CARDINAL
OPERATING COMPANY

6677 Busch Blvd.
Columbus, OH 43229
614.846.5757

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 – FAR II 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 Fly Ash Reservoir II 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 complete conversion to a dry fly ash system for future disposal at the on-site FAR I RSW Landfill.

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,

M. Alban

Thomas M. Alban
Vice President

cc: Kristen Hillyer
Frank Behan
Richard Huggins

CARDINAL
OPERATING COMPANY

Cardinal Power Plant
Fly Ash Reservoir II

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

Report SL-015643
Revision 1
November 30, 2020
Issue Purpose: Use
Project No.: 13770-007

55 East Monroe Street
Chicago, IL 60603-5780 USA
312-269-2000
www.sargentlundy.com

Sargent & Lundy

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EXECUTIVE SUMMARY

Fly Ash Reservoir (FAR) II at the Cardinal Power Plant in Brilliant, Ohio does not meet the liner design criteria or the uppermost aquifer location 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 FAR II as soon as technically feasible and 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 FAR II – both permanent and temporary – the Cardinal Operating Company has concluded that no alternative disposal is available for the waste streams currently being sent to FAR II, 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 FAR II.

The Cardinal Power Plant currently sends the following coal combustion residual (CCR) and non-CCR waste streams to FAR II: fly ash transport water (CCR), excess process water from the station’s Bottom Ash Pond Complex (non-CCR), and leachate and contact storm water run-off from the station’s landfill (non-CCR). After evaluating several options for providing permanent alternative disposal capacity to FAR II for these waste streams, the Cardinal Operating Company elected to install a multiple technology system: convert the Cardinal Power Plant’s wet fly ash-handling system to a dry system to utilize the plant’s landfill for fly ash disposal, and install a waste water treatment system for the landfill’s leachate and contact storm water run-off prior to discharge. In addition to providing compliance with the EPA CCR Rule, the dry fly ash system also eliminates the generation of fly ash transport water at the Cardinal Power Plant and therefore inherently provides compliance with the EPA’s zero liquid discharge standard for fly ash transport water in the agency’s recently revised effluent limitation guidelines for steam electric power generating stations.

The dry fly ash system is currently being constructed at all three of the Cardinal Power Plant’s generating units, and the waste water treatment system is currently being designed and permitted for the landfill leachate and contact storm water run-off. Both systems are scheduled to be installed and operational by June 7, 2021. Accordingly, the Cardinal Operating Company is requesting the EPA allow FAR II to continue receiving the CCR and non-CCR waste streams currently managed therein until June 7, 2021.

1.0 DEVELOPMENT OF ALTERNATIVE CAPACITY

This section presents the option selected by the Cardinal Operating Company to provide alternative disposal capacity to Fly Ash Reservoir II for the CCR and non-CCR waste streams managed therein. In addition, this section provides background information on the Cardinal Power Plant, Fly Ash Reservoir II and the waste streams managed therein, the adverse impact to plant operations if Fly Ash Reservoir II 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 Fly Ash Reservoir II beyond April 11, 2021 is 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.

1.1.1.1 PLANT OWNERSHIP & SERVICE AREA

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.

1.1.1.2 FLY ASH-HANDLING SYSTEM

Fly ash produced by all three of the station's units is initially collected by the hoppers underneath the casings of each unit's electrostatic precipitators (ESPs). The fly ash is then vacuum-pneumatically conveyed from these hoppers to one of two Hydroveyor® exhausters, where the dry fly ash is mixed with water recycled from the Recirculation Pond in the station's Bottom Ash Pond (BAP) Complex and the conveying air is discharged to the environment. The fly ash-water mixture (slurry) is then temporarily stored in tanks before ultimately being sluiced to the plant's existing Fly Ash Reservoir (FAR) II via three slurry pumps.

1.1.2 FLY ASH RESERVOIR II

1.1.2.1 RESERVOIR CHARACTERISTICS

FAR II is a coal combustion residual (CCR) surface impoundment that occupies a narrow valley due north of Cardinal Units 1 and 2. The reservoir was created by constructing a dam across the valley to retain the fly ash sluice water. A figure of the Cardinal facility and associated CCR units is presented in Figure 1.

1.1.2.2 RESERVOIR INFLOWS & OPERATIONS

Based on the Fact Sheet submitted with Cardinal Operating Company's 2018 National Pollution Discharge Elimination System (NPDES) permit application for the Cardinal Power Plant (Ref. 3), an average of approximately 8.9 million gallons of fly ash transport water (FATW) is sent to FAR II per day. In addition to FATW, the plant also conveys the following low-volume waste (LVW) streams to FAR II at a collective average of approximately 2.9 million gallons per day (MGD):

- Excess process water recycled from the Recirculation Pond to control the water level in BAP Complex (2.0 MGD), and
- Leachate collected and removed from the adjacent FAR I Landfill (0.1 MGD),
- Contact storm water run-off from the adjacent FAR I Landfill (0.8 MGD).

Table 1 summarizes the waste streams currently sent to FAR II. 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. The water balance diagram associated with Cardinal's NPDES Permit 0IB00009*XD is presented in Figure 2.

Table 1 – Inflows into Cardinal Fly Ash Reservoir II

Waste Stream	Description	Average Flow, MGD (Max. 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		**2.90** **(28.60)**
Excess Process Water Through Unit 1 & 2 Fly Ash-Handling Systems	Water removed from the BAP Complex to control the pond's water level that bypasses the Unit 1 and 2 Hydroveyors®	0.96 (2.88)
Excess Process Water Through Unit 3 Fly-Ash Handling System	Water removed from the BAP Complex to control the pond's water level that bypasses the Unit 3 Hydroveyors®	1.06 (3.17)
FAR I Landfill Leachate	Leachate collected and removed from FAR I Landfill	0.09 (0.41)
FAR I Landfill Storm Water Run-Off	Contact storm water run-off from FAR I Landfill	0.79 (22.14)

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

1.1.2.2.1 FLY ASH TRANSPORT WATER

The primary purpose of FAR II is to store fly ash produced by Cardinal during power-generating operations. FATW enters the northern end of the reservoir, and the suspended fly ash particles undergo sedimentation as the water flows towards the outfall at the southern end of the pond. The pond effluent then discharges through the station's NPDES-permitted Outfall 019.

1.1.2.2.2 EXCESS PROCESS WATER

In order to control the water level in the BAP Complex, particularly during unit outages and significant storm events, Cardinal will recover additional water from the complex's Recirculation Pond and route it to FAR II while bypassing the fly ash-handling systems. This process allows the station to limit discharges through NPDES-permitted Outfall 023 at the southern end of the Recirculation Pond, especially after significant storm events.

1.1.2.2.3 FAR I LANDFILL LEACHATE & CONTACT STORM WATER RUN-OFF

Cardinal's FAR I Landfill has a perimeter containment berm system that prevents storm water that comes into contact with solid waste ("contact storm water") from leaving the active landfill area. A perimeter drainage ditch inside and adjacent to the containment berm route collected contact water to chimney drains that flow into the landfill's leachate collection pipes. Contact water and leachate are ultimately conveyed to FAR II, which serves as FAR I Landfill's leachate treatment pond.

1.1.2.3 APPLICABLE REGULATIONS

1.1.2.3.1 FEDERAL CCR RULE

FAR II 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, FAR II 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 FAR II 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 FAR II – specifically discharges through NPDES-permitted Outfall 019 – is also subject to compliance with the EPA's effluent limitation guidelines for steam electric power plants ("ELG Rule"). The 2015 update to the ELG Rule (Ref. 8) set new limits for discharging FATW and other waste streams generated by steam electric power plants to waters of the U.S. Pursuant to 40 CFR 423.13(h)(1)(i), the ELG Rule establishes a zero-liquid discharge (ZLD) standard for Cardinal's FATW – including any LVW streams that come into contact with FATW – unless the FATW is used in a flue gas desulfurization (FGD) scrubber. In this case, the waste water may be discharged in accordance with the ELGs specified in 40 CFR 423.13(g)(1)(i) for FGD waste water.

Cardinal will be subject to the ZLD standard for FATW 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, 2023.

1.1.2.4 FUTURE HANDLING OF FLY ASH

FAR II 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. In addition, the pond's base is within five feet of the upper limit of the site's uppermost aquifer (Ref. 11). Thus, per 40 CFR 257.101(a)(1), (a)(3), (b)(1)(i), and (b)(4), Cardinal must cease placing the CCR and non-CCR waste streams listed in Table 1 into FAR II 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 FAR II after April 11, 2021 while it develops alternative capacity to replace the reservoir because:

- No existing alternative disposal capacity is available on- or off-site for these waste streams, and
- It was technically infeasible to develop the alternative capacity selected by April 11, 2021 for these waste streams.

1.1.3 ADVERSE IMPACT TO PLANT OPERATIONS WITHOUT FAR II

In order to generate power at Cardinal, it is necessary to dispose of the fly ash produced from the combustion of pulverized coal in the station's boilers. Without suitable replacements for the FAR II, the Cardinal plant would be forced to stop power-generating operations. Additionally, if FAR II was forced to initiate closure, Cardinal would be subject to NPDES violations. Treatment systems designed to treat the LVW streams (landfill leachate, contact stormwater and non-contact stormwater) to meet effluent limits would not have been constructed, and the waste streams 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 bottom ash transport water (BATW) in the 2015 ELG Rule (Ref. 8), which included (and still include) non-CCR waste streams that are commingled with FATW and BATW, the Cardinal Operating Company 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, the Cardinal Operating Company 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 several different methods for disposing of Cardinal's fly ash in lieu of sluicing it to FAR II. This study expanded a similar assessment performed in 2016 to identify additional fly ash storage capacity and, in accordance with the Cardinal Operating Company's desire for a holistic solution, assessed not only permanent disposal solutions for Cardinal's FATW but also the LVW streams managed by the reservoir. 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 FAR II. 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 FAR II and how these waste streams were ultimately dispositioned.

1.3.1 EXISTING ON-SITE DISPOSAL SOLUTIONS

1.3.1.1 FLY ASH TRANSPORT WATER

Because FATW 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: FAR II, the BAP Complex, and FAR I Landfill. The BAP Complex is comprised of two CCR surface impoundments used by the station to store and treat its BATW and several miscellaneous non-CCR waste streams. However, like FAR II, both ponds in the BAP Complex are not compliant with the EPA CCR Rule's liner design criteria and are therefore subject to the closure-for-cause requirements promulgated by 40 CFR 257.101. Moreover, the BAP Complex is significantly smaller than FAR II (approximately 25 acres versus 160 acres) and was not designed to provide adequate detention time for the finer ash particles in Cardinal's FATW prior to being discharged in accordance with the station's NPDES permit. Finally, the BAP Complex was not designed to contain Cardinal's total daily volume of FATW and BATW. Thus, the BAP Complex would not be an acceptable alternative disposal facility for Cardinal's fly ash even if the necessary mechanical equipment and piping were installed to divert FATW from FAR II to the BAP Complex.

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 fly ash and has sufficient capacity to accommodate Cardinal's daily generation of fly ash, the Ohio EPA prohibits industrial solid waste landfills like FAR I Landfill from receiving bulk or noncontainerized liquids wastes like Cardinal's FATW (Ref. 10). Thus, the station cannot utilize its landfill for directly disposing of its fly ash while it has a wet fly ash-handling system. Cardinal would need a fly ash dewatering system or an entirely dry fly ash-handling system to directly send its fly ash to FAR I Landfill. Because Cardinal does not currently have these systems, the station does not presently have the means to directly dispose of its fly ash in FAR I Landfill.

In summary, there is no alternative on-site disposal capacity to FAR II available for Cardinal's wet-generated fly ash because:

- The station's only other wet CCR disposal facility, the BAP Complex, is not compliant with the EPA CCR Rule's liner design criteria and, like FAR II, is subject to closure for cause, and
- Neither a dry fly ash-handling system nor a fly 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 EXCESS PROCESS WATER FROM BAP COMPLEX

Excess process water recovered from the BAP Complex and sent to FAR II to maintain the former's water level inherently has an alternative disposal solution at Cardinal: the BAP Complex from which it comes. However, the station needs to remove this water during unit outages (all three units have outages scheduled for spring 2021) and during significant storm events. Otherwise, it is unlikely the BAP Complex would provide adequate detention time for the surplus volume of wastewater to meet Cardinal's NPDES permit requirements before having to discharge through Outfall 023 to avoid overtopping. Thus, this water needs to continue being sent to FAR II to avoid NPDES permit violations.

It should be noted that management of excess water sent to the BAP Complex after FAR II has initiated closure will be the responsibility of the contractor repurposing the BAP Complex in accordance with the Cardinal Operating Company's demonstration for a site-specific alternative initiation of closure deadline for the BAP Complex. Per the Cardinal Operating Company's workplan for repurposing the BAP Complex, that contractor is expected to mobilize to the site as FAR II is taken out of service and start drawing down the water level in the BAP Complex. All discharges from the BAP Complex at that time will be performed in accordance with Cardinal's NPDES permit.

1.3.1.2.2 FAR I LANDFILL LEACHATE & CONTACT STORM WATER RUN-OFF

The leachate and contact storm water from FAR I Landfill require adequate detention time for sedimentation to reduce the concentration of total suspended solids (TSS) to adequate discharge levels in accordance with the station's NPDES permit. Given its size, the reservoir has historically been able to accept and treat this secondary waste stream in addition to the FATW that it treats. The only other existing facility at the Cardinal station that might be able to accept leachate and contact storm water run-off from FAR I Landfill would be the BAP Complex. However, as previously stated, this facility cannot accept new waste streams since it is subject to the closure-for-cause requirements promulgated by 40 CFR 257.101. Thus, the BAP Complex would not be an acceptable alternative disposal facility for the leachate and contact storm water run-off from FAR I Landfill even if the necessary mechanical equipment and piping were installed to divert this waste stream from FAR II to the BAP Complex.

While Cardinal has two, small coal pile runoff ponds, these ponds are not an alternative to FAR II. 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. If these ponds were to accept leachate, they would need to be lined and have a groundwater monitoring system installed pursuant to Ohio Residual Solid Waste regulations.

1.3.2 EXISTING OFF-SITE DISPOSAL SOLUTIONS

1.3.2.1 TEMPORARY OFF-SITE DISPOSAL FACILITIES

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 FATW, FAR I Landfill leachate, and contact storm water run-off from FAR I Landfill to an off-site disposal facility until a permanent disposal facility could be installed on-site. 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 the BAP Complex. Consequently, CCR and non-CCR waste streams sent to this pond would also need to be transported to an off-site treatment facility if alternative disposal capacity does not currently exist on-site. As demonstrated in the corresponding workplan for the BAP Complex, 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 12.1 MGD of CCR and non-CCR waste water would need to be sent to a temporary facility off-site in addition to the noted FAR II 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 FAR II and the BAP Complex, 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 the Cardinal Bottom Ash Pond Complex Requiring Alternative Disposal

Waste Stream	Description	Average 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**
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	Contact storm water collected by sumps and drains in the Unit 3 power block	0.02
Coal Pile Run-Off Pond Overflow	Waste water collected by the station’s Coal Pile Run-Off Pond. Includes contact 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

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.

In this scenario, fly ash slurry temporarily stored in the existing tanks downstream of the station's Hydroveyors® would be directly pumped into the trucks' tank trailers. Meanwhile, based on an average continuous flow rate of 8,400 gpm, 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. 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 FATW and BATW generated by the station.

Even if the station could support the number of tank trucks to keep up with its daily production rate of ash 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 FATW, FAR I Landfill leachate, and contact storm water run-off from FAR I Landfill. 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 FAR II.

1.3.3.1 EVALUATION OF ASH DISPOSAL METHODS

As previously stated, the Cardinal Operating Company commenced a study in the third quarter of 2018 that evaluated several different methods for disposing of Cardinal's fly ash in lieu of sluicing it to FAR II. This study was an expansion of a similar assessment performed two years earlier and included the following fly ash-handling technologies:

- 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
- Convert Cardinal's fly ash-handling system to a dry, vacuum-pneumatic system (with final disposal in FAR I Landfill).

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, FATW lines could be routed directly to a series of these tubes to filter fly ash particles out of the transport water. As the fly 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 fly ash particles, FATW 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 its contents 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 FATW, 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 fly ash-handling system.

While geotextile filter tubes have been used as a method for dewatering bottom ash ponds, this option could be considered a “first-of-a-kind” technology for dewatering a power plant’s daily product of fly ash. Consequently, this option would have a lot of uncertainties, especially as it pertains to dewatering and filtering out very fine fly ash particles. Filter aids such as coagulants and polymers may be required to coagulate the ash particles together, making them easier to filter; a series of tests would likely be required to determine the appropriate aids. This option would also require active monitoring to ensure the tube being filled is being done so uniformly and that all the tubes are being filled systematically. Finally, there would be challenges in operating and dewatering these tubes during below-freezing weather conditions and significant rain events.

Based on the permitting, engineering and design, procurement, and construction activities required to implement this option, the Cardinal Operating Company estimated that a new geotextile tube facility would take approximately 2.5 years to construct. The primary driver of this schedule would be the permitting required to modify the existing wet fly ash-handling system with this new treatment option.

1.3.3.1.2 NEW SURFACE IMPOUNDMENT

The Cardinal Operating Company also considered replacing FAR II 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 FATW 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 modify the station’s FATW piping, 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 FAR II.

1.3.3.1.3 CONCRETE SETTLING TANKS

In lieu of a traditional ash pond, fly 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, FATW in the surge tank would ultimately be recirculated back to the station to comply with the revised ELG Rule. Cardinal would sluice FATW 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, could be considered "first of a kind" for regularly handling fly ash. The finer fly ash particles require a longer detention time than bottom ash to settle out of transport water, and therefore it is questionable whether fly ash can be adequate dewatered in a concrete settling tank. Filter aids such as coagulants and polymers could be introduced to the FAW, but this would require adequate bench testing to assure operational reliability. Moreover, given the inherent ability of fly ash to retain water, it is anticipated that the amount of manual labor required to dewater this material would be significant. Dewatering would also be further inhibited by adverse weather conditions, especially during the winter. Finally, 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.

Given this option's similarities to the geotextile filter tube option, it was anticipated that this option would take a similar amount of time to implement. Thus, the Cardinal Operating Company estimated that it would take approximately 2.5 years to construct new concrete settling tanks and the ancillary operating equipment to handle Cardinal's fly ash.

1.3.3.1.4 DRY FLY ASH CONVERSION

Finally, the Cardinal Operating Company evaluated the conversion of Cardinal's existing wet fly ash-handling system to a dry system. In addition to providing inherent compliance with the ELG Rule, this would enable Cardinal to utilize FAR I Landfill as the alternative disposal capacity for FAR II without the operational risks of geotextile filter tubes or concrete settling tanks. This option would entail a new vacuum-pneumatic system for each unit that would utilize air flow and conveying pipes to transfer fly ash from the units' ESPs to filter separators, which would separate the conveying air from the fly ash. The fly ash would ultimately be discharged into a silo for temporary storage until the material is loaded onto trucks for either on-site disposal in FAR I Landfill or beneficial re-use.

For this option, the primary schedule driver would be the procurement of the temporary storage silos and the other fly ash-handling equipment required for the project. While some time would be required to apply for and receive an air permit for this option, the overall permitting effort would not be as extensive as the preceding three options. Overall, it was estimated that it would take a little over 2 years to convert Cardinal's wet fly ash-handling system into a dry system.

1.3.3.2 OPTION SELECTED

Ultimately, the Cardinal Operating Company elected to comply with the EPA CCR and ELG Rules by installing a new vacuum-pneumatic fly ash conveying system at each unit, temporarily storing dry fly ash in new storage silos, and ultimately transporting the stored fly ash to Cardinal's existing FAR I Landfill for final disposal. This option provided the station with a proven technology widely utilized by power plants that also eliminates FATW which inherently provides compliance with the EPA ELG Rule's ZLD standard for this waste stream.

Although a conversion to a dry fly ash-handling system provides access to alternative disposal capacity for Cardinal's fly ash (FAR I Landfill), this system does not provide alternative storage for FAR I Landfill's leachate or contact storm water run-off. Accordingly, the Cardinal Operating Company has also been developing alternative disposal capacity for these non-CCR waste streams. Specifically, a new leachate collection system is being developed to treat the leachate and contact storm water run-off from FAR I Landfill. In essence, the Cardinal Operating Company has opted to replace FAR II with a multiple technology system that consists of converting the station's wet fly ash-handling system to a dry system and installing a new waste water treatment system for FAR I Landfill's leachate and contact storm water run-off.

1.3.3.3 JUSTIFICATION OF OPTION SELECTED

Of the new, permanent on-site disposal alternatives considered to replace FAR II, the multiple technology system selected – convert Cardinal's wet fly ash-handling system to a dry system to utilize FAR I Landfill and install a waste water treatment facility for FAR I Landfill's leachate and contact storm water run-off – is the alternative disposal capacity that could be implemented the fastest and is technically feasible. In addition, both components ultimately provide the Cardinal station with a holistic solution for compliance with the EPA CCR and ELG Rules. Both systems provide alternative disposal capacity for the various waste streams currently managed by FAR II (EPA CCR Rule compliance), and the dry fly ash system eliminates the generation of FATW at the station and therefore inherently eliminates the future discharge of FATW from the Cardinal plant (EPA ELG Rule compliance).

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 are not proven technologies for handling a power plant's daily generation of fly ash. 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 just over three years to design, permit, and construct the FATW piping to and from the impoundment, the composite liner system, the dams necessary to form a reservoir, and the well network for groundwater monitoring (including establishing background levels). Conversely, a vacuum-pneumatic conveying system requires less time to construct at the Cardinal plant (just over two years) and is a proven dry fly ash-handling technology that is widely utilized in the power industry.

1.4 CONCEPTUAL DESIGN OF ALTERNATIVE DISPOSAL CAPACITY

This section describes the conceptual designs for Cardinal's dry fly ash conversion and the waste water treatment for FAR I Landfill's leachate and contact storm water run-off.

1.4.1 DRY FLY ASH CONVERSION

1.4.1.1 CONCEPTUAL DESIGN OF VACUUM-PNEUMATIC CONVEYING SYSTEM

In general, the new vacuum-pneumatic system for each unit will utilize air flow and conveying pipes to transfer fly ash from the units' ESPs to filter separators, which will separate the conveying air from the fly ash. The fly ash will then be discharged into a silo for temporary storage until the material is loaded onto trucks for either on-site disposal at Cardinal's existing landfill or beneficial re-use.

The fly ash vacuum-pneumatic conveying system for each unit will utilize the existing branch line pipes and the ash feed valves located under the two precipitators. New conveying pipes will be installed between each unit's fly ash collection hoppers (one pipe per precipitator casing) to a new storage silo dedicated to each unit. A crossover pipe downstream of the precipitator will allow fly ash to be conveyed to the given unit's storage silo by either conveying pipe. New vacuum exhausters will be installed to provide the conveying vacuum to the storage silos and will be cross-tied to allow the station to switch between vacuum conveying trains or operating filter separators. Fly ash will be separated from the conveying air via one of two filter separators installed on top of each storage silo.

To empty each silo, the fly ash will be aerated by fluidizing blowers and air heaters at the bottom of the silo. The discharge of the silo will be provided with a water-based ash conditioner (i.e. pin mixer) for loading trucks hauling the fly ash to Cardinal's existing landfill for disposal. The plant's existing service water system will supply the water to the pin mixers on each silo. Each silo's discharge will also be equipped with a telescoping spout for loading dry ash into enclosed truck trailers.

A new transformer and motor control center (MCC) will be installed to power the auxiliary equipment for each unit's vacuum-pneumatic conveying system. Each unit's MCC will be installed within a new power distribution center (PDC) near the given unit's vacuum exhausters and storage silo. Finally, the existing fly ash system programmable logic controls (PLCs) will be migrated to the station's distributed control system (DCS), and new DCS controllers and input/output (I/O) hardware will be added where needed for the new fly ash system and integrated into the existing station DCS.

1.4.1.2 IMPACTS TO STATION WATER BALANCE

Historically, Cardinal has discharged FATW and non-CCR waste streams sent to FAR II through NPDES-permitted Outfall 019. As previously mentioned, contact storm water run-off and leachate from FAR I Landfill also drain to FAR II. Upon revising the station's NPDES permit in accordance with the revised ELG Rule (see Section 1.1.2), these streams would be considered FATW in accordance with 40 CFR 423.13(h)(1)(i) and thus could not be discharged to waters of the U.S. Accordingly, the new vacuum-pneumatic conveying system eliminates FATW sent to and discharged from FAR II. In addition, Cardinal Operating Company is in the process of designing and permitting a new waste water treatment system for the contact storm water run-off and leachate from FAR I Landfill such that these waste streams will no longer be sent to FAR II.

1.4.2 TREATMENT FOR FAR I LANDFILL WASTE STREAMS

In addition to treating Cardinal's FATW, FAR II also serves as the treatment pond for FAR I Landfill's leachate and contact storm water run-off prior to discharge to the Ohio River via NPDES-permitted Outfall 019. Given its size, FAR II provides adequate detention time to treat the TSS in the landfill's leachate and contact storm water run-off via sedimentation. Therefore, the replacement disposal capacity for these waste streams would need to provide similar treatment. Indeed, the Cardinal Operating Company is currently developing a waste water treatment system comprised of settling and treatment tanks to handle and treat FAR I Landfill's leachate and contact storm water run-off prior to discharge through Outfall 019.

The Cardinal Operating Company plans to install the settling and treatment tanks at the FAR I Landfill. New piping will convey the landfill's leachate and contact storm water run-off to these tanks by tying into the existing piping currently conveying these waste streams into FAR II. New piping will also be installed to convey treated effluent from the tanks to the existing Outfall 019. These tanks will be adequately sized to promote settling of the TSS in both waste streams prior to NPDES-permitted concentrations.

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 that the EPA allow FAR II to continue operating until June 7, 2021, when the vacuum-pneumatic conveying systems for all three units will be operational. During this period, the following CCR and non-CCR waste streams would be placed into FAR II since they do not currently have alternative disposal options at Cardinal or offsite:

- Unit 1 and 2 FATW,
- Unit 3 FATW,
- Excess process water from the BAP Complex,
- FAR I Landfill leachate, and
- FAR I Landfill contact storm water run-off.

The Cardinal Operating Company is requesting this additional time to continue operating FAR II not only because of the time required to develop the selected alternative disposal capacity, but also because of the time required to perform the preliminary engineering for the project and the time required to secure project funding from the electric cooperatives for which it serves. These items are discussed in the following paragraphs. A detailed explanation and justification for the time required to convert Cardinal's wet fly ash-handling system to a dry system and to install the waste water treatment system for FAR I Landfill's leachate and contact storm water run-off, starting with the engineering and design phase, are 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 FAR II until the new vacuum-pneumatic conveying systems are operational. This evaluation is summarized at the end of this section.

1.5.1.1 PLANNING & INITIAL DESIGN

As previously stated, the Cardinal Operating Company has been actively evaluating different means of handling and disposing of its fly ash since even before the *USWAG* decision in August of 2018. Shortly after completing the aforementioned conceptual assessment of different fly ash-handling technologies in late 2018, the Cardinal Operating Company opted to convert Cardinal's wet fly ash-handling system to a dry system and initiated a more detailed study for the new vacuum-pneumatic fly ash conveying system required to do so. This preliminary engineering phase included developing conceptual design drawings such as general arrangements, electrical one-lines, and process flow diagrams; updating the station's water balance to reflect the conversion to dry fly ash handling; and estimating the capital and operation and maintenance (O&M) costs for the dry system. This study was completed in late 2018.

1.5.1.2 PROJECT FUNDING & INITIATION

The capital and O&M cost estimates developed during the dry fly ash conversion study were ultimately used to obtain the necessary funding for the project. The dry fly ash conversion project at Cardinal 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 August 2018 *USWAG* decision (and subsequent October 2018 mandate by the U.S. Court of Appeals for the D.C. Circuit) (Ref. 2), this project also provides operational changes required to comply with the EPA ELG Rule regulations for FATW. Therefore, funding for the entire project was able to be approved prior to the EPA finalizing its updates to its CCR Rule in response to the aforementioned court mandate. However, it was not possible to start the project sooner on the basis of forecasted changes to the EPA CCR Rule due to the October 2018 court mandate given the project approval process utilized by Cardinal Operating Company.

Ultimately, the Cardinal Operating Company secured the funding required to initiate the dry fly ash conversion project shortly after finalizing the detailed study in late 2018. Detailed engineering and design commenced in March 2019 and construction is currently ongoing at all three units of the station. See Sections 2.0 and 3.0 for the visual timeline representation and narrative discussion of the project schedule, respectively. For the progress made to date on the dry fly ash conversion project, see Section 4.0.

1.5.1.3 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 FAR II until the new vacuum-pneumatic conveying systems and landfill leachate treatment system are operational at all three units on June 7, 2021: tanks and water treatment trailers.

1.5.1.3.1 STORAGE TANKS

Based on the Cardinal Operating Company's current forecast of obtaining permanent alternative disposal capacity to replace FAR II, enough tanks would need to be procured and installed at the site to provide storage of waste water produced by the plant for approximately eight months. Given an average daily inflow of 9.8 MGD into FAR II for Cardinal's FATW, FAR I Landfill leachate, and contact storm water run-off from FAR I Landfill (see Table 1), these temporary tanks would need to provide almost 2.4 billion gallons-worth of storage. It is not technically feasible to install this many tanks at the Cardinal site to provide temporary storage.

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. Given that fly ash particles are generally very fine and given the daily volume of FATW produced at Cardinal, this is not a technically feasible option for Cardinal's FATW. 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).

As previously stated, this option is being implemented as the permanent alternative disposal solution for the leachate and contact storm water run-off from FAR I Landfill. However, the leachate treatment system will not be operational until June 7, 2021 given the time required to design, permit, and construct this system. The primary schedule driver is modifying the station's NPDES permit for this alternative treatment system for these waste streams, which Cardinal anticipates taking six months based on recent experience with similar PTIs submitted to the Ohio EPA.

1.5.1.3.2 WASTE WATER TREATMENT TRAILERS

While it is technically infeasible to use tanks to temporarily treat the large flow of FATW currently going into FAR II, waste water treatment trailers from a vendor that specializes in such technology may be capable of treating Cardinal's FATW. The amount of waste water a trailer can treat is dependent on water chemistry, but 1 MGD is generally achievable. So, it would take approximately nine trailers to treat Cardinal's daily average generation of FATW (8.93 MGD). Despite its ability to treat this large flow, waste water treatment trailers are not appropriate for waste streams with restricted discharge rates since a trailer would not have the size required to detain treated waste water. Thus, temporary storage tanks would still need to be installed downstream of these trailers to detain treated FATW which, per the previous subsection, is not technically feasible at Cardinal. Consequently, a network of waste water treatment trailers is also a technically infeasible solution for providing temporary storage capacity for Cardinal's FATW in lieu of FAR II while the station is being retrofitted with a dry fly ash-handling system.

2.0 PROJECT SCHEDULE: VISUAL TIMELINE

This section presents a visual timeline representation of the Cardinal Operating Company's schedule for converting Cardinal's current wet fly ash-handling system to a dry system. 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 convert Cardinal's wet fly ash-handling system to a dry system, and
- How long each phase and step within each phase will take.

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

- Engineering & Design,
- Permitting,
- Procurement, and
- Construction.

In accordance with 40 CFR 257.103(f)(iv)(1)(A)(*2*)(*iv*), the project schedule includes the following sub-phases in the Procurement and Construction phases:

- Procurement:
  - Fabrication and delivery of piles, concrete (including rebar), structural steel, the fly ash system, a pre-fabricated PDC building, and transformers.
  - Selection of a contractor to install the piles supporting the base mats for the new fly ash storage silos.
  - Selection of a contractor to install civil works (*e.g.*, roads, site grading) and substructures,
  - Selection of a contractor to install the dry fly ash system and its ancillary components (*i.e.*, general work contractor).
  - Selection of a contractor to install the electrical components.
- Construction:
  - Commissioning (*i.e.*, start-up and implementation) of the Unit 1, 2, and 3 dry fly ash systems and components, and
  - Substantial completion (*i.e.*, tuning and optimization) of the Unit 1, 2, and 3 dry fly ash systems and components.

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

Activity ID	Activity Name	Activity % Complete	Start	Finish
Cardinal Units 1-3 Dry Fly Ash Conversion - Sargent & Lundy - Pern			11-Mar-19 A	21-Nov-21
Cardinal Units 1-3 Dry Fly Ash Conversion - Sargent & Lundy - Permi			11-Mar-19 A	21-Nov-21
Milestones			11-Mar-19 A	10-May-21
M01000.00	Project Authorization (LVL2)	100%	11-Mar-19 A	
M01010.00	Receive Construction Permit	100%		22-Aug-19 A
M01100.00	Unit 1 Operational	0%		12-Jan-21*
M01200.00	Unit 2 Operational	0%		25-Mar-21*
M01300.00	Unit 3 Operational	0%		10-May-21
Permitting			01-Jun-19 A	22-Aug-19 A
P01000.00	Prepare Permit (LVL2)	100%	01-Jun-19 A	26-Jun-19 A
P01100.00	Obtain Permit (LVL2)	100%	01-Aug-19 A	22-Aug-19 A
Engineering & Design			11-Mar-19 A	08-Jun-21
General			11-Mar-19 A	08-Jun-21
Design Basis			11-Mar-19 A	29-Jul-19 A
G100-00	Design Basis - Summary	100%	11-Mar-19 A	29-Jul-19 A
G100-10	Design Basis - Prep & Review	100%	11-Mar-19 A	10-May-19 A
G100-20	Design Basis - Issue for Owner Review	100%	13-May-19 A	17-May-19 A
G100-25	Design Basis - Owner Review	100%	20-May-19 A	12-Jul-19 A
G100-30	Design Basis - Incorp Comms/Issue for Design	100%	15-Jul-19 A	29-Jul-19 A
Model			11-Mar-19 A	10-Feb-20 A
G110-0L	Plant & Equipment Modeling	100%	11-Mar-19 A	10-Feb-20 A
Demolition / Relocation/Redesign				
Cost Estimate			11-Mar-19 A	08-Jul-19 A
G130-00	Cost Estimate - Summary	100%	11-Mar-19 A	08-Jul-19 A
G130-10	Update Cost Estimate - Prep & Review	100%	11-Mar-19 A	03-Jul-19 A
G130-20	Cost Estimate - Issue for Use	100%	04-Jul-19 A	08-Jul-19 A
Permitting Support			24-Jun-19 A	22-Aug-19 A
G140-0L	Permitting Support	100%	24-Jun-19 A	22-Aug-19 A
Permit List			11-Jun-19 A	26-Jun-19 A
G142-0L	Develop Permit List - WBS Summary	100%	11-Jun-19 A	26-Jun-19 A
G142-10	Permit Application Prep & Review	100%	11-Jun-19 A	26-Jun-19 A
G142-20	Permit Application - Issue to the Agency	100%	26-Jun-19 A	26-Jun-19 A
Air Emissions Plan			11-Mar-19 A	10-May-19 A
G144-00	Air Emissions Plan	100%	11-Mar-19 A	10-May-19 A
G144-10	Air Emissions Plan - Prep & Review	100%	11-Mar-19 A	03-May-19 A
G144-20	Air Emissions Plan - Issue for Use	100%	06-May-19 A	10-May-19 A
Air Emissions Calculatiion			13-May-19 A	21-Jun-19 A
G146-00	Air Emissions Calculatiion	100%	13-May-19 A	21-Jun-19 A
G146-10	Air Emissions Calculatiion - Prep & Review	100%	13-May-19 A	21-Jun-19 A
G146-20	Air Emissions Calculatiion - Issue for Use	100%	21-Jun-19 A	21-Jun-19 A
Dwg Closeout/File Return			11-May-21	08-Jun-21
X800-0L	Dwg Closeout/File Return	0%	11-May-21	08-Jun-21
Home Office Construction Support			17-Feb-20 A	10-May-21
X900-0L	Home Office Construction Support	51.12%	17-Feb-20 A	10-May-21

🟦 Actual Work
🟥 Critical Remaining Work
▭ % Complete
🟩 Remaining Work
◆ Milestone
▼ Summary

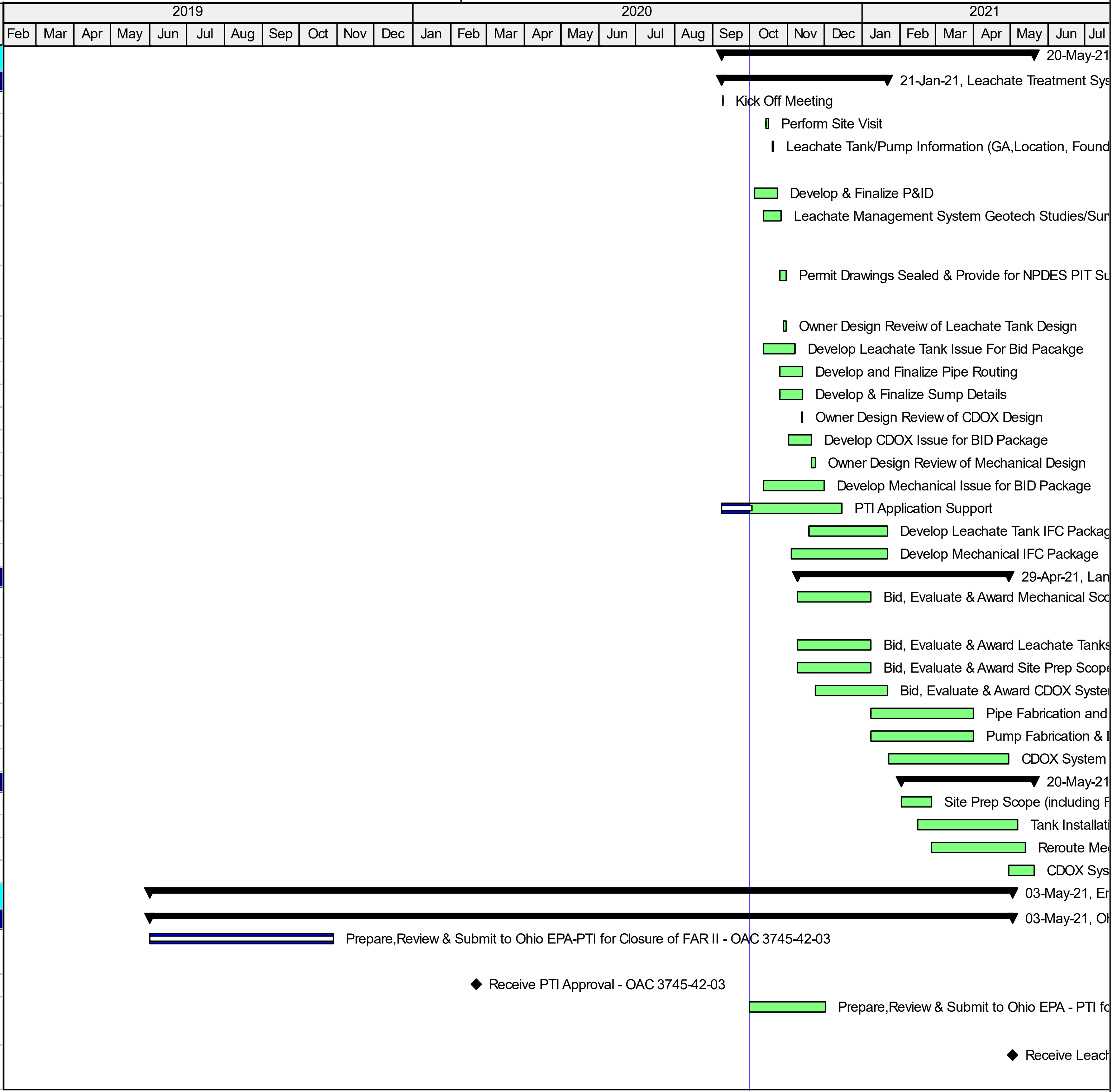
TASK filter: All Activities

Activity ID	Activity Name	Activity % Complete	Start	Finish
Cardinal Units 1-3 Dry Fly Ash Conversion - Sargent & Lundy - Pern			11-Mar-19 A	21-Nov-21
Cardinal Units 1-3 Dry Fly Ash Conversion - Sargent & Lundy - Permi			11-Mar-19 A	21-Nov-21
Milestones			11-Mar-19 A	10-May-21
M01000.00	Project Authorization (LVL2)	100%	11-Mar-19 A	
M01010.00	Receive Construction Permit	100%		22-Aug-19 A
M01100.00	Unit 1 Operational	0%		12-Jan-21*
M01200.00	Unit 2 Operational	0%		25-Mar-21*
M01300.00	Unit 3 Operational	0%		10-May-21
Permitting			01-Jun-19 A	22-Aug-19 A
P01000.00	Prepare Permit (LVL2)	100%	01-Jun-19 A	26-Jun-19 A
P01100.00	Obtain Permit (LVL2)	100%	01-Aug-19 A	22-Aug-19 A
Engineering & Design			11-Mar-19 A	08-Jun-21
General			11-Mar-19 A	08-Jun-21
Design Basis			11-Mar-19 A	29-Jul-19 A
G100-00	Design Basis - Summary	100%	11-Mar-19 A	29-Jul-19 A
G100-10	Design Basis - Prep & Review	100%	11-Mar-19 A	10-May-19 A
G100-20	Design Basis - Issue for Owner Review	100%	13-May-19 A	17-May-19 A
G100-25	Design Basis - Owner Review	100%	20-May-19 A	12-Jul-19 A
G100-30	Design Basis - Incorp Comms/Issue for Design	100%	15-Jul-19 A	29-Jul-19 A
Model			11-Mar-19 A	10-Feb-20 A
G110-0L	Plant & Equipment Modeling	100%	11-Mar-19 A	10-Feb-20 A
Demolition / Relocation/Redesign				
Cost Estimate			11-Mar-19 A	08-Jul-19 A
G130-00	Cost Estimate - Summary	100%	11-Mar-19 A	08-Jul-19 A
G130-10	Update Cost Estimate - Prep & Review	100%	11-Mar-19 A	03-Jul-19 A
G130-20	Cost Estimate - Issue for Use	100%	04-Jul-19 A	08-Jul-19 A
Permitting Support			24-Jun-19 A	22-Aug-19 A
G140-0L	Permitting Support	100%	24-Jun-19 A	22-Aug-19 A
Permit List			11-Jun-19 A	26-Jun-19 A
G142-0L	Develop Permit List - WBS Summary	100%	11-Jun-19 A	26-Jun-19 A
G142-10	Permit Application Prep & Review	100%	11-Jun-19 A	26-Jun-19 A
G142-20	Permit Application - Issue to the Agency	100%	26-Jun-19 A	26-Jun-19 A
Air Emissions Plan			11-Mar-19 A	10-May-19 A
G144-00	Air Emissions Plan	100%	11-Mar-19 A	10-May-19 A
G144-10	Air Emissions Plan - Prep & Review	100%	11-Mar-19 A	03-May-19 A
G144-20	Air Emissions Plan - Issue for Use	100%	06-May-19 A	10-May-19 A
Air Emissions Calculatiion			13-May-19 A	21-Jun-19 A
G146-00	Air Emissions Calculatiion	100%	13-May-19 A	21-Jun-19 A
G146-10	Air Emissions Calculatiion - Prep & Review	100%	13-May-19 A	21-Jun-19 A
G146-20	Air Emissions Calculatiion - Issue for Use	100%	21-Jun-19 A	21-Jun-19 A
Dwg Closeout/File Return			11-May-21	08-Jun-21
X800-0L	Dwg Closeout/File Return	0%	11-May-21	08-Jun-21
Home Office Construction Support			17-Feb-20 A	10-May-21
X900-0L	Home Office Construction Support	51.12%	17-Feb-20 A	10-May-21

🟦 Actual Work
🟥 Critical Remaining Work
▭ % Complete
🟩 Remaining Work
◆ ◆ Milestone
▬ Summary

TASK filter: All Activities

Activity ID	Activity Name	Activity % Complete	Start	Finish
Landfill Leachate			08-Sep-20 A	20-May-21
Leachate Treatment System - Phase 1			08-Sep-20 A	21-Jan-21
X900-0L085	Kick Off Meeting	100%	09-Sep-20 A	09-Sep-20 A
X900-0L090	Perform Site Visit	0%	14-Oct-20	16-Oct-20
X900-0L100	Leachate Tank/Pump Information (GA,Location, Foundation design etc.)	0%	19-Oct-20	20-Oct-20
X900-0L110	Develop & Finalize P&ID	0%	05-Oct-20	23-Oct-20
X900-0L120	Leachate Management System Geotech Studies/Survey/Review & Comment Existing Data	0%	12-Oct-20	26-Oct-20
X900-0L130	Permit Drawings Sealed & Provide for NPDES PIT Submittal to Ohio EPA	0%	26-Oct-20	30-Oct-20
X900-0L140	Owner Design Reveiw of Leachate Tank Design	0%	29-Oct-20	30-Oct-20
X900-0L150	Develop Leachate Tank Issue For Bid Pacakge	0%	12-Oct-20	06-Nov-20
X900-0L160	Develop and Finalize Pipe Routing	0%	26-Oct-20	13-Nov-20
X900-0L170	Develop & Finalize Sump Details	0%	26-Oct-20	13-Nov-20
X900-0L180	Owner Design Review of CDOX Design	0%	12-Nov-20	13-Nov-20
X900-0L190	Develop CDOX Issue for BID Package	0%	02-Nov-20	20-Nov-20
X900-0L200	Owner Design Review of Mechanical Design	0%	20-Nov-20	23-Nov-20
X900-0L210	Develop Mechanical Issue for BID Package	0%	12-Oct-20	30-Nov-20
X900-0L220	PTI Application Support	25.71%	08-Sep-20 A	15-Dec-20
X900-0L230	Develop Leachate Tank IFC Package	0%	18-Nov-20	21-Jan-21
X900-0L240	Develop Mechanical IFC Package	0%	04-Nov-20	21-Jan-21
Landfill Leachate Procurement			09-Nov-20	29-Apr-21
X900-0L250	Bid, Evaluate & Award Mechanical Scope (Includes Pipe, Pump, & Accessories)	0%	09-Nov-20	07-Jan-21
X900-0L310	Bid, Evaluate & Award Leachate Tanks	0%	09-Nov-20	07-Jan-21
X900-0L320	Bid, Evaluate & Award Site Prep Scope	0%	09-Nov-20	07-Jan-21
X900-0L330	Bid, Evaluate & Award CDOX System	0%	23-Nov-20	21-Jan-21
X900-0L340	Pipe Fabrication and Delivery	0%	08-Jan-21	01-Apr-21
X900-0L350	Pump Fabrication & Delivery	0%	08-Jan-21	01-Apr-21
X900-0L360	CDOX System Fabrication & Delivery	0%	22-Jan-21	29-Apr-21
Landfill Leachate Construction			01-Feb-21	20-May-21
X900-0L300	Site Prep Scope (including Foundations)	0%	01-Feb-21	26-Feb-21
X900-0L370	Tank Installation	0%	15-Feb-21	07-May-21
X900-0L380	Reroute Mechnical Construction & Commissioning	0%	26-Feb-21	13-May-21
X900-0L390	CDOX System & Installation & Commissioning	0%	30-Apr-21	20-May-21
Environmental Permitting LF/FAR II			01-Jun-19 A	03-May-21
Ohio EPA Surface Water Permitting			01-Jun-19 A	03-May-21
X900-0L400	Prepare,Review & Submit to Ohio EPA-PTI for Closure of FAR II - OAC 3745-42-03	100%	01-Jun-19 A	28-Oct-19 A
X900-0L410	Receive PTI Approval - OAC 3745-42-03	100%		21-Feb-20 A
X900-0L420	Prepare,Review & Submit to Ohio EPA - PTI for Leachate Conveyance - OAC 3745-42-03	0%	01-Oct-20 A	01-Dec-20
X900-0L460	Receive Leachate Conveyance Approval - OAC 3745-42-03	0%		03-May-21



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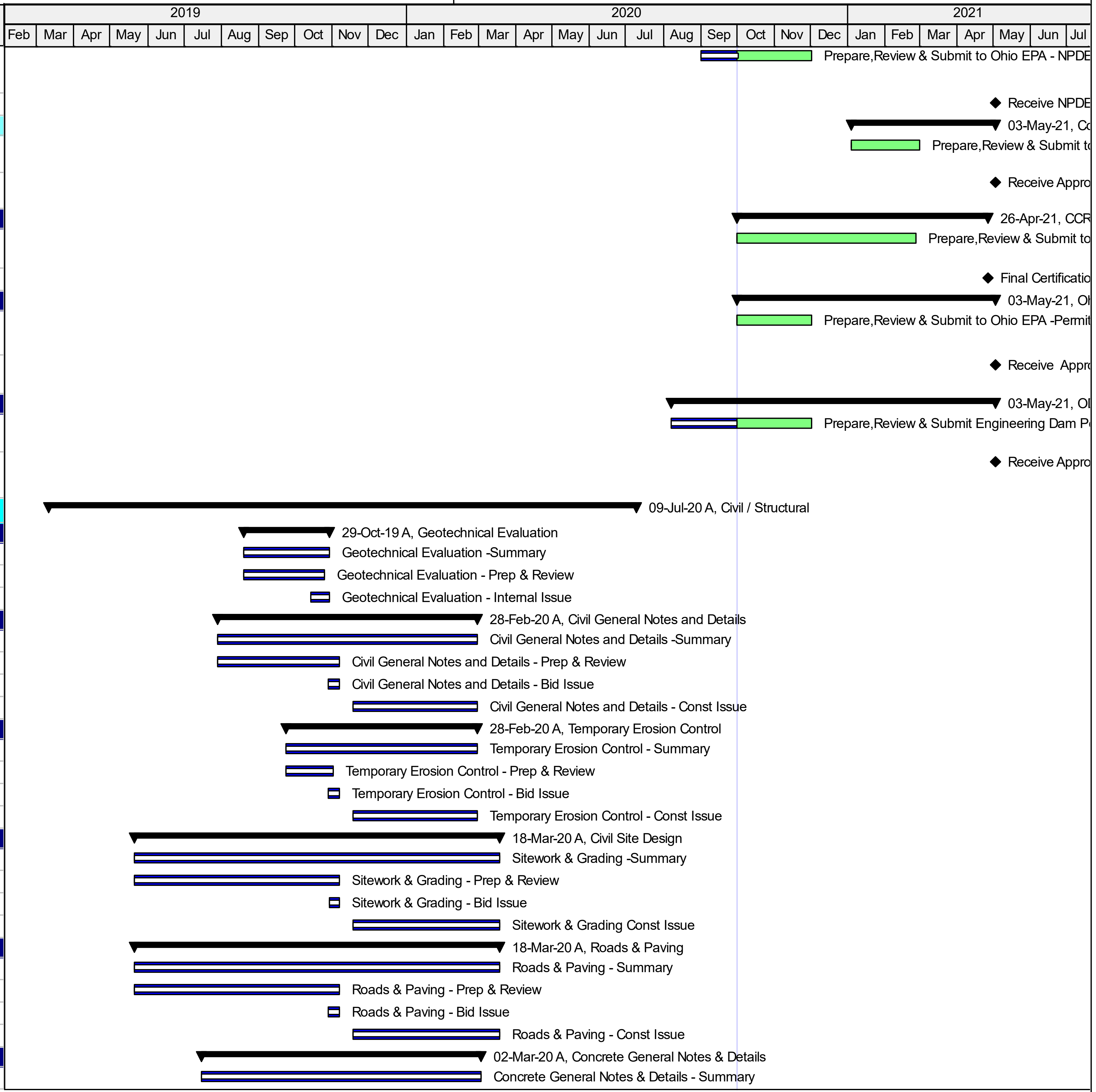
▼ Summary

TASK filter: All Activities

Activity ID	Activity Name	Activity % Complete	Start	Finish
X900-0L490	Prepare,Review & Submit to Ohio EPA - NPDES Modification(s) - OAC-3745-1	33.33%	01-Sep-20 A	01-Dec-20
X900-0L500	Receive NPDES Modification(s) Approval - OAC-3745-1	0%		03-May-21
Construction			04-Jan-21	03-May-21
X900-0L510	Prepare,Review & Submit to Ohio EPA-Construction SWPPP - OAC 3745-39-04	0%	04-Jan-21*	01-Mar-21
X900-0L520	Receive Approval for Construction SWPPP - OAC 3745-39-04	0%		03-May-21
CCR Semi Annual Progress Reports			01-Oct-20 A	26-Apr-21
X900-0L430	Prepare,Review & Submit to Ohio EPA - CCR Semi Annual Progress Report #1 - 40 CFR 257.103(f)(1)(x)	0%	01-Oct-20 A	26-Feb-21
X900-0L530	Final Certification for Use	0%		26-Apr-21
Ohio EPA Waste Permitting			01-Oct-20 A	03-May-21
X900-0L470	Prepare,Review & Submit to Ohio EPA -Permit Alteration to Construct Leachate Tanks - OAC 3745-30-14	0%	01-Oct-20 A	01-Dec-20
X900-0L540	Receive Approval for Alteration to Construct Leachate Tanks - OAC 3745-30-14	0%		03-May-21
ODNR Dam Permitting			07-Aug-20 A	03-May-21
X900-0L480	Prepare,Review & Submit Engineering Dam Permit ODNR - OAC 1501:21.06	47.5%	07-Aug-20 A	01-Dec-20
X900-0L550	Receive Approval for Engineering Dam Permit ODNR - OAC 1501:21.06	0%		03-May-21
Civil / Structural			11-Mar-19 A	09-Jul-20 A
Geotechnical Evaluation			20-Aug-19 A	29-Oct-19 A
C200-00	Geotechnical Evaluation -Summary	100%	20-Aug-19 A	29-Oct-19 A
C200-10	Geotechnical Evaluation - Prep & Review	100%	20-Aug-19 A	25-Oct-19 A
C200-60	Geotechnical Evaluation - Internal Issue	100%	14-Oct-19 A	29-Oct-19 A
Civil General Notes and Details			29-Jul-19 A	28-Feb-20 A
C090-00	Civil General Notes and Details -Summary	100%	29-Jul-19 A	28-Feb-20 A
C090-10	Civil General Notes and Details - Prep & Review	100%	29-Jul-19 A	06-Nov-19 A
C090-30	Civil General Notes and Details - Bid Issue	100%	28-Oct-19 A	06-Nov-19 A
C090-60	Civil General Notes and Details - Const Issue	100%	18-Nov-19 A	28-Feb-20 A
Temporary Erosion Control			24-Sep-19 A	28-Feb-20 A
C100-00	Temporary Erosion Control - Summary	100%	24-Sep-19 A	28-Feb-20 A
C100-10	Temporary Erosion Control - Prep & Review	100%	24-Sep-19 A	01-Nov-19 A
C100-30	Temporary Erosion Control - Bid Issue	100%	28-Oct-19 A	06-Nov-19 A
C100-60	Temporary Erosion Control - Const Issue	100%	18-Nov-19 A	28-Feb-20 A
Civil Site Design			21-May-19 A	18-Mar-20 A
C110-00	Sitework & Grading -Summary	100%	21-May-19 A	18-Mar-20 A
C110-10	Sitework & Grading - Prep & Review	100%	21-May-19 A	06-Nov-19 A
C110-30	Sitework & Grading - Bid Issue	100%	29-Oct-19 A	06-Nov-19 A
C110-60	Sitework & Grading Const Issue	100%	18-Nov-19 A	18-Mar-20 A
Roads & Paving			21-May-19 A	18-Mar-20 A
C120-00	Roads & Paving - Summary	100%	21-May-19 A	18-Mar-20 A
C120-10	Roads & Paving - Prep & Review	100%	21-May-19 A	06-Nov-19 A
C120-30	Roads & Paving - Bid Issue	100%	28-Oct-19 A	06-Nov-19 A
C120-60	Roads & Paving - Const Issue	100%	18-Nov-19 A	18-Mar-20 A
Concrete General Notes & Details			15-Jul-19 A	02-Mar-20 A
C095-00	Concrete General Notes & Details - Summary	100%	15-Jul-19 A	02-Mar-20 A



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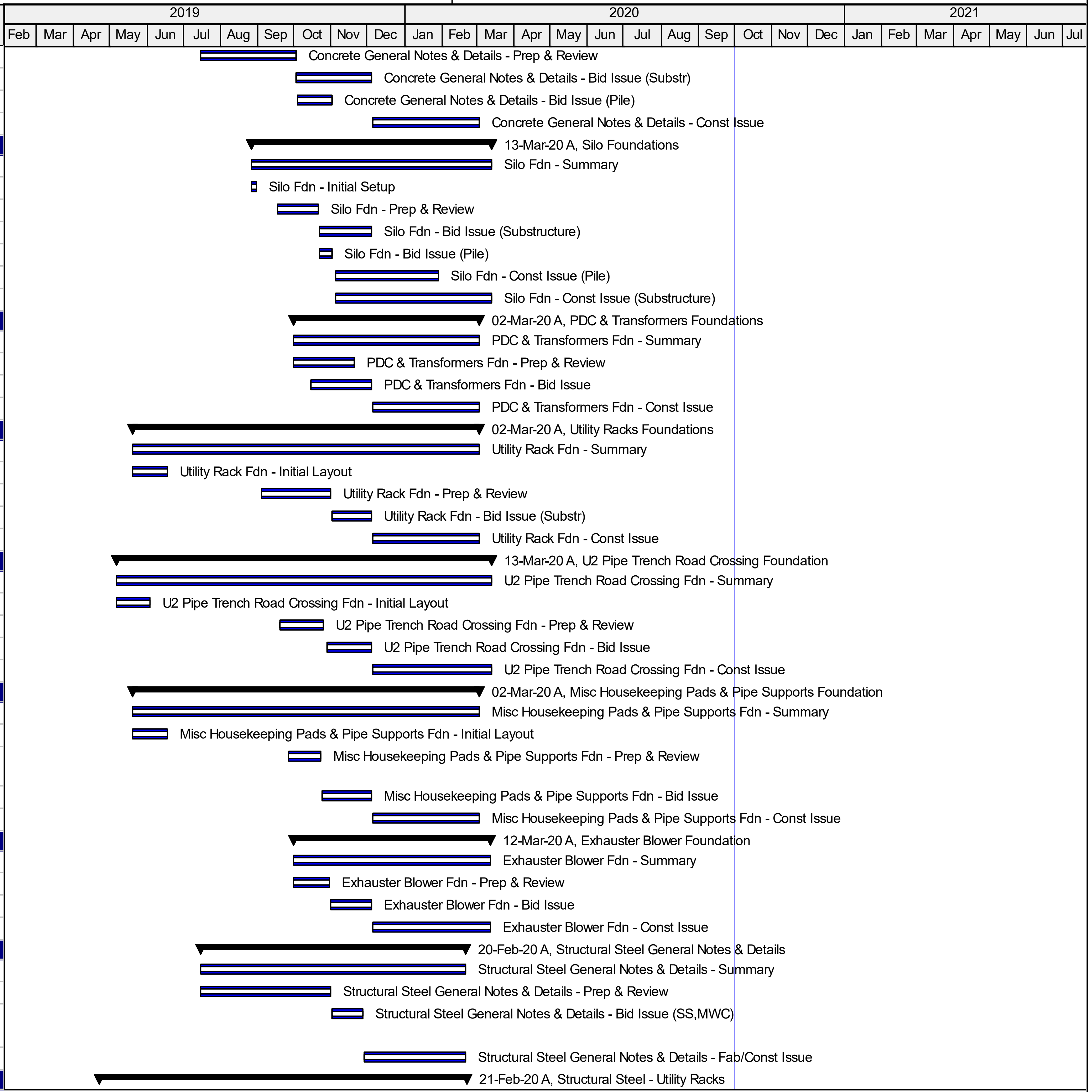
TASK filter: All Activities

Activity ID	Activity Name	Activity % Complete	Start	Finish
C095-10	Concrete General Notes & Details - Prep & Review	100%	15-Jul-19 A	02-Oct-19 A
C095-30	Concrete General Notes & Details - Bid Issue (Substr)	100%	03-Oct-19 A	04-Dec-19 A
C095-31	Concrete General Notes & Details - Bid Issue (Pile)	100%	04-Oct-19 A	01-Nov-19 A
C095-60	Concrete General Notes & Details - Const Issue	100%	05-Dec-19 A	02-Mar-20 A
Silo Foundations			**26-Aug-19 A**	**13-Mar-20 A**
S100-00	Silo Fdn - Summary	100%	26-Aug-19 A	13-Mar-20 A
S100-05	Silo Fdn - Initial Setup	100%	26-Aug-19 A	30-Aug-19 A
S100-10	Silo Fdn - Prep & Review	100%	17-Sep-19 A	21-Oct-19 A
S100-30	Silo Fdn - Bid Issue (Substructure)	100%	22-Oct-19 A	04-Dec-19 A
S100-31	Silo Fdn - Bid Issue (Pile)	100%	22-Oct-19 A	01-Nov-19 A
S100-60	Silo Fdn - Const Issue (Pile)	100%	04-Nov-19 A	29-Jan-20 A
S100-61	Silo Fdn - Const Issue (Substructure)	100%	04-Nov-19 A	13-Mar-20 A
PDC & Transformers Foundations			**30-Sep-19 A**	**02-Mar-20 A**
S110-00	PDC & Transformers Fdn - Summary	100%	30-Sep-19 A	02-Mar-20 A
S110-10	PDC & Transformers Fdn - Prep & Review	100%	30-Sep-19 A	20-Nov-19 A
S110-30	PDC & Transformers Fdn - Bid Issue	100%	15-Oct-19 A	04-Dec-19 A
S110-60	PDC & Transformers Fdn - Const Issue	100%	05-Dec-19 A	02-Mar-20 A
Utility Racks Foundations			**20-May-19 A**	**02-Mar-20 A**
S120-00	Utility Rack Fdn - Summary	100%	20-May-19 A	02-Mar-20 A
S120-05	Utility Rack Fdn - Initial Layout	100%	20-May-19 A	17-Jun-19 A
S120-10	Utility Rack Fdn - Prep & Review	100%	04-Sep-19 A	31-Oct-19 A
S120-30	Utility Rack Fdn - Bid Issue (Substr)	100%	01-Nov-19 A	04-Dec-19 A
S120-60	Utility Rack Fdn - Const Issue	100%	05-Dec-19 A	02-Mar-20 A
U2 Pipe Trench Road Crossing Foundation			**06-May-19 A**	**13-Mar-20 A**
S130-00	U2 Pipe Trench Road Crossing Fdn - Summary	100%	06-May-19 A	13-Mar-20 A
S130-05	U2 Pipe Trench Road Crossing Fdn - Initial Layout	100%	06-May-19 A	03-Jun-19 A
S130-10	U2 Pipe Trench Road Crossing Fdn - Prep & Review	100%	19-Sep-19 A	25-Oct-19 A
S130-30	U2 Pipe Trench Road Crossing Fdn - Bid Issue	100%	28-Oct-19 A	04-Dec-19 A
S130-60	U2 Pipe Trench Road Crossing Fdn - Const Issue	100%	05-Dec-19 A	13-Mar-20 A
Misc Housekeeping Pads & Pipe Supports Foundation			**20-May-19 A**	**02-Mar-20 A**
S140-00	Misc Housekeeping Pads & Pipe Supports Fdn - Summary	100%	20-May-19 A	02-Mar-20 A
S140-05	Misc Housekeeping Pads & Pipe Supports Fdn - Initial Layou	100%	20-May-19 A	17-Jun-19 A
S140-10	Misc Housekeeping Pads & Pipe Supports Fdn - Prep & Review	100%	26-Sep-19 A	23-Oct-19 A
S140-30	Misc Housekeeping Pads & Pipe Supports Fdn - Bid Issue	100%	24-Oct-19 A	04-Dec-19 A
S140-60	Misc Housekeeping Pads & Pipe Supports Fdn - Const Issue	100%	05-Dec-19 A	02-Mar-20 A
Exhauster Blower Foundation			**30-Sep-19 A**	**12-Mar-20 A**
S150-00	Exhauster Blower Fdn - Summary	100%	30-Sep-19 A	12-Mar-20 A
S150-10	Exhauster Blower Fdn - Prep & Review	100%	30-Sep-19 A	30-Oct-19 A
S150-30	Exhauster Blower Fdn - Bid Issue	100%	31-Oct-19 A	04-Dec-19 A
S150-60	Exhauster Blower Fdn - Const Issue	100%	05-Dec-19 A	12-Mar-20 A
Structural Steel General Notes & Details			**15-Jul-19 A**	**20-Feb-20 A**
S090-00	Structural Steel General Notes & Details - Summary	100%	15-Jul-19 A	20-Feb-20 A
S090-10	Structural Steel General Notes & Details - Prep & Review	100%	15-Jul-19 A	31-Oct-19 A
S090-30	Structural Steel General Notes & Details - Bid Issue (SS,MWC)	100%	01-Nov-19 A	27-Nov-19 A
S090-60	Structural Steel General Notes & Details - Fab/Const Issue	100%	28-Nov-19 A	20-Feb-20 A
Structural Steel - Utility Racks			**22-Apr-19 A**	**21-Feb-20 A**



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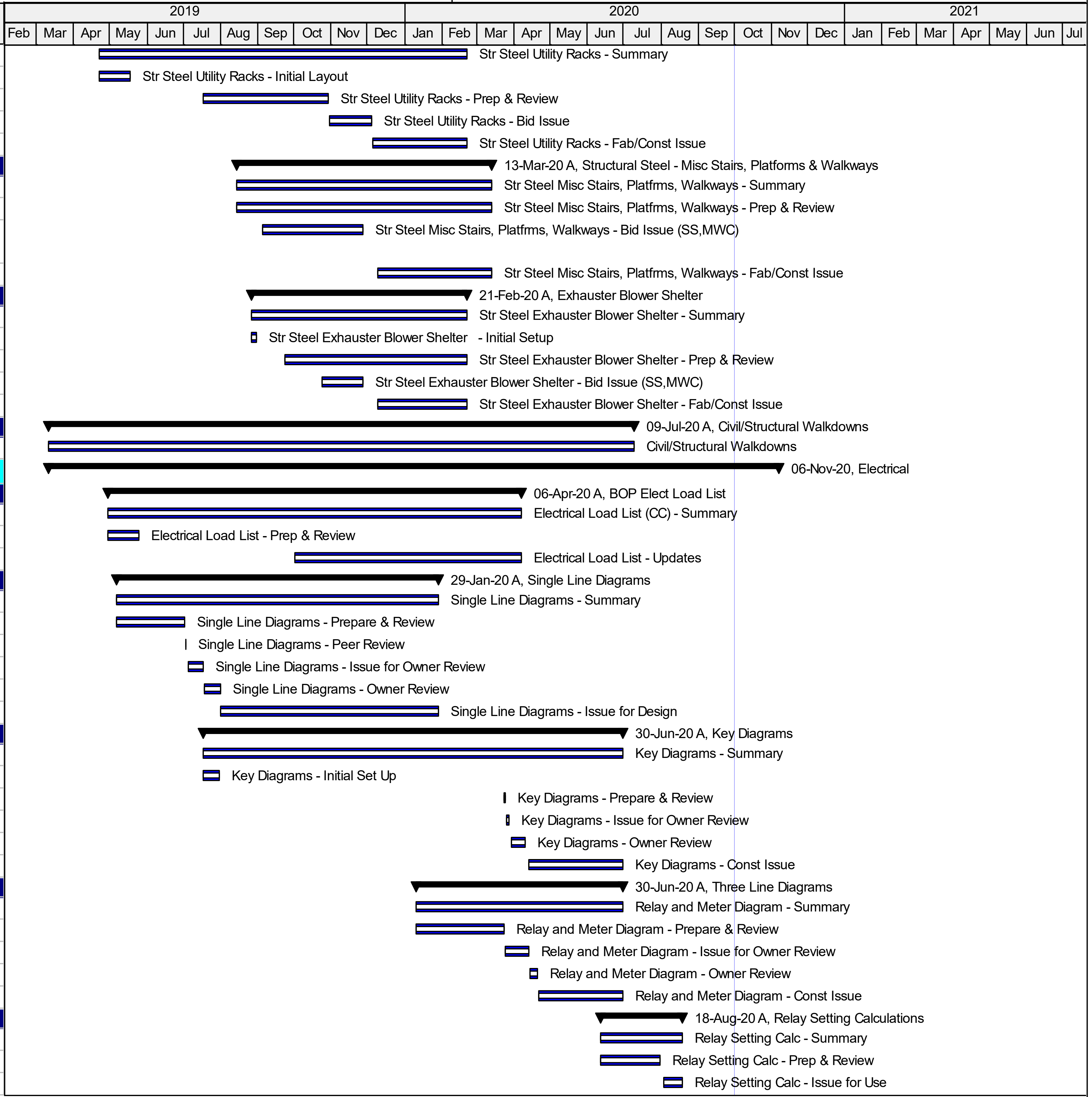
TASK filter: All Activities

Activity ID	Activity Name	Activity % Complete	Start	Finish
S220-00	Str Steel Utility Racks - Summary	100%	22-Apr-19 A	21-Feb-20 A
S220-05	Str Steel Utility Racks - Initial Layout	100%	22-Apr-19 A	17-May-19 A
S220-10	Str Steel Utility Racks - Prep & Review	100%	17-Jul-19 A	29-Oct-19 A
S220-30	Str Steel Utility Racks - Bid Issue	100%	30-Oct-19 A	04-Dec-19 A
S220-60	Str Steel Utility Racks - Fab/Const Issue	100%	05-Dec-19 A	21-Feb-20 A
Structural Steel - Misc Stairs, Platforms & Walkways			14-Aug-19 A	13-Mar-20 A
S260-00	Str Steel Misc Stairs, Platfrms, Walkways - Summary	100%	14-Aug-19 A	13-Mar-20 A
S260-10	Str Steel Misc Stairs, Platfrms, Walkways - Prep & Review	100%	14-Aug-19 A	13-Mar-20 A
S260-30	Str Steel Misc Stairs, Platfrms, Walkways - Bid Issue (SS,MWC)	100%	05-Sep-19 A	27-Nov-19 A
S260-60	Str Steel Misc Stairs, Platfrms, Walkways - Fab/Const Issue	100%	09-Dec-19 A	13-Mar-20 A
Exhauster Blower Shelter			26-Aug-19 A	21-Feb-20 A
S250-00	Str Steel Exhauster Blower Shelter - Summary	100%	26-Aug-19 A	21-Feb-20 A
S250-05	Str Steel Exhauster Blower Shelter - Initial Setup	100%	26-Aug-19 A	30-Aug-19 A
S250-10	Str Steel Exhauster Blower Shelter - Prep & Review	100%	24-Sep-19 A	21-Feb-20 A
S250-30	Str Steel Exhauster Blower Shelter - Bid Issue (SS,MWC)	100%	24-Oct-19 A	27-Nov-19 A
S250-60	Str Steel Exhauster Blower Shelter - Fab/Const Issue	100%	09-Dec-19 A	21-Feb-20 A
Civil/Structural Walkdowns			11-Mar-19 A	09-Jul-20 A
S800-0L	Civil/Structural Walkdowns	100%	11-Mar-19 A	09-Jul-20 A
Electrical			11-Mar-19 A	06-Nov-20
BOP Elect Load List			29-Apr-19 A	06-Apr-20 A
M620-00	Electrical Load List (CC) - Summary	100%	29-Apr-19 A	06-Apr-20 A
M620-10	Electrical Load List - Prep & Review	100%	29-Apr-19 A	24-May-19 A
M620-65	Electrical Load List - Updates	100%	02-Oct-19 A	06-Apr-20 A
Single Line Diagrams			06-May-19 A	29-Jan-20 A
E100-00	Single Line Diagrams - Summary	100%	06-May-19 A	29-Jan-20 A
E100-10	Single Line Diagrams - Prepare & Review	100%	06-May-19 A	02-Jul-19 A
E100-16	Single Line Diagrams - Peer Review	100%	03-Jul-19 A	03-Jul-19 A
E100-20	Single Line Diagrams - Issue for Owner Review	100%	05-Jul-19 A	17-Jul-19 A
E100-25	Single Line Diagrams - Owner Review	100%	18-Jul-19 A	31-Jul-19 A
E100-30	Single Line Diagrams - Issue for Design	100%	01-Aug-19 A	29-Jan-20 A
Key Diagrams			17-Jul-19 A	30-Jun-20 A
E110-00	Key Diagrams - Summary	100%	17-Jul-19 A	30-Jun-20 A
E110-05	Key Diagrams - Initial Set Up	100%	17-Jul-19 A	30-Jul-19 A
E110-10	Key Diagrams - Prepare & Review	100%	23-Mar-20 A	24-Mar-20 A
E110-20	Key Diagrams - Issue for Owner Review	100%	25-Mar-20 A	27-Mar-20 A
E110-25	Key Diagrams - Owner Review	100%	30-Mar-20 A	10-Apr-20 A
E110-60	Key Diagrams - Const Issue	100%	13-Apr-20 A	30-Jun-20 A
Three Line Diagrams			10-Jan-20 A	30-Jun-20 A
E120-00	Relay and Meter Diagram - Summary	100%	10-Jan-20 A	30-Jun-20 A
E120-10	Relay and Meter Diagram - Prepare & Review	100%	10-Jan-20 A	23-Mar-20 A
E120-20	Relay and Meter Diagram - Issue for Owner Review	100%	24-Mar-20 A	13-Apr-20 A
E120-25	Relay and Meter Diagram - Owner Review	100%	14-Apr-20 A	20-Apr-20 A
E120-60	Relay and Meter Diagram - Const Issue	100%	21-Apr-20 A	30-Jun-20 A
Relay Setting Calculations			12-Jun-20 A	18-Aug-20 A
E130-00	Relay Setting Calc - Summary	100%	12-Jun-20 A	18-Aug-20 A
E130-10	Relay Setting Calc - Prep & Review	100%	12-Jun-20 A	31-Jul-20 A
E130-30	Relay Setting Calc - Issue for Use	100%	03-Aug-20 A	18-Aug-20 A



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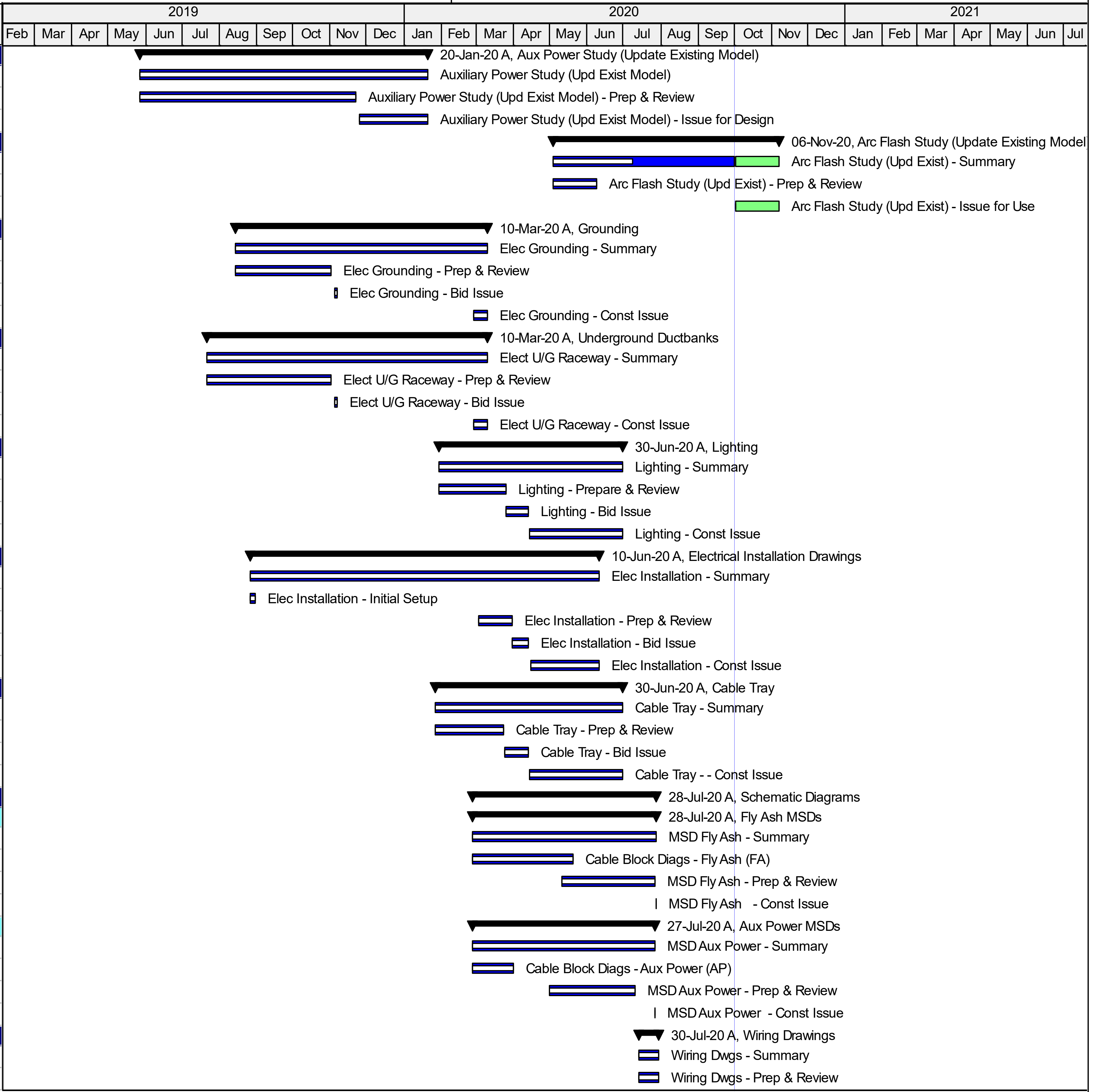
TASK filter: All Activities

Activity ID	Activity Name	Activity % Complete	Start	Finish
Aux Power Study (Update Existing Model)			27-May-19 A	20-Jan-20 A
E140-00	Auxiliary Power Study (Upd Exist Model)	100%	27-May-19 A	20-Jan-20 A
E140-10	Auxiliary Power Study (Upd Exist Model) - Prep & Review	100%	27-May-19 A	22-Nov-19 A
E140-30	Auxiliary Power Study (Upd Exist Model) - Issue for Design	100%	25-Nov-19 A	20-Jan-20 A
Arc Flash Study (Update Existing Model)			04-May-20 A	06-Nov-20
E150-00	Arc Flash Study (Upd Exist) - Summary	35%	04-May-20 A	06-Nov-20
E150-10	Arc Flash Study (Upd Exist) - Prep & Review	100%	04-May-20 A	08-Jun-20 A
E150-30	Arc Flash Study (Upd Exist) - Issue for Use	0%	02-Oct-20*	06-Nov-20
Grounding			14-Aug-19 A	10-Mar-20 A
E200-00	Elec Grounding - Summary	100%	14-Aug-19 A	10-Mar-20 A
E200-10	Elec Grounding - Prep & Review	100%	14-Aug-19 A	01-Nov-19 A
E200-30	Elec Grounding - Bid Issue	100%	04-Nov-19 A	06-Nov-19 A
E200-60	Elec Grounding - Const Issue	100%	28-Feb-20 A	10-Mar-20 A
Underground Ductbanks			22-Jul-19 A	10-Mar-20 A
E210-00	Elect U/G Raceway - Summary	100%	22-Jul-19 A	10-Mar-20 A
E210-10	Elect U/G Raceway - Prep & Review	100%	22-Jul-19 A	01-Nov-19 A
E210-30	Elect U/G Raceway - Bid Issue	100%	04-Nov-19 A	06-Nov-19 A
E210-60	Elect U/G Raceway - Const Issue	100%	28-Feb-20 A	10-Mar-20 A
Lighting			30-Jan-20 A	30-Jun-20 A
E220-00	Lighting - Summary	100%	30-Jan-20 A	30-Jun-20 A
E220-10	Lighting - Prepare & Review	100%	30-Jan-20 A	25-Mar-20 A
E220-30	Lighting - Bid Issue	100%	26-Mar-20 A	13-Apr-20 A
E220-60	Lighting - Const Issue	100%	14-Apr-20 A	30-Jun-20 A
Electrical Installation Drawings			26-Aug-19 A	10-Jun-20 A
E230-00	Elec Installation - Summary	100%	26-Aug-19 A	10-Jun-20 A
E230-05	Elec Installation - Initial Setup	100%	26-Aug-19 A	30-Aug-19 A
E230-10	Elec Installation - Prep & Review	100%	03-Mar-20 A	30-Mar-20 A
E230-30	Elec Installation - Bid Issue	100%	31-Mar-20 A	13-Apr-20 A
E230-60	Elec Installation - Const Issue	100%	15-Apr-20 A	10-Jun-20 A
Cable Tray			27-Jan-20 A	30-Jun-20 A
E240-00	Cable Tray - Summary	100%	27-Jan-20 A	30-Jun-20 A
E240-10	Cable Tray - Prep & Review	100%	27-Jan-20 A	23-Mar-20 A
E240-30	Cable Tray - Bid Issue	100%	24-Mar-20 A	13-Apr-20 A
E240-60	Cable Tray - - Const Issue	100%	14-Apr-20 A	30-Jun-20 A
Schematic Diagrams			27-Feb-20 A	28-Jul-20 A
Fly Ash MSDs			27-Feb-20 A	28-Jul-20 A
E300-00	MSD Fly Ash - Summary	100%	27-Feb-20 A	28-Jul-20 A
E300-05	Cable Block Diags - Fly Ash (FA)	100%	27-Feb-20 A	20-May-20 A
E300-10	MSD Fly Ash - Prep & Review	100%	11-May-20 A	27-Jul-20 A
E300-60	MSD Fly Ash - Const Issue	100%	28-Jul-20 A	28-Jul-20 A
Aux Power MSDs			27-Feb-20 A	27-Jul-20 A
E301-00	MSD Aux Power - Summary	100%	27-Feb-20 A	27-Jul-20 A
E301-05	Cable Block Diags - Aux Power (AP)	100%	27-Feb-20 A	31-Mar-20 A
E301-10	MSD Aux Power - Prep & Review	100%	01-May-20 A	10-Jul-20 A
E301-60	MSD Aux Power - Const Issue	100%	27-Jul-20 A	27-Jul-20 A
Wiring Drawings			14-Jul-20 A	30-Jul-20 A
E310-00	Wiring Dwgs - Summary	100%	14-Jul-20 A	30-Jul-20 A
E310-10	Wiring Dwgs - Prep & Review	100%	14-Jul-20 A	30-Jul-20 A



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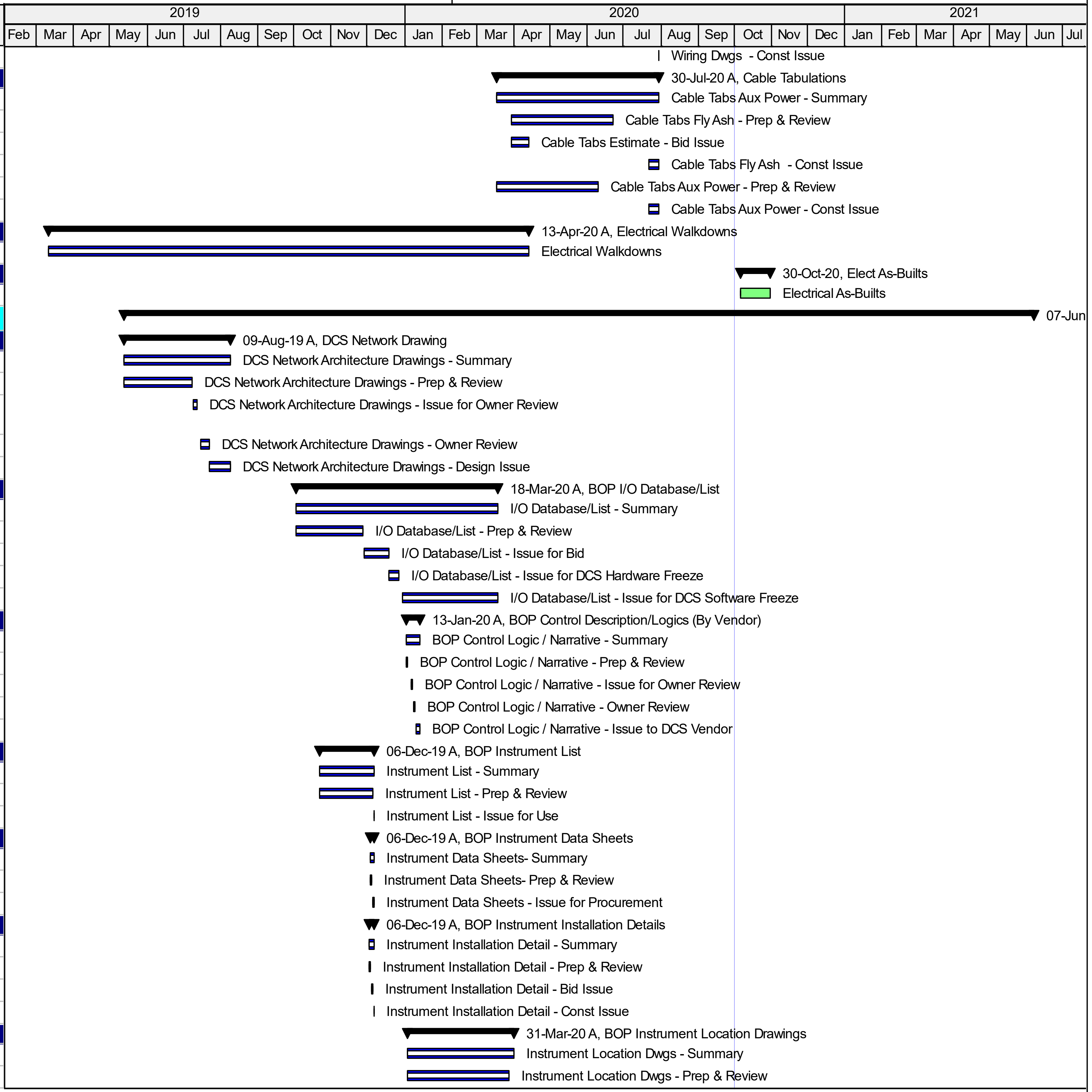
TASK filter: All Activities

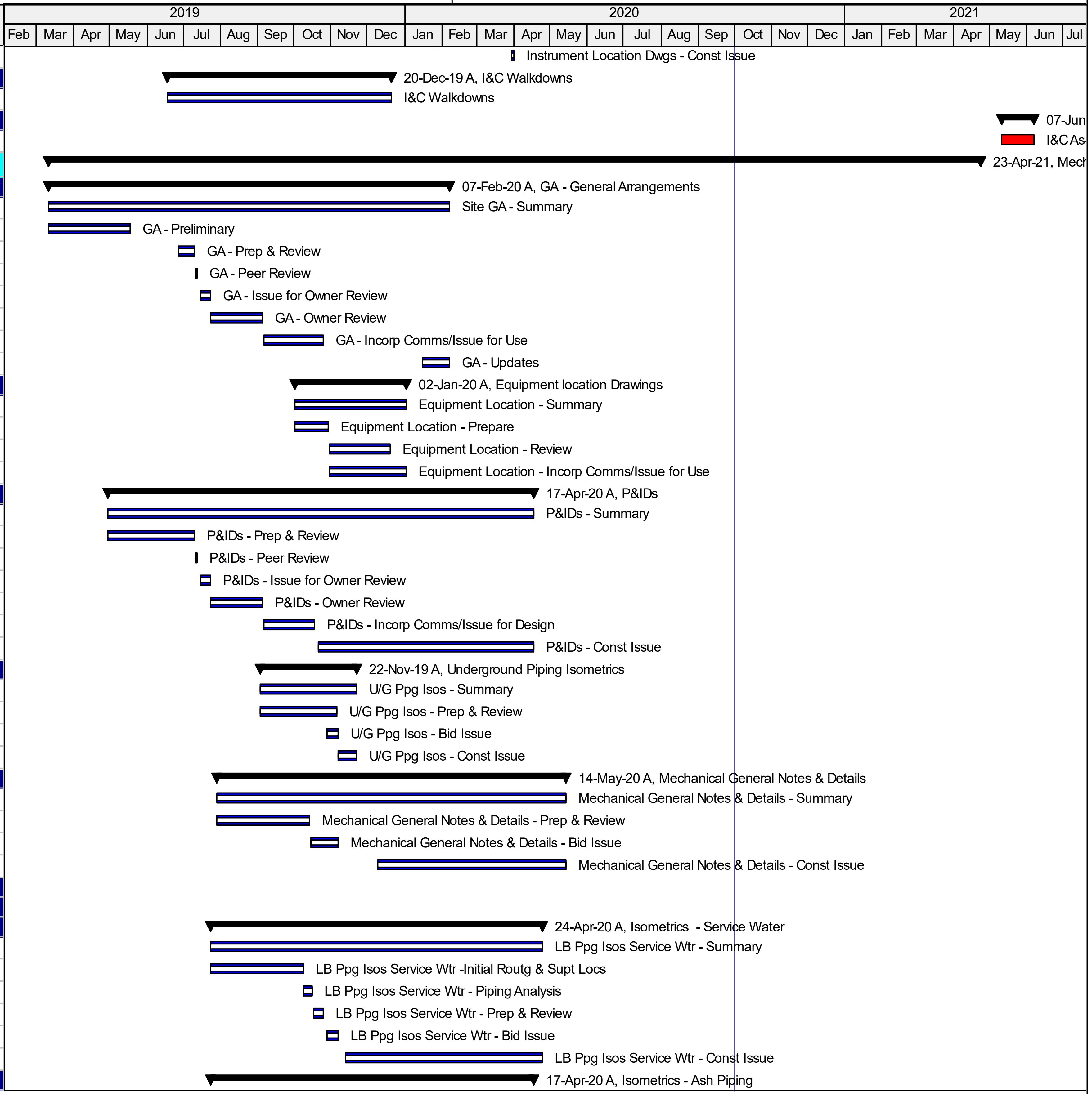
Activity ID	Activity Name	Activity % Complete	Start	Finish
E310-60	Wiring Dwgs - Const Issue	100%	30-Jul-20 A	30-Jul-20 A
Cable Tabulations			17-Mar-20 A	30-Jul-20 A
E320-00	Cable Tabs Aux Power - Summary	100%	17-Mar-20 A	30-Jul-20 A
E320-10	Cable Tabs Fly Ash - Prep & Review	100%	30-Mar-20 A	22-Jun-20 A
E320-30	Cable Tabs Estimate - Bid Issue	100%	30-Mar-20 A	13-Apr-20 A
E320-60	Cable Tabs Fly Ash - Const Issue	100%	22-Jul-20 A	30-Jul-20 A
E321-10	Cable Tabs Aux Power - Prep & Review	100%	17-Mar-20 A	09-Jun-20 A
E321-60	Cable Tabs Aux Power - Const Issue	100%	22-Jul-20 A	30-Jul-20 A
Electrical Walkdowns			11-Mar-19 A	13-Apr-20 A
E800-0L	Electrical Walkdowns	100%	11-Mar-19 A	13-Apr-20 A
Elect As-Builts			06-Oct-20	30-Oct-20
E900-0L	Electrical As-Builts	0%	06-Oct-20	30-Oct-20*
I&C			13-May-19 A	07-Jun-21
DCS Network Drawing			13-May-19 A	09-Aug-19 A
J100-00	DCS Network Architecture Drawings - Summary	100%	13-May-19 A	09-Aug-19 A
J100-10	DCS Network Architecture Drawings - Prep & Review	100%	13-May-19 A	08-Jul-19 A
J100-20	DCS Network Architecture Drawings - Issue for Owner Review	100%	09-Jul-19 A	12-Jul-19 A
J100-25	DCS Network Architecture Drawings - Owner Review	100%	15-Jul-19 A	22-Jul-19 A
J100-30	DCS Network Architecture Drawings - Design Issue	100%	23-Jul-19 A	09-Aug-19 A
BOP I/O Database/List			03-Oct-19 A	18-Mar-20 A
J200-00	I/O Database/List - Summary	100%	03-Oct-19 A	18-Mar-20 A
J200-10	I/O Database/List - Prep & Review	100%	03-Oct-19 A	27-Nov-19 A
J200-30	I/O Database/List - Issue for Bid	100%	28-Nov-19 A	18-Dec-19 A
J200-31	I/O Database/List - Issue for DCS Hardware Freeze	100%	19-Dec-19 A	27-Dec-19 A
J200-32	I/O Database/List - Issue for DCS Software Freeze	100%	30-Dec-19 A	18-Mar-20 A
BOP Control Description/Logics (By Vendor)			02-Jan-20 A	13-Jan-20 A
J700-00	BOP Control Logic / Narrative - Summary	100%	02-Jan-20 A	13-Jan-20 A
J700-10	BOP Control Logic / Narrative - Prep & Review	100%	02-Jan-20 A	03-Jan-20 A
J700-20	BOP Control Logic / Narrative - Issue for Owner Review	100%	06-Jan-20 A	07-Jan-20 A
J700-25	BOP Control Logic / Narrative - Owner Review	100%	08-Jan-20 A	09-Jan-20 A
J700-30	BOP Control Logic / Narrative - Issue to DCS Vendor	100%	10-Jan-20 A	13-Jan-20 A
BOP Instrument List			22-Oct-19 A	06-Dec-19 A
J300-00	Instrument List - Summary	100%	22-Oct-19 A	06-Dec-19 A
J300-10	Instrument List - Prep & Review	100%	22-Oct-19 A	05-Dec-19 A
J300-30	Instrument List - Issue for Use	100%	06-Dec-19 A	06-Dec-19 A
BOP Instrument Data Sheets			03-Dec-19 A	06-Dec-19 A
J400-00	Instrument Data Sheets- Summary	100%	03-Dec-19 A	06-Dec-19 A
J400-10	Instrument Data Sheets- Prep & Review	100%	03-Dec-19 A	04-Dec-19 A
J400-30	Instrument Data Sheets - Issue for Procurement	100%	05-Dec-19 A	06-Dec-19 A
BOP Instrument Installation Details			02-Dec-19 A	06-Dec-19 A
J500-00	Instrument Installation Detail - Summary	100%	02-Dec-19 A	06-Dec-19 A
J500-10	Instrument Installation Detail - Prep & Review	100%	02-Dec-19 A	03-Dec-19 A
J500-30	Instrument Installation Detail - Bid Issue	100%	04-Dec-19 A	05-Dec-19 A
J500-60	Instrument Installation Detail - Const Issue	100%	06-Dec-19 A	06-Dec-19 A
BOP Instrument Location Drawings			03-Jan-20 A	31-Mar-20 A
J600-00	Instrument Location Dwgs - Summary	100%	03-Jan-20 A	31-Mar-20 A
J600-10	Instrument Location Dwgs - Prep & Review	100%	03-Jan-20 A	27-Mar-20 A



🟦 Actual Work 🟥 Critical Remaining Work ▭ % Complete
🟩 Remaining Work ◆ ◆ Milestone ▬ Summary

TASK filter: All Activities

Activity ID	Activity Name	Activity % Complete	Start	Finish
J600-60	Instrument Location Dwgs - Const Issue	100%	30-Mar-20 A	31-Mar-20 A
I&C Walkdowns			18-Jun-19 A	20-Dec-19 A
J800-0L	I&C Walkdowns	100%	18-Jun-19 A	20-Dec-19 A
I&C As-Builts			11-May-21	07-Jun-21
J900-0L	I&C As-Builts	0%	11-May-21	07-Jun-21
Mechanical			11-Mar-19 A	23-Apr-21
GA - General Arrangements			11-Mar-19 A	07-Feb-20 A
M100-00	Site GA - Summary	100%	11-Mar-19 A	07-Feb-20 A
M100-05	GA - Preliminary	100%	11-Mar-19 A	17-May-19 A
M100-10	GA - Prep & Review	100%	27-Jun-19 A	10-Jul-19 A
M100-16	GA - Peer Review	100%	11-Jul-19 A	12-Jul-19 A
M100-20	GA - Issue for Owner Review	100%	15-Jul-19 A	23-Jul-19 A
M100-25	GA - Owner Review	100%	24-Jul-19 A	05-Sep-19 A
M100-30	GA - Incorp Comms/Issue for Use	100%	06-Sep-19 A	25-Oct-19 A
M100-65	GA - Updates	100%	16-Jan-20 A	07-Feb-20 A
Equipment location Drawings			02-Oct-19 A	02-Jan-20 A
M101-00	Equipment Location - Summary	100%	02-Oct-19 A	02-Jan-20 A
M101-10	Equipment Location - Prepare	100%	02-Oct-19 A	29-Oct-19 A
M101-16	Equipment Location - Review	100%	30-Oct-19 A	19-Dec-19 A
M101-30	Equipment Location - Incorp Comms/Issue for Use	100%	30-Oct-19 A	02-Jan-20 A
P&IDs			29-Apr-19 A	17-Apr-20 A
M200-00	P&IDs - Summary	100%	29-Apr-19 A	17-Apr-20 A
M200-10	P&IDs - Prep & Review	100%	29-Apr-19 A	10-Jul-19 A
M200-16	P&IDs - Peer Review	100%	11-Jul-19 A	12-Jul-19 A
M200-20	P&IDs - Issue for Owner Review	100%	15-Jul-19 A	23-Jul-19 A
M200-25	P&IDs - Owner Review	100%	24-Jul-19 A	05-Sep-19 A
M200-30	P&IDs - Incorp Comms/Issue for Design	100%	06-Sep-19 A	18-Oct-19 A
M200-60	P&IDs - Const Issue	100%	21-Oct-19 A	17-Apr-20 A
Underground Piping Isometrics			03-Sep-19 A	22-Nov-19 A
M330-00	U/G Ppg Isos - Summary	100%	03-Sep-19 A	22-Nov-19 A
M330-10	U/G Ppg Isos - Prep & Review	100%	03-Sep-19 A	05-Nov-19 A
M330-30	U/G Ppg Isos - Bid Issue	100%	28-Oct-19 A	06-Nov-19 A
M330-60	U/G Ppg Isos - Const Issue	100%	07-Nov-19 A	22-Nov-19 A
Mechanical General Notes & Details			29-Jul-19 A	14-May-20 A
M090-00	Mechanical General Notes & Details - Summary	100%	29-Jul-19 A	14-May-20 A
M090-10	Mechanical General Notes & Details - Prep & Review	100%	29-Jul-19 A	14-Oct-19 A
M090-30	Mechanical General Notes & Details - Bid Issue	100%	15-Oct-19 A	06-Nov-19 A
M090-60	Mechanical General Notes & Details - Const Issue	100%	09-Dec-19 A	14-May-20 A
Isometrics - U1&2 Recirc to FGD				
Isometrics - U3 Recirc to Cooling Tower-1				
Isometrics - Service Water			24-Jul-19 A	24-Apr-20 A
M320-00	LB Ppg Isos Service Wtr - Summary	100%	24-Jul-19 A	24-Apr-20 A
M320-05	LB Ppg Isos Service Wtr -Initial Routg & Supt Locs	100%	24-Jul-19 A	08-Oct-19 A
M320-07	LB Ppg Isos Service Wtr - Piping Analysis	100%	09-Oct-19 A	16-Oct-19 A
M320-10	LB Ppg Isos Service Wtr - Prep & Review	100%	17-Oct-19 A	25-Oct-19 A
M320-30	LB Ppg Isos Service Wtr - Bid Issue	100%	28-Oct-19 A	06-Nov-19 A
M320-60	LB Ppg Isos Service Wtr - Const Issue	100%	13-Nov-19 A	24-Apr-20 A
Isometrics - Ash Piping			24-Jul-19 A	17-Apr-20 A



🟦 Actual Work
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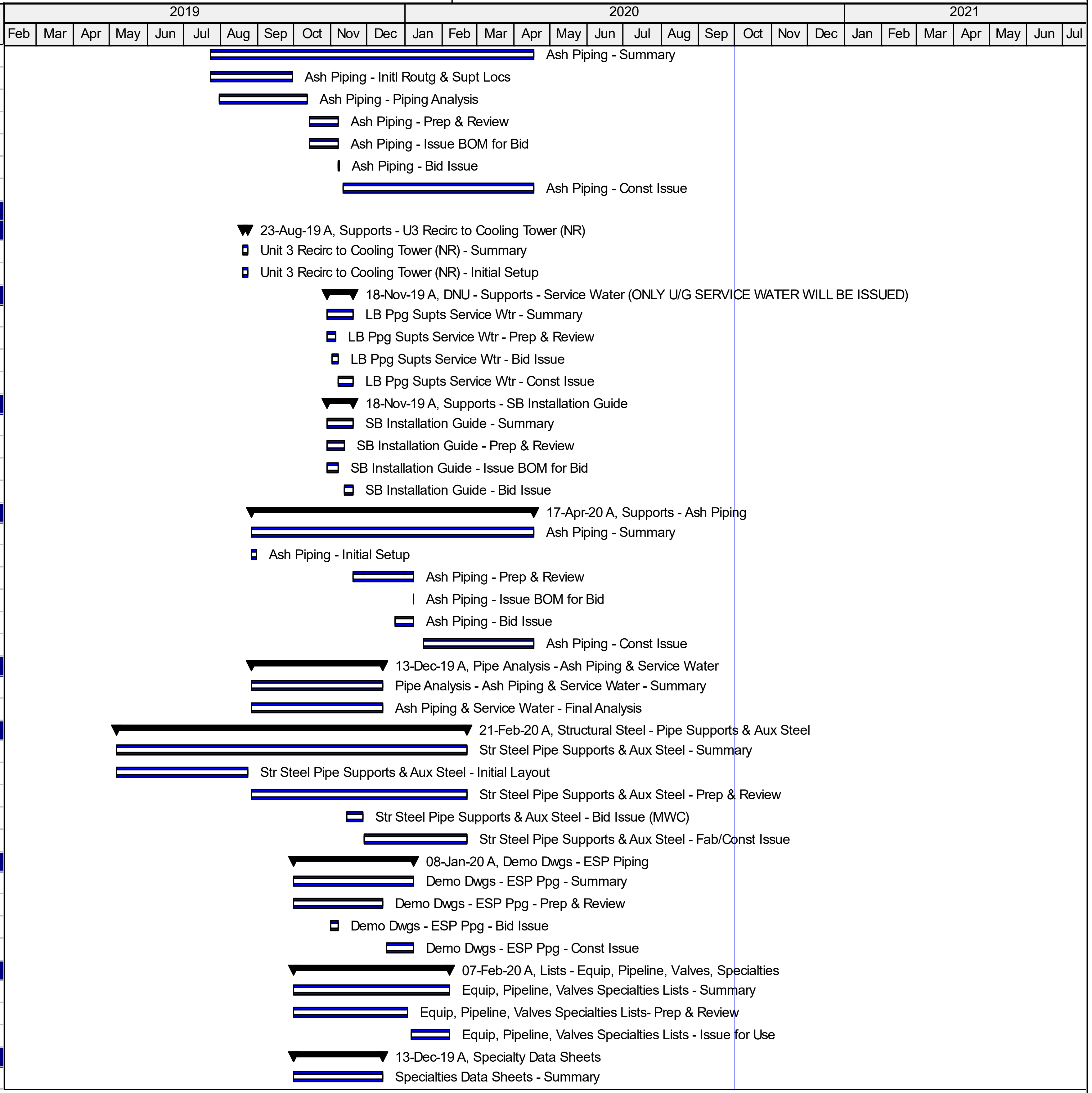
▭ % Complete
🟩 Remaining Work ◆
◆ Milestone
▼ Summary

TASK filter: All Activities

Activity ID	Activity Name	Activity % Complete	Start	Finish
M340-00	Ash Piping - Summary	100%	24-Jul-19 A	17-Apr-20 A
M340-05	Ash Piping - Initl Routg & Supt Locs	100%	24-Jul-19 A	30-Sep-19 A
M340-07	Ash Piping - Piping Analysis	100%	31-Jul-19 A	11-Oct-19 A
M340-10	Ash Piping - Prep & Review	100%	14-Oct-19 A	06-Nov-19 A
M340-29	Ash Piping - Issue BOM for Bid	100%	14-Oct-19 A	06-Nov-19 A
M340-30	Ash Piping - Bid Issue	100%	07-Nov-19 A	07-Nov-19 A
M340-60	Ash Piping - Const Issue	100%	11-Nov-19 A	17-Apr-20 A
Supports - U1&2 Recirc to FGD				
Supports - U3 Recirc to Cooling Tower (NR)			19-Aug-19 A	23-Aug-19 A
M410-00	Unit 3 Recirc to Cooling Tower (NR) - Summary	100%	19-Aug-19 A	23-Aug-19 A
M410-05	Unit 3 Recirc to Cooling Tower (NR) - Initial Setup	100%	19-Aug-19 A	23-Aug-19 A
DNU - Supports - Service Water (ONLY U/G SERVICE WATER WILL BE ISSUED)			28-Oct-19 A	18-Nov-19 A
M420-00	LB Ppg Supts Service Wtr - Summary	100%	28-Oct-19 A	18-Nov-19 A
M420-10	LB Ppg Supts Service Wtr - Prep & Review	100%	28-Oct-19 A	04-Nov-19 A
M420-30	LB Ppg Supts Service Wtr - Bid Issue	100%	01-Nov-19 A	06-Nov-19 A
M420-60	LB Ppg Supts Service Wtr - Const Issue	100%	07-Nov-19 A	18-Nov-19 A
Supports - SB Installation Guide			28-Oct-19 A	18-Nov-19 A
M440-00	SB Installation Guide - Summary	100%	28-Oct-19 A	18-Nov-19 A
M440-10	SB Installation Guide - Prep & Review	100%	28-Oct-19 A	11-Nov-19 A
M440-29	SB Installation Guide - Issue BOM for Bid	100%	28-Oct-19 A	06-Nov-19 A
M440-30	SB Installation Guide - Bid Issue	100%	12-Nov-19 A	18-Nov-19 A
Supports - Ash Piping			26-Aug-19 A	17-Apr-20 A
M450-00	Ash Piping - Summary	100%	26-Aug-19 A	17-Apr-20 A
M450-05	Ash Piping - Initial Setup	100%	26-Aug-19 A	30-Aug-19 A
M450-10	Ash Piping - Prep & Review	100%	19-Nov-19 A	08-Jan-20 A
M450-29	Ash Piping - Issue BOM for Bid	100%	08-Jan-20 A	08-Jan-20 A
M450-30	Ash Piping - Bid Issue	100%	24-Dec-19 A	08-Jan-20 A
M450-60	Ash Piping - Const Issue	100%	17-Jan-20 A	17-Apr-20 A
Pipe Analysis - Ash Piping & Service Water			26-Aug-19 A	13-Dec-19 A
M480-00	Pipe Analysis - Ash Piping & Service Water - Summary	100%	26-Aug-19 A	13-Dec-19 A
M480-60	Ash Piping & Service Water - Final Analysis	100%	26-Aug-19 A	13-Dec-19 A
Structural Steel - Pipe Supports & Aux Steel			06-May-19 A	21-Feb-20 A
S240-00	Str Steel Pipe Supports & Aux Steel - Summary	100%	06-May-19 A	21-Feb-20 A
S240-05	Str Steel Pipe Supports & Aux Steel - Initial Layout	100%	06-May-19 A	23-Aug-19 A
S240-10	Str Steel Pipe Supports & Aux Steel - Prep & Review	100%	26-Aug-19 A	21-Feb-20 A
S240-30	Str Steel Pipe Supports & Aux Steel - Bid Issue (MWC)	100%	14-Nov-19 A	27-Nov-19 A
S240-60	Str Steel Pipe Supports & Aux Steel - Fab/Const Issue	100%	28-Nov-19 A	21-Feb-20 A
Demo Dwgs - ESP Piping			01-Oct-19 A	08-Jan-20 A
M500-00	Demo Dwgs - ESP Ppg - Summary	100%	01-Oct-19 A	08-Jan-20 A
M500-10	Demo Dwgs - ESP Ppg - Prep & Review	100%	01-Oct-19 A	13-Dec-19 A
M500-30	Demo Dwgs - ESP Ppg - Bid Issue	100%	31-Oct-19 A	06-Nov-19 A
M500-60	Demo Dwgs - ESP Ppg - Const Issue	100%	17-Dec-19 A	08-Jan-20 A
Lists - Equip, Pipeline, Valves, Specialties			01-Oct-19 A	07-Feb-20 A
M600-00	Equip, Pipeline, Valves Specialties Lists - Summary	100%	01-Oct-19 A	07-Feb-20 A
M600-10	Equip, Pipeline, Valves Specialties Lists- Prep & Review	100%	01-Oct-19 A	03-Jan-20 A
M600-30	Equip, Pipeline, Valves Specialties Lists - Issue for Use	100%	06-Jan-20 A	07-Feb-20 A
Specialty Data Sheets			01-Oct-19 A	13-Dec-19 A
M610-00	Specialties Data Sheets - Summary	100%	01-Oct-19 A	13-Dec-19 A



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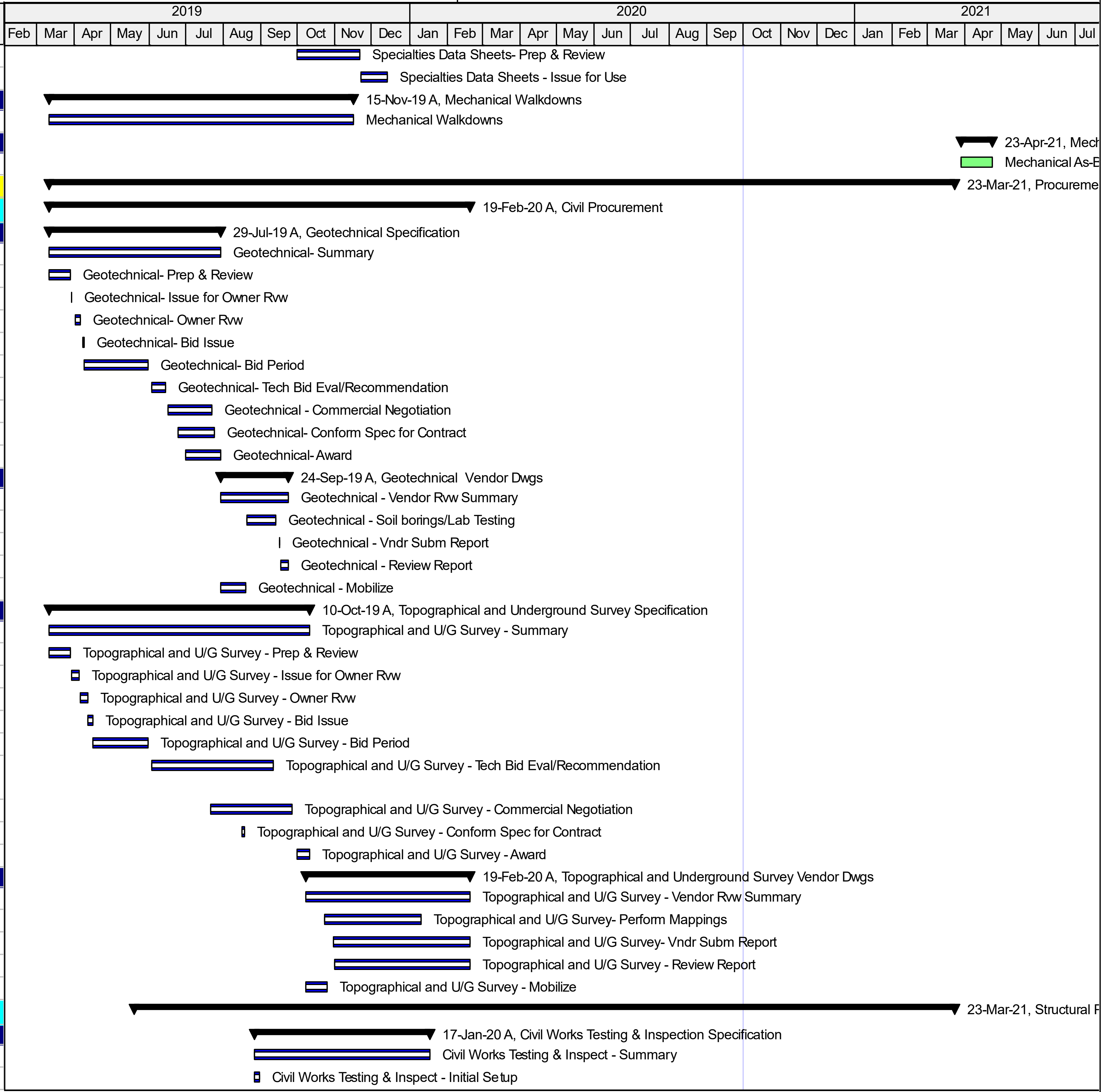
TASK filter: All Activities

Activity ID	Activity Name	Activity % Complete	Start	Finish
M610-10	Specialties Data Sheets- Prep & Review	100%	01-Oct-19 A	21-Nov-19 A
M610-30	Specialties Data Sheets - Issue for Use	100%	22-Nov-19 A	13-Dec-19 A
Mechanical Walkdowns			11-Mar-19 A	15-Nov-19 A
M800-0L	Mechanical Walkdowns	100%	11-Mar-19 A	15-Nov-19 A
Mechanical As-Builts			29-Mar-21	23-Apr-21
M900-0L	Mechanical As-Builts	0%	29-Mar-21	23-Apr-21*
Procurement			11-Mar-19 A	23-Mar-21
Civil Procurement			11-Mar-19 A	19-Feb-20 A
Geotechnical Specification			11-Mar-19 A	29-Jul-19 A
PC10-00	Geotechnical- Summary	100%	11-Mar-19 A	29-Jul-19 A
PC10-10	Geotechnical- Prep & Review	100%	11-Mar-19 A	28-Mar-19 A
PC10-20	Geotechnical- Issue for Owner Rvw	100%	29-Mar-19 A	29-Mar-19 A
PC10-25	Geotechnical- Owner Rvw	100%	01-Apr-19 A	05-Apr-19 A
PC10-30	Geotechnical- Bid Issue	100%	08-Apr-19 A	08-Apr-19 A
PC10-40	Geotechnical- Bid Period	100%	09-Apr-19 A	31-May-19 A
PC10-50	Geotechnical- Tech Bid Eval/Recommendation	100%	03-Jun-19 A	14-Jun-19 A
PC10-52	Geotechnical - Commercial Negotiation	100%	17-Jun-19 A	22-Jul-19 A
PC10-55	Geotechnical- Conform Spec for Contract	100%	25-Jun-19 A	24-Jul-19 A
PC10-60	Geotechnical- Award	100%	01-Jul-19 A	29-Jul-19 A
Geotechnical Vendor Dwgs			30-Jul-19 A	24-Sep-19 A
VC10-0V	Geotechnical - Vendor Rvw Summary	100%	30-Jul-19 A	24-Sep-19 A
VC10-70	Geotechnical - Soil borings/Lab Testing	100%	20-Aug-19 A	13-Sep-19 A
VC10-71	Geotechnical - Vndr Subm Report	100%	16-Sep-19 A	16-Sep-19 A
VC10-99	Geotechnical - Review Report	100%	17-Sep-19 A	24-Sep-19 A
VC10-A0	Geotechnical - Mobilize	100%	30-Jul-19 A	19-Aug-19 A
Topographical and Underground Survey Specification			11-Mar-19 A	10-Oct-19 A
PC20-00	Topographical and U/G Survey - Summary	100%	11-Mar-19 A	10-Oct-19 A
PC20-10	Topographical and U/G Survey - Prep & Review	100%	11-Mar-19 A	28-Mar-19 A
PC20-20	Topographical and U/G Survey - Issue for Owner Rvw	100%	29-Mar-19 A	04-Apr-19 A
PC20-25	Topographical and U/G Survey - Owner Rvw	100%	05-Apr-19 A	11-Apr-19 A
PC20-30	Topographical and U/G Survey - Bid Issue	100%	12-Apr-19 A	15-Apr-19 A
PC20-40	Topographical and U/G Survey - Bid Period	100%	16-Apr-19 A	31-May-19 A
PC20-50	Topographical and U/G Survey - Tech Bid Eval/Recommendation	100%	03-Jun-19 A	11-Sep-19 A
PC20-52	Topographical and U/G Survey - Commercial Negotiation	100%	22-Jul-19 A	27-Sep-19 A
PC20-55	Topographical and U/G Survey - Conform Spec for Contract	100%	16-Aug-19 A	19-Aug-19 A
PC20-60	Topographical and U/G Survey - Award	100%	01-Oct-19 A	10-Oct-19 A
Topographical and Underground Survey Vendor Dwgs			08-Oct-19 A	19-Feb-20 A
VC20-0V	Topographical and U/G Survey - Vendor Rvw Summary	100%	08-Oct-19 A	19-Feb-20 A
VC20-70	Topographical and U/G Survey- Perform Mappings	100%	23-Oct-19 A	10-Jan-20 A
VC20-71	Topographical and U/G Survey- Vndr Subm Report	100%	30-Oct-19 A	19-Feb-20 A
VC20-99	Topographical and U/G Survey - Review Report	100%	31-Oct-19 A	19-Feb-20 A
VC20-A0	Topographical and U/G Survey - Mobilize	100%	08-Oct-19 A	25-Oct-19 A
Structural Procurement			20-May-19 A	23-Mar-21
Civil Works Testing & Inspection Specification			26-Aug-19 A	17-Jan-20 A
PS10-00	Civil Works Testing & Inspect - Summary	100%	26-Aug-19 A	17-Jan-20 A
PS10-05	Civil Works Testing & Inspect - Initial Setup	100%	26-Aug-19 A	30-Aug-19 A



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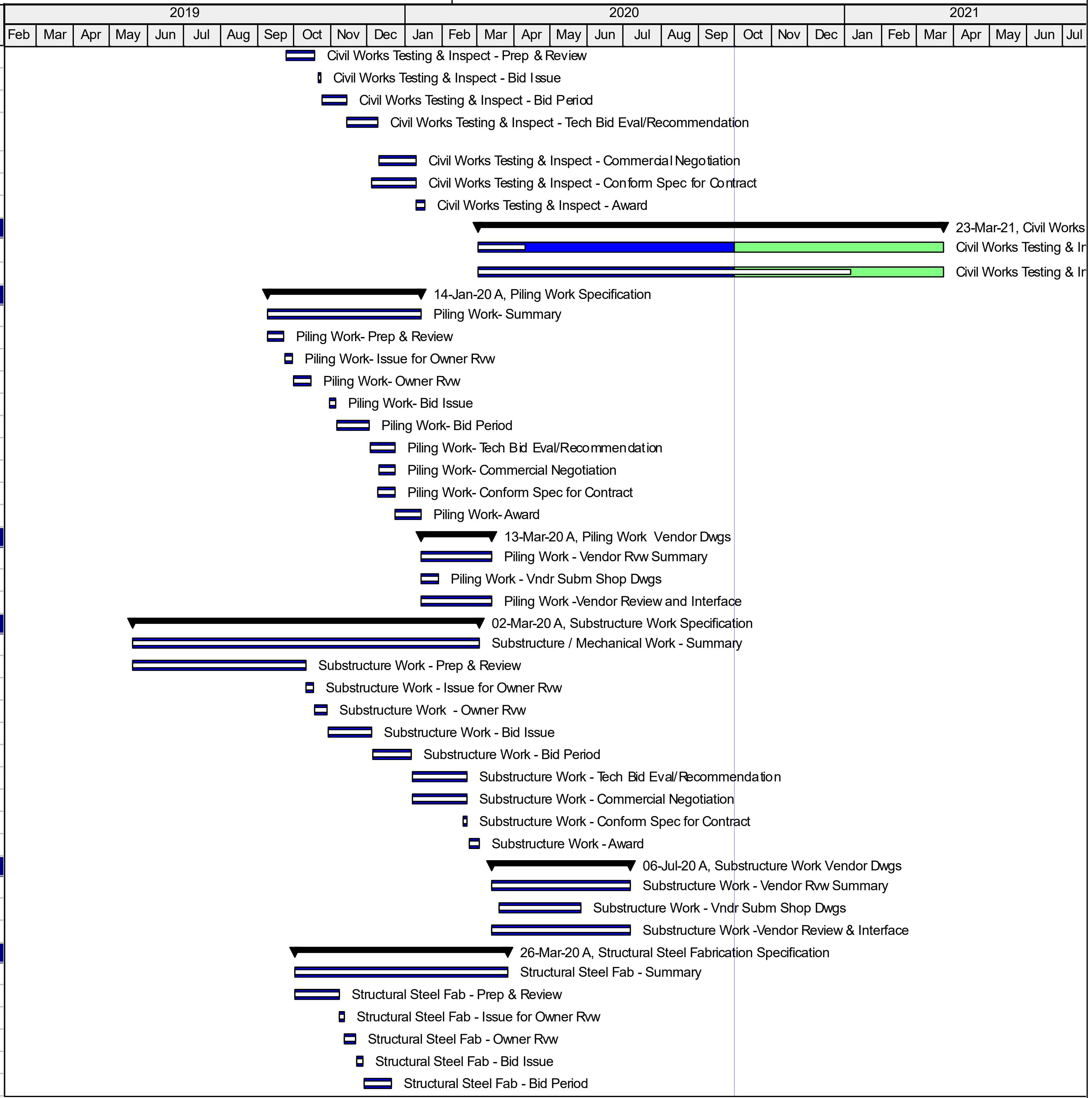
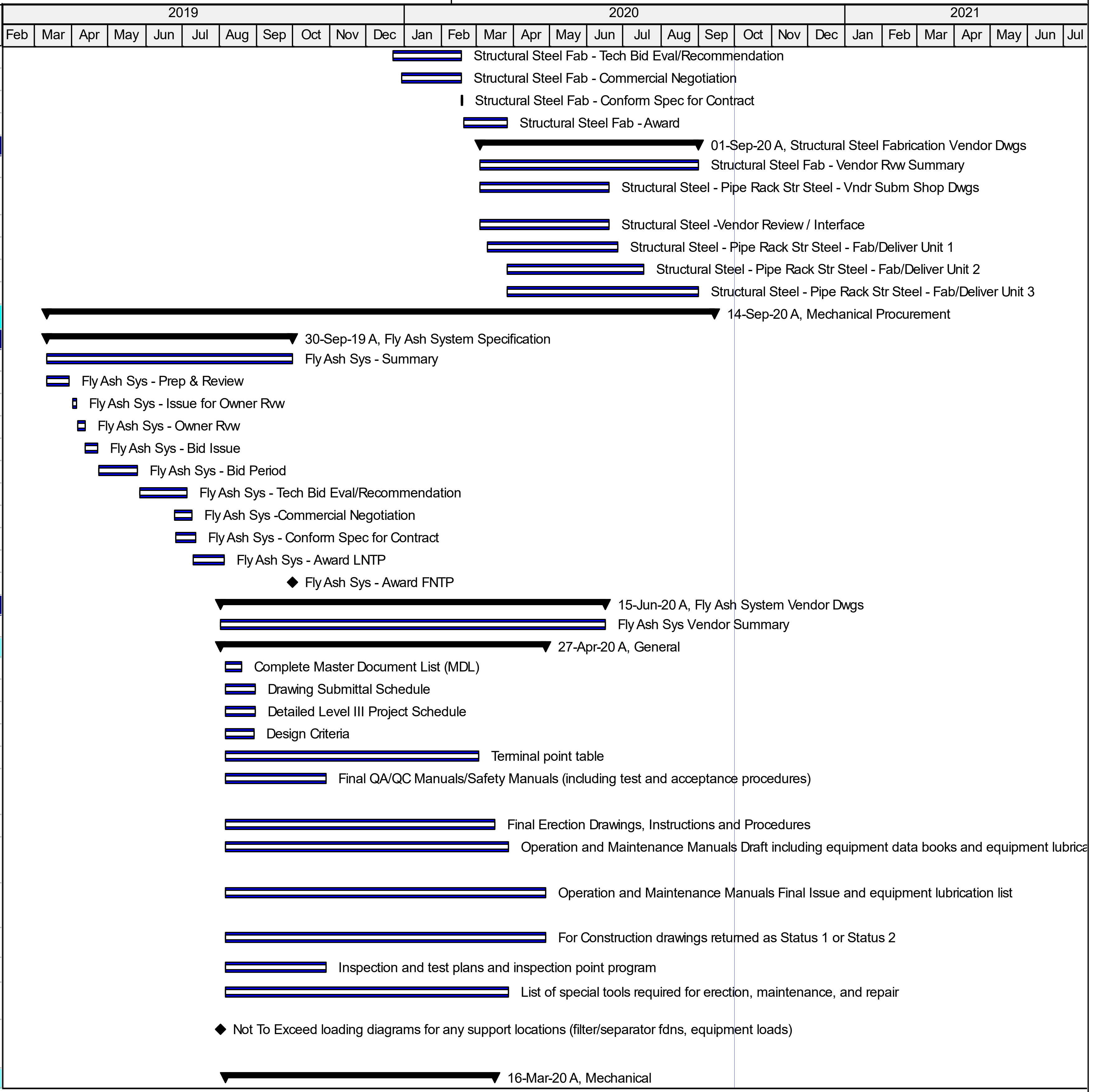
TASK filter: All Activities

Activity ID	Activity Name	Activity % Complete	Start	Finish
PS10-10	Civil Works Testing & Inspect - Prep & Review	100%	25-Sep-19 A	18-Oct-19 A
PS10-30	Civil Works Testing & Inspect - Bid Issue	100%	21-Oct-19 A	23-Oct-19 A
PS10-40	Civil Works Testing & Inspect - Bid Period	100%	24-Oct-19 A	13-Nov-19 A
PS10-50	Civil Works Testing & Inspect - Tech Bid Eval/Recommendation	100%	14-Nov-19 A	09-Dec-19 A
PS10-52	Civil Works Testing & Inspect - Commercial Negotiation	100%	10-Dec-19 A	10-Jan-20 A
PS10-55	Civil Works Testing & Inspect - Conform Spec for Contract	100%	04-Dec-19 A	10-Jan-20 A
PS10-60	Civil Works Testing & Inspect - Award	100%	10-Jan-20 A	17-Jan-20 A
Civil Works Testing & Inspection Field Work			**02-Mar-20 A**	**23-Mar-21**
VS10-0V	Civil Works Testing & Inspect - Contractor Interface Summary	10%	02-Mar-20 A	23-Mar-21
VS10-70	Civil Works Testing & Inspection	80%	02-Mar-20 A	23-Mar-21
Piling Work Specification			**09-Sep-19 A**	**14-Jan-20 A**
PS20-00	Piling Work- Summary	100%	09-Sep-19 A	14-Jan-20 A
PS20-10	Piling Work- Prep & Review	100%	09-Sep-19 A	23-Sep-19 A
PS20-20	Piling Work- Issue for Owner Rvw	100%	24-Sep-19 A	30-Sep-19 A
PS20-25	Piling Work- Owner Rvw	100%	01-Oct-19 A	15-Oct-19 A
PS20-30	Piling Work- Bid Issue	100%	30-Oct-19 A	04-Nov-19 A
PS20-40	Piling Work- Bid Period	100%	05-Nov-19 A	02-Dec-19 A
PS20-50	Piling Work- Tech Bid Eval/Recommendation	100%	03-Dec-19 A	23-Dec-19 A
PS20-52	Piling Work- Commercial Negotiation	100%	10-Dec-19 A	23-Dec-19 A
PS20-55	Piling Work- Conform Spec for Contract	100%	09-Dec-19 A	23-Dec-19 A
PS20-60	Piling Work- Award	100%	24-Dec-19 A	14-Jan-20 A
Piling Work Vendor Dwgs			**14-Jan-20 A**	**13-Mar-20 A**
VS20-0V	Piling Work - Vendor Rvw Summary	100%	14-Jan-20 A	13-Mar-20 A
VS20-70	Piling Work - Vndr Subm Shop Dwgs	100%	14-Jan-20 A	29-Jan-20 A
VS20-99	Piling Work -Vendor Review and Interface	100%	14-Jan-20 A	13-Mar-20 A
Substructure Work Specification			**20-May-19 A**	**02-Mar-20 A**
PS30-00	Substructure / Mechanical Work - Summary	100%	20-May-19 A	02-Mar-20 A
PS30-10	Substructure Work - Prep & Review	100%	20-May-19 A	10-Oct-19 A
PS30-20	Substructure Work - Issue for Owner Rvw	100%	11-Oct-19 A	17-Oct-19 A
PS30-25	Substructure Work - Owner Rvw	100%	18-Oct-19 A	28-Oct-19 A
PS30-30	Substructure Work - Bid Issue	100%	29-Oct-19 A	04-Dec-19 A
PS30-40	Substructure Work - Bid Period	100%	05-Dec-19 A	06-Jan-20 A
PS30-50	Substructure Work - Tech Bid Eval/Recommendation	100%	07-Jan-20 A	21-Feb-20 A
PS30-52	Substructure Work - Commercial Negotiation	100%	07-Jan-20 A	21-Feb-20 A
PS30-55	Substructure Work - Conform Spec for Contract	100%	18-Feb-20 A	21-Feb-20 A
PS30-60	Substructure Work - Award	100%	24-Feb-20 A	02-Mar-20 A
Substructure Work Vendor Dwgs			**13-Mar-20 A**	**06-Jul-20 A**
VS30-0V	Substructure Work - Vendor Rvw Summary	100%	13-Mar-20 A	06-Jul-20 A
VS30-70	Substructure Work - Vndr Subm Shop Dwgs	100%	19-Mar-20 A	26-May-20 A
VS30-99	Substructure Work -Vendor Review & Interface	100%	13-Mar-20 A	06-Jul-20 A
Structural Steel Fabrication Specification			**02-Oct-19 A**	**26-Mar-20 A**
PS40-00	Structural Steel Fab - Summary	100%	02-Oct-19 A	26-Mar-20 A
PS40-10	Structural Steel Fab - Prep & Review	100%	02-Oct-19 A	07-Nov-19 A
PS40-20	Structural Steel Fab - Issue for Owner Rvw	100%	08-Nov-19 A	11-Nov-19 A
PS40-25	Structural Steel Fab - Owner Rvw	100%	12-Nov-19 A	21-Nov-19 A
PS40-30	Structural Steel Fab - Bid Issue	100%	22-Nov-19 A	27-Nov-19 A
PS40-40	Structural Steel Fab - Bid Period	100%	28-Nov-19 A	20-Dec-19 A



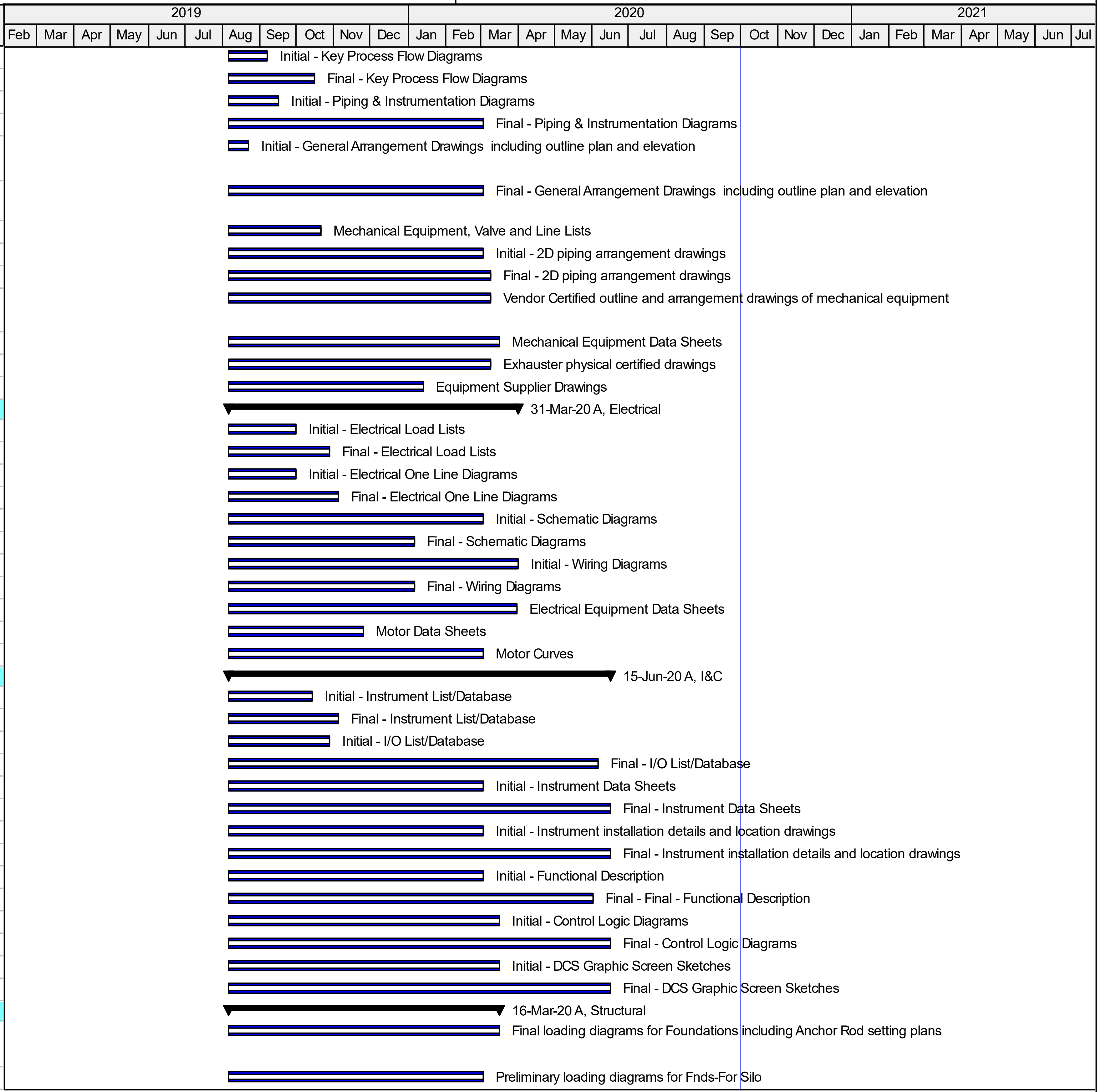
Activity ID	Activity Name	Activity % Complete	Start	Finish
PS40-50	Structural Steel Fab - Tech Bid Eval/Recommendation	100%	23-Dec-19 A	17-Feb-20 A
PS40-52	Structural Steel Fab - Commercial Negotiation	100%	30-Dec-19 A	17-Feb-20 A
PS40-55	Structural Steel Fab - Conform Spec for Contract	100%	17-Feb-20 A	18-Feb-20 A
PS40-60	Structural Steel Fab - Award	100%	19-Feb-20 A	26-Mar-20 A
Structural Steel Fabrication Vendor Dwgs			04-Mar-20 A	01-Sep-20 A
VS40-0V	Structural Steel Fab - Vendor Rvw Summary	100%	04-Mar-20 A	01-Sep-20 A
VS40-70	Structural Steel - Pipe Rack Str Steel - Vndr Subm Shop Dwgs	100%	04-Mar-20 A	19-Jun-20 A
VS40-99	Structural Steel -Vendor Review / Interface	100%	04-Mar-20 A	19-Jun-20 A
VS40-A6	Structural Steel - Pipe Rack Str Steel - Fab/Deliver Unit 1	100%	10-Mar-20 A	26-Jun-20 A
VS40-A7	Structural Steel - Pipe Rack Str Steel - Fab/Deliver Unit 2	100%	27-Mar-20 A	17-Jul-20 A
VS40-A8	Structural Steel - Pipe Rack Str Steel - Fab/Deliver Unit 3	100%	27-Mar-20 A	01-Sep-20 A
Mechanical Procurement			11-Mar-19 A	14-Sep-20 A
Fly Ash System Specification			11-Mar-19 A	30-Sep-19 A
PM10-00	Fly Ash Sys - Summary	100%	11-Mar-19 A	30-Sep-19 A
PM10-10	Fly Ash Sys - Prep & Review	100%	11-Mar-19 A	29-Mar-19 A
PM10-20	Fly Ash Sys - Issue for Owner Rvw	100%	01-Apr-19 A	04-Apr-19 A
PM10-25	Fly Ash Sys - Owner Rvw	100%	05-Apr-19 A	11-Apr-19 A
PM10-30	Fly Ash Sys - Bid Issue	100%	12-Apr-19 A	22-Apr-19 A
PM10-40	Fly Ash Sys - Bid Period	100%	23-Apr-19 A	24-May-19 A
PM10-50	Fly Ash Sys - Tech Bid Eval/Recommendation	100%	27-May-19 A	05-Jul-19 A
PM10-52	Fly Ash Sys -Commercial Negotiation	100%	25-Jun-19 A	09-Jul-19 A
PM10-55	Fly Ash Sys - Conform Spec for Contract	100%	26-Jun-19 A	12-Jul-19 A
PM10-60	Fly Ash Sys - Award LNTP	100%	10-Jul-19 A	05-Aug-19 A
PM10-61	Fly Ash Sys - Award FNTP	100%		30-Sep-19 A
Fly Ash System Vendor Dwgs			01-Aug-19 A	15-Jun-20 A
VM10-0V	Fly Ash Sys Vendor Summary	100%	01-Aug-19 A	15-Jun-20 A
General			01-Aug-19 A	27-Apr-20 A
VM10-4.1.02	Complete Master Document List (MDL)	100%	06-Aug-19 A	19-Aug-19 A
VM10-4.1.03	Drawing Submittal Schedule	100%	06-Aug-19 A	30-Aug-19 A
VM10-4.1.04	Detailed Level III Project Schedule	100%	06-Aug-19 A	30-Aug-19 A
VM10-4.1.05	Design Criteria	100%	06-Aug-19 A	29-Aug-19 A
VM10-4.1.06	Terminal point table	100%	06-Aug-19 A	02-Mar-20 A
VM10-4.1.07	Final QA/QC Manuals/Safety Manuals (including test and acceptance procedures)	100%	06-Aug-19 A	28-Oct-19 A
VM10-4.1.08	Final Erection Drawings, Instructions and Procedures	100%	06-Aug-19 A	16-Mar-20 A
VM10-4.1.09	Operation and Maintenance Manuals Draft including equipment data books and equipment lubrication list	100%	06-Aug-19 A	27-Mar-20 A
VM10-4.1.10	Operation and Maintenance Manuals Final Issue and equipment lubrication list	100%	06-Aug-19 A	27-Apr-20 A
VM10-4.1.11	For Construction drawings returned as Status 1 or Status 2	100%	06-Aug-19 A	27-Apr-20 A
VM10-4.1.12	Inspection and test plans and inspection point program	100%	06-Aug-19 A	28-Oct-19 A
VM10-4.1.13	List of special tools required for erection, maintenance, and repair	100%	06-Aug-19 A	27-Mar-20 A
VM10-4.5.01	Not To Exceed loading diagrams for any support locations (filter/separator fdns, equipment loads)	100%		01-Aug-19 A
Mechanical			06-Aug-19 A	16-Mar-20 A



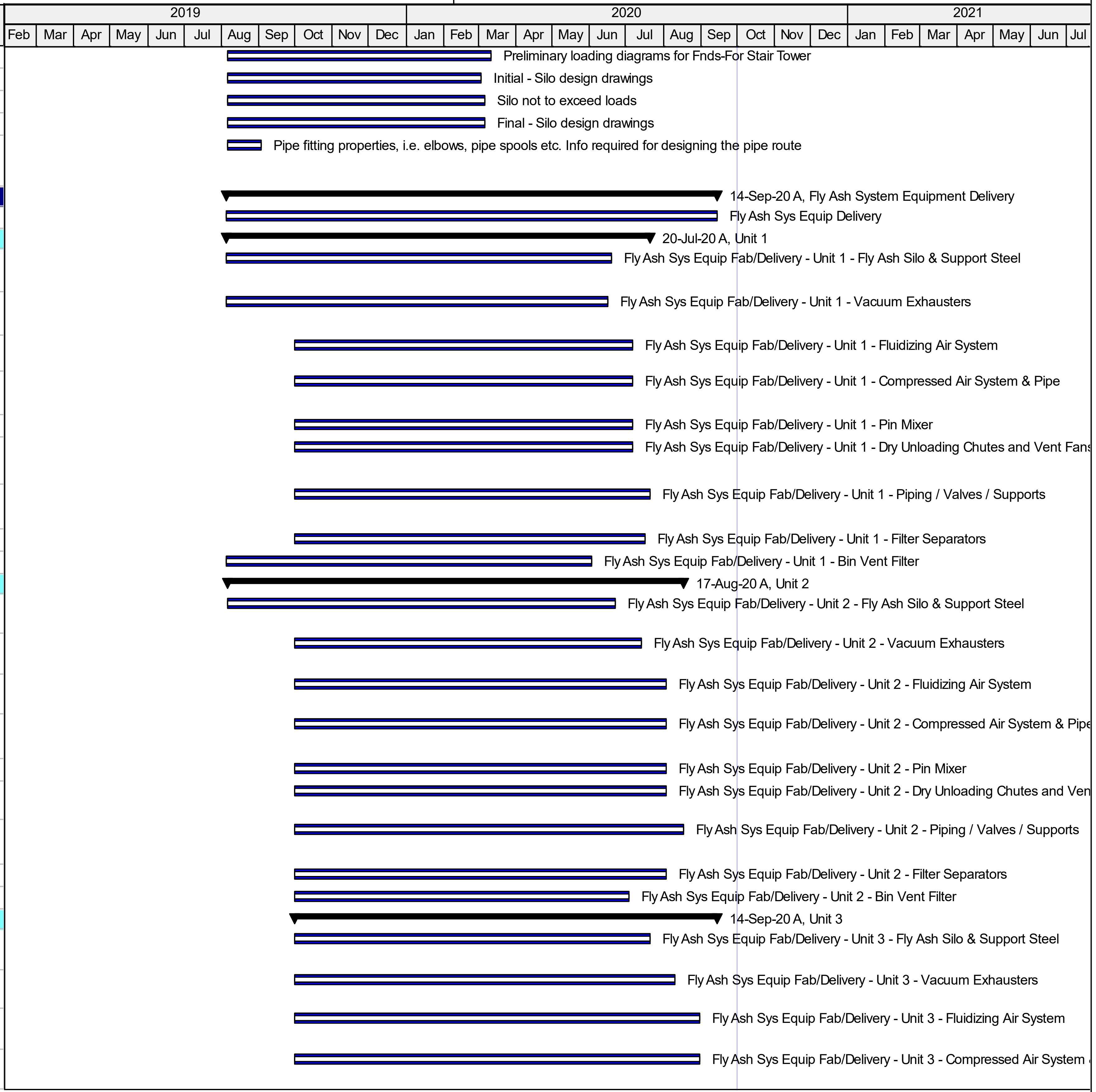
🟦 Actual Work 🟥 Critical Remaining Work ▭ % Complete
🟩 Remaining Work ◆ ◆ Milestone ▬ Summary

TASK filter: All Activities

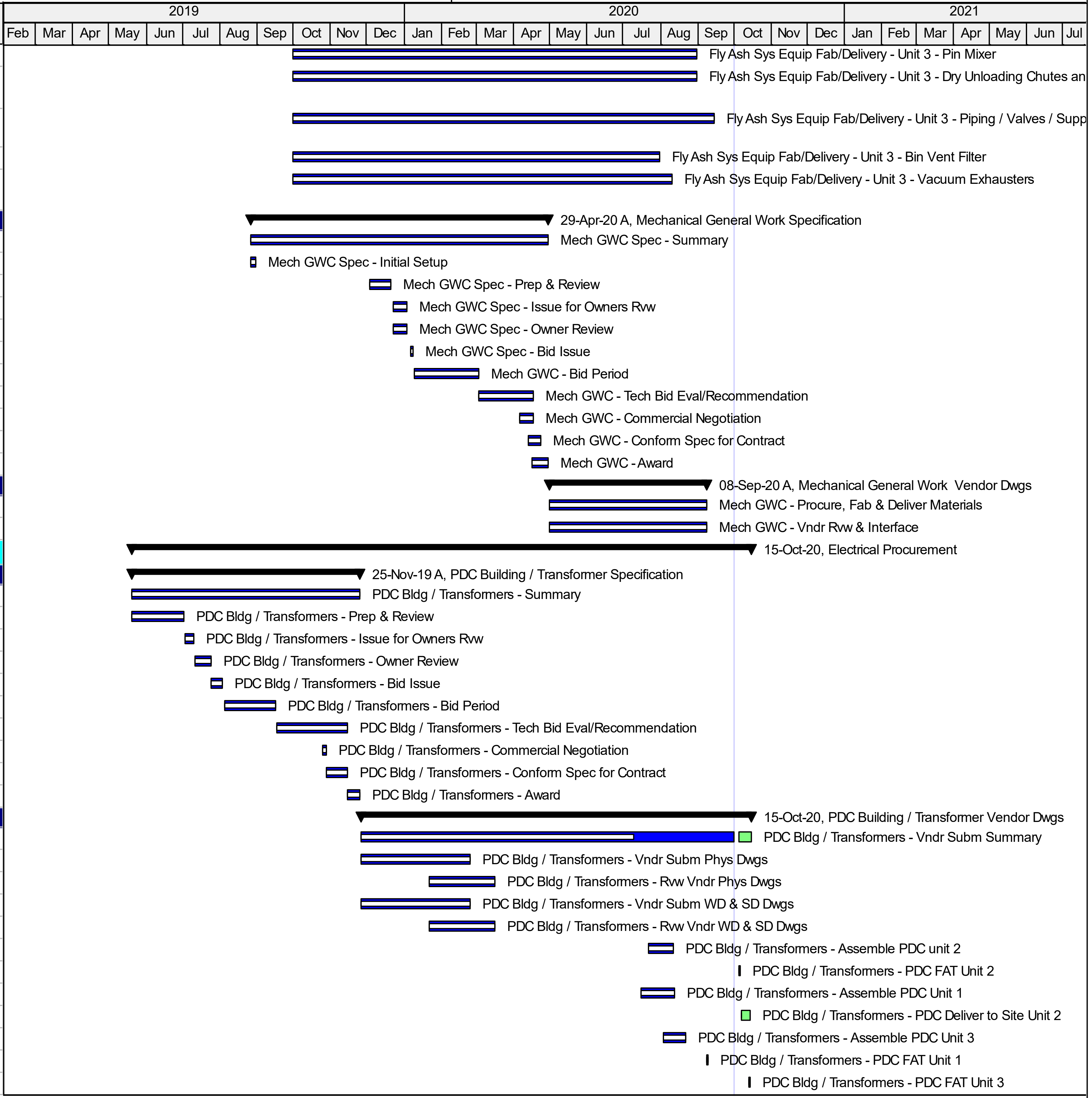
Activity ID	Activity Name	Activity % Complete	Start	Finish
VM10-4.2.01	Initial - Key Process Flow Diagrams	100%	06-Aug-19 A	06-Sep-19 A
VM10-4.2.02	Final - Key Process Flow Diagrams	100%	06-Aug-19 A	16-Oct-19 A
VM10-4.2.03	Initial - Piping & Instrumentation Diagrams	100%	06-Aug-19 A	16-Sep-19 A
VM10-4.2.04	Final - Piping & Instrumentation Diagrams	100%	06-Aug-19 A	02-Mar-20 A
VM10-4.2.05	Initial - General Arrangement Drawings including outline plan and elevation	100%	06-Aug-19 A	22-Aug-19 A
VM10-4.2.06	Final - General Arrangement Drawings including outline plan and elevation	100%	06-Aug-19 A	02-Mar-20 A
VM10-4.2.07	Mechanical Equipment, Valve and Line Lists	100%	06-Aug-19 A	21-Oct-19 A
VM10-4.2.08	Initial - 2D piping arrangement drawings	100%	06-Aug-19 A	02-Mar-20 A
VM10-4.2.09	Final - 2D piping arrangement drawings	100%	06-Aug-19 A	09-Mar-20 A
VM10-4.2.10	Vendor Certified outline and arrangement drawings of mechanical equipment	100%	06-Aug-19 A	09-Mar-20 A
VM10-4.2.11	Mechanical Equipment Data Sheets	100%	06-Aug-19 A	16-Mar-20 A
VM10-4.2.12	Exhauster physical certified drawings	100%	06-Aug-19 A	09-Mar-20 A
VM10-4.2.13	Equipment Supplier Drawings	100%	06-Aug-19 A	13-Jan-20 A
Electrical			06-Aug-19 A	31-Mar-20 A
VM10-4.3.01	Initial - Electrical Load Lists	100%	06-Aug-19 A	30-Sep-19 A
VM10-4.3.02	Final - Electrical Load Lists	100%	06-Aug-19 A	28-Oct-19 A
VM10-4.3.03	Initial - Electrical One Line Diagrams	100%	06-Aug-19 A	30-Sep-19 A
VM10-4.3.04	Final - Electrical One Line Diagrams	100%	06-Aug-19 A	04-Nov-19 A
VM10-4.3.05	Initial - Schematic Diagrams	100%	06-Aug-19 A	02-Mar-20 A
VM10-4.3.06	Final - Schematic Diagrams	100%	06-Aug-19 A	06-Jan-20 A
VM10-4.3.07	Initial - Wiring Diagrams	100%	06-Aug-19 A	31-Mar-20 A
VM10-4.3.08	Final - Wiring Diagrams	100%	06-Aug-19 A	06-Jan-20 A
VM10-4.3.09	Electrical Equipment Data Sheets	100%	06-Aug-19 A	30-Mar-20 A
VM10-4.3.10	Motor Data Sheets	100%	06-Aug-19 A	25-Nov-19 A
VM10-4.3.11	Motor Curves	100%	06-Aug-19 A	02-Mar-20 A
I&C			06-Aug-19 A	15-Jun-20 A
VM10-4.4.02	Initial - Instrument List/Database	100%	06-Aug-19 A	14-Oct-19 A
VM10-4.4.03	Final - Instrument List/Database	100%	06-Aug-19 A	04-Nov-19 A
VM10-4.4.04	Initial - I/O List/Database	100%	06-Aug-19 A	28-Oct-19 A
VM10-4.4.05	Final - I/O List/Database	100%	06-Aug-19 A	05-Jun-20 A
VM10-4.4.06	Initial - Instrument Data Sheets	100%	06-Aug-19 A	02-Mar-20 A
VM10-4.4.07	Final - Instrument Data Sheets	100%	06-Aug-19 A	15-Jun-20 A
VM10-4.4.08	Initial - Instrument installation details and location drawings	100%	06-Aug-19 A	02-Mar-20 A
VM10-4.4.09	Final - Instrument installation details and location drawings	100%	06-Aug-19 A	15-Jun-20 A
VM10-4.4.10	Initial - Functional Description	100%	06-Aug-19 A	02-Mar-20 A
VM10-4.4.11	Final - Final - Functional Description	100%	06-Aug-19 A	01-Jun-20 A
VM10-4.4.12	Initial - Control Logic Diagrams	100%	06-Aug-19 A	16-Mar-20 A
VM10-4.4.13	Final - Control Logic Diagrams	100%	06-Aug-19 A	15-Jun-20 A
VM10-4.4.14	Initial - DCS Graphic Screen Sketches	100%	06-Aug-19 A	16-Mar-20 A
VM10-4.4.15	Final - DCS Graphic Screen Sketches	100%	06-Aug-19 A	15-Jun-20 A
Structural			06-Aug-19 A	16-Mar-20 A
VM10-4.5.02	Final loading diagrams for Foundations including Anchor Rod setting plans	100%	06-Aug-19 A	16-Mar-20 A
VM10-4.5.02.a.1	Preliminary loading diagrams for Fnds-For Silo	100%	06-Aug-19 A	02-Mar-20 A



Activity ID	Activity Name	Activity % Complete	Start	Finish
VM10-4.5.02.a.2	Preliminary loading diagrams for Fnds-For Stair Tower	100%	06-Aug-19 A	11-Mar-20 A
VM10-4.5.03	Initial - Silo design drawings	100%	06-Aug-19 A	02-Mar-20 A
VM10-4.5.04	Silo not to exceed loads	100%	06-Aug-19 A	06-Mar-20 A
VM10-4.5.05	Final - Silo design drawings	100%	06-Aug-19 A	06-Mar-20 A
VM10-4.5.06	Pipe fitting properties, i.e. elbows, pipe spools etc. Info required for designing the pipe route	100%	06-Aug-19 A	02-Sep-19 A
Fly Ash System Equipment Delivery			**05-Aug-19 A**	**14-Sep-20 A**
VM10-V0	Fly Ash Sys Equip Delivery	100%	05-Aug-19 A	14-Sep-20 A
Unit 1			**05-Aug-19 A**	**20-Jul-20 A**
VM10-1-91	Fly Ash Sys Equip Fab/Delivery - Unit 1 - Fly Ash Silo & Support Steel	100%	05-Aug-19 A	19-Jun-20 A
VM10-1-92	Fly Ash Sys Equip Fab/Delivery - Unit 1 - Vacuum Exhausters	100%	05-Aug-19 A	15-Jun-20 A
VM10-1-93	Fly Ash Sys Equip Fab/Delivery - Unit 1 - Fluidizing Air System	100%	01-Oct-19 A	06-Jul-20 A
VM10-1-94	Fly Ash Sys Equip Fab/Delivery - Unit 1 - Compressed Air System & Pipe	100%	01-Oct-19 A	06-Jul-20 A
VM10-1-95	Fly Ash Sys Equip Fab/Delivery - Unit 1 - Pin Mixer	100%	01-Oct-19 A	06-Jul-20 A
VM10-1-96	Fly Ash Sys Equip Fab/Delivery - Unit 1 - Dry Unloading Chutes and Vent Fans	100%	01-Oct-19 A	06-Jul-20 A
VM10-1-97	Fly Ash Sys Equip Fab/Delivery - Unit 1 - Piping / Valves / Supports	100%	01-Oct-19 A	20-Jul-20 A
VM10-1-98	Fly Ash Sys Equip Fab/Delivery - Unit 1 - Filter Separators	100%	01-Oct-19 A	16-Jul-20 A
VM10-1-99	Fly Ash Sys Equip Fab/Delivery - Unit 1 - Bin Vent Filter	100%	05-Aug-19 A	02-Jun-20 A
Unit 2			**06-Aug-19 A**	**17-Aug-20 A**
VM10-2-91	Fly Ash Sys Equip Fab/Delivery - Unit 2 - Fly Ash Silo & Support Steel	100%	06-Aug-19 A	22-Jun-20 A
VM10-2-92	Fly Ash Sys Equip Fab/Delivery - Unit 2 - Vacuum Exhausters	100%	01-Oct-19 A	13-Jul-20 A
VM10-2-93	Fly Ash Sys Equip Fab/Delivery - Unit 2 - Fluidizing Air System	100%	01-Oct-19 A	03-Aug-20 A
VM10-2-94	Fly Ash Sys Equip Fab/Delivery - Unit 2 - Compressed Air System & Pipe	100%	01-Oct-19 A	03-Aug-20 A
VM10-2-95	Fly Ash Sys Equip Fab/Delivery - Unit 2 - Pin Mixer	100%	01-Oct-19 A	03-Aug-20 A
VM10-2-96	Fly Ash Sys Equip Fab/Delivery - Unit 2 - Dry Unloading Chutes and Vent Fans	100%	01-Oct-19 A	03-Aug-20 A
VM10-2-97	Fly Ash Sys Equip Fab/Delivery - Unit 2 - Piping / Valves / Supports	100%	01-Oct-19 A	17-Aug-20 A
VM10-2-98	Fly Ash Sys Equip Fab/Delivery - Unit 2 - Filter Separators	100%	01-Oct-19 A	03-Aug-20 A
VM10-2-99	Fly Ash Sys Equip Fab/Delivery - Unit 2 - Bin Vent Filter	100%	01-Oct-19 A	03-Jul-20 A
Unit 3			**01-Oct-19 A**	**14-Sep-20 A**
VM10-3-91	Fly Ash Sys Equip Fab/Delivery - Unit 3 - Fly Ash Silo & Support Steel	100%	01-Oct-19 A	20-Jul-20 A
VM10-3-92	Fly Ash Sys Equip Fab/Delivery - Unit 3 - Vacuum Exhausters	100%	01-Oct-19 A	10-Aug-20 A
VM10-3-93	Fly Ash Sys Equip Fab/Delivery - Unit 3 - Fluidizing Air System	100%	01-Oct-19 A	31-Aug-20 A
VM10-3-94	Fly Ash Sys Equip Fab/Delivery - Unit 3 - Compressed Air System & Pipe	100%	01-Oct-19 A	31-Aug-20 A



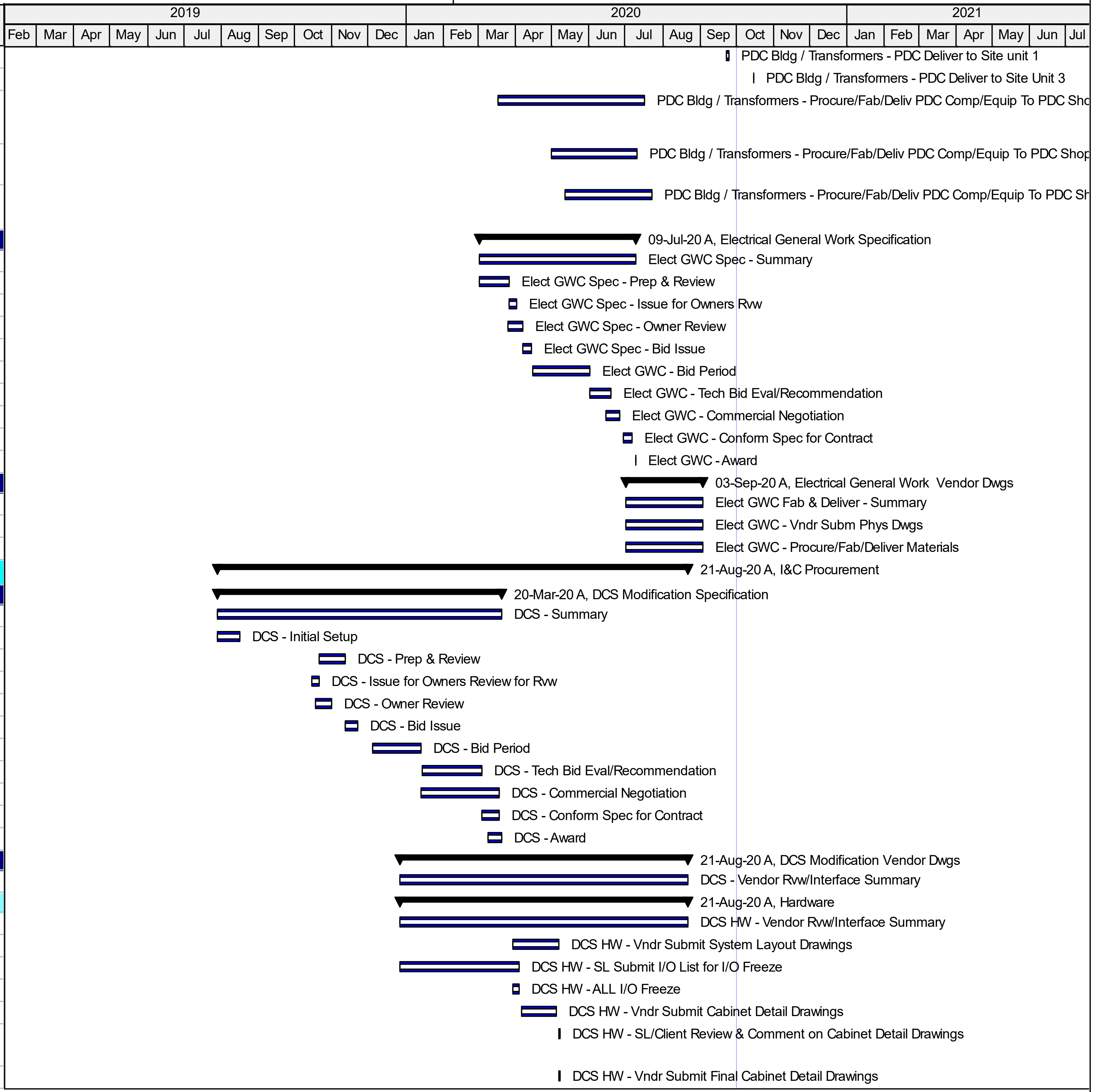
Activity ID	Activity Name	Activity % Complete	Start	Finish
VM10-3-95	Fly Ash Sys Equip Fab/Delivery - Unit 3 - Pin Mixer	100%	01-Oct-19 A	31-Aug-20 A
VM10-3-96	Fly Ash Sys Equip Fab/Delivery - Unit 3 - Dry Unloading Chutes and Vent Fans	100%	01-Oct-19 A	31-Aug-20 A
VM10-3-97	Fly Ash Sys Equip Fab/Delivery - Unit 3 - Piping / Valves / Supports	100%	01-Oct-19 A	14-Sep-20 A
VM10-3-98	Fly Ash Sys Equip Fab/Delivery - Unit 3 - Bin Vent Filter	100%	01-Oct-19 A	31-Jul-20 A
VM10-3-99	Fly Ash Sys Equip Fab/Delivery - Unit 3 - Vacuum Exhausters	100%	01-Oct-19 A	10-Aug-20 A
Mechanical General Work Specification			26-Aug-19 A	29-Apr-20 A
PM20-00	Mech GWC Spec - Summary	100%	26-Aug-19 A	29-Apr-20 A
PM20-05	Mech GWC Spec - Initial Setup	100%	26-Aug-19 A	30-Aug-19 A
PM20-10	Mech GWC Spec - Prep & Review	100%	03-Dec-19 A	20-Dec-19 A
PM20-20	Mech GWC Spec - Issue for Owners Rvw	100%	23-Dec-19 A	03-Jan-20 A
PM20-25	Mech GWC Spec - Owner Review	100%	23-Dec-19 A	03-Jan-20 A
PM20-30	Mech GWC Spec - Bid Issue	100%	06-Jan-20 A	08-Jan-20 A
PM20-40	Mech GWC - Bid Period	100%	09-Jan-20 A	02-Mar-20 A
PM20-50	Mech GWC - Tech Bid Eval/Recommendation	100%	03-Mar-20 A	17-Apr-20 A
PM20-52	Mech GWC - Commercial Negotiation	100%	06-Apr-20 A	17-Apr-20 A
PM20-55	Mech GWC - Conform Spec for Contract	100%	13-Apr-20 A	23-Apr-20 A
PM20-60	Mech GWC - Award	100%	16-Apr-20 A	29-Apr-20 A
Mechanical General Work Vendor Dwgs			01-May-20 A	08-Sep-20 A
PM20-89	Mech GWC - Procure, Fab & Deliver Materials	100%	01-May-20 A	08-Sep-20 A
PM20-99	Mech GWC - Vndr Rvw & Interface	100%	01-May-20 A	08-Sep-20 A
Electrical Procurement			20-May-19 A	15-Oct-20
PDC Building / Transformer Specification			20-May-19 A	25-Nov-19 A
PE10-00	PDC Bldg / Transfomers - Summary	100%	20-May-19 A	25-Nov-19 A
PE10-10	PDC Bldg / Transformers - Prep & Review	100%	20-May-19 A	02-Jul-19 A
PE10-20	PDC Bldg / Transformers - Issue for Owners Rvw	100%	03-Jul-19 A	10-Jul-19 A
PE10-25	PDC Bldg / Transformers - Owner Review	100%	11-Jul-19 A	24-Jul-19 A
PE10-30	PDC Bldg / Transformers - Bid Issue	100%	25-Jul-19 A	02-Aug-19 A
PE10-40	PDC Bldg / Transformers - Bid Period	100%	05-Aug-19 A	16-Sep-19 A
PE10-50	PDC Bldg / Transformers - Tech Bid Eval/Recommendation	100%	17-Sep-19 A	14-Nov-19 A
PE10-52	PDC Bldg / Transformers - Commercial Negotiation	100%	25-Oct-19 A	28-Oct-19 A
PE10-55	PDC Bldg / Transformers - Conform Spec for Contract	100%	28-Oct-19 A	14-Nov-19 A
PE10-60	PDC Bldg / Transformers - Award	100%	15-Nov-19 A	25-Nov-19 A
PDC Building / Transformer Vendor Dwgs			26-Nov-19 A	15-Oct-20
VE10-0V	PDC Bldg / Transfomers - Vndr Subm Summary	70%	26-Nov-19 A	15-Oct-20
VE10-70	PDC Bldg / Transfomers - Vndr Subm Phys Dwgs	100%	26-Nov-19 A	24-Feb-20 A
VE10-75	PDC Bldg / Transfomers - Rvw Vndr Phys Dwgs	100%	22-Jan-20 A	16-Mar-20 A
VE10-90	PDC Bldg / Transfomers - Vndr Subm WD & SD Dwgs	100%	26-Nov-19 A	24-Feb-20 A
VE10-95	PDC Bldg / Transfomers - Rvw Vndr WD & SD Dwgs	100%	22-Jan-20 A	16-Mar-20 A
VE10-A16	PDC Bldg / Transfomers - Assemble PDC unit 2	100%	22-Jul-20 A	11-Aug-20 A
VE10-A26	PDC Bldg / Transfomers - PDC FAT Unit 2	0%	05-Oct-20*	06-Oct-20
VE10-A3	PDC Bldg / Transfomers - Assemble PDC Unit 1	100%	16-Jul-20 A	12-Aug-20 A
VE10-A36	PDC Bldg / Transfomers - PDC Deliver to Site Unit 2	0%	07-Oct-20*	14-Oct-20
VE10-A46	PDC Bldg / Transfomers - Assemble PDC Unit 3	100%	03-Aug-20 A	21-Aug-20 A
VE10-A5	PDC Bldg / Transfomers - PDC FAT Unit 1	100%	08-Sep-20 A	09-Sep-20 A
VE10-A56	PDC Bldg / Transfomers - PDC FAT Unit 3	0%	13-Oct-20*	14-Oct-20



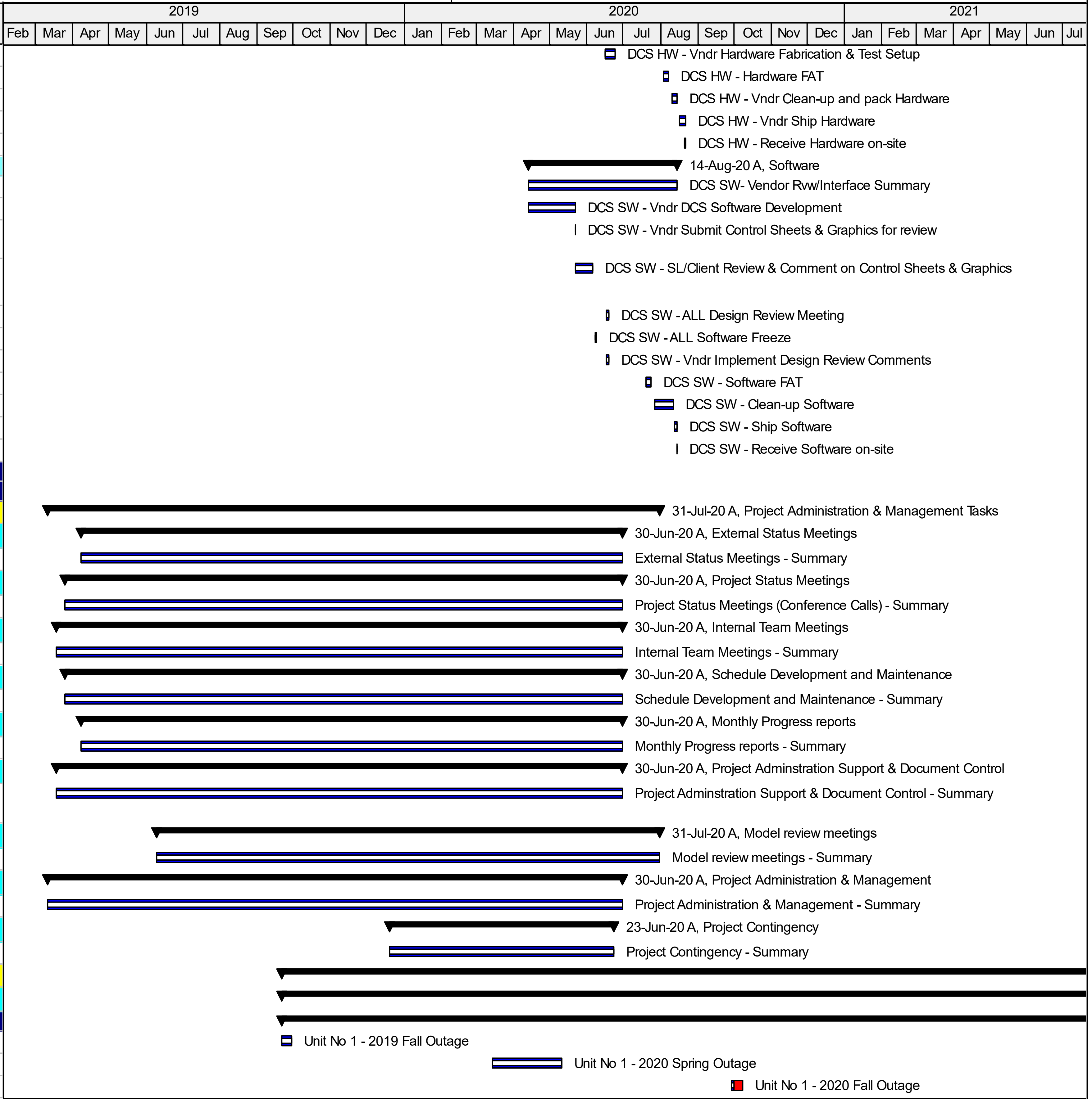
🟦 Actual Work	🟥 Critical Remaining Work	▭ % Complete
🟩 Remaining Work	◆ ◆ Milestone	Summary

TASK filter: All Activities

Activity ID	Activity Name	Activity % Complete	Start	Finish
VE10-A6	PDC Bldg / Transformers - PDC Deliver to Site unit 1	100%	23-Sep-20 A	24-Sep-20 A
VE10-A66	PDC Bldg / Transformers - PDC Deliver to Site Unit 3	0%	15-Oct-20*	15-Oct-20
VE10A-A1	PDC Bldg / Transformers - Procure/Fab/Deliv PDC Comp/Equip To PDC Shop Unit 1	100%	17-Mar-20 A	16-Jul-20 A
VE10A-A2	PDC Bldg / Transformers - Procure/Fab/Deliv PDC Comp/Equip To PDC Shop Unit 2	100%	30-Apr-20 A	10-Jul-20 A
VE10A-A3	PDC Bldg / Transformers - Procure/Fab/Deliv PDC Comp/Equip To PDC Shop Unit 3	100%	12-May-20 A	22-Jul-20 A
Electrical General Work Specification			02-Mar-20 A	09-Jul-20 A
PE20-00	Elect GWC Spec - Summary	100%	02-Mar-20 A	09-Jul-20 A
PE20-10	Elect GWC Spec - Prep & Review	100%	02-Mar-20 A	26-Mar-20 A
PE20-20	Elect GWC Spec - Issue for Owners Rvw	100%	27-Mar-20 A	01-Apr-20 A
PE20-25	Elect GWC Spec - Owner Review	100%	25-Mar-20 A	06-Apr-20 A
PE20-30	Elect GWC Spec - Bid Issue	100%	07-Apr-20 A	14-Apr-20 A
PE20-40	Elect GWC - Bid Period	100%	15-Apr-20 A	01-Jun-20 A
PE20-50	Elect GWC - Tech Bid Eval/Recommendation	100%	01-Jun-20 A	19-Jun-20 A
PE20-52	Elect GWC - Commercial Negotiation	100%	15-Jun-20 A	26-Jun-20 A
PE20-55	Elect GWC - Conform Spec for Contract	100%	29-Jun-20 A	06-Jul-20 A
PE20-60	Elect GWC - Award	100%	09-Jul-20 A	09-Jul-20 A
Electrical General Work Vendor Dwgs			01-Jul-20 A	03-Sep-20 A
VE20-0V	Elect GWC Fab & Deliver - Summary	100%	01-Jul-20 A	03-Sep-20 A
VE20-70	Elect GWC - Vndr Subm Phys Dwgs	100%	01-Jul-20 A	03-Sep-20 A
VE20-98	Elect GWC - Procure/Fab/Deliver Materials	100%	01-Jul-20 A	03-Sep-20 A
I&C Procurement			29-Jul-19 A	21-Aug-20 A
DCS Modification Specification			29-Jul-19 A	20-Mar-20 A
PJ10-00	DCS - Summary	100%	29-Jul-19 A	20-Mar-20 A
PJ10-05	DCS - Initial Setup	100%	29-Jul-19 A	16-Aug-19 A
PJ10-10	DCS - Prep & Review	100%	21-Oct-19 A	11-Nov-19 A
PJ10-20	DCS - Issue for Owners Review for Rvw	100%	15-Oct-19 A	21-Oct-19 A
PJ10-25	DCS - Owner Review	100%	18-Oct-19 A	31-Oct-19 A
PJ10-30	DCS - Bid Issue	100%	12-Nov-19 A	22-Nov-19 A
PJ10-40	DCS - Bid Period	100%	04-Dec-19 A	13-Jan-20 A
PJ10-50	DCS - Tech Bid Eval/Recommendation	100%	14-Jan-20 A	03-Mar-20 A
PJ10-52	DCS - Commercial Negotiation	100%	13-Jan-20 A	18-Mar-20 A
PJ10-55	DCS - Conform Spec for Contract	100%	04-Mar-20 A	18-Mar-20 A
PJ10-60	DCS - Award	100%	09-Mar-20 A	20-Mar-20 A
DCS Modification Vendor Dwgs			27-Dec-19 A	21-Aug-20 A
VJ10-0V	DCS - Vendor Rvw/Interface Summary	100%	27-Dec-19 A	21-Aug-20 A
Hardware			27-Dec-19 A	21-Aug-20 A
VJ10H1-0V	DCS HW - Vendor Rvw/Interface Summary	100%	27-Dec-19 A	21-Aug-20 A
VJ10H1-1120	DCS HW - Vndr Submit System Layout Drawings	100%	30-Mar-20 A	06-May-20 A
VJ10H1-1160	DCS HW - SL Submit I/O List for I/O Freeze	100%	27-Dec-19 A	03-Apr-20 A
VJ10H1-1170	DCS HW - ALL I/O Freeze	100%	30-Mar-20 A	03-Apr-20 A
VJ10H1-1180	DCS HW - Vndr Submit Cabinet Detail Drawings	100%	06-Apr-20 A	04-May-20 A
VJ10H1-1190	DCS HW - SL/Client Review & Comment on Cabinet Detail Drawings	100%	07-May-20 A	07-May-20 A
VJ10H1-1200	DCS HW - Vndr Submit Final Cabinet Detail Drawings	100%	07-May-20 A	07-May-20 A



Activity ID	Activity Name	Activity % Complete	Start	Finish
VJ10H1-1240	DCS HW - Vndr Hardware Fabrication & Test Setup	100%	16-Jun-20 A	24-Jun-20 A
VJ10H1-1250	DCS HW - Hardware FAT	100%	03-Aug-20 A	07-Aug-20 A
VJ10H1-1260	DCS HW - Vndr Clean-up and pack Hardware	100%	10-Aug-20 A	14-Aug-20 A
VJ10H1-1270	DCS HW - Vndr Ship Hardware	100%	17-Aug-20 A	21-Aug-20 A
VJ10H1-1280	DCS HW - Receive Hardware on-site	100%	21-Aug-20 A	21-Aug-20 A
Software			13-Apr-20 A	14-Aug-20 A
VJ10S1-0V	DCS SW- Vendor Rvw/Interface Summary	100%	13-Apr-20 A	14-Aug-20 A
VJ10S1-1300	DCS SW - Vndr DCS Software Development	100%	13-Apr-20 A	22-May-20 A
VJ10S1-1330	DCS SW - Vndr Submit Control Sheets & Graphics for review	100%	22-May-20 A	22-May-20 A
VJ10S1-1340	DCS SW - SL/Client Review & Comment on Control Sheets & Graphics	100%	22-May-20 A	05-Jun-20 A
VJ10S1-1350	DCS SW - ALL Design Review Meeting	100%	17-Jun-20 A	19-Jun-20 A
VJ10S1-1360	DCS SW - ALL Software Freeze	100%	08-Jun-20 A	08-Jun-20 A
VJ10S1-1370	DCS SW - Vndr Implement Design Review Comments	100%	17-Jun-20 A	19-Jun-20 A
VJ10S1-1390	DCS SW - Software FAT	100%	20-Jul-20 A	24-Jul-20 A
VJ10S1-1400	DCS SW - Clean-up Software	100%	27-Jul-20 A	11-Aug-20 A
VJ10S1-1410	DCS SW - Ship Software	100%	12-Aug-20 A	14-Aug-20 A
VJ10S1-1420	DCS SW - Receive Software on-site	100%	14-Aug-20 A	14-Aug-20 A
Instrumentation BOM				
Instrumentation BOMVendor Dwgs				
Project Administration & Management Tasks			11-Mar-19 A	31-Jul-20 A
External Status Meetings			08-Apr-19 A	30-Jun-20 A
X020-0L	External Status Meetings - Summary	100%	08-Apr-19 A	30-Jun-20 A
Project Status Meetings			25-Mar-19 A	30-Jun-20 A
X030-0L	Project Status Meetings (Conference Calls) - Summary	100%	25-Mar-19 A	30-Jun-20 A
Internal Team Meetings			18-Mar-19 A	30-Jun-20 A
X040-0L	Internal Team Meetings - Summary	100%	18-Mar-19 A	30-Jun-20 A
Schedule Development and Maintenance			25-Mar-19 A	30-Jun-20 A
X050-0L	Schedule Development and Maintenance - Summary	100%	25-Mar-19 A	30-Jun-20 A
Monthly Progress reports			08-Apr-19 A	30-Jun-20 A
X060-0L	Monthly Progress reports - Summary	100%	08-Apr-19 A	30-Jun-20 A
Project Adminstration Support & Document Control			18-Mar-19 A	30-Jun-20 A
X070-0L	Project Adminstration Support & Document Control - Summary	100%	18-Mar-19 A	30-Jun-20 A
Model review meetings			09-Jun-19 A	31-Jul-20 A
X080-0L	Model review meetings - Summary	100%	09-Jun-19 A	31-Jul-20 A
Project Administration & Management			11-Mar-19 A	30-Jun-20 A
X100-0L	Project Administration & Management - Summary	100%	11-Mar-19 A	30-Jun-20 A
Project Contingency			20-Dec-19 A	23-Jun-20 A
X990-0L	Project Contingency - Summary	100%	20-Dec-19 A	23-Jun-20 A
Construction			21-Sep-19 A	21-Nov-21
Unit 1			21-Sep-19 A	21-Nov-21
Unit 1 - Outages			21-Sep-19 A	21-Nov-21
OUTU1.001	Unit No 1 - 2019 Fall Outage	100%	21-Sep-19 A	29-Sep-19 A
OUTU1.002	Unit No 1 - 2020 Spring Outage	100%	14-Mar-20 A	10-May-20 A
OUTU1.003	Unit No 1 - 2020 Fall Outage	20%	29-Sep-20 A	08-Oct-20*



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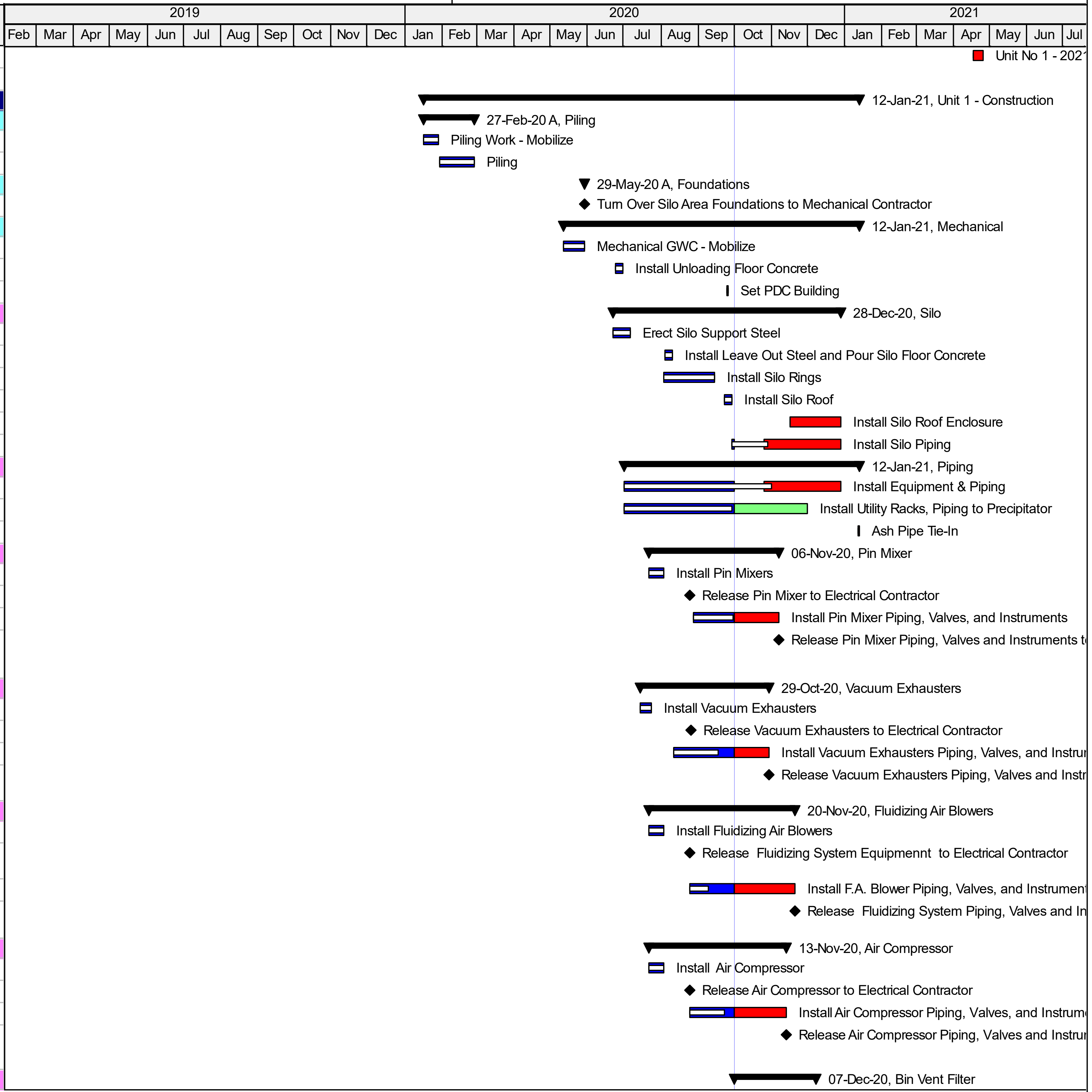
TASK filter: All Activities

Activity ID	Activity Name	Activity % Complete	Start	Finish
OUTU1.004	Unit No 1 - 2021 Spring Outage	0%	17-Apr-21*	25-Apr-21*
OUTU1.005	Unit No 1 - 2021 Fall Outage	0%	30-Oct-21*	21-Nov-21
Unit 1 - Construction			17-Jan-20 A	12-Jan-21
Piling			17-Jan-20 A	27-Feb-20 A
C0000	Piling Work - Mobilize	100%	17-Jan-20 A	29-Jan-20 A
C0050	Piling	100%	30-Jan-20 A	27-Feb-20 A
Foundations			29-May-20 A	29-May-20 A
C1009	Turn Over Silo Area Foundations to Mechanical Contractor	100%		29-May-20 A
Mechanical			12-May-20 A	12-Jan-21
C1007	Mechanical GWC - Mobilize	100%	12-May-20 A	29-May-20 A
C1012	Install Unloading Floor Concrete	100%	24-Jun-20 A	30-Jun-20 A
C1042	Set PDC Building	100%	25-Sep-20 A	25-Sep-20 A
Silo			22-Jun-20 A	28-Dec-20
C1008	Erect Silo Support Steel	100%	22-Jun-20 A	06-Jul-20 A
C1024	Install Leave Out Steel and Pour Silo Floor Concrete	100%	04-Aug-20 A	10-Aug-20 A
C1026	Install Silo Rings	100%	03-Aug-20 A	14-Sep-20 A
C1028	Install Silo Roof	100%	23-Sep-20 A	28-Sep-20 A
C1033	Install Silo Roof Enclosure	0%	16-Nov-20	28-Dec-20
C1036	Install Silo Piping	32.79%	29-Sep-20 A	28-Dec-20
Piping			01-Jul-20 A	12-Jan-21
C1010	Install Equipment & Piping	67.97%	01-Jul-20 A	28-Dec-20
C1044	Install Utility Racks, Piping to Precipitator	59%	01-Jul-20 A	30-Nov-20
C1050	Ash Pipe Tie-In	0%	12-Jan-21	12-Jan-21
Pin Mixer			22-Jul-20 A	06-Nov-20
C1016	Install Pin Mixers	100%	22-Jul-20 A	03-Aug-20 A
C1017	Release Pin Mixer to Electrical Contractor	100%		24-Aug-20 A
C1021	Install Pin Mixer Piping, Valves, and Instruments	46%	28-Aug-20 A	06-Nov-20
C1031	Release Pin Mixer Piping, Valves and Instruments to Electrical Contractor	0%		06-Nov-20
Vacuum Exhausters			15-Jul-20 A	29-Oct-20
C1014	Install Vacuum Exhausters	100%	15-Jul-20 A	24-Jul-20 A
C1015	Release Vacuum Exhausters to Electrical Contractor	100%		25-Aug-20 A
C1041	Install Vacuum Exhausters Piping, Valves, and Instruments	47.5%	11-Aug-20 A	29-Oct-20
C1043	Release Vacuum Exhausters Piping, Valves and Instruments to Electrical Contractor	0%		29-Oct-20
Fluidizing Air Blowers			22-Jul-20 A	20-Nov-20
C1018	Install Fluidizing Air Blowers	100%	22-Jul-20 A	03-Aug-20 A
C1019	Release Fluidizing System Equipmennt to Electrical Contractor	100%		24-Aug-20 A
C1045	Install F.A. Blower Piping, Valves, and Instruments	17.78%	25-Aug-20 A	20-Nov-20
C1046	Release Fluidizing System Piping, Valves and Instruments to Electrical Contractor	0%		20-Nov-20
Air Compressor			22-Jul-20 A	13-Nov-20
C1022	Install Air Compressor	100%	22-Jul-20 A	03-Aug-20 A
C1023	Release Air Compressor to Electrical Contractor	100%		24-Aug-20 A
C1047	Install Air Compressor Piping, Valves, and Instruments	36%	25-Aug-20 A	13-Nov-20
C1048	Release Air Compressor Piping, Valves and Instruments to Electrical Contractor	0%		13-Nov-20
Bin Vent Filter			01-Oct-20	07-Dec-20



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◆ Milestone
▼ Summary

TASK filter: All Activities

Activity ID	Activity Name	Activity % Complete	Start	Finish
C1034	Install Bin Vent Filter	0%	01-Oct-20	14-Oct-20
C1039	Release Bin Vent Filter to Electrical Contractor	0%		24-Nov-20
C1051	Release Bin Vent Filter Piping, Valves and Instruments to Electrical Contractor	0%		07-Dec-20
Filter Separtors			01-Oct-20	10-Dec-20
C1032	Install Filter Separators	0%	01-Oct-20	14-Oct-20
C1037	Release Filter Separators to Electrical Contractor	0%		24-Nov-20
C1049	Release Filter Separators Piping, Valves and Instruments to Electrical Contractor	0%		10-Dec-20
Electrical			10-Aug-20 A	08-Jan-21
C1020	Electrical GWC - Mobilize	100%	10-Aug-20 A	21-Aug-20 A
C1025	LOTO & Install DCS Hardware	100%	16-Sep-20 A	17-Sep-20 A
C1027	Transfer Precip Valve Wiring from PLC to DCS	100%	18-Sep-20 A	20-Sep-20 A
C1030	Electrical Contractor Install Electrical	14.1%	16-Sep-20 A	08-Jan-21
C1035	Electrical Tie-In Outage	20%	29-Sep-20 A	08-Oct-20
C1080	Perform Maintenance on Existing ESP Valves	100%	01-Sep-20 A	10-Sep-20 A
Turnover to Commissioning			27-Nov-20	05-Jan-21
C1031C	Pin Mixer Turnover to Commissioning	0%		27-Nov-20*
C1043C	Vacuum Exhausters Turnover to Commissioning	0%		21-Dec-20*
C1046C	Fluidizing System Turnover to Commissioning	0%		07-Dec-20*
C1048C	Air Compressor Turnover to Commissioning	0%		14-Dec-20*
C1049C	Filter Separators Turnover to Commissioning	0%		17-Dec-20
C1050A	Wet and Dry Unloading Complete System Turnover to Commissioning	0%		31-Dec-20
C1050B	Vacuum Conveying Complete System Turnover to Commissioning	0%		05-Jan-21
C1051C	Bin Vent Filter Turnover to Commissioning	0%		29-Dec-20*
Commissioning			21-Sep-20 A	12-Jan-21
C1029	Commision Precip Valve in DCS	100%	21-Sep-20 A	25-Sep-20 A
C1040	Commissioning	0%	19-Oct-20	12-Jan-21
C1052	Commission Pin Mixer Subsystem	0%	28-Nov-20	07-Dec-20
C1054	Commission F.A. Blowers Subsystem	0%	08-Dec-20	17-Dec-20
C1056	Commission Air Compressor Subsystem	0%	15-Dec-20	24-Dec-20
C1058	Commission Vacuum Exhausters Subsystem	0%	22-Dec-20	26-Dec-20
C1060	Commission Filter Separtators Subsystem	0%	30-Dec-20*	05-Jan-21
C1062	Commission Bin Vent Filter Subsystem	0%	30-Dec-20*	05-Jan-21
C1064	Commission Vacuum System	0%	06-Jan-21	12-Jan-21
C1066	Commission Unloading System	0%	06-Jan-21	12-Jan-21
C1090	Commission Aux Power Subsystem	0%	09-Oct-20	13-Oct-20
Unit 2			19-Oct-19 A	11-Oct-21
Unit 2 - Outages			19-Oct-19 A	11-Oct-21
OUTU2.001	Unit No 2 - 2019 Fall Outage	100%	19-Oct-19 A	18-Nov-19 A
OUTU2.002	Unit No 2 - 2020 Spring Outage	100%	04-Apr-20 A	13-Apr-20 A
OUTU2.003	Unit No 2 - 2020 Fall Outage	55.56%	26-Sep-20 A	04-Oct-20*
OUTU2.004	Unit No 2 - 2021 Spring Outage	0%	27-Mar-21*	24-May-21*
OUTU2.005	Unit No 2 - 2021 Fall Outage	0%	02-Oct-21*	11-Oct-21*
Unit 2 - Construction			02-Mar-20 A	30-Mar-21

🟦 Actual Work
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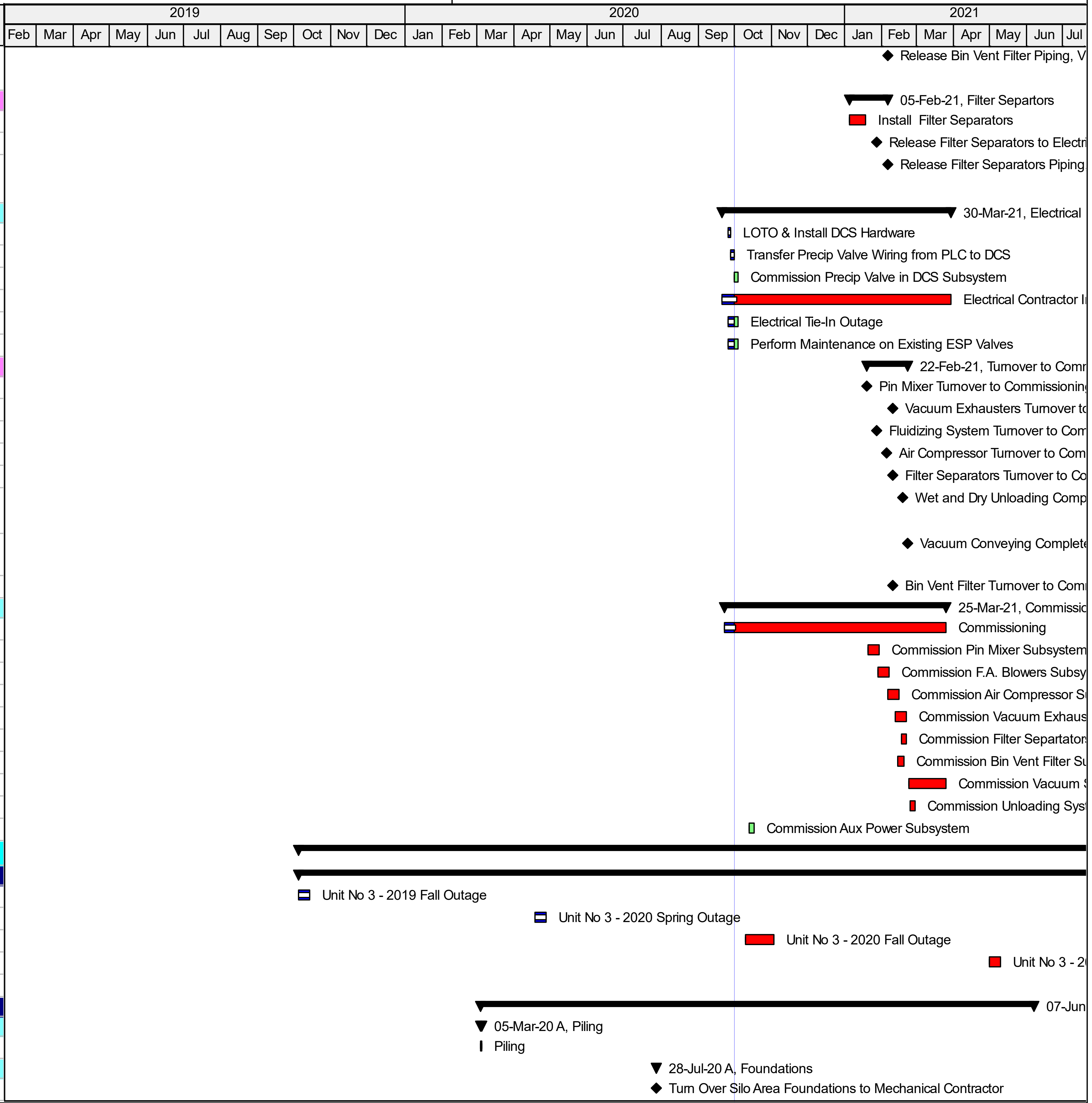
TASK filter: All Activities

Activity ID	Activity Name	Activity % Complete	Start	Finish
Piling			02-Mar-20 A	03-Mar-20 A
C1950	Piling	100%	02-Mar-20 A	03-Mar-20 A
Foundations			20-Apr-20 A	17-Jul-20 A
C2009	Turn Over Silo Area Foundations to Mechanical Contractor	100%		17-Jul-20 A
C2011	Relocate U2 Trench Piping and Conduit	100%	20-Apr-20 A	07-May-20 A
C2099	Unit 2 Trench Crossing Bridge	100%		26-Jun-20 A
Mechanical			13-Jul-20 A	25-Mar-21
C2012	Install Unloading Floor Concrete	100%	20-Jul-20 A	24-Jul-20 A
C2042	Set PDC Building	0%	15-Oct-20	15-Oct-20
Silo			13-Jul-20 A	04-Feb-21
C2008	Erect Silo Support Steel	100%	13-Jul-20 A	24-Jul-20 A
C2024	Install Leave Out Steel and Pour Silo Floor Concrete	100%	14-Sep-20 A	18-Sep-20 A
C2026	Install Silo Rings	6%	28-Sep-20 A	08-Dec-20
C2028	Install Silo Roof	0%	09-Dec-20	22-Dec-20
C2033	Install Silo Roof Enclosure	0%	19-Jan-21	04-Feb-21
Piping			15-Jul-20 A	25-Mar-21
C2010	Install Equipment & Piping	36.42%	15-Jul-20 A	15-Mar-21
C2036	Install Silo Piping	0%	08-Jan-21	18-Feb-21
C2044	Install Utility Racks, Piping to Precipitator	28.36%	07-Aug-20 A	18-Feb-21
C2050	Ash Pipe Tie-In	0%	25-Mar-21	25-Mar-21
Pin Mixer			21-Aug-20 A	13-Dec-20
C2016	Install Pin Mixers	100%	21-Aug-20 A	11-Sep-20 A
C2017	Release Pin Mixer to Electrical Contractor	0%		01-Oct-20
C2021	Install Pin Mixer Piping, Valves, and Instruments	0%	01-Oct-20	11-Nov-20
C2031	Release Pin Mixer Piping, Valves and Instruments to Electrical Contractor	0%		13-Dec-20
Vacuum Exhausters			21-Aug-20 A	04-Dec-20
C2014	Install Vacuum Exhausters	100%	21-Aug-20 A	11-Sep-20 A
C2015	Release Vacuum Exhausters to Electrical Contractor	0%		01-Oct-20
C2041	Install Vacuum Exhausters Piping, Valves, and Instruments	0%	01-Oct-20	11-Nov-20
C2043	Release Vacuum Exhausters Piping, Valves and Instruments to Electrical Contractor	0%		04-Dec-20
Fluidizing Air Blowers			21-Aug-20 A	28-Dec-20
C2018	Install Fluidizing Air Blowers	100%	21-Aug-20 A	11-Sep-20 A
C2019	Release Fluidizing System Equipmennt to Electrical Contractor	0%		01-Oct-20
C2045	Install F.A. Blower Piping, Valves, and Instruments	0%	01-Oct-20	25-Nov-20
C2046	Release Fluidizing System Piping, Valves and Instruments to Electrical Contractor	0%		28-Dec-20
Air Compressor			21-Aug-20 A	18-Dec-20
C2022	Install Air Compressor	100%	21-Aug-20 A	11-Sep-20 A
C2023	Release Air Compressor to Electrical Contractor	0%		01-Oct-20
C2047	Install Air Compressor Piping, Valves, and Instruments	0%	01-Oct-20	25-Nov-20
C2048	Release Air Compressor Piping, Valves and Instruments to Electrical Contractor	0%		18-Dec-20
Bin Vent Filter			05-Jan-21	05-Feb-21
C2034	Install Bin Vent Filter	0%	05-Jan-21	18-Jan-21
C2039	Release Bin Vent Filter to Electrical Contractor	0%		27-Jan-21

Activity ID	Activity Name	Activity % Complete	Start	Finish
C2051	Release Bin Vent Filter Piping, Valves and Instruments to Electrical Contractor	0%		05-Feb-21
Filter Separtors			05-Jan-21	05-Feb-21
C2032	Install Filter Separators	0%	05-Jan-21	18-Jan-21
C2037	Release Filter Separators to Electrical Contractor	0%		27-Jan-21
C2049	Release Filter Separators Piping, Valves and Instruments to Electrical Contractor	0%		05-Feb-21
Electrical			21-Sep-20 A	30-Mar-21
C2025	LOTO & Install DCS Hardware	100%	26-Sep-20 A	27-Sep-20 A
C2027	Transfer Precip Valve Wiring from PLC to DCS	100%	28-Sep-20 A	30-Sep-20 A
C2029	Commission Precip Valve in DCS Subsystem	0%	01-Oct-20	04-Oct-20
C2030	Electrical Contractor Install Electrical	6.06%	21-Sep-20 A	30-Mar-21
C2035	Electrical Tie-In Outage	55.56%	26-Sep-20 A	04-Oct-20
C2080	Perform Maintenance on Existing ESP Valves	55.56%	26-Sep-20 A	04-Oct-20
Turnover to Commissioning			19-Jan-21	22-Feb-21
C2031C	Pin Mixer Turnover to Commissioning	0%		19-Jan-21
C2043C	Vacuum Exhausters Turnover to Commissioning	0%		09-Feb-21
C2046C	Fluidizing System Turnover to Commissioning	0%		27-Jan-21
C2048C	Air Compressor Turnover to Commissioning	0%		04-Feb-21
C2049C	Filter Separators Turnover to Commissioning	0%		09-Feb-21
C2050A	Wet and Dry Unloading Complete System Turnover to Commissioning	0%		17-Feb-21
C2050B	Vacuum Conveying Complete System Turnover to Commissioning	0%		22-Feb-21
C2051C	Bin Vent Filter Turnover to Commissioning	0%		09-Feb-21
Commissioning			23-Sep-20 A	25-Mar-21
C2040	Commissioning	4.72%	23-Sep-20 A	25-Mar-21
C2052	Commission Pin Mixer Subsystem	0%	20-Jan-21	29-Jan-21
C2054	Commission F.A. Blowers Subsystem	0%	28-Jan-21	06-Feb-21
C2056	Commission Air Compressor Subsystem	0%	05-Feb-21	14-Feb-21
C2058	Commission Vacuum Exhausters Subsystem	0%	12-Feb-21	21-Feb-21
C2060	Commission Filter Separtators Subsystem	0%	17-Feb-21	21-Feb-21
C2062	Commission Bin Vent Filter Subsystem	0%	14-Feb-21	18-Feb-21
C2064	Commission Vacuum System	0%	23-Feb-21	25-Mar-21
C2066	Commission Unloading System	0%	24-Feb-21	28-Feb-21
C2090	Commission Aux Power Subsystem	0%	13-Oct-20	17-Oct-20
Unit 3			05-Oct-19 A	04-Oct-21
Unit 3 - Outages			05-Oct-19 A	04-Oct-21
OUTU3.001	Unit No 3 - 2019 Fall Outage	100%	05-Oct-19 A	14-Oct-19 A
OUTU3.002	Unit No 3 - 2020 Spring Outage	100%	18-Apr-20 A	27-Apr-20 A
OUTU3.003	Unit No 3 - 2020 Fall Outage	0%	10-Oct-20*	02-Nov-20*
OUTU3.004	Unit No 3 - 2021 Spring Outage	0%	01-May-21*	10-May-21*
OUTU3.005	Unit No 3 - 2021 Fall Outage	0%	25-Sep-21*	04-Oct-21*
Unit 3 - Construction			04-Mar-20 A	07-Jun-21
Piling			04-Mar-20 A	05-Mar-20 A
C2950	Piling	100%	04-Mar-20 A	05-Mar-20 A
Foundations			28-Jul-20 A	28-Jul-20 A
C3009	Turn Over Silo Area Foundations to Mechanical Contractor	100%		28-Jul-20 A



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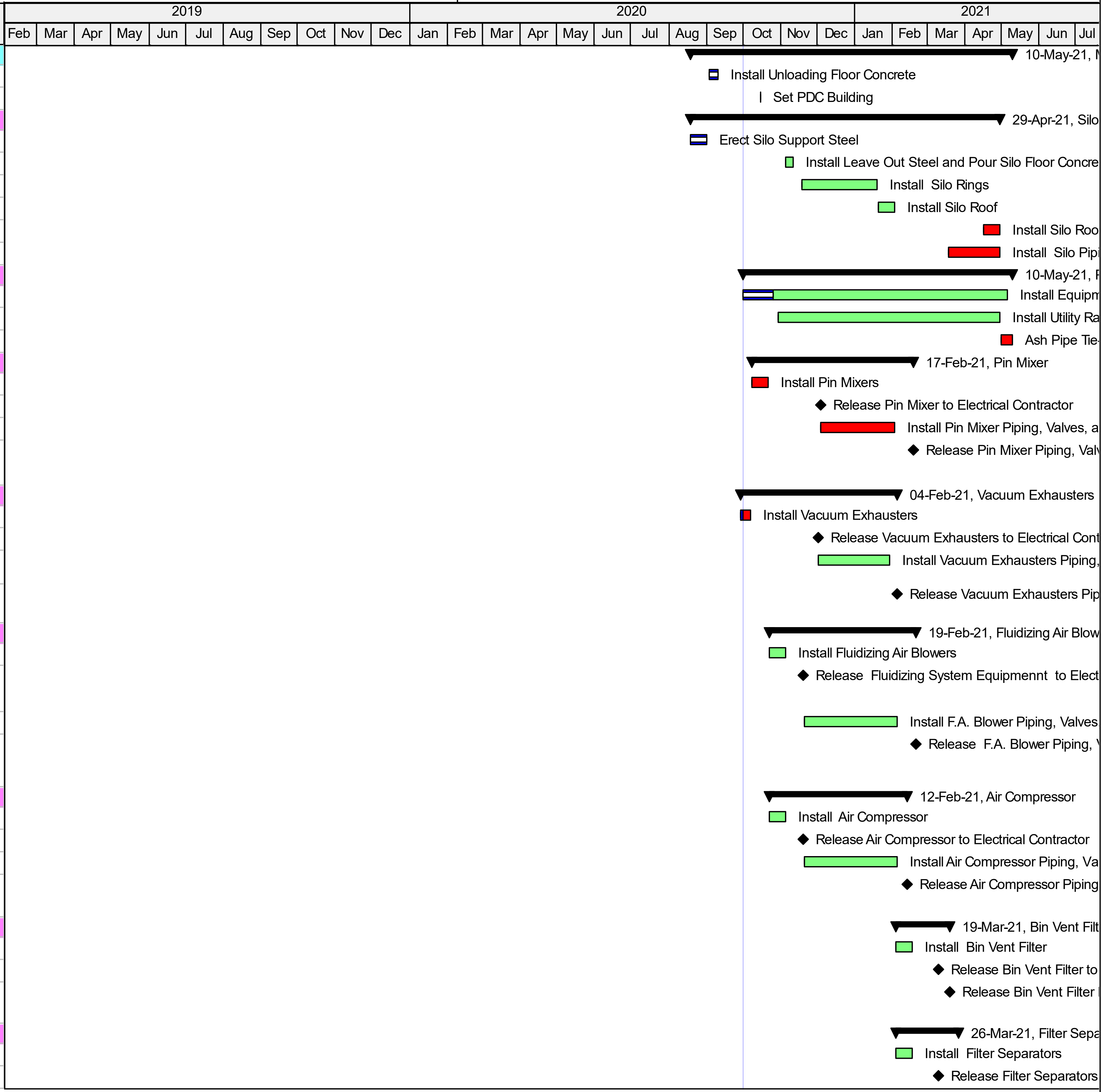
TASK filter: All Activities

Activity ID	Activity Name	Activity % Complete	Start	Finish
Mechanical			19-Aug-20 A	10-May-21
C3012	Install Unloading Floor Concrete	100%	03-Sep-20 A	10-Sep-20 A
C3042	Set PDC Building	0%	15-Oct-20	15-Oct-20
Silo			19-Aug-20 A	29-Apr-21
C3008	Erect Silo Support Steel	100%	19-Aug-20 A	01-Sep-20 A
C3024	Install Leave Out Steel and Pour Silo Floor Concrete	0%	05-Nov-20	11-Nov-20
C3026	Install Silo Rings	0%	18-Nov-20	19-Jan-21
C3028	Install Silo Roof	0%	20-Jan-21	02-Feb-21
C3033	Install Silo Roof Enclosure	0%	16-Apr-21	29-Apr-21
C3036	Install Silo Piping	0%	19-Mar-21	29-Apr-21
Piping			01-Oct-20 A	10-May-21
C3010	Install Equipment & Piping	11.26%	01-Oct-20 A	06-May-21
C3044	Install Utility Racks, Piping to Precipitator	0%	30-Oct-20	29-Apr-21
C3050	Ash Pipe Tie-In	0%	01-May-21	10-May-21
Pin Mixer			08-Oct-20	17-Feb-21
C3016	Install Pin Mixers	0%	08-Oct-20	21-Oct-20
C3017	Release Pin Mixer to Electrical Contractor	0%		03-Dec-20
C3021	Install Pin Mixer Piping, Valves, and Instruments	0%	04-Dec-20	02-Feb-21
C3031	Release Pin Mixer Piping, Valves and Instruments to Electrical Contractor	0%		17-Feb-21
Vacuum Exhausters			29-Sep-20 A	04-Feb-21
C3014	Install Vacuum Exhausters	0%	29-Sep-20 A	07-Oct-20
C3015	Release Vacuum Exhausters to Electrical Contractor	0%		01-Dec-20
C3041	Install Vacuum Exhausters Piping, Valves, and Instruments	0%	02-Dec-20	29-Jan-21
C3043	Release Vacuum Exhausters Piping, Valves and Instruments to Electrical Contractor	0%		04-Feb-21
Fluidizing Air Blowers			22-Oct-20	19-Feb-21
C3018	Install Fluidizing Air Blowers	0%	22-Oct-20	04-Nov-20
C3019	Release Fluidizing System Equipmennt to Electrical Contractor	0%		19-Nov-20
C3045	Install F.A. Blower Piping, Valves, and Instruments	0%	20-Nov-20	04-Feb-21
C3046	Release F.A. Blower Piping, Valves and Instruments to Electrical Contractor	0%		19-Feb-21
Air Compressor			22-Oct-20	12-Feb-21
C3022	Install Air Compressor	0%	22-Oct-20	04-Nov-20
C3023	Release Air Compressor to Electrical Contractor	0%		19-Nov-20
C3047	Install Air Compressor Piping, Valves, and Instruments	0%	20-Nov-20	04-Feb-21
C3048	Release Air Compressor Piping, Valves and Instruments to Electrical Contractor	0%		12-Feb-21
Bin Vent Filter			03-Feb-21	19-Mar-21
C3034	Install Bin Vent Filter	0%	03-Feb-21	16-Feb-21
C3039	Release Bin Vent Filter to Electrical Contractor	0%		10-Mar-21
C3051	Release Bin Vent Filter Piping, Valves and Instruments to Electrical Contractor	0%		19-Mar-21
Filter Separtors			03-Feb-21	26-Mar-21
C3032	Install Filter Separators	0%	03-Feb-21	16-Feb-21
C3037	Release Filter Separators to Electrical Contractor	0%		10-Mar-21



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TASK filter: All Activities

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 FAR II. This narrative follows and supplements the visual timeline representation of the project schedule provided in Section 2.0.

Section 3.1 presents the engineering and design activities for the balance-of-plant components to support the dry fly ash system and for the dry fly ash system itself. Section 3.2 Section 3.2 discusses the steps required to procure the vacuum-pneumatic conveying system and its auxiliary components and the contracting strategy employed for this project. Finally, Section 3.4 presents the construction activities for this project and the general sequence in which those activities will be executed, ultimately concluding with the commissioning of the new dry fly ash-handling system.

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 FAR II.

3.1 ENGINEERING & DESIGN

The engineering and design phase of the project was divided into two sub-phases: (1) balance-of-plant (BOP) and (2) fly ash system. The design work for these two sub-phases were awarded under two separate contracts, with the latter being a portion of the overall contract for the vacuum-pneumatic conveying system.

3.1.1 BALANCE-OF-PLANT COMPONENTS

Detailed engineering and design of the BOP components for the vacuum-pneumatic conveying system started in March of 2019, shortly after the completion of the dry fly ash conversion study (see Section 1.3.3). This work required coordination between several different engineering disciplines. The following subsections summarize the BOP engineering effort for this project as it pertained to each discipline.

3.1.1.1 GENERAL

The general engineering and design tasks for this project began once the project was initially authorized in March of 2019 and are scheduled to last approximately 15 months. This work primarily includes project planning activities and tasks that do not belong to a specific discipline.

3.1.1.1.1 PROJECT PLANNING

The initial project planning and engineering tasks began at the authorization of the project in March 2019 and were completed a few months thereafter. These activities included the development of the project design basis, the creation of a three-dimensional computer model to aid in engineering and design tasks, and updating the project cost estimate per changes made to the design since the conceptual design study. The project design basis, which provides the design requirements of the project and design inputs for the engineering and design work, was drafted within two months of the project starting and was finalized at the end of July 2019. Meanwhile, the plant and equipment modeling work continued through the engineering and design work, with updates to the model being made in accordance with the progress made in the detailed engineering and design work. The modeling was substantially completed in early 2020 once most of the civil, structural, and mechanical design work was finished.

3.1.1.1.2 PERMITTING SUPPORT

The engineering tasks to support the Cardinal Operating Company's air emissions permit application also started once the project was initiated in March of 2019. Specifically, an air emissions plan and calculation were prepared to be included in the air emissions permit application submitted to the Ohio EPA. These documents took three months to complete, which enabled the Cardinal Operating Company to submit the corresponding permit application at the end of June 2019. Permitting support was provided as needed throughout the agency's review of the application. The air emissions permit for the project was ultimately approved at the end of August 2019, approximately two months after the application was submitted to the agency.

3.1.1.1.3 PROJECT CLOSE-OUT

The remaining general engineering and design activities, primarily construction support and drawing closeout, will be performed during and after construction of the new vacuum-pneumatic handling system and auxiliary components. Specifically, construction support is scheduled to last throughout construction at all three units (early 2020 at Unit 1 through spring 2021 at Unit 3), while drawing close-out will not start until construction is complete and the fly ash system vendor is optimizing and tuning the system for Cardinal's use. Both tasks will be completed by the day after start-up and implementation of the new dry fly ash system on June 7, 2021.

3.1.1.2 CIVIL & STRUCTURAL

The engineering and design work for the civil and structural aspects of the project began once the project was authorized in March of 2019. This discipline's work was performed concurrently with the design and engineering work performed by the other disciplines and included preparing and/or designing:

- Civil sitework and grading plans;
- Roads and paving for the updated site layout;
- Foundations for:
    - Fly ash storage silos;
    - PDCs and transformers,

  - Utility racks supporting new piping, cable tray, *etc*.,
  - Exhauster blowers, and
  - Miscellaneous equipment pads and pipe supports;
- Structural steel for:
  - Utility racks supporting new piping, cable tray, *etc*.,
  - Shelters for the exhauster blowers, and
  - Miscellaneous stairs, platforms, and walkways.

In addition to the preceding engineering work, a geotechnical evaluation was performed to assess the soil boring data and laboratory test results received from the contractor that performed the subsurface investigation for the project. This data ultimately provided design inputs for the project's various foundations. Given its nature, this work was performed concurrently with the subsurface investigation at the site and concluded when the contractor issued its final report.

Due to the design inputs required from the subsurface investigation (see Section 3.3.1), fly ash system vendor, and other engineering disciplines, most of the detailed civil and structural engineering and design work started in the summer or fall of 2019. The early work primarily entailed developing initial layouts for the pipe racks supporting new piping for the dry fly ash system and the site in general. Each detailed design task was generally completed within a few months after it was started, with most design tasks being substantially complete by December 2019. Notably, the pile designs for the ash storage silo foundations were completed about a month earlier to facilitate earlier procurement of and ultimately an earlier start date for the contractor installing the piles relative to the other contractions hired to install the dry fly ash system and its ancillary components.

Issuance of construction drawings was generally scheduled to align with the awarding of the contract for which a given scope of work was included. The piling drawings were issued first in late January 2020 shortly after the piling contractor was selected. This enabled the piling contractor to mobilize to the site and start installing piles prior to the other construction work in 2020. The remaining foundation and civil work drawings were issued approximately six weeks later, shortly after the civil/substructure contractor was selected in early March 2020. Meanwhile, structural steel drawings for the pipe racks were released for fabrication in late February 2020 as the Cardinal Operating Company was conforming the structural steel fabrication contract with the designated fabricator.

Overall, the civil and structural engineering and design work was completed within about a year after the project began (*i.e.*, March 2019 to March 2020).

3.1.1.3 MECHANICAL

Like the civil and structural engineering design scope, the mechanical engineering and design work began once the project was authorized in March 2019. This discipline's work was performed concurrently with the design and engineering work performed by the other disciplines and included preparing and/or designing:

- General arrangement drawings;
- Equipment location drawings;
- Service water, fly ash, and underground piping, including:
    - Pipe and instrumentation diagrams (P&IDs),
    - Isometrics, and
    - Supports, including auxiliary steel; and
- Demolition work for existing electrostatic precipitator piping.

The early mechanical engineering work took approximately four months to complete (March 2019 through July 2019) and included preparing general arrangements of the project site and, similar to the structural and civil work, developing initial layouts for equipment, piping, and auxiliary steel. P&IDs corresponding to the proposed layouts were then prepared and subsequently issued to the Cardinal Operating Company for review.

As the Cardinal Operating Company was reviewing P&IDs, the underground, service water, and ash piping for the project were routed and analyzed. Upon establishing an initial route and during the initial analysis, preliminary pipe supports were located and designed in coordination with the structural and auxiliary steel design. Pipe analyses and isometrics were mostly completed by early November 2019 when the underground work was issued for bids from potential contractors for the substructure work. Demolition drawings for existing piping to be removed from the station's ESPs were also prepared in the fall of 2019. Finally, equipment location drawings were started in October 2019, shortly after the fly ash system vendor received a full notice to proceed with its design.

By December of 2019, the final analyses for the ash and service water piping were completed. The corresponding pipe support drawings and bills of materials were substantially completed about a month later, as were construction drawings for the pipe demolition work in the ESPs. At this time, equipment locations drawings had also been prepared and were ready to be issued. These mechanical drawings, in addition to those previously issued, were ultimately incorporated into the bid package issued to potential contractors that would be responsible for installing the project's mechanical equipment ("mechanical general work contractor").

Issuance of construction drawings was generally scheduled to align with the awarding of the mechanical general work contract in late April 2020. Drawings and design documents issued at that time included the project's P&IDs, service water and ash piping isometrics, and pipe supports.

Overall, the mechanical engineering and design work was completed about 13 months after the project began (*i.e.*, March 2019 to April 2020). As-built drawings are also scheduled to be prepared near the end of construction in the spring of 2021 and are anticipated to take approximately one month to complete.

3.1.1.4 ELECTRICAL

Like the previous disciplines, the electrical engineering and design work began once the project was authorized in March 2019. This discipline's work was performed concurrently with the design and engineering work performed by the other disciplines and included preparing and/or designing:

- Project electrical load list,
- Single line and phasing diagrams,
- Auxiliary power and arc flash studies,
- Grounding,
- Underground duct banks,
- Lighting,
- Electrical installation drawings, and
- Cable and cable tray routing,
- Updating the project electrical load list as necessary,
- Performing relay setting calculations, and
- Preparing electrical schematic diagrams, wiring drawings, and cable tabulations.

Given that most of the electrical work for the project will not be installed until relatively late in the construction schedule, the corresponding detailed electrical engineering and design work was not scheduled to start until January 2020. Notable exceptions to this were the initial set up of the electrical load list, key diagrams and electrical load drawings, all of which were done concurrently with the initial set up work by the other engineering disciplines. Single line diagrams were also developed throughout the summer of 2019 to conceptualize the overall auxiliary power design. Finally, electrical-related work within the substructure scope of work was also started in the summer of 2019 to be included in the bid package and subsequent construction issue in November 2019 and March 2020, respectively. This work included the designs for electrical grounding and the underground ductbanks.

In January 2020, work began on preparing the detailed wiring diagrams (*i.e.*, three-line diagrams) and the lighting design for the project. Cable tray routes were also starting to be established at this time. Approximately two months into this design work, the detailed design work for the electrical installation drawings also started. This work was substantially completed by mid-April 2020 and was incorporated into the bid packaged issued to potential contractors that would be responsible for installing the project's electrical equipment ("electrical general work contractor").

Issuance of construction drawings was generally scheduled to align with the awarding of the electrical general work contract in July 2020. From February to July 2020, schematic diagrams and cable tabulations were prepared for the fly ash and auxiliary power systems, and the key diagrams, three-line diagrams, lighting design, and cable tray design were all finalized and issued for construction. Shortly thereafter, wiring drawings and relay setting calculations were also issued (late-July and mid-August 2020, respectively).

Overall, the electrical engineering and design work is scheduled to be completed about 20 months after the project began (*i.e.*, March 2019 to November 2020). As-built electrical drawings and an update to the existing arc flash study are both scheduled to be completed by the beginning of November 2020.

3.1.1.5 INSTRUMENTATION AND CONTROLS (I&C)

The engineering and design work for the project's instrumentation and controls (I&C) began in May 2019 after the project design basis had been drafted and issued to the Cardinal Operating Company for review. The work was divided into initial work and final work. Like the other engineering disciplines on this project, the I&C engineering and design work was performed concurrently with the other engineering and design work and included preparing and/or designing:

- DCS network architecture drawings;
- Control logic; and
- Instrument lists, data sheets, installation details, and location drawings.

Once the project design basis was drafted in mid-May 2019, preparation of the DCS network architecture drawings commenced. These drawings were finalized and issued for use approximately three months later.

Following the issuance of P&IDs for design by the mechanical discipline in late October 2019, the BOP instrument list, data sheets, and installation details were started. These documents took approximately six weeks to finalize.

Finally, the BOP control logic and instrument location drawings were started once the mechanical discipline issued the equipment location drawings for use in early January 2020. The BOP control logic was prepared within a week and a half and subsequently issued to the DCS vendor for use. Meanwhile, the BOP instrument location drawings were completed approximately three months later in late March 2020 and issued for construction to the vendor performing the DCS modifications.

Overall, the I&C engineering and design work is scheduled to be completed about 25 months after the discipline's work started in May 2019. While most of the engineering and design work has been substantially completed, as-built I&C drawings still need to be prepared. These as-built drawings will not be prepared until the fly ash system vendor has started tuning and optimizing the system for Cardinal in May 2021.

3.1.2 VACUUM-PNEUMATIC CONVEYING SYSTEM

Once the project was authorized in March of 2019, the Cardinal Operating Company began preparing a technical specification detailing the requirements for designing, furnishing, manufacturing, and delivering the vacuum-pneumatic conveying system for/to Cardinal. One month later, the Cardinal Operating Company started soliciting bids from potential vendors. The bidding period last approximately one month, and the Cardinal Operating Company took six weeks to evaluate the bids, select a vendor, and enter into commercial negotiations with the vendor. During commercial negotiations, the technical specification issued with the bid package was also conformed in accordance with the forthcoming contract requirements.

The vacuum-pneumatic conveying system contract was awarded in two phases. The first phase, which was awarded in early August 2019, was for the engineering and design scope of work. This limited notice-to-proceed (LNTP) also allowed the fly ash system vendor to start the project planning process. Because the fly ash storage silos would be the first pieces of equipment of the new dry fly ash-handling system to be installed on site, this LNTP also included the fabrication and delivery of the silos. The fly ash system vendor was awarded the full contract about two months later in later September 2019, which included the full fabrication and delivery scope of work.

Like the engineering and design work for the BOP components of the project, the fly ash system work required coordination between several different engineering disciplines. Accordingly, the following subsections summarize the engineering and design work performed by the dry fly ash system vendor as it pertained to each discipline.

3.1.2.1 GENERAL

The general engineering and design tasks for the vacuum-pneumatic conveying system began once the vendor received its LNTP from the Cardinal Operating Company in early August 2019. Like the general BOP engineering and design work, this work primarily includes planning level activities and tasks that do not belong to a specific discipline.

3.1.2.1.1 PROJECT PLANNING

Upon receiving a LNTP, the dry fly ash system vendor began developing a plan to execute the project. Project planning activities included compiling a master document list, documenting the dry fly ash system design criteria, and preparing schedules for drawing submittals and for executing the overall project. These tasks were all prepared concurrently with each other and were finalized by the end of August 2019.

3.1.2.1.2 QUALITY ASSURANCE / QUALITY CONTROL

Concurrent with completing its initial equipment and component lists, the fly ash system vendor prepared quality assurance/quality control (QA/QC) manuals and safety manuals for the system equipment. These manuals also included testing and acceptance procedures to be performed at the end of the project during the commissioning, optimization, and tuning phases. Corresponding inspection and test plans were also prepared. These QA/QC and commissioning planning documents took approximately three months to prepare and were all submitted to the Cardinal Operating Company at the end of October 2019.

3.1.2.1.3 CONSTRUCTION AND OPERATION AND MAINTENANCE (O&M) SUPPORT

To support the contractors installing its dry fly ash system design at Cardinal, the fly ash system vendor prepared a terminal point table; erection drawings, instructions, and procedures; and a list of special tools required for erection, maintenance, and repair. In addition, the vendor prepared operation and maintenance (O&M) manuals for the system and its components. These documents were prepared and submitted to the Cardinal Operating Company by the time the mechanical general work contractor began mobilizing the site to start installing the fly ash storage silo at Unit 1 (late April 2020).

3.1.2.2 MECHANICAL

The fly ash system vendor began performing the mechanical engineering and design work once the vendor was given a LNTP from the Cardinal Operating Company in early August 2019. This discipline’s work was performed concurrently with the design and engineering work performed by the other disciplines and included preparing, reviewing, and/or designing:

- General arrangement drawings;
- Process flow diagrams;
- P&IDs;
- Mechanical equipment, valve, and line lists;
- Equipment supplier drawings;
- Piping arrangement drawings;
- Exhauster physical certified drawings; and
- Mechanical equipment data sheets.

At the onset of the dry fly ash system design, the vendor prepared general arrangement drawings, key process flow diagrams, and P&IDs for the system. These initial design documents were prepared concurrently and submitted to the Cardinal Operating Company for review within six weeks of receiving the

LNTP. The process flow diagrams were finalized approximately one month later in mid-October 2019. Shortly thereafter, the vendor submitted the mechanical equipment, valve, and line lists.

Throughout the fall and winter of 2019, the fly ash system vendor analyzed and designed the piping for the fly ash storage silo at each unit, which included conveyor piping, vacuum transport air piping, water piping, silo fluidizing piping, and compressed air piping. This engineering and design work was substantially completed in the first quarter of 2020, after which the general arrangement and piping arrangement drawings were finalized. By the beginning of March of 2020, approximately seven months after receiving the LNTP, the mechanical engineering and design work for the dry fly ash system piping was substantially completed.

3.1.2.3 ELECTRICAL

The fly ash system vendor also started the electrical engineering and design work when the vendor received the LNTP from the Cardinal Operating Company in early August 2019. This discipline’s work was performed concurrently with the design and engineering work performed by the other disciplines and included preparing and/or reviewing:

- Electrical load lists,
- Single line diagrams,
- Motor data sheets,
- Schematic and wiring diagrams,
- Motor curves, and
- Electrical equipment data sheets.

The vendor first prepared the electrical loads required for to power the system and the corresponding single line diagrams to conceptualize the system’s auxiliary power design. The vendor completed these design documents less than two months after receiving the LNTP and subsequently submitted them to the Cardinal Operating Company for review. Like the mechanical arrangements and diagrams, these electrical design inputs were finalized about one month later. Finally, motor data sheets were prepared and submitted by the end of November 2019.

Through the fall and winter of 2019 and extending into the first quarter of 2020, the vendor prepared the schematic and wiring diagrams for the electrical design of the dry fly ash system. The initial sheets were submitted to the Cardinal Operating Company to review in early January 2020 and were finalized by the end of March 2020. Around the same time, the vendor finalized the performance curves for the system’s motors as well as the electrical equipment data sheets. Thus, the vendor’s electrical engineering and design work was substantially completed by the end of March 2020.

3.1.2.4 INSTRUMENTATION AND CONTROLS (I&C)

The I&C work for the dry fly ash system commenced right after the initial mechanical and electrical design documents were prepared and submitted for review in September 2020. This work was performed concurrently with the design and engineering work performed by the other disciplines and included preparing, reviewing, and/or designing:

- Instrument lists,
- Input and output lists,
- Instrument data sheets,
- Instrument installation details and location drawings,
- Functional descriptions,
- Control logic diagrams, and
- DCS graphic screens.

After preparing the initial P&IDs and process flow diagrams, the vendor began preparing a list of the instruments required for the system as well as input and output data. These initial design documents were submitted to the Cardinal Operating Company for review in October 2019, and the instrument list was finalized in early November 2019.

Concurrent with the mechanical and electrical engineering work, the vendor performed the I&C engineering work throughout the fall and winter of 2019. During this time, the vendor prepared a functional description for the system, control logic diagrams, and sketches for the DCS graphic screens. These documents were submitted for review in March 2020 as the vendor was finalizing the mechanical and electrical designs. Approximately three months later, in mid-June of 2020, the I&C engineering and design work was substantially completed.

3.1.2.5 STRUCTURAL

The structural engineering and design of the fly ash storage silo and corresponding stair tower also started in early August 2019 with the other engineering and design work and was performed concurrently with the other engineering disciplines. In addition to the design of the silo structure and stair tower, this work included preparing, reviewing, and/or designing pipe fittings and anchor rod setting plans for the silo structure.

To support the engineering and design of the silo foundation, the initial structural engineering and design work focused on preparing preliminary design drawings and loading diagrams. These preliminary design documents were submitted in September 2019. To support the issuance of the piling and substructure bid packages in November of 2019, the vendor calculated not-to-exceed loads to be used as inputs in the foundation design.

Final engineering and design work for the storage silo and stair tower structure continued through the first quarter of 2020. Like the mechanical and electrical engineering and design work, the structural engineering and design for the storage silo and stair tower structure were substantially completed by mid-March 2020. At this time, the vendor submitted final structural design drawings which included final structural steel member sizes, structural steel connection information, base plate information, and anchor rod setting plans.

3.2 PERMITTING

In order to install the new dry fly ash-handling system at Cardinal, the Cardinal Operating Company needed to obtain an air pollution permit-to-install (PTI) from the Ohio EPA. After drafting the project design basis in May of 2019, the Cardinal Operating Company began preparing the necessary PTI application forms and assembling relevant input data (*e.g.*, pin mixer ash moisture content, fly ash throughput, anticipated truck traffic to FAR I Landfill). This work was performed concurrently with the air emissions plan and calculation in the engineering and design phase of the project, both of which were included in the PTI application.

The air pollution PTI application was submitted to the Ohio EPA in late June 2019, about one month after the permitting support work started. Approximately two months later, in late August 2019, the Ohio EPA issued the final PTI authorizing the Cardinal Operating Company to construct and operate the new dry fly ash-handling system at Cardinal.

3.3 PROCUREMENT

The procurement phase of the project schedule was generally divided amongst the scopes of work for the different engineering disciplines involved in this project. However, the procurement work for this project was generally executed in the following three subphases:

1. Site Investigations
2. Contractor Selection
3. Equipment Fabrication and Delivery

3.3.1 SITE INVESTIGATIONS

Two investigations were performed at the project site in the fall of 2019 to obtain geotechnical and underground utility data. This data was required for necessary design inputs for the foundation and substructure designs, civil site work, and underground utility routing. Two contractors were procured to perform these site investigations: a geotechnical consultant to perform the subsurface investigation and a surveyor to perform the underground surveys.

The procurement schedules for both contractors were generally concurrent with each other. Technical specifications for both contracts were prepared once the project was initiated in March of 2019 and took approximately one month to prepare, review, and issue to the respective bidders. The bid periods for both contracts concluded at the end of May 2019.

3.3.1.1 SUBSURFACE INVESTIGATION

Given the need to obtain geotechnical data to support the foundation design work being performed in the fall of 2019, the subsurface investigation contract was awarded first. This contract was awarded at the end of July 2019 approximately two months after the bid period ended during which the Cardinal Operating Company evaluated the bids, selected a contractor, negotiated the commercial terms and conditions, and finally conformed the technical specification.

Upon being awarded the contract, the geotechnical contractor began mobilizing its crew, drill rigs, *etc*. to the project site, which took approximately one month. Once fully mobilized, the contractor began drilling soil borings and collecting soil samples for laboratory testing. Throughout the field and laboratory work, the contractor compiled the requested geotechnical data into a report which was issued in mid-September 2019. Afterwards, the geotechnical data was evaluated and incorporated into the foundation and subsurface designs (see Section 3.1.1).

3.3.1.2 UNDERGROUND SURVEY

While going through the process of awarding the subsurface investigation contract, the Cardinal Operating Company was also evaluating the bids received for the underground survey work. Commercial negotiations with the selected contractor were initiated just before the geotechnical contract was awarded and continued through the end of September 2019. The underground survey contract was then awarded approximately two weeks later in mid-October 2019.

The surveyor mobilized to the project site within three weeks after being awarded the contract. In addition to mapping underground utilities, the surveyor also prepared some topographic maps of the project site. This data was ultimately incorporated into the civil and substructure designs and provided to the substructure contractor for information. Accordingly, the surveys were performed throughout the engineering and design phase in the fall of 2019 and were finalized in mid-February 2020, just before the substructure contract was awarded in early March 2020.

3.3.2 CONTRACTOR SELECTION

The Cardinal Operating Company opted to hire four different contractors for the dry fly ash conversion project at Cardinal, each corresponding to a different phase of construction. As outlined in Section 3.4, construction was divided into the following four principal phases:

1. Piling
2. Foundations (i.e., Substructures)

3. Mechanical General Work
4. Electrical General Work

In addition to the four preceding installation contractors, the Cardinal Operating Company also hired a testing and inspection agency, a structural steel fabricator, a vendor for the electric PDC building and transformers, and a vendor for the DCS modifications.

The following subsections provide detailed narratives of the selection process for each of the preceding contractors and vendors and their respective timelines.

3.3.2.1 INSTALLATION CONTRACTORS

3.3.2.1.1 PILING WORK

Since the piles under the new fly ash storage silos would need to be installed before the other substructure elements in the area, the first installation contract that the Cardinal Operating Company awarded for the dry fly ash conversion project was that for the piling work. As previously stated in Section 3.1.1, the piling engineering and design work was mostly completed by November of 2019, and shortly thereafter the work was issued for bids from prospective piling contractors. Prior to issuing the bid package, the corresponding technical specification was prepared simultaneously with the piling design and took approximately two months to prepare, review, and finalize (September 2019 to November 2019).

The bid period for the piling work lasted about a month, after which the Cardinal Operating Company began evaluating the bids. By mid-December of 2019, the Cardinal Operating Company had selected a contractor and entered into commercial negotiations. Following negotiations and conforming of the technical specification for the contract, the Cardinal Operating Company awarded the piling contract in mid-January 2020, approximately six weeks after the corresponding bid period had ended.

Within two weeks after being awarded the contract, the piling contractor submitted several documents to the Cardinal Operating Company, including its plan for installing the piles required for the project (equipment, sequence, *etc*.), grout mix design, shop drawings for the reinforcing steel, and pile testing criteria. These documents were reviewed and subsequently approved prior to the first pile being installed in January of 2020.

3.3.2.1.2 SUBSTRUCTURE WORK

Because the storage silo foundation work could start after the piles had been installed, the second contract the Cardinal Operating Company awarded for this project was that for the substructure work. Given that the foundation engineering and design work was performed concurrently with the piling engineering and design, the substructure package was issued for bids about a month later (early December 2019). The technical specification for the work was started in mid-May of 2019 after the project design basis was drafted and much of the initial project layout had been completed (including preliminary general arrangement drawings). Preparation of the specification continued through the summer and fall of 2019 concurrent with the corresponding engineering and design work.

Like the piling contract, the bid period for the substructure contract lasted about a month. The Cardinal Operating Company then spent January and February of 2019 evaluating the bids, selecting a contractor, entering into negotiations with the selected contractor, and conforming the technical specification with the contract. The substructure contract was ultimately awarded in early March 2020. This contract was awarded just as the piling work was being finished at Unit 1, so the substructure contractor was able to immediately mobilize to the Unit 1 area and start the foundation work for that unit's vacuum-pneumatic conveying system.

3.3.2.1.3 MECHANICAL GENERAL WORK

The third contract issued by the Cardinal Operating Company for the dry fly ash conversion project covered most of the aboveground installation work except for the electrical equipment and components to be installed later by the electrical general work contractor. This contract covered demolition of existing site structures or systems necessary to install the new dry fly ash system, installation of the fly ash storage silos and dry fly ash-handling equipment furnished by the fly ash system vendor, installation of BOP piping and supports, and erection of BOP structural steel. Accordingly, this contract was awarded after the structural and mechanical engineering and design work (both for BOP and for the dry fly ash system) were substantially completed in mid-April 2020.

Preparation of the mechanical general work specification began in December of 2019, just after the bid period for the piling work started. Given the amount of engineering and design work already completed to that point, the corresponding specification was prepared within a month, and the bid package was issued in early January 2020. Based on the large scope of work for this contract relative to the other contracts issued for this project, the bid period lasted until early March 2020, a duration of approximately two months. The Cardinal Operating Company then spent six weeks reviewing the bids it received for the work, selecting a contractor, and entering into commercial negotiations with that contractor. Shortly after concluding commercial negotiations, the technical specification was conformed in accordance with the contract. The mechanical general work contract was ultimately awarded at the end of April 2020, which allowed the contractor to start mobilizing to the site in May of 2020.

3.3.2.1.4 ELECTRICAL GENERAL WORK

Since the electrical equipment and components would not need to be installed until later in the construction schedule, the Cardinal Operating Company awarded the electrical general work contract last of the four installation contracts. The scope of this contract included furnishing, installing, and/or testing, multi-voltage switchgear modifications to provide power to the fly ash storage silo area; DCS hardware in the control system and in the PDCs; all power, grounding, instrument and control cables to and from equipment in the fly ash storage silo area; all conduit and raceway; and all lighting, receptacles, and lighting protection in the fly ash storage silo area.

Preparation of the electrical general work specification began in early March of 2020, just as the grounding and underground ductbank designs were being issued for construction by the substructure contractor. Given the scope of work involved relative to the other three installation contracts, this specification took about six weeks to prepare and was issued in a bid package to prospective contractors in mid-April 2020. The bid period also lasted approximately six weeks, after which the Cardinal Operating Company began evaluating bids. The bid evaluation, commercial negation, and specification conformance period for this specification ultimately took about a month to complete, and the electrical general work contract was awarded in early July 2020.

3.3.2.2 VENDORS/SUPPLIERS

3.3.2.2.1 CIVIL WORKS TESTING AND INSPECTION

For this project, the Cardinal Operating Company hired an independent contractor to inspect and, where necessary, test the civil work performed by the installation contractors. This scope of work included testing and inspecting the following civil engineering-related works: concrete, earthwork, aggregate surfacing, and road pavement.

The technical specification for this work was prepared concurrently with the civil and structural engineering and design work during the fall of 2019 and was issued for bids from prospective testing and inspection agencies in mid-October 2019 (after the piling work and before the substructure work). The bid period lasted approximately three weeks, after which the Cardinal Operating Company evaluated the bids. A testing and inspection contractor was selected by early December 2019, after which commercial negotiations began. Approximately one month later, in mid-January of 2020, the testing and inspection specification was conformed and the contract was awarded. The timing of this contract was such that the testing and inspection contractor could mobilize to the project site by the time the substructure contractor was hired and had started mobilizing to the site (early March 2020).

3.3.2.2.2 STRUCTURAL STEEL FABRICATION

While the mechanical general work contractor would be responsible for erecting the structural steel, the Cardinal Operating Company hired a separate structural steel fabricator to furnish the structural steel needed for the project. This scope of work included furnishing the structural steel required for utility racks for piping, the exhauster blower shelters, access platforms, and stairs. This contract also included various walkway components including grating, handrail, guard plate, ladders, stair treads, and stair stringers.

Preparation of the technical specification for the structural steel fabrication work began in October of 2019, shortly after the steel design work started for the exhauster blower shelters (the utility rack steel had been well underway at this point). The specification was then issued for bids from potential fabricators at the end of November 2019. The bid period lasted approximately three weeks, after which the Cardinal Operating Company started evaluating the bids. A structural steel fabricator was selected by the end of December 2019, after which commercial negotiations began and the specification was conformed. By the beginning of March 2020, the structural steel fabrication contract was awarded. This timeline ultimately provided the fabricator with a four-month window before the structural steel was to be erected for the Unit 1 utility rack (July 2020).

3.3.2.2.3 ELECTRIC PDCS AND TRANSFORMERS

Because the new dry fly ash system equipment installed at Cardinal Units 1, 2, and 3 will add new electrical loads to each unit, new electric power distribution equipment is required. This equipment will be located in a pre-fabricated PDC building installed at each unit. In addition, outdoor step-down transformers are also required to reduce the electrical voltage from the existing equipment to the new equipment. Accordingly, the Cardinal Operating Company hired a vendor to design, manufacture, furnish, test, inspect, and deliver three dry-type transformers, three PDCs, and all auxiliary equipment and components required for the PDCs.

Once the BOP electrical load list had been prepared and reviewed in late May of 2019, the technical specification for the electric PDCs and transformers was started. Just over two months later, in August of 2019, the bid package was issued to prospective vendors. Bidders were given approximately six weeks to submit their bids, which the Cardinal Operating Company began evaluating in mid-September 2019. A vendor was selected in late October 2019, with whom the Cardinal Operating Company began commercial negotiations and conforming the technical specification with the forthcoming contract. The contract was ultimately awarded in late November 2019, after the which the vendor began preparing schematic diagrams, wiring diagrams, and equipment layout and arrangement drawings.

3.3.2.2.4 DCS MODIFICATIONS

The Cardinal Operating Company opted have control and monitoring of the new dry fly ash system be implemented in the station DCS. Thus, the PLC programming and I/O hardware for the new components will be added and integrated into the station DCS. Meanwhile, all existing PLC programming for existing fly ash system equipment remaining in service will be migrated into the station DCS. To execute this work, the Cardinal Operating Company elected to hire a vendor Accordingly, the Cardinal Operating Company hired a vendor to design, procure, fabricate, test, implement, configure, program, deliver, and provide commissioning support for these DCS modifications.

The Cardinal Operating Company began preparing the technical specification for the Cardinal DCS modifications in late July 2019, just after the DCS network drawings were issued for design. Preparation work continued through the preparation of P&IDs, which were issued for design in mid-October 2019. The specification was then finalized in late-November 2019 and issued for bids from prospective vendors. The bid period lasted approximately six weeks, concluding in mid-January 2020. The Cardinal Operating Company then spent approximately six weeks evaluating the bids, selecting a vendor, negotiating the contract with the selected vendor, and conforming the specification with the forthcoming contract requirements. The contract for performing the required DCS modifications was ultimately executed in mid-March 2020.

3.3.3 EQUIPMENT FABRICATION & DELIVERY

The major equipment and materials being fabricated for the dry fly ash conversion project at Cardinal are the equipment and materials for the dry fly ash system itself, structural steel for the utility racks, the PDCs and transformers, and the DCS modifications. The following subsections provide narratives of how these items will be fabricated and delivered to the Cardinal site.

3.3.3.1 FLY ASH SYSTEM

Concurrent with its engineering and design work, the fly ash vendor began procuring the equipment and materials needed for the dry fly ash system. In general, the vendor worked with other third-party vendors to procure and/or fabricate the equipment and piping required for the dry fly ash system consistent with its engineering and design. The procurement process would start with a material release and purchase order submitted to the specific third-party vendor, after which the third-party vendor would submit shop drawings to fly ash system vendor to review and approve. Once approve, the equipment was fabricated, then inspected, and finally shipped to the Cardinal site to be installed by the mechanical general work contractor. In general, this process took approximately six to eight months from material release to delivery at the Cardinal site.

The fly ash system vendor had equipment and material procured in accordance with its forecasted installation sequence. Because the Unit 1 fly ash storage silo, bin vent filter, and vacuum exhausters were scheduled to be installed first, these items were the first to be procured and were included in the LNTP that the Cardinal Operating Company gave to the vendor in early August 2019. Starting in early October 2019, the vendor began placing material orders for the dry unloading chutes and vent fans, fluidizing air system, compressed air system and piping, and the pin mixer for Unit 1. A few weeks later, the filter separators and the balance of the system piping (including valves and supports) were ordered. This procurement sequence facilitated the delivery of each piece of equipment and component to the Cardinal site in advance of when the mechanical general work contractor was scheduled to install it.

All of the equipment and components for the Unit 1 dry fly ash system were delivered to the site between June and July of 2020. Like most of this project, the procurement of the equipment and components for the Unit 2 and 3 dry fly ash systems followed a similar sequence as that for Unit 1 but with staggered starts by about two to four weeks. Consequently, the Unit 2 and 3 dry fly ash system equipment and components were delivered to the project site by mid-August 2020 and mid-September 2020, respectively. Overall, the equipment fabrication and delivery process for the dry fly ash systems at all three units took approximately 13 months to complete following the LNTP issued by the Cardinal Operating Company in August of 2019.

3.3.3.2 STRUCTURAL STEEL

To fabricate the structural steel for the project’s utility racks, exhauster blower shelters, and miscellaneous platforms and stairs, the fabricator first prepared shop drawings based on the structural design drawings. These shop drawings were started in early March 2020 after the fabricator was awarded the contract and approximately two weeks after the corresponding design drawings had been issued for construction. Because construction of the Unit 1 dry fly ash system was scheduled to occur first, the fabricator began preparing the corresponding shop drawings for the structural steel to be erected at Unit 1, followed by the Unit 2 and 3 shop drawings a few weeks later. After the shop drawings were accepted by the Cardinal Operating Company, the fabricator began fabricating the steel components at its shop.

In general, the structural steel for all three units was fabricated in a concurrent fashion with staggered start times based on the anticipated erection date for each unit. The steel for Unit 1 was ultimately delivered to the site at the end of June 2020, approximately one week before it was erected by the mechanical general work contractor. The steel for Units 2 and 3 followed several weeks thereafter, arriving to the project site in mid-July 2020 and early September 2020, respectively.

3.3.3.3 ELECTRIC PDCS & TRANSFORMERS

Upon receiving the contract for the electric PDCs and transformers for the new dry fly ash system in late November 2019, the vendor began preparing the corresponding wiring diagrams, schematic diagrams, and physical drawings. These drawings were submitted to the Cardinal Operating Company for review approximately two to three months later and ultimately finalized by mid-March 2020.

Once the design drawings were approved, the vendor began fabricating the PDC equipment and the transformers. The vendor generally fabricated the equipment for all three units in a continuous fashion with staggered start dates for each unit. Because construction would start at Unit 1 first, the vendor started fabricating the Unit 1 equipment first and then continued with the equipment for Units 2 and 3. The PDC equipment for each unit was completed and delivered to the PDC assembly shop by the end of July 2020.

Following delivery of a unit's PDC equipment to the shop, that unit's PDC was assembled. This process generally took three to four weeks, and the PDCs for all three units were assembled by the end of August 2020. Prior to delivery to the site, each PDC will undergo a factory acceptance test (FAT) to ensure it was built and operates in accordance with the design specifications. Following a successful FAT, the PDC will be shipped to Cardinal for installation at its corresponding unit.

The PDCs and transformers underwent FATs in early September (Unit 1) and early October (Units 2 and 3). Approximately one week after their respective successful FATs, the PDCs and transformers for Units 1, 2, and 3 were delivered to the project site. The Unit 1 set arrived on September 24, 2020, while the PDCs and transformers for Units 2 and 3 arrived on October 14, 2020.

3.3.3.4 DCS HARDWARE & SOFTWARE

After being awarded the DCS modifications contract in late March 2020, the designated vendor began preparing cabinet detail drawings and system layout drawings. These drawings were submitted to the Cardinal Operating Company for review and approval, and they were ultimately finalized by early May 2020. During this time, the DCS modifications vendor was also developing the software for the new system and submitted the proposed control sheets and graphics for the DCS workstations to the Cardinal Operating Company in late May 2020. A design review meeting was then held in mid-June 2020, after which the vendor started finalizing the new DCS software and fabricating the new DCS hardware.

Approximately one month after the design review meeting with the Cardinal Operating Company, the vendor performed an FAT for the new DCS software to ensure it was built and operating in accordance with the design specifications. After performing the FAT and addressing issues identified during the FAT, the vendor shipped the software to the project site in mid-August 2020.

The FAT was performed for the DCS hardware approximately two weeks after the corresponding test for the DCS software. As was done for the DCS software, the vendor then addressed any issues identified in the hardware during the FAT before finally shipping the hardware to the project site. The DCS hardware was delivered to the Cardinal station in late August 2020, approximately one week after the DCS software arrived.

3.4 CONSTRUCTION

Construction of Cardinal's new dry fly ash system commenced in mid-January 2020 when the piling contractor mobilized to the project site. The construction schedule was set up in phases corresponding to the four installation contractors hired to install the various components of the dry fly ash system. For each unit, the piling for the new fly ash storage silo would be installed first, then the foundation work for the silo would commence, then the mechanical installation work would start, and finally the electrical installation work would begin. While the mechanical and electrical installation work were generally performed concurrently at a given unit, the piling and substructure work were performed sequentially prior to the mechanical installation work starting.

Overall, construction was performed concurrently at all three units but with staggered starts. Construction started at Unit 1 first, followed by Unit 2 and then finally Unit 3. The dry fly ash systems for all three units are expected to take approximately 16 months to install, starting at Unit 1 in mid-January 2020 and ending at Unit 3 in mid-May 2021.

3.4.1 WORKER SCHEDULES

Upon mobilizing to the Cardinal site, each contractor's crew generally worked five days per week at eight hours per workday. Holiday and weekend work were and will be kept to a minimum.

3.4.2 PILING

Having been awarded the piling contract in mid-January 2020, the piling contractor mobilized to the project site by the end of January 2020. Upon fully mobilizing to the site, the piling contractor installed test piles and conducted the necessary load tests to qualify the piles specified for the project. After performing successful load tests, the piling contractor started boring holes for the piles the Unit 1 silo site, installed the rebar cage in each hole, and finally cast the piles. The same work was performed at Units 2 and 3 around the same time. Overall, the piling for all three units' new fly ash storage silos was installed by early March 2020, after which the piling contractor demobilized from the project site.

3.4.3 SUBSTRUCTURES / FOUNDATIONS

Upon mobilizing to the project site in March 2020, the substructure contractor started the civil grading work. In addition, since the piling had been installed at all three units by this time, the contractor also started installing the storage silo foundation as well as the foundations for the vacuum exhauster shelter, for the PDC building and transformer, and for the utility racks. The grounding grids, underground piping, and duct banks were also installed at this time.

Like the other construction work for this project, the substructure contractor started installing the foundations and underground utilities at Unit 1 first, followed by Unit 2 and finally by Unit 3. Although the start times were staggered, foundation work was generally ongoing at each unit throughout the spring and summer of 2020. The foundations for Unit 1's dry fly ash system were completed by the end of May 2020, after which the project site was turned over to the mechanical general work contractor. The Unit 2 and 3 foundations were fully installed by the end of July 2020, finishing within two weeks of each other. After turning over the Unit 3 site to the mechanical general work contractor, the substructure contractor demobilized from Cardinal.

3.4.4 MECHANICAL EQUIPMENT INSTALLATION

3.4.4.1 DRY FLY ASH SYSTEM EQUIPMENT & COMPONENTS

Once the foundations are installed at a given unit, the mechanical general work contractor can start installing and erecting the mechanical equipment and components of the dry fly ash system. In general, each system will be installed in accordance with the dry fly ash system vendor's component delivery schedule. Thus, the storage silo and support steel will be erected first since these components will be delivered to the site first. The erection of each storage silo will include the installation of the silo's rings, roof, piping, and roof enclosure, in that order. As the mechanical general work contractor erects each storage silo, the major system components – bin vent filter, vacuum exhausters, silo unloading chutes, vent fans, fluidizing and compressed air systems, pin mixers, and filter separators – will arrive to the project site in approximately two-week intervals. These components will be installed concurrent with the erection of each storage silo. As each component is installed, the mechanical general work contractor will turn the component over to the electrical general work contractor to be tied into the auxiliary power system.

Overall, each unit's storage silo is expected to take approximately six to eight months to erect, depending on the dry fly ash system's components delivery schedule and the time required to install each component.

The mechanical general work contractor mobilized to the project site at Unit 1 in late May 2020, just as the substructure contractor was finishing the foundation work at that unit. A few weeks thereafter, in mid-June 2020, the bin vent filter, vacuum exhausters, and fly ash storage silo (with supporting steel) were delivered to the site by the dry fly ash system vendor. Upon delivery of the silo components, the mechanical general work contractor began erecting the silo on the foundation installed by the substructure contractor. A similar sequence was followed at Units 2 and 3, with the mechanical general work contractor ultimately starting the erection of the fly ash storage silos at those units in late July 2020 and early September 2020, respectively. The equipment and components furnished by the dry fly ash system vendor are expected to be fully installed by late December 2020, early February 2021, and early May 2021 for Units 1, 2, and 3, respectively.

3.4.4.2 BALANCE-OF-PLANT EQUIPMENT & COMPONENTS

As the mechanical general work contractor is erecting the fly ash storage silo and installing the other equipment and components furnished by the dry fly ash system vendor, the contractor will also be installing the BOP equipment and piping. Equipment piping will be installed first followed by the piping to/from each unit's precipitator, which will be installed as the utility racks are erected. Erection of the utility racks will commence about one week after the structural steel fabricator has delivered all of the steel to the given unit. Thus, erection of the Unit 1 utility racks and installation of the corresponding piping commenced in early July 2020. The corresponding Unit 2 and 3 work began in early August and the end of October 2020, respectively.

Overall, it is expected to take approximately six to seven months to install the piping to each unit's precipitator and erect the utility racks to support the piping. After all of the BOP equipment and piping has been installed, the mechanical general work contractor will finally tie the new system into the existing fly ash system remaining in service. At this point, the mechanical general work contractors work at a given unit will conclude. Based on the preceding timeframes, the tie-ins at Units 1, 2, and 3 are currently anticipated to occur in mid-January 2021, late March 2021, and early May 2021, respectively.

Finally, while the mechanical general work contractor is still erecting the fly ash storage silo at each unit, the PDC buildings were delivered to the project site. As they arrived, the contractor installed them on the corresponding foundations previously installed by the substructure contractor. The PDC enclosures were erected on September 25, 2020 (Unit 1) and on October 15 (Units 2 and 3).

3.4.5 ELECTRICAL EQUIPMENT INSTALLATION & TIE-IN

The electrical general work contractor will start installing the electrical equipment for each unit's dry fly ash system once the PDC and transformer for that unit are delivered to the project site and the corresponding enclosure has been erected. Accordingly, it is expected that the electrical installation work will have started at all three units by October 2020. As the contractor installs the electrical equipment in the PDCs, the contractor will also install the wires and cables (including cable tray), lighting, and other electrical components at all three units. Like the rest of the construction activities for this project, the start dates for installing the units' electrical equipment will be staggered and will start at Unit 1.

While the electrical general work contractor is installing the electrical equipment and components at the dry fly ash system site for a given unit, the contractor will also be installing the DCS hardware prepared by the DCS modifications vendor and transferring the unit's PLC valve wiring to the station DCS. The new electrical lines will be tied into the existing unit systems during the unit's scheduled outage in the fall of 2020. Thus, this work occurred between September 29 and October 8, 2020 for Unit 1 and between September 26 and October 4, 2020 for Unit 2. This work is ongoing for Unit 3, which is scheduled to have its outage end on November 2, 2020.

Overall, the electrical installation work for the project is expected to take approximately six months to complete. Consequently, the electrical work is scheduled to be finished by mid-January 2021, late March 2021, and early May 2021 for Units 1, 2, and 3, respectively, just as the mechanical work is being finished.

3.5 START-UP & IMPLEMENTATION (COMMISSIONING)

As each major component of the new dry fly ash-handling system is installed, it will be turned over for commissioning to ensure it operates as intended. To ensure its reliability, each component will be tested over a period of one to two weeks. In addition to the overall vacuum-pneumatic conveying system, the following major components will be individually tested and commissioned as the necessary mechanical and electrical work is completed: pin mixers, air fluidizing and compressor systems, vacuum exhausters, filter separators, bin vent filters, silo conditioned and dry unloading systems. To commission each of the preceding dry fly ash system components and the dry fly ash system as a whole, field service engineers from the fly ash system vendor will use a prepared start-up plan to ensure each piece of equipment is operational and functional. Based on the projected installation schedule at each unit, it is expected that the commissioning process will take approximately two months per unit. Thus, the dry fly ash systems at Units 1, 2, and 3 are expected to be fully commissioned by mid-January 2021, late March 2021, and mid-May 2021.

In addition to commissioning the dry fly ash system and its components, the precipitator valves in the DCS and the auxiliary power subsystems will also be commissioned. This commissioning work will occur during each unit's scheduled outage in the fall of 2020.

After the dry fly ash system is commissioned, the fly ash system vendor will work with the optimize and tune the system in accordance with the Cardinal Operating Company's acceptance criteria. In general, this process will ensure the system operates at maximum efficiency and in accordance with the project design criteria and all permits (*i.e.*, Ohio EPA air pollution PTI). During this "performance guarantees" period, a third-party testing agency hired by the fly ash system vendor will observe the system tests and document the results. For each individual guarantee that is not met, modifications will be made as necessary in order to meet the guaranteed performance.

In accordance with the dry fly ash system contract, the "performance guarantees" period within 30 days after the dry fly ash system is operational. Thus, the fly ash-handling system at Cardinal is expected to be fully converted into a dry system approximately 30 days after the Unit 3 system has been commissioned in May of 2021. Therefore, per the visual timeline representation of the project schedule in Section 2.0, the Cardinal Operating Company expects Cardinal to have access to alternative disposal capacity to replace FAR II by June 7, 2021.

4.0 PROJECT SCHEDULE: PROGRESS TO DATE

4.1 ENGINEERING & DESIGN

4.1.1 BALANCE-OF-PLANT COMPONENTS

The engineering and design for the BOP components of the dry fly ash-handling system mostly took place between March 2019 and July 2020. The following subsections summarize the BOP engineering that has been completed for this project as it pertained to each discipline.

4.1.1.1 GENERAL

The general engineering and design tasks for this project primarily included activities that otherwise did not fall under a specific discipline. Most of these general tasks were initiated at the beginning of the project in March 2019 and completed a few months thereafter. These activities included the development of the project design basis, the creation of a three-dimensional computer model to aid in engineering and design tasks, and any necessary engineering support during the permitting process. The remaining general engineering and design activities, primarily construction support and drawing closeout, will be completed after the new vacuum-pneumatic handling system and auxiliary components are commissioned, optimized, and tuned.

4.1.1.2 CIVIL & STRUCTURAL

The engineering and design work for the civil and structural aspects of the project began in March 2019 and was completed by March 2020. This work included preparing and/or designing:

- Geotechnical investigations and evaluations;
- Temporary erosion control;
- Topographic surveys and underground utility locations;
- Civil sitework and grading plans;
- Roads and paving for the updated site layout;
- Foundations for:
    - Fly ash storage silos;
    - PDCs and transformers,
    - Utility racks supporting new piping, cable tray, *etc*.,
    - Exhauster blowers, and
    - Miscellaneous equipment pads and pipe supports; and
- Structural steel for:
    - Utility racks supporting new piping, cable tray, *etc*.,
    - Shelters for the exhauster blowers, and
    - Miscellaneous stairs, platforms, and walkways.

The only anticipated civil and structural engineering work remaining for the project is to support the ongoing construction of the new dry fly ash-handling system.

4.1.1.3 MECHANICAL

The mechanical engineering and design work began in March 2019 and was completed by April 2020. This work included preparing and/or designing:

- General arrangement drawings;
- Equipment location drawings;
- Service water, fly ash, and underground piping, including:
    - Pipe and instrumentation diagrams (P&IDs),
    - Isometrics, and
    - Supports, including auxiliary steel; and
- Demolition work for existing electrostatic precipitator piping.

The only anticipated mechanical engineering and design work remaining for the project is preparation of as-built drawings for the project's mechanical components. This activity will be performed near the end of construction.

4.1.1.4 ELECTRICAL

The electrical engineering and design work began in March 2019 and was completed by July 2020. The work completed to date included preparing and/or designing:

- Project electrical load list,
- Single line and phasing diagrams,
- Auxiliary power and arc flash studies,
- Grounding,
- Underground duct banks,
- Lighting,
- Electrical installation drawings, and
- Cable and cable tray routing.
- Updating the project electrical load list as necessary,
- Performing relay setting calculations, and
- Preparing electrical schematic diagrams, wiring drawings, and cable tabulations.

Finally, as-built drawings for the project's electrical components will be prepared shortly after these components have been installed. This work is currently expected to be finished by the beginning of November 2020.

4.1.1.5 INSTRUMENTATION & CONTROLS

The engineering and design work for the project's instrumentation and controls began in May 2019 and was completed by March 2020. This work included preparing and/or designing:

- Distributed control system (DCS) network architecture drawings;
- Control logic; and
- Instrument lists, data sheets, installation details, and location drawings.

The only anticipated instrumentation and control work remaining for the project is preparation of corresponding as-built drawings. Similar to the mechanical as-builts, this activity will be performed near the end of construction.

4.1.2 VACUUM-PNEUMATIC CONVEYING SYSTEM

About one month following the start of the BOP engineering and design work, Cardinal Operating Company solicited bids from potential vendors for the vacuum-pneumatic conveying systems to be installed at each unit. This contract was ultimately awarded to a vendor in August 2019. Upon receiving the notice to proceed, this vendor began the engineering and design work for each unit's vacuum-pneumatic conveying system. These activities included, among other tasks, the design of the required process and the associated equipment including fly ash storage silos; vacuum exhausters; pin mixers; filter separators; and the corresponding piping, electrical wiring, and instrumentation for the conveying system. The vendor has completed these design tasks to date and finished its design by the end of July 2020.

4.2 PERMITTING

The Cardinal Operating Company submitted the air pollution PTI application for the project to the Ohio EPA in late June 2019. Approximately two months later, on August 22, 2019, the Ohio EPA issued the final PTI authorizing the Cardinal Operating Company to construct and operate the new dry fly ash-handling system at Cardinal.

In addition, the Cardinal Operating Company submitted a PTI application to close FAR II on October 18, 2019 and received an approved PTI on February 20, 2020. The Cardinal Operating Company is currently finalizing the appropriate state and federal permits for storm water pollution prevention, sediment and erosion control, wetland and endangered species evaluations, landfill leachate waste water treatment system, and modifications to the station's NPDES permit (by Ohio EPA) and FAR II dam permit (by Ohio Department of

Natural Resources). These permit applications are expected to be submitted to the appropriate agencies by the end of 2020.

4.3 PROCUREMENT

Including the vacuum-pneumatic conveying system, Cardinal Operating Company has awarded all of the contacts for obtaining the necessary components for the new dry fly ash-handling system. These procurement contracts were awarded between November 2019 and March 2020 and cover the structural steel for the utility racks, auxiliary mechanical equipment and piping, the required DCS modifications, and the pre-manufactured electrical PDC buildings with electrical equipment and transformers.

The installation of the new dry fly ash-handling system is being performed under four separate contracts: a piling contract, a substructure contract, a mechanical general work contract, and an electrical general work contract. All installation contracts have been awarded to date.

4.4 CONSTRUCTION

Construction started at Unit 1 in January 2020 when the piling contractor mobilized to the project site and started installing test piles. Since then, the various installation contractors for this project have installed the piling and foundations for the fly ash storage silos and the foundations for the PDCs, transformers, and utility racks; the underground utilities; and the underground ductbanks. The mechanical general work contractor also recently finished erecting the support steel for the fly ash storage silos and the PDCs at all three units.

Given that construction of each component of the dry fly ash system started at Unit 1, the system at that unit is further along in construction. To date, the following components have also been installed at Unit 1 in addition to those stated earlier:

- Silo rings,
- Silo roof,
- Pin mixers,
- Vacuum exhausters,
- Fluidizing air blowers, and
- Air compressor.

Due to the staggered construction schedule, Unit 2 is also ahead of Unit 3 in construction. To date, the following components have also been installed at Unit 2 in addition to those stated earlier:

- Pin mixers,
- Vacuum exhausters,
- Fluidizing air blowers, and
- Air compressor.

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.

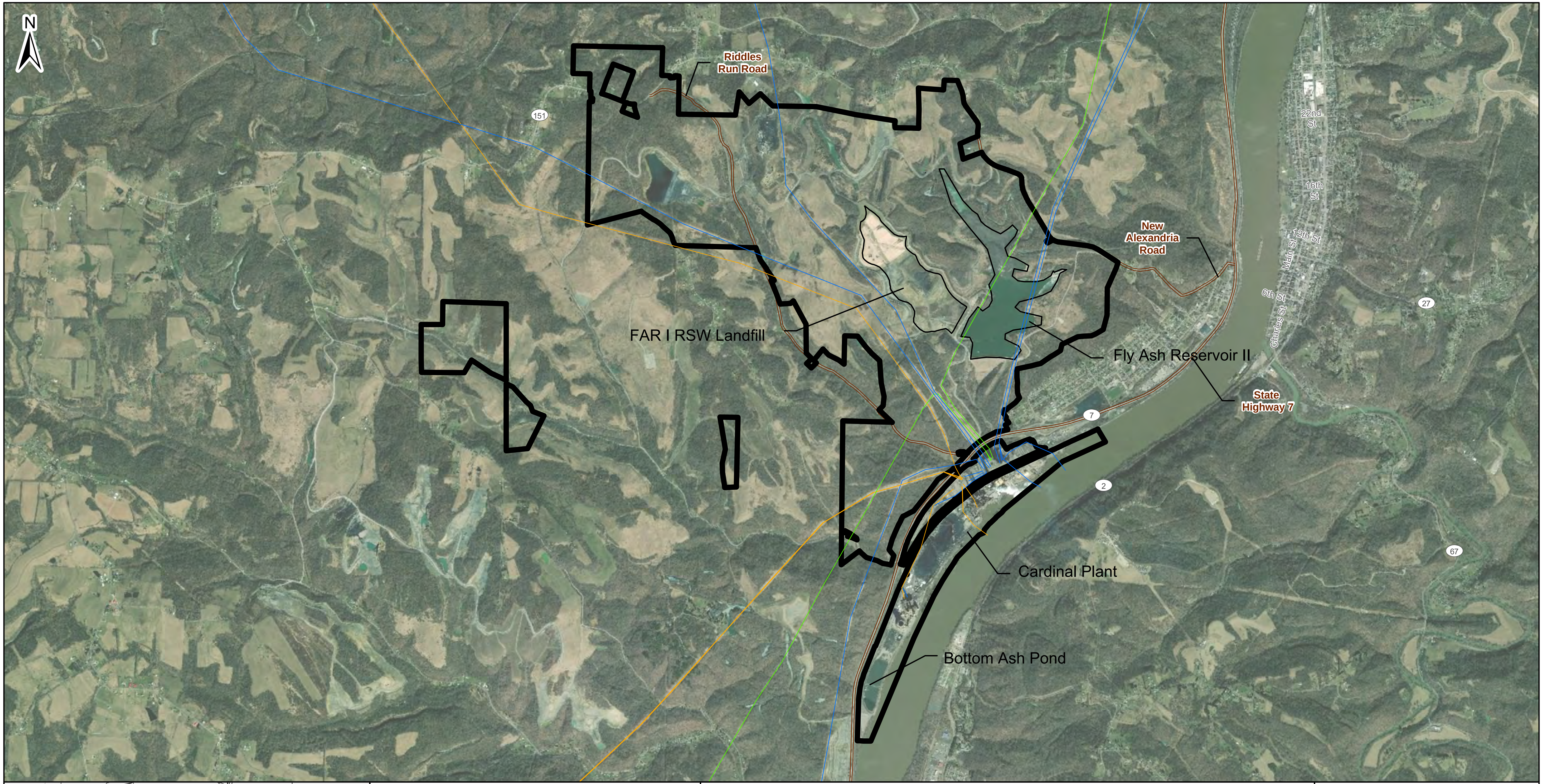
8. Environmental Protection Agency, “Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category,” 80 Fed. Reg. 212, pp. 67838–67903, 11/03/2015.

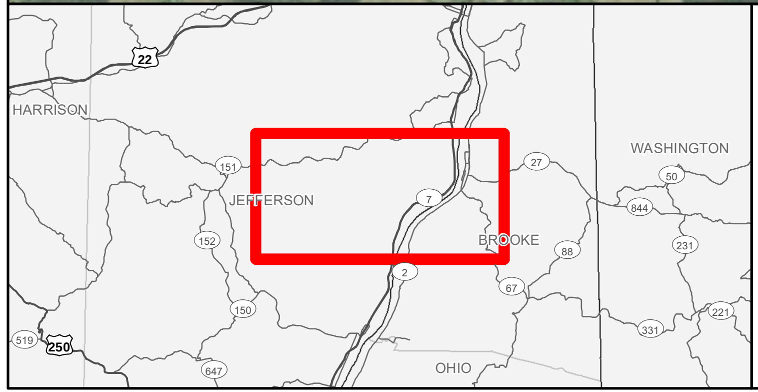
9. Environmental Protection Agency, “Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals From Electric Utilities; A Holistic Approach to Closure Part A: Deadline to Initiate Closure,” 85 Fed. Reg. 168, pp. 53516–53566, 08/28/2020.

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

11. Geosyntec Consultants, “Location Restriction Evaluation, Cardinal FAR II, Brilliant, Ohio,” August 2018.

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

Feet
0 1,500 3,000 6,000
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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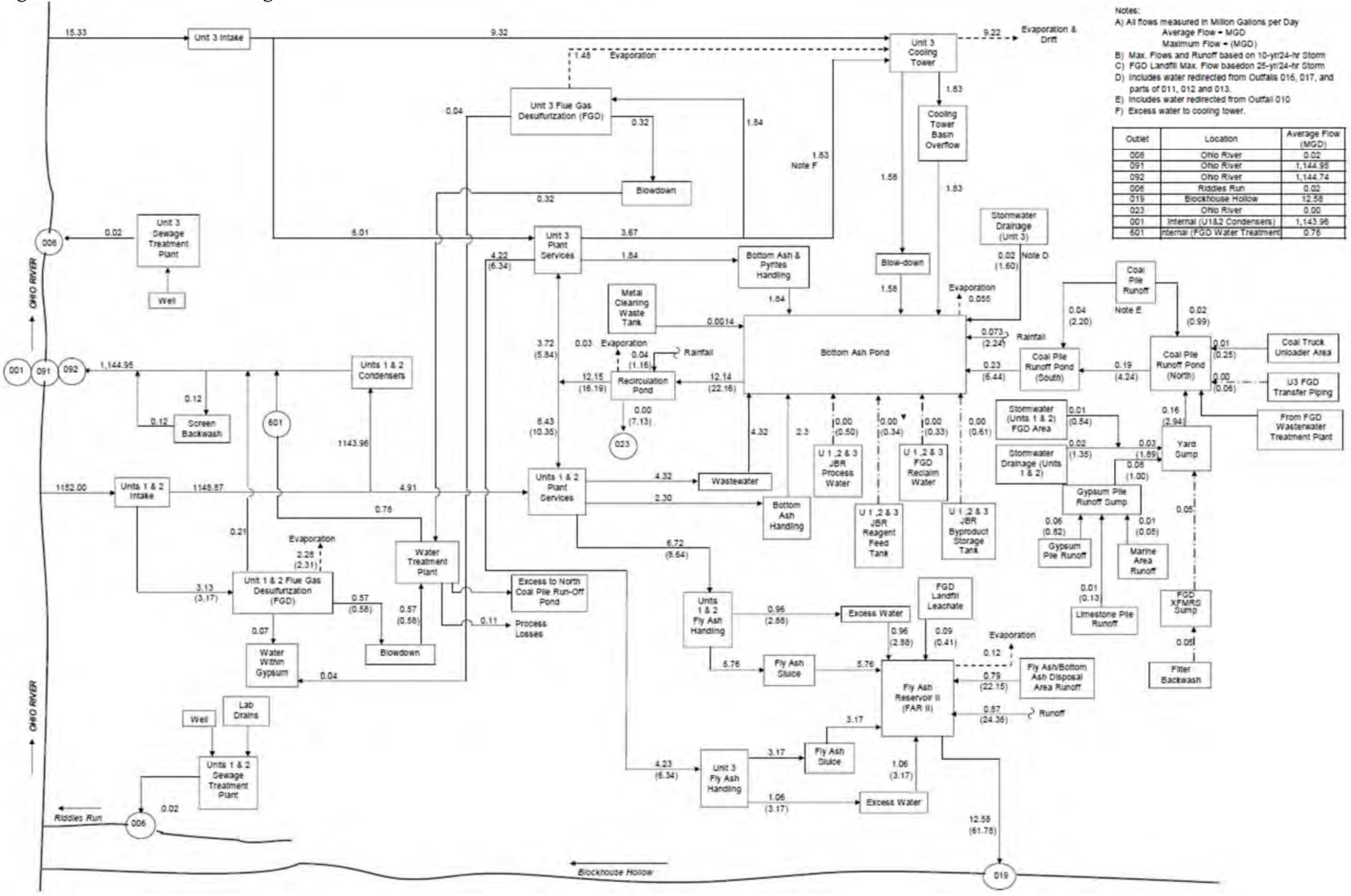
Figure 2- Water Balance from Cardinal NPDES Permit

Figure 2. Water Balance Diagram



Notes:

A) All flows measured in Million Gallons per Day
Average Flow - MGD
Maximum Flow - (MGD)

B) Max. Flows and Runoff based on 10-yr/24-hr Storm

C) FGD Landfill Max. Flow basedon 25-yr/24-hr Storm

D) Includes water redirected from Outfalls 016, 017, and parts of 011, 012 and 013.

E) Includes water redirected from Outfall 010

F) Excess water to cooling tower.

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	nternal (FGD Water Treatment	0.78

CARDINAL
OPERATING COMPANY

6677 Busch Blvd.
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.

TL 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. 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 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.

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

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

Water Level, ft	▽	▼	▼
TIME			
DATE			

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								Loose, grayish brown to orange, silty **SAND** (SM); dry; non-plastic; micaceous.		
							15					
9	SS	16.0										
10	SS	18.0										
										Moderately hard, greenish gray, **SANDSTONE**;		

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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"

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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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	SAMPLE DEPTH IN FEET 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**

PROJECT **CARDINAL LANDFILL**

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

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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**

PROJECT **CARDINAL LANDFILL**

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

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
9	RC	100.0	110.0				100			Hard, gray, **LIMESTONE**; massive.		
										Soft, gray (GLEY1-4/1-N), **CLAYSTONE**; massive.		
							105					
10	RC	110.0	120.0				110					
							115					
11	RC	120.0	130.0				120					
										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	SAMPLE DEPTH IN FEET 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
										Light gray, **LIMESTONE**.		
							125					
										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	SAMPLE DEPTH IN FEET 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					
15	RC	160.0	170.0				160					
							165					
										Hard, gray (GLEY2-5/1-10B), **SANDSTONE**; medium grained.		
16	RC	170.0	180.0				170					
										Vertical fracture at 172.0 ft.		
							175					

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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	SAMPLE DEPTH IN FEET 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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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					
20	RC	210.0	220.0				210			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					
21	RC	220.0	230.0				220					
										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	SAMPLE DEPTH IN FEET 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

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**

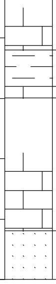
HGT. RISER ABOVE GROUND **2.359** DIA **2"**

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

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

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

Water Level, ft	▽	▼	▼
TIME			
DATE			

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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	SAMPLE DEPTH IN FEET 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 40			**SOFT 5YR 4/1 BROWNISH GRAY CLAY SHALE** w/5G 6/1 greenish gray clay shale, w/high angle fracture		
5	NQ	40.7	49.2		8.2	28	45			**HARD TO MEDIUM 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 **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					
										HARD 5G 6/1 GREENISH GRAY CLAY SHALE		
							55			**SOFT 5G 6/1 GEEENISH GRAY CLAY SHALE**		
										HARD 5G 6/1 GREENISH GRAY CLAY SHALE w/traces of limestone		
7	NQ	59.2	69.2		7.7	43				**HARD 5G 6/1 GREENISH GRAY LIMESTONE**		
							60			**HARD 5G 6/1 GREENISH GRAY CLAY SHALE** w/fracture 64.0' and 65.0 high angles		
							65					
8	NQ	69.2	75.2		6.0	33				**HARD 5G 6/1 GREENISH GRAY CLAY SHALE**		
							70					

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

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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
										HARD N5 MEDIUM GRAY LIMESTONE broken up		
							75					
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**

PROJECT **CARDINAL LANDFILL**

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

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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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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	SAMPLE DEPTH IN FEET 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				**HARD N5 MEDIUM GRAY CLAY SHALE** w/fractures		
							130					
							135					
17	NQ	139.2	149.2		10.0	41				**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
							140					
							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	SAMPLE DEPTH IN FEET 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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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	SAMPLE DEPTH IN FEET 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		
							195			**N5 MEDIUM GRAY WELL CEMENTED MEDIUM GRAIN SANDSTONE**		
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

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**

Water Level, ft	▽	▼	▼
TIME			
DATE			

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					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'

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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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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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	SAMPLE DEPTH IN FEET 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	SAMPLE DEPTH IN FEET 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		
							100					
4	NQ	104.6	114.6		10.0	67	105			**SOFT 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
										HARD SILTY FINE 5B 5/1 MEDIUM BLUISH GRAY SANDSTONE w/limestone nodules		
							110					
										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**

PROJECT **CARDINAL LANDFILL**

BORING NO. **CA-0616**

DATE **7/17/15**

SHEET **6** OF **11**

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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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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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	SAMPLE DEPTH IN FEET TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	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	SAMPLE DEPTH IN FEET 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	SAMPLE DEPTH IN FEET 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

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**

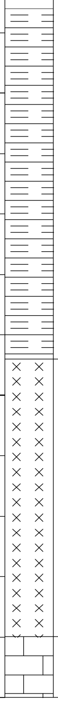
HGT. RISER ABOVE GROUND **2.45** DIA **2"**

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**

Water Level, ft	▽	▼	▼
TIME			
DATE			

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 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'
1	NQ	8.6	14.4		3.7	11	10			**SOFT N6 MEDIUM LIGHT GRAY BROKEN SILTY CLAYSHALE**		
2	NQ	14.4	24.4		6.3	30	15			**N5 MEDIUM GRAY BROKEN SILTSTONE**		
										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

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	SAMPLE DEPTH IN FEET 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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Monitoring Well: M-15

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

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

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					
										N1 BLACK COAL		
10	NQ	79.9	89.9		6.6	23	80					
										N5 MEDIUM GRAY SILTSTONE w/high angle fracture		
							85					
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

LOG OF BORING

Monitoring Well: M-15

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	SAMPLE DEPTH IN FEET 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**		
							105			**N6 MEDIUM LIGHT GRAY WELL CEMENTED FINE GRAIN SANDSTONE** w/high angle fracture throughout whole piece		
13	NQ	106.9	114.9		5.6	0				**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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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 **6** OF **11**

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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 CLAYSHALE		
							125					
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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JOB NUMBER

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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LOG OF BORING

Monitoring Well: M-15

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

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

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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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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**

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

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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		
							220			**N5 MEDIUM GRAY FINE GRAIN SILTSTONE** w/sandstone lenses		
										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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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**

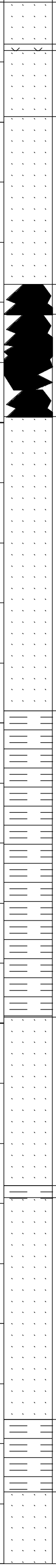
BORING NO. **CA-0614**

DATE **7/17/15**

SHEET **10** OF **11**

BORING START **7/18/07**

BORING FINISH **7/25/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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		
										N6 MEDIUM LIGHT GRAY MEDIUM GRAIN SANDSTONE w/clayshale crossbedding		
							250					
										N2 GRAYISH BLACK CLAYSHALE crossbedded w/fine grain sandstone		
										HARD N7 MEDIUM LIGHT GRAY MEDIUM GRAIN WELL CEMENTED SANDSTONE		

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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**

PROJECT **CARDINAL LANDFILL**

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

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
LOG OF BORING

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JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

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

GROUND ELEVATION **984.9** SYSTEM

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**

Water Level, ft	▽	▼	▼
TIME			
DATE			

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**		

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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"

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**

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 **2** OF **8**

PROJECT **CARDINAL LANDFILL**

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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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LOG OF BORING

Monitoring Well: M-14

JOB NUMBER ______

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	SAMPLE DEPTH IN FEET 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**		
										HARD 5G 6/1 GREENISH GRAY CLAY SHALE w/limestone nodules		
							70					

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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 **4** OF **8**

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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		
										HARD 5G 6/1 GREENISH GRAY LIMESTONE		
10	NQ	79.7	89.7		10.0	67	80					
										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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Monitoring Well: M-14

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

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

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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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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 **6** OF **8**

PROJECT **CARDINAL LANDFILL**

BORING START **3/6/07**

BORING FINISH **3/21/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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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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 **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	SAMPLE DEPTH IN FEET 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
										FINE TO MEDIUM N7 LIGHT GRAY WELL CEMENTED SANDSTONE w/limestone nodules		
20	NQ	179.7	189.7		9.8	93	180			**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**

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 & H**

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

Water Level, ft	▽	▼	▼
TIME			
DATE			

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		STOPPED SAMPLING / AUGER REFUSAL @ 7.0' / SET 4" CASING
1	NQ	8.2	14.1		5.9	22				HARD LIGHT OLIVE GRAY 5Y 5/2 CLAYSHALE		
							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				VERY HARD MEDIUM LIGHT GRAY N6 LIMEY SHALE w/limestone nodules @ 4.5'		
							55					
							60					
9	NQ	64.1	69.1		5	16				VERY HARD MEDIUM LIGHT GRAY N6 LIMEY SHALE		
							65					
10	NQ	69.1	74.1		5	20				HARD MEDIUM DARK GRAY N4 CLAYSHALE		
							70					

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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**

PROJECT **CARDINAL FLY ASH DAM**

BORING NO. **B-1309D**

DATE **7/17/15**

SHEET **4** OF **15**

BORING START **5/2/13**

BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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'		
										HARD MEDIUM BLUISH GRAY 5B 5/1 CLAYSHALE		
							80					
12	NQ	84.1	94.1		10	98	85					
							90					
13	NQ	94.1	104.1		10	72				HARD MEDIUM DARK GRAY N4 CLAYSHALE		
							95			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				HARD MEDIUM DARK GRAY N4 SILTSTONE		
							115					
							120					
										HARD BLACK N1 COAL		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

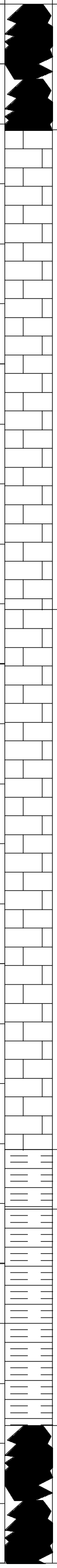
LOG OF BORING

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

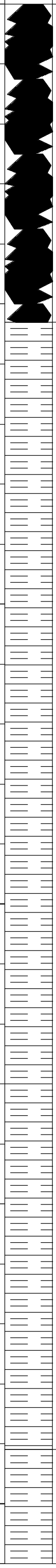
LOG OF BORING

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	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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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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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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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	SAMPLE DEPTH IN FEET 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				HARD GREENISH GRAY 5G 6/1 CLAYSHALE		
							265					
										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		
										HARD DARK REDDISH BROWN 10R 3/4 SHALE		
							275					
										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	285			HARD MEDIUM LIGHT GRAY N6 SANDY SHALE		
							290					
33	NQ	294.1	304.1		10	97	295			HARD MEDIUM DARK GRAY N4 WELL CEMENTED FINE SANDSTONE		
							300					
34	NQ	304.1	314.1		10	100	305			HARD MEDIUM LIGHT GRAY N6 WELL CEMENTED FINE SANDSTONE		

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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					
										HARD MEDIUM LIGHT GRAY N6 WELL CEMENTED FINE SANDSTONE w/limestone fragments		
							330					

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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**

PROJECT **CARDINAL FLY ASH DAM**

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

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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				HARD MEDIUM GRAY N5 SHALEY SANDSTONE		
							335					
										HARD MEDIUM LIGHT GRAY N6 WELL CEMENTED MEDIUM SANDSTONE		
							340					
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					

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

Monitoring Well: M-1302

LOG OF BORING

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	U S C S	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					STIFF DARK YELLOWISH BROWN 10YR 4/2 MINE SPOIL		
8	SPT	10.5	12.0	6-8-8	.1		10			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"

Continued Next Page

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

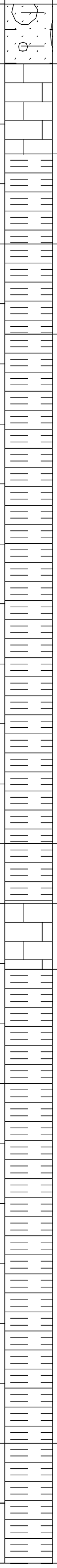
WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER

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		
							25					
1	NQ	25.5	34.0		8.5	27				MEDIUM HARD MEDIUM BLUISH GRAY 5B 5/1 SANDY CLAYSHALE		
							30					
2	NQ	34.0	44.0		5.3	28				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'
							40					
3	NQ	44.0	54.0		3.9	51				MEDIUM HARD LIGHT BLUISH GRAY 5B 7/1 SANDY CLAYSHALE w/iron stains throughout		
							45					

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JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL FLY ASH DAM**

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

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	55			MEDIUM HARD LIGHT BLUISH GRAY 5B 7/1 TO GRAYISH PURPLE 5P 4/2 CLAYSHALE		
							60					
5	NQ	64.0	74.0		7.7	62	65			HARD LIGHT BLUISH 5B 7/1 WELL CEMENTED FINE GRAIN SANDSTONE		
							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**

PROJECT **CARDINAL FLY ASH DAM**

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

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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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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	SAMPLE DEPTH IN FEET 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	125 130			HARD MEDIUM GRAY 5B 5/1 CLAYSHALE w/limestone nodules, high angle fracture @ 2.8' (126.8')		
12	NQ	134.0	144.0		10	46	135 140			HARD MEDIUM GRAY N5 CLAYSHALE		
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**

PROJECT **CARDINAL FLY ASH DAM**

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

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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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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**

PROJECT **CARDINAL FLY ASH DAM**

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

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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		
										HARD MEDIUM GRAY N5 CLAYSHALE w/limestone nodules throughout		
21	NQ	209.0	219.0		10	56	210 215			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

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**

Water Level, ft	▽	▼	▼
TIME			
DATE			

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**		
							30			**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE** w/trace of iron staining throughout		
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	SAMPLE DEPTH IN FEET 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				**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
							60					
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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Monitoring Well: M-13

JOB NUMBER
COMPANY **AMERICAN ELECTRIC POWER**
PROJECT **CARDINAL LANDFILL**
BORING NO. **CA-0610** DATE **7/17/15** SHEET **4** OF **8**
BORING START **4/3/07** BORING FINISH **4/3/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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**

PROJECT **CARDINAL LANDFILL**

BORING NO. **CA-0610**

DATE **7/17/15**

SHEET **5** OF **8**

BORING START **4/3/07**

BORING FINISH **4/3/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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**		
							105			**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE** high angle fracture @ 103.9		
13	NQ	106.4	114.4		6.5	74				**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**		
										HARD 5YR 6/1 LIGHT BROWNISH GRAY CLAY SHALE		
14	NQ	114.4	124.4		10.0	68	115			**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	SAMPLE DEPTH IN FEET 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		
							130			**MEDIUM N5 MEDIUM GRAY SANDSTONE** well cemented		
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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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**		
							160			**HARD 5GY 4/1 DARK GREENISH GRAY SILTSTONE**		
19	NQ	164.4	169.4		5.0	20	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**

PROJECT **CARDINAL LANDFILL**

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

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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					
										HARD N5 MEDIUM GRAY SHALEY LIMESTONE		
22	NQ	189.4	194.4		5.0	58	190			**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

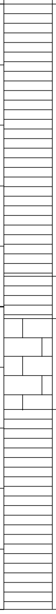
Monitoring Well: M-12

JOB NUMBER
COMPANY **AMERICAN ELECTRIC POWER**
PROJECT **CARDINAL LANDFILL**
COORDINATES **N 833,112.2 E 2,516,013.2**
GROUND ELEVATION **1187.7** SYSTEM

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**

Water Level, ft	▽	▼	▼
TIME			
DATE			

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"

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

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	SAMPLE DEPTH IN FEET 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		
							30			**HARD N7 LIGHT GRAY LIMESTONE**		
										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	SAMPLE DEPTH IN FEET 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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JOB NUMBER ____
COMPANY **AMERICAN ELECTRIC POWER**
PROJECT **CARDINAL LANDFILL**
BORING NO. **CA-0608** DATE **7/17/15** SHEET **4** OF **16**
BORING START **12/13/06** BORING FINISH **12/13/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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**		
							85			**HARD N7 LIGHT GRAY LIMESTONE**		
										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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JOB NUMBER ______
COMPANY **AMERICAN ELECTRIC POWER**
PROJECT **CARDINAL LANDFILL**
BORING NO. **CA-0608** DATE **7/17/15** SHEET **5** OF **16**
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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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 **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
							125			**SOFT N5 MEDIUM GRAY CLAY SHALE** **HARD N4 MEDIUM DARK GRAY CLAY SHALE** w/fractures		w/ NQ rods @ 149.5'
										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**		139.0' - 153.6' Possible Connellsville
16	NQ	139.5	149.5		10.0	74	140			**HARD 5G 6/1 GREENISH GRAY FINE GRAIN SILTY SANDSTONE** w/crossbedding throughout		
							145					
17	NQ	149.5	156.5		5.5	40				**HARD 5G 6/1 GREENISH GRAY FINE GRAIN**		

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LOG OF BORING

Monitoring Well: M-12

JOB NUMBER ______

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

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

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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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 **8** OF **16**

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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			**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		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
21	NQ	186.6	194.8		7.3	56	190			**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
22	NQ	194.8	204.8		9.3	73	195			**HARD N7 LIGHT GRAY LIMESTONE**		
										MEDIUM HARD N5 MEDIUM GRAY SILTY CLAY SHALE		
							200			**HARD 5G 6/1 GREENISH GRAY SILTY CLAY SHALE** w/limestone nodules throughout		

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LOG OF BORING

Monitoring Well: M-12

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	SAMPLE DEPTH IN FEET 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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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

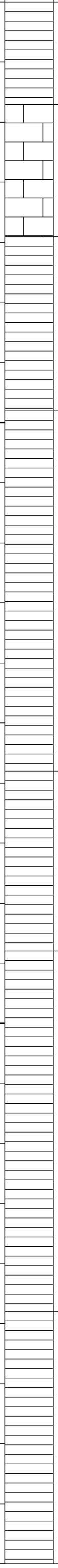
Monitoring Well: M-12

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0608** DATE **7/17/15** SHEET **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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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	SAMPLE DEPTH IN FEET 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	SAMPLE DEPTH IN FEET 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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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**

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

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				**HARD N4 MEDIUM DARK GRAY FINE GRAIN STILTY SANDSTONE**		
							315					
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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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**

BORING NO. **CA-0608**

DATE **7/17/15**

SHEET **14** OF **16**

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		
										HARD N5 MEDIUM DARK GRAY FINE SILTY SANDSTONE		
							335					
										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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LOG OF BORING

Monitoring Well: M-12

JOB NUMBER

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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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-12

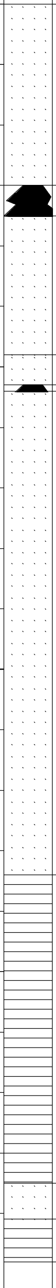
JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

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

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

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**

Water Level, ft	▽	▼	▼
TIME			
DATE			

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**

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				**N5 MEDIUM GRAY CLAY SHALE**		
							70					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	SAMPLE DEPTH IN FEET 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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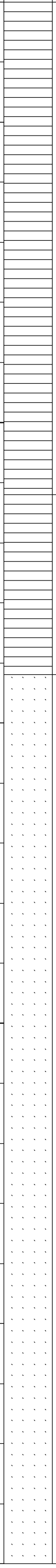
JOB NUMBER
COMPANY **AMERICAN ELECTRIC POWER**
BORING NO. **MW-5** DATE **7/20/15** SHEET **5** OF **12**
PROJECT **CARDINAL FLY ASH DAM**
BORING START
BORING FINISH **5/4/99**

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		
										10YR 5/4 MODERATE YELLOWISH BROWN SANDSTONE		
							110					
23	NQ-2	114.6	124.2		10.0	96	115					
							120					



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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		

Continued Next Page

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)		
										N6 MEDIUM LIGHT GRAY SHALEY LIMESTONE		
35	NQ-2	224.6	234.6		10.0	83	225			**N5 MEDIUM GRAY CLAY SHALE**		
										N5 MEDIUM GRAY SANDY SHALE		

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JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

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

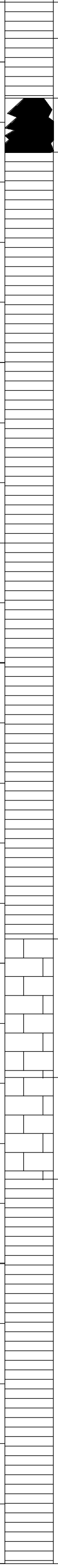
PROJECT **CARDINAL FLY ASH DAM**

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**		
										N5 MEDIUM GRAY CLAY SHALE Broken up		Mud seam at 239.9'
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'

Continued Next Page

JOB NUMBER
COMPANY **AMERICAN ELECTRIC POWER**
PROJECT **CARDINAL FLY ASH DAM**
BORING NO. **MW-5**
DATE **7/20/15**
SHEET **11** OF **12**
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

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**

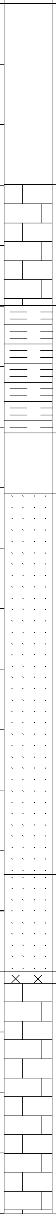
HGT. RISER ABOVE GROUND **2.65** DIA **2"**

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

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

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

Water Level, ft	▽	▼	▼
TIME			
DATE			



SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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		
2	SPT	5.0	6.2	5-23-50/.2			5			**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	10			**HARD MEDIUM BLUISH GRAY 5B 5/1 SILTY FINE GRAIN SANDSTONE** w/high angle fracture @ 1.4'		
2	NQ	14.4	24.4		10	70	15			**HARD MEDIUM BLUISH GRAY 5B 5/1 SILTY FINE GRAIN SANDSTONE**		
										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"

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

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

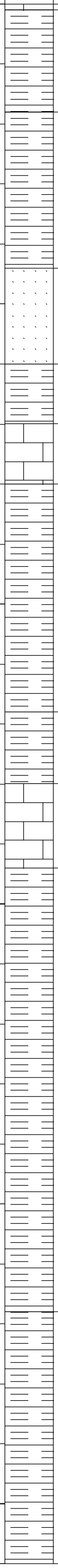
LOG OF BORING

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	SAMPLE DEPTH IN FEET 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**

PROJECT **CARDINAL LANDFILL**

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

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

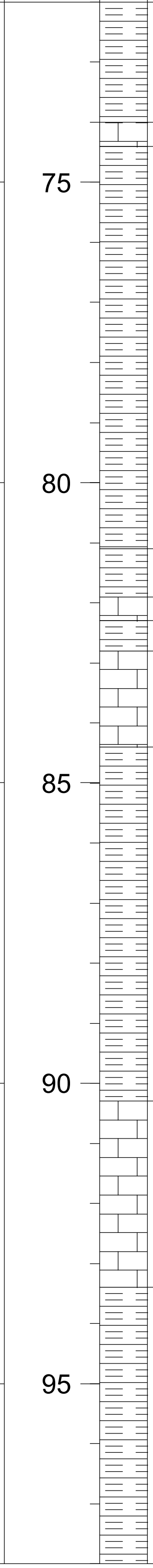
COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

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

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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	74.4	84.4		9.9	59				**HARD MEDIUM LIGHT GRAY N6 LIMESTONE** **HARD GREENISH GRAY 5G 6/1 CLAYSHALE** w/limestone nodules **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				**HARD DARK GREENISH GRAY 5G 4/1 CLAYSHALE** **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		



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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	SAMPLE DEPTH IN FEET 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'		
							105					
13	NQ	109.4	119.4		9.4	66	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		
14	NQ	119.4	129.4		10	62	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	SAMPLE DEPTH IN FEET 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**

PROJECT **CARDINAL LANDFILL**

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

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	160			**HARD MEDIUM BLUISH GRAY 5B 5/1 WELL CEMENTED MEDIUM TO FINE GRAIN SANDSTONE**		
							165					
19	NQ	169.4	179.4		10	98	170					
							175					

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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	SAMPLE DEPTH IN FEET 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		
							185			**HARD MEDIUM LIGHT GRAY N6 WELL CEMENTED MEDIUM GRAIN SANDSTONE** w/Hard Black N1 Clayshale streaks		
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**	BORING NO.	**M-1003**
DATE	**7/17/15**	SHEET	**1** OF **7**
PROJECT	**CARDINAL LANDFILL**	BORING START	**4/7/10**
BORING FINISH	**4/7/10**	COORDINATES	**N 829,139.1 E 2,516,070.9**
PIEZOMETER TYPE	**N/A**	WELL TYPE	**OW**
GROUND ELEVATION	**933.6**	SYSTEM	
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**

Water Level, ft	▽	▼	▼
TIME			
DATE			

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	10			**SOFT DARK REDDISH BROWN 10R 3/4 CLAYSHALE**		
3	NQ	14.4	24.4		2.7	0	15			**HARD LIGHT BLUISH GRAY 5B 7/1 CLAYSHALE** badly broken		

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

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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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 70			**HARD MEDIUM BLUISH GRAY 5B 5/1 WELL CEMENTED MEDIUM GRAIN SANDSTONE**		

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JOB NUMBER
COMPANY **AMERICAN ELECTRIC POWER**
PROJECT **CARDINAL LANDFILL**
BORING NO. **M-1003** DATE **7/17/15** SHEET **4** OF **7**
BORING START **4/7/10** BORING FINISH **4/7/10**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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'		
							80					
13	NQ	84.4	94.4		10	100	85					
							90					
14	NQ	94.4	104.4		10	100	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	SAMPLE DEPTH IN FEET 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**

PROJECT **CARDINAL LANDFILL**

BORING NO. **M-1003** DATE **7/17/15** SHEET **6** OF **7**

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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	125 130			**HARD LIGHT GRAY N7 WELL CEMENTED FINE GRAIN SANDSTONE** w/gravel nodules 124.9' - 125.3'; w/black N1 shale streaks throughout		
18	NQ	134.4	144.4		10	100	135 140			**HARD MEDIUM BLUISH GRAY 5B 5/1 WELL CEMENTED FINE TO MEDIUM GRAIN SANDSTONE**		
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**

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**

Water Level, ft	▽	▼	▼
TIME			
DATE			

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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		

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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"

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**

PROJECT **CARDINAL FLY ASH DAM**

BORING NO. **FA-8**

DATE **7/20/15**

SHEET **2** OF **7**

BORING START **3/8/04**

BORING FINISH **3/23/04**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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**

PROJECT **CARDINAL FLY ASH DAM**

BORING NO. **FA-8** DATE **7/20/15** SHEET **3** OF **7**

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**		
							60			**5B 5/1 MEDIUM BLUISH GRAY MEDIUM GRAIN SANDSTONE** Well cemented		
7	NQ2	65.0	75.0		9.8	100	65 70			**5B 5/1 MEDIUM BLUISH GRAY MEDIUM GRAIN SANDSTONE** w/ black shale streaks throughout		

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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
8	NQ2	75.0	85.0		10	100	75			**5B 5/1 MEDIUM BLUISH GRAY MEDIUM to COARSE GRAIN SANDSTONE** w/ coal lenses throughout		Some water return @ 75.0'
							80					
9	NQ2	85.0	95.0		10	100	85			**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					
10	NQ2	95.0	105.0		10	100	95			**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	SAMPLE DEPTH IN FEET 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					

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

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**

Water Level, ft	▽	▼	▼
TIME			
DATE			

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				5					**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'**
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**		

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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"

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	SAMPLE DEPTH IN FEET 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		25			**5B 5/1 MEDIUM BLUISH GRAY SHALE** fractured		
										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		35 40			**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE** fractured in bottom 1.5'		
6	NQ	43.9	46.9		3.0		45			**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE**		

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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		
										HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE		
8	NQ	53.9	63.9		9.6							
							55					
										HARD N5 MEDIUM GRAY SHALEY LIMESTONE		
							60					
9	NQ	63.9	73.9		10.0					**HARD 5B 5/1 MEDIUM BLUISH GRAY to N6 MEDIUM LIGHT GRAY SHALE**		
							65					
										HARD N4 MEDIUM DARK GRAY SHALE small coal band @ 73.8		
							70					

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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	SAMPLE DEPTH IN FEET 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					**HARD N6 MEDIUM LIGHT GRAY SHALE** w/ coal band @ 74.4, angle fracture @ 75.7		
							75					
										SOFT N4 MEDIUM DARK GRAY SHALE		
							80					
										HARD N2 GRAYISH BLACK SHALE		
										COAL		
										HARD 5B 5/1 MEDIUM BLUISH GRAY SHALE		
11	NQ	83.9	93.9		10.0					**HARD N5 MEDIUM GRAY SHALE**		
							85					
							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					**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALE**		
							95					

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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		
										HARD N6 MEDIUM LIGHT GRAY SHALE w/ sandstone streaks		
							120					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

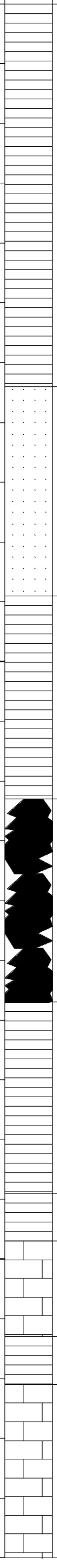
LOG OF BORING

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	SAMPLE DEPTH IN FEET 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	SAMPLE DEPTH IN FEET 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)**
							160			**HARD N5 MEDIUM GRAY SHALE/LIMESTONE**		
19	NQ	163.9	168.9		1.9	84	165			**VOID**		
										SOFT 5B 5/1 MEDIUM BLUISH GRAY SHALE		
20	NQ	168.9	170.9		1.3	0	170			**SOFT N5 MEDIUM GRAY SHALE** wet		**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		
							175			**HARD N6 MEDIUM LIGHT GRAY SHALE** fractured		

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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	SAMPLE DEPTH IN FEET 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	SAMPLE DEPTH IN FEET 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	205			**HARD N4 MEDIUM DARK GRAY SHALE**		
										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		
							210			**N5 MEDIUM GRAY SHALE** fracture, wet		
										5G 6/1 GREENISH GRAY SHALE		
										5G 6/1 GREENISH GRAY SHALE wet		
27	NQ	214.4	219.4		5.0	66	215			**5GY 6/1 GREENISH GRAY SHALE/LIMESTONE**		
										N5 MEDIUM GRAY SHALE		
										SOFT 5YR 6/1 LIGHT BROWNISH GRAY SANDY SHALE		
28	NQ	219.4	229.4		9.9	81	220			**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALE** w/limestone fractures		
							225			**5B 5/1 MEDIUM BLUISH GRAY SHALE** w/limestone		
										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	SAMPLE DEPTH IN FEET 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							**5B 5/1 MEDIUM BLUISH GRAY SHALE/ LIMESTONE** fracture		
							230					
										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**

PROJECT **CARDINAL LANDFILL**

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

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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		

Continued Next Page

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							**N4 MEDIUM DARK GRAY SHALE** w/fractures of limestone		
							285					
										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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JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

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

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	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							310				
38	NQ	314.4	324.4		10.0				**N4 MEDIUM DARK GRAY SHALE**		
							315				
									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				**HARD MEDIUM GRAY & MEDIUM DARK GRAY SHALE** w/trace of coarse sandstone		
							325				
							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**

PROJECT **CARDINAL LANDFILL**

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

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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					**N6 MEDIUM LIGHT GRAY SANSDSTONE**		
							335			**HARD N3 DARK GRAY SHALE** w/trace of fine sandstone		
							340			**N2 GRAYISH BLACK SHALE**		
										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		
							350			**HARD N4 MEDIUM DARK GRAY SHALE** w/trace of fine sandstone		
										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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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	375			**HARD N3 DARK GRAY CLAY SHALE**		
										N2 GRAYISH BLACK CLAY SHALE SEAM		
										N1 BLACK COAL SEAM		
							380			**HARD N5 MEDIUM GRAY CLAY SHALE**		
												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**

PROJECT **CARDINAL LANDFILL**

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

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

AEP

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**

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**

WATER LEVEL	▽ 52.7	▼	▽
TIME			
DATE	7-30-90		

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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				5 10 15					WATER RETURNED AFTER SEATING CASING.
							20			**GRAY SILTY CLAYSHALE** Calcareous, vertical cracks 20.8-21.1, 21.6-21.8		
										GRAY SHALEY LIMESTONE Hard.		
2	NQ	25.6	30.4		4.8	59	25			**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**		
							35			**GRAY SILTY SANDSTONE** F-fine grain. **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		
							45			**GRAY TO LIGHT TO DARK GRAY CLAYSHALE** Broken slightly calcareous.		
										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**

BORING NO. **90CA22** DATE ________ SHEET **2** 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
5	NQ	50.4	60.4		9.3	78	55			slightly calcareous. **DEEP MAROON PURPLE CLAYSHALE** Blocky, slightly calcareous, slightly weathered. **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.		
9	NQ	75.4	80.4		4.7	25	75			**SILTY CLAYSHALE** Soft, crack, appears to have been very plastic in the drill bit. **LIGHT TO MEDIUM GRAY LIMESTONE** Slightly sandy. **MEDIUM GRAY LIMESTONE** Slightly shaley.		
10	NQ	80.4	90.4		9.9	79	80 85			**GRAY CLAYSHALE** Some silt bedding. **GRAY SILTY CLAYSHALE** Limestone nodules throughout, hard.		
11	NQ	90.4	100.4		10.0	84	90 95			**GRAY CLAYSHALE** Hard, with traces of limestone throughout, fine grain sand throughout. **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**

PROJECT **TIDD ASH POND SITE INVESTIGATION**

BORING NO. **90CA22** DATE ____________ SHEET **3** 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	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										very hard, some silty bedding.		
14	NQ	120.4	130.4		9.8	71	120			**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					
15	NQ	130.4	140.4		10.0	83	130					
							135					135.5 TOP OF SEAL.
16	NQ	140.4	150.4		10.0	100	140			**GRAY LIGHT GRAY SILTY SHALE** Silt cross bedding throughout.		
							145					144.2 TOP OF SAND.
										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	150					
							155					
18	NQ	160.4	170.4		10.0	100	160					
							165					
19	NQ	170.4	180.4		10.0	100	170					
							175					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-6

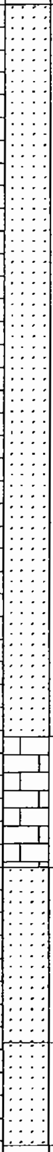
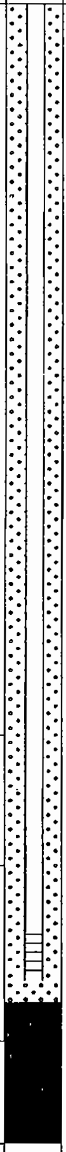
JOB NUMBER ____________

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	SAMPLE DEPTH IN FEET 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					
21	NQ	190.4	200.4		10.0	100	190			SOME MICACEOUS PARTINGS		
							195					
23	NQ	200.4	210.4		8.7	87	200					
							205			THIN COAL LENSES AT 205.1-205.5 BECOMING MORE BROKEN BELOW 205.5		
24	NQ	210.4	215.4		4.6	92	210			BOTTOM OF MORGANTOWN SANDSTONE SANDY LIMESTONE CONGLOMERATE		
25	NQ	215.7	225.7		10.0	100	215			SANDSTONE Fine grain, calcareous.		
							220					220.4 CHECL VALVE. 221.0 TOP OF SCREEN. 223.0 BOTTOM OF SCREEN. 224.0 BOTTOM OF SAND.
26	NQ	225.7	230.2		4.5	100	225			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**

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**

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

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		0.0	1.0		0.0					**BROWN TOPSOIL**		
2		1.0	40.0		0.0					**COAL AND SHALE**, FILL		
							5					
							10					
							15					

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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"

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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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	SAMPLE DEPTH IN FEET 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	NW	75.0	85.0		10.0		75			**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**

PROJECT **CARDINAL PLANT**

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

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

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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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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**

PROJECT **CARDINAL PLANT**

BORING NO. **85W-3**

DATE **7/20/15**

SHEET **7** OF **11**

BORING START **8/9/85**

BORING FINISH **8/13/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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					

Continued Next Page

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					
18	NW	185.0	195.0		10.0		185					
							190					
19	NW	195.0	205.0		10.0		195					
							200					

Continued Next Page

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					

Continued Next Page

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
												228.9 CHECK VALVE. 229.5 TOP OF SCREEN. 230.5 BOTTOM OF SCREEN.
							230					
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					

Continued Next Page

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**

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

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					

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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					SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
				Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)			
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

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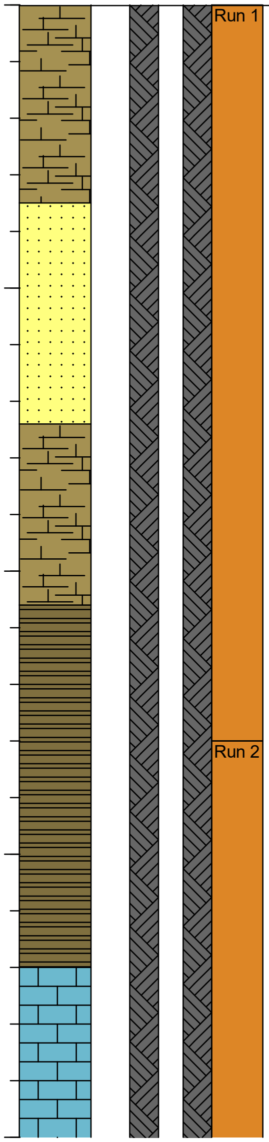
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. M-GS-1

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)
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
25									(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
30									(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
									(30.6') Silty SHALE: strong, greenish gray (5G 6/1), fissile, slightly decomposed, competent, moderately fractured.		
35				Run 2			110/ 180	20	(33') Silty SHALE: strong, greenish gray (5G 6/1), fissile, slightly decomposed, competent, intensely fractured. (34.8') Very fissile, highly decomposed, moderately disintegrated, weak.		35
40									(37') Clayey LIMESTONE: moderately strong to strong, dark greenish gray (5G 4/1), massive to nodular, moderately fractured, microcrystalline, slightly decomposed, moderately disintegrated.		40

NOTES:

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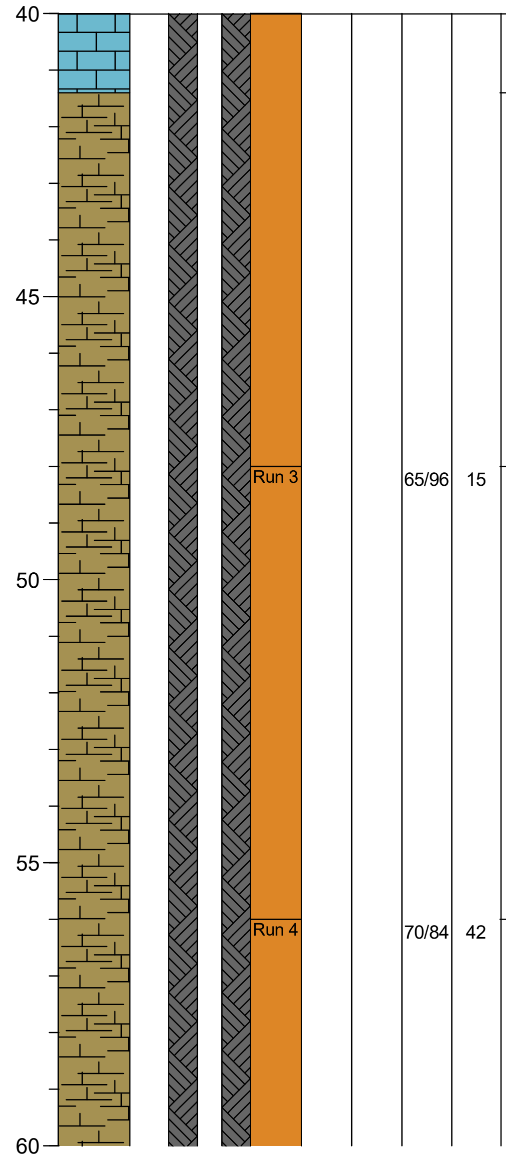
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. M-GS-1

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)	Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS
41.4						(41.4') Sandy CLAYSTONE: weak to very weak, dark greenish gray (5G 4/1), massive, highly decomposed, intensely fractured.	
48	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. (51.3') Highly decomposed (4 inch thick). (52.3') Highly decomposed (3 inch thick). (52.9') Highly decomposed (3 inch thick).	
56	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).	

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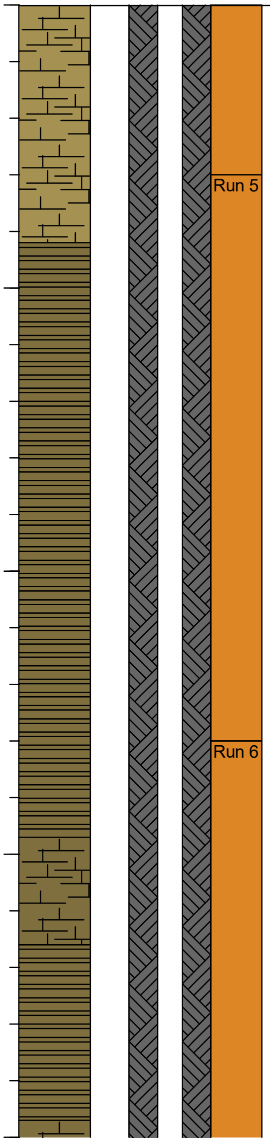
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. M-GS-1

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:

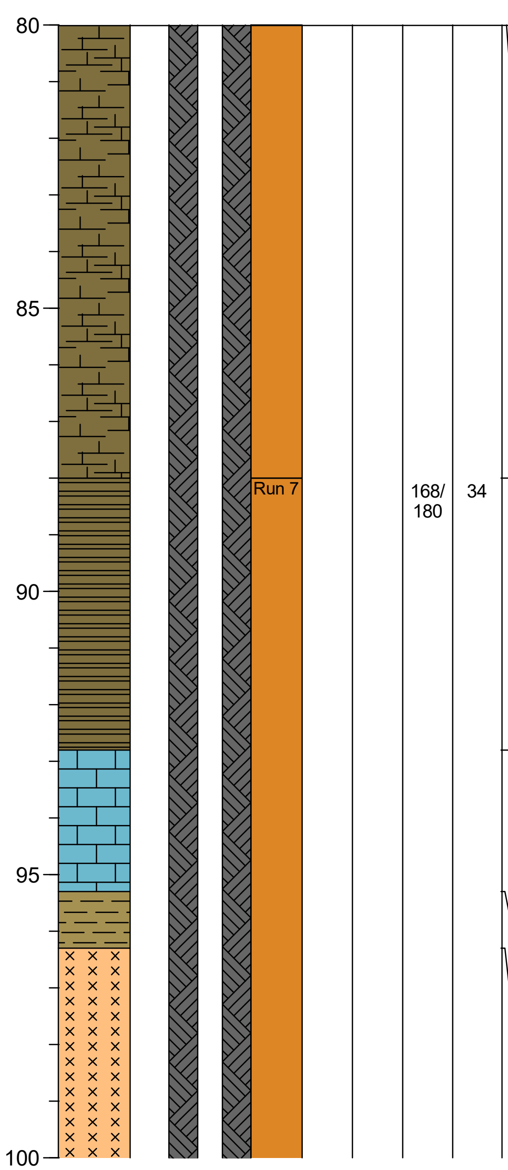
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. M-GS-1
Page: 5 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)



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.

(88') Sandy SHALE: strong, medium bluish gray (5B 5/1), fissile, fresh, competent, intensely fractured.

(89') Changes to massive.

(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)

(95.3') 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)

NOTES:

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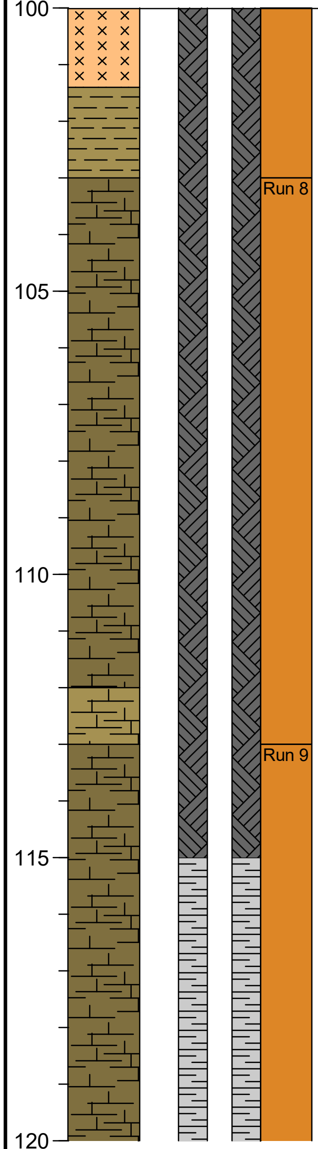
Drilling Start Date:	**03/11/2016 14:00**	Boring Depth (ft):	**198**	Well Depth (ft):	**132**
Drilling End Date:	**03/17/2016 15:00**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**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. (114.4') Thin coal veins occasionally appear.		
115											115
120											120

NOTES:

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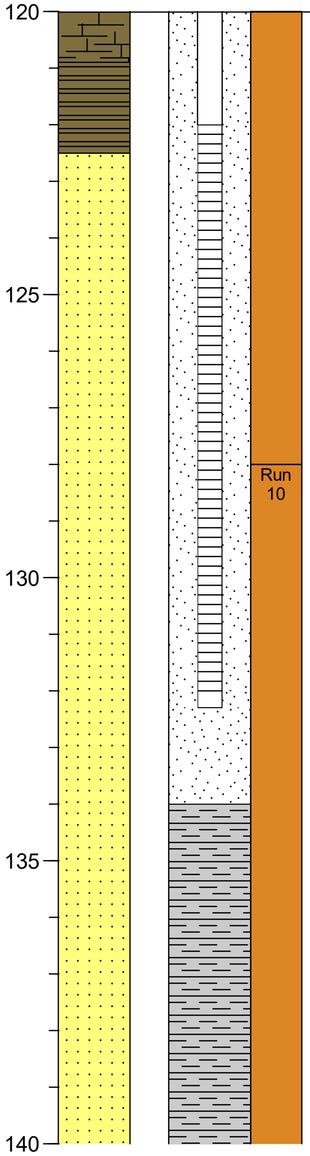
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. M-GS-1
Page: 7 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**



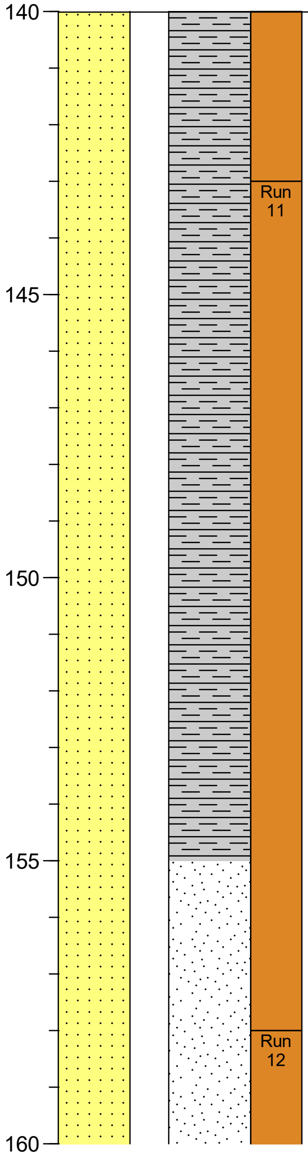
DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
120											120
									(120.9') Coal-bearing SHALE: very strong, grayish black (N2) to black (N1), massive, micaceous, fresh, 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:

Drilling Start Date: **03/11/2016 14:00**
Drilling End Date: **03/17/2016 15:00**
Drilling Company: **Layne Drilling**
Drilling Method: **Rock Core**
Drilling Equipment: **CS1500 Wireline Rig**
Driller: **Bill Womack**
Logged By: **Doug Mateas**

Boring Depth (ft): **198**
Boring Diameter (in): **6**
Sampling Method(s): **Rock Core**
DTW During Drilling (ft):
Ground Surface Elev. (ft): **988.68**
Top of Casing Elev. (ft): **991.87**
Location (X,Y): **N 832,687.2 E 2,518,763.6**

Well Depth (ft): **132**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Pre-packed Sch 40 PVC**
Seal Material(s): **Bentonite Pellets**
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									(142.5') Intensely fractured.		140
				Run 11			180/ 180	91	(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. (151.5') Coal veins appear again, slightly to moderately fractured for rest of Run 11. (153.4') Changes to light gray (N7).		
				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:

	Client: AEP-Cardinal **Project:** CHE8126L **Address:** 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-1** **Page: 9 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					SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
				Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)			
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
175				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
180											180

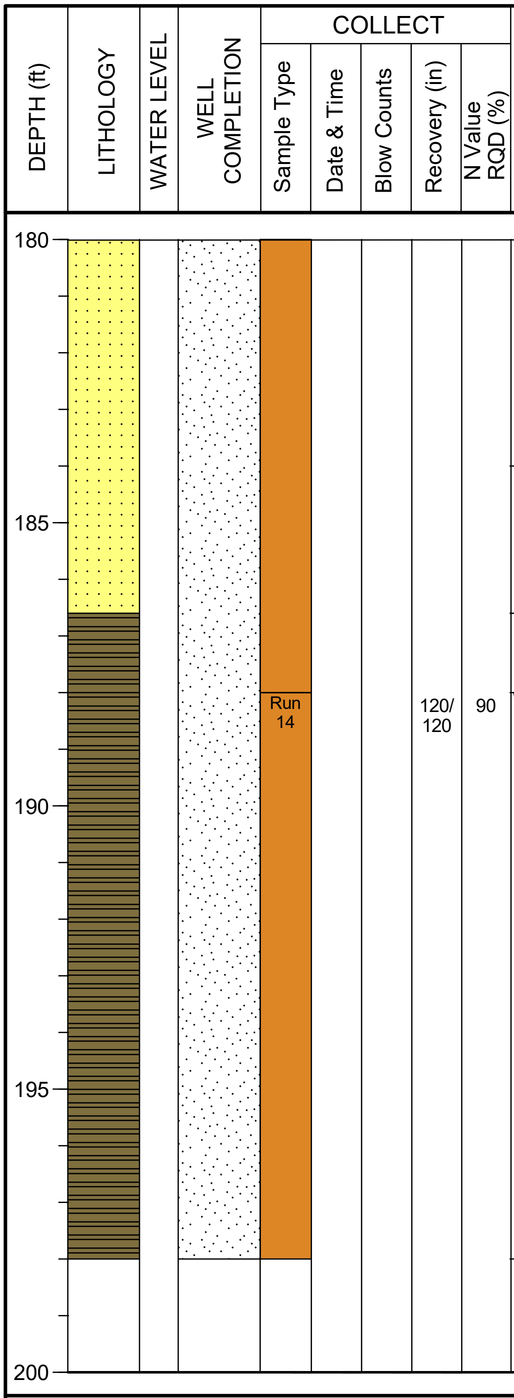
NOTES:

Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. M-GS-1

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**



SOIL/ROCK VISUAL DESCRIPTION

(181.5-188') Extensive coal veining.

(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.

(187.8') Limestone nodules.

(188') Silty SHALE: strong, greenish gray (5GY 6/1), fresh, competent, massive, slightly fractured, no limestone nodules.

End of borehole at 198 ft bgs.

Well installed on 04/13/2016, centralizer at 65 ft bgs.

REMARKS

DEPTH (ft)

NOTES:

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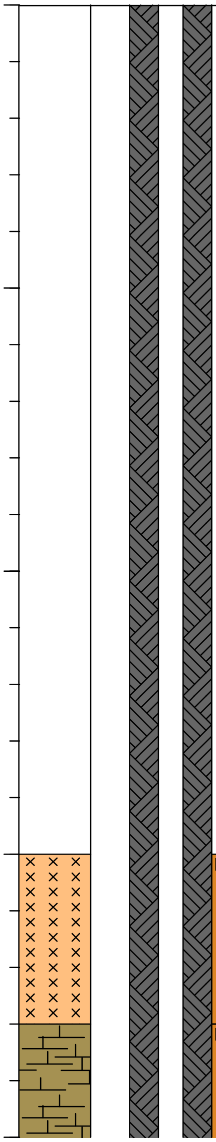
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. M-GS-2
Page: 1 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)
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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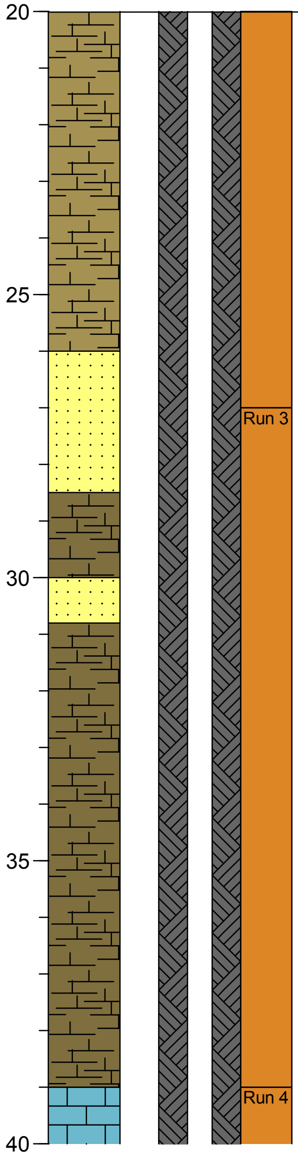
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. M-GS-2
Page: 2 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)	COLLECT Sample Type	Date & Time	Blow Counts	Recovery (in)	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:

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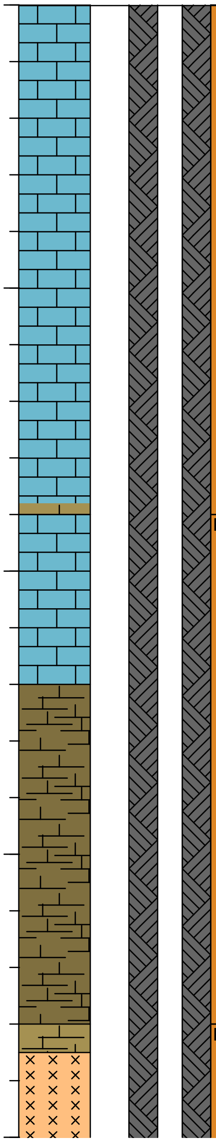
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. M-GS-2
Page: 3 of 11

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



DEPTH (ft)	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.		
50						(49') LIMESTONE: strong, medium dark gray (N4), nodular, massive, slightly fractured.		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:

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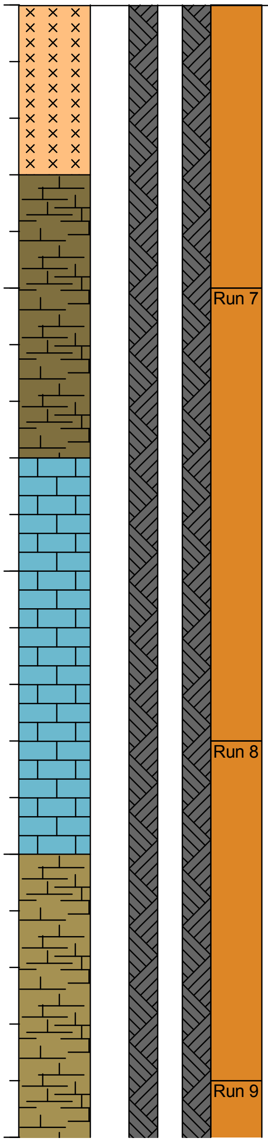
Drilling Start Date:	**03/22/2016 08:30**	Boring Depth (ft):	**209**	Well Depth (ft):	**140**
Drilling End Date:	**03/23/2016 09:45**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**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					SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
				Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)			
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:

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Client:	**AEP-Cardinal**
Project:	**CHE8126L**
Address:	**3202 Twp Rd 163, Brilliant, OH**

BORING LOG

Boring/Well No. **M-GS-2**
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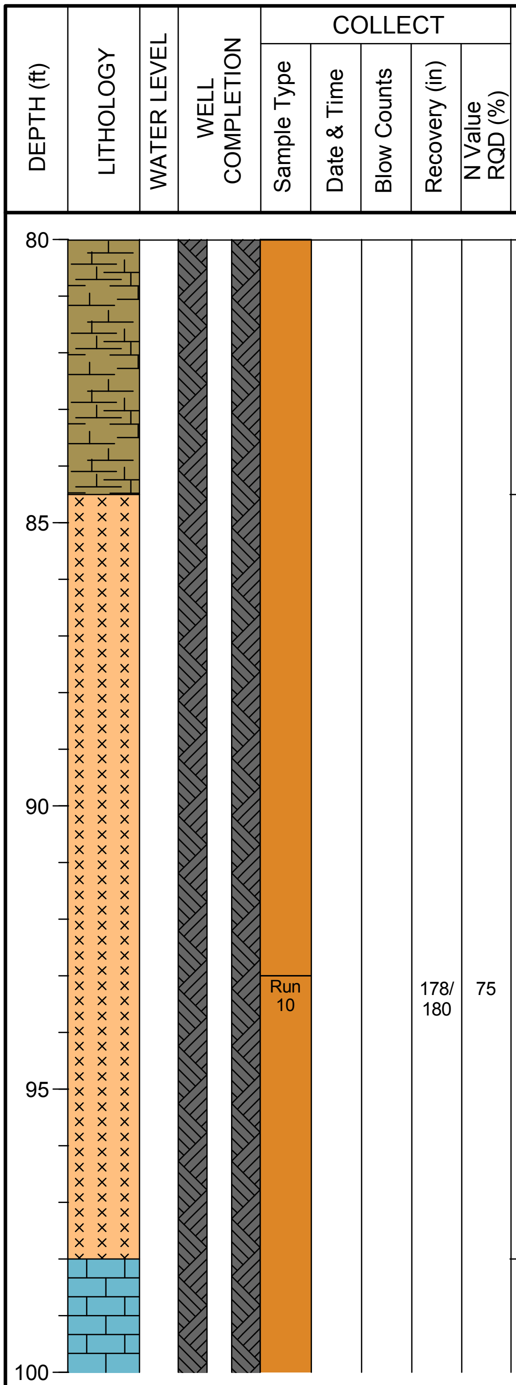
Drilling Start Date:	**03/22/2016 08:30**	Boring Depth (ft):	**209**	Well Depth (ft):	**140**
Drilling End Date:	**03/23/2016 09:45**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**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**



SOIL/ROCK VISUAL DESCRIPTION	REMARKS
(82-84.5') White to yellowish gray calcareous veins.	
(84.5') Shaly SILTSTONE: moderately strong, medium bluish gray (5B 5/1), slightly fractured, few calcareous veins - lenses, fresh. (93') Changing to strong. (95') Changing to moderately to intensely fractured, clay infillings, moderately decomposed 97-98 ft.	
(98') Shaly LIMESTONE: strong, massive, microcrystalline, nodular, medium bluish gray (5B 5/1), moderately fractured, slightly decomposed.	

NOTES:

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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. M-GS-2
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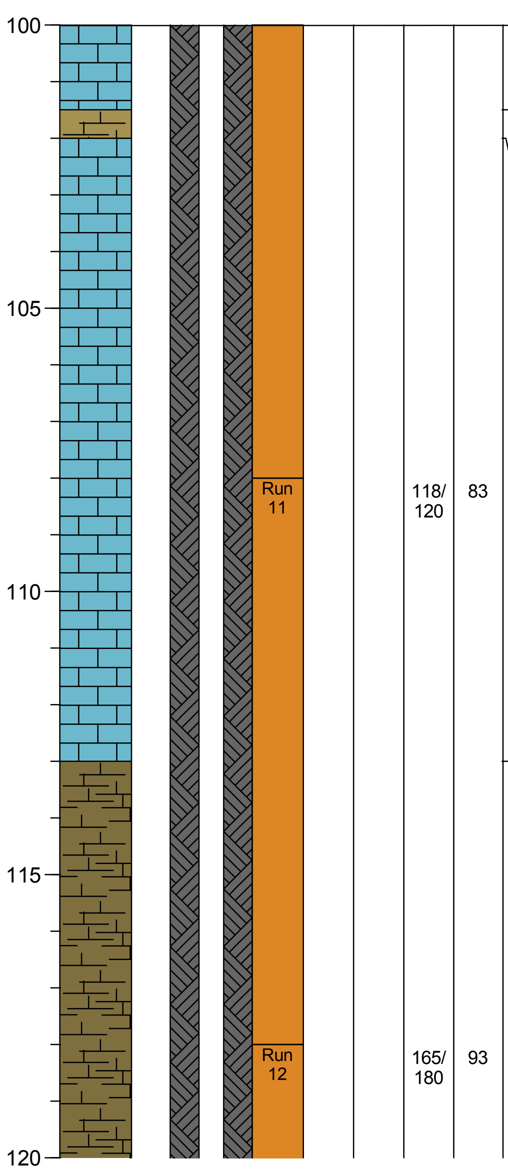
Drilling Start Date: **03/22/2016 08:30**
Drilling End Date: **03/23/2016 09:45**
Drilling Company: **Layne Drilling**
Drilling Method: **Rock Core**
Drilling Equipment: **CS1500 Wireline Rig**
Driller: **Bill Womack**
Logged By: **Chad Gregory**

Boring Depth (ft): **209**
Boring Diameter (in): **6**
Sampling Method(s): **Rock Core**
DTW During Drilling (ft):
Ground Surface Elev. (ft): **987.62**
Top of Casing Elev. (ft): **990.81**
Location (X,Y): **N 832,174.6 E 2,519,357.6**

Well Depth (ft): **140**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Pre-packed Sch 40 PVC**
Seal Material(s): **Bentonite Pellets**
Filter Pack: **#5 Medium Coarse Sand**



Sample Type	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS
			(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.	
Run 11	118/ 120	83		
			(113') CLAYSHALE: strong, medium dark gray (N4), calcareous, limestone nodules, moderately to intensely fractured, slightly pyritic, less calcareous towards end of run.	
			(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.	

DEPTH (ft): 100, 105, 110, 115, 120

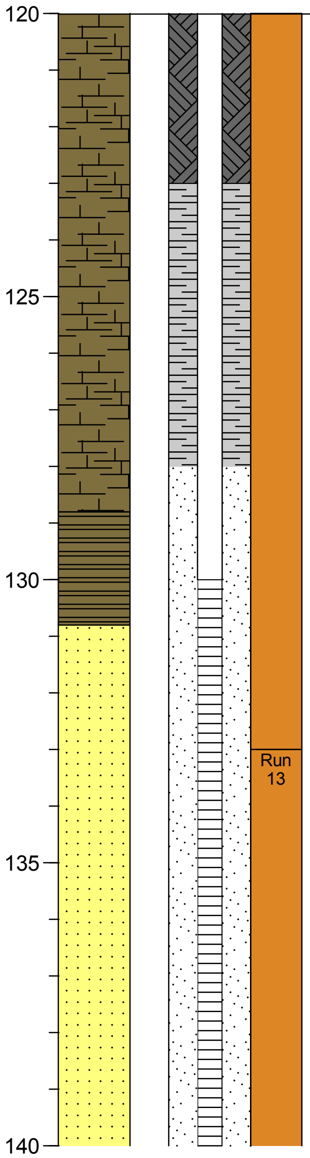
NOTES:

Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. M-GS-2

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)	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
124						(124') Changing to less calcareous.		
128.8						(128.8') Coal-bearing SHALE: strong, grayish black (N2), coal lenses black (N1), slightly fractured, slightly decomposed.		
130.8						(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]		
133	Run 13			192/ 192	100			

NOTES:

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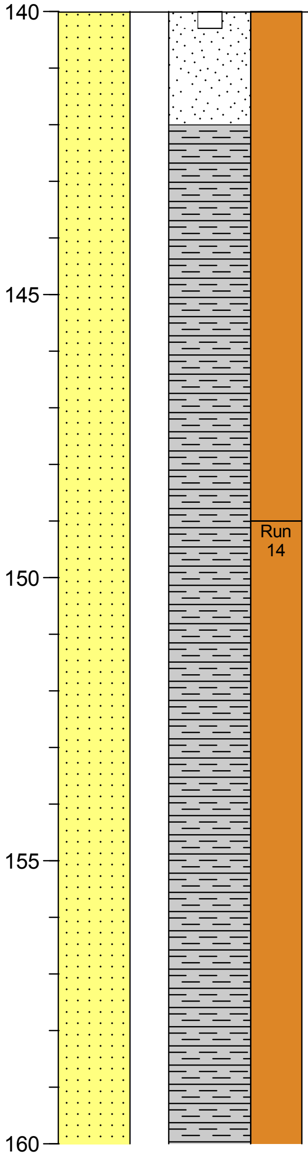
Client:	**AEP-Cardinal**
Project:	**CHE8126L**
Address:	**3202 Twp Rd 163, Brilliant, OH**

BORING LOG

Boring/Well No. **M-GS-2**
Page: **8 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					SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
				Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)			
140											140
145											145
				Run 14			180/ 180	98			
150											150
155											155
									(157-159') Mud inclusions.		
160											160

NOTES:

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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. M-GS-2
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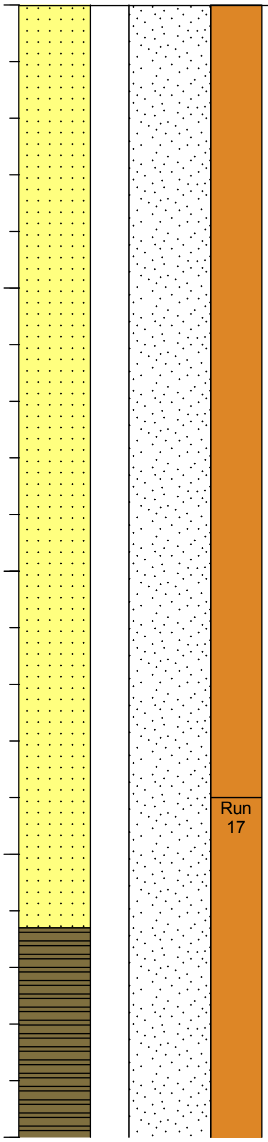
Drilling Start Date:	**03/22/2016 08:30**	Boring Depth (ft):	**209**	Well Depth (ft):	**140**
Drilling End Date:	**03/23/2016 09:45**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**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)
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:

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

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Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. M-GS-2
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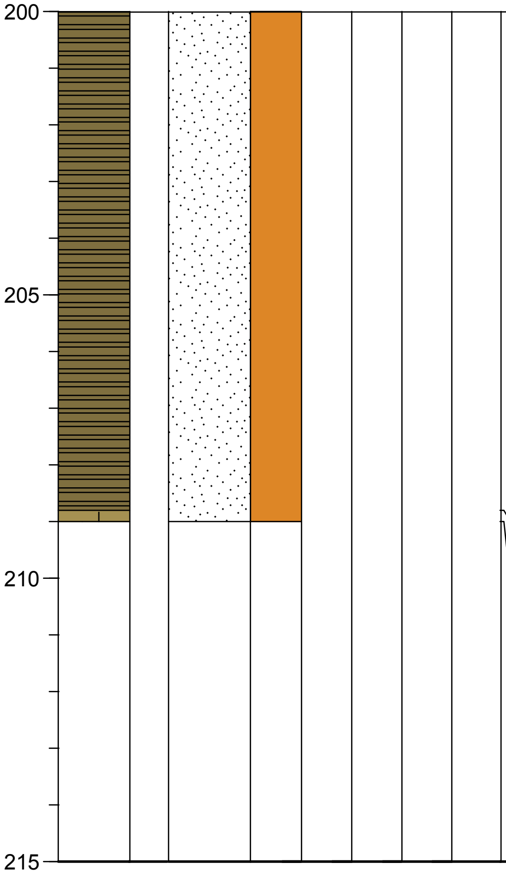
Drilling Start Date:	**03/22/2016 08:30**	Boring Depth (ft):	**209**	Well Depth (ft):	**140**
Drilling End Date:	**03/23/2016 09:45**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**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	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)



(208') Changing to intensely fractured, claystone infillings.

(208.8') CLAYSTONE: moderately strong to weak, dark gray (N3), crumbled.

End of borehole at 209 ft bgs.

Well installed on 04/13/2016, centralizer at 70 ft bgs.

200
205
210
215

NOTES:

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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

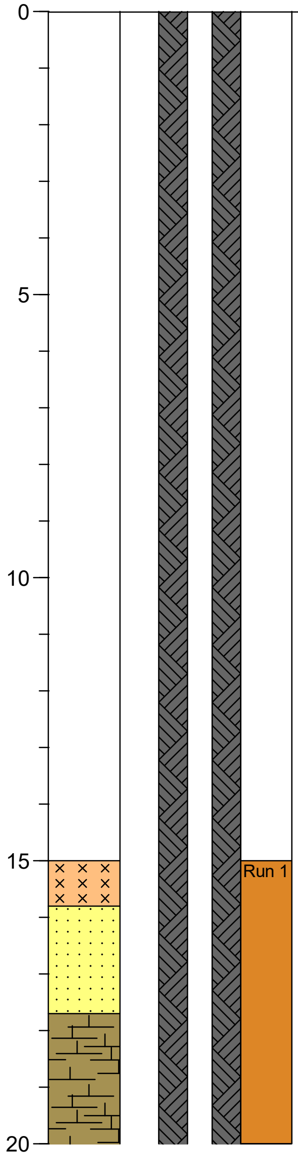
BORING LOG

Boring/Well No. M-GS-3
Page: 1 of 11

Drilling Start Date: **03/10/2016 10:25**
Drilling End Date: **03/11/2016 12:20**
Drilling Company: **Layne Drilling**
Drilling Method: **Rock Core**
Drilling Equipment: **CS1500 Wireline Rig**
Driller: **Bill Womack**
Logged By: **Doug Mateas**

Boring Depth (ft): **203.5**
Boring Diameter (in): **6**
Sampling Method(s): **Rock Core**
DTW During Drilling (ft):
Ground Surface Elev. (ft): **997.42**
Top of Casing Elev. (ft): **1,000.33**
Location (X,Y): **N 830,875.6 E 2,518,721.9**

Well Depth (ft): **146**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Pre-packed Sch 40 PVC**
Seal Material(s): **Bentonite Pellets**
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)
0									Overburden: No sample recovered with coring wireline rig.		0
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
									(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.		
20											20

NOTES:

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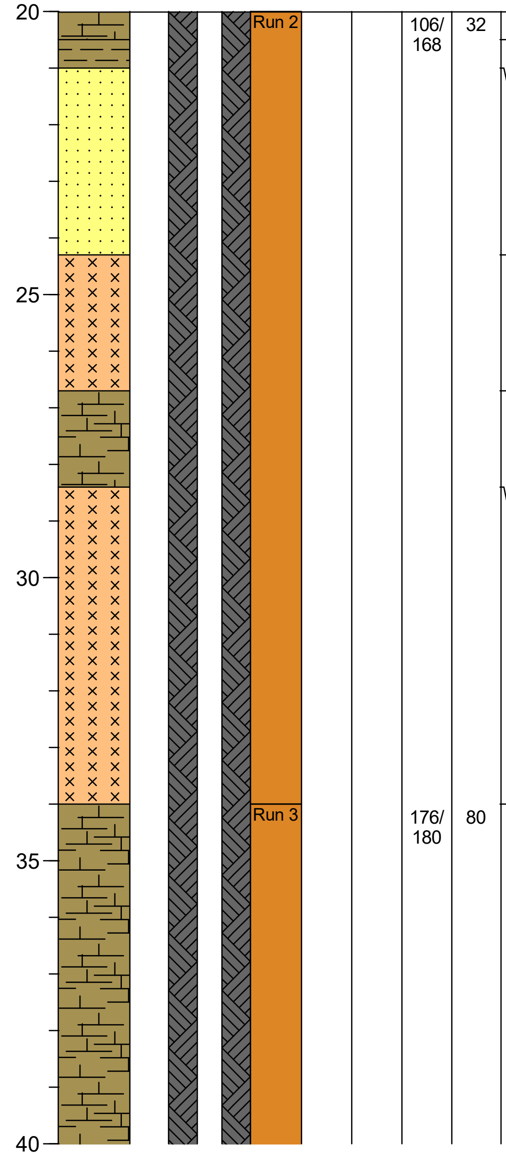
Client:	**AEP-Cardinal**
Project:	**CHE8126L**
Address:	**3202 Twp Rd 163, Brilliant, OH**

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)	Sample Type	Date & Time	Blow Counts	Recovery (in)	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.		
30						(28.4') SILTSTONE: moderately strong, greenish gray (5GY 6/1), massive, fresh to slightly decomposed, competent, moderately fractured.		30
35	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
40								40

NOTES:

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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. M-GS-3
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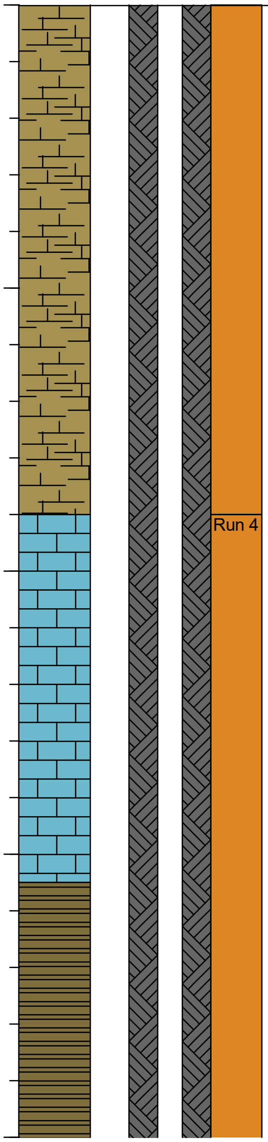
Drilling Start Date:	**03/10/2016 10:25**	Boring Depth (ft):	**203.5**	Well Depth (ft):	**146**
Drilling End Date:	**03/11/2016 12:20**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**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**

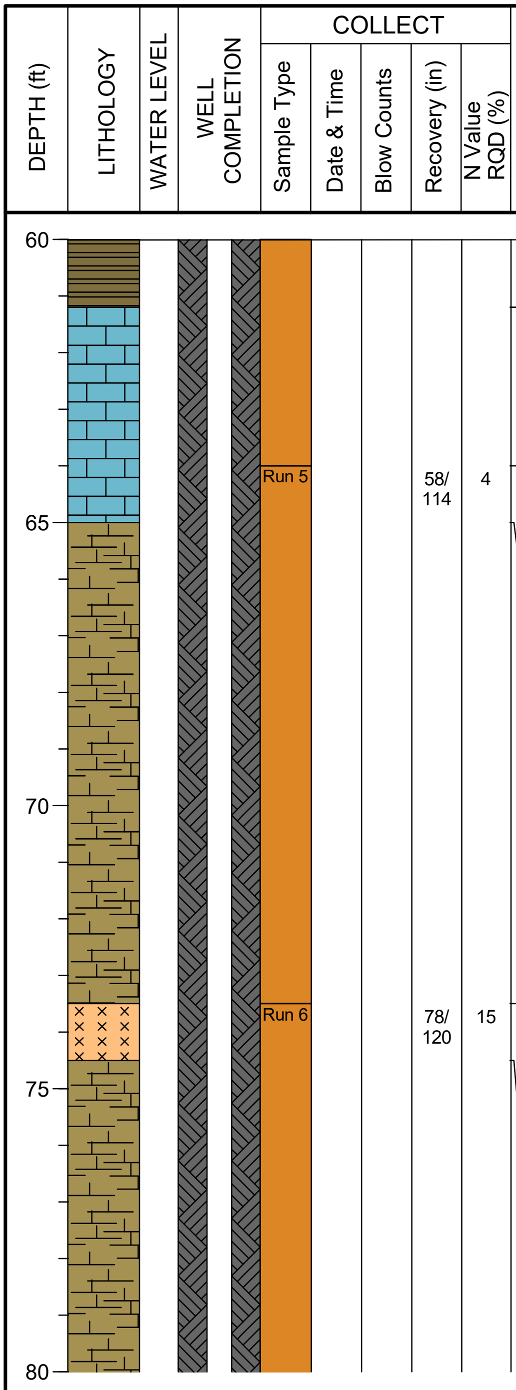


DEPTH (ft)	Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
40–49						(45.7') Becomes moderately to intensely fractured, slightly fissile. (46') Highly decomposed MUDSTONE (0.5 ft thick). (47.2') Highly decomposed MUDSTONE for 0.5 ft, very weak, medium dark gray.		40–49
49–55.5	Run 4			162/ 180	65	(49') LIMESTONE: very strong to strong, medium light gray (N6), microcrystalline, slightly fractured, fresh to slightly decomposed, competent.		49–55.5
55.5–60						(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.		55.5–60

Depth scale: 40, 45, 50, 55, 60

NOTES:

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					SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
				Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)			
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.		
									(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											75
									(77.6') Becomes highly decomposed, very intensely fractured.		
80											80

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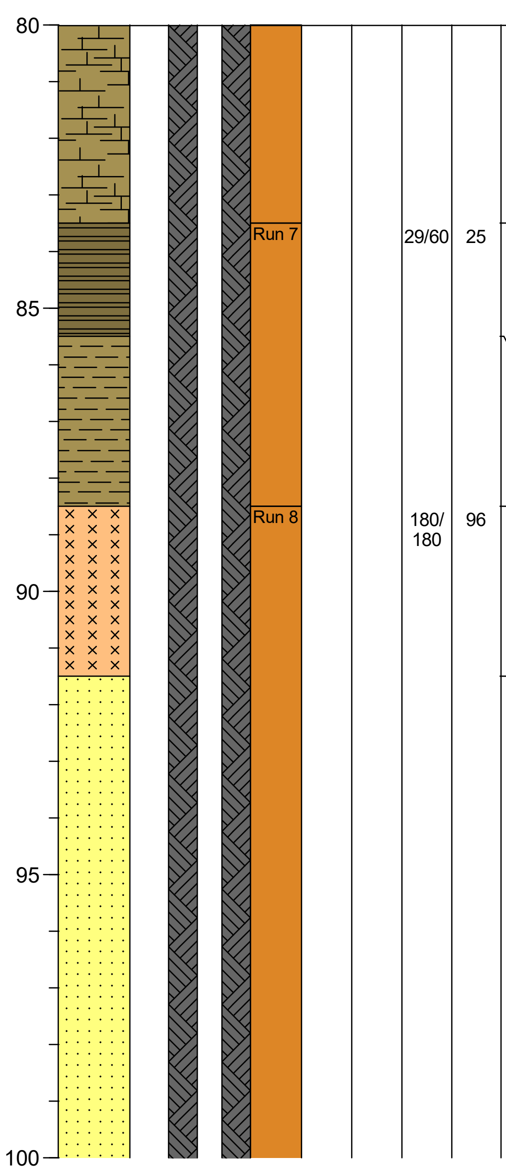
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

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)	Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
80								80
83.5	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.		
85.5						(85.5') MUDSTONE: dark greenish gray (5G 4/1), highly decomposed.		
88.5	Run 8			180/ 180	96	(88.5') SILTSTONE: strong, greenish gray (5G 6/1), massive, slightly decomposed, competent, slightly to moderately fractured.		
91.5						(91.5') Silty SANDSTONE: strong, greenish gray (5G 6/1), massive, fresh, competent, unfractured to slightly fractured, fine grained.		
100								100

NOTES:

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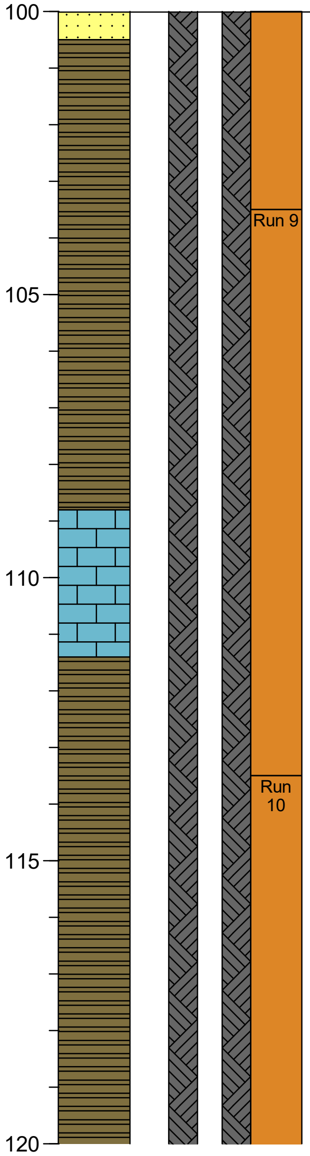
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

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)	Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS
100.5						(100.5') Sandy SHALE to SILTSTONE: strong, greenish gray (5G 6/1), massive, fresh, competent, unfractured to slightly fractured, fine grained, less sand content.	
103.5	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)
108.8						(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.	
111.4						(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.	
113.5	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. (119') Intensely fractured, moderately decomposed.	

NOTES:

Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

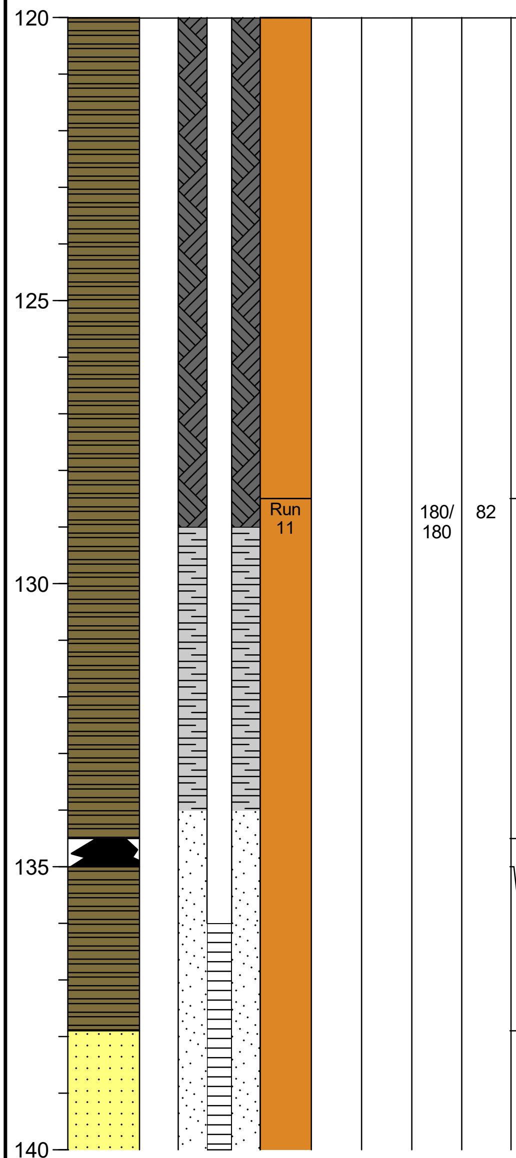
BORING LOG

Boring/Well No. M-GS-3

Drilling Start Date: **03/10/2016 10:25**
Drilling End Date: **03/11/2016 12:20**
Drilling Company: **Layne Drilling**
Drilling Method: **Rock Core**
Drilling Equipment: **CS1500 Wireline Rig**
Driller: **Bill Womack**
Logged By: **Doug Mateas**

Boring Depth (ft): **203.5**
Boring Diameter (in): **6**
Sampling Method(s): **Rock Core**
DTW During Drilling (ft):
Ground Surface Elev. (ft): **997.42**
Top of Casing Elev. (ft): **1,000.33**
Location (X,Y): **N 830,875.6 E 2,518,721.9**

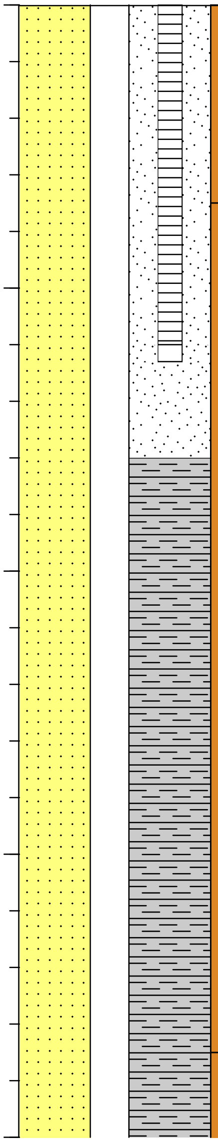
Well Depth (ft): **146**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Pre-packed Sch 40 PVC**
Seal Material(s): **Bentonite Pellets**
Filter Pack: **#5 Medium Coarse Sand**



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
									(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.		135
									(137.9') SANDSTONE: strong, medium dark gray (N4), medium grained, very micaceous, minor cross bedding, fresh, competent, unfractured. [MORGANTOWN]		
140											140

NOTES:

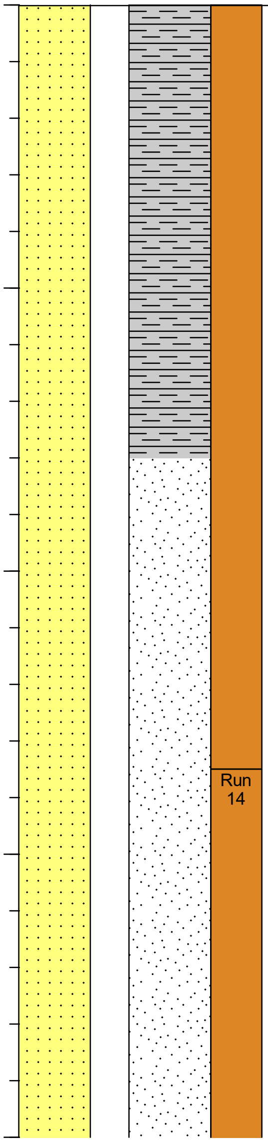
Drilling Start Date:	**03/10/2016 10:25**	Boring Depth (ft):	**203.5**	Well Depth (ft):	**146**
Drilling End Date:	**03/11/2016 12:20**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**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)	Sample Type	Date & Time	Blow Counts	Recovery (in)	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:

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
									(173') 0.2 ft layer of COAL.		
				Run 14			179/ 180	97	(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:

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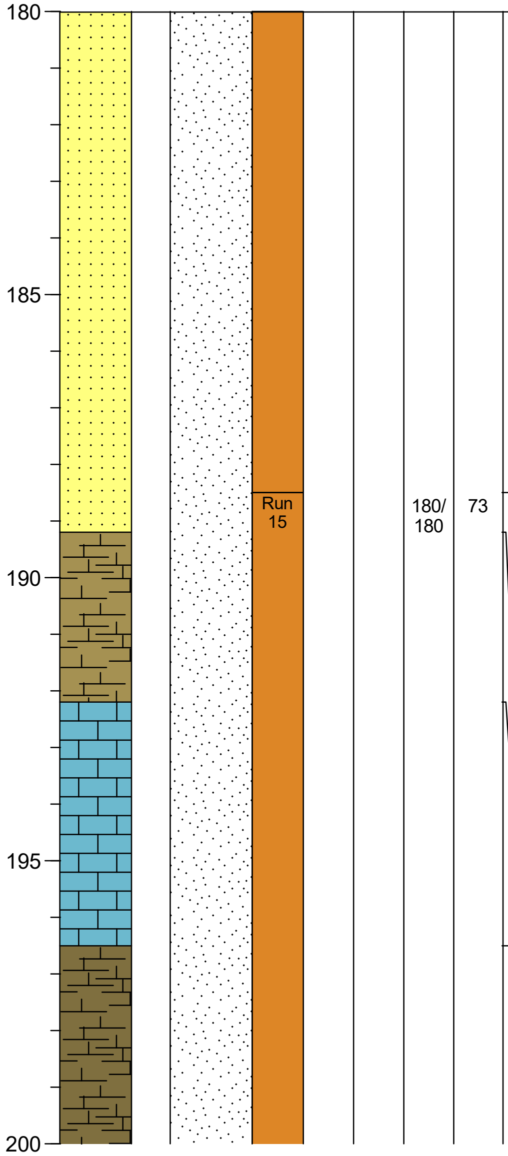
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. M-GS-3
Page: 10 of 11

Drilling Start Date: **03/10/2016 10:25**
Drilling End Date: **03/11/2016 12:20**
Drilling Company: **Layne Drilling**
Drilling Method: **Rock Core**
Drilling Equipment: **CS1500 Wireline Rig**
Driller: **Bill Womack**
Logged By: **Doug Mateas**

Boring Depth (ft): **203.5**
Boring Diameter (in): **6**
Sampling Method(s): **Rock Core**
DTW During Drilling (ft):
Ground Surface Elev. (ft): **997.42**
Top of Casing Elev. (ft): **1,000.33**
Location (X,Y): **N 830,875.6 E 2,518,721.9**

Well Depth (ft): **146**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Pre-packed Sch 40 PVC**
Seal Material(s): **Bentonite Pellets**
Filter Pack: **#5 Medium Coarse Sand**



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT					SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
				Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)			
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											185
									(186.4') 0.3 ft of imbedded conglomerate.		
				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											190
									(189.2') CLAYSTONE: moderately strong, dark bluish greenish gray, intensely fractured, moderately decomposed, moderately disintegrated, clay infillings in fractures, massive.		
									(192.2') LIMESTONE: moderately strong to strong, dark greenish gray (5G 4/1), fresh, competent, slightly fractured, microcrystalline, massive.		
195											195
									(196.5') CLAYSHALE: strong, greenish gray (5G 6/1), massive, slickensides, slightly decomposed, competent, slightly fractured, with carbonaceous prominent nodules and veins.		
200											200

NOTES:

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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

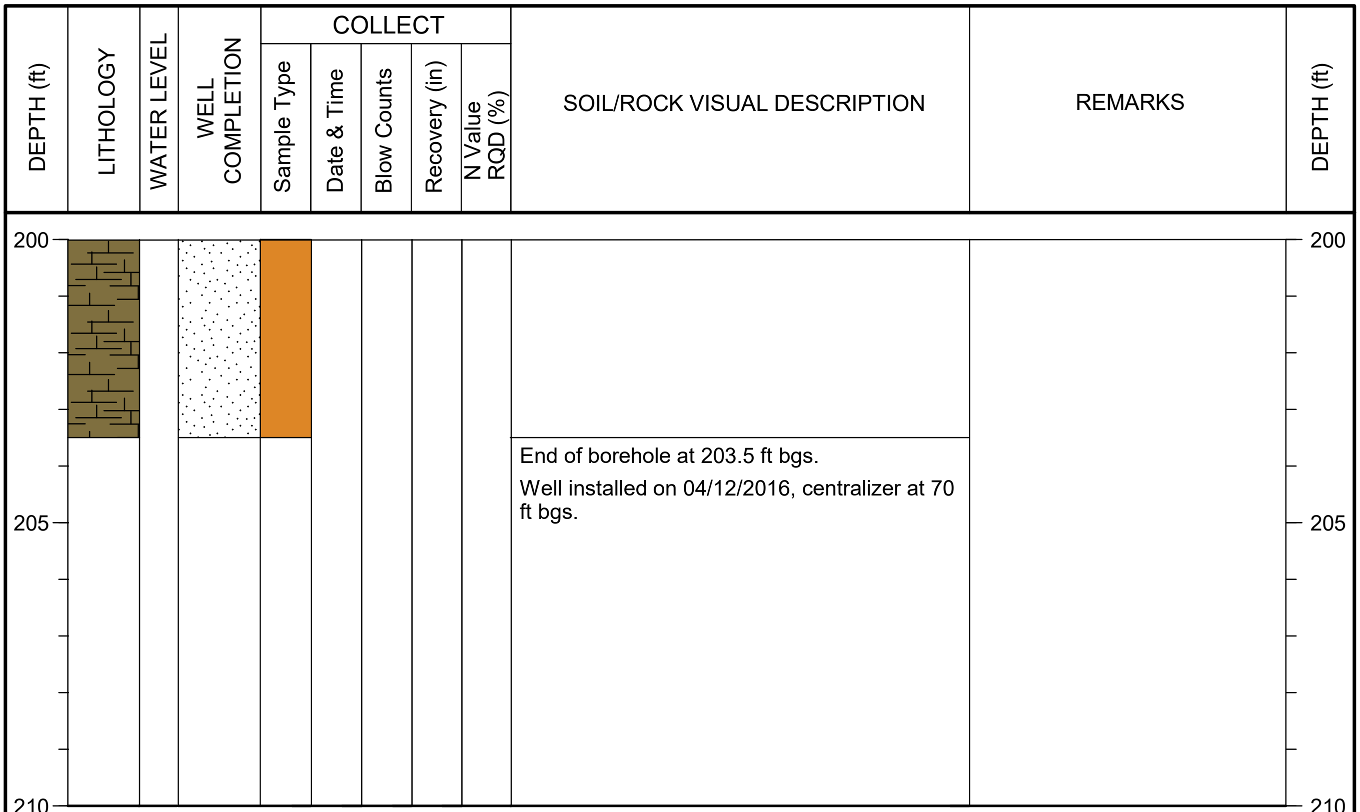
BORING LOG

Boring/Well No. M-GS-3
Page: 11 of 11

Drilling Start Date: **03/10/2016 10:25**
Drilling End Date: **03/11/2016 12:20**
Drilling Company: **Layne Drilling**
Drilling Method: **Rock Core**
Drilling Equipment: **CS1500 Wireline Rig**
Driller: **Bill Womack**
Logged By: **Doug Mateas**

Boring Depth (ft): **203.5**
Boring Diameter (in): **6**
Sampling Method(s): **Rock Core**
DTW During Drilling (ft):
Ground Surface Elev. (ft): **997.42**
Top of Casing Elev. (ft): **1,000.33**
Location (X,Y): **N 830,875.6 E 2,518,721.9**

Well Depth (ft): **146**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Pre-packed Sch 40 PVC**
Seal Material(s): **Bentonite Pellets**
Filter Pack: **#5 Medium Coarse Sand**



End of borehole at 203.5 ft bgs.

Well installed on 04/12/2016, centralizer at 70 ft bgs.

NOTES:

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Client: AEP-Cardinal		**BORING LOG**
Project: CHE8126L		**Boring/Well No.** M-GS-4
Address: 3202 Twp Rd 163, Brilliant, OH		**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					SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
				Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)			
0									Overburden: No sample recovered with wireline coring rig.		0
5											5
10											10
15											15
20											20

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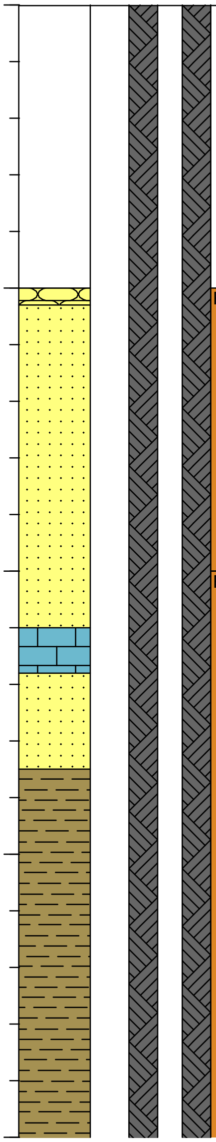
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. M-GS-4

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)	COLLECT Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS
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.
						(25.3') 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		
						(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.	
						(33.5') MUDSTONE: very weak, light gray (N7), planar structure, intensely fractured, highly decomposed, highly disintegrated.	
35							
40							

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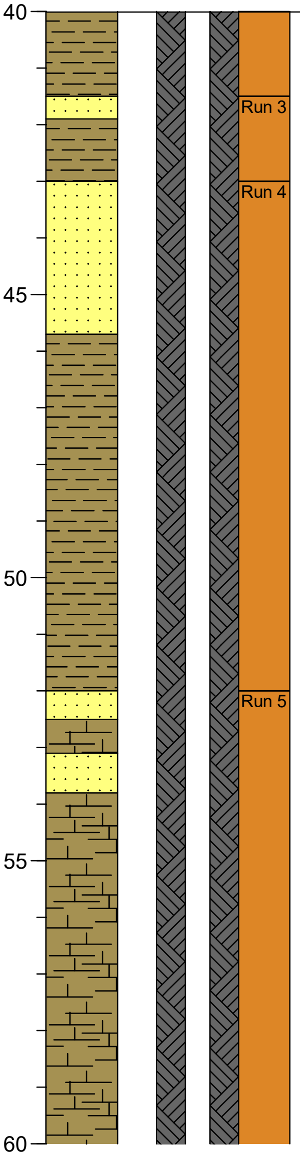
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. M-GS-4
Page: 3 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)	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
50						(45.7') MUDSTONE: very weak, light gray (N7), planar structure, very intensely fractured, highly decomposed, highly disintegrated.		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

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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. M-GS-4
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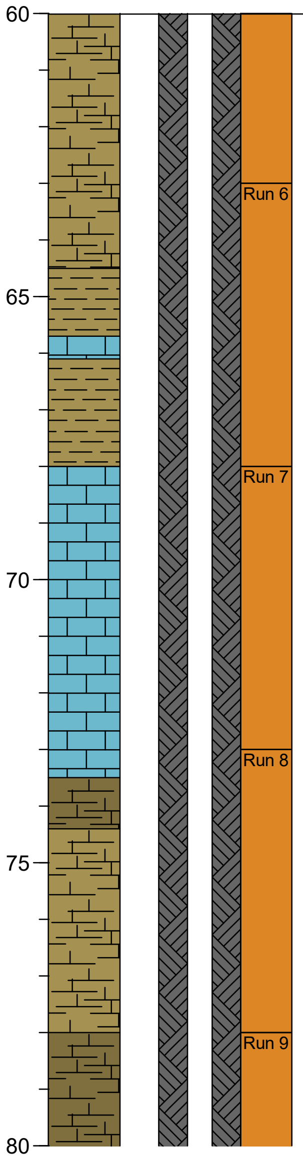
Drilling Start Date:	**03/13/2016 07:45**	Boring Depth (ft):	**228**	Well Depth (ft):	**202**
Drilling End Date:	**03/14/2016 12:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**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)	Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)
63.2	Run 6			49/60	0
68.2	Run 7			51/60	19
73.2	Run 8			28/60	0
78.2	Run 9			180/ 180	48

SOIL/ROCK VISUAL DESCRIPTION

gray (5G 6/1), massive, imbedded conglomerate, unfractured, moderately decomposed, moderately disintegrated, becomes fissile in bottom 0.5 ft.

(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.

(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.

(64') Becomes fissile, weak.

(64.5') MUDSTONE: very weak, light gray (N7), planar structure, very intensely fractured, highly decomposed, highly disintegrated.

(65.7') LIMESTONE.

(66.1') MUDSTONE: very weak, light gray (N7), planar structure, very intensely fractured, highly decomposed, highly disintegrated.

(68') LIMESTONE: strong, olive gray (5Y 4/1), massive, microcrystalline, intensely fractured, slightly decomposed, slightly disintegrated.

(69.5') 1 ft vertical fracture.

(73') LIMESTONE: strong, olive gray (5Y 4/1), massive, microcrystalline, intensely fractured, slightly decomposed, slightly disintegrated.

(73.5') CLAYSHALE: very strong, dark greenish gray (5G 4/1), massive, slickensides, intensely fractured, slightly decomposed, slightly disintegrated, calcareous nodules.

(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.

(78') CLAYSHALE: very strong to strong, dark greenish gray (5G 4/1), massive, fresh to slightly decomposed, competent to slightly

REMARKS

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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. M-GS-4
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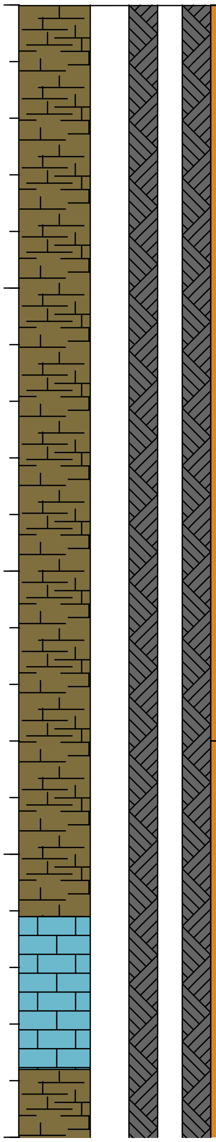
Drilling Start Date:	**03/13/2016 07:45**	Boring Depth (ft):	**228**	Well Depth (ft):	**202**
Drilling End Date:	**03/14/2016 12:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**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)
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
									(98.8') CLAYSHALE: strong, dark greenish gray (5G 4/1), massive, intensely fractured,		
100											100

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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**
Drilling End Date: **03/14/2016 12:30**
Drilling Company: **Layne Drilling**
Drilling Method: **Rock Core**
Drilling Equipment: **CS1500 Wireline Rig**
Driller: **Bill Womack**
Logged By: **Doug Mateas**

Boring Depth (ft): **228**
Boring Diameter (in): **6**
Sampling Method(s): **Rock Core**
DTW During Drilling (ft):
Ground Surface Elev. (ft): **1,025.65**
Top of Casing Elev. (ft): **1,028.73**
Location (X,Y): **N 834,146.7 E 2,517,597.8**

Well Depth (ft): **202**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Pre-packed Sch 40 PVC**
Seal Material(s): **Bentonite Pellets**
Filter Pack: **#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT					SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
				Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)			
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
									(105.4') LIMESTONE: strong, medium gray (N5), massive, microcrystalline, slightly fractured, competent, fresh.		
									(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

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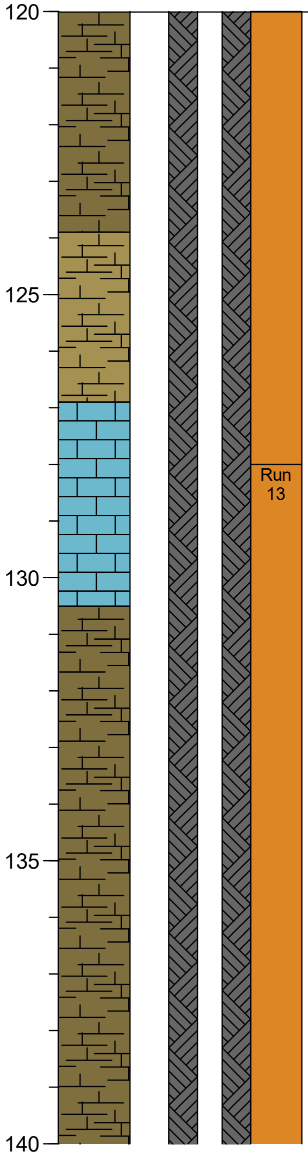
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. M-GS-4

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**



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

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Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. M-GS-4
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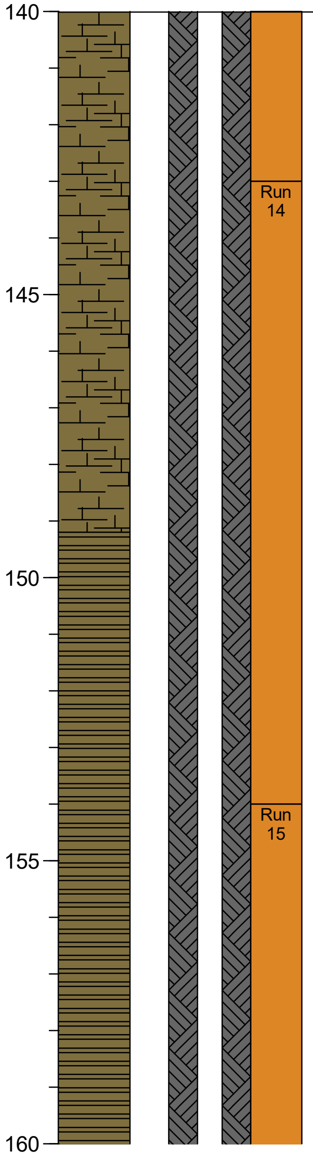
Drilling Start Date:	**03/13/2016 07:45**	Boring Depth (ft):	**228**	Well Depth (ft):	**202**
Drilling End Date:	**03/14/2016 12:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**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)	Sample Type	Date & Time	Blow Counts	Recovery (in)	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
155	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
160								160

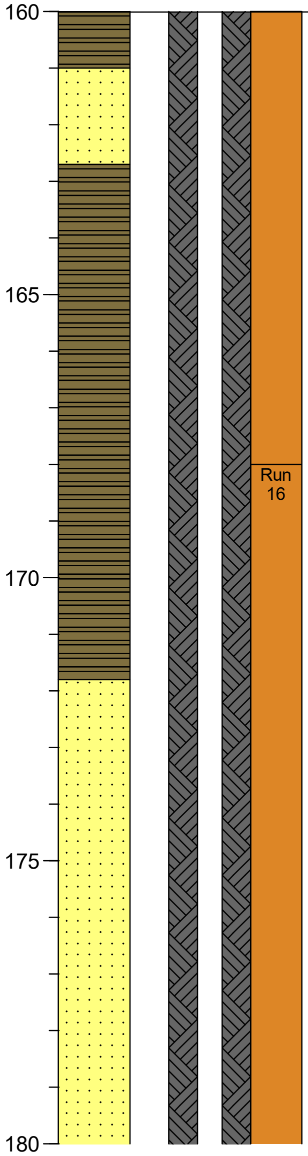
NOTES:

Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. M-GS-4

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)	COLLECT Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS
161						(161') SANDSTONE: strong, medium light gray (N6), some grayish black laminations (shale or coal), micaceous, slightly fractured, fine grained, fresh, competent.	
162.7						(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. (165.2') 0.3 ft vertical fracture.	
168	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.	
171.8						(171.8') SANDSTONE: strong, medium gray (N5), fine grained, micaceous, massive, weak coal veins, slightly fractured, fresh, competent, mud inclusions.	

NOTES:

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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. M-GS-4
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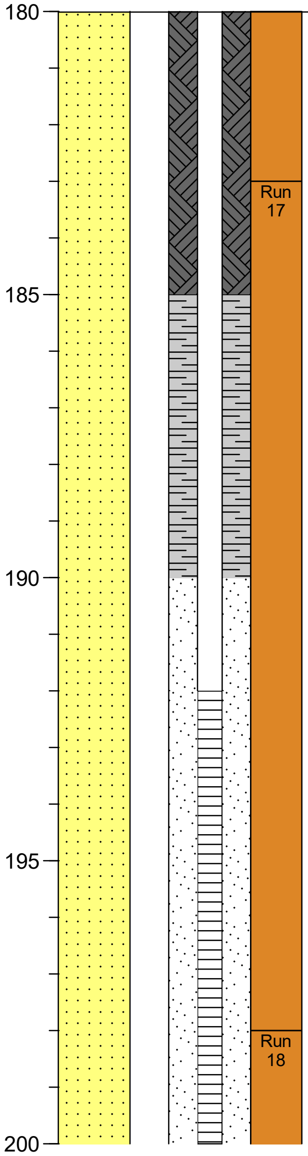
Drilling Start Date:	**03/13/2016 07:45**	Boring Depth (ft):	**228**	Well Depth (ft):	**202**
Drilling End Date:	**03/14/2016 12:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**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)	Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
183	Run 17			180/ 180	93	(183') SANDSTONE: strong, medium gray (N5), fine grained, micaceous, massive, weak coal veins, slightly fractured, fresh, competent.		
187.4						(187.4') Becomes medium grained.		
188.8						(188.8') Becomes moderately fractured.		
192.5						(192.5') Coal veins increase for rest of run.		
196.3						(196.3') Mud inclusions begin to appear.		
198.3	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,		

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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. M-GS-4
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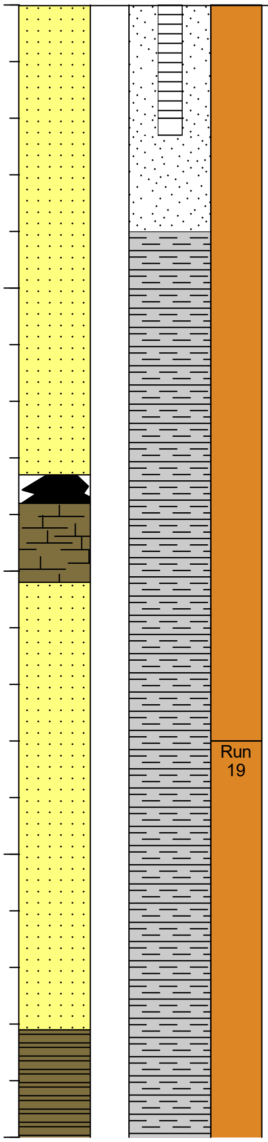
Drilling Start Date: **03/13/2016 07:45**
Drilling End Date: **03/14/2016 12:30**
Drilling Company: **Layne Drilling**
Drilling Method: **Rock Core**
Drilling Equipment: **CS1500 Wireline Rig**
Driller: **Bill Womack**
Logged By: **Doug Mateas**

Boring Depth (ft): **228**
Boring Diameter (in): **6**
Sampling Method(s): **Rock Core**
DTW During Drilling (ft):
Ground Surface Elev. (ft): **1,025.65**
Top of Casing Elev. (ft): **1,028.73**
Location (X,Y): **N 834,146.7 E 2,517,597.8**

Well Depth (ft): **202**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Pre-packed Sch 40 PVC**
Seal Material(s): **Bentonite Pellets**
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									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
				Run 19			180/ 180	93	(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.		
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

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Client:	**AEP-Cardinal**
Project:	**CHE8126L**
Address:	**3202 Twp Rd 163, Brilliant, OH**

BORING LOG

Boring/Well No. **M-GS-4**

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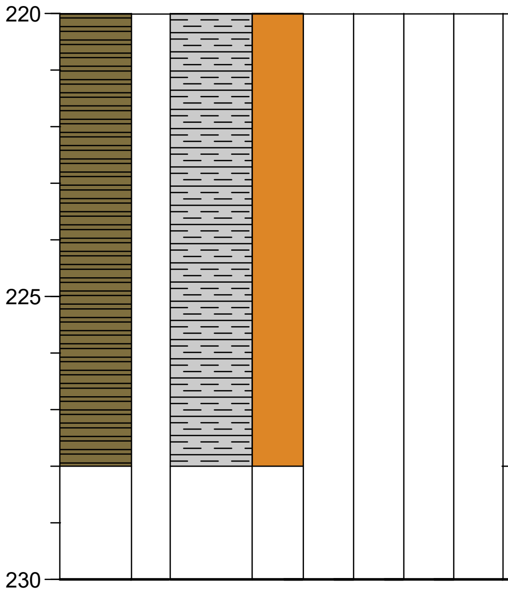
Drilling Start Date:	**03/13/2016 07:45**	Boring Depth (ft):	**228**	Well Depth (ft):	**202**
Drilling End Date:	**03/14/2016 12:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**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					SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
				Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)			



End of borehole at 228 ft bgs.
Well installed on 04/21/2016

NOTES:

Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. M-GS-5
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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					SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
				Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)			
0									Overburden: No sample recovered with wireline coring rig.		0
5											5
10											10
15											15
20											20

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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. M-GS-5
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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

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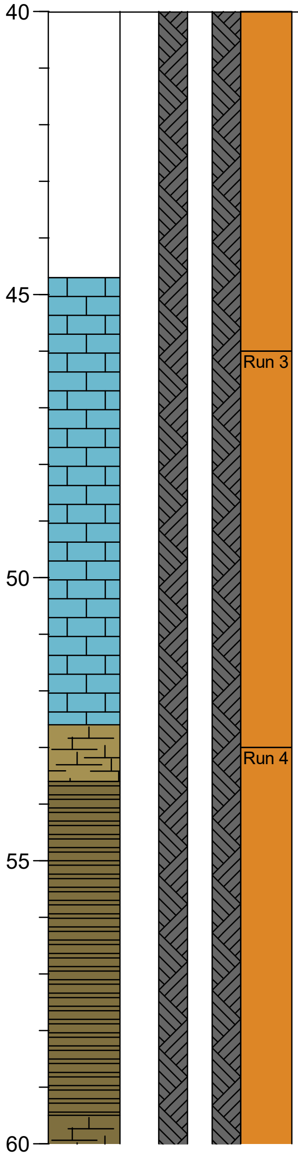
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. M-GS-5

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**



COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS
					End of overburden, begin bedrock.	
Run 3			84/84	69	(44.7') LIMESTONE: strong, greenish black (5GY 2/1), microcrystalline, moderately fractured, slightly decomposed, slightly disintegrated, clay in fractures.	
Run 4			175/ 180	78	(52.6') CLAYSTONE: very weak, medium dark gray (N4), massive, highly decomposed, highly disintegrated, intensely fractured.	
					(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.	
					(59.5') CLAYSHALE: strong, medium dark	

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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. M-GS-5
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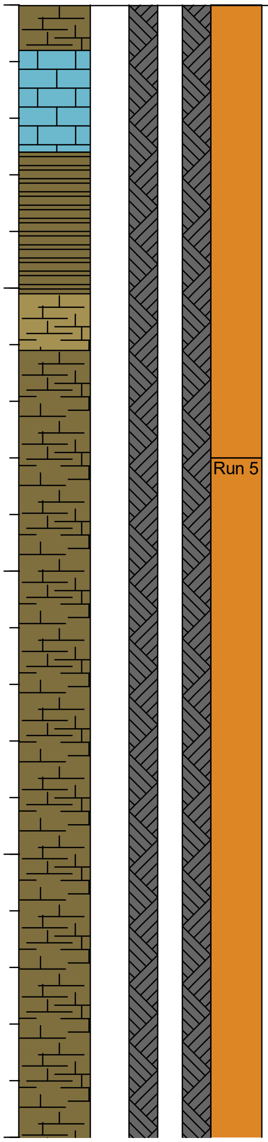
Drilling Start Date: **03/14/2016 14:45**
Drilling End Date: **03/16/2016 09:30**
Drilling Company: **Layne Drilling**
Drilling Method: **Rock Core**
Drilling Equipment: **CS1500 Wireline Rig**
Driller: **Bill Womack**
Logged By: **Doug Mateas**

Boring Depth (ft): **233**
Boring Diameter (in): **6**
Sampling Method(s): **Rock Core**
DTW During Drilling (ft):
Ground Surface Elev. (ft): **1,036.92**
Top of Casing Elev. (ft): **1,039.54**
Location (X,Y): **N 835,739.3 E 2,511,662.3**

Well Depth (ft): **224**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Pre-packed Sch 40 PVC**
Seal Material(s): **Bentonite Pellets**
Filter Pack: **#5 Medium Coarse Sand**



DEPTH (ft)	Sample Type	Date & Time	Blow Counts	Recovery (in)	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								70
						(71.5') Highly decomposed.		
75								75
						(78.8') Sandy SHALE: laminated.		
80								80

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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. M-GS-5
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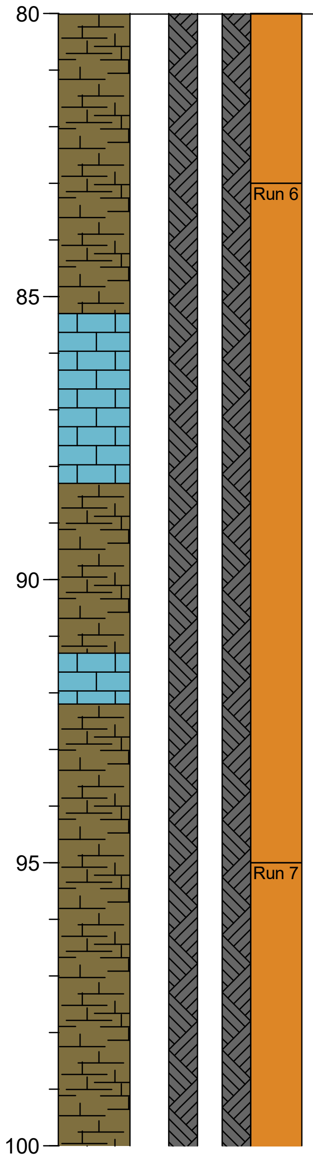
Drilling Start Date:	**03/14/2016 14:45**	Boring Depth (ft):	**233**	Well Depth (ft):	**224**
Drilling End Date:	**03/16/2016 09:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**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)
80											80
									(81') Limestone nodules increase.		
				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.		
90									(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
									(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

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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. M-GS-5
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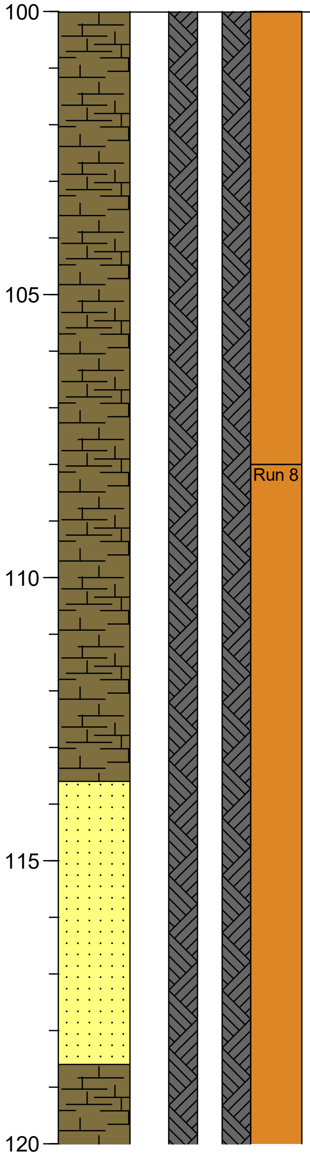
Drilling Start Date:	**03/14/2016 14:45**	Boring Depth (ft):	**233**	Well Depth (ft):	**224**
Drilling End Date:	**03/16/2016 09:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**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
				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.		
									(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).		
									(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

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Client: AEP-Cardinal
Project: CHE8126L
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BORING LOG
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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
									(136.8') Silty SHALE: strong, medium dark gray (N4), massive, competent, fresh, moderately fractured, abundant limestone nodules.		
				Run 10			176/ 180	87	(138') Silty SHALE: strong, medium dark gray (N4) to dark gray (N3), massive, competent, fresh, slightly to moderately fractured,		
140											140

NOTES:

Client:	**AEP-Cardinal**
Project:	**CHE8126L**
Address:	**3202 Twp Rd 163, Brilliant, OH**

BORING LOG

Boring/Well No. **M-GS-5**

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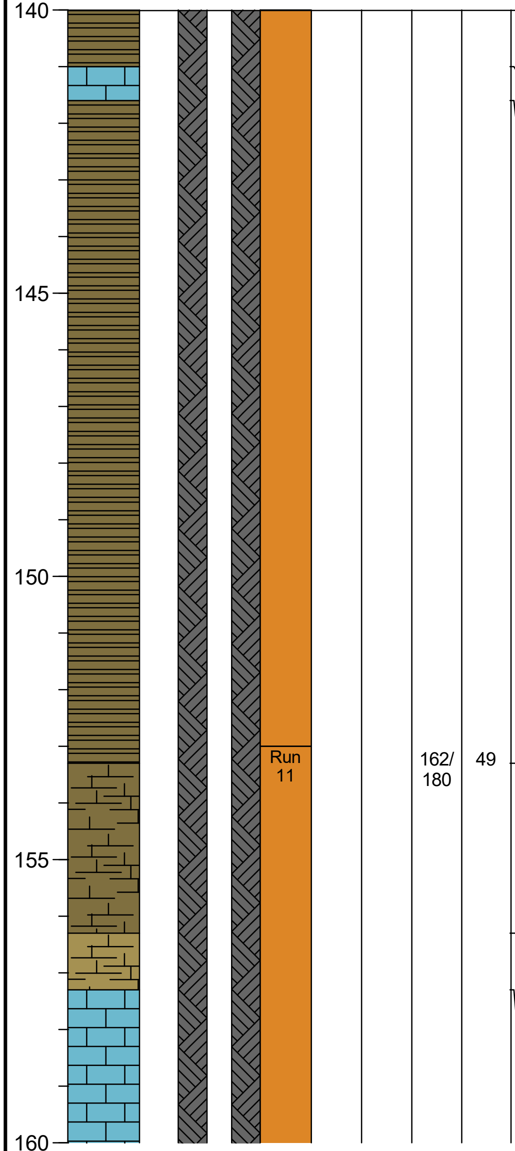
Drilling Start Date:	**03/14/2016 14:45**	Boring Depth (ft):	**233**	Well Depth (ft):	**224**
Drilling End Date:	**03/16/2016 09:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**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)
140									abundant limestone nodules.		140
									(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.		
145											145
150											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.		
155											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,		
160											160



NOTES:

Geosyntec consultants
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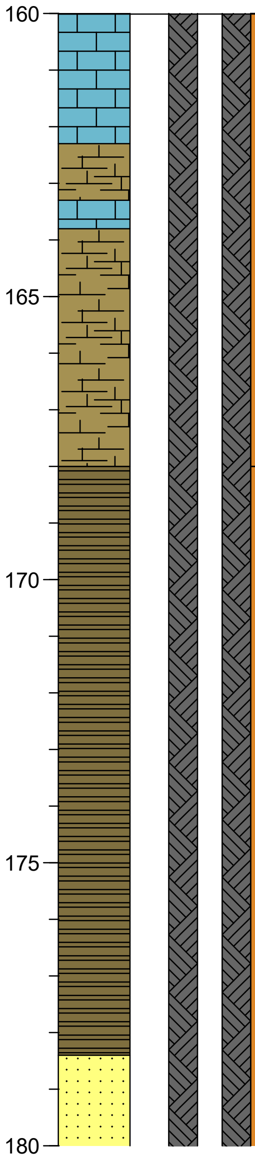
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

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)	Sample Type	Date & Time	Blow Counts	Recovery (in)	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.		
						(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.		165
	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
175						(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
180						(178.4') SANDSTONE: strong, medium light gray (N6), fine grained, micaceous, cross-bedded, competent, fresh, mud		180

NOTES:

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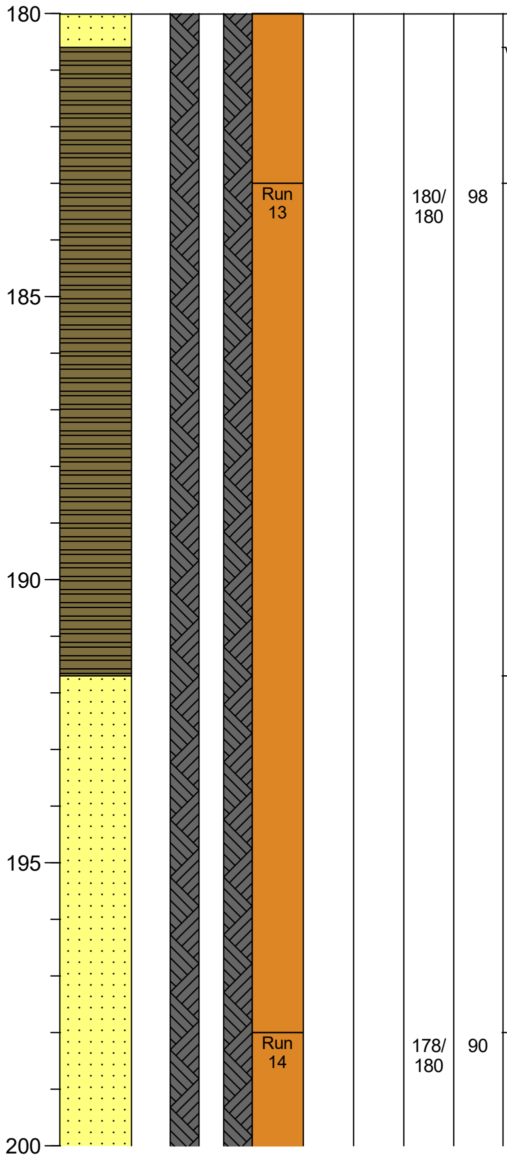
Client:	**AEP-Cardinal**
Project:	**CHE8126L**
Address:	**3202 Twp Rd 163, Brilliant, OH**

BORING LOG

Boring/Well No. **M-GS-5**
Page: **10 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)	COLLECT Sample Type	Date & Time	Blow Counts	Recovery (in)	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:

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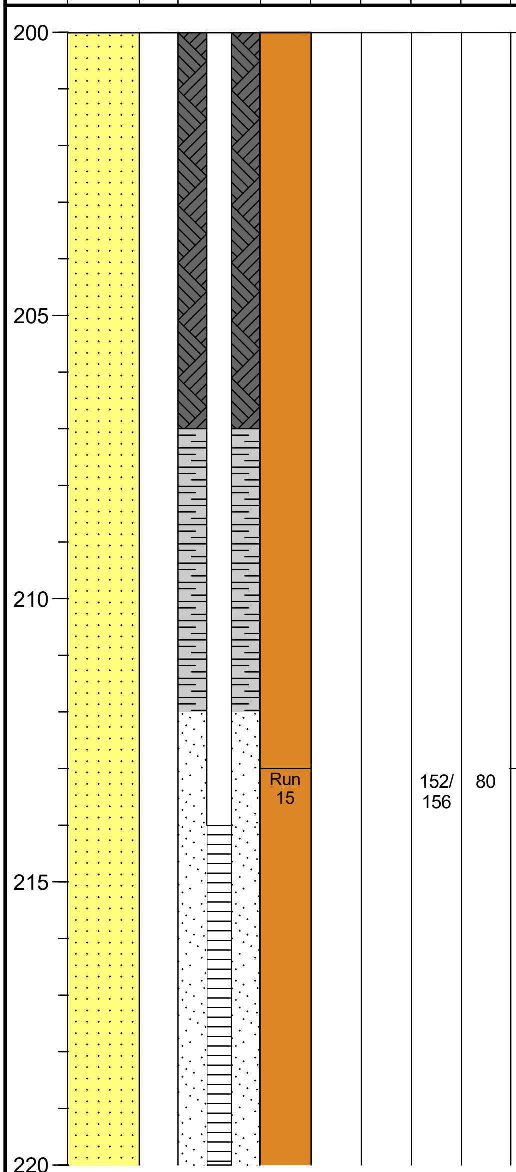
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

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)	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
200						competent, some coal veining, some imbedded conglomerate, shale lenses, mud inclusions. [MORGANTOWN]		200
						(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]		
220								220

NOTES:

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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

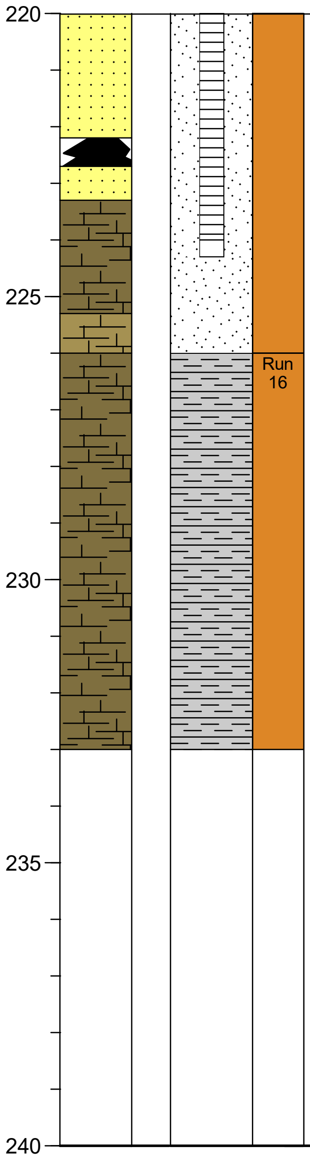
BORING LOG

Boring/Well No. M-GS-5
Page: 12 of 12

Drilling Start Date: **03/14/2016 14:45**
Drilling End Date: **03/16/2016 09:30**
Drilling Company: **Layne Drilling**
Drilling Method: **Rock Core**
Drilling Equipment: **CS1500 Wireline Rig**
Driller: **Bill Womack**
Logged By: **Doug Mateas**

Boring Depth (ft): **233**
Boring Diameter (in): **6**
Sampling Method(s): **Rock Core**
DTW During Drilling (ft):
Ground Surface Elev. (ft): **1,036.92**
Top of Casing Elev. (ft): **1,039.54**
Location (X,Y): **N 835,739.3 E 2,511,662.3**

Well Depth (ft): **224**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Pre-packed Sch 40 PVC**
Seal Material(s): **Bentonite Pellets**
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)
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									(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]		225
				Run 16			84/84	92			
									(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

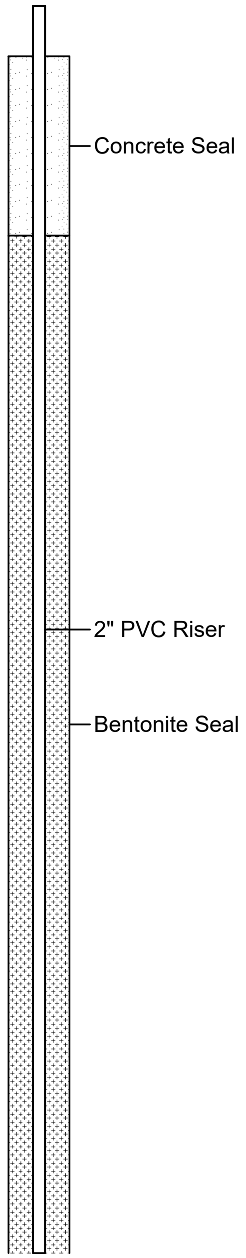
(Page 1 of 4)

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
0				▨		Straight drill using 4.25-inch Hollow Stem Augers to bedrock refusal. Bottom Ash (0-32')
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						



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

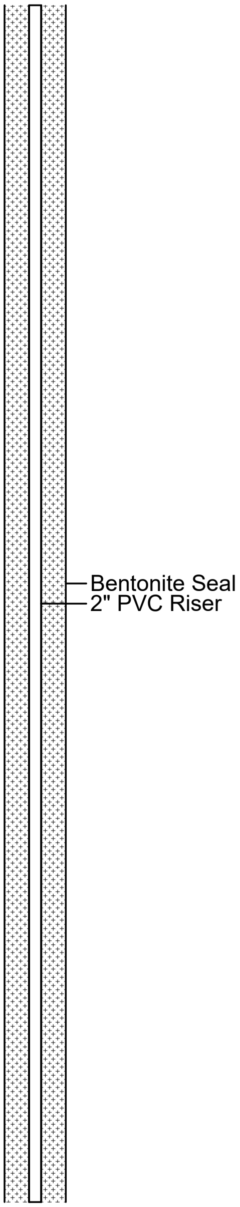
(Page 2 of 4)

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						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%
40						



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

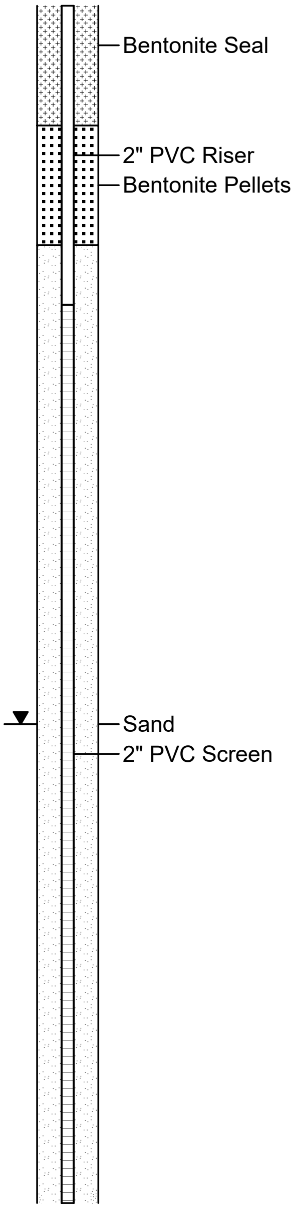
(Page 3 of 4)

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	Water Level	DESCRIPTION
40				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%
60				



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

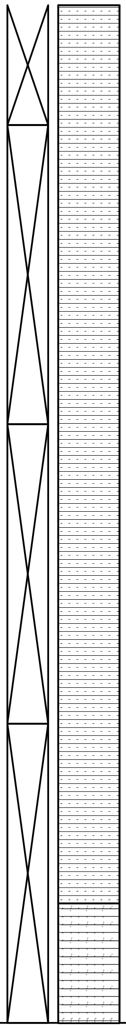
(Page 4 of 4)

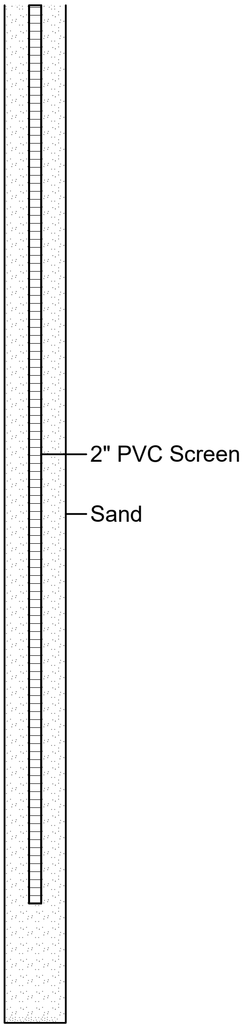
Soil Samples
☒ Sample Intervals
■ Sample Sent to Lab

Water Levels
▼ Static
▽ During Drilling

Well: M-2000

Depth in Feet	Sample Interval/ Sample Recovery	Sampler Type/ Sample Number	DESCRIPTION
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%
67	5/5	RC-9 67.0-72.0	
69			Medium, grey, unweathered, medium strong SANDSTONE; slightly fractured. RQD = 60%
72	5/5	RC-10 72.0-77.0	RQD = 68.3%
75			Soft grey fine CLAY and unweathered blue grey SHALE; moderately strong; laminated; bedding; moderately fractured.
77			End of Boring @ 77'





APPENDIX D

WELL CONSTRUCTION LOGS

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

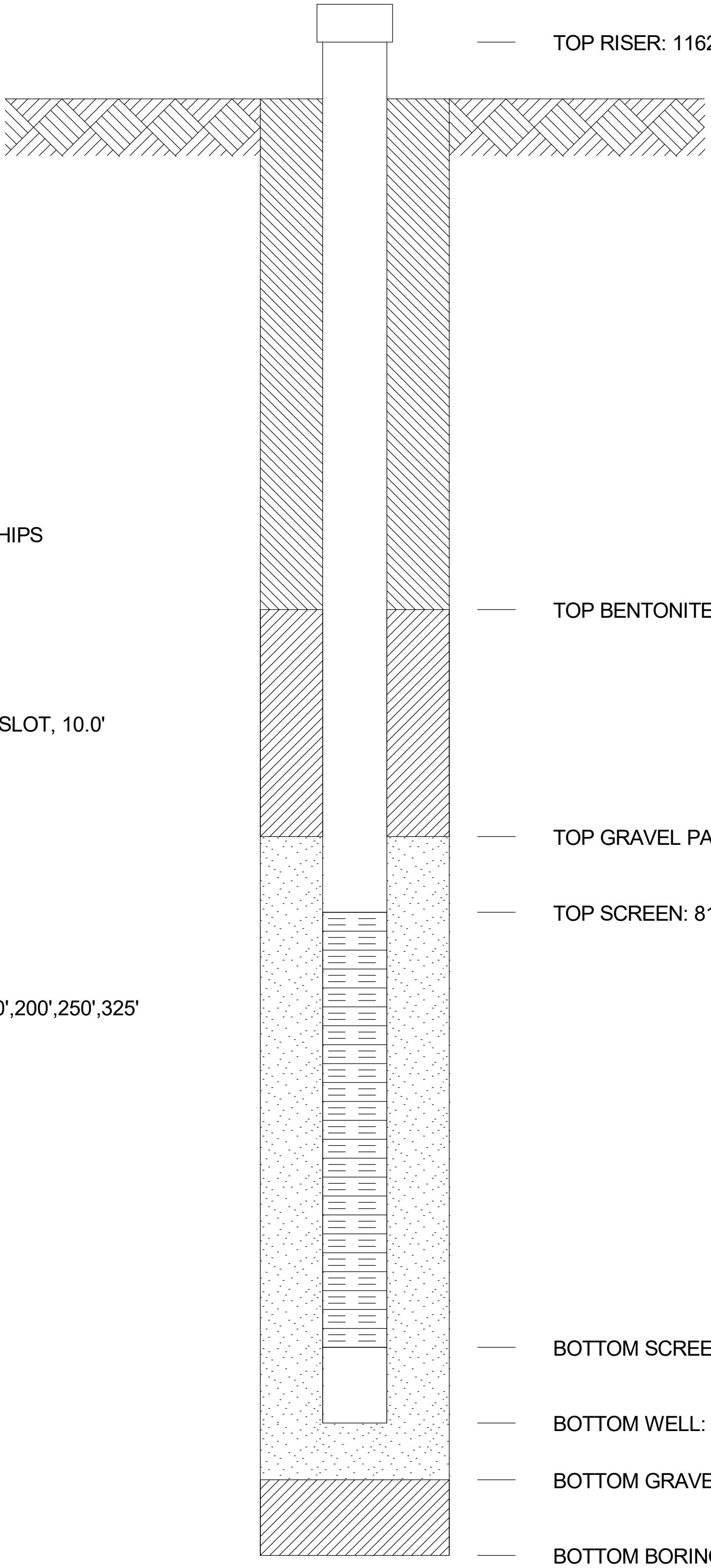
WELL No. **CA-0622A** BORING No. **CA-0622A** INSTALLED **8/16/16**

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

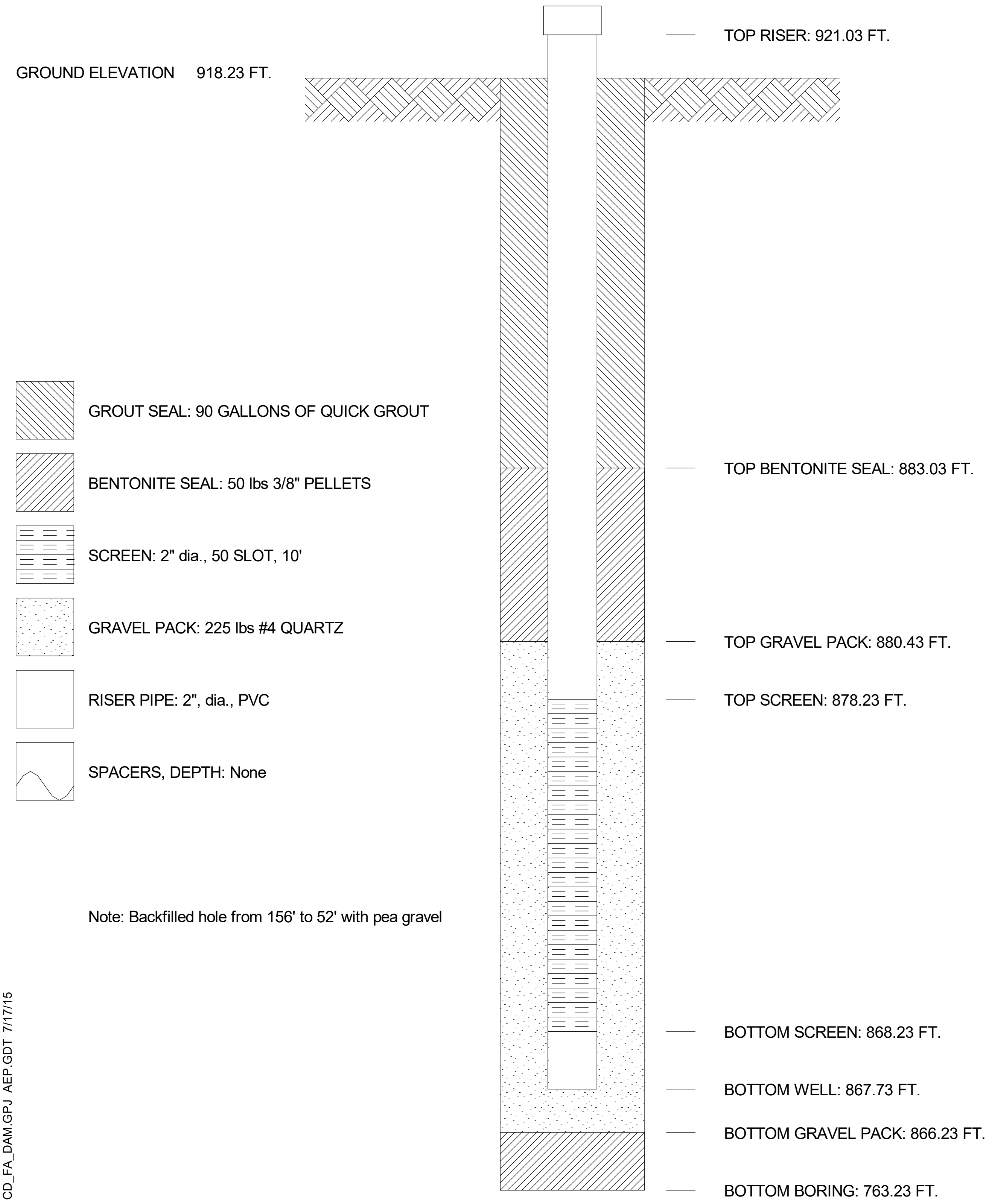
JOB NUMBER

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**



▧ 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**

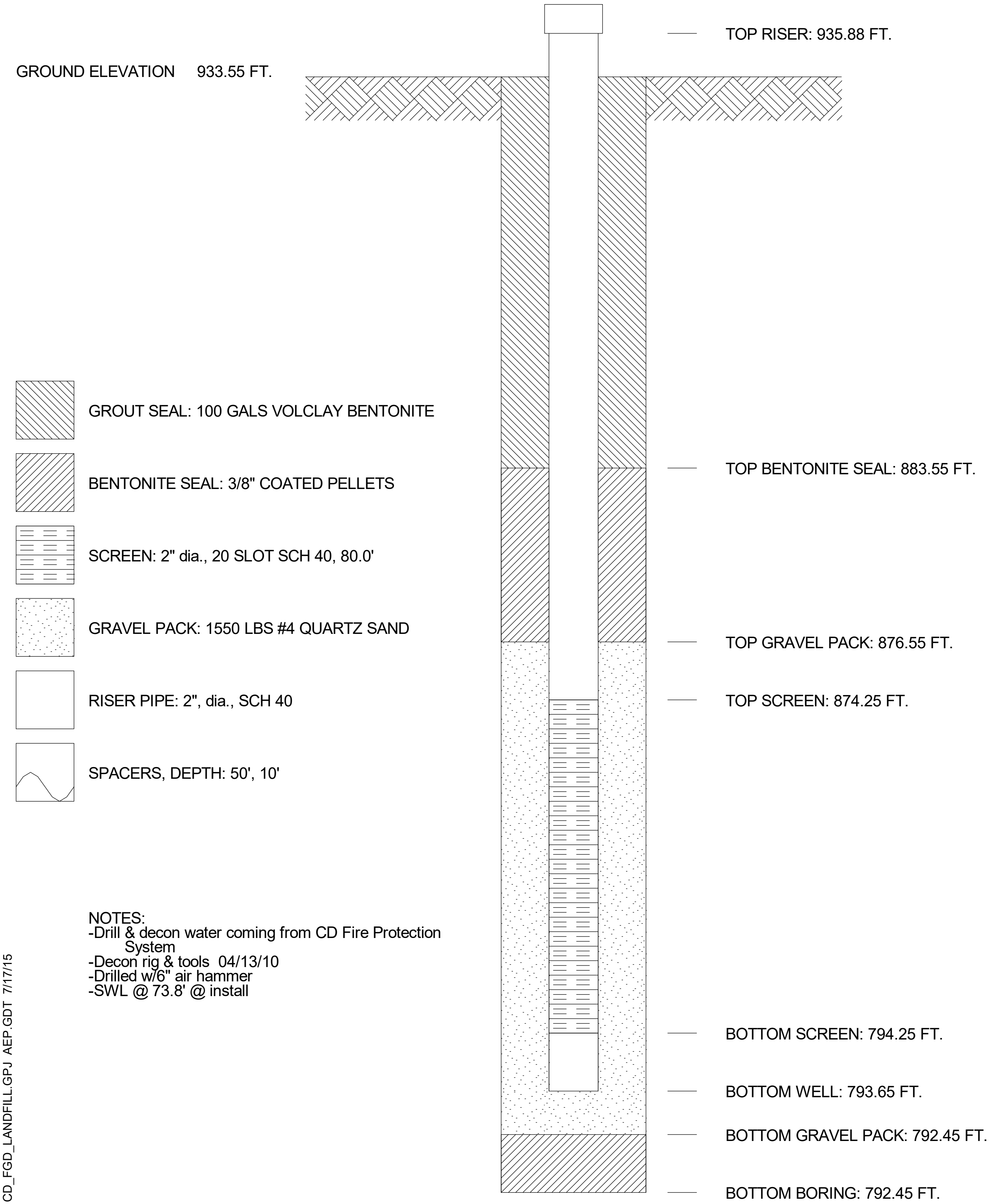
WELL No. **M-1003** BORING No. **M-1003** INSTALLED **4/7/10**

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**

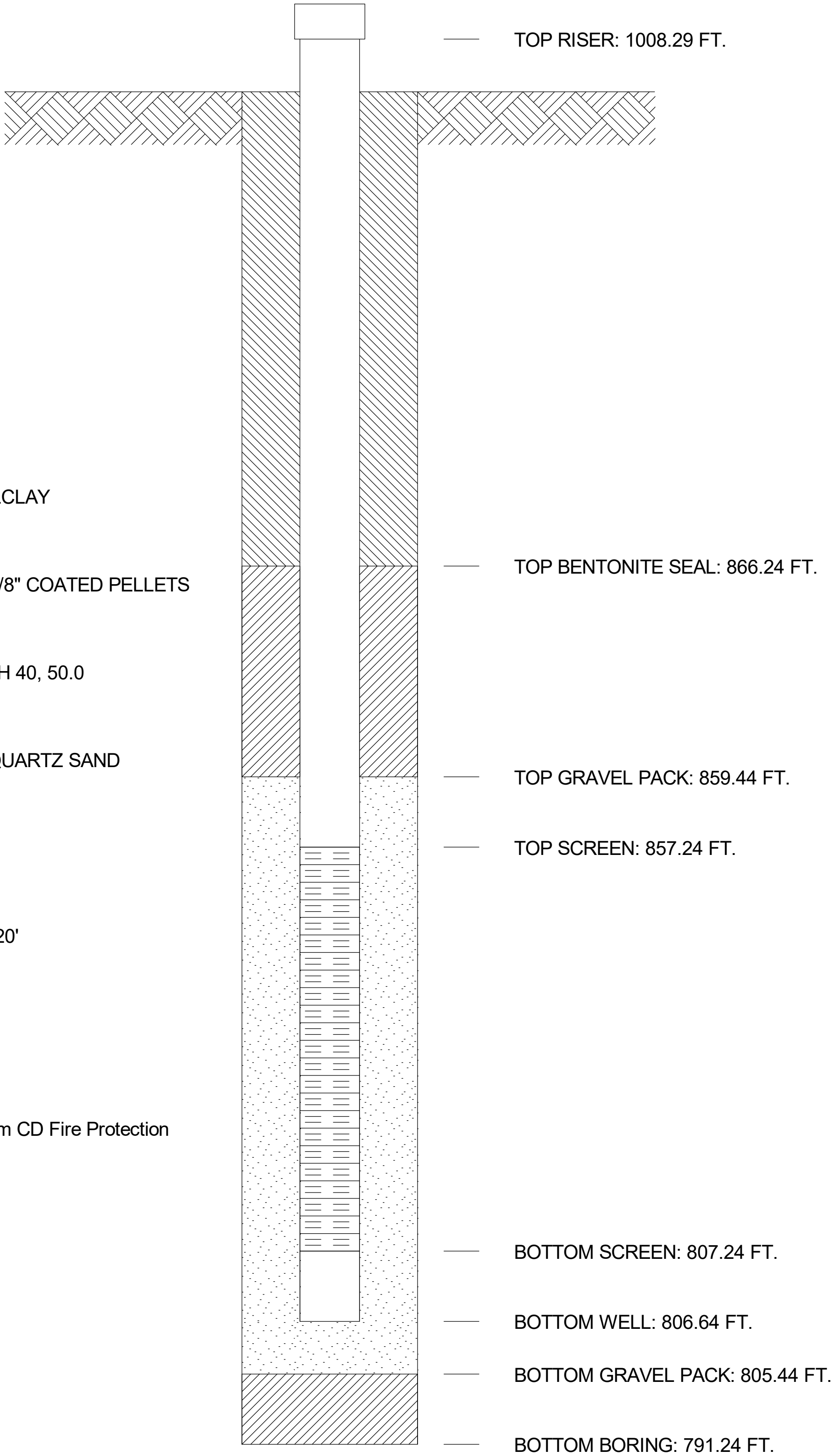
WELL No. **M-1004** BORING No. **M-1004D** INSTALLED **3/31/10**

PROJECT **CARDINAL LANDFILL**

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

SYSTEM

GROUND ELEVATION 1005.64 FT.



▧ 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**

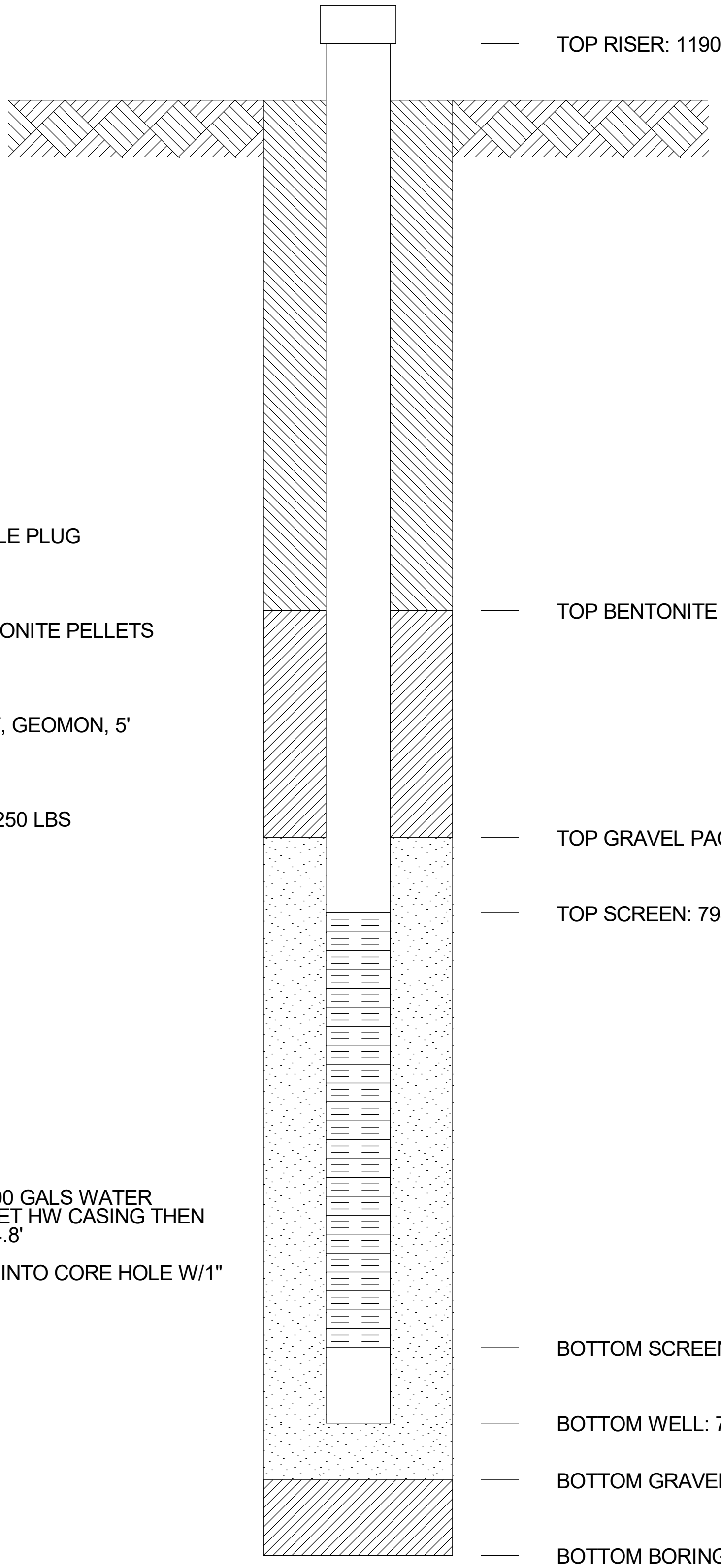
INSTALLED **12/13/06**

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**

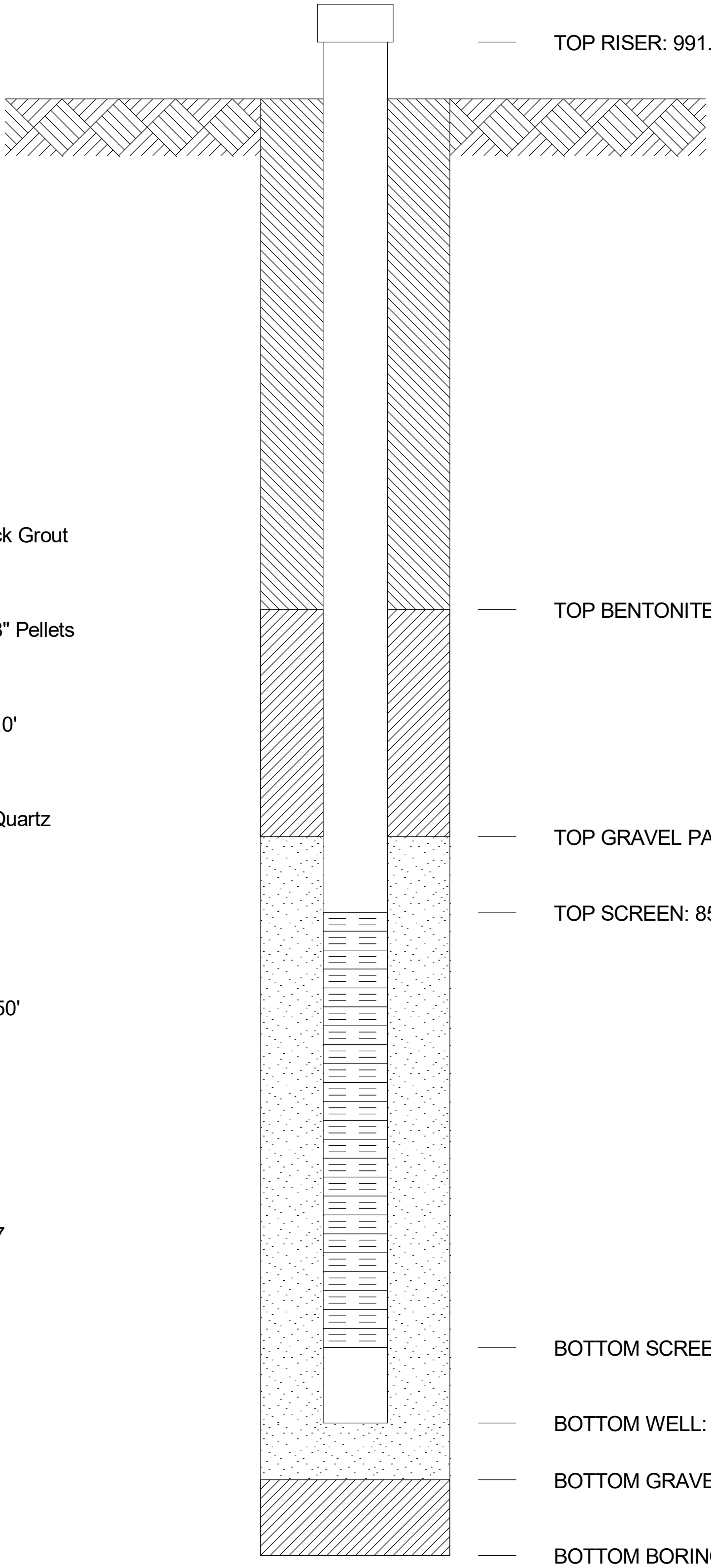
INSTALLED **4/3/07**

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**

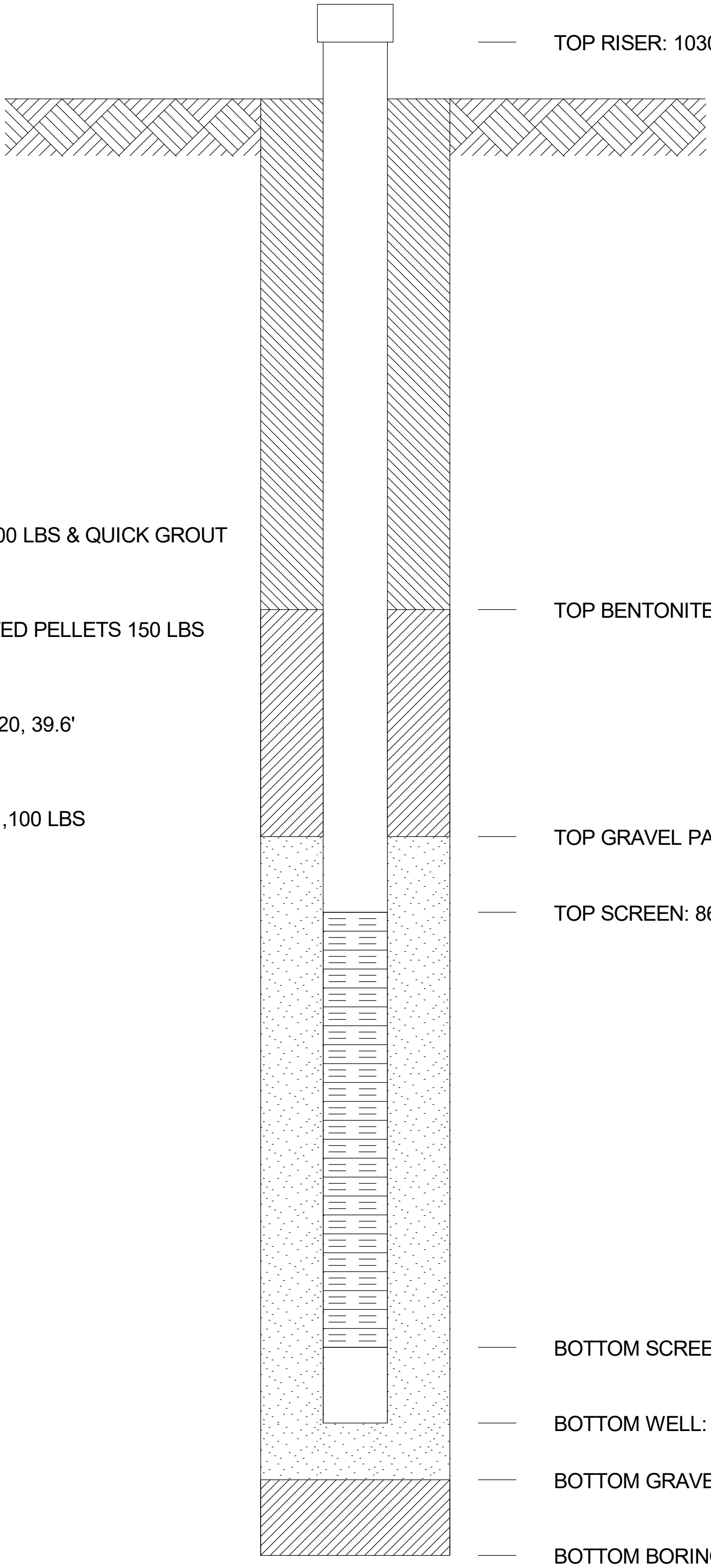
WELL No. **M-1302** BORING No. **B-1302M** INSTALLED **5/30/13**

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

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
MONITORING WELL CONSTRUCTION

AEP

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

WELL No. **M-1309**

BORING No. **B-1309D**

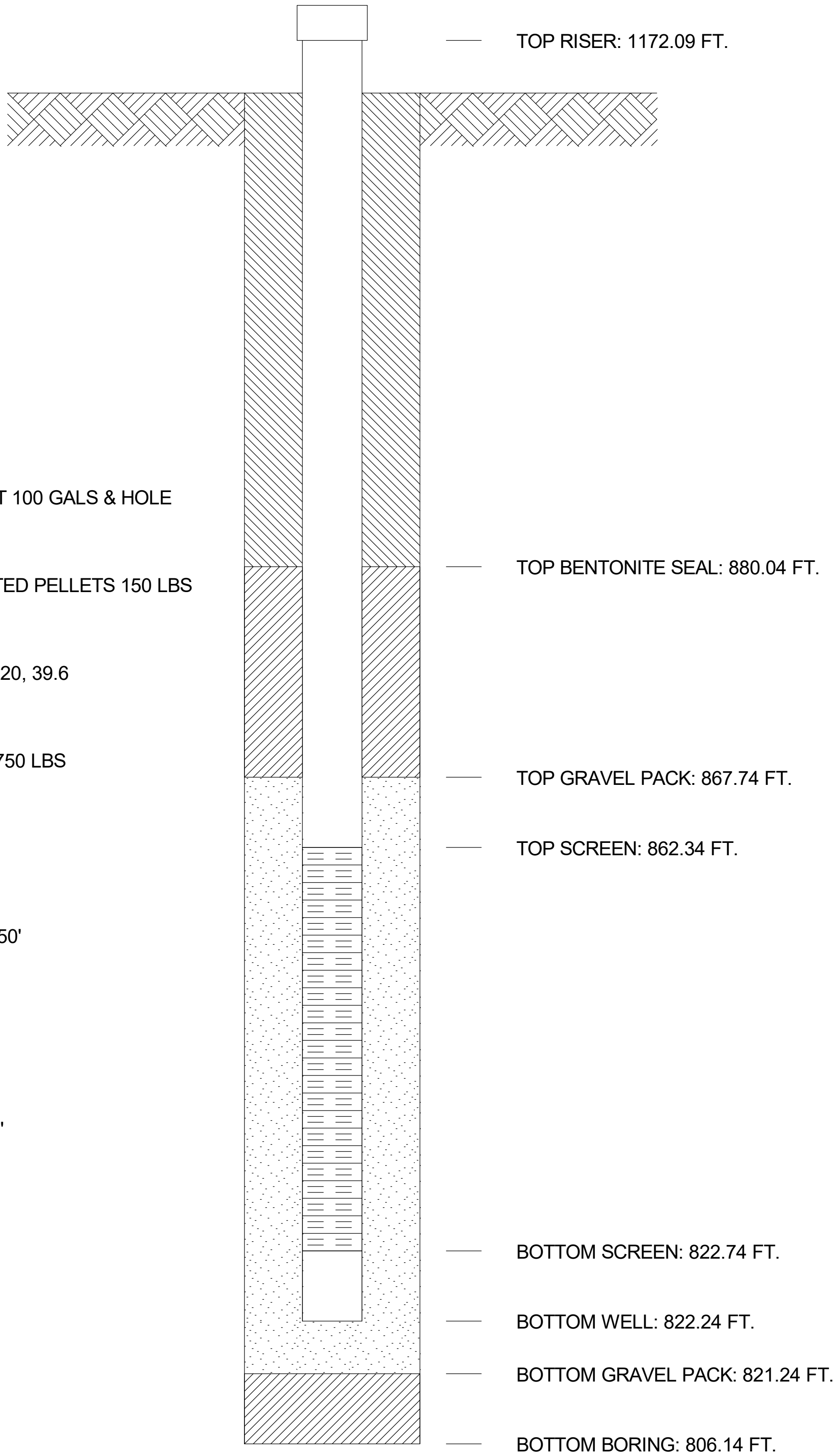
INSTALLED **5/30/13**

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.



▧ 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

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

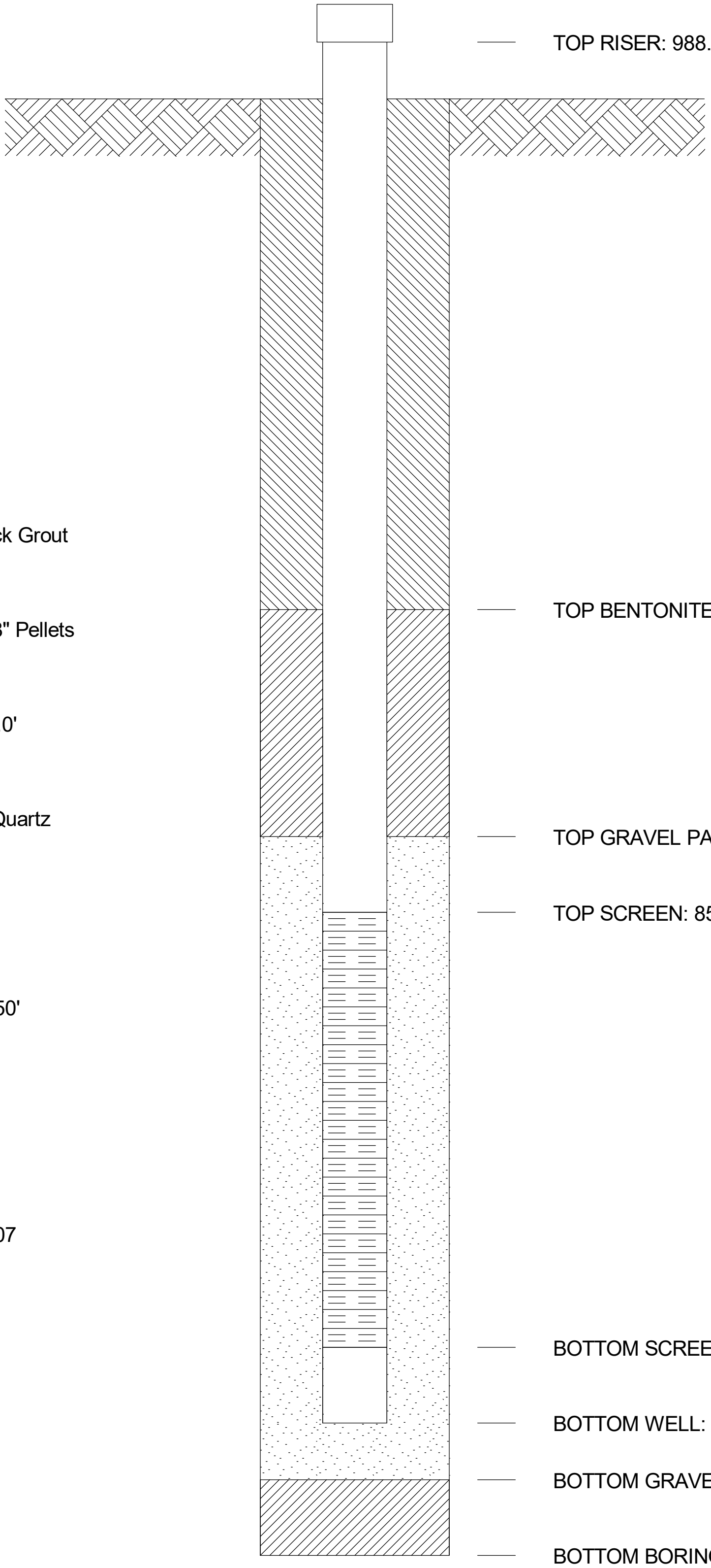
WELL No. **M-14** BORING No. **CA-0612** INSTALLED **3/21/07**

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**

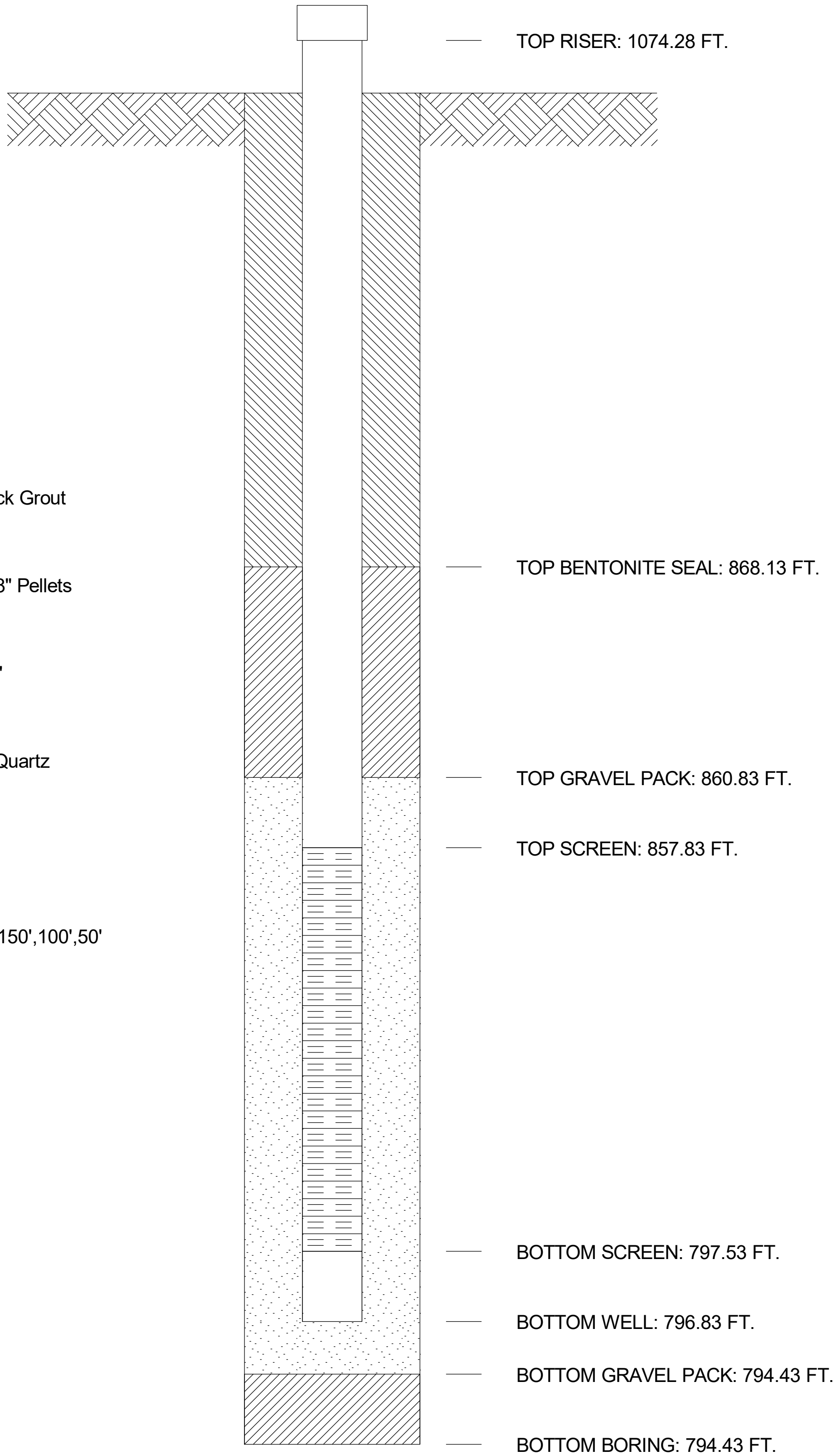
WELL No. **M-15** BORING No. **CA-0614** INSTALLED **7/25/07**

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

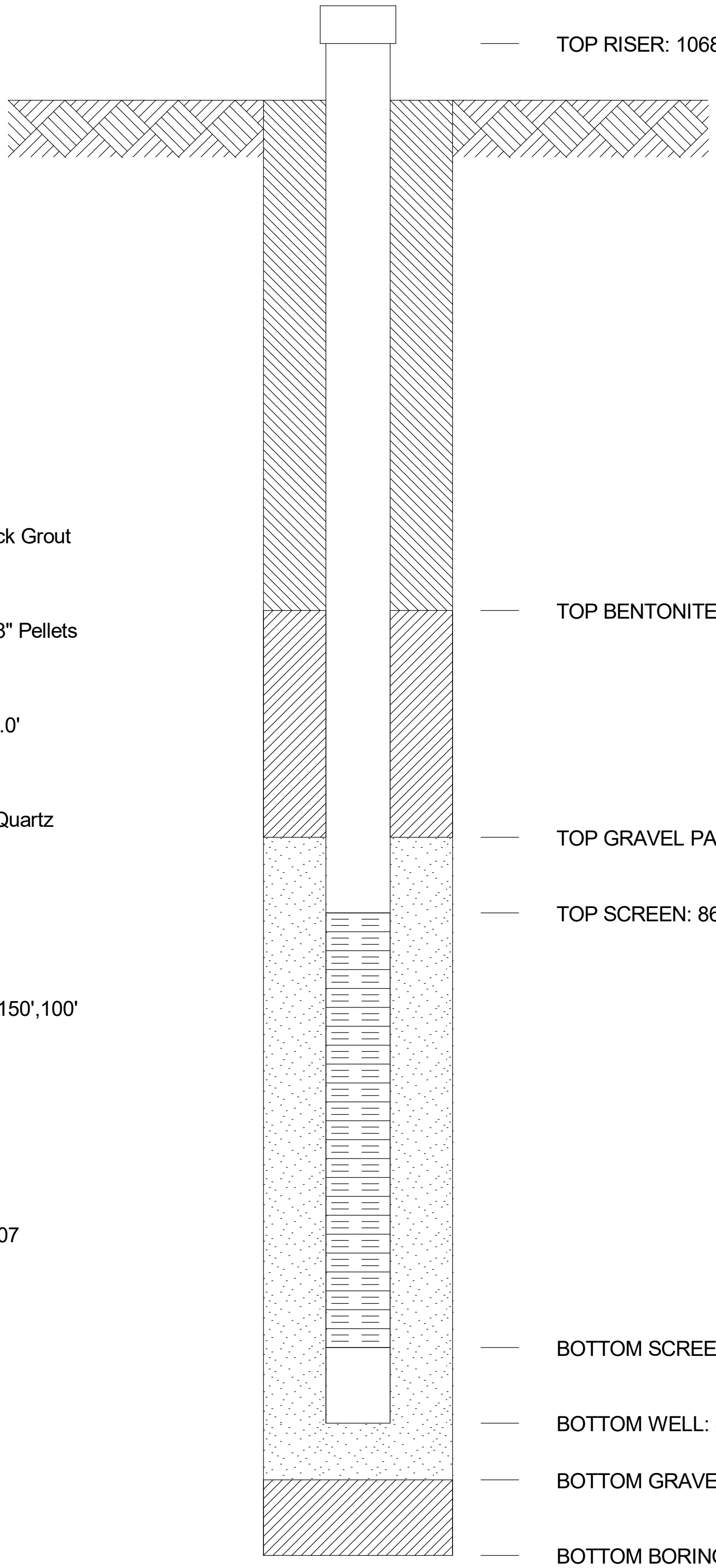
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **M-16** BORING No. **CA-0616** INSTALLED **1/24/07**

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**

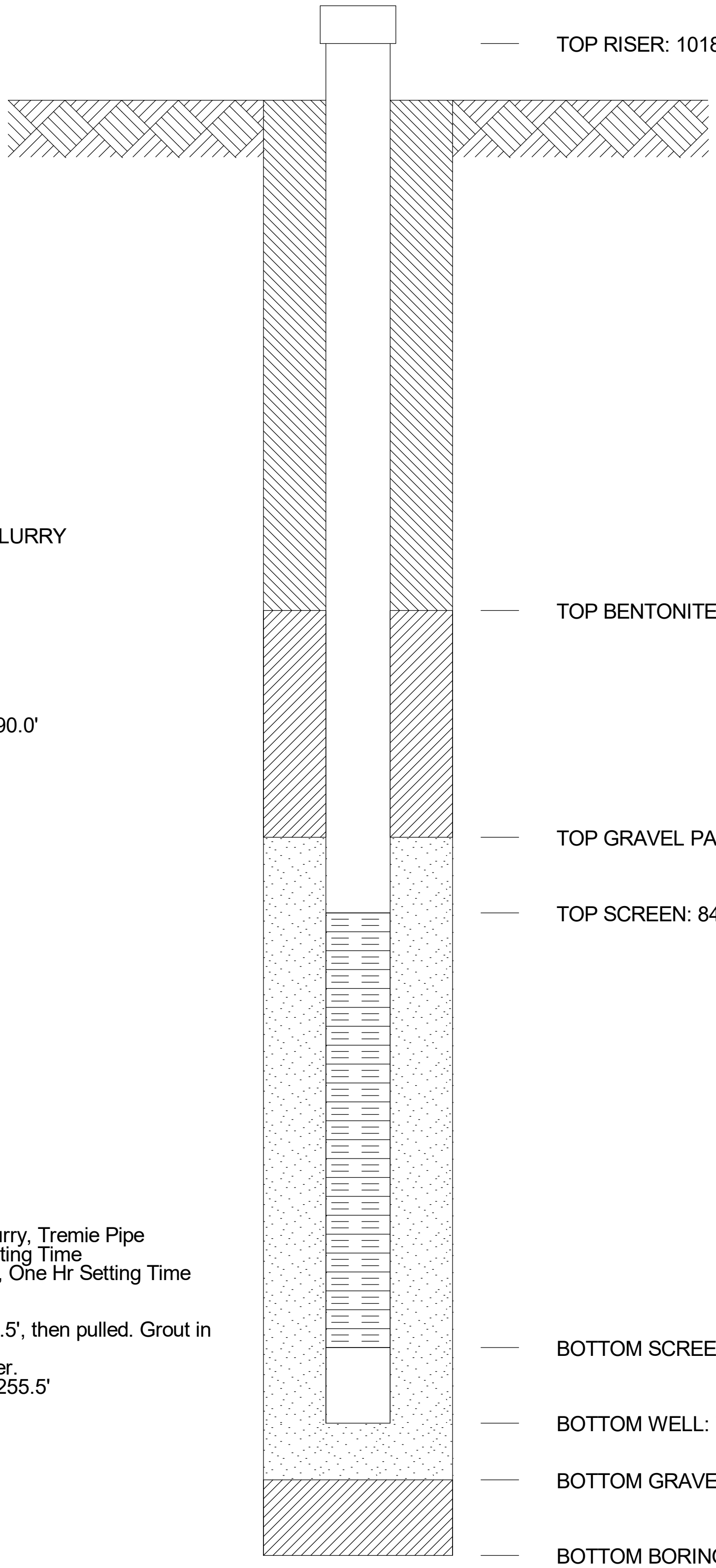
WELL No. **M-21** BORING No. **CA-0620** INSTALLED **6/1/06**

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**

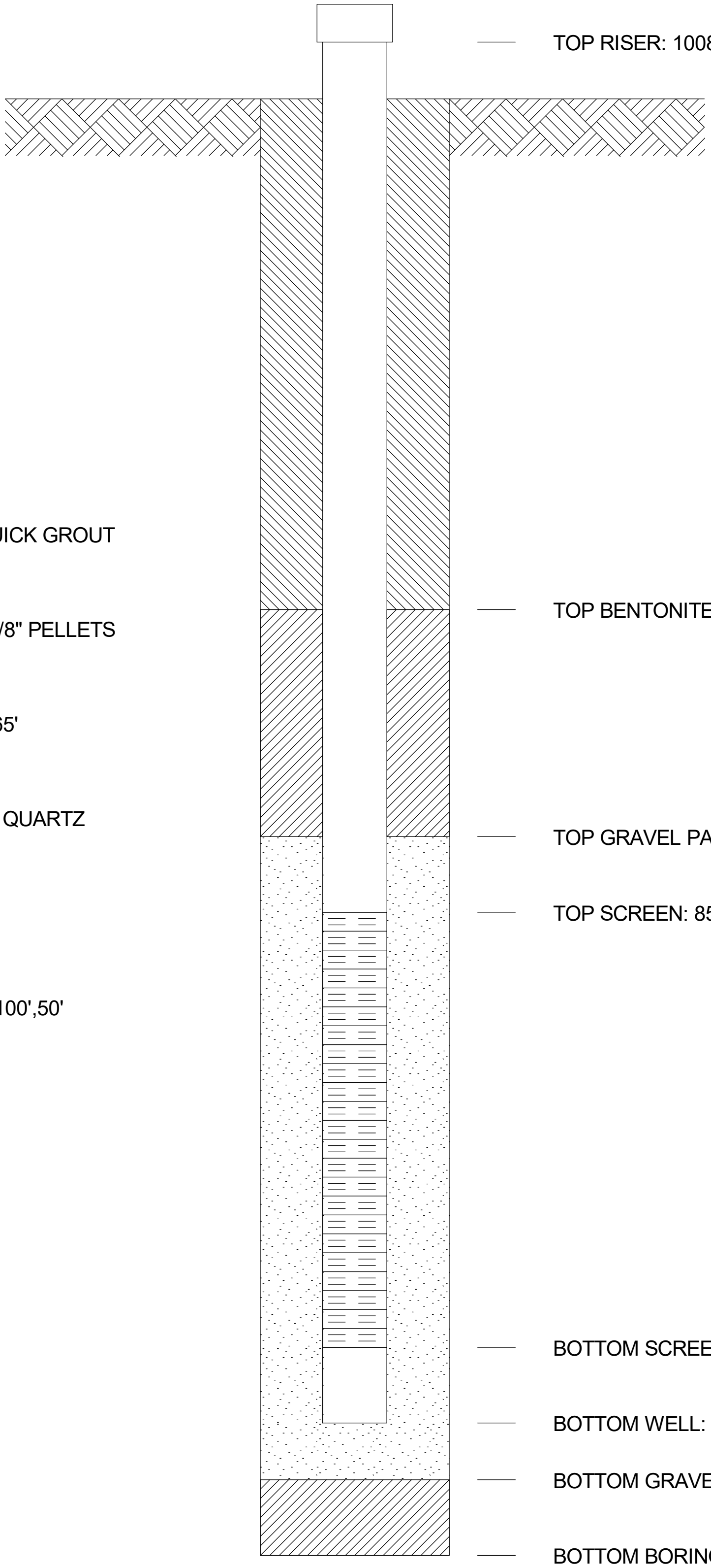
WELL No. **M-22** BORING No. **CA-0702** INSTALLED **5/21/07**

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**

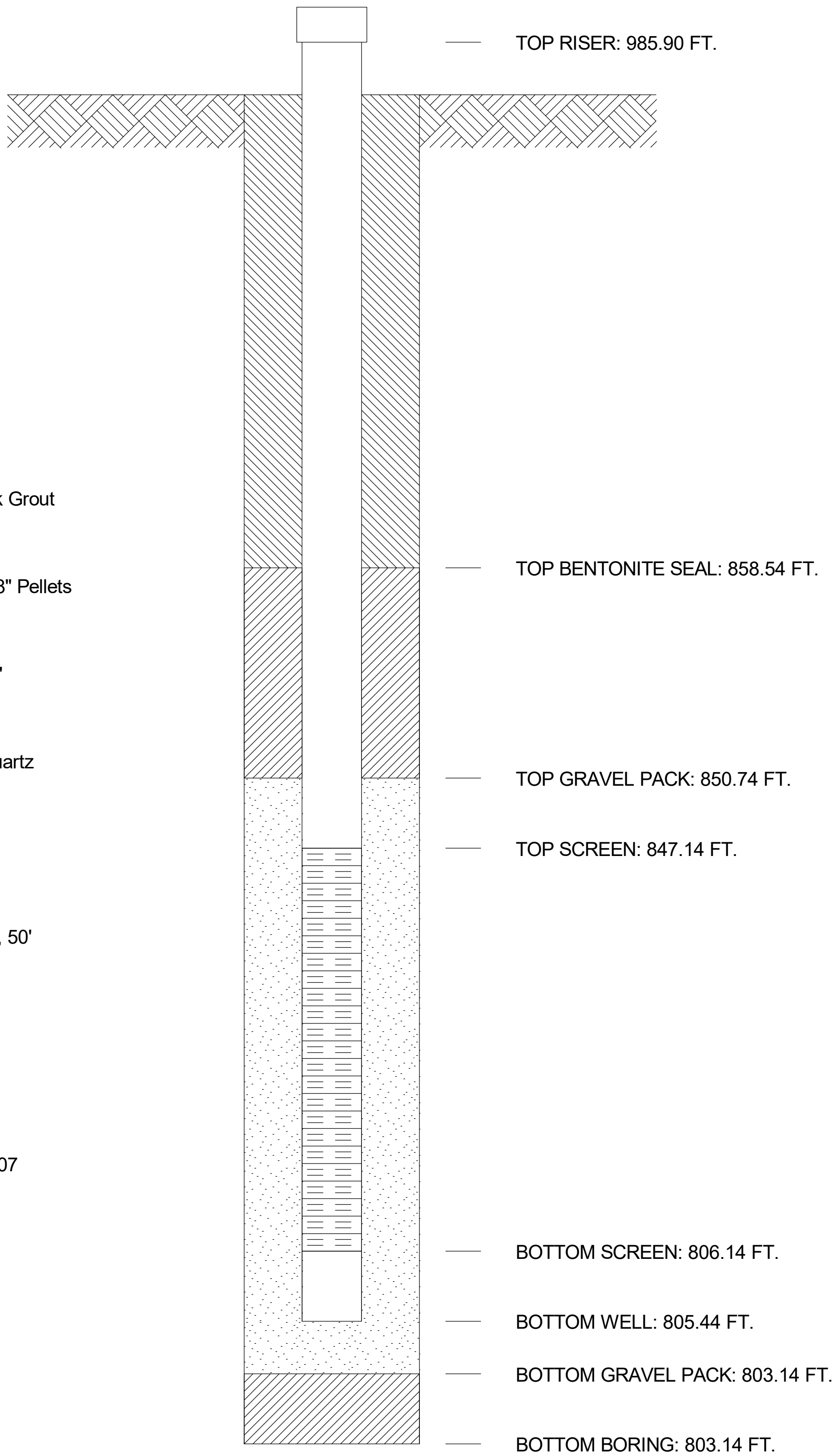
INSTALLED **4/23/07**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 830,051.2 E 2,518,092.0**

SYSTEM

GROUND ELEVATION 983.44 FT.



▧ 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

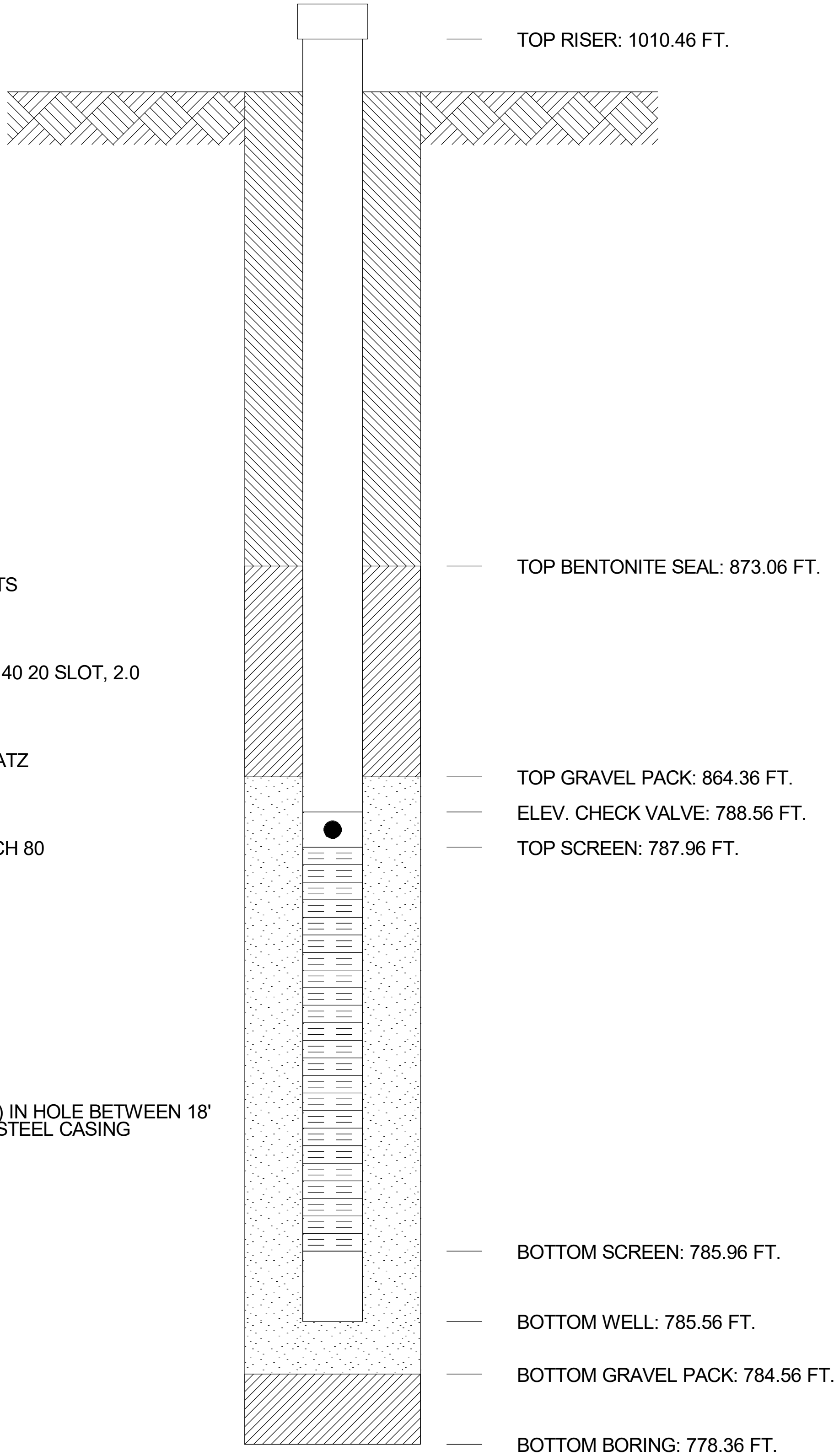
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **M-6** BORING No. **90CA22** INSTALLED **8/9/90**

PROJECT **CARDINAL PLANT**

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

SYSTEM **STATE PLANE**

GROUND ELEVATION 1008.56 FT.



▧ 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

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

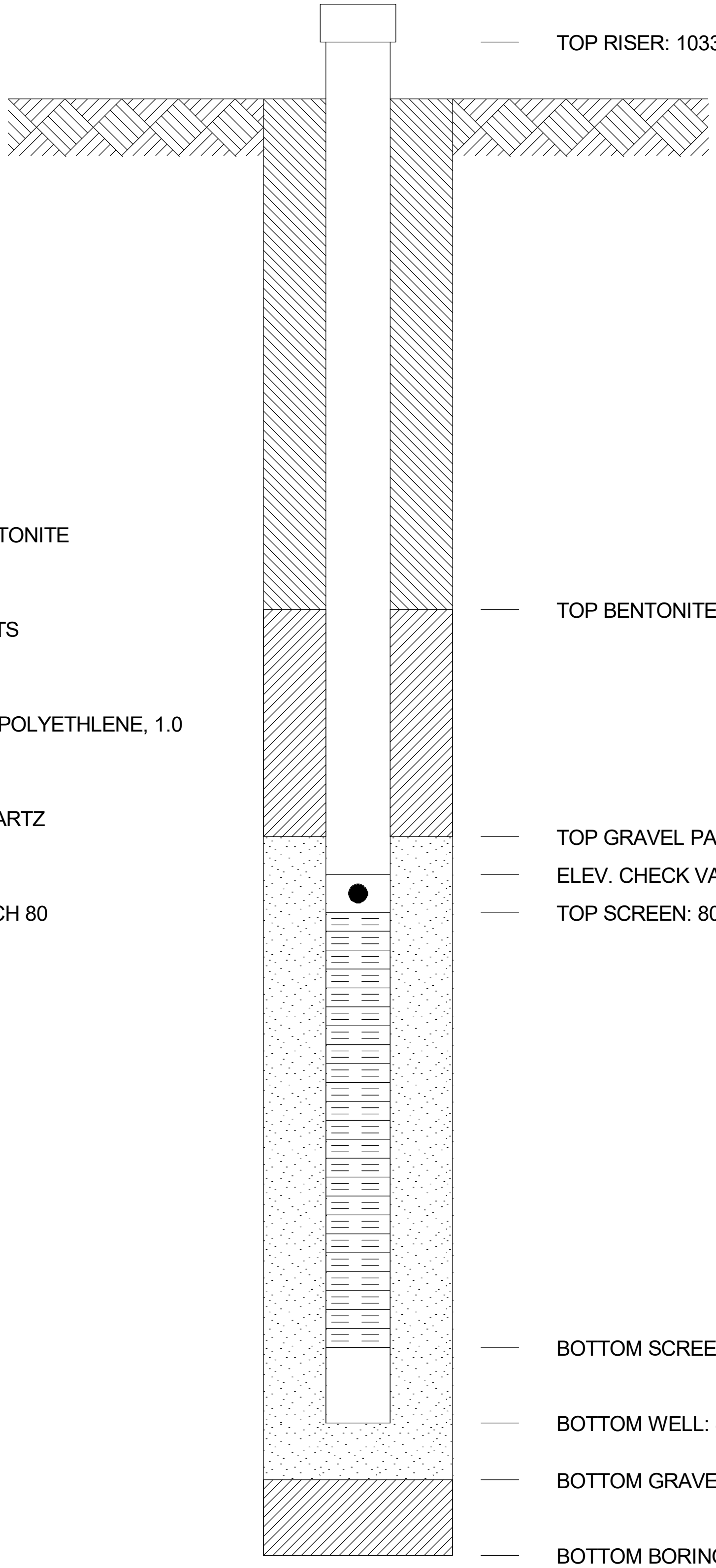
WELL No. **M-10** BORING No. **85W-3** INSTALLED **8/13/85**

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:

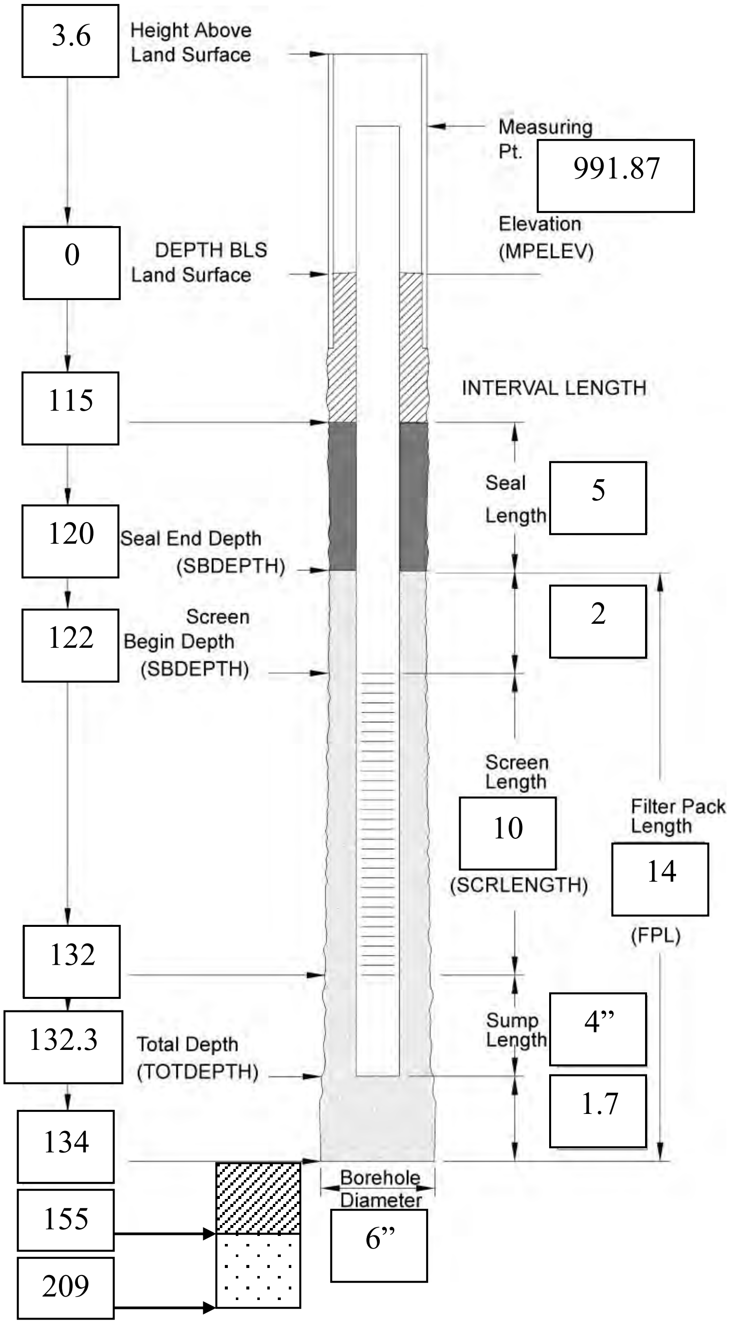
GEOMON 12"GEOMON

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):



3.6 Height Above Land Surface
Measuring Pt. Elevation (MPELEV) 991.87
0 DEPTH BLS Land Surface
115
120 Seal End Depth (SBDEPTH)
Seal Length 5
2
122 Screen Begin Depth (SBDEPTH)
Screen Length 10 (SCRLENGTH)
Filter Pack Length 14 (FPL)
132
Sump Length 4”
132.3 Total Depth (TOTDEPTH)
1.7
134
155
209
Borehole Diameter 6”

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

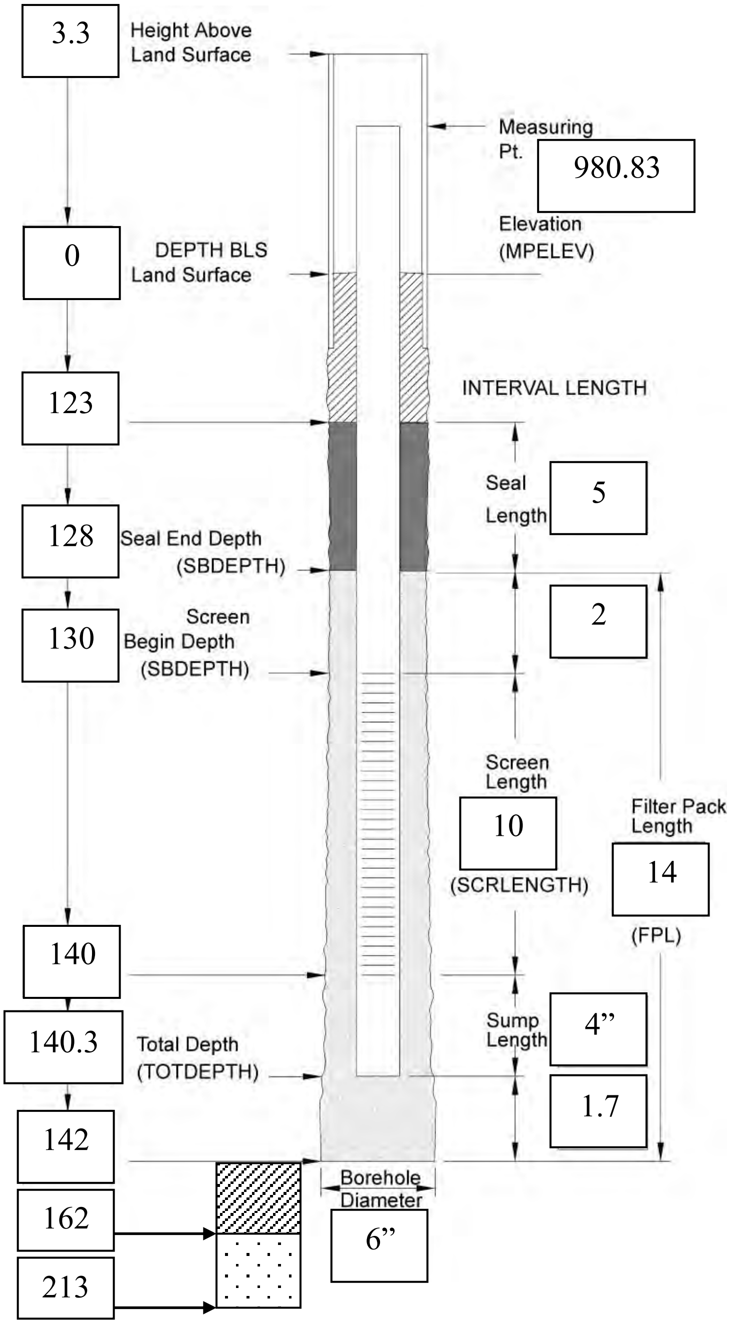
Installation Method: HSA

Casing Installation Date (INSDATE): 4/13/16

Well Type (WTCCODE): Monitoring Well

Well Completion Method (WCMCODE): Above Grade

Geologic Completion Zone (GZCODE):



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

Comments

Total drilled depth = 213’; backfilled to 142’ with sand and chips (20’ seal); 1 centralizer used at 70’

Geosyntec consultants

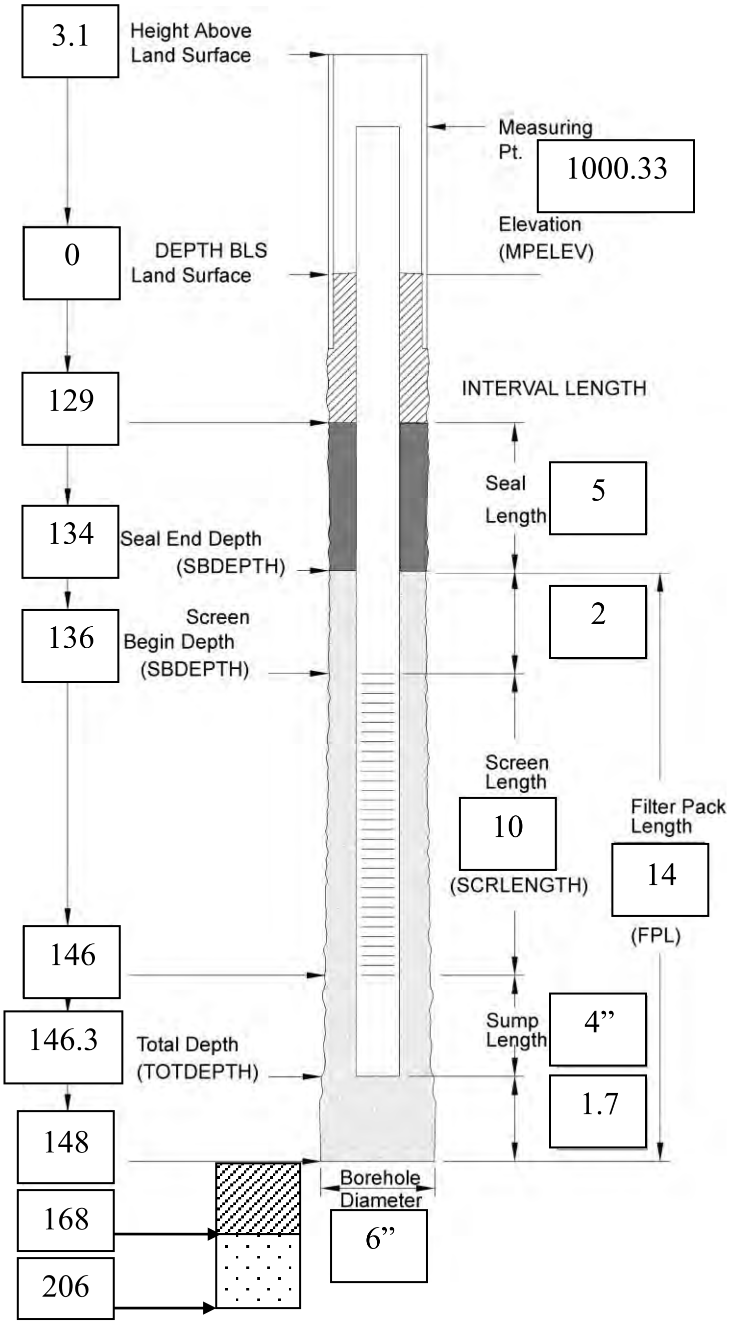
WELL CONSTRUCTION LOG
ABOVE GROUND COMPLETION

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):



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): -

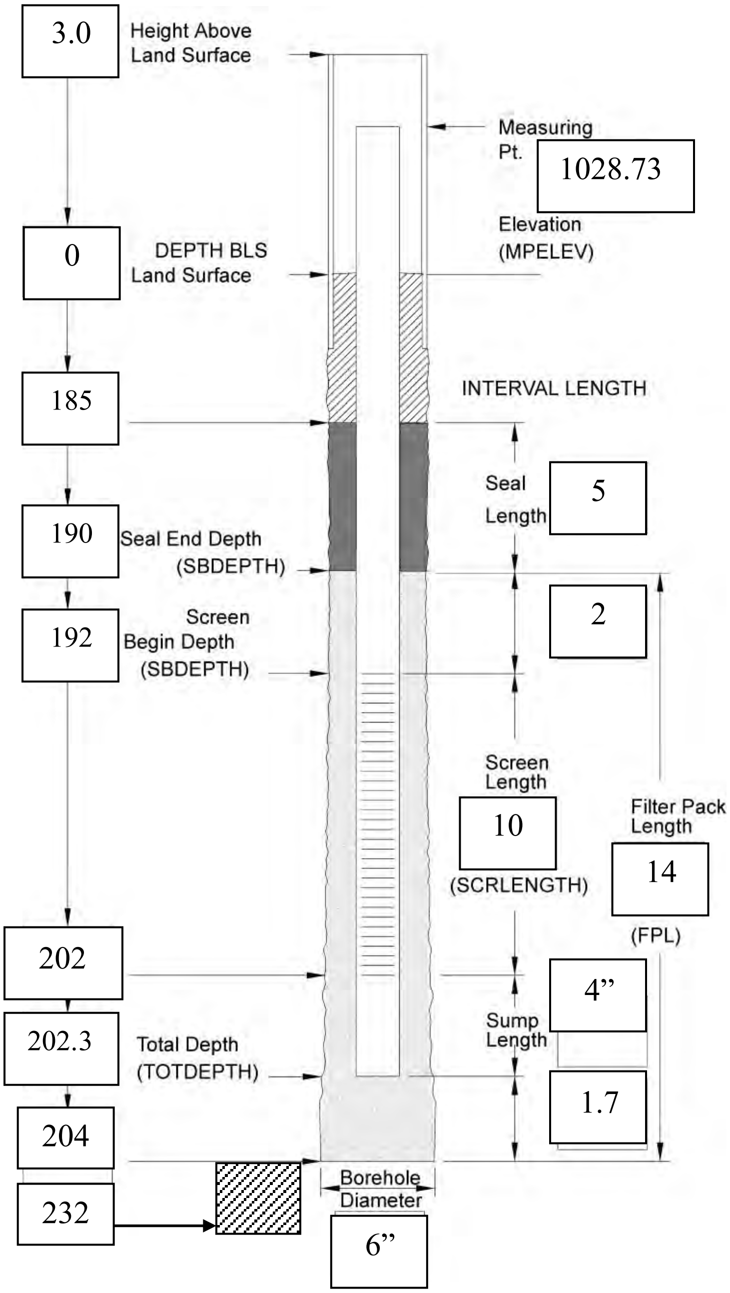
Reviewed By: J. Neil Couch Date: 4/22/2016

Comments
Total boring depth = 206’; backfilled with sand then chips To 148’; centralizer used at 70’

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:

Total Water Volume During Construction
Introduced (Gal): Recovered (Gal):

Reviewed By: J. Neil Couch Date: 5/03/2016

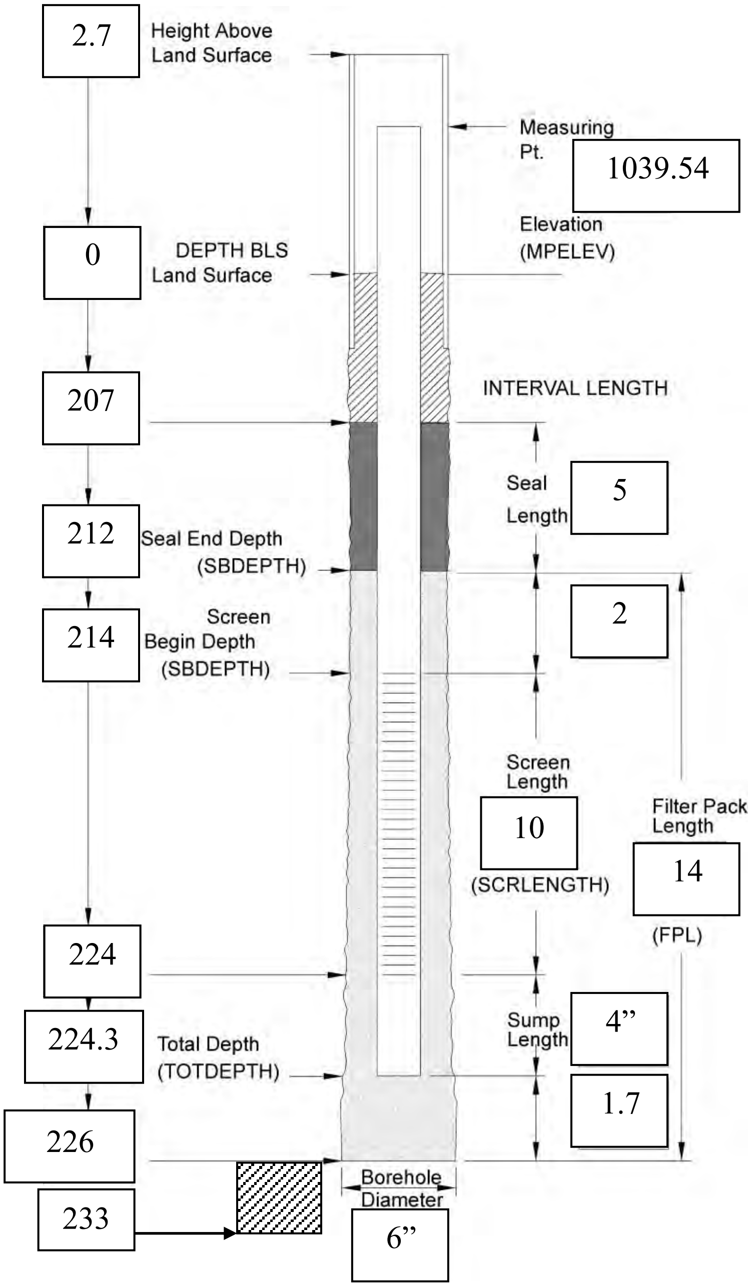
Comments
Total drilled depth = 232’; backfilled with chips to 204’.

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):



2.7 Height Above Land Surface
Measuring Pt. Elevation (MPELEV) 1039.54
0 DEPTH BLS Land Surface
207
INTERVAL LENGTH
Seal Length 5
212 Seal End Depth (SBDEPTH)
2
214 Screen Begin Depth (SBDEPTH)
Screen Length 10 (SCRLENGTH)
Filter Pack Length 14 (FPL)
224
Sump Length 4"
224.3 Total Depth (TOTDEPTH)
1.7
226
233
Borehole Diameter 6"

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'

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

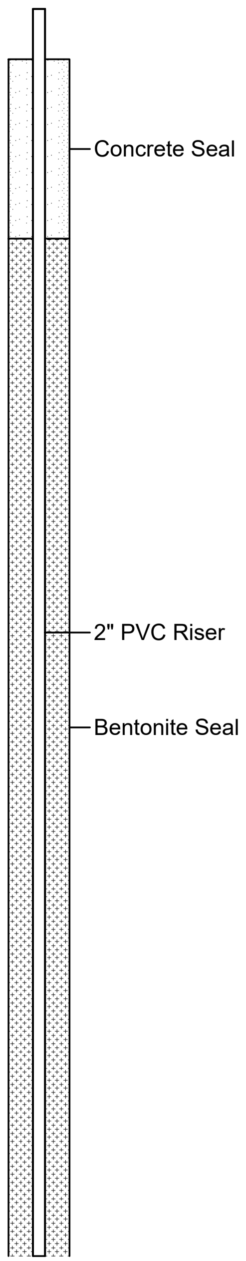
(Page 1 of 4)

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. Bottom Ash (0-32')
1				▨		
2				▨		
3				▨		
4				▨		
5				▨		
6				▨		
7				▨		
8				▨		
9				▨		
10				▨		
11				▨		
12				▨		
13				▨		
14				▨		
15				▨		
16				▨		
17				▨		
18				▨		
19				▨		
20				▨		

Well: M-2000



03-14-2019 F:\Clients\Active\BPG\BPG003\Boring Logs\M-2000.bor

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

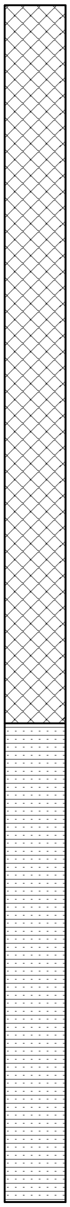
(Page 2 of 4)

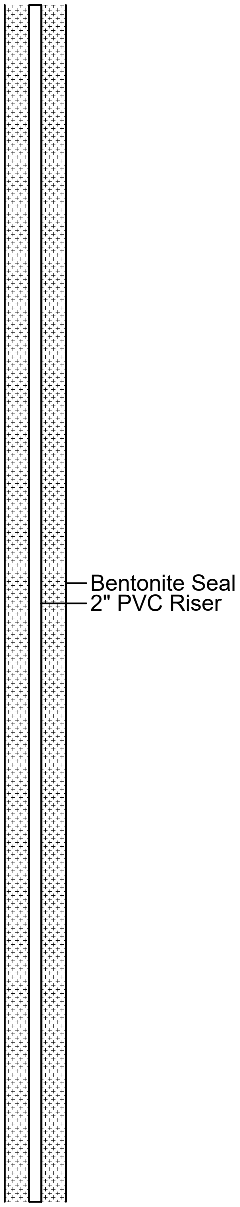
Soil Samples
☒ Sample Intervals
■ Sample Sent to Lab

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						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

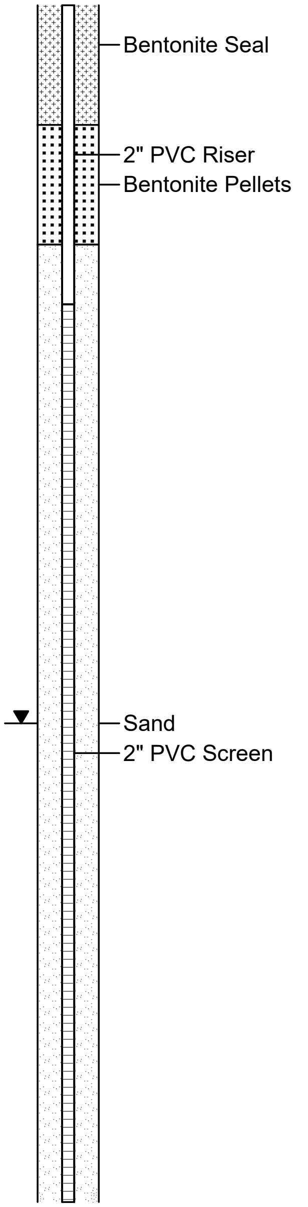
(Page 3 of 4)

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	Water Level	DESCRIPTION
40				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%
60				



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

(Page 4 of 4)

Soil Samples

☒ Sample Intervals

■ Sample Sent to Lab

Water Levels

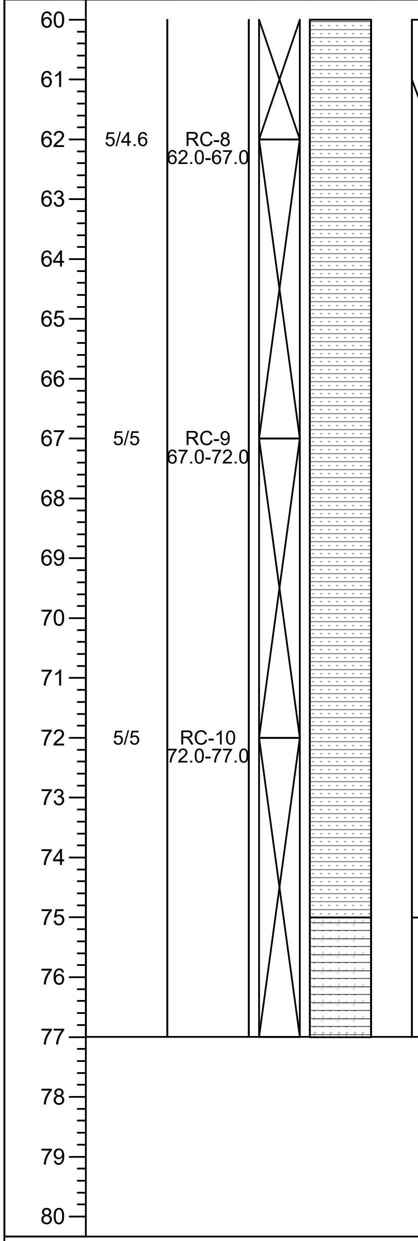
▼ Static

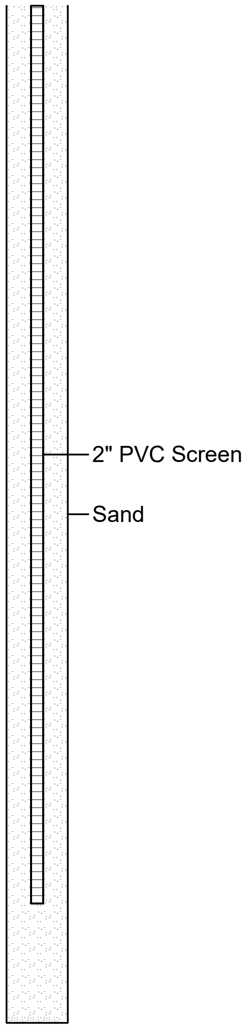
▽ During Drilling

Well: M-2000

Depth in Feet	Sample Interval/ Sample Recovery	Sampler Type/ Sample Number	DESCRIPTION
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%
67	5/5	RC-9 67.0-72.0	
69			Medium, grey, unweathered, medium strong SANDSTONE; slightly fractured. RQD = 60%
72	5/5	RC-10 72.0-77.0	RQD = 68.3%
75			Soft grey fine CLAY and unweathered blue grey SHALE; moderately strong; laminated; bedding; moderately fractured.
77			End of Boring @ 77'

Sample Water Level GRAPHIC





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

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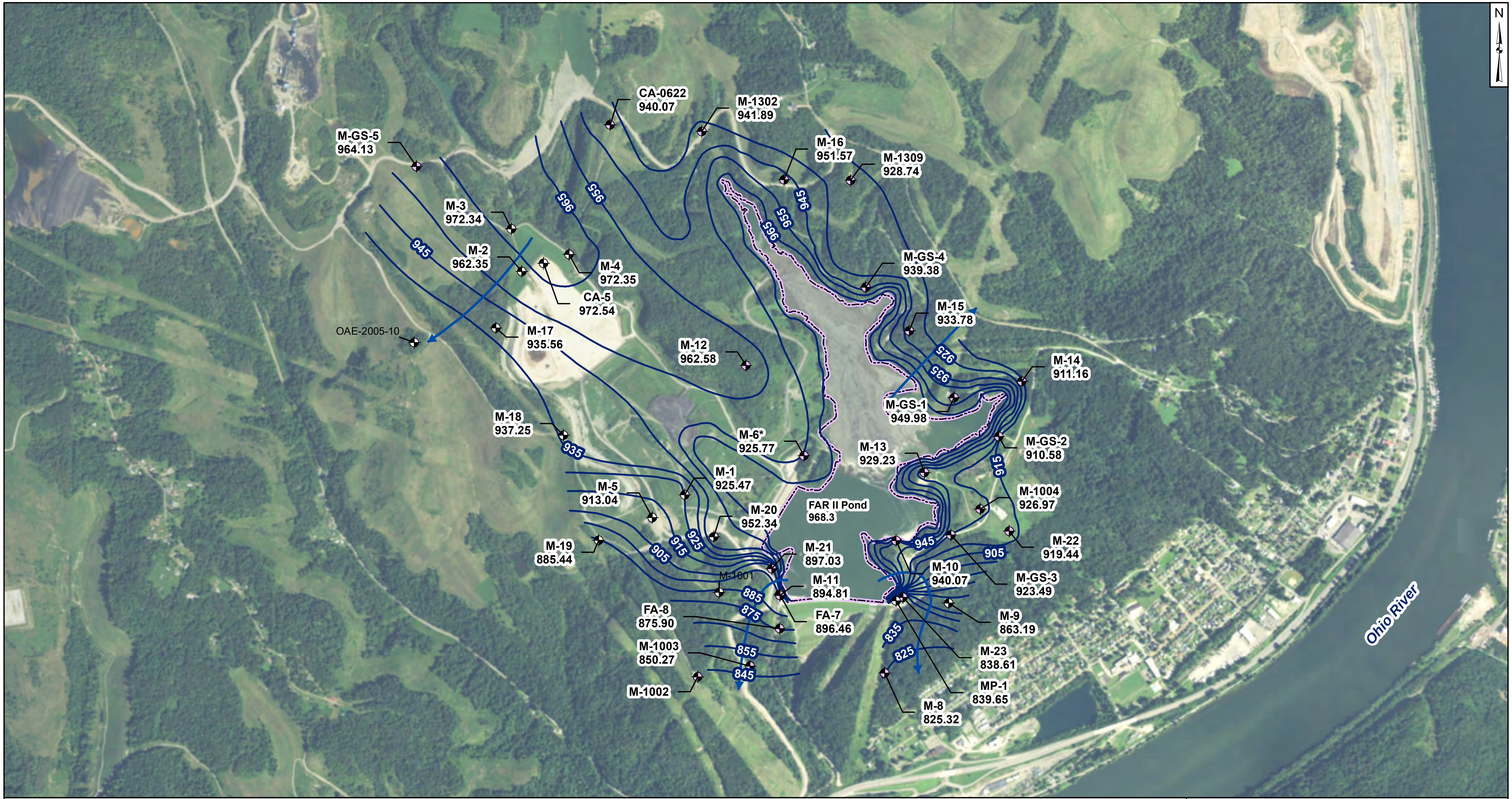

Legend

⊕ 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

Figure

2

Columbus, Ohio

2017/12/19

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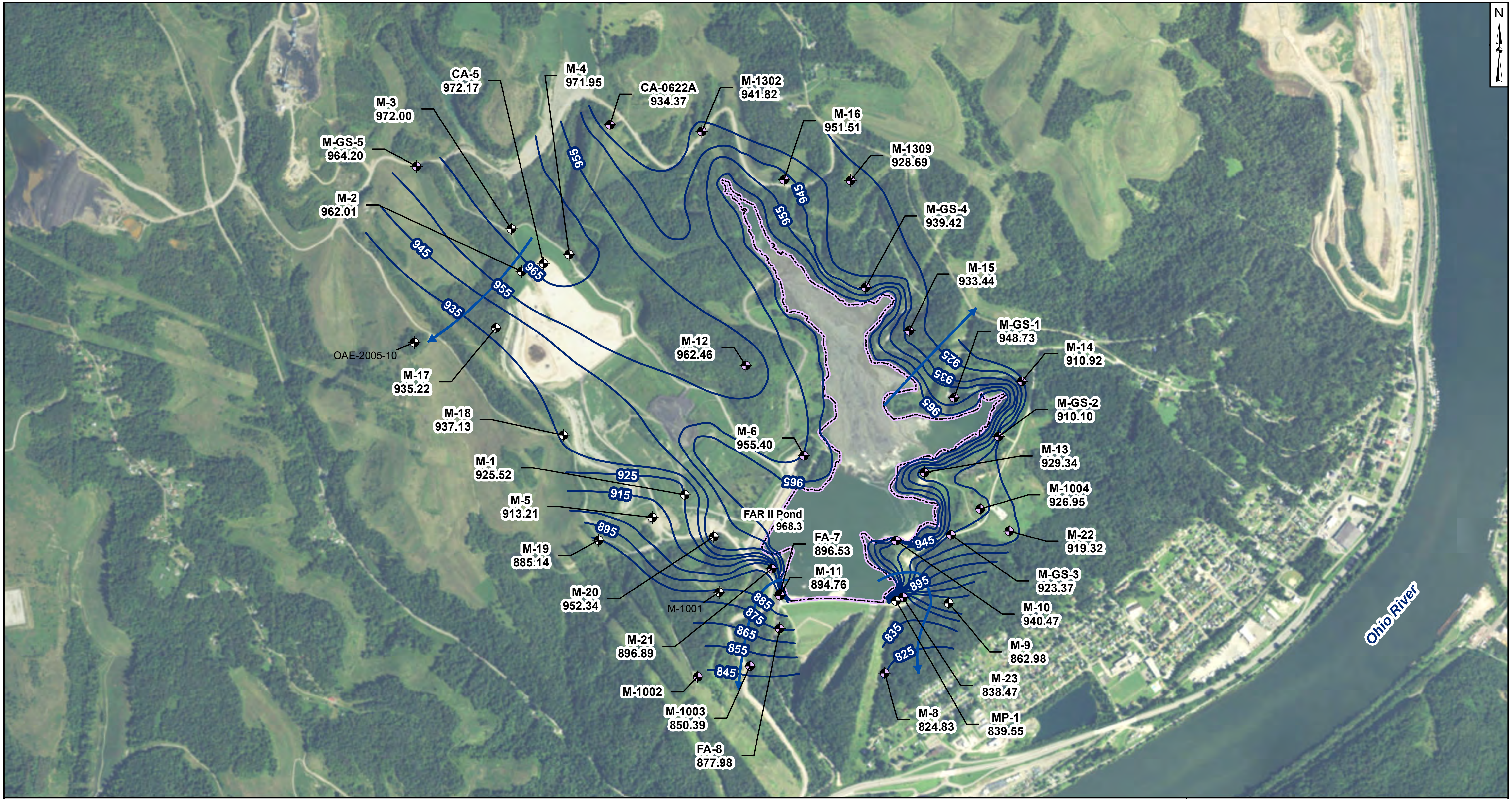

Legend

- ⊕ 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

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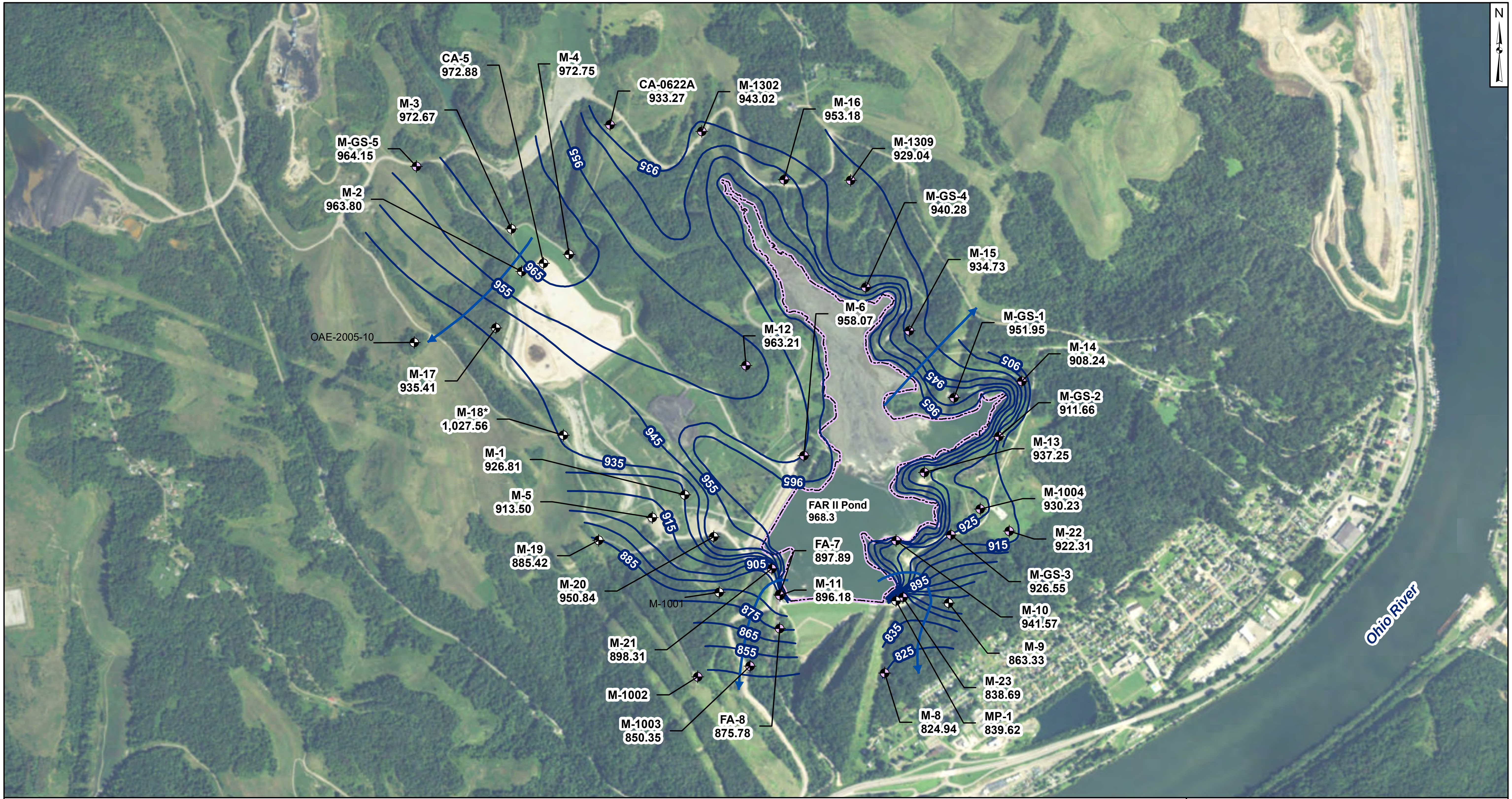

Legend

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

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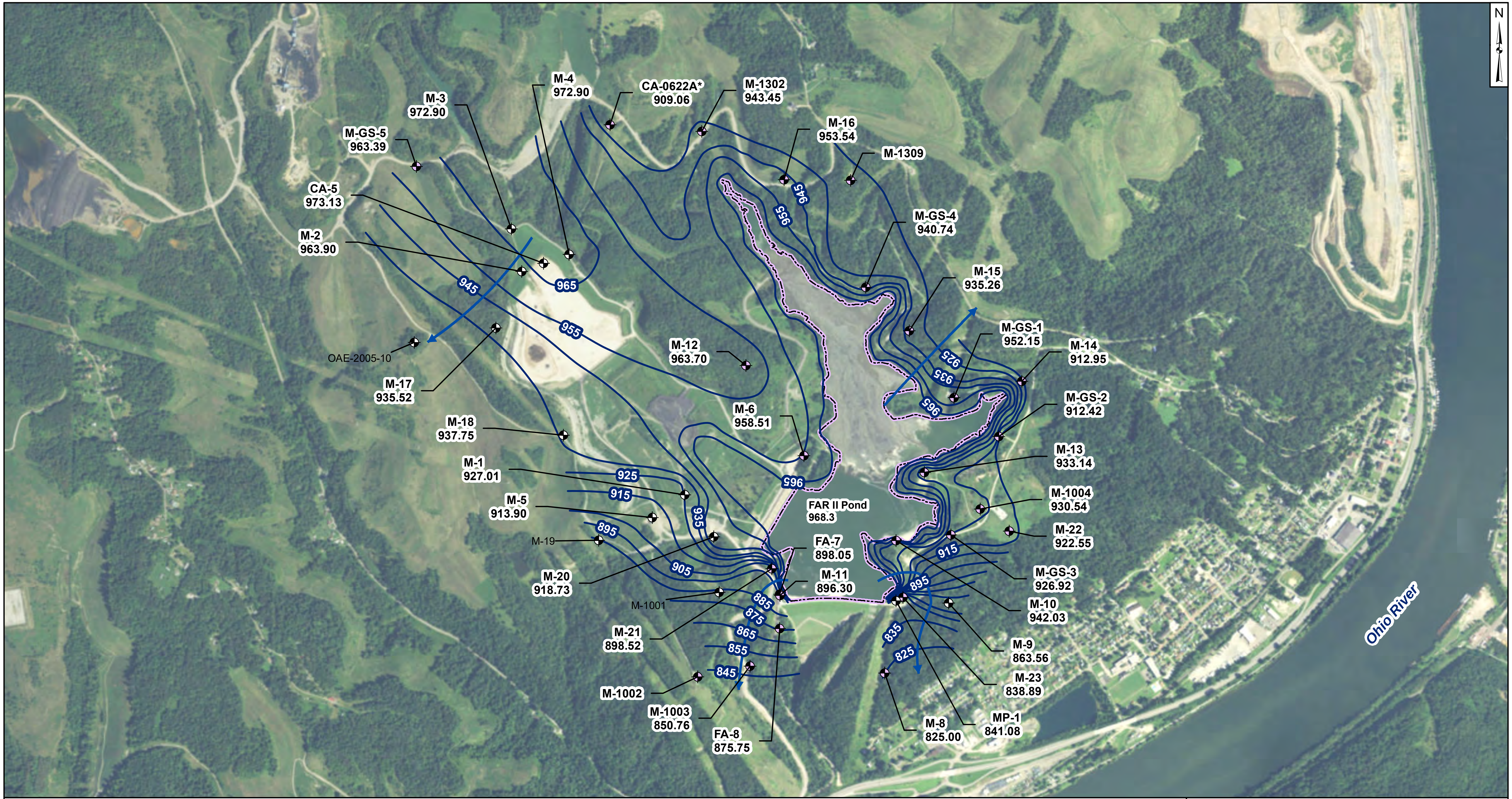

Legend

- ⊕ 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

Figure
5

Columbus, Ohio
2017/12/20

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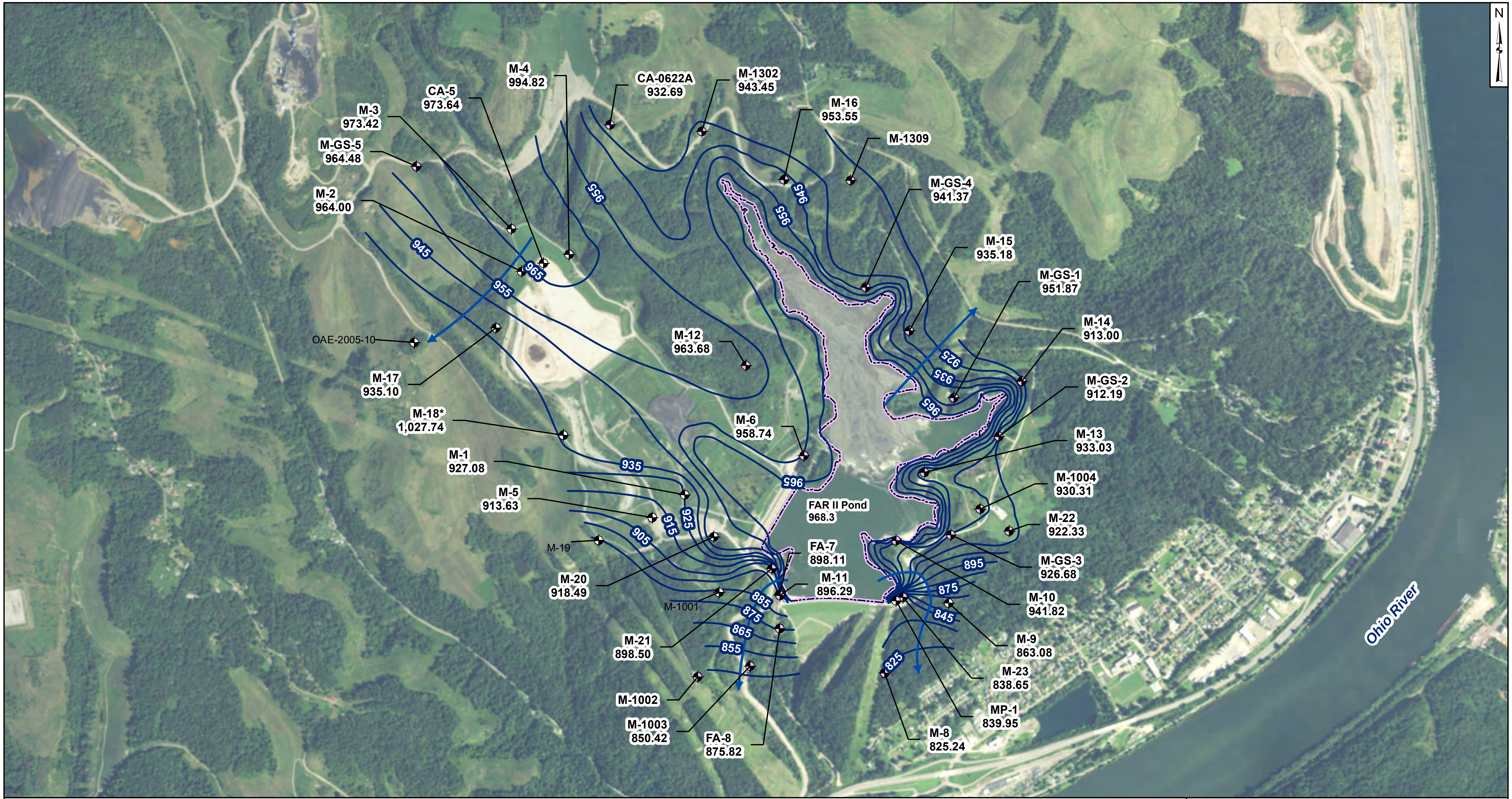

Legend

⊕ 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

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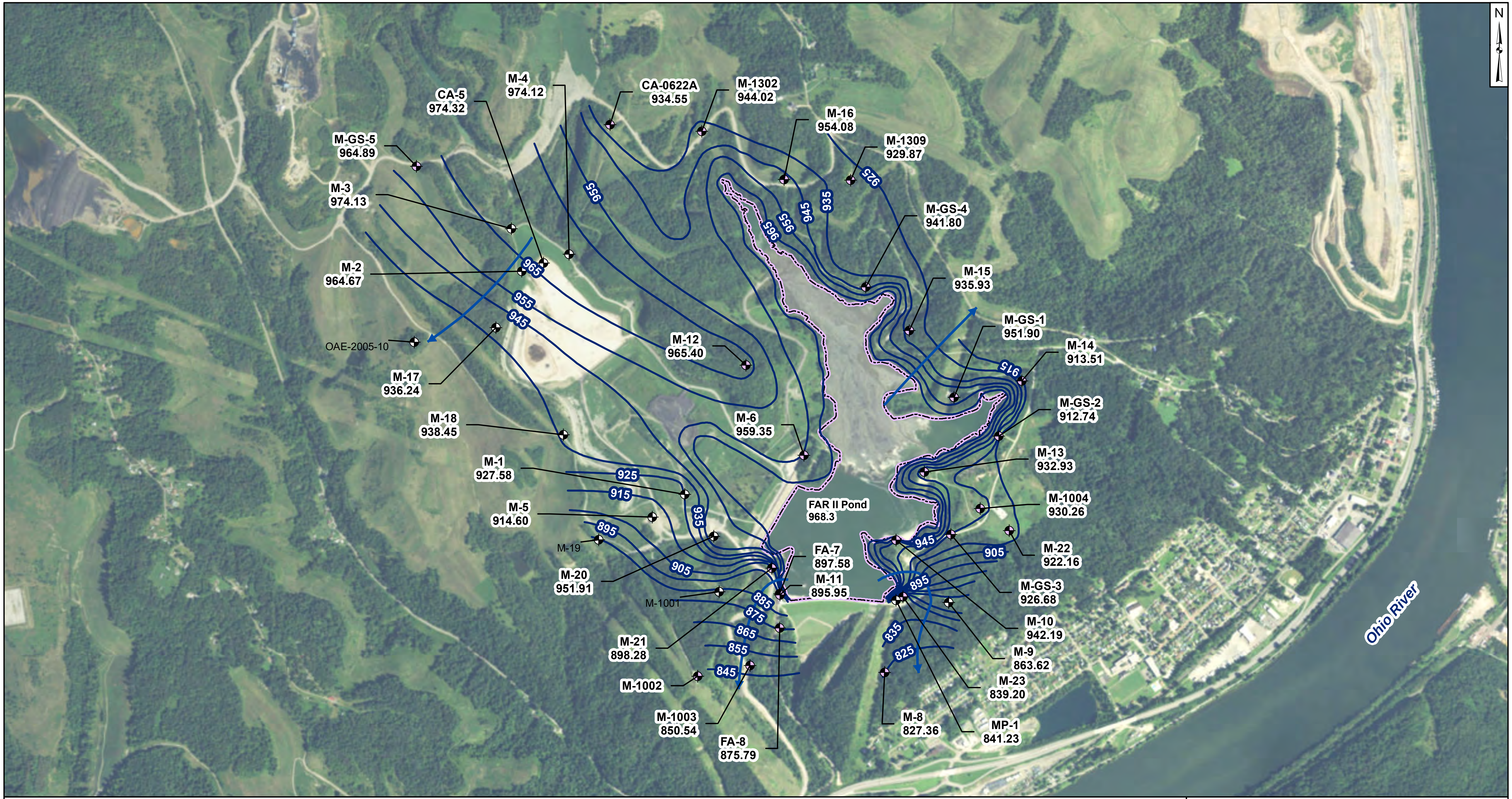

Legend

- ⌖ 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

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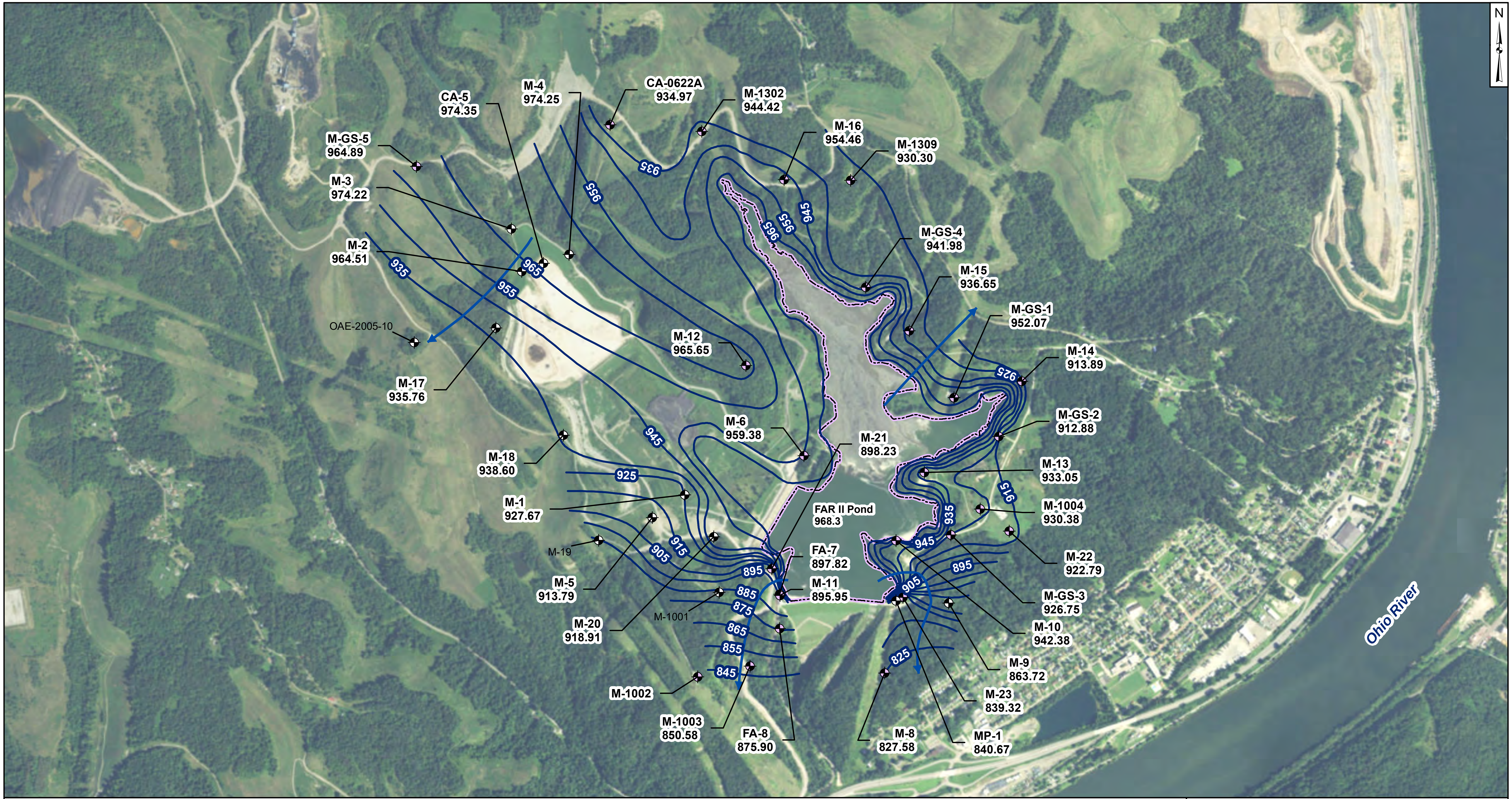

1,000 500 0 1,000
Feet

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.

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

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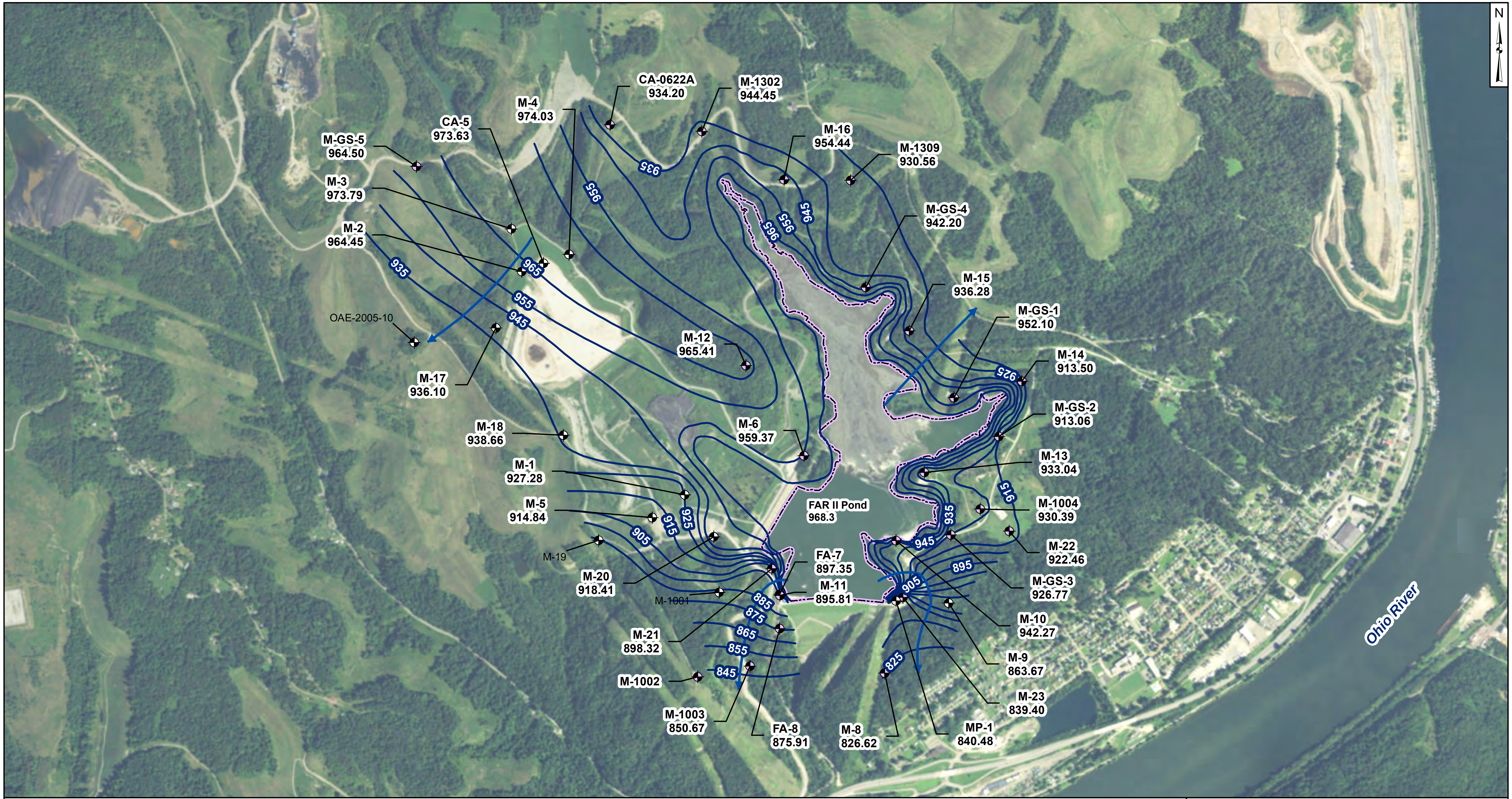

Legend

⊕ 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

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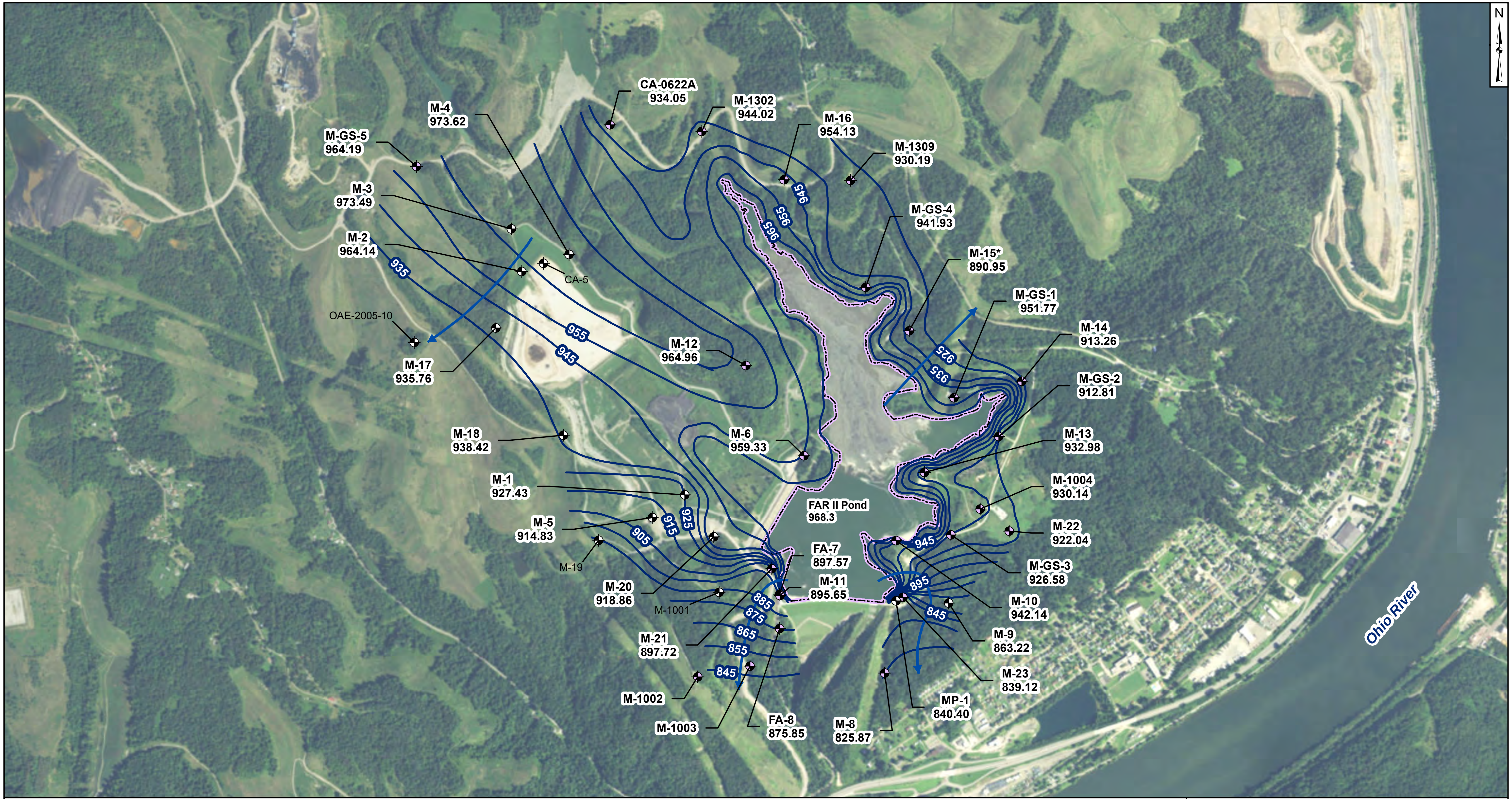

Legend

- ⌖ 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.

1,000 500 0 1,000 Feet

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

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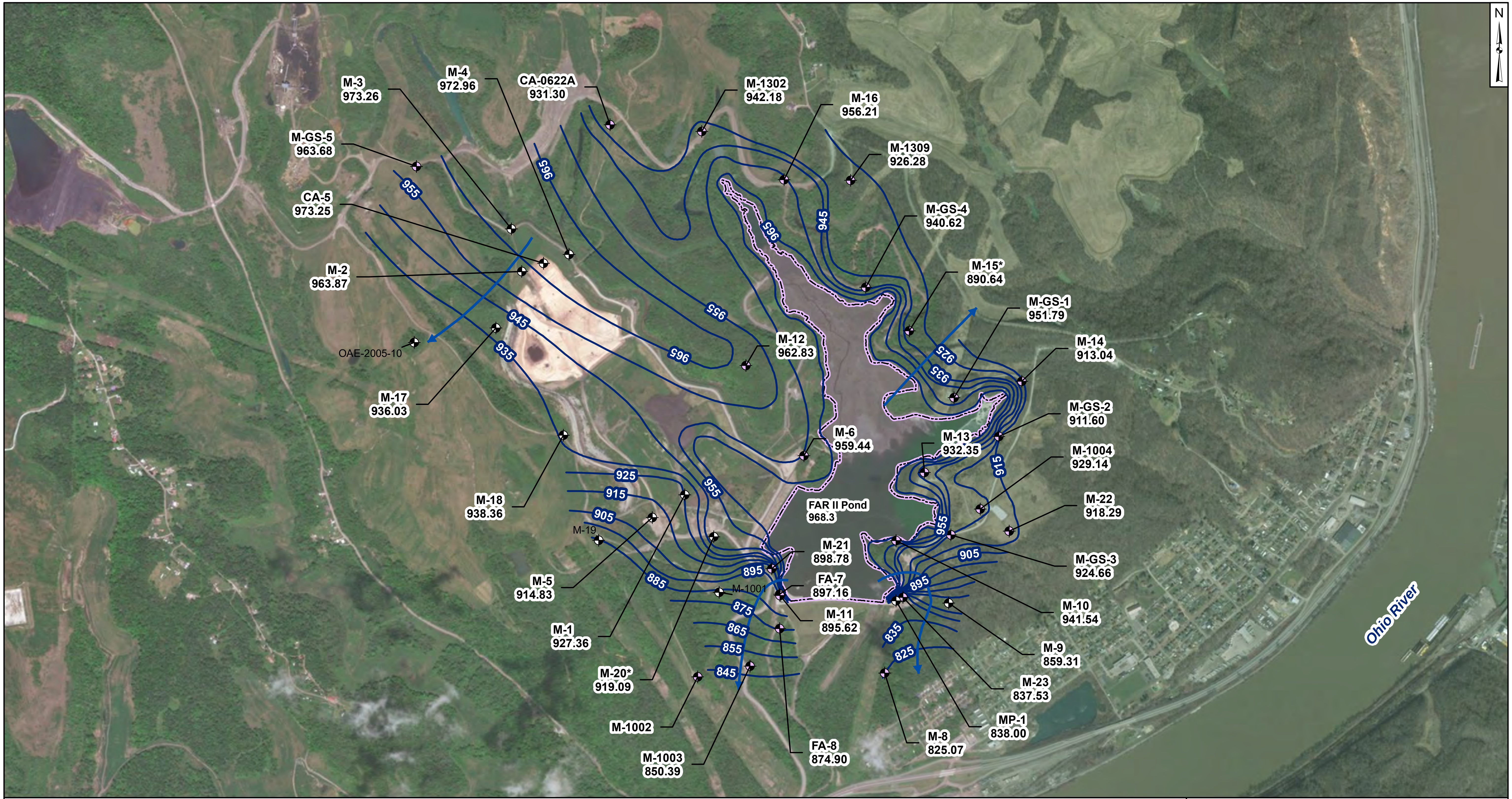

Legend

- ⊕ 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									
		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
		Background									Detection
Antimony	µg/L	0.05J	0.02J	0.05J	0.03J	0.06	-	0.05	0.04J	0.04J	-
Arsenic	µg/L	1.07	1.36	1.39	1.11	1.23	-	1.3	1.19	1.03	-
Barium	µg/L	79.5	138	99.7	130	122	-	141	128	90.8	-
Beryllium	µg/L	0.121	0.027	0.139	0.255	0.184	-	0.132	0.114	0.116	-
Boron	mg/L	0.157	0.254	0.176	0.164	0.198	-	0.243	0.233	0.257	0.287
Cadmium	µg/L	0.17	0.02U	0.02	0.01J	0.01J	-	0.03	0.008J	0.009J	-
Calcium	mg/L	6.77	13.1	8.65	9.01	8.86	-	10.5	11.5	7.71	7.8
Chloride	mg/L	2.76	2.03	2.74	2.62		2.65	2.42	2.23	2.53	2.43
Chromium	µg/L	0.9	0.3	0.9	0.285	0.846	-	0.657	0.544	0.606	-
Cobalt	µg/L	0.301	0.096	0.358	0.383	0.389	-	0.29	0.241	0.266	-
Combined Radium	pCi/L	2.687	0.976	1.243	4.1	2.36	-	1.854	2.583	2.284	-
Fluoride	mg/L	1.26	1.66	1.01	0.99		1.14	1.28	1.43	1.19	1.19
Lead	µg/L	0.859	0.221	1.06	1.33	1.47	-	1.11	0.933	0.853	-
Lithium	mg/L	0.021	0.013	0.008	0.01	0.007	-	0.009	0.015	0.012	-
Mercury	µg/L	0.005U	0.005U	0.002J	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	-
Selenium	µg/L	0.1	0.07J	0.2	0.06J	0.3	-	0.2	0.2	0.2	-
Total Dissolved Solids	mg/L	478	485	459	482	-	482	498	487	492	485
Sulfate	mg/L	11.7	22.1	8.6	5.6		8.9	14	18	10.2	12.4
Thallium	µg/L	0.01J	0.05U	0.114	0.06	0.02J	-	0.02J	0.01J	0.02J	-
pH	SU	8.55	8.26	8.83	8.61	8.7	8.45	8.23	8.07	8.36	8.63

Parameter	Unit	M-14									
		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
Antimony	µg/L	0.02J	0.01J	0.02J	0.02J	0.05U	-	0.05U	0.01J	0.05U	-
Arsenic	µg/L	0.36	0.29	0.32	0.24	0.17	-	0.16	0.14	0.15	-
Barium	µg/L	25	19.3	22.9	20.9	14.9	-	15.9	14.9	14.8	-
Beryllium	µg/L	0.062	0.026	0.044	0.035	0.006J	-	0.01J	0.008J	0.007J	-
Boron	mg/L	0.208	0.226	0.188	0.188	0.199	-	0.214	0.218	0.189	0.261
Cadmium	µg/L	0.09	0.02U	0.006J	0.005J	0.02U	-	0.02U	0.02U	0.008J	-
Calcium	mg/L	1.17	0.736	1.05	0.739	0.526	-	0.534	0.595	0.531	0.485
Chloride	mg/L	1.36	1.29	1.33	1.38		1.39	1.31	1.38	1.49	1.4
Chromium	µg/L	0.4	0.2	0.8	0.332	0.092	-	0.117	0.084	0.127	-
Cobalt	µg/L	0.118	0.047	0.107	0.078	0.01	-	0.022	0.02J	0.01J	-
Combined Radium	pCi/L	1.002	1.088	1.229	1.543	0.3533	-	0.3893	1.469	1.353	-
Fluoride	mg/L	0.79	0.74	0.75	0.7		0.76	0.7	0.74	0.84	0.74
Lead	µg/L	0.763	0.285	0.68	0.512	0.037	-	0.082	0.053	0.031	-
Lithium	mg/L	0.009	0.008	0.003	0.005	0.007	-	0.006	0.0003J	0.008	-
Mercury	µg/L	0.005U	0.005U	0.005U	0.005U	0.005U	-	0.005U	0.005U	0.005U	-
Molybdenum	µg/L	0.3	0.74	0.44	0.55	1.11	-	0.26	0.33	0.39	-
Selenium	µg/L	0.2	0.07J	0.1	0.07J	0.1U	-	0.1U	0.1U	0.1U	-
Total Dissolved Solids	mg/L	383	380	381	364	-	379	373	1010	395	381
Sulfate	mg/L	3	0.9	0.3	0.6	-	0.2	0.5	0.5	0.3	0.5
Thallium	µg/L	0.02J	0.05U	0.172	0.068	0.05U		0.05U	0.01J	0.05U	-
pH	SU	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											M-22										
		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	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	Background										Detection
Antimony	µg/L	0.27	0.09	0.17	0.07	0.3	-	-	0.07J	0.06J	0.04J	-	0.01J	0.05U	0.01J	0.02J	0.05U	-	-	0.05U	0.05U	0.05U	-
Arsenic	µg/L	5.49	2.66	4.24	2.92	5.7	-	-	1.89	2.59	4.62	-	0.49	0.47	0.53	0.62	0.55	-	-	0.56	0.52	0.51	-
Barium	µg/L	12.8	12.2	12.5	12.3	17.4	-	-	10.1	11.3	13.7	-	24.6	23.4	25.3	25.1	24.1	-	-	26.1	25.4	24.4	-
Beryllium	µg/L	0.915	0.379	0.739	0.247	0.512	-	-	0.244	0.191	0.091	-	0.041	0.032	0.038	0.041	0.033	-	-	0.04	0.037	0.037	-
Boron	mg/L	3.08	3.33	2.68	2.88	2.78	-	-	3.15	3.15	3.21	3.08	3.56	3.81	3.39	3.79	3.5	-	-	3.96	4.14	4.08	4.14
Cadmium	µg/L	0.03	0.01J	0.009J	0.006J	0.02J	-	-	0.04U	0.04U	0.01J	-	0.006J	0.01J	0.02U	0.004J	0.02U	-	-	0.02U	0.02U	0.02U	-
Calcium	mg/L	298	282	262	229	214	-	-	254	241	203	247	194	182	189	176	161	-	-	175	185	182	195
Chloride	mg/L	100	79.6	68.6	64.5	-	65.2	-	59.2	64.1	65.8	62.5	46.1	46.3	46.7	47.8	-	-	49.4	49.4	49.6	50.2	51.8
Chromium	µg/L	0.3	0.1	0.2	0.262	0.124	-	-	0.119	0.407	0.492	-	0.1	0.1	0.2	0.258	0.04J	-	-	0.04J	0.052	0.118	-
Cobalt	µg/L	2.95	2.07	2.41	2.02	1.89	-	-	2.66	2.99	1.89	-	0.922	1.17	1.13	1.16	1.17	-	-	1.15	1	1.06	-
Combined Radium	pCi/L	1.007	0.4449	0.393	0.838	0.811	-	-	1.19	1.306	1.849	-	1.947	1.197	3.244	2.084	1.255	-	-	1.494	5.156	0.769	-
Fluoride	mg/L	0.1J	0.1J	0.1J	0.1J	-	0.1J	-	0.07J	0.08J	0.1J	0.08	0.46	0.4	0.44	0.41	-	-	0.42	0.4	0.37	0.43	0.35
Lead	µg/L	1.52	0.446	0.983	0.544	1.67	-	-	0.392	0.349	0.328	-	0.007J	0.02J	0.039	0.029	0.027	-	-	0.01J	0.02J	0.02U	-
Lithium	mg/L	0.082	0.09	0.074	0.082	0.074	-	-	0.08	0.082	0.081	-	0.068	0.054	0.046	0.057	0.052	-	-	0.062	0.064	0.068	-
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	20.9	14.9	17.2	18.9	16.6	-	-	16.9	18.8	16.9	-	90.8	92.5	97.8	92.7	89	-	-	94.3	93.6	86.8	-
Selenium	µg/L	0.4	0.2	0.3	0.1	0.5	-	-	0.1J	0.07J	0.2U	-	0.1	0.1U	0.04J	0.05J	0.04J	-	-	0.05J	0.04J	0.1U	-
Total Dissolved Solids	mg/L	1940	1840	1810	1850	-	1850	891	1770	1830	1840	1830	883	913	916	929	-	-	938	946	961	963	985
Sulfate	mg/L	1070	995	990	986	-	990	-	1020	1030	1080	998	378	386	383	390	-	-	399	403	409	415	435
Thallium	µg/L	0.02J	0.02J	0.055	0.02J	0.05U	-	-	0.05J	0.1U	0.1U		0.04J	0.01J	0.064	0.082	0.05U	-		0.05U	0.01J	0.05U	
pH	SU	6.94	7.07	7.53	6.42	7.03	8.02	-	6.98	7.43	8.11	7.14	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
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	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:
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	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:
mg/L: milligrams per liter
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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-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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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	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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- : Not sampled
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_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

941 Chatham Lane, Suite 103
Columbus, Ohio 43221

January 13, 2020

CHA8468

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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.

7. REFERENCES

American Electric Power (AEP) and Geosyntec Consultants, Inc. 2006. Hydrogeological Investigation Report. May.

Buckeye Power Generating I, Inc. (Buckeye Power). 2019. Notification of Exceedance of Groundwater Protection Standards at Fly Ash Reservoir II. February.

Geosyntec Consultants, Inc. 2017a. Groundwater Monitoring Network Evaluation, Cardinal Site – Fly Ash Reservoir II, February.

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

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

Geosyntec Consultants, Inc. 2019b. Statistical Analysis Summary – Fly Ash Reservoir II. January.

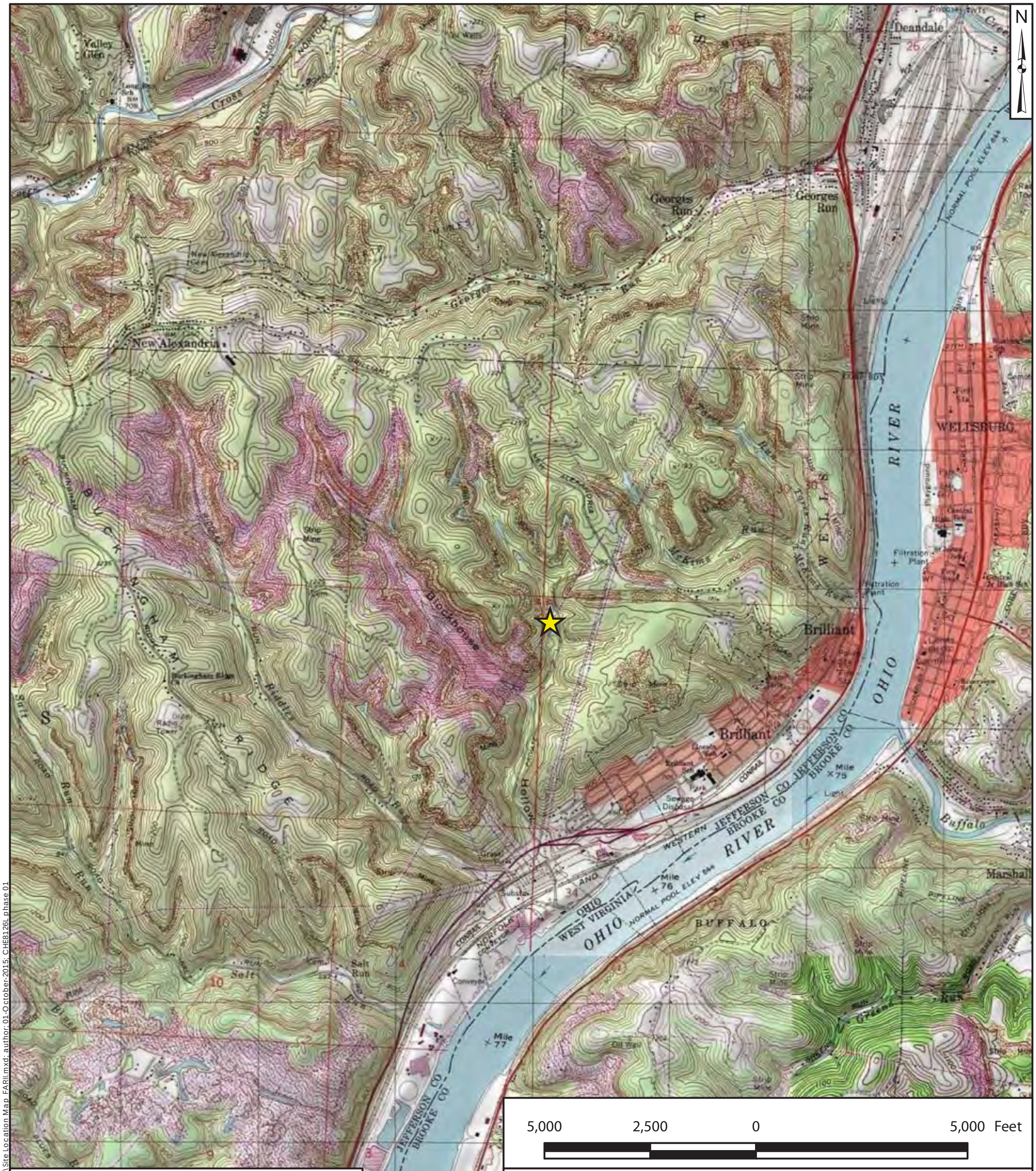
Geosyntec Consultants, Inc, 2019c. Groundwater Characterization Report, Cardinal Site – Fly Ash Reservoir II. July.

Geosyntec Consultants, Inc. 2019d. Assessment of Corrective Measures, Cardinal Site – Fly Ash Reservoir II. July.

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

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

FIGURES



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

Figure
2

Columbus, Ohio
2020/01/14

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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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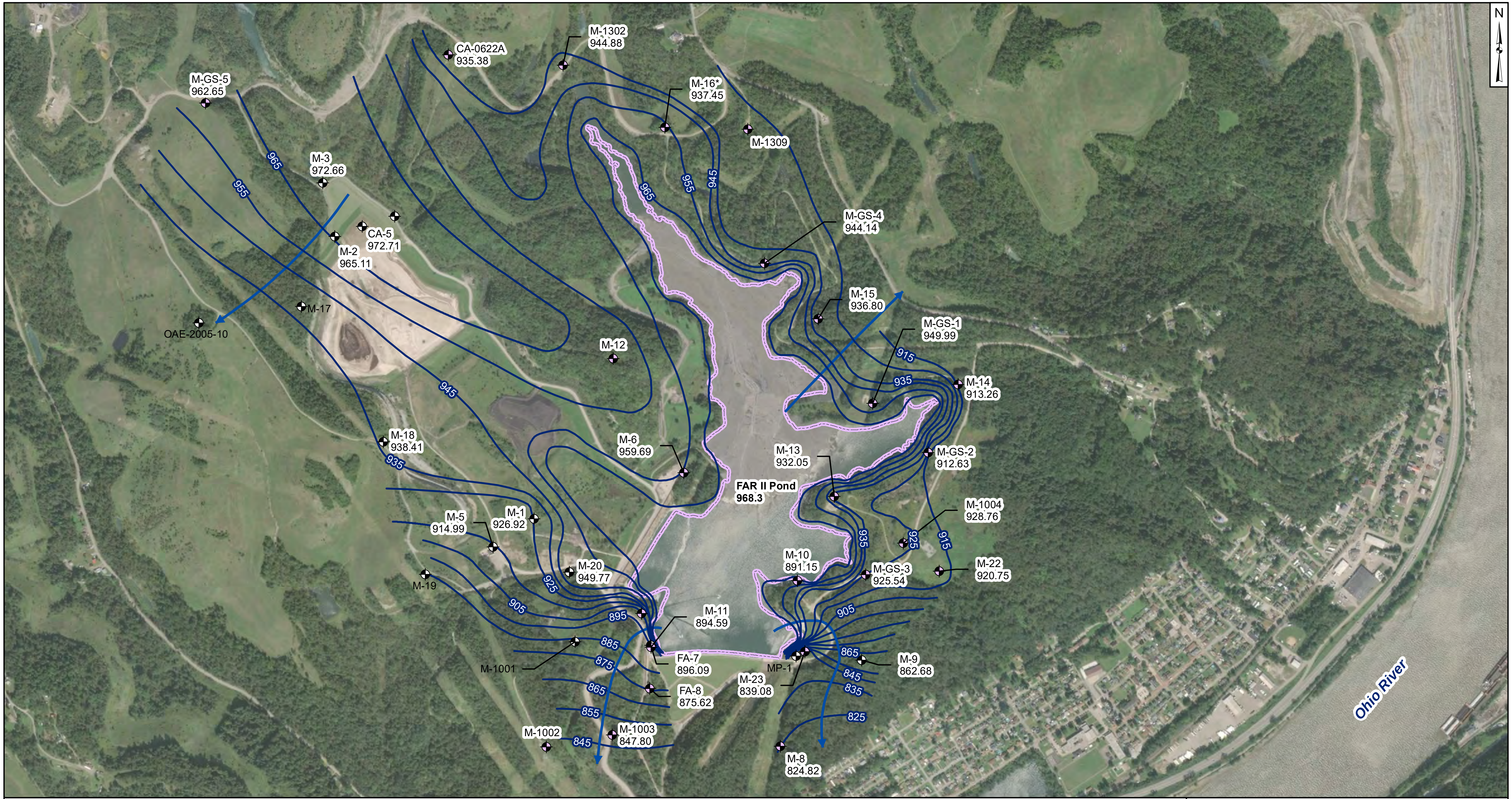

Legend

⊕ 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

Figure
X

Columbus, Ohio

2019/12/31

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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:
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-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:
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-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:
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 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

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

(Page 1 of 4)

Soil Samples

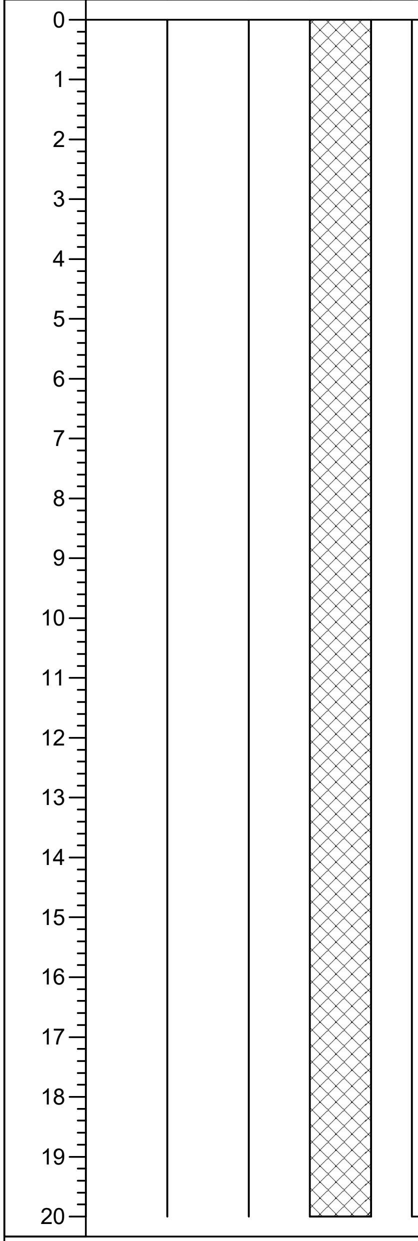
- ☒ Sample Intervals
- ■ Sample Sent to Lab

Water Levels

- ▼ Static
- ▽ During Drilling

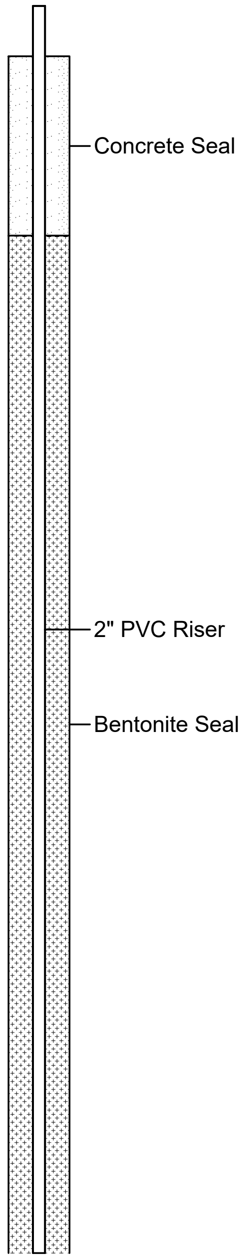
Well: M-2000

Depth in Feet	Sample Interval/ Sample Recovery	Sampler Type/ Sample Number	Sample	GRAPHIC	Water Level	DESCRIPTION



Straight drill using 4.25-inch Hollow Stem Augers to bedrock refusal.

Bottom Ash (0-32')



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

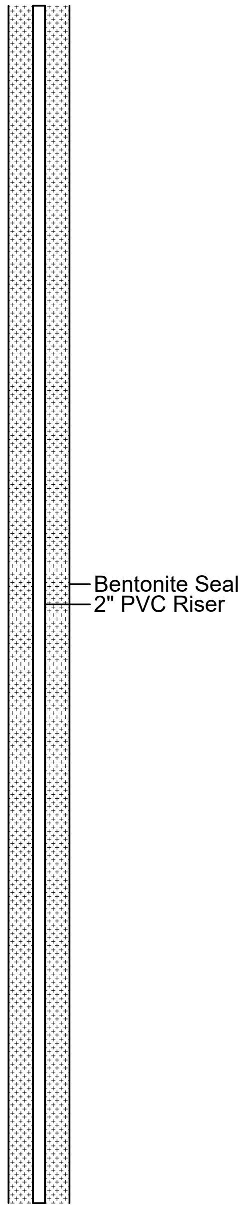
(Page 2 of 4)

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						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%
40						



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

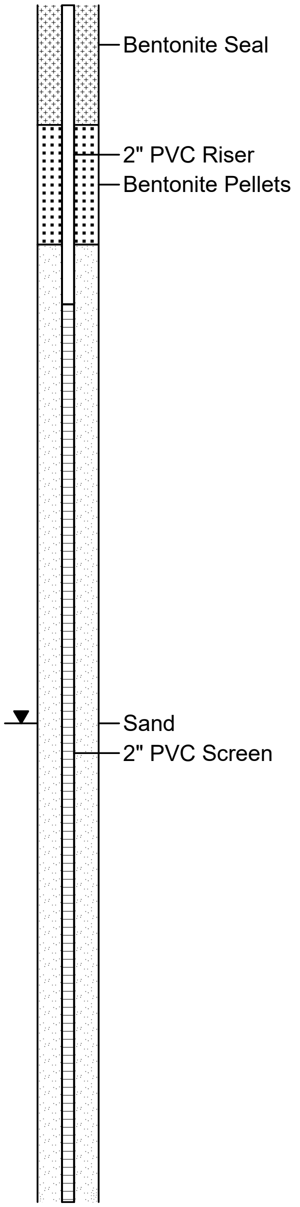
(Page 3 of 4)

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	Water Level	DESCRIPTION
40				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%
60				



HULL

Environment / Energy / Infrastructure

Cardinal Operating Company
306 County Road 7E
Brilliant, Ohio
BPG003

Date Started : 3-6-2019
Date Completed : 3-8-2019
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Drilling Contractor : Terra Testing
Drilling Method : 4.25" HSA
Sampling Method : 4" Core Barrel
Total Depth (ft.) : 77.0'

LOG OF BORING M-2000

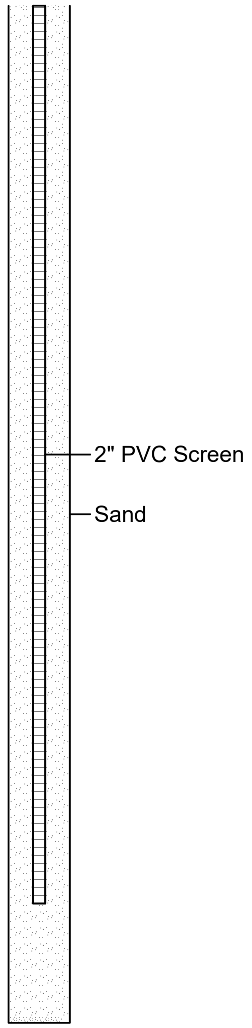
(Page 4 of 4)

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
60			Medium, very thin to medium, yellow brown to grey, moderately weathered, moderately strong; bedding fractured to moderately fractured. 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%
67	5/5	RC-9 67.0-72.0	
69			Medium, grey, unweathered, medium strong SANDSTONE; slightly fractured. RQD = 60%
72	5/5	RC-10 72.0-77.0	RQD = 68.3%
75			Soft grey fine CLAY and unweathered blue grey SHALE; moderately strong; laminated; bedding; moderately fractured. End of Boring @ 77'



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

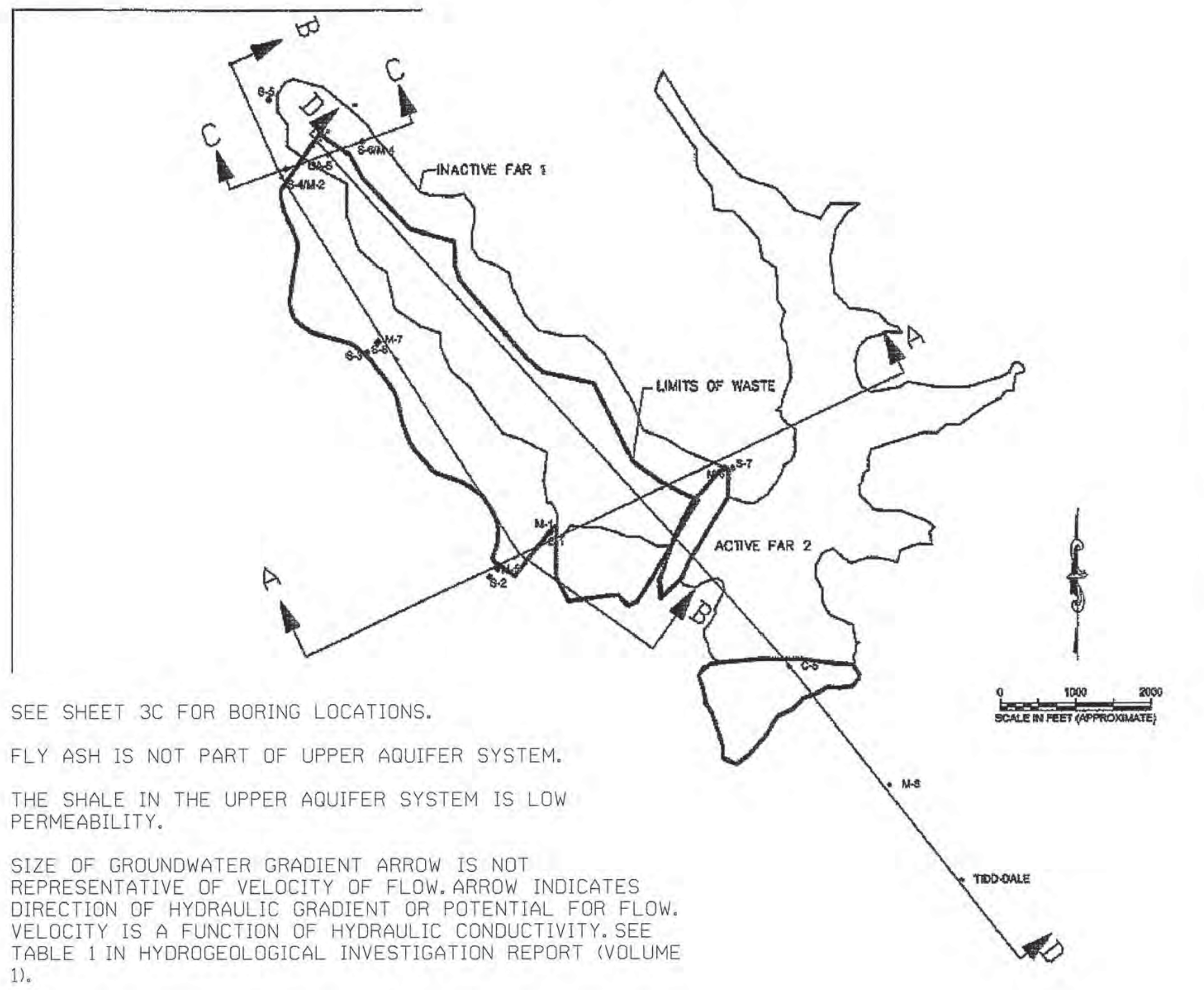
The groundwater monitoring network is shown on Figure 3-2 and consists of five (5) monitoring wells (CA-0622, M-6, M-12, M-1302 and M-GS-5) located upgradient and 18 monitoring wells (FA-8, M-8, M-10, M-11, M-13, M-14, M-15, M-16, M-21, M-22, M-23, M-1003, M-1004, M-1309, M-GS-1, M-GS-2, M-GS-3 and M-GS-4) 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

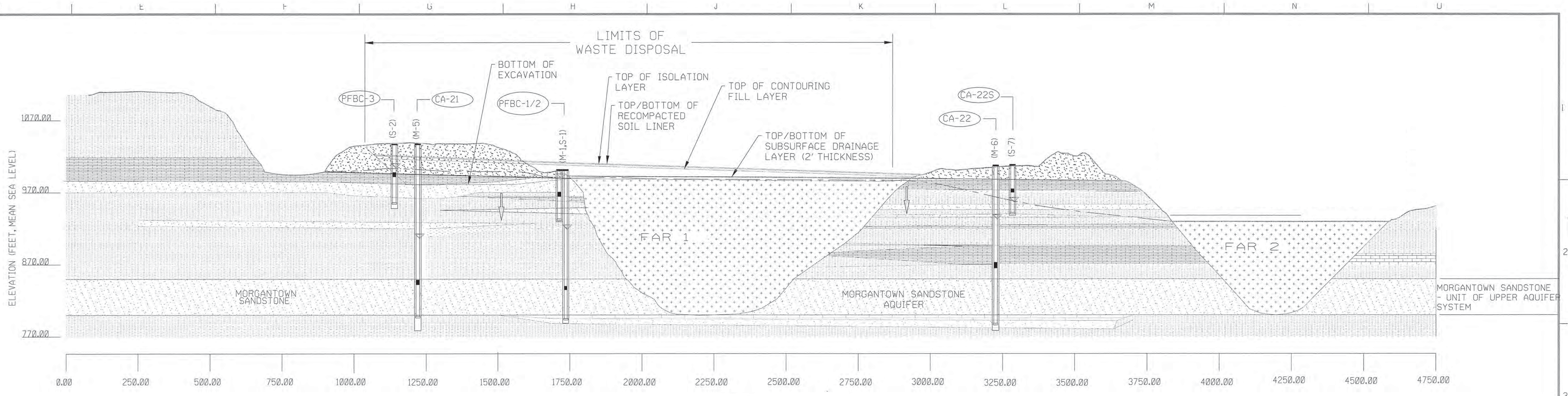
Review of the existing groundwater monitoring well network in relation to the geologic and hydrogeologic conditions in the area of FAR II indicates that the monitoring well network consists of a sufficient number of wells installed at the appropriate depths to collect groundwater samples from the uppermost 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

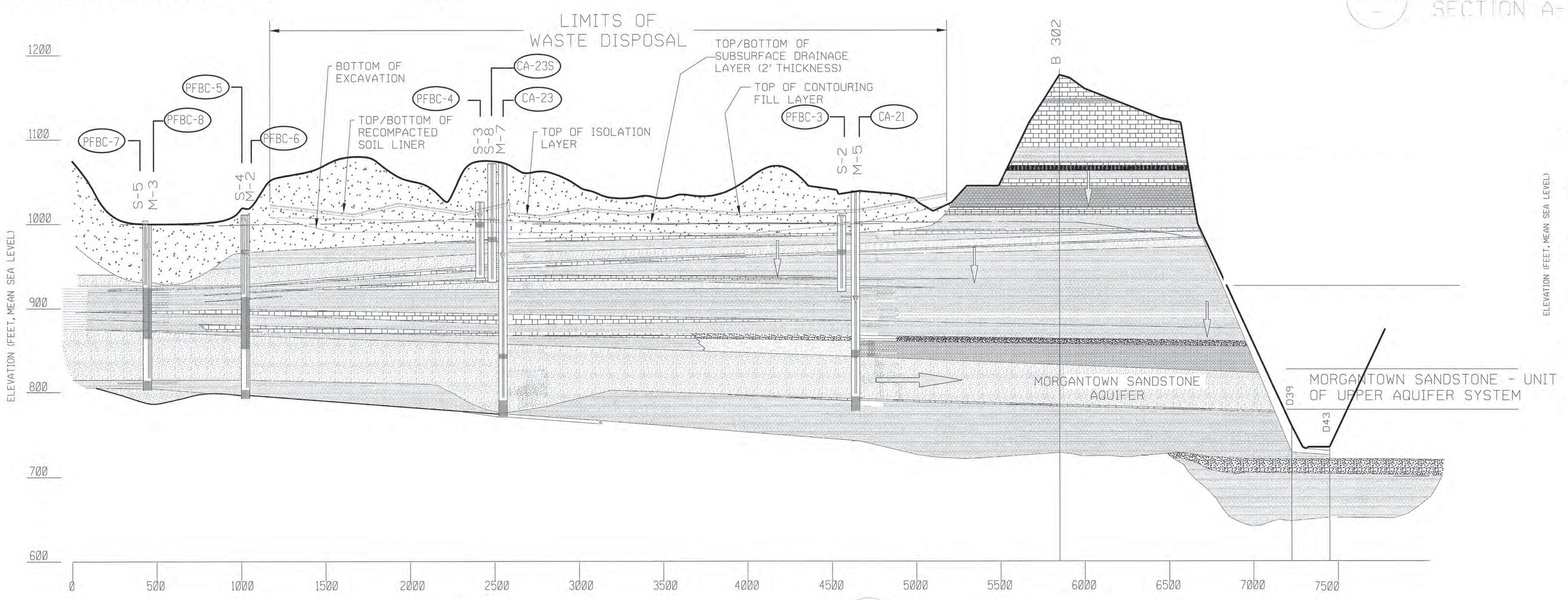


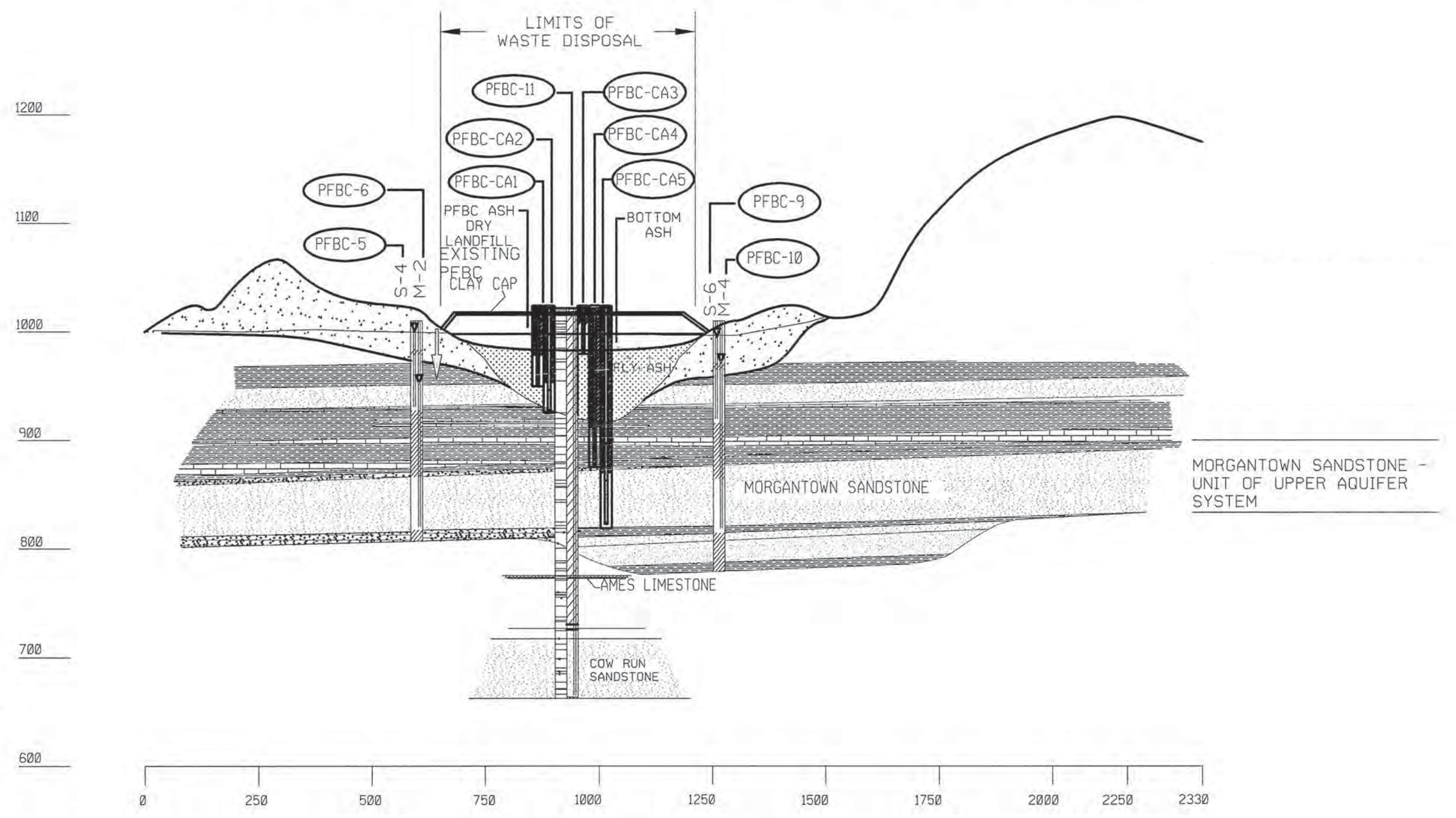
1. SEE SHEET 3C FOR BORING LOCATIONS.
2. FLY ASH IS NOT PART OF UPPER AQUIFER SYSTEM.
3. THE SHALE IN THE UPPER AQUIFER SYSTEM IS LOW PERMEABILITY.
4. SIZE OF GROUNDWATER GRADIENT ARROW IS NOT REPRESENTATIVE OF VELOCITY OF FLOW. ARROW INDICATES DIRECTION OF HYDRAULIC GRADIENT OR POTENTIAL FOR FLOW. VELOCITY IS A FUNCTION OF HYDRAULIC CONDUCTIVITY. SEE TABLE 1 IN HYDROGEOLOGICAL INVESTIGATION REPORT (VOLUME 1).



A SECTION
SECTION A-A'

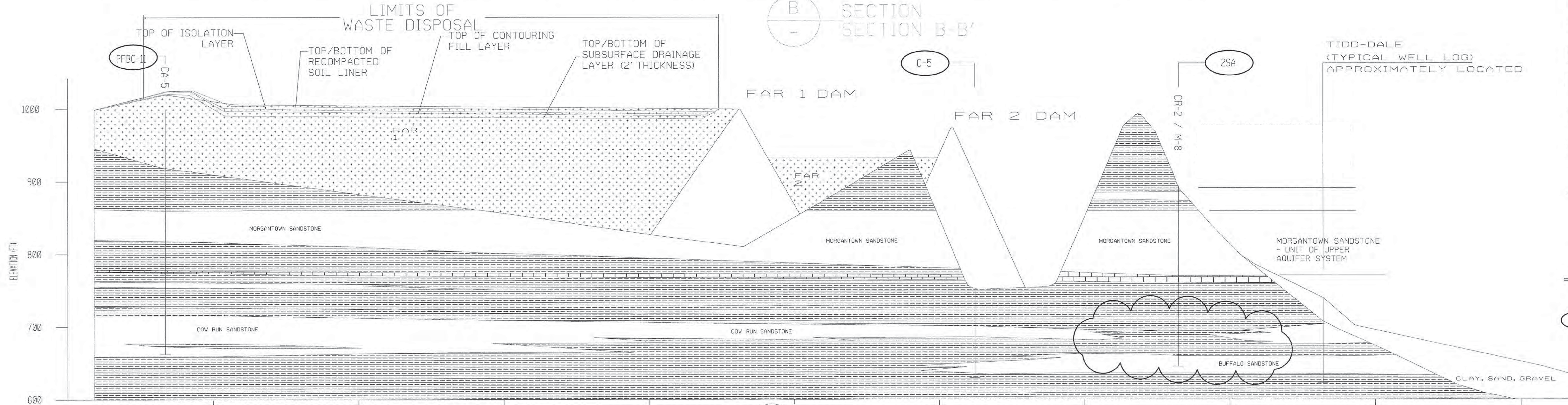
NOTE: SEE DRAWING 13-30560 FOR EXTENSION OF THIS SECTION FROM RIDDLES RUN TO CROTS CREEK.





C SECTION
SECTION C-C'

B SECTION
SECTION B-B'



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

GEOSYNTEC CONSULTANTS
55 WEST WACKER DRIVE, SUITE 1100
CHICAGO, IL 60601 USA
(312) 658-0500

SIGNATURE

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MAY 25 2006	B	REVISED NOD 1 RESPONSE	DGB
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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

SCALE:
CIVIL ENGINEERING DIVISION
DR:
CH:
ENGR.
PROJ. ENGR.
DATE:
APPROVED BY Pedro J. Amaya

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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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].

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[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.

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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			○	●
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.

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

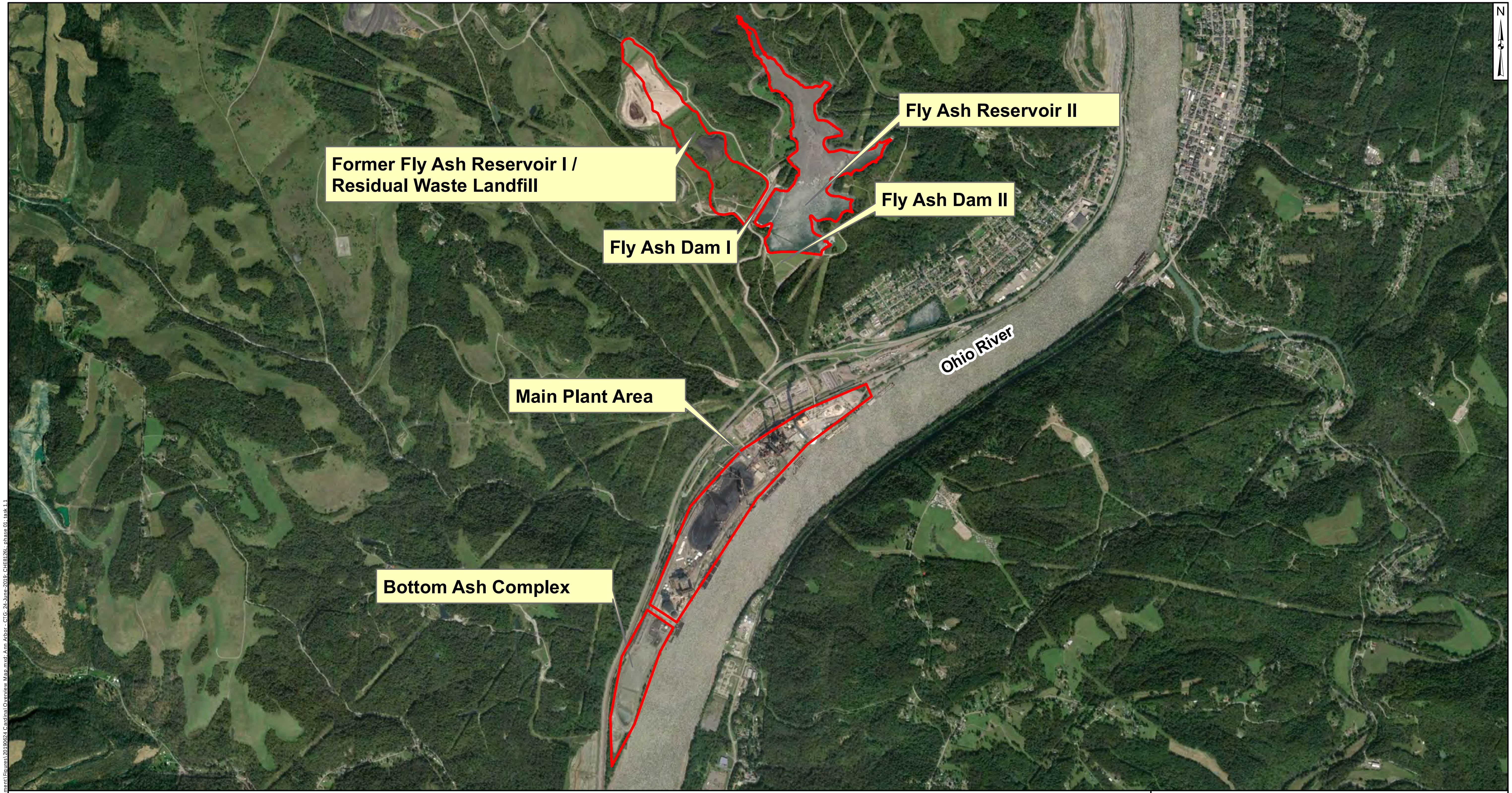
Possible Corrective Measures Technologies / Evaluation Criteria Considered		**Corrective Measures Options**			
		CMO #1: MNA	CMO #2: Closure and Monitoring	CMO #3: Bedrock Grouting	CMO #4: Hydraulic Gradient Control
Primary Corrective Measure Technologies	Monitored Natural Attenuation	●	●		
	Vertical 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

FIGURES



Legend

🟥 Site Boundary

Notes
- Aerial imagery courtesy of ESRI.
- All boundaries are approximate.
- CCR = Coal Combustion 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

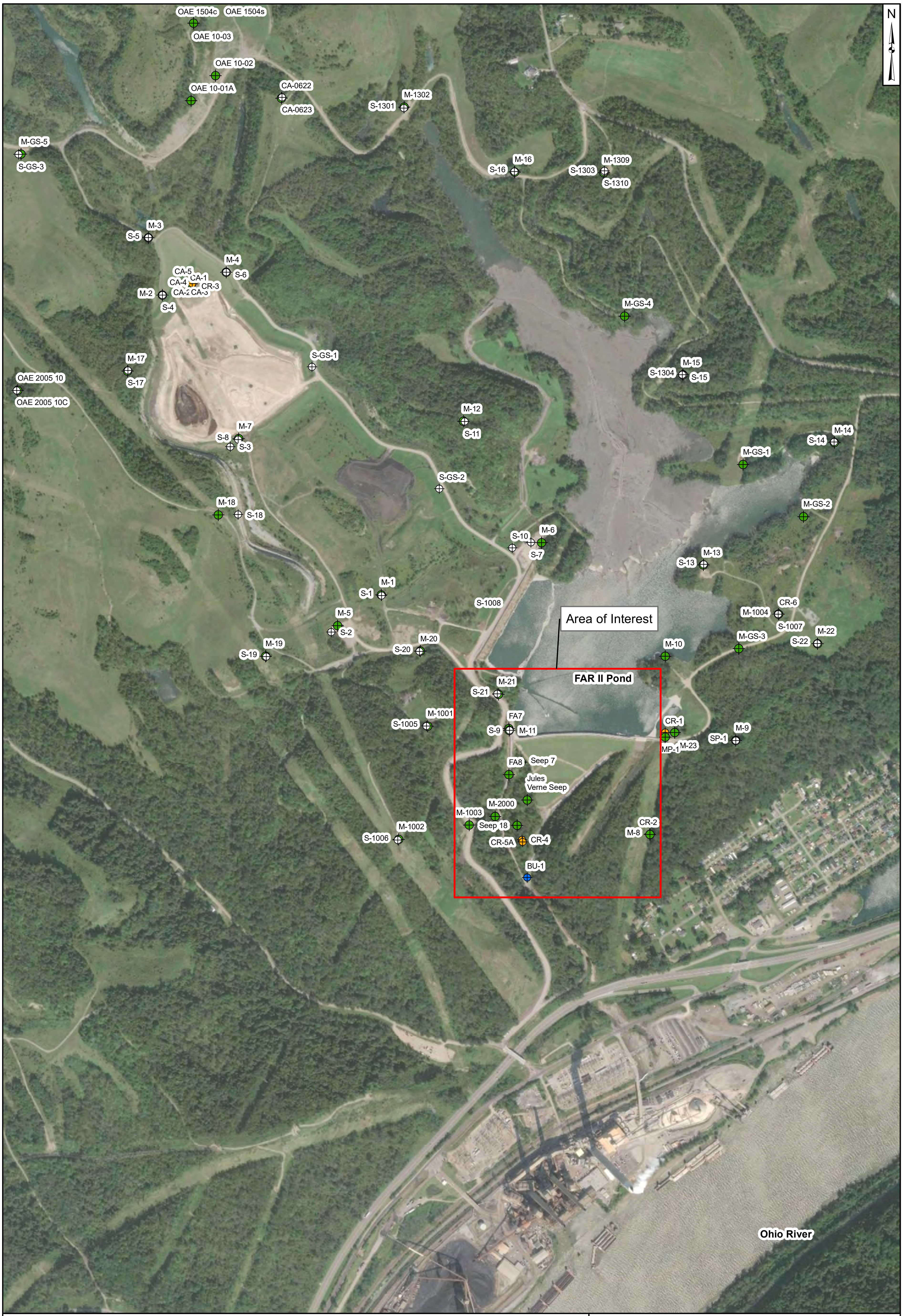
Ann Arbor, Michigan

06/24/2019

Figure

1

\\annarbor-01\Projects\AEP\Cardinal\CCR Compliance Document\Figures\20190624 Cardinal Overview Map.mxd; Ann Arbor - CTG; 24-June-2019; CHE8126L; 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

Figure

2

Columbus, Ohio

2019/06/21

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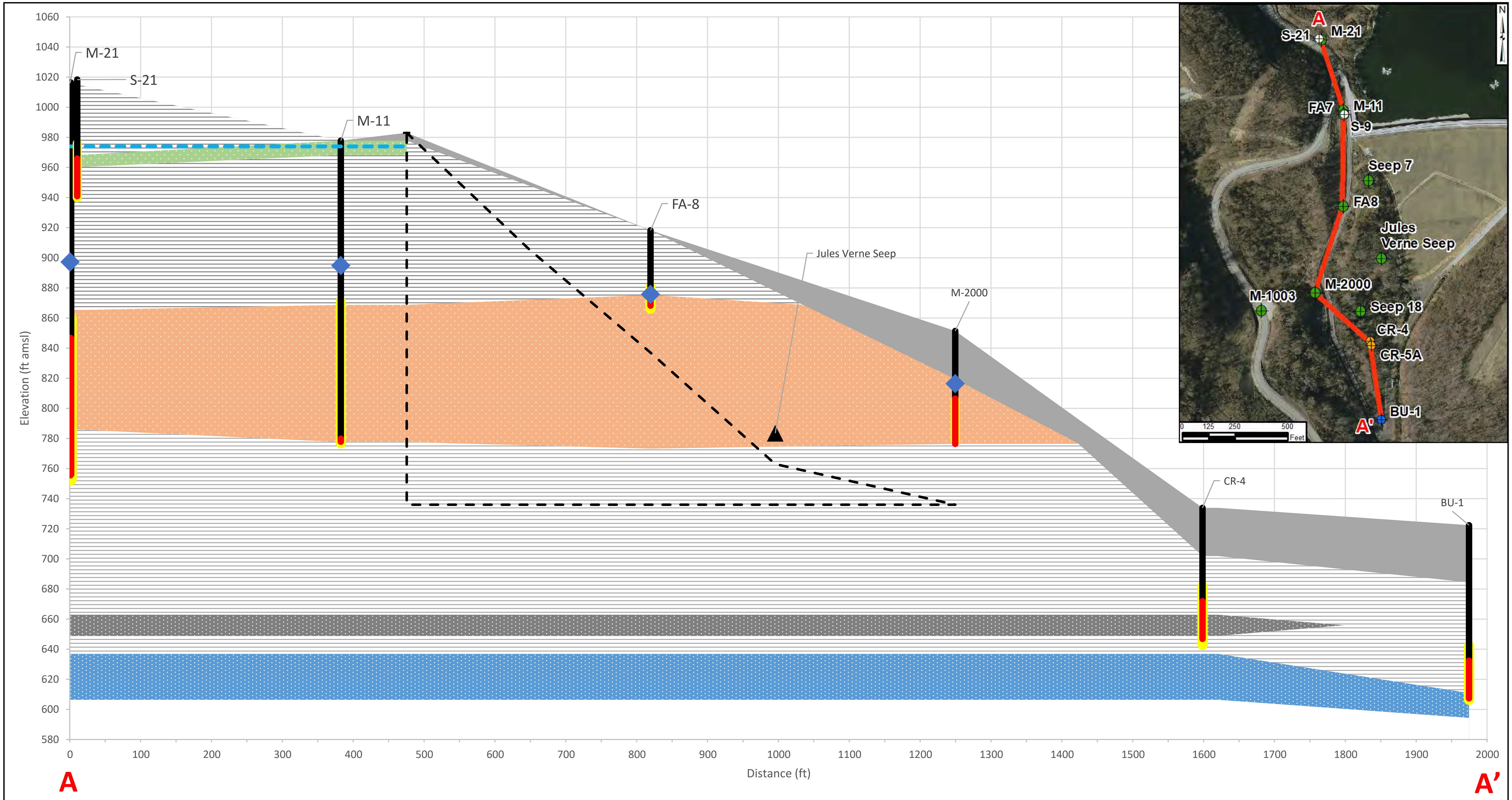

Legend

▨ 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:

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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.
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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

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June 2019

Figure
3

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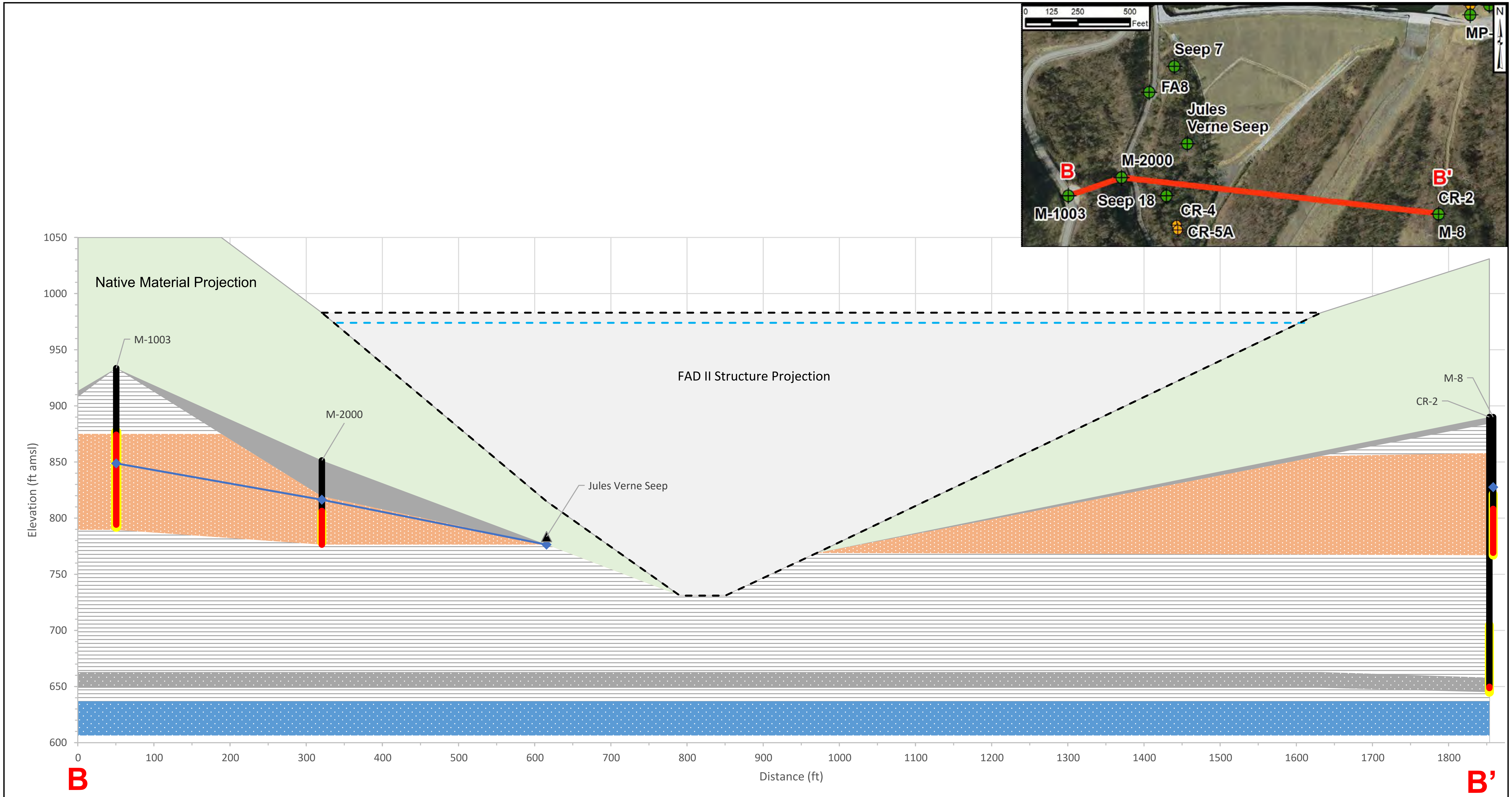

Legend

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Cross Section B-B'
Fly Ash Reservoir II

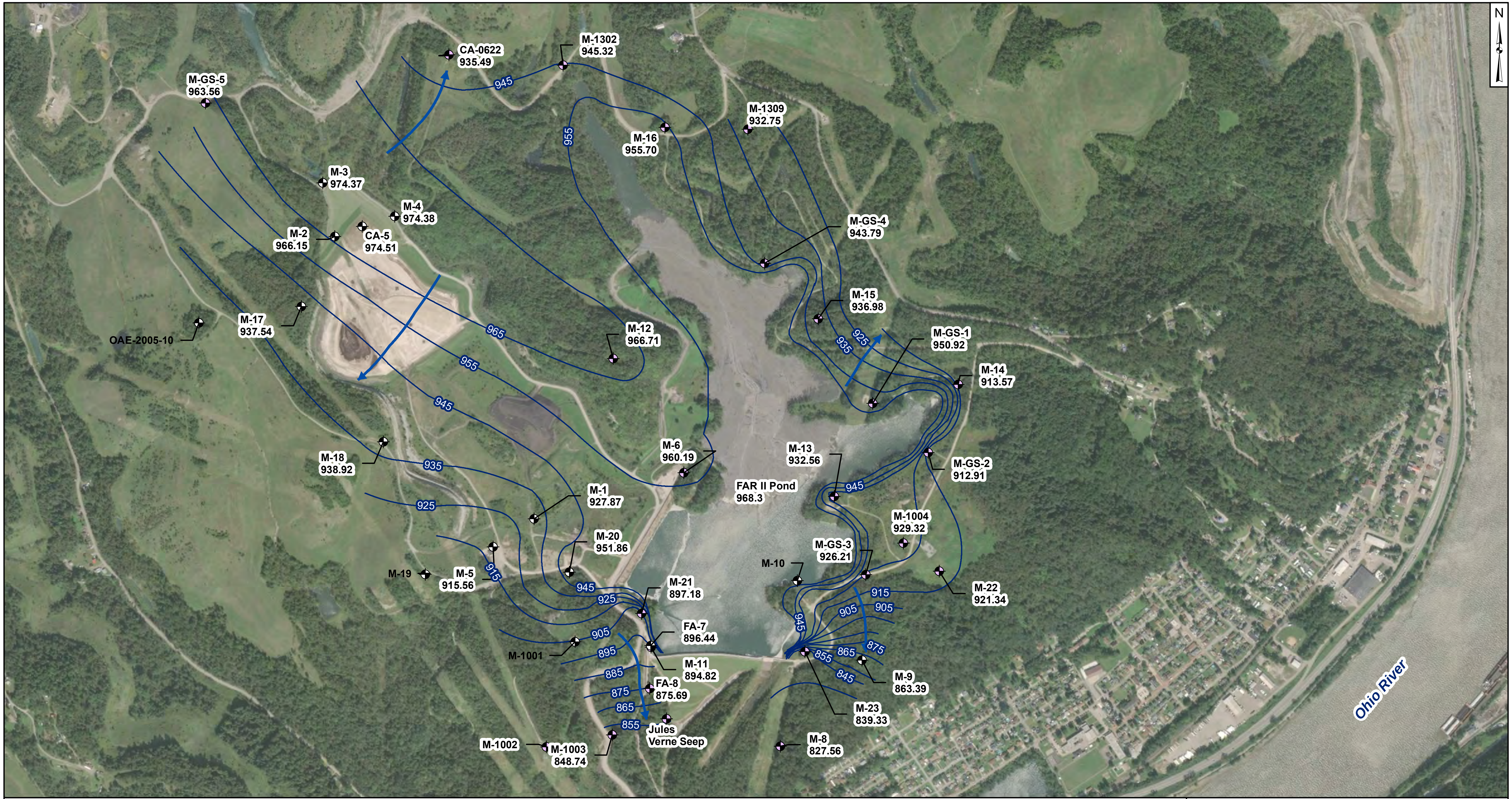
Buckeye Power Cardinal Generating Plant
Brilliant, OH

Geosyntec consultants

Figure
4

CHA8468
June 2019

\\annarbor-01\data\Projects\Buckeye Power\Corrective Measures Assessment\Cross Sections



1,000 500 0 1,000 Feet

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.

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

CARDINAL
OPERATING COMPANY

Prepared by

Geosyntec
consultants

engineers | scientists | innovators

941 Chatham Lane, Suite 103
Columbus, OH 43221
Project Number CHA8468

November 2020

LIST OF TABLES

LIST OF FIGURES

TABLES

Table 1: Groundwater Elevation Data - March 2019
Cardinal Plant - Fly Ash Reservoir II

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

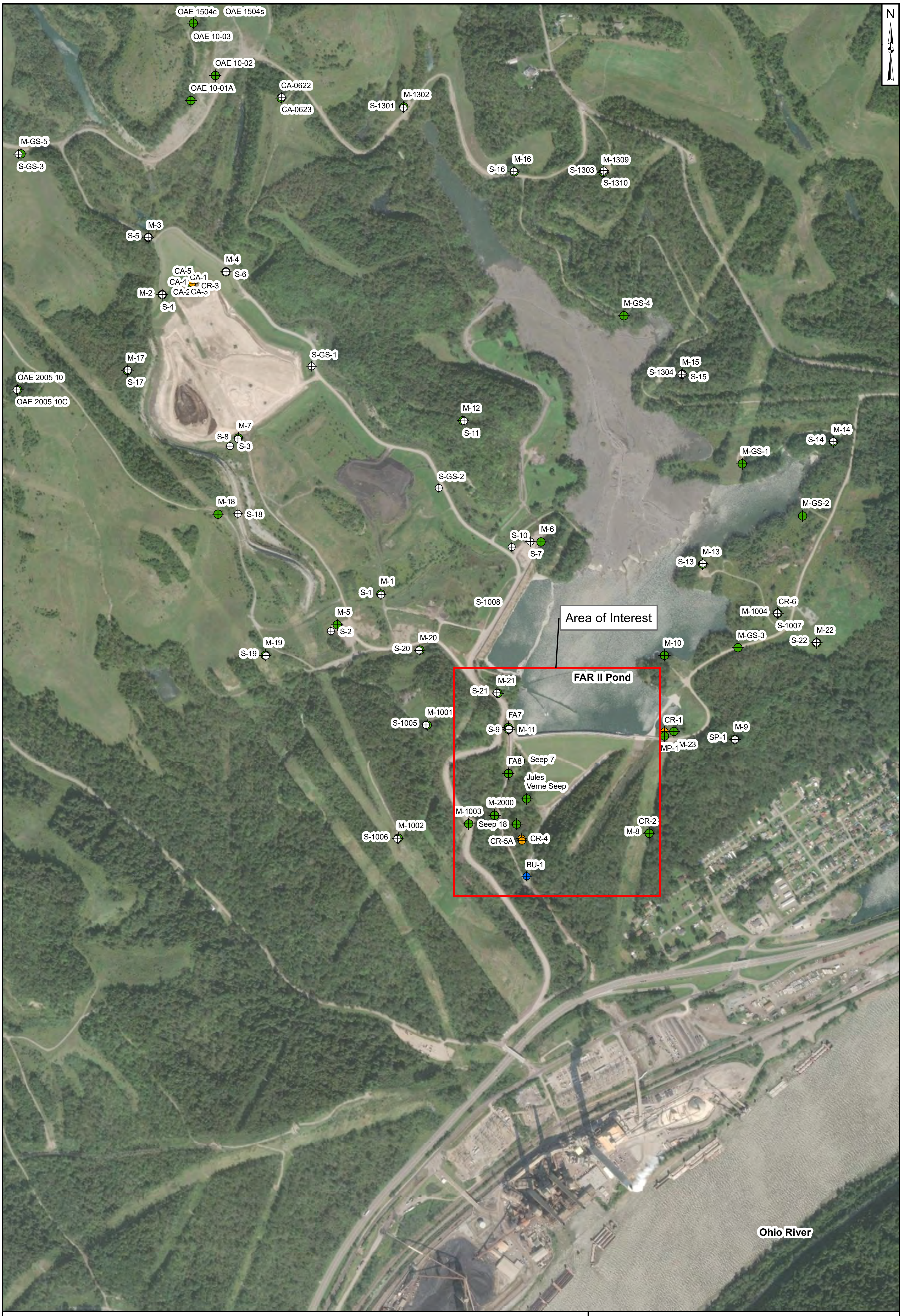
Parameter	Average Concentration (µg/L)	Mass Released (lbs)
Lithium	265	2,124
Molybdenum	463	3,702

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
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0 250 500 1,000
Feet

Monitoring Well **Network**
Fly Ash Reservoir II

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

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Columbus, Ohio

2019/06/21

Figure

1

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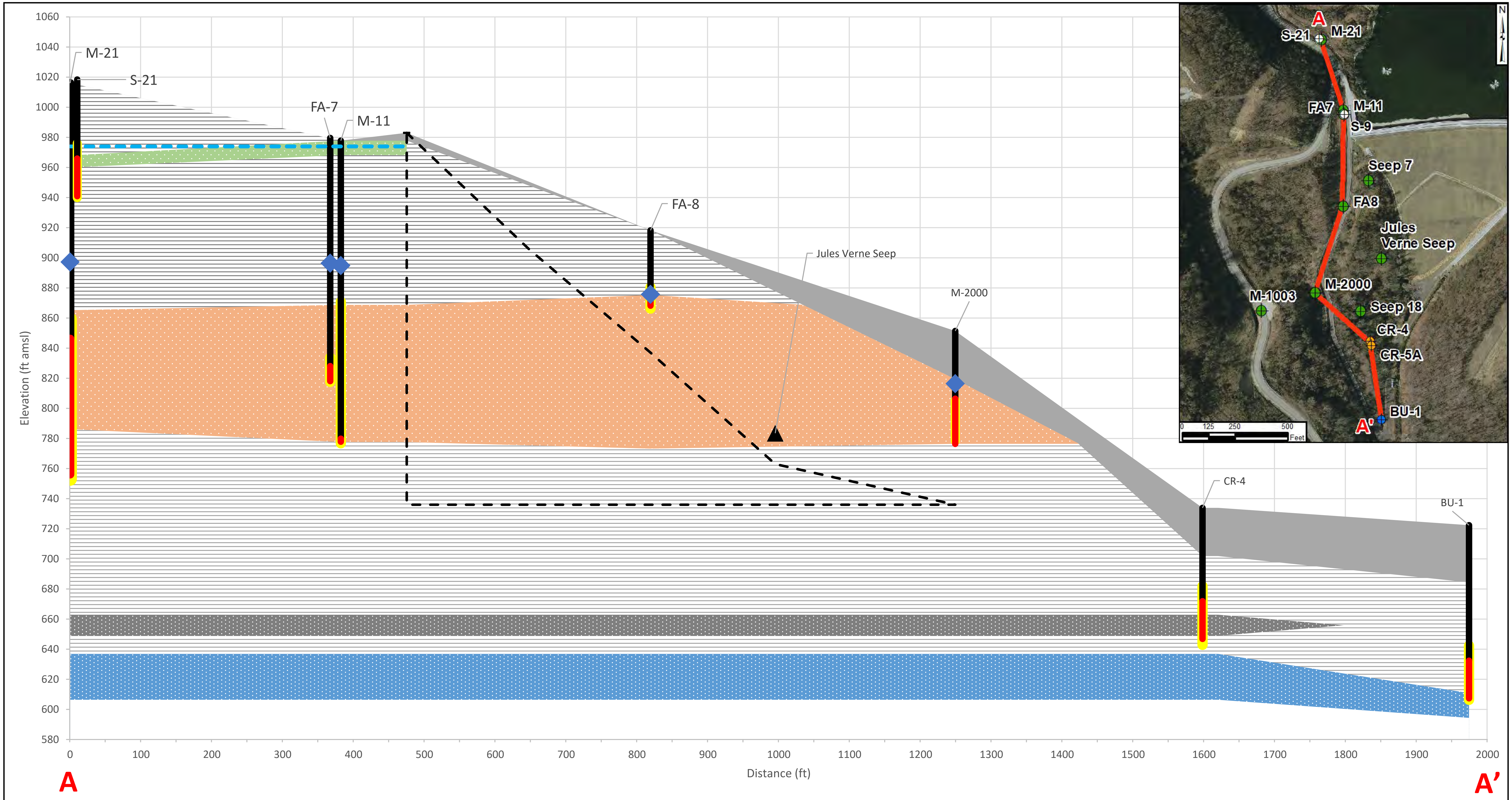

Legend

▨ Overburden

▤ Shales, Limestones, Minor Sandstones

🟩 Connellsville Sandstone

🟧 Morgantown Sandstone

▨ Cow Run Sandstone

🟦 Buffalo Sandstone

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— Well Screen

— Well Sand Pack

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- - FAR II Max Stage

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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

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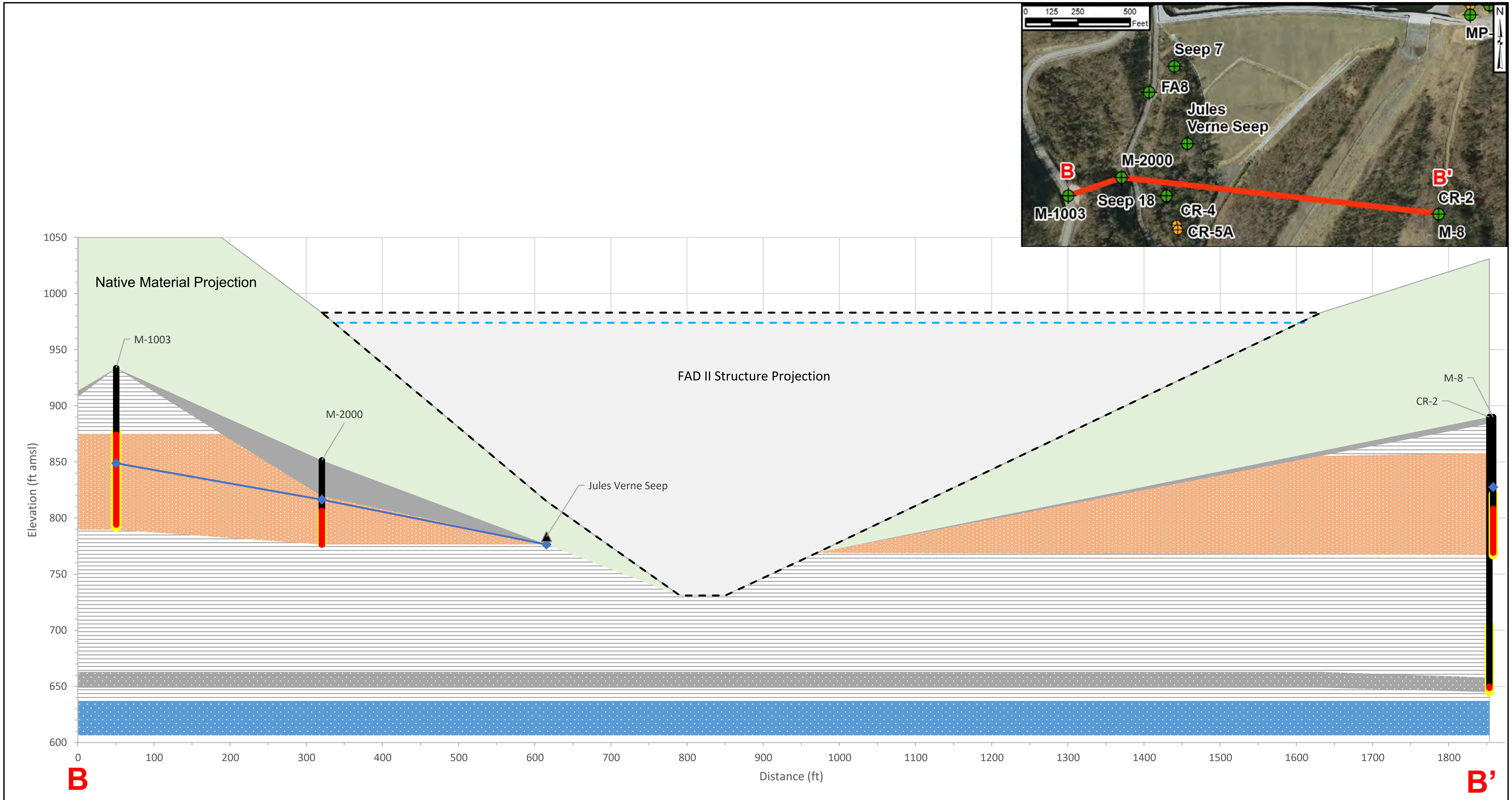

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Cross Section B-B'
Fly Ash Reservoir II

Buckeye Power Cardinal Generating Plant
Brilliant, OH

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CHA8468
June 2019

Figure
3

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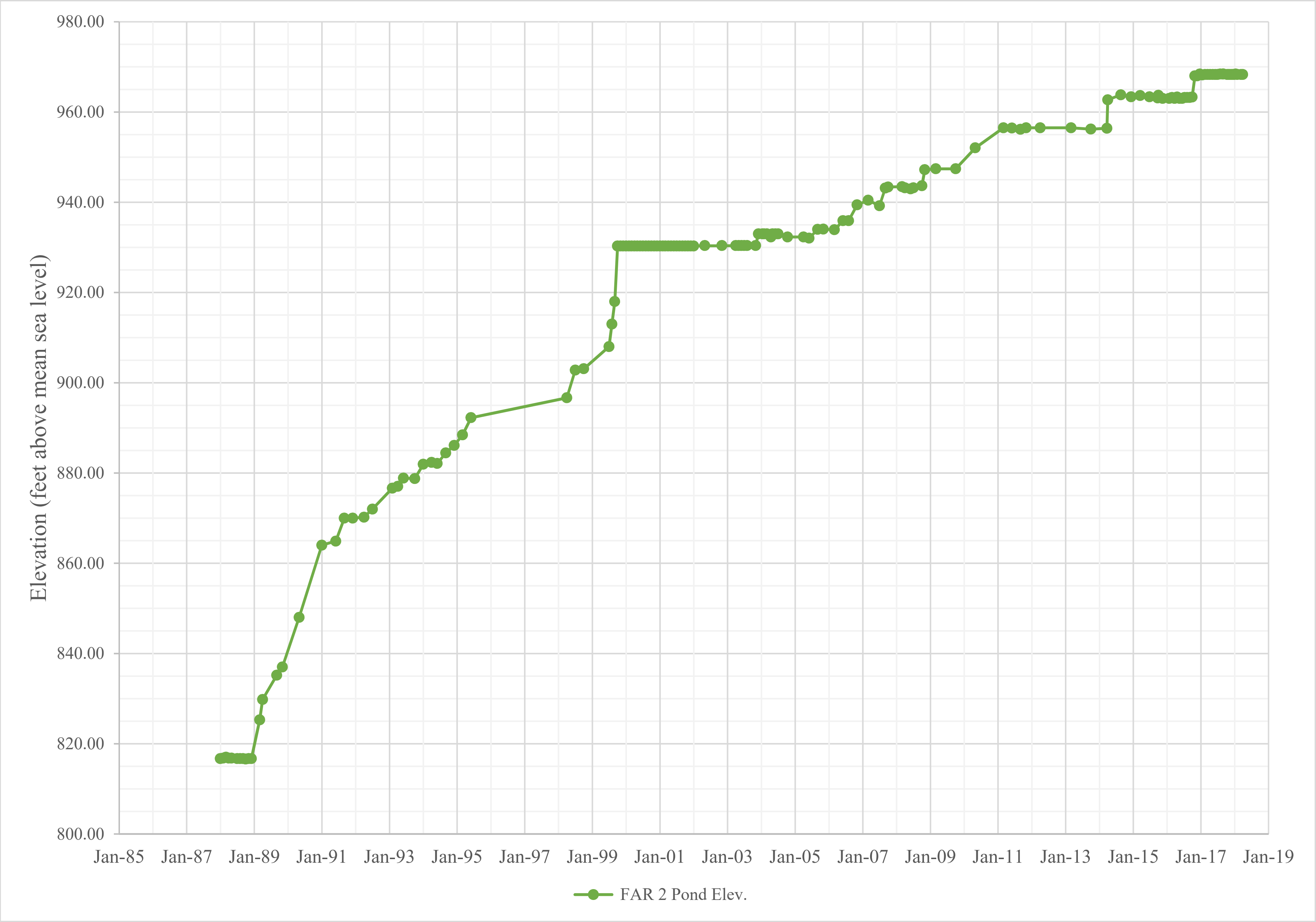
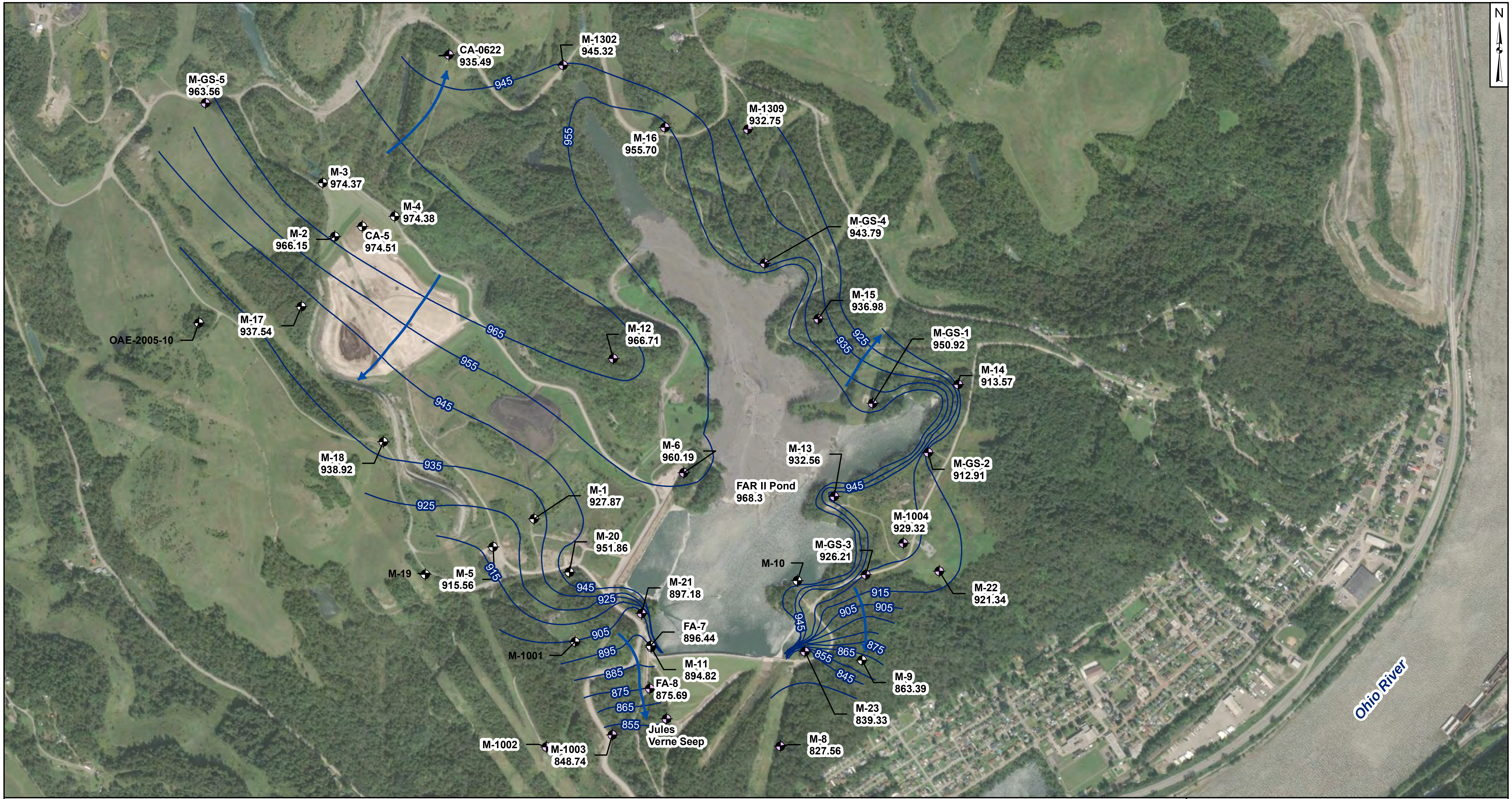
Figure 4
Historical FAR II Groundwater Elevation





Legend

- FAR II Network Monitoring Well
- State/Other Program Monitoring Well
- Groundwater Elevation Contour
- Approximate Groundwater Flow Direction

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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

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consultants

Columbus, Ohio | 2019/06/24

Figure
5

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Figure 6
Sodium vs Lithium in Morgantown Aquifer and Seeps

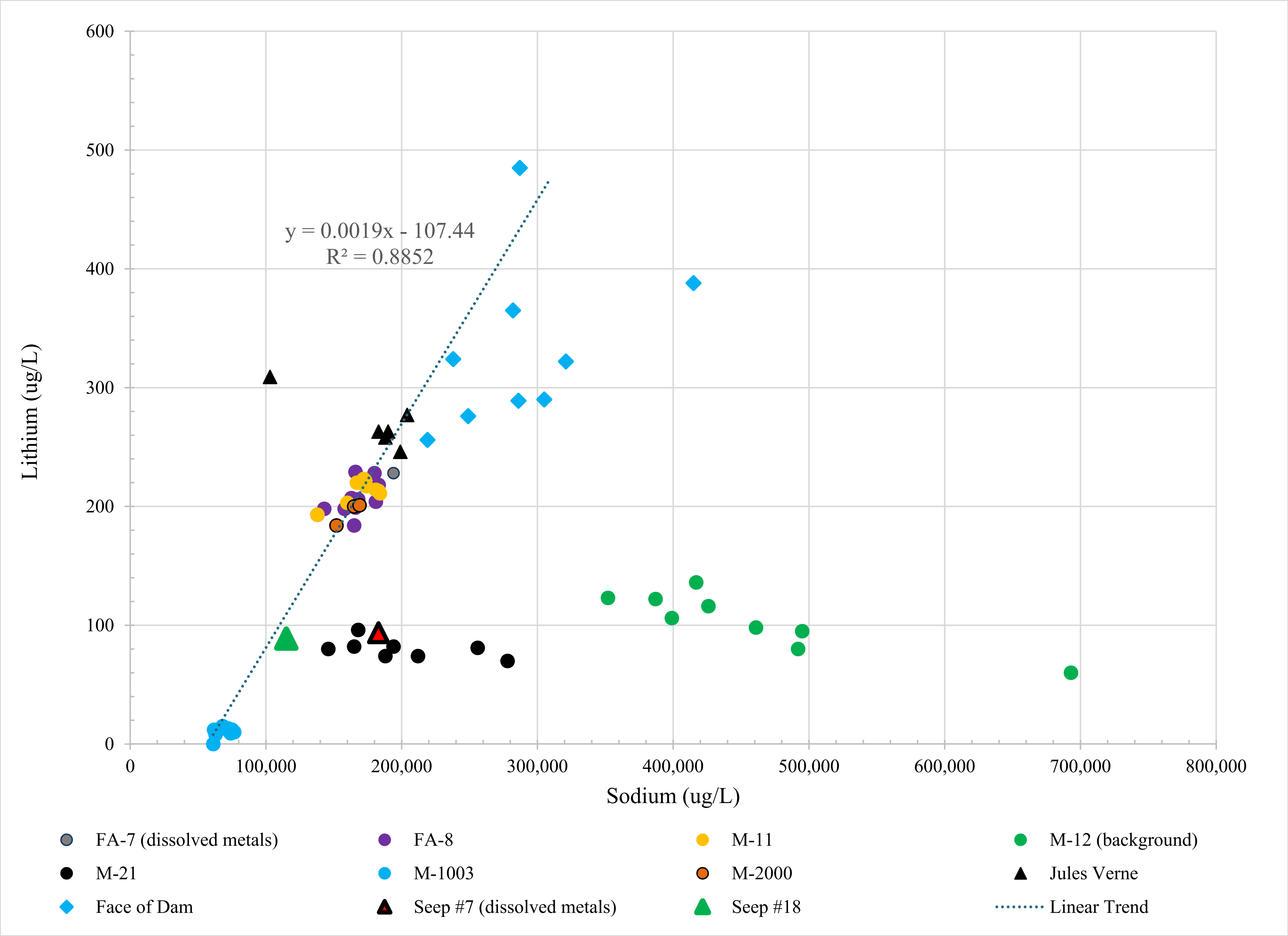
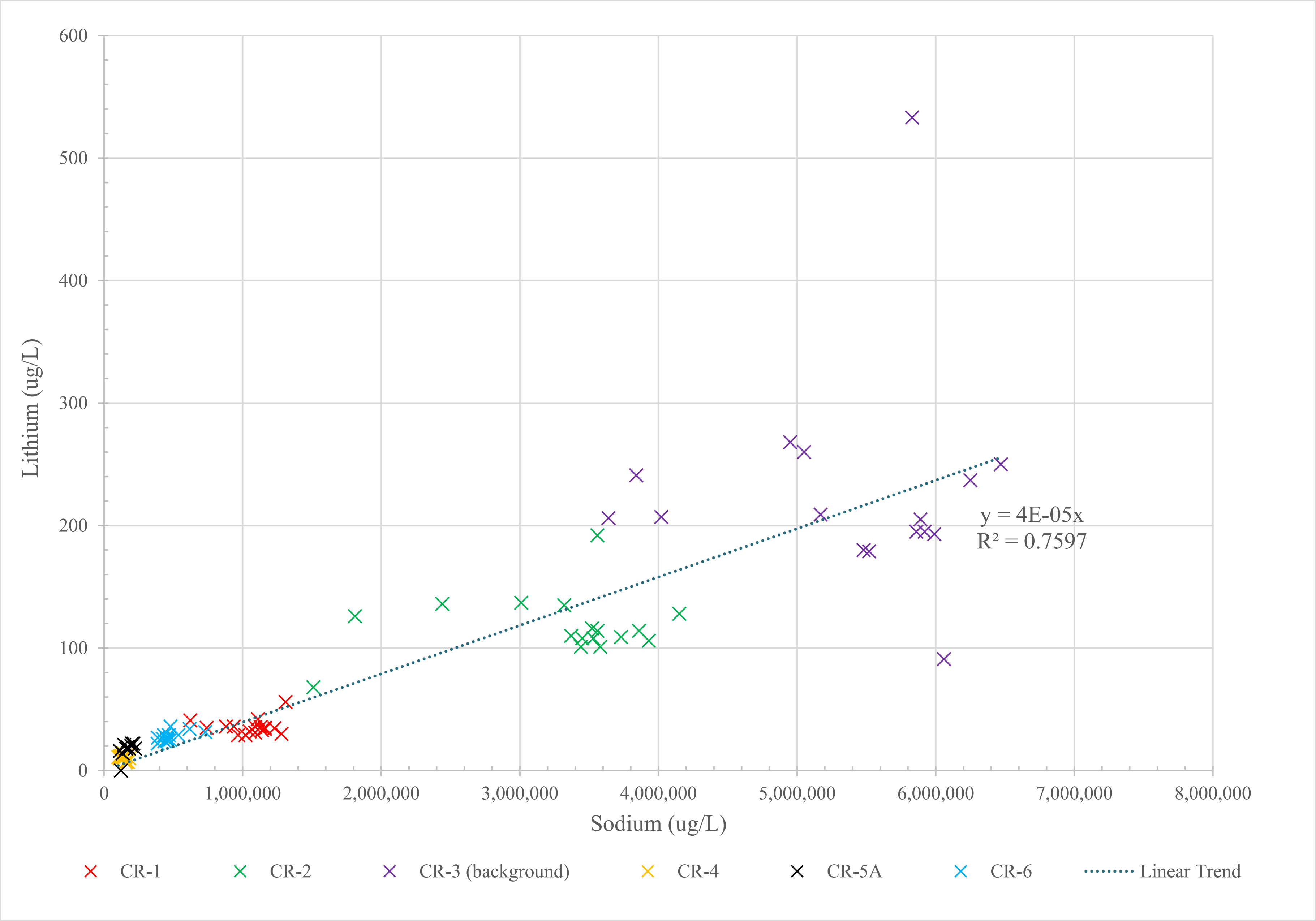


Figure 7

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)

OHIO'S ELECTRIC COOPERATIVES | BUCKEYE POWER GENERATING I, INC.
Your Touchstone Energy® Cooperatives

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.

OHIO'S ELECTRIC COOPERATIVES | BUCKEYE POWER GENERATING I, INC.
Your Touchstone Energy® Cooperatives

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

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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 1×10^{-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 Source Control

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 Removal of Released Material

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

JOHN
SEYMOUR
E-85326

John Seymour

Signature

E-85326

Registration No.

Ohio

Registration State

10/19/2020

Date

SECTION 7

REFERENCES

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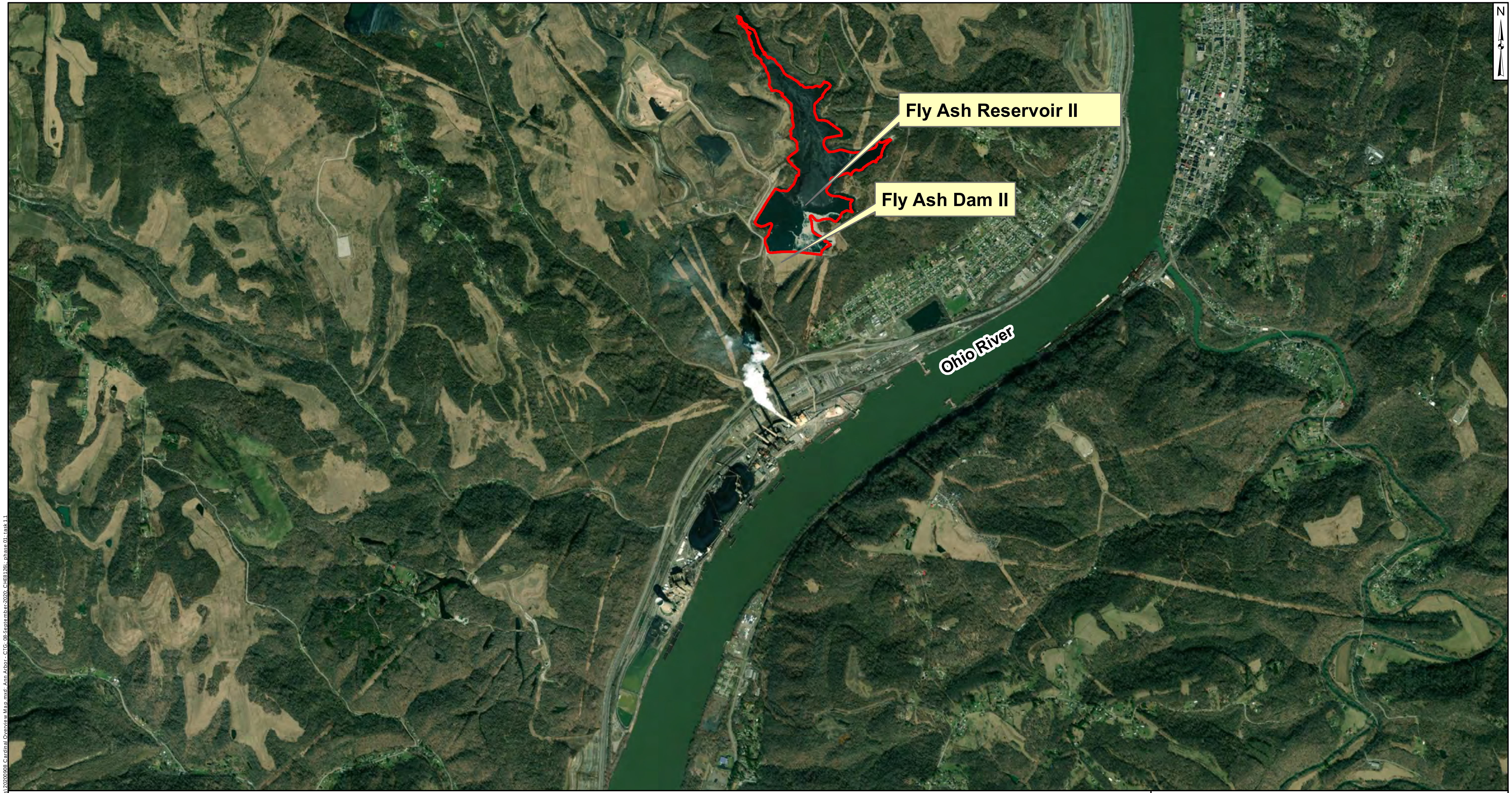
FIGURES



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; CHE8126L; phase 01; task 1.1

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.

Monitoring Well Network
Fly Ash Reservoir II

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio
2020/09/09

Figure
2

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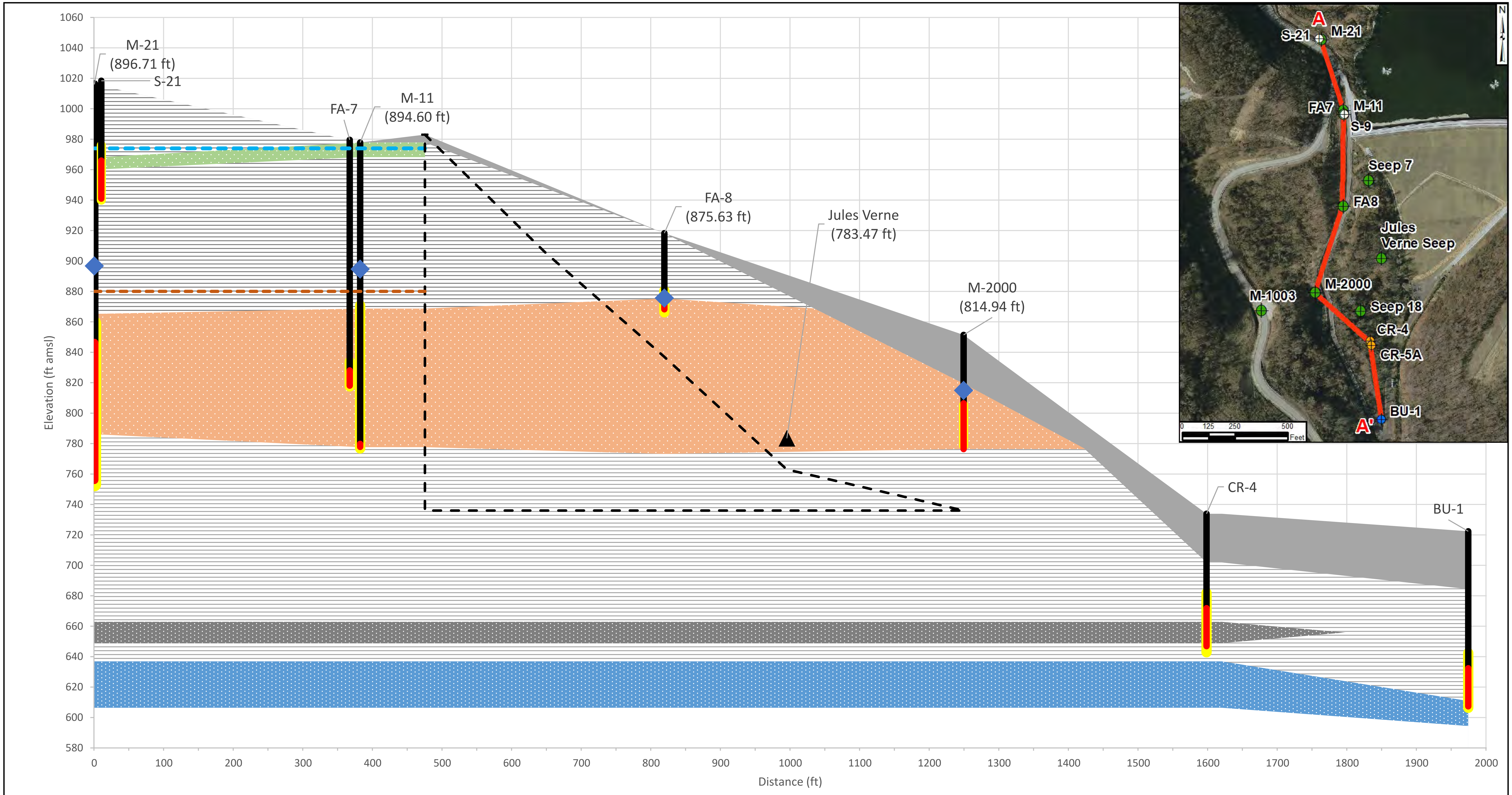


Legend

- ▨ 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.

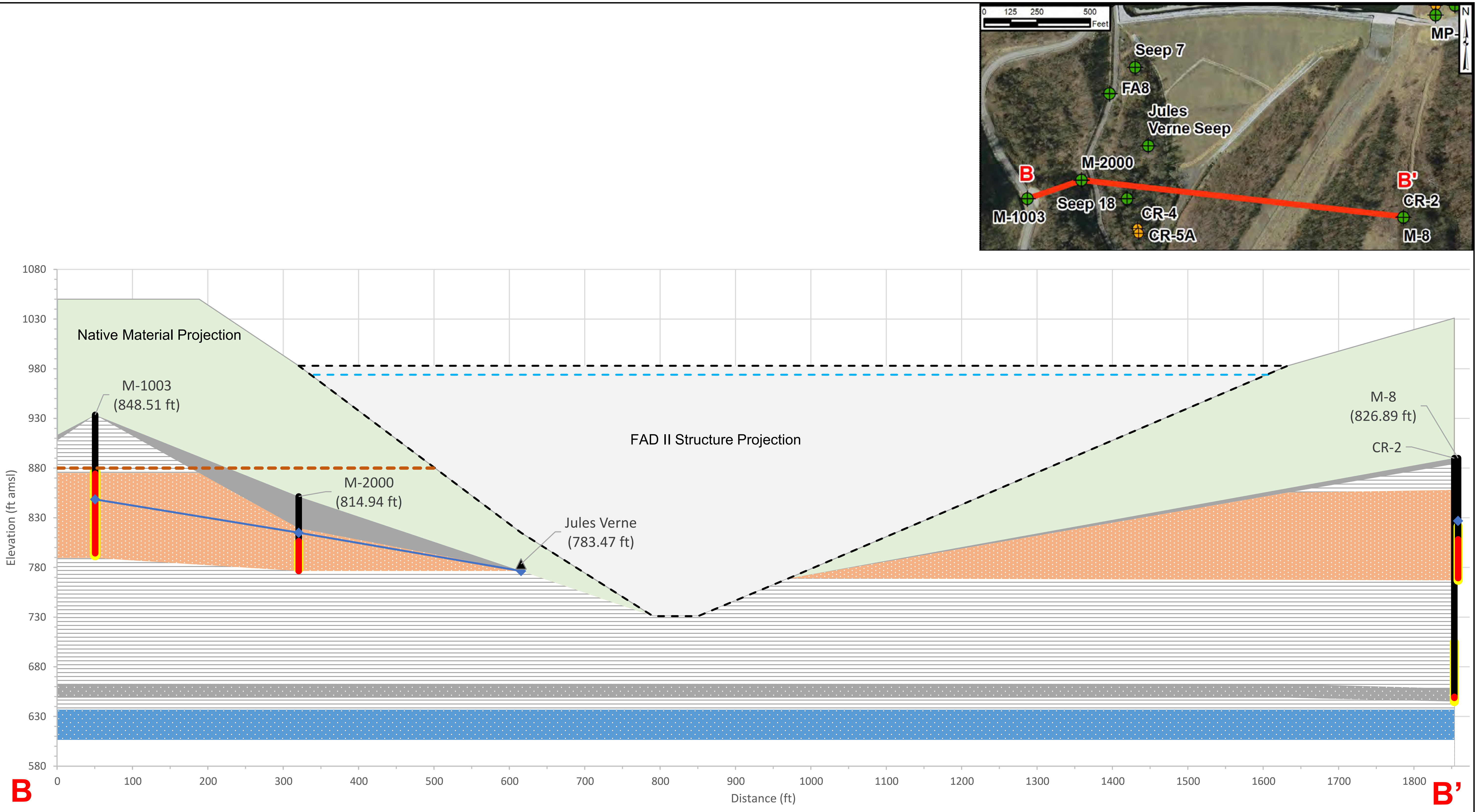
Cross Section A-A'
Fly Ash Reservoir II

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

CHA8468
August 2020

Figure
3



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

CHA8468

August 2020

Figure

4

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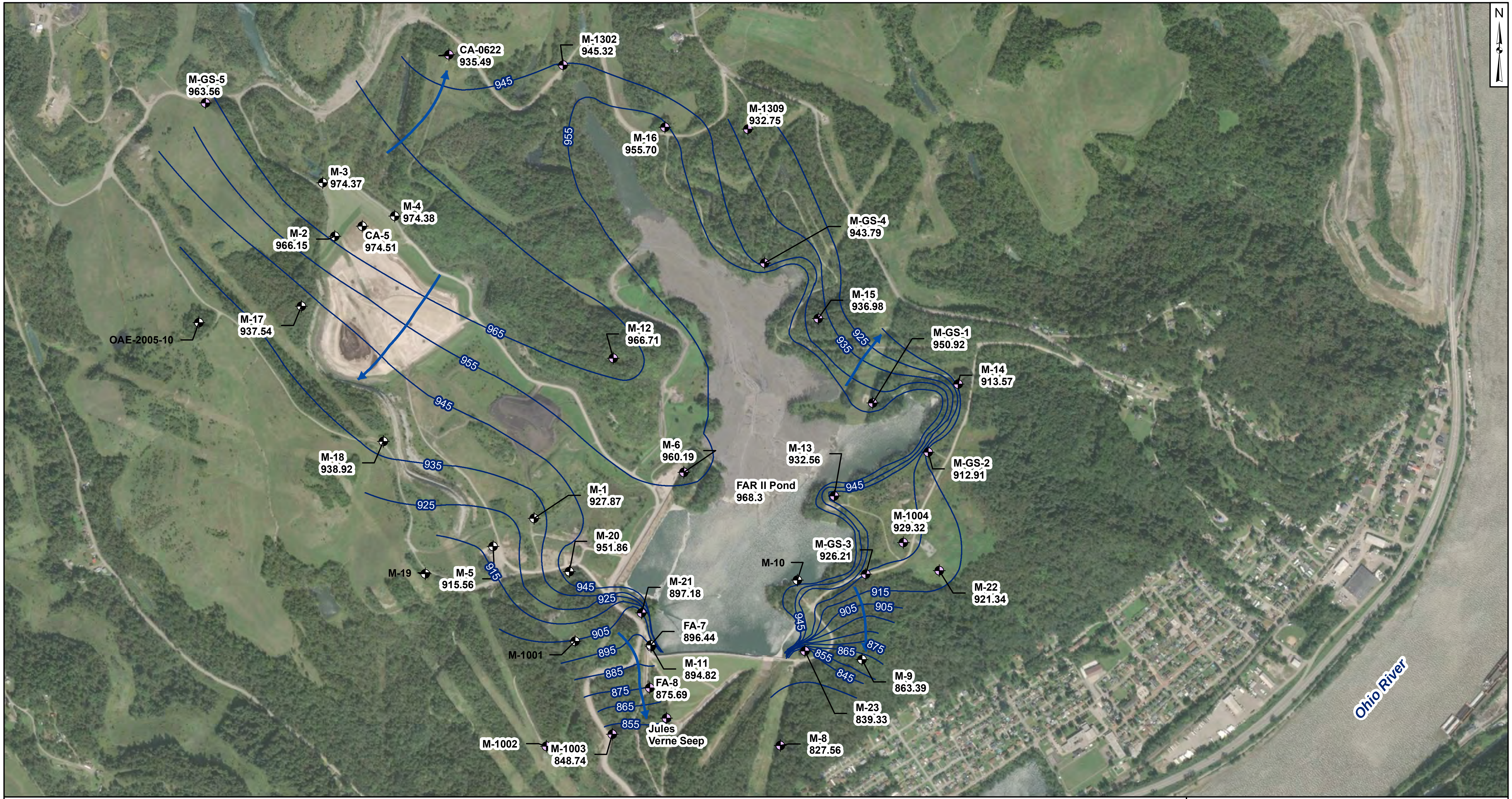

Legend

- ⯐ 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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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 J. T. Massey-Norton
John T. Massey-Norton **DATE** 9/29/2016

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

STATE OF OHIO
MOHAMMAD
A
AJLOUNI
67074
REGISTERED
PROFESSIONAL ENGINEER

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

TABLE OF CONTENTS

1.0 OBJECTIVE 257.73(d)

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

2.0 NAME AND DESCRIPTION OF CCR SURFACE IMPOUNDMENT

The Cardinal Power Plant in Wells Township, Jefferson County, near the town of Brilliant in eastern Ohio. 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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Appendices

1.0 Introduction

1.1 Background

In April of 2015, the US EPA formally published national regulations for disposal of coal combustion residuals (CCR) from electric facilities. As part of the rule, the owner or operator of the CCR unit must obtain a certification from a qualified professional engineer stating that aspects of the CCR impoundments are in accordance with the rules. Based on our understanding of the Request for Fee Estimate received from AEP on April 29, 2015, AEP specifically requested P.E. certification to fulfill the requirements of 40 CFR § 257.73(e), *Periodic Safety Factor Assessments*. 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

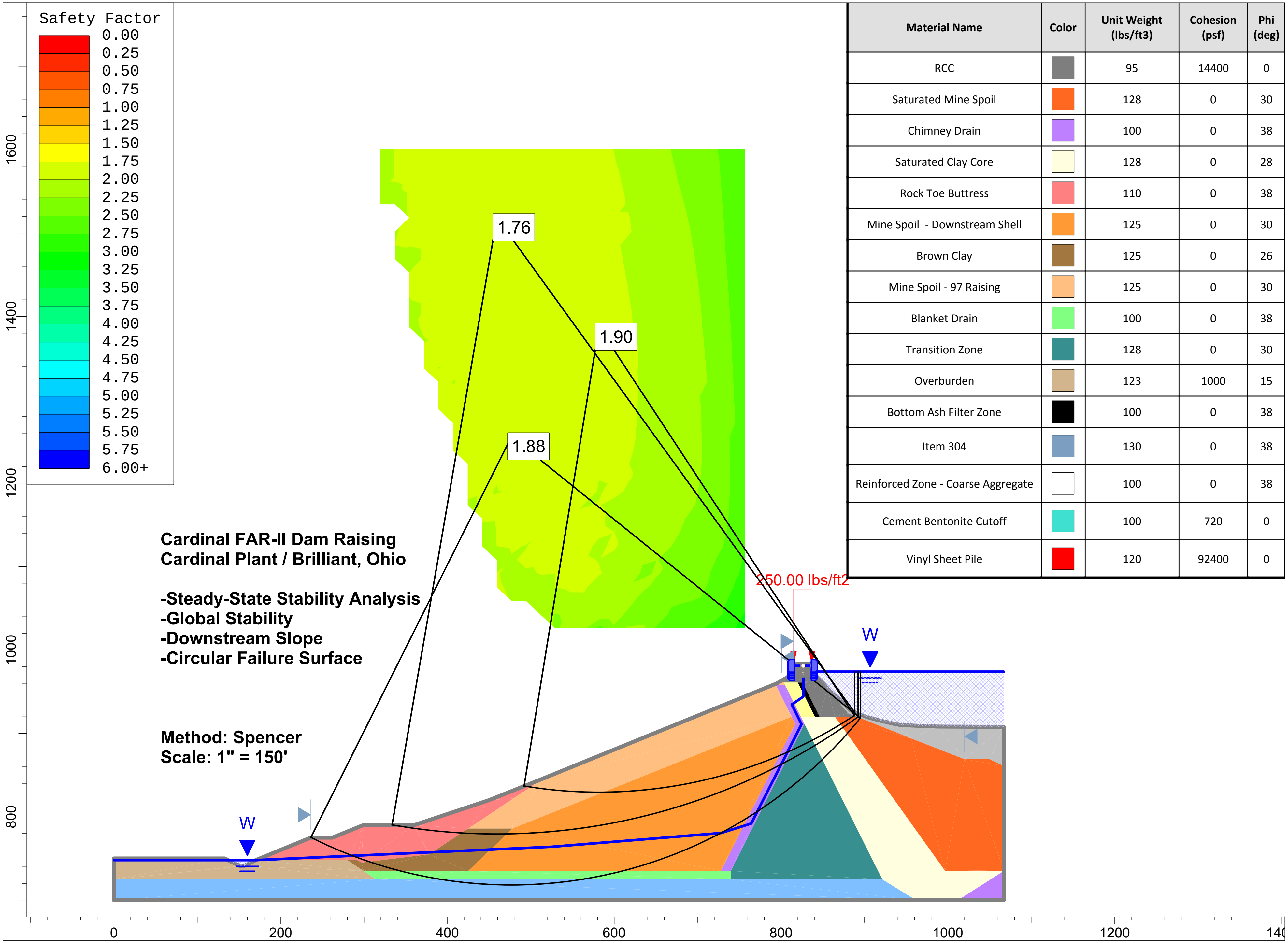
STATE OF OHIO
MICHAEL
GILBERT
ROWLAND
#E-65559
REGISTERED
PROFESSIONAL ENGINEER

9-18-15

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

Appendices

Appendix I – Safety Factor Assessment Figures

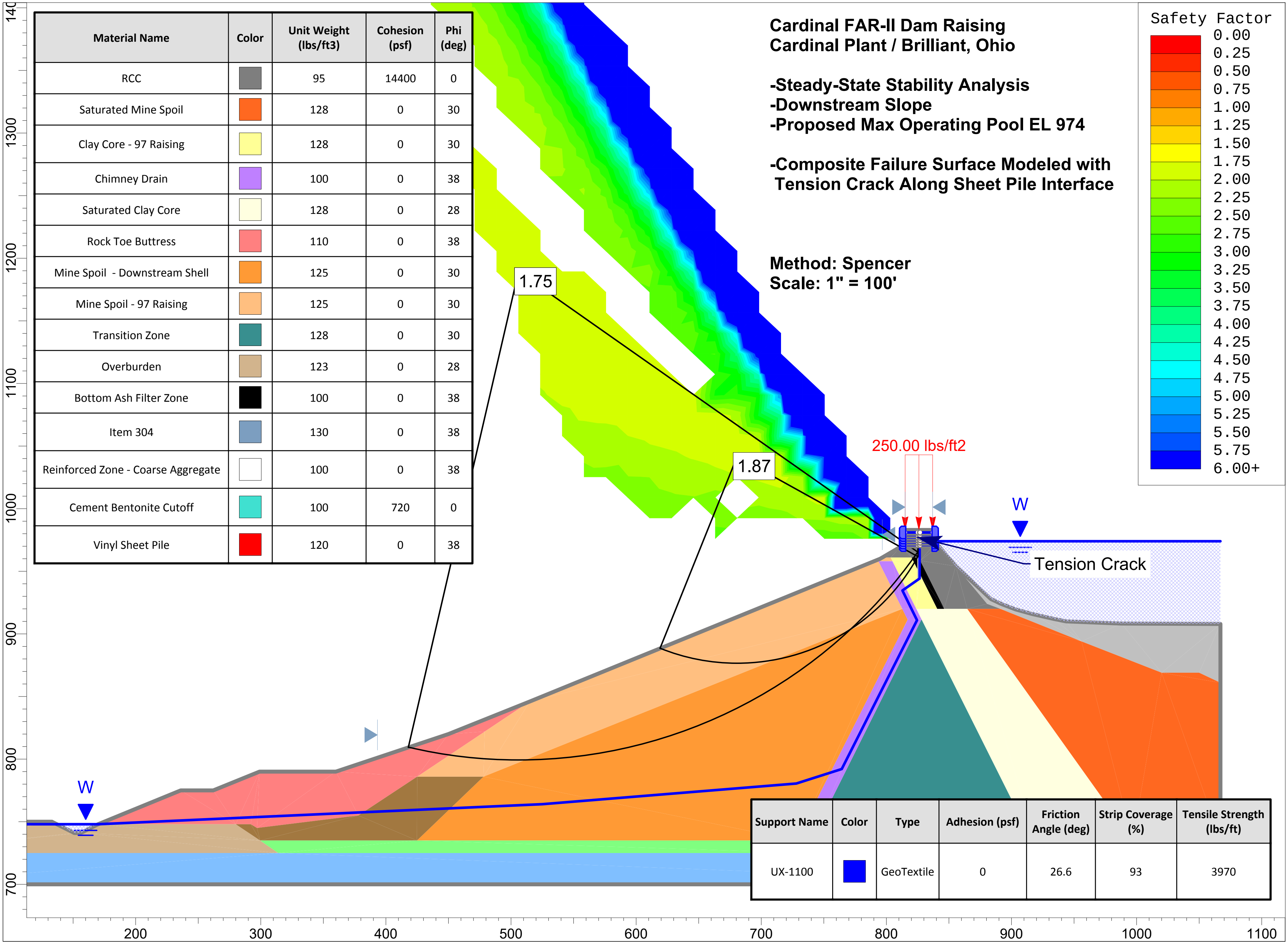


Cardinal FAR-II Dam Raising
Cardinal Plant / Brilliant, Ohio

-Steady-State Stability Analysis
-Global Stability
-Downstream Slope
-Circular Failure Surface

Method: Spencer
Scale: 1" = 150'

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



Cardinal FAR-II Dam Raising
Cardinal Plant / Brilliant, Ohio

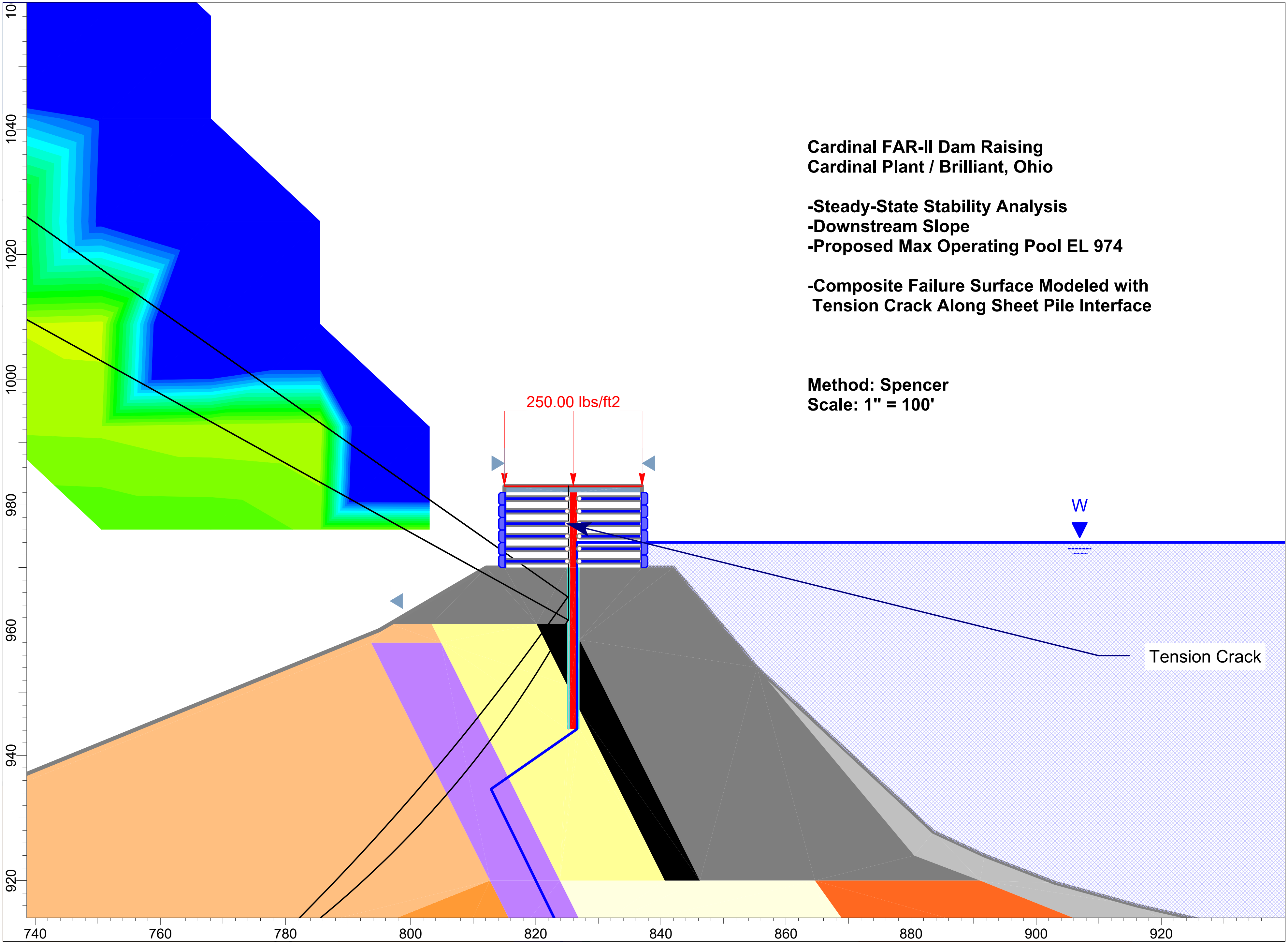
-Steady-State Stability Analysis
-Downstream Slope
-Proposed Max Operating Pool EL 974

-Composite Failure Surface Modeled with
Tension Crack Along Sheet Pile Interface

Method: Spencer
Scale: 1" = 100'

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

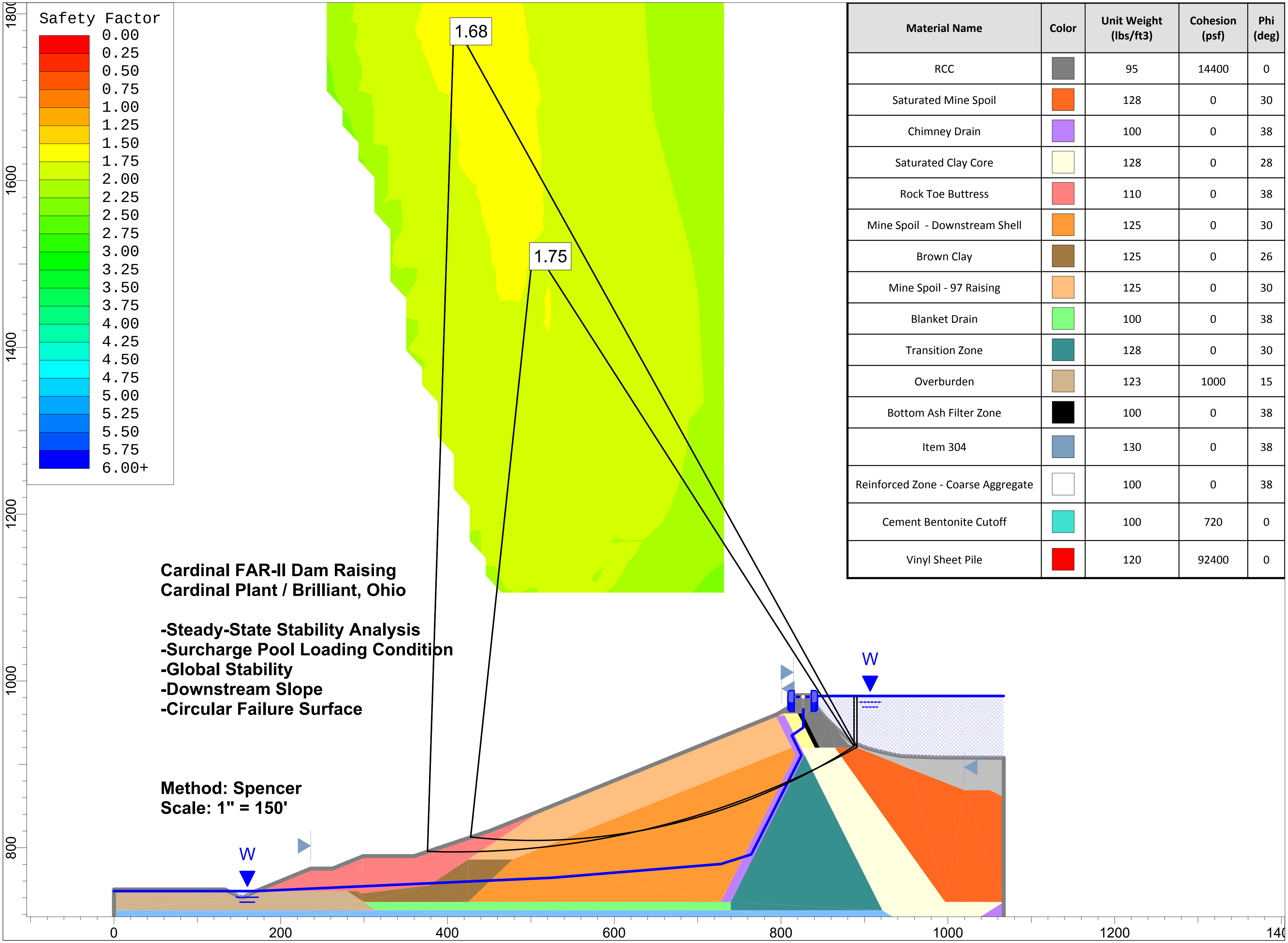


Cardinal FAR-II Dam Raising
Cardinal Plant / Brilliant, Ohio

-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'

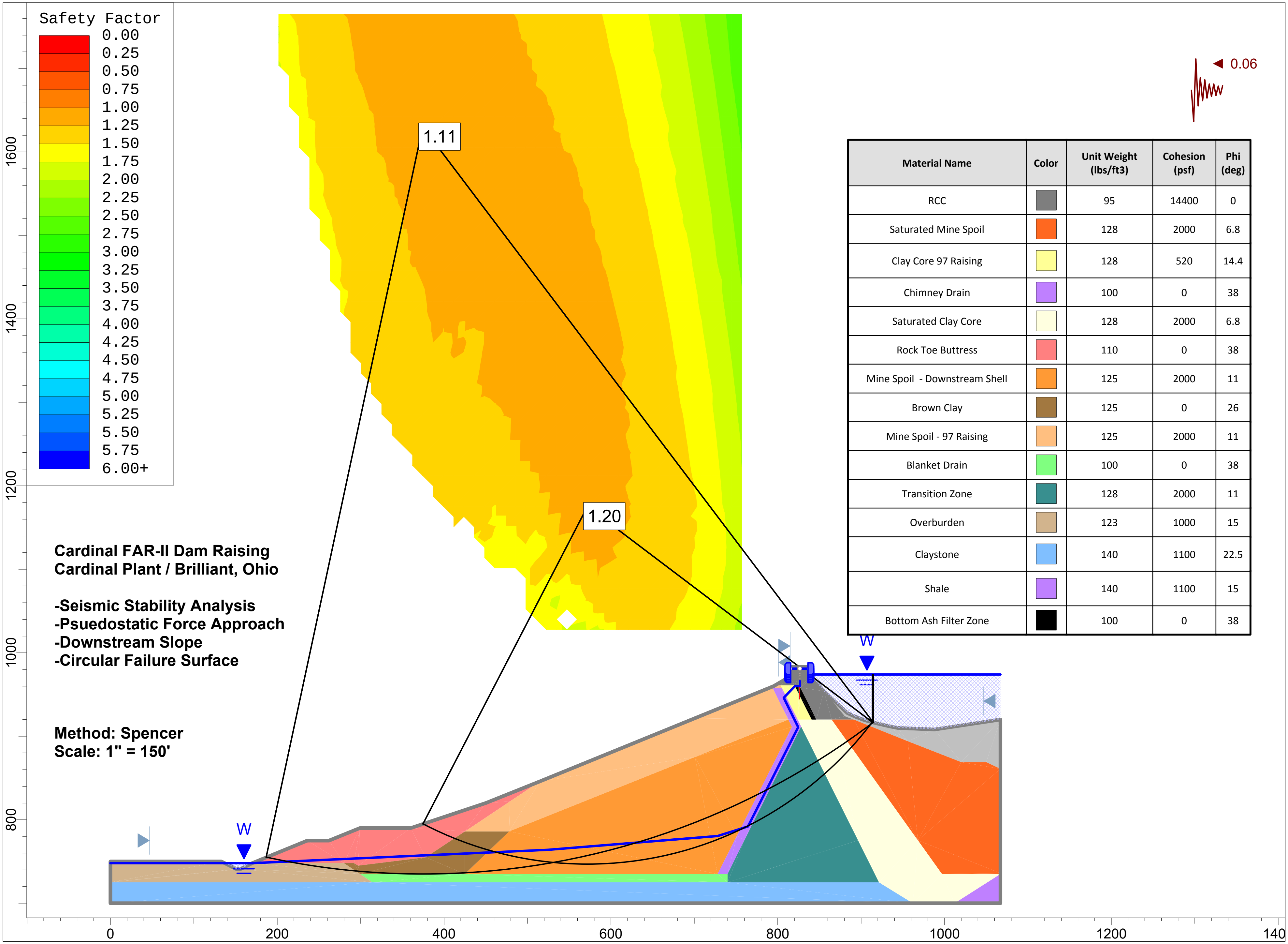


Cardinal FAR-II Dam Raising
Cardinal Plant / Brilliant, Ohio

-Steady-State Stability Analysis
-Surcharge Pool Loading Condition
-Global Stability
-Downstream Slope
-Circular Failure Surface

Method: Spencer
Scale: 1" = 150'

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



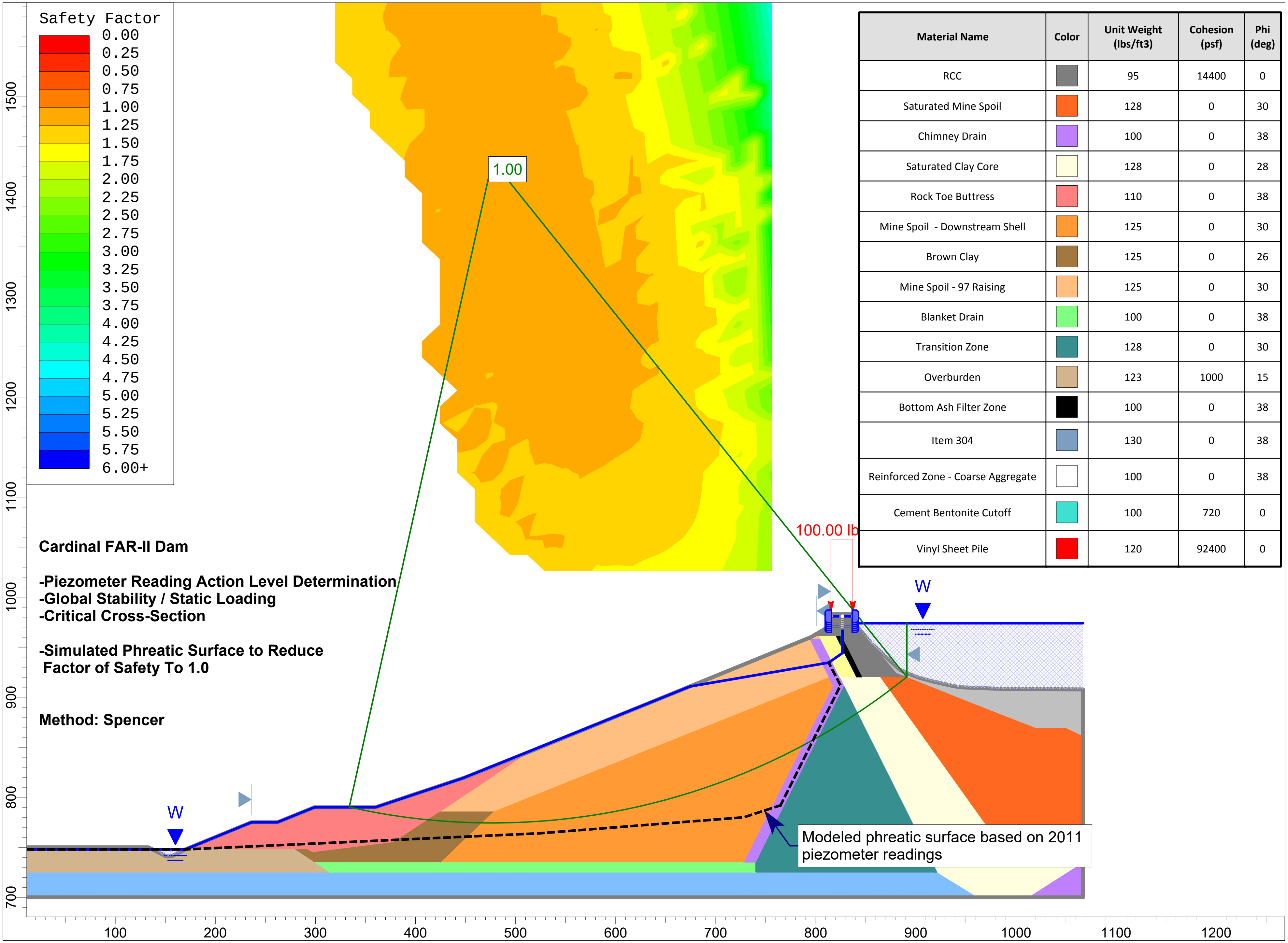
Cardinal FAR-II Dam Raising
Cardinal Plant / Brilliant, Ohio

-Seismic Stability Analysis
-Psuedostatic Force Approach
-Downstream Slope
-Circular Failure Surface

Method: Spencer
Scale: 1" = 150'

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

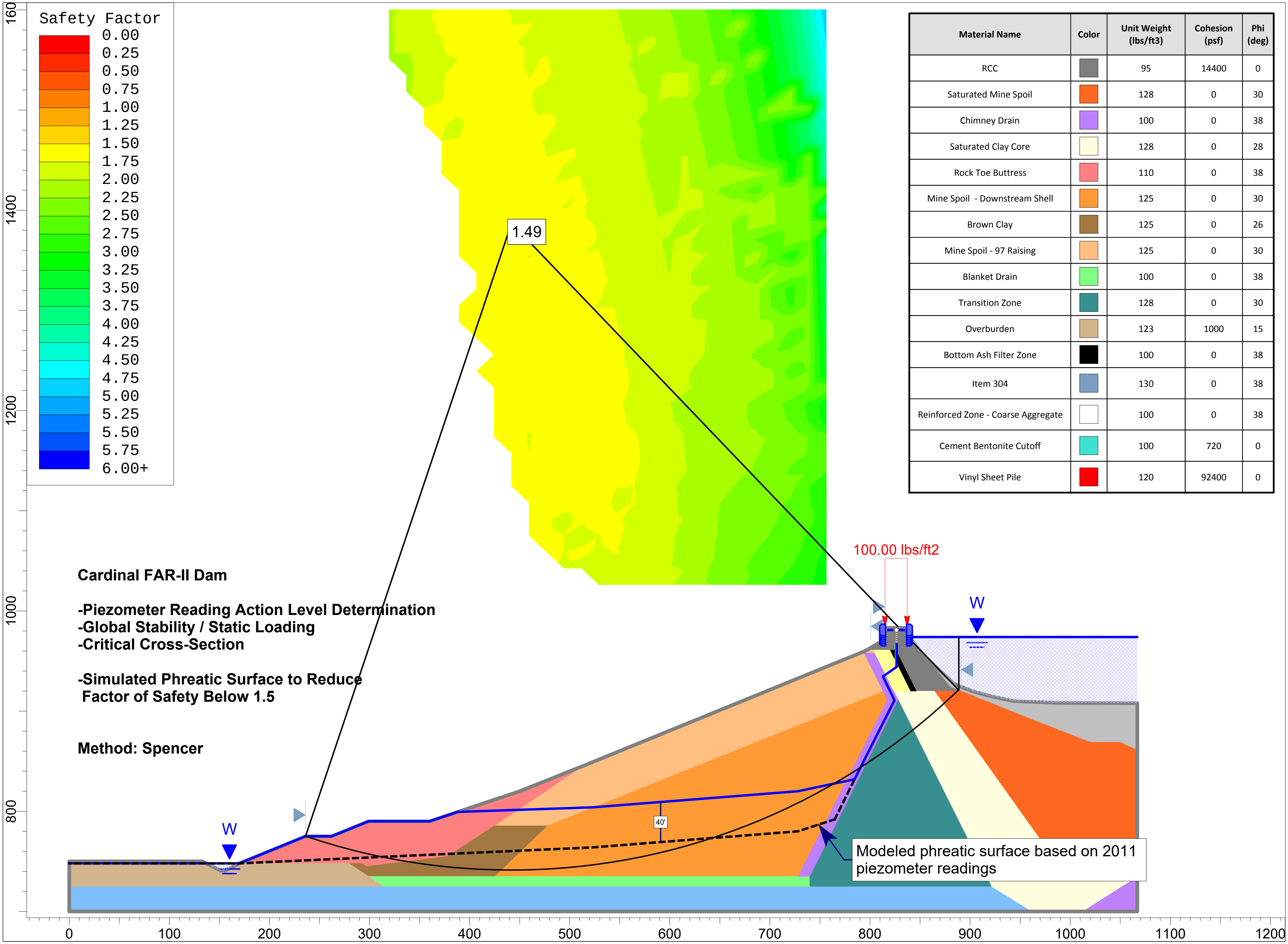
Cardinal FAR-II Dam

-Piezometer Reading Action Level Determination
-Global Stability / Static Loading
-Critical Cross-Section

-Simulated Phreatic Surface to Reduce Factor of Safety To 1.0

Method: Spencer

Modeled phreatic surface based on 2011 piezometer readings



Cardinal FAR-II Dam

-Piezometer Reading Action Level Determination
-Global Stability / Static Loading
-Critical Cross-Section

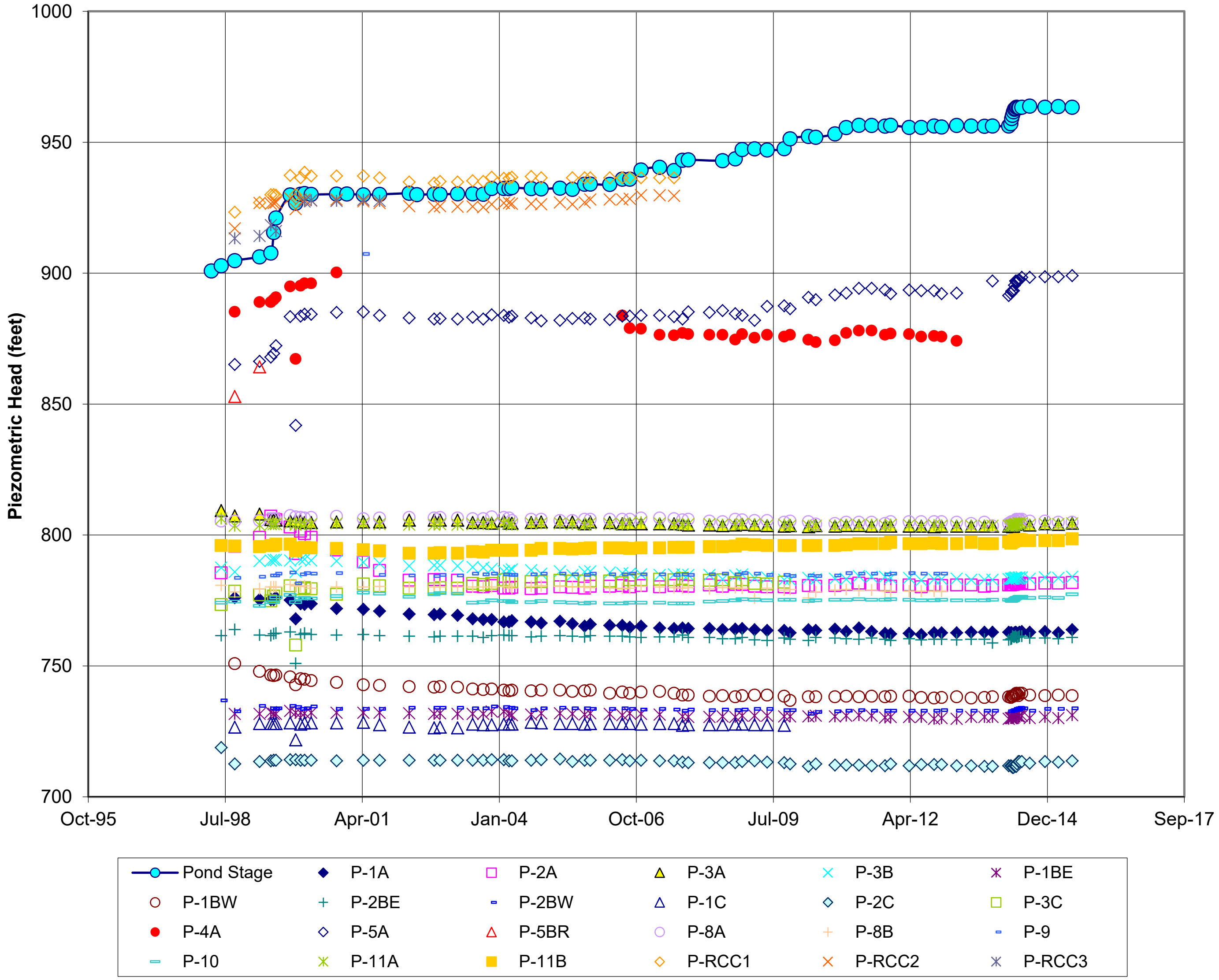
-Simulated Phreatic Surface to Reduce Factor of Safety Below 1.5

Method: Spencer

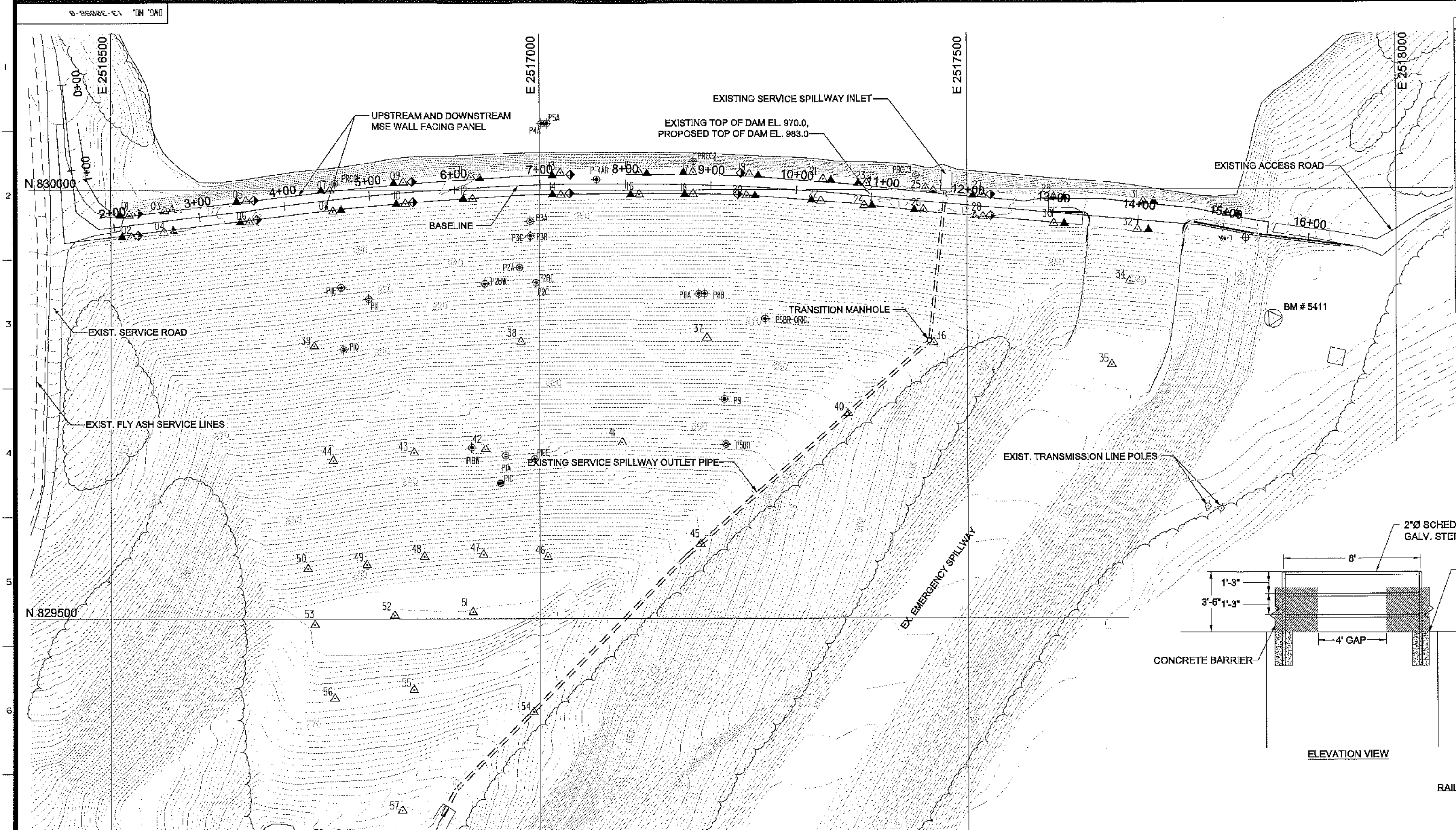
Modeled phreatic surface based on 2011 piezometer readings

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



DWG. NO. 13-30098-0



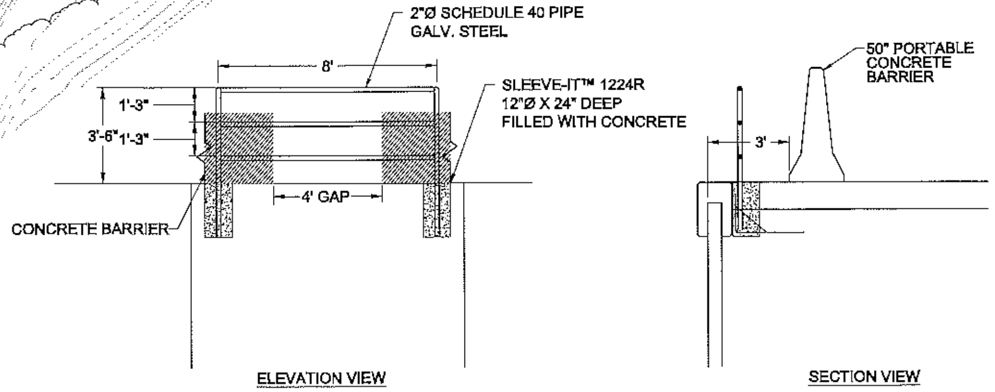
PIEZOMETER #	NORTH	EAST	TIP ELEV.
P8B	829880.385	2517198.101	776.0
P8A	829880.185	2517191.730	802.1
P2BE nested	829893.405	2517001.135	730.0
P2C nested	829893.405	2517001.135	711.0
P3B nested	829965.095	2516994.335	772.3
P3A nested	829965.095	2516994.335	802.3
P3C	829947.865	2516994.545	712.3
P2BW	829892.685	2516941.390	731.5
P2A	829910.895	2516891.870	771.0
P11	829874.275	2516805.610	802.6
P11B	829887.670	2516773.430	789.1
P10	829815.120	2516776.440	769.1
P9	829757.800	2517221.000	771.2
P1BE	829687.655	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.807.0
P1BW	829701.320	2516925.760	735.9
PRCC3	830018.040	2517445.700	913.3
PRCC2	830034.680	2517105.460	913.4
PRCC1	830008.870	2516765.950	923.3
P4A	830078.650	2517007.900	801.7
P4AR	830014.140	2517072.240	969.6
P5A	830079.170	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

GENERAL NOTES

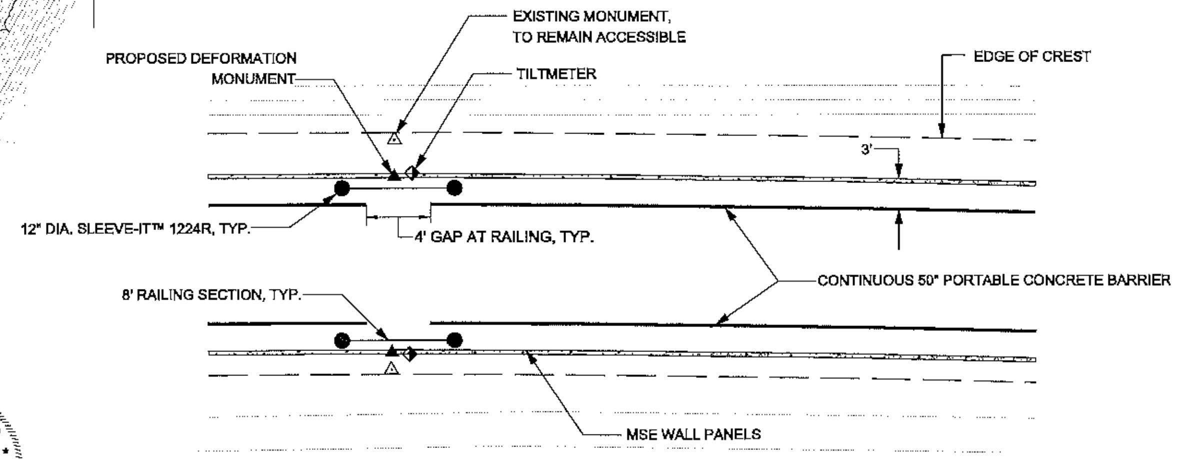
1. TOPOGRAPHIC MAPPING DEVELOPED FROM AERIAL SURVEY PERFORMED ON 3/5/2009 AND 1986 AS-BUILT DATA.



ELEVATION VIEW

SECTION VIEW

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

MICHAEL GILBERT ROWLAND
E-65559

Michael G. Rowland

MICHAEL GILBERT ROWLAND	E-65559 NUMBER	JAN 16, 2013 DATE

PROJECT NUMBER:	011-11497-042	DRAWN BY:	EDV
DRAWING DATE:	9/28/12	ENGINEER:	MTR
LAST UPDATED:	1/16/13	APPROVED BY:	MGR
		SCALE:	AS NOTED

S&ME

DATE	NO.	DESCRIPTION	APPD.
[illegible]	[illegible]	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 SUMMITTAL	MGR

REVISIONS

CARDINAL OPERATING COMPANY
CARDINAL PLANT
BRILLIANT OHIO

DAM RAISING
FLY ASH RETENTION DAM II
INSTRUMENTATION PLAN

DWG. NO. 13-30098-0

ARCH — ELEC — MECH — STR GS
SCALE: AS SHOWN
DR:
CH:
SOE SUPV:
DATE:
APPROVED BY
CIVIL ENGINEERING DIVISION

AEP AMERICAN ELECTRIC POWER
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

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:

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

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

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

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

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

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

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

SOIL DESCRIPTIONS

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

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

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

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

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

PLATE 2

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

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

2010 NEW DEFAULT BORING LOG-W/ N60

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	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 - 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
	5	3	■	15/6/8	18	27	FILL: Medium-dense gray fine to coarse grave, little to some fine to coarse sand, trace silt to some silty clay, cobbles, dry.		
662.8		4	■	7/40/7	59	67			
		5	■	7/4/5	11	87	FILL: Stiff to very-stiff brown silty clay, some to "and" fine to coarse sand, some fine to coarse gravel, contains fine to coarse sand seams and sandstone fragments, damp.		H=2.5
		6	■	8/11/4	19	100			H=3.0
658.3	10	7	■	6/8/5	16	100			H=2.5-3.5
		8	■	10/8/7	19	67	FILL: Medium-dense fine to coarse gravel, some to "and" fine to coarse sand, some clayey silt, damp becoming moist.		
		9	■	3/3/6	11	100	- 3" pocket of sand at 14.5'.		
653.8	15	10	■	5/3/7	13	53			H=1.25
652.3		11	■	4/3/3	8	67	Stiff gray clayey silt, "and" fine to coarse sand, little to some fine gravel, moist.		H=1.25
650.6		12	■	3/2/4	8	53	Loose brown fine to coarse sand, "and" silty clay, some fine to coarse gravel, moist.		H=1.0
	20	13	■	7/8/5	16	93	Loose to medium-dense brown fine to coarse gravel, some to "and" fine to coarse sand, some silty clay, damp to moist.		H=4.5
		14	■	4/6/5	14	80			
		15	■	5/8/4	15	67			
		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									
	30	18	■	2/2/	4	100	Stiff dark-brown clayey silt, little to some fine to medium sand, slightly organic, damp.		H=1.25-2.25

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

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

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

-CONTINUED-

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

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

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

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

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE EFFORT	N60	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
	30						
638.8	▽						
		19	SH/SH/SH	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	Very-loose gray fine to coarse sand, interbedded with silty clay seams, wet.	H=1.0-1.5
	40						
628.8		23	1/2/3	6	60	Loose brown fine to coarse sand, trace fine gravel, trace silt, wet.	
626.8						Dense brown fine to coarse gravel, some to "and" fine to coarse sand, trace silt.	
	45						
		24	13/17/23	50	47		G
		25	19/14/18	40	67		
	50						
618.8		26	9/7/8	19	47	Medium-dense brown fine to coarse sand, trace fine gravel, trace clay.	
617.3							
	55						
	60						

- 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).

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

2010 NEW DEFAULT BORING LOG-W/ N60

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

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

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

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

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	FILL: Dense to very-dense dark-gray fine to coarse sand, trace to little fine gravel, trace to little silt, moist.	
666.3		2	25/33/30	79	47	FILL: Stiff to hard brown and dark-brown silty clay, some to "and" fine to coarse sand, little to some fine to coarse gravel, few pockets of gravel, dry becoming damp.	
	5	3	33/11/8	24	60		H=2.0
		4	11/9/15	30	67		H=4.5
		5	8/9/13	28	80		
		6	4/6/9	19	60		
	10	7	7/5/5	13	87		
		8	4/10/8	23	80		H=2.0-4.5
655.4		9	2/8/3	14	53		H=2.5
	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	FILL: Very-loose dark-gray silt, trace fine to coarse sand, slightly organic, wet.	H=0.5
643.9		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

2010 NEW DEFAULT BORING LOG-W/ N60

-CONTINUED-

Page 2 of 2

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

S&ME

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

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

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

2010 NEW DEFAULT BORING LOG-W/ N60

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

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

	▽	▼
WATER LEVEL:	29.2	
WATER NOTE:	Inside Well	
DATE:	12/15/15	

SYMBOLS USED TO INDICATE TEST RESULTS

- G - Gradation
- Q - Uncon Comp
- T - Triax Comp
- C - Consol.

See Separate Curves

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

Drill Rod Energy Ratio : 0.75

Last Calibration Date : 8/2/2013

Drill Rig Number : S&ME ATV 550-2

JOB: 7217-15-007B

PLATE 6

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

S&ME

LOCATION: **N. 819,111, E. 2,513,519**
ELEVATION: **669.9**
DATE: **11/11/15 - 11/12/15**
DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger**
COMPLETION DEPTH: **55.0'**
SAMPLER(S): **2" O.D. Split-barrel Sampler**

2010 NEW DEFAULT BORING LOG-W/ N60

NATURAL CONSISTENCY INDEX — NATURAL MOISTURE CONTENT — PLASTIC LIMIT — LIQUID LIMIT: 10 20 30 40

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		
	20	13	1/4/2	8	67		
649.4							
		14	2/3/4	9	53	Medium-stiff to stiff brown clayey silt, "and" fine to coarse sand, some fine to coarse gravel, wet.	H=1.0-2.0
647.3		15A	2/2/3	6	100		H=0.5
		15B				Loose gray fine to medium sand, trace coarse sand, trace fine gravel, little silt, wet.	
		16	1/3/1	5	100		
644.4	25						
		17	1/1/SH	0	100	Very-loose gray silt, little fine to medium sand, wet.	
641.9	▽						
		18	1/2/	8	100	Soft to stiff dark-brown mottled with dark-gray slithly organic to organic clayey silt, little to some fine to medium sand, contains silt seams, fine	H=1.0-1.5
	30						

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

SYMBOLS USED TO INDICATE TEST RESULTS

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

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

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

-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**

NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT / PLASTIC LIMIT / LIQUID LIMIT: 10 20 30 40

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE EFFORT	N60	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
	30					sand seams and roots, wet. Soft to stiff dark-brown mottled with dark-gray slithly organic to organic clayey silt, little to some fine to medium sand, contains silt seams, fine sand seams and roots, wet.	
		19	1 4 / 2 / 2	5	100		
		20	SH / 2 / 1	4	100		
634.4	35					Soft to medium-stiff dark-brown mottled with gray slightly organic to organic clayey silt, some to "and" fine to medium sand, wet.	
		21	SH / 2 / 1	4	100		
		22	SH / 1 / 2	4	100		
629.4	40					Soft to medium-stiff gray mottled with brown silty clay, trace to some fine to coarse sand, slightly organic, contains fine sand seams, wet.	
		23	SH / 2 / 1	4	100		
		24	SH / 4 / 7	14	100		
624.9	45					Medium-dense to very-dense brown fine to coarse gravel, some to "and" fine to coarse sand, trace to little silt, wet.	
		25	6 / 11 / 17	35	80	- Contains zones of fine to coarse sand at 49.0'.	
		26	22 / 35 / 25	75	53		G
	50						
		27	21 / 8 / 8	20	33		
614.9	55						
	60					- 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	

WATER LEVEL: ▽ 28.2 ▼

WATER NOTE: Inside Well

DATE: 12/11/15

SYMBOLS USED TO INDICATE TEST RESULTS

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

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

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

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

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

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

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

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N60	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

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

S&ME

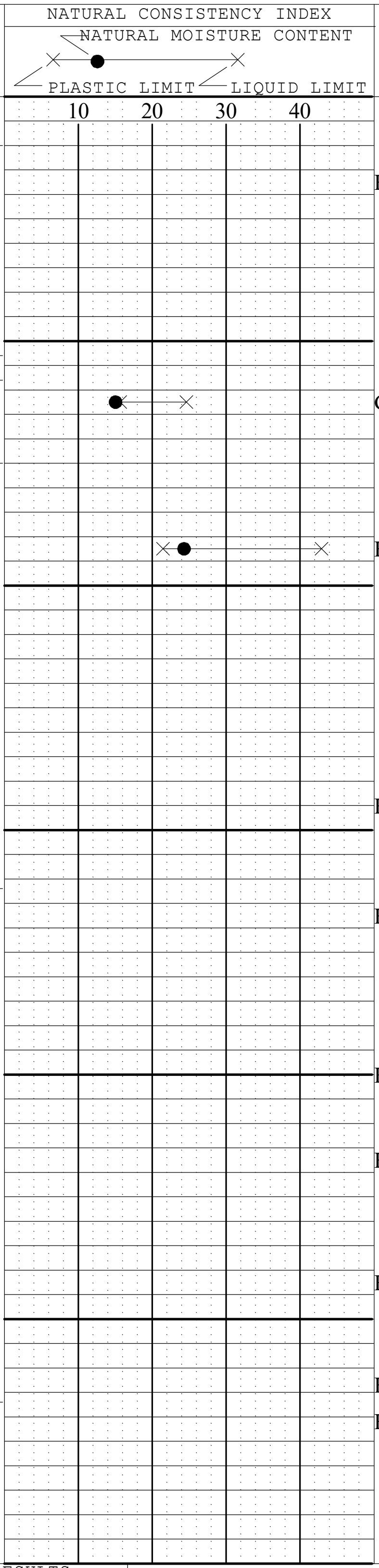
LOCATION: **N. 820,880, E. 2,513,617** ELEVATION: **661.1** DATE: **11/20/15 - 11/23/15**

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

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

2010 NEW DEFAULT BORING LOG-W/ N60

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE EFFORT	N60	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		
655.8	5	3	6/9/7	20	67		
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 2S	7/7/7/10	18	100		H=2.25-3.25
	20						
		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						



	▽	▼
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

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Page 2 of 2

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

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**

NATURAL CONSISTENCY INDEX
NATURAL MOISTURE CONTENT
PLASTIC LIMIT — LIQUID LIMIT
10 20 30 40

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
630.6	30						Medium-stiff to stiff brown clayey silt, "and" fine to medium sand, trace coarse sand, includes sand seams, moist.	
		13	■	SH 1 / SH / 1	0	100	Very-loose brown and gray fine to medium sand, little to "and" silt (percent varies), contains zones with a trace of coarse sand, wet.	G
		14	■	SH / SH / 1	0	67		
	35							
		15	■	SH / 1 / 1	3	67		
		16	■	SH / SH / 1	0	100		G
621.1	40							
	45							
	50							
	55							
	60							

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

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

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

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

2010 NEW DEFAULT BORING LOG-W/ N60

JOB: 7217-15-007B

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

S&ME

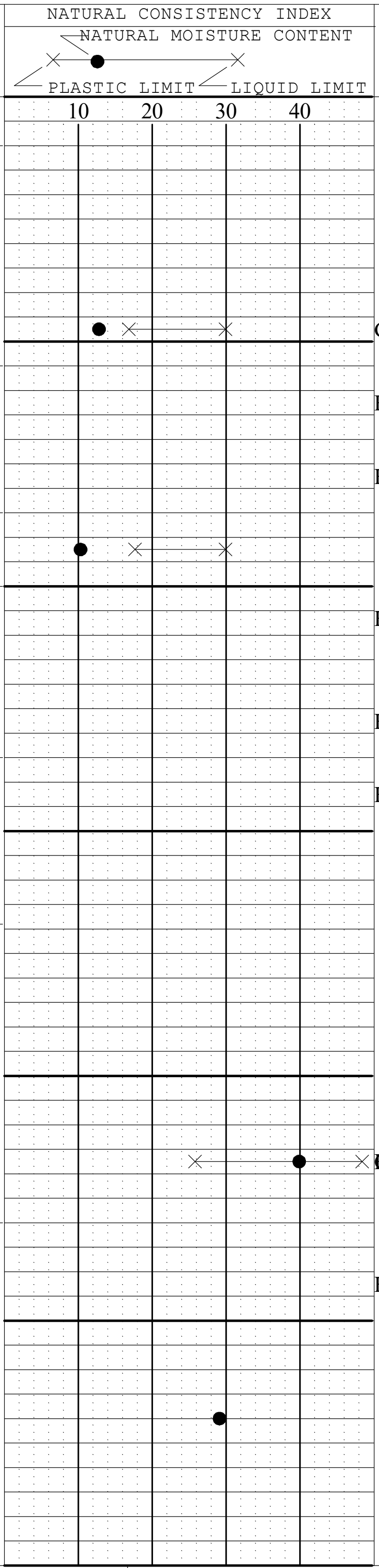
LOCATION: **N. 820,052, E. 2,513,277** ELEVATION: **669.2** DATE: **11/24/15 - 11/25/15**

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

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

2010 NEW DEFAULT BORING LOG-W/ N60

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N60	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 10B		4/6/10	20	100	Medium-stiff to stiff gray mottled with dark-gray and brown silty clay, trace fine to coarse sand, trace fine gravel, few roots, few silt seams, slightly organic, moist.	
				P				
	20							
		11		SH/1/3	5	100		G H=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							



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-

Page 2 of 3

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

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

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

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

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT / PLASTIC LIMIT / LIQUID LIMIT (10, 20, 30, 40)	TEST RESULTS
	30						Medium-stiff to very-stiff brown mottled with gray silty clay, trace to little fine to coarse sand, damp.		
		13		2/4/6	13	100			H=2.0-3.5
		14		3/4/5	11	100			H=2.5-3.0
	35								
		15		2/5/6	14	100			H=2.5
		16		2/3/5	10	100			H=2.5
	40								
		17		SH/2/3	6	100		●	H=1.25
		18		SH/SH/SH	0	100			H=1.25
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								

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

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**

2010 NEW DEFAULT BORING LOG-W/ N60

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT / PLASTIC LIMIT / LIQUID LIMIT (10 20 30 40)	TEST RESULTS
	60	25	■	8/4/5 16	11	60	Medium-dense to dense gray and brown fine to coarse sand, "and" fine to coarse gravel, little silt, wet.		
606.7							- Encountered water at 17.0'. - 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).		
	65								
	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 (%)

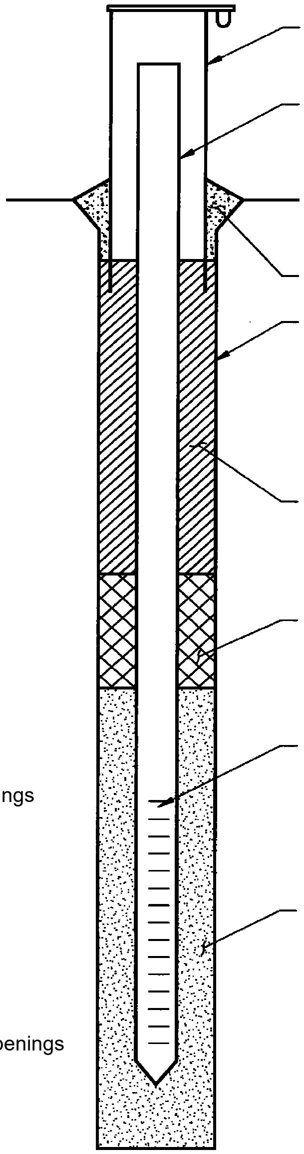
Drill Rod Energy Ratio : 0.75

Last Calibration Date : 8/2/2013

Drill Rig Number : S&ME ATV 550-2

S&ME

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



(NOT TO SCALE)

4 - Inch Diameter Protective Steel Casing

2 - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)
8 " **0.0** to **52.0**
" to
" to

Grout: **Portland & Quick Gel**

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

10 - Slot Screen

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

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

Well Development:

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

Water Quality Readings (Horiba U-52)

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

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

WELL COMPLETION DIAGRAM

Project Name:
AEP CD Bottom Ash Pond Monitoring Wells

Project Location:
Cardinal Plant / Brilliant, Ohio

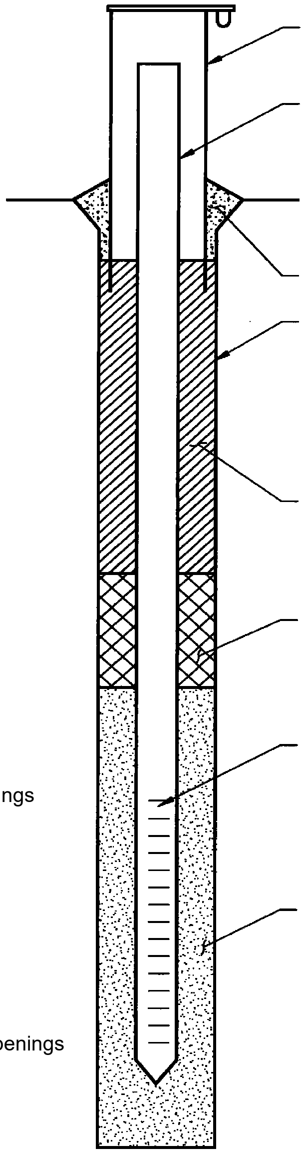
Project Number:
7217-15-007A

Boring Number:
MW-BAP-1

Date Well Installed:
12/10/2015

S&ME

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



(NOT TO SCALE)

4 - Inch Diameter Protective Steel Casing

2 - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)

8 " **0.0** to **44.5**

" to

" to

Grout: **Portland & Quick Gel**

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

10 - Slot Screen

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

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

Well Development:

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

Water Quality Readings (Horiba U-52)

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

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

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

WELL COMPLETION DIAGRAM

Project Name:
AEP CD Bottom Ash Pond Monitoring Wells

Project Location:
Cardinal Plant / Brilliant, Ohio

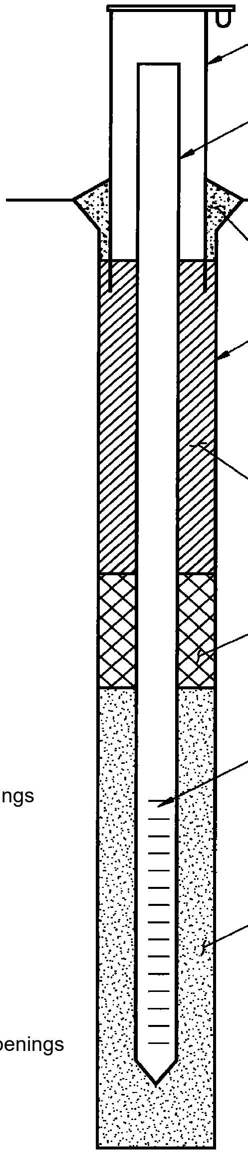
Project Number:
7217-15-007A

Boring Number:
MW-BAP-2

Date Well Installed:
12/2/2015

S&ME

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


(NOT TO SCALE)

4 - Inch Diameter Protective Steel Casing

2 - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)

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

Grout: **Portland & Quick Gel**

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

10 - Slot Screen

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

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

Well Development:

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

Water Quality Readings (Horiba U-52)

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

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

WELL COMPLETION DIAGRAM

Project Name:
AEP CD Bottom Ash Pond Monitoring Wells

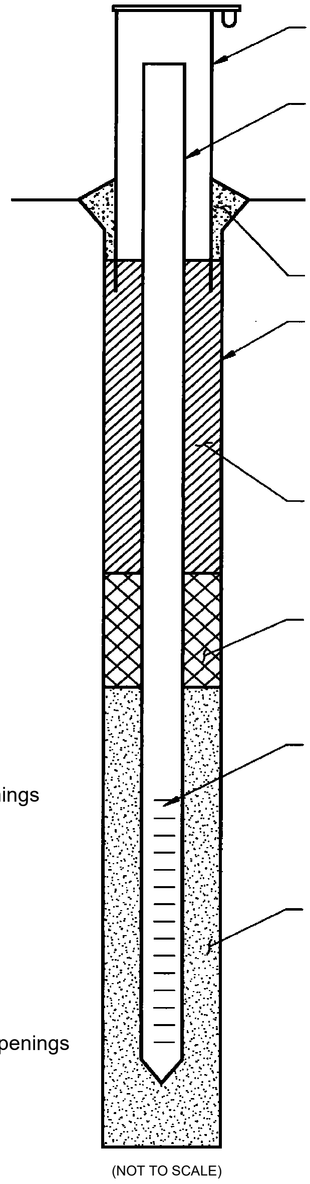
Project Location:
Cardinal Plant / Brilliant, Ohio

Project Number:
7217-15-007A

Boring Number:
MW-BAP-3

Date Well Installed:
11/13/2015

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


(NOT TO SCALE)

4 - Inch Diameter Protective Steel Casing

2 - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)

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

Grout: **Portland & Quick Gel**

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

10 - Slot Screen

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

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

Well Development:

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

Water Quality Readings (Horiba U-52)

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

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

WELL COMPLETION DIAGRAM

Project Name:
AEP CD Bottom Ash Pond Monitoring Wells

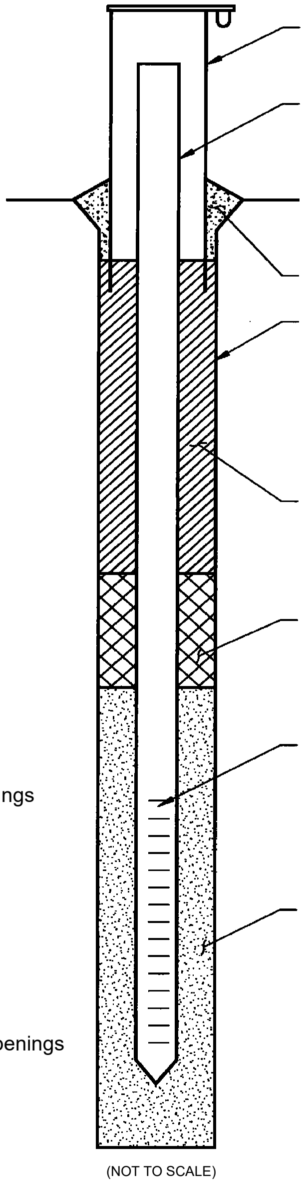
Project Location:
Cardinal Plant / Brilliant, Ohio

Project Number:
7217-15-007A

Boring Number:
MW-BAP-4

Date Well Installed:
11/23/2015

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



4 - Inch Diameter Protective Steel Casing

2 - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)

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

" to

" to

Grout: **Portland & Quick Gel**

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

10 - Slot Screen

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

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

Well Development:

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

Water Quality Readings (Horiba U-52)

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

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

WELL COMPLETION DIAGRAM

Project Name:
AEP CD Bottom Ash Pond Monitoring Wells

Project Location:
Cardinal Plant / Brilliant, Ohio

Project Number:
7217-15-007A

Boring Number:
MW-BAP-5

Date Well Installed:
11/25/2015

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.

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

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Legend

⊕ Groundwater Monitoring Well

→ Approximate Groundwater Flow Direction

— Groundwater Elevation Contour

Notes

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

250 125 0 250
Feet

Potentiometric Surface Map - Uppermost Aquifer
Bottom Ash Complex
October 2016

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec
consultants

Figure
3

Columbus, Ohio	2017/08/16

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Legend

⊕ Groundwater Monitoring Well

→ Approximate Groundwater Flow Direction

— Groundwater Elevation Contour

Notes

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

Potentiometric Surface Map - Uppermost Aquifer
Bottom Ash Complex
November 2016

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec
consultants

Figure
4

Columbus, Ohio
2017/08/16

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Legend

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

Notes

- Monitoring well coordinates and water level data (collected 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.

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

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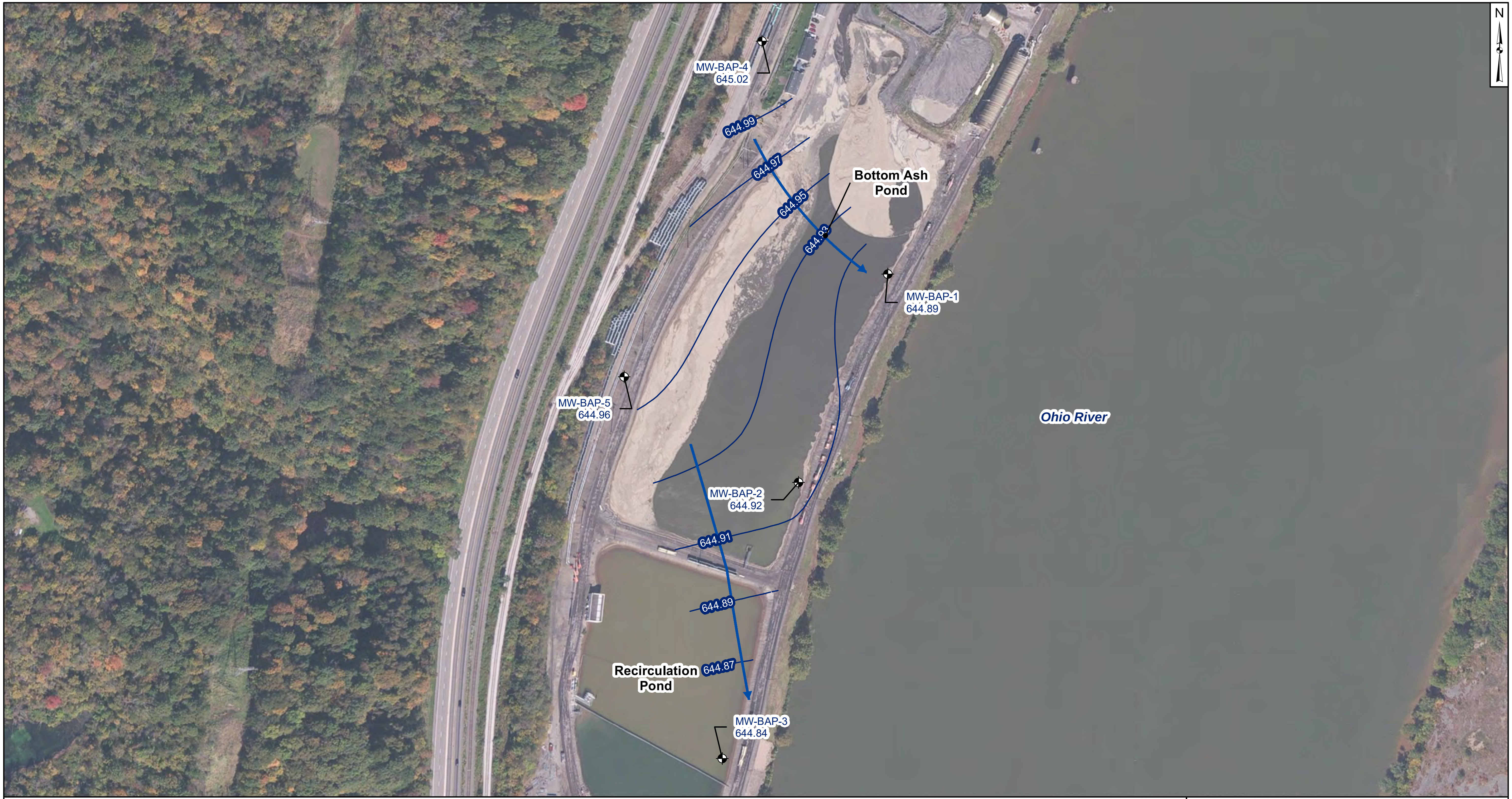

Legend

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

Notes

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

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

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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 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

Figure
9

Columbus, Ohio	2017/08/23

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Legend

⊕ Groundwater Monitoring Well

— Groundwater Elevation Contour

→ Approximate Groundwater Flow Direction

Notes

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

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

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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

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

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

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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.

8. REFERENCES

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

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

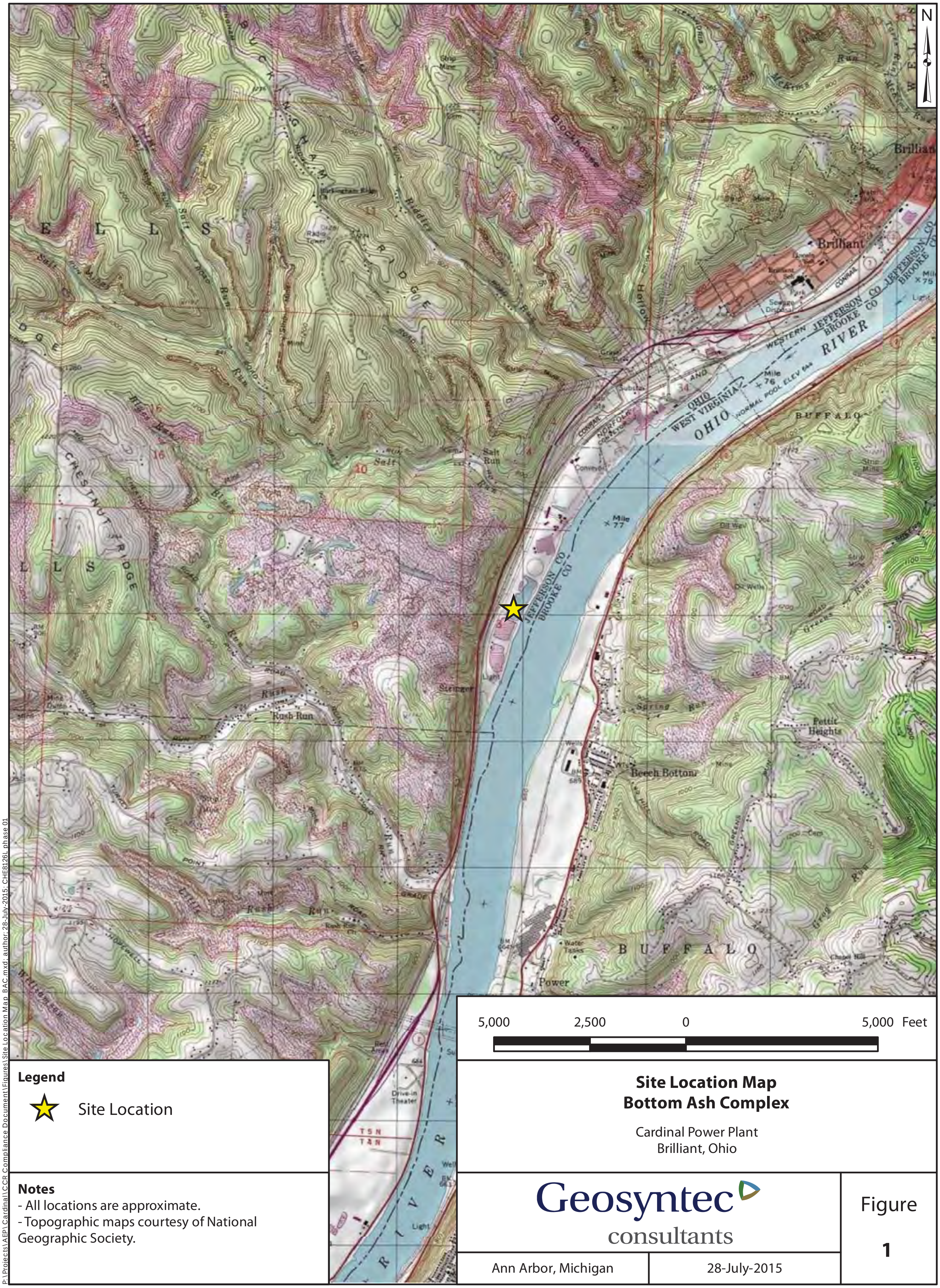
Geosyntec Consultants, Inc. 2019a. 2018 Annual Groundwater Monitoring Report, Federal CCR Rule, Cardinal Plant – Bottom Ash Pond. January.

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

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

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

FIGURES



Legend

★ Site Location

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

Site Location Map
Bottom Ash Complex

Cardinal Power Plant
Brilliant, Ohio

Geosyntec
consultants

Ann Arbor, Michigan

28-July-2015

Figure
1

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

Monitoring Well Network

- ⊕ Compliance Sampling Location
- ⊕ Background Sampling Location

▭ Bottom Ash Pond

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

250 125 0 250
Feet

Site Layout
Bottom Ash Complex

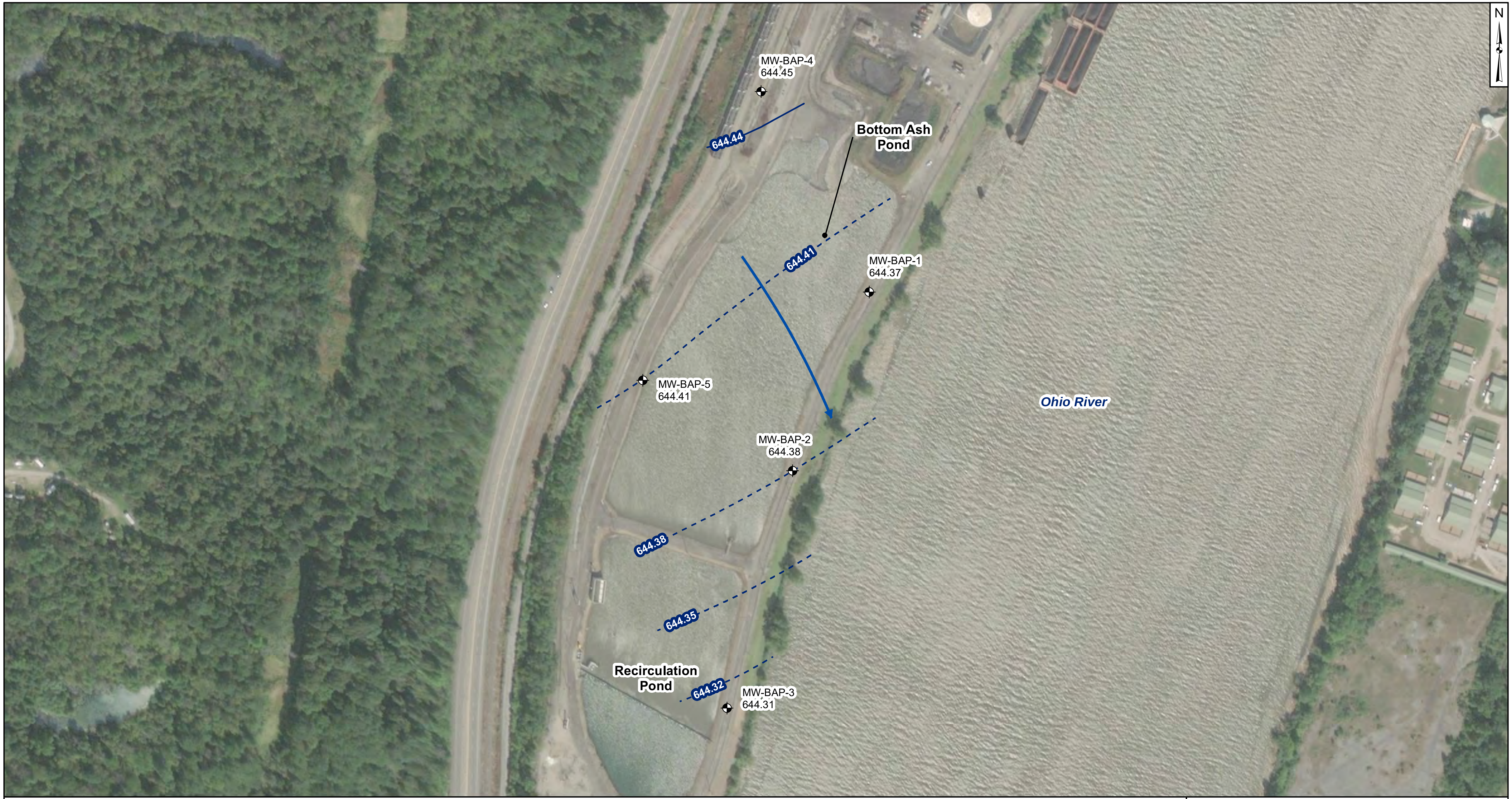
Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec
consultants

Columbus, Ohio
2018/01/25

Figure
2

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



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

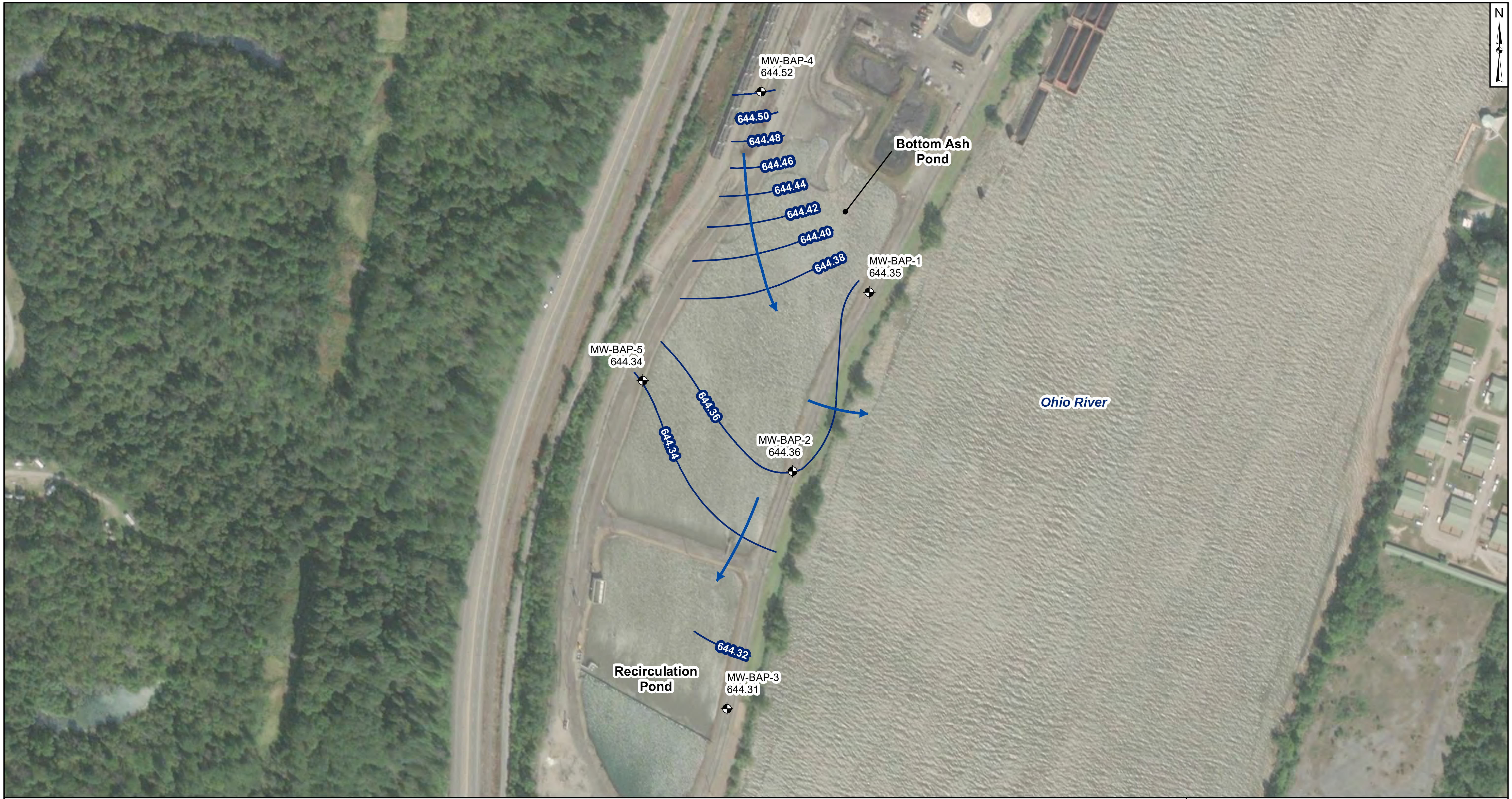
Figure

3

Columbus, Ohio

2020/01/03

P:\Projects\Buckeye Power\GIS\MXDs\BAP\Buckeye-Cardinal_BAP_GW_2019-03.mxd. ARevezzo. 1/3/2020. CHA8423/01/08.



Legend

⌖ Groundwater Monitoring Well

→ Approximate Groundwater Flow Direction

— Groundwater Elevation Contour

Notes

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

250 125 0 250
Feet

Potentiometric Surface Map - Uppermost Aquifer
Bottom Ash Complex
October 2019

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec
consultants

Columbus, Ohio

2019/12/31

Figure
4

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TABLES

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

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

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

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

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

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

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).

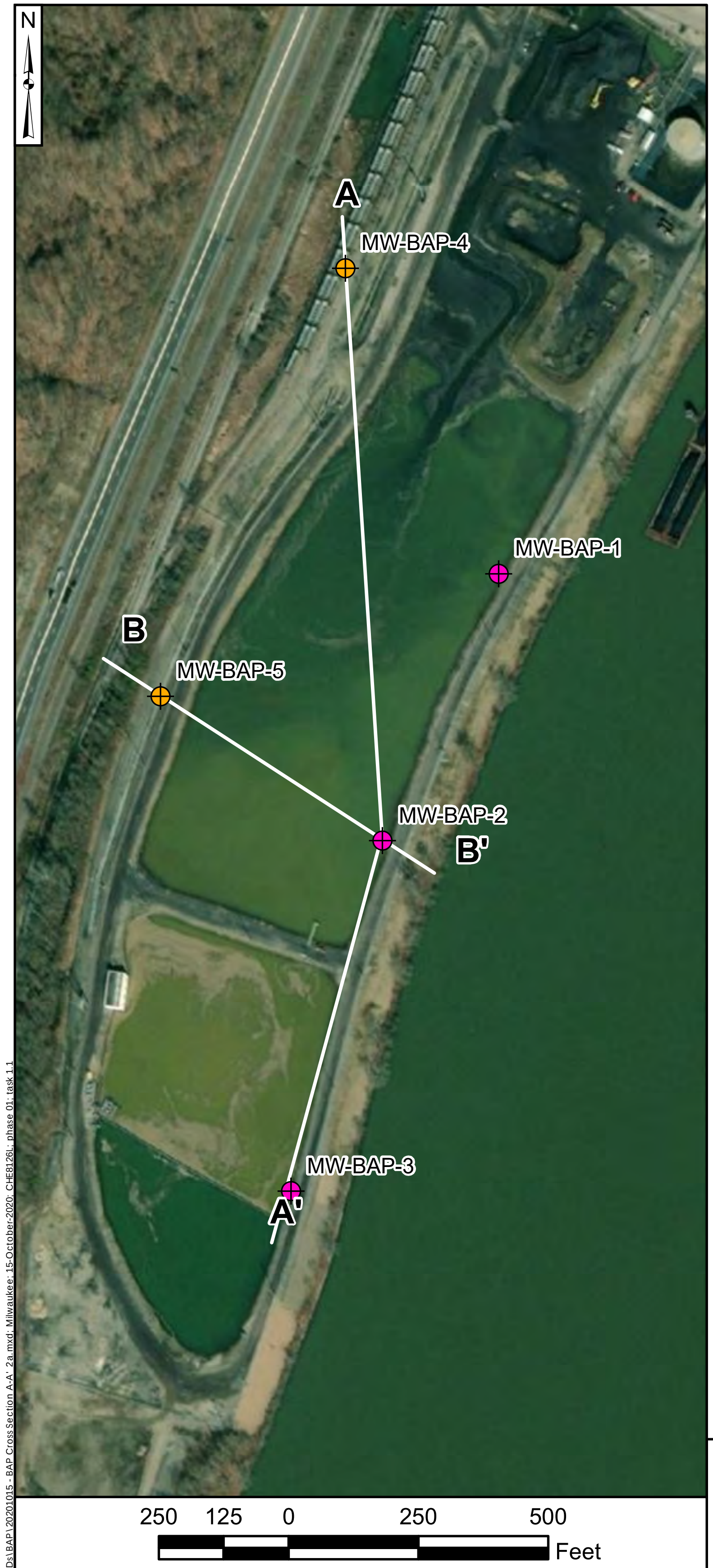
3.3 Review of Existing Monitoring Network

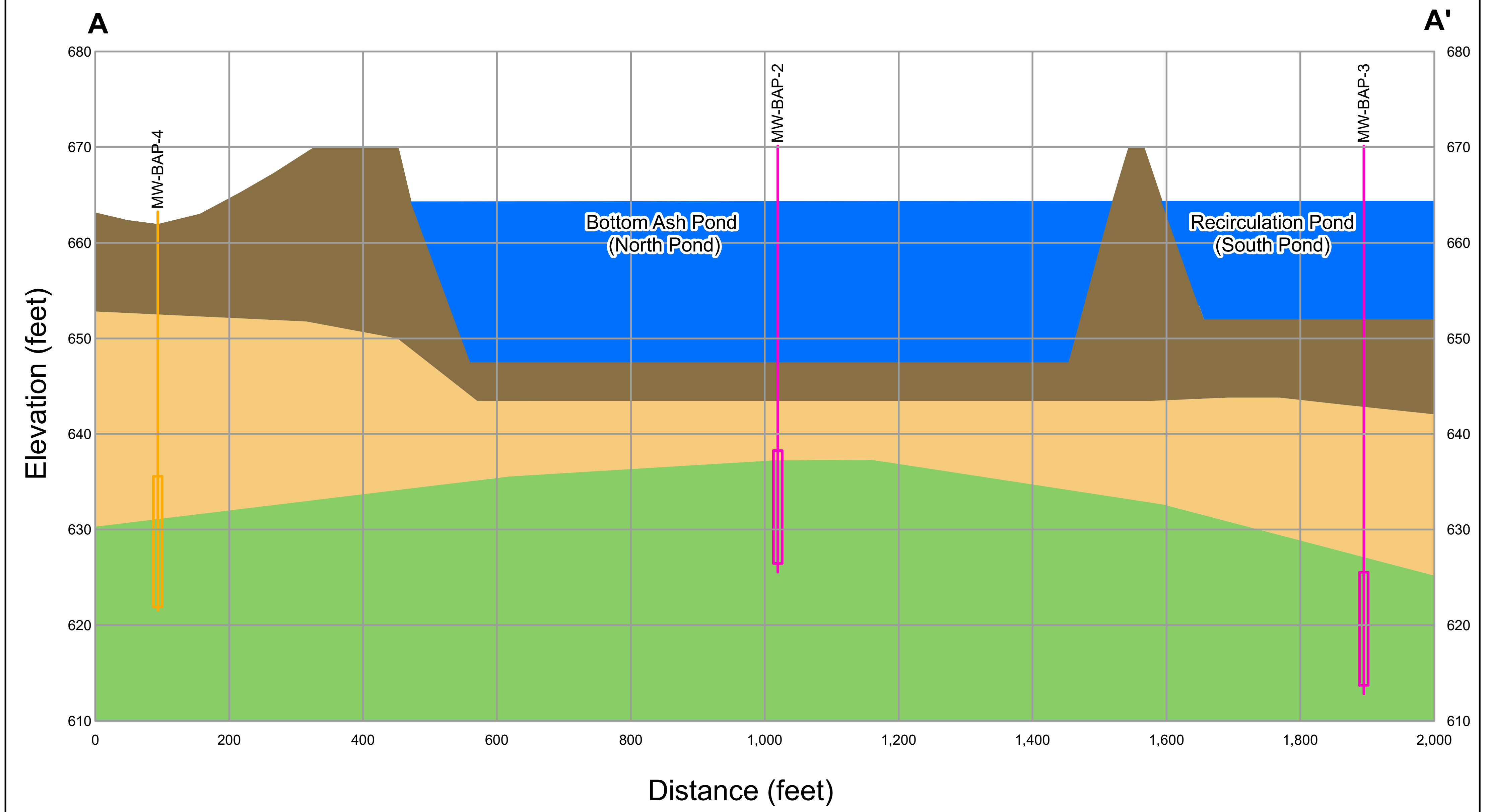
3.3.1 Overview

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

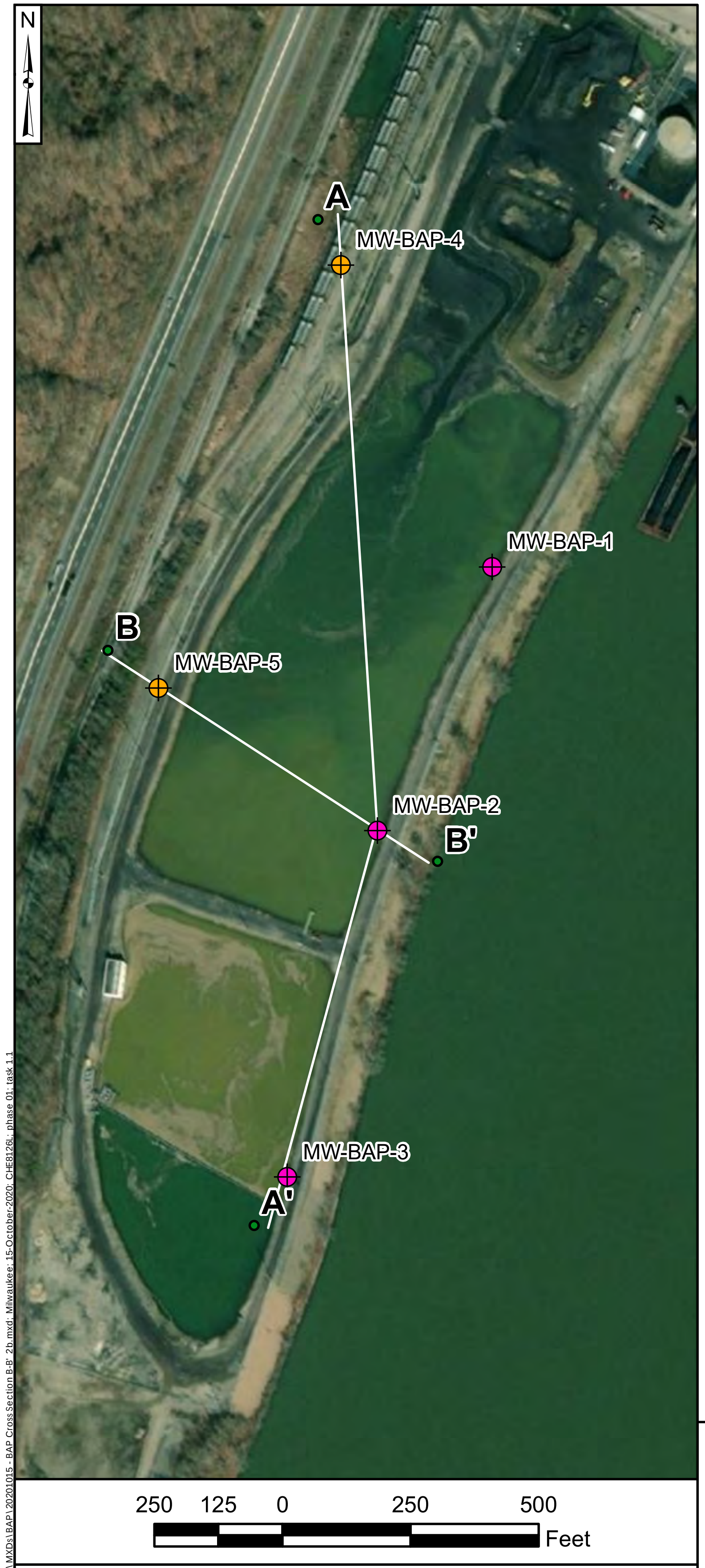
- ⊕ Monitoring Well, Background
- ⊕ Monitoring Well, Compliance
- 🟦 Surface Water
- 🟫 Fill
- 🟧 Alluvium (Silt/Clay)
- 🟩 Glacial Outwash

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

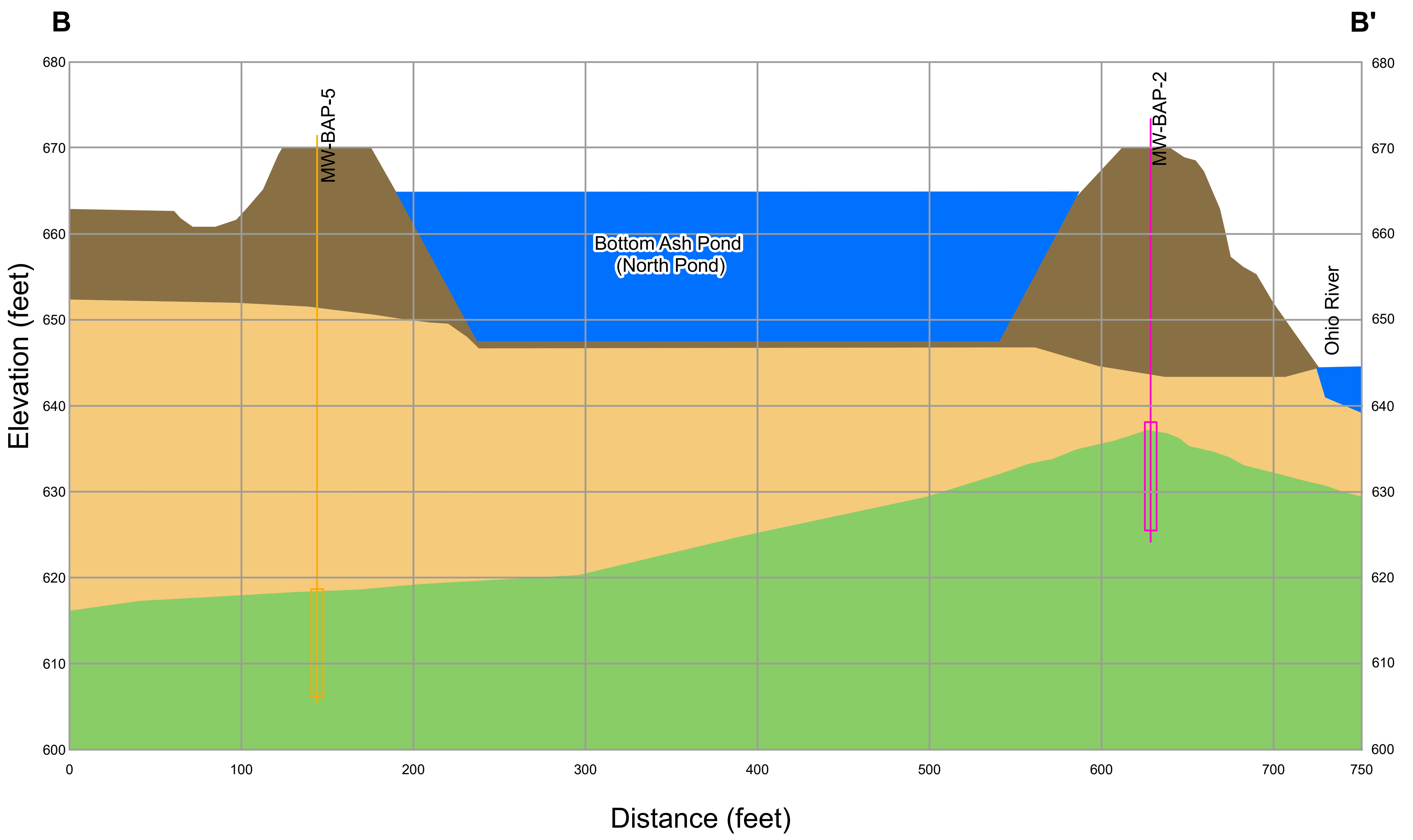
Geosyntec
consultants

Columbus, Ohio
August 2020

Figure
Xa



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\20201015 - BAP Cross Section B-B' 2b.mxd; Milwaukee; 15-October-2020; CHE8126L; 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 J T Massey-Norton
John T. Massey-Norton **DATE** 10/4/2016

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

STATE OF OHIO
MOHAMMAD
A
AJLOUNI
67074
REGISTERED
PROFESSIONAL ENGINEER

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

TABLE OF CONTENTS

1.0 OBJECTIVE 257.73(d)

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

2.0 NAME AND DESCRIPTION OF CCR SURFACE IMPOUNDMENT

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

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

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

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

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

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

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

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

Table 1 Strength Parameters for main Natural/constructed zones.

Layer	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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Appendices

1.0 Introduction

1.1 Background

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

1.2 Location and Geologic Conditions

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

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

Figure 1-1 – Cardinal Plant

1.3 Previous Investigations

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

2.0 Scope of Work

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

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

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

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

3.0 Information Review and Site Visit

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

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

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

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

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

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

4.0 Field and Laboratory Work

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

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

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

5.0 Subsurface Conditions

5.1 Stratigraphy

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

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

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

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

5.2 Groundwater Conditions

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

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

5.3 Shear Strength and Permeability

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

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

Table 5-1 – Shear Strength Parameters

Material Description	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 E-74384

12-30-15

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

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

Appendices

Appendix I – 2009 & 2015 Site Investigation Figures

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

DATUM: NAD 27/NGVD 29 OHIO SOUTH

SCALE IN FEET

0 100 200

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

REFERENCE: AEP CARDINAL DRAWING 94151038

DATE	NO.	DESCRIPTION	APPD.
		REVISIONS	

A.E.P.
CARDINAL PLANT
BRILLIANT OHIO

BOTTOM ASH POND
INVESTIGATION
PLAN OF BORINGS

DWG. NO. PLATE 1

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

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

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

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

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

IGS0694

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

SAMPLING DATA

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

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

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

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

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

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

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

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

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

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

SOIL DESCRIPTIONS

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

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

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

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

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

Page 1 of 1

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**

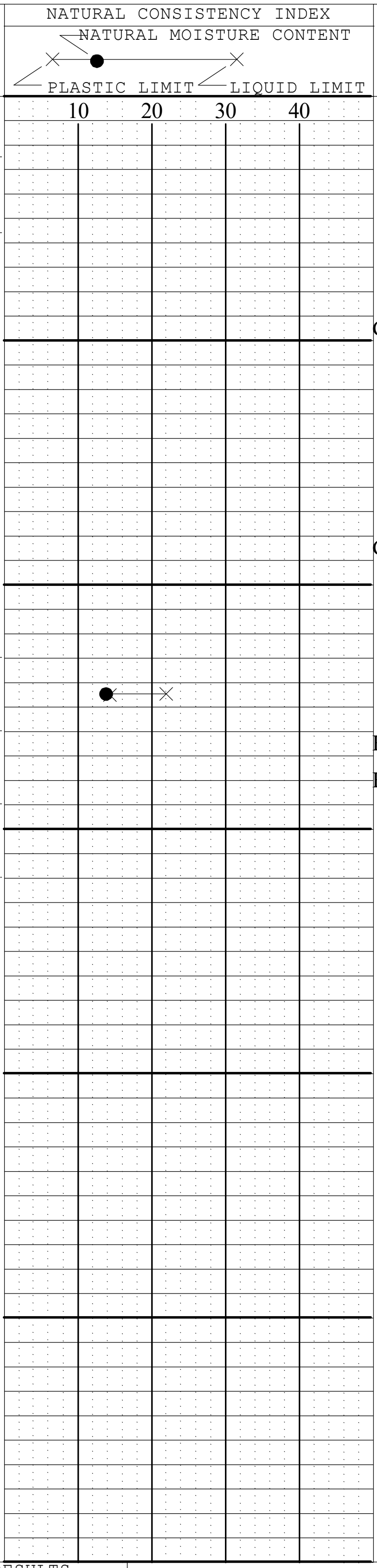
DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **16.0'**

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

ELEV.	SAMPLE NUMBER	SAMPLE EFFORT	N60	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
					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.	
	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
	7	50-1"R		0		
659.5	8	8/19/13	40	73	FILL: Dense brown fine to coarse sand, trace fine gravel, some to "and" clayey silt, damp.	
658.0	9A	10/15/19	43	100	FILL: Stiff to very-stiff gray silty clay, some to "and" fine to coarse sand, little fine to coarse gravel, damp.	H=1.75-2.25
	9B					H=3.0-4.0
656.5	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						

DEPTH, FEET: 0, 5, 10, 15, 20, 25, 30

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



2010 NEW DEFAULT BORING LOG-W/ N60

WATER LEVEL: ▽ ▼

WATER NOTE:

DATE:

SYMBOLS USED TO INDICATE TEST RESULTS

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

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

Drill Rod Energy Ratio : 0.75

Last Calibration Date : 2/20/2013

Drill Rig Number : S&ME ATV 550-2

JOB: 7217-15-007A

PLATE 3

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

S&ME

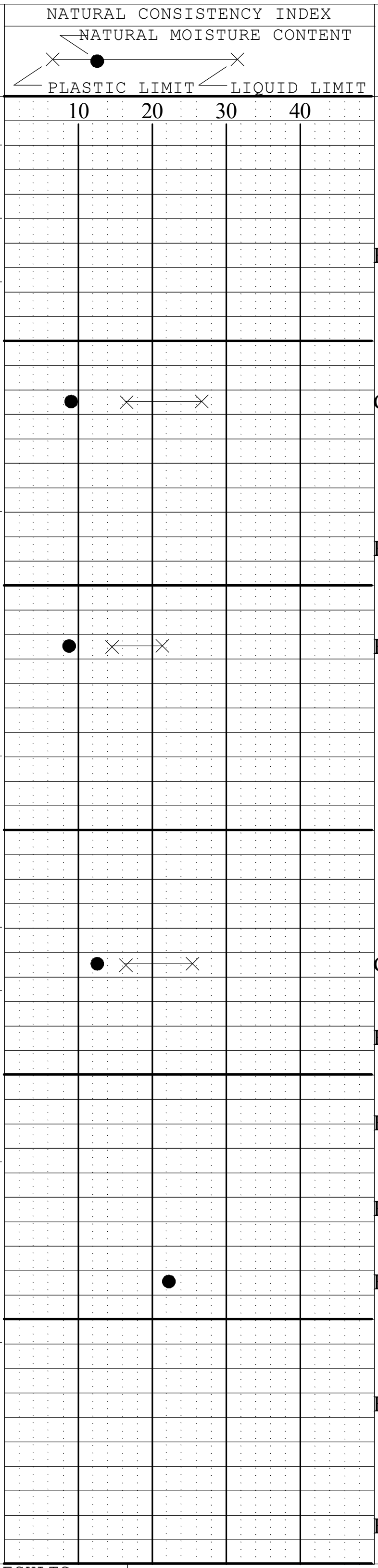
LOCATION: **N. 820,839, E. 2,513,713** ELEVATION: **671** DATE: **11/18/15**

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

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

2010 NEW DEFAULT BORING LOG-W/ N60

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE EFFORT	N₆₀	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
670.0	0					AGGREGATE - 12 INCHES	
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		
		6	9/11/15	33	87	FILL: Hard gray and brown clayey silt, some to "and" fine to coarse sand, little fine to coarse gravel, damp.	H=4.5
	10	7	11/15/18	41	53		H=4.5
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
		10	7/6/3	11	100	Stiff gray clayey silt, some fine to coarse sand, some fine gravel, moist.	H=1.25
649.2	20		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



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**

NATURAL CONSISTENCY INDEX
NATURAL MOISTURE CONTENT
PLASTIC LIMIT LIQUID LIMIT
10 20 30 40

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

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

WATER LEVEL: ▽ ▼
WATER NOTE:
DATE:

SYMBOLS USED TO INDICATE TEST RESULTS

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

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

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

Page 1 of 1

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**

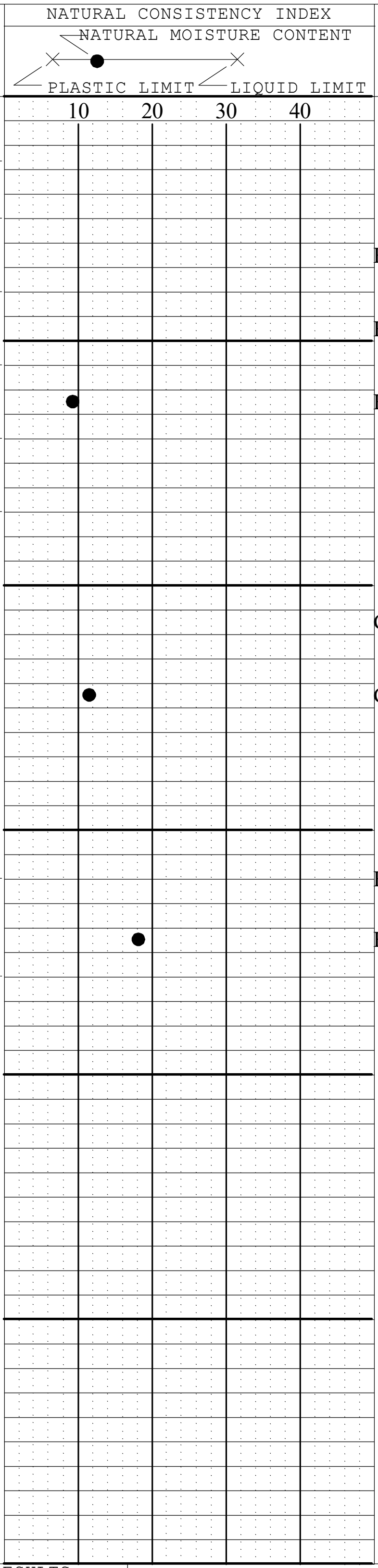
DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **18.0'**

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

2010 NEW DEFAULT BORING LOG-W/ N60

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N60	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
	0						AGGREGATE - 16 INCHES	
668.7		1		27/18/14	40	87	FILL: Hard gray and brown silty clay, some fine to coarse sand, brown fine gravel, dry.	
667.5		2		18/10/9	24	80	FILL: Medium-dense dark-brown fine to coarse sand, trace fine gravel, trace silt, dry.	H=4.0
666.0	5	3		4/20/19	49	93	FILL: Hard gray and brown silty clay, "and" fine to coarse sand, little fine gravel, dry.	H=4.0
664.5		4		11/18/24	53	100	FILL: Dense dark-gray and brown fine to coarse sand, little to some fine to coarse gravel, some silty clay, dry.	H=4.0
663.0		▽ 5		24/17/14	39	67	FILL: Hard brown silty clay, some fine to coarse sand, little fine gravel, dry.	
661.5		6		11/14/21	44	33	FILL: Medium-dense to dense brown and dark-gray fine to coarse sand, little to some fine to coarse gravel (sandstone fragments), little to "and" silty clay, dry.	
	10	7		7/11/16	34	67		G
		8		11/8/10	23	27		G
		9		8/27/16	54	47		
	15	10		2/4/7	14	0		
654.0		11	2S	11		100		H=1.5-2.0
		12		1/4/4	10		FILL: Medium-stiff to stiff brown and gray silty clay, some fine to coarse sand, little fine to coarse gravel, damp becoming wet.	H=0.75-1.5
652.0								
	20							
	25							
	30							

- 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).



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

PLATE 6

Page 1 of 1

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

S&ME

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

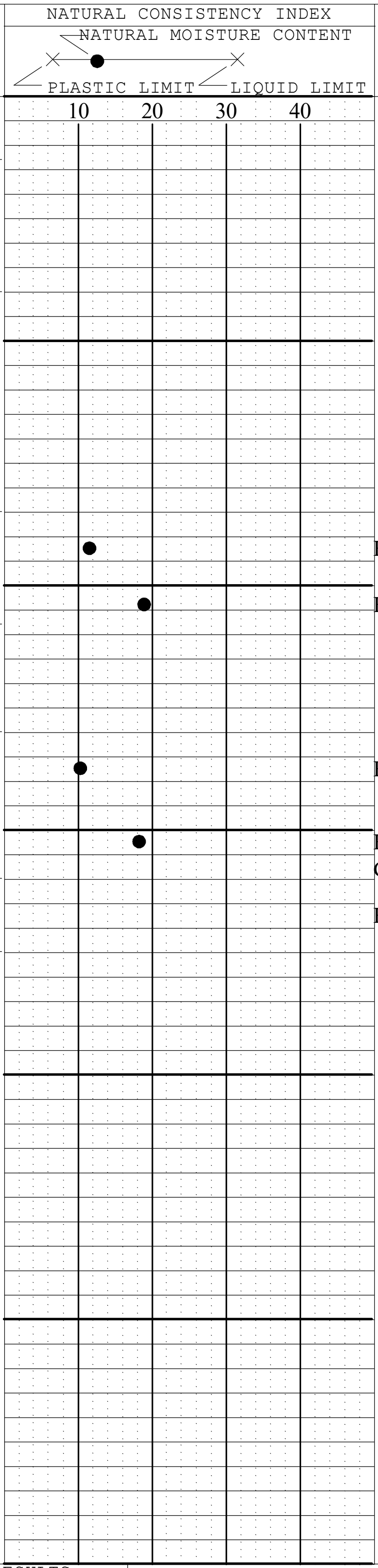
DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **17.5'**

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

2010 NEW DEFAULT BORING LOG-W/ N60

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

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



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

SYMBOLS USED TO INDICATE TEST RESULTS

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

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

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

JOB: 7217-15-007A

PLATE 7

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

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 EFFORT	N60	SAMPLE REC-%	DESCRIPTION	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		
	5	3	6/9/7	20	67		
654.7						FILL: Very-soft brown and gray silty clay, "and" fine to coarse sand, little fine to coarse gravel.	
654.2		4	35/13/12	31	87	FILL: Dense bown fine to coarse sand, little fine to coarse gravel, "and" clayey silt, cobbles, moist.	
		5	50-3"R		20		
652.5		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						
	15		P				H=1.25-2.5
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
	20	8 2S	7/7/7 10	18	100		H=2.25-3.25
		9	3/5/6	14	100		H=3.0
	25	10	3/5/6	14	100		H=3.25

NATURAL CONSISTENCY INDEX
NATURAL MOISTURE CONTENT
PLASTIC LIMIT — LIQUID LIMIT
10 20 30 40

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

2010 NEW DEFAULT BORING LOG-W/ N60

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**

NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT / PLASTIC LIMIT / LIQUID LIMIT: 10 20 30 40

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	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						
	45						
	50						

- 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).

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

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**

2010 NEW DEFAULT BORING LOG-W/ N60

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX NATURAL MOISTURE CONTENT PLASTIC LIMIT — LIQUID LIMIT	TEST RESULTS
	0						AGGREGATE - 12 INCHES	10 20 30 40	
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					Medium-stiff to stiff gray mottled with dark-gray and brown silty clay, trace fine to coarse sand, trace fine gravel, few roots, few silt seams, slightly organic, moist.		
				P					
	20								
		11		SH/1/3	5	100			H=0.5-1.25
647.0									
		12		2/2/4	8	100	Medium-stiff to very-stiff brown mottled with gray silty clay, trace to little fine to coarse sand, damp.		H=3.5
	25								

WATER LEVEL: ▽ ▼

WATER NOTE:

DATE:

SYMBOLS USED TO INDICATE TEST RESULTS

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

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

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

-CONTINUED-

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**

2010 NEW DEFAULT BORING LOG-W/ N60

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N60	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT / PLASTIC LIMIT / LIQUID LIMIT 10 20 30 40	TEST RESULTS
	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						Stiff gray mottled with brown and dark-gray silty clay, trace fine to coarse sand, slightly organic, damp.		
		19	■	SH/SH/1	0	100			H=0.75
622.0							Medium-stiff to stiff gray and dark-gray organic clayey silt, trace fine to coarse sand, damp.		
		20	■	SH/SH/SH	0	100			H=0.75-1.25
	50								

WATER LEVEL: ▽ ▼

WATER NOTE:

DATE:

SYMBOLS USED TO INDICATE TEST RESULTS

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

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

Drill Rod Energy Ratio : 0.75

Last Calibration Date : 8/2/2013

Drill Rig Number : S&ME ATV 550-2

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								
	70								
	75								

- 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).

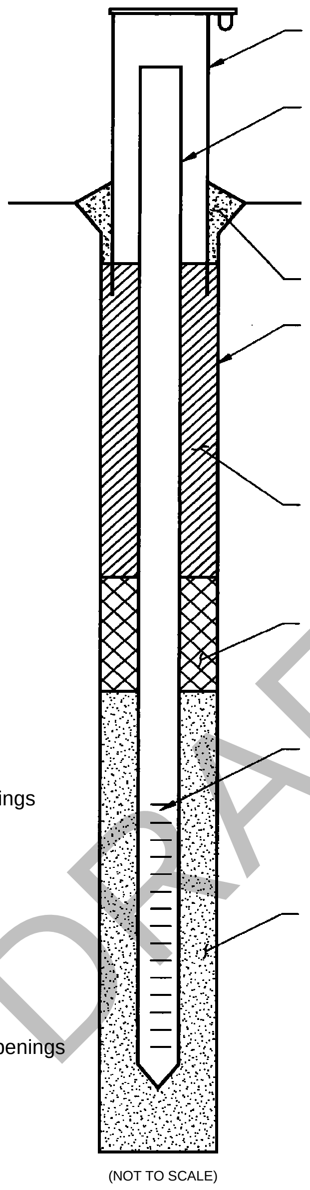
WATER LEVEL: ▽ ▼
WATER NOTE:
DATE:

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

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

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



4 - Inch Diameter Protective Steel Casing

2 - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)

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

" to

" to

Grout: **Portland & Quick Gel**

Bentonite Seal: **Bentonite pellets**

10 - Slot Screen

Filter Pack: **#5 quartz sand**

(NOT TO SCALE)

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

Well Development:

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

Water Quality Readings (Horiba U-52)

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

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

WELL COMPLETION DIAGRAM

Project Name:
AEP CD Bottom Ash Pond Monitoring Wells

Project Location:
Cardinal Plant / Brilliant, Ohio

Project Number:
7217-15-007A

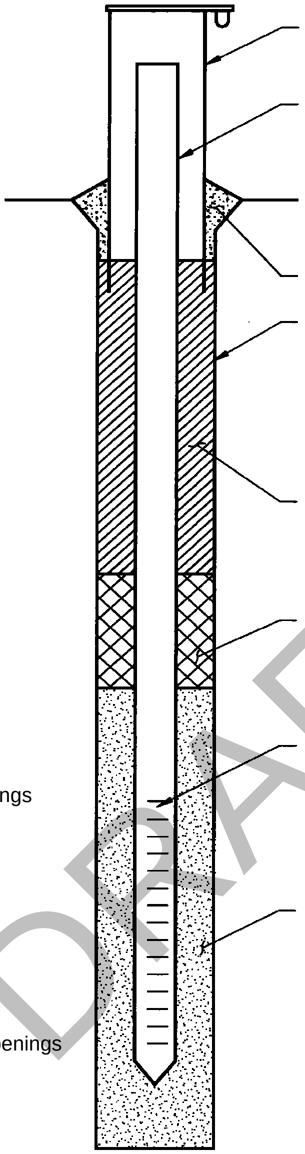
Boring Number:
MW-BAP-4

Date Well Installed:
11/23/2015

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

S&ME

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



(NOT TO SCALE)

4 - Inch Diameter Protective Steel Casing

2 - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)

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

" to

" to

Grout: **Portland & Quick Gel**

Bentonite Seal: **Bentonite pellets**

10 - Slot Screen

Filter Pack: **#5 quartz sand**

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

Well Development:

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

Water Quality Readings (Horiba U-52)

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

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

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

WELL COMPLETION DIAGRAM

Project Name:
AEP CD Bottom Ash Pond Monitoring Wells

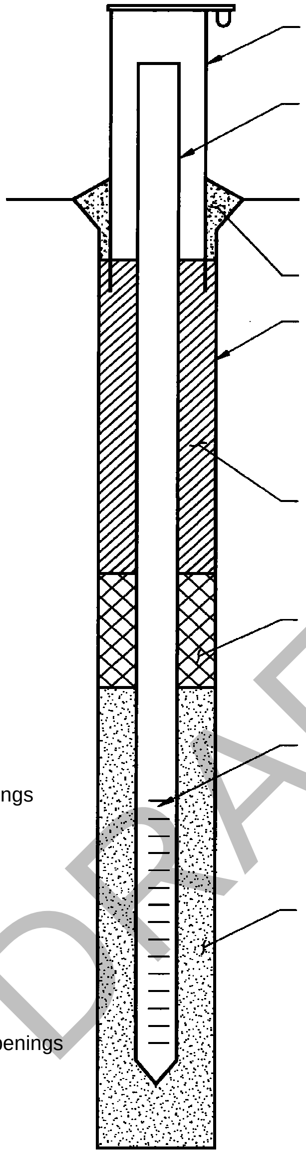
Project Location:
Cardinal Plant / Brilliant, Ohio

Project Number:
7217-15-007A

Boring Number:
MW-BAP-5

Date Well Installed:
11/25/2015

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


(NOT TO SCALE)

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

2 - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Hole Plug

Boring Diameter (in inches)

8 "	**0.0**	to	**18.0**
"		to	
"		to	

Grout: **no grout**

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

10 - Slot Screen

Filter Pack: **#5 quartz sand**

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

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

WELL COMPLETION DIAGRAM

Project Name:
AEP CD Bottom Ash Pond Monitoring Wells

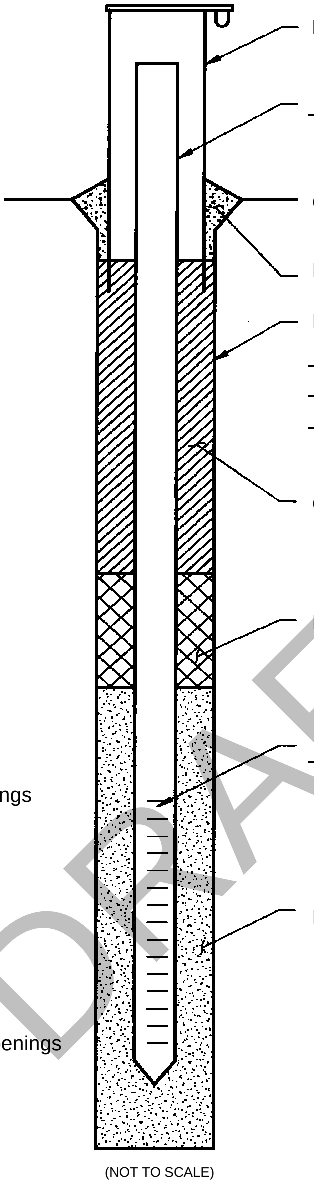
Project Location:
Cardinal Plant / Brilliant, Ohio

Project Number:
7217-15-007A

Boring Number:
CD-BAP-1504

Date Well Installed:
11/25/2015

Elevation (Feet above MSL)	Depth Below Ground Surface (Feet)	
		Top of Cover
673.33	**3.33**	Top of PVC
670.0	**0.0**	Ground Surface
669.5	**0.5**	Top of Grout
659.6	**10.4**	Top of Bentonite
657.2	**12.8**	Top of Filter Pack
		Top of Aquifer
658.0	**12.0**	Top of Screen Openings
653.2	**16.8**	Bottom of Screen Openings
652.5	**17.5**	Bottom of Well
		Bottom of Aquifer
652.5	**17.5**	Bottom of Boring



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

2 - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Hole Plug

Boring Diameter (in inches)

8 " **0.0** to **17.5**

" to

" to

Grout: **Portland & Quick Gel**

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

10 - Slot Screen

Filter Pack: **#5 quartz sand**

Depth to Static Water:	11.4	12.15	11.54		
Static Water Elevation:	661.93	661.18	661.79		
Date:	**11/29/15**	**12/11/15**	**12/15/15**		

Well Location: N. 819,448' E. 2,513,591'
Datum: NAD27/NGVD29 OH S

WELL COMPLETION DIAGRAM

Project Name:
AEP CD Bottom Ash Pond Monitoring Wells

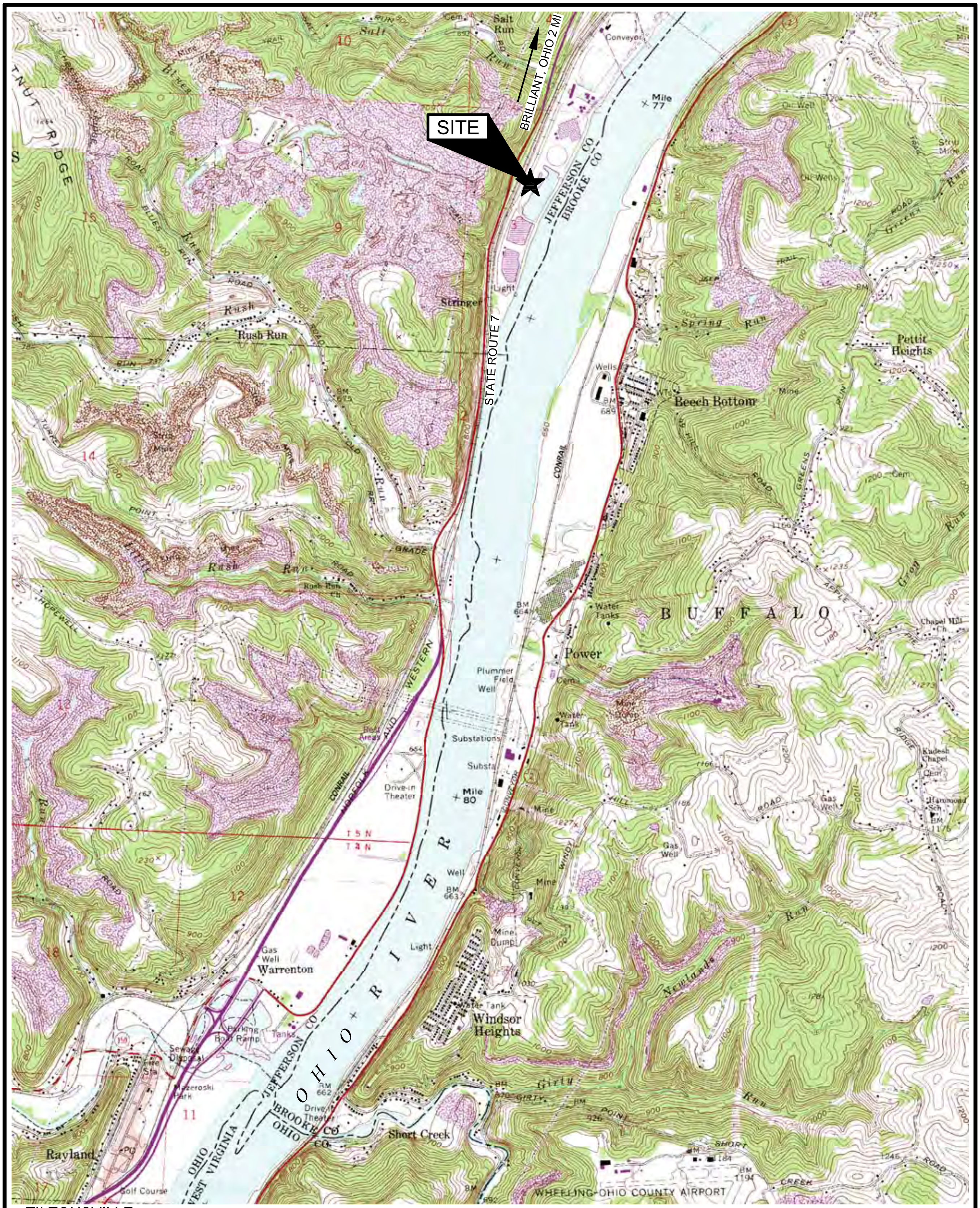
Project Location:
Cardinal Plant / Brilliant, Ohio

Project Number:
7217-15-007A

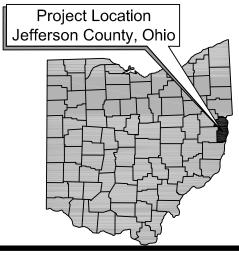
Boring Number:
CD-BAP-1505

Date Well Installed:
11/25/2015

2009 SITE INVESTIGATION



TILTONSVILLE



Tiltonsville Quadrangle

VICINITY MAP

Cardinal Generating Plant
Ash Pond Investigation
Brilliant, Ohio

Project: 011-11497-013
Drawn By: MTR
Drawing Date: 7-2-09
Approved By: MGR
Last Updated: 7-6-2009
Scale: 1" = 3000' 1:1

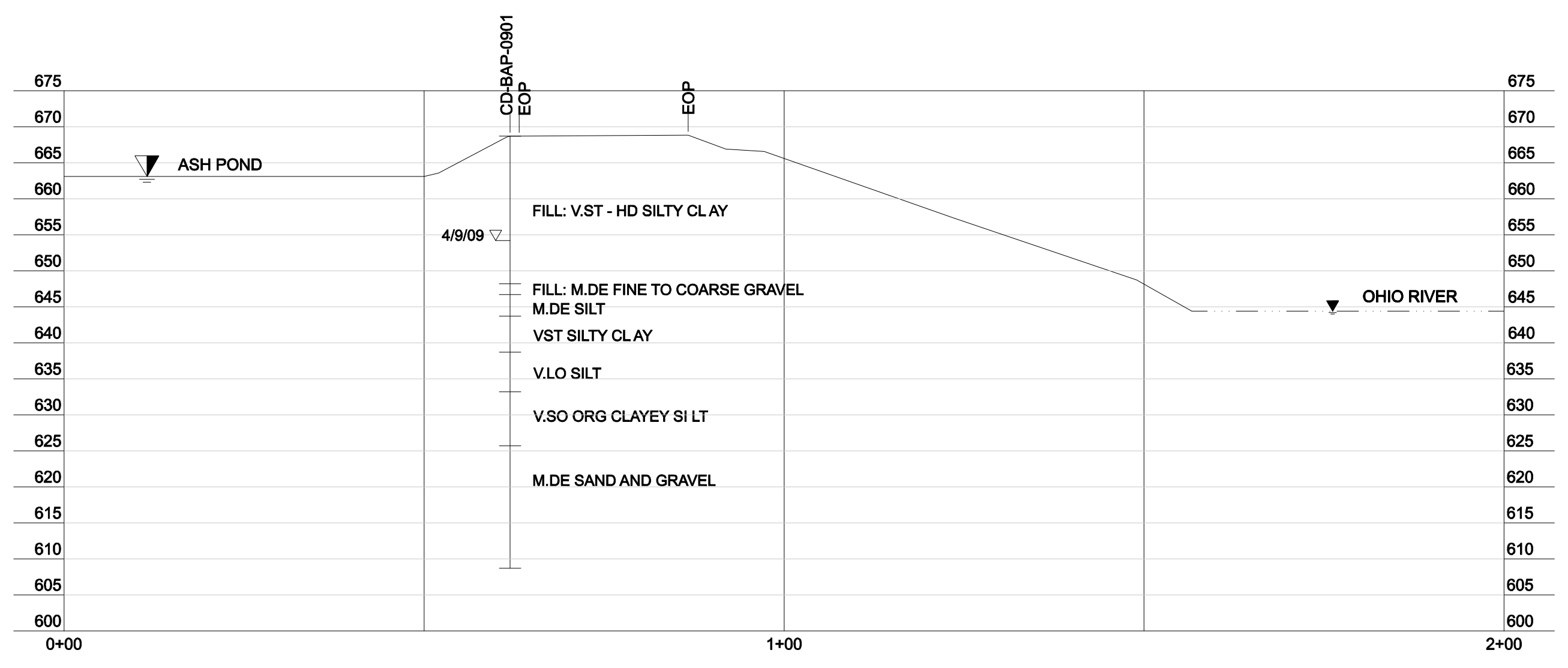
BBCM
SOLUTIONS TO BUILD ON

Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 424-1011

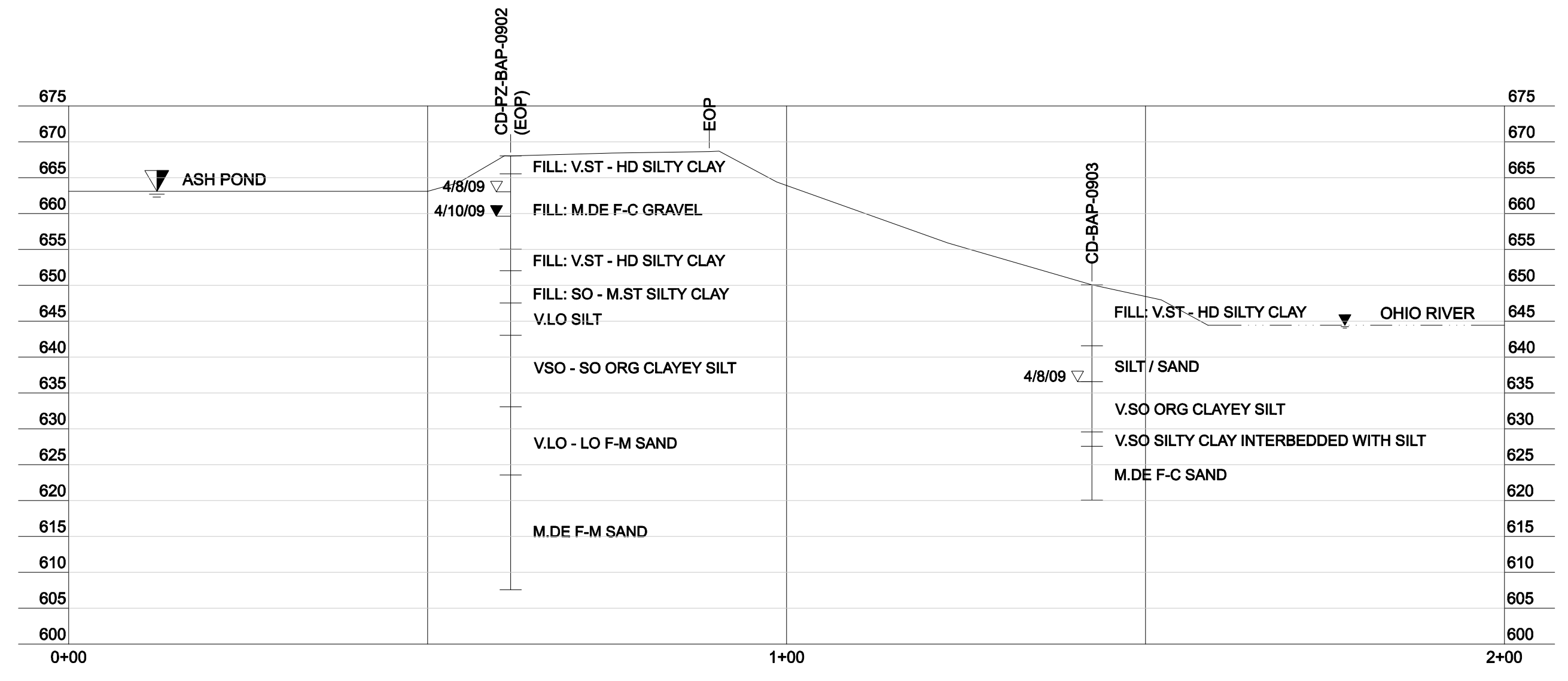
PLATE 1

Images: ~Tiltonsville Ohio Quad Map.tif
Xrefs:
File Last Updated: Jul 06, 2009
Plot Info: 7-22-2009 @ 3:23pm By: MRomanello
BBC&M Filename: I:\DEPTS\CADD\Drawings\Projects\011-11497-013\VMap.dwg Layout: 8.5x11P

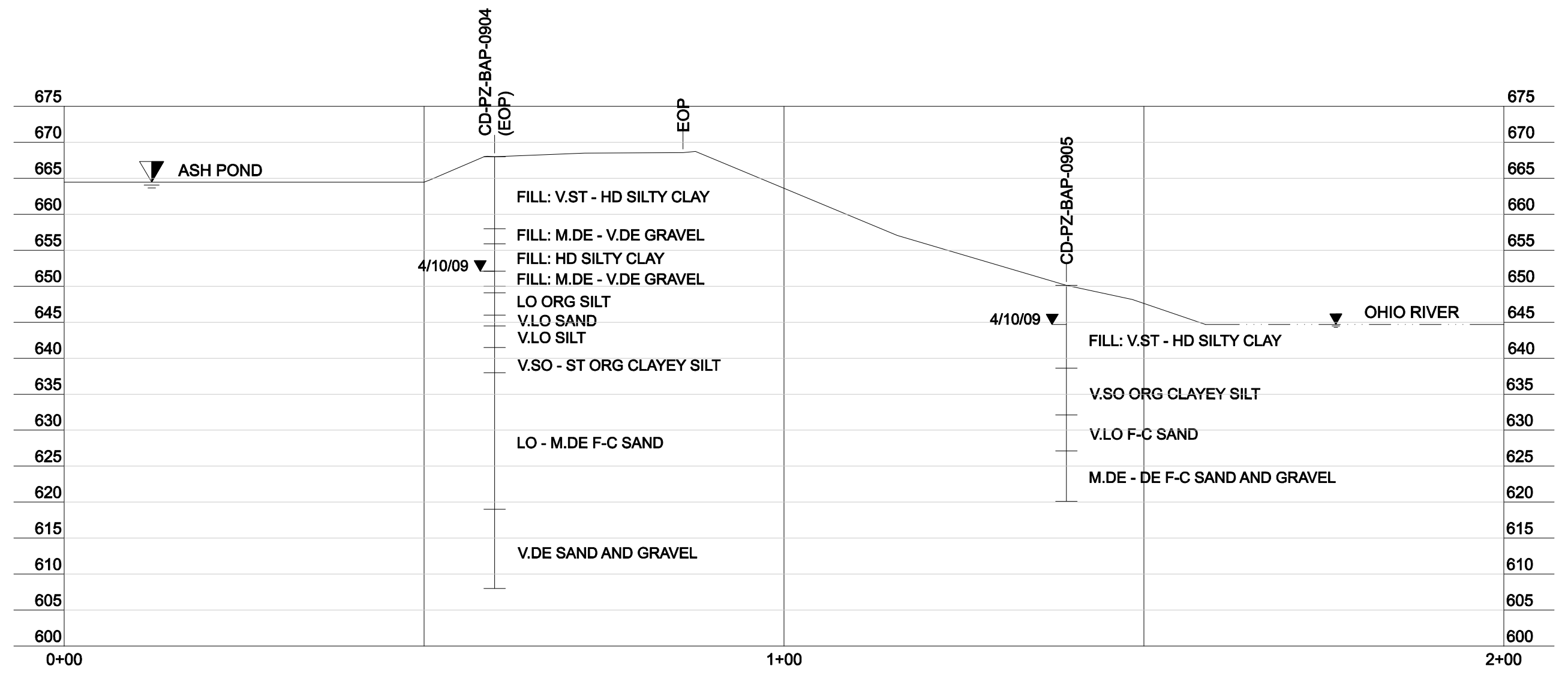
DWG. NO. PLATE 3



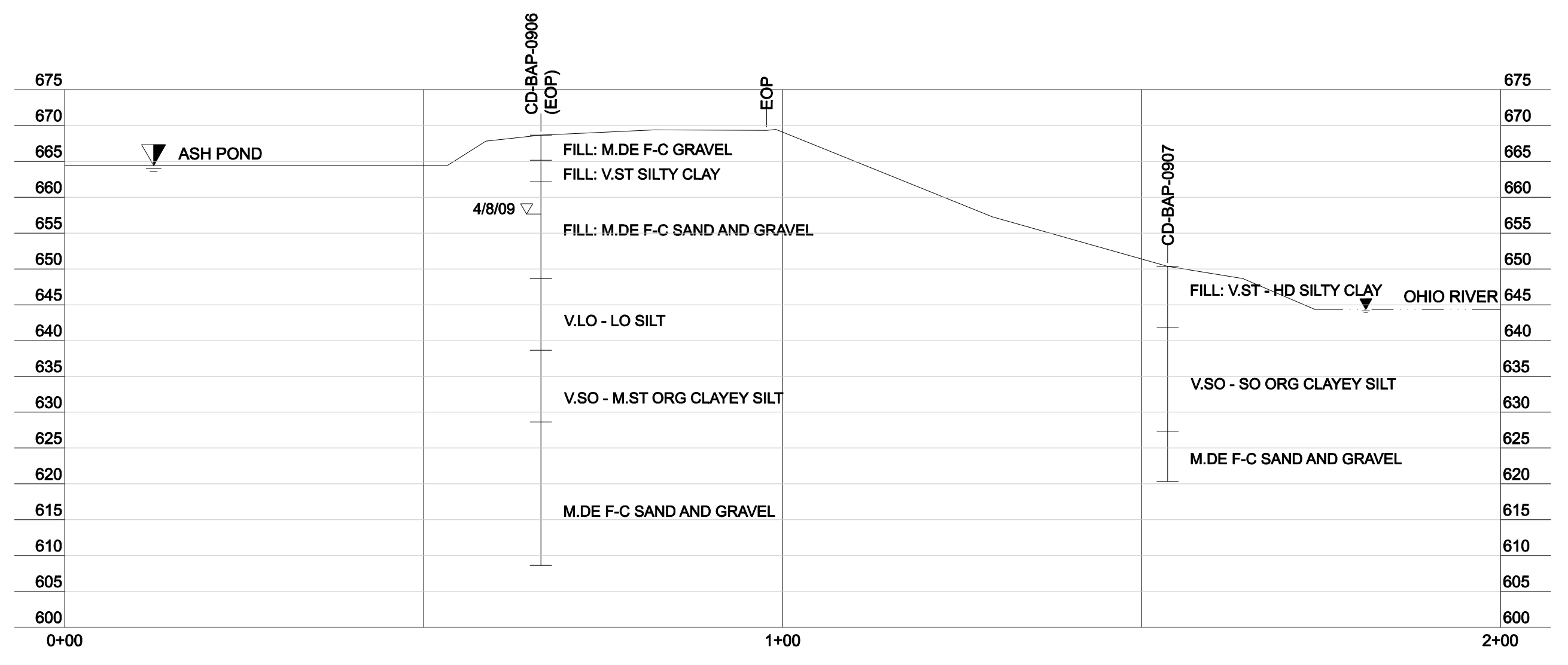
SECTION 'A'
Boring BAP-0901



SECTION 'B'
Borings BAP-0902 & BAP-0903



SECTION 'C'
Borings BAP-0904 & BAP-0905



SECTION 'D'
Borings BAP-0906 & BAP-0907

LEGEND

4/20/09 ▼	OBSERVATION WELL READING: ELEVATION AND DATE
4/3/09 ▽	SEEPAGE ENCOUNTERED DURING DRILLING
V.SO / SO	SOFT / VERY SOFT
M.ST	M. STIFF
ST / V.ST	STIFF / VERY STIFF
HD	HARD
V.LO / LO	VERY LOOSE / LOOSE
M.DE	MEDIUM DENSE
DE / V.DE	DENSE / VERY DENSE
ORG	ORGANIC
— — —	EXISTING WATER SURFACE (AT TIME OF INVESTIGATION)

SCALE IN FEET
0 20 40

REFERENCE: AEP CARDINAL DRAWING 94151038
DATUM: NAD 27/NGVD 29 OHIO SOUTH

PROJECT NUMBER:	011-11497-013	DRAWN BY:	RSH
DRAWING DATE:	7-1-09	ENGINEER:	MTR
LAST UPDATED:	7-23-09	APPROVED BY:	MGR
		SCALE:	1" = 20'

BBCM
SOLUTIONS TO BUILD ON
Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 424-1011

DATE	NO.	DESCRIPTION	APPD.
		REVISIONS	

A.E.P.
CARDINAL PLANT
BRILLIANT OHIO

BOTTOM ASH POND
INVESTIGATION
SECTIONS

DWG. NO. PLATE 3

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

AEP AMERICAN ELECTRIC POWER

AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

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

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

SAMPLING DATA

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

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

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

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

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

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

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

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

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

SOIL DESCRIPTIONS

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

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

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

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

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

LOG OF BORING NO. CD-BAP-0901
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

BBCM

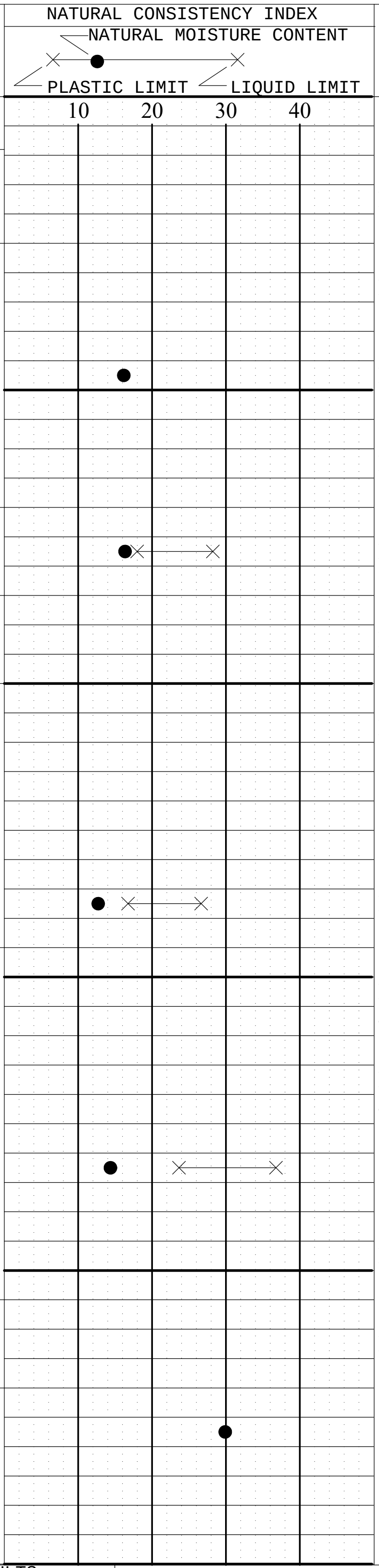
LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.7** DATE: **4/8/09 - 4/9/09**

DRILLING METHOD: **3-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

2008 NEW DEFAULT BORING LOG-W/ N60 11149701 3.GPJ BBCM.GDT 8/4/09

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
667.8	0						GRAVEL FILL - 0.9 FEET	
666.2		1		8/13/8	30	80	FILL: Hard gray and brown silty clay, some fine to coarse sand, some fine to coarse gravel (sandstone, siltstone, and shale fragments), dry.	H=4.5+
		2		6/4/7	16	67	FILL: Medium-dense to dense brown and gray fine to coarse gravel (sandstone, siltstone, and shale fragments), some fine to coarse sand, "and" silty clay, dry.	H=2.5-3.5
	5	3		12/12/30	60	100		H=2.5
661.7		4		13/22/20	60	80		H=4.5+
660.2		5		5/10/16	37	93	FILL: Hard gray clayey silt, some fine to coarse sand, some fine to coarse gravel (sandstone, siltstone and shale fragments), dry.	H=4.5+
658.7		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
643.7	25	16A		P				



WATER LEVEL: ▽ 13.8 ▼

WATER NOTE: Inside HSA

DATE: 4/9/09

SYMBOLS USED TO INDICATE TEST RESULTS

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

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

Drill Rod Energy Ratio : 0.86

Last Calibration Date : 02/17/09

Drill Rig Number : TRUCK 55

LOG OF BORING NO. CD-BAP-0901
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

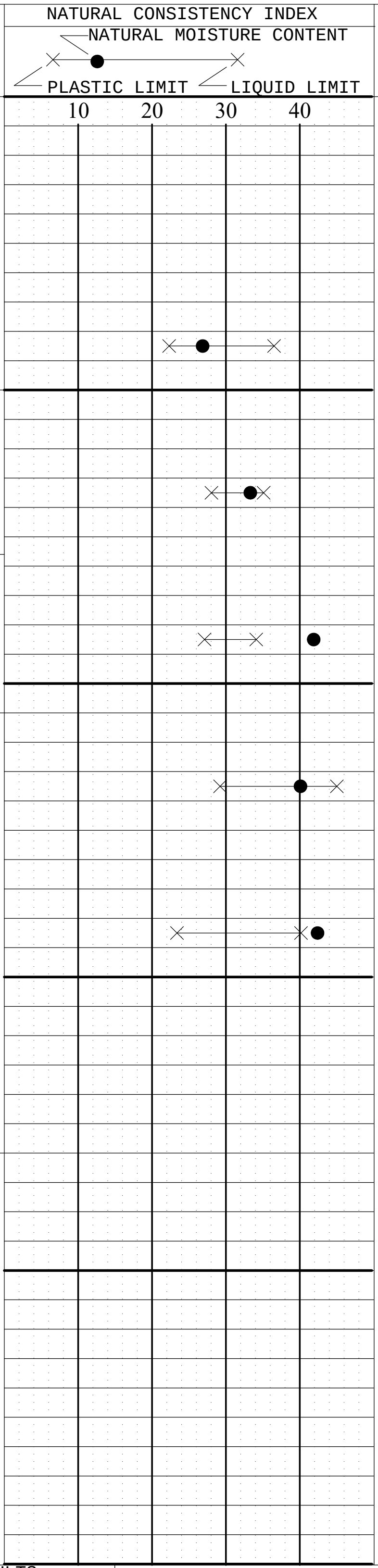
BBCM

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.7** DATE: **4/8/09 - 4/9/09**

DRILLING METHOD: **3-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
	25	16B					
		17	3/6/9	22	67	Very-stiff brown mottled with gray silty clay, trace fine sand, damp.	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

-CONTINUED-

LOG OF BORING NO. CD-BAP-0901
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

BBCM

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.7** DATE: **4/8/09 - 4/9/09**

DRILLING METHOD: **3-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

2008 NEW DEFAULT BORING LOG-W/ N60 111497013.GPJ BBCM.GDT 8/4/09

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
	50						Medium-dense to dense brown and gray fine to coarse gravel, some fine to coarse sand, trace silt, wet.	
		27	■	10/16/21	53	33		
		28	■	6/10/10	29	33		
	55							
		29	■	6/11/10	30	40		
610.7							Medium-dense brown fine to medium sand, trace coarse sand, trace fine gravel, trace silt, wet.	
		30	■	7/10/10	29	40		
608.7	60							
							- Seepage encountered at 14.5'. - Borehole grouted upon completion. - Boring location and elevation surveyed by AEP.	
	65							
	70							
	75							

NATURAL CONSISTENCY INDEX

NATURAL MOISTURE CONTENT

PLASTIC LIMIT — LIQUID LIMIT

10 20 30 40

WATER LEVEL: ▽ 13.8 ▼

WATER NOTE: Inside HSA

DATE: 4/9/09

SYMBOLS USED TO INDICATE TEST RESULTS

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

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

Drill Rod Energy Ratio : 0.86

Last Calibration Date : 02/17/09

Drill Rig Number : TRUCK 55

LOG OF BORING NO. CD-PZ-BAP-0902
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

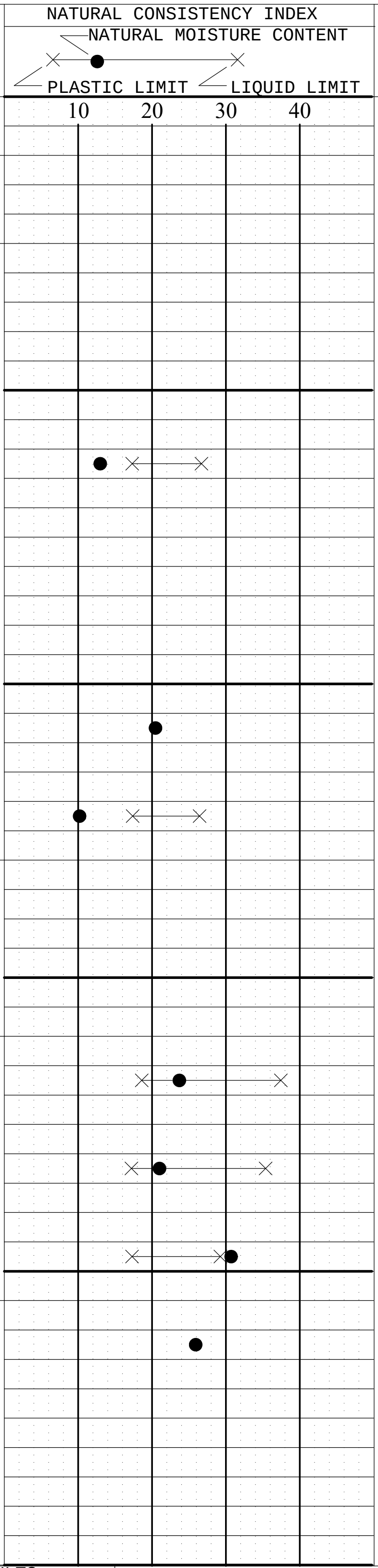
BBCM

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	N60	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
	0						GRAVEL FILL - 1.0 FEET	
667.0								
		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
665.5		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+
		8		3/5/7	17	73		H=3.0-3.75 G
655.0								
		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+
	15	10		2/2/3	7	40		H=2.5-2.75
652.0								
		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
		13		1/SH/1	1	20		H=0.0-0.25 G
647.5	20							
		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
		16		SH/SH/1	1	53		
643.0	25							



WATER LEVEL:	▽ 10.7	▼ 8.4
WATER NOTE:	Inside HSA	Inside Well
DATE:	4/8/09	4/10/09

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

Drill Rod Energy Ratio : 0.86
Last Calibration Date : 02/17/09
Drill Rig Number : TRUCK 55

LOG OF BORING NO. CD-PZ-BAP-0902
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

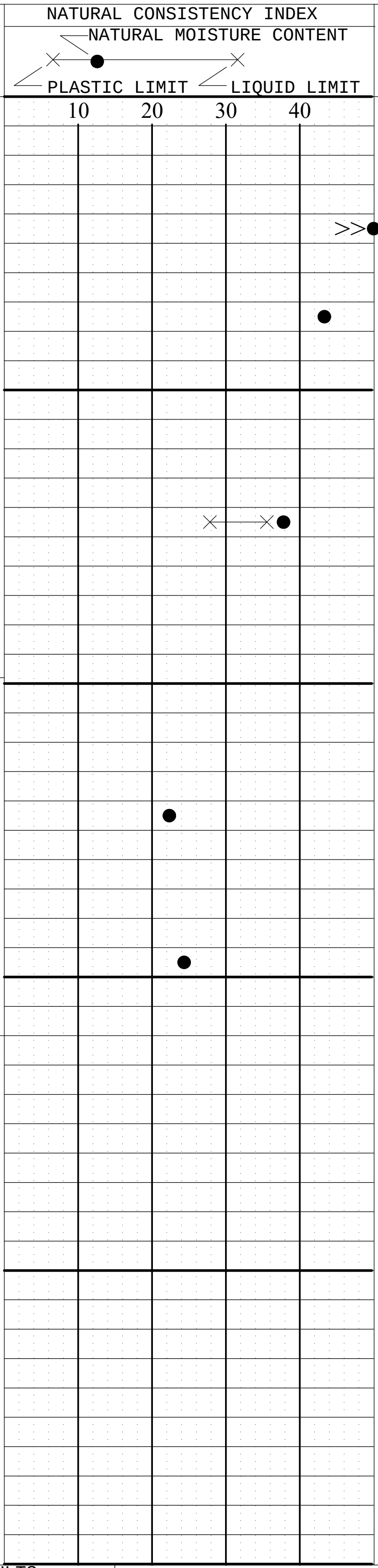
BBCM

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.0** DATE: **4/8/09**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.5'**

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

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
	25	17	1/1/2	4	80	Very-soft to soft gray mottled with dark-gray organic clayey silt, trace fine sand, few lenses of organic silt near bottom of stratum, wet.	H=0.3
		18	SH/1/2	4	80		LOI=10.4% >> 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
		21A	2/3/3	9			
633.1	35	21B				Very-loose to loose brown and gray fine to medium sand, trace coarse sand, trace to little silt interbedded with organic clayey silt, wet.	
		22	2/2/3	7	73		G
	40	23	SH/1/2	4	80		G
627.0						Medium-dense brown fine to medium sand, trace coarse sand, trace silt, trace to some fine gravel, trace coarse gravel, trace silt, wet.	
		24	2/3/10	19	100		G
		25A	5/7/11	26			
	45	25B					
		26	6/10/13	33	67		
		27	10/15/13	40	33		
	50						



WATER LEVEL: ▽ 10.7 ▼ 8.4
WATER NOTE: Inside HSA | Inside Well
DATE: 4/8/09 | 4/10/09

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

Drill Rod Energy Ratio : 0.86
Last Calibration Date : 02/17/09
Drill Rig Number : TRUCK 55

2008 NEW DEFAULT BORING LOG-W/ N60 111497013.GPJ BBCM.GDT 8/4/09

LOG OF BORING NO. CD-PZ-BAP-0902
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

BBCM

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.0** DATE: **4/8/09**
DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.5'**
SAMPLER(S): **2" O.D. Split-barrel Sampler**

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE EFFORT	N60	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT / PLASTIC LIMIT / LIQUID LIMIT 10 20 30 40	TEST RESULTS
	50					Medium-dense brown fine to medium sand, trace coarse sand, trace silt, trace to some fine gravel, trace coarse gravel, trace silt, wet.		
		28	1/8/10	26	80			
	55	29	1/2/9	16	67			
		30	3/3/7	14	67			
		31	4/3/7	14				
607.9	60							
	65							
	70							
	75							

- 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.

	▽	▼
WATER LEVEL:	10.7	8.4
WATER NOTE:	Inside HSA	Inside Well
DATE:	4/8/09	4/10/09

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

Drill Rod Energy Ratio : 0.86
Last Calibration Date : 02/17/09
Drill Rig Number : TRUCK 55

LOG OF BORING NO. CD-BAP-0903
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

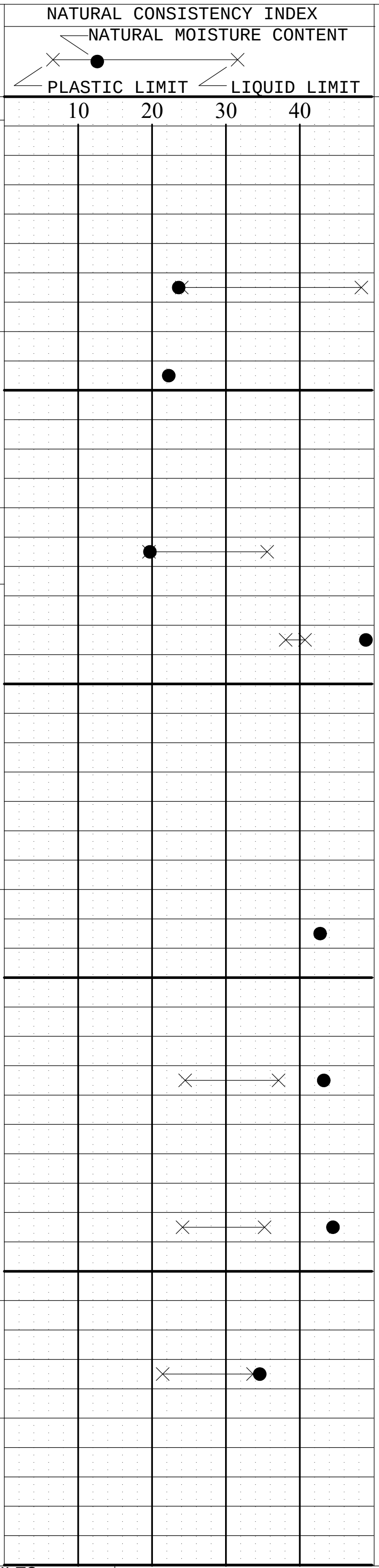
LOCATION: **See Plate 2 of Appendix A** ELEVATION: **650.1** DATE: **4/8/09**

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**

2008 NEW DEFAULT BORING LOG-W/ N60 11497013.GPJ BBCM.GDT 8/4/09

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N60	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
649.7	0						TOPSOIL - 0.4 FEET	
							FILL: Very-stiff to hard brown mottled with gray and dark-brown silty clay, trace fine to medium sand, few roots, damp.	
		1		2/5/6	15	67		H=3.6-3.8
		2		4/6/6	16	53		H=3.3-4.5 G
646.1							FILL: Very-stiff to hard brown mottled with gray silty clay, trace fine sand, damp.	
	5	3		2/5/6	15	80		H=2.6-4.1
		4		8/11/13	33	80		H=4.5
643.1							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.	
		5		6/6/6	16	67		H=3.5-4.5 G
641.8							Medium-stiff dark-gray organic clayey silt, trace fine sand, many lenses of fine sand, few decayed roots, damp to moist.	
		6		5/6/6	16	67		H=0.6 G
	10							
			P					
636.6							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.	
		7		SH/1/1	3	67		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
	20							
629.6							Very-soft gray silty clay interbedded with silt, trace fine sand, few seams of fine sand, few roots, moist to wet.	
		10		1/2/4	8	60		H=0.2 G
627.6							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.	
		11		2/4/7	15	47		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

Page 2 of 2

LOG OF BORING NO. CD-BAP-0903
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

BBCM

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **650.1** DATE: **4/8/09**

DRILLING METHOD: **3-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **30.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT / PLASTIC LIMIT / LIQUID LIMIT (10 20 30 40)	TEST RESULTS
624.6	25						Medium-dense brown and gray fine to coarse gravel, some fine to coarse sand, trace silt, wet.		
		12	■	6/10/12	30	33			
		13	■	7/7/7	19	47			
620.1	30						- Seepage encountered at 13.5'. - 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

LOG OF BORING NO. CD-PZ-BAP-0904
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

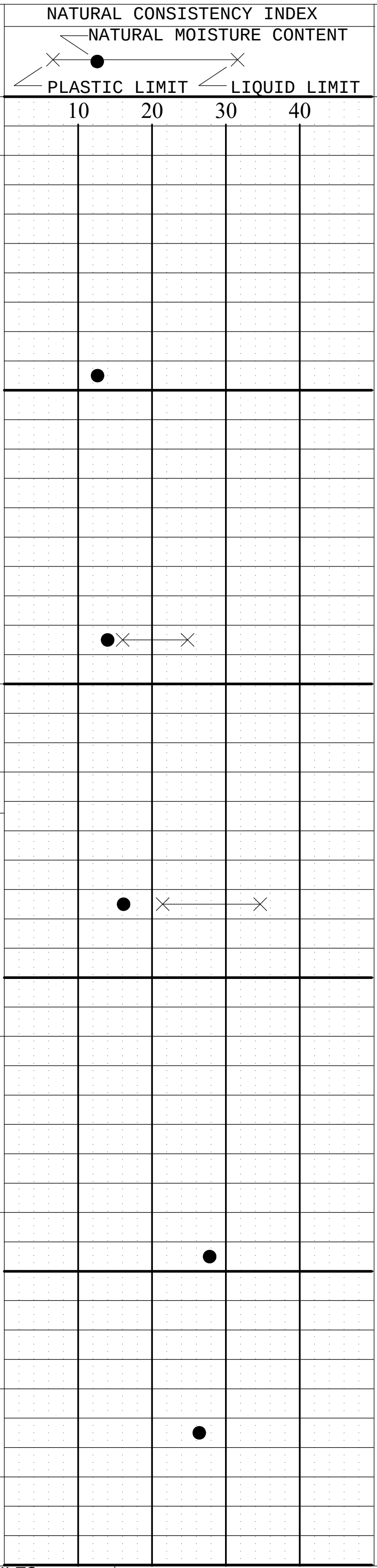
BBCM

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	N60	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		8A	13/14/17	44		FILL: Dense brown and gray fine to coarse	
655.9		8B				gravel (sandstone fragments), cobbles, "and" fine to medium sand, trace coarse sand, trace silt, dry.	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						



	▽	▼
WATER LEVEL:	16.0	15.9
WATER NOTE:	Inside HSA	Inside Well
DATE:	4/7/09	4/10/09

SYMBOLS USED TO INDICATE TEST RESULTS

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

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

Drill Rod Energy Ratio : 0.86
Last Calibration Date : 02/17/09
Drill Rig Number : TRUCK 55

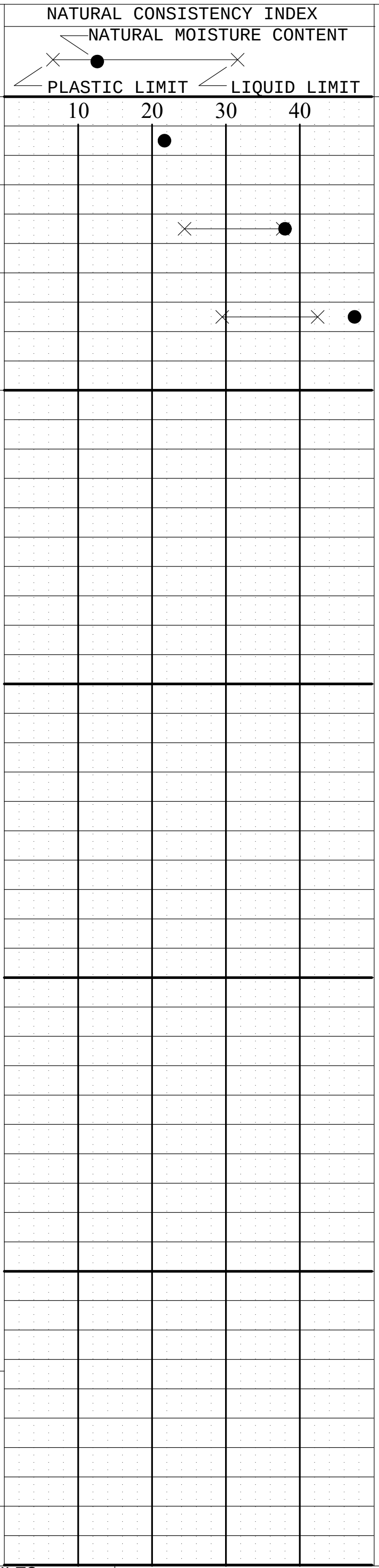
LOG OF BORING NO. CD-PZ-BAP-0904
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.1** DATE: **4/7/09**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE EFFORT	N60	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
641.6	25	17	SR/SH/3	4	53	Very-loose gray silt, little clay, little fine sand, wet.	G
640.1		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 G
638.1		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
	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		
621.4	45	25A 25B	4/11/17	40			
619.1						Medium-dense brown and gray fine to coarse gravel, "and" fine to coarse sand, trace silt, wet.	
	50	26	12/29/50-5"R		93	See description on the following page.	



WATER LEVEL:	▽ 16.0	▼ 15.9
WATER NOTE:	Inside HSA	Inside Well
DATE:	4/7/09	4/10/09

SYMBOLS USED TO INDICATE TEST RESULTS

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

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

Drill Rod Energy Ratio : 0.86
Last Calibration Date : 02/17/09
Drill Rig Number : TRUCK 55

LOG OF BORING NO. CD-PZ-BAP-0904
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

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	N60	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT / PLASTIC LIMIT / LIQUID LIMIT (10 20 30 40)	TEST RESULTS
	50						Very-dense brown and gray fine to coarse sand, some fine to coarse sand, trace silt, zones of fine to coarse gravel, wet.		
		27	■	8/40/50-4"R		87			
		28	■	10/50-5"R		33			
	55								
		29	■	9/28/50-3"R		67			
		30	■	16/50-5"R		67			
608.1	60								
	65								
	70								
	75								

- 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.

	▽	▼
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

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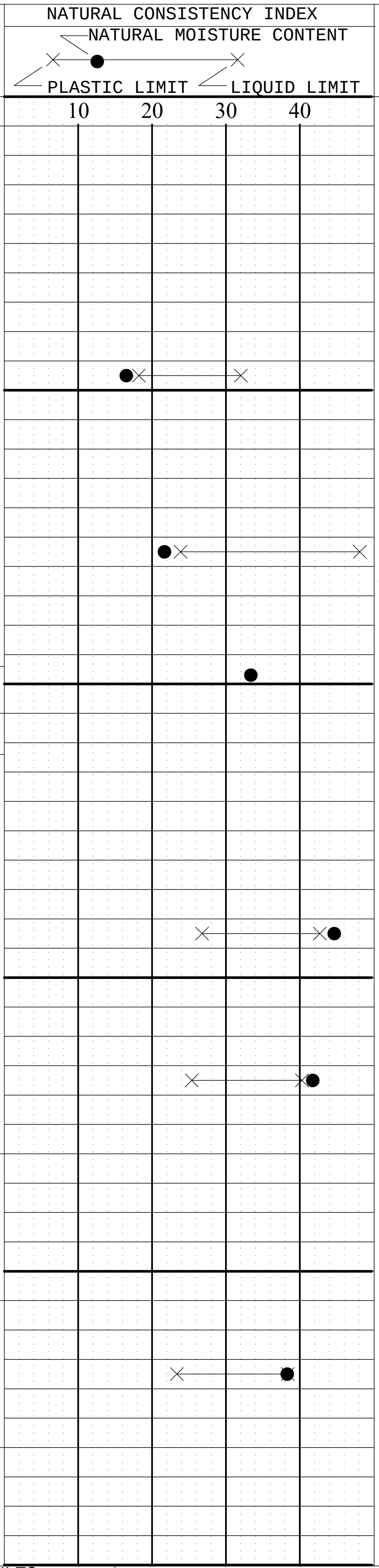
LOG OF BORING NO. CD-PZ-BAP-0905
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **650.1** DATE: **4/6/09**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **30.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

2008 NEW DEFAULT BORING LOG-W/ N60 11497013.GPJ BBCM.GDT 8/4/09



ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N60	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
649.6	0						ROOTMAT - 0.5 FEET	
		1		3/3/5	11	67	FILL: Very-stiff to hard brown mottled with gray silty clay, trace fine sand, few lenses of dark-gray silt and fine sand near bottom of stratum, moist.	H=4.0-4.5
		2		3/6/8	19	100		H=4.0-4.5
	5	3		6/7/10	23	100		H=3.0-4.5 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					FILL: Stiff to very-stiff brown mottled with gray silty clay interbedded with dark-gray organic silt, little fine to coarse sand, trace fine gravel, moist.	H=1.5-3.0 G
639.6		7A		2/2/2	5			H=3.5-3.75
638.9		7B					FILL: Very-stiff brown mottled with gray silty clay, trace fine to coarse sand, trace fine gravel, moist.	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

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								
	35								
	40								
	45								
	50								

- 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.

	▽	▼
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 111497013.GPJ BBCM.GDT 8/4/09

LOG OF BORING NO. CD-BAP-0906
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

BBCM

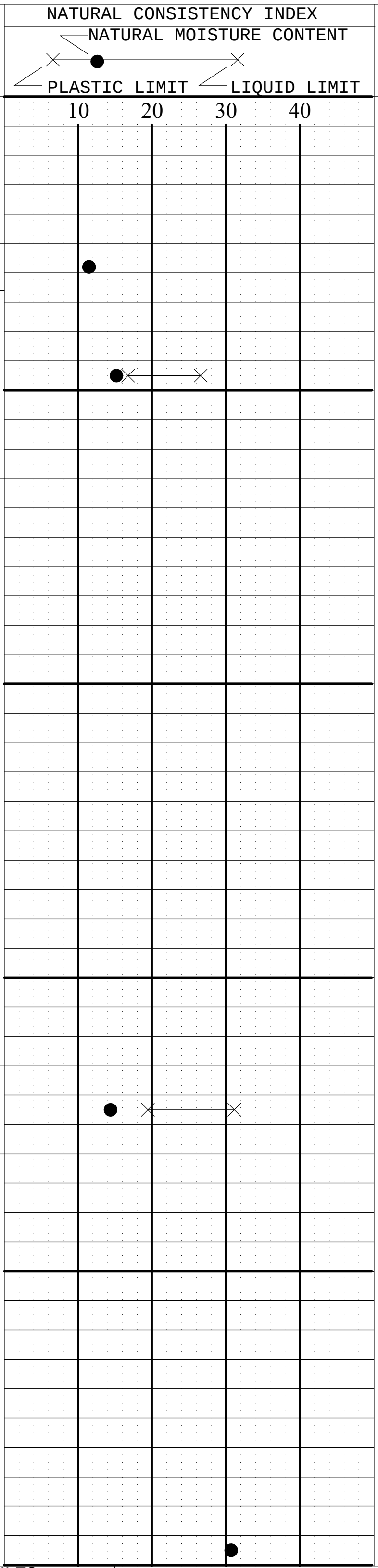
LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.6** DATE: **4/9/09 - 4/10/09**

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**

2008 NEW DEFAULT BORING LOG-W/ N60 111497013.GPJ BBCM.GDT 8/4/09

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE EFFORT	N60	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						FILL: Medium-dense dark-gray fine to medium sand, trace coarse sand, little fine gravel, some clayey silt, dry to damp.	
		2A	16/8/8	23			
665.3		2B				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=2.5-3.5
	5	3	6/4/5	13	33		H=2.3
662.1		4	6/8/9	24	40		H=2.3-3.3
						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.	
		5	6/7/7	20	67		
		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						FILL: Very-stiff brown silty clay, some fine to coarse sand, some fine to coarse gravel, damp to moist.	
		11	7/7/6	19	53		H=2.2 G
650.6						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'.	
		12A	P				
		12B					
	20						
		13	1/1/3	6			80
			SR/SR/SR	0	0		
		14	SH/SH/1	1	67		
		15	1/1/1	3	100		
	25						



WATER LEVEL: ▽ **10.3** ▼

WATER NOTE: **Inside HSA**

DATE: **4/10/09**

SYMBOLS USED TO INDICATE TEST RESULTS

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

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

Drill Rod Energy Ratio : 0.86
Last Calibration Date : 02/17/09
Drill Rig Number : TRUCK 55

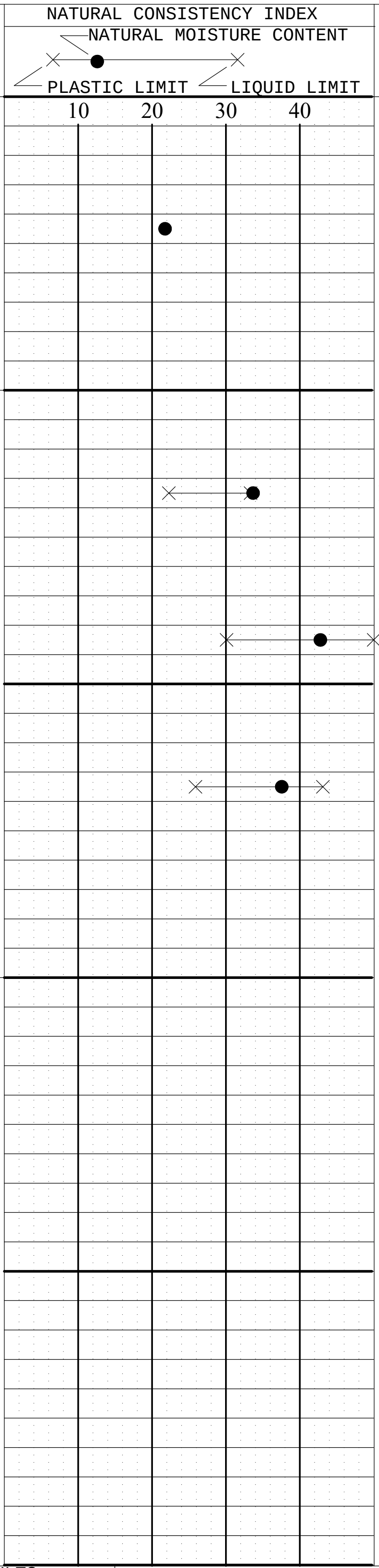
LOG OF BORING NO. CD-BAP-0906
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.6** DATE: **4/9/09 - 4/10/09**

DRILLING METHOD: **3-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N60	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
	25						Very-loose to loose gray silt, trace to some fine sand, trace to little fine to medium sand, trace fine gravel, few seams of gray fine to medium sand, damp becoming wet at 20'.	G
		16		3/4/5	13	67		G
		17		3/1/2	4	80		G
		18		2/2/2	6	67		
638.6	30						Very-soft to medium-stiff gray organic clayey silt, trace fine to coarse sand, trace fine gravel, contains seams of silty clay, silt and fine to medium sand, wet.	
		19		1/1/3	6	67		H=0.9 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							



WATER LEVEL: ▽ 10.3 ▼
WATER NOTE: Inside HSA
DATE: 4/10/09

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

Drill Rod Energy Ratio : 0.86
Last Calibration Date : 02/17/09
Drill Rig Number : TRUCK 55

2008 NEW DEFAULT BORING LOG-W/ N60 111497013.GPJ BBCM.GDT 8/4/09

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 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

LOG OF BORING NO. CD-BAP-0907
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

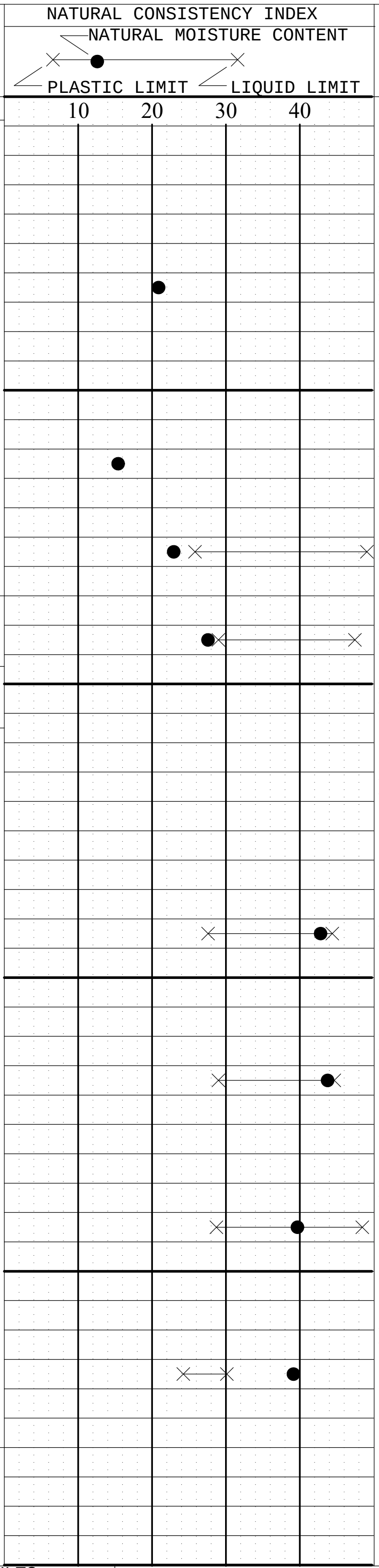
LOCATION: **See Plate 2 of Appendix A** ELEVATION: **650.3** DATE: **4/8/09**

DRILLING METHOD: **3-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **30.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

2008 NEW DEFAULT BORING LOG-W/ N60 111497013.GPJ BBCM.GDT 8/4/09

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE EFFORT	N60	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
649.9	0					TOPSOIL - 0.4 FEET	
		1	4/5/5	14	47	FILL: Very-stiff to hard brown mottled with gray silty clay, trace to little fine to coarse sand, trace fine gravel, few roots near top of stratum, contains fine to medium sand lenses and seams near middle of stratum, damp.	H=2.2-2.4
		2	4/5/10	21	73		H=3.9-4.2
	5	3	4/6/7	18	80		H=4.5
		4	9/11/15	36	100		H=4.5
		5	5/7/8	21	67		H=4.1-4.5
641.8		6A	P			FILL: Hard brown, gray and dark-gray silty clay intermixed with organic silt, little fine to coarse sand, trace fine gravel, damp.	H=4.5 G
640.6	10	6B				Stiff gray organic silt, little fine to medium sand, few lenses of fine sand, damp to moist.	H=2.2
639.6		7	SH/SH/SH	0	67	Very-soft to soft gray organic clayey silt, little fine to medium sand, trace fine gravel, damp to moist.	H=0.0 G
	15	8	SH/SH/SH	0	73		H=0.0 G
	▽	9	SH/SH/SH	0	67		H=0.0-0.25 G
	20	10	SH/SH/SH	0	73		H=0.0-0.25 G
		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

JOB: 011-11497-013 -CONTINUED-

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

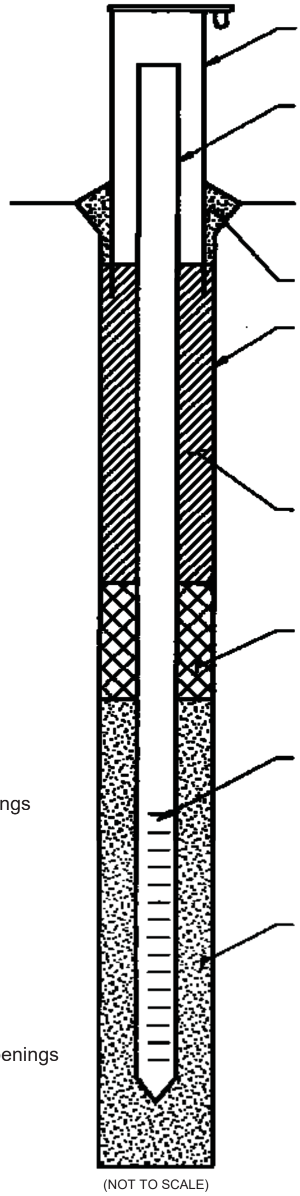
G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
(G, Q, T, C: See Separate Curves)

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

Drill Rod Energy Ratio : 0.82
Last Calibration Date : 11/19/07
Drill Rig Number : D50

2008 NEW DEFAULT BORING LOG-W/ N60 111497013.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



4 - Inch Diameter Protective Steel Casing

2 - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)

7 " **0.0** to **60.5**

" to

" to

Grout: **N/A**

Bentonite Seal: **Hole Plug**

10 - Slot Screen

Filter Pack: **No. 4 Quartz Sand8.2' - 24.9'**

Natural Sand 24.9' - 60.5'

Static Water Level:	**657.30**	**659.60**			
Date:	**4/8/09**	**4/10/09**			

Well Development:

Removed approximately 10 well volumes during development and well remained silty. Additional well development performed and well remained slightly silty at completion of bailing. Set steel casing in 3'x3' concrete pad. Placed steel bollards around concrete pad.

WELL COMPLETION DIAGRAM

Project Name:
Cardinal Plant Ash Pond Investigation

Project Location:
Brilliant, Ohio

Project Number:
011-11497-013

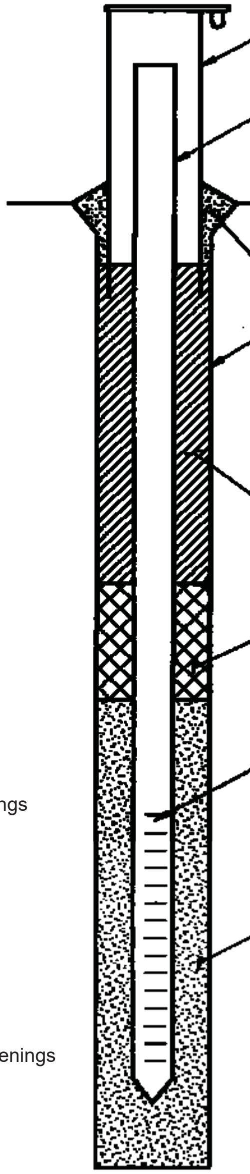
Boring Number:
CD-PZ-BAP-0902

Date Well Installed:
4/8/2009

PLATE 23

BBCM
SOLUTIONS TO BUILD ON

Elevation (Feet above MSL)	Depth Below Ground Surface (Feet)	
		Top of Cover
		Top of PVC
668.1	**0.0**	Ground Surface
N/A	**N/A**	Top of Grout
665.1	**3.0**	Top of Bentonite
660.1	**8.0**	Top of Filter Pack
N/A	**N/A**	Top of Aquifer
658.6	**9.5**	Top of Screen Openings
608.6	**59.5**	Bottom of Screen Openings
608.6	**59.5**	Bottom of Well
N/A	**N/A**	Bottom of Aquifer
608.1	**60.0**	Bottom of Boring


(NOT TO SCALE)

4 - Inch Diameter Protective Steel Casing

2 - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)
7 " **0.0** to **60.0**
" to
" to

Grout: **N/A**

Bentonite Seal: **Hole Plug**

10 - Slot Screen

Filter Pack: **No. 4 Quartz Sand 8.0' - 32.5'**
Natural Sand 32.5' - 60.0'

Static Water Level:	**652.20**				
Date:	**4/10/09**				

Well Development:
Removed approximately 10 well volumes during development and well remained silty. Additional well development performed and well remained slightly silty at completion of bailing. Set steel casing in 3'x3' concrete pad. Placed steel bollards around concrete pad.

WELL COMPLETION DIAGRAM

Project Name:
Cardinal Plant Ash Pond Investigation

Project Location:
Brilliant, Ohio

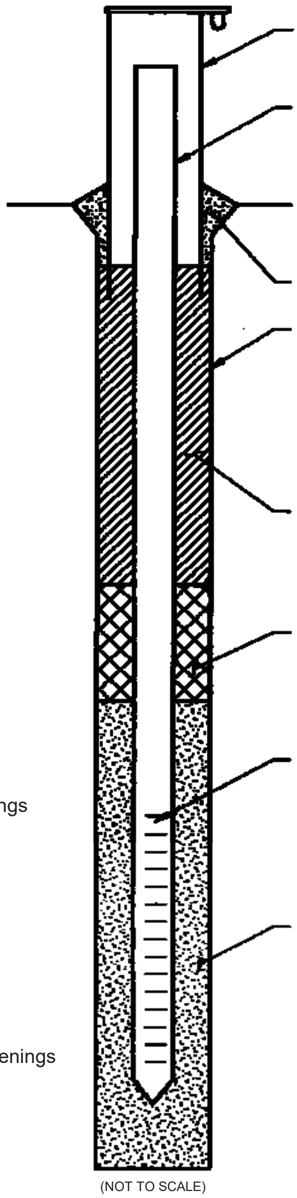
Project Number:
011-11497-013

Boring Number:
CD-PZ-BAP-0904

Date Well Installed:
4/7/2009

PLATE 24

Elevation (Feet above MSL)	Depth Below Ground Surface (Feet)	
		Top of Cover
		Top of PVC
650.1	0.0	Ground Surface
N/A	N/A	Top of Grout
647.6	2.5	Top of Bentonite
642.1	8.0	Top of Filter Pack
N/A	N/A	Top of Aquifer
641.6	8.5	Top of Screen Openings
621.6	28.5	Bottom of Screen Openings
621.6	28.5	Bottom of Well
N/A	N/A	Bottom of Aquifer
620.1	30.0	Bottom of Boring



(NOT TO SCALE)

4 - Inch Diameter Protective Steel Casing

2 - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)
7 " **0.0** to **30.0**
" to
" to

Grout: **N/A**

Bentonite Seal: **Hole Plug**

10 - Slot Screen

Filter Pack: **No. 4 Quartz Sand 8.0' - 32.5'**
Natural Sand 18.0' - 30.0'

Static Water Level:	**642.10**	**644.70**			
Date:	**4/7/09**	**4/10/09**			

Well Development:
Removed approximately 10 well volumes during development. Well remained silty at completion of bailing. Set steel casing in 3'x3' concrete pad. Placed steel bollards around concrete pad.

WELL COMPLETION DIAGRAM

Project Name:
Cardinal Plant Ash Pond Investigation

Project Location:
Brilliant, Ohio

Project Number:
011-11497-013

Boring Number:
CD-PZ-BAP-0905

Date Well Installed:
4/6/2009

PLATE 25

Appendix II – 2009 & 2015 Laboratory Testing Results

SUMMARY OF LABORATORY TEST RESULTS

BORING	G'int Id.	MC	LL	PL	PI	GRADATION			COMPACTION		TRIAXIAL			DIRECT SHEAR			UNCONFIN COMPRESS	CONSOLID.	SPECIFIC GRAVITY	UNIT DRY WEIGHT	REMOLDED	PERMEABILITY				RELATIVE DENSITY	LOI	ROCK CORE	SHELBY TUBE	Slake Index
						sieve	Hydrometer short	Hydrometer long	standard	modified	uncons. undrain	consolid undrain w/pores	drained	drained	undrain	residual						cohesive	non/cohes	rigid wall	flexible wall					
		%	%	%	%	* SEE INDIVIDUAL TEST CURVES														PCF						%	%			
CD-BAP-1501	4.75					*																								
CD-BAP-1501	9.25					*																								
CD-BAP-1501	12.25	13.9	22	14	8																									
CD-BAP-1502	6.25	9.1	27	16	11	*		*																						
CD-BAP-1502	11.25	8.9	21	14	7																									
CD-BAP-1502	17.75	12.7	26	16	10	*		*																						
CD-BAP-1502	20.00																												*	
CD-BAP-1502	24.25	22.4																												
CD-BAP-1502	32.50																												*	
CD-BAP-1502	40.75					*																								
CD-BAP-1504	6.25	9.4																												
CD-BAP-1504	10.75					*																								
CD-BAP-1504	12.25	11.6				*																								
CD-BAP-1504	17.25	18.2																												
CD-BAP-1505	9.25	11.6																												
CD-BAP-1505	10.40	19.0																												
CD-BAP-1505	13.75	10.4																												
CD-BAP-1505	15.25	18.3				*																								

SUM REG

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

SUMMARY OF LABORATORY TEST RESULTS

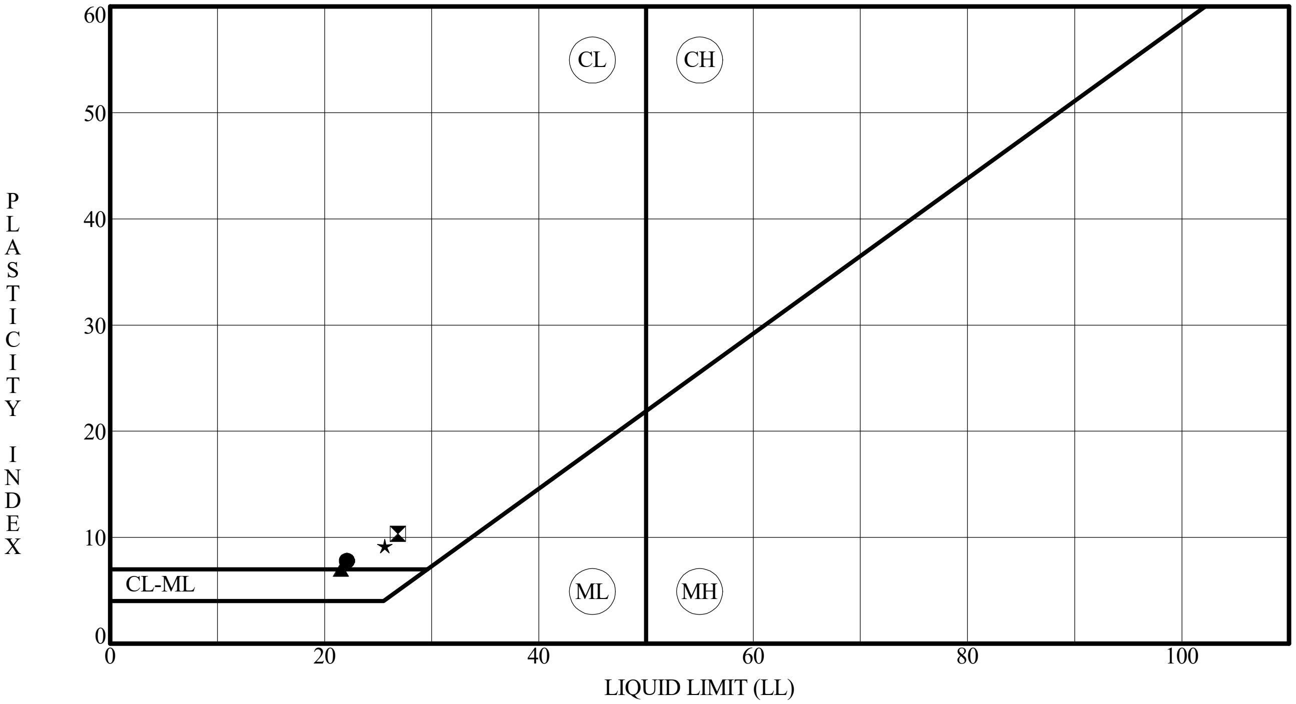
BORING	G'int Id.	MC	LL	PL	PI	GRADATION			COMPACTION		TRIAXIAL			DIRECT SHEAR			UNCONFIN COMPRESS	CONSOLID.	SPECIFIC GRAVITY	UNIT DRY WEIGHT	REMOLDED	PERMEABILITY				RELATIVE DENSITY	LOI	ROCK CORE	SHELBY TUBE	Slake Index
							Hydrometer																							
						sieve	short	long	standard	modified	uncons. undrain	consolid undrain w/pores	drained	drained	undrain	residual						cohesive	non/cohes	rigid wall	flexible wall					
		%	%	%	%	* SEE INDIVIDUAL TEST CURVES														PCF						%	%			
MW-BAP-4	6.25	15.0	25	16	9	*		*																						
MW-BAP-4	9.25	24.3	43	21	22																									
MW-BAP-4	14.50																												*	
MW-BAP-4	32.25					*																								
MW-BAP-4	39.25					*																								
MW-BAP-5	4.75	12.8	30	17	13	*		*																						
MW-BAP-5	9.25	10.3	30	18	12																									
MW-BAP-5	11.00																												*	
MW-BAP-5	21.75	39.9	48	26	22	*		*																			5.9			
MW-BAP-5	27.00																												*	
MW-BAP-5	29.00																												*	
MW-BAP-5	41.75	29.7																												
MW-BAP-5	51.75					*																								
MW-BAP-5	59.25					*																								

S&ME

TESTING SUMMARY - STANDARD

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A DATE 12/30/15

ATTERBERG LIMITS' RESULTS - ASTM D4318

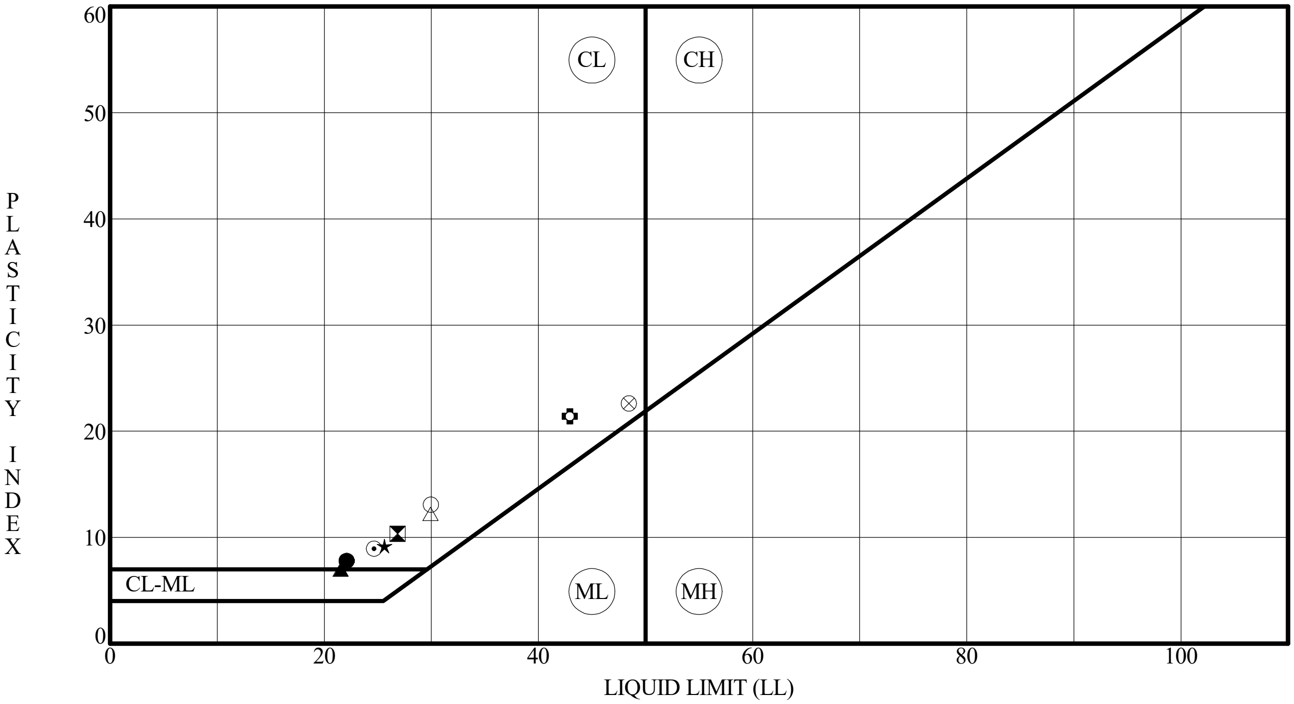


Specimen Id.	Depth	MC	LL	PL	PI	Fines	ASTM Classification
● CD-BAP-1501	12.25	14	22	14	8		
⧗ CD-BAP-1502	6.25	9	27	16	11	28.6	CLAYEY SAND with GRAVEL SC
▲ CD-BAP-1502	11.25	9	21	14	7		
★ CD-BAP-1502	17.75	13	26	16	10	27.9	CLAYEY SAND with GRAVEL SC

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A **DATE** 12/30/15

ALPI-REG

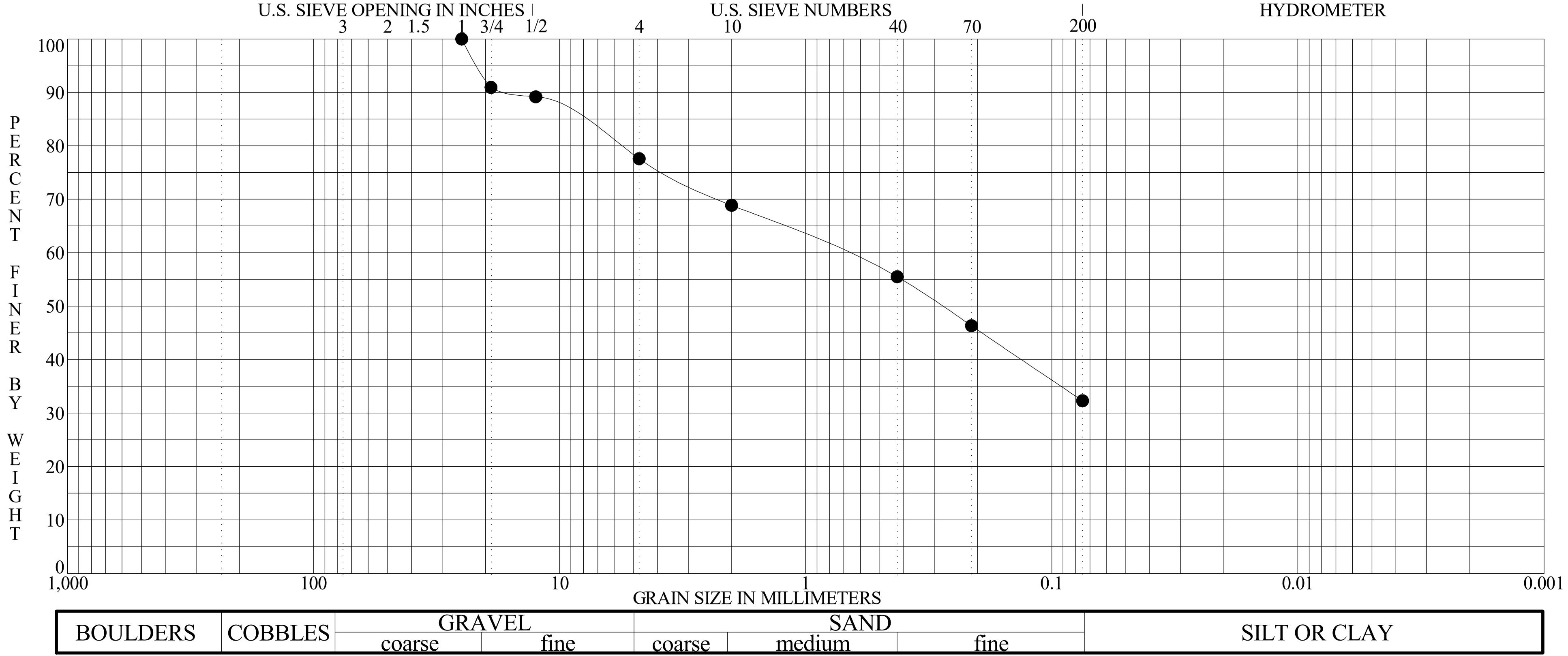
ATTERBERG LIMITS' RESULTS - ASTM D4318



ALPI-REG

Specimen Id.	Depth	MC	LL	PL	PI	Fines	ASTM Classification
● CD-BAP-1501	12.25	14	22	14	8		
⧗ CD-BAP-1502	6.25	9	27	16	11	28.6	CLAYEY SAND with GRAVEL SC
▲ CD-BAP-1502	11.25	9	21	14	7		
★ CD-BAP-1502	17.75	13	26	16	10	27.9	CLAYEY SAND with GRAVEL SC
⊙ MW-BAP-4	6.25	15	25	16	9	41.2	CLAYEY SAND SC
✣ MW-BAP-4	9.25	24	43	21	22		
○ MW-BAP-5	4.75	13	30	17	13	38.8	CLAYEY SAND with GRAVEL SC
△ MW-BAP-5	9.25	10	30	18	12		
⊗ MW-BAP-5	21.75	40	48	26	22	94.9	LEAN CLAY CL

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A **DATE** 12/30/15



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	

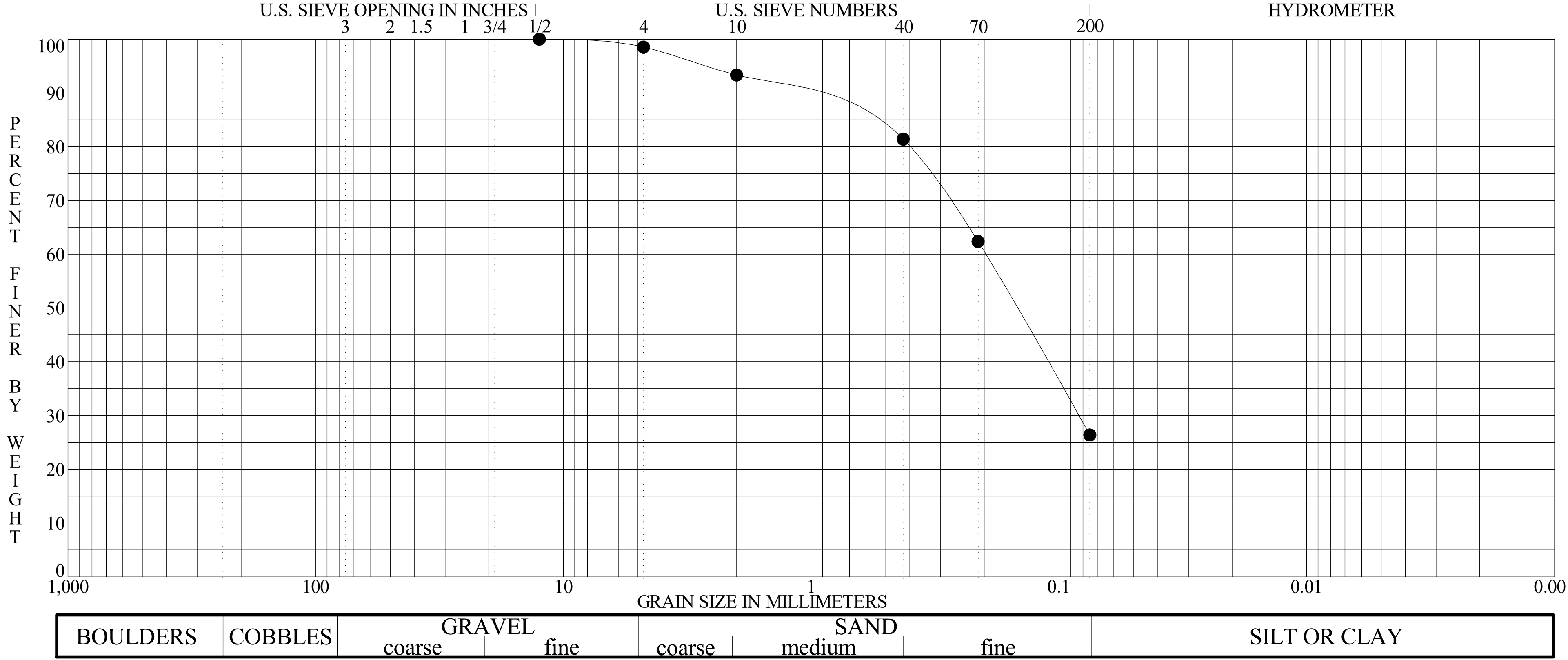
ASTM D422

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.

S&ME



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.**						

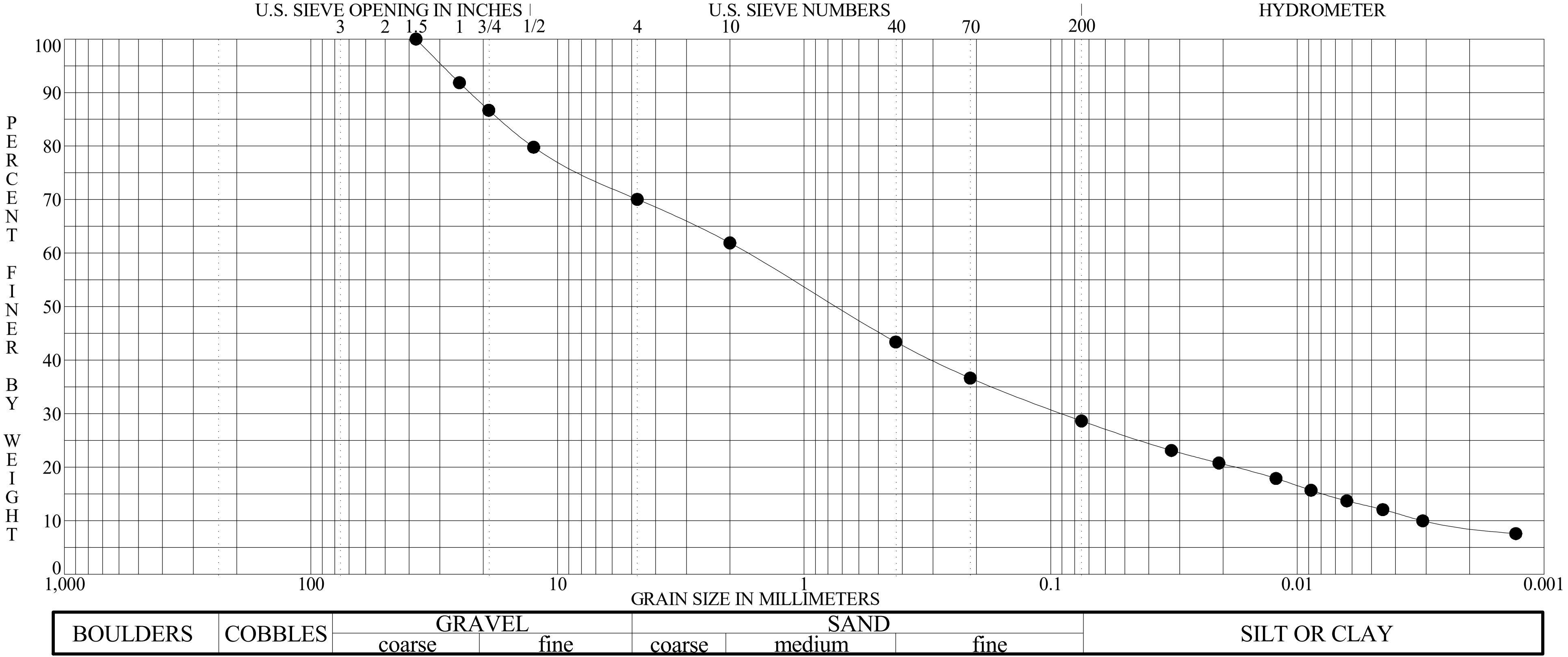
Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-BAP-1501 S-6 8.5' to 9.7'**	**12.5000**	**2.6291**	**0.1978**	**0.1482**		**1.5**	**72.1**	**26.4**	

ASTM D422

GRADATION CURVE

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A **DATE** 12/30/15

PLATE 6



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.** **CLAYEY SAND with GRAVEL SC**	**9**	**27**	**16**	**11**	**1.508**	**547.388**

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● CD-BAP-1502 S-4 5.5' to 6.7'	**37.5000**	**29.2411**	**1.7048**	**0.7385**	**0.0031**	**29.9**	**41.4**	**16.1**	**12.6**

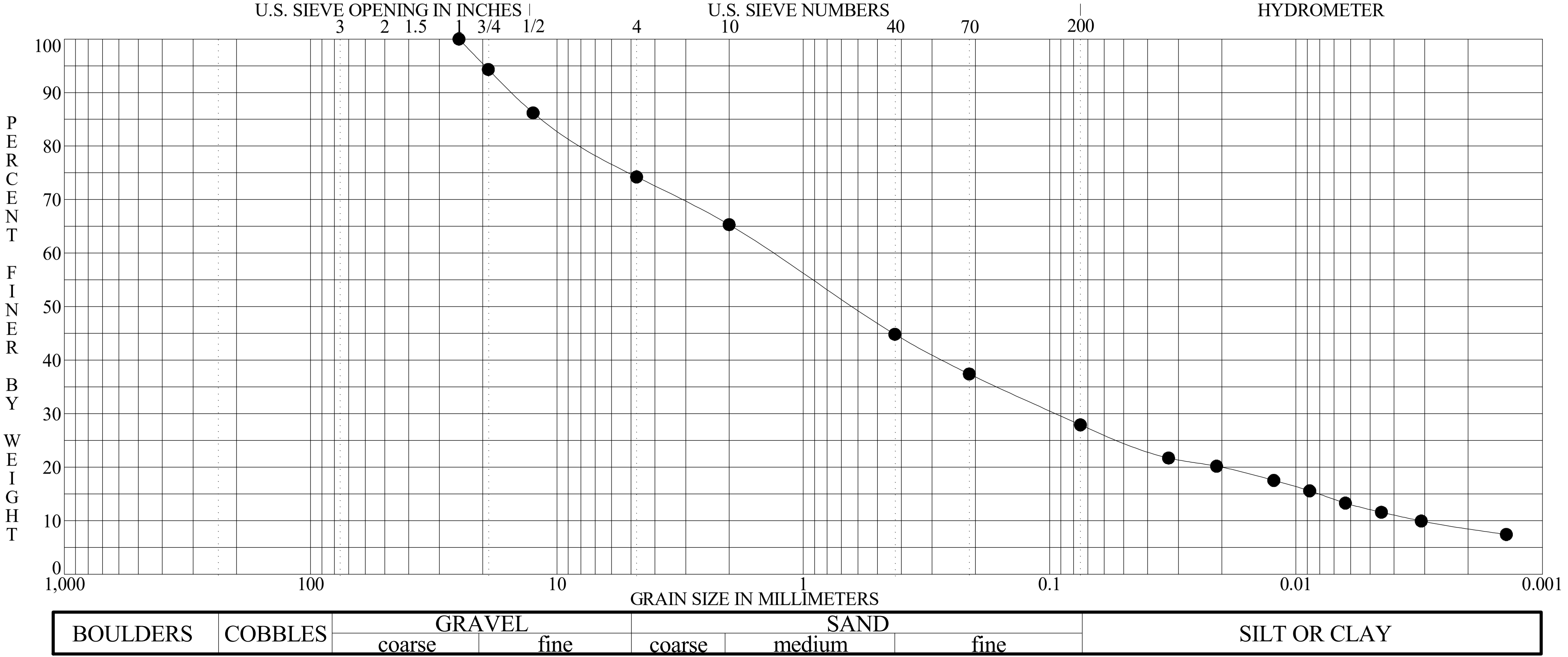
ASTM D422

GRADATION CURVE

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A DATE 12/30/15

GRN-REG W/ASTM DESC.

PLATE 7



	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.** **CLAYEY SAND with GRAVEL SC**	13	26	16	10	2.113	425.827

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	CD-BAP-1502 S-9 17.0' to 18.3	25.0000	19.6384	1.3380	0.6282	0.0031	25.8	46.3	15.8	12.1

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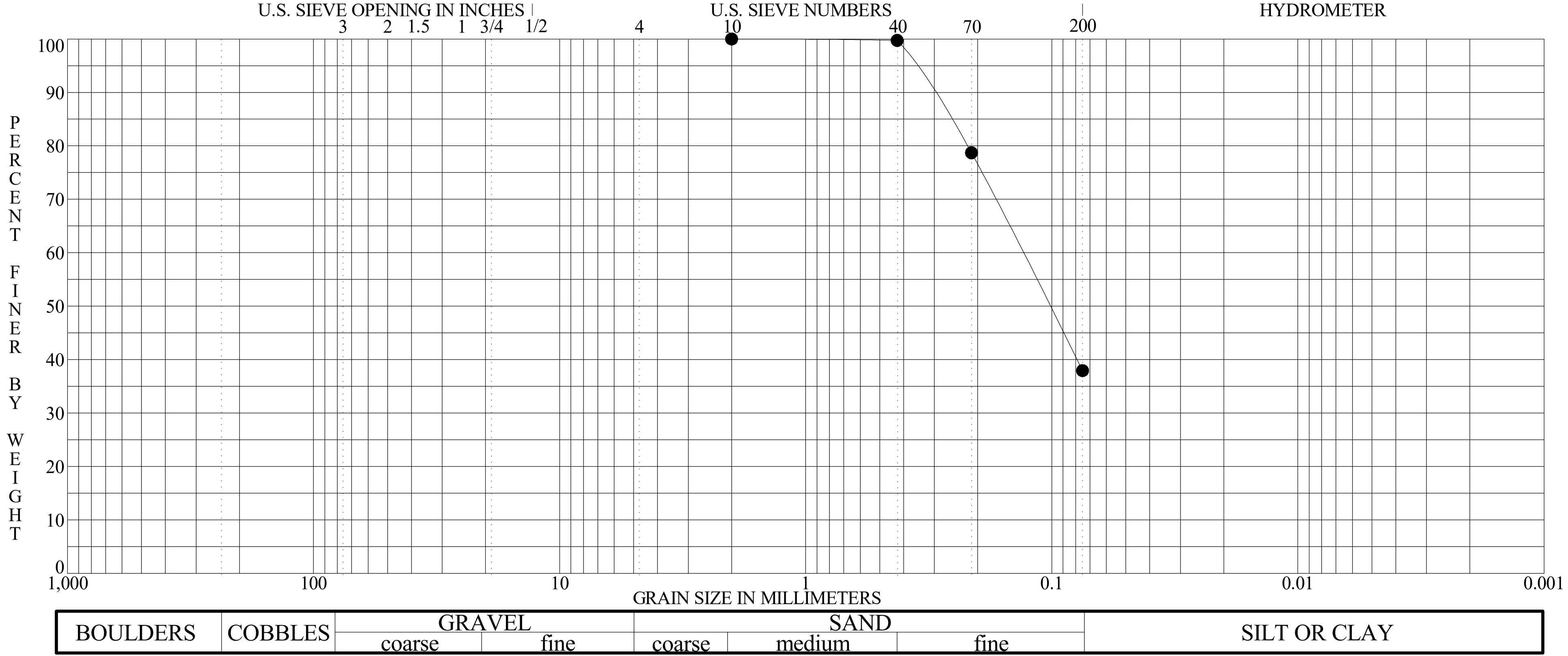
GRADATION CURVE

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.

PLATE 8



	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**	

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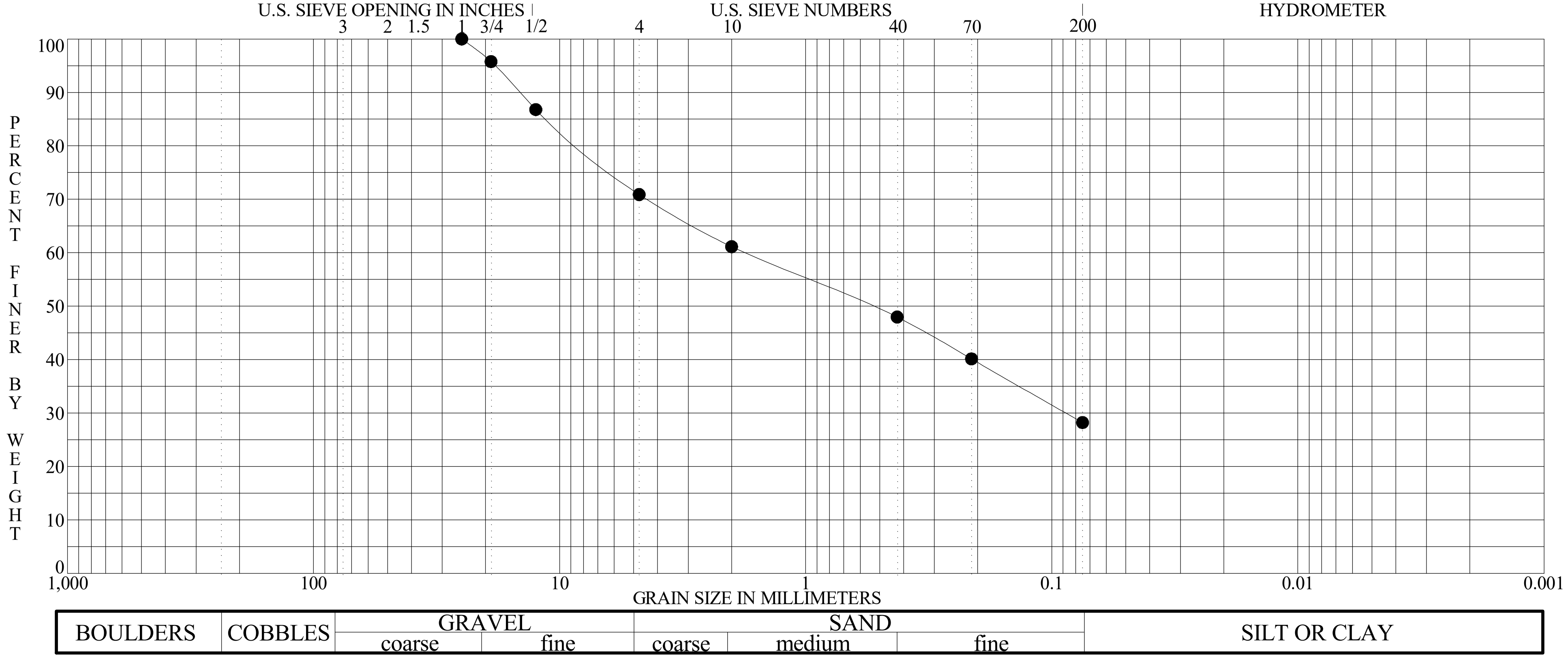
GRADATION CURVE

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A **DATE** 12/30/15

GRN-REG W/ASTM DESC.



	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	CD-BAP-1504 S-7 10.0' to 11.0'	Dark-gray fine to coarse sand, some fine to coarse gravel (sandstone fragments), some silty clay.						

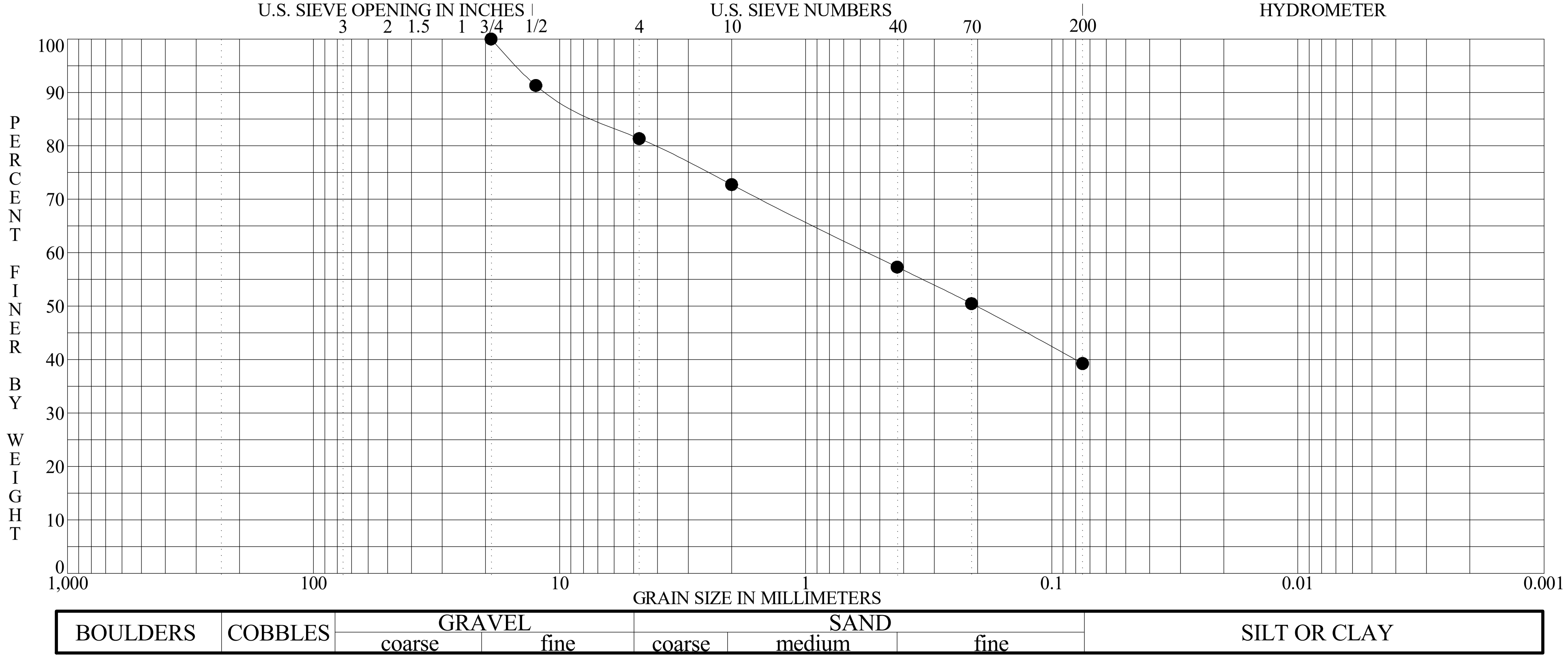
	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	CD-BAP-1504 S-7 10.0' to 11.0'	25.0000	18.3349	1.7501	0.5398		29.1	42.7	28.2	

ASTM D422

GRADATION CURVE

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A **DATE** 12/30/15

GRN-REG W/ASTM DESC.



Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● CD-BAP-1504 S-8 11.5' to 11.9'	Dark-gray and brown fine to coarse sand, little fine gravel, "and" silt.	12					

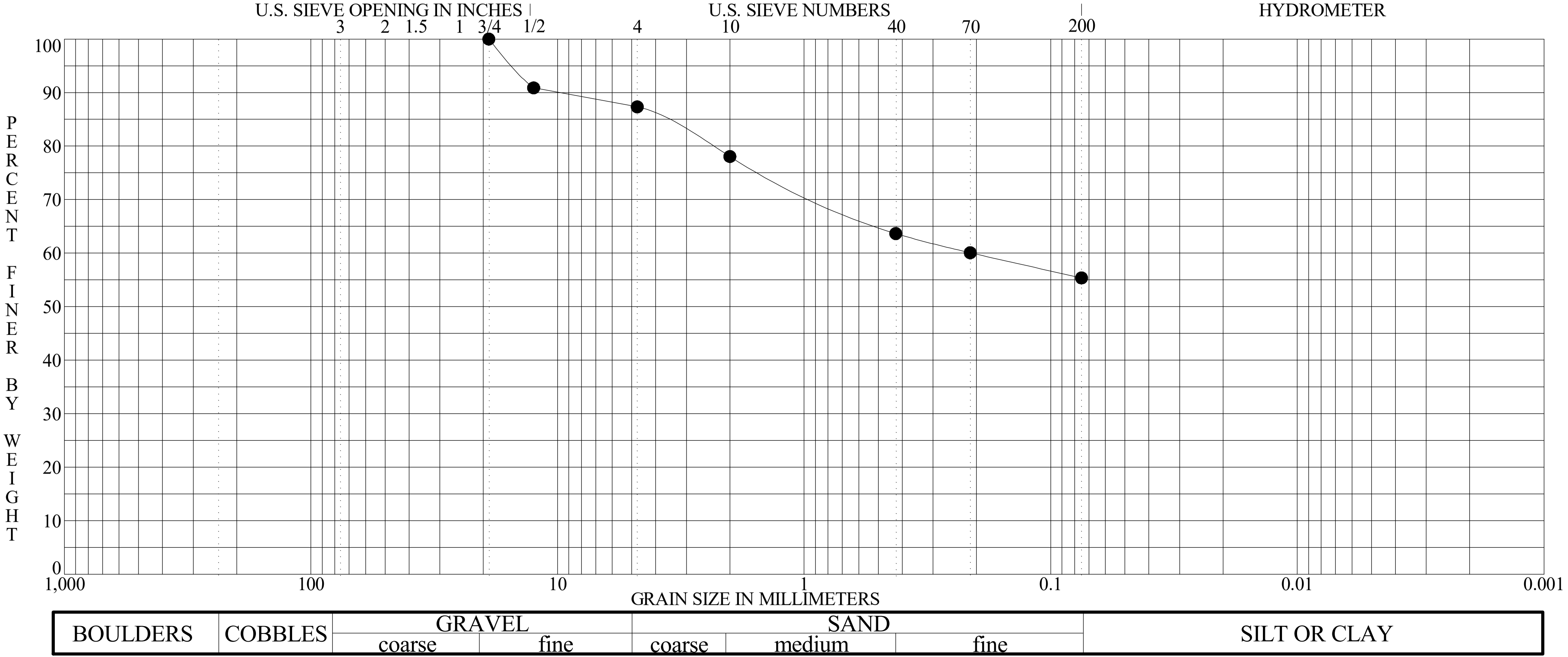
Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● CD-BAP-1504 S-8 11.5' to 11.9'	19.0000	14.9354	0.5566	0.2026		18.6	42.1	39.3	

ASTM D422

GRADATION CURVE

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A
DATE 12/30/15

GRN-REG W/ASTM DESC.



	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-1505 S-10 14.5' to 15.8'**	**Yellow-brown and brown silty clay, some fine to coarse sand, little fine gravel.**	**18**					

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-1505 S-10 14.5' to 15.8'**	**19.0000**	**15.1011**	**0.2089**			**12.7**	**32.0**	**55.4**	

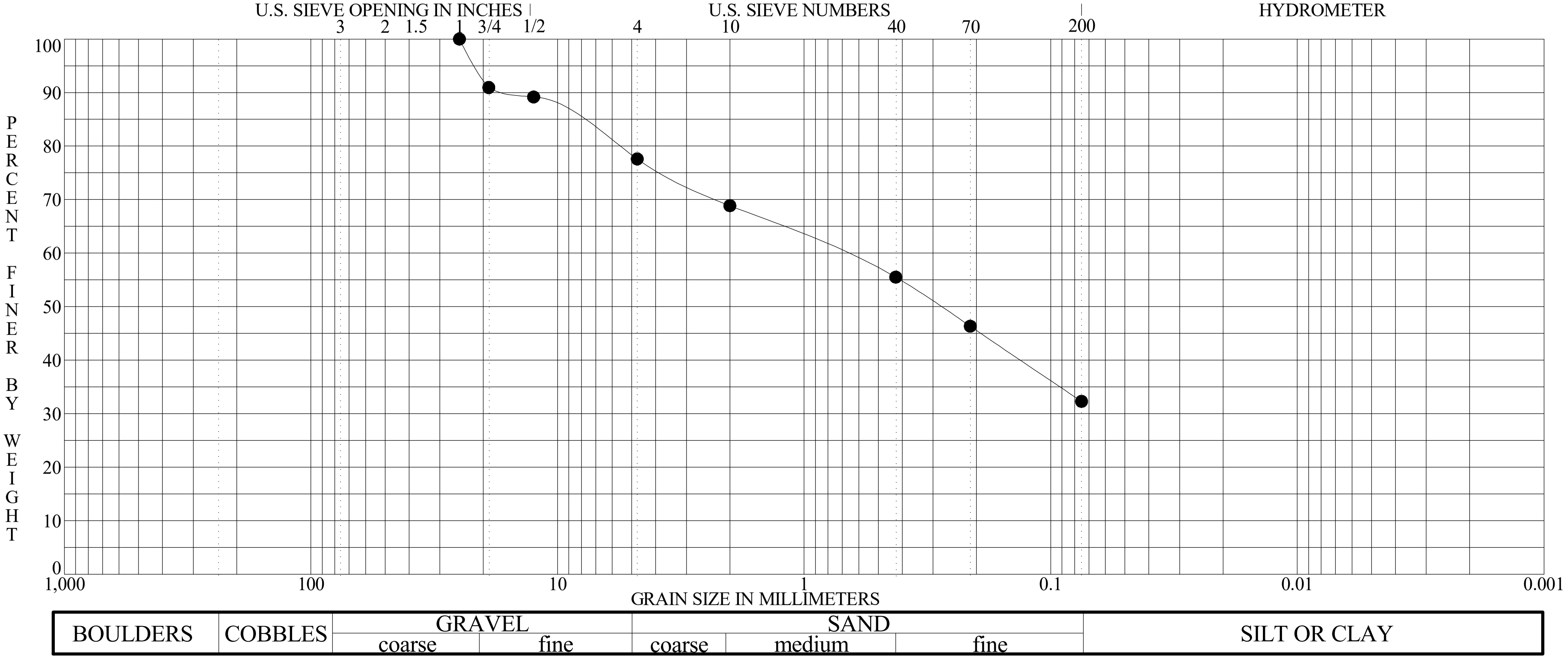
ASTM D422

GRADATION CURVE

PROJECT **BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION**
LOCATION **CARDINAL PLANT, BRILLIANT, OH**
JOB NO. **7217-15-007A** **DATE** **12/30/15**

GRN-REG W/ASTM DESC.

S&ME



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**	

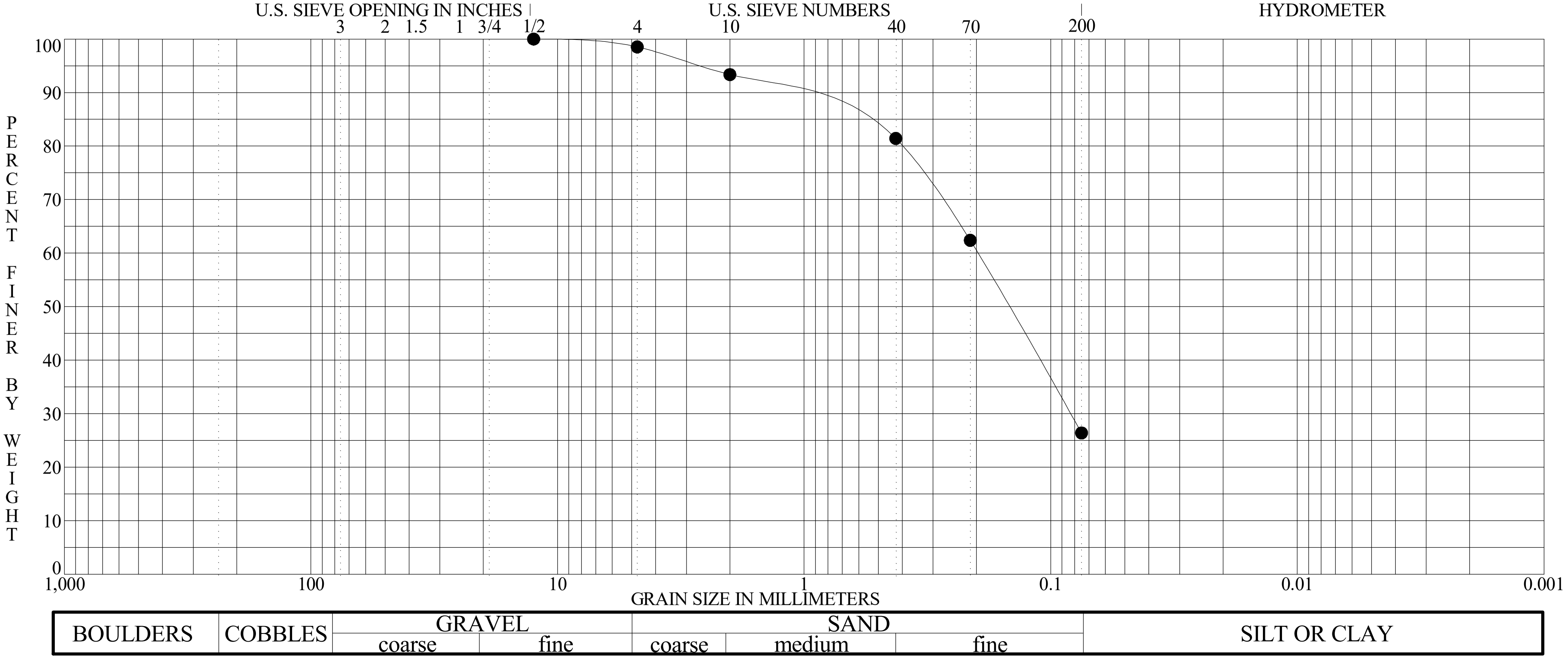
ASTM D422

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.

S&ME



Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● CD-BAP-1501 S-6 8.5' to 9.7'	Red-brown and gray fine to coarse sand, trace fine gravel, some silt.						

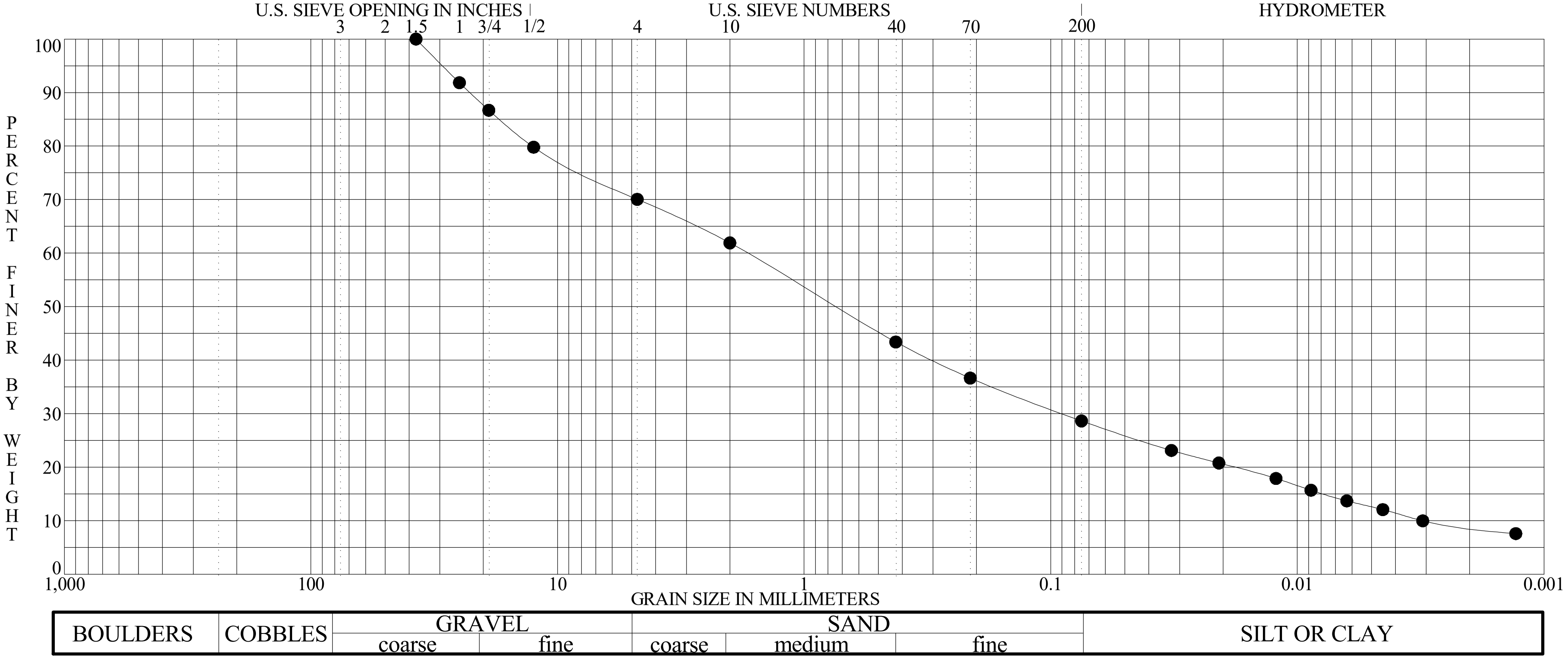
Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● CD-BAP-1501 S-6 8.5' to 9.7'	12.5000	2.6291	0.1978	0.1482		1.5	72.1	26.4	

ASTM D422

GRADATION CURVE

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A DATE 12/30/15

GRN-REG W/ASTM DESC.



Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-BAP-1502 S-4 5.5' to 6.7'**	**Gray and brown fine to coarse sand, some fine to coarse gravel, some silty clay.** **CLAYEY SAND with GRAVEL SC**	**9**	**27**	**16**	**11**	**1.508**	**547.388**

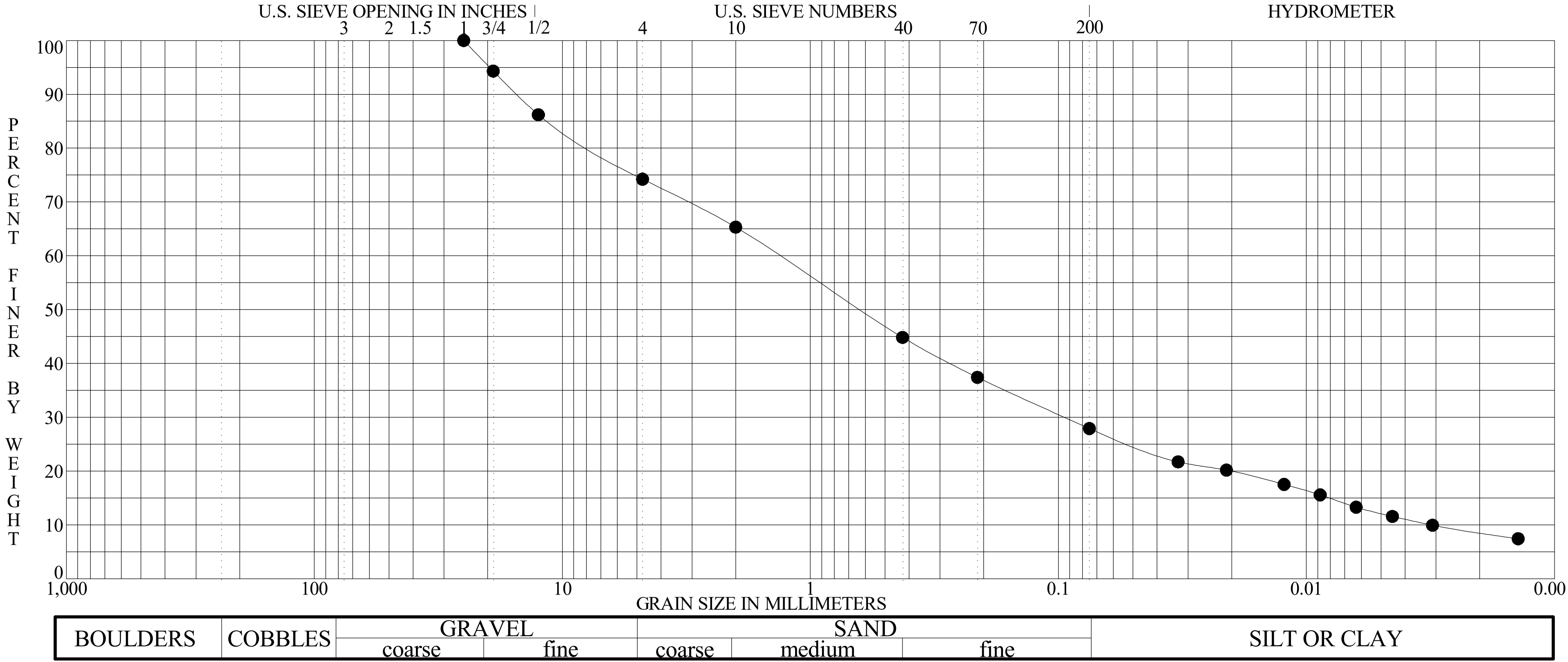
Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-BAP-1502 S-4 5.5' to 6.7'**	**37.5000**	**29.2411**	**1.7048**	**0.7385**	**0.0031**	**29.9**	**41.4**	**16.1**	**12.6**

ASTM D422

GRADATION CURVE

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A **DATE** 12/30/15

PLATE 15



	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-1502 S-9 17.0' to 18.3**	**Gray fine to coarse sand, some fine to coarse gravel, some clayey silt.**	**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**

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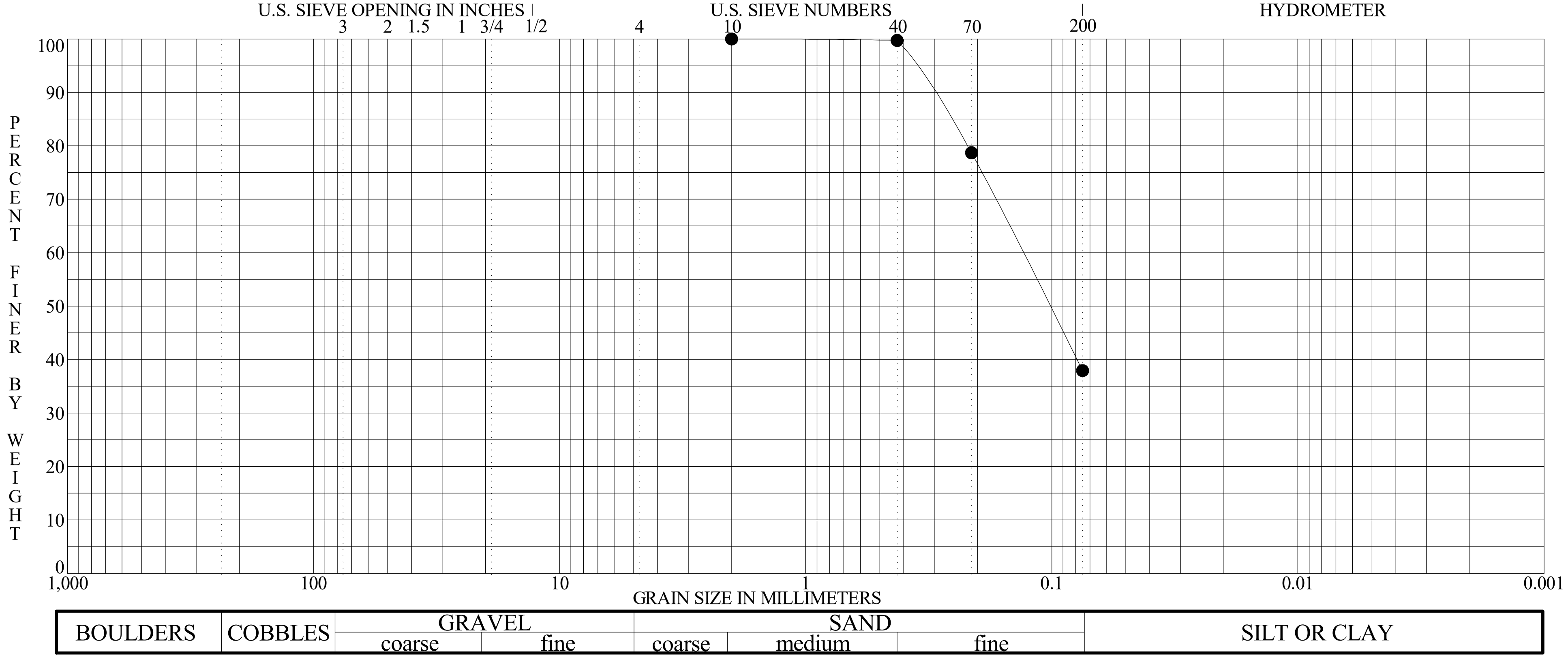
GRADATION CURVE

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A **DATE** 12/30/15

GRN-REG W/ASTM DESC.



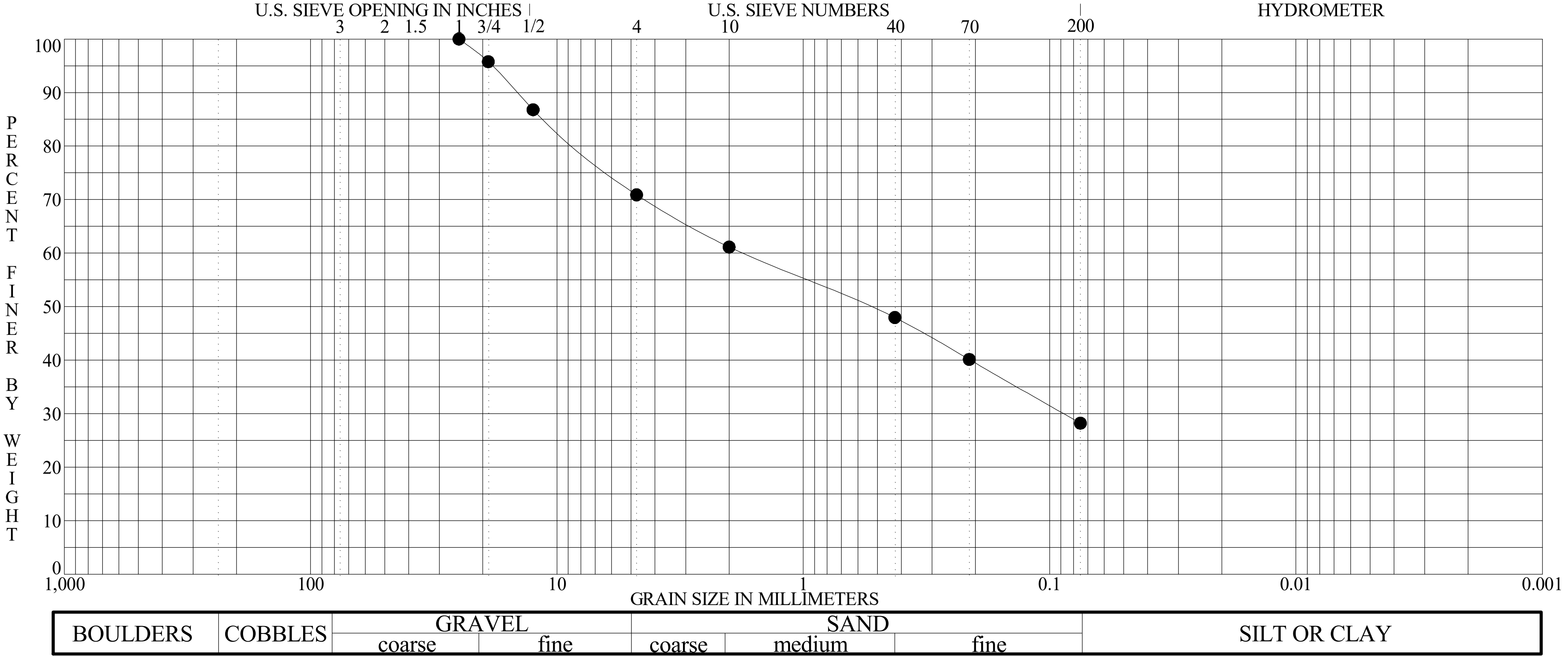
	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-1502 S-18 40.0' to 41.0'**	**Brown fine to medium sand, "and" silt.**						

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-1502 S-18 40.0' to 41.0'**	**2.0000**	**0.3633**	**0.1316**	**0.1020**		**0.0**	**62.1**	**37.9**	

ASTM D422

GRADATION CURVE

PROJECT **BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION**
LOCATION **CARDINAL PLANT, BRILLIANT, OH**
JOB NO. **7217-15-007A** **DATE** **12/30/15**



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	

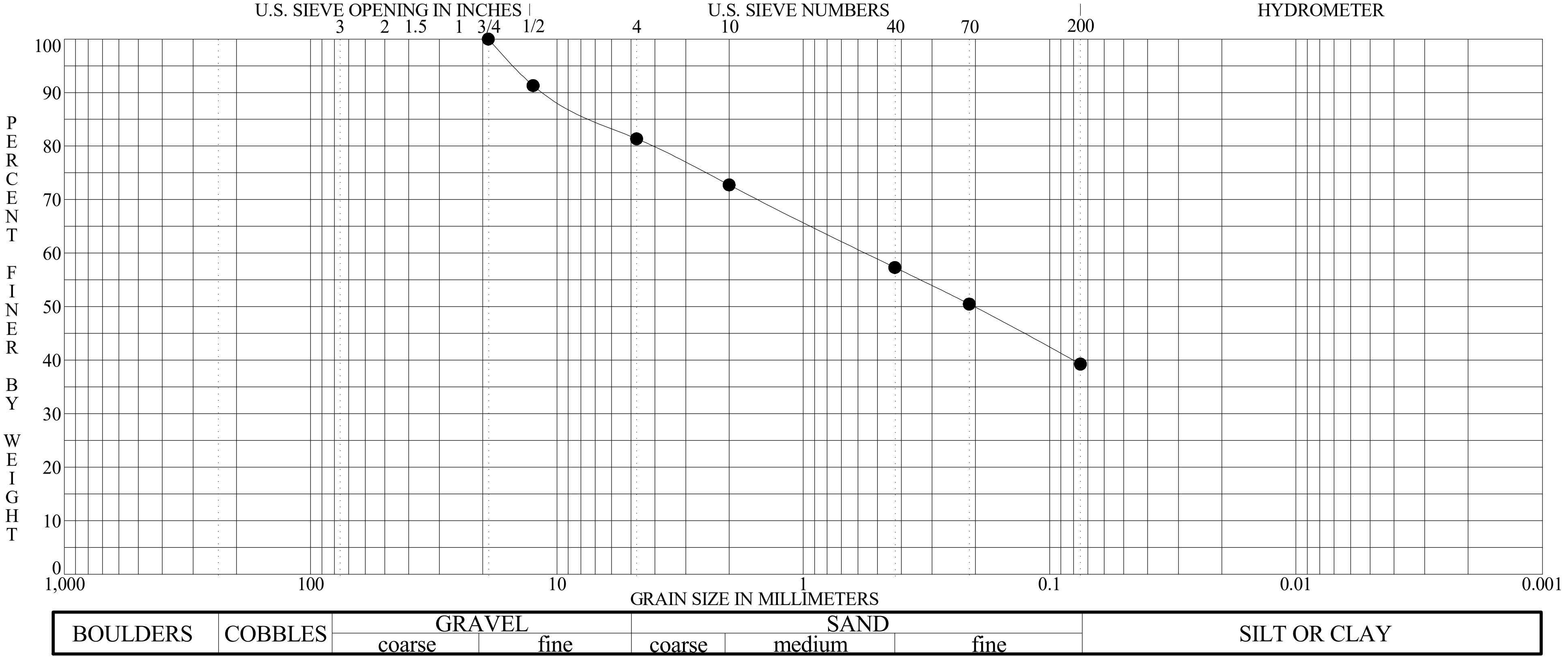
ASTM D422

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.

PLATE 18



	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	CD-BAP-1504 S-8 11.5' to 11.9'	Dark-gray and brown fine to coarse sand, little fine gravel, "and" silt.	12					

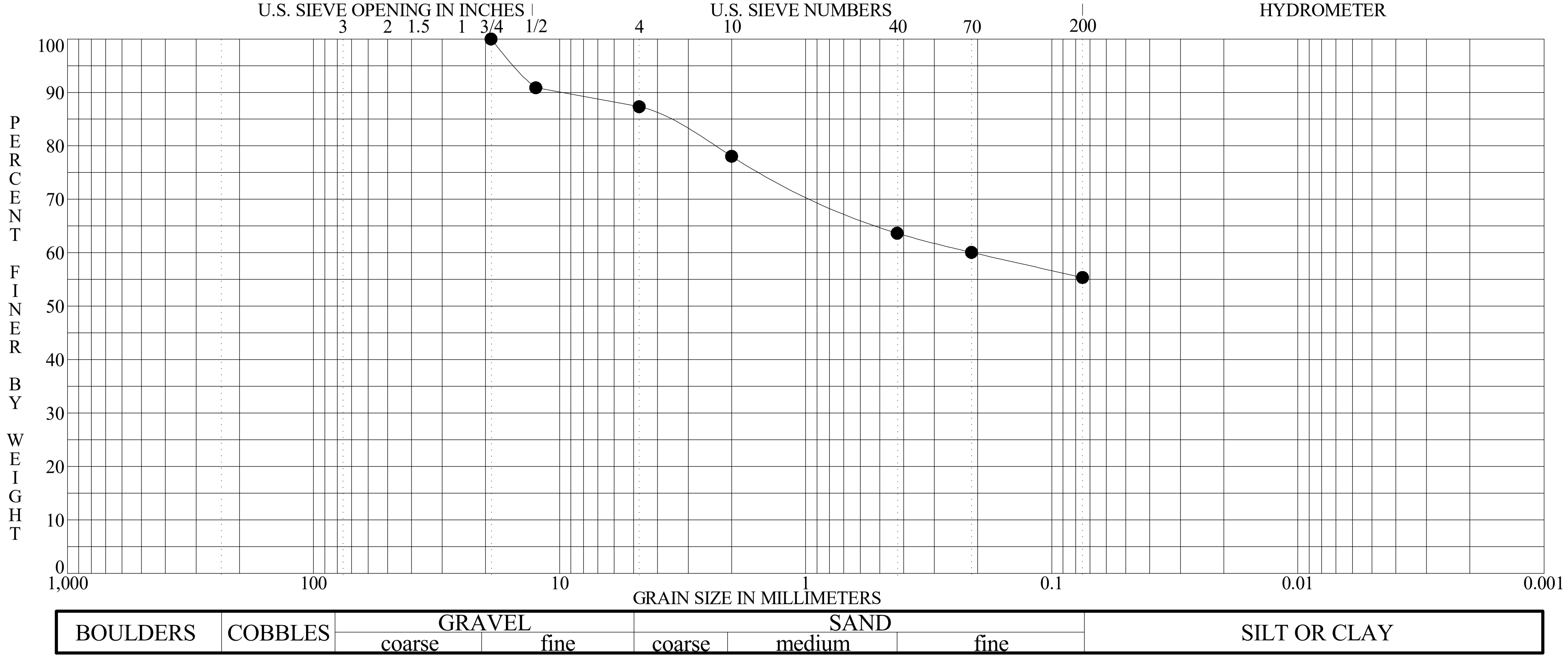
	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	CD-BAP-1504 S-8 11.5' to 11.9'	19.0000	14.9354	0.5566	0.2026		18.6	42.1	39.3	

ASTM D422

GRADATION CURVE

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A **DATE** 12/30/15

GRN-REG W/ASTM DESC.



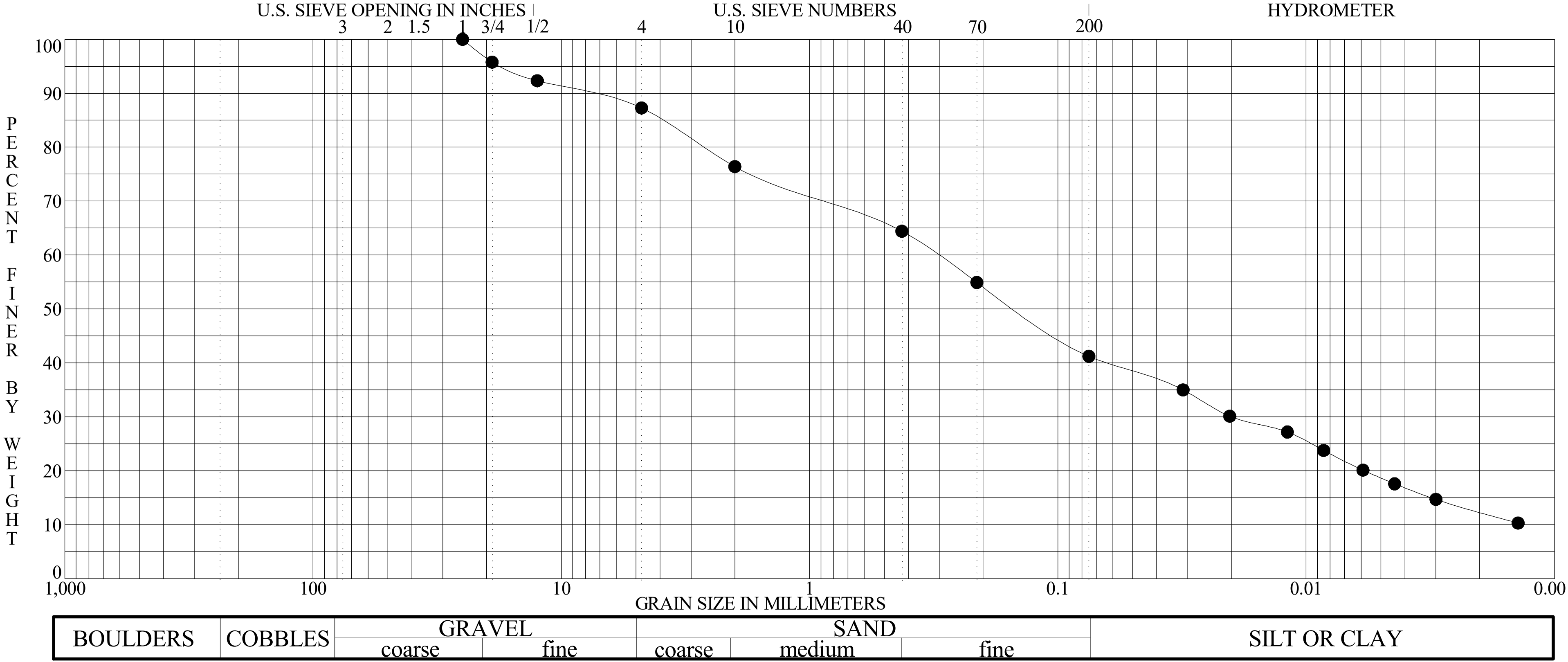
	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-1505 S-10 14.5' to 15.8'**	**Yellow-brown and brown silty clay, some fine to coarse sand, little fine gravel.**	**18**					

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-1505 S-10 14.5' to 15.8'**	**19.0000**	**15.1011**	**0.2089**			**12.7**	**32.0**	**55.4**	

ASTM D422

GRADATION CURVE

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A **DATE** 12/30/15



	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	MW-BAP-4 S-4 5.5' to 6.8'	**Brown fine to coarse sand, little fine to coarse gravel, "and" clayey silt.** **CLAYEY SAND SC**	15	25	16	9		

	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

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GRADATION CURVE

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A
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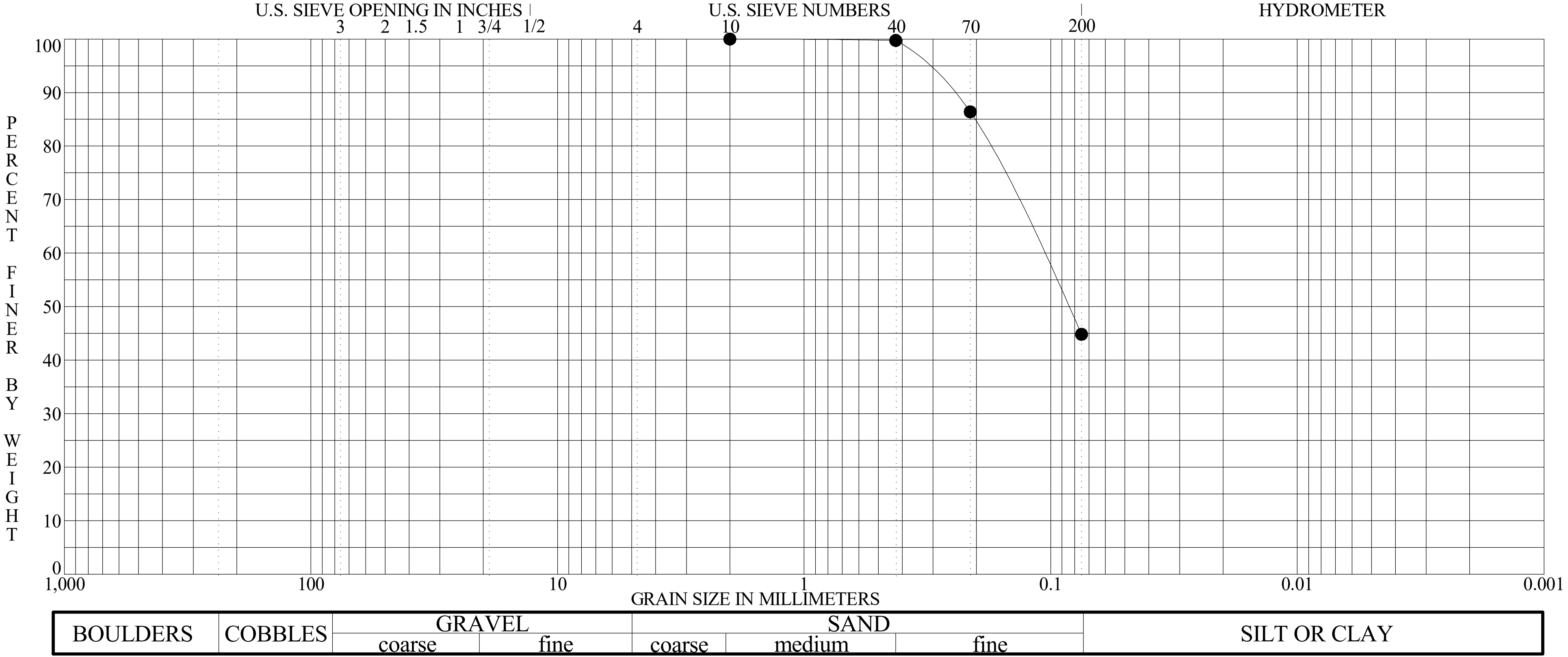
GRN-REG W/ASTM DESC.

S&ME



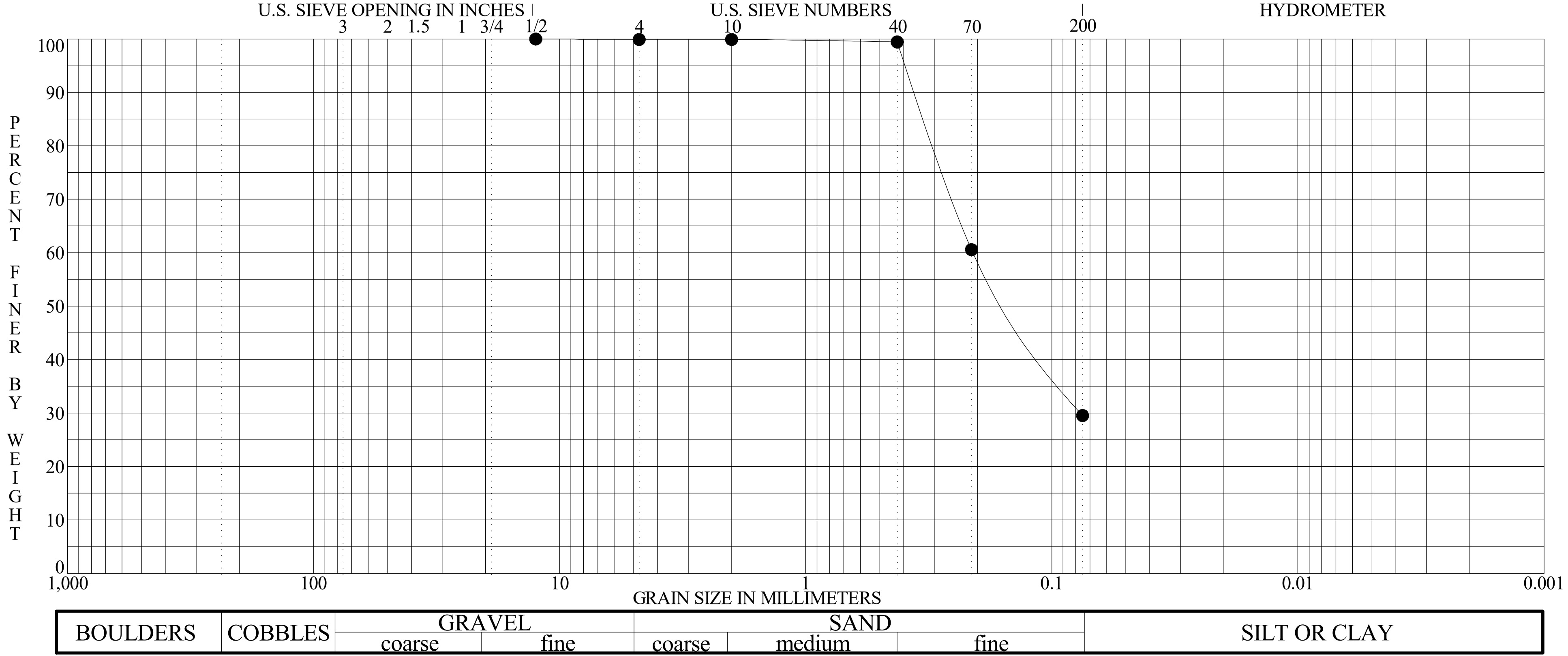
Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **MW-BAP-4 S-13 31.5' to 32.5'**	**Gray fine to medium sand, "and" silt.**						

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



	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.**						

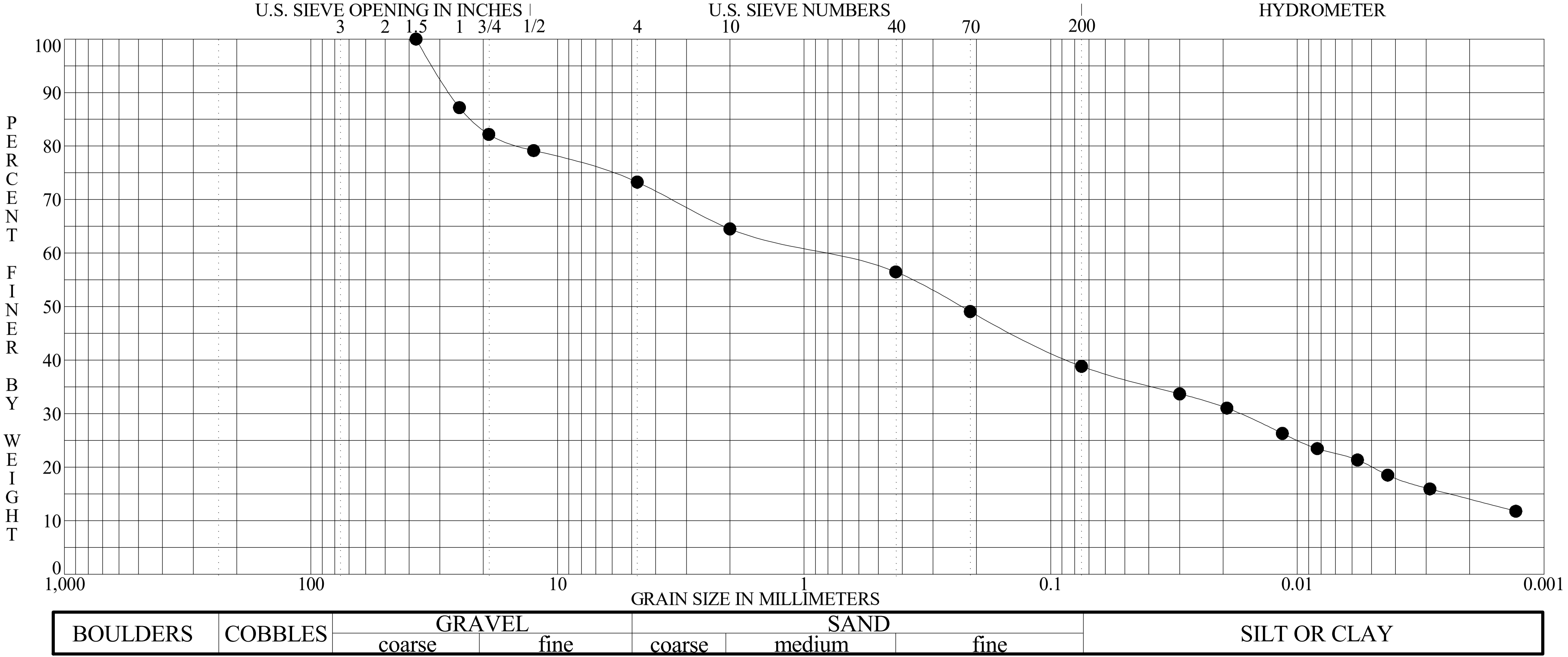
	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**MW-BAP-4 S-16 38.5' to 40.0'**	**12.5000**	**0.3925**	**0.2079**	**0.1488**		**0.1**	**70.4**	**29.5**	

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.



	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.** **CLAYEY SAND with GRAVEL SC**	**13**	**30**	**17**	**13**		

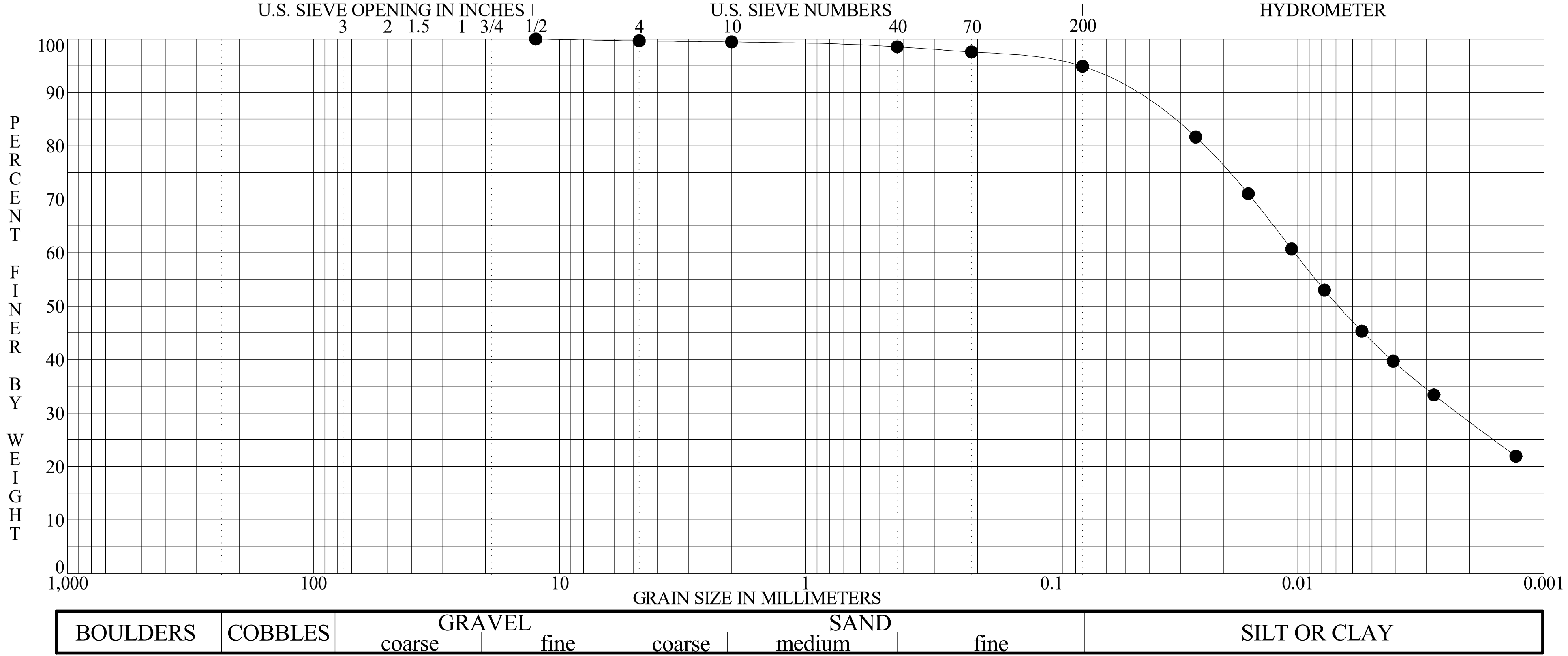
	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**MW-BAP-5 S-3 4.0' to 5.1'**	**37.5000**	**32.0064**	**0.8357**	**0.2310**		**26.7**	**34.4**	**18.8**	**20.0**

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.



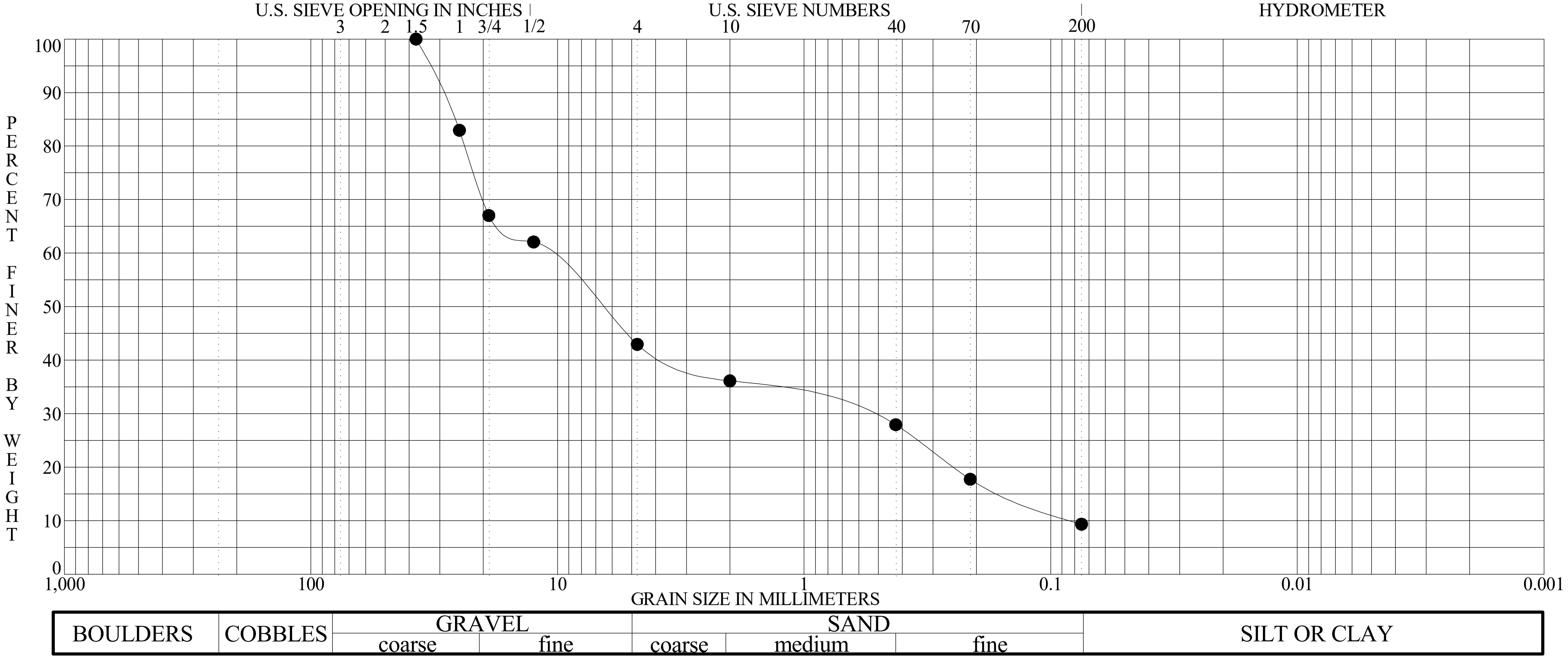
Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● MW-BAP-5 S-11 21.0' to 22.5'	Gray mottled with dark-gray and brown silty clay, trace fine to coarse sand, trace fine gravel, few roots and silt seams, slightly organic. LEAN CLAY CL	40	48	26	22		

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



	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	MW-BAP-5 S-21 51.0' to 51.3'	Gray fine to coarse gravel, some fine to coarse sand, trace silt.					0.432	138.404

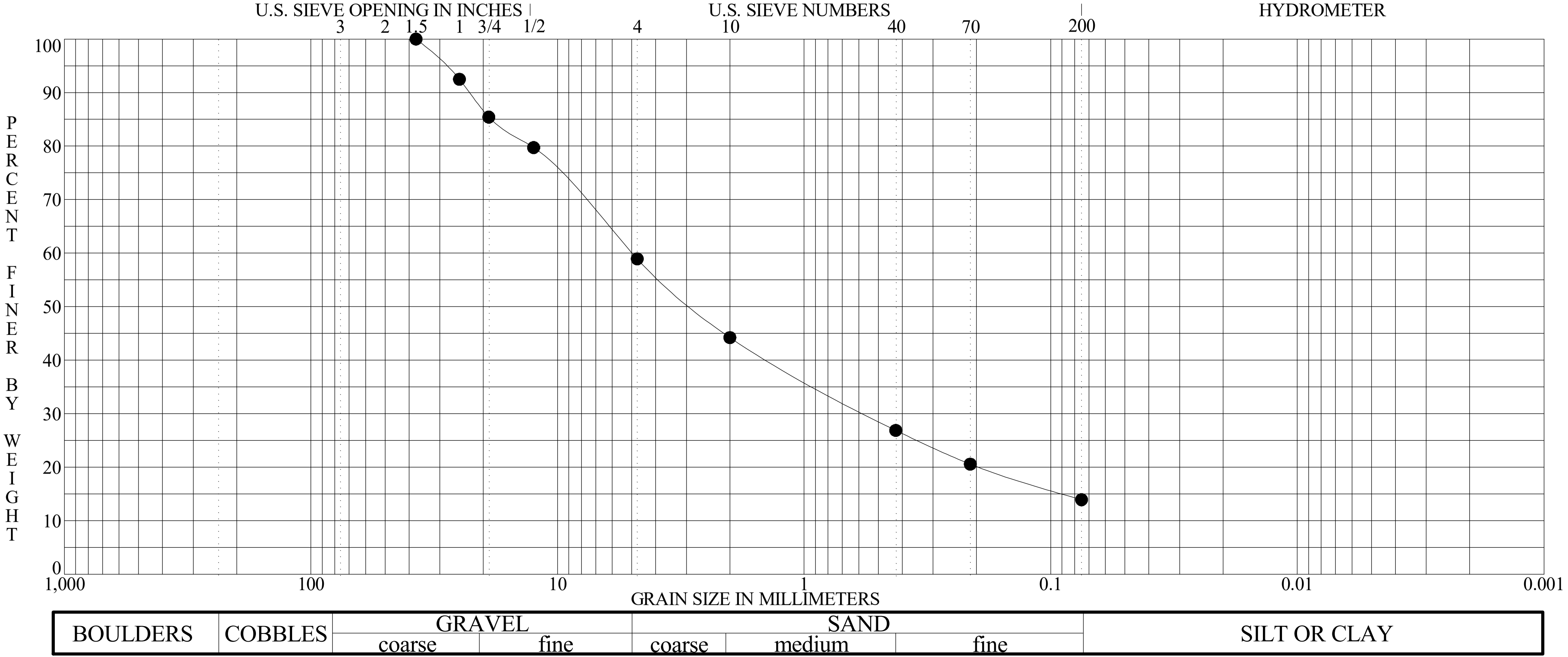
	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	MW-BAP-5 S-21 51.0' to 51.3'	37.5000	33.2943	11.2464	6.7824	0.0813	57.0	33.6	9.4	

ASTM D422

GRADATION CURVE

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A DATE 12/30/15

GRN-REG W/ASTM DESC.



	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**MW-BAP-5 S-24 58.5' to 59.4'**	**Gray fine to coarse sand, "and" fine to coarse gravel, little silt.**						

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**MW-BAP-5 S-24 58.5' to 59.4'**	**37.5000**	**28.6237**	**4.9922**	**2.8092**		**41.1**	**45.0**	**13.9**	

ASTM D422

GRADATION CURVE

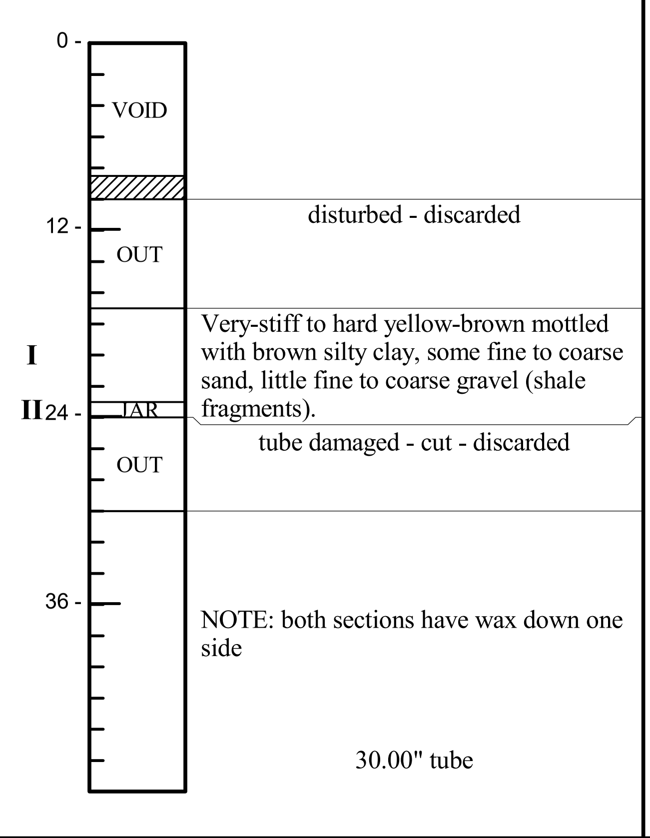
PROJECT **BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION**
LOCATION **CARDINAL PLANT, BRILLIANT, OH**
JOB NO. **7217-15-007A** **DATE** **12/30/15**

JOB NUMBER : **7217-15-007A**
PROJECT : **BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION**
LOCATION : **CARDINAL PLANT, BRILLIANT, OH**

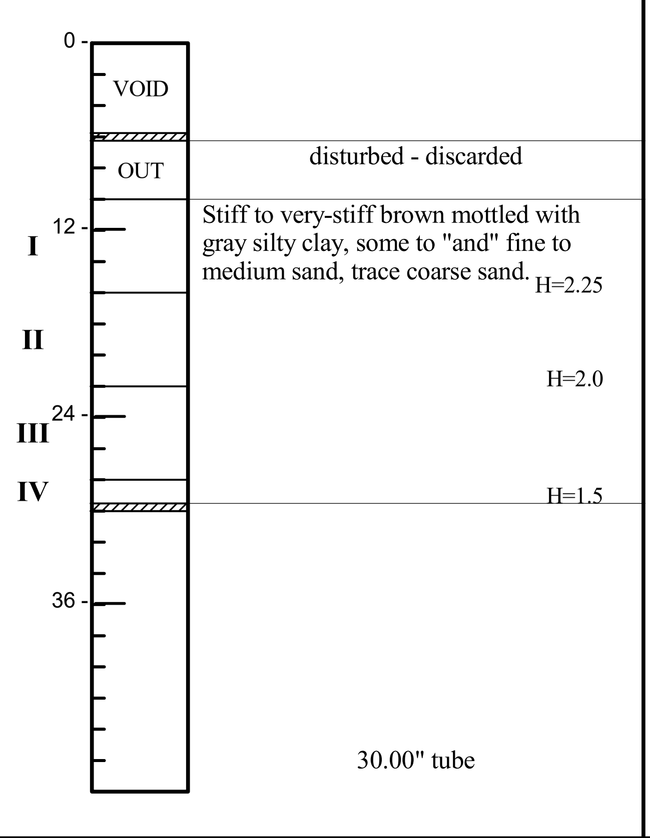
LABORATORY LOG OF SHELBY TUBES

SHELBY TUBE LOG

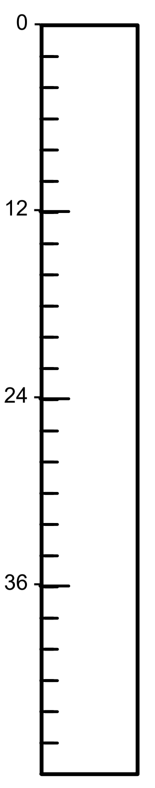
Boring : **CD-BAP-1502** Sample : **ST-1**
Depth : **20.0' to 22.0'** Recovery : **7.00"**



Boring : **CD-BAP-1502** Sample : **ST-2**
Depth : **32.5' to 34.5'** Recovery : **19.50"**



Boring : Sample :
Depth : Recovery :



LEGEND

- Consolidation, Incremental
C R S - Consolidation, C R S
P P - Permeability, Vertical / Horizontal
Swelling, Test
In/B Sa-Cl
▨ - Wax
- Unconfined Compression Test
- Triaxial Compression Test

H - Hand Penetrometer (tsf)
Ds - Direct Shear
LOI - Loss on Ignition
AL - Atterberg Limits
MA - Sieve/Hydrometer
SG - Specific Gravity

SL - Shrinkage Limit
POR - Porosity
UDW - Unit Dry Weight
MC - Moisture Content
D_R - Relative Density
S - Sieve

2009 SITE INVESTIGATION

SUMMARY OF LABORATORY TEST RESULTS

BORING	G'int Id.	MC	LL	PL	PI	GRADATION			COMPACTION		TRIAXIAL			DIRECT SHEAR			UNCONFIN COMPRESS	CONSOLID.	SPECIFIC GRAVITY	UNIT DRY WEIGHT	REMOLDED	PERMEABILITY				RELATIVE DENSITY	LOI	ROCK CORE	SHELBY TUBE	CBR
							Hydrometer																							
						sieve	short	long	standard	modified	uncons. undrain	consolid undrain w/popres	drained	drained	undrain	residual						cohesive	non/cohes	rigid wall	flexible wall					
		%	%	%	%	* SEE INDIVIDUAL TEST CURVES														PCF						%	%			
BAP-0901	4.75	16																												
BAP-0901	7.75	16	28	18	10																									
BAP-0901	13.75	13	27	17	10																									
BAP-0901	18.25	14	37	24	13	*		*																						
BAP-0901	22.75	30	NP	NP	NP	*		*																						
BAP-0901	24.50																												*	
BAP-0901	29.25	27	37	22	15	*		*																						
BAP-0901	31.25											*																		
BAP-0901	31.75	33	35	28	7	*		*				*																	*	
BAP-0901	32.25											*																		
BAP-0901	34.25	42	34	27	7	*		*																						
BAP-0901	36.75	40	45	29	16	*																								
BAP-0901	39.25	42	40	23	17	*		*																						
BAP-0902	6.25	13	27	17	10	*		*																						
BAP-0902	10.75	20																												
BAP-0902	12.25	10	26	17	9	*		*																						
BAP-0902	16.75	24	37	19	18																									
BAP-0902	18.25	21	35	17	18	*		*																						
BAP-0902	19.75	31	29	17	12	*		*																						
BAP-0902	21.25	26	NP	NP	NP	*		*																						

BBCM
SOLUTIONS TO BUILD ON

TESTING SUMMARY - STANDARD

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 DATE 7/6/09

SUM REG 111497013.GPJ BBCM.GDT 7/6/09

SUMMARY OF LABORATORY TEST RESULTS

BORING	G'int Id.	MC	LL	PL	PI	GRADATION			COMPACTION		TRIAXIAL			DIRECT SHEAR			UNCONFIN COMPRESS	CONSOLID.	SPECIFIC GRAVITY	UNIT DRY WEIGHT	REMOLDED	PERMEABILITY				RELATIVE DENSITY	LOI	ROCK CORE	SHELBY TUBE	CBR
						sieve	Hydrometer		standard	modified	uncons. undrain	consolid undrain w/pores	drained	drained	undrain	residual						cohesive	non/cohes	rigid wall	flexible wall					
							short	long																						
		%	%	%	%	* SEE INDIVIDUAL TEST CURVES														PCF						%	%			
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

PLATE 2

SUM REG 11497013.GPJ BBCM.GDT 7/6/09

SUMMARY OF LABORATORY TEST RESULTS

BORING	G'int Id.	MC	LL	PL	PI	GRADATION			COMPACTION		TRIAXIAL			DIRECT SHEAR			UNCONFIN COMPRESS	CONSOLID.	SPECIFIC GRAVITY	UNIT DRY WEIGHT	REMOLDED	PERMEABILITY				RELATIVE DENSITY	LOI	ROCK CORE	SHELBY TUBE	CBR
						sieve	Hydrometer short	Hydrometer long	standard	modified	uncons. undrain	consolid undrain w/pores	drained	drained	undrain	residual						cohesive	non/cohes	rigid wall	flexible wall					
		%	%	%	%	* SEE INDIVIDUAL TEST CURVES														PCF						%	%			
BAP-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 DRY WEIGHT	REMOLDED	PERMEABILITY				RELATIVE DENSITY	LOI	ROCK CORE	SHELBY TUBE	CBR
						sieve	Hydrometer		standard	modified	uncons. undrain	consolid undrain w/pores	drained	drained	undrain	residual						cohesive	non/cohes	rigid wall	flexible wall					
							short	long																						
		%	%	%	%	* SEE INDIVIDUAL TEST CURVES														PCF						%	%			
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

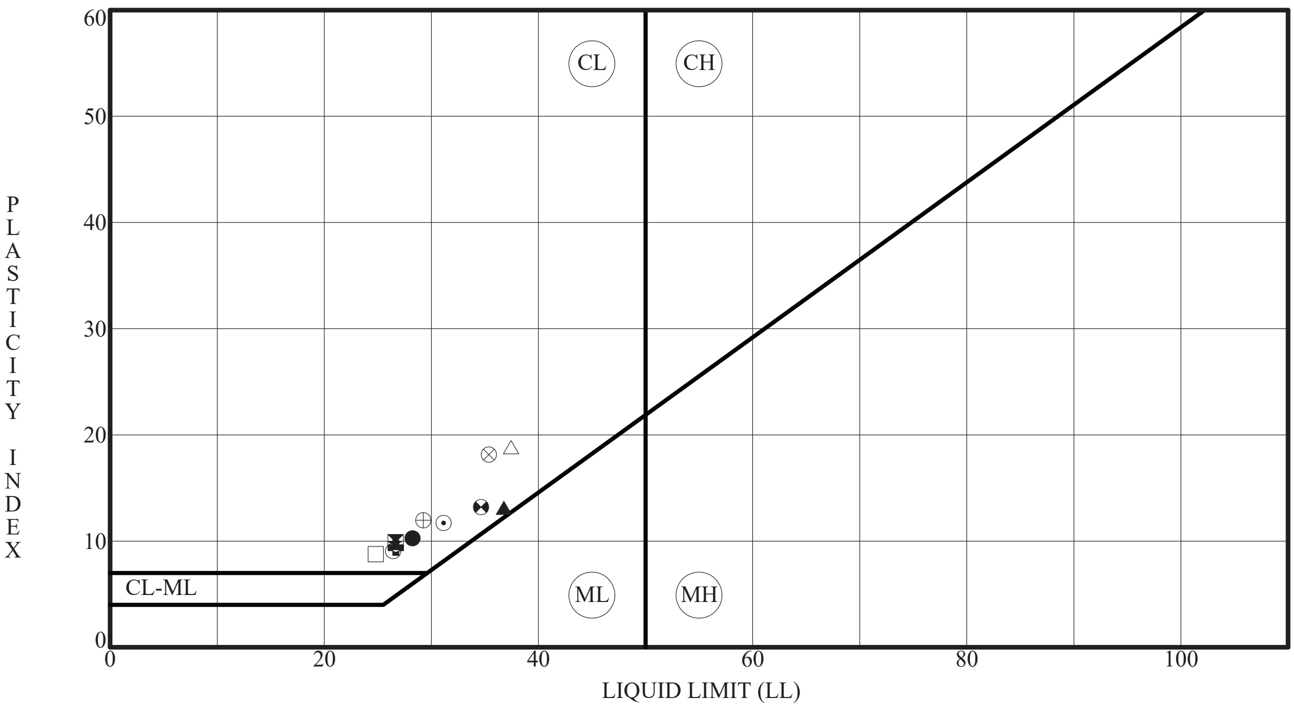
PROJECT CARDINAL PLANT ASH POND INVESTIGATION

LOCATION BRILLIANT, OHIO

JOB NO. 011-11497-013 **DATE** 7/6/09

ATTERBERG LIMITS' RESULTS

BBCM

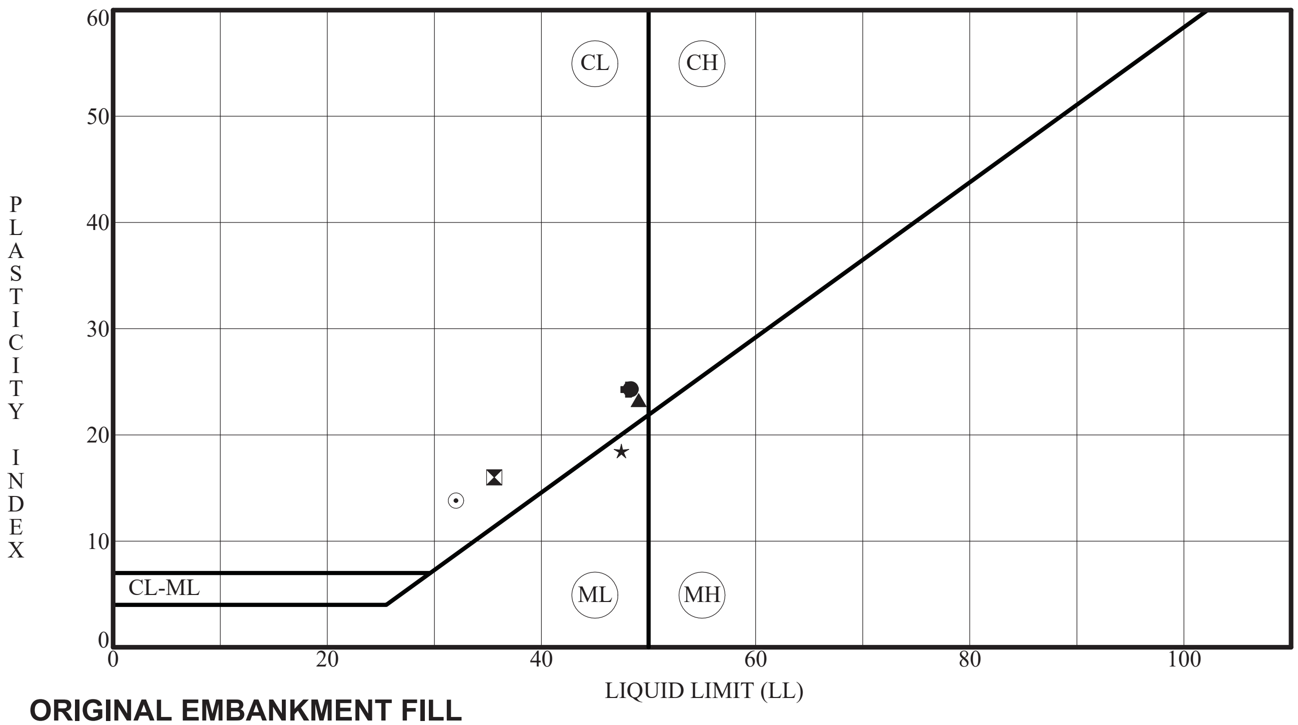


Specimen Id.		Depth	MC	LL	PL	PI	Fines	ASTM Classification
●	BAP-0901	7.75	16	28	18	10		
⧗	BAP-0901	13.75	13	27	17	10		
▲	BAP-0901	18.25	14	37	24	13	60.6	SANDY LEAN CLAY CL
★	BAP-0906	4.75	15	27	17	10		
⊙	BAP-0906	17.25	14	31	19	12	38.0	CLAYEY SAND with GRAVEL SC
✤	BAP-0902	6.25	13	27	17	10	23.6	CLAYEY 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

ATTERBERG LIMITS' RESULTS

BBCM



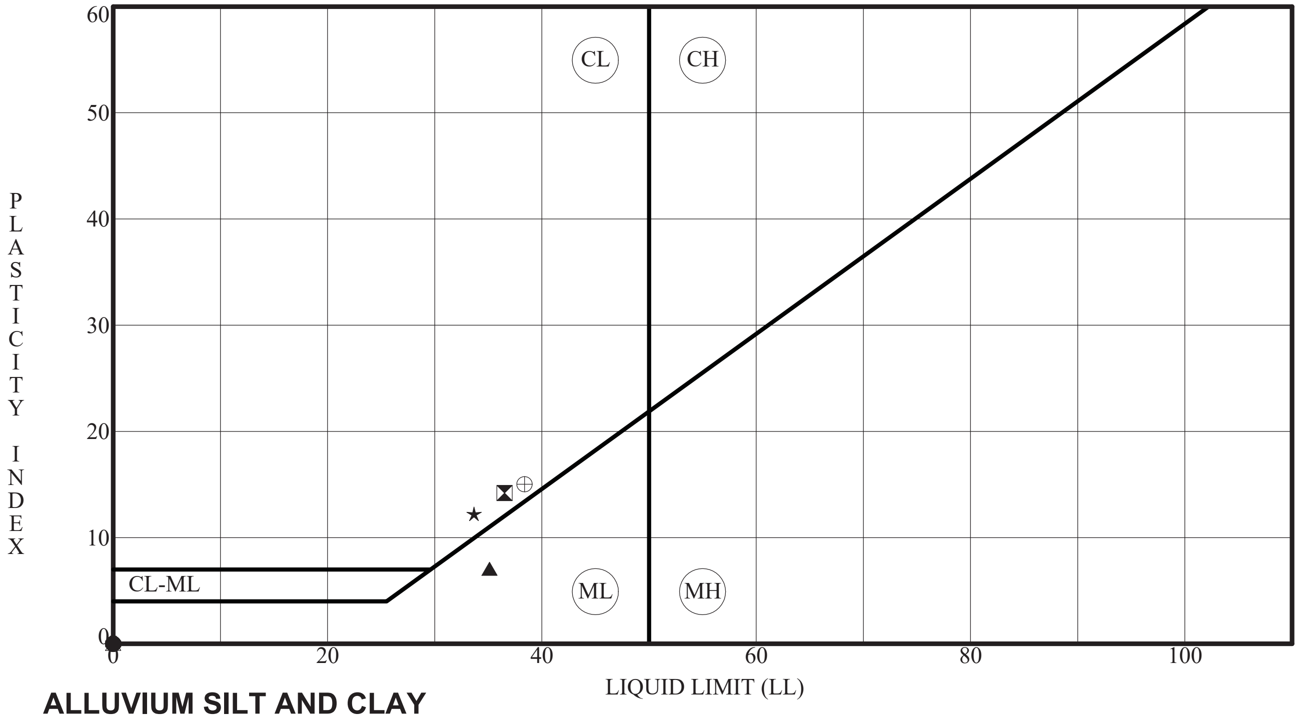
ALPI-REG 111497013.GPJ BBCM.GDT 7/6/09

ORIGINAL EMBANKMENT FILL

	Specimen Id.	Depth	MC	LL	PL	PI	Fines	ASTM Classification
●	**BAP-0903**	**3.25**	**24**	**48**	**24**	**24**	**91.6**	**LEAN CLAY CL**
⧗	**BAP-0903**	**7.75**	**20**	**36**	**20**	**16**	**86.2**	**LEAN CLAY CL**
▲	**BAP-0907**	**7.75**	**23**	**49**	**26**	**23**		
★	**BAP-0907**	**9.25**	**28**	**47**	**29**	**18**	**95.2**	**SILT ML**
⊙	**BAP-0905**	**4.75**	**17**	**32**	**18**	**14**	**75.2**	**LEAN CLAY with SAND CL**
✿	**BAP-0905**	**7.75**	**22**	**48**	**24**	**24**		

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

ATTERBERG LIMITS' RESULTS



ALLUVIUM SILT AND CLAY

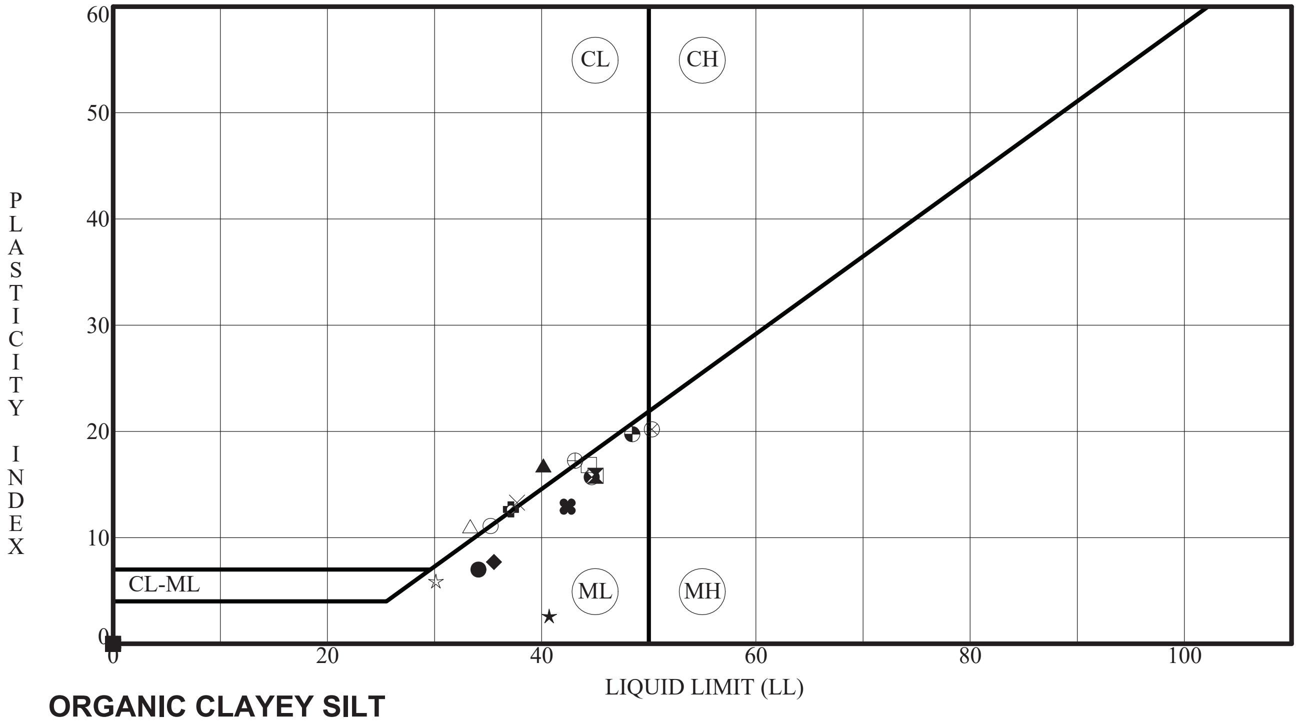
	Specimen Id.	Depth	MC	LL	PL	PI	Fines	ASTM Classification
●	**BAP-0901**	**22.75**	**30**	**NP**	**NP**	**NP**	**95.3**	**SILT ML**
⧗	**BAP-0901**	**29.25**	**27**	**37**	**22**	**15**	**91.0**	**LEAN CLAY CL**
▲	**BAP-0901**	**31.75**	**33**	**35**	**28**	**7**	**73.9**	**SILT with SAND ML**
★	**BAP-0903**	**21.75**	**35**	**34**	**21**	**13**	**70.1**	**LEAN CLAY with SAND CL**
⊙	**BAP-0906**	**24.75**	**31**	**NP**	**NP**	**NP**	**95.2**	**SILT ML**
✿	**BAP-0906**	**27.25**	**22**	**NP**	**NP**	**NP**	**75.2**	**SILT with SAND ML**
○	**BAP-0902**	**21.25**	**26**	**NP**	**NP**	**NP**	**86.8**	**SILT ML**
△	**BAP-0904**	**22.75**	**26**	**NP**	**NP**	**NP**	**47.4**	**SILTY SAND SM**
⊗	**BAP-0904**	**25.75**	**22**	**NP**	**NP**	**NP**	**91.4**	**SILT ML**
⊕	**BAP-0905**	**21.75**	**38**	**38**	**23**	**15**	**62.0**	**SANDY LEAN CLAY CL**

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

BBCM



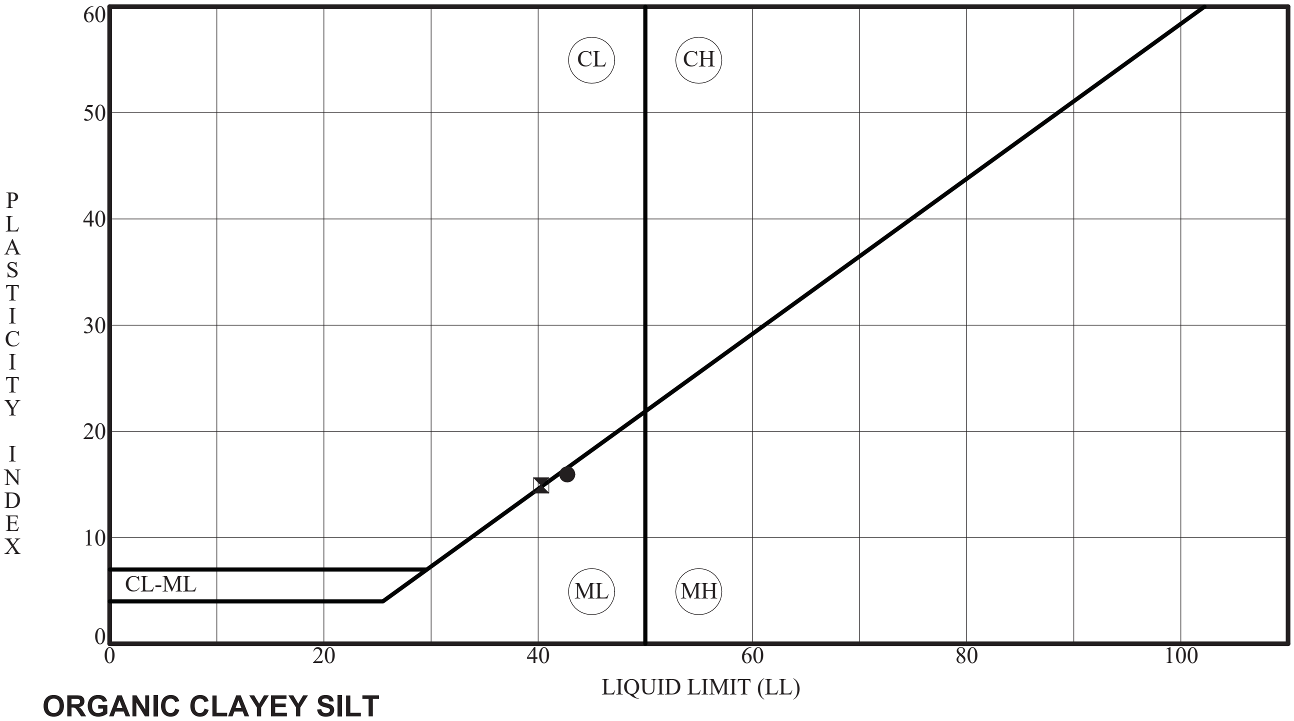
ORGANIC CLAYEY SILT

	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

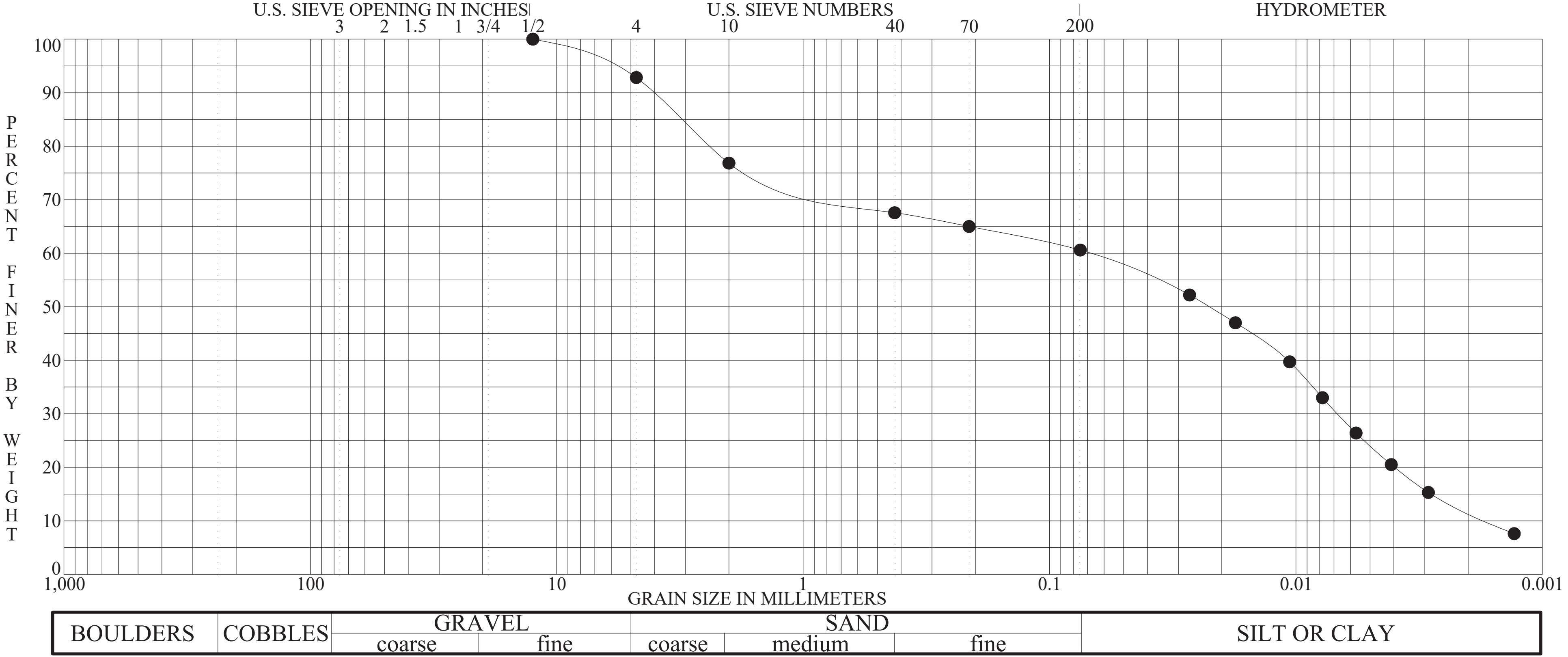
	Specimen Id.	Depth	MC	LL	PL	PI	Fines	ASTM Classification
●	**BAP-0905**	**14.25**	**45**	**43**	**27**	**16**	**80.5**	**ORGANIC SILT with SAND OL**
⧗	**BAP-0905**	**16.75**	**42**	**40**	**25**	**15**	**84.5**	**ORGANIC CLAY with SAND OL**

PROJECT CARDINAL PLANT ASH POND INVESTIGATION

LOCATION BRILLIANT, OHIO

JOB NO. 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM



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).** **SANDY LEAN CLAY CL**	**14**	**37**	**24**	**13**	**0.393**	**41.763**

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-BAP-0901 S-12 17.5' to 18.3'**	**12.5000**	**6.3655**	**0.0697**	**0.0225**	**0.0017**	**7.17**	**32.23**	**48.87**	**11.73**

ASTM D422

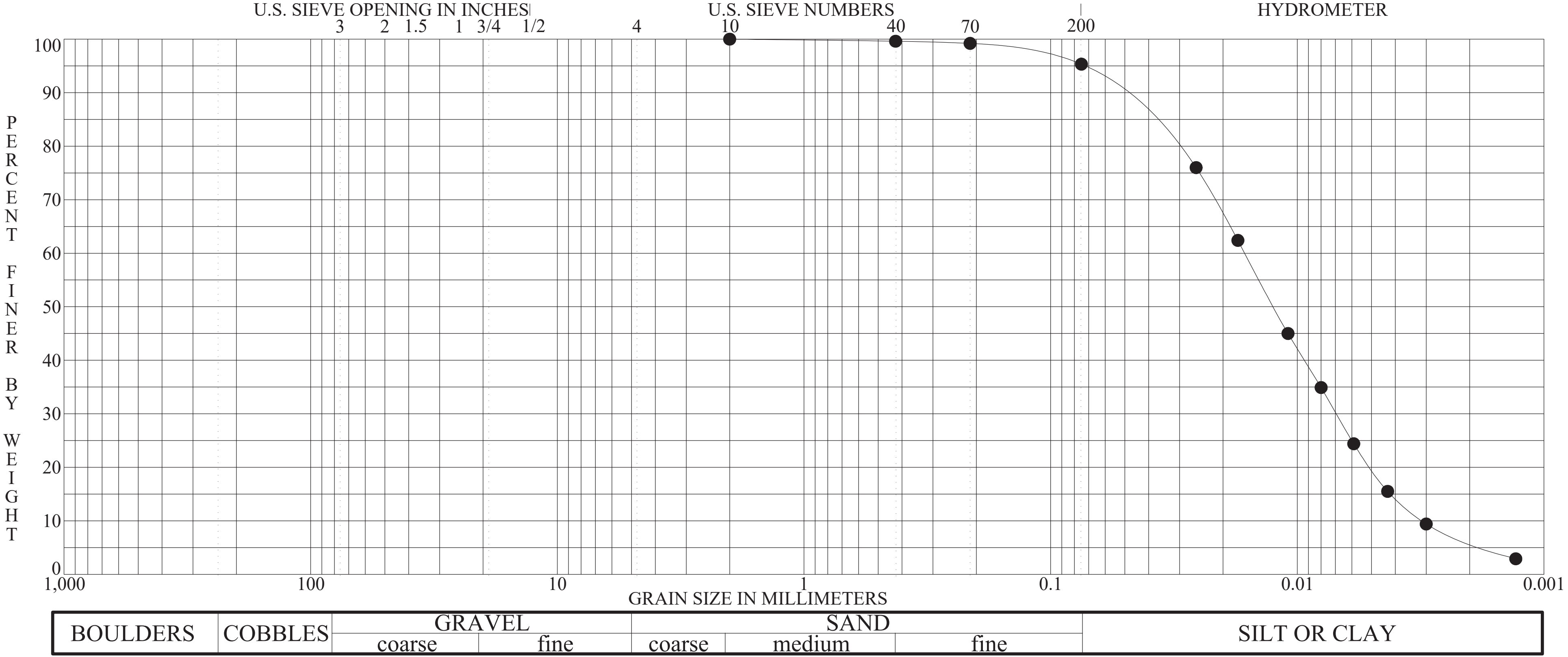
GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

PLATE 10

GRN-EPA W/ASTM-BBCM

BBCM



	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0901 S-15 22.0' to 23.2'**	**Dark-gray brown silt, trace clay, trace fine to medium sand.** **SILT ML**	**30**	**NP**	**NP**	**NP**	**0.950**	**5.248**

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0901 S-15 22.0' to 23.2'**	**2.0000**	**0.0736**	**0.0163**	**0.0125**	**0.0031**	**0.00**	**4.67**	**89.08**	**6.25**

ASTM D422

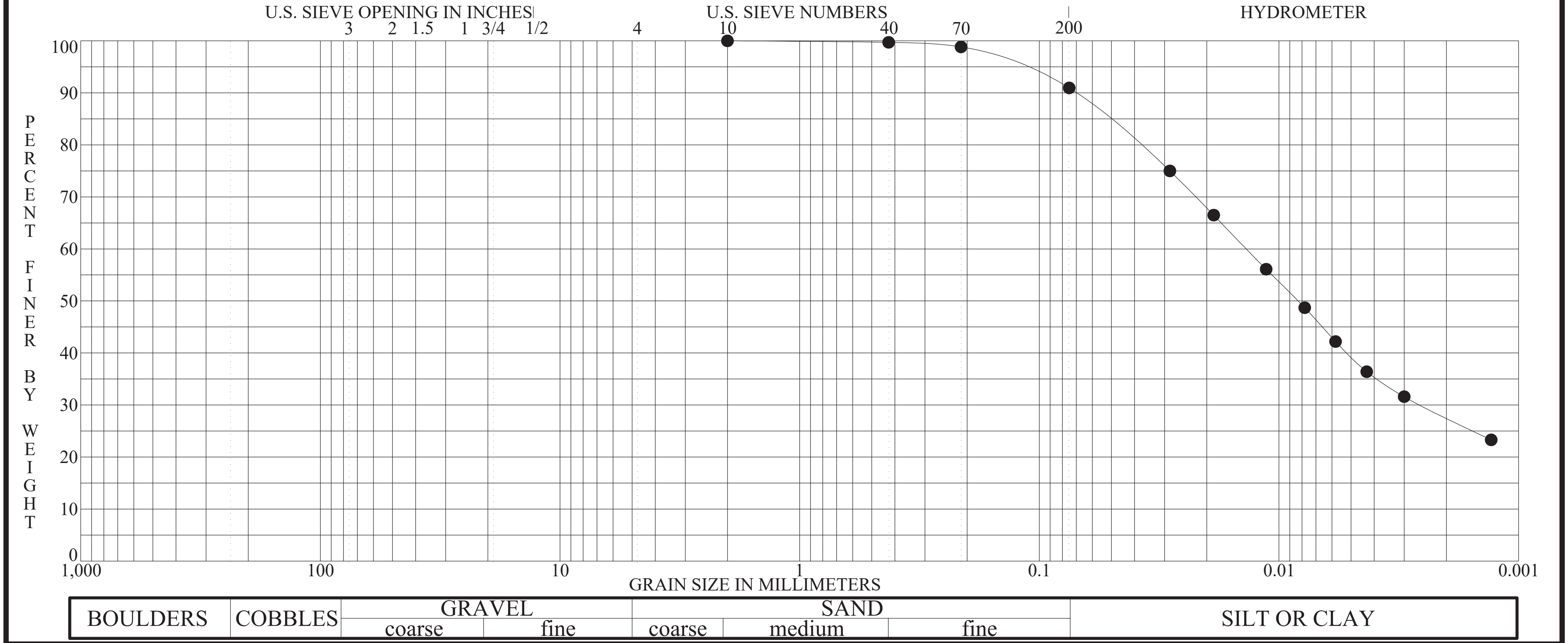
GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

PLATE 11

GRN-EPA W/ASTM-BBCM

BBCM



	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0901 S-18 28.5' to 30.0'**	**Brown mottled with gray and dark-gray siltty clay inter-bedded with organic silt, trace fine to medium sand.** **LEAN CLAY CL**	**27**	**37**	**22**	**15**		

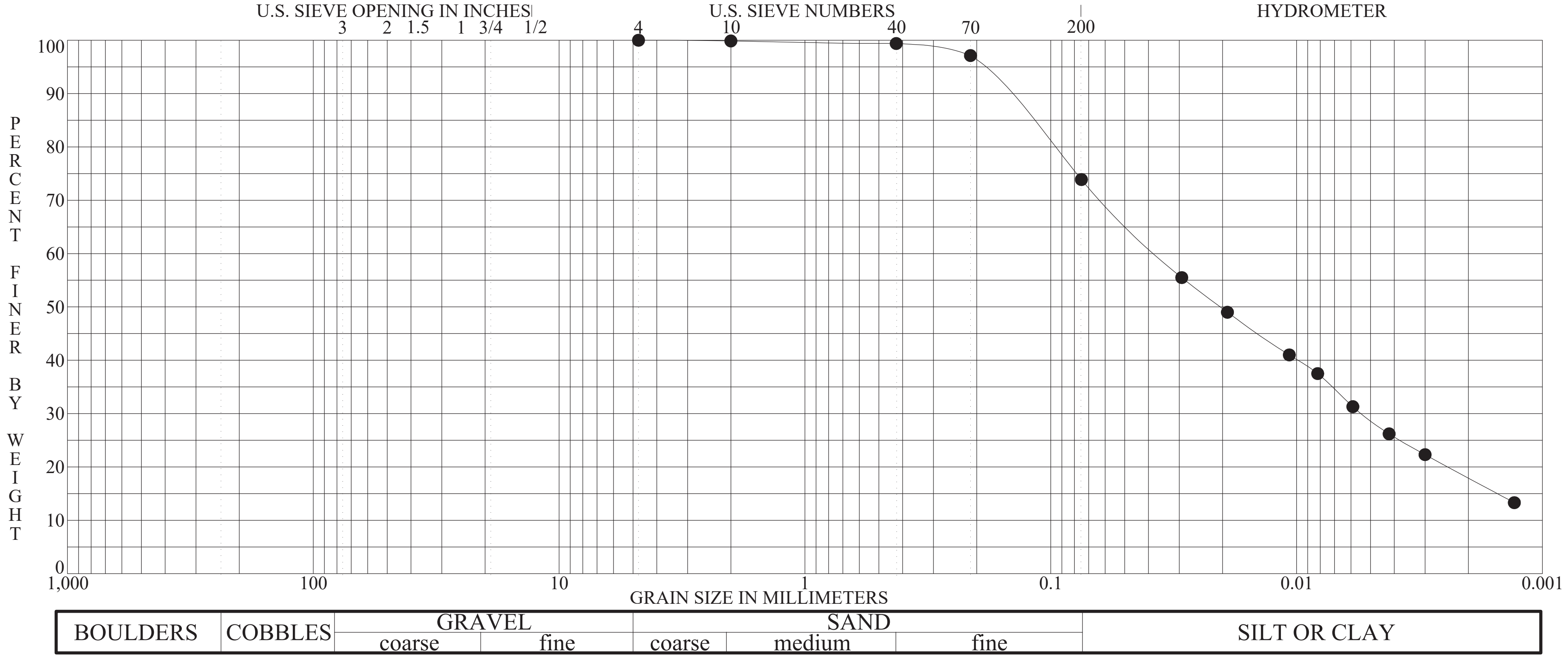
	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0901 S-18 28.5' to 30.0'**	**2.0000**	**0.1279**	**0.0136**	**0.0083**		**0.00**	**9.04**	**63.38**	**27.58**

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

PLATE 12



	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0901 ST-19A II** **31.0' to 32.8'**	**Gray mottled with dark-gray and brown clayey silt, some fine sand, trace medium to coarse sand, few seams and lenses of silty clay and fine sand.** **SILT with SAND ML**	**33**	**35**	**28**	**7**		

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0901 ST-19A II** **31.0' to 32.8'**	**4.7500**	**0.1927**	**0.0369**	**0.0204**		**0.00**	**26.12**	**55.95**	**17.94**

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

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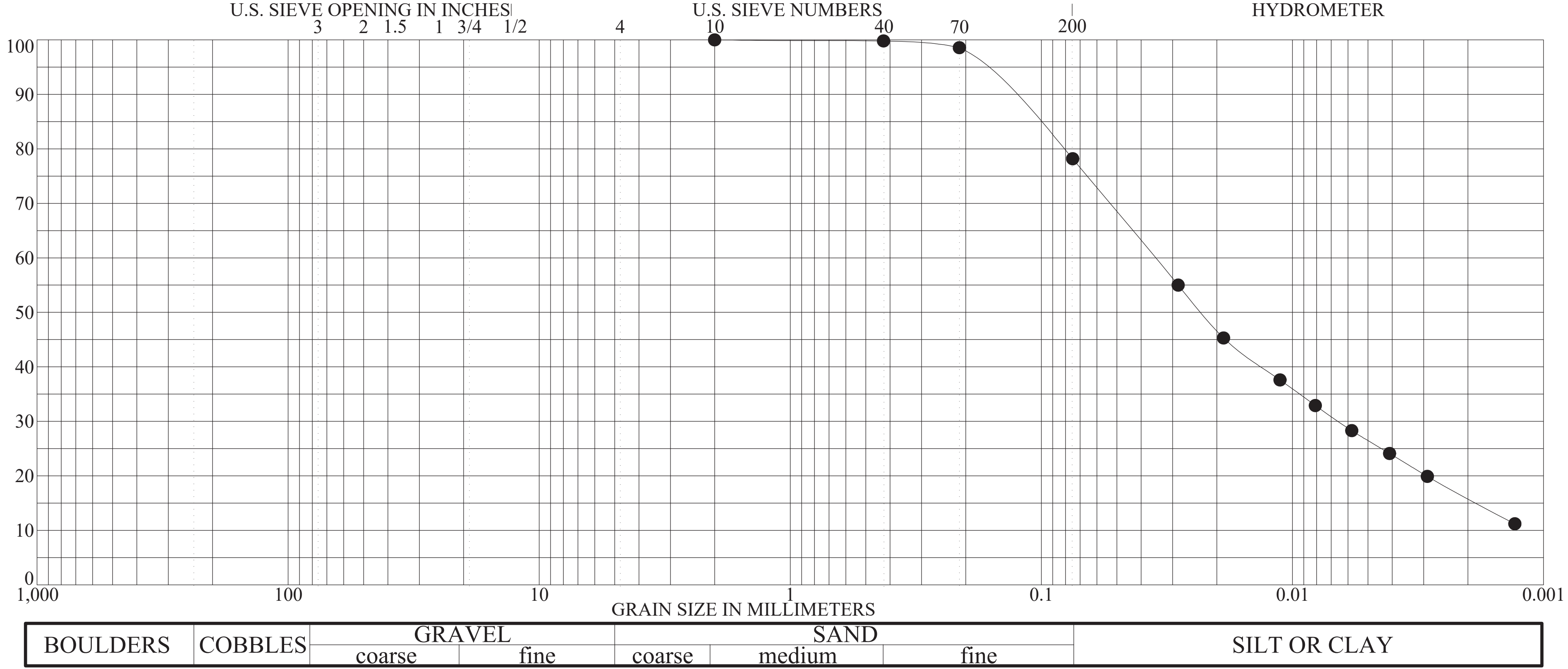

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0901 S-20 33.5' to 35.0'**	**Dark-gray organic clayey silt, some fine sand, trace medium sand.** **ORGANIC SILT with SAND OL**	**42**	**34**	**27**	**7**		

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0901 S-20 33.5' to 35.0'**	**2.0000**	**0.1767**	**0.0351**	**0.0230**		**0.00**	**21.81**	**62.32**	**15.87**

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
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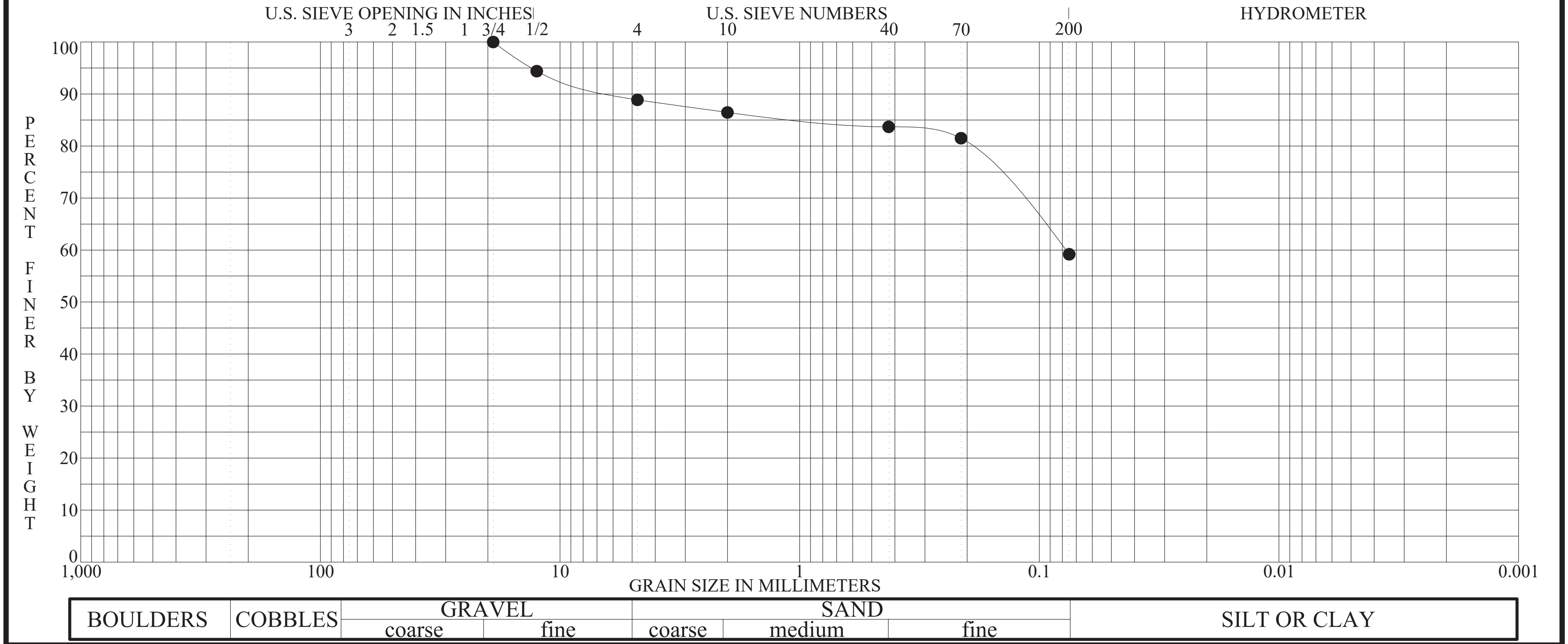

Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-BAP-0901 S-21 36.0' to 37.5'**	**Gray mottled with dark-gray organic clayey silt inter-bedded with organic silt, some fine sand, trace medium to coarse sand, little fine gravel.** **SANDY ORGANIC SILT OL**	**40**	**45**	**29**	**16**		

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-BAP-0901 S-21 36.0' to 37.5'**	**19.0000**	**13.0775**	**0.0779**			**11.11**	**29.71**	**59.18**	

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GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

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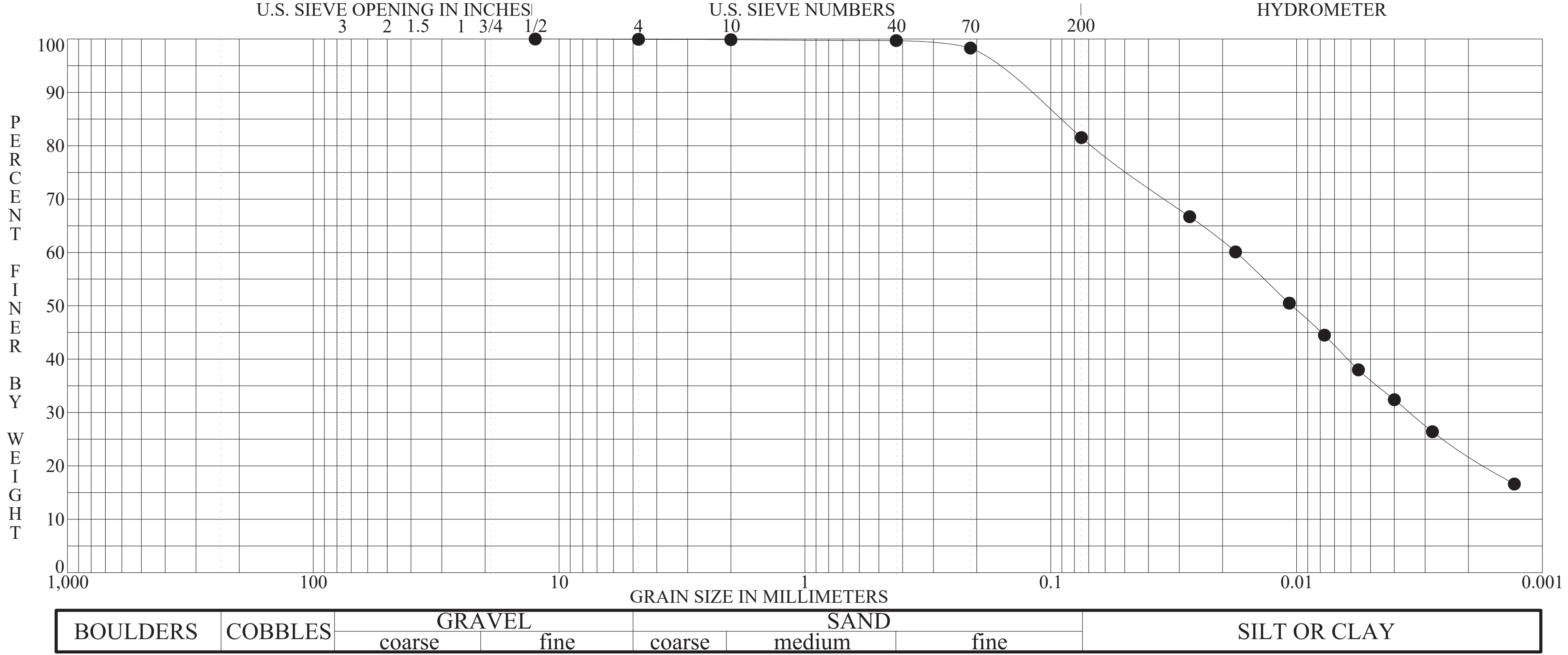

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0901 S-22 38.5' to 40.0'**	**Gray mottled with dark-gray organic clayey silt, little fine sand, trace medium to coarse sand, trace fine gravel, few lenses of fine sand.** **ORGANIC CLAY with SAND OL**	**42**	**40**	**23**	**17**		

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0901 S-22 38.5' to 40.0'**	**12.5000**	**0.1726**	**0.0176**	**0.0104**		**0.05**	**18.42**	**59.43**	**22.10**

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GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
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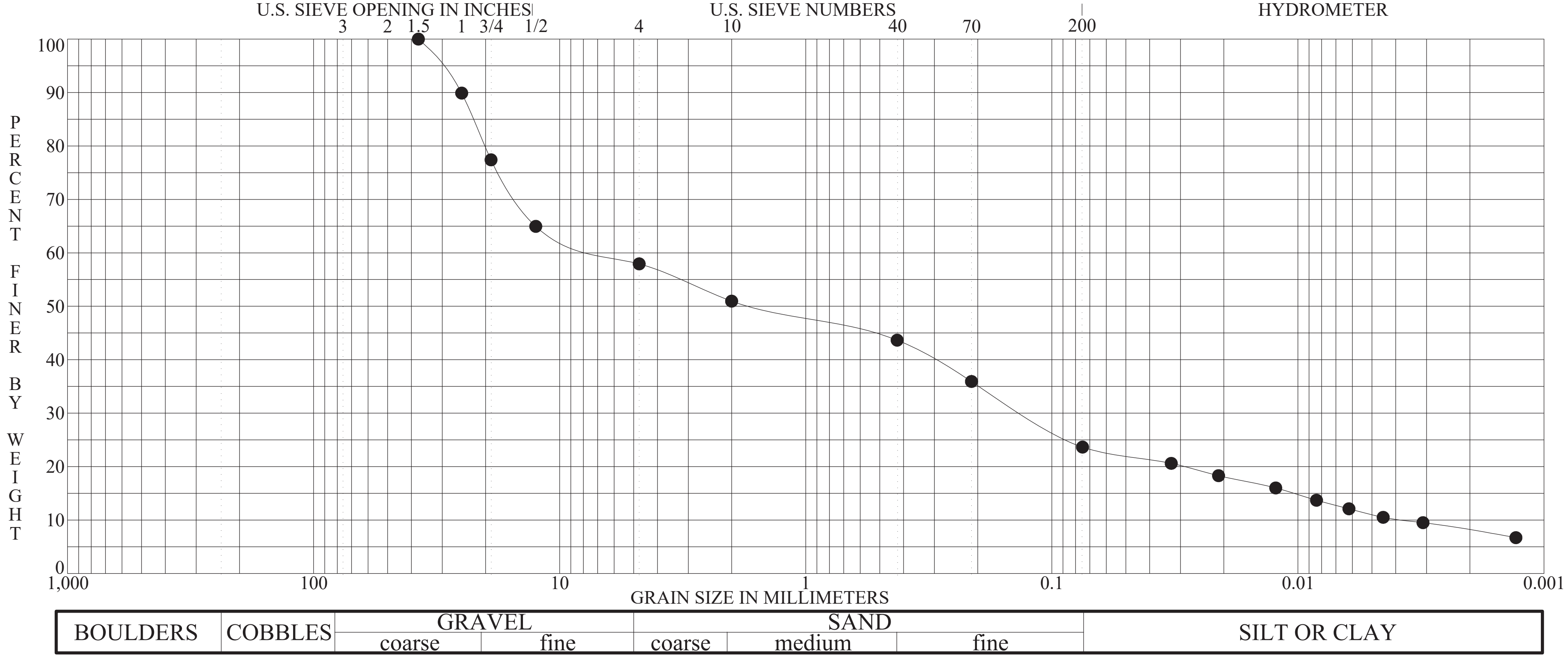

Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-PZ-BAP-0902 S-4 5.5' to 6.6'**	**FILL: Brown and gray fine to coarse gravel(sandstone, siltstone and shale fragments), some fine to coarse sand, some clayey silt.** **CLAYEY GRAVEL with SAND GC**	**13**	**27**	**17**	**10**	**0.699**	**1690.044**

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-PZ-BAP-0902 S-4 5.5' to 6.6'**	**37.5000**	**30.6832**	**6.3123**	**1.6307**	**0.0037**	**42.06**	**34.29**	**15.56**	**8.09**

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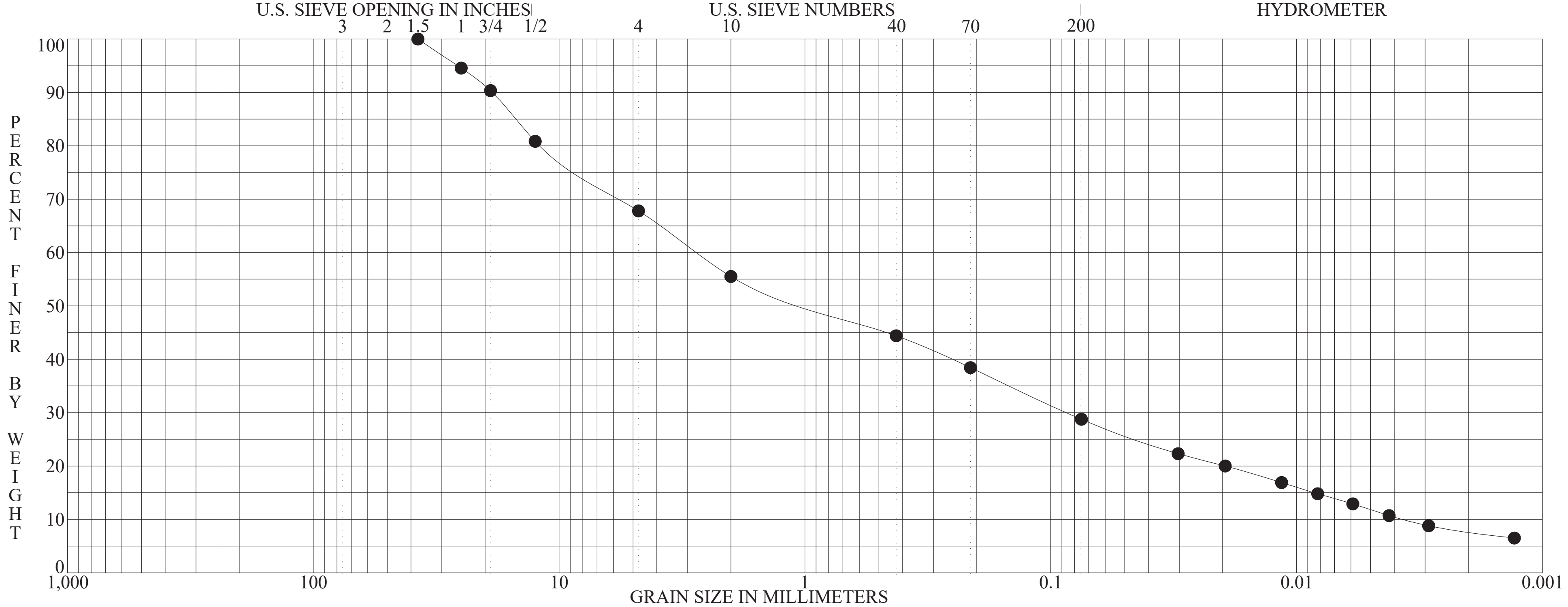
GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

PLATE 17

BBCM



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-PZ-BAP-0902 S-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.** **CLAYEY SAND with GRAVEL SC**	**10**	**26**	**17**	**9**	**0.731**	**748.575**

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-PZ-BAP-0902 S-8 11.5' to 12.6'**	**37.5000**	**25.8279**	**2.7430**	**0.9275**	**0.0037**	**32.20**	**39.04**	**21.02**	**7.73**

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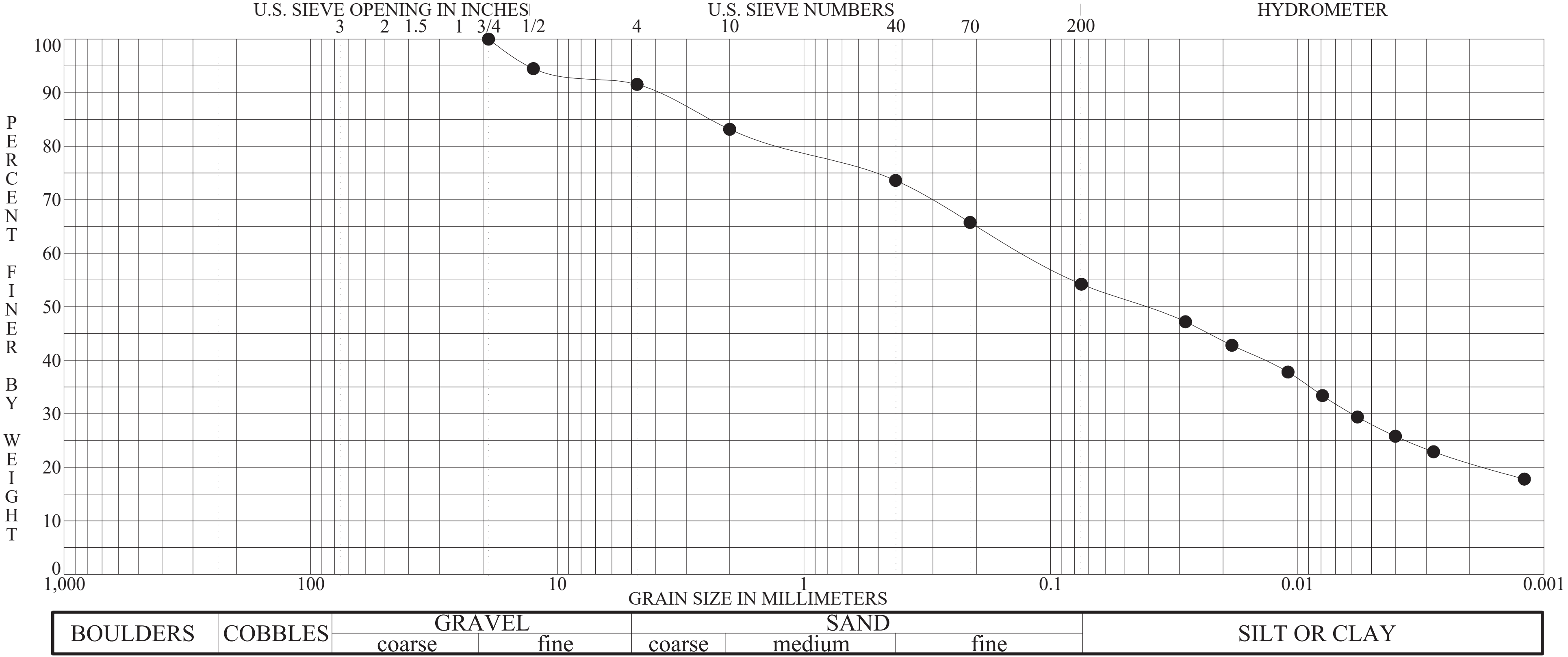
GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09



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).** **SANDY LEAN CLAY CL**	**21**	**35**	**17**	**18**		

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-PZ-BAP-0902 S-12 17.5' to 18.1'**	**19.0000**	**12.9863**	**0.1263**	**0.0418**		**8.45**	**37.34**	**33.34**	**20.87**

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GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
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JOB NO. 011-11497-013 **DATE** 7/6/09

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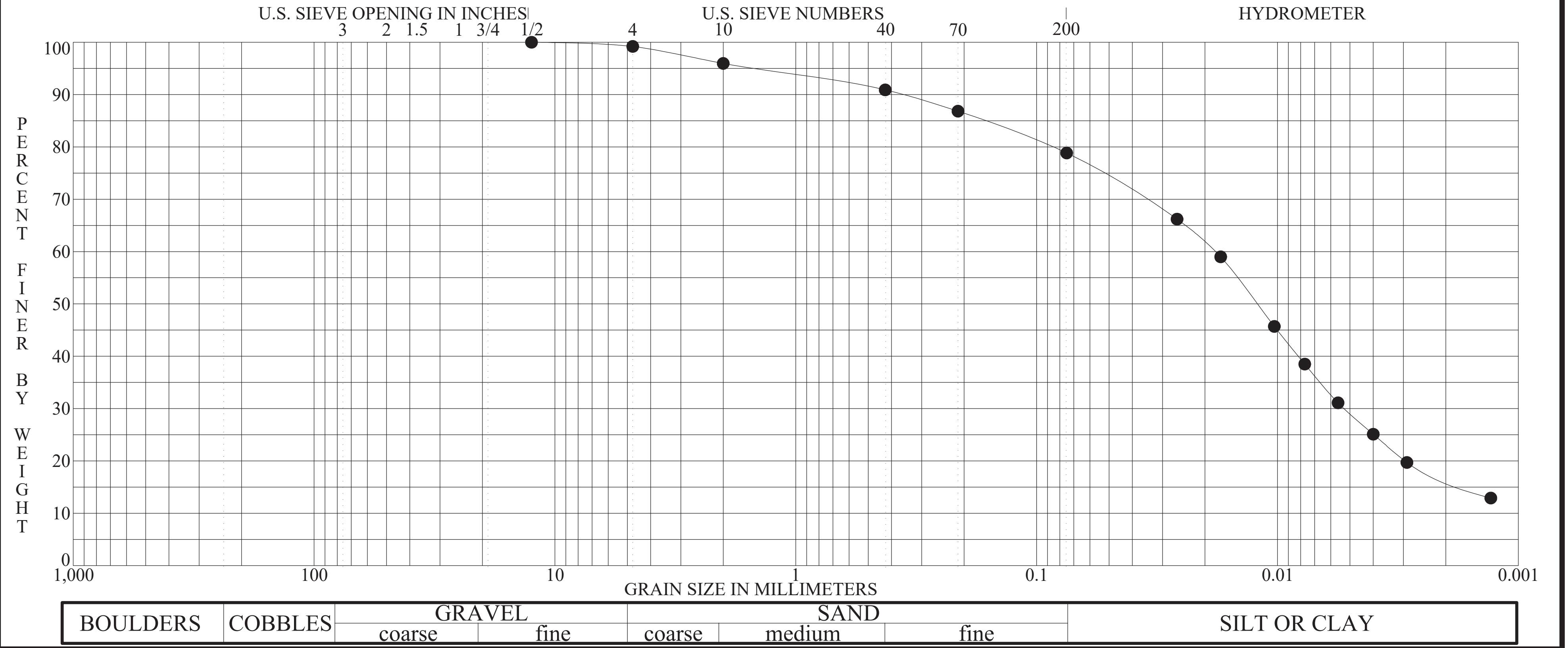

Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-PZ-BAP-0902 S-13 19.0' to 19.3'**	**FILL: Gray and brown silty clay, litle fine to coarse sand, trace fine gravel(shale fragments).** **LEAN CLAY with SAND CL**	**31**	**29**	**17**	**12**		

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-PZ-BAP-0902 S-13 19.0' to 19.3'**	**12.5000**	**1.4898**	**0.0182**	**0.0122**		**0.79**	**20.36**	**62.29**	**16.55**

ASTM D422

GRADATION CURVE

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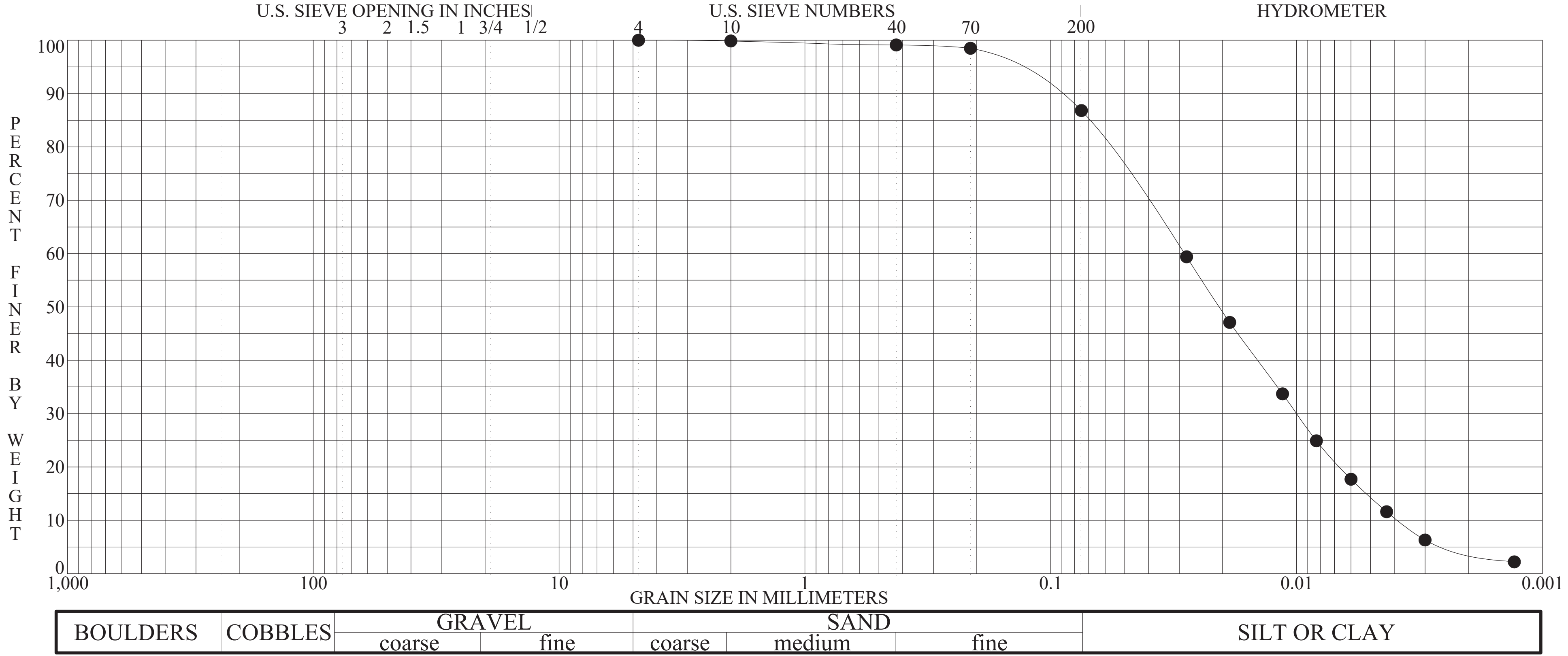

Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-PZ-BAP-0902 S-14 20.5' to 22.0'**	**Gray and dark-gray silt, trace clay, little fine to coarse sand.**	**26**	**NP**	**NP**	**NP**	**0.902**	**7.417**
	SILT ML						

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**

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GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
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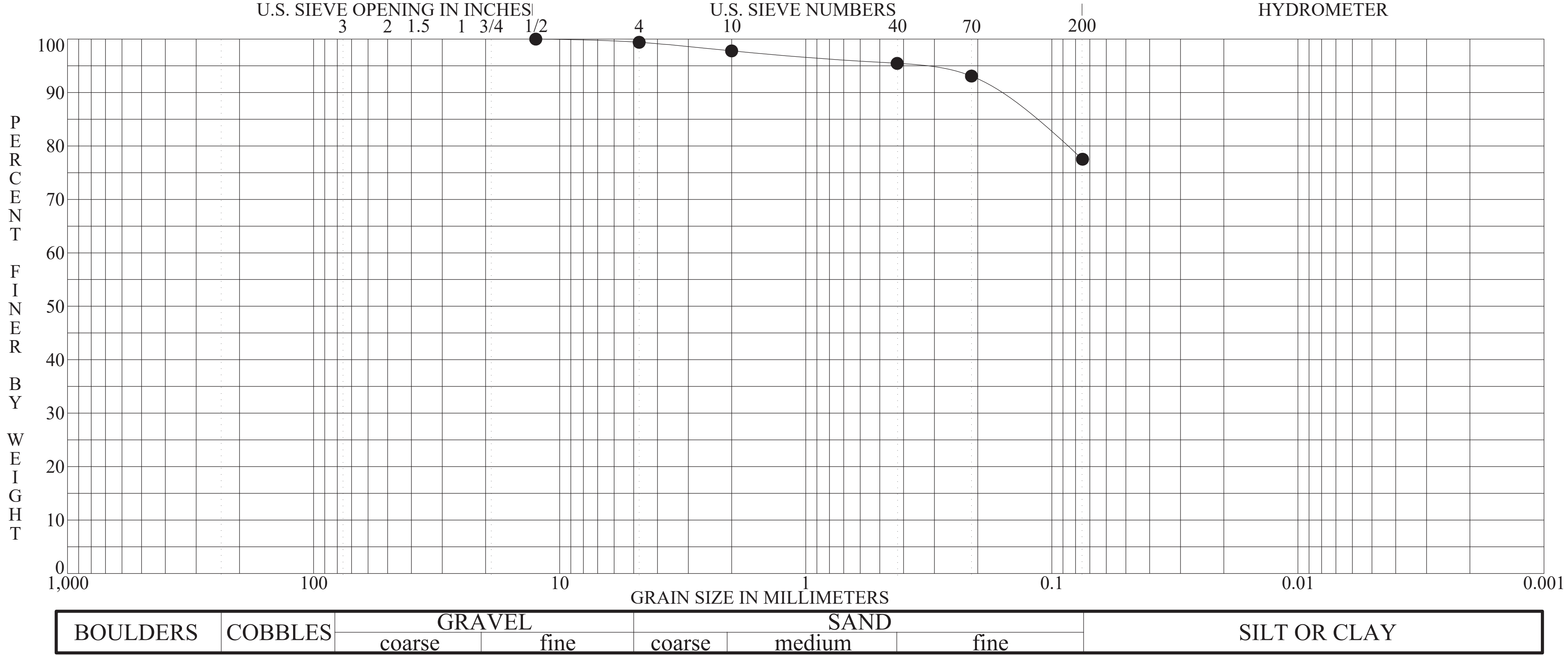

Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-PZ-BAP-0902 S-15 22.0' to 22.8'**	**Gray and dark-gray silt, some clay, little fine sand, trace medium to coarse sand, trace fine gravel.**						

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**	

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GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
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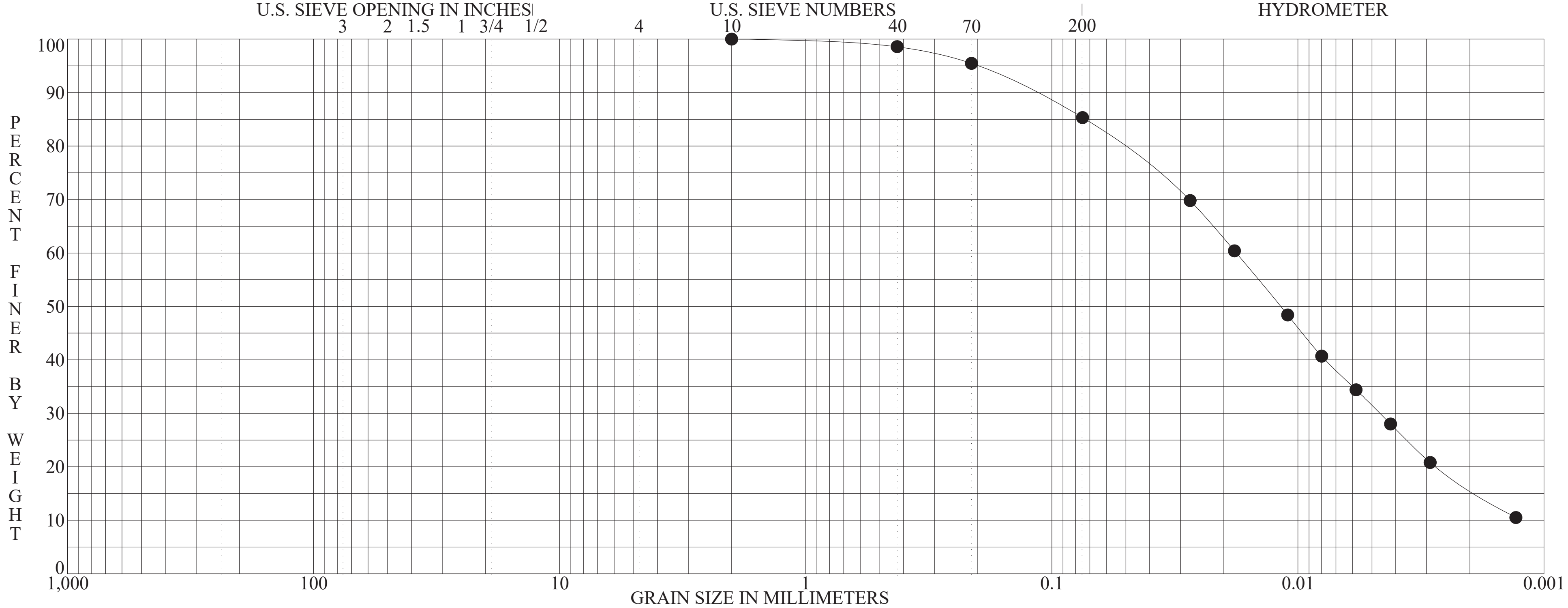

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-PZ-BAP-0902 S-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**

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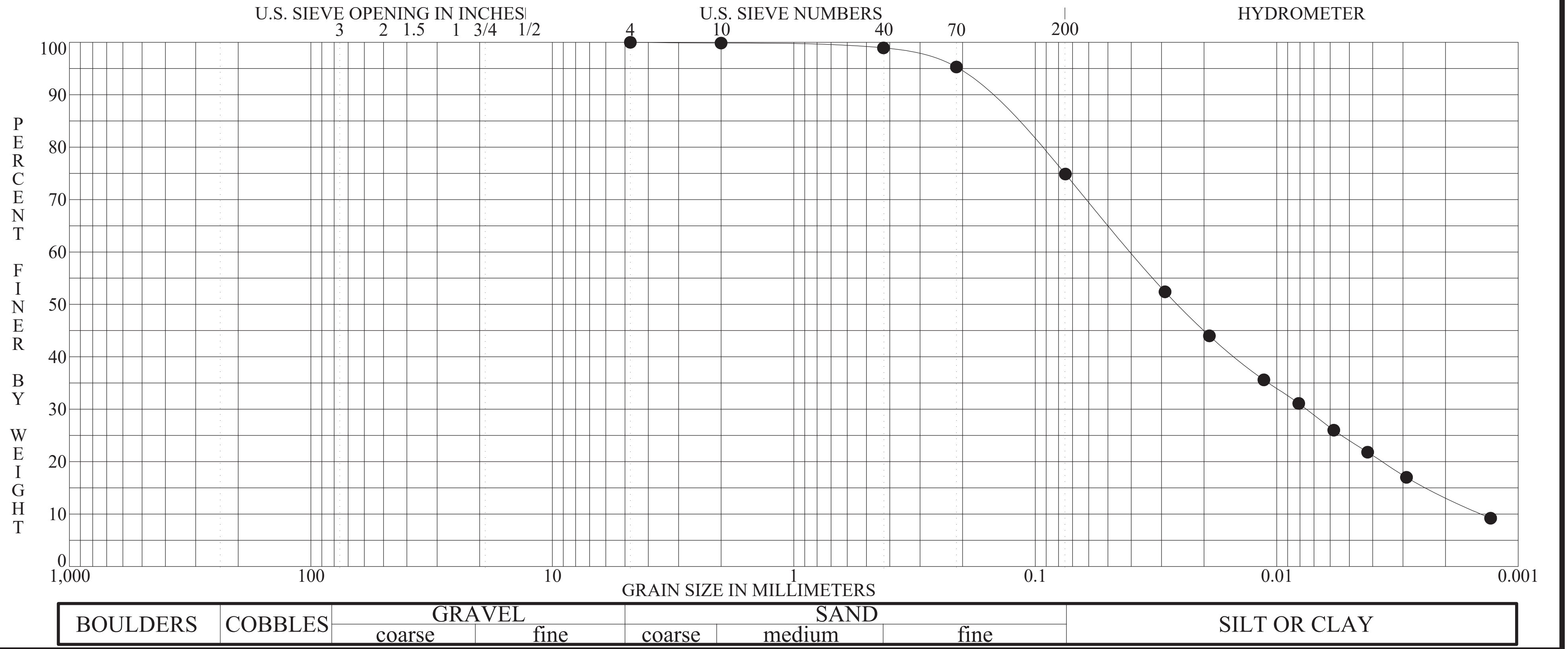

Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-PZ-BAP-0902 S-19 28.0' to 29.5'**	**Gray mottled with dark-gray organic silt, little clay, some fine sand, trace medium to coarse sand.** **ORGANIC SILT with SAND OL**	**43**	**NP**	**NP**	**NP**	**1.006**	**28.333**

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-PZ-BAP-0902 S-19 28.0' to 29.5'**	**4.7500**	**0.2088**	**0.0400**	**0.0257**	**0.0014**	**0.00**	**25.13**	**61.48**	**13.39**

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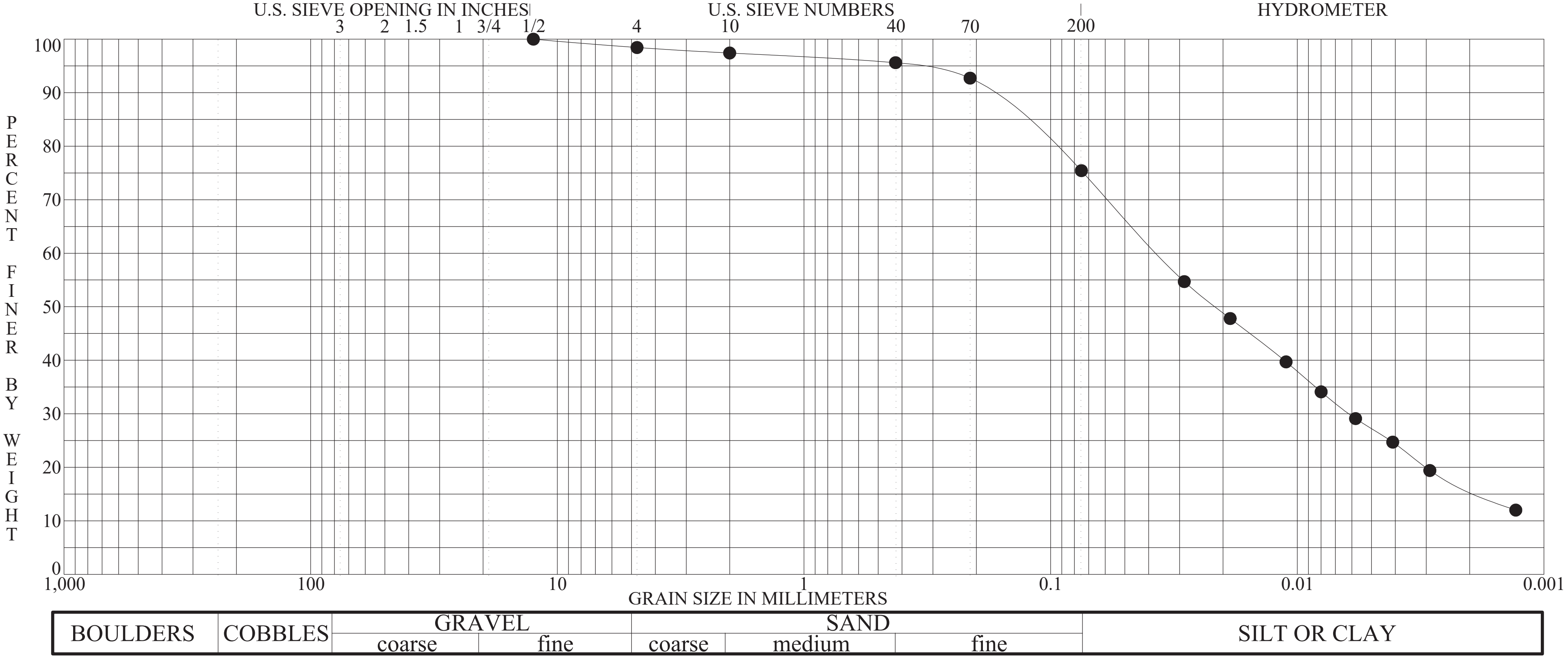

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-PZ-BAP-0902 S-20 31.5' to 32.6'**	**Gray mottled with dark-gray organic clayey silt, some fine to medium sand, trace coarse sand, trace fine gravel.** **ORGANIC SILT with SAND OL**	**38**	**36**	**28**	**8**		

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-PZ-BAP-0902 S-20 31.5' to 32.6'**	**12.5000**	**0.3667**	**0.0367**	**0.0214**		**1.56**	**23.01**	**59.45**	**15.97**

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GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
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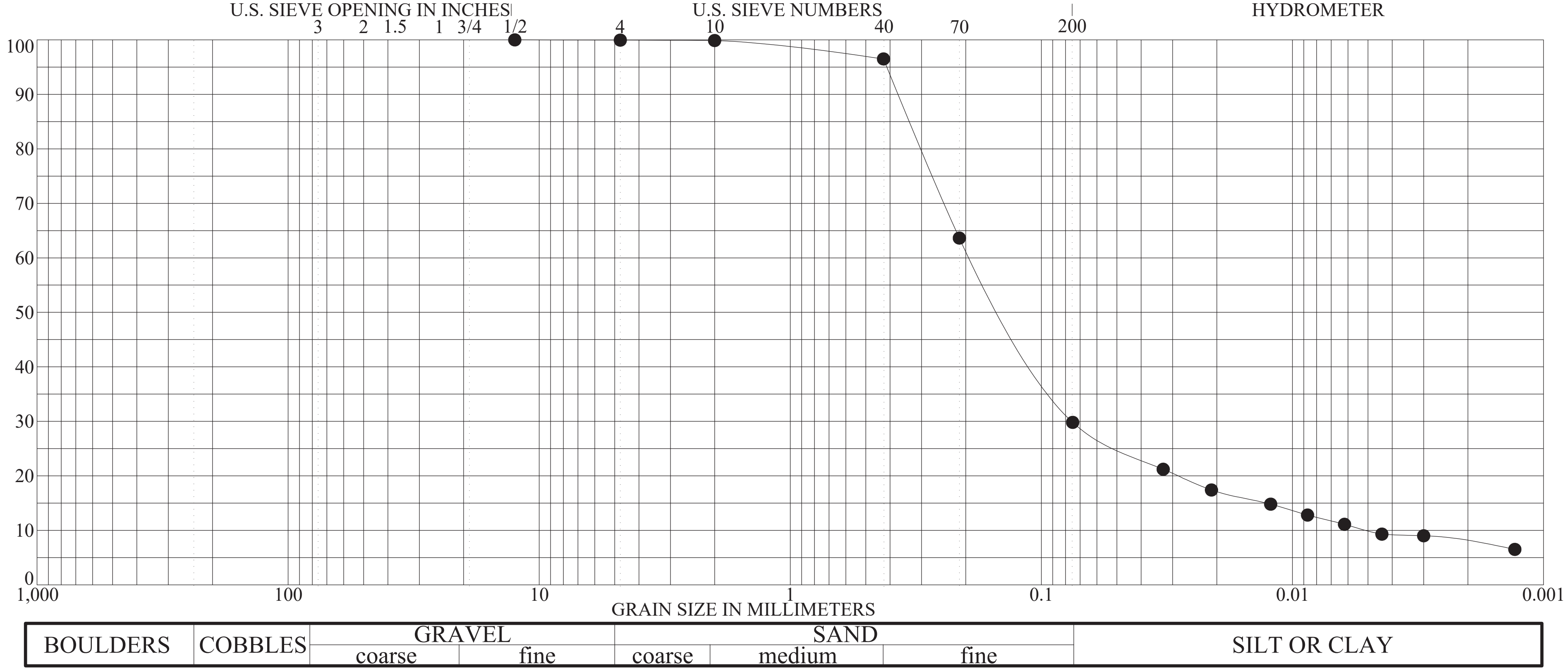

Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-PZ-BAP-0902 S-22 36.5' to 37.6'**	**Brown fine sand, trace medium to coarse sand, trace fine gravel, some silt, trace clay.**	**22**				**5.969**	**37.720**

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**

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GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
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PLATE 26

GRN-EPA W/ASTM-BBCM

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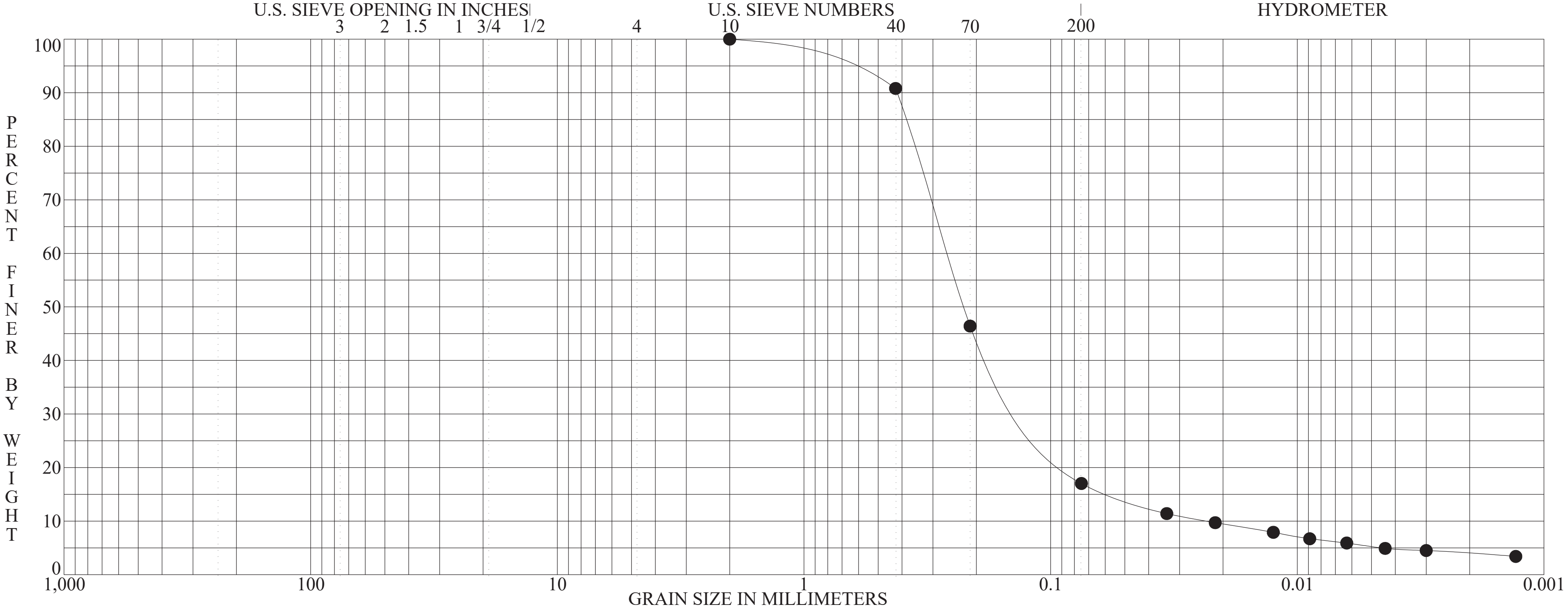

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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**

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PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
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PLATE 27

GRN-EPA W/ASTM-BBCM

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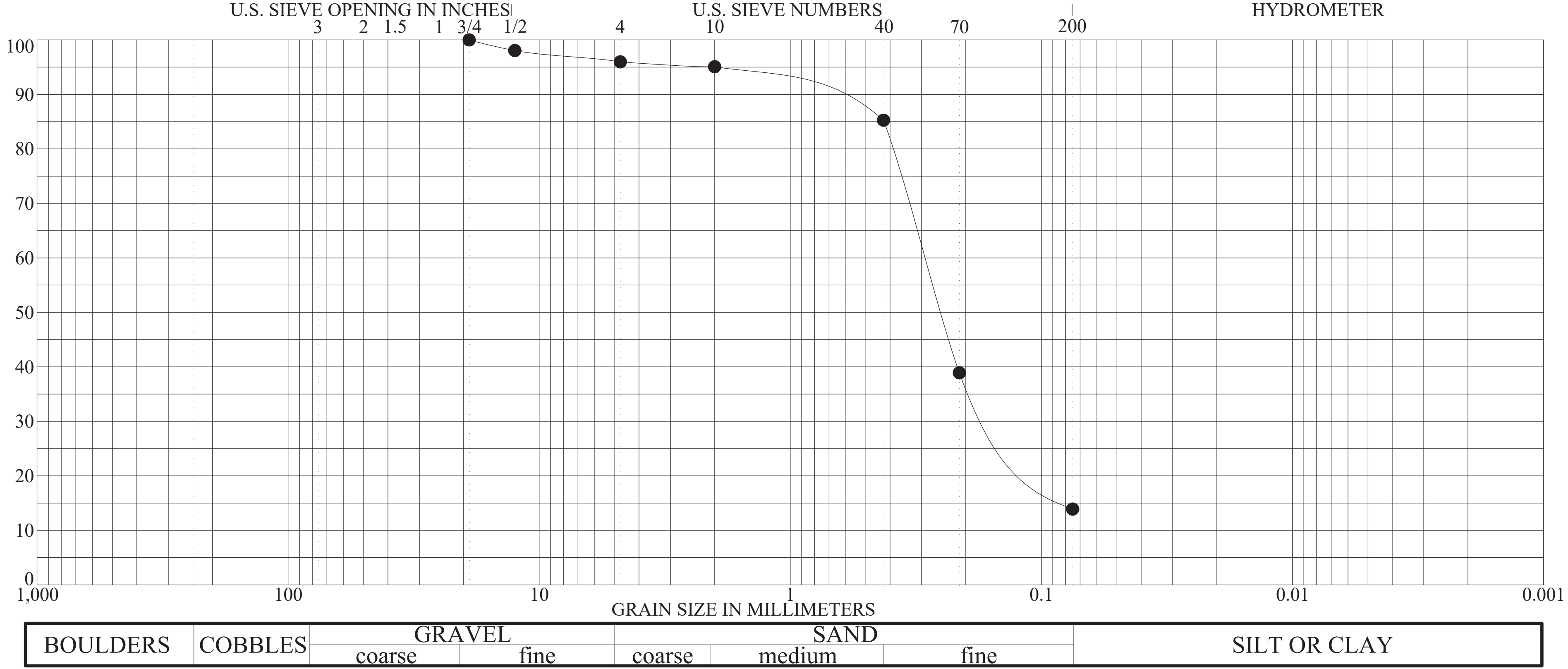

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-PZ-BAP-0902 S-24 41.5' to 43.0'**	**Brown fine to medium sand, trace coarse sand, trace silt.**						

	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**	

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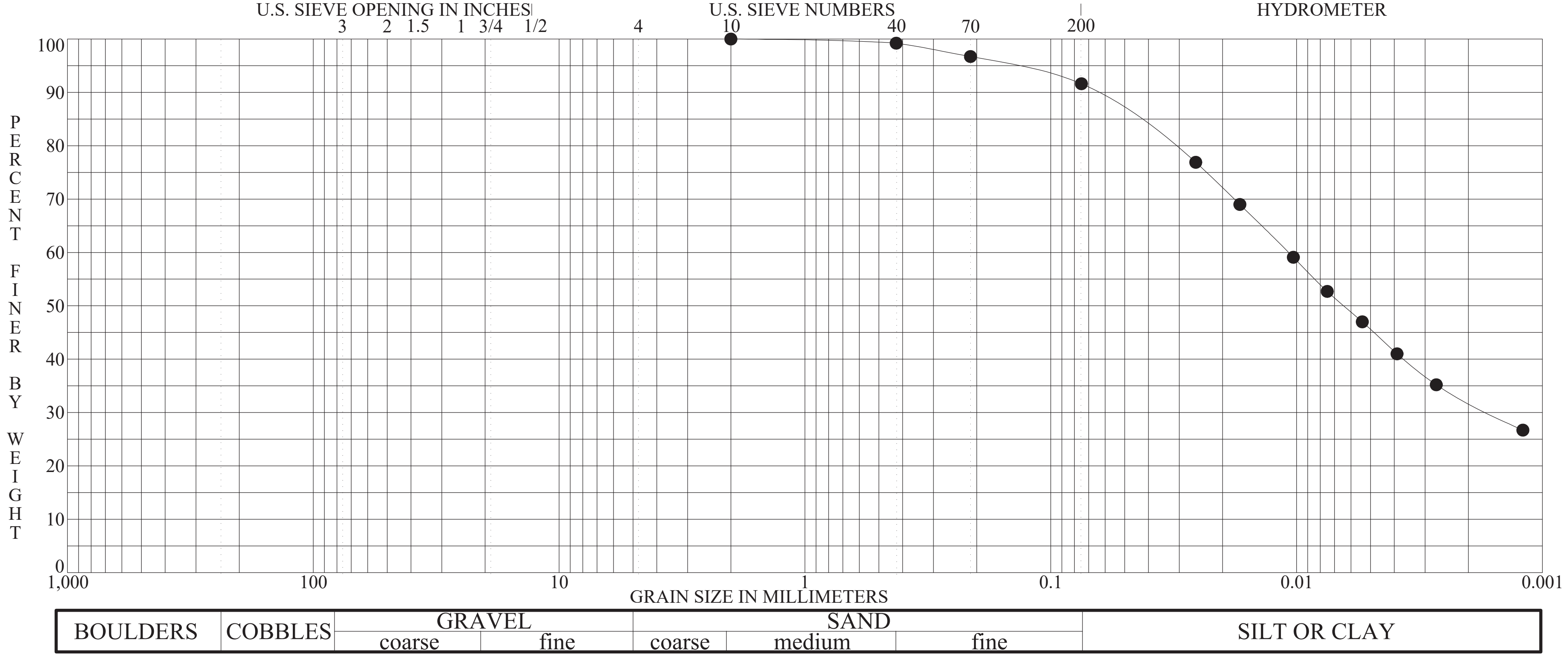
GRADATION CURVE

PROJECT **CARDINAL PLANT ASH POND INVESTIGATION**
LOCATION **BRILLIANT, OHIO**
JOB NO. **011-11497-013** **DATE** **7/6/09**



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.** **LEAN CLAY CL**	**24**	**48**	**24**	**24**		

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-BAP-0903 S-2 2.5' to 3.3'**	**2.0000**	**0.1492**	**0.0108**	**0.0064**		**0.00**	**8.37**	**59.57**	**32.05**

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GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
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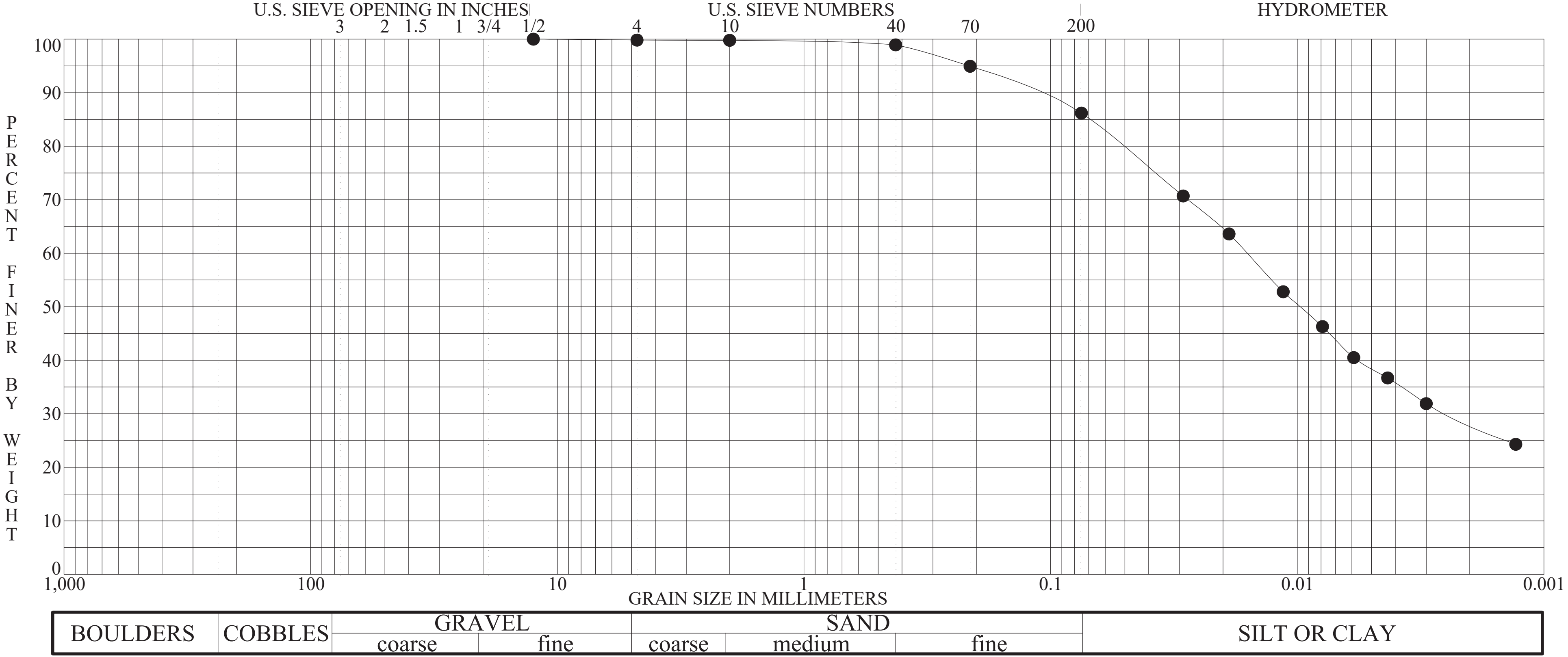


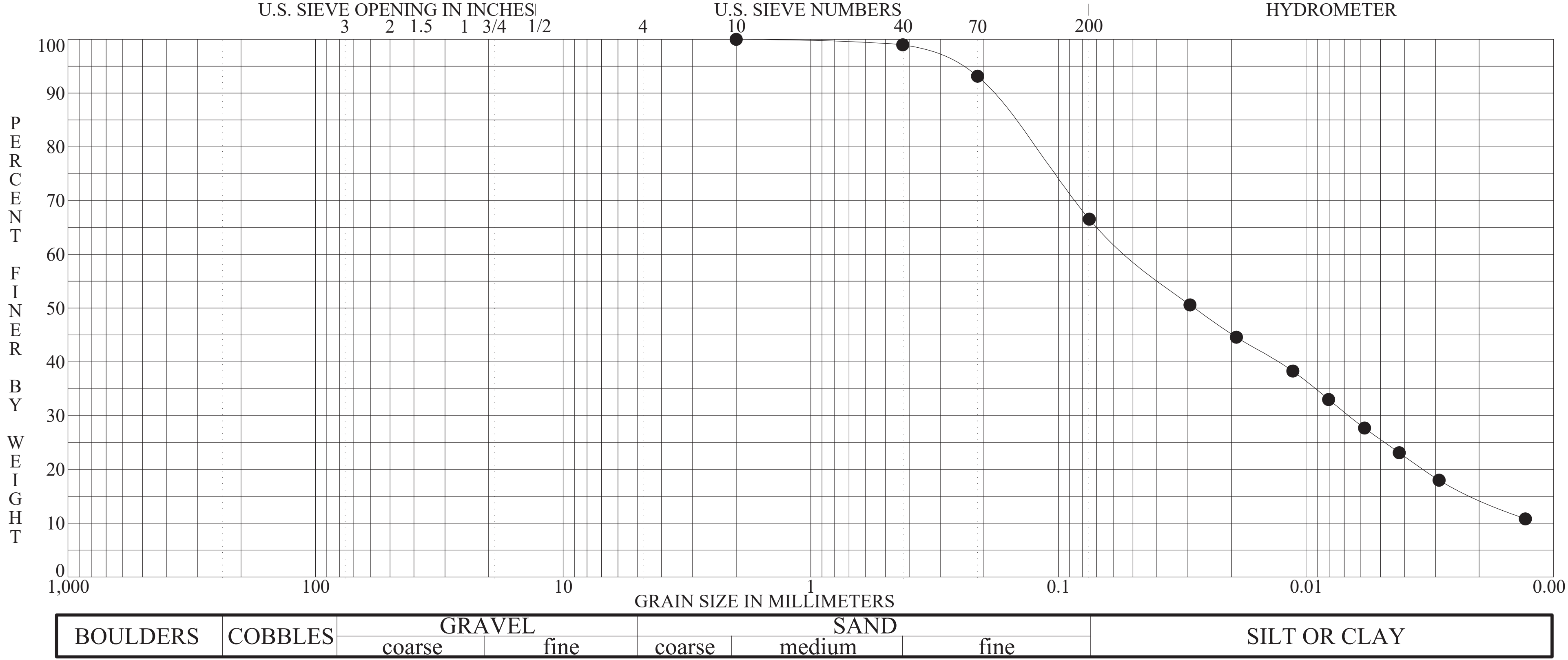
Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-BAP-0903 S-5 7.0' to 8.0'**	**FILL: Brown mottled with dark-brown and gray silty clay, little fine to coarse sand, trace fine gravel, few lenses of organic silt.** **LEAN CLAY CL**	**20**	**36**	**20**	**16**		

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-BAP-0903 S-5 7.0' to 8.0'**	**12.5000**	**0.2141**	**0.0160**	**0.0097**		**0.17**	**13.64**	**57.97**	**28.22**

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09



Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● CD-BAP-0903 S-6 8.5' to 9.5'	**Dark-gray organic silt, little clay, some fine sand, trace medium sand, few lenses of fine sand.**	**49**	**41**	**38**	**3**		
	SANDY ORGANIC SILT OL						

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● CD-BAP-0903 S-6 8.5' to 9.5'	**2.0000**	**0.2643**	**0.0510**	**0.0282**		**0.00**	**33.45**	**51.89**	**14.67**

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

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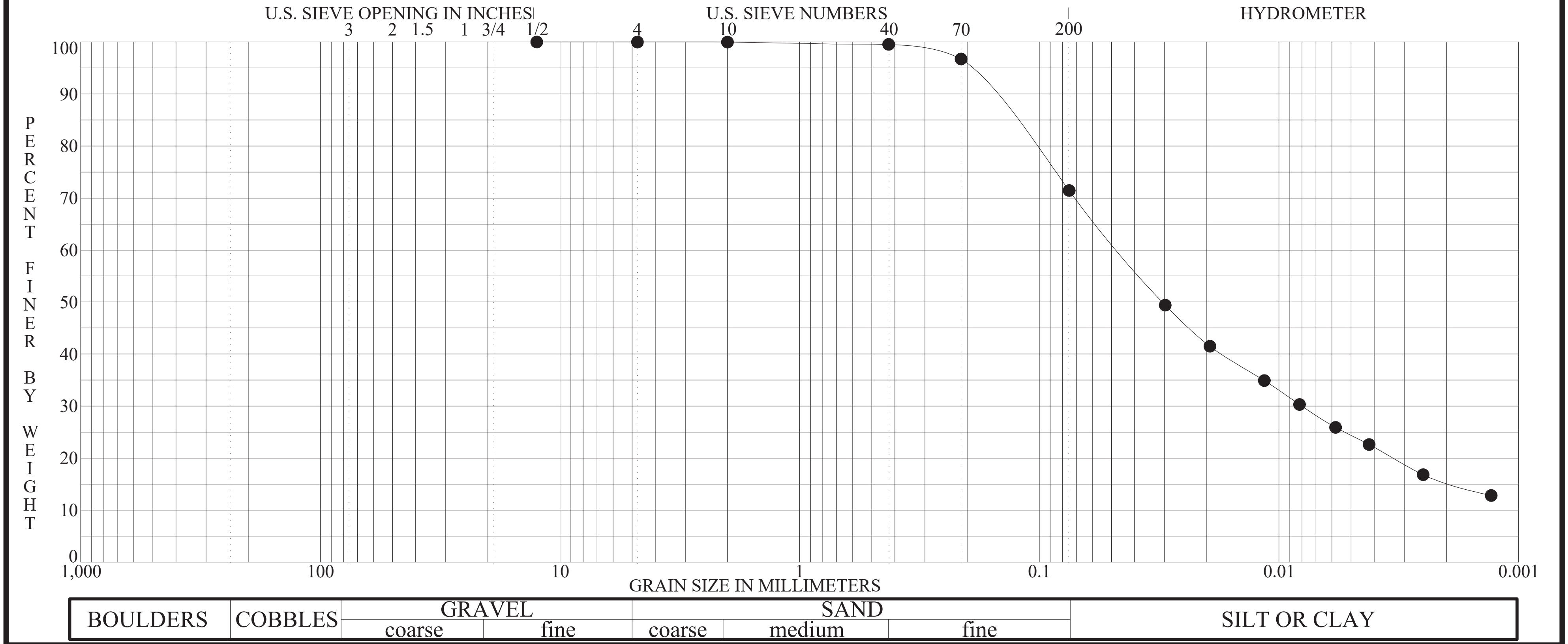

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0903 S-7 13.5' to 14.5'**	**Gray mottled with dark-gray organic silt inter-bedded with organic clayey silt, some fine sand, trace medium to coarse sand, trace fine gravel.** **ORGANIC SILT with SAND OL**	**43**	**NP**	**NP**	**NP**		

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0903 S-7 13.5' to 14.5'**	**12.5000**	**0.1974**	**0.0464**	**0.0306**		**0.01**	**28.55**	**56.01**	**15.44**

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

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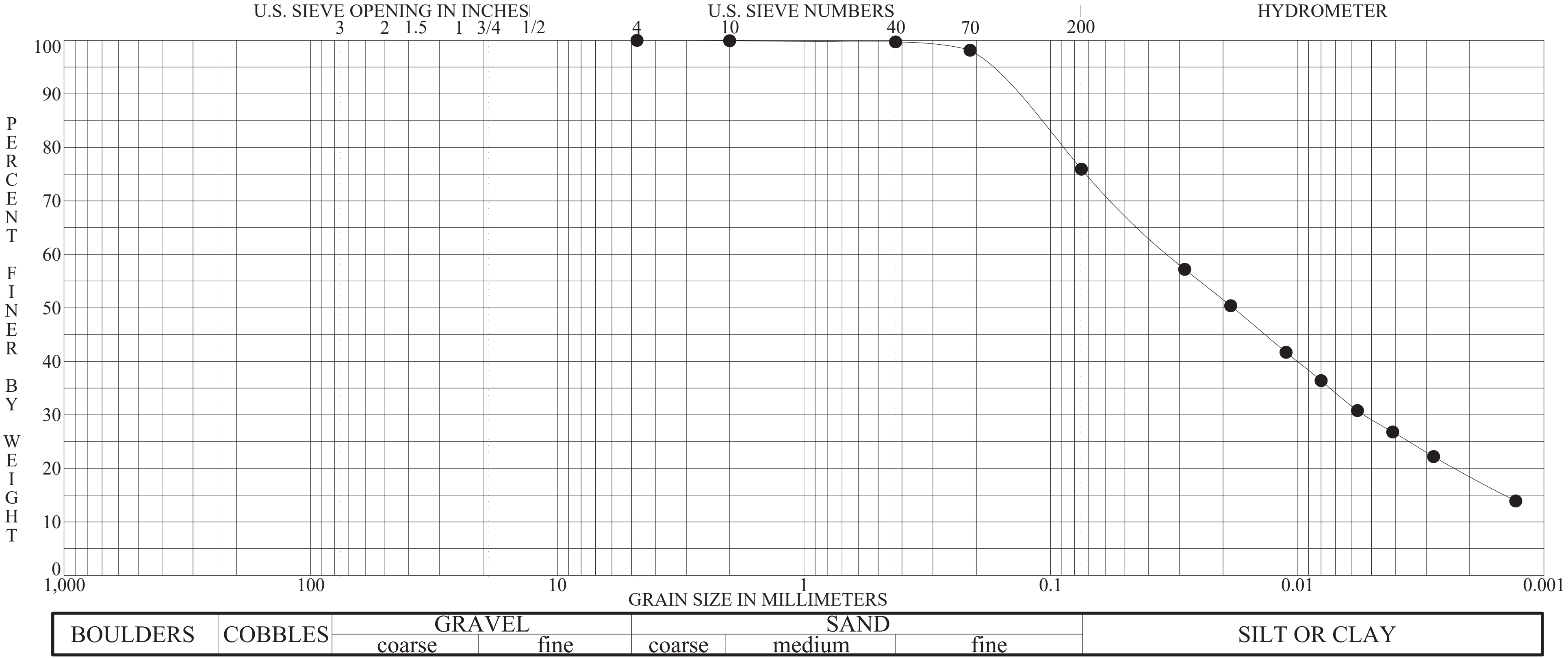


Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-BAP-0903 S-8 16.0' to 17.0'**	**Gray mottled with dark-gray organic clayey silt, some fine sand, trace medium to coarse sand, few seams of silt and fine sand.** **ORGANIC CLAY with SAND OL**	**43**	**37**	**24**	**13**		

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-BAP-0903 S-8 16.0' to 17.0'**	**4.7500**	**0.1829**	**0.0330**	**0.0182**		**0.00**	**24.07**	**57.37**	**18.56**

ASTM D422

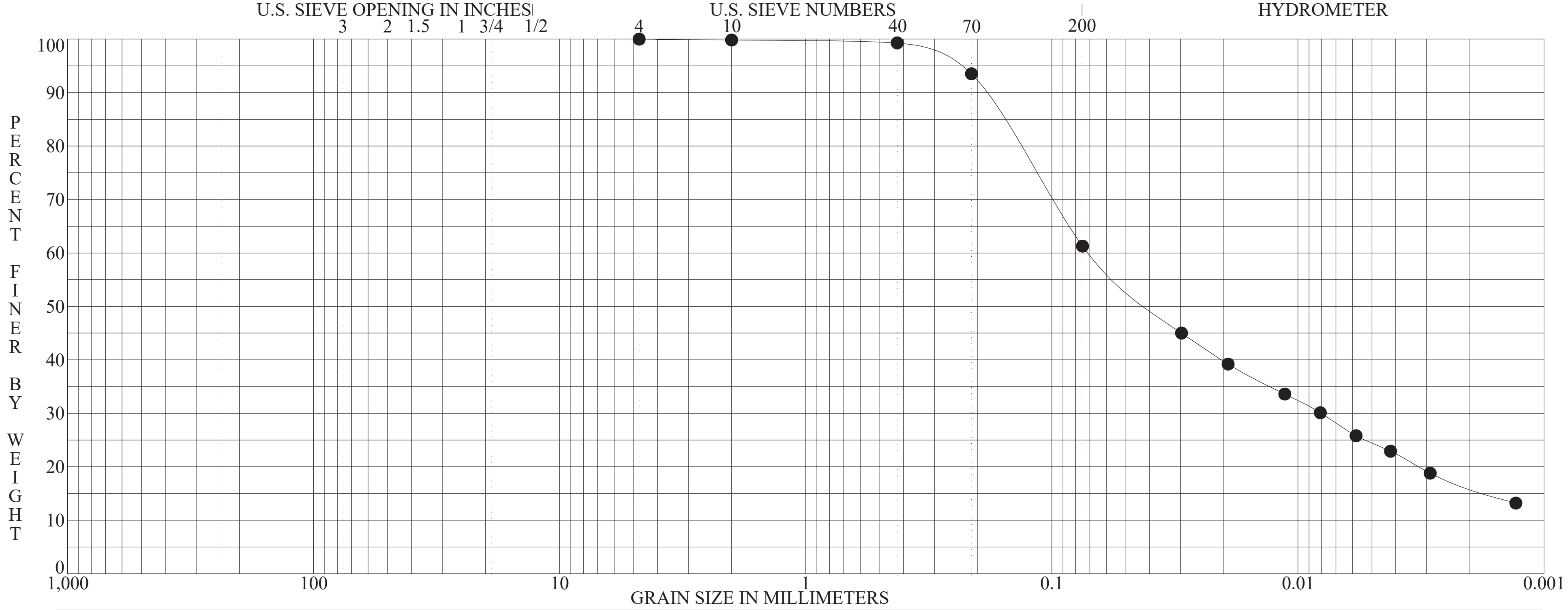
GRADATION CURVE

PROJECT **CARDINAL PLANT ASH POND INVESTIGATION**
LOCATION **BRILLIANT, OHIO**
JOB NO. **011-11497-013** **DATE** **7/6/09**

PLATE 33

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-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.** **SANDY ORGANIC CLAY OL**	**44**	**35**	**24**	**11**		

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-BAP-0903 S-9 18.5' to 19.6'**	**4.7500**	**0.2536**	**0.0697**	**0.0395**		**0.00**	**38.72**	**45.07**	**16.21**

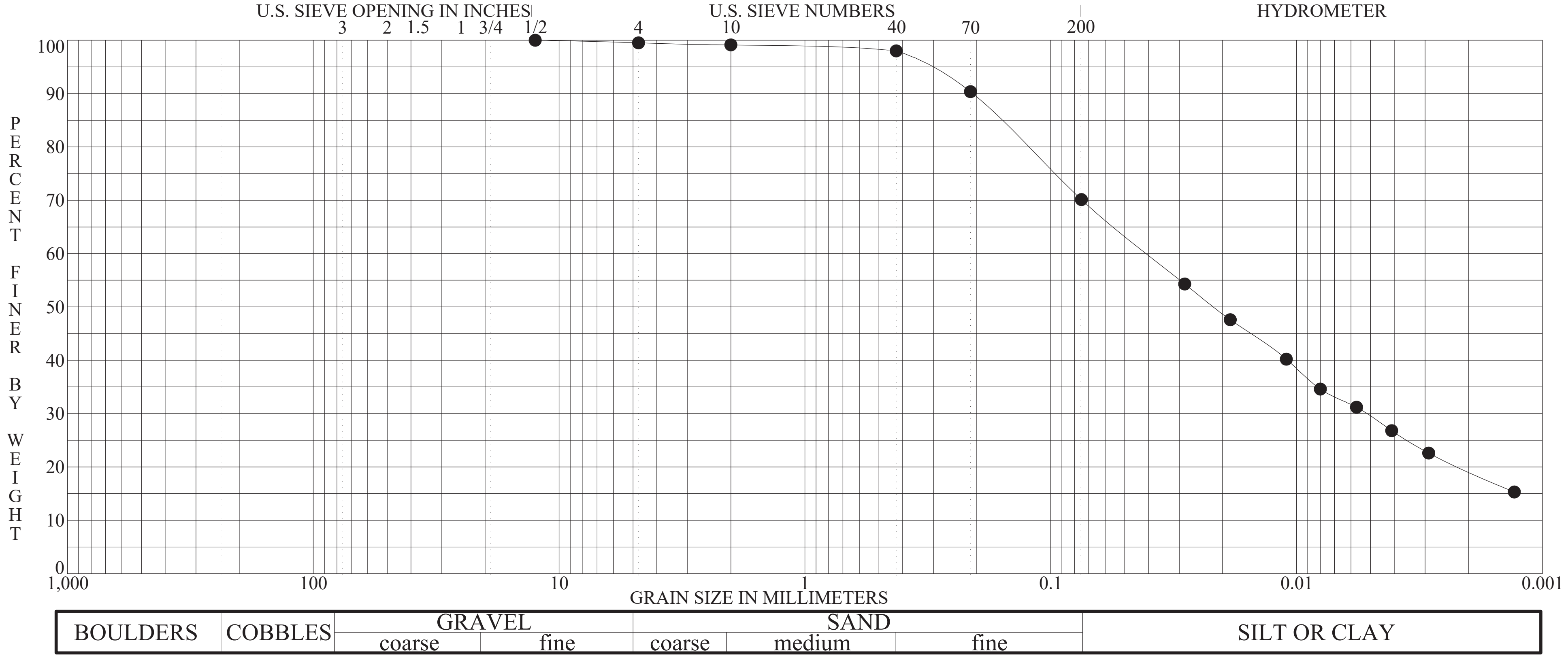
ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

PLATE 34

BBCM



	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0903 S-10 21.0' to 21.9'**	**Gray silty clay inter-bedded with silt, some fine sand, trace medium to coarse sand, trace fine gravel, few seams of fine sand.** **LEAN CLAY with SAND CL**	**35**	**34**	**21**	**13**		

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0903 S-10 21.0' to 21.9'**	**12.5000**	**0.3233**	**0.0404**	**0.0217**		**0.48**	**29.39**	**50.91**	**19.22**

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

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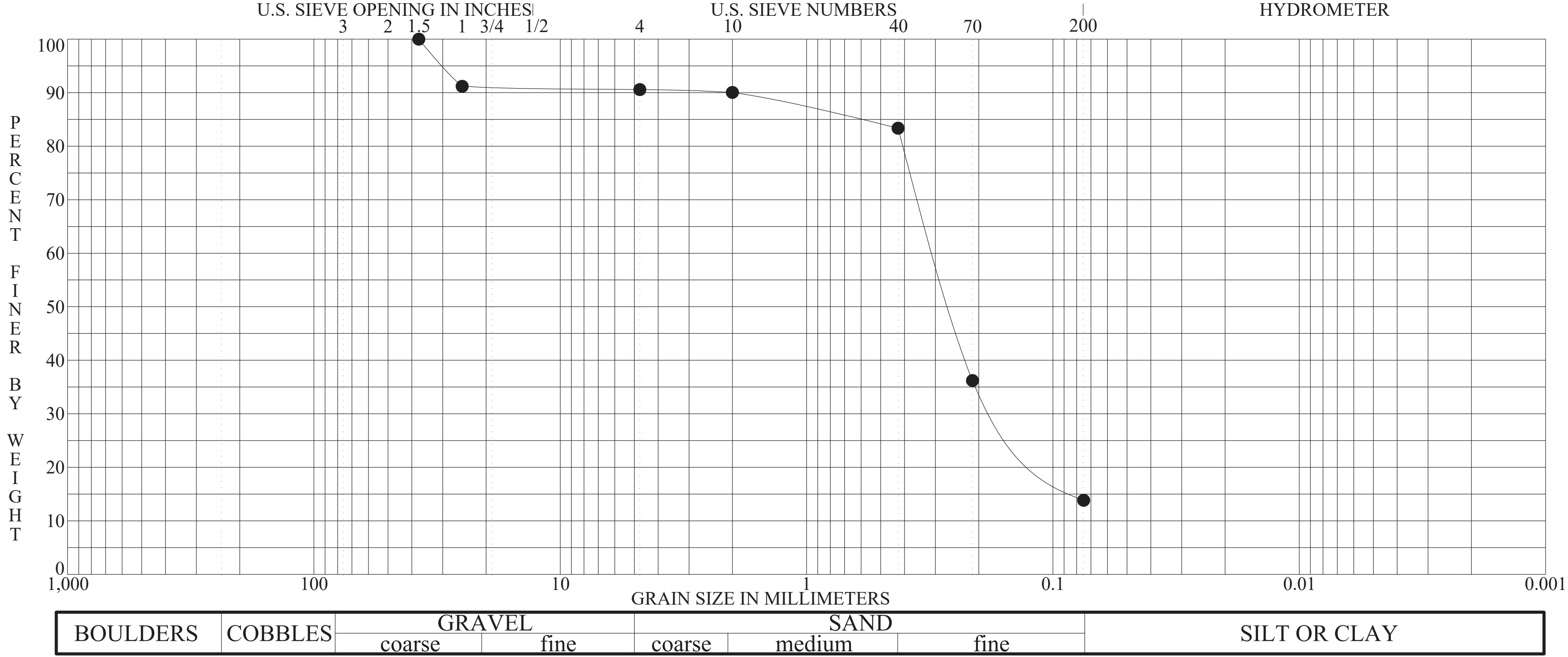

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0903 S-11 23.5' to 24.2'**	**Brown and gray fine sand, trace medium to coarse sand, trace fine to coarse gravel, little silt, few seams of silty clay.**						

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0903 S-11 23.5' to 24.2'**	**37.5000**	**29.7874**	**0.3011**	**0.2598**		**9.42**	**76.74**	**13.84**	

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

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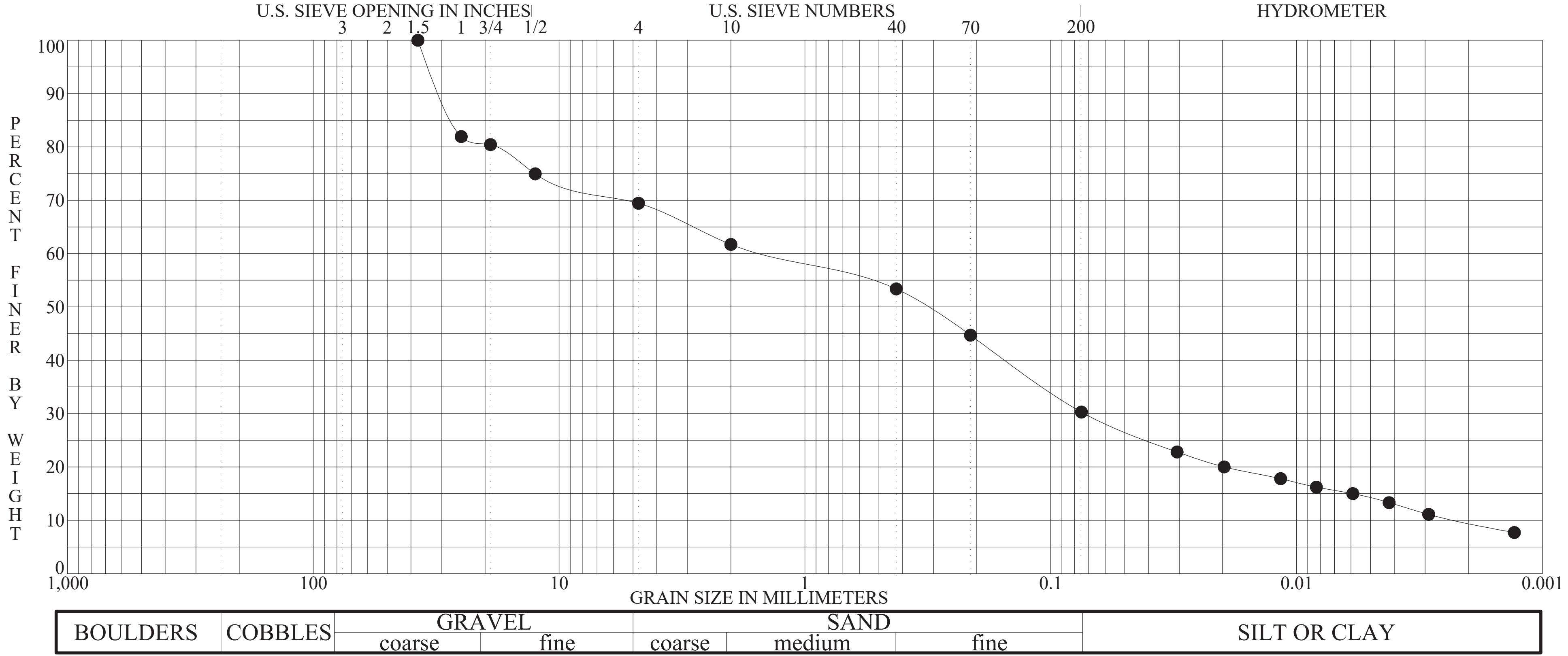

Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-PZ-BAP-0904 S-6 8.5' to 9.7'**	**FILL: Brown and gray fine to coarse sand, some fine to coarse gravel(sandstone, siltstone and shale fragments), some clayey silt.** **CLAYEY SAND with GRAVEL SC**	**14**	**25**	**16**	**9**	**1.616**	**650.322**

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-PZ-BAP-0904 S-6 8.5' to 9.7'**	**37.5000**	**33.5189**	**1.4548**	**0.3242**	**0.0022**	**30.57**	**39.15**	**20.76**	**9.53**

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013
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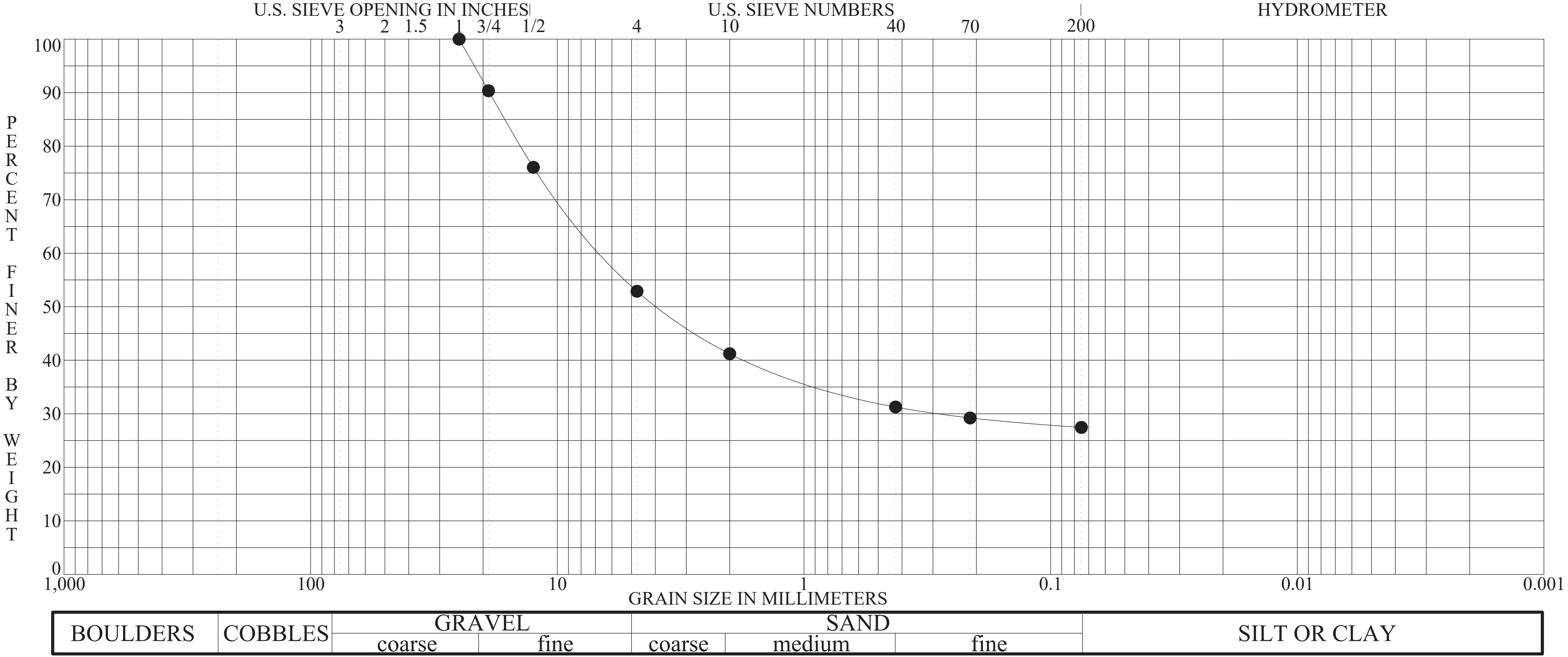

Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-PZ-BAP-0904 S-11 16.0' to 16.9'**	**FILL: Brown and gray fine to coarse gravel(very-soft shale fragments), some fine to coarse sand, some silty clay.**						

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-PZ-BAP-0904 S-11 16.0' to 16.9'**	**25.0000**	**21.6832**	**6.3914**	**3.8325**		**47.10**	**25.44**	**27.45**	

ASTM D422

GRADATION CURVE

PROJECT **CARDINAL PLANT ASH POND INVESTIGATION**
LOCATION **BRILLIANT, OHIO**
JOB NO. **011-11497-013** **DATE** **7/6/09**

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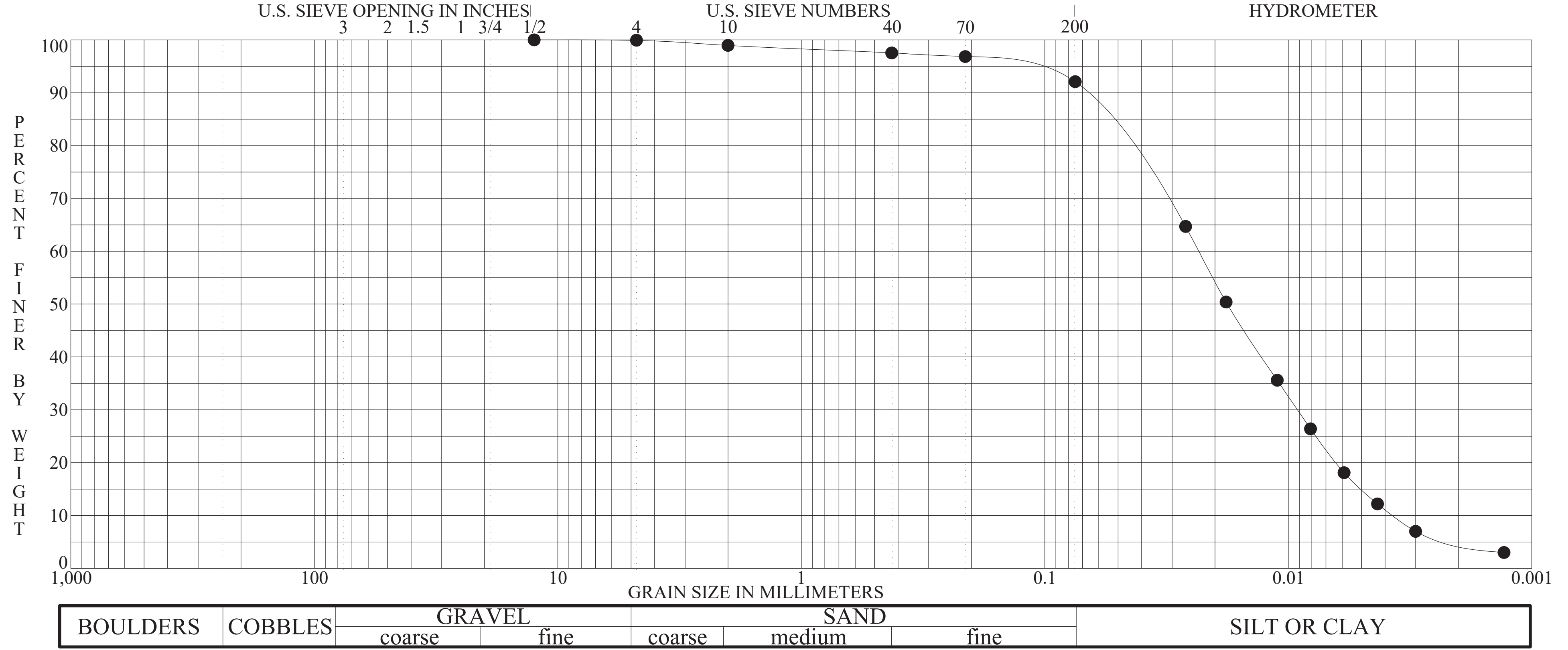

Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-PZ-BAP-0904 S-13 19.0' to 20.3'**	**Gray and dark-gray organic silt, trace clay, trace fine to coarse sand, trace fine gravel.** **ORGANIC SILT OL**	**28**	**NP**	**NP**	**NP**	**0.977**	**6.304**

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-PZ-BAP-0904 S-13 19.0' to 20.3'**	**12.5000**	**0.1414**	**0.0233**	**0.0178**	**0.0037**	**0.06**	**7.85**	**87.03**	**5.06**

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
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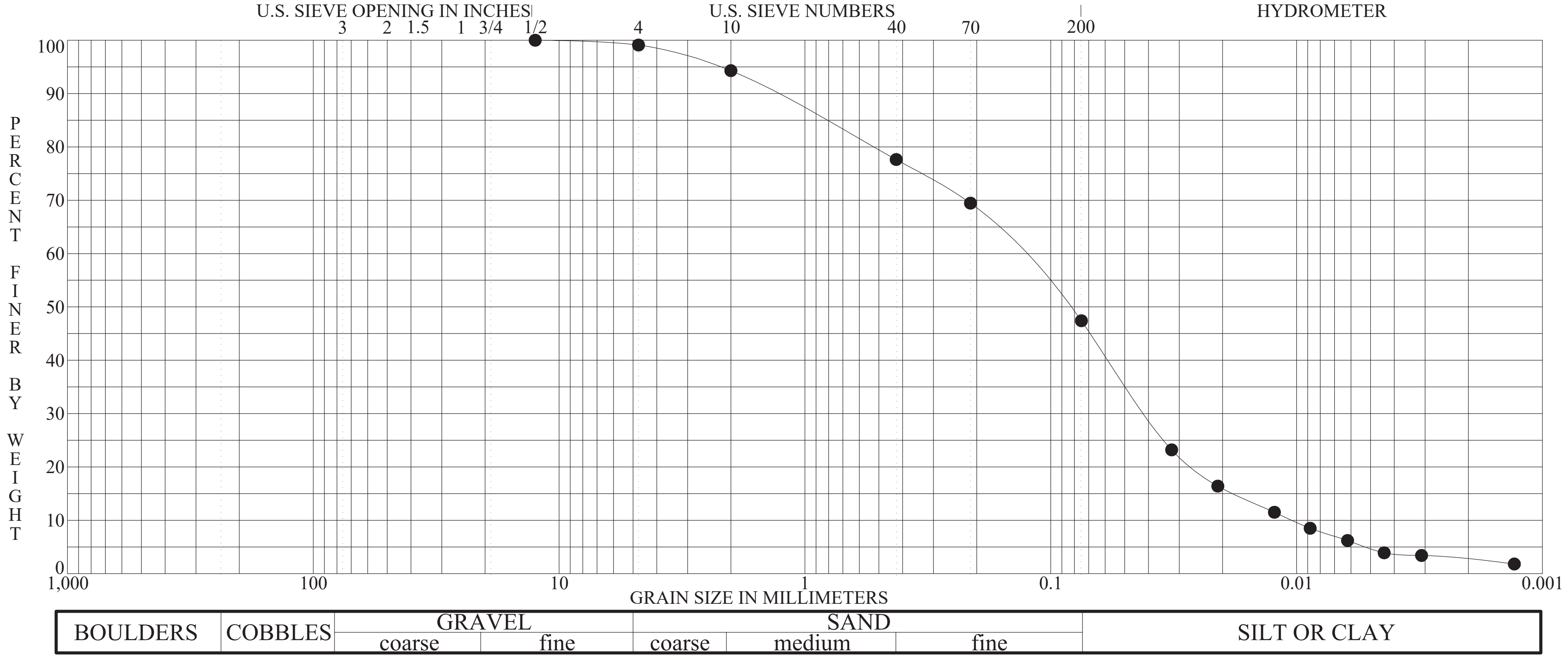

Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-PZ-BAP-0904 S-15 22.0' to 22.7'**	**Gray and dark-gray fine to medium sand, trace coarse sand, trace fine gravel, "and" organic silt, trace clay.** **SILTY SAND SM**	**26**	**NP**	**NP**	**NP**	**1.180**	**13.048**

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-PZ-BAP-0904 S-15 22.0' to 22.7'**	**12.5000**	**2.2672**	**0.1358**	**0.0847**	**0.0104**	**0.90**	**51.69**	**44.82**	**2.59**

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

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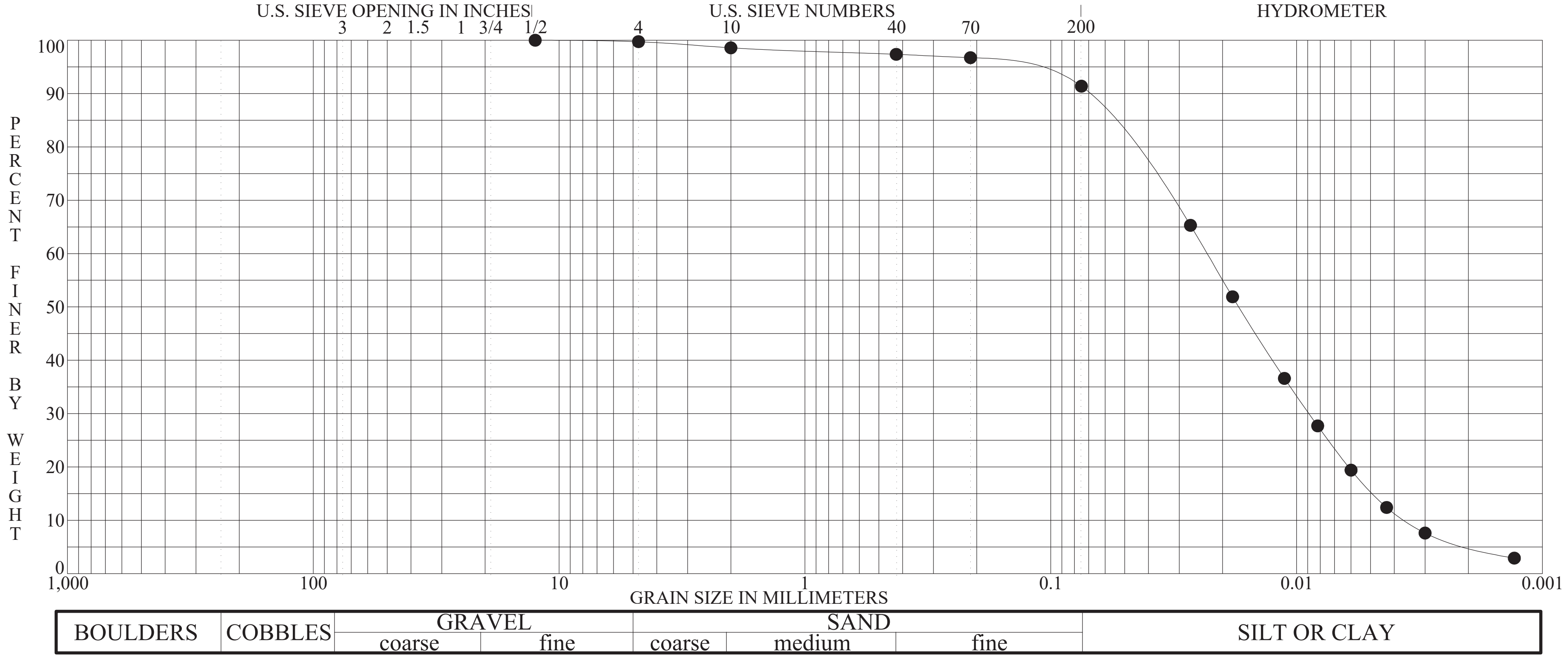


	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-PZ-BAP-0904 S-17 25.0' to 25.8'**	**Gray silt, trace clay, trace fine to coarse sand, trace fine gravel.** **SILT ML**	**22**	**NP**	**NP**	**NP**	**0.952**	**6.432**

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-PZ-BAP-0904 S-17 25.0' to 25.8'**	**12.5000**	**0.1513**	**0.0231**	**0.0171**	**0.0036**	**0.26**	**8.35**	**86.07**	**5.32**

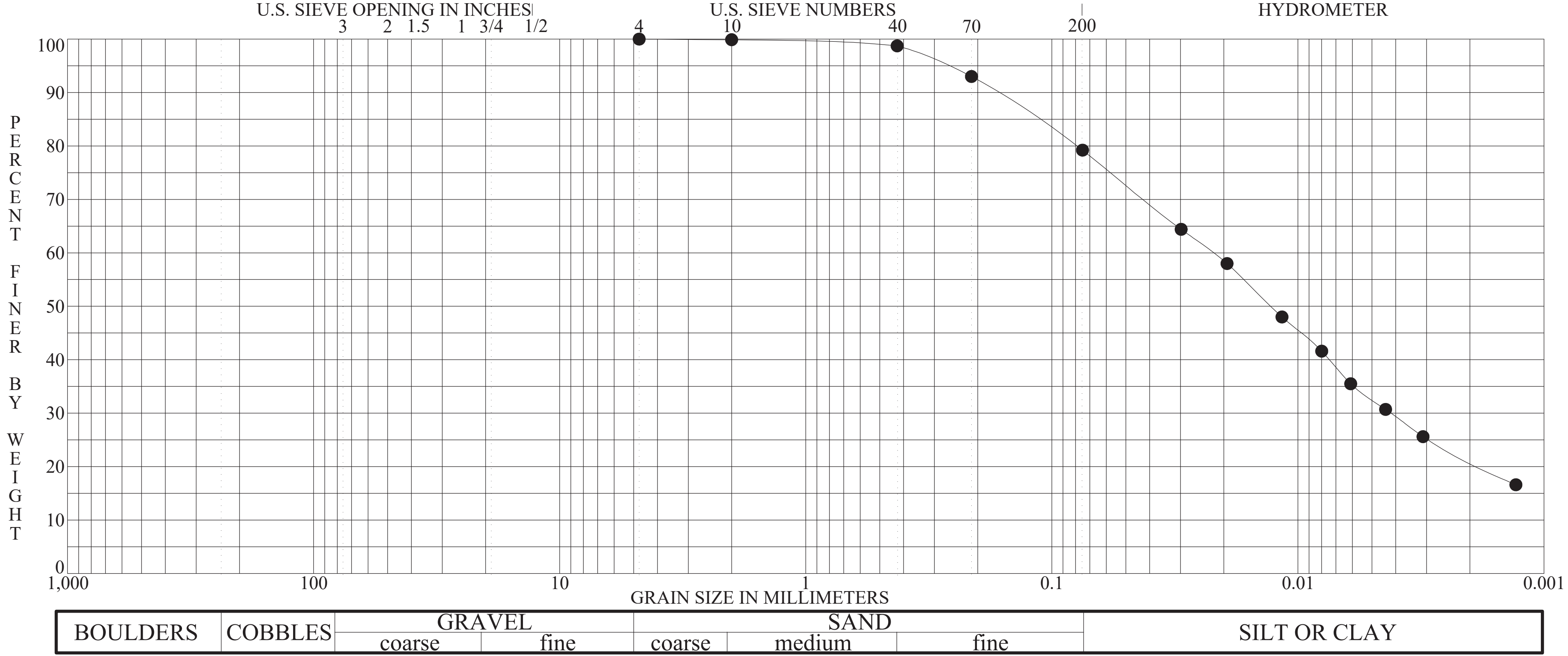
ASTM D422

GRADATION CURVE

PROJECT **CARDINAL PLANT ASH POND INVESTIGATION**
LOCATION **BRILLIANT, OHIO**
JOB NO. **011-11497-013** **DATE** **7/6/09**

PLATE 41

BBCM



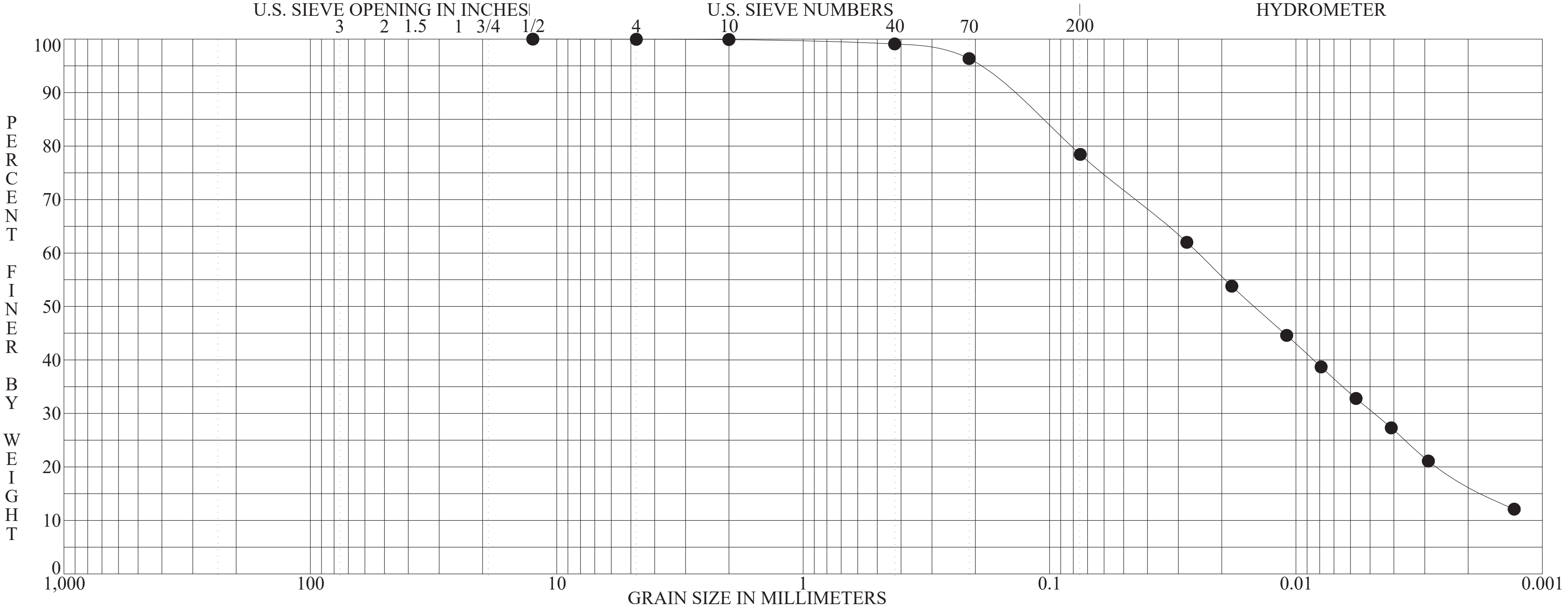
Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-PZ-BAP-0904 S-18 26.5' to 28.0'**	**Gray mottled with dark-gray organic clayey silt inter-bedded with organic silt, Little fine to coarse sand, trace fine gravel.** **ORGANIC CLAY with SAND OL**	**38**	**38**	**24**	**14**		

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-PZ-BAP-0904 S-18 26.5' to 28.0'**	**4.7500**	**0.2701**	**0.0222**	**0.0129**		**0.00**	**20.78**	**58.16**	**21.06**

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

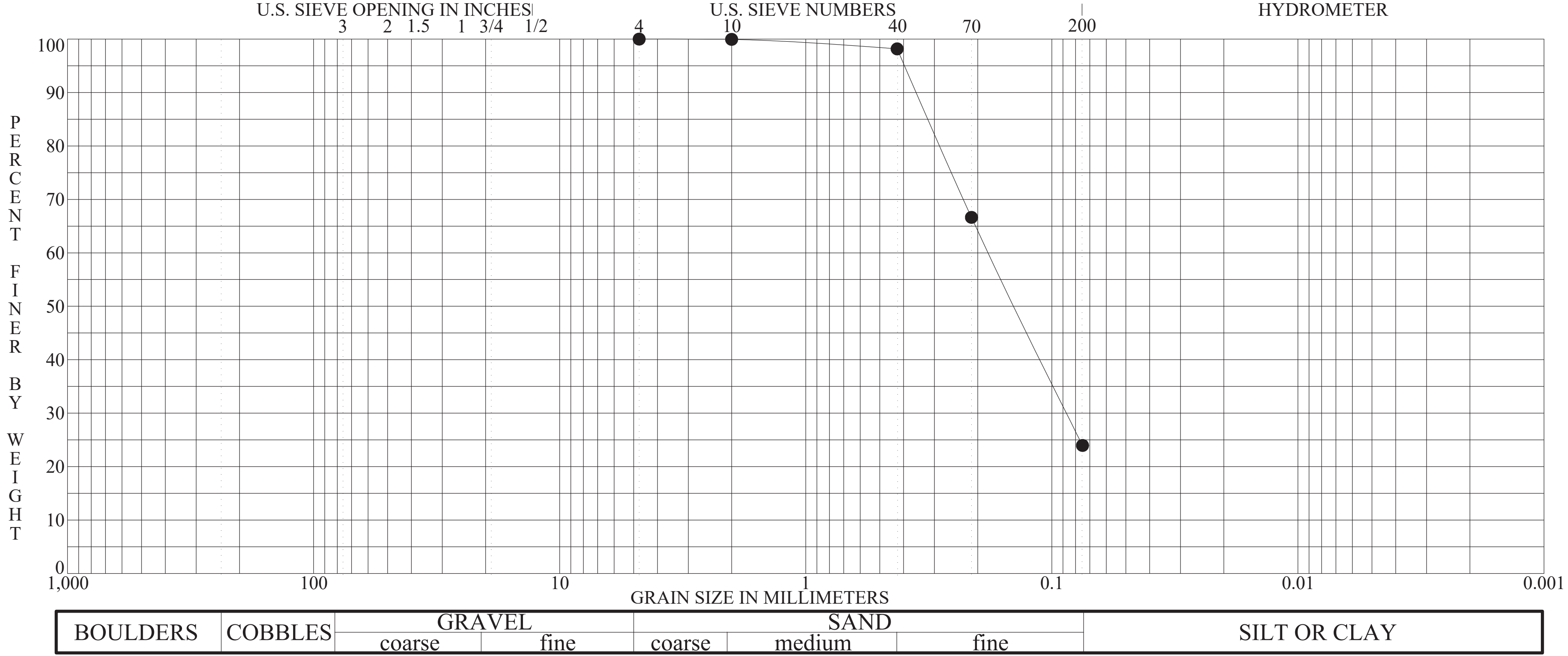
	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-PZ-BAP-0904 S-19 28.0' to 29.3'**	**Gray mottled with dark-gray organic clayey silt, some fine sand, trace medium to coarse sand, trace fine gravel.** **ORGANIC SILT with SAND OL**	**47**	**42**	**30**	**12**		

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-PZ-BAP-0904 S-19 28.0' to 29.3'**	**12.5000**	**0.1959**	**0.0250**	**0.0147**		**0.03**	**21.53**	**61.51**	**16.93**

ASTM D422

GRADATION CURVE

PROJECT **CARDINAL PLANT ASH POND INVESTIGATION**
LOCATION **BRILLIANT, OHIO**
JOB NO. **011-11497-013** **DATE** **7/6/09**



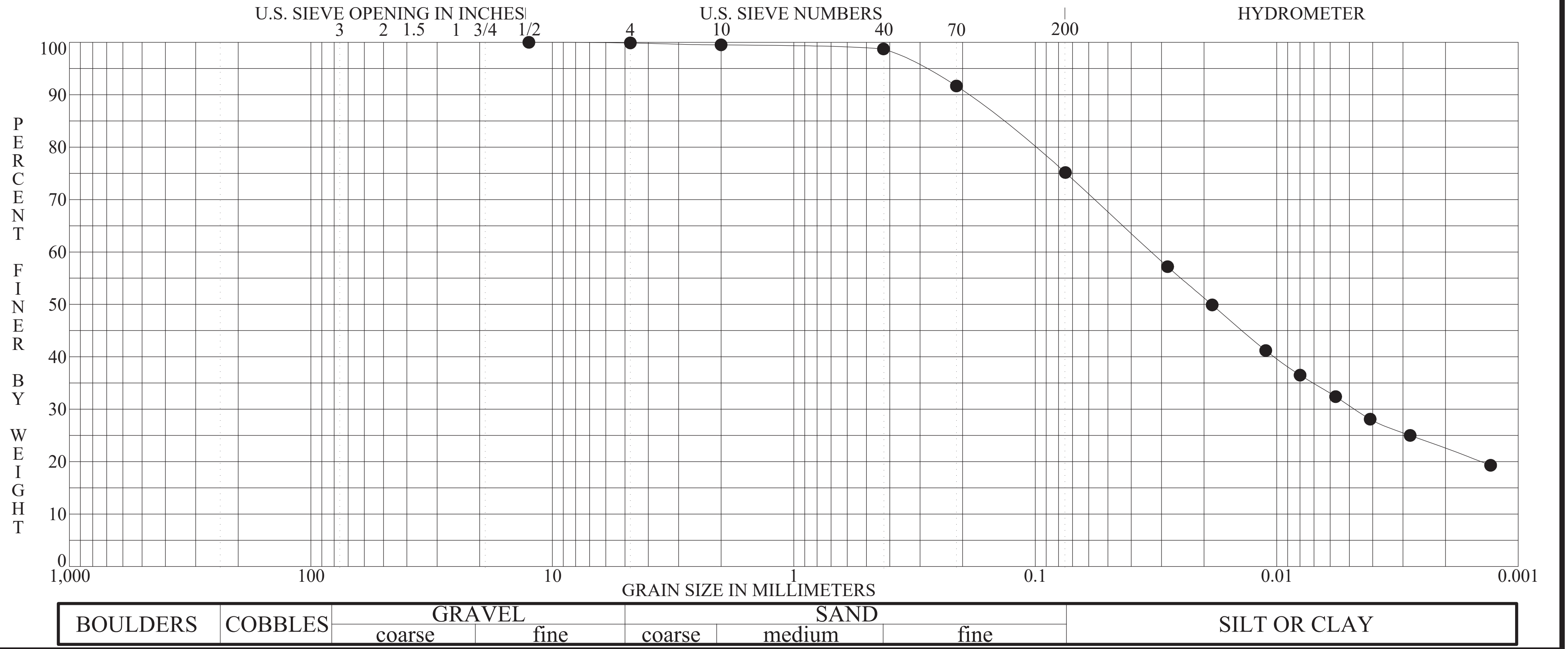
Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-PZ-BAP-0904 S-21 36.0' to 37.4'**	**Brown and gray fine sand, trace medium to coarse sand, some silt.**						

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



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.** **LEAN CLAY with SAND CL**	**17**	**32**	**18**	**14**		

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-PZ-BAP-0905 S-3 4.0' to 5.5'**	**12.5000**	**0.2941**	**0.0329**	**0.0186**		**0.10**	**24.74**	**52.66**	**22.50**

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GRADATION CURVE

PROJECT **CARDINAL PLANT ASH POND INVESTIGATION**
LOCATION **BRILLIANT, OHIO**
JOB NO. **011-11497-013** **DATE** **7/6/09**

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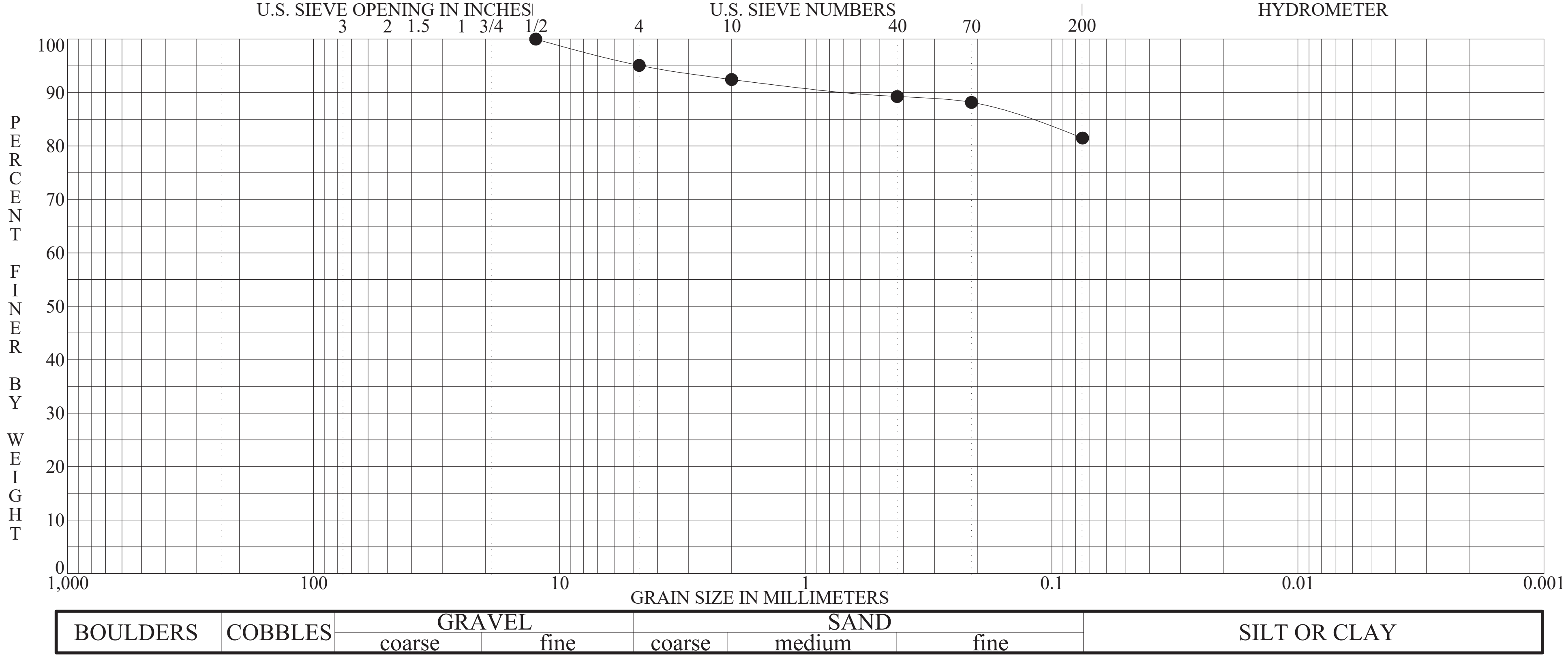

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-PZ-BAP-0905 S-6B 9.7' to 10.0'**	**FILL: Brown mottled with gray silty clay inter-bedded with dark-gray organic silt, little fine to coarse sand, trace fine gravel.**	**33**					

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-PZ-BAP-0905 S-6B 9.7' to 10.0'**	**12.5000**	**4.6215**				**4.92**	**13.60**	**81.48**	

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
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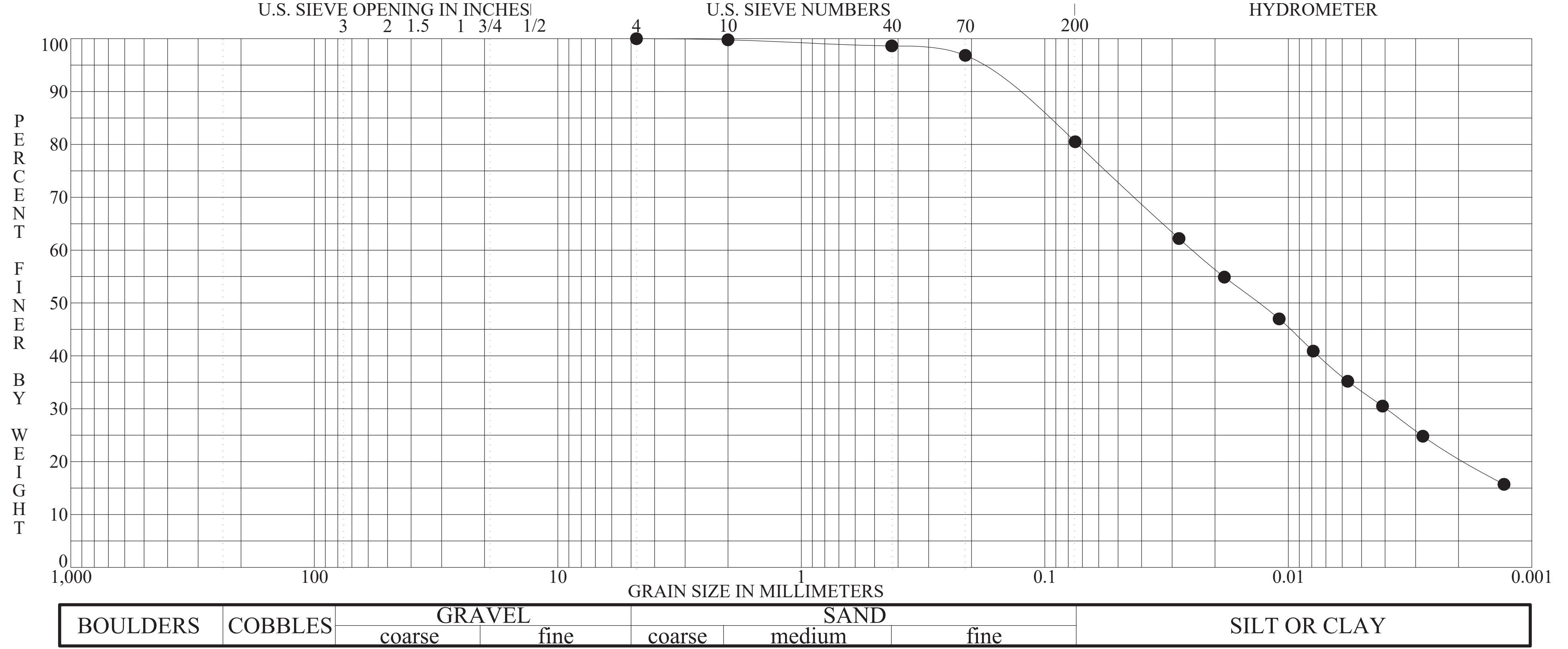

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-PZ-BAP-0905 S-8 13.5' to 15.0'**	**Gray mottled with dark-gray organic clayey silt, little fine sand, trace medium to coarse sand.** **ORGANIC SILT with SAND OL**	**45**	**43**	**27**	**16**		

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-PZ-BAP-0905 S-8 13.5' to 15.0'**	**4.7500**	**0.1885**	**0.0247**	**0.0133**		**0.00**	**19.49**	**59.70**	**20.81**

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

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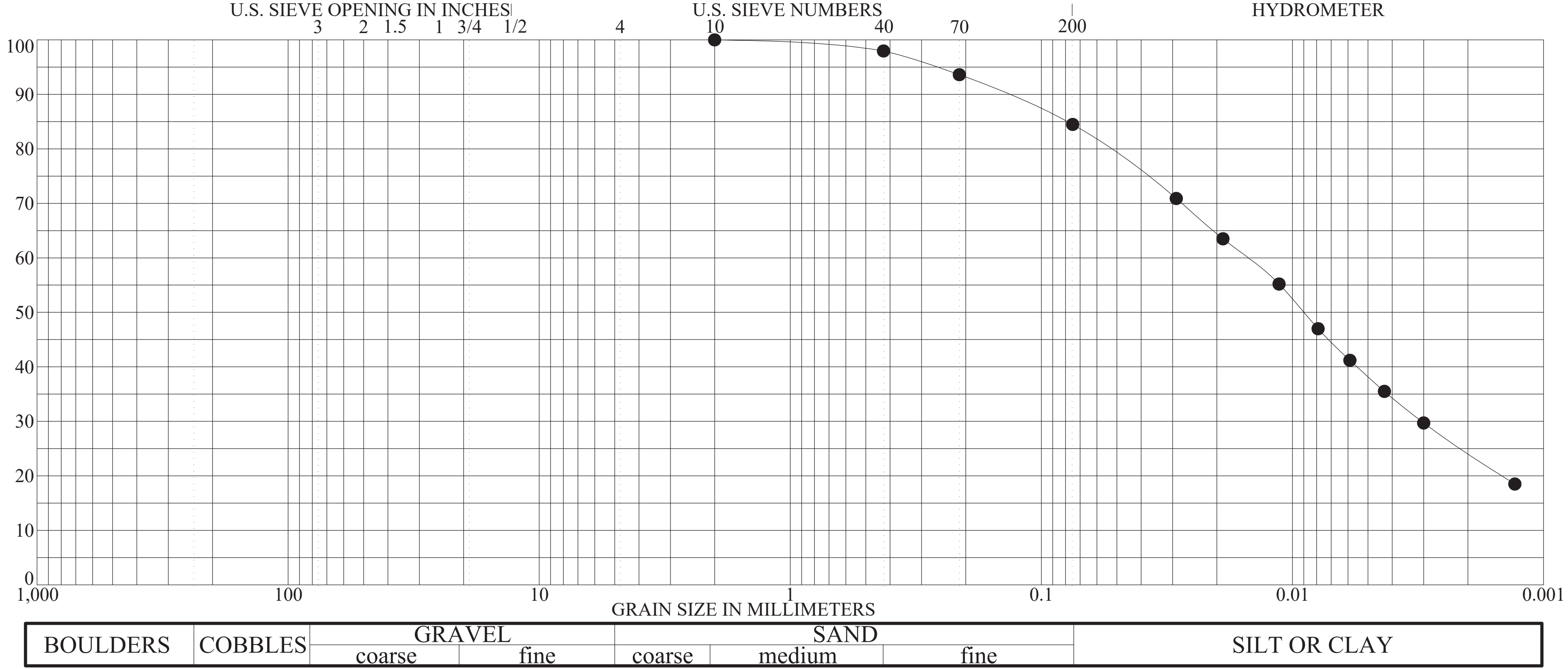

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-PZ-BAP-0905 S-9 16.0' to 17.5'**	**Gray mottled with dark-gray organic clayey silt, little fine to medium sand.** **ORGANIC CLAY with SAND OL**	**42**	**40**	**25**	**15**		

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-PZ-BAP-0905 S-9 16.0' to 17.5'**	**2.0000**	**0.2645**	**0.0152**	**0.0090**		**0.00**	**15.51**	**60.22**	**24.27**

ASTM D422

GRADATION CURVE

PROJECT **CARDINAL PLANT ASH POND INVESTIGATION**
LOCATION **BRILLIANT, OHIO**
JOB NO. **011-11497-013** **DATE** **7/6/09**

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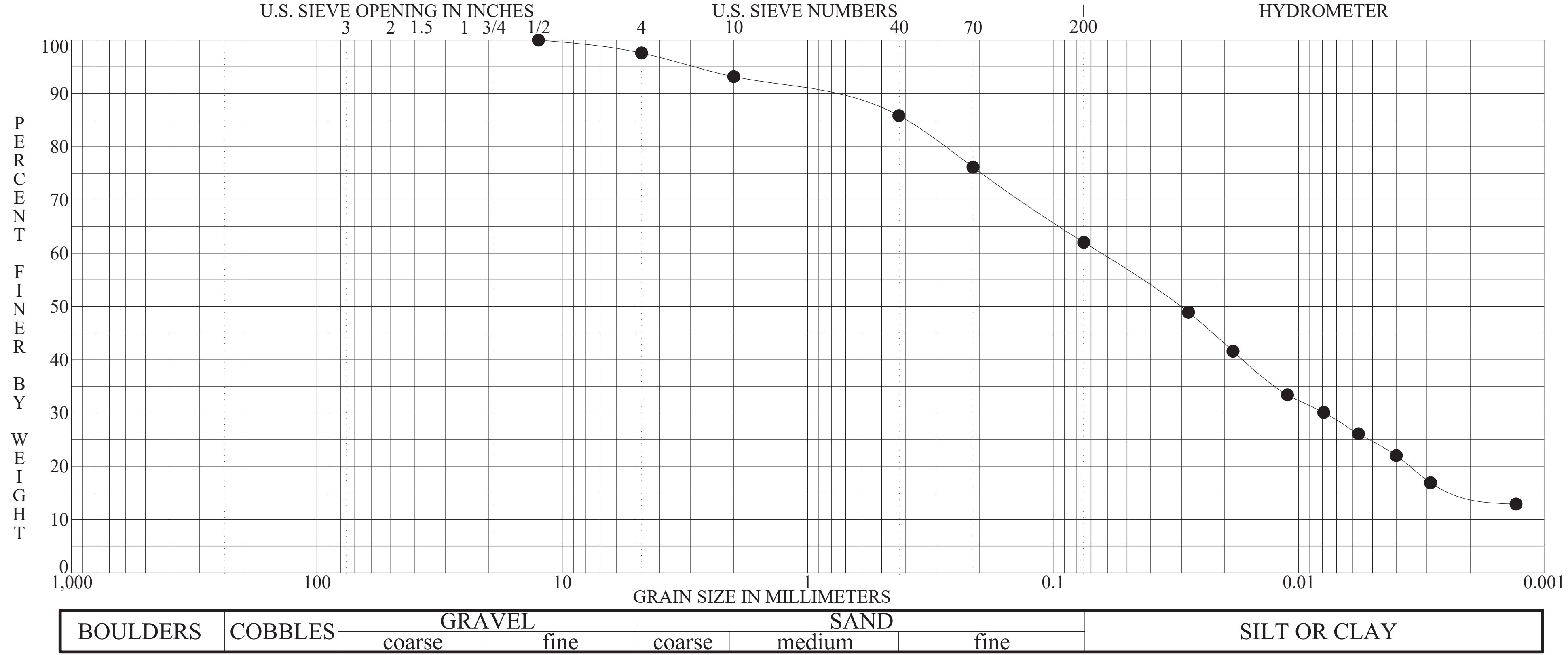

Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-PZ-BAP-0905 S-11 21.0' to 21.4'**	**Gray mottled with brown silty clay, some fine to medium sand, trace coarse sand, trace fine gravel, few seams of fine to medium sand.** **SANDY LEAN CLAY CL**	**38**	**38**	**23**	**15**		

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-PZ-BAP-0905 S-11 21.0' to 21.4'**	**12.5000**	**2.8652**	**0.0644**	**0.0305**		**2.41**	**35.54**	**47.00**	**15.05**

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
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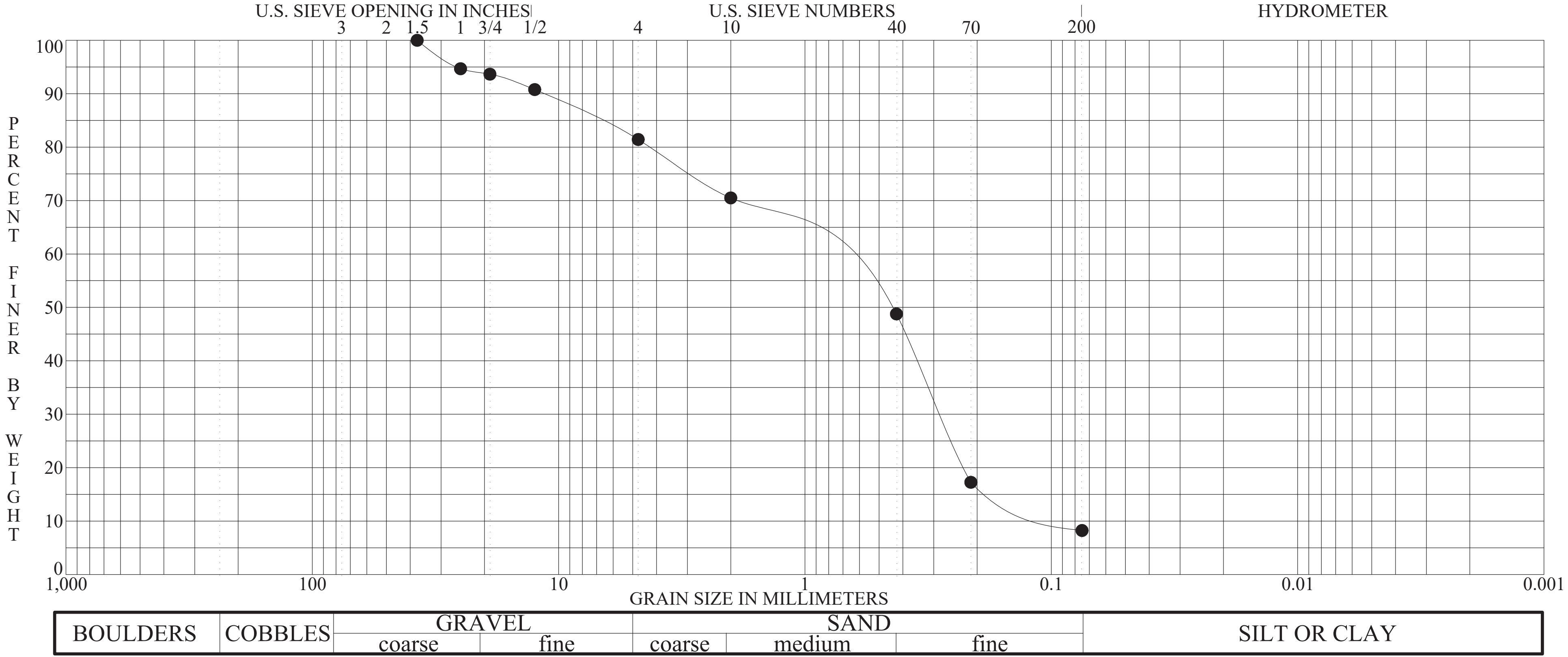
PLATE 49

GRN-EPA W/ASTM-BBCM



Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-PZ-BAP-0905 S-13 26.0' to 27.0'**	**Brown and gray fine to coarse sand, little fine gravel, trace silt.**					**0.907**	**10.293**

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-PZ-BAP-0905 S-13 26.0' to 27.0'**	**37.5000**	**25.6140**	**0.9461**	**0.4637**	**0.0919**	**18.56**	**73.20**	**8.23**	

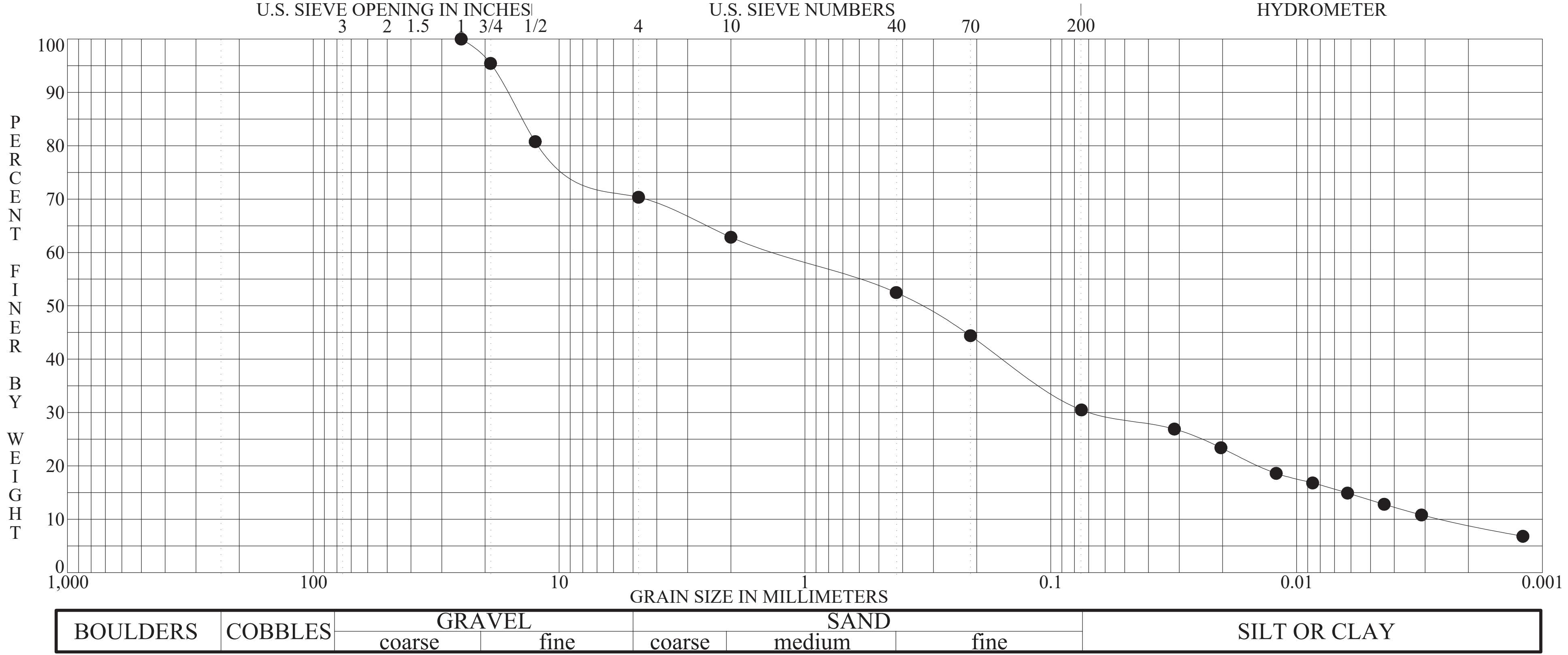
ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0906 S-8 12.0' to 13.0'**	**FILL: Gray and brown fine to coarse sand, some fine to coarse gravel(sandstone fragments), some silty clay.**					**1.328**	**509.008**

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0906 S-8 12.0' to 13.0'**	**25.0000**	**18.7626**	**1.3051**	**0.3431**	**0.0026**	**29.65**	**39.87**	**21.53**	**8.95**

ASTM D422

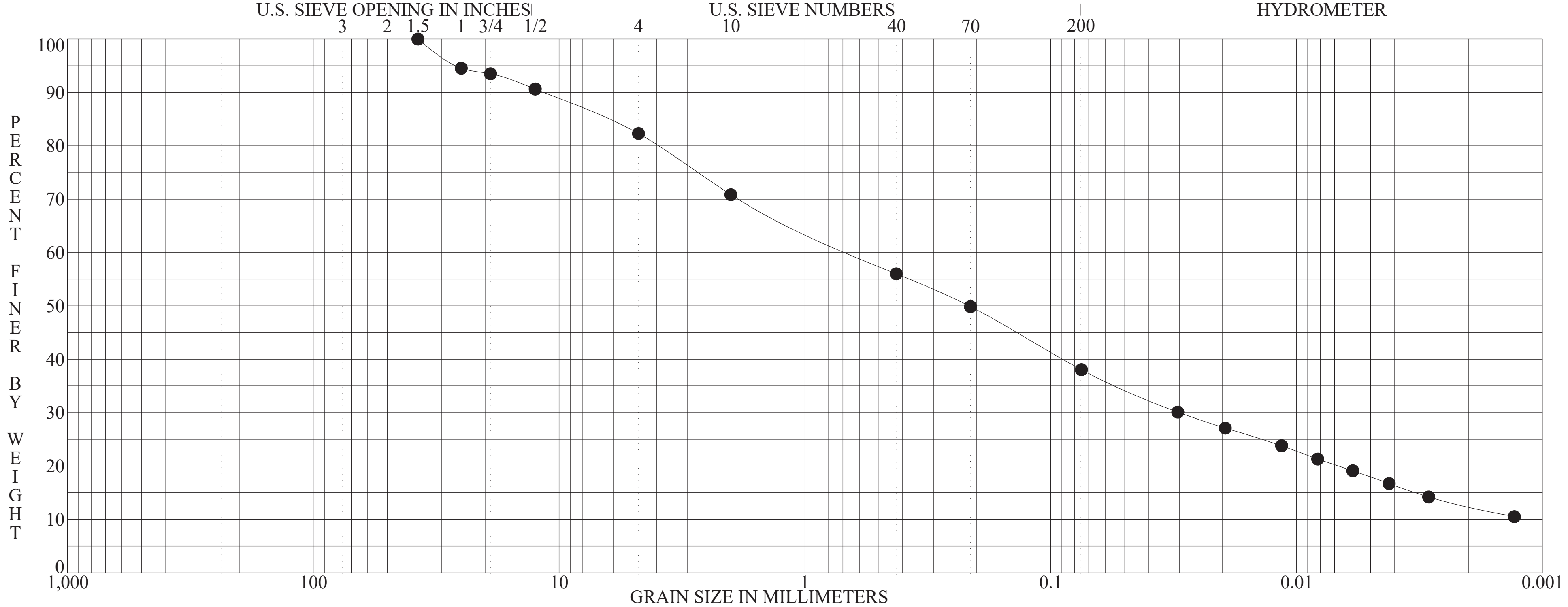
GRADATION CURVE

PROJECT **CARDINAL PLANT ASH POND INVESTIGATION**
LOCATION **BRILLIANT, OHIO**
JOB NO. **011-11497-013** **DATE** **7/6/09**

PLATE 51

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-0906 S-11 16.5' to 17.3'**	**FILL: Brown fine to coarse sand, little fine to coarse gravel, "and" silty clay.** **CLAYEY SAND with GRAVEL SC**	**14**	**31**	**19**	**12**		

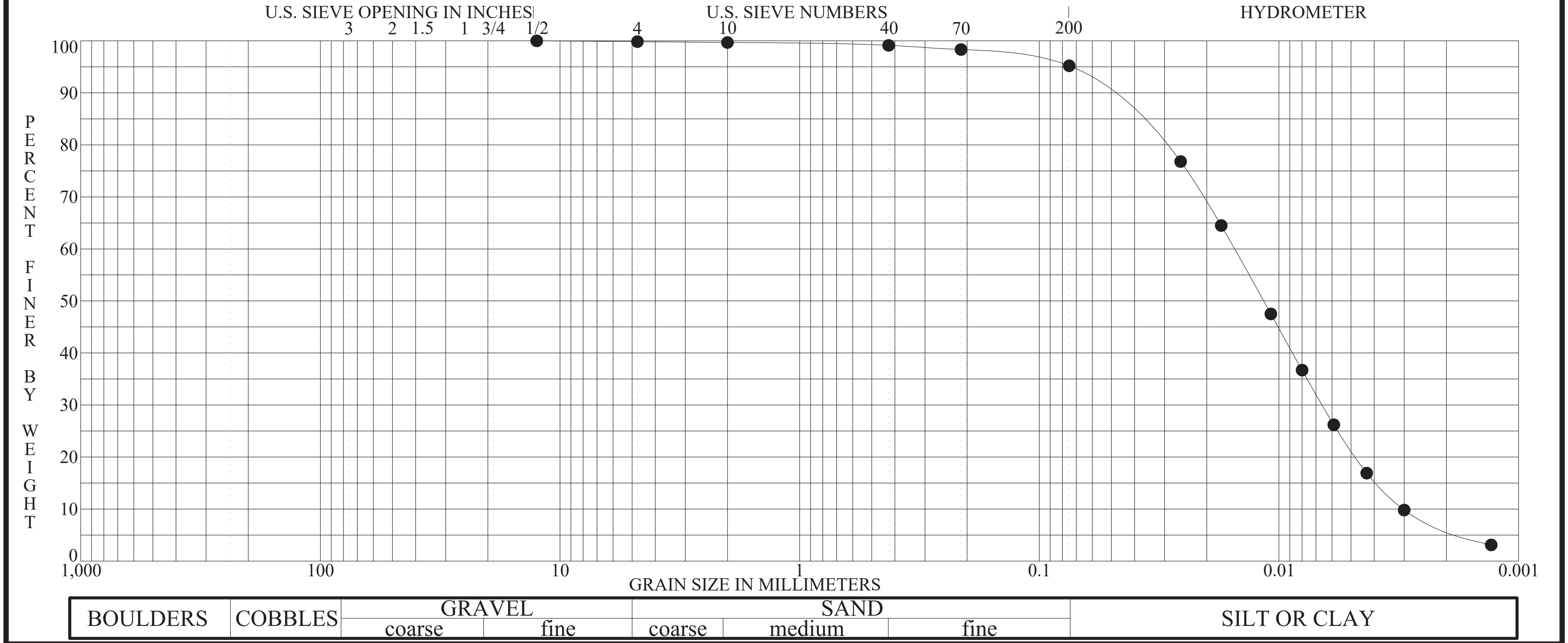
Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-BAP-0906 S-11 16.5' to 17.3'**	**37.5000**	**25.8719**	**0.6448**	**0.2152**		**17.70**	**44.25**	**25.56**	**12.49**

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

BBCM



Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-BAP-0906 S-15 24.0' to 25.0'**	**Gray silt, trace clay, trace fine to coarse sand, trace fine gravel.** **SILT ML**	**31**	**NP**	**NP**	**NP**	**0.934**	**5.061**

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-BAP-0906 S-15 24.0' to 25.0'**	**12.5000**	**0.0741**	**0.0153**	**0.0116**	**0.0030**	**0.15**	**4.64**	**88.66**	**6.55**

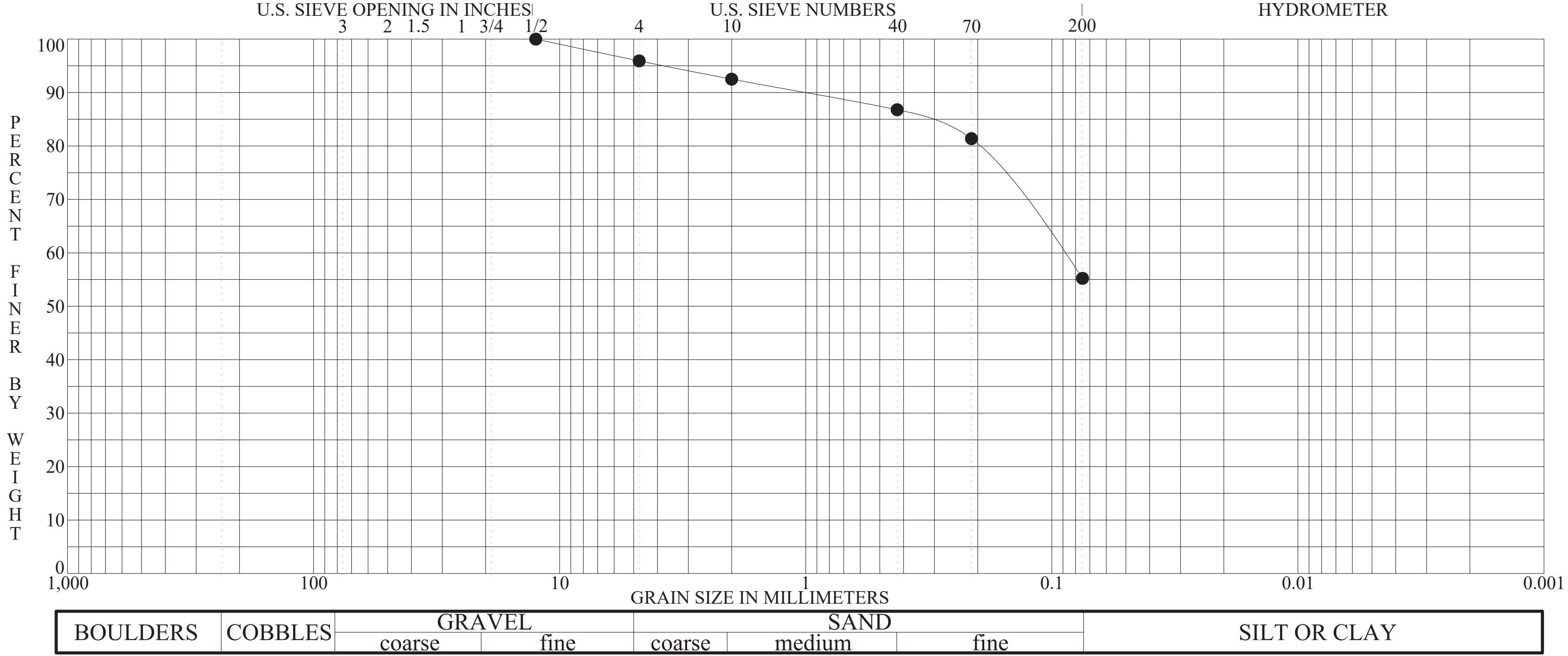
ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



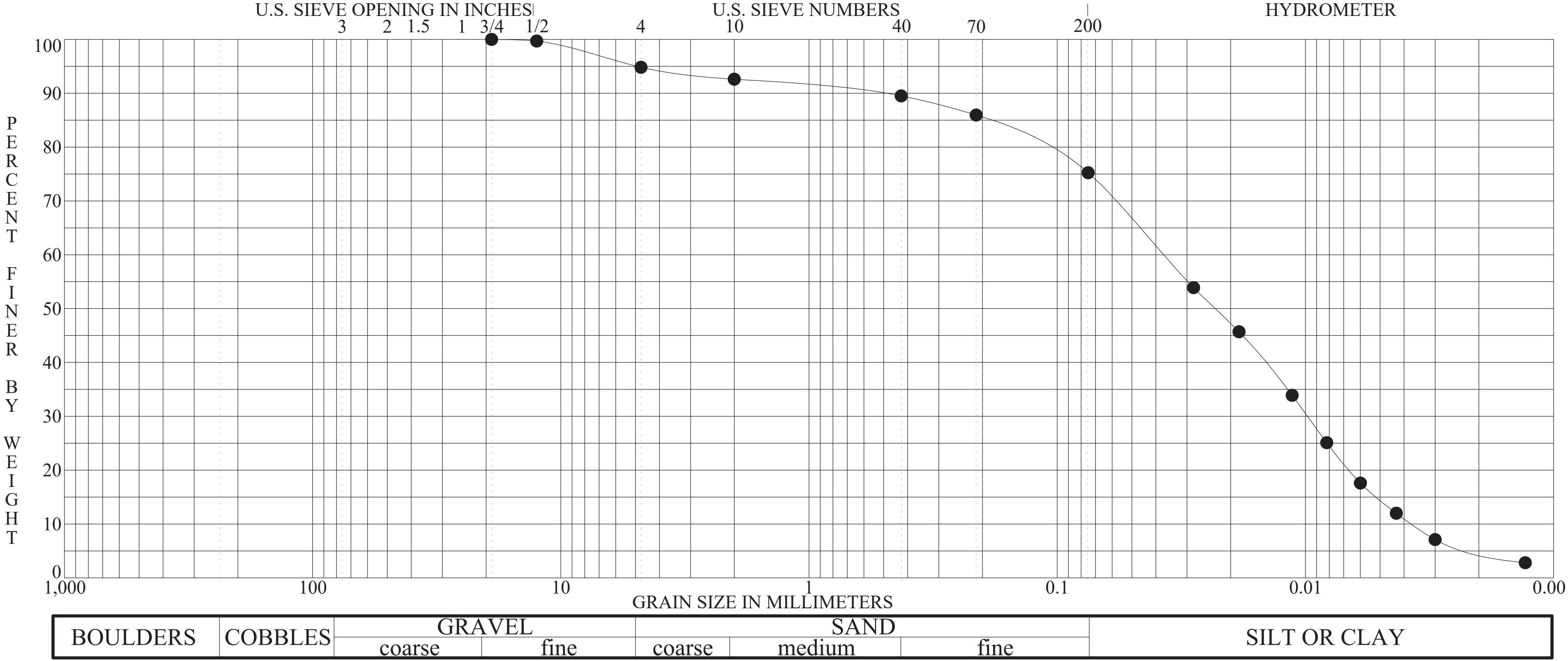
Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-BAP-0906 S-16 25.5' to 26.5'**	**Gray silt, some fine sand, trace medium to coarse sand, trace fine gravel.**						

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-BAP-0906 S-16 25.5' to 26.5'**	**12.5000**	**3.7584**	**0.0907**			**4.08**	**40.69**	**55.23**	

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09



	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** **SILT with SAND ML**	**22**	**NP**	**NP**	**NP**	**0.694**	**10.046**

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0906 S-17 27.0' to 28.2'**	**19.0000**	**4.9211**	**0.0373**	**0.0231**	**0.0037**	**5.18**	**19.58**	**70.23**	**5.02**

ASTM D422

GRADATION CURVE

PROJECT **CARDINAL PLANT ASH POND INVESTIGATION**
LOCATION **BRILLIANT, OHIO**
JOB NO. **011-11497-013** **DATE** **7/6/09**

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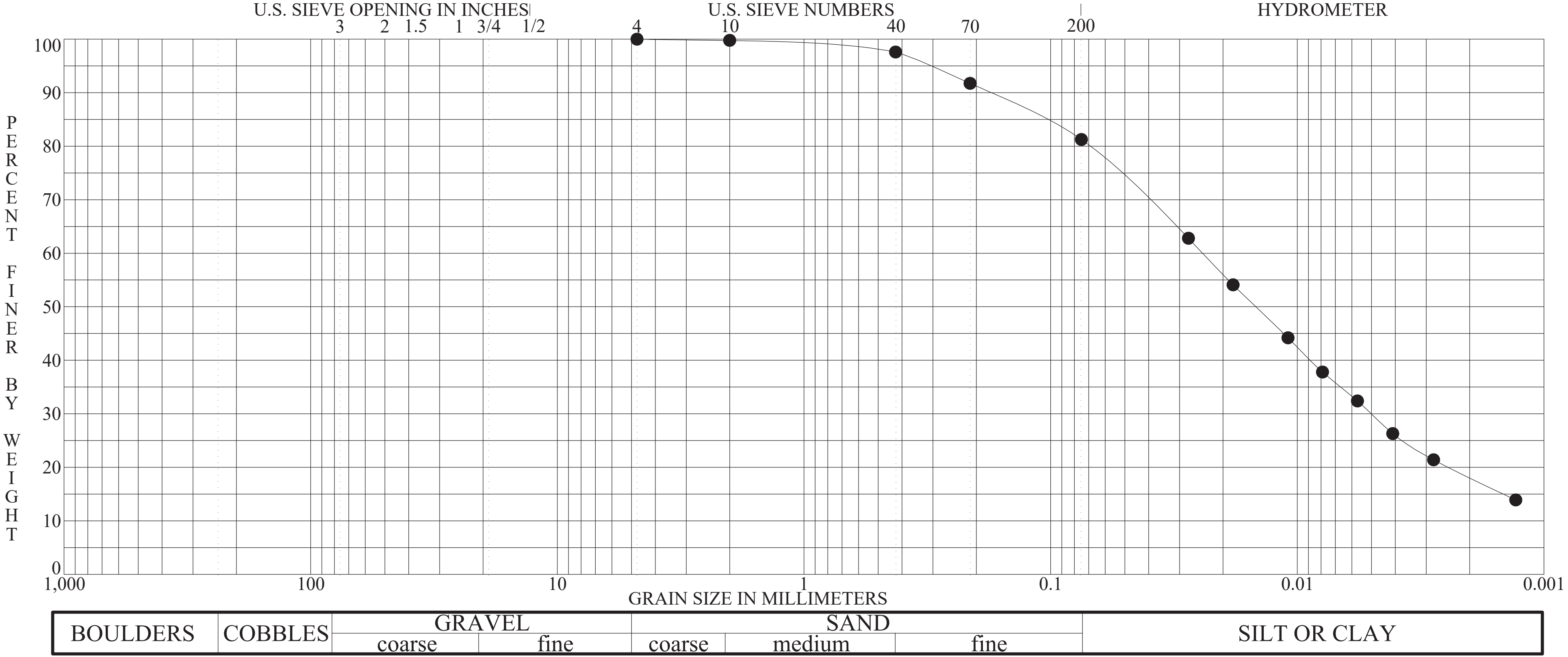


	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0906 S-19 31.0' to 32.0'**	**Dark-gray organic clayey silt, little fine sand, trace medium to coarse sand inter-bedded with silt and silty clay.** **ORGANIC CLAY with SAND OL**	**34**	**33**	**22**	**11**		

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0906 S-19 31.0' to 32.0'**	**4.7500**	**0.3120**	**0.0241**	**0.0147**		**0.00**	**18.75**	**63.14**	**18.11**

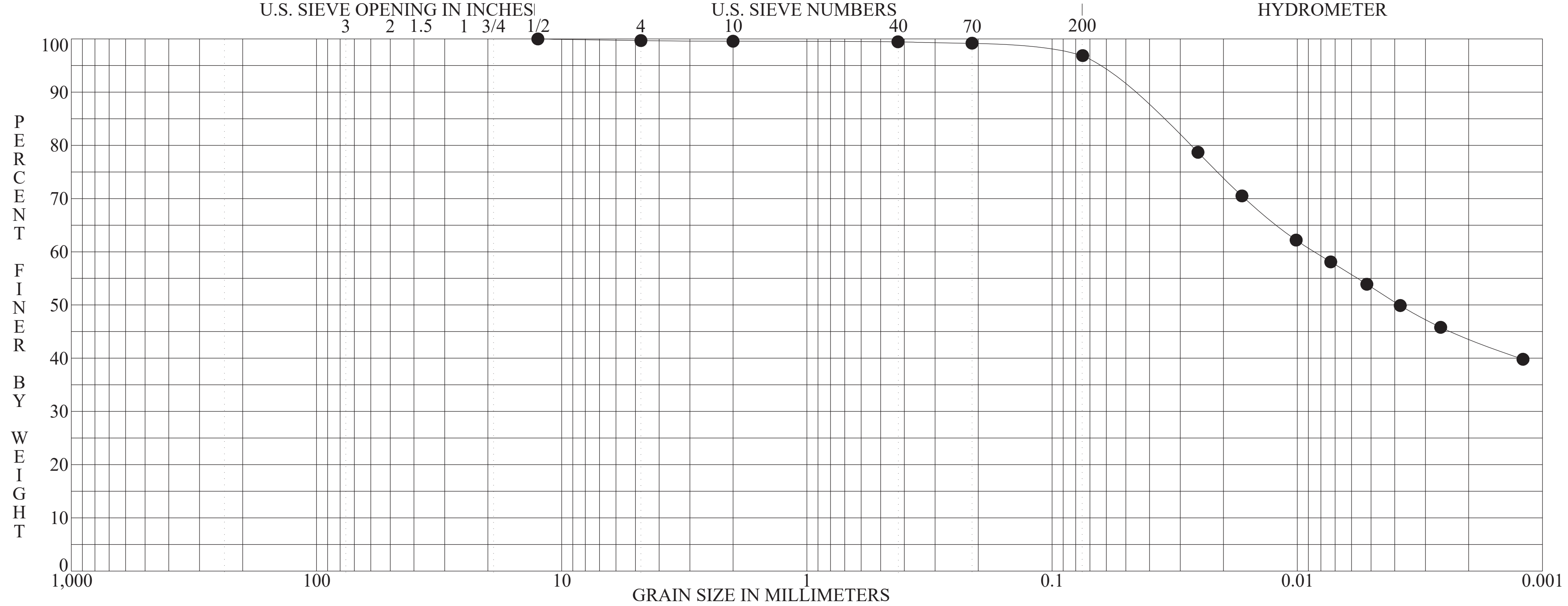
ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● CD-BAP-0906 S-20 33.5' to 34.4'	**Gray organic clayey silt, trace fine to coarse sand, trace fine gravel.** **ORGANIC SILT OH**	**43**	**50**	**30**	**20**		

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● CD-BAP-0906 S-20 33.5' to 34.4'	**12.5000**	**0.0671**	**0.0085**	**0.0038**		**0.30**	**2.82**	**53.11**	**43.76**

ASTM D422

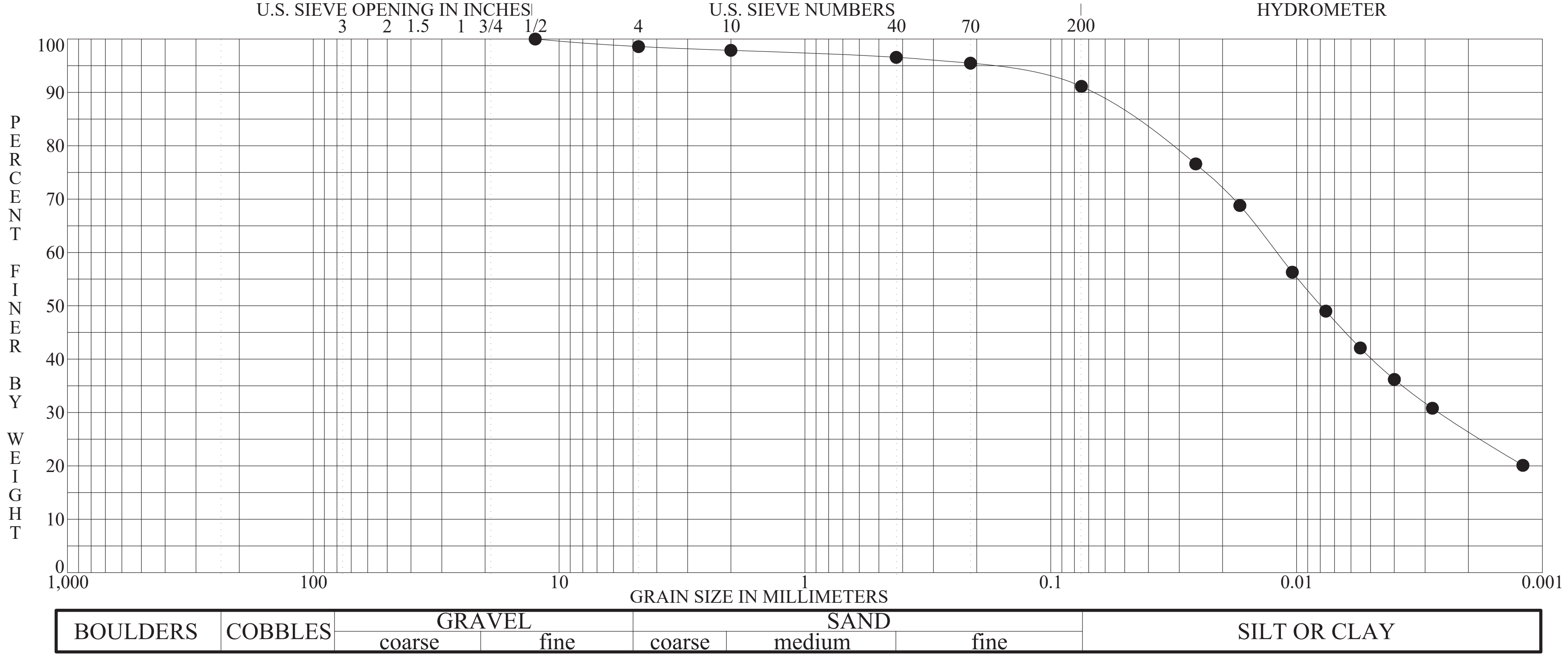
GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

PLATE 57

GRN-EPA W/ASTM-BBCM

BBCM



Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-BAP-0906 S-21 36.0' to 36.7'**	**Gray organic clayey silt, trace fine to coarse sand, trace fine gravel.** **ORGANIC CLAY OL**	**38**	**43**	**26**	**17**		

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-BAP-0906 S-21 36.0' to 36.7'**	**12.5000**	**0.1891**	**0.0120**	**0.0079**		**1.41**	**7.45**	**64.58**	**26.55**

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

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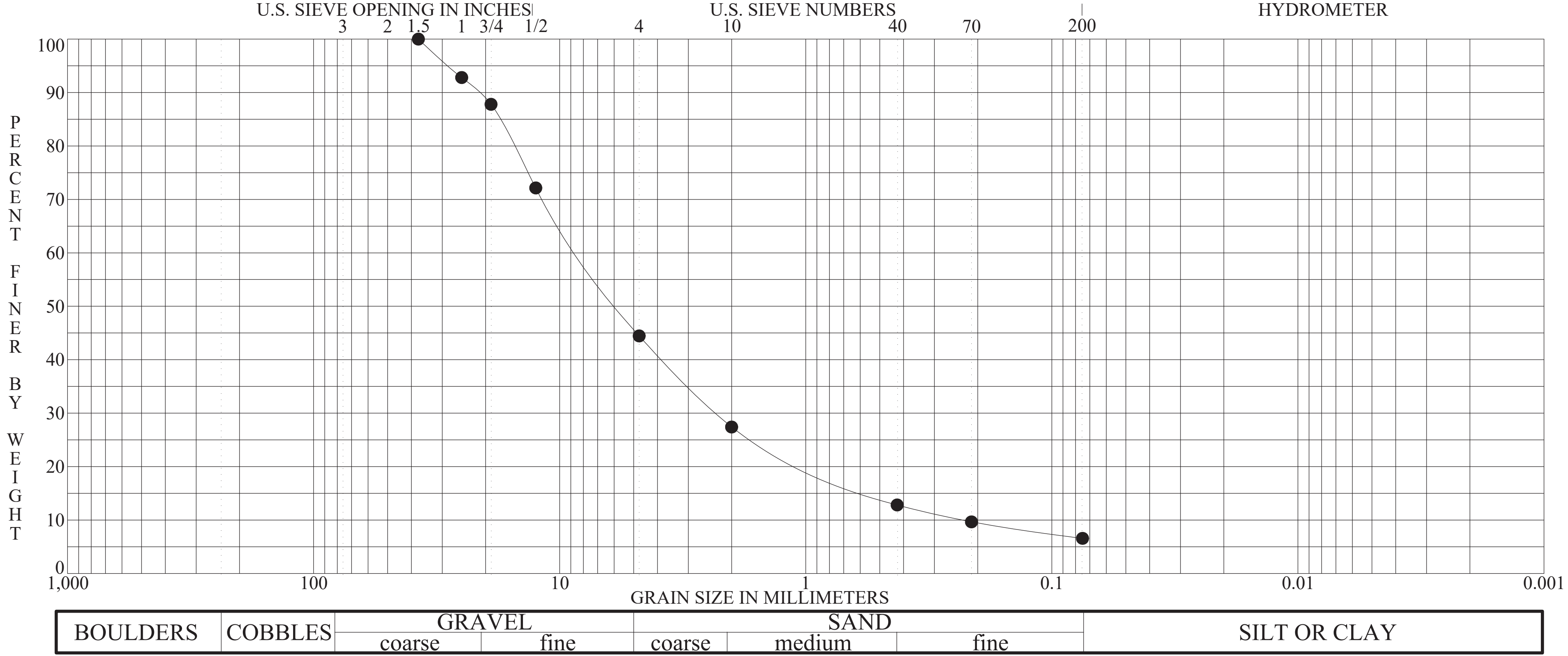


Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● CD-BAP-0906 S-24 43.5' to 44.2'	Brown fine to coarse gravel, "and" fine to coarse sand, trace silt.					2.781	35.724

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

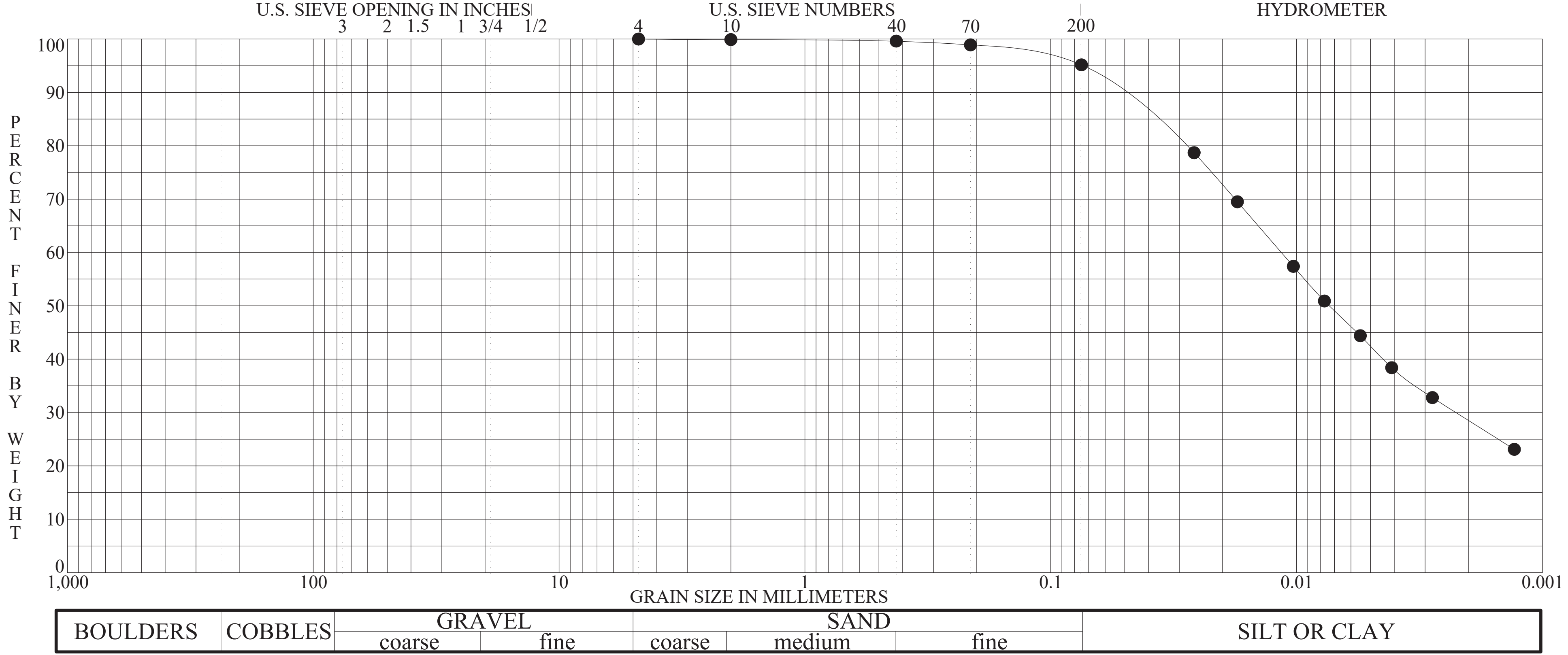
GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

PLATE 59

GRN-EPA W/ASTM-BBCM

BBCM



Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-BAP-0907 ST-6A II 8.5' to 9.9'**	**FILL: Hard brown, gray and dark-gray silty clay inter-mixed with organic silt, trace fine to coarse sand.** **SILT ML**	**28**	**47**	**29**	**18**		

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-BAP-0907 ST-6A II 8.5' to 9.9'**	**4.7500**	**0.0742**	**0.0115**	**0.0073**		**0.00**	**4.83**	**66.62**	**28.55**

ASTM D422

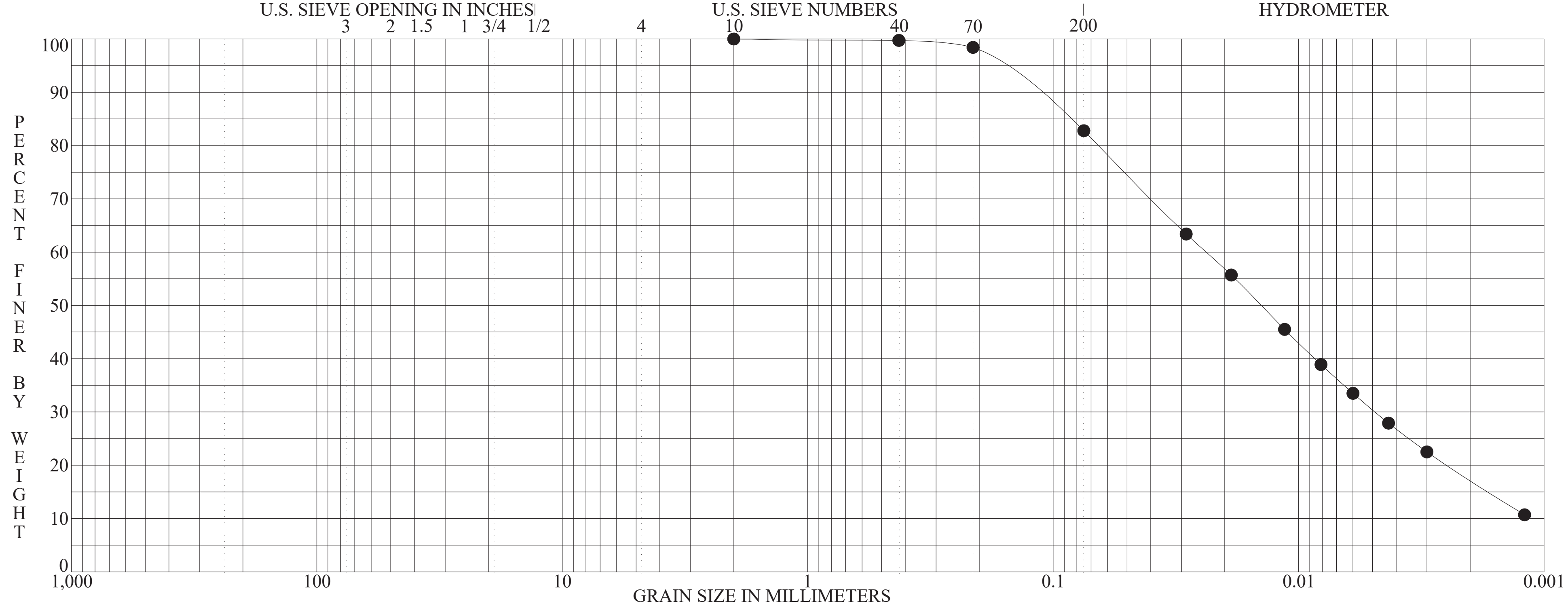
GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

PLATE 60

GRN-EPA W/ASTM-BBCM

BBCM



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0907 S-7 11.0' to 12.0'**	**Gray organic clayey silt, little fine to medium sand.**						

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0907 S-7 11.0' to 12.0'**	**2.0000**	**0.1688**	**0.0238**	**0.0142**		**0.00**	**17.21**	**65.51**	**17.28**

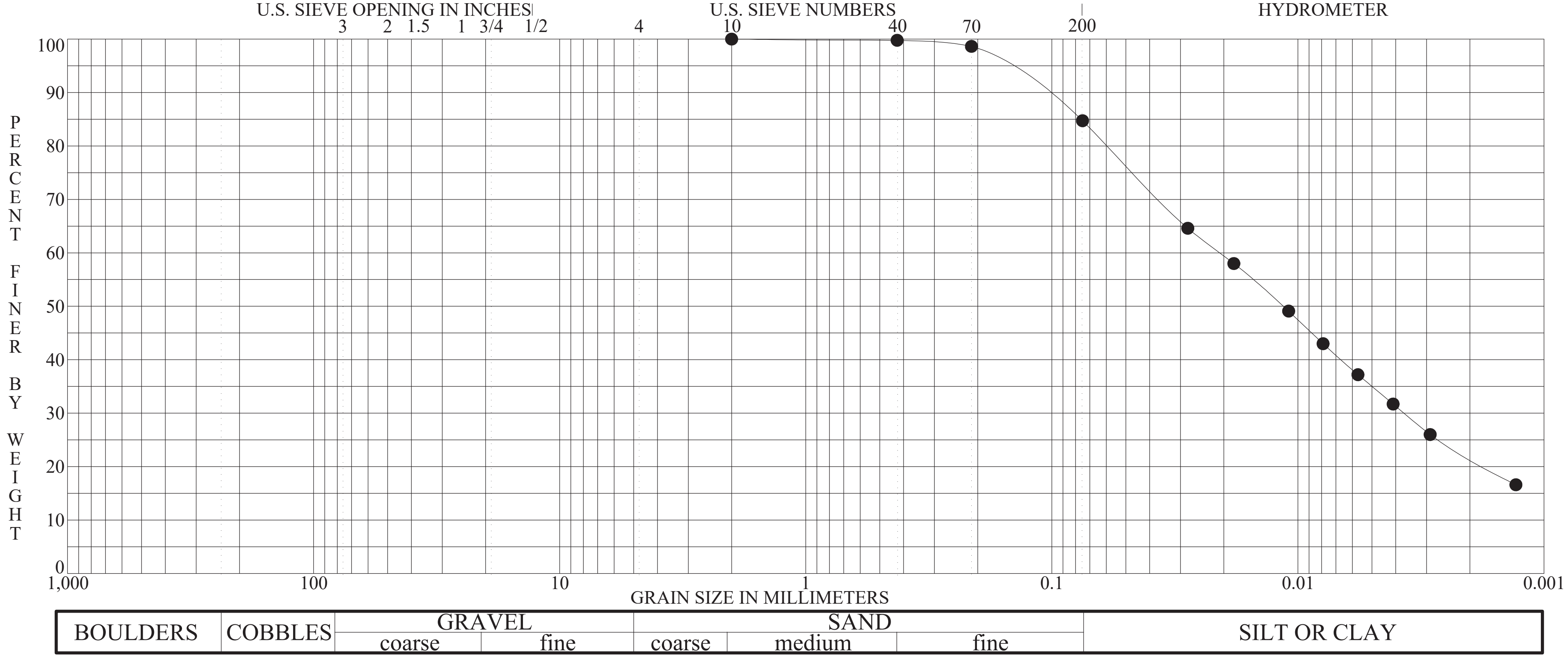
ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

PLATE 61

GRN-EPA W/ASTM-BBCM



	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0907 S-8 13.5' to 14.6'**	**Gray organic clayey silt, little fine to medium sand, few seams of fine sand.** **ORGANIC SILT with SAND OL**	**43**	**44**	**28**	**16**		

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0907 S-8 13.5' to 14.6'**	**2.0000**	**0.1615**	**0.0207**	**0.0115**		**0.00**	**15.27**	**63.08**	**21.65**

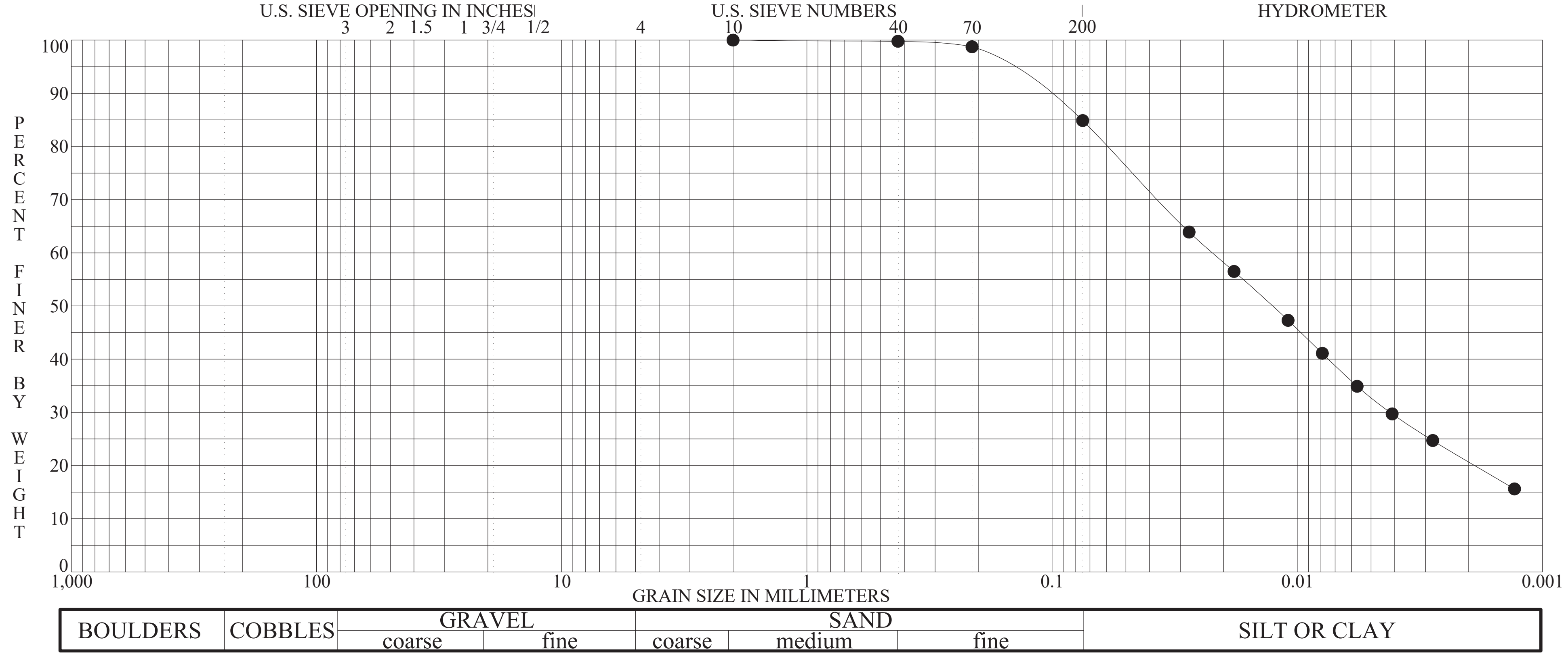
ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013
DATE 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-BAP-0907 S-9 16.0' to 17.0'**	**Gray organic clayey silt, little fine sand, trace medium sand.**	**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**

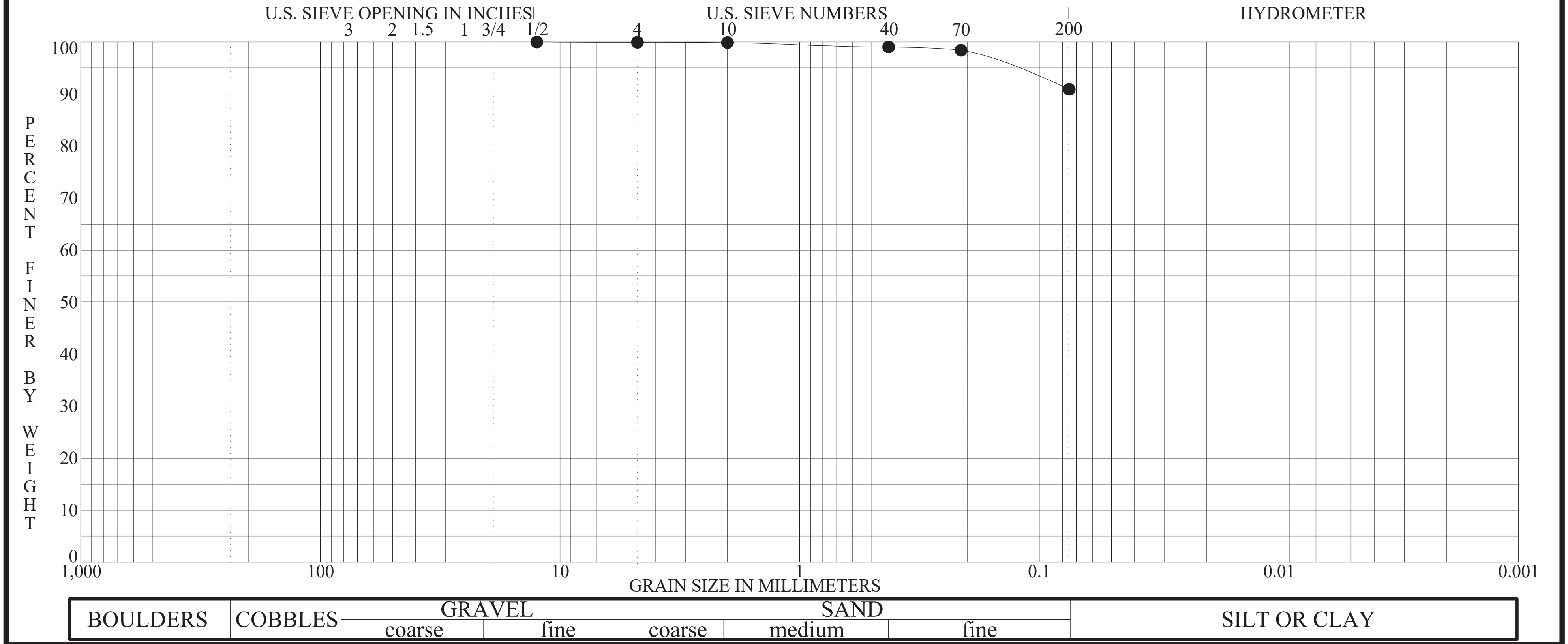
ASTM D422

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



	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.** **ORGANIC SILT OL**	**40**	**48**	**29**	**19**		

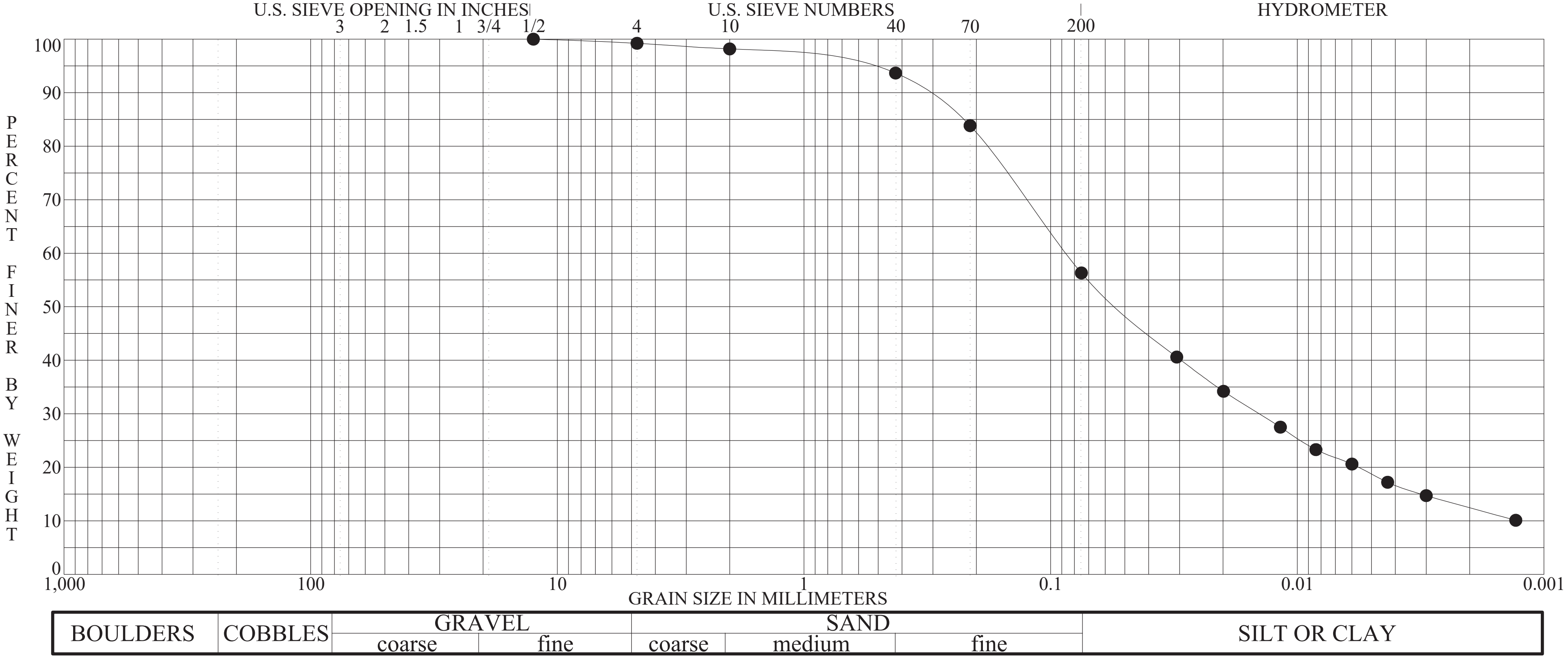
	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0907 S-10 18.5' to 19.6'**	**12.5000**	**0.1321**				**0.05**	**9.03**	**90.92**	

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

BBCM



Specimen Identification - Depth		Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0907 S-11 21.0' to 22.0'**	**Gray organic silt, little clay, "and" fine sand, trace medium to coarse sand, trace fine gravel.**	**39**	**30**	**24**	**6**		
		SANDY ORGANIC SILT OL						

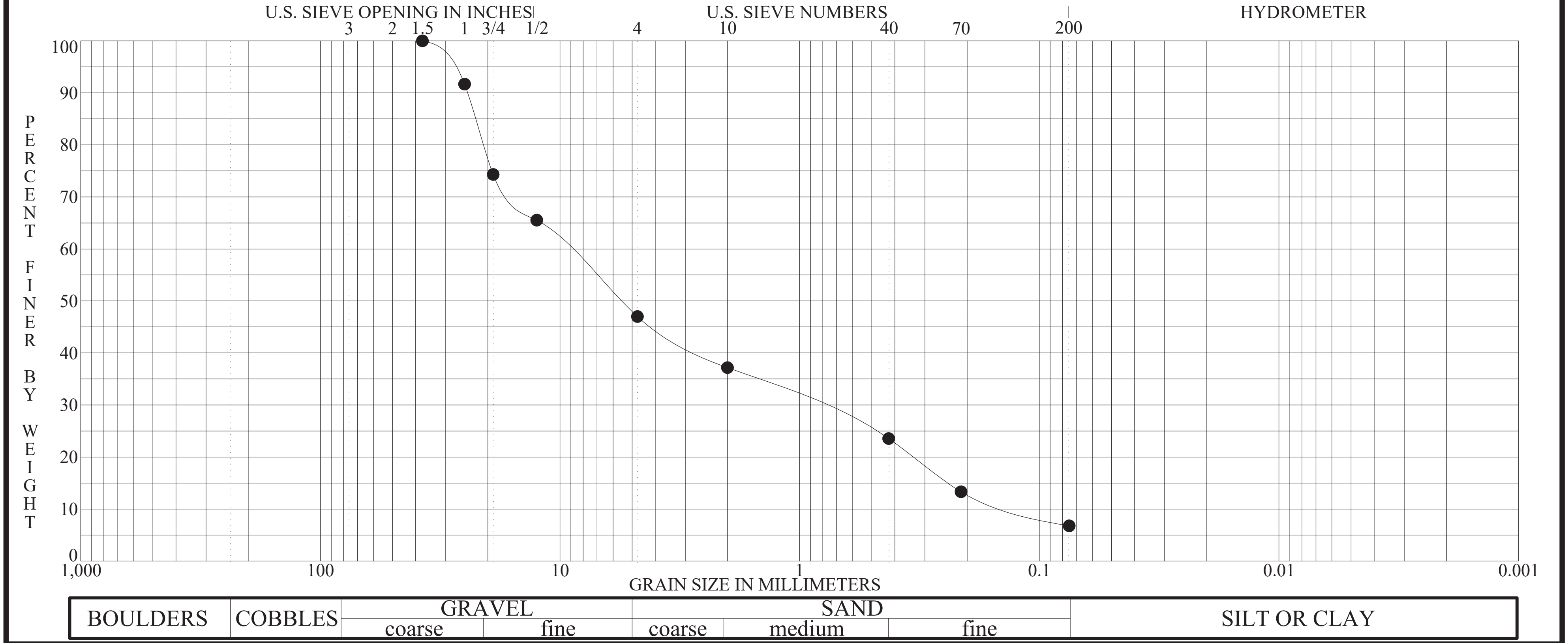
Specimen Identification - Depth		D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0907 S-11 21.0' to 22.0'**	**12.5000**	**0.6714**	**0.0862**	**0.0525**		**0.77**	**42.92**	**43.85**	**12.47**

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

BBCM



	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0907 S-13 26.0' to 26.6'**	**Brown fine to coarse gravel, "and" fine to coarse sand, trace silt.**					**0.668**	**74.823**

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0907 S-13 26.0' to 26.6'**	**37.5000**	**29.3892**	**9.3620**	**5.5538**	**0.1251**	**52.99**	**40.23**	**6.77**	

ASTM D422

GRADATION CURVE

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

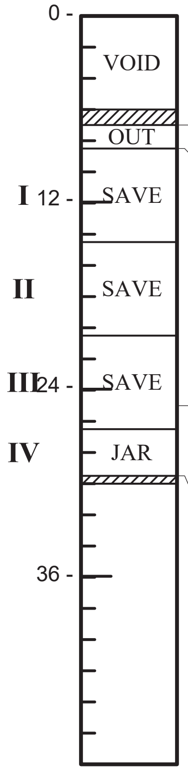
JOB NUMBER : **011-11497-013**
PROJECT : **CARDINAL PLANT ASH POND INVESTIGATION**
LOCATION : **BRILLIANT, OHIO**

BBCM

LABORATORY LOG OF SHELBY TUBES

Boring : **CD-PZ-BAP-0901** Sample : **16A**

Depth : **23.5' to 25.3'** Recovery : **21.00"**



disturbed - discarded

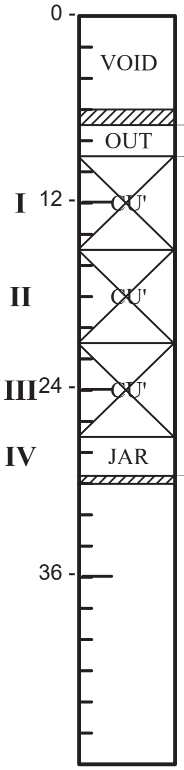
Gray silt, trace clay, trace fine to medium sand.

Stiff gray mottled with brown silty clay, trace fine to medium sand, many lenses of silt. H=1.8

30.00" tube

Boring : **CD-PZ-BAP-0901** Sample : **19A**

Depth : **31.0' to 32.8'** Recovery : **20.50"**



disturbed - discarded

Gray mottled with dark-gray and brown clayey silt, some fine sand, trace medium to coarse sand, few seams and lenses of silty clay and fine sand.

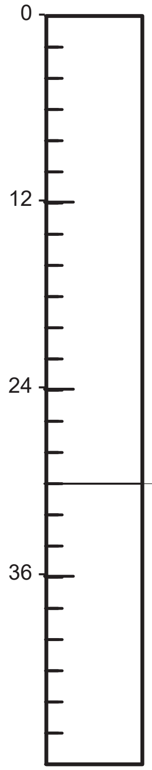
H=1.2

NOTE: AL/MA on representative sample.

30.00" tube

Boring : **CD-PZ-BAP-0906** Sample : **6A**

Depth : **8.5' to 9.4'** Recovery : **0.00"**



Severly Damaged - Could Not Extrude

LEGEND

■ - Consolidation, Incremental

▭ Swelling, Test

▨ - Wax

CRS - Consolidation, C R S

P P - Permeability, Vertical / Horizontal

◪ - Unconfined Compression Test

☒ - Triaxial Compression Test

H - Hand Penetrometer (tsf)
Ds - Direct Shear
LOI - Loss on Ignition
AL - Atterberg Limits
MA - Sieve/Hydrometer
SG - Specific Gravity

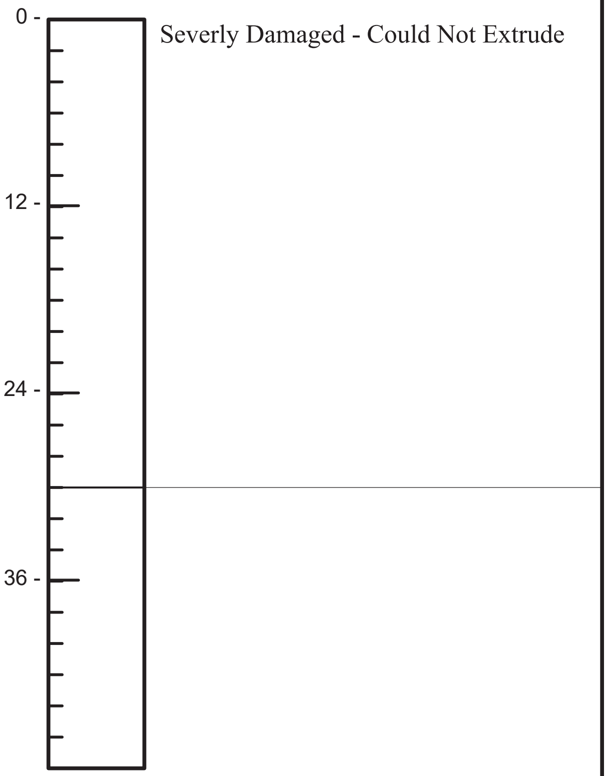
SL - Shrinkage Limit
POR - Porosity
UDW - Unit Dry Weight
MC - Moisture Content
D_R - Relative Density
S - Sieve

SHELBY TUBE LOG 111497013.GPJ BBCM.GDT 6/16/09

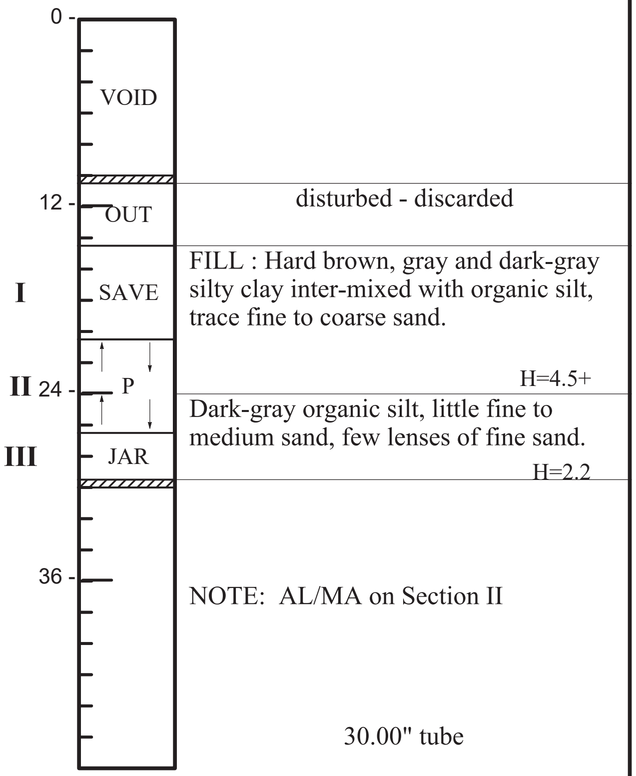
JOB NUMBER : **011-11497-013**
PROJECT : **CARDINAL PLANT ASH POND INVESTIGATION**
LOCATION : **BRILLIANT, OHIO**

LABORATORY LOG OF SHELBY TUBES

Boring : **CD-PZ-BAP-0906** Sample : **12A**	Boring : **CD-PZ-BAP-0907** Sample : **6A**	Boring : Sample :
Depth : **18.0' to 18.8'** Recovery : **0.00"**	Depth : **8.5' to 9.9'** Recovery : **15.00"**	Depth : Recovery :



Severly Damaged - Could Not Extrude



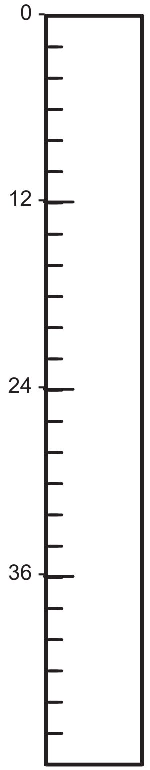
disturbed - discarded

FILL : Hard brown, gray and dark-gray silty clay inter-mixed with organic silt, trace fine to coarse sand.

Dark-gray organic silt, little fine to medium sand, few lenses of fine sand.

NOTE: AL/MA on Section II

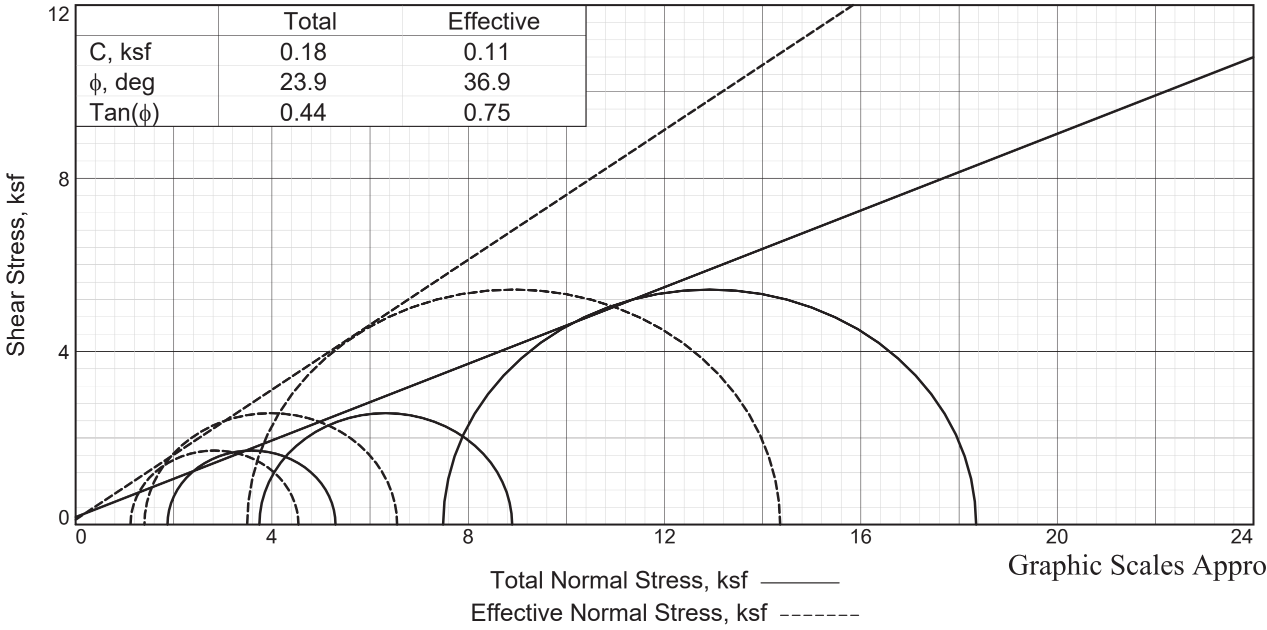
30.00" tube



LEGEND

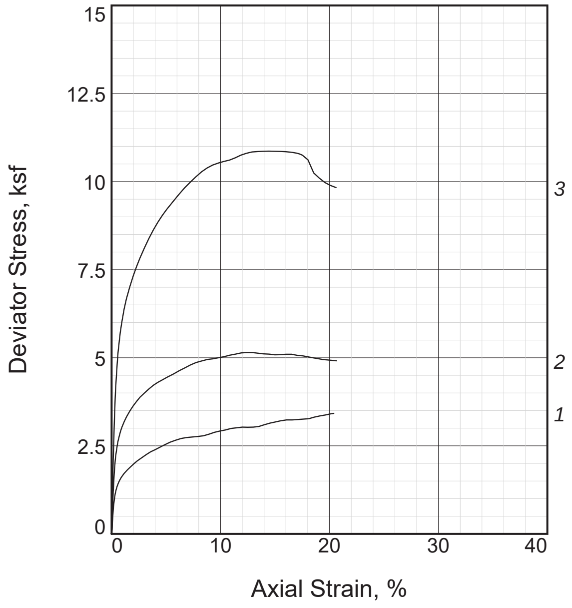
- ■ - Consolidation, Incremental
- ≋ Swelling, Test
- ▨ - Wax
- C R S - Consolidation, C R S
- P P - Permeability, Vertical / Horizontal
- ◫ - Unconfined Compression Test
- ☒ - Triaxial Compression Test

H - Hand Penetrometer (tsf)	SL - Shrinkage Limit
Ds - Direct Shear	POR - Porosity
LOI - Loss on Ignition	UDW - Unit Dry Weight
AL - Atterberg Limits	MC - Moisture Content
MA - Sieve/Hydrometer	D_R - Relative Density
SG - Specific Gravity	S - Sieve



	Total	Effective
C, ksf	0.18	0.11
ϕ, deg	23.9	36.9
Tan(ϕ)	0.44	0.75

Graphic Scales Approximate



	Sample No.	1	2	3
Initial	Water Content, %	35.1	43.8	31.9
	Dry Density, pcf	83.0	76.2	85.0
	Saturation, %	92.2	97.7	87.6
	Void Ratio	1.0297	1.2123	0.9833
	Diameter, in.	2.90	2.85	2.90
	Height, in.	5.59	5.59	5.59
At Test	Water Content, %	33.3	38.9	31.0
	Dry Density, pcf	86.9	82.6	90.3
	Saturation, %	95.6	101.0	96.5
	Void Ratio	0.9402	1.0401	0.8674
	Diameter, in.	2.86	2.78	2.85
	Height, in.	5.49	5.42	5.43
	Strain rate, in./min.	0.00	0.00	0.00
	Back Pressure, psi	40.00	40.00	40.00
	Cell Pressure, psi	53.00	66.00	92.00
	Fail. Stress, ksf	3.4	5.1	10.9
	Total Pore Pr., ksf	6.5	8.1	9.8
	Ult. Stress, ksf	3.4	4.9	9.8
	Total Pore Pr., ksf	6.5	8.0	9.9
	$\bar{\sigma}_1$ Failure, ksf	4.5	6.6	14.4
	$\bar{\sigma}_3$ Failure, ksf	1.1	1.4	3.5

Type of Test:
CU with Pore Pressures

Sample Type: Shelby Tube

Description: Gray mottled with dark-gray and brown clayey silt, some fine sand, trace medium to

LL= 35 **PL=** 28 **PI=** 7

Assumed Specific Gravity= 2.7

Remarks:

1

Client:

Project: Cardinal Plant Ash Pond Investigation
Brilliant, Ohio

Location: CD-PZ-BAP-0901

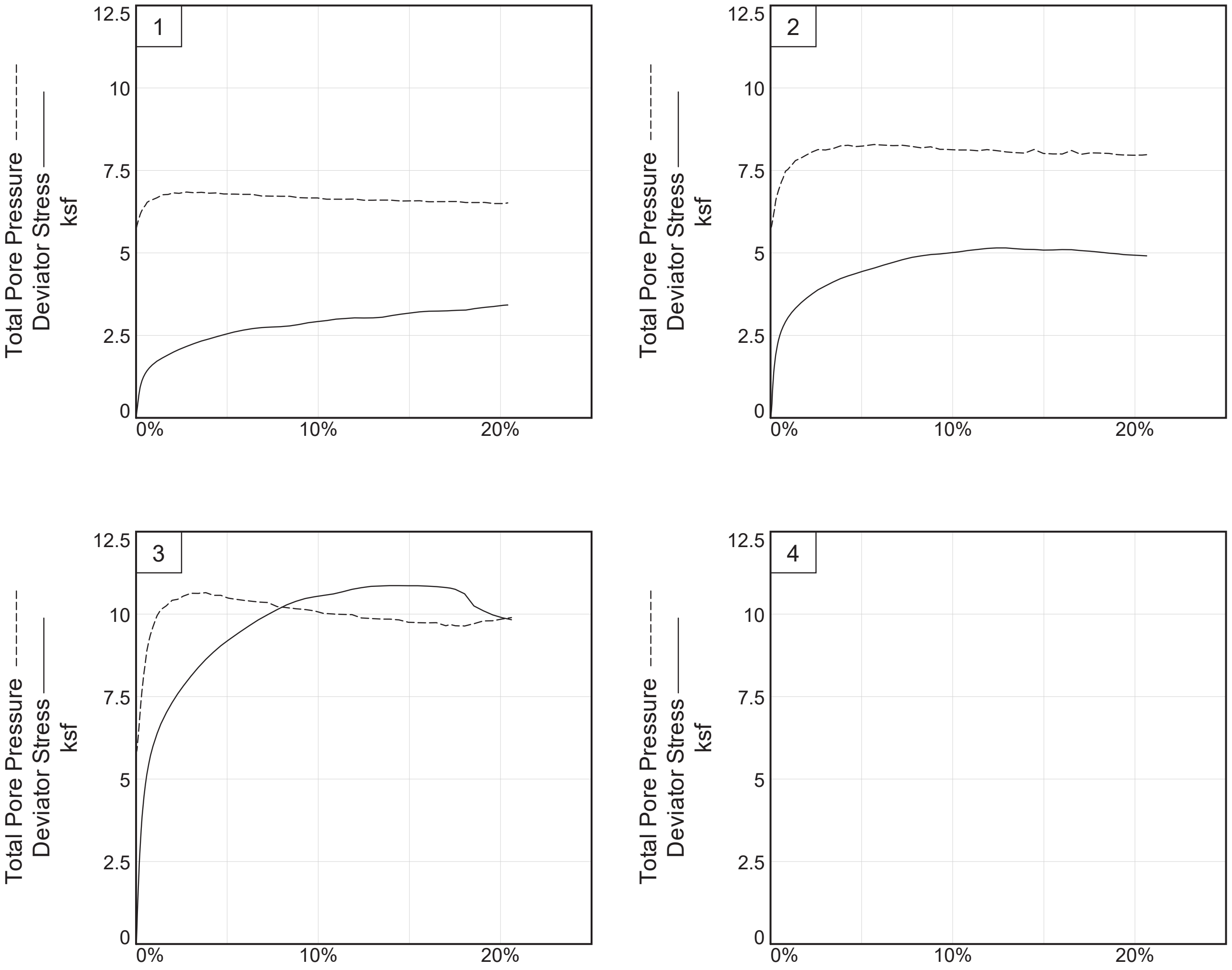
Sample Number: ST-19A **Depth:** 31.0' to 32.8'

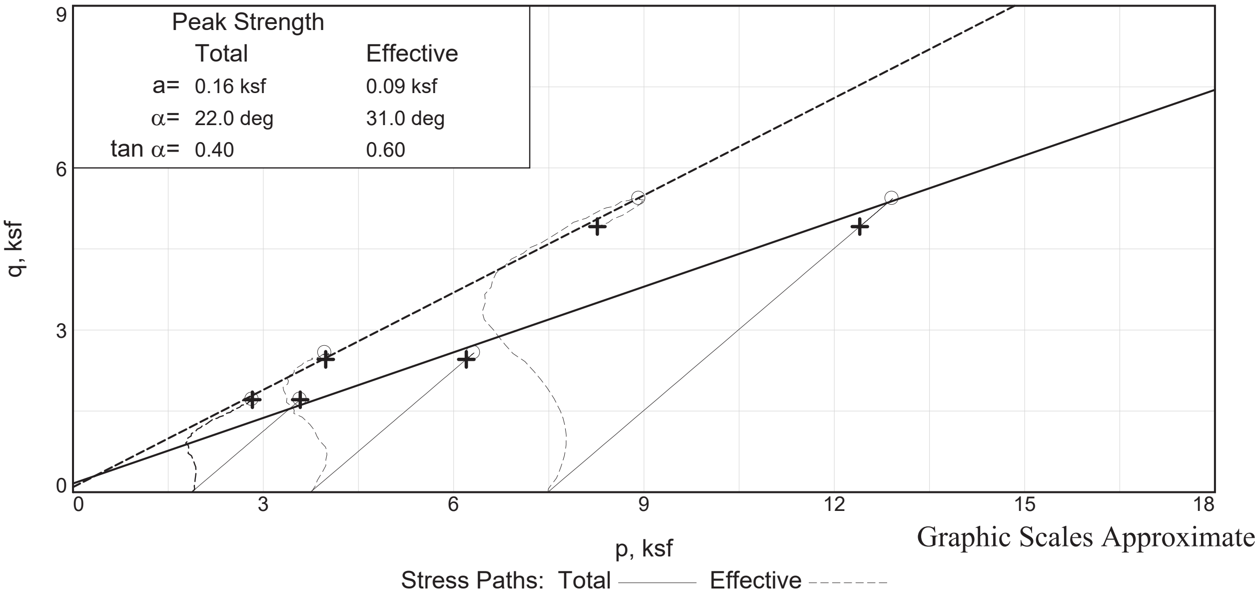
Proj. No.: 011.11497.013 **Date Sampled:** 5/1/09

TRIAXIAL SHEAR TEST REPORT

BBC&M Engineering, Inc.

Tested By: PJM **Checked By:** JJ





	Total	Effective
a=	0.16 ksf	0.09 ksf
α=	22.0 deg	31.0 deg
tan α=	0.40	0.60

Graphic Scales Approximate

Client:

Project: Cardinal Plant Ash Pond Investigation

Location: CD-PZ-BAP-0901 **Depth:** 31.0' to 32.8' **Sample Number:** ST-19A

Project No.: 011.11497.013 2

BBC&M Engineering, Inc.

Tested By: PJM **Checked By:** JJ

PLATE 70

PERMEABILITY TEST DATA AND COMPUTATION SHEET

((ASTM D-5084) FALLING HEAD, METHOD C)

BBCM
SOLUTIONS TO BUILD ON

Job Number: **011.11497.013**
Project Name: **Cardinal Ash Pond Investigation**
Project Location: **Brilliant, Ohio**
Tested By: **PJM**
Remarks:
Material: **FILL : Hard brown, gray and dark-gray silty clay inter-mixed with organic silt, trace fine to coarse sand.**

Date: **5/6-7/2009**
Boring: **CD-PZ-BAP-0907**
Sample: **ST-6A Sec. II**
Depth: **8.5' to 9.9'**

Maximum Dry Density:
Optimum Moisture Content:
% Compaction.:
Optimum +/-:
Natural: **X**
Remolded:

Sample:

Initial Length: 5.5945 in = 14.210 cm
Final Ave. Length (L): 5.6042 in = 14.235 cm
Diameter: 2.8765 in = 7.31 cm
Area (A): 6.499 sq in = 41.93 sq cm
Volume (V): 36.356 cu in = 595.77 cu cm
Wet Wt.: 1144.17 grams
Unit Wet Wt.: 119.90 pcf
Unit Dry Wt.: 93.99 pcf

Test Conditions:

Chamber Pressure: 62 psi
Back Pressure: 58 psi
Confining Pressure: 4 psi
Temp. @ Start: 22.5 °C
Temp. @ End: 22.5 °C
Average Temp.: 22.5 °C
B Parameter: 0.96

Moisture Content:	Before Test	After Test
Pan No. =	D	D
Wet Wt. + Pan =	1144.17	1157.03
Dry Wt. + Pan =	896.92	896.92
Wt. of Pan =	0.00	0.00
Wt. of Dry Soil =	896.92	896.92
Wt. of Water =	247.25	260.11
% Moisture =	27.57	29.00
% SATURATIO	**93.80**	**98.30**

S.G.(est) = 2.7000

Pipette Pressures During Test:

Top Pipette: 60 psi = 4220.3 cm
Bottom Pipette: 58 psi = 4079.6 cm

Pipette:

Area (a): 0.3435 sq in = 0.8725 sq cm

Calculations:

$$\boxed{k = \frac{a \cdot L}{2 \cdot A \cdot \Delta t} \ln\left(\frac{h_1}{h_2}\right)}$$

where:

k = Hydraulic Conductivity
a = Pipette Cross-Sectional Area
L = Length of Sample
A = Sample Cross-Sectional Area

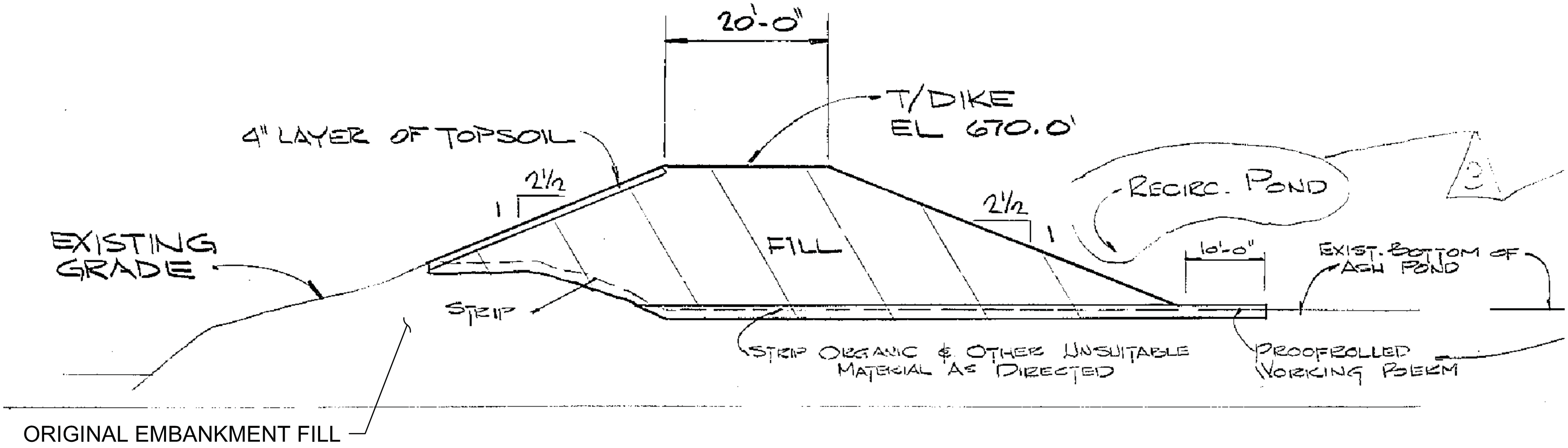
Δt = Time Interval (t_2 - t_1)
h_1 = Head Loss Across Permeameter/Specimen at t_1
h_2 = Head Loss Across Permeameter/Specimen at t_2
ln = Natural Logarithm (Base e = 2.71828)

Date	Time Readings	Time Interval Δt Seconds	Top Pipette cc	Hydraulic Head Headwater H_1 cm	Bottom Pipette cc	Hydraulic Head Tailwater H_2 cm	Head Loss h = H_1-H_2 cm	ℓn (h_1/h_2)	Temp. Corr. Permeability k cm/sec
5/6/2009	9:45 AM	0.00	48.45	4092.08	14.20	4272.01	-179.93	–	–
5/6/2009	10:51 AM	3,960	48.40	4092.14	14.45	4271.73	-179.59	0.00191	6.740E-08
5/6/2009	12:15 PM	5,040	48.20	4092.36	14.65	4271.50	-179.13	0.00256	7.077E-08
5/6/2009	1:45 PM	5,400	48.05	4092.54	15.00	4271.09	-178.56	0.00320	8.280E-08
5/6/2009	3:17 PM	5,520	47.85	4092.77	15.25	4270.81	-178.04	0.00289	7.312E-08
5/7/2009	8:21 AM	61,440	45.60	4095.34	18.00	4267.66	-172.31	0.03272	7.431E-08

Time Weighted Average, k [cm/sec] = **7.423E-08**

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

PLATE 1

HISTORIC SECTION A-A

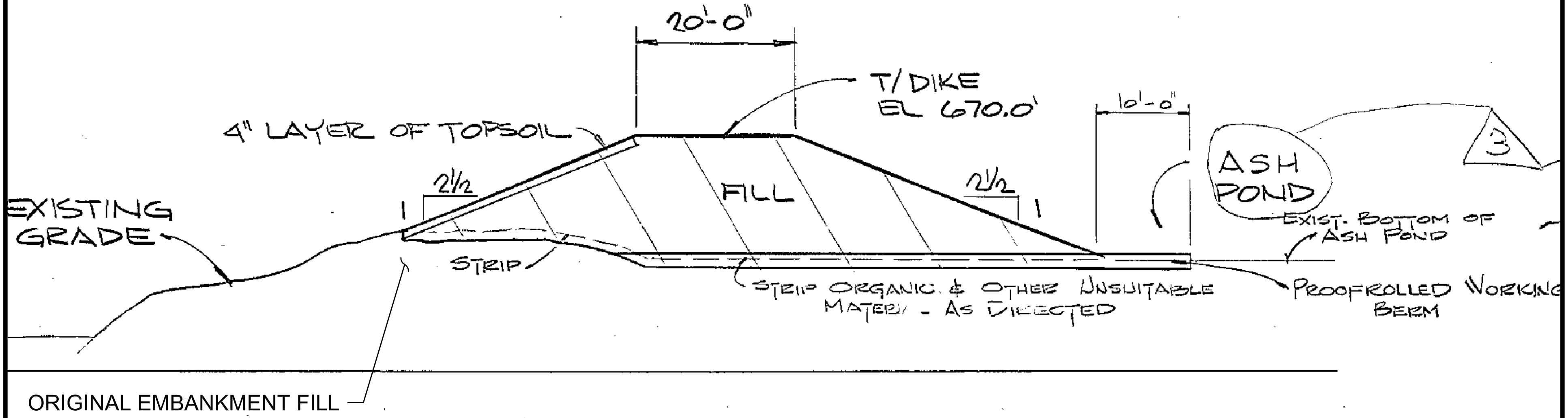
Cardinal Generating Plant
Bottom Ash Pond Investigation
Brilliant, Ohio

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

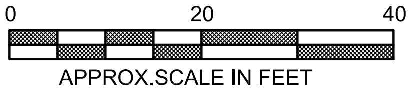
Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 424-1011

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



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

BBCM
SOLUTIONS TO BUILD ON

Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 424-1011

Project: 011-11497-013	Drawn By: MTR
Drawing Date: 6-16-2009	Approved By: MGR
Last Updated: 7-6-2009	Scale: 1" = 20' 1:1

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

PLATE 3

Cardinal Plant Ash Pond Investigation
Brilliant, Ohio
BBCM Engineering

INDEX TESTING SUMMARY

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

Project/Proposal No. 011.11497.013 Calculated By MTR Date 6-29-09
Project/Proposal Name CARDINAL ASH POND Checked By MAR Date 7-2-09
Subject STRENGTH & PERM. PARAMETERS Sheet 1 of 8

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) $\phi' = \sqrt{15.4\,(N_{60})} + 20°$ (HANTANAKA AND UCHIDA, 1996)

2) COMPARE EQN 1) WITH TYPICAL VALUES ESTABLISHED BY SCHROEDER ET AL

TABLE 7.1 Relative Density of Cohesionless Soils

Relative Density Designation	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

PLATE 8

Project/Proposal No. 01.11497.013
Calculated By MTR
Date 6-29-09
Project/Proposal Name CARDINAL ASH POND
Checked By MLR
Date 7-2-09
Subject STRENGTH & PERM PARAMETERS
Sheet 2 of 8

+ PERMEABILITY

- EMBANKMENT FILL:

  ESTIMATE PERM BASED ON RESULTS FROM FLEX WALL PERMEABILITY TEST PERFORMED ON UNDISTURBED SAMPLE. ESTIMATE PERM. HIGHER THAN TEST VALUE TO ACCOUNT FOR PERMEABILITY ON A MACRO SCALE, AS WELL AS ACCOUNTING FOR SAMPLES WITH A HIGHER GRANULAR CONTENT.

  → ADJUST K, K_V/K_H RATIO DURING ANALYSIS TO MATCH FIELD CONDITIONS.

- ORIGINAL EMBANKMENT FILL & NATURAL COHESIVE LAYERS

  ESTIMATE PERM. BASED ON TYPICAL PUBLISHED VALUES USING SOIL DESCRIPTION & GRAIN SIZE ANALYSIS

- GRANULAR FOUNDATION LAYERS

  ESTIMATE PERMEABILITY BASED ON TYPICAL PUBLISHED VALUES BASED ON RELATIVE DENSITY & GRAIN SIZE ANALYSIS.

  AS A GUIDE, USE $K = (\underline{100}\ D_{10})^2$ μsec $(cm \times 10^{-4}/sec)$

  (HAZEN)

  ALSO USE d_{15} VALUE AND COMPARE TYPICAL RANGE OF PERMEABILITY BASED ON GRAIN SIZE (GEOSYNTEC, 1991)

Project/Proposal No. 011.11497.013 Calculated By MTR Date 6-29-09
Project/Proposal Name CARDINAL ASH POND Checked By MGR Date 7-3-09
Subject STRENGTH & PERM. PARAMETERS Sheet 3 of 8

LAYER: NEWER EMBANKMENT FILL (1970s)

- DESCRIPTION: CONTAINS ZONES AND POCKETS OF THE FOLLOWING
  1) MED DENSE TO DENSE BROWN AND GRAY FINE TO COARSE GRAVEL, SOME FINE TO COARSE SAND, SOME TO "AND" SILTY CLAY
  2) SOFT TO HARD BROWN AND GRAY SILTY CLAY, SOME FINE TO COARSE SAND, SOME FINE TO COARSE GRAVEL

- N_{60} VALUES (IN GRANULAR ZONES)
  LOW: 16
  HIGH: 50
  AVG: 26

- HAND PENETROMETER (ON SAMPLES EXHIBITING COHESION)
  $H = 0.0 - 4.5^{+}$ tsf

- STRENGTH PARAMETER:

IF CONSIDERED GRANULAR, $\phi = 34-35°$ BASED ON TABLE 7.1 USING AVERAGE N_{60}-VALUE. ADJUST FOR HIGH FINE GRAINED CONTENT, SAY $\phi' = 32°$

1) CORRELATION TO STARK CHARTS
   - FOR CORRELATION, CONSIDER BOTH $\phi_{v0}' = 50$ KPa AND 100 KPa TO ACCOUNT FOR PROBABLE DEPTH OF FAILURE SURFACE.
   - RESULTS: $\phi_{fs}' = 31°$ (SEE CORRELATIONS THIS APPENDIX)

2) GRAPH OF 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, $\phi' = 31°$	$5\times>10^{-7}$
CL	INORG CLAYS OF LOW-MED PI	$C' = 270$ psf, $\phi' = 28°$	$>10^{-7}$

DESIGN STRENGTH: $C' = 0$ psf, $\phi' = 31°$

- PERMEABILITY: BASED ON PERMEABILITY CORRELATIONS & TYPICAL RANGE OF PERMEABILITY, USE $K_v = 1\times10^{-5}$ cm/sec. SEE CORRELATION THIS APPENDIX. ADJUST K_v/K_H RATIO DURING ANALYSIS TO MATCH FIELD CONDITIONS

Project/Proposal No. 011.11497.013 Calculated By MTR Date 6-29-09
Project/Proposal Name CARDINAL ASH POND Checked By MHR Date 7-2-09
Subject STRENGTH & PERM PARAMETERS Sheet 4 of 8

LAYER : ORIGINAL EMBANKMENT FILL (OLDER FILL)

- DESCRIPTION : STIFF TO HARD BROWN MOTTLED WITH GRAY SILTY CLAY (USCS : LEAN CLAY)

- HAND PENETROMETER RANGE : 1.5 - 4.5 tsf

- STRENGTH PARAMETER :

1) CORRELATION TO STARK CHARTS
CONSIDER $\phi'_{vo} = 50$ KPa BASED ON RELATION OF THIS LAYER TO THE FAILURE PLANE.
- RESULTS : $\phi'_{FS} = 30°$

(SEE CORRELATION THIS APPENDIX)

2) ϕ' VRS PI
- RESULTS : FOR PI = 24 , $\phi' = 30°$ (SEE CHART THIS APPENDIX)

3) N/A FOR FILL SOILS

4) NAVFAC TABLE 1

GROUP	SOIL TYPE	TYP UNDRAINED STRENGTH	TYP K (cm/sec)
CL	INORGANIC CLAYS OF LOW TO MED PLASTICITY	$c' = 270$ psf $\phi' = 28°$	$> 10^{-7}$

DESIGN STRENGTH PARAMETER : $c' = 100$ psf , $\phi' = 30°$

- PERMEABILITY :

FLEX WALL PERMEABILITY TEST PERFORMED ON SAMPLE ST-6A OF BORING BAP-0907

- RESULTS $K_v = 7.42 \times 10^{-8}$ cm/sec

- DESIGN : USE $K_v = 1 \times 10^{-7}$ cm/sec TO ACCOUNT FOR PERM ON A MACRO SCALE.

=> K_v ADJUSTED TO 5×10^{-8} cm/sec WITH $K_H/K_v = 5$ DURING SEEPAGE ANALYSIS

PLATE 11

SOLUTIONS TO BUILD ON
Cincinnati (513) 771-8471
Cleveland (216) 901-1000
Columbus (614) 793-2226
Dayton (937) 424-1011

Project/Proposal No. 011.11497.013 Calculated By MTR Date 6-29-09
Project/Proposal Name CARDINAL ASH POND Checked By MGR Date 7-2-09
Subject STRENGTH & PERM. Sheet 5 of 8

LAYER : ALLUVIUM SILT & CLAY

- DESCRIPTION: VERY LOOSE TO MED DENSE GRAY SILT, CONTAINS ZONES OF STIFF TO HARD SILTY CLAY AND THIN LAYERS OF VERY LOOSE TO LOOSE FINE TO COARSE SAND

- N_{60} RANGE : 0 TO 27 , AVG = 8 bpf

- HAND PENETROMETER : 0 - 3.5 tsf ON SICL SAMPLES

- STRENGTH PARAMETERS

1) STARK CORRELATION:
   - CONSIDER BOTH 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

$$\phi'_{NC} = 36 - 0.2665\,(\%\ \text{CLAY})$$

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)

PLATE 12

Project/Proposal No. 0111497.013 Calculated By MTR Date 6-29-09
Project/Proposal Name CARDINAL ASH POND Checked By MLR Date 7-2-09
Subject STRENGTH & PERMEABILITY Sheet 6 of 8

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 σ'_{vo} = 100 kPa AND 400 kPa WITH TENDANCY TOWARD 100 kPa
   - RESULTS : $\phi'_{FS} = 26°$ (SEE CORRELATION THIS APPENDIX)

2) ϕ' VRS PI
   - RESULTS : FOR PI = 16, $\phi' = 31°$ (SEE CHART THIS APPENDIX)

3) HALL'S THESIS

$$\phi'_{NC} = 36 - 0.2665\ (\%\ CLAY)$$

FOR CF = 16, $\phi'_{NC} = 31.7°$

5) CU TRIAXIAL TEST - SAMPLE WAS NOT DESCRIBED AS 'ORGANIC', BUT DESCRIPTION BEST MATCHES THIS LAYER

   RESULTS : $\phi' = 36.9°$, $c' = 110$ psf

- PERMEABILITY : D_{15} -
  LOW = 0.0015
  HIGH = 0.005
  AVG = 0.0023
  } $K_v = 5 \times 10^{-6}$ cm/s (GEOSYNTEC, SEE APPENDIX)
  (4 SAMPLES TOO COARSE FOR D_{15} VALUE

* PER FHWA GEC 5, LOI < 20% SOIL
PROPERTIES CONTROLLED BY NON-ORGANIC
PORTION ∴ REGULAR CORRELATIONS OK

DESIGN STRENGTH PARAMETER : $\phi' = 30°$, $c' = 0$ psf

Project/Proposal No. 011.11497.013 Calculated By MTR Date 6-29-09
Project/Proposal Name CARDINAL ASH POND Checked By MGR Date 7-2-09
Subject STRENGTH & PERM. Sheet 7 of 8

+ LAYER: VERY LOOSE - LOOSE GLACIAL OUTWASH SAND & GRAVEL

- DESCRIPTION: VERY LOOSE TO LOOSE BROWN AND GY FINE TO MEDIUM SAND, TRACE TO SOME SILT OR INTERBEDDED WITH SILT, FEW SEAMS OF SILTY CLAY

- N_{60} RANGE:

ϕ'

		EQN 72	TABLE 7.1
LOW	4	27.8	28°
HIGH	29	41.1	35°- 36°
AVG	12	33.6	30 - 31°

USE $\phi' = 29°$ & $c' = 0$

- PERMEABILITY: USE GRAIN SIZE ANALYSIS

BORING CV-PZ-BAP-0904, SAMPLE 21, $D_{15} \approx 0.06$

$k_v = 1 \times 10^{-2}$ cm/s (See appendix → Geosyntec, 1991)

+ LAYER: MED DENSE GLACIAL OUTWASH SAND & GRAVEL

- DESCRIPTION: MED DENSE TO DENSE BROWN AND GRAY FINE TO COARSE GRAVEL AND FINE TO MED SAND.

ϕ'

			EQN 72	TABLE 7.1
- N_{60} RANGE:	LOW	14	34.7	31°- 32°
	HIGH	69	52.6	> 41
	AVG	32	42.2	36°

USE $\phi' = 34°$ & $c' = 0$

Permeability:

BORING	SAMPLE	D_{15}
0903	S-11	0.09
0905	S-13	0.19
0906	S-24	0.6
0907	S-13	0.25
0902	S-24	0.09

(See appendix)

PLATE 14

Use $k_v = 1 \times 10^{-3}$ cm/s (Geosyntec, 1991)

Project/Proposal No. 011.11497.013 Calculated By MTR Date 7/15/09
Project/Proposal Name CARDINAL ASH POND Checked By ______ Date ______
Subject SEISMIC STRENGTH PARAMETERS Sheet 8 of 8

- PERFORM SEISMIC STABILITY ANALYSIS, WITH A PSEUDOSTATIC APPROACH USING LIMIT EQUILIBRIUM METHOD

  ⇒ APPLY HORIZONTAL LOAD TO STATIC MODEL EQUAL TO THE PEAK HORIZONTAL ACCELERATION, a, DETERMINED FROM SEISMIC HAZARD MAPPING

- ASSUMED ORIGINAL EMBANKMENT FILL LAYER WILL EXHIBIT UNDRAINED RESPONSE DURING AN EARTHQUAKE EVENT.
  ∴ USE USACE 'R' ENVELOPE TO MODEL THE STRENGTH PROPERTIES.

SINCE NO CU TEST DATA IS AVAILABLE FOR THE ORIGINAL FILL, COMPARE INDEX TESTING RESULTS TO VALUES PRESENTED BY DUNCAN AND WRIGHT (2005) FOR 'R' TEST RESULTS.

BASED ON COMPARISON, USE THE FOLLOWING STRENGTH VALUES

LAYER	C	ϕ
ORIGINAL EMBANKMENT FILL	50 psf	22°

SEE TABLE 10.3 ON FOLLOWING PG.

CU TEST PERFORMED IN ORG CL&I LAYER – USE R-ENVELOPE TO MODEL STRENGTHS FOR SEISMIC

ORG. CL&I → 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
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

ORIGINAL EMBANKMENT FILL
USE C=50 psf & φ=22°
LL=48, PI=24

^{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.

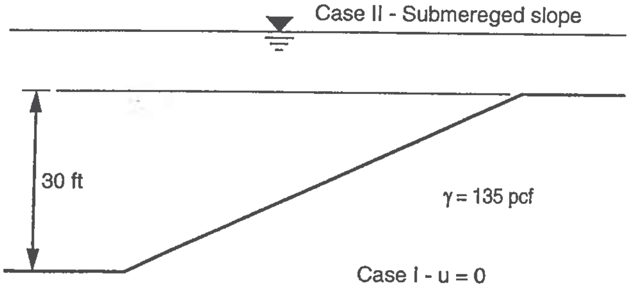


Figure 10.6 Slope used to compare simple, single-stage and rigorous, two-stage pseudostatic analyses.

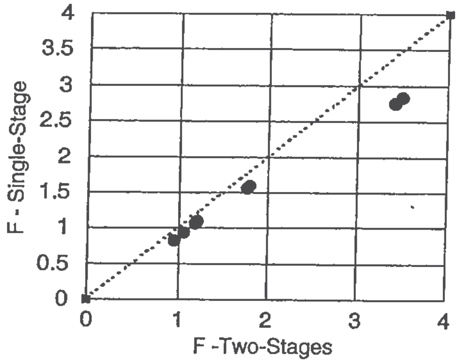


Figure 10.7 Comparison of factors of safety by simplified single-stage pseudostatic and more rigorous two-stage pseudostatic analyses.

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-

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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

$$\frac{\text{ball-milled derived LL}}{\text{ASTM derived LL}} = .003\ (\text{ASTM derived LL}) + 1.23$$

LL_{ASTM} = 27
LL_{BM} = 35.4

$$\frac{\text{ball-milled derived CF}}{\text{ASTM derived CF}} = 0.0003\ (\text{ASTM derived CF})2 - 0.037(\text{ASTM derived CF}) + 2.254$$

CF_{ASTM} = 12
CF_{BM} = 22.2

where: LL = Liquid Limit
CF = Clay-sized Fraction

BBCM
SOLUTIONS TO BUILD ON

DRAINED SHEAR STRENGTH PARAMETER CORRELATION

Soil Layer: Newer Embankment Fill

LL_{BM} = 35.4

CF_{BM} = 22.2

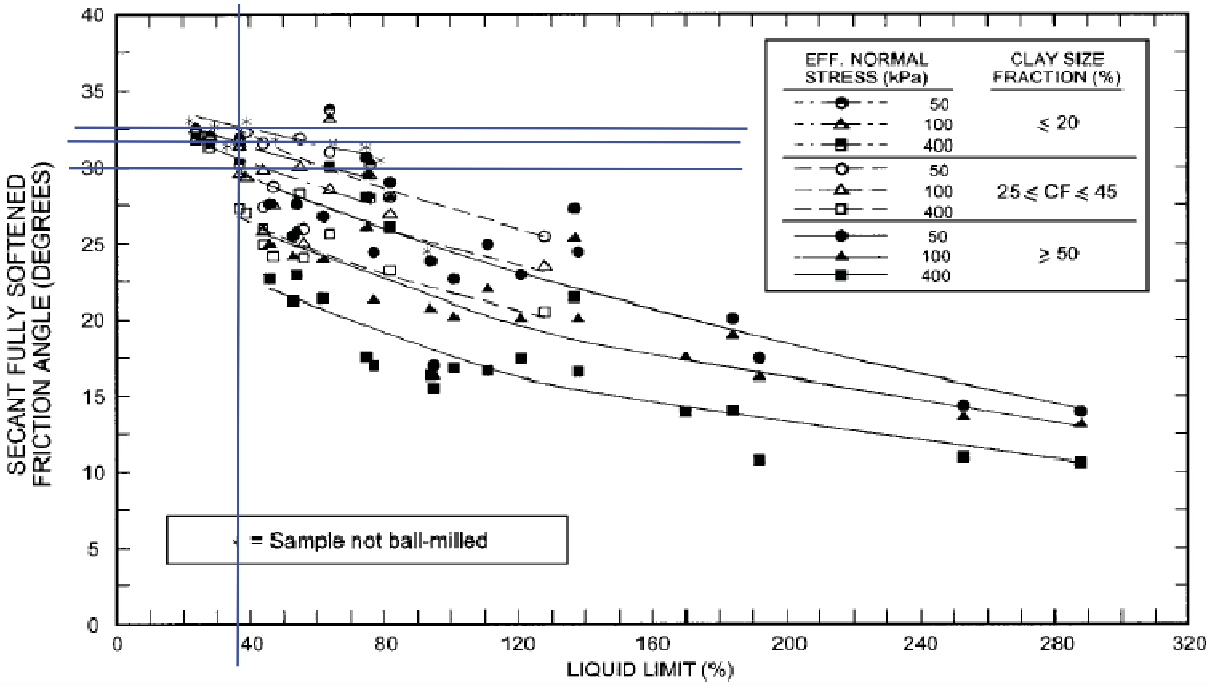

Fig. 5. Secant fully softened friction angle relationships with liquid limit, clay-size fraction, and effective normal stress

Secant Fully Softened Friction Angle

		Effective Normal Stress	
		50 kPa	*100 kPa*
Clay Sized Fraction, %	*CF ≤ 20*	32.5°	31.5°
	25 ≤ CF ≤ 45	32.5°	30°

Design Friction Angle Value	31°

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

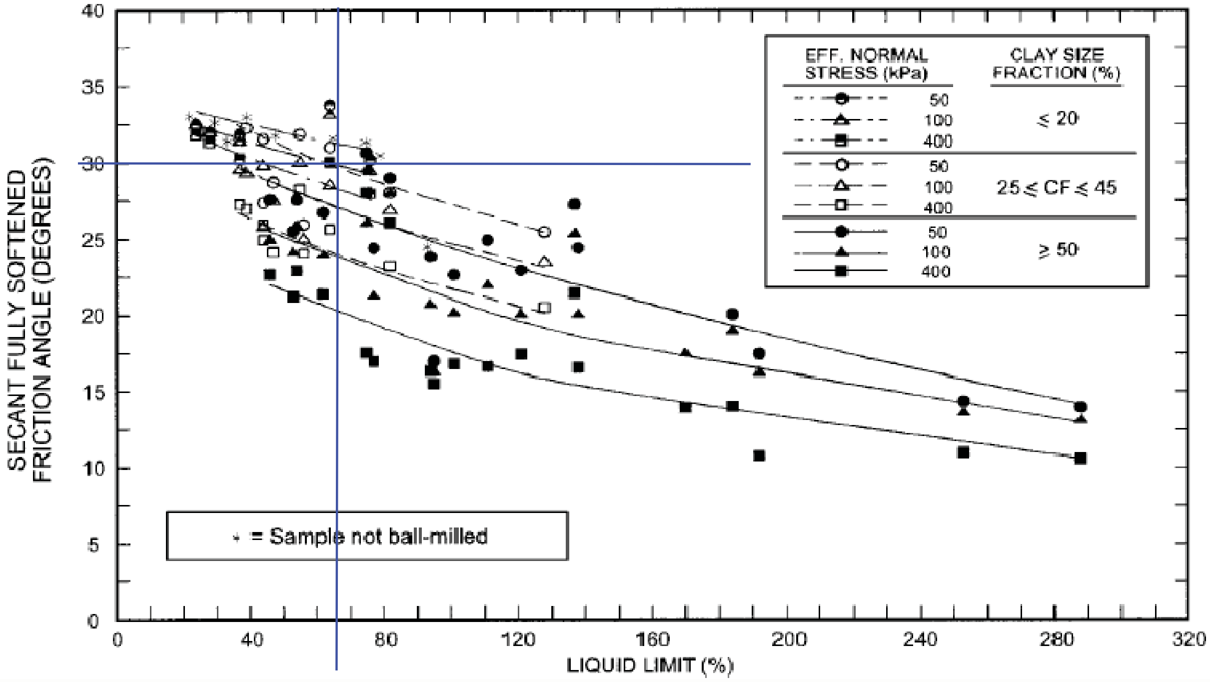

Fig. 5. Secant fully softened friction angle relationships with liquid limit, clay-size fraction, and effective normal stress

Effective Normal Stress, kPa	50
Secant Fully Softened Friction Angle	**30°**

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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

DRAINED SHEAR STRENGTH PARAMETER CORRELATION

Soil Layer: Organic Clayey Silt

LL_{BM} = 61.4

CF_{BM} = 32.7

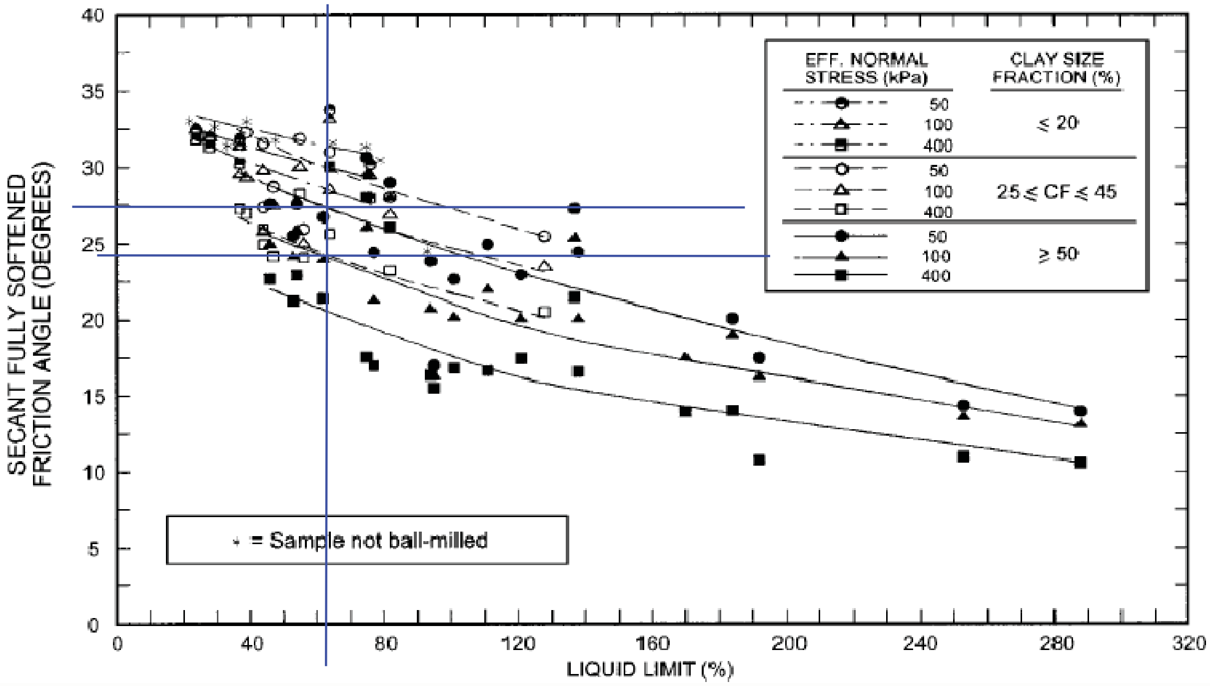


Fig. 5. Secant fully softened friction angle relationships with liquid limit, clay-size fraction, and effective normal stress

Secant Fully Softened Friction Angle

		Effective Normal Stress	
		100 kPa	*400 kPa*
Clay Sized Fraction, %	*CF ≤ 20*	27.5°	24°
	25 ≤ CF ≤ 45	-	-

Design Friction Angle Value	26°

PLATE 22

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

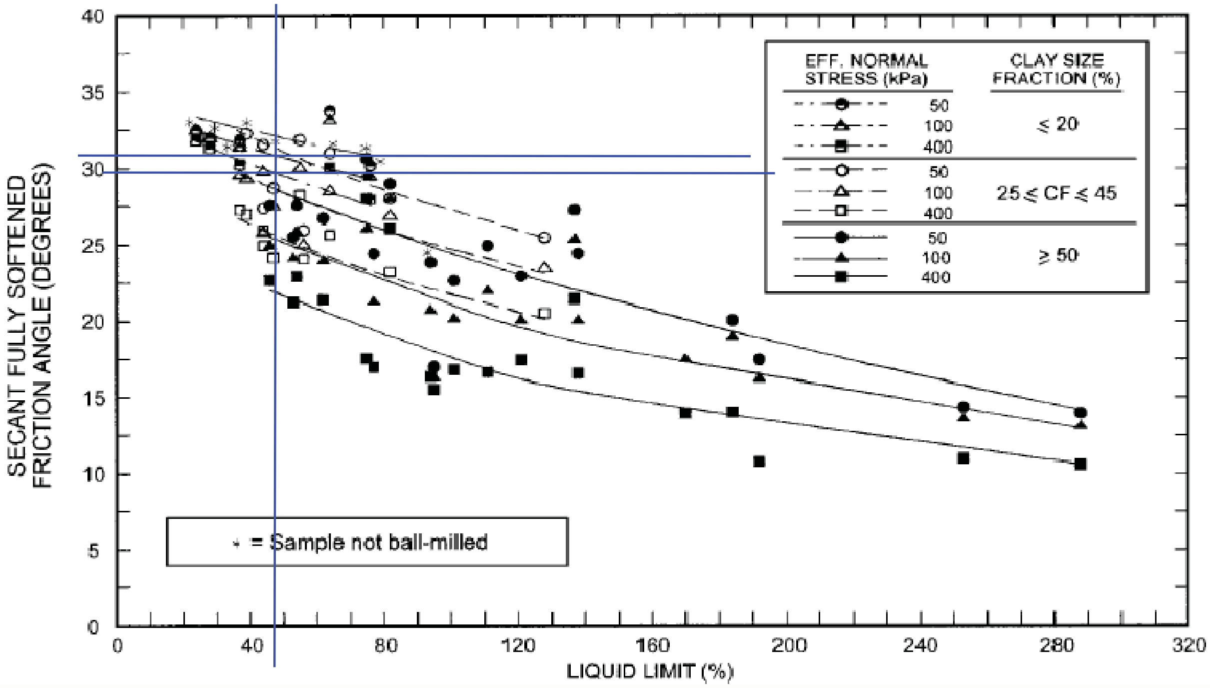


Fig. 5. Secant fully softened friction angle relationships with liquid limit, clay-size fraction, and effective normal stress

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°

PLATE 24

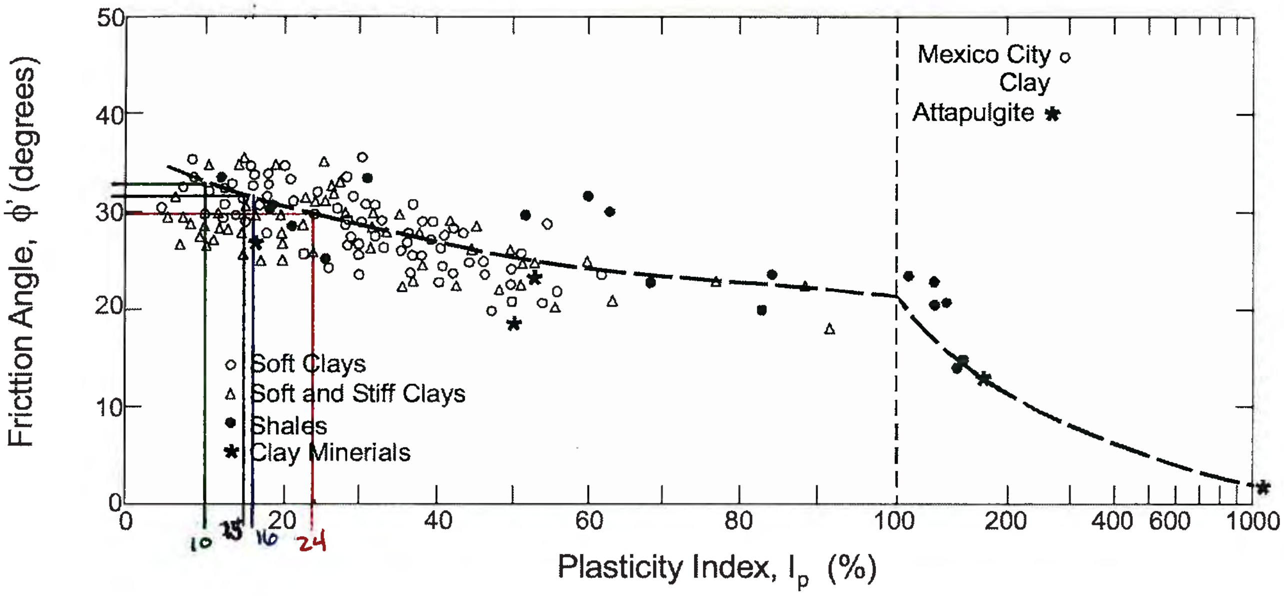


Figure 74. Relationship between φ′ and PI (Terzaghi, Peck, and Mesri, 1996).

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	137.5	35
	Loose	25	<20	1.83	114.2	0.47	134	32
SW: well-graded sands, gravelly sands	Dense	75	65	1.89	118	0.43	136.8	37
	Medium dense	50	35	1.79	111.7	0.49	132.2	34
	Loose	25	<15	1.70	106.1	0.57	128.8	30
SP: poorly graded sands, gravelly sands	Dense	75	50	1.76	109.9	0.52	131.3	36
	Medium dense	50	30	1.67	104.2	0.60	127.6	33
	Loose	25	<10	1.59	99.3	0.65	124	29
SM: silty sands	Dense	75	45	1.65	103	0.62	127	35
	Medium dense	50	25	1.55	97	0.74	123.5	32
	Loose	25	<8	1.49	93	0.80	120.7	29
ML: inorganic silts, very fine sands	Dense	75	35	1.49	93	0.80	120.7	33
	Medium dense	50	20	1.41	88	0.90	117.6	31
	Loose	25	<4	1.35	84.3	1.0	115.5	27

*N is blows per foot of penetration in the SPT. Adjustments for gradation are after Burmister (1962).[13] See Table 3.23 for general relationships of D_R vs. N.

†Density given is for G_s = 2.65 (quartz grains).

‡Friction angle ϕ depends on mineral type, normal stress, and grain angularity as well as D_R and gradation (see Fig. 3.63).

$1\ g/cm^3 = 9.81\ kN/m^3$

$$\gamma_{SAT} = \frac{(G_s + e)\gamma_w}{1 + e}$$

$$\gamma_{SAT} = \gamma_d + \frac{e\gamma_w}{(1 + e)}$$

Newer Embankment Fill: Permeability

D_{15} Range = 0.002 - 0.080

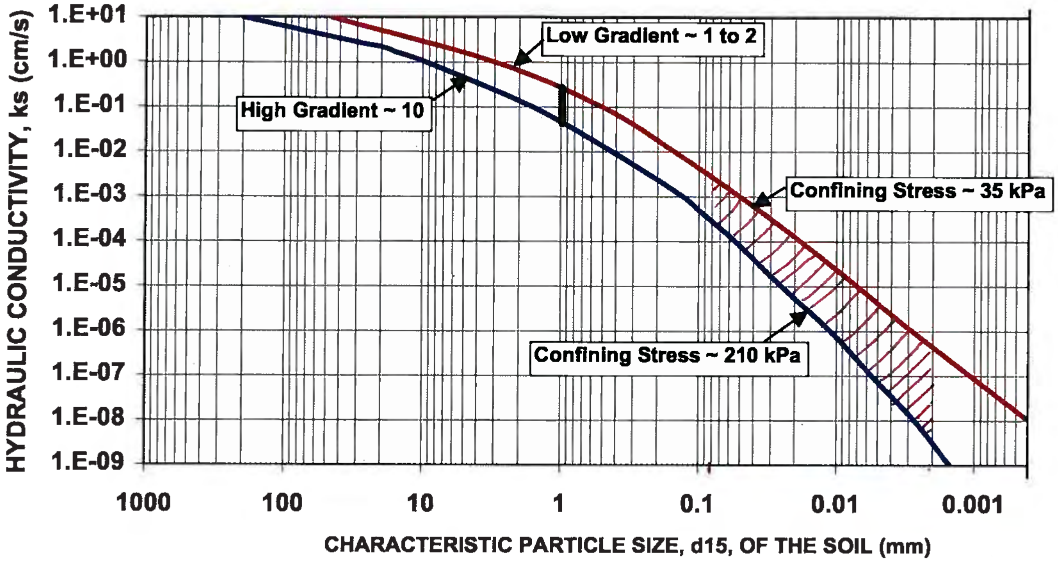


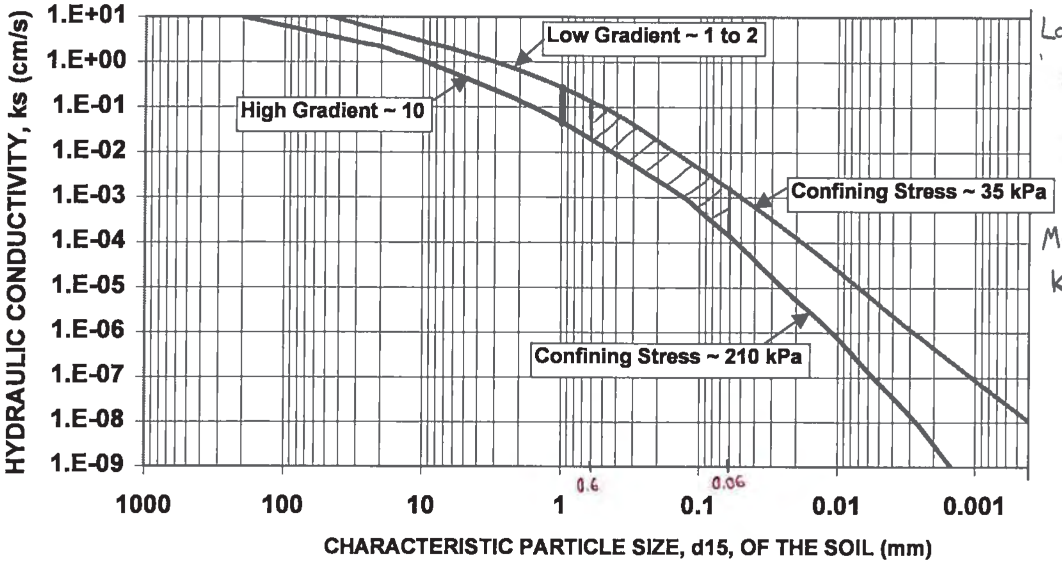
Figure 91. Range of hydraulic conductivity based on grain size (after GeoSyntec, 1991).

Considering the site geology, the laboratory and field data should be tabulated with other known data for the sample/test location and with depth, soil/rock type, grain size distribution, Atterberg limits, and water content. This table should also include important test information such as: stress conditions, gradients, and test method. Once this table is constructed it will be much easier to group like soil types and k values, to delineate distinct areas within the site, and to eliminate potentially erroneous data. Once these values have been grouped together and potentially erroneous values eliminated, it may be useful to compute an average value for each grouping. When averaging, the log of the hydraulic conductivity value must be taken before performing an arithmetic mean or incorrect results will be produced. First, the logarithm of each value should be taken. Second, an average value should be calculated from these logarithmic values. Finally, the antilog of this average value should be taken to calculate the average hydraulic conductivity value. Table 35 illustrates how to calculate the mean of the log of k data and compares this value with an incorrect direct arithmetic mean.

K_s range: $1 \times 10^{-8} - 1 \times 10^{-3}$ cm/s

Geotechnical Engineering Circular No. 5
Evaluation of Soil and Rock Properties.

Glacial outwash sand and gravel.



Loose: $k_v = 1 \times 10^{-2}$ cm/s

Medium-dense: $k_v = 1 \times 10^{-3}$ cm/s

Figure 91. Range of hydraulic conductivity based on grain size (after GeoSyntec, 1991).

Considering the site geology, the laboratory and field data should be tabulated with other known data for the sample/test location and with depth, soil/rock type, grain size distribution, Atterberg limits, and water content. This table should also include important test information such as: stress conditions, gradients, and test method. Once this table is constructed it will be much easier to group like soil types and k values, to delineate distinct areas within the site, and to eliminate potentially erroneous data. Once these values have been grouped together and potentially erroneous values eliminated, it may be useful to compute an average value for each grouping. When averaging, the log of the hydraulic conductivity value must be taken before performing an arithmetic mean or incorrect results will be produced. First, the logarithm of each value should be taken. Second, an average value should be calculated from these logarithmic values. Finally, the antilog of this average value should be taken to calculate the average hydraulic conductivity value. Table 35 illustrates how to calculate the mean of the log of k data and compares this value with an incorrect direct arithmetic mean.

Geotechnical Engineering Circular No. 5
Evaluation of Soil and Rock Properties.

Method: Geosyntec
Source: FHWA GEC No 5: pg 184

Equation: Graphic

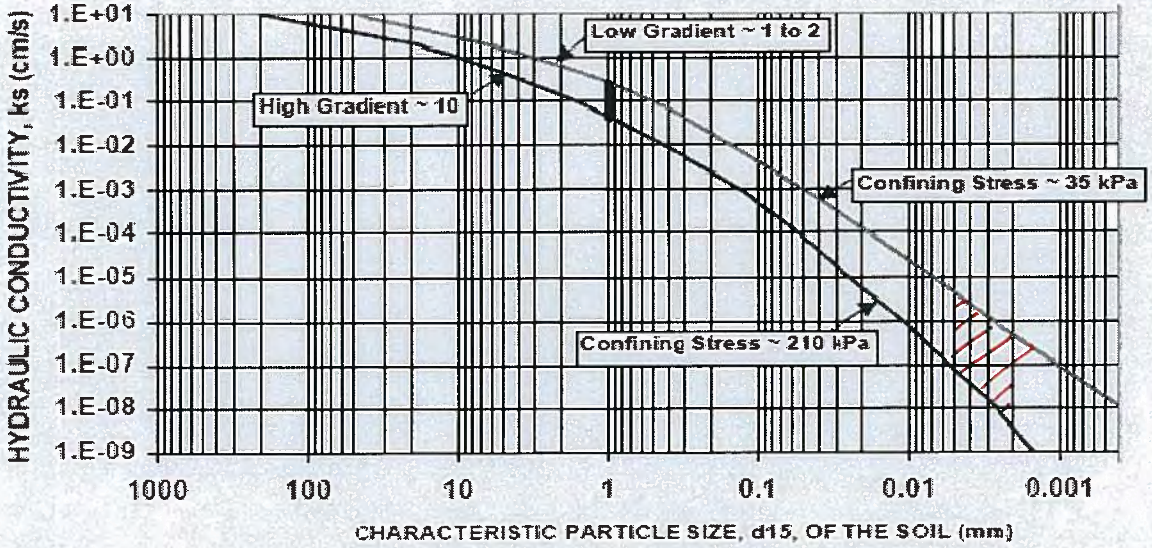


Figure 91. Range of hydraulic conductivity based on grain size after GeoSyntec, 1991).

LAYER: ORGANIC CLAYEY SILT

d_{15} RANGE = 0.0015 mm - 0.005 mm

AVG d_{15} = 0.002 mm

USE $K_v = 5 \times 10^{-6}$ cm/SEC BASED ON INCLUSION OF SILT SEAMS

PERMEABILITY TEST DATA AND COMPUTATION SHEET

((ASTM D-5084) FALLING HEAD, METHOD C)

BBCM SOLUTIONS TO BUILD ON

Job Number: **011.11497.013**
Project Name: **Cardinal Ash Pond Investigation**
Project Location: **Brilliant, Ohio**
Tested By: **PJM**
Remarks:
Material: **FILL : Hard brown, gray and dark-gray silty clay inter-mixed with organic silt, trace fine to coarse sand.**

Date: **5/6-7/2009**
Boring: **CD-PZ-BAP-0907**
Sample: **ST-6A Sec. II**
Depth: **8.5' to 9.9'**

Maximum Dry Density:
Optimum Moisture Content:
% Compaction.:
Optimum +/-:
Natural: **X**
Remolded:

Sample:

Initial Length: 5.5945 in = 14.210 cm
Final Ave. Length (L): 5.6042 in = 14.235 cm
Diameter: 2.8765 in = 7.31 cm
Area (A): 6.499 sq in = 41.93 sq cm
Volume (V): 36.356 cu in = 595.77 cu cm
Wet Wt.: 1144.17 grams
Unit Wet Wt.: 119.90 pcf
Unit Dry Wt.: 93.99 pcf

Test Conditions:

Chamber Pressure: 62 psi
Back Pressure: 58 psi
Confining Pressure: 4 psi
Temp. @ Start: 22.5 °C
Temp. @ End: 22.5 °C
Average Temp.: 22.5 °C
B Parameter: 0.96

Moisture Content:	Before Test	After Test
Pan No. =	D	D
Wet Wt. + Pan =	1144.17	1157.03
Dry Wt. + Pan =	896.92	896.92
Wt. of Pan =	0.00	0.00
Wt. of Dry Soil =	896.92	896.92
Wt. of Water =	247.25	260.11
% Moisture =	27.57	29.00
% SATURATIOI	**93.80**	**98.30**
S.G.(est) =	2.7000	

Pipette Pressures During Test:

Top Pipette: 60 psi = 4220.3 cm
Bottom Pipette: 58 psi = 4079.6 cm

Pipette:

Area (a): 0.3435 sq in = 0.8725 sq cm

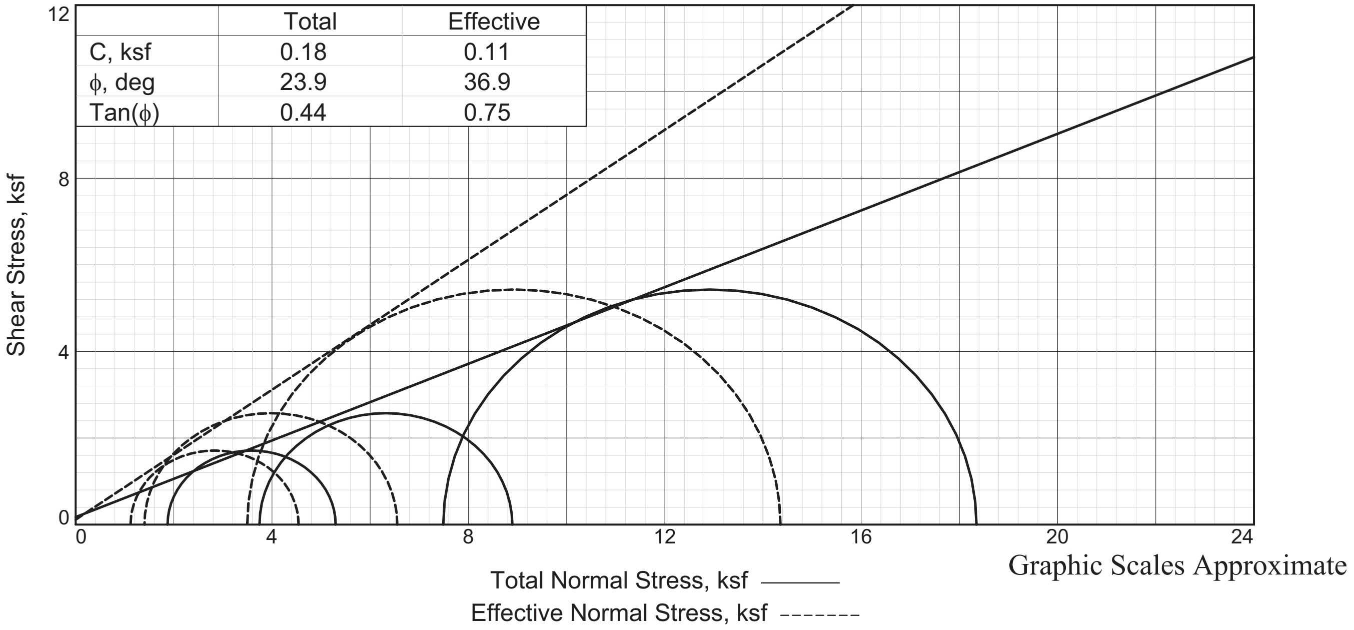
Calculations:

$$\boxed{k = \frac{a \cdot L}{2 \cdot A \cdot \Delta t} \ln\left(\frac{h_1}{h_2}\right)}$$

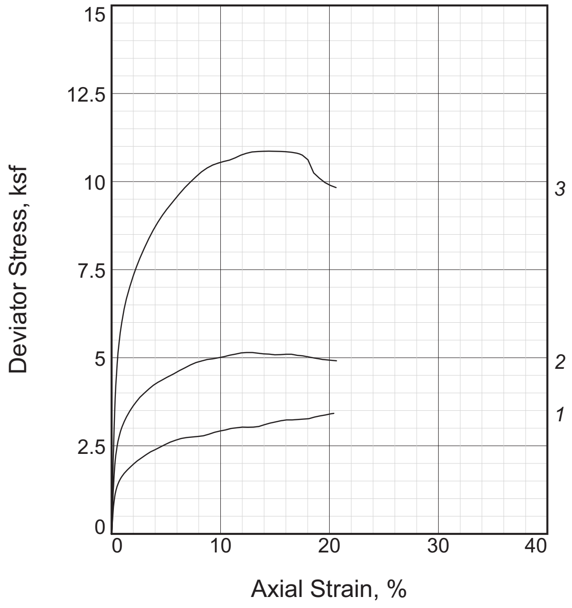
where:
k = Hydraulic Conductivity
a = Pipette Cross-Sectional Area
L = Length of Sample
A = Sample Cross-Sectional Area
Δt = Time Interval (t_2 - t_1)
h_1 = Head Loss Across Permeameter/Specimen at t_1
h_2 = Head Loss Across Permeameter/Specimen at t_2
ln = Natural Logarithm (Base e = 2.71828)

Date	Time Readings	Time Interval Δt Seconds	Top Pipette cc	Hydraulic Head Headwater H_1 cm	Bottom Pipette cc	Hydraulic Head Tailwater H_2 cm	Head Loss h = H_1-H_2 cm	ℓn (h_1/h_2)	Temp. Corr. Permeability k cm/sec
5/6/2009	9:45 AM	0.00	48.45	4092.08	14.20	4272.01	-179.93	–	–
5/6/2009	10:51 AM	3,960	48.40	4092.14	14.45	4271.73	-179.59	0.00191	6.740E-08
5/6/2009	12:15 PM	5,040	48.20	4092.36	14.65	4271.50	-179.13	0.00256	7.077E-08
5/6/2009	1:45 PM	5,400	48.05	4092.54	15.00	4271.09	-178.56	0.00320	8.280E-08
5/6/2009	3:17 PM	5,520	47.85	4092.77	15.25	4270.81	-178.04	0.00289	7.312E-08
5/7/2009	8:21 AM	61,440	45.60	4095.34	18.00	4267.66	-172.31	0.03272	7.431E-08

Time Weighted Average, k [cm/sec] = **7.423E-08**



	Total	Effective
C, ksf	0.18	0.11
ϕ, deg	23.9	36.9
Tan(ϕ)	0.44	0.75



Sample No.		1	2	3
Initial	Water Content, %	35.1	43.8	31.9
	Dry Density, pcf	83.0	76.2	85.0
	Saturation, %	92.2	97.7	87.6
	Void Ratio	1.0297	1.2123	0.9833
	Diameter, in.	2.90	2.85	2.90
	Height, in.	5.59	5.59	5.59
At Test	Water Content, %	33.3	38.9	31.0
	Dry Density, pcf	86.9	82.6	90.3
	Saturation, %	95.6	101.0	96.5
	Void Ratio	0.9402	1.0401	0.8674
	Diameter, in.	2.86	2.78	2.85
	Height, in.	5.49	5.42	5.43
Strain rate, in./min.		0.00	0.00	0.00
Back Pressure, psi		40.00	40.00	40.00
Cell Pressure, psi		53.00	66.00	92.00
Fail. Stress, ksf		3.4	5.1	10.9
Total Pore Pr., ksf		6.5	8.1	9.8
Ult. Stress, ksf		3.4	4.9	9.8
Total Pore Pr., ksf		6.5	8.0	9.9
$\bar{\sigma}_1$ Failure, ksf		4.5	6.6	14.4
$\bar{\sigma}_3$ Failure, ksf		1.1	1.4	3.5

Type of Test:
CU with Pore Pressures

Sample Type: Shelby Tube

Description: Gray mottled with dark-gray and brown clayey silt, some fine sand, trace medium to

LL= 35 **PL=** 28 **PI=** 7

Assumed Specific Gravity= 2.7

Remarks:

1

Client:

Project: Cardinal Plant Ash Pond Investigation
Brilliant, Ohio

Location: CD-PZ-BAP-0901

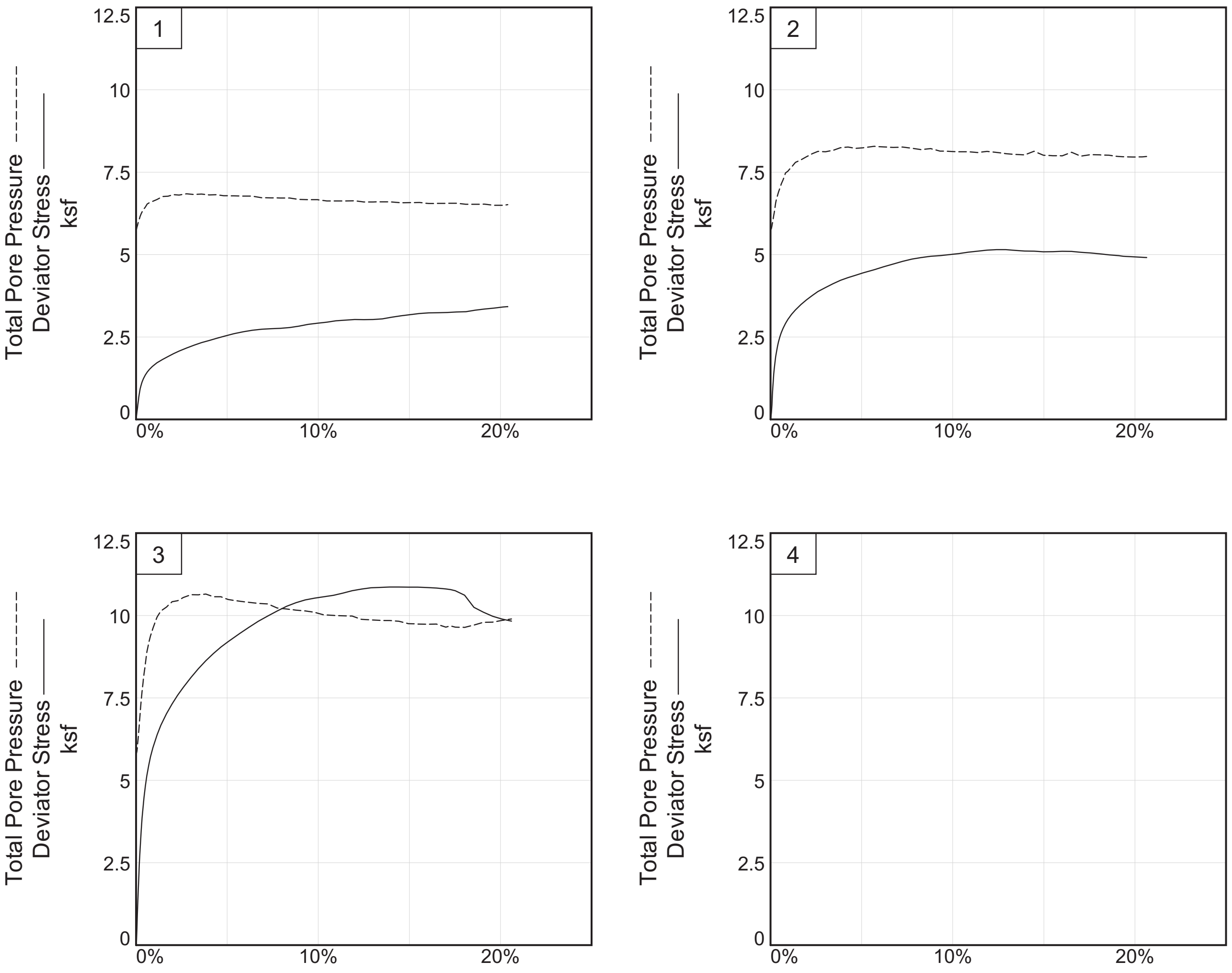
Sample Number: ST-19A **Depth:** 31.0' to 32.8'

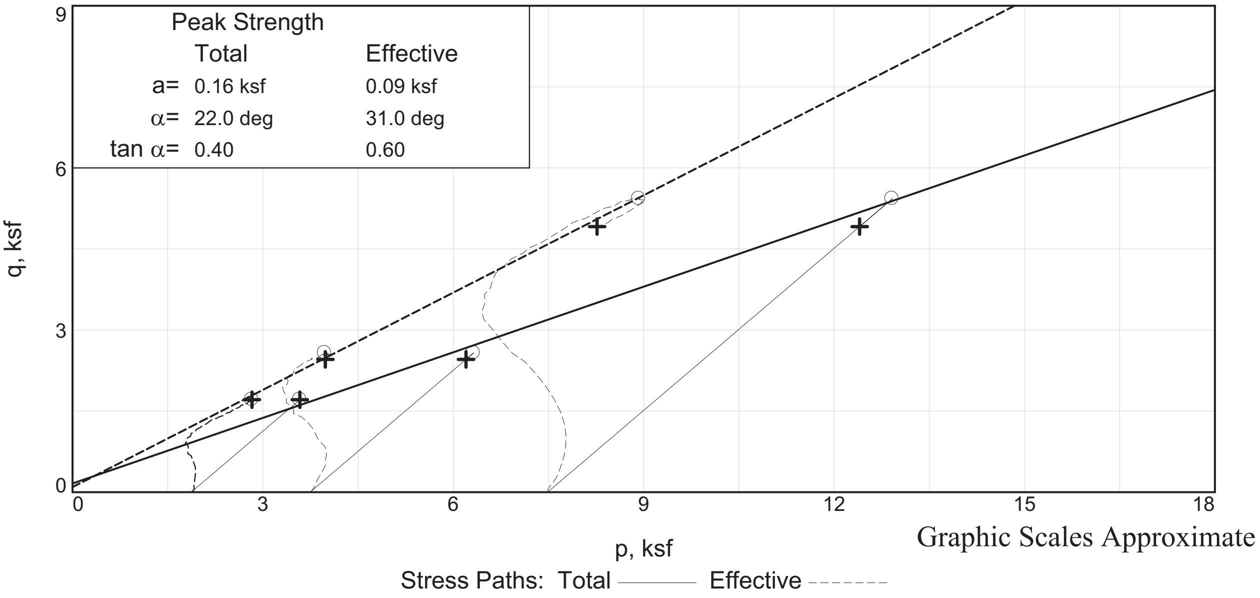
Proj. No.: 011.11497.013 **Date Sampled:** 5/1/09

TRIAXIAL SHEAR TEST REPORT

BBC&M Engineering, Inc.

Tested By: PJM **Checked By:** JJ





Peak Strength	Total	Effective
a=	0.16 ksf	0.09 ksf
α=	22.0 deg	31.0 deg
tan α=	0.40	0.60

Graphic Scales Approximate

Client:

Project: Cardinal Plant Ash Pond Investigation

Location: CD-PZ-BAP-0901 **Depth:** 31.0' to 32.8' **Sample Number:** ST-19A

Project No.: 011.11497.013 2

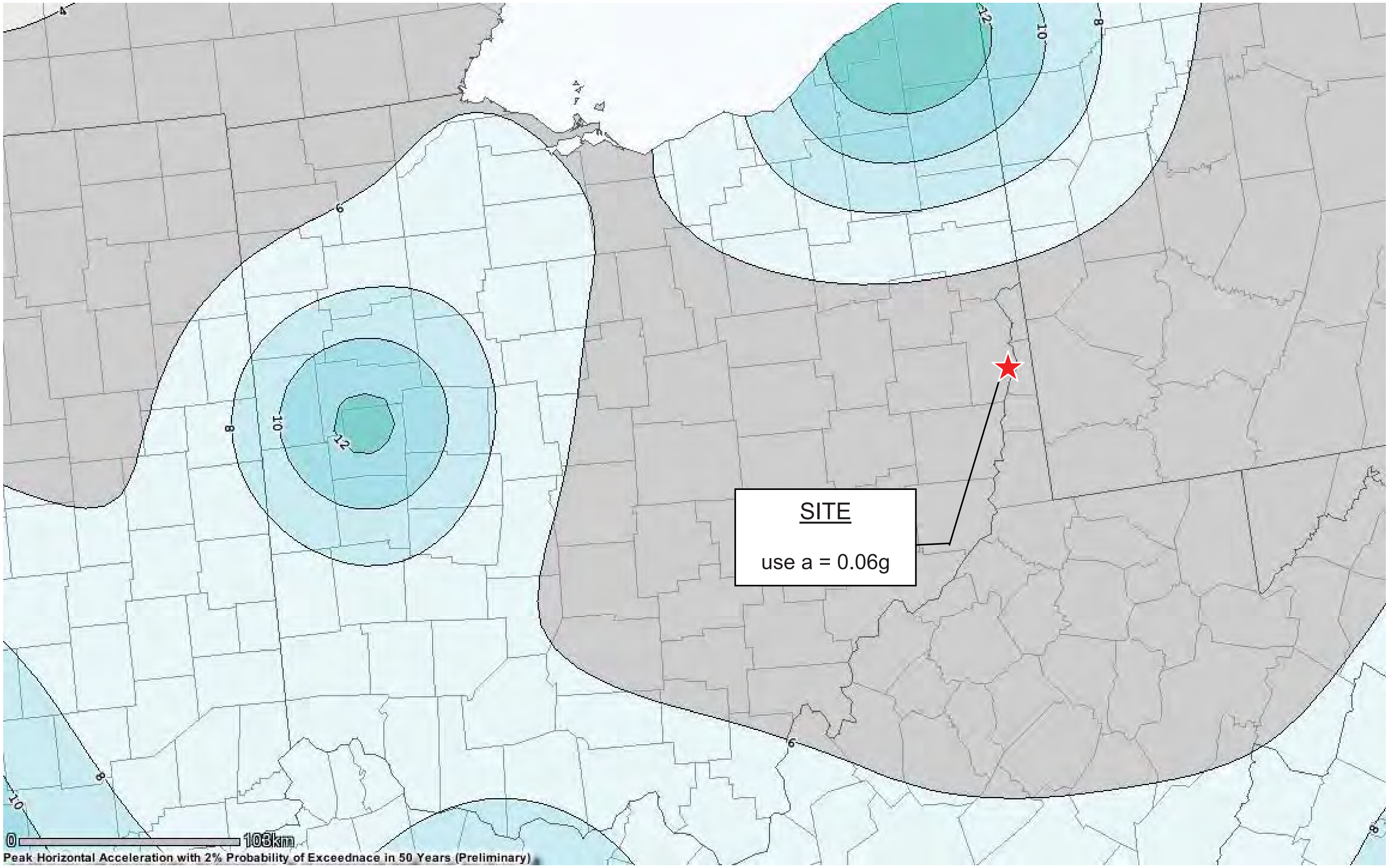
BBC&M Engineering, Inc.

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



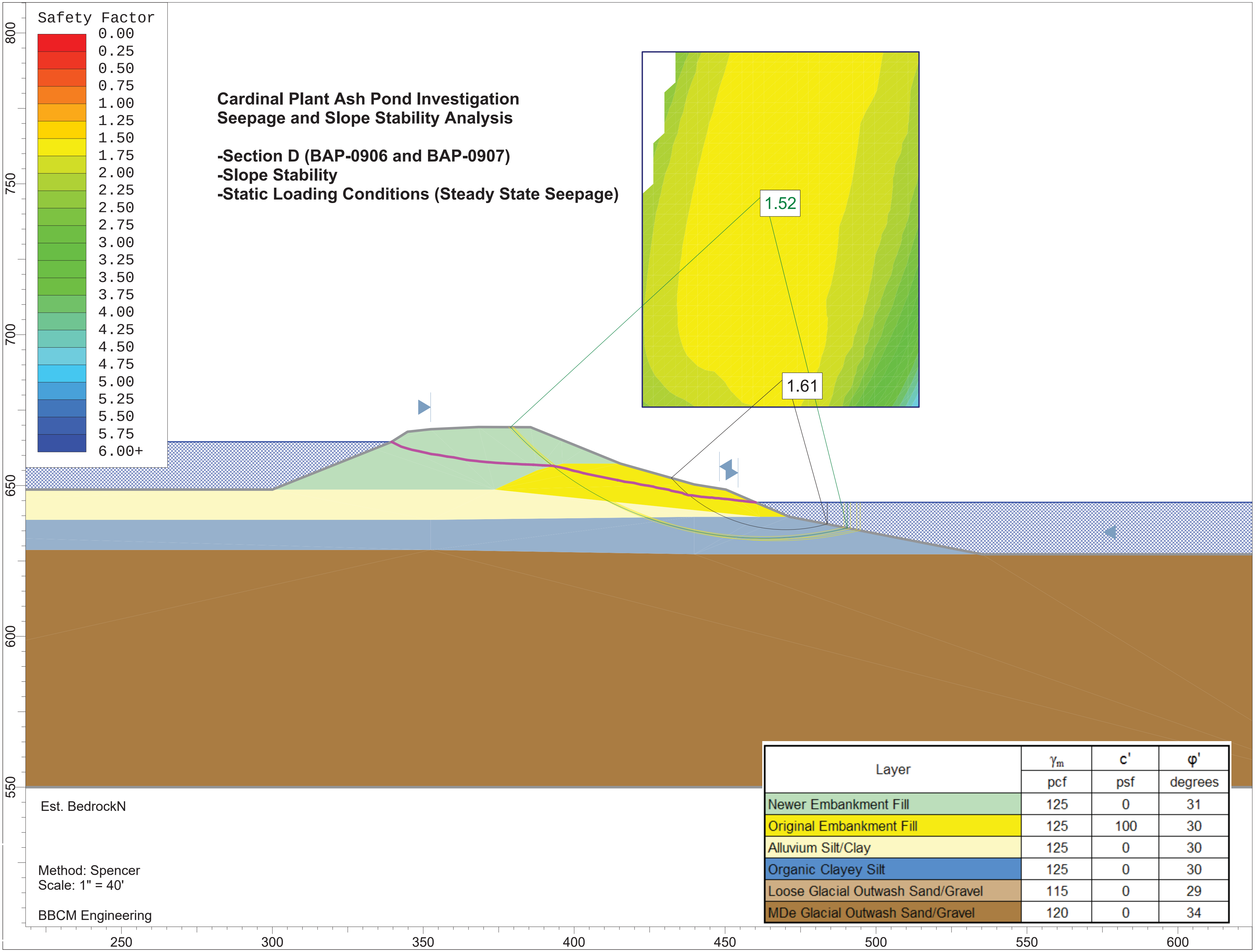
SITE

use a = 0.06g

Appendix IV – Limit Equilibrium Analysis

Cardinal Plant Ash Pond Investigation
Seepage and Slope Stability Analysis

-Section D (BAP-0906 and BAP-0907)
-Slope Stability
-Static Loading Conditions (Steady State Seepage)

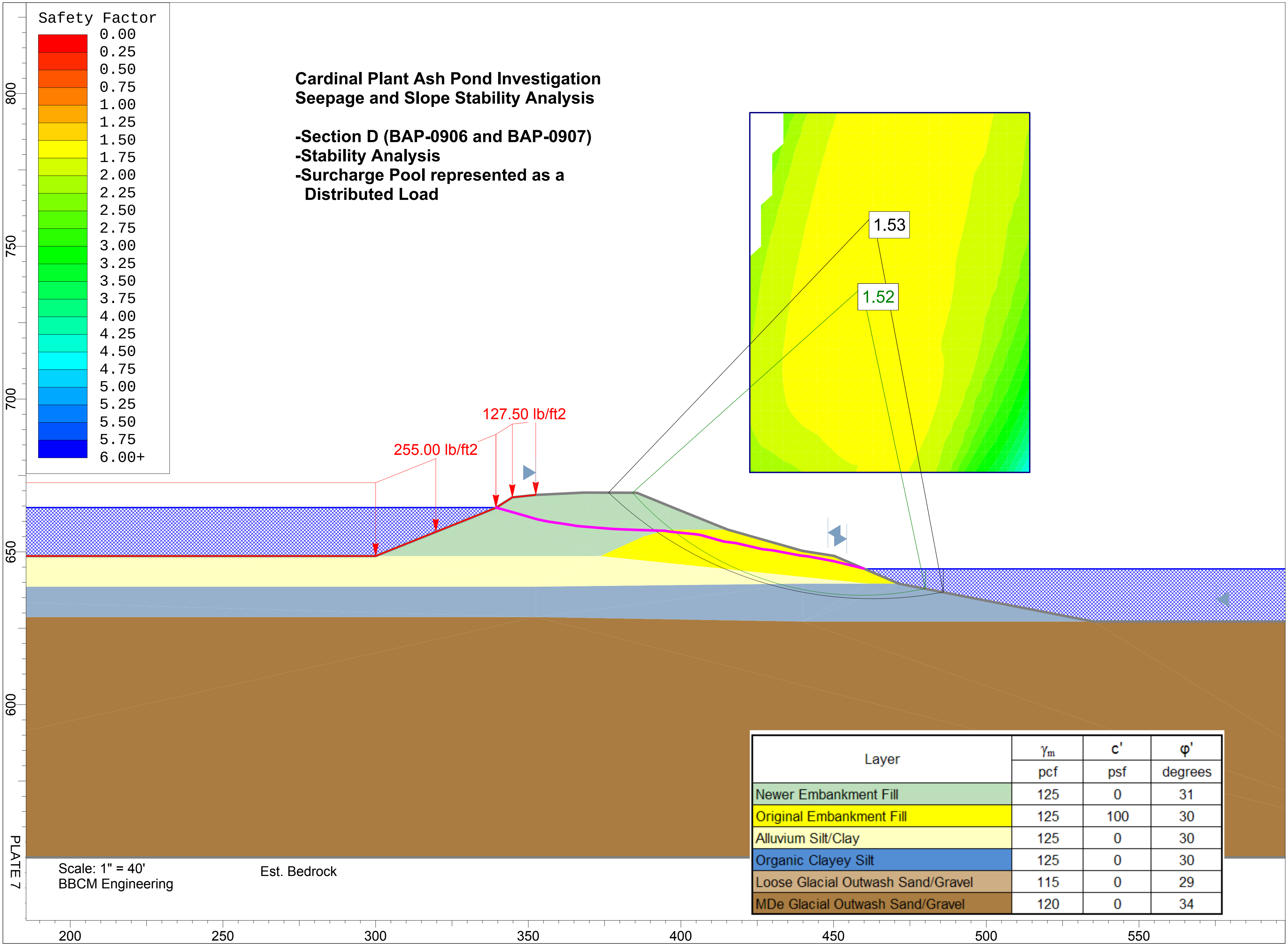


Layer	γ_m	c'	φ'
	pcf	psf	degrees
Newer Embankment Fill	125	0	31
Original Embankment Fill	125	100	30
Alluvium Silt/Clay	125	0	30
Organic Clayey Silt	125	0	30
Loose Glacial Outwash Sand/Gravel	115	0	29
MDe Glacial Outwash Sand/Gravel	120	0	34

Method: Spencer
Scale: 1" = 40'

BBCM Engineering

PLATE 10



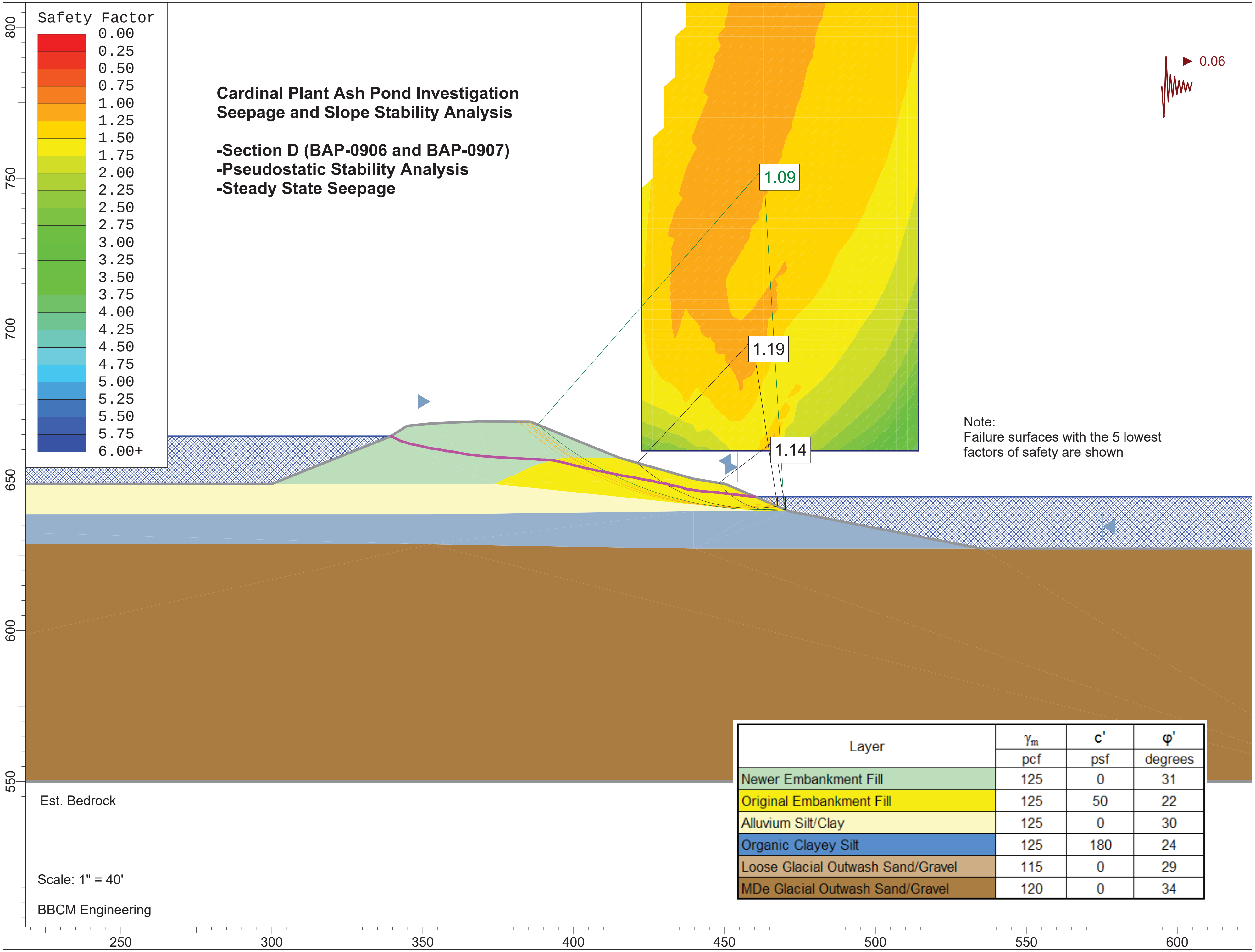
Cardinal Plant Ash Pond Investigation
Seepage and Slope Stability Analysis

-Section D (BAP-0906 and BAP-0907)
-Stability Analysis
-Surcharge Pool represented as a
Distributed Load

Layer	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

Scale: 1" = 40'
BBCM Engineering

PLATE 7



Cardinal Plant Ash Pond Investigation
Seepage and Slope Stability Analysis

-Section D (BAP-0906 and BAP-0907)
-Pseudostatic Stability Analysis
-Steady State Seepage

Note:
Failure surfaces with the 5 lowest factors of safety are shown

Layer	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

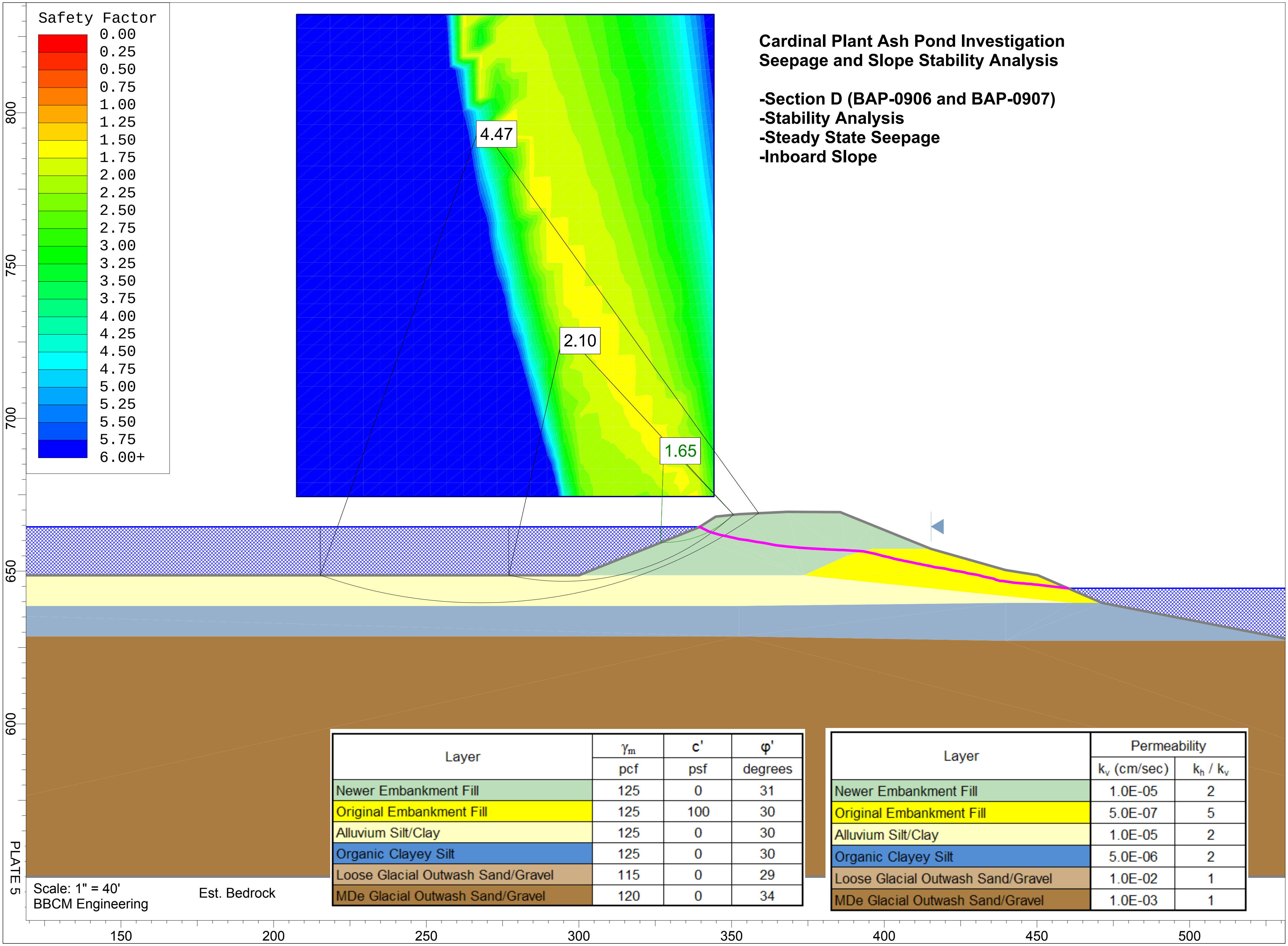
Scale: 1" = 40'

BBCM Engineering

PLATE 11

Cardinal Plant Ash Pond Investigation
Seepage and Slope Stability Analysis

-Section D (BAP-0906 and BAP-0907)
-Stability Analysis
-Steady State Seepage
-Inboard Slope



Layer	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

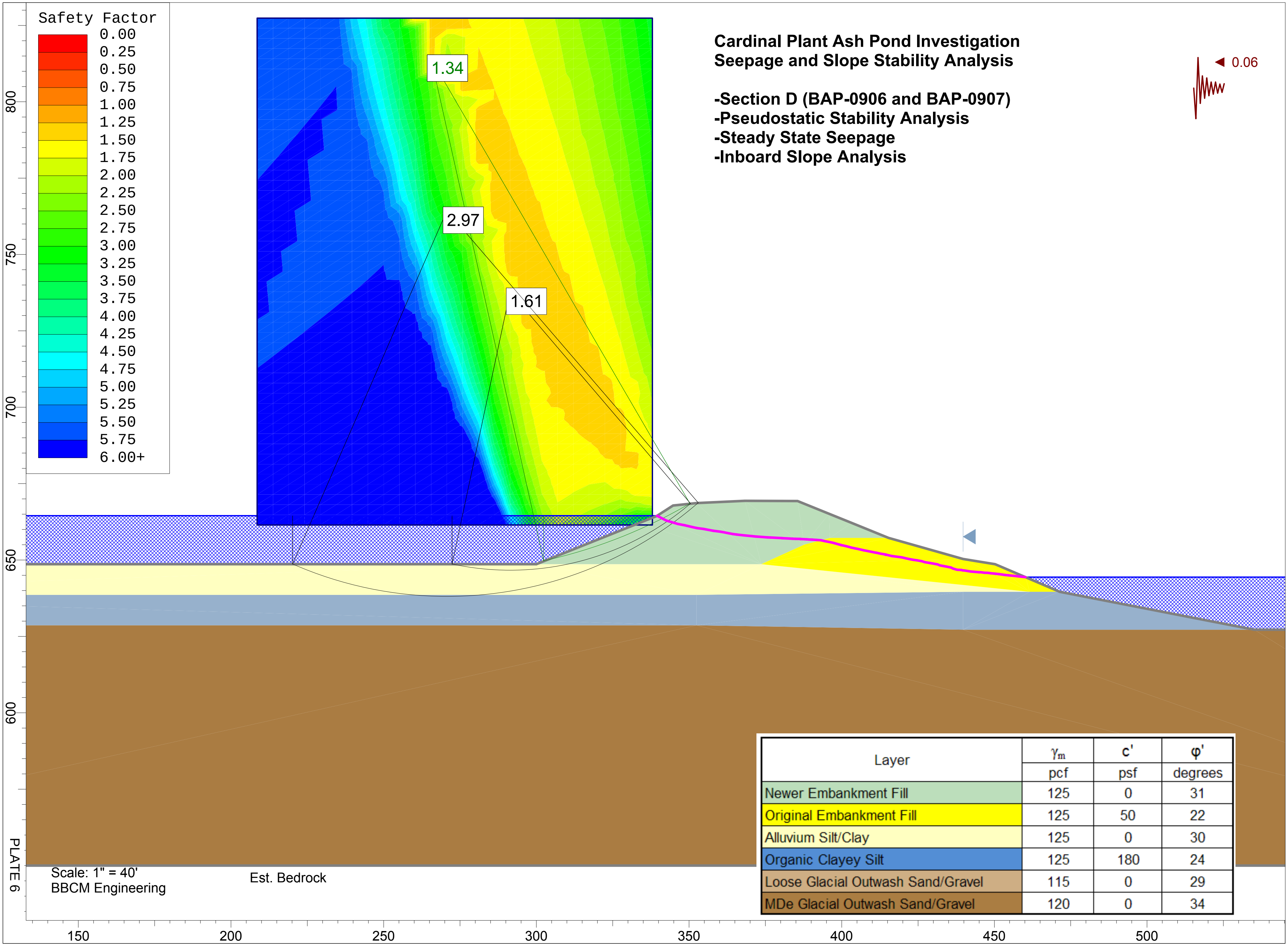
Layer	Permeability	
	k_v (cm/sec)	k_h / k_v
Newer Embankment Fill	1.0E-05	2
Original Embankment Fill	5.0E-07	5
Alluvium Silt/Clay	1.0E-05	2
Organic Clayey Silt	5.0E-06	2
Loose Glacial Outwash Sand/Gravel	1.0E-02	1
MDe Glacial Outwash Sand/Gravel	1.0E-03	1

Scale: 1" = 40'
BBCM Engineering

PLATE 5

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



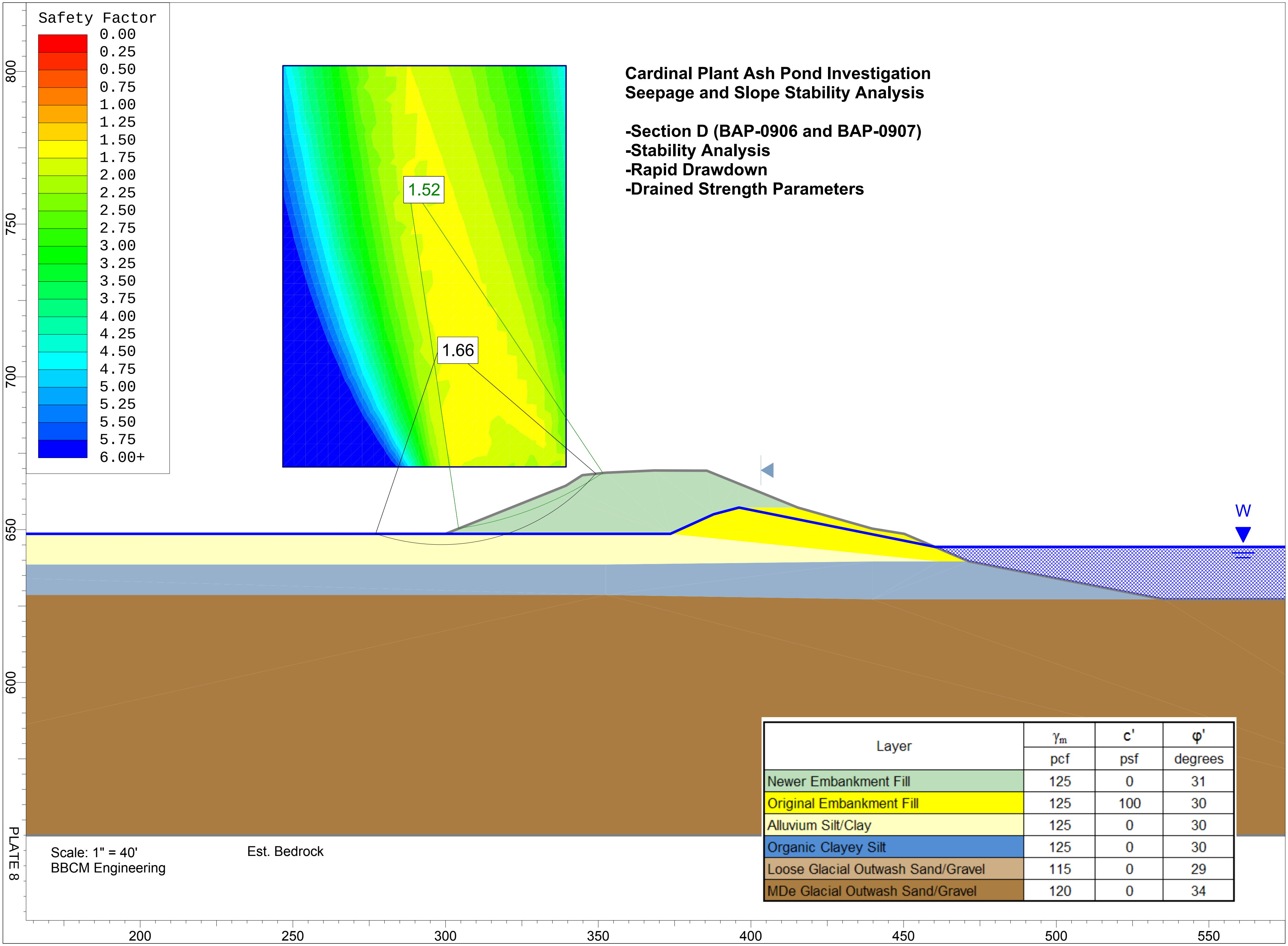
Layer	γ_m	c'	φ'
	pcf	psf	degrees
Newer Embankment Fill	125	0	31
Original Embankment Fill	125	50	22
Alluvium Silt/Clay	125	0	30
Organic Clayey Silt	125	180	24
Loose Glacial Outwash Sand/Gravel	115	0	29
MDe Glacial Outwash Sand/Gravel	120	0	34

Scale: 1" = 40'
BBCM Engineering

PLATE 6

Cardinal Plant Ash Pond Investigation
Seepage and Slope Stability Analysis

-Section D (BAP-0906 and BAP-0907)
-Stability Analysis
-Rapid Drawdown
-Drained Strength Parameters



Layer	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

Scale: 1" = 40'
BBCM Engineering

Est. Bedrock

PLATE 8

INDEX TESTING SUMMARY
LIQUEFACTION SCREENING

Fine Grained Soil Liquefaction Screening
Cardinal Bottom Ash Pond

Layer: NEWER EMBANKMENT FILL

BORING NUMBER	SAMPLE NUMBER	SAMPLE DEPTH	NATURAL MOISTURE CONTENT	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTIC INDEX %	GRAVEL %	SAND %	SILT %	CLAY .005 mm %	CLAY .002 mm %	SILT/CLAY %	USCS CLASSIFICATION
BAP-0901	S-5	7.75	16	28	18	10							
BAP-0901	S-9	13.75	13	27	17	10							
BAP-0901	S-12	18.25	14	37	24	13	7	32	49	23	12	61	SANDY LEAN CLAY CL
BAP-0902	S-11	16.75	24	37	19	18							
BAP-0902	S-12	18.25	21	35	17	18	8	37	33	28	21	54	SANDY LEAN CLAY CL
BAP-0902	S-13	19.75	31	29	17	12	1	20	62	28	17	79	LEAN CLAY with SAND CL
BAP-0904	S-9	13.75	16	35	21	14							
BAP-0906	S-3	4.75	15	27	17	10							
BAP-0906	S-8	12.75					30	40	22	13	9	31	
BAP-0906	S-11	17.25	14	31	19	12	18	44	26	18	12	38	CLAYEY SAND with GRAVEL SC

Fines Content and Plasticity Index Screening			Is Soil Sample Liquefiable (meets all three criteria)
	% Passing		
LL < 35	0.005 < 15	WC < 0.9LL	
Yes	-	Yes	-
Yes	-	Yes	-
No	No	Yes	No
No	-	Yes	No
No	No	Yes	No
Yes	No	No	No
No	-	Yes	No
Yes	-	Yes	-
-	Yes	-	-
Yes	No	Yes	No

Layer: ORIGINAL EMBANKMENT FILL

BORING NUMBER	SAMPLE NUMBER	SAMPLE DEPTH	NATURAL MOISTURE CONTENT	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTIC INDEX %	GRAVEL %	SAND %	SILT %	CLAY .005 mm %	CLAY .002 mm %	SILT/CLAY %	USCS CLASSIFICATION
BAP-0903	S-2	3.25	24	48	24	24	0	8	60	45	32	92	LEAN CLAY CL
BAP-0903	S-5	7.75	20	36	20	16	0	14	58	38	28	86	LEAN CLAY CL
BAP-0905	S-3	4.75	17	32	18	14	0	25	53	30	23	76	LEAN CLAY with SAND CL
BAP-0905	S-5	7.75	22	48	24	24							
BAP-0907	S-5	7.75	23	49	26	23							
BAP-0907	S-6A	9.25	28	47	29	18	0	5	67	43	29	96	SILT ML

Fines Content and Plasticity Index Screening			Is Soil Sample Liquefiable (meets all three criteria)
	% Passing		
LL < 35	0.005 < 15	WC < 0.9LL	
No	No	Yes	No
No	No	Yes	No
Yes	No	Yes	No
No	-	Yes	No
No	-	Yes	No
No	No	Yes	No

Appendix V – 2009 Investigation Report Text

BBCM
SOLUTIONS TO BUILD ON

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

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

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**

Water Level, ft	▽	▼	▼
TIME			
DATE			

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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"

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

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		25			**5B 5/1 MEDIUM BLUISH GRAY SHALE** fractured		
										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		35			**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE** fractured in bottom 1.5'		
							40					
6	NQ	43.9	46.9		3.0		45			**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE**		

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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		
										HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE		
8	NQ	53.9	63.9		9.6							
							55					
										HARD N5 MEDIUM GRAY SHALEY LIMESTONE		
							60					
9	NQ	63.9	73.9		10.0					**HARD 5B 5/1 MEDIUM BLUISH GRAY to N6 MEDIUM LIGHT GRAY SHALE**		
							65					
										HARD N4 MEDIUM DARK GRAY SHALE small coal band @ 73.8		
							70					

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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	SAMPLE DEPTH IN FEET 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					**HARD N6 MEDIUM LIGHT GRAY SHALE** w/ coal band @ 74.4, angle fracture @ 75.7		
							75					
										SOFT N4 MEDIUM DARK GRAY SHALE		
							80					
										HARD N2 GRAYISH BLACK SHALE		
										COAL		
										HARD 5B 5/1 MEDIUM BLUISH GRAY SHALE		
11	NQ	83.9	93.9		10.0					**HARD N5 MEDIUM GRAY SHALE**		
							85					
							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					**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALE**		
							95					

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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	SAMPLE DEPTH IN FEET 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**		
										HARD 5GY 4/1 DARK GREENISH GRAY SHALE		
							115					
										5GY 4/1 DARK GREENISH GRAY SHALE		
										HARD N6 MEDIUM LIGHT GRAY SHALE w/ sandstone streaks		
							120					

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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**

PROJECT **CARDINAL LANDFILL**

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

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					**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALE** bottom 0.8 N3 dark gray carbonious		
							125					
							130					
										N5 MEDIUM GRAY FINE GRAIN SANDSTONE w/ shale band		
16	NQ	133.9	143.9		10.0					**HARD N5 MEDIUM GRAY SHALE**		
							135					
										COAL w/ hard shale bands		
							140					
										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	SAMPLE DEPTH IN FEET 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	SAMPLE DEPTH IN FEET 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-0623A

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	SAMPLE DEPTH IN FEET 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							**5B 5/1 MEDIUM BLUISH GRAY SHALE/ LIMESTONE** fracture		
							230					
										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	SAMPLE DEPTH IN FEET 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							**SOFT MEDIUM BLUISH GRAY SHALE**		
							255					
										HARD 5GY 6/1 GREENISH GRAY SHALE w/fractures of limestone		
							260					
										5YR 4/1 BROWNISH GRAY RED SHALE		
										MEDIUM BLUISH GRAY SHALE w/fractures of limestone		
33	NQ	264.4	274.4							**N4 MEDIUM DARK GRAY SHALE**		
							265					
										SOFT N4 MEDIUM DARK GRAY SHALE wet		
							270					
34	NQ	274.4	284.4							**SOFT N4 MEDIUM DARK GRAY SHALE**		
							275					
										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	SAMPLE DEPTH IN FEET 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							**N4 MEDIUM DARK GRAY SHALE** w/fractures of limestone		
							285					
										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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Monitoring Well: CA-0623A

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	SAMPLE DEPTH IN FEET 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-0623A

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		
							340			**N2 GRAYISH BLACK SHALE**		
										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		
							350			**HARD N4 MEDIUM DARK GRAY SHALE** w/trace of fine sandstone		
										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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LOG OF BORING

Monitoring Well: CA-0623A

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	375			**HARD N3 DARK GRAY CLAY SHALE**		
										N2 GRAYISH BLACK CLAY SHALE SEAM		
										N1 BLACK COAL SEAM		
							380			**HARD N5 MEDIUM GRAY CLAY SHALE**		
												STOPPED BORING

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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 **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

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**

Water Level, ft	▽	▼	▼
TIME			
DATE			

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					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.
1	NQ	14.0	15.5				15			**SOFT 5Y 6/1 LIGHT OLIVE GRAY CLAY**		
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

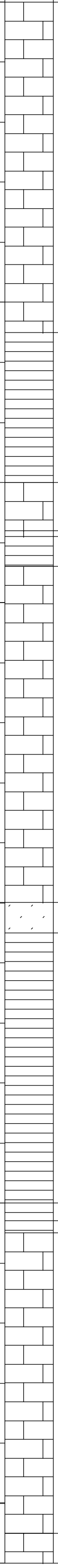
JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

BORING NO. **CA-0601** DATE **7/17/15** SHEET **2** OF **17**

BORING START **6/5/07** BORING FINISH **6/12/07**



SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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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LOG OF BORING

Monitoring Well: S-17

JOB NUMBER

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	SAMPLE DEPTH IN FEET 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	60			**HARD MEDIUM LIGHT GRAY SHALE**		
8	NQ	60.5	70.5		10	70				**N5 MEDIUM GRAY SHALE**		
										N5 MEDIUM GRAY SHALE w/ vertical fracture		
							65 70			**LIMESTONE**		
9	NQ	70.5	76.5		6	47				**HARD N5 MEDIUM GRAY SHALE**		

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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 **4** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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					
										N4 MEDIUM DARK GRAY SHALE w/iron staining		
10	NQ	76.5	85.5		9	44				**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		
										HARD N6 BROKEN CLAY SHALE w/vertical fracture		
							95					
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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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

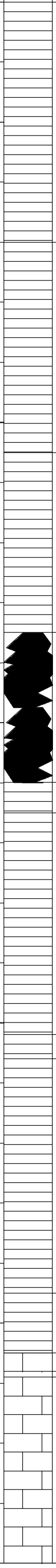
LOG OF BORING

Monitoring Well: S-17

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **5** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**



SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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					
							105			**5YR 4/1 BROWNISH GRAY LIMEY CLAY SHALE**		
13	NQ	105.5	111.5		5.6	54				**SOFT N4 MEDIUM DARK GRAY CLAY SHALE**		
							110			**N1 BLACK COAL**		
										N2 GRAYISH BLACK CLAY SHALE		
14	NQ	111.5	120.5		9		115			**SOFT N4 MEDIUM DARK GRAY CLAY SHALE**		
										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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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-0601** DATE **7/17/15** SHEET **6** 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
										SOFT N5 MEDIUM DARK GRAY CLAY SHALE		
							125					
										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					
17	NQ	140.5	150.5		10	60				**N7 LIGHT GRAY LIMESTONE**		
										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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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 **7** 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	USCS	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		
									N2 GRAYISH BLACK DARK CLAY SHALE		
							170		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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LOG OF BORING

Monitoring Well: S-17

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

BORING NO. **CA-0601** DATE **7/17/15** SHEET **8** OF **17**

BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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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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 **9** 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
										N6 MEDIUM LIGHT GRAY LIMESTONE		
							205			**SOFT N5 MEDIUM GRAY CLAY SHALE**		
										N7 LIGHT GRAY CLAYEY LIMESTONE w/pyrite		
24	NQ	210.5	220.5		10	83	210			**N6 MEDIUM LIGHT GRAY LIMESTONE**		
							215			**N4 MEDIUM DARK GRAY CLAY SHALE**		
										N7 LIGHT GRAY FINE GRAIN SILTSTONE		
										N7 LIGHT GRAY CLAY SHALE/SILTSTONE		
25	NQ	220.5	230.5		10	79	220			**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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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 **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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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 **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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Monitoring Well: S-17

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

BORING NO. **CA-0601** DATE **7/17/15** SHEET **12** 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
										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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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**

BORING NO. **CA-0601**

DATE **7/17/15**

SHEET **13** OF **17**

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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Monitoring Well: S-17

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

BORING NO. **CA-0601** DATE **7/17/15** SHEET **14** 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 N7 LIGHT GRAY FINE GRAIN SANDSTONE		
										HARD N5 MEDIUM GRAY SILTSTONE		
							335					
38	NQ	335.5	345.5		10	97						
										MEDIUM LIGHT GRAY FINE GRAIN SANDSTONE w/crossbedding throughout		
							340					
							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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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 **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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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 **16** OF **17**

PROJECT **CARDINAL LANDFILL**

BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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					
										HARD N6 MEDIUM LIGHT GRAY FINE GRAIN SANDSTONE		
							395					
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

Monitoring Well: S-17

JOB NUMBER

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

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**

Water Level, ft	▽	▼	▼
TIME			
DATE			

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	15			**MEDIUM HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
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"

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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 **MCR**

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**

BORING NO. **CA-0607** DATE **7/17/15** SHEET **2** OF **5**

BORING START **1/9/07** BORING FINISH **1/9/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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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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	SAMPLE DEPTH IN FEET 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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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	SAMPLE DEPTH IN FEET 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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LOG OF BORING

Monitoring Well: S-10

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

BORING NO. **CA-0607** DATE **7/17/15** SHEET **5** OF **5**

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**

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**

Water Level, ft	▽	▼	▽
TIME			
DATE			

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

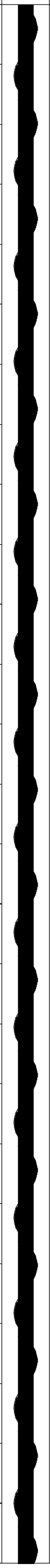
WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

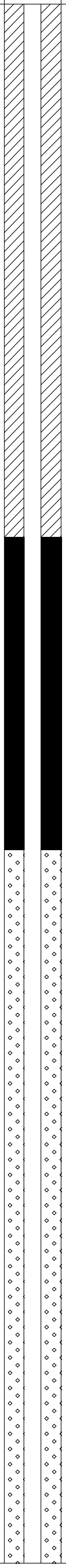
RECORDER

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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Monitoring Well: S-1

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL PLANT**

BORING NO. **8502** DATE **7/17/15** SHEET **3** OF **3**

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					

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 **1** OF **4**

PROJECT **CARDINAL PLANT** BORING START **12/12/85** BORING FINISH **12/17/85**

COORDINATES **N 831,038.2 E 2,514,714.2** PIEZOMETER TYPE WELL TYPE **GM**

GROUND ELEVATION **1038.6** SYSTEM **STATE PLANE** 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**

Water Level, ft	▽	▼	▼
TIME			
DATE			

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**

PROJECT **CARDINAL PLANT**

BORING NO. **8503** DATE **7/17/15** SHEET **2** OF **4**

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		

Continued Next Page

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**

BORING NO. **8503**

DATE **7/17/15**

SHEET **3** OF **4**

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

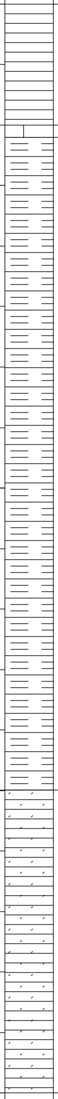
Monitoring Well: S-2

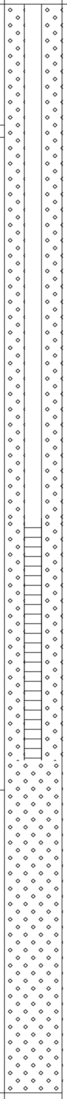
JOB NUMBER

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	SAMPLE DEPTH IN FEET 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. 84.5 BOTTOM 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.		
							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**

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**

Water Level, ft	▽ 20.3	▼ 20.0	▽
TIME	7:20	7:15	
DATE	8-16-88	8-17-88	

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
												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.

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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"

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

Monitoring Well: S-4

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL PLANT**

BORING NO. **88-5-6** DATE **7/17/15** SHEET **3** OF **9**

BORING START **8/11/88** BORING FINISH **8/16/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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					**GREEN AND GRAY SANDY SHALE** Partially cemented.		
							55					
12	SS	57.5	57.8	50/.3	.2					**RED CLAY SHALE**		
13	NQ	58.0	61.6		.8					**RED AND GRAY CLAYSTONE** Soft.		58.0 SET CASING
							60					
14	NQ	61.6	65.0		3.4	88				**GRAY CLAYEY SANDSTONE** Hard, calcareous, grading to fine grain hard sandstone.		
										GRAY SANDSTONE Fine, hard.		
15	NQ	65.0	71.7		6.6	89	65					
										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	SAMPLE DEPTH IN FEET 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		
										79.3-79.7 BROKEN WITH IRON STAIN ON SOFT.		79.4 CHECK VALVE.
							80					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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LOG OF BORING

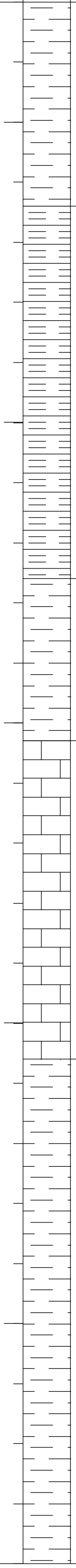
Monitoring Well: S-4

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	SAMPLE DEPTH IN FEET 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 CLAYSTONE Soft, calcareous, with calcite seams.		
							100					
										GRAY CLAY SHALE Soft with some red and gray layers.		
20	NQ	105.0	115.0		10.0	68	105					
										GRAY CLAYSTONE Soft.		
							110					
										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**

PROJECT **CARDINAL PLANT**

BORING NO. **88-5-6** DATE **7/17/15** SHEET **8** OF **9**

BORING START **8/11/88** BORING FINISH **8/16/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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					
28	NQ	185.0	195.0		10.0	100	185					
							190					191.9 CHECK VALVE. 192.5 TOP OF SCREEN.
										GRAY SHALEY SANDSTONE Soft.		194.5 BOTTOM OF SCREEN.
29	NQ	195.0	205.0		9.9	95	195					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	▨			■	

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**

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**

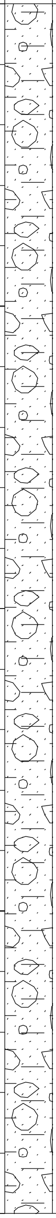
HGT. RISER ABOVE GROUND **SEE NOTE** DIA **1.0**

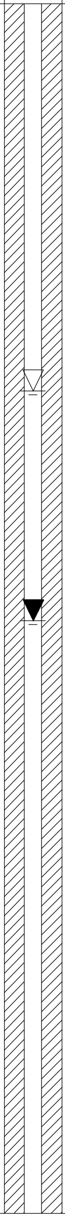
DEPTH TO TOP OF WELL SCREEN **SEE NOTE** BOTTOM **SEE NOTE**

WELL DEVELOPMENT BACKFILL **GROUT**

FIELD PARTY **MCR=TJH** RIG **B-61**

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**





SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	U S C S	SOIL / ROCK IDENTIFICATION	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**

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
												20.0 TOP OF SEAL.
5	SS	22.7	24.2	11-6-9	.3					**LIMESTONE FRAGMENTS**		
							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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Monitoring Well: S-5

JOB NUMBER
COMPANY **AMERICAN ELECTRIC POWER**
PROJECT **CARDINAL PLANT**
BORING NO. **88-7-8**
DATE **7/17/15**
SHEET **3** OF **8**
BORING START **8/8/88**
BORING FINISH **8/10/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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					70.0 CHECK VALVE.
										GRAY CLAYSTONE Soft.		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**

PROJECT **CARDINAL PLANT**

BORING NO. **88-7-8**

DATE **7/17/15**

SHEET **4** OF **8**

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
												72.6 BOTTOM OF SCREEN.
12	NQ	73.2	74.8		1.5	0				**LIGHT BROWN SILTY LIMESTONE** Hard.		
												74.6 BOTTOM OF SAND.
13	NQ	74.8	77.0		.7		75			**GRAY CLAYSTONE** Soft.		
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**

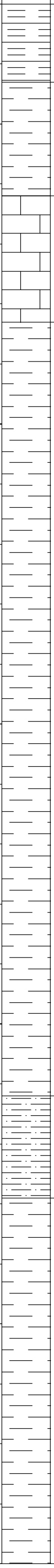
DATE **7/17/15**

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
										**GRAY CLAYSTONE** Soft.		
22	NQ	99.8	101.9		2.1	0	100					
										GRAY LIMESTONE Hard.		
23	NQ	101.9	102.5		.5	0						
24	NQ	102.5	104.8		2.1	51						
										GRAY CLAYSTONE Soft, calcareous, changing to red at 105.1.		
25	NQ	104.8	109.8		5.0	76	105					
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					

Continued Next Page

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**

BORING NO. **88-7-8** DATE **7/17/15** SHEET **6** OF **8**

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					

Continued Next Page

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

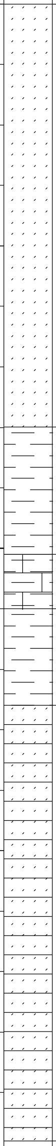
JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL PLANT**

BORING NO. **88-7-8** DATE **7/17/15** SHEET **8** OF **8**

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. 182.7 BOTTOM OF SCREEN
										GRAY CLAYSTONE Soft, calcareous.		
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**

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**

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**

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
												DRILLED NW CASING TO 53.2'. DRILL WATER IN POND 7.36 TESTED BY CARDINAL PLANT PERSONAL.
							5					
							10					
							15					

Continued Next Page

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"

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

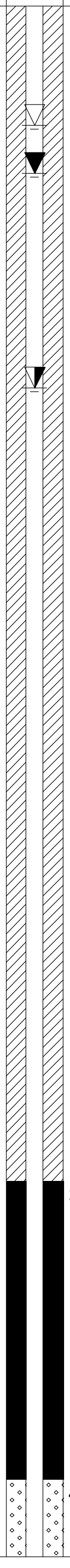
Monitoring Well: S-6

JOB NUMBER

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.		
							80			**LIGHT GRAY LIMESTONE** Hard.		
										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. 94.7 BOTTOM OF SAND.
7	NQ	95.0	105.0		9.8	83	95					

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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					
										1.3' of GRAY LIMESTONE Hard.		
9	NQ	108.0	115.0		1.6	0						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	SAMPLE DEPTH IN FEET 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.

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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 **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**

PROJECT **CARDINAL PLANT**

BORING NO. **88-9-10**

DATE **7/17/15**

SHEET **8** OF **10**

BORING START **7/28/88**

BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET 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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Monitoring Well: S-6

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL PLANT**

BORING NO. **88-9-10** DATE **7/17/15** SHEET **9** OF **10**

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					
										GRAY SILTSTONE Hard.		
27	NQ	220.0	230.0		10.0	70	220					
										GRAY CLAYSTONE Soft, calcareous.		
							225					

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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 **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				■	

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-7

AEP

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**

BORING NO. **90CA22-S** DATE ______ SHEET **1** OF **2**

BORING START **08/13/90** BORING FINISH **08/14/90**

PIEZOMETER TYPE ______ WELL TYPE **GM**

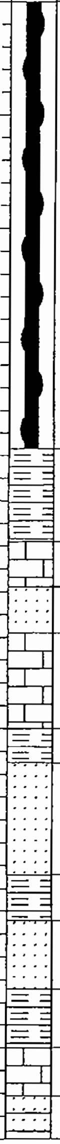
HGT. RISER ABOVE GROUND **1.94** DIA **1.0**

DEPTH TO TOP OF WELL SCREEN **66.2** BOTTOM **68.2**

WELL DEVELOPMENT ______ BACKFILL **BENSEAL**

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

WATER LEVEL	▽ 52.7	▼	▽
TIME			
DATE			



SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	SOIL / ROCK IDENTIFICATION	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. vertical cracks	33.1 TOP OF SEAL.
4	NQ	35.6	45.6		?				
							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,	

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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"

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**

PROJECT **TIDD ASH POND SITE INVESTIGATION**

BORING NO. **90CA22-S** DATE

SHEET **2** OF **2**

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	U S C S	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. **LIGHT GREEN TO LIGHT GRAY CLAYSHALE** Slightly broken.		PLUGGED OFF.
8	NQ	57.0	65.6		8.6	100	55			**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.		
9	NQ	65.6	70.6		5.0	43	65 70			**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

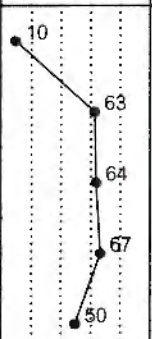
GeoSyntec Consultants

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	Sample No.	Recovery, in.	Blows / 6 in.	Standard Penetration Resistance Blows/ft N-Value	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			
		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			
		RC-1	74/84			31		
14	Hard, light gray, **LIMESTONE**; vertical fracture at 15.5 ft.; iron staining in fractures.							
15.5	Green brown to orange brown, **SANDSTONE**; medium grained; 7 vertical and horizontal fractures; iron staining along fractures.	RC-2	59/84			35		
20.5	Soft, gray, **CLAYSHALE**; with high sand content.							
22	Green brown to orange brown, **SANDSTONE**; iron staining.							
25	Hard, light gray, **LIMESTONE**; vertical and horizontal fractures; iron staining along fractures.	RC-3	94/120			35		
27	Hard, green gray, **LIMESTONE**. Horizontal fracture at 32.5 ft.; iron staining. Orange brown secondary mineral at 34.0 ft Iron staining at 34.5 to 35.0 ft.							
35	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 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.								
45	43	Soft, gray, **CLAYSHALE**; massive. Vertical fracture with iron staining at 47.5 ft.		RC-5	116/120			68		
50										
55	52.5	Hard, light gray, **LIMESTONE**. Vertical fracture at 55.0 ft. Vertical fracture at 56.5 ft.		RC-6	113/120			61		
60	57	Soft, dark greenish gray, **CLAYSHALE**; broken limestone in upper 1 ft; massive.								S-20 screen from 60.0 - 85.0 ft.
65	62	Hard, gray, **SANDSTONE**; fine grained. Hard, gray, **SANDSTONE**; fine grained.		RC-7	113/120			99		
70	67	Soft to moderately hard, dark greenish gray, **CLAYSHALE**; massive.								
75	75	Hard, gray, **LIMESTONE**; broken; gradational contacts.								
	76	Soft to moderately hard, dark greenish gray to gray to black, (GLEY1-5G), **CLAYSHALE**; massive. Gray, medium to fine sandstone at 78.5 to 80.0 ft. Vertical fracture at 79.0 ft.		RC-8	119/120			54		

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	116/120			55		

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		
130		Black between 129.0 and 131.5 ft.								
	131	Coal at 131 ft.; pyrite crystals at 131 ft.								
	131.5	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 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 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. Coal streaks at 216 ft.		RC-22	120/120			87		
	217	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 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.	▨	RC-25	120/120			59		
	Horizontal fracture at 246.5 ft.	▨							
	Slicken slides at 248.0 ft.	▨							
250		▨							
251.5	Gray, coarse to fine **SANDSTONE** from 251.5 to 252.0 ft.	░							
252	Hard, dark gray, **CLAYSHALE** from 252.0 to 252.5 ft.; massive.	▨							
252.5	Gray, medium to fine **SANDSTONE** from 252.5 to 254.5 ft.	░							
254.5	Hard, dark gray, **CLAYSHALE**; massive.	▨							
255		▨	RC-26	119/120			95		
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 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

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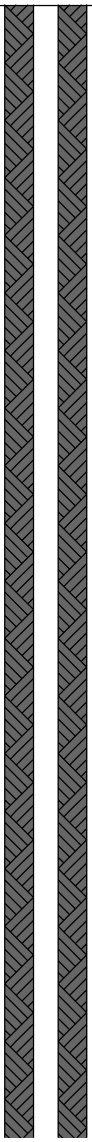
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

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

NOTES:

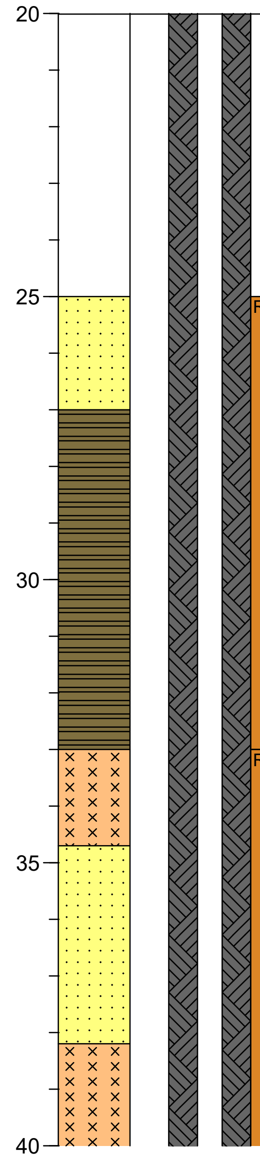
Client:	**AEP-Cardinal**
Project:	**CHE8126L**
Address:	**3202 Twp Rd 163, Brilliant, OH**

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)	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.		
						(34.7') Silty SANDSTONE: strong, medium light gray (N6), massive, micaceous, fresh to slightly decomposed, slightly disintegrated, moderately fractured.		
35								35
						(38.2') SILTSTONE to CLAYSTONE: moderately strong, medium light gray (N6), calcite nodules, massive, locally fissile, moderately decomposed, moderately to		
40								40

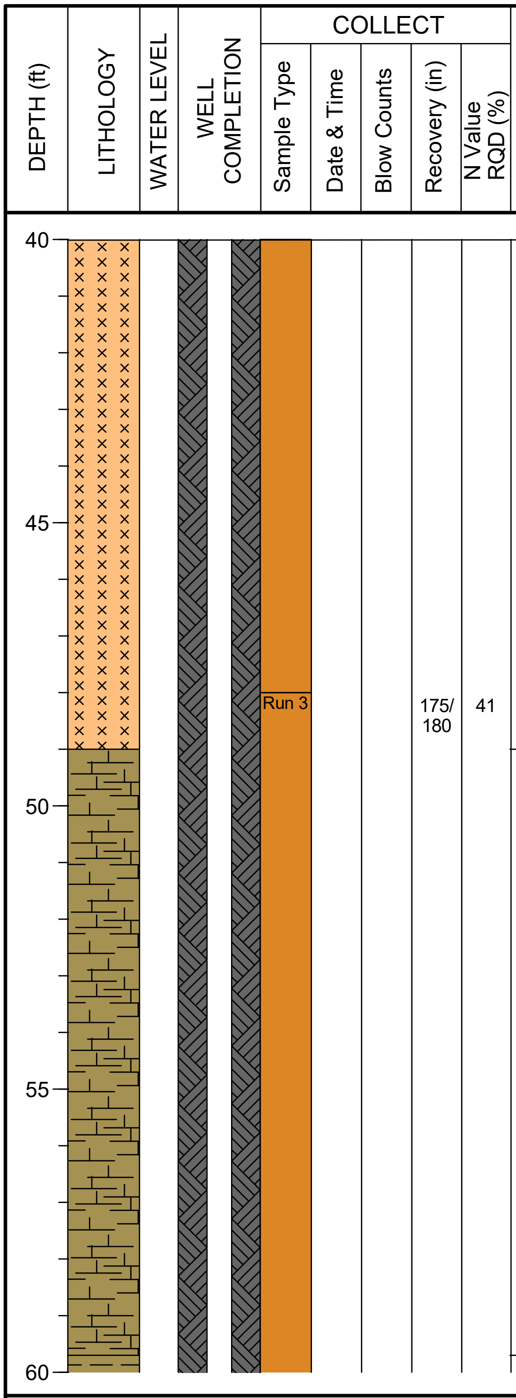
NOTES:

Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. S-GS-1
Page: 3 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)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
40	intensely fractured, at top of unit heavy clay infillings in fractures.		40
49	(49') CLAYSTONE: strong, light gray to greenish gray, massive, fresh to slightly decomposed, slightly disintegrated, moderately fractured.		
60			60

NOTES:

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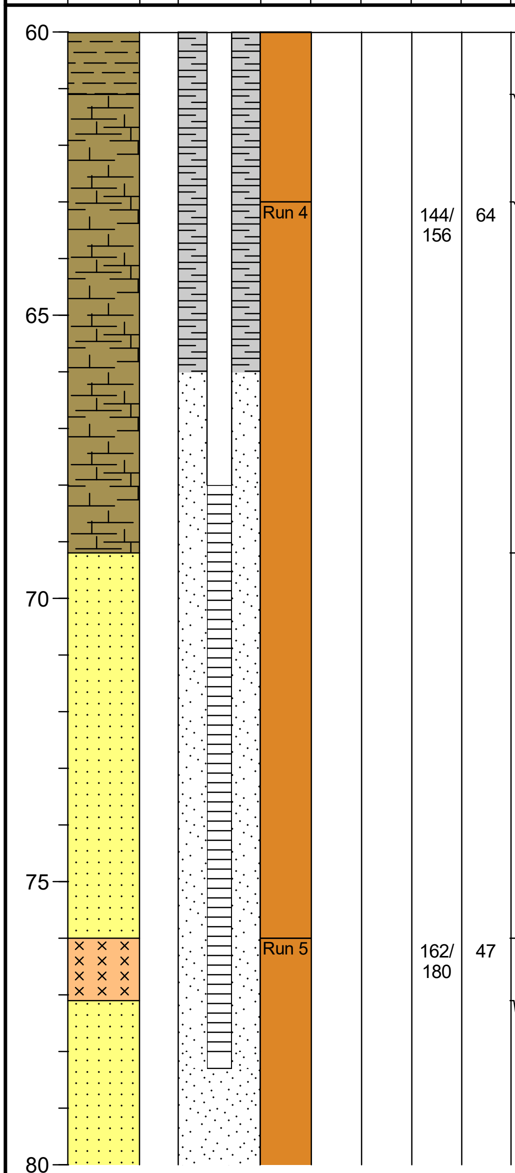
Client:	**AEP-Cardinal**
Project:	**CHE8126L**
Address:	**3202 Twp Rd 163, Brilliant, OH**

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)	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									(59.7') MUDSTONE: very weak, greenish gray, massive, highly decomposed, highly disintegrated.		60
									(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. (65.2') 0.5 ft of highly decomposed, intensely fractured.		
65											65
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. (74.2') 0.5 ft of moderately disintegrated, very intensely fractured.		70
75											75
				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											80

NOTES:

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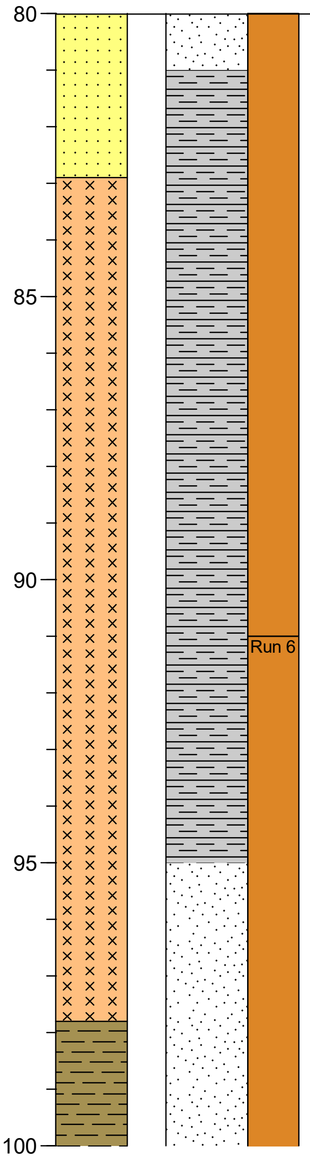
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

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)	Sample Type	Date & Time	Blow Counts	Recovery (in)	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
						(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								85
90								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.		
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:

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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					SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
				Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)			
100	▤		░	🟧							100
									End of borehole at 102 ft bgs. Well installed on 04/12/2016		
105											105

NOTES:

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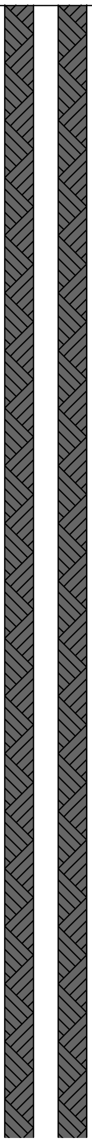
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

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

NOTES:

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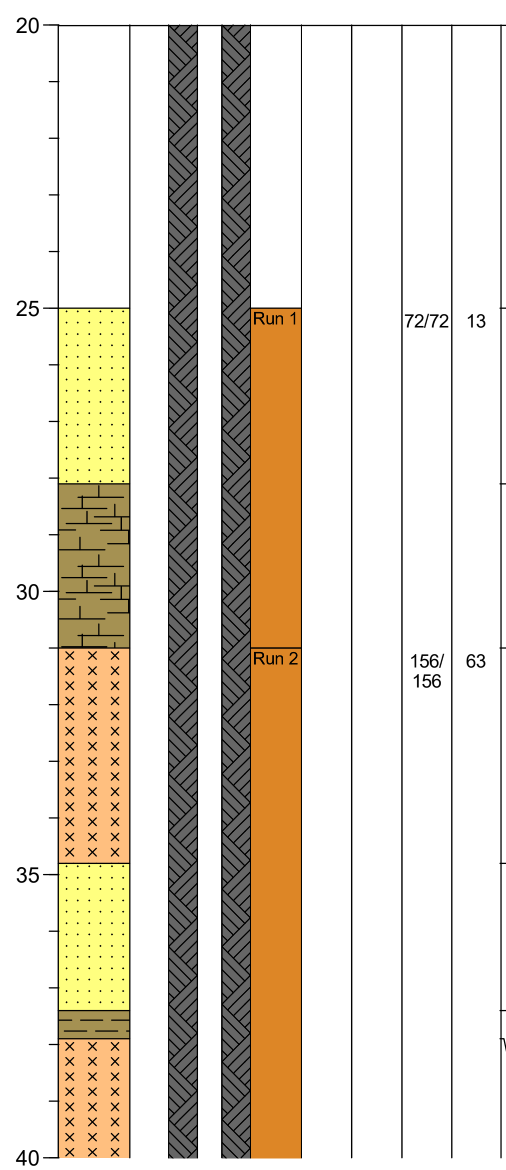
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. S-GS-2

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**



Sample Type	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS
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.	
			(28.1') Sandy CLAYSTONE: moderately strong, medium dark gray (N4) and grayish black (N2), locally sandy, micaceous, intensely fractured, moderately decomposed, moderately disintegrated.	
Run 2	156/156	63	(31') SILTSTONE: strong, medium gray (N5), massive, some limestone nodules, fresh to slightly decomposed, competent, slightly fractured.	
			(34.8') Silty SANDSTONE: strong, medium gray (N5), fine grained, micaceous, cross bedding, slightly fractured, fresh, competent, mica content grades to more down unit.	
			(37.4') MUDSTONE: dark greenish gray (5GY 4/1), highly decomposed.	
			(37.9') Sandy SILTSTONE: strong, medium light gray (N6), locally sandy, slightly fractured, slightly to moderately decomposed,	

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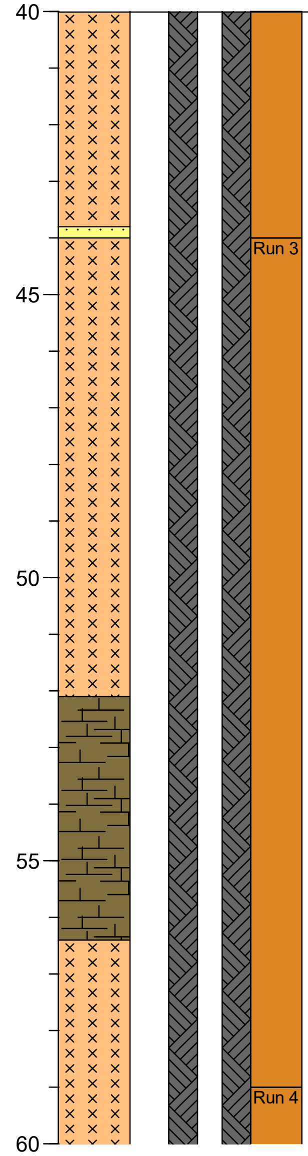
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. S-GS-2

Drilling Start Date: **03/09/2016 13:20**
Drilling End Date: **03/09/2016 18:00**
Drilling Company: **Layne Drilling**
Drilling Method: **Rock Core**
Drilling Equipment: **CS1500 Wireline Rig**
Driller: **Bill Womack**
Logged By: **Doug Mateas**

Boring Depth (ft): **89**
Boring Diameter (in): **6**
Sampling Method(s): **Rock Core**
DTW During Drilling (ft):
Ground Surface Elev. (ft): **1,009.07**
Top of Casing Elev. (ft): **1,011.75**
Location (X,Y): **N 832,448.3 E 2,515,777.5**

Well Depth (ft): **84**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Pre-packed Sch 40 PVC**
Seal Material(s): **Bentonite Pellets**
Filter Pack: **#5 Medium Coarse Sand**

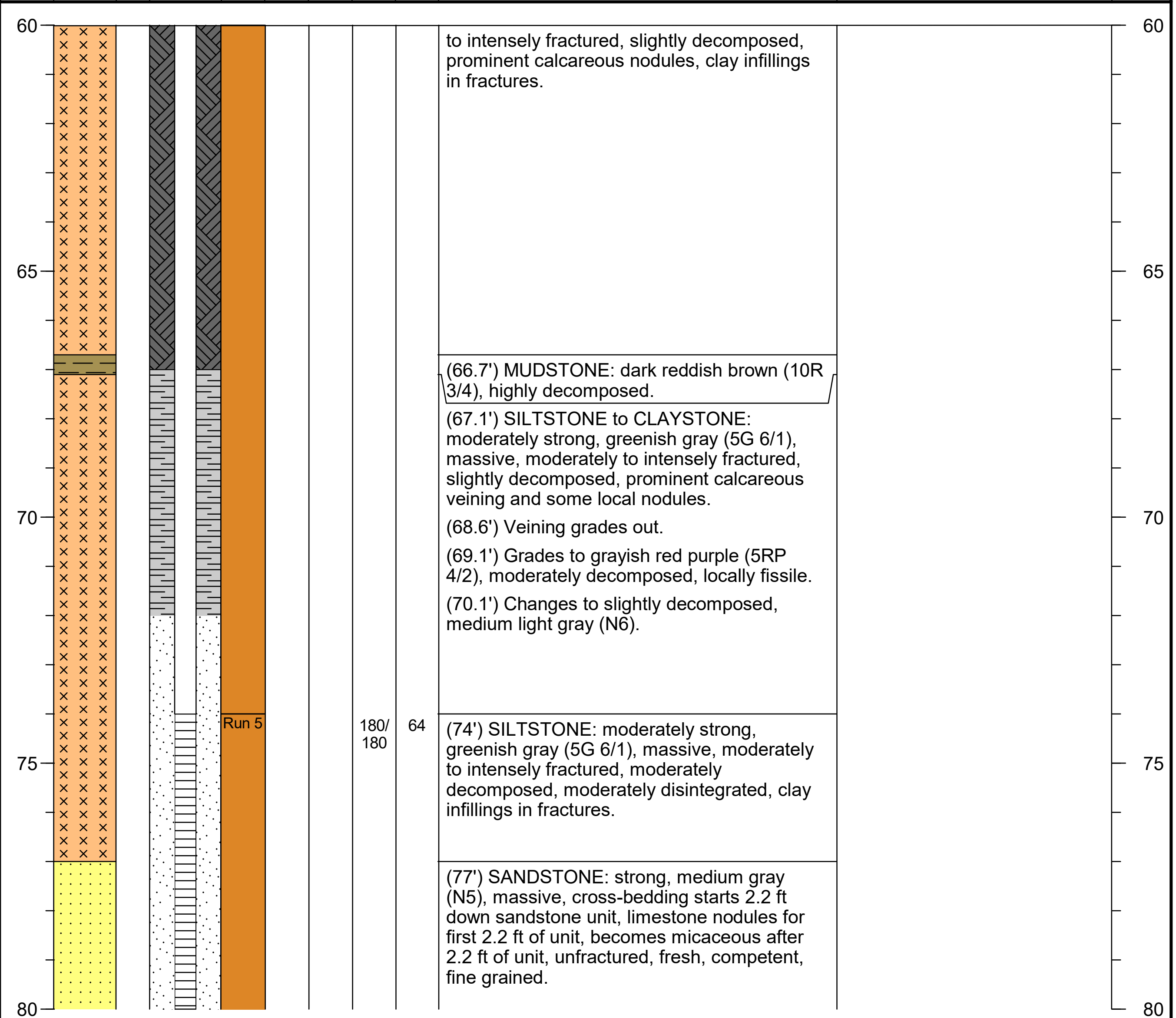


Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS
					slightly to moderately disintegrated, massive. (42.5') Vertical fracture with calcite infillings for rest of unit, dusky yellow to light brown color change.	
Run 3			180/ 180	69	(43.8') Silty SANDSTONE: strong, medium light gray (N6), fine grained, cross bedding, fresh, competent, slightly fractured.	
					(44') SILTSTONE: strong, greenish gray (5G 6/1), massive, limestone nodules/veining in fractures, fresh to slightly decomposed, competent, slightly fractured.	
					(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.	
					(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.	
					(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	

NOTES:

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					SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
				Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)			
74				Run 5			180/ 180	64			



to intensely fractured, slightly decomposed, prominent calcareous nodules, clay infillings in fractures.

(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.

(68.6') Veining grades out.

(69.1') Grades to grayish red purple (5RP 4/2), moderately decomposed, locally fissile.

(70.1') Changes to slightly decomposed, medium light gray (N6).

(74') SILTSTONE: moderately strong, greenish gray (5G 6/1), massive, moderately to intensely fractured, moderately decomposed, moderately disintegrated, clay infillings in fractures.

(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.

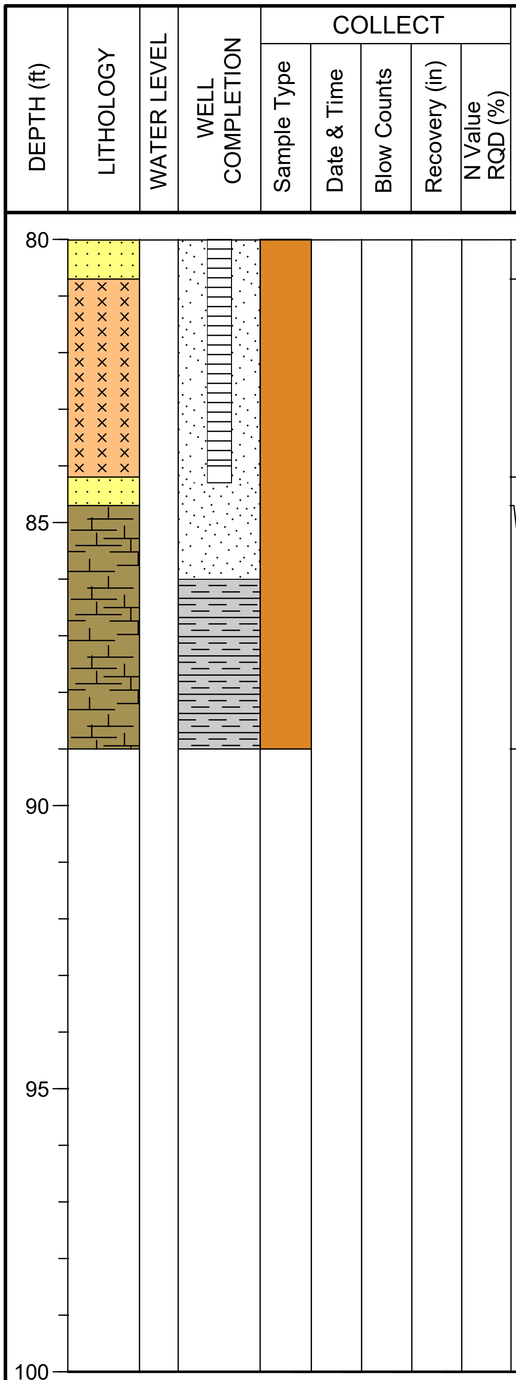
NOTES:

Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG

Boring/Well No. S-GS-2
Page: 5 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**



SOIL/ROCK VISUAL DESCRIPTION | REMARKS | DEPTH (ft)

(80.7') SILTSTONE: moderately strong, greenish gray (5G 6/1), massive, unfractured to slightly fractured, fresh, competent, clay infillings in fractures, minor limestone nodules.

(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.

End of borehole at 89 ft bgs.

Well installed on 04/12/2016

NOTES:

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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	 Date & Time	 Blow Counts	 Recovery (in)	 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

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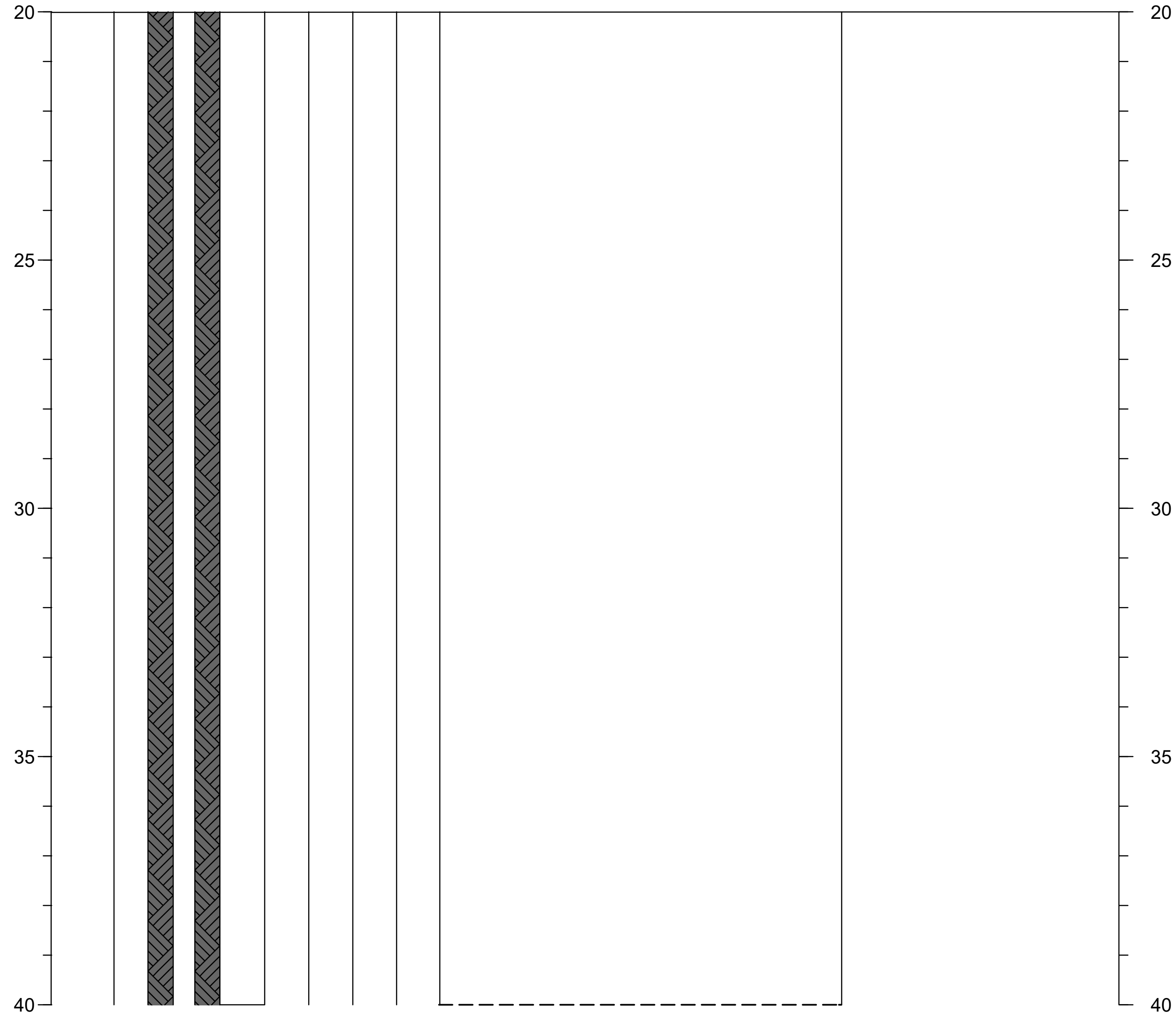
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

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					SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
				Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)			



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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

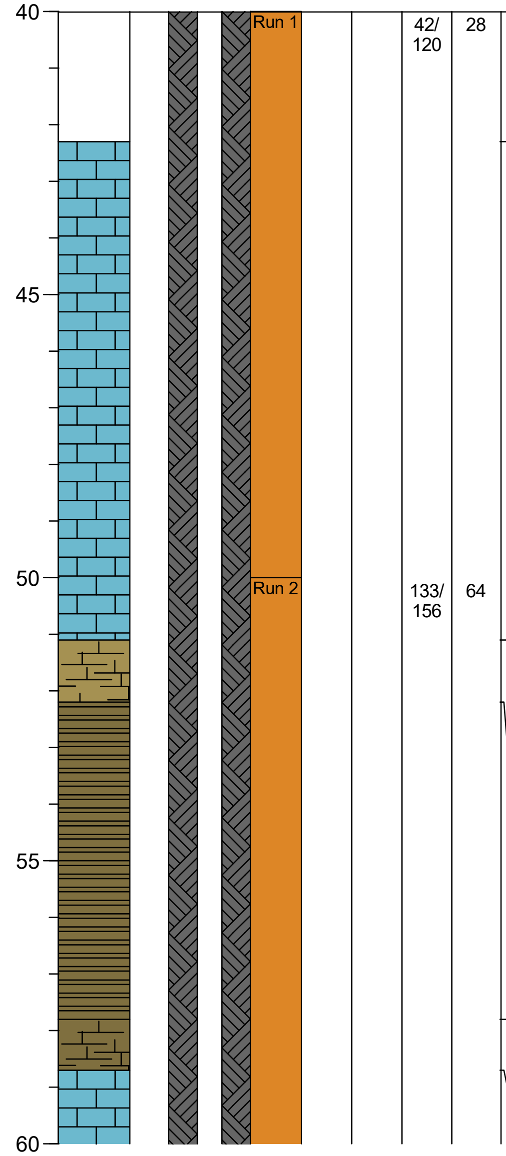
BORING LOG

Boring/Well No. S-GS-3

Drilling Start Date: **03/16/2016 10:45**
Drilling End Date: **03/21/2016 16:15**
Drilling Company: **Layne Drilling**
Drilling Method: **Rock Core**
Drilling Equipment: **CS1500 Wireline Rig**
Driller: **Bill Womack**
Logged By: **D. Mateas & C. Gregory**

Boring Depth (ft): **143**
Boring Diameter (in): **6**
Sampling Method(s): **Rock Core**
DTW During Drilling (ft):
Ground Surface Elev. (ft): **1,036.93**
Top of Casing Elev. (ft): **1,039.42**
Location (X,Y): **N 835,737.2 E 2,511,639.3**

Well Depth (ft): **140**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Pre-packed Sch 40 PVC**
Seal Material(s): **Bentonite Pellets**
Filter Pack: **#5 Medium Coarse Sand**



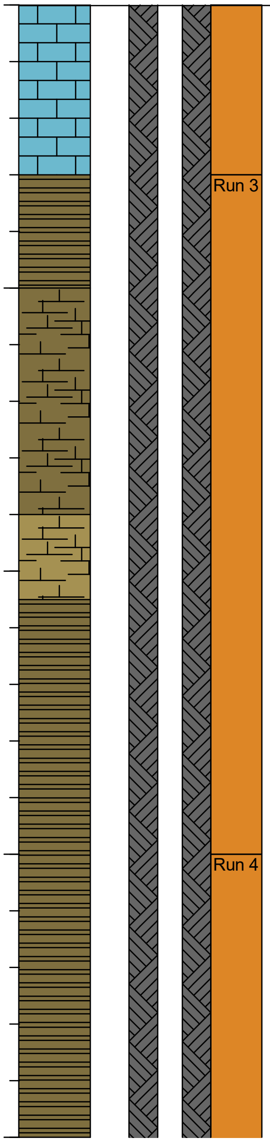
DEPTH (ft)	COLLECT Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS
40	Run 1			42/ 120	28	Overburden: See remarks.	Began coring at 40 ft bgs due to boulders in overburden that roller bit could not drill through.
						(42.3') LIMESTONE: strong, greenish 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.	
						(49.2') Vertical fracture (0.8 ft long).	
50	Run 2			133/ 156	64		
						(51.1') CLAYSTONE: moderately strong, medium dark gray (N4), massive, moderately decomposed, intensely fractured. (51.6') Changes to very weak, highly decomposed.	
						(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.	
						(58.7') LIMESTONE: strong, medium dark	
60							

NOTES:

Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

BORING LOG
Boring/Well No. S-GS-3

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
									(70.5') Sandy silty SHALE: strong, medium to dark gray (N3 to N4), moderately fractured, some fine sandy laminations, minor cross bedding.		
75				Run 4			156/ 156	73			75
80											80

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Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

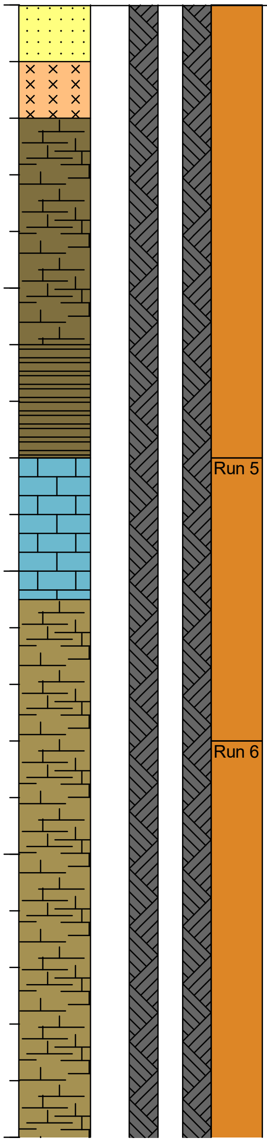
BORING LOG

Boring/Well No. S-GS-3

Drilling Start Date: **03/16/2016 10:45**
Drilling End Date: **03/21/2016 16:15**
Drilling Company: **Layne Drilling**
Drilling Method: **Rock Core**
Drilling Equipment: **CS1500 Wireline Rig**
Driller: **Bill Womack**
Logged By: **D. Mateas & C. Gregory**

Boring Depth (ft): **143**
Boring Diameter (in): **6**
Sampling Method(s): **Rock Core**
DTW During Drilling (ft):
Ground Surface Elev. (ft): **1,036.93**
Top of Casing Elev. (ft): **1,039.42**
Location (X,Y): **N 835,737.2 E 2,511,639.3**

Well Depth (ft): **140**
Well Diameter (in): **2**
Screen Slot (in): **0.010**
Riser Material: **Sch 40 PVC**
Screen Material: **Pre-packed Sch 40 PVC**
Seal Material(s): **Bentonite Pellets**
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).		
85									(82') CLAYSHALE: medium dark gray (N4), silty slightly pyritic, with dark greenish gray claystone lenses. (84-85') Very intensely fractured.		85
									(86') Silty SHALE: strong, medium dark gray, moderately fractured. (87-88') Calcareous.		
90				Run 5			58/60	55	(88') LIMESTONE: strong, greenish gray (5G 6/1), massive, intensely fractured, slightly decomposed.		90
									(90.5') Silty CLAYSTONE: moderately strong, medium dark gray to dark greenish gray, moderately decomposed.		
95				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
100											100

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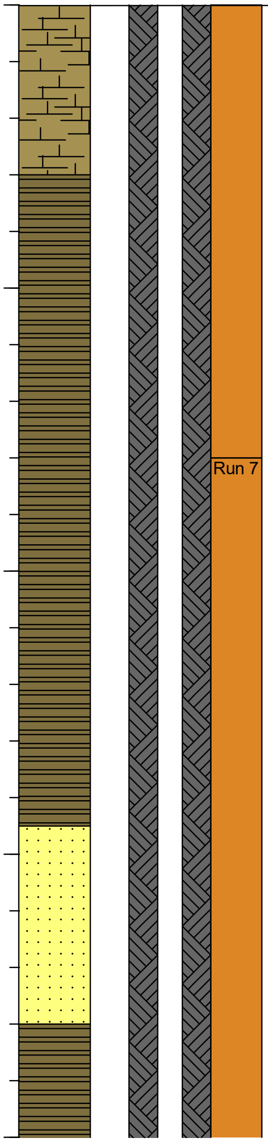
Client: AEP-Cardinal
Project: CHE8126L
Address: 3202 Twp Rd 163, Brilliant, OH

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									(101-101.5') Intensely fractured. (102.5-103') Intensely fractured, soft claystone seams.		100
									(103') Silty SHALE: strong, medium dark gray (N4), few claystone lenses, moderately fractured, slightly decomposed.		105
				Run 7			176/ 180	99	(108') Silty sandy SHALE: strong, medium dark gray, few yellowish gray areas, slightly fractured.		110
									(114.5') Silty SANDSTONE: strong, medium light gray (N6), few dark gray (N3) lenses, thinly bedded, cross-bedded, slightly micaceous, slightly fractured.		115
120									(118') Sandy SHALE: strong, grayish black (N2) with few medium light gray sandstone lenses (N6), slightly fractured.		120

NOTES:

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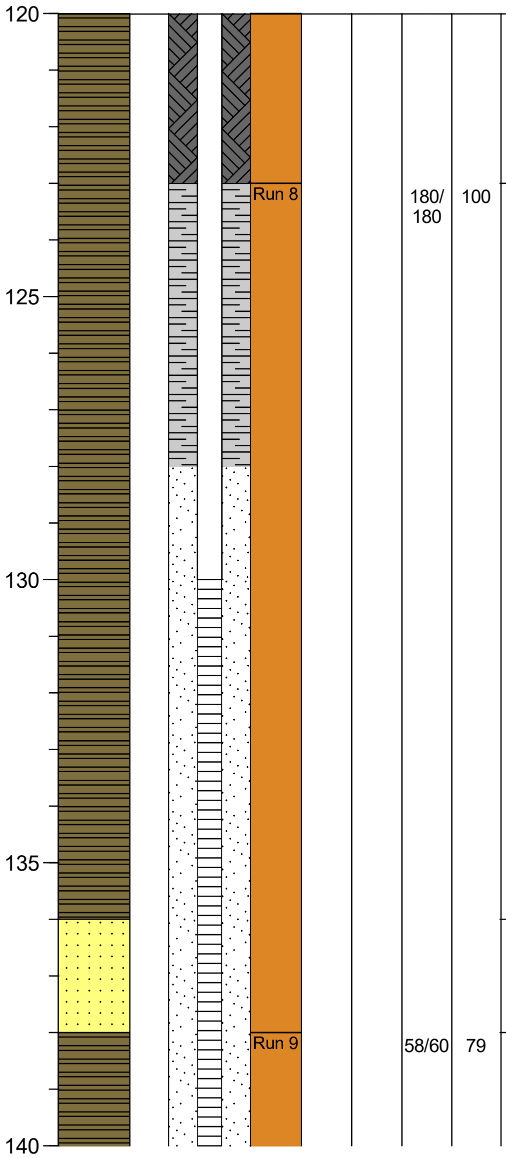
Drilling Start Date:	**03/16/2016 10:45**	Boring Depth (ft):	**143**	Well Depth (ft):	**140**
Drilling End Date:	**03/21/2016 16:15**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**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)	Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
123	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).		
133						(133') Extremely limestone nodular.		
136						(136') SANDSTONE: strong, light gray to medium dark gray, thinly bedded, cross-bedded, slightly fractured.		
138	Run 9			58/60	79	(138') Sandy SHALE: dark gray (N3), few limestone nodules (light gray N7), slightly decomposed, moderately fractured.		

NOTES:

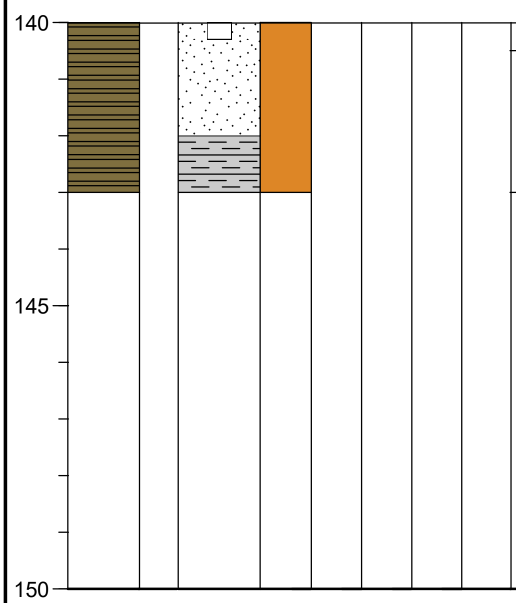
Geosyntec consultants
engineers | scientists | innovators

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					SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
				Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)			



(140.5') Silty SHALE: grayish black (N2), intensely fractured, moderately decomposed.

(141-143') Medium gray, calcareous, massive.

End of borehole at 143 ft bgs.

Well installed on 04/05/2016

140
145
150

NOTES:

APPENDIX D

WELL CONSTRUCTION LOGS

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
MONITORING WELL CONSTRUCTION

JOB NUMBER

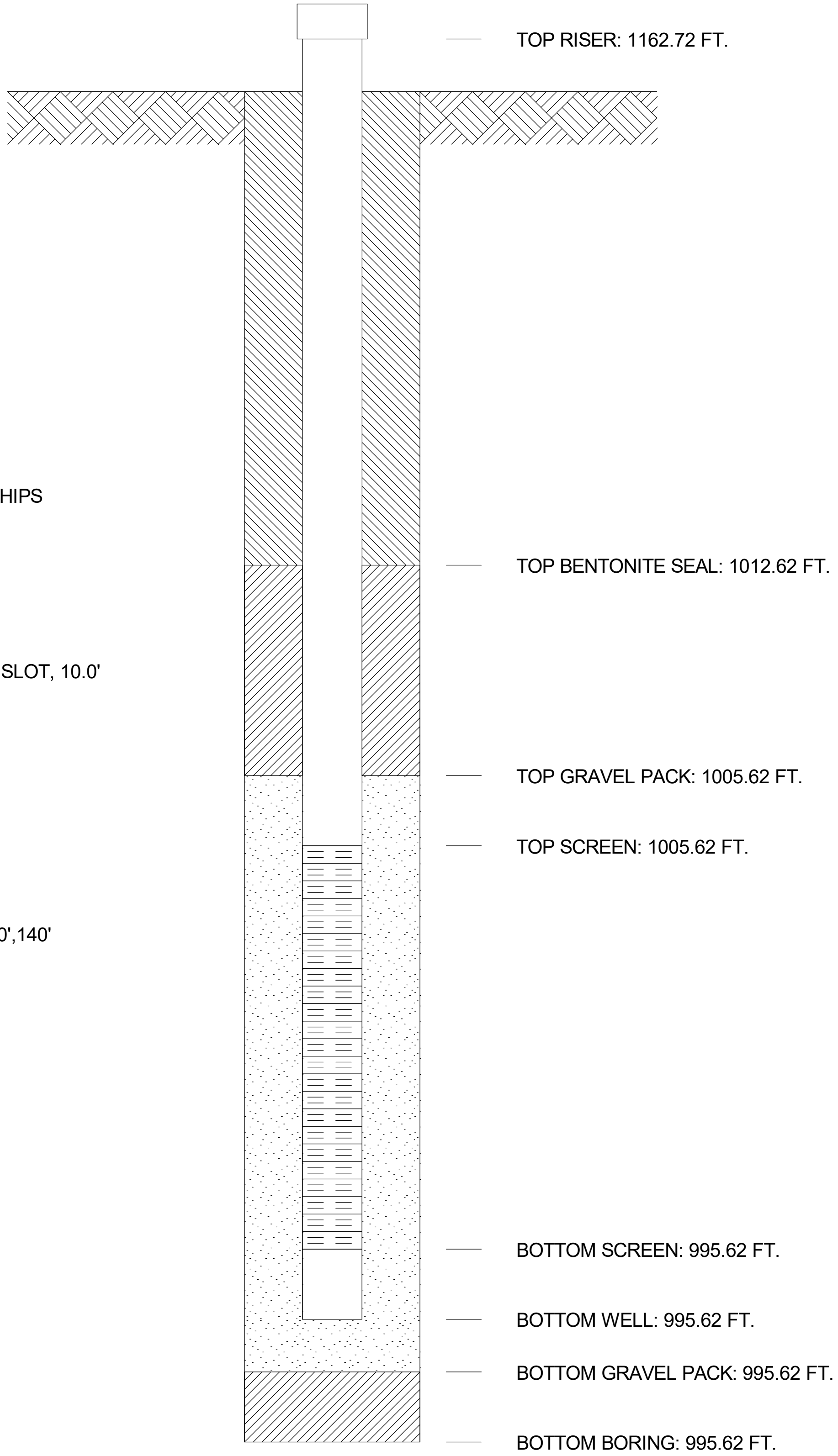
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **CA-0623A** BORING No. **CA-0623A** INSTALLED **8/16/16**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 836,300.1 E 2,514,227.5**

SYSTEM **State Plane using NAD27/29**

GROUND ELEVATION 1159.62 FT.



- ▨ 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'

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**

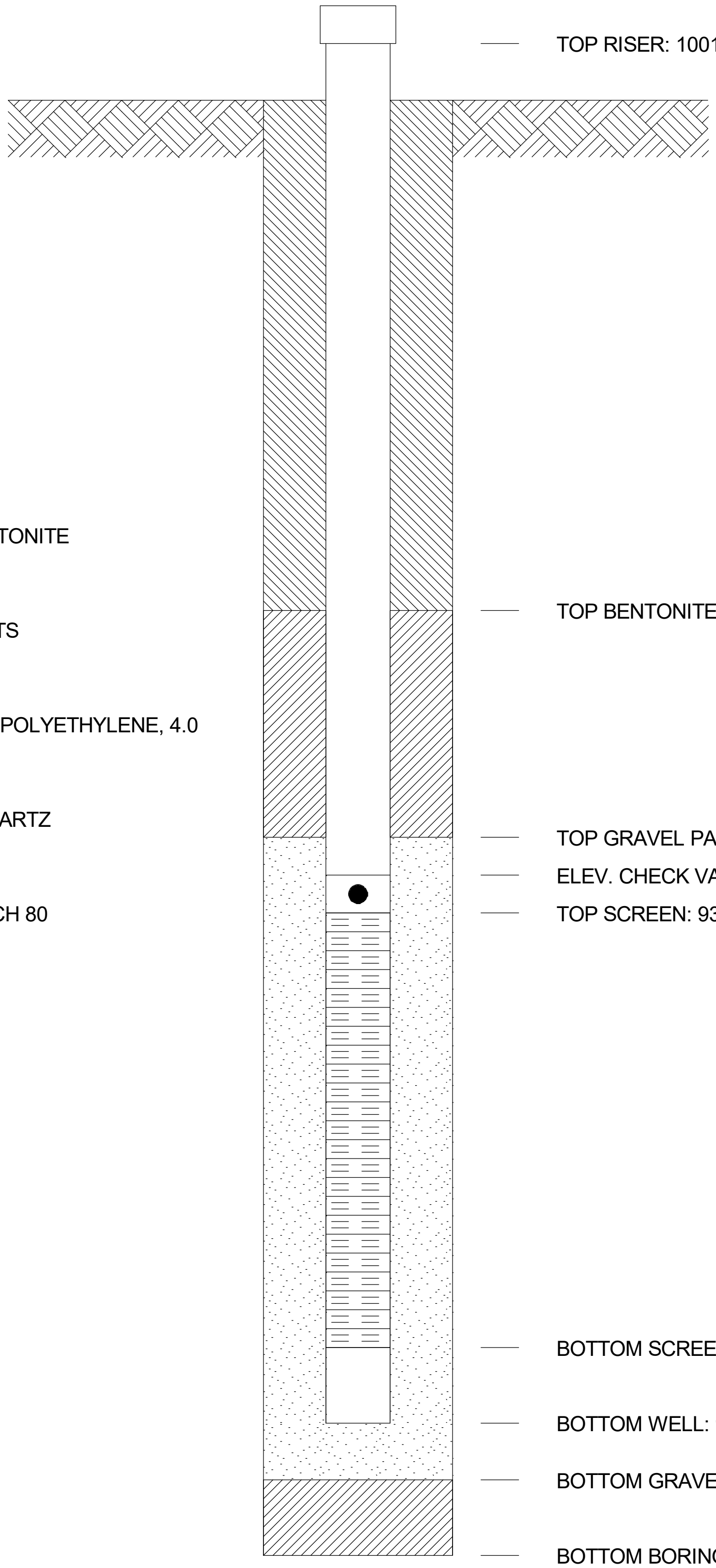
INSTALLED **12/12/85**

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

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**

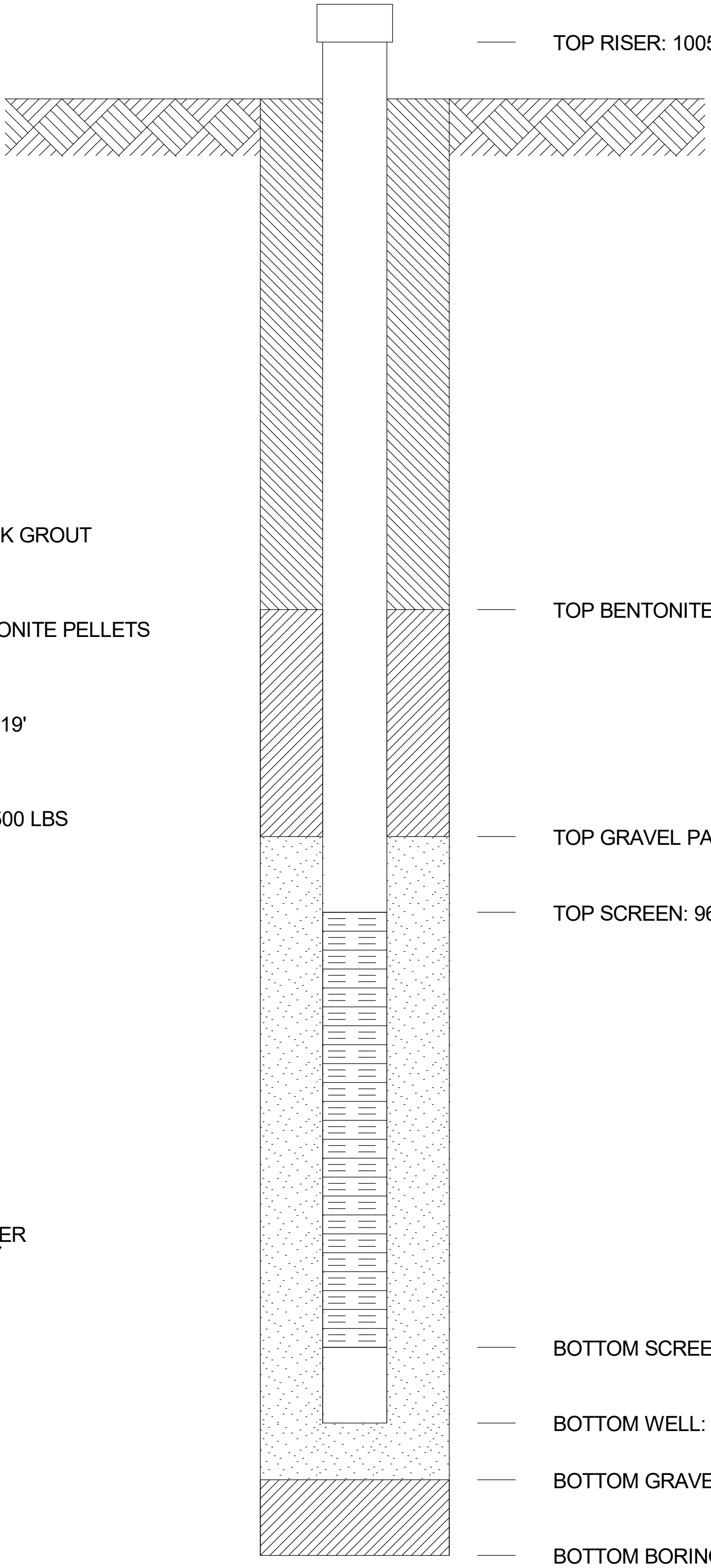
INSTALLED **1/9/07**

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**

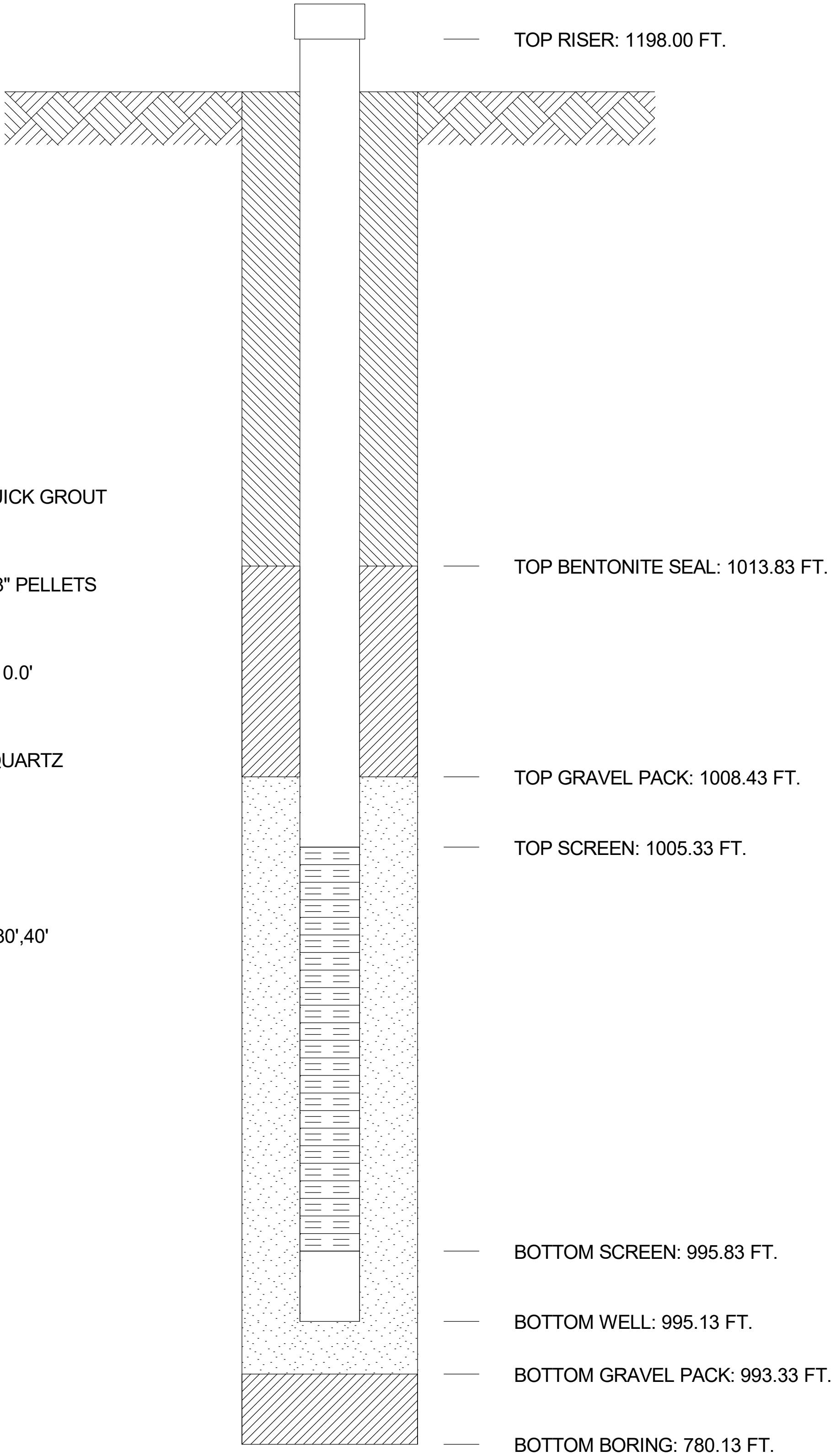
INSTALLED **6/12/07**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 833,612.2 E 2,512,715.1**

SYSTEM

GROUND ELEVATION 1195.63 FT.



▧ 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**

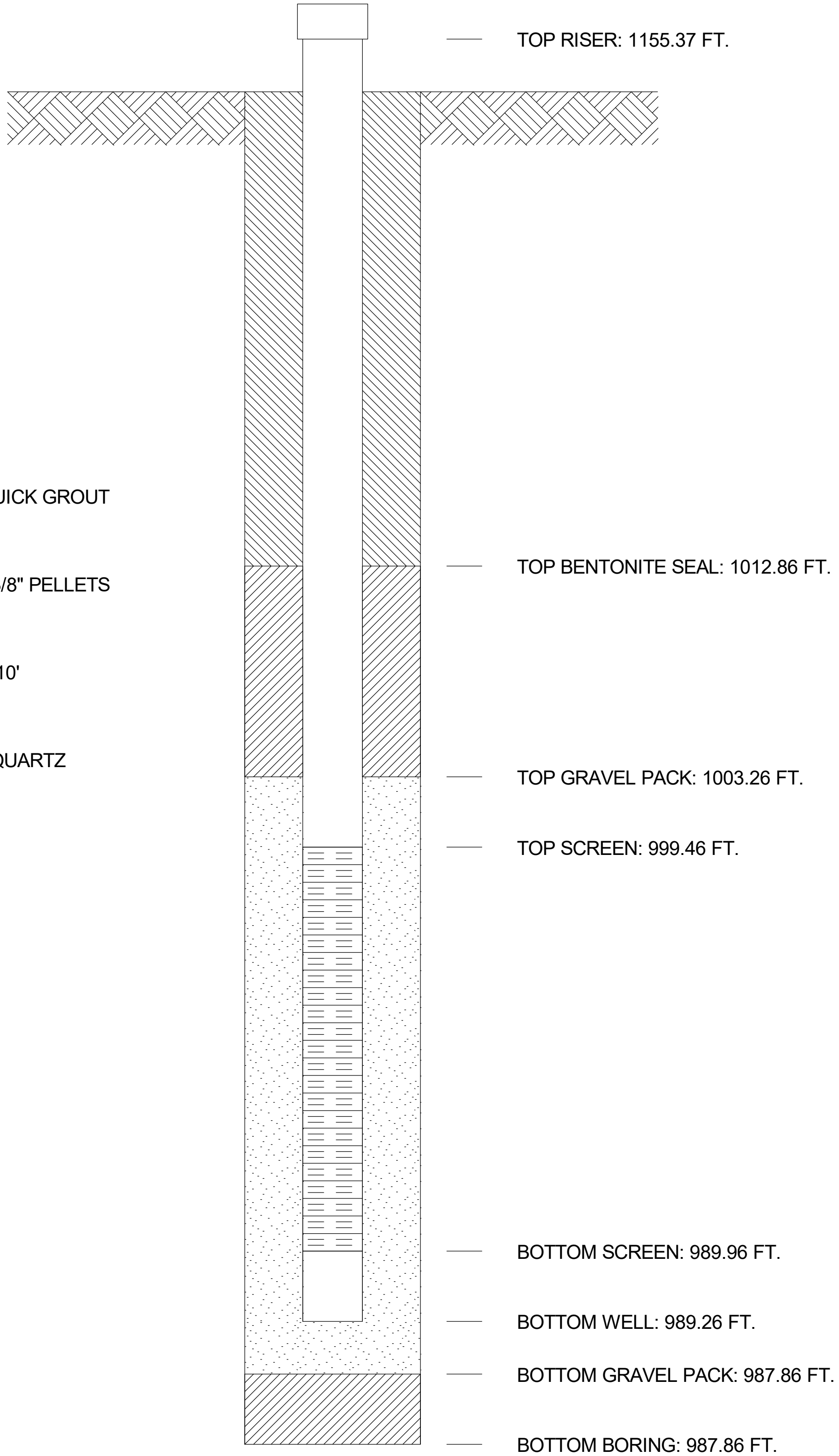
INSTALLED **8/22/07**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 832,194.6 E 2,513,596.2**

SYSTEM

GROUND ELEVATION 1153.26 FT.



- ▧ 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**

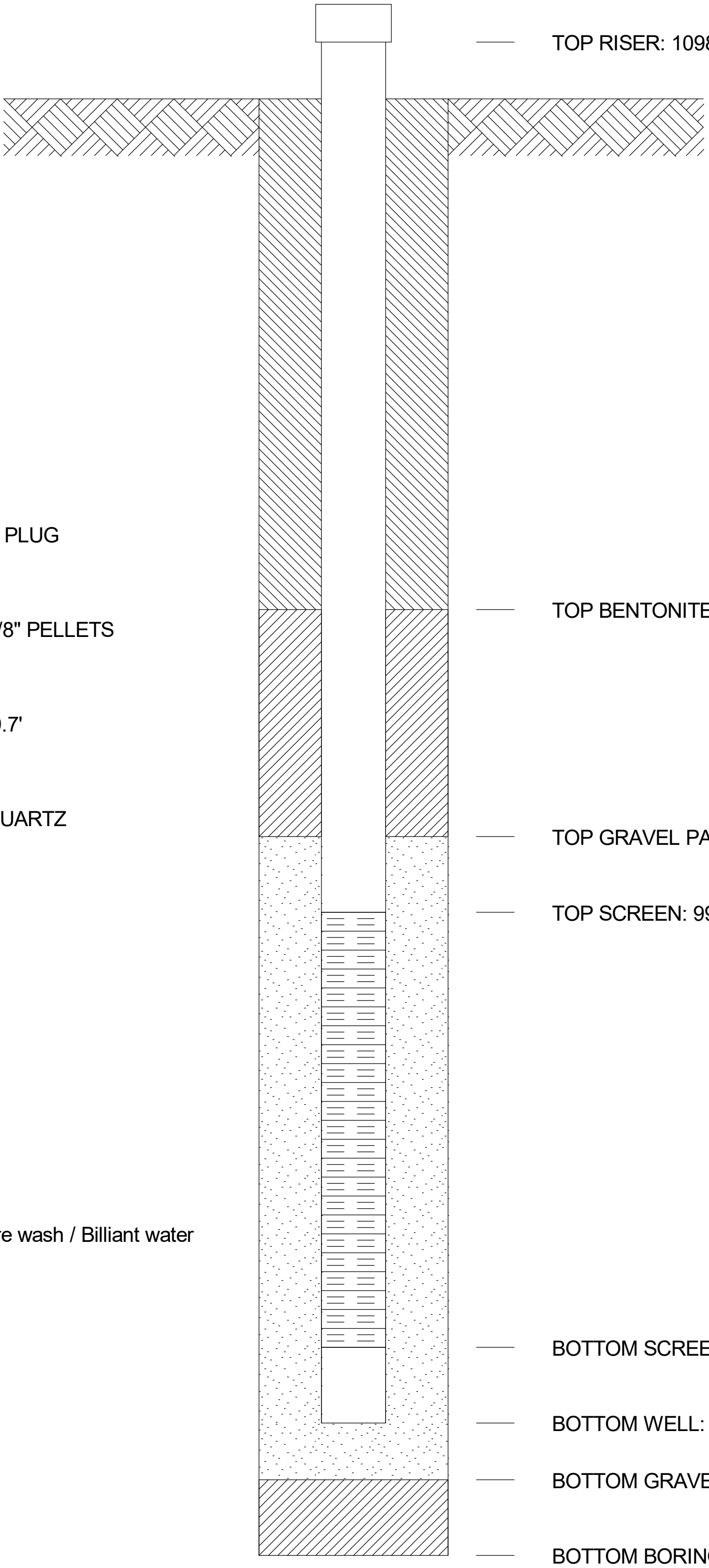
WELL No. **S-19A** BORING No. **CA-0606A** INSTALLED **7/28/11**

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**

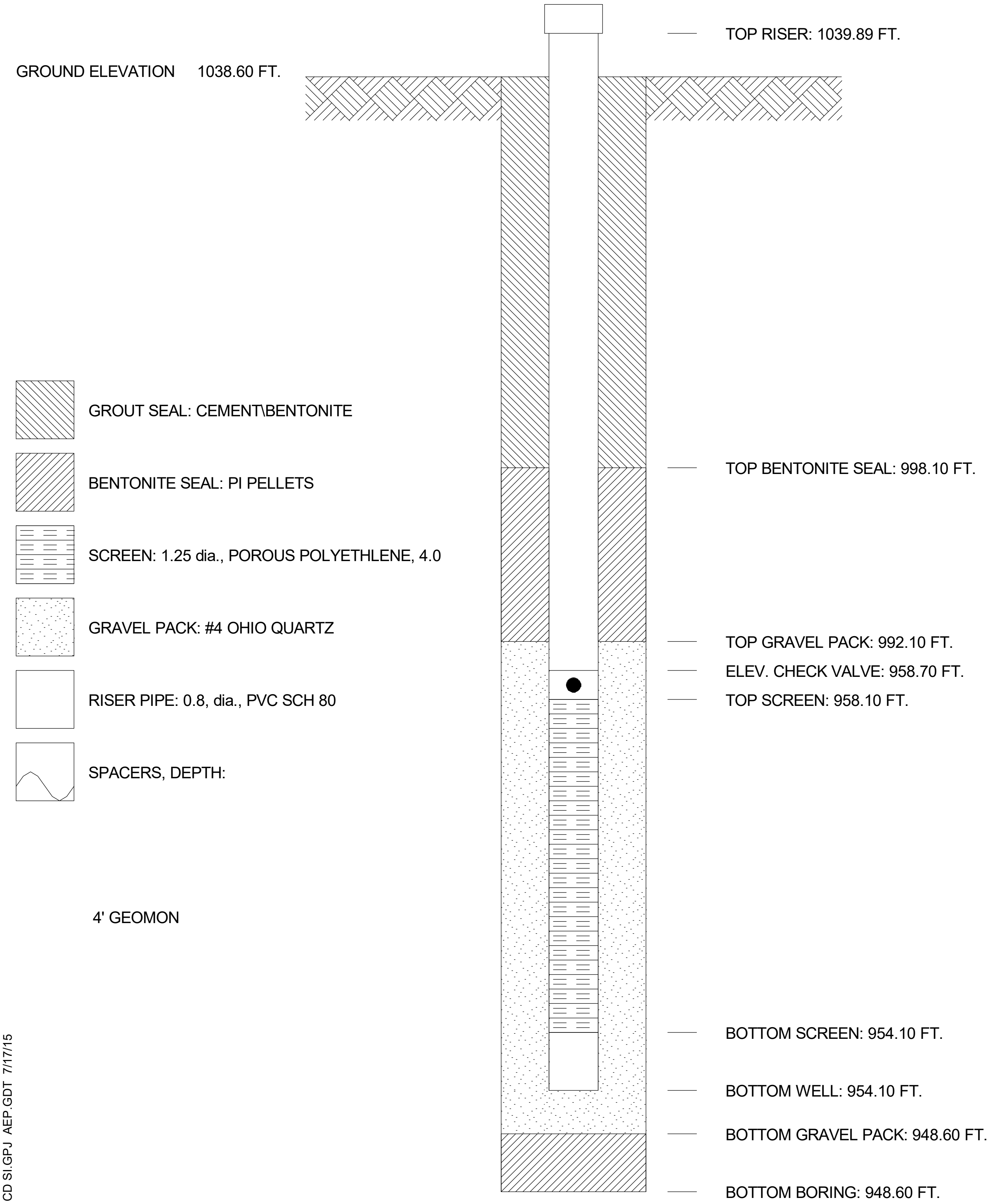
WELL No. **S-2** BORING No. **8503** INSTALLED **12/17/85**

PROJECT **CARDINAL PLANT**

COORDINATES **N 831,038.2 E 2,514,714.2**

SYSTEM **STATE PLANE**

GROUND ELEVATION 1038.60 FT.



▧ 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**

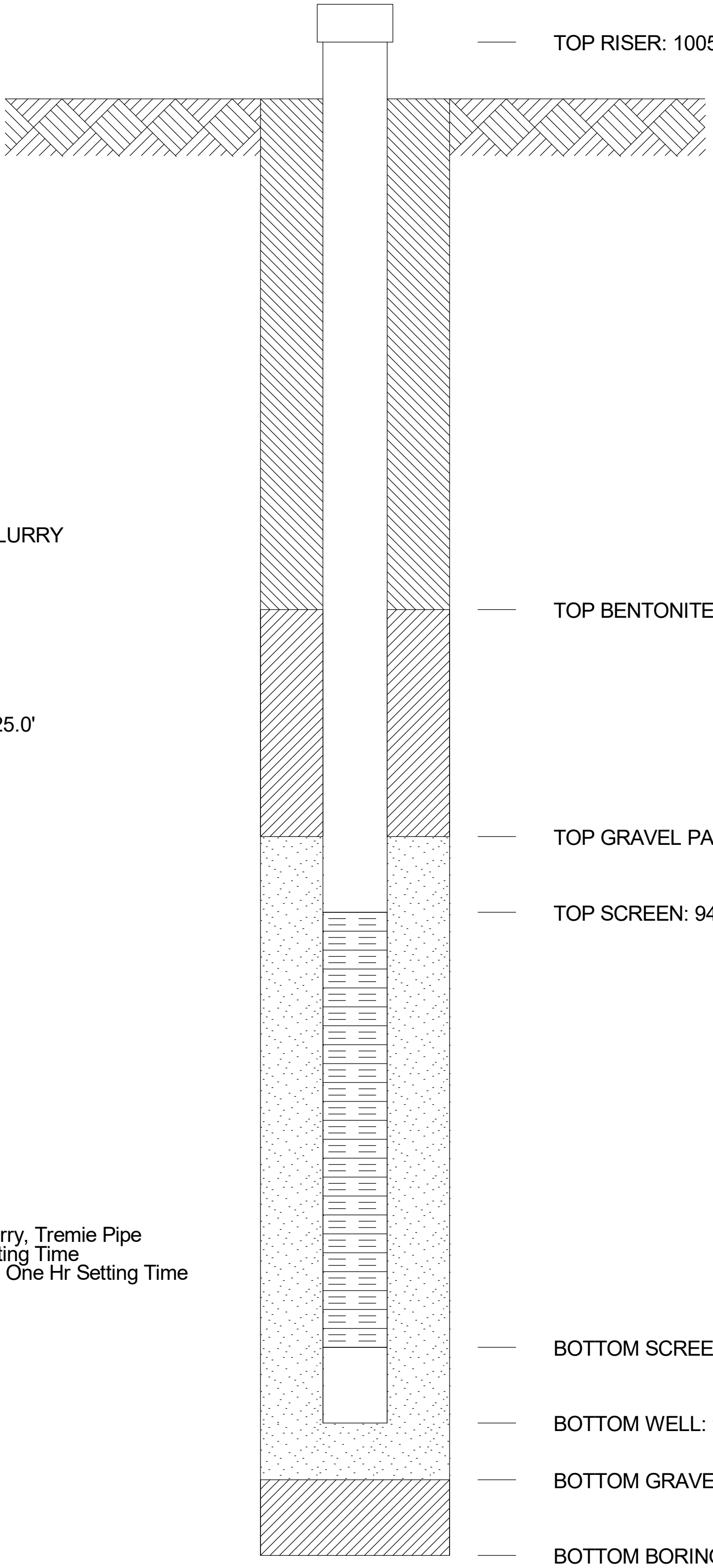
WELL No. **S-20** BORING No. **CA-0619** INSTALLED **8/24/06**

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
☐	RIRISER 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**

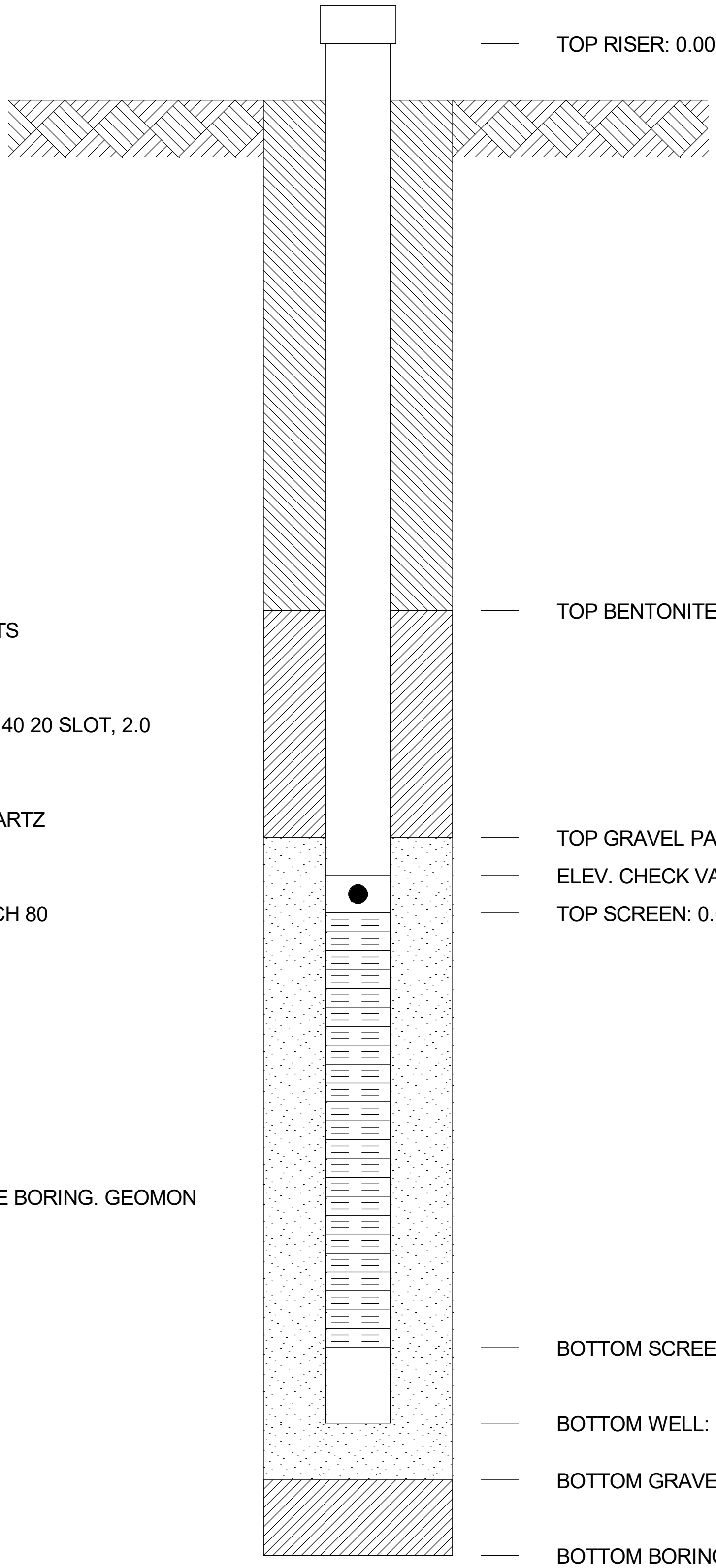
INSTALLED **8/16/88**

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

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

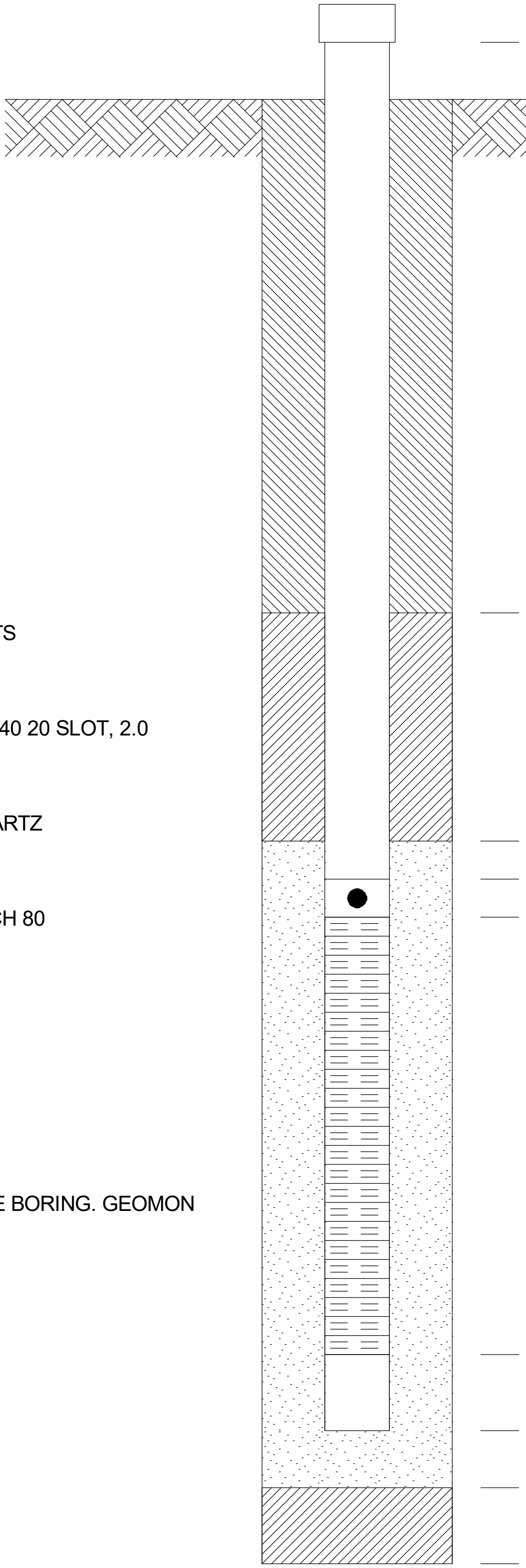
WELL No. **S-5** BORING No. **88-7-8** INSTALLED **8/10/88**

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**

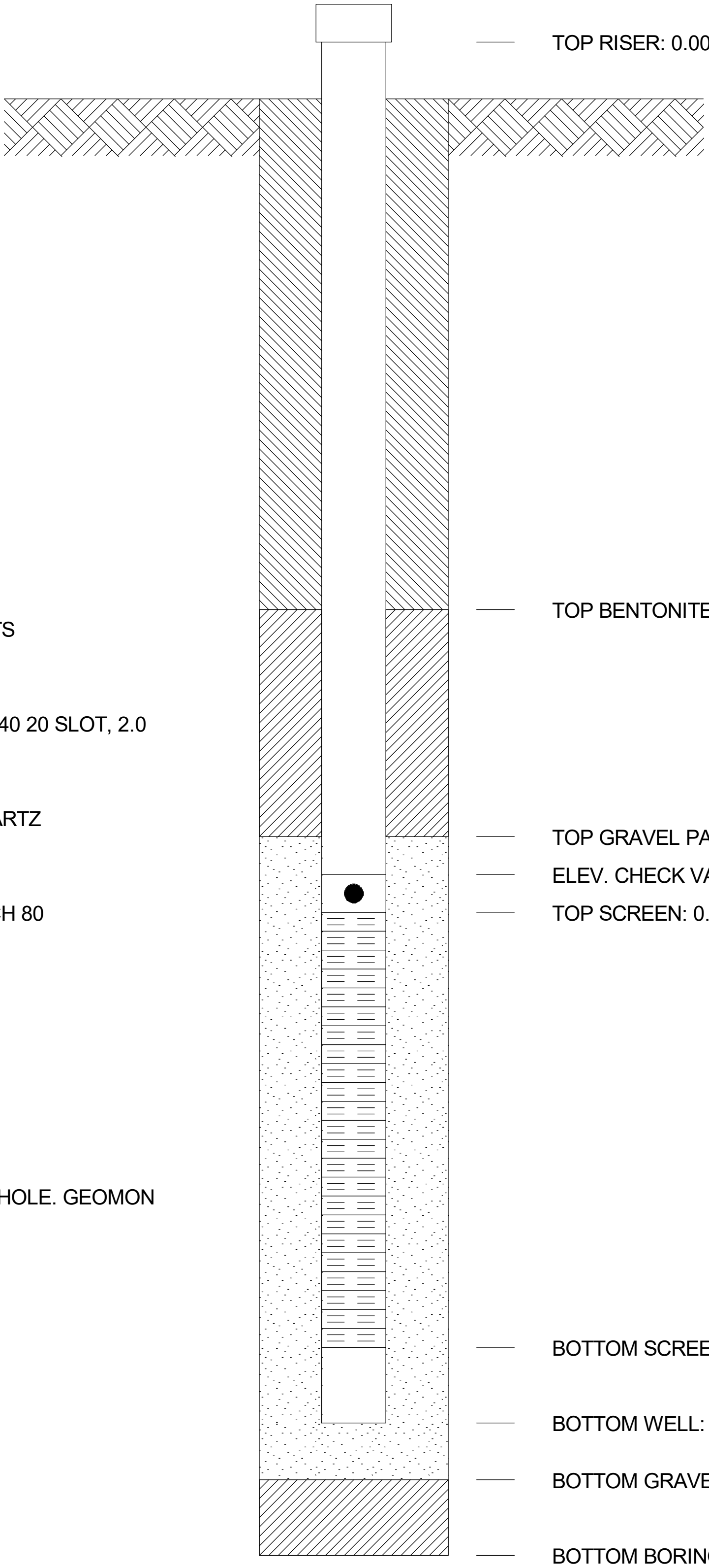
WELL No. **S-6** BORING No. **88-9-10** INSTALLED **8/4/88**

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

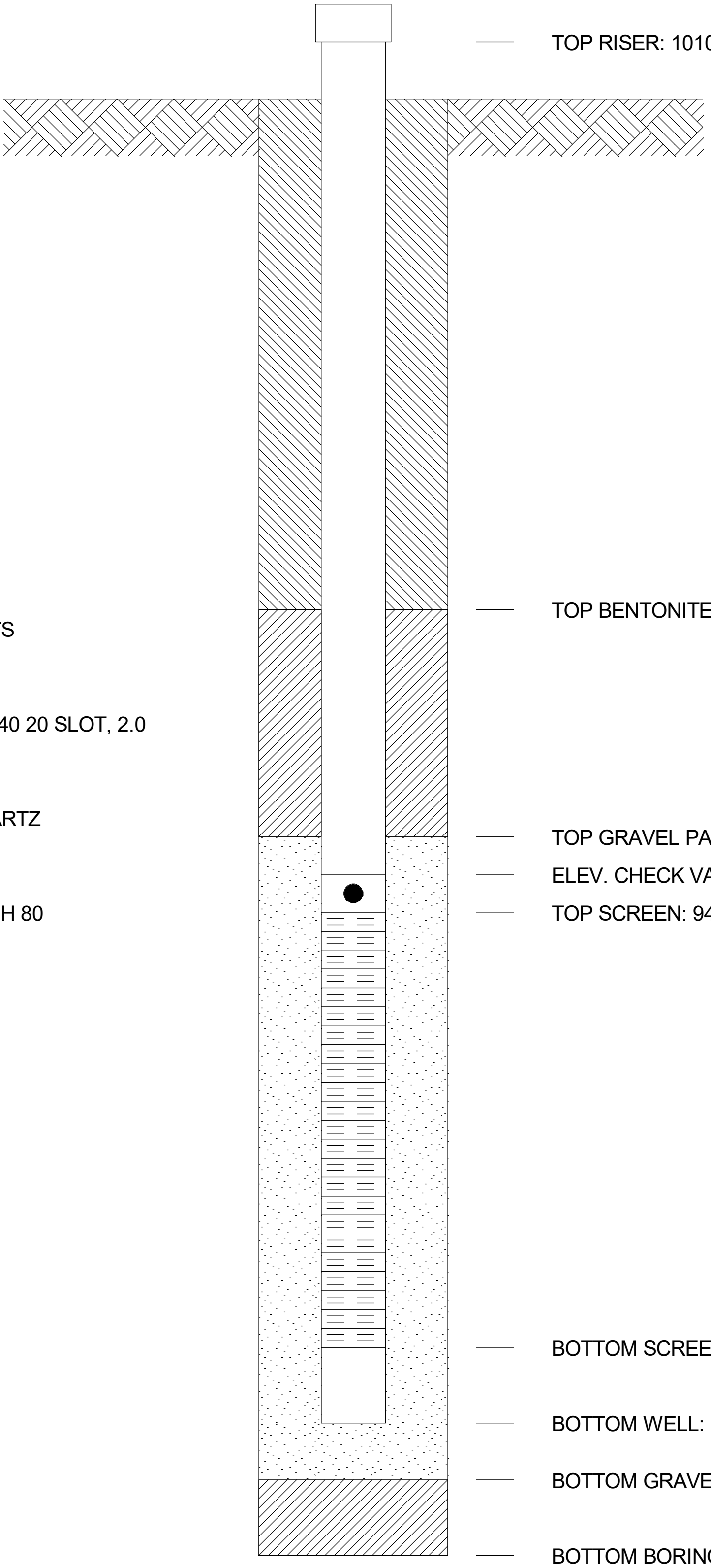
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-7** BORING No. **90CA22-S** INSTALLED **8/14/90**

PROJECT **CARDINAL PLANT**

COORDINATES **N 831,920.2 E 2,516,676.4**

SYSTEM **STATE PLANE**

GROUND ELEVATION 1008.52 FT.



▧ 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

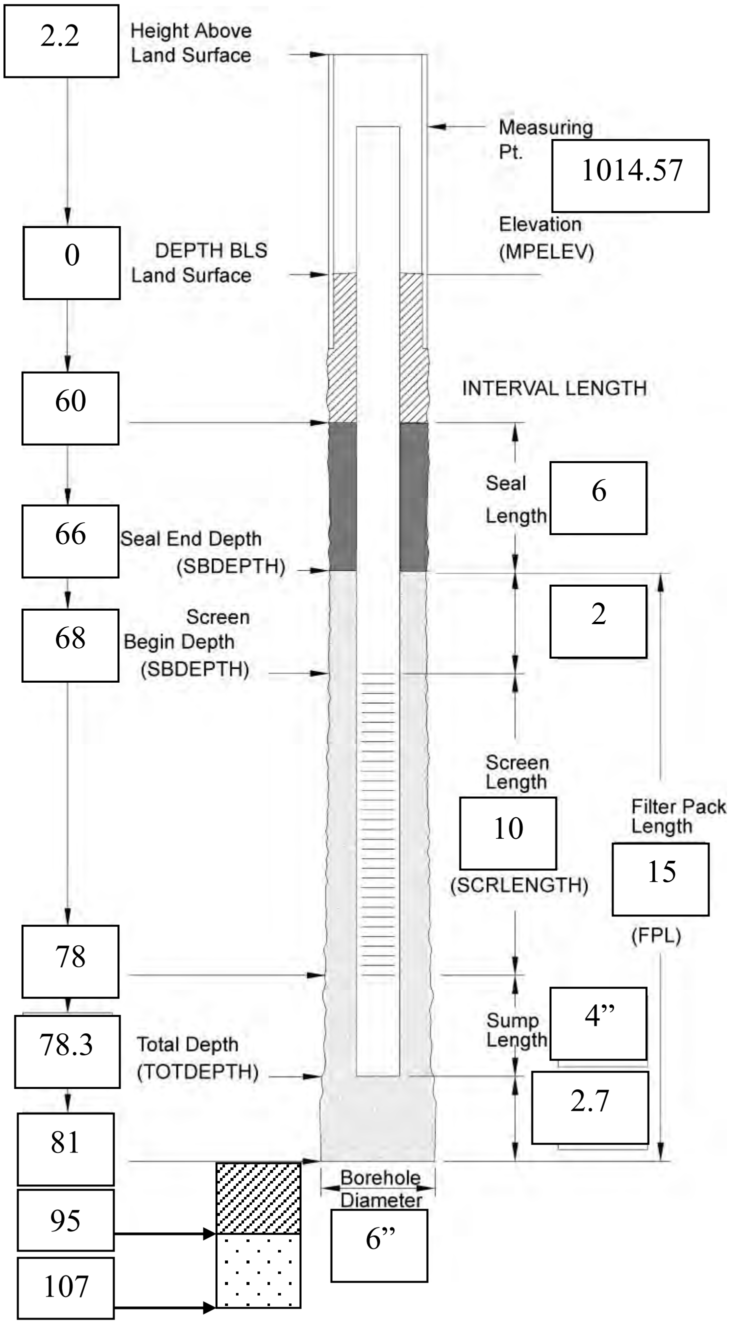
∿ SPACERS, DEPTH:

GEOMON

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):


Height Above Land Surface: 2.2
Measuring Pt. Elevation (MPELEV): 1014.57
DEPTH BLS Land Surface: 0
60
Seal Length: 6
Seal End Depth (SBDEPTH): 66
2
Screen Begin Depth (SBDEPTH): 68
Screen Length (SCRLENGTH): 10
Filter Pack Length (FPL): 15
78
Sump Length: 4”
Total Depth (TOTDEPTH): 78.3
2.7
81
Borehole Diameter: 6”
95
107

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.

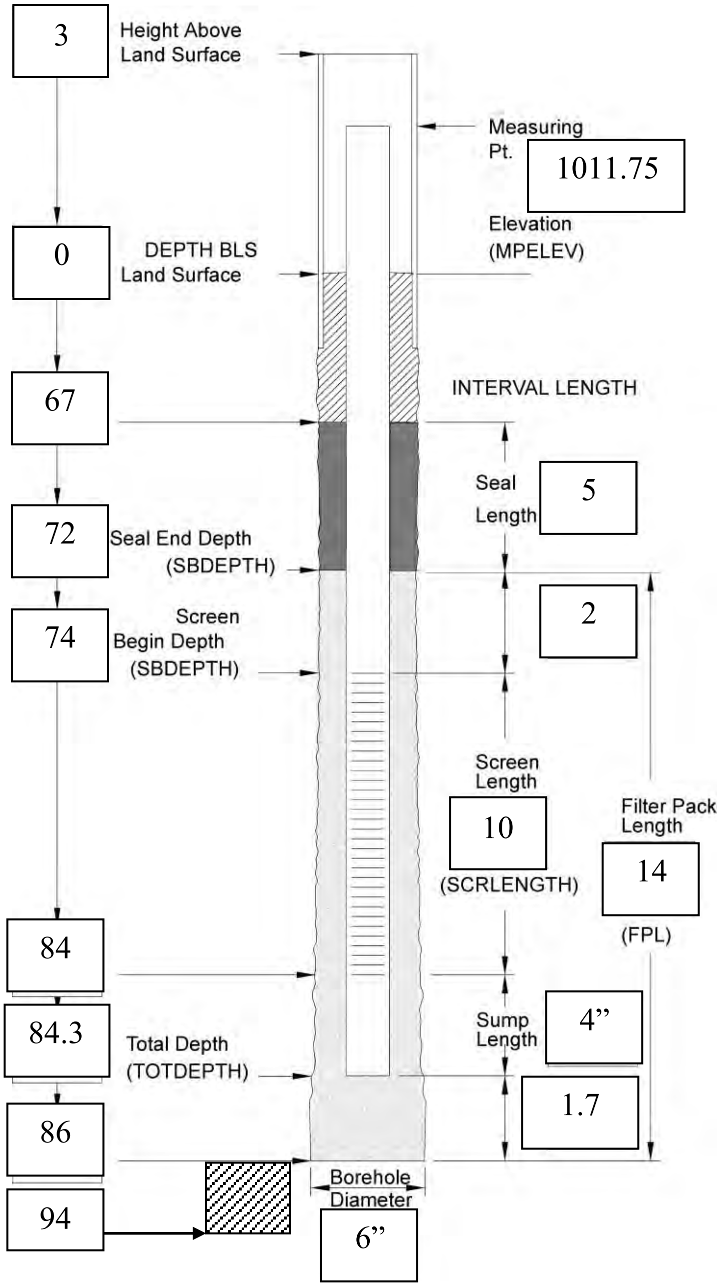
Total Water Volume During Construction
Introduced (Gal): 0 Recovered (Gal): -
Reviewed By: J. Neil Couch Date: 4/22/2016

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):


3 Height Above Land Surface
Measuring Pt. Elevation (MPELEV) 1011.75
0 DEPTH BLS Land Surface
67
INTERVAL LENGTH
Seal Length 5
72 Seal End Depth (SBDEPTH)
2
74 Screen Begin Depth (SBDEPTH)
Screen Length 10 (SCRLENGTH)
Filter Pack Length 14 (FPL)
84
Sump Length 4”
84.3 Total Depth (TOTDEPTH)
1.7
86
94
Borehole Diameter 6”

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’.

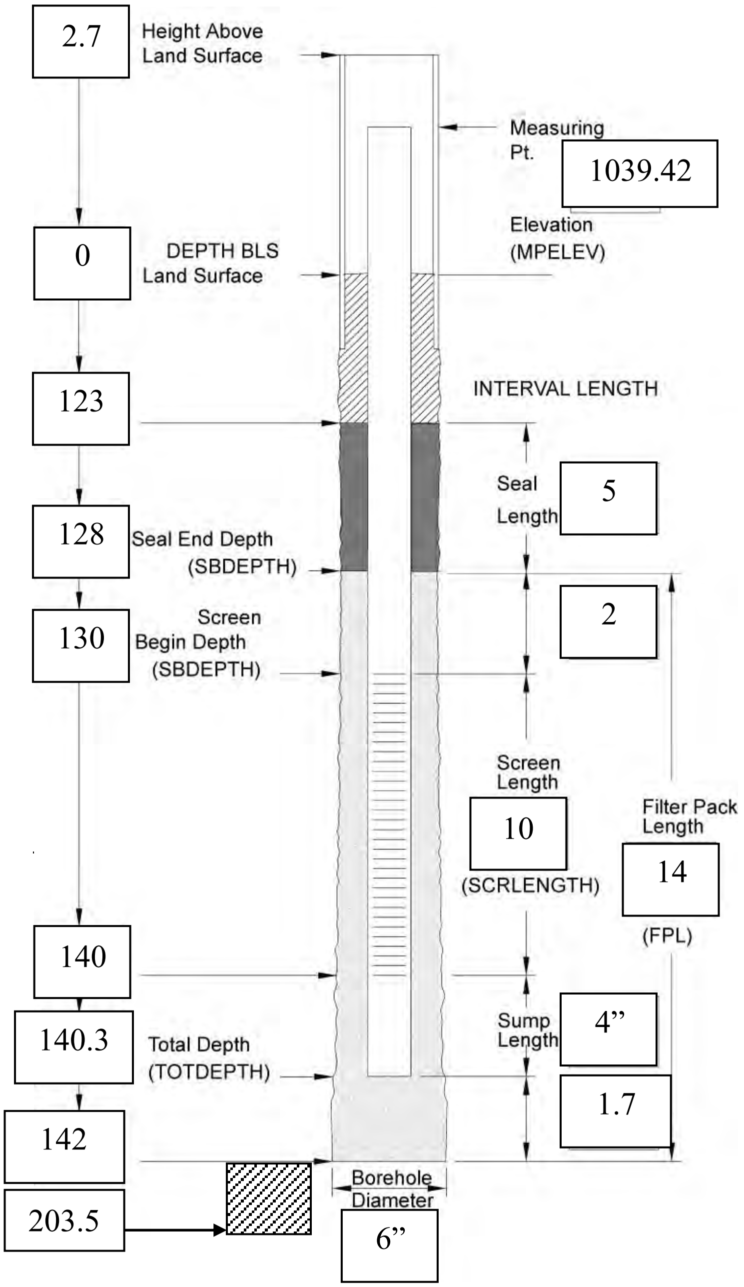
Total Water Volume During Construction
Introduced (Gal): 0 Recovered (Gal): -
Reviewed By: J. Neil Couch Date: 4/22/2016

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’.

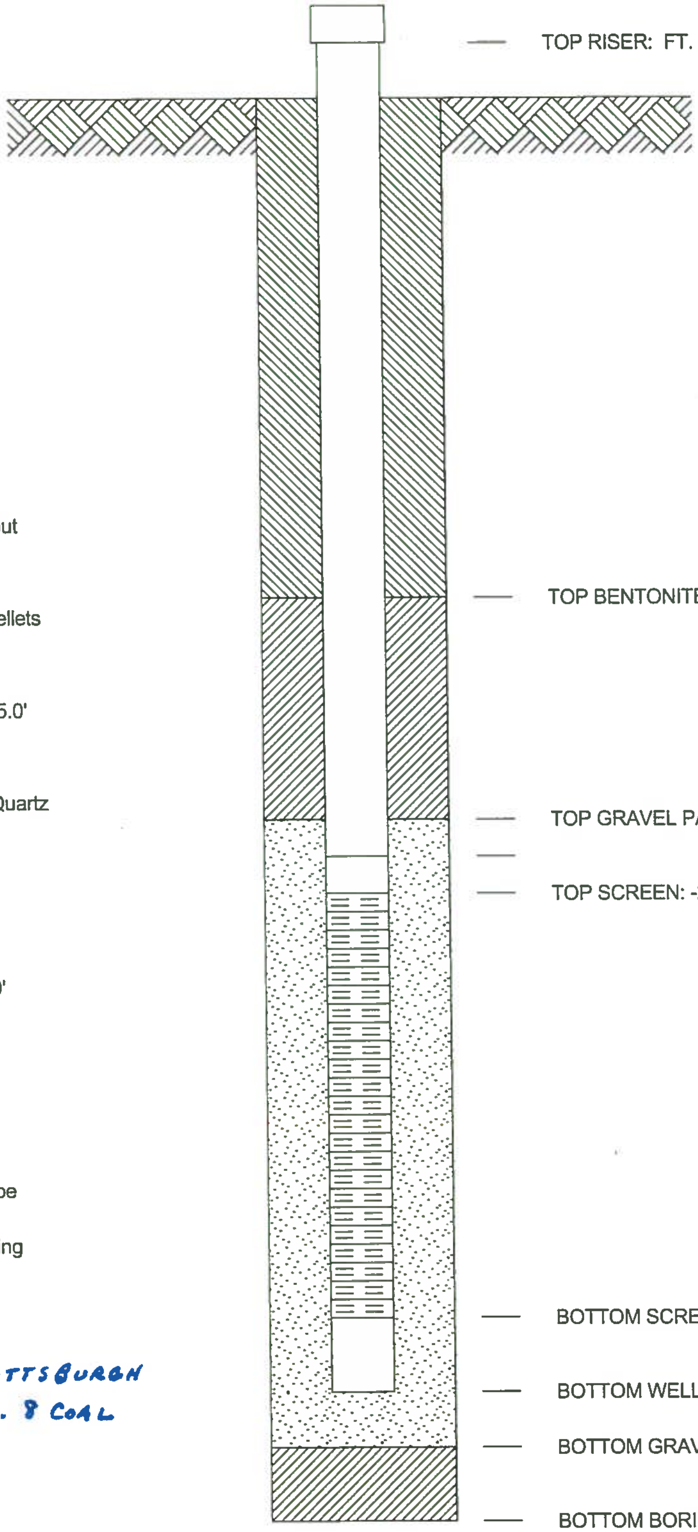
AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
MONITORING WELL CONSTRUCTION

JOB NUMBER ______
COMPANY **AMERICAN ELECTRIC POWER**
PROJECT **CARDINAL FLY ASH DAM**
COORDINATES N 833, 417.3 E 2,511, 621.5
SYSTEM ______

WELL No. **OAE 0610-C** BORING No. ______
INSTALLED **2/16/06**

WELL No. OAE 2005 10C

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'

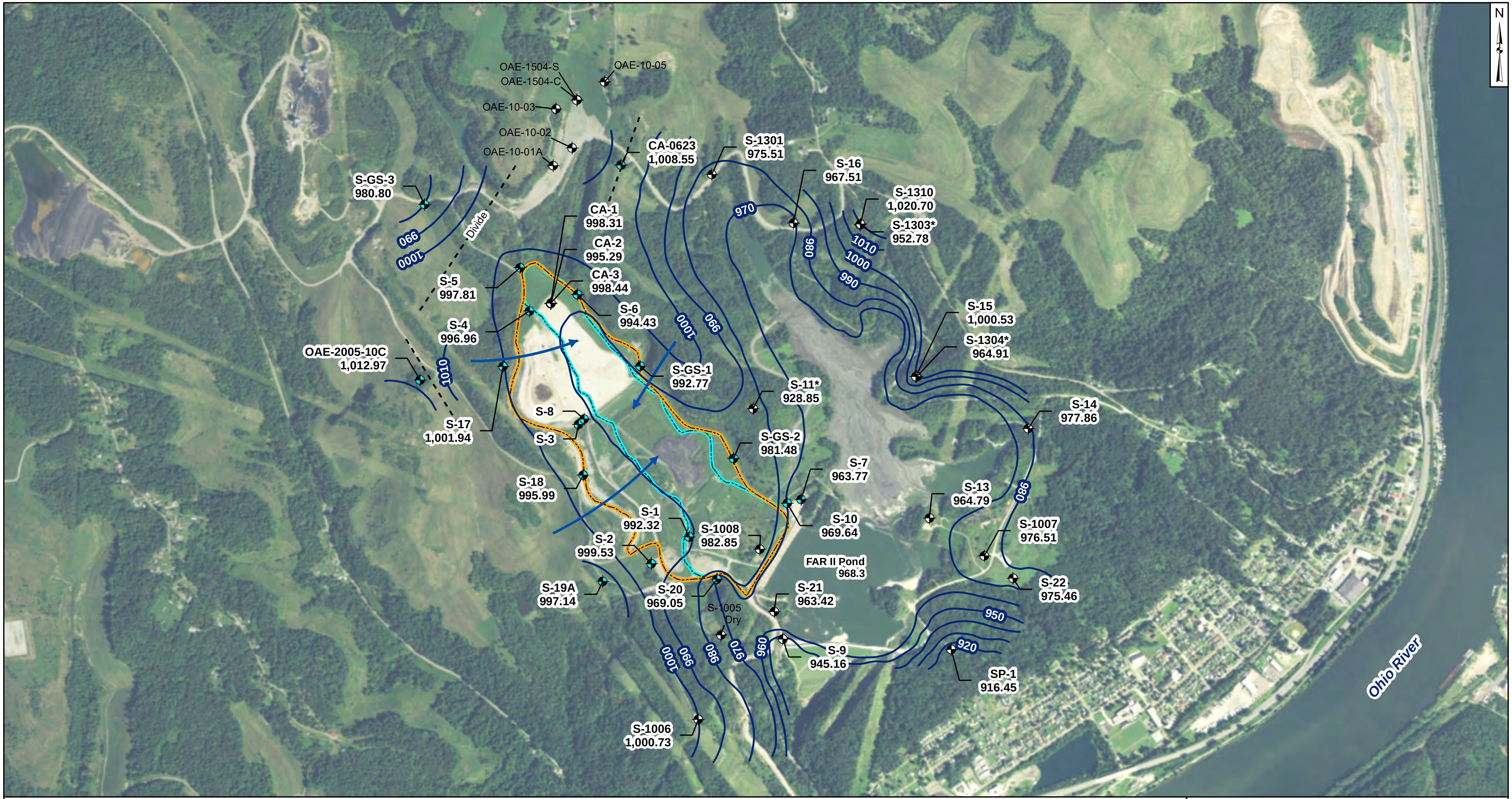
NOTES:
-Set 1" Geomon on 2" riser pipe
-SWL @ 52.4'
-Drilled w/6" air hammer
-Deconned 02/13/06 / No bailing
-Flushed w/1,000 gals water
-Set protector / poured pad

MONITORS PITTSBURGH No. 8 COAL

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

Figure
1

Columbus, Ohio
2017/08/24

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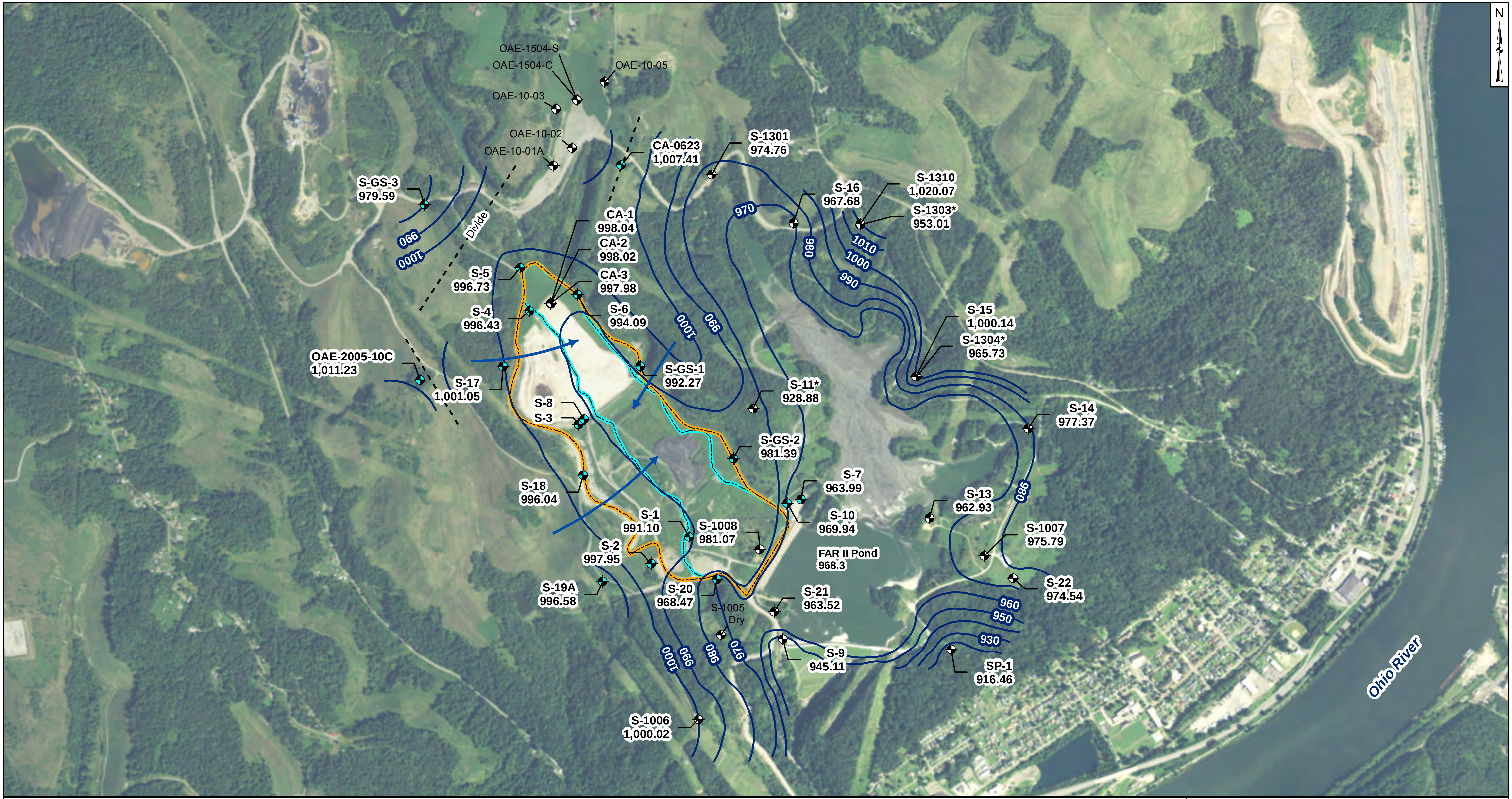

Legend

- ⊕ 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

Figure
2

Columbus, Ohio
2017/08/18

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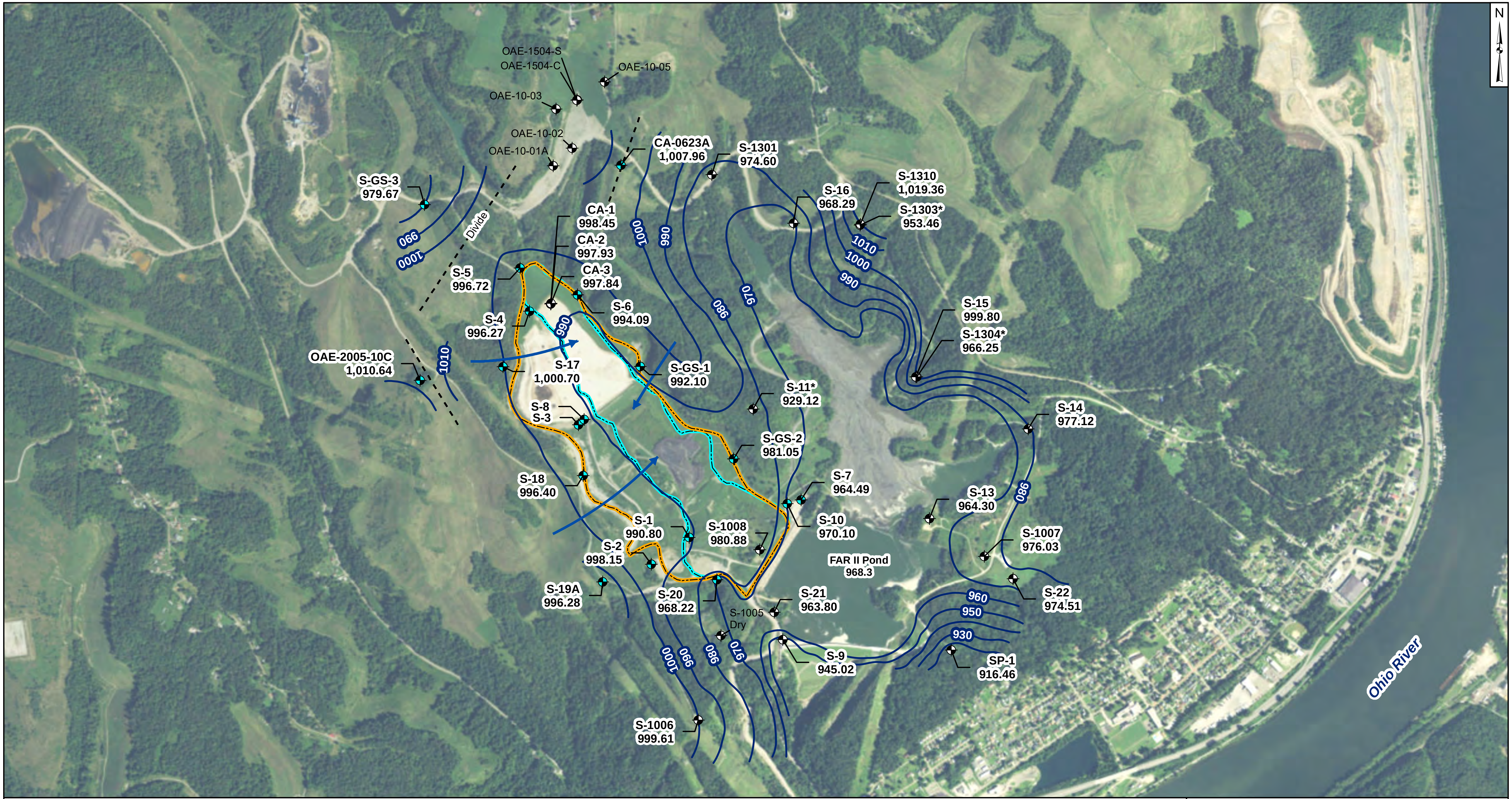

Legend

⊕ 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

Figure
3

Columbus, Ohio
2017/08/24

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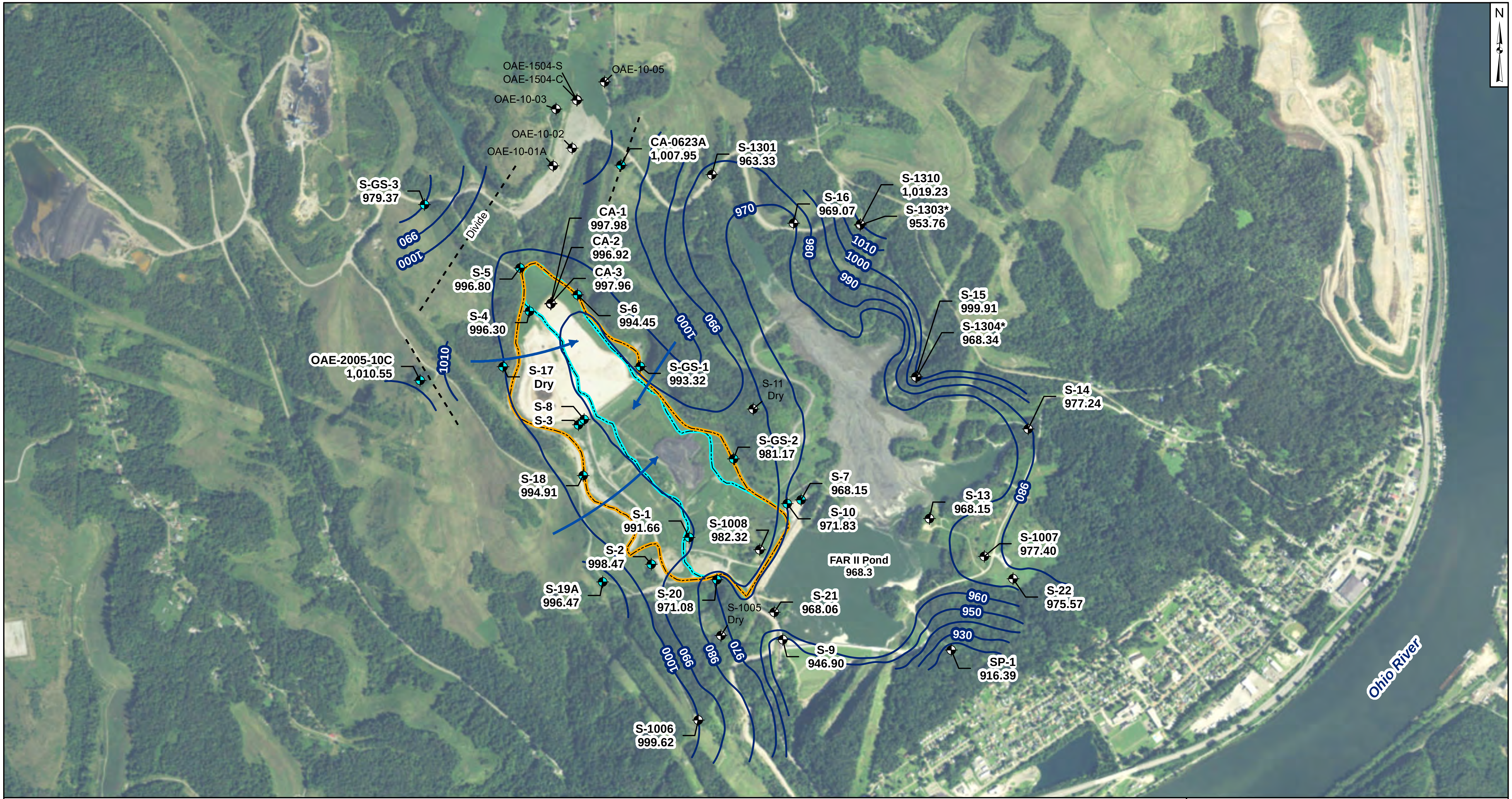

Legend

- ⊕ 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

Figure
4

Columbus, Ohio
2017/08/24

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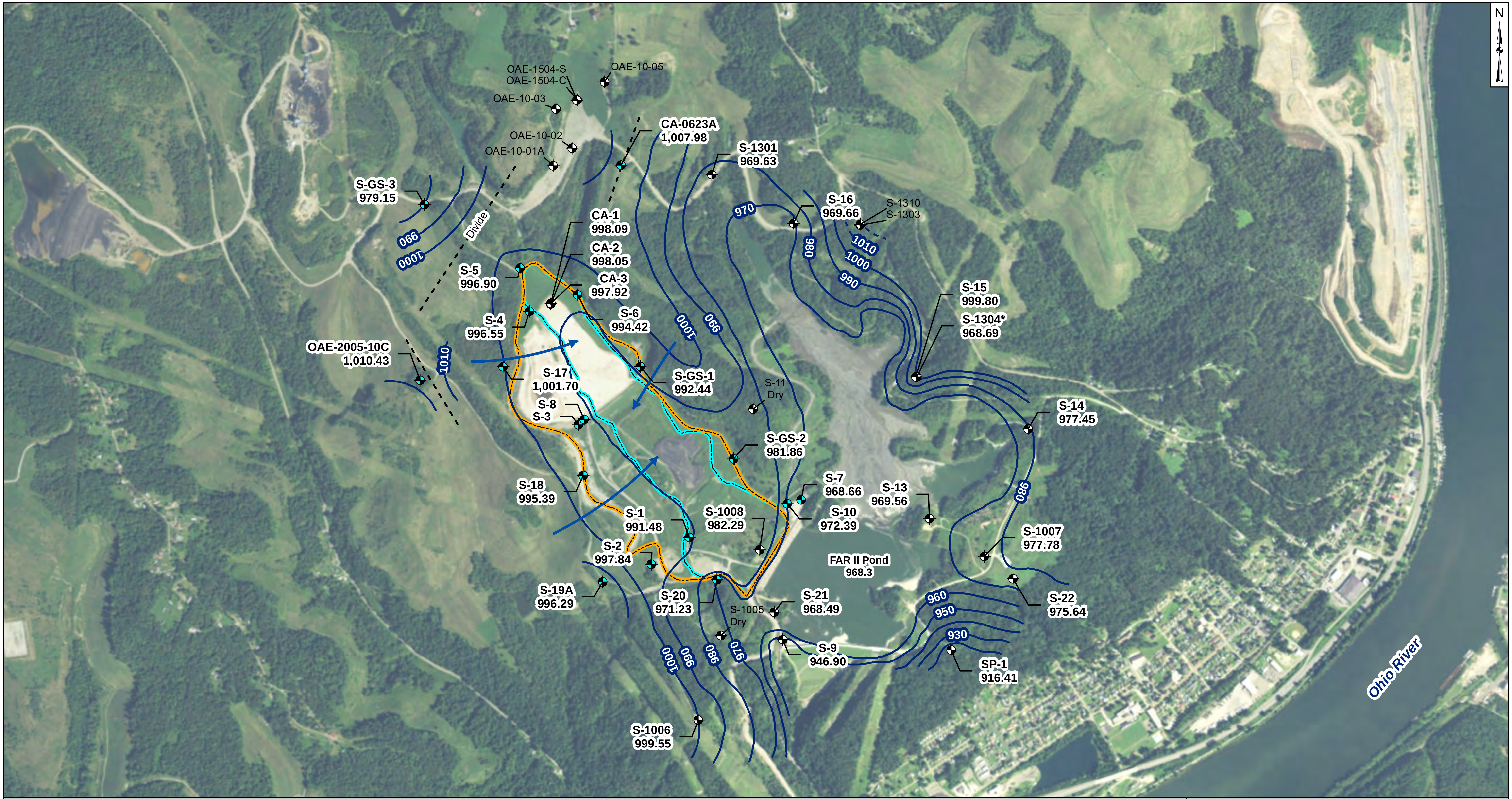

Legend

⊕ 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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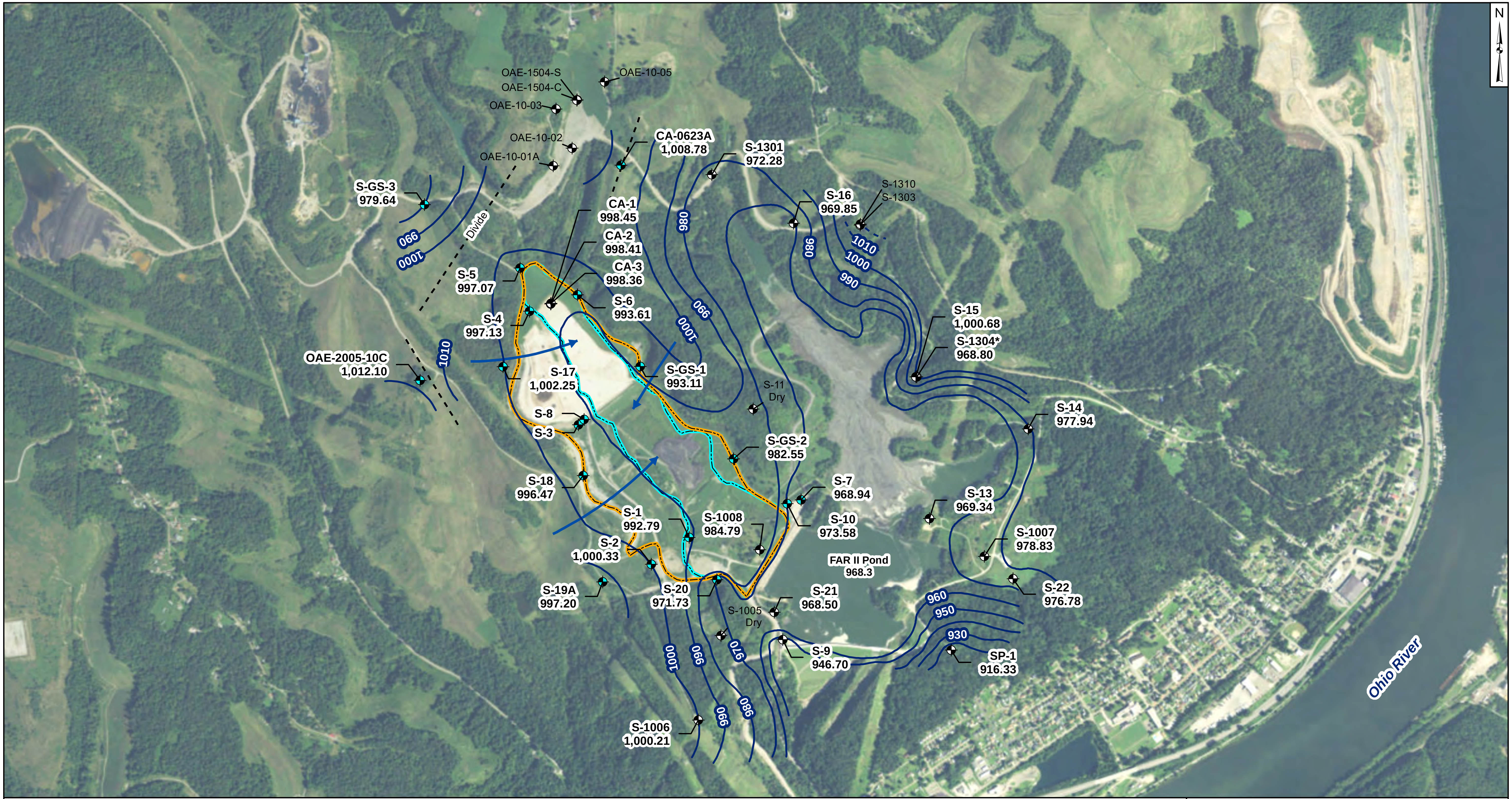


Legend

- ● 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

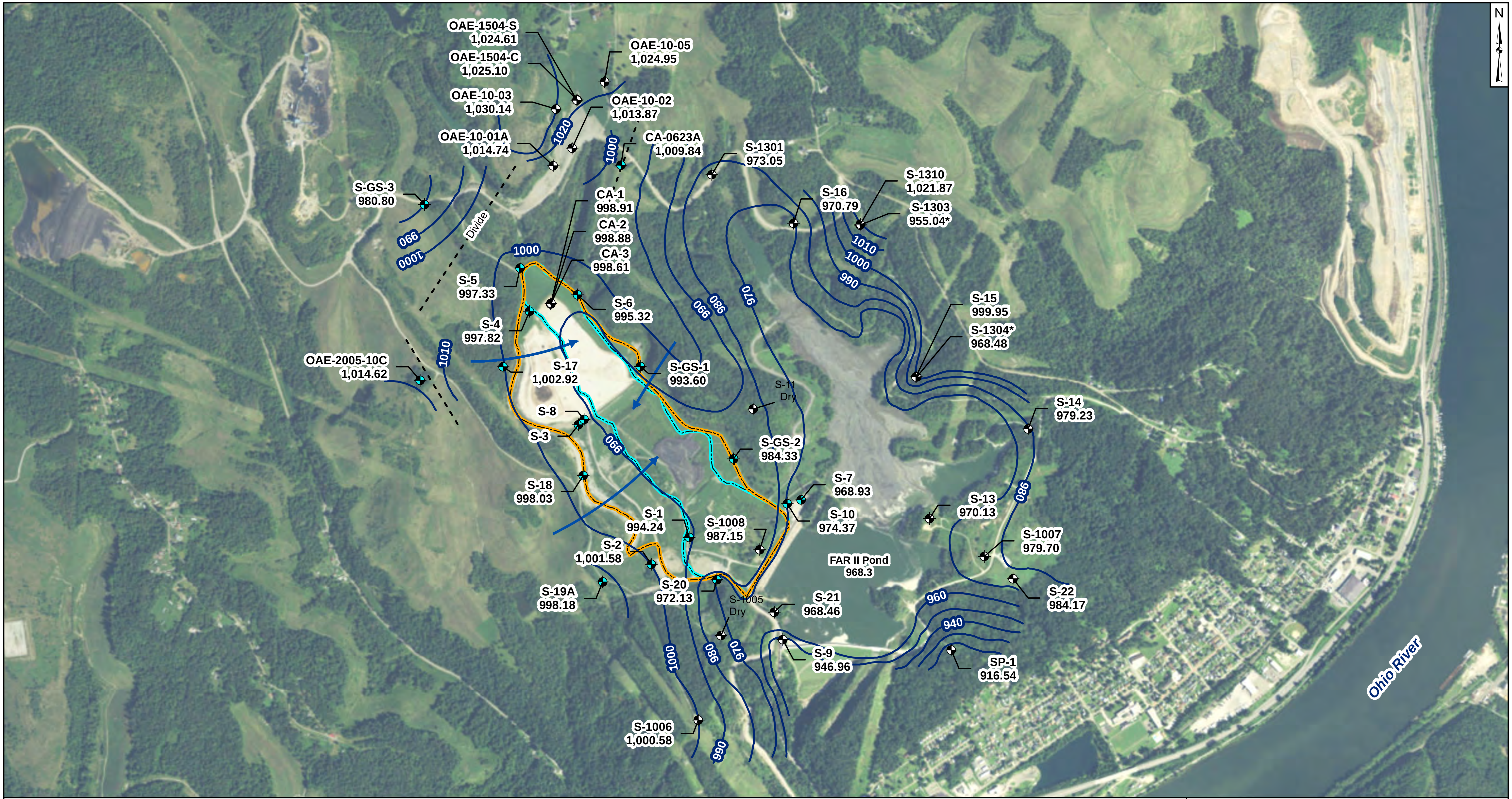
Geosyntec
consultants

Figure
6

Columbus, Ohio

2017/08/24

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_I\AEP-Cardinal_FAR I_GW_2017-01_January.mxd. MMuenich. 8/24/2017. CHA8423/01/08.



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

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Columbus, Ohio	2017/08/24

Figure
7

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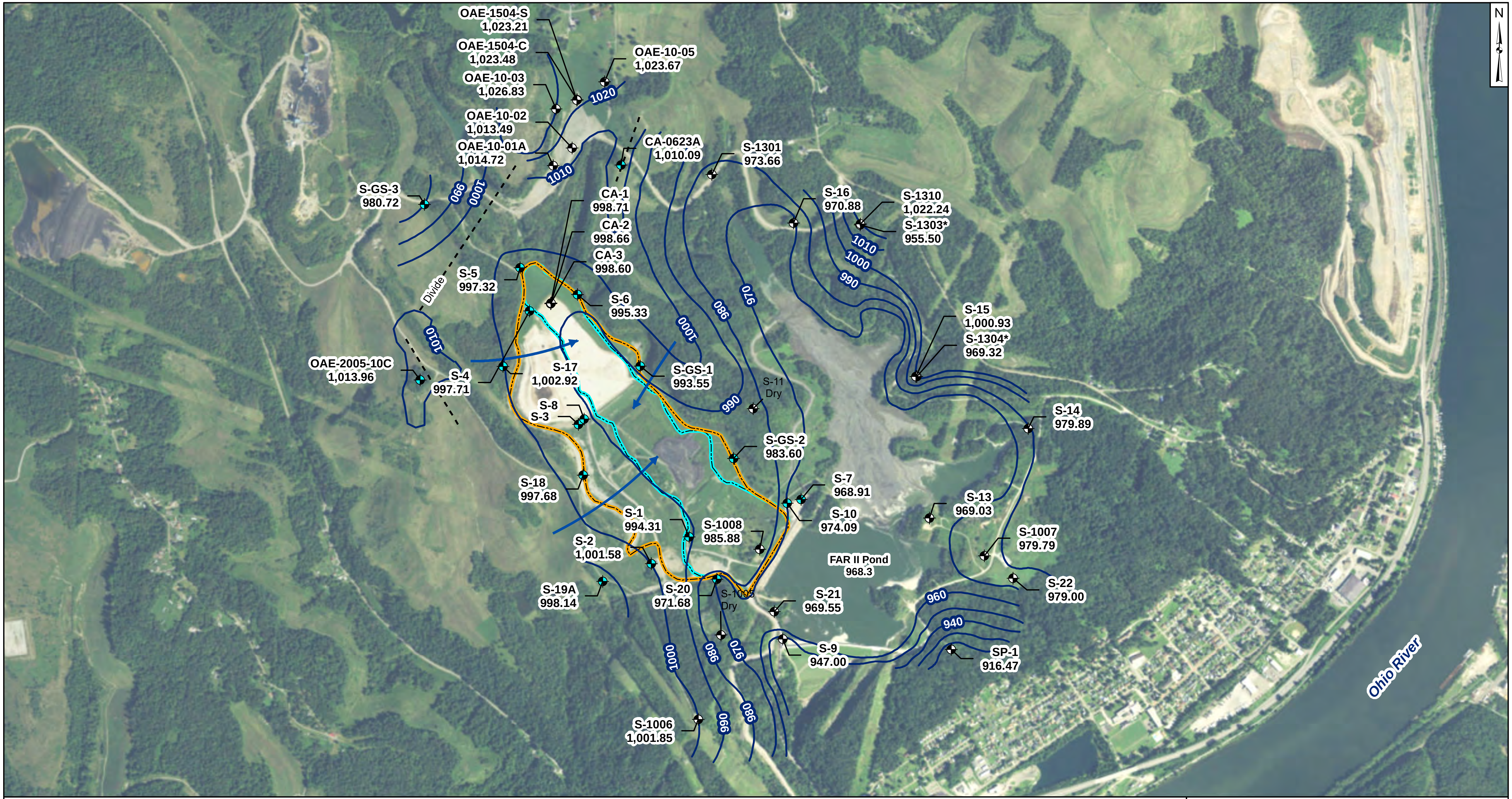

Legend

- ⊕ 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
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Columbus, Ohio | 2017/08/24

Figure
8

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

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

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

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 x 10^{-1} to 1 x 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 x 10^{-7} to 1 x 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 Review of Existing Monitoring Network

3.3.1 Overview

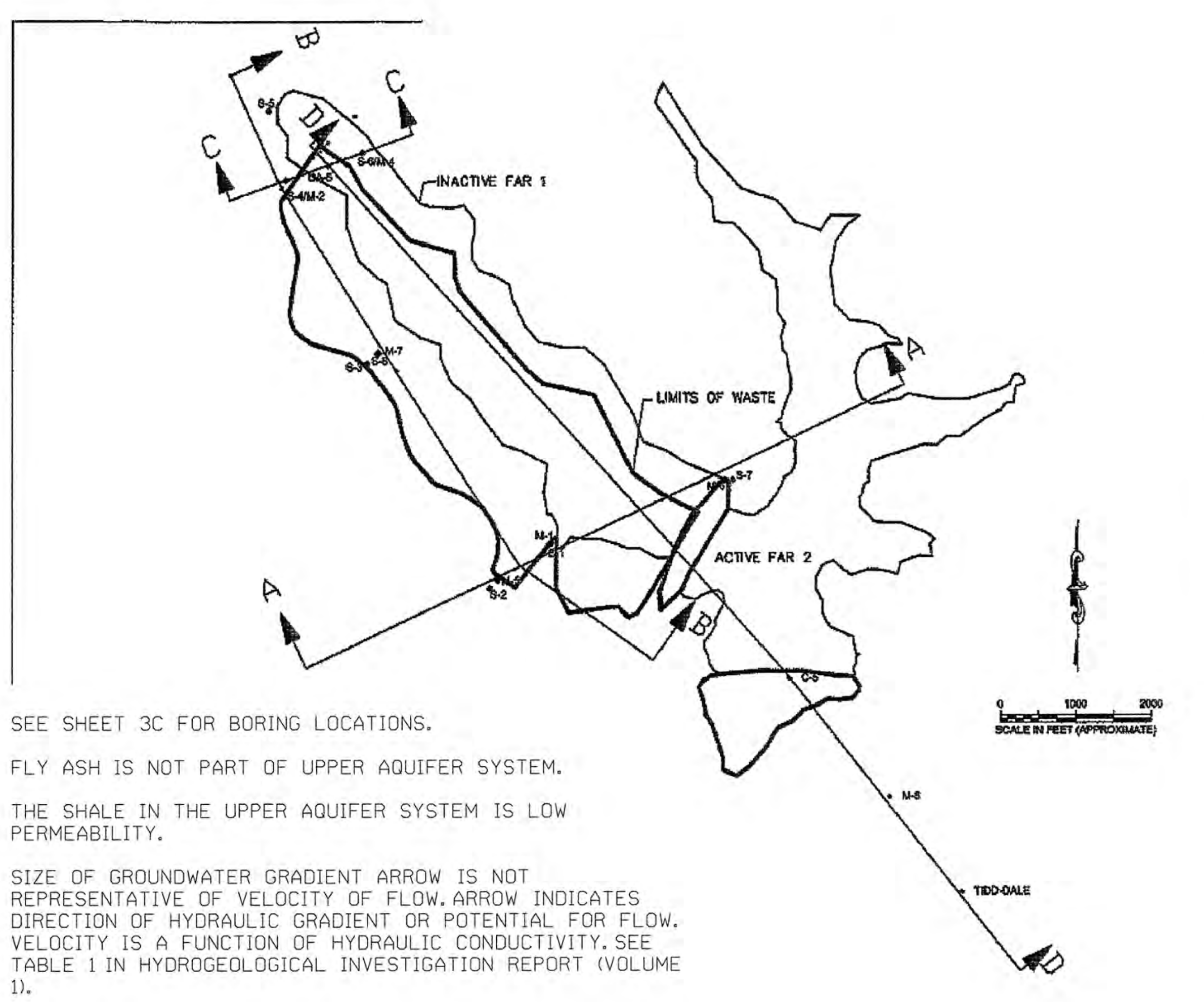
The groundwater monitoring network is shown in Figure 3-2 and consists of seven (7) wells located upgradient (0AE 2005 10C, CA-0623A, S-GS-3, S-4, S-5, S-6 and S-17) and nine (9) monitoring wells located downgradient (S-GS-1, S-GS-2, S-1, S-2, S-7, S-10, S-18, S-19 and S-20) of the former FAR I RSW Landfill. 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

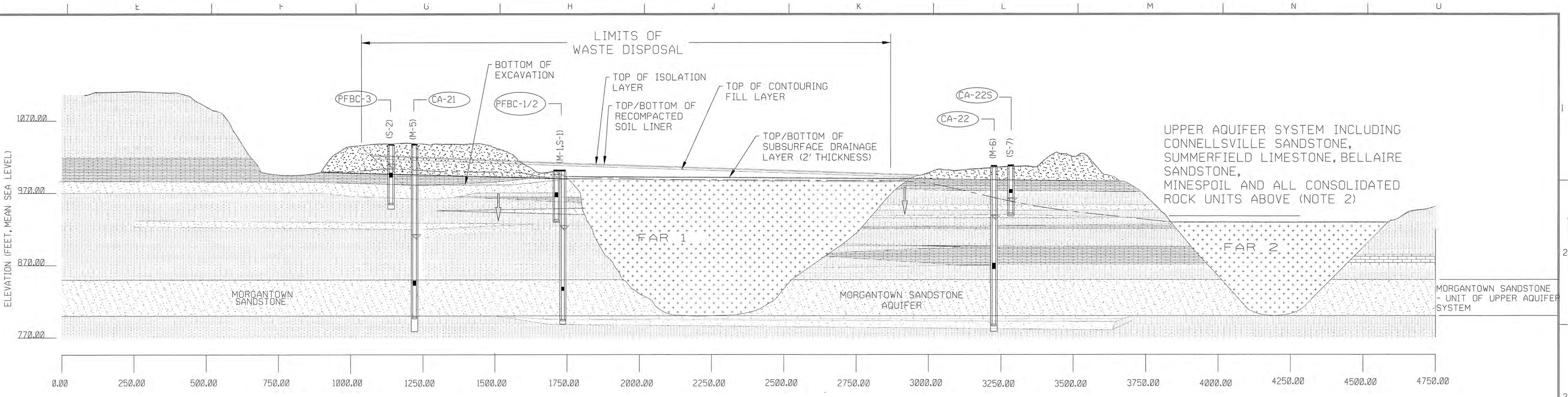
Review of the existing groundwater monitoring well network in relation to the geologic and hydrogeologic conditions in the area of the former FAR I RSW Landfill indicates that the monitoring well network consists of a sufficient number of wells installed at the appropriate depths to collect groundwater 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

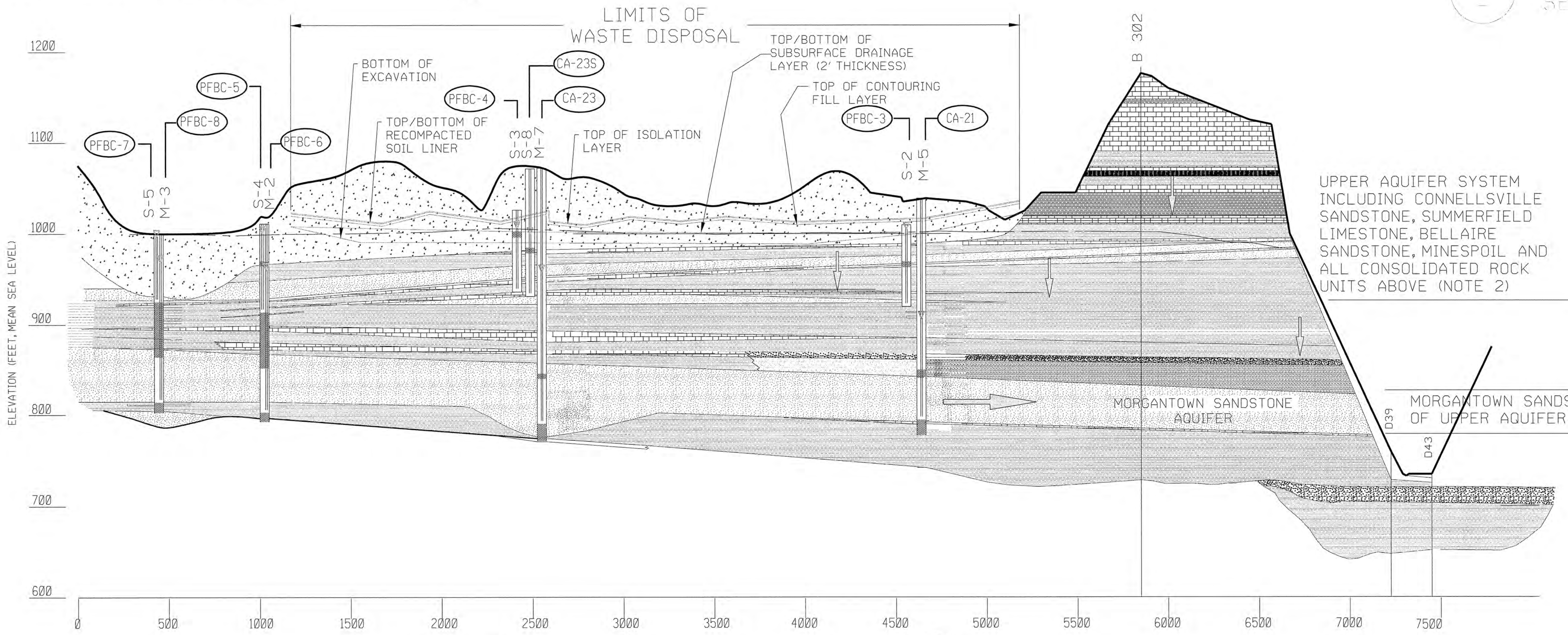
SECTION LOCATION PLAN



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).

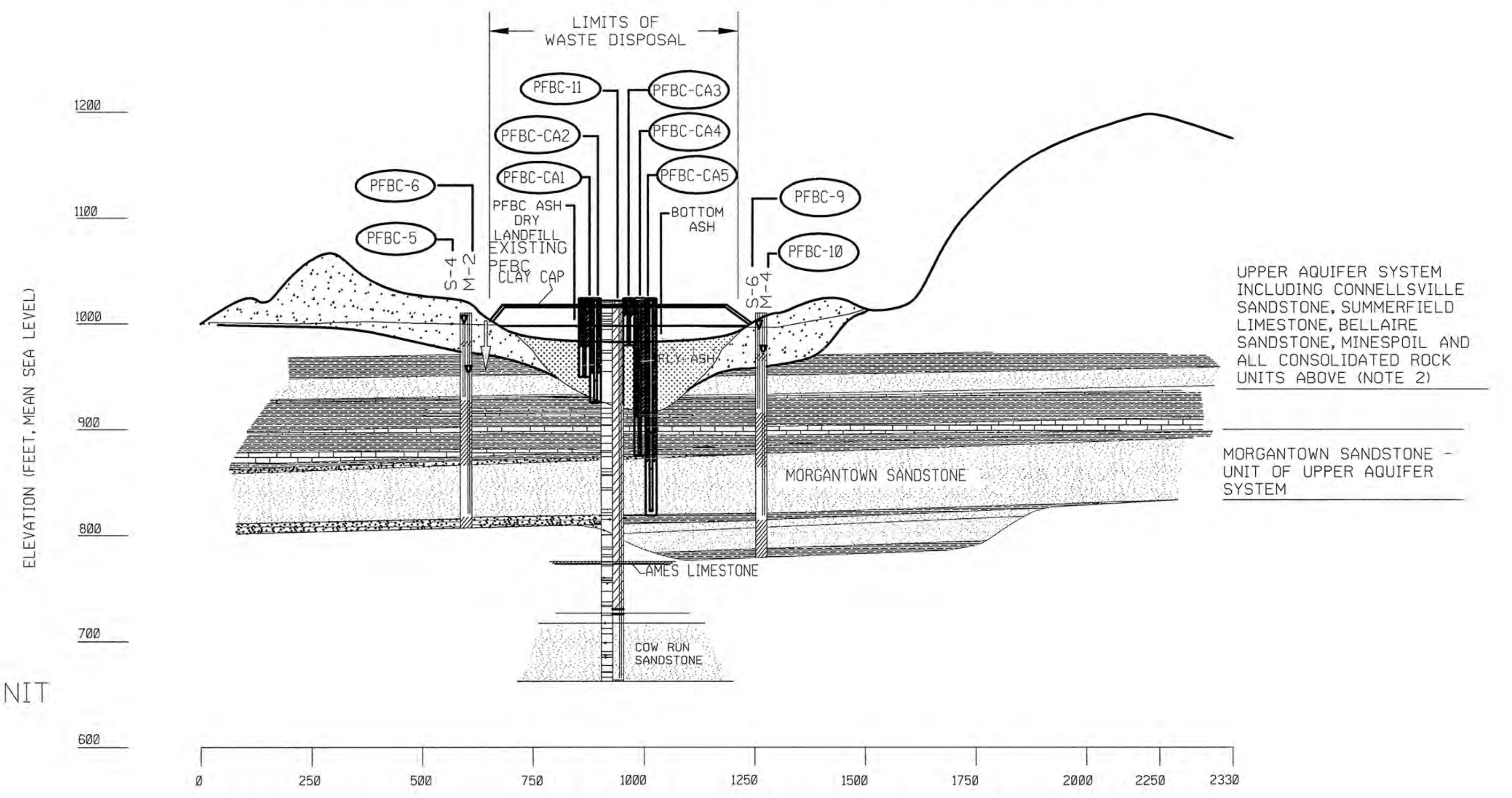


A SECTION
SECTION A-A'



B SECTION
SECTION B-B'

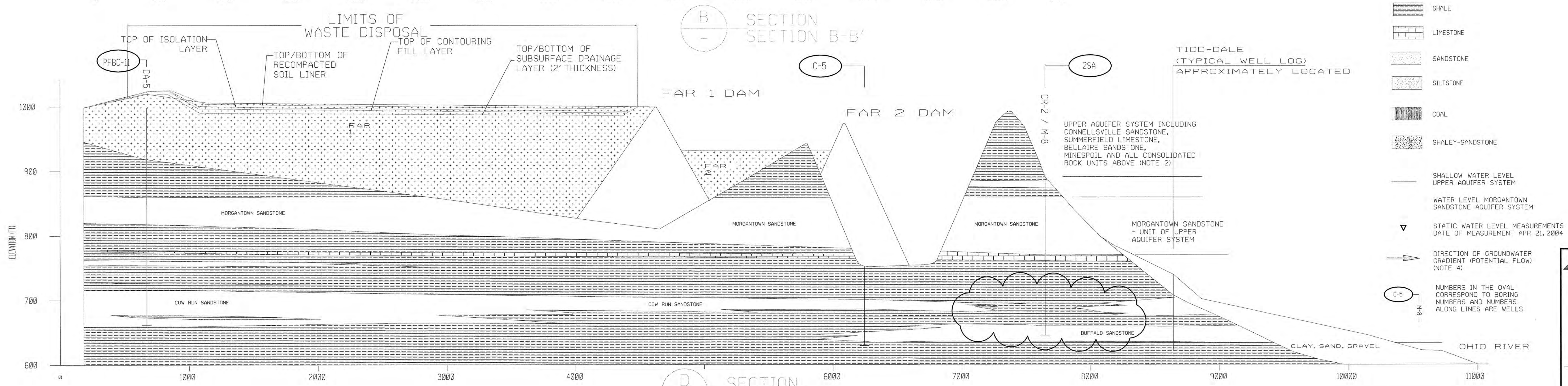
NOTE: SEE DRAWING 13-30560 FOR EXTENSION OF THIS SECTION FROM RIDDLES RUN TO CROTS CREEK.



C SECTION
SECTION C-C'

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



D SECTION
SECTION D-D'

DATE	NO.	DESCRIPTION	APPD.
5/8/12	D	REVISED BY AEP FOR SECTION D-D TO SHOW SHALE STRATA SEPARATING COW RUN FROM BUFFALO SANDSTONE. Amanda Graphics	MFZ
NOV 17 2006	C	REVISED - NOD 2 RESPONSE	DGB
MAY 25 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

GEOSYNTEC CONSULTANTS
55 WEST WACKER DRIVE, SUITE 1100
CHICAGO, IL 60601 USA
(312) 658-0500

SIGNATURE

DATE

PROJECT NO. CHE8126
FILE NO.
DRAWING 5A OF 39

TITLE:
CARDINAL FAR 1
RESIDUAL WASTE LANDFILL
GEOLOGIC/HYDROGEOLOGIC
CROSS SECTIONS

DWG. NO. 13-30100-5A-D

SCALE:
CIVIL ENGINEERING DIVISION
DR:
CH:
ENGR.
PROJ. ENGR.
DATE:
APPROVED BY Pedro J. Amaya

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