

Prepared for



American Electric Power

1 Riverside Plaza
Columbus, Ohio 43215

GROUNDWATER MONITORING NETWORK EVALUATION

CARDINAL SITE – BOTTOM ASH POND

BRILLIANT, OHIO

Prepared by



1420 Kensington Road, Suite 103
Oak Brook, Illinois 60523

Geosyntec Project No.: CHE8126L

July 2016

**GROUNDWATER MONITORING NETWORK EVALUATION
CARDINAL BOTTOM ASH POND
BRILLIANT, OHIO**

TABLE OF CONTENTS

1.	OBJECTIVE	1-1
1.1	Purpose	1-1
1.2	Organization of Report.....	1-1
1.3	Coordinate System and Datum.....	1-1
2.	BACKGROUND INFORMATION	2-1
2.1	Facility Location Description.....	2-1
2.2	Description of CCR Unit.....	2-1
2.2.1	Embankment Configuration.....	2-1
2.2.2	Area and Volume of CCR Units	2-2
2.2.3	Construction and Operational History	2-2
2.2.4	Surface Water Control	2-2
2.3	Previous Investigations	2-2
2.4	Hydrogeologic Setting.....	2-3
2.4.1	Climate and Water Budget.....	2-3
2.4.2	Regional and Local Geologic Setting	2-4
2.4.3	Surface Water and Surface Water-Groundwater Interactions	2-4
2.4.4	Water Users.....	2-4
3.	MONITORING NETWORK EVALUATION	3-1
3.1	Hydrostratigraphic Units.....	3-1
3.1.1	Horizontal and Vertical Position relative to CCR Unit	3-1
3.1.2	Overall Flow Conditions.....	3-1
3.2	Uppermost Aquifer.....	3-1
3.2.1	CCR Rule Definition.....	3-1
3.2.2	Identified Onsite Hydrostratigraphic Unit	3-2
3.3	Review of Existing Monitoring Network.....	3-2
3.3.1	Overview.....	3-2
3.3.2	Compliance Assessment	3-2

4. CERTIFICATION BY QUALIFIED PROFESSIONAL ENGINEER4-1

LIST OF TABLES

Table 3-1	Groundwater Monitoring Network Well Construction Details
-----------	--

LIST OF FIGURES

Figure 2-1	Site Location Map
Figure 2-2	Plant and CCR Unit Location Map
Figure 3-1	Potentiometric Surface – Uppermost Aquifer
Figure 3-2	Groundwater Monitoring Network Well Locations

LIST OF APPENDICES

Appendix A	References
Appendix B	Geologic Cross Sections
Appendix C	Boring Logs
Appendix D	Monitoring Well Construction Logs

LIST OF ACRONYMS

AEP	American Electric Power
BAC	Bottom Ash Complex
BAP	Bottom Ash Pond
CFR	Code of Federal Regulations
ESP	Electrostatic Precipitator
FAD	Fly Ash Dam
FAR	Fly Ash Reservoir
FGD	Flue Gas Desulfurization
MW	Megawatts
MW	Monitoring Well
NAD	North American Datum
NGVD	National Geodetic Vertical Datum
NPDES	National Pollutant Discharge Elimination System
OAC	Ohio Administrative Code
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
RCP	Recirculation Pond
RWL	Residual Waste Landfill
SCR	Selective Catalytic Reduction
TDS	Total Dissolved Solids
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency

1. OBJECTIVE

1.1 Purpose

The purpose of this report is to provide an assessment of the groundwater monitoring network associated with the Bottom Ash Pond (BAP) at the Cardinal Operating Company (AEP) Cardinal Plant relative to its compliance with the United States Environmental Protection Agency (USEPA) Coal Combustion Residual (CCR) Rule section 40 CFR 257.91.

1.2 Organization of Report

- Section 2 presents background information on the power plant and CCR unit;
- Section 3 presents and evaluation of the existing monitoring well network; and
- Section 4 provides a certification from a qualified Professional Engineer (PE).

1.3 Coordinate System and Datum

The horizontal coordinate values provided in this report are based upon the North American Datum of 1927 (NAD27). The vertical datum utilized for reporting the elevations within this report is National Geodetic Vertical Datum of 1929 (NGVD 29).

2. BACKGROUND INFORMATION

2.1 Facility Location Description

The Cardinal Plant is a three-unit, 1,830 MW total capacity coal-fired generating station located in Jefferson County south of Brilliant, Ohio along the Ohio River (Figure 2-1). Each generating unit is equipped with an electrostatic precipitator (ESP) for removal of fly ash particulate matter, a selective catalytic reduction (SCR) system for removal of nitrogen oxide, and flue gas desulphurization (FGD) systems for removal of sulfur dioxide (AEP, 2005a; AEP, 2014). The existing CCR unit considered in this groundwater evaluation is the Bottom Ash Pond (BAP). The BAP and the main plant area are shown on Figure 2-2.

2.2 Description of CCR Unit

The BAP is part of the Bottom Ash Complex (BAC), which also consists of a Recirculation Pond (RCP) situated along the Ohio River south of Cardinal Plant Unit 3. The BAP perimeter dikes enclosing the facility are approximately 6,500 feet in length with a 20 ft average height and were originally constructed in the 1960s with major reconstruction in 1974 as part of the Unit 3 addition (S&L, 1976; AEP, 2014). The BAP receives bottom ash, pyrite and other wastes from the coal burning process. Additionally, it receives storm water drainage and other wastewater flows from the property.

Solids in the BAP are occasionally dredged and stored on the northern end of the BAC before reuse as construction material or placement in the FAR 1/RWL, a dry landfill disposal unit on site. A 36-inch diameter outlet pipe conveys water through the divider dike from the BAP to the RCP. Typically, all water in the RCP is pumped back to the plant for reuse. However, during high rainfall events, a principal spillway may activate, releasing water into the Ohio River through a permitted NPDES outfall.

2.2.1 Embankment Configuration

The BAP perimeter dikes are constructed of fill with 2.5 horizontal to 1 vertical (2.5H:1V) side slopes over the existing stripped grade and original dike fill which varies in elevation. The BAP is separated from the RCP by an interior (separator) dike also constructed of fill with 2.5H:1V slopes. Both the perimeter and interior dikes have a top-of-berm Elevation of 670.0 ft. Borings completed in 2009 suggest the original embankment fill consisted of a very-stiff to hard brown gray silty clay (BBC&M, 2009). The newer embankment fill consisted of silty clay, sand, and gravel. The crests of the outer embankments serve as access drives and vary in width from 20 to 40 feet. According to a 2009 site inspection, significant vegetation is limited to the east dike of the BAP, which faces the Ohio River (CHA, 2009). Several of the dikes showed evidence of minor erosion such as erosion

rills, including the separator dike between the BAP and RCP. In 2009, AEP added fill to the top of berms to re-establish the design top-of-berm elevation and repair some of the erosion rills.

2.2.2 Area and Volume of CCR Units

The BAC occupies approximately 25 acres. The surface areas of the BAP and RCP are approximately 12 and 7 acres, respectively. Based upon a maximum height of 22 feet, the BAP has approximately 11.5 million cubic feet of storage volume. With a maximum height of 18 feet, the RCP has a storage capacity of approximately 5.5 million cubic feet, assuming no freeboard.

2.2.3 Construction and Operational History

The BAC was originally constructed in the 1960s as part of the construction of Generating Units 1 and 2. The original pond was constructed with embankments rising less than 10 ft above the pond bottom. In 1974, the pond underwent extensive modification, including the addition of the berm separating the BAP and RCP. During this time, the current dikes were founded above the original basin dikes, extending the dikes to their current crest elevation of 670 ft. In 2008, a vinyl sheet pile wall was installed in the RCP with a top elevation of 668.0 ft separating the RCP into two pond segments, one a recirculation pond where treatment (if needed) is performed and the other a final ash water settlement pond where discharge to the Ohio River via NPDES Outfall 023 (AEP, 2014; CHA, 2009). Typically, ash water from the recirculation pond side is pumped back to the plant where it is reused. Discharge to the Ohio River through the principal spillway occurs only during high rainfall events where the spillway may activate releasing the water.

2.2.4 Surface Water Control

The outside toe of slope of the BAP western dike terminates in a drainage swale containing pipes. The drainage swale collects surface water runoff and other facility surface flows and discharges into a concrete sump located at the north end of the swale (CHA, 2009). The sump water is then pumped to the BAP. Additionally, a concrete pipe beneath the separator dike delivers partially clarified water from the BAP to the RCP. Typically, all water in the RCP is pumped back to the plant for reuse, although water may be released to the Ohio River through a permitted NPDES outfall during periods of high rainfall. The outlet structure is a concrete drop inlet connected to a corrugated metal pipe which releases water from the south end of the RCP to rip-rap protection on the slope of the dike (BBC&M, 2009).

2.3 Previous Investigations

Six previous geotechnical assessments and/or investigations have been performed regarding the BAP with an emphasis on subsurface material identification, embankment stability, safety verification, and monitoring well installation. The completed investigations are as follows:

- Cardinal Generating Plant Bottom Ash Pond Investigation, August, 2009. BBC&M Engineering, Inc.
- Assessment of Dam Safety – Coal Combustion Surface Impoundments (Task 3) Final Report, December, 2009. CHA Companies.
- Cardinal Generating Plant – Addendum to Bottom Ash Pond Investigation, December 2010. BBC&M Engineering, Inc.
- Cardinal Power Plant Bottom Ash Complex – Enhanced Risk Analysis, August 2014. AEP.
- Bottom Ash Pond Initial Safety Factor Assessment, December 30, 2015, S&ME.
- Bottom Ash Pond Monitoring Well Installation Report, February 4, 2016

2.4 Hydrogeologic Setting

2.4.1 Climate and Water Budget

Water that is used to sluice and transfer bottom ash and miscellaneous wastes to the BAP is transferred to the RCP and typically pumped back to the plant for reuse.

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 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 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 1×10^{-1} to 1×10^{-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.

4. CERTIFICATION BY QUALIFIED PROFESSIONAL ENGINEER

By means of this certification, I certify that I have reviewed the groundwater monitoring network and well construction details in the vicinity of the Bottom Ash Pond at the AEP Cardinal Plant and it meets the requirements of section 40 CFR 257.91.

Daniel G. Bodine

Printed Name of Registered Professional Engineer


Daniel G. Bodine

Signature

E-61363

Registration No.

Ohio

Registration State

1 Aug 2016

Date

TABLES

Table 3-1. Groundwater Monitoring Well Construction Details

Bottom Ash Complex (BAC)

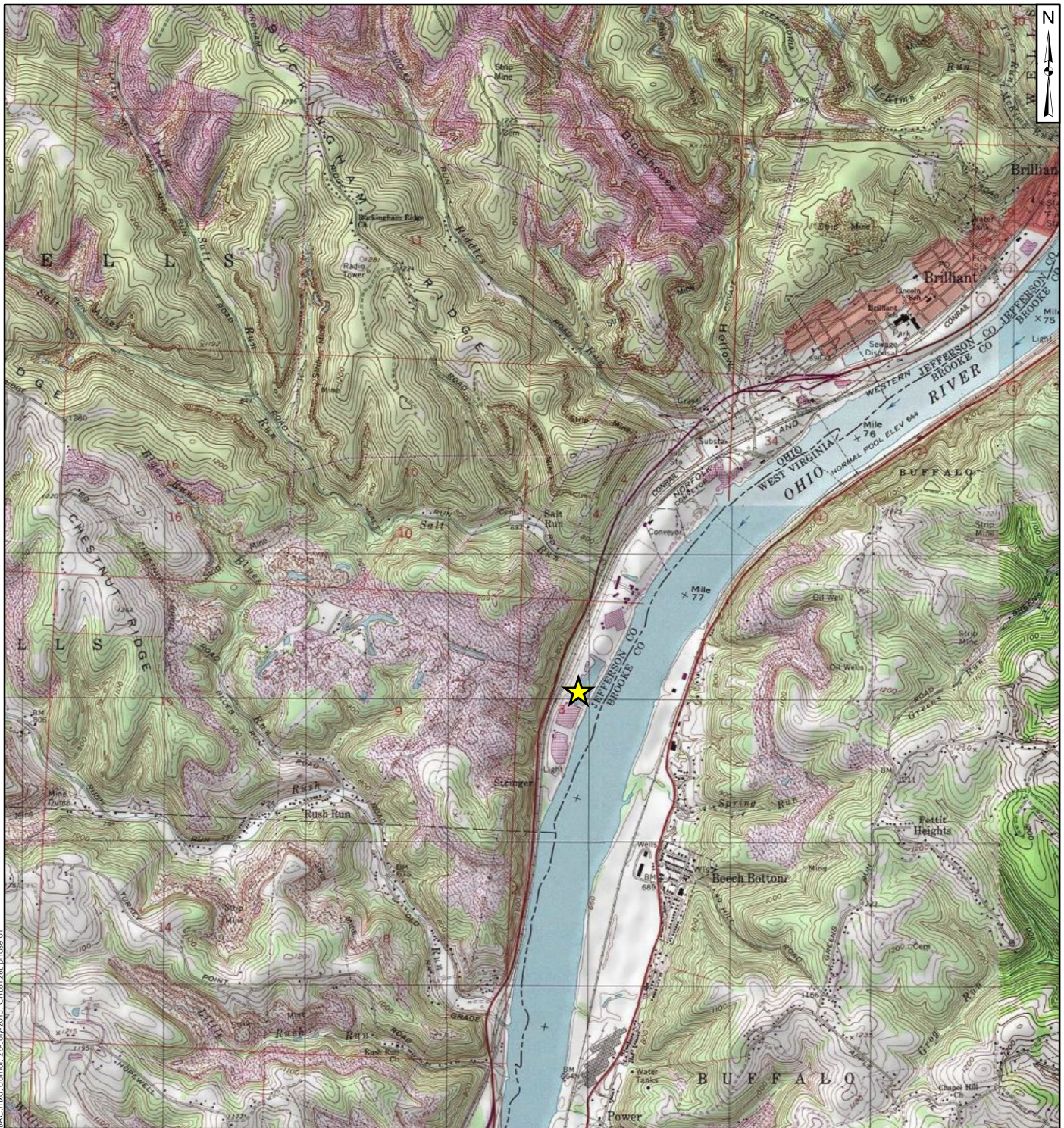
Cardinal Power Plant

Brilliant, Ohio

Monitoring Well Number	Boring Number	Date Installed	Northing (OH State Plane South (ft.) NAD 27/NGVD 29)	Easting (OH State Plane South (ft.) NAD 27/NGVD 29)	Top of Casing (ft.)	Ground Elevation (ft.)	Top of Bentonite Seal (ft.)	Top of Gravel Pack (ft.)	Top of Screen (ft.)	Bottom of Screen (ft.)	Bottom of Gravel Pack (ft.)	Bottom of Bore Hole (ft.)	Total Well Depth From TOC (ft.)	Casing Type (PVC)	Casing Diameter (In.)	Borehole Diameter (In.)	Hydrologic Unit
MW-BAP-1	MW-BAP-1	12/10/2015	N 820,305.3'	E 2,513,927.4'	672.29	669.79	638.90	632.20	628.20	618.40	617.80	617.80	51.99	PVC	2.00	8.00	Sand & Gravel
MW-BAP-2	MW-BAP-2	12/2/2015	N 819,792.3'	E 2,513,707.0'	673.24	669.92	644.20	638.20	635.80	626.00	625.40	624.90	44.52	PVC	2.00	8.00	Sand & Gravel
MW-BAP-3	MW-BAP-3	11/13/2015	N 819,112.0'	E 2,513,519.4'	672.84	669.93	632.50	626.50	624.50	614.50	613.90	613.90	58.94	PVC	2.00	8.00	Sand & Gravel
MW-BAP-4	MW-BAP-4	11/23/2015	N 820,879.5'	E 2,513,616.9'	663.54	661.05	639.50	634.20	632.20	622.40	621.80	621.10	41.74	PVC	2.00	8.00	Sand & Gravel
MW-BAP-5	MW-BAP-5	11/25/2015	N 820,052.1'	E 2,513,277.5'	672.00	669.18	625.00	619.50	617.50	607.70	607.10	606.70	64.90	PVC	2.00	8.00	Sand & Gravel

Notes:Data taken from the *Bottom Ash Pond Monitoring Well Installation Report AEP Cardinal Plant* (S&ME, 2016).

FIGURES



Legend



Site Location

Notes

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

5,000 2,500 0 5,000 Feet



**Site Location Map
Bottom Ash Complex**

Cardinal Power Plant
Brilliant, Ohio

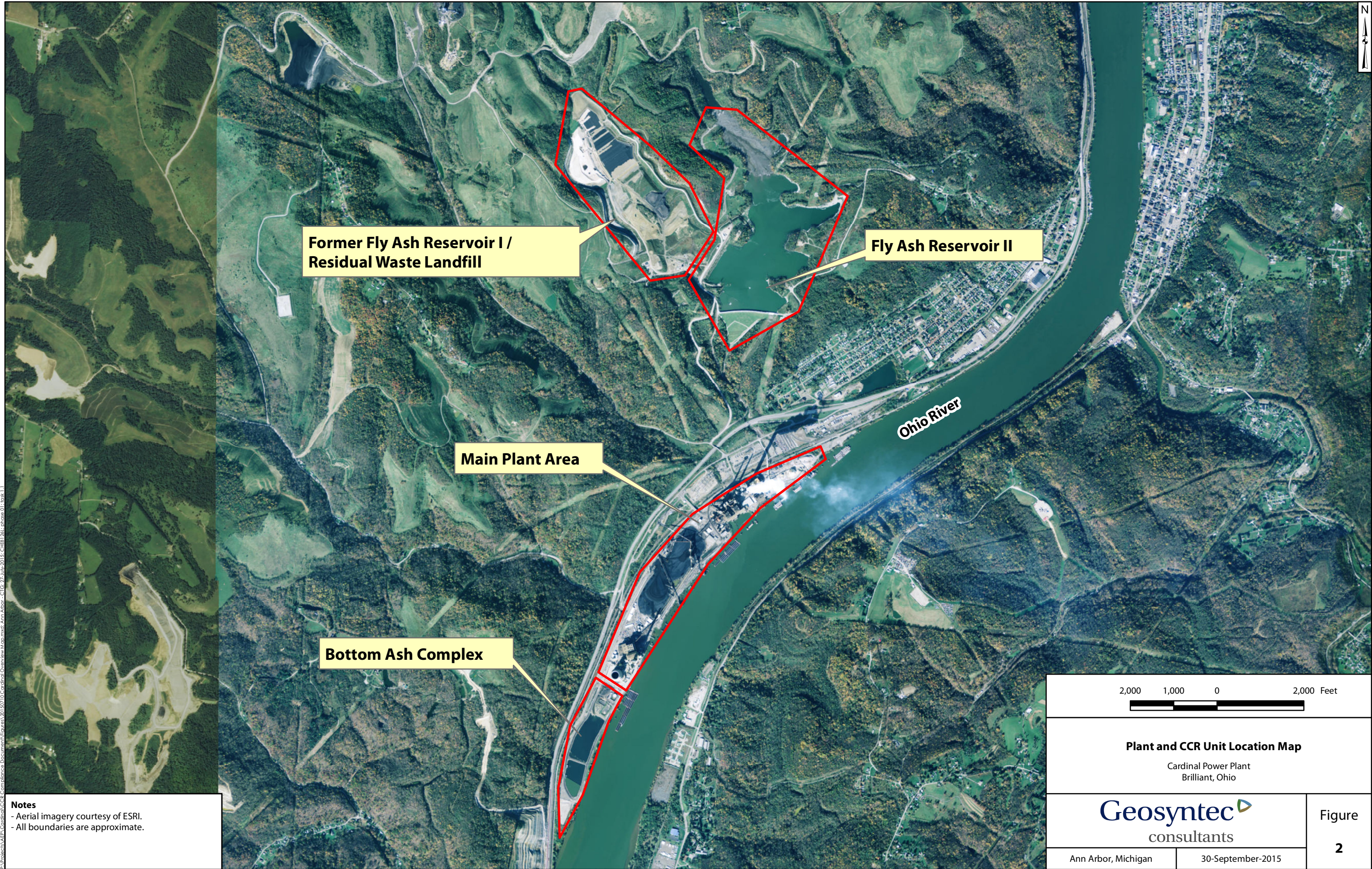
Geosyntec
consultants

Figure

2-1

Ann Arbor, Michigan

28-July-2015



\\na\p\m\A\A\Cardinal\CCB Compliance Documents\Virtual\20150710 Cardinal Overview Map.mxd; Ann Arbor - CCB 27 July 2015; C:\E\1\261 phase 01 task 1.1


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

2,000 1,000 0 2,000 Feet	
Plant and CCR Unit Location Map	
Cardinal Power Plant Brilliant, Ohio	
Geosyntec consultants	
Ann Arbor, Michigan	30-September-2015
Figure 2	



P:\GIS\PROJECTS\AEP\Cardinal\Envi\BAG-GW_Corribus_6-2016.mxd; Ann Arbor - CTG; 17 June 2016; CHE120; photo011.mxd; 11



Legend
 Monitoring Well Location

Notes

- Only monitoring wells in the network are shown; other installed piezometers around the BAC are not shown.
- Aerial imagery courtesy of ESRI.

3001500300 Feet

**Groundwater Monitoring Well Network
Bottom Ash Complex**
Cardinal Power Plant
Brilliant, Ohio




Figure
3-2

Chicago, IL

June 2016

APPENDIX A

REFERENCES

American Electric Power. December 2014. Fall 2014 Groundwater Monitoring Data and Statistical Analyses for Cardinal Operating Company's Cardinal Waste Management Units.

BBC&M Engineering, Inc. August 2009. Cardinal Generating Plant Bottom Ash Pond Investigation.

CHA Companies. December 2009. Assessment of Dam Safety – Coal Combustion Surface Impounds (Final Report).

Geosyntec Consultants, Inc. May 2006. Hydrogeological Investigation Report.

Jefferson County Water and Sewer District. 2014. 2014 Drinking Water Consumer Confidence Report (For Service Area A).

National Oceanic and Atmospheric Administration (NOAA). 2015. Annual Climatological Summary. Station: Steubenville, OH US GHCND:USC0003380025.

Ohio Department of Natural Resources. June 2016. Water Well Log Interactive Map. <https://apps.ohiodnr.gov/water/maptechs/wellogs/appNEW/ERINMapSearch.shtml>

Ohio Environmental Protection Agency. February 2008. Technical Guidance Manual for Ground Water Investigations, Chapter 7: Monitoring Well Design and Installation.

Ohio Environmental Protection Agency. March 2013. Solid Waste and Infections Waste Regulations: Definitions. OAC 3745:27-01.

Ohio River Navigation Charts: Pittsburgh, Pennsylvania to New Martinsville, West Virginia. January, 2003. United States Army Corps of Engineers.

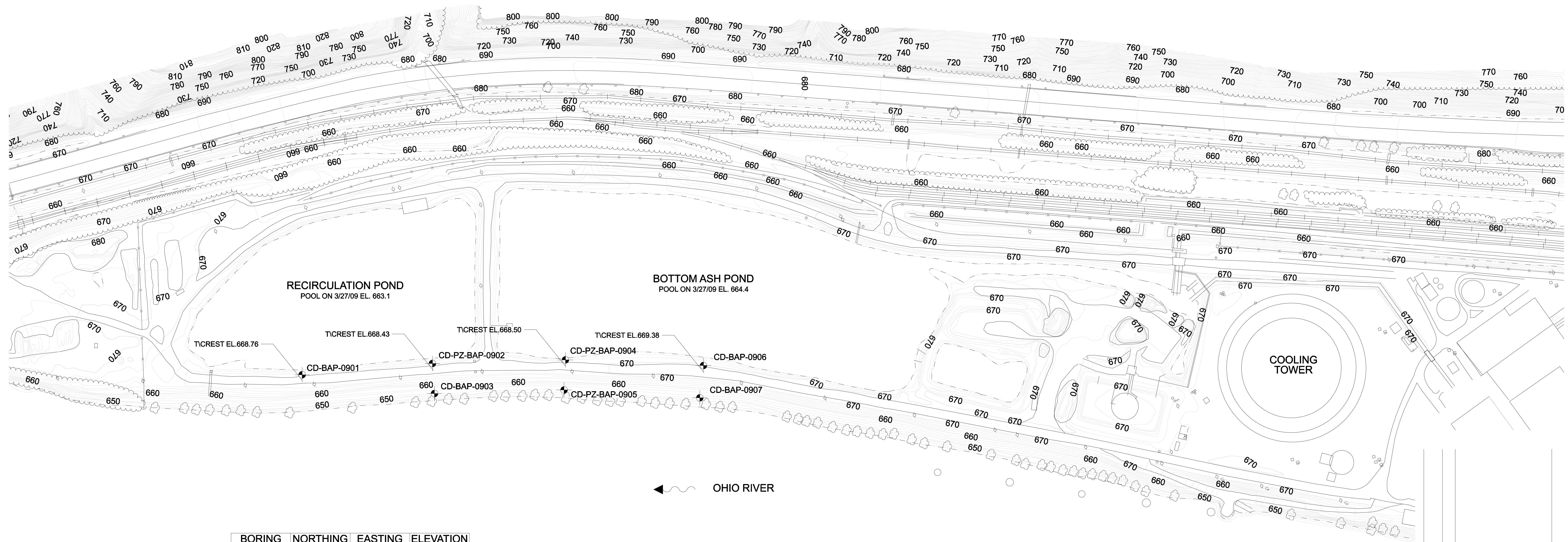
U.S. Environmental Protection Agency. Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities. 40 C.F.R. § 257.53.

S&ME, Inc. April 2012. Dam Raising Design Summary, Prepared as Part of the Cardinal Fly Ash Retention Pond II Wastewater PTI Application.

S&ME, Inc. February, 2016. Bottom Ash Pond Monitoring Well Installation Report.

APPENDIX B

GEOLOGIC CROSS SECTIONS








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	2513866.71	650.34

DATUM: NAD 27/NGVD 29 OHIO SOUTH

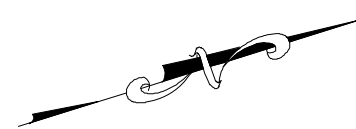
OHIO RIVER

LEGEND

- | | | |
|---|----------|--|
|  | 570 | EXISTING GRADE CONTOUR (2 FT. INTERVAL) |
|  | | EXISTING WATER SURFACE (AT TIME OF SURVEY) |
|  | | FENCE LINE |
|  | | EXISTING VEGETATION |
|  | BAP-0901 | BORING NUMBER
AND LOCATION |

SCALE IN FEET

0 100 200



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" = 100'



**AEP AMERICA
ELECTRIC
POWER**

AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

" THIS DRAWING IS THE PROPERTY OF THE AMERICAN ELECTRIC POWER SERVICE CORP. AND IS LOANED UPON CONDITION THAT IT IS NOT TO BE REPRODUCED OR COPIED, IN WHOLE OR IN PART, OR USED FOR FURNISHING INFORMATION TO ANY PERSON WITHOUT THE WRITTEN CONSENT OF THE AEP SERVICE CORP., OR FOR ANY PURPOSE DETRIMENTAL TO THEIR INTEREST, AND IS TO BE RETURNED UPON REQUEST "

A.E.P.
CARDINAL PLANT
BRILLIANT OHIO
BOTTOM ASH POND
INVESTIGATION
PLAN OF BORINGS

DWG. NO. PLATE 2

SCALE:	CIVIL ENGINEERING
--------	-------------------

DR:	
-----	--

CH₂

ENGR:	PROV
DD:	

ENGR:	AP

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466
---	---	---	---	---	---	---	---	---	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

**AEP AMERICA
ELECTRIC**

POWER	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	
31	
32	
33	
34	
35	
36	
37	
38	
39	
40	
41	
42	
43	
44	
45	
46	
47	
48	
49	
50	
51	
52	
53	
54	
55	
56	
57	
58	
59	
60	
61	
62	
63	
64	
65	
66	
67	
68	
69	
70	
71	
72	
73	
74	
75	
76	
77	
78	
79	
80	
81	
82	
83	
84	
85	
86	
87	
88	
89	
90	
91	
92	
93	
94	
95	
96	
97	
98	
99	
100	

A.E.P.

CARDINAL PLANT
BRILLIANT OHIO

BOTTOM ASH POND
INVESTIGATION
PLAN OF BORINGS

50694

A

B

C

D

E

F

G

H

J

K

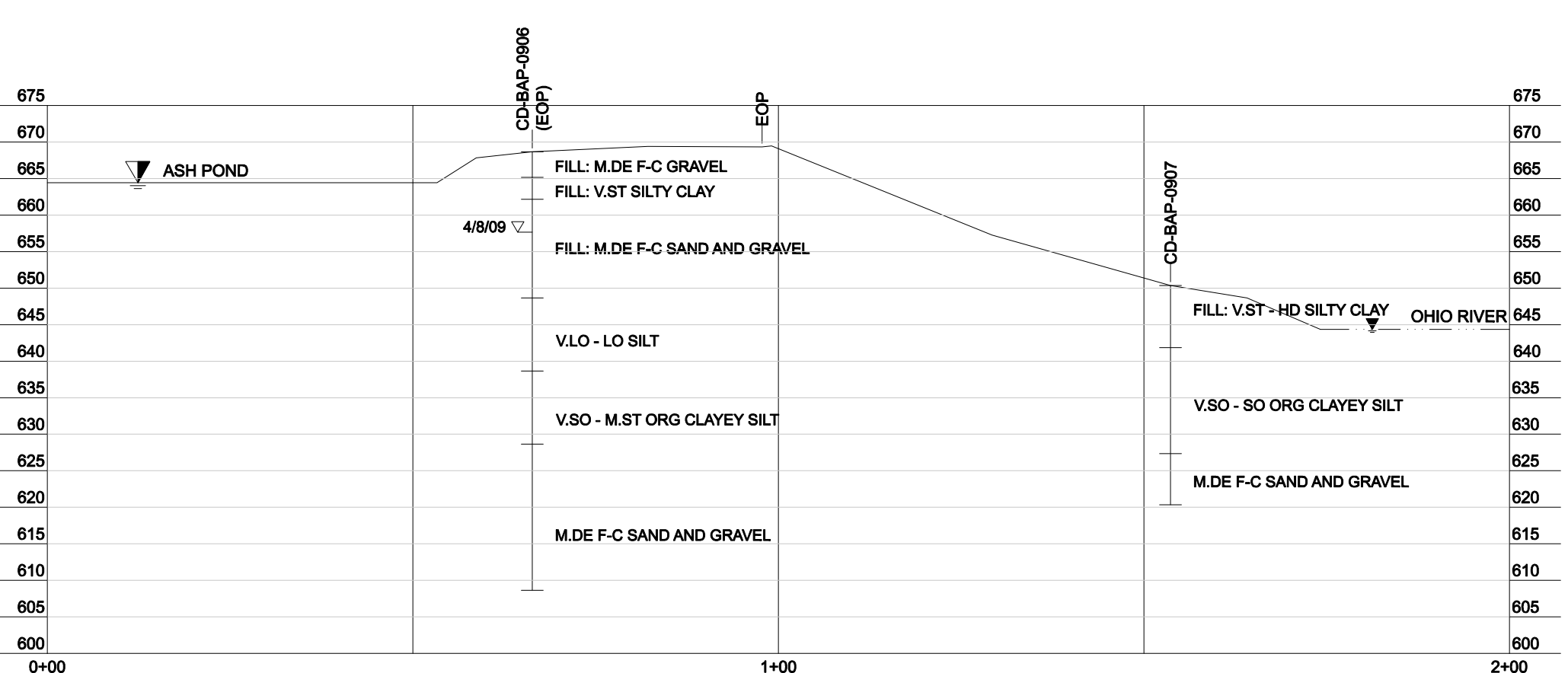
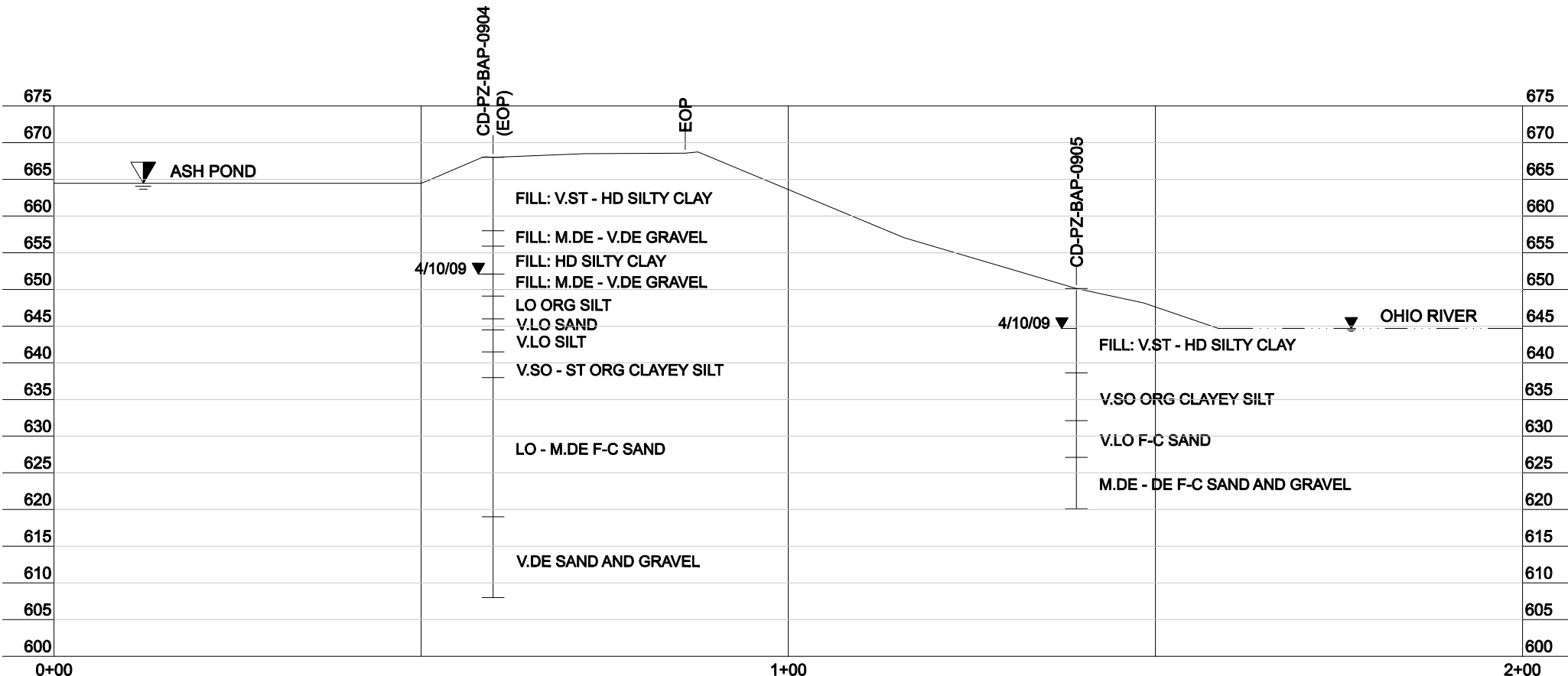
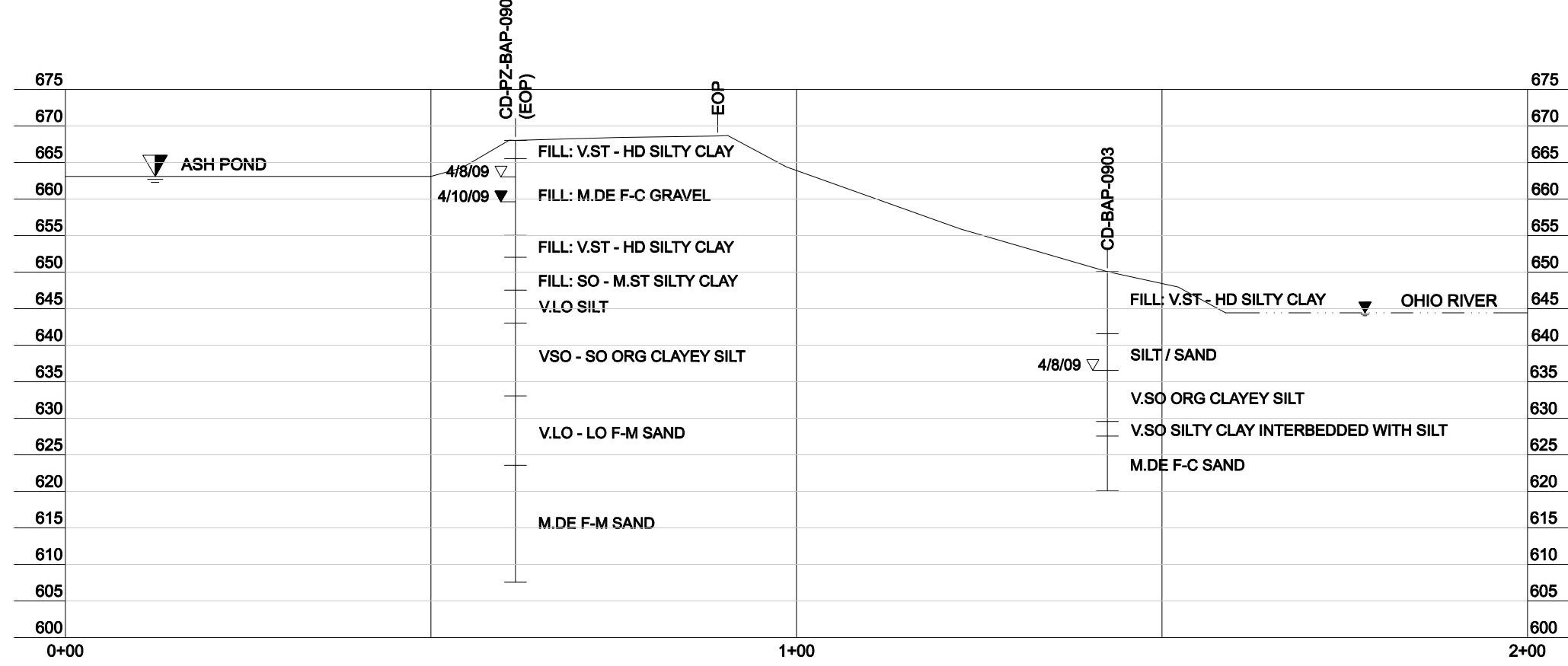
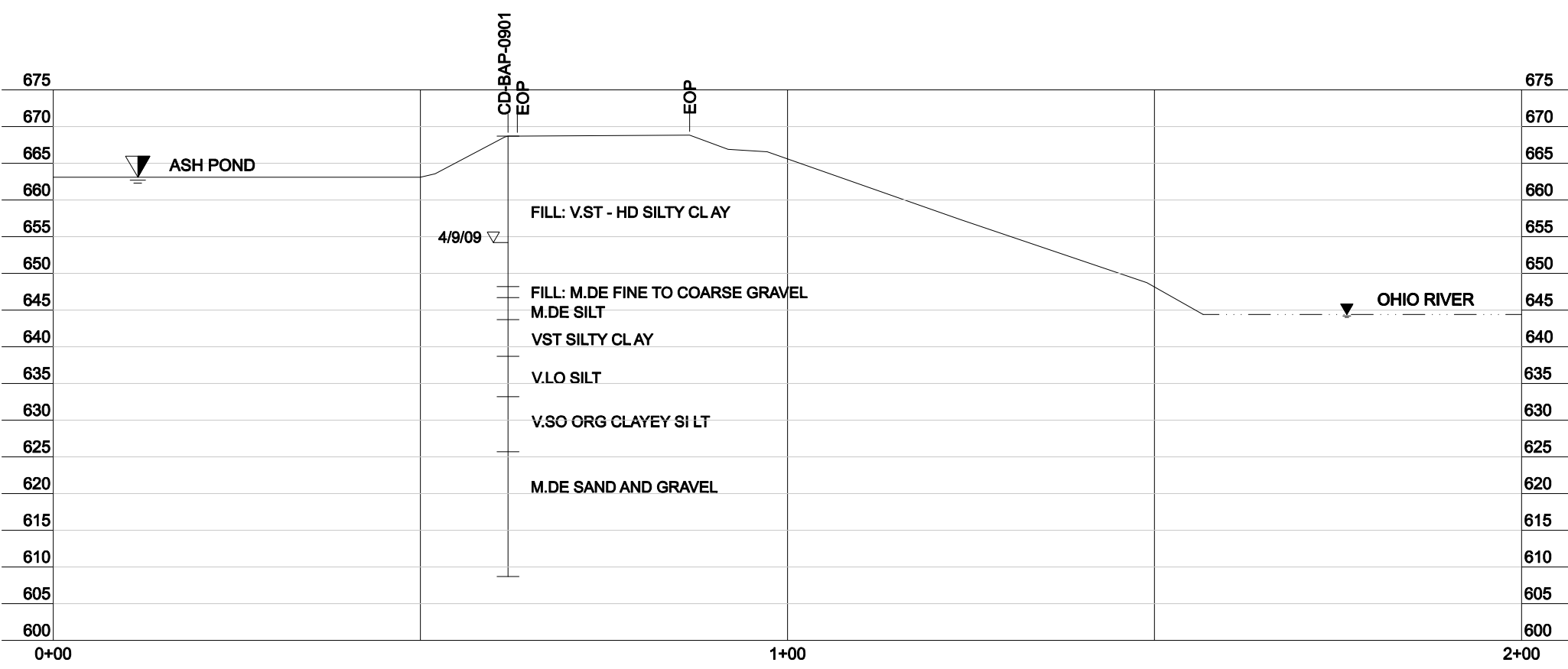
L

M

N

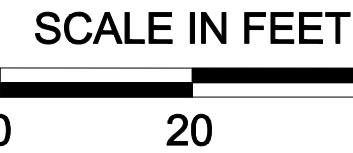
O

DWG. NO. PLATE 3



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)



REFERENCE: AEP CARDINAL DRAWING 94151038
DATUM: NAD 27/NGVD 29 OHIO SOUTH





DATE	NO.	DESCRIPTION	APPD.
REVISIONS			
* THIS DRAWING IS THE PROPERTY OF THE AMERICAN ELECTRIC POWER SERVICE CORP. AND IS LOANED UPON CONDITION THAT IT IS NOT TO BE REPRODUCED OR COPIED, IN WHOLE OR IN PART, OR USED FOR FURNISHING INFORMATION TO ANY PERSON WITHOUT THE WRITTEN CONSENT OF THE AEP SERVICE CORP., OR FOR ANY PURPOSE DETRIMENTAL TO THEIR INTEREST, AND IS TO BE RETURNED UPON REQUEST *			
A.E.P. CARDINAL PLANT BRILLIANT OHIO BOTTOM ASH POND INVESTIGATION SECTIONS			
DWG. NO. PLATE 3			
SCALE:		CIVIL ENGINEERING	
DR.		APPROVED BY	
CH.			
ENGR.			
PROJ. ENGR.			
DATE:		AEP SERVICE CORP. 1 RIVERSIDE PLAZA COLUMBUS, OH 43215	
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'	
Columbus (614) 785-2228 Cleveland (216) 861-0000 Cincinnati (513) 771-9471 Dayton (937) 424-1011		AEP AMERICAN ELECTRIC POWER	
SYSTEM DATE: DD-MMM-YYYY SYSTEM TIME: HOUR:MINUTE			

APPENDIX C

BORING LOGS

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:
-  - 2½" O.D. split-barrel sampler
-  - 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:

<u>Adjective</u>	<u>Percent by Weight</u>
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:

<u>Term (Granular Soils)</u>	<u>Blows per foot</u>
Very-loose	Less than 5
Loose	5 to 10
Medium-dense	11 to 30
Dense	31 to 50
Very-dense	Over 50
<u>Term (Cohesive Soils)</u>	<u>Qu (tsf)</u>
Very-soft	Less than 0.25
Soft	0.25 to 0.5
Medium-stiff	0.5 to 1.0
Stiff	1.0 to 2.0
Very-stiff	2.0 to 4.0
Hard	Over 4.0

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



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

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N ₆₀	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX				TEST RESULTS	
								NATURAL MOISTURE CONTENT					
	0						AGGREGATE - 34 INCHES	10	20	30	40		
667.0		1	47 3/4	26	75	100							
		2	4 1/2	30	64	100	FILL: Hard brown silty clay, some fine to coarse sand, some fine to coarse gravel, cobbles, moist.					H=3.0	
665.3		3	15 6/8	8	18	27	FILL: Medium-dense gray fine to coarse gravel, little to some fine to coarse sand, trace silt to some silty clay, cobbles, dry.						
662.8		4	7 1/4	7	59	67							
		5	7 1/4	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 1/11	4	19	100						H=3.0	
		7	6 1/8	5	16	100						H=2.5-3.5	
658.3		8	10 1/8	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 1/3	6	11	100	- 3" pocket of sand at 14.5'.						
653.8		10	5 1/3	7	13	53						H=1.25	
		11	4 1/3	3	8	67	Stiff gray clayey silt, "and" fine to coarse sand, little to some fine gravel, moist.					H=1.25	
652.3		12	3 1/2	4	8	53	Loose brown fine to coarse sand, "and" silty clay, some fine to coarse gravel, moist.					H=1.0	
650.6		13	7 1/8	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 1/6	5	14	80							
		15	5 1/8	4	15	67							
		16	6 1/3	2	6	80							
643.8													
		17	4 1/4	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	
		18	2 1/2		4	100	Stiff dark-brown clayey silt, little to some fine to medium sand, slightly organic, damp.					H=1.25-2.25	
	30												
WATER LEVEL: 31.0								SYMBOLS USED TO INDICATE TEST RESULTS				Drill Rod Energy Ratio : 0.75	
WATER NOTE: Inside HSA								G - Gradation Q - Uncon Comp T - Triax Comp C - Consol. See Separate Curves H - Penetrometer (tsf) W - Unit Dry Wt (pcf) D - Relative Dens (%)				Last Calibration Date : 8/2/2013	
DATE: 12/7/15												Drill Rig Number : S&ME	
27.5													
Inside Well													
12/15/15													

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**

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

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N ₆₀	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX				TEST RESULTS	
								NATURAL MOISTURE CONTENT					
								PLASTIC LIMIT		LIQUID LIMIT			
	30							10	20	30	40		
638.8	▽												
		19	SH	1	0	100	Very-soft to medium-stiff brown, gray and dark-gray organic clayey silt, little fine sand, contains silt seams and lenses, contains seams of fine to coarse sand, wet.						H=0.0-0.25
			SH										
			SH										
		20	SH		0	100							H=0.0-0.75
	-35		SH										
			SH										
		21	SH		0	100							H=0.0-0.75
			SH										
			SH										
630.7		22A	SH		0	100							H=1.0-1.5
		22B	SH										
	-40	22C		1			Very-loose gray fine to coarse sand, interbedded with silty clay seams, wet.						
628.8													
		23	1/2/3		6	60	Loose brown fine to coarse sand, trace fine gravel, trace silt, wet.						
626.8													
							Dense brown fine to coarse gravel, some to "and" fine to coarse sand, trace silt.						
	-45												
		24	13/17/23		50	47							G
		25	19/14/18		40	67							
	-50												
618.8													
		26	9/7/8		19	47	Medium-dense brown fine to coarse sand, trace fine gravel, trace clay.						
617.3													
	-55						- Encountered water at 31.0'. - Encountered cobbles at 4.4 and 18.2'. - Borehole converted to monitoring well upon completions. See separate well completion diagram. - Boring locations and elevation surveyed by AEP. - Datum: Ohio State Plane South. - NAD 27/NAVD 29 (Plant Grid).						
	-60												
WATER LEVEL:		31.0		27.5		SYMBOLS USED TO INDICATE TEST RESULTS		Drill Rod Energy Ratio : 0.75					
WATER NOTE:		Inside HSA		Inside Well		G - Gradation } See Q - Uncon Comp } Separate T - Triax Comp } Curves C - Consol. }		H - Penetrometer (tsf) W - Unit Dry Wt (pcf) D - Relative Dens (%)					
DATE:		12/7/15		12/15/15				Last Calibration Date : 8/2/2013					
								Drill Rig Number : S&ME					

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



LOCATION: **N. 819,792, E. 2,513,707** ELEVATION: **669.9** DATE: **12/2/15 - 12/4/15**
 DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **45.0'**
 SAMPLER(S): **2" O.D. Split-barrel Sampler**

2010 NEW DEFAULT BORING LOG-W/ N60

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N ₆₀	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX				TEST RESULTS	
								NATURAL MOISTURE CONTENT					
	0							PLASTIC LIMIT		LIQUID LIMIT			
							AGGREGATE - 23 INCHES	10	20	30	40		
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								
655.4	5	3	33 11/8	24	60		FILL: Stiff to hard brown and dark-brown silty clay, some to "and" fine to coarse sand, little to some fine to coarse gravel, few pockets of gravel, dry becoming damp.					H=2.0	
		4	11 9/15	30	67							H=4.5	
		5	8 9/13	28	80								
		6	4 6/9	19	60								
	10	7	7 5/5	13	87								
		8	4 10/8	23	80							H=2.0-4.5	
		9	2 8/3	14	53							H=2.5	
		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		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. - Contains sand seams at 20.0' to 20.3'.						H=2.0
644.7	20	14	3 4/3	9	67								
		15	SH 1	0	100								
		16	SH 1/1	3	100								
		17	1 1/1	3	100							H=0.5	
643.9		18	SH 3	0	53			FILL: Very-loose dark-gray silt, trace fine to coarse sand, slightly organic, wet. Stiff gray mottled with brown silty clay, some fine sand, trace medium to coarse sand, slightly organic, silt seams, damp. Medium-stiff dark-gray organic clayey silt, little fine sand, damp.					H=2.0
641.9		19	SH	0	100							H=1.0	
	30												
WATER LEVEL: 29.2								SYMBOLS USED TO INDICATE TEST RESULTS				Drill Rod Energy Ratio : 0.75	
WATER NOTE: Inside Well								G - Gradation } See Q - Uncon Comp } Separate T - Triax Comp } Curves C - Consol. }				Last Calibration Date : 8/2/2013	
DATE: 12/15/15								H - Penetrometer (tsf) W - Unit Dry Wt (pcf) D - Relative Dens (%)				Drill Rig Number : S&ME	

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

[illegible]

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



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

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N ₆₀	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX				TEST RESULTS
								NATURAL MOISTURE CONTENT				
	0						AGGREGATE - 12 INCHES	10	20	30	40	
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
	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	1 2/3	5	100		Loose gray fine to medium sand, trace coarse sand, trace fine gravel, little silt, wet.					
		16	1 3/1	0	100							
	644.4	25										
		17	1 1/SH	0	100		Very-loose gray silt, little fine to medium sand, wet.					
	641.9											
		18	1 2/2	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				SYMBOLS USED TO INDICATE TEST RESULTS						Drill Rod Energy Ratio : 0.75
WATER NOTE:		Inside Well				G - Gradation		See		H - Penetrometer (tsf)		Last Calibration Date : 8/2/2013
DATE:		12/11/15				Q - Uncon Comp		Separate		W - Unit Dry Wt (pcf)		Drill Rig Number : S&ME
						T - Triax Comp		Curves		D - Relative Dens (%)		
						C - Consol.						

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**

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

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N ₆₀	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX				TEST RESULTS	
								NATURAL MOISTURE CONTENT					
								PLASTIC LIMIT	LIQUID LIMIT				
634.4	30						sand seams and roots, wet. Soft to stiff dark-brown mottled with dark-gray slightly organic to organic clayey silt, little to some fine to medium sand, contains silt seams, fine sand seams and roots, wet.	10	20	30	40		
		19	1	2	4								
629.4	35						Soft to medium-stiff dark-brown mottled with gray slightly organic to organic clayey silt, some to "and" fine to medium sand, wet.						
		20	SH	2	1	4							
624.9	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.						
		21	SH	2	1	4							
614.9	45						Medium-dense to very-dense brown fine to coarse gravel, some to "and" fine to coarse sand, trace to little silt, wet. - Contains zones of fine to coarse sand at 49.0'.					G	
		22	SH	4	7	14							
614.9	50						- 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						
		23	SH	2	1	4							
614.9	55												
		24	SH	6	11	17		35	80				
614.9	60												
		25	22	35	25	75		53					
614.9	60												
		26	21	8	8	20		33					
SYMBOLS USED TO INDICATE TEST RESULTS								Drill Rod Energy Ratio : 0.75					
G - Gradation								Last Calibration Date : 8/2/2013					
Q - Uncon Comp								Drill Rig Number : S&ME					
T - Triax Comp													
C - Consol.													
See Separate Curves													
H - Penetrometer (tsf)													
W - Unit Dry Wt (pcf)													
D - Relative Dens (%)													

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

[illegible]

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

[illegible]

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				TEST RESULTS		
								NATURAL MOISTURE CONTENT						
	30							10	20	30	40			
		13	2 / 4 / 6		13	100	Medium-stiff to very-stiff brown mottled with gray silty clay, trace to little fine to coarse sand, damp.						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		SYMBOLS USED TO INDICATE TEST RESULTS		Drill Rod Energy Ratio : 0.75	
WATER NOTE: Inside Well		G - Gradation } See		H - Penetrometer (tsf)	
DATE: 12/15/15		Q - Uncon Comp } Separate		W - Unit Dry Wt (pcf)	
		T - Triax Comp } Curves		D - Relative Dens (%)	
		C - Consol. }		Drill Rig Number : S&ME	

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**

**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				TEST RESULTS
								NATURAL MOISTURE CONTENT				
								PLASTIC LIMIT	LIQUID LIMIT			
606.7	60	25	8 / 4 / 16 / 5	11	60		Medium-dense to dense gray and brown fine to coarse sand, "and" fine to coarse gravel, little silt, wet.					
	65						- Encountered water at 17.0'. - Borehole converted to monitoring well upon completion. See separate well completion diagram. - Boring location and elevation surveyed by AEP. - Datum: Ohio State Plane South NAD 27/NAVD 29 (Plant Grid).					
	70											
	75											
	80											
	85											
	90											

WATER LEVEL: ∇ **27.1** ∇

WATER NOTE: **Inside Well**

DATE: **12/15/15**

SYMBOLS USED TO INDICATE TEST RESULTS

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

Drill Rod Energy Ratio : 0.75

Last Calibration Date : 8/2/2013

Drill Rig Number : S&ME

2010 NEW DEFAULT BORING LOG-W/ N60

APPENDIX D

WELL CONSTRUCTION LOGS

Elevation (Feet above MSL)	Depth Below Ground Surface (Feet)
672.65	-2.86
672.29	-2.50
669.79	0.0
667.2	2.6
638.9	30.9
632.2	37.6
628.2	41.6
618.4	51.4
617.8	52.0
617.8	52.0

Top of Cover

Top of PVC

Ground Surface

Top of Grout

Top of Bentonite

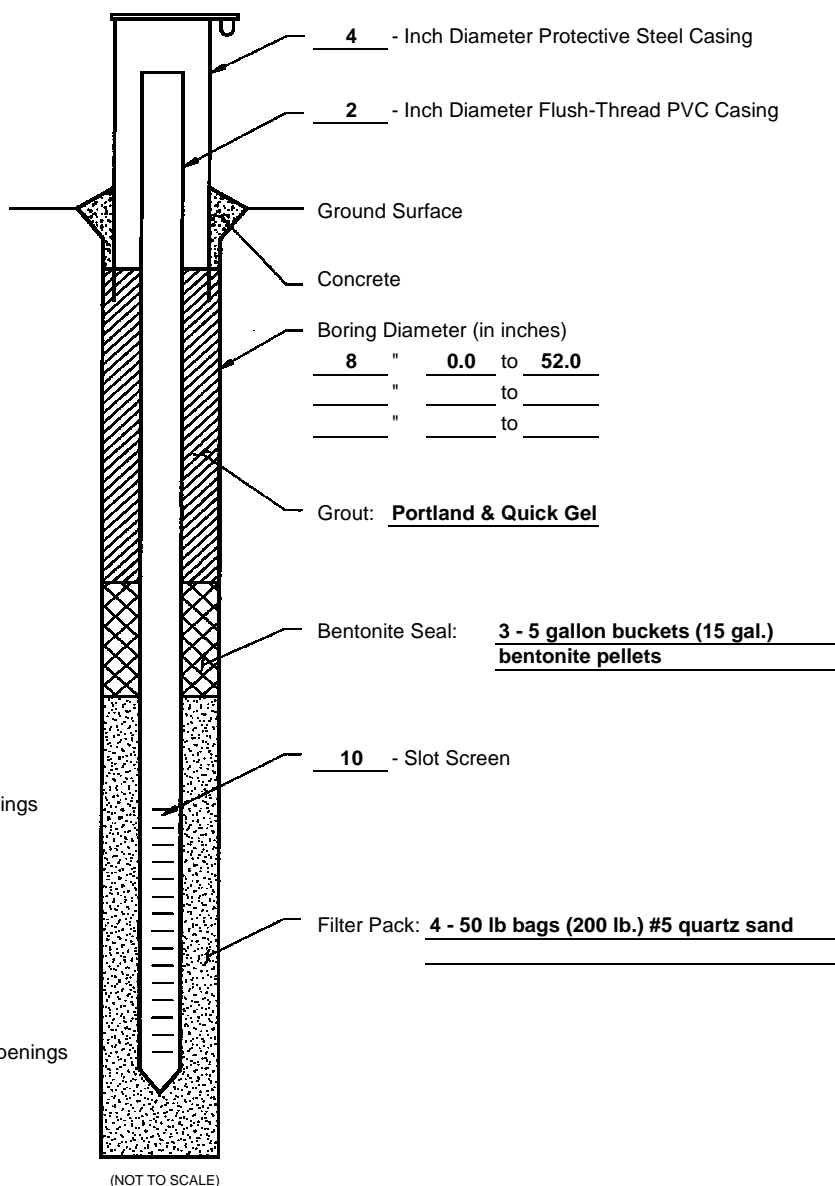
Top of Filter Pack

Top of Screen Openings

Bottom of Screen Openings

Bottom of Well

Bottom of Boring



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

Well Development:

12/10 - Bailed 175 gallons of water (approx. 41 well volumes) via submersible pump. Water level stayed steady during pumping. NTU = 7 at 155 gallons, but increased to NTU = 12 upon terminating pump. Bailed additional 20 gallons during which initial NTU readings were initially high but decreased to NTU = 25.4.

-Water level measurement on 12/15 was immediately before slug testing.

-Top cover set in 3'x3' concrete pad. Protective steel bollards placed around concrete pad.

Water Quality Readings (Horiba U-52)

Cumulative Gallons	NTU	C	ms/cm	PH	ORPmV
175	25.4	18.09	1.31	7.15	-6
Location: N. 820,305.3' E. 2,513,927.4' Datum: NAD27/NGVD29 OH S					

WELL COMPLETION DIAGRAM

Project Name:

AEP CD Bottom Ash Pond Monitoring Wells

Project Location:

Cardinal Plant / Brilliant, Ohio

Project Number:

7217-15-007A

Boring Number:

MW-BAP-1

Date Well Installed:

12/10/2015

Elevation (Feet above MSL)	Depth Below Ground Surface (Feet)
673.47	-3.55
673.24	-3.32
669.92	0.0
667.3	2.7
644.2	25.7
638.2	31.7
635.8	34.1
626.0	43.9
625.4	44.5
624.9	45.0

Top of Cover

Top of PVC

Ground Surface

Top of Grout

Top of Bentonite

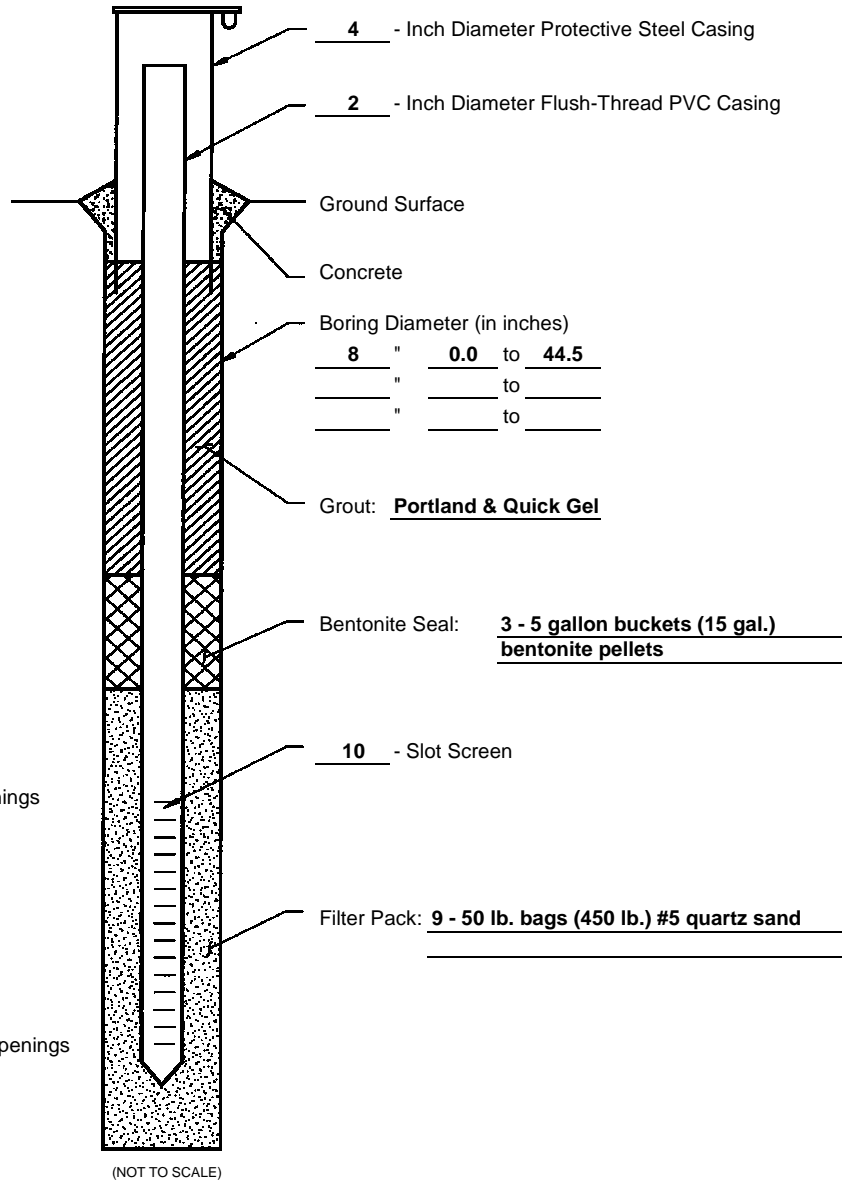
Top of Filter Pack

Top of Screen Openings

Bottom of Screen Openings

Bottom of Well

Bottom of Boring



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

Well Development:

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

Water Quality Readings (Horiba U-52)

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

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

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

WELL COMPLETION DIAGRAM

Project Name:

AEP CD Bottom Ash Pond Monitoring Wells

Project Location:

Cardinal Plant / Brilliant, Ohio

Project Number:

7217-15-007A

Boring Number:

MW-BAP-2

Date Well Installed:

12/2/2015

Elevation (Feet above MSL)	Depth Below Ground Surface (Feet)
673.26	-3.33
672.84	-2.91
669.93	0.0
667.4	2.5
632.5	37.4
626.5	43.4
624.5	45.4
614.5	55.4
613.9	56.0
613.9	56.0

Top of Cover

Top of PVC

Ground Surface

Top of Grout

Top of Bentonite

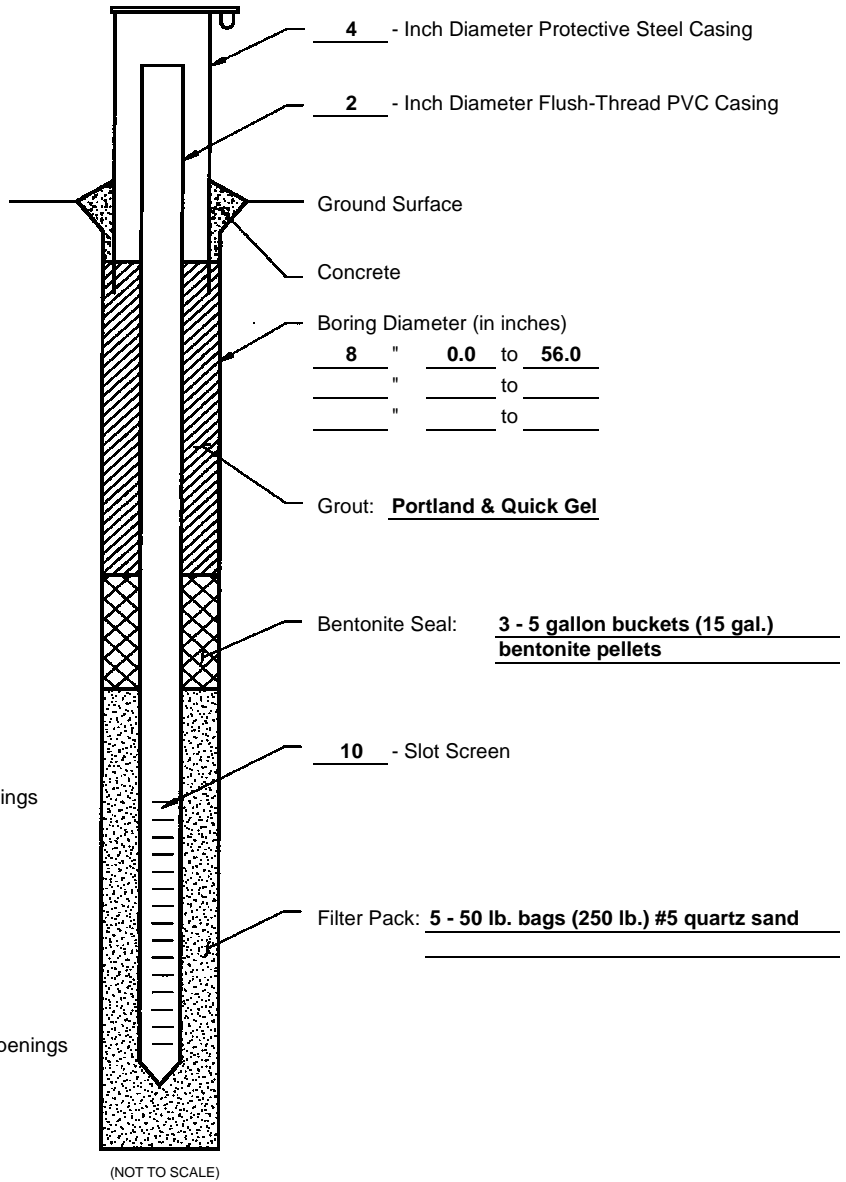
Top of Filter Pack

Top of Screen Openings

Bottom of Screen Openings

Bottom of Well

Bottom of Boring



Depth to Static Water:

28.2	28.0	28.2		
------	------	------	--	--

Static Water Elevation:

638.8	639.1	638.8		
-------	-------	-------	--	--

Date:

11/29/15	12/8/15	12/11/15		
----------	---------	----------	--	--

Well Development:

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

Water Quality Readings (Horiba U-52)

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

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

WELL COMPLETION DIAGRAM

Project Name:

AEP CD Bottom Ash Pond Monitoring Wells

Project Location:

Cardinal Plant / Brilliant, Ohio

Project Number:

7217-15-007A

Boring Number:

MW-BAP-3

Date Well Installed:

11/13/2015

Elevation (Feet above MSL)	Depth Below Ground Surface (Feet)
663.80	-2.75
663.54	-2.49
661.05	0.0
658.4	2.7
639.5	21.6
634.2	26.9
632.2	28.9
622.4	38.7
621.8	39.3
621.1	40.0

Top of Cover

Top of PVC

Ground Surface

Top of Grout

Top of Bentonite

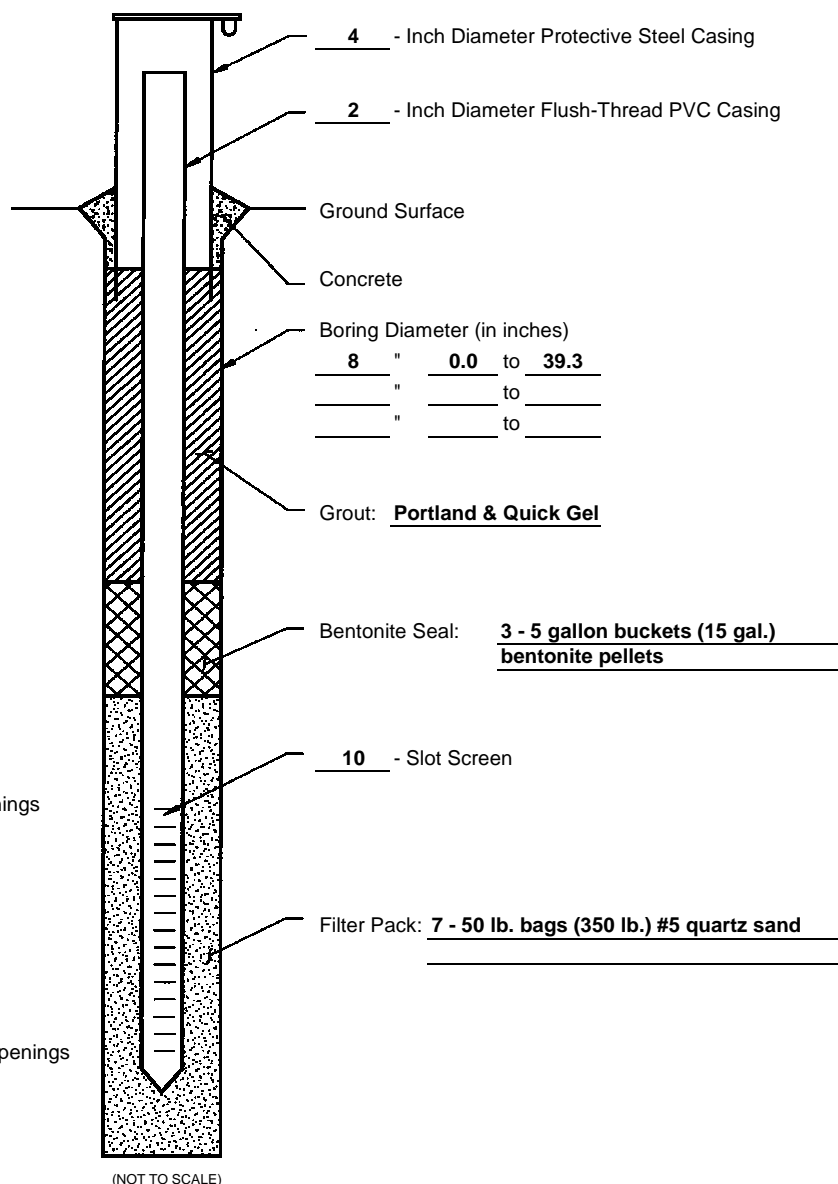
Top of Filter Pack

Top of Screen Openings

Bottom of Screen Openings

Bottom of Well

Bottom of Boring



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

Well Development:

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

Water Quality Readings (Horiba U-52)

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

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

WELL COMPLETION DIAGRAM

Project Name:

AEP CD Bottom Ash Pond Monitoring Wells

Project Location:

Cardinal Plant / Brilliant, Ohio

Project Number:

7217-15-007A

Boring Number:

MW-BAP-4

Date Well Installed:

11/23/2015



Elevation (Feet above MSL)	Depth Below Ground Surface (Feet)
672.28	-3.10
672.00	-2.82
669.18	0.0
662.6	6.6
625.0	44.2
619.5	49.7
617.5	51.7
607.7	61.5
607.1	62.1
606.7	62.5

Top of Cover

Top of PVC

Ground Surface

Top of Grout

Top of Bentonite

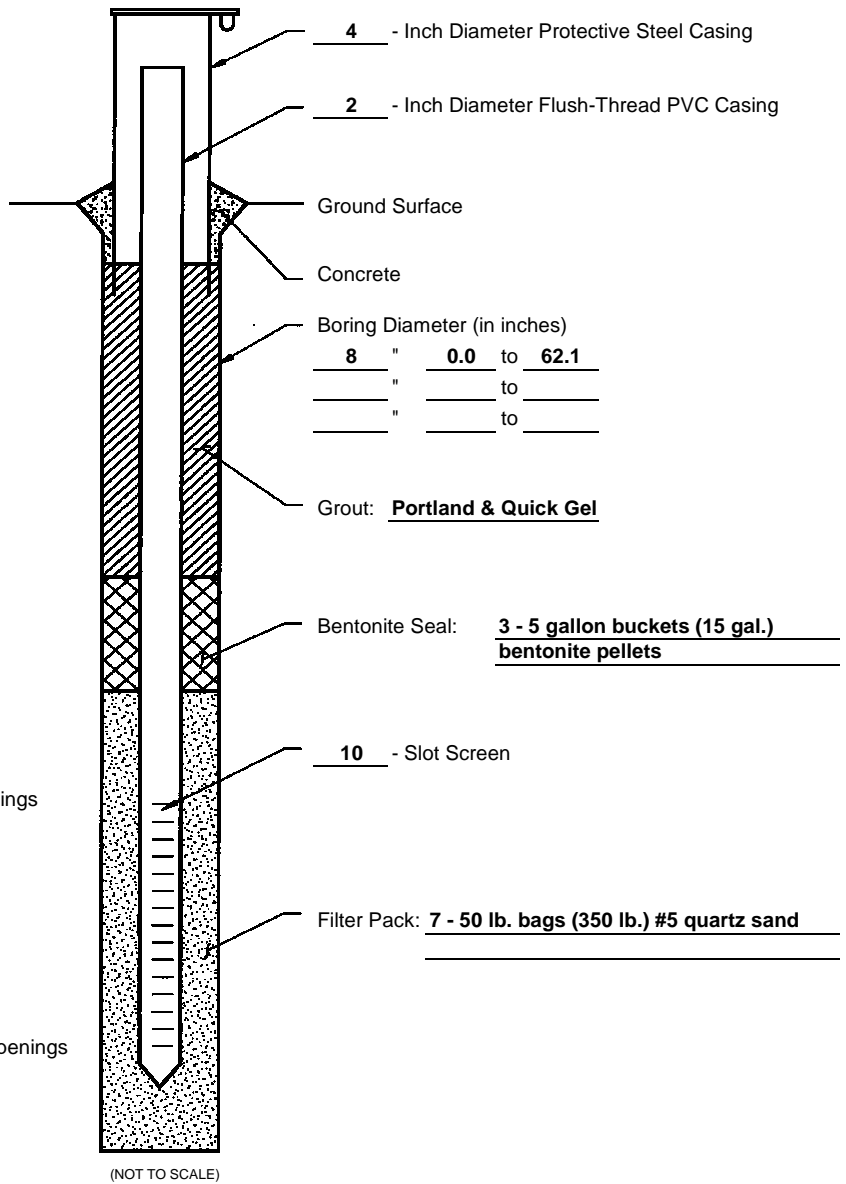
Top of Filter Pack

Top of Screen Openings

Bottom of Screen Openings

Bottom of Well

Bottom of Boring



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

Well Development:

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

Water Quality Readings (Horiba U-52)

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

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

WELL COMPLETION DIAGRAM

Project Name:

AEP CD Bottom Ash Pond Monitoring Wells

Project Location:

Cardinal Plant / Brilliant, Ohio

Project Number:

7217-15-007A

Boring Number:

MW-BAP-5

Date Well Installed:

11/25/2015