2019 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

FEDERAL CCR RULE

BRANDYWINE ASH MANAGEMENT FACILITY PHASE II, BRANDYWINE, MARYLAND

GenOn MD Ash Management LLC
25100 Chalk Point Road
Aquasco, Maryland 20608

January 2020

Prepared by:

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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 to prepare a Groundwater Monitoring and Corrective Action Report (Report) no later than 31 January 2020. Geosyntec Consultants (Geosyntec) has prepared this Report for Phase II at the Brandywine Ash Management Facility in Brandywine, Maryland (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 in Brandywine, Prince George's County, Maryland (**Figure 1**) and is operated by GenOn MD Ash Management LLC (MD Ash). The Site is a dry ash management operation and does not have CCR surface impoundments (SI) as defined in the CCR Rule. The Site encompasses 217 acres of which approximately 29 acres have been used to manage CCR at the Phase II cell. Phase I, Historical Area 1, and Historical Area 2, are located adjacent to Phase II, are inactive and therefore are not regulated by the Federal CCR Rule. Phase II was constructed with a geosynthetic bottom liner and associated leachate collection system that directs leachate to Pond 006, located directly to the east. Non-contact stormwater runoff is directed away from Phase II through perimeter ditches. In addition to leachate, Pond 006 is used to manage contact stormwater. Pond 006 is exempt from the Federal CCR Rule. Features of the Site and their locations are presented on **Figure 2**.

2.2 Regional Physiographic Setting

The Site is located on the Atlantic Coastal Plain province of Maryland and was previously used for sand and gravel mining operations. The sand and gravel unit is the upper aquifer at the Site as defined in the CCR Rule. A regional aquitard (the Calvert Formation) underlies the sand and gravel.

Regional groundwater flow in the upper aquifer in the Site vicinity is to the north/northeast toward the Mataponi Creek that is considered to be the discharge location for shallow groundwater in the upper aquifer. The Mataponi Creek is incised into the Calvert Formation confining unit. Groundwater flow directions are locally variable and are influenced by nearby tributaries to Mataponi Creek that are localized groundwater discharge zones.

3. GROUNDWATER MONITORING SYSTEM

This section describes the groundwater monitoring well network for the CCR Rule at Phase II. This network utilizes several monitoring wells initially installed as part of a separate site-wide hydrogeologic investigation in addition to wells installed explicitly for the CCR Rule. As described in the *Basis for Groundwater Monitoring Network* (Geosyntec, 2017a), the groundwater

monitoring network around Phase II was designed to comply with 40 CFR 257.91. No monitoring wells were installed or decommissioned during 2019.

Groundwater quality is monitored around Phase II through a network of eleven monitoring wells. As shown on **Figure 3**, there are seven compliance monitoring wells (B15S, B16, B26, B27, B37, B38, and B39) and four background monitoring wells (B34, B35, B36, and B41). These background locations were selected in consultation with Maryland Department of Environment (MDE) under a separate regulatory program. Monitoring well construction and soil boring logs were provided in *Basis for Groundwater Monitoring Network* (Geosyntec, 2017a). Compliance and background monitoring well construction details are summarized in **Table 1**.

4. CCR RULE GROUNDWATER MONITORING COMPLETED – 2019

4.1 Groundwater Monitoring

The baseline monitoring program was completed in August 2017 and the Site transitioned to detection monitoring beginning in October 2017. Groundwater monitoring continued in 2019 and was conducted in accordance with the *Sampling and Analysis Plan* (SAP) provided in Geosyntec (2015). Detection monitoring is performed on a semi-annual basis.

4.1.1 Detection Monitoring Program

Table 2 summarizes the history of baseline and detection monitoring events through 2019. Sampling occurred in February and August of 2019. In accordance with 40 CFR 257.94(a) of the CCR Rule, samples were analyzed for Appendix III list constituents only. Prior to sampling, a synoptic round of groundwater measurements was conducted which included the compliance and background monitoring wells. Groundwater elevation data are presented in **Table 3**. Analytical results for background and compliance wells are summarized in **Table 4** and **Table 6**, respectively. The Site remains in detection monitoring.

4.1.2 Groundwater Elevation and Flow Velocities

Groundwater elevation monitoring was conducted in February and August 2019. A synoptic round of water level measurements was made at the start of each monitoring event. Groundwater elevation measurements were collected in accordance with the SAP. Potentiometric surface maps based on the elevations measured during the February and August 2019 monitoring events are presented on **Figure 4** and **Figure 5**, respectively. Groundwater elevation data are summarized in **Table 3**. As shown by **Figure 4** and **Figure 5**, groundwater under the eastern half of Phase II flows from west to east. The groundwater elevations and flow directions are very stable among the various monitoring events.

The average hydraulic gradient around Phase II ranged from 0.0252 ft/ft between monitoring wells B16 and B28 to 0.0075 ft/ft between monitoring wells B16 and B27. The groundwater flow velocity calculation submitted in the *2018 Annual Groundwater Monitoring and Corrective Action*

Report is provided in **Appendix A** (Geosyntec, 2019). **Table A-2** shows groundwater flow velocities at the Site ranges from $1.39X10^{-4}$ centimeters per second (cm/sec) (144 inches/month; 144 feet/year) between monitoring wells B16 and B28 to $4.13\ X10^{-6}$ cm/sec (4.27 inches/month; 4.27 feet/year) between monitoring wells B26 and B27.

4.2 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 was complete;
- Precision was within SAP control limits using relative percent differences of blind duplicate samples;
- Matrix spike and matrix spike duplicate recoveries and laboratory control samples were within the SAP control limits; and
- Potential for positive bias was evaluated using method blanks concentrations.

Upon completion of the data usability assessment the data were qualified as needed and added to the data tables. All data received were considered complete and usable.

4.3 Statistically Significant Increases Comparison Test

The baseline monitoring data from the four background wells (B34, B35, B36, and B41) between 2015 and 2017 were previously used to select statistical methods for calculating the range of background concentrations for Appendix III constituents. These data are discussed and presented in the *2017 Annual Groundwater Monitoring and Corrective Action Report* (Geosyntec, 2018a).

In January 2018, the calculated background concentrations were compared to the results of the first Detection Monitoring Sampling Event conducted in October 2017. The comparison of those data to the calculated background concentrations resulted in statistically significant increases (SSIs) over background and triggered an alternate source demonstration (ASD).

In July and October 2018, the calculated background concentrations were compared to the results of the April/May 2018 and July/August 2018 Detection Monitoring Sampling Events. The comparison of those data to the calculated background concentrations resulted in SSIs over background and triggered supplemental alternate source demonstrations.

4.4 Alternate Source Demonstration

Following the comparison of calculated background concentrations to the October 2017 detection monitoring concentrations, an *Alternate Source Demonstration Report* (Geosyntec, 2018b) (ASD) was prepared for MD Ash. The ASD concluded that alternative sources (i.e. the adjacent unlined

Phase I CCR landfill) had contributed to the SSIs, and that the data did not indicate a release of Appendix III constituents from Phase II. This Report was completed within 180 days of the SSI trigger date and certified by a professional Engineer.

4.5 Supplemental Alternative Source Demonstration

Upon completion of the April/May and July/August 2018 detection monitoring events statistical testing for SSIs over background concentrations was completed. The data indicated that there were SSIs of Appendix III constituents during the 2018 detection monitoring events. Furthermore, increases in boron, calcium, chloride, and sulfate were observed in monitoring wells B16, B27, B37, and B38 compared to the October 2017 samples that were considered by the ASD. A *Supplemental Alternate Source Demonstration Report* (Geosyntec, 2018c) (SASD) was prepared for MD Ash to discuss the 2018 results, consider possible alternative sources for the SSIs, and provide rationale for whether or not there is a release from the Phase II cell. This Report was completed within 180 days of the SSI trigger date and certified by a professional Engineer.

4.6 Transition to Intra-Well Statistical Analysis

After the ASD and SASD were completed and an alternate source for CCB constituents in Phase II compliance well groundwater was identified, the Site statistical analysis was transitioned from inter-well to intra-well statistical analysis (Geosyntec, 2018d). The intra-well statistical analysis compared groundwater concentrations from each monitoring well against the baseline data collected from the respective well. The intra-well statistical analysis was certified by a professional Engineer. New background concentrations for each Appendix III constituent were calculated for use in last year's annual report. The new background concentrations are presented in **Table 5**.

5. DETECTION MONITORING STATISTICS

In accordance with 40 CFR 257.93(b)(2), intra-well detection monitoring statistics were used to evaluate groundwater concentrations of Appendix III constituents collected during February 2019 and August 2019 detection monitoring events. **Table 6** provides a comparison of the Appendix III detection monitoring results to the calculated background concentrations.

SSIs above background were detected in the following compliance well samples:

- Calcium at B27 during August 2019.

There were no other SSIs above background detected at compliance wells during the monitoring period. The SSI is not likely related to a release from Phase II, as primary CCR constituents (namely boron and sulfate) are not detected above background concentrations in B27. The concentration of calcium detected in B27 is likely attributed to natural variation. An alternate source demonstration is currently in progress.

6. ASSESSMENT MONITORING STATISTICS

Based on the results of the ASD and SASD the Site is not in assessment monitoring.

7. PROBLEMS ENCOUNTERED AND RESOLUTIONS

The following section discusses problems encountered during the detection monitoring program and their resolution.

Problem 1: SSIs of Appendix III constituents were detected in the October 2017 detection monitoring event.

Resolution 1: An ASD was performed which successfully demonstrated that SSIs in Phase II compliance wells were not due to a release from the Phase II CCR unit, but from the adjacent unlined Phase I unit not regulated under the CCR Rule. As a result, an assessment monitoring program was not initiated, and the Site remained in the detection monitoring program.

Problem 2: SSIs of Appendix III constituents were detected from the two 2018 detection monitoring events. Furthermore, some of the 2018 Appendix III parameter concentrations were greater than the initial October 2017 detection monitoring event concentrations that were addressed by the ASD.

Resolution 2: An SASD was completed that successfully demonstrated the 2018 SSIs in Phase II compliance wells were not due to a release from the Phase II CCR unit but were from the adjacent unlined Phase I unit not regulated under the CCR Rule.

Problem 3: Analytical laboratory data did not concur with field data or other analytical data results. For example, the laboratory measured total dissolved solids did not concur with the field measured specific conductivity and the summation of the laboratory measured cations and anions did not match the laboratory measured total dissolved solids, indicating analytical laboratory error.

Resolution 3: Geosyntec worked with the analytical laboratory to correct analytical and reporting errors. Additionally, Geosyntec implemented several additional quality assurance checks to assess the quality of the analytical laboratory data.

Problem 4: SSI of an Appendix III constituent was detected in the August 2019 detection monitoring event.

Resolution 4: An ASD is currently in progress to evaluate whether the calcium SSI in the Phase II compliance well B27 is due to a release from the Phase II CCR unit.

8. STATUS OF MONITORING PROGRAM

As of December 31, 2019, the Site is currently undergoing detection monitoring and has successfully demonstrated an alternate source of Appendix III constituents in groundwater detected in Phase II compliance wells.

9. PLANNED KEY ACTIVITIES FOR 2020

The following section discusses the planned activities for 2020.

January 2020: This 2019 Annual Groundwater Monitoring and Corrective Action Report will be entered into the facility's operating record and notification will be sent to the Maryland Department of Environment (MDE)**.**

February 2020: Completion of semi-annual detection groundwater monitoring.

March 2020: The 2019 Annual Groundwater Monitoring and Corrective Action Report will be posted to the public internet site. An ASD will be completed to address the SSI detected at B27.

May/June 2020: SSI testing of the February 2020 groundwater monitoring results.

August 2020: Completion of semi-annual detection groundwater monitoring.

November/December 2020: SSI testing of the August 2020 groundwater monitoring results.

December 2020: Preparation of the 2020 Annual Groundwater Monitoring and Corrective Action Report will begin.

10. REFERENCES

Driscoll, F.G., 1986.Groundwater and Wells, Second Edition. St. Paul, Minnesota, H.M. Smyth Company.

Geosyntec Consultants, Inc., 2015. Sampling and Analysis Plan, Brandywine Ash Management Facility, Brandywine Maryland, September.

Geosyntec Consultants, Inc., 2017a. Basis for Groundwater Monitoring Network, Brandywine Ash Management Facility, Brandywine, Maryland, October.

Geosyntec Consultants, Inc. 2017b. Statistical Analysis Calculations Package for Background Groundwater – Phase II, Brandywine Ash Storage Facility, Brandywine, MD

Geosyntec Consultants, Inc., 2018a. 2017 Annual Groundwater Monitoring and Corrective Action Report – Federal CCR Rule, Brandywine Ash Management Facility Phase II, Brandywine, MD

Geosyntec Consultants, Inc., 2018b. Alternate Source Demonstration Report – Federal CCR Rule, Brandywine Ash Management Facility, Phase II, Brandywine, MD

Geosyntec Consultants, Inc., 2018c. Supplemental Alternate Source Demonstration Report – Federal CCR Rule, Brandywine Ash Management Facility, Phase II, Brandywine, MD

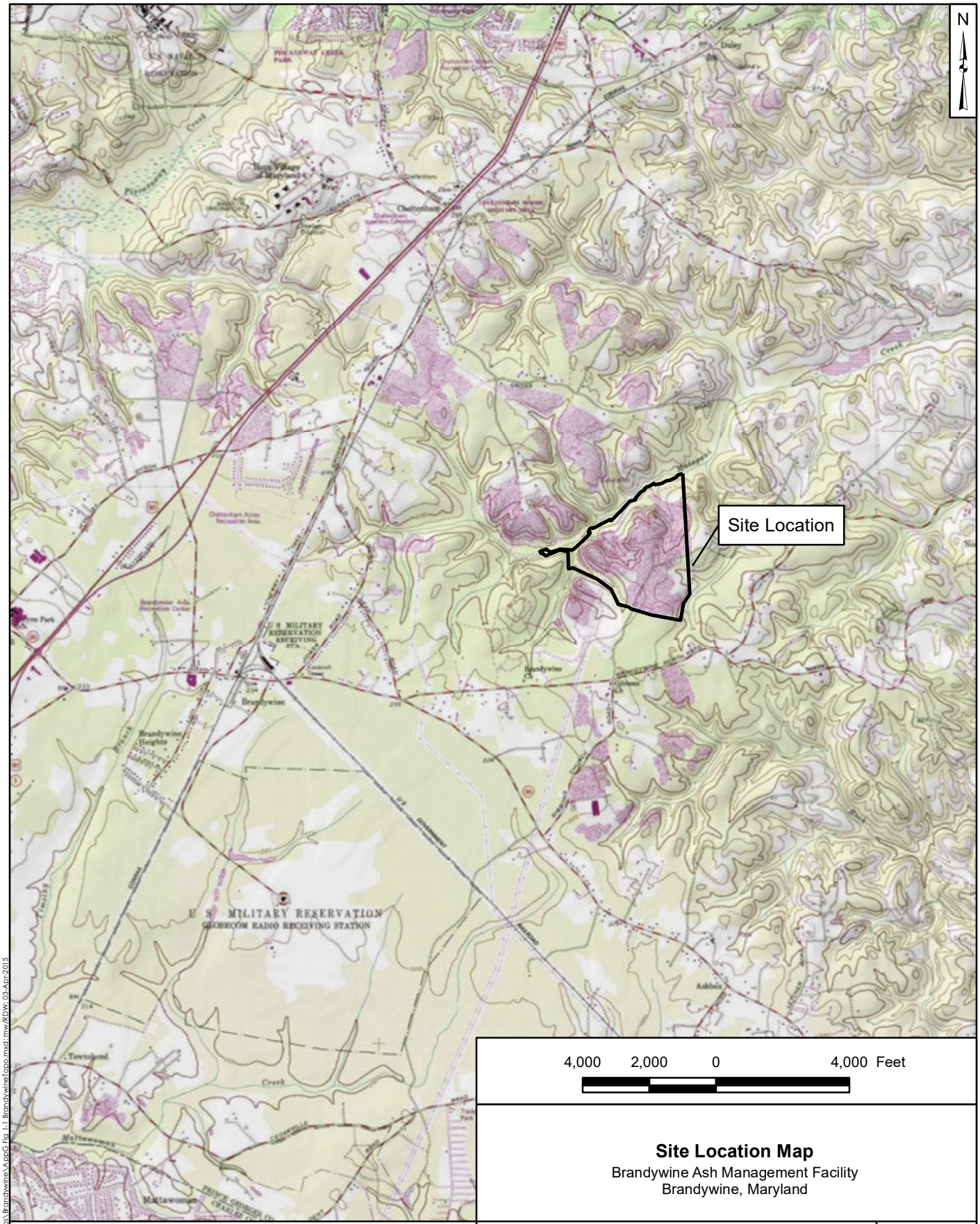
Geosyntec Consultants, Inc., 2018d. Intra-Well Statistical Analysis Calculation Package for Background Groundwater - Phase II, Brandywine Ash Management Facility, Brandywine, MD

Geosyntec Consultants, Inc., 2019. 2018 Annual Groundwater Monitoring and Corrective Action Report – Federal CCR Rule, Brandywine Ash Management Facility Phase II, Brandywine, MD

U.S. EPA, 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. March.

U.S. EPA, 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



Site Location Map
Brandywine Ash Management Facility
Brandywine, Maryland

Source:
USGS Topographic Quadrangle - Brandywine, Maryland, provided by the National Geographic Society and i-cubed. © 2011 National Geographic Society, i-cubed

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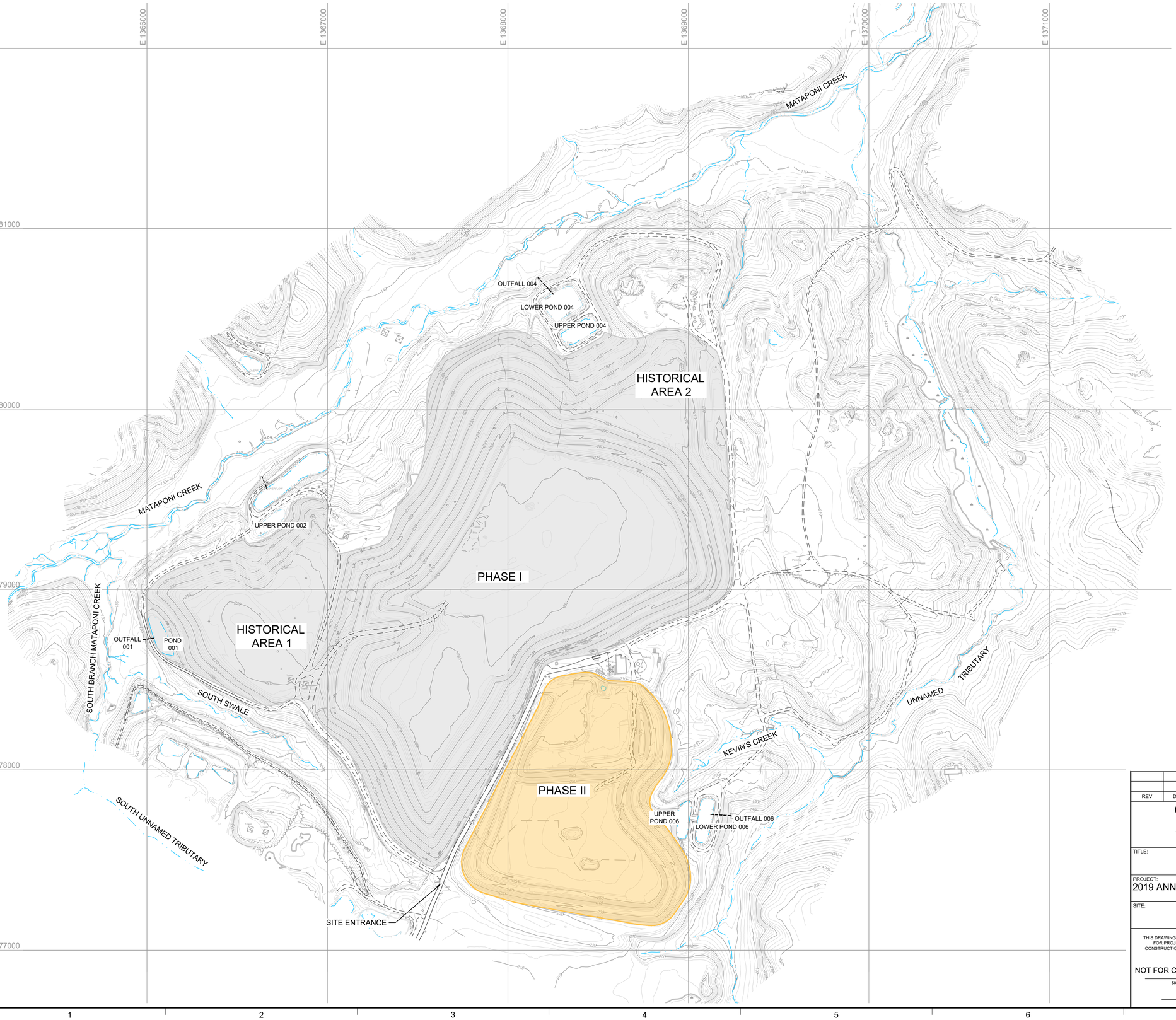
Columbia, Maryland | January 2020

Figure 1

Path: P:\GIS\NRG\GeoOnx\Maps\Brandywine\Apdg Fig. 1-1 BrandywineTopo.mxd; mw; RDW; 03-Apr-2015



LEGEND

- PROPERTY BOUNDARY (NOTE 3)
- ADJACENT PROPERTY BOUNDARY (NOTE 3)
- GRADE CONTOUR (FEET, MSL)
- PAVED / UNPAVED ROAD
- BUILDING
- WATER / CHANNEL LINE
- WET AREA
- NPDES OUTFALL
- CCB MANAGEMENT UNITS NOT REGULATED UNDER THE CCR RULE (APPROXIMATE LIMITS)
- CCB MANAGEMENT UNIT REGULATED BY THE CCR RULE (APPROXIMATE LIMITS)

NOTES:

1. EXISTING CONDITIONS FROM GROUND CONTROL SURVEY DATED 28 DECEMBER 2013 BY L. ROBERT KIMBALL INC. AND FROM AERIAL PHOTOGRAPHY DATED 13 DECEMBER 2012 BY AIR PHOTOGRAPHICS INC.
2. HORIZONTAL CONTROL IS BASED ON NAD83 MARYLAND STATE PLANE DATUM; VERTICAL CONTROL IS BASED ON NAVD88 DATUM.
3. PROPERTY BOUNDARIES ACCESSED VIA TOWSON UNIVERSITY'S ArcGIS SERVER AT HTTP://MDIMAP.TOWSON.EDU/ARCGIS/SERVICES ON 26 AUGUST 2014.

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SCALE IN FEET

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COLUMBIA MARYLAND 21044 USA
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TITLE: SITE FEATURES MAP

PROJECT: 2019 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT FEDERAL CCR RULE

SITE: BRANDYWINE ASH MANAGEMENT FACILITY, PHASE II
BRANDYWINE, MARYLAND

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CHECKED BY:	KWH	FILE:	FIG 2
REVIEWED BY:	MB	FIGURE NO.:	2
APPROVED BY:	RMG		

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- PROPERTY BOUNDARY (NOTE 3)
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- WET AREA
- NPDES OUTFALL
- EXISTING PIEZOMETER
- MONITORING WELL USED FOR WATER LEVELS ONLY
- BACKGROUND MONITORING WELL
- COMPLIANCE MONITORING WELL
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TITLE: GROUNDWATER MONITORING WELL NETWORK

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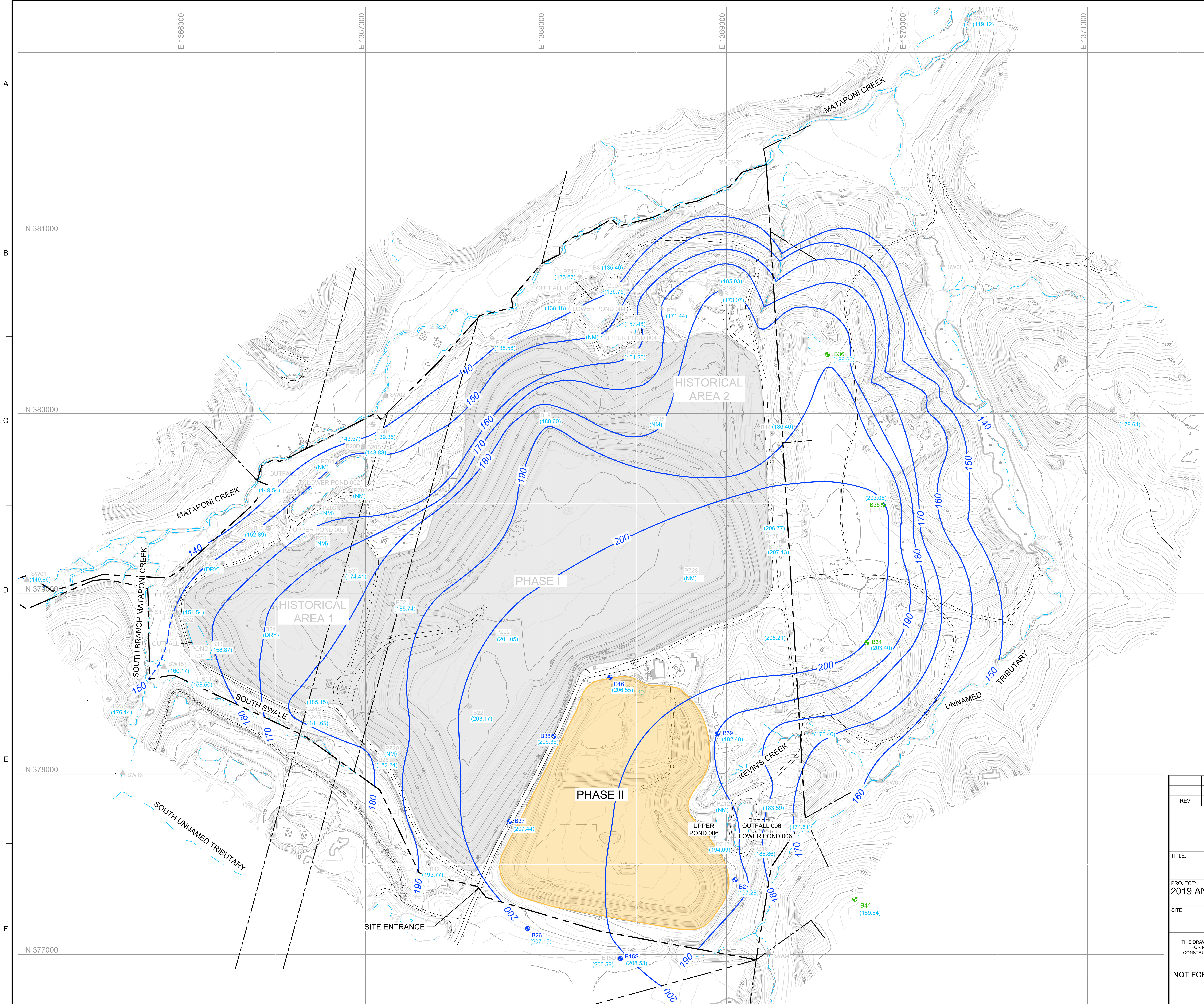
CHECKED BY:	KWH	FILE:	FIG 3
REVIEWED BY:	MB	FIGURE NO.:	
APPROVED BY:	RMG		3



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LEGEND

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- ADJACENT PROPERTY BOUNDARY (NOTE 3)
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- PAVED / UNPAVED ROAD
- BUILDING
- WATER / CHANNEL LINE
- WET AREA
- NPDES OUTFALL
- EXISTING PIEZOMETER
- MONITORING WELL USED FOR WATER LEVELS ONLY
- SURFACE WATER STATION USED FOR WATER LEVELS ONLY
- BACKGROUND MONITORING WELL
- COMPLIANCE MONITORING WELL
- 200 — POTENTIOMETRIC SURFACE CONTOUR (NOTE 4)
- INFERRED POTENTIOMETRIC SURFACE CONTOUR
- (202.43) GROUNDWATER ELEVATION (FEET-MSL) (NOTE 4)
- (204.11) GROUNDWATER ELEVATION (FEET-MSL) (NOTE 4, 5)
- (NM) NOT MEASURED
- CCB MANAGEMENT UNITS NOT REGULATED UNDER THE CCR RULE (APPROXIMATE LIMITS)
- CCB MANAGEMENT UNIT REGULATED BY THE CCR RULE (APPROXIMATE LIMITS)

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3. PROPERTY BOUNDARIES ACCESSED VIA TOWSON UNIVERSITY'S ARCGIS SERVER AT HTTP://MDIMAP.TOWSON.EDU/ARCGIS/SERVICES ON 26 AUGUST 2014.
4. GROUNDWATER ELEVATION DATA FROM SYNOPTIC WATER LEVEL MEASUREMENTS ON 5 FEBRUARY 2019.
5. ELEVATION OF GROUNDWATER IN THIS DEEP WELL WAS NOT USED DEVELOP THE POTENTIOMETRIC SURFACE.

0 250' 500'
SCALE IN FEET

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TITLE:
GROUNDWATER POTENTIOMETRIC SURFACE - FEBRUARY 2019

PROJECT:
2019 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT
FEDERAL CCR RULE

SITE:
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CHECKED BY:	MAH	FILE:	FIG 4
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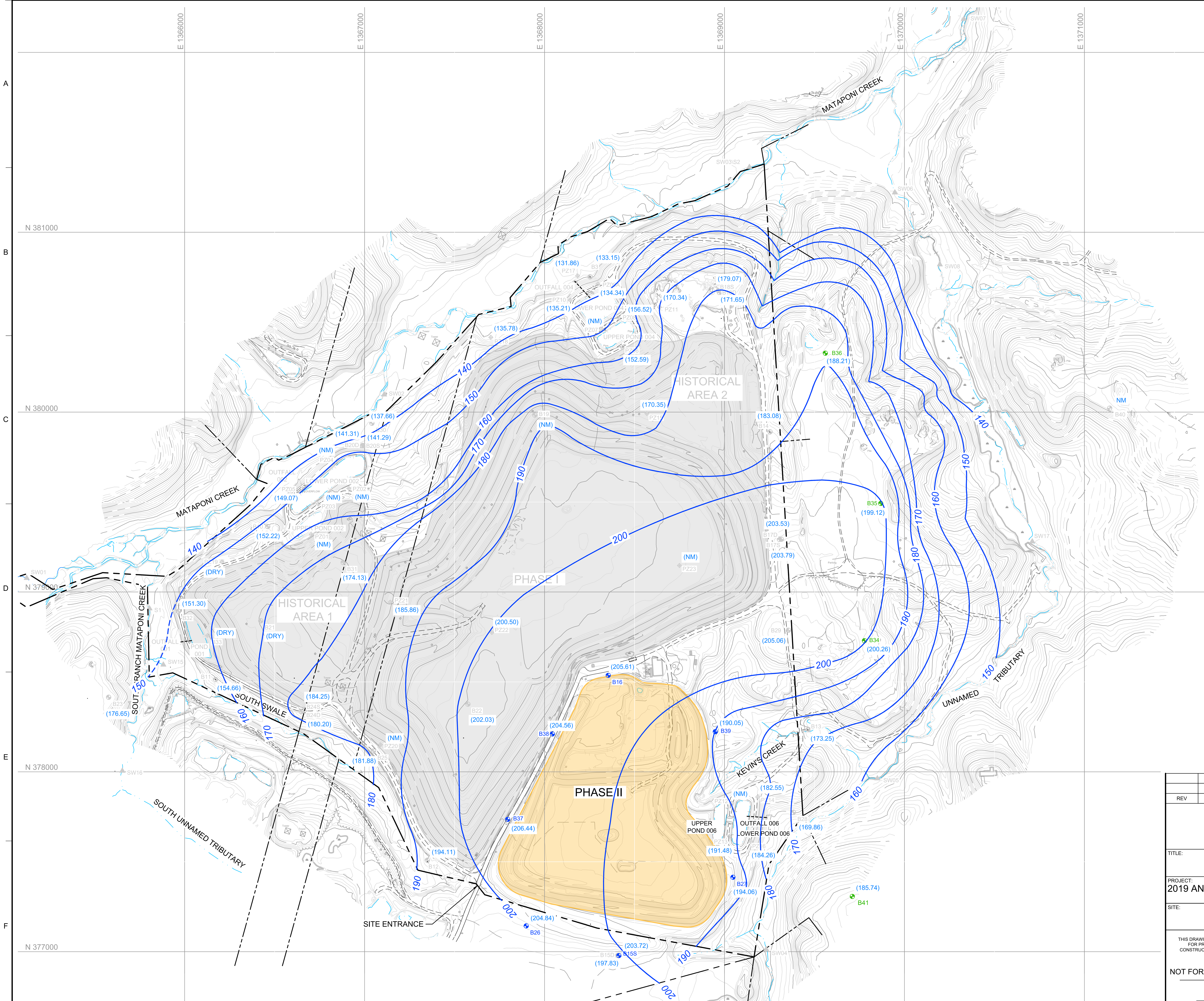

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LEGEND

- PROPERTY BOUNDARY (NOTE 3)
- ADJACENT PROPERTY BOUNDARY (NOTE 3)
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- 200 POTENTIOMETRIC SURFACE CONTOUR (NOTE 4)
- INFERRED POTENTIOMETRIC SURFACE CONTOUR
- (202.43) GROUNDWATER ELEVATION (FEET-MSL) (NOTE 4)
- CCB MANAGEMENT UNITS NOT REGULATED UNDER THE CCR RULE (APPROXIMATE LIMITS)
- CCB MANAGEMENT UNIT REGULATED BY THE CCR RULE (APPROXIMATE LIMITS)

NOTES:

1. EXISTING CONDITIONS FROM GROUND CONTROL SURVEY PERFORMED BY BEN DYER AND ASSOCIATES, INC. WEEK OF 19 OCTOBER 2015. AND FROM AERIAL PHOTOGRAPHY DATED 13 DECEMBER 2012 BY AIR PHOTOGRAPHICS INC.
2. HORIZONTAL CONTROL IS BASED ON NAD83 MARYLAND STATE PLANE DATUM; VERTICAL CONTROL IS BASED ON NAVD88 DATUM.
3. PROPERTY BOUNDARIES ACCESSED VIA TOWSON UNIVERSITY'S ARCGIS SERVER AT HTTP://MDIMAP.TOWSON.EDU/ARCGIS/SERVICES ON 26 AUGUST 2014.
4. GROUNDWATER ELEVATION DATA FROM SYNOPTIC WATER LEVEL MEASUREMENTS ON 20 AUGUST 2019.
5. ELEVATION OF GROUNDWATER IN THIS DEEP WELL WAS NOT USED DEVELOP THE POTENTIOMETRIC SURFACE.

0 250' 500'
SCALE IN FEET

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APPROVED BY:	MAJ		

TABLES

TABLE 1
WELL CONSTRUCTION DETAILS

FEDERAL CCR RULE - 2019 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT
Brandywine Ash Management Facility, Phase II - MD

Well ID	Compliance / Background	Permit Number	Installation Date	Northing (feet) Maryland State Plane 1900 NAD 1983	Easting (feet) Maryland State Plane 1900 NAD 1983	Ground Surface Elevation (ft msl)	Top of Casing Elevation (ft msl)	Inner Casing Diameter (inches)	Top of Sand Pack (ft bgs)	Screen Interval (ft bgs)	Screen Length (feet)	Screen Slot Size (inch)
B15S	Compliance	PG-11-0414	10/20/2015	376978.815	1368413.012	212.71	214.95	2	6.0	7.75 - 17.75	10	0.010
B16	Compliance	PG-11-0431	6/2/2015	378557.6383	1368348.641	233.73	236.11	2	23.5	24.75 - 34.75	10	0.010
B26	Compliance	PG-11-0416	10/21/2015	377144.555	1367902.054	216.00	218.41	2	14.0	16.75 - 26.75	10	0.010
B27	Compliance	PG-11-0417	6/3/2015	377411.8764	1369043.668	212.05	214.77	2	13.0	14.75 - 24.75	10	0.010
B34	Background	PG-11-0437	6/9/2015	378729.3841	1369777.659	212.73	215.34	2	8.0	10.00 - 20.00	10	0.010
B35	Background	PG-11-0438	6/9/2015	379488.9853	1369866.212	204.31	206.82	2	5.0	7.00 - 17.00	10	0.010
B36	Background	PG-11-0439	6/18/2015	380323.7961	1369560.447	204.25	206.68	2	7.6	9.75 - 19.75	10	0.010
B37	Compliance	PG-11-0461	8/12/2015	377761.92	1367808.354	220.29	220.23	2	17.5	19.75 - 29.75	10	0.010
B38	Compliance	PG-11-0460	8/12/2015	378210.411	1368043.469	233.59	233.66	2	27.5	29.75 - 39.75	10	0.010
B39	Compliance	PG-11-0462	8/10/2015	378222.643	1368948.299	200.56	202.71	2	8.5	10.75 - 20.75	10	0.010
B41	Background	PG-14-0171	9/16/2016	377307.030	1369709.911	209.00	211.50 [1]	2	18.0	20.00 - 30.00	10	0.010

Notes:

ft msl feet above mean sea level

ft bgs feet below ground surface

Professional land survey performed week of 19 October 2015 by Ben Dyer and Associates, Inc.

[1] Elevation is an estimated value

TABLE 2
SUMMARY OF 2015-2019 MONITORING EVENTS

FEDERAL CCR RULE - 2019 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT
Brandywine Ash Management Facility, Phase II - MD

Monitoring Program:	Baseline Monitoring																			
Monitoring Event:	3Q 2015			4Q 2015			1Q 2016			2Q 2016			3Q 2016			4Q 2016			1Q 2017		
Sample Date:	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17
Well ID																					
Background Wells																					
B34													III,IV [1,2]					III,IV	III,IV		III,IV
B35													III,IV [1,2]					III,IV	III,IV	III,IV	
B36													III,IV [1,2]					III,IV	III,IV		III,IV
B41													[4]			III,IV [1,2]	[3]	III,IV [1]		III,IV [1,2]	III,IV
Compliance Wells																					
B15S		[4]			III,IV			III,IV		III,IV			III,IV			III,IV			III,IV		
B16		III,IV [2]			III,IV		III,IV			III,IV			III,IV			III,IV			III,IV [1]		
B26		[4]			III,IV			III,IV		III,IV			III,IV			III,IV			III,IV		
B27		III,IV			III,IV		III,IV			III,IV			III,IV			III,IV			III,IV		
B37		III,IV			III,IV		III,IV			III,IV			III,IV			III,IV				III,IV	
B38		III,IV			III,IV		III,IV			III,IV			III,IV			III,IV				III,IV	
B39		III,IV			III,IV			III,IV		III,IV			III,IV			III,IV				III,IV	

Monitoring Program:	Baseline Monitoring							Detection Monitoring												
Monitoring Event:	2Q 2017			3Q 2017			Total Baseline Sampling Events [5]	4Q 2017			1Q 2018			2Q 2018			3Q 2018			4Q 2018		
Sample Date:	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17		Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-19	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
Well ID																						
Background Wells																						
B34	III,IV	III,IV	III,IV	III,IV	III,IV		≥8	III							III			III				
B35	III,IV	III,IV	III,IV	III,IV	III,IV		≥8	III						III				III				
B36	III,IV	III,IV	III,IV	III,IV	III,IV		≥8	III							III			III				
B41	III,IV	III,IV	III,IV	III,IV	III,IV		≥6	III							III			III				
Compliance Wells																						
B15S	III,IV			III,IV			8	III							III			III				
B16	III,IV						8	III						III			III					
B26	III,IV			III,IV			8	III							III			III				
B27	III,IV						8	III							III			III				
B37	III,IV						8	III							III			III				
B38	III,IV						8	III							III			III				
B39	III,IV						8	III							III			III				

TABLE 2
SUMMARY OF 2015-2019 MONITORING EVENTS

FEDERAL CCR RULE - 2019 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT
Brandywine Ash Management Facility, Phase II - MD

Monitoring Program:	Detection Monitoring												
Monitoring Event:	1Q 2019			2Q 2019			3Q 2019			4Q 2019			Total Detection Sampling Events
Sample Date: / Well ID	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	
Background Wells													
B34		III						III					5
B35		III						III					5
B36		III						III					5
B41		III						III					5
Compliance Wells													
B15S		III						III					5
B16		III						III					5
B26		III						III					5
B27		III						III					5
B37		III						III					5
B38		III						III					5
B39		III						III					5

Notes:

III Groundwater samples collected for laboratory analysis of Appendix III parameters.
IV Groundwater samples collected for laboratory analysis of Appendix IV parameters.
[1] Radium was omitted from sampling or the well went dry before sampling of these parameters could be completed.
[2] Fluoride was omitted from analysis.
[3] Monitoring well was dry at the time of sampling, no samples were collected.
[4] Monitoring well not yet installed.
[5] All background and compliance monitoring wells met the minimum number of samples collected, except for B41, which went dry during sampling and only a partial sample set was collected over nine sampling events, which resulted in 6 complete sample sets.

TABLE 3
2019 GROUNDWATER ELEVATION MEASUREMENTS

FEDERAL CCR RULE - 2019 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT
Brandywine Ash Management Facility, Phase II - MD

Well ID	Top of Casing Elevation (ft msl)	Depth to Water Measurement Date	Depth to Water (ft btoic)	Groundwater Elevation (ft msl)
B15S	214.95	2/5/2019	6.42	208.53
		8/20/2019	11.23	203.72
B16	236.11	2/5/2019	29.56	206.55
		8/20/2019	30.50	205.61
B26	218.41	2/5/2019	11.26	207.15
		8/20/2019	13.57	204.84
B27	214.77	2/5/2019	17.49	197.28
		8/20/2019	20.71	194.06
B34	215.34	2/5/2019	11.94	203.40
		8/20/2019	15.08	200.26
B35	206.82	2/5/2019	3.77	203.05
		8/20/2019	7.70	199.12
B36	206.68	2/5/2019	17.02	189.66
		8/20/2019	18.47	188.21
B37	220.23	2/5/2019	12.79	207.44
		8/20/2019	13.79	206.44
B38	233.66	2/5/2019	27.30	206.36
		8/20/2019	29.10	204.56
B39	202.71	2/5/2019	10.31	192.40
		8/20/2019	12.66	190.05
B41	211.50 [1]	2/5/2019	21.86	189.64
		8/20/2019	25.76	185.74

Notes:

ft bgs feet below ground surface
ft msl feet above mean sea level
ft btoic feet below top of inner case
NM Not measured
NA Not Available
[1] Top of casing elevation is estimated value based on ground elevation.

TABLE 4
APPENDIX III ANALYTICAL DATA - BACKGROUND WELLS

FEDERAL CCR RULE - 2019 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT
Brandywine Ash Management Facility, Phase II - MD

	Analyte:	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	TDS
Well ID	**Sample Date**	µg/L	mg/L	mg/L	mg/L	S.U.	mg/L	mg/L
B34	5/2/2018	<10.1 U	0.639	3.6	<0.25 U	5.2	7.2	49.0 J
	8/3/2018	13.4 J	2.4	2.4	<0.25 U	5.4	6.4	54.0 J
	8/3/2018 [1]	19.3 J	2.34	2.2	NS	NS	6.4	52.5 J
	2/6/2019	12.1 J	1.69	1.4 J	<0.25 U	5.5	14.5	46.5 J
	8/26/2019	<9.9 U	0.362 J	2.5	<0.25 U	5.4	5.4	28.5 J
	8/26/2019 [1]	<9.9 U	0.332 J	2.4	<0.25 U	5.7	5.2	21.0 J
B35	4/30/2018	<10.1 U	2.4	2.9	<0.25 U	5.6	10.7	37.0 J
	8/2/2018	<12.0 U	1.94	3.4	<0.25 U	5.4	7.0	39.0 J
	2/6/2019	<12.0 U	2.1	2.8	<0.25 U	5.7	6.8	34.5 J
	8/26/2019	<9.9 U	1.82	3.6	<0.25 U	5.7	6.2	37.0
B36	5/1/2018	15.3 J	4.75	7.0	<0.25 U	5.1	4.7 J	86.5
	8/6/2018	<12.0 U	5.40	7.1	<0.25 U	4.7	16.1	75.5
	2/11/2019	21.1 J	4.95	6.5	<0.25 U	5.5	5.3	67.0
	8/22/2019	13.9 J	4.83	8.1	<0.25 U	4.5	8.5	66.5
B41	5/1/2018	<10.1 U	2.93	6.0	<0.25 U	6.0	<1.50 U	47.5 J
	8/6/2018	<12.0 U	4.79	4.7	<0.25 U	3.4 [2] J	21.9	66.0
	2/11/2019	12.2 J	2.74	8.3	<0.25 U	6.7	9.5	51.0 J
	8/22/2019	<9.9 U	1.0	4.7	<0.25 U	5.9	<1.5 U	37.0

Notes:

µg/L micrograms per Liter
mg/L milligrams per Liter
S.U. Standard Units
J Constituent detected below reportable quantitation limit; result is an estimated value.
U Constituent not detected above method detection limit.
N.D. Non-Detect
NS Not Sampled
[1] Duplicate sample collected.
[2] Result is suspected to be erroneous.

TABLE 5
APPENDIX III INTRA-WELL STATISCAL BACKGROUND CONCENTRATIONS

FEDERAL CCR RULE - 2019 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT
Brandywine Ash Management Facility, Phase II - MD

Analyte:	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	TDS
Well ID	µg/L	mg/L	mg/L	mg/L	S.U.	mg/L	mg/L
B15S	43.4	5.58	12.4	DQR [1]	3.84 - 6.71	41.7	121
B16	59,057	497	2,950	DQR [1]	5.76 - 7.48	791 [2]	16,227
B26	124	11.7	20.6	DQR [1]	4.20 - 5.90	62.9	213
B27	1,494	59.6	233	0.47	4.87 - 8.40	654	1,247
B37	4,011	213	32.9 [2]	2.21	2.90 - 5.87	779	2,559
B38	27,194	566	810	1.04	4.08 - 9.01	2,540	5,185
B39	1,346 [2]	188	59.8 [2]	2.87	2.01 - 4.20	184 [2]	364 [2]

Notes:

µg/L micrograms per Liter
mg/L milligrams per Liter
S.U. Standard Units
[1] Fluoride at wells B15S, B16, and B26 follows the Double Quantification Rule (DQR).
[2] The background value is the Upper Prediction Limit (UPL) for the residuals of the background dataset. To identify SSIs, the UPLs are compared to the residuals of the detection monitoring results based on the linear regression for the background dataset.

TABLE 6
APPENDIX III STATISTICALLY SIGNIFICANT INCREASES (SSIs)
FEDERAL CCR RULE - 2019 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT
Brandywine Ash Management Facility, Phase II - MD

Analyte:		Boron	Calcium	Chloride	Fluoride	pH	Sulfate	TDS
		µg/L	mg/L	mg/L	mg/L	S.U.	mg/L	mg/L
Well ID	**Background:**	**43.4**	**5.58**	**12.4**	**DQR [3]**	**3.84 - 6.71**	**41.7**	**121**
B15S	5/2/2018	14.1 J	1.84	5.4	0.50 U	5.5	16.7	59.5 J
	5/2/2018 [1]	14.5 J	1.81	5.5	0.50 U	5.5	16.8	68.0
	8/1/2018	36.4 J	1.60	4.8	0.31 J	5.7	15.0	60.5
	2/6/2019	13.6 J	2.18	3.6	0.50 U	5.7	30.2	77.0
	8/23/2019	18.9	1.17	3.8	0.50 U	6.0	9.1	44.0
	Background:	**59,057**	**497**	**2,950**	**DQR**	**5.76 - 7.48**	**791 [2]**	**16,227**
B16	4/30/2018	58,200	426	1,870	0.50 U	6.7	1,032 [4]	13,400
	7/31/2018	53,500	385	1,850	0.50 U	6.9	1,997 [4]	13,400
	2/11/2019	56,100	307	1,850	100 U	7.3	207	13,500
	8/22/2019	40,900	199	1,380	0.50 U	7.2	-1,709	10,900
	Background:	**124**	**11.7**	**20.6**	**DQR**	**4.20 - 5.90 [5]**	**62.9**	**213**
B26	5/1/2018	22.3 J	4.45	10.0	0.50 U	5.2	12.1	67.5
	8/1/2018	18.6 J	4.85	9.9	0.50 U	5.2	13.4	59.0 J
	2/6/2019	12.0 U	4.62	9.4	0.50 U	5.5	13.4	69.0
	8/23/2019	31.7 J	4.97	8.8	0.50 U	5.3	12.3	55.0
	Background:	**1,494**	**59.6**	**233**	**0.47**	**4.87 - 8.40**	**654**	**1,247**
B27	5/1/2018	665	53.9	23.4	0.50 U	7.0	74.1	419
	8/2/2018	547	41.4	13.4	0.50 U	7.1	53.7	306
	2/7/2019	261	26.8	5.8	0.50 U	6.9	44.1	197
	8/22/2019	593	98.7 [6]	35.2	0.50 U	7.0	285	824
	Background:	**4,011**	**213**	**32.9 [2]**	**2.21**	**2.90 - 5.87**	**779**	**2,559**
B37	5/1/2018	1,430	90.2	6.5	0.61	5.0	422	964
	8/3/2018	899	56.1	-52.1	0.39 J	5.2	197	512
	2/8/2019	1,400	77.4	-44.3	0.50 U	4.7	437	802
	8/22/2019	2,020	104	19.2	1.20	4.2	672	1,240
	Background:	**27,194**	**566**	**810**	**1.04**	**4.08 - 9.01**	**2,540**	**5,185**
B38	5/1/2018	14,000	421	248	0.50 J	6.4	2,390	3,260
	8/3/2018	14,400	341	225	0.50 J	6.8	2,360	3,270
	2/8/2019	15,000	351	284	0.50 U	6.1	2,210	3,690
	8/22/2019	18,700	429	224	0.50 U	6.1	2,150	3,180
	Background:	**1,346 [2]**	**188**	**59.8 [2]**	**2.87**	**2.01 - 4.20**	**184 [2]**	**364 [2]**
B39	5/1/2018	-1,114	107	-88.4	0.50 U	3.1 J	-393	288
	5/1/2018 [1]	-1,044	105	-78.4	0.50 U	3.2 J	-393	-252
	8/3/2018	-2,497	60.3	-275	0.50 U	2.7 J	-470	-1,047
	2/8/2019	-3,477	76.0	-207	0.50 U	3.1 J	-1,024	-957
	8/23/2019	-1,606	96.1	-166	0.50 U	3.1 J	-644	-231

Notes:

Concentration is a statistically significant increase (SSI) over background.

µg/L micrograms per Liter

mg/L milligrams per Liter

S.U. Standard Units

J Constituent detected below reportable quantitation limit; result is an estimated value.

U Constituent not detected above method detection limit; result shown as the reporting limit.

[1] Duplicate sample collected.

[2] For datasets that exhibited upward trends, the background value is the Upper Prediction Limit (UPL) for the residuals of the background dataset. To identify SSIs, the UPLs are compared to the residuals of the detection monitoring results based on the linear regression for the background dataset. In some cases, the values are negative and indicate a decrease.

[3] Fluoride at wells B15S, B16, and B26 follows the Double Quantification Rule (DQR).

[4] Alternate Source Demonstration successful.

[5] For nonparametric pH distributions, the nonparametric prediction limits are the minimum and maximum background concentration (Unified Guidance, 2009, p. 18.16).

[6] An alternate source demonstration is currently underway.

APPENDIX A

Groundwater Flow Velocity Calculation

Appendix A

Groundwater Velocity Calculation

Brandywine Ash Management Facility Phase II

Brandywine, Maryland

1. Governing Equation

Groundwater flow velocity at the Site was calculated between several monitoring wells around Phase II. The calculations were performed using the following equation.

$$V_{\eta} = \frac{K}{\eta} \times \frac{\Delta h}{\Delta l}$$

Where:

V_{η} = Groundwater velocity (cm per second)
K = Hydraulic conductivity estimated through aquifer slug tests (cm per second)
η = Effective porosity % (unitless)
Δh = Change in groundwater elevation between two points (ft)
Δl = Distance between two points (ft)

This equation is for Darcy flow through porous media.

2. Hydraulic Conductivity Estimated

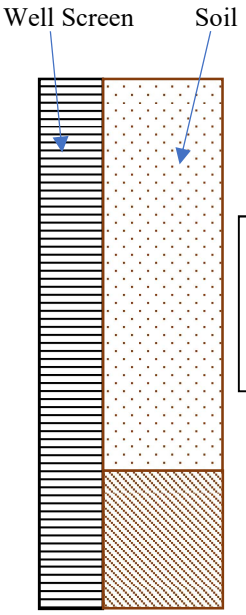
Hydraulic conductivity (*K*) was calculated at select monitoring wells around Phase II. Monitoring wells B15S, B16, B26, B27, and B28 were slug tested at least two times (rising and falling head tests). The location of the slug tested wells are shown on **Figure 3**. The *K* value for each slug test at a given well was averaged, which generated an average *K* for each monitoring well. *K* values are presented in **Table A-1**. The average of the K value between two monitoring wells is presented in **Table A-2**.

3. Average Porosity

As shown in **Table A-1**, each monitoring well has an average porosity (η) calculated for each screen interval. The averaged η values were obtained from *Groundwater and Wells, Second Edition, Driscoll* [Driscoll, 1986]. A range for η is presented in [Driscoll, 1986] and the average for each η range was used in the calculation. The published η values and the calculated average η values are presented in **Table A-1**.

The averaged η value was then used to estimate an η value for each screen based on the geology observed during the well installation. See diagram below to see how η was estimated for each monitoring well screen.

EXAMPLE POROSITY ESTIMATION FOR WELL SCREEN



$$Average\ \eta\ of\ the\ well\ screen = (\eta_{SP} \times 0.8) + (\eta_{ML} \times 0.2)$$

$$Average\ \eta\ of\ the\ well\ screen = (32.5_{SP} \times 0.8) + (42.5_{ML} \times 0.2)$$

$$Average\ \eta\ of\ the\ well\ screen = (26) + (8.5)$$

$$Average\ \eta\ of\ the\ well\ screen = 34.5\%$$

The top 8 feet of the screen is screened in sand (SP). The average η of SP is 32.5%.

The bottom 2 feet of the screen is screened in silt (ML). The average η of ML is 42.5%.

Boring logs were provided in *Basis for Groundwater Monitoring Network* [Geosyntec, 2017a].

After the average η value was calculated for each well screen, the average of the η values between the two monitoring wells along a groundwater flow path was calculated. See **Table A-1** for the calculated average η for each monitoring well screen. The average η value between the two monitoring wells was then used to calculate the groundwater velocity. Average η value between monitoring wells is presented in **Table A-2**.

4. Monitoring Well Selection

To estimate groundwater velocity, monitoring wells upgradient and downgradient of Phase II were selected. Ideally, monitoring wells should be along a groundwater flow path. Based on that requirement, the groundwater velocity was calculated between B16 to B27, B16 to B28, B26 to B27, and B26 to B28. See **Figure 3** to **Figure 5** for the selected well locations relative to groundwater flow.

5. Groundwater Velocity

Groundwater velocity around Phase II ranged from 1.59 X 10^{-4} centimeters per second (cm/sec) (165 inches/month) between monitoring wells B16 and B28 to 5.12 X 10^{-6} cm/sec (5.4 inches/month) between monitoring wells B26 and B27. The average groundwater velocity around Phase II was calculated at 3.07 X 10^{-5} cm/sec (32 inches/month). **Table A-2** of **Appendix A** presents the calculated groundwater velocities. Therefore, to be considered independent samples, groundwater monitoring events should be at least two (2) weeks apart for groundwater to completely travel through the 8-inch diameter borehole.

APPENDIX A
TABLE A-1
Groundwater Flow Velocity Variables

Brandywine CCR Management Facility Phase II
Brandywine, Maryland

Groundwater Velocity Equation

$$V_{\eta} = \frac{K}{\eta} \times \frac{\Delta h}{\Delta l}$$

V_{η} = linear groundwater velocity (cm/sec)
K = hydraulic conductivity (cm/sec)
η = effective porosity (unitless)
Δh = change in head between wells (ft)
Δl = distance between wells (ft)

Upgradient Well	Downgradient Well	Δl (ft)	Δh (ft)
B16	B27	1,315	9.84
B16	B28	1,270	32.06
B26	B27	1,172.5	10.15
B26	B28	1,612.5	32.37

Well ID:	Average Hydraulic Conductivity (K) (cm/sec) [1]
B16	2.81E-03
B26	5.50E-06
B27	3.85E-04
B28	8.17E-04

Well Location	Soil Observed in the Screen	Average η of Screen
B16	(SP/GP) (75%),(SP/ML) (25%)	24.5
B26	ML 100%	42.5
B27	ML/SP 50% and CL/SP 50%	39.4
B28	SP/CL 100%	41.3

Sediment Size	Effective Porosity % (η)	Average η [2]
Clay (CL)	45-55	50
Silt (ML)	35-50	42.5
Sand (SP)	25-40	32.5
Gravel (GP)	25-40	32.5
Sand and Gravel (SP/GP)	10-35	22.5

Notes:
ft - feet
cm/sec - centimeters per second
[1] Average hydraulic conductivity is an average result of the falling and rising head slug tests.
[2] Average effective porosity is an average of the published effective porosities for each soil type.
[3] Δl values were calculated from groundwater elevation measurements collected on 31 July 2018.

APPENDIX A
Table A-2
Groundwater Flow Velocity Calculation

Brandywine CCR Management Facility Phase II
Brandywine, Maryland

Upgradient Well	Downgradient Well	Hydraulic Conductivity (K) (cm/sec)	Average Porosity of Screen Interval (%)	DTW (ft btoic) [1]	TOC Elevation	Groundwater Elevation (ft-msl)	Average K (cm/sec) [2]	Average η	Δ h (ft)	Δ l (ft)	Δ h/Δ l	Linear Velocity (cm/sec)	Linear Velocity (inches/month)
B16	B27	3.85E-04	39.4	18.06	214.77	196.71	1.60E-03	0.3195	9.84	1,315	0.0075	**3.74E-05**	**38.71**
B16	B28	8.17E-04	41.3	5.29	179.78	174.49	1.81E-03	0.329	32.06	1,270	0.0252	**1.39E-04**	**143.97**

Upgradient Well	Downgradient Well	Hydraulic Conductivity (K) (cm/sec)	Average Porosity of Screen Interval (%)	DTW (ft btoic)	TOC Elevation	Groundwater Elevation (ft-msl)	Average K (cm/sec) [1]	Average η	Δ h (ft)	Δ l (ft)	Δ h/Δ l	Linear Velocity (cm/sec)	Linear Velocity (inches/month)
B26	B27	3.85E-04	39.4	18.06	214.77	196.71	1.95E-04	0.4095	10.15	1,173	0.0087	**4.13E-06**	**4.27**
B26	B28	8.17E-04	41.3	5.29	179.78	174.49	4.11E-04	0.419	32.37	1,613	0.0201	**1.97E-05**	**20.39**

Groundwater Velocity Equation

$$V_{\eta} = \frac{K}{\eta} \times \frac{\Delta h}{\Delta l}$$

Groundwater Velocity Mean	**2.55E-05**	**cm/sec**	**26.39**	**inches/month**
Groundwater Velocity Median	**2.86E-05**	**cm/sec**	**29.55**	**inches/month**

V_{η} = linear groundwater velocity
K = hydraulic conductivity (cm/sec)
η = effective porosity (unitless)
Δh = change in head between wells (ft)
Δl = distance between wells (ft)
[1] Groundwater flow velocities were calculated form groundwater elevation measurements collected on 31 July 2018.
[2] Average hydraulic conductivity is the average hydraulic conductivities between B16 or B26 and identified well.