INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN

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Chesapeake Energy Center CCR Surface Impoundment: Bottom Ash Pond

Submitted To: Chesapeake Energy Center
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1.0 CERTIFICATION

This Inflow Design Flood Control System Plan for the Chesapeake Energy Center's Bottom Ash Pond was prepared by Golder Associates Inc. (Golder). The document and Certification/Statement of Professional Opinion are based on and limited to information that Golder has relied on from Dominion and others, but not independently verified, as well as work products produced by Golder.

On the basis of and subject to the foregoing, it is my professional opinion as a Professional Engineer licensed in the Commonwealth of Virginia that this document has been prepared in accordance with good and accepted engineering practices as exercised by other engineers practicing in the same discipline(s), under similar circumstances, at the same time, and in the same locale. It is my professional opinion that the document was prepared consistent with the requirements in §257.82 of the United States Environmental Protection Agency's "Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments," published in the Federal Register on April 17, 2015, with an effective date of October 19, 2015 (40 CFR §257.82), as well as with the requirements in §257.100 resulting from the EPA's "Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals From Electric Utilities; Extension of Compliance Deadlines for Certain Inactive Surface Impoundments; Response to Partial Vacatur" published in the Federal Register on August 5, 2016 with an effective date of October 4, 2016 (40 CFR §257.100).

The use of the word "certification" and/or "certify" in this document shall be interpreted and construed as a Statement of Professional Opinion, and is not and shall not be interpreted or construed as a guarantee, warranty, or legal opinion.

Daniel McGrath
Print Name

Associate and Senior Consultant
Title

Daniel McGrath
Signature

4/12/18
Date

2.0 INTRODUCTION

This Inflow Design Flood Control System (FCS) Plan was prepared for the Chesapeake Energy Center's (CEC) inactive Coal Combustion Residuals (CCR) surface impoundment known as the Bottom Ash Pond (BAP). This FCS Plan was prepared in accordance with 40 CFR Part §257, Subpart D and is consistent with the requirements of 40 CFR §257.82.

The CEC, owned and operated by Virginia Electric and Power Company d/b/a Dominion Energy Virginia (Dominion), is located in the City of Chesapeake, Virginia at 2701 Vepco Street. The CEC includes an existing, inactive CCR surface impoundment, the BAP, as defined by the Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule and Direct Final Rule (40 CFR §257; the CCR rule). This FCS Plan has been developed based on the existing BAP topography as of January 15, 2018.

3.0 INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN

3.1 Hazard Potential Classification

As indicated in Golder's *Hazard Potential Classification Assessment*, the BAP is assigned a "Significant" hazard potential rating per 40 CFR §257.73.

3.2 Inflow Design Flood

According to 40 CFR §257.82(a)(3)(ii), a hazard potential rating of Significant requires an evaluation of the 1000-year storm event. Per the NOAA Atlas-14, provided in Appendix A, the 1000-year event rainfall total for the 24-hour duration is 14.6 inches.

3.3 Inflow and Outflow Control

Inflow to the BAP is primarily stormwater runoff from the adjacent inactive CCR landfill, totaling approximately 23.1 acres of contributing area. The majority of stormwater arrives at the BAP in the northeast corner from the eastern perimeter channel. Other than maintaining pre-established runoff control measures on the landfill, there are no inflow control measures proposed.

The BAP's primary outlet for stormwater is a 30-inch corrugated high-density polyethylene (CHDPE) pipe installed in the western embankment. This pipe drains to the adjacent existing sedimentation basin. The BAP normally does not maintain a pool of water due to the free-draining nature of the bottom ash, for which a small allowance has been made in the hydraulic model. The stage-storage curve for the BAP was developed using the January 15, 2018 topography, and shows that the BAP has approximately 13 acre-feet of available water storage volume at the embankment crest.

The BAP stormwater system was modeled in the U.S. Army Corps of Engineers Hydrologic Engineering Center's Hydraulic Modeling System (HEC-HMS), and the analysis is included in Appendix B. The analysis was conducted using the 24-hour, 1,000-year event, which was modeled as 14.6 inches of rain Based on this analysis, the BAP inflow design flood control system is capable of adequately managing the inflow from the 1,000-year event without overtopping the embankment, and has adequate spillway capacity to manage the resulting outflow.

The following table summarizes the results of the HEC-HMS analysis for the 1,000-Yr storm event.

Table 1: CEC HEC-HMS Output

Bottom Ash Pond				Sedimentation Basin		
Q_{in} (CFS)	Max Hw (Ft El*)	Primary Q_{out} (CFS)	BA Infiltration (CFS)	Q_{in} (CFS)	Max Hw (Ft El*)	Q_{out} (CFS)
309.9	19.04	41.0	6.0	245.9	13.75	28.8

* Top of berm elevation = 20.0 feet

4.0 CONCLUSIONS

Through work performed by Golder, both field inspection and document review, it is our opinion that the BAP inflow design flood control system has sufficient capacity for the 1000-year storm event, as required by 40 CFR §257.82.

APPENDIX A

Precipitation Frequency Data Server (NOAA Atlas 14)

NOAA Atlas 14, Volume 2, Version 3
Location name: Chesapeake, Virginia, USA*
Latitude: 36.7613°, Longitude: -76.3019°
Elevation: 13.16 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.432 (0.393-0.476)	0.507 (0.461-0.560)	0.575 (0.522-0.634)	0.658 (0.595-0.725)	0.740 (0.667-0.816)	0.814 (0.731-0.898)	0.882 (0.788-0.973)	0.948 (0.842-1.05)	1.03 (0.906-1.14)	1.11 (0.966-1.23)
10-min	0.690 (0.629-0.761)	0.811 (0.738-0.896)	0.921 (0.836-1.02)	1.05 (0.951-1.16)	1.18 (1.06-1.30)	1.30 (1.17-1.43)	1.40 (1.25-1.55)	1.50 (1.34-1.66)	1.63 (1.43-1.80)	1.74 (1.52-1.93)
15-min	0.862 (0.786-0.951)	1.02 (0.928-1.13)	1.16 (1.06-1.29)	1.33 (1.20-1.47)	1.50 (1.35-1.65)	1.64 (1.48-1.81)	1.77 (1.58-1.95)	1.90 (1.69-2.09)	2.05 (1.80-2.27)	2.19 (1.91-2.42)
30-min	1.18 (1.08-1.30)	1.41 (1.28-1.56)	1.65 (1.50-1.83)	1.93 (1.74-2.13)	2.22 (2.00-2.44)	2.47 (2.22-2.73)	2.71 (2.42-2.99)	2.95 (2.62-3.26)	3.26 (2.87-3.61)	3.54 (3.09-3.93)
60-min	1.47 (1.34-1.63)	1.77 (1.61-1.95)	2.12 (1.93-2.34)	2.51 (2.27-2.77)	2.95 (2.66-3.25)	3.35 (3.01-3.70)	3.74 (3.34-4.12)	4.14 (3.68-4.57)	4.68 (4.12-5.17)	5.17 (4.51-5.73)
2-hr	1.73 (1.56-1.92)	2.08 (1.87-2.30)	2.54 (2.29-2.81)	3.05 (2.75-3.37)	3.66 (3.28-4.04)	4.23 (3.77-4.66)	4.79 (4.24-5.28)	5.39 (4.75-5.95)	6.21 (5.42-6.86)	6.98 (6.04-7.71)
3-hr	1.86 (1.68-2.08)	2.23 (2.01-2.49)	2.74 (2.46-3.05)	3.31 (2.97-3.69)	4.01 (3.58-4.46)	4.69 (4.15-5.20)	5.37 (4.72-5.94)	6.11 (5.33-6.75)	7.13 (6.16-7.89)	8.11 (6.93-8.99)
6-hr	2.24 (2.01-2.51)	2.68 (2.40-3.01)	3.30 (2.95-3.70)	4.00 (3.56-4.47)	4.86 (4.31-5.43)	5.70 (5.02-6.35)	6.55 (5.72-7.28)	7.49 (6.49-8.32)	8.80 (7.53-9.78)	10.1 (8.52-11.2)
12-hr	2.64 (2.36-2.98)	3.16 (2.81-3.56)	3.90 (3.47-4.39)	4.75 (4.21-5.35)	5.83 (5.13-6.54)	6.88 (6.01-7.71)	7.97 (6.90-8.92)	9.19 (7.87-10.3)	10.9 (9.21-12.2)	12.6 (10.5-14.0)
24-hr	3.00 (2.76-3.27)	3.65 (3.36-3.98)	4.71 (4.33-5.14)	5.61 (5.14-6.11)	6.94 (6.32-7.54)	8.08 (7.30-8.78)	9.34 (8.36-10.1)	10.7 (9.51-11.7)	12.8 (11.2-14.0)	14.6 (12.5-15.9)
2-day	3.48 (3.20-3.81)	4.21 (3.88-4.61)	5.41 (4.98-5.92)	6.44 (5.90-7.04)	7.99 (7.26-8.71)	9.33 (8.41-10.2)	10.8 (9.65-11.8)	12.5 (11.0-13.6)	15.0 (13.0-16.5)	17.2 (14.6-18.9)
3-day	3.69 (3.40-4.02)	4.47 (4.13-4.88)	5.71 (5.27-6.23)	6.77 (6.21-7.37)	8.33 (7.59-9.05)	9.66 (8.74-10.5)	11.1 (9.96-12.1)	12.7 (11.3-13.9)	15.2 (13.2-16.6)	17.4 (14.9-19.1)
4-day	3.90 (3.61-4.24)	4.72 (4.37-5.14)	6.02 (5.55-6.54)	7.09 (6.53-7.69)	8.66 (7.92-9.40)	9.99 (9.07-10.8)	11.4 (10.3-12.4)	13.0 (11.6-14.1)	15.3 (13.4-16.8)	17.5 (15.1-19.3)
7-day	4.56 (4.24-4.93)	5.50 (5.12-5.95)	6.92 (6.42-7.47)	8.09 (7.48-8.73)	9.78 (9.00-10.5)	11.2 (10.2-12.1)	12.7 (11.5-13.7)	14.4 (12.9-15.5)	16.8 (14.8-18.2)	18.7 (16.3-20.5)
10-day	5.18 (4.84-5.57)	6.22 (5.80-6.67)	7.71 (7.18-8.27)	8.94 (8.31-9.58)	10.7 (9.90-11.5)	12.2 (11.2-13.1)	13.7 (12.5-14.8)	15.4 (13.9-16.6)	17.8 (15.9-19.3)	19.8 (17.4-21.6)
20-day	7.02 (6.59-7.52)	8.37 (7.85-8.95)	10.2 (9.53-10.9)	11.6 (10.9-12.4)	13.7 (12.7-14.7)	15.4 (14.3-16.5)	17.2 (15.8-18.4)	19.1 (17.4-20.5)	21.8 (19.5-23.5)	23.9 (21.2-25.9)
30-day	8.66 (8.16-9.24)	10.3 (9.70-11.0)	12.4 (11.6-13.2)	14.0 (13.2-15.0)	16.3 (15.2-17.4)	18.1 (16.9-19.3)	20.0 (18.5-21.4)	21.9 (20.1-23.4)	24.5 (22.3-26.4)	26.6 (24.0-28.7)
45-day	10.8 (10.1-11.5)	12.7 (12.0-13.6)	15.2 (14.3-16.2)	17.2 (16.1-18.3)	20.0 (18.7-21.3)	22.3 (20.7-23.7)	24.6 (22.8-26.2)	27.0 (24.8-28.9)	30.4 (27.6-32.6)	33.1 (29.8-35.7)
60-day	12.9 (12.2-13.7)	15.2 (14.4-16.1)	17.9 (16.9-19.0)	20.1 (18.9-21.3)	23.0 (21.6-24.4)	25.3 (23.7-26.9)	27.6 (25.8-29.4)	30.0 (27.8-31.9)	33.1 (30.4-35.5)	35.6 (32.4-38.2)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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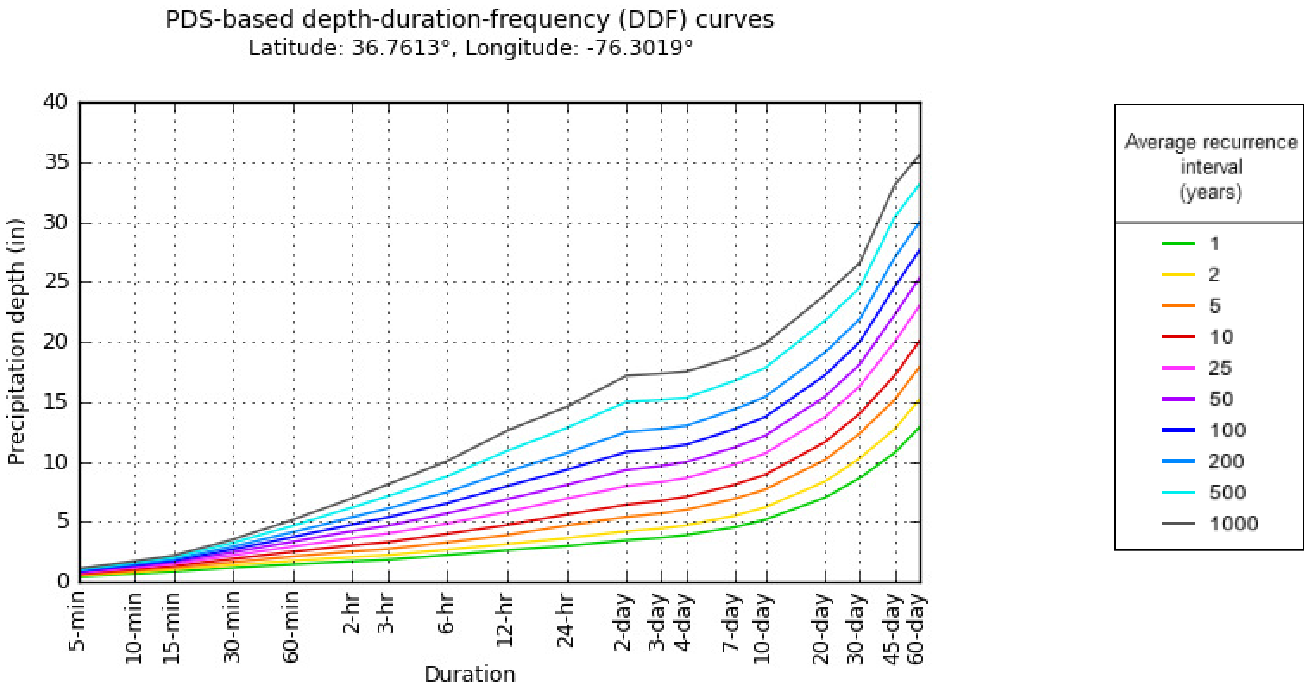
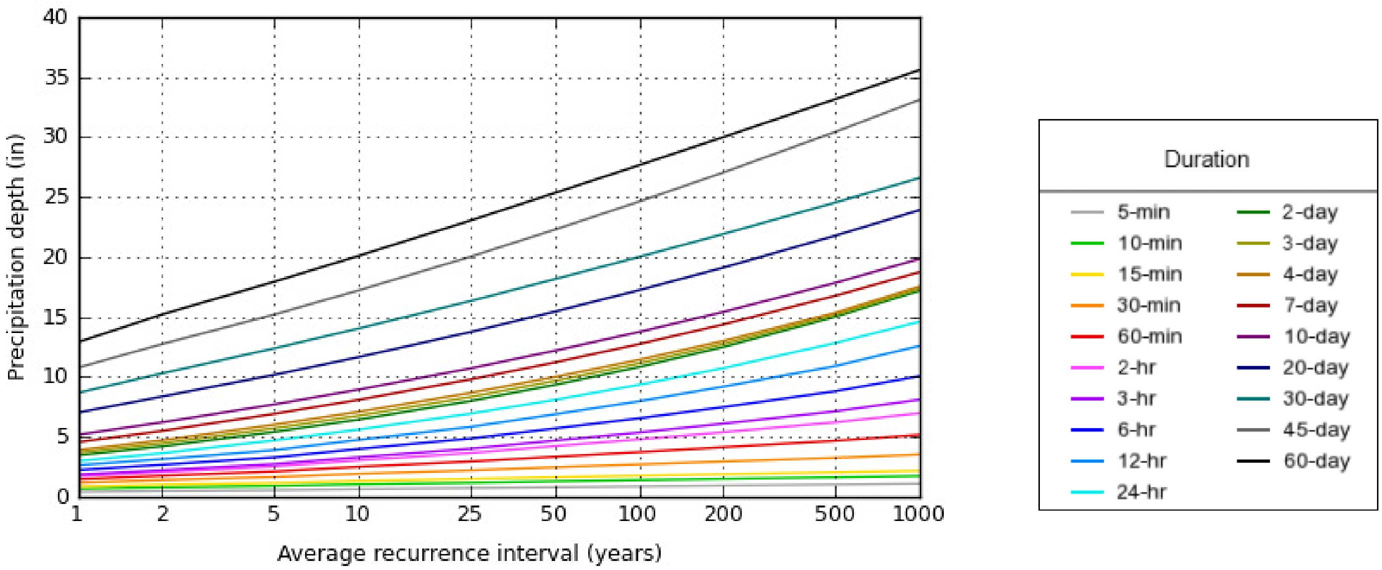
PF graphical





NOAA Atlas 14, Volume 2, Version 3 Created (GMT): Tue Dec 5 20:54:46 2017

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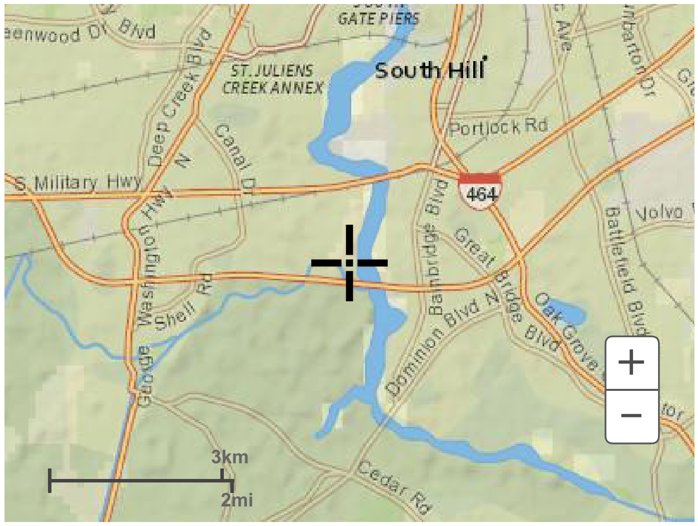
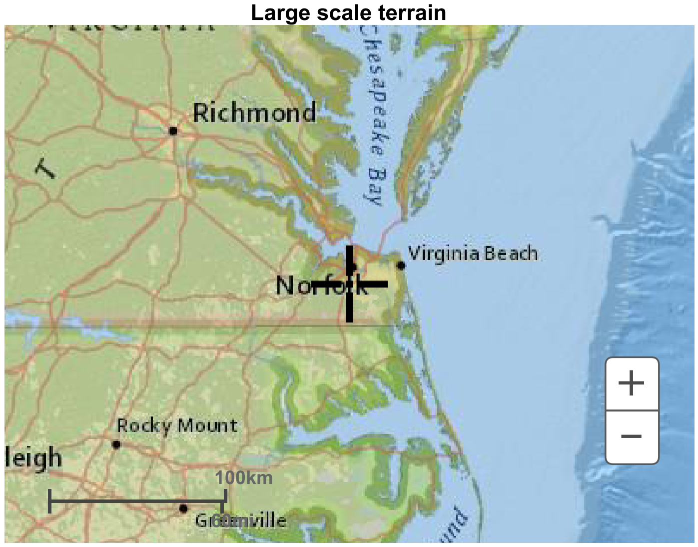
Maps & aerials

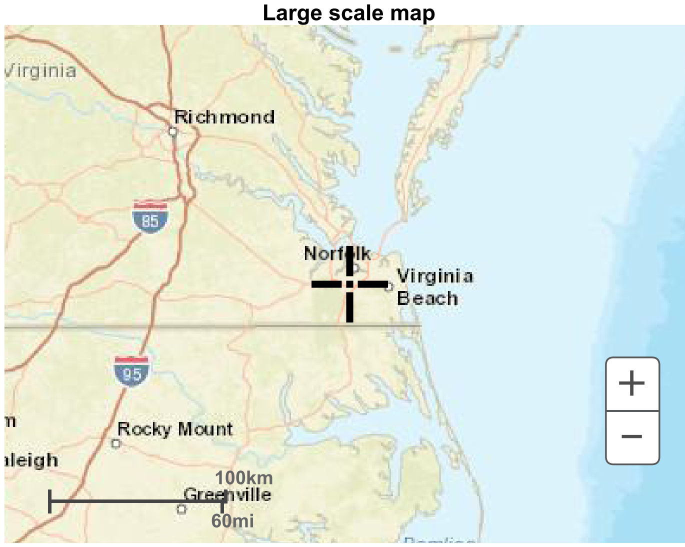
Small scale terrain



Large scale terrain



Large scale map



Large scale aerial

APPENDIX B

Bottom Ash Pond Hydraulic Modeling Analysis

Date:	January 23, 2018	**Made by:**	DPM
Project No.:	130-0193	**Checked by:**	KAL
Subject:	CEC BA Pond Inflow Design Flood Analysis	**Reviewed by:**	

Project: **CEC BOTTOM ASH POND – EXISTING CONDITION**

The purpose of this evaluation is to determine the hydraulic performance of the existing Bottom Ash Pond CCR impoundment at the Chesapeake Energy Center (CEC) during the 1,000-year storm event. This evaluation is in support of the Inflow Design Flood Control System Plan, and is based on a "Significant" hazard potential classification as defined in §257.53 of the *CCR Rule*.

1.0 CALCULATIONS

1.1 Pond Storage Volume

The bottom ash pond storage volume was computed based on the existing conditions, as surveyed in January 2018, as partially excavated for beneficial reuse. The stored bottom ash was considered a solid, and available water storage was based on the developed surface contours. The maximum available storage in the pond is 12.9 acre-feet at elevation 20.0. Overtopping occurs above elevation 20.0. Attachment 1 contains the stage storage rating table used in the HMS model.

1.2 Outlet Design and Capacity

The existing spillway is a 30-inch diameter, 48-foot long horizontal culvert with an invert elevation of 15.15 feet that discharges into the adjacent sediment basin. There is no auxiliary spillway. The peak capacity of the culvert is 49.0 cubic feet per second (CFS). The pond normally does not retain water in a permanent pool due to the relatively free-draining nature of the bottom ash. As such, an allowance has been made for a small amount of infiltration in the model. This is consistent with the observed behavior of the pond during small storm events. Attachment 1 contains the outlet rating tables.

1.3 Storm Routing Calculations

The bottom ash pond stormwater system analysis was performed using the US Army Corps of Engineers Hydrologic Engineering Center's Hydraulic Modeling System (HEC-HMS) software package (ref #1). The direct drainage area to the pond is 23.1 acres. The predominant soil types in the area are Hydrologic Soil Group (HSG) 'B' soils. Approximately 3.2 acres of the top of the landfill is covered with a geomembrane rain cover. The bottom ash pond discharges directly to the adjacent sediment basin, so the evaluation also considers the overall water level and discharge from the sediment basin.

Design Storm

Per §257.82(a)(3)(ii), the impoundment is required to adequately manage flow resulting from the 24-hour, 1,000-Yr storm event. The 24-hour, 1,000-Yr storm event precipitation amount was obtained from the Precipitation Frequency Data Server (PFDS, ref #2) for Chesapeake, Virginia, as 14.6 inches.

HMS Model Input

Figure 1 illustrates the connectivity of the stormwater elements and the data inputs as modeled in HEC-HMS.

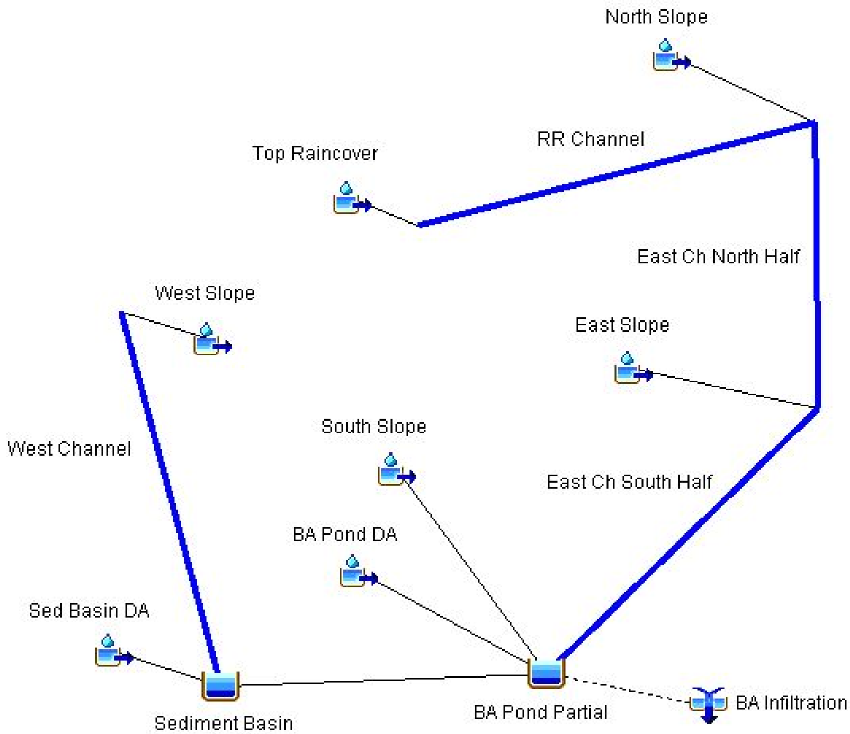


Figure 1 – CEC BA Pond HEC-HMS Model

HMS Model Output

The following table summarizes the results of the HEC-HMS analysis for the 1,000-Yr storm event.

Table 1: CEC HEC-HMS Output

Bottom Ash Pond				Sediment Basin		
Q_{in} (CFS)	Max Hw (Ft El*)	Primary Q_{out} (CFS)	BA Infiltration (CFS)	Q_{in} (CFS)	Max Hw (Ft El*)	Q_{out} (CFS)
309.9	19.04	41.0	6.0	245.9	13.75	28.8

* Top of berm elevation = 20.0 feet

2.0 CONCLUSIONS

Based on the calculations presented herein, the existing bottom ash pond and culvert outlet at the Chesapeake Energy Center can pass the 1,000-Yr event without overtopping. The adjacent sediment basin is also capable of receiving the design storm event discharge without overtopping. The 30-inch culvert outlet for the bottom ash pond is suitable for the design storm event.

3.0 REFERENCES

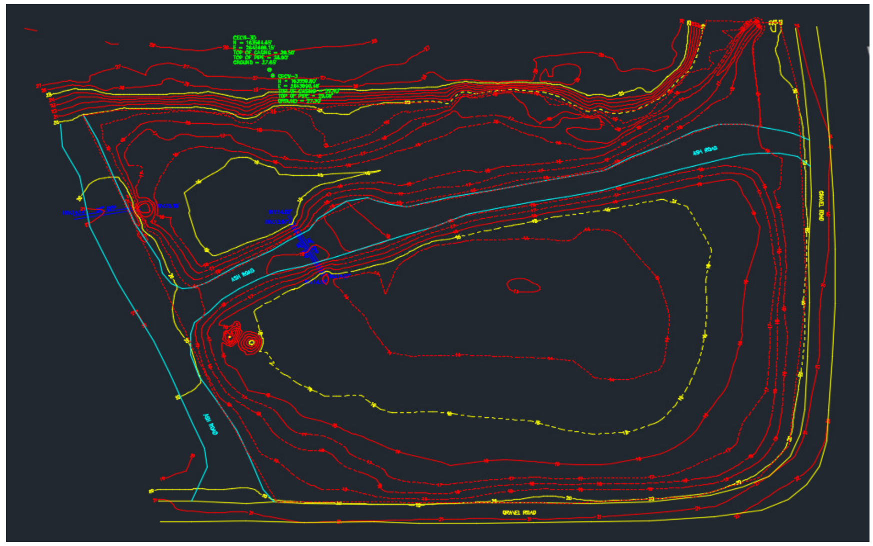
1) U.S. Army Corps of Engineers Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) release 4.2.1
2) Precipitation Frequency Data Server (NOAA Atlas 14) https://hdsc.nws.noaa.gov/hdsc/pfds/

4.0 ATTACHMENTS

1) BA Pond Stage-Storage and Culvert Outlet Rating Tables

BAP - North Section

ELEVATION	AREA (SF)	AREA (AC)
15	5067	0.12
16	13,341	0.31
17	20,928	0.48
18	28,572	0.66
19	36,436	0.84



BAP - South Section

ELEVATION	AREA (SF)	AREA (AC)
13	203	0.0047
14	20901	0.48
15	45858	1.05
16	64,500	1.48
17	77,178	1.77
18	84,547	1.94
19	92,312	2.12
20	153,740	3.53

Combined Sections stage storage

ELEVATION	AREA (SF)	VOLUME, ft^3	AC-FT	TOTAL
20	153,740	141,059	3.24	12.89
19	128,748	120,849	2.77	9.66
18	113,119	105,523	2.42	6.88
17	98,106	87,778	2.02	4.46
16	77,841	63,909	1.47	2.44
15	50,925	34,817	0.80	0.98
14	20,901	7,721	0.18	0.18
13	203	0	0	0

Drainage Areas for Partial Excavation

Area Description	Size, Ac.	CN	H_L	Slope, ft/ft	T_L, min	Drains to
Top Rain Cover	3.246	98	873	0.01	8.10	RR Channel
North Slope	5.496	61	335	0.131	3.71	East Channel
East Slope	8.206	61	297	0.145	3.20	East Channel (half)
South Slope	1.994	61	363	0.118	4.16	BA Pond
BA Pond Proper	4.157	79	120	0.075	1.32	Self

Drainage Areas for Sediment Basin

Area Description	Size, Ac.	CN	H_L	Slope, ft/ft	T_L, min	Drains to
West Slope	8.03	61	297	0.145	3.20	West Channel
Sed Basin Proper	6.41	77	120	0.075	1.40	Self

Assumed k for bottom ash:	0.005	cm/s
Pond floor constant (q):	1.64E-04	CFS/ft2

30" CPP Rating	
Elevation	Q out (CFS)
14	0
15.15	0
15.25	0.1
15.5	0.60
15.75	2.00
16	3.80
16.25	6.20
16.5	8.80
16.75	11.70
17	15.10
17.25	18.70
17.5	22.50
17.75	26.20
18	29.60
18.25	32.70
18.5	35.50
18.75	38.10
19	40.60
19.25	42.90
19.5	45.00
19.75	47.10
20	49.00

Pond Floor*
Q out (CFS)
0
0.831
0.831
0.831
0.831
2.189
2.189
2.189
2.189
3.433
3.433
3.433
3.433
4.687
4.687
4.687
4.687
5.977
5.977
5.977
5.977
5.977

*pond floor area = only northern section area due to road

Sediment pond elevation-area as of 1/15/18

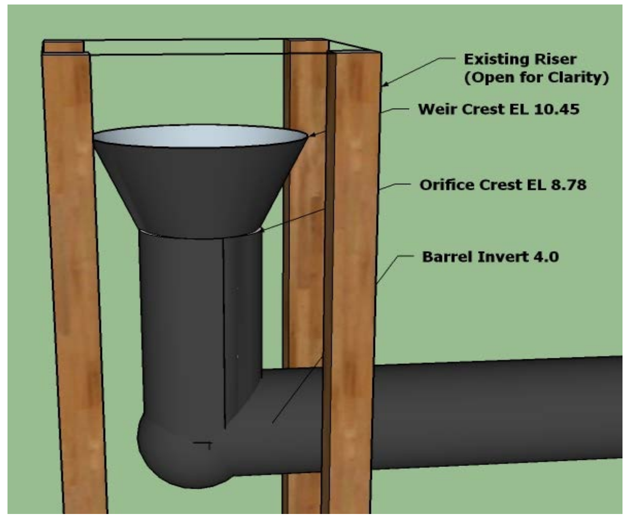
ELEVATION	AREA (SF)	AREA (ACRES)
10	142,846	3.28
11	158,617	3.64
12	169,987	3.90
13	180,322	4.14
14	191,892	4.41
15	201,158	4.62
16	210,383	4.83
17	219,732	5.04
18	229,705	5.27
19	242,218	5.56
20	279,160	6.41

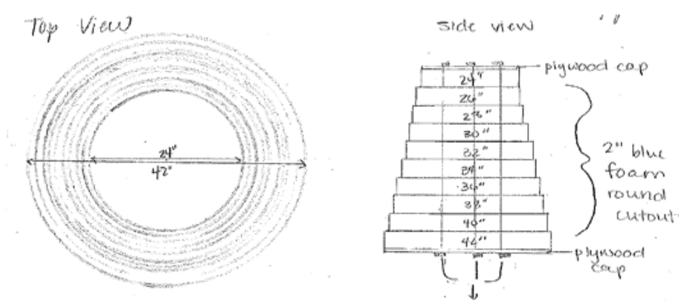
CEC Existing Sediment Basin Riser

Weir 1 elevation	10.45
Weir 1 length	11
Orifice 1 area	9.62
Weir discharge coefficient	3.3
Orifice discharge coefficient	0.6

Culvert Outlet from UD culvert:		
Inv in	4	
Inv out	-2.1	
Length	129	
Dia	21	inches (24" SDR-17 HDPE)
Slope	0.0473	
Tw El	2	

Elevation	Weir 1	Orifice 1	Min	Culvert	Rating
10.45				0.00	0.00
10.5	0.41	0.05	0.05	35.80	0.05
10.75	5.96	0.79	0.79	36.60	0.79
11	14.81	1.96	1.96	37.40	1.96
11.25	25.97	3.45	3.45	38.20	3.45
11.5	39.06	5.18	5.18	38.90	5.18
11.75	53.80	7.14	7.14	39.70	7.14
12	70.05	9.29	9.29	40.40	9.29
12.25	87.66	11.63	11.63	41.10	11.63
12.5	106.55	14.13	14.13	41.80	14.13
12.75	126.62	16.80	16.80	42.50	16.80
13	147.81	19.61	19.61	43.20	19.61
13.25	170.08	22.56	22.56	43.90	22.56
13.5	193.36	25.65	25.65	44.50	25.65
13.75	217.61	28.86	28.86	45.20	28.86
14	242.80	32.21	32.21	45.80	32.21
14.25	268.89	35.67	35.67	46.40	35.67
14.5	295.86	39.24	39.24	47.10	39.24
14.75	323.68	42.93	42.93	47.70	42.93
15	352.31	46.73	46.73	48.30	46.73
15.25	381.74	50.64	50.64	48.90	48.90
15.5	411.95	54.64	54.64	49.50	49.50
15.75	442.92	58.75	58.75	50.10	50.10
16	474.62	62.96	62.96	50.60	50.60
16.25	507.05	67.26	67.26	51.20	51.20
16.5	540.18	71.65	71.65	51.80	51.80
16.75	574.01	76.14	76.14	52.30	52.30
17	608.51	80.72	80.72	52.90	52.90
17.25	643.68	85.38	85.38	53.40	53.40
17.5	679.50	90.13	90.13	54.00	54.00
17.75	715.96	94.97	94.97	54.50	54.50
18	753.06	99.89	99.89	55.00	55.00
18.25	790.77	104.89	104.89	55.60	55.60
18.5	829.09	109.97	109.97	56.10	56.10
18.75	868.01	115.14	115.14	56.60	56.60
19	907.52	120.38	120.38	57.10	57.10
19.25	947.61	125.70	125.70	57.60	57.60
19.5	988.28	131.09	131.09	58.10	58.10
19.75	1029.51	136.56	136.56	58.60	58.60
20	1071.30	142.10	142.10	59.10	59.10





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