Unstable Areas Documentation

Yorktown Power Station
Ash Landfill

Submitted to:

Virginia Electric and Power Company d/b/a Dominion Energy Virginia
5000 Dominion Boulevard
Glen Allen, VA 23060

Submitted by:

Golder Associates Inc.
2108 West Laburnum Ave, Suite 200
Richmond, Virginia 23227

Project No. 1239-6405
October 17, 2018

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APPENDICES

1.0 CERTIFICATION

I certify that the information contained within this Unstable Areas Demonstration Report was prepared by me or under my direct supervision and meets the requirements of Section §257.64 of the Federal Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals (CCR) from Electric Utilities; Final Rule (40 CFR 257; the *CCR rule*). The document and Certification/Statement of Professional Opinion are based on and limited to information that Golder has relied on from Virginia Electric and Power Company d/b/a Dominion Energy Virginia (Dominion) and others, but not independently verified, as well as work products produced by Golder.

As used herein, the words “certification” and/or “certify” shall mean an expression of the Engineer’s professional opinion to the best of his or her information, knowledge, and belief, and does not constitute a warranty or guarantee by the Engineer.

Daniel McGrath, P.E.	Associate and Senior Consultant
Print Name	Title
Daniel McGrath	10/17/18
Signature	Date

2.0 INTRODUCTION

This Unstable Areas Demonstration was prepared for the Yorktown Power Station Coal Combustion Residual (CCR) Landfill (*Landfill*) located in York County, Virginia, in accordance with 40 CFR §257.64. This demonstration documents how the Landfill meets the requirements of each condition in the CCR Rule section. As of the date of this report (October 2018), Dominion continues to operate the Landfill for CCR disposal.

2.1 Landfill Site Background

The Landfill is permitted as an approximately 48-acre facility for the disposal of CCR from the Yorktown Power Station. A Site Location Map is included as Figure 1. The property is located in an industrial area and is in the Coastal Plain physiographic province of Virginia.

2.2 Disposal Facility Permitting and Construction History

The Landfill was originally permitted in January 1985 under solid waste permit # 457. The Landfill is permitted under the Virginia Solid Waste Management Regulations (VSWMR) and subject to the location and design requirements applicable at the time of the original permit. Cell 12 was the last of the “base” permitted areas to be constructed, completing the overall footprint in 2008. A major permit amendment completed in October 2009 added four additional disposal cells to be constructed on top of the existing “base” landfill. Phase 1 of the Vertical Expansion was constructed in 2011; however, it was never placed into service.

3.0 UNSTABLE AREA EVALUATION

3.1 Requirement

§257.64 (a): *An existing or new CCR landfill, existing or new CCR surface impoundment, or any lateral expansion of a CCR unit must not be located in an unstable area unless the owner or operator demonstrates by the dates specified in paragraph (d) of this section that recognized and generally accepted good engineering practices have been incorporated into the design of the CCR unit to ensure that the integrity of the structural components of the CCR unit will not be disrupted.*

3.2 Demonstration

Assessment of unstable areas includes an evaluation of the soil conditions at the site, which may result in significant differential settling, a review of site geologic or geomorphologic features, and consideration of human-made features on site that may cause unstable conditions. A summary of the unstable area evaluation is presented in this document.

3.2.1 *Soil Conditions*

Based on the soil boring records and geotechnical testing of soils encountered, the subsurface conditions at the Landfill are expected to adequately support the landfill without significant differential settlement. The site investigations did not identify features that would suggest recent landslide activities or other indicators of unstable soil conditions, such as sinkholes or significant unconsolidated materials.

Between 1980 and 2006, approximately 60 investigative test borings, piezometer installations, test pits and monitoring wells were made by Golder and others to characterize the hydrogeologic and geotechnical properties of the subsurface soils. Geotechnical test borings were advanced to various depths ranging between 10 and 41 feet below grade. In general, the test borings drilled during these investigations were advanced to a depth required for a minimum 20 feet below the lowest elevation of the bottom liner.

The subsurface site investigations show the soils generally consist of an approximately 15-foot thick layer of medium dense layer of clayey sand, underlain by silty sand containing shell fragments. Pockets of sandy clay and clay also exist. Groundwater at the site ranges from approximately 1.5 to 10 feet below grade. Bedrock is deeper than 500 feet. The Yorktown Landfill site is bisected by the Suffolk Scarp that is believed to be the remnant edge of the Chesapeake Impact Crater (see Section 3.2.3). The scarp creates a discontinuity in the groundwater aquifers on site between the Windsor formation to the west and the Norfolk formation to the east. Structurally, the materials on either side of the scarp are suitable for supporting the landfill. Both formations consist of sands and clays of marine origin.

3.2.2 *Differential Settlement*

Significant differential settlement is not anticipated to occur at the Landfill due to the relatively small fill thicknesses of the base landfill, ranging from 15 to 34 feet in thickness. Calculations prepared by Golder (2007) during the VE permitting process predicted subgrade settlement ranging from 0.33 to 4.06 feet as a result of the vertical expansion loading (Appendix B). The Yorktown Landfill base liner consists of bentonite-amended soil, which can be compared in behavior to a plastic clay. The greatest calculated distortion for the VE loading was 1.12%, which is within the acceptable range for a clay soil. This distortion calculation is based on the full-height load of the VE (approximately

150 feet) being applied; however, the VE was never placed into service. As a result, the calculated foundation settlement mentioned above is anticipated to be much smaller, and therefore also acceptable.

3.2.3 *Site Geology and Geomorphology*

The Landfill is located on layers of competent soils and moderate to densely compacted sands as indicated in the boring logs. The subsurface soil layers were determined to be of adequate strength to support the Landfill. The Landfill is not located in an area of karst topography as indicated by the depth to bedrock of over 500 feet. No active seismic faults are located within 20 miles of the Landfill site. The closest active fault area is the Central Virginia Seismic Zone, located approximately 65 miles away. The Seismic Activity Map in Appendix A shows the location of the site relative to the Central Virginia Seismic Zone. The Landfill site is not located within the 100-year floodplain. The 100-Year flood map for the area is included in Appendix A.

As mentioned above, the north-south Suffolk Scarp has been interpreted as marking a former high sea level stand of the Atlantic Ocean (landward extent of the Outer Coastal Plain) and, more recently, as paralleling the western outer rim of a crater caused by a meteor striking the vicinity of the Delmarva Peninsula in the late Eocene Period. This Chesapeake Impact Crater is thought to be approximately 35 million years old and does not present a geologic hazard to the Landfill. A map of the crater is included in Appendix A.

3.2.4 *Human-Made Features*

An evaluation of the site’s history does not reveal, nor has evidence been found of, human-made conditions on site that could cause unstable conditions. Prior to the site’s use by Dominion for CCR storage, the site appeared to be undeveloped woodlands. No evidence of surficial or shaft mining on the site has been encountered in either the literature or during on-site evaluations. There are no known impounding structures upstream or downstream of the site that pose inundation threat due to structure failure.

4.0 CONCLUSIONS

Golder Associates Inc. has performed an evaluation of site conditions and historical documentation in relation to requirements established in 40 CFR 257.64. Our evaluation shows that the Yorktown Ash Landfill, as designed, constructed, and operated, meets the requirements of this regulation.

5.0 REFERENCES

Sources evaluated for this report include the following:

1. Soil boring logs, test pit logs, and well installation logs from Golder Associates, Inc., D'Appolonia, and Geraghty & Miller, Inc.
2. GAI Consultants, Inc. Hydrogeologic and Geotechnical Report – Yorktown Station Fly Ash Structural Fill, March 1991
3. D'Appolonia Consulting Engineers, Inc. Ash Waste Disposal Facility Report, August 1980
4. Golder Associates Inc. Groundwater Monitoring Plan – Yorktown Power Station Ash Landfill, October 2017
5. Virginia Department of Mines, Minerals and Energy (DMME) Interactive Maps (https://www.dmme.virginia.gov/webmaps/options.shtml)
6. United States Geological Service (USGS) historical topographic maps (http://historicalmaps.arcgis.com/usgs/):
   a. Hampton Quadrangle (1907)
   b. Harris Grove Quadrangle (1944, 1954)
   c. Poquoson West Quadrangle (1965, 1979)
7. USGS Historical Aerial Imagery (https://earthexplorer.usgs.gov/)
   a. March 24, 1963 aerial
8. Google Earth (https://www.google.com/earth/)
9. Federal Emergency Management Agency (FEMA) National Flood Hazard Layer (NFHL) Viewer (https://www.fema.gov/national-flood-hazard-layer-nfhl)
10. Fly Ash Structural Fill and Haul Road Design Drawings, June 1993, GAI Consultants, Inc.
11. Yorktown Power Station Industrial Solid Waste Landfill Vertical Expansion (VE) Major Permit Amendment, November 2008, Golder Associates Inc.

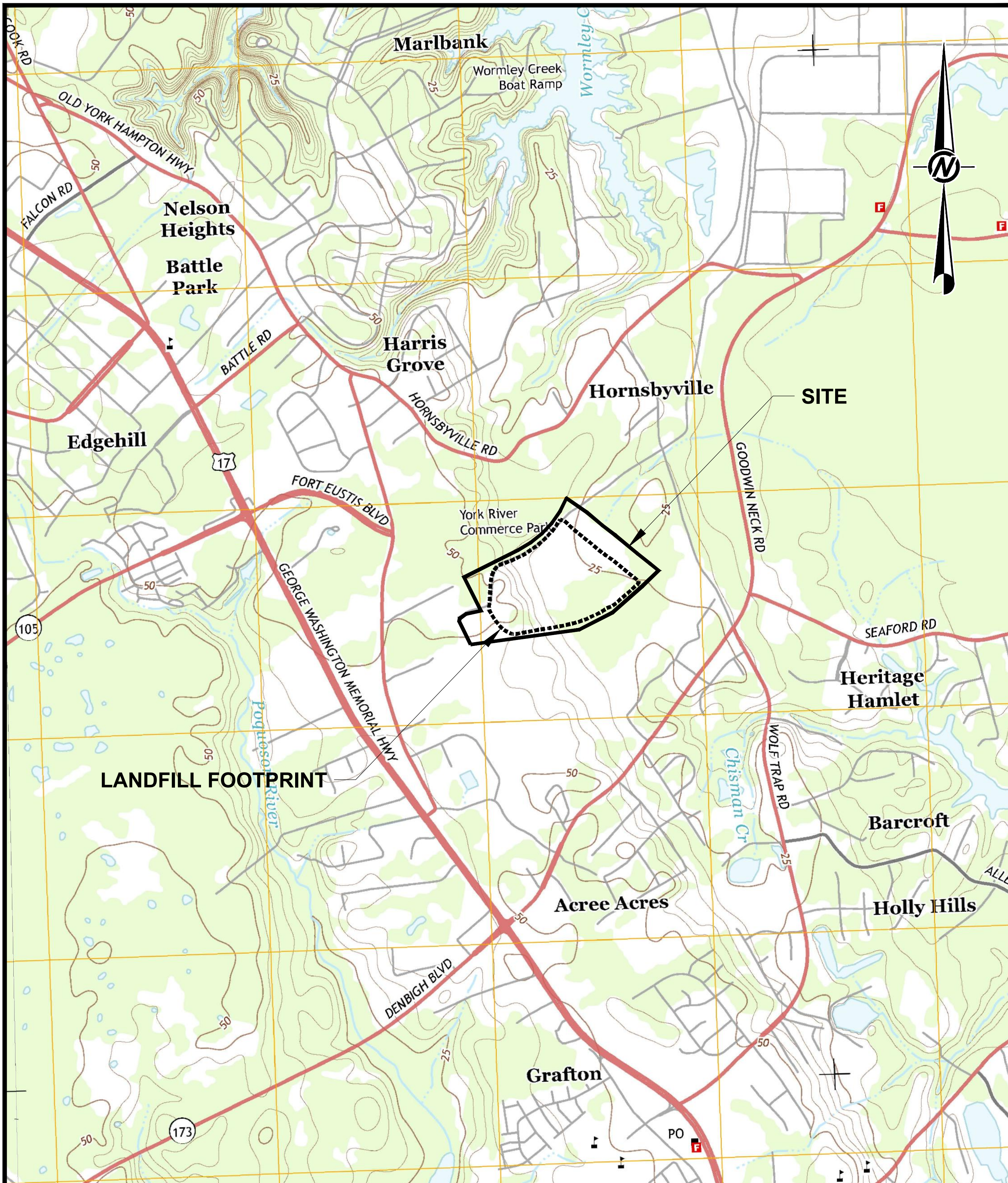
APPENDIX A

FIGURE 1 – SITE LOCATION MAP

FIGURE 2 – SEISMIC ACTIVITY MAP

FIGURE 3 – 100-YEAR FLOOD MAP

FIGURE 4 – CHESAPEAKE IMPACT CRATER MAP



REFERENCE

BASE LAYER: USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE NAMED YORKTOWN AND POQUOSON WEST, VIRGINIA.

PROJECTION: TRAVERSE MERCATOR DATUM:NAD 83 COORDINATE SYSTEM: UTM ZONE 18S

Golder Associates
Richmond, Virginia

PROJECT No.	14-03044	DATE	3/7/18
SCALE	AS SHOWN	DESIGN	CJL
REV.	0	CADD	ABR
		CHECK	MGW
		REVIEW	TCP

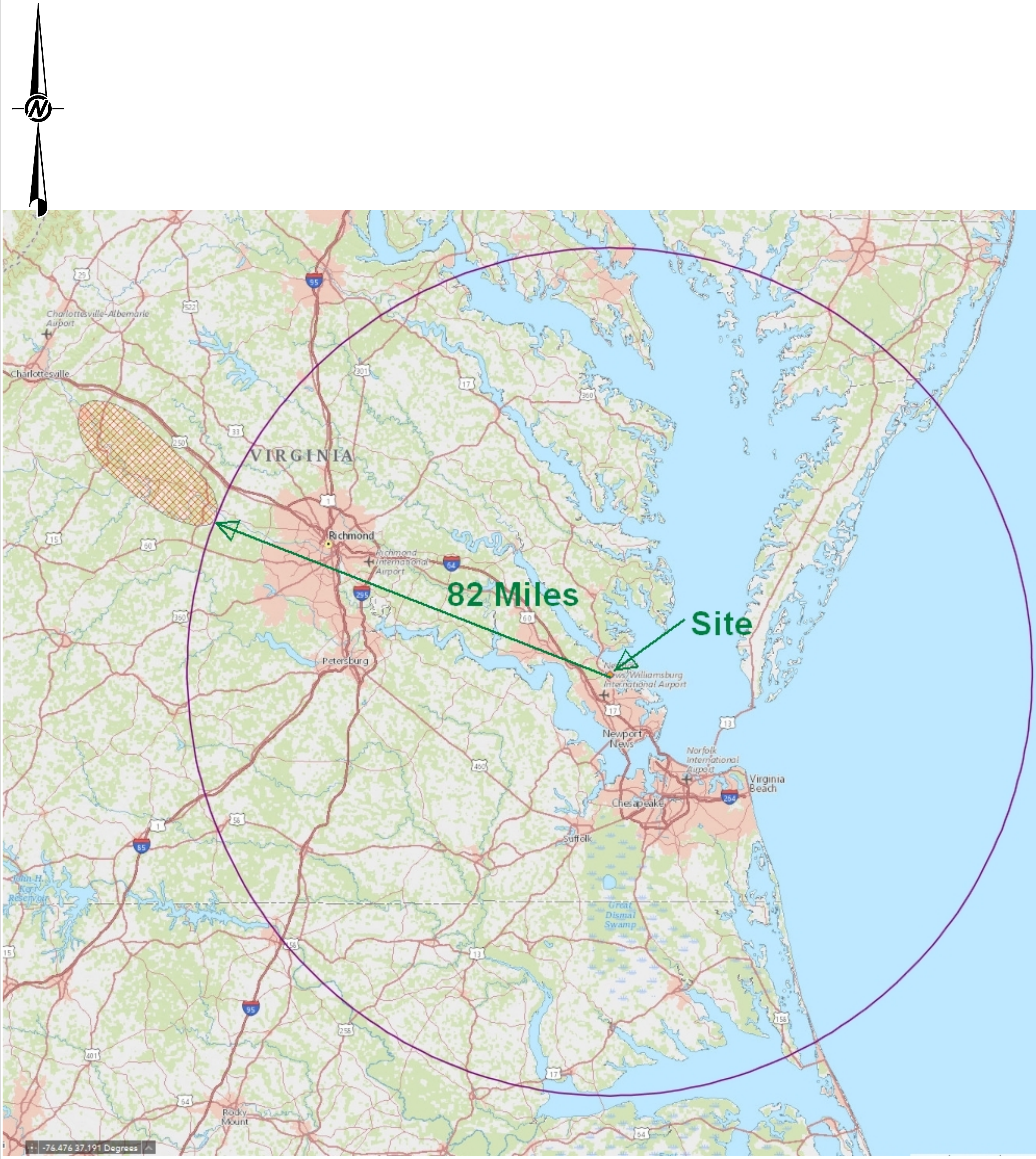
TITLE

SITE LOCATION MAP

DOMINION ENERGY - YORKTOWN ASH LF

FIGURE 1

G:\Plan Production Data Files\Drawing Data Files\14-03044\B - Yorktown\Active Drawings\1403044B01.dwg



REFERENCE

IMAGE FROM USGS NATIONAL MAPPER
https://viewer.nationalmap.gov/advanced-viewer/

CLIENT
DOMINION ENERGY

PROJECT
YORKTOWN POWER STATION
YORK COUNTY, VIRGINIA

CONSULTANT

GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	DPM
PREPARED	BPG
REVIEWED	BPG
APPROVED	DPM

TITLE
SEISMIC ACTIVITY MAP

PROJECT NO.	REV.	FIGURE
1239-6405	0	2

National Flood Hazard Layer FIRMette

FEMA

37°11'27.43"N

76°28'38.32"W

76°28'0.87"W

37°10'58.77"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS		Without Base Flood Elevation (BFE) *Zone A, V, A99*
		With BFE or Depth *Zone AE, AO, AH, VE, AR*
		Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD		0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
		Future Conditions 1% Annual Chance Flood Hazard *Zone X*
		Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
		Area with Flood Risk due to Levee *Zone D*
OTHER AREAS	NO SCREEN	Area of Minimal Flood Hazard *Zone X*
		Effective LOMRs
		Area of Undetermined Flood Hazard *Zone D*
GENERAL STRUCTURES		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
OTHER FEATURES	B 20.2 / 17.5	Cross Sections with 1% Annual Chance Water Surface Elevation
	8	Coastal Transect
	513	Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary
		Coastal Transect Baseline
		Profile Baseline
		Hydrographic Feature
MAP PANELS		Digital Data Available
		No Digital Data Available
		Unmapped

N

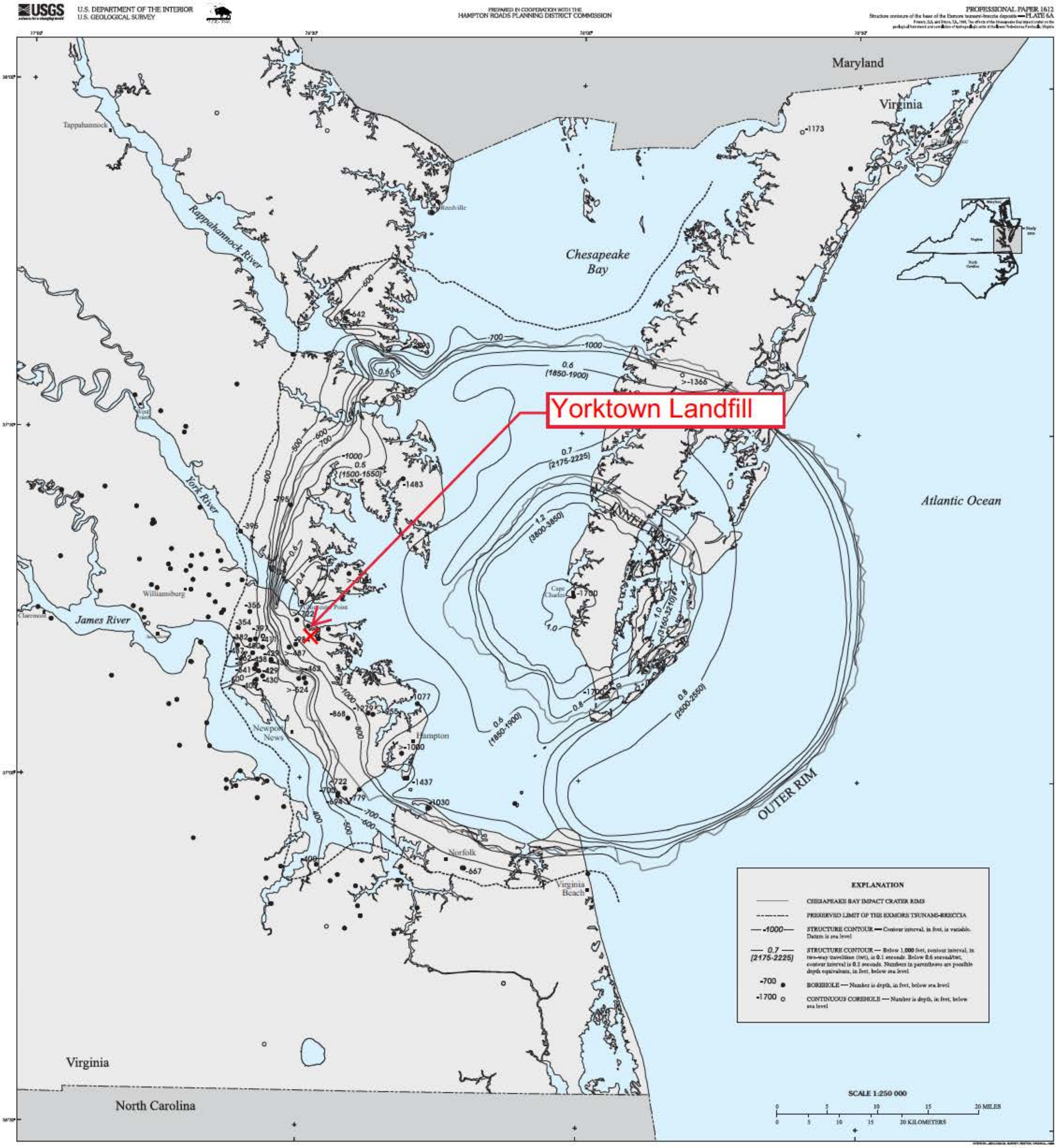
The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 9/24/2018 at 1:35:41 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

Figure 3



STRUCTURE CONTOURS OF THE BASE
OF THE EXMORE TSUNAMI-BRECCIA DEPOSITS

By
David S. Powars and T. Scott Bruce
1999

Figure 4

APPENDIX B

2007 FOUNDATION SETTLEMENT CALCULATIONS

Table 1
Yorktown Power Station Ash Structural Fill Facility- Subsurface Strata

Layer Information							Existing Ash				Strata 1				Strata 2			
location	Groundwater	Original Base Grades	Existing Ground Surface	Proposed base grade	Proposed Final Grade	Reference Boring	Top	Depth to Mid Point	Base	Thick	Top	Depth to Mid Point	Base	Thick	Top	Depth to Mid Point	Base	Thick*
1	39.5	49	49	50	50	B-07A, B-07B	49	0	49	0	49	4.5	40	9	40	34	-10	50
2	34.5	33.5	56.5	64	126	B-20	56.5	11.5	33.5	23	33.5	25.5	28.5	5	28.5	53	-21.5	50
3	29.5	30	50	65.5	180	B-21	50	10	30	20	30	20	30	0	30	45	-20	50
4	31.5	31.5	57	63	94	B-21	57	12.75	31.5	25.5	31.5	26	30.5	1	30.5	51.5	-19.5	50
5	33	35	35	44	44	B-09A, B-09B	35	0	35	0	35	4	27	8	27	33	-23	50

*Assume Strata 2 thickness is 50 feet.

Table 2
Yorktown Power Station Ash Structural Fill Facility- Subsurface Strata
Consolidation Test Results

Boring	USCS Description	Depth	w_n	e_o	C_c	C_r	OCR	RR	CR
B-07B	Sandy CH	10-12'	54.0%	0.56	0.27	0.05	1.5	0.03	0.17
B-10	SC	20-22'	29.4%	1.63	0.63	0.08	1.1	0.03	0.24
B-02	Sandy CH	14-16'	44.6%	1.29	0.32	--	--	--	0.14
B-09B	Sandy CH	4-6'	19.3%	0.57	0.14	0.02	9.0	0.01	0.09
mean			36.8%	1.01	0.34	0.05	3.9	0.02	0.16
median			37.0%	0.93	0.29	0.05	1.5	0.03	0.16
Ash				0.87	0.11	0.01		0.01	0.06

Table 3
Primary Settlement Due to Waste Placement

Layer Information						
location	Groundwater	Original Base Grades	Existing Ground Surface	Proposed base grade	Proposed Final Grade	Reference Boring
1	39.5	49	49	50	50	B-07A, B-07B
2	34.5	33.5	56.5	64	126	B-20
3	29.5	30	50	65.5	180	B-21
4	31.5	31.5	57	63	94	B-21
5	33	35	35	44	44	B-09A, B-09B

Notes: Influence factor assumed to be 1.0 at all locations and depths
ΔP = contact pressure of new load times Influence factor
Settlement
in ash
$=CR*H_o log((P_o+\Delta P))/P_o$
where H_o = layer thickness
in Strata 1 (modeled as a clay)
$= H_o*(RR*Log(P_c/P_o) + CR*log((P_o+\Delta P)/P_c)$
where $P_c = P_o*OCR$
in Strata 2 (modeled as sands)
$=\Delta PH_o/mP_a(sqrt(0.5(P_o+(P_o+\Delta P))/P_a)$
where Pa = atmospheric pressure (psf) = 2116
m = 100 janbu modulus number for loose sands, slightly overconsolidated

Table 3
Primary Settlement Due to Waste Placement

Layer Information						Existing Ash										
location	Groundwater	Original Base Grades	Existing Ground Surface	Proposed base grade	Proposed Final Grade	RR	CR	OCR	Depth to Center (ft)	P_o Center	P_{mpp}	Influence Factor	ΔP	Thickness Layer	Settlement
1	39.5	49	49	50	50	0.01	0.06	1.00	0	0	0	1.00	90	0	0.000
2	34.5	33.5	56.5	64	126	0.01	0.06	1.00	11.5	1035	1035	1.00	6255	23	1.170
3	29.5	30	50	65.5	180	0.01	0.06	1.00	10	900	900	1.00	11700	20	1.375
4	31.5	31.5	57	63	94	0.01	0.06	1.00	12.75	1148	1148	1.00	3330	25.5	0.905
5	33	35	35	44	44	0.01	0.06	1.00	0	0	0	1.00	810	0	0.000

Notes: Influence factor assumed to be 1.0 at all locations and depths
ΔP = contact pressure of new load times Influence factor
Settlement
in ash
$=CR*H_o\log((P_o+\Delta P))/P_o$
where H_o = layer thickness
in Strata 1 (modeled as a clay)
$= H_o*(RR*Log(P_c/P_o) + CR*\log((P_o+\Delta P)/P_c)$
where $P_c = P_o*OCR$
in Strata 2 (modeled as sands)
$=\Delta PH_o/mP_a(sqrt(0.5(P_o+(P_o+\Delta P))/P_a)$
where Pa = atmospheric pressure (psf) =
m = 100 janbu modulu
loose sands, slightly ove

Density of ash = 90 pcf
Density of Strata 1 = 135 pcf
Density of Strata 2 = 120 pcf

Table 3
Primary Settlement Due to Waste Placement

Layer Information						Strata 1										
location	Groundwater	Original Base Grades	Existing Ground Surface	Proposed base grade	Proposed Final Grade	RR	CR	OCR	Depth to Center (ft)	Depth to GW (ft)	P_o Center	Influence Factor	ΔP	Thickness Layer	Settlement
1	39.5	49	49	50	50	0.03	0.17	1.50	4.5	9.5	608	1.00	90	9	0.275
2	34.5	33.5	56.5	64	126	0.03	0.17	1.50	25.5	22	2189	1.00	6255	5	0.689
3	29.5	30	50	65.5	180	0.01	0.09	9.00	20	20.5	1800	1.00	11700	0	0.000
4	31.5	31.5	57	63	94	0.01	0.09	9.00	26	25.5	2363	1.00	3330	1	0.033
5	33	35	35	44	44	0.01	0.09	9.00	4	2	540	1.00	810	8	0.322

Notes: Influence factor assumed to be 1.0 at all locations and depths
ΔP = contact pressure of new load times Influence factor
Settlement
in ash
$=CR*H_o log((P_o+\Delta P))/P_o$
where H_o = layer thickness
in Strata 1 (modeled as a clay)
$= H_o*(RR*Log(P_c/P_o) + CR*log((P_o+\Delta P)/P_c)$
where $P_c = P_o*OCR$
in Strata 2 (modeled as sands)
$=\Delta P H_o/mP_a(sqrt(0.5(P_o+(P_o+\Delta P))/P_a)$
where Pa = atmospheric pressure (psf) =
m = 100 janbu modulu
loose sands, slightly ove

Table 3
Primary Settlement Due to Waste Placement

Layer Information						Strata 2						
location	Groundwater	Original Base Grades	Existing Ground Surface	Proposed base grade	Proposed Final Grade	Depth to Center (ft)	P_o Center	Influence Factor	ΔP	Thickness Layer	Settlement	**Primary Settlement from Waste Fill (ft)**
1	39.5	49	49	50	50	34	2686	1.00	90	50	0.019	0.29
2	34.5	33.5	56.5	64	126	53	3811	1.00	6255	50	0.816	2.67
3	29.5	30	50	65.5	180	45	3271	1.00	11700	50	1.332	2.71
4	31.5	31.5	57	63	94	51.5	3808	1.00	3330	50	0.489	1.43
5	33	35	35	44	44	33	2146	1.00	810	50	0.174	0.50

Notes: Influence factor assumed to be 1.0 at all locations and depths
ΔP = contact pressure of new load times Influence factor
Settlement
in ash
$=CR*H_o\log((P_o+\Delta P))/P_o$
where H_o = layer thickness
in Strata 1 (modeled as a clay)
$= H_o*(RR*Log(P_c/P_o) + CR*\log((P_o+\Delta P)/P_c)$
where $P_c = P_o*OCR$
in Strata 2 (modeled as sands)
$=\Delta PH_o/mP_a(sqrt(0.5(P_o+(P_o+\Delta P))/P_a)$
where Pa = atmospheric pressure (psf) =
m = 100 janbu modulu
loose sands, slightly ove

Table 4
Secondary Settlement

Layer Information						Existing Ash		Strata 1		Strata 2		**Total Settlement (ft)**
location	Original Base Grades	Existing Ground Surface	Proposed base grade	Proposed Final Grade	Reference Boring	Primary Settlement	Secondary Settlement	Layer Thickness	Secondary Settlement	Primary Settlement	Secondary Settlement	
1	49	49	50	50	B-07A, B-07B	0.00	0.000	9.0	0.027	0.0	0.009	**0.04**
2	33.5	56.5	64	126	B-20	1.17	0.585	5.0	0.015	0.8	0.408	**1.01**
3	30	50	65.5	180	B-21	1.38	0.688	0.0	0.000	1.3	0.666	**1.35**
4	31.5	57	63	94	B-21	0.90	0.452	1.0	0.003	0.5	0.245	**0.70**
5	35	35	44	44	B-09A, B-09B	0.00	0.000	8.0	0.024	0.2	0.087	**0.11**

Notes:

Secondary settlement in sands estimated as

Total settlement at time t = S_pC_t for Pleistocene soils

where

S_p = primary settlement

c_t = time rate factor = 1.5 for 30 years (see table 5.2, Engineering Manual for Shallow Foundations)

then secondary settlement = total settlement at time t - primary settlement

Settlement due to secondary compression in clays is estimated as

$S_s = c_sH_o\log(t_{sc}/t_p)$

where

H_o = thickness soil layer

t_{sc} = time for secondary settlement estimated = 30 years

tp = time for primary consolidation = 1 years

c_s = coefficient of secondary compression = 0.002 for Strata1 Table 5.8 w_n = 50%, OCR > 5

values of c_s taken from Table 5.8, Engineering Manual for Shallow Foundations

Table 5
Total Settlement Summary and Differential Settlement

Point	Primary Settlement	Secondary Settlement	Total Settlement	Differential Settlement		
				Location	Distance	Distortion
1	0.29	0.04	0.33	Points 1 - 2	300	-1.12%
2	2.67	1.01	3.68	Points 2 - 3	680	-0.06%
3	2.71	1.35	4.06	Points 3 - 4	310	0.62%
4	1.43	0.70	2.13	Points 4 - 5	210	0.72%
5	0.50	0.11	0.61	--	--	--

Secondary settlement is modeled as total settlement 30 years after loading complete

GOLDER

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