

**APPENDIX A**  
**SUBSURFACE CONDITIONS**



## **SUBSURFACE CONDITIONS**

### **Available Data**

To characterize the site conditions at The Hague, several pertinent geotechnical and laboratory data were used. Even though the data is somewhat limited to design different flood mitigation systems, the data can still be used for preliminary site characterization, conceptual design and the general practicality of alternative flood mitigation systems. The historic development of The Hague area is shown in Figure 4-1. The data available to interpret the subsurface stratigraphy and idealized soil properties are the following:

- Geotechnical borings drilled in 1961 for the Route 599 Prestressed Concrete Bridge over The Hague. In addition to the boring data, the data from one flat dilatometer test was used to characterize the undrained shear strength properties of the Norfolk Clay unit. The dilatometer data was obtained near the northwest end of Smith Creek.
- Geotechnical borings and laboratory data for the Norfolk Transit Rail Project. The data was collected in 2006 by GET Solutions, Inc.
- Geotechnical borings and laboratory data for a bulkhead replacement project at the NOAA Marine Operations Center in Norfolk, Virginia. The subsurface explorations and laboratory data were collected in June and July, 2010 by the United States Army Corps of Engineers (USACE).

### **Regional Geology**

Regionally, The Hague project area is located in the Coastal Plain physiographic province. Flat-lying plains and terraces dominate the landscape. The Coastal Plain is underlain by a wedge of Cretaceous to Holocene age sediments that thicken to the east and pinch out at the Fall Line approximately 70 miles west of the project area. Jurassic-Triassic age basement rocks lie approximately 1,800 feet beneath the site. The wedge of Cretaceous and younger sediments were deposited as a result of multiple marine transgressions and regressions. Sediments within the upper 150 feet beneath the site are Pliocene to Recent in age. The Pliocene and younger sediments have been deposited and subsequently eroded in places during the rising and falling sea levels that resulted from glacial and interglacial periods.

### **Subsurface Stratigraphy**

The stratigraphic units encountered beneath The Hague area are described in descending sequence in the following discussion.

#### **Artificial Fill**

The top soil layer comprises of very loose to dense artificial fill. The thickness of the fill layer, on both sides of Smith Creek, varies between 6 and 16 feet. The fill material generally comprises of silty to clayey fine sand with gravel, brick and marine shell fragments.

## Alluvium

Underlying the artificial fill is an alluvium unit, which comprises predominantly of Norfolk Marine Clay layer. This layer is a thick, extremely soft to firm, normally consolidated fat clay (CH) layer. The clay layer does not include sub-layers with high undrained shear strength, evidence of desiccation or exposure, or other evidence of crust layers. It is inferred that the entire unit to be marine deposits of Holocene-age, which have been deposited subsequent to the submergence of the paleo-bay bottom of the lower Chesapeake Bay about 10,000 years ago as sea level rose and flooded the main channel of the paleo-Subsquehanna River (Chesapeake Bay) since the last glacial sea level lowstand.

The Norfolk Clay layer has a variable thickness. The layer is thickest near the northwest end of Smith Creek with an average thickness of about 50 feet. The thickness gradually decreases with increasing distance from the creek. The shape and trend of the clay unit below Smith Creek is a clear indication of channelization processes (Figures 4-2 and 4-3). At the southeast end of Smith Creek, the clay layer thickness varies between 15 to 25 feet.

## The Yorktown Formation

The Yorktown Sand is a regionally-extensive medium dense to dense silty fine to fine sand that is commonly used as a bearing stratum for pile foundations. At the Hague area, the top of the Yorktown Sand was encountered between El. -28 and El. -64 feet (Figures 4-2 and 4-3). Based on the available geotechnical data, the bottom elevation of this layer was not encountered. The deepest borings extended to El. -100 feet and was terminated in the Yorktown sand layer. The marine drilling program for the neighboring Craney Island Eastward Expansion Project, conducted in 2003 (Fugro Atlantic, 2009) demonstrated a bottom elevation of the Yorktown Sand layer between El. -120 to El. -145 feet.

## Design Subsurface Profiles for Concept Evaluation

In order to conceptually evaluate possible flood mitigation systems at The Hague, it was necessary to idealize the subsurface conditions, and determine soil properties that will govern the flood mitigation system selection and design. Based on the available data and published correlations between different soil parameters, the following were interpreted:

- Two idealized soil profiles representing an upper and lower bound of expected stratigraphy;
- Idealized moisture content profiles;
- Idealized undrained shear strength profiles for the Norfolk Clay layer;
- Friction angle profiles for the artificial fill and Yorktown Sand layers;
- Ultimate bearing capacity values for the upper and lower boundary profiles based on a continuous strip footing with a unit width;
- Active and passive earth pressure coefficients. A drained condition was assumed for the Norfolk Clay material;

- Compressibility values for the Norfolk Clay layer.

### Idealized Stratigraphy

The subsurface condition at The Hague was idealized into two profiles for conceptual evaluation of various flood mitigation systems. The first profile is located at the alluvium channel where the Norfolk Clay layer is expected to be thickest. This profile represents a lower bound of anticipated soil properties and shear strength values. Profile one comprises of a 7 feet artificial fill layer, which is overlying a 50 feet thick Norfolk Clay layer. The bottom layer is the Yorktown Sand layer, which extends to El. -100 feet (equivalent to the deepest available borings).

The second profile is located at the southeast end of Smith Creek where the Norfolk Clay layer is thinnest. This profile represents an upper bound of the anticipated soil properties. The profile comprises of a 13 feet Norfolk Clay layer overlying about 70 feet of Yorktown Sand. The profile extends to El. -100 feet NAVD88.

According to the available geotechnical data, the Plasticity Index (PI) for the Norfolk Clay layer ranges from 24 to 70, and the percent passing the No. 200 sieve ranges between 76 and 94%. The average percent fines content for the artificial fill and Yorktown Sand layers was about 18%. This value was later used to correct the Standard Penetration Test (SPT) blow counts for clean sands.

### Idealized Moisture Content Profiles

The idealized moisture content for profiles one and two are shown in Figures A-1 and A-2, respectively. The data shows that the moisture content for the Norfolk Clay layer decreases with depth whereas the moisture content profile for the Yorktown Sand is about 33% for both profiles.

The moisture content profiles were used to estimate a total unit weight profile using phase diagram correlations, and assuming 100% saturation and an average specific gravity ( $G_s$ ) of 2.7. Based on the total unit weights, effective stress profiles were determined (Figures A-3 and A-4).

### Undrained Shear Strength of the Norfolk Clay

The undrained shear strength ( $S_u$ ) of the Norfolk Clay was calculated based on the shear strength data reduced from one flat dilatometer test. The location of the test, which was performed as part of the Norfolk Rail Transit Project, is shown on Figure 4-3. A mean  $S_u$  profile was interpreted for profile one as shown in Figure A-5. This mean profile was assumed to be an upper bound of expected in situ shear strength values. According to the OCR profile, also determined from the dilatometer data, the clay material is normally consolidated. Therefore, the undrained shear strength ratio for normally consolidated material  $(S_u/\sigma'_v)_{NC}$  was calculated to be about 0.3. Based on Duncan (2000) recommendations a Coefficient of Variation (COV) for  $(S_u/\sigma'_v)_{NC}$  was selected to be 10%. Based on a COV of 10%, a lower bound  $(S_u/\sigma'_v)_{NC}$  was

calculated to be about 0.25. From this value, a lower bound  $S_u$  profile was determined (Figure A-5). The same upper and lower  $(S_u/\sigma'_{v})_{NC}$  values were used to back-calculate  $S_u$  for the profile two (Figure A-6).

### Idealized Friction Angle

The strength properties for the artificial fill and Yorktown Sand were determined by interpreting idealized friction angle ( $\phi$ ) profiles from SPT blow counts (N-values). The N-values were corrected for rod length, fines content, and overburden pressure using the correlation provided by Liao and Whitman (1986). The correlations provided by Peck et al. (1974) and the American Petroleum Institute (API) (2000) were then used to estimate  $\phi$  from corrected N-values. The API method resulted in considerably higher  $\phi$  values. Therefore, the mean  $\phi$  values for each layer was calculated based on Peck et al. (1974) and used as an upper bound profile. Two standard deviations were subtracted from the mean value to calculate the lower bound  $\phi$  profile as shown in Figures A-7 and A-8. The upper and lower design  $\phi$  values for each profile are shown in Table A-1.

**Table A-1. Idealized Friction Angles**

Soil Layer	Effective Stress Friction Angle (degrees)					
	Profile 1			Profile 2		
	Upper Bound	Lower Bound	COV (%)	Upper Bound	Lower Bound	COV (%)
Artificial Fill	29	27	3	-	-	-
Yorktown Sand	33	28	7	33	28	7

### Ultimate Bearing Capacity

Some flood mitigation alternatives may be supported on shallow foundations. Therefore, ultimate bearing capacity values were calculated for profiles 1 and 2 based on a continuous strip footing with a unit width. For each profile, lower and upper bound bearing capacity values were determined from the mean and lower bound friction angles, respectively (Figures A-9 and A-10). Further, ultimate bearing capacities for the Norfolk Clay layer were estimated based on undrained and drained conditions. For drained conditions, the upper bound effective stress friction angle was assumed to be 33° degrees. To obtain a lower bound effective stress friction angle, a 7% COV was applied to the upper bound value based on Duncan (2000) recommendations. Tables A-2 and A-3 summarize the bearing capacity factors, which were based on Meyerhof (1963).



**Table A-2. Bearing Capacity Factors – Profile 1**

Bearing Capacity Factor	Artificial Fill		Norfolk Clay			Yorktown Sand	
	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Undrained	Upper Bound	Lower Bound
$N_c$	28	24	39	27	5	39	26
$N_q$	17	14	26	16	1	26	15
$N_\gamma$	13	9	26	11	0	26	11
COV (%)	3	-	7	-	-	7	-

**Table A-3. Bearing Capacity Factors – Profile 2**

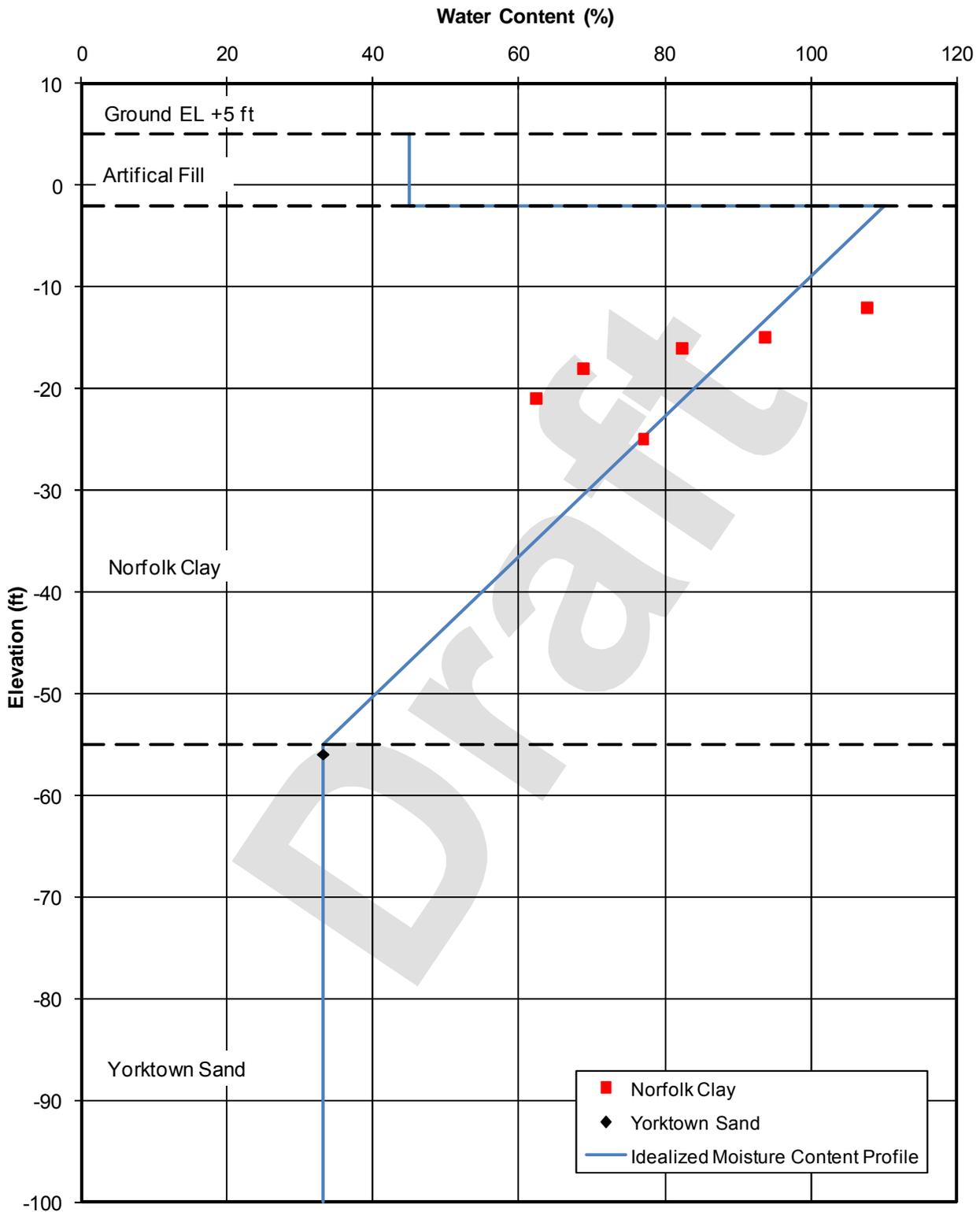
Bearing Capacity Factor	Norfolk Clay			Yorktown Sand	
	Upper Bound	Lower Bound	Undrained	Upper Bound	Lower Bound
$N_c$	39	27	5	39	26
$N_q$	26	16	1	26	15
$N_\gamma$	26	11	0	26	11
COV (%)	7	-	-	7	-

#### Active and Passive Earth Pressure Coefficients

In addition to the aforementioned engineering parameters, active ( $k_a$ ) and passive ( $k_p$ ) earth pressure coefficients were calculated for the two idealized profiles. This will assist in the conceptual design of some flood mitigation alternatives where lateral earth pressure loadings are expected behind a flood mitigation structure such as a retaining or sheet pile wall. The pressure at which the soil fails as the wall moves away from the retained soil is called active earth pressure, whereas the pressure at which the soil fails as the wall moves into the retained soil is called passive pressure. Active and passive earth pressure coefficients were calculated according to Rankine's and Coulomb's theories (Figures A-11 to A-14). Rankine's  $k_a$  and  $k_p$  were determined based on a frictionless wall where the interface friction ( $\delta$ ) between the retaining structure and the soil is neglected. Coulomb's  $k_a$  and  $k_p$  were calculated for a steel and concrete wall by varying the value of  $\delta$ . For a steel wall,  $\delta$  was equal to  $\phi - 5^\circ$ , while for a concrete wall,  $\delta$  was equal to  $0.58 \cdot \phi$ .

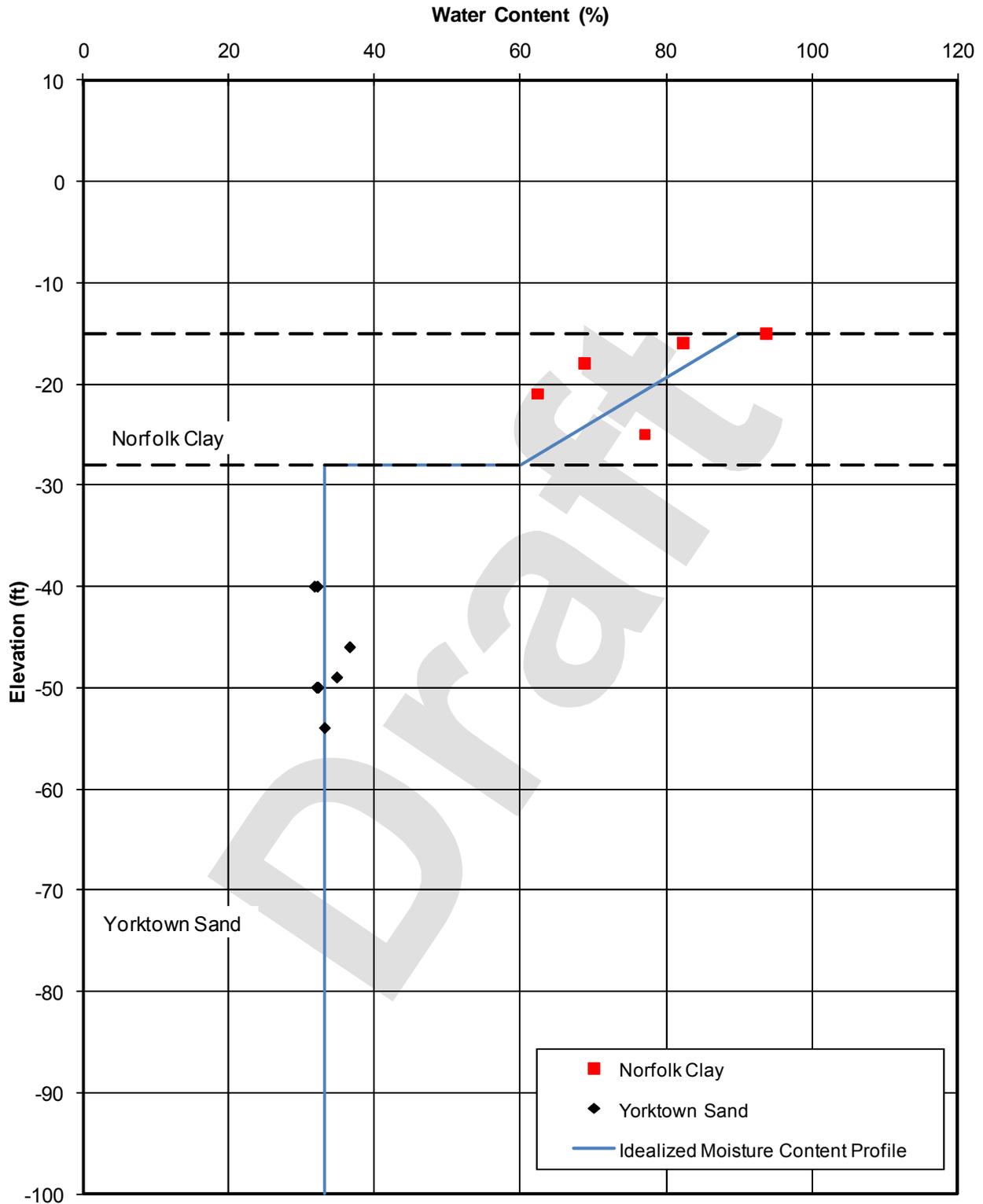
#### Compressibility

One consolidation test provided by GET Solutions, Inc. was pertinent to The Hague area. The test was conducted on a Norfolk Clay sample obtained from a depth of about 24.5 feet. The test results indicate a compression ratio ( $C_c$ ) and a recompression ratio ( $C_r$ ) of 0.77 and 0.08, respectively.



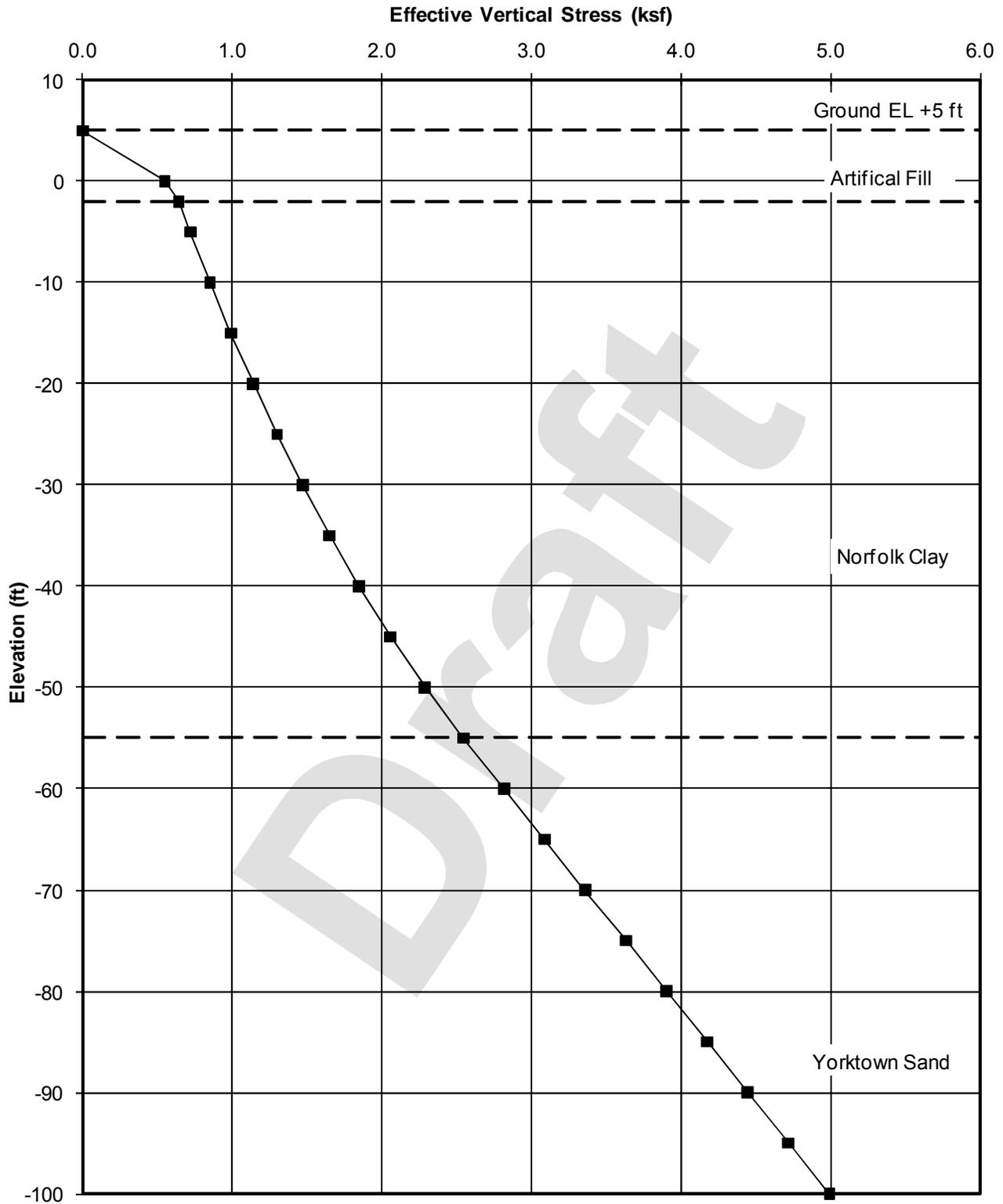
### IDEALIZED WATER CONTENT - PROFILE 1

City-wide Coastal Flooding Study  
Norfolk, Virginia

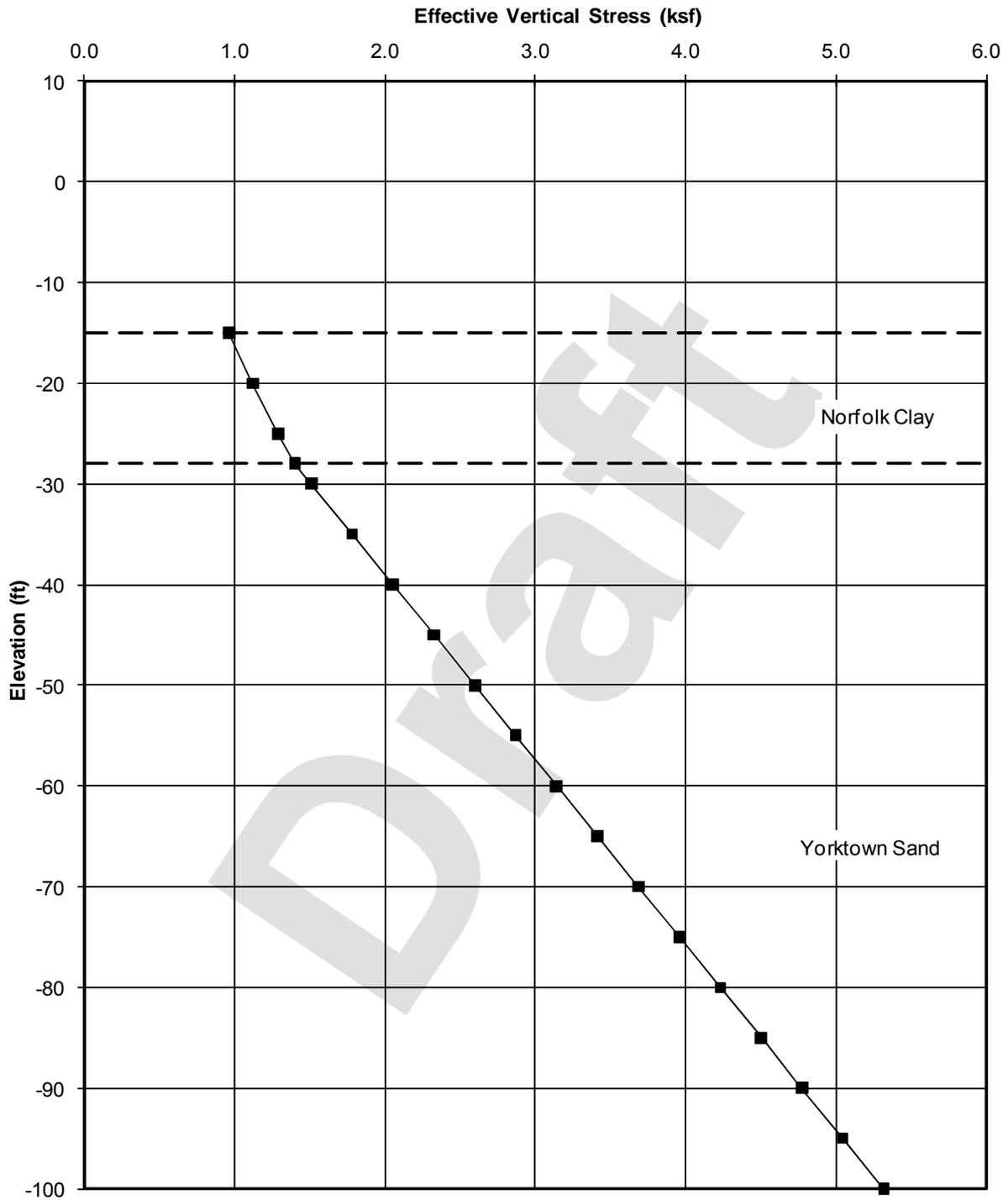


### IDEALIZED WATER CONTENT - PROFILE 2

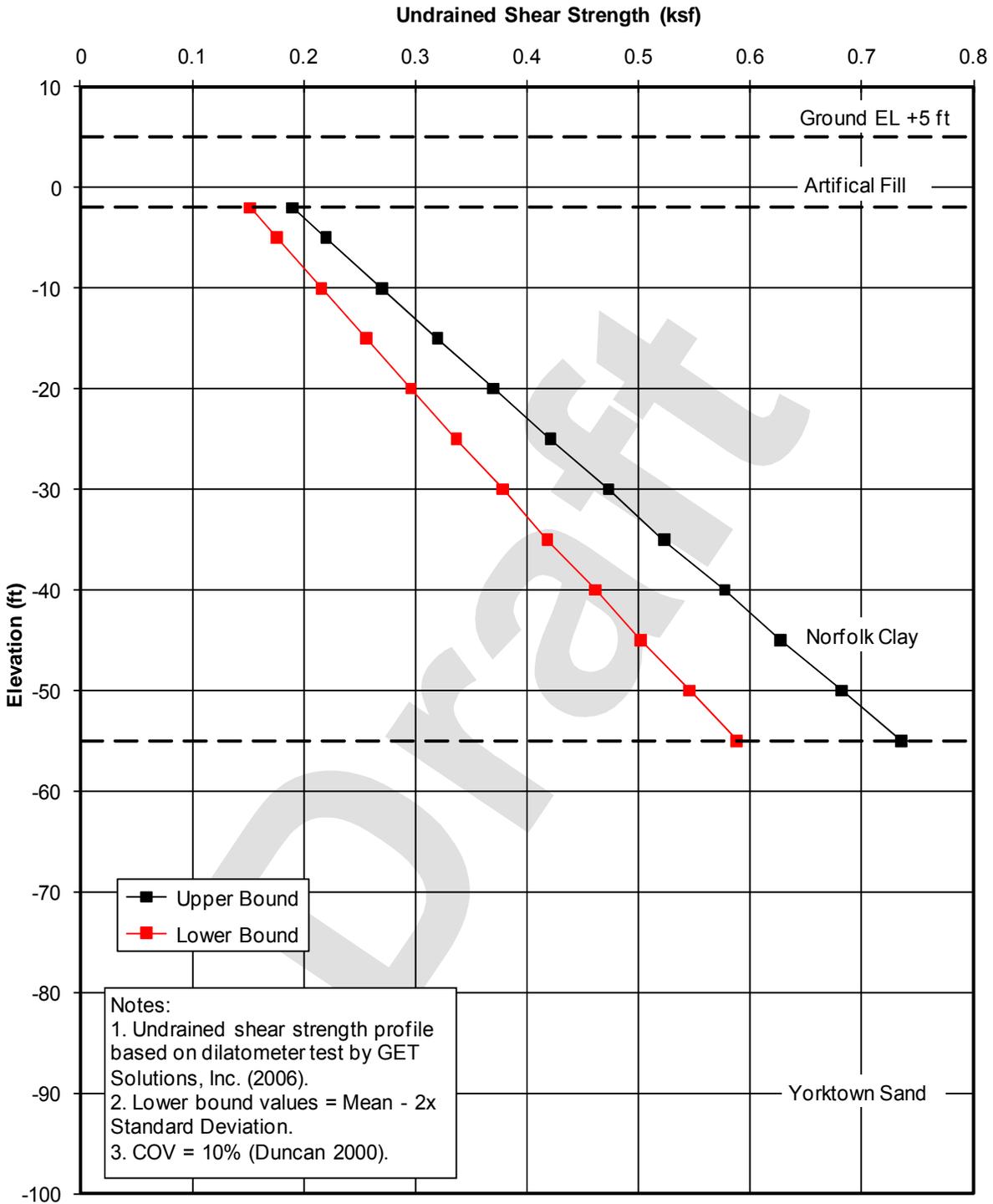
City-wide Coastal Flooding Study  
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**EFFECTIVE STRESS - PROFILE 1**  
City-wide Coastal Flooding Study  
Norfolk, Virginia



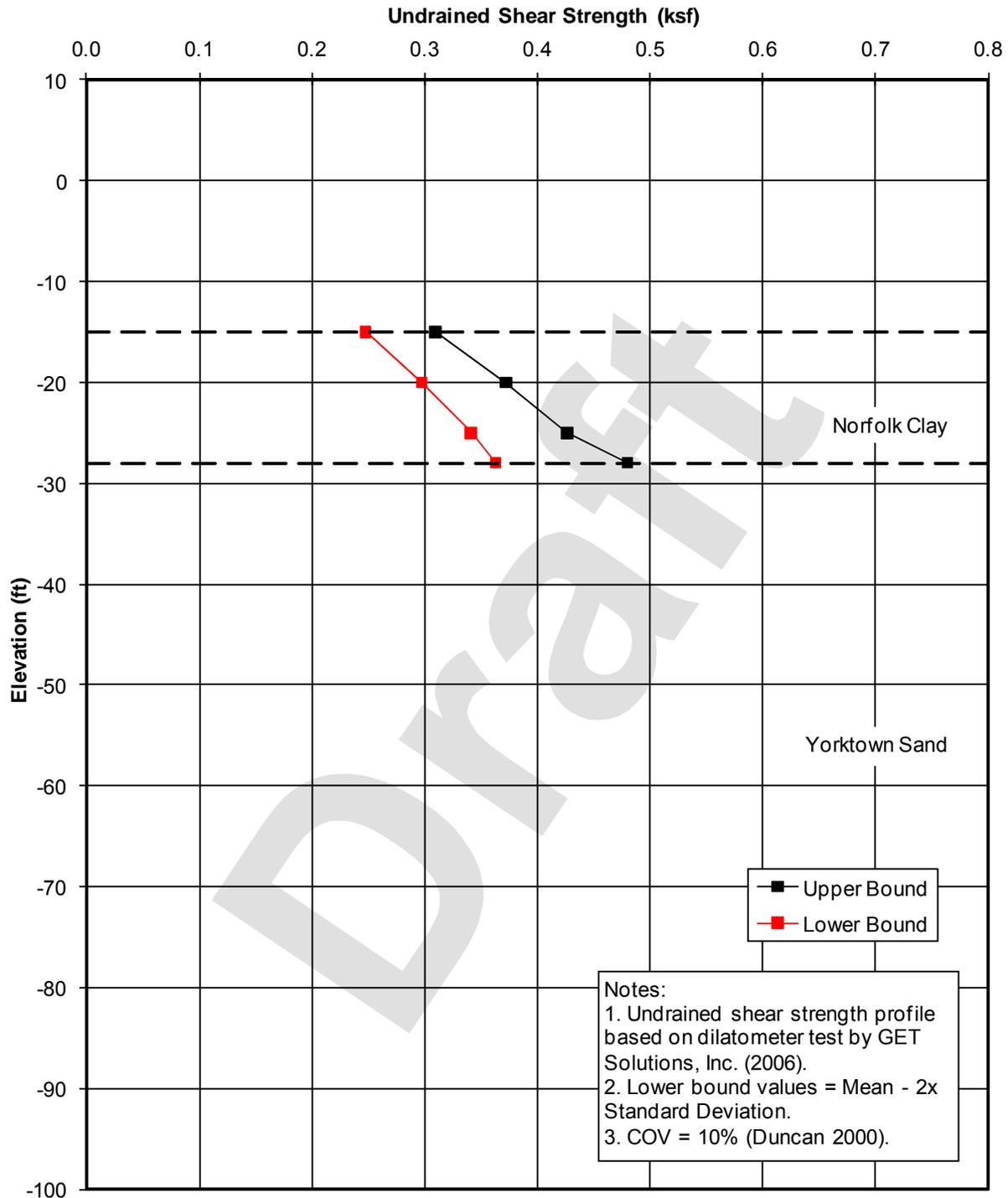
**EFFECTIVE STRESS - PROFILE 2**  
City-wide Coastal Flooding Study  
Norfolk, Virginia



**UNDISTURBED SHEAR STRENGTH - PROFILE 1**

City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE A-5

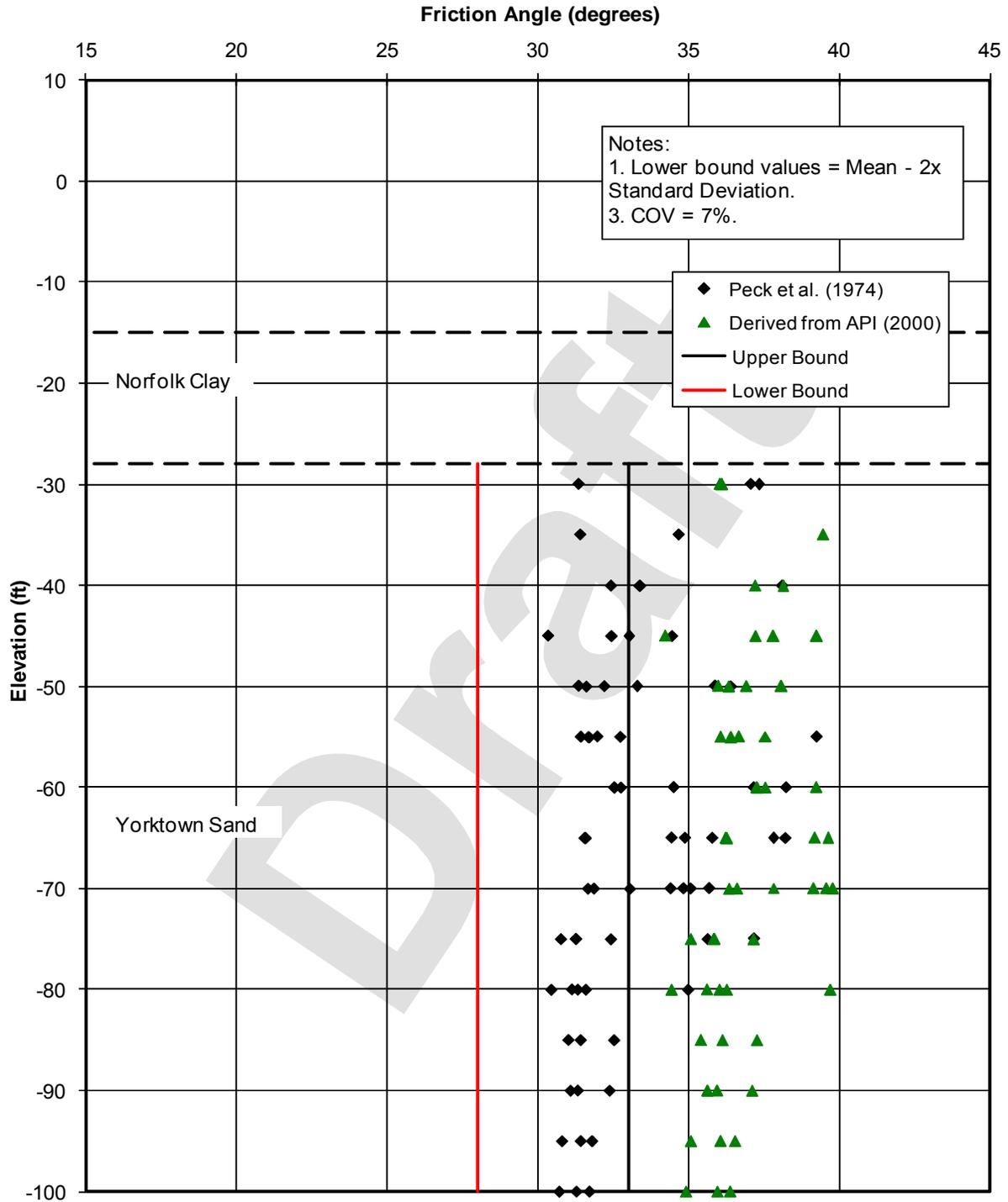


### UNDISTURBED SHEAR STRENGTH - PROFILE 2

City-wide Coastal Flooding Study  
Norfolk, Virginia

FIGURE A-6





**FRICITION ANGLE - PROFILE 2**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

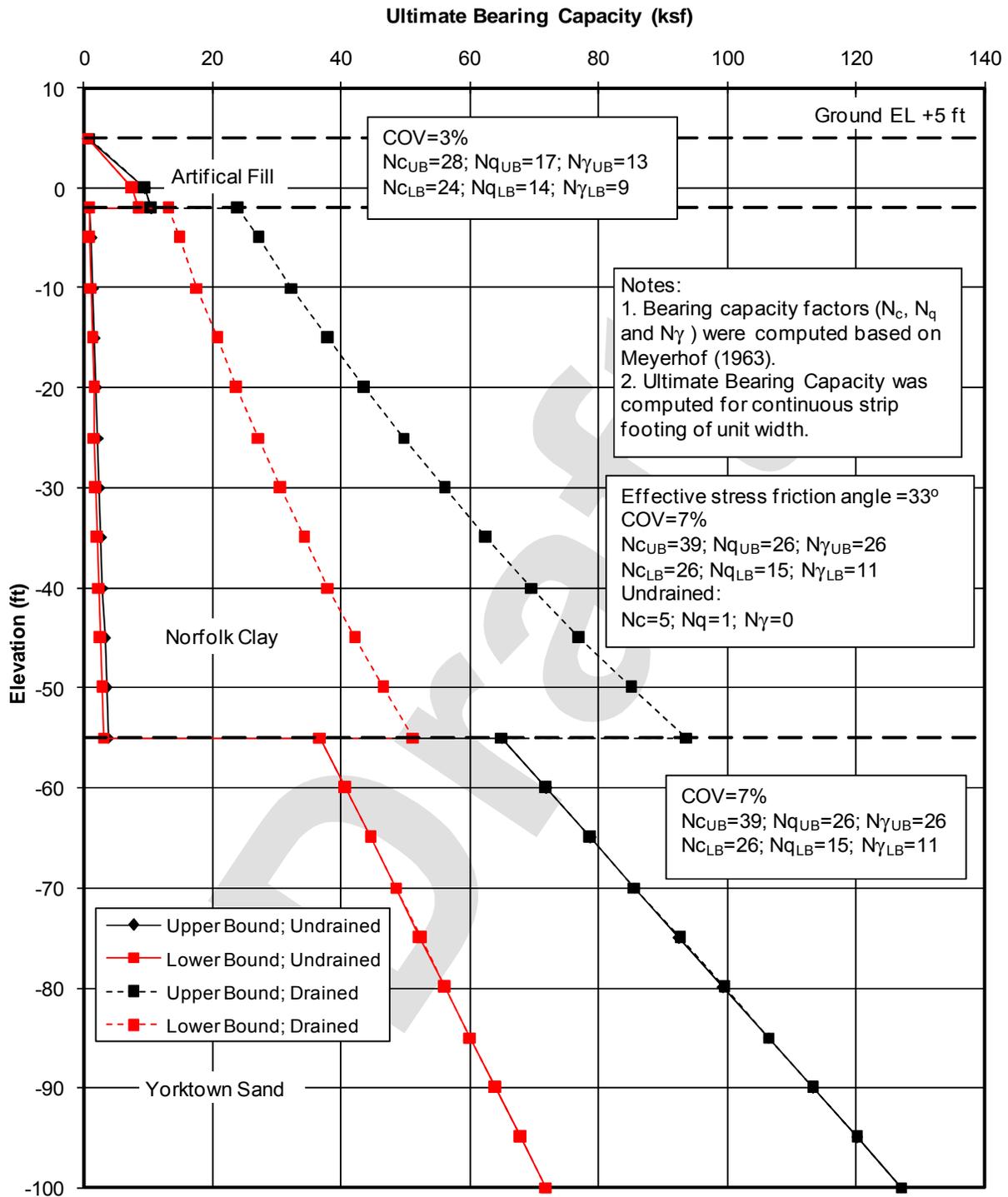
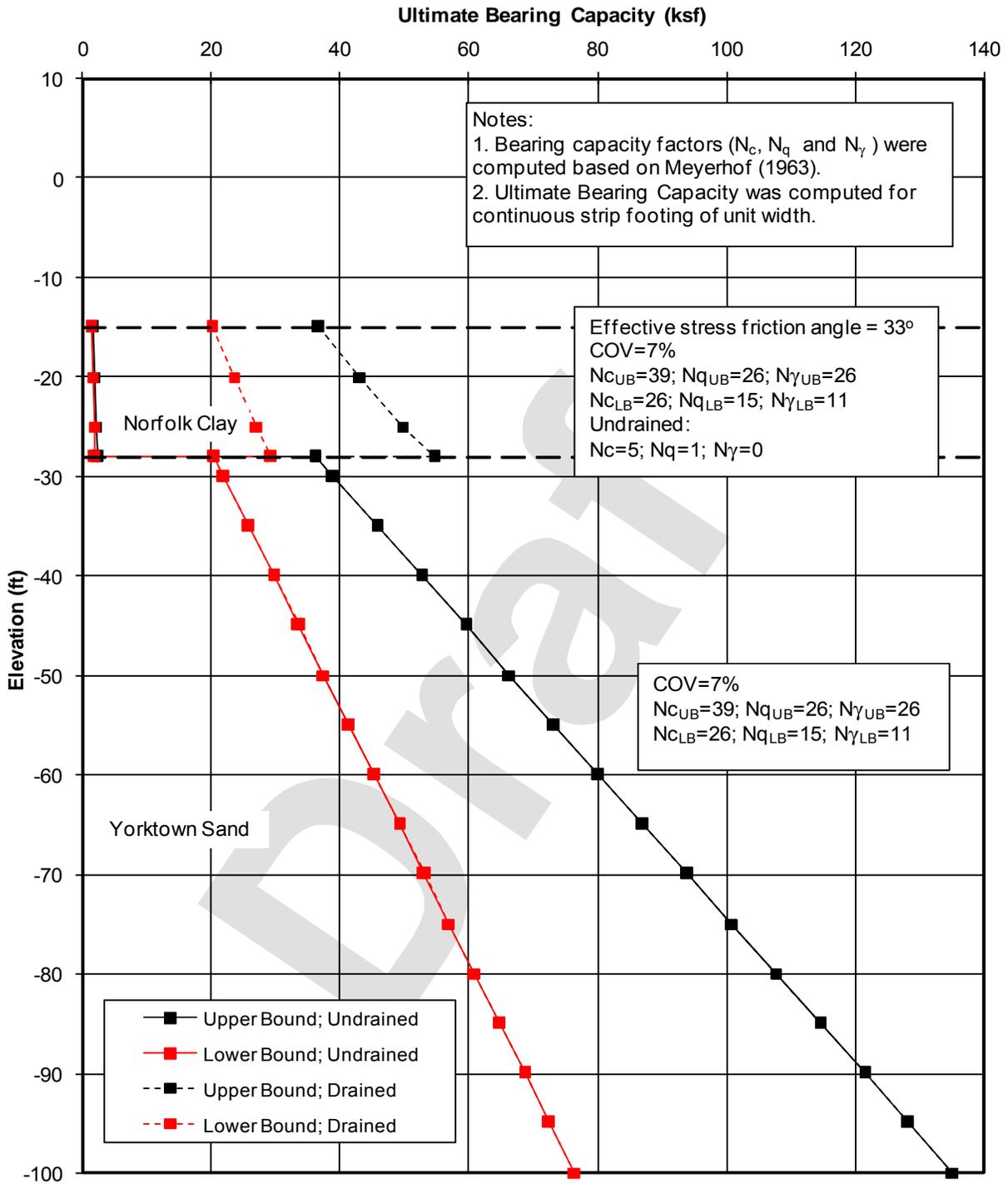
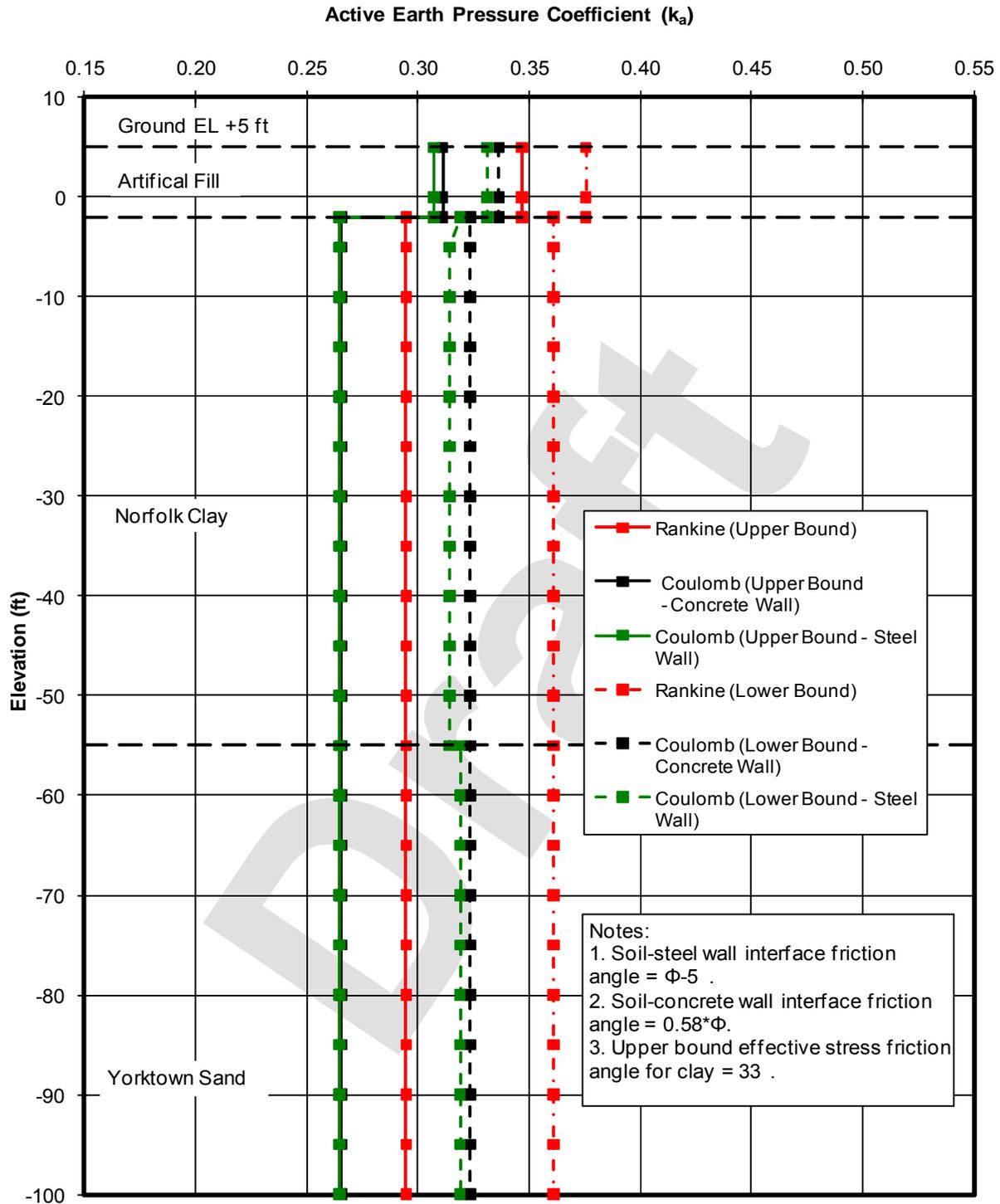


FIGURE A-9



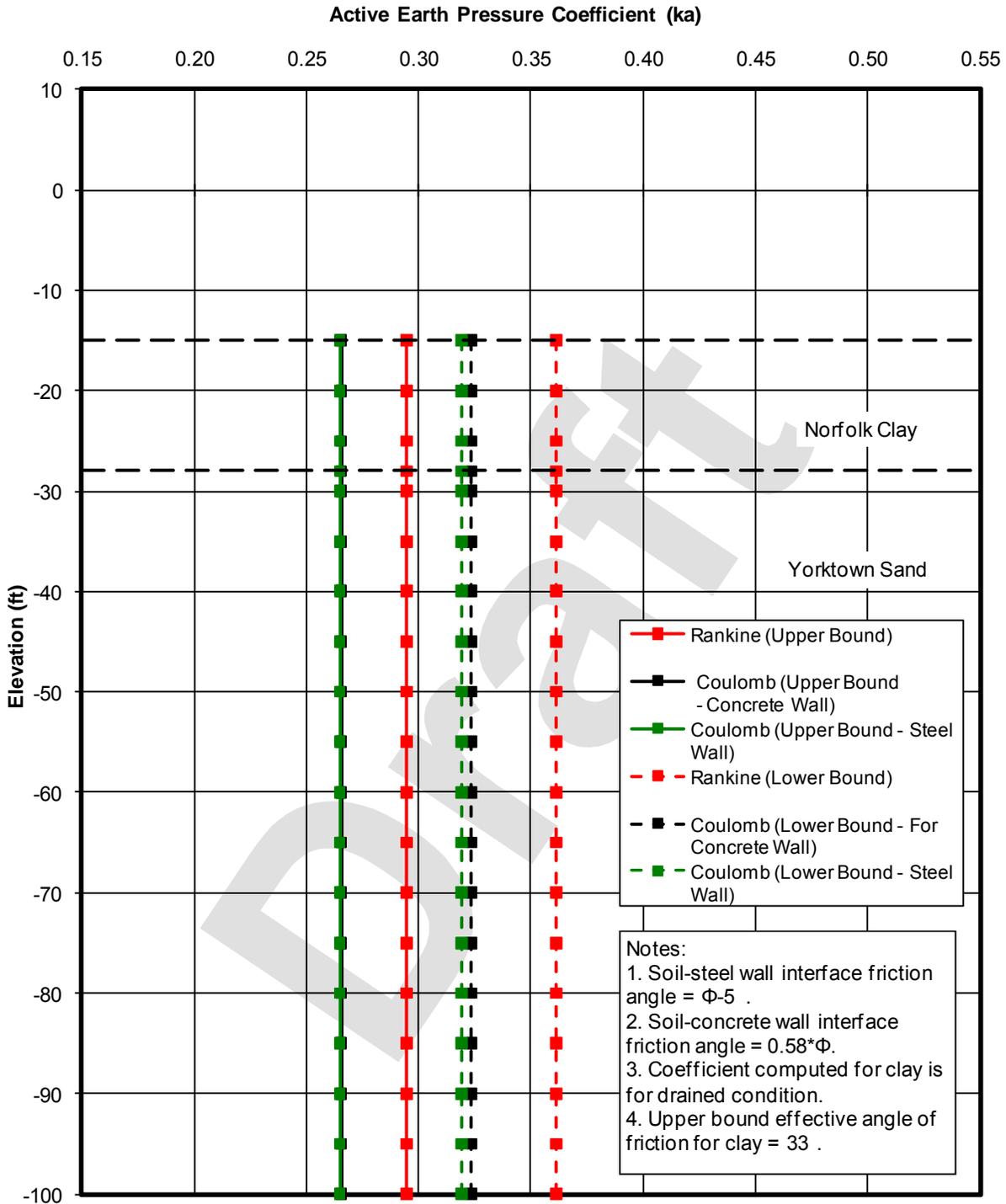
**ULTIMATE BEARING CAPACITY - PROFILE 2**

City-wide Coastal Flooding Study  
 Norfolk, Virginia



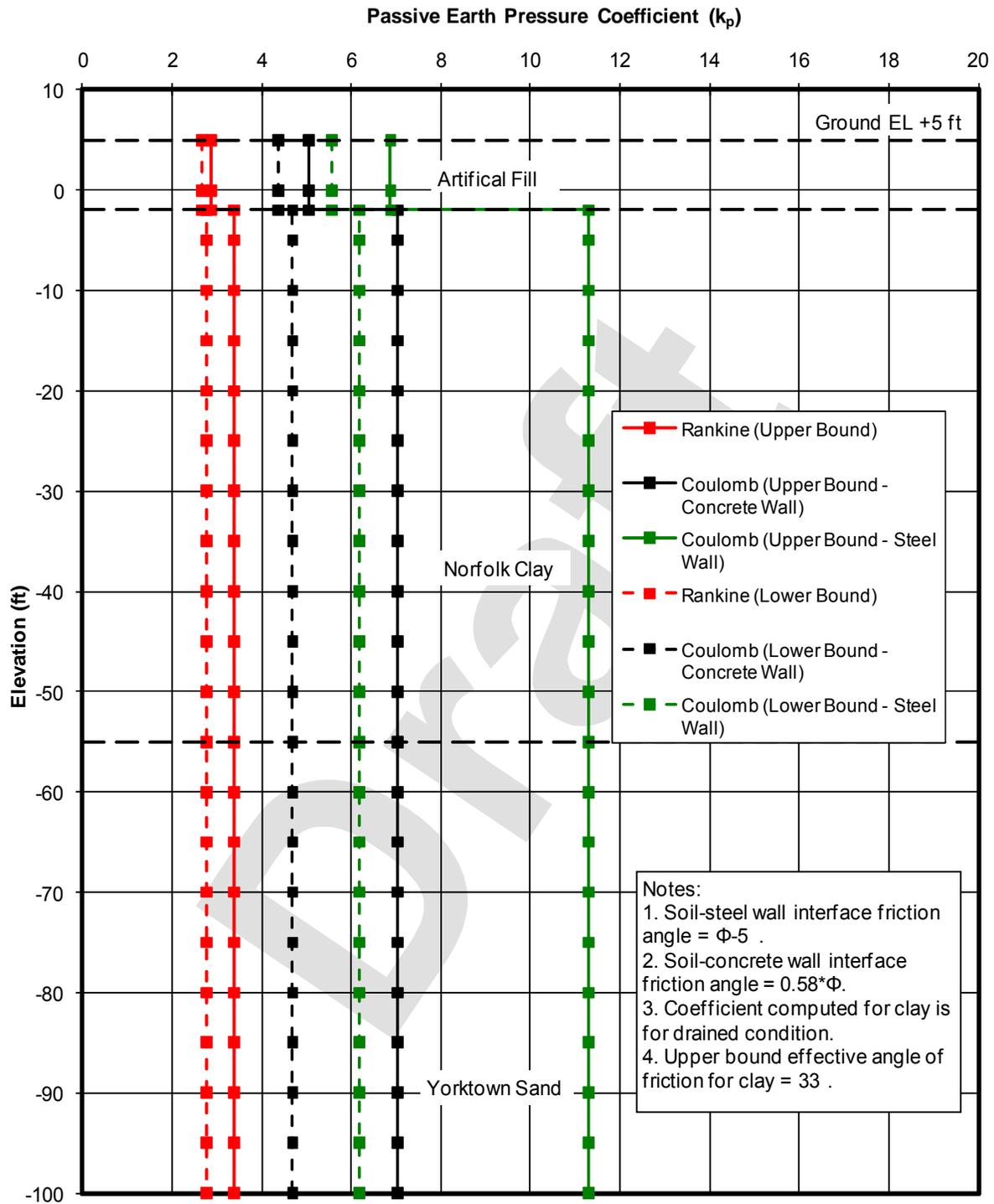
**ACTIVE EARTH PRESSURE COEFFICIENT - PROFILE 1**

City-wide Coastal Flooding Study  
 Norfolk, Virginia



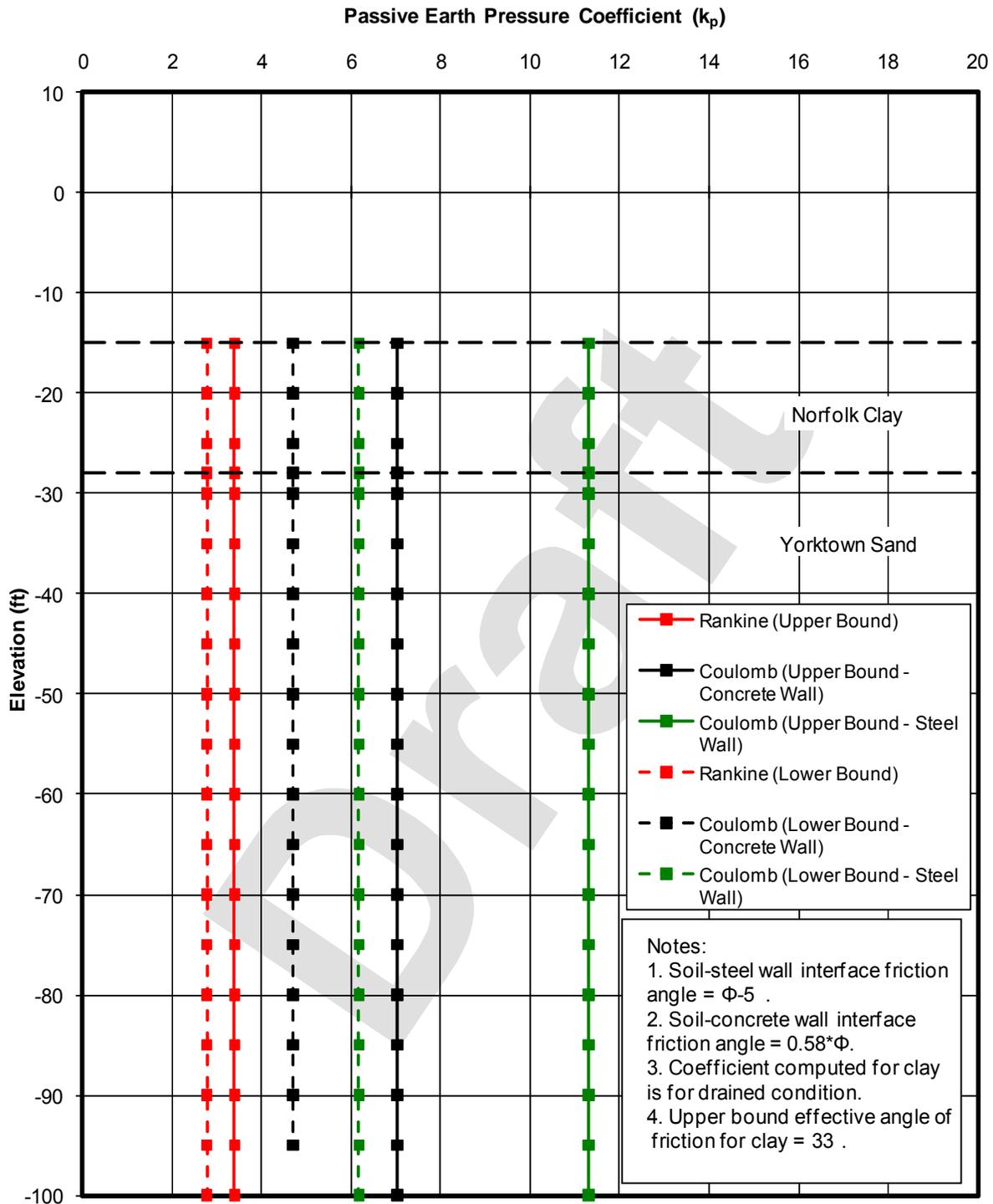
**ACTIVE EARTH PRESSURE COEFFICIENT - PROFILE 2**

City-wide Coastal Flooding Study  
 Norfolk, Virginia



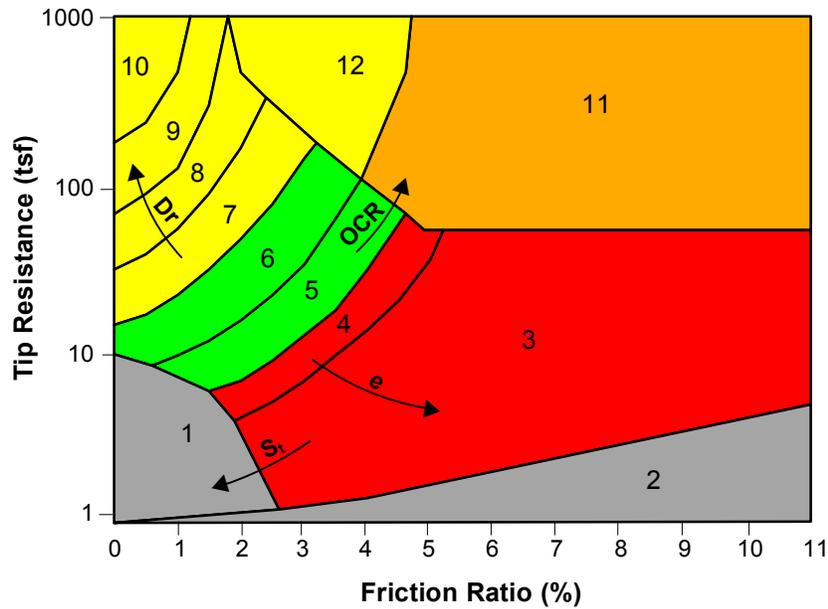
**PASSIVE EARTH PRESSURE COEFFICIENT - PROFILE 1**

City-wide Coastal Flooding Study  
 Norfolk, Virginia



**PASSIVE EARTH PRESSURE COEFFICIENT - PROFILE 2**

City-wide Coastal Flooding Study  
 Norfolk, Virginia

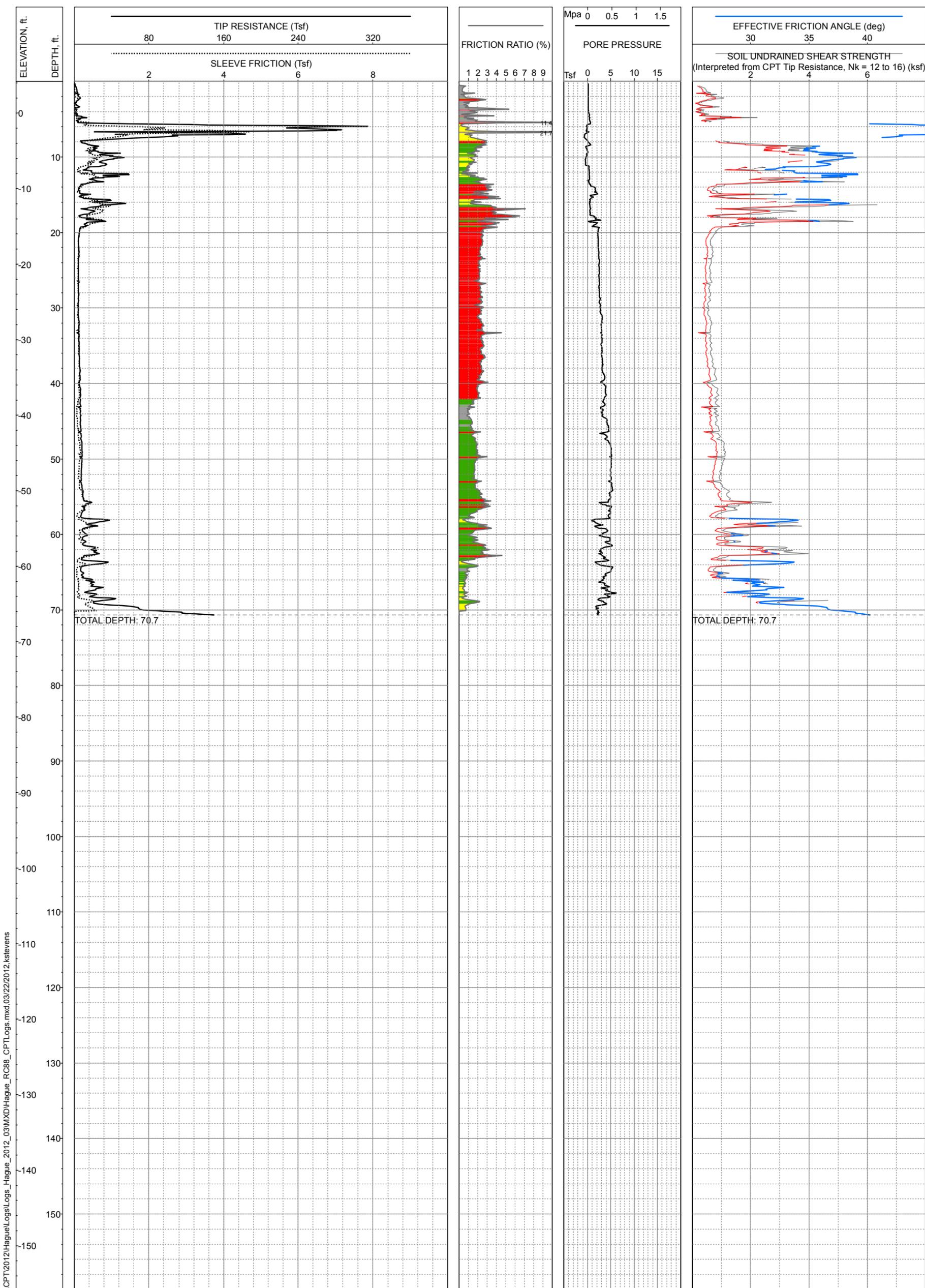


Zone	Soil Behavior Type	U.S.C.S.
1	Sensitive Fine-grained	OL-CH
2	Organic Material	OL-OH
3	Clay	CH
4	Silty Clay to Clay	CL-CH
5	Clayey Silt to Silty Clay	MH-CL
6	Sandy Silt to Clayey Silt	ML-MH
7	Silty Sand to Sandy Silt	SM-ML
8	Sand to Silty Sand	SM-SP
9	Sand	SW-SP
10	Gravelly Sand to Sand	SW-GW
11	Very Stiff Fine-grained *	CH-CL
12	Sand to Clayey Sand *	SC-SM

\*overconsolidated or cemented

**CPT CORRELATION CHART  
(Robertson and Campanella, 1988)**

**CPT SOIL BEHAVIOR TYPE KEY**  
City-wide Coastal Flooding Study  
Norfolk, Virginia

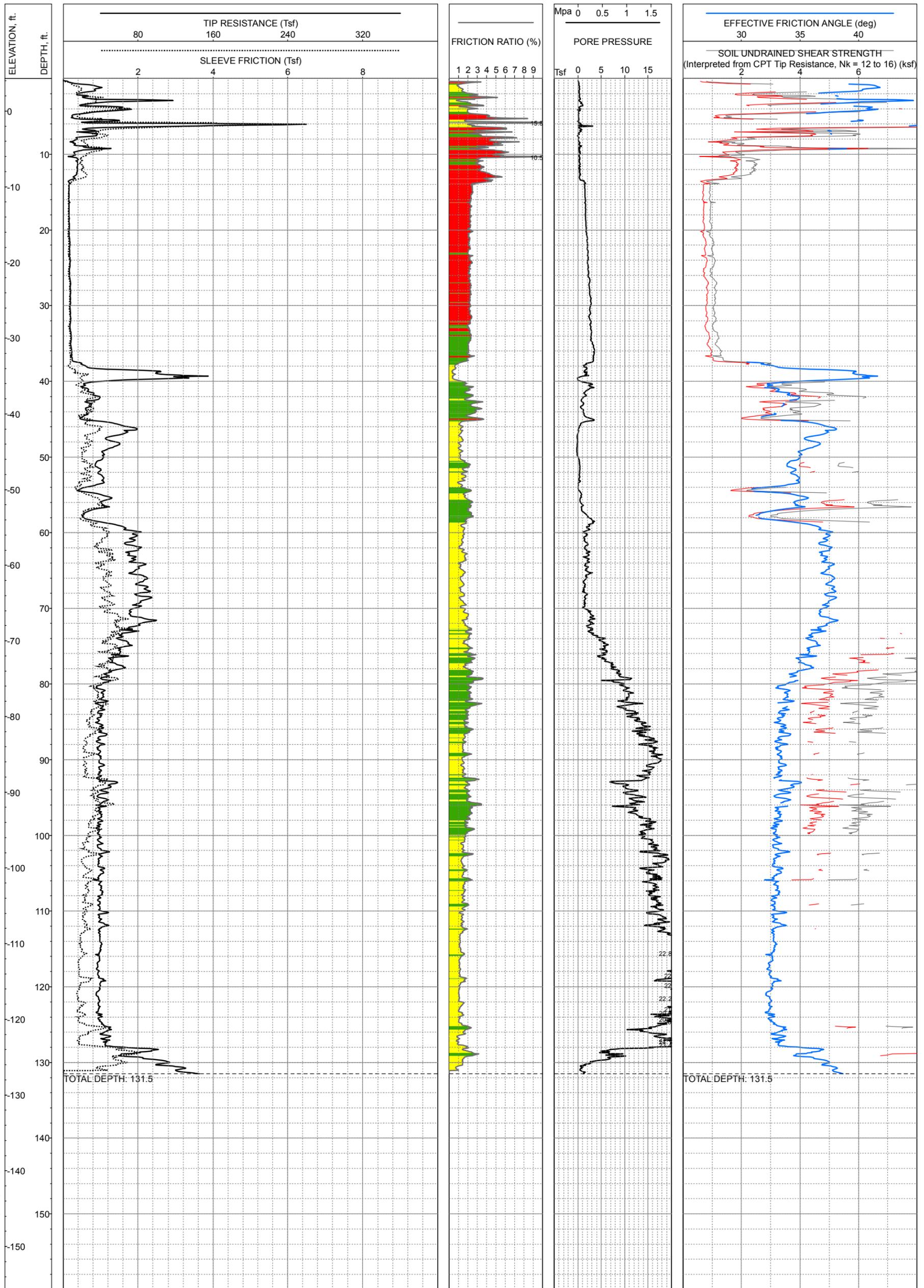


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LOCATION: N: 3,478,357, E: 12,126,614 (State Plane Virginia South Zone, NAD 83, feet)  
 SURFACE EL: 4.2ft (NAVD88)  
 COMPLETION DEPTH: 70.7ft  
 TEST DATE: 3/2/2012

EXPLORATION METHOD: CPT  
 PERFORMED BY: Fugro  
 REVIEWED BY: KSmith  
 Soil behavior type based on Robertson and Campanella (1988)

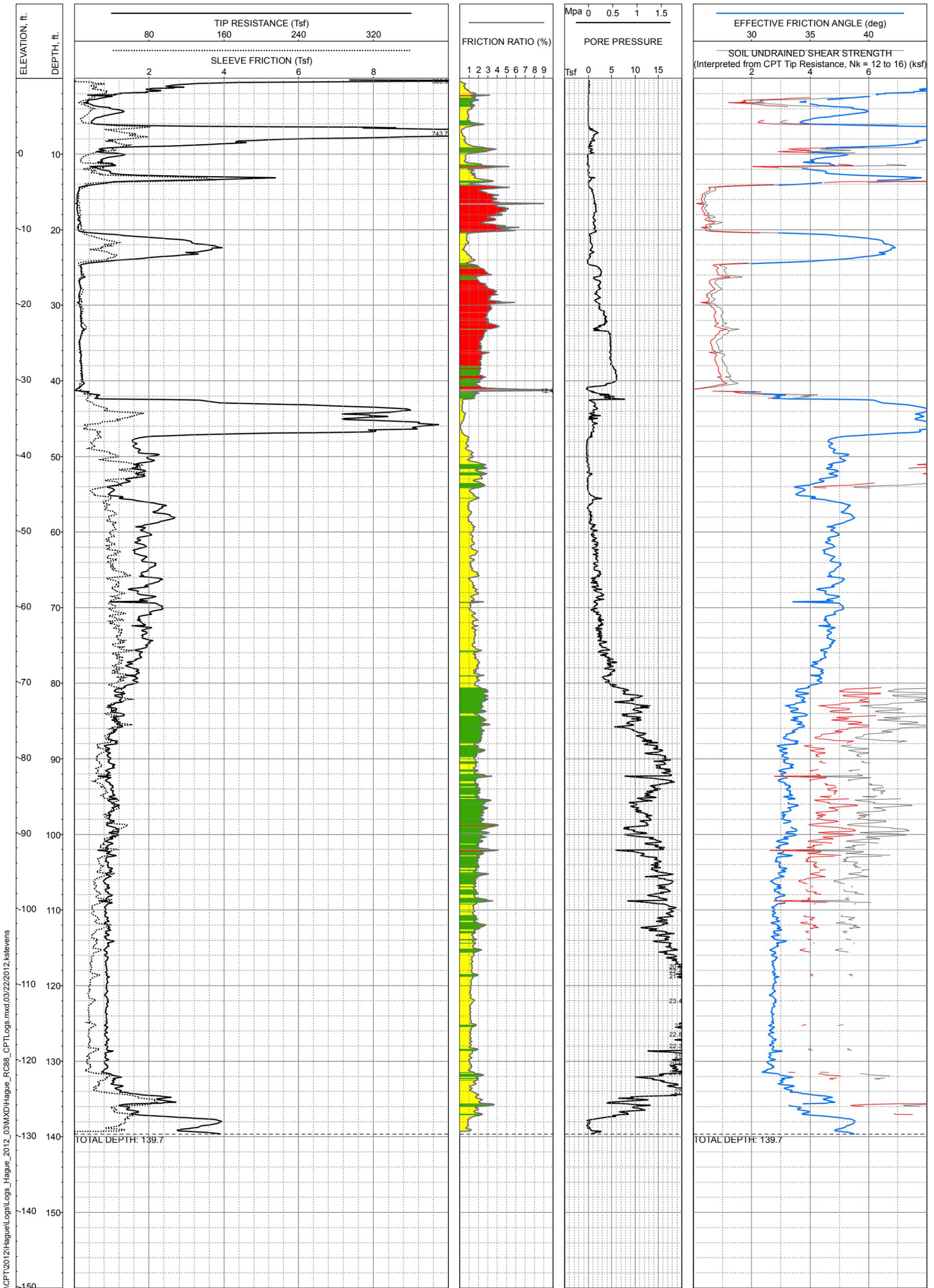
**LOG OF CPT NO: C-1**  
 The Hague Area  
 Norfolk, Virginia



LOCATION: N: 3,478,551, E: 12,126,492 (State Plane Virginia South Zone, NAD 83, feet)  
 SURFACE EL: 4.3ft (NAVD88)  
 COMPLETION DEPTH: 131.5ft  
 TEST DATE: 3/2/2012

EXPLORATION METHOD: CPT  
 PERFORMED BY: Fugro  
 REVIEWED BY: KSmith  
 Soil behavior type based on Robertson and Campanella (1988)

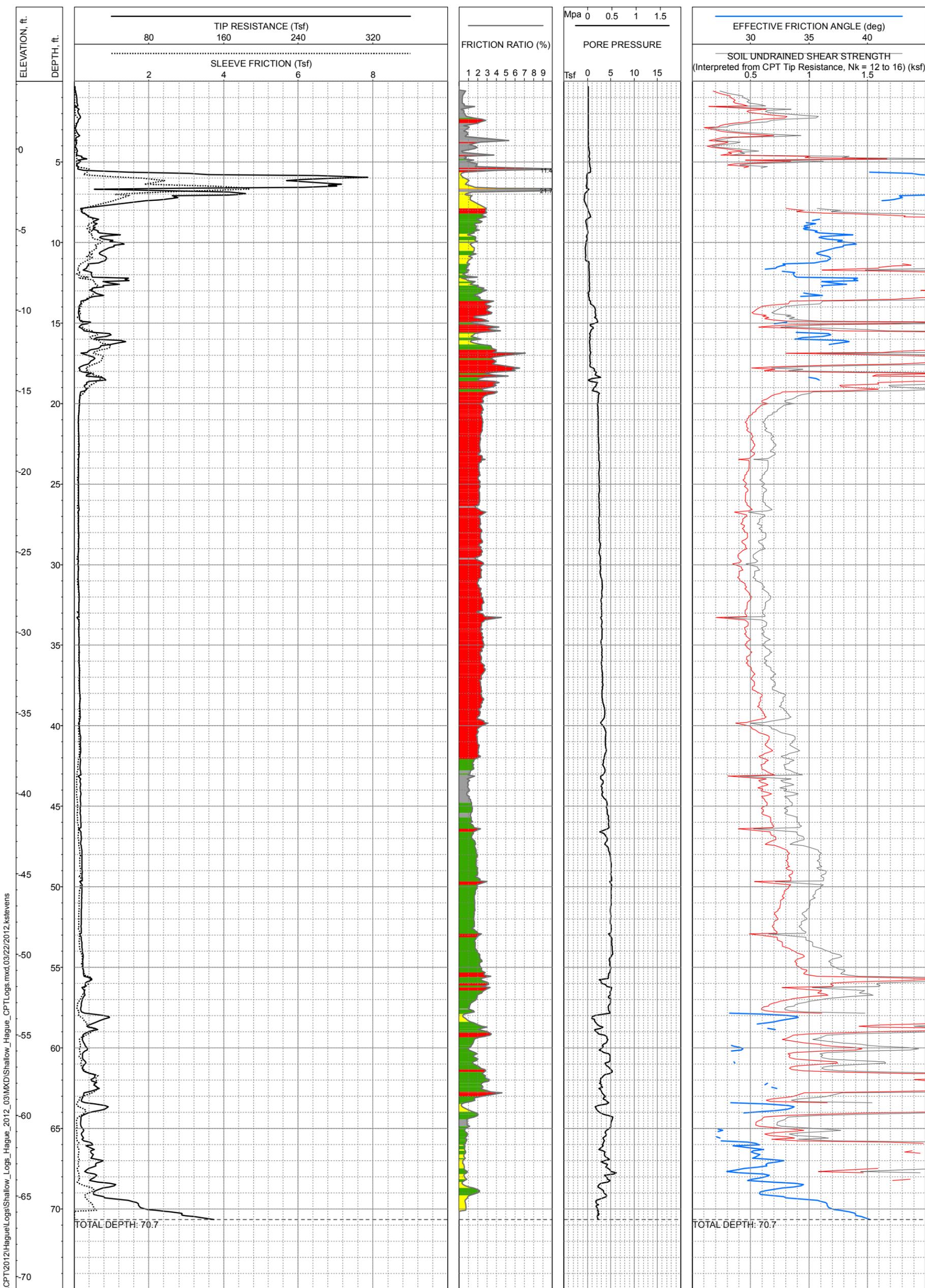
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 The Hague Area  
 Norfolk, Virginia



LOCATION: N: 3,477,974, E: 12,127,269 (State Plane Virginia South Zone, NAD 83, feet)  
 SURFACE EL: 9.8ft (NAVD88)  
 COMPLETION DEPTH: 139.7ft  
 TEST DATE: 3/3/2012

EXPLORATION METHOD: CPT  
 PERFORMED BY: Fugro  
 REVIEWED BY: KSmith  
 Soil behavior type based on Robertson and Campanella (1988)

**LOG OF CPT NO: C-3**  
 The Hague Area  
 Norfolk, Virginia



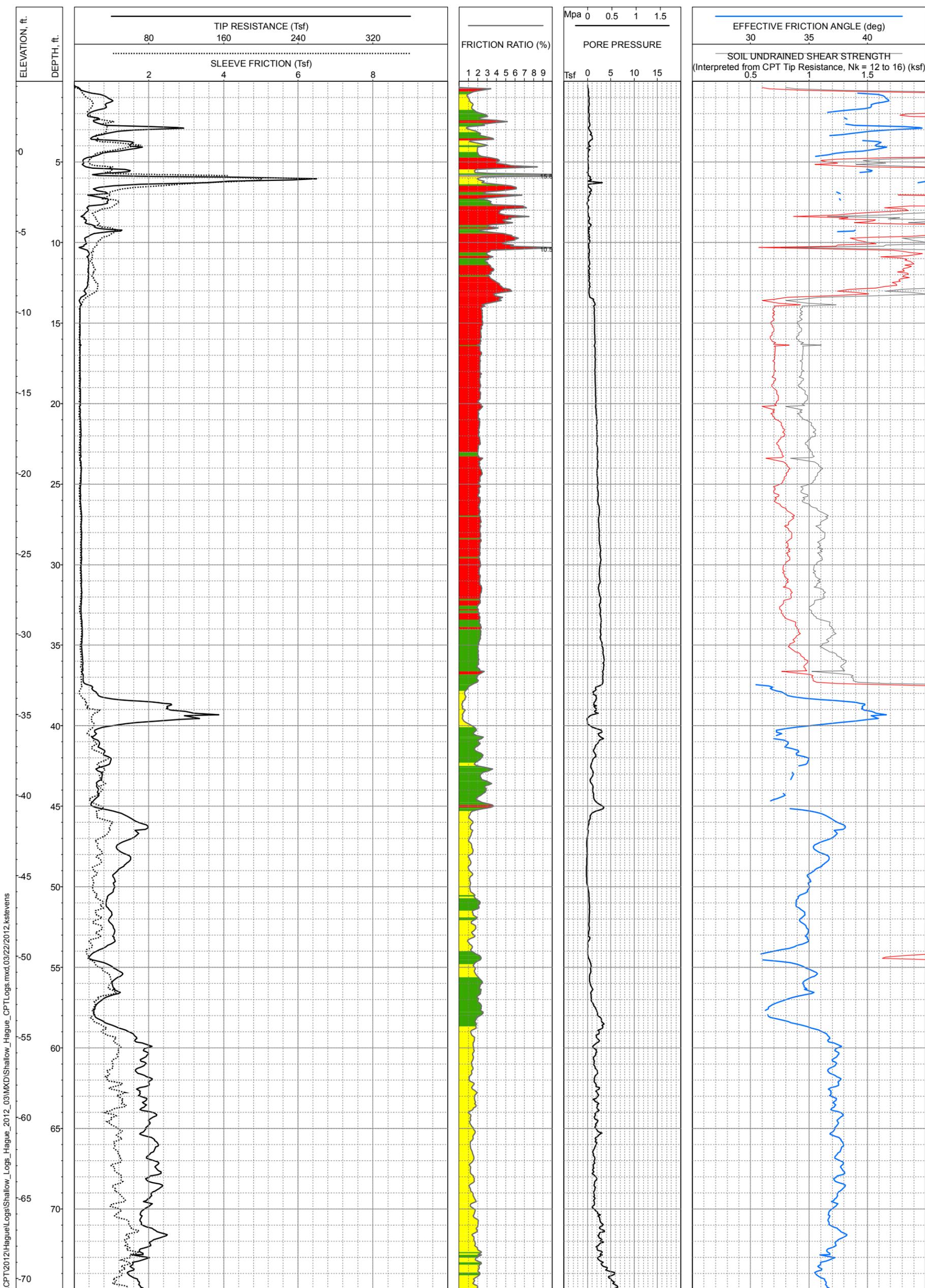
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LOCATION: N: 3,478,357, E: 12,126,614 (State Plane Virginia South Zone, NAD 83, feet)  
 SURFACE EL: 4.2ft (NAVD88)  
 COMPLETION DEPTH: 70.7ft  
 TEST DATE: 3/2/2012

EXPLORATION METHOD: CPT  
 PERFORMED BY: Fugro  
 REVIEWED BY: KSmith

Soil behavior type based on Robertson and Campanella (1988)

**SHALLOW LOG (UPPER 75 FT) OF CPT NO: C-1**  
 The Hague Area  
 Norfolk, Virginia



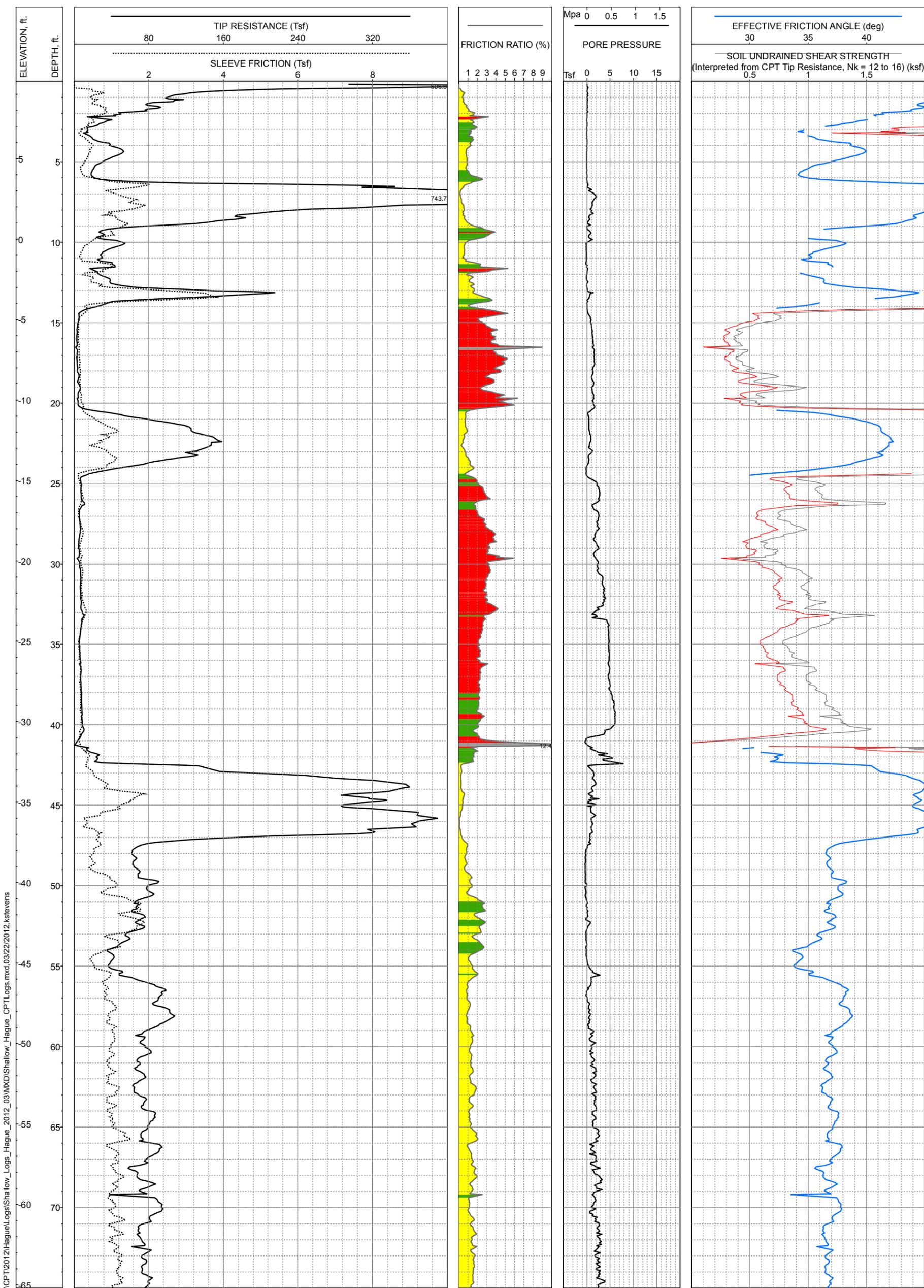
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LOCATION: N: 3,478,551, E: 12,126,492 (State Plane Virginia South Zone, NAD 83, feet)  
 SURFACE EL: 4.3ft (NAVD88)  
 COMPLETION DEPTH: 131.5ft  
 TEST DATE: 3/2/2012

EXPLORATION METHOD: CPT  
 PERFORMED BY: Fugro  
 REVIEWED BY: KSmith

Soil behavior type based on Robertson and Campanella (1988)

**SHALLOW LOG (UPPER 75 FT) OF CPT NO: C-2**  
 The Hague Area  
 Norfolk, Virginia



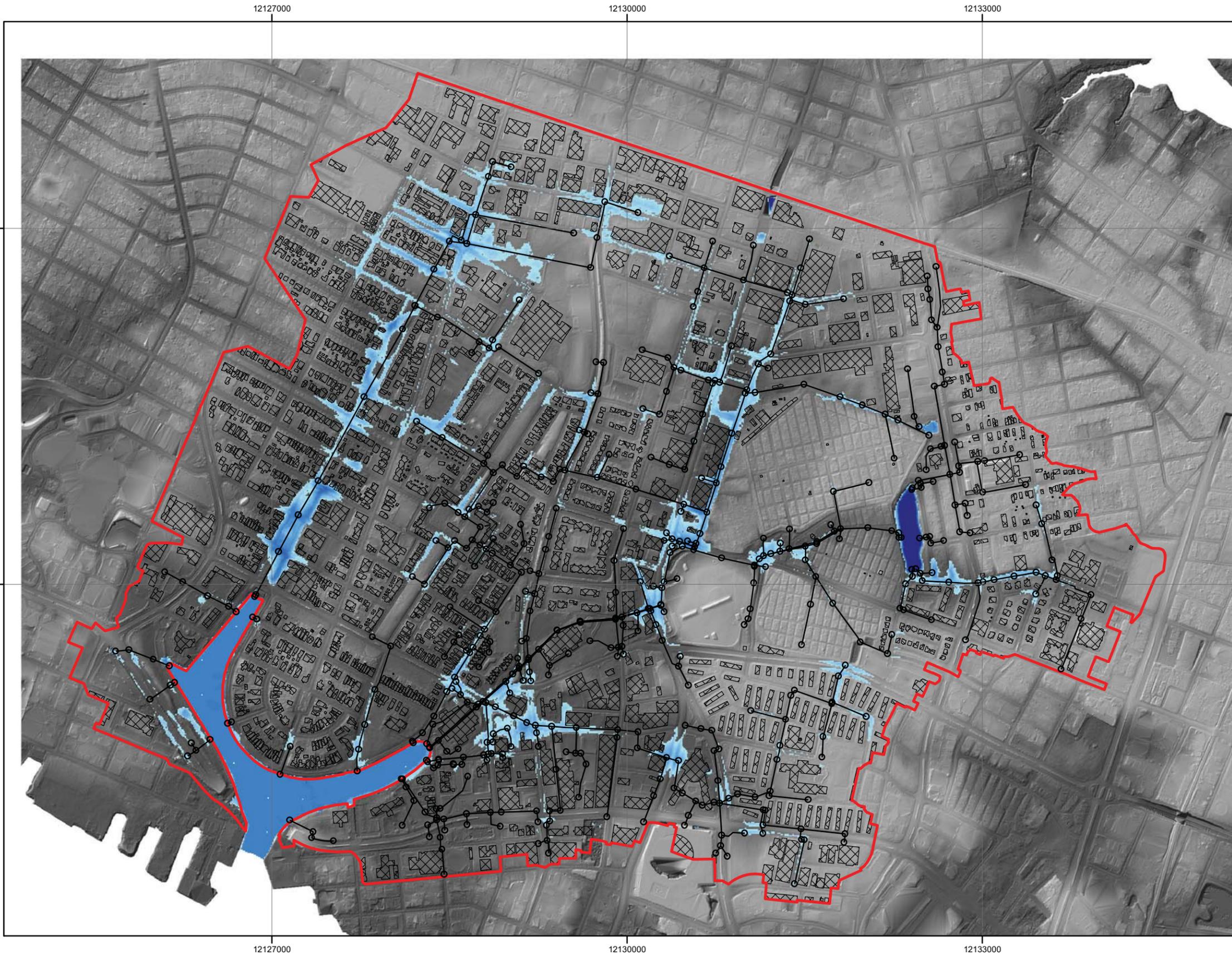
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 SURFACE EL: 9.8ft (NAVD88)  
 COMPLETION DEPTH: 139.7ft  
 TEST DATE: 3/3/2012

EXPLORATION METHOD: CPT  
 PERFORMED BY: Fugro  
 REVIEWED BY: KSmith  
 Soil behavior type based on Robertson and Campanella (1988)

**SHALLOW LOG (UPPER 75 FT) OF CPT NO: C-3**  
 The Hague Area  
 Norfolk, Virginia

**APPENDIX B**  
**MODELING RESULTS**

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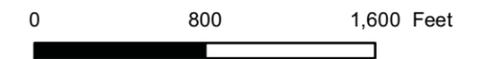
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

**Notes:**

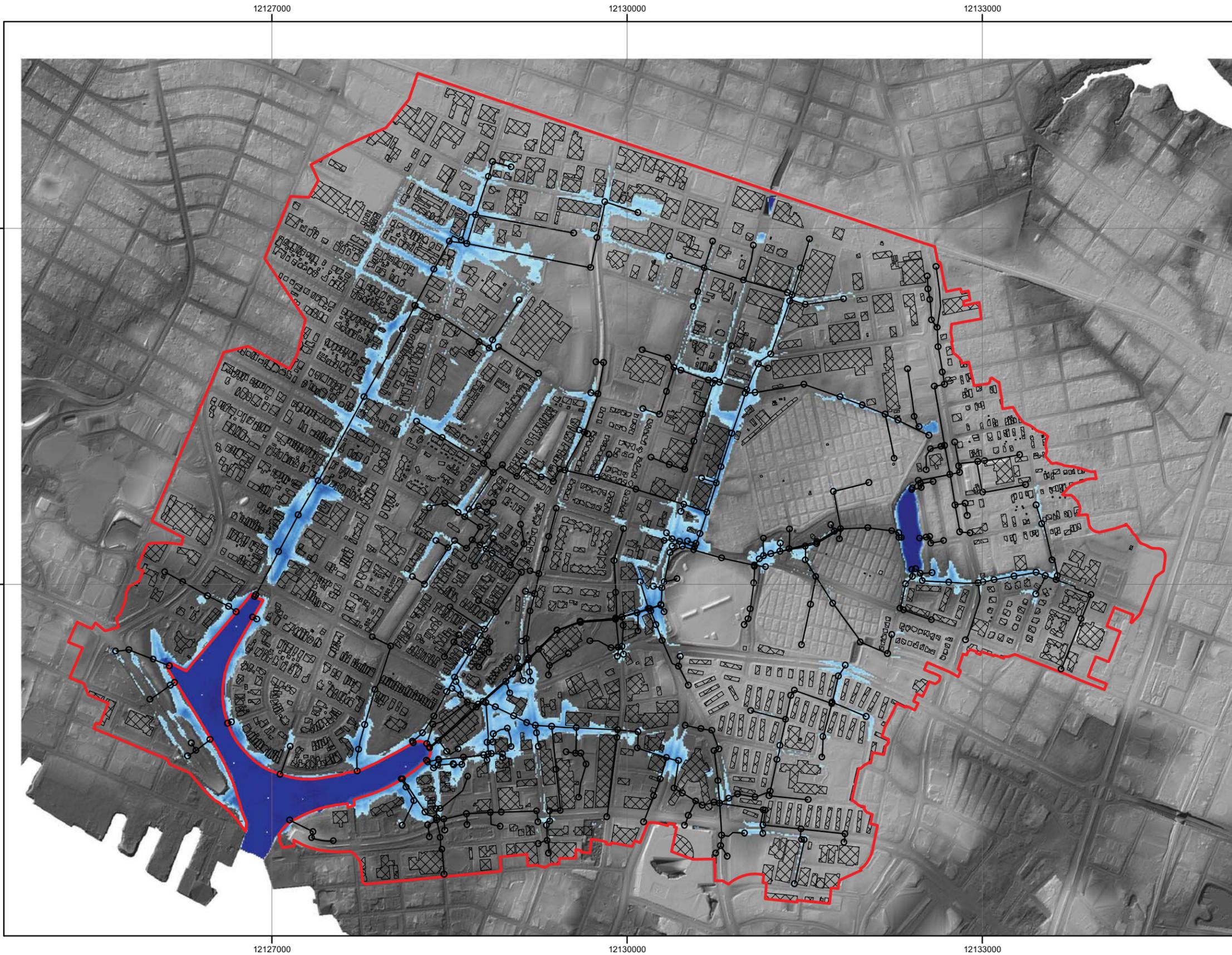
1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 1YR 24-HR STORM,  
 TAILWATER = MHHW**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

**FIGURE B-1**

N:\Projects\3627\_City\_Norfolk\3627-005\_Hague\Outputs\2010\_12\_13\_Draft\_Flood\_Mitigation\_Report\mxd\11x17\_Figure\_Template.mxd, 01/14/11, kspencer



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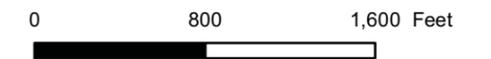
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

**Notes:**

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 1YR 24-HR STORM,  
 TAILWATER = 1YR STORM SURGE**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

**FIGURE B-2**

N:\Projects\3627\_City\_Norfolk\3627-005\_Hague\Outputs\2010\_12\_13\_Draft\_Flood\_Mitigation\_Report\mxd\11x17\_Figure\_Template.mxd, 01/14/11, kspencer



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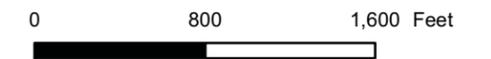
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
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- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

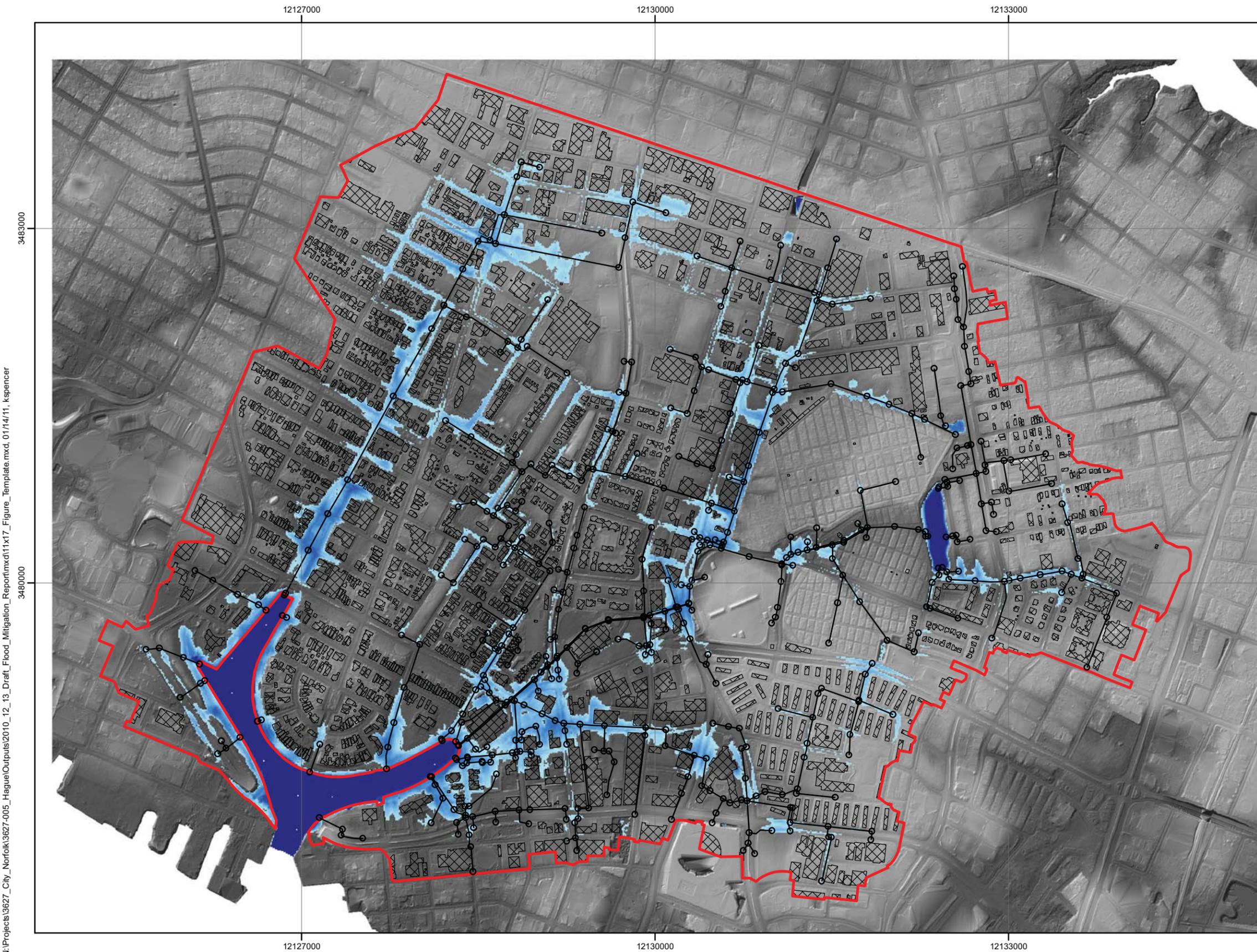
**Notes:**

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 2YR 24-HR STORM,  
 TAILWATER = MHHW**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

**FIGURE B-3**



**LEGEND**

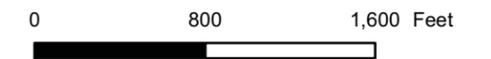
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

Notes:

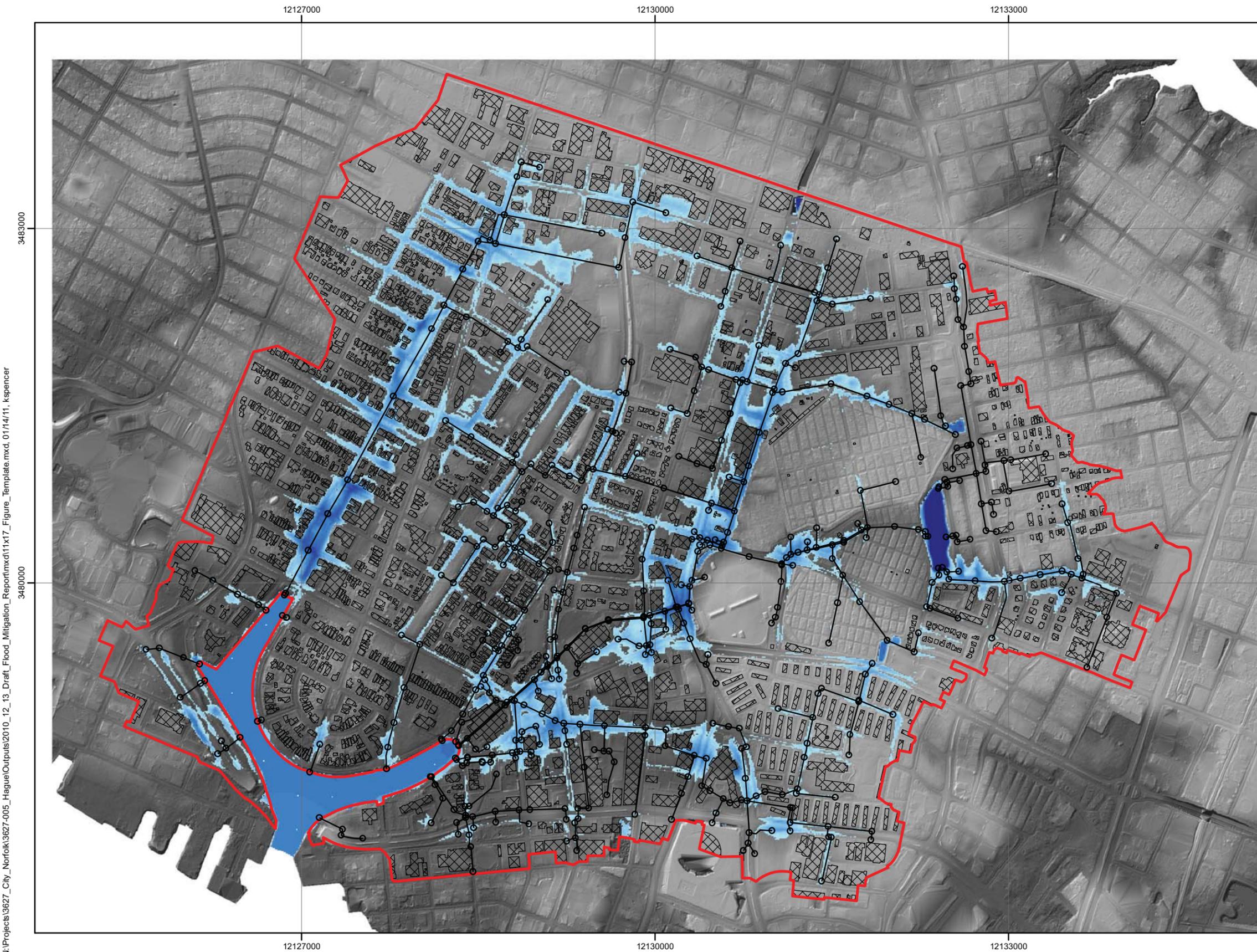
1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 2YR 24-HR STORM,  
 TAILWATER = 2YR STORM SURGE**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-4

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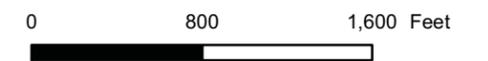
**LEGEND**

- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

Notes:  
 1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.

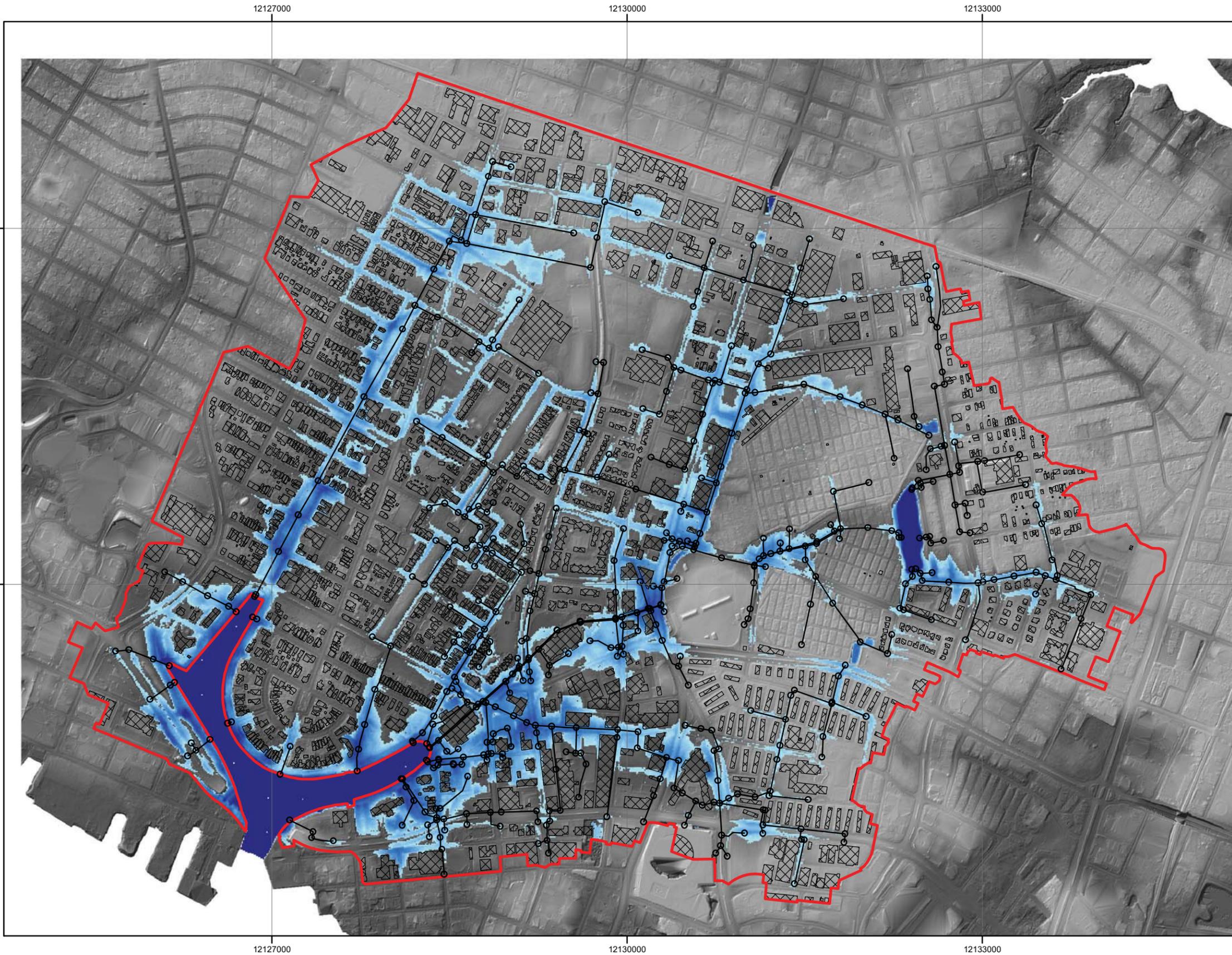


**SWMM RESULTS FOR 10YR 24-HR STORM,  
 TAILWATER = MHHW**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-5

N:\Projects\3627\_City\_Norfolk\3627-005\_Hague\Outputs\2010\_12\_13\_Draft\_Flood\_Mitigation\_Report\mxd\11x17\_Figure\_Template.mxd, 01/14/11, kspencer

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**LEGEND**

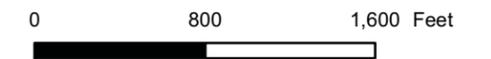
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

**Notes:**

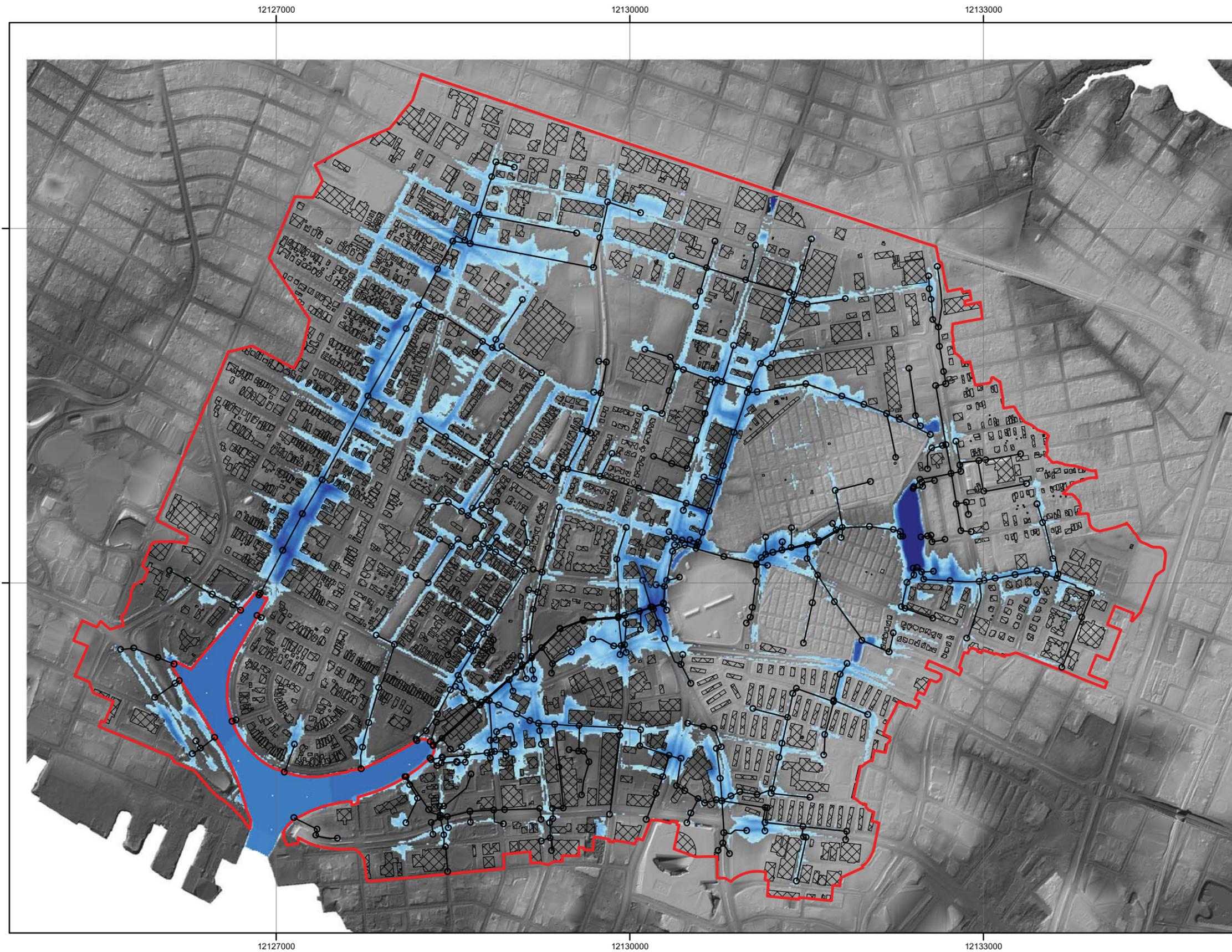
1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 10YR 24-HR STORM,  
 TAILWATER = 10YR STORM SURGE**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

**FIGURE B-6**

N:\Projects\3627\_City\_Norfolk\3627-005\_Hague\Outputs\2010\_12\_13\_Draft\_Flood\_Mitigation\_Report\mxd\11x17\_Figure\_Template.mxd\_01/14/11\_kspencer



**LEGEND**

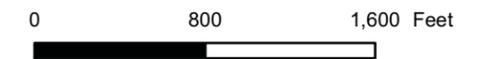
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

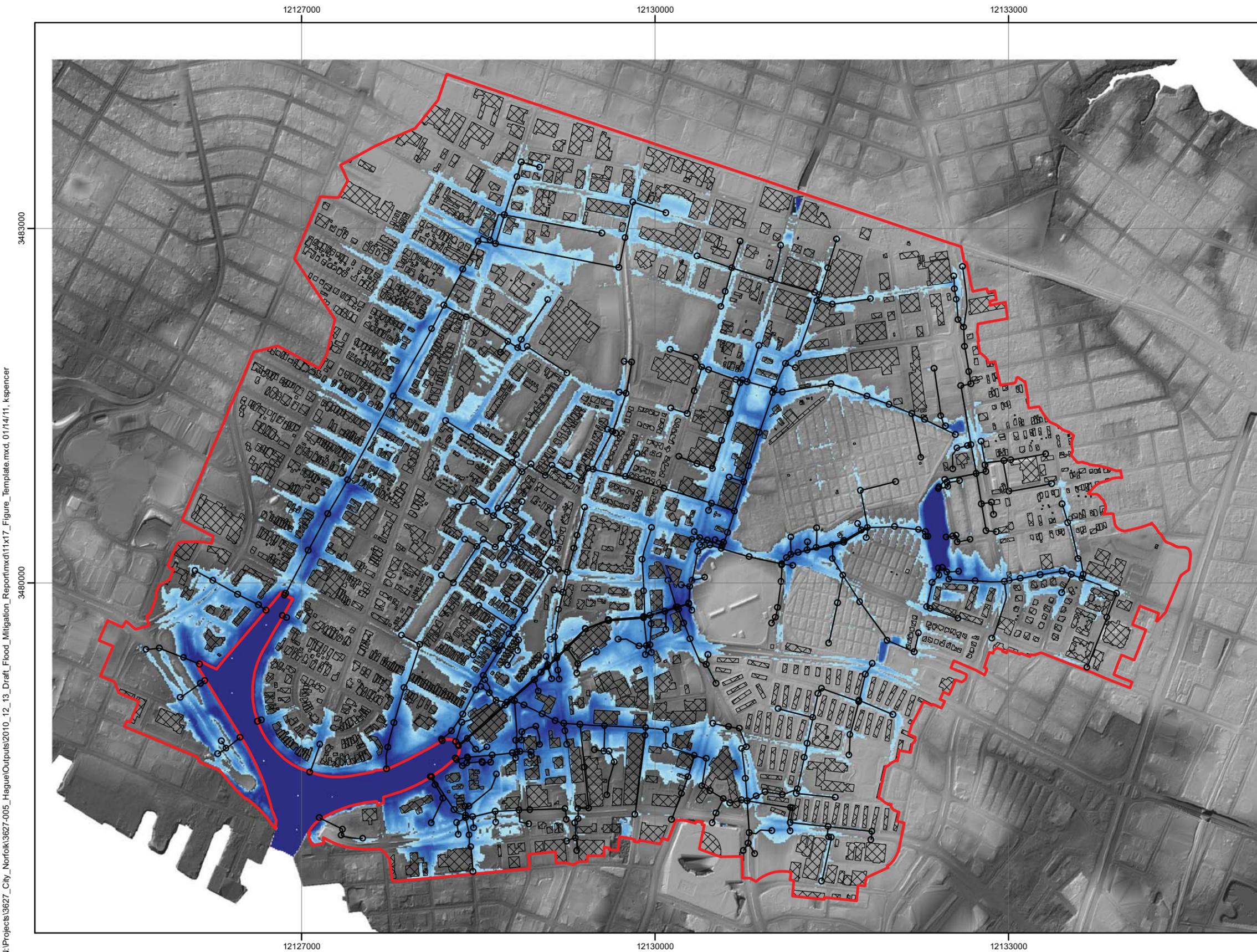
**Notes:**

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 25YR 24-HR STORM,  
 TAILWATER = MHHW**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

**FIGURE B-7**



**LEGEND**

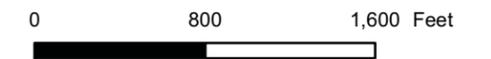
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

**Notes:**

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.

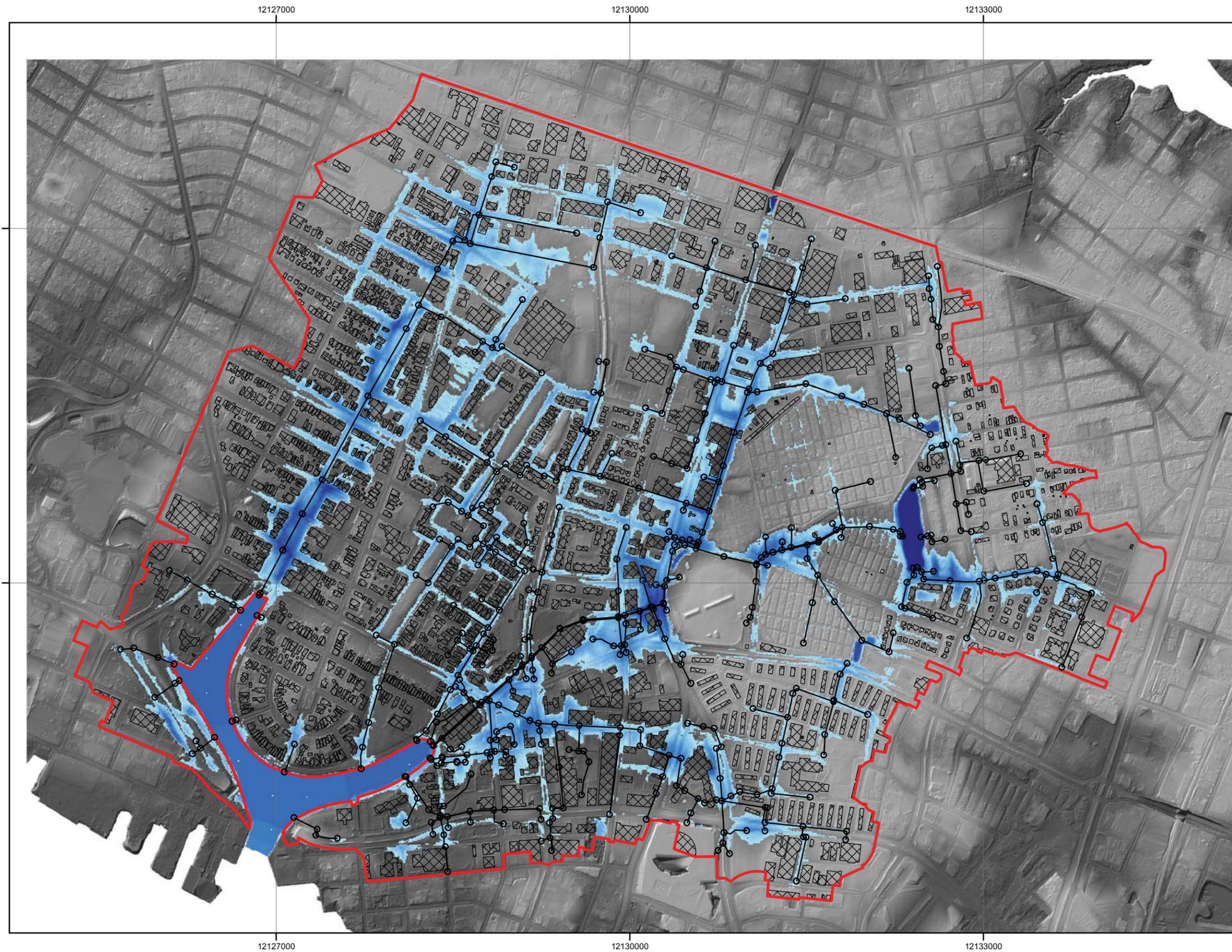


**SWMM RESULTS FOR 25YR 24-HR STORM,  
 TAILWATER = 25YR STORM SURGE**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

**FIGURE B-8**

N:\Projects\3627\_City\_Norfolk\3627-005\_Hague\Outputs\2010\_12\_13\_Draft\_Flood\_Mitigation\_Report\mxd\11x17\_Figure\_Template.mxd, 01/14/11, kspencer

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**LEGEND**

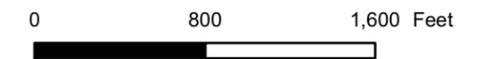
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

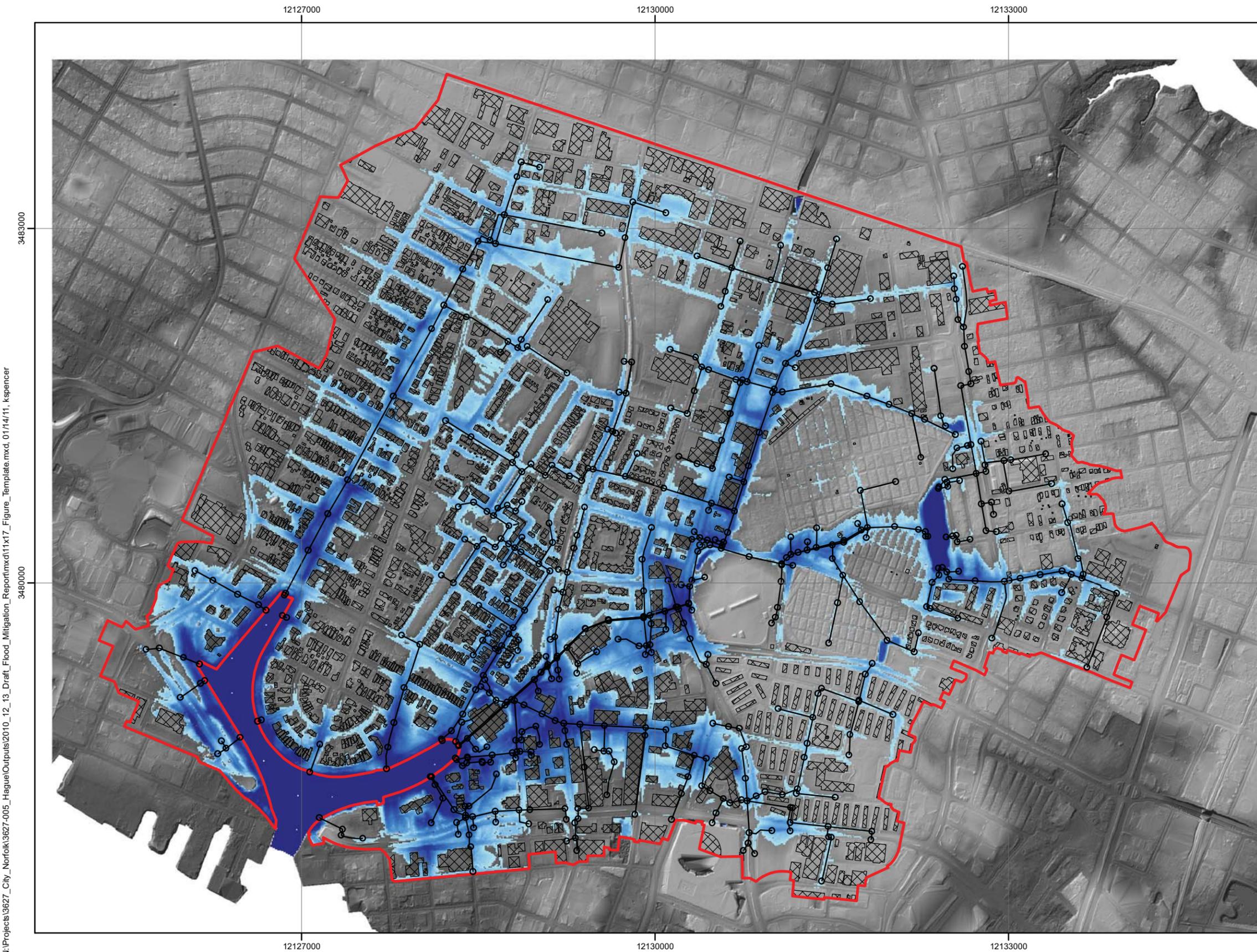
Notes:

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 50YR 24-HR STORM,  
 TAILWATER = MHHW**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-9



**LEGEND**

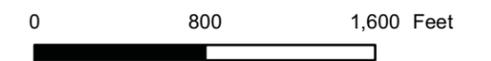
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

Notes:

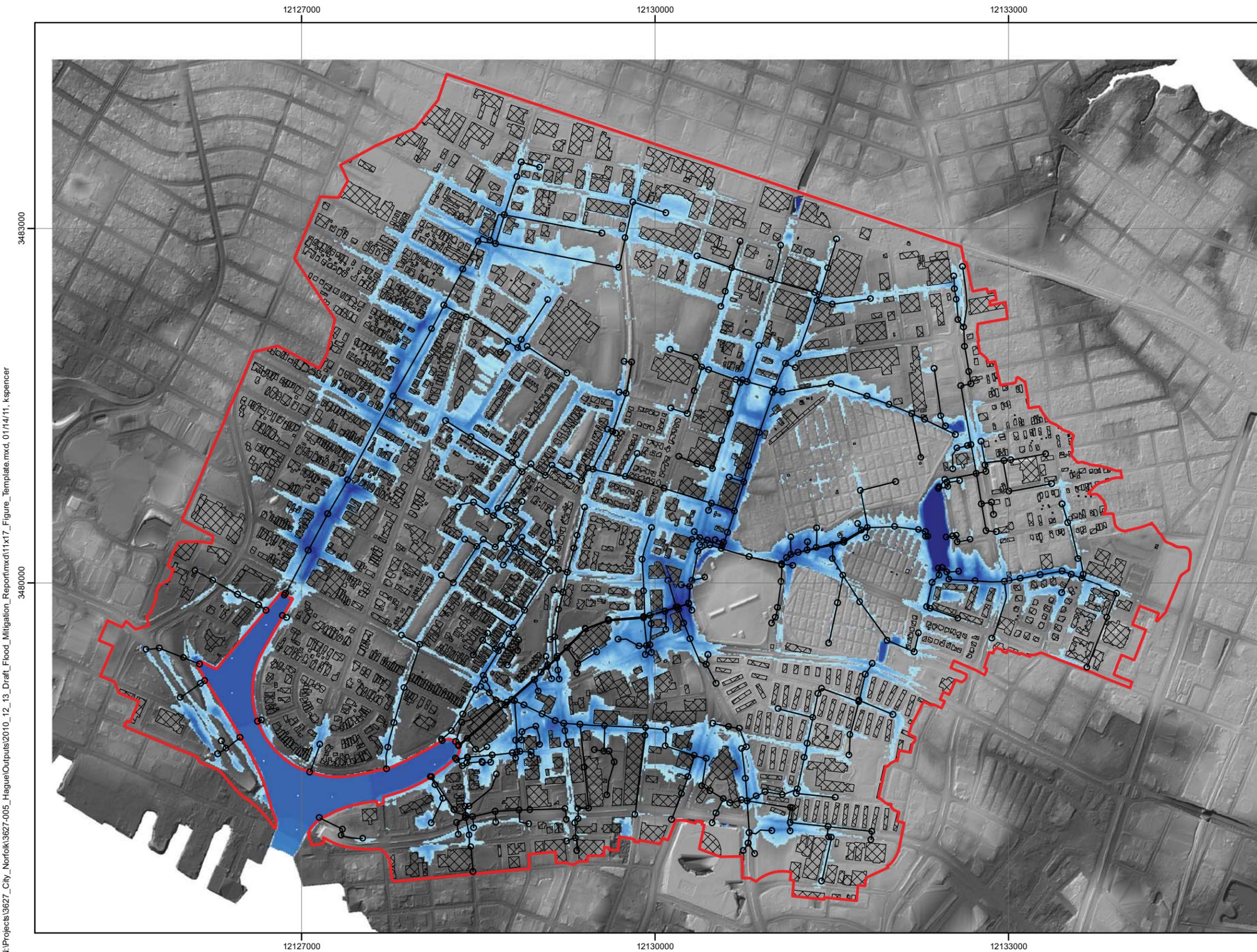
1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 50YR 24-HR STORM,  
 TAILWATER = 50YR STORM SURGE**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-10

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**LEGEND**

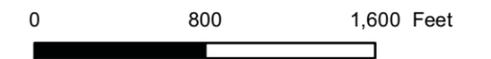
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

Notes:

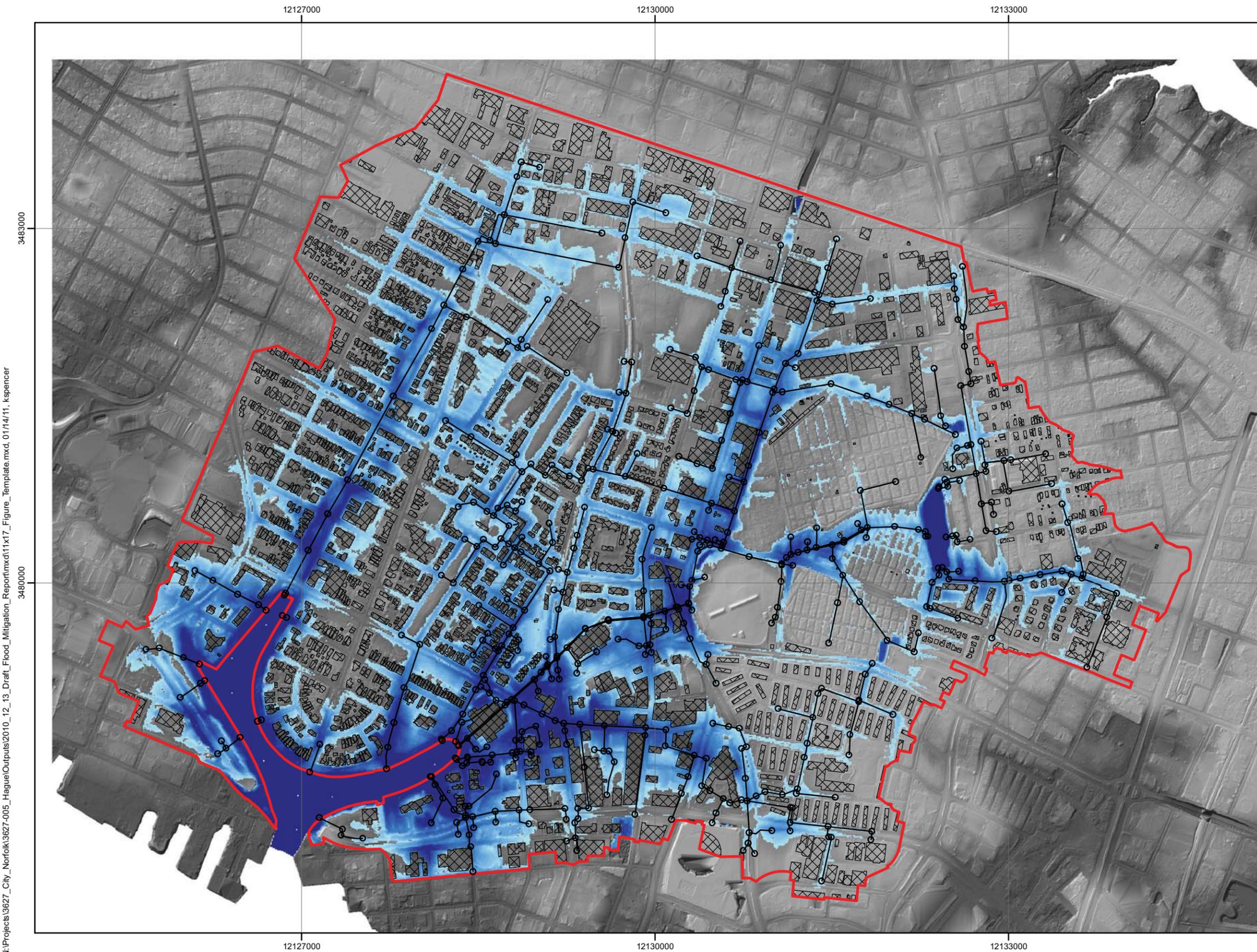
1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 100YR 24-HR STORM,  
 TAILWATER = MHHW**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-11

N:\Projects\3627\_City\_Norfolk\3627-005\_Hague\Outputs\2010\_12\_13\_Draft\_Flood\_Mitigation\_Report\mxd\11x17\_Figure\_Template.mxd\_01/14/11\_kspencer



**LEGEND**

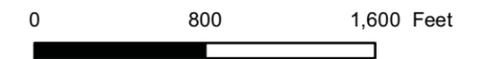
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

Notes:

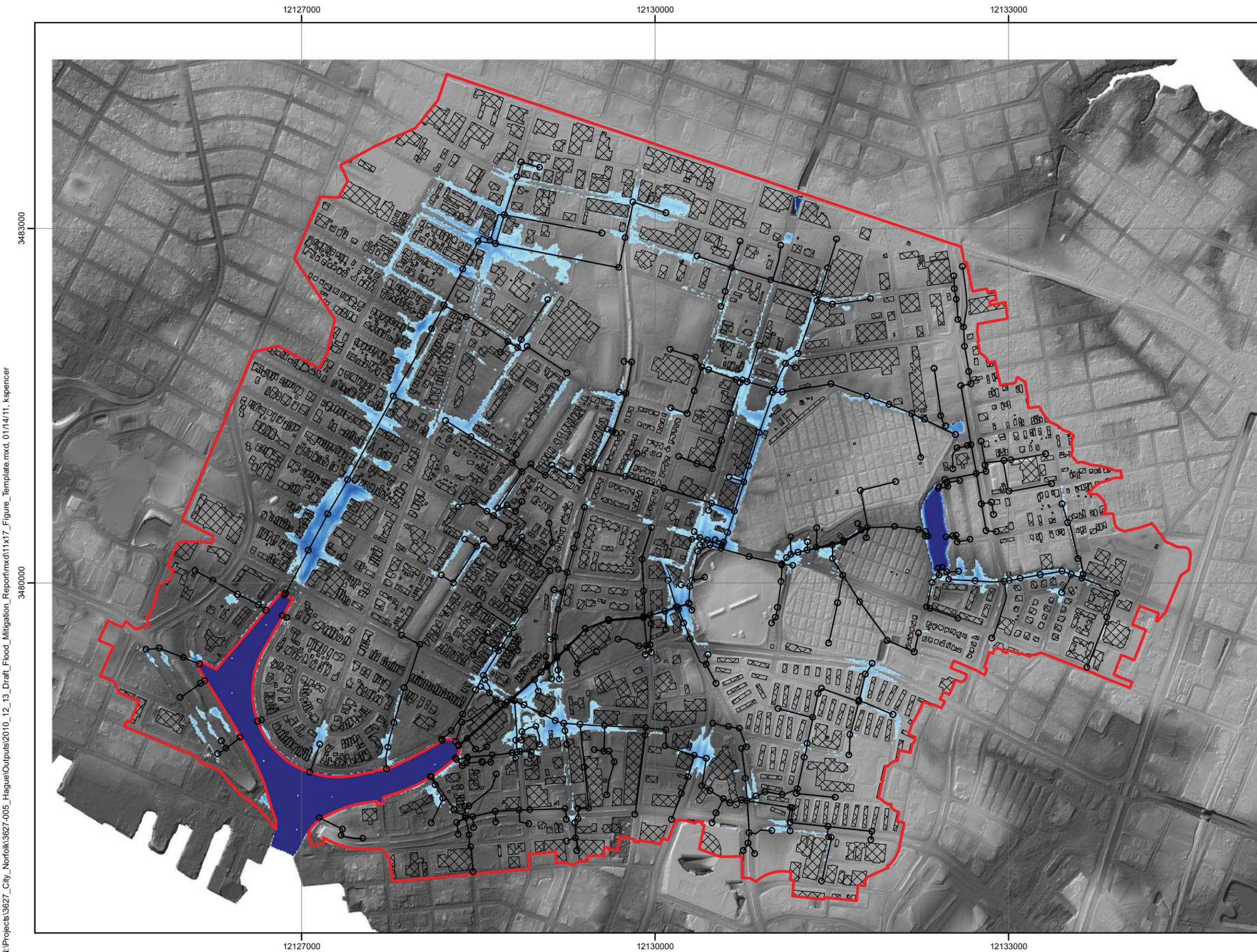
1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 100YR 24-HR STORM,  
 TAILWATER = 100YR STORM SURGE**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-12

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**LEGEND**

- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

**Notes:**

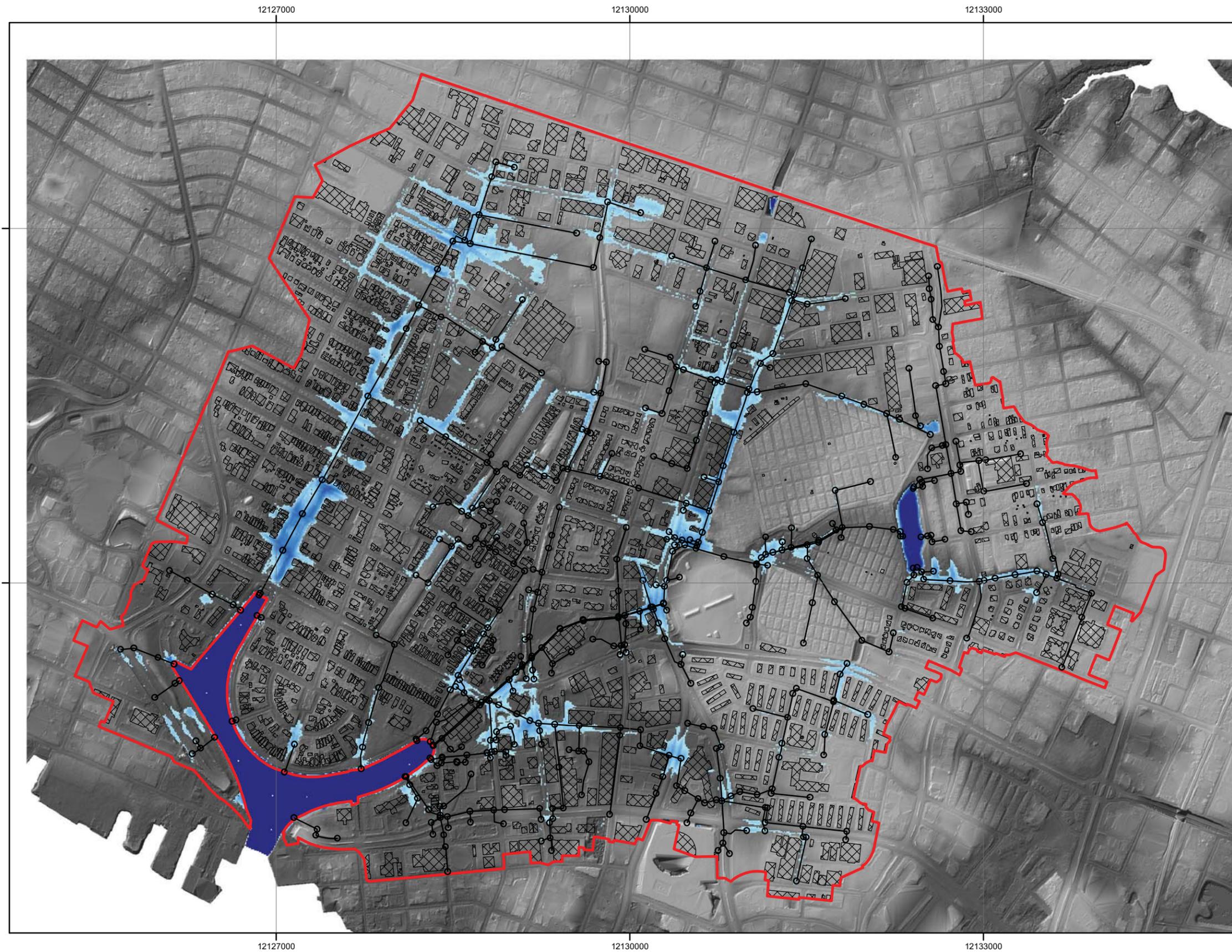
1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 1YR 24-HR STORM,  
TAILWATER = 1YR STORM SURGE  
ALTERNATIVE: 2 x 60-inch Pumps**  
City-wide Coastal Flooding Study  
Norfolk, Virginia

FIGURE B-13

N:\Projects\3627\_City\_Norfolk\3627-005\_Hague\Outputs\2010\_12\_13\_Draft\_Flood\_Mitigation\_Report\mxd\11x17\_Figure\_Template.mxd\_01/14/11\_kspencer



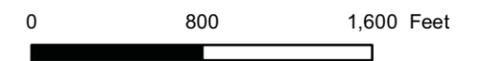
**LEGEND**

- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

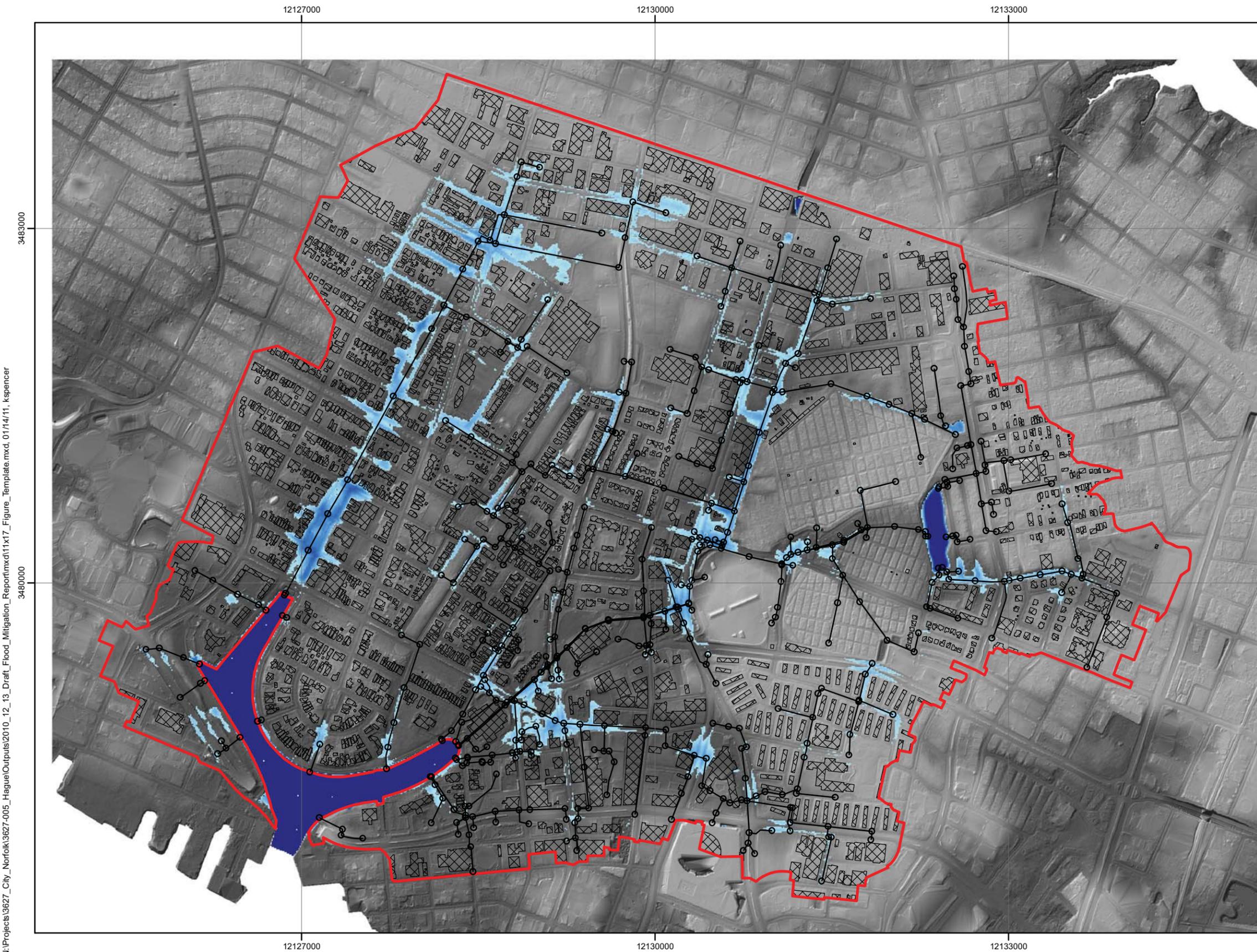
- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

Notes:  
 1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 1YR 24-HR STORM,  
 TAILWATER = 1YR STORM SURGE  
 ALTERNATIVE: 4 x 60-inch Pumps**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-14



**LEGEND**

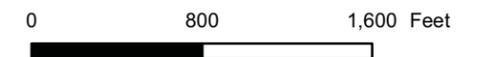
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

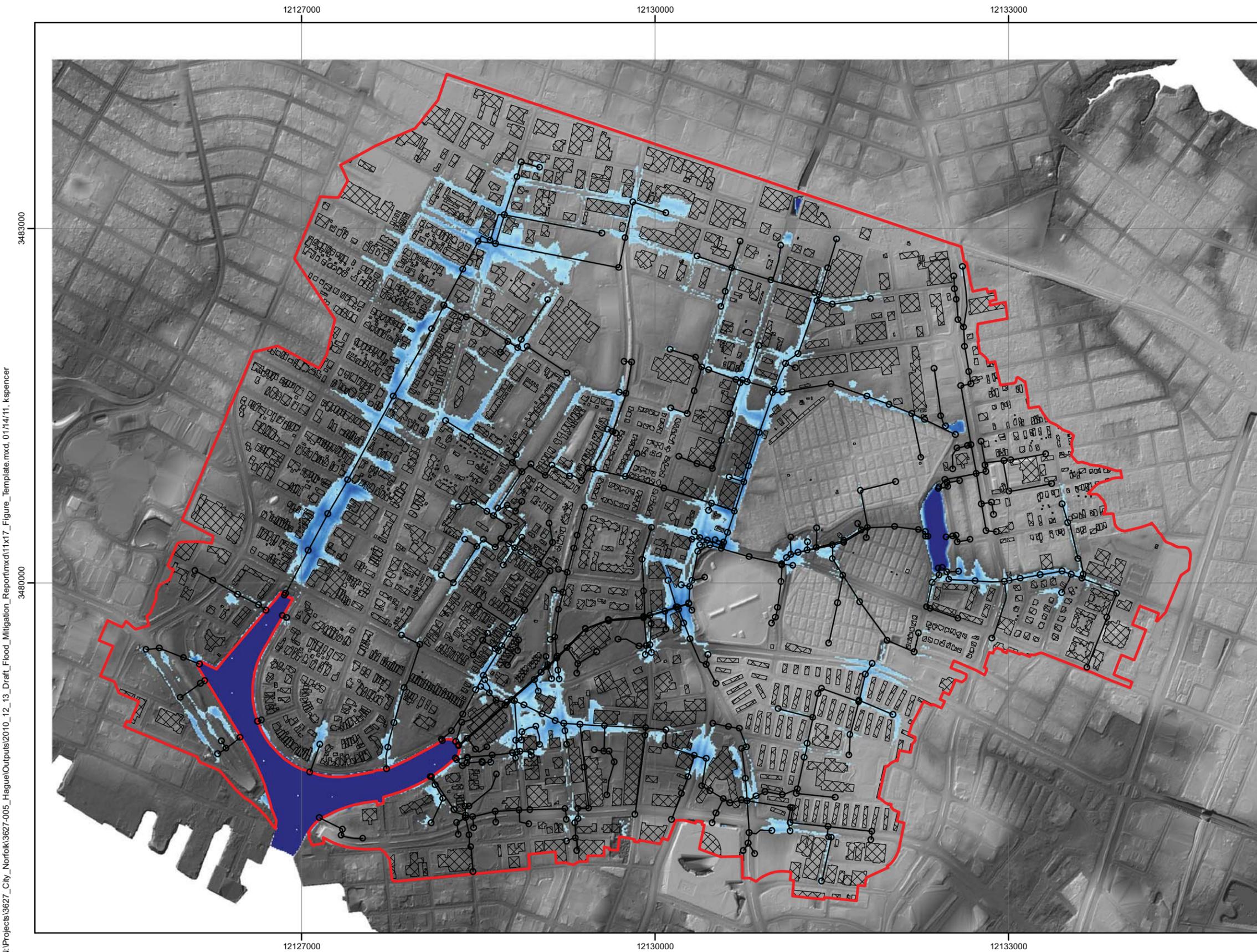
**Notes:**

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 1YR 24-HR STORM,  
 TAILWATER = 1YR STORM SURGE  
 ALTERNATIVE: 4 x 96-inch Pumps**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-15



**LEGEND**

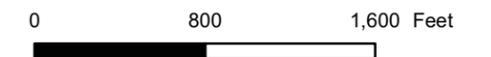
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

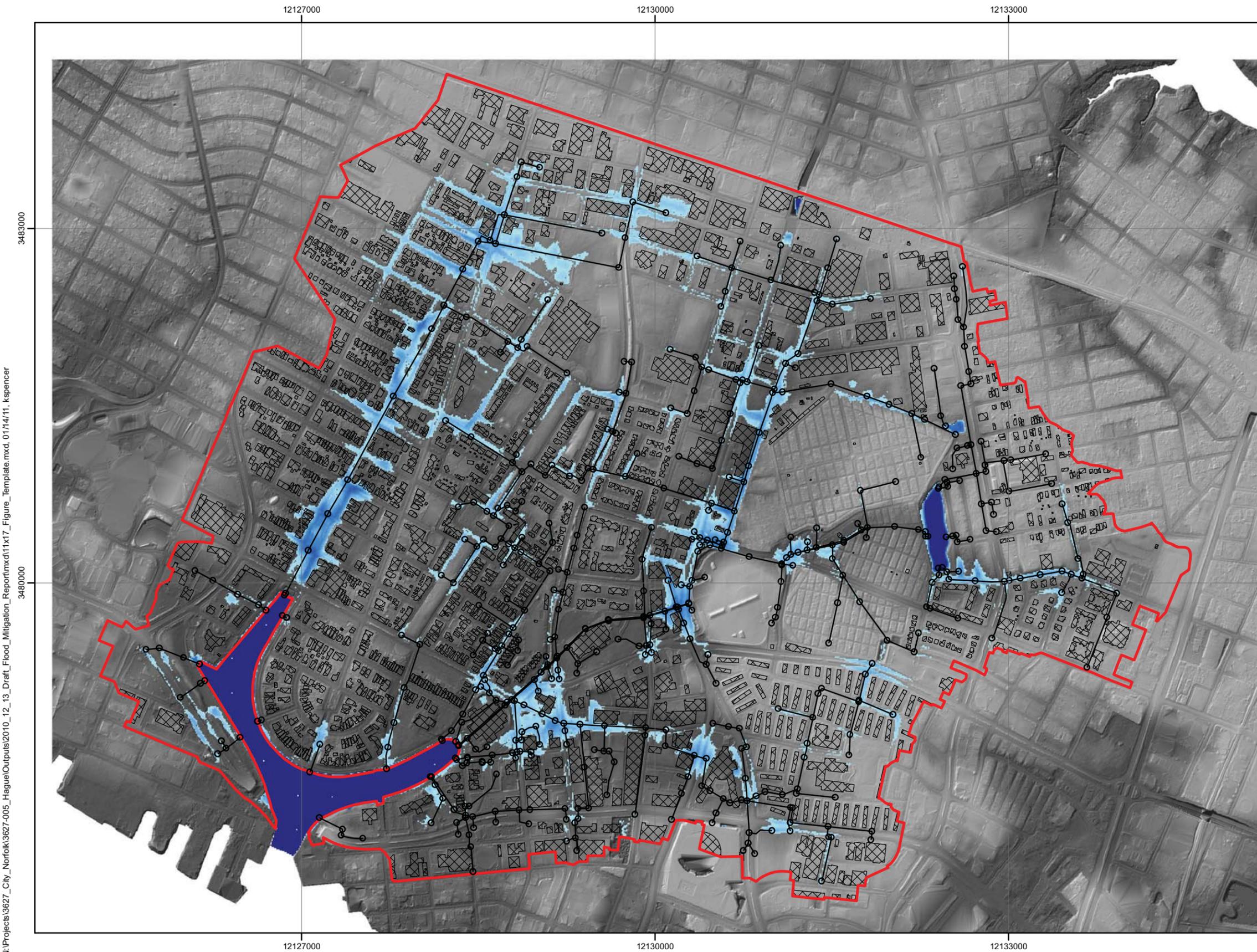
**Notes:**

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 2YR 24-HR STORM,  
 TAILWATER = 2YR STORM SURGE  
 ALTERNATIVE: 2 x 60-inch Pumps**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-16



**LEGEND**

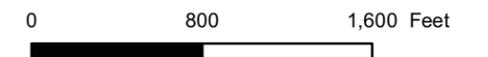
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

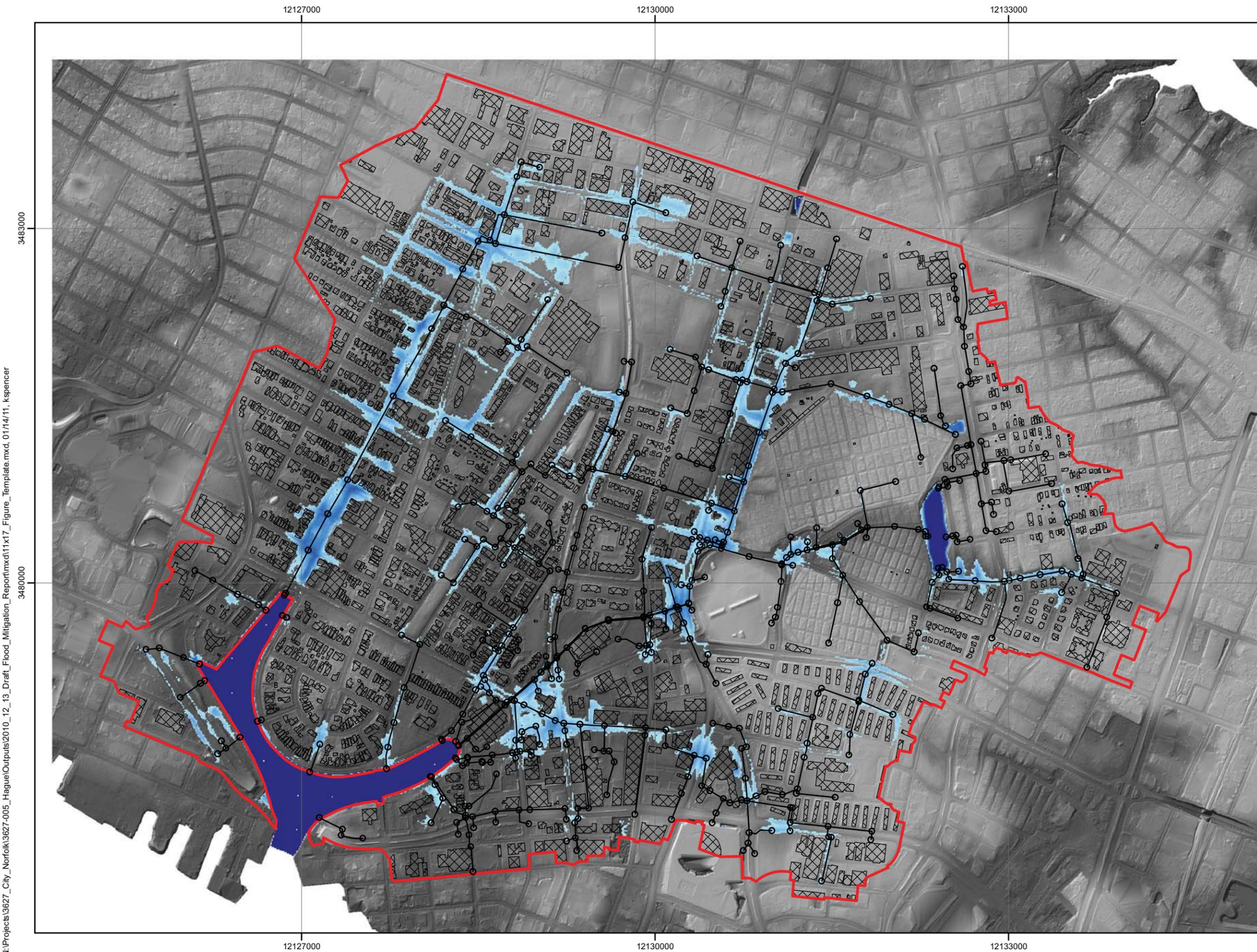
Notes:

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 2YR 24-HR STORM,  
 TAILWATER = 2YR STORM SURGE  
 ALTERNATIVE: 4 x 60-inch Pumps**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-17



**LEGEND**

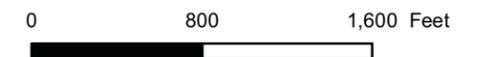
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

**Notes:**

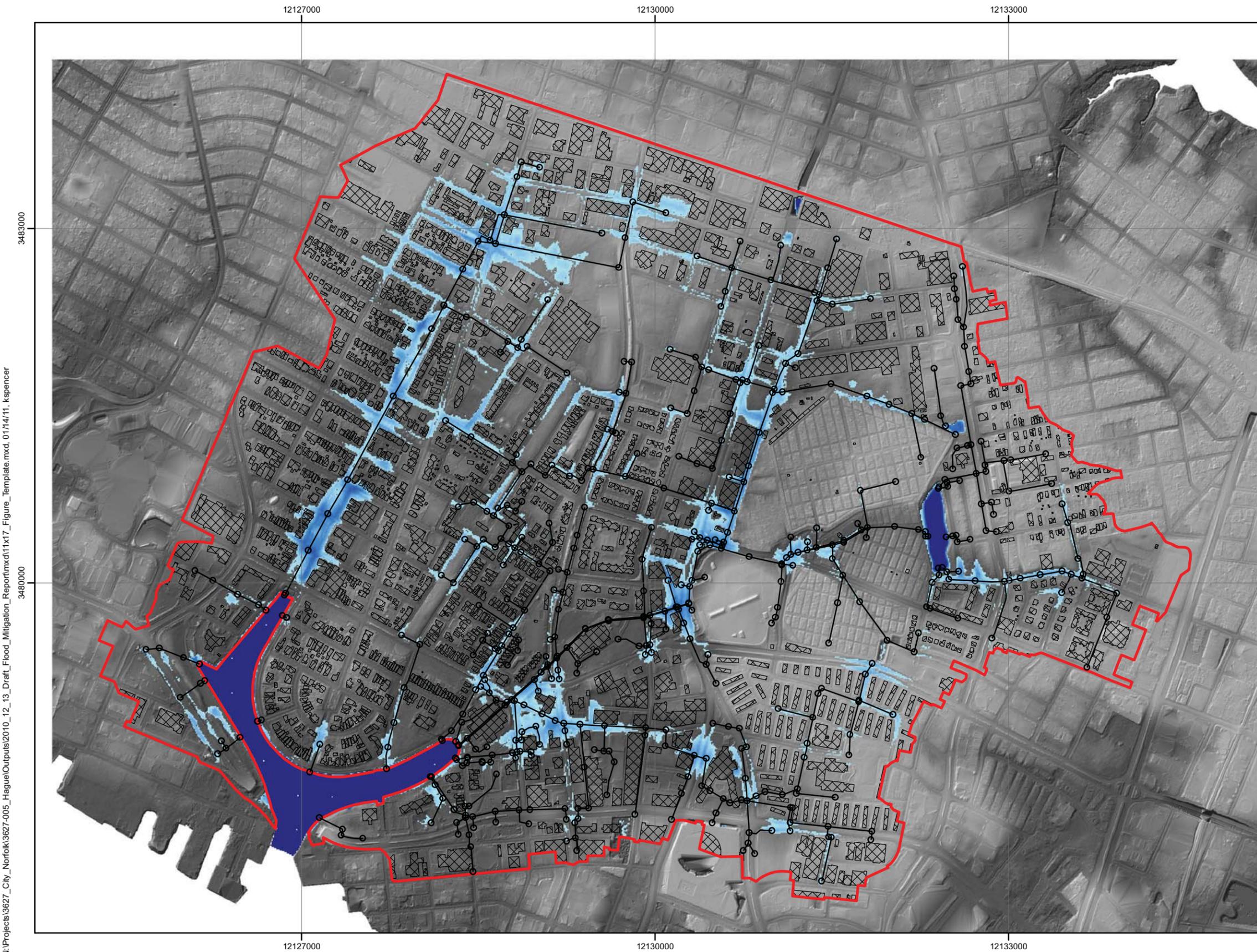
1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 2YR 24-HR STORM,  
 TAILWATER = 2YR STORM SURGE  
 ALTERNATIVE: 4 x 96-inch Pumps**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-18

N:\Projects\3627\_City\_Norfolk\3627-005\_Hague\Outputs\2010\_12\_13\_Draft\_Flood\_Mitigation\_Report\mxd\11x17\_Figure\_Template.mxd, 01/14/11, kspencer



**LEGEND**

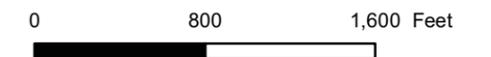
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

Notes:

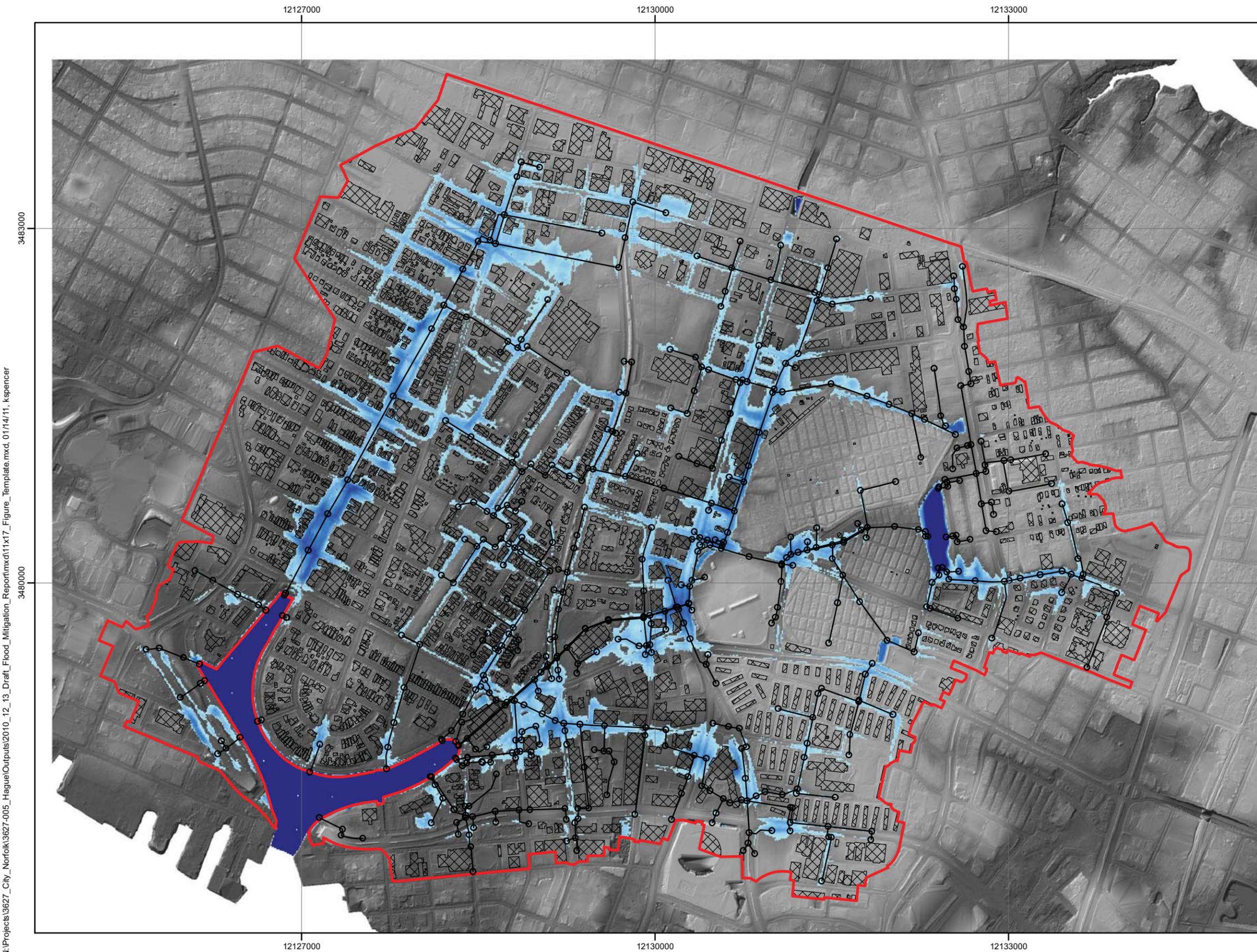
1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 2YR 24-HR STORM,  
 TAILWATER = MHHW  
 ALTERNATIVE: 4 x 60-inch Pumps  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia**

FIGURE B-19

N:\Projects\3627\_City\_Norfolk\3627-005\_Hague\Outputs\2010\_12\_13\_Draft\_Flood\_Mitigation\_Report\mxd\11x17\_Figure\_Template.mxd, 01/14/11, kspencer



**LEGEND**

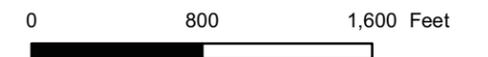
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

**Notes:**

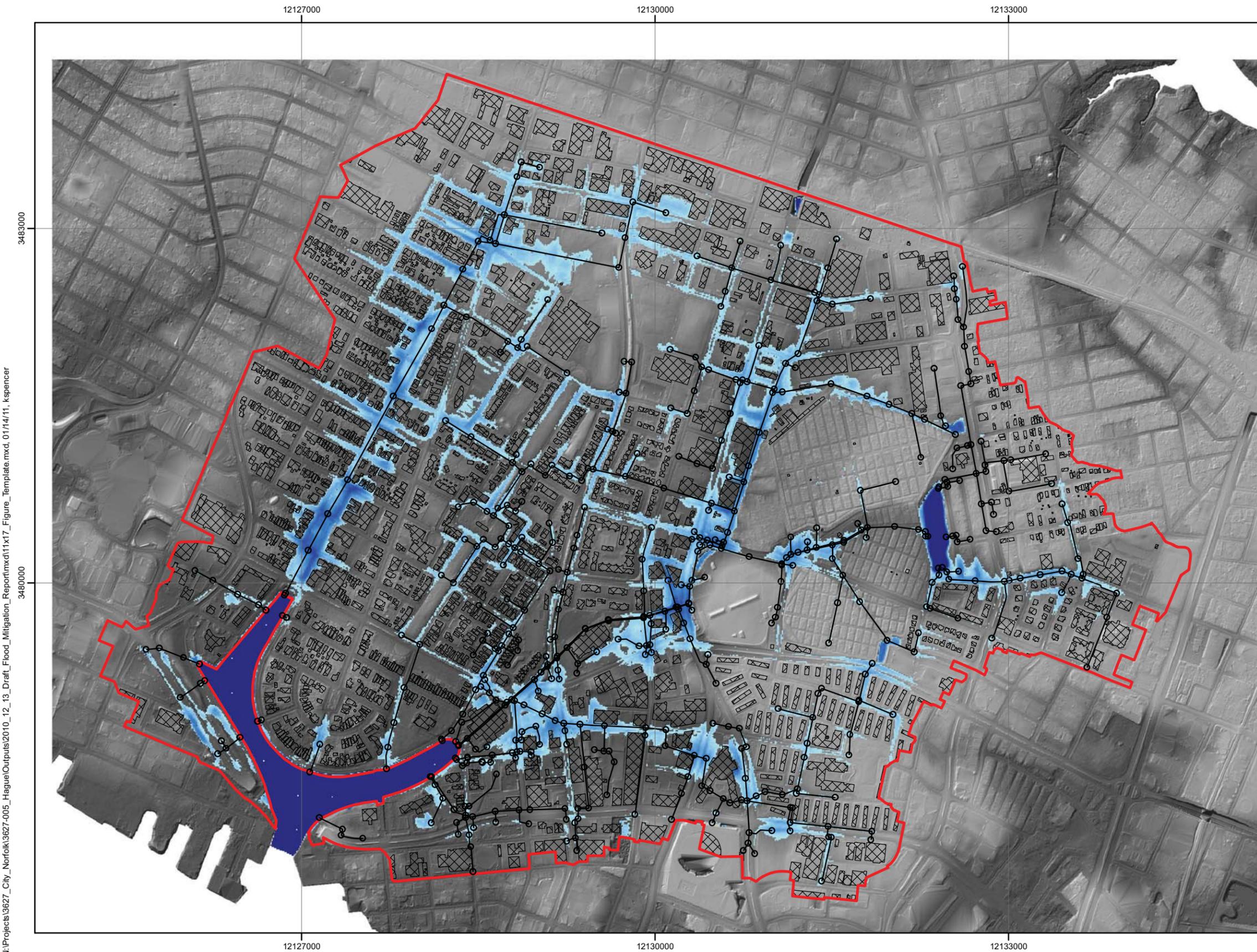
1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 10YR 24-HR STORM,  
 TAILWATER = 10YR STORM SURGE  
 ALTERNATIVE: 2 x 60-inch Pumps**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-20

N:\Projects\3627\_City\_Norfolk\3627-005\_Hague\Outputs\2010\_12\_13\_Draft\_Flood\_Mitigation\_Report\mxd\11x17\_Figure\_Template.mxd, 01/14/11, kspencer



**LEGEND**

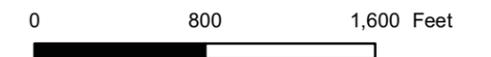
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

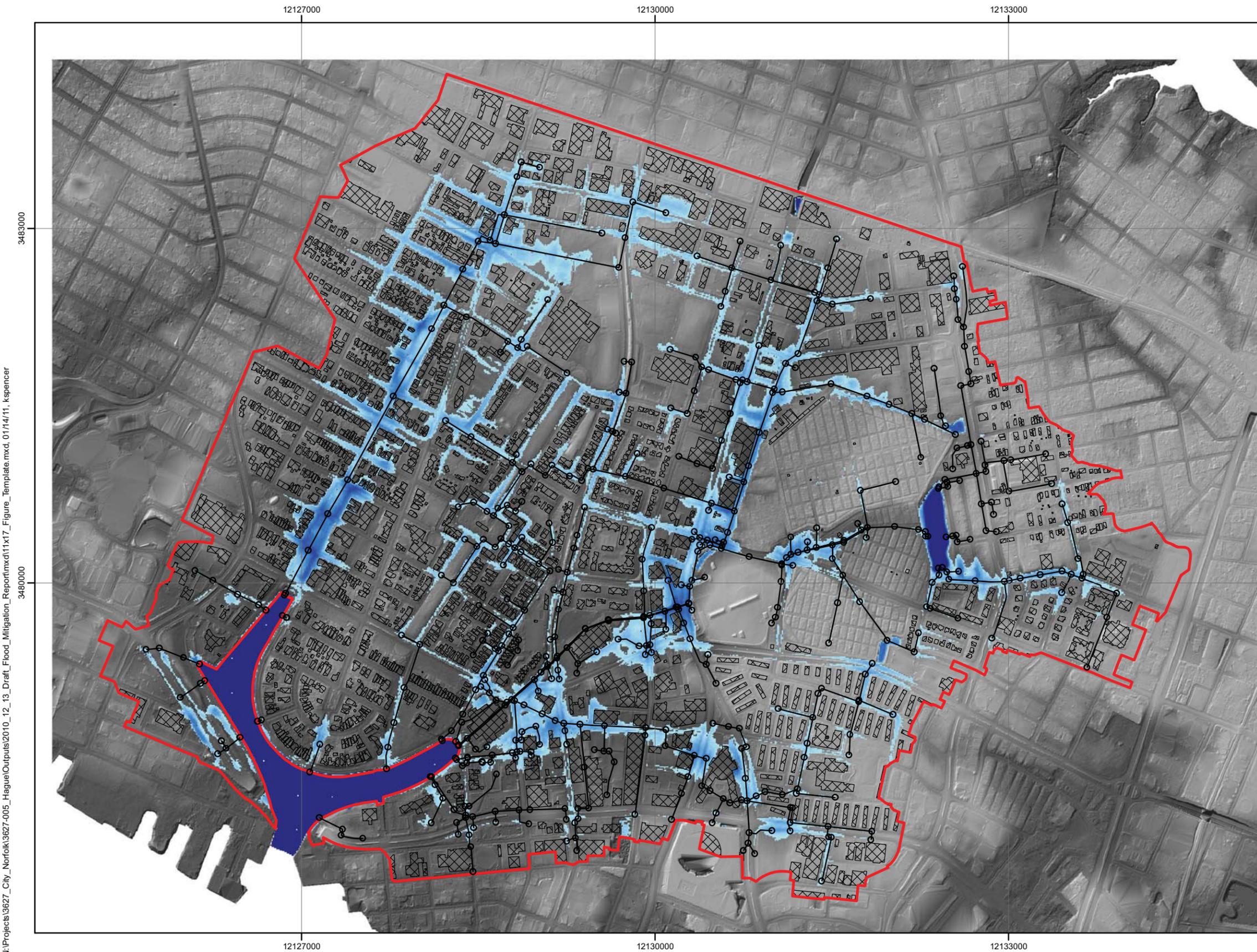
**Notes:**

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 10YR 24-HR STORM,  
 TAILWATER = 10YR STORM SURGE  
 ALTERNATIVE: 4 x 60-inch Pumps**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-21



**LEGEND**

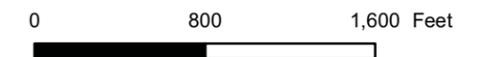
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

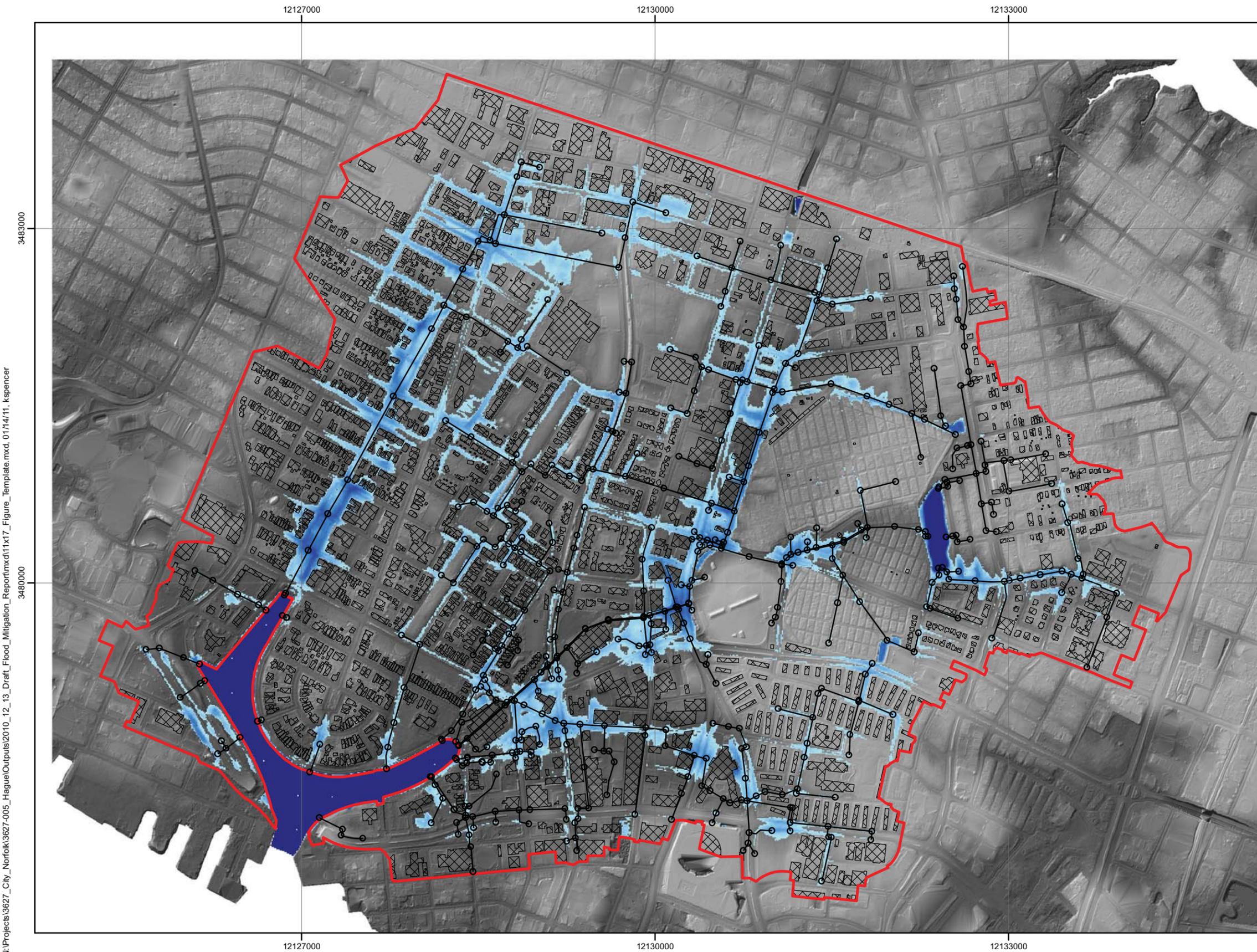
**Notes:**

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 10YR 24-HR STORM,  
 TAILWATER = 10YR STORM SURGE  
 ALTERNATIVE: 4 x 96-inch Pumps**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-22



**LEGEND**

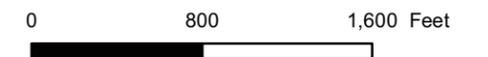
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

**Notes:**

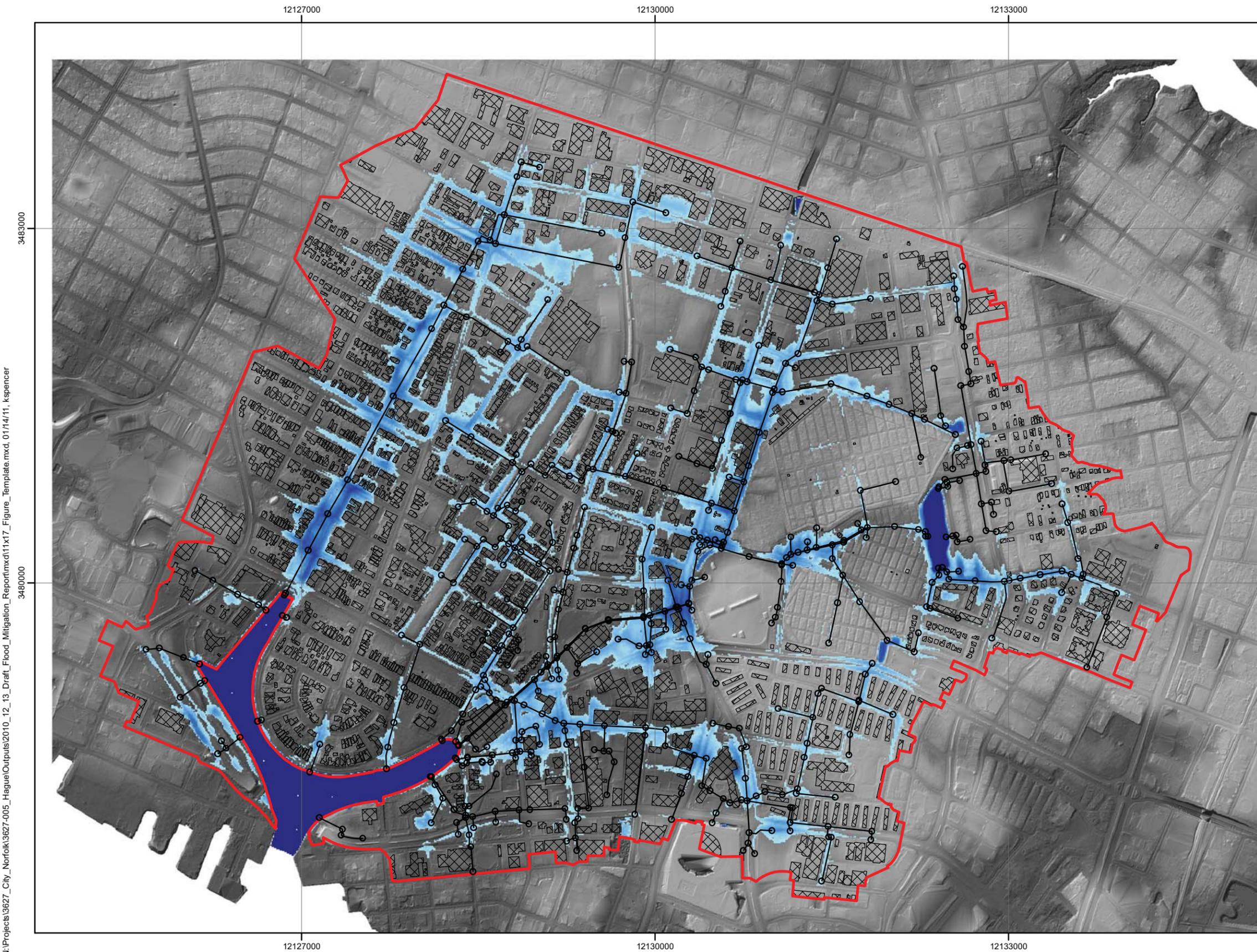
1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 10YR 24-HR STORM,  
TAILWATER = MHHW  
ALTERNATIVE: 4 x 60-inch Pumps  
City-wide Coastal Flooding Study  
Norfolk, Virginia**

FIGURE B-23

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**LEGEND**

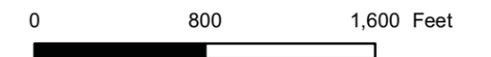
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

Notes:

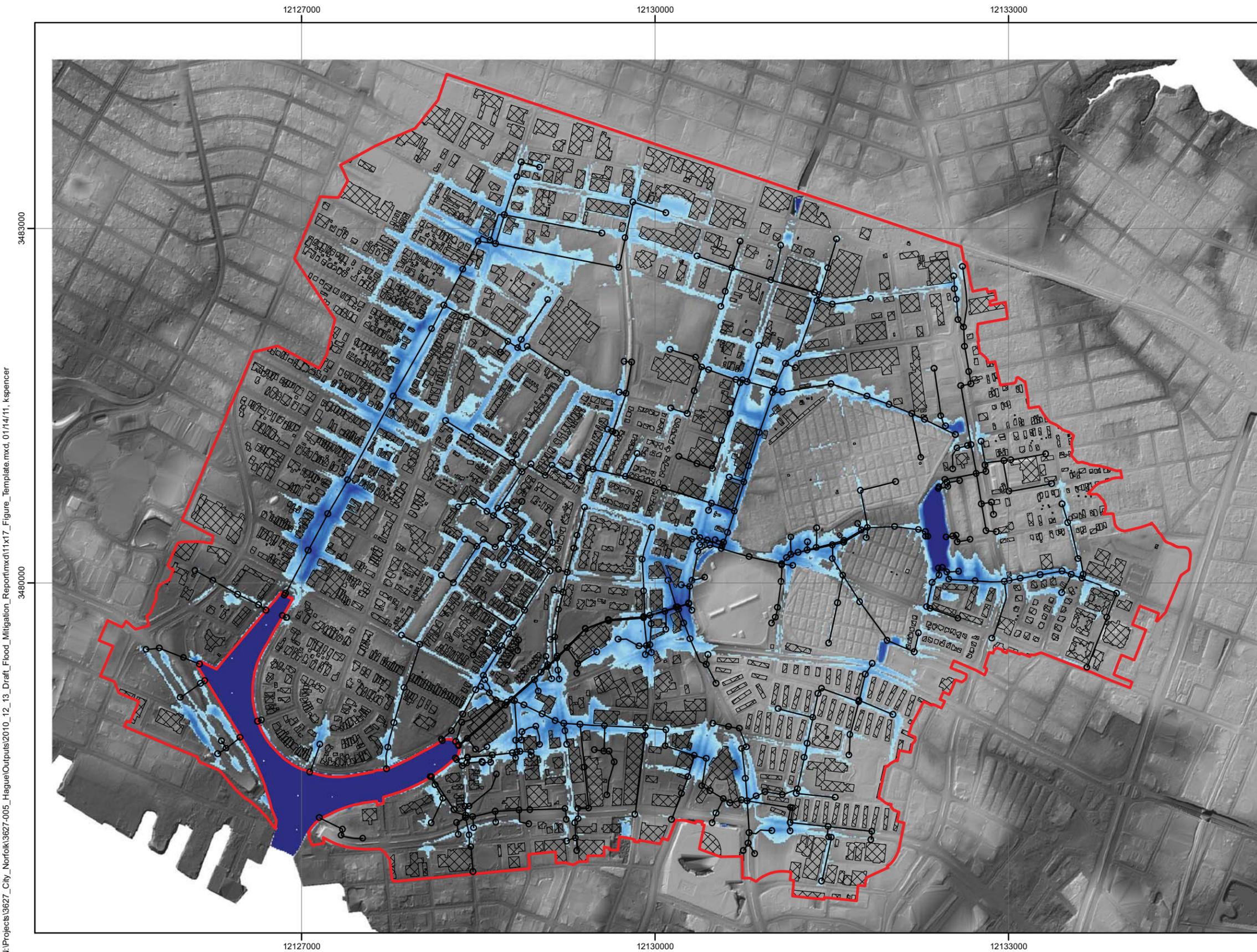
1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 25YR 24-HR STORM,  
 TAILWATER = 25YR STORM SURGE  
 ALTERNATIVE: 2 x 60-inch Pumps**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-24

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**LEGEND**

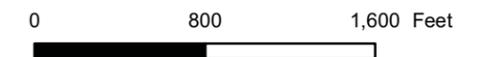
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

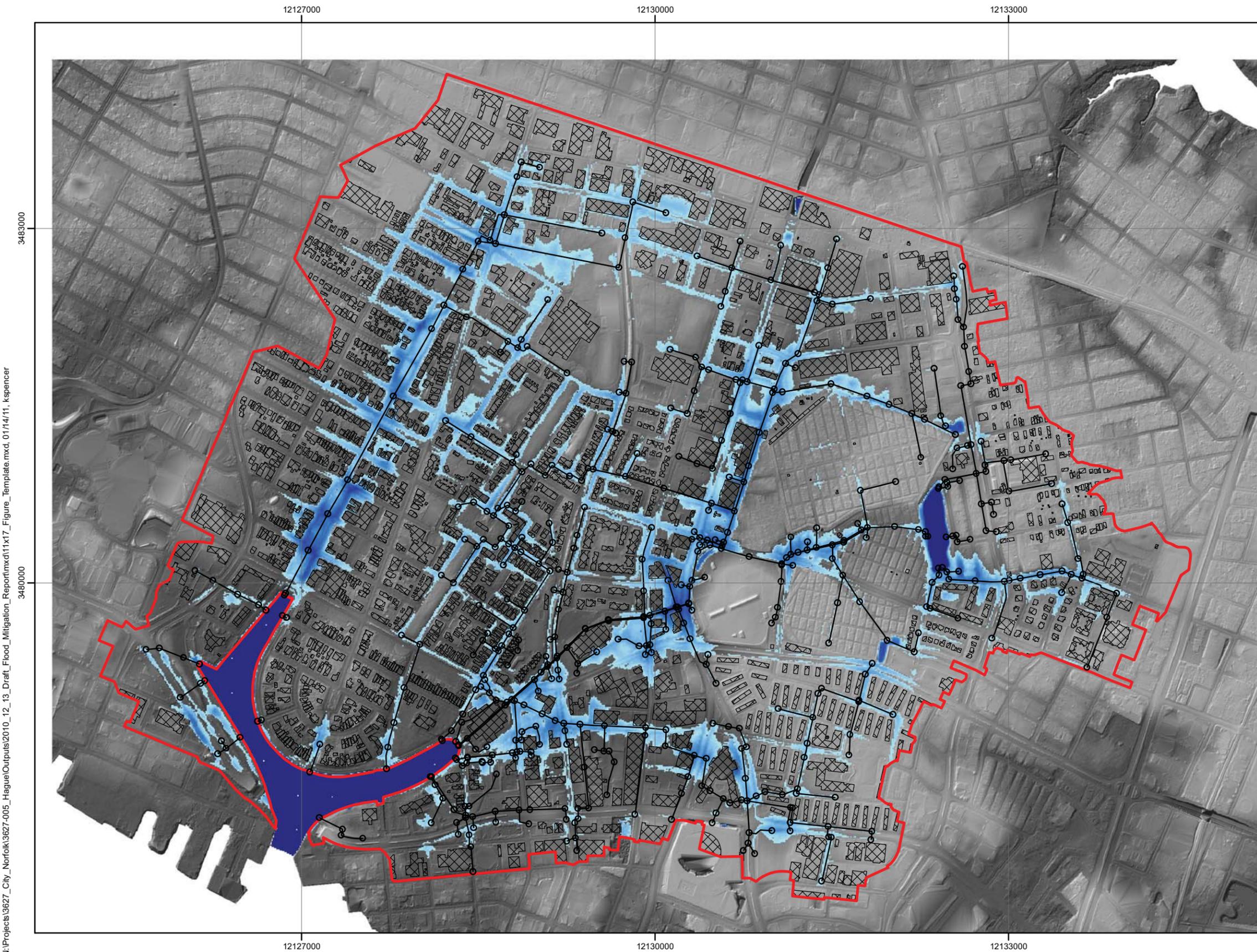
Notes:

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 25YR 24-HR STORM,  
 TAILWATER = 25YR STORM SURGE  
 ALTERNATIVE: 4 x 60-inch Pumps**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-25



**LEGEND**

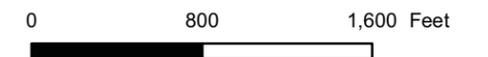
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

**Notes:**

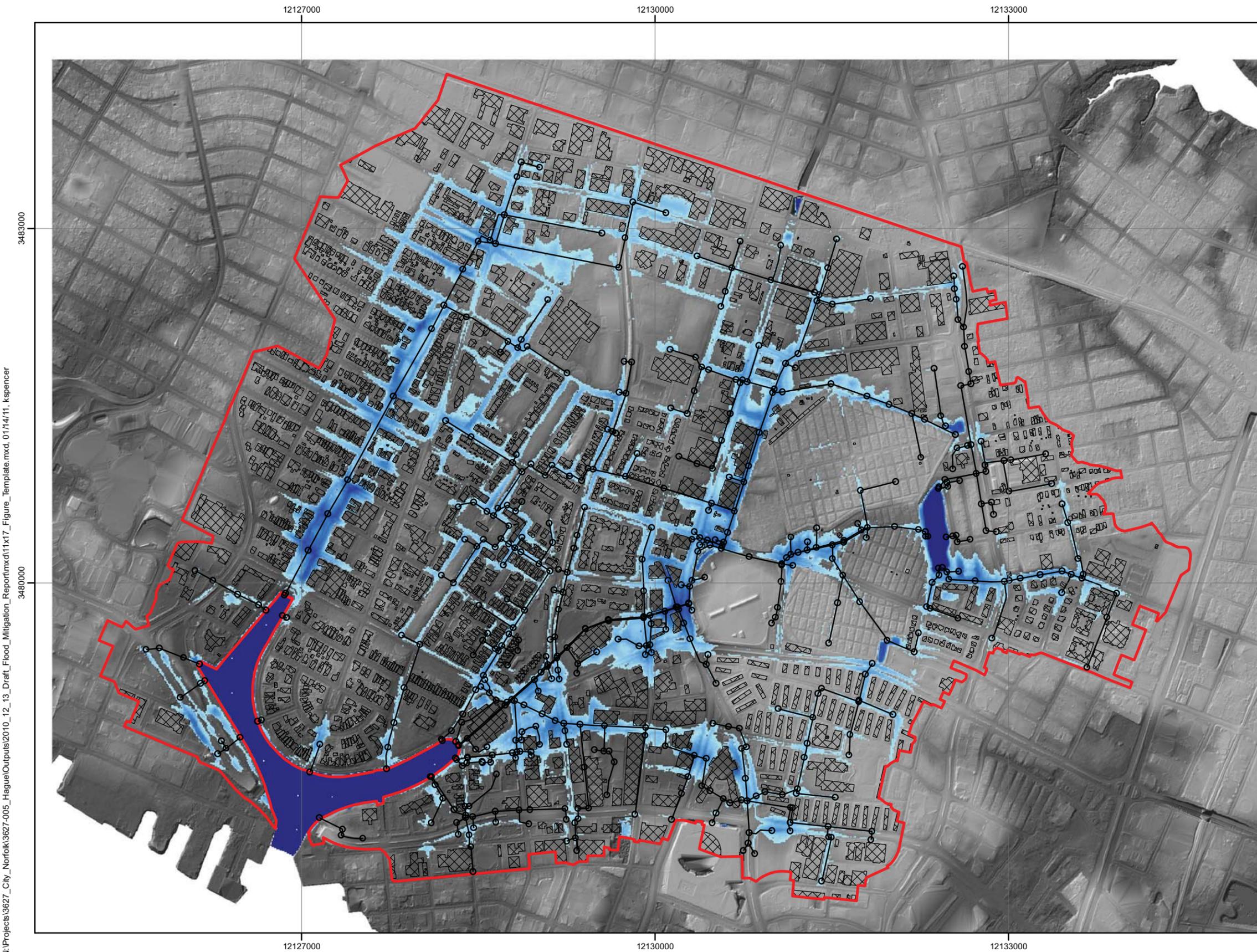
1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 25YR 24-HR STORM,  
 TAILWATER = 25YR STORM SURGE  
 ALTERNATIVE: 4 x 96-inch Pumps**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-26

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**LEGEND**

- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

Notes:

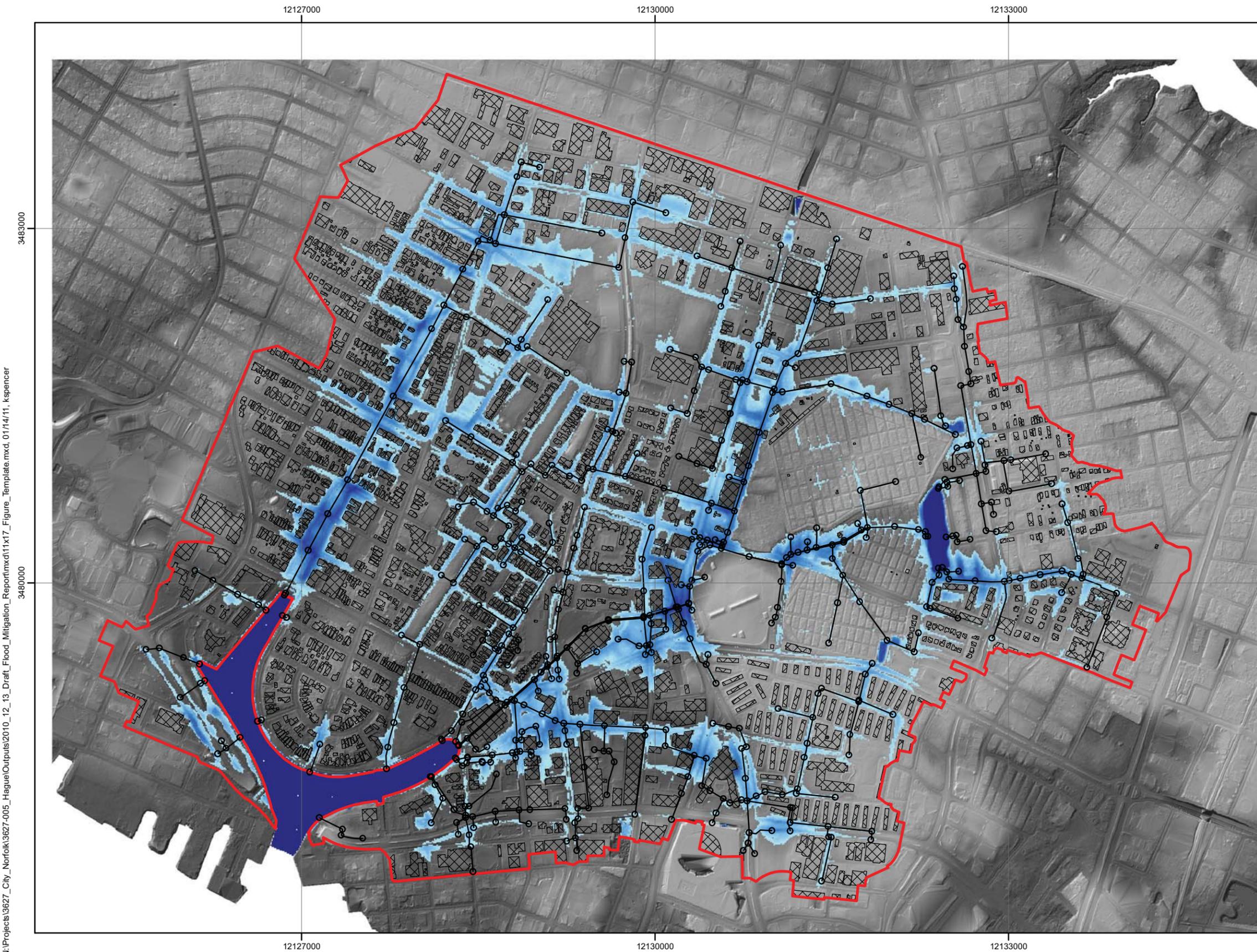
1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 25YR 24-HR STORM,  
 TAILWATER = MHHW  
 ALTERNATIVE: 4 x 60-inch Pumps  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia**

FIGURE B-27

N:\Projects\3627\_City\_Norfolk\3627-005\_Hague\Outputs\2010\_12\_13\_Draft\_Flood\_Mitigation\_Report\mxd\11x17\_Figure\_Template.mxd\_01/14/11\_kspencer



**LEGEND**

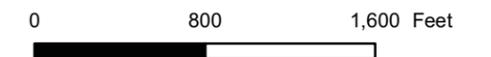
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

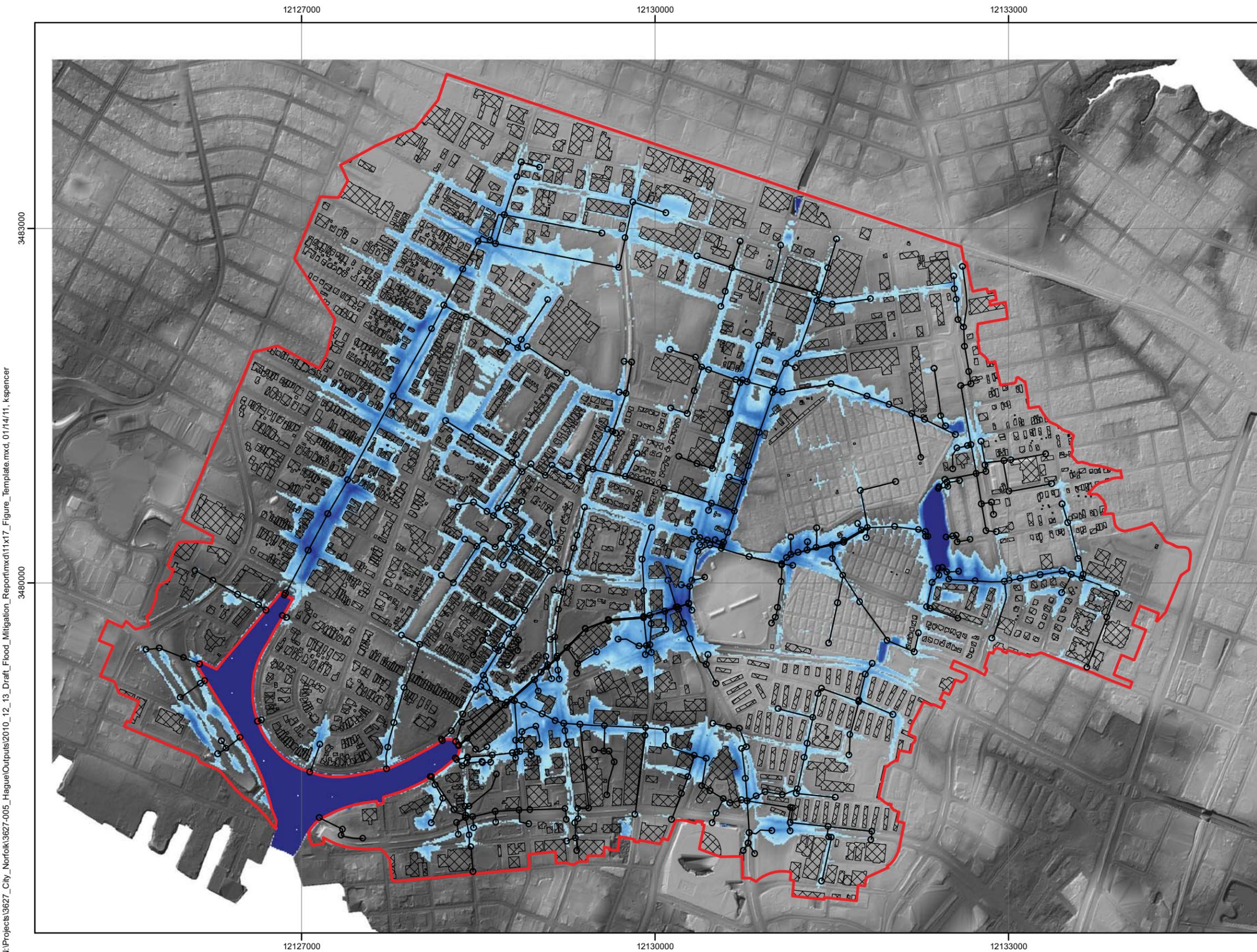
**Notes:**

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 50YR 24-HR STORM,  
 TAILWATER = 50YR STORM SURGE  
 ALTERNATIVE: 2 x 60-inch Pumps**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-28



**LEGEND**

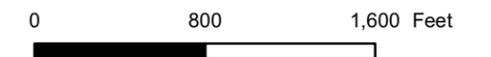
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

**Notes:**

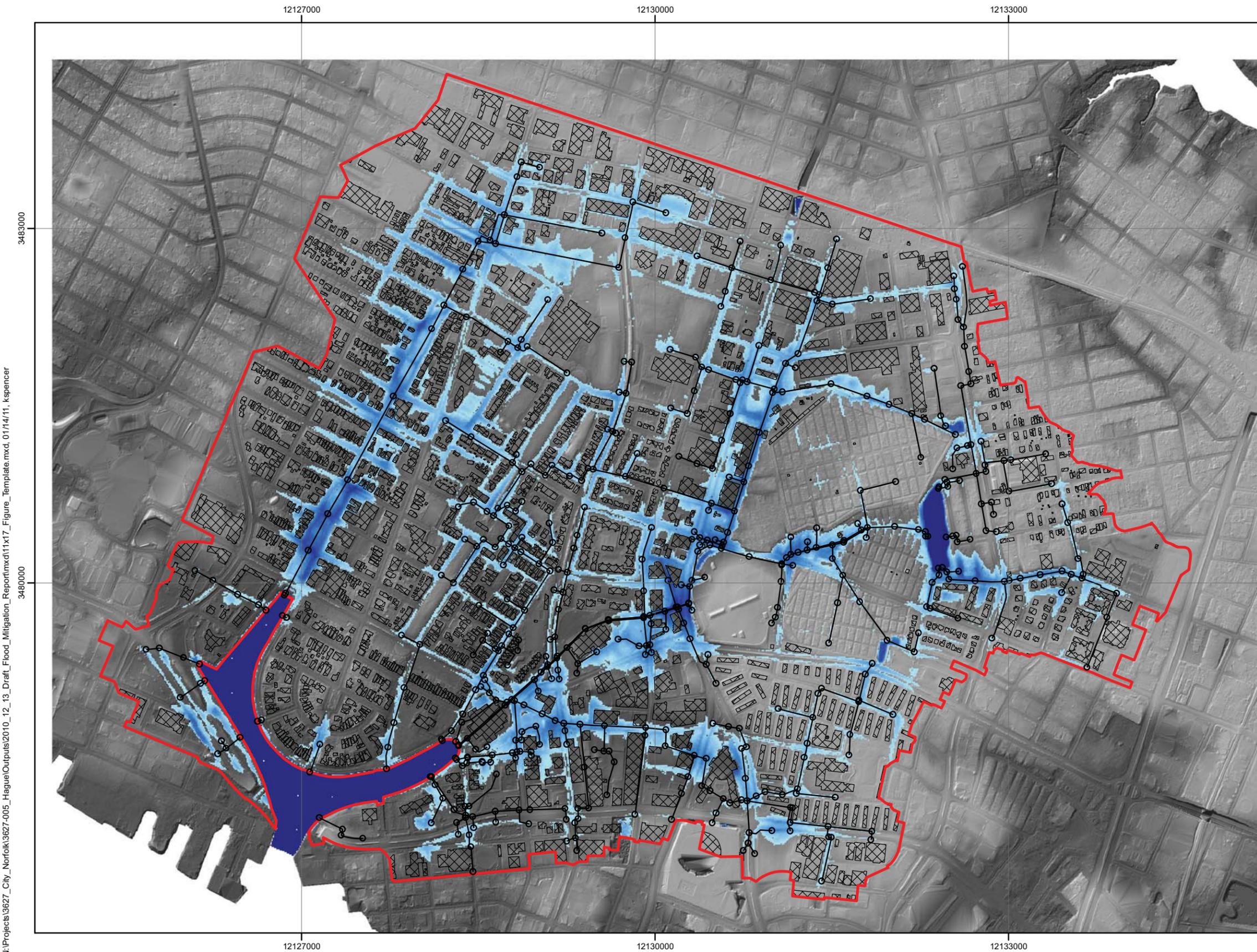
1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 50YR 24-HR STORM,  
 TAILWATER = 50YR STORM SURGE  
 ALTERNATIVE: 4 x 60-inch Pumps**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-29

N:\Projects\3627\_City\_Norfolk\3627-005\_Hague\Outputs\2010\_12\_13\_Draft\_Flood\_Mitigation\_Report\mxd\11x17\_Figure\_Template.mxd, 01/14/11, kspencer



**LEGEND**

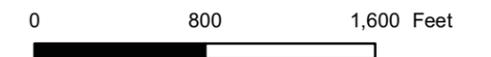
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

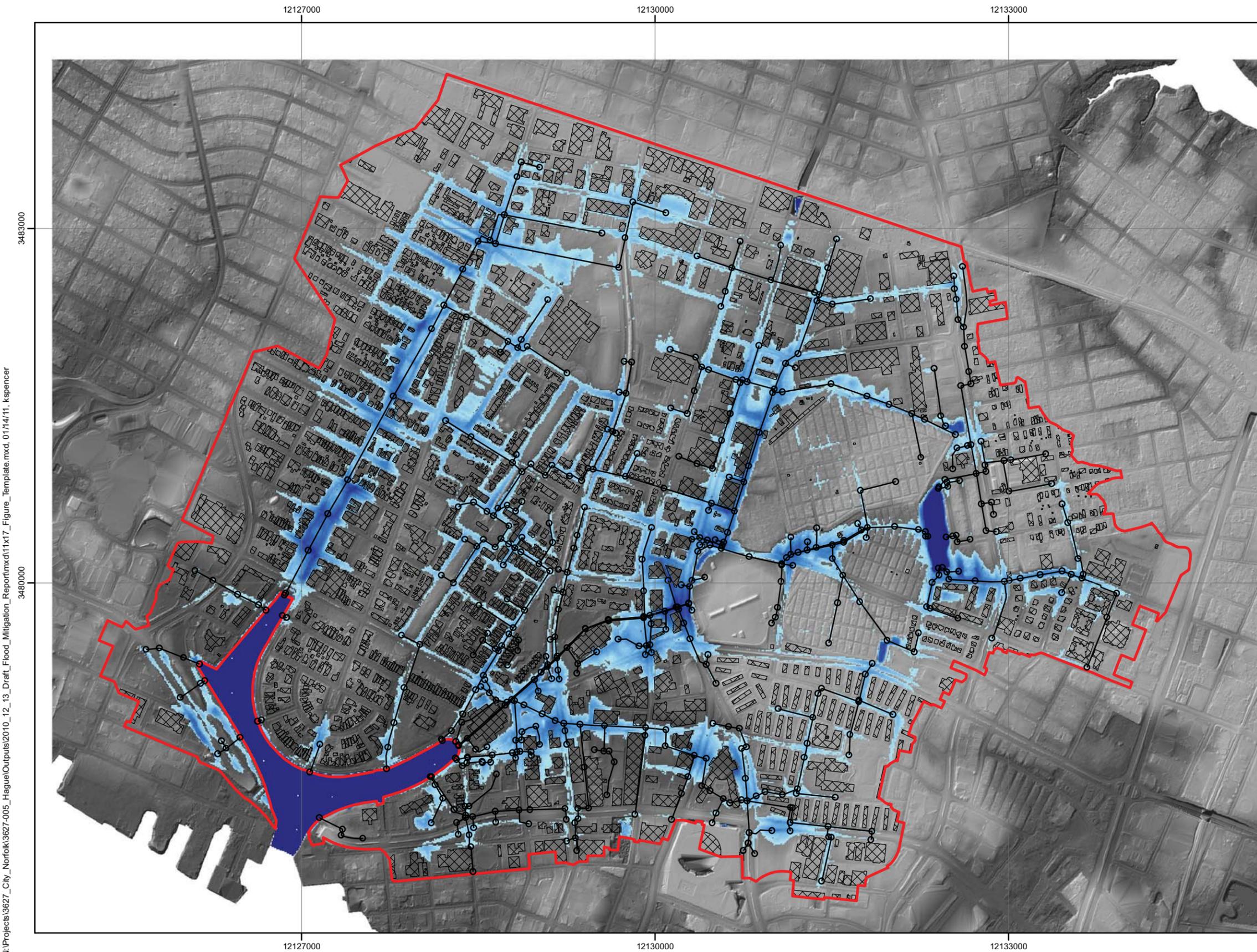
**Notes:**

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 50YR 24-HR STORM,  
 TAILWATER = 50YR STORM SURGE  
 ALTERNATIVE: 4 x 96-inch Pumps  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia**

FIGURE B-30



**LEGEND**

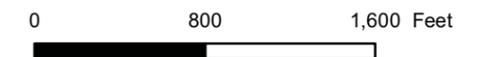
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

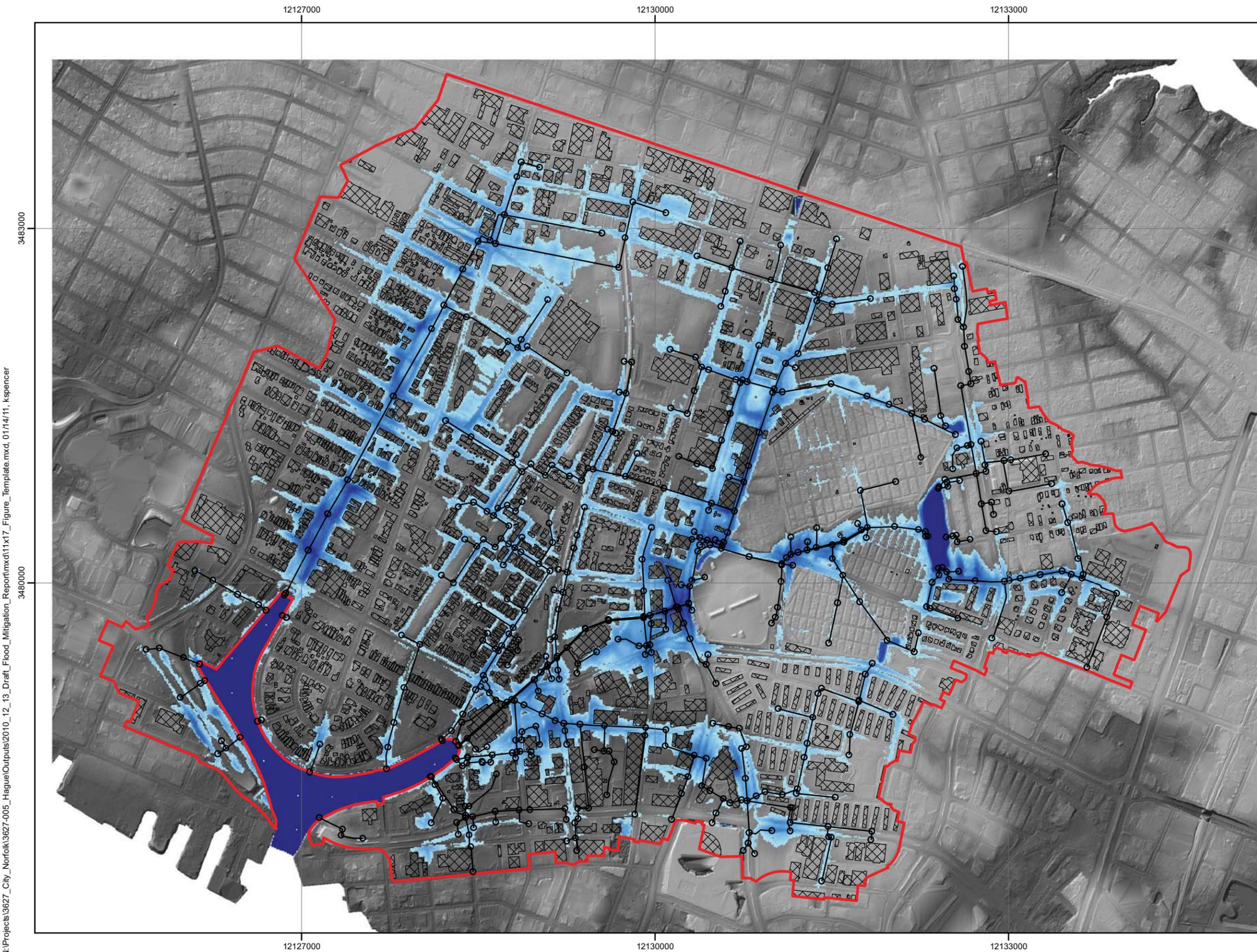
**Notes:**

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 50YR 24-HR STORM,  
 TAILWATER = MHHW  
 ALTERNATIVE: 4 x 60-inch Pumps  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia**

FIGURE B-31



**LEGEND**

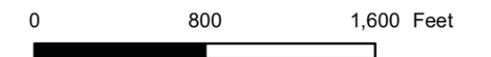
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

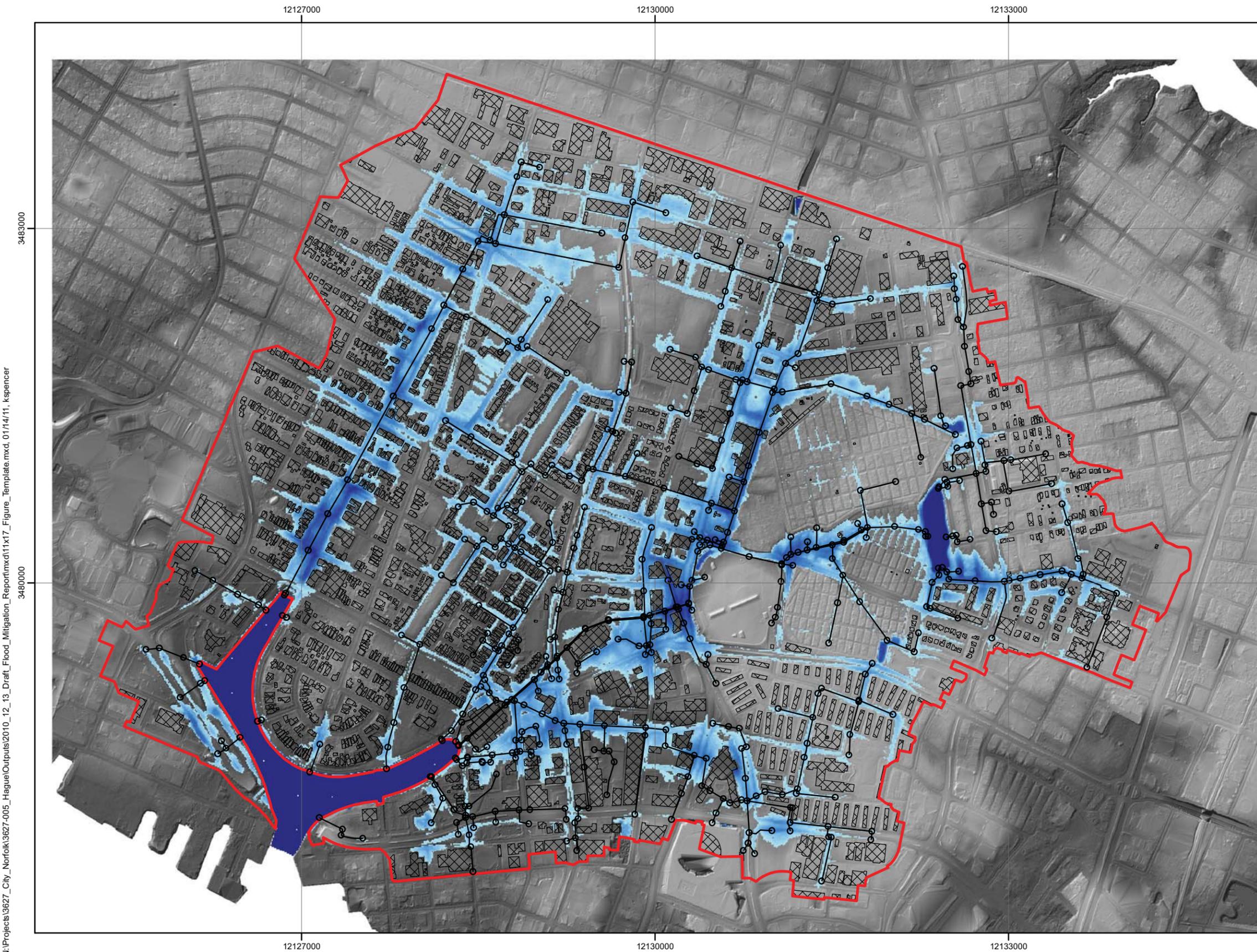
Notes:

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 100YR 24-HR STORM,  
 TAILWATER = 100YR STORM SURGE  
 ALTERNATIVE: 2 x 60-inch Pumps**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-32



**LEGEND**

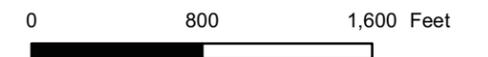
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

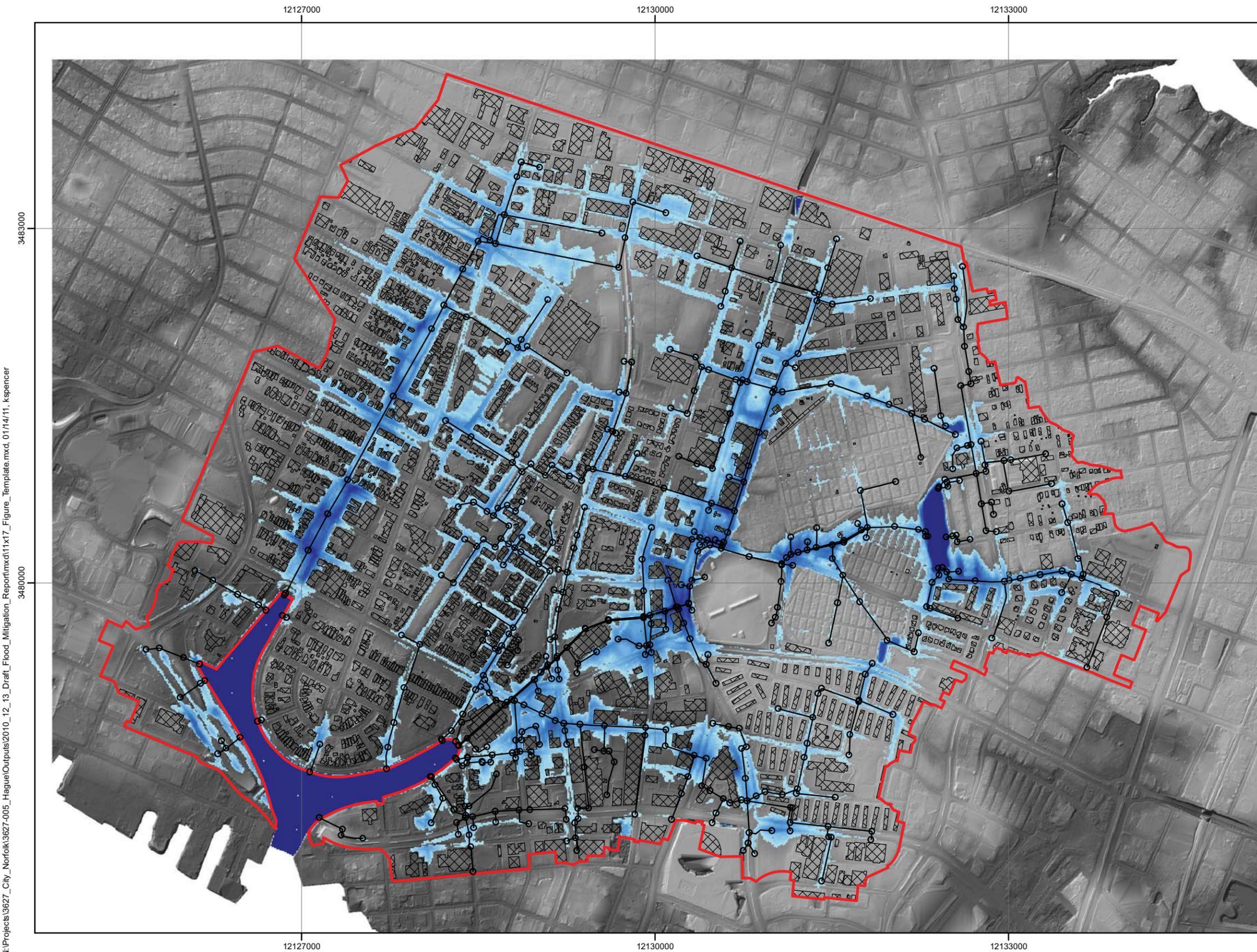
Notes:

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 100YR 24-HR STORM,  
 TAILWATER = 100YR STORM SURGE  
 ALTERNATIVE: 4 x 60-inch Pumps**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-33



**LEGEND**

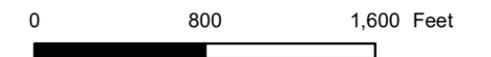
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

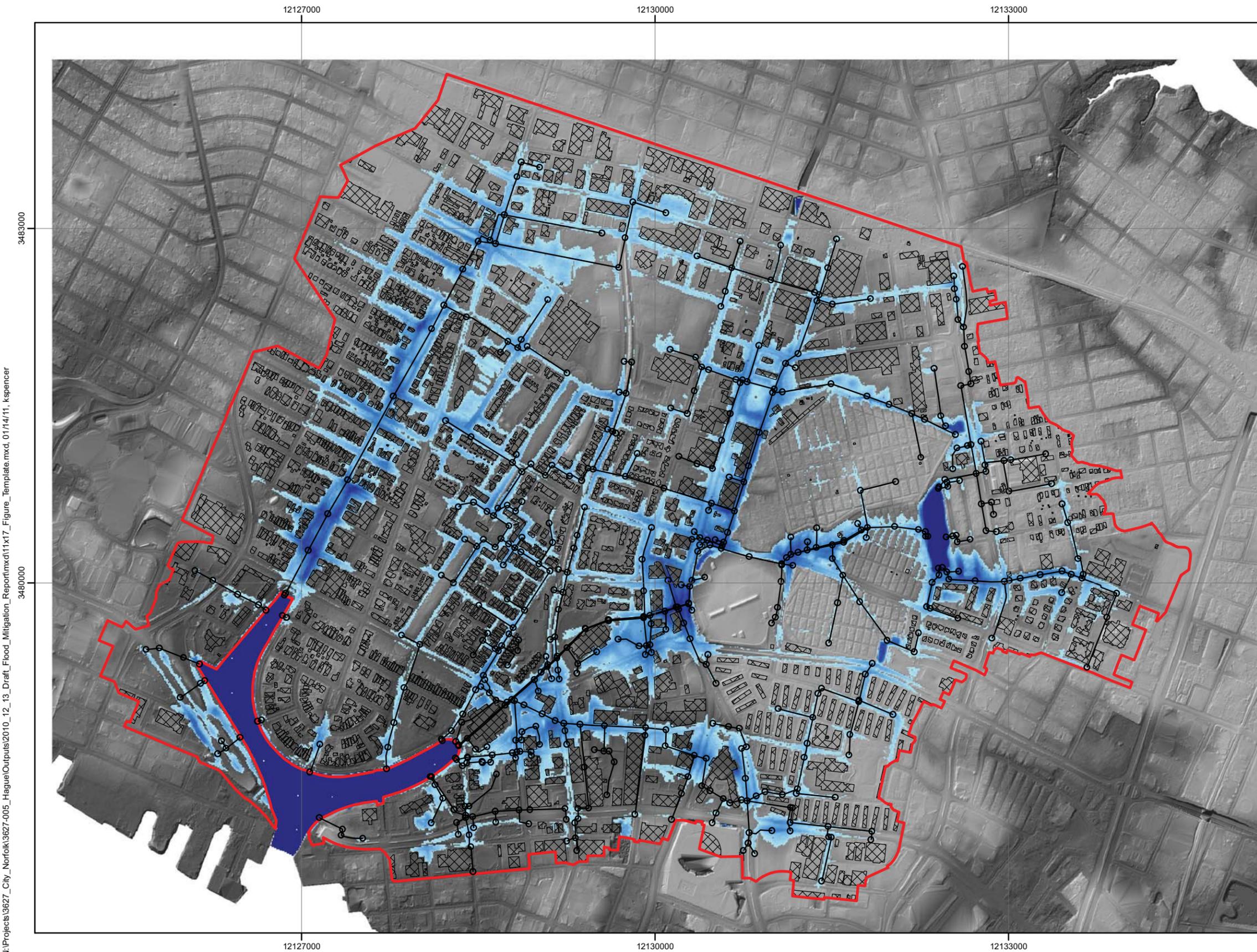
Notes:

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 100YR 24-HR STORM,  
TAILWATER = 100YR STORM SURGE  
ALTERNATIVE: 4 x 96-inch Pumps**  
City-wide Coastal Flooding Study  
Norfolk, Virginia

FIGURE B-34



**LEGEND**

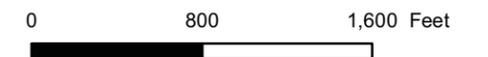
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

Notes:

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 100YR 24-HR STORM,  
TAILWATER = MHHW  
ALTERNATIVE: 4 x 60-inch Pumps  
City-wide Coastal Flooding Study  
Norfolk, Virginia**

FIGURE B-35

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**LEGEND**

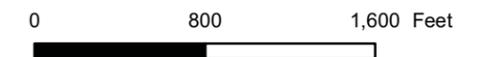
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

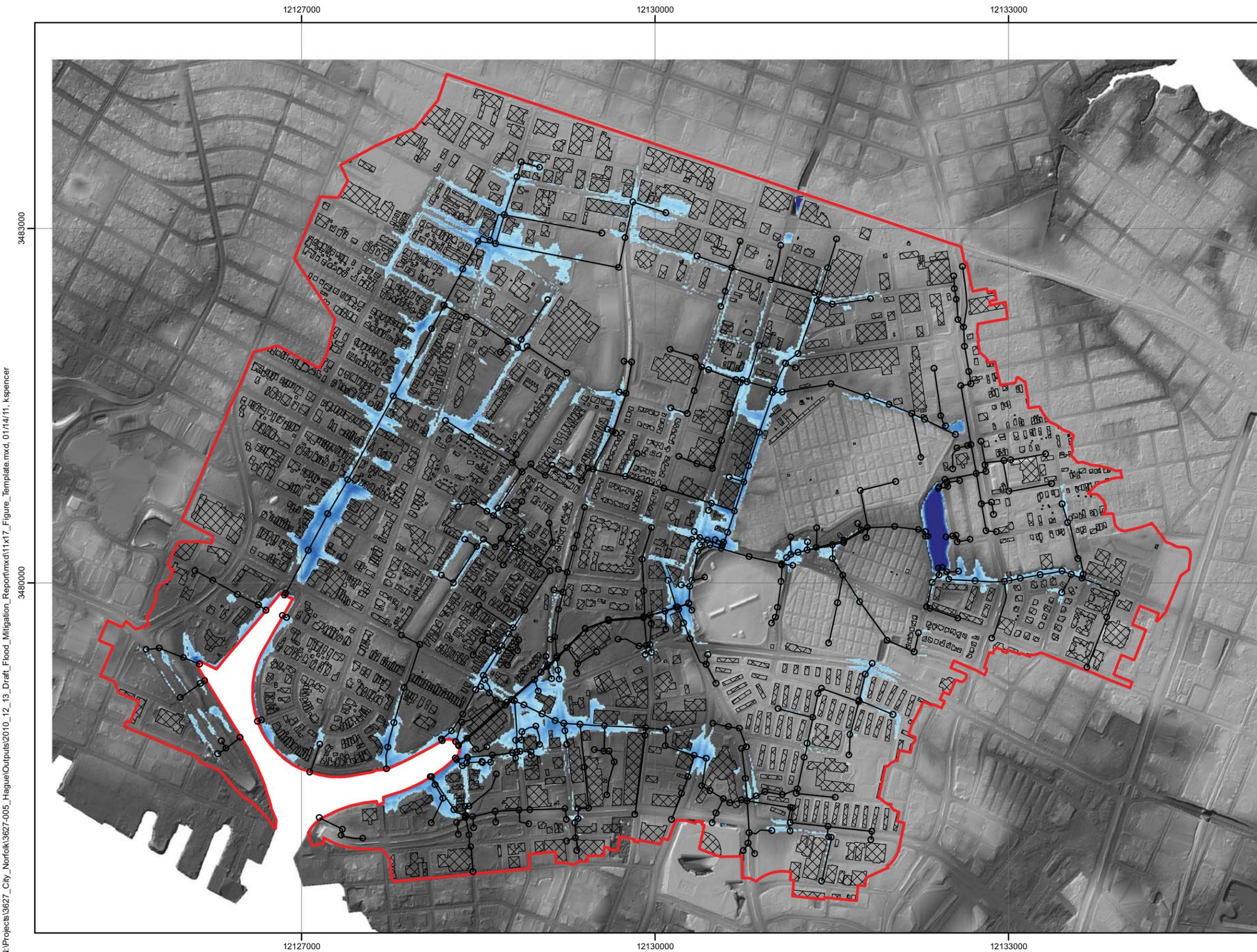
**Notes:**

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 1YR 24-HR STORM,  
 TAILWATER = MHHW  
 ALTERNATIVE: BULKHEAD WALL**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-36



**LEGEND**

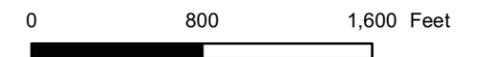
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

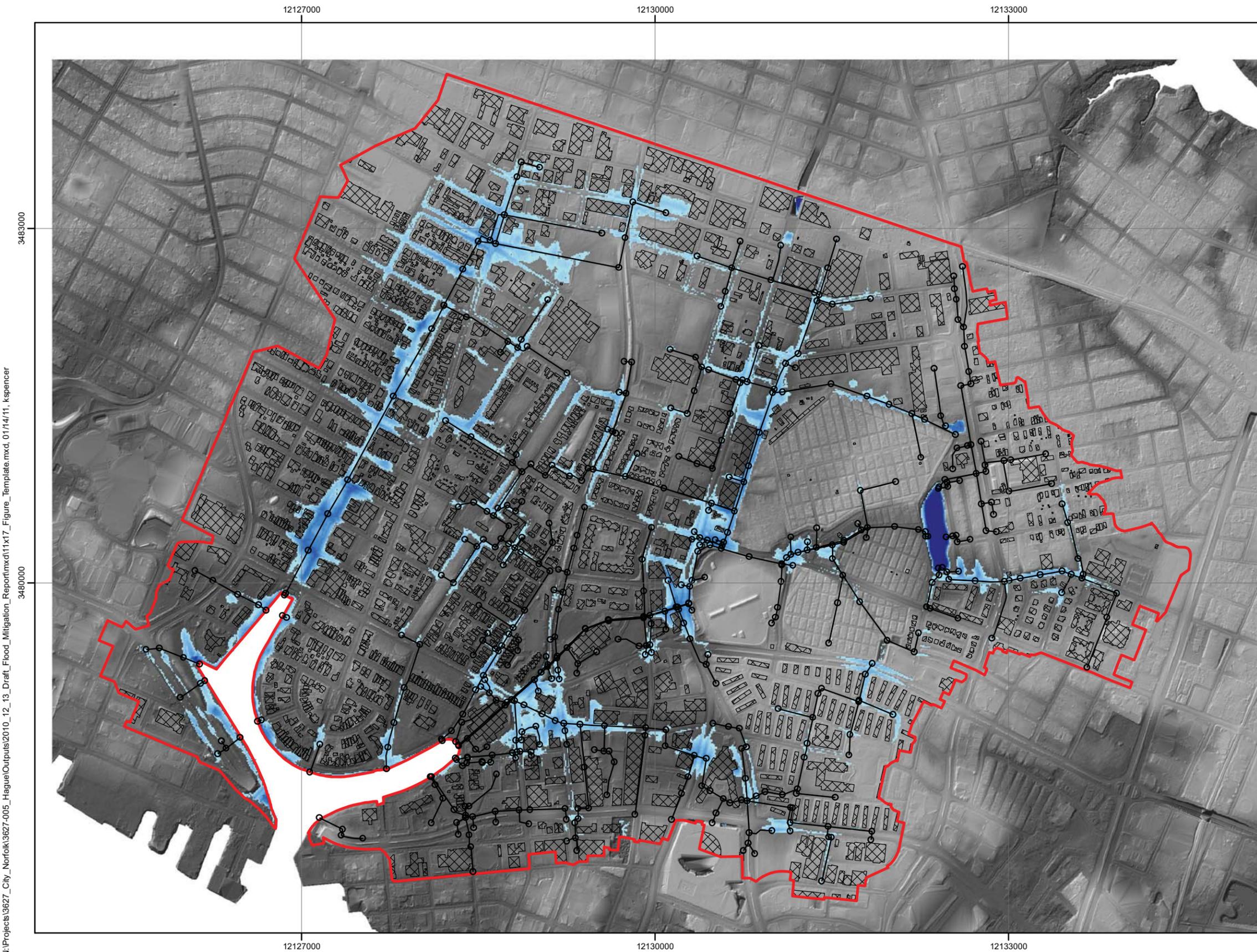
Notes:

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 1YR 24-HR STORM,  
 TAILWATER = 1YR STORM SURGE  
 ALTERNATIVE: BULKHEAD WALL**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-37



**LEGEND**

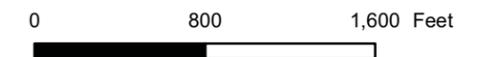
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

Notes:

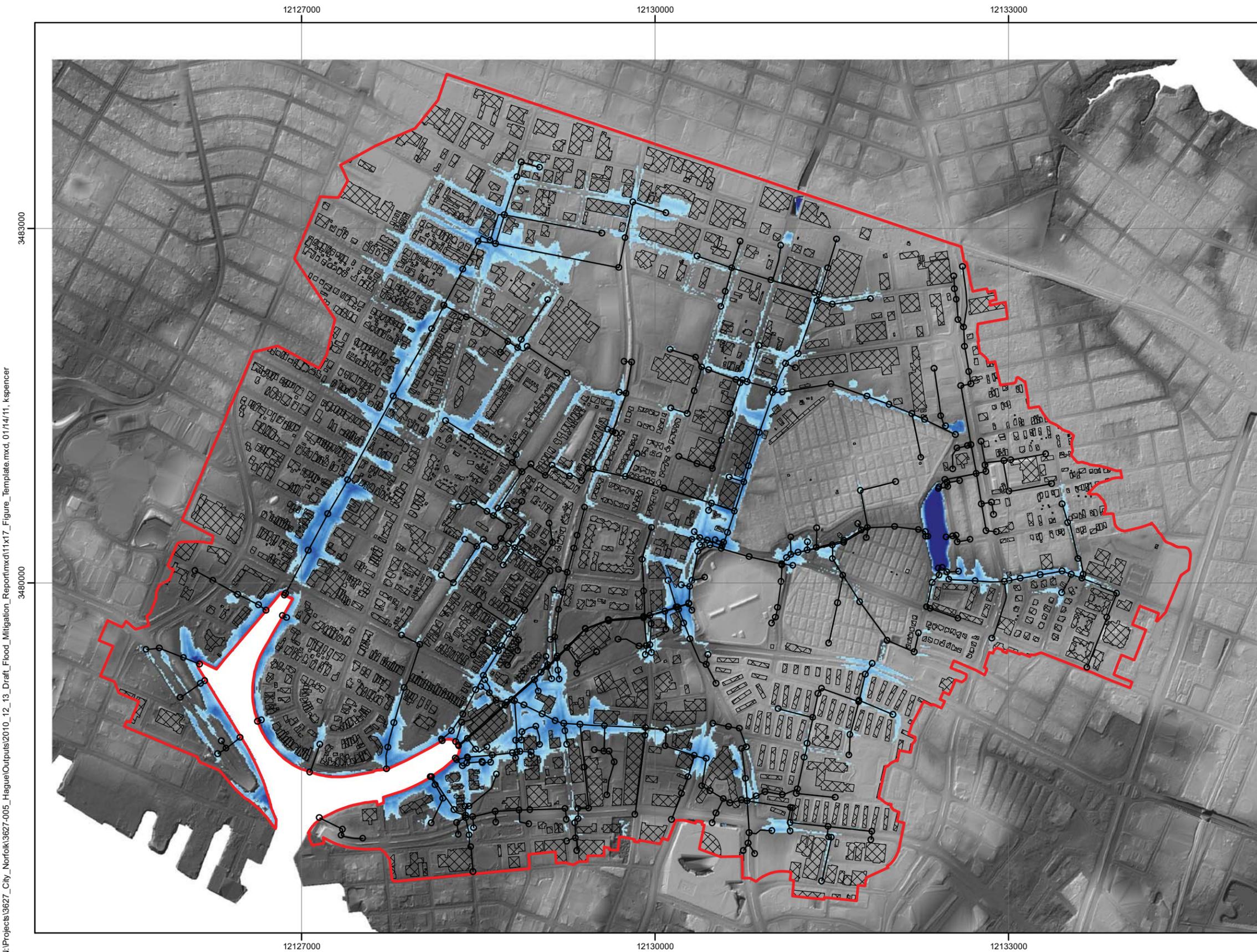
1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 2YR 24-HR STORM,  
 TAILWATER = MHHW  
 ALTERNATIVE: BULKHEAD WALL**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-38

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**LEGEND**

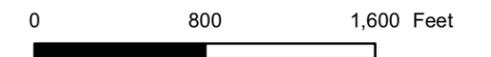
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

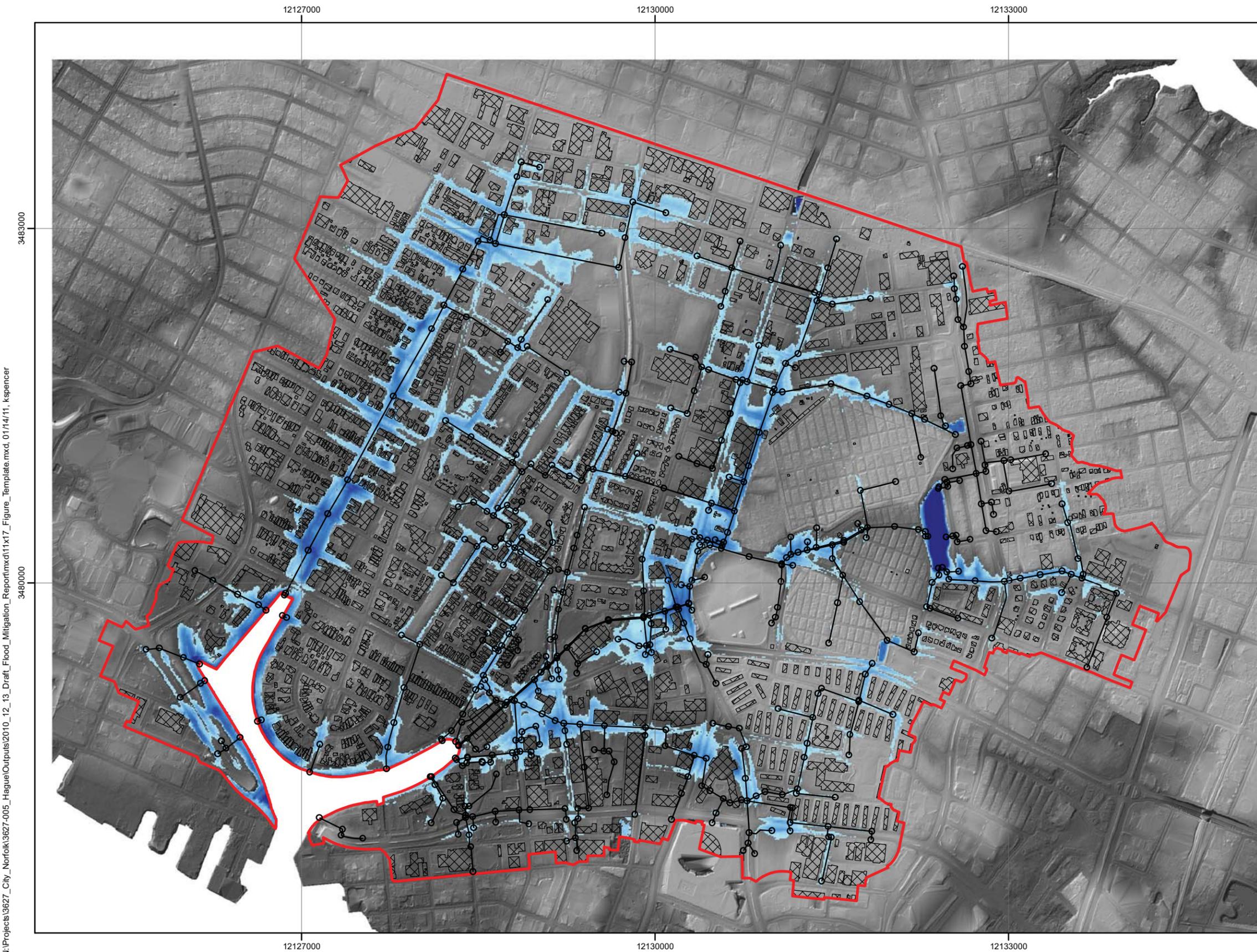
- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

Notes:

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 2YR 24-HR STORM,  
 TAILWATER = 2YR STORM SURGE  
 ALTERNATIVE: BULKHEAD WALL**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia



**LEGEND**

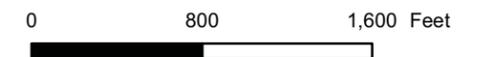
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

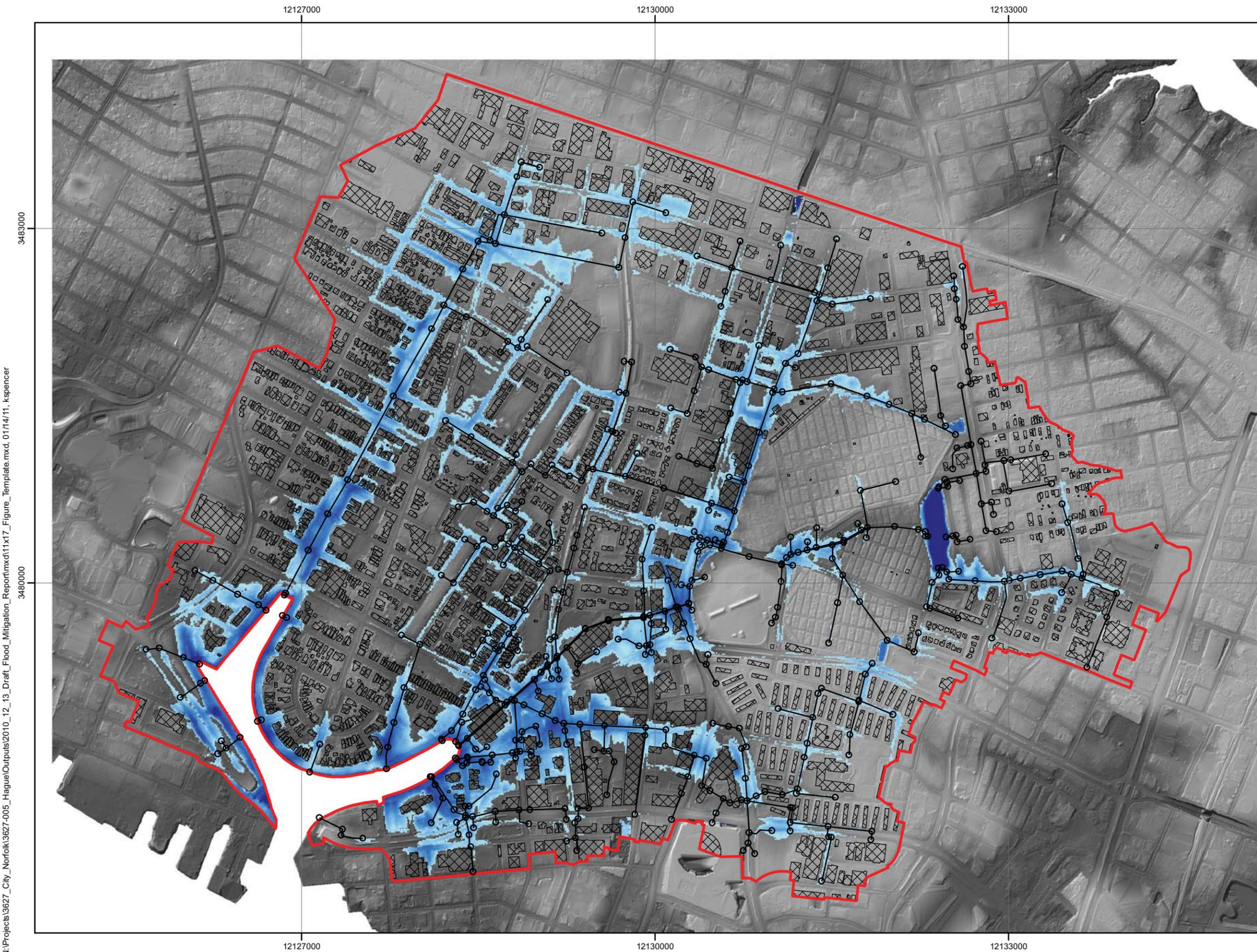
**Notes:**

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 10YR 24-HR STORM,  
 TAILWATER = MHHW  
 ALTERNATIVE: BULKHEAD WALL**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-40



**LEGEND**

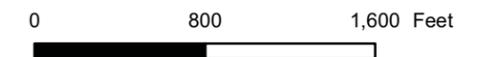
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

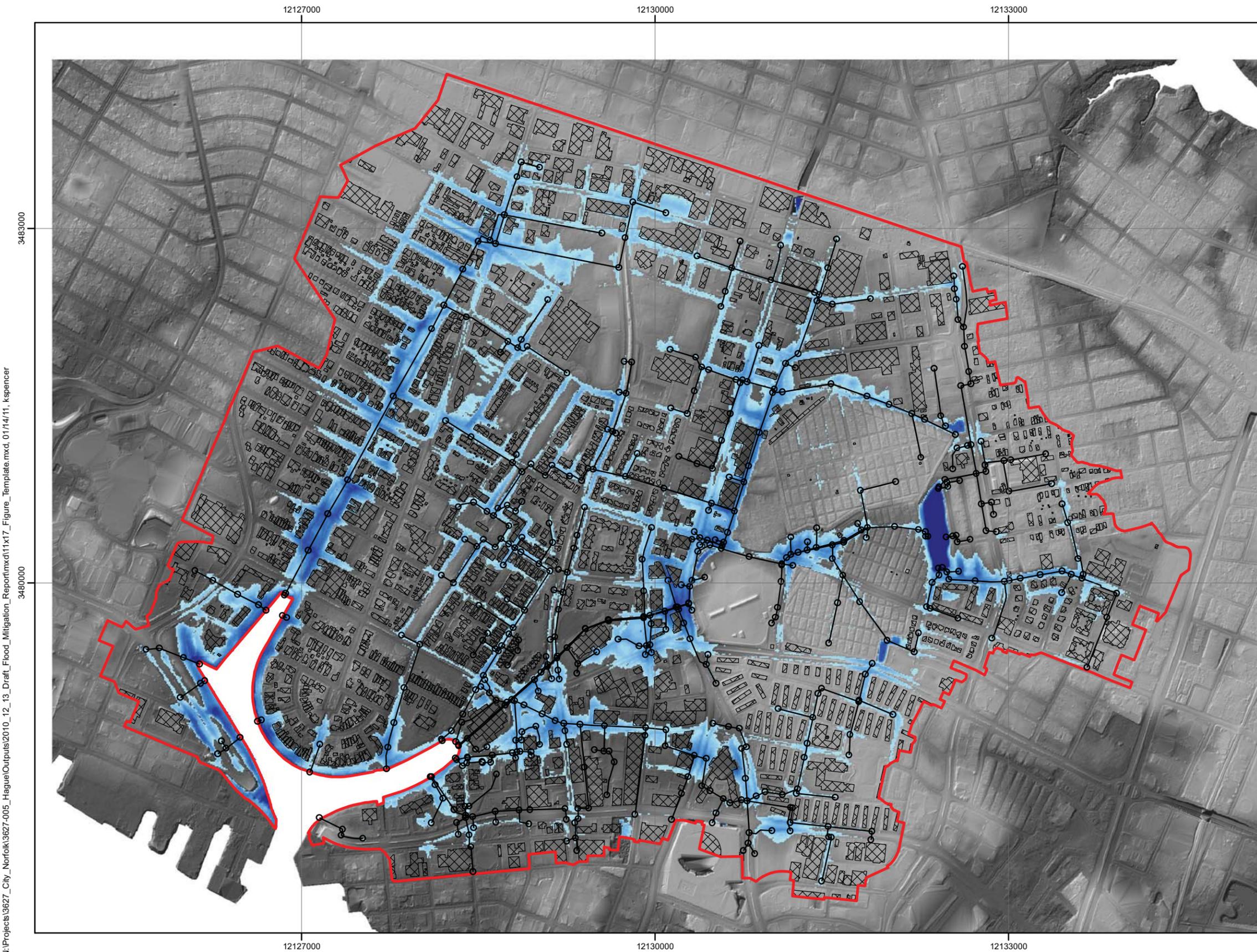
Notes:

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 10YR 24-HR STORM,  
 TAILWATER = 10YR STORM SURGE  
 ALTERNATIVE: BULKHEAD WALL**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-41



**LEGEND**

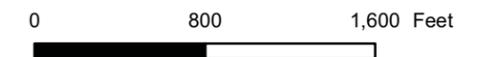
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

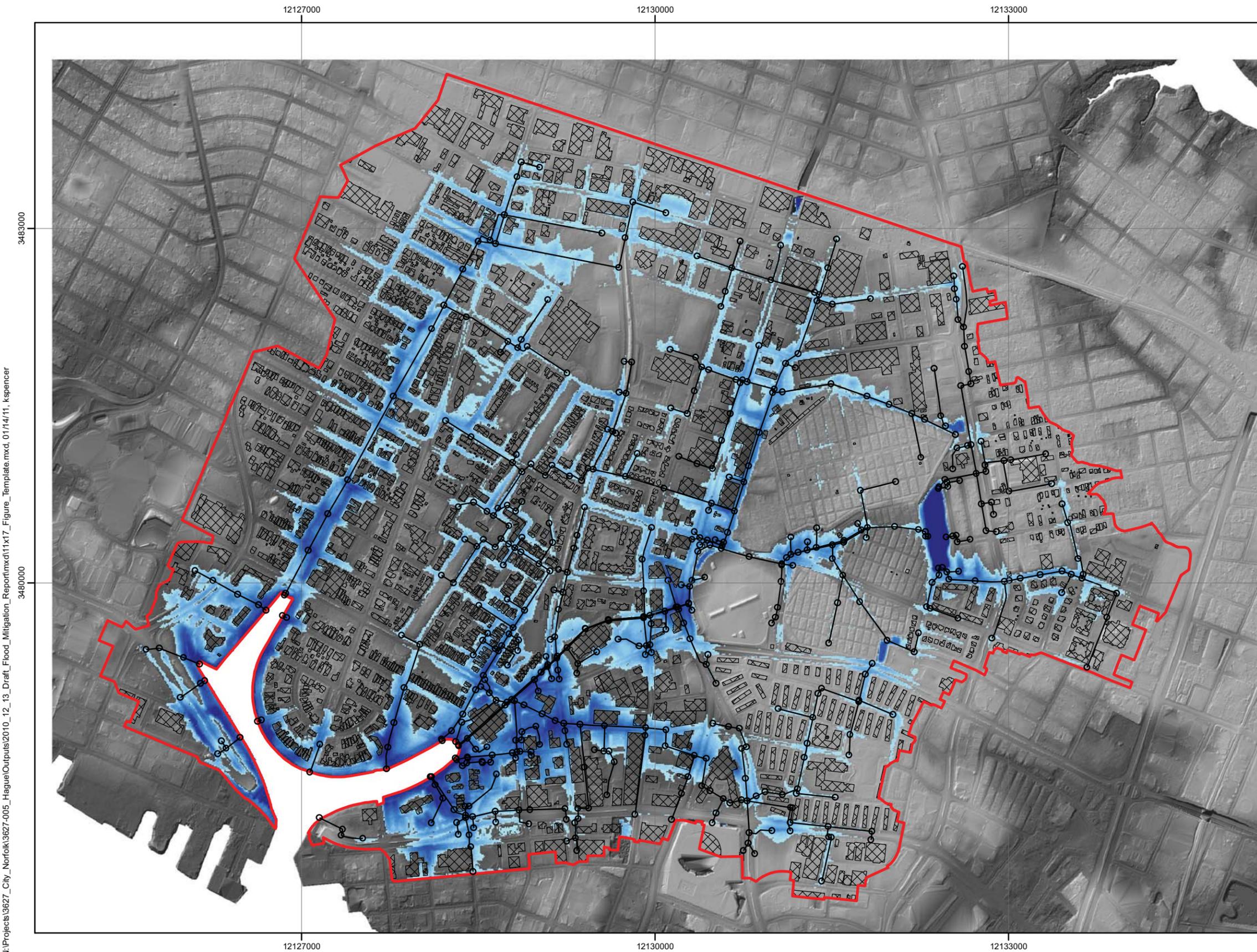
Notes:

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 25YR 24-HR STORM,  
 TAILWATER = MHHW  
 ALTERNATIVE: BULKHEAD WALL**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-42



**LEGEND**

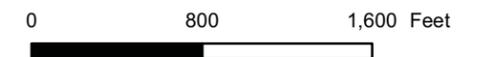
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

Notes:

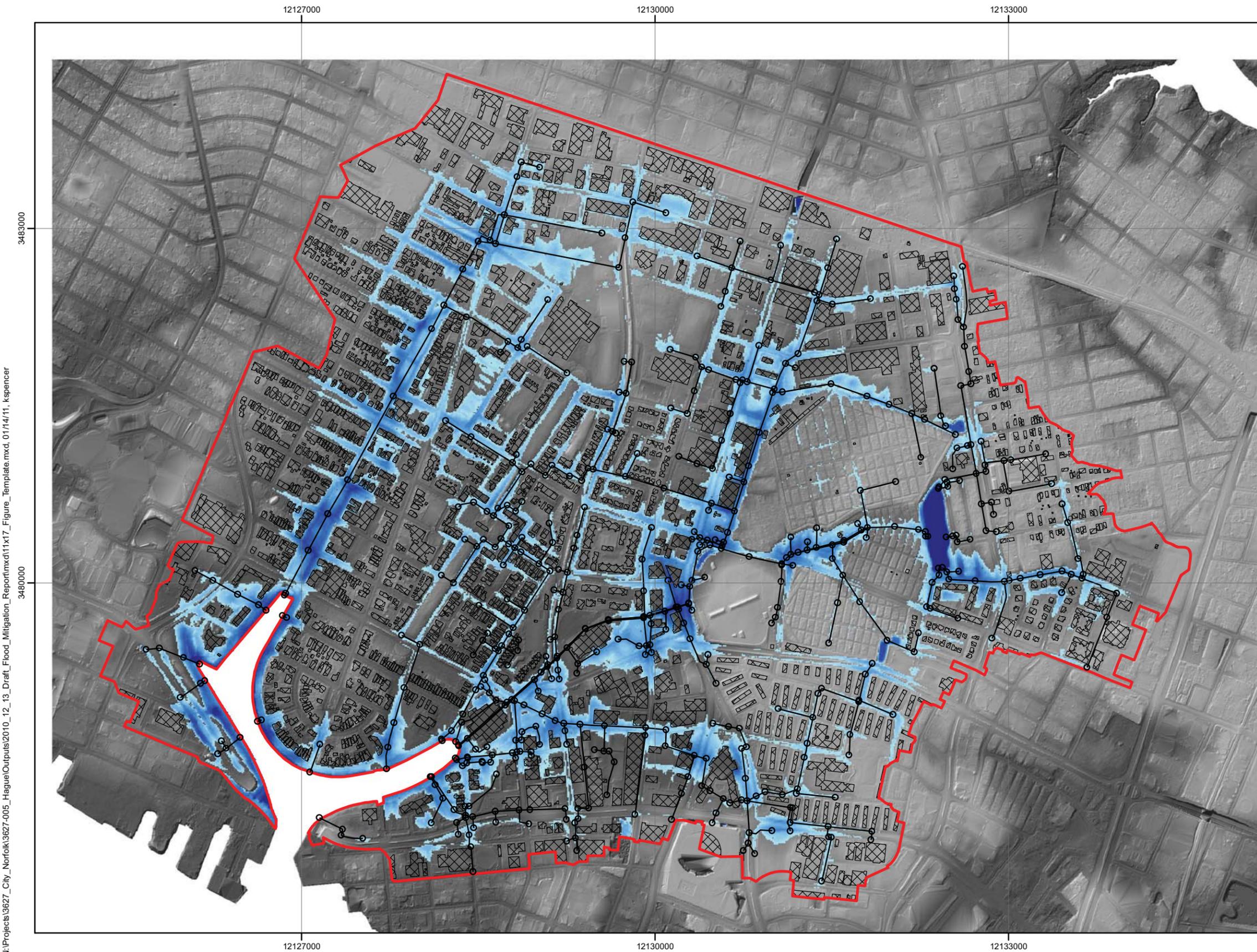
1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 25YR 24-HR STORM,  
 TAILWATER = 25YR STORM SURGE  
 ALTERNATIVE: BULKHEAD WALL**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-43

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**LEGEND**

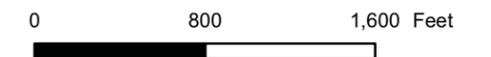
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

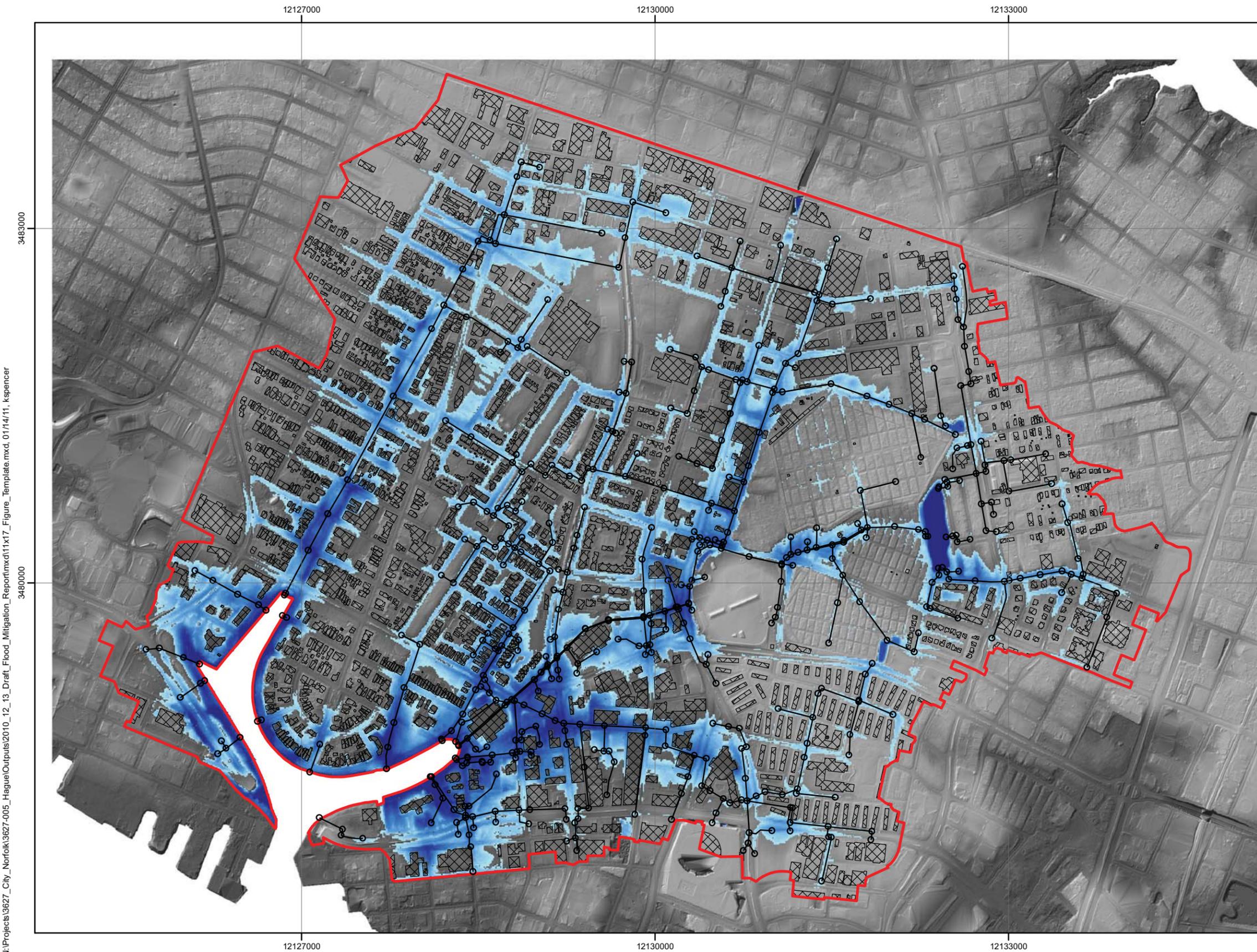
Notes:

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 50YR 24-HR STORM,  
 TAILWATER = MHHW  
 ALTERNATIVE: BULKHEAD WALL**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-44



**LEGEND**

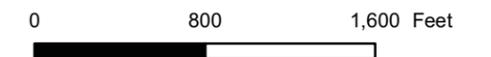
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

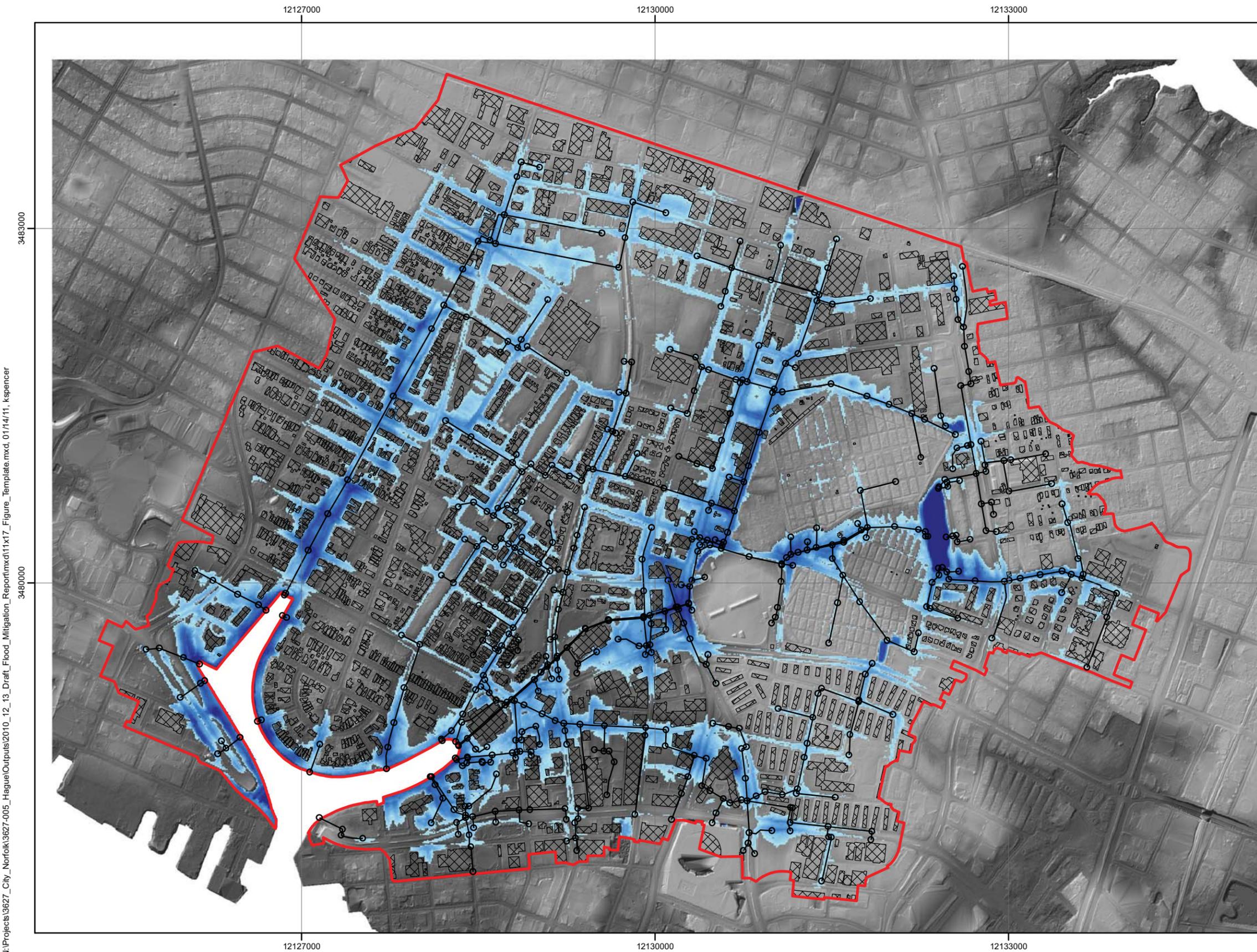
**Notes:**

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 50YR 24-HR STORM,  
 TAILWATER = 50YR STORM SURGE  
 ALTERNATIVE: BULKHEAD WALL**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-45



**LEGEND**

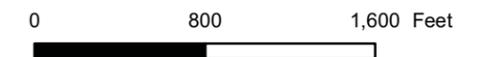
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

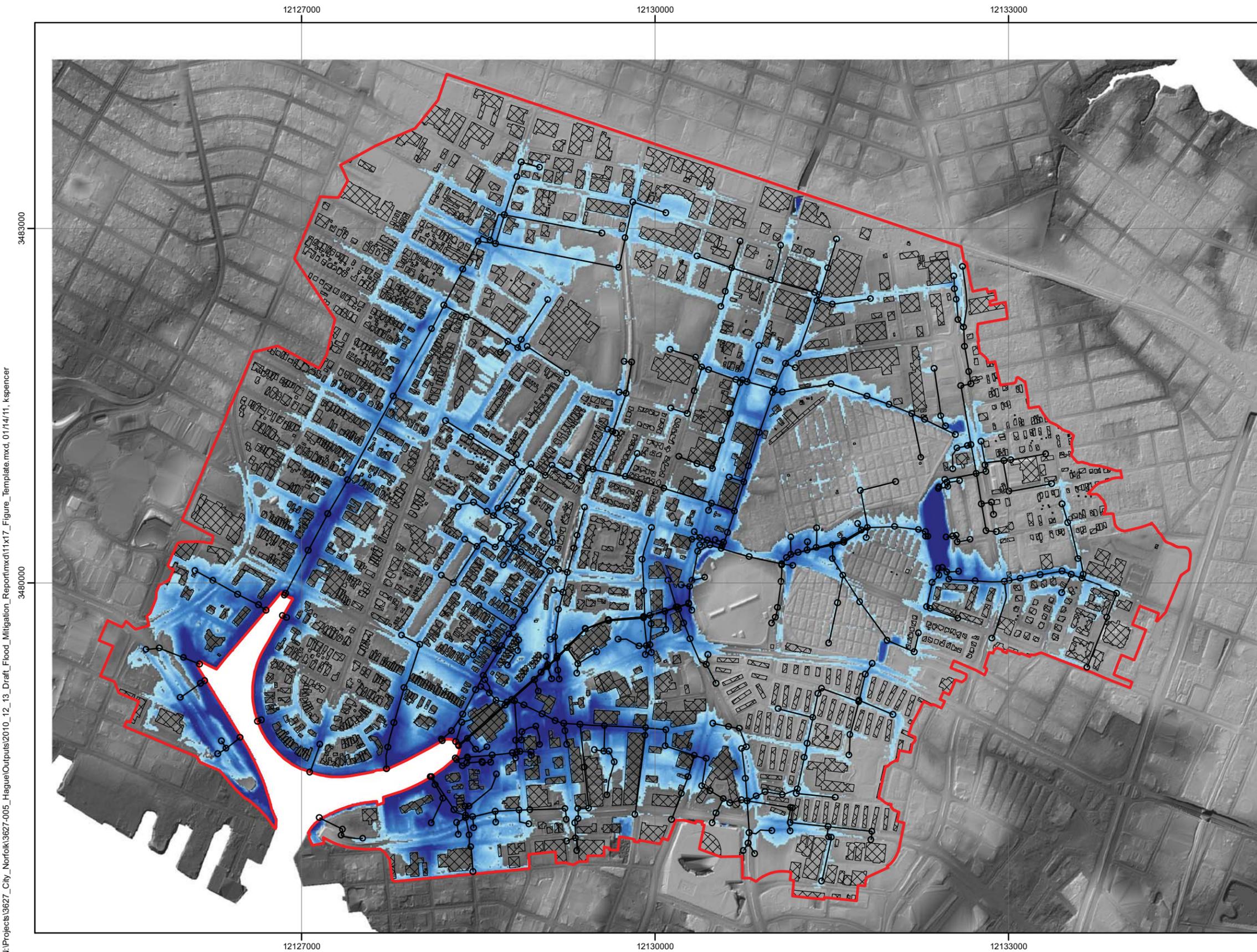
Notes:

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 100YR 24-HR STORM,  
 TAILWATER = MHHW  
 ALTERNATIVE: BULKHEAD WALL**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-46



**LEGEND**

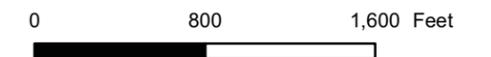
- Model Nodes
- Model Links
- ▭ Hague Watershed Boundary
- ▨ Hague Buildings

**Max Depth (ft)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2.0 - 2.25
- 2.25 - 2.5
- 2.5 - 2.75
- 2.75 - 3
- 3.0 - 3.25
- 3.25 - 3.5
- 3.5 - 3.75
- 3.75 - 4
- 4.0 - 4.25
- 4.25 - 4.5
- 4.5 - 4.75
- 4.75 - 10

Notes:

1. City digital elevation model (DEM) hillshade relief generated from 2009 LIDAR survey conducted by Pictometry, Inc. under contract to the City of Norfolk.



**SWMM RESULTS FOR 100YR 24-HR STORM,  
 TAILWATER = 100YR STORM SURGE  
 ALTERNATIVE: BULKHEAD WALL**  
 City-wide Coastal Flooding Study  
 Norfolk, Virginia

FIGURE B-47

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**APPENDIX C**

**OPINION OF PROBABLE COST AND OPERATIONAL COST**

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia			CONSTRUCTION CONTRACT NO. IDENTIFICATION NUMBER		
PROJECT TITLE <b>Pretty Lake - Alternative 1a                  Tidal Barrier with Steel Gate, 2 - 60" Dia. Pumps, and                  Road Raise</b>			ESTIMATED BY Moffatt & Nichol		CATEGORY CODE NUMBER
			STATUS OF DESIGN	JOB ORDER NUMBER 6822-06	
<b>Summary</b>					
Scenario			Opinion of Probable Cost		
2 Year Surge with Rain			\$27,700,000		
10 Year Surge with Rain			\$34,900,000		
25 Year Surge with Rain			\$36,200,000		
50 Year Surge with Rain			\$37,400,000		
100 Year Surge with Rain			\$38,400,000		

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION		CONSTRUCTION CONTRACT NO.	IDENTIFICATION NUMBER		
City of Norfolk Norfolk, Virginia		ESTIMATED BY	CATEGORY CODE NUMBER		
PROJECT TITLE		Moffatt & Nichol			
Alt. 1a - Tidal Barrier with Steel Gate, 2 - 60" Dia. Pumps, and Road Raise For 2 Year Event @ ELEV +4.2'		STATUS OF DESIGN	JOB ORDER NUMBER		
			6822-06		
ITEM DESCRIPTION	QUANTITY		ENGINEERING ESTIMATE		
	NUMBER	UNIT	UNIT COST	TOTAL	
<b>Site Civil</b>					
Road Raise (2-Lane Road)	0.00	LF/VLF	\$250.00	\$0	
Road Raise (4-Lane Road)	0.00	LF/VLF	\$450.00	\$0	
Utility Relocation	0	LF	\$300.00	\$0	
Elevating Homes along North Side of Dunning Ave	0	EA	\$70,000.00	\$0	
<b>Sliding Gate</b>					
<u>Piling: Steel</u>					
Install AZ 14 Steel Sheet Piles	56,400	SF	\$28.50	\$1,607,400	
Treat Embedded Interlocks	13,000	LF	\$7.25	\$94,250	
30" DIA Steel Pipe End Piles	320	LF	\$363.00	\$116,160	
Special Sheet Fabrication	480	LF	\$42.50	\$20,400	
<u>Site Work: Excavation &amp; Fill</u>					
Gravel Base	38,000	CY	\$32.25	\$1,225,500	
<u>Concrete: Gate Base Slab</u>					
Precast Concrete Gate Base	50	CY	\$1,832.50	\$91,625	
Tremie Concrete Base	150	CY	\$985.00	\$147,750	
<u>Gate Assembly</u>					
Framed Steel Gate	65	Tons	\$10,125.00	\$658,125	
Flanged Steel Wheel Assembly	6	EA	\$3,120.00	\$18,720	
Rail	150	LF	\$298.00	\$44,700	
Capstan & Cabling	1	LS	\$193,500.00	\$193,500	
UHMW Rollers	12	EA	\$2,587.00	\$31,044	
Pocket Seal	35	LF	\$4,650.00	\$162,750	
<u>Finish Work</u>					
Concrete Fascia	8,100	SF	\$85.00	\$688,500	
Top Slab	180	CY	\$630.00	\$113,400	
Handrail	830	LF	\$178.00	\$147,740	
<b>Pump Stations</b>					
60" pumps	3	EA	\$1,380,000.00	\$4,140,000	
Support Structure - piles,header,rods, etc.	1	EA	\$28,000.00	\$28,000	
Misc 60" Pipe Sections	3	EA	\$8,000.00	\$24,000	
Concrete Headwall	1	EA	\$80,000.00	\$80,000	
Flapgates	3	EA	\$19,200.00	\$57,600	
Brick Enclosure for Generator	1	EA	\$450,000.00	\$450,000	
Aesthetic Features of Pump Station	1	LS	\$150,000.00	\$150,000	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION		CONSTRUCTION CONTRACT NO.	IDENTIFICATION NUMBER		
City of Norfolk Norfolk, Virginia		ESTIMATED BY	CATEGORY CODE NUMBER		
PROJECT TITLE		Moffatt & Nichol			
Alt. 1a - Tidal Barrier with Steel Gate, 2 - 60" Dia. Pumps, and Road Raise For 2 Year Event @ ELEV +4.2'		STATUS OF DESIGN	JOB ORDER NUMBER		
			6822-06		
ITEM DESCRIPTION	QUANTITY		ENGINEERING ESTIMATE		
	NUMBER	UNIT	UNIT COST	TOTAL	
<b>Electrical</b>					
Dominion Power Installation Costs	1	LS	\$100,000.00	\$100,000	
<i>Common Costs</i>					
Line Truck	20	DY	\$283.25	\$5,665	
Backhoe	10	DY	\$395.52	\$3,955	
Scissors Lift	40	DY	\$265.20	\$10,608	
<i>Site Work</i>					
Trench & Backfill	400	LF	\$1.96	\$784	
Pole, Foundation & Flood It	6	EA	\$1,223.02	\$7,338	
Quasite Handhole	3	EA	\$607.04	\$1,821	
<i>Power</i>					
Switchboard	1	LS	\$74,231.00	\$74,231	
400A 208V service panel W/MCB	1	EA	\$4,475.00	\$4,475	
100A 30ckt 208v 3 phase panel	6	EA	\$2,090.00	\$12,540	
225A 42 ckt 208v 3 phase panel	2	EA	\$3,400.00	\$6,800	
100-225A 3P 208v CB	4	EA	\$998.00	\$3,992	
20A 1P 120v Circuit Breaker	42	EA	\$53.30	\$2,239	
Surge Arrestor (SPD) 208V 10-Mode NEMA 4x box	2	EA	\$9,849.00	\$19,698	
4" GRS Conduit	1500	LF	\$49.80	\$74,700	
3/4" GRS Conduit	2500	LF	\$7.93	\$19,825	
1/2" GRS Conduit	5000	LF	\$7.14	\$35,700	
4" GRS Fittings	100	EA	\$455.00	\$45,500	
3/4" GRS Fittings	200	EA	\$42.95	\$8,590	
1/2" GRS Fittings	200	EA	\$35.45	\$7,090	
# 500 kcmil XHHW	7500	LF	\$14.10	\$105,750	
#4/0 AWG THWN	1500	LF	\$6.86	\$10,290	
#8 THWN Copper	1500	LF	\$0.91	\$1,365	
#12 THWN Copper	25000	LF	\$0.50	\$12,500	
# 500 kcmil cable connector	18	EA	\$160.00	\$2,880	
GFI Receptacle W/ Box & Cover	25	EA	\$107.09	\$2,677	
Duplex Receptacle W/Box & Cover	80	EA	\$60.82	\$4,866	
Motor Connection	3	EA	\$9,203.13	\$27,609	
VFD Drive	3	EA	\$150,000.00	\$450,000	
2500 KW Standby Generator - natural gas	2	EA	\$1,245,875.00	\$2,491,750	
Paralleling Switchgear	1	LS	\$429,800.00	\$429,800	
150 KVA Dry Transformer	1	EA	\$15,452.00	\$15,452	
30kVA UPS owner purchase (including commissioning)	1	EA	\$40,000.00	\$40,000	
Annunciator	1	LS	\$14,200.00	\$14,200	
Insurance & Taxes for Electrical	1	LS	\$159,404.00	\$159,404	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia		CONSTRUCTION CONTRACT NO.		IDENTIFICATION NUMBER	
PROJECT TITLE <b>Alt. 1a - Tidal Barrier with Steel Gate, 2 - 60" Dia. Pumps, and Road Raise</b> <b>For 2 Year Event @ ELEV +4.2'</b>		ESTIMATED BY Moffatt & Nichol		CATEGORY CODE NUMBER	
		STATUS OF DESIGN		JOB ORDER NUMBER 6822-06	
		QUANTITY		ENGINEERING ESTIMATE	
ITEM DESCRIPTION		NUMBER	UNIT	UNIT COST	TOTAL
Sales Tax for Electrical		1	LS	\$173,859.00	\$173,859
<b>SUBTOTAL</b>					<b>\$14,679,117</b>
Overhead & Profit		15%			\$2,201,868
Mobilization/Demobilization		10%			\$1,467,912
Difficult Waterside Conditions		est - lump sum			\$1,000,000
Erosion/Sediment Control		5%			\$733,956
Traffic Control		2%			\$293,582
Surveying/Engineering/Construction Observation		12%			\$1,761,494
<b>Subtotal with Mark-ups</b>					<b>\$22,137,929</b>
Contingency		25%			\$5,534,482
<b>Subtotal</b>					<b>\$27,672,411</b>
<b>TOTAL</b>					<b>\$27,672,411</b>
				<b>SAY</b>	<b>\$27,700,000</b>

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION		CONSTRUCTION CONTRACT NO.		IDENTIFICATION NUMBER	
City of Norfolk Norfolk, Virginia					
PROJECT TITLE		ESTIMATED BY		CATEGORY CODE NUMBER	
<b>Alt. 1a - Tidal Barrier with Steel Gate, 2 - 60" Dia. Pumps, and Road Raise For 10 Year Event @ ELEV +5.6'</b>		Moffatt & Nichol			
		STATUS OF DESIGN		JOB ORDER NUMBER	
				6822-06	
		QUANTITY		ENGINEERING ESTIMATE	
ITEM DESCRIPTION	NUMBER	UNIT	UNIT COST	TOTAL	
<b>Site Civil</b>					
Road Raise (2-Lane Road)	1,650.00	LF/VLF	\$250.00	\$412,500	
Road Raise (4-Lane Road)	1,100.00	LF/VLF	\$450.00	\$495,000	
Utility Relocation	2,750	LF	\$300.00	\$825,000	
Elevating Homes along North Side of Dunning Ave	30	EA	\$70,000.00	\$2,100,000	
<b>Sliding Gate</b>					
<u>Piling: Steel</u>					
Install AZ 14 Steel Sheet Piles	61,100	SF	\$28.50	\$1,741,350	
Treat Embedded Interlocks	14,000	LF	\$7.25	\$101,500	
30" DIA Steel Pipe End Piles	340	LF	\$363.00	\$123,420	
Special Sheet Fabrication	520	LF	\$42.50	\$22,100	
<u>Site Work: Excavation &amp; Fill</u>					
Gravel Base	38,000	CY	\$32.25	\$1,225,500	
<u>Concrete: Gate Base Slab</u>					
Precast Concrete Gate Base	50	CY	\$1,832.50	\$91,625	
Tremie Concrete Base	150	CY	\$985.00	\$147,750	
<u>Gate Assembly</u>					
Framed Steel Gate	65	Tons	\$10,125.00	\$658,125	
Flanged Steel Wheel Assembly	6	EA	\$3,120.00	\$18,720	
Rail	150	LF	\$298.00	\$44,700	
Capstan & Cabling	1	LS	\$193,500.00	\$193,500	
UHMW Rollers	12	EA	\$2,587.00	\$31,044	
Pocket Seal	35	LF	\$4,650.00	\$162,750	
<u>Finish Work</u>					
Concrete Fascia	8,100	SF	\$85.00	\$688,500	
Top Slab	180	CY	\$630.00	\$113,400	
Handrail	830	LF	\$178.00	\$147,740	
<b>Pump Stations</b>					
60" pumps	3	EA	\$1,380,000.00	\$4,140,000	
Support Structure - piles,header,rods, etc.	1	EA	\$28,000.00	\$28,000	
Misc 60" Pipe Sections	3	EA	\$8,000.00	\$24,000	
Concrete Headwall	1	EA	\$80,000.00	\$80,000	
Flapgates	3	EA	\$19,200.00	\$57,600	
Brick Enclosure for Generator	1	EA	\$450,000.00	\$450,000	
Aesthetic Features of Pump Station	1	LS	\$150,000.00	\$150,000	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION		CONSTRUCTION CONTRACT NO.		IDENTIFICATION NUMBER	
City of Norfolk Norfolk, Virginia					
PROJECT TITLE		ESTIMATED BY		CATEGORY CODE NUMBER	
Alt. 1a - Tidal Barrier with Steel Gate, 2 - 60" Dia. Pumps, and Road Raise For 10 Year Event @ ELEV +5.6'		Moffatt & Nichol			
		STATUS OF DESIGN		JOB ORDER NUMBER	
				6822-06	
		QUANTITY		ENGINEERING ESTIMATE	
ITEM DESCRIPTION		NUMBER	UNIT	UNIT COST	TOTAL
<b>Electrical</b>					
Dominion Power Installation Costs	1	LS	\$100,000.00	\$100,000	
<u>Common Costs</u>					
Line Truck	20	DY	\$283.25	\$5,665	
Backhoe	10	DY	\$395.52	\$3,955	
Scissors Lift	40	DY	\$265.20	\$10,608	
<u>Site Work</u>					
Trench & Backfill	400	LF	\$1.96	\$784	
Pole, Foundation & Flood It	6	EA	\$1,223.02	\$7,338	
Quasite Handhole	3	EA	\$607.04	\$1,821	
<u>Power</u>					
Switchboard	1	LS	\$74,231.00	\$74,231	
400A 208V service panel W/MCB	1	EA	\$4,475.00	\$4,475	
100A 30ckt 208v 3 phase panel	6	EA	\$2,090.00	\$12,540	
225A 42 ckt 208v 3 phase panel	2	EA	\$3,400.00	\$6,800	
100-225A 3P 208v CB	4	EA	\$998.00	\$3,992	
20A 1P 120v Circuit Breaker	42	EA	\$53.30	\$2,239	
Surge Arrestor (SPD) 208V 10-Mode NEMA 4x box	2	EA	\$9,849.00	\$19,698	
4" GRS Conduit	1500	LF	\$49.80	\$74,700	
3/4" GRS Conduit	2500	LF	\$7.93	\$19,825	
1/2" GRS Conduit	5000	LF	\$7.14	\$35,700	
4" GRS Fittings	100	EA	\$455.00	\$45,500	
3/4" GRS Fittings	200	EA	\$42.95	\$8,590	
1/2" GRS Fittings	200	EA	\$35.45	\$7,090	
# 500 kcmil XHHW	7500	LF	\$14.10	\$105,750	
#4/0 AWG THWN	1500	LF	\$6.86	\$10,290	
#8 THWN Copper	1500	LF	\$0.91	\$1,365	
#12 THWN Copper	25000	LF	\$0.50	\$12,500	
# 500 kcmil cable connector	18	EA	\$160.00	\$2,880	
GFI Receptacle W/ Box & Cover	25	EA	\$107.09	\$2,677	
Duplex Receptacle W/Box & Cover	80	EA	\$60.82	\$4,866	
Motor Connection	3	EA	\$9,203.13	\$27,609	
VFD Drive	3	EA	\$150,000.00	\$450,000	
2500 KW Standby Generator - natural gas	2	EA	\$1,245,875.00	\$2,491,750	
Paralleling Switchgear	1	LS	\$429,800.00	\$429,800	
150 KVA Dry Transformer	1	EA	\$15,452.00	\$15,452	
30kVA UPS owner purchase (including commissioning)	1	EA	\$40,000.00	\$40,000	
Annunciator	1	LS	\$14,200.00	\$14,200	
Insurance & Taxes for Electrical	1	LS	\$159,404.00	\$159,404	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11		
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia		CONSTRUCTION CONTRACT NO.		IDENTIFICATION NUMBER		
		ESTIMATED BY Moffatt & Nichol		CATEGORY CODE NUMBER		
PROJECT TITLE <b>Alt. 1a - Tidal Barrier with Steel Gate, 2 - 60" Dia.                  Pumps, and Road Raise                  For 10 Year Event @ ELEV +5.6'</b>		STATUS OF DESIGN		JOB ORDER NUMBER 6822-06		
		QUANTITY		ENGINEERING ESTIMATE		
ITEM DESCRIPTION		NUMBER	UNIT	UNIT COST	TOTAL	
Sales Tax for Electrical		1	LS	<b>\$173,859.00</b>	\$173,859	
<b>SUBTOTAL</b>					<b>\$18,661,777</b>	
Overhead & Profit		15%			\$2,799,267	
Mobilization/Demobilization		10%			\$1,866,178	
Difficult Waterside Conditions		est - lump sum				\$1,000,000
Erosion/Sediment Control		5%			\$933,089	
Traffic Control		2%			\$373,236	
Surveying/Engineering/Construction Observation		12%			\$2,239,413	
<b>Subtotal with Mark-ups</b>					<b>\$27,872,959</b>	
Contingency		25%			\$6,968,240	
<b>Subtotal</b>					<b>\$34,841,199</b>	
<b>TOTAL</b>					<b>\$34,841,199</b>	
				<b>SAY \$34,900,000</b>		

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia		CONSTRUCTION CONTRACT NO.		IDENTIFICATION NUMBER	
PROJECT TITLE <b>Alt. 1a - Tidal Barrier with Steel Gate, 2 - 60" Dia. Pumps, and Road Raise For 25 Year Event @ ELEV +6.4'</b>		ESTIMATED BY Moffatt & Nichol		CATEGORY CODE NUMBER	
		STATUS OF DESIGN		JOB ORDER NUMBER 6822-06	
ITEM DESCRIPTION	QUANTITY		ENGINEERING ESTIMATE		
	NUMBER	UNIT	UNIT COST	TOTAL	
<b>Site Civil</b>					
Road Raise (2-Lane Road)	2,970.00	LF/VLF	\$250.00	\$742,500	
Road Raise (4-Lane Road)	1,980.00	LF/VLF	\$450.00	\$891,000	
Utility Relocation	2,750	LF	\$300.00	\$825,000	
Elevating Homes along North Side of Dunning Ave	30	EA	\$70,000.00	\$2,100,000	
<b>Sliding Gate</b>					
<u>Piling: Steel</u>					
Install AZ 14 Steel Sheet Piles	61,100	SF	\$28.50	\$1,741,350	
Treat Embedded Interlocks	14,000	LF	\$7.25	\$101,500	
30" DIA Steel Pipe End Piles	340	LF	\$363.00	\$123,420	
Special Sheet Fabrication	520	LF	\$42.50	\$22,100	
<u>Site Work: Excavation &amp; Fill</u>					
Gravel Base	38,000	CY	\$32.25	\$1,225,500	
<u>Concrete: Gate Base Slab</u>					
Precast Concrete Gate Base	50	CY	\$1,832.50	\$91,625	
Tremie Concrete Base	150	CY	\$985.00	\$147,750	
<u>Gate Assembly</u>					
Framed Steel Gate	65	Tons	\$10,125.00	\$658,125	
Flanged Steel Wheel Assembly	6	EA	\$3,120.00	\$18,720	
Rail	150	LF	\$298.00	\$44,700	
Capstan & Cabling	1	LS	\$193,500.00	\$193,500	
UHMW Rollers	12	EA	\$2,587.00	\$31,044	
Pocket Seal	35	LF	\$4,650.00	\$162,750	
<u>Finish Work</u>					
Concrete Fascia	8,100	SF	\$85.00	\$688,500	
Top Slab	180	CY	\$630.00	\$113,400	
Handrail	830	LF	\$178.00	\$147,740	
<b>Pump Stations</b>					
60" pumps	3	EA	\$1,380,000.00	\$4,140,000	
Support Structure - piles,header,rods, etc.	1	EA	\$28,000.00	\$28,000	
Misc 60" Pipe Sections	3	EA	\$8,000.00	\$24,000	
Concrete Headwall	1	EA	\$80,000.00	\$80,000	
Flapgates	3	EA	\$19,200.00	\$57,600	
Brick Enclosure for Generator	1	EA	\$450,000.00	\$450,000	
Aesthetic Features of Pump Station	1	LS	\$150,000.00	\$150,000	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION		CONSTRUCTION CONTRACT NO.	IDENTIFICATION NUMBER		
City of Norfolk Norfolk, Virginia					
PROJECT TITLE		ESTIMATED BY	CATEGORY CODE NUMBER		
<b>Alt. 1a - Tidal Barrier with Steel Gate, 2 - 60" Dia. Pumps, and Road Raise</b>		Moffatt & Nichol			
<b>For 25 Year Event @ ELEV +6.4'</b>		STATUS OF DESIGN	JOB ORDER NUMBER		
			6822-06		
ITEM DESCRIPTION	QUANTITY		ENGINEERING ESTIMATE		
	NUMBER	UNIT	UNIT COST	TOTAL	
<b>Electrical</b>					
Dominion Power Installation Costs	1	LS	\$100,000.00	\$100,000	
<i>Common Costs</i>					
Line Truck	20	DY	\$283.25	\$5,665	
Backhoe	10	DY	\$395.52	\$3,955	
Scissors Lift	40	DY	\$265.20	\$10,608	
<i>Site Work</i>					
Trench & Backfill	400	LF	\$1.96	\$784	
Pole, Foundation & Flood It	6	EA	\$1,223.02	\$7,338	
Quasite Handhole	3	EA	\$607.04	\$1,821	
<i>Power</i>					
Switchboard	1	LS	\$74,231.00	\$74,231	
400A 208V service panel W/MCB	1	EA	\$4,475.00	\$4,475	
100A 30ckt 208v 3 phase panel	6	EA	\$2,090.00	\$12,540	
225A 42 ckt 208v 3 phase panel	2	EA	\$3,400.00	\$6,800	
100-225A 3P 208v CB	4	EA	\$998.00	\$3,992	
20A 1P 120v Circuit Breaker	42	EA	\$53.30	\$2,239	
Surge Arrestor (SPD) 208V 10-Mode NEMA 4x box	2	EA	\$9,849.00	\$19,698	
4" GRS Conduit	1500	LF	\$49.80	\$74,700	
3/4" GRS Conduit	2500	LF	\$7.93	\$19,825	
1/2" GRS Conduit	5000	LF	\$7.14	\$35,700	
4" GRS Fittings	100	EA	\$455.00	\$45,500	
3/4" GRS Fittings	200	EA	\$42.95	\$8,590	
1/2" GRS Fittings	200	EA	\$35.45	\$7,090	
# 500 kcmil XHHW	7500	LF	\$14.10	\$105,750	
#4/0 AWG THWN	1500	LF	\$6.86	\$10,290	
#8 THWN Copper	1500	LF	\$0.91	\$1,365	
#12 THWN Copper	25000	LF	\$0.50	\$12,500	
# 500 kcmil cable connector	18	EA	\$160.00	\$2,880	
GFI Receptacle W/ Box & Cover	25	EA	\$107.09	\$2,677	
Duplex Receptacle W/Box & Cover	80	EA	\$60.82	\$4,866	
Motor Connection	3	EA	\$9,203.13	\$27,609	
VFD Drive	3	EA	\$150,000.00	\$450,000	
2500 KW Standby Generator - natural gas	2	EA	\$1,245,875.00	\$2,491,750	
Paralleling Switchgear	1	LS	\$429,800.00	\$429,800	
150 KVA Dry Transformer	1	EA	\$15,452.00	\$15,452	
30kVA UPS owner purchase (including commissioning)	1	EA	\$40,000.00	\$40,000	
Annunciator	1	LS	\$14,200.00	\$14,200	
Insurance & Taxes for Electrical	1	LS	\$159,404.00	\$159,404	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia		CONSTRUCTION CONTRACT NO.		IDENTIFICATION NUMBER	
PROJECT TITLE <b>Alt. 1a - Tidal Barrier with Steel Gate, 2 - 60" Dia. Pumps, and Road Raise                  For 25 Year Event @ ELEV +6.4'</b>		ESTIMATED BY Moffatt & Nichol		CATEGORY CODE NUMBER	
		STATUS OF DESIGN		JOB ORDER NUMBER 6822-06	
		QUANTITY		ENGINEERING ESTIMATE	
ITEM DESCRIPTION		NUMBER	UNIT	UNIT COST	TOTAL
Sales Tax for Electrical		1	LS	<b>\$173,859.00</b>	\$173,859
<b>SUBTOTAL</b>					<b>\$19,387,777</b>
Overhead & Profit		15%			\$2,908,167
Mobilization/Demobilization		10%			\$1,938,778
Difficult Waterside Conditions		est - lump sum			\$1,000,000
Erosion/Sediment Control		5%			\$969,389
Traffic Control		2%			\$387,756
Surveying/Engineering/Construction Observation		12%			\$2,326,533
<b>Subtotal with Mark-ups</b>					<b>\$28,918,399</b>
Contingency		25%			\$7,229,600
<b>Subtotal</b>					<b>\$36,147,999</b>
<b>TOTAL</b>					<b>\$36,147,999</b>
				<b>SAY</b>	<b>\$36,200,000</b>

		Opinion of Probable Cost		DATE PREPARED	
				17-Jan-11	
ACTIVITY AND LOCATION		CONSTRUCTION CONTRACT NO.		IDENTIFICATION NUMBER	
City of Norfolk Norfolk, Virginia					
PROJECT TITLE		ESTIMATED BY		CATEGORY CODE NUMBER	
<b>Alt. 1a - Tidal Barrier with Steel Gate, 2 - 60" Dia. Pumps, and Road Raise</b>		Moffatt & Nichol			
<b>For 50 Year Event @ ELEV +7.0'</b>		STATUS OF DESIGN		JOB ORDER NUMBER	
				6822-06	
ITEM DESCRIPTION	QUANTITY		ENGINEERING ESTIMATE		
	NUMBER	UNIT	UNIT COST	TOTAL	
<b>Site Civil</b>					
Road Raise (2-Lane Road)	3,960.00	LF/VLF	\$250.00	\$990,000	
Road Raise (4-Lane Road)	2,640.00	LF/VLF	\$450.00	\$1,188,000	
Utility Relocation	2,750	LF	\$300.00	\$825,000	
Elevating Homes along North Side of Dunning Ave	30	EA	\$70,000.00	\$2,100,000	
<b>Sliding Gate</b>					
<u>Piling: Steel</u>					
Install AZ 14 Steel Sheet Piles	65,800	SF	\$28.50	\$1,875,300	
Treat Embedded Interlocks	15,000	LF	\$7.25	\$108,750	
30" DIA Steel Pipe End Piles	360	LF	\$363.00	\$130,680	
Special Sheet Fabrication	560	LF	\$42.50	\$23,800	
<u>Site Work: Excavation &amp; Fill</u>					
Gravel Base	38,000	CY	\$32.25	\$1,225,500	
<u>Concrete: Gate Base Slab</u>					
Precast Concrete Gate Base	50	CY	\$1,832.50	\$91,625	
Tremie Concrete Base	150	CY	\$985.00	\$147,750	
<u>Gate Assembly</u>					
Framed Steel Gate	65	Tons	\$10,125.00	\$658,125	
Flanged Steel Wheel Assembly	6	EA	\$3,120.00	\$18,720	
Rail	150	LF	\$298.00	\$44,700	
Capstan & Cabling	1	LS	\$193,500.00	\$193,500	
UHMW Rollers	12	EA	\$2,587.00	\$31,044	
Pocket Seal	35	LF	\$4,650.00	\$162,750	
<u>Finish Work</u>					
Concrete Fascia	8,100	SF	\$85.00	\$688,500	
Top Slab	180	CY	\$630.00	\$113,400	
Handrail	830	LF	\$178.00	\$147,740	
<b>Pump Stations</b>					
60" pumps	3	EA	\$1,380,000.00	\$4,140,000	
Support Structure - piles,header,rods, etc.	1	EA	\$28,000.00	\$28,000	
Misc 60" Pipe Sections	3	EA	\$8,000.00	\$24,000	
Concrete Headwall	1	EA	\$80,000.00	\$80,000	
Flapgates	3	EA	\$19,200.00	\$57,600	
Brick Enclosure for Generator	1	EA	\$450,000.00	\$450,000	
Aesthetic Features of Pump Station	1	LS	\$150,000.00	\$150,000	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION		CONSTRUCTION CONTRACT NO.	IDENTIFICATION NUMBER		
City of Norfolk Norfolk, Virginia					
PROJECT TITLE		ESTIMATED BY	CATEGORY CODE NUMBER		
<b>Alt. 1a - Tidal Barrier with Steel Gate, 2 - 60" Dia. Pumps, and Road Raise</b>		Moffatt & Nichol			
<b>For 50 Year Event @ ELEV +7.0'</b>		STATUS OF DESIGN	JOB ORDER NUMBER		
			6822-06		
		QUANTITY		ENGINEERING ESTIMATE	
ITEM DESCRIPTION		NUMBER	UNIT	UNIT COST	TOTAL
<b>Electrical</b>					
Dominion Power Installation Costs	1	LS	\$100,000.00	\$100,000	
<i>Common Costs</i>					
Line Truck	20	DY	\$283.25	\$5,665	
Backhoe	10	DY	\$395.52	\$3,955	
Scissors Lift	40	DY	\$265.20	\$10,608	
<i>Site Work</i>					
Trench & Backfill	400	LF	\$1.96	\$784	
Pole, Foundation & Flood It	6	EA	\$1,223.02	\$7,338	
Quasite Handhole	3	EA	\$607.04	\$1,821	
<i>Power</i>					
Switchboard	1	LS	\$74,231.00	\$74,231	
400A 208V service panel W/MCB	1	EA	\$4,475.00	\$4,475	
100A 30ckt 208v 3 phase panel	6	EA	\$2,090.00	\$12,540	
225A 42 ckt 208v 3 phase panel	2	EA	\$3,400.00	\$6,800	
100-225A 3P 208v CB	4	EA	\$998.00	\$3,992	
20A 1P 120v Circuit Breaker	42	EA	\$53.30	\$2,239	
Surge Arrestor (SPD) 208V 10-Mode NEMA 4x box	2	EA	\$9,849.00	\$19,698	
4" GRS Conduit	1500	LF	\$49.80	\$74,700	
3/4" GRS Conduit	2500	LF	\$7.93	\$19,825	
1/2" GRS Conduit	5000	LF	\$7.14	\$35,700	
4" GRS Fittings	100	EA	\$455.00	\$45,500	
3/4" GRS Fittings	200	EA	\$42.95	\$8,590	
1/2" GRS Fittings	200	EA	\$35.45	\$7,090	
# 500 kcmil XHHW	7500	LF	\$14.10	\$105,750	
#4/0 AWG THWN	1500	LF	\$6.86	\$10,290	
#8 THWN Copper	1500	LF	\$0.91	\$1,365	
#12 THWN Copper	25000	LF	\$0.50	\$12,500	
# 500 kcmil cable connector	18	EA	\$160.00	\$2,880	
GFI Receptacle W/ Box & Cover	25	EA	\$107.09	\$2,677	
Duplex Receptacle W/Box & Cover	80	EA	\$60.82	\$4,866	
Motor Connection	3	EA	\$9,203.13	\$27,609	
VFD Drive	3	EA	\$150,000.00	\$450,000	
2500 KW Standby Generator - natural gas	2	EA	\$1,245,875.00	\$2,491,750	
Paralleling Switchgear	1	LS	\$429,800.00	\$429,800	
150 KVA Dry Transformer	1	EA	\$15,452.00	\$15,452	
30kVA UPS owner purchase (including commissioning)	1	EA	\$40,000.00	\$40,000	
Annunciator	1	LS	\$14,200.00	\$14,200	
Insurance & Taxes for Electrical	1	LS	\$159,404.00	\$159,404	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia		CONSTRUCTION CONTRACT NO.		IDENTIFICATION NUMBER	
PROJECT TITLE <b>Alt. 1a - Tidal Barrier with Steel Gate, 2 - 60" Dia. Pumps, and Road Raise                  For 50 Year Event @ ELEV +7.0'</b>		ESTIMATED BY Moffatt & Nichol		CATEGORY CODE NUMBER	
		STATUS OF DESIGN		JOB ORDER NUMBER 6822-06	
		QUANTITY		ENGINEERING ESTIMATE	
ITEM DESCRIPTION		NUMBER	UNIT	UNIT COST	TOTAL
Sales Tax for Electrical		1	LS	<b>\$173,859.00</b>	\$173,859
<b>SUBTOTAL</b>					<b>\$20,082,437</b>
Overhead & Profit		15%			\$3,012,366
Mobilization/Demobilization		10%			\$2,008,244
Difficult Waterside Conditions		est - lump sum			\$1,000,000
Erosion/Sediment Control		5%			\$1,004,122
Traffic Control		2%			\$401,649
Surveying/Engineering/Construction Observation		12%			\$2,409,892
<b>Subtotal with Mark-ups</b>					<b>\$29,918,710</b>
Contingency		25%			\$7,479,677
<b>Subtotal</b>					<b>\$37,398,387</b>
<b>TOTAL</b>					<b>\$37,398,387</b>
				<b>SAY</b>	<b>\$37,400,000</b>

		Opinion of Probable Cost		DATE PREPARED	
				17-Jan-11	
ACTIVITY AND LOCATION		CONSTRUCTION CONTRACT NO.		IDENTIFICATION NUMBER	
City of Norfolk Norfolk, Virginia					
PROJECT TITLE		ESTIMATED BY		CATEGORY CODE NUMBER	
<b>Alt. 1a - Tidal Barrier with Steel Gate, 2 - 60" Dia. Pumps, and Road Raise</b>		Moffatt & Nichol			
<b>For 100 Year Event @ ELEV +7.6'</b>		STATUS OF DESIGN		JOB ORDER NUMBER	
				6822-06	
ITEM DESCRIPTION	QUANTITY		ENGINEERING ESTIMATE		
	NUMBER	UNIT	UNIT COST	TOTAL	
<b>Site Civil</b>					
Road Raise (2-Lane Road)	4,950.00	LF/VLF	\$250.00	\$1,237,500	
Road Raise (4-Lane Road)	3,300.00	LF/VLF	\$450.00	\$1,485,000	
Utility Relocation	2,750	LF	\$300.00	\$825,000	
Elevating Homes along North Side of Dunning Ave	30	EA	\$70,000.00	\$2,100,000	
<b>Sliding Gate</b>					
<u>Piling: Steel</u>					
Install AZ 14 Steel Sheet Piles	65,800	SF	\$28.50	\$1,875,300	
Treat Embedded Interlocks	15,000	LF	\$7.25	\$108,750	
30" DIA Steel Pipe End Piles	360	LF	\$363.00	\$130,680	
Special Sheet Fabrication	560	LF	\$42.50	\$23,800	
<u>Site Work: Excavation &amp; Fill</u>					
Gravel Base	38,000	CY	\$32.25	\$1,225,500	
<u>Concrete: Gate Base Slab</u>					
Precast Concrete Gate Base	50	CY	\$1,832.50	\$91,625	
Tremie Concrete Base	150	CY	\$985.00	\$147,750	
<u>Gate Assembly</u>					
Framed Steel Gate	65	Tons	\$10,125.00	\$658,125	
Flanged Steel Wheel Assembly	6	EA	\$3,120.00	\$18,720	
Rail	150	LF	\$298.00	\$44,700	
Capstan & Cabling	1	LS	\$193,500.00	\$193,500	
UHMW Rollers	12	EA	\$2,587.00	\$31,044	
Pocket Seal	35	LF	\$4,650.00	\$162,750	
<u>Finish Work</u>					
Concrete Fascia	8,100	SF	\$85.00	\$688,500	
Top Slab	180	CY	\$630.00	\$113,400	
Handrail	830	LF	\$178.00	\$147,740	
<b>Pump Stations</b>					
60" pumps	3	EA	\$1,380,000.00	\$4,140,000	
Support Structure - piles,header,rods, etc.	1	EA	\$28,000.00	\$28,000	
Misc 60" Pipe Sections	3	EA	\$8,000.00	\$24,000	
Concrete Headwall	1	EA	\$80,000.00	\$80,000	
Flapgates	3	EA	\$19,200.00	\$57,600	
Brick Enclosure for Generator	1	EA	\$450,000.00	\$450,000	
Aesthetic Features of Pump Station	1	LS	\$150,000.00	\$150,000	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION		CONSTRUCTION CONTRACT NO.	IDENTIFICATION NUMBER		
City of Norfolk Norfolk, Virginia					
PROJECT TITLE		ESTIMATED BY	CATEGORY CODE NUMBER		
<b>Alt. 1a - Tidal Barrier with Steel Gate, 2 - 60" Dia. Pumps, and Road Raise</b>		Moffatt & Nichol			
<b>For 100 Year Event @ ELEV +7.6'</b>		STATUS OF DESIGN	JOB ORDER NUMBER		
			6822-06		
		QUANTITY		ENGINEERING ESTIMATE	
ITEM DESCRIPTION		NUMBER	UNIT	UNIT COST	TOTAL
<b>Electrical</b>					
Dominion Power Installation Costs	1	LS	\$100,000.00	\$100,000	
<i>Common Costs</i>					
Line Truck	20	DY	\$283.25	\$5,665	
Backhoe	10	DY	\$395.52	\$3,955	
Scissors Lift	40	DY	\$265.20	\$10,608	
<i>Site Work</i>					
Trench & Backfill	400	LF	\$1.96	\$784	
Pole, Foundation & Flood It	6	EA	\$1,223.02	\$7,338	
Quasite Handhole	3	EA	\$607.04	\$1,821	
<i>Power</i>					
Switchboard	1	LS	\$74,231.00	\$74,231	
400A 208V service panel W/MCB	1	EA	\$4,475.00	\$4,475	
100A 30ckt 208v 3 phase panel	6	EA	\$2,090.00	\$12,540	
225A 42 ckt 208v 3 phase panel	2	EA	\$3,400.00	\$6,800	
100-225A 3P 208v CB	4	EA	\$998.00	\$3,992	
20A 1P 120v Circuit Breaker	42	EA	\$53.30	\$2,239	
Surge Arrestor (SPD) 208V 10-Mode NEMA 4x box	2	EA	\$9,849.00	\$19,698	
4" GRS Conduit	1500	LF	\$49.80	\$74,700	
3/4" GRS Conduit	2500	LF	\$7.93	\$19,825	
1/2" GRS Conduit	5000	LF	\$7.14	\$35,700	
4" GRS Fittings	100	EA	\$455.00	\$45,500	
3/4" GRS Fittings	200	EA	\$42.95	\$8,590	
1/2" GRS Fittings	200	EA	\$35.45	\$7,090	
# 500 kcmil XHHW	7500	LF	\$14.10	\$105,750	
#4/0 AWG THWN	1500	LF	\$6.86	\$10,290	
#8 THWN Copper	1500	LF	\$0.91	\$1,365	
#12 THWN Copper	25000	LF	\$0.50	\$12,500	
# 500 kcmil cable connector	18	EA	\$160.00	\$2,880	
GFI Receptacle W/ Box & Cover	25	EA	\$107.09	\$2,677	
Duplex Receptacle W/Box & Cover	80	EA	\$60.82	\$4,866	
Motor Connection	3	EA	\$9,203.13	\$27,609	
VFD Drive	3	EA	\$150,000.00	\$450,000	
2500 KW Standby Generator - natural gas	2	EA	\$1,245,875.00	\$2,491,750	
Paralleling Switchgear	1	LS	\$429,800.00	\$429,800	
150 KVA Dry Transformer	1	EA	\$15,452.00	\$15,452	
30kVA UPS owner purchase (including commissioning)	1	EA	\$40,000.00	\$40,000	
Annunciator	1	LS	\$14,200.00	\$14,200	
Insurance & Taxes for Electrical	1	LS	\$159,404.00	\$159,404	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia		CONSTRUCTION CONTRACT NO.		IDENTIFICATION NUMBER	
PROJECT TITLE <b>Alt. 1a - Tidal Barrier with Steel Gate, 2 - 60" Dia.                  Pumps, and Road Raise                  For 100 Year Event @ ELEV +7.6'</b>		ESTIMATED BY Moffatt & Nichol		CATEGORY CODE NUMBER	
		STATUS OF DESIGN		JOB ORDER NUMBER 6822-06	
		QUANTITY		ENGINEERING ESTIMATE	
ITEM DESCRIPTION		NUMBER	UNIT	UNIT COST	TOTAL
Sales Tax for Electrical		1	LS	<b>\$173,859.00</b>	\$173,859
<b>SUBTOTAL</b>					<b>\$20,626,937</b>
Overhead & Profit		15%			\$3,094,041
Mobilization/Demobilization		10%			\$2,062,694
Difficult Waterside Conditions		est - lump sum			\$1,000,000
Erosion/Sediment Control		5%			\$1,031,347
Traffic Control		2%			\$412,539
Surveying/Engineering/Construction Observation		12%			\$2,475,232
<b>Subtotal with Mark-ups</b>					<b>\$30,702,790</b>
Contingency		25%			\$7,675,697
<b>Subtotal</b>					<b>\$38,378,487</b>
<b>TOTAL</b>					<b>\$38,378,487</b>
				<b>SAY</b>	<b>\$38,400,000</b>

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia			CONSTRUCTION CONTRACT NO. IDENTIFICATION NUMBER		
PROJECT TITLE <b>Pretty Lake - Alternative 1b                  Tidal Barrier with Obermeyer Gate, 2 - 60" Dia.                  Pumps, and Road Raise</b>			ESTIMATED BY <b>Moffatt &amp; Nichol</b>		CATEGORY CODE NUMBER
			STATUS OF DESIGN		JOB ORDER NUMBER 6822-06
<b>Summary</b>					
Scenario			Opinion of Probable Cost		
2 Year Surge with Rain			\$29,900,000		
10 Year Surge with Rain			\$37,600,000		
25 Year Surge with Rain			\$39,200,000		
50 Year Surge with Rain			\$40,600,000		
100 Year Surge with Rain			\$41,900,000		

		Opinion of Probable Cost		DATE PREPARED	
				17-Jan-11	
ACTIVITY AND LOCATION		CONSTRUCTION CONTRACT NO.	IDENTIFICATION NUMBER		
City of Norfolk Norfolk, Virginia					
PROJECT TITLE		ESTIMATED BY	CATEGORY CODE NUMBER		
<b>Alt. 1b - Tidal Barrier with Obermeyer Gate, 2 - 60" Dia. Pumps, and Road Raise</b>		Moffatt & Nichol			
<b>For 2 Year Event @ ELEV +4.2'</b>		STATUS OF DESIGN	JOB ORDER NUMBER		
			6822-06		
ITEM DESCRIPTION	QUANTITY		ENGINEERING ESTIMATE		
	NUMBER	UNIT	UNIT COST	TOTAL	
<b>Site Civil</b>					
Road Raise (2-Lane Road)	0.00	LF/VLF	\$250.00	\$0	
Road Raise (4-Lane Road)	0.00	LF/VLF	\$450.00	\$0	
Utility Relocation	0	LF	\$300.00	\$0	
Elevating Homes along North Side of Dunning Ave	0	EA	\$70,000.00	\$0	
<b>Obermeyer Gate w/ Bulkhead (Pretty Lake is 475 LF )</b>					
<u>Piling: Steel</u>					
Install AZ 14 Steel Sheet Piles	51,700	SF	\$28.50	\$1,473,450	
Treat Embedded Interlocks	12,000	LF	\$7.25	\$87,000	
30" DIA Steel Pipe End Piles	300	LF	\$363.00	\$108,900	
Special Sheet Fabrication	600	LF	\$42.50	\$25,500	
<u>Site Work: Excavation &amp; Fill</u>					
Gravel Base	38,000	CY	\$32.25	\$1,225,500	
<u>Concrete: Gate Base Slab</u>					
Precast Concrete Gate Base	50	CY	\$1,832.50	\$91,625	
Tremie Concrete Base	150	CY	\$985.00	\$147,750	
<u>Dam Assembly</u>					
Gate with Operating System - 12.3' High x 50 LF	615	SF	\$4,000.00	\$2,460,000	
<u>Finish Work</u>					
Concrete Fascia	8,100	SF	\$85.00	\$688,500	
Top Slab	180	CY	\$630.00	\$113,400	
Handrail	830	LF	\$178.00	\$147,740	
<b>Pump Stations</b>					
60" pumps	3	EA	\$1,380,000.00	\$4,140,000	
Support Structure - piles,header,rods, etc.	1	EA	\$28,000.00	\$28,000	
Misc 60" Pipe Sections	3	EA	\$8,000.00	\$24,000	
Concrete Headwall	1	EA	\$80,000.00	\$80,000	
Flapgates	3	EA	\$19,200.00	\$57,600	
Brick Enclosure for Generator	1	EA	\$450,000.00	\$450,000	
Aesthetic Features of Pump Station	1	LS	\$150,000.00	\$150,000	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia		CONSTRUCTION CONTRACT NO.		IDENTIFICATION NUMBER	
PROJECT TITLE <b>Alt. 1b - Tidal Barrier with Obermeyer Gate, 2 - 60" Dia. Pumps, and Road Raise For 2 Year Event @ ELEV +4.2'</b>		ESTIMATED BY Moffatt & Nichol		CATEGORY CODE NUMBER	
		STATUS OF DESIGN		JOB ORDER NUMBER 6822-06	
ITEM DESCRIPTION	QUANTITY		ENGINEERING ESTIMATE		
	NUMBER	UNIT	UNIT COST	TOTAL	
<b>Electrical</b>					
Dominion Power Installation Costs	1	LS	\$100,000.00	\$100,000	
<i>Common Costs</i>					
Line Truck	20	DY	\$283.25	\$5,665	
Backhoe	10	DY	\$395.52	\$3,955	
Scissors Lift	40	DY	\$265.20	\$10,608	
<i>Site Work</i>					
Trench & Backfill	400	LF	\$1.96	\$784	
Pole, Foundation & Flood It	6	EA	\$1,223.02	\$7,338	
Quasite Handhole	3	EA	\$607.04	\$1,821	
<i>Power</i>					
Switchboard	1	LS	\$74,231.00	\$74,231	
400A 208V service panel W/MCB	1	EA	\$4,475.00	\$4,475	
100A 30ckt 208v 3 phase panel	6	EA	\$2,090.00	\$12,540	
225A 42 ckt 208v 3 phase panel	2	EA	\$3,400.00	\$6,800	
100-225A 3P 208v CB	4	EA	\$998.00	\$3,992	
20A 1P 120v Circuit Breaker	42	EA	\$53.30	\$2,239	
Surge Arrestor (SPD) 208V 10-Mode NEMA 4x box	2	EA	\$9,849.00	\$19,698	
4" GRS Conduit	1500	LF	\$49.80	\$74,700	
3/4" GRS Conduit	2500	LF	\$7.93	\$19,825	
1/2" GRS Conduit	5000	LF	\$7.14	\$35,700	
4" GRS Fittings	100	EA	\$455.00	\$45,500	
3/4" GRS Fittings	200	EA	\$42.95	\$8,590	
1/2" GRS Fittings	200	EA	\$35.45	\$7,090	
# 500 kcmil XHHW	7500	LF	\$14.10	\$105,750	
#4/0 AWG THWN	1500	LF	\$6.86	\$10,290	
#8 THWN Copper	1500	LF	\$0.91	\$1,365	
#12 THWN Copper	25000	LF	\$0.50	\$12,500	
# 500 kcmil cable connector	18	EA	\$160.00	\$2,880	
GFI Receptacle W/ Box & Cover	25	EA	\$107.09	\$2,677	
Duplex Receptacle W/Box & Cover	80	EA	\$60.82	\$4,866	
Motor Connection	3	EA	\$9,203.13	\$27,609	
VFD Drive	3	EA	\$150,000.00	\$450,000	
2500 KW Standby Generator - natural gas	2	EA	\$1,245,875.00	\$2,491,750	
Paralleling Switchgear	1	LS	\$429,800.00	\$429,800	
150 KVA Dry Transformer	1	EA	\$15,452.00	\$15,452	
30kVA UPS owner purchase (including commissioning)	1	EA	\$40,000.00	\$40,000	
Annunciator	1	LS	\$14,200.00	\$14,200	
Insurance & Taxes for Electrical	1	LS	\$159,404.00	\$159,404	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11																																																																	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia		CONSTRUCTION CONTRACT NO.		IDENTIFICATION NUMBER																																																																	
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ITEM DESCRIPTION		NUMBER	UNIT	UNIT COST	TOTAL																																																																
		<table border="0" style="width: 100%;"> <tr> <td style="width: 50%;">Sales Tax for Electrical</td> <td style="width: 10%; text-align: center;">1</td> <td style="width: 10%; text-align: center;">LS</td> <td style="width: 15%; text-align: right;">\$173,859.00</td> <td style="width: 10%; text-align: right;">\$173,859</td> </tr> <tr> <td><b>SUBTOTAL</b></td> <td></td> <td></td> <td></td> <td style="text-align: right;"><b>\$15,886,918</b></td> </tr> <tr> <td>Overhead &amp; Profit</td> <td style="text-align: center;">15%</td> <td></td> <td></td> <td style="text-align: right;">\$2,383,038</td> </tr> <tr> <td>Mobilization/Demobilization</td> <td style="text-align: center;">10%</td> <td></td> <td></td> <td style="text-align: right;">\$1,588,692</td> </tr> <tr> <td>Difficult Waterside Conditions</td> <td style="text-align: center;">est - lump sum</td> <td></td> <td></td> <td style="text-align: right;">\$1,000,000</td> </tr> <tr> <td>Erosion/Sediment Control</td> <td style="text-align: center;">5%</td> <td></td> <td></td> <td style="text-align: right;">\$794,346</td> </tr> <tr> <td>Traffic Control</td> <td style="text-align: center;">2%</td> <td></td> <td></td> <td style="text-align: right;">\$317,738</td> </tr> <tr> <td>Surveying/Engineering/Construction Observation</td> <td style="text-align: center;">12%</td> <td></td> <td></td> <td style="text-align: right;">\$1,906,430</td> </tr> <tr> <td><b>Subtotal with Mark-ups</b></td> <td></td> <td></td> <td></td> <td style="text-align: right;"><b>\$23,877,162</b></td> </tr> <tr> <td>Contingency</td> <td style="text-align: center;">25%</td> <td></td> <td></td> <td style="text-align: right;">\$5,969,291</td> </tr> <tr> <td><b>Subtotal</b></td> <td></td> <td></td> <td></td> <td style="text-align: right;"><b>\$29,846,453</b></td> </tr> <tr> <td><b>TOTAL</b></td> <td></td> <td></td> <td></td> <td style="text-align: right;"><b>\$29,846,453</b></td> </tr> <tr> <td></td> <td></td> <td></td> <td style="text-align: right;"><b>SAY</b></td> <td style="text-align: right;"><b>\$29,900,000</b></td> </tr> </table>					Sales Tax for Electrical	1	LS	\$173,859.00	\$173,859	<b>SUBTOTAL</b>				<b>\$15,886,918</b>	Overhead & Profit	15%			\$2,383,038	Mobilization/Demobilization	10%			\$1,588,692	Difficult Waterside Conditions	est - lump sum			\$1,000,000	Erosion/Sediment Control	5%			\$794,346	Traffic Control	2%			\$317,738	Surveying/Engineering/Construction Observation	12%			\$1,906,430	<b>Subtotal with Mark-ups</b>				<b>\$23,877,162</b>	Contingency	25%			\$5,969,291	<b>Subtotal</b>				<b>\$29,846,453</b>	<b>TOTAL</b>				<b>\$29,846,453</b>			
Sales Tax for Electrical	1	LS	\$173,859.00	\$173,859																																																																	
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Surveying/Engineering/Construction Observation	12%			\$1,906,430																																																																	
<b>Subtotal with Mark-ups</b>				<b>\$23,877,162</b>																																																																	
Contingency	25%			\$5,969,291																																																																	
<b>Subtotal</b>				<b>\$29,846,453</b>																																																																	
<b>TOTAL</b>				<b>\$29,846,453</b>																																																																	
			<b>SAY</b>	<b>\$29,900,000</b>																																																																	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia		CONSTRUCTION CONTRACT NO.	IDENTIFICATION NUMBER		
		ESTIMATED BY Moffatt & Nichol	CATEGORY CODE NUMBER		
PROJECT TITLE <b>Alt. 1b - Tidal Barrier with Obermeyer Gate, 2 - 60" Dia. Pumps, and Road Raise For 10 Year Event @ ELEV +5.6'</b>		STATUS OF DESIGN		JOB ORDER NUMBER 6822-06	
		ITEM DESCRIPTION		QUANTITY	
NUMBER	UNIT			UNIT COST	TOTAL
<b>Site Civil</b>					
Road Raise (2-Lane Road)	1,650.00	LF/VLF	\$250.00	\$412,500	
Road Raise (4-Lane Road)	1,100.00	LF/VLF	\$450.00	\$495,000	
Utility Relocation	2,750	LF	\$300.00	\$825,000	
Elevating Homes along North Side of Dunning Ave	30	EA	\$70,000.00	\$2,100,000	
<b>Obermeyer Gate w/ Bulkhead (Pretty Lake is 475 LF) -</b>					
<u>Piling: Steel</u>					
Install AZ 14 Steel Sheet Piles	56,400	SF	\$28.50	\$1,607,400	
Treat Embedded Interlocks	13,000	LF	\$7.25	\$94,250	
30" DIA Steel Pipe End Piles	320	LF	\$363.00	\$116,160	
Special Sheet Fabrication	520	LF	\$42.50	\$22,100	
<u>Site Work: Excavation &amp; Fill</u>					
Gravel Base	38,000	CY	\$32.25	\$1,225,500	
<u>Concrete: Gate Base Slab</u>					
Precast Concrete Gate Base	50	CY	\$1,832.50	\$91,625	
Tremie Concrete Base	150	CY	\$985.00	\$147,750	
<u>Dam Assembly</u>					
Gate with Operating System - 13.7' High x 50 LF	685	SF	\$4,000.00	\$2,740,000	
<u>Finish Work</u>					
Concrete Fascia	8,100	SF	\$85.00	\$688,500	
Top Slab	180	CY	\$630.00	\$113,400	
Handrail	830	LF	\$178.00	\$147,740	
<b>Pump Stations</b>					
60" pumps	3	EA	\$1,380,000.00	\$4,140,000	
Support Structure - piles,header,rods, etc.	1	EA	\$28,000.00	\$28,000	
Misc 60" Pipe Sections	3	EA	\$8,000.00	\$24,000	
Concrete Headwall	1	EA	\$80,000.00	\$80,000	
Flapgates	3	EA	\$19,200.00	\$57,600	
Brick Enclosure for Generator	1	EA	\$450,000.00	\$450,000	
Aesthetic Features of Pump Station	1	LS	\$150,000.00	\$150,000	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION		CONSTRUCTION CONTRACT NO.	IDENTIFICATION NUMBER		
City of Norfolk Norfolk, Virginia		ESTIMATED BY	CATEGORY CODE NUMBER		
PROJECT TITLE		Moffatt & Nichol			
<b>Alt. 1b - Tidal Barrier with Obermeyer Gate, 2 - 60" Dia. Pumps, and Road Raise For 10 Year Event @ ELEV +5.6'</b>		STATUS OF DESIGN	JOB ORDER NUMBER		
			6822-06		
ITEM DESCRIPTION	QUANTITY		ENGINEERING ESTIMATE		
	NUMBER	UNIT	UNIT COST	TOTAL	
<b>Electrical</b>					
Dominion Power Installation Costs	1	LS	\$100,000.00	\$100,000	
<i>Common Costs</i>					
Line Truck	20	DY	\$283.25	\$5,665	
Backhoe	10	DY	\$395.52	\$3,955	
Scissors Lift	40	DY	\$265.20	\$10,608	
<i>Site Work</i>					
Trench & Backfill	400	LF	\$1.96	\$784	
Pole, Foundation & Flood It	6	EA	\$1,223.02	\$7,338	
Quasite Handhole	3	EA	\$607.04	\$1,821	
<i>Power</i>					
Switchboard	1	LS	\$74,231.00	\$74,231	
400A 208V service panel W/MCB	1	EA	\$4,475.00	\$4,475	
100A 30ckt 208v 3 phase panel	6	EA	\$2,090.00	\$12,540	
225A 42 ckt 208v 3 phase panel	2	EA	\$3,400.00	\$6,800	
100-225A 3P 208v CB	4	EA	\$998.00	\$3,992	
20A 1P 120v Circuit Breaker	42	EA	\$53.30	\$2,239	
Surge Arrestor (SPD) 208V 10-Mode NEMA 4x box	2	EA	\$9,849.00	\$19,698	
4" GRS Conduit	1500	LF	\$49.80	\$74,700	
3/4" GRS Conduit	2500	LF	\$7.93	\$19,825	
1/2" GRS Conduit	5000	LF	\$7.14	\$35,700	
4" GRS Fittings	100	EA	\$455.00	\$45,500	
3/4" GRS Fittings	200	EA	\$42.95	\$8,590	
1/2" GRS Fittings	200	EA	\$35.45	\$7,090	
# 500 kcmil XHHW	7500	LF	\$14.10	\$105,750	
#4/0 AWG THWN	1500	LF	\$6.86	\$10,290	
#8 THWN Copper	1500	LF	\$0.91	\$1,365	
#12 THWN Copper	25000	LF	\$0.50	\$12,500	
# 500 kcmil cable connector	18	EA	\$160.00	\$2,880	
GFI Receptacle W/ Box & Cover	25	EA	\$107.09	\$2,677	
Duplex Receptacle W/Box & Cover	80	EA	\$60.82	\$4,866	
Motor Connection	3	EA	\$9,203.13	\$27,609	
VFD Drive	3	EA	\$150,000.00	\$450,000	
2500 KW Standby Generator - natural gas	2	EA	\$1,245,875.00	\$2,491,750	
Paralleling Switchgear	1	LS	\$429,800.00	\$429,800	
150 KVA Dry Transformer	1	EA	\$15,452.00	\$15,452	
30kVA UPS owner purchase (including commissioning)	1	EA	\$40,000.00	\$40,000	
Annunciator	1	LS	\$14,200.00	\$14,200	
Insurance & Taxes for Electrical	1	LS	\$159,404.00	\$159,404	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11																																																																	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia		CONSTRUCTION CONTRACT NO.		IDENTIFICATION NUMBER																																																																	
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		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION		CONSTRUCTION CONTRACT NO.	IDENTIFICATION NUMBER		
City of Norfolk Norfolk, Virginia		ESTIMATED BY	CATEGORY CODE NUMBER		
PROJECT TITLE		Moffatt & Nichol			
<b>Alt. 1b - Tidal Barrier with Obermeyer Gate, 2 - 60" Dia. Pumps, and Road Raise For 25 Year Event @ ELEV +6.4'</b>		STATUS OF DESIGN	JOB ORDER NUMBER		
			6822-06		
ITEM DESCRIPTION	QUANTITY		ENGINEERING ESTIMATE		TOTAL
	NUMBER	UNIT	UNIT COST		
<b>Site Civil</b>					
Road Raise (2-Lane Road)	2,970.00	LF/VLF	\$250.00		\$742,500
Road Raise (4-Lane Road)	1,980.00	LF/VLF	\$450.00		\$891,000
Utility Relocation	2,750	LF	\$300.00		\$825,000
Elevating Homes along North Side of Dunning Ave	30	EA	\$70,000.00		\$2,100,000
<b>Obermeyer Gate w/ Bulkhead (Pretty Lake is 475 LF )</b>					
<u>Piling: Steel</u>					
Install AZ 14 Steel Sheet Piles	56,400	SF	\$28.50		\$1,607,400
Treat Embedded Interlocks	13,000	LF	\$7.25		\$94,250
30" DIA Steel Pipe End Piles	320	LF	\$363.00		\$116,160
Special Sheet Fabrication	520	LF	\$42.50		\$22,100
<u>Site Work: Excavation &amp; Fill</u>					
Gravel Base	38,000	CY	\$32.25		\$1,225,500
<u>Concrete: Gate Base Slab</u>					
Precast Concrete Gate Base	50	CY	\$1,832.50		\$91,625
Tremie Concrete Base	150	CY	\$985.00		\$147,750
<u>Dam Assembly</u>					
Gate with Operating System - 15.1' High x 50 LF	725	SF	\$4,000.00		\$2,900,000
<u>Finish Work</u>					
Concrete Fascia	8,100	SF	\$85.00		\$688,500
Top Slab	180	CY	\$630.00		\$113,400
Handrail	830	LF	\$178.00		\$147,740
<b>Pump Stations</b>					
60" pumps	3	EA	\$1,380,000.00		\$4,140,000
Support Structure - piles,header,rods, etc.	1	EA	\$28,000.00		\$28,000
Misc 60" Pipe Sections	3	EA	\$8,000.00		\$24,000
Concrete Headwall	1	EA	\$80,000.00		\$80,000
Flapgates	3	EA	\$19,200.00		\$57,600
Brick Enclosure for Generator	1	EA	\$450,000.00		\$450,000
Aesthetic Features of Pump Station	1	LS	\$150,000.00		\$150,000

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION		CONSTRUCTION CONTRACT NO.	IDENTIFICATION NUMBER		
City of Norfolk Norfolk, Virginia					
PROJECT TITLE		ESTIMATED BY	CATEGORY CODE NUMBER		
<b>Alt. 1b - Tidal Barrier with Obermeyer Gate, 2 - 60" Dia. Pumps, and Road Raise For 25 Year Event @ ELEV +6.4'</b>		Moffatt & Nichol			
		STATUS OF DESIGN	JOB ORDER NUMBER		
			6822-06		
ITEM DESCRIPTION	QUANTITY		ENGINEERING ESTIMATE		
	NUMBER	UNIT	UNIT COST	TOTAL	
<b>Electrical</b>					
Dominion Power Installation Costs	1	LS	\$100,000.00	\$100,000	
<i>Common Costs</i>					
Line Truck	20	DY	\$283.25	\$5,665	
Backhoe	10	DY	\$395.52	\$3,955	
Scissors Lift	40	DY	\$265.20	\$10,608	
<i>Site Work</i>					
Trench & Backfill	400	LF	\$1.96	\$784	
Pole, Foundation & Flood It	6	EA	\$1,223.02	\$7,338	
Quasite Handhole	3	EA	\$607.04	\$1,821	
<i>Power</i>					
Switchboard	1	LS	\$74,231.00	\$74,231	
400A 208V service panel W/MCB	1	EA	\$4,475.00	\$4,475	
100A 30ckt 208v 3 phase panel	6	EA	\$2,090.00	\$12,540	
225A 42 ckt 208v 3 phase panel	2	EA	\$3,400.00	\$6,800	
100-225A 3P 208v CB	4	EA	\$998.00	\$3,992	
20A 1P 120v Circuit Breaker	42	EA	\$53.30	\$2,239	
Surge Arrestor (SPD) 208V 10-Mode NEMA 4x box	2	EA	\$9,849.00	\$19,698	
4" GRS Conduit	1500	LF	\$49.80	\$74,700	
3/4" GRS Conduit	2500	LF	\$7.93	\$19,825	
1/2" GRS Conduit	5000	LF	\$7.14	\$35,700	
4" GRS Fittings	100	EA	\$455.00	\$45,500	
3/4" GRS Fittings	200	EA	\$42.95	\$8,590	
1/2" GRS Fittings	200	EA	\$35.45	\$7,090	
# 500 kcmil XHHW	7500	LF	\$14.10	\$105,750	
#4/0 AWG THWN	1500	LF	\$6.86	\$10,290	
#8 THWN Copper	1500	LF	\$0.91	\$1,365	
#12 THWN Copper	25000	LF	\$0.50	\$12,500	
# 500 kcmil cable connector	18	EA	\$160.00	\$2,880	
GFI Receptacle W/ Box & Cover	25	EA	\$107.09	\$2,677	
Duplex Receptacle W/Box & Cover	80	EA	\$60.82	\$4,866	
Motor Connection	3	EA	\$9,203.13	\$27,609	
VFD Drive	3	EA	\$150,000.00	\$450,000	
2500 KW Standby Generator - natural gas	2	EA	\$1,245,875.00	\$2,491,750	
Paralleling Switchgear	1	LS	\$429,800.00	\$429,800	
150 KVA Dry Transformer	1	EA	\$15,452.00	\$15,452	
30kVA UPS owner purchase (including commissioning)	1	EA	\$40,000.00	\$40,000	
Annunciator	1	LS	\$14,200.00	\$14,200	
Insurance & Taxes for Electrical	1	LS	\$159,404.00	\$159,404	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia		CONSTRUCTION CONTRACT NO.		IDENTIFICATION NUMBER	
PROJECT TITLE <b>Alt. 1b - Tidal Barrier with Obermeyer Gate, 2 - 60"                  Dia. Pumps, and Road Raise                  For 25 Year Event @ ELEV +6.4'</b>		ESTIMATED BY Moffatt & Nichol		CATEGORY CODE NUMBER	
		STATUS OF DESIGN		JOB ORDER NUMBER 6822-06	
ITEM DESCRIPTION		QUANTITY		ENGINEERING ESTIMATE	
		NUMBER	UNIT	UNIT COST	TOTAL
Sales Tax for Electrical		1	LS	<b>\$173,859.00</b>	\$173,859
<b>SUBTOTAL</b>					<b>\$21,030,478</b>
Overhead & Profit		15%		\$3,154,572	
Mobilization/Demobilization		10%		\$2,103,048	
Difficult Waterside Conditions		est - lump sum		\$1,000,000	
Erosion/Sediment Control		5%		\$1,051,524	
Traffic Control		2%		\$420,610	
Surveying/Engineering/Construction Observation		12%		\$2,523,657	
<b>Subtotal with Mark-ups</b>					<b>\$31,283,889</b>
Contingency		25%		\$7,820,972	
<b>Subtotal</b>					<b>\$39,104,861</b>
<b>TOTAL</b>					<b>\$39,104,861</b>
				<b>SAY</b>	<b>\$39,200,000</b>

		Opinion of Probable Cost		DATE PREPARED	
				17-Jan-11	
ACTIVITY AND LOCATION		CONSTRUCTION CONTRACT NO.		IDENTIFICATION NUMBER	
City of Norfolk Norfolk, Virginia					
PROJECT TITLE		ESTIMATED BY		CATEGORY CODE NUMBER	
<b>Alt. 1b - Tidal Barrier with Obermeyer Gate, 2 - 60" Dia. Pumps, and Road Raise For 50 Year Event @ ELEV +7.0'</b>		Moffatt & Nichol			
		STATUS OF DESIGN		JOB ORDER NUMBER	
				6822-06	
ITEM DESCRIPTION	QUANTITY		ENGINEERING ESTIMATE		
	NUMBER	UNIT	UNIT COST	TOTAL	
<b>Site Civil</b>					
Road Raise (2-Lane Road)	3,960.00	LF/VLF	\$250.00	\$990,000	
Road Raise (4-Lane Road)	2,640.00	LF/VLF	\$450.00	\$1,188,000	
Utility Relocation	2,750	LF	\$300.00	\$825,000	
Elevating Homes along North Side of Dunning Ave	30	EA	\$70,000.00	\$2,100,000	
<b>Obermeyer Gate w/ Bulkhead (Pretty Lake is 475 LF )</b>					
<u>Piling: Steel</u>					
Install AZ 14 Steel Sheet Piles	61,100	SF	\$28.50	\$1,741,350	
Treat Embedded Interlocks	14,000	LF	\$7.25	\$101,500	
30" DIA Steel Pipe End Piles	340	LF	\$363.00	\$123,420	
Special Sheet Fabrication	520	LF	\$42.50	\$22,100	
<u>Site Work: Excavation &amp; Fill</u>					
Gravel Base	38,000	CY	\$32.25	\$1,225,500	
<u>Concrete: Gate Base Slab</u>					
Precast Concrete Gate Base	50	CY	\$1,832.50	\$91,625	
Tremie Concrete Base	150	CY	\$985.00	\$147,750	
<u>Dam Assembly</u>					
Gate with Operating System - 15.1' High x 50 LF	755	SF	\$4,000.00	\$3,020,000	
<u>Finish Work</u>					
Concrete Fascia	8,100	SF	\$85.00	\$688,500	
Top Slab	180	CY	\$630.00	\$113,400	
Handrail	830	LF	\$178.00	\$147,740	
<b>Pump Stations</b>					
60" pumps	3	EA	\$1,380,000.00	\$4,140,000	
Support Structure - piles,header,rods, etc.	1	EA	\$28,000.00	\$28,000	
Misc 60" Pipe Sections	3	EA	\$8,000.00	\$24,000	
Concrete Headwall	1	EA	\$80,000.00	\$80,000	
Flapgates	3	EA	\$19,200.00	\$57,600	
Brick Enclosure for Generator	1	EA	\$450,000.00	\$450,000	
Aesthetic Features of Pump Station	1	LS	\$150,000.00	\$150,000	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION		CONSTRUCTION CONTRACT NO.	IDENTIFICATION NUMBER		
City of Norfolk Norfolk, Virginia					
PROJECT TITLE		ESTIMATED BY	CATEGORY CODE NUMBER		
<b>Alt. 1b - Tidal Barrier with Obermeyer Gate, 2 - 60" Dia. Pumps, and Road Raise For 50 Year Event @ ELEV +7.0'</b>		Moffatt & Nichol			
		STATUS OF DESIGN	JOB ORDER NUMBER		
			6822-06		
ITEM DESCRIPTION	QUANTITY		ENGINEERING ESTIMATE		TOTAL
	NUMBER	UNIT	UNIT COST		
<b>Electrical</b>					
Dominion Power Installation Costs	1	LS	\$100,000.00		\$100,000
<i>Common Costs</i>					
Line Truck	20	DY	\$283.25		\$5,665
Backhoe	10	DY	\$395.52		\$3,955
Scissors Lift	40	DY	\$265.20		\$10,608
<i>Site Work</i>					
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Pole, Foundation & Flood It	6	EA	\$1,223.02		\$7,338
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Switchboard	1	LS	\$74,231.00		\$74,231
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Surge Arrestor (SPD) 208V 10-Mode NEMA 4x box	2	EA	\$9,849.00		\$19,698
4" GRS Conduit	1500	LF	\$49.80		\$74,700
3/4" GRS Conduit	2500	LF	\$7.93		\$19,825
1/2" GRS Conduit	5000	LF	\$7.14		\$35,700
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#4/0 AWG THWN	1500	LF	\$6.86		\$10,290
#8 THWN Copper	1500	LF	\$0.91		\$1,365
#12 THWN Copper	25000	LF	\$0.50		\$12,500
# 500 kcmil cable connector	18	EA	\$160.00		\$2,880
GFI Receptacle W/ Box & Cover	25	EA	\$107.09		\$2,677
Duplex Receptacle W/Box & Cover	80	EA	\$60.82		\$4,866
Motor Connection	3	EA	\$9,203.13		\$27,609
VFD Drive	3	EA	\$150,000.00		\$450,000
2500 KW Standby Generator - natural gas	2	EA	\$1,245,875.00		\$2,491,750
Paralleling Switchgear	1	LS	\$429,800.00		\$429,800
150 KVA Dry Transformer	1	EA	\$15,452.00		\$15,452
30kVA UPS owner purchase (including commissioning)	1	EA	\$40,000.00		\$40,000
Annunciator	1	LS	\$14,200.00		\$14,200
Insurance & Taxes for Electrical	1	LS	\$159,404.00		\$159,404

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11																																																																	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia		CONSTRUCTION CONTRACT NO.		IDENTIFICATION NUMBER																																																																	
		ESTIMATED BY Moffatt & Nichol		CATEGORY CODE NUMBER																																																																	
PROJECT TITLE <b>Alt. 1b - Tidal Barrier with Obermeyer Gate, 2 - 60"                  Dia. Pumps, and Road Raise                  For 50 Year Event @ ELEV +7.0'</b>		STATUS OF DESIGN		JOB ORDER NUMBER 6822-06																																																																	
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ITEM DESCRIPTION		NUMBER	UNIT	UNIT COST	TOTAL																																																																
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		Opinion of Probable Cost			DATE PREPARED
					17-Jan-11
ACTIVITY AND LOCATION		CONSTRUCTION CONTRACT NO.	IDENTIFICATION NUMBER		
City of Norfolk Norfolk, Virginia					
PROJECT TITLE		ESTIMATED BY	CATEGORY CODE NUMBER		
<b>Alt. 1b - Tidal Barrier with Obermeyer Gate, 2 - 60" Dia. Pumps, and Road Raise For 100 Year Event @ ELEV +7.6'</b>		Moffatt & Nichol			
		STATUS OF DESIGN	JOB ORDER NUMBER		
			6822-06		
ITEM DESCRIPTION	QUANTITY		ENGINEERING ESTIMATE		
	NUMBER	UNIT	UNIT COST	TOTAL	
<b>Site Civil</b>					
Road Raise (2-Lane Road)	4,950.00	LF/VLF	\$250.00	\$1,237,500	
Road Raise (4-Lane Road)	3,300.00	LF/VLF	\$450.00	\$1,485,000	
Utility Relocation	2,750	LF	\$300.00	\$825,000	
Elevating Homes along North Side of Dunning Ave	30	EA	\$70,000.00	\$2,100,000	
<b>Obermeyer Gate w/ Bulkhead (Pretty Lake is 475 LF )</b>					
<u>Piling: Steel</u>					
Install AZ 14 Steel Sheet Piles	61,100	SF	\$28.50	\$1,741,350	
Treat Embedded Interlocks	14,000	LF	\$7.25	\$101,500	
30" DIA Steel Pipe End Piles	340	LF	\$363.00	\$123,420	
Special Sheet Fabrication	520	LF	\$42.50	\$22,100	
<u>Site Work: Excavation &amp; Fill</u>					
Gravel Base	38,000	CY	\$32.25	\$1,225,500	
<u>Concrete: Gate Base Slab</u>					
Precast Concrete Gate Base	50	CY	\$1,832.50	\$91,625	
Tremie Concrete Base	150	CY	\$985.00	\$147,750	
<u>Dam Assembly</u>					
Gate with Operating System - 15.7' High x 50 LF	795	SF	\$4,000.00	\$3,180,000	
<u>Finish Work</u>					
Concrete Fascia	8,100	SF	\$85.00	\$688,500	
Top Slab	180	CY	\$630.00	\$113,400	
Handrail	830	LF	\$178.00	\$147,740	
<b>Pump Stations</b>					
60" pumps	3	EA	\$1,380,000.00	\$4,140,000	
Support Structure - piles,header,rods, etc.	1	EA	\$28,000.00	\$28,000	
Misc 60" Pipe Sections	3	EA	\$8,000.00	\$24,000	
Concrete Headwall	1	EA	\$80,000.00	\$80,000	
Flapgates	3	EA	\$19,200.00	\$57,600	
Brick Enclosure for Generator	1	EA	\$450,000.00	\$450,000	
Aesthetic Features of Pump Station	1	LS	\$150,000.00	\$150,000	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia		CONSTRUCTION CONTRACT NO.		IDENTIFICATION NUMBER	
PROJECT TITLE <b>Alt. 1b - Tidal Barrier with Obermeyer Gate, 2 - 60" Dia. Pumps, and Road Raise For 100 Year Event @ ELEV +7.6'</b>		ESTIMATED BY Moffatt & Nichol		CATEGORY CODE NUMBER	
		STATUS OF DESIGN		JOB ORDER NUMBER 6822-06	
ITEM DESCRIPTION	QUANTITY		ENGINEERING ESTIMATE		
	NUMBER	UNIT	UNIT COST	TOTAL	
<b>Electrical</b>					
Dominion Power Installation Costs	1	LS	\$100,000.00	\$100,000	
<i>Common Costs</i>					
Line Truck	20	DY	\$283.25	\$5,665	
Backhoe	10	DY	\$395.52	\$3,955	
Scissors Lift	40	DY	\$265.20	\$10,608	
<i>Site Work</i>					
Trench & Backfill	400	LF	\$1.96	\$784	
Pole, Foundation & Flood It	6	EA	\$1,223.02	\$7,338	
Quasite Handhole	3	EA	\$607.04	\$1,821	
<i>Power</i>					
Switchboard	1	LS	\$74,231.00	\$74,231	
400A 208V service panel W/MCB	1	EA	\$4,475.00	\$4,475	
100A 30ckt 208v 3 phase panel	6	EA	\$2,090.00	\$12,540	
225A 42 ckt 208v 3 phase panel	2	EA	\$3,400.00	\$6,800	
100-225A 3P 208v CB	4	EA	\$998.00	\$3,992	
20A 1P 120v Circuit Breaker	42	EA	\$53.30	\$2,239	
Surge Arrestor (SPD) 208V 10-Mode NEMA 4x box	2	EA	\$9,849.00	\$19,698	
4" GRS Conduit	1500	LF	\$49.80	\$74,700	
3/4" GRS Conduit	2500	LF	\$7.93	\$19,825	
1/2" GRS Conduit	5000	LF	\$7.14	\$35,700	
4" GRS Fittings	100	EA	\$455.00	\$45,500	
3/4" GRS Fittings	200	EA	\$42.95	\$8,590	
1/2" GRS Fittings	200	EA	\$35.45	\$7,090	
# 500 kcmil XHHW	7500	LF	\$14.10	\$105,750	
#4/0 AWG THWN	1500	LF	\$6.86	\$10,290	
#8 THWN Copper	1500	LF	\$0.91	\$1,365	
#12 THWN Copper	25000	LF	\$0.50	\$12,500	
# 500 kcmil cable connector	18	EA	\$160.00	\$2,880	
GFI Receptacle W/ Box & Cover	25	EA	\$107.09	\$2,677	
Duplex Receptacle W/Box & Cover	80	EA	\$60.82	\$4,866	
Motor Connection	3	EA	\$9,203.13	\$27,609	
VFD Drive	3	EA	\$150,000.00	\$450,000	
2500 KW Standby Generator - natural gas	2	EA	\$1,245,875.00	\$2,491,750	
Paralleling Switchgear	1	LS	\$429,800.00	\$429,800	
150 KVA Dry Transformer	1	EA	\$15,452.00	\$15,452	
30kVA UPS owner purchase (including commissioning)	1	EA	\$40,000.00	\$40,000	
Annunciator	1	LS	\$14,200.00	\$14,200	
Insurance & Taxes for Electrical	1	LS	\$159,404.00	\$159,404	

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ITEM DESCRIPTION		QUANTITY		ENGINEERING ESTIMATE	
		NUMBER	UNIT	UNIT COST	TOTAL
<b>Site Civil</b>					
Road Raise (2-Lane Road)	4,950.00	F/VL	\$250.00		\$1,237,500
Road Raise (4-Lane Road)	3,300.00	F/VL	\$450.00		\$1,485,000
Utility Relocation	2,750	LF	\$300.00		\$825,000
Elevating Homes along North Side of Dunning Ave	30	EA	\$70,000.00		\$2,100,000
<b>Inflatable Dam w/ Bulkhead (Pretty Lake is 475 LF )</b>					
<u>Piling: Steel</u>					
Install AZ 14 Steel Sheet Piles	61,100	SF	\$28.50		\$1,741,350
Treat Embedded Interlocks	14,000	LF	\$7.25		\$101,500
30" DIA Steel Pipe End Piles	340	LF	\$363.00		\$123,420
Special Sheet Fabrication	520	LF	\$42.50		\$22,100
<u>Site Work: Excavation &amp; Fill</u>					
Gravel Base	38,000	CY	\$32.25		\$1,225,500
<u>Concrete: Gate Base Slab</u>					
Precast Concrete Gate Base	50	CY	\$1,832.50		\$91,625
Tremie Concrete Base	150	CY	\$985.00		\$147,750
<u>Dam Assembly</u>					
Rubber Dam - 15.7' High x 111 LF	1,765	SF	\$3,000.00		\$5,294,700
Dam Operating System	1	LS	\$248,000.00		\$248,000
<u>Finish Work</u>					
Concrete Fascia	8,100	SF	\$85.00		\$688,500
Top Slab	180	CY	\$630.00		\$113,400
Handrail	830	LF	\$178.00		\$147,740
<b>Pump Stations</b>					
60" pumps	3	EA	\$1,380,000.00		\$4,140,000
Support Structure - piles,header,rods, etc.	1	EA	\$28,000.00		\$28,000
Misc 60" Pipe Sections	3	EA	\$8,000.00		\$24,000
Concrete Headwall	1	EA	\$80,000.00		\$80,000
Flapgates	3	EA	\$19,200.00		\$57,600
Brick Enclosure for Generator	1	EA	\$450,000.00		\$450,000
Aesthetic Features of Pump Station	1	LS	\$150,000.00		\$150,000

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION		CONSTRUCTION CONTRACT NO. IDENTIFICATION NUMBER			
City of Norfolk Norfolk, Virginia					
PROJECT TITLE		ESTIMATED BY			
Alt. 1c - Tidal Barrier with Inflatable Dam, 2 - 60" Dia. Pumps, and Road Raise		Moffatt & Nichol			
For 100 Year Event @ ELEV +7.6'		STATUS OF DESIGN		JOB ORDER NUMBER	
				6822-06	
ITEM DESCRIPTION	QUANTITY		ENGINEERING ESTIMATE		
	NUMBER	UNIT	UNIT COST	TOTAL	
<b>Electrical</b>					
Dominion Power Installation Costs	1	LS	\$100,000.00	\$100,000	
<i>Common Costs</i>					
Line Truck	20	DY	\$283.25	\$5,665	
Backhoe	10	DY	\$395.52	\$3,955	
Scissors Lift	40	DY	\$265.20	\$10,608	
<i>Site Work</i>					
Trench & Backfill	400	LF	\$1.96	\$784	
Pole, Foundation & Flood It	6	EA	\$1,223.02	\$7,338	
Quasite Handhole	3	EA	\$607.04	\$1,821	
<i>Power</i>					
Switchboard	1	LS	\$74,231.00	\$74,231	
400A 208V service panel W/MCB	1	EA	\$4,475.00	\$4,475	
100A 30ckt 208v 3 phase panel	6	EA	\$2,090.00	\$12,540	
225A 42 ckt 208v 3 phase panel	2	EA	\$3,400.00	\$6,800	
100-225A 3P 208v CB	4	EA	\$998.00	\$3,992	
20A 1P 120v Circuit Breaker	42	EA	\$53.30	\$2,239	
Surge Arrestor (SPD) 208V 10-Mode NEMA 4x box	2	EA	\$9,849.00	\$19,698	
4" GRS Conduit	1500	LF	\$49.80	\$74,700	
3/4" GRS Conduit	2500	LF	\$7.93	\$19,825	
1/2" GRS Conduit	5000	LF	\$7.14	\$35,700	
4" GRS Fittings	100	EA	\$455.00	\$45,500	
3/4" GRS Fittings	200	EA	\$42.95	\$8,590	
1/2" GRS Fittings	200	EA	\$35.45	\$7,090	
# 500 kcmil XHHW	7500	LF	\$14.10	\$105,750	
#4/0 AWG THWN	1500	LF	\$6.86	\$10,290	
#8 THWN Copper	1500	LF	\$0.91	\$1,365	
#12 THWN Copper	25000	LF	\$0.50	\$12,500	
# 500 kcmil cable connector	18	EA	\$160.00	\$2,880	
GFI Receptacle W/ Box & Cover	25	EA	\$107.09	\$2,677	
Duplex Receptacle W/Box & Cover	80	EA	\$60.82	\$4,866	
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VFD Drive	3	EA	\$150,000.00	\$450,000	
2500 KW Standby Generator - natural gas	2	EA	\$1,245,875.00	\$2,491,750	
Paralleling Switchgear	1	LS	\$429,800.00	\$429,800	
150 KVA Dry Transformer	1	EA	\$15,452.00	\$15,452	
30kVA UPS owner purchase (including commissioning)	1	EA	\$40,000.00	\$40,000	
Annunciator	1	LS	\$14,200.00	\$14,200	
Insurance & Taxes for Electrical	1	LS	\$159,404.00	\$159,404	

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia		CONSTRUCTION CONTRACT NO. IDENTIFICATION NUMBER			
PROJECT TITLE <b>Alt. 1c - Tidal Barrier with Inflatable Dam, 2 - 60" Dia. Pumps, and Road Raise</b> <b>For 100 Year Event @ ELEV +7.6'</b>		ESTIMATED BY Moffatt & Nichol		CATEGORY CODE NUMBER	
		STATUS OF DESIGN		JOB ORDER NUMBER 6822-06	
ITEM DESCRIPTION		QUANTITY		ENGINEERING ESTIMATE	
		NUMBER	UNIT	UNIT COST	TOTAL
Sales Tax for Electrical		1	LS	\$173,859.00	\$173,859
<b>SUBTOTAL</b>					<b>\$24,910,638</b>
Overhead & Profit			15%		\$3,736,596
Mobilization/Demobilization			10%		\$2,491,064
Difficult Waterside Conditions			est - lump sum		\$1,000,000
Erosion/Sediment Control			5%		\$1,245,532
Traffic Control			2%		\$498,213
Surveying/Engineering/Construction Observation			12%		\$2,989,277
<b>Subtotal with Mark-ups</b>					<b>\$36,871,319</b>
Contingency			25%		\$9,217,830
<b>Subtotal</b>					<b>\$46,089,149</b>
<b>TOTAL</b>					<b>\$46,089,149</b>
				<b>SAY</b>	<b>\$46,100,000</b>

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia			CONSTRUCTION CONTRACT NO. IDENTIFICATION NUMBER		
PROJECT TITLE <b>Pretty Lake - Alternative 2a                  Tidal Barrier with Steel Gate, 4 - 60" Dia. Pumps, and                  Road Raise</b>			ESTIMATED BY Moffatt & Nichol		
			STATUS OF DESIGN JOB ORDER NUMBER 6822-06		
<b>Summary</b>					
Scenario			Opinion of Probable Cost		
2 Year Surge with Rain			\$39,800,000		
10 Year Surge with Rain			\$46,900,000		
25 Year Surge with Rain			\$48,200,000		
50 Year Surge with Rain			\$49,500,000		
100 Year Surge with Rain			\$50,500,000		

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia			CONSTRUCTION CONTRACT NO. IDENTIFICATION NUMBER		
PROJECT TITLE <b>Pretty Lake - Alternative 2b                  Tidal Barrier with Obermeyer Gate, 4 - 60" Dia.                  Pumps, and Road Raise</b>			ESTIMATED BY <b>Moffatt &amp; Nichol</b>		CATEGORY CODE NUMBER
			STATUS OF DESIGN		JOB ORDER NUMBER 6822-06
<b>Summary</b>					
Scenario			Opinion of Probable Cost		
2 Year Surge with Rain			\$41,800,000		
10 Year Surge with Rain			\$49,400,000		
25 Year Surge with Rain			\$51,000,000		
50 Year Surge with Rain			\$52,500,000		
100 Year Surge with Rain			\$53,800,000		

		<b>Opinion of Probable Cost</b>		DATE PREPARED <b>17-Jan-11</b>	
ACTIVITY AND LOCATION <b>City of Norfolk</b> <b>Norfolk, Virginia</b>			CONSTRUCTION CONTRACT NO. IDENTIFICATION NUMBER		
			ESTIMATED BY <b>Moffatt &amp; Nichol</b>		CATEGORY CODE NUMBER
PROJECT TITLE <b>Pretty Lake - Alternative 2c</b> <b>Tidal Barrier with Inflatable Dam, 4 - 60" Dia.</b> <b>Pumps, and Road Raise</b>			STATUS OF DESIGN		JOB ORDER NUMBER <b>6822-06</b>
			<b>Summary</b>		
<b>Scenario</b>			<b>Opinion of Probable Cost</b>		
2 Year Surge with Rain			\$45,300,000		
10 Year Surge with Rain			\$53,300,000		
25 Year Surge with Rain			\$55,100,000		
50 Year Surge with Rain			\$56,700,000		
100 Year Surge with Rain			\$57,600,000		

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia			CONSTRUCTION CONTRACT NO. IDENTIFICATION NUMBER		
PROJECT TITLE <b>Pretty Lake - Alternative 3a                  Tidal Barrier with Steel Gate, 4 - 96" Dia. Pumps, and                  Road Raise</b>			ESTIMATED BY Moffatt & Nichol		CATEGORY CODE NUMBER
			STATUS OF DESIGN	JOB ORDER NUMBER 6822-03	
<b>Summary</b>					
Scenario			Opinion of Probable Cost		
2 Year Surge with Rain			\$74,300,000		
10 Year Surge with Rain			\$81,500,000		
25 Year Surge with Rain			\$82,800,000		
50 Year Surge with Rain			\$84,000,000		
100 Year Surge with Rain			\$85,000,000		

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia			CONSTRUCTION CONTRACT NO. IDENTIFICATION NUMBER		
PROJECT TITLE <b>Pretty Lake - Alternative 3b                  Tidal Barrier with Obermeyer Gate, 4 - 96" Dia.                  Pumps, and Road Raise</b>			ESTIMATED BY <b>Moffatt &amp; Nichol</b>		CATEGORY CODE NUMBER
			STATUS OF DESIGN		JOB ORDER NUMBER 6822-06
<b>Summary</b>					
Scenario			Opinion of Probable Cost		
2 Year Surge with Rain			\$76,500,000		
10 Year Surge with Rain			\$84,100,000		
25 Year Surge with Rain			\$85,700,000		
50 Year Surge with Rain			\$87,200,000		
100 Year Surge with Rain			\$88,500,000		

		<b>Opinion of Probable Cost</b>		DATE PREPARED <b>17-Jan-11</b>	
ACTIVITY AND LOCATION <b>City of Norfolk</b> <b>Norfolk, Virginia</b>			CONSTRUCTION CONTRACT NO. IDENTIFICATION NUMBER		
			ESTIMATED BY <b>Moffatt &amp; Nichol</b>		
PROJECT TITLE <b>Pretty Lake - Alternative 3c</b> <b>Tidal Barrier with Inflatable Dam, 4 - 96" Dia.</b> <b>Pumps, and Road Raise</b>			STATUS OF DESIGN		
<b>Summary</b>					
<b>Scenario</b>			<b>Opinion of Probable Cost</b>		
2 Year Surge with Rain			\$79,900,000		
10 Year Surge with Rain			\$90,400,000		
25 Year Surge with Rain			\$92,200,000		
50 Year Surge with Rain			\$93,800,000		
100 Year Surge with Rain			\$94,100,000		

		Opinion of Probable Cost		DATE PREPARED 17-Jan-11	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia			CONSTRUCTION CONTRACT NO. IDENTIFICATION NUMBER		
PROJECT TITLE <b>Pretty Lake - Alternative 4</b> <b>Bulkhead Wall, Earthen Berm and Road Raise</b>			ESTIMATED BY Moffatt & Nichol		CATEGORY CODE NUMBER
			STATUS OF DESIGN		JOB ORDER NUMBER 6822-06
Summary					
Scenario			Opinion of Probable Cost		
2 Year Surge with Rain			\$55,500,000		
10 Year Surge with Rain			\$94,700,000		
25 Year Surge with Rain			\$117,400,000		
50 Year Surge with Rain			\$154,500,000		
100 Year Surge with Rain			\$189,700,000		

		Opinion of Probable Cost		DATE PREPARED 20-Dec-10	
ACTIVITY AND LOCATION City of Norfolk Norfolk, Virginia		CONSTRUCTION CONTRACT NO. IDENTIFICATION NUMBER			
PROJECT TITLE <b>Pretty Lake - Alternative 5</b>  <b>Buyout 20% Damage Level</b>		ESTIMATED BY <b>Moffatt &amp; Nichol</b>		CATEGORY CODE NUMBER	
		STATUS OF DESIGN Conceptual		JOB ORDER NUMBER 6822-06	
<b>Summary</b>					
Scenario			Opinion of Probable Cost		
2 - Year Storm Event			\$50,366,925		
10 - Year Storm Event			\$174,241,900		
25 - Year Storm Event			\$265,390,650		
50 - Year Storm Event			\$356,736,888		
100 - Year Storm Event			\$473,696,563		

		Opinion of Probable Cost		DATE PREPARED 7-Dec-10	
ACTIVITY AND LOCATION			CONSTRUCTION CONTRACT IDENTIFICATION NUMBER		
PROJECT TITLE			ESTIMATED BY		
<b>Pretty Lake - Steel Gate with Steel Bulkhead &amp; Pumpstation with 2 - 60" Pumps                  Operational &amp; Maintenance Costs (Anticipated Service Life of 50 Years)</b>			Moffatt & Nichol		
			STATUS OF DESIGN		
		Quantities	Price	Unit	Total Price
<b>Bulkhead &amp; Gate</b>					
Inspections (Completed Every 5 Years)		10	\$75,000	EACH	\$750,000.00
Minor Repairs (Years 15, 35, 45)		3	\$400,000	EACH	\$1,200,000.00
Major Repairs (Years 25 & 40)		2	\$1,250,000	EACH	\$2,500,000.00
Operational Cost per Event (8 Events per Year)		400	\$500	EACH	\$200,000.00
<b>Pump Station</b>					
Maintenance Cost Per Generator Per Year (2 Gen Sets)		100	\$2,000	EACH	\$200,000.00
Operational Cost for Generator Per Event (Once Every 5 Yr)		20	\$40,000	EACH	\$800,000.00
Maintenance Cost Per Pump (Per Year Per Pump)		100	\$40,000	EACH	\$4,000,000.00
Replacement of Pumps (Year 30)		2	\$690,000	EACH	\$1,380,000.00
Operational Cost per Pump Per Event Per Pump Per Year		100	\$785	EACH	\$78,500.00
Operation Cost (City Employees - 2 Employees per Event)		19200	\$25	HOUR	\$480,000.00
<b>Total</b>					<b>\$11,588,500.00</b>

		Opinion of Probable Cost		DATE PREPARED 7-Dec-10	
ACTIVITY AND LOCATION			CONSTRUCTION CONTRACT IDENTIFICATION NUMBER		
PROJECT TITLE			ESTIMATED BY		
<b>Pretty Lake - Obermeyer Gate with Steel Bulkhead &amp; Pumpstation with 2 - 60" Pumps Operational &amp; Maintenance Costs (Anticipated Service Life of 50 Years)</b>			Moffatt & Nichol		
			STATUS OF DESIGN		
			JOB ORDER NUMBER		
		Quantities	Price	Unit	Total Price
<b>Bulkhead &amp; Gate</b>					
Inspections (Completed Every 5 Years)		10	\$75,000	EACH	\$750,000.00
Minor Repairs (Years 15, 35, 45)		3	\$300,000	EACH	\$900,000.00
Major Repairs (Years 25 & 40)		2	\$1,000,000	EACH	\$2,000,000.00
Replacement of Rubber Dam (Year 30)		1	\$984,000	EACH	\$984,000.00
Operational Cost per Event (8 Events per Year)		400	\$500	EACH	\$200,000.00
<b>Pump Station</b>					
Maintenance Cost Per Generator Per Year (2 Gen Sets)		100	\$2,000	EACH	\$200,000.00
Operational Cost for Generator Per Event (Once Every 5 Yr)		20	\$40,000	EACH	\$800,000.00
Maintenance Cost Per Pump (Per Year Per Pump)		100	\$40,000	EACH	\$4,000,000.00
Replacement of Pumps (Year 30)		2	\$690,000	EACH	\$1,380,000.00
Operational Cost per Pump Per Event Per Pump Per Year		100	\$785	EACH	\$78,500.00
Operation Cost (City Employees - 2 Employees per Event)		19200	\$25	HOUR	\$480,000.00
<b>Total</b>					<b>\$11,772,500.00</b>

		Opinion of Probable Cost		DATE PREPARED 7-Dec-10	
ACTIVITY AND LOCATION			CONSTRUCTION CONTRACT IDENTIFICATION NUMBER		
PROJECT TITLE			ESTIMATED BY		
<b>Pretty Lake - Inflatable Gate with Steel Bulkhead &amp; Pumpstation with 2 - 60" Pumps Operational &amp; Maintenance Costs (Anticipated Service Life of 50 Years)</b>			Moffatt & Nichol		
			STATUS OF DESIGN		
			JOB ORDER NUMBER		
		Quantities	Price	Unit	Total Price
<b>Bulkhead &amp; Gate</b>					
Inspections (Completed Every 5 Years)		10	\$75,000	EACH	\$750,000.00
Minor Repairs (Years 15, 35, 45)		3	\$300,000	EACH	\$900,000.00
Major Repairs (Years 25 & 40)		2	\$1,000,000	EACH	\$2,000,000.00
Replacement of Rubber Dam (Year 30)		1	\$2,200,000	EACH	\$2,200,000.00
Operational Cost per Event (8 Events per Year)		400	\$500	EACH	\$200,000.00
<b>Pump Station</b>					
Maintenance Cost Per Generator Per Year (2 Gen Sets)		100	\$2,000	EACH	\$200,000.00
Operational Cost for Generator Per Event (Once Every 5 Yr)		20	\$40,000	EACH	\$800,000.00
Maintenance Cost Per Pump (Per Year Per Pump)		100	\$40,000	EACH	\$4,000,000.00
Replacement of Pumps (Year 30)		2	\$690,000	EACH	\$1,380,000.00
Operational Cost per Pump Per Event Per Pump Per Year		100	\$785	EACH	\$78,500.00
Operation Cost (City Employees - 2 Employees per Event)		19200	\$25	HOUR	\$480,000.00
<b>Total</b>					<b>\$12,988,500.00</b>



Opinion of Probable Cost

DATE PREPARED  
7-Dec-10

ACTIVITY AND LOCATION	CONSTRUCTION CONTRACT IDENTIFICATION NUMBER
PROJECT TITLE	ESTIMATED BY
<b>Pretty Lake - Steel Gate with Steel Bulkhead &amp; Pumpstation with 4 - 60" Pumps Operational &amp; Maintenance Costs (Anticipated Service Life of 50 Years)</b>	Moffatt & Nichol
	CATEGORY CODE NUMBER
	STATUS OF DESIGN
	JOB ORDER NUMBER

	Quantities	Price	Unit	Total Price
<b>Bulkhead &amp; Gate</b>				
Inspections (Completed Every 5 Years)	10	\$75,000	EACH	\$750,000.00
Minor Repairs (Years 15, 35, 45)	3	\$400,000	EACH	\$1,200,000.00
Major Repairs (Years 25 & 40)	2	\$1,250,000	EACH	\$2,500,000.00
Operational Cost per Event (8 Events per Year)	400	\$500	EACH	\$200,000.00
<b>Pump Station</b>				
Maintenance Cost Per Generator Per Year (4 Gen Sets)	200	\$2,000	EACH	\$400,000.00
Operational Cost for Generator Per Event (Once Every 5 Yr)	40	\$40,000	EACH	\$1,600,000.00
Maintenance Cost Per Pump (Per Year Per Pump)	200	\$40,000	EACH	\$8,000,000.00
Replacement of Pumps (Year 30)	4	\$690,000	EACH	\$2,760,000.00
Operational Cost per Pump Per Event (8 Events per Year)	200	\$785	EACH	\$157,000.00
Operation Cost (City Employees - 2 Employees per Event)	19200	\$25	Hour	\$480,000.00
<b>Total</b>				<b>\$18,047,000.00</b>



Opinion of Probable Cost

DATE PREPARED  
7-Dec-10

ACTIVITY AND LOCATION	CONSTRUCTION CONTRACT IDENTIFICATION NUMBER
PROJECT TITLE	ESTIMATED BY
<b>Pretty Lake - Obermeyer Gate with Steel Bulkhead &amp; Pumpstation with 4 - 60" Pumps Operational &amp; Maintenance Costs (Anticipated Service Life of 50 Years)</b>	Moffatt & Nichol
	CATEGORY CODE NUMBER
	STATUS OF DESIGN
	JOB ORDER NUMBER

	Quantities	Price	Unit	Total Price
<b>Bulkhead &amp; Gate</b>				
Inspections (Completed Every 5 Years)	10	\$75,000	EACH	\$750,000.00
Minor Repairs (Years 15, 35, 45)	3	\$300,000	EACH	\$900,000.00
Major Repairs (Years 25 & 40)	2	\$1,000,000	EACH	\$2,000,000.00
Replacement of Rubber Dam (Year 30)	1	\$984,000	EACH	\$984,000.00
Operational Cost per Event (8 Events per Year)	400	\$500	EACH	\$200,000.00
<b>Pump Station</b>				
Maintenance Cost Per Generator Per Year (4 Gen Sets)	200	\$2,000	EACH	\$400,000.00
Operational Cost for Generator Per Event (Once Every 5 Yr)	40	\$40,000	EACH	\$1,600,000.00
Maintenance Cost Per Pump (Per Year Per Pump)	200	\$40,000	EACH	\$8,000,000.00
Replacement of Pumps (Year 30)	4	\$690,000	EACH	\$2,760,000.00
Operational Cost per Pump Per Event (8 Events per Year)	200	\$785	EACH	\$157,000.00
Operation Cost (City Employees - 2 Employees per Event)	19200	\$25	Hour	\$480,000.00
<b>Total</b>				<b>\$18,231,000.00</b>



Opinion of Probable Cost

DATE PREPARED  
7-Dec-10

ACTIVITY AND LOCATION	CONSTRUCTION CONTRACT IDENTIFICATION NUMBER
PROJECT TITLE	ESTIMATED BY <b>Moffatt &amp; Nichol</b>
<b>Pretty Lake - Inflatable Gate with Steel Bulkhead &amp; Pumpstation with 4 - 60" Pumps Operational &amp; Maintenance Costs (Anticipated Service Life of 50 Years)</b>	CATEGORY CODE NUMBER
	STATUS OF DESIGN      JOB ORDER NUMBER

	Quantities	Price	Unit	Total Price
<b>Bulkhead &amp; Gate</b>				
Inspections (Completed Every 5 Years)	10	\$75,000	EACH	\$750,000.00
Minor Repairs (Years 15, 35, 45)	3	\$300,000	EACH	\$900,000.00
Major Repairs (Years 25 & 40)	2	\$1,000,000	EACH	\$2,000,000.00
Replacement of Rubber Dam (Year 30)	1	\$2,200,000	EACH	\$2,200,000.00
Operational Cost per Event (8 Events per Year)	400	\$500	EACH	\$200,000.00
<b>Pump Station</b>				
Maintenance Cost Per Generator Per Year (4 Gen Sets)	200	\$2,000	EACH	\$400,000.00
Operational Cost for Generator Per Event (Once Every 5 Yr)	40	\$40,000	EACH	\$1,600,000.00
Maintenance Cost Per Pump (Per Year Per Pump)	200	\$40,000	EACH	\$8,000,000.00
Replacement of Pumps (Year 30)	4	\$690,000	EACH	\$2,760,000.00
Operational Cost per Pump Per Event (8 Events per Year)	200	\$785	EACH	\$157,000.00
Operation Cost (City Employees - 2 Employees per Event)	19200	\$25	Hour	\$480,000.00
<b>Total</b>				<b>\$19,447,000.00</b>



Opinion of Probable Cost

DATE PREPARED  
7-Dec-10

ACTIVITY AND LOCATION	CONSTRUCTION CONTRACT IDENTIFICATION NUMBER
PROJECT TITLE	ESTIMATED BY <b>Moffatt &amp; Nichol</b>
<b>Pretty Lake - Inflatable Gate with Steel Bulkhead &amp; Pumpstation with 4 - 96" Pumps Operational &amp; Maintenance Costs (Anticipated Service Life of 50 Years)</b>	CATEGORY CODE NUMBER STATUS OF DESIGN JOB ORDER NUMBER

	Quantities	Price	Unit	Total Price
<b>Bulkhead &amp; Gate</b>				
Inspections (Completed Every 5 Years)	10	\$75,000	EACH	\$750,000.00
Minor Repairs (Years 15, 35, 45)	3	\$300,000	EACH	\$900,000.00
Major Repairs (Years 25 & 40)	2	\$1,000,000	EACH	\$2,000,000.00
Operational Cost per Event (8 Events per Year)	400	\$500	EACH	\$200,000.00
<b>Pump Station</b>				
Maintenance Cost Per Generator Per Year (4 Gen Sets)	200	\$2,000	EACH	\$400,000.00
Operational Cost for Generator Per Event (Once Every 5 Yr)	40	\$40,000	EACH	\$1,600,000.00
Maintenance Cost Per Pump (Per Year Per Pump)	200	\$40,000	EACH	\$8,000,000.00
Replacement of Pumps (Year 30)	4	\$1,975,000	EACH	\$7,900,000.00
Operational Cost per Pump Per Event (8 Events per Year)	200	\$1,245	EACH	\$249,000.00
Operation Cost (City Employees - 2 Employees per Event)	19200	\$25	Hour	\$480,000.00
<b>Total</b>				<b>\$22,479,000.00</b>



Opinion of Probable Cost

DATE PREPARED  
7-Dec-10

ACTIVITY AND LOCATION	CONSTRUCTION CONTRACT IDENTIFICATION NUMBER
	ESTIMATED BY: <b>Moffatt &amp; Nichol</b> CATEGORY CODE NUMBER
PROJECT TITLE <b>Pretty Lake - Inflatable Gate with Steel Bulkhead &amp; Pumpstation with 4 - 96" Pumps Operational &amp; Maintenance Costs (Anticipated Service Life of 50 Years)</b>	STATUS OF DESIGN
	JOB ORDER NUMBER

	Quantities	Price	Unit	Total Price
<b>Bulkhead &amp; Gate</b>				
Inspections (Completed Every 5 Years)	10	\$75,000	EACH	\$750,000.00
Minor Repairs (Years 15, 35, 45)	3	\$300,000	EACH	\$900,000.00
Major Repairs (Years 25 & 40)	2	\$1,000,000	EACH	\$2,000,000.00
Replacement of Rubber Dam (Year 30)	1	\$984,000	EACH	\$984,000.00
Operational Cost per Event (8 Events per Year)	400	\$500	EACH	\$200,000.00
<b>Pump Station</b>				
Maintenance Cost Per Generator Per Year (4 Gen Sets)	200	\$2,000	EACH	\$400,000.00
Operational Cost for Generator Per Event (Once Every 5 Yr)	40	\$40,000	EACH	\$1,600,000.00
Maintenance Cost Per Pump (Per Year Per Pump)	200	\$40,000	EACH	\$8,000,000.00
Replacement of Pumps (Year 30)	4	\$1,975,000	EACH	\$7,900,000.00
Operational Cost per Pump Per Event (8 Events per Year)	200	\$1,245	EACH	\$249,000.00
Operation Cost (City Employees - 2 Employees per Event)	19200	\$25	Hour	\$480,000.00
<b>Total</b>				<b>\$23,463,000.00</b>



Opinion of Probable Cost

DATE PREPARED  
7-Dec-10

ACTIVITY AND LOCATION	CONSTRUCTION CONTRACT IDENTIFICATION NUMBER
	ESTIMATED BY: <b>Moffatt &amp; Nichol</b> CATEGORY CODE NUMBER
PROJECT TITLE	STATUS OF DESIGN: JOB ORDER NUMBER

	Quantities	Price	Unit	Total Price
<b>Bulkhead &amp; Gate</b>				
Inspections (Completed Every 5 Years)	10	\$75,000	EACH	\$750,000.00
Minor Repairs (Years 15, 35, 45)	3	\$300,000	EACH	\$900,000.00
Major Repairs (Years 25 & 40)	2	\$1,000,000	EACH	\$2,000,000.00
Replacement of Rubber Dam (Year 30)	1	\$2,200,000	EACH	\$2,200,000.00
Operational Cost per Event (8 Events per Year)	400	\$500	EACH	\$200,000.00
<b>Pump Station</b>				
Maintenance Cost Per Generator Per Year (4 Gen Sets)	200	\$2,000	EACH	\$400,000.00
Operational Cost for Generator Per Event (Once Every 5 Yr)	40	\$40,000	EACH	\$1,600,000.00
Maintenance Cost Per Pump (Per Year Per Pump)	200	\$40,000	EACH	\$8,000,000.00
Replacement of Pumps (Year 30)	4	\$1,975,000	EACH	\$7,900,000.00
Operational Cost per Pump Per Event (8 Events per Year)	200	\$1,245	EACH	\$249,000.00
Operation Cost (City Employees - 2 Employees per Event)	19200	\$25	Hour	\$480,000.00
<b>Total</b>				<b>\$24,679,000.00</b>

**APPENDIX D**

**BENEFIT/COST RATIO CALCULATIONS**

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 2-60" PUMPS - 2 YR SURGE						
PROJ NO: DESIGNER: JDM						DATE: 19-Apr-11
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,211,756			
		0.50		\$19,579,002	\$9,787,543	\$9,787,543
0.500	2		\$21,946,248			
		0.40		\$31,726,980	\$12,690,792	\$22,478,335
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$25,315,023
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$26,556,918
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$27,387,231
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$377,964,229 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 2-60" PUMPS - 2 YR SURGE						
PROJ NO: DESIGNER: JDM						DATE: 19-Apr-11
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,452,865			
		0.50		\$18,778,579	\$9,387,412	\$9,387,412
0.500	2		\$20,104,294			
		0.4		\$30,806,003	\$12,322,401	\$21,709,813
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$24,546,501
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$25,788,396
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$26,618,709
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$367,358,052 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 2-60" PUMPS - 2 YR SURGE						
PROJ NO: DESIGNER: JDM						DATE: 19-Apr-11
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION
0.990	1		(\$241,108)			
		0.49		\$800,423	\$392,286	\$392,286
0.500	2		\$1,841,954			
		0.4		\$920,977	\$368,391	\$760,677
0.100	10		\$0			
		0.06		\$0	\$0	\$760,677
0.040	25		\$0			
		0.02		\$0	\$0	\$760,677
0.020	50		\$0			
		0.01		\$0	\$0	\$760,677
0.010	100		\$0			

7.00% INTEREST RATE  
50 YEARS  
\$10,497,911 PRESENT WORTH

**Inflatable Gate with Steel Bulkhead & Pumpstation with 2 - 60" Pumps**

\$48,500,000	PRESENT WORTH PROJECT COST	\$275,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$3,795,205	PRESENT WORTH O&M COSTS	\$52,295,205	PRESENT WORTH TOTAL PROJECT COST
0.20 B/C RATIO			

**Obermeyer Gate with Steel Bulkhead & Pumpstation with 2 - 60" Pumps**

\$43,900,000	PRESENT WORTH PROJECT COST	\$251,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$3,463,987	PRESENT WORTH O&M COSTS	\$47,363,987	PRESENT WORTH TOTAL PROJECT COST
0.22 B/C RATIO			

**Steel Gate with Steel Bulkhead & Pumpstation with 2 - 60" Pumps**

\$42,200,000	PRESENT WORTH PROJECT COST	\$231,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$3,187,972	PRESENT WORTH O&M COSTS	\$45,387,972	PRESENT WORTH TOTAL PROJECT COST
0.23 B/C RATIO			

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 2-60" PUMPS - 10 YR SURGE							
PROJ NO: DESIGNER: JDM DATE: 19-Apr-11							
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION	
1.000	1		\$17,211,756				
		0.50		\$19,579,002	\$9,787,543	\$9,787,543	
0.500	2		\$21,946,248				
		0.40		\$31,726,980	\$12,690,792	\$22,478,335	
0.100	10		\$41,507,713				
		0.06		\$47,278,132	\$2,836,688	\$25,315,023	
0.040	25		\$53,048,551				
		0.02		\$62,094,719	\$1,241,894	\$26,556,918	7.00% INTEREST RATE
0.020	50		\$71,140,888				50 YEARS
		0.01		\$83,031,352	\$830,314	\$27,387,231	\$377,964,229 PRESENT WORTH
0.010	100		\$94,921,815				
0.99							

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 2-60" PUMPS - 10 YR SURGE							
PROJ NO: DESIGNER: JDM DATE: 19-Apr-11							
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION	
1.000	1		\$17,452,865				
		0.50		\$18,778,579	\$9,387,412	\$9,387,412	
0.500	2		\$20,104,294				
		0.4		\$25,166,575	\$10,066,630	\$19,454,042	
0.100	10		\$30,228,856				
		0.06		\$41,638,703	\$2,498,322	\$21,952,364	
0.040	25		\$53,048,551				
		0.02		\$62,094,719	\$1,241,894	\$23,194,259	7.00% INTEREST RATE
0.020	50		\$71,140,888				50 YEARS
		0.01		\$83,031,352	\$830,314	\$24,024,572	\$331,557,024 PRESENT WORTH
0.010	100		\$94,921,815				
0.99							

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 2-60" PUMPS - 10 YR SURGE							
PROJ NO: DESIGNER: JDM DATE: 19-Apr-11							
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION	
0.990	1		(\$241,108)				
		0.49		\$800,423	\$392,286	\$392,286	
0.500	2		\$1,841,954				
		0.4		\$6,560,405	\$2,624,162	\$3,016,448	
0.100	10		\$11,278,857				
		0.06		\$5,639,428	\$338,366	\$3,354,814	
0.040	25		\$0				
		0.02		\$0	\$0	\$3,354,814	7.00% INTEREST RATE
0.020	50		\$0				50 YEARS
		0.01		\$0	\$0	\$3,354,814	\$46,298,939 PRESENT WORTH
0.010	100		\$0				

Inflatable Gate with Steel Bulkhead & Pumpstation with 2 - 60" Pumps	
\$52,200,000 PRESENT WORTH PROJECT COST	\$275,000 ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$3,795,205 PRESENT WORTH O&M COSTS	\$55,995,205 PRESENT WORTH TOTAL PROJECT COST
<b>0.83 B/C RATIO</b>	

Obermeyer Gate with Steel Bulkhead & Pumpstation with 2 - 60" Pumps	
\$47,200,000 PRESENT WORTH PROJECT COST	\$251,000 ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$3,463,987 PRESENT WORTH O&M COSTS	\$50,663,987 PRESENT WORTH TOTAL PROJECT COST
<b>0.91 B/C RATIO</b>	

Steel Gate with Steel Bulkhead & Pumpstation with 2 - 60" Pumps	
\$44,600,000 PRESENT WORTH PROJECT COST	\$231,000 ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$3,187,972 PRESENT WORTH O&M COSTS	\$47,787,972 PRESENT WORTH TOTAL PROJECT COST
<b>0.97 B/C RATIO</b>	

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 2-60" PUMPS - 25 YR SURGE						
PROJ NO:		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,211,756			
		0.50		\$19,579,002	\$9,787,543	\$9,787,543
0.500	2		\$21,946,248			
		0.40		\$31,726,980	\$12,690,792	\$22,478,335
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$25,315,023
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$26,556,918
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$27,387,231
0.010	100		\$94,921,815			
7.00% INTEREST RATE 50 YEARS \$377,964,229 PRESENT WORTH						
0.99						

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 2-60" PUMPS - 25 YR SURGE						
PROJ NO:		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,452,865			
		0.50		\$18,778,579	\$9,387,412	\$9,387,412
0.500	2		\$20,104,294			
		0.4		\$25,166,575	\$10,066,630	\$19,454,042
0.100	10		\$30,228,856			
		0.06		\$31,913,593	\$1,914,816	\$21,368,858
0.040	25		\$33,598,330			
		0.02		\$52,369,609	\$1,047,392	\$22,416,250
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$23,246,563
0.010	100		\$94,921,815			
7.00% INTEREST RATE 50 YEARS \$320,819,922 PRESENT WORTH						
0.99						

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 2-60" PUMPS - 25 YR SURGE						
PROJ NO:		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION
0.990	1		(\$241,108)			
		0.49		\$800,423	\$392,286	\$392,286
0.500	2		\$1,841,954			
		0.4		\$6,560,405	\$2,624,162	\$3,016,448
0.100	10		\$11,278,857			
		0.06		\$15,364,538	\$921,872	\$3,938,321
0.040	25		\$19,450,220			
		0.02		\$9,725,110	\$194,502	\$4,132,823
0.020	50		\$0			
		0.01		\$0	\$0	\$4,132,823
0.010	100		\$0			
7.00% INTEREST RATE 50 YEARS \$57,036,041 PRESENT WORTH						

Inflatable Gate with Steel Bulkhead & Pumpstation with 2 - 60" Pumps	
\$53,400,000 PRESENT WORTH PROJECT COST	\$275,000 ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$3,795,205 PRESENT WORTH O&M COSTS	\$57,195,205 PRESENT WORTH TOTAL PROJECT COST
1.00 B/C RATIO	

Obermeyer Gate with Steel Bulkhead & Pumpstation with 2 - 60" Pumps	
\$48,000,000 PRESENT WORTH PROJECT COST	\$251,000 ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$3,463,987 PRESENT WORTH O&M COSTS	\$51,463,987 PRESENT WORTH TOTAL PROJECT COST
1.11 B/C RATIO	

Steel Gate with Steel Bulkhead & Pumpstation with 2 - 60" Pumps	
\$45,100,000 PRESENT WORTH PROJECT COST	\$231,000 ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$3,187,972 PRESENT WORTH O&M COSTS	\$48,287,972 PRESENT WORTH TOTAL PROJECT COST
1.18 B/C RATIO	

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 2-60" PUMPS - 50 YR SURGE						
PROJ NO:		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,211,756			
		0.50		\$19,579,002	\$9,787,543	\$9,787,543
0.500	2		\$21,946,248			
		0.40		\$31,726,980	\$12,690,792	\$22,478,335
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$25,315,023
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$26,556,918
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$27,387,231
0.010	100		\$94,921,815			
7.00% INTEREST RATE 50 YEARS \$377,964,229 PRESENT WORTH						
0.99						

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 2-60" PUMPS - 50 YR SURGE						
PROJ NO:		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,452,865			
		0.50		\$18,778,579	\$9,387,412	\$9,387,412
0.500	2		\$20,104,294			
		0.4		\$25,166,575	\$10,066,630	\$19,454,042
0.100	10		\$30,228,856			
		0.06		\$31,913,593	\$1,914,816	\$21,368,858
0.040	25		\$33,598,330			
		0.02		\$35,624,809	\$712,496	\$22,081,354
0.020	50		\$37,651,287			
		0.01		\$66,286,551	\$662,866	\$22,744,219
0.010	100		\$94,921,815			
7.00% INTEREST RATE 50 YEARS \$313,887,200 PRESENT WORTH						
0.99						

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 2-60" PUMPS - 50 YR SURGE						
PROJ NO:		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION
0.990	1		(\$241,108)			
		0.49		\$800,423	\$392,286	\$392,286
0.500	2		\$1,841,954			
		0.4		\$6,560,405	\$2,624,162	\$3,016,448
0.100	10		\$11,278,857			
		0.06		\$15,364,538	\$921,872	\$3,938,321
0.040	25		\$19,450,220			
		0.02		\$26,469,910	\$529,398	\$4,467,719
0.020	50		\$33,489,601			
		0.01		\$16,744,800	\$167,448	\$4,635,167
0.010	100		\$0			
7.00% INTEREST RATE 50 YEARS \$63,968,764 PRESENT WORTH						

Inflatable Gate with Steel Bulkhead & Pumpstation with 2 - 60" Pumps			
<b>\$55,600,000</b>	PRESENT WORTH PROJECT COST	<b>\$275,000</b>	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
<b>\$3,795,205</b>	PRESENT WORTH O&M COSTS	<b>\$59,395,205</b>	PRESENT WORTH TOTAL PROJECT COST
<b>1.08</b> B/C RATIO			

Obermeyer Gate with Steel Bulkhead & Pumpstation with 2 - 60" Pumps			
<b>\$49,900,000</b>	PRESENT WORTH PROJECT COST	<b>\$251,000</b>	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
<b>\$3,463,987</b>	PRESENT WORTH O&M COSTS	<b>\$53,363,987</b>	PRESENT WORTH TOTAL PROJECT COST
<b>1.20</b> B/C RATIO			

Steel Gate with Steel Bulkhead & Pumpstation with 2 - 60" Pumps			
<b>\$46,800,000</b>	PRESENT WORTH PROJECT COST	<b>\$231,000</b>	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
<b>\$3,187,972</b>	PRESENT WORTH O&M COSTS	<b>\$49,987,972</b>	PRESENT WORTH TOTAL PROJECT COST
<b>1.28</b> B/C RATIO			

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 2-60" PUMPS - 100 YR SURGE						
PROJ NO: DESIGNER: JDM					DATE: 19-Apr-11	
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES	
					INTERVAL	SUMMATION
1.000	1		\$17,211,756			
		0.50		\$19,579,002	\$9,787,543	\$9,787,543
0.500	2		\$21,946,248			
		0.40		\$31,726,980	\$12,690,792	\$22,478,335
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$25,315,023
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$26,556,918
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$27,387,231
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$377,964,229 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 2-60" PUMPS - 100 YR SURGE						
PROJ NO: DESIGNER: JDM					DATE: 19-Apr-11	
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES	
					INTERVAL	SUMMATION
1.000	1		\$17,452,865			
		0.50		\$18,778,579	\$9,387,412	\$9,387,412
0.500	2		\$20,104,294			
		0.4		\$25,166,575	\$10,066,630	\$19,454,042
0.100	10		\$30,228,856			
		0.06		\$31,913,593	\$1,914,816	\$21,368,858
0.040	25		\$33,598,330			
		0.02		\$35,624,809	\$712,496	\$22,081,354
0.020	50		\$37,651,287			
		0.01		\$39,971,402	\$399,714	\$22,481,068
0.010	100		\$42,291,517			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$310,255,513 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 2-60" PUMPS - 100 YR SURGE						
PROJ NO: DESIGNER: JDM					DATE: 19-Apr-11	
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS	
					INTERVAL	SUMMATION
0.990	1		(\$241,108)			
		0.49		\$800,423	\$392,286	\$392,286
0.500	2		\$1,841,954			
		0.4		\$6,560,405	\$2,624,162	\$3,016,448
0.100	10		\$11,278,857			
		0.06		\$15,364,538	\$921,872	\$3,938,321
0.040	25		\$19,450,220			
		0.02		\$26,469,910	\$529,398	\$4,467,719
0.020	50		\$33,489,601			
		0.01		\$43,059,950	\$430,599	\$4,898,318
0.010	100		\$52,630,298			

7.00% INTEREST RATE  
50 YEARS  
\$67,600,451 PRESENT WORTH

**Inflatable Gate with Steel Bulkhead & Pumpstation with 2 - 60" Pumps**

\$56,700,000	PRESENT WORTH PROJECT COST	\$275,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$3,795,205	PRESENT WORTH O&M COSTS	\$60,495,205	PRESENT WORTH TOTAL PROJECT COST
1.12 B/C RATIO			

**Obermeyer Gate with Steel Bulkhead & Pumpstation with 2 - 60" Pumps**

\$50,800,000	PRESENT WORTH PROJECT COST	\$251,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$3,463,987	PRESENT WORTH O&M COSTS	\$54,263,987	PRESENT WORTH TOTAL PROJECT COST
1.25 B/C RATIO			

**Steel Gate with Steel Bulkhead & Pumpstation with 2 - 60" Pumps**

\$47,400,000	PRESENT WORTH PROJECT COST	\$231,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$3,187,972	PRESENT WORTH O&M COSTS	\$50,587,972	PRESENT WORTH TOTAL PROJECT COST
1.34 B/C RATIO			

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-60" PUMPS - 2 YR SURGE						
PROJ NO: DESIGNER: JDM					DATE: 19-Apr-11	
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,211,756			
		0.50		\$19,579,002	\$9,787,543	\$9,787,543
0.500	2		\$21,946,248			
		0.40		\$31,726,980	\$12,690,792	\$22,478,335
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$25,315,023
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$26,556,918
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$27,387,231
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$377,964,229 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 4-60" PUMPS - 2 YR SURGE						
PROJ NO: DESIGNER: JDM					DATE: 19-Apr-11	
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,448,169			
		0.50		\$18,779,798	\$9,388,021	\$9,388,021
0.500	2		\$20,111,427			
		0.4		\$30,809,570	\$12,323,828	\$21,711,849
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$24,548,537
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$25,790,431
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$26,620,745
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$367,386,148 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-60" PUMPS - 2 YR SURGE						
PROJ NO: DESIGNER: JDM					DATE: 19-Apr-11	
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION
0.990	1		(\$236,413)			
		0.49		\$799,204	\$391,689	\$391,689
0.500	2		\$1,834,821			
		0.4		\$917,410	\$366,964	\$758,653
0.100	10		\$0			
		0.06		\$0	\$0	\$758,653
0.040	25		\$0			
		0.02		\$0	\$0	\$758,653
0.020	50		\$0			
		0.01		\$0	\$0	\$758,653
0.010	100		\$0			

7.00% INTEREST RATE  
50 YEARS  
\$10,469,980 PRESENT WORTH

**Inflatable Gate with Steel Bulkhead & Pumpstation with 4 - 60" Pumps**

\$60,500,000	PRESENT WORTH PROJECT COST	\$404,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$5,575,502	PRESENT WORTH O&M COSTS	\$66,075,502	PRESENT WORTH TOTAL PROJECT COST
0.16 B/C RATIO			

**Obermeyer Gate with Steel Bulkhead & Pumpstation with 4 - 60" Pumps**

\$55,900,000	PRESENT WORTH PROJECT COST	\$380,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$5,244,284	PRESENT WORTH O&M COSTS	\$61,144,284	PRESENT WORTH TOTAL PROJECT COST
0.17 B/C RATIO			

**Steel Gate with Steel Bulkhead & Pumpstation with 4- 60" Pumps**

\$53,600,000	PRESENT WORTH PROJECT COST	\$360,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$4,968,269	PRESENT WORTH O&M COSTS	\$58,568,269	PRESENT WORTH TOTAL PROJECT COST
0.18 B/C RATIO			

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-60" PUMPS - 10 YR SURGE						
PROJ NO: DESIGNER: JDM						DATE: 19-Apr-11
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,211,756			
		0.50		\$19,579,002	\$9,787,543	\$9,787,543
0.500	2		\$21,946,248			
		0.40		\$31,726,980	\$12,690,792	\$22,478,335
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$25,315,023
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$26,556,918
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$27,387,231
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$377,964,229 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 4-60" PUMPS - 10 YR SURGE						
PROJ NO: DESIGNER: JDM						DATE: 19-Apr-11
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,448,169			
		0.50		\$18,779,798	\$9,388,021	\$9,388,021
0.500	2		\$20,111,427			
		0.4		\$25,169,106	\$10,067,642	\$19,455,663
0.100	10		\$30,226,784			
		0.06		\$41,637,667	\$2,498,260	\$21,953,924
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$23,195,818
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$24,026,131
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$331,578,544 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-60" PUMPS - 10 YR SURGE						
PROJ NO: DESIGNER: JDM						DATE: 19-Apr-11
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION
0.990	1		(\$236,413)			
		0.49		\$799,204	\$391,689	\$391,689
0.500	2		\$1,834,821			
		0.4		\$6,557,875	\$2,623,150	\$3,014,839
0.100	10		\$11,280,929			
		0.06		\$5,640,464	\$338,428	\$3,353,267
0.040	25		\$0			
		0.02		\$0	\$0	\$3,353,267
0.020	50		\$0			
		0.01		\$0	\$0	\$3,353,267
0.010	100		\$0			

7.00% INTEREST RATE  
50 YEARS  
\$46,277,584 PRESENT WORTH

**Inflatable Gate with Steel Bulkhead & Pumpstation with 4 - 60" Pumps**

\$63,800,000	PRESENT WORTH PROJECT COST	\$404,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$5,575,502	PRESENT WORTH O&M COSTS	\$69,375,502	PRESENT WORTH TOTAL PROJECT COST
0.67 B/C RATIO			

**Obermeyer Gate with Steel Bulkhead & Pumpstation with 4 - 60" Pumps**

\$58,700,000	PRESENT WORTH PROJECT COST	\$380,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$5,244,284	PRESENT WORTH O&M COSTS	\$63,944,284	PRESENT WORTH TOTAL PROJECT COST
0.72 B/C RATIO			

**Steel Gate with Steel Bulkhead & Pumpstation with 4- 60" Pumps**

\$56,100,000	PRESENT WORTH PROJECT COST	\$360,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$4,968,269	PRESENT WORTH O&M COSTS	\$61,068,269	PRESENT WORTH TOTAL PROJECT COST
0.76 B/C RATIO			

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-60" PUMPS - 25 YR SURGE						
PROJ NO: DESIGNER: JDM						DATE: 19-Apr-11
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,211,756			
		0.50		\$19,579,002	\$9,787,543	\$9,787,543
0.500	2		\$21,946,248			
		0.40		\$31,726,980	\$12,690,792	\$22,478,335
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$25,315,023
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$26,556,918
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$27,387,231
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$377,964,229 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 4-60" PUMPS - 25 YR SURGE						
PROJ NO: DESIGNER: JDM						DATE: 19-Apr-11
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,448,169			
		0.50		\$18,779,798	\$9,388,021	\$9,388,021
0.500	2		\$20,111,427			
		0.4		\$25,169,106	\$10,067,642	\$19,455,663
0.100	10		\$30,226,784			
		0.06		\$31,910,564	\$1,914,634	\$21,370,297
0.040	25		\$33,594,344			
		0.02		\$52,367,616	\$1,047,352	\$22,417,650
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$23,247,963
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$320,839,241 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-60" PUMPS - 25 YR SURGE						
PROJ NO: DESIGNER: JDM						DATE: 19-Apr-11
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION
0.990	1		(\$236,413)			
		0.49		\$799,204	\$391,689	\$391,689
0.500	2		\$1,834,821			
		0.4		\$6,557,875	\$2,623,150	\$3,014,839
0.100	10		\$11,280,929			
		0.06		\$15,367,568	\$922,054	\$3,936,893
0.040	25		\$19,454,207			
		0.02		\$9,727,103	\$194,542	\$4,131,435
0.020	50		\$0			
		0.01		\$0	\$0	\$4,131,435
0.010	100		\$0			

7.00% INTEREST RATE  
50 YEARS  
\$57,016,887 PRESENT WORTH

**Inflatable Gate with Steel Bulkhead & Pumpstation with 4 - 60" Pumps**

\$65,500,000	PRESENT WORTH PROJECT COST	\$404,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$5,575,502	PRESENT WORTH O&M COSTS	\$71,075,502	PRESENT WORTH TOTAL PROJECT COST
<b>0.80 B/C RATIO</b>			

**Obermeyer Gate with Steel Bulkhead & Pumpstation with 4 - 60" Pumps**

\$59,400,000	PRESENT WORTH PROJECT COST	\$380,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$5,244,284	PRESENT WORTH O&M COSTS	\$64,644,284	PRESENT WORTH TOTAL PROJECT COST
<b>0.88 B/C RATIO</b>			

**Steel Gate with Steel Bulkhead & Pumpstation with 4- 60" Pumps**

\$56,500,000	PRESENT WORTH PROJECT COST	\$360,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$4,968,269	PRESENT WORTH O&M COSTS	\$61,468,269	PRESENT WORTH TOTAL PROJECT COST
<b>0.93 B/C RATIO</b>			

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-60" PUMPS - 50 YR SURGE						
PROJ NO: DESIGNER: JDM						DATE: 19-Apr-11
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,211,756			
		0.50		\$19,579,002	\$9,787,543	\$9,787,543
0.500	2		\$21,946,248			
		0.40		\$31,726,980	\$12,690,792	\$22,478,335
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$25,315,023
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$26,556,918
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$27,387,231
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$377,964,229 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 4-60" PUMPS - 50 YR SURGE						
PROJ NO: DESIGNER: JDM						DATE: 19-Apr-11
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,448,169			
		0.50		\$18,779,798	\$9,388,021	\$9,388,021
0.500	2		\$20,111,427			
		0.4		\$25,169,106	\$10,067,642	\$19,455,663
0.100	10		\$30,226,784			
		0.06		\$31,910,564	\$1,914,634	\$21,370,297
0.040	25		\$33,594,344			
		0.02		\$35,318,439	\$706,369	\$22,076,666
0.020	50		\$37,042,534			
		0.01		\$65,982,175	\$659,822	\$22,736,488
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$313,780,500 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-60" PUMPS - 50 YR SURGE						
PROJ NO: DESIGNER: JDM						DATE: 19-Apr-11
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION
0.990	1		(\$236,413)			
		0.49		\$799,204	\$391,689	\$391,689
0.500	2		\$1,834,821			
		0.4		\$6,557,875	\$2,623,150	\$3,014,839
0.100	10		\$11,280,929			
		0.06		\$15,367,568	\$922,054	\$3,936,893
0.040	25		\$19,454,207			
		0.02		\$26,776,280	\$535,526	\$4,472,419
0.020	50		\$34,098,354			
		0.01		\$17,049,177	\$170,492	\$4,642,910
0.010	100		\$0			

7.00% INTEREST RATE  
50 YEARS  
\$64,075,628 PRESENT WORTH

**Inflatable Gate with Steel Bulkhead & Pumpstation with 4 - 60" Pumps**

\$67,600,000	PRESENT WORTH PROJECT COST	\$404,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$5,575,502	PRESENT WORTH O&M COSTS	\$73,175,502	PRESENT WORTH TOTAL PROJECT COST
<b>0.88 B/C RATIO</b>			

**Obermeyer Gate with Steel Bulkhead & Pumpstation with 4 - 60" Pumps**

\$61,900,000	PRESENT WORTH PROJECT COST	\$380,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$5,244,284	PRESENT WORTH O&M COSTS	\$67,144,284	PRESENT WORTH TOTAL PROJECT COST
<b>0.95 B/C RATIO</b>			

**Steel Gate with Steel Bulkhead & Pumpstation with 4- 60" Pumps**

\$58,800,000	PRESENT WORTH PROJECT COST	\$360,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$4,968,269	PRESENT WORTH O&M COSTS	\$63,768,269	PRESENT WORTH TOTAL PROJECT COST
<b>1.00 B/C RATIO</b>			

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-60" PUMPS - 100 YR SURGE						
PROJ NO:		DESIGNER: JDM	DATE: 19-Apr-11			
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES	
					INTERVAL	SUMMATION
1.000	1		\$17,211,756			
		0.50		\$19,579,002	\$9,787,543	\$9,787,543
0.500	2		\$21,946,248			
		0.40		\$31,726,980	\$12,690,792	\$22,478,335
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$25,315,023
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$26,556,918
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$27,387,231
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$377,964,229 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 4-60" PUMPS - 100 YR SURGE						
PROJ NO:		DESIGNER: JDM	DATE: 19-Apr-11			
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES	
					INTERVAL	SUMMATION
1.000	1		\$17,448,169			
		0.50		\$18,779,798	\$9,388,021	\$9,388,021
0.500	2		\$20,111,427			
		0.4		\$25,169,106	\$10,067,642	\$19,455,663
0.100	10		\$30,226,784			
		0.06		\$31,910,564	\$1,914,634	\$21,370,297
0.040	25		\$33,594,344			
		0.02		\$35,318,439	\$706,369	\$22,076,666
0.020	50		\$37,042,534			
		0.01		\$40,065,894	\$400,659	\$22,477,325
0.010	100		\$43,089,254			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$310,203,860 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-60" PUMPS - 100 YR SURGE						
PROJ NO:		DESIGNER: JDM	DATE: 19-Apr-11			
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS	
					INTERVAL	SUMMATION
0.990	1		(\$236,413)			
		0.49		\$799,204	\$391,689	\$391,689
0.500	2		\$1,834,821			
		0.4		\$6,557,875	\$2,623,150	\$3,014,839
0.100	10		\$11,280,929			
		0.06		\$15,367,568	\$922,054	\$3,936,893
0.040	25		\$19,454,207			
		0.02		\$26,776,280	\$535,526	\$4,472,419
0.020	50		\$34,098,354			
		0.01		\$42,965,458	\$429,655	\$4,902,073
0.010	100		\$51,832,561			

7.00% INTEREST RATE  
50 YEARS  
\$67,652,268 PRESENT WORTH

Inflatable Gate with Steel Bulkhead & Pumpstation with 4 - 60" Pumps			
\$68,700,000	PRESENT WORTH PROJECT COST	\$404,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$5,575,502	PRESENT WORTH O&M COSTS	\$74,275,502	PRESENT WORTH TOTAL PROJECT COST
0.91 B/C RATIO			

Obermeyer Gate with Steel Bulkhead & Pumpstation with 4 - 60" Pumps			
\$62,300,000	PRESENT WORTH PROJECT COST	\$380,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$5,244,284	PRESENT WORTH O&M COSTS	\$67,544,284	PRESENT WORTH TOTAL PROJECT COST
1.00 B/C RATIO			

Steel Gate with Steel Bulkhead & Pumpstation with 4- 60" Pumps			
\$59,500,000	PRESENT WORTH PROJECT COST	\$360,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$4,968,269	PRESENT WORTH O&M COSTS	\$64,468,269	PRESENT WORTH TOTAL PROJECT COST
1.05 B/C RATIO			

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-96" PUMPS - 2 YR SURGE						
PROJ NO: DESIGNER: JDM			DATE: 19-Apr-11			
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES	
					INTERVAL	SUMMATION
1.000	1		\$17,211,756			
		0.50		\$19,579,002	\$9,787,543	\$9,787,543
0.500	2		\$21,946,248			
		0.40		\$31,726,980	\$12,690,792	\$22,478,335
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$25,315,023
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$26,556,918
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$27,387,231
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$377,964,229 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 4-96" PUMPS - 2 YR SURGE						
PROJ NO: DESIGNER: JDM			DATE: 19-Apr-11			
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES	
					INTERVAL	SUMMATION
1.000	1		\$17,463,659			
		0.50		\$18,781,776	\$9,389,010	\$9,389,010
0.500	2		\$20,099,894			
		0.4		\$30,803,803	\$12,321,521	\$21,710,532
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$24,547,219
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$25,789,114
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$26,619,427
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$367,367,964 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-96" PUMPS - 2 YR SURGE						
PROJ NO: DESIGNER: JDM			DATE: 19-Apr-11			
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS	
					INTERVAL	SUMMATION
0.990	1		(\$251,903)			
		0.49		\$797,226	\$390,719	\$390,719
0.500	2		\$1,846,354			
		0.4		\$923,177	\$369,271	\$759,990
0.100	10		\$0			
		0.06		\$0	\$0	\$759,990
0.040	25		\$0			
		0.02		\$0	\$0	\$759,990
0.020	50		\$0			
		0.01		\$0	\$0	\$759,990
0.010	100		\$0			

7.00% INTEREST RATE  
50 YEARS  
\$10,488,432 PRESENT WORTH

**Inflatable Gate with Steel Bulkhead & Pumpstation with 4 - 96" Pumps**

\$95,000,000	PRESENT WORTH PROJECT COST	\$509,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$7,024,580	PRESENT WORTH O&M COSTS	\$102,024,580	PRESENT WORTH TOTAL PROJECT COST
0.10 B/C RATIO			

**Obermeyer Gate with Steel Bulkhead & Pumpstation with 4 - 96" Pumps**

\$90,500,000	PRESENT WORTH PROJECT COST	\$485,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$6,693,362	PRESENT WORTH O&M COSTS	\$97,193,362	PRESENT WORTH TOTAL PROJECT COST
0.11 B/C RATIO			

**Steel Gate with Steel Bulkhead & Pumpstation with 4 - 96" Pumps**

\$88,800,000	PRESENT WORTH PROJECT COST	\$465,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$6,417,347	PRESENT WORTH O&M COSTS	\$95,217,347	PRESENT WORTH TOTAL PROJECT COST
0.11 B/C RATIO			

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-96" PUMPS - 10 YR SURGE						
PROJ NO: DESIGNER: JDM						DATE: 19-Apr-11
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,211,756			
		0.50		\$19,579,002	\$9,787,543	\$9,787,543
0.500	2		\$21,946,248			
		0.40		\$31,726,980	\$12,690,792	\$22,478,335
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$25,315,023
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$26,556,918
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$27,387,231
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$377,964,229 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 4-96" PUMPS - 10 YR SURGE						
PROJ NO: DESIGNER: JDM						DATE: 19-Apr-11
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,463,659			
		0.50		\$18,781,776	\$9,389,010	\$9,389,010
0.500	2		\$20,099,894			
		0.4		\$25,158,503	\$10,063,401	\$19,452,411
0.100	10		\$30,217,112			
		0.06		\$41,632,831	\$2,497,970	\$21,950,381
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$23,192,276
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$24,022,589
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$331,529,660 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-96" PUMPS - 10 YR SURGE						
PROJ NO: DESIGNER: JDM						DATE: 19-Apr-11
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION
0.990	1		(\$251,903)			
		0.49		\$797,226	\$390,719	\$390,719
0.500	2		\$1,846,354			
		0.4		\$6,568,477	\$2,627,391	\$3,018,110
0.100	10		\$11,290,600			
		0.06		\$5,645,300	\$338,718	\$3,356,828
0.040	25		\$0			
		0.02		\$0	\$0	\$3,356,828
0.020	50		\$0			
		0.01		\$0	\$0	\$3,356,828
0.010	100		\$0			

7.00% INTEREST RATE  
50 YEARS  
\$46,326,736 PRESENT WORTH

**Inflatable Gate with Steel Bulkhead & Pumpstation with 4 - 96" Pumps**

\$97,900,000	PRESENT WORTH PROJECT COST	\$509,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$7,024,580	PRESENT WORTH O&M COSTS	\$104,924,580	PRESENT WORTH TOTAL PROJECT COST
0.44 B/C RATIO			

**Obermeyer Gate with Steel Bulkhead & Pumpstation with 4 - 96" Pumps**

\$92,700,000	PRESENT WORTH PROJECT COST	\$485,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$6,693,362	PRESENT WORTH O&M COSTS	\$99,393,362	PRESENT WORTH TOTAL PROJECT COST
0.47 B/C RATIO			

**Steel Gate with Steel Bulkhead & Pumpstation with 4 - 96" Pumps**

\$90,100,000	PRESENT WORTH PROJECT COST	\$465,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$6,417,347	PRESENT WORTH O&M COSTS	\$96,517,347	PRESENT WORTH TOTAL PROJECT COST
0.48 B/C RATIO			

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-96" PUMPS - 25 YR SURGE						
PROJ NO: DESIGNER: JDM					DATE: 19-Apr-11	
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES	
					INTERVAL	SUMMATION
1.000	1		\$17,211,756			
		0.50		\$19,579,002	\$9,787,543	\$9,787,543
0.500	2		\$21,946,248			
		0.40		\$31,726,980	\$12,690,792	\$22,478,335
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$25,315,023
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$26,556,918
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$27,387,231
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$377,964,229 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 4-96" PUMPS - 25 YR SURGE						
PROJ NO: DESIGNER: JDM					DATE: 19-Apr-11	
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES	
					INTERVAL	SUMMATION
1.000	1		\$17,463,659			
		0.50		\$18,781,776	\$9,389,010	\$9,389,010
0.500	2		\$20,099,894			
		0.4		\$25,158,503	\$10,063,401	\$19,452,411
0.100	10		\$30,217,112			
		0.06		\$31,904,244	\$1,914,255	\$21,366,666
0.040	25		\$33,591,375			
		0.02		\$52,366,131	\$1,047,323	\$22,413,989
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$23,244,302
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$320,788,718 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-96" PUMPS - 25 YR SURGE						
PROJ NO: DESIGNER: JDM					DATE: 19-Apr-11	
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS	
					INTERVAL	SUMMATION
0.990	1		(\$251,903)			
		0.49		\$797,226	\$390,719	\$390,719
0.500	2		\$1,846,354			
		0.4		\$6,568,477	\$2,627,391	\$3,018,110
0.100	10		\$11,290,600			
		0.06		\$15,373,888	\$922,433	\$3,940,544
0.040	25		\$19,457,176			
		0.02		\$9,728,588	\$194,572	\$4,135,115
0.020	50		\$0			
		0.01		\$0	\$0	\$4,135,115
0.010	100		\$0			

7.00% INTEREST RATE  
50 YEARS  
\$57,067,678 PRESENT WORTH

**Inflatable Gate with Steel Bulkhead & Pumpstation with 4 - 96" Pumps**

\$98,900,000	PRESENT WORTH PROJECT COST	\$509,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$7,024,580	PRESENT WORTH O&M COSTS	\$105,924,580	PRESENT WORTH TOTAL PROJECT COST
<b>0.54 B/C RATIO</b>			

**Obermeyer Gate with Steel Bulkhead & Pumpstation with 4 - 96" Pumps**

\$93,500,000	PRESENT WORTH PROJECT COST	\$485,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$6,693,362	PRESENT WORTH O&M COSTS	\$100,193,362	PRESENT WORTH TOTAL PROJECT COST
<b>0.57 B/C RATIO</b>			

**Steel Gate with Steel Bulkhead & Pumpstation with 4 - 96" Pumps**

\$90,600,000	PRESENT WORTH PROJECT COST	\$465,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$6,417,347	PRESENT WORTH O&M COSTS	\$97,017,347	PRESENT WORTH TOTAL PROJECT COST
<b>0.59 B/C RATIO</b>			

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-96" PUMPS - 50 YR SURGE						
PROJ NO: DESIGNER: JDM				DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,211,756			
		0.50		\$19,579,002	\$9,787,543	\$9,787,543
0.500	2		\$21,946,248			
		0.40		\$31,726,980	\$12,690,792	\$22,478,335
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$25,315,023
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$26,556,918
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$27,387,231
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$377,964,229 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 4-96" PUMPS - 50 YR SURGE						
PROJ NO: DESIGNER: JDM				DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,463,659			
		0.50		\$18,781,776	\$9,389,010	\$9,389,010
0.500	2		\$20,099,894			
		0.4		\$25,158,503	\$10,063,401	\$19,452,411
0.100	10		\$30,217,112			
		0.06		\$31,904,244	\$1,914,255	\$21,366,666
0.040	25		\$33,591,375			
		0.02		\$35,343,999	\$706,880	\$22,073,546
0.020	50		\$37,096,622			
		0.01		\$66,009,219	\$660,092	\$22,733,638
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$313,741,174 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-96" PUMPS - 50 YR SURGE						
PROJ NO: DESIGNER: JDM				DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION
0.990	1		(\$251,903)			
		0.49		\$797,226	\$390,719	\$390,719
0.500	2		\$1,846,354			
		0.4		\$6,568,477	\$2,627,391	\$3,018,110
0.100	10		\$11,290,600			
		0.06		\$15,373,888	\$922,433	\$3,940,544
0.040	25		\$19,457,176			
		0.02		\$26,750,720	\$535,014	\$4,475,558
0.020	50		\$34,044,265			
		0.01		\$17,022,133	\$170,221	\$4,645,779
0.010	100		\$0			

7.00% INTEREST RATE  
50 YEARS  
\$64,115,222 PRESENT WORTH

**Inflatable Gate with Steel Bulkhead & Pumpstation with 4 - 96" Pumps**

\$101,100,000	PRESENT WORTH PROJECT COST	\$509,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$7,024,580	PRESENT WORTH O&M COSTS	\$108,124,580	PRESENT WORTH TOTAL PROJECT COST
0.59 B/C RATIO			

**Obermeyer Gate with Steel Bulkhead & Pumpstation with 4 - 96" Pumps**

\$96,500,000	PRESENT WORTH PROJECT COST	\$485,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$6,693,362	PRESENT WORTH O&M COSTS	\$103,193,362	PRESENT WORTH TOTAL PROJECT COST
0.62 B/C RATIO			

**Steel Gate with Steel Bulkhead & Pumpstation with 4 - 96" Pumps**

\$93,400,000	PRESENT WORTH PROJECT COST	\$465,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$6,417,347	PRESENT WORTH O&M COSTS	\$99,817,347	PRESENT WORTH TOTAL PROJECT COST
0.64 B/C RATIO			

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-96" PUMPS - 100 YR SURGE						
PROJ NO:		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,211,756			
		0.50		\$19,579,002	\$9,787,543	\$9,787,543
0.500	2		\$21,946,248			
		0.40		\$31,726,980	\$12,690,792	\$22,478,335
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$25,315,023
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$26,556,918
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$27,387,231
0.010	100		\$94,921,815			
7.00% INTEREST RATE 50 YEARS \$377,964,229 PRESENT WORTH						
0.99						

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 4-96" PUMPS - 100 YR SURGE						
PROJ NO:		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$17,463,659			
		0.50		\$18,781,776	\$9,389,010	\$9,389,010
0.500	2		\$20,099,894			
		0.4		\$25,158,503	\$10,063,401	\$19,452,411
0.100	10		\$30,217,112			
		0.06		\$31,904,244	\$1,914,255	\$21,366,666
0.040	25		\$33,591,375			
		0.02		\$35,343,999	\$706,880	\$22,073,546
0.020	50		\$37,096,622			
		0.01		\$40,092,564	\$400,926	\$22,474,472
0.010	100		\$43,088,505			
7.00% INTEREST RATE 50 YEARS \$310,164,482 PRESENT WORTH						
0.99						

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 4-96" PUMPS - 100 YR SURGE						
PROJ NO:		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION
0.990	1		(\$251,903)			
		0.49		\$797,226	\$390,719	\$390,719
0.500	2		\$1,846,354			
		0.4		\$6,568,477	\$2,627,391	\$3,018,110
0.100	10		\$11,290,600			
		0.06		\$15,373,888	\$922,433	\$3,940,544
0.040	25		\$19,457,176			
		0.02		\$26,750,720	\$535,014	\$4,475,558
0.020	50		\$34,044,265			
		0.01		\$42,938,788	\$429,388	\$4,904,946
0.010	100		\$51,833,310			
7.00% INTEREST RATE 50 YEARS \$67,691,913 PRESENT WORTH						

Inflatable Gate with Steel Bulkhead & Pumpstation with 4 - 96" Pumps	
\$102,200,000 PRESENT WORTH PROJECT COST	\$509,000 ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$7,024,580 PRESENT WORTH O&M COSTS	\$109,224,580 PRESENT WORTH TOTAL PROJECT COST
0.62 B/C RATIO	

Obermeyer Gate with Steel Bulkhead & Pumpstation with 4 - 96" Pumps	
\$97,400,000 PRESENT WORTH PROJECT COST	\$485,000 ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$6,693,362 PRESENT WORTH O&M COSTS	\$104,093,362 PRESENT WORTH TOTAL PROJECT COST
0.65 B/C RATIO	

Steel Gate with Steel Bulkhead & Pumpstation with 4 - 96" Pumps	
\$94,000,000 PRESENT WORTH PROJECT COST	\$465,000 ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$6,417,347 PRESENT WORTH O&M COSTS	\$100,417,347 PRESENT WORTH TOTAL PROJECT COST
0.67 B/C RATIO	

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT:		CITY OF NORFOLK - HAGUE - 2-yr Bulkhead - SURGE				DATE:		20-Apr-11
PROJ NO:		DESIGNER: JDM						
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION		
1.000	1		\$17,211,756					
		0.50		\$19,579,002	\$9,787,543	\$9,787,543		
0.500	2		\$21,946,248					
		0.40		\$31,726,980	\$12,690,792	\$22,478,335		
0.100	10		\$41,507,713					
		0.06		\$47,278,132	\$2,836,688	\$25,315,023		
0.040	25		\$53,048,551					
		0.02		\$62,094,719	\$1,241,894	\$26,556,918	7.00% INTEREST RATE	
0.020	50		\$71,140,888				50 YEARS	
		0.01		\$83,031,352	\$830,314	\$27,387,231	\$377,964,229 PRESENT WORTH	
0.010	100		\$94,921,815					
0.99								

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT:		CITY OF NORFOLK - HAGUE - 2-yr Bulkhead - SURGE				DATE:		20-Apr-11
PROJ NO:		DESIGNER: JDM						
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION		
1.000	1		\$16,843,327					
		0.50		\$19,106,893	\$9,551,536	\$9,551,536		
0.500	2		\$21,370,458					
		0.4		\$31,439,086	\$12,575,634	\$22,127,170		
0.100	10		\$41,507,713					
		0.06		\$47,278,132	\$2,836,688	\$24,963,858		
0.040	25		\$53,048,551					
		0.02		\$62,094,719	\$1,241,894	\$26,205,752	7.00% INTEREST RATE	
0.020	50		\$71,140,888				50 YEARS	
		0.01		\$83,031,352	\$830,314	\$27,036,066	\$373,117,887 PRESENT WORTH	
0.010	100		\$94,921,815					
0.99								

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT:		CITY OF NORFOLK - HAGUE - 2-yr Bulkhead - SURGE				DATE:		20-Apr-11
PROJ NO:		DESIGNER: JDM						
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION		
0.990	1		\$368,429					
		0.49		\$472,109	\$231,380	\$231,380		
0.500	2		\$575,789					
		0.4		\$287,895	\$115,158	\$346,538		
0.100	10		\$0					
		0.06		\$0	\$0	\$346,538		
0.040	25		\$0					
		0.02		\$0	\$0	\$346,538	7.00% INTEREST RATE	
0.020	50		\$0				50 YEARS	
		0.01		\$0	\$0	\$346,538	\$4,782,484 PRESENT WORTH	
0.010	100		\$0					

Hague Floodwall, Earthen Berm and Bulkhead	
\$19,400,000 PRESENT WORTH PROJECT COST	\$97,000 ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$1,338,672 PRESENT WORTH O&M COSTS	\$20,738,672 PRESENT WORTH TOTAL PROJECT COST
0.23 B/C RATIO	

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT:		CITY OF NORFOLK - HAGUE - 10-yr Bulkhead - SURGE				DATE:	
PROJ NO:		DESIGNER: JDM				20-Apr-11	
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	SUMMATION	
1.000	1		\$17,211,756				
		0.50		\$19,579,002	\$9,787,543	\$9,787,543	
0.500	2		\$21,946,248				
		0.40		\$31,726,980	\$12,690,792	\$22,478,335	
0.100	10		\$41,507,713				
		0.06		\$47,278,132	\$2,836,688	\$25,315,023	
0.040	25		\$53,048,551				
		0.02		\$62,094,719	\$1,241,894	\$26,556,918	
0.020	50		\$71,140,888				
		0.01		\$83,031,352	\$830,314	\$27,387,231	
0.010	100		\$94,921,815				
							0.99

7.00% INTEREST RATE  
50 YEARS  
PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT:		CITY OF NORFOLK - HAGUE - 10-yr Bulkhead - SURGE				DATE:	
PROJ NO:		DESIGNER: JDM				20-Apr-11	
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	SUMMATION	
1.000	1		\$16,843,327				
		0.50		\$19,106,893	\$9,551,536	\$9,551,536	
0.500	2		\$21,370,458				
		0.4		\$30,480,076	\$12,192,030	\$21,743,566	
0.100	10		\$39,589,693				
		0.06		\$46,319,122	\$2,779,147	\$24,522,714	
0.040	25		\$53,048,551				
		0.02		\$62,094,719	\$1,241,894	\$25,764,608	
0.020	50		\$71,140,888				
		0.01		\$83,031,352	\$830,314	\$26,594,922	
0.010	100		\$94,921,815				
							0.99

7.00% INTEREST RATE  
50 YEARS  
PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT:		CITY OF NORFOLK - HAGUE - 10-yr Bulkhead - SURGE				DATE:	
PROJ NO:		DESIGNER: JDM				20-Apr-11	
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	SUMMATION	
0.990	1		\$368,429				
		0.49		\$472,109	\$231,380	\$231,380	
0.500	2		\$575,789				
		0.4		\$1,246,904	\$498,762	\$730,142	
0.100	10		\$1,918,019				
		0.06		\$959,010	\$57,541	\$787,682	
0.040	25		\$0				
		0.02		\$0	\$0	\$787,682	
0.020	50		\$0				
		0.01		\$0	\$0	\$787,682	
0.010	100		\$0				

7.00% INTEREST RATE  
50 YEARS  
PRESENT WORTH

**\$10,870,606**

<b>Hague Floodwall, Earthen Berm and Bulkhead</b>			
<b>\$22,400,000</b>	PRESENT WORTH PROJECT COST	<b>\$112,000</b>	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
<b>\$1,545,684</b>	PRESENT WORTH O&M COSTS	<b>\$23,945,684</b>	PRESENT WORTH TOTAL PROJECT COST
		<b>0.45</b>	B/C RATIO

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT:		CITY OF NORFOLK - HAGUE - 25-yr Bulkhead - SURGE				DATE:		20-Apr-11
PROJ NO:		DESIGNER: JDM						
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION		
1.000	1		\$17,211,756					
		0.50		\$19,579,002	\$9,787,543	\$9,787,543		
0.500	2		\$21,946,248					
		0.40		\$31,726,980	\$12,690,792	\$22,478,335		
0.100	10		\$41,507,713					
		0.06		\$47,278,132	\$2,836,688	\$25,315,023		
0.040	25		\$53,048,551					
		0.02		\$62,094,719	\$1,241,894	\$26,556,918		7.00% INTEREST RATE
0.020	50		\$71,140,888					50 YEARS
		0.01		\$83,031,352	\$830,314	\$27,387,231		PRESENT WORTH
0.010	100		\$94,921,815					
0.99								

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT:		CITY OF NORFOLK - HAGUE - 25-yr Bulkhead - SURGE				DATE:		20-Apr-11
PROJ NO:		DESIGNER: JDM						
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION		
1.000	1		\$16,843,327					
		0.50		\$19,106,893	\$9,551,536	\$9,551,536		
0.500	2		\$21,370,458					
		0.4		\$30,480,076	\$12,192,030	\$21,743,566		
0.100	10		\$39,589,693					
		0.06		\$43,973,965	\$2,638,438	\$24,382,004		
0.040	25		\$48,358,237					
		0.02		\$59,749,562	\$1,194,991	\$25,576,995		7.00% INTEREST RATE
0.020	50		\$71,140,888					50 YEARS
		0.01		\$83,031,352	\$830,314	\$26,407,309		PRESENT WORTH
0.010	100		\$94,921,815					
0.99								

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT:		CITY OF NORFOLK - HAGUE - 25-yr Bulkhead - SURGE				DATE:		20-Apr-11
PROJ NO:		DESIGNER: JDM						
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION		
0.990	1		\$368,429					
		0.49		\$472,109	\$231,380	\$231,380		
0.500	2		\$575,789					
		0.4		\$1,246,904	\$498,762	\$730,142		
0.100	10		\$1,918,019					
		0.06		\$3,304,167	\$198,250	\$928,392		
0.040	25		\$4,690,314					
		0.02		\$2,345,157	\$46,903	\$975,295		7.00% INTEREST RATE
0.020	50		\$0					50 YEARS
		0.01		\$0	\$0	\$975,295	\$13,459,800	PRESENT WORTH
0.010	100		\$0					

**Hague Floodwall, Earthen Berm and Bulkhead**

\$23,400,000	PRESENT WORTH PROJECT COST	\$117,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$1,614,687	PRESENT WORTH O&M COSTS	\$25,014,687	PRESENT WORTH TOTAL PROJECT COST
		0.54	B/C RATIO

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT:		CITY OF NORFOLK - HAGUE - 50-yr Bulkhead - SURGE				DATE:		20-Apr-11
PROJ NO:		DESIGNER: JDM						
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION		
1.000	1		\$17,211,756					
		0.50		\$19,579,002	\$9,787,543	\$9,787,543		
0.500	2		\$21,946,248					
		0.40		\$31,726,980	\$12,690,792	\$22,478,335		
0.100	10		\$41,507,713					
		0.06		\$47,278,132	\$2,836,688	\$25,315,023		
0.040	25		\$53,048,551					
		0.02		\$62,094,719	\$1,241,894	\$26,556,918		7.00% INTEREST RATE
0.020	50		\$71,140,888					50 YEARS
		0.01		\$83,031,352	\$830,314	\$27,387,231		PRESENT WORTH
0.010	100		\$94,921,815					
		0.99						

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT:		CITY OF NORFOLK - HAGUE - 50-yr Bulkhead - SURGE				DATE:		20-Apr-11
PROJ NO:		DESIGNER: JDM						
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION		
1.000	1		\$16,843,327					
		0.50		\$19,106,893	\$9,551,536	\$9,551,536		
0.500	2		\$21,370,458					
		0.4		\$30,480,076	\$12,192,030	\$21,743,566		
0.100	10		\$39,589,693					
		0.06		\$43,973,965	\$2,638,438	\$24,382,004		
0.040	25		\$48,358,237					
		0.02		\$55,844,672	\$1,116,893	\$25,498,898		7.00% INTEREST RATE
0.020	50		\$63,331,106					50 YEARS
		0.01		\$79,126,461	\$791,265	\$26,290,162		PRESENT WORTH
0.010	100		\$94,921,815					
		0.99						

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT:		CITY OF NORFOLK - HAGUE - 50-yr Bulkhead - SURGE				DATE:		20-Apr-11
PROJ NO:		DESIGNER: JDM						
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION		
0.990	1		\$368,429					
		0.49		\$472,109	\$231,380	\$231,380		
0.500	2		\$575,789					
		0.4		\$1,246,904	\$498,762	\$730,142		
0.100	10		\$1,918,019					
		0.06		\$3,304,167	\$198,250	\$928,392		
0.040	25		\$4,690,314					
		0.02		\$6,250,048	\$125,001	\$1,053,393		7.00% INTEREST RATE
0.020	50		\$7,809,781					50 YEARS
		0.01		\$3,904,891	\$39,049	\$1,092,442	\$15,076,512	PRESENT WORTH
0.010	100		\$0					

<b>Hague Floodwall, Earthen Berm and Bulkhead</b>	
\$25,400,000 PRESENT WORTH PROJECT COST	\$127,000 ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$1,752,695 PRESENT WORTH O&M COSTS	\$27,152,695 PRESENT WORTH TOTAL PROJECT COST
<b>0.56 B/C RATIO</b>	

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT:		CITY OF NORFOLK - HAGUE - 100-yr Bulkhead - SURGE				DATE:		20-Apr-11
PROJ NO:		DESIGNER: JDM						
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION		
1.000	1		\$17,211,756					
		0.50		\$19,579,002	\$9,787,543	\$9,787,543		
0.500	2		\$21,946,248					
		0.40		\$31,726,980	\$12,690,792	\$22,478,335		
0.100	10		\$41,507,713					
		0.06		\$47,278,132	\$2,836,688	\$25,315,023		
0.040	25		\$53,048,551					
		0.02		\$62,094,719	\$1,241,894	\$26,556,918		
0.020	50		\$71,140,888					
		0.01		\$83,031,352	\$830,314	\$27,387,231		
0.010	100		\$94,921,815					
		0.99						

7.00% INTEREST RATE  
50 YEARS  
\$377,964,229 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT:		CITY OF NORFOLK - HAGUE - 100-yr Bulkhead - SURGE				DATE:		20-Apr-11
PROJ NO:		DESIGNER: JDM						
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION		
1.000	1		\$16,843,327					
		0.50		\$19,106,893	\$9,551,536	\$9,551,536		
0.500	2		\$21,370,458					
		0.4		\$30,480,076	\$12,192,030	\$21,743,566		
0.100	10		\$39,589,693					
		0.06		\$43,973,965	\$2,638,438	\$24,382,004		
0.040	25		\$48,358,237					
		0.02		\$55,844,672	\$1,116,893	\$25,498,898		
0.020	50		\$63,331,106					
		0.01		\$72,653,712	\$726,537	\$26,225,435		
0.010	100		\$81,976,317					
		0.99						

7.00% INTEREST RATE  
50 YEARS  
\$361,930,572 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT:		CITY OF NORFOLK - HAGUE - 100-yr Bulkhead - SURGE				DATE:		20-Apr-11
PROJ NO:		DESIGNER: JDM						
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION		
0.990	1		\$368,429					
		0.49		\$472,109	\$231,380	\$231,380		
0.500	2		\$575,789					
		0.4		\$1,246,904	\$498,762	\$730,142		
0.100	10		\$1,918,019					
		0.06		\$3,304,167	\$198,250	\$928,392		
0.040	25		\$4,690,314					
		0.02		\$6,250,048	\$125,001	\$1,053,393		
0.020	50		\$7,809,781					
		0.01		\$10,377,640	\$103,776	\$1,157,169		
0.010	100		\$12,945,498					

7.00% INTEREST RATE  
50 YEARS  
\$15,969,799 PRESENT WORTH

Hague Floodwall, Earthen Berm and Bulkhead			
\$26,400,000	PRESENT WORTH PROJECT COST	\$132,000	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$1,821,699	PRESENT WORTH O&M COSTS	\$28,221,699	PRESENT WORTH TOTAL PROJECT COST
		0.57	B/C RATIO

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 2 YR BUYOUT		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$18,910,700			
		0.50		\$20,428,474	\$10,212,194	\$10,212,194
0.500	2		\$21,946,248			
		0.40		\$31,726,980	\$12,690,792	\$22,902,986
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$25,739,674
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$26,981,569
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$27,811,882
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$383,824,731 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 2 YR BUYOUT		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$15,681,737			
		0.50		\$16,915,823	\$8,456,220	\$8,456,220
0.500	2		\$18,149,909			
		0.4		\$27,388,134	\$10,955,254	\$19,411,473
0.100	10		\$36,626,359			
		0.06		\$41,904,538	\$2,514,272	\$21,925,746
0.040	25		\$47,182,716			
		0.02		\$55,870,488	\$1,117,410	\$23,043,155
0.020	50		\$64,558,260			
		0.01		\$76,110,887	\$761,109	\$23,804,264
0.010	100		\$87,663,514			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$328,516,613 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 2 YR BUYOUT		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION
0.990	1		\$3,228,964			
		0.49		\$3,512,651	\$1,721,547	\$1,721,547
0.500	2		\$3,796,339			
		0.4		\$4,338,846	\$1,735,539	\$3,457,086
0.100	10		\$4,881,354			
		0.06		\$5,373,594	\$322,416	\$3,779,501
0.040	25		\$5,865,834			
		0.02		\$6,224,231	\$124,485	\$3,903,986
0.020	50		\$6,582,628			
		0.01		\$6,920,465	\$69,205	\$3,973,190
0.010	100		\$7,258,302			

7.00% INTEREST RATE  
50 YEARS  
\$54,832,993 PRESENT WORTH

Hague Buyout 20% Damage Level	
\$31,308,900 PRESENT WORTH PROJECT COST	\$344,398 ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$4,752,948 PRESENT WORTH O&M COSTS	\$36,061,848 PRESENT WORTH TOTAL PROJECT COST
1.52 B/C RATIO	

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 10 YR BUYOUT						
PROJ NO:		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1	0.50	\$18,910,700	\$20,428,474	\$10,212,194	\$10,212,194
0.500	2	0.40	\$21,946,248	\$31,726,980	\$12,690,792	\$22,902,986
0.100	10	0.06	\$41,507,713	\$47,278,132	\$2,836,688	\$25,739,674
0.040	25	0.02	\$53,048,551	\$62,094,719	\$1,241,894	\$26,981,569
0.020	50	0.01	\$71,140,888	\$83,031,352	\$830,314	\$27,811,882
0.010	100		\$94,921,815			\$383,824,731
0.99						

7.00% INTEREST RATE  
50 YEARS  
PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 10 YR BUYOUT						
PROJ NO:		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1	0.50	\$14,112,344	\$15,078,258	\$7,537,621	\$7,537,621
0.500	2	0.4	\$16,044,171	\$24,641,261	\$9,856,504	\$17,394,125
0.100	10	0.06	\$33,238,350	\$38,156,140	\$2,289,368	\$19,683,494
0.040	25	0.02	\$43,073,929	\$51,490,297	\$1,029,806	\$20,713,300
0.020	50	0.01	\$59,906,665	\$71,159,805	\$711,598	\$21,424,898
0.010	100		\$82,412,946			\$295,679,578
0.99						

7.00% INTEREST RATE  
50 YEARS  
PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 10 YR BUYOUT						
PROJ NO:		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION
0.990	1	0.49	\$4,798,356	\$5,350,216	\$2,622,136	\$2,622,136
0.500	2	0.4	\$5,902,077	\$7,085,720	\$2,834,288	\$5,456,424
0.100	10	0.06	\$8,269,362	\$9,121,992	\$547,320	\$6,003,743
0.040	25	0.02	\$9,974,621	\$10,604,422	\$212,088	\$6,215,832
0.020	50	0.01	\$11,234,223	\$11,871,546	\$118,715	\$6,334,547
0.010	100		\$12,508,870			\$87,421,476

7.00% INTEREST RATE  
50 YEARS  
PRESENT WORTH

**Hague Buyout 20% Damage Level**

\$76,871,725	PRESENT WORTH PROJECT COST	\$845,589	ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$11,669,759	PRESENT WORTH O&M COSTS	\$88,541,484	PRESENT WORTH TOTAL PROJECT COST
		0.99	B/C RATIO

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 25 YR BUYOUT		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$18,910,700			
		0.50		\$20,428,474	\$10,212,194	\$10,212,194
0.500	2		\$21,946,248			
		0.40		\$31,726,980	\$12,690,792	\$22,902,986
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$25,739,674
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$26,981,569
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$27,811,882
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$383,824,731 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 25 YR BUYOUT		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$12,510,404			
		0.50		\$13,238,248	\$6,617,800	\$6,617,800
0.500	2		\$13,966,092			
		0.4		\$20,570,594	\$8,228,238	\$14,846,038
0.100	10		\$27,175,096			
		0.06		\$31,158,197	\$1,869,492	\$16,715,530
0.040	25		\$35,141,298			
		0.02		\$42,668,829	\$853,377	\$17,568,906
0.020	50		\$50,196,360			
		0.01		\$60,379,682	\$603,797	\$18,172,703
0.010	100		\$70,563,004			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$250,796,865 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 25 YR BUYOUT		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION
0.990	1		\$6,400,296			
		0.49		\$7,190,226	\$3,523,923	\$3,523,923
0.500	2		\$7,980,156			
		0.4		\$11,156,386	\$4,462,554	\$7,986,477
0.100	10		\$14,332,617			
		0.06		\$16,119,935	\$967,196	\$8,953,673
0.040	25		\$17,907,253			
		0.02		\$19,425,890	\$388,518	\$9,342,191
0.020	50		\$20,944,528			
		0.01		\$22,651,669	\$226,517	\$9,568,708
0.010	100		\$24,358,811			

7.00% INTEREST RATE  
50 YEARS  
\$132,055,307 PRESENT WORTH

Hague Buyout 20% Damage Level	
\$199,107,825 PRESENT WORTH PROJECT COST	\$2,190,186 ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$30,226,202 PRESENT WORTH O&M COSTS	\$229,334,027 PRESENT WORTH TOTAL PROJECT COST
<b>0.58 B/C RATIO</b>	

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 50 YR BUYOUT		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$18,910,700			
		0.50		\$20,428,474	\$10,212,194	\$10,212,194
0.500	2		\$21,946,248			
		0.40		\$31,726,980	\$12,690,792	\$22,902,986
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$25,739,674
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$26,981,569
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$27,811,882
0.010	100		\$94,921,815			
		0.99				

7.00% INTEREST RATE  
50 YEARS  
\$383,824,731 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 50 YR BUYOUT		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$9,253,732			
		0.50		\$10,345,249	\$5,171,590	\$5,171,590
0.500	2		\$11,436,766			
		0.4		\$16,000,104	\$6,400,042	\$11,571,632
0.100	10		\$20,563,443			
		0.06		\$23,514,565	\$1,410,874	\$12,982,506
0.040	25		\$26,465,687			
		0.02		\$34,131,281	\$682,626	\$13,665,131
0.020	50		\$41,796,875			
		0.01		\$50,115,493	\$501,155	\$14,166,286
0.010	100		\$58,434,112			
		0.99				

7.00% INTEREST RATE  
50 YEARS  
\$195,505,322 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 50 YR BUYOUT		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION
0.990	1		\$9,656,968			
		0.49		\$10,083,225	\$4,941,779	\$4,941,779
0.500	2		\$10,509,482			
		0.4		\$15,726,876	\$6,290,750	\$11,232,529
0.100	10		\$20,944,269			
		0.06		\$23,763,566	\$1,425,814	\$12,658,343
0.040	25		\$26,582,864			
		0.02		\$27,963,438	\$559,269	\$13,217,612
0.020	50		\$29,344,013			
		0.01		\$32,915,858	\$329,159	\$13,546,770
0.010	100		\$36,487,703			

7.00% INTEREST RATE  
50 YEARS  
\$186,955,541 PRESENT WORTH

Hague Buyout 20% Damage Level	
\$292,957,350 PRESENT WORTH PROJECT COST	\$3,222,531 ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$44,473,331 PRESENT WORTH O&M COSTS	\$337,430,681 PRESENT WORTH TOTAL PROJECT COST
	0.55 B/C RATIO

**EXPECTED ANNUAL DAMAGES  
EXISTING CONDITIONS**

PROJECT: CITY OF NORFOLK - HAGUE - 100 YR BUYOUT		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$18,910,700			
		0.50		\$20,428,474	\$10,212,194	\$10,212,194
0.500	2		\$21,946,248			
		0.40		\$31,726,980	\$12,690,792	\$22,902,986
0.100	10		\$41,507,713			
		0.06		\$47,278,132	\$2,836,688	\$25,739,674
0.040	25		\$53,048,551			
		0.02		\$62,094,719	\$1,241,894	\$26,981,569
0.020	50		\$71,140,888			
		0.01		\$83,031,352	\$830,314	\$27,811,882
0.010	100		\$94,921,815			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$383,824,731 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
RESIDUAL DAMAGES WITH PROJECT**

PROJECT: CITY OF NORFOLK - HAGUE - 100 YR BUYOUT		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	DAMAGES	AVERAGE DAMAGES	EXPECTED ANNUAL DAMAGES INTERVAL	EXPECTED ANNUAL DAMAGES SUMMATION
1.000	1		\$7,964,746			
		0.50		\$8,526,663	\$4,262,479	\$4,262,479
0.500	2		\$9,088,581			
		0.4		\$12,927,399	\$5,170,960	\$9,433,439
0.100	10		\$16,766,217			
		0.06		\$18,372,037	\$1,102,322	\$10,535,761
0.040	25		\$19,977,856			
		0.02		\$25,066,178	\$501,324	\$11,037,084
0.020	50		\$30,154,499			
		0.01		\$37,826,075	\$378,261	\$11,415,345
0.010	100		\$45,497,651			
0.99						

7.00% INTEREST RATE  
50 YEARS  
\$157,540,283 PRESENT WORTH

**EXPECTED ANNUAL DAMAGES  
NET BENEFITS**

PROJECT: CITY OF NORFOLK - HAGUE - 100 YR BUYOUT		DESIGNER: JDM		DATE: 19-Apr-11		
FREQUENCY %	RETURN PERIOD	INTERVAL	BENEFITS	AVERAGE BENEFITS	EXPECTED ANNUAL BENEFITS INTERVAL	EXPECTED ANNUAL BENEFITS SUMMATION
0.990	1		\$10,945,954			
		0.49		\$11,901,811	\$5,833,066	\$5,833,066
0.500	2		\$12,857,667			
		0.4		\$18,799,581	\$7,519,832	\$13,352,898
0.100	10		\$24,741,496			
		0.06		\$28,906,095	\$1,734,366	\$15,087,264
0.040	25		\$33,070,694			
		0.02		\$37,028,542	\$740,571	\$15,827,835
0.020	50		\$40,986,389			
		0.01		\$45,205,277	\$452,053	\$16,279,887
0.010	100		\$49,424,165			

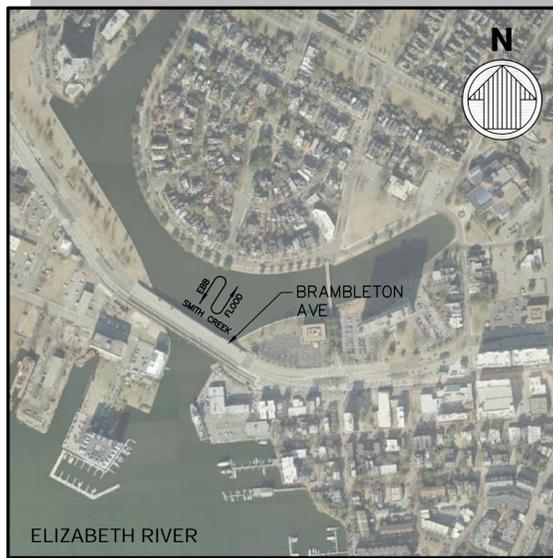
7.00% INTEREST RATE  
50 YEARS  
\$224,674,596 PRESENT WORTH

Hague Buyout 20% Damage Level	
\$462,079,800 PRESENT WORTH PROJECT COST	\$5,082,878 ANNUAL OPERATION & MAINTENANCE (O&M) COSTS
\$70,147,507 PRESENT WORTH O&M COSTS	\$532,227,307 PRESENT WORTH TOTAL PROJECT COST
0.42 B/C RATIO	

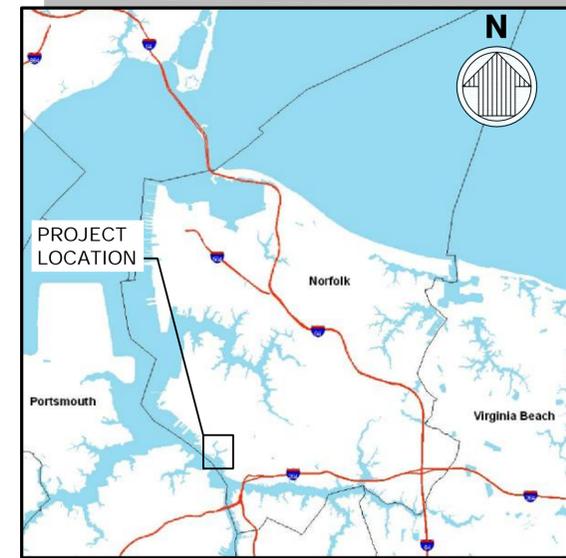
**APPENDIX E**

**PRELIMINARY (10% LEVEL) DESIGN PLANS AND SECTIONS**

# THE HAGUE COASTAL FLOODING MITIGATION CITY OF NORFOLK DEPARTMENT OF PUBLIC WORKS ENVIRONMENTAL STORM WATER MANAGEMENT DIVISION



LOCATION MAP  
NTS

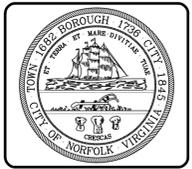


VICINITY MAP  
NTS



BEFORE YOU DIG,  
CALL  
"MISS UTILITY"  
OF VIRGINIA  
1-800-552-7001  
(TOLL FREE)

INDEX OF DRAWINGS		
NO.	SHEET	SHEET TITLE
<b>GENERAL</b>		
1	G-001	TITLE SHEET LOCATION MAP & INDEX OF DRAWINGS
2	G-002	ABBREVIATIONS & LEGEND
3	G-101	GENERAL ARRANGEMENT PLAN
4	V-101	EXISTING CONDITIONS PLAN
5	V-102	EXISTING UTILITIES
<b>GEOTECHNICAL</b>		
6	GR-101	SOIL BORING LOCATION
<b>STRUCTURAL</b>		
7	S-001	STRUCTURAL NOTES
8	S-101	STRUCTURAL PLAN
9	S-102	WEST OVERLAND FLOOD WALL PROFILE -- OPTION 1
10	S-103	EAST OVERLAND FLOOD WALL PLAN -- SHEET 1 OF 2
11	S-104	EAST OVERLAND FLOOD WALL PLAN -- SHEET 2 OF 2
12	S-105	EAST OVERLAND FLOOD WALL PROFILE
13	S-106	WEST OVERLAND FLOOD WALL PLAN -- OPTION 2 -- SHEET 1 OF 2
14	S-107	WEST OVERLAND FLOOD WALL PLAN -- OPTION 2 -- SHEET 2 OF 2
15	S-108	WEST OVERLAND FLOOD WALL PROFILE -- OPTION 2
16	S-201	ELEVATION VIEW OF FLOOD WALL
17	S-401	PARTIAL FLOOD GATE PLAN
18	S-501	FLOOD GATE WALL DETAILS
19	S-502	EAST & WEST OVERLAND FLOOD WALL DETAILS
<b>ELECTRICAL</b>		
20	E-101	ELECTRICAL SITE PLAN
21	E-102	GENERATOR BUILDING ELECTRICAL PLAN
22	E-201	GENERATOR BUILDING ELEVATION
23	E-601	ELECTRICAL SINGLE LINE DIAGRAM



<b>PRELIMINARY</b>
NOT TO BE USED FOR CONSTRUCTION
Date
Description
Mark

**THE HAGUE COASTAL FLOODING  
MITIGATION, NORFOLK, VA**

TITLE SHEET LOCATION MAP &  
INDEX OF DRAWINGS

Date:	JAN, 2012	Rev.:	-
Designed by:	BJ	M&N Project No.:	7607-01
Drawn by:	BA	Drawing code:	
Reviewed by:		Drawing Scale:	NONE
Submitted by:	MOFFATT & NICHOL	Plot scale:	1:1 (0 SHEET)

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**moffatt & nichol**

PREPARED FOR:  
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ENVIRONMENTAL STORM WATER  
MANAGEMENT DIVISION

SEAL

Sheet Reference Number:  
**G-001**  
Sheet 1 of 23

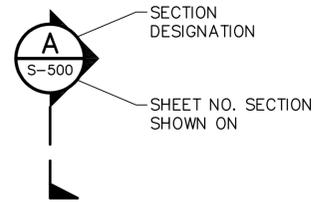
**ABBREVIATIONS**

AASHTO = AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS  
 ACI = AMERICAN CONCRETE INSTITUTE  
 ACQ = ALKALINE COPPER QUATERNARY  
 ACZA = AMMONIACAL COPPER ZINC ARSENATE  
 AISC = AMERICAN INSTITUTE OF STEEL CONSTRUCTION  
 AISI = AMERICAN IRON AND STEEL INSTITUTE  
 ALT = ALTERNATE  
 ALUM = ALUMINUM  
 ANSI = AMERICAN NATIONAL STANDARDS INSTITUTE  
 APPROX = APPROXIMATE  
 ASCE = AMERICAN SOCIETY OF CIVIL ENGINEERS  
 ASTM = AMERICAN SOCIETY FOR TESTING AND MATERIALS  
 AWG = AMERICAN WIRE GAUGE  
 AWPA = AMERICAN WOOD PROTECTION ASSOCIATION  
 AWS = AMERICAN WELDING SOCIETY  
 BM = BENCHMARK  
 BOTM = BOTTOM  
 BTW = BETWEEN  
 CA-B = COPPER AZOLE TYPE B  
 CCA = COPPER CHROME ARSENATE  
 CF = CUBIC FEET  
 CIP = CAST-IN-PLACE  
 CJ = CONSTRUCTION JOINT  
 CKD = CHECKED  
 CLR = CLEAR  
 CONC = CONCRETE  
 CONN = CONNECTION  
 CONSTR = CONSTRUCTION  
 CONT = CONTINUOUS  
 CY = CUBIC YARD  
 DBL = DOUBLE  
 DIA = DIAMETER  
 DIM = DIMENSION  
 DIP = DUCTILE IRON PIPE  
 DISCONT = DISCONTINUOUS  
 DSGN = DESIGNED  
 DWGS = DRAWINGS  
 DWN = DRAWN  
 E = EAST  
 EA = EACH  
 EJ = EXPANSION JOINT  
 EL = ELEVATION  
 ELEV = ELEVATION  
 EMBED = EMBEDMENT  
 EQ = EQUAL  
 ETC = ET CETERA  
 EW = EACH WAY  
 EXIST = EXISTING  
 EXP = EXPANSION  
 EXT = EXTENSION  
 F = FAHRENHEIT  
 FPS = FEET PER SECOND  
 FT = FEET  
 GA = GAUGE  
 GALV = GALVANIZED  
 GR = GRADE  
 HORIZ = HORIZONTAL  
 HOWL = HIGHEST OBSERVED WATER LEVEL  
 HSS = HOLLOW STRUCTURAL SECTION  
 ICC = INTERNATIONAL CODE COUNCIL  
 ID = IDENTIFICATION  
 IN = INCHES  
 INC = INCORPORATED  
 INFO = INFORMATION  
 INT = INTERMEDIATE  
 JT = JOINT  
 K = KIPS OR 1000 POUNDS  
 KLF = KIPS PER LINEAR FOOT  
 KSI = KIPS PER SQUARE INCH  
 L = ANGLE OR LENGTH  
 LB = POUND  
 LF = LINEAR FEET  
 LG = LONG  
 LONG. = LONGITUDINAL  
 LOWL = LOWEST OBSERVED WATER LEVEL  
 LT = LEFT  
 MAX = MAXIMUM  
 MFR = MANUFACTURER  
 MHHW = MEAN HIGHER HIGH WATER  
 MHW = MEAN HIGH WATER  
 MIN = MINIMUM

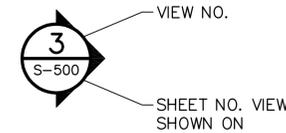
MISC = MISCELLANEOUS  
 MLLW = MEAN LOWER LOW WATER  
 MLW = MEAN LOW WATER  
 MPH = MILES PER HOUR  
 MSL = MEAN SEA LEVEL  
 MTL = MEAN TIDE LEVEL  
 MUTCD = MANUAL OF UNIFORM TRAFFIC CONTROL DEVICES (2009)  
 N = NORTH  
 N/A = NOT APPLICABLE  
 NAD = NORTH AMERICAN DATUM  
 NAVD = NORTH AMERICAN VERTICAL DATUM  
 NGVD = NATIONAL GEODETIC VERTICAL DATUM  
 NIC = NOT IN CONTRACT  
 NO. = NUMBER  
 NOAA = NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION  
 NOS = NATIONAL OCEAN SERVICE  
 NTS = NOT TO SCALE  
 OC = ON CENTER  
 OSHA = OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION  
 P/C = PRECAST  
 PP = PIPE PILE  
 P/S = PRESTRESSED  
 PCF = POUNDS PER CUBIC FOOT  
 PDA = PILE DYNAMIC ANALYZER  
 PEN = PENETRATION  
 PSF = POUNDS PER SQUARE FOOT  
 PSI = POUNDS PER SQUARE INCH  
 PVC = POLYVINYLCHLORIDE  
 QTY = QUANTITY  
 R = RADIUS  
 REINF = REINFORCEMENT OR REINFORCED  
 REQ'D = REQUIRED  
 REV = REVISION  
 R/F = REINFORCEMENT OR REINFORCED  
 RT = RIGHT  
 S = SOUTH  
 SCH = SCHEDULE  
 SF = SQUARE FOOT  
 SHT = SHEET  
 SPA = SPACES  
 SQ = SQUARE  
 SS = STAINLESS STEEL  
 STA = STATION  
 STD = STANDARD  
 STL = STEEL  
 SY = SQUARE YARD  
 T = TON  
 TEMP = TEMPORARY OR TEMPERATURE  
 TYP = TYPICAL  
 UFC = UNIFIED FACILITIES CRITERIA  
 UON = UNLESS OTHERWISE NOTED  
 U.S. = UNITED STATES  
 USGS = UNITED STATES GEOLOGICAL SURVEY  
 VERT = VERTICAL  
 VLF = VERTICAL LINEAR FEET  
 W = WEST  
 W/ = WITH  
 WWF = WELDED WIRE FABRIC  
 " = SECONDS OR INCHES  
 ' = MINUTES OR FEET  
 \* = ASTERISK  
 # = NUMBER OR POUND  
 & = AND  
 @ = AT  
 € = CENTERLINE  
 r = PLATE  
 ø = DIAMETER  
 ° = DEGREES  
 ± = PLUS OR MINUS  
 % = PERCENT

**LEGEND**

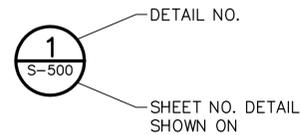
**SECTION CUT SYMBOL**



**VIEW/ELEVATION SYMBOL**



**DETAIL CALLOUT SYMBOL**



**PRELIMINARY**  
 NOT TO BE USED FOR CONSTRUCTION

Date	Description	Mark

**THE HAGUE COASTAL FLOODING MITIGATION, NORFOLK, VA**

**ABBREVIATIONS & LEGEND**

Designed by: BJ	Rev. -
Drawn by: BA	Date: JAN, 2012
Reviewed by: -	M&M Project No. 7607-01
Submitted by: MOFFATT & NICHOL	Drawing code: -
	Drawing Scale: NONE
	Plot Scale: 1:1 (0 SHEET)

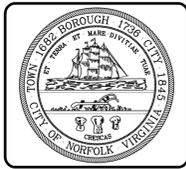
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Sheet Reference Number:  
**G-002**  
 Sheet 2 of 23



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Date	Appr.

**THE HAGUE COASTAL FLOODING MITIGATION, NORFOLK, VA**

GENERAL ARRANGEMENT PLAN

Designed by: BJ	Rev: -
Own by: BA	Date: JAN, 2012
Reviewed by: -	M&E Project No. 7607-01
Submitted by: MOFFATT & NICHOL	Drawing code: -
	Drawing Scale: NONE
	Plot scale: 1:1 (0 SHEET)

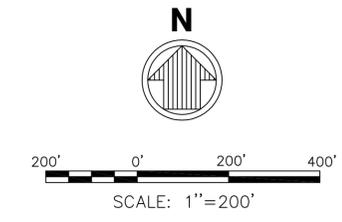
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**G-101**  
Sheet 3 of 23



DRAWING SCALES SHOWN BASED ON 22"x34" DRAWING

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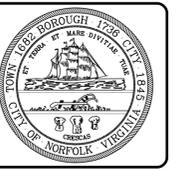


**NOTE:**

- BORINGS BY \_\_\_\_\_  
DATED \_\_\_\_\_

**LEGEND:**

- BORING LOCATION



<b>PRELIMINARY</b> NOT TO BE USED FOR CONSTRUCTION	Mark	Date	Appr.

<b>THE HAGUE COASTAL FLOODING MITIGATION, NORFOLK, VA</b>	<b>SOIL BORING LOCATION</b>
---------------------------------------------------------------	-----------------------------

Designed by: BJ	Drawn by: BA	Checked by: BA	Reviewed by: BA	Submitted by: MOFFATT & NICHOL
Date: JAN, 2012	M&E Project No.: 7607-01	Drawing code:	Drawing Scale: NONE	Plot scale: 1:1 (0 SHEET)

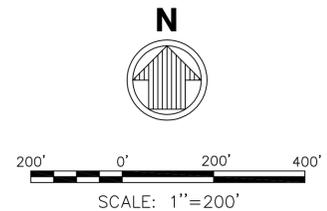
**moffatt & nichol**

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Sheet Reference Number:  
**GR-101**  
Sheet 6 of 23



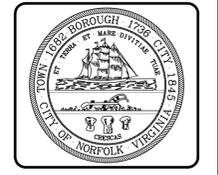
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**THE HAGUE COASTAL FLOODING MITIGATION, NORFOLK, VA**

**EAST OVERLAND FLOOD WALL PLAN - SHEET 1 OF 2**

Designed by: MR Drawn by: BA Reviewed by:	Date: JAN, 2012 M&N Project No.: 7607-01 Drawing code:	Drawing Scale: NONE Plot scale: 1:1 (0 SHEET)
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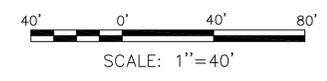
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Sheet Reference Number:  
**S-103**  
Sheet 10 of 23



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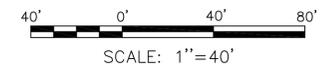
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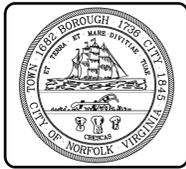




**C1** PLAN - WEST OVERLAND FLOOD WALL (OPTION 2)  
 G-101 SCALE: 1"=30'



DRAWING SCALES SHOWN BASED ON 22"x34" DRAWING



**PRELIMINARY**  
 NOT TO BE USED FOR CONSTRUCTION

Mark	Description	Date	Appr.

**THE HAGUE COASTAL FLOODING MITIGATION, NORFOLK, VA**  
 WEST OVERLAND FLOOD WALL  
 PLAN - OPTION 2 - SHEET 1 OF 2

Designed by: MR/JEG	Date: JAN, 2012	Rev: -
Drawn by: BA	M&N Project No. 7607-01	
Reviewed by:	Drawing code:	
Submitted by: MOFFATT & NICHOL	Drawing Scale: NONE	
	Plot scale: 1:1 (0 SHEET)	

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Sheet Reference Number:  
**S-106**  
 Sheet 13 of 23

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**THE HAGUE COASTAL FLOODING MITIGATION, NORFOLK, VA**

ELEVATION VIEW OF FLOOD WALL

Designed by:	Rev. -
Drawn by:	Date: JAN, 2012
Reviewed by:	M&N Project No. 7607-01
Submitted by:	Drawing code:
MOFFATT & NICHOL	Drawing Scale: NONE
	Plot scale: 1:1 (0 SHEET)

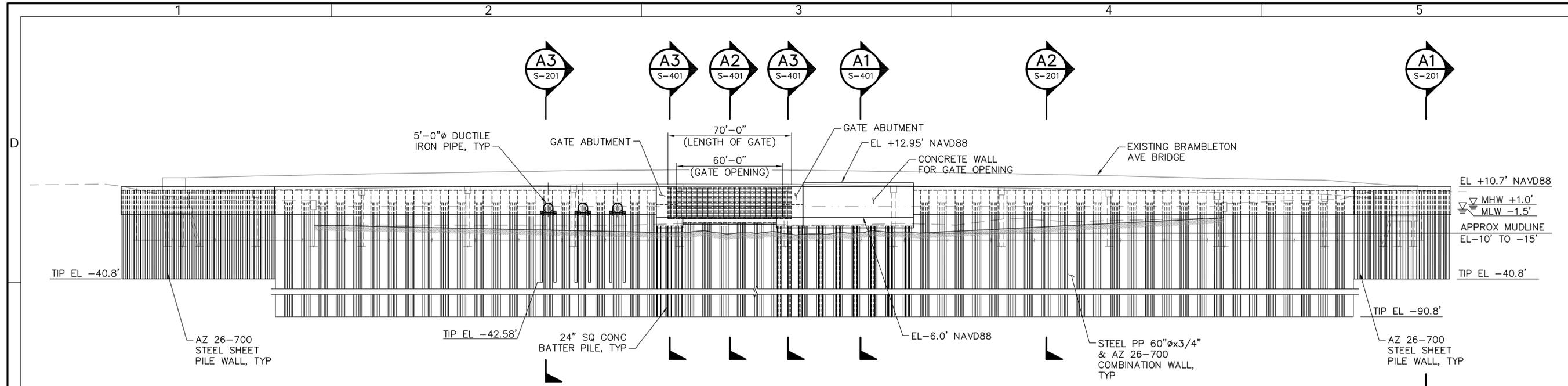
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PREPARED FOR:  
CITY OF NORFOLK  
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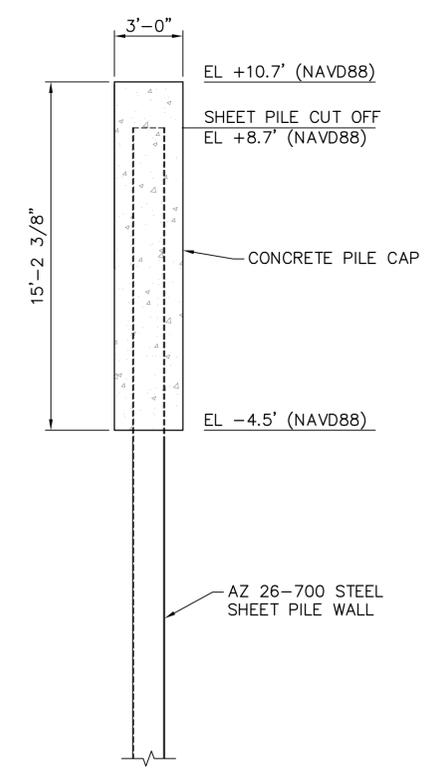
moffatt & nichol

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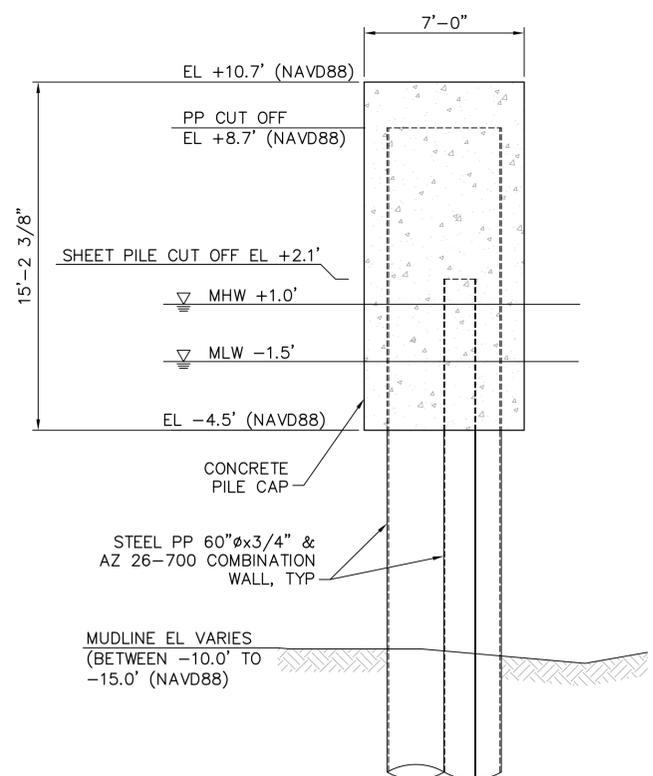
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**S-201**  
Sheet 16 of 23



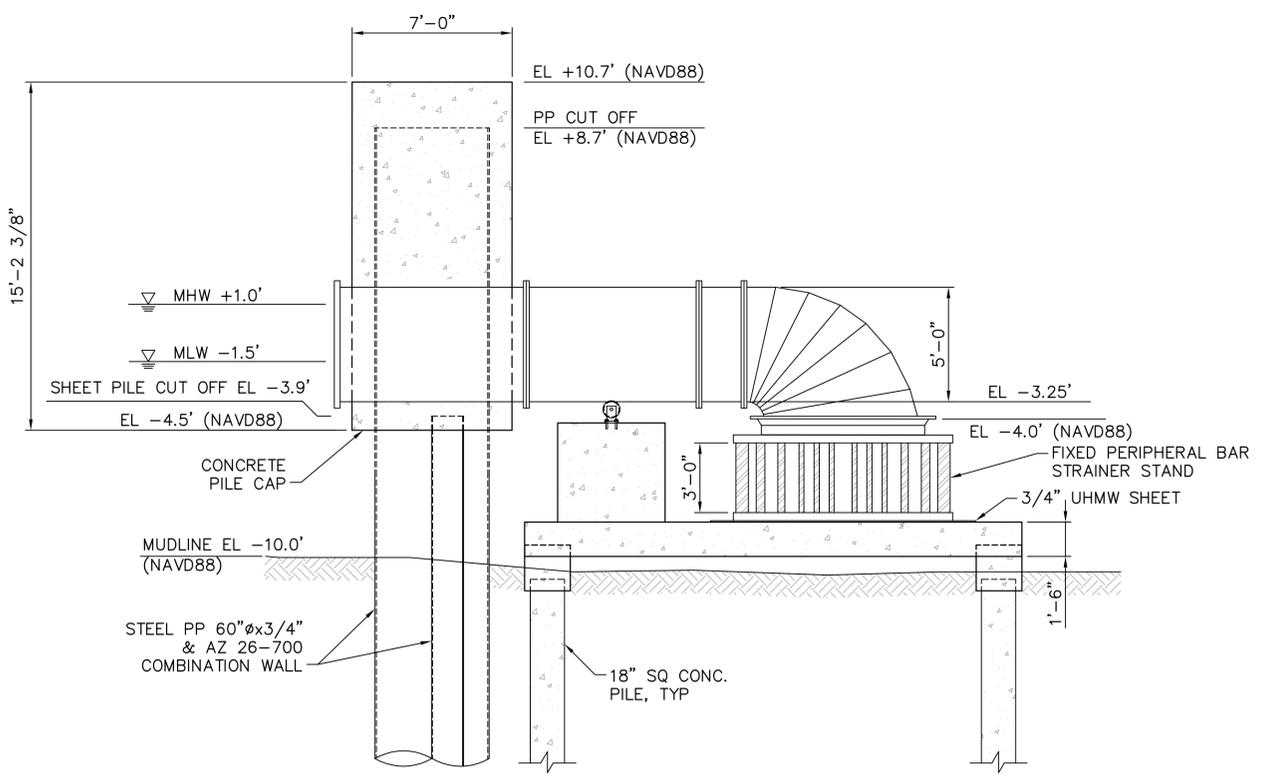
**C1 ELEVATION - SHEET PILE WALL**  
S-101 SCALE: 1"=30'-0"



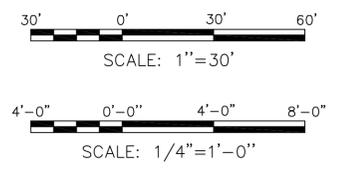
**A1 SECTION - TYP WALL @ SHEET PILE WALL**  
S-201 SCALE: 1/4"=1'-0"



**A2 SECTION - TYP WALL @ COMBI-WALL**  
S-401 S-201 SCALE: 1/4"=1'-0"



**A3 SECTION - TYP WALL @ PUMPS**  
S-201 SCALE: 1/4"=1'-0"



DRAWING SCALES SHOWN BASED ON 22"x34" DRAWING

File: P:\1760717607-01-04\500 CADD\520 submittals\760701-S-201\_Plot.dwg; 3/15/2012 5:45 PM by OWEN, STEPHEN; Saved: 3/15/2012 4:55 PM by SOWEN



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	Description	Date

**THE HAGUE COASTAL FLOODING MITIGATION, NORFOLK, VA**

PARTIAL FLOOD GATE PLAN

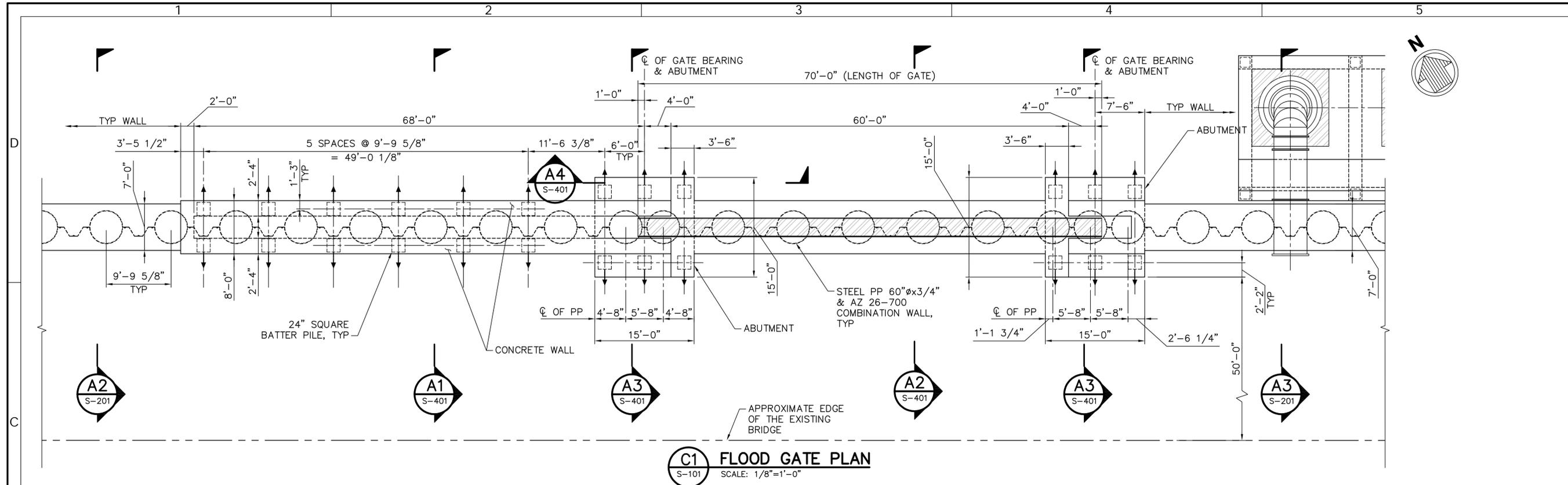
Designed by: MR	Rev: -
Drawn by: BA	Date: JAN, 2012
Reviewed by: -	M&N Project No. 7607-01
Submitted by: MOFFATT & NICHOL	Drawing code: -
MOFFATT & NICHOL	Drawing Scale: NONE
	Plot Scale: 1:1 (0 SHEET)

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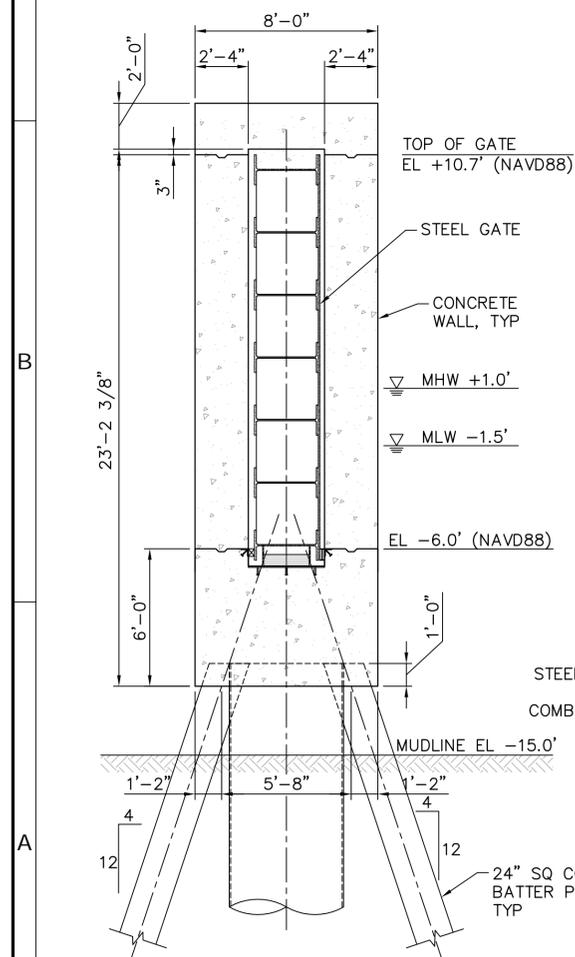
PREPARED FOR:  
CITY OF NORFOLK  
DEPARTMENT OF PUBLIC WORKS  
ENVIRONMENTAL STORM WATER  
MANAGEMENT DIVISION

SEAL

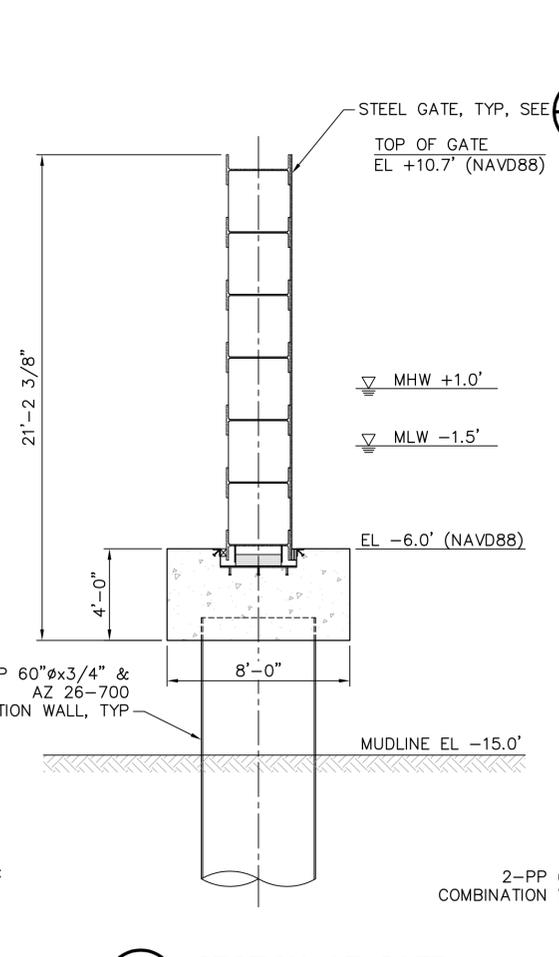
Sheet Reference Number:  
**S-401**  
Sheet 17 of 23



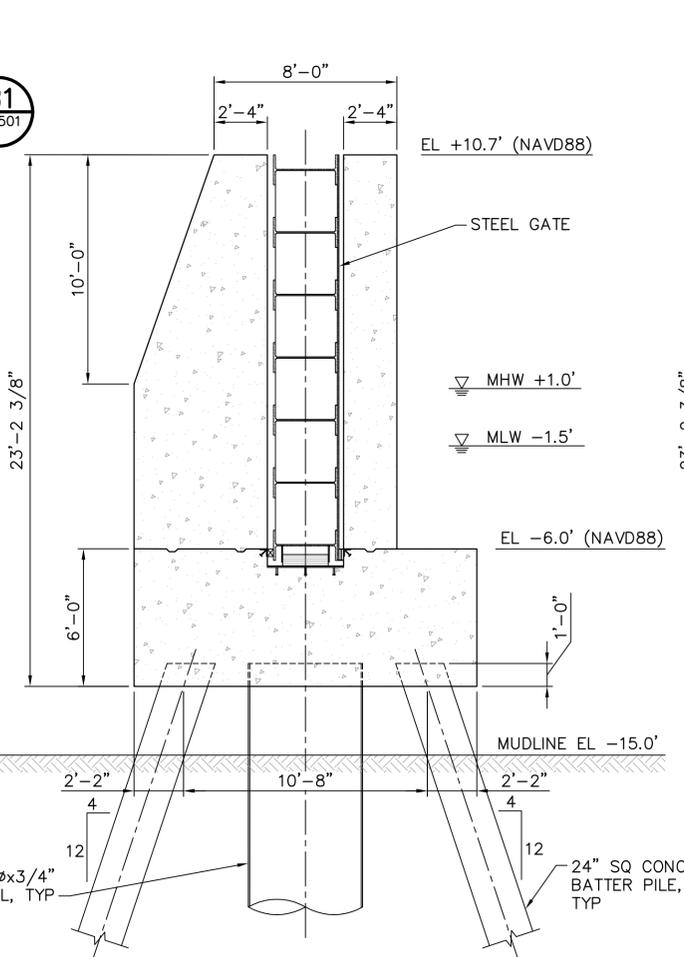
**C1 FLOOD GATE PLAN**  
S-101 SCALE: 1/8"=1'-0"



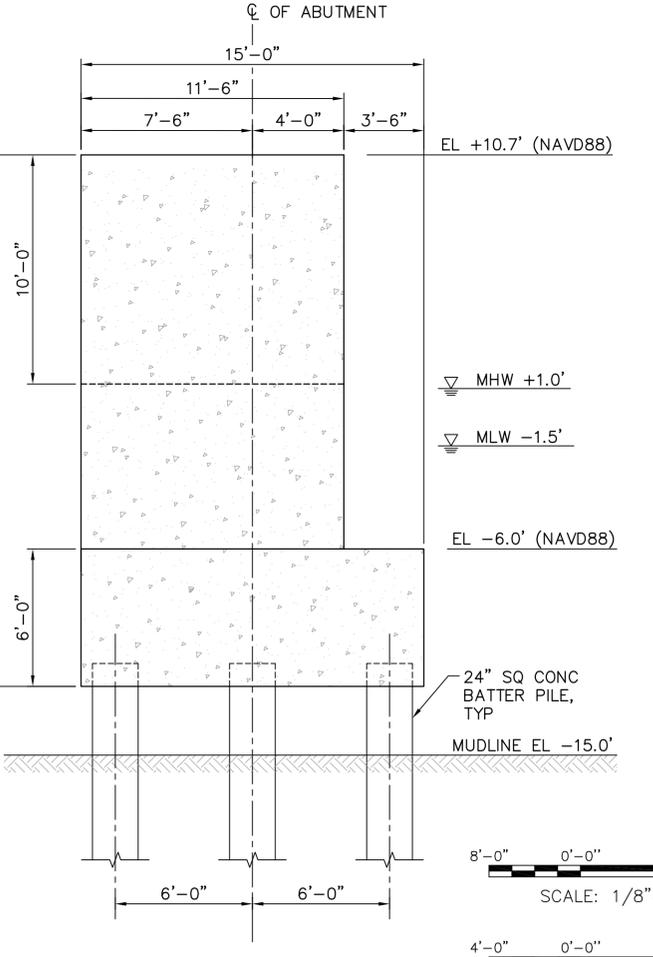
**A1 SECTION**  
S-201 SCALE: 1/4"=1'-0"



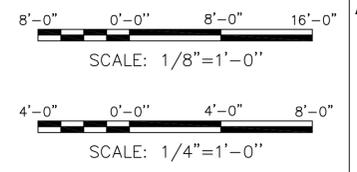
**A2 SECTION AT GATE**  
S-401 SCALE: 1/4"=1'-0"



**A3 SECTION**  
S-201 SCALE: 1/4"=1'-0"



**A4 SECTION**  
S-401 SCALE: 1/4"=1'-0"



DRAWING SCALES SHOWN BASED ON 22"x34" DRAWING

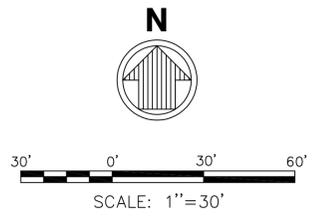
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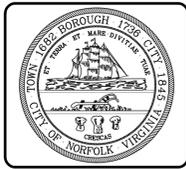




**A1** ELECTRICAL SITE PLAN  
E-101 SCALE: 1"=30'



DRAWING SCALES SHOWN BASED ON 22"x34" DRAWING



<b>PRELIMINARY</b>		Date
NOT TO BE USED FOR CONSTRUCTION		Apr.
Mark	Description	

**THE HAGUE COASTAL FLOODING MITIGATION, NORFOLK, VA**

ELECTRICAL SITE PLAN

Designed by:	Date:	Rev.:
Own by:	JAN, 2012	-
Reviewed by:	M&N Project No.	
Submitted by:	7607-01	
	Drawing code:	
	Drawing Scale:	NONE
	Plot scale:	1:1 (0 SHEET)

**moffatt & nichol**

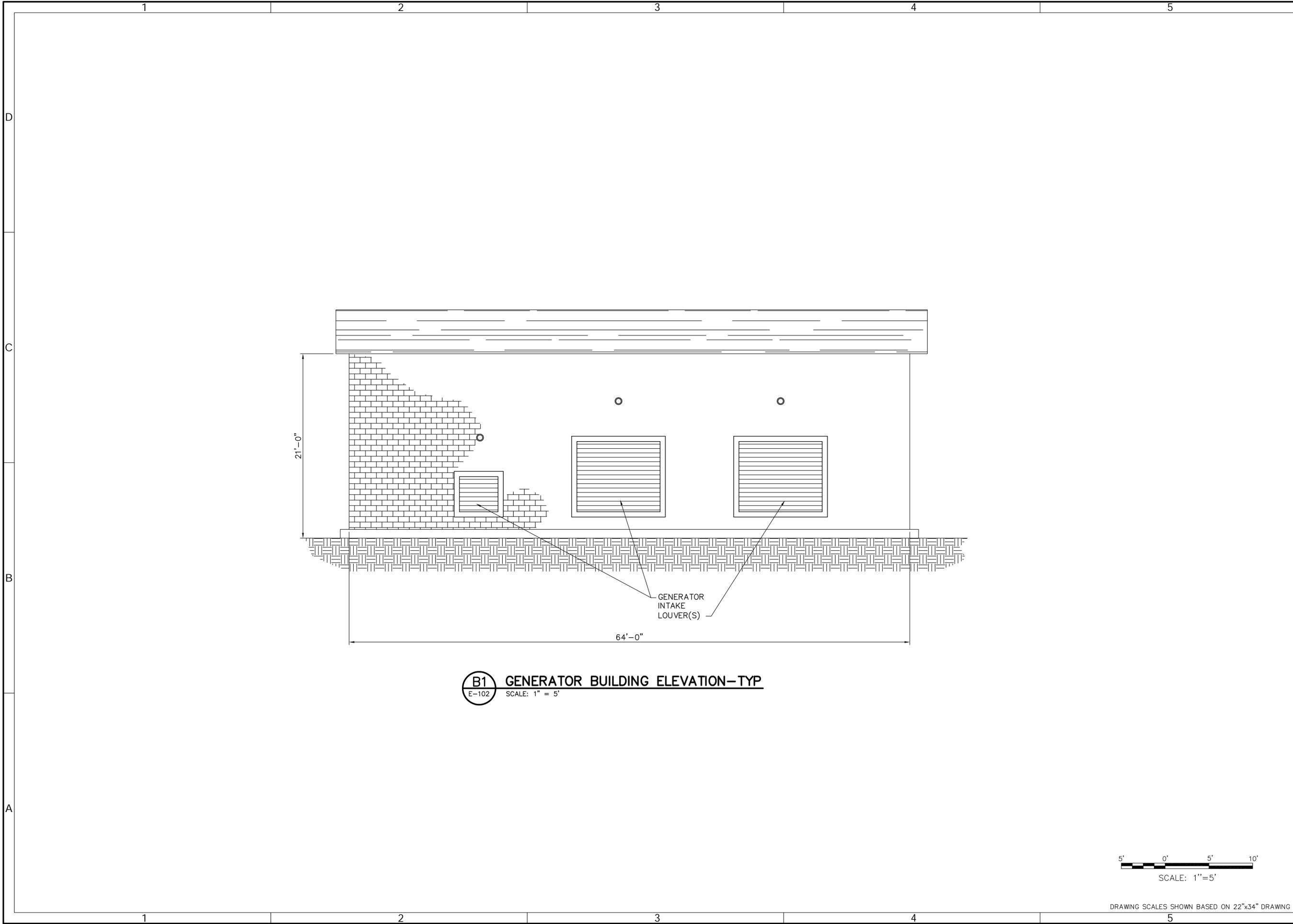
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ENVIRONMENTAL STORM WATER  
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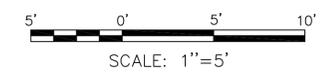
SEAL

Sheet Reference Number:  
**E-101**  
Sheet 20 of 23





**B1** GENERATOR BUILDING ELEVATION-TYP  
 E-102 SCALE: 1" = 5'



DRAWING SCALES SHOWN BASED ON 22"x34" DRAWING



**PRELIMINARY**  
 NOT TO BE USED FOR CONSTRUCTION

Mark	Description	Date	Appr.

**THE HAGUE COASTAL FLOODING MITIGATION, NORFOLK, VA**

GENERATOR BUILDING ELEVATION

Designed by: R.C.	Rev. -
Drawn by: R.C.	Date: JAN, 2012
Reviewed by: JW	M&N Project No. 7607-01
Submitted by: MOFFATT & NICHOL	Drawing code:
	Drawing Scale: NONE
	Plot scale: 1:1 (0 SHEET)

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Sheet Reference Number:  
**E-201**  
 Sheet 22 of 23

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1

2

3

4

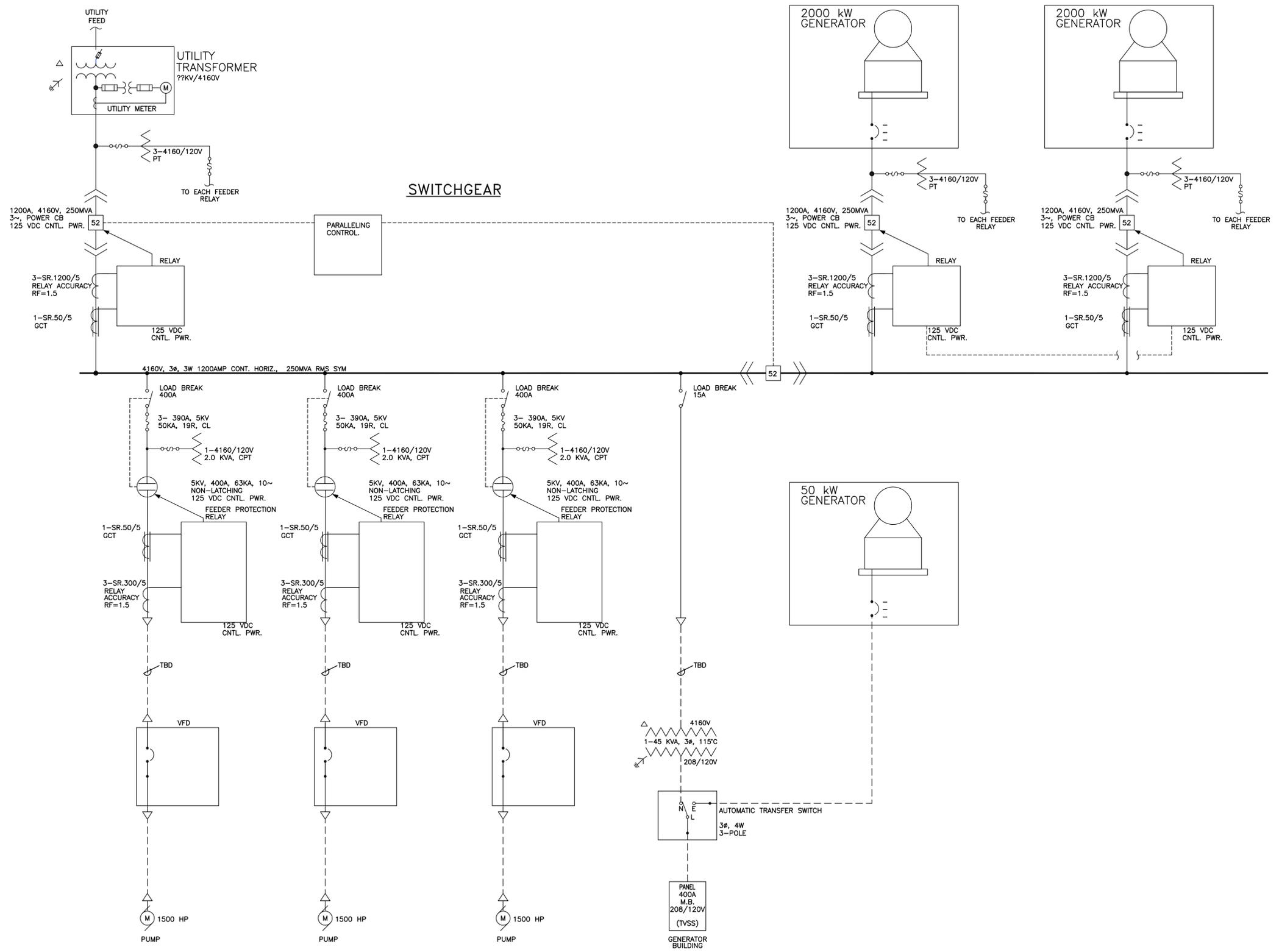
5

D

C

B

A



**A1** ELECTRICAL SINGLE LINE DIAGRAM  
E-601 SCALE: NTS



**PRELIMINARY**  
NOT TO BE USED FOR CONSTRUCTION

Mark	Description	Date	Appr.

**THE HAGUE COASTAL FLOODING MITIGATION, NORFOLK, VA**  
ELECTRICAL SINGLE LINE DIAGRAM

Designed by: R.C.	Rev: -
Drawn by: R.C.	Date: JAN, 2012
Reviewed by: J.W.	M&E Project No. 7607-01
Submitted by: MOFFATT & NICHOL	Drawing code: -
	Drawing Scale: NONE
	Plot Scale: 1:1 (0 SHEET)

**moffatt & nichol**  
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Sheet Reference Number:  
**E-601**  
Sheet 23 of 23