

FIGURES

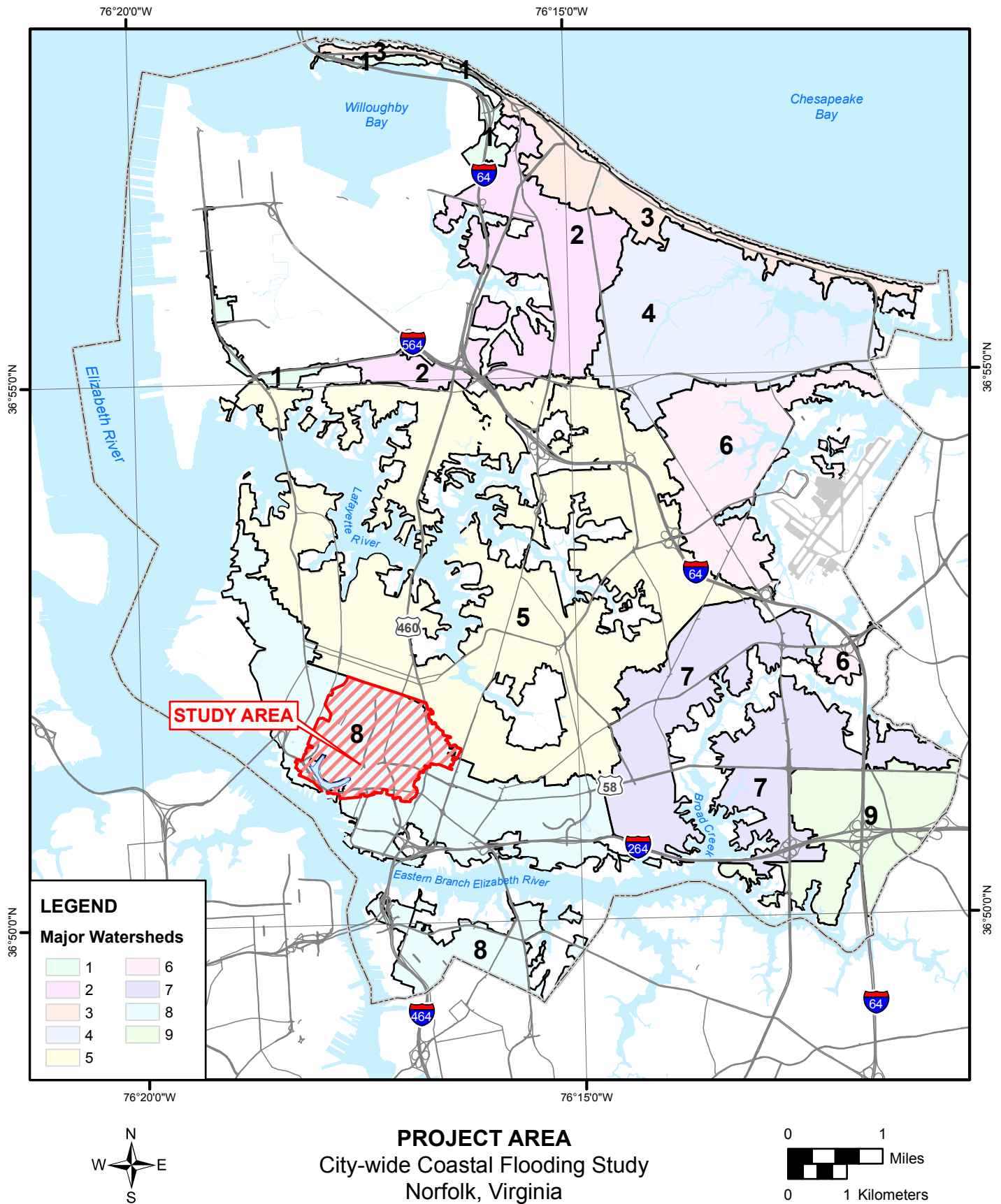


FIGURE 1-1

N:\Projects\3627_City_Norfolk\3627-005_Hague\Outputs\2011_04_20_Draft_Flood_Mitigation_Report\mxd\Fig-1-2_Hague_Watershed.mxd, 04/21/11, jfisher



LEGEND

 Hague Watershed Boundary

Note:
1. City 2009 aerial photograph mosaic provided by City of Norfolk GIS Department.

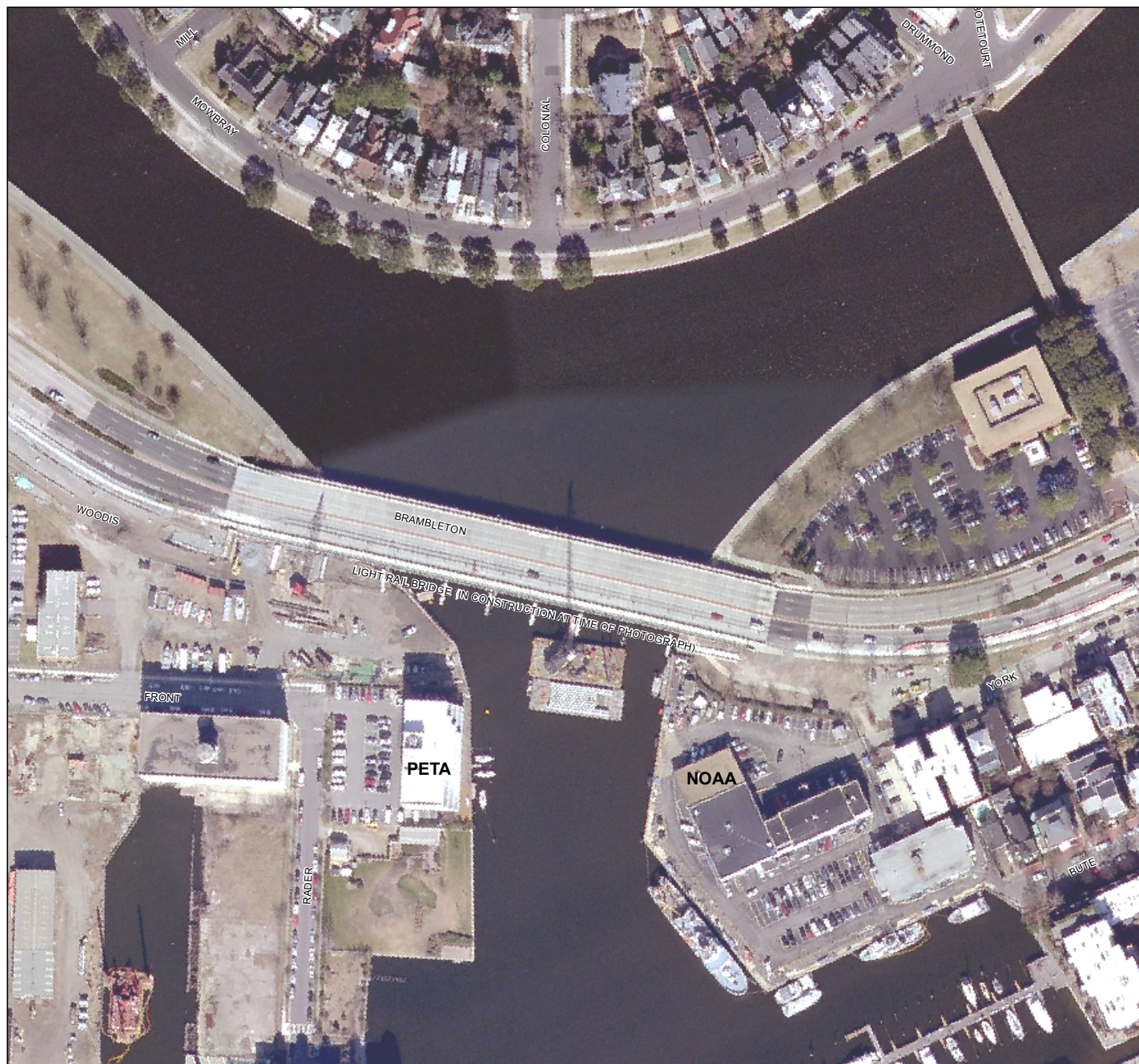


0 800 1,600 Feet



HAGUE WATERSHED
City-wide Coastal Flooding Study
Norfolk, Virginia

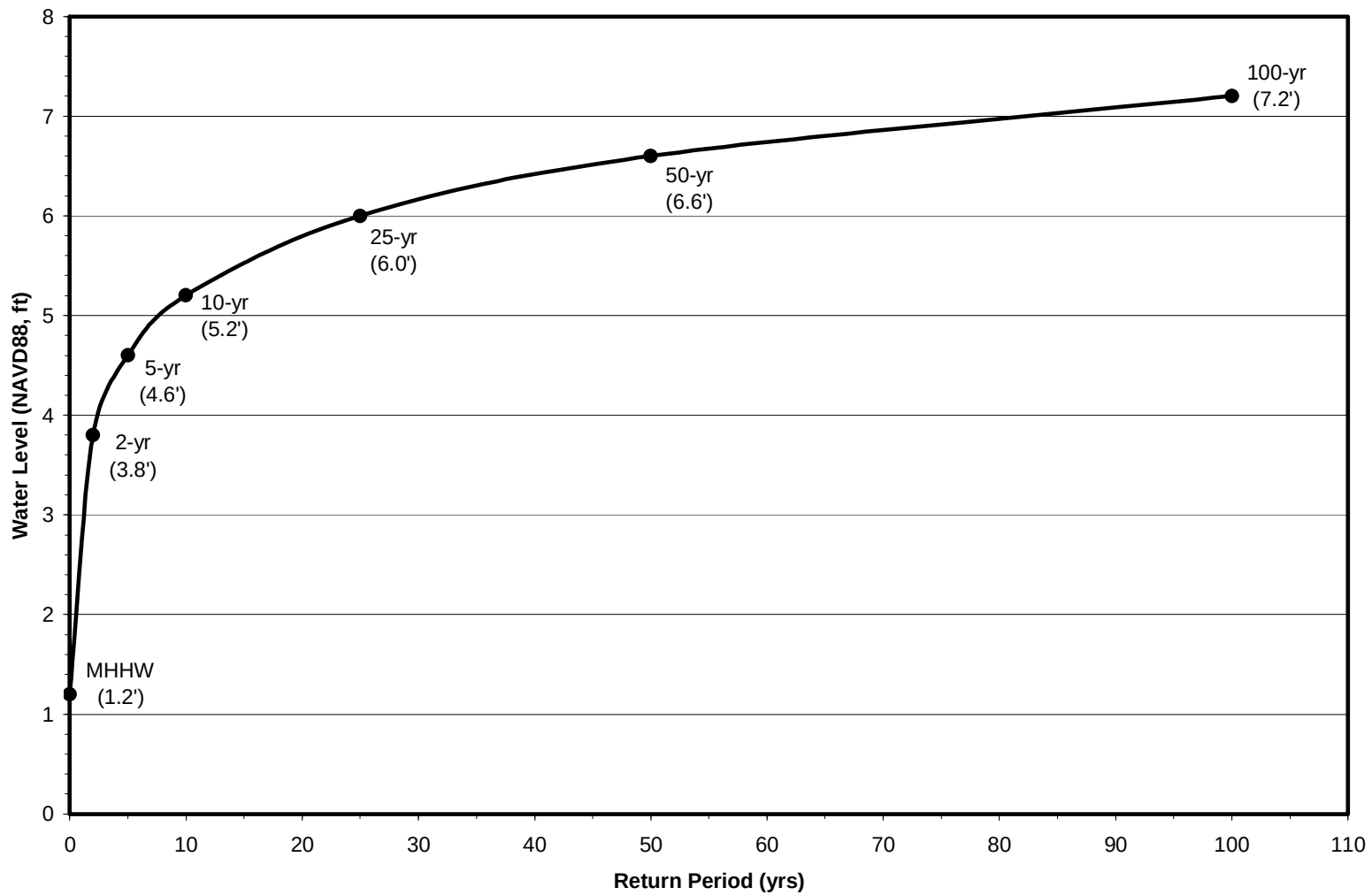
FIGURE 1-2



0 100 200
Feet

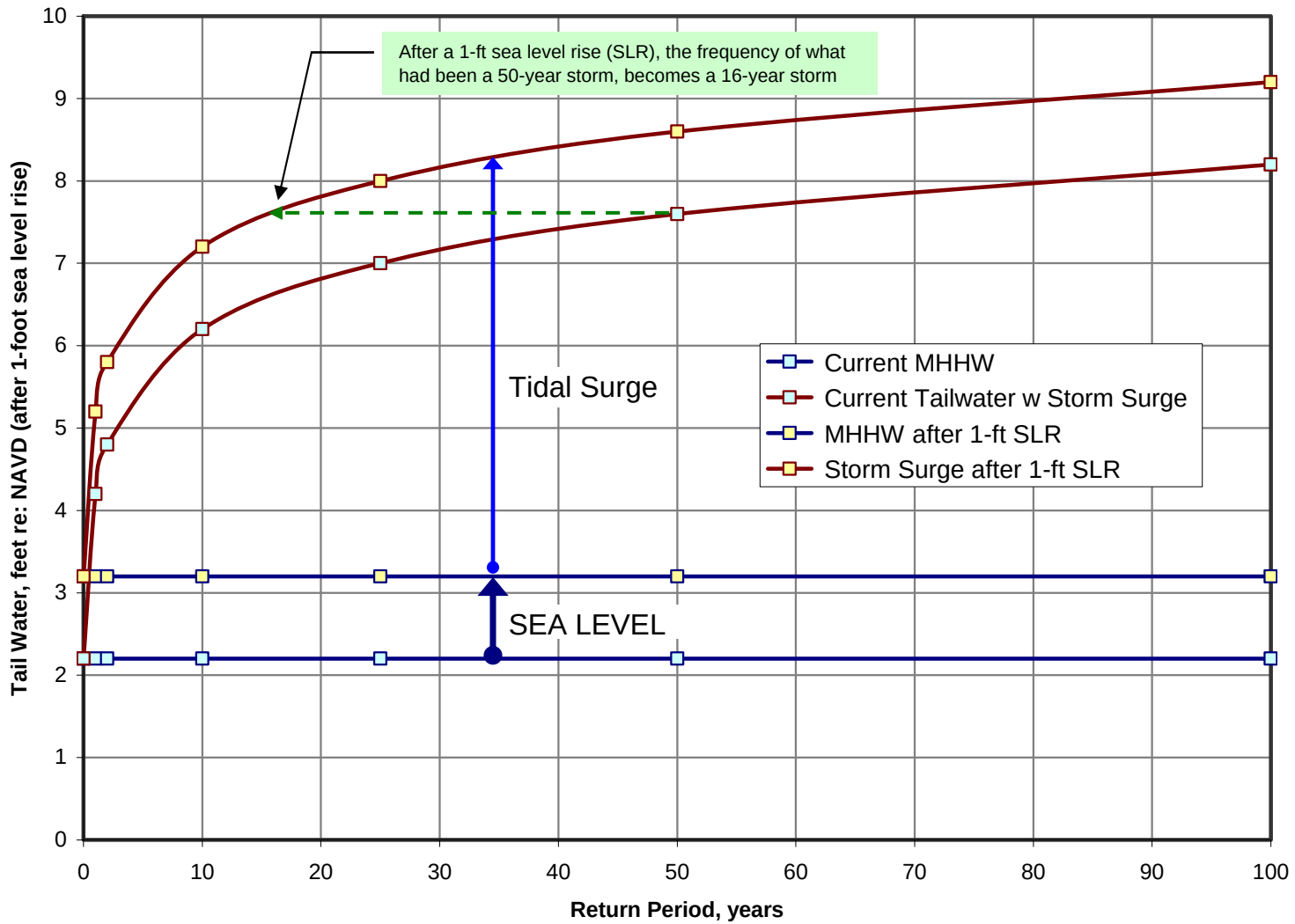
BASIN OUTLET
City-wide Coastal Flooding Study
Norfolk, Virginia

FIGURE 1-3



WATER LEVEL ELEVATIONS AT SEWELLS POINT FOR VARIOUS RETURN PERIODS
Based on Current Sea Level Elevation
City-wide Coastal Flooding Study
Norfolk, Virginia

FIGURE 2-1



IMPLICATIONS OF FUTURE SEA LEVEL RISE
City-wide Coastal Flooding Study
Norfolk, Virginia



LEGEND

Topographic Elevation (ft. NAVD88)
Based on 2009 LiDAR Survey

- < 3
- 3 to 4
- 4 to 5
- 5 to 6
- 6 to 7
- 7 to 8
- 8 to 9
- 9 to 10
- 10 to 11
- 11 to 12
- > 12

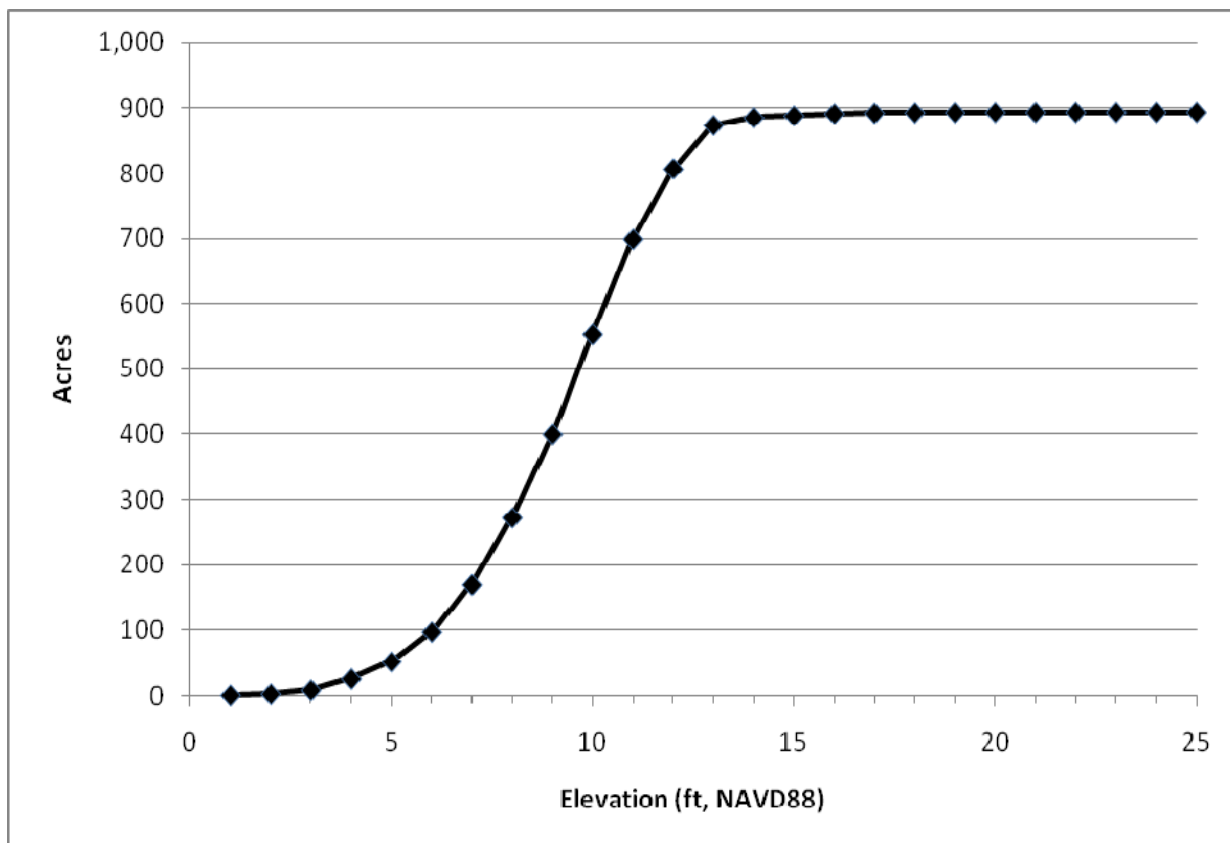
TOPOGRAPHY

City-wide Coastal Flooding Study
Norfolk, Virginia



0 500 1,000
Feet

FIGURE 3-1

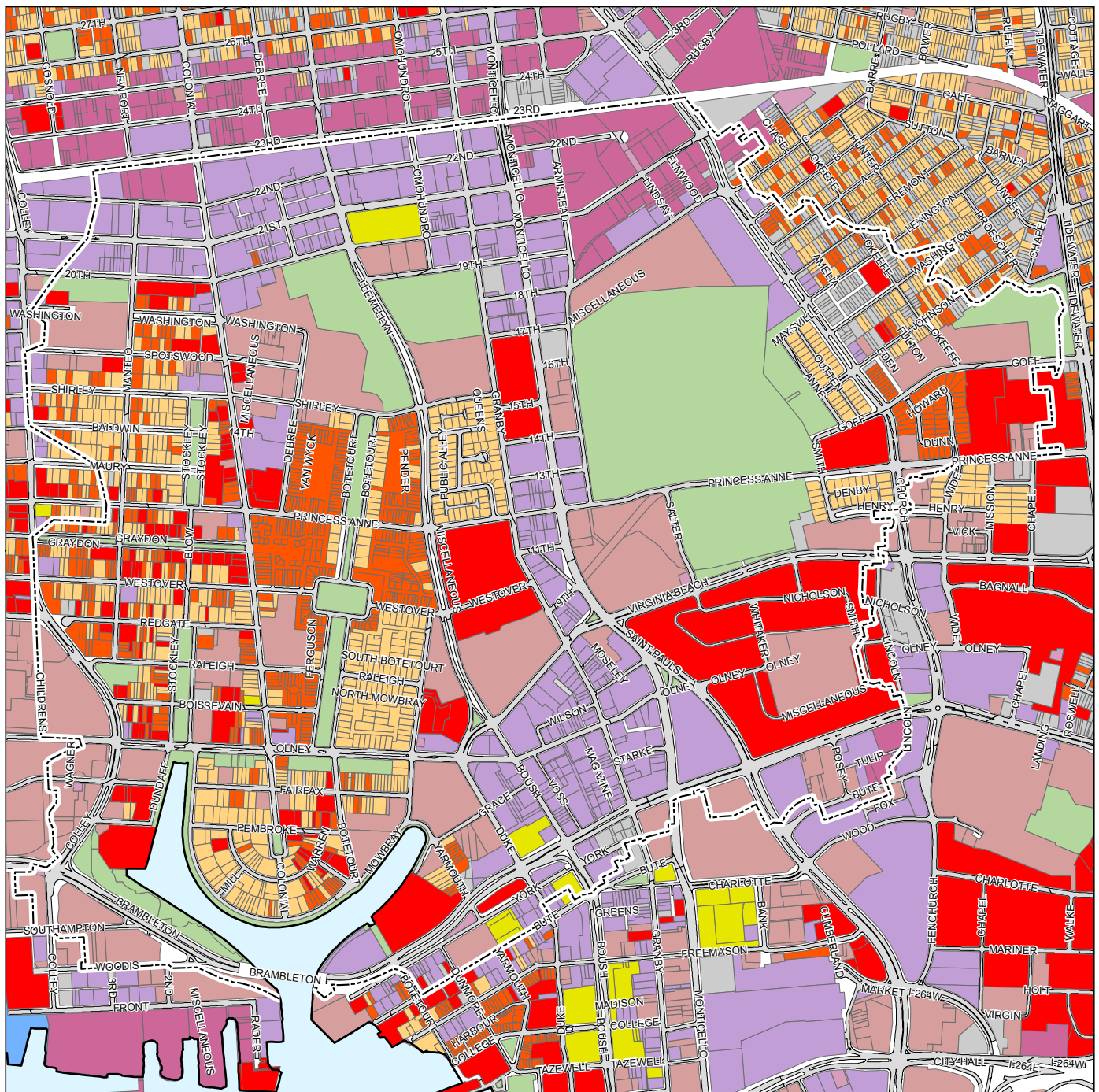


This graph represents a statistical characterization of the ground surface elevation within the Hague watershed. This cumulative frequency graph is based on the 2009 LiDAR survey data that has a 3-ft by 3-ft bin size (horizontal footprint is 3-ft by 3-ft). The watershed encompasses approximately 895 acres. Acreage estimates in this graph do not include the Hague water body.

Examples of how this graph may be interpreted:

- 1) 50 acres of the study area is equal to or below elevation 5 feet (NAVD88).
- 2) 400 acres of the study area is equal to or below elevation 9 feet (NAVD88).

STATISTICAL DISTRIBUTION OF TOPOGRAPHY
Cumulative Frequency
City-wide Coastal Flooding Study
Norfolk, Virginia



LEGEND

----- Hague Watershed Boundary

Existing Land Use

- High Density Residential
- Medium Density Residential
- Low Density Residential
- Mixed Use
- Commercial
- Industrial
- Institutional
- Military
- Transportation/Utility
- Open Space/Recreation
- Vacant

EXISTING LAND USE AREAS

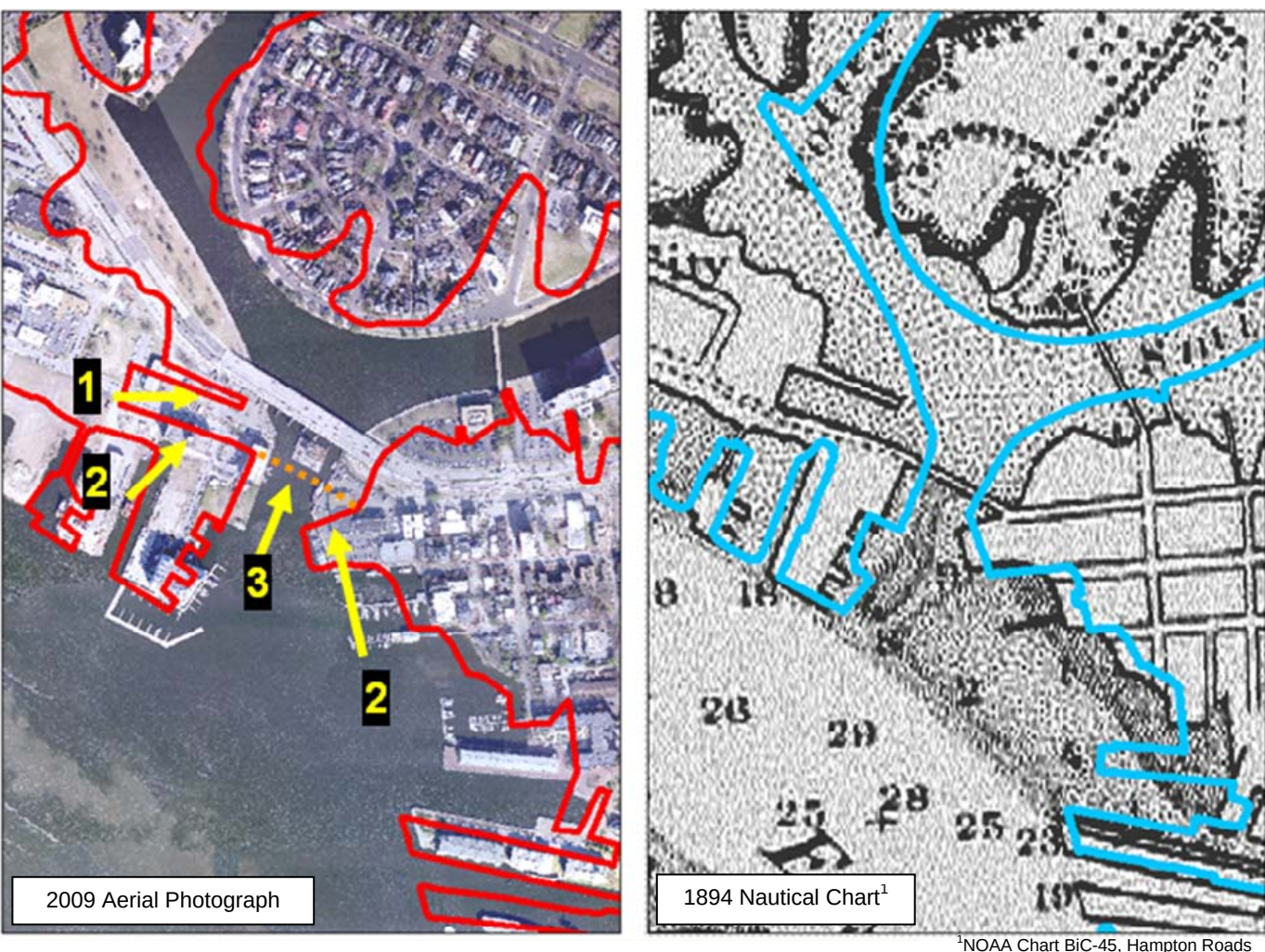
City-wide Coastal Flooding Study
Norfolk, Virginia



0 500 1,000
Feet

FIGURE 3-3





¹NOAA Chart BiC-45, Hampton Roads

Numerous former structures may be present and challenging to tie new structures into shore

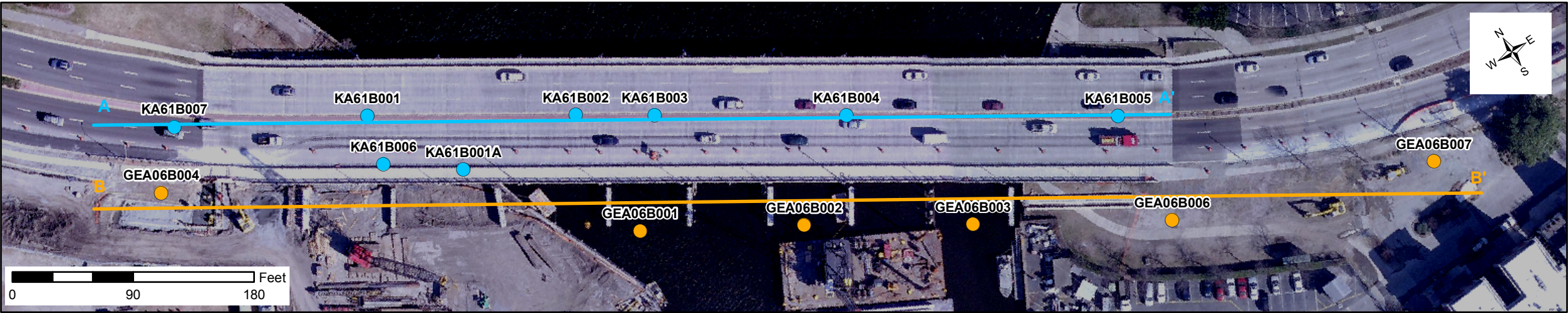
- 1 - Former Pier
- 2 - Former Hard Shoreline; possible concrete or piling structures
- 3 - Former Bridge

FORMER SHORELINE STRUCTURES

Basin Outlet

City-wide Coastal Flooding Study

Norfolk, Virginia



LEGEND

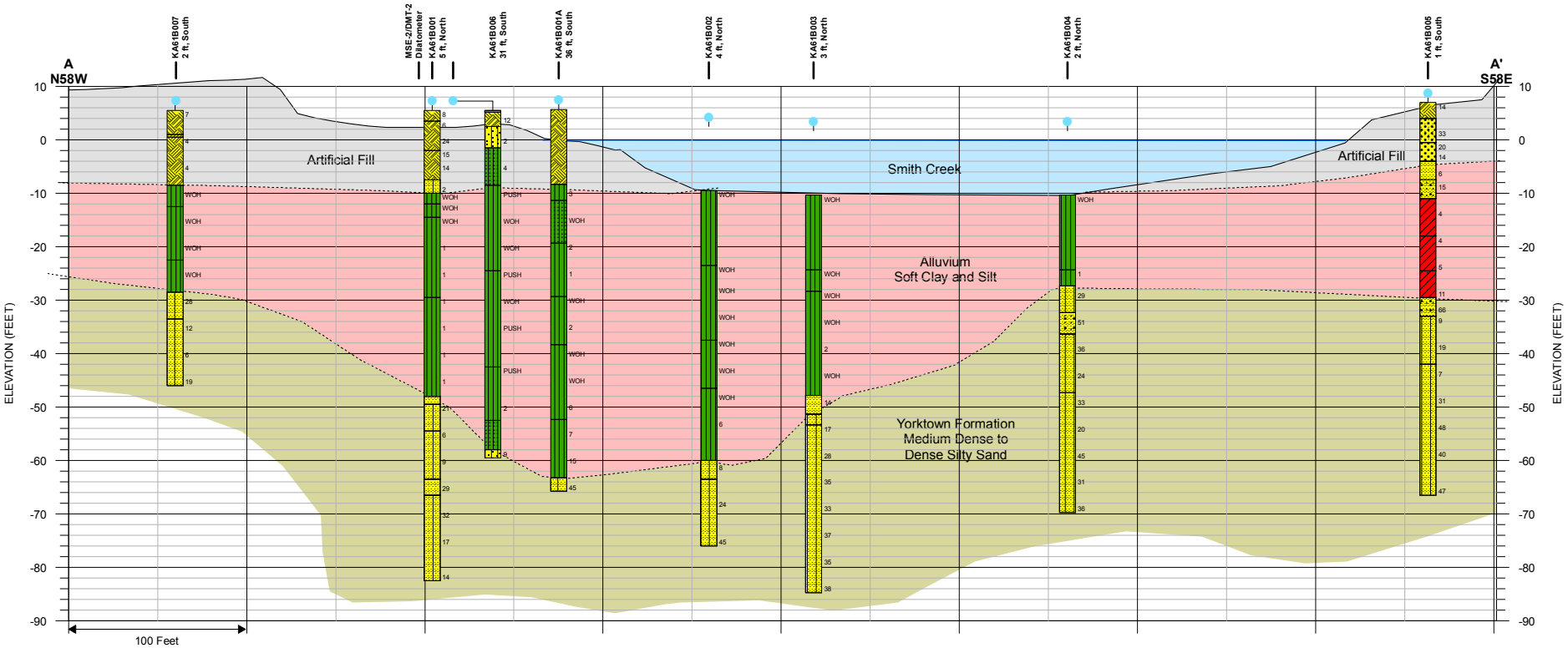
- 1961 Geotechnical Boring
- 2006 Geotechnical Boring
- Cross Section Location AA'
- Cross Section Location BB'

Stratigraphic Units

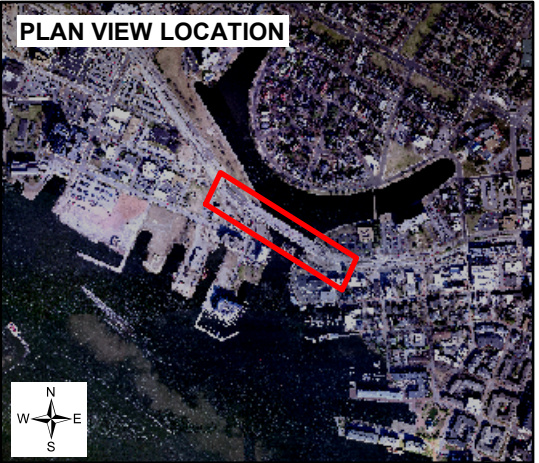
- af Artificial Fill
- Qals Sand Alluvium
- Qal Soft Silt and Clay Alluvium
- Ty Yorktown Formation - Silty Sand

Soil Types

- Pavement
- FILL
- Poorly graded GRAVEL (GP)
- Poorly graded SAND (SP)
- SAND with gravel (SW)
- Silty SAND (SM)
- SAND with silt (SP-SM)
- Fat CLAY (CH)
- Lean CLAY (CL)
- Sandy lean CLAY (CL)
- Elastic SILT (MH)
- SILT (ML)
- Sandy SILT (ML)
- Highly plastic ORGANICS (OH)

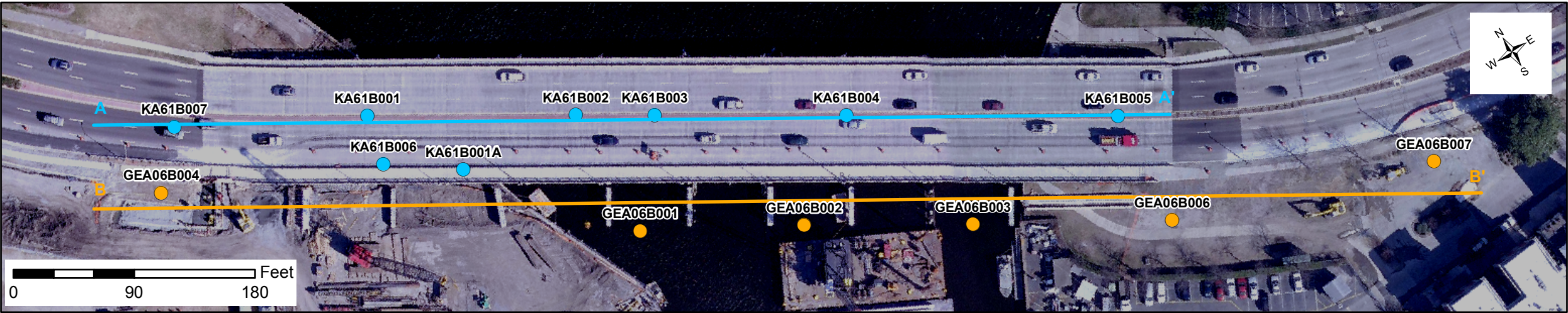


30 ft
90 ft
Vertical Exaggeration is 3x.



**BRAMBLETON BRIDGE PRELIMINARY
SUBSURFACE CROSS SECTION**
City-wide Coastal Flooding Study
Norfolk, Virginia

FIGURE 4-2



LEGEND

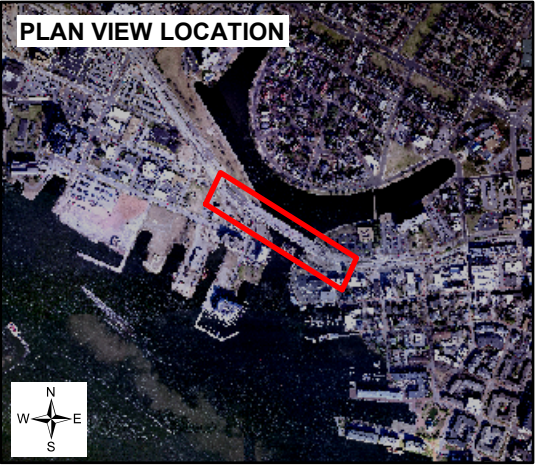
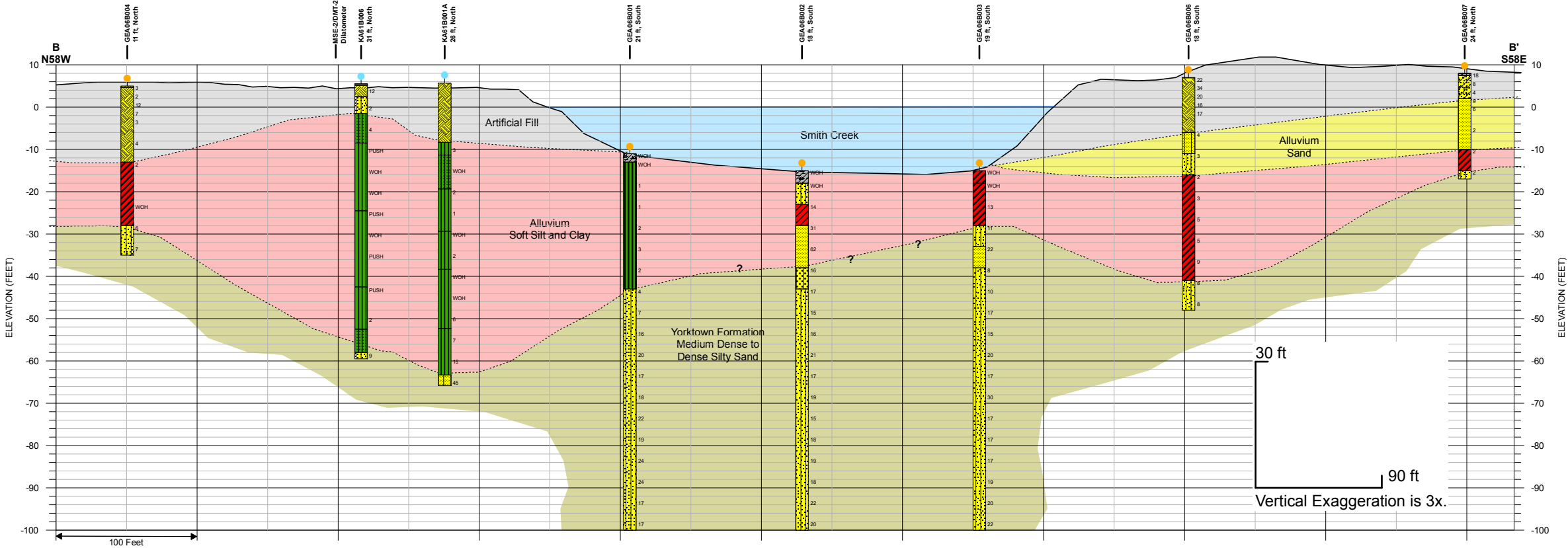
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- 2006 Geotechnical Boring
- Cross Section Location AA'
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- Qals Sand Alluvium
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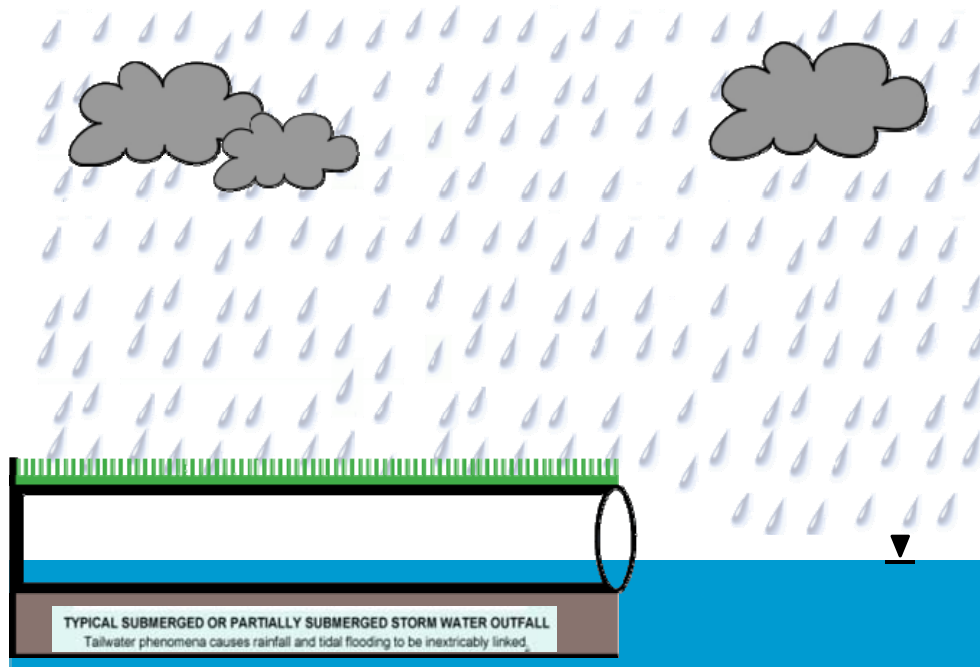
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- FILL
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- Poorly graded SAND (SP)
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- Sandy lean CLAY (CL)
- Elastic SILT (MH)
- SILT (ML)
- Sandy SILT (ML)
- Highly plastic ORGANICS (OH)



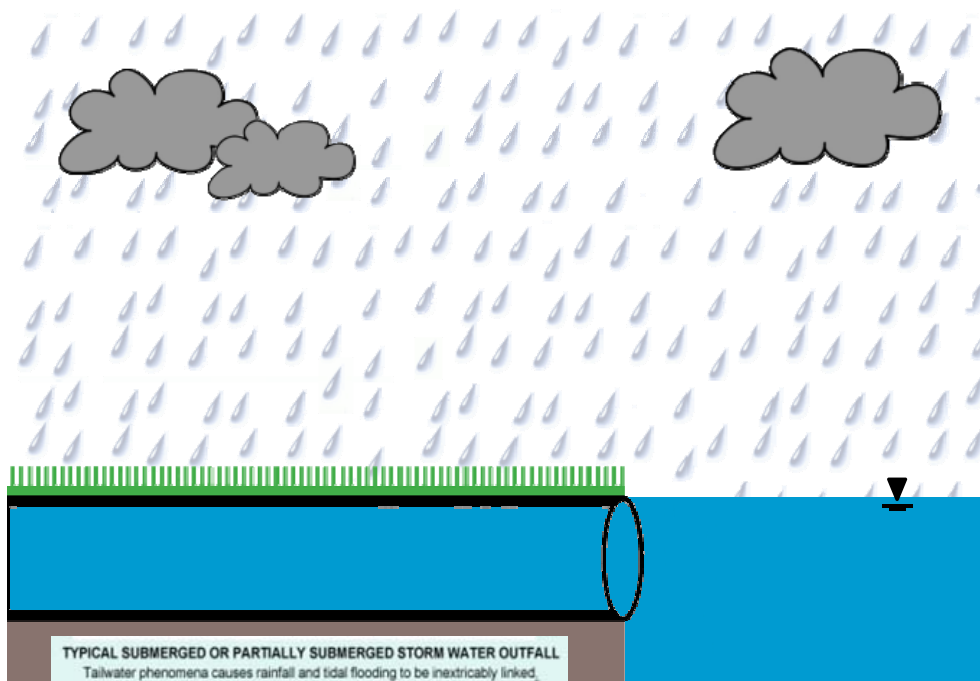
**LIGHT RAIL BRIDGE PRELIMINARY
SUBSURFACE CROSS SECTION**
City-wide Coastal Flooding Study
Norfolk, Virginia

FIGURE 4-3

Rainfall Predominant



Coincident Surge Event



TAILWATER PHENOMENA

City-wide Coastal Flooding Study Norfolk, Virginia



FIGURE 6-1



FIGURE 6-2

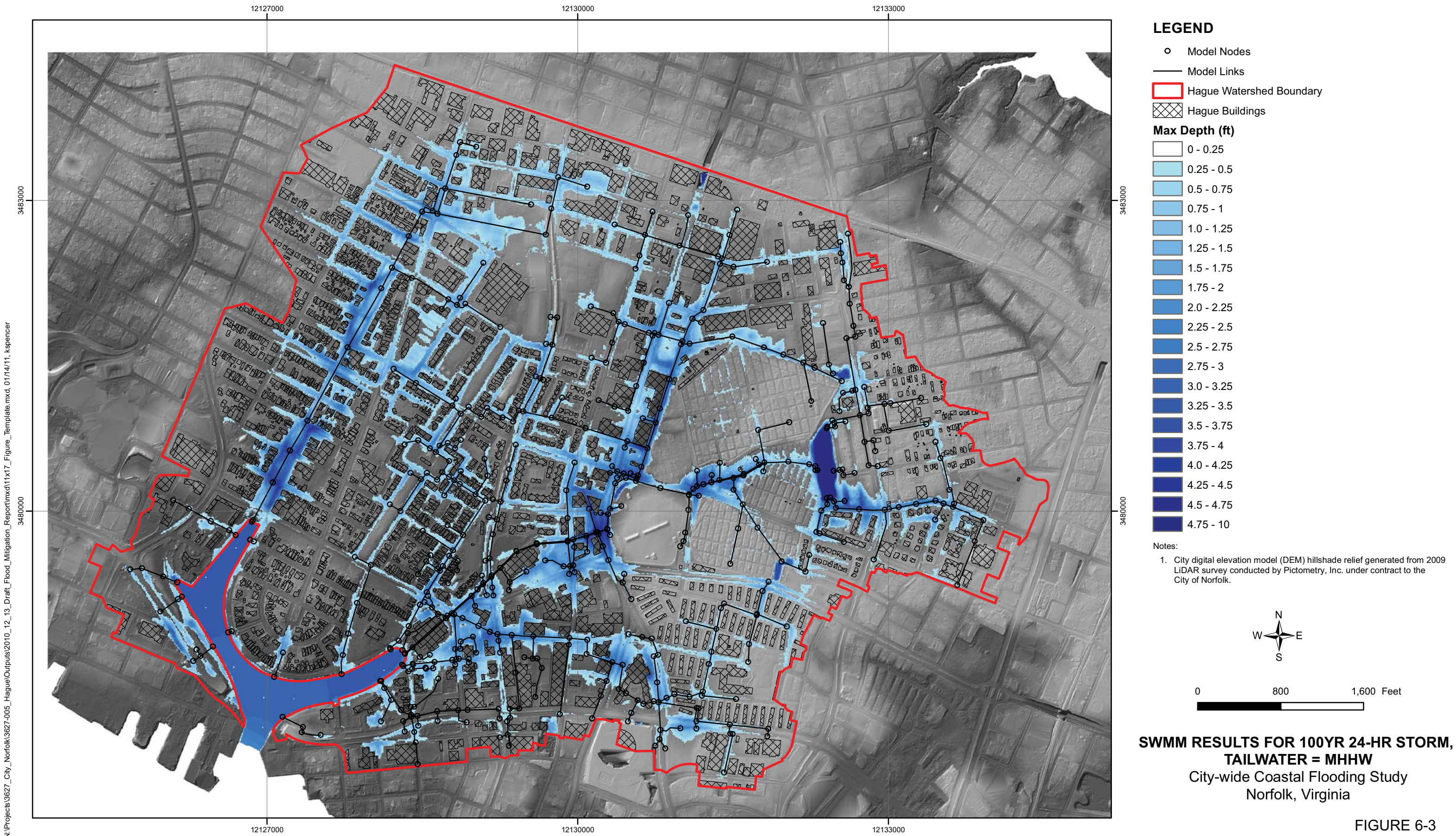


FIGURE 6-3

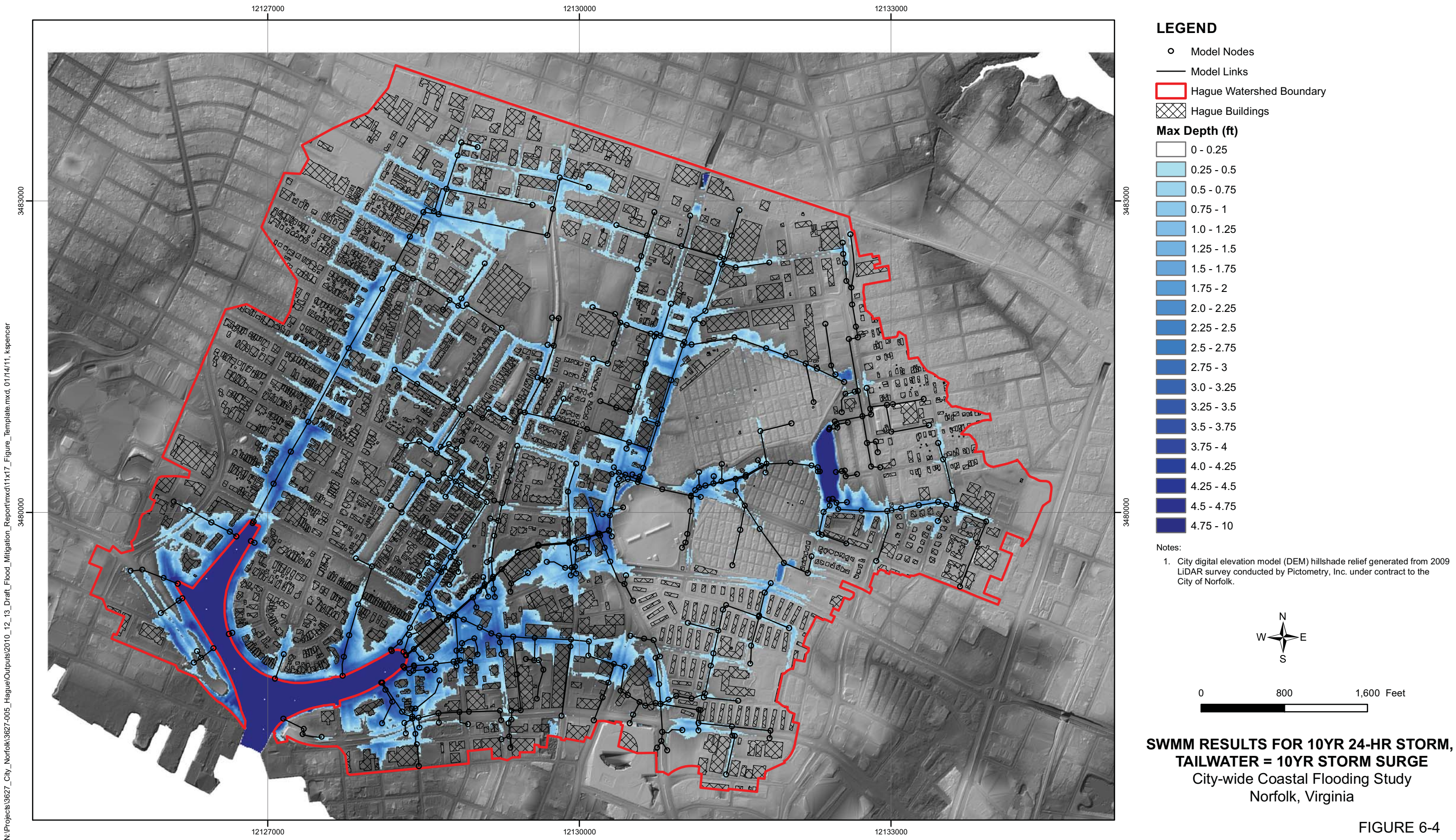


FIGURE 6-4

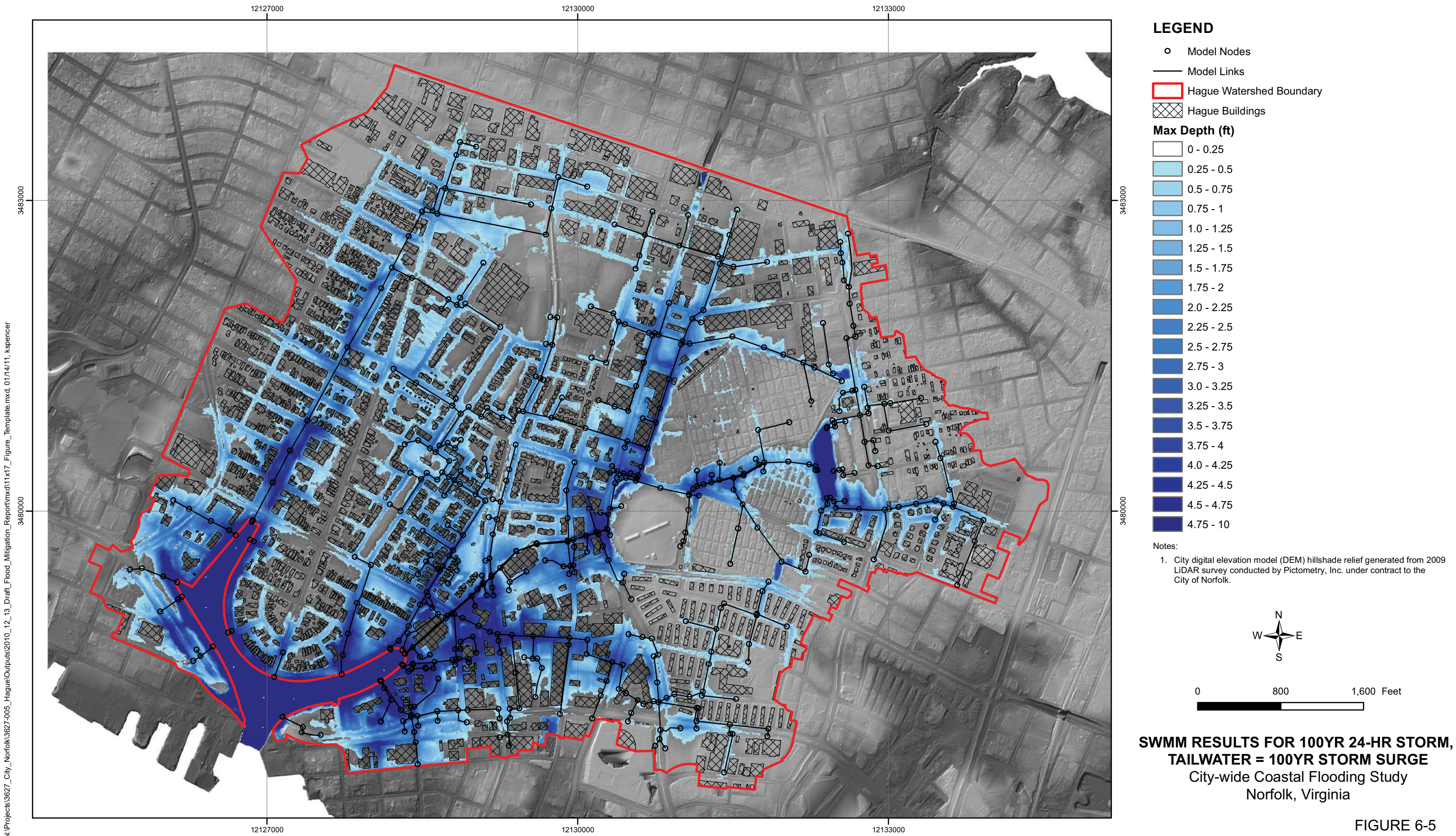


FIGURE 6-5

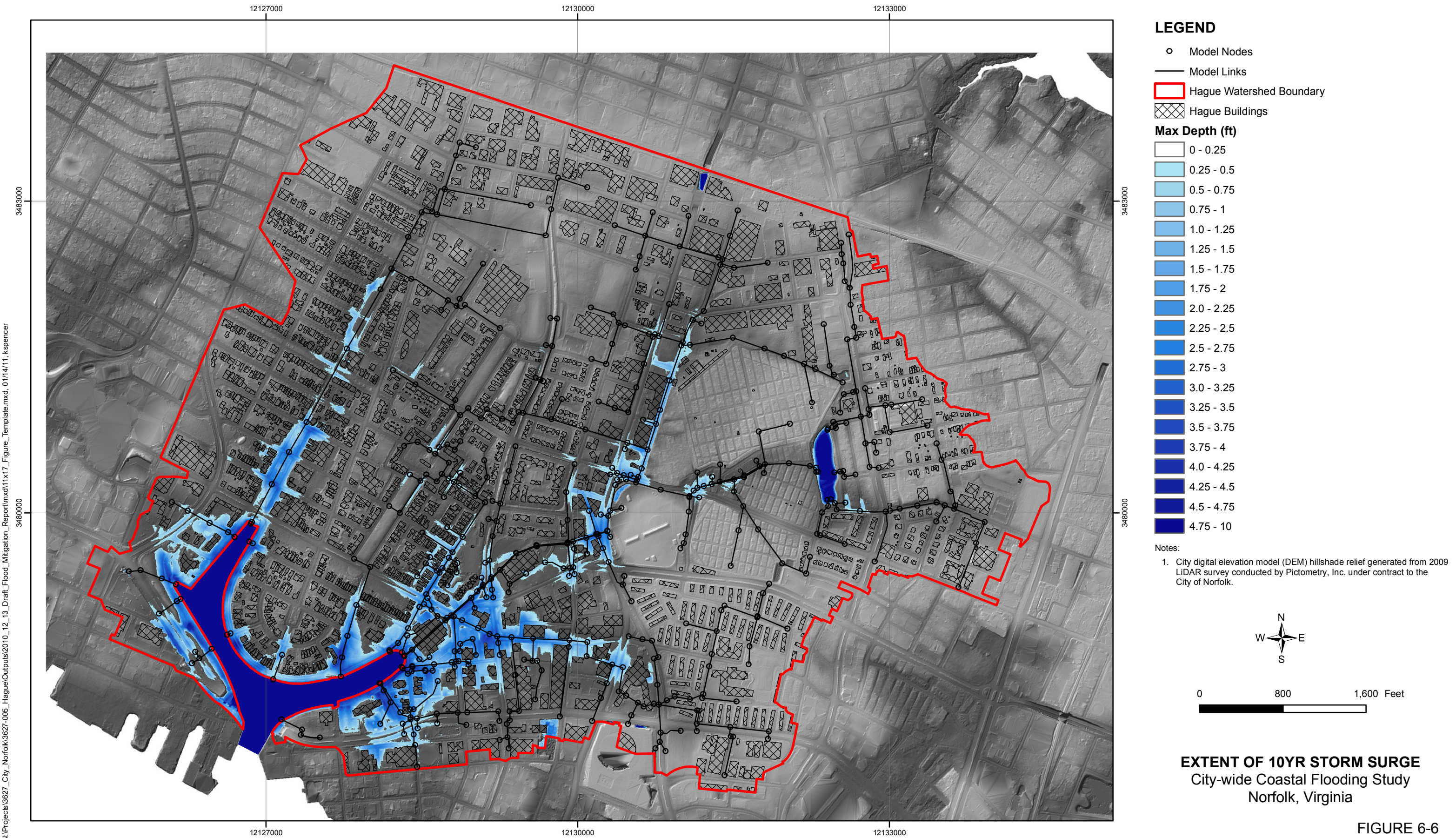


FIGURE 6-6

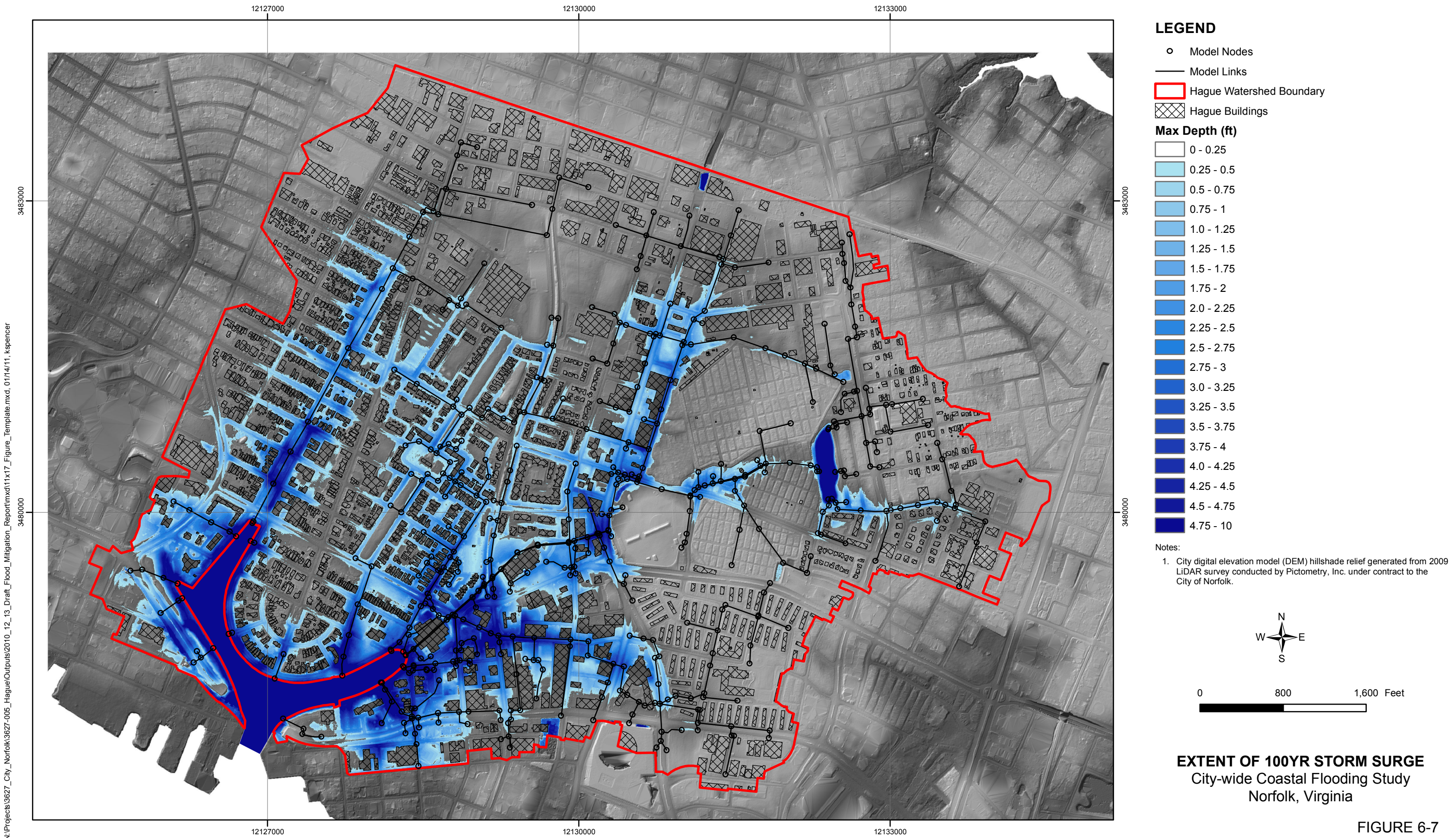
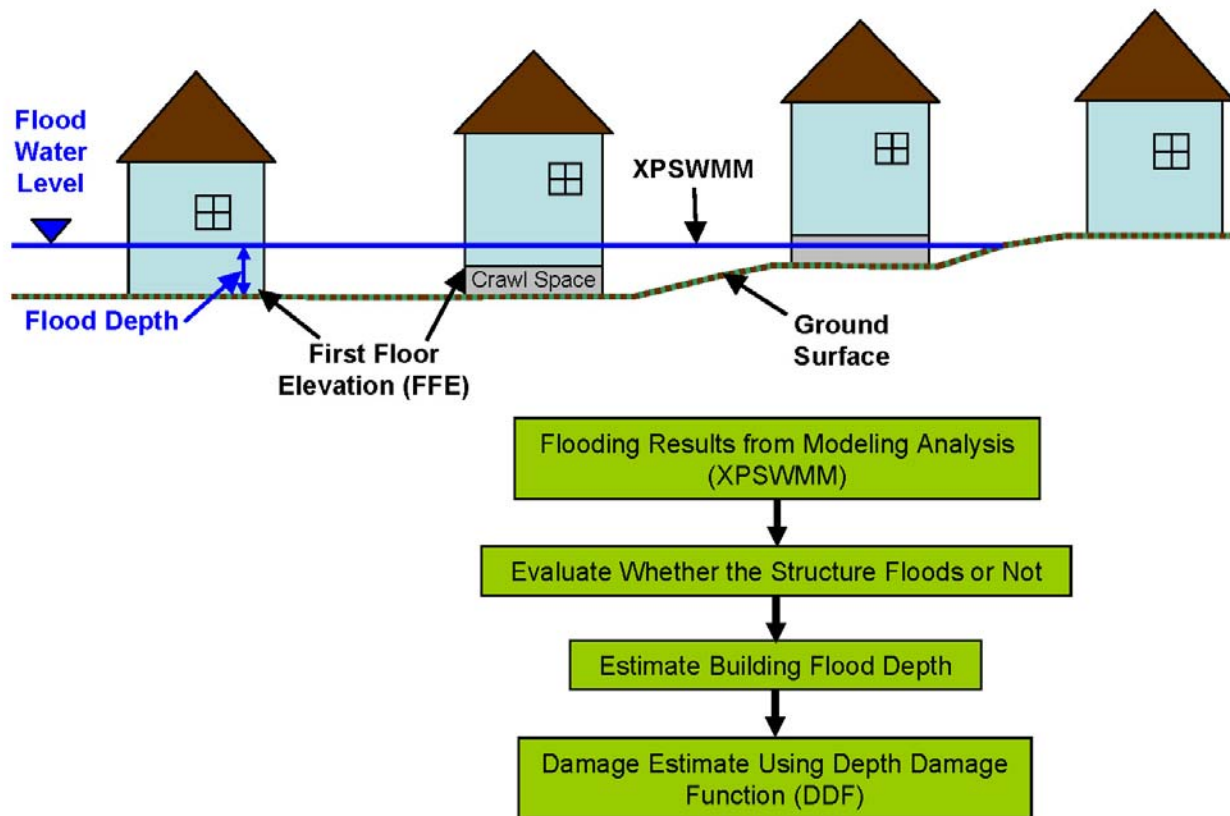


FIGURE 6-7



DEPTH DAMAGE FUNCTION CONCEPT
City-wide Coastal Flooding Study
Norfolk, Virginia

FIGURE 7-1

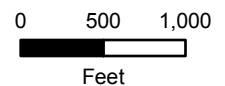
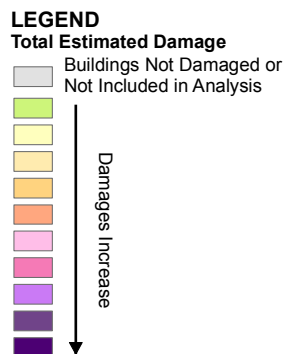
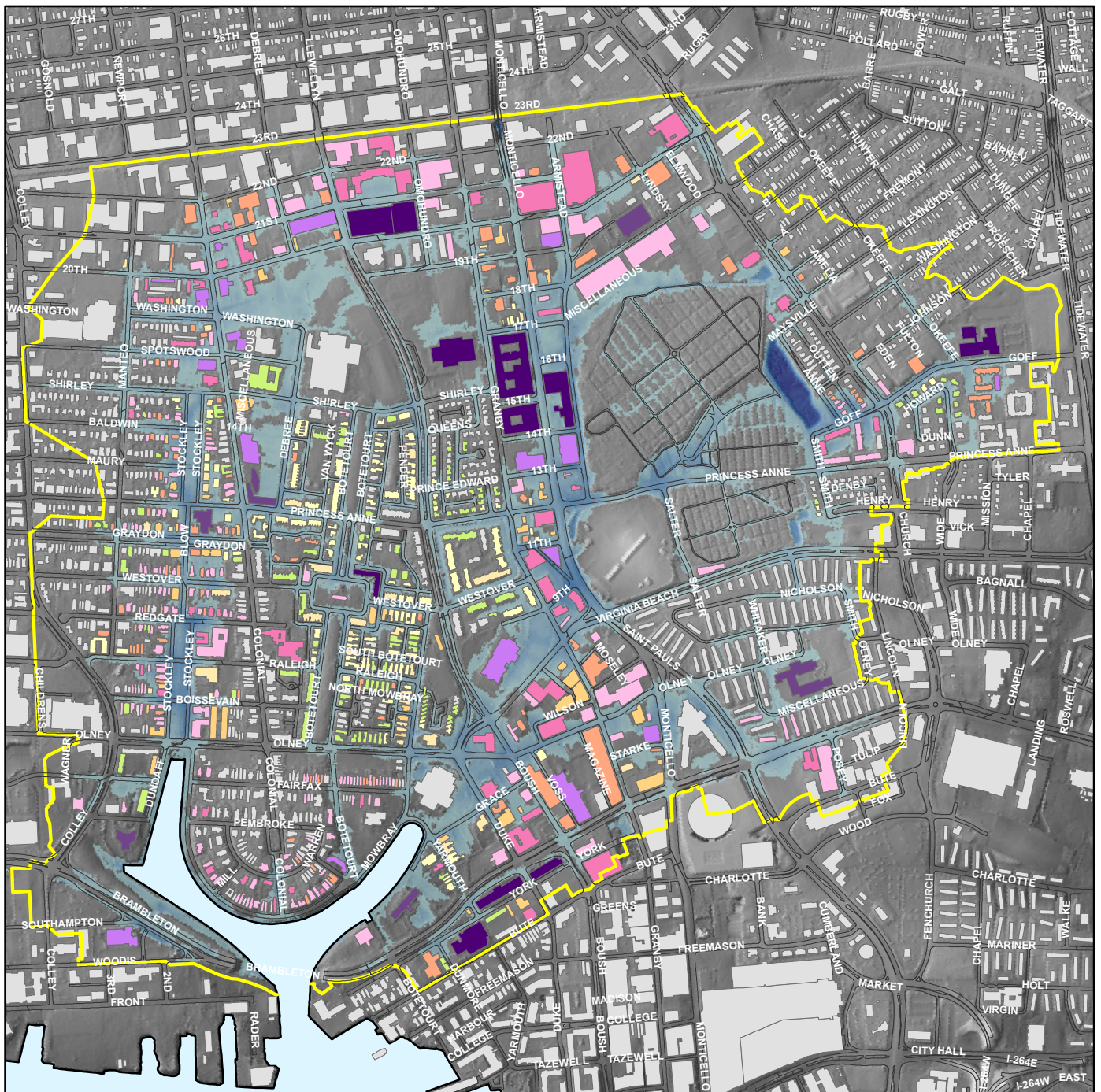


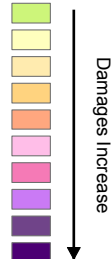
FIGURE 7-2

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LEGEND

Total Estimated Damage
Buildings Not Damaged or
Not Included in Analysis

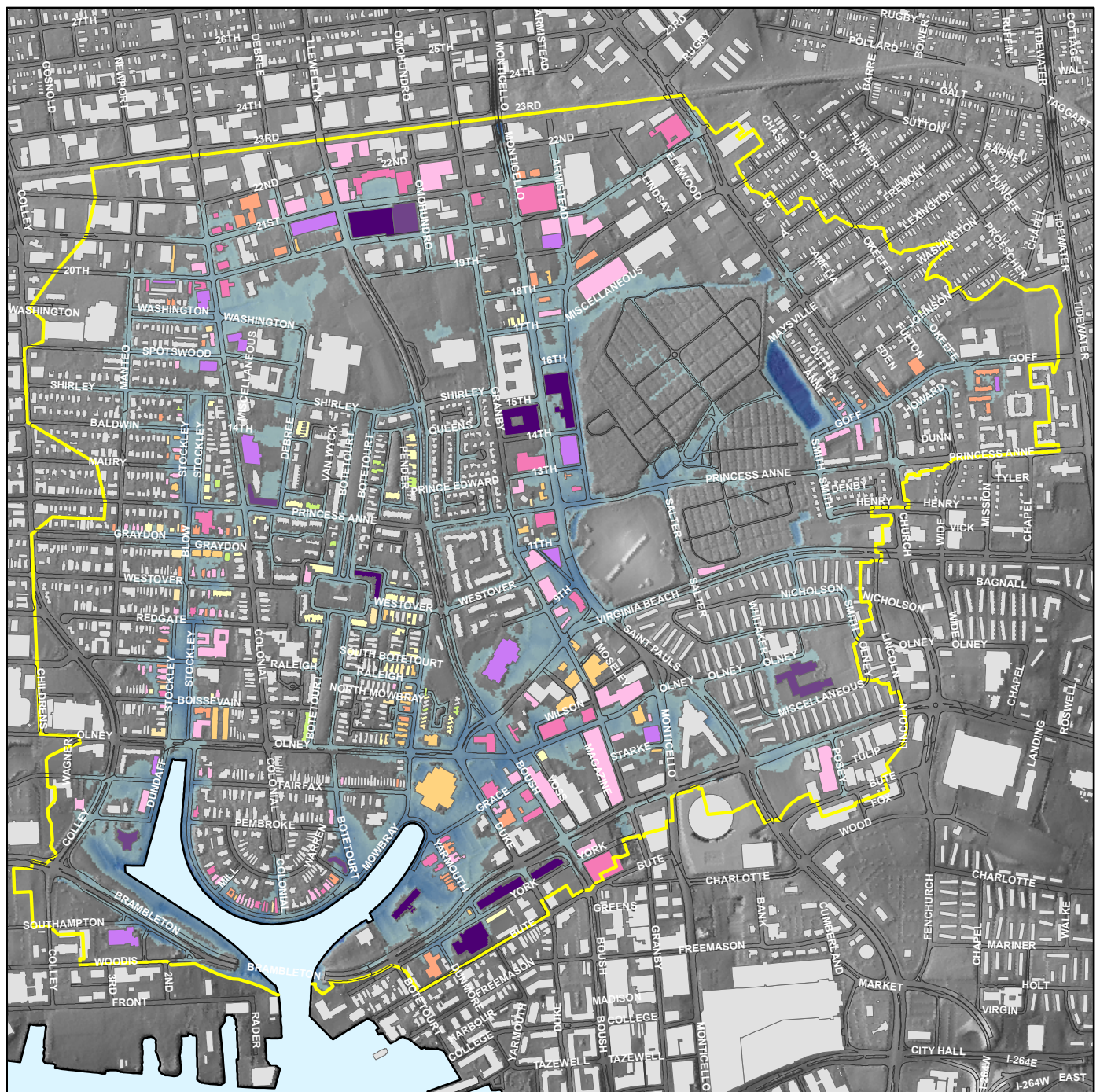


FLOOD DAMAGE ESTIMATES
100YR 24-HR STORM,
TAILWATER = MHHW
City-wide Coastal Flooding Study
Norfolk, Virginia



0 500 1,000
Feet

FIGURE 7-3

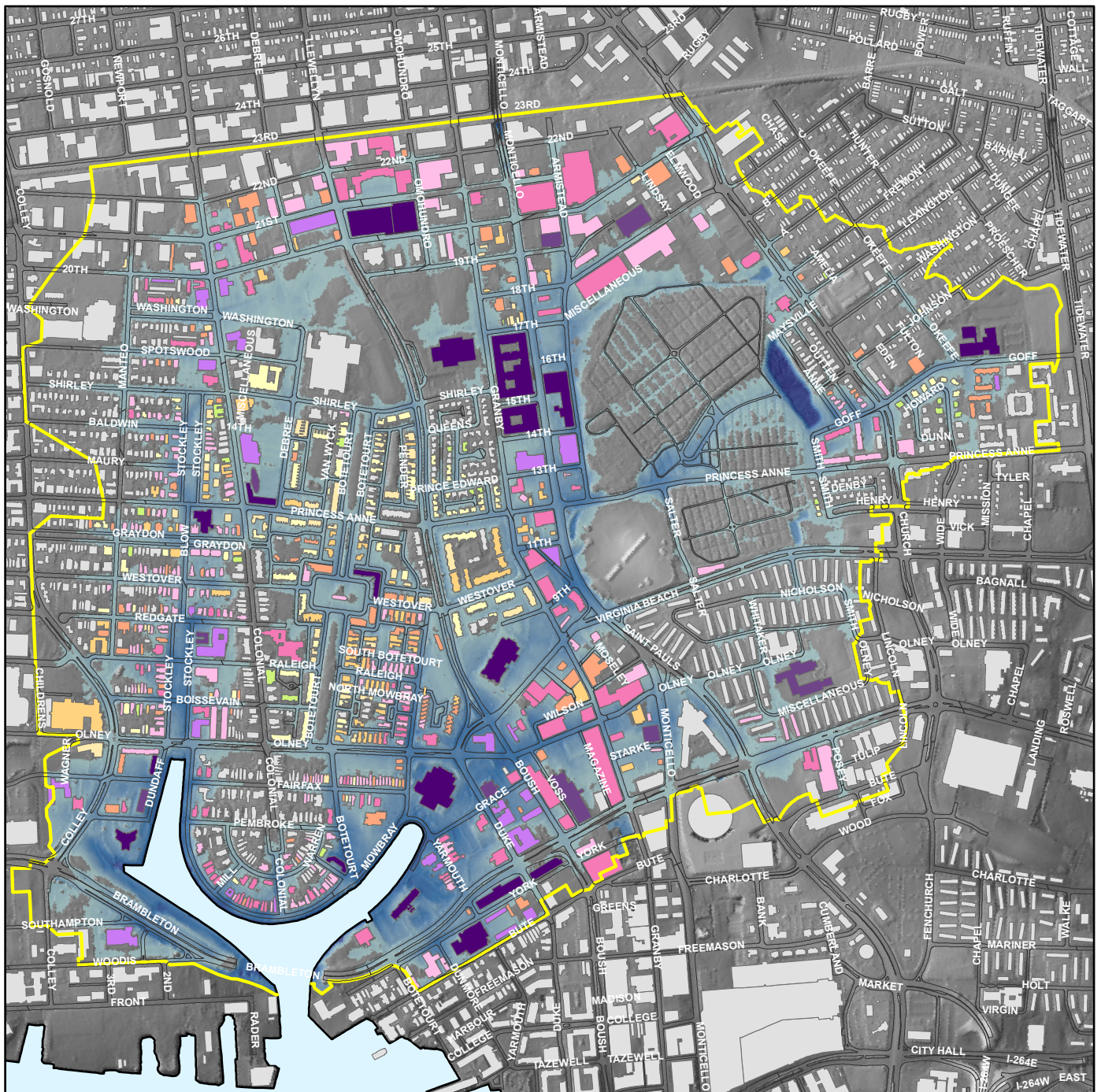


FLOOD DAMAGE ESTIMATES
10YR 24-HR STORM,
TAILWATER = 10YR STORM SURGE
 City-wide Coastal Flooding Study
 Norfolk, Virginia



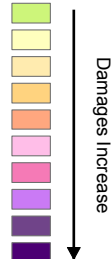
FIGURE 7-4

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LEGEND

Total Estimated Damage
Buildings Not Damaged or
Not Included in Analysis

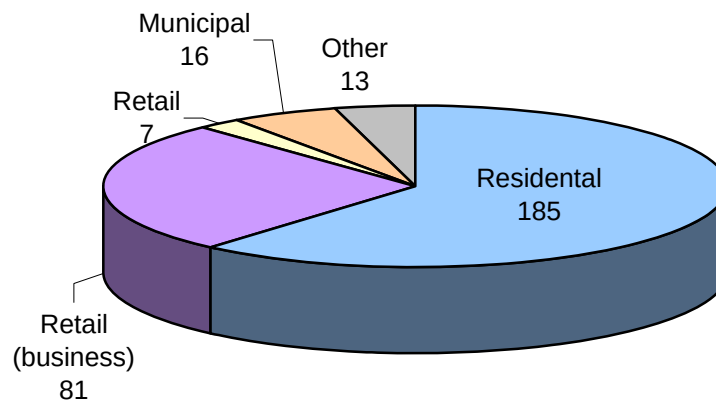


FLOOD DAMAGE ESTIMATES 100YR 24-HR STORM, TAILWATER = 100YR STORM SURGE City-wide Coastal Flooding Study Norfolk, Virginia

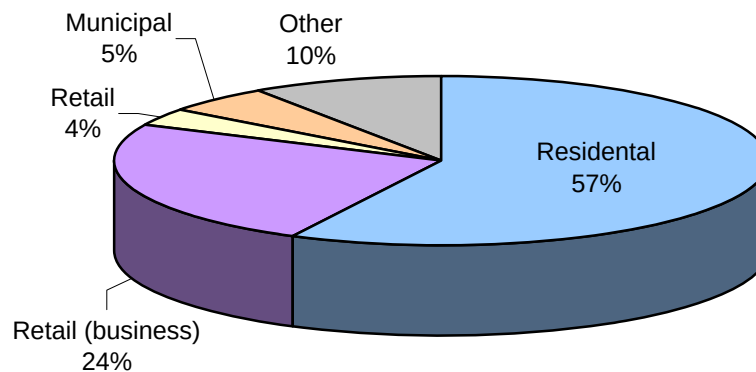


0 500 1,000
Feet

FIGURE 7-5



Number of Buildings Damaged by Flood



Cost Distribution of Flood Damage

Description and example subtypes for the above general categories:

Retail - Commodity-based businesses (department stores, grocery stores, convenience markets, gas stations, etc)

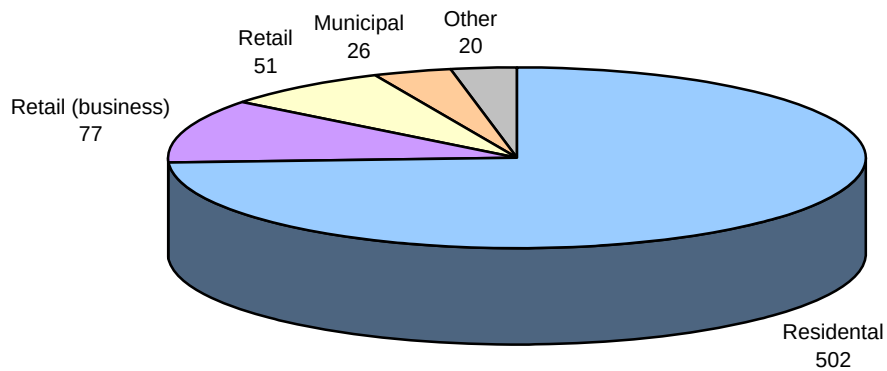
Retail (business) - Service-based businesses (office buildings, hotels, storage centers, service stations, funeral homes, exercise centers, etc)

Municipal - Government owned or operated facilities as well as health service facilities (hospitals, schools, parks, medical clinics/health centers, museums, etc)

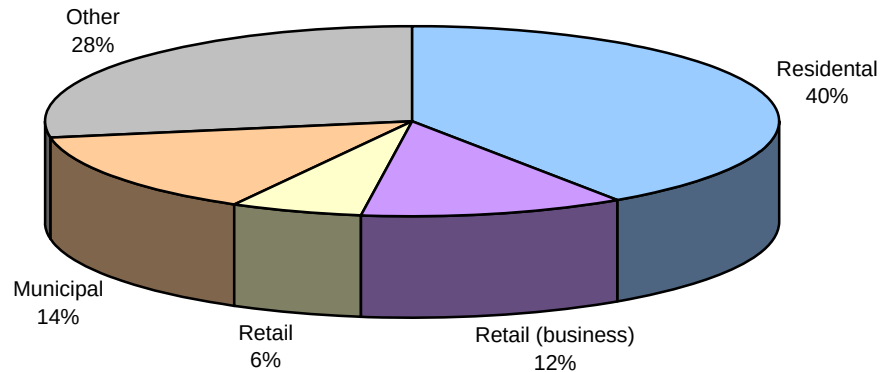
Residential - All private owned or government owned dwellings (single-family homes, condominiums, apartments, duplexes, etc)

Other - Unclassified property

SUMMARY OF FLOOD DAMAGE ESTIMATES
10YR 24-HR STORM, TAILWATER = 10YR STORM SURGE
 City-wide Coastal Flooding Study
 Norfolk, Virginia



Number of Buildings Damaged by Flood



Cost Distribution of Flood Damage

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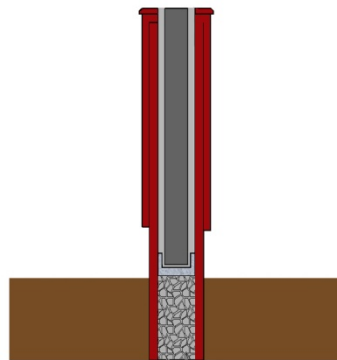
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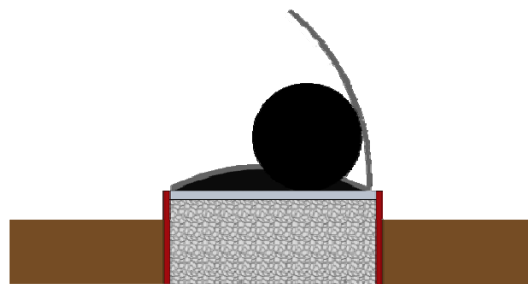
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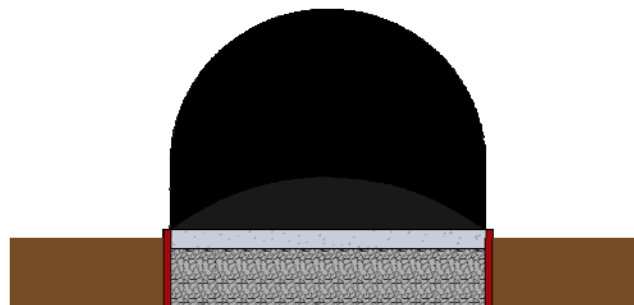
SUMMARY OF FLOOD DAMAGE ESTIMATES
100YR 24-HR STORM, TAILWATER = 100YR STORM SURGE
City-wide Coastal Flooding Study
Norfolk, Virginia



Steel Gate Option



Obermeyer Gate Option



Inflatable Dam Option

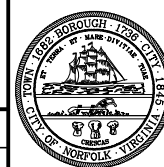
SCHEMATIC OF TIDE GATE TYPE OPTIONS
City-wide Coastal Flooding Study
Norfolk, Virginia



—— PRIMARY OPTION
- - - - ADDITIONAL OPTION

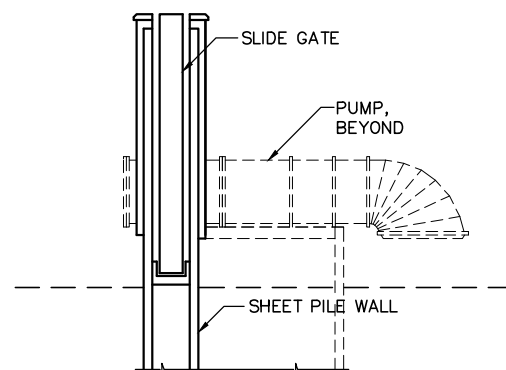
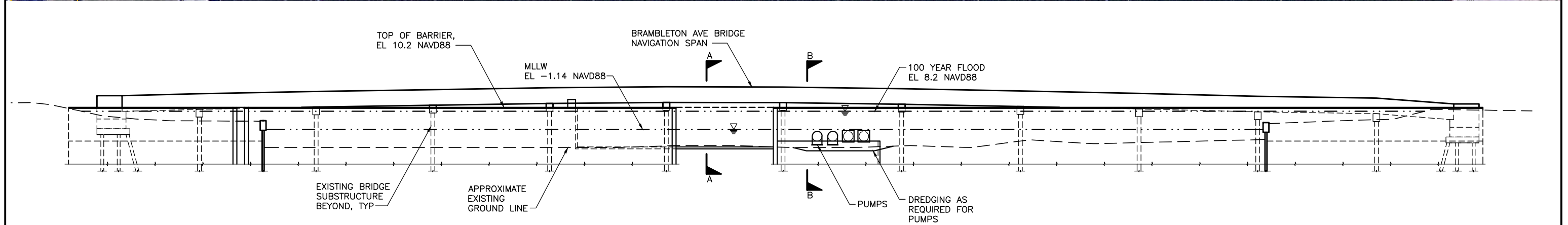
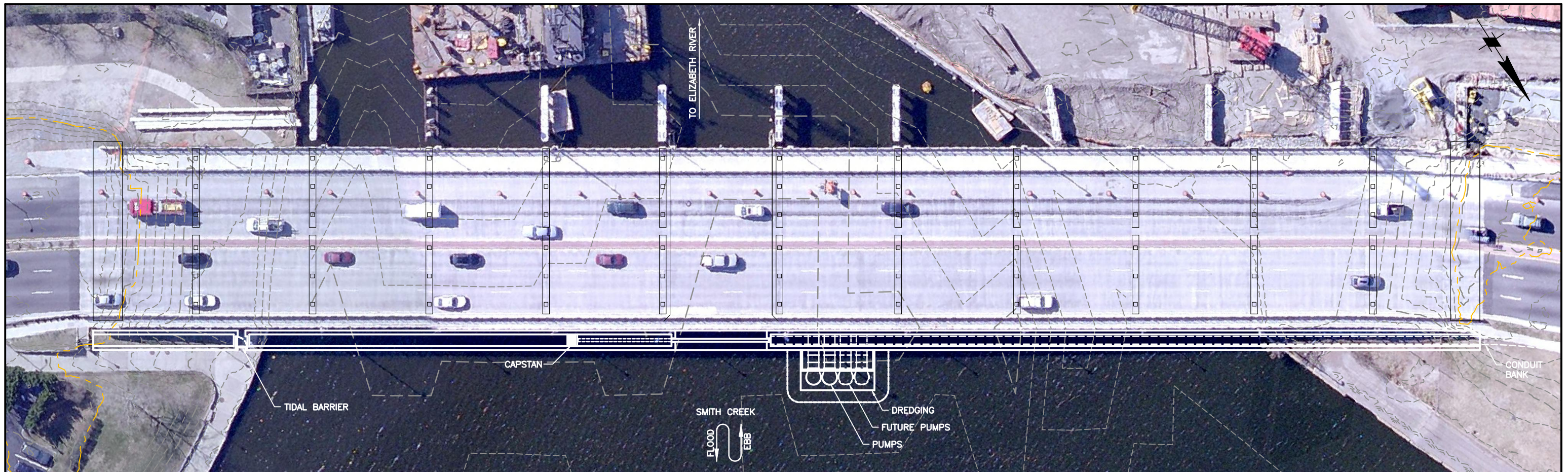


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JOB NO.	SCALE	DATE
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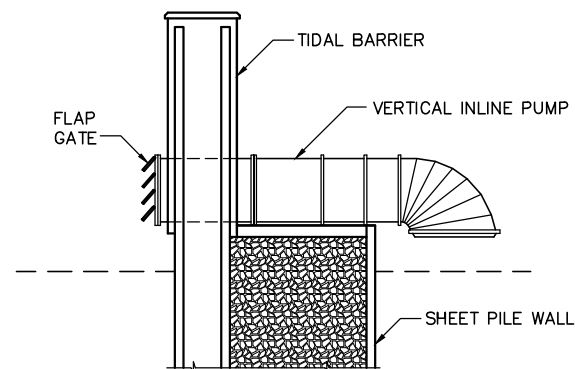


COASTAL FLOODING PROJECT
 NORFOLK, VIRGINIA
 THE HAGUE
 TIDAL BARRIER WITH TIDE GATE, PUMPS,
 AND CLOSURE WALLS — BERMS

FIGURE
8-2



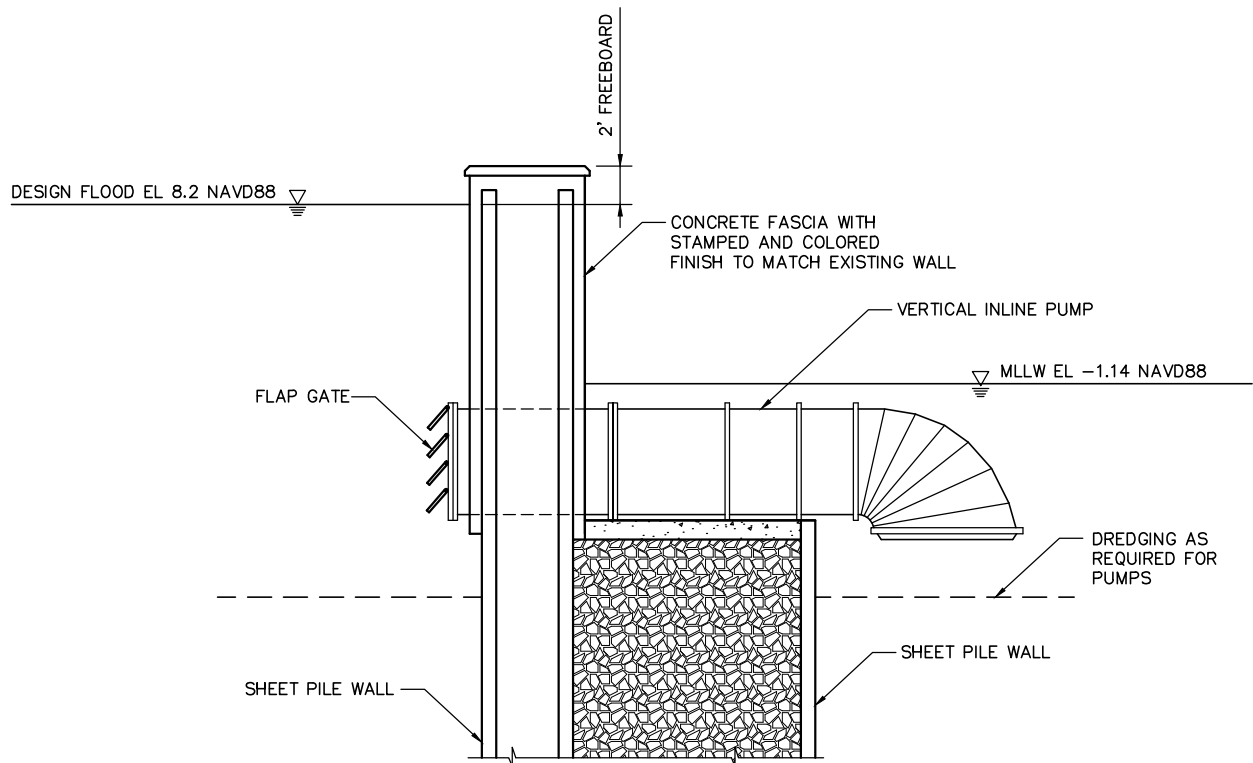
SECTION A-A



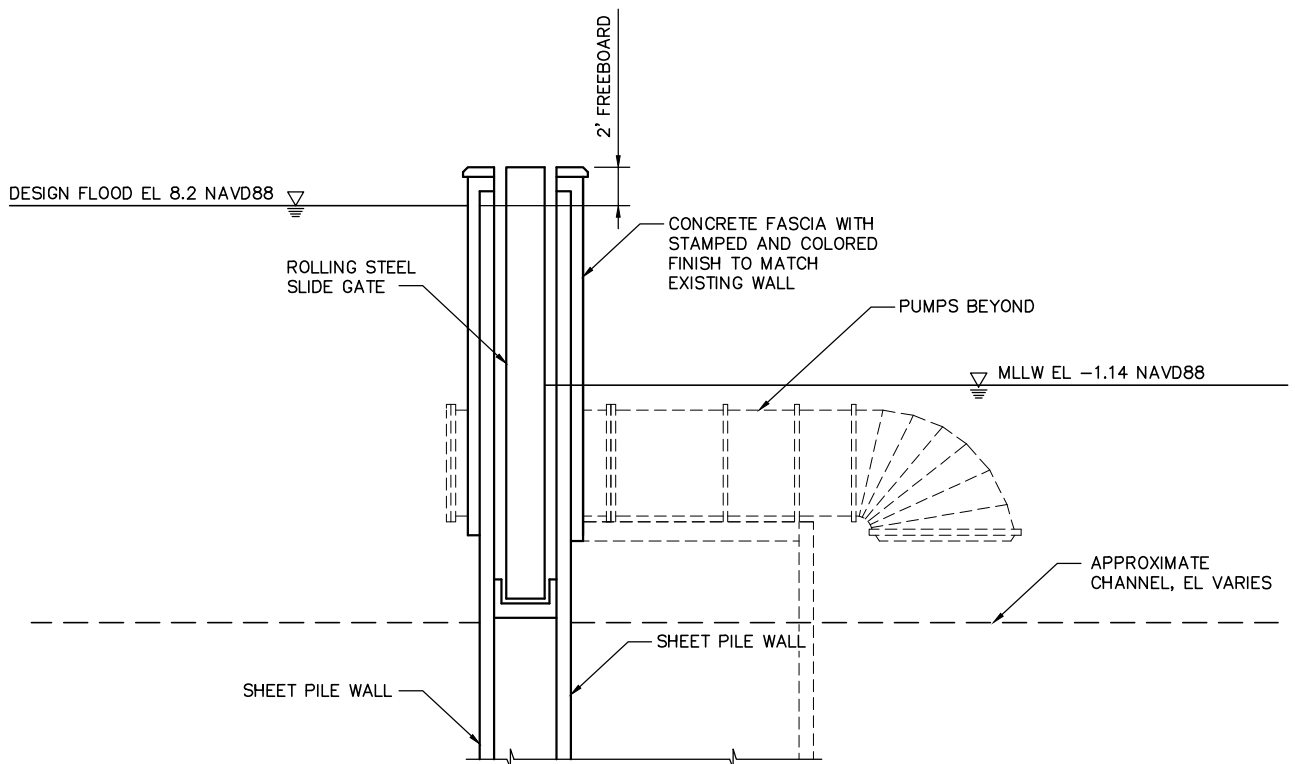
SECTION B-B



 moffatt & nichol					COASTAL FLOODING PROJECT NORFOLK, VIRGINIA		FIGURE 8-3
DSGN	DR KOONS	CHK .	THE HAGUE BRAMBLETON AVENUE BRIDGE STEEL GATE OPTION				
JOB NO. 6822-03	SCALE 1"=50'	DATE 12-14-2010					

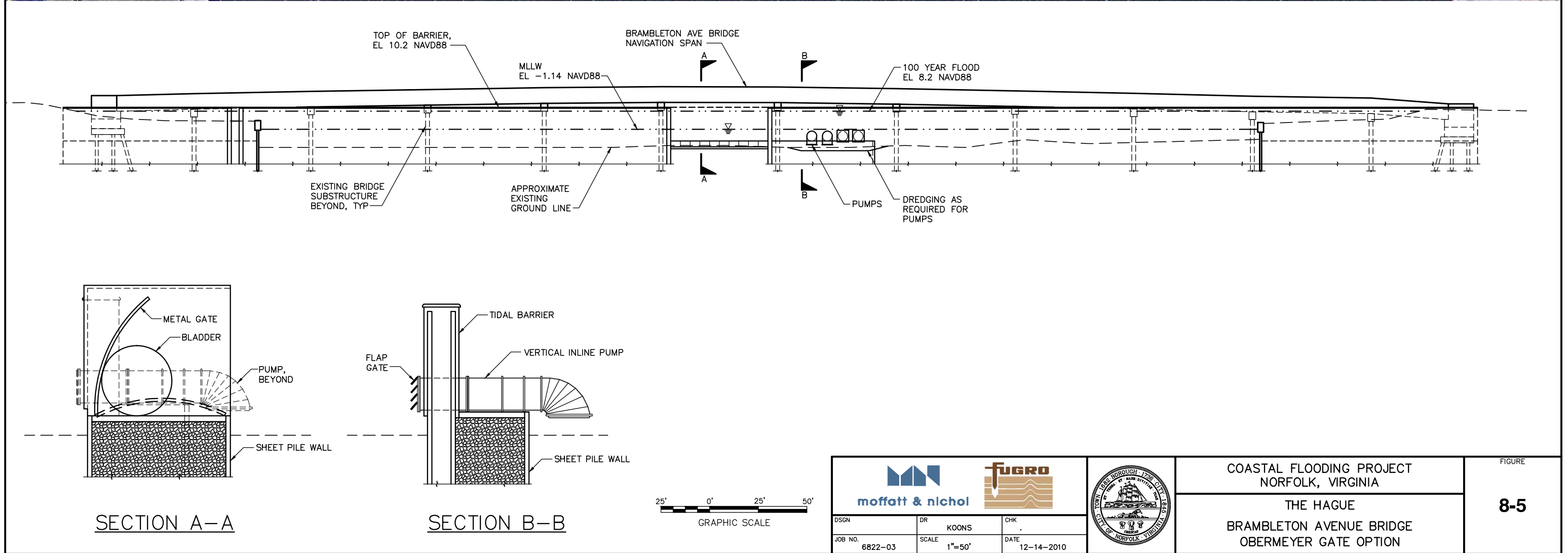
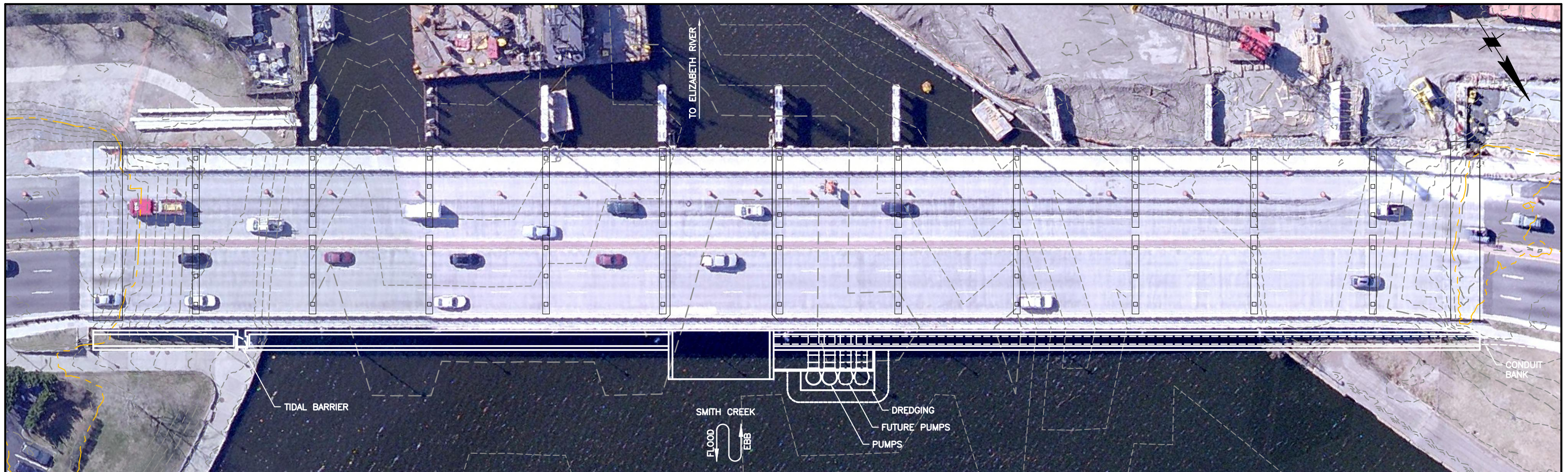


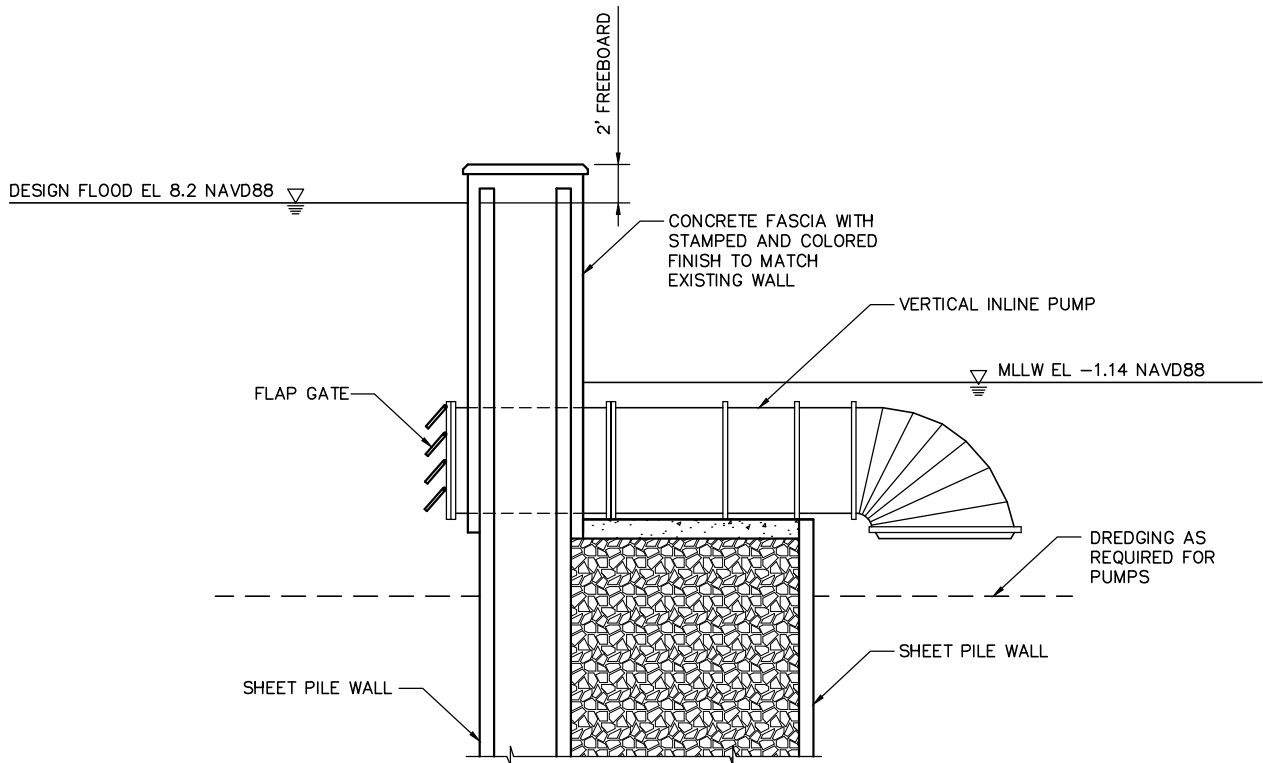
WALL SECTION AT PUMPS



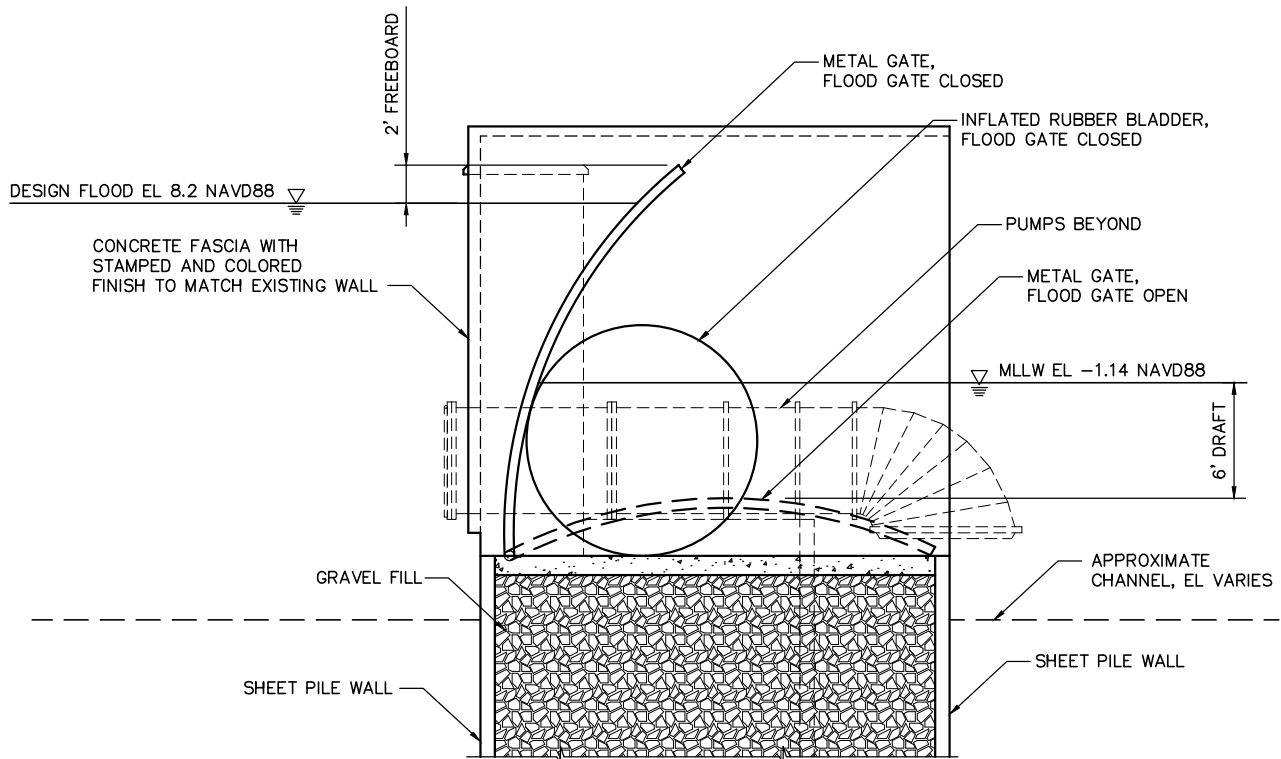
SECTION AT FLOOD STEEL GATE

 				COASTAL FLOODING PROJECT NORFOLK, VIRGINIA	FIGURE 8-4
DSGN	DR	CHK		THE HAGUE	
JOB NO. 6822-03	SCALE 1"=10'	DATE 12-14-2010		BRAMBLETON AVENUE BRIDGE STEEL GATE OPTION - SECTIONS	



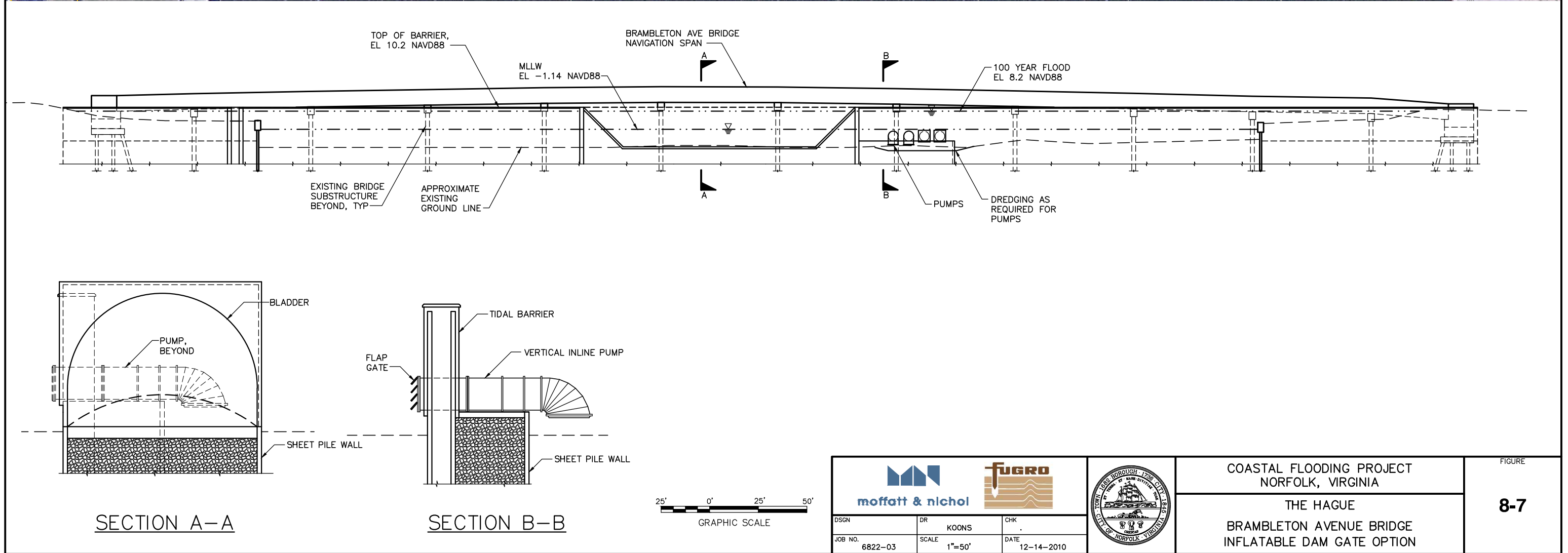
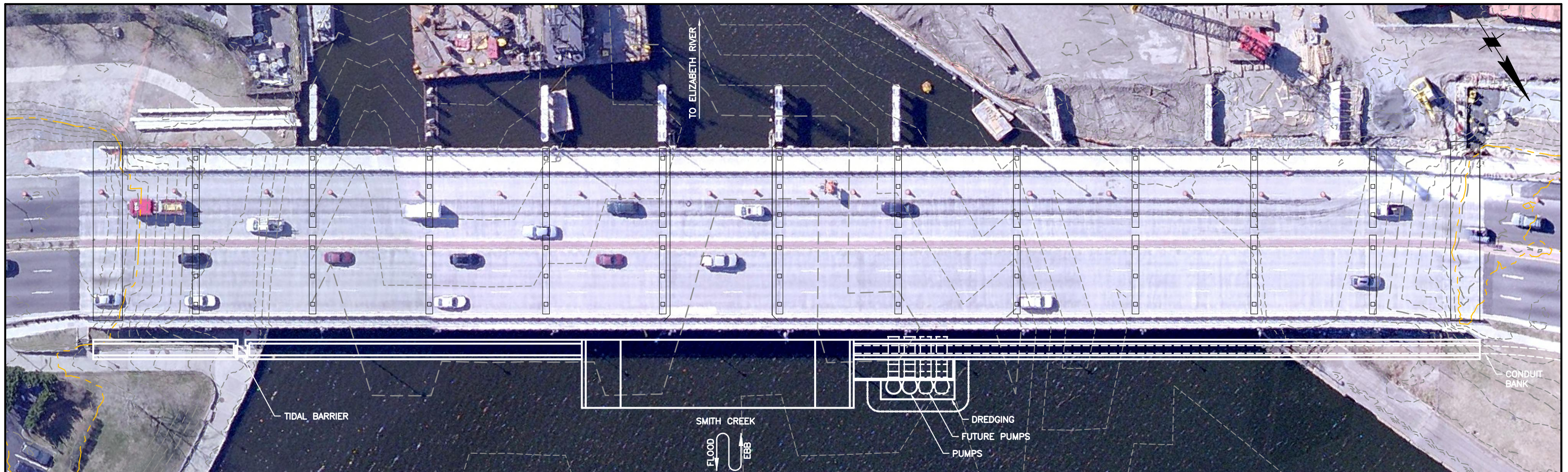


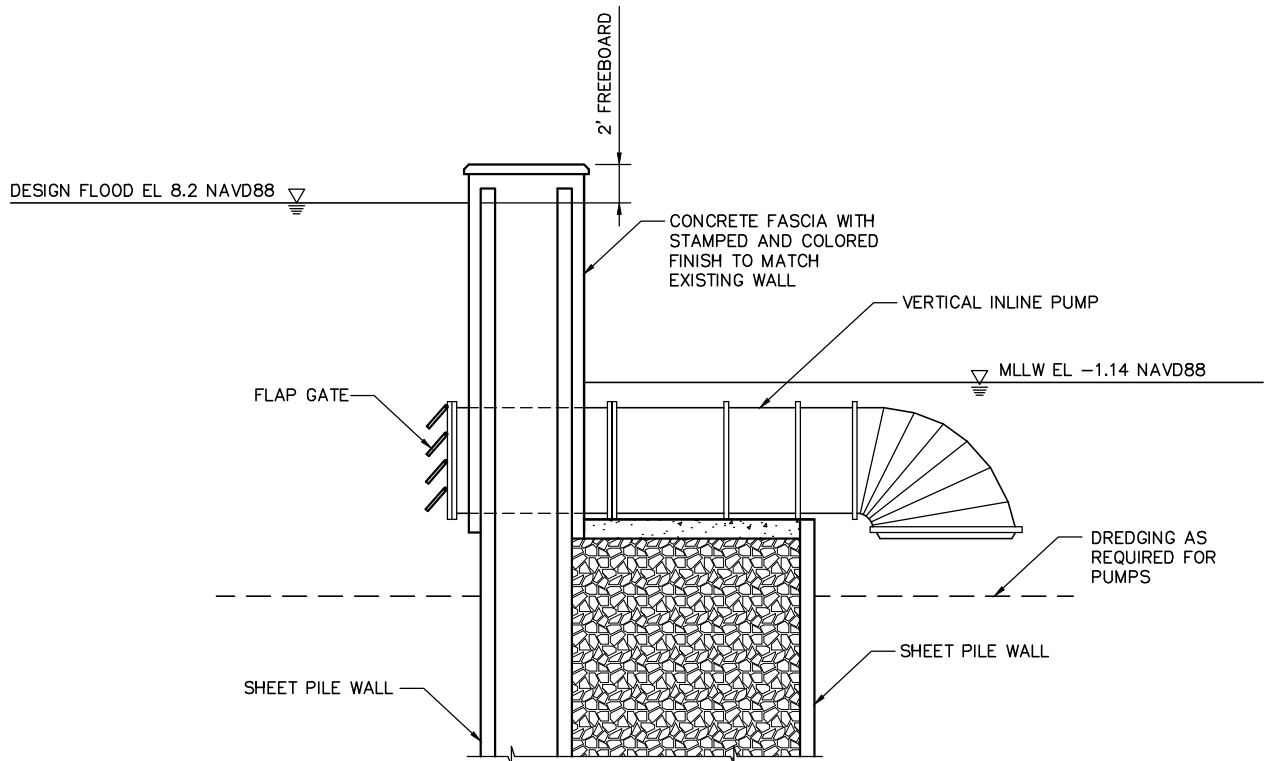
WALL SECTION AT PUMPS



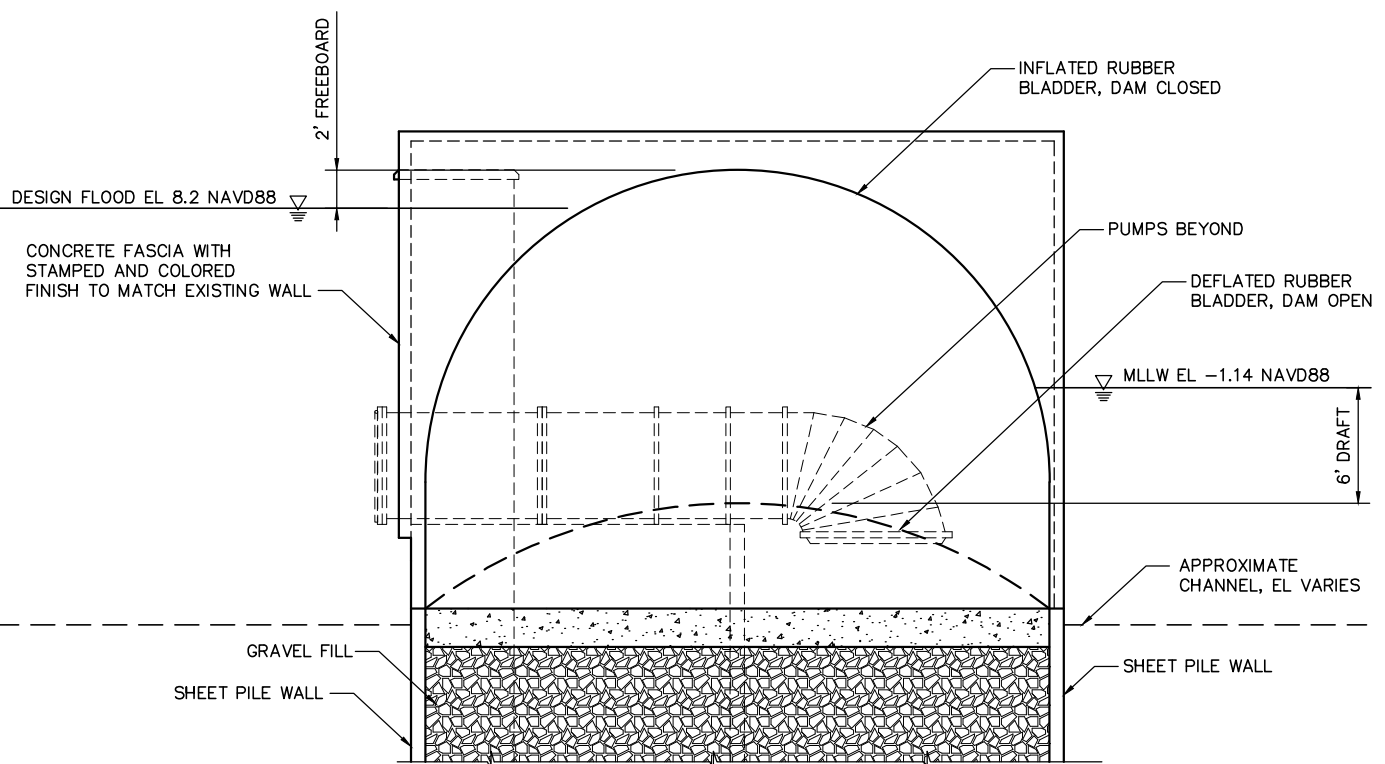
SECTION AT OBERMEYER GATE

 				COASTAL FLOODING PROJECT NORFOLK, VIRGINIA	FIGURE 8-6
DSGN	DR KOONS	CHK		THE HAGUE	
JOB NO. 6822-03	SCALE 1"=10'	DATE 12-14-2010		BRAMBLETON AVENUE BRIDGE OBERMEYER GATE OPTION - SECTIONS	





WALL SECTION AT PUMPS



SECTION AT INFLATABLE BLADDER



COASTAL FLOODING PROJECT
NORFOLK, VIRGINIA

THE HAGUE

BRAMBLETON AVENUE BRIDGE
INFLATABLE DAM OPTION – SECTIONS

FIGURE

8-8

DSGN	DR	CHK
	KOONS	.
JOB NO.	SCALE	DATE
6822-03	1"=10'	12-14-2010



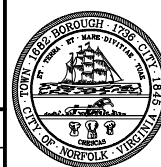
 moffatt & nichol					COASTAL FLOODING PROJECT NORFOLK, VIRGINIA	FIGURE 8-9
					THE HAGUE SUBSTATION LOCATION	
DSGN	DR	CHK				
JOB NO. 6822-03	SCALE 1"=50'	DATE 12-14-2010				



— BULKHEAD
 - - - - - BERM



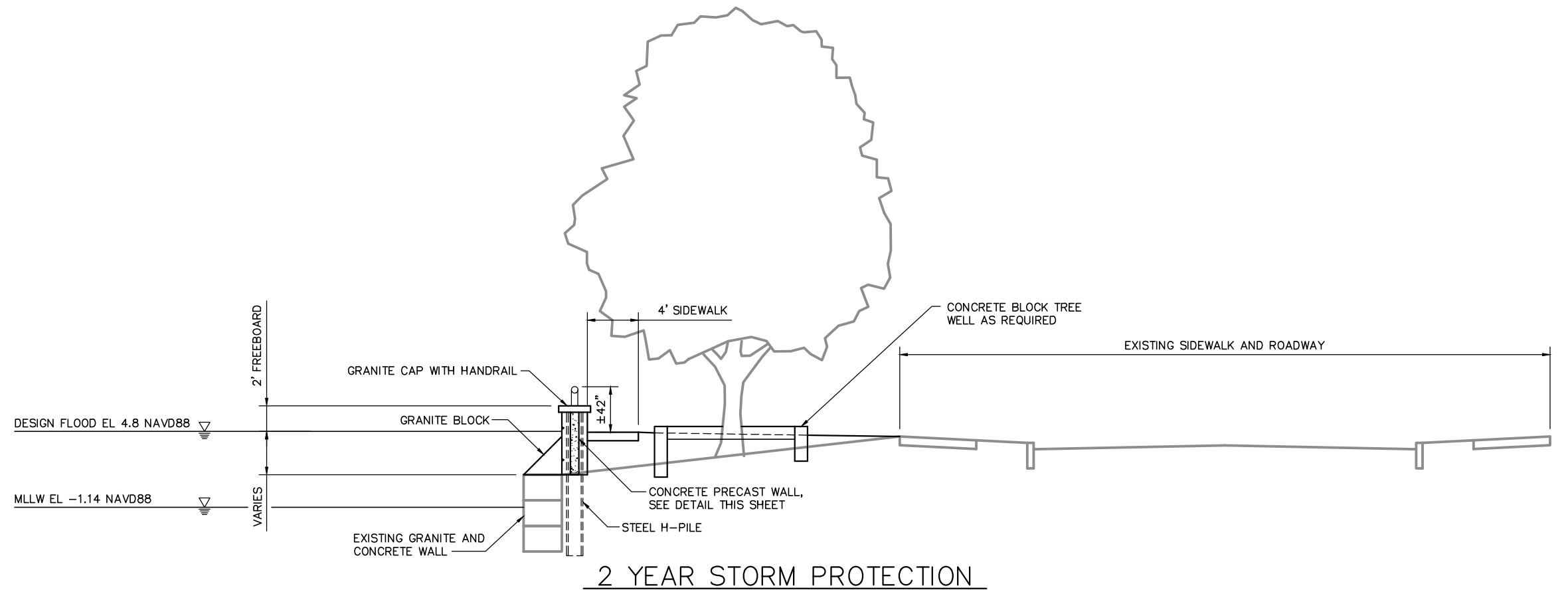
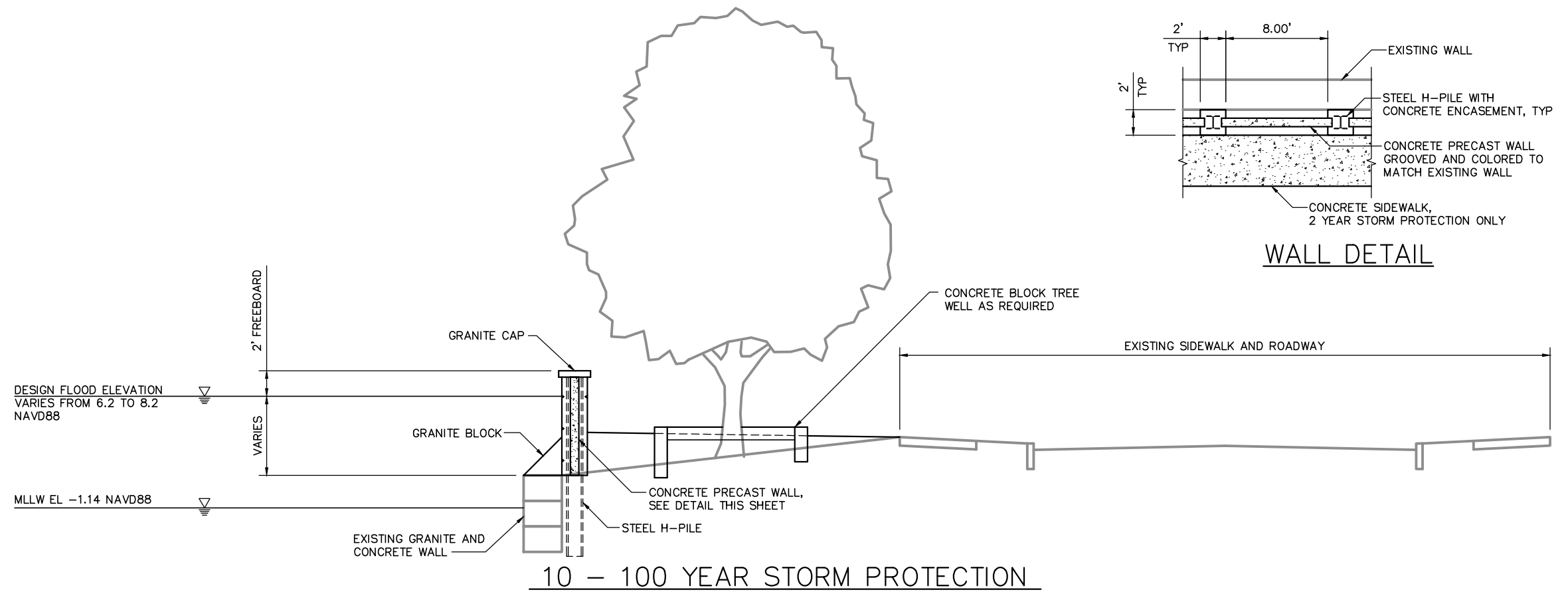
DSGN	DR	CHK
JOB NO.	SCALE	DATE
6822-03	1"=500'	12-14-2010



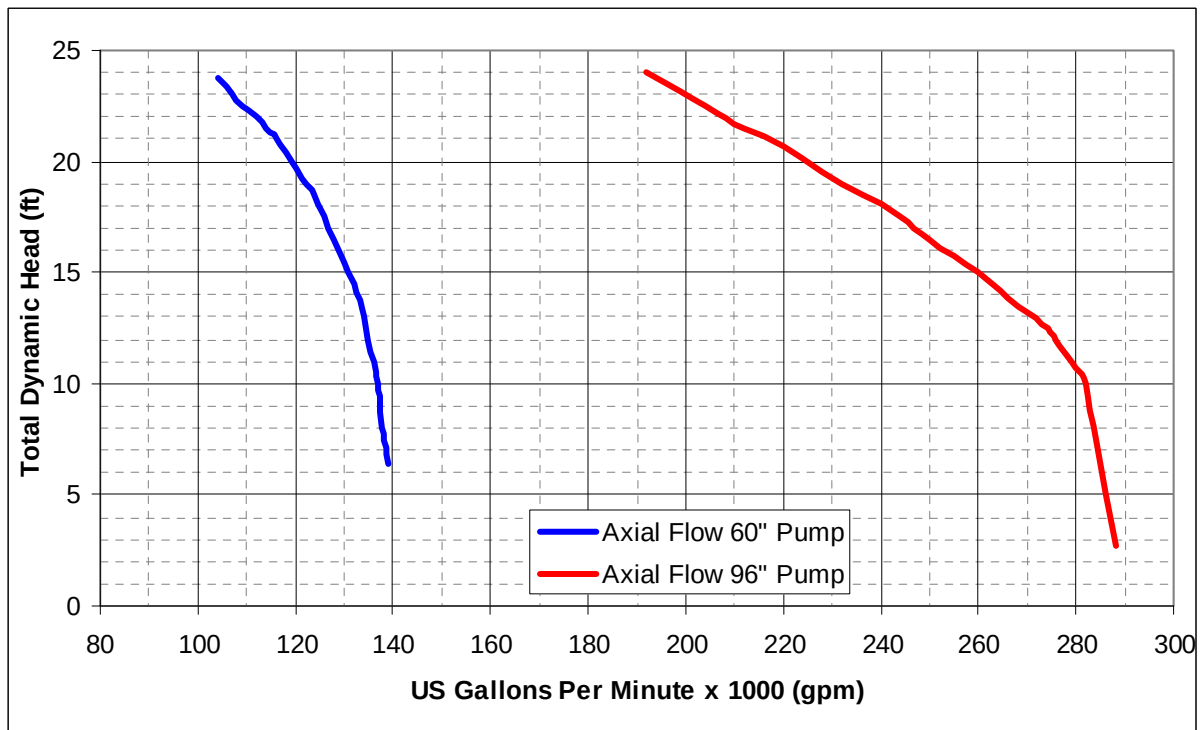
COASTAL FLOODING PROJECT
 NORFOLK, VIRGINIA
 THE HAGUE
 BULKHEAD WALL AND EARTHEN BERM

FIGURE

8-10



 					COASTAL FLOODING PROJECT NORFOLK, VIRGINIA THE HAGUE BULKHEAD WALL TYPICAL SECTIONS	FIGURE 8-11
DSGN	DR	CHK	JOB NO.	SCALE	DATE	
	KOONS	.	6822-03	1"=10'	12-14-2010	



PUMP CURVES FOR SWMM MODELS
City-wide Coastal Flooding Study
Norfolk, Virginia

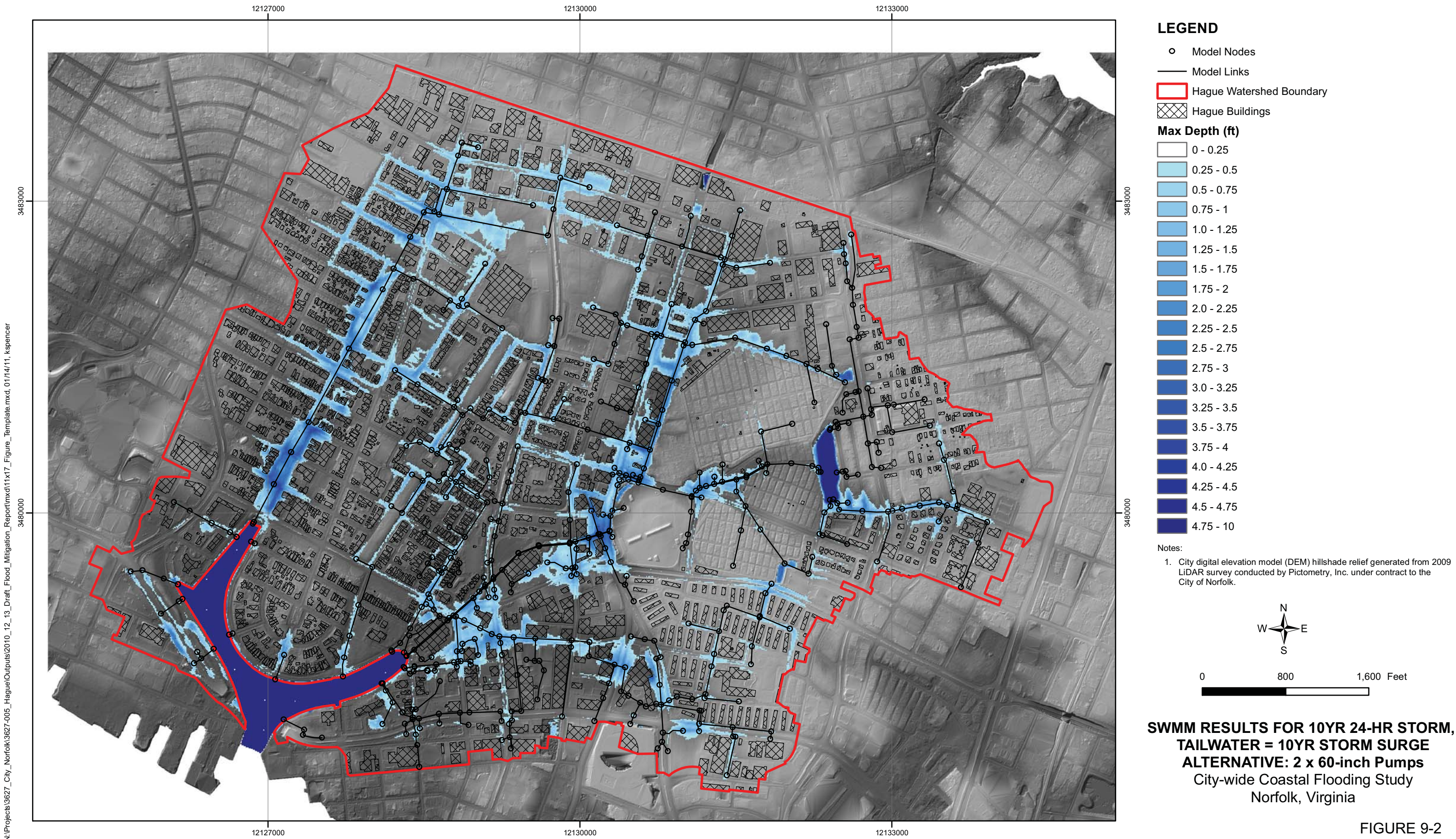


FIGURE 9-2



FIGURE 9-3



FIGURE 9-4

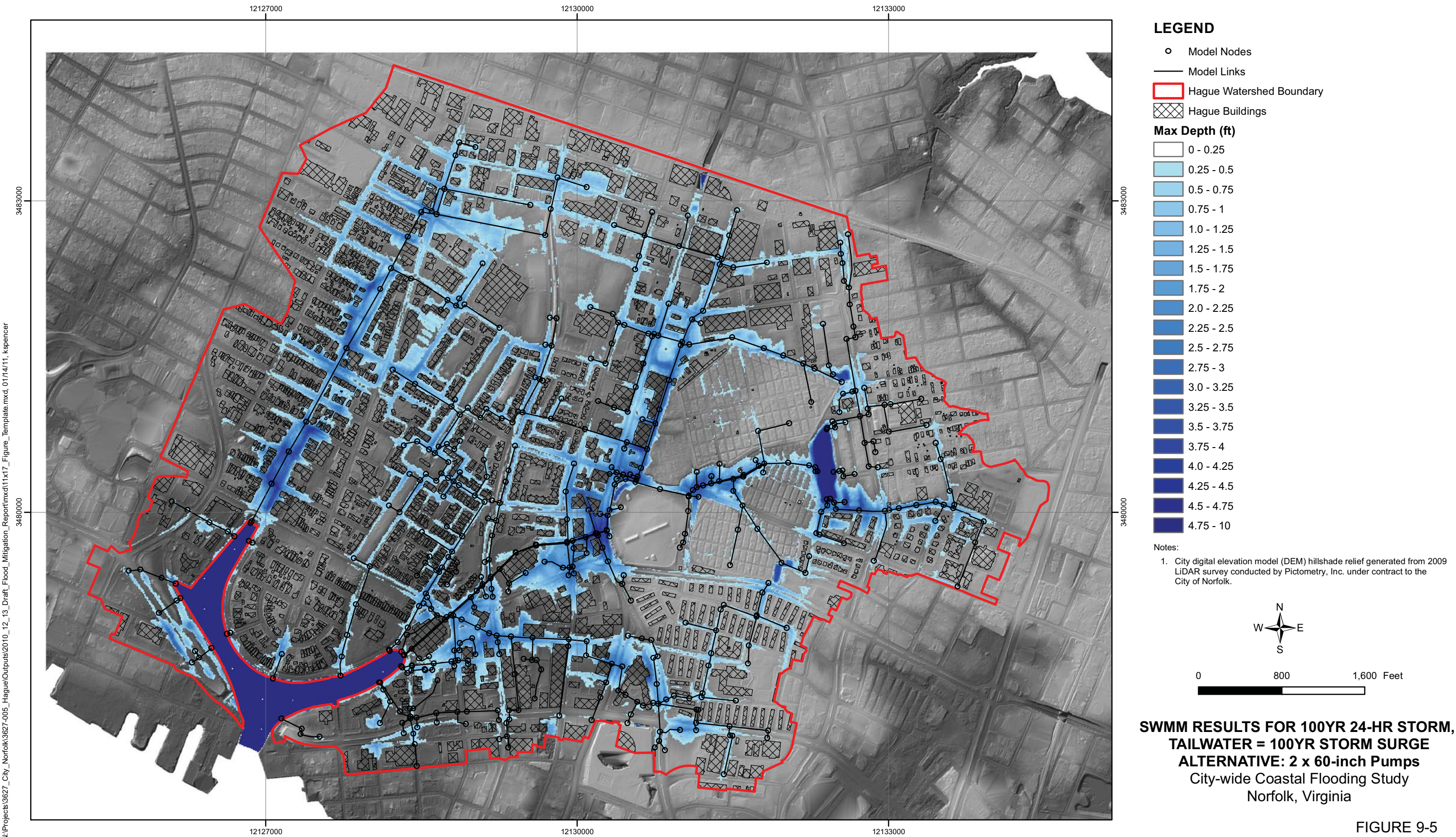


FIGURE 9-5



FIGURE 9-6



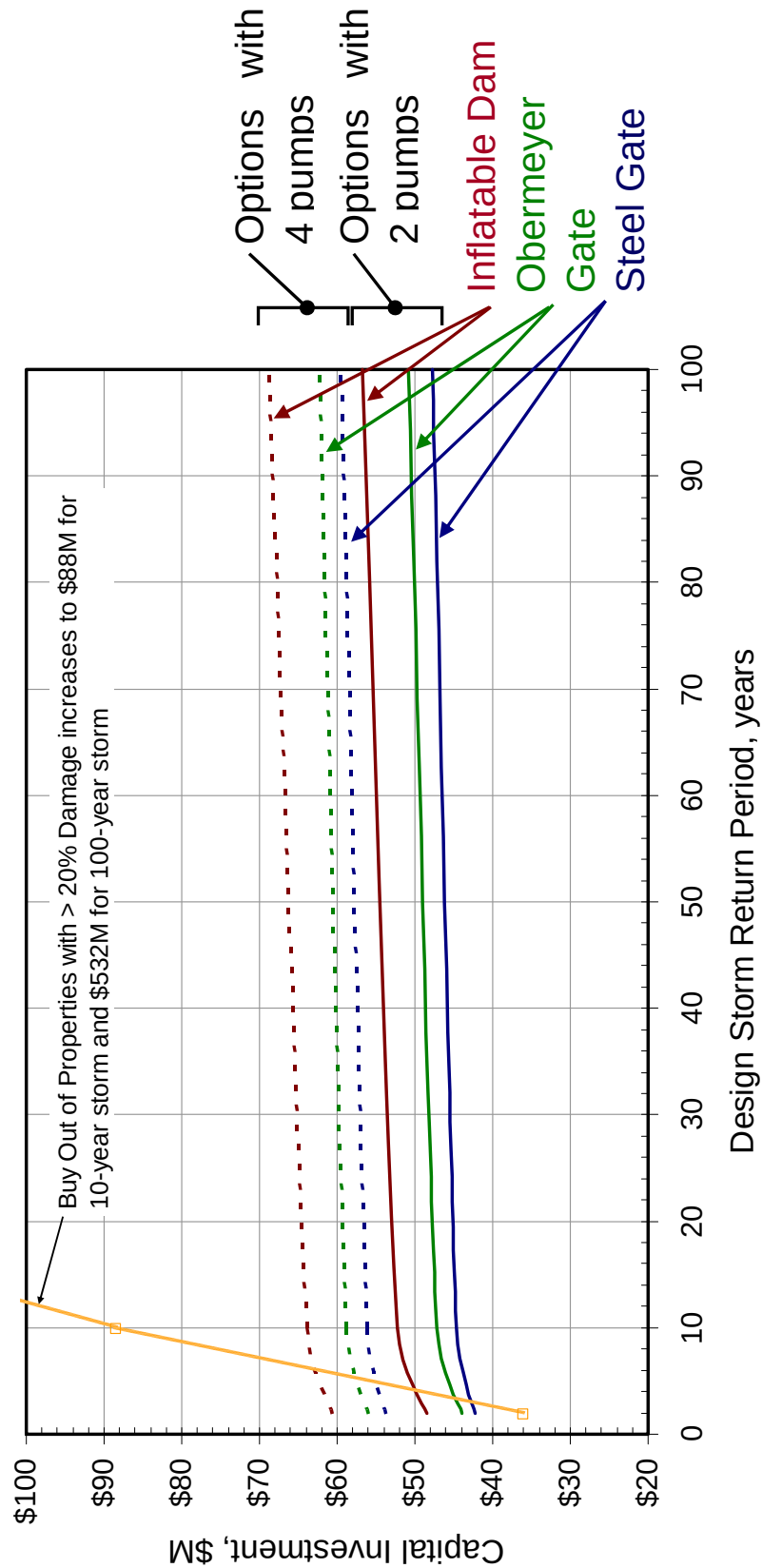
FIGURE 9-7



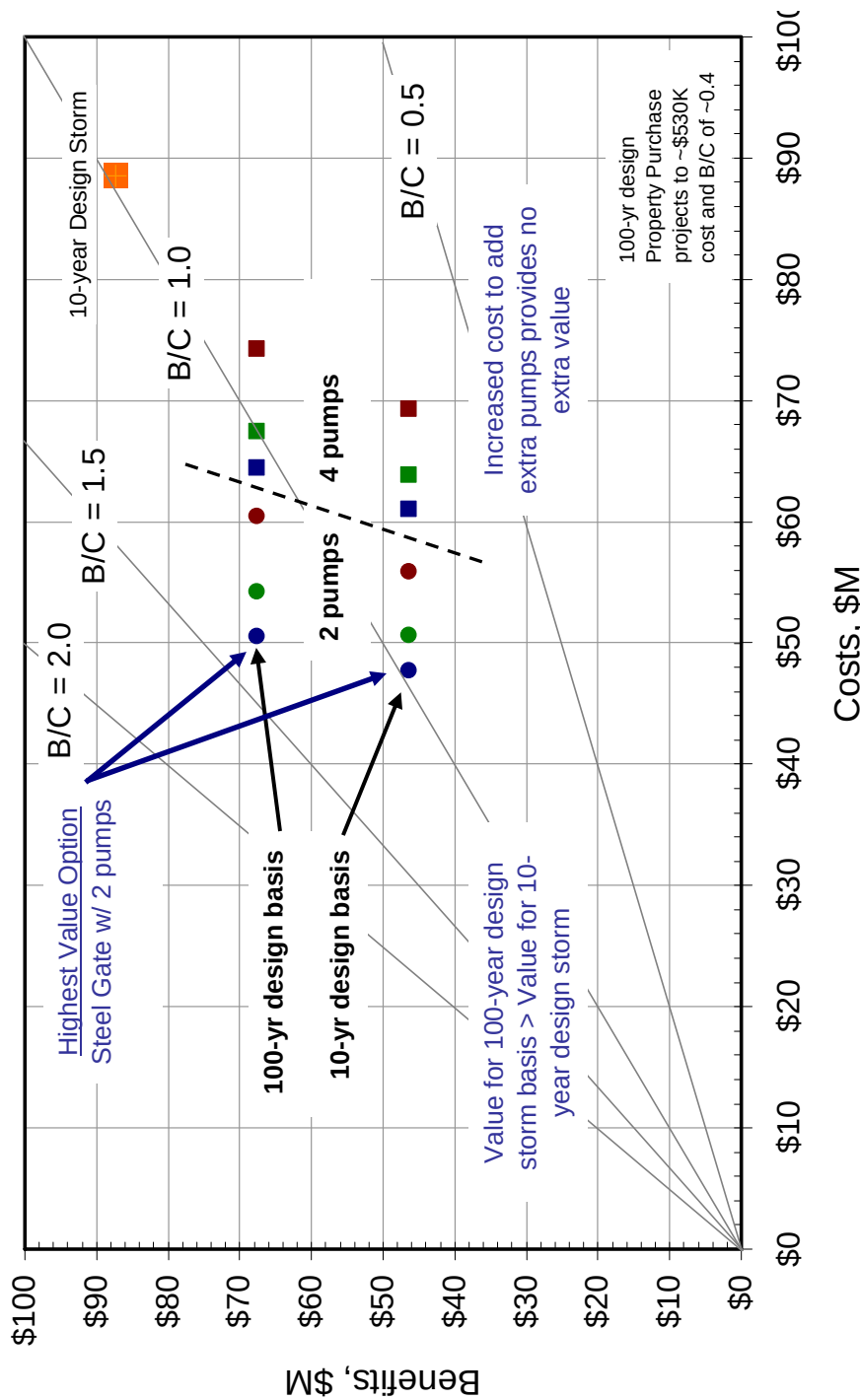
FIGURE 9-8



FIGURE 9-9



ESTIMATED PROJECT COSTS FOR FLOOD MITIGATION OPTIONS
City-wide Coastal Flooding Study
Norfolk, Virginia



BENEFIT/COST EVALUATION
City-wide Coastal Flooding Study
Norfolk, Virginia