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City of Norfolk Coastal Flood Mitigation Program

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Moffatt & Nichol, Inc.

City of Norfolk
Coastal Flood Mitigation Program

March 13, 2013

moffatt & nichol

FUGRO

Topics

- Brief overview of Norfolk's Coastal Flood Program
- Data-driven analysis and decision making
- City-wide vulnerability, project concepts, scoring and ranking
- Use of hydrodynamic modeling and GIS technology
- Acknowledgments

Norfolk City-wide Coastal Flooding Study

- Ongoing since 2008; precursors since 1990s
- Prioritize public works expenditures
- Increase ability to communicate risks and decisions to public
- Develop long-term adaptation approach

http://norfolk.gov/flooding

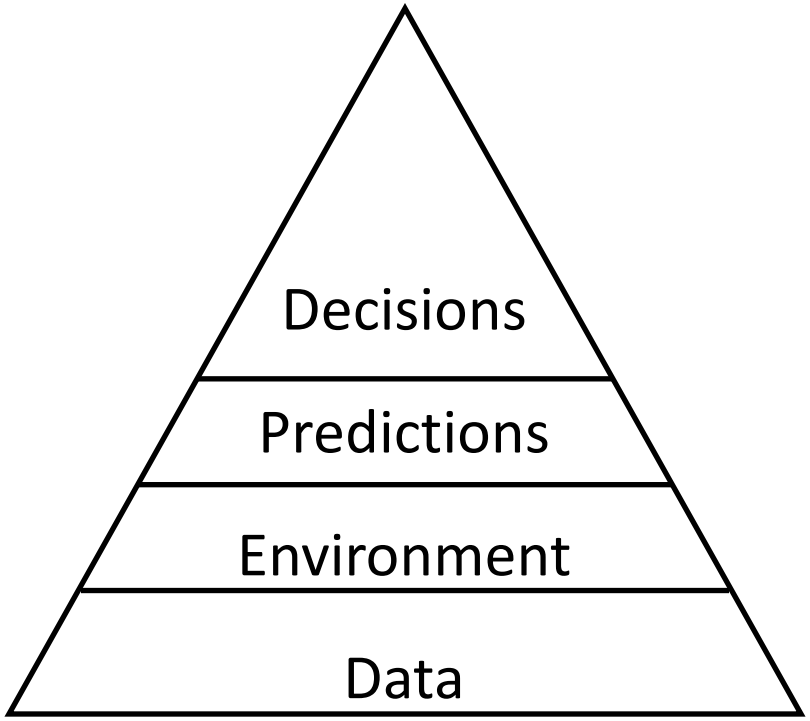
Norfolk City-wide Coastal Flooding Study

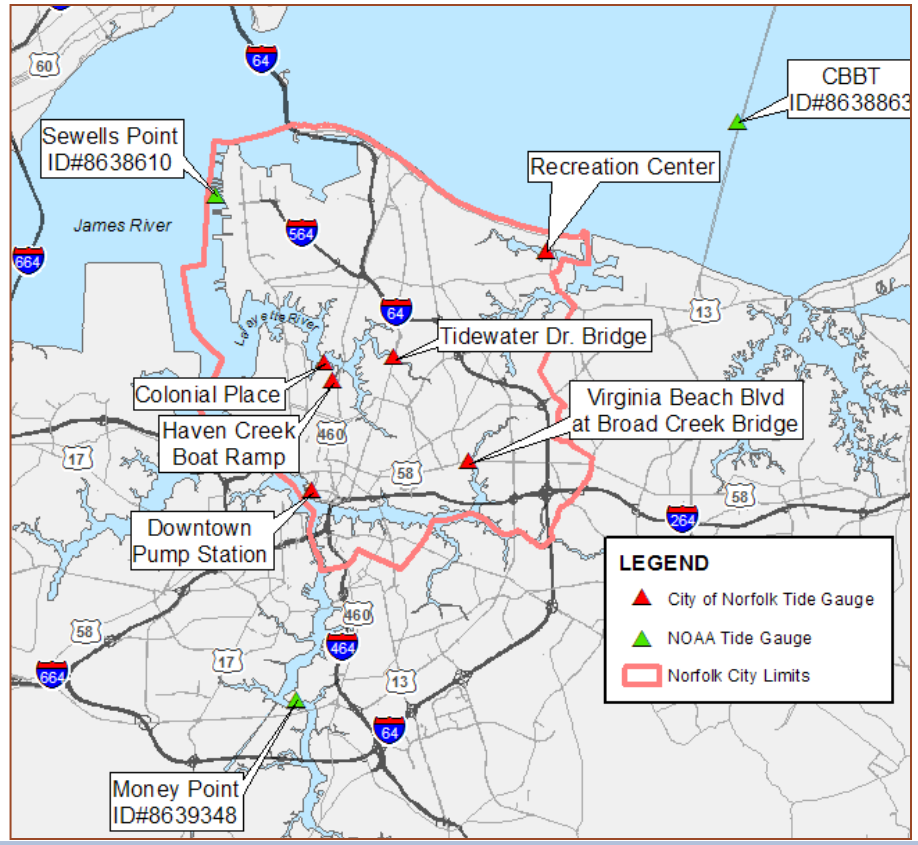
Broad Task Categories

- Measurement of tide levels in City, relate to Sewells Point
- Predictive flooding models of tidal/surge flooding, with effects of storm drainage network & rainfall flooding
- Evaluation of design criteria and mitigation alternatives
- Conceptual project design, total design life Benefit-Cost Analysis for selected local projects
- Initial stages of City-wide Coastal Flooding Mitigation Master Plan (with long-term adaptation vision)

Data-Driven Analysis and Decision Making

- 2009-2010 Initial phase of tide gauge program
- Define physical environment and how water levels vary in City, with storm conditions





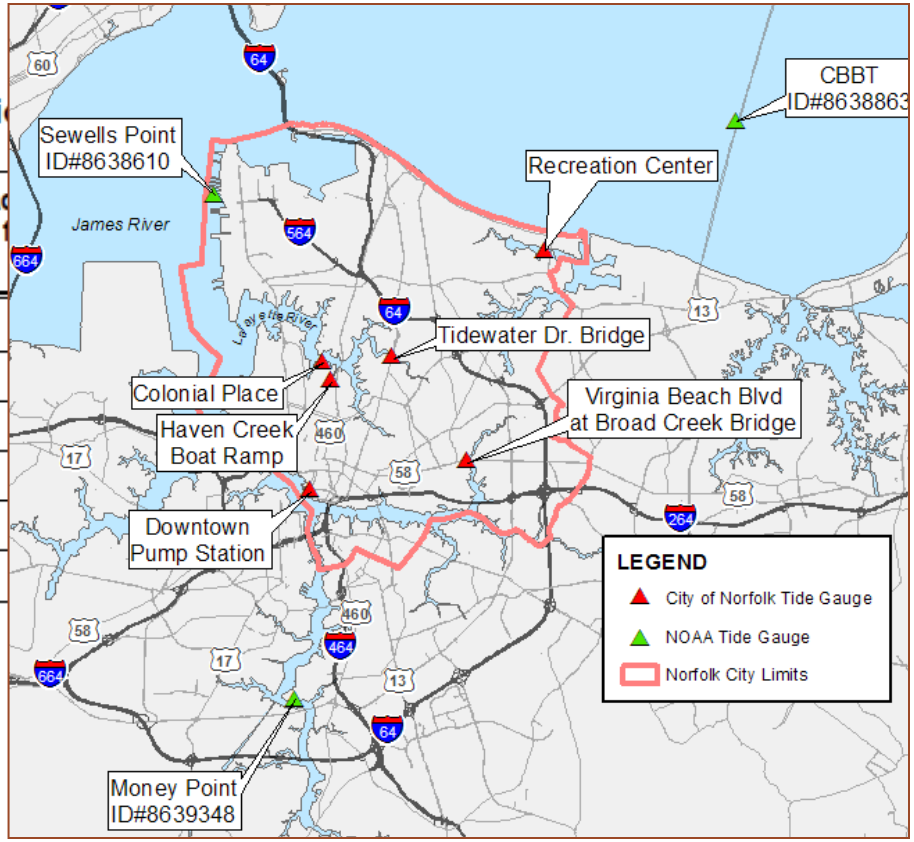
Data-Driven Analysis and Decision Making

- Variation in high water levels within the City; relationship to Sewells Point for studies and real-time flood information

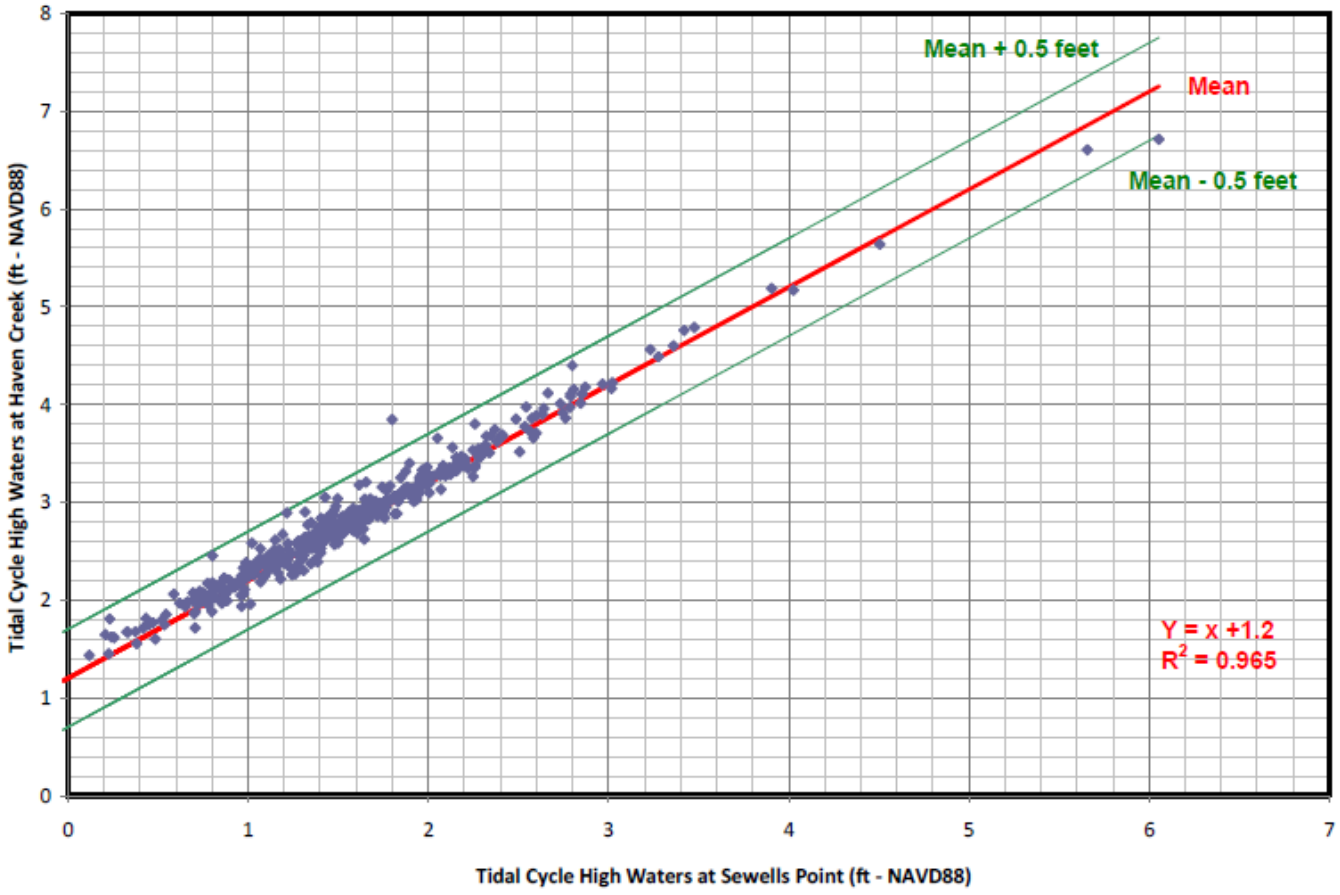
Table 1. Summary of Statistical Water Level Relati

Tide Gauge	Average Water Level, feet	Difference compared to Sewells Point, feet	Ac
Sewells Point	0.3	--	
Recreation Center	0.3	-0.1	
Havens Creek	1.5	1.2	
Tidewater Bridge	0.9	0.5	
Downtown Pump Station	0.8	0.4	
Broad Creek	0.6	0.2	

Notes: Statistical analyses are shown on Figures 2 through 6.
All values have been rounded to the nearest tenth of a foot.
All elevations are re: NAVD88.

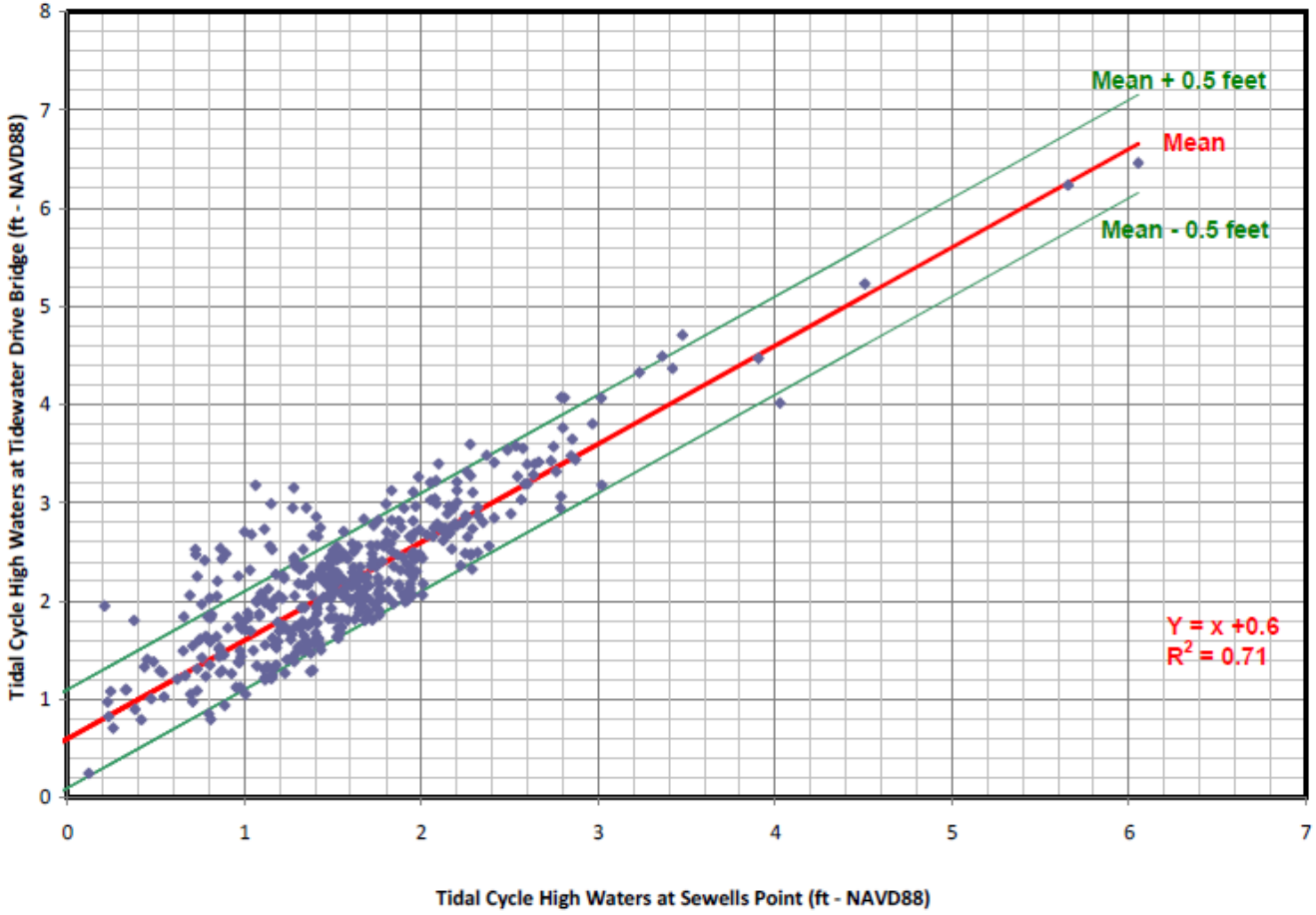


Tide gauges: Haven Creek vs. Sewells Point



COMPARISON OF TIDE GAUGE MEASUREMENTS AND SEWELLS POINT
Lafayette River – Haven Creek Boat Ramp (P13HC)

Tide gauges: Tidewater Drive Br. vs. Sewells Point



COMPARISON OF TIDE GAUGE MEASUREMENTS AND SEWELLS POINT
Lafayette River – Wayne Creek at Tidewater Drive Bridge (P13TW)

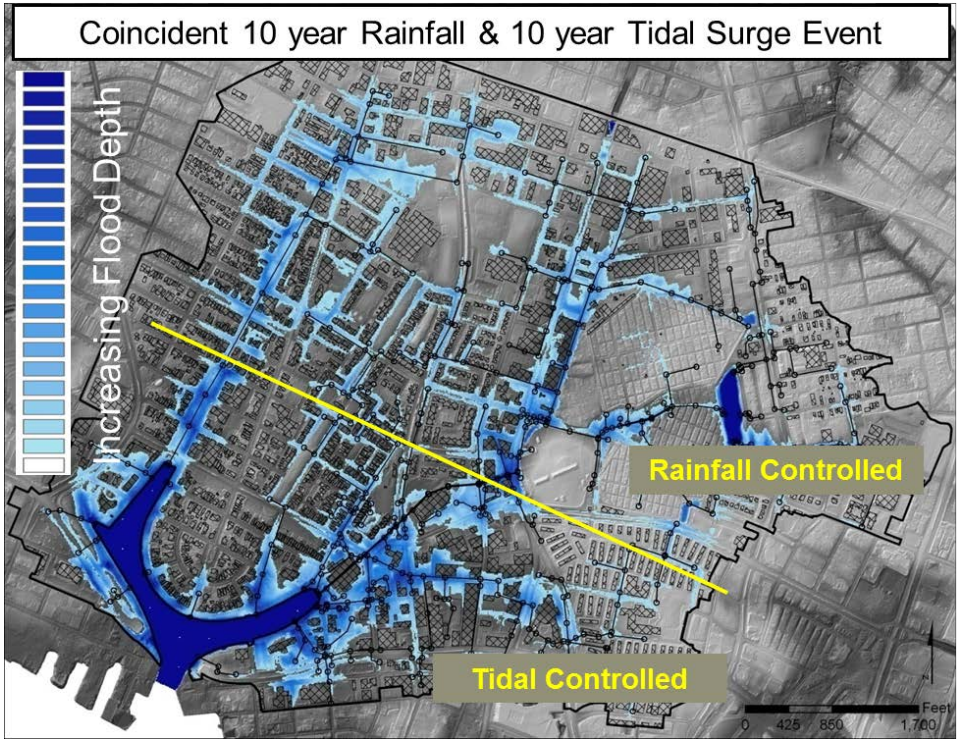
Coastal Flooding Evaluation Methods

- High-level City-wide evaluation of tide/surge driven inundation
- For each Planning Districts
  - Number of parcels and buildings
  - Assessed value of improvements
  - Historic losses
  - Miles of roadways


Willoughby
Norfolk Naval Base
NNB - NIT
Mason Creek
Pretty Lake
Lake Whitehurst
(No Coastal Flooding)
Lafayette River
Lamberts Point
West Ghent
Hague
Broad Creek
Tidewater
Ohio Creek
Eastern Branch - Ingleside
Downtown
Eastern Branch - I-264
Eastern Branch - Military
Berkley and Campostella

Coastal Flooding Evaluation Methods

- Local project-scale detailed hydrology / hydraulics modeling
  - Based on present topography and storm drain system
  - Detailed, unsteady-state hydraulics of both tide/surge and rainfall-runoff
  - Estimate extent, depth, and duration of flooding for baseline vulnerability, with-project evaluation
  - Compute reduction in flood damage with mitigation projects

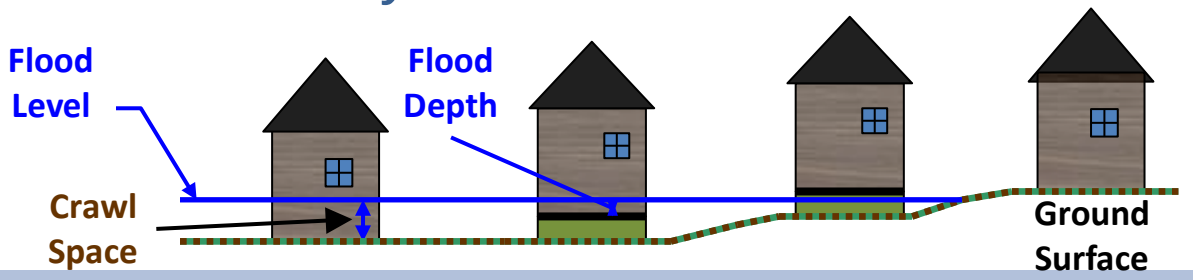


Coastal Flooding Evaluation Methods: Technology

- Computer model of present-day flood hydrology / hydraulics
- 1-D/2-D linked model in *XP-SWMM*
  - More accurate representation of ponding areas and flow along streets
  - Detailed grid of depth in each grid cell, to relate to property within each grid cell
  - Saves on labor costs (for same level of accuracy); prepared for long run times

Coastal Flooding Evaluation Methods: Technology

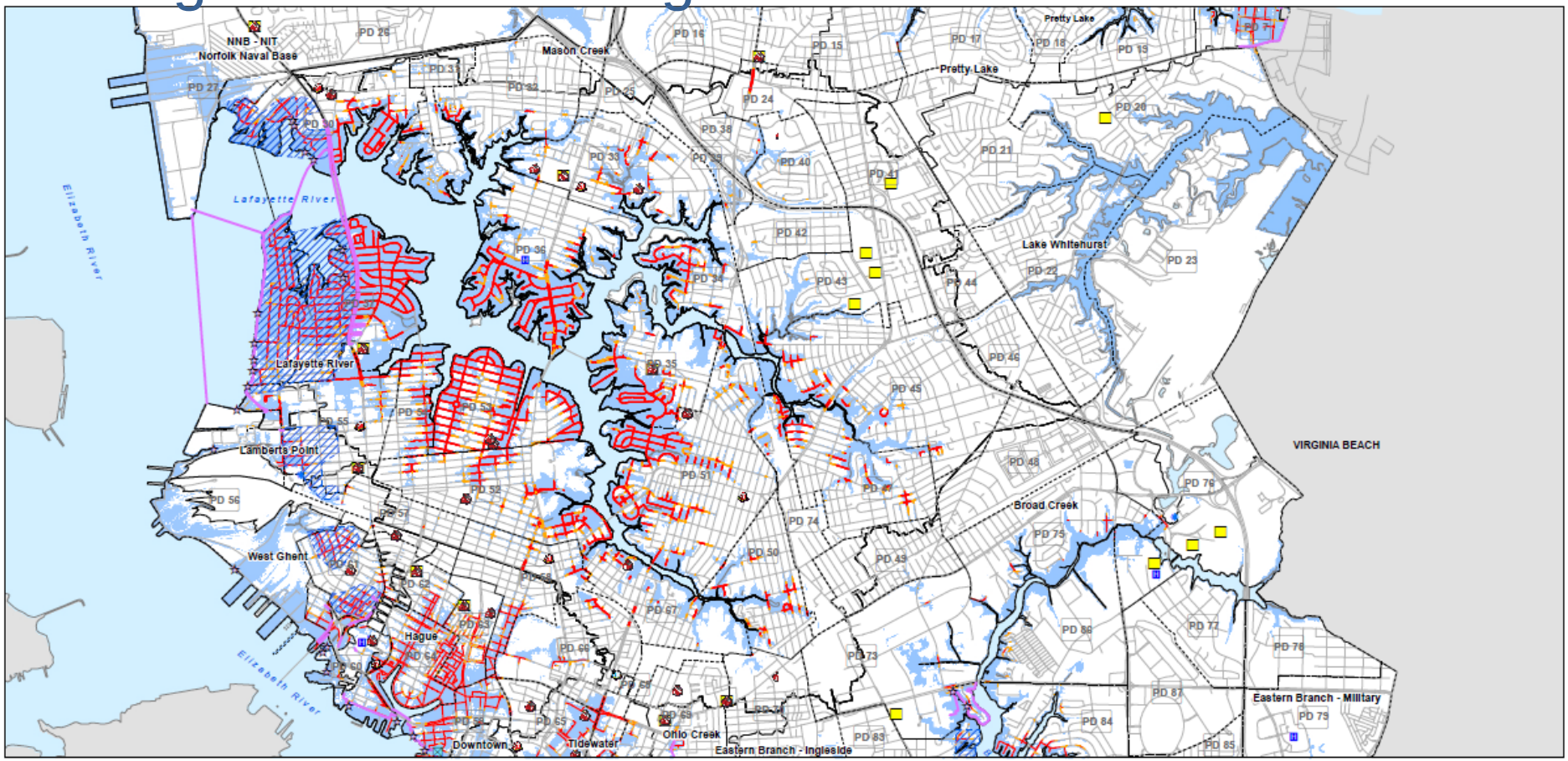
- GIS-based approach using FEMA and USACE procedures
  - Flood depths at each structure from *XP-SWMM* models; depth-damage curves applied in GIS
  - Semi-automated setup is scalable from small project areas to City-wide analysis
- Damage analysis includes structures & contents utilizing the City parcel database, with limited field verification
- Additional factors: ancillary structures, vehicles, displacement, loss of use, and City infrastructure considered



City-wide Vulnerability and Mitigation Planning

- May 2012: *Preliminary City-wide Coastal Flooding Mitigation Concept Evaluation and Master Plan Development*
- Infrastructure and property vulnerability
  - Transportation corridors, routes to critical facilities

City-wide Vulnerability and Mitigation Planning



LEGEND

- Planning District Boundary
- Street Centerline

Road Accessibility

- Emergency Only (1.0 - 1.5 feet of water)
- Impassable (Greater than 1.5 feet of water)

Approximate Coastal Flooding
Does not include precipitation.

- 1% Annual Chance Coastal Flood Extent

Mitigation Options

- Potential Mitigation Option
- Existing Topography
- Outfall Flap Valve
- Pump Station
- House Raising

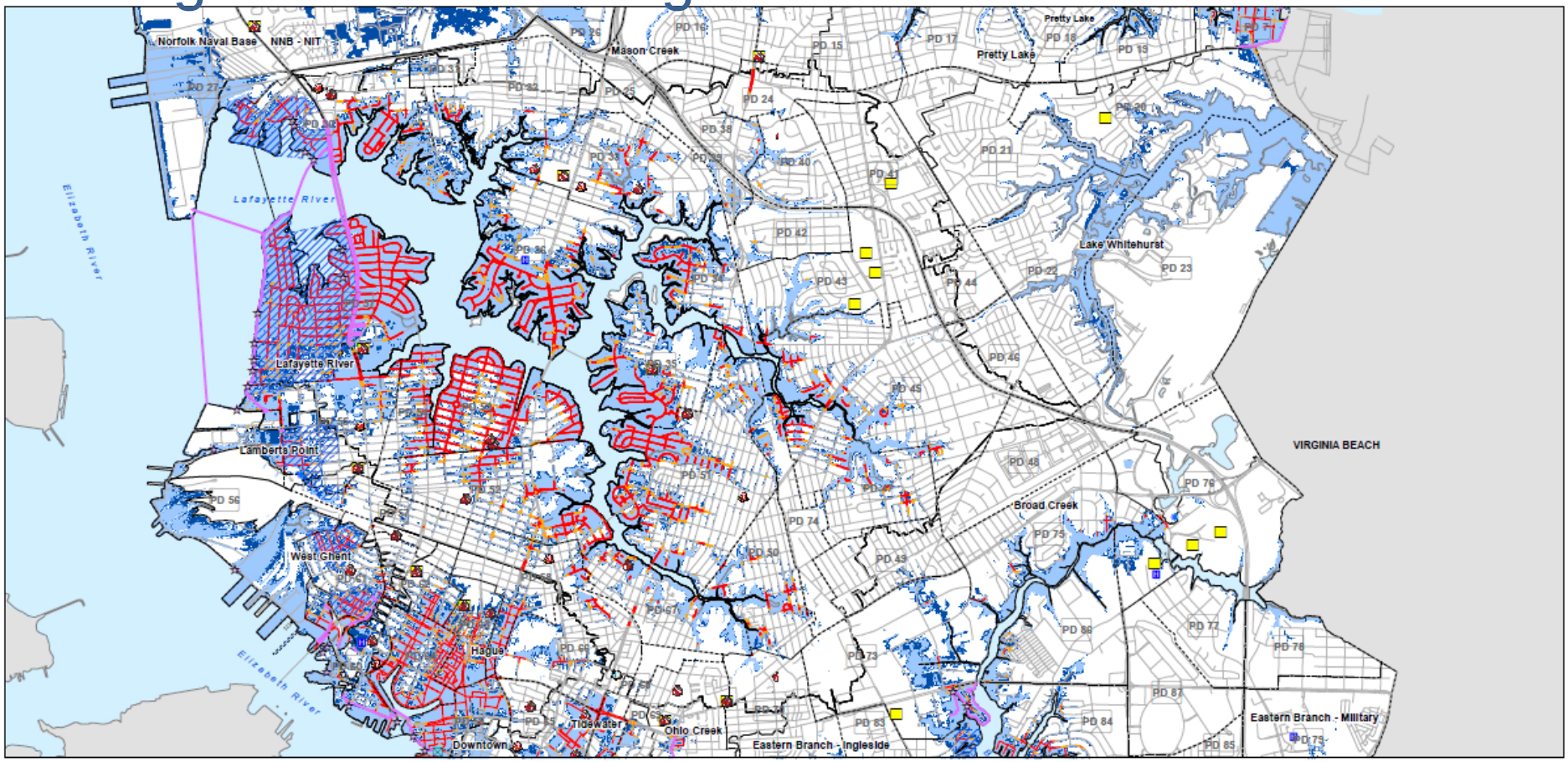
Critical and Essential Facilities

- Emergency Shelters
- Fire Station
- Hospitals
- Police Station
- School
- Water Treatment Facilities

CURRENT CONDITIONS IMPASSABLE ROADS
Central Map
City-wide Coastal Flooding Study
Norfolk, Virginia

FIGURE 3-12b

City-wide Vulnerability and Mitigation Planning



LEGEND

Planning District Boundary
Street Centerline

Road Accessibility
Emergency Only (1.0 - 1.5 feet of water)
Impassable (Greater than 1.5 feet of water)

Approximate Coastal Flooding
Does not include precipitation.
1% Annual Chance Coastal Flood Extent
1% Annual Chance Coastal Flood Extent with 1-Foot Sea Level Rise (SLR)

Mitigation Options
Potential Mitigation Option
Existing Topography
Outfall Flap Valve
Pump Station
House Raising

Critical and Essential Facilities
Emergency Shelters
Fire Station
Hospitals
Police Station
School
Water Treatment Facilities

Eastern Branch

N
W E
S

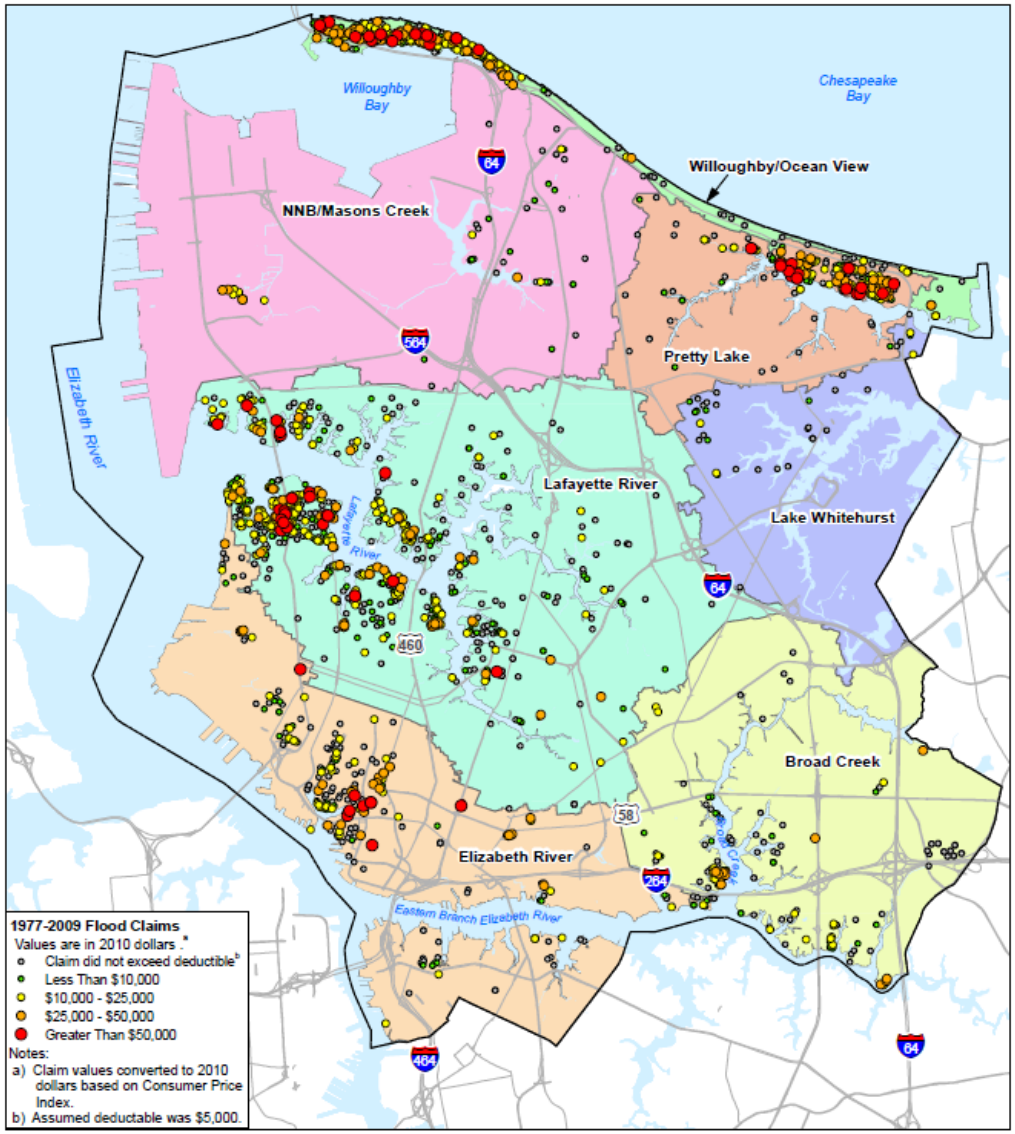
0 3,000 6,000 Feet

1-FOOT SEA LEVEL RISE IMPASSABLE ROADS
Central Map
City-wide Coastal Flooding Study
Norfolk, Virginia

FIGURE 3-13b

City-wide Vulnerability and Mitigation Planning

- Infrastructure and property vulnerability
  - FEMA claims
  - Depth-damage curves on GIS-based grid analysis
  - HAZUS-style analysis for detailed looks at local areas

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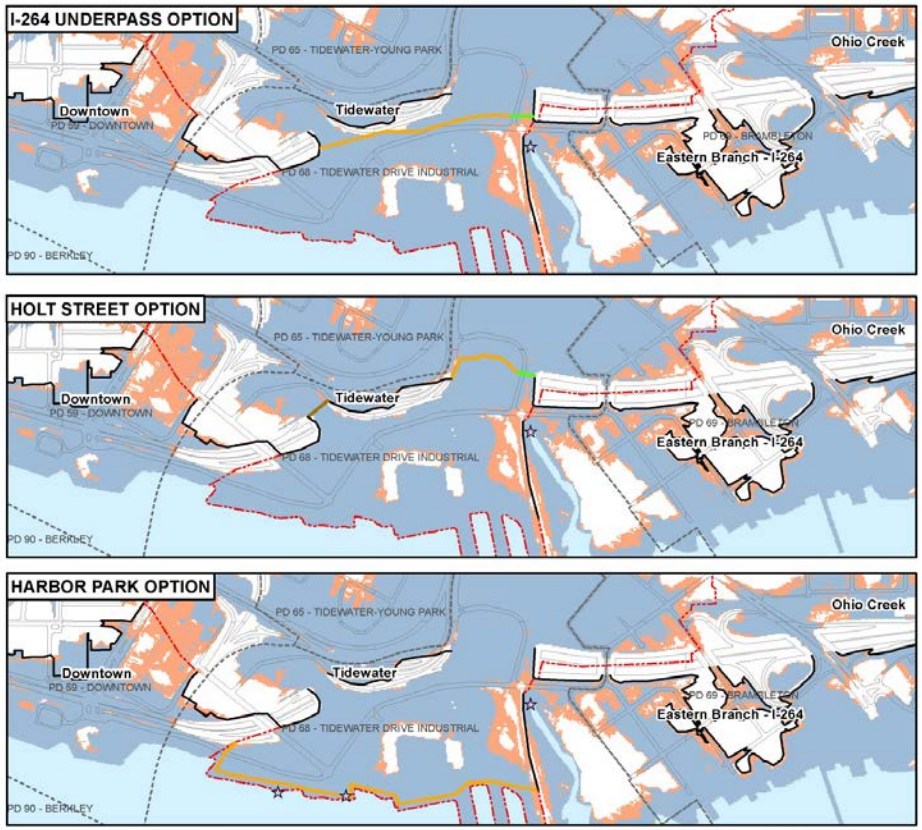
City-wide Vulnerability and Mitigation Planning

- Various mitigation types considered (with and without additional built infrastructure)



LEGEND

Project Area

Planning District Boundary

Approximate Coastal Flooding

Does not include precipitation.

1% Annual Chance Coastal Flood Extent

1% Annual Chance Coastal Flood Extent with 1-Foot Sea Level Rise

Mitigation Options

Road Raise

Berm

Flood Gate

Floodwall

Culvert

Existing Floodwall

Existing Topography

Feature with Yellow Highlight Required for 1-foot of Sea Level Rise

House Raising

Outfall Flap Valve

Pump Station

Critical and Essential Facilities

Emergency Shelters

Fire Station

Hospitals

Police Station

School

Water Treatment Facilities

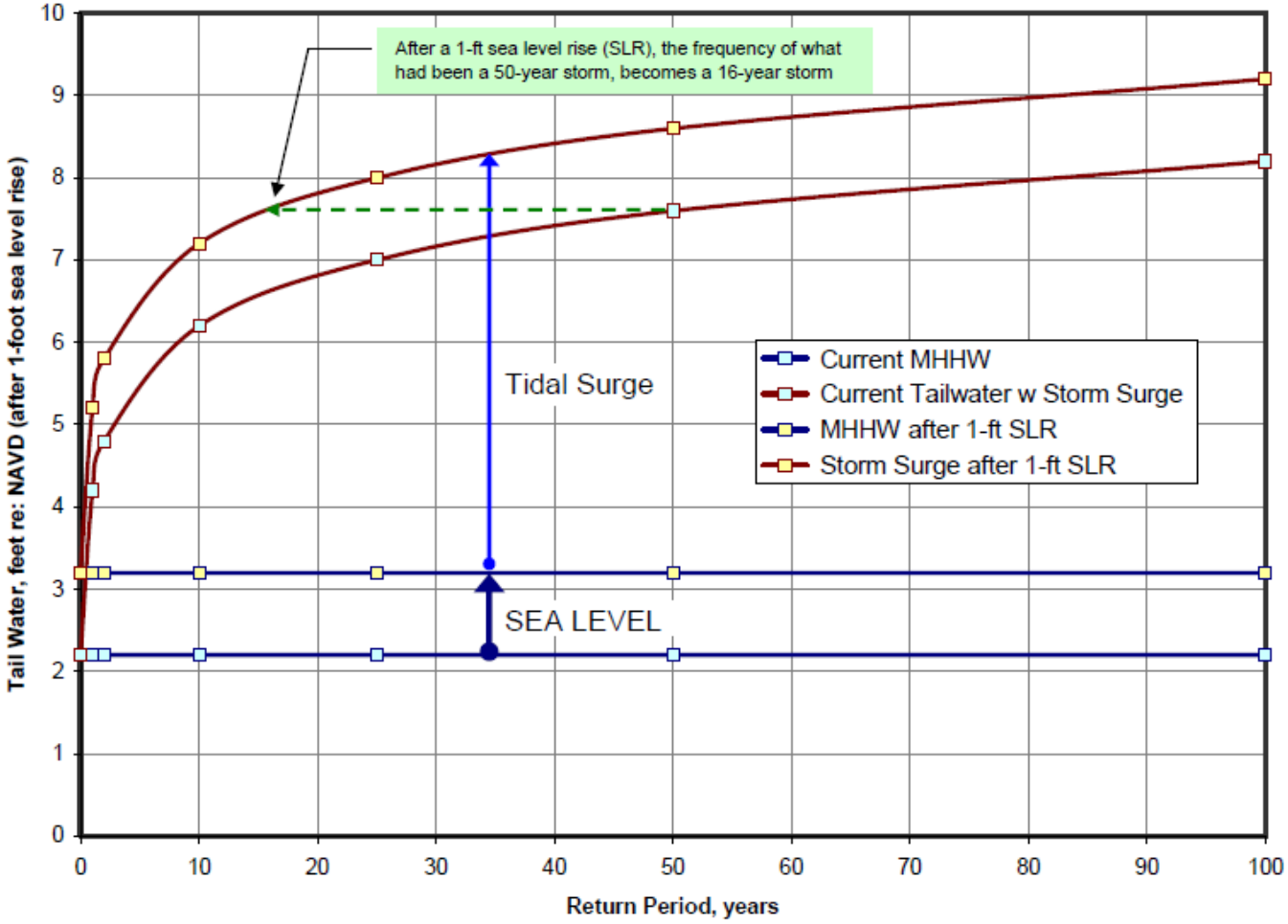
City-wide Vulnerability and Mitigation Planning

- Project development, scoring and ranking
  - Present and future risk (to property, infrastructure, etc.)
  - Investment (cost) vs. Benefit of mitigation (not just flood damage avoidance); multiple options examined for most project areas [Score = Reduced Damage / Cost x 100]
  - Additional points scored for mitigation risk to critical or essential facilities
- Lafayette River watershed contributes nearly *half* of the economic damage risk within the City
- City-wide economics for 100-year return period coastal flood magnitude

How Does Sea Level Rise Play Into All This?

- NOAA: relative mean sea level has risen …
  - +3.76 mm/year (1.23 ft/100 yrs) at Portsmouth (shipyard)
  - +4.44 mm/year (1.46 ft/100 yrs) at Sewells Point
  - +6.05 mm/yr (1.98 ft/100 yrs) at Ches. Bay Bridge-Tunnel
  - Acceleration scenarios
- Flooding problems and vulnerabilities exist today
- Relative sea level rise becomes a design parameter, depending on mitigation strategy design life
  - Influences project lateral extents; a couple of feet can make a big difference
  - Modifies “return period” of design water levels

How Does Sea Level Rise Play Into All This?



Next Steps

- Continue to develop tools to inform public
- Bring additional areas of the City to conceptual mitigation design stage
- Promote local and regional benefits of coastal flood mitigation within Norfolk
- Share “what’s worked” for the Norfolk process with other localities and regions

Questions?