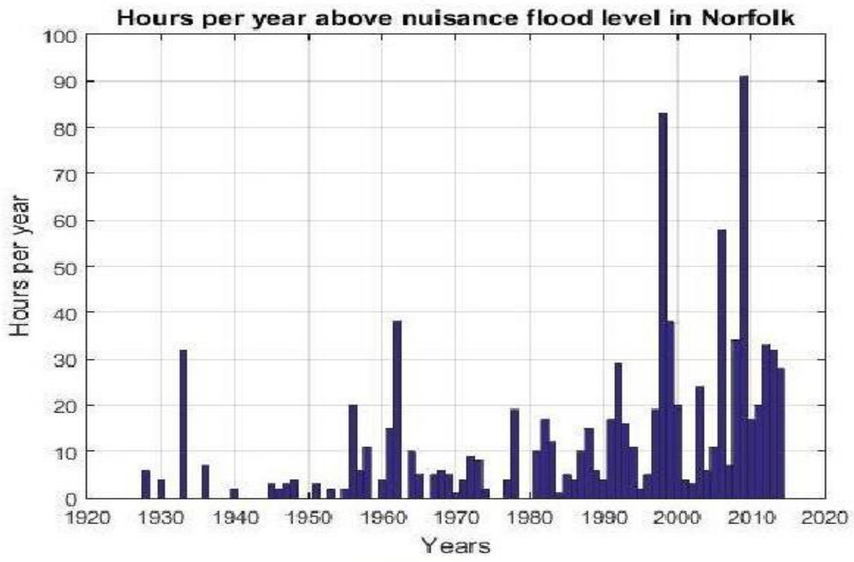
Resilient Norfolk

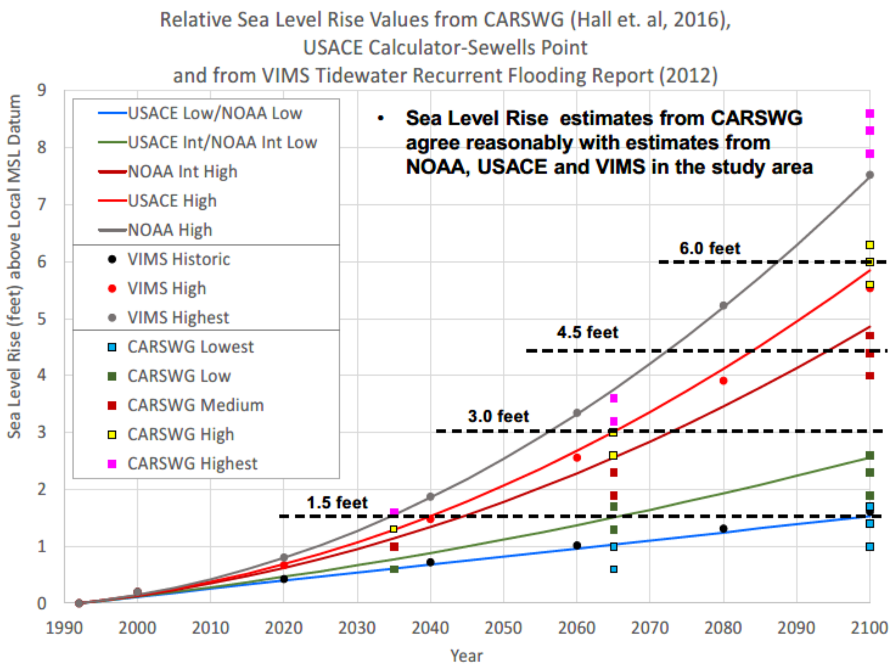
Designing the Coastal Community of the Future

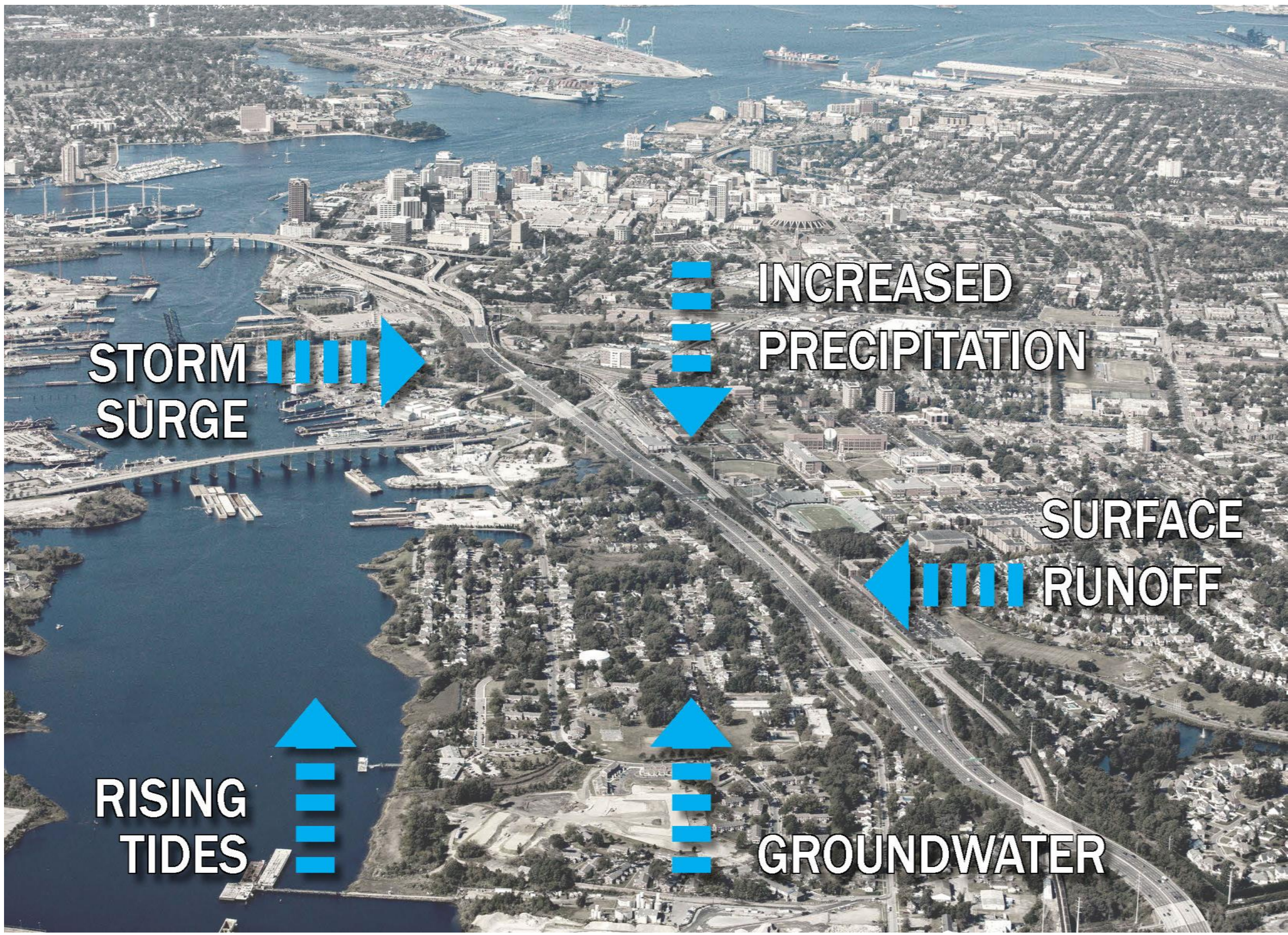
Kyle Spencer

Deputy Resilience Officer

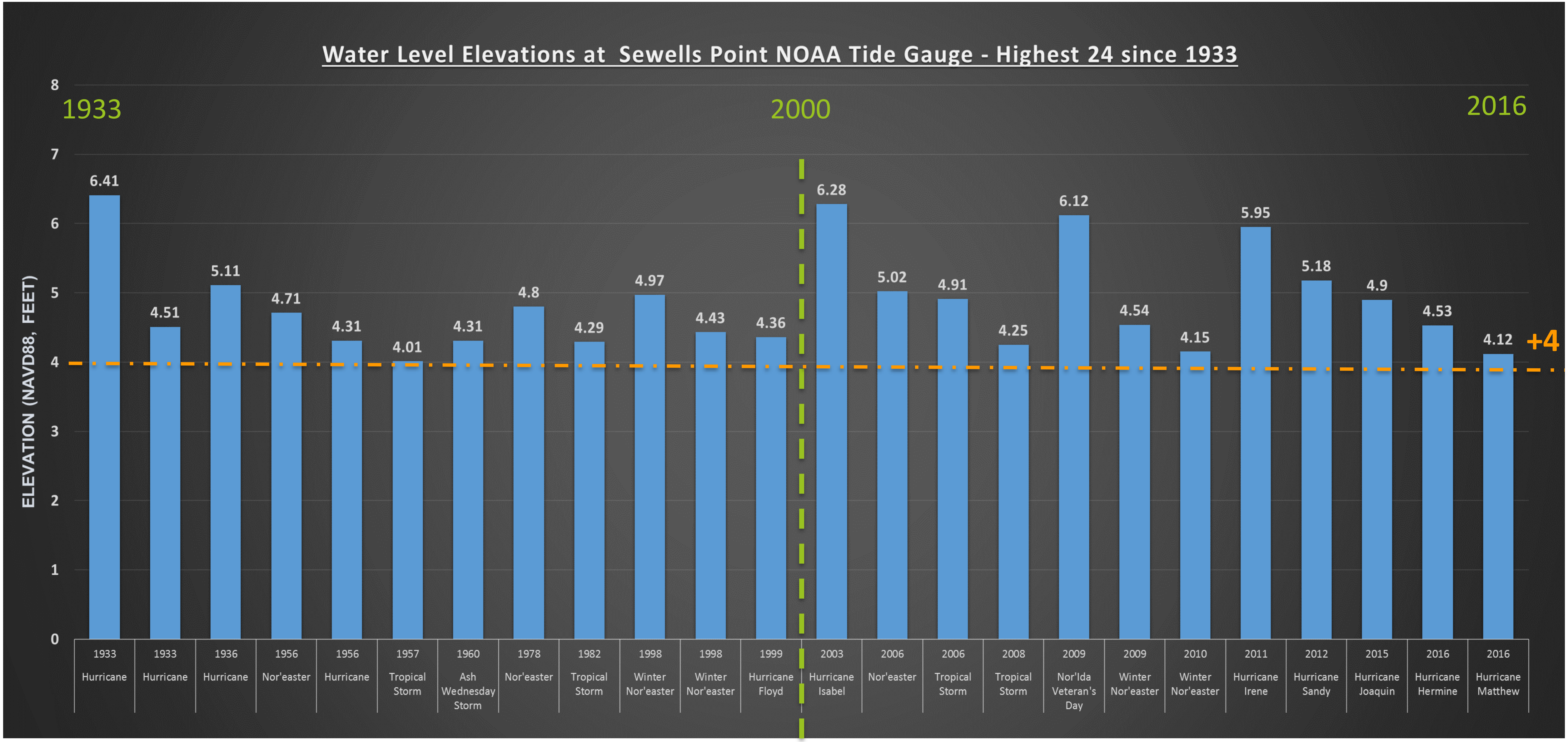
Flooding Challenges in Norfolk



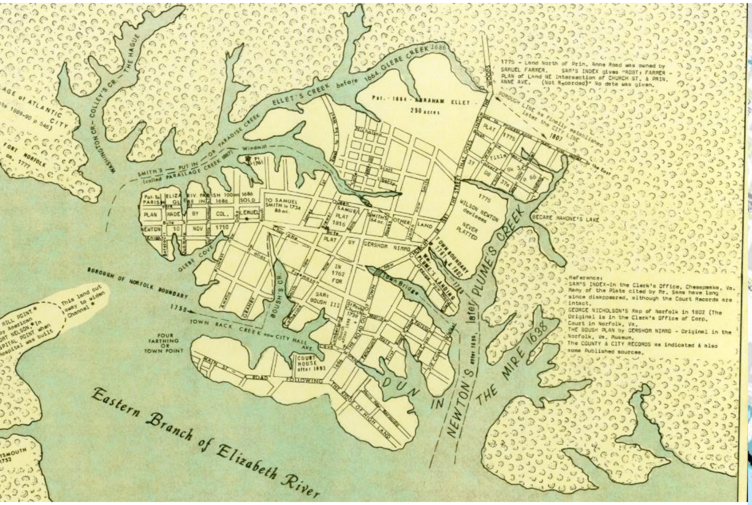




Highest Recorded Tidal Events at Sewells Point

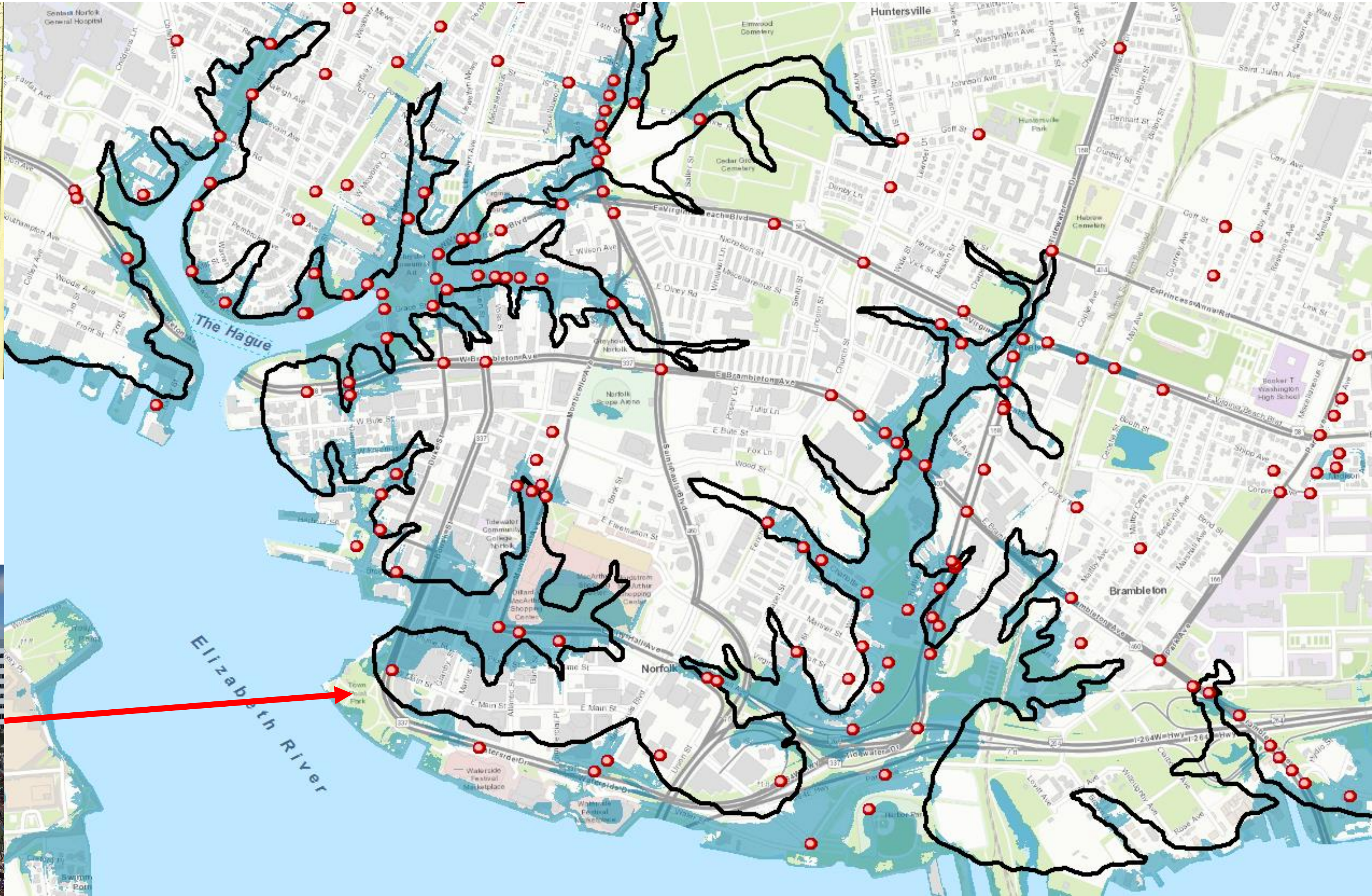


We Flood Where We Filled!



1736 Historic Shoreline (**black**) with reported flooded street locations (**red**)

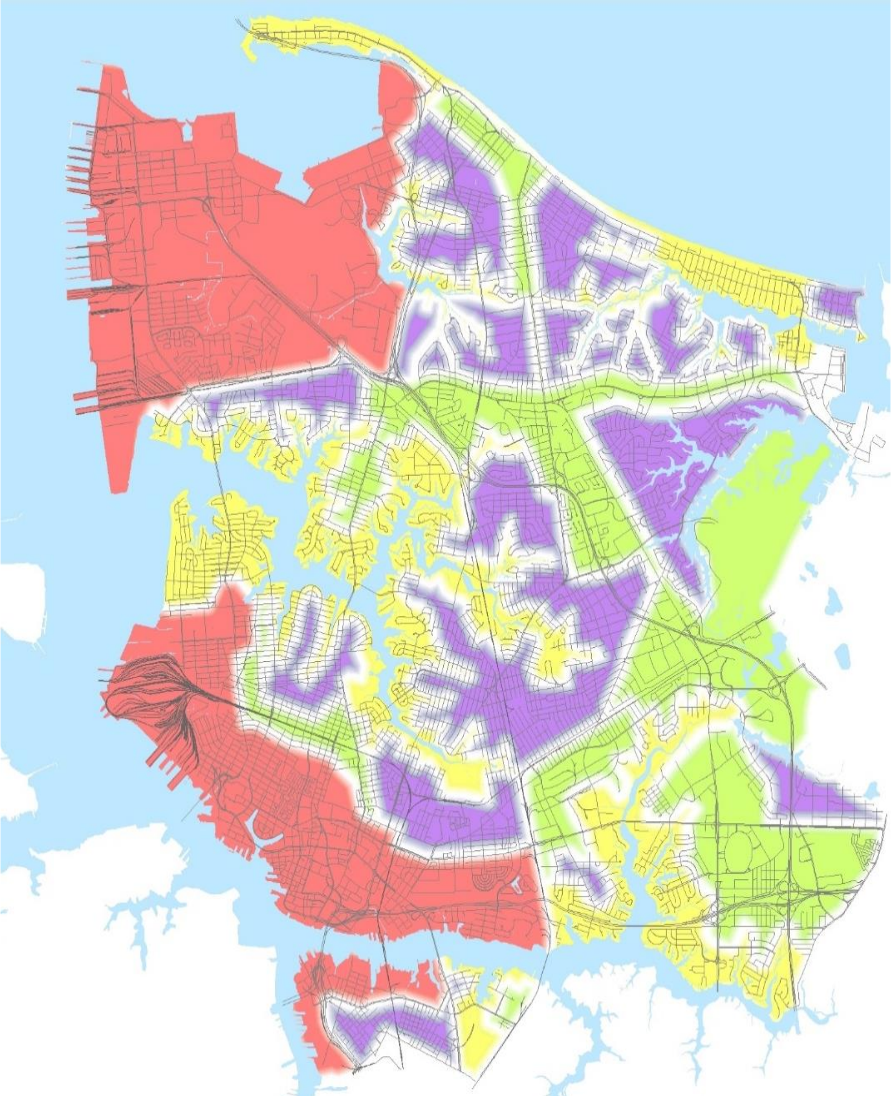
+6’ (NAVD88) inundation extent (blue)



Vision 2100 and Citywide Resilience Zoning Strategy

1. Resilience standards
2. Resilience quotient
3. Ground-floor elevations 16" to 3ft above grade
4. Enhanced buffering, landscape, open space standards

- "Red" – "economic engines"
- "Yellow" – "adaptation areas"
- "Green" – "new urban centers"
- "Purple" – "future neighborhoods"



5. Incentivizing adaptive re-use and retrofits of existing buildings
6. Coastal Resilience Overlay
7. Upland Resilience Overlay
8. Neighborhood Resilience Overlay

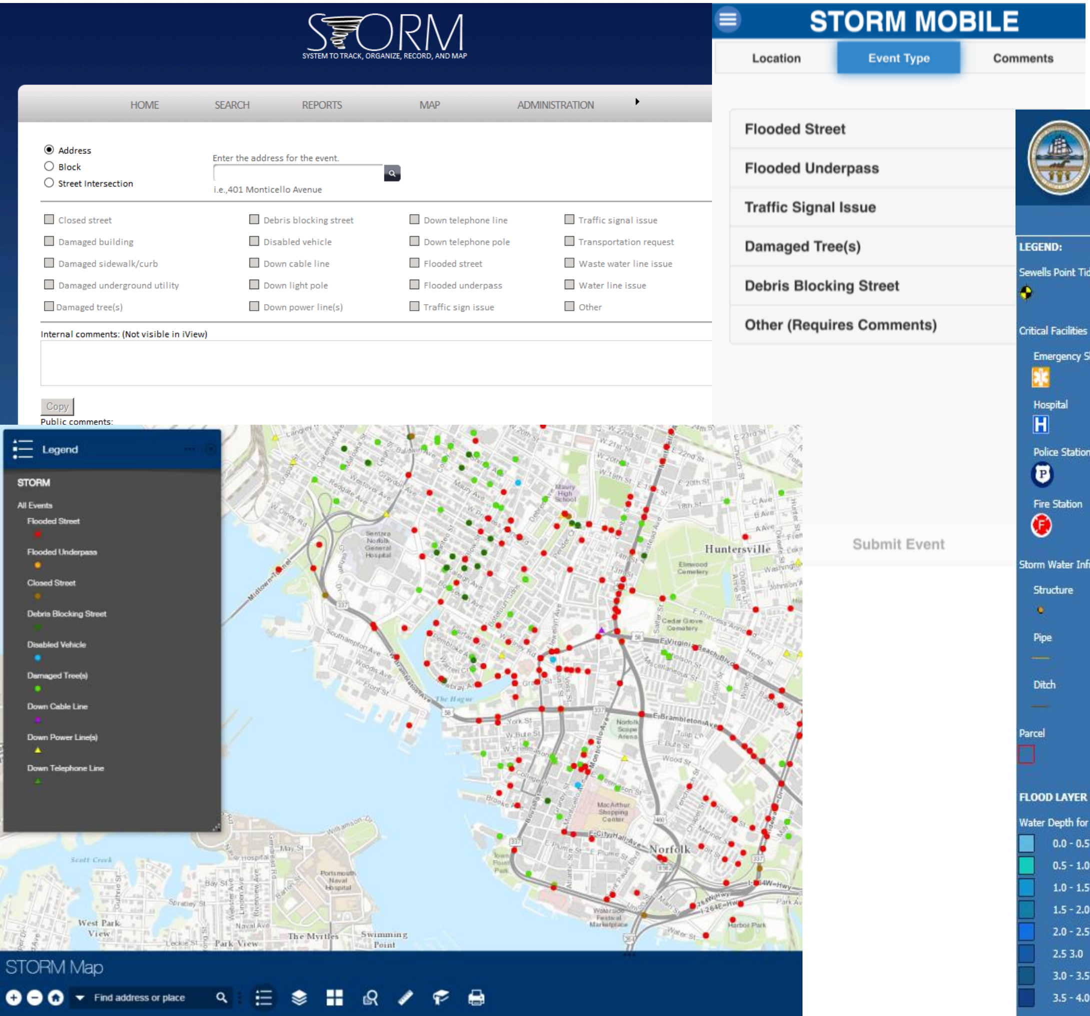
Existing Web Applications

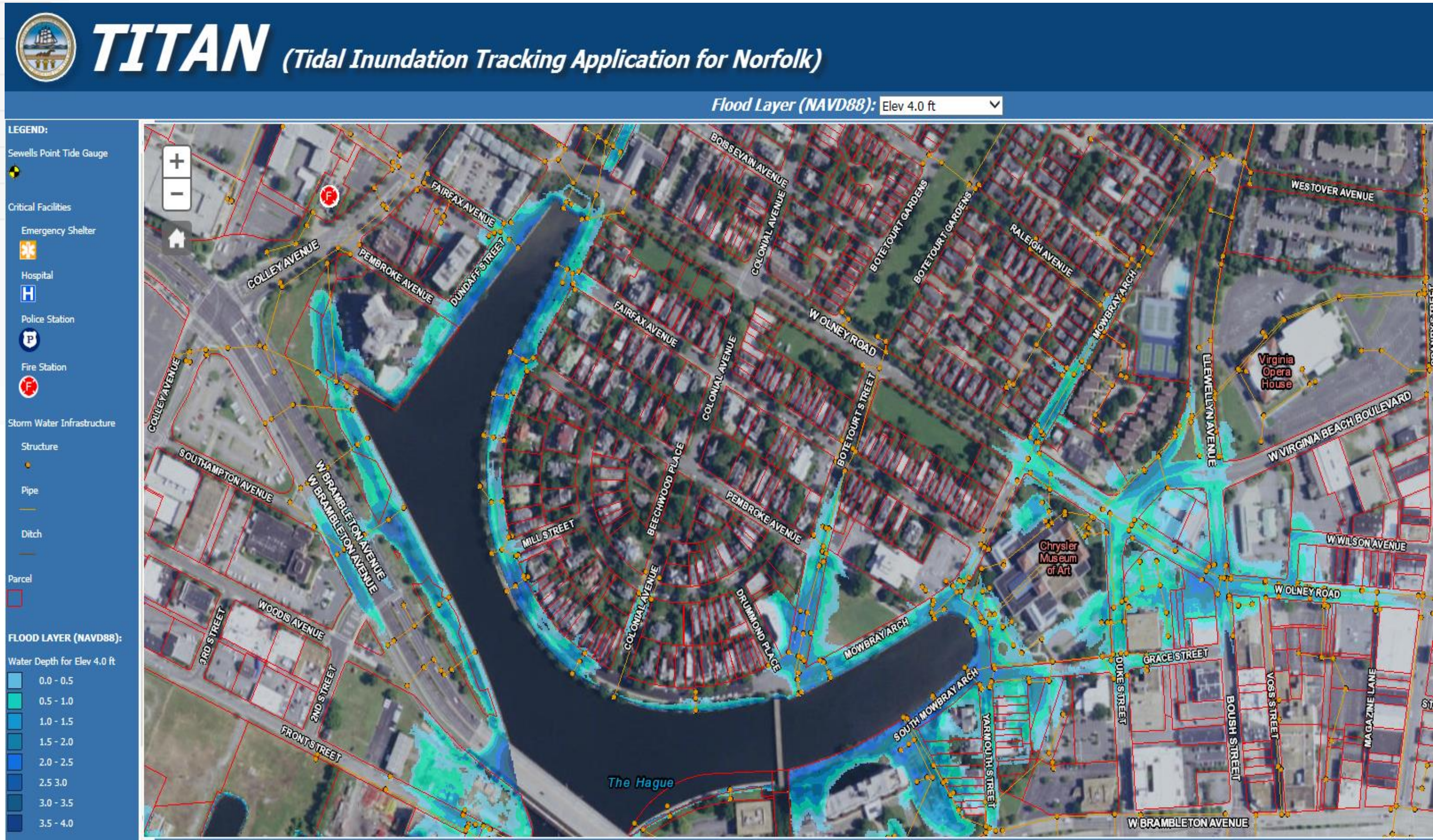
STORM – System to Track, Organize, Report, and Map

- STORM Mobile – crowd sourcing, light version of storm for public use http://gisapp1.norfolk.gov/stormmobile
- STORM Map – Searchable online mapping application http://gisapp1.norfolk.gov/stormmap

TITAN – Tidal Inundation Tracking Application for Norfolk

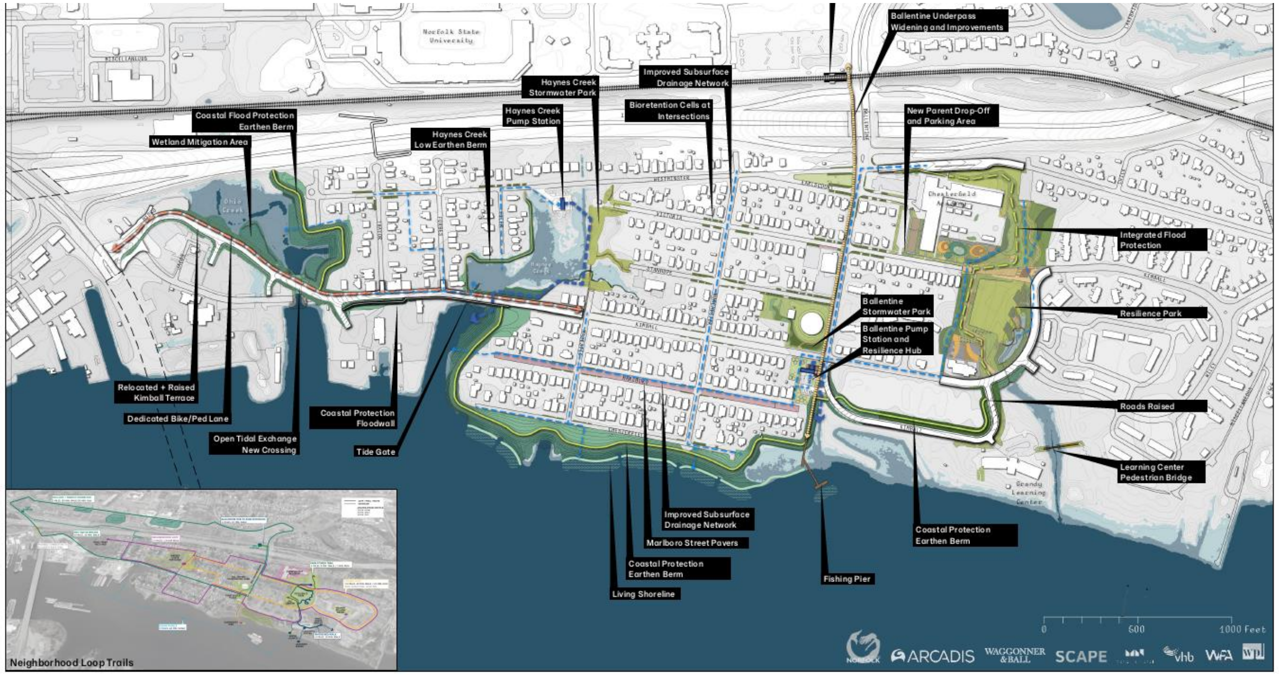
http://gisapp1.norfolk.gov/titan/





Neighborhood Development and Engineering Efforts

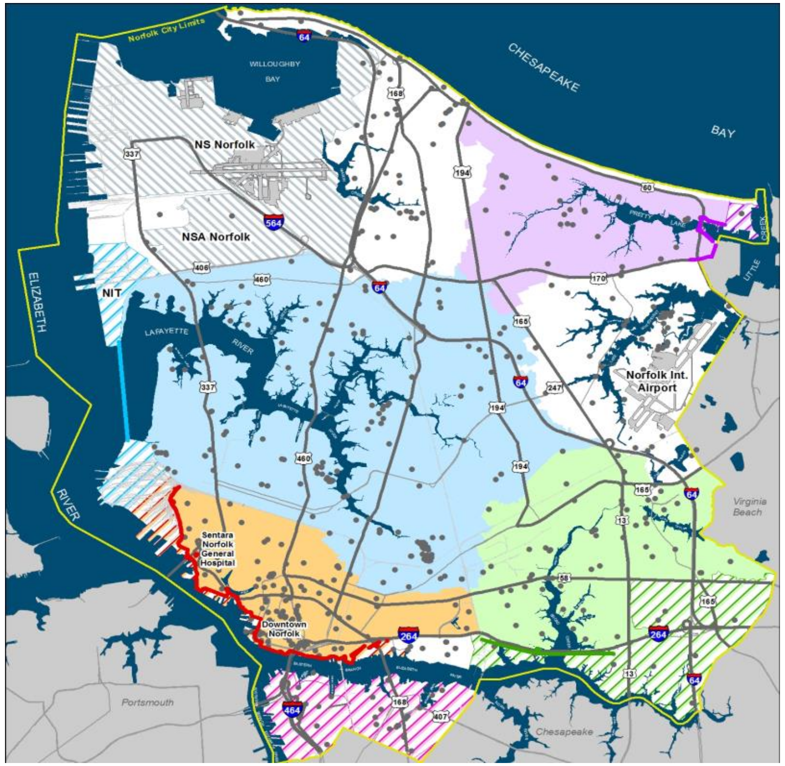
Ohio Creek/Chesterfield Heights (NDRC)



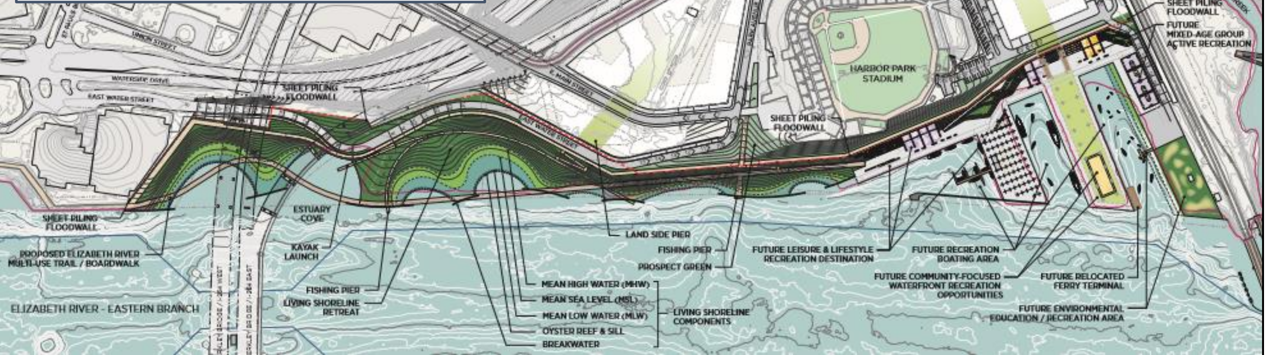
USACE - CSRM

3.2 BCR - Overall

5.5 BCR - Downtown System



Brownfield Grants for Planning, Design, & Construction

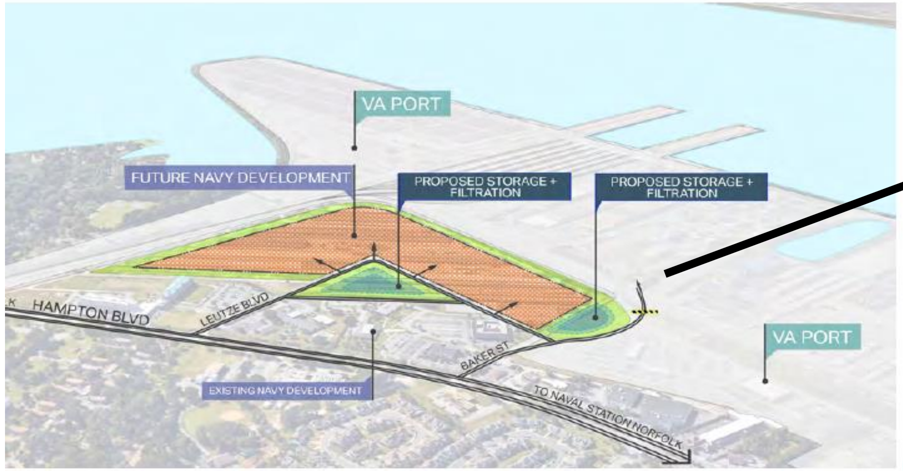


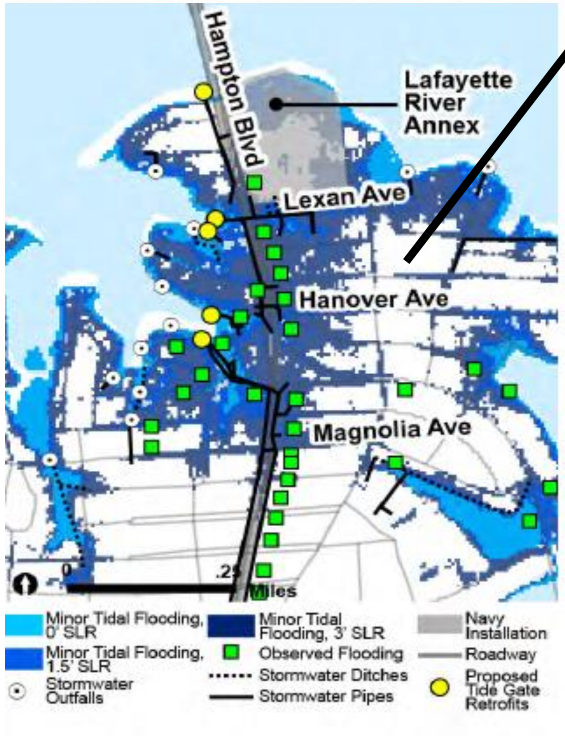
St. Paul's Area

Redevelopment using a resilient lens

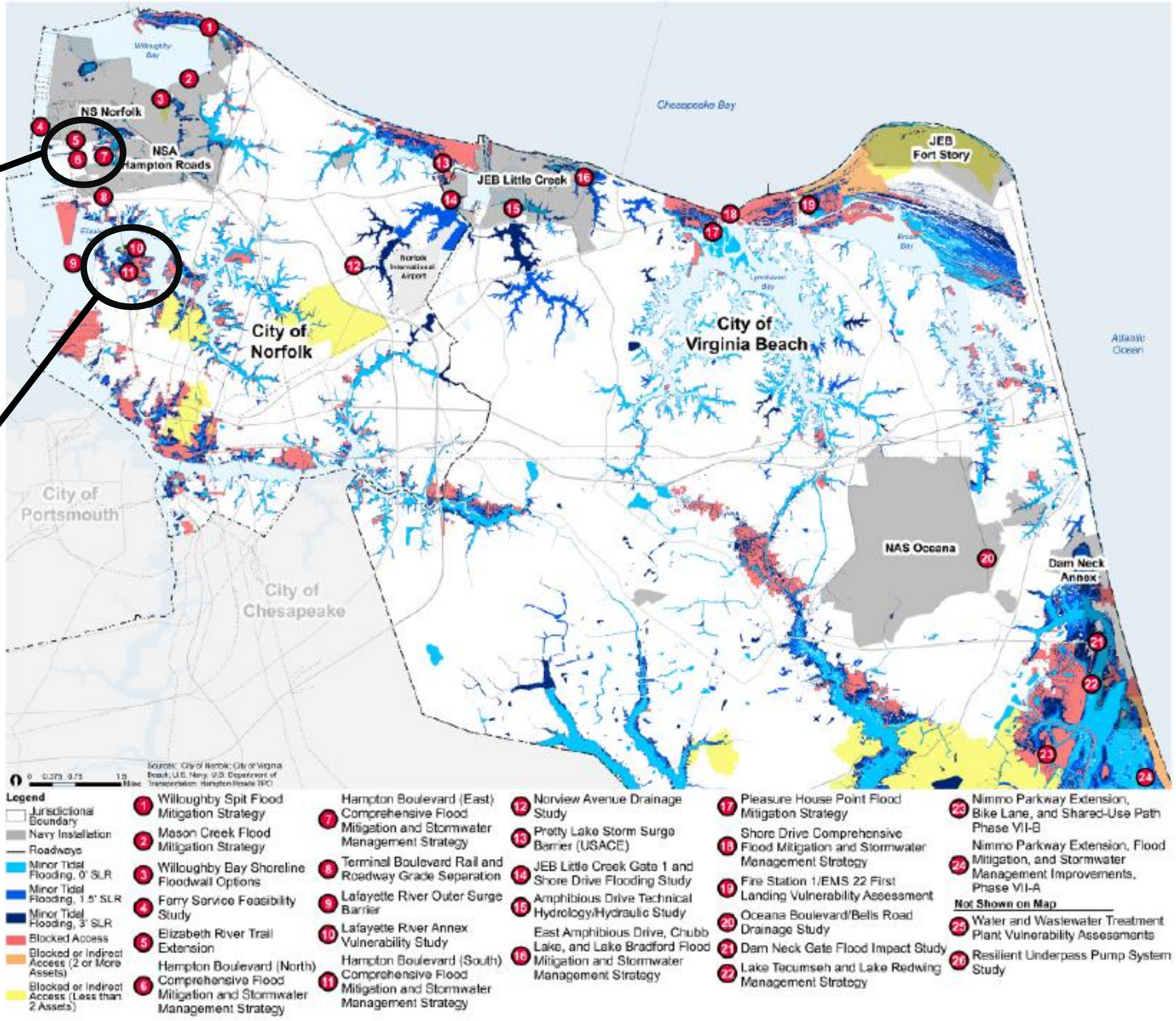
- Provide opportunities for upward mobility for current residents
- Use the land differently to solve flooding issues
- Redevelop using a mixed-income/mixed-use model

Regional Efforts – JLUS



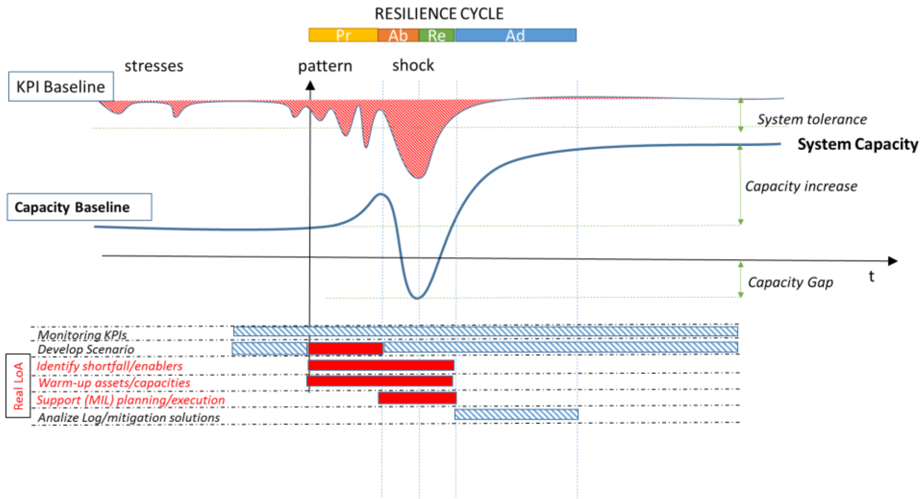


CheckMate
(backflow preventer)



Applying Smart Cities Solutions

- Early warning for residents:
  - Text message, email, Alexa, Google Home, Facebook, Google+, Twitter
- Updates to social mapping/traffic applications (Waze)
- Targeted location-based notifications
- Early warning to emergency services (EOC, fire, rescue, traffic center)
- Redirect to avoid flooding
- Data can support calibration of water level models.
- Foundation for a predictive model.



Related Efforts

- RISE Wireless Communications Evaluation Program
  - Vendors invited to install wireless gateways and sensors
  - RISE's evaluation team will document the performance
  - Coastal Community Resilience Challenge – $1.5 million awarded
- Dept. Homeland Security – Flood Sensor Collaborator
  - 3 Performers with 11 sensors each
  - Alpha sensor evaluation ended March 2019 – Beta sensors on the way
- StormSense Project – VIMS (CCRFR)
  - Installed 33 Sensors in the HR Region for better tidal prediction and street-level flood forecasting
- dMIST Project – University of Virginia
  - Smart Cities Approach to Sense, Predict, and Control Stormwater and Traffic Systems (NSF-CRISP)

RISE Resilience Innovations

Homeland Security

StormSense Project
Forecasting Flooding from Storm Surge, Rain, and Tide

UVA ENGINEERING
LINK LAB

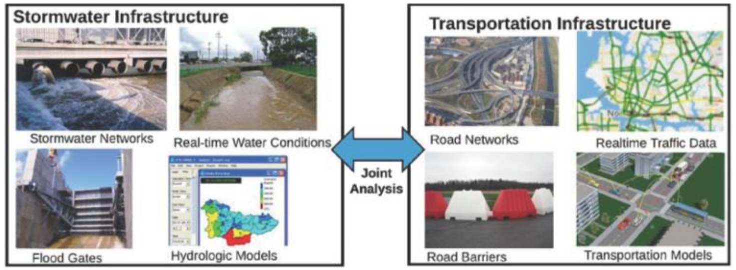
dMIST: Data-driven Management for Interdependent Stormwater and Transportation Systems

Jon Goodall (Civil Engineering), Madhur Behl (Computer Science), Donna Chen (Civil Engineering), Michael Gorman (Engineering and Society), and Kamin Whitehouse (Computer Science)

Problem Statement

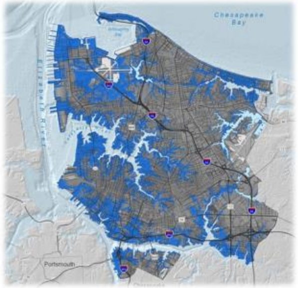
- Climate change and sea level rise caused recurrent flooding to occur with increased frequency in coastal cities
- Lack of holistic and dynamic infrastructure management and effective decision support systems
- The need for interdependent systems to best guide expensive, large-scale infrastructure investments

➢ Addressing these scenarios and their potential benefit to system resilience requires a systems-level perspective for joint analysis of coupled stormwater and transportation infrastructure systems



Testbed: the City of Norfolk, Virginia

- Low-lying topography surrounded on 3 sides by major water bodies
- Approximately 13% of Norfolk in FEMA flood hazard zone (not including Naval Base)
- Installing infrastructure including sea walls to protect the city from just one additional foot of sea level would cost $1B
- Historical hurricanes flooded the major roadways impacting average annual daily traffic volumes up to 34,000 vehicles



Overarching Objectives

1. Data-driven modeling for real-time operations

   ➢ How do we leverage dense, adaptive sensor networks to improve road- link resolution predictions of inundation of roadways that are relevant for city–scale system operation?

2. Hybrid-modeling for long-term planning of infrastructure systems

   ➢ How do we create hybrid physical/data-driven models of interdependent infrastructure systems to explore infrastructure planning scenarios to assist decision makers in increasing overall system resilience?

3. Interpretable recommendation systems

   ➢ How do we provide recommendations to the human managers that are interpretable and credible so that they are best able to assist both short-term operational and long-term planning decision makers

4. Reduce sensing cost

   ➢ How can infrastructure operators minimize the cost of additional sensing points based on the marginal cost and added confidence in model recommendations?

Interdependent Datasets: Established + Emerging

RITIS

iPeMs

VDOT

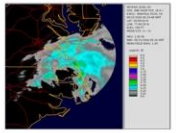
Google maps waze

Transportation data: Roadway, speed, travel time, volume

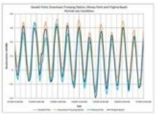
Google waze data: Flooding reports

NOAA HRSD WEATHER UNDERGROUND

Time-series precipitation/water level

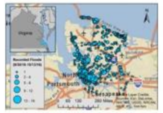


NEXRAD precipitation



Tidal data

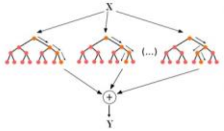
GIS data



Citizen flood reports

Drone footage

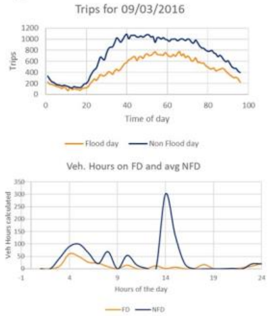
Innovative Approaches



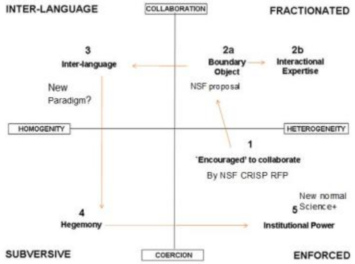
Random Forest Regression for prediction models

PySWMM for real time storm water control

Long-Range Low-Cost Lora Sensor Networks



Transportation and Flooding Cross-Analysis



Interactional expertise & trading zones Analysis

Interdisciplinary Research Team

Jon Goodall
Civil Engineering
Hydroinformatics

Donna Chen
Civil Engineering
TransportationSystems

Data-driven modeling **dMIST** Cyber-Physical Systems

Interdisciplinary Trading Zones

Madhur Behl
Computer Science

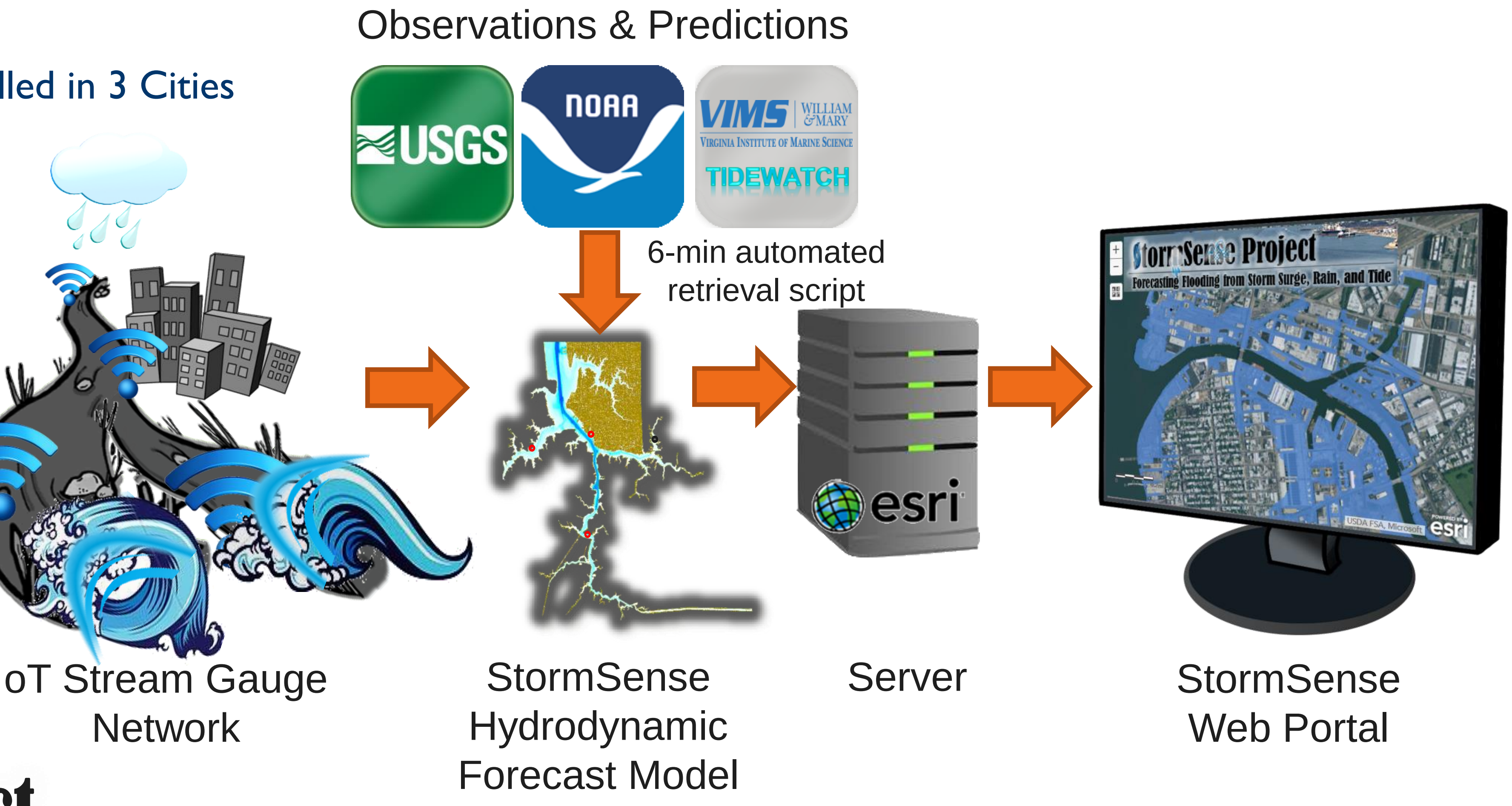
Michael Gorman
Engineering & Society

Kamin Whitehouse
Computer Science

StormSense Project

Sensor Network and Modeling Approach

- 33 IoT water level sensors installed in 3 Cities
  - 9 installed in Newport News
  - 6 installed in Norfolk
  - 18 installed in Virginia Beach
- Harmonic Analysis for and integration into CCRFR's Tidewatch service
- More sensors and data integration planned



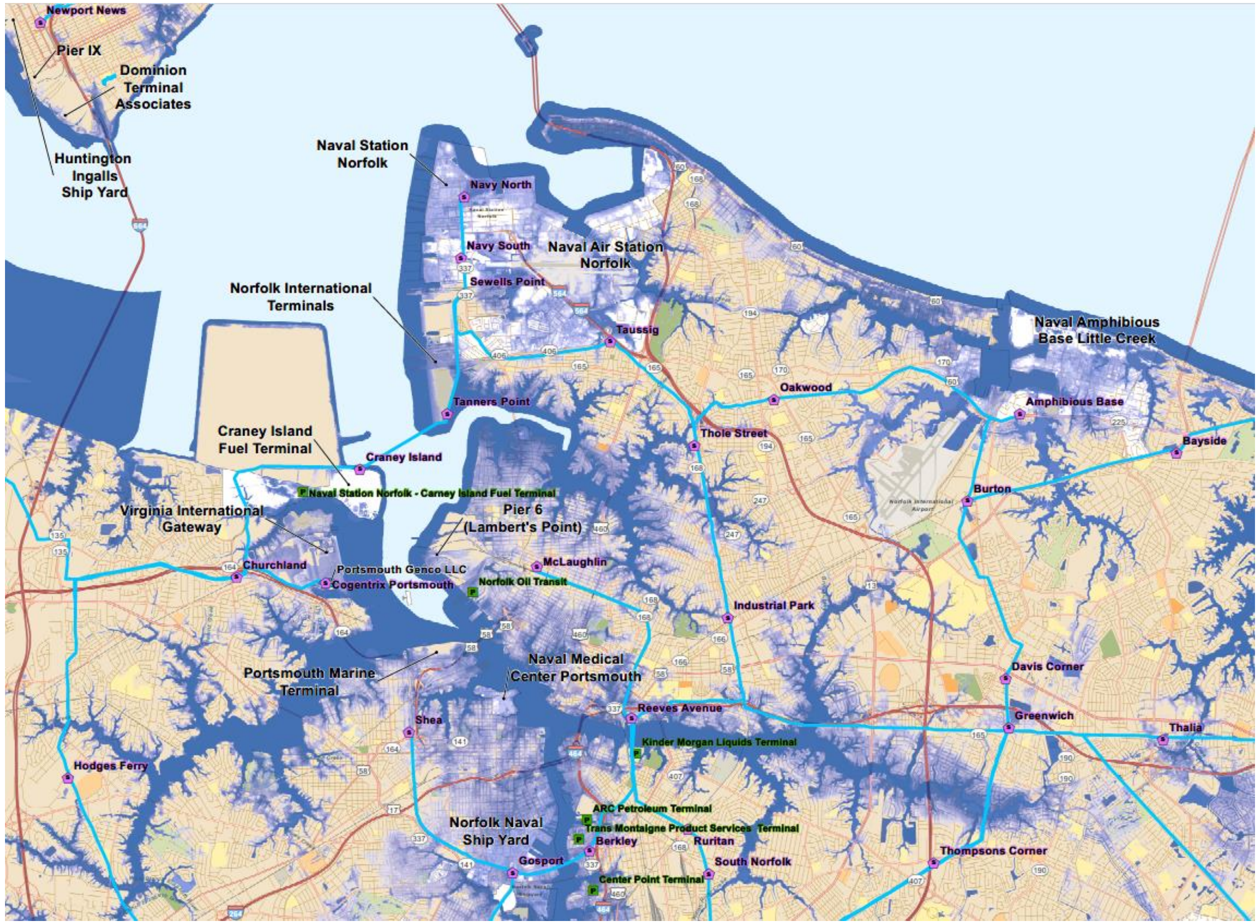
StormSense Project
Forecasting Flooding from Storm Surge, Rain, and Tide

stormsense.com

Looking Ahead:

- Continue to define resilience modeling requirements & available city datasets
- Continue to use the City as laboratory for resilience innovations
- Access to data and sharing with key stakeholders, and researchers
- Integration with other modeling/simulation programs
- Partners: 100RC, NATO, DHS, HUD, DOE, DOD, RISE, ODU, UVA, VIMS, Sandia Nat. Labs

NORFOLK RESILIENT CITY



NORFOLK RESILIENT CITY

Thank You!

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