AMERICAN PUBLIC WORKS ASSOCIATION

APWA

Your Comprehensive Public Works Resource

VIRGINIA D.C. MARYLAND CHAPTER

Sea Level Rise Impacts on Municipal Stormwater Systems in Hampton Roads

Presentation at the

APWA Mid-Atlantic Chapter
February Lunch and Learn
Norfolk, Virginia

February 27, 2013

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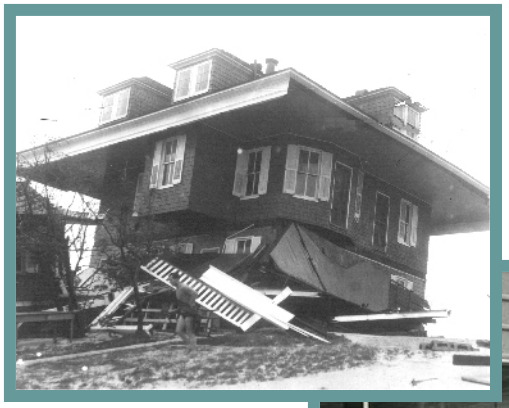
NORFOLK

Flooding
(1938 Rain event)

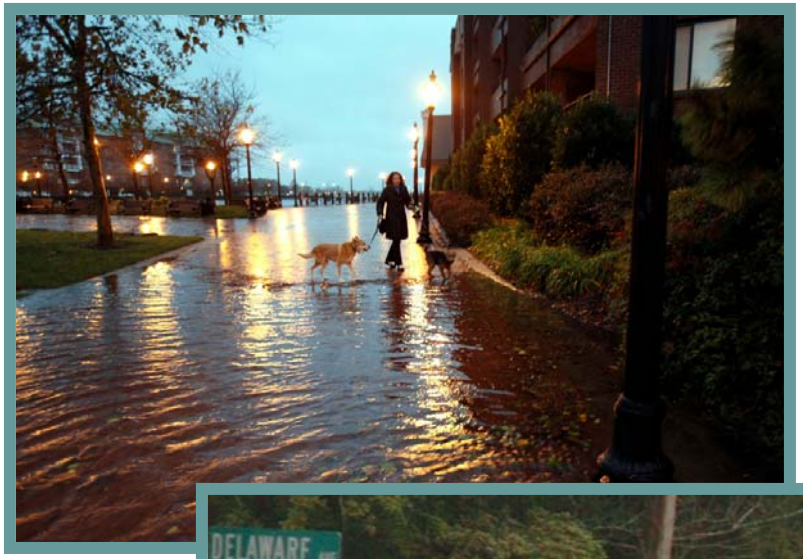
Flooding (1933)

City Hall Ave - 1962

Flooding (1962)

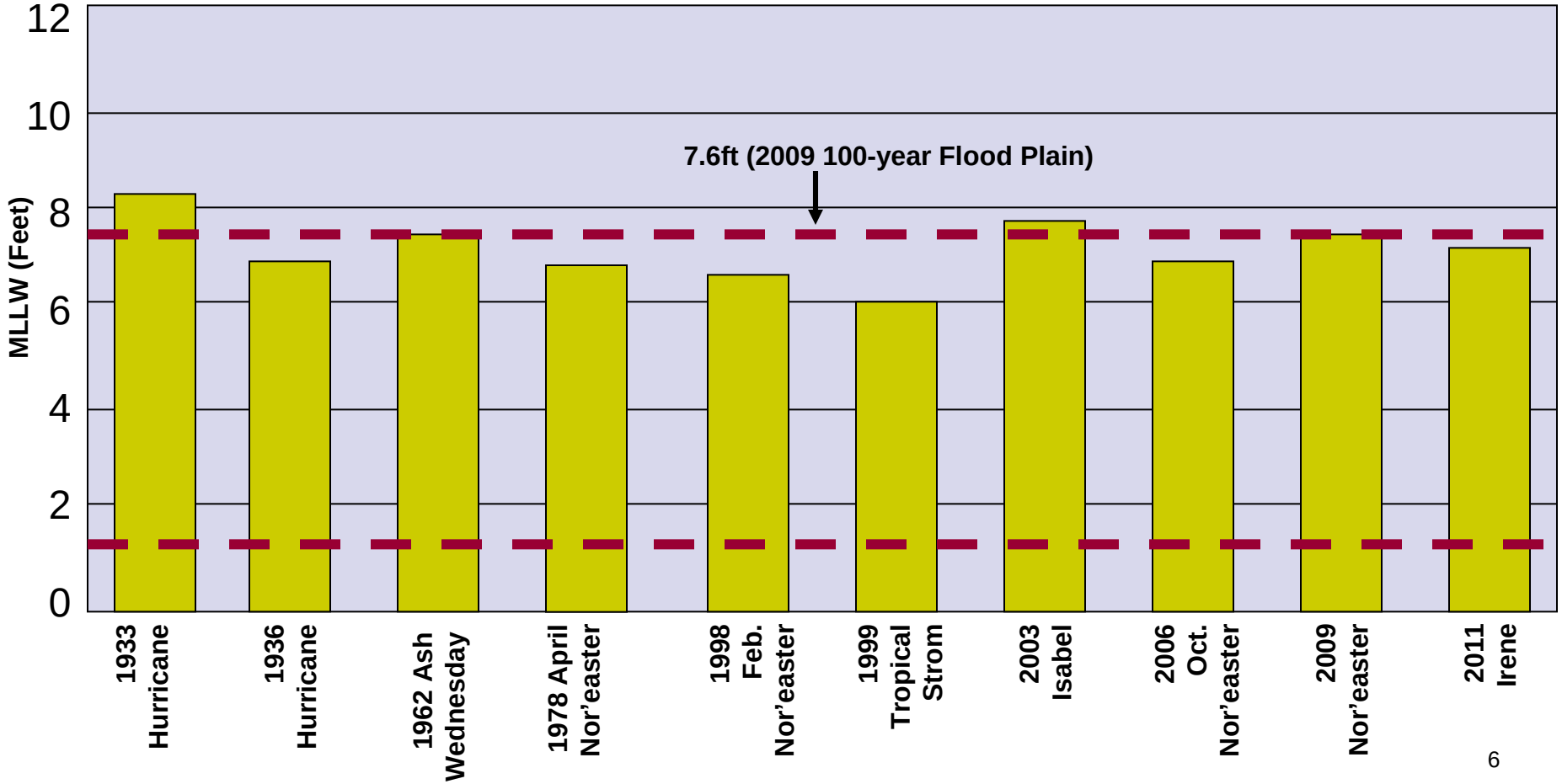


Flooding (2009)



Hampton Roads' Major Tidal Events

Comparison of Datum with 10 of the Most Significant Storms
(Note: 7 out of have occurred in the last 13-years)



Why Flooding Occurs

In Norfolk, flooding is caused by rainfall, tides or a combination of both

Rainfall Flooding

- Rain intensity exceeds capacity of the storm drain system

Tidal Flooding

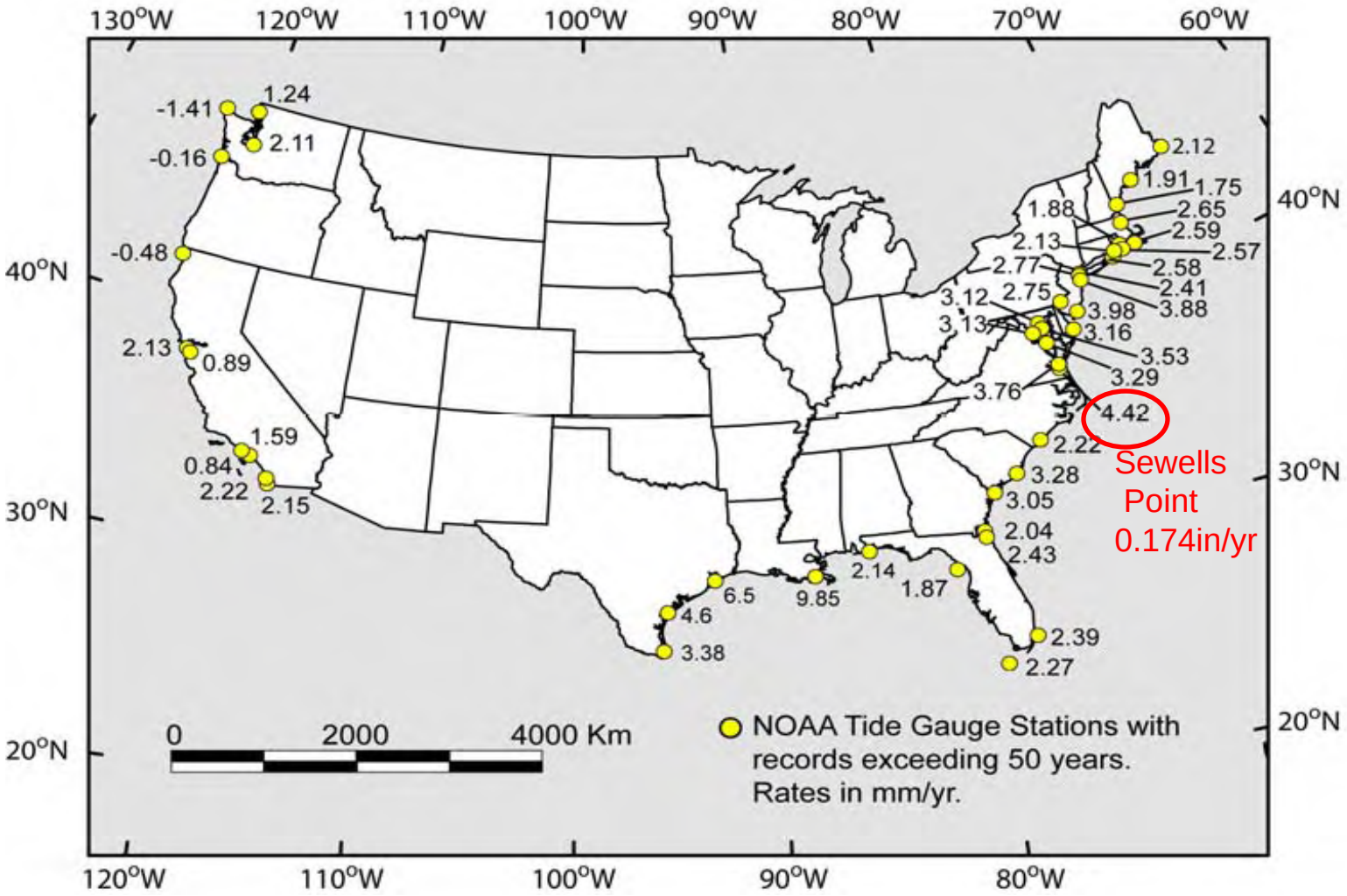
- Caused by tidal variations and storm surges
- Directly related to land elevation and proximity to coastline
- Can exacerbate rainfall flooding

Tidal Flooding Projections

- Tidal flooding has occurred with greater frequency in recent years – a trend that can be expected to continue due to several factors:
  - Weather events of greater severity (related to increased ocean water temperatures)
  - Sea level rise
  - Land subsidence (land sinking)

U. S. Relative Sea Level Change

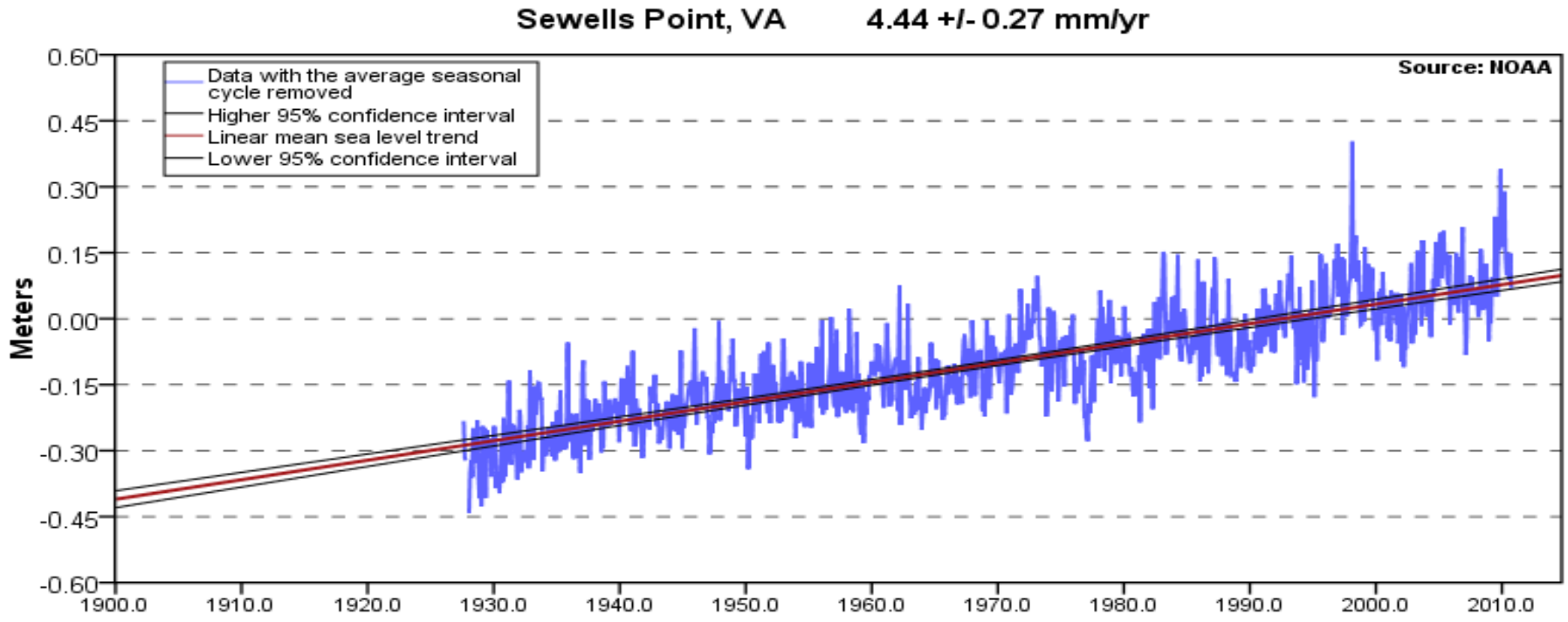
Hampton Roads' rise has been the greatest of any location on the east coast



EPA 2008

Sea Level Rise

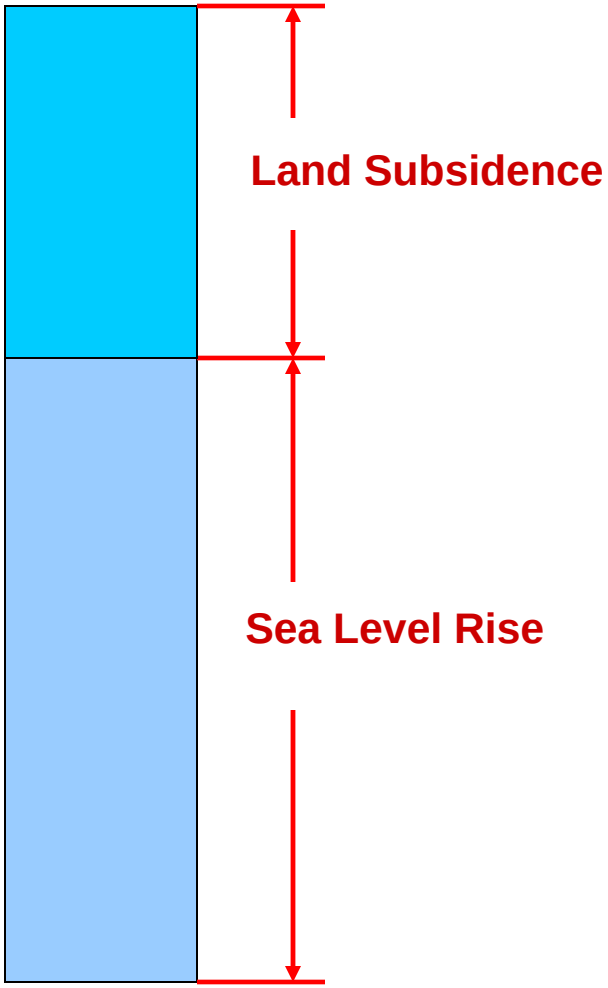
- Sea level rise @ Sewells Point – 1.46 ft/century (since 1927)
  - Compare to other mid-Atlantic locations more typically ~ 1-ft/century
- Sea Level Rise @ Sewells Point over last decade about 1.5 X long term average ~2.25 ft/century
- Implication – Flooding will worsen in the future unless actions are taken



Land Subsidence

- Land subsidence is occurring faster in Hampton Roads than surrounding areas
    - •Filled areas sink faster than others
    - •Areas near the Chesapeake Bay impact crater are shifting
    - •Average rate of subsidence in Hampton Roads is estimated by the Chesapeake Bay Program's Scientific and Technical Advisory Committee at 0.57 inches per decade

Relative Sea Level Rise



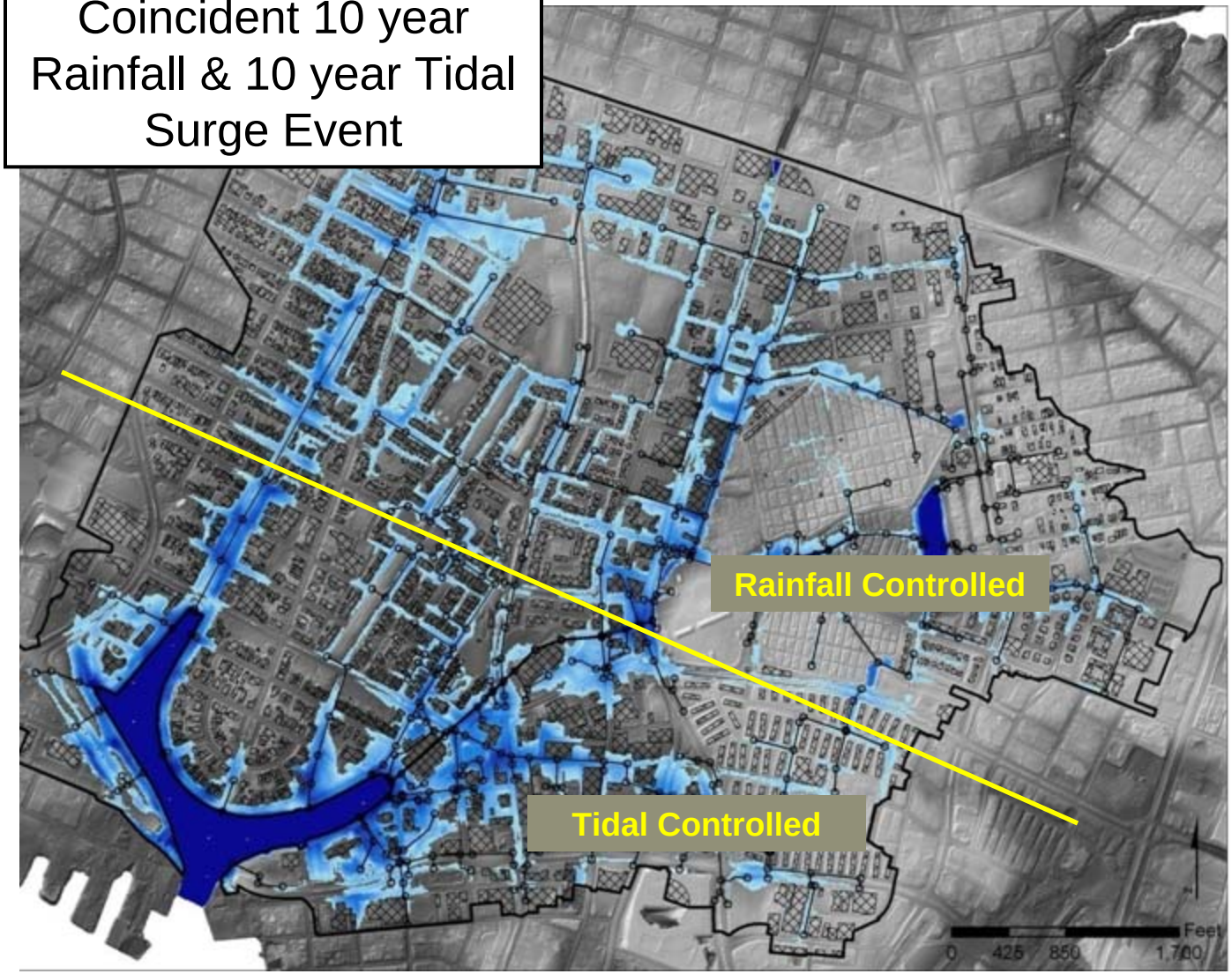
- Relative Sea Level = Sea Level Rise + Land Subsidence
- Among Scientists there is a wide range of future sea level rise projections
- Mid-range future projections of Relative Sea Level Rise for Hampton Roads are 2 - 4 inches per decade

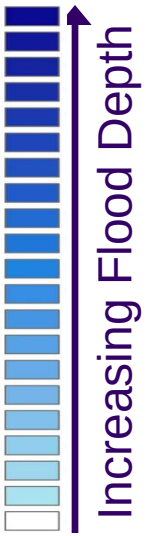
Potential Long-Term Impacts of Relative Sea Level Rise

- More frequent and severe flooding
- Flood insurance required for more properties and at higher cost
- Public facilities and infrastructure more susceptible to flooding
- Transportation disruptions
- Reduction in suitable land for development/redevelopment
- Environmental effects including loss of wetlands and wildlife habitat
- Businesses and residents may relocate inland from coastal areas

Combined Rainfall & Coastal Flooding

Coincident 10 year Rainfall & 10 year Tidal Surge Event



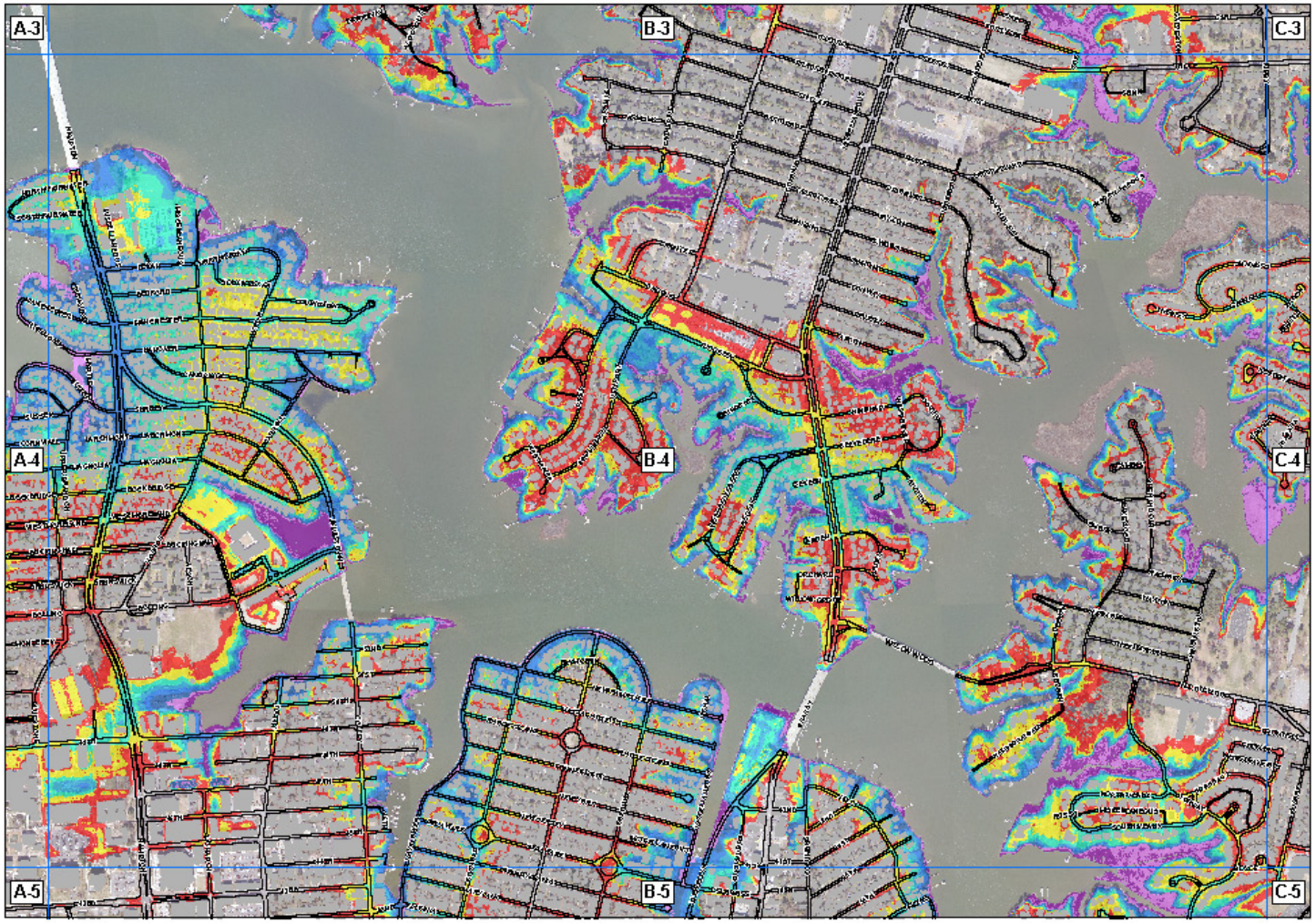


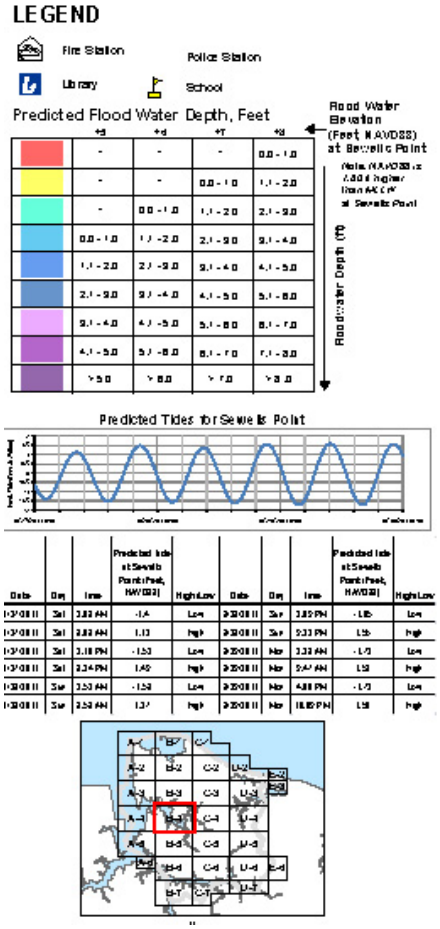
Tidal surge:

1) Increases area of rainfall flooding
2) Increases depth of rainfall flooding and
3) Holds water upstream longer and increases duration of flooding

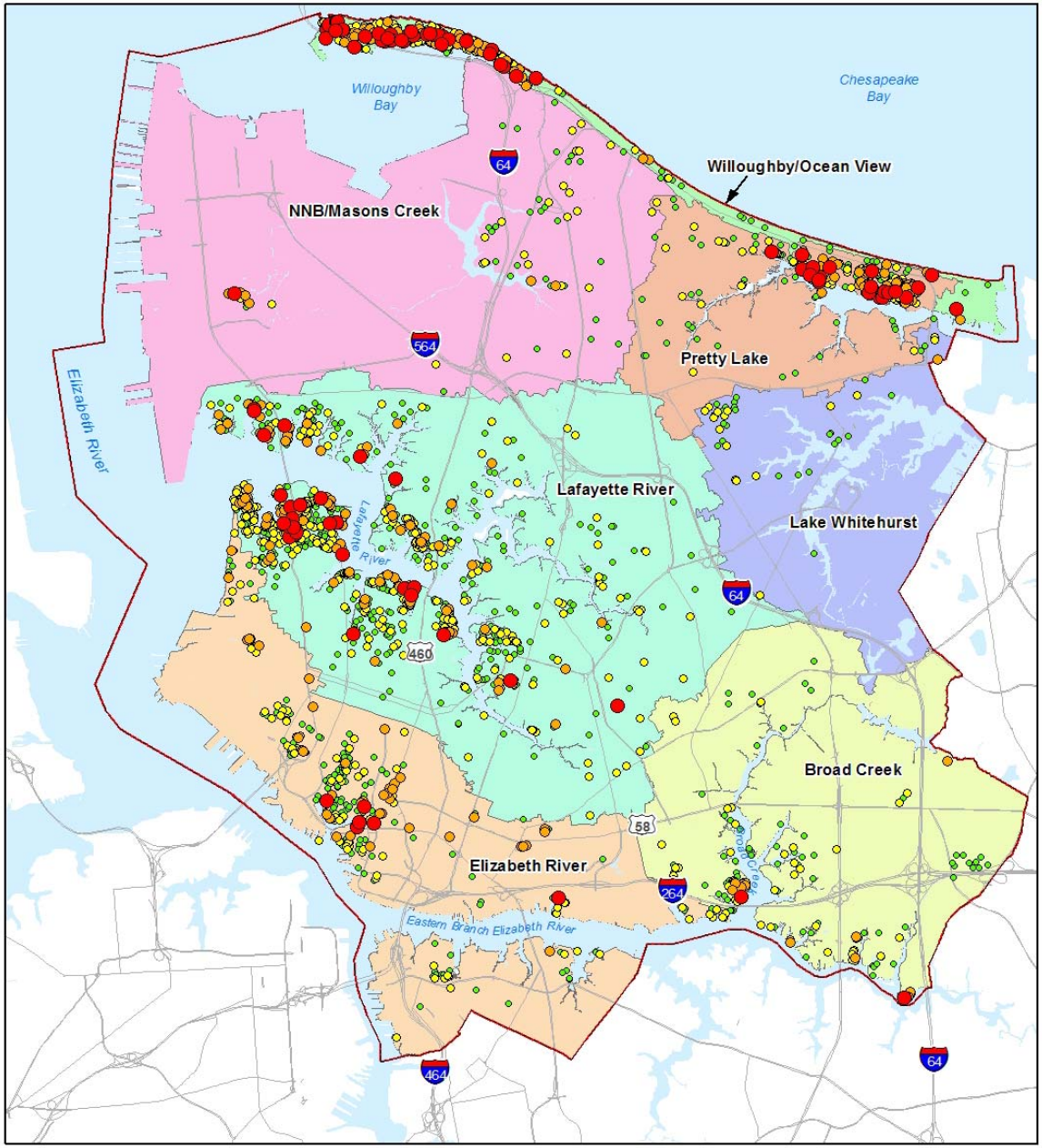
Analysis of Flooding Conditions

Close to Real Time Hurricane Irene Flooding Conditions





Analysis of Flood Damage City-Wide



1977-2009 Flood Claims (4,267)[a]

Values are in 2010 dollars .

Total ~ $69,819,000

- Claim did not exceed deductible[b]
- Less Than $10,000
- $10,000 - $25,000
- $25,000 - $50,000
- Greater Than $50,000

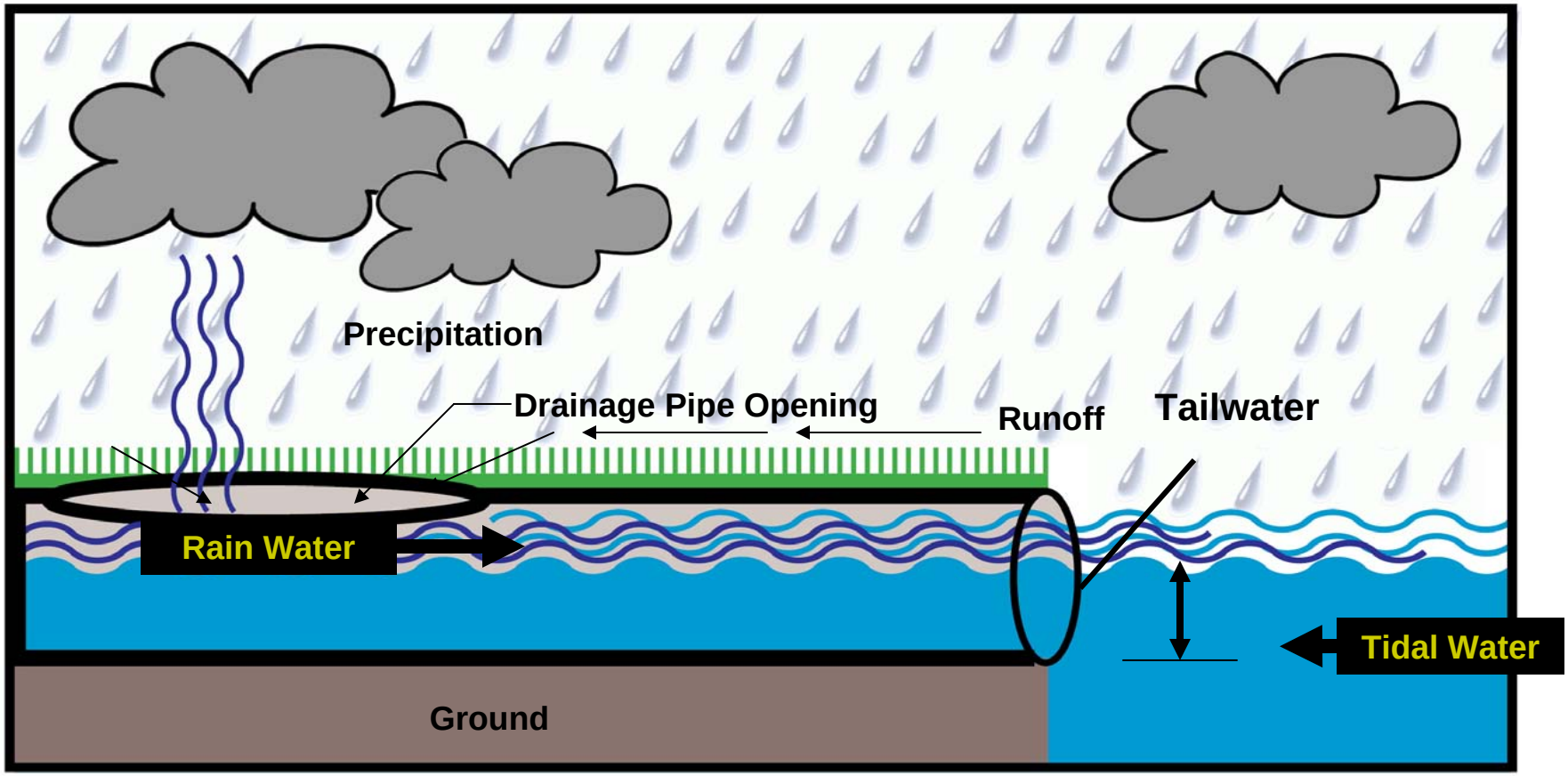
Notes:

a) Claim values converted to 2010 dollars based on Consumer Price Index.

b) Assumed deductable was $5,000.

Understanding Tail Water

Where Precipitation Runoff Meets Tidal Waters



TYPICAL SUBMERGED OR PARTIALLY SUBMERGED STORM WATER OUTFALL

Tailwater phenomena causes rainfall and tidal flooding to be inextricably linked.

Storm Intensity and Norfolk's Drainage System

- Largely over 60 years old and primarily designed for the 2-year rainfall storm
- Consists of:
  - 1,824,000 linear feet of pipes
  - 28,100 structures
  - 260,832 linear feet of ditches
  - 13 City maintained storm water ponds
  - 10 rail and roadway pumping facilities
  - the Downtown floodwall and its pumping station

- Since 2000, new and replacement facilities have been designed for 10-year storm

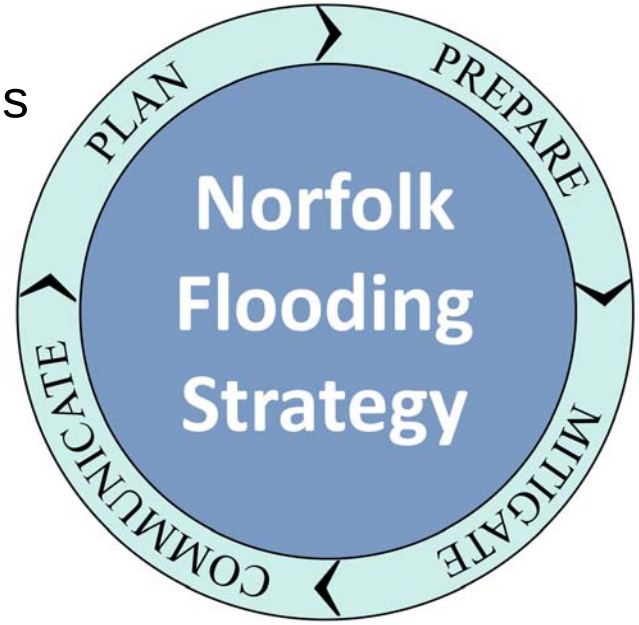
Norfolk Flooding Strategy

Plan

- City planning
- Study and analysis
- Modeling & simulation

Prepare

- Emergency Preparedness & Response
- Education & Training



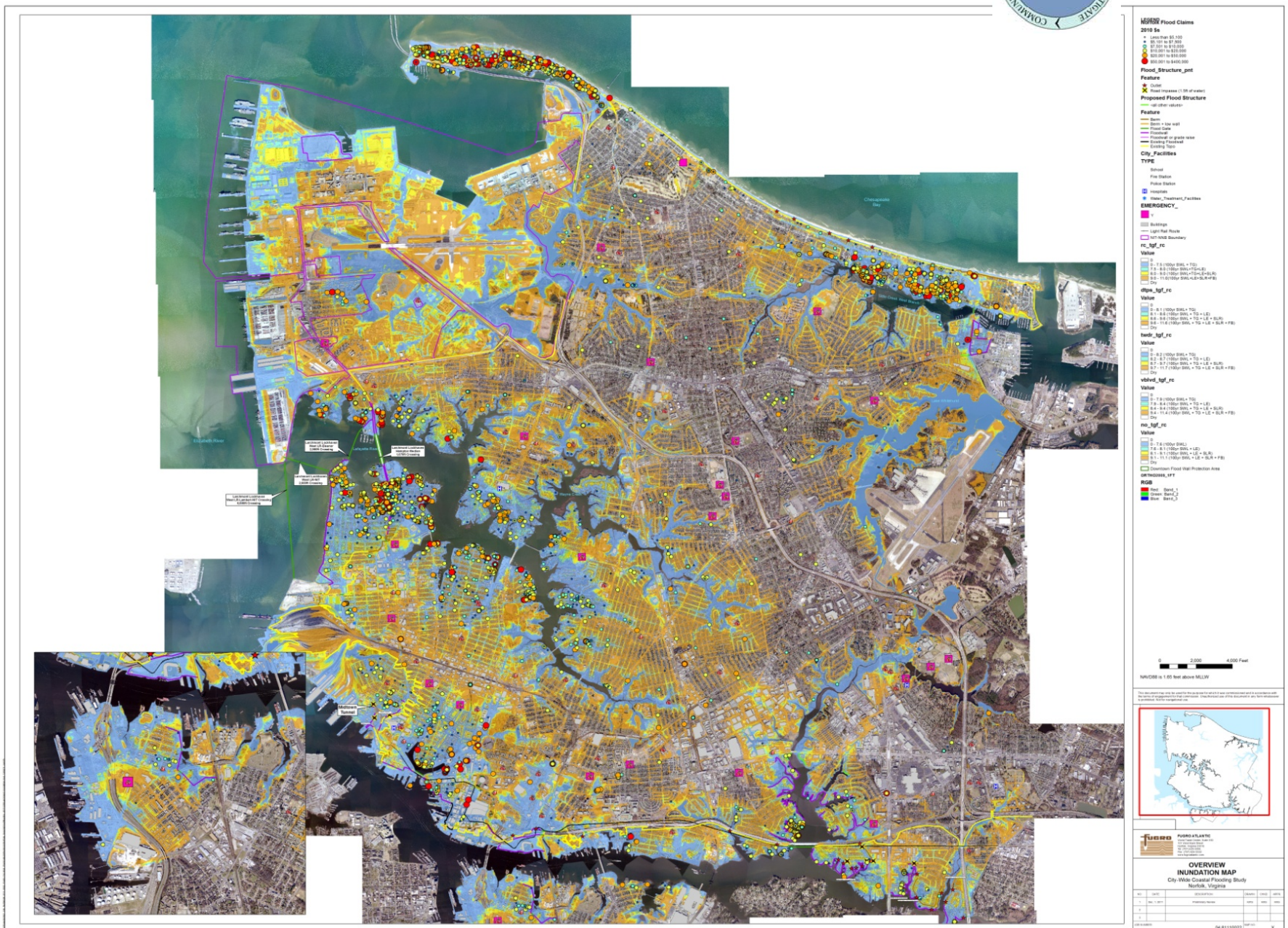
Communicate

- Citizen outreach
- Partnerships
- Online resources

Mitigate

- Infrastructure development
- Flood remediation and mitigation

Risk Analysis & Options



Options Considered In Coastal Flooding Study

- Public Information, Notification and Education
- Land use options & Government policy
  - Zoning regulations
- Development requirements
  - Minimum floor elevations for house
  - Minimum floor elevation for garages and ancillary structures
  - Flood proofing vulnerable elevations
  - Foundation, structural, mechanical design requirements
- Property Purchase
- Infrastructure Approaches

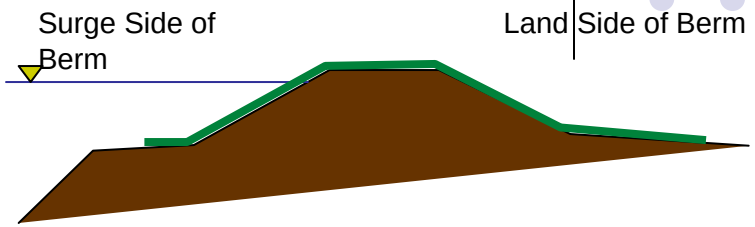
Flood Mitigation Tools – Major Structures

- Floodwalls and levees
  - Can provide continuous tidal protection
  - Require pump stations to pump rainfall out
  - Significant visual and environmental impacts
  - Costly

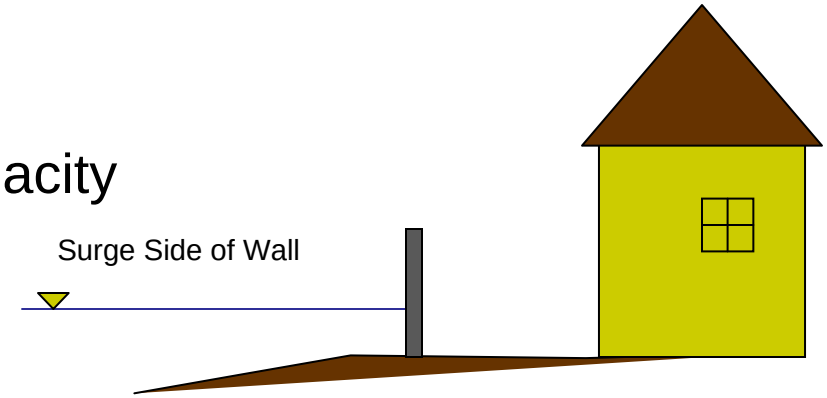
Seawall: Galveston, Texas

Infrastructure Approaches

- Infrastructure
  - Structures and barriers
    - Tide gates with pump stations
    - Earth berms (and raised roads)
    - Floodwalls & bulkheads
  - Storm water system upgrades
    - Retention ponds
    - Increase drainage system capacity
  - Raising of structures and roads



Earthen Berm

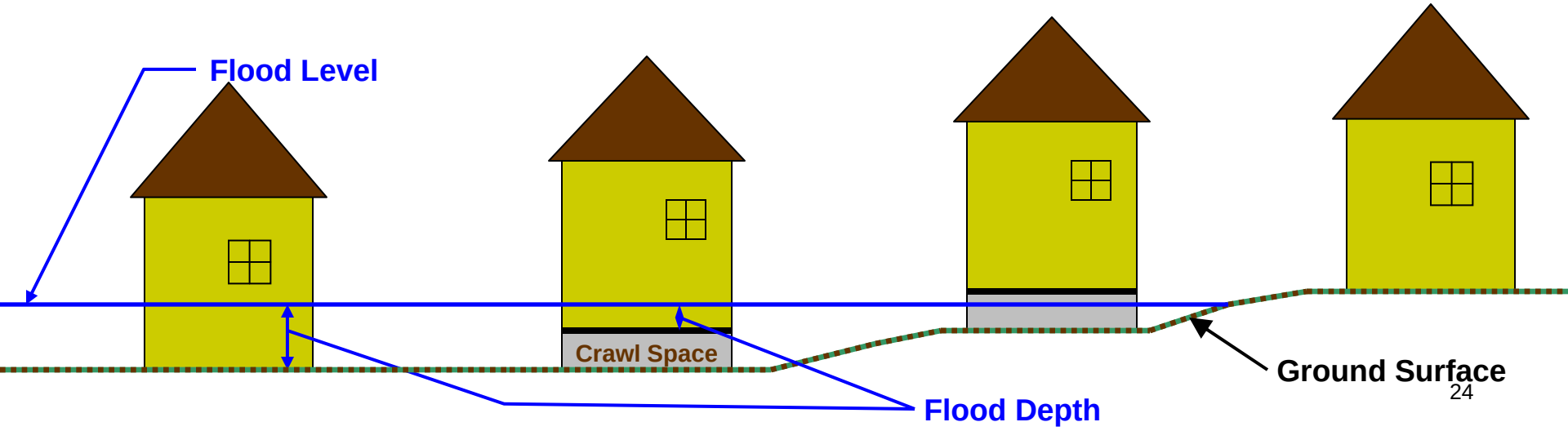


Flood Wall

Evaluation Process

- Modeling includes structures & contents utilizing the City parcel database and field verification was performed

- Not included in model are ancillary structures, vehicles, displacement, loss of use and city infrastructure



Land Use Options

- Zoning Restrictions & Code Requirements
  - Pros
    - No immediate capital costs
    - Limit future problems/conflicts
  - Cons
    - Flooding still occurs – no relief for existing properties
    - Possible lost tax base for the City
    - Difficult to implement in developed areas
    - Increased development costs
- Property Purchase
  - Pros
    - Reduced Costs
    - Add Open Space
    - Permanent (if FEMA funding used)
  - Cons
    - Displacement of residents
    - Demolition costs
    - Lost tax base for the City
    - Very costly in densely developed areas
    - Historical structures

Flood Mitigation Tools – Shoreline Protection

- Sand dunes, beaches, wetlands or living shorelines can be constructed or expanded to protect coastal properties

Flood Mitigation Tools – Adaptation of Structures

- Requirements that new facilities be built above the 100-year flood plain or another defined elevation
  - Finished floors
  - Parking areas
  - Roads
- Programs to raise existing structures
- Purchase and demolition of flood prone structures

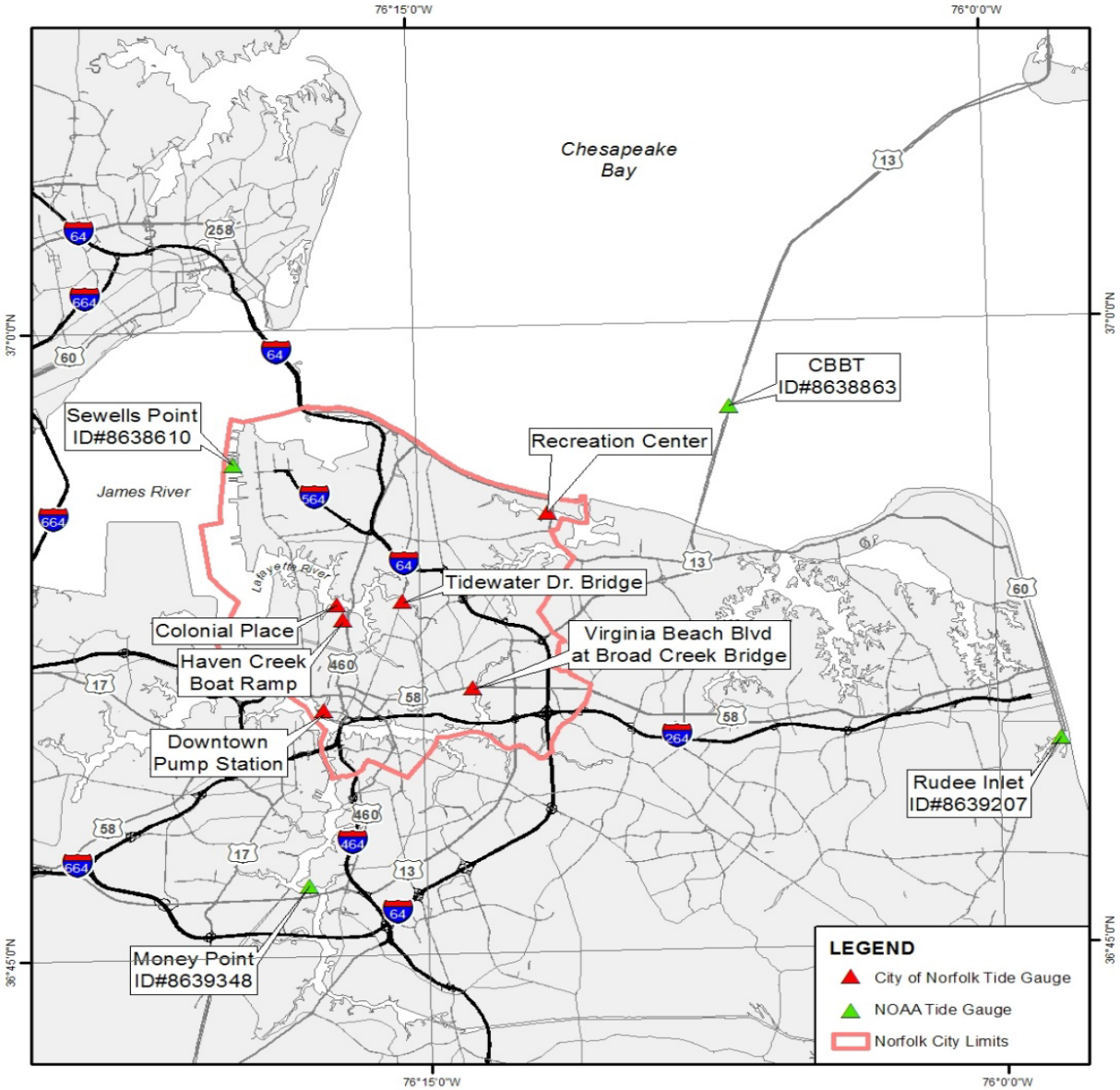
Flood Mitigation Tools – Plans & Regulations

- Zoning can be used to reduce the susceptibility of future development to flooding through regulations that address
  - Finished floor elevations
  - Land use densities
  - Lot sizes
  - Land-to-building ratios

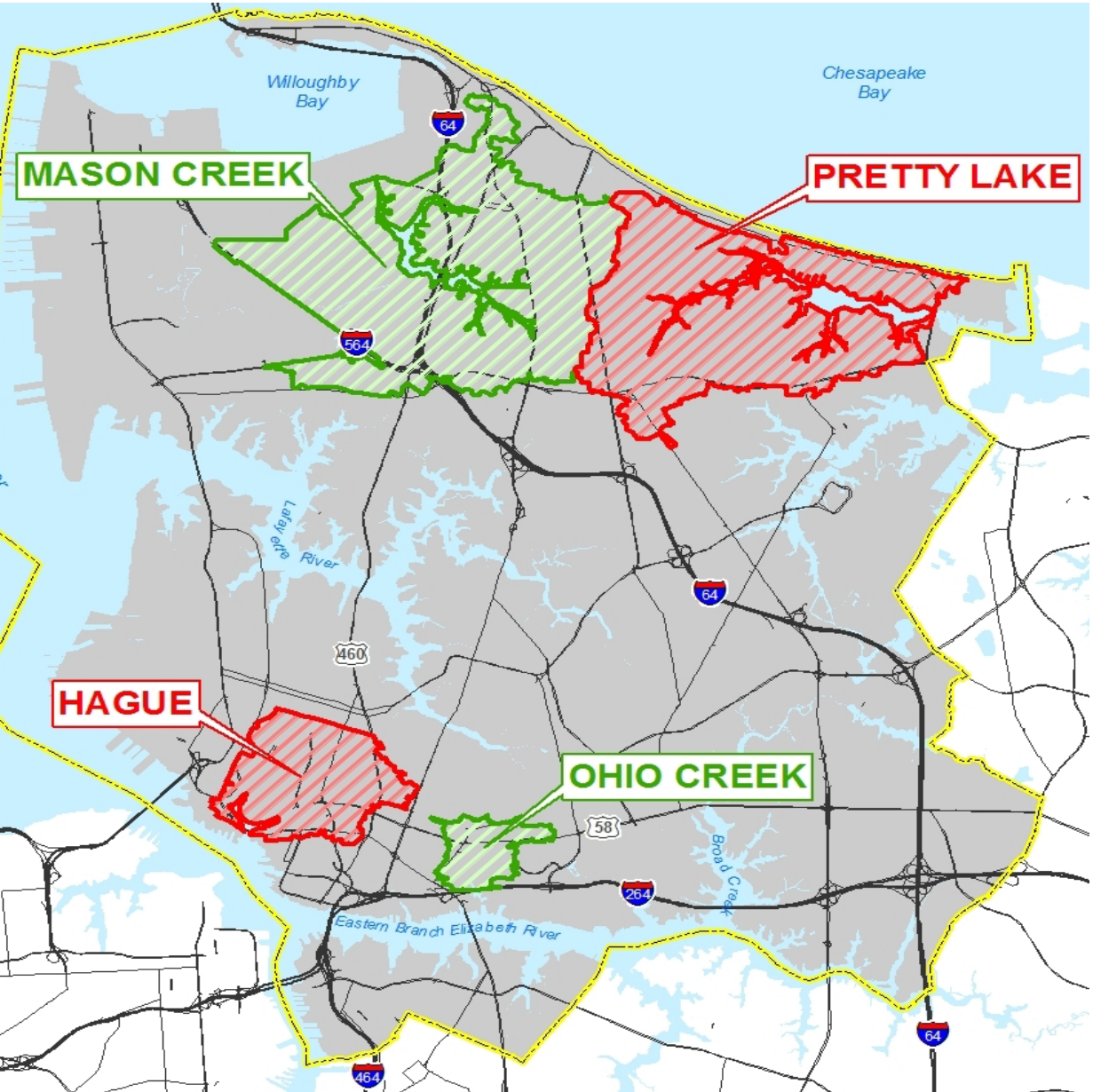
Flood Mitigation Tools – Plans & Regulations

- Comprehensive land-use plans
  - Optimize the use of flood-prone properties
    - Parks and public amenities adjacent to waterways
      - Enhance public access to rivers, bays and lakes
      - Potential to raise property values for all rather than a few
      - Opportunity to improve environment by creating water quality buffers and wildlife habitat
  - Minimize the impact of flooding
    - Leave flood-prone properties undeveloped

Tidal Gauges & Analysis of Data



Flooding Study: Initial Focus



Choices based on:

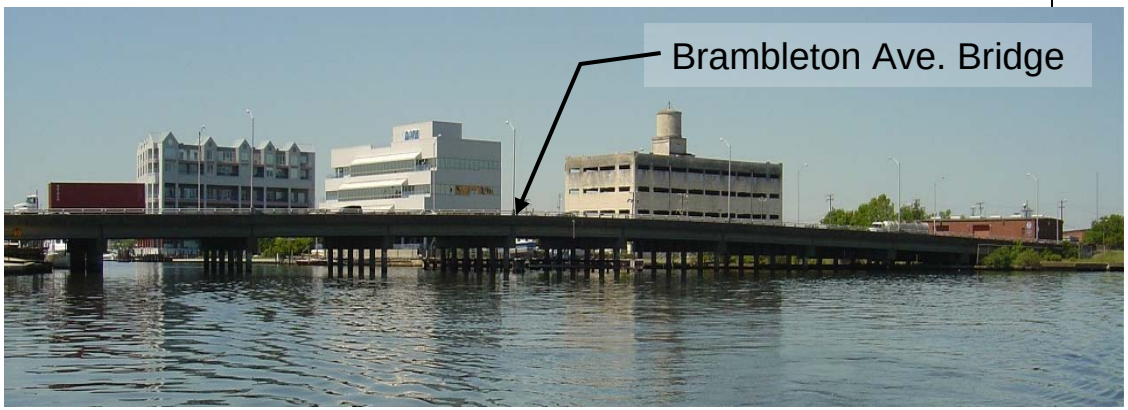
- Geographic setting areas with narrow tidal mouths (natural constriction points)
- Watersheds which were expected to lend themselves to specific, basin-wide mitigation options (simpler cases)
- Areas of recurring damage

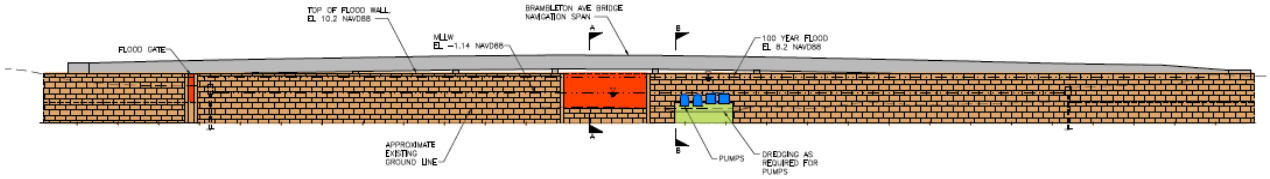
The Hague

Recommended Mitigation Approach

<u>Project Elements</u>

- Floodwall
- Tide Gate
- Pump Station
- Closure Walls

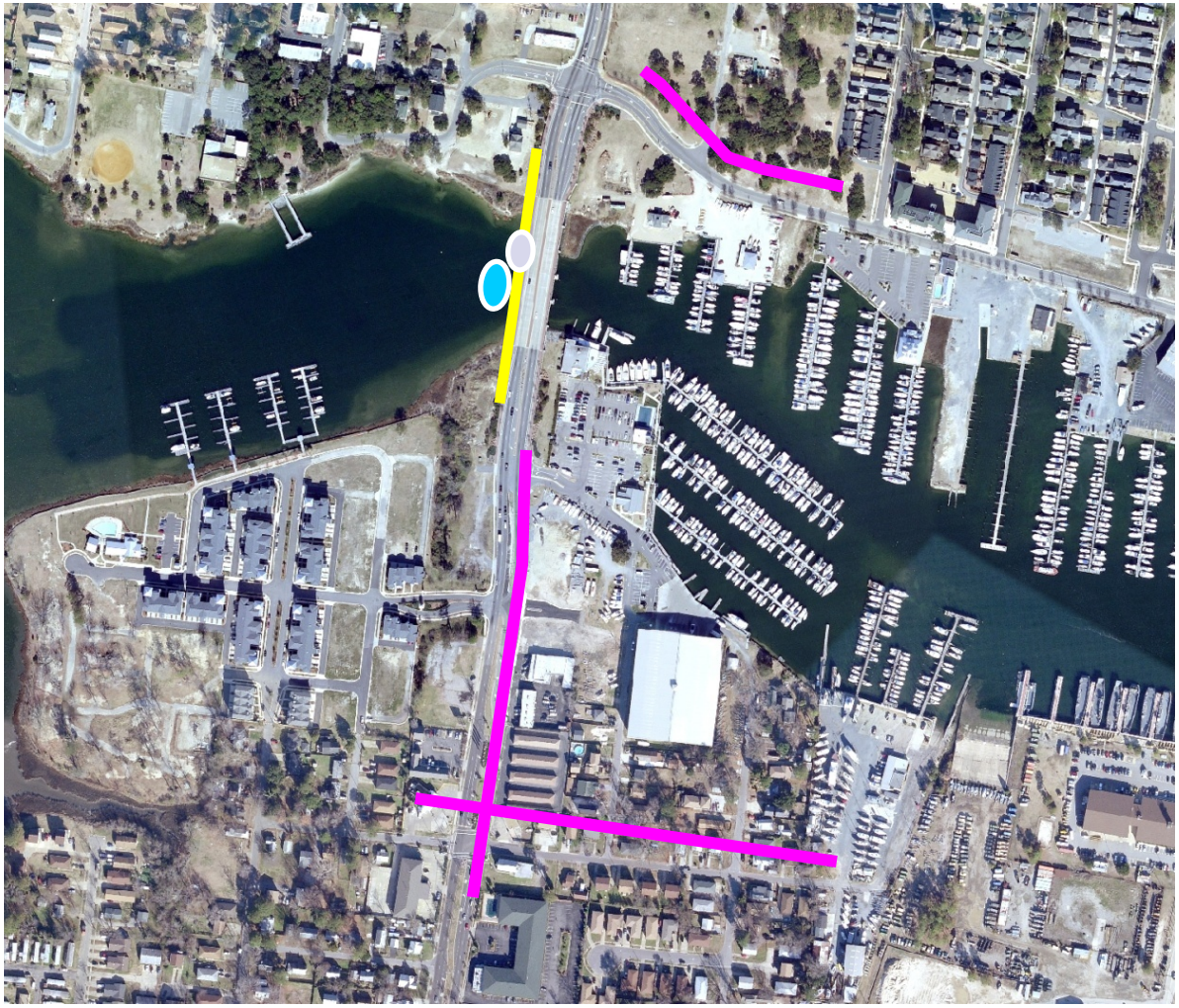




Pretty Lake – Project Elements

Capital Project intended to protect against both coastal flooding (tidal surge) and rainfall runoff will require:

- Tidal Barrier (floodwall) structure to protect against inundation from tidal surge
- With tide gate to preserve navigation access required
  - Tide gate needs foundation
- Pump station to remove rainfall runoff when gate closed
- Raise roads where land surface is low around basin/watershed perimeter



Precipitation Study Evaluation

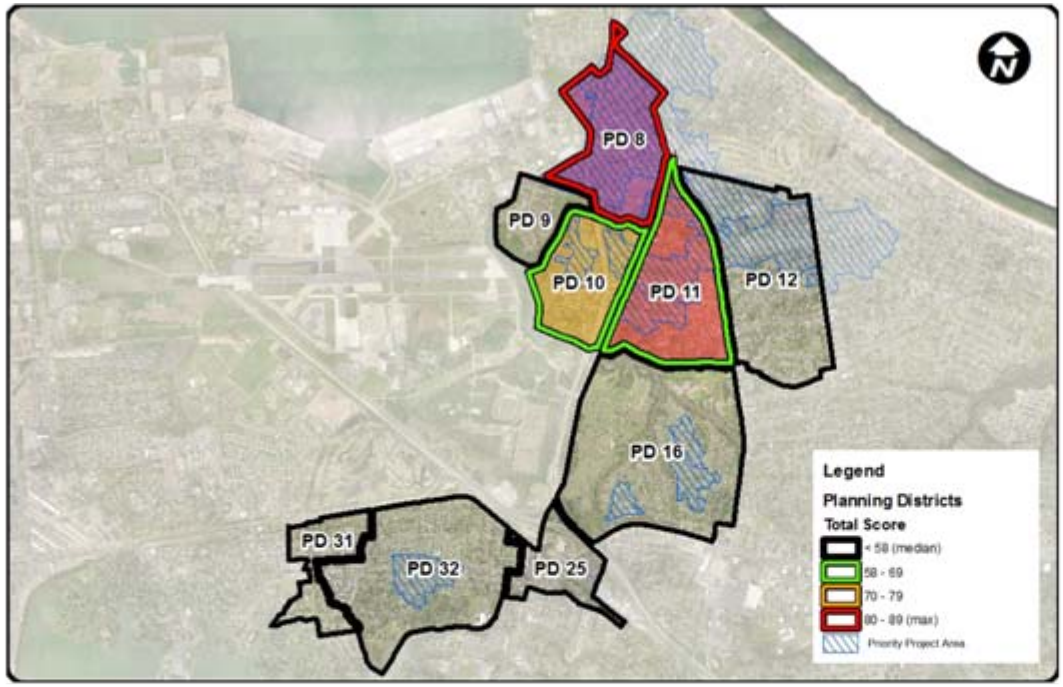
1. Utilize existing resources
   - GIS data
     - Readily available
     - Easily developable
   - Previous study results
   - Actual construction costs
2. Prioritize drainage areas (DAs) based on criteria
3. Develop planning district cost projections based on DA severity
4. Identify priority projects

Precipitation Study Analysis

Scoring system

- Technical criteria
  - Identified Problem Areas
  - CIP Project Locations
  - Existing Infrastructure Capacity
  - Designed to Convey a 10yr Storm
  - Infrastructure Condition
- Other criteria (Social & Economic)
  - Road Classification
  - Critical Infrastructure
  - Presence of Business Development Focus Areas

Precipitation Study Summary



WS #2 Mason Creek Watershed

Watershed Description:

The Mason Creek Watershed is located in the northern portion of the City of Norfolk. It drains by way of Oastes and Mason Creeks, north to the Chesapeake Bay. The watershed is mostly made up of residential neighborhoods and also includes golf courses, parks, and the Forest Lawn Cemetery.

The map to the left depicts a total of nine planning districts that are located within the general watershed area.

Planning District Prioritization Criteria

Planning District Number	Flooding/Maint. Complaints	CIP Project Locations	Minimal System Capacity	Not Designed for 10yr Storm	Poor/Old Infrastructure	Evacuation Routes	Critical Infrastructure	Business Development Areas	Planning District Score	
8	vv	vvv	v	vvv	vvv	vvv	v	vvv	87	1st Ranked
11	vv	v	vvv	vvv	v	vv	v	vvv	68	2nd Ranked
10	vv	v	vvv	vvv	v	v		v	67	3rd Ranked
16	vv	v	vvv	vvv	v	v		v	55	
32	vv	v	vv	vvv	vv	v		v	54	
25	vv	vv	v	vvv	vv	v		v	54	
12	v	vv	vv	vvv	v	v	v	vv	51	
9				vv	v				40	
31	v	v	v	vvv	v	v		v	38	

Estimated Planning District Improvement Costs and Priority Areas

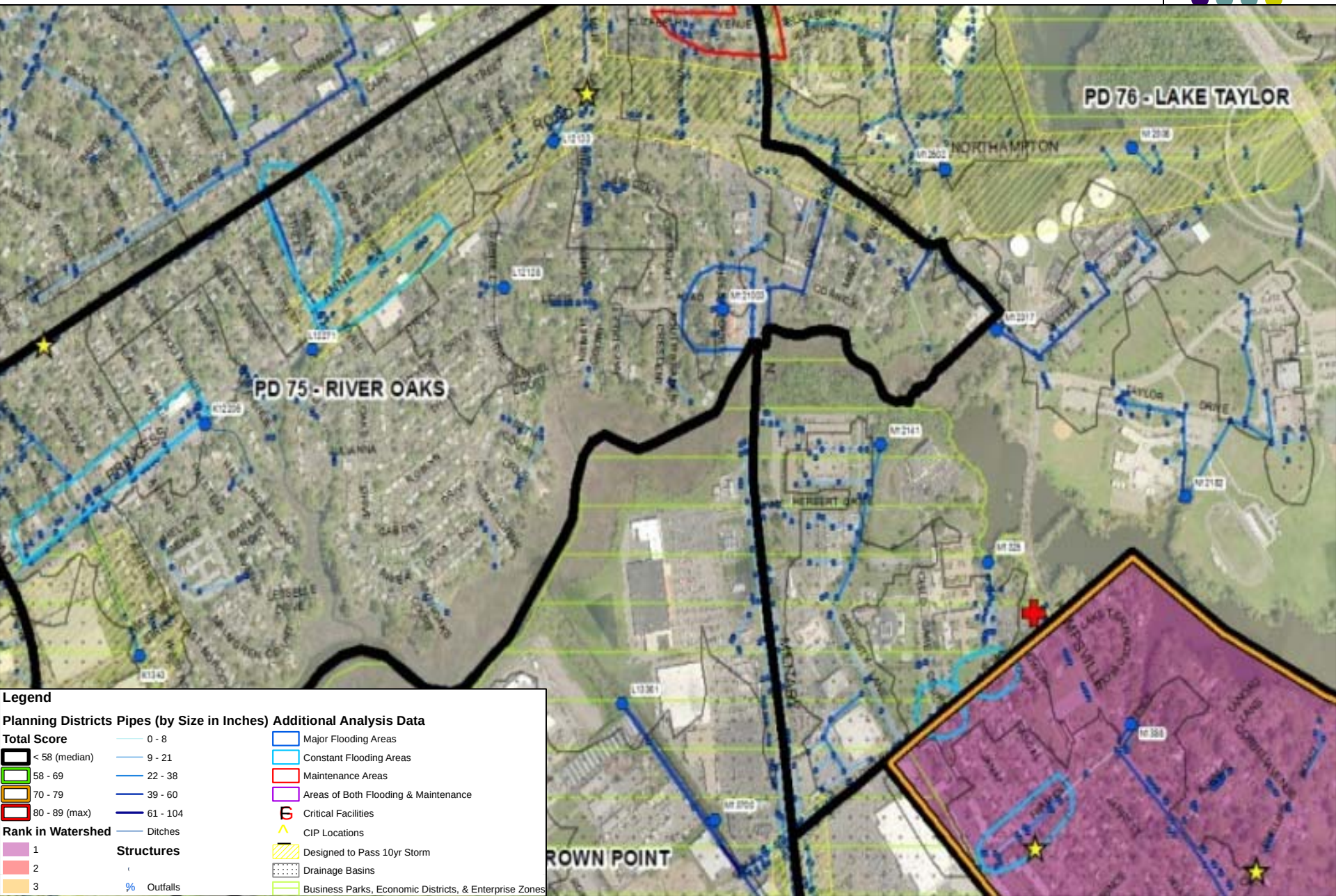
Planning District			Drainage Improvement Cost ($ in thousands)					Additional Element Cost ($ in thousands)	Priority Project Area (Est. Cost $ in thousands)
Number	Name	Land Area (ac)	Public	Private	State	Federal	Total Cost		
8	Pamlico	247	$11,785	--	--	$42	$11,827	$3,160 - $5,457	Granby St (Bayview Blvd & Bay Av)* ($403)
11	Northside	261	$7,324	--	--	--	$7,324	$1,818 - $2,867	Granby St (Bayview Blvd & Bay Av)* ($403)
10	Commodore Park	151	$2,953	--	--	--	$2,953	$774 - $1,306	Granby St (Bayview Blvd & Bay Av)* ($403)
16	Oakdale Farms	492	$4,001	--	--	--	$4,001	$1,041 - $1,743	Burksdale Rd/Dixie Dr/Diggs Rd ($553)
32	Sussex	357	$3,536	--	--	--	$3,536	$964 - $1,701	Restmere Rd/W Littl Creek Rd ($144)
25	Wards Corner	114	$1,522	--	--	--	$1,522	$399 - $673	
12	Oceanair	360	$3,060	$78	--	--	$3,138	$863 - $1,539	Tidwater Dr/Old Oceanview Rd ($160)
9	Merrimac Park	79	$420	$378	--	$37	$835	$231 - $414	
31	Titustown	110	$1,082	--	--	--	$1,082	$311 - $580	

* Priority project area crosses planning district (PD) boundaries

Total Estimated Watershed Improvement Costs (including Additional Elements)

Total Cost: $55,494,000

Precipitation Infrastructure Analysis



Precipitation Prioritization

Scoring System Criteria

- Impact on residences and businesses
- Identified problem areas
- Impact on access to critical facilities and infrastructure
- Condition and capacity of existing system
- Relative cost/affordability
- Opportunities with other projects and development
- Design to 10-yr storm capacity

Norfolk's Actions To Date

- Created Environmental Stormwater Fund for Water Quality & Water Quantity Improvements
- Implemented Numerous Stormwater Systems Upgrades
- Improved Planning & Design of New Projects
- Installed Tide Gauges Across the City to Determine Differential Tide Levels
- Programmatic Assessment of Watersheds City-wide
  - What options work
  - Prioritizing efforts across watersheds
- Established Regional Partnerships to Expand Outreach
- Engaged Citizens in the Flooding Conversation
- Completed Coastal Flood Study with Fugro Atlantic
- Completed City-wide Precipitation Flood Study with Timmons

Norfolk's Actions (cont'd)

- Developing a strategic plan for the entire City that will guide the application of resources city-wide to address storm water and flooding
- Met with Congressmen Bobby Scott and Scott Rigell and their staff to discuss the City's flooding issues and the federal government's role
- Conducted tour of coastal flood prone areas of the City for the U.S. Army Corps of Engineers, District, Division and Headquarters officials
- Work with the City's delegation to have the State Legislature begin studying and addressing this issue
- Attempting to reallocate existing funds to begin work on some immediate projects at the federal level

Summary

- The City is developing comprehensive strategy to address precipitation and tidal flooding.

- The City continues to establish enhanced communication and collaboration efforts to increase awareness about our flood prone areas.

- The City has identified specific mitigation projects that will require significant public investment and intergovernmental coordination.

Questions?

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