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Water Infrastructure Resiliency Planning for the City of Norfolk

Chris Harbin

Water Infrastructure Resiliency Planning for the City of Norfolk

Chris Harbin, Water Production Manager,
Department of Utilities

THE CITY OF NORFOLK
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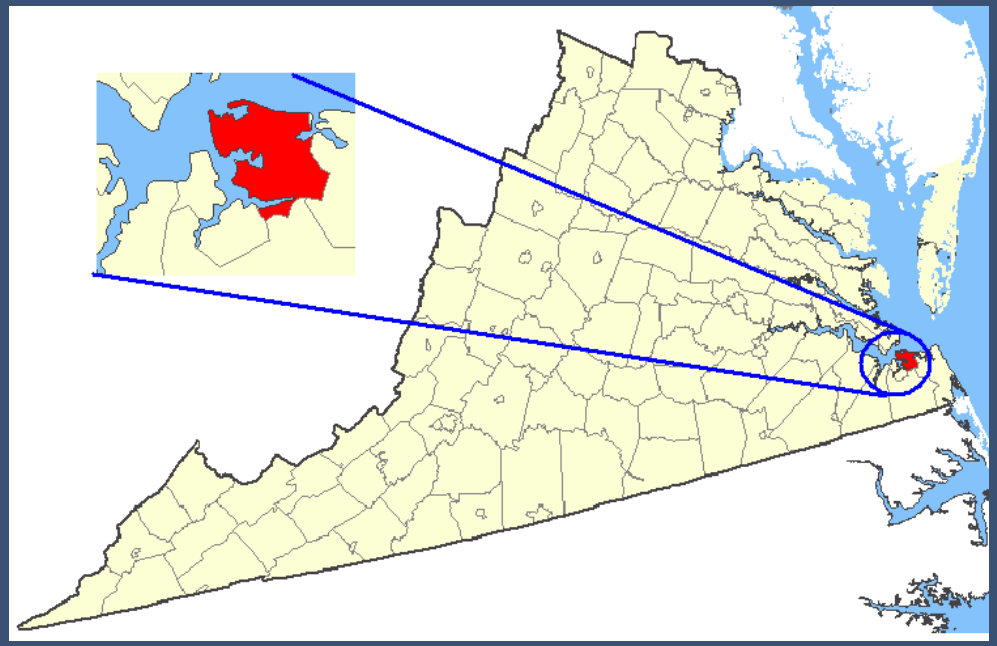
Agenda

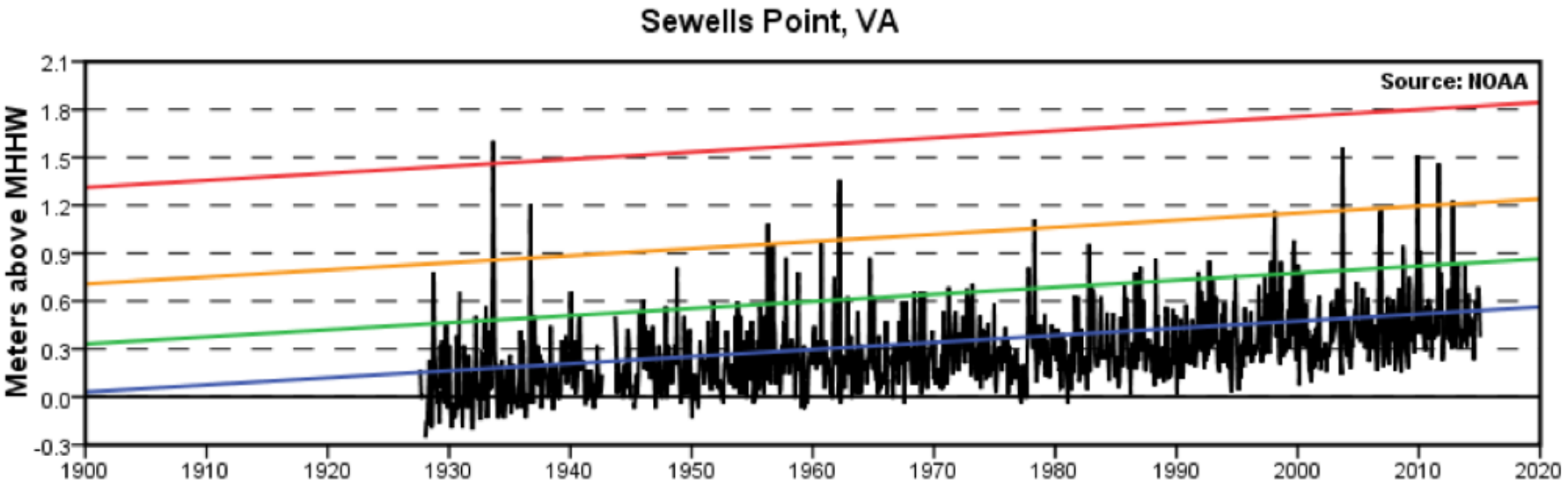
1. City of Norfolk Resiliency Efforts
2. Norfolk's Water System
3. Resilience of Norfolk's Water System
4. Next Steps
5. Conclusions

City of Norfolk Resiliency Efforts



Current Challenge

- 90% developed area
- 12 feet above MSL



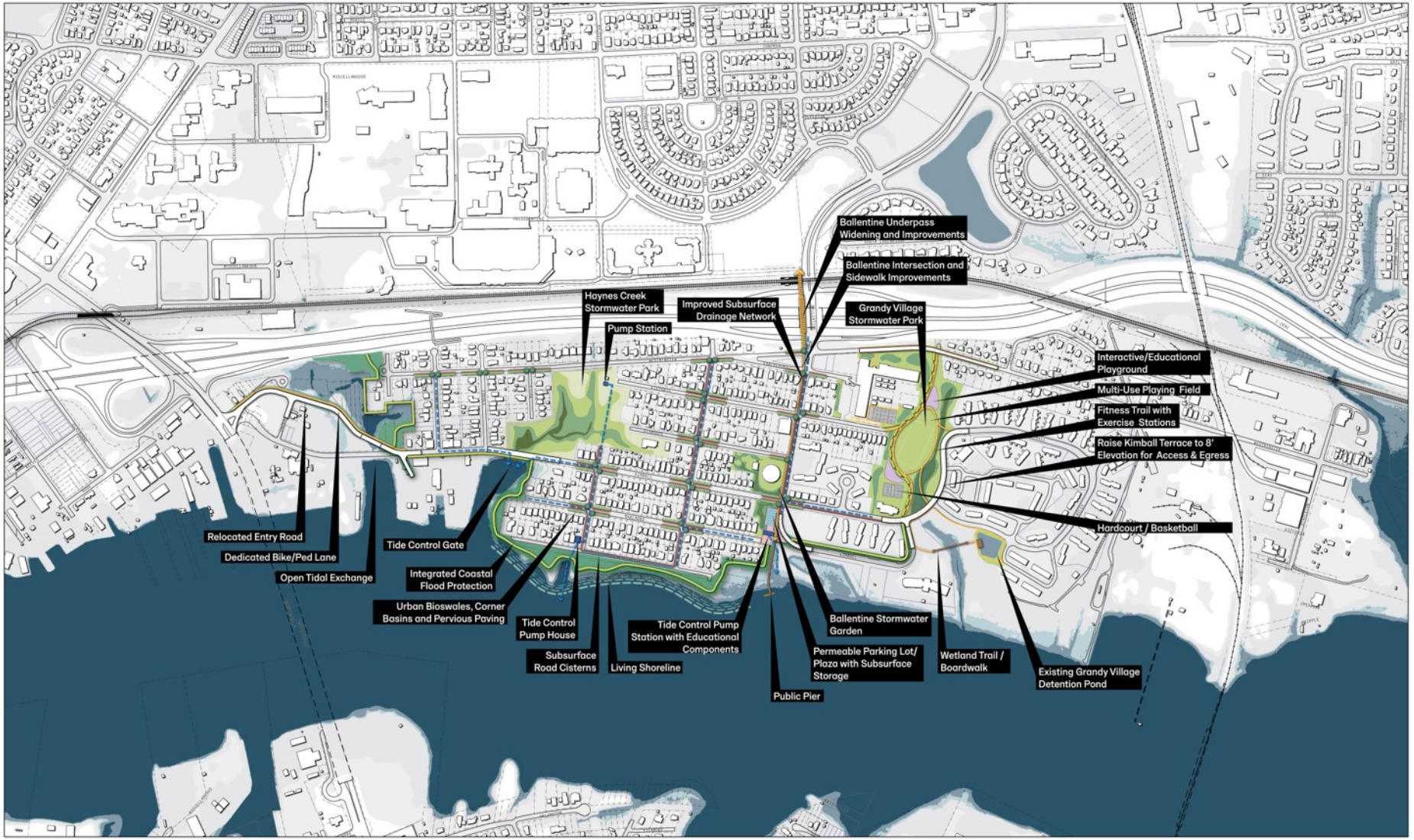
Highest Relative SLR on East Coast

Approx. SLR = 14 inches since 1930

Resiliency Efforts

- 2015 Dutch Dialogues
- 100 Resilient Cities (Rockefeller Foundation)
  - Resilience Strategy
  - Vision 2100
- Flood Risk Study (with USACOE)
- Ohio Creek Project
- **Water Infrastructure Resiliency Planning**

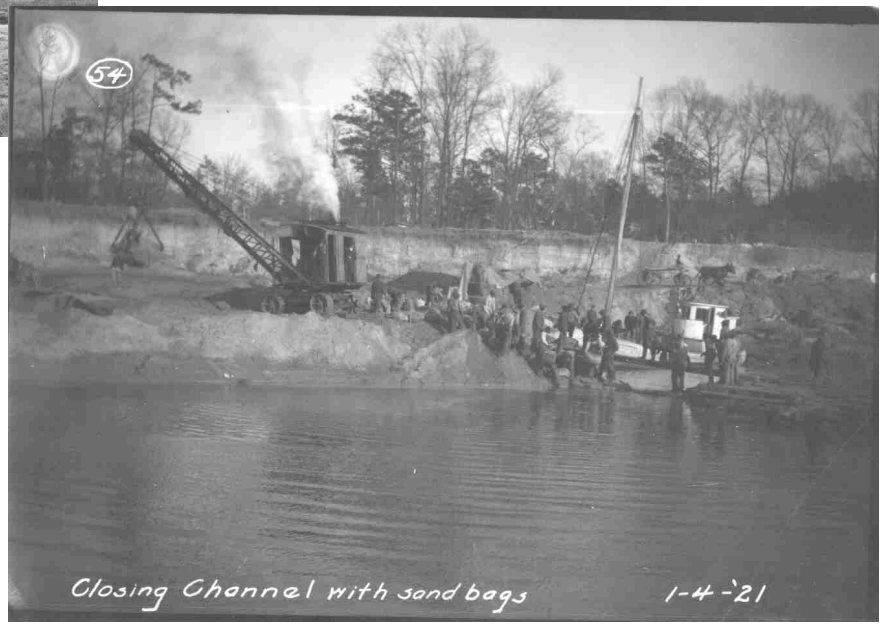
Ohio Creek Conceptual Design



Norfolk's Water System

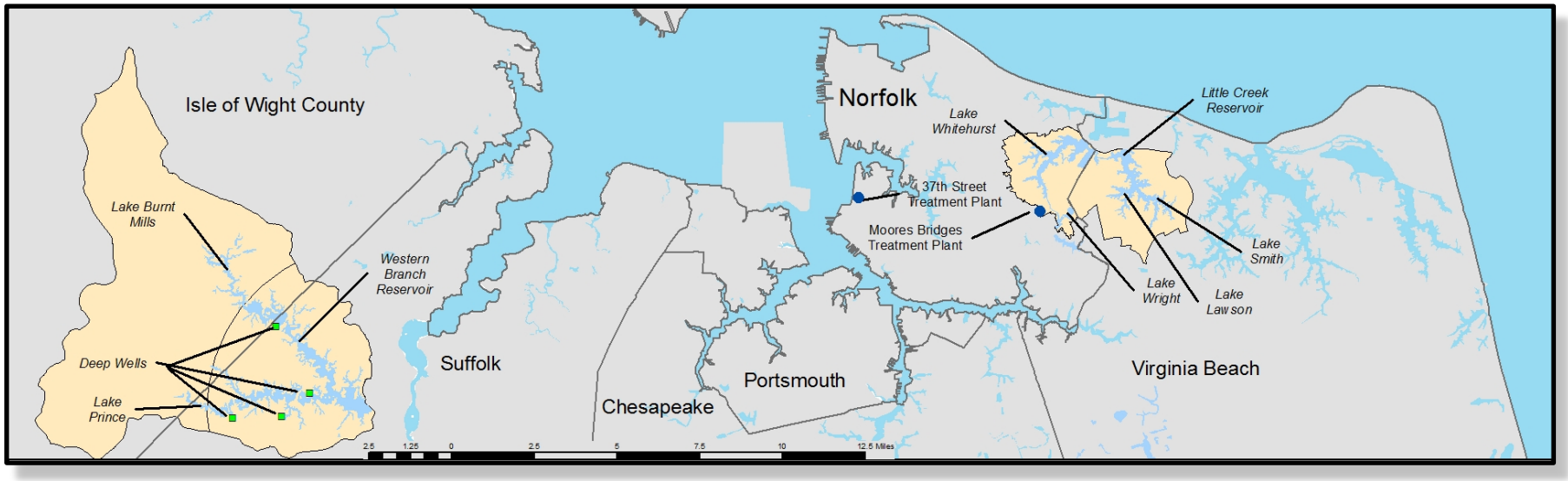
Norfolk's Water System – the Early Days

Moores Bridges mid-1870s



Lake Prince construction

Norfolk's Water System Today



- Norfolk's raw water sources are located throughout southeast Virginia
  - 5 Reservoirs in Norfolk and Virginia Beach
  - 3 Reservoirs in Suffolk and Isle of Wight
  - 2 River Sources on Nottoway and Blackwater Rivers
  - 4 Deep Wells in Suffolk
- Norfolk operates two water treatment plants: 37th Street and Moores Bridges with a combined capacity of 136 MGD

Resilience of Norfolk's Water System

How Can We Improve Resilience of Norfolk's Water System?

For over 140 years, the City of Norfolk has consistently treated and delivered drinking water to our customers.

Recent events with widespread flooding:

- 2009: Tropical Depression Ida and a Nor'easter
- 2011: Hurricane Irene
- 2012: Hurricane Sandy
- 2016: Hurricane Matthew

Flood and Wind Vulnerability Assessment and Hazard Mitigation Plan

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Evaluate vulnerabilities to the City's water production infrastructure and develop adaptation measures to improve resiliency

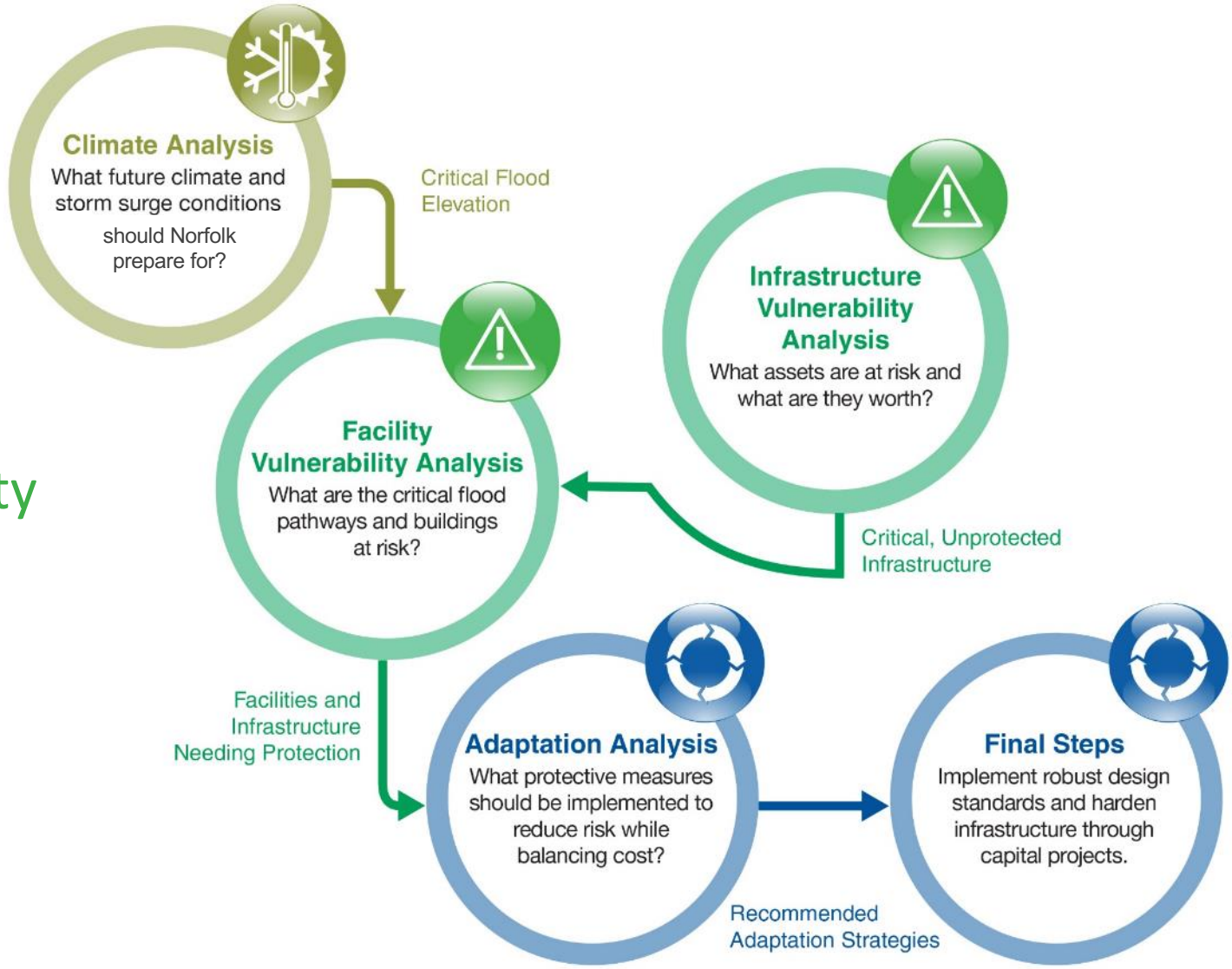
- Moores Bridges Water Treatment Plant
- 37th Street Water Treatment Plant

Risk Based Evaluation

Phase 1
Climate Analysis

Phase 2
Vulnerability Analysis

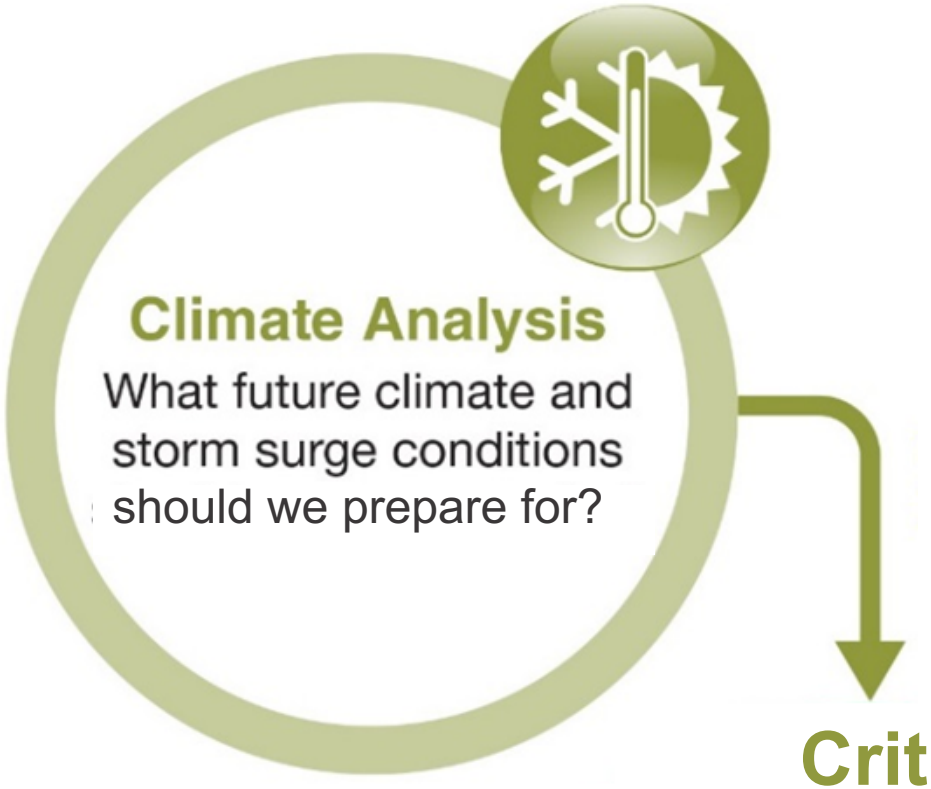
Phase 3
Adaptation Analysis



Benefits of Risk Management Approach

- Provides transparent, accountable and defensible business case for resiliency implementation
- Quantifies potential risks and impacts
- Facilitates analyses of tradeoffs
- Streamlines evaluation of multiple alternatives

Phase 1: Climate Analysis

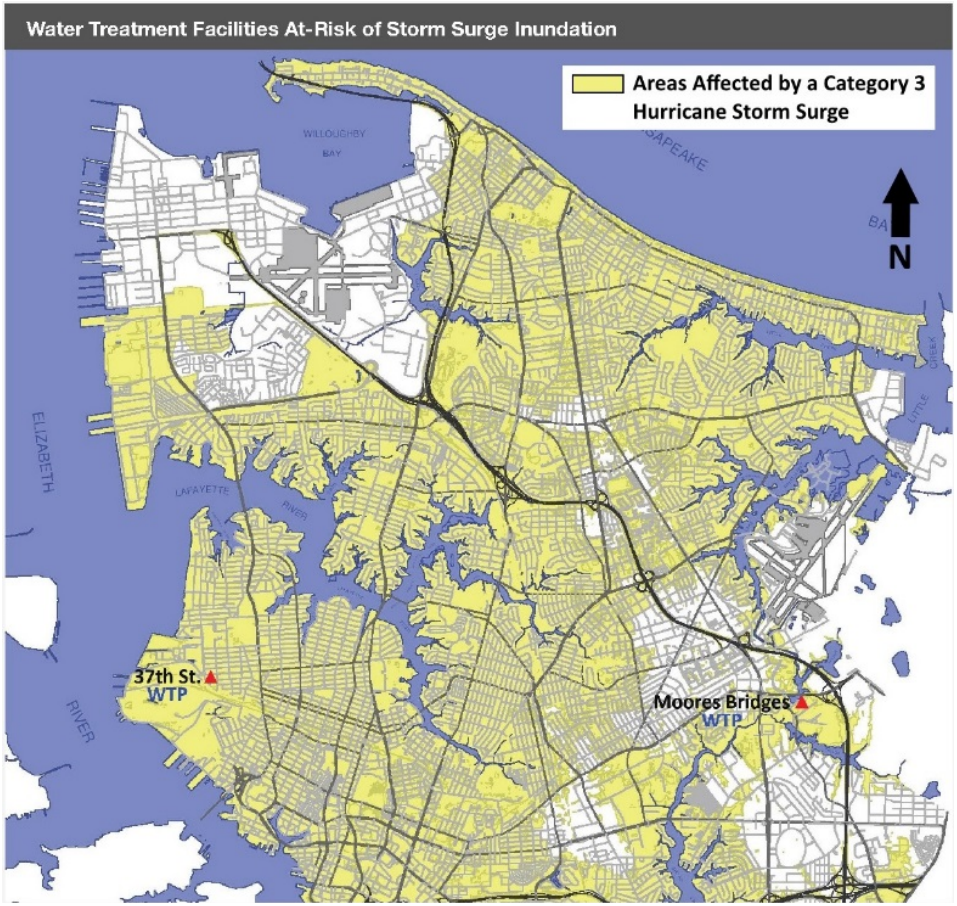


Critical Flood Elevation

- Established to evaluate what is at risk
- The elevation to which assets must be protected may vary depending on funding agency requirements

Storm Levels Considered

- 100 Year Storm Recurrence: **El 7.6 ft**
- City of Norfolk Building Code Ordinance: **El 10.6 ft**
- Hurricane Storm Surge – Category 3: **El 13.7 ft**



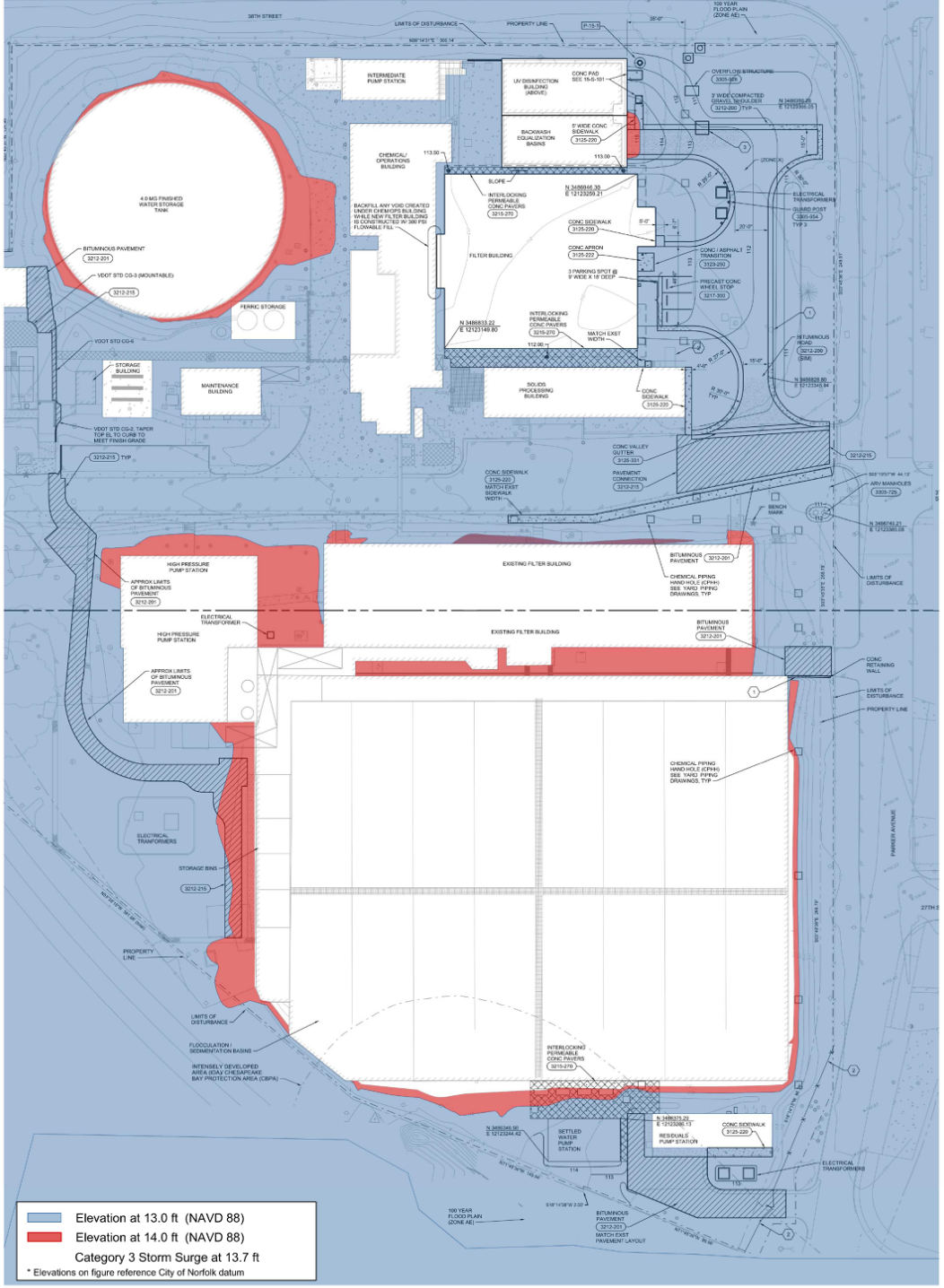
Moores Bridges WTP

City of Norfolk
Department of Utilities

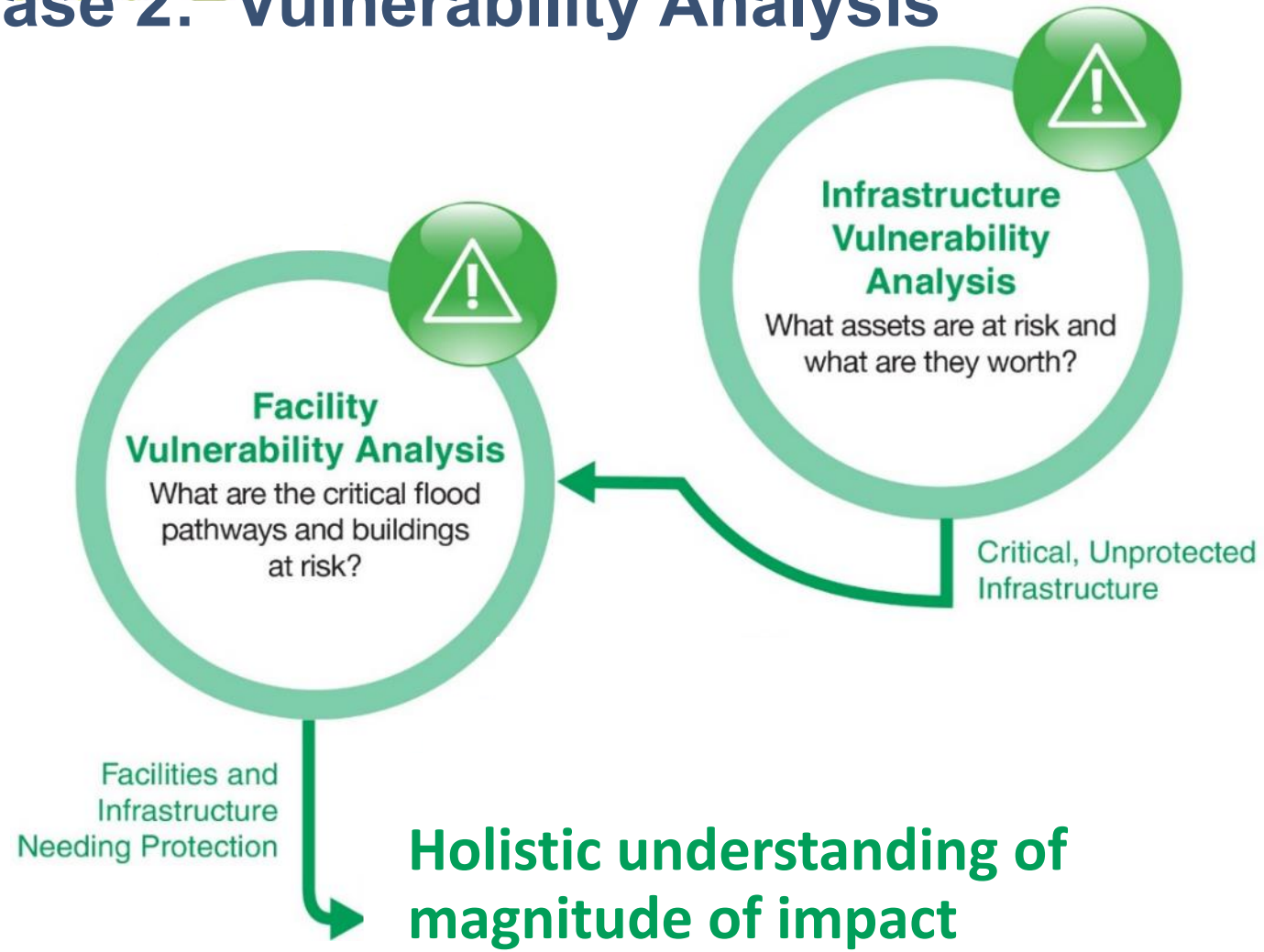
MOORES BRIDGES WTP
FLOOD POTENTIAL MAP

Hazen

37th Street WTP



Phase 2: Vulnerability Analysis



Holistic understanding of magnitude of impact

- Field Survey, Facility Database, Asset Database, and Storm Surge Placards

Investigate Flood Pathways and Establish Threshold Flood Elevations

Rollup Doors

Doorways & Windows

Areaways

Tunnels

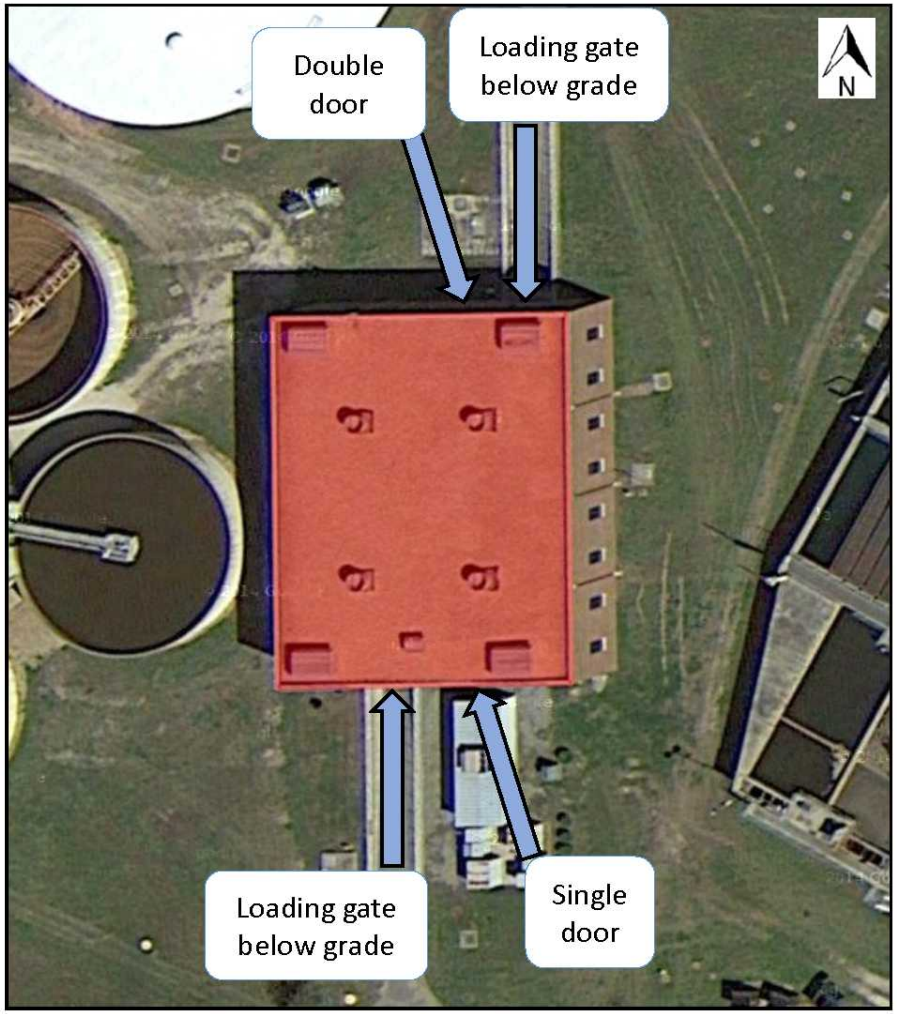
Grates

Electrical Conduits and Manholes

Other flood pathways: open process tanks, outfalls, storm drains and plant drains, wet wells, and interconnected buildings.

Facility Analysis – Flood Pathway Assessment

High Pressure Pump Station



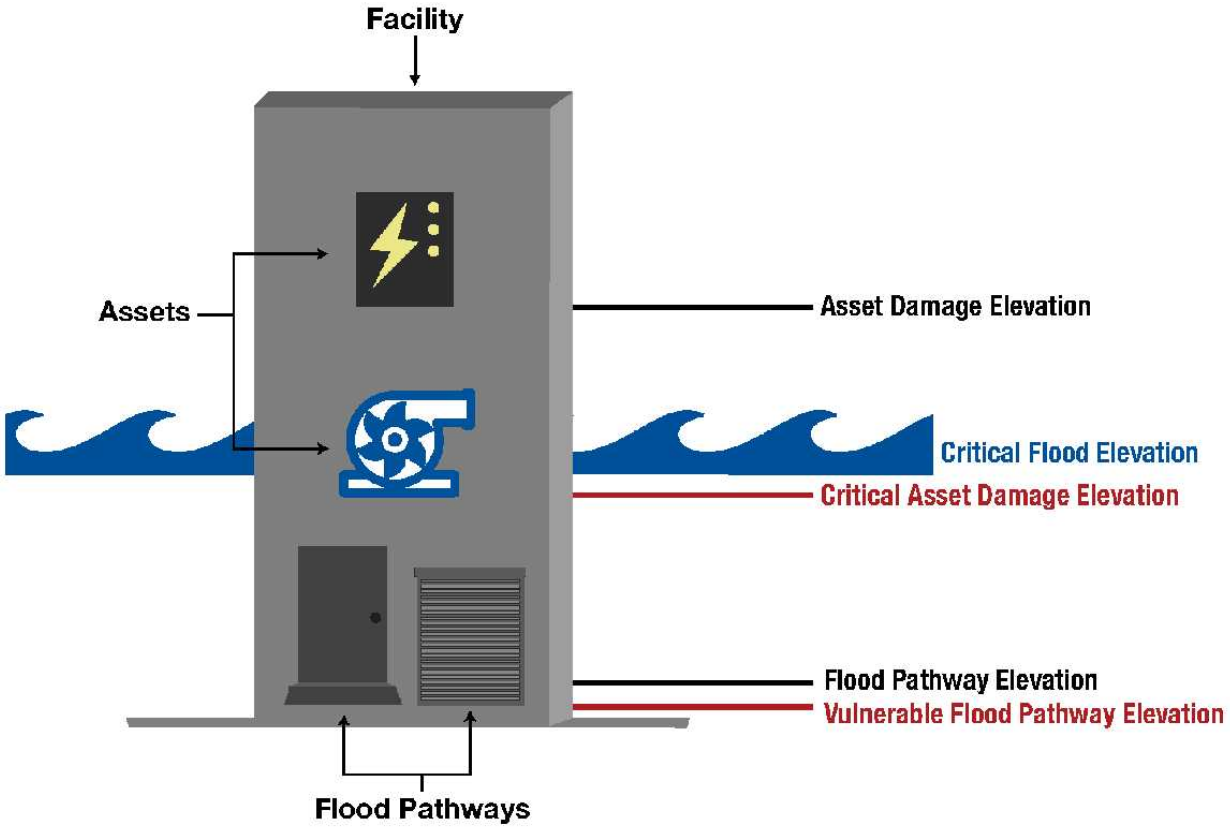
Flood Pathway Key:

Non-Vulnerable

Vulnerable

Critical Flood Elevation

Figure 3.5: Different Elevations of a Facility Analysis



Facility Analysis – Field Survey

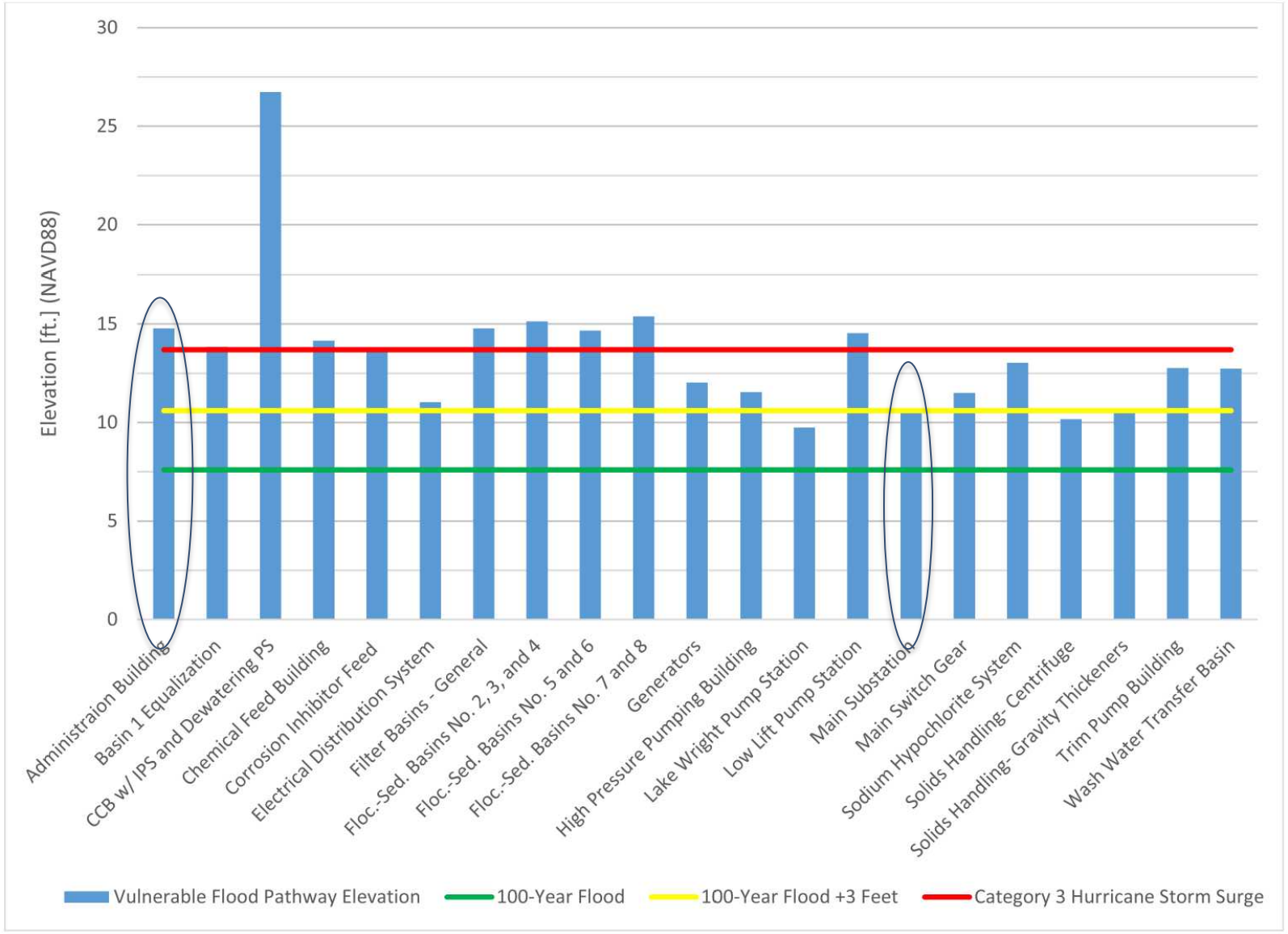
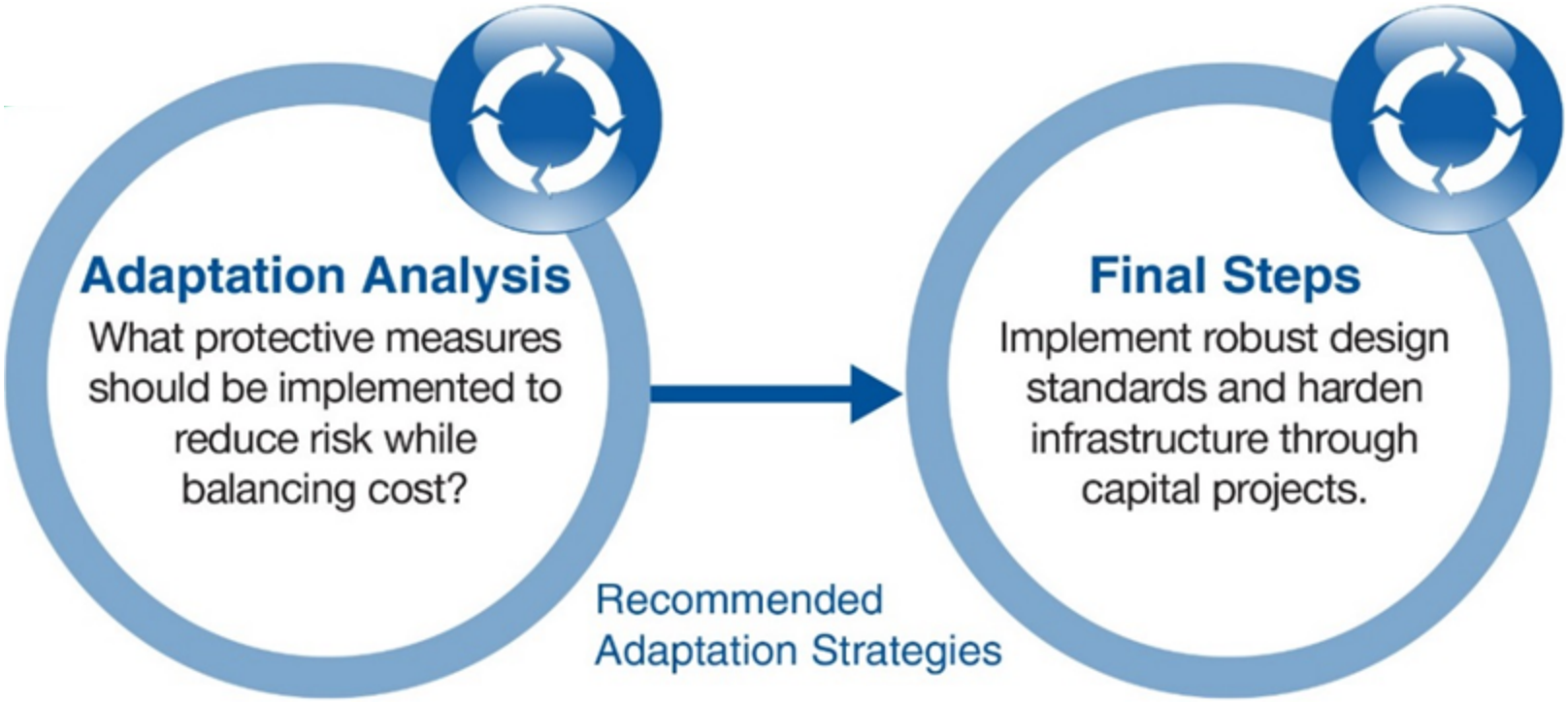


Figure 3.2: Flood Pathway Elevations for Moores Bridges WTP Facilities

Phase 3: Adaptation Analysis



- Prioritize processes/assets for adaptation
- Discuss stakeholder objectives
- Evaluate alternative adaptation strategies, including feasibility, costs and levels of protection provided

Asset Criticality Assessment

Must be Protected

Cost-Benefit Driven Decision

High Criticality

Impact conveyance, disinfection, or power generation

E.g.: Influent Motors, Effluent Pumps, Emergency Generators, Main Plant Feed and Transformers, Chlorination or UV Equipment

Moderate Criticality

Reduce level of service

E.g.: Collectors for Settling Tanks, Sludge Pumps, Aeration Blowers

Low Criticality

Minor or no impact to process

E.g.: Odor Control Blowers and Scrubbers, Maintenance Equipment

Table PO-2: Moores Bridges WTP Vulnerable Facilities Summary

Facility	Vulnerable FPE (NAVD 88)	Critical ADE (NAVD 88)	Vulnerable Assets(s)	Criticality Rating
Electrical Distribution System	11.04'	12.04'	Electrical Distribution System	5
Generators	12.03'	12.03'	Electrical Equipment	5
High Pressure Pumping Building	11.54'	10.04'	High Pressure Pumps	5
Lake Wright Pump Station	9.74'	9.74'	Pumps	5
Main Plant Substation	10.53'	10.53'	Electrical Equipment	5
Main Plant Switchgear	11.50'	11.50'	Electrical Equipment	5
Sodium Hypochlorite	13.04'	13.04'	Motor Control Center	5
Solids Handling - Centrifuge	10.17'	10.87'	Polymer Feed Pumps	3
Solids Handling - Gravity Thickening	10.50'	11.33'	Transfer Pumps	4
Trim Pump Building	12.77'	13.02'	Variable Frequency Drive	5
Wash Water Transfer Basin	12.74'	14.24'	Pump	3

Asset Level Adaptation Strategies

Individual Asset

Multiple Assets

Elevate Equipment

Flood Proof Equipment

Install Static Barrier

Provide Emergency Generator

Seal Building

Sandbag

Resiliency/Effectiveness

Low — High

Low — High

Low — High

Does not protect equipment but facilitates rapid service recovery.

Low — High

Low — High

Cost

$

$

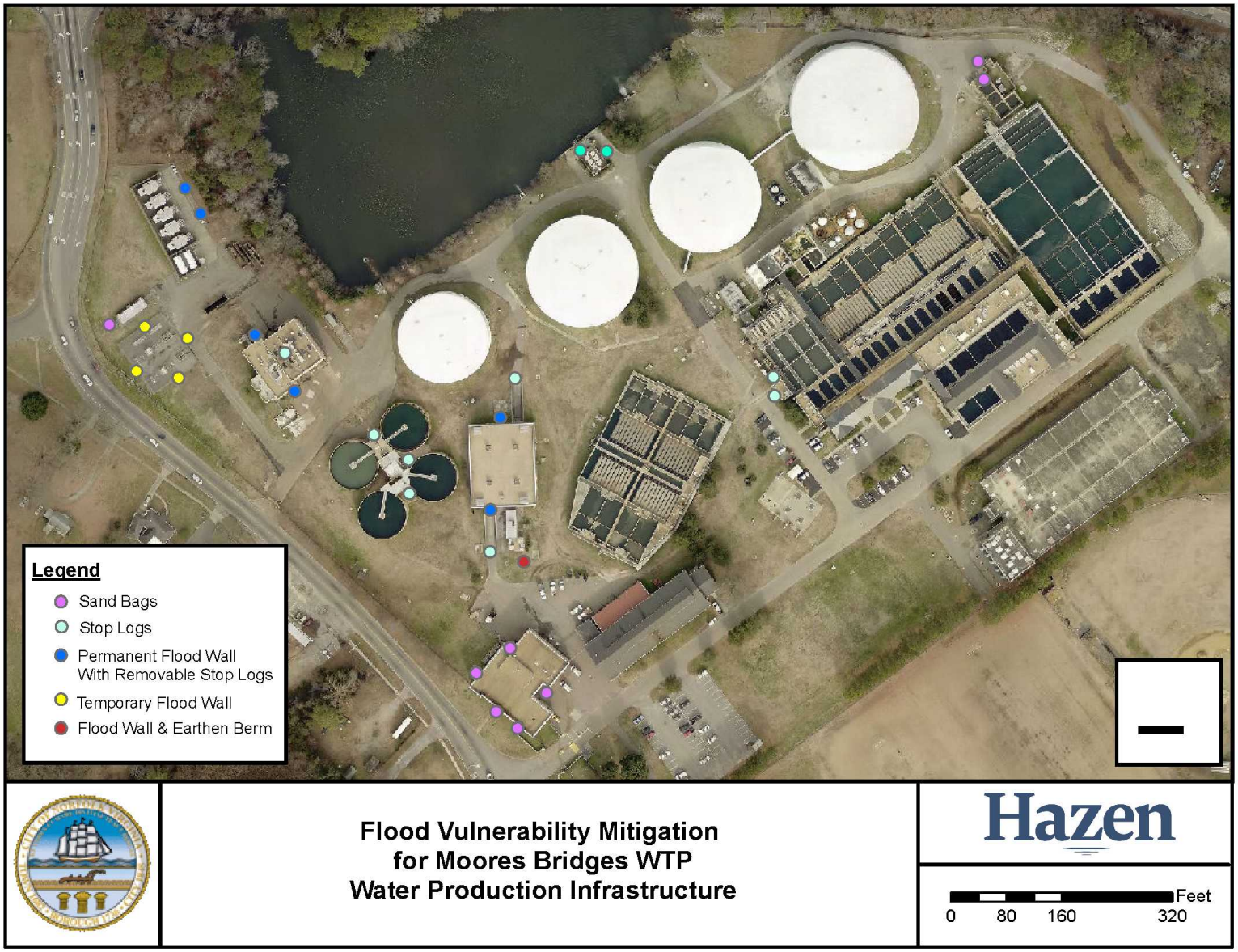
$

$

$

$

Adaptation Recommendations



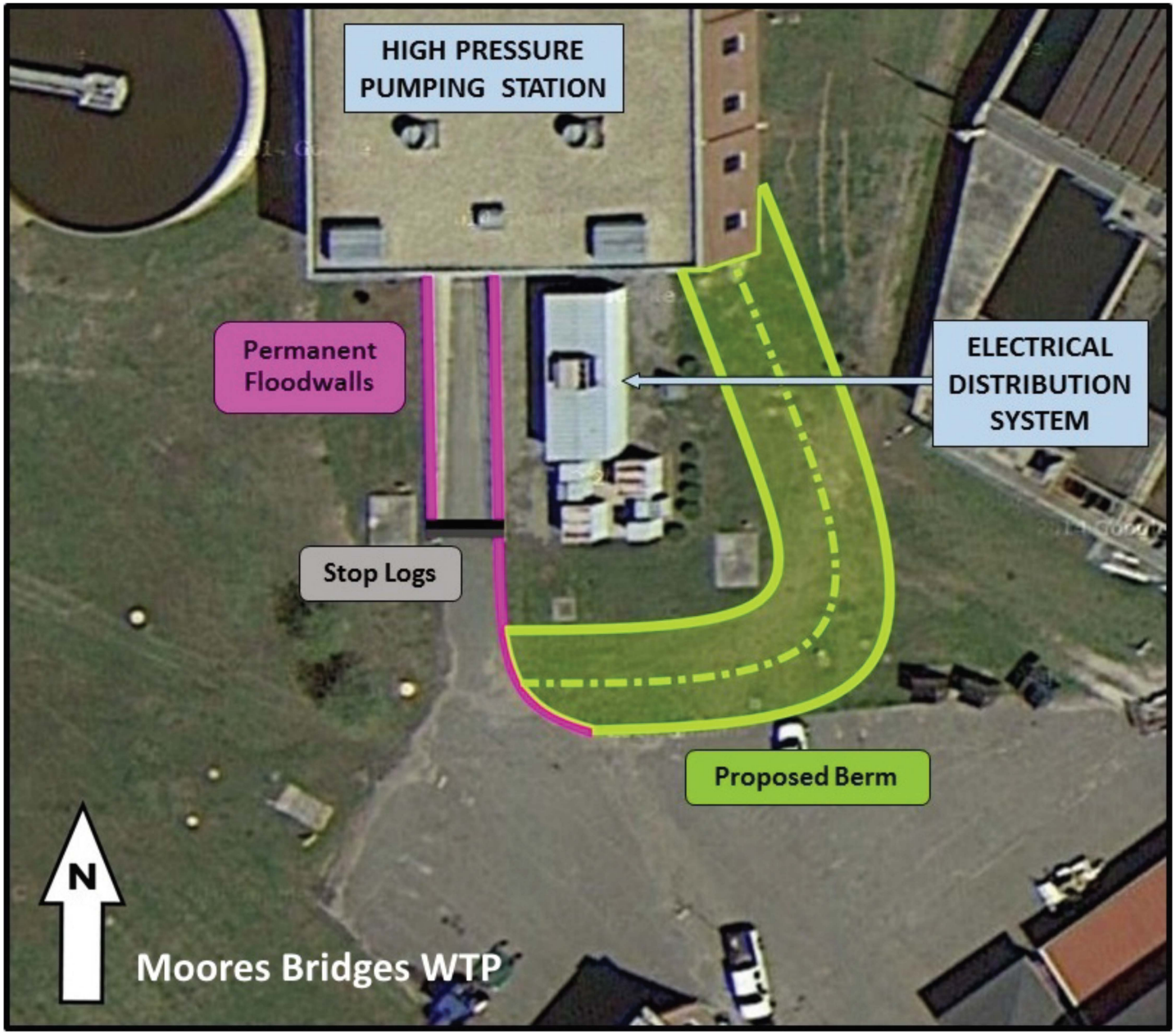
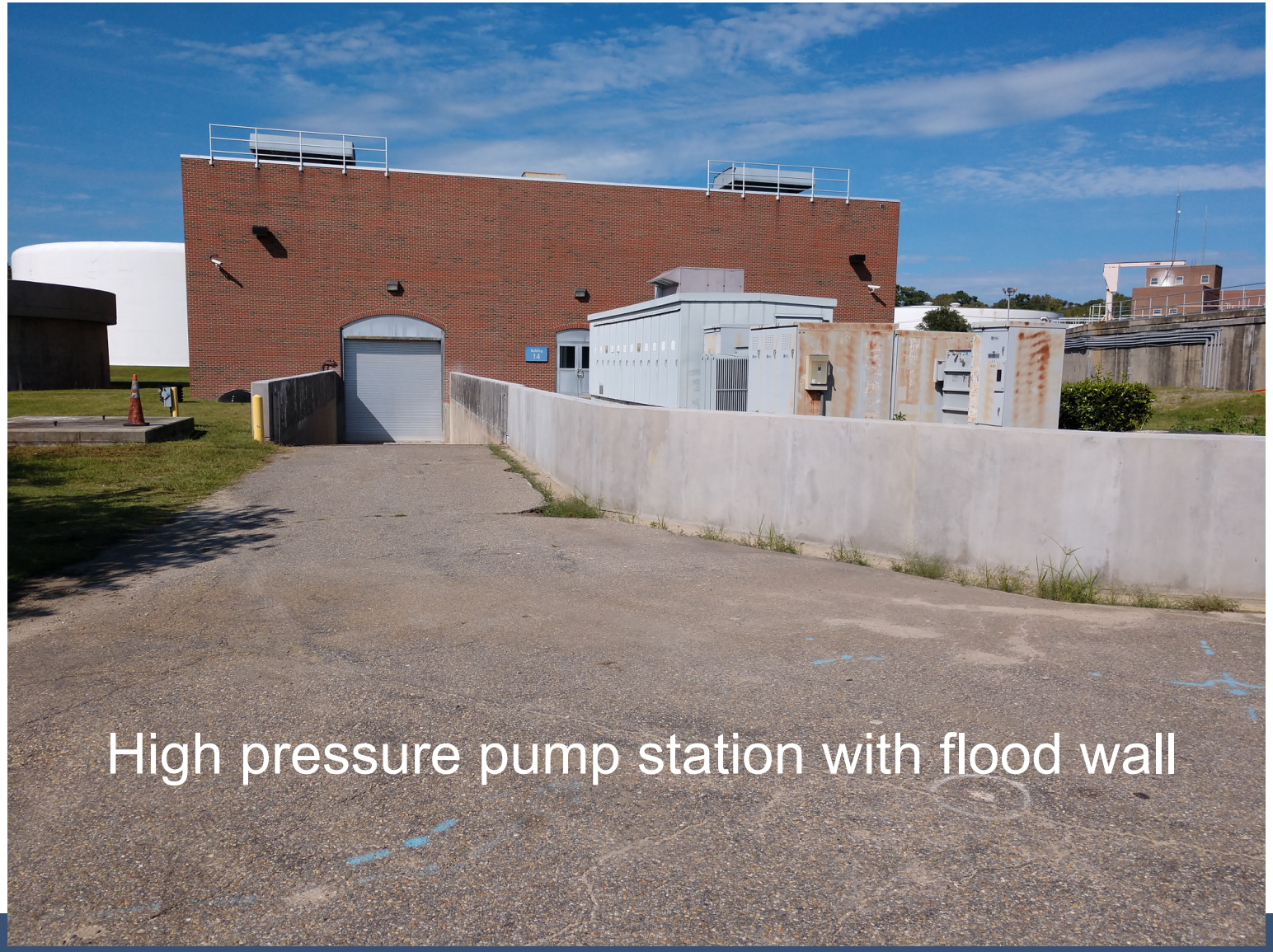

HIGH PRESSURE PUMPING STATION
Permanent Floodwalls
ELECTRICAL DISTRIBUTION SYSTEM
Stop Logs
Proposed Berm
N
Moores Bridges WTP

Table 4.2: Moores Bridges WTP Individual Facility Mitigation Cost Comparison

Facility	Mitigation Alternative	Mitigation Strategy Cost
Electrical Distribution System	Berm with flood wall	$158,000
Generators	Temporary flood barrier	$20,000
High Pressure Pump Station	Permanent flood barrier with removable stop logs	$53,000
Lake Wright Pump Station	Permanent flood barriers with removable stop log sections. Seal old entrance.	$12,000
Main Plant Substation	Temporary flood barrier	$50,000
Main Plant Switchgear	Flood stop plate at one door, permanent flood barrier with stop logs on other door	$27,000
Sodium Hypochlorite Building	Sand Bag at doors below flood elevation	$1,000
Solids Handling - Centrifuge Building	Flood stop plates and permanent flood barriers with removable stop log sections	$16,000
Solids Handling - Gravity Thickening	Flood stop plates and permanent flood barriers with removable stop log sections	$13,000
Trim Pump Building	Flood stop plates and permanent flood barriers with removable stop log sections	$16,000
Wash Water Transfer Basin	Concrete improvements to raise curb around grates	$5,000

Implementation



High pressure pump station with flood wall

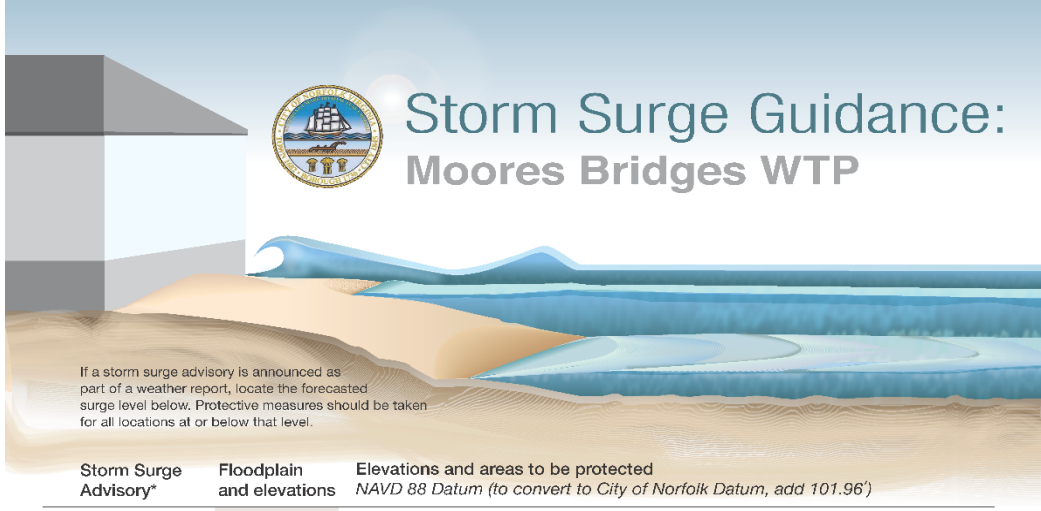
Implementation

Overall cost of implementation of protective measures at Moores Bridges: $520K

Storm Surge Placards

Emergency Preparedness:

These charts allow plant staff to quickly determine vulnerability to flood from approaching storms and begin implementing temporary adaptation strategies, such as sandbags.



Storm Surge Guidance:
Moores Bridges WTP

If a storm surge advisory is announced as part of a weather report, locate the forecasted surge level below. Protective measures should be taken for all locations at or below that level.

Storm Surge Advisory*	Floodplain and elevations	Elevations and areas to be protected *NAVD 88 Datum (to convert to City of Norfolk Datum, add 101.96')*
16′		17.0′
15′		16.0′
14′		15.0′ — Flocculation–Sedimentation Basins #5 and 6, Front Office, Filter Basins–General, Flocculation–Sedimentation Basins #2, 3, 4, 7, and 8
13′		14.5′ — Low Lift Pump Station
	Cat 3 Hurricane 13.7′	14.0′ — Corrosion Inhibitor Feed, Basin 1 Equalization, Chemical Feed Building
12′		13.5′
		13.0′ — Water Transfer Basin, Trim Pump Building, Sodium Hypochlorite System
11′		12.0′ — Generators
10′		11.5′ — Main Plant Switchgear, High Pressure Pumping Building, Storage Building
	100 yr. + 3′ 10.6′	11.0′ — Main Distribution Switchgear
9′		10.5′ — Solids Handling–Gravity Thickeners
		10.0′ — Lake Wright Pump Station, Solids Handling–Centrifuge
8′		9.0′
7′		8.0′
	100 yr. 7.6′	
6′		7.0′

*Storm surge added to Mean Higher High Water at City of Norfolk, which is 1.12 ft (NAVD 88 Datum).

HAZEN AND SAWYER
Environmental Engineers & Scientists

Next Steps

New Moores Bridges WTP Emergency Entrance

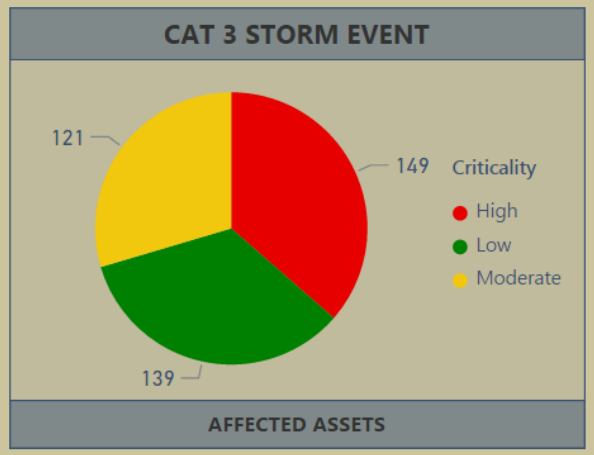
Integrating Asset Management and Resiliency Planning

- An Asset Management Plan was completed for Moores Bridges in 2017
- Asset Management and Resiliency Planning include similar evaluations of the same assets
- Combining AM and Resiliency together reduces redundancy and improves capital planning
- **City of Norfolk will incorporate Resiliency Planning into Asset Management Program for City sewer and water infrastructure**

Resiliency Planning Dashboard

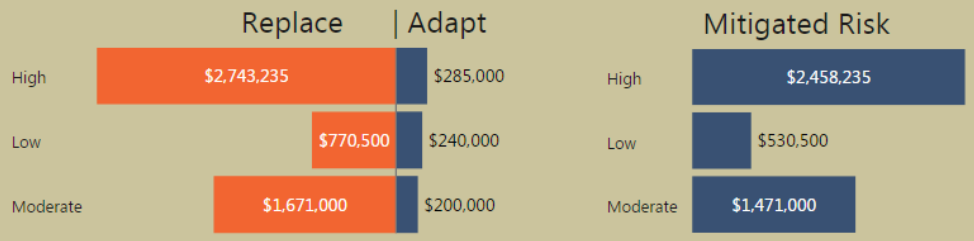
Flood Event	Critical Flood Elevation (ft)
☐ 100 Year	7.60
☐ 500 Year	8.50
☐ Category 1 Storm	10.40
☐ Category 2 Storm	12.10
■ Category 3 Storm	13.70

Critical Flood Elevation is based on:
Base Flood Elevation + 2' Sea Level Rise (SLR) + 1' Freeboard + 0.25' Subsidence



Facility	Replacement Cost	Adaptation Cost	Mitigated Risk
Dewatering Building	$314,835	$75,000	$239,835
Emergency Electrical	$2,000,000	$150,000	$1,850,000
Pumping Station	$2,405,000	$400,000	$2,005,000
Thickening System	$464,900	$100,000	$364,900

Total Replacement Cost	Total Mitigated Risk	Benefit Cost Ratio
$5,184,735	$4,459,735	6.15



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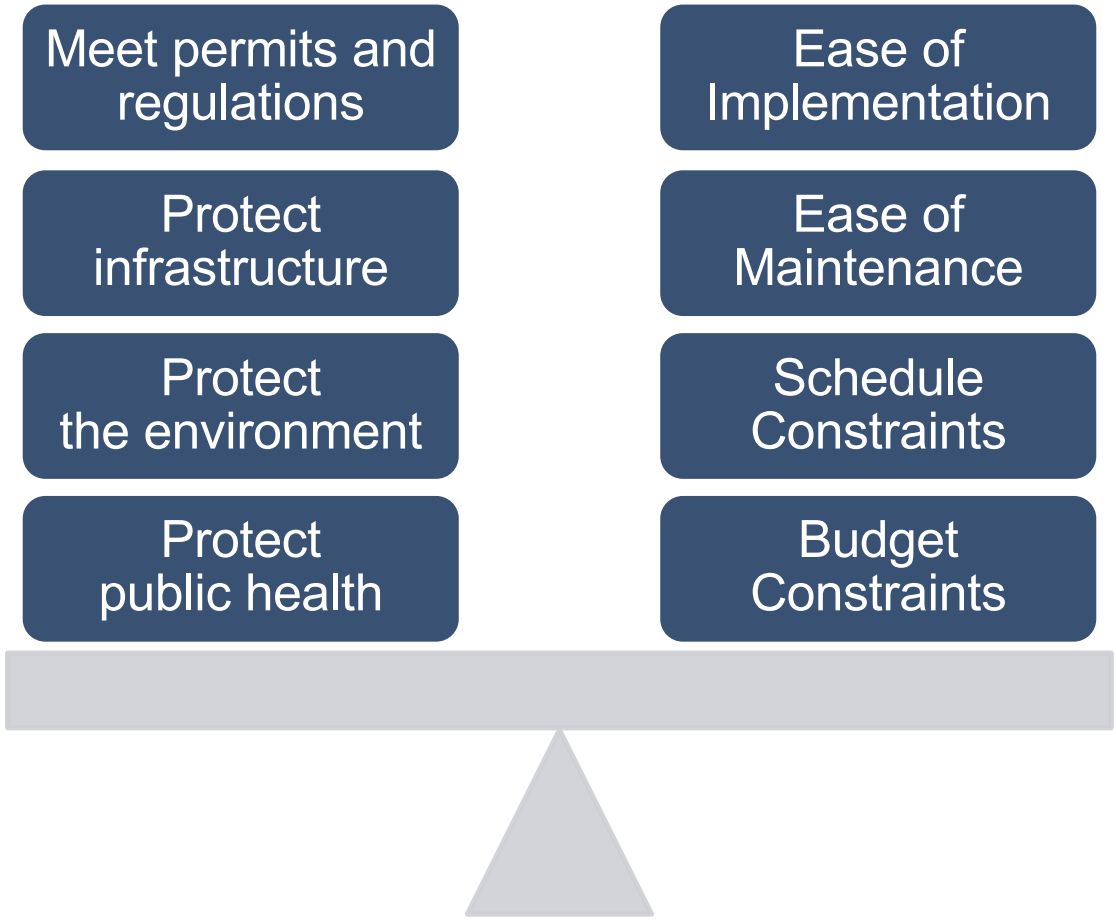
Conclusions

Resiliency Adaptation Requires Balance



Conclusions

- **Increases water production reliability during extreme storm events for Norfolk citizens and customers**
- Reduces risk of flood damage and costly repair / replacement of infrastructure
- Provides a cost effective solution to improve resilience to many potential storm events
- Provides a framework for Department of Utility infrastructure moving forward

Acknowledgements:

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Questions?