→ **2023 NEWEA Annual Conference**
Session 14 – January 24, 2023
Sara Greenberg / Anastasia Rudenko

Adapting Wastewater Infrastructure To Changing Flood Vulnerabilities

Southeastern Massachusetts Case Studies

Welcome

Presentation overview

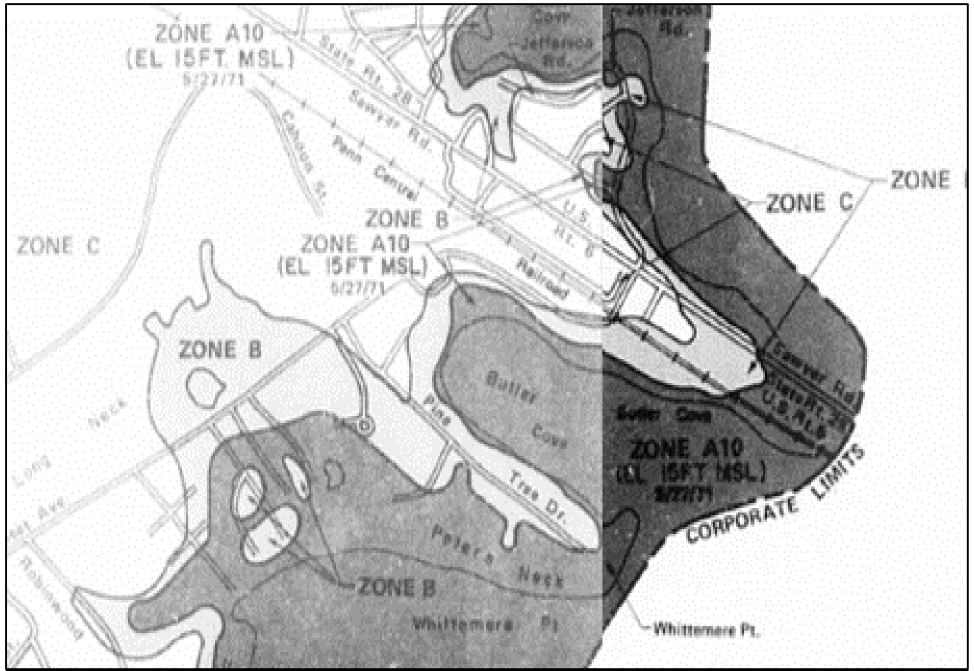
Background

- Changing vulnerability to flooding events
- Design approach

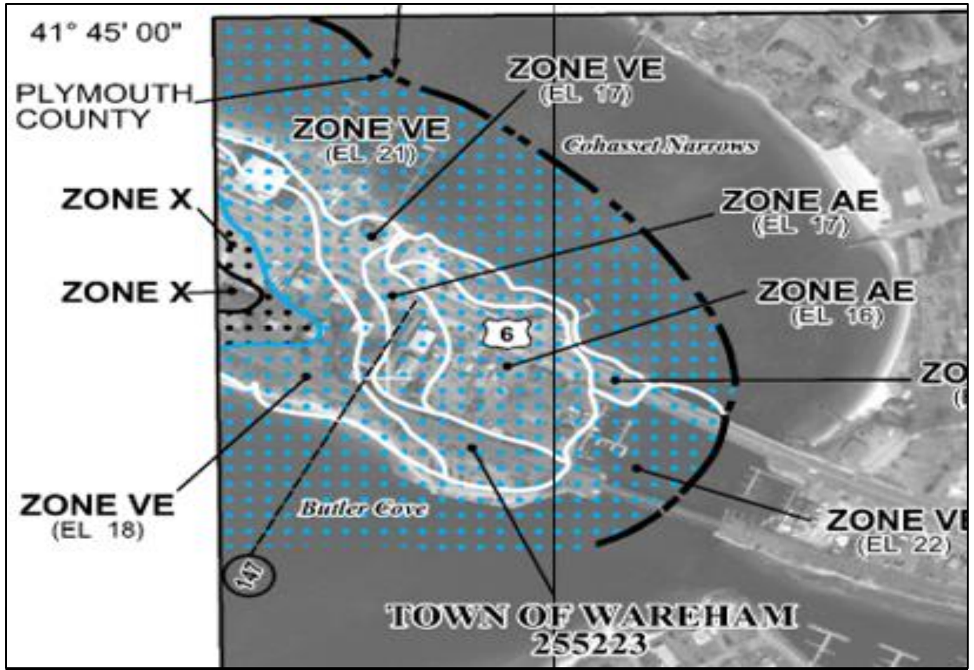
Case studies

- Vulnerable Coastal Wastewater Infrastructure
  - **Wareham, MA:**
    Vulnerability assessment and Retrofit design
  - **Falmouth, MA:**
    Force main evaluation and lift station coastal resilience conceptual designs

Changing Flood Maps

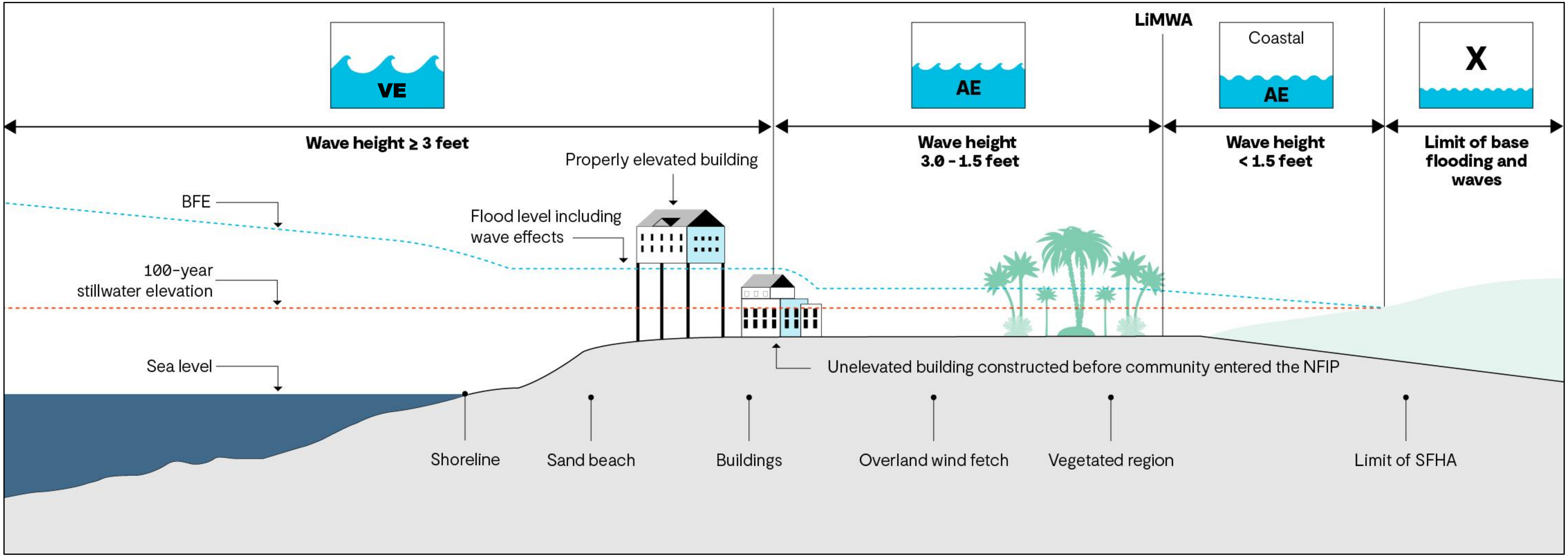


- 1983 FEMA Firm Map
- Zone AE = 15 ft MSL
- Zone B = Area between 100 yr and 500 yr flood
- Zone C = Areas outside 500 yr flood



- 2012 FEMA Firm Map
- AE Zones = 16, 17
- VE Zones = 17, 21, 22

FEMA coastal flood hazard zones and base flood elevation



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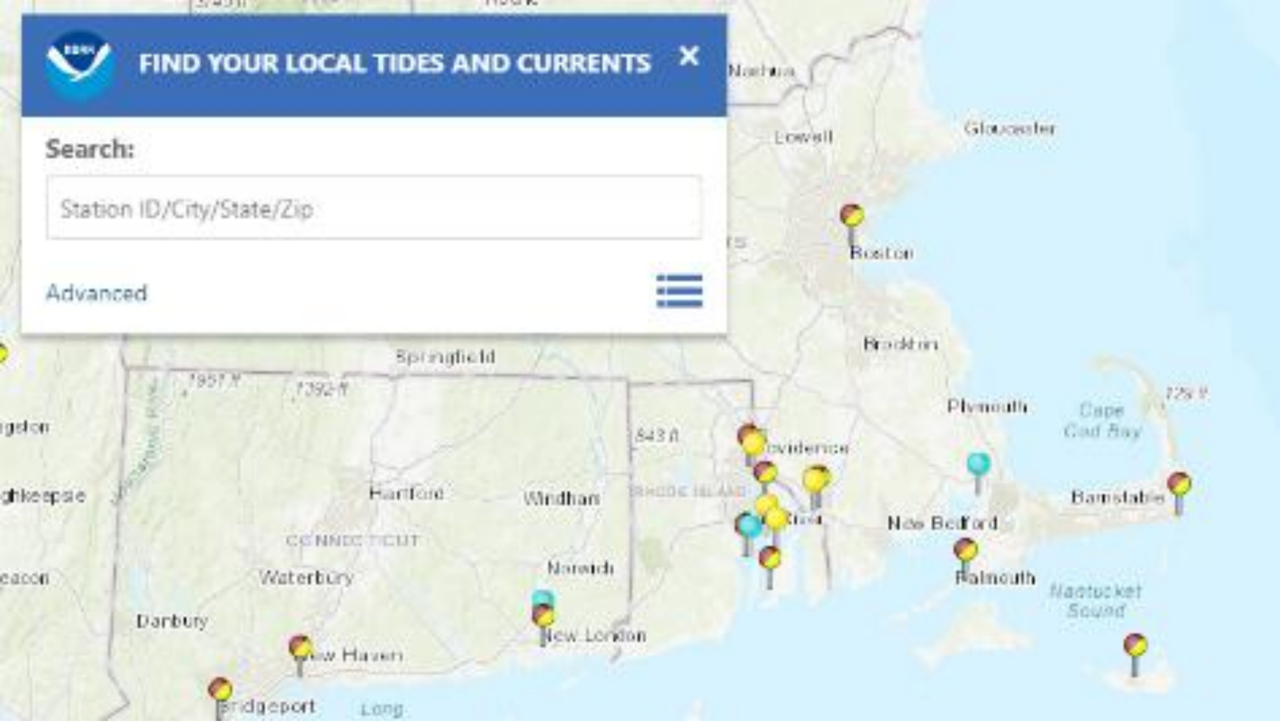
Freeboard requirements

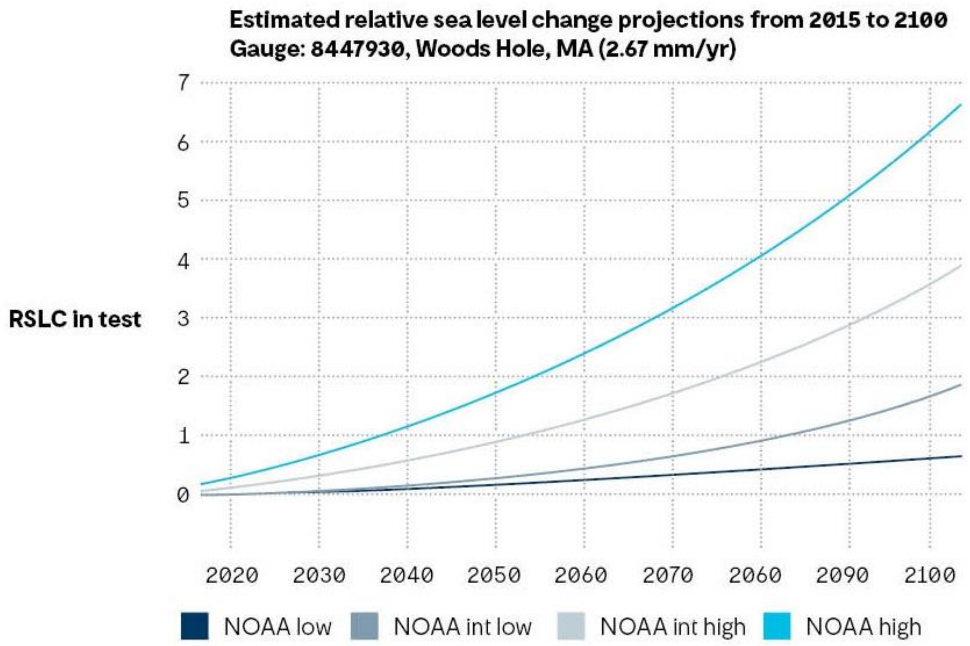
Previous design standard

- Design to 100-year flood elevation
- No required minimum freeboard

Updated design standards

- More stringent minimum freeboard requirements
- TR-16 (NE WW Standards)
  - Critical equipment = 3 ft
  - Non-critical equipment = 2 ft
- ASCE 24-14 – flood resistant design and construction, 2014
  - Requirement of Massachusetts 9th building code
  - Specifies minimum freeboard requirements based on criticality of infrastructure





Sea level rise projections

- United States Army Corps of Engineers (USACE) Sea Level Change Curve Calculator
- National Oceanic and Atmospheric Administration (NOAA) sea level change projections
- 20 year projection used for all proposed mechanical improvements
- 50 year projection used for all proposed structural improvements

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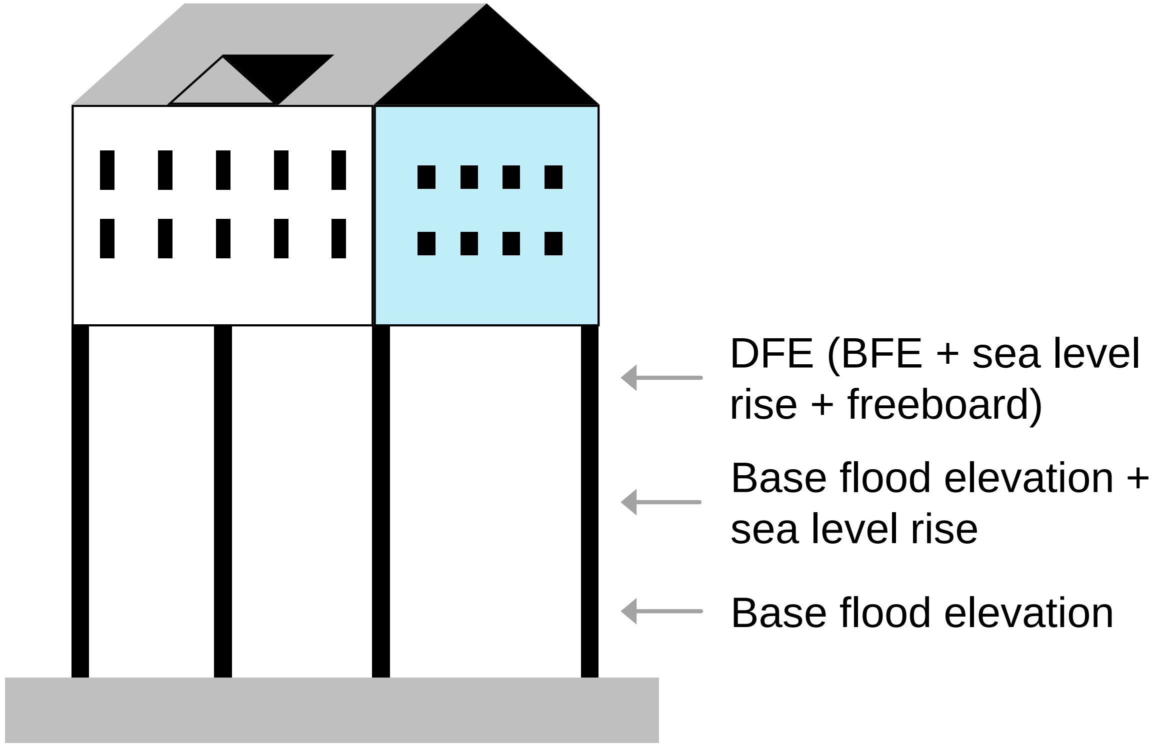
Design approach – determine design flood elevation

Design flood elevation (DFE) =

Base flood elevation (BFE) +

Freeboard +

{optional **Sea Level Rise (Coastal)**}



Flood resilience strategies

Dry flood proofing

- Reinforce structure to withstand forces of a hydrostatic flood load
- Preventing flood water from entering structure (make structure watertight)

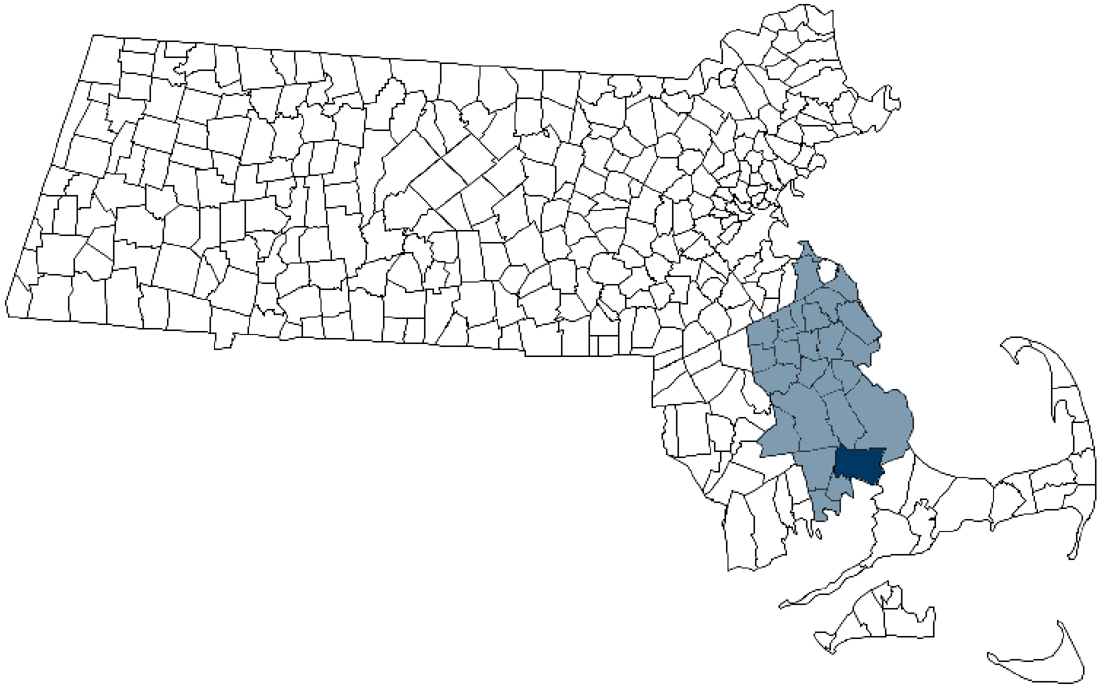
Wet flood proofing

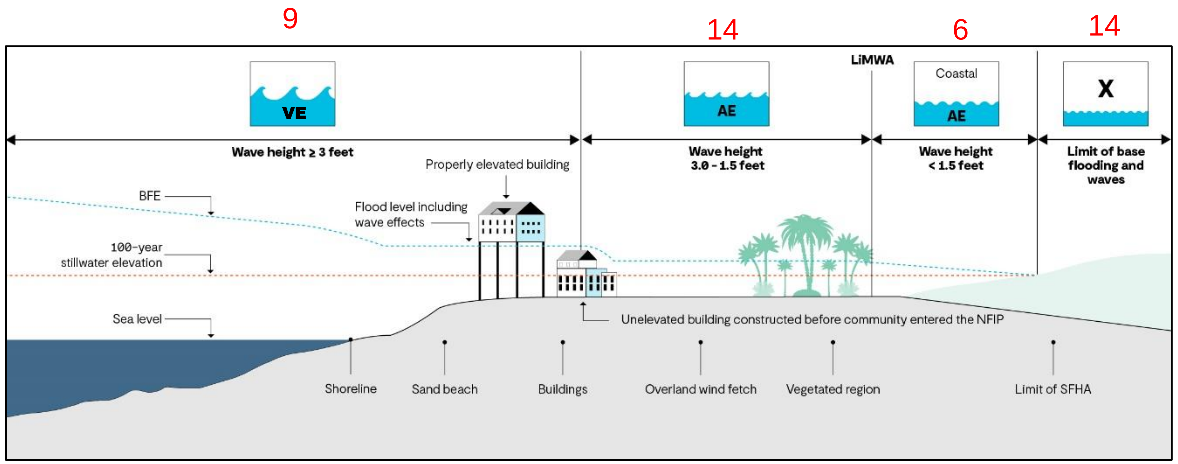
- Allow flood waters to infiltration the structure
- Protect contents of building from water damage (elevate or floodproof)

Vulnerable Coastal Wastewater Infrastructure

Case Study 1

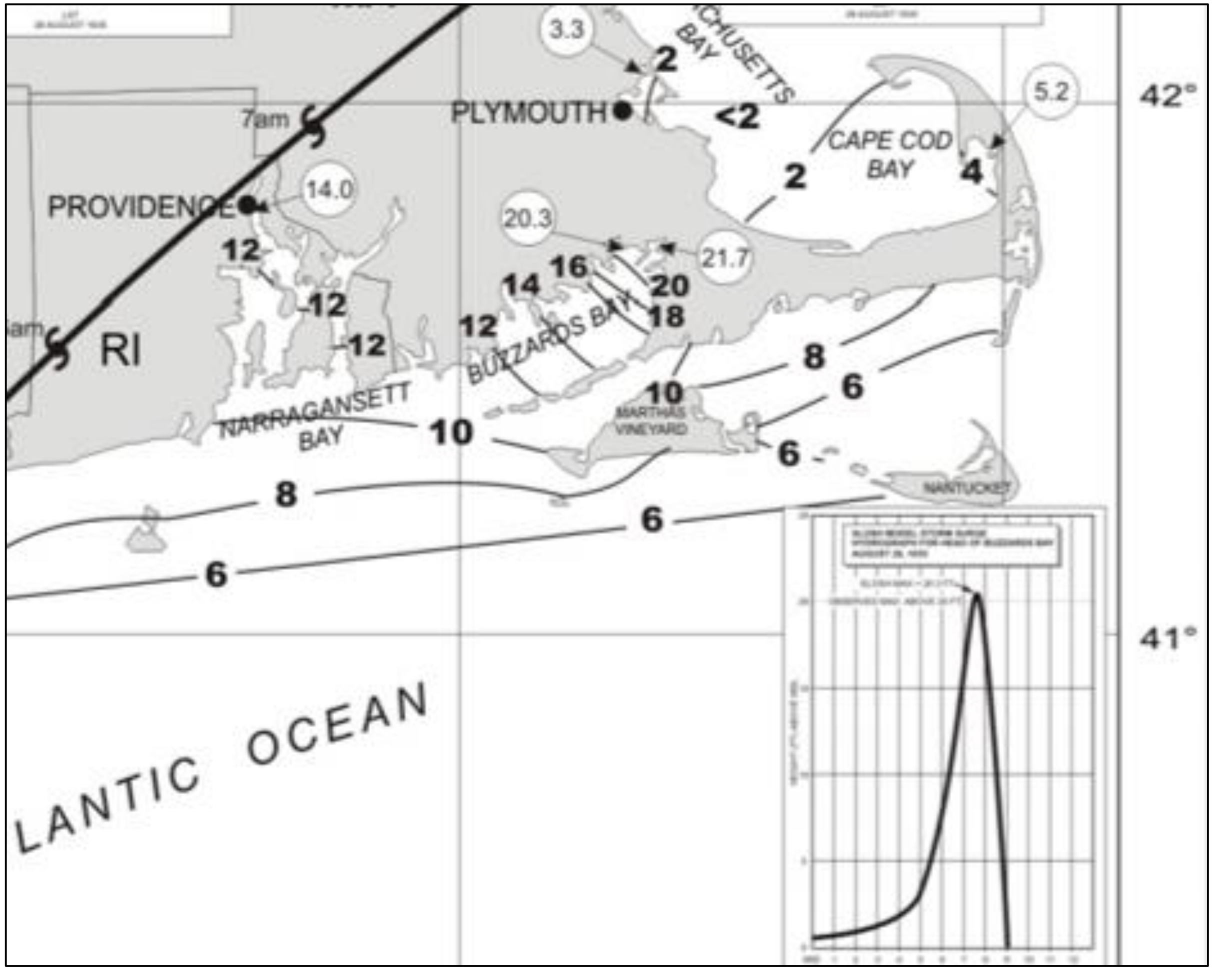
- Town of Wareham
- 54 miles of coastline
- 43 pump stations and 1 wastewater treatment plant
- 29 pump stations in 100 year flood zone

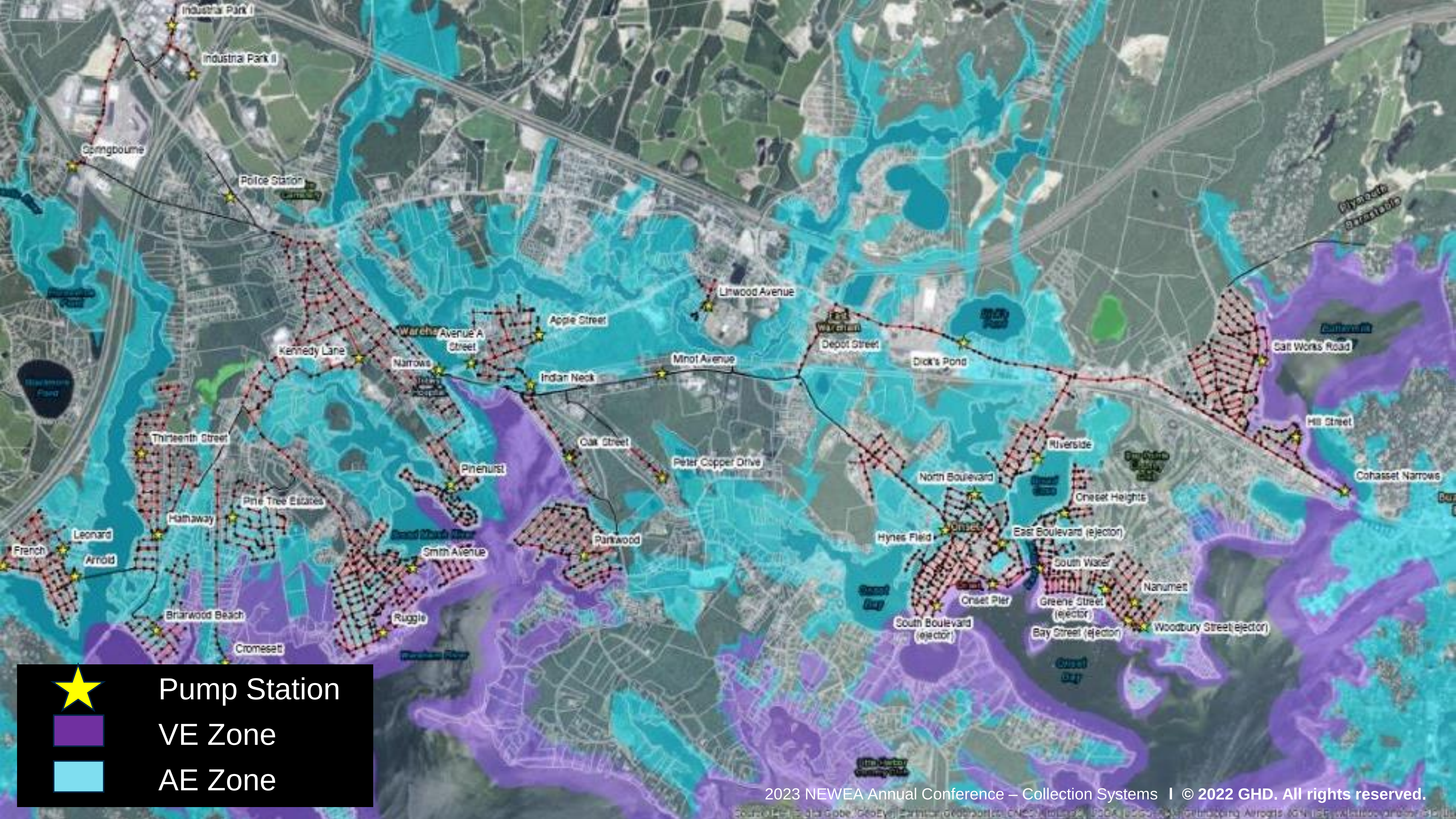




What makes Wareham so vulnerable

- Complex Coastal Estuarine System
- Throttling impact of Buzzards Bay
- SLOSH model run for the 1635 Category 5 hurricane
- SLOSH – “Sea, Lake and Overland Surges from Hurricanes” model by NWS




Industrial Park I
Industrial Park II
Springbourne
Police Station
Linwood Avenue
Apple Street
Avenue A Street
Kennedy Lane
Narrows
Indian Neck
Minot Avenue
Depot Street
Dick's Pond
Salt Works Road
Hill Street
Riverside
Cohasset Narrows
Thirteenth Street
Oak Street
Peter Copper Drive
Pinehurst
North Boulevard
Onset Heights
Pine Tree Estates
Hathaway
Leonard
French
Arnold
Parkwood
Smith Avenue
Hynes Field
East Boulevard (ejector)
South Water
Nanumett
Onset Pier
Greene Street (ejector)
Bay Street (ejector)
Woodbury Street (ejector)
South Boulevard (ejector)
Briarwood Beach
Ruggie
Cromeset
Pump Station
VE Zone
AE Zone

 |

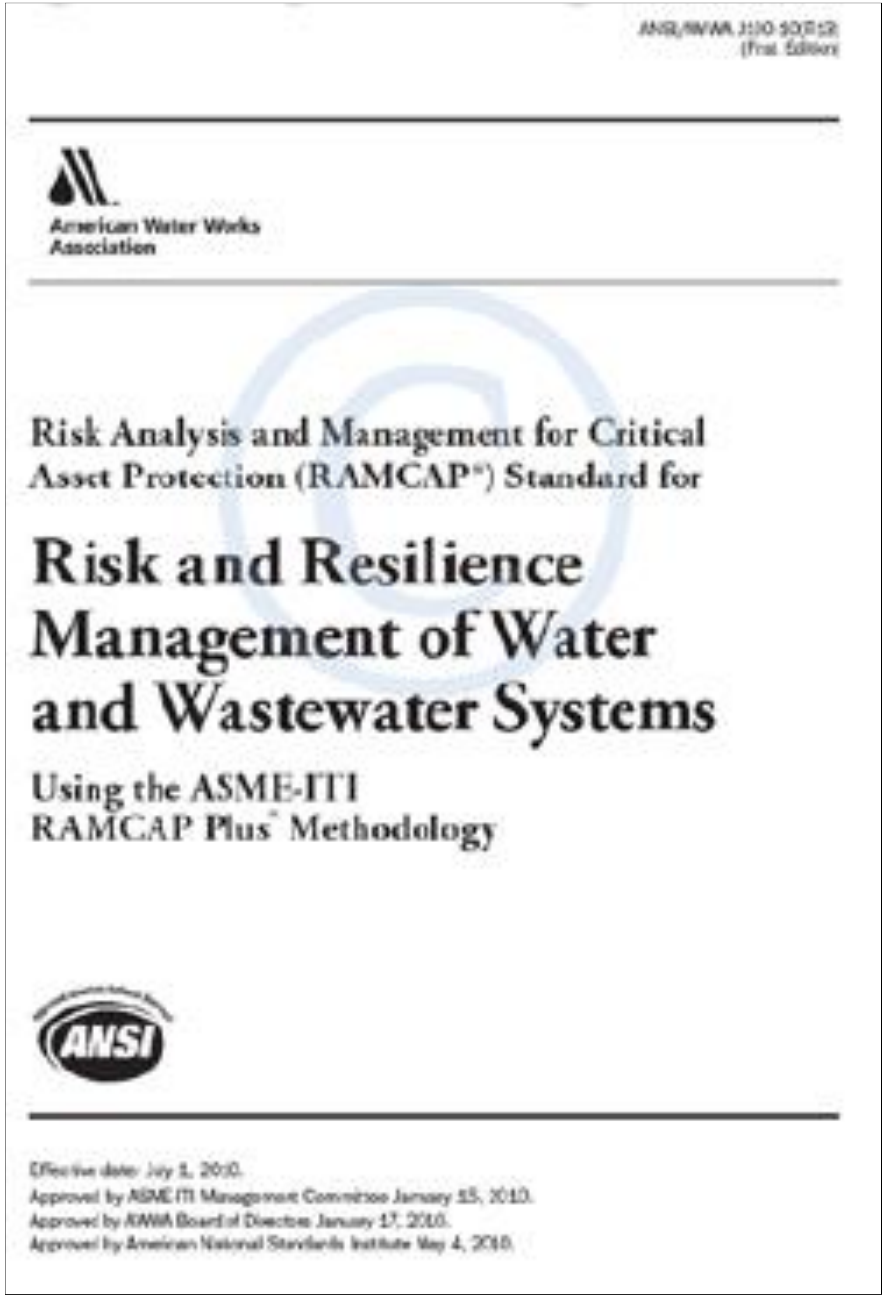
Approach

- Town needed methodology to prioritize pump station retrofits
- Risk and vulnerability assessment
- Assessed annual flood risk for each vulnerable station

Risk and vulnerability assessment

1. Determine design flood elevations
2. Determine which components will be damage/ruined in 1% storm (100 year) and replacement costs
3. Determine estimated monetary total loss:

   FEMA Benefit Cost Analysis (BCA) Software
4. Flood Risk ($) = (Threat of Likelihood) x (Total Loss)



American Water Works Association

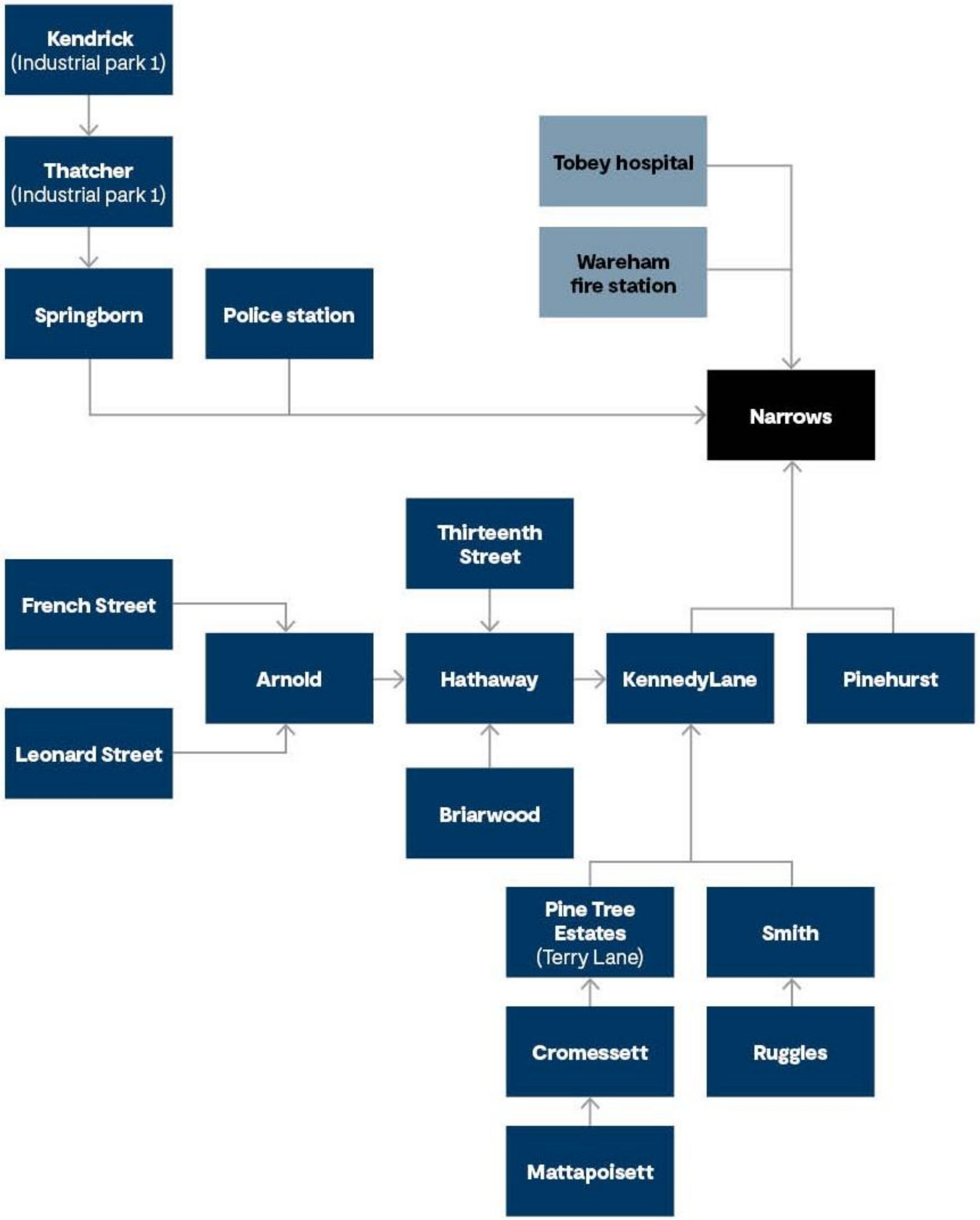
Risk Analysis and Management for Critical Asset Protection (RAMCAP®) Standard for

Risk and Resilience Management of Water and Wastewater Systems

Using the ASME-ITI RAMCAP Plus Methodology

ANSI

Effective date: July 1, 2010.
Approved by ASME ITI Management Committee January 15, 2010.
Approved by AWWA Board of Directors January 17, 2010.
Approved by American National Standards Institute May 4, 2010.



Coastal resilience design phase

Three high priority wet pit/dry pit stations:

- Narrows pump station
- Hynes Field pump station
- Cohasset narrows pump station

All three stations serve:

- Multiple dependent pump stations
- Critical infrastructure

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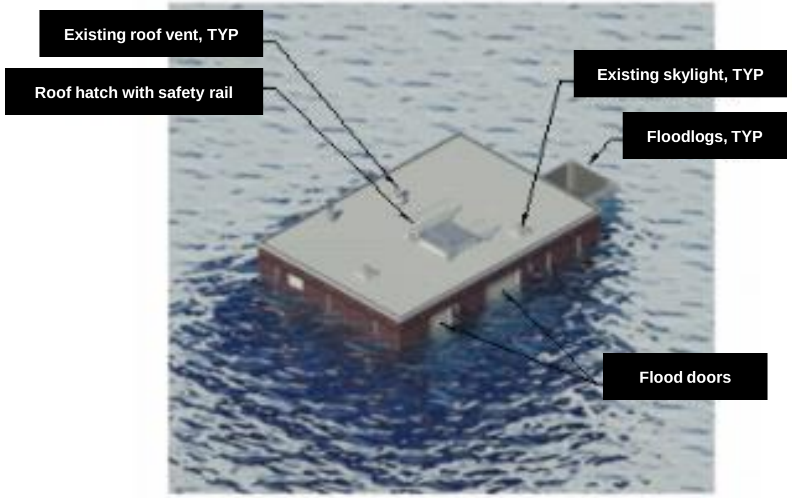
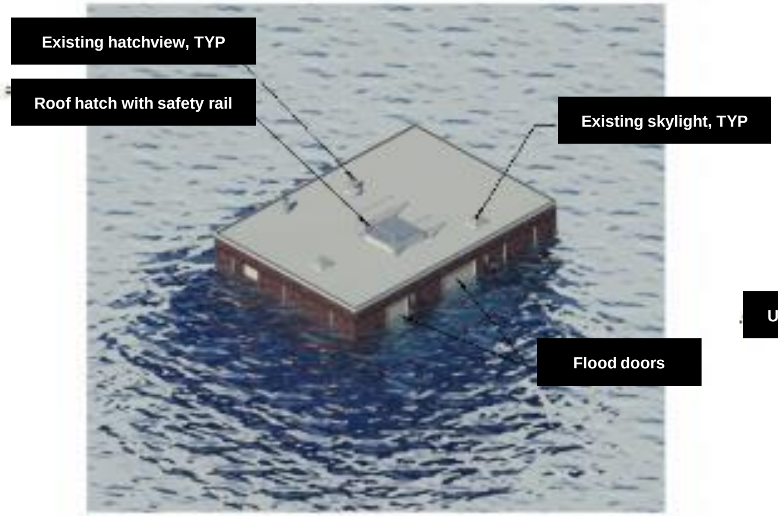
Priority pump stations

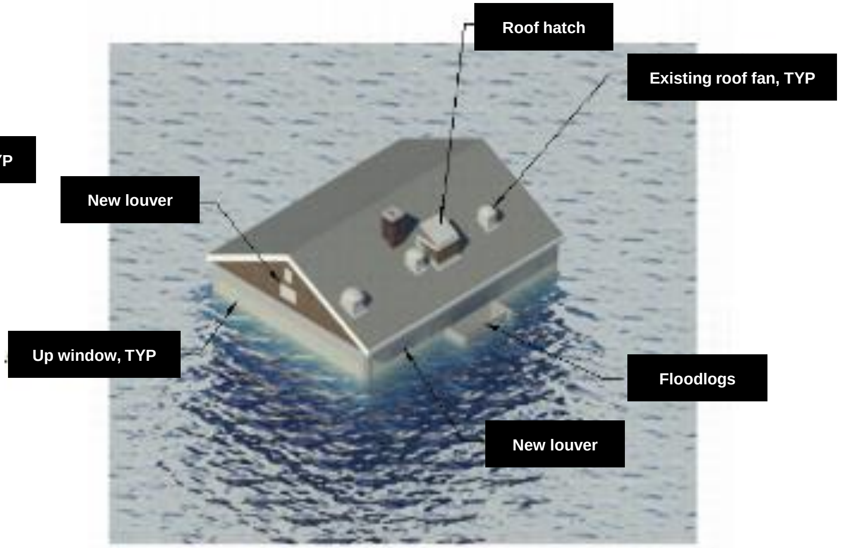
Narrows



Hynes Field



Cohasset Narrows



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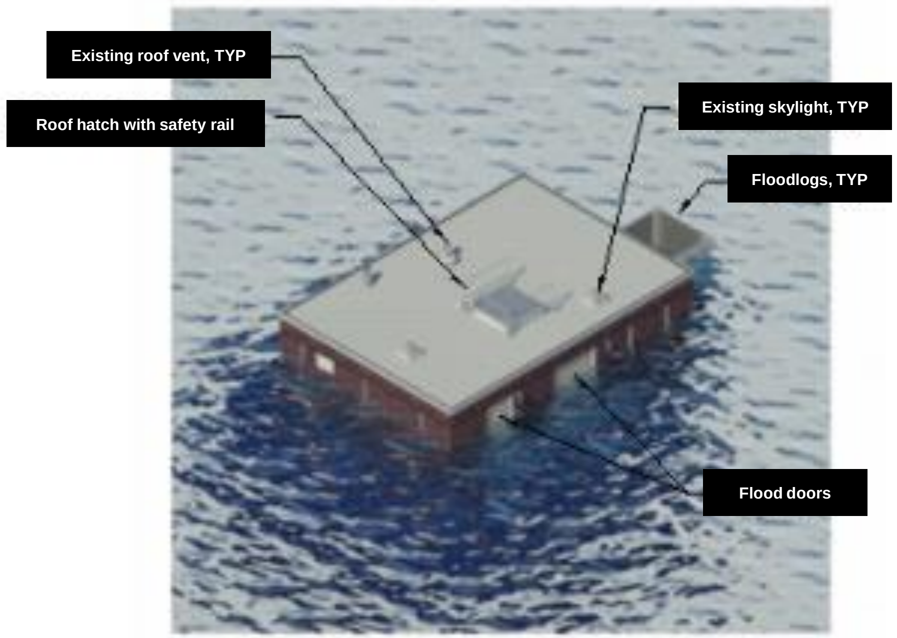
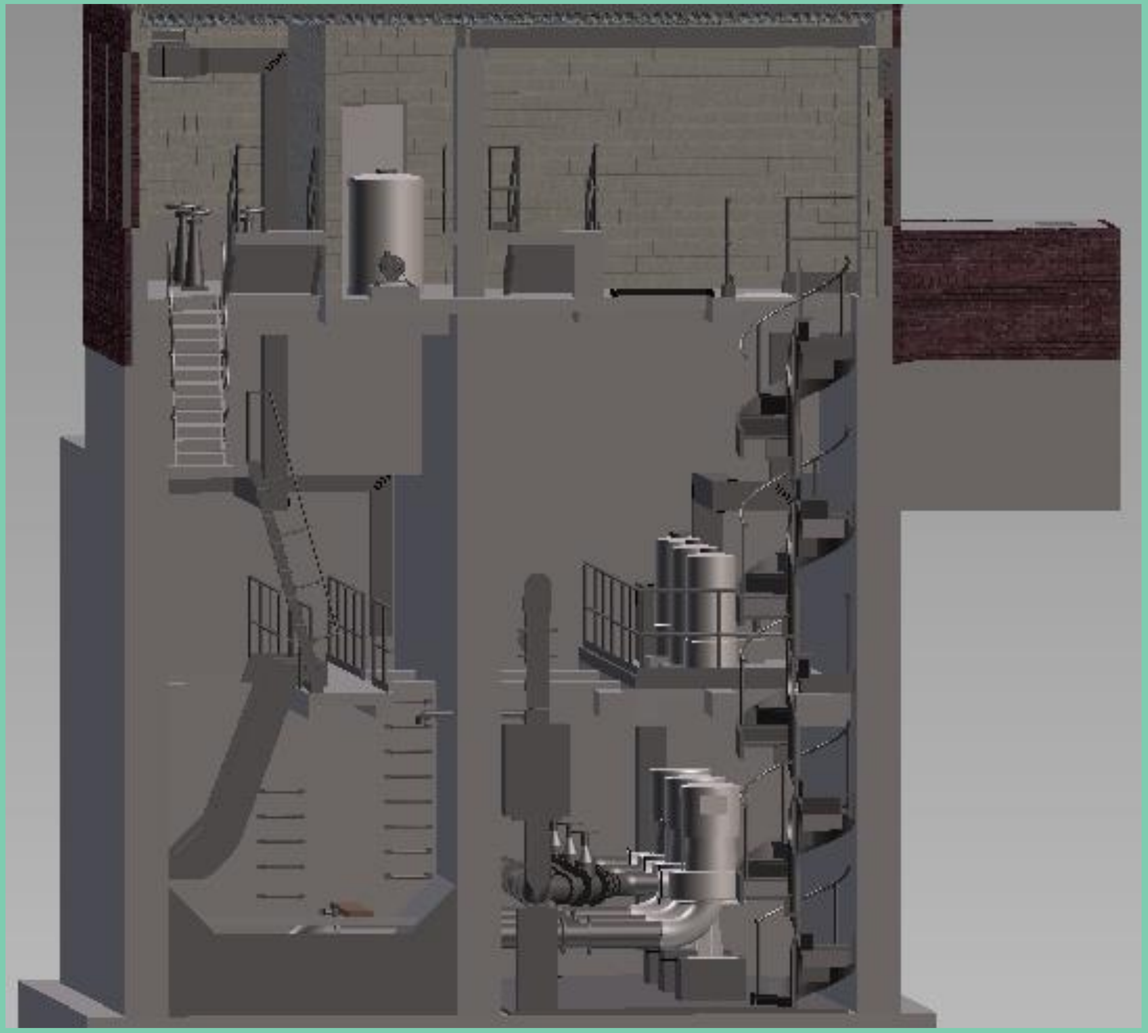
Priority pump station

Existing equipment not waterproof

- Equipment damage
- Electrical damage

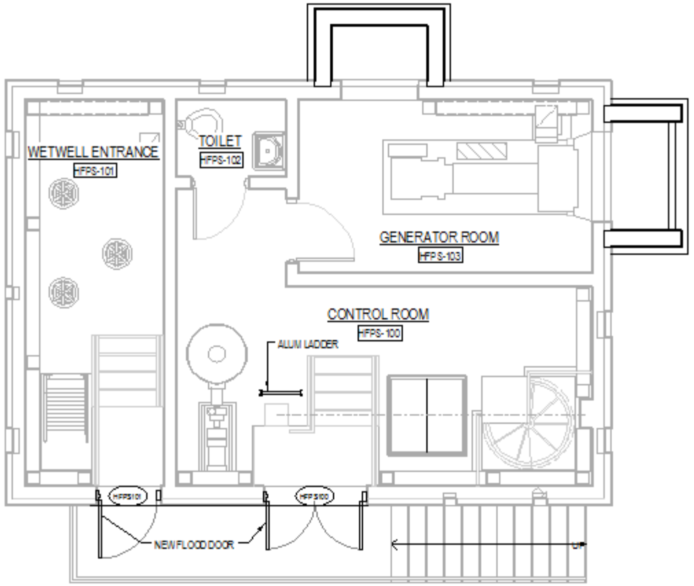
Potential structure collapse

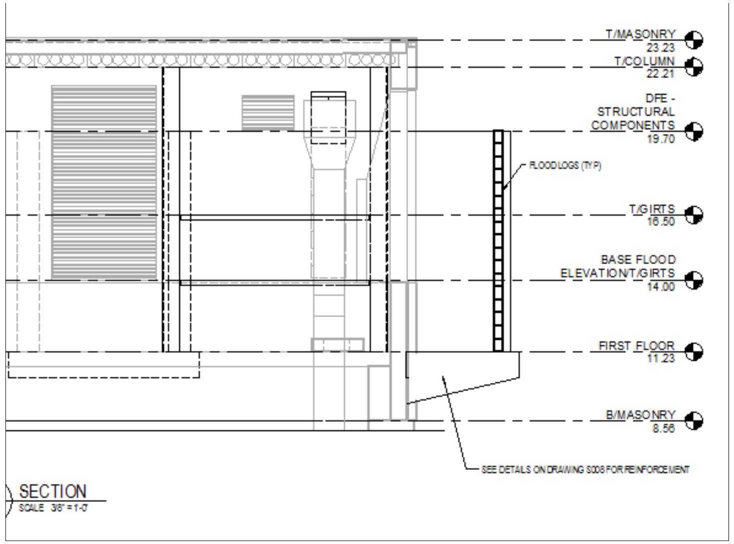




Sealing potential entry points

- Flood proof doors
- Flood plank systems
- Relocating openings below DFE





Structural reinforcement

Carbon reinforcing strips

Internal structural bracing

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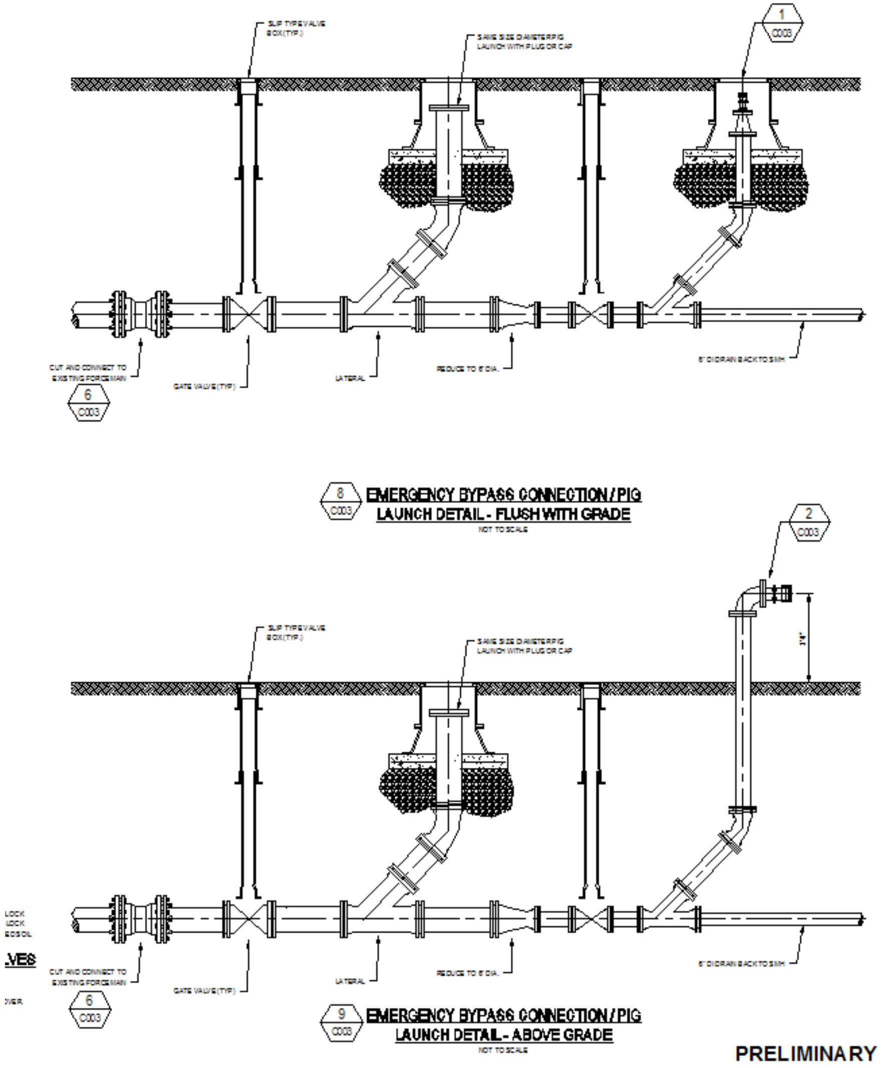
Emergency bypass connection



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Vulnerable Coastal Wastewater Infrastructure

Case Study 2

- Town of Falmouth
- Southwestern portion of Cape Cod
- 4 lift stations and 1 force main in vulnerable locations
- Examples:
  - Lift Station without Superstructure
  - Lift Station with Superstructure

Falmouth Sewer and Collection System Infrastructure

Problems:

- Sewer system components are some of the most critical municipal assets and most vulnerable to impacts of climate change

FY-22 Municipal Vulnerability Action Grant:

- Evaluate alternatives for the Woods Hole sewer force main
- Evaluate and compare conceptual designs to increase coastal resilience of four vulnerable lift stations

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Historical Storm Events

Hurricane of 1938 – Falmouth, MA

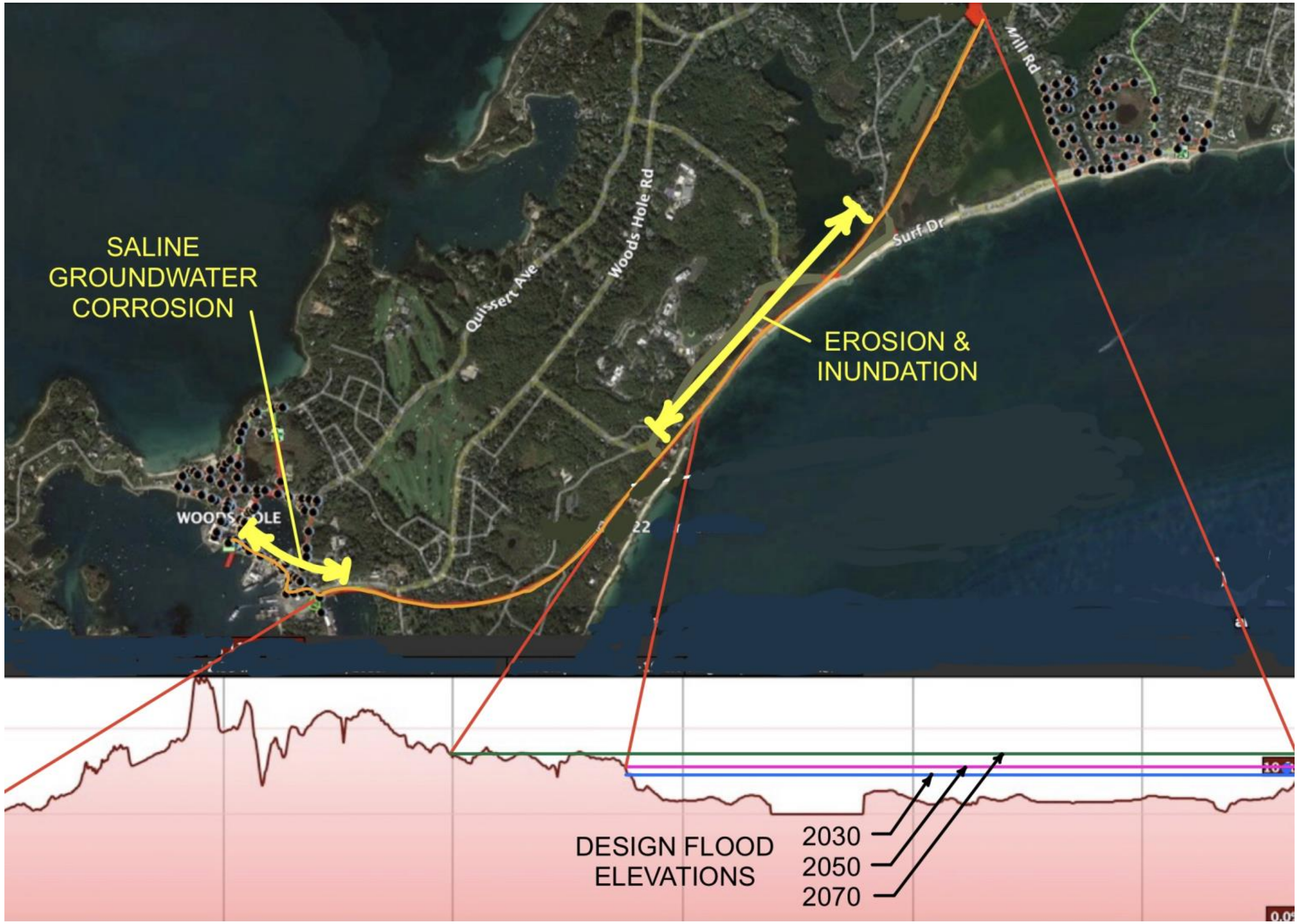
Hurricane Bob (1991) – Surf Drive

Hurricane Bob (1991) – Shuckers in Woods Hole

Woods Hole Force Main Evaluation

Background:

- 4.6 miles from Woods Hole to Jones-Palmer Lift Station
- Section along south coast was lined in 2012 but is vulnerable to erosion / undermining
- Section in Woods Hole village vulnerable to corrosion from saline groundwater



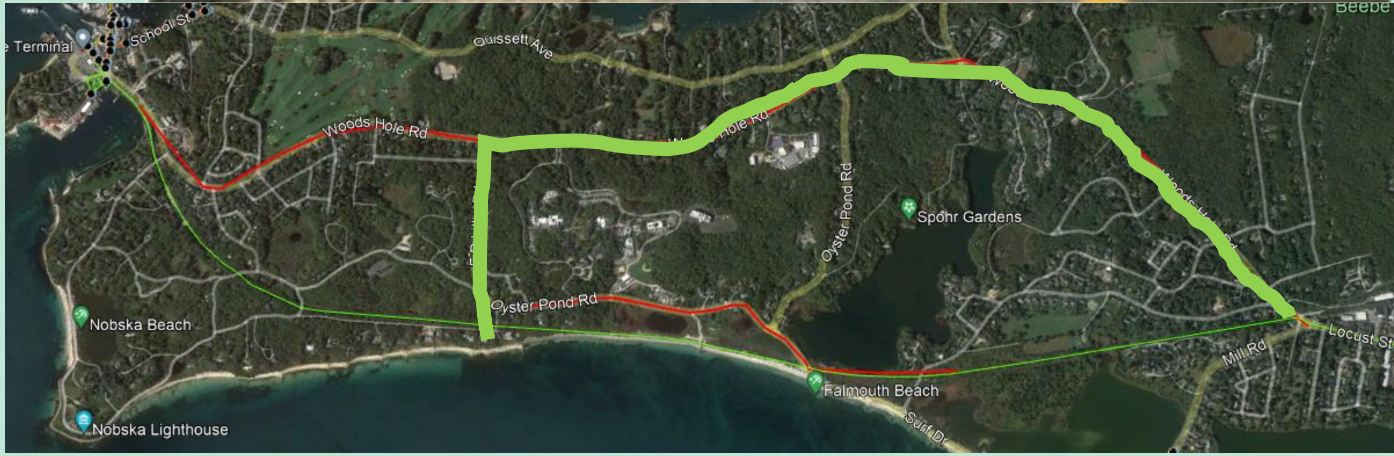
Mitigation measures

For section along southcoast vulnerable to erosion/ undermining:

- Relocate force main inland – several route/length options
- Replace with corrosion-proof pipe at depth – directional drilling

For section in Woods Hole village vulnerable to corrosion:

- Line existing pipe (for this area, as effective and lower cost than replacement)



Lift Stations Without Superstructures

Park Road Lift Station

Falmouth Beach Lift Station

Inner Harbor **Lift** Station

2070 Design Flood = 19.9 ft
2050 Design Flood = 19.1 ft

2030 Base Flood = 13.4 ft

Park Road Design Flood Elevations

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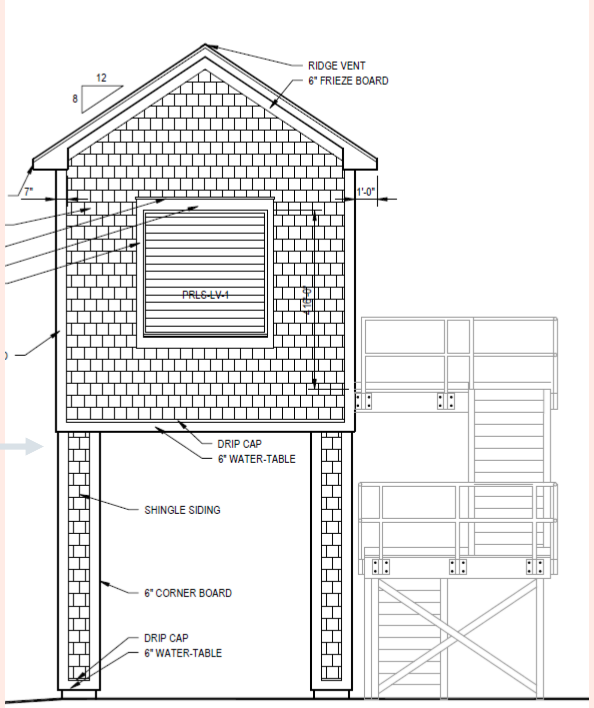
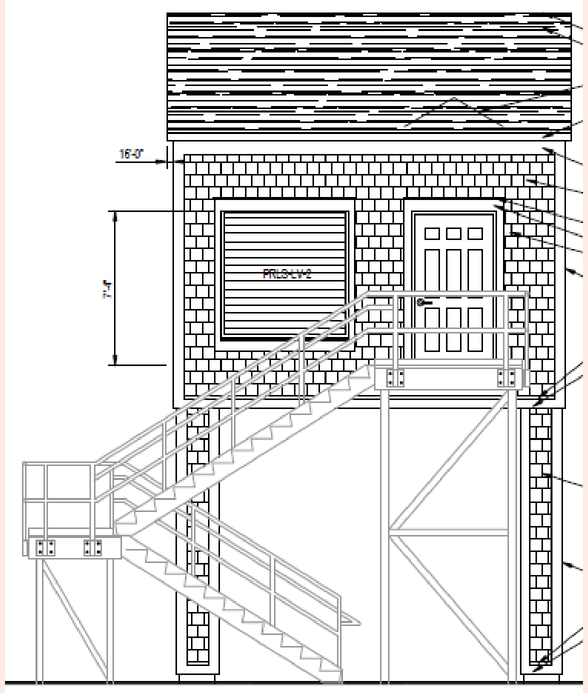
Park Road Option – Elevated Structure

- Construct elevated building to house gas-powered generator and lift station electrical
- Building **<u>“floor” > 19 ft above ground</u>**
- **<u>Operational Concept</u>**: Keep station operational during a design flood event



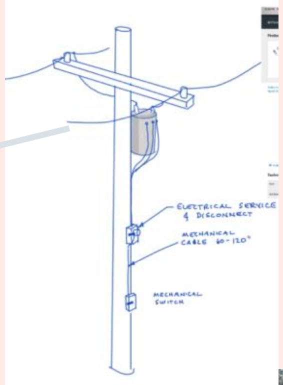


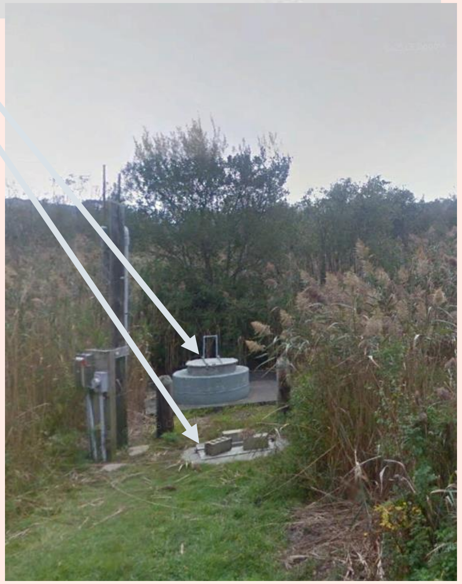
Park Road Option – Low Pressure Sewer

- Replace gravity system with low pressure piping.
- Provide grinder pump for each house
- **Operational Concept:** System will continue to operate during design flooding until pump control panels are flooded; pumps will not run when power is lost unless owner installs home generator.

Park Road Option– Electrical Relocation

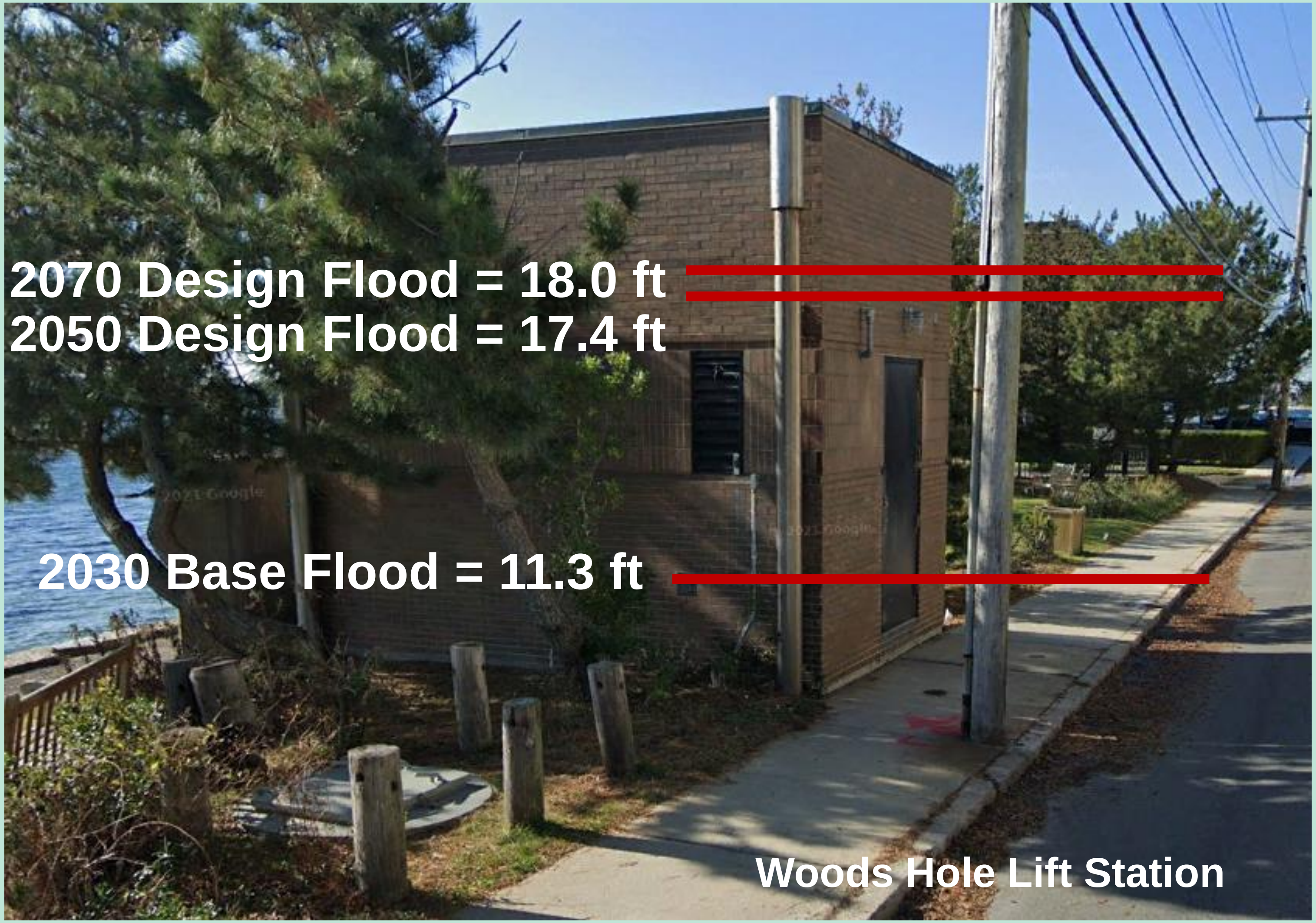
- Relocate electrical (use portable generator in outage)
- **<u>Operational Concept:</u>** Station will operate during moderate flooding but not during "100 year storms"; will be protected from water damage.





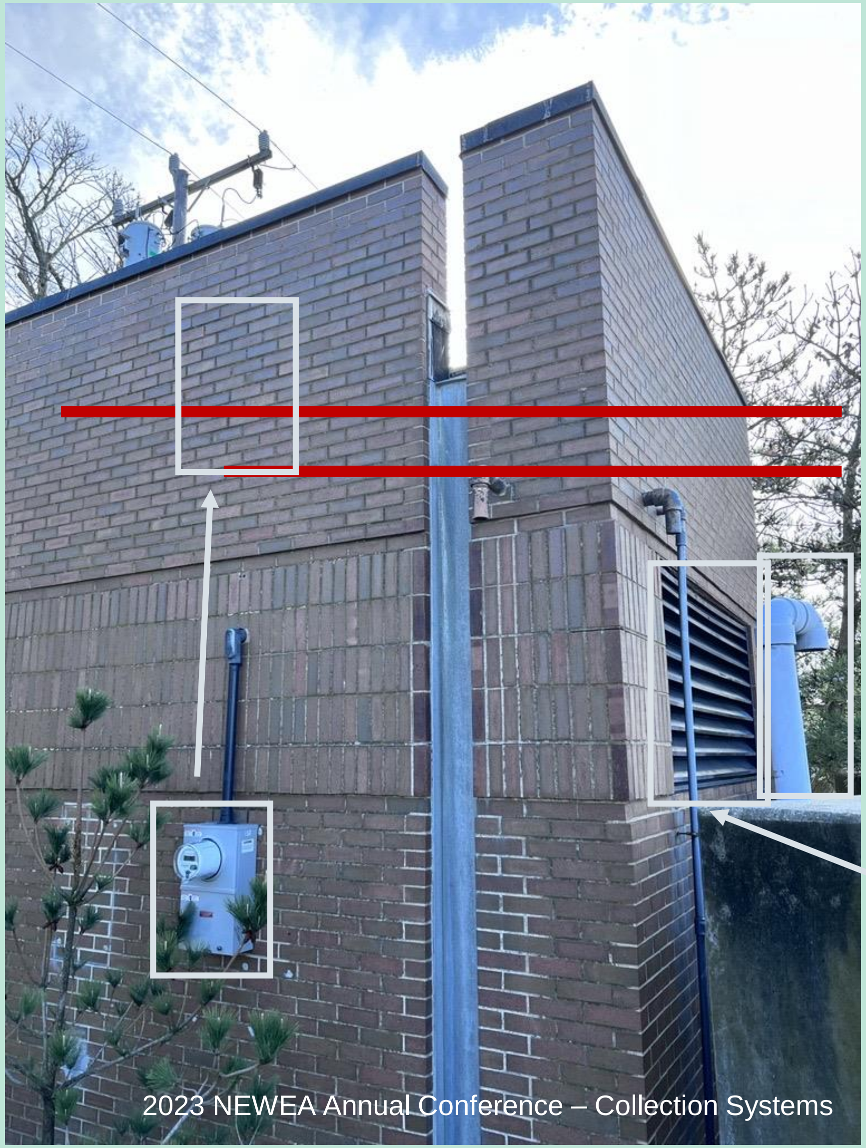
Lift Station with Superstructure

- Goal of Design: Keep station operational during a design flood event.
- Lift Station Serves: <u>all of Woods Hole</u>
  - Woods Hole US Coast Guard Station, MBL, WHOI, NOAA Northeast Fisheries Center, and Steamship Authority.

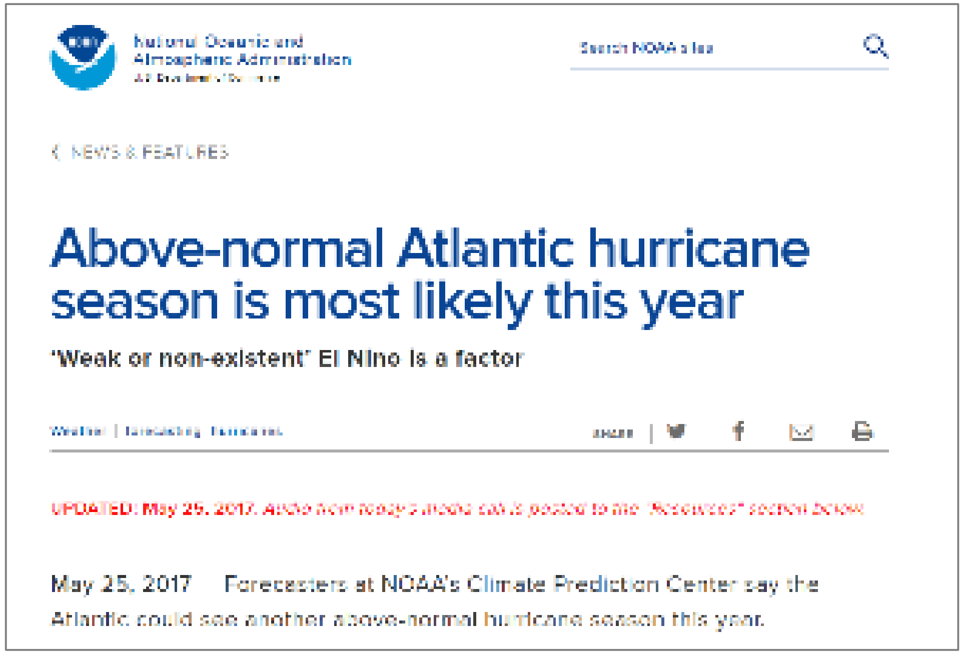


Woods Hole Lift Station Design

– Move vents to roof
– Flood-proof louvers and door
– Raise exterior electrical meter and disconnect switch
– Seal all wall penetrations
– Test flood proofing of hatches



2070 = 18.0 ft
2050 = 17.4 ft


National Oceanic and Atmospheric Administration

NEWS & FEATURES

Above-normal Atlantic hurricane season is most likely this year

'Weak or non-existent' El Nino is a factor

UPDATED: May 25, 2017. Audio from today's media call is posted to the "Resources" section below.

May 25, 2017 Forecasters at NOAA's Climate Prediction Center say the Atlantic could see another above-normal hurricane season this year.

Summary

- Recent FEMA flood map revisions indicate low-lying wastewater infrastructure is becoming increasingly vulnerable in multiple coastal communities.
- Towns can get creative in using grant funding for some of this work – and to get this finally implemented!
- Opportunities to implement cost-effective coastal resilience retrofits to protect vulnerable infrastructure as municipalities continue developing long-term adaptation strategies

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Thank You!
Questions?
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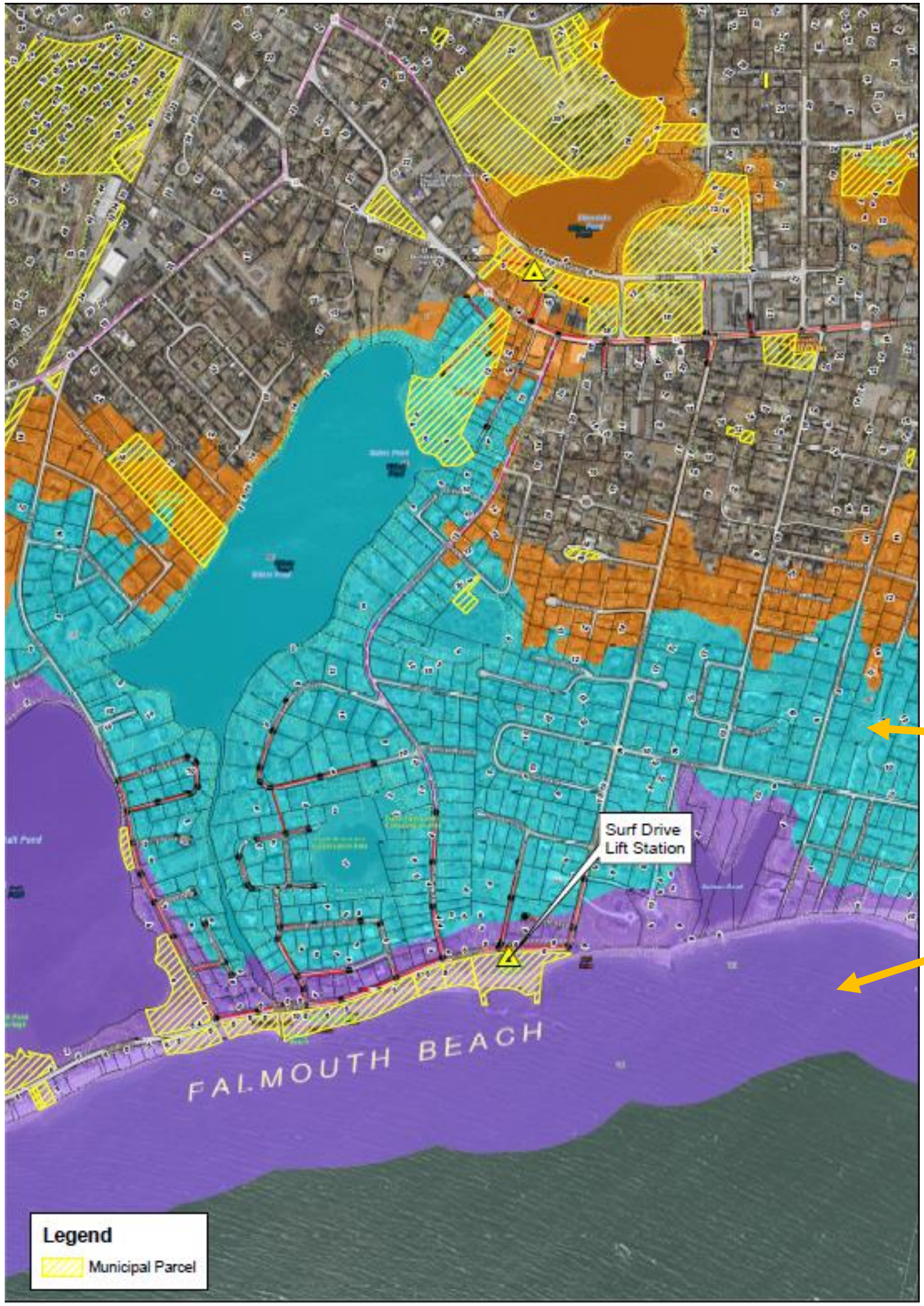
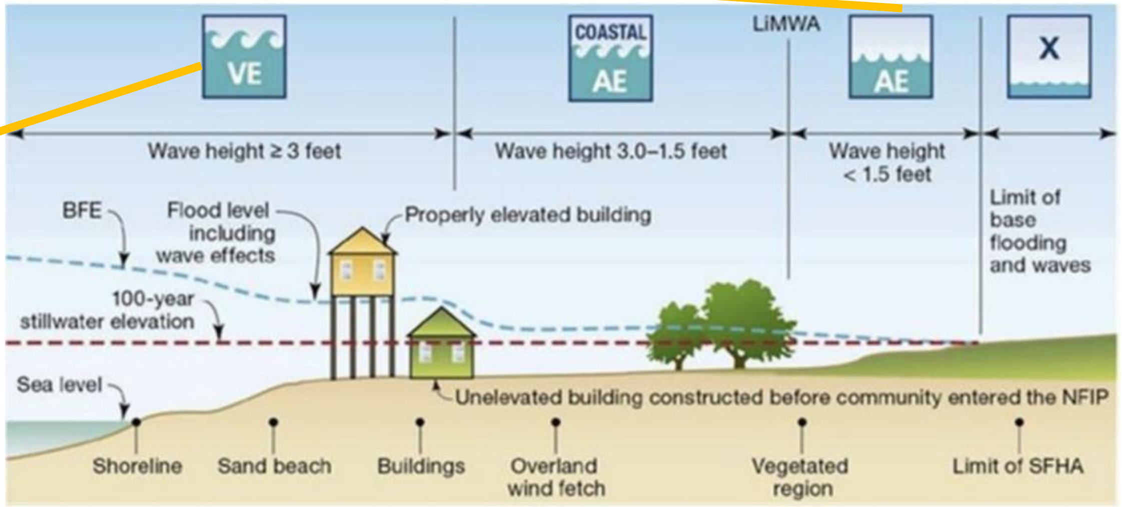
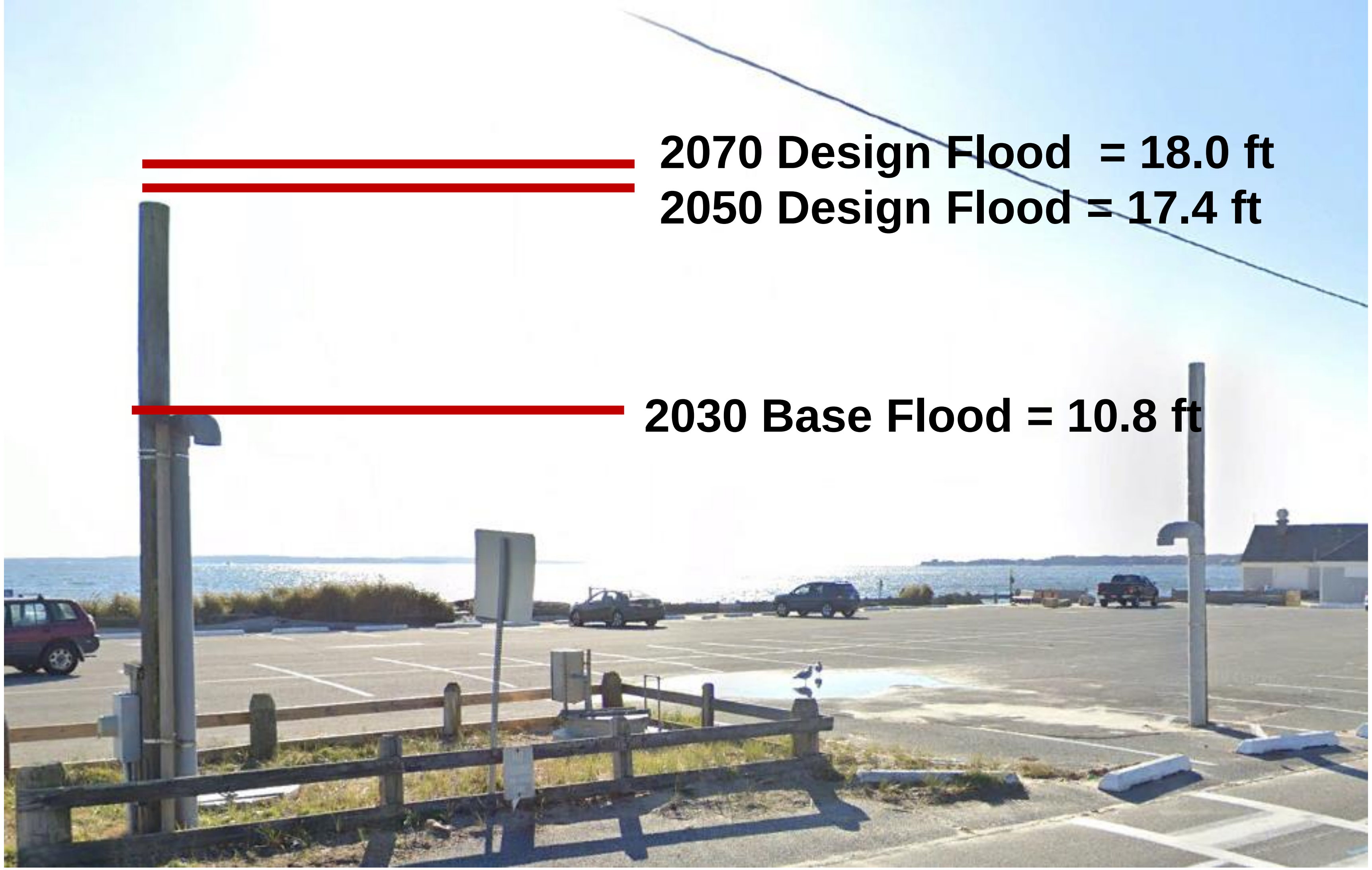
Falmouth Beach Lift Station



Station serves residential properties, all in VE or AE zone

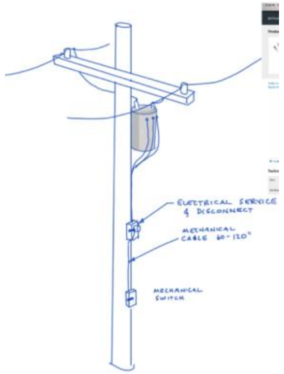


Falmouth Beach Design Flood Elevations



Goal: Keep station operational during a design flood event

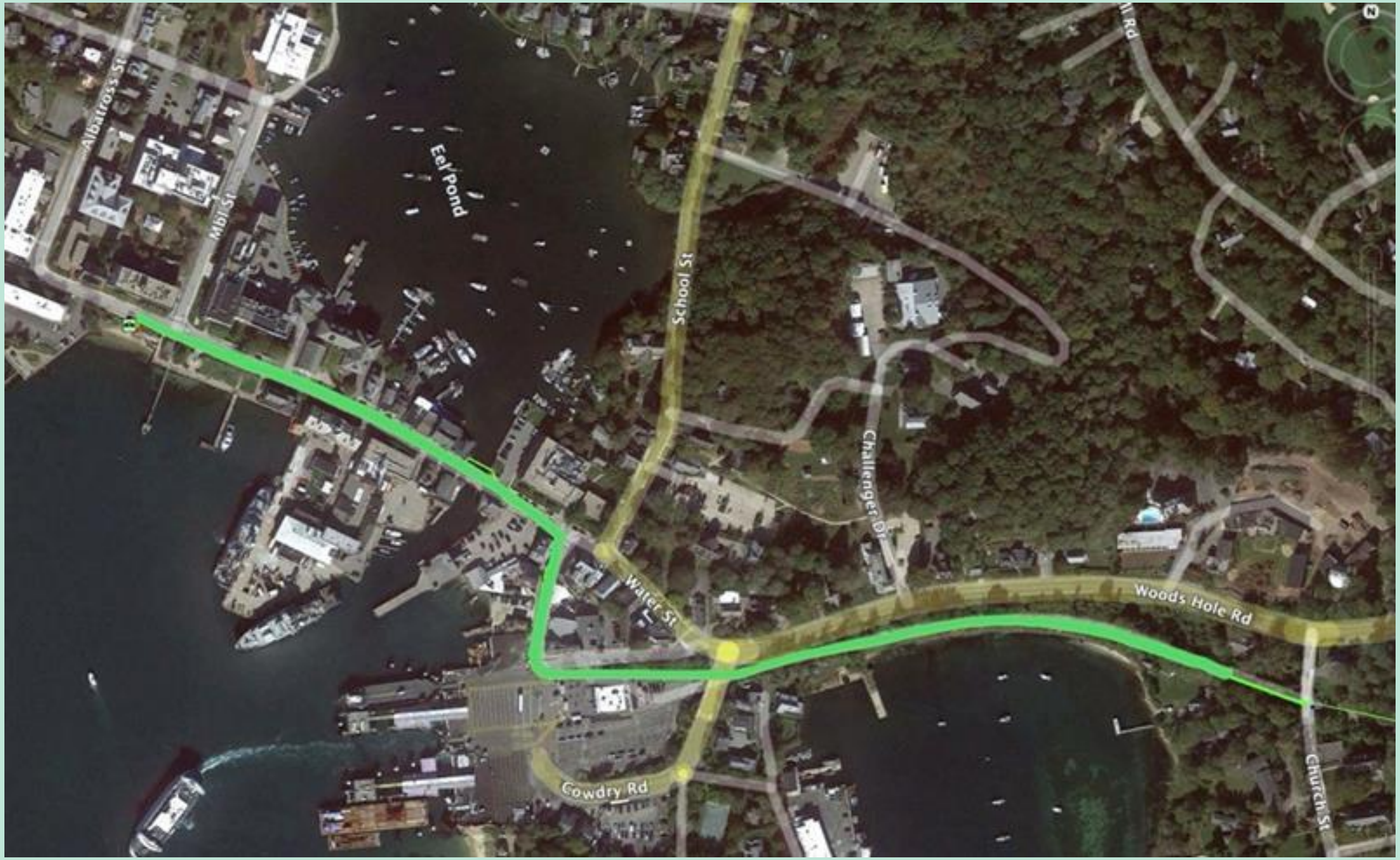
Lift Stations Without Superstructures



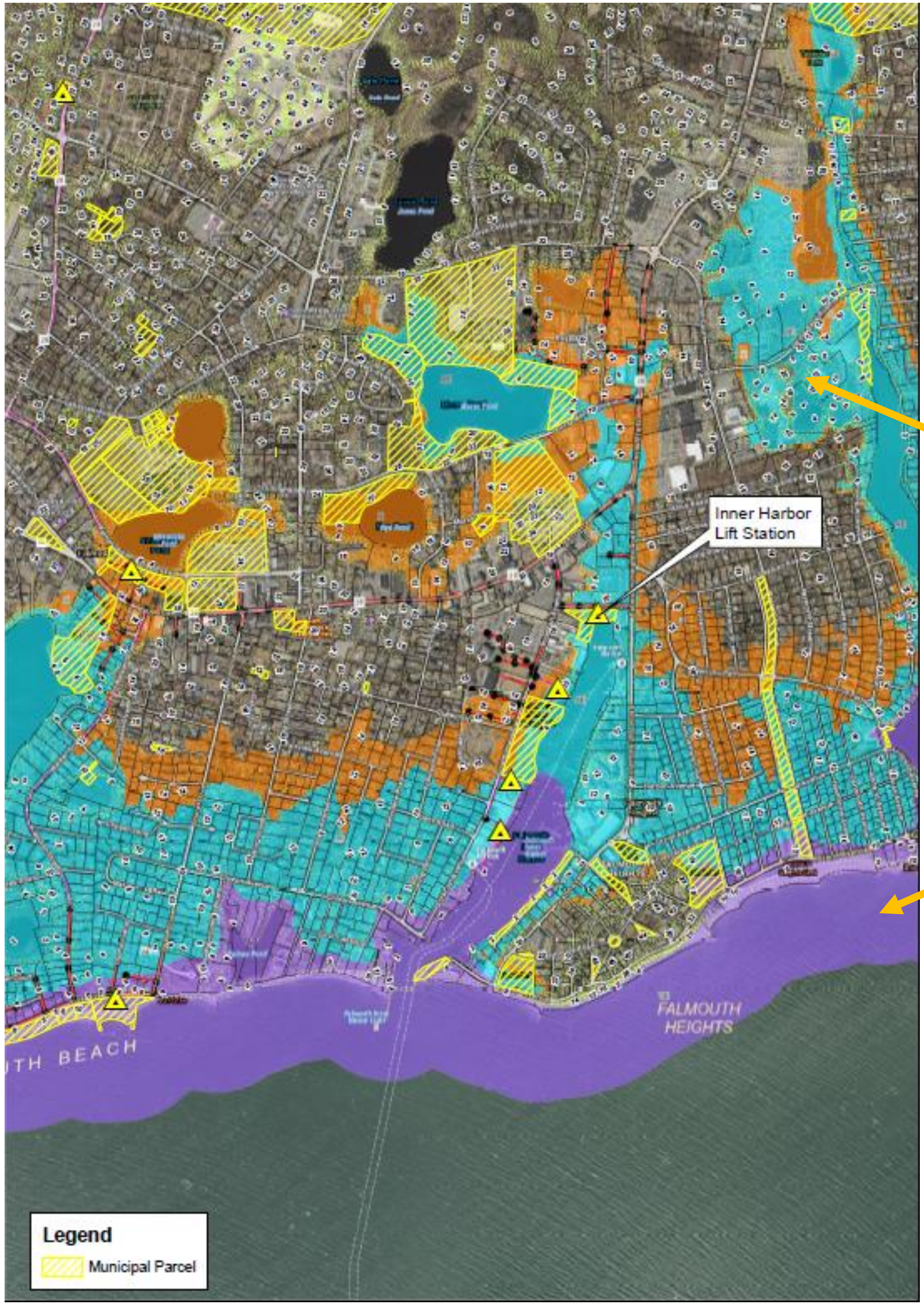
- Flood proof hatch
- Raise meter, shut-off, vents
- Install permanent by-pass

Woods Hole Village Force Main Lining

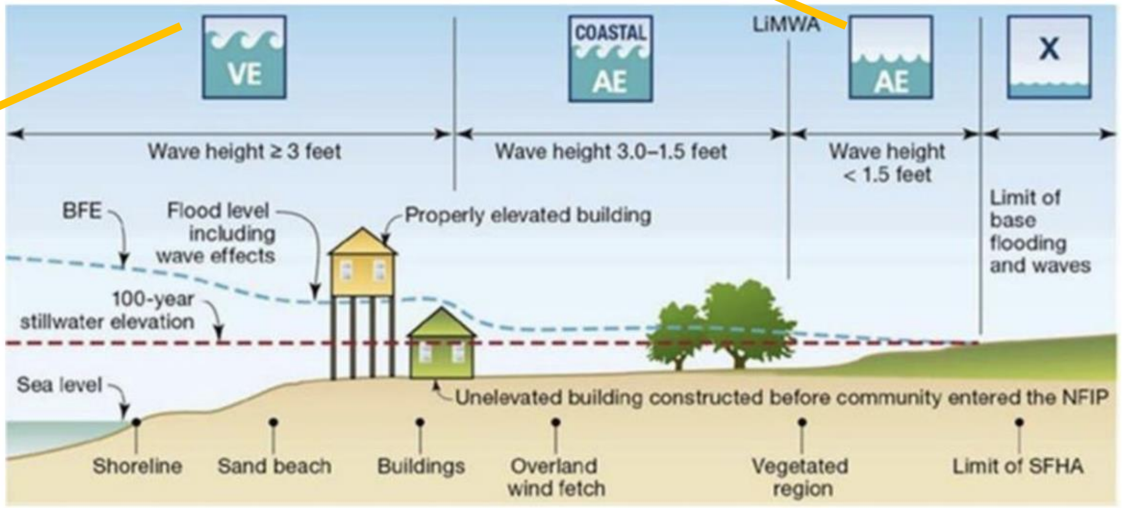
- **<u>Under all options</u>**, line up to 3,200 feet of force main in Woods Hole village subject to corrosion
- $1.7 million



Inner Harbor Lift Station



Serves commercial, municipal and residential properties in Davis Straits/Scranton Ave area, as well as Falmouth Heights, much of service area in AE zone



Woods Hole – Additional Info

- The current generator is anticipated to power the station for 14 hours under peak conditions.
- Longest predicted flood duration is <6 hours.
- Buoyancy analysis indicated station is anticipated to remain in-ground during flooding events.
- Flooding will cause hydrostatic pressure on the superstructure’s walls. Existing walls are anticipated to support short-term flooding.

Lift Station Operation As Sea Level Rises

- Optimum: Continuous operation, even during and immediately after flood events.
- Will not be possible under some flood conditions because:
  - i. Equipment will get damaged by flood water and/or
  - ii. System will be overwhelmed (pipes full of flood water; pumps cannot keep up)
- Evaluated means of protecting stations from 2050 design flood
- Did not evaluate relocating or elevating stations. See how Town's strategy for "adaptation, protection and retreat" progresses.


Woods Hole Lift Station


Falmouth Beach Lift Station


Inner Harbor Lift Station

Park Road Option Evaluation - DRAFT

Alternative	Capital Cost Estimate (2022$)	Pro	Con
Elevated Structure	$1,100,000	Would operate during design flooding; back-up power onsite	Visual impact; challenging construction; highest cost
Electrical Relocation	$250,000	Lowest cost; would allow operation during moderate flooding; electrical protected from flood damage	Portable generator must be brought to site when power out; will not operate during extreme flooding. Continue to operate lift station in marsh.
Low Pressure	$900,000	Eliminate lift station in increasingly flooded marsh	Each resident would need grinder pump; pumps won't run when power out (if no home generator); control panel damage during flood; cost

Sealing existing manholes from inflow would be additional cost for elevated structure and electrical relocation options

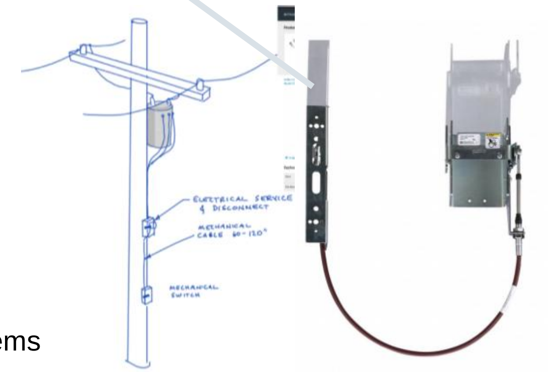
Inner Harbor Design Flood Elevations

2070 Design Flood = 18.4 ft
2050 Design Flood = 17.8 ft

2030 Base Flood = 10.4 ft

Goal: Keep station operational during a design flood event

Inner Harbor Design

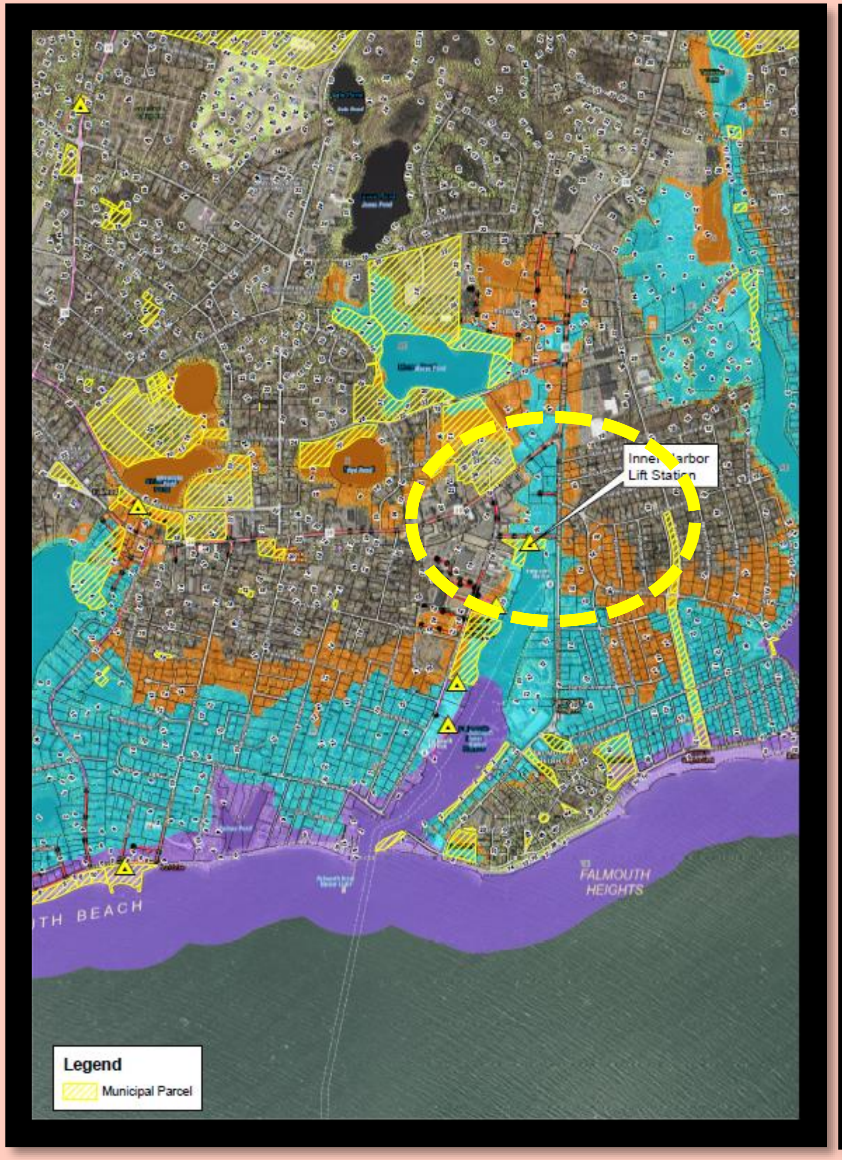


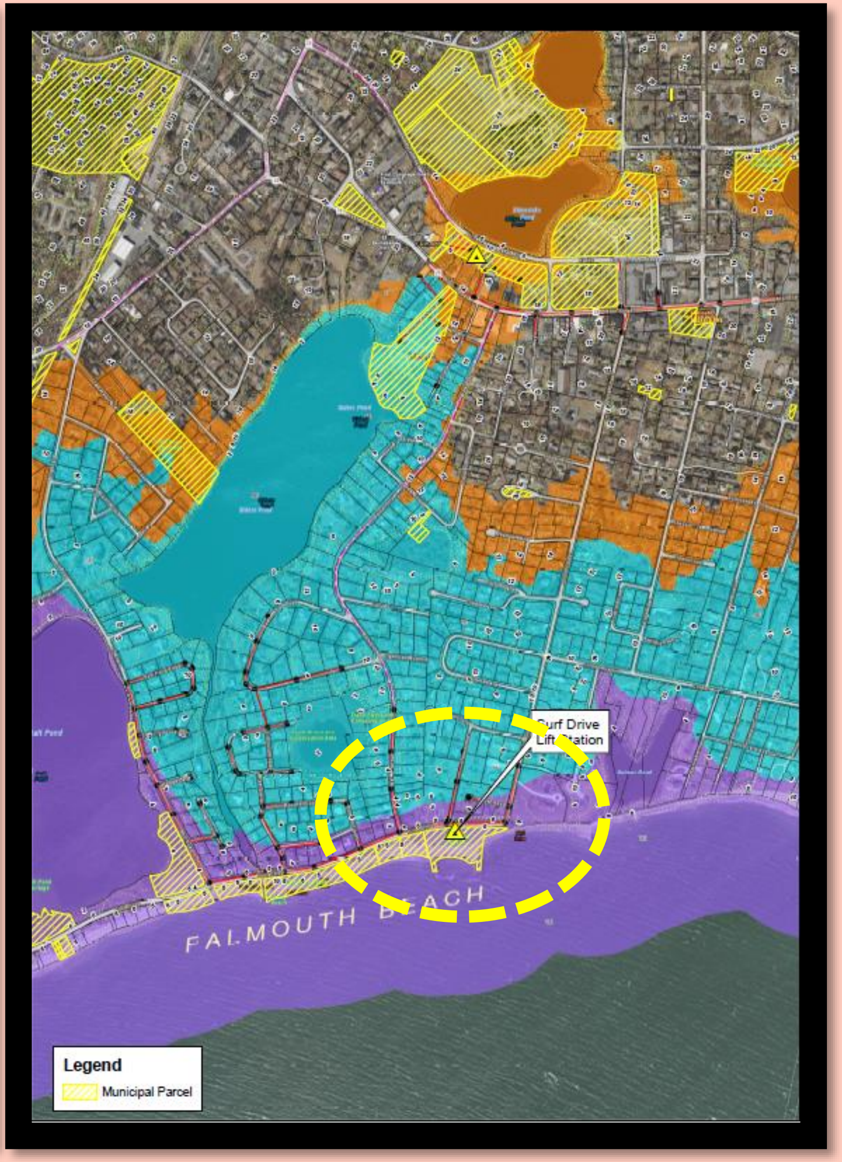
Lift Station Flood Proofing Cost Estimates
DRAFT

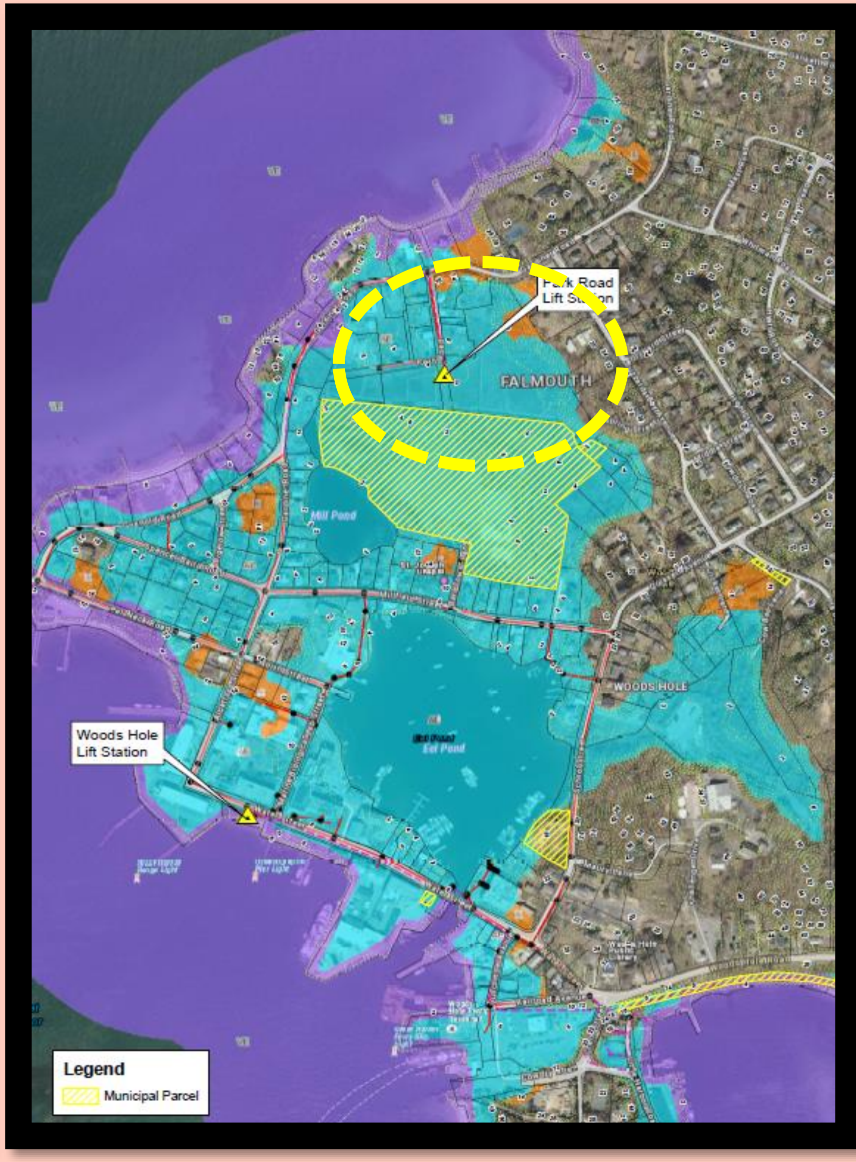
Lift Station	Capital Cost Estimates (2022$)
Woods Hole	$150,000
Falmouth Beach	$150,000
Inner Harbor	$ 80,000

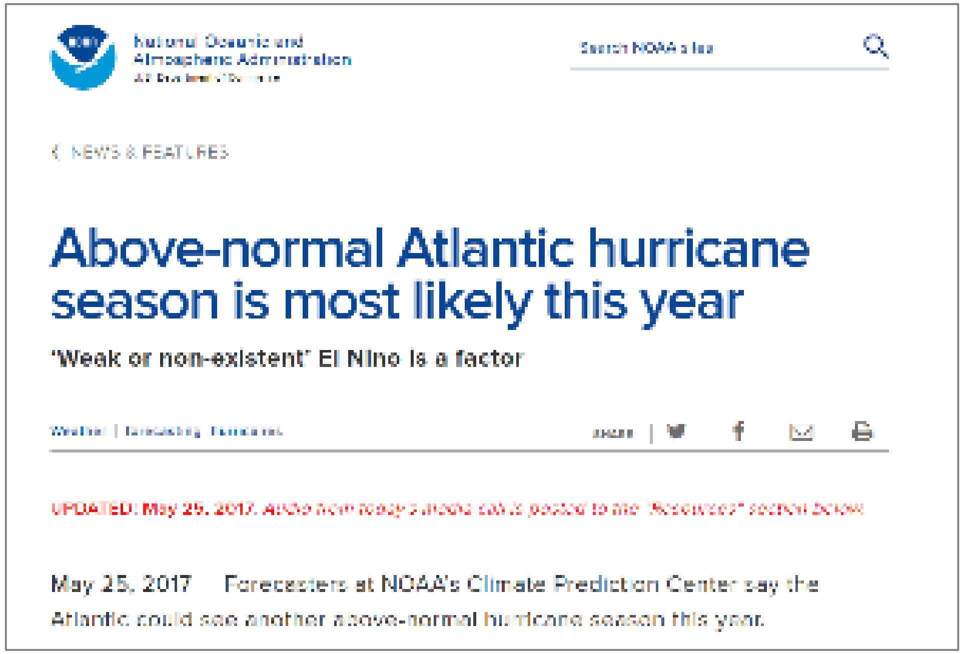
Sealing existing manholes from inflow is additional cost, not included

Lift Stations Without Superstructures









National Oceanic and Atmospheric Administration

NEWS & FEATURES

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'Weak or non-existent' El Nino is a factor

UPDATED: May 25, 2017.

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Summary

Towns can get creative in using grant funding for some of this work – and to get this finally implemented!

Impact majority of critical infrastructure in coastal communities

Increasing importance of flood proof mitigation measures to strengthen resilience of critical infrastructure

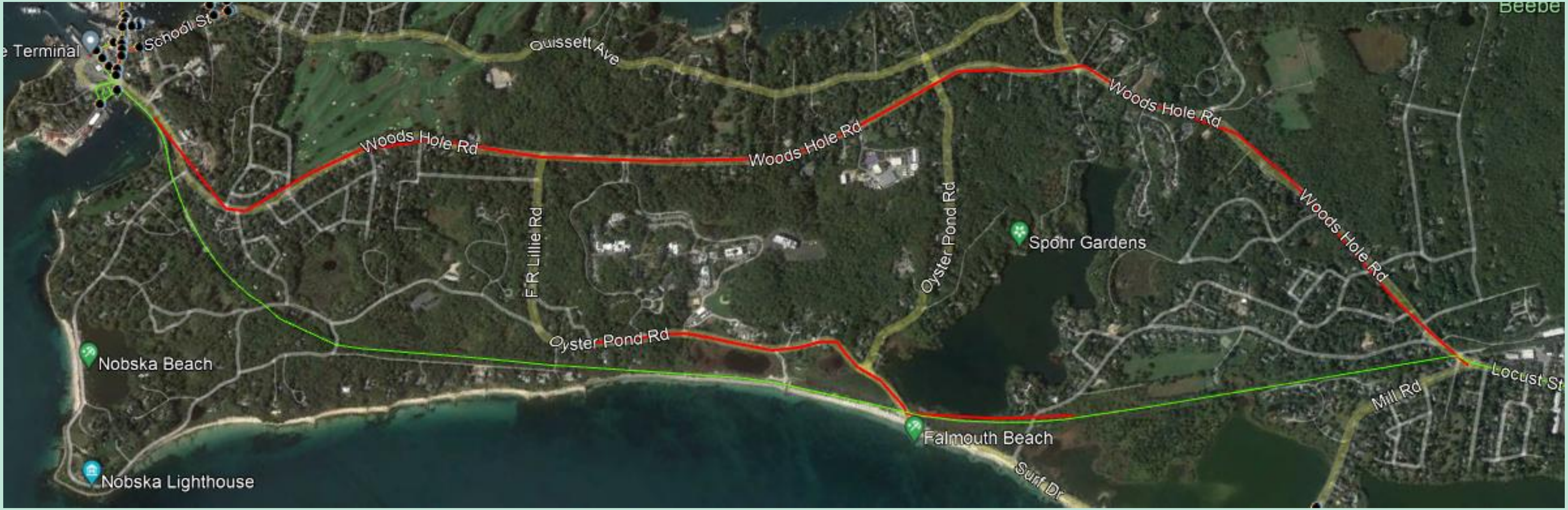
Evaluation methodology

HAZUS – a nationally applicable standardized methodology that contains models for estimating potential losses from earthquakes, floods, hurricanes, and tsunamis. Hazus uses Geographic Information Systems (GIS) technology to estimate physical, economic, and social impacts of disasters.

BCA 5.1 – Benefit Cost Analysis was developed using the FEMA software program BCA 5.1. This software analyzes proposed project costs and benefits, and produces a benefit-cost ratio (BCR). This model considered many factors including the local environment, critical facilities served and interdependency of pump stations.

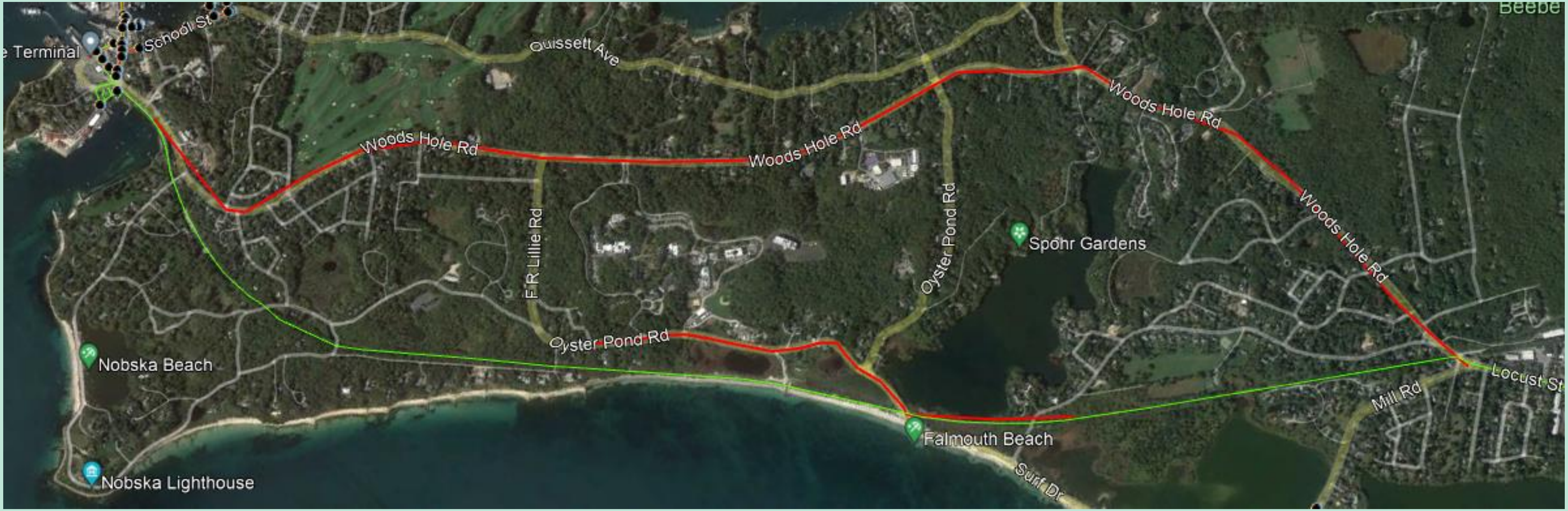
Woods Hole Force Main Options

1) Relocate most vulnerable section to Oyster Pond Road



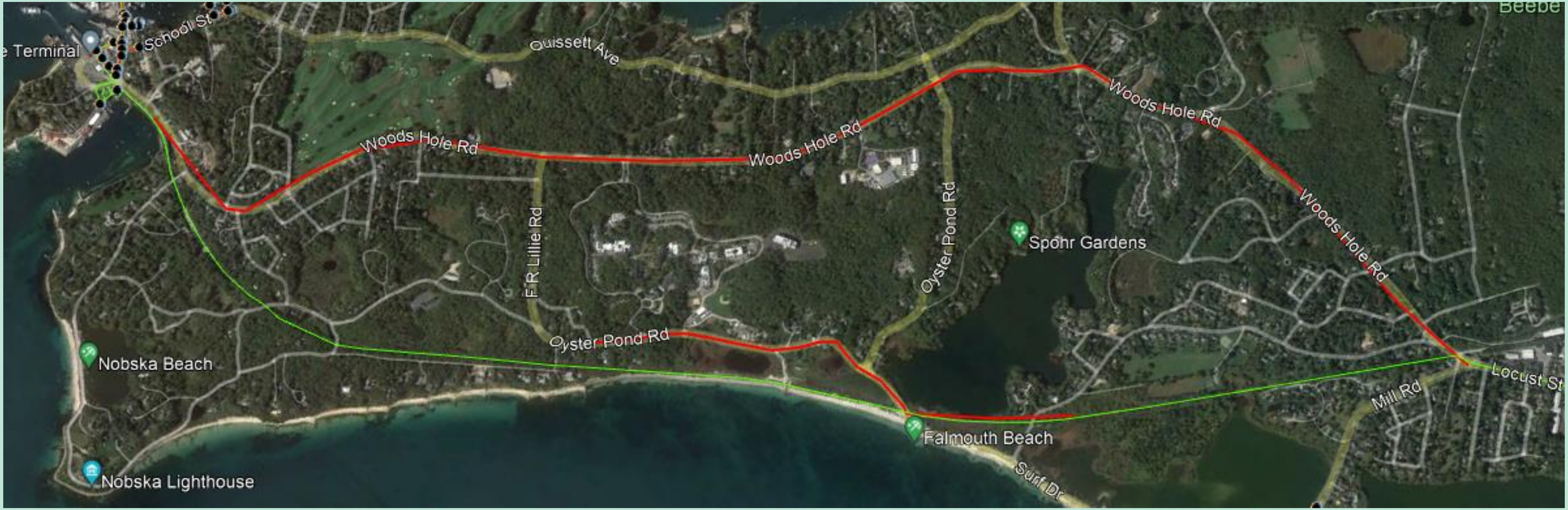
Woods Hole Force Main Options

2) Relocate most of coastal section inland via FR Lillie and Woods Hole Rd



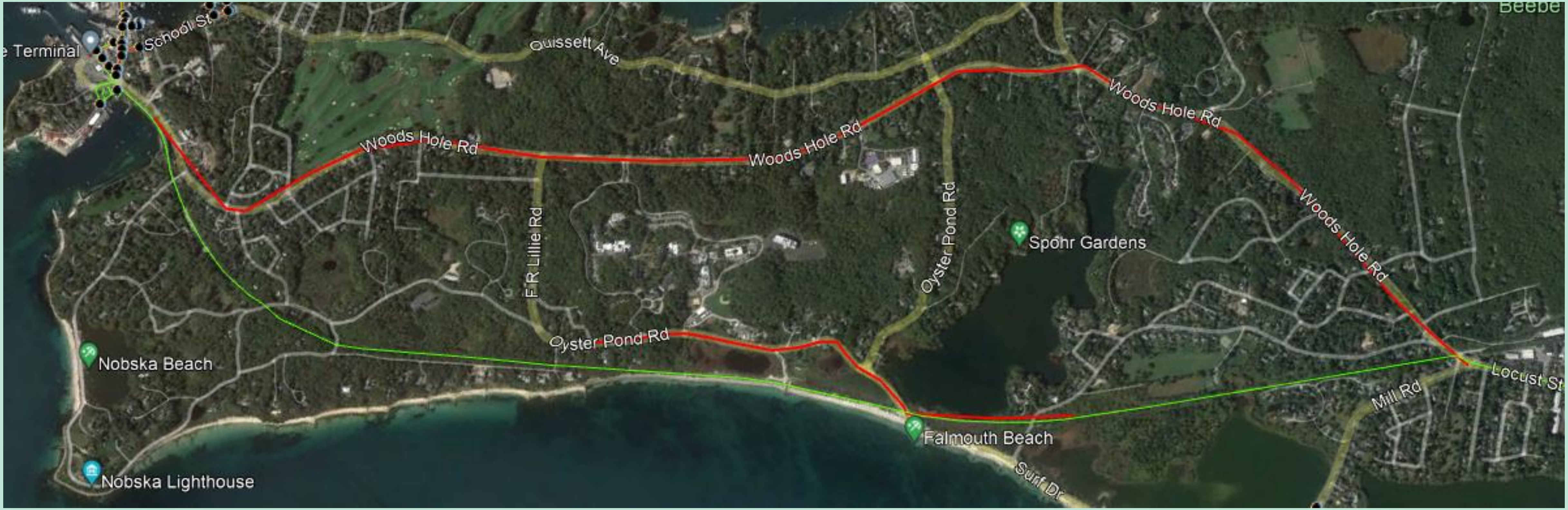
Woods Hole Force Main Options

3) Relocate entire coastal section inland to Woods Hole Road



Woods Hole Force Main Options

4) Directionally drill new HDPE pipe at depth under current location



Woods Hole Force Main Evaluation Matrix

Option	Length (feet)	Cost (millions, 2022$)	Pro	Con
Relocate most vulnerable section to Oyster Pond Rd	4,500	$4.0	Shortest relocation, lower cost	Future erosion potential if bike path/ Surf Drive abandoned
Relocate large section to F.R. Lillie and Woods Hole Rds	14,000	$11.5	Relocates all vulnerable sections	Higher cost, higher disturbance
Relocate entire southern section to Woods Hole Rd	16,000	$12.9	Complete replacement, no gap	Highest cost, most disturbance
Directional drill pipe ~ 40 ft under current bike path	5,000	$4.6	Least disturbance, lower cost	New pipe will be inaccessible, under receding shoreline