Town of Hingham
Climate Change Vulnerability, Risk Assessment and Adaptation Study

Conservation Commission/Planning Board Update
July 20, 2015

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Today's Agenda

- Overview of Project Methodology
- Review of Flood Modeling Results
- Vulnerability Assessments
- Photo Renderings
- Natural Resources Evolution
- Adaptation Strategies and Costs
- Review of Policies and Regulations

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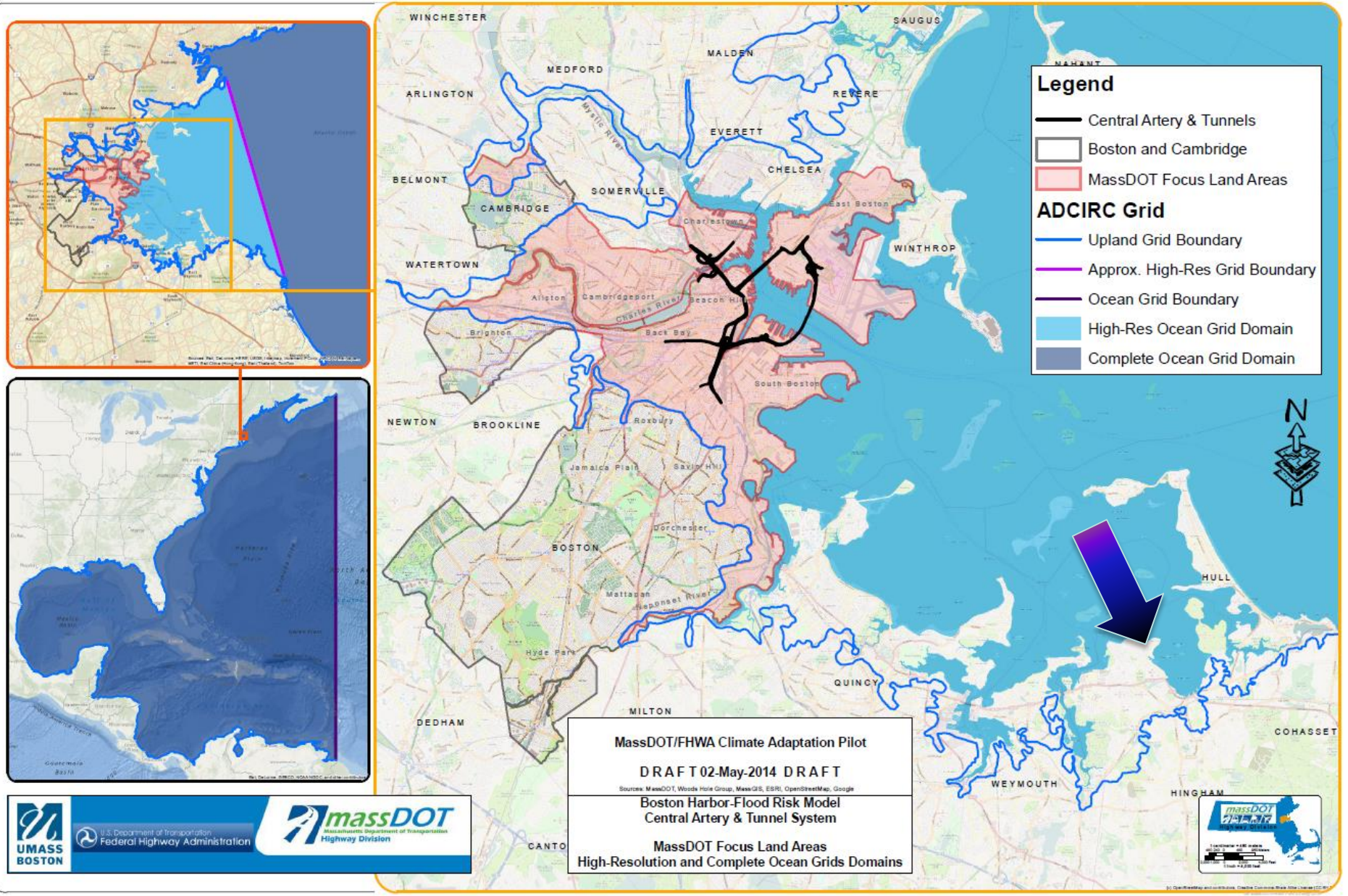
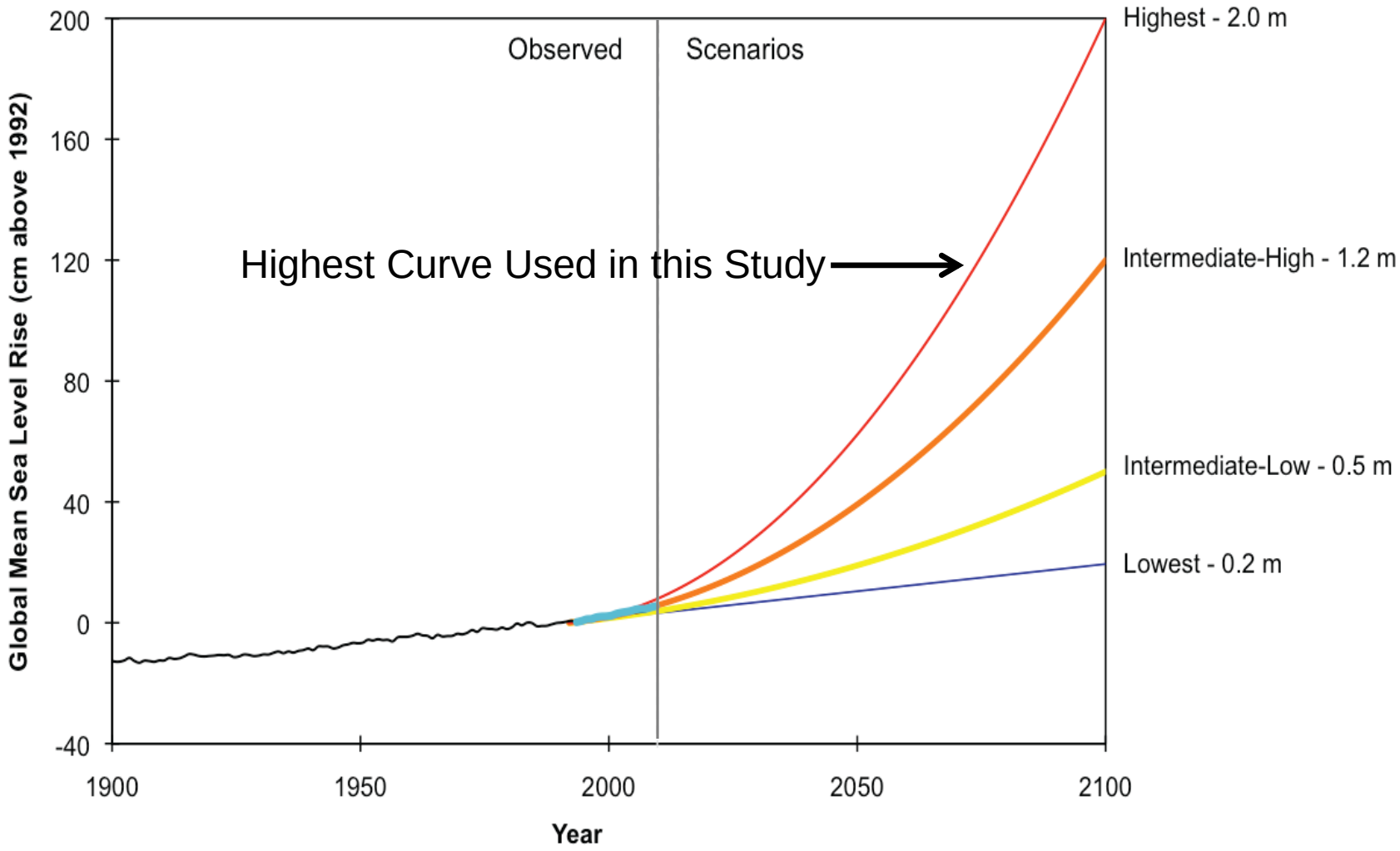
A Detailed Water Surface Model



UMASS BOSTON
U.S. Department of Transportation Federal Highway Administration
massDOT Massachusetts Department of Transportation Highway Division

Global Mean Sea Level Rise Projections



NOAA Technical Report *Global Sea Level Rise Scenarios for the United States National Climate Assessment*, December 2012

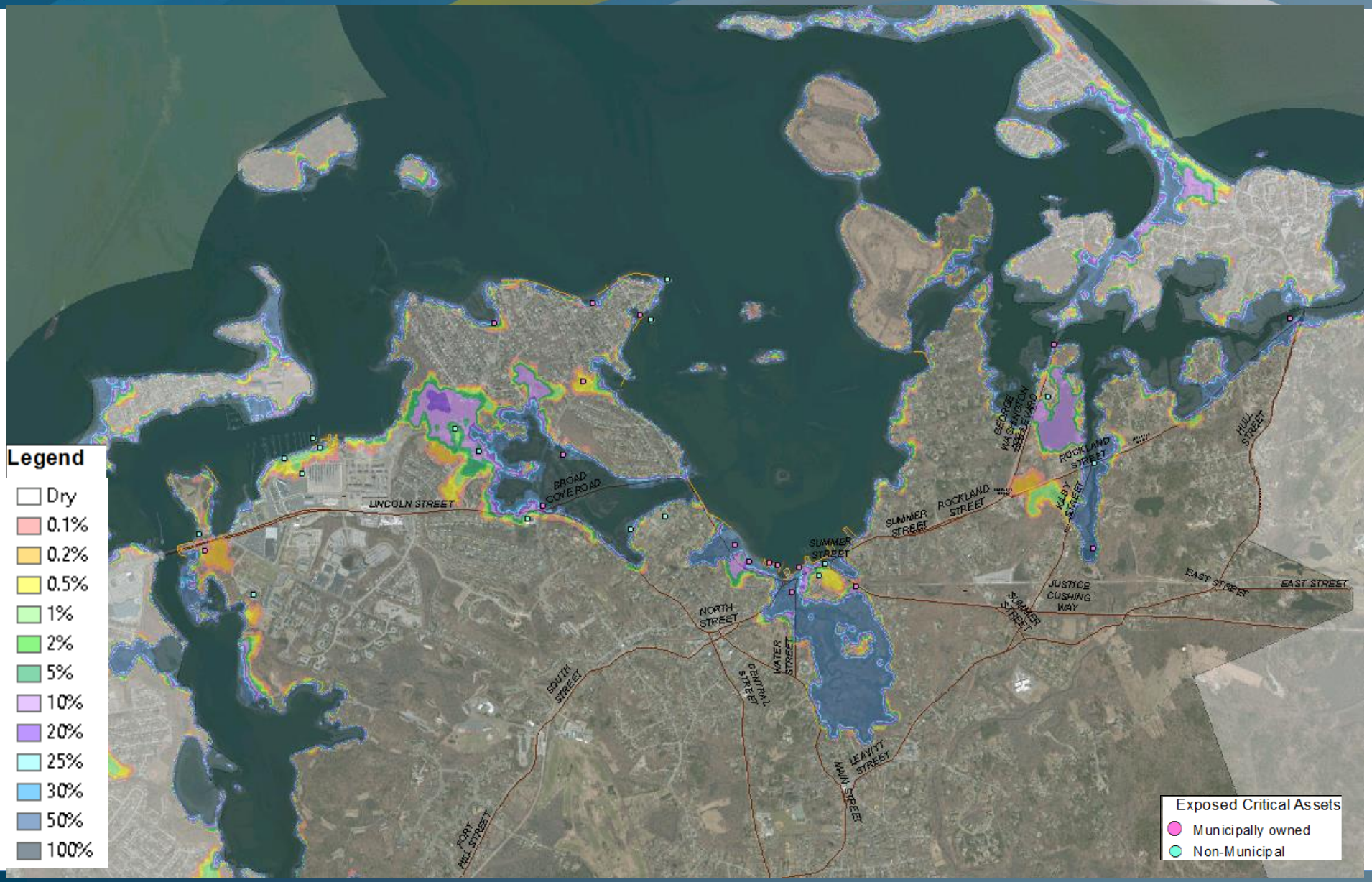
Planning Horizons

- **2015 - Present**
- **2030 – 15 years out – Near term**
- **2070 – 55 years out – Long term**

Flood Modeling Results

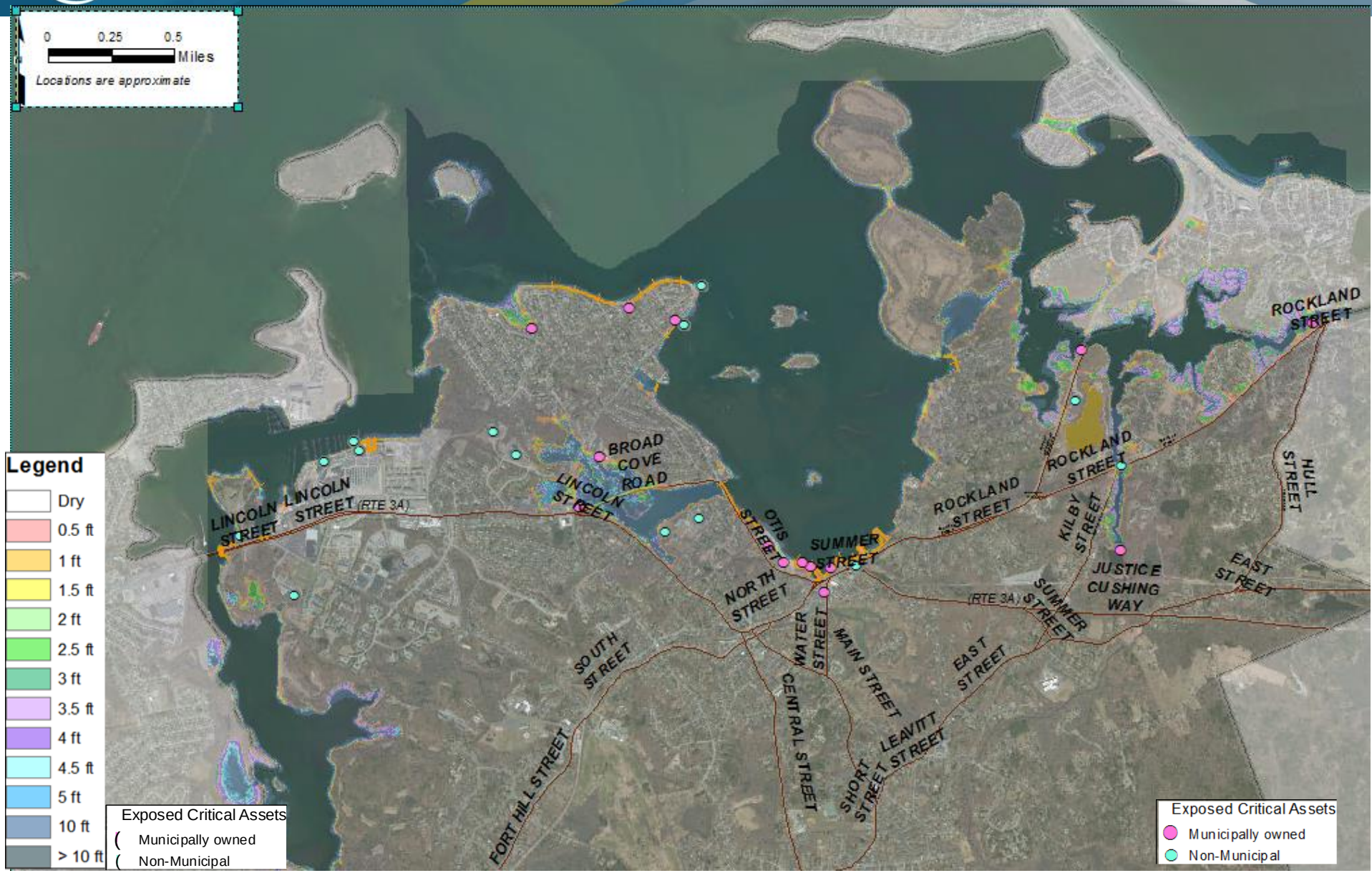
2030 – Risk of Flooding Map

2070 – Risk of Flooding Map

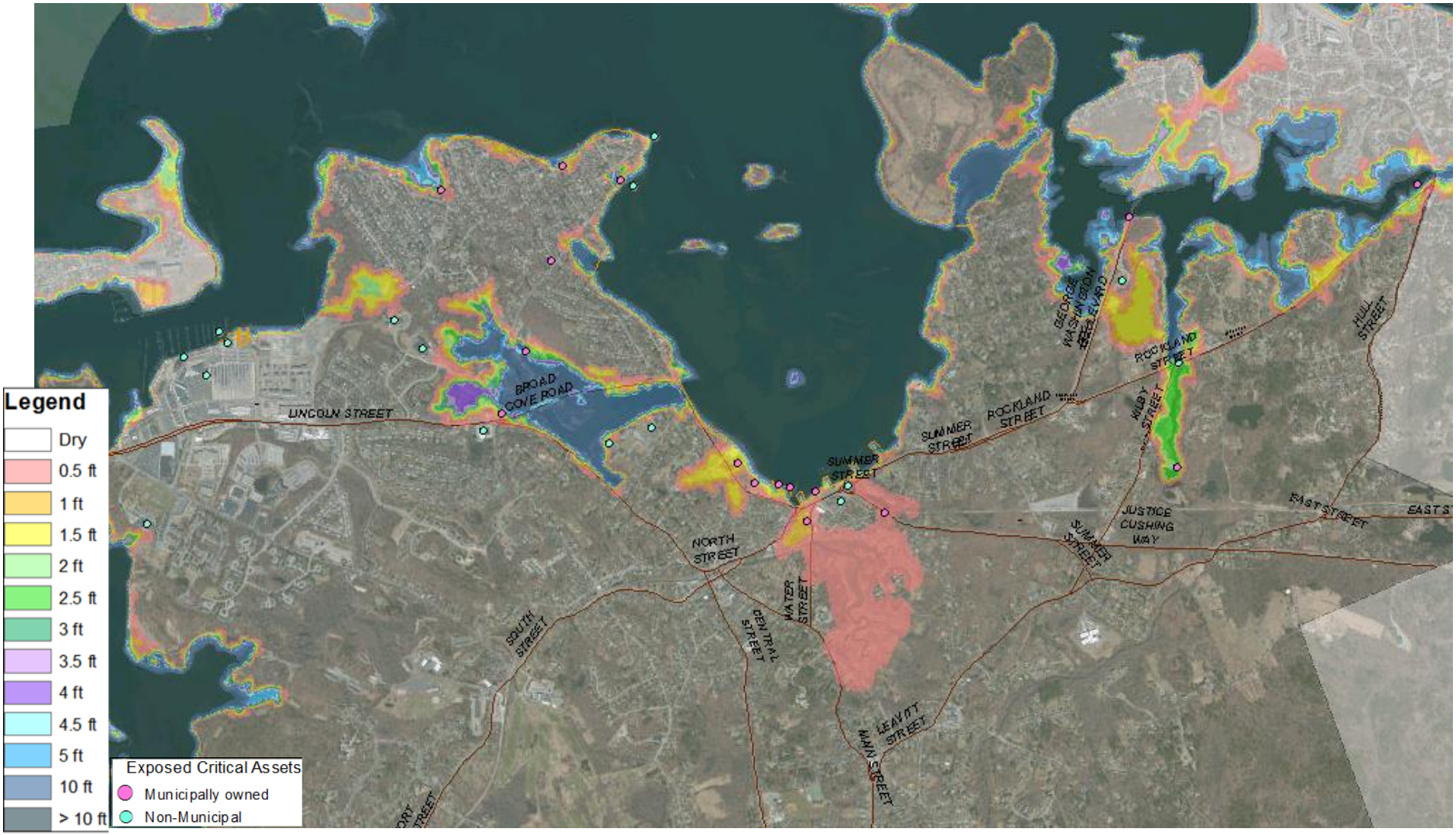


Sea Level Rise - 2030

Sea Level Rise - 2070

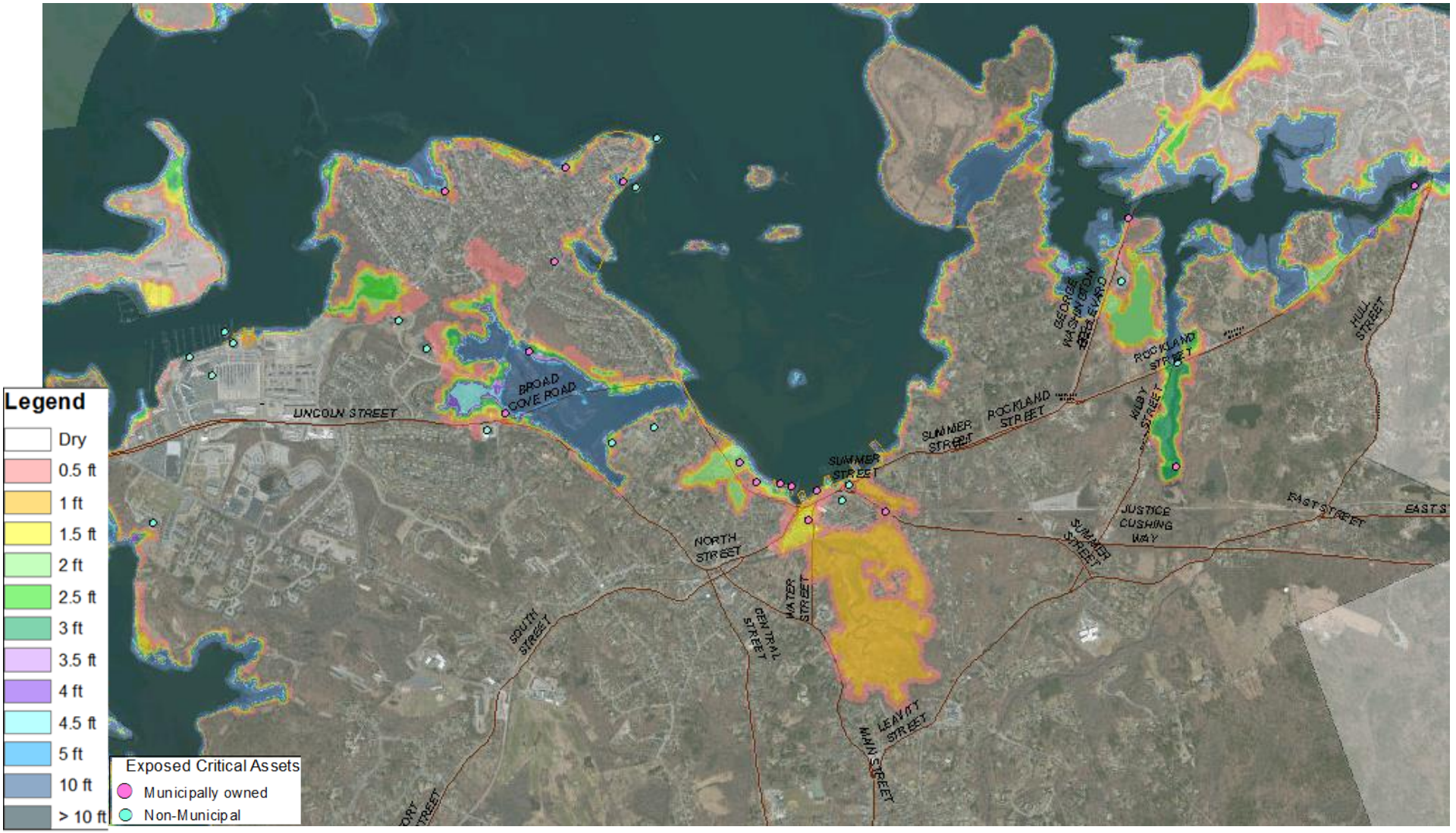


2030: 1% Annual Probability (≈100 yr Recurrence)



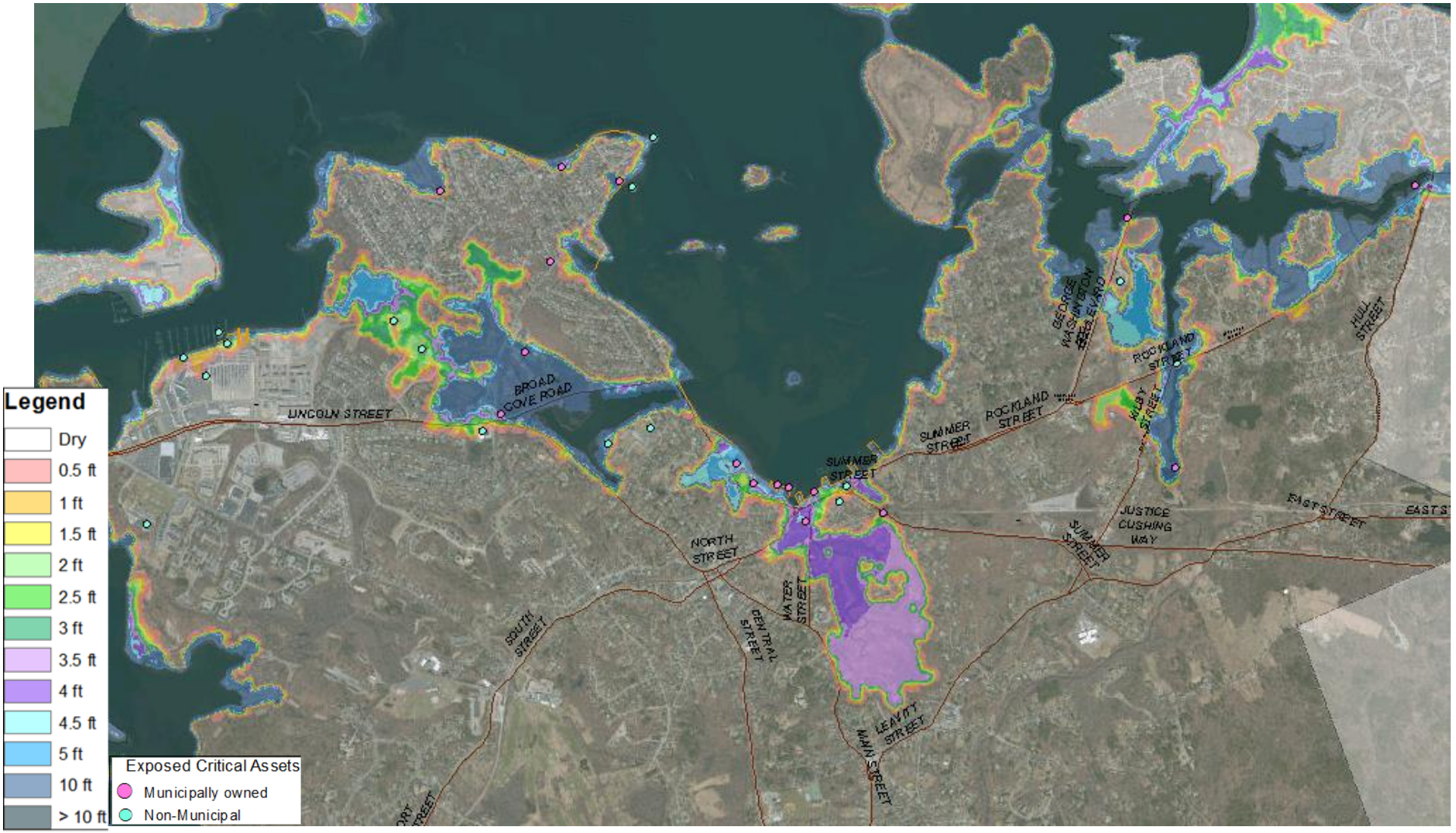
Depth of Flooding above Ground

2030: 0.2% Annual Probability (≈500 yr Recurrence)



Depth of Flooding above Ground

2070: 1% Annual Probability (≈100 yr Recurrence)



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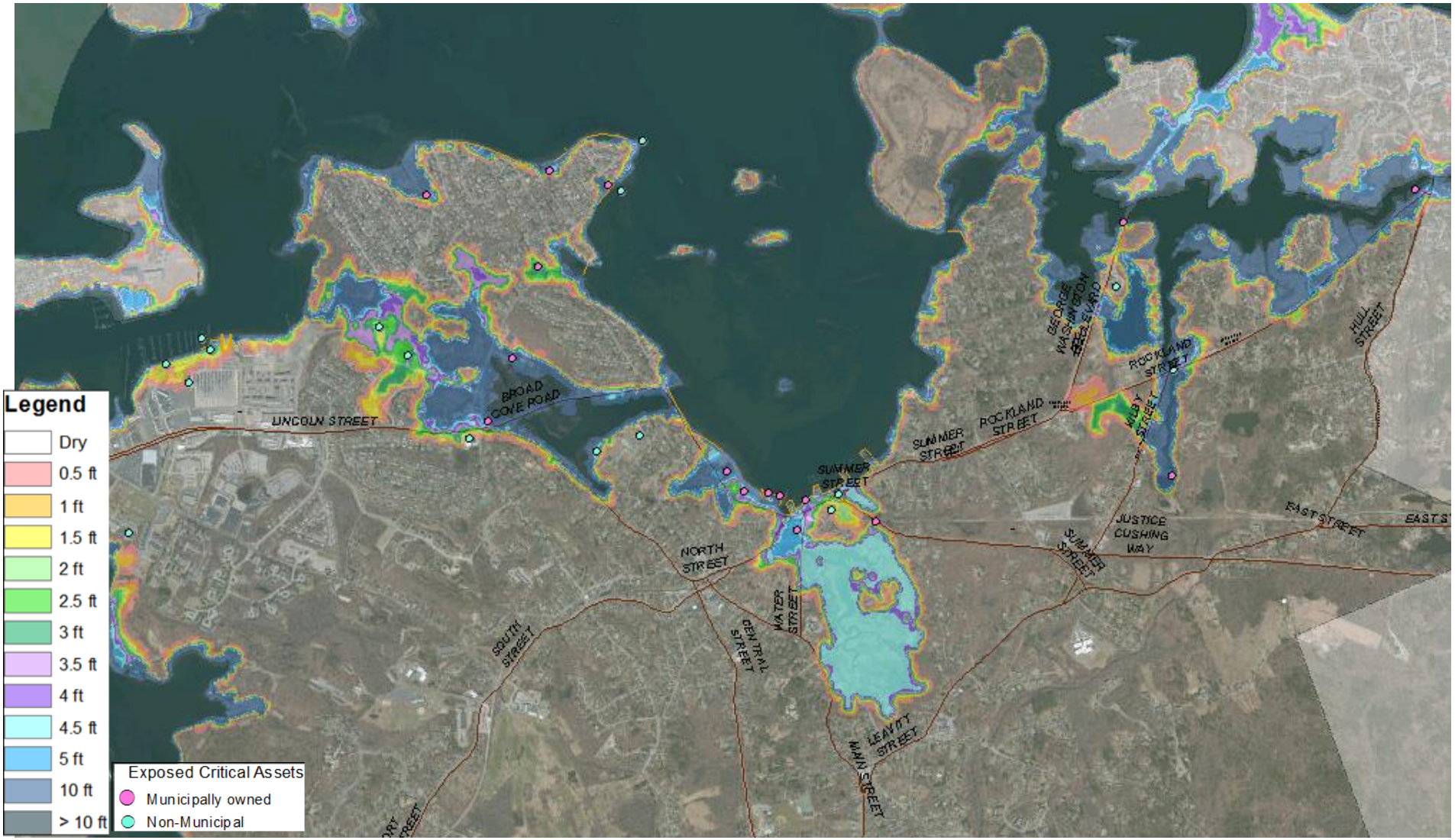
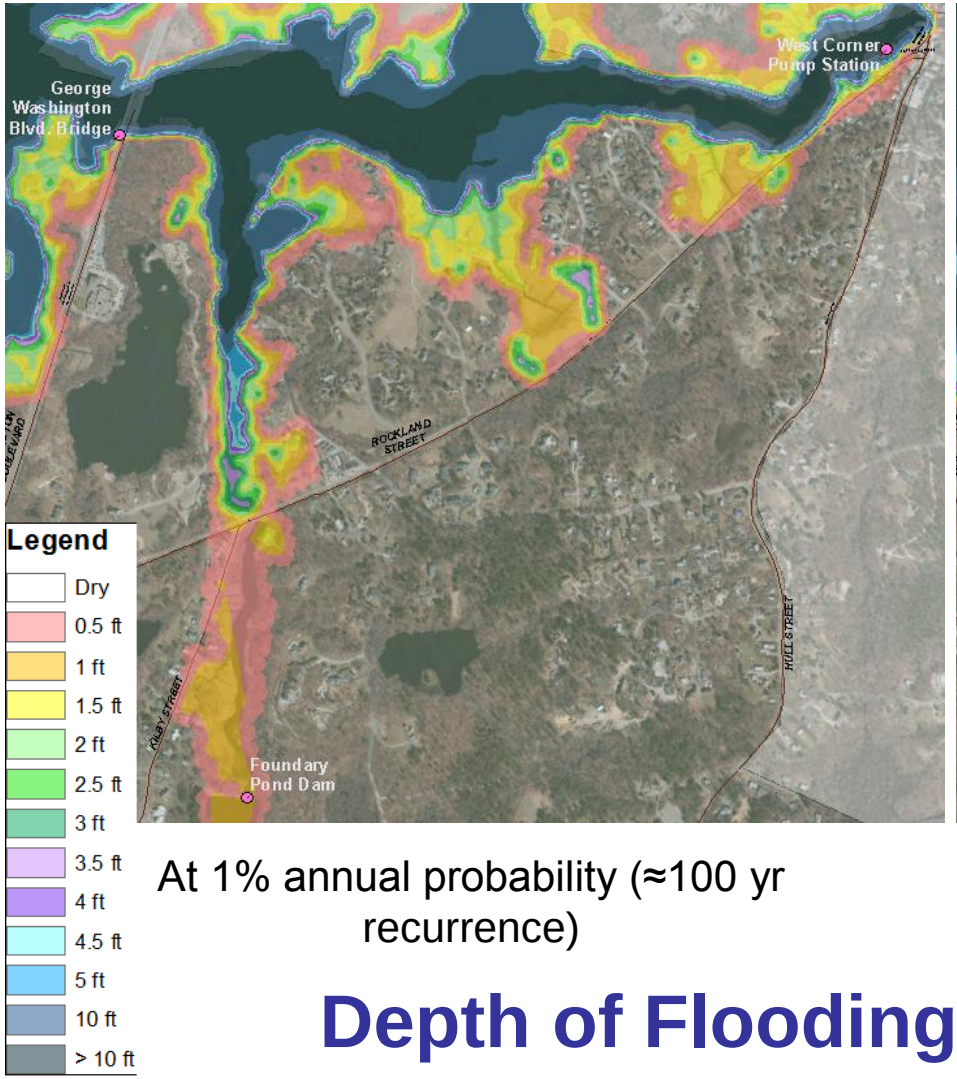
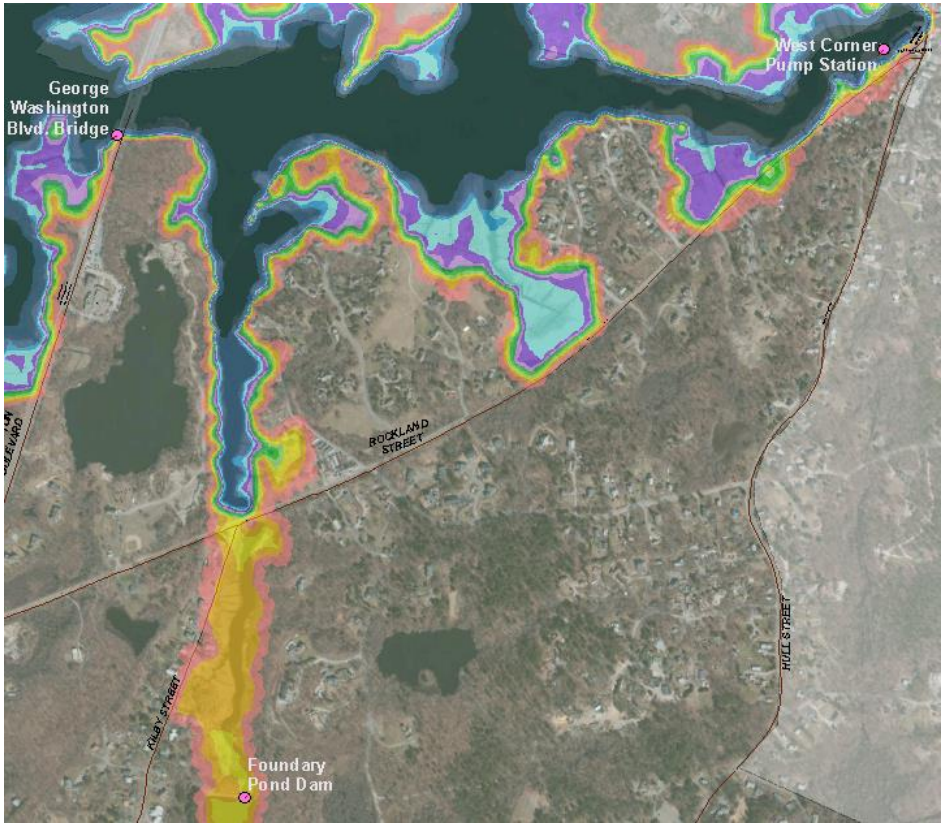


Depth of Flooding above Ground

Present Inundation: Hingham-Hull Connectors



At 1% annual probability (≈100 yr recurrence)



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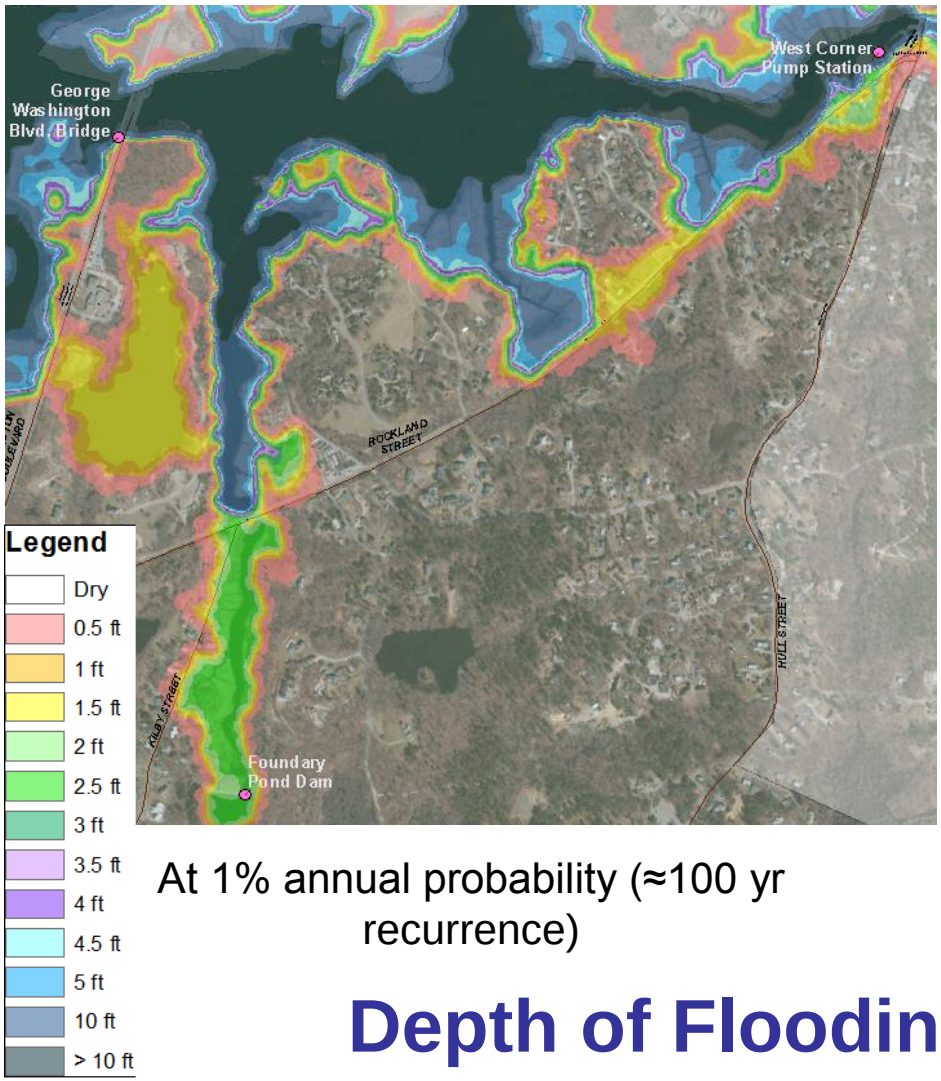
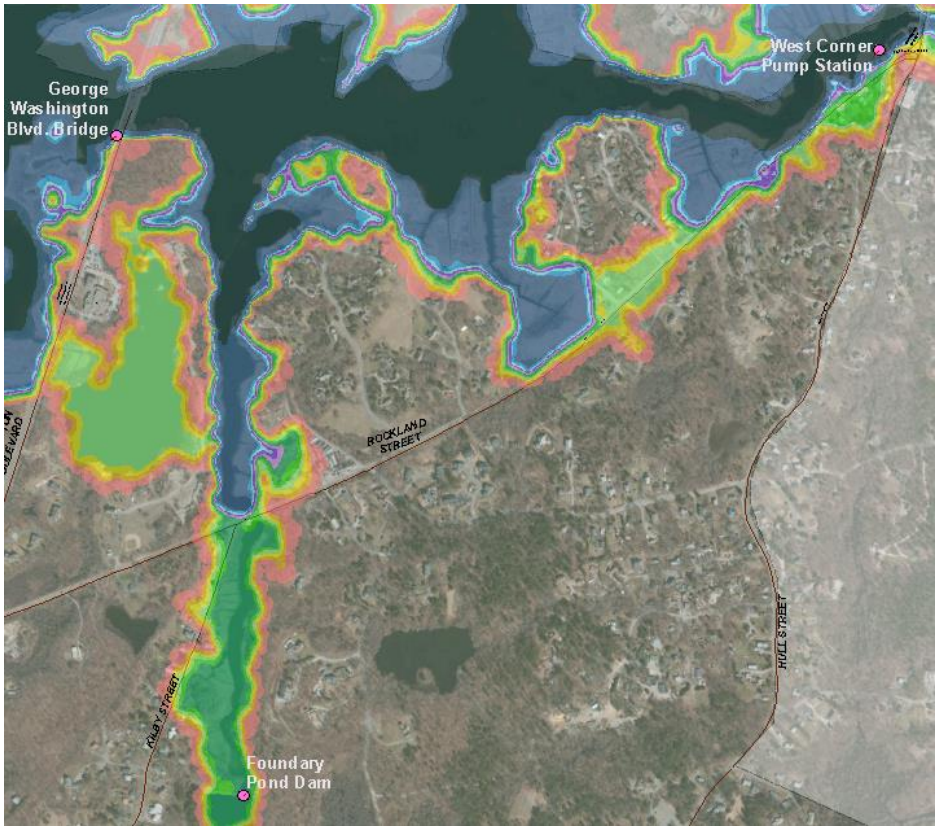
Depth of Flooding above Ground

2030 Inundation: Hingham-Hull Connectors



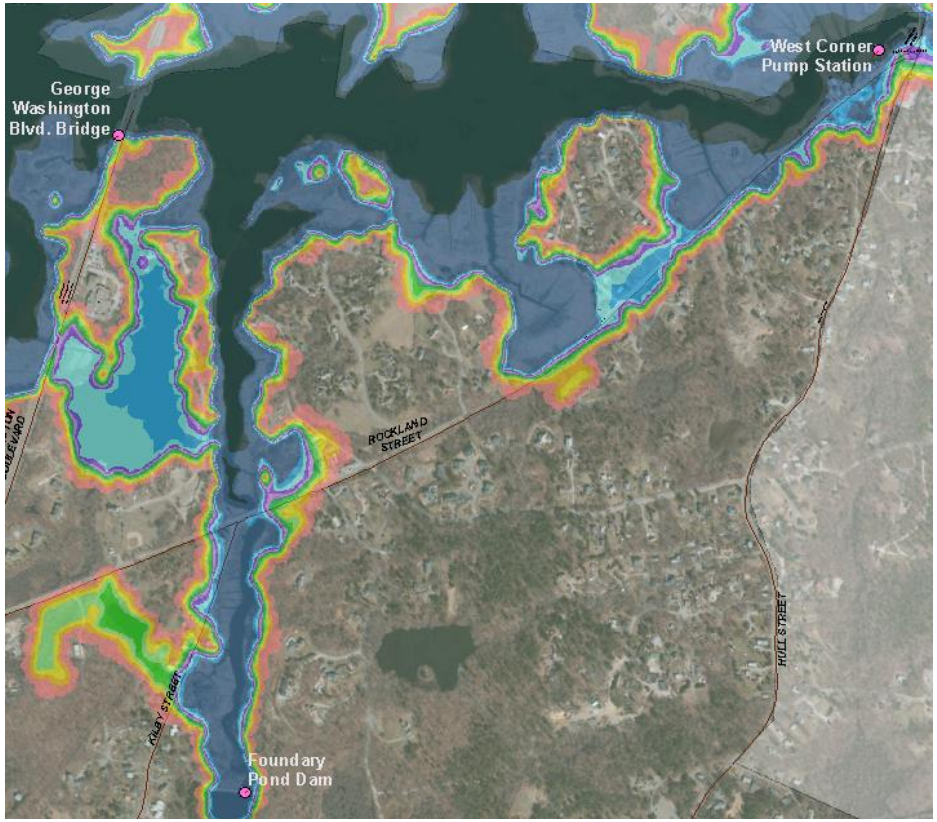
At 1% annual probability (≈100 yr recurrence)



At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

2070 Inundation: Hingham-Hull Connectors



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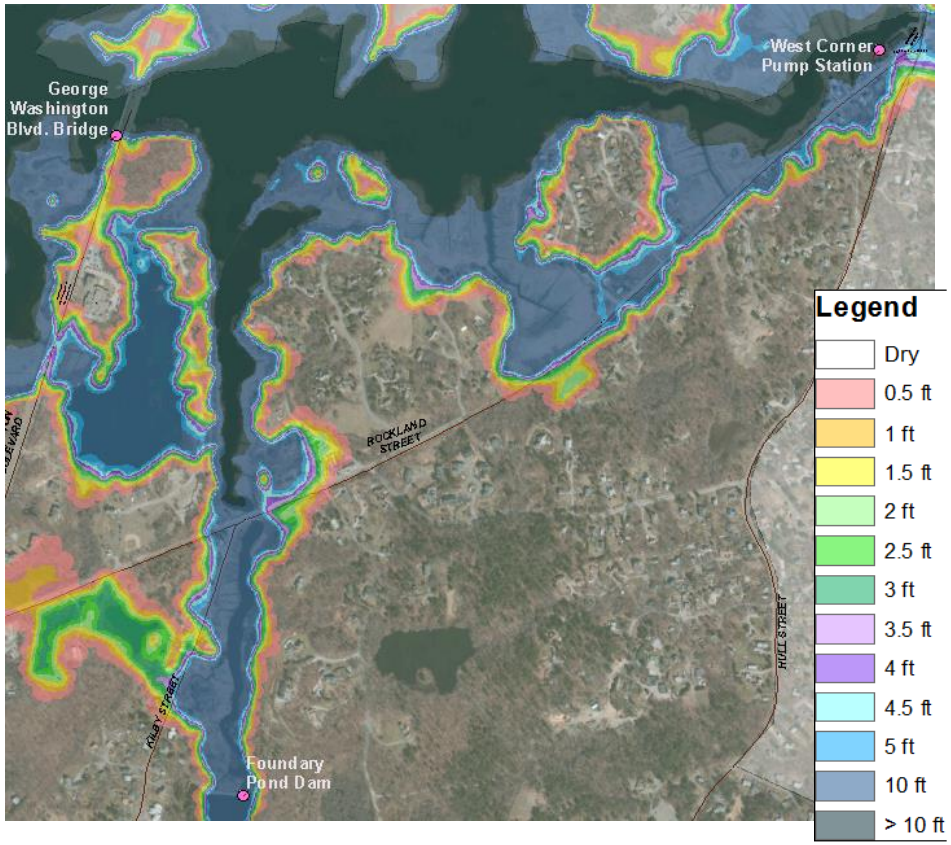
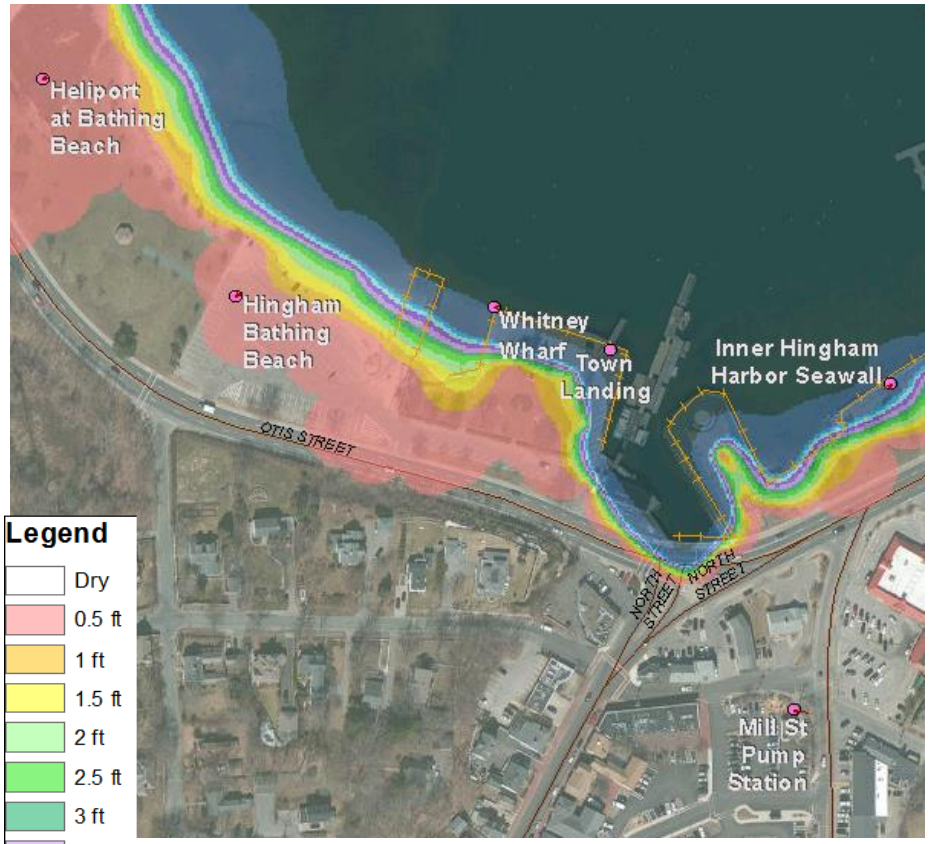


At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

Present Inundation: Inner Hingham Harbor

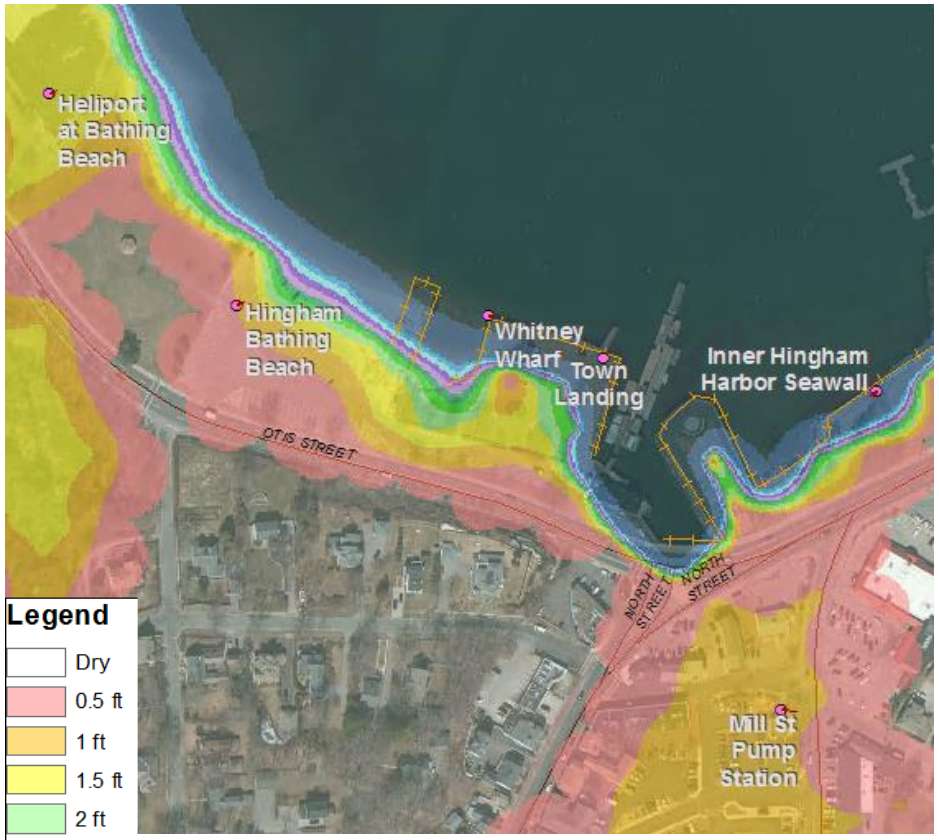


At 1% annual probability (≈100 yr recurrence)

At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

2030 Inundation: Inner Hingham Harbor



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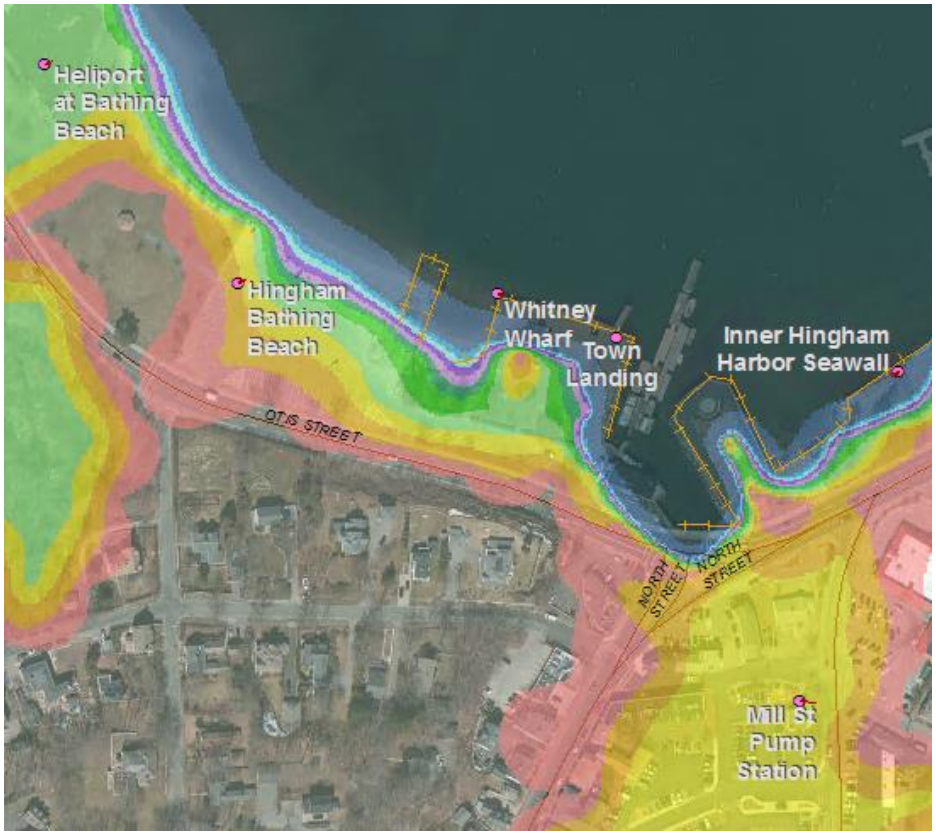
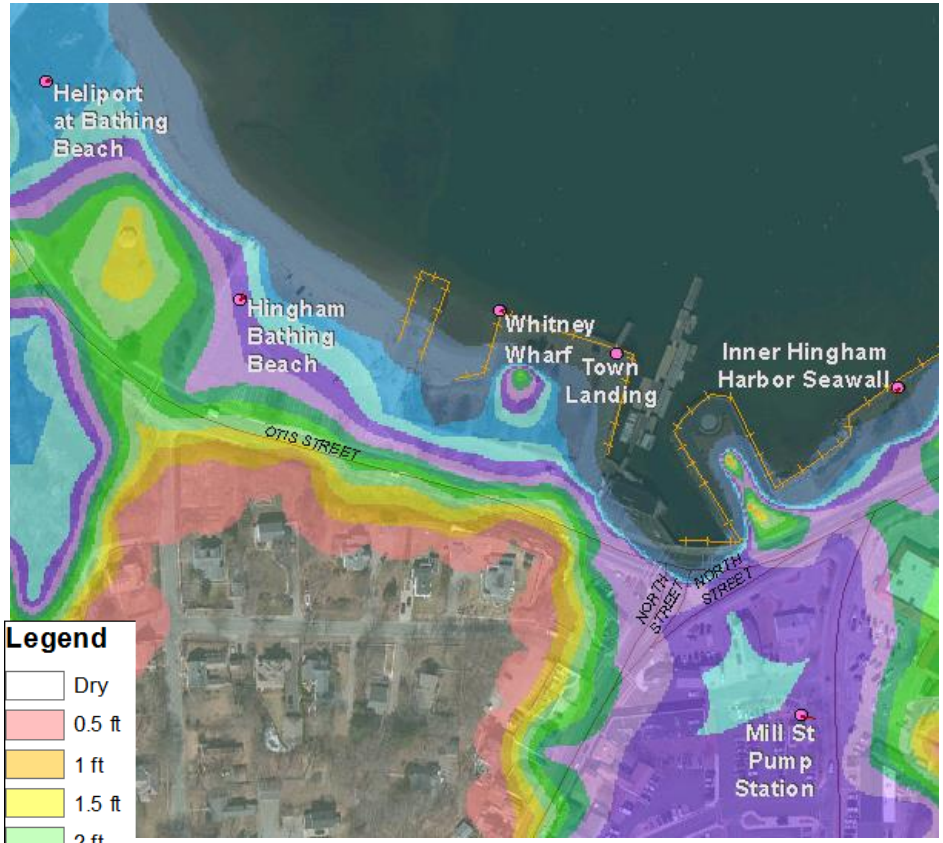


At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

2070 Inundation: Inner Hingham Harbor

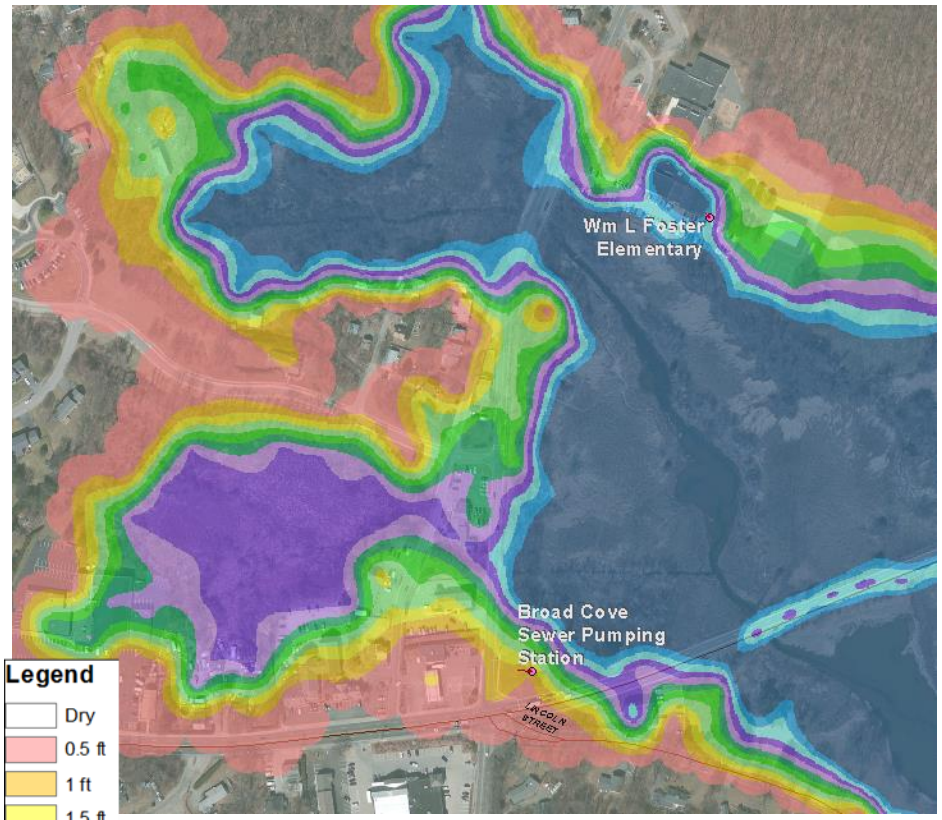


At 1% annual probability (≈100 yr recurrence)

At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

2030 Inundation: Foster Elementary and Broad Cove PS



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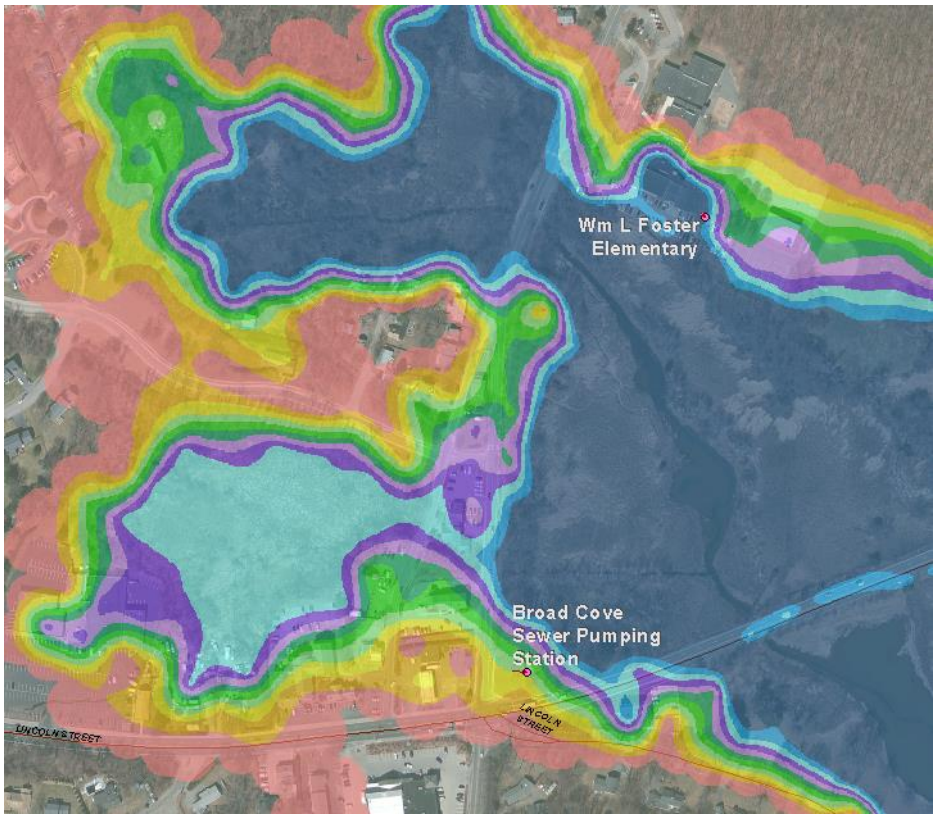
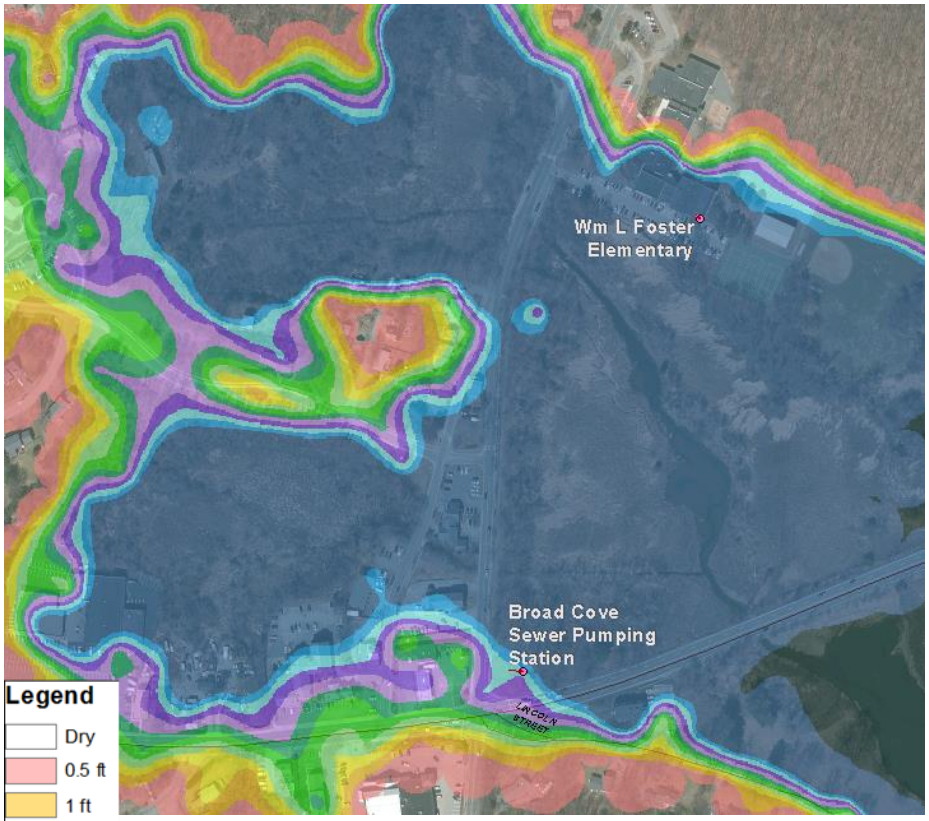


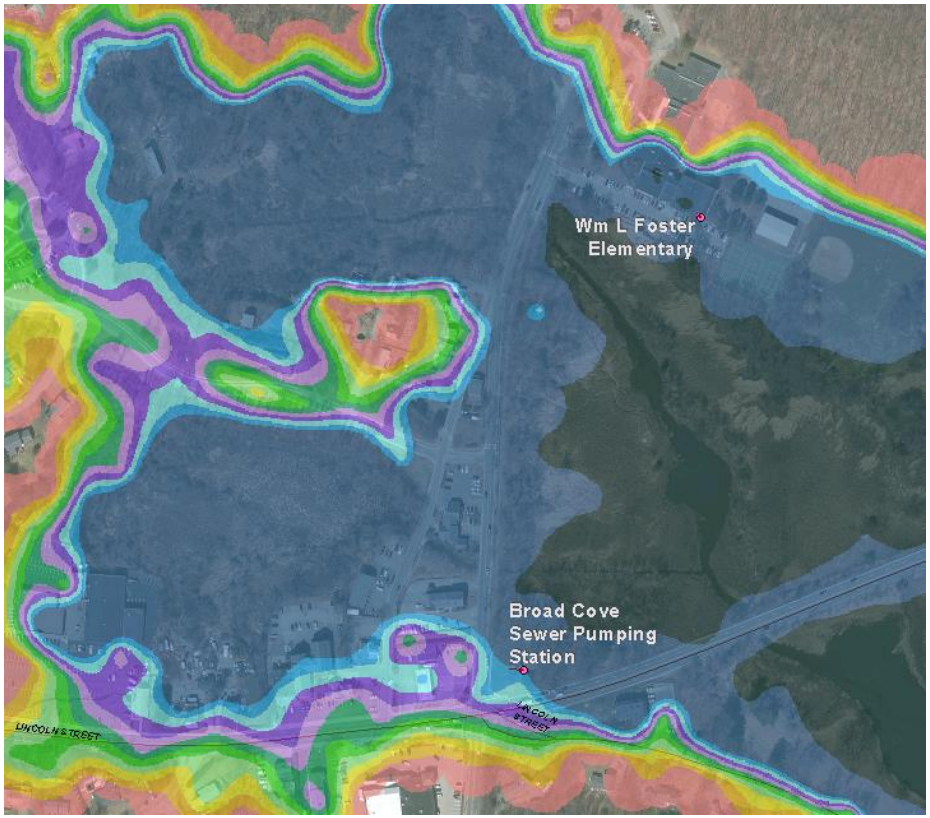
At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

2070 Inundation: Foster Elementary and Broad Cove PS



At 1% annual probability (≈100 yr recurrence)



At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

Risk Based Vulnerability Assessment

Risk Based Vulnerability Assessment

For each infrastructure asset, assess:

Risk (R) = Probability of Flooding (P) x Consequence of Flooding (C)

R = P X C

Probability of Exceedence Data

Mill Street Pump Station

Critical Elevation Threshold = **8.69 ft. NAVD88**

	Present		2030		2070	
% Probability	Flood elevation	Depth above critical elev.	Flood elevation	Depth above critical elev.	Flood elevation	Depth above critical elev.
0.1	dry	0	11.8	3.11	14.1	5.41
0.2	dry	0	11.5	2.81	14	5.31
0.5	dry	0	11	2.31	13.5	4.81
1	dry	0	10.3	1.61	12.8	4.11
2	dry	0	10	1.31	12.5	3.81
5	dry	0	9.3	0.61	12.1	3.41
10	dry	0	dry	0	11.5	2.81
20	dry	0	dry	0	11.1	2.41
25	dry	0	dry	0	10.9	2.21
30	dry	0	dry	0	10.8	2.11
50	dry	0	dry	0	9.3	0.61
100	dry	0	dry	0	dry	0

Consequence of Failure Score

Rating	Area of Service Loss	Duration of Service Loss	Cost of Damage	Impact on Public Safety & Emergency Services	Impact on Important Economic Activities	Impact on Public Health & Environment
5	Whole town/city	> 30 days	> $10m	Very high	Very high	Very high
4	Multiple neighborhoods	14 - 30 days	$1m - $10m	High	High	High
3	Neighborhood	7 - 14 days	$100k - $1m	Moderate	Moderate	Moderate
2	Locality	1 - 7 days	$10k - $100k	Low	Low	Low
1	Property	< 1 day	< $10k	None	None	None

Mill St. Pump Station

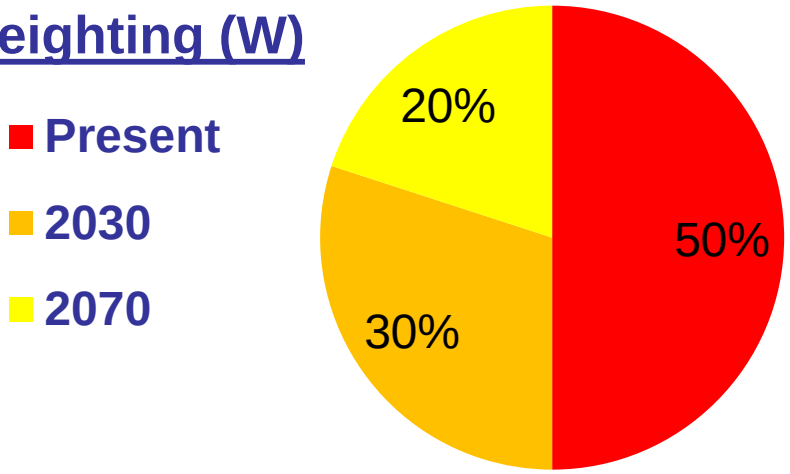
	Area of Service Loss	Duration of Service Loss	Cost of Damage	Impacts to Public Safety Services	Impacts to Economic Activities	Impacts to Public Health/ Environment	Consequence score
Rating	2	4	2	1	5	5	63

Calculate Risk Scores and Rankings

$$R_{tn} = P_{tn} \text{ X } C_{tn}$$

$$R_{composite} = R_{pres.}(W_{pres.}) + R_{2030}(W_{2030}) + R_{2070}(W_{2070})$$

Weighting (W)



Risk Scores and Rankings

Example - Mill Street Pump Station

	Probability of Exceedance	Consequence Score	Risk Score	Weight	Composite Risk Score
Present	0	63	0	0.5	728
2030	5	63	317	0.3	
2070	50	63	3167	0.2	

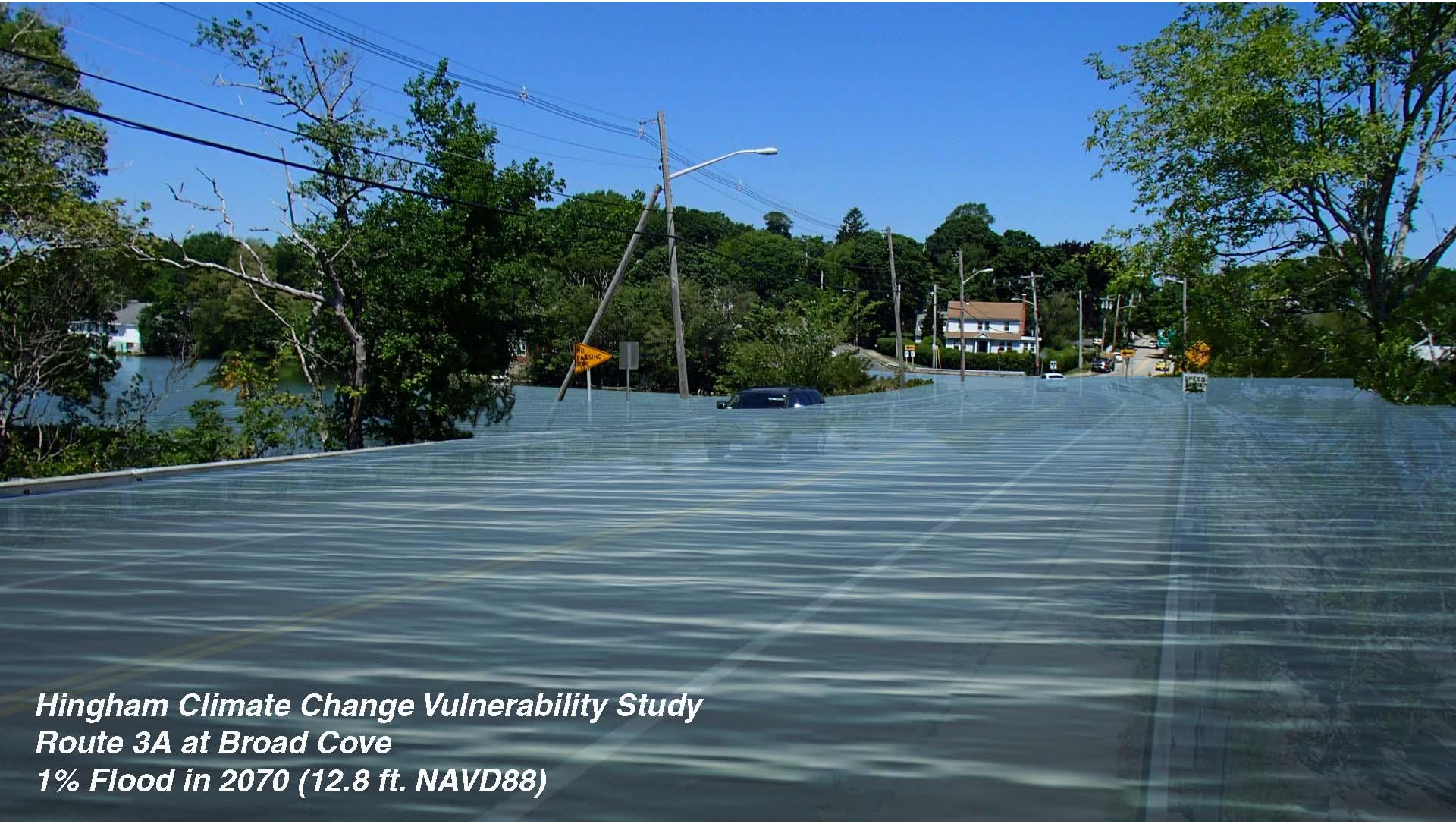
Top 20 Assets Subject to Flooding Ranked by Composite Risk Score

Asset Name	Type	Consequence Score	Present Probability (%)	2030 Probability (%)	2070 Probability (%)	Composite Risk Score
Walton Cove 034-027-000-059-100	Bulkhead/ Seawall	37	100	100	100	3667
Iron Horse Park Area 034-051-000-003-100	Bulkhead/ Seawall	60	25	50	100	2850
Iron Horse Park Area 034-051-000-005B-200	Bulkhead/ Seawall	57	30	50	100	2833
Bridge Street 034-045-000-002-100	Revetment	50	30	50	100	2500
Iron Horse Park Area 034-051-000-059-100	Bulkhead/ Seawall	33	50	50	100	2000
Iron Horse Park Area 034-051-000-001-200	Bulkhead/ Seawall	60	5	30	100	1890
Bridge Street 034-045-000-002-200	Bulkhead/ Seawall	50	10	30	100	1700
Bridge Street 034-045-000-002-300	Revetment	50	10	30	100	1700
William L. Foster Elementary School	Facility	63	0	10	100	1457
Iron Horse Park Area 034-051-000-004-100	Bulkhead/ Seawall	60	2	10	100	1440
Iron Horse Park Area 034-050-000-050-200	Bulkhead/ Seawall	40	10	30	100	1360
Rockland St and Kilby St	Roadway	30	10	50	100	1200
Otis St (Rt 3A) at Hingham Bathing Beach	Roadway	50	1	10	100	1175
Martin's Well 034-030-000-011-100	Revetment	23	30	50	100	1167
Bridge Street 034-045-000-002-400	Groin/ Jetty	23	30	50	100	1167
Iron Horse Park Area 034-051-000-005-100	Bulkhead/ Seawall	50	1	10	100	1163
Broad Cove Entrance 034-039-000-009-100	Revetment	47	2	10	100	1120
West Corner Pump Station	Facility	50	1	5	100	1088
Broad Cove Rd (Rt 3A)	Roadway	47	0	10	100	1073
Beach Rd and Beach Ln	Roadway	33	5	25	100	1000

Photo Renderings

Rt. 3A at Broad Cove
2030 1% (100 YR)

Rt. 3A at Broad Cove
2070 1% (100 YR)



Hingham Climate Change Vulnerability Study
Route 3A at Broad Cove
1% Flood in 2070 (12.8 ft. NAVD88)

Rt. 3A - North St. to Water St. 2030 1% (100 YR)

Rt. 3A - North St. to Water St.
2070 1% (100 YR)

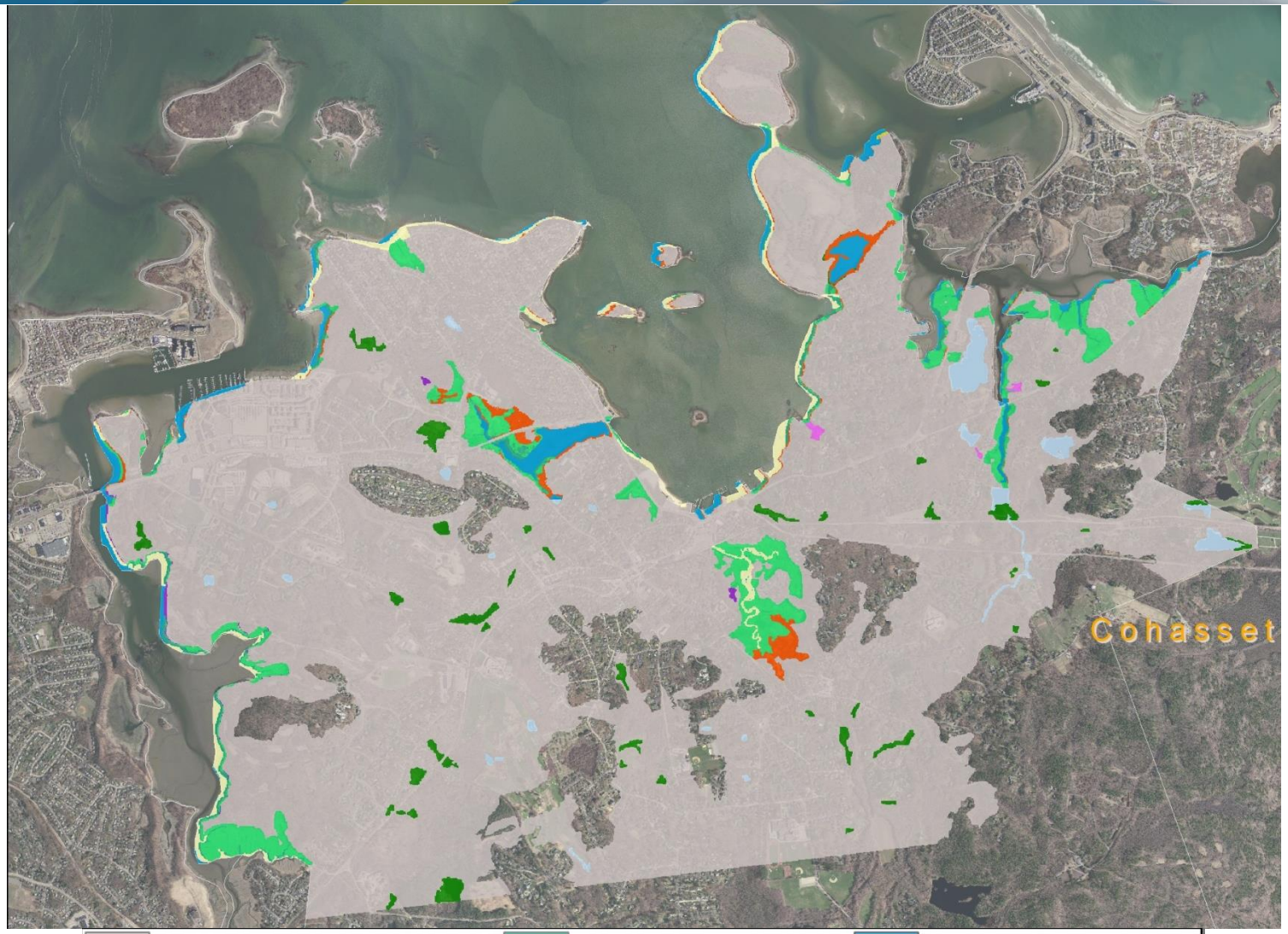
George Washington Blvd. 2070 1% (100 YR)

Natural Resources Evolution

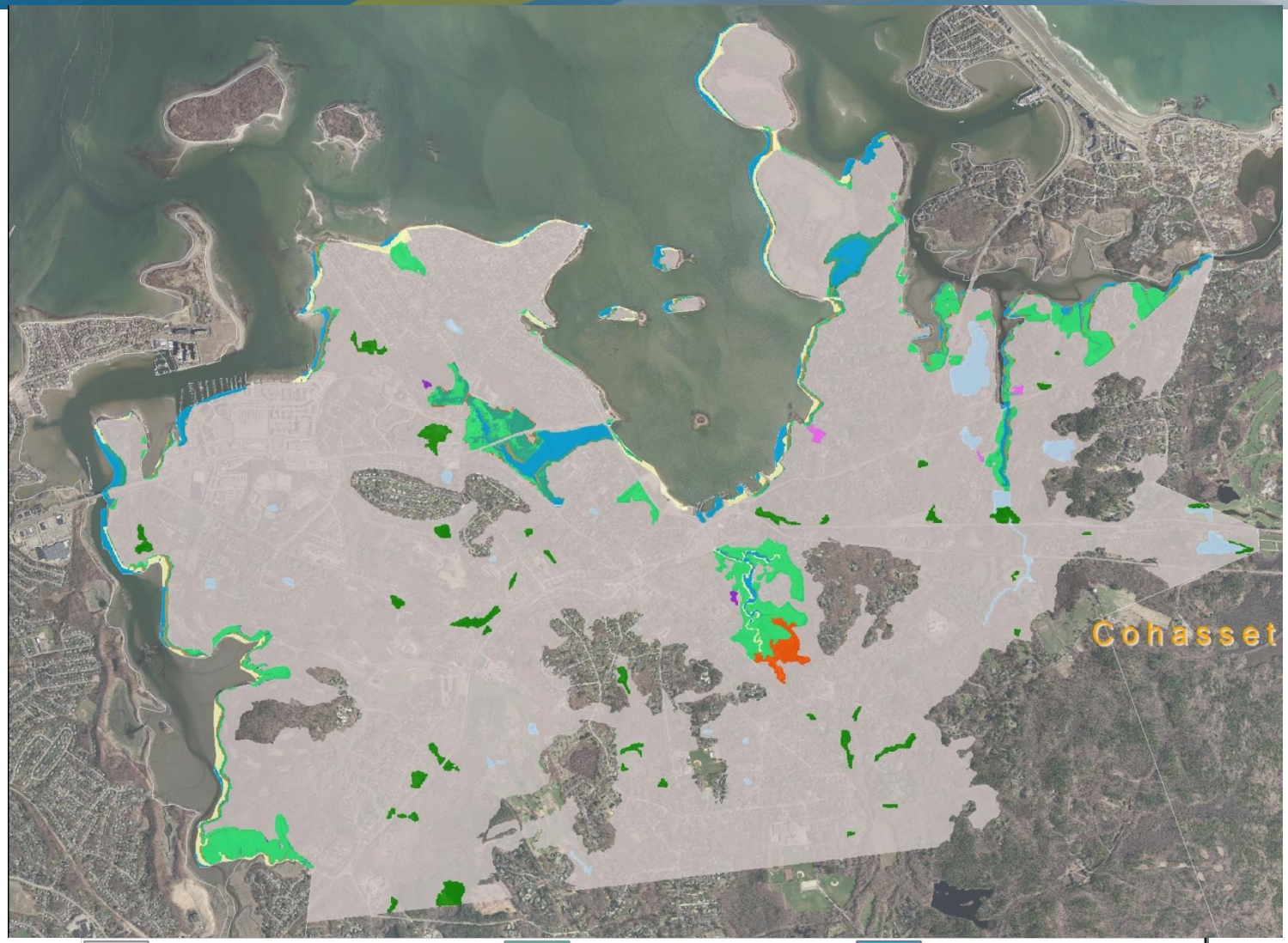
Natural Resources Evolution

- Evolution of natural resources modeled using Sea Level Affecting Marsh Migration (SLAMM) software
- Topography based on 2011 USGS LiDAR from Mass GIS
- 2011 wetland layer classified by National Wetland Inventory (NWI) used as base line
- Model inputs include:
  - Accretion rates (marsh, beach, etc.)
  - Tidal range and attenuation
  - Freshwater parameters
  - Impervious surfaces
  - Storm surge not included

Natural Resources Evolution - 2011

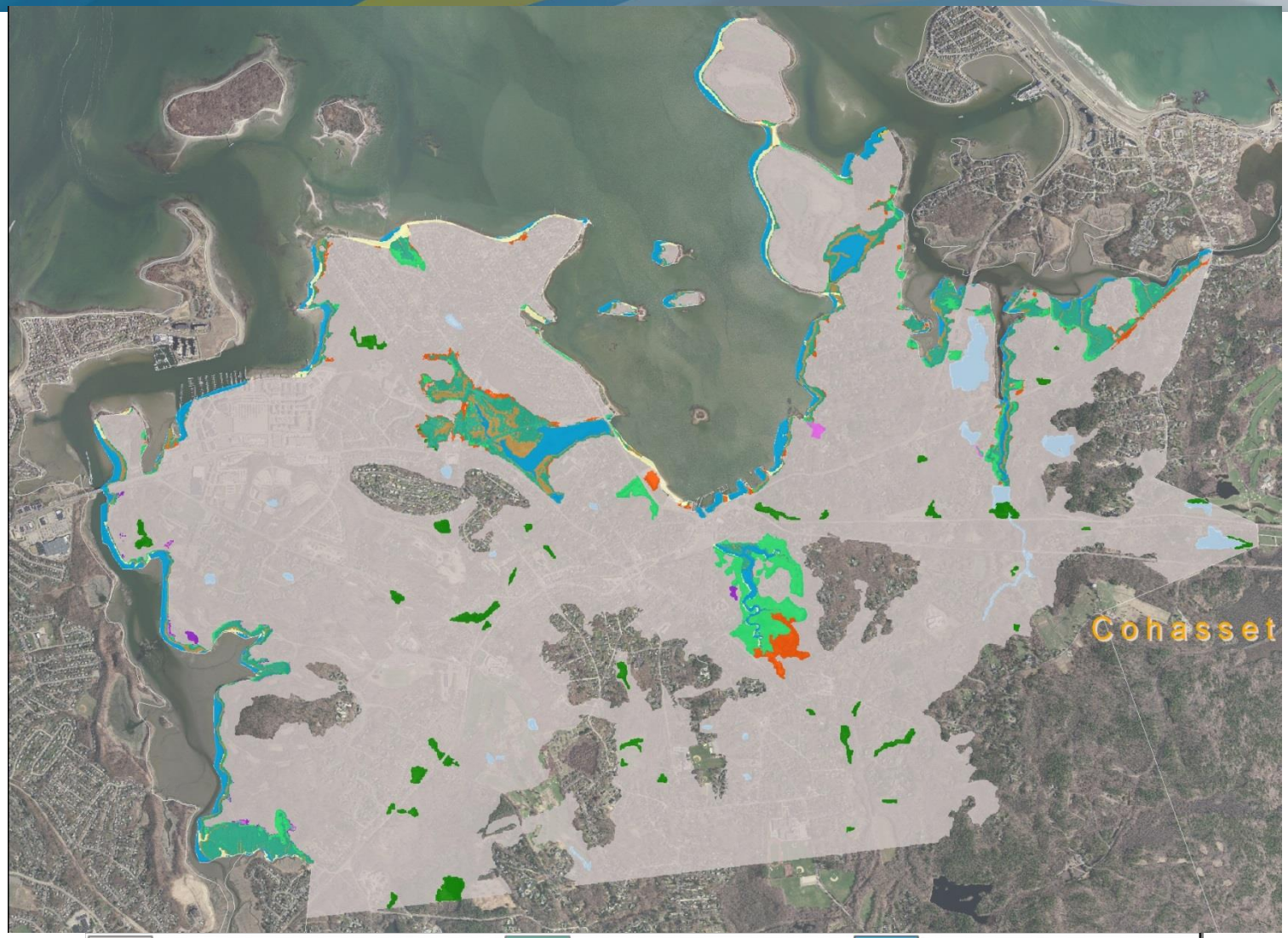


Natural Resources Evolution - 2030



Upland	Regularly Flooded Marsh	Estuarine Open Water
Inland Fresh Marsh	Estuarine Beach	Irregularly Flooded Marsh
Tidal Fresh Marsh	Ocean Beach	Tidal Swamp
Transitional Marsh/Scrub-Shrub	Inland Open Water	

Natural Resources Evolution - 2070



Natural Resources Evolution - Summary

Town-wide Changes

2011 - 2030

- Loss of approximately 13 acres of high marsh (to low marsh – not necessarily a problem)
- Loss of approximately 10 – 30 acres of upland area
- Loss of approximately 28 acres of transitional marsh to high marsh
- Gain of approximately 28 acres of low marsh
- Gain of approximately 25 acres of tidal flats

Natural Resources Evolution - Summary

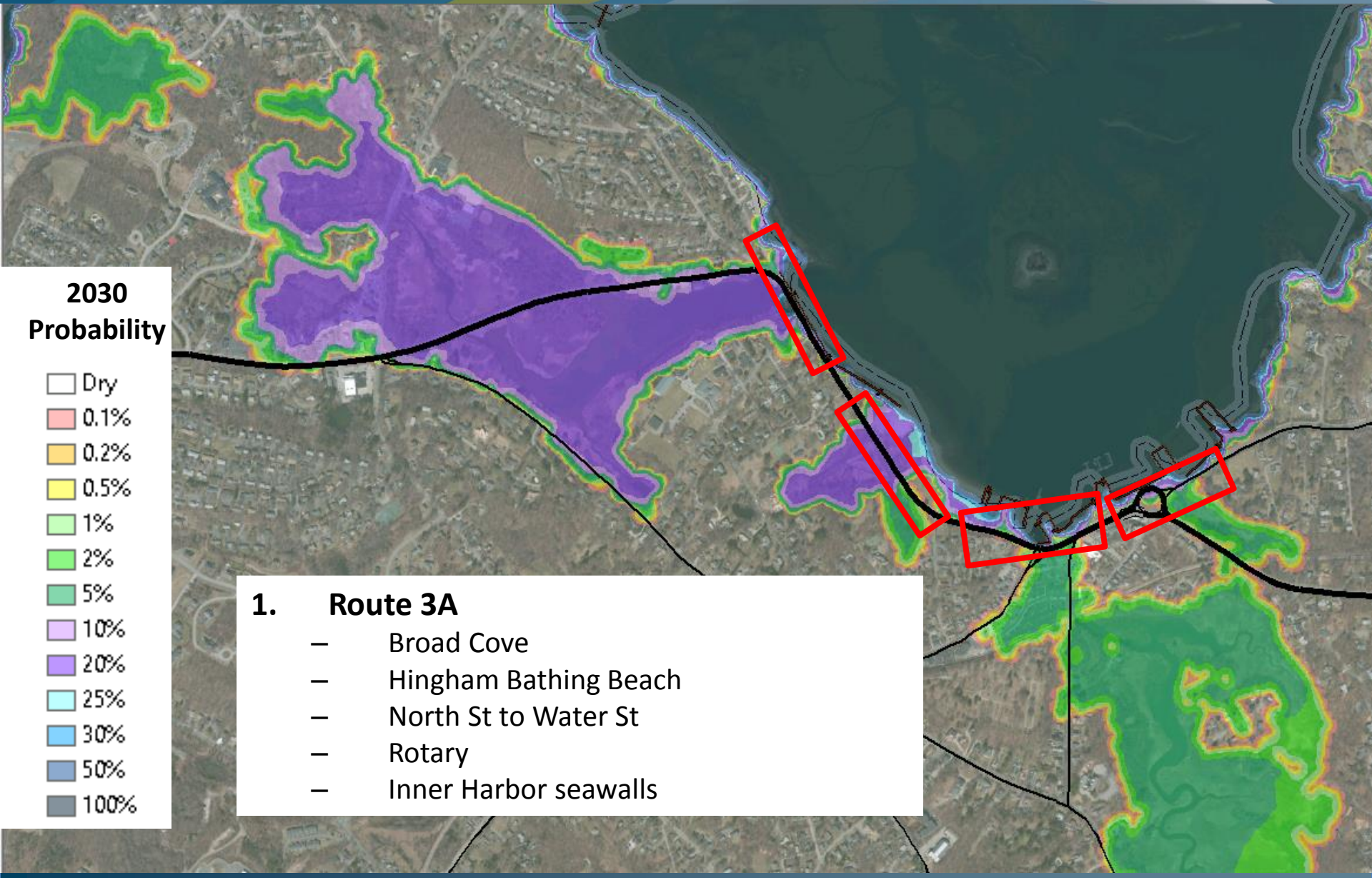
Town-wide Changes

2030 - 2070

- Loss of approximately 98 acres of high marsh (to low marsh)
- Loss of approximately 70 – 100 additional acres of upland area along edges of water bodies
- Loss of approximately 26 acres of estuarine beach along edges of estuaries – increase in tidal creeks
- Gain of approximately 100 acres of low marsh
- Gain of approximately 32 additional acres of tidal flats, especially in Broad Cove area
- Gain of approximately 38 acres of tidal creeks

Adaptation Strategies

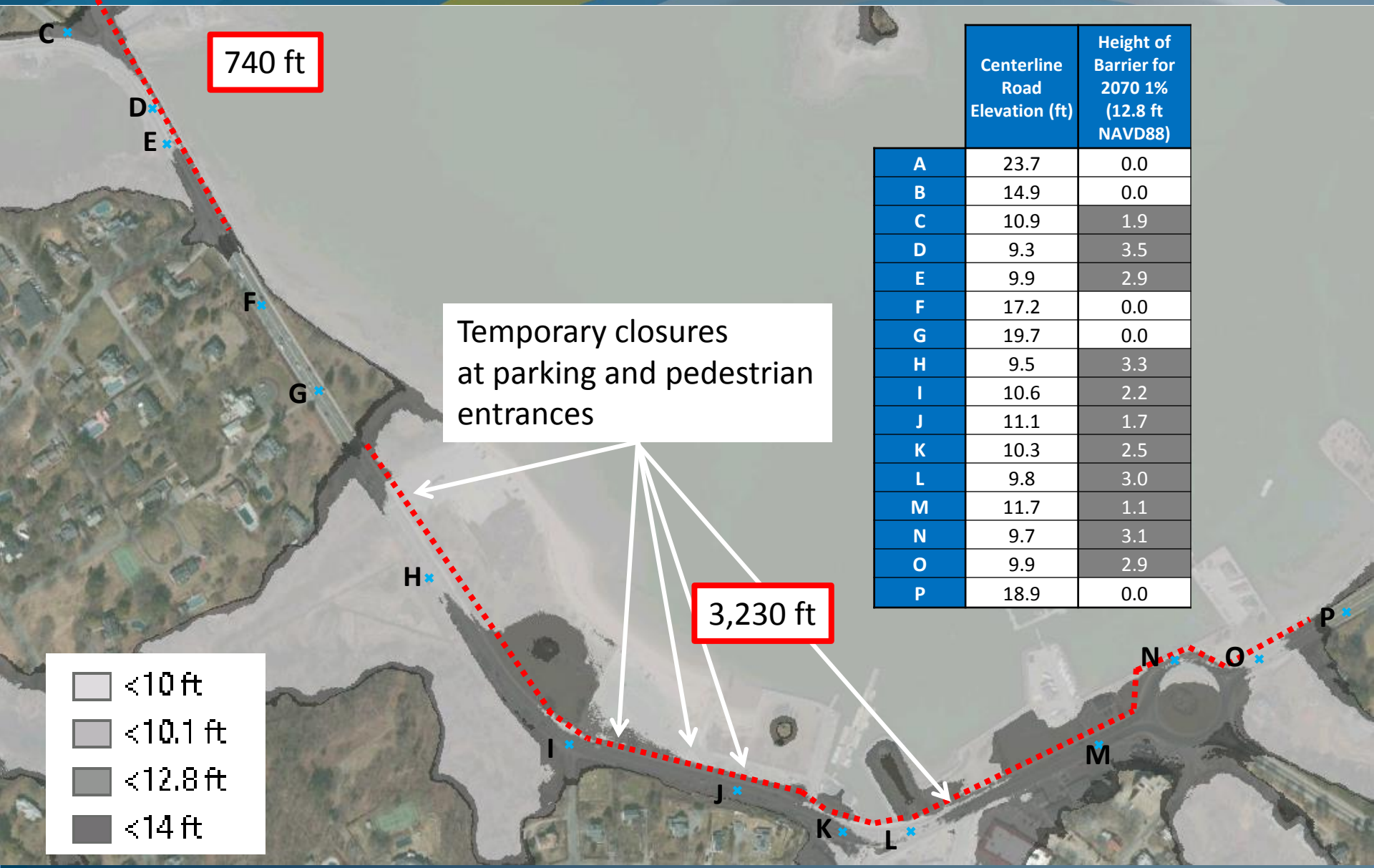
Route 3A (Broad Cove-Inner Harbor)



1. Route 3A

- Broad Cove
- Hingham Bathing Beach
- North St to Water St
- Rotary
- Inner Harbor seawalls

Vulnerable Segments – Long Term



	Centerline Road Elevation (ft)	Height of Barrier for 2070 1% (12.8 ft NAVD88)
A	23.7	0.0
B	14.9	0.0
C	10.9	1.9
D	9.3	3.5
E	9.9	2.9
F	17.2	0.0
G	19.7	0.0
H	9.5	3.3
I	10.6	2.2
J	11.1	1.7
K	10.3	2.5
L	9.8	3.0
M	11.7	1.1
N	9.7	3.1
O	9.9	2.9
P	18.9	0.0

Adaptation

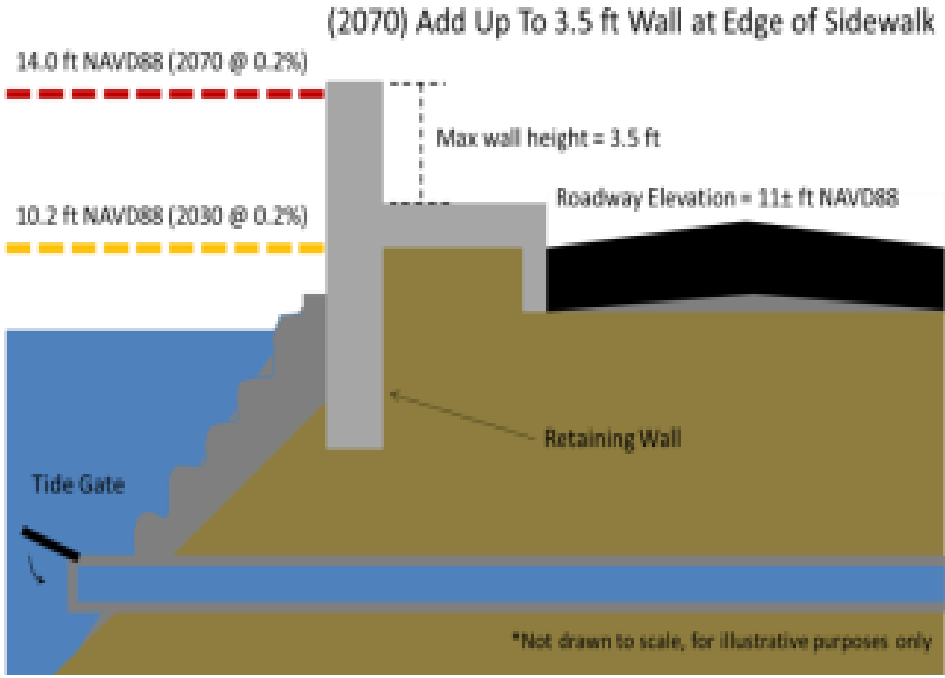
Route 3A / Inner Harbor:

- Raise 5,000 ft. of seawalls (excluding Kimball's Wharf) at unit cost ranging from $1,000 to $3,000/ft:
  - $5,000,000 - $15,000,000
- Raise 450 ft. Kimball's Wharf:
  - $450,000 - $1,350,000

Adaptation

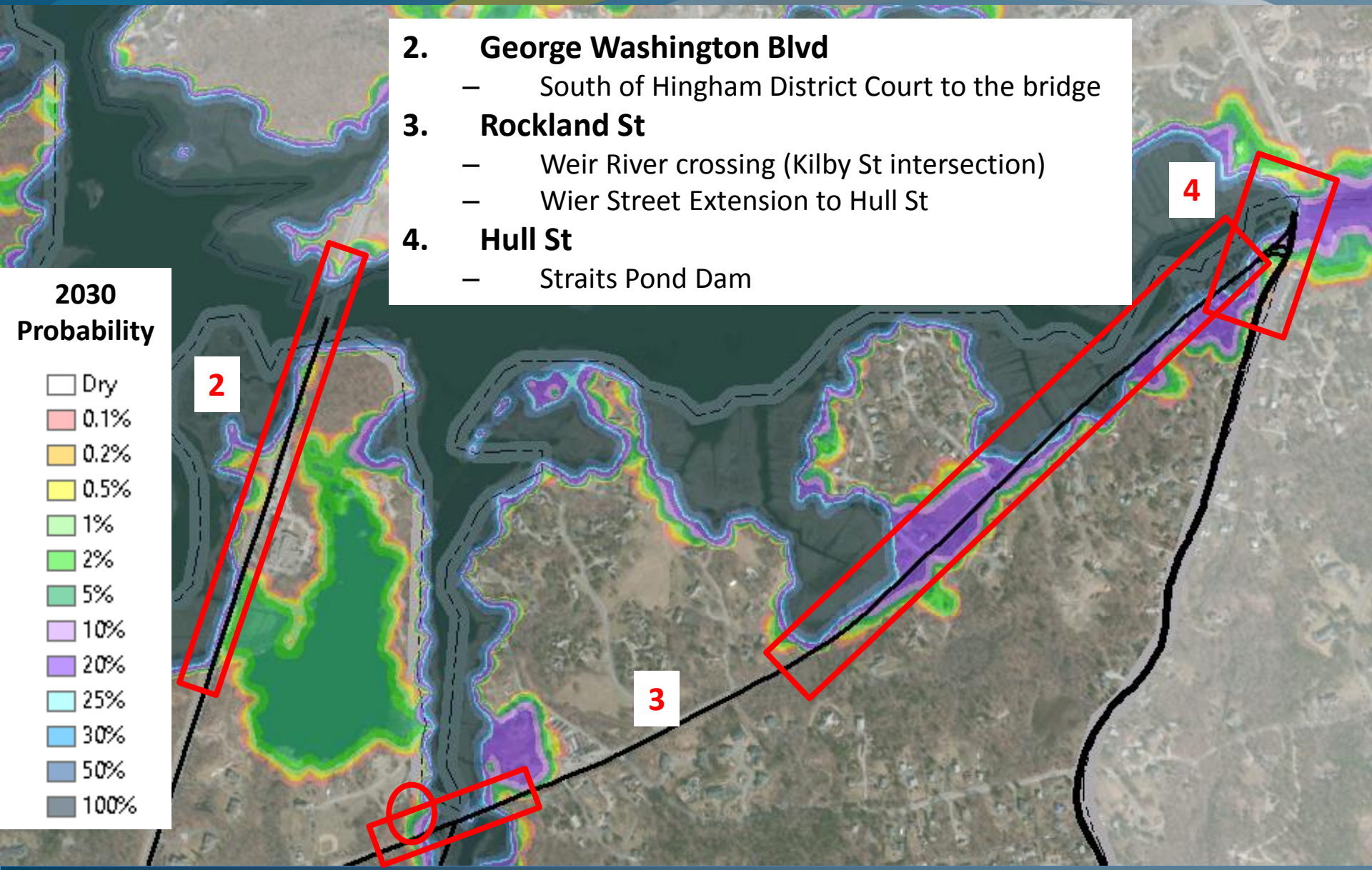
Route 3A / Inner Harbor:

- Raise 1,880 ft. Rt. 3A to El. 10.2 NAVD88
  - Construction $4,750,000
  - Design: $475,000
- Construct 4,250 ft. flood walls/berms from El. 10.2 to 14 NAVD88 @ $500/ft.
  - Construction $2,337,000



Examples of Flood Walls

Regional Connectors



2. **George Washington Blvd**
   - South of Hingham District Court to the bridge
3. **Rockland St**
   - Weir River crossing (Kilby St intersection)
   - Wier Street Extension to Hull St
4. **Hull St**
   - Straits Pond Dam

Adaptation

George Washington Boulevard:

- Raise 850 ft. George Washington Blvd. to El. 10.2 NAVD88
  - Construction $2,225,000
  - Design: $223,000
- Construct 2,000 ft. flood walls/berms from El. 10.2 to 14 NAVD88 @ $500/ft.
  - Construction $1,100,000

Adaptation

Rockland Street to Hull Street:

- Raise 6,000 ft. Rockland St. to El. 10.2 NAVD88
  - Construction $15,169,000
  - Design: $1,517,000
- Construct 6,000 ft. flood walls/berms from El. 10.2 to 14 NAVD88 @ $500/ft.
  - Construction $3,300,000

Adaptation

Foster Elementary School:

2030

- High level water alarm and sump pump: $10,000
- Flood proof stairwell enclosure: $10,000
- Flood proof vents and doorways: $30,000
- Seal underground electrical conduits and install shut-off valves in drains/sewers: $5,000

2070

- Perimeter flood protection system (walls/berms): $820,000
- New School??

Foster Elementary School – Near Term

Foster Elementary School – Near Term

Figure 7-4. Low wall construction

Build small enclosures around louvers and crawl space entrance on vulnerable sides of School building

Foster Elementary School – Medium Term

Adaptation

Mill Street Pump Station:

2030

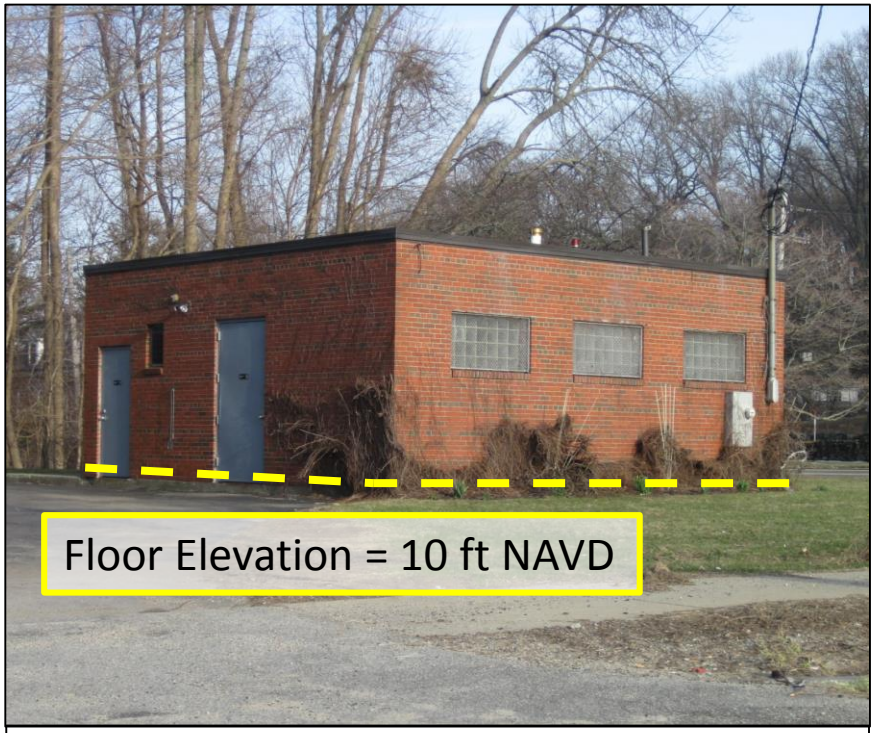
- Purchase and have ready to deploy 5 ft. high temporary flood barriers: $56,000
- Seal underground electrical conduits: $2,000
- Install high water alarm and sump pump: $10,000

Mill St Pump Station – Medium/Long Term

Well Elevation = 8.7 ft NAVD

Install 4 ft high 160 ft long temporary flood barrier around perimeter of pump station and generator

Sewer Pump Stations – Long Term



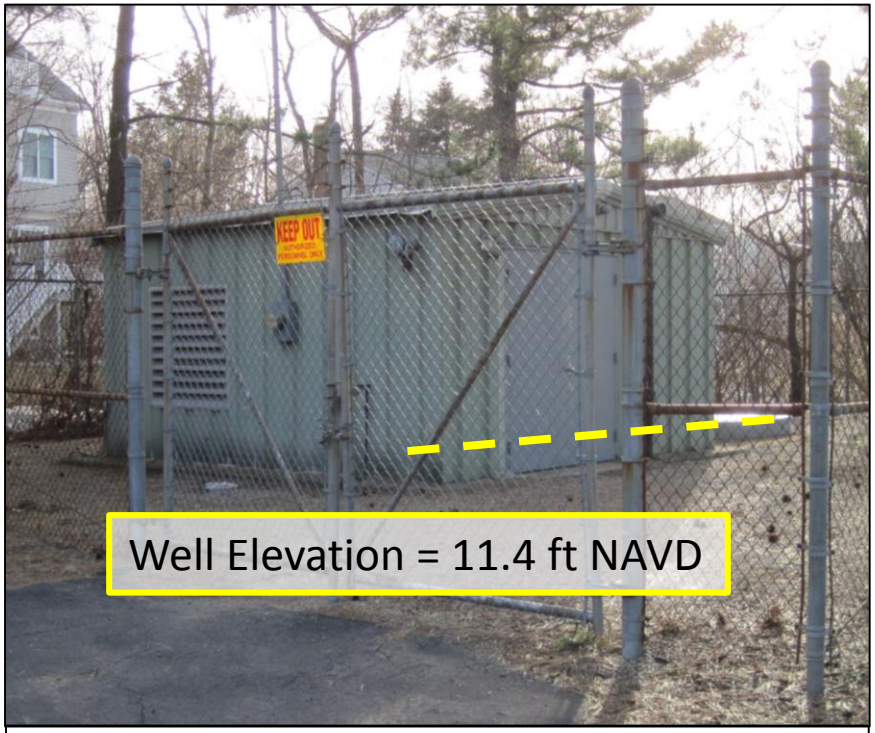
Broad Cove Pump Station

2070

- Dry – Floodproof: 13,000

or

- Temporary Barriers: $56,000



Bel Air Pump Station

2070

- Floodwall: $120,000
- Seal electrical conduits and pump system: $4,000

Adaptation

Install a Tide Gauge in Hingham Harbor:

- Install an automated tide gauge to help monitor actual sea level rise in Hingham.
  - Will help in the design and permitting of future projects

Policies/Regulations

Potential Wetlands Regulations Changes:

- Section 2.0 (Jurisdiction)
  - Subsection (6): Change (1-4) to (1-5) which will then include land within a minimum distance of 100 ft. from land subject to flooding or inundation.
- Section 7.4 (Notice of Intent)
  - Add subsection requiring applicants to submit discussion on effects of SLR.
- Consider increasing width of buffer zone for LSCSF

Policies/Regulations

Potential Wetlands Regulations Changes:

- Update and Combine Performance Standards in Sections 20.0 (Land Subject to Coastal Storm Flowage) and 24.0 (Additional Protection of Special Flood Hazard Zones)
  - Consider specifying a specific SLR curve rather than relying on historic rate of 1 ft. per 100 years.
  - Prohibition of impermeable surfaces is unrealistic for roadway work (i.e. Route 3A)
  - Current language only permits expansion of coastal engineering structures that are loose, slope-stone design. Prevents use of green infrastructure and walls.
  - Consider adding standards for temporary barriers
  - Clarify definitions of expansion of existing structures.

Policies/Regulations

Potential Zoning By-Law Changes:

- Consider establishing a Coastal Management Zone (CMZ) district:
  - Use FEMA FIRM map as basis
  - Possibly use 0.2% flood level instead of 1%
  - Add performance standards for wet- and dry-floodproofing of commercial facilities
  - Add performance standards for temporary flood barriers.
  - Clearly define permissible and prohibited uses, and those uses that are permissible by Special Permit.
  - Oak Bluffs has a good Flood Plain Protection by-law

Policies/Regulations

Potential Zoning By-Law Changes:

- Consider amending By-Law to provide incentives to residential and commercial property owners to raise and protect structures:
  - Consider allowing higher maximum height restrictions in Section IV-A in the case of structures being elevated to improve flood protection.
  - Consider adopting a freeboard incentive for residential and commercial building elevation projects. Town of Hull adopted a $500 permit fee reduction for an additional 2 ft. of freeboard.

Policies/Regulations

Potential Subdivision Rules and Regulations Changes:

- Consider amending Subdivision Rules and Regulations to allow for Cluster Development in the CMZ or other wetland protection districts.
  - Could provide a density bonus for projects that provide open space to accommodate expanding wetlands due to SLR.

Policies/Regulations

Potential Land/Resource Acquisition:

- Consider acquiring land adjacent to coastal resource areas to accommodate changing natural resource area:
  - Open Space Acquisition Committee can use information in this study to identify priority areas for acquisition. Include in 2015—2016 update to Open Space and Recreation Plan.
  - Investigate possibility of implementing a rolling easements program in which the town purchases an easement from a property owner today in exchange for a promise to surrender the property once it is substantially damaged by a flood.
  - 7 repetitive-loss properties with 2 or more flood claims

Policies/Regulations

Potential Policies for Public Projects:

- Develop policies for public projects that incorporate effects of SLR and promote sustainable practices:
  - Require that all town-funded projects take into account climate change and SLR.
  - Investigate costs and benefits of becoming a Green Community.
  - Re-evaluate Hazard Mitigation Plan.
  - Evaluate opportunities to relocate snow storage areas away from Town Bathing Beach parking lot.
  - Develop a regular inventory/report of resiliency actions taken by community.

Policies/Regulations

Develop a Coastal Flood Operations Plan:

- Develop a flood operations plan to minimize flood damage due to coastal flooding.
  - Plan should utilize actual maximum predicted water elevations for a storm.
  - Plan should clearly define actions to be taken, responsibilities, and timelines based on maximum predicted water elevations.
  - Identify training needs for deployment of specific equipment such as temporary flood barriers.

Discussion


Hingham Climate Change Vulnerability Study
Route 3A from North Street to Water Street
1% Flood in 2070 (12.8 ft. NAVD88)