Town of Hingham

Climate Change Vulnerability, Risk Assessment and Adaptation Study

April 16, 2015

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Today's Presentation

- Overview of Project
- Methodology Used for Study
- Review of Flood Modeling Results:
  - Risk of Flooding Maps (2030 and 2070)
  - Sea Level Rise Only (2030 and 2070)
  - Depth of Flooding Maps (Present, 2030 and 2070)
- Municipally-Owned Infrastructure Subject to Flooding
- Methodology for Assessing Vulnerability of Critical Municipally-Owned Infrastructure Subject to Flooding
- Preliminary Vulnerability Ranking

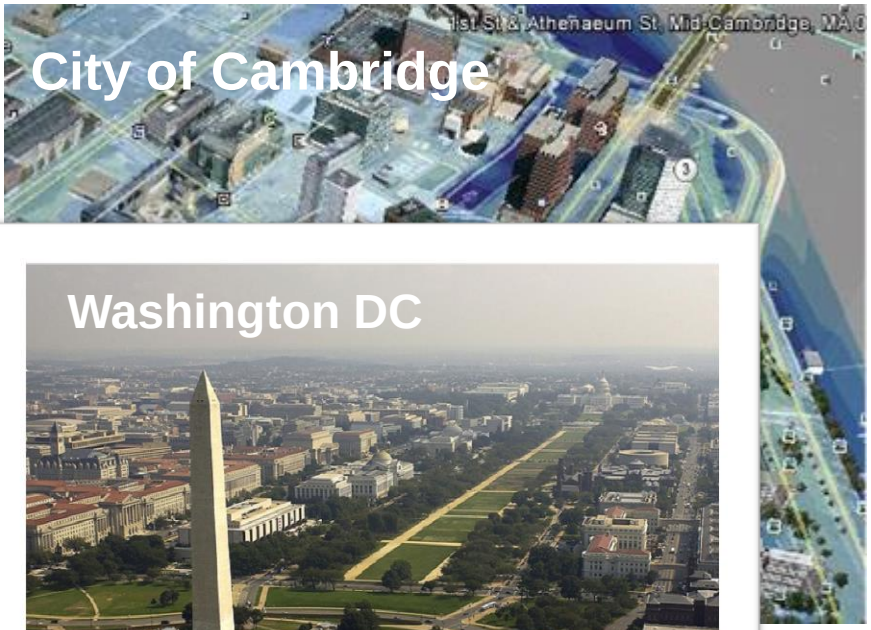
Town Steering Committee

- Monica Conyngham
- Mary Savage Dunham
- Roger Fernandes
- Scott McIsaac
- Jim Murphy
- Abby Piersall (Project Manager)
- Walter Sullivan
- Randy Sylvester
- Richard Cook
- Ken Corson
- Brian Knies

Grant Award

- Hingham awarded a CZM "*Coastal Community Resilience Grant*"
- Grant amount = $44,461
- One of nine awards totaling $1.0 million
- 25% Town in-kind match
- Town retained Kleinfelder of Cambridge, MA as the project consultant

Project Experience



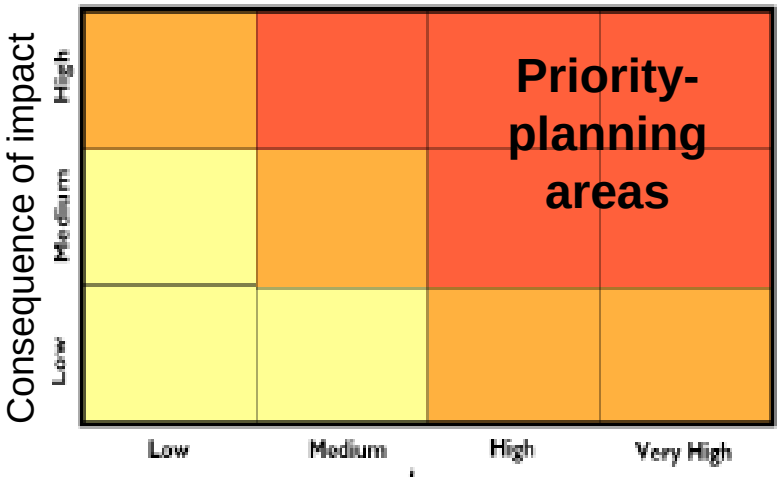
Project Objectives

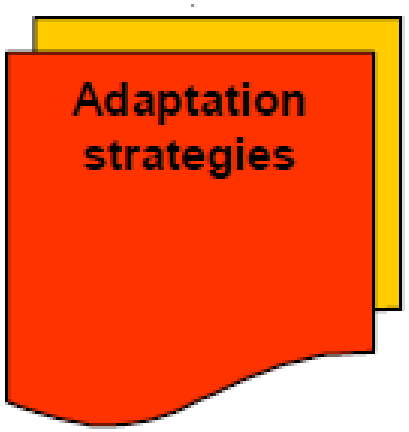
- Develop appropriate sea level rise and storm surge scenarios
- Understand vulnerability of municipal infrastructure and natural resources to sea level rise and storm surge
- Develop potential short-, mid- and long-term adaptation strategies:
  - Protect
  - Accommodate
  - Retreat

Project Objectives

- Produce high quality maps and graphics
- Undertake a public outreach and education program
- This project is not related to FEMA flood mapping or flood insurance rates!

Project Approach





Phase I

Sea Level Rise/Storm Surge Projections

Scenario Development

Phase II

Mapping Inundation Modeling Results

Vulnerability/Risk Assessment

Phase III

Develop Adaptation Strategies

Public Outreach

Phase I: Establish Study Parameters

- Choice of sea level rise and storm surge model
- Types of storm and storm climatology
- Selection of sea level rise scenarios
- Planning horizons
- Display of output results

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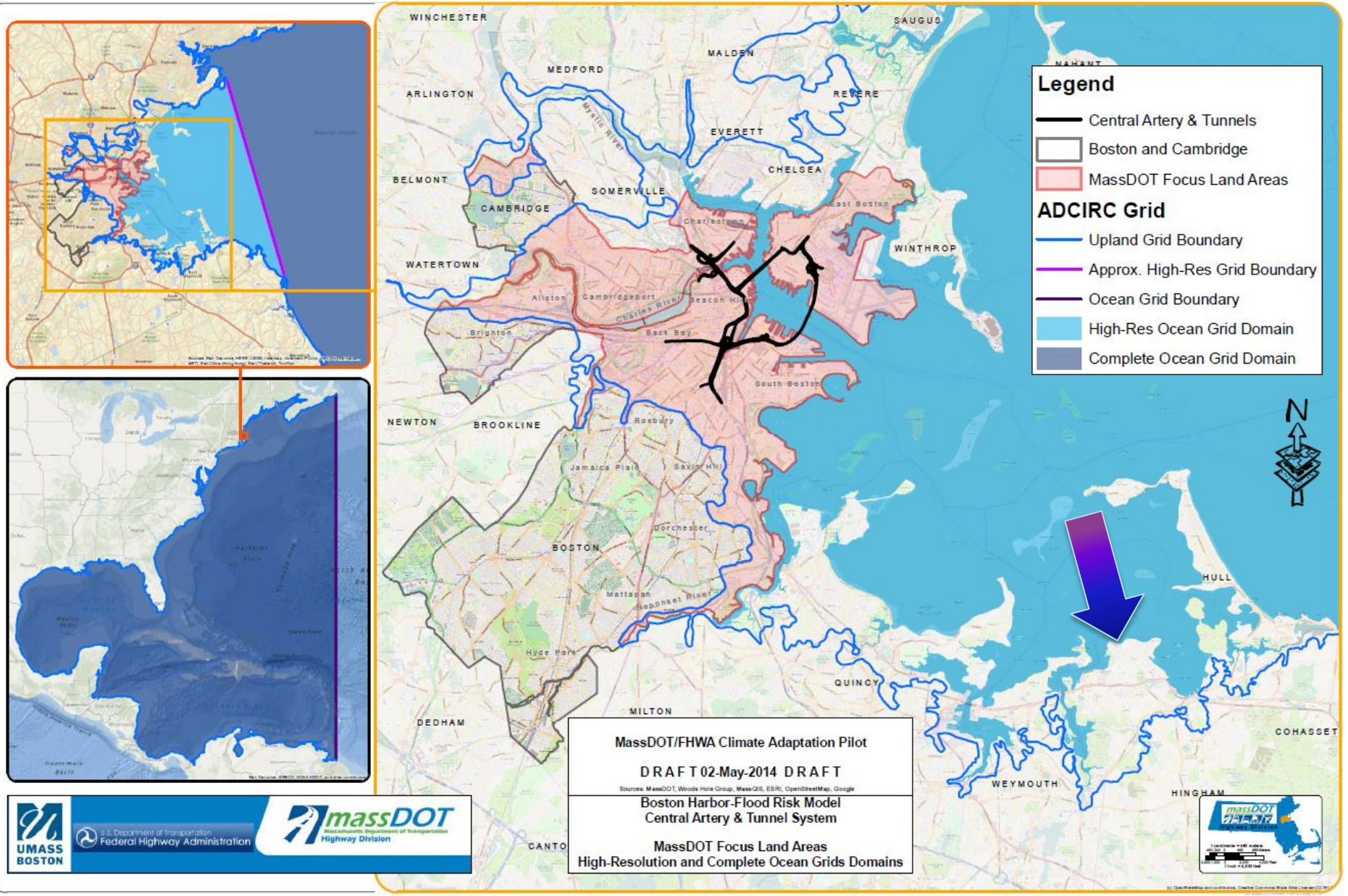
A Detailed Water Surface Model

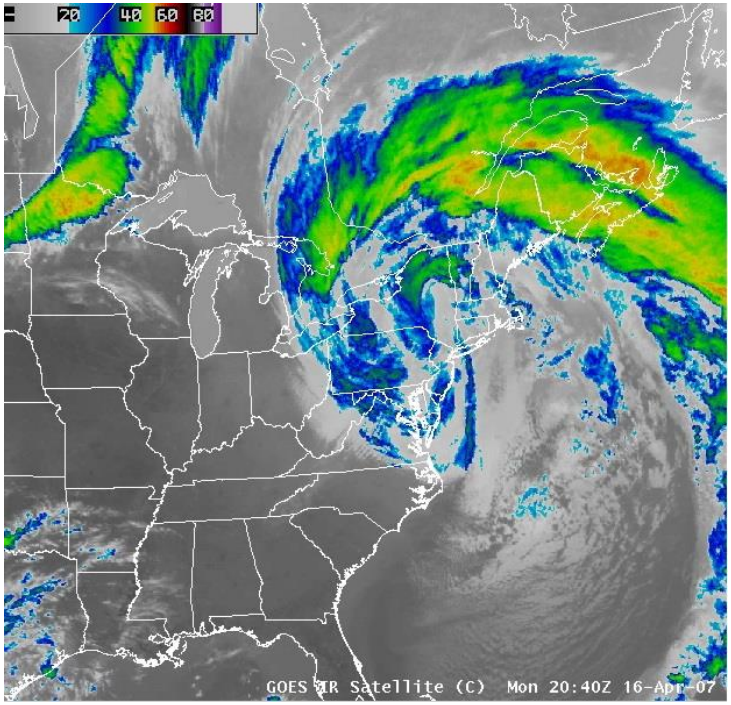


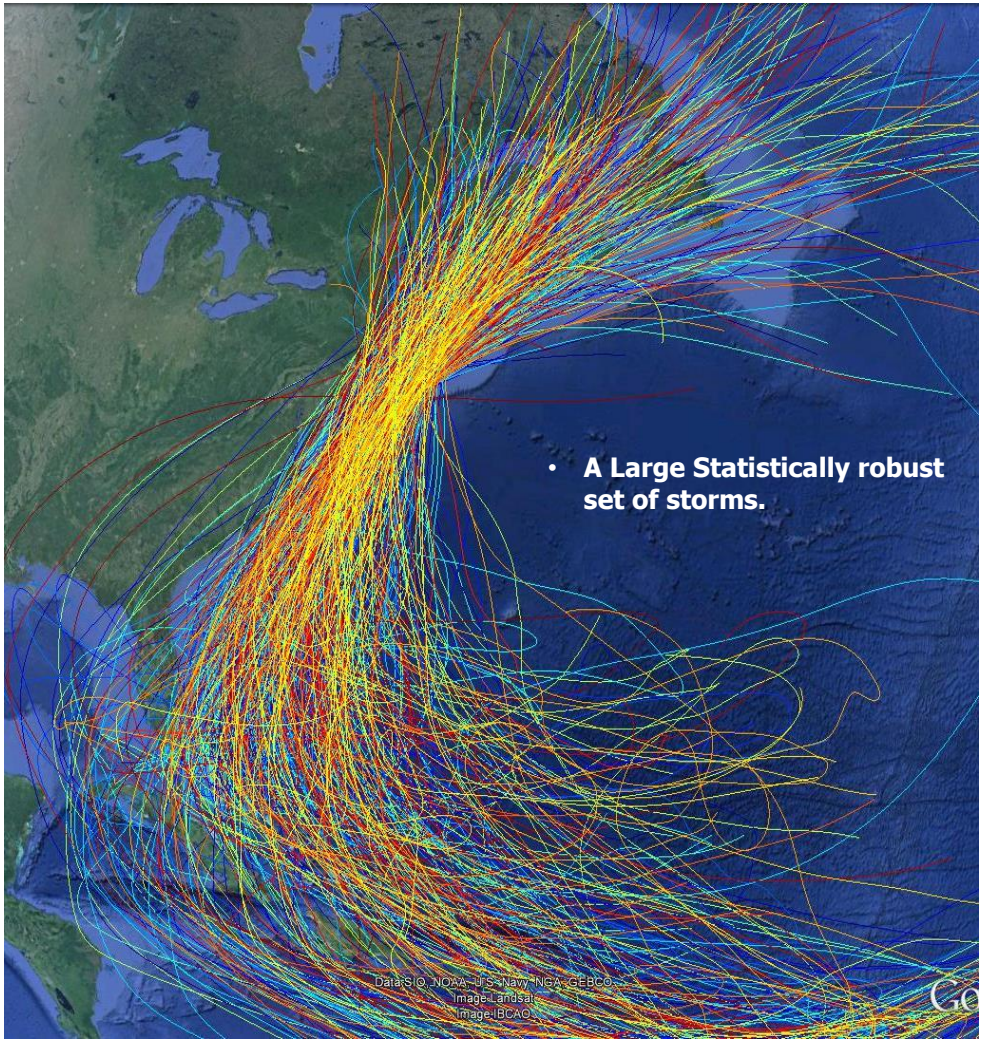
ADCIRC Model Grid

Advantages of The Proposed Model

Storm Climatology

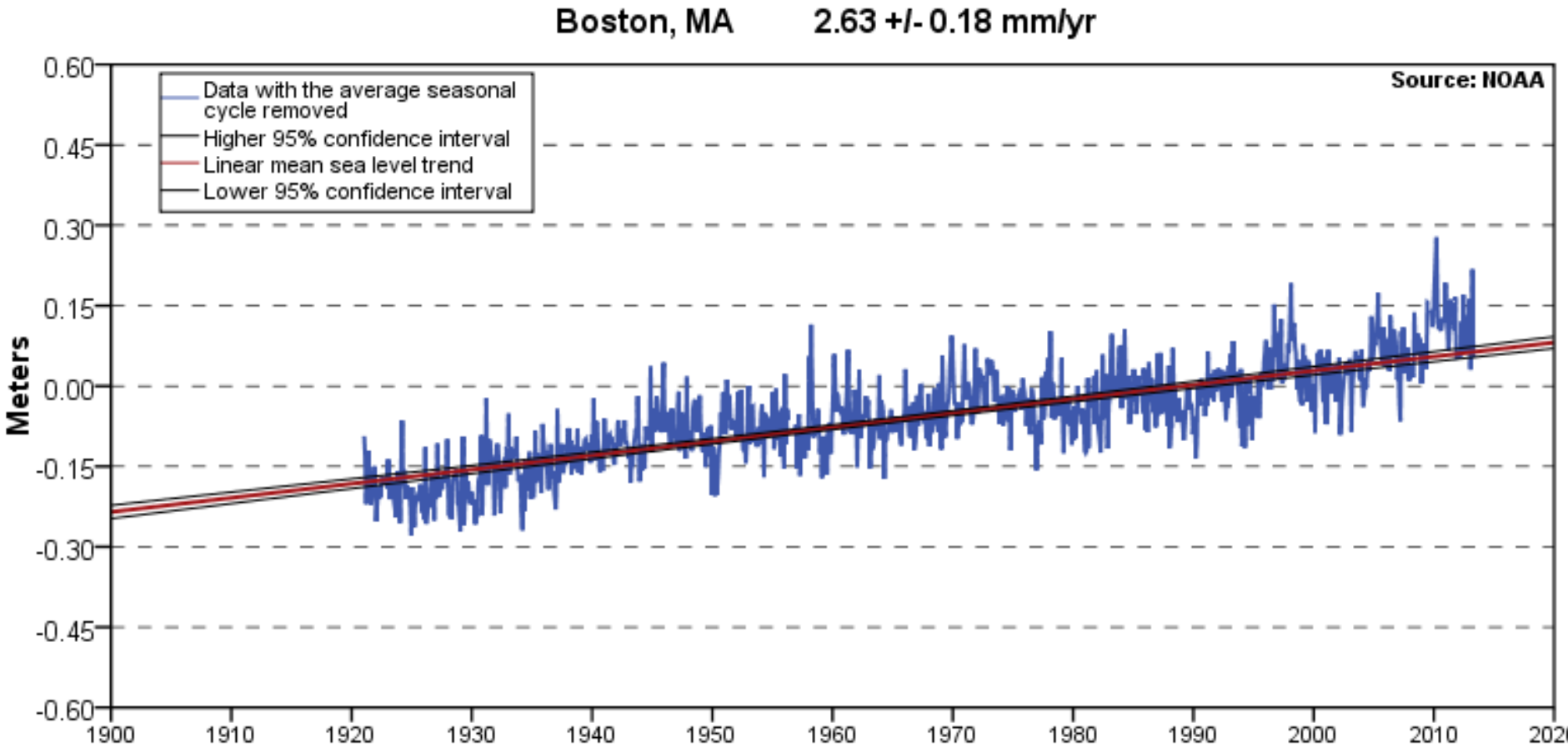
- Includes both tropical and extra-tropical storm sets





Global Mean Sea Level Rise Projections

Mean Sea Level Trend
8443970 Boston, Massachusetts

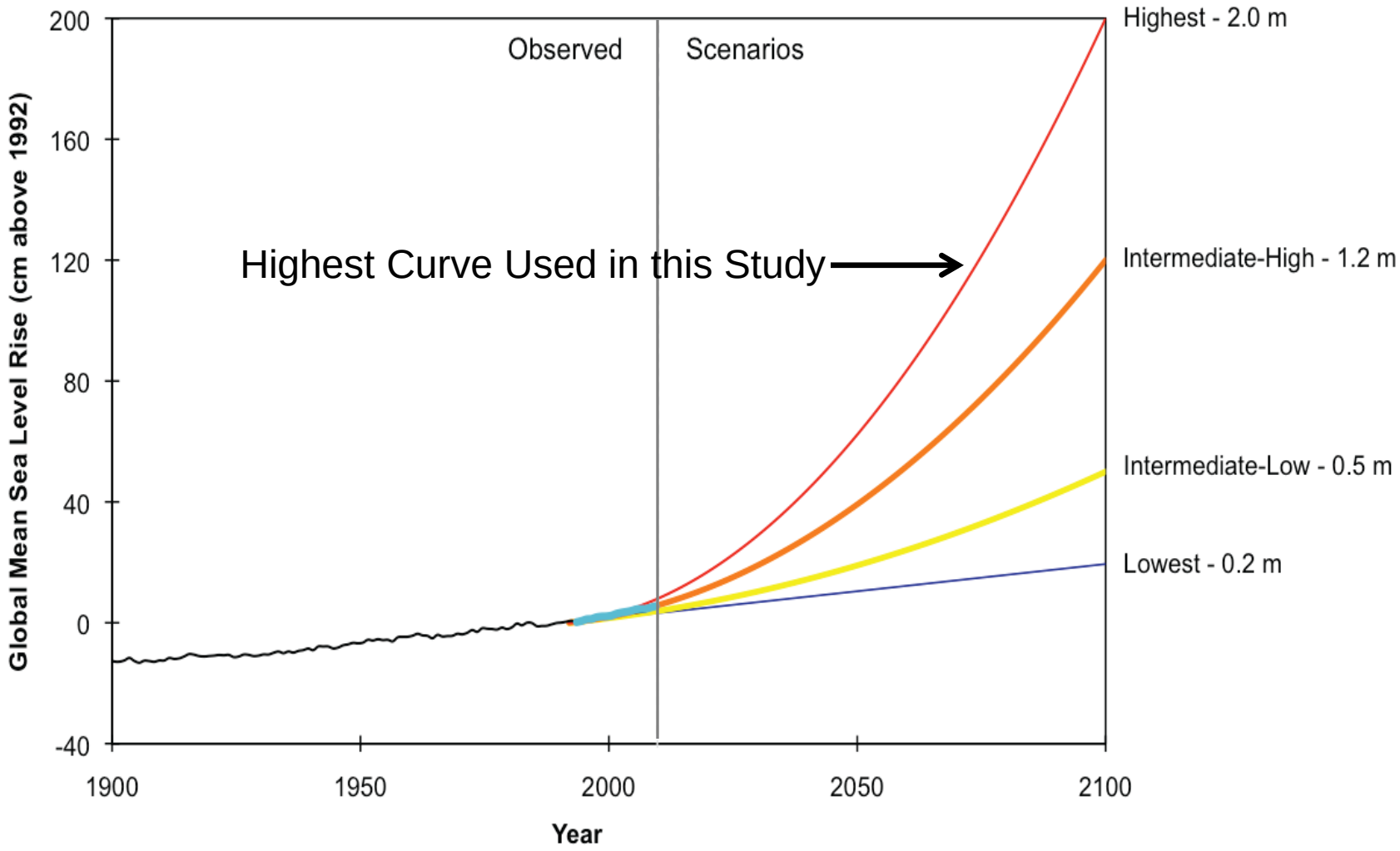


What Causes Sea Level Rise?

- Global Sea Level Change
  - Thermal expansion of oceans
  - Freshwater addition from melting of glaciers
- Local Sea Level Change
  - Land subsidence
  - Changes in ocean currents

Glacier Bay National Park, Alaska

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

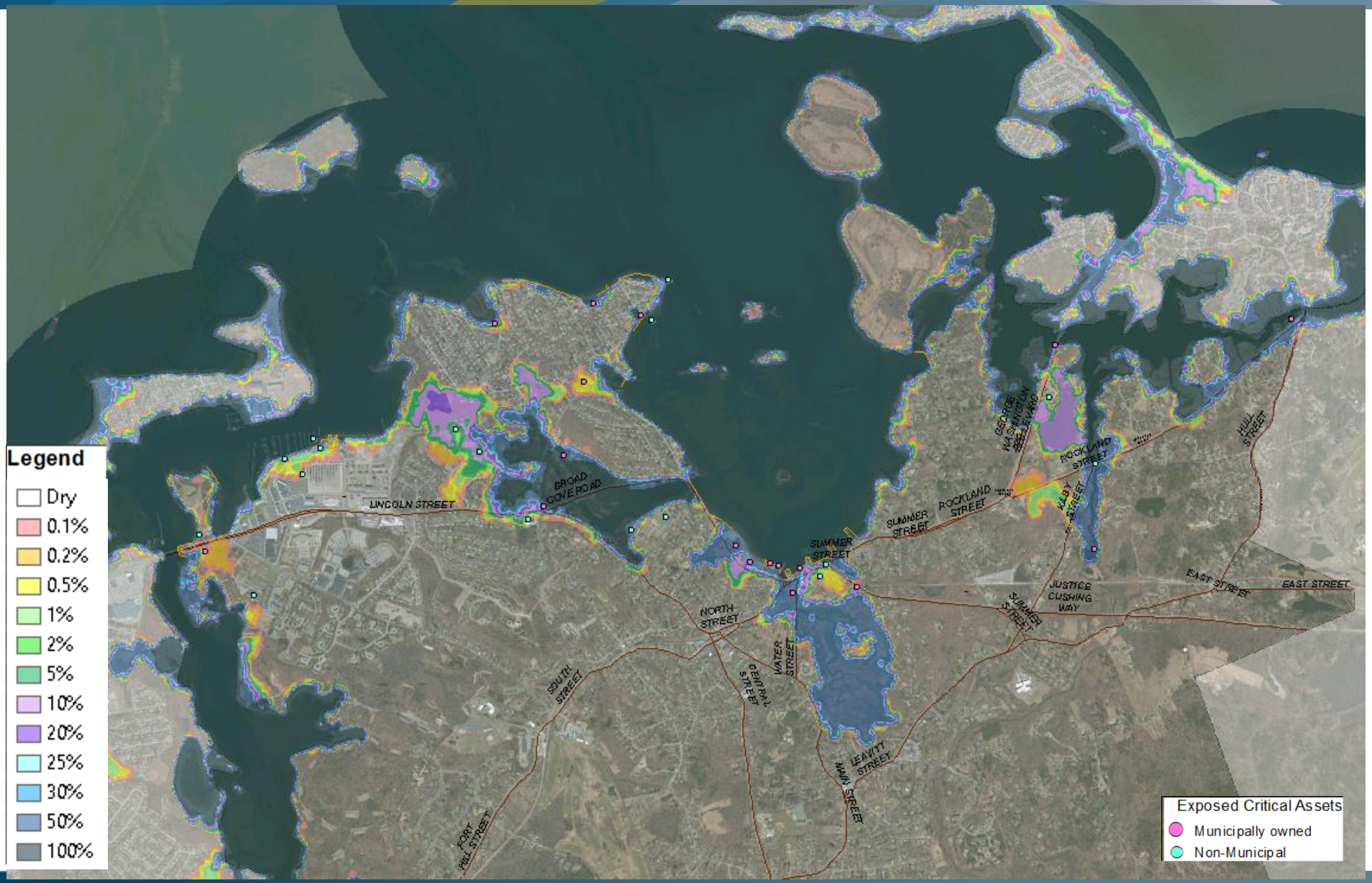
- **2015 - Present**
- **2030 – 15 years out – Near term**
- **2070 – 55 years out – Long term**

Phase II: Mapping and Vulnerability Assessment

- Inundation Mapping for Different Scenarios
  - Sea level rise and storm surge simulations
  - Risk-based maps and exceedance curves
  - Maps for sea level rise alone
- Vulnerability Assessment on
  - Municipal Infrastructure
  - Natural Resources

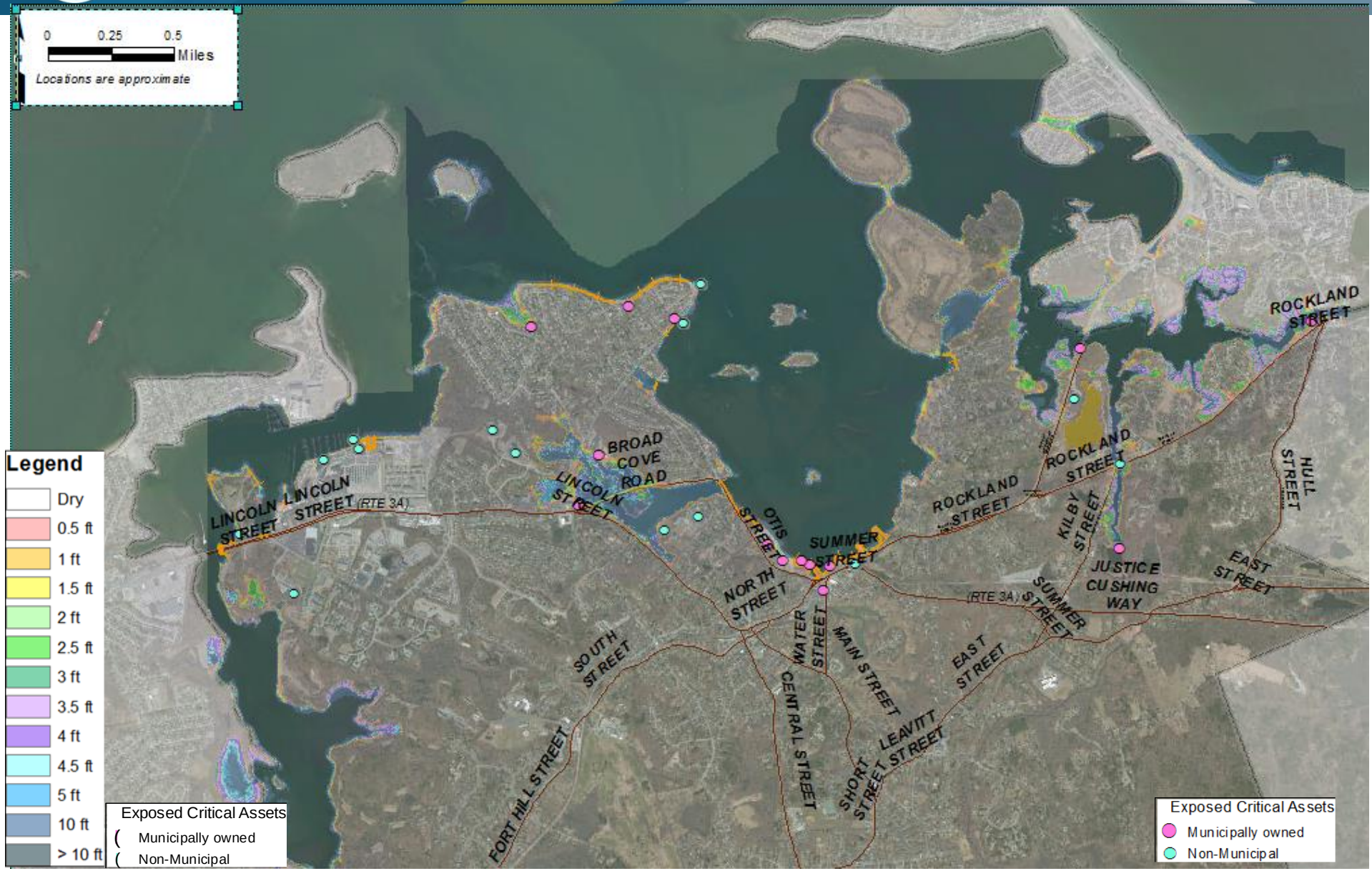
2030 – Risk of Flooding Map

2070 – Risk of Flooding Map



Sea Level Rise - 2030

Sea Level Rise - 2070



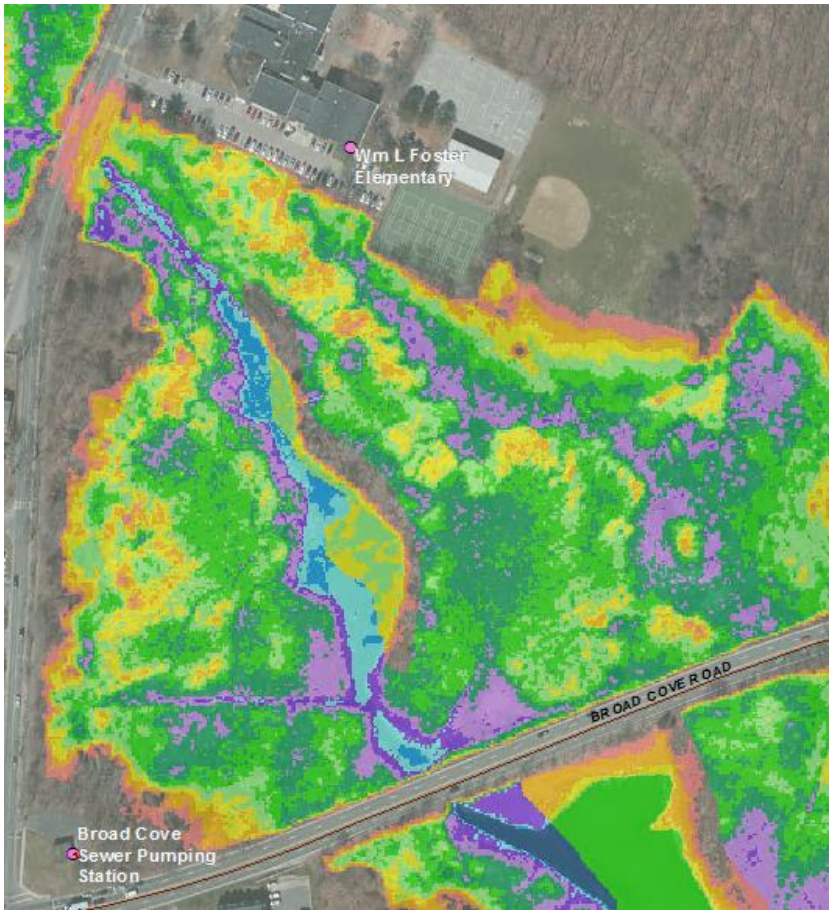
Sea Level Rise Comparison: Inner Hingham Harbor

2030 SLR only

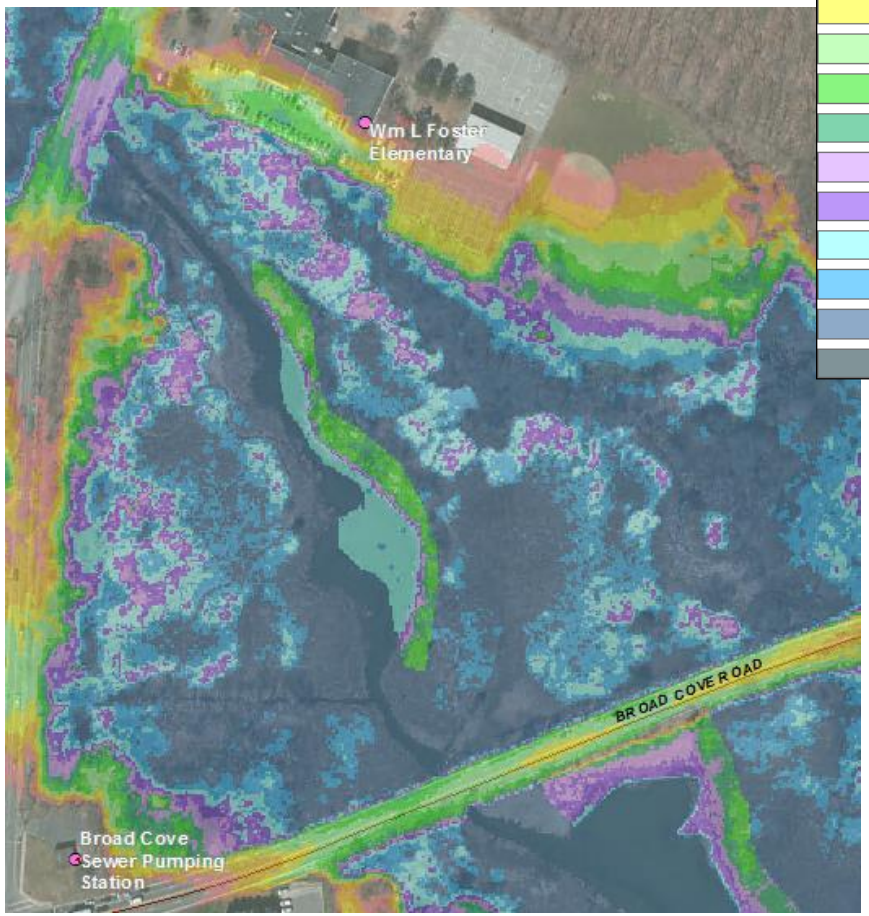
2070 SLR only

Depth of Flooding above Ground: SLR Only

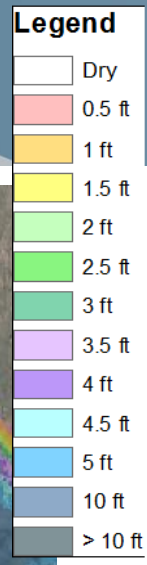
Sea Level Rise Comparison: Foster Elementary and Broad Cove PS



2030 SLR only



2070 SLR only



Depth of Flooding above Ground: SLR Only

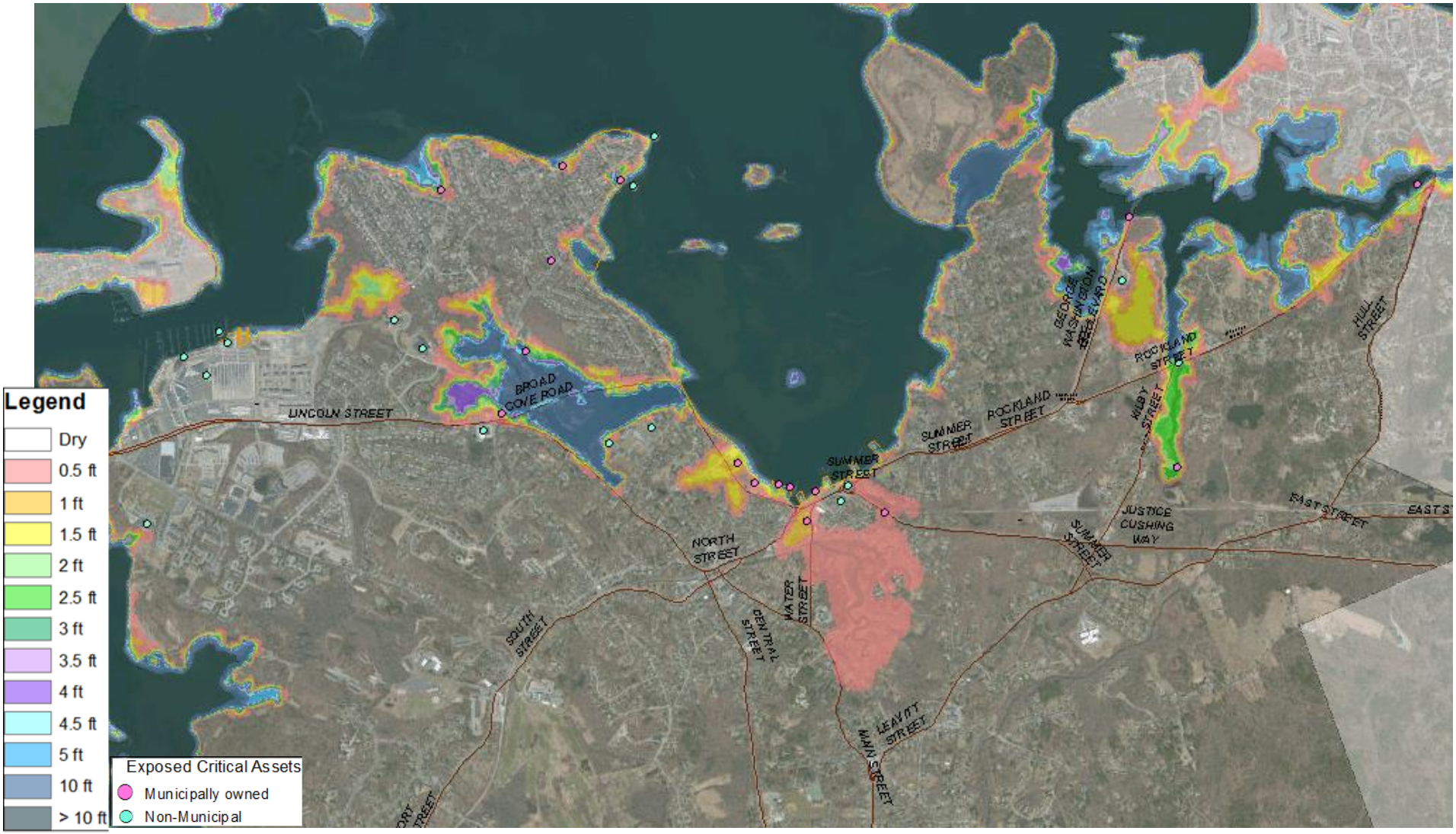
Present: 1% Annual Probability (≈100 yr Recurrence)

Depth of Flooding above Ground

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

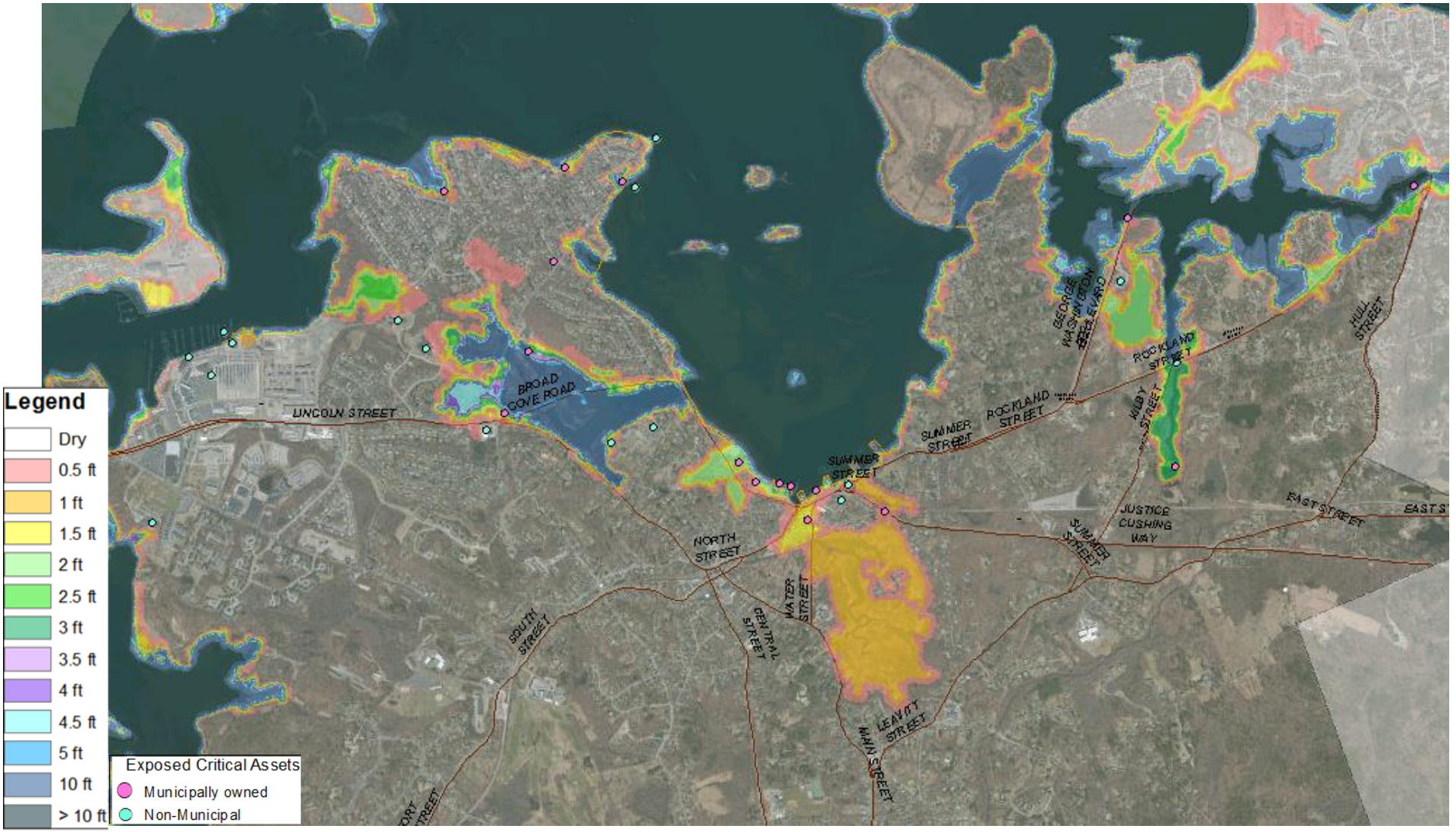
Depth of Flooding above Ground

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



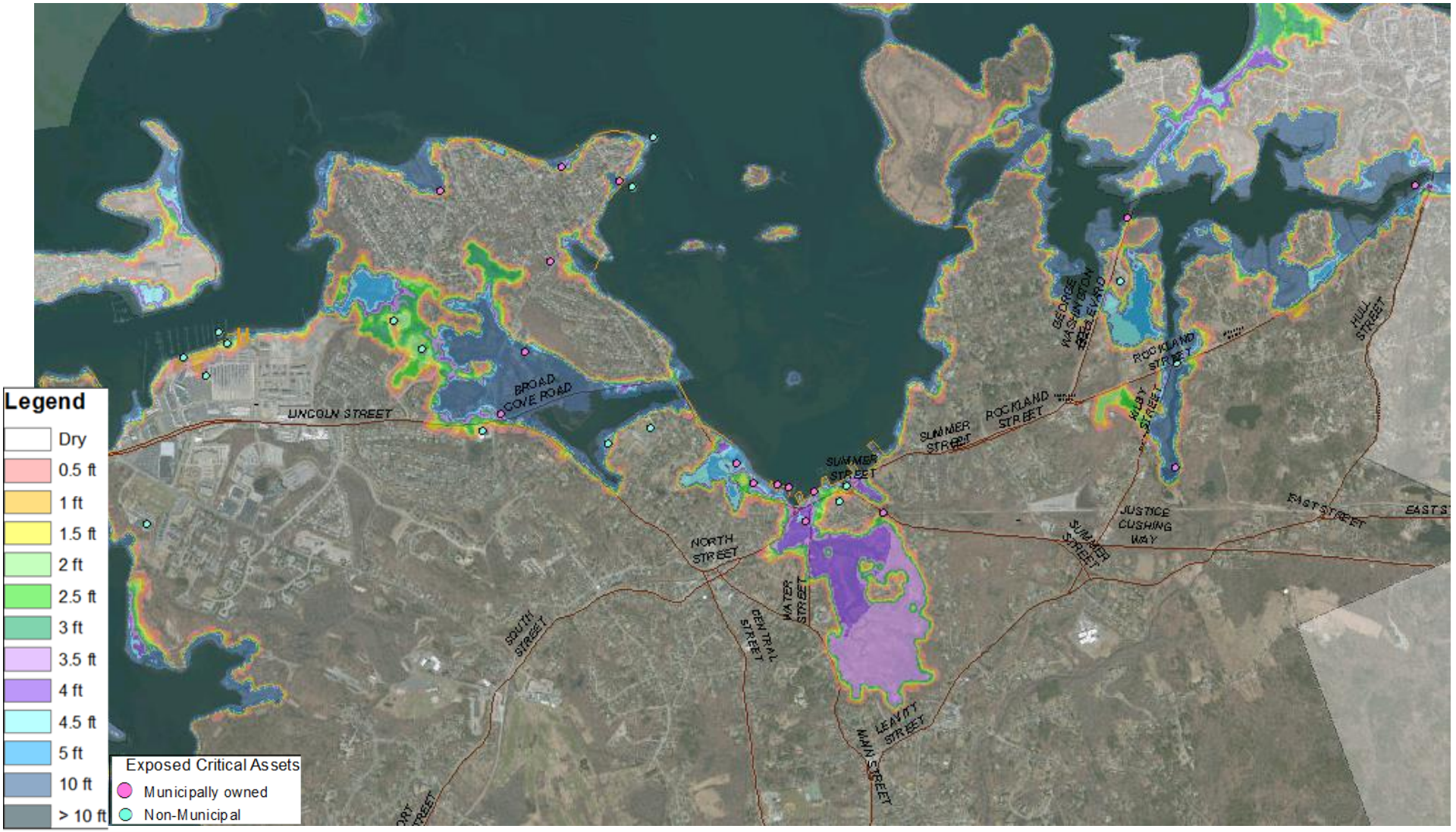
Depth of Flooding above Ground

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



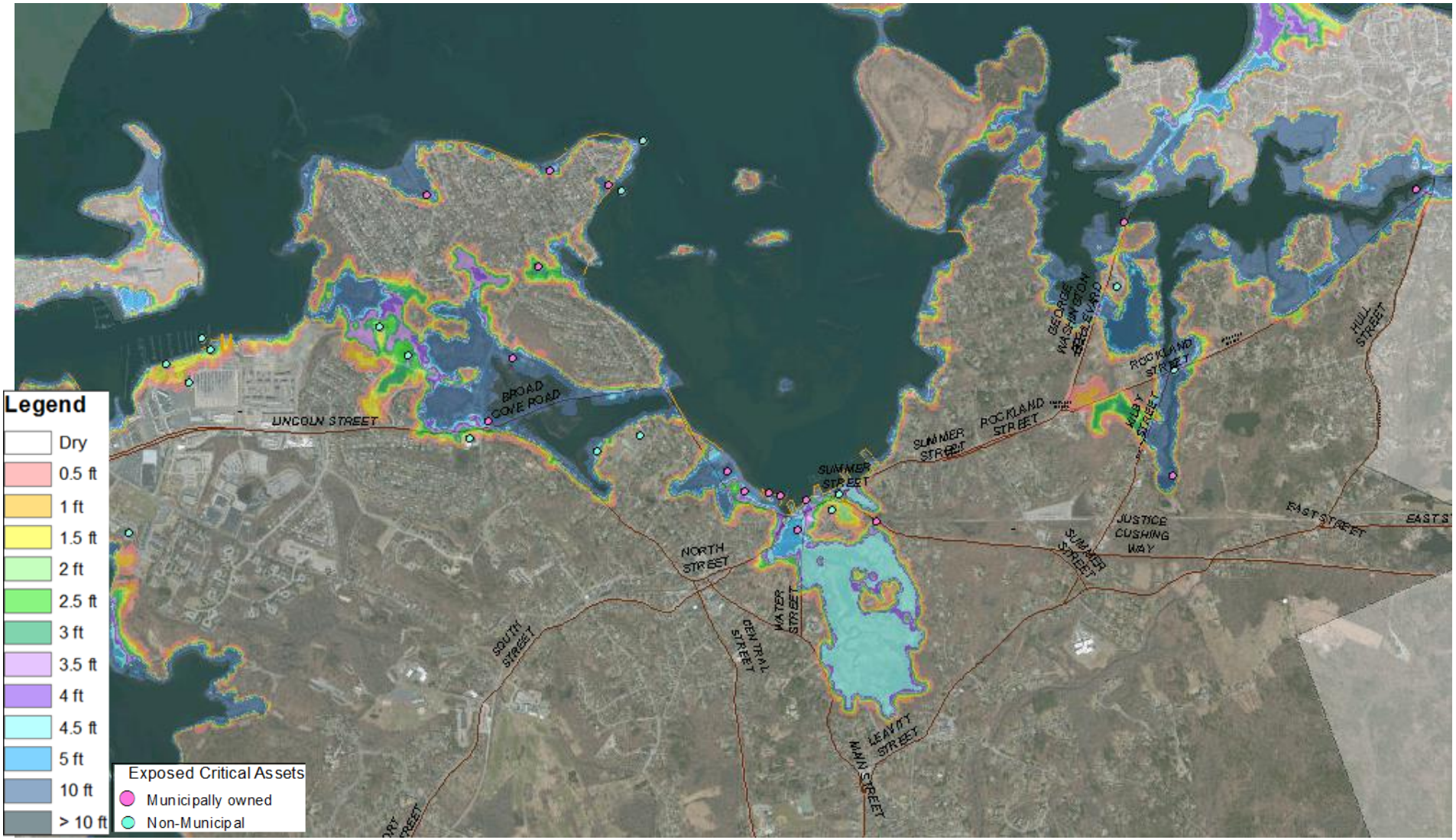
Depth of Flooding above Ground

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



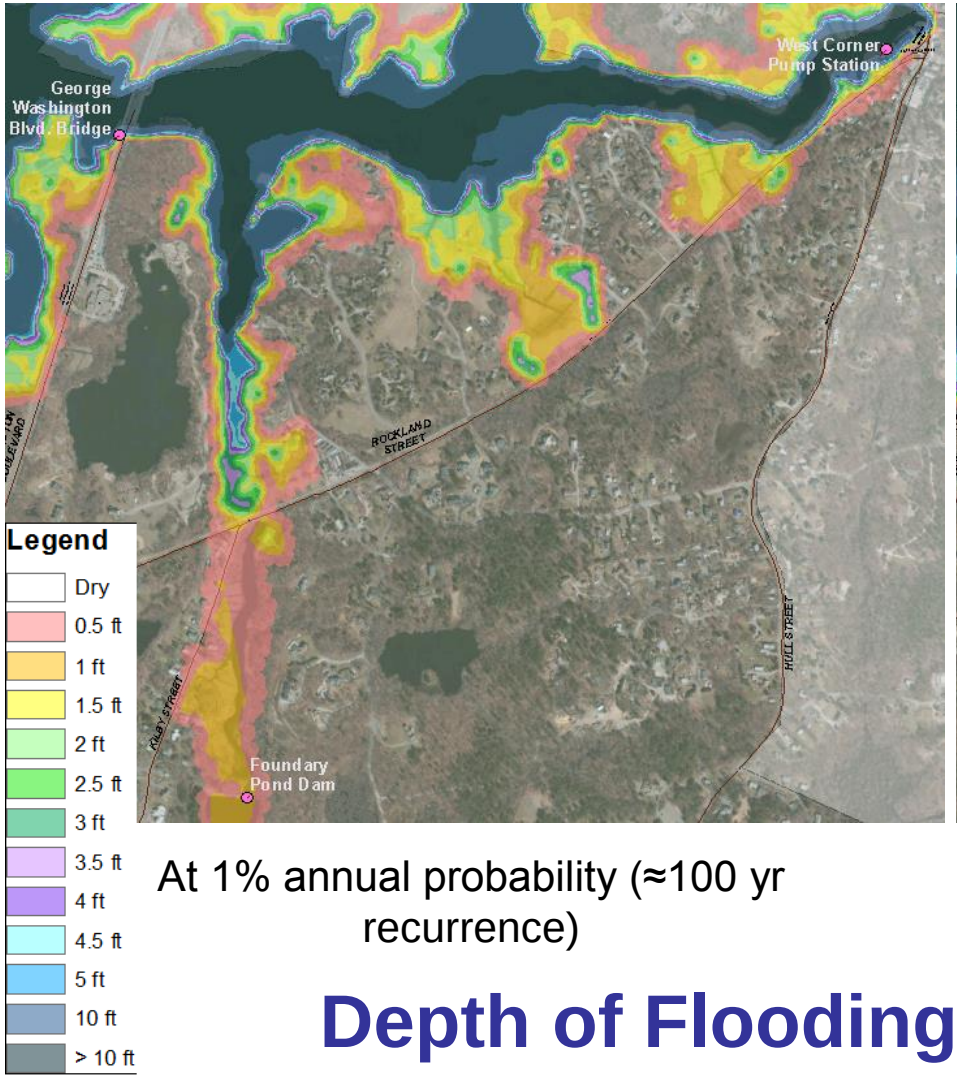
Depth of Flooding above Ground

2070: 0.2% Annual Probability (≈500 yr Recurrence)

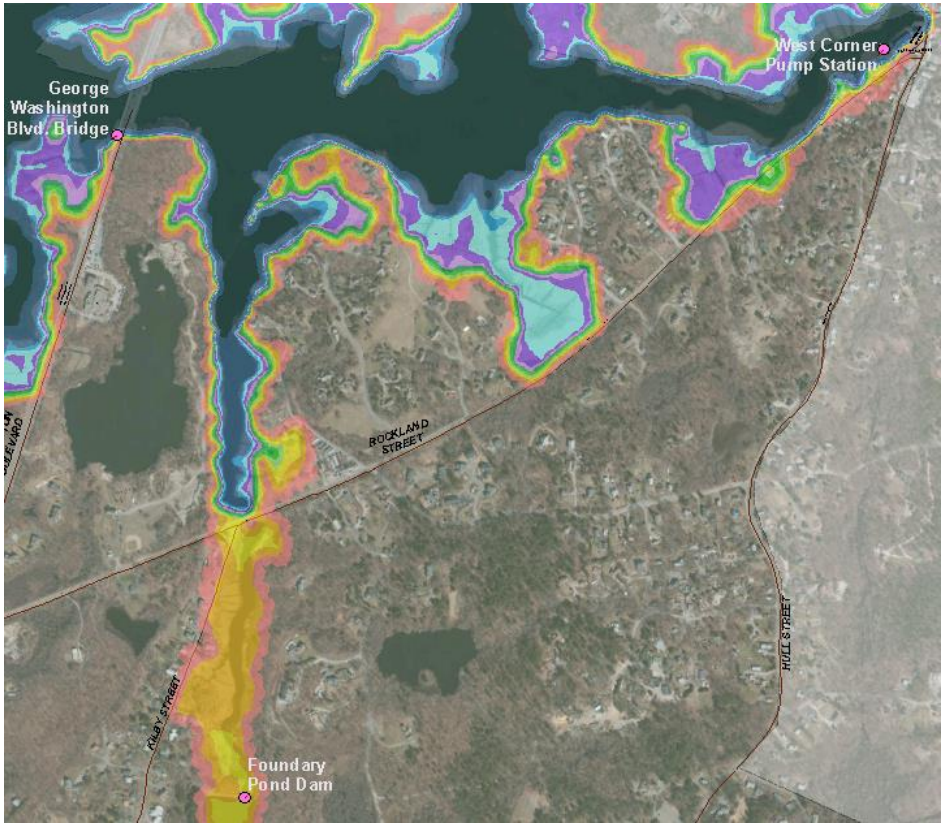


Depth of Flooding above Ground

Present Inundation: Hingham-Hull Connectors



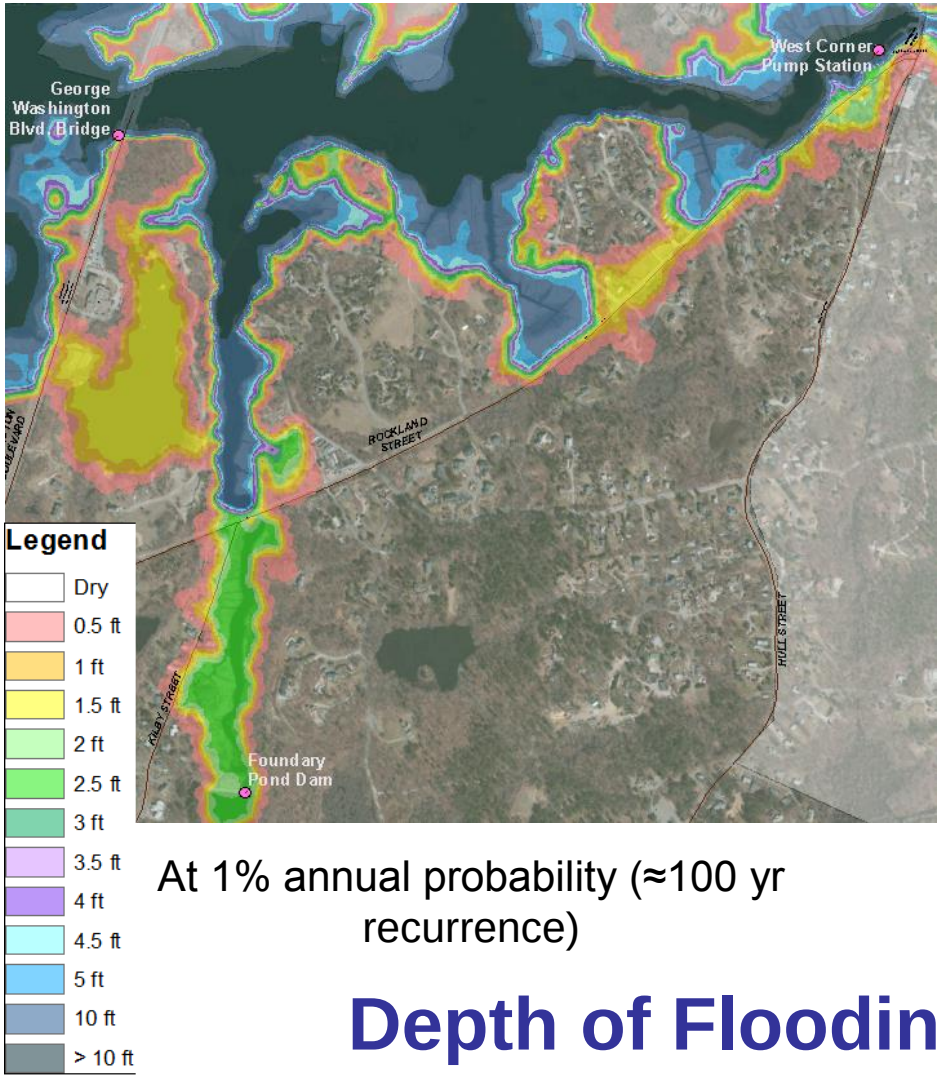
At 1% annual probability (≈100 yr recurrence)



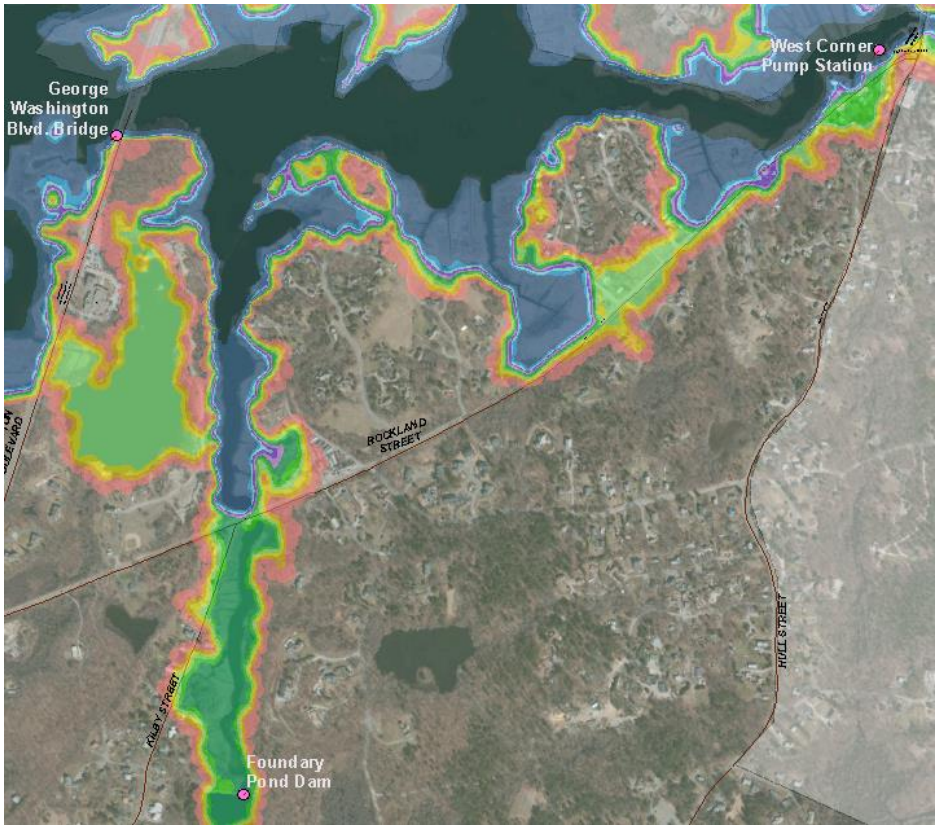
At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

2030 Inundation: Hingham-Hull Connectors



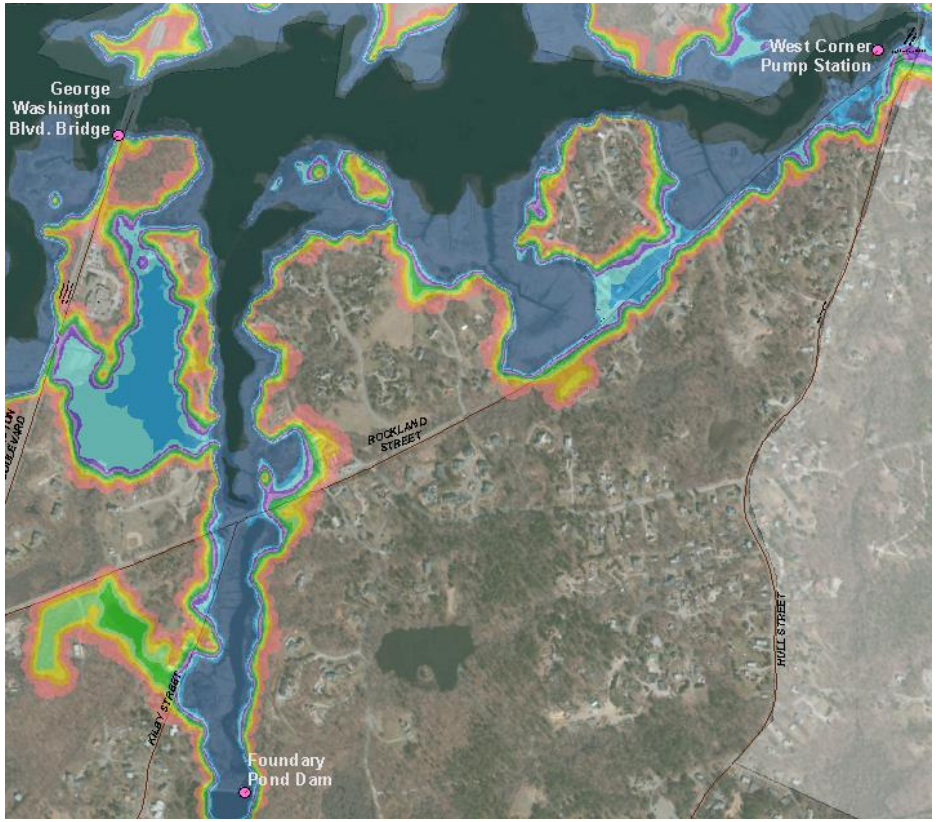
At 1% annual probability (≈100 yr recurrence)



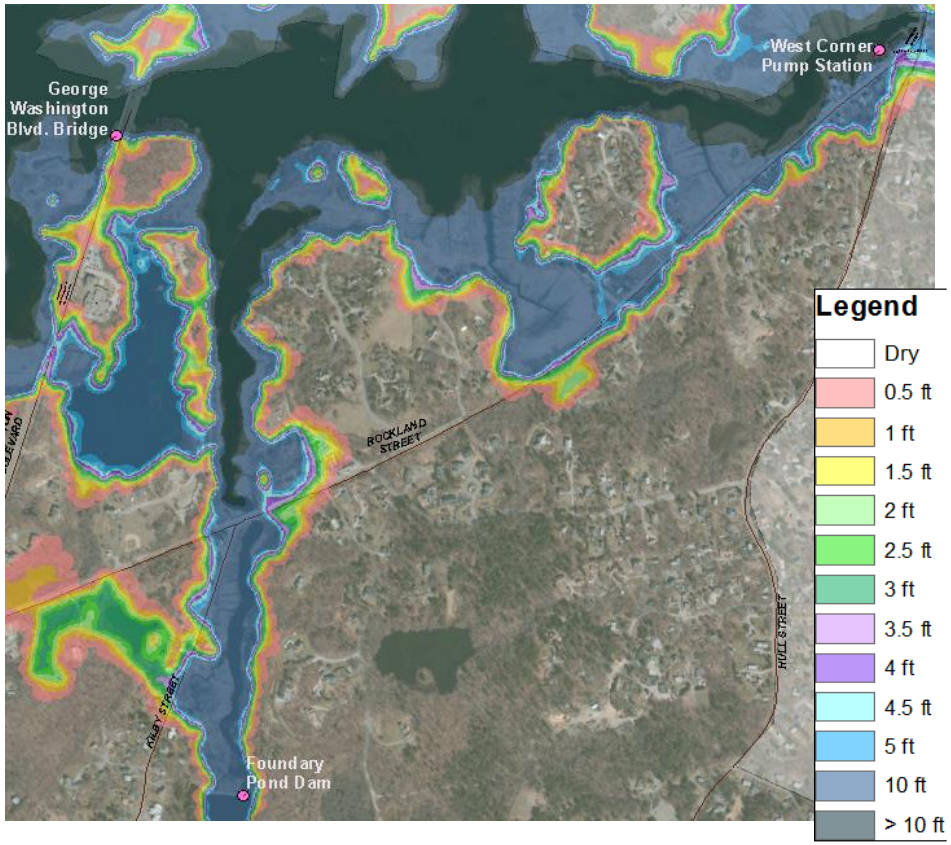
At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

2070 Inundation: Hingham-Hull Connectors



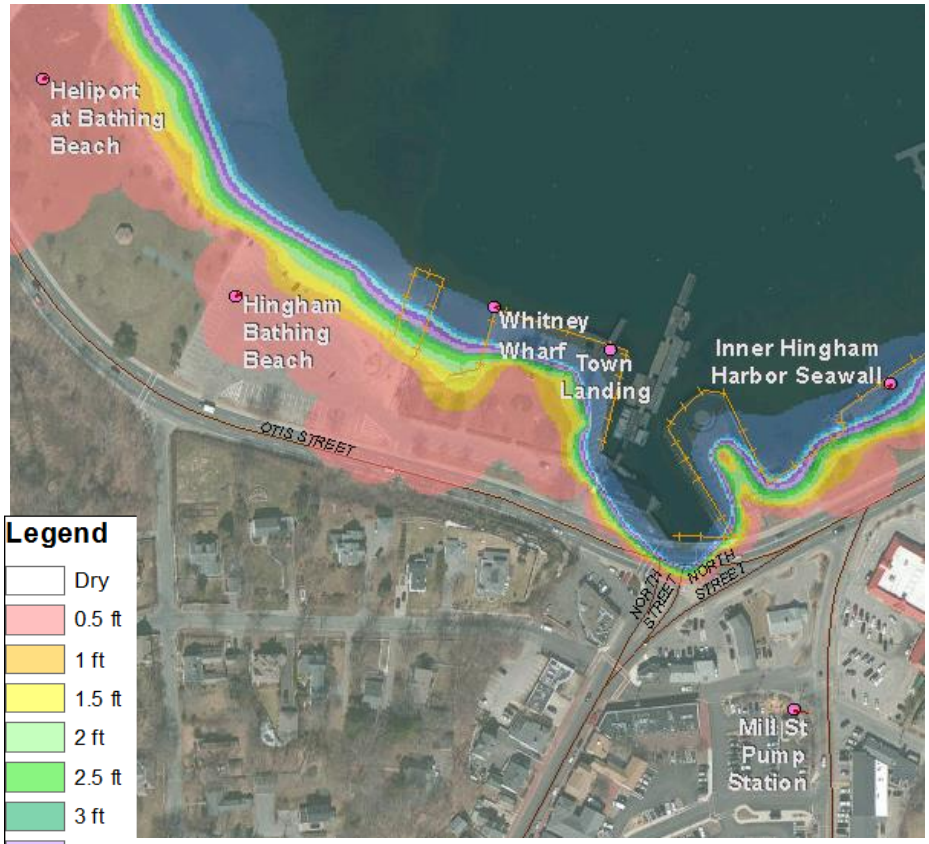
At 1% annual probability (≈100 yr recurrence)



At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

Present Inundation: Inner Hingham Harbor

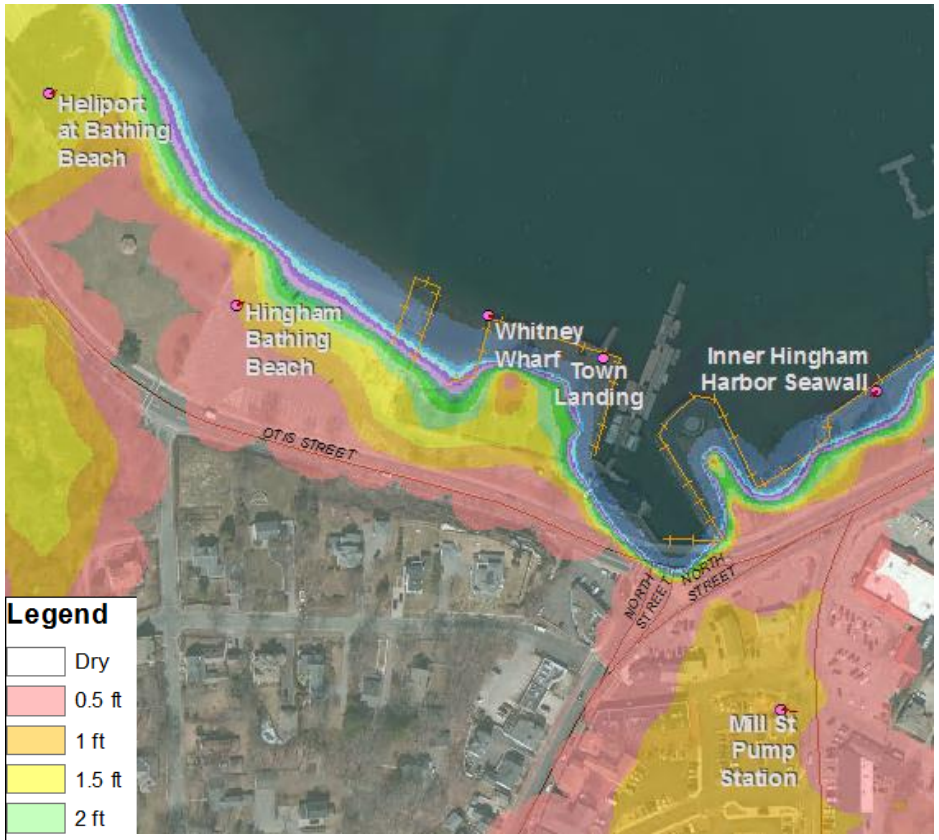


At 1% annual probability (≈100 yr recurrence)

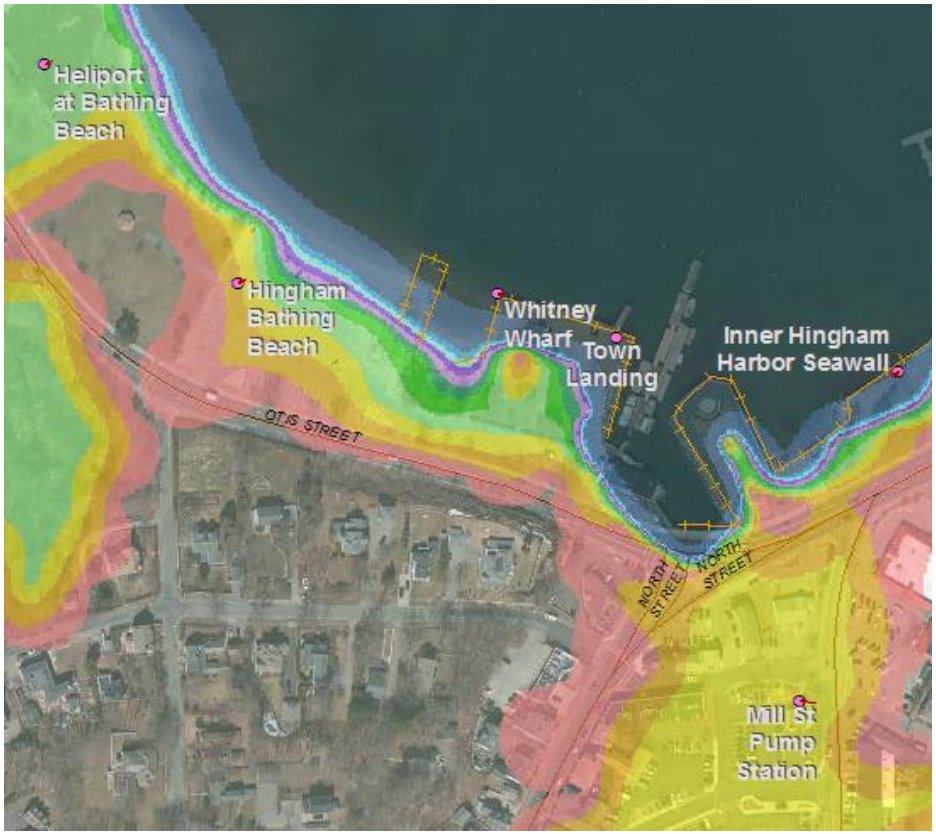
At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

2030 Inundation: Inner Hingham Harbor



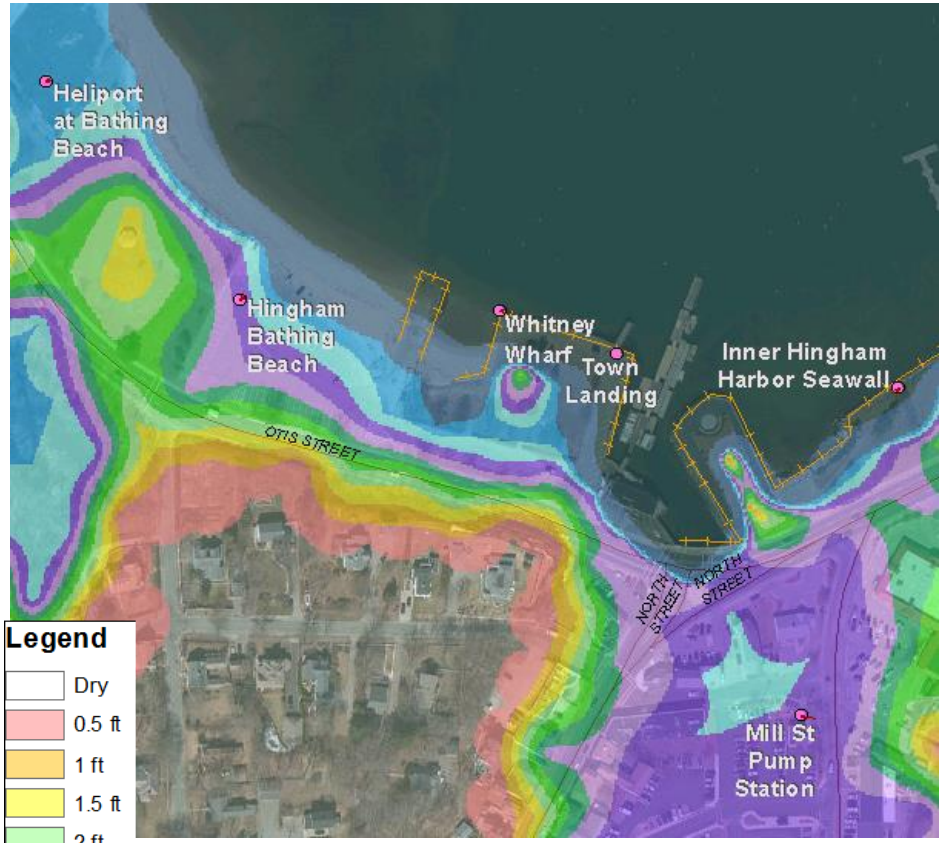
At 1% annual probability (≈100 yr recurrence)



At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

2070 Inundation: Inner Hingham Harbor

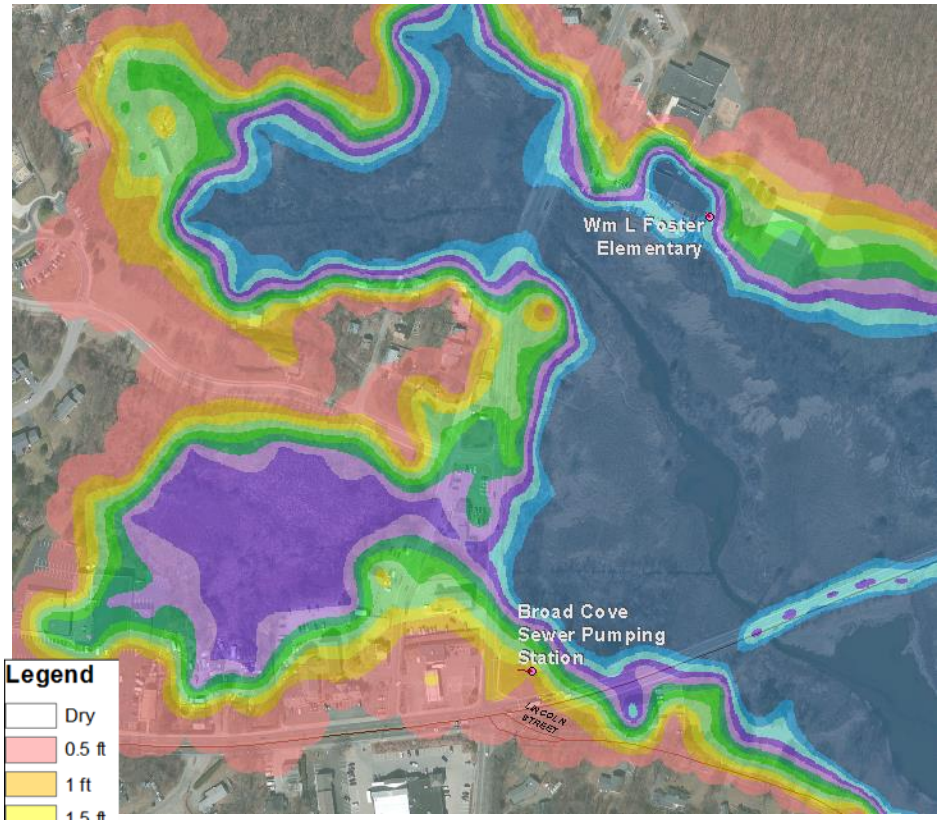


At 1% annual probability (≈100 yr recurrence)

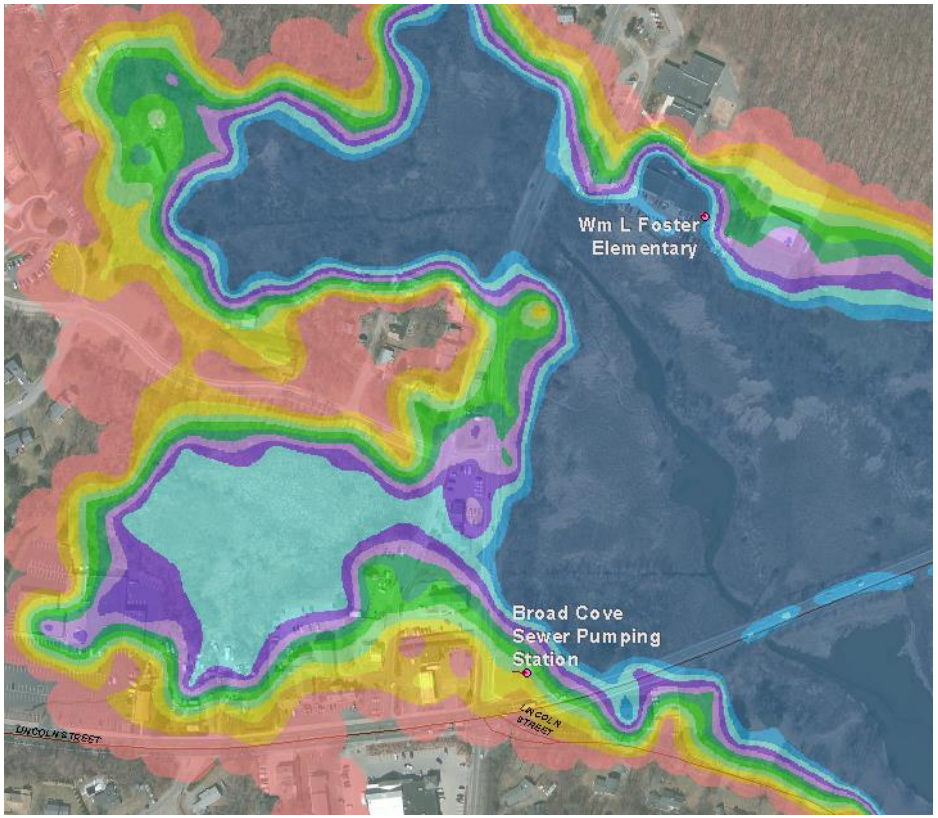
At 0.2 % annual probability (≈ 500 yr recurrence)

Depth of Flooding above Ground

2030 Inundation: Foster Elementary and Broad Cove PS



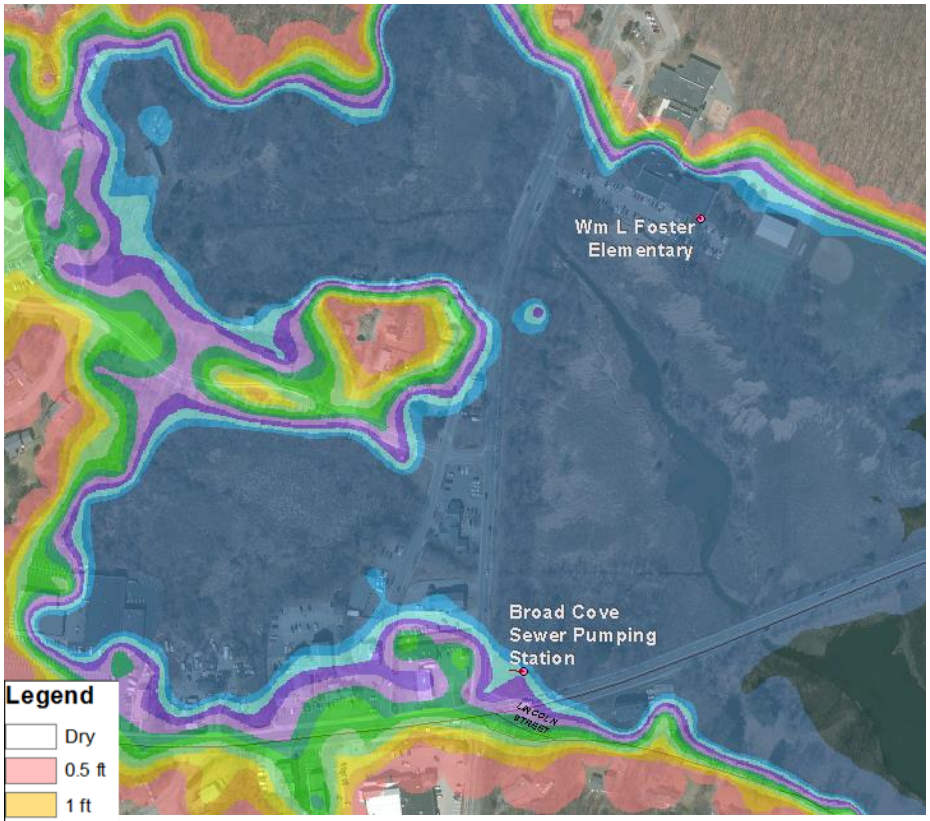
At 1% annual probability (≈100 yr recurrence)



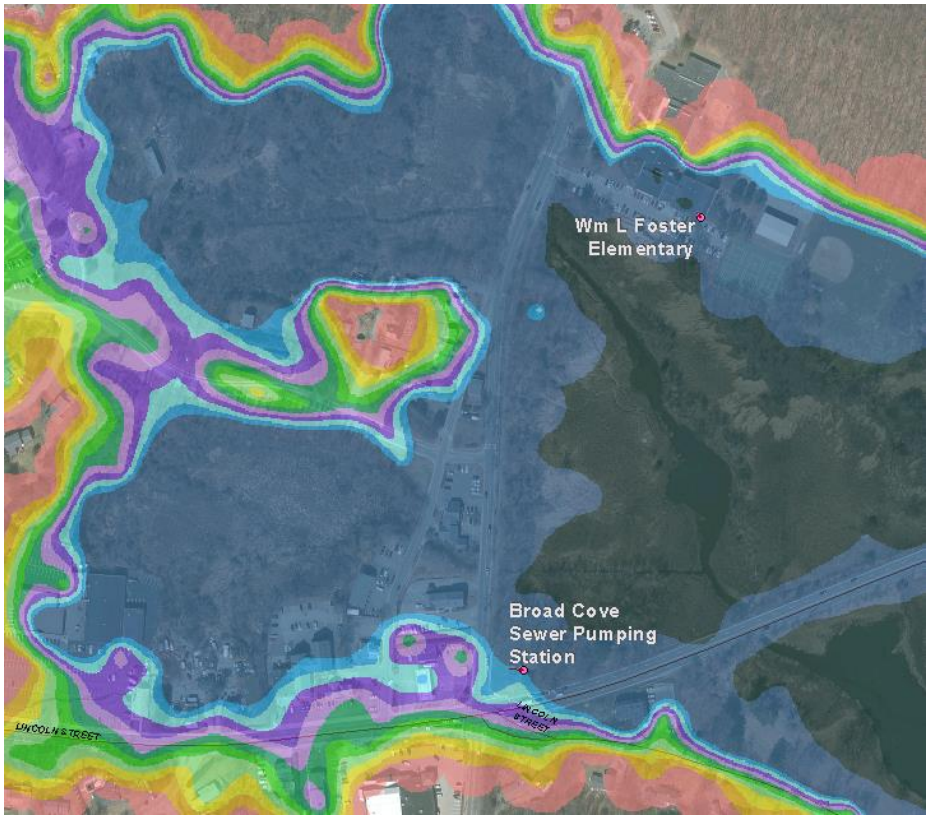
At 0.2 % annual probability (≈ 500 yr recurrence)

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

Infrastructure Vulnerable to Flooding - Facilities

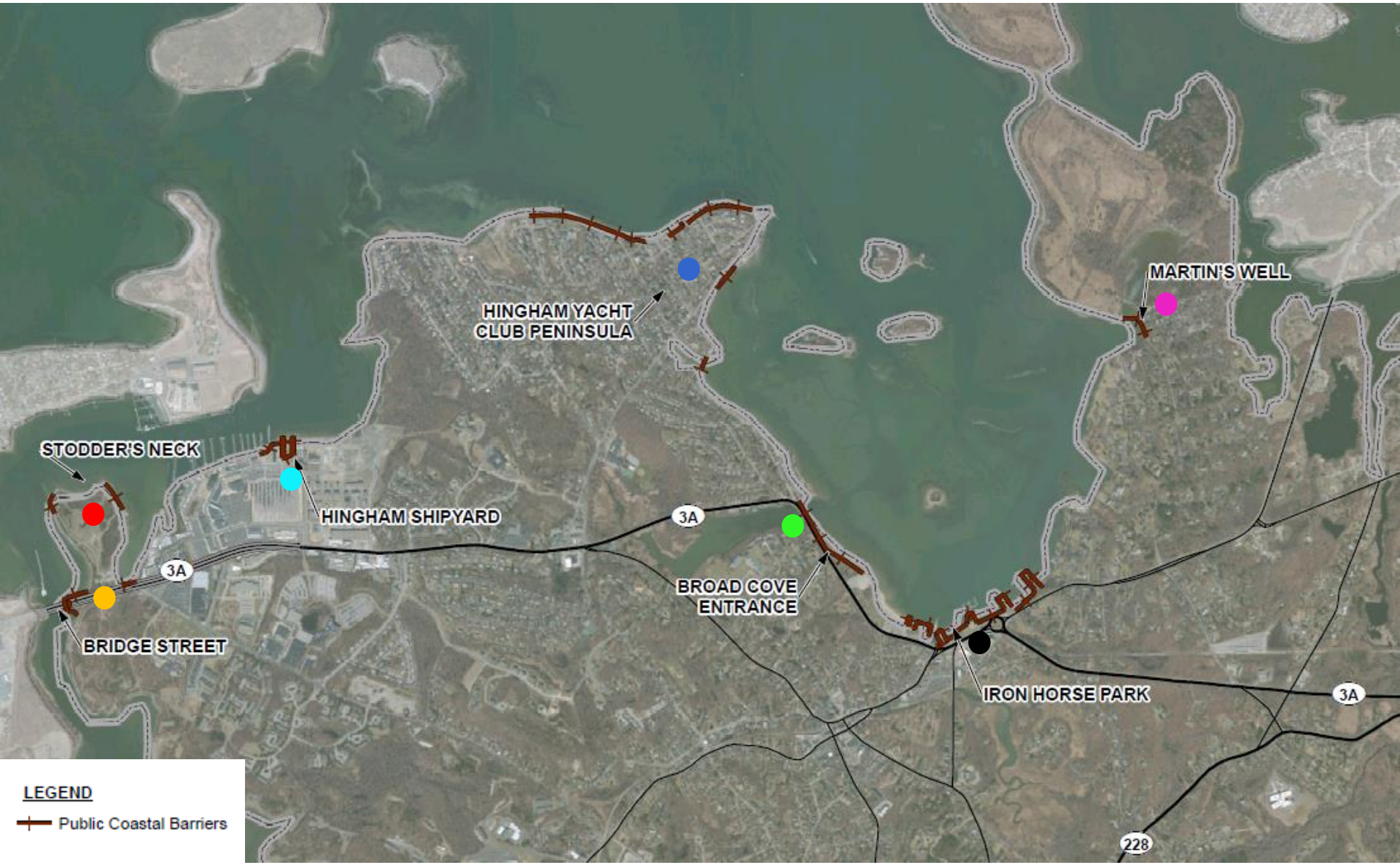
Facility/Building Name	Critical Elevation (NAVD88)	First Vulnerable Time Horizon
Bel Air Pump Station	7.30	Present
Howe St Pump Station	8.30	Present
West Corner Pump Station	8.50	Present
Hingham Bathing Beach (Parking Lot)	9.06*	Present
Heliport at Bathing Beach	8.12*	Present
William L Foster Elementary School	6.10	2030
Mill St. Pump Station	8.69*	2030
Broad Cove Sewer Pump Station	8.10	2030
Whitney Wharf	10.36*	2070
Downer Ave Sewer Pump	11.90	2070
Beal Street Pump Station	12.20	2070
Walton Cove Pump Station	11.40	2070

(*) Critical elevation provided by Town of Hingham

Infrastructure Vulnerable to Flooding - Roadways

Roadway Name
Rockland St/Kilby St at Foundary Pond Dam
Summer St/Rte 3A Rotary
Otis St at Hingham Bathing Beach
44 North St at MBTA Greenbush
Broad Cove Road
32 Eldridge Court toward Mill St PS
Rockland St/Hull St at West Corner PS
Rockland St at Meadow Road
Lincoln St
George Washington Blvd Bridge (approach)
Beach Road and Beach Lane Intersection
Parker Drive and Howe St Intersection at Howe St PS
Main St at Winter St
Fresh River Ave
Downer Ave and Condito Rd
62 Downer Ave toward Foster Elem
Otis St

Infrastructure Vulnerable to Flooding – Coastal Stabilization Structures



Infrastructure Vulnerable to Flooding – Coastal Stabilization Structures

Structure Type	CZM Coastal Stabilization Structure Name
Bulkhead/ Seawall	034-051-000-003-100
Bulkhead/ Seawall	034-051-000-001-200
Revetment	034-030-000-011-100
Bulkhead/ Seawall	034-051-000-005B-100
Bulkhead/ Seawall	034-030-000-011-200
Bulkhead/ Seawall	034-050-000-050-200
Bulkhead/ Seawall	034-051-000-005B-200
Revetment	034-050-000-050-100
Bulkhead/ Seawall	034-051-000-001-300
Bulkhead/ Seawall	034-051-000-001-100
Bulkhead/ Seawall	034-051-000-059-100
Bulkhead/ Seawall	034-051-000-001-400
Bulkhead/ Seawall	034-051-000-005-100
Bulkhead/ Seawall	034-051-000-004-100
Bulkhead/ Seawall	034-045-000-002-200
Revetment	034-045-000-002-300
Revetment	034-045-000-002-100
Revetment	034-046-000-001-100
Revetment	034-039-000-009-100
Bulkhead/ Seawall	034-017-000-113-100
Bulkhead/ Seawall	034-027-000-059-100
Bulkhead/ Seawall	034-016-000-183-100
Revetment	034-016-000-183-200
Revetment	034-050-000-051-100
Bulkhead/ Seawall	034-036-000-106-300

Structure Type	CZM Coastal Stabilization Structure Name
Bulkhead/ Seawall	034-017-000-099-100
Revetment	034-036-000-106-200
Revetment	034-011-000-005-100
Revetment	034-034-000-000-100
Revetment	034-035-000-001-100
Bulkhead/ Seawall	034-036-000-106-100
Groin/ Jetty	034-045-000-002-400
Groin/ Jetty	034-017-000-100-100
Revetment	034-039-000-008-100

- Martin's Well
- Bridge Street
- Stodder's Neck
- Hingham Shipyard
- Hingham Yacht Club
- Broad Cove Entrance
- Iron Horse Park

Risk Based Vulnerability Assessment

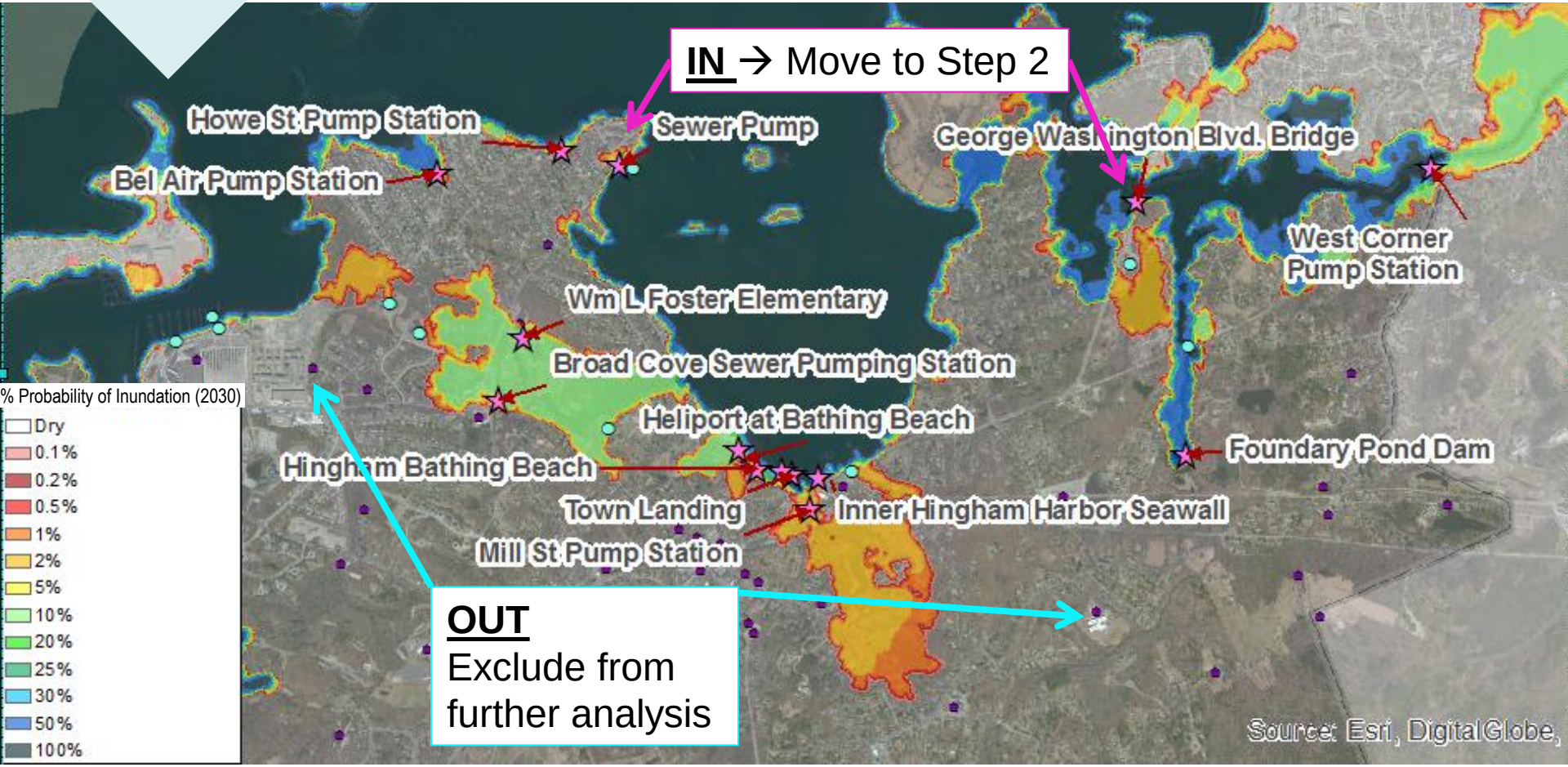
Risk Based Vulnerability Assessment

For each infrastructure asset, assess:

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

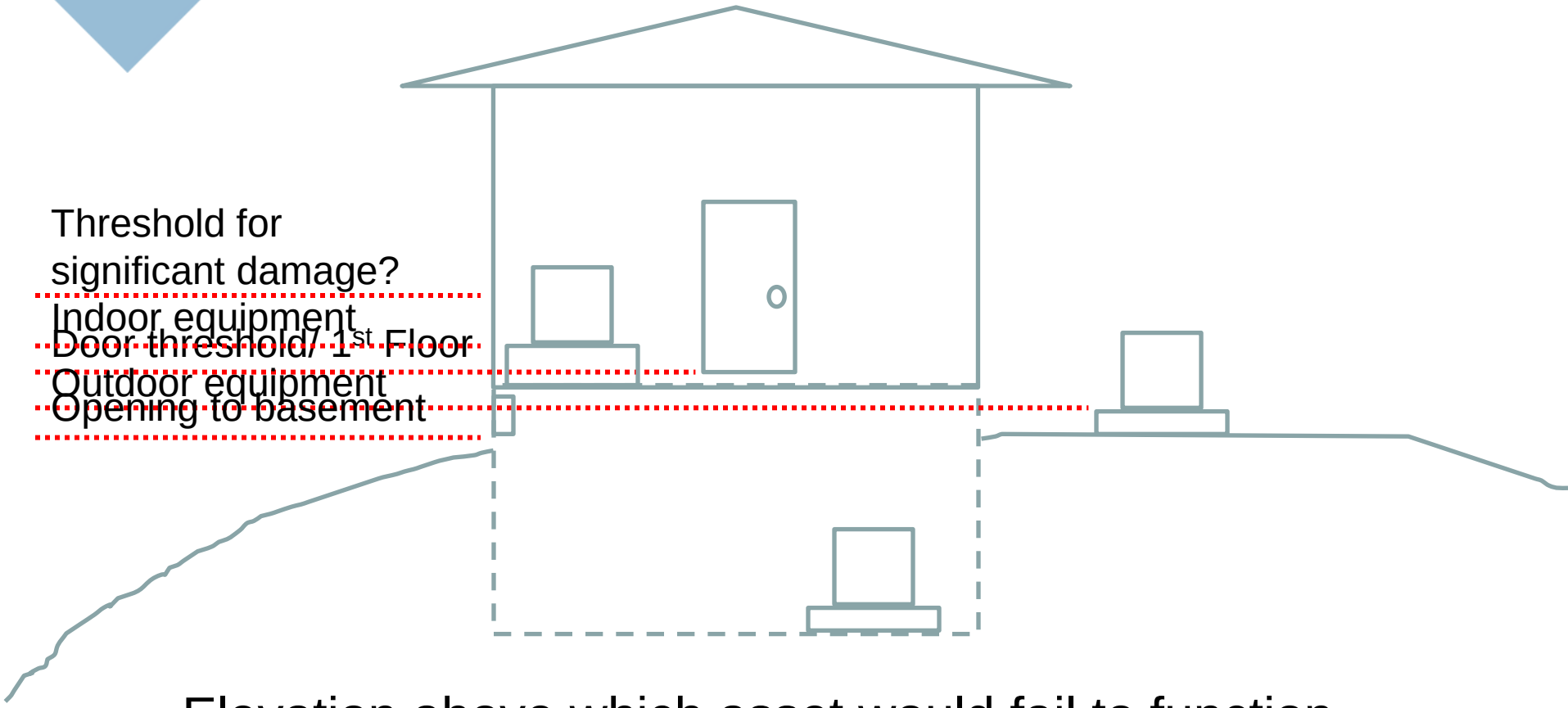
R = P X C

1 Determine Critical Assets



Selecting Critical Elevation

2 Determine Critical Elevations



Elevation above which asset would fail to function

2 Determine Critical Elevations

Mill Street Pump Station

Critical Elevation Threshold:
Rim Elevation at Well = 8.69 ft. NAVD88
(Source: Town data)

Intersection of Rockland & Kilby Street

Critical Elevation Threshold:
Road Elevation = 8.10 ft. NAVD88
(Source: LiDAR, assumptions)

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3 Obtain 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

4 Determine 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

5 Calculate Risk Scores and Rankings

tn = Time horizon, n
P = Probability
C = Consequence
R = Risk

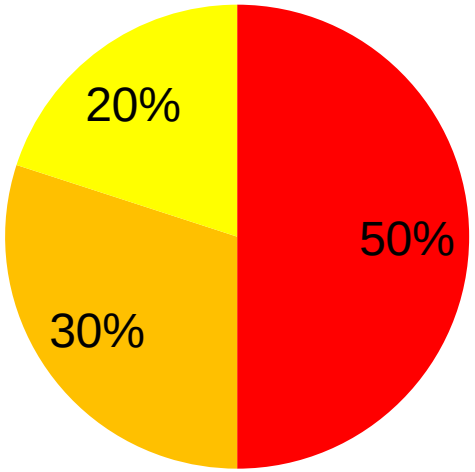
$$R_{tn} = P_{tn} \text{ X } C_{tn}$$

$$R_{t1}(W_{t1}) + R_{t2}(W_{t2}) + R_{t3}(W_{t3}) = R_{t1,t2,t3}$$

t1 = Present
t2 = 2030
t3 = 2070
W = Weight

Weighting

- **Present**
- **2030**
- **2070**



5 Calculate 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 15 Assets Vulnerable to Flooding Ranked by Composite Risk Score (Preliminary)

Type	Name/Number	Consequence Score	Present Probability (%)	Present Risk Score	2030 Probability (%)	2030 Risk Score	2070 Probability (%)	2070 Risk Score	Composite Risk Score
Bulkhead/ Seawall	034-051-000-003-100 ●	60	25	1500	50	3000	100	6000	2850
Facility	Bel Air Pump Station	50	20	1000	50	2500	100	5000	2250
Bulkhead/ Seawall	034-051-000-001-200 ●	60	5	300	30	1800	100	6000	1890
Facility	William L Foster Elementary School	63	0	0	10	633	100	6333	1457
Facility	Howe St Pump Station	47	2	93	25	1167	100	4667	1330
Roadway	Rockland St/Kilby St at Foundary Pond Dam	30	10	300	50	1500	100	3000	1200
Revetment	034-030-000-011-100 ●	23	30	700	50	1167	100	2333	1167
Facility	Broad Cove Sewer Pump Station	53	0	0	2	107	100	5333	1099
Facility	West Corner Pump Station	50	1	25	5	250	100	5000	1088
Bulkhead/ Seawall	034-051-000-005B-100 ●	33	5	167	30	1000	100	3333	1050
Facility	Hingham Bathing Beach (Parking Lot)	43	1	22	5	217	100	4333	943
Bulkhead/ Seawall	034-030-000-011-200 ●	33	2	67	20	667	100	3333	900
Bulkhead/ Seawall	034-050-000-050-200 ●	40	1	20	5	200	100	4000	870
Facility	Mill St. Pump Station	63	0	0	5	317	50	3167	728
Facility	Heliport at Bathing Beach	27	1	27	10	267	100	2667	627

● Martin's Well

● Iron Horse Park

Top 15 Assets Vulnerable to Flooding Ranked by Present Day Risk Score

Type	Name/Number	Consequence Score	Present Probability (%)	Present Risk Score
Bulkhead/ Seawall	034-051-000-003-100 ●	60	25	1500
Facility	Bel Air Pump Station	50	20	1000
Revetment	034-030-000-011-100 ●	23	30	700
Bulkhead/ Seawall	034-051-000-001-200 ●	60	5	300
Roadway	Rockland St/Kilby St at Foundary Pond Dam	30	10	300
Bulkhead/ Seawall	034-051-000-005B-100 ●	33	5	167
Facility	Howe St Pump Station	47	2	93
Bulkhead/ Seawall	034-030-000-011-200 ●	33	2	67
Facility	Heliport at Bathing Beach	27	1	27
Facility	West Corner Pump Station	50	1	25
Facility	Hingham Bathing Beach (Parking Lot)	43	1	22
Bulkhead/ Seawall	034-050-000-050-200 ●	40	1	20
Revetment	034-050-000-050-100 ●	23	1	12
Facility	William L Foster Elementary School	63	0	0
Facility	Broad Cove Sewer Pump Station	53	0	0

● Martin's Well
● Iron Horse Park

Top 15 Assets Vulnerable to Flooding Ranked by 2030 Risk Score

Type	Name/Number	Consequence Score	2030 Probability (%)	2030 Risk Score
Bulkhead/ Seawall	034-051-000-003-100 ●	60	50	3000
Facility	Bel Air Pump Station	50	50	2500
Bulkhead/ Seawall	034-051-000-001-200 ●	60	30	1800
Roadway	Rockland St/Kilby St at Foundary Pond Dam	30	50	1500
Revetment	034-030-000-011-100 ●	23	50	1167
Facility	Howe St Pump Station ●	47	25	1167
Bulkhead/ Seawall	034-051-000-005B-100	33	30	1000
Bulkhead/ Seawall	034-030-000-011-200 ●	33	20	667
Facility	William L Foster Elementary School	63	10	633
Facility	Mill St. Pump Station	63	5	317
Facility	Heliport at Bathing Beach	27	10	267
Facility	West Corner Pump Station	50	5	250
Facility	Hingham Bathing Beach (Parking Lot)	43	5	217
Bulkhead/ Seawall	034-050-000-050-200 ●	40	5	200
Revetment	034-050-000-050-100 ●	23	5	117

● Martin's Well
● Iron Horse Park

Top 15 Assets Vulnerable to Flooding Ranked by 2070 Risk Score

Type	Name/Number	Consequence Score	2070 Probability (%)	2070 Risk Score
Facility	William L Foster Elementary School	63	100	6333
Bulkhead/ Seawall	034-051-000-003-100 ●	60	100	6000
Bulkhead/ Seawall	034-051-000-001-200 ●	60	100	6000
Facility	Broad Cove Sewer Pump Station	53	100	5333
Facility	Bel Air Pump Station	50	100	5000
Facility	West Corner Pump Station	50	100	5000
Facility	Howe St Pump Station	47	100	4667
Facility	Hingham Bathing Beach (Parking Lot)	43	100	4333
Bulkhead/ Seawall	034-050-000-050-200 ●	40	100	4000
Bulkhead/ Seawall	034-051-000-005B-100 ●	33	100	3333
Bulkhead/ Seawall	034-030-000-011-200 ●	33	100	3333
Facility	Mill St. Pump Station	63	50	3167
Roadway	Rockland St/Kilby St at Foundary Pond Dam	30	100	3000
Bulkhead/ Seawall	034-051-000-005B-200 ●	57	50	2833
Facility	Heliport at Bathing Beach	27	100	2667

● Martin's Well
● Iron Horse Park

Thank You - Questions?