

# City of Cambridge Climate Change Vulnerability Assessment

*Public Meeting*

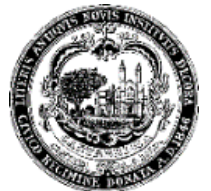
*December 3<sup>rd</sup> , 2015*

*Cambridge Public Library, Cambridge MA*



# Welcome

Richard Rossi, City Manager  
City of Cambridge





# AGENDA

6:15 Welcome & Meeting Overview

6:30 CCVA Review

7:00 Sea Level Rise / Storm Surge

7:30 Completing CCVA

8:00 Preparedness Plan

8:30 Adjourn

# Meeting Goals

- Provide an overview of the Cambridge Climate Change Vulnerability Assessment's findings on key vulnerabilities and priority planning areas.
- Share sea level rise and storm surge model results.
- Provide participants a chance to think about and discuss the project results.
- Seek input from participants on ideas for key next steps.

# Audience Poll

About this polling tool...

- This is just a standard rate text message, so it may be free for you
- The polling tool we are using is serious about privacy. We cannot see your phone numbers and you'll never receive follow-up text messages outside this presentation
- All answers are anonymous
- **You can also vote on the hand-out and give to a City staff at the end of the meeting**

**Let's try it!**

# Audience Poll

There are three ways to participate in the poll:

1. Sending a standard rate text message to **22333**

OR

2. Visiting the voting webpage:  
**<http://www.pollev.com/ccva>**

You can only select one response.

OR

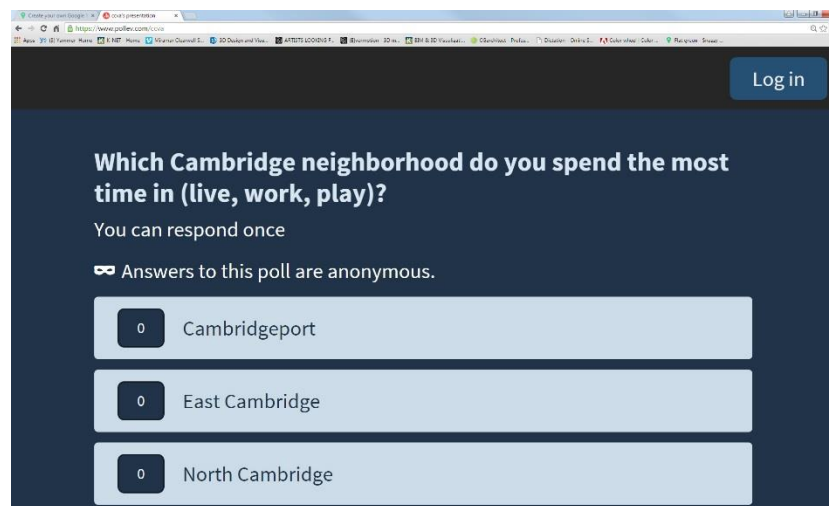
3. Use the provided hand-out for voting

# Audience Poll

To participate by voting on the webpage:

STEP 1 – Go to: <http://www.pollev.com/ccva>

- You may have to connect your smart phone or mobile device to the Public Library’s Wi-fi (if it hasn’t already done it) – go to “Settings”, then “Wi-fi”, and then select “Cambridge Public Internet”
- If you participate by voting on the website, simply “click” or select your response and it will automatically be counted



Log in

**Which Cambridge neighborhood do you spend the most time in (live, work, play)?**

You can respond once

Answers to this poll are anonymous.

0	Cambridgeport
0	East Cambridge
0	North Cambridge

## To participate by text

STEP 1 - Join the polling session by typing the message **CCVA** and sending it to **22333**

- CCVA is all one word
- Lower or uppercase – it doesn't matter!





# Audience Poll

## To participate by text

STEP 2 - Once you have joined the session you can submit poll responses by texting the corresponding letter (A,B,C,D, etc.) to **22333**

- You just text a letter ! That's it



# Audience Poll

## To participate using the paper survey

**STEP 1** – Circle the letter that corresponds to your answer. Only circle one answer per question.

**STEP 2** – Turn in your completed survey at the end of the meeting (or just leave it on your chair)

# Question 1

**Which Cambridge neighborhood do you spend the most time in (live, work, play)?**

A: Cambridgeport

I: Agassiz

B: East Cambridge

J: Neighborhood Nine

C: North Cambridge

K: West Cambridge

D: Area 2/MIT

L: Cambridge Highlands

E: Wellington-Harrington

M: Strawberry Hill

F: Area Four/The Port

N: Outside Cambridge

G: Mid-Cambridge

O: Do not know

H: Riverside



# Your poll will show here

1

Install the app from  
[pollev.com/app](https://pollev.com/app)

2

Make sure you are in  
Slide Show mode

Still not working? Get help at [pollev.com/app/help](https://pollev.com/app/help)  
or

[Open poll in your web browser](#)



## Question 2

**Demographic indicators of social vulnerability include poverty, elderly, elderly living alone, children under 5, low education, and language isolation. On a scale of 1 (low) to 5 (high), how socially vulnerable do you feel?**

A: 1 (low)

B: 2

C: 3

D: 4

E: 5 (high)



# Your poll will show here

1

Install the app from  
[pollev.com/app](https://pollev.com/app)

2

Make sure you are in  
Slide Show mode

Still not working? Get help at [pollev.com/app/help](https://pollev.com/app/help)  
or

[Open poll in your web browser](#)



# Purpose of the Vulnerability Assessment

- Climate change threatens Cambridge's economy, quality of life, public health, and safety.
- Plan for disasters and for "new normal".
- The assessment represents a "climate stress test" on Cambridge. It is not a precise prediction of the future.
- Identify key physical and social vulnerabilities and priority planning areas and issues to inform the preparedness plan.
- Develop a shared understanding of the implications of climate change and empower the community and the City to make preparations and to work together.

# CCVA – Progress Up to this Point

- Climate change projections for temperature, humidity, and precipitation for 2030 and 2070
- Mapping of urban heat islands/areas of relative higher temperatures
- Mapping of precipitation-driven flooding for 10 and 100 year storms
- Rating and ranking vulnerabilities to projected heat and precipitation driven flooding of about 1,000 physical assets and social factors
- Economic impact assessment
- Public health impact assessment
- Urban forest vulnerability assessment



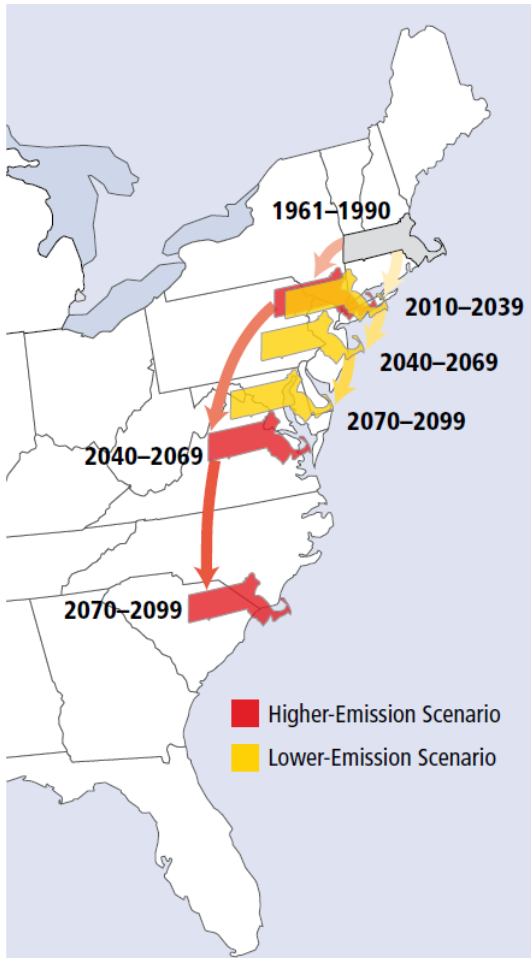
# The Challenge

- Many systems were designed for the climate of the past.
- Past is no longer a reliable indicator of present or future conditions.
- What are the key vulnerabilities and what do we plan for?



# Climate Scenarios

## Temperature



## Precipitation



## More extreme events

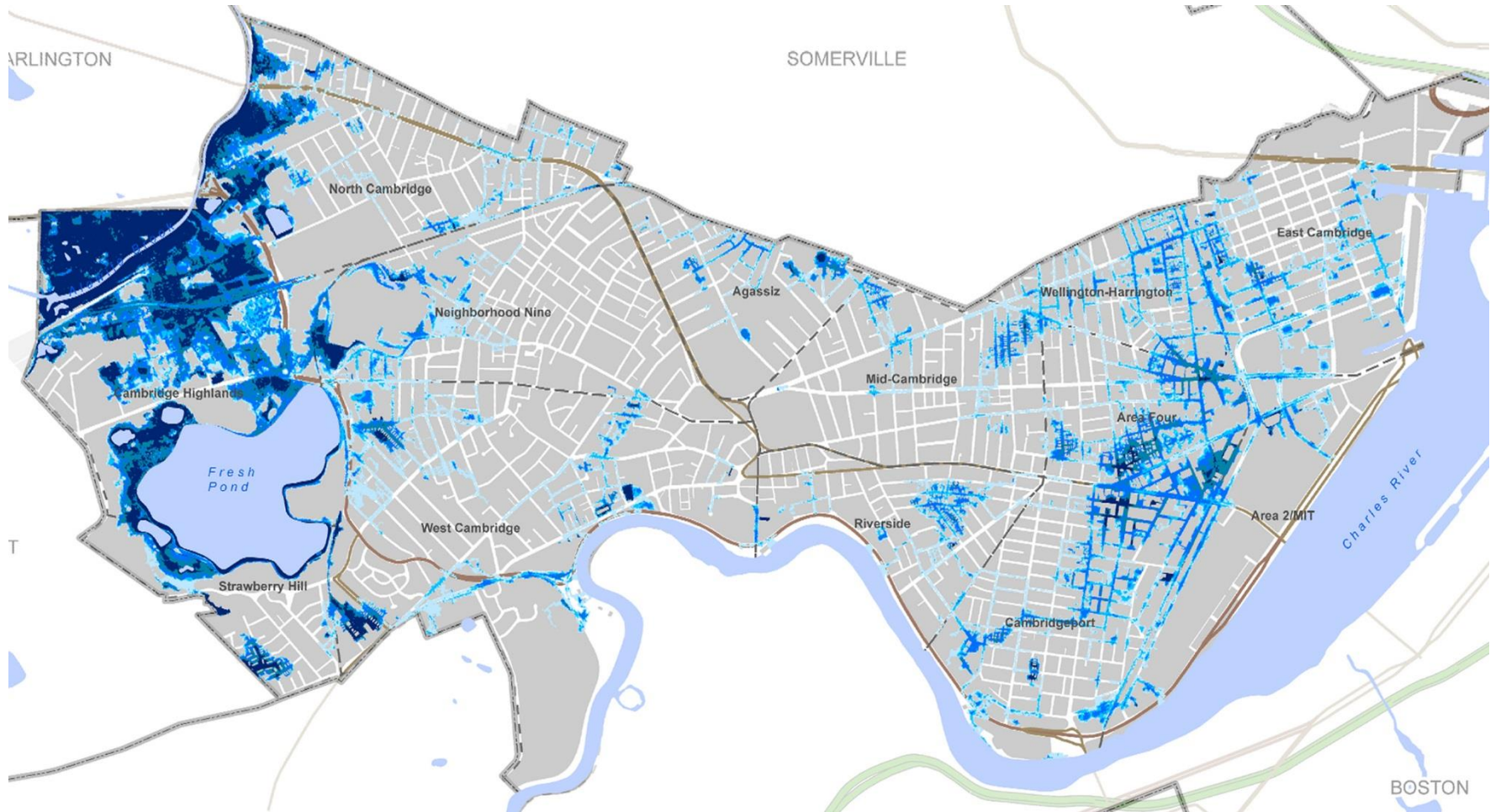


## Sea Level Rise (SLR)

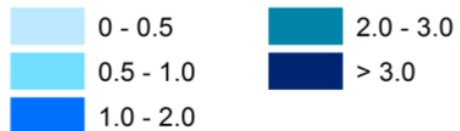


# Precipitation Flooding – 2070

## High Scenario



Depth of flooding above ground (ft)



**100 year 24-hour storm**  
**(11.7 inches over 24 hours)**

Manhole flooding by MWH, Riverine flooding by VHB

# Temperature Projections

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

**1971 - 2000**

(Baseline)

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

**2015 - 2044**

(2030)

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

**2055 - 2084**






(2070)

Above 90°F - Low Scenario
  Above 90°F - High Scenario
  Above 100°F - Low Scenario
  High 100°F - High Scenario





\*Summer is considered to be the 91 days of June through August

# Identifying Critical Assets & Resources

## The Built Environment

-  Energy
-  Transportation
-  Water
-  Telecommunication
-  Critical Services
-  The Urban Forest

## The Social Environment

-  Public Health
-  Community Resources
-  Vulnerable Population
-  Economic Impact

# Urban Infrastructure & Services

## Flooding Stress Test

### Water

Fresh Pond Reservoir



### Stormwater

New St Pump Station  
 Separated Stormwater  
 CAM 400 (Alewife)  
 CAM 004 (Alewife)  
 Western Flagg (Charles)  
 Lechmere (Charles)  
 D46 (Alewife)  
 Combined Sewer  
 CAM 017 (Charles)  
 CAM 001

### Roadway

Concord Tpke, Broadway  
 Memorial Drive, Land Blvd  
 Cambridge St Underpass  
 Monsignor O'Brien Hwy  
 Alewife Brook Pkwy  
 Massachusetts Ave  
 Lars Anderson Bridge  
 Longfellow Bridge  
 Eliot Bridge  
 Fresh Pond Pkwy



### Transit

Alewife-Davis-Porter Rail Line  
 Fitchburg Commuter Rail  
 Central-Kendall Rail Line  
 Harvard-Central Rail Line  
 Lechmere T & Rail Line  
 Central Square T Station  
 Kendall T Station  
 Alewife T Station  
 Porter Square Station

### Critical Services

Youville Hospital  
 Fire Company 2  
 Fire Department  
 Headquarters



### Critical Services

Windsor Street Health Center  
 & Public Health Department  
 Police Headquarters  
 Professional Ambulance  
 Services Office

### Energy

North Cambridge Substation  
 Brookford St Take Station  
 Third St. Regulator Station  
 MIT Cogeneration Plant  
 Putnam Substation  
 Prospect Substation

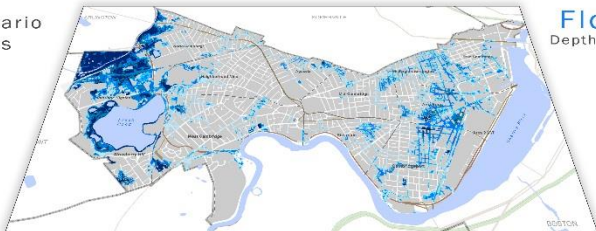


### Telecom

City Emergency Com  
 Center (Police HQ)  
 AT&T Data Hub/300 Bent St  
 BBN Data Hub/CO-LOC:  
 10-12 Moulton St  
 AT&T Office/Long Line  
 Switch: 250 Bent St

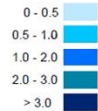


2070 Scenario  
 11.7 inches  
 rainfall in  
 24 hours



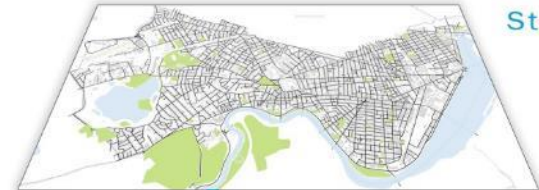
### Flood Risk

Depth of flooding (ft)



## Heat Stress Test

### Water



### Storm Water

### Roadway



### Transit

Porter-Harvard Rail Line  
 Lechmere-Science  
 Park Rail Line  
 Alewife-Davis-Porter  
 Rail Line  
 Fitchburg Commuter  
 Rail Line

### Critical Services

Cambridge Water  
 Department building  
 (the City's Emergency  
 Operations Center)



### Critical Services

Public Health Department  
 building on Windsor Street  
 Police Headquarters  
 Professional Ambulance  
 Services office  
 Fire Department  
 headquarters

### Energy

Third Street  
 Regulator Station



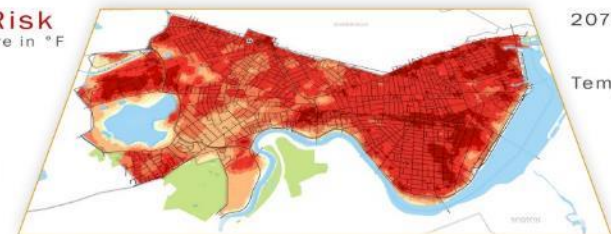
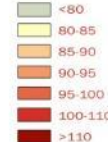
### Communication

City Emergency  
 Communications  
 Center (Police HQ)



### Heat Risk

Temperature in °F



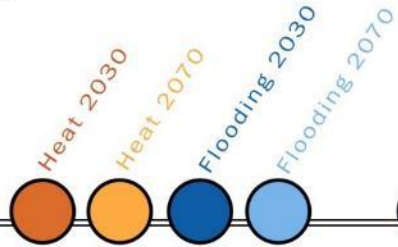
2070s Scenario  
 Estimated  
 Ambient  
 Temperature on  
 100° F Day

# Climate Change Priority Planning Areas

ARLINGTON

SOMERVILLE

BOSTON



**VULNERABILITY**

**AFFECTED SERVICES**



# Key Findings of CCVA Part 1

- **Heat vulnerability** and **inland flooding** are more imminent.
- **Social vulnerability** is not evenly distributed among neighborhoods or households
  - Heat stress, heat-sensitive disease, critical services, indoor air, food safety, housing/shelter, communications
- **Key infrastructure assets** are vulnerable in the near-term.
- **Economic losses** from a flood event or an area-wide power loss would be significant.
  - Disruption of **economic** activity could be greater than property damage.
- **Adaptation** will require coordination with other entities



# Climate Change Vulnerability Assessment

November 2015



City of Cambridge,  
Massachusetts

**1**  
Part

# The CCVA Report

The Report and Technical Appendices online at [www.cambridgema.gov/climateprep](http://www.cambridgema.gov/climateprep)



## Question 3

Which climate change stressor do you expect will most negatively affect your quality of life by 2030?

- A: Increased temperatures
- B: Increased precipitation and flooding
- C: More extreme storms
- D: All of the above



# Your poll will show here

1

Install the app from  
[pollev.com/app](https://pollev.com/app)

2

Make sure you are in  
Slide Show mode

Still not working? Get help at [pollev.com/app/help](https://pollev.com/app/help)  
or

[Open poll in your web browser](#)



## Question 4

Which economic impacts from flooding or extreme heat are you most concerned about by 2030?

A: Costs of property damage

(e.g., car, home, business, community)

B: Reduced economic activity

(e.g., wages, business income, opportunities)

C: Both property damage and reduced economic activity



# Your poll will show here

1

Install the app from  
[pollev.com/app](https://pollev.com/app)

2

Make sure you are in  
Slide Show mode

Still not working? Get help at [pollev.com/app/help](https://pollev.com/app/help)  
or

[Open poll in your web browser](#)



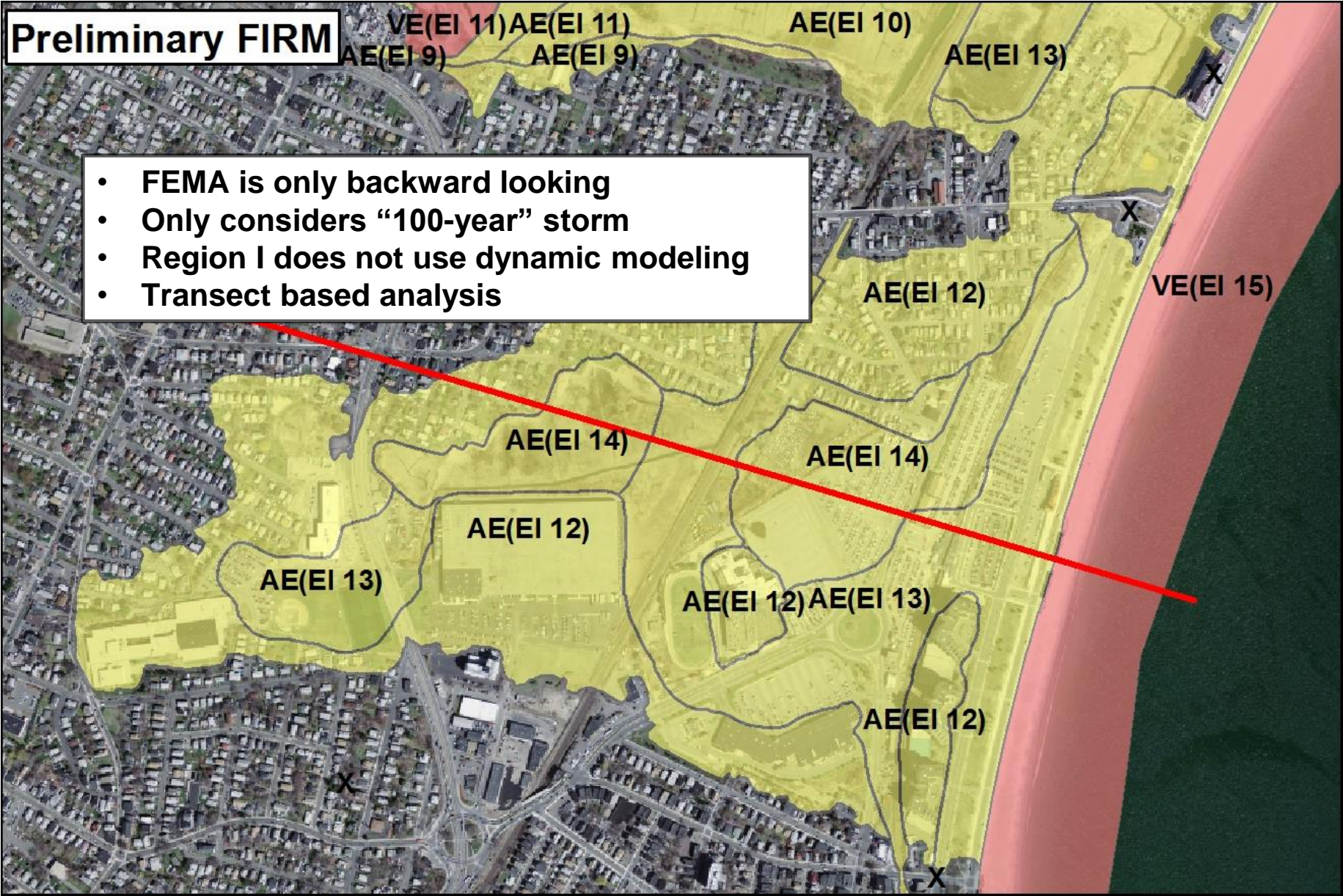
# Sea Level Rise and Storm Surge



# Flood Map Options - FEMA

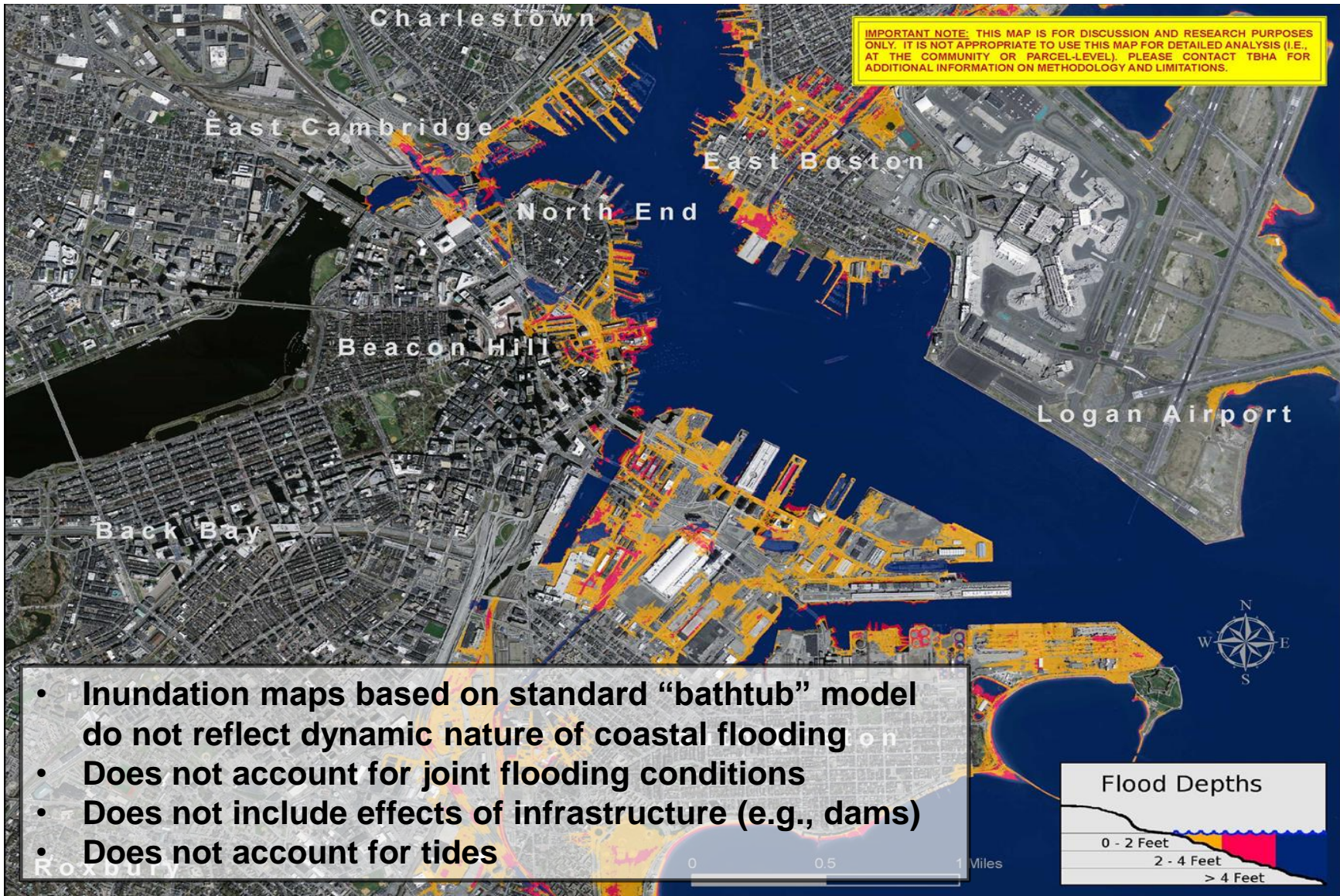
**Preliminary FIRM**

- FEMA is only backward looking
- Only considers “100-year” storm
- Region I does not use dynamic modeling
- Transect based analysis

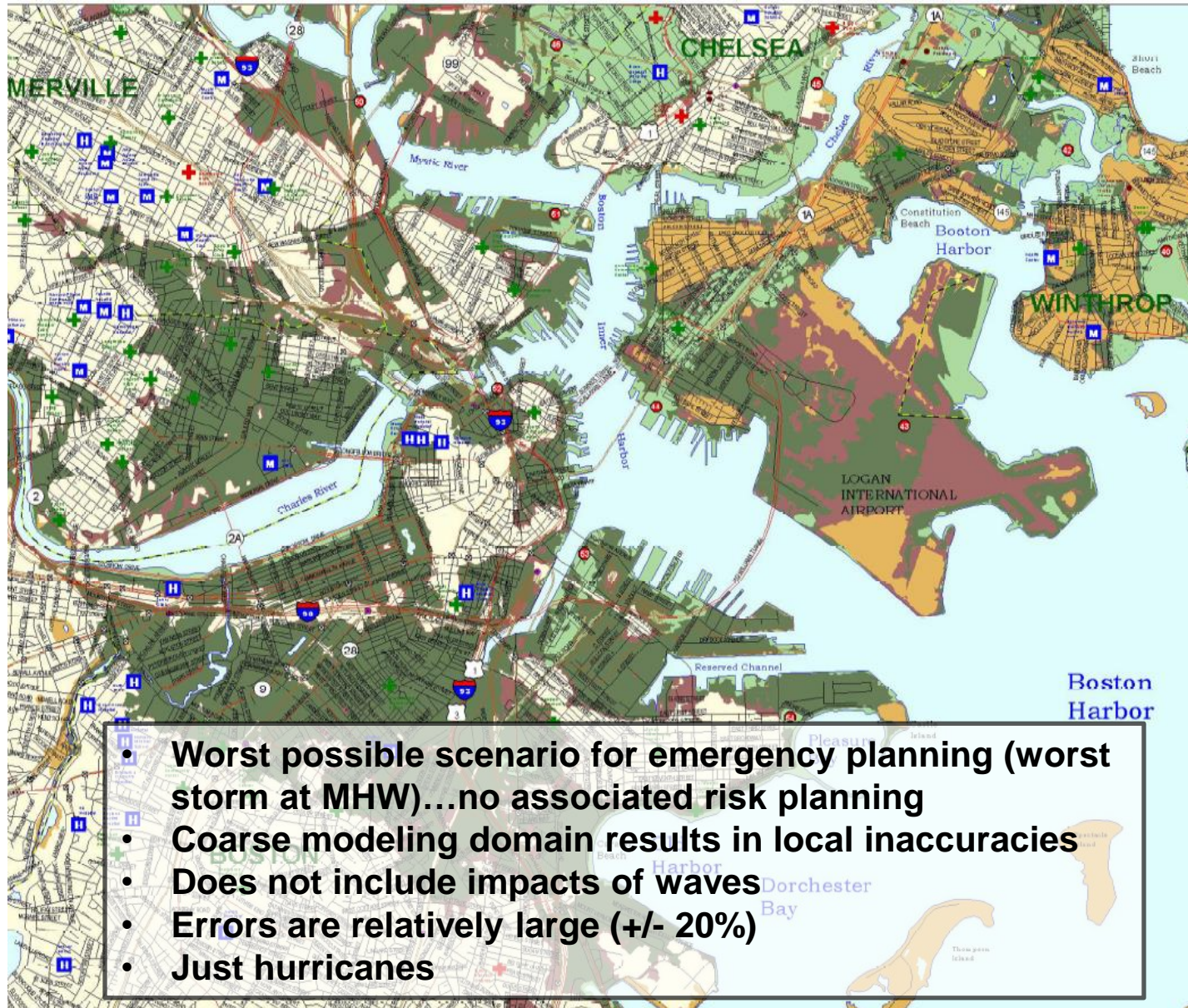




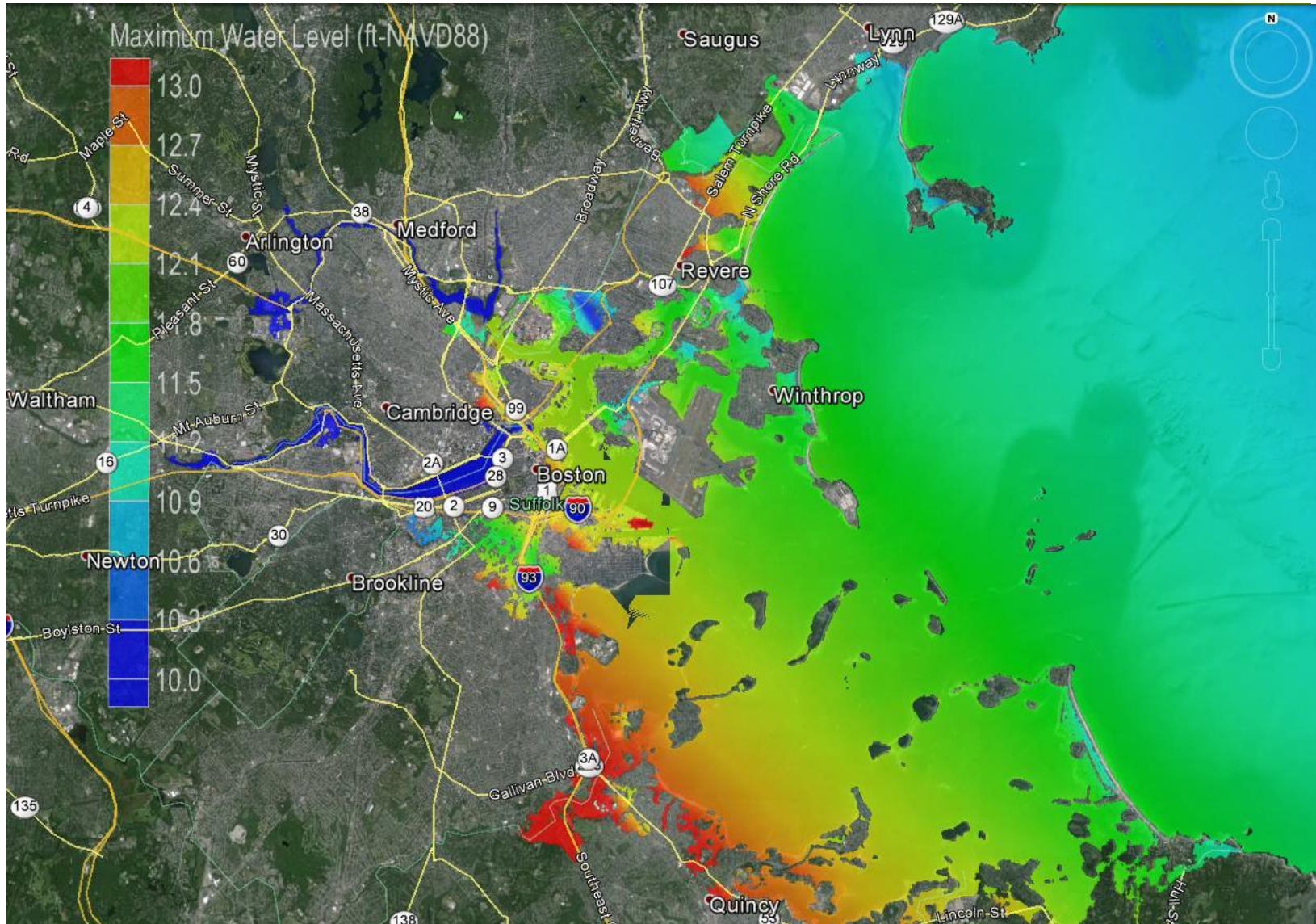
# Flood Map Options - Bathtub



# Flood Map Options – Hurricane Evacuation

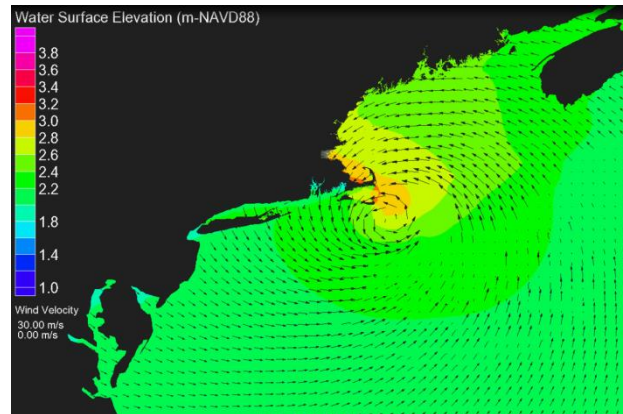


# Why Existing Maps are not good enough...

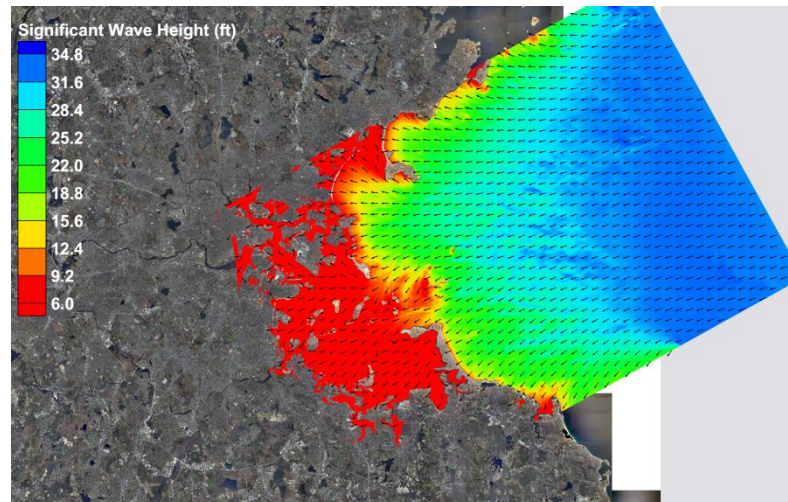
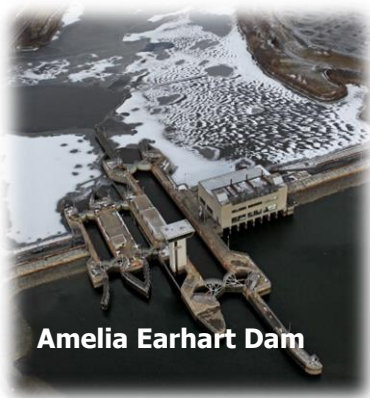


# High Resolution Hydrodynamic Modeling

- Includes relevant physical processes (tides, storm surge, wind, waves, wave setup, river discharge, sea level rise, future climate scenarios)



- Currents
- Storm Surge
- Tides
- Water Levels
- Winds
- SLR
- Discharge
- Infrastructure

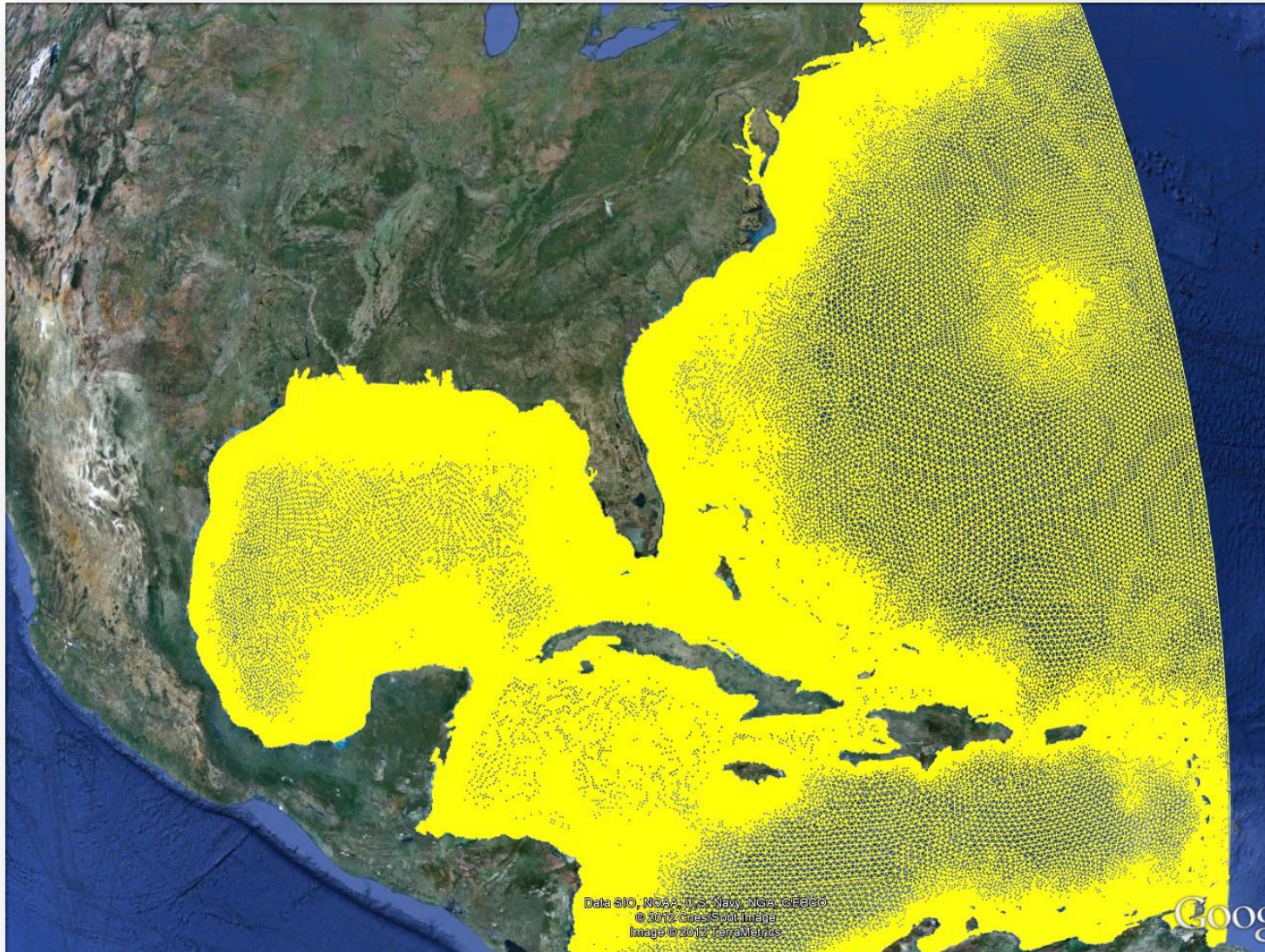


- Waves
- Wave Setup

**Tightly Coupled**

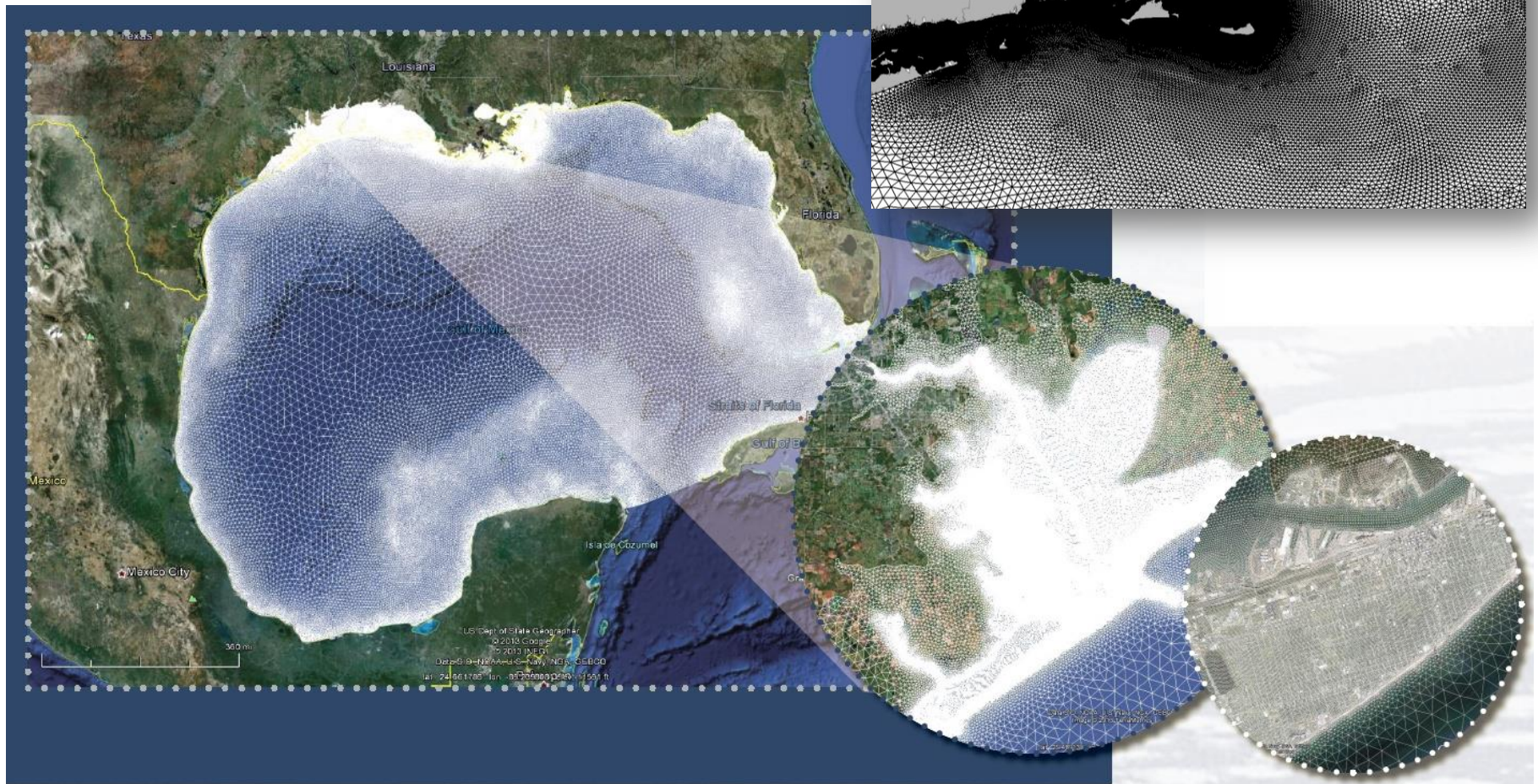
# Regional Grid Requirements

Grid covers a large regional area (North Atlantic) to capture large-scale storm (hurricane, nor'easter) dynamics.



# Unstructured Grid

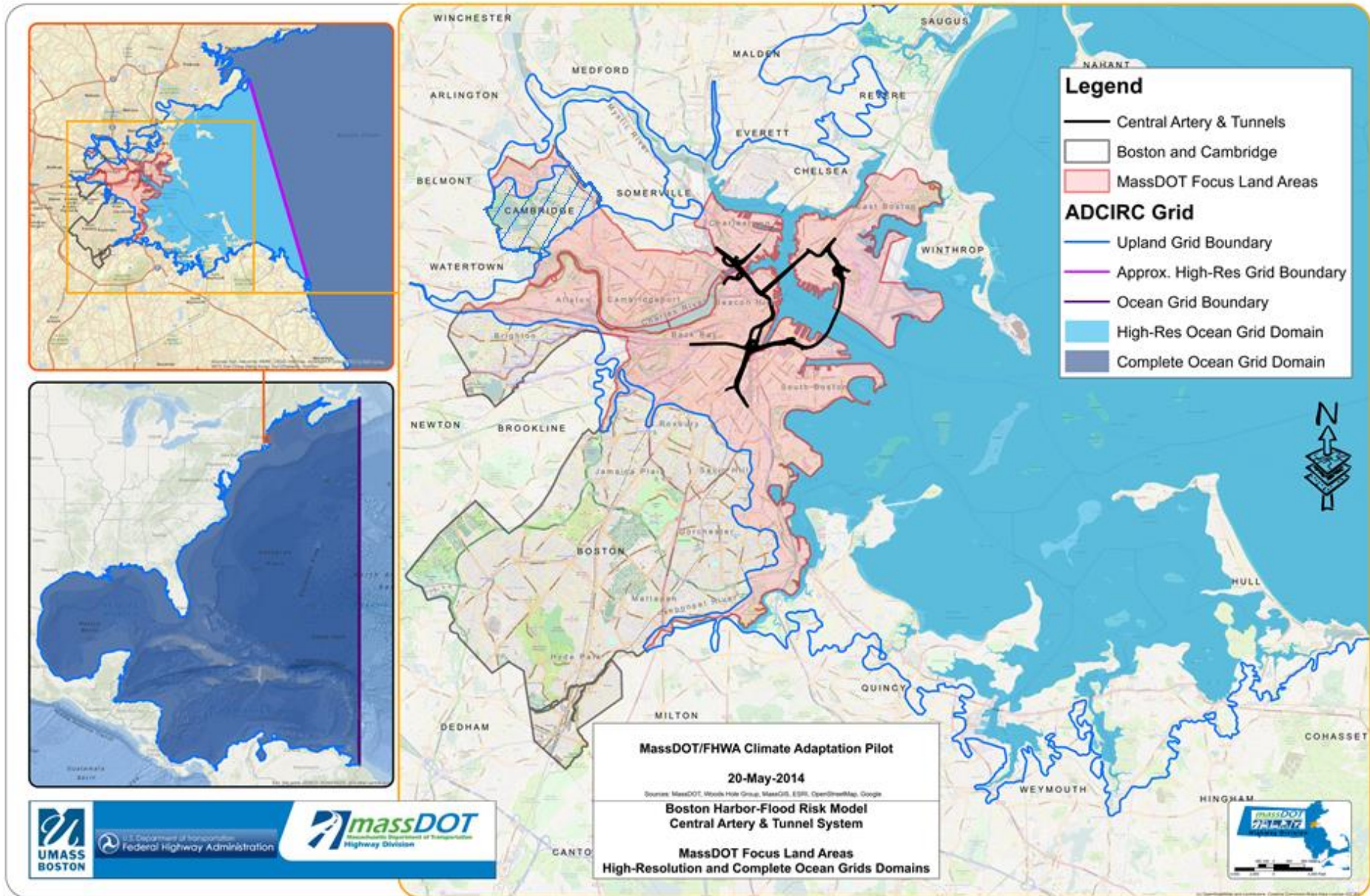
Varying resolution with high resolution in areas of interest



# Downtown Boston Grid



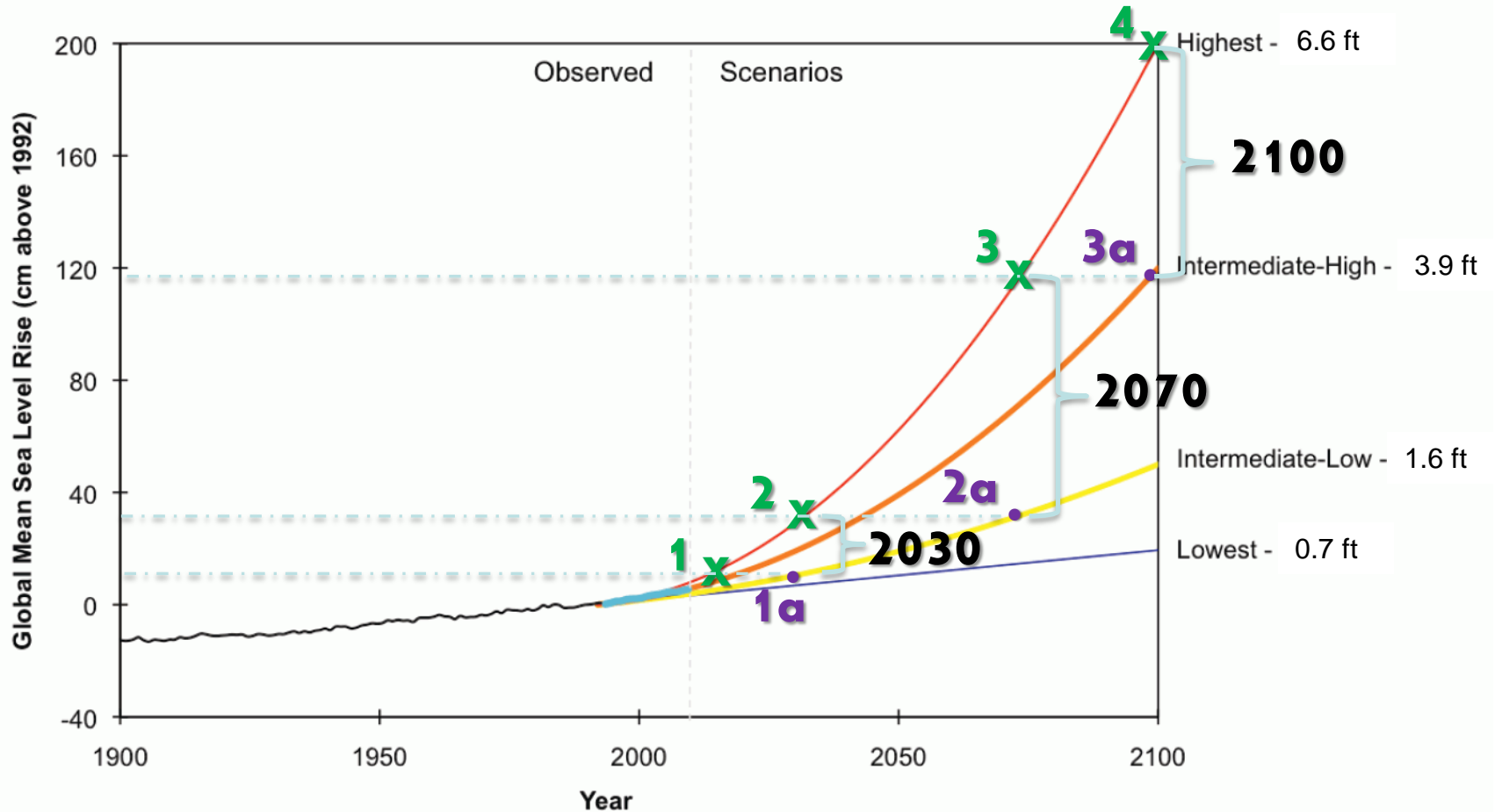
# Boston Harbor Flood Risk Model





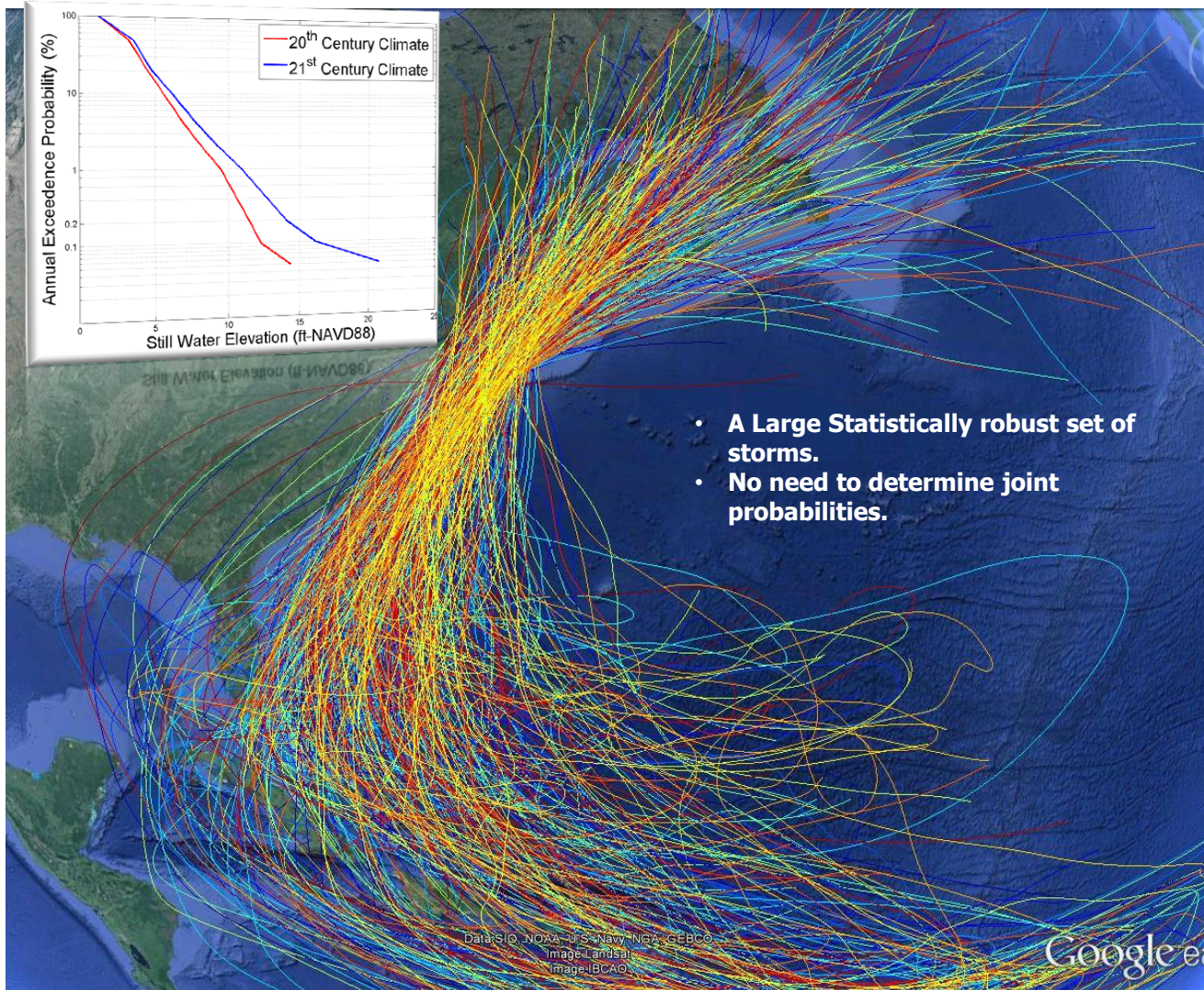
# Sea Level Rise Projections

Scenarios	2020	2030	2040	2050	2060	2070	2080	2090	2100
"Highest" Global SLR (from 2013-2020) (feet)	0.21	0.61	1.10	1.70	2.40	3.21	4.11	5.12	6.23
Land subsidence (feet) @ 0.003 ft/yr	0.02	0.06	0.09	0.12	0.15	0.19	0.22	0.25	0.29
"Highest" Relative SLR (from 2013-2020) - (feet)	0.24	0.66	1.19	1.82	2.56	3.39	4.33	5.37	6.52



NOAA (2012). Global Sea Level Rise Scenarios for the United States National Climate Assessment

# Storm Climatology



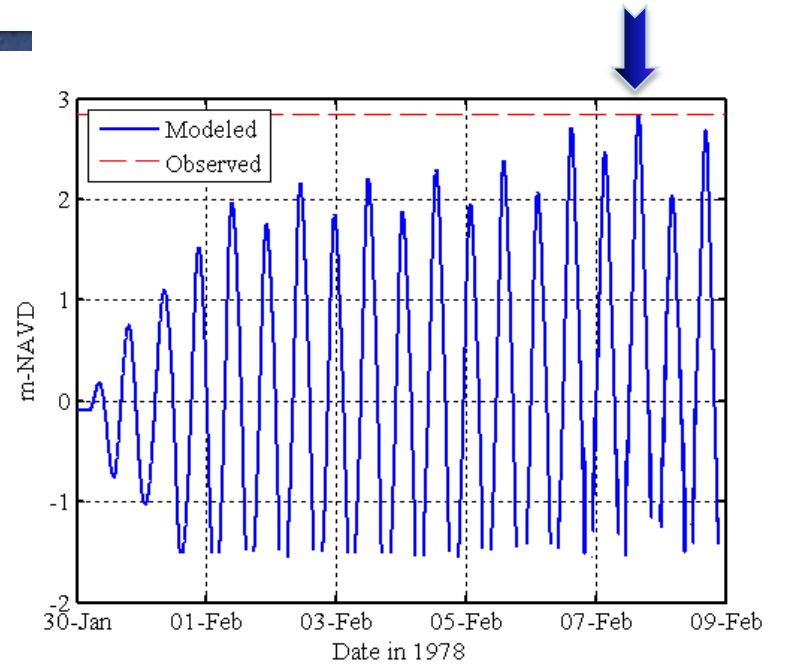
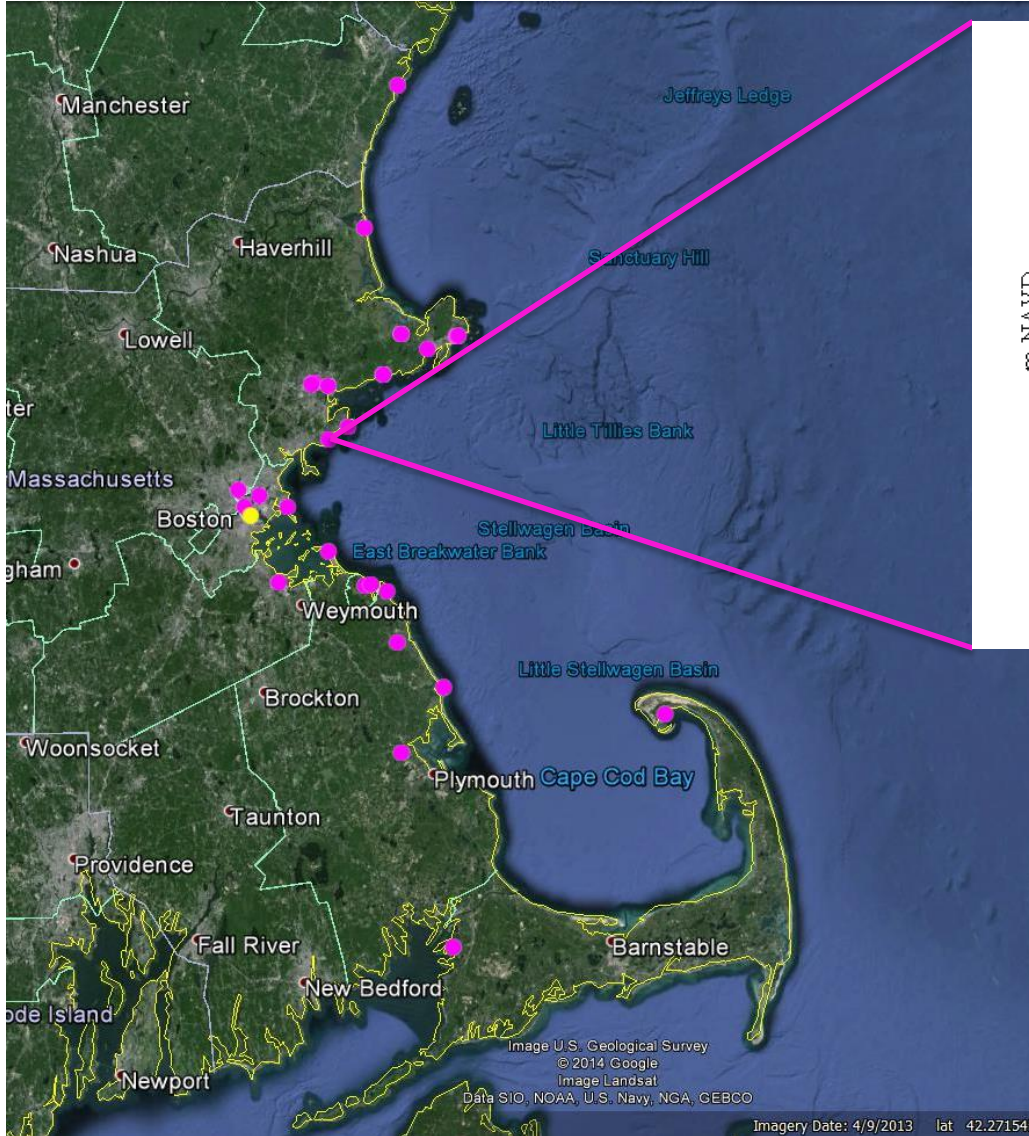
Monte Carlo  
simulations

Present and future  
climate change  
scenarios

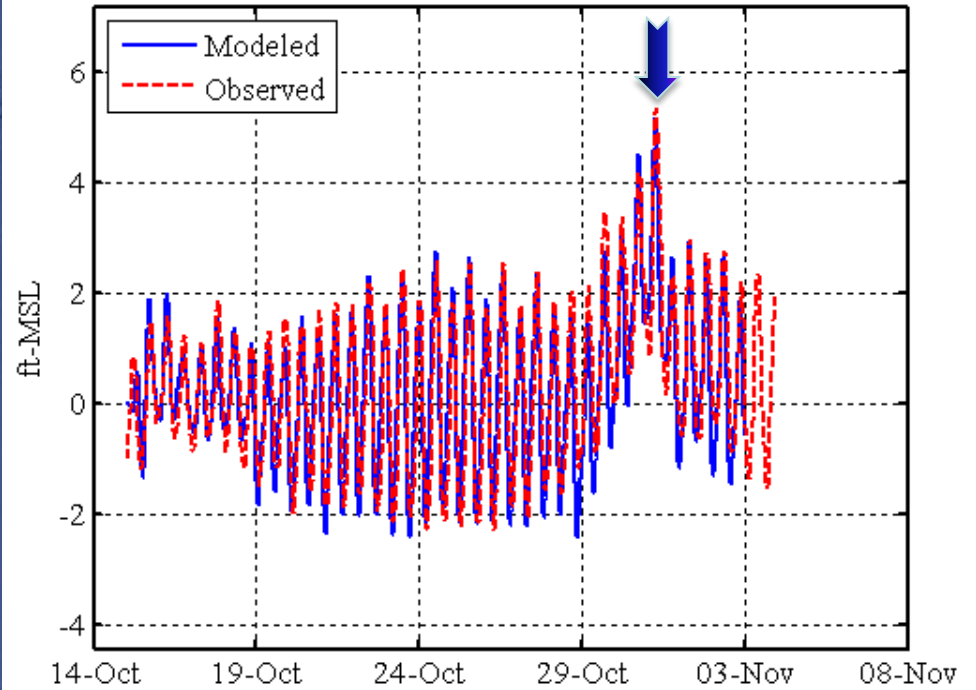
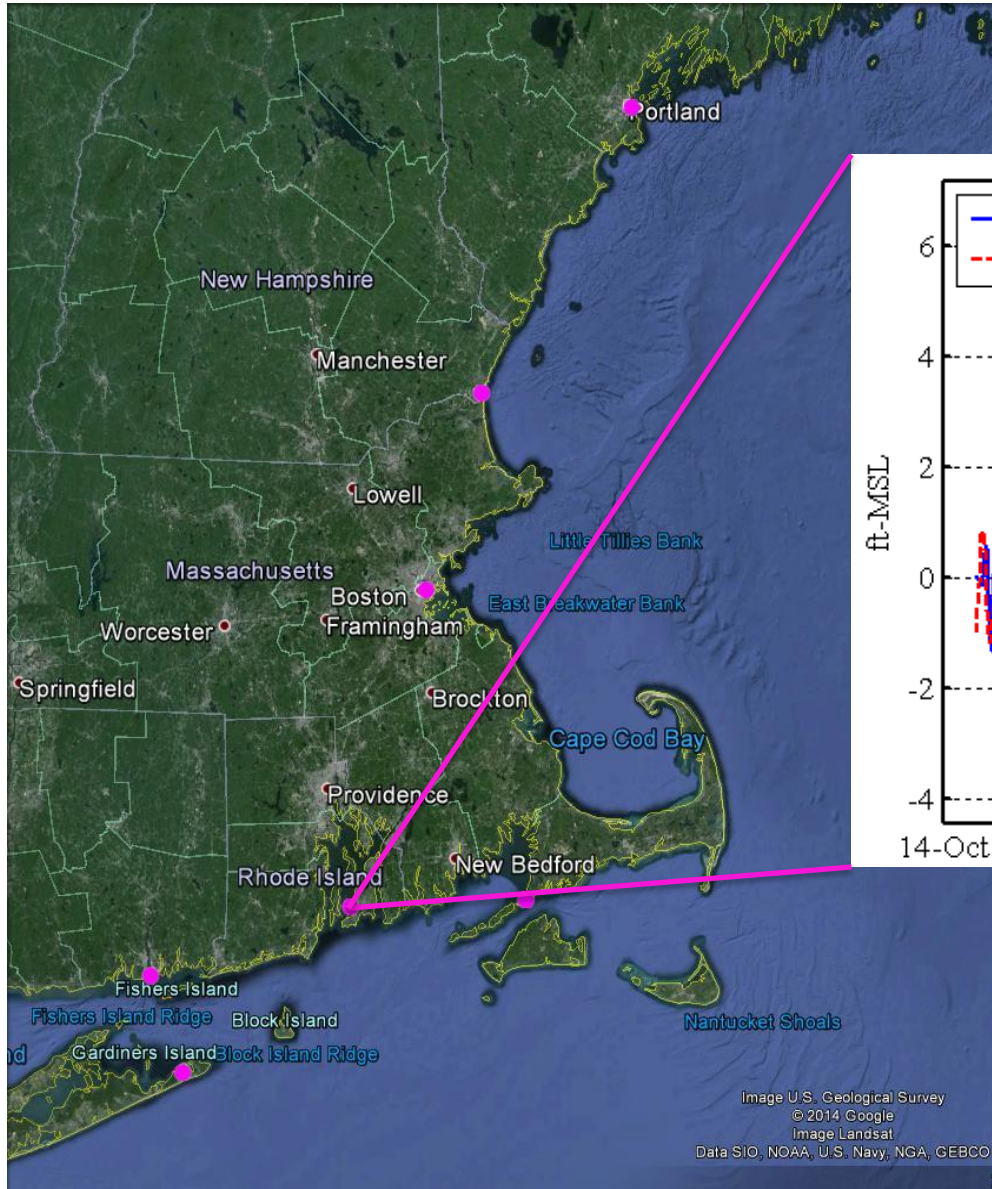
Tropical and Extra-  
Tropical Storms

Simulates storms  
combined with SLR  
and river discharge

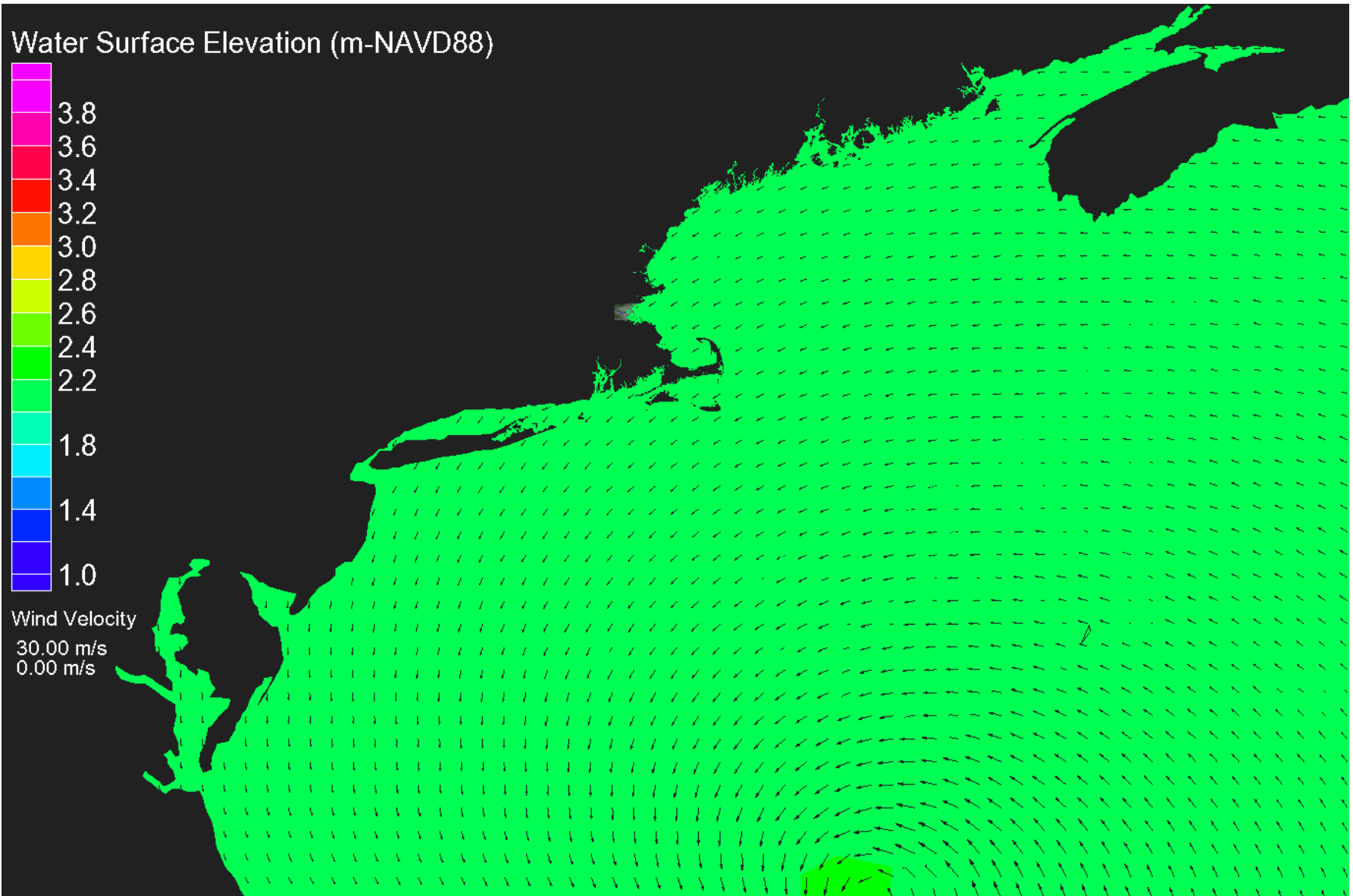
# Blizzard of 1978



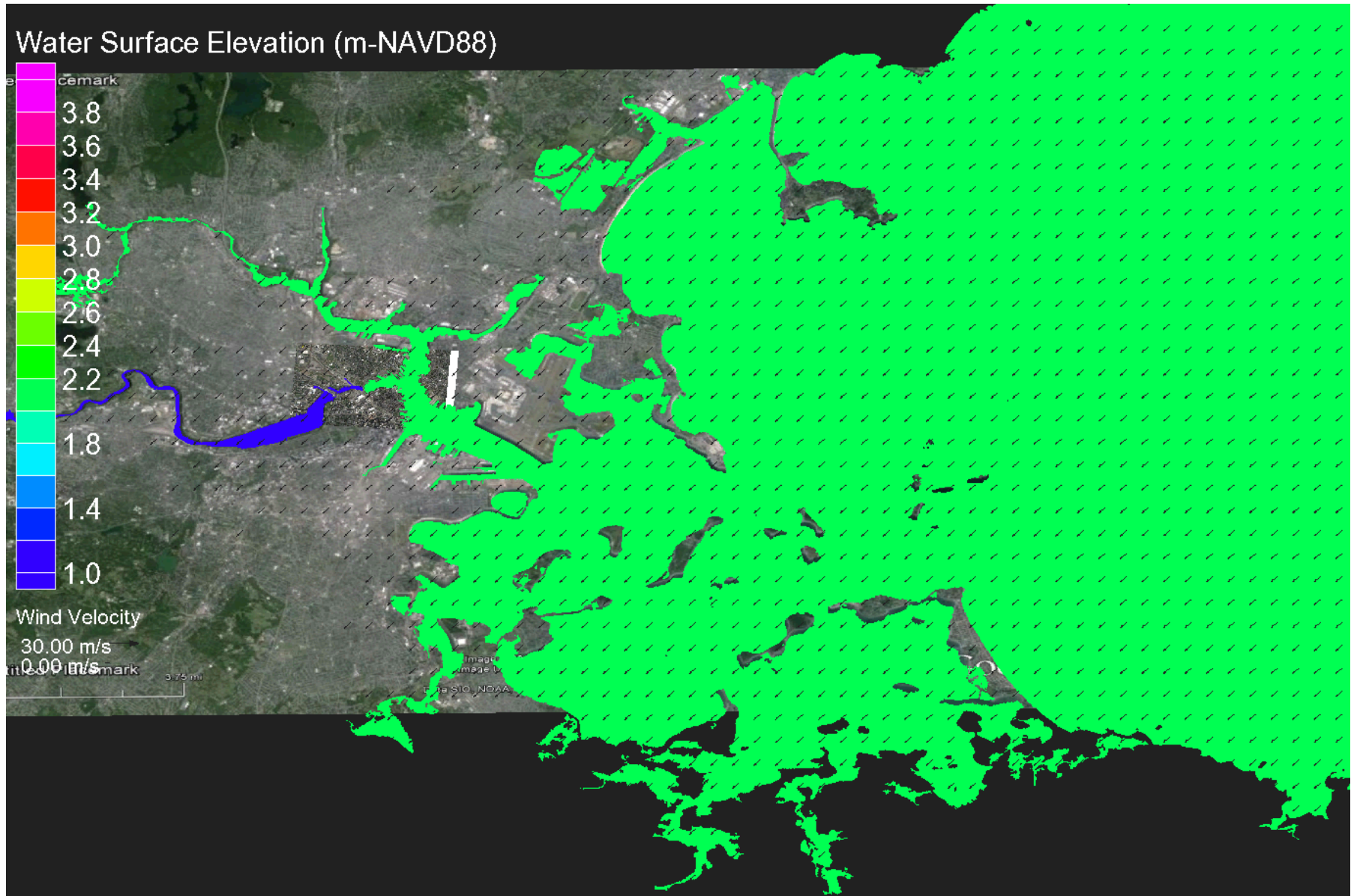
# The Perfect Storm



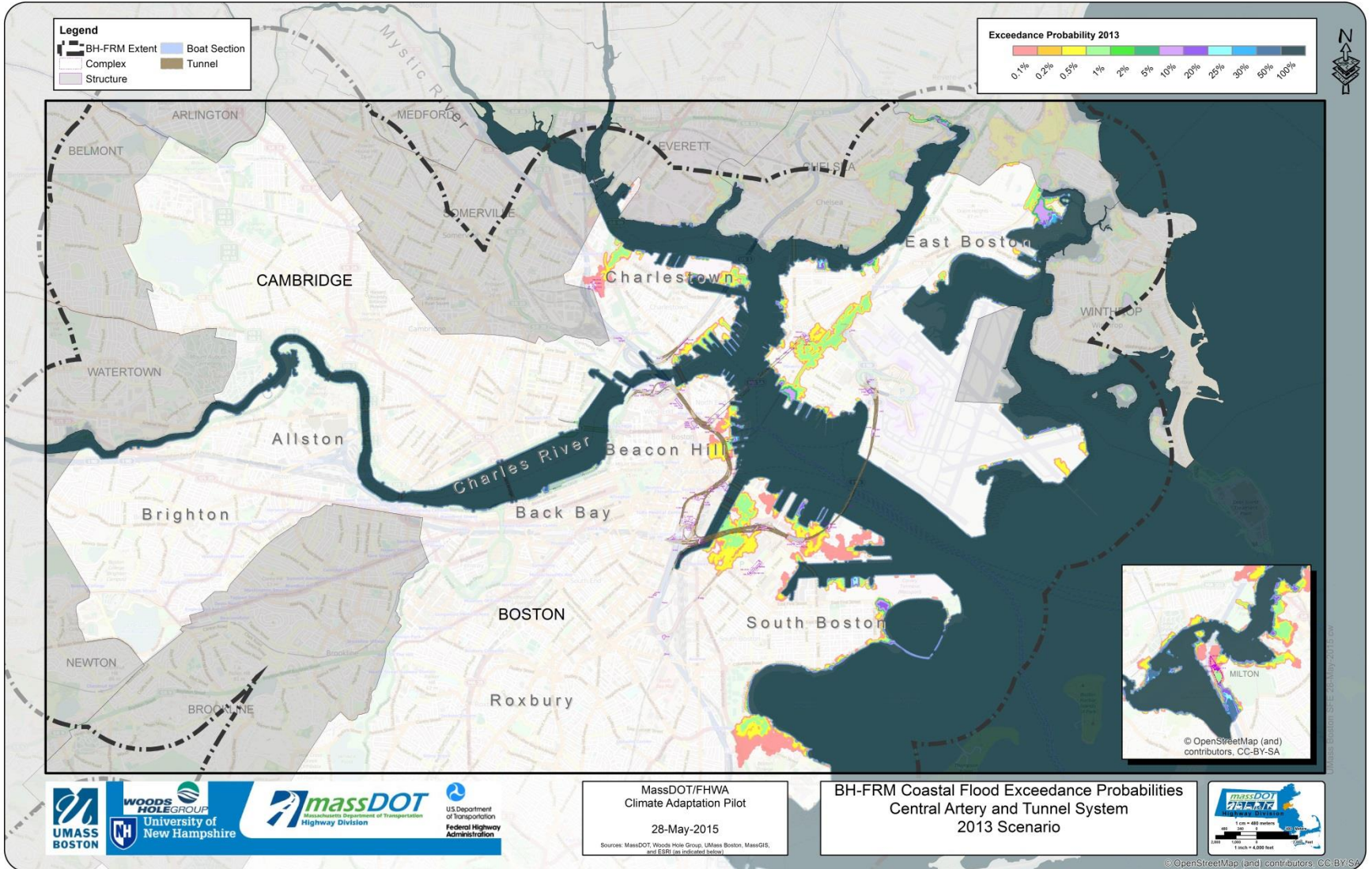
# Example Results



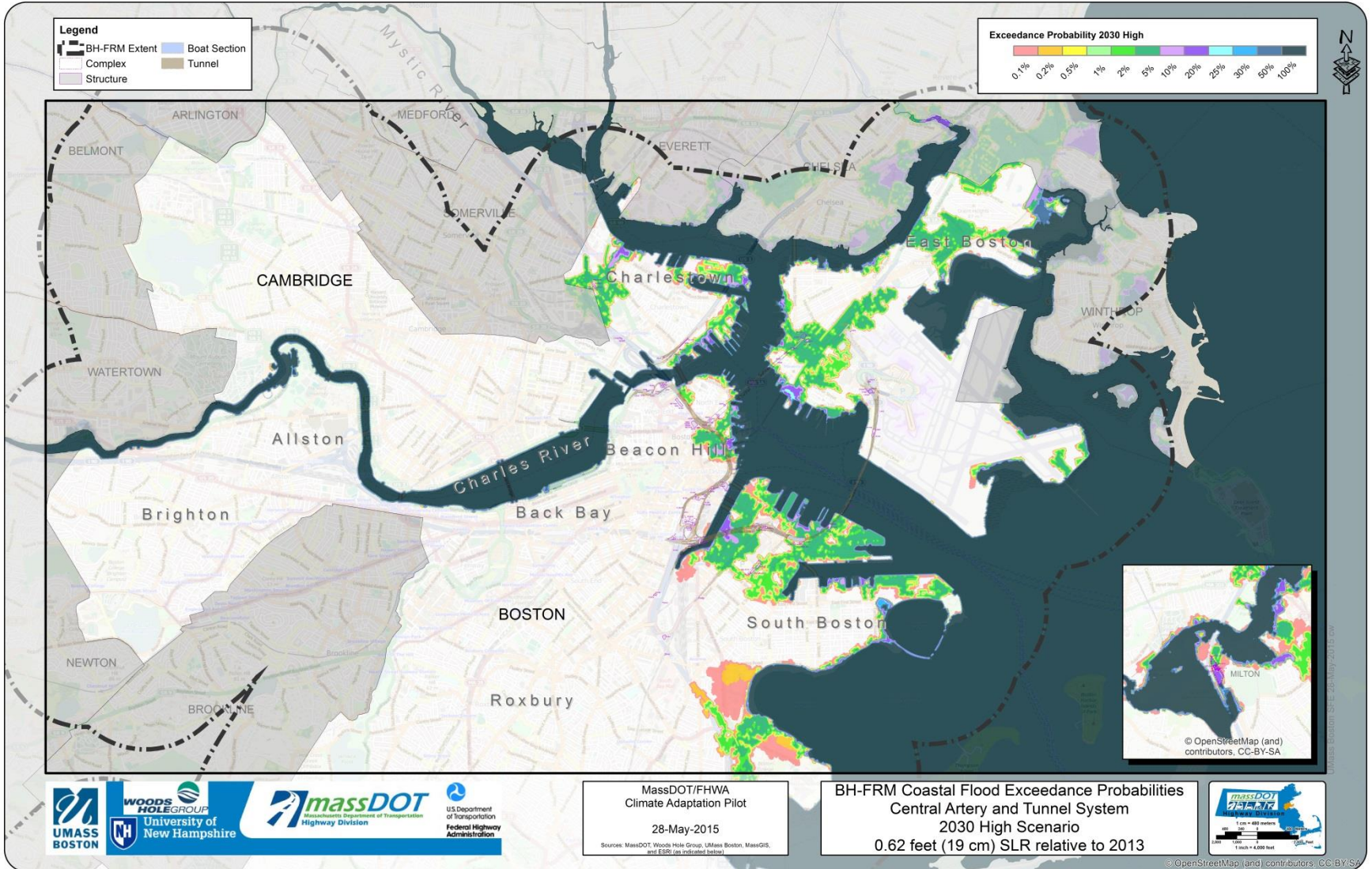
# Example Results



# Exceedance Probability Maps - 2013



# Exceedance Probability Maps - 2030



MassDOT/FHWA  
Climate Adaptation Pilot  
28-May-2015

Sources: MassDOT, Woods Hole Group, UMass Boston, MassGIS, and ESRI (as indicated below)

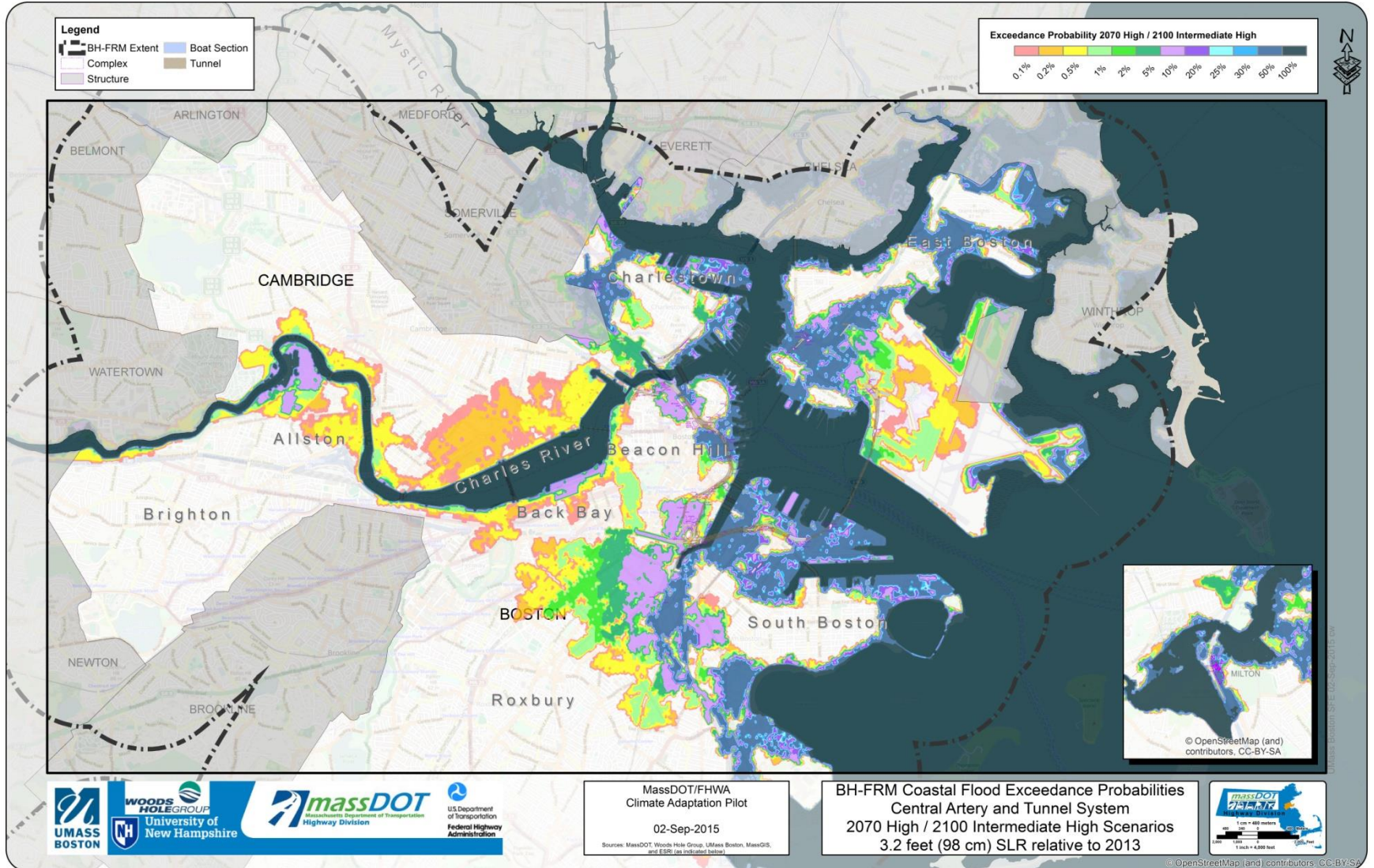
BH-FRM Coastal Flood Exceedance Probabilities  
Central Artery and Tunnel System  
2030 High Scenario  
0.62 feet (19 cm) SLR relative to 2013



© OpenStreetMap (and) contributors, CC-BY-SA

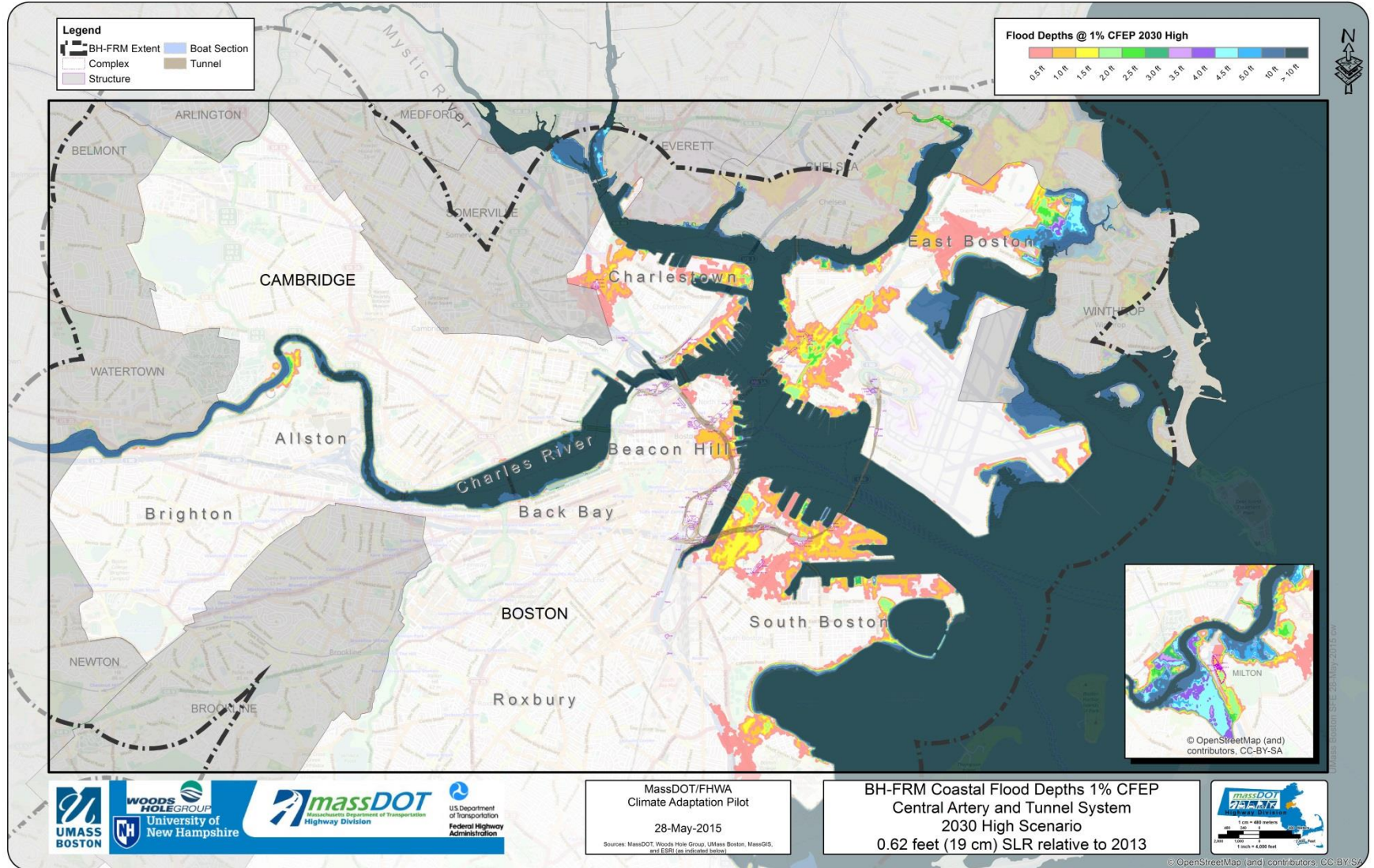


# Exceedance Probability Maps - 2070

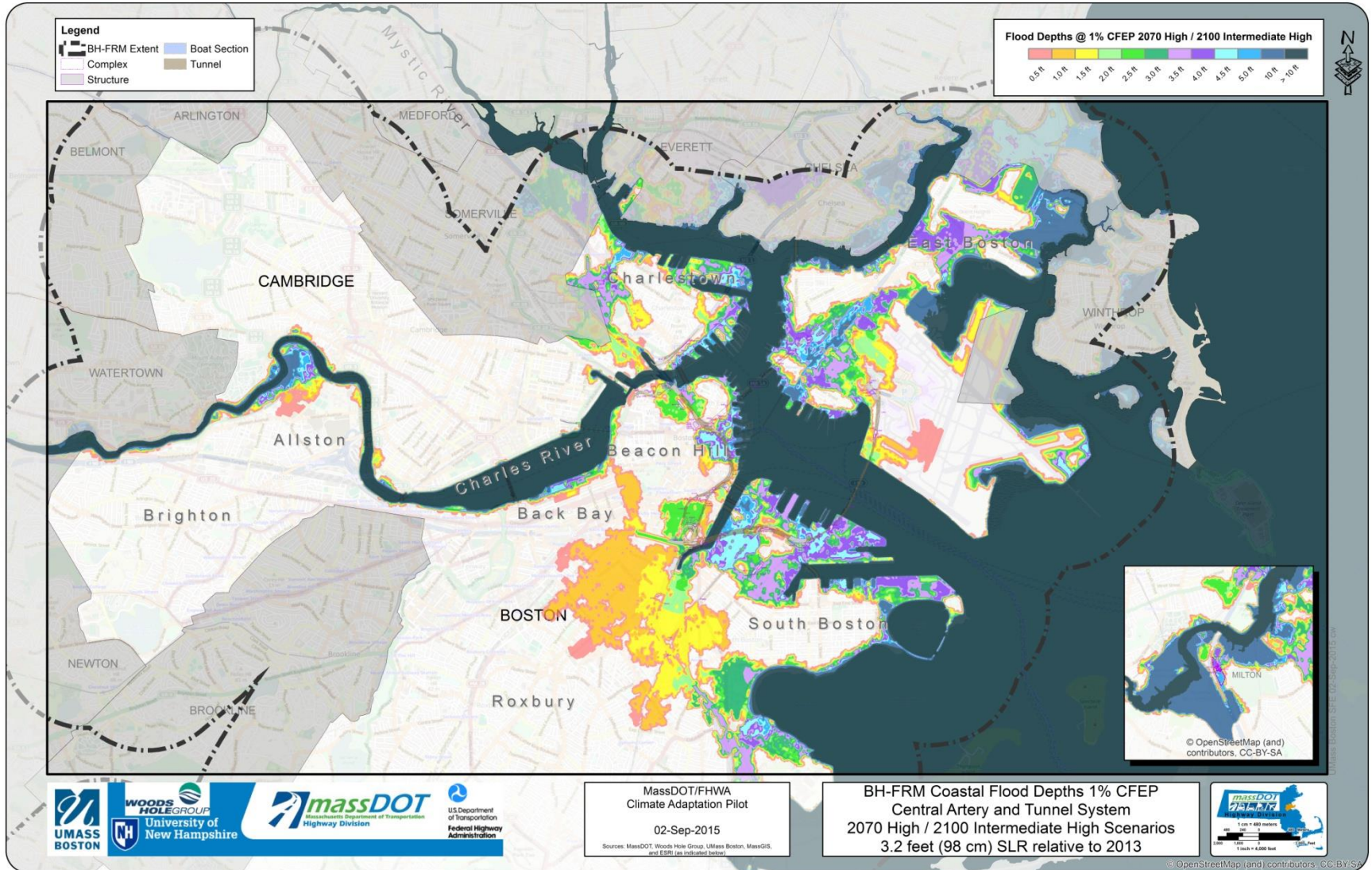




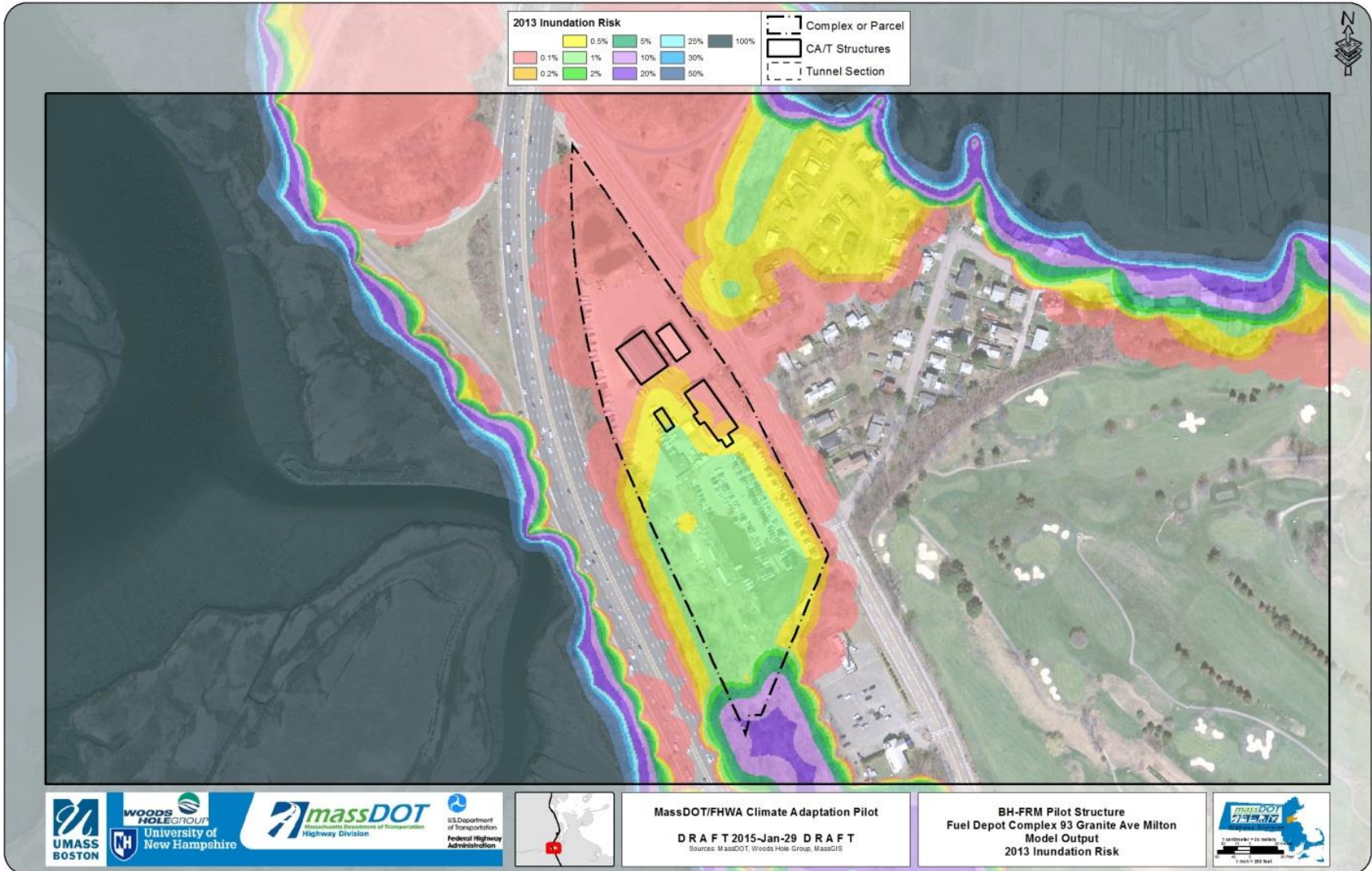
# Depth of Inundation Maps - 1% Depths 2030



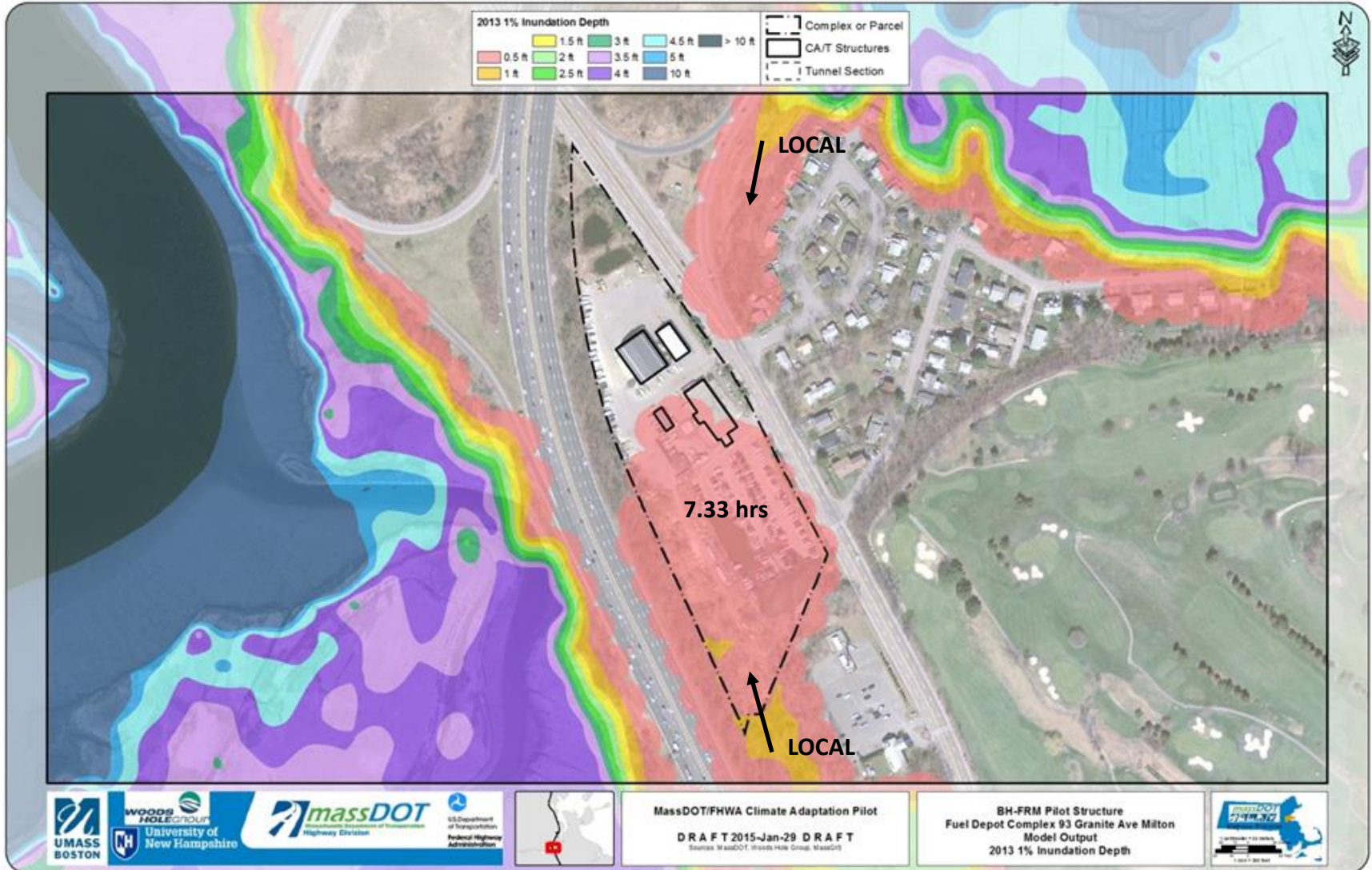
# Depth of Inundation Maps - 1% Depths 2070



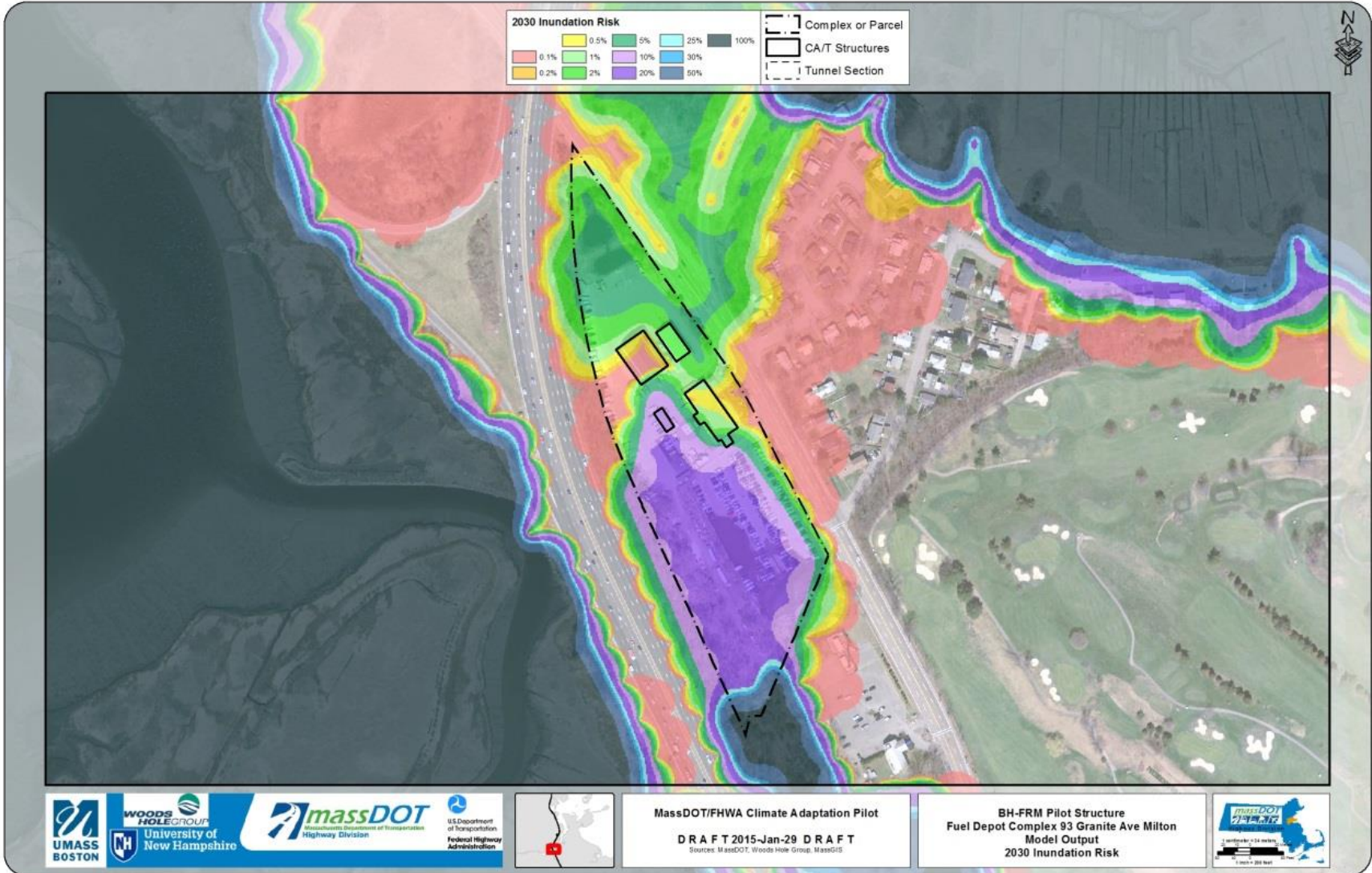
# Example Assessment – Probabilities 2013



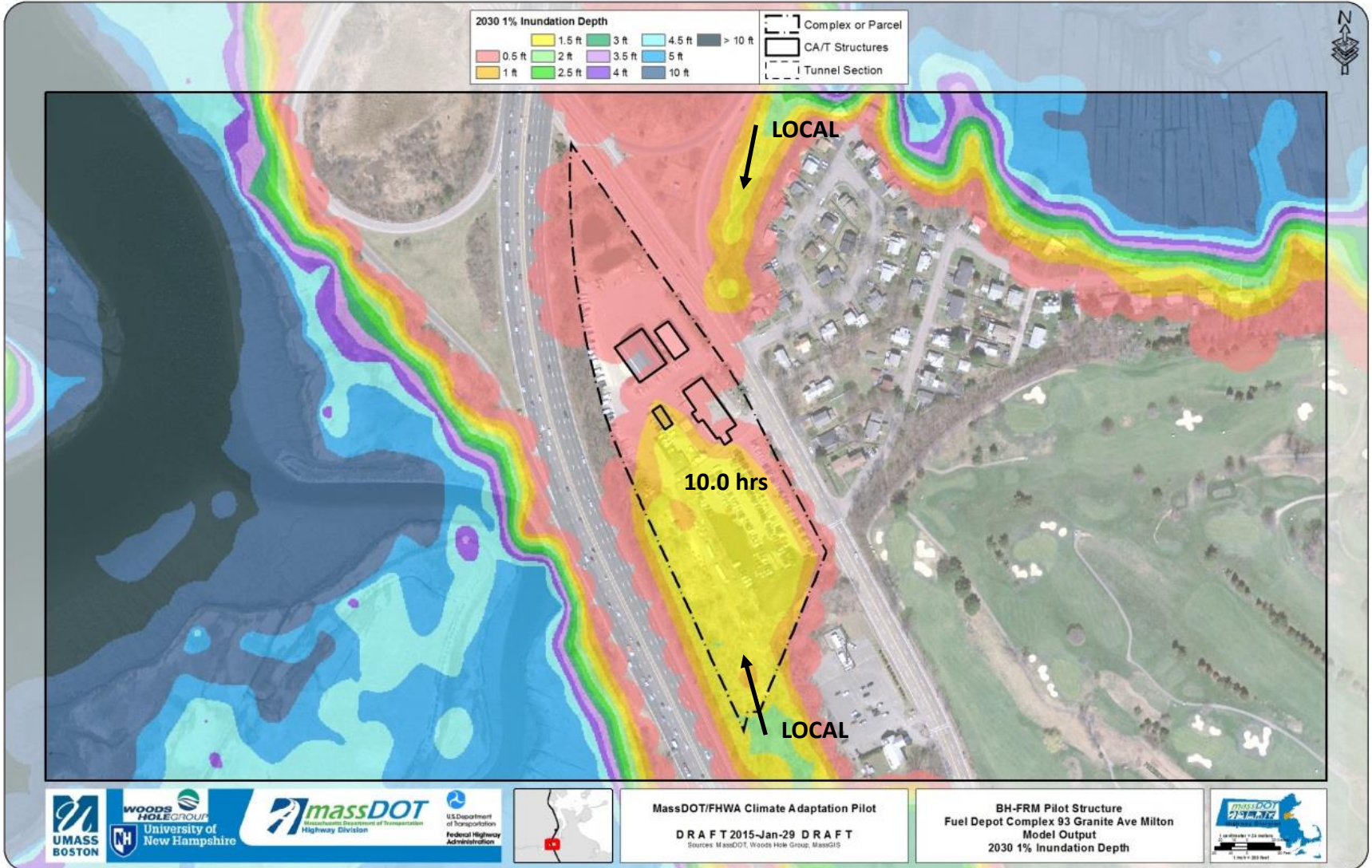
# Example Assessment – 1% Depth 2013



# Example Assessment – Probabilities 2030



# Example Assessment – 1% Depths 2030

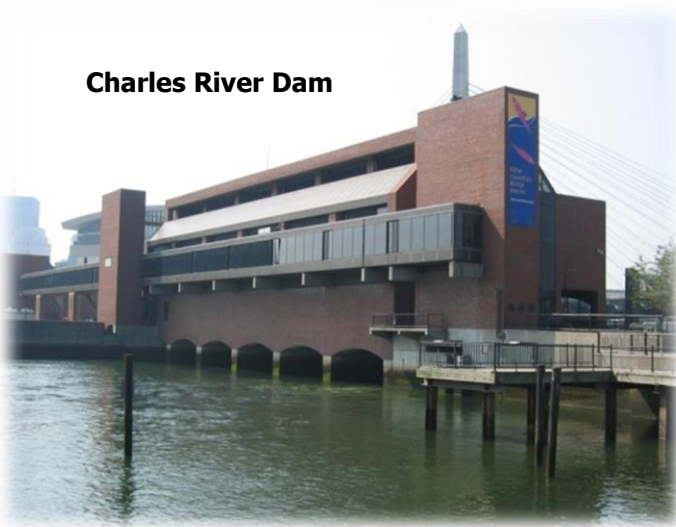




# Flooding Impacts at the Dams

(Assuming high rate of SLR)

Charles River Dam



- At 1% (100-yr):
  - Flanked in 2055-2060
  - Overtopped in 2065
- At 0.2% (500-yr):
  - Flanked in 2045
  - Overtopped in 2050



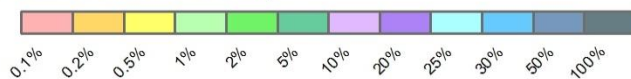
Amelia Earhart Dam

- At 1% (100-yr):
  - Flanked in 2045-2050
  - Overtopped in 2055-2060
- At 0.2% (500-yr):
  - Flanked in 2030-2035
  - Overtopped in 2040

Moving Massachusetts Forward  
**massDOT**



**2070 Exceedance Probability**

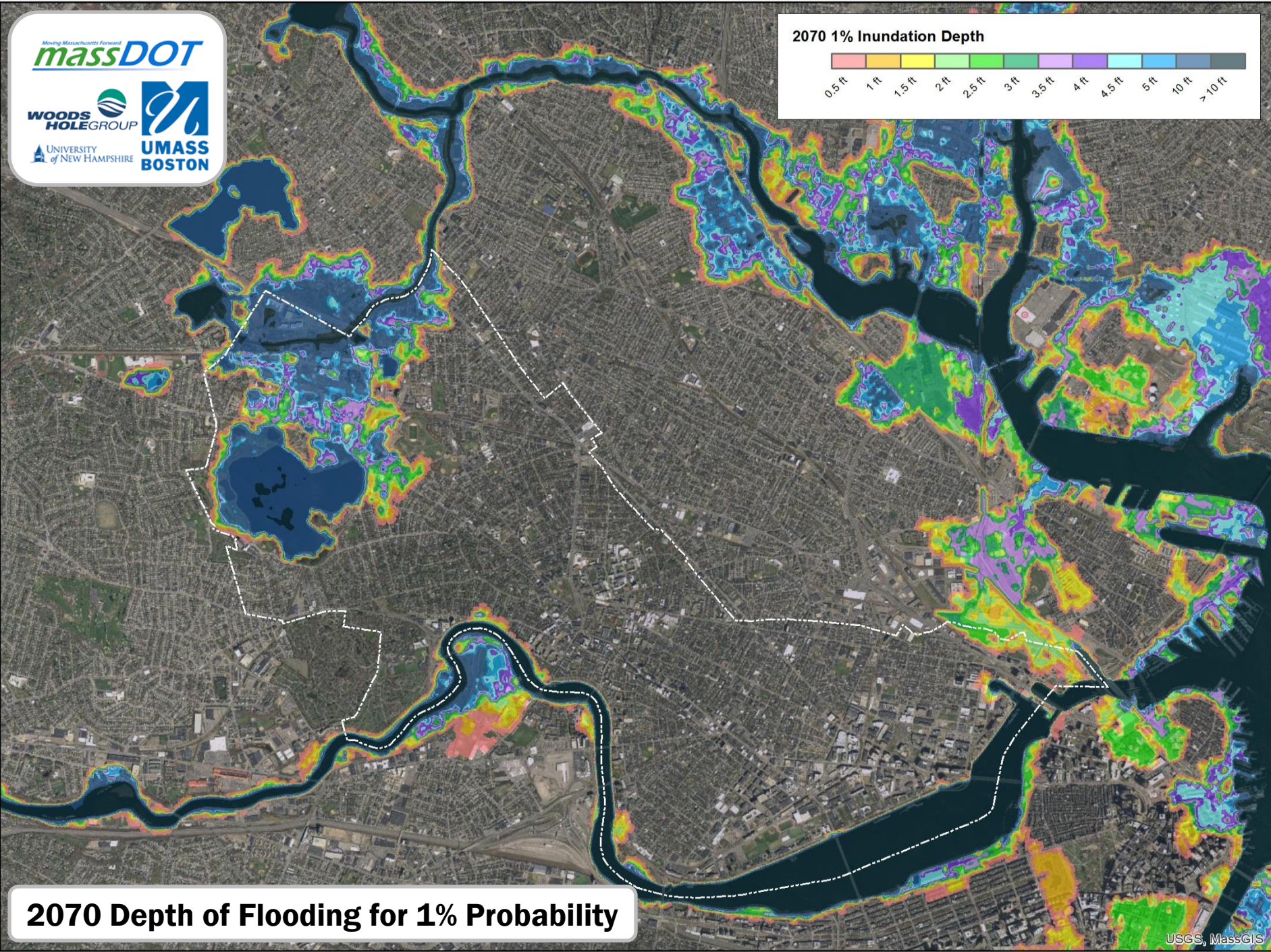
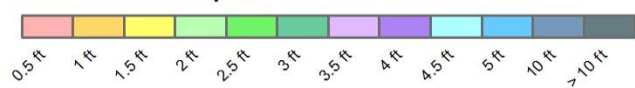


**2070 Probability of Flooding**

Moving Massachusetts Forward  
**massDOT**

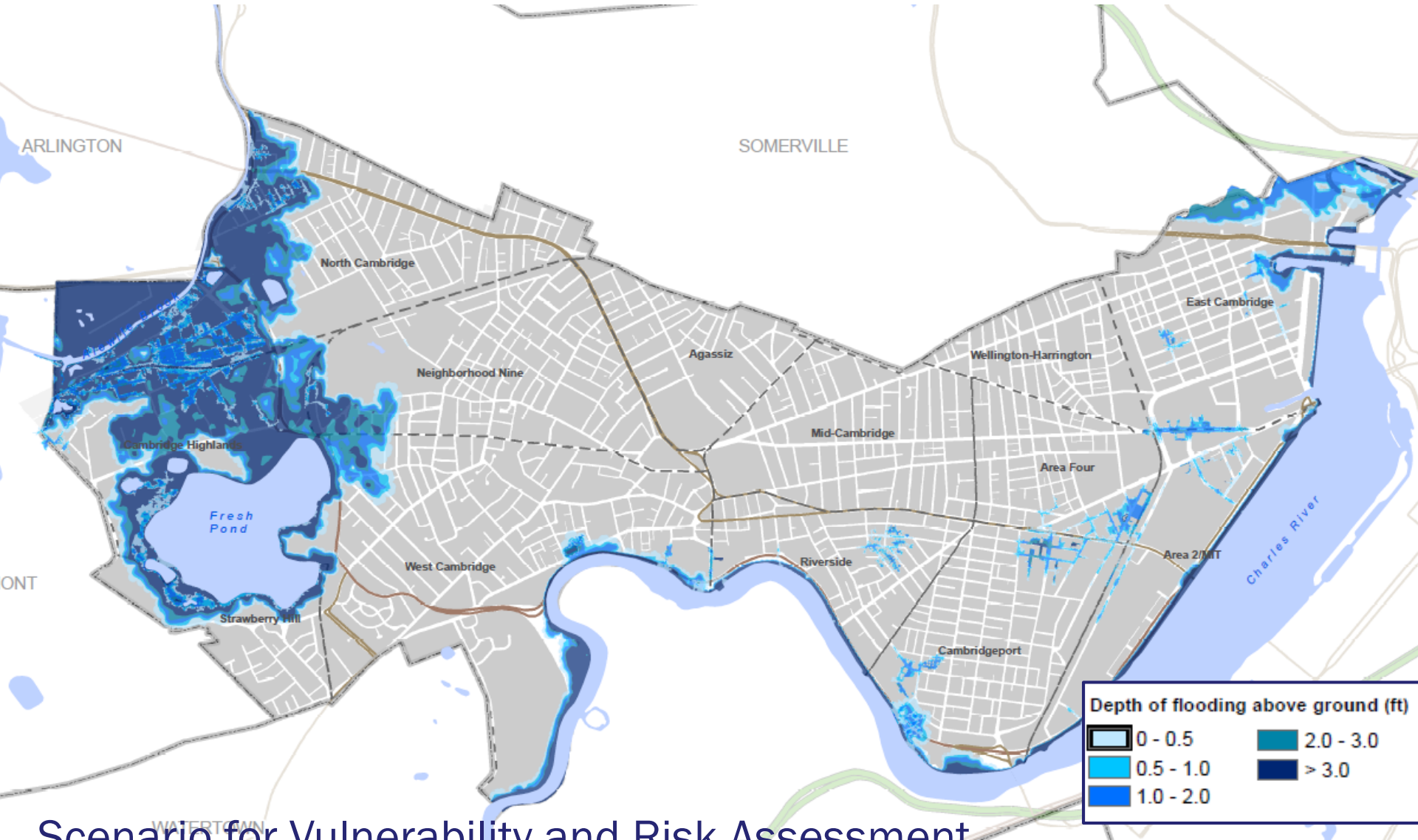


**2070 1% Inundation Depth**



**2070 Depth of Flooding for 1% Probability**

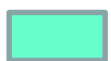
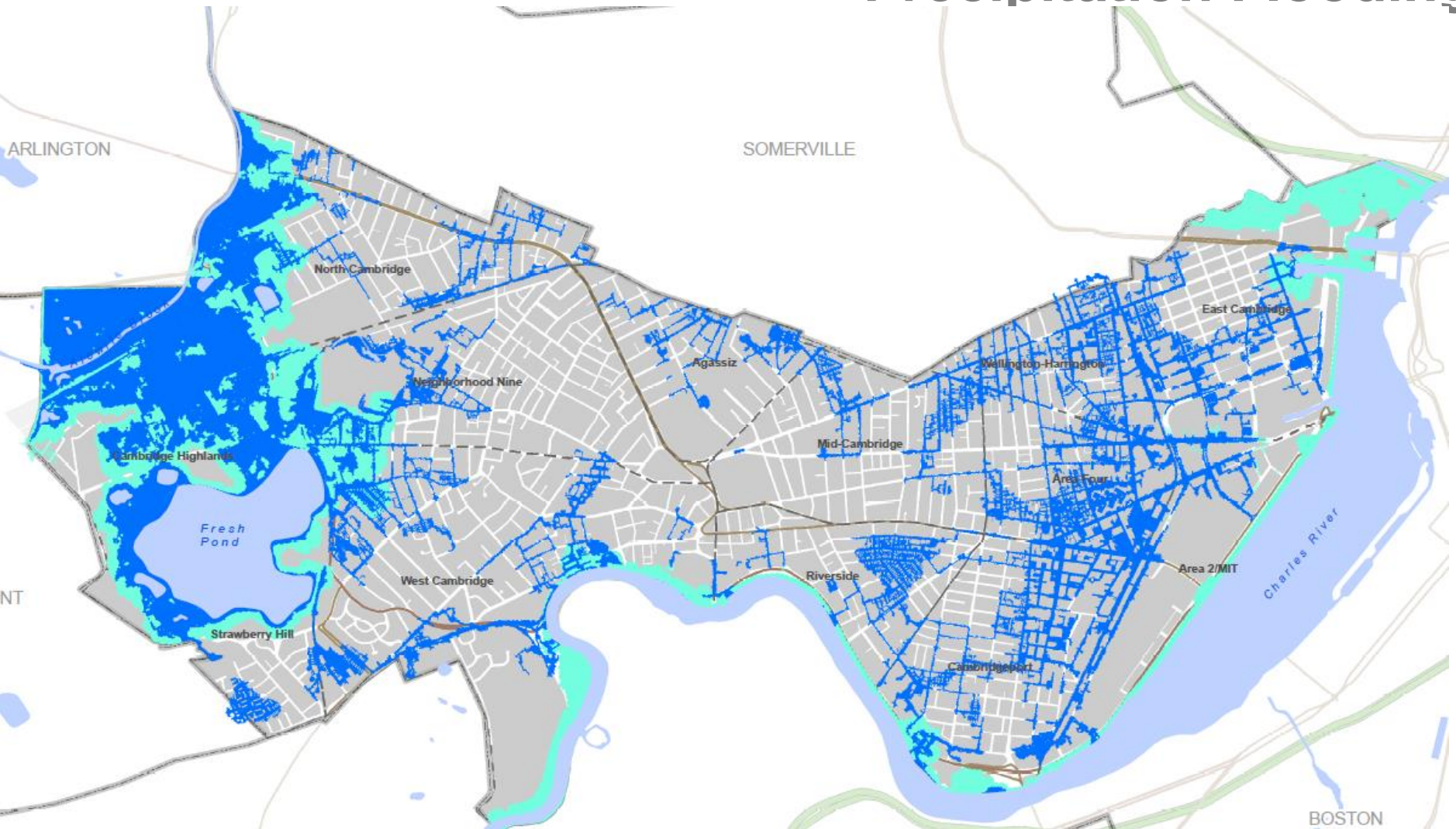
# 2070 Depth of Flooding for 1% Probability



Scenario for Vulnerability and Risk Assessment  
SLR/ Storm Surge + propagation through piped infrastructure

Source: Kleinfelder based on WHG & MWH analyses, October 2015

# Comparison of Storm Surge and Precipitation Flooding



Extent of flooding from 1% flood by 2070 with SLR and storm surge and propagation through piped infrastructure (no rain)



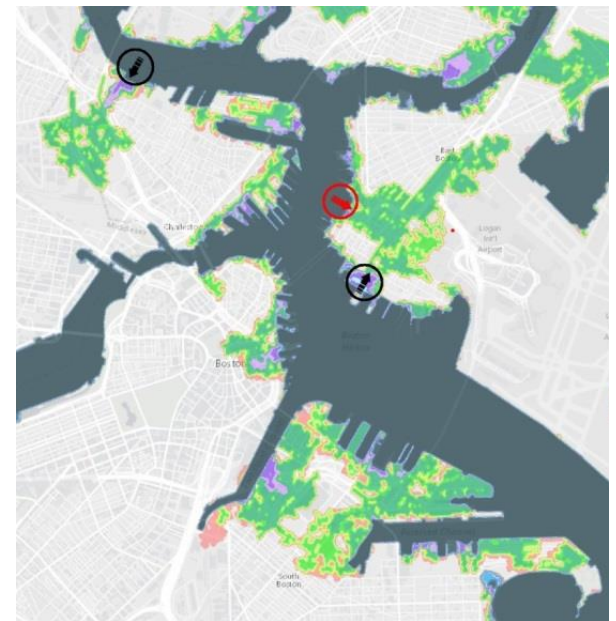
Extent of flooding from 100-yr 24 hr rain storm by 2070

# What We Learned About SLR/ Storm Surge

- Dams effectively protect Cambridge until at least 2030
- Storm surge could impact regional systems outside the City
- Both dams would be flanked before they are overtopped. For the 1% probability level (100-yr flood) by 2070, both dams are overtopped.
- Ability of the dams to pump after an event will affect the duration of flooding in the City
- Storm surge flooding would be a new experience for Cambridge

# What We Learned About SLR/ Storm Surge

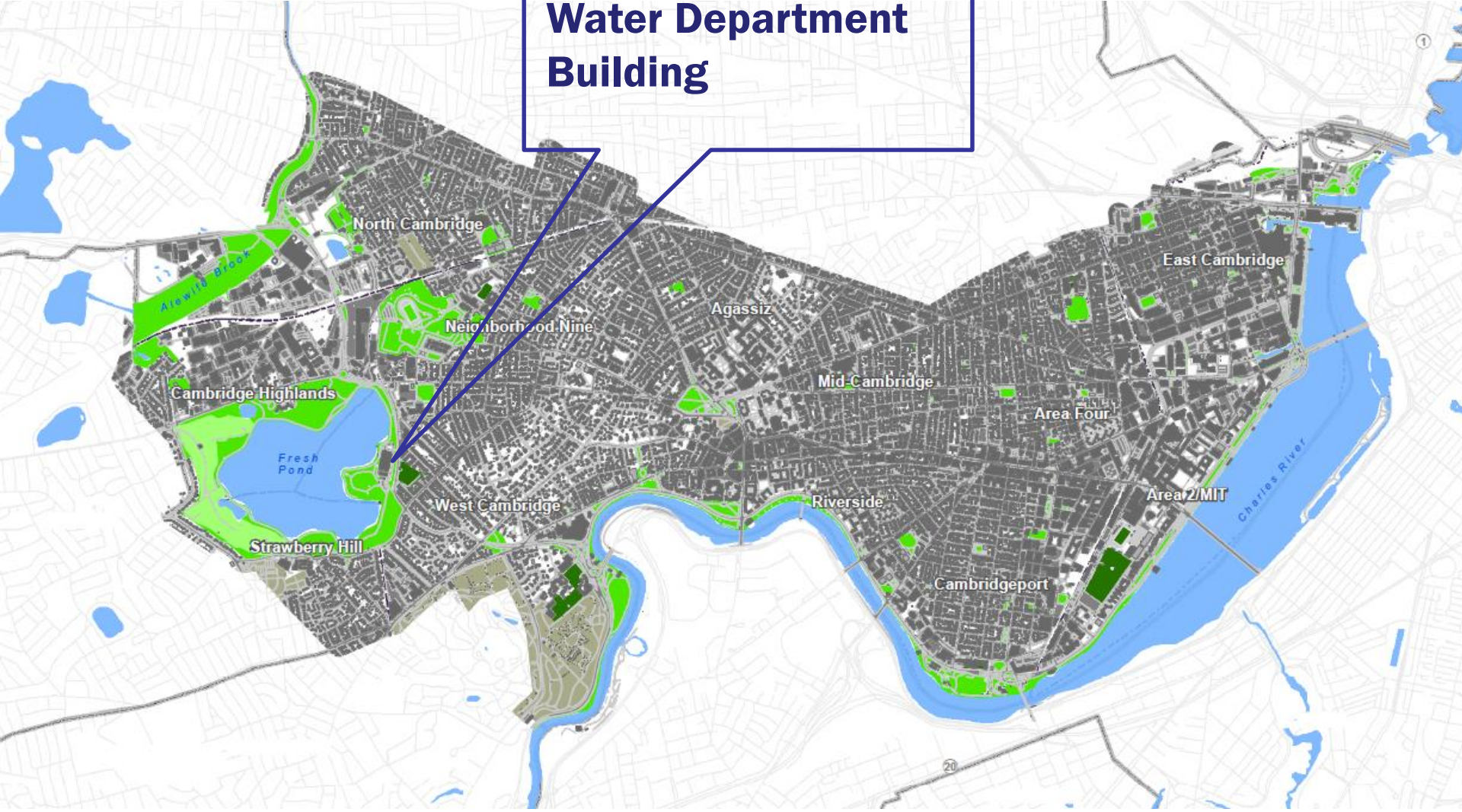
- Storm surge risks more significant in
  - Alewife/Fresh Pond area by 2050
  - North Point area by 2070
- Alewife area – more impacted by storm surge flooding  
Eastern Cambridge – more impacted by precipitation driven flooding
- One potential significant pathway for storm surge is through Charlestown and Somerville; there may be a temporary fix
- Storm surge flooding is a regional challenge



Regional adaptations (MassDOT, 2015)

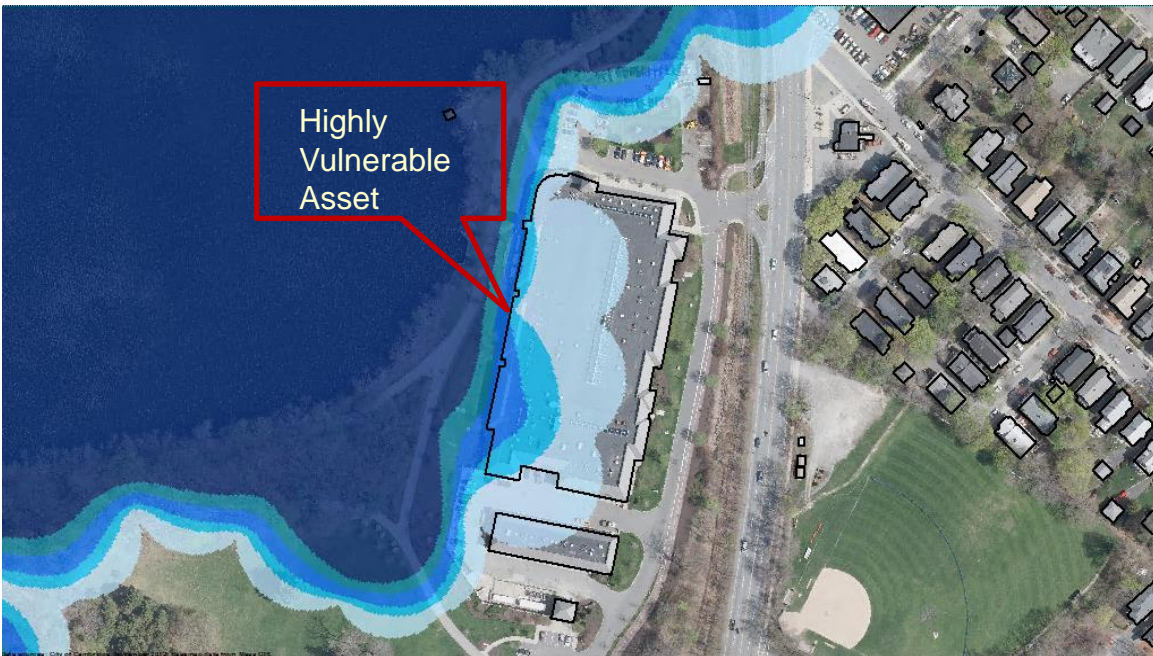
# Vulnerability and Risk Ranking SLR/ Storm Surge

**Example:  
Water Department  
Building**



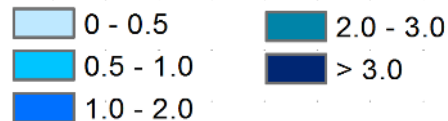


# Vulnerability and Risk Ranking SLR/ Storm Surge

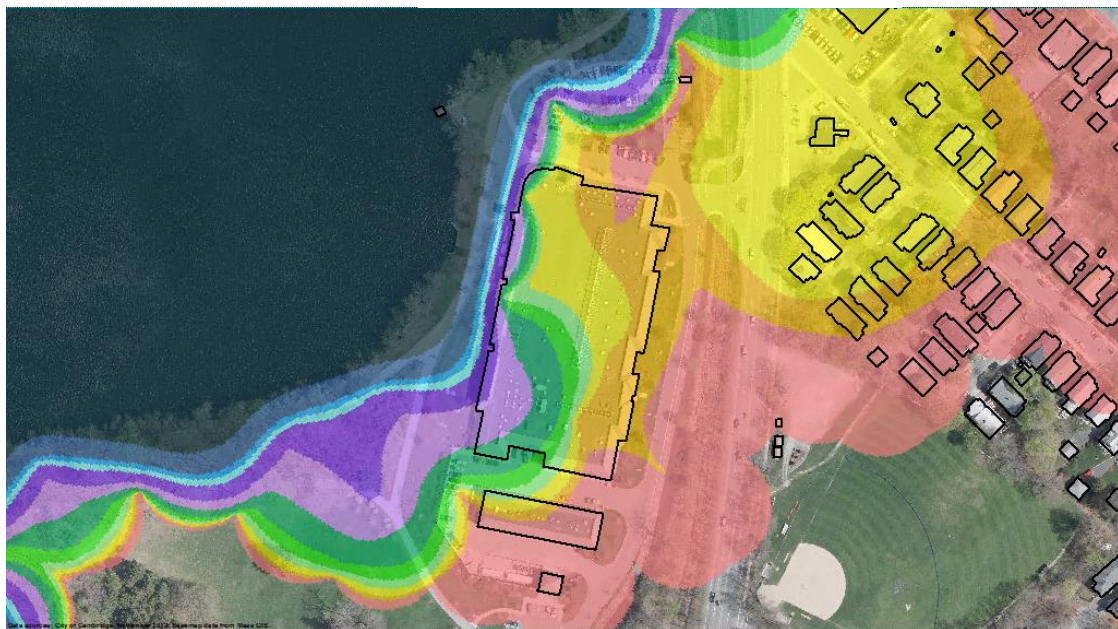
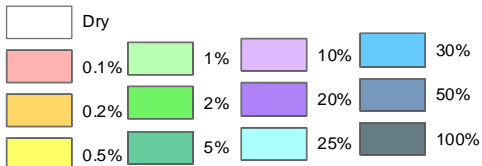


## Example: Water Department Building

Cambridge 2070 1% Probability  
Depth of flooding above ground (ft)



Cambridge 2070  
Percent probability of flooding



# Vulnerability and Risk – Example Results

Critical Asset	Flooding Risk 2070	
	Sea Level Rise/Storm Surge	Precipitation
Water Dept. (City's EOC)	High Risk (Red)	Low Risk (Green)
North Cambridge Substation	High Risk (Red)	High Risk (Red)
Intersection of Alewife Brook Pkwy and Mass Ave	High Risk (Red)	High Risk (Red)
MBTA Lechmere Station	Low Risk (Green)	High Risk (Red)

Of the 500 critical assets identified in CCVA Part 1, about 100 are likely to be impacted by SLR/ Storm Surge

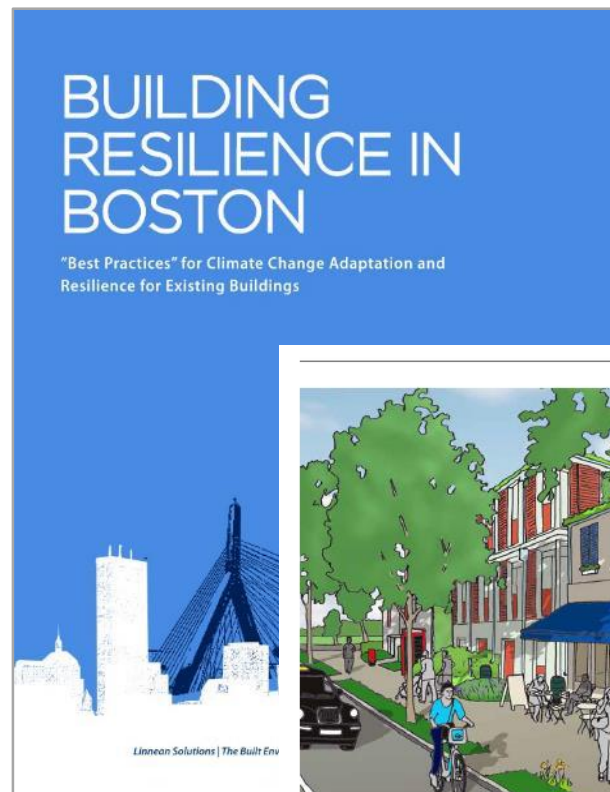


# Next Steps

- Complete the vulnerability and risk assessment based on SLR/ storm surge results
- Hold small group meetings to discuss results in more depth
- Issue CCVA Report – Part 2 by early 2016
- Start the Climate Change Preparedness and Resilience Plan and coordinate with Citywide Plan

# Approaches to Resiliency Planning

- Gather “best practices” looking at examples in the region and internationally
- Develop strategies at four scales: Building, Neighborhood, City, Region
- Develop appropriate risk-based standards to inform building and structural design

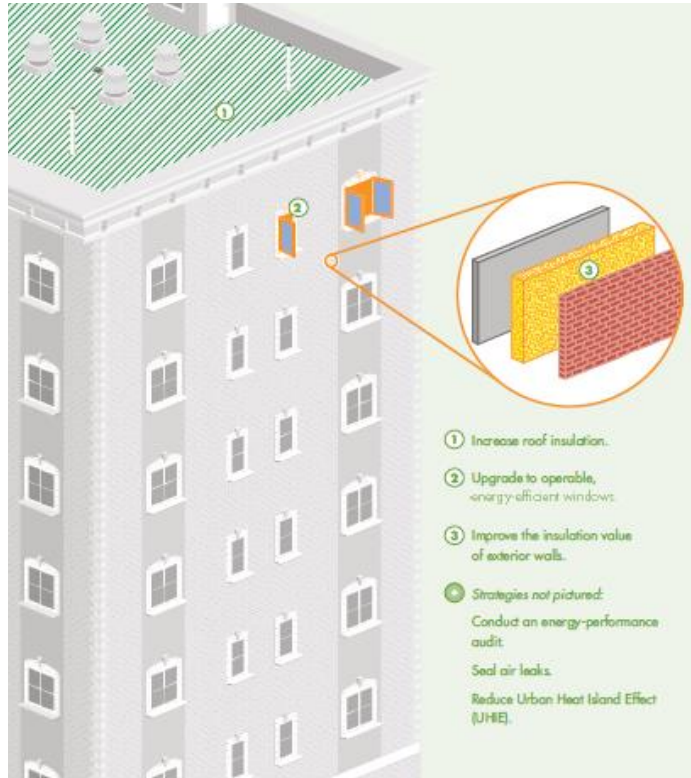


## MANAGING RISKS AND INCREASING RESILIENCE

THE MAYOR'S CLIMATE CHANGE ADAPTATION STRATEGY  
OCTOBER 2011

MAYOR OF LONDON

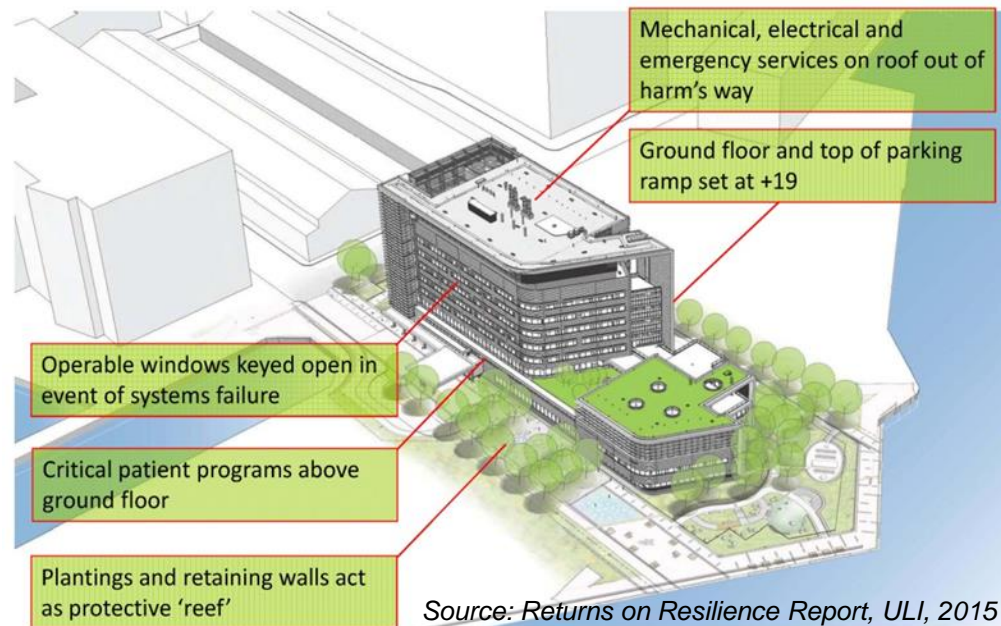
# Resiliency at the Building Scale



Source: *Strategies for Multifamily Building Resilience*, Enterprise green communities, 2015

## Heat Resiliency for Multifamily Housing

## Flood Resiliency for Institutional Building



Source: *Returns on Resilience Report*, ULI, 2015

# Resiliency at the Neighborhood Scale

- ## Roof
- Green roof
  - Raised utilities
  - Solar panels

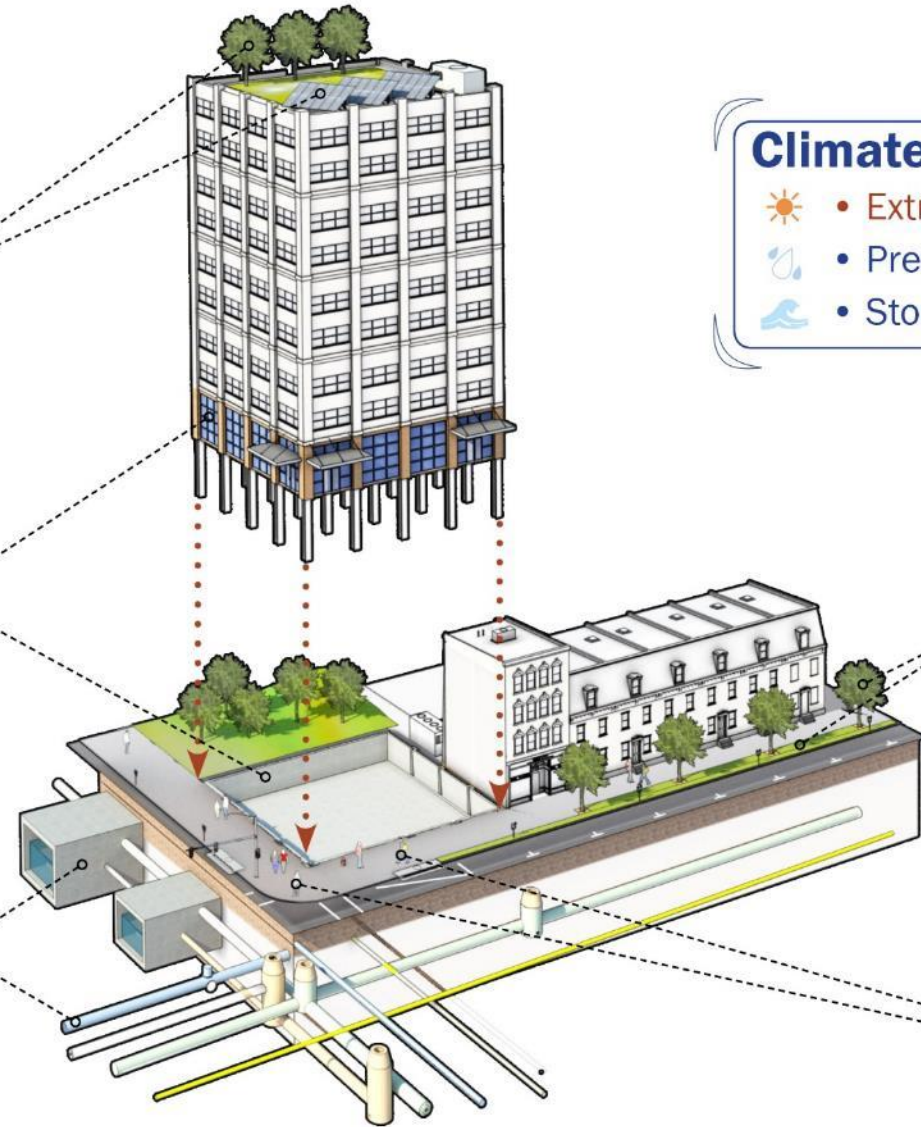
- ## Building and structure
- Flood proofing
  - Passive energy
  - Passive cooling

- ## Infrastructure
- Detention tanks
  - Larger pipes
  - Protected utilities

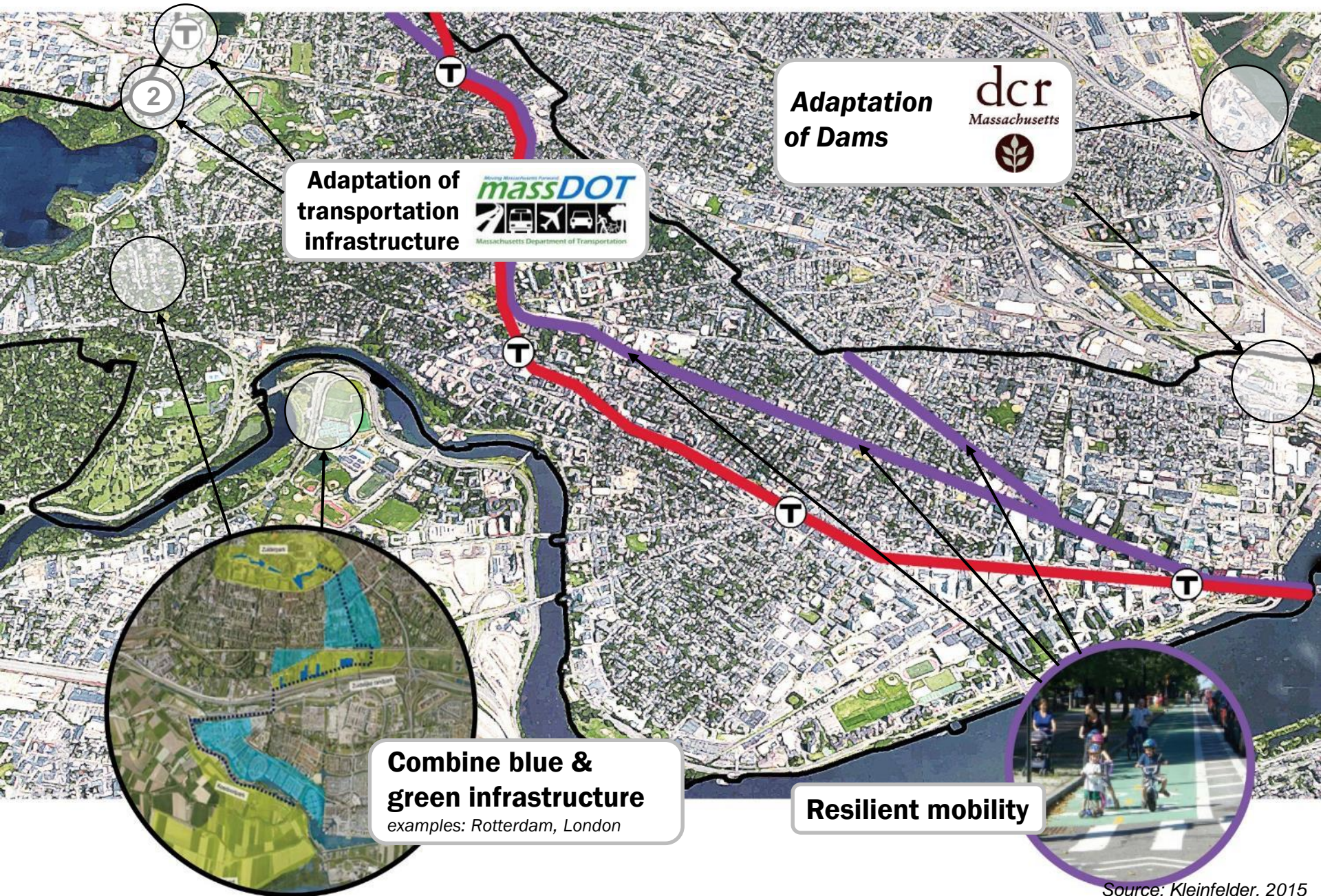
- ## Climate stresses
- Extreme heat
  - Precipitation
  - Storm surge

- ## Green Infrastructure
- Porous pavement
  - Rain gardens
  - Shaded streets

- ## Community
- Network
  - Shelter
  - Contingency plan
  - Pre-ID people at risk



# Resiliency at City & Regional Scale



**Adaptation of transportation infrastructure**  
*massDOT*  
Massachusetts Department of Transportation

**Adaptation of Dams**  
*dcr*  
Massachusetts

**Combine blue & green infrastructure**  
*examples: Rotterdam, London*

**Resilient mobility**

Source: Kleinfelder, 2015



# Looking Forward

- Work on regional coordination and cooperation, such as the Metro Mayors climate resilience initiative
- Coordinate with stakeholders undertaking their own preparedness efforts
- Coordinate with upcoming Citywide Plan
- Start the Preparedness Plan in January– a two year effort – and program early actions.



## Question 5

In which ways do you anticipate YOU will need to adapt?

A: Making my building more resilient

B: Preparing in advance for emergencies

(e.g., business, home, family contingency plans)

C: No need to adapt



# Your poll will show here

1

Install the app from  
[pollev.com/app](https://pollev.com/app)

2

Make sure you are in  
Slide Show mode

Still not working? Get help at [pollev.com/app/help](https://pollev.com/app/help)  
or

[Open poll in your web browser](#)



## Question 6

In which ways do you anticipate YOUR NEIGHBORHOOD will need to adapt?

- A: Provide community resources for extreme events  
(e.g. cooling center)
- B: Build a stronger social network  
(e.g., checking on neighbors)
- C: Upgrade infrastructure  
(e.g. shaded streets, raised sidewalks)
- D: No need to adapt



# Your poll will show here

1

Install the app from  
[pollev.com/app](https://pollev.com/app)

2

Make sure you are in  
Slide Show mode

Still not working? Get help at [pollev.com/app/help](https://pollev.com/app/help)  
or

[Open poll in your web browser](#)



## Question 7

In which ways do you anticipate THE CITY will need to adapt?

A: Provide assistance to residents & business owners

B: Educate the population on measures to adapt

C: Change zoning and regulation

D: No need to adapt



# Your poll will show here

1

Install the app from  
[pollev.com/app](https://pollev.com/app)

2

Make sure you are in  
Slide Show mode

Still not working? Get help at [pollev.com/app/help](https://pollev.com/app/help)  
or

[Open poll in your web browser](#)





## Question 8

In which ways do you anticipate THE REGION will need to adapt?

- A: Upgrade energy supply and distribution infrastructure
- B: Protect critical transportation systems
- C: Build flood protection from sea level rise and storm surge
- D: No need to adapt



# Your poll will show here

1

Install the app from  
[pollev.com/app](https://pollev.com/app)

2

Make sure you are in  
Slide Show mode

Still not working? Get help at [pollev.com/app/help](https://pollev.com/app/help)  
or

[Open poll in your web browser](#)



# Thank You.

*We look forward to working with you,  
please contact us with questions.*

*John Bolduc*

[jbolduc@cambridgema.gov](mailto:jbolduc@cambridgema.gov)

617-349-4628

<http://www.cambridgema.gov/climateprep>