GREAT MARSH RESILIENCY MODELING WORKSHOP

April 11, 2016

Preparing for Sea Level Rise and Climate Change at a Community and Individual Asset Scale

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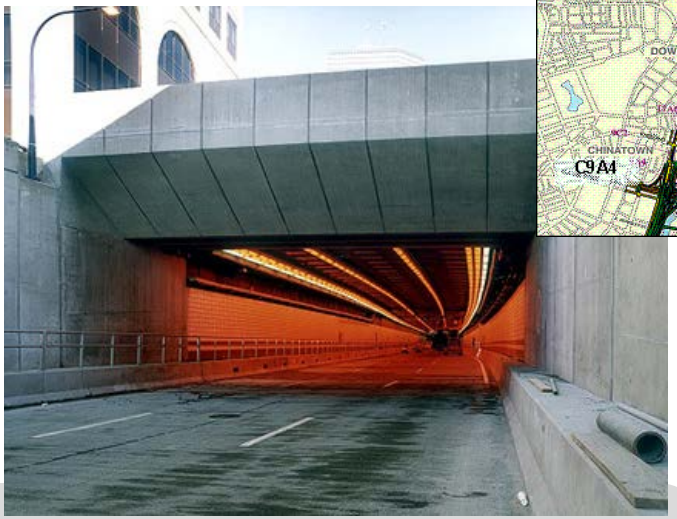
Outline

1. MassDOT / FHWA Pilot Study
2. Example Applications of Results
3. Essex County Phase I NWF Mapping
4. MA CZM SLAMM Modeling Effort
5. MassDOT Model Extension

Project Overview

The **Central Artery** is a critical link in regional transportation and a vitally important asset in the Boston metropolitan area.

1. What is the probability of flooding?
2. What is vulnerable and what is the priority?
3. What interventions are available and what is the plan?



Project Team:

Kirk Bosma, Woods Hole Group, Inc.
Ellen Douglas, Paul Kirshen, and Chris Watson, UMass Boston
Steven Miller and Katherin McArthur, MassDOT

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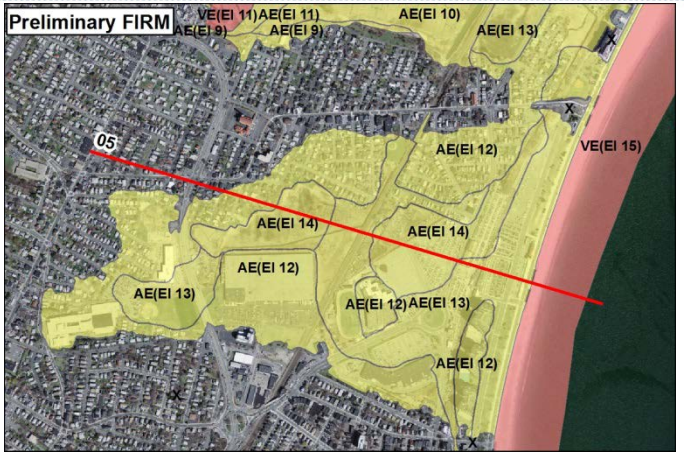
Probability of flooding options

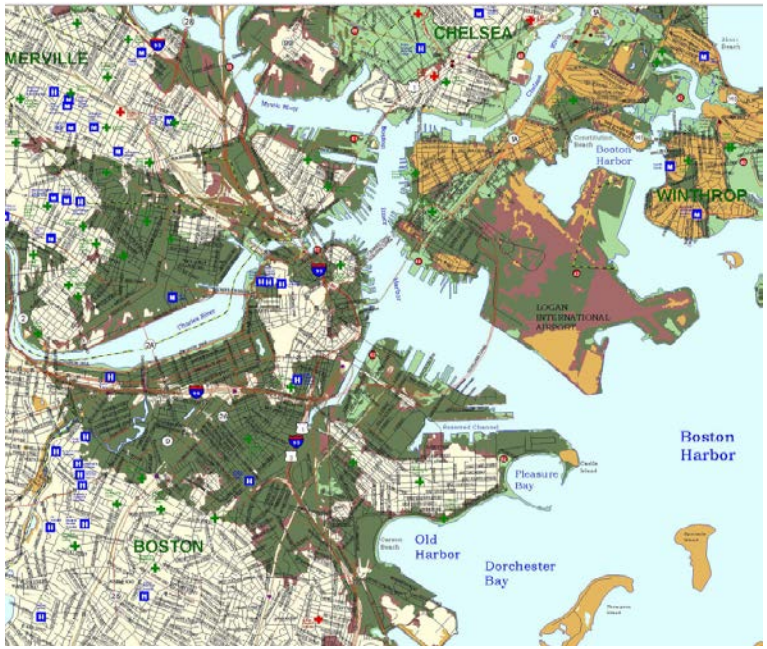
FEMA Maps

- **FEMA is only backward looking**
- **Only considers "100-year" storm**
- **Transect based analysis**



Bathtub Approach

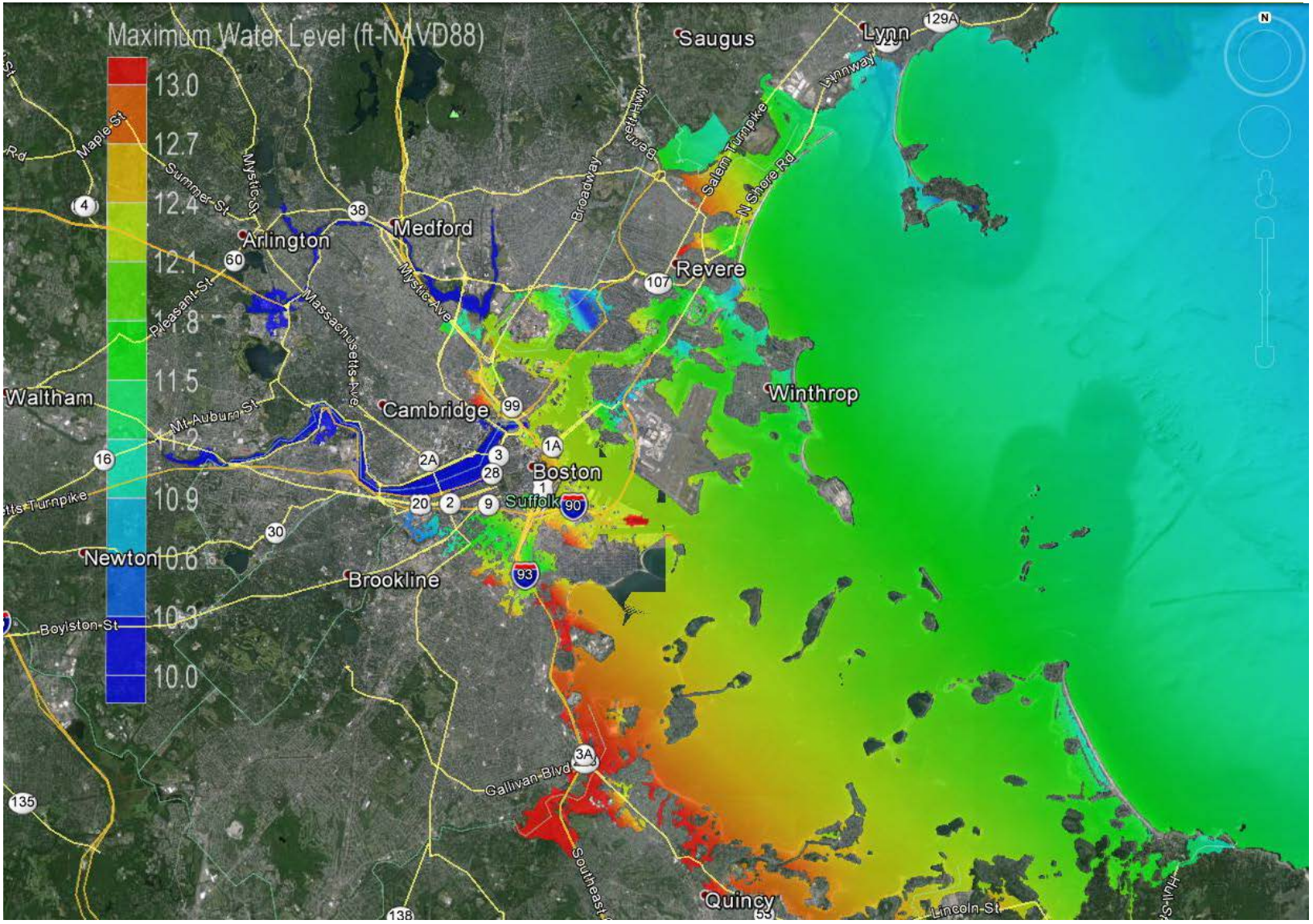
- **Inundation maps do not reflect dynamic nature of coastal flooding**
- **Does not account for joint flooding conditions**
- **Does not account for tides**



Hurricane Evacuation Maps

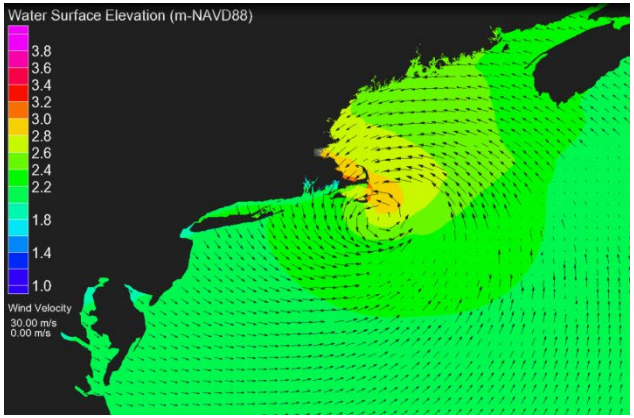
- **Worst possible scenario for emergency planning (worst storm at MHW)…no associated risk planning**
- **Coarse modeling domain results in local inaccuracies**
- **Does not include impacts of waves**
- **Just hurricanes**

Why existing maps were not good enough

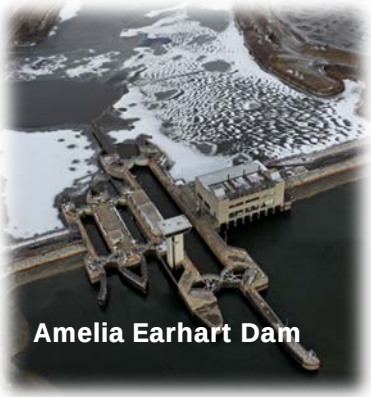


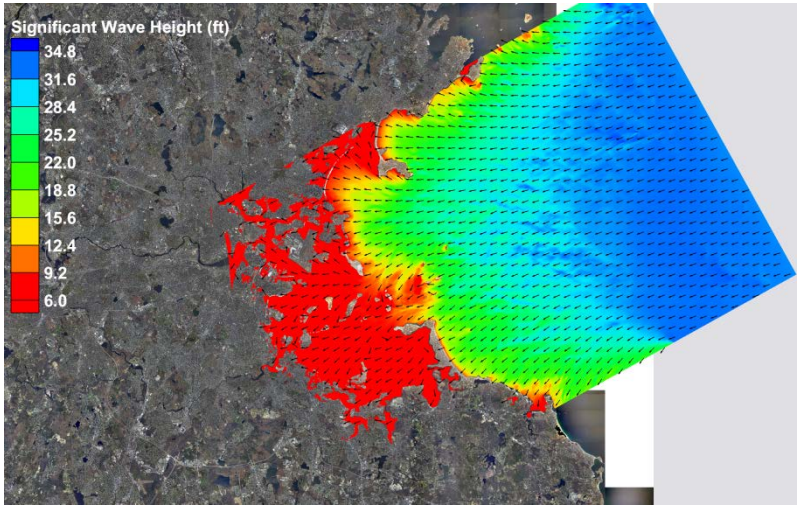
Hi-Res Hydrodynamic Modeling

- 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

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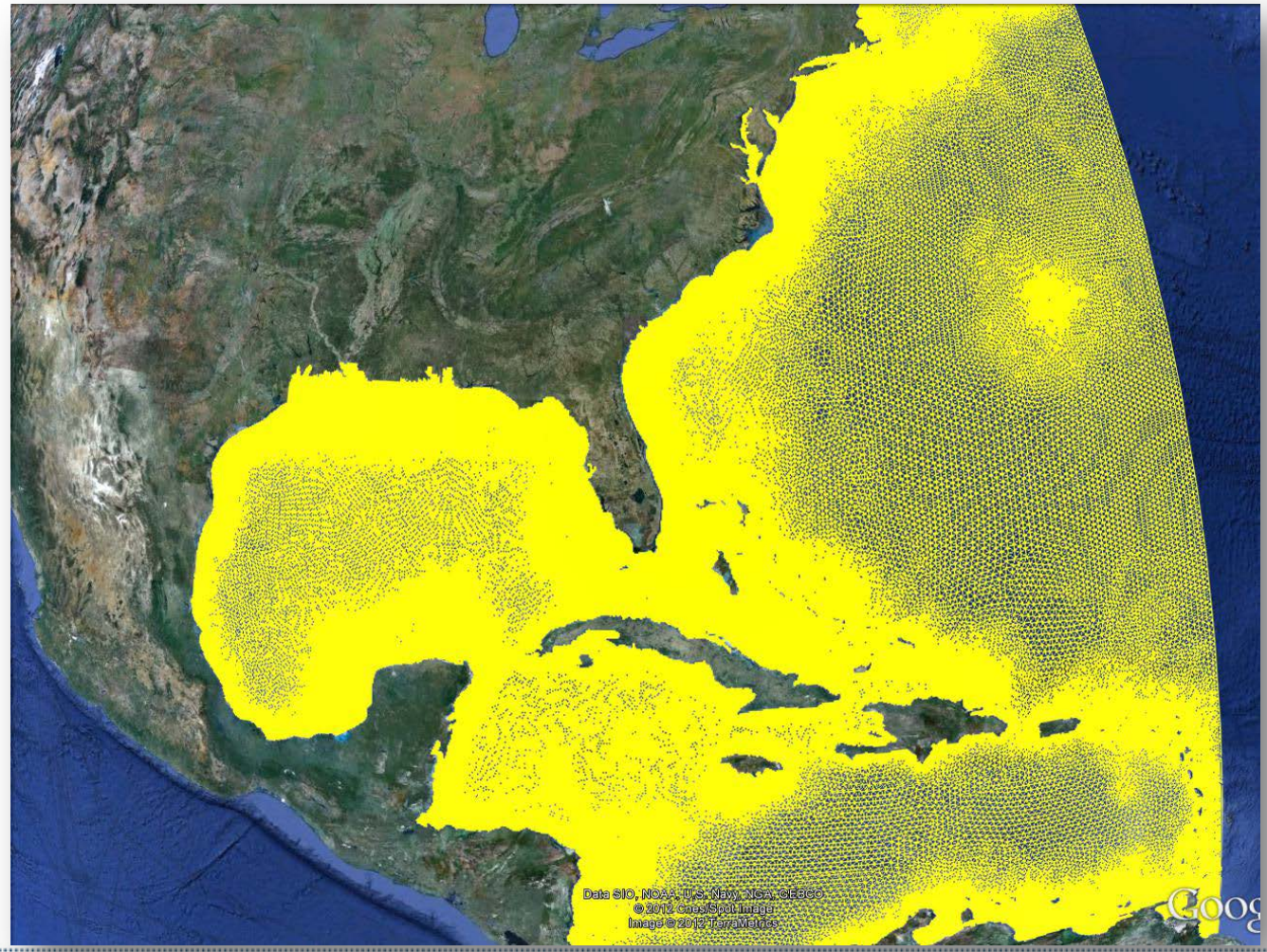
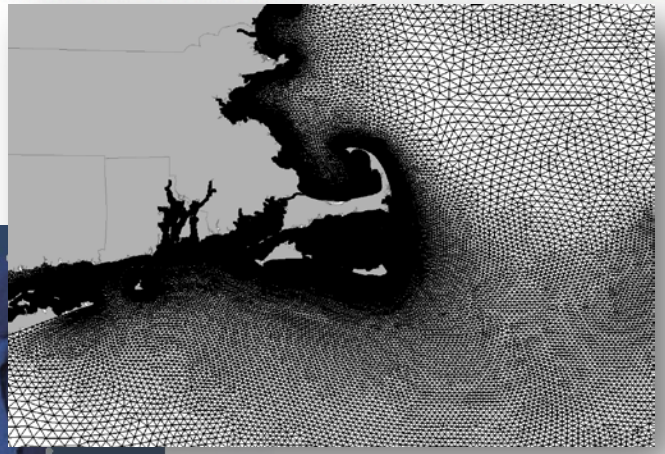
Regional Grid Requirements

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

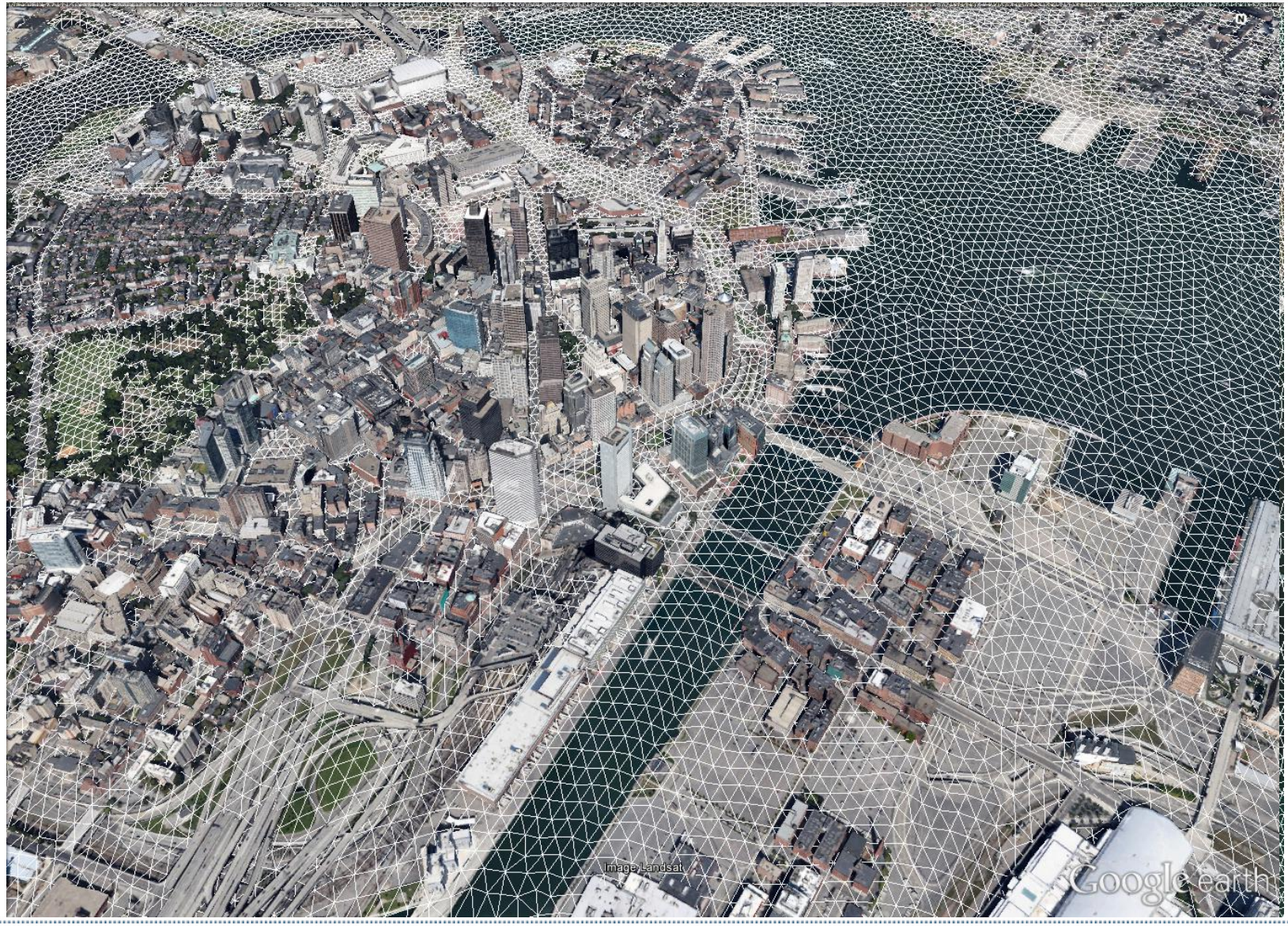


Unstructured Grid

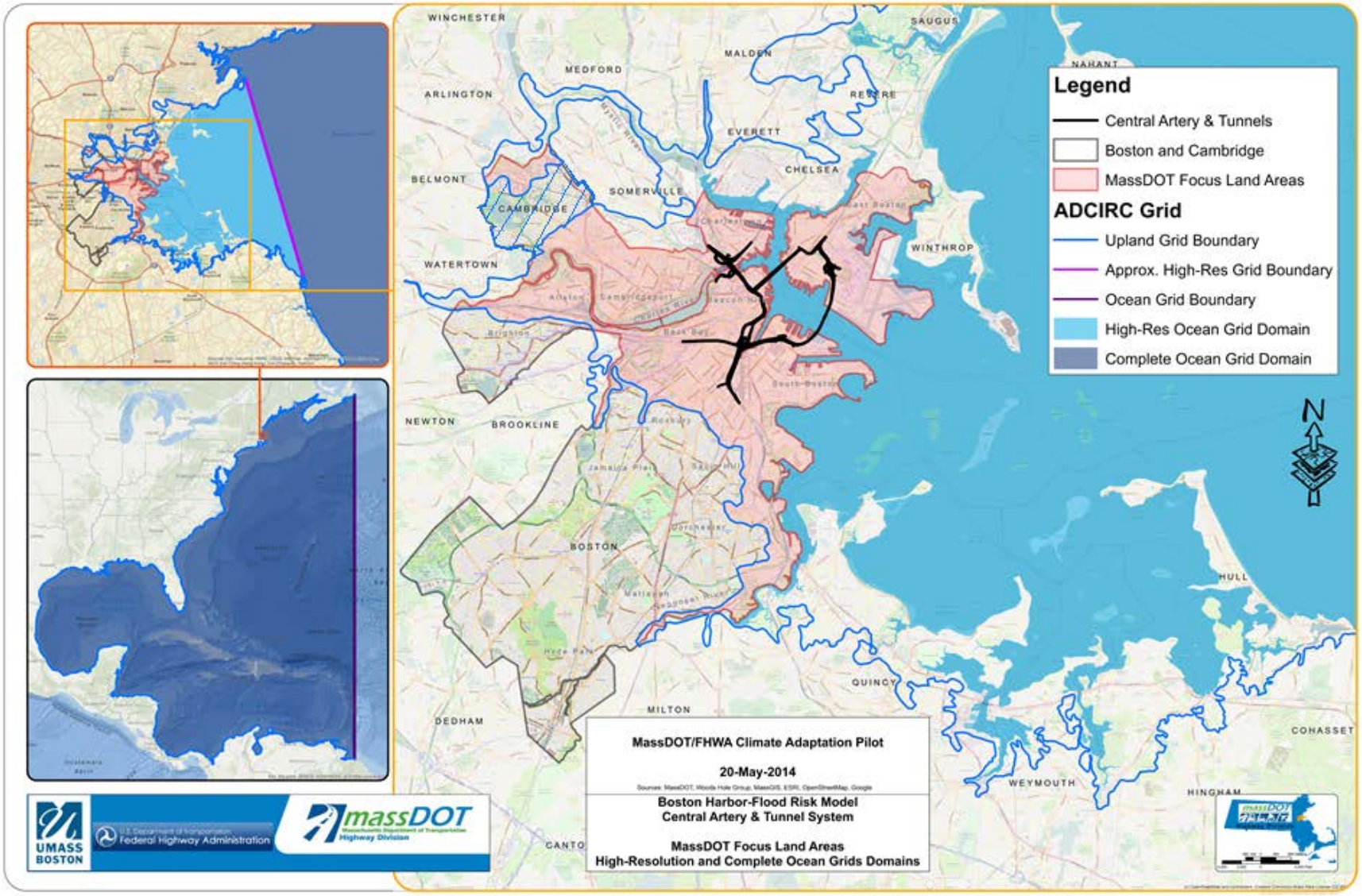
Varying resolution with high resolution in areas of interest



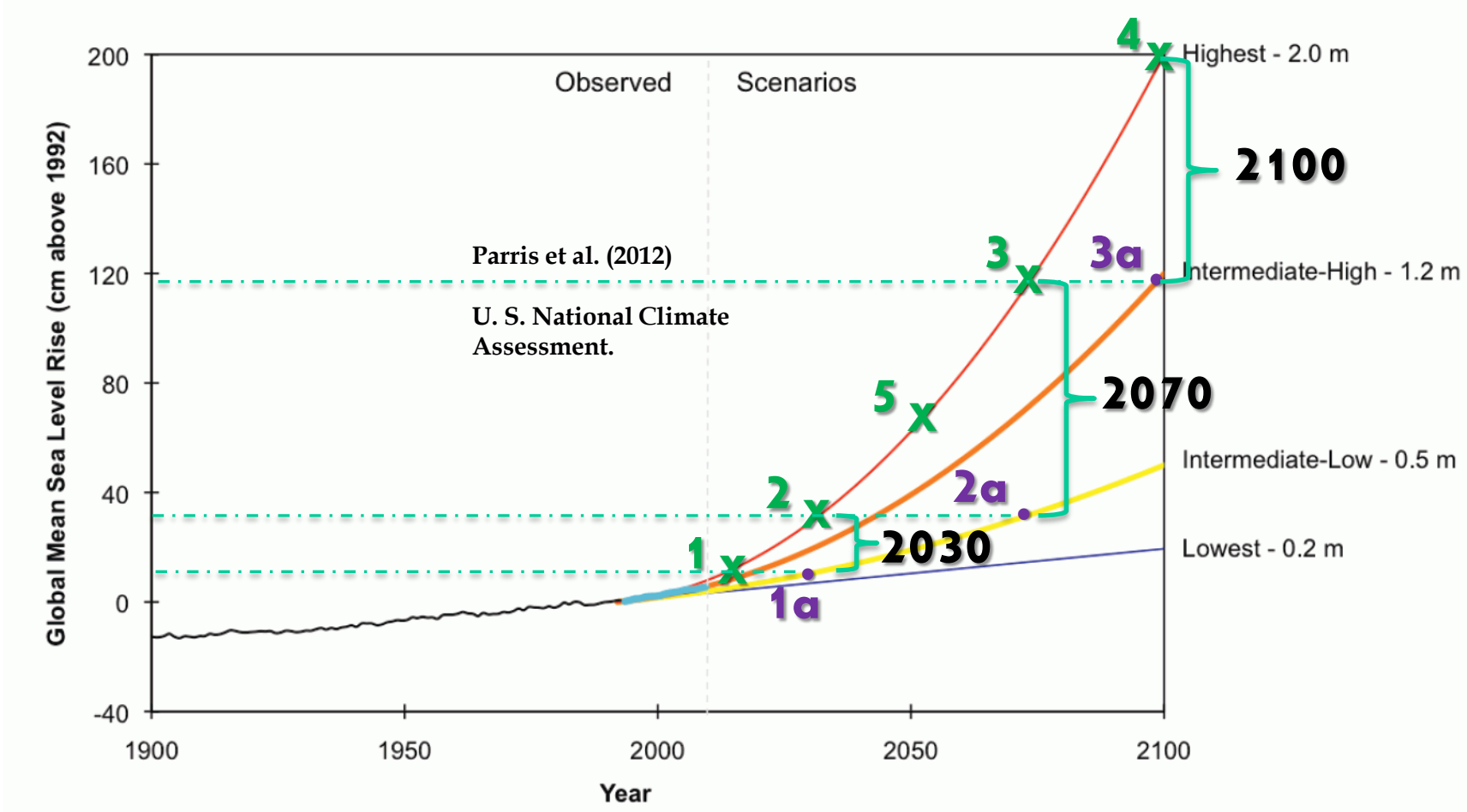
Boston Grid



Focus Areas


WINCHESTER
MEDFORD
MALDEN
SAUGUS
NAHANT
ARLINGTON
REVERE
EVERETT
CHELSEA
BELMONT
SOMERVILLE
CAMBRIDGE
WINTHROP
WATERTOWN
NEWTON
BROOKLINE
BOSTON
HULL
QUINCY
MILTON
DEDHAM
COHASSET
WEYMOUTH
HINGHAM
CANTO
Legend
Central Artery & Tunnels
Boston and Cambridge
MassDOT Focus Land Areas
ADCIRC Grid
Upland Grid Boundary
Approx. High-Res Grid Boundary
Ocean Grid Boundary
High-Res Ocean Grid Domain
Complete Ocean Grid Domain
N
MassDOT/FHWA Climate Adaptation Pilot
20-May-2014
Boston Harbor-Flood Risk Model
Central Artery & Tunnel System
MassDOT Focus Land Areas
High-Resolution and Complete Ocean Grids Domains
UMASS BOSTON
U.S. Department of Transportation
Federal Highway Administration
massDOT
Highway Division

Using Projections to Bracket Risk



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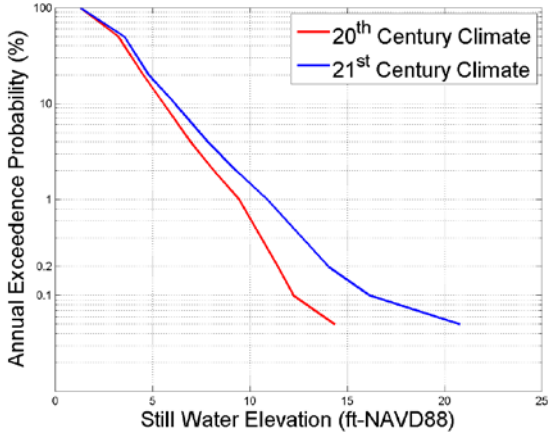
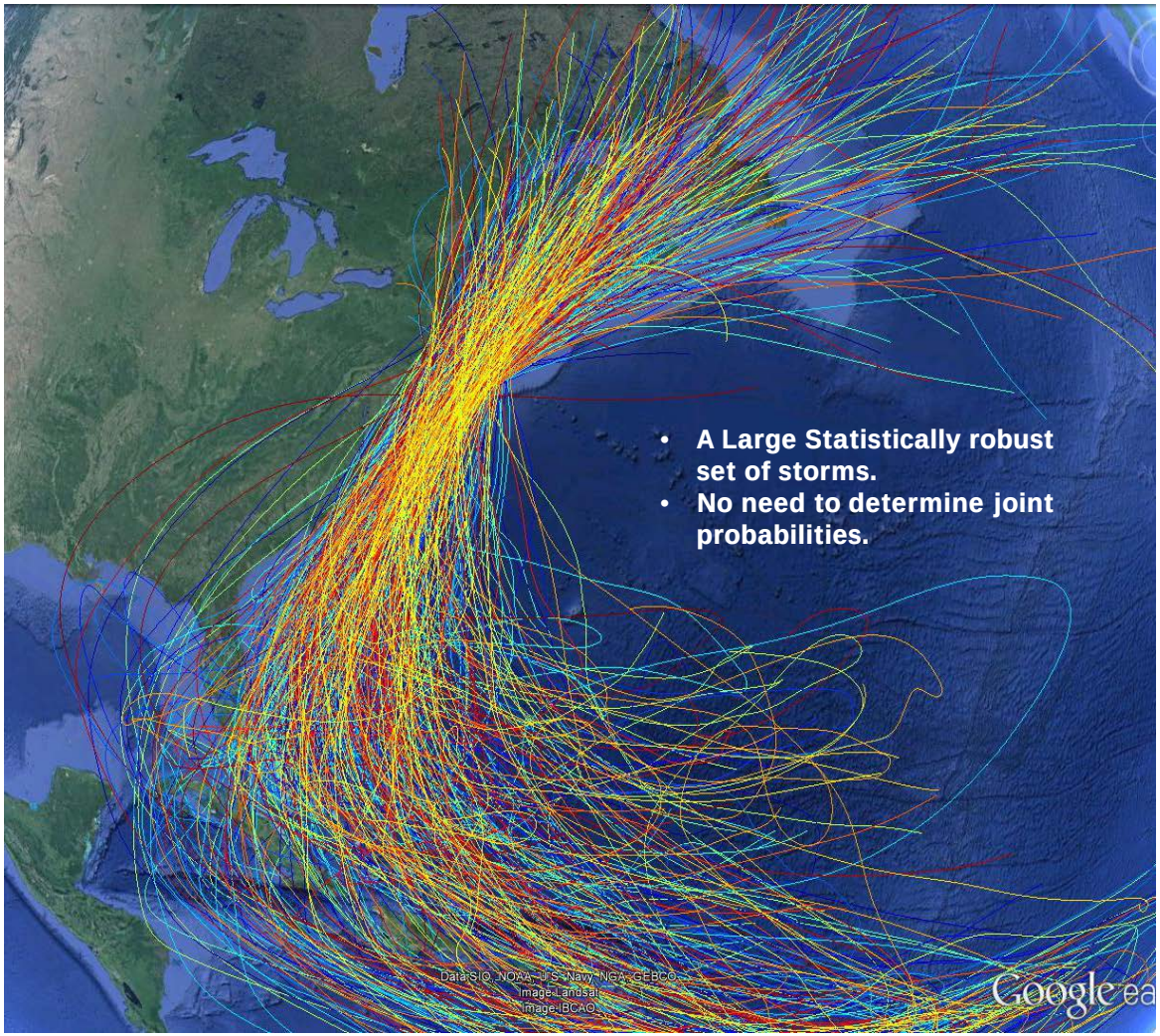
Storm Climatology - Hurricanes

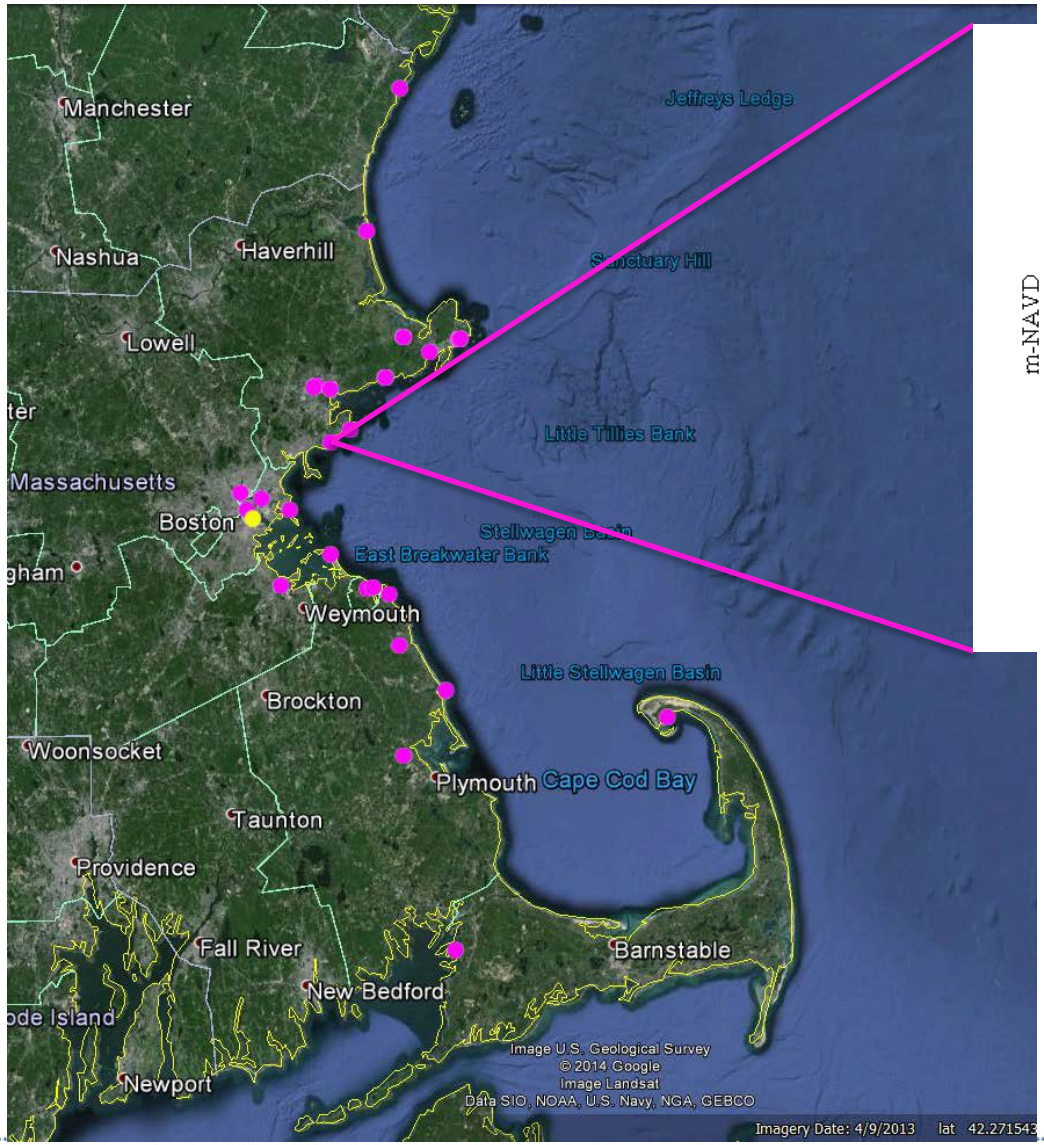
- Monte Carlo simulations, using a large statistically robust set of storms (Emanuel, et al., 2006) and a physics based approach
- Present and future climate change scenarios

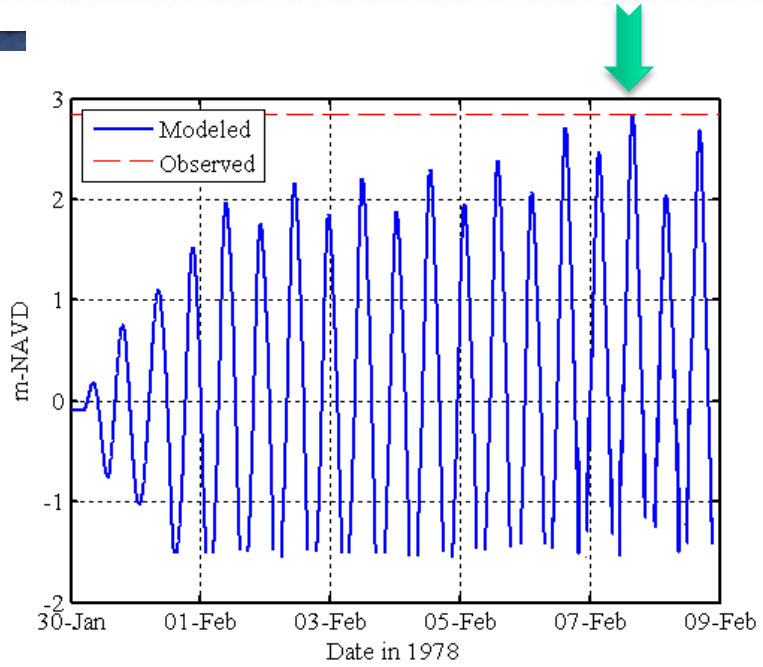


- Simulates storms (both hurricane and nor'easter) combined with SLR and precipitation

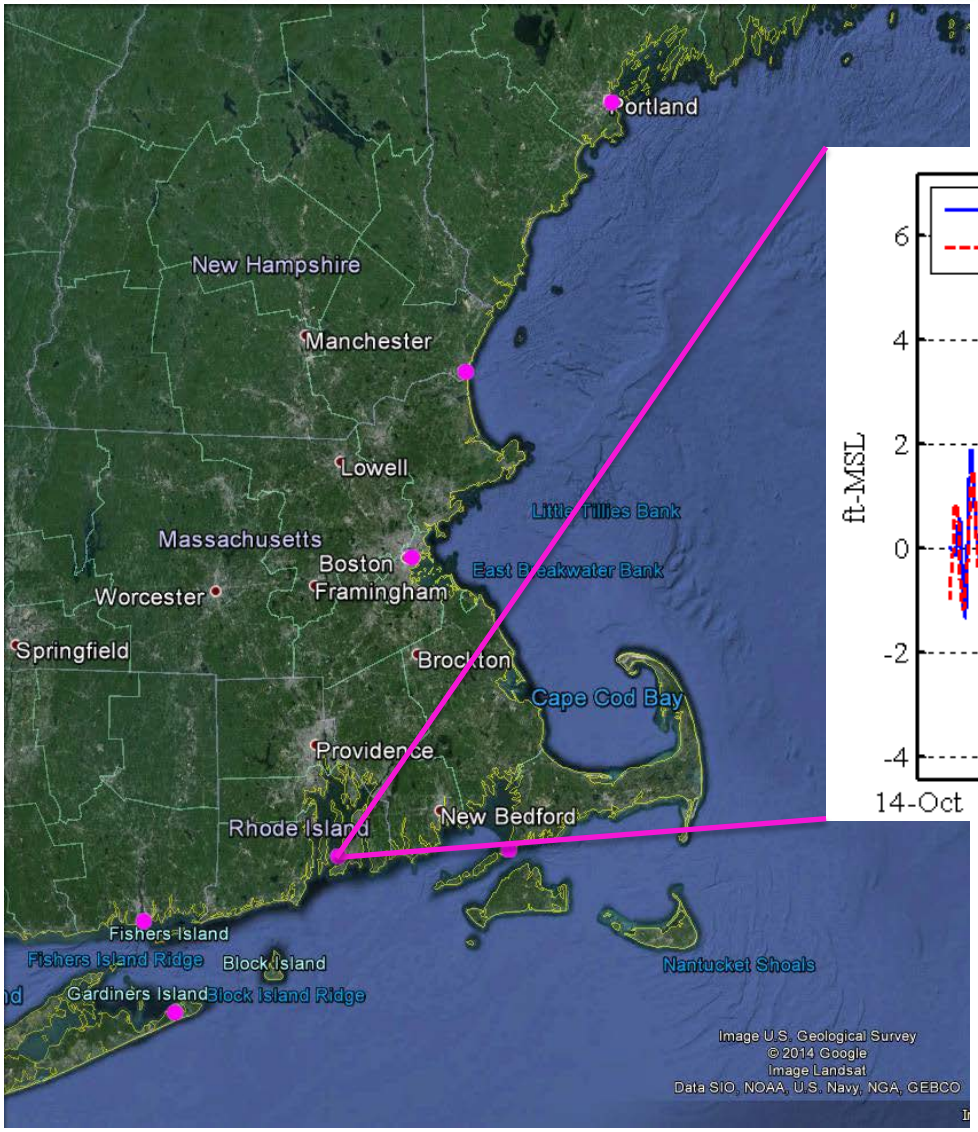


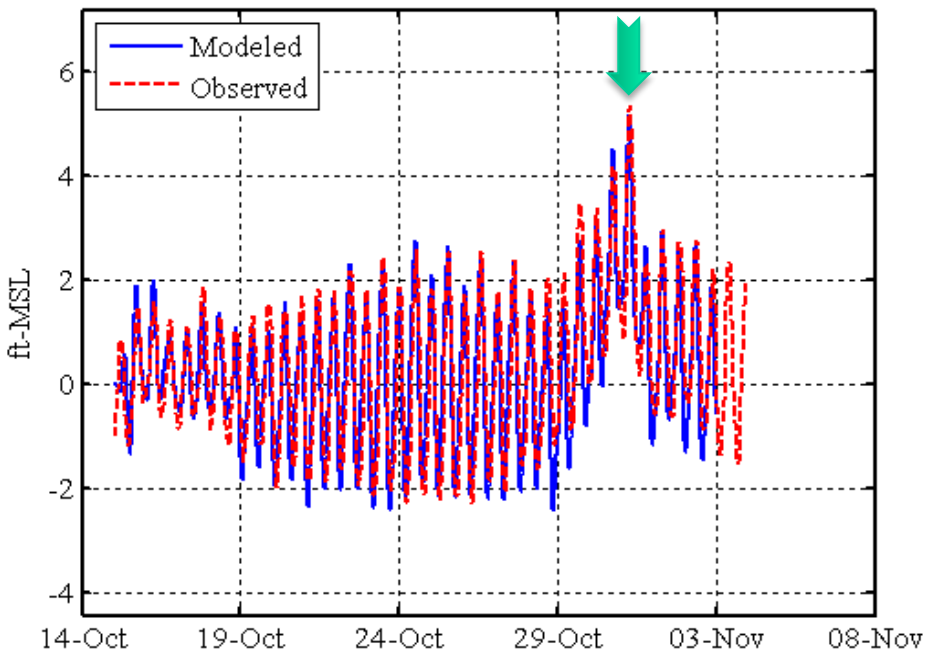
Model Calibration – Blizzard of '78





Model Validation – Perfect Storm





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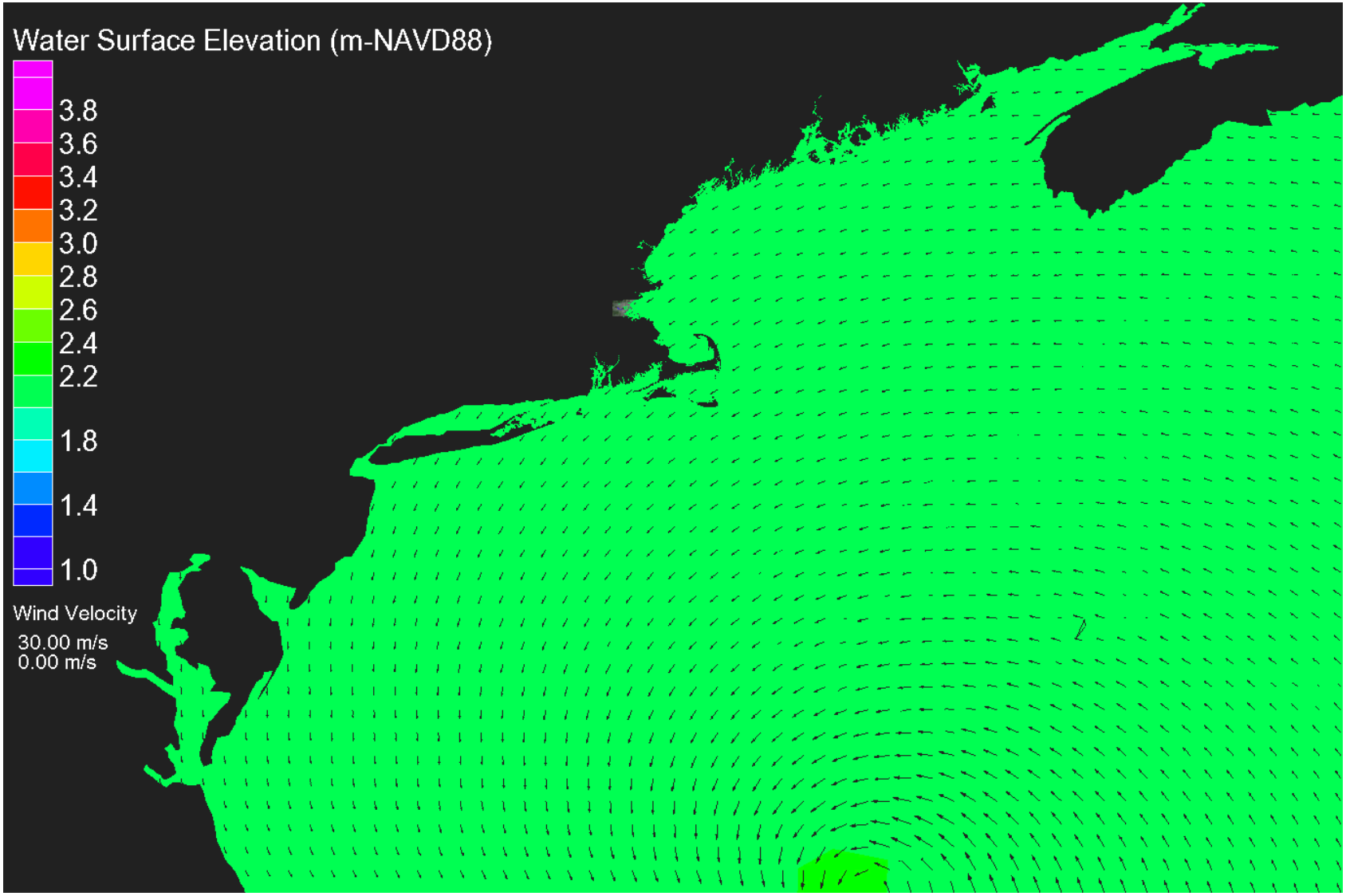
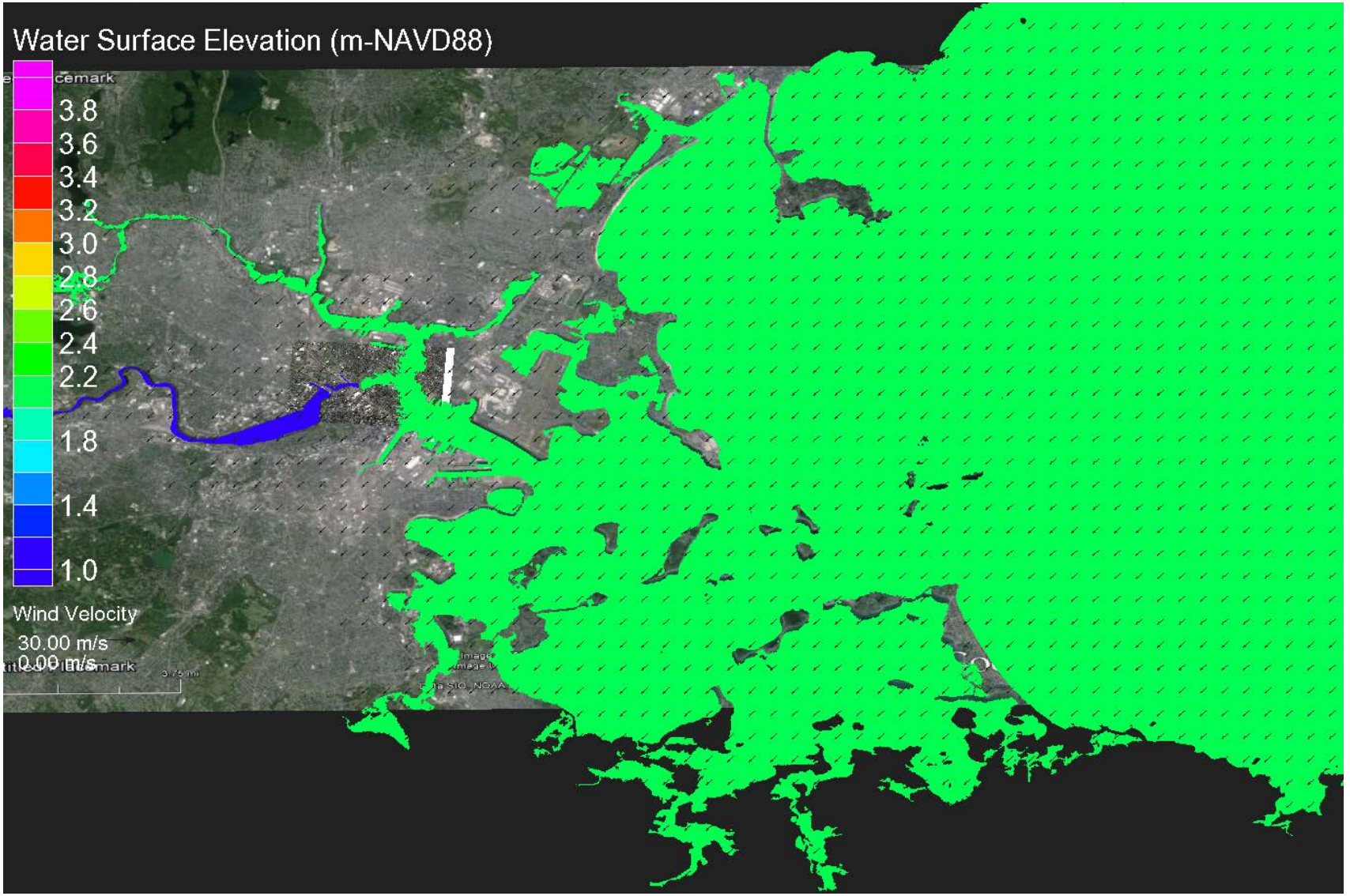
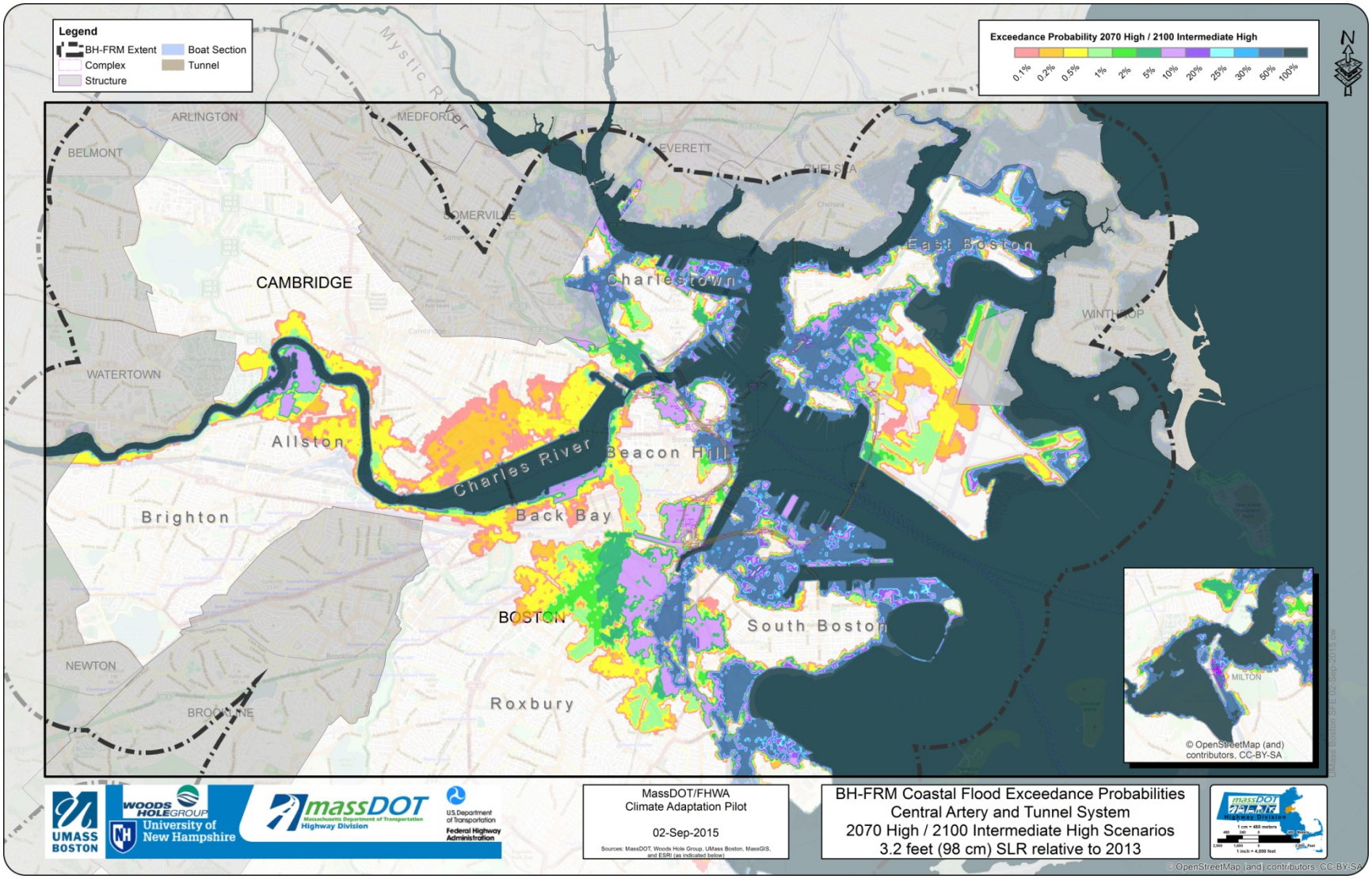
Example Results – Winds



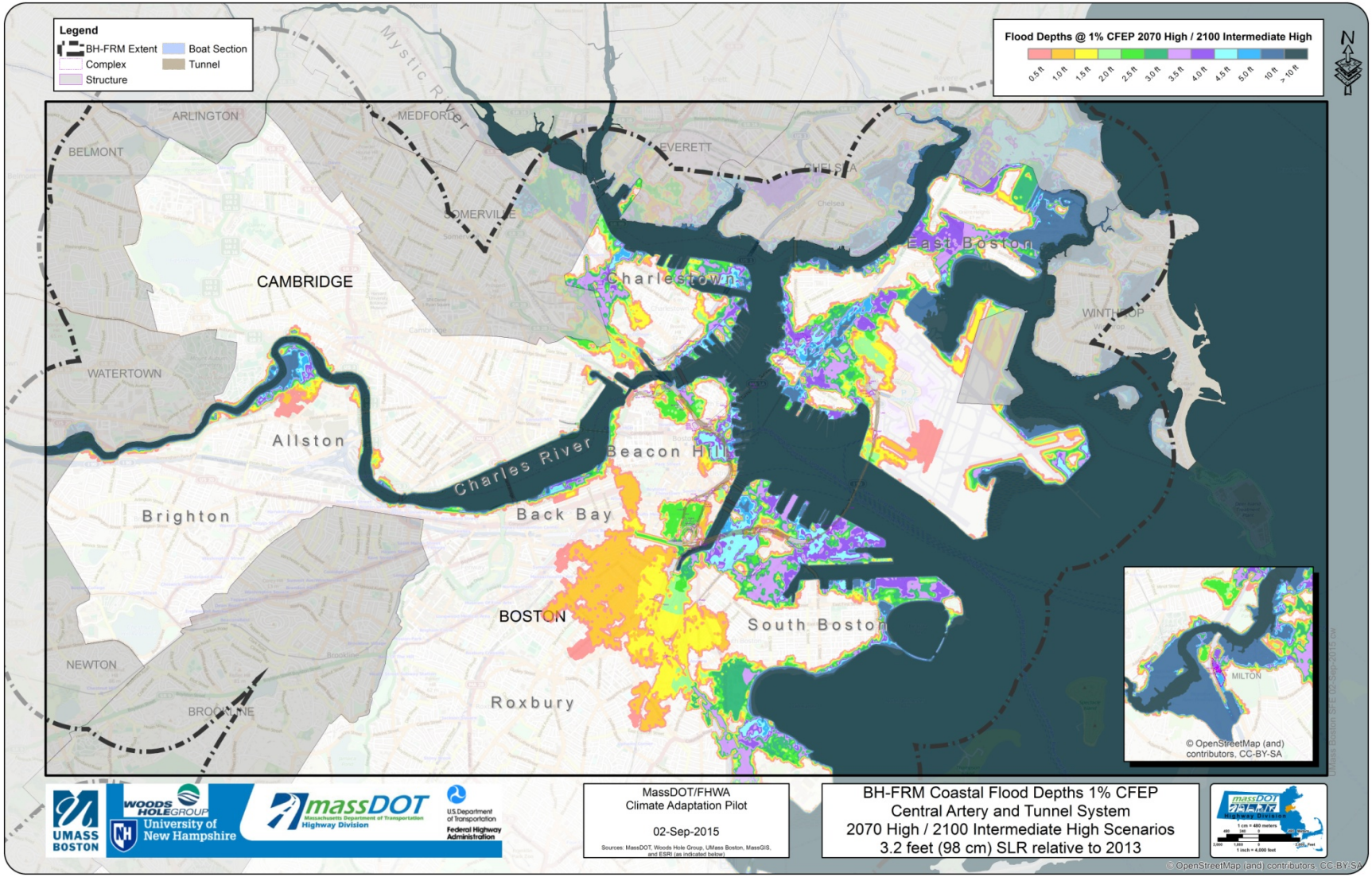
Example Results - Hurricane



Exceedance Probability Maps



Depth of Inundation Maps



UMASS BOSTON | WOODS HOLE GROUP | University of New Hampshire | massDOT Massachusetts Department of Transportation Highway Division | U.S. Department of Transportation Federal Highway Administration

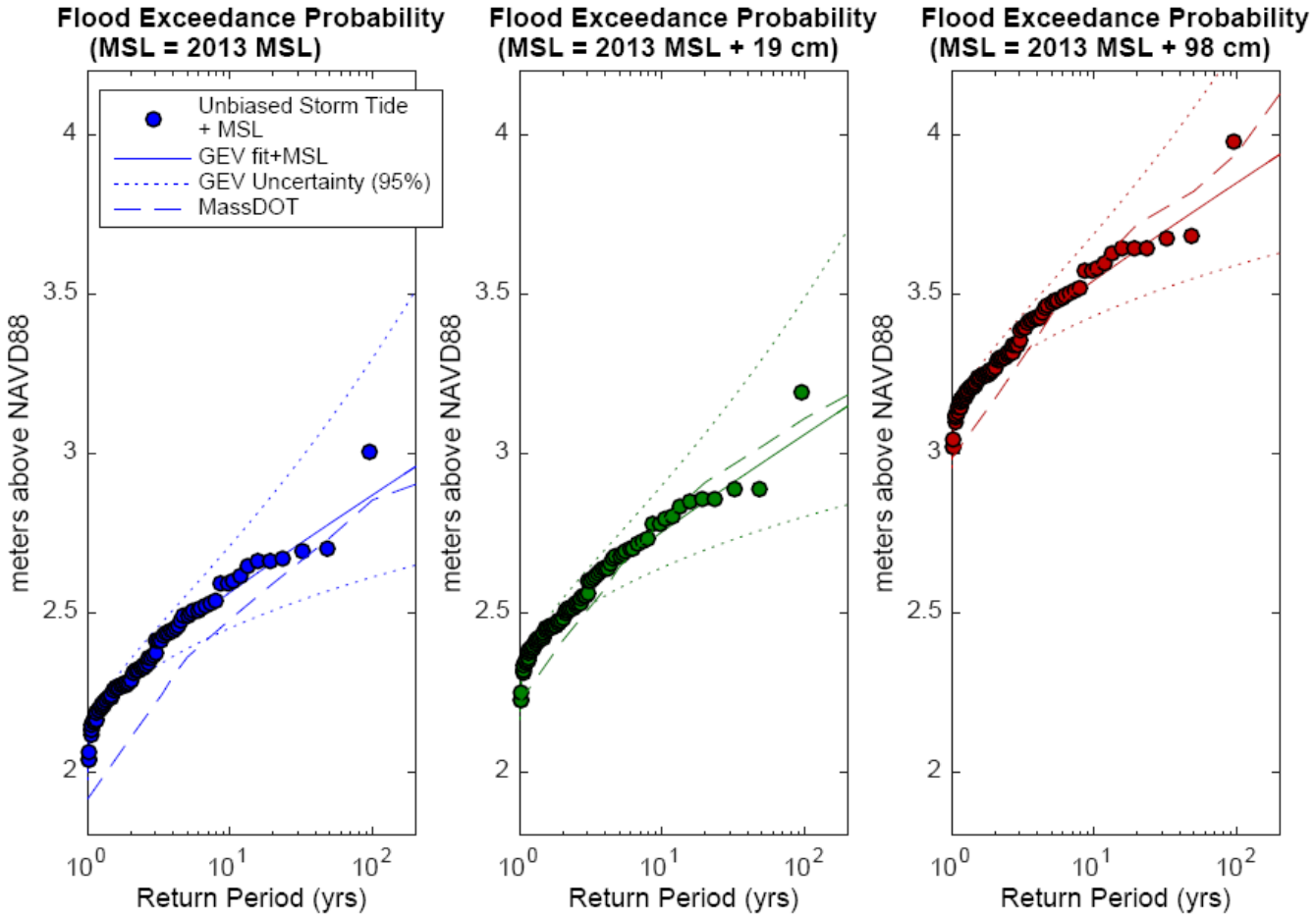
MassDOT/FHWA
Climate Adaptation Pilot

02-Sep-2015

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

BH-FRM Coastal Flood Depths 1% CFEP
Central Artery and Tunnel System
2070 High / 2100 Intermediate High Scenarios
3.2 feet (98 cm) SLR relative to 2013

Changing Climatology



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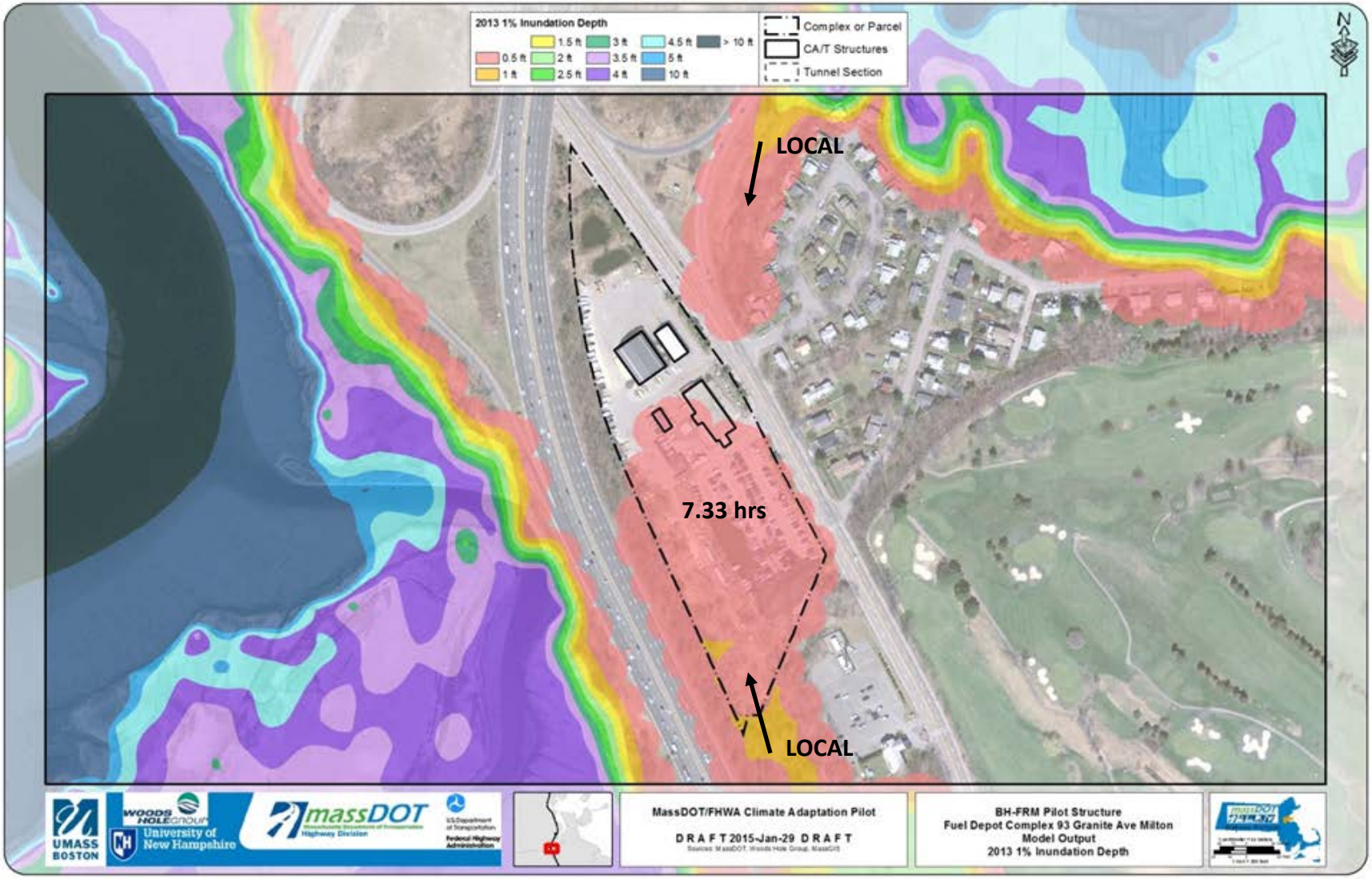
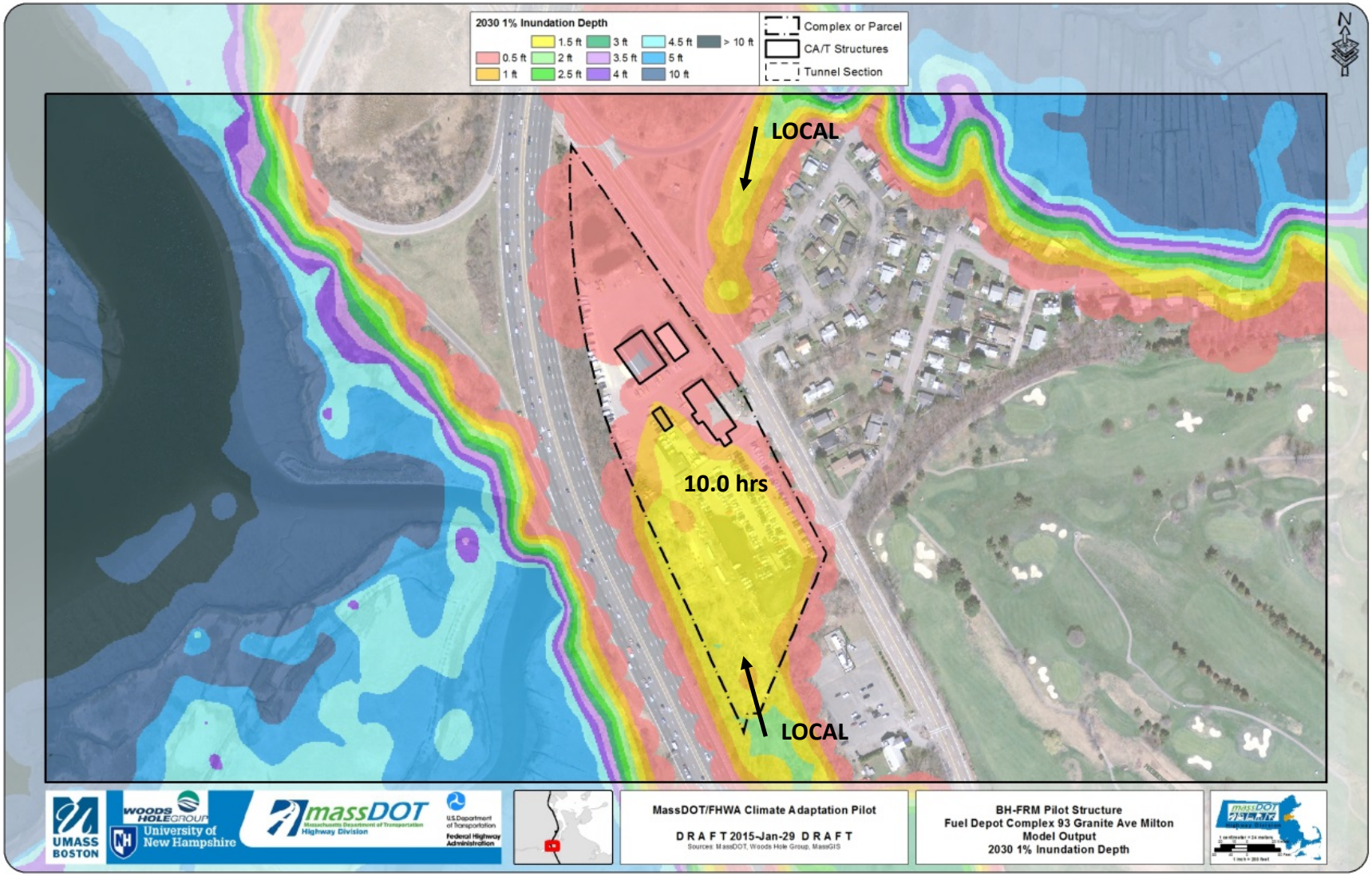
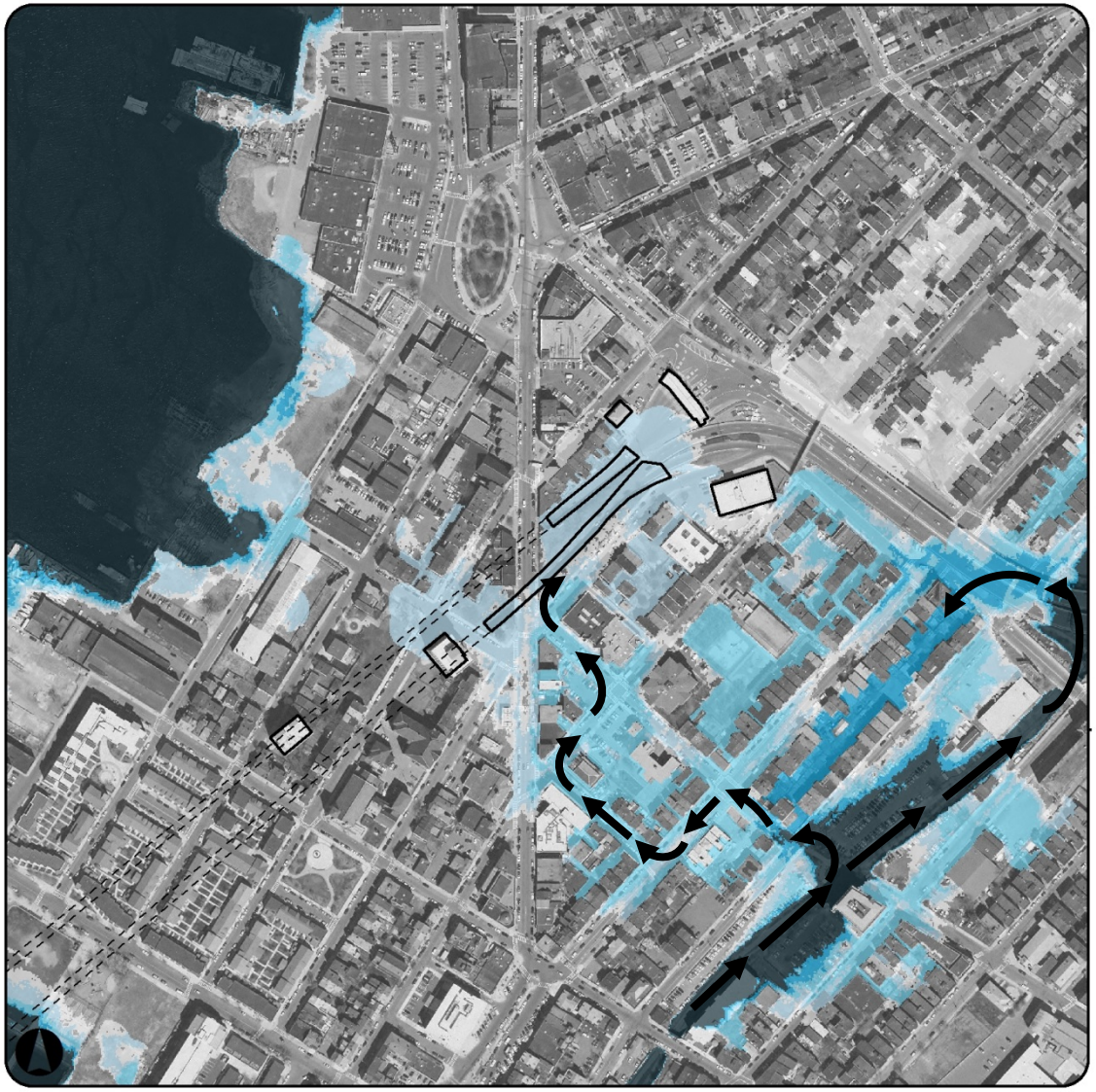
Example Assessment



Example Assessment



Flood Pathways



MassDOT/FHWA Climate Adaptation Pilot
BH-FRM Flood Pathway Analysis

2013 Regional and Local Flood Pathways

Callahan Tunnel
East Boston, MA

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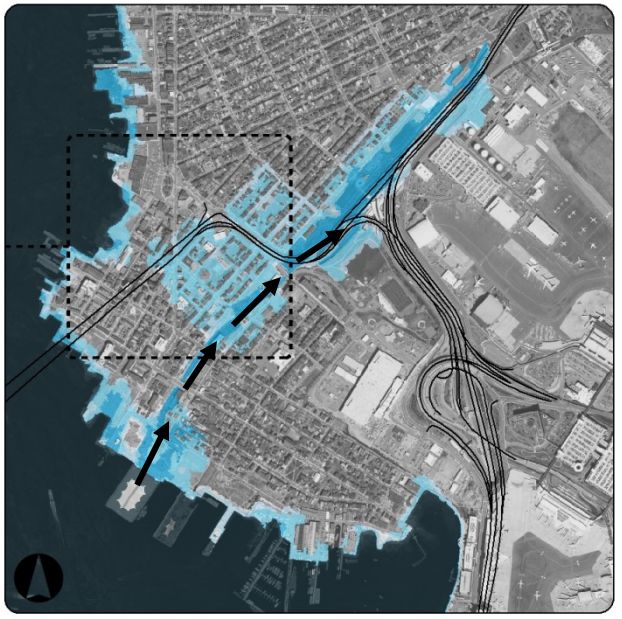
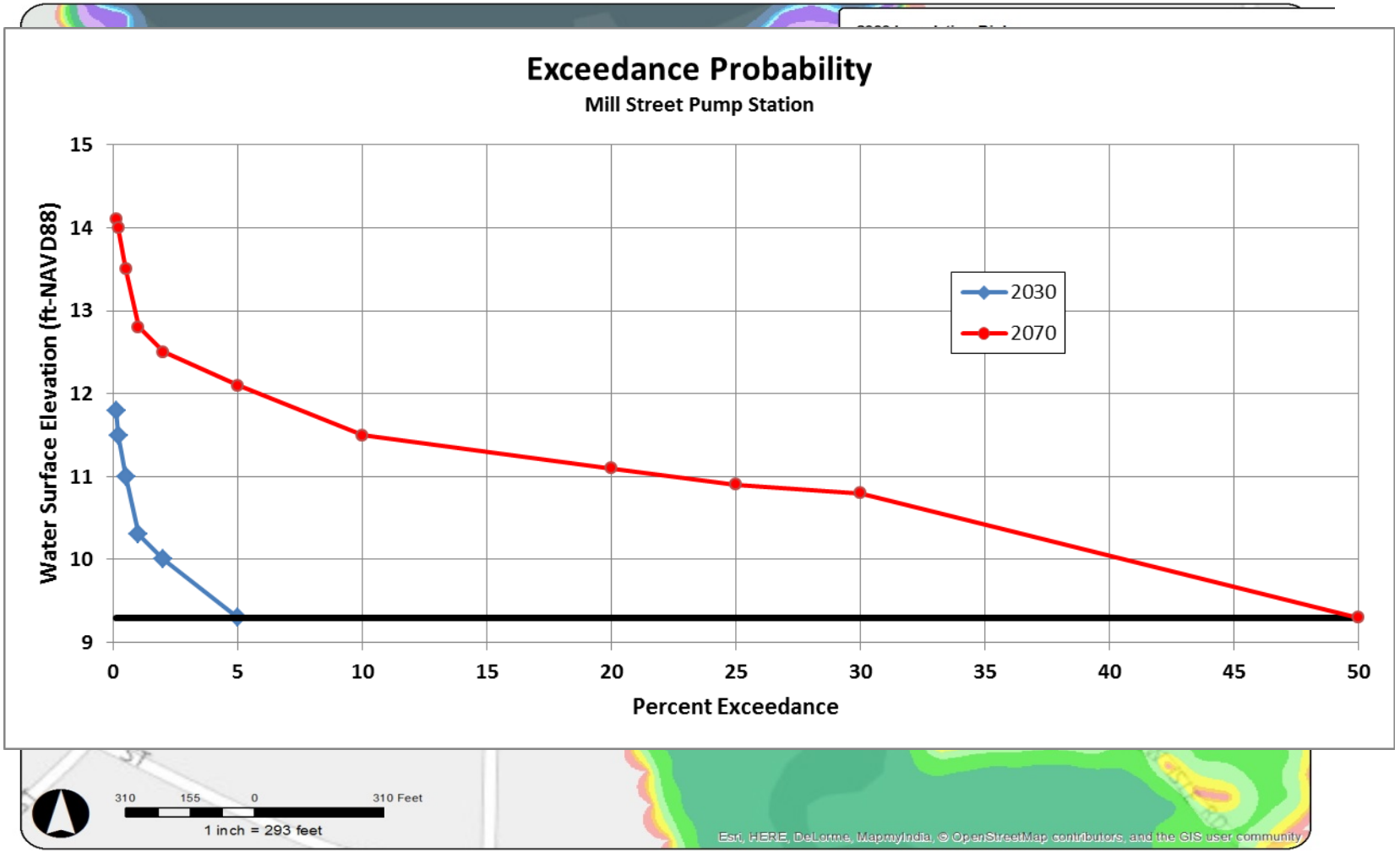
CA/T System

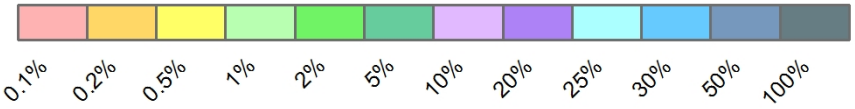
Complex or Parcel | CA/T Structures | Tunnel Section

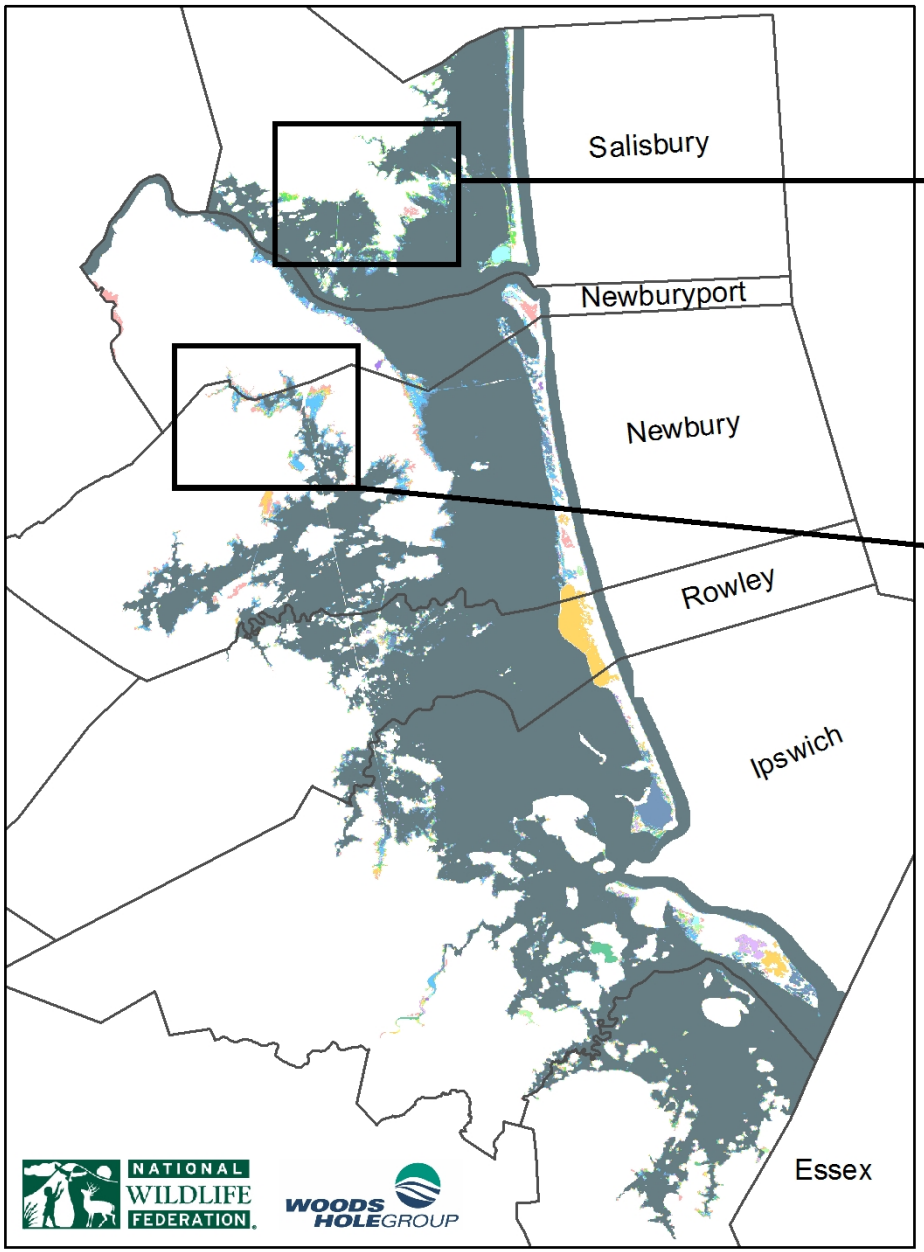


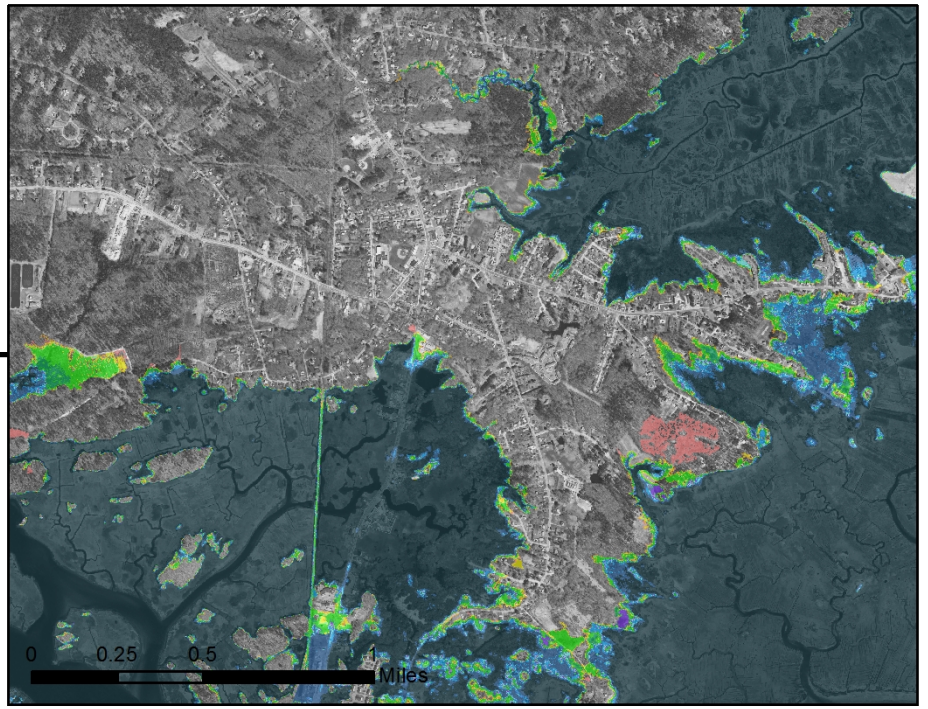
Local Community Assessment

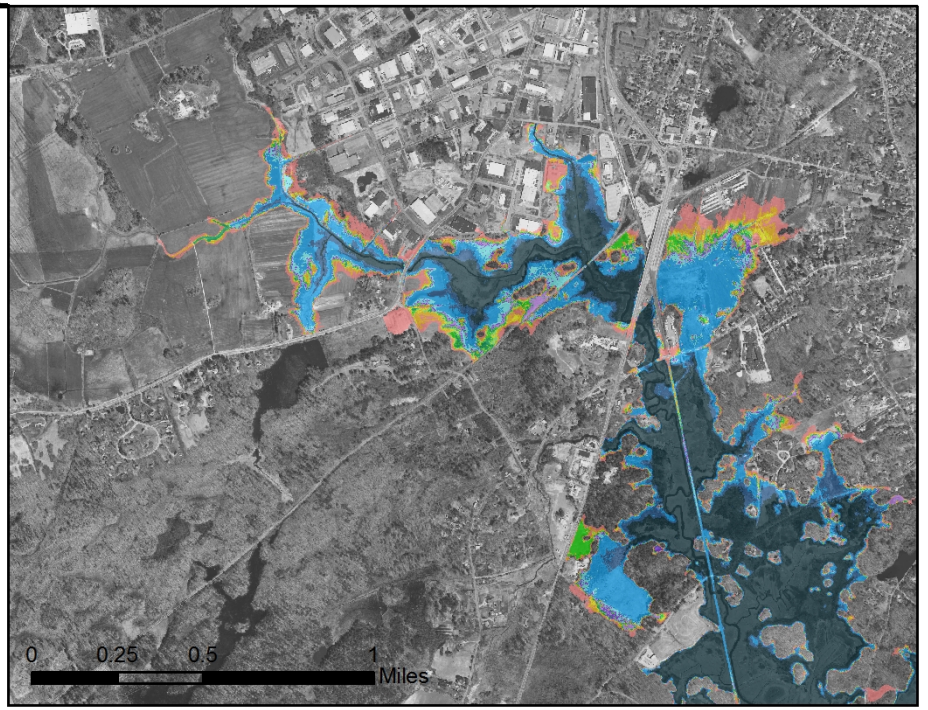


2030 Inundation Probability - Great Marsh Communities

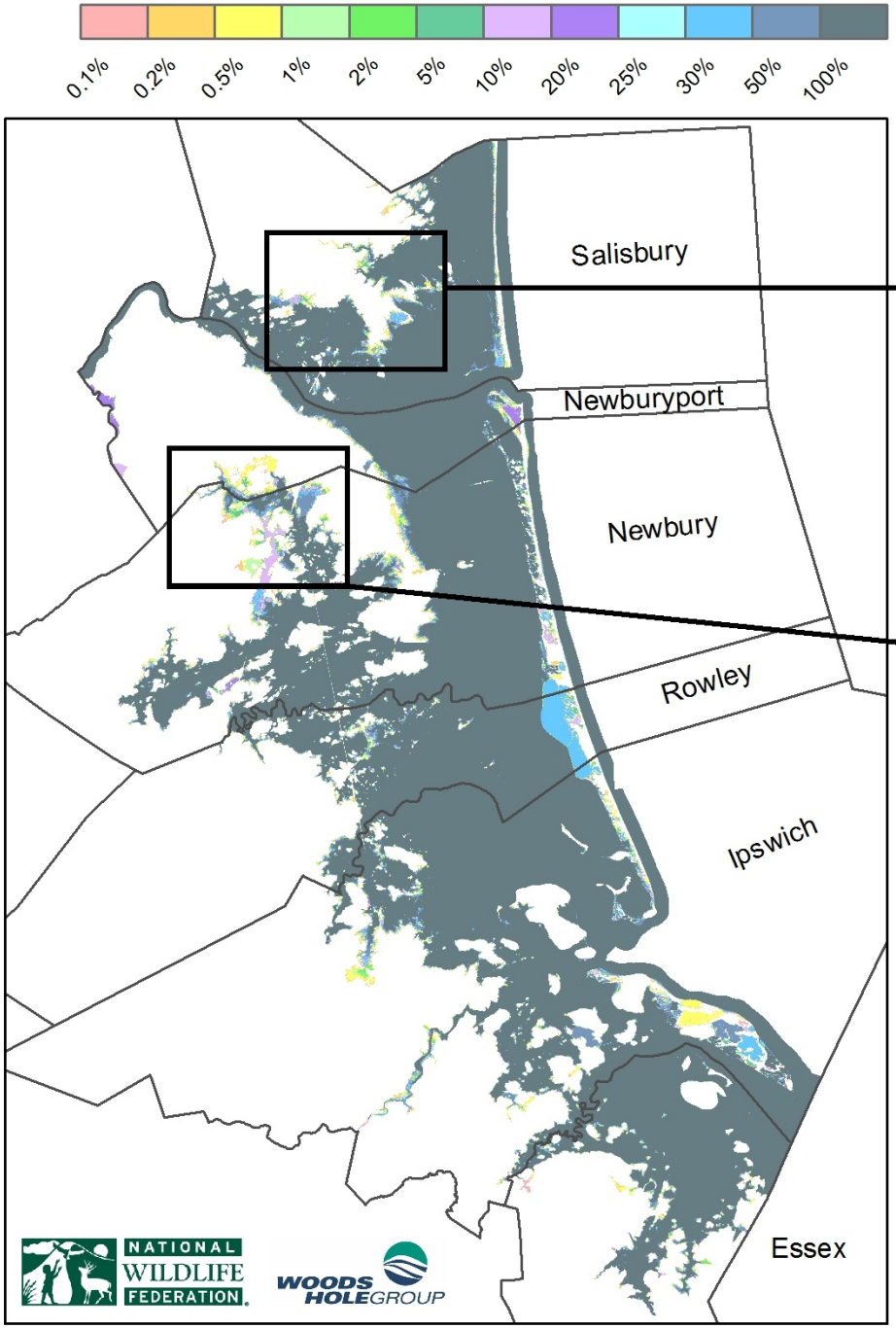


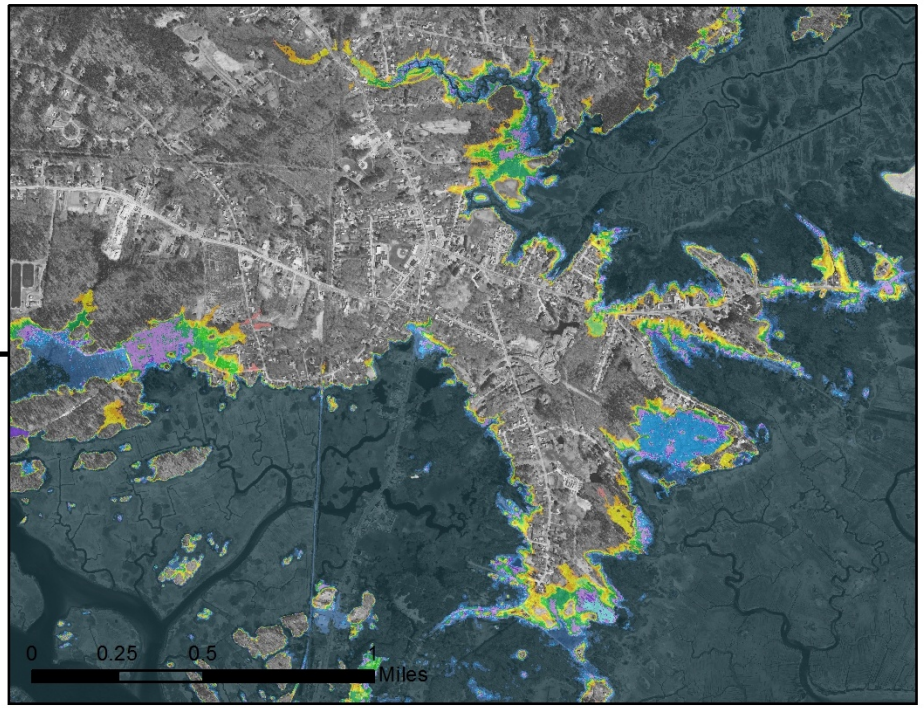


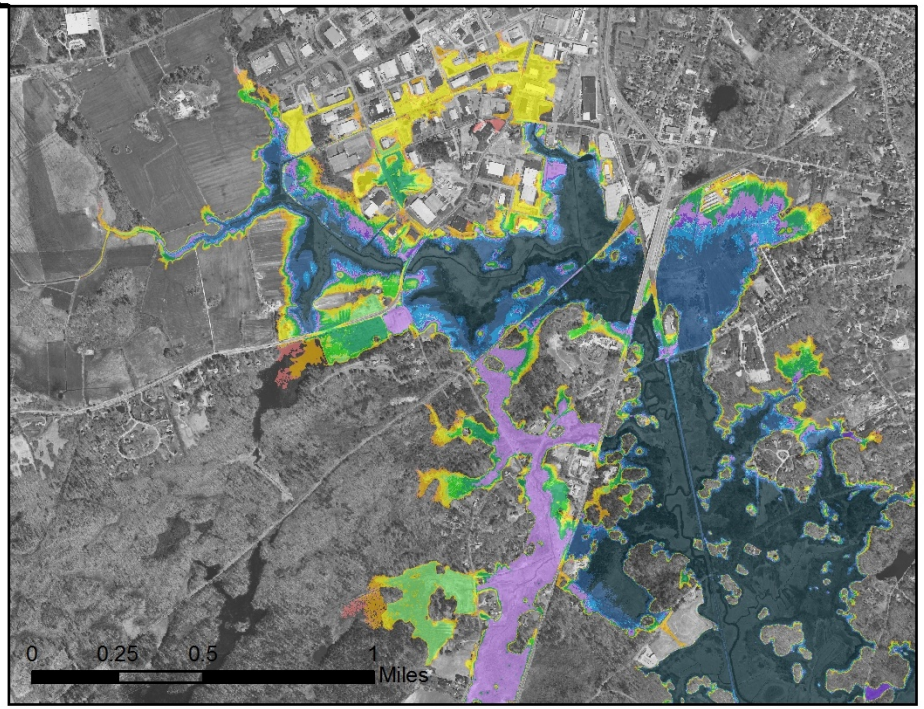




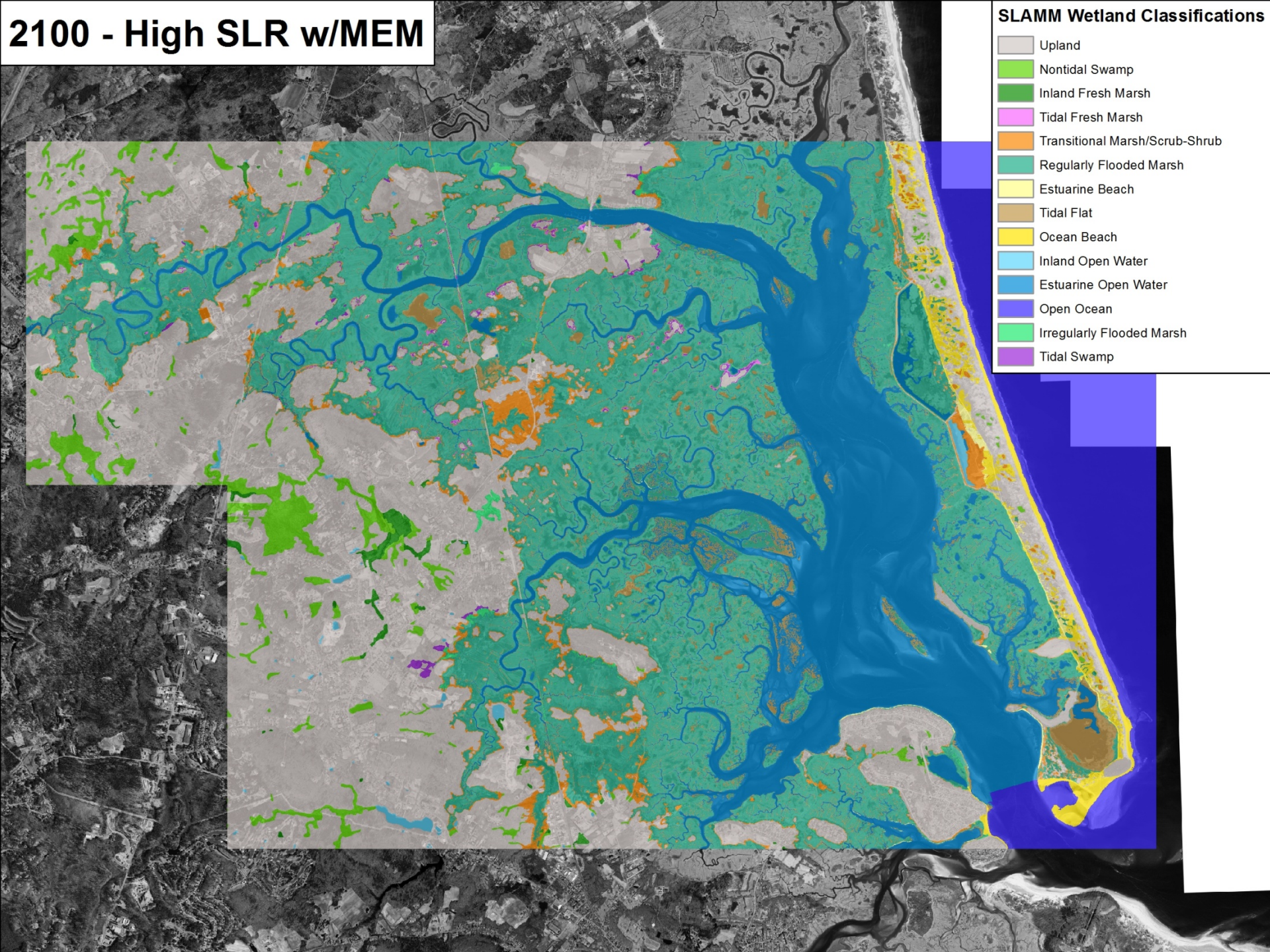
2070 Inundation Probability - Great Marsh Communities

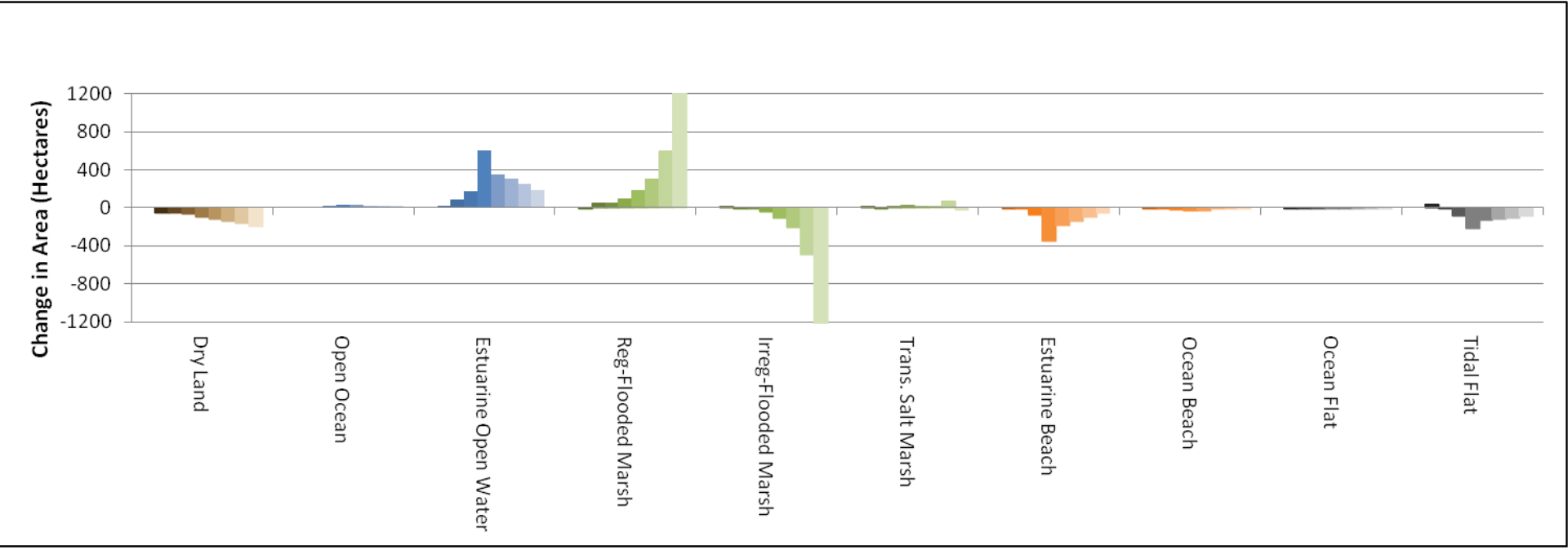




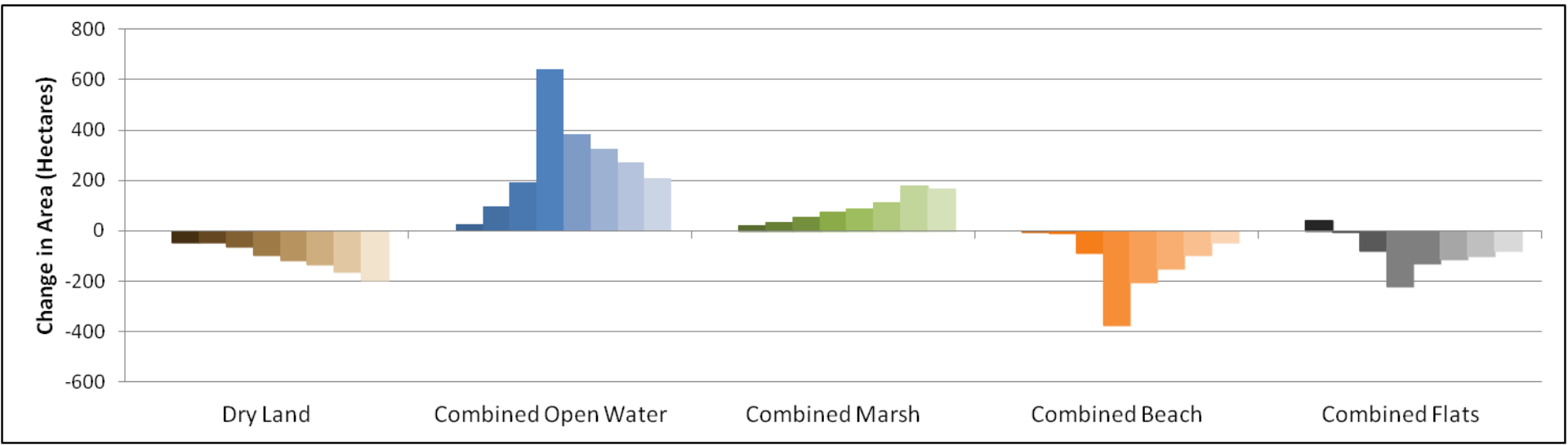


2100 - High SLR w/MEM

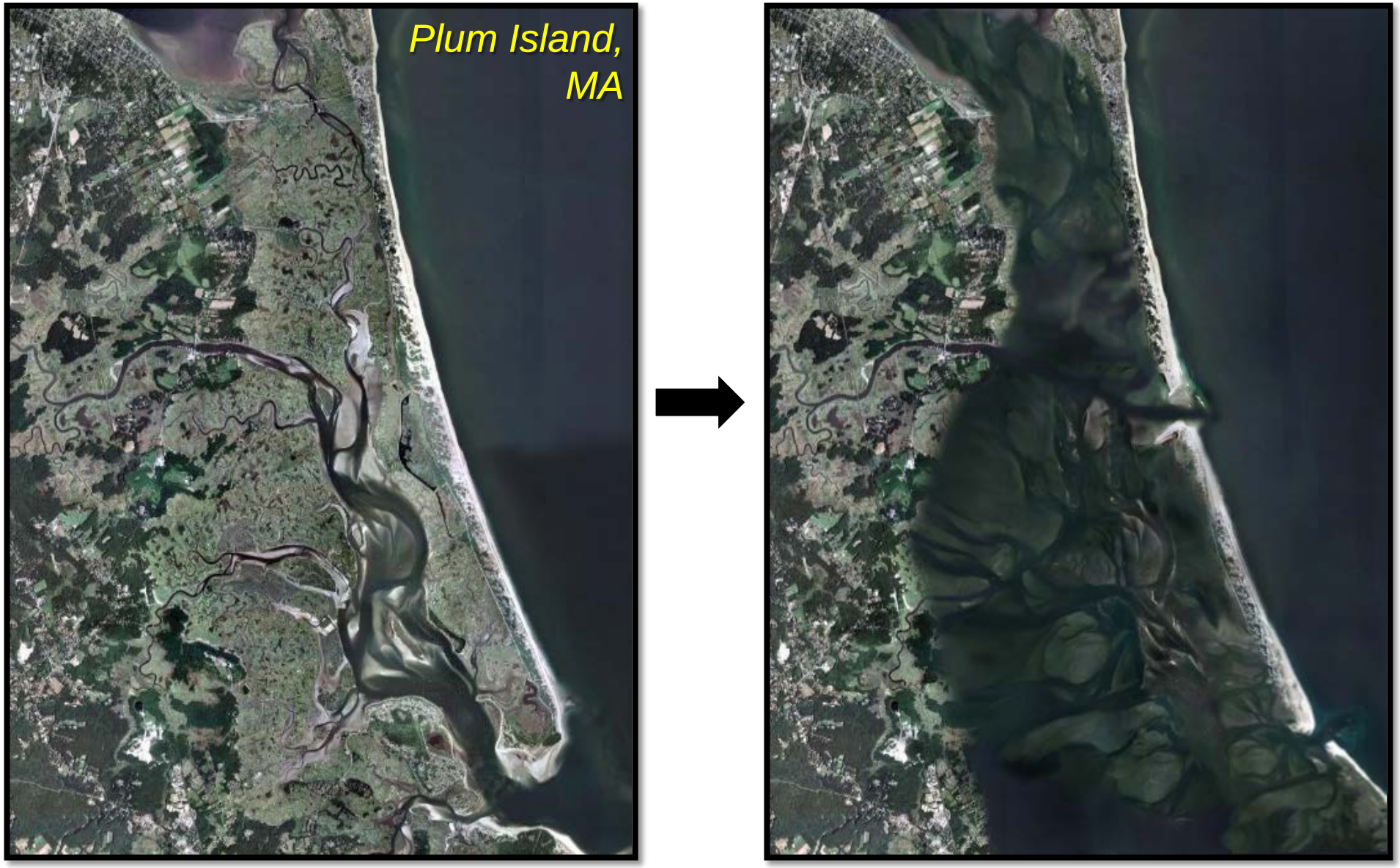




Great Marsh Panel Wetlands Change Summary



Hein et al., 2012 (Marine Geology)



Summary

https://www.massdot.state.ma.us/highway/Departments/EnvironmentalServices/EMSSustainabilityUnit/Sustainability.aspx

1. This model approach provides high-resolution flooding results for projected climate change scenarios.
2. Peer-reviewed by WHOI, USGS, NOAA, USACE, and USEPA.
3. Includes relevant processes, storm types, and joint probabilities.
4. Provides realistic probability based results that can be more effectively used to assess vulnerabilities and provide planning prioritization.
5. The model can be used to test various adaptation and engineering options, connected to ecological, piped infrastructure, and economic models.
6. The model is currently being extended to the entire coastline of Massachusetts, with time varying topography.