



TRANSPORTATION RESEARCH BOARD

September 17, 2015

Surface Transportation System Resilience to Climate Change and Extreme Weather Events

Storm Surge Risk Modeling in a Changing Climate: Assessing Impacts to Key Transportation Assets of the Central Artery System

 U.S. Department of Transportation
Federal Highway Administration

Moving Massachusetts Forward.
massDOT


WOODS HOLE GROUP

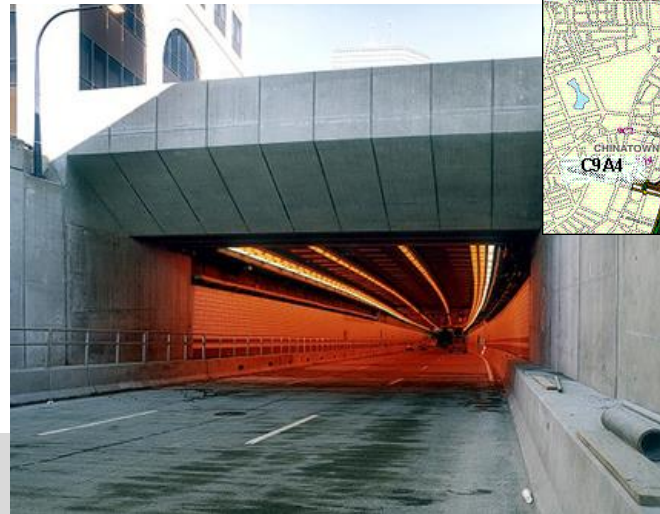
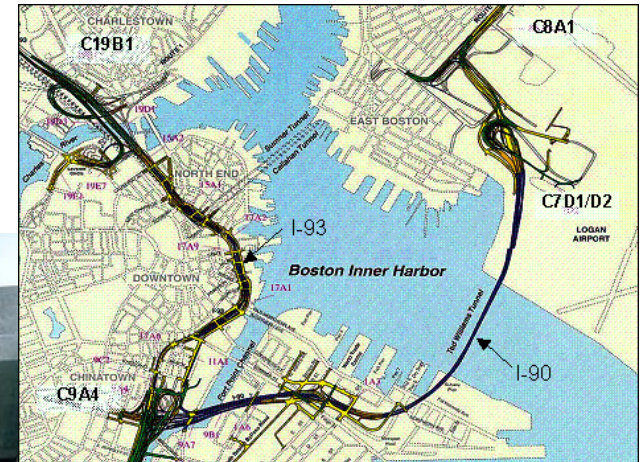
 UNIVERSITY of NEW HAMPSHIRE

UMASS BOSTON

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 is the plan?



Project Team:

Kirk Bosma, Woods Hole Group, Inc.
Ellen Douglas and Chris Watson, UMass Boston
Paul Kirshen, University of New Hampshire
Steven Miller, MassDOT

Probability of flooding options

FEMA Maps

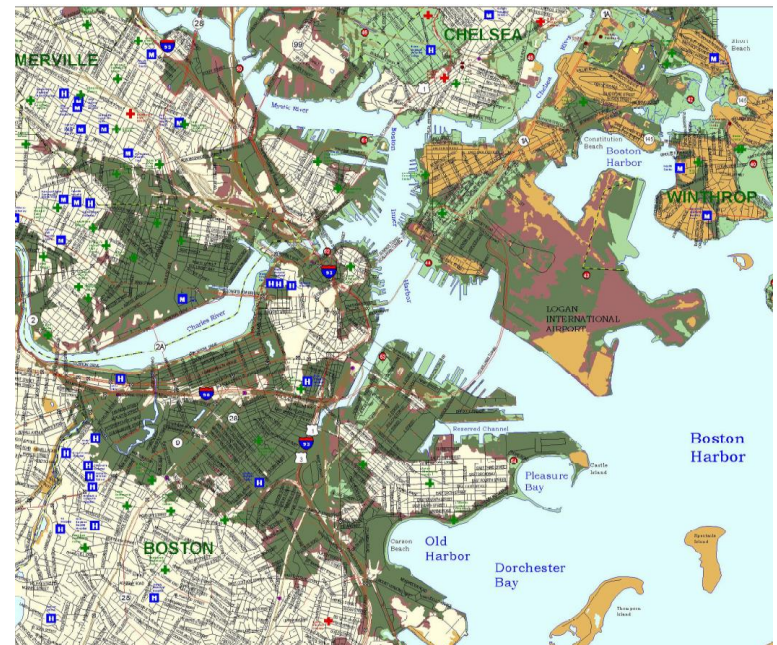
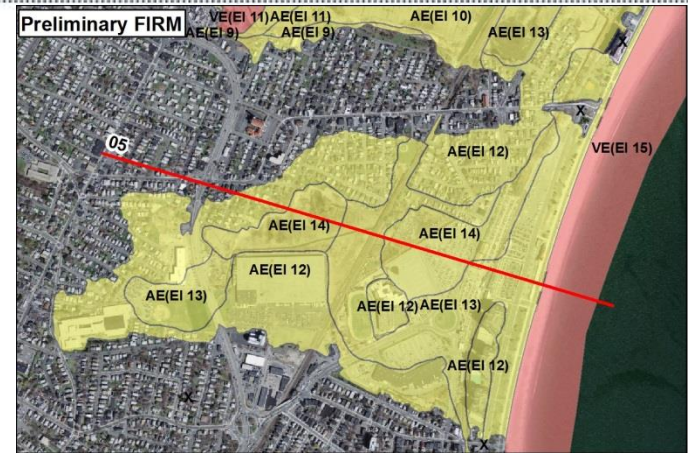
- FEMA is only backward looking
- Only considers “100-year” storm
- Transect based analysis

Bathtub Approach

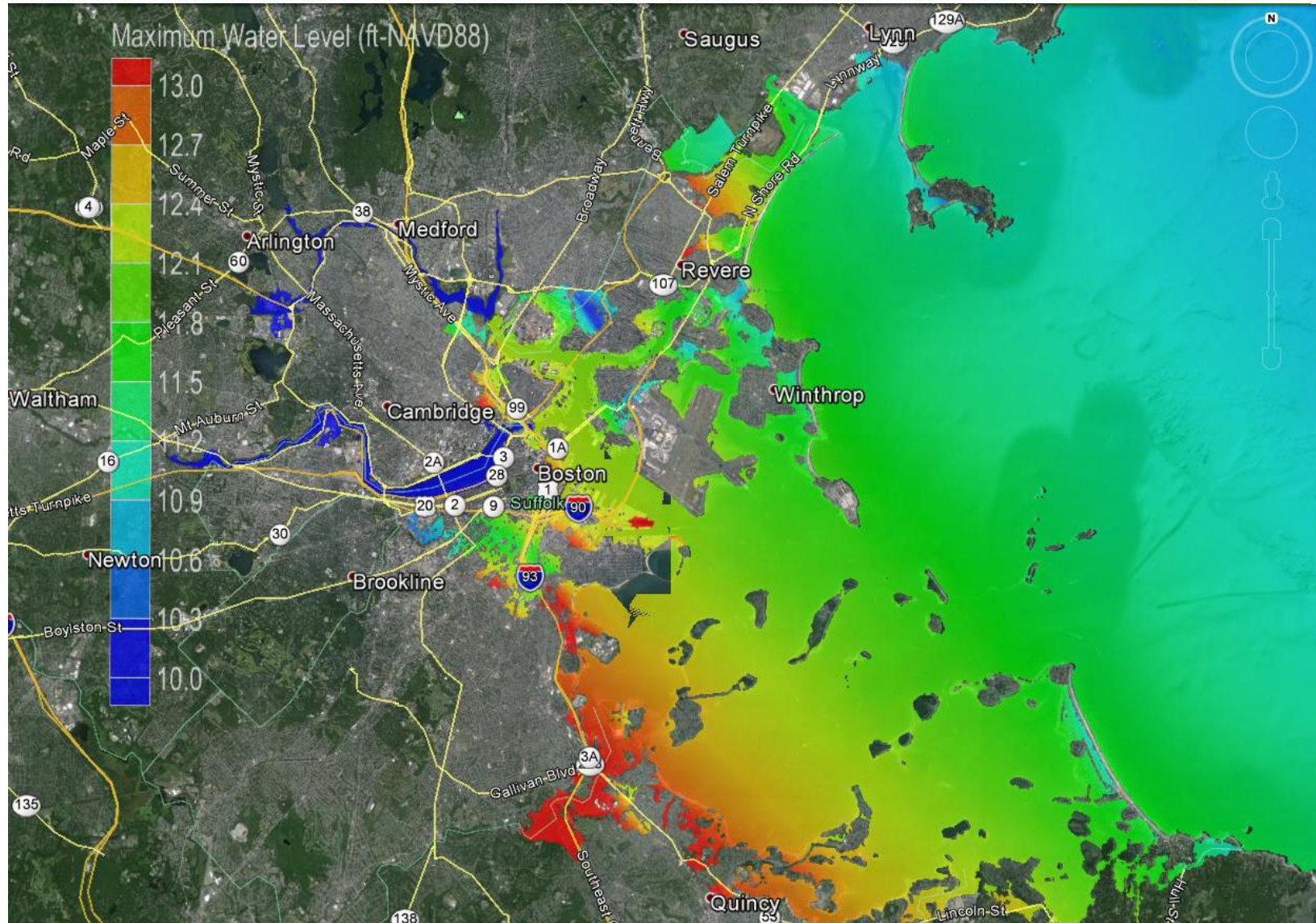
- Inundation maps do not reflect dynamic nature of coastal flooding
- Does not account for joint flooding conditions
- Does not account for tides

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



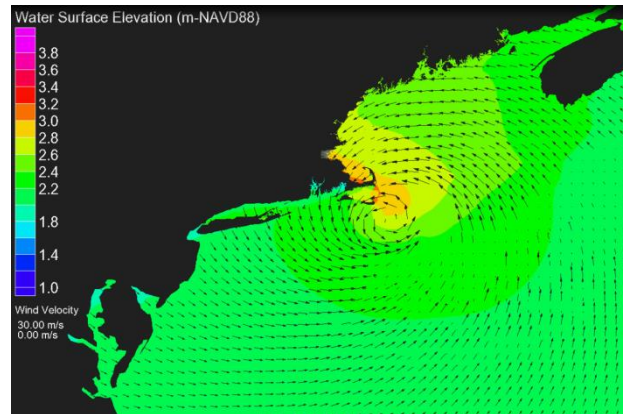
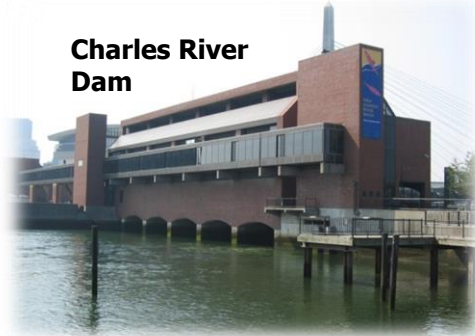
Why existing maps were not good enough



Hi-Res Hydrodynamic Modeling

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

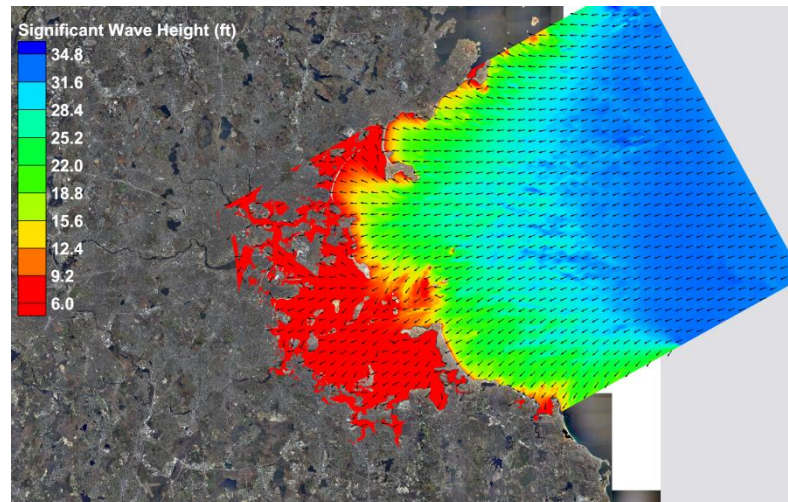
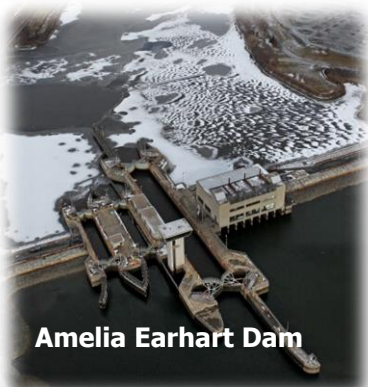
Charles River Dam



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

Tightly Coupled

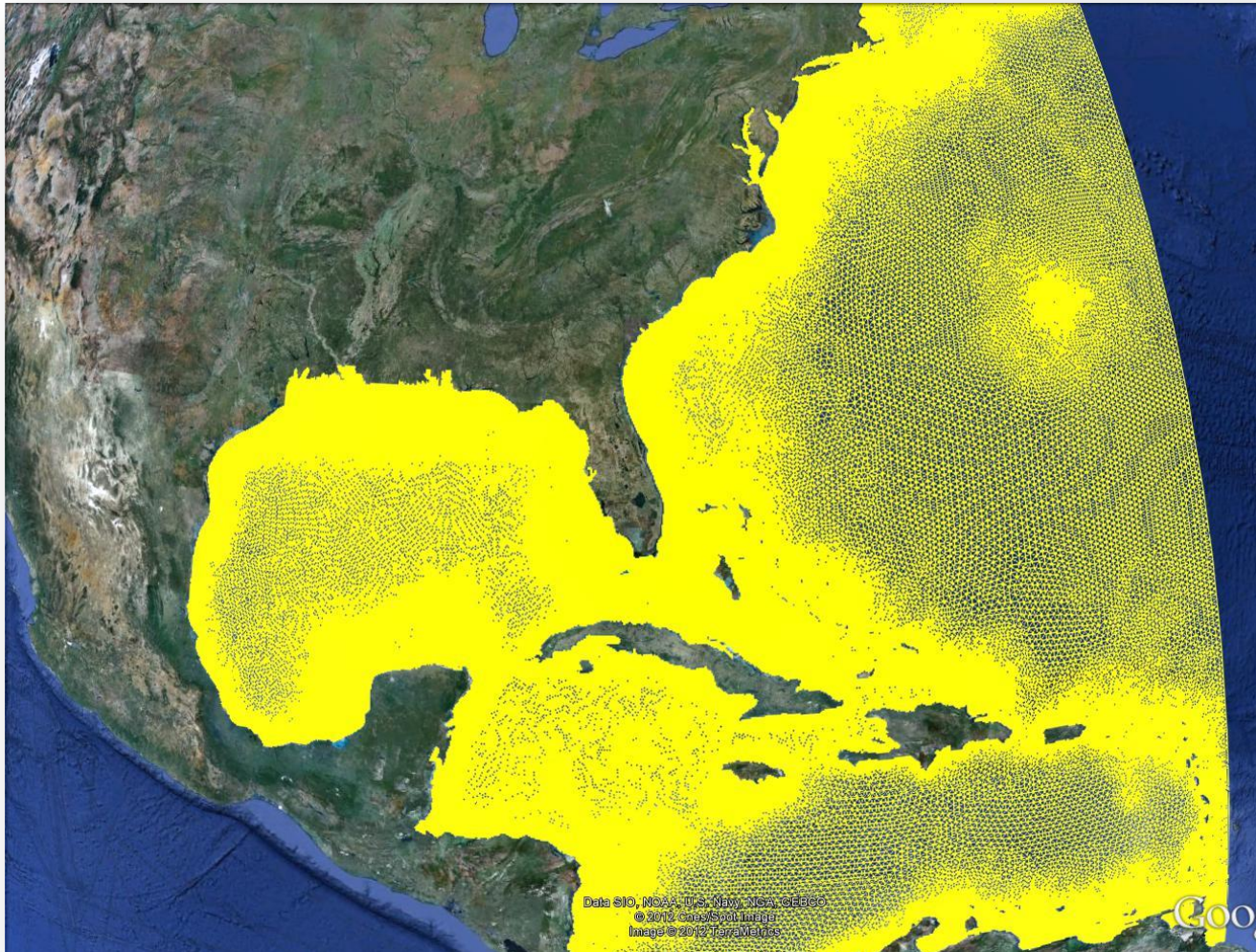
Amelia Earhart Dam



- Waves
- Wave Setup

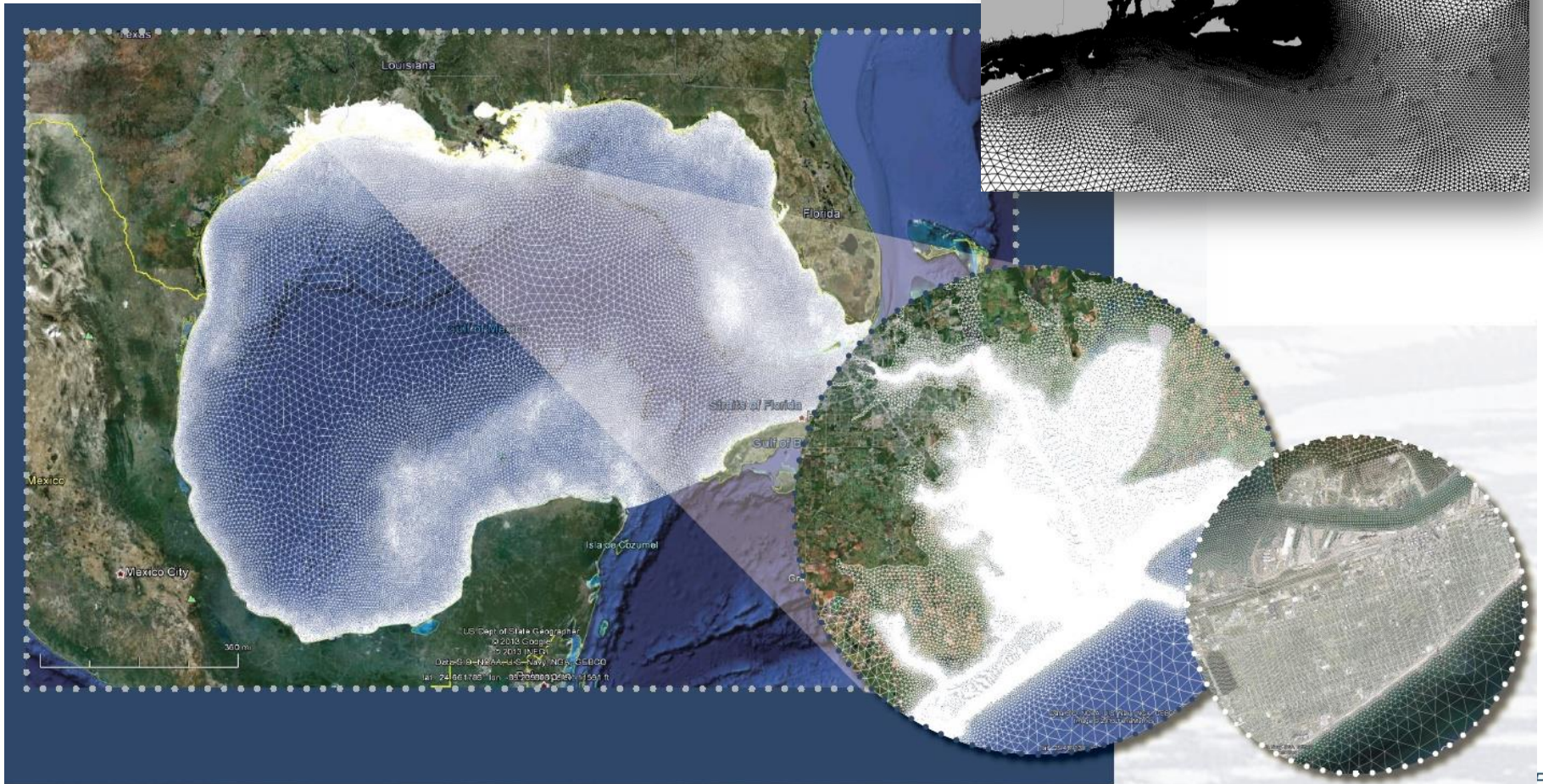
Regional Grid Requirements

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

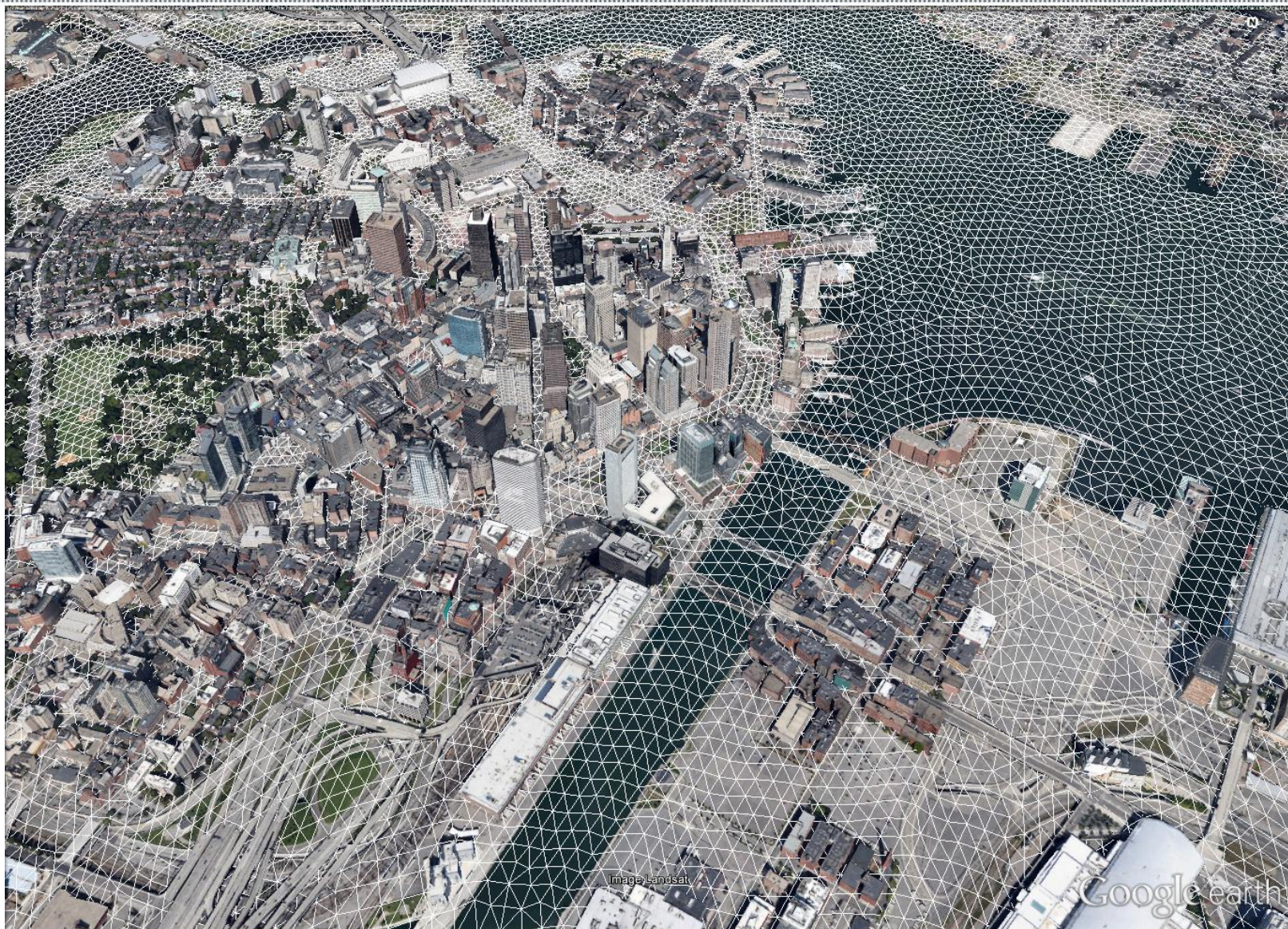


Unstructured Grid

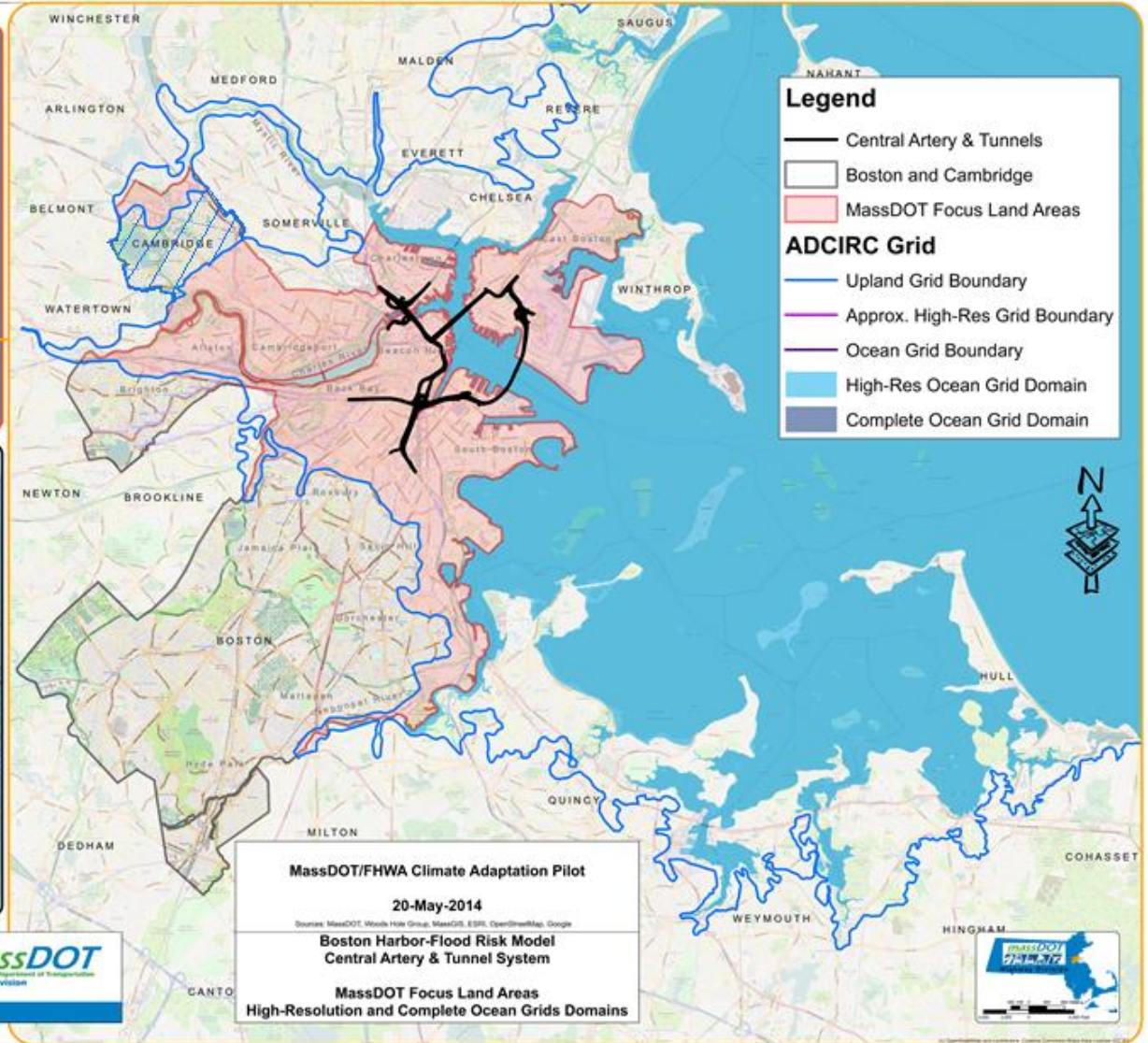
Varying resolution with high resolution in areas of interest



Boston Grid



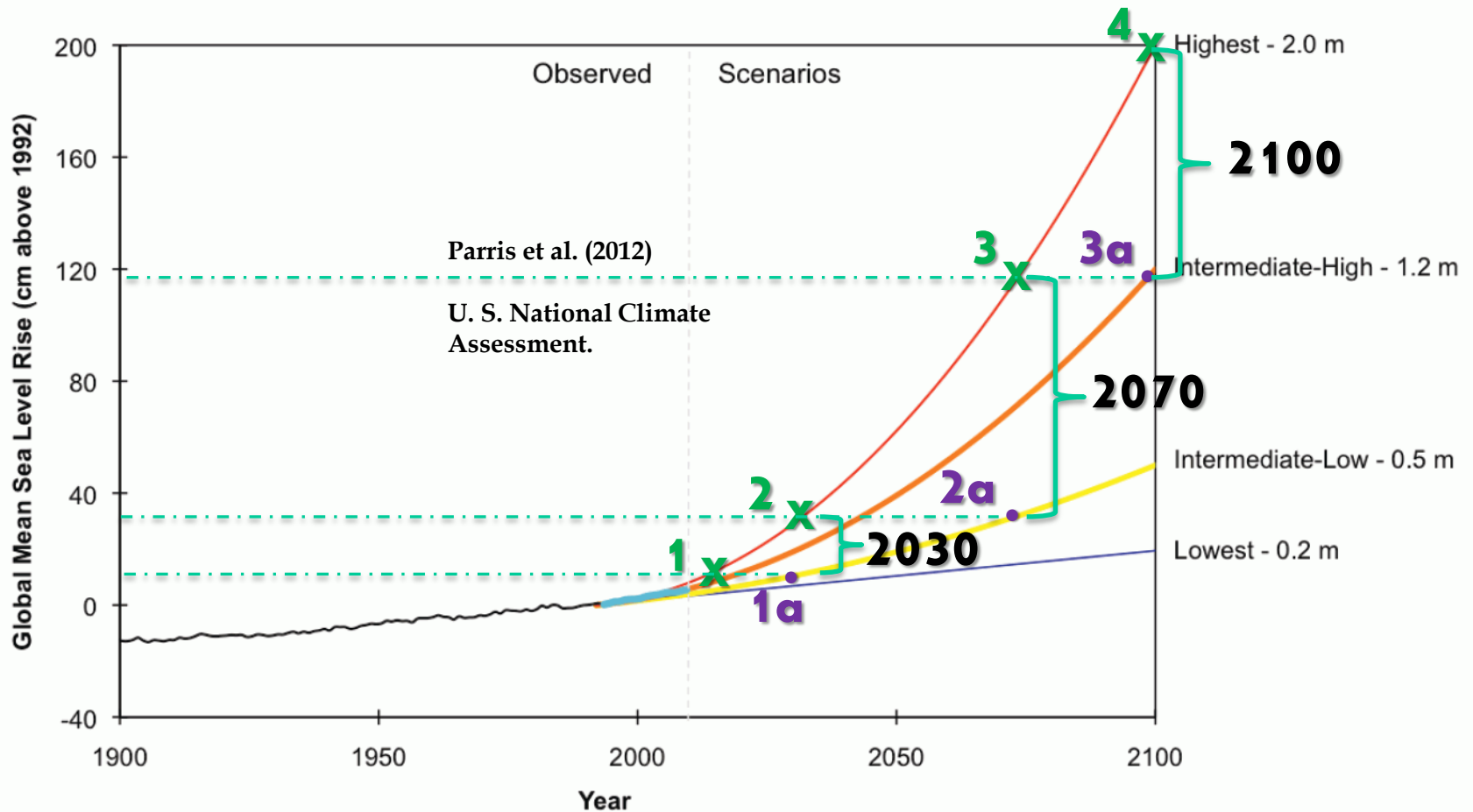
Focus Areas



U.S. Department of Transportation
Federal Highway Administration

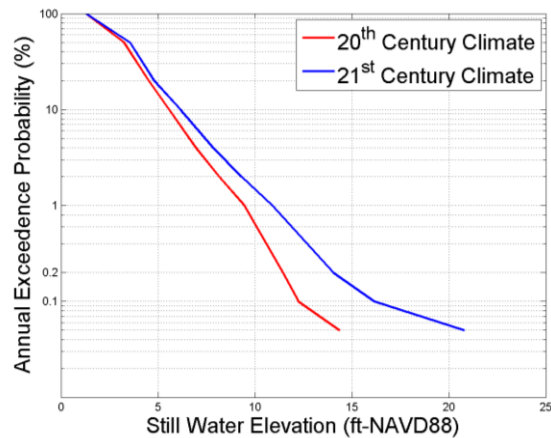


Using Projections to Bracket Risk

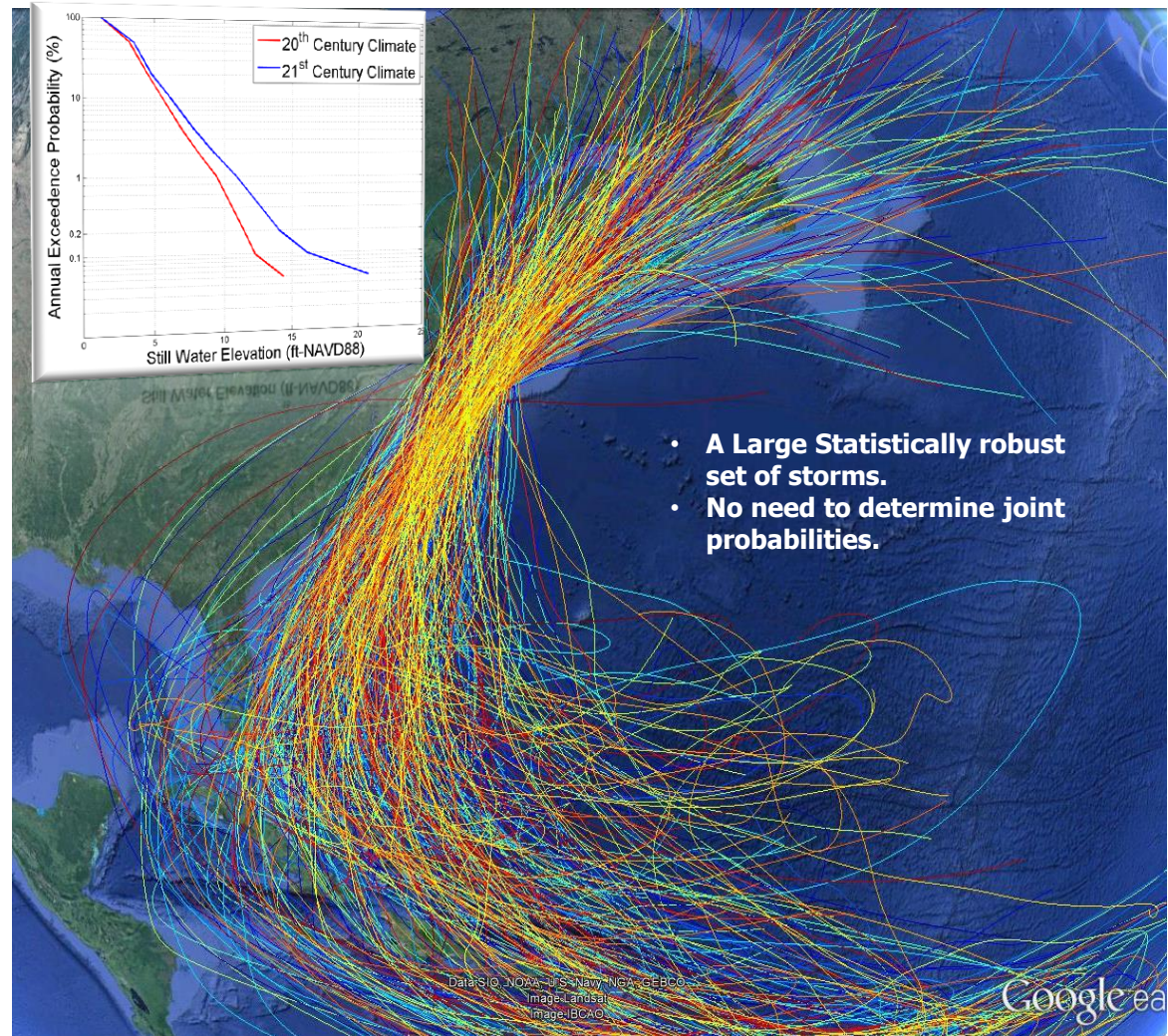


Storm Climatology - Hurricanes

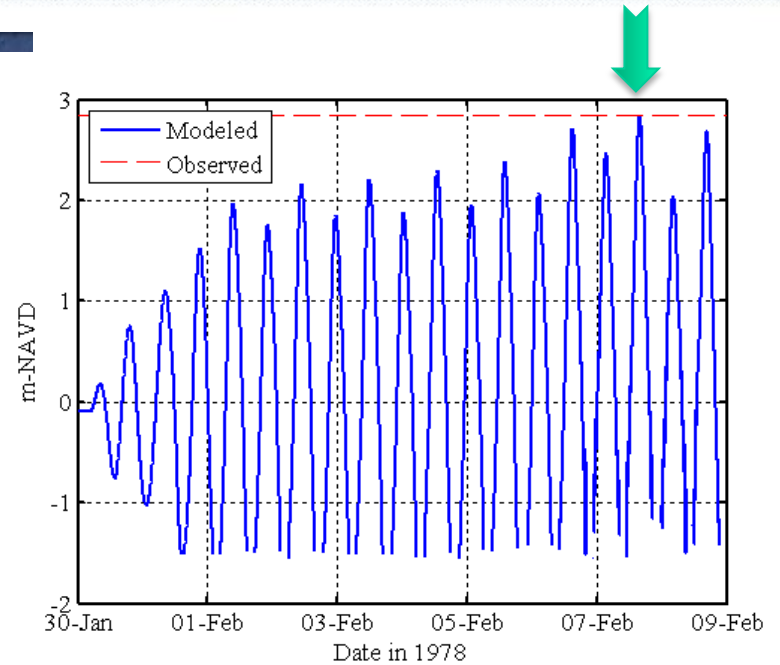
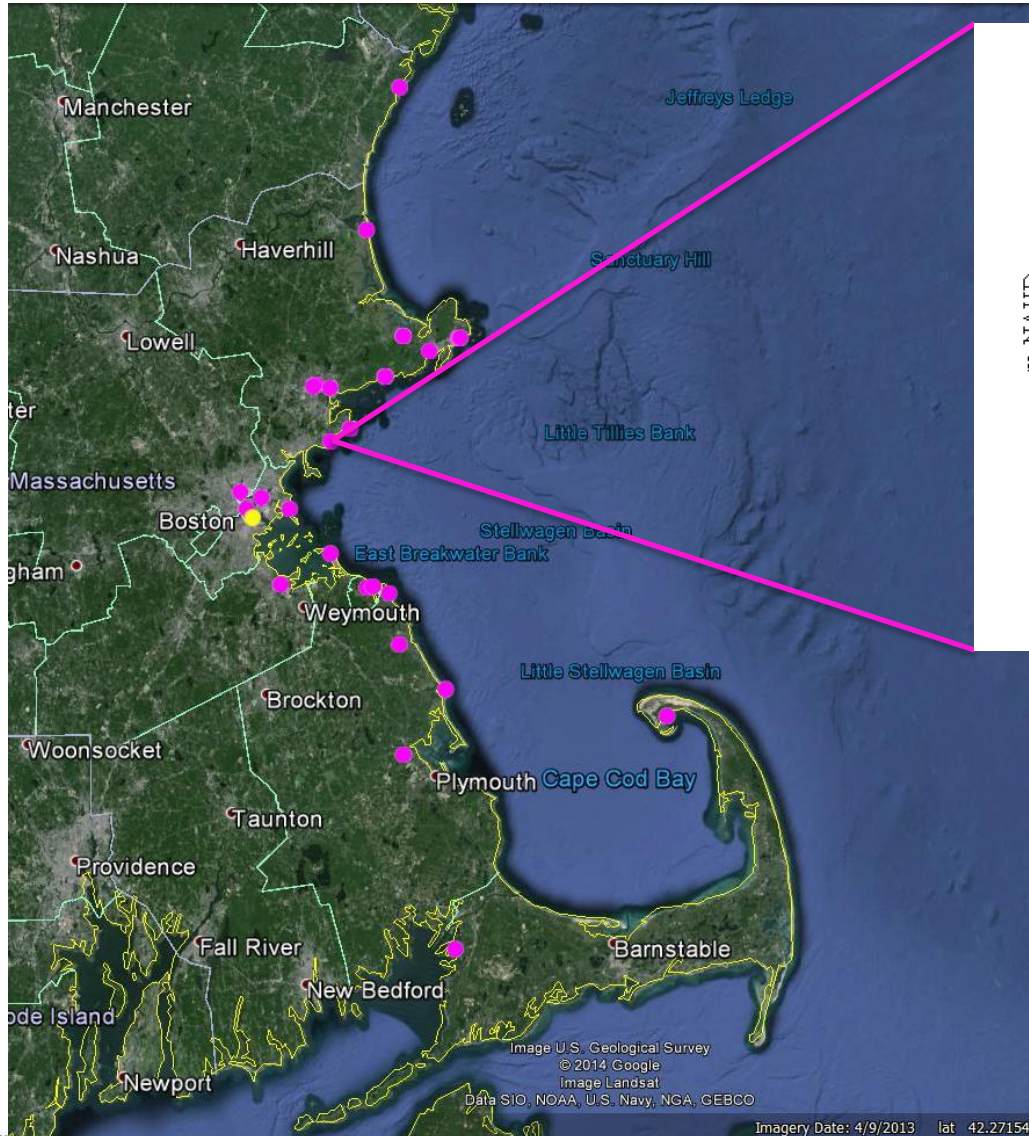
- Monte Carlo simulations, using a large statistically robust set of storms (Emanuel, et al., 2006) and a physics based approach
- Present and future climate change scenarios



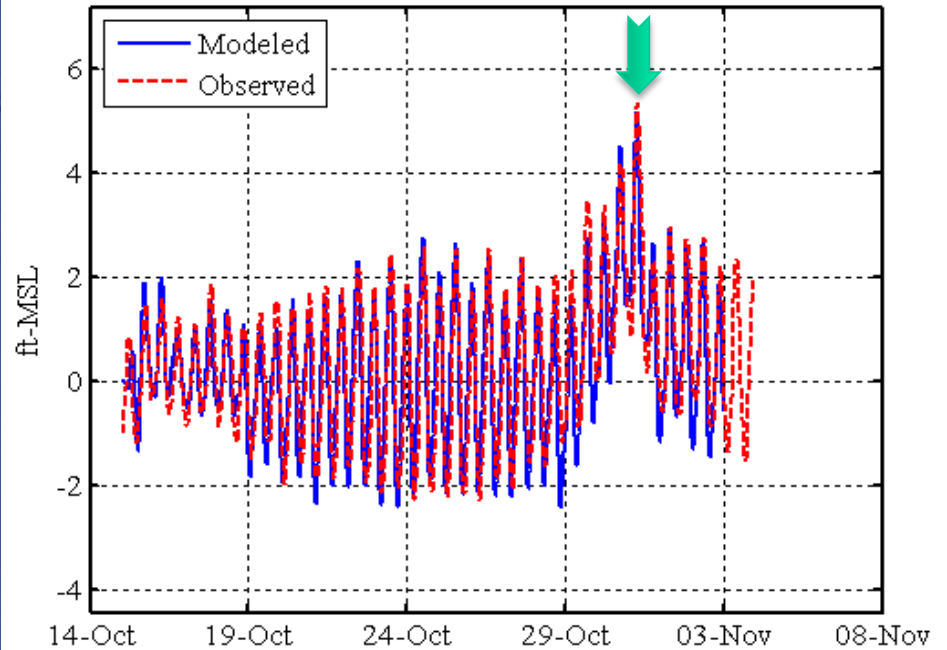
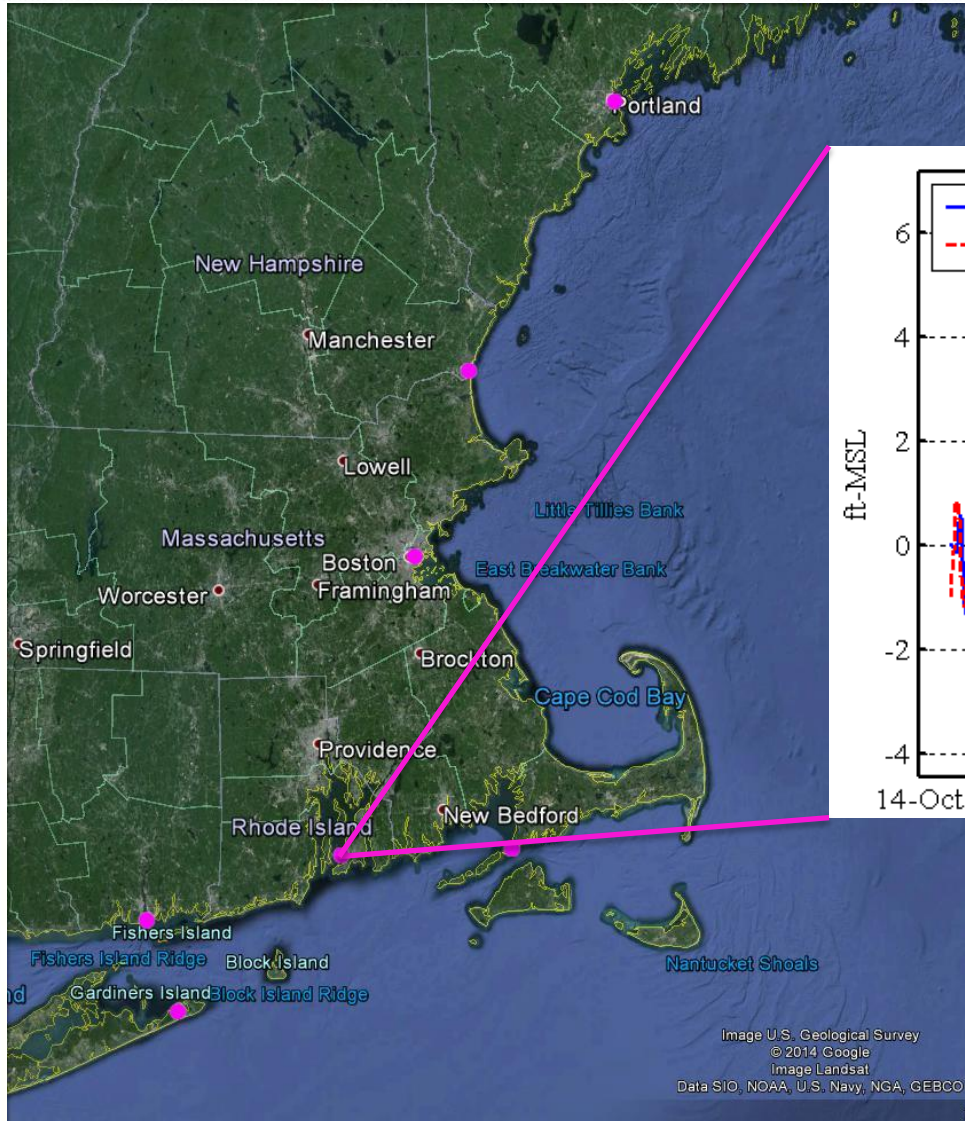
- Simulates storms (both hurricane and nor'easter) combined with SLR and precipitation



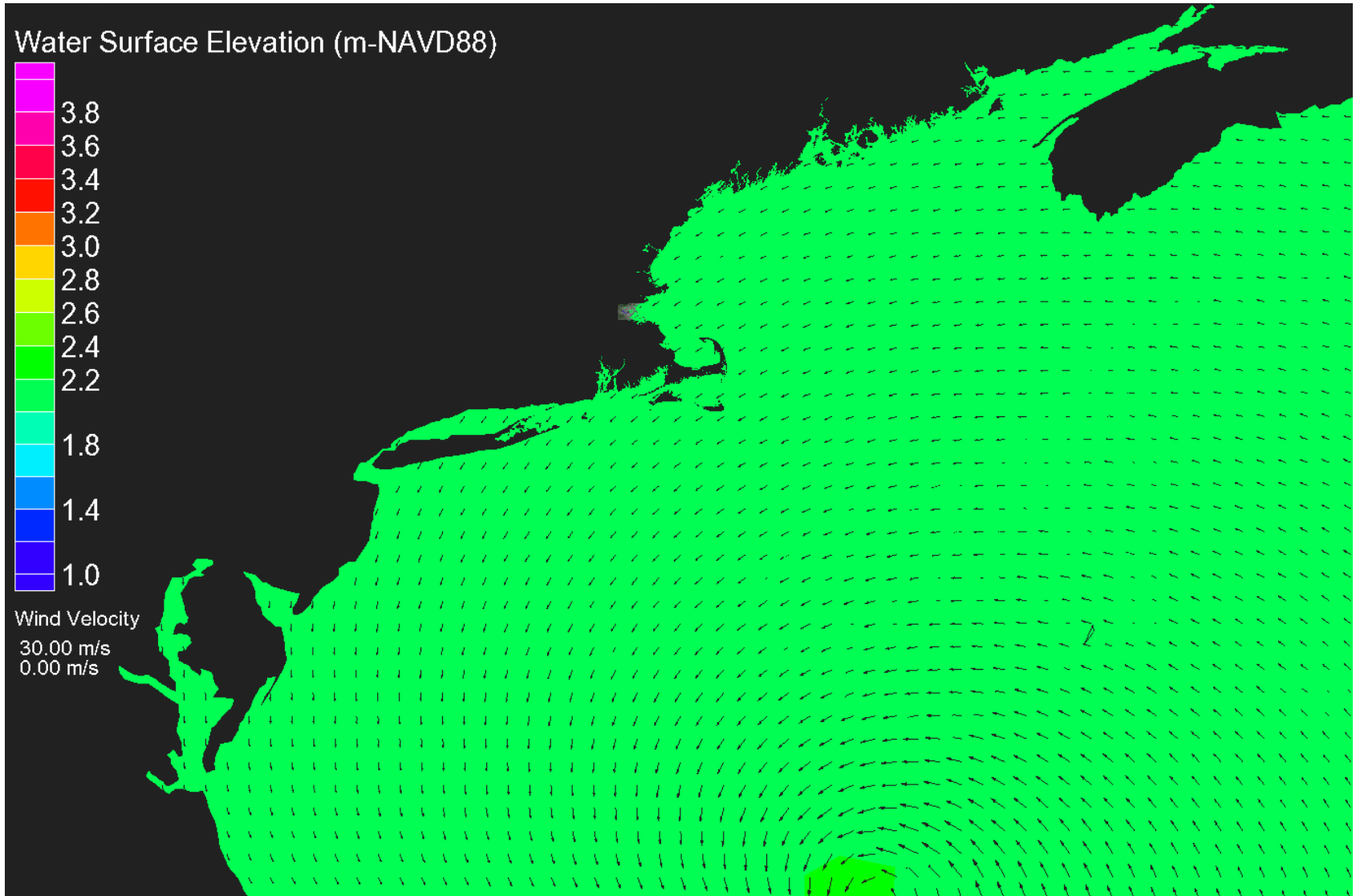
Model Calibration - Blizzard of '78



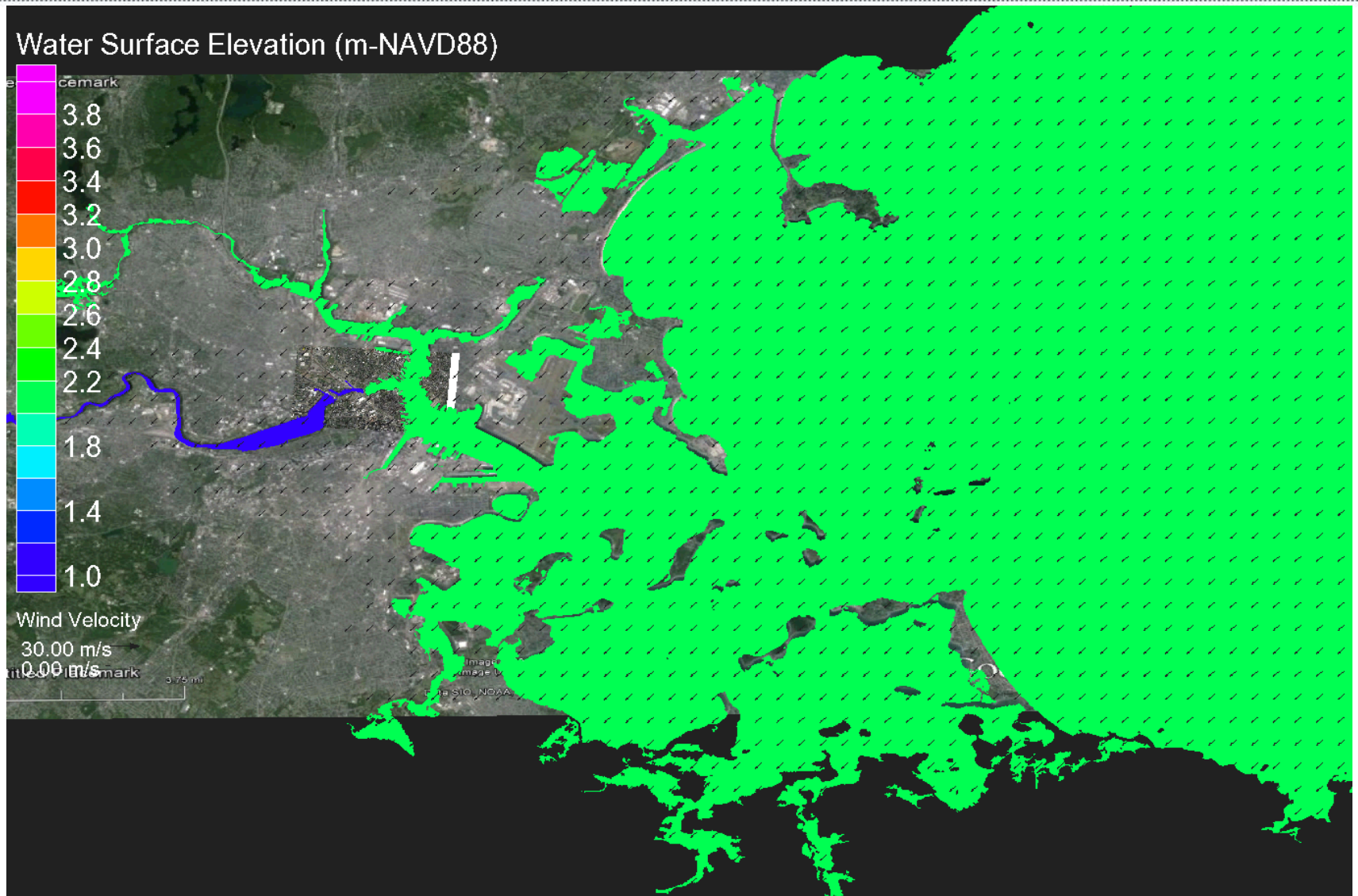
Model Validation - Perfect Storm



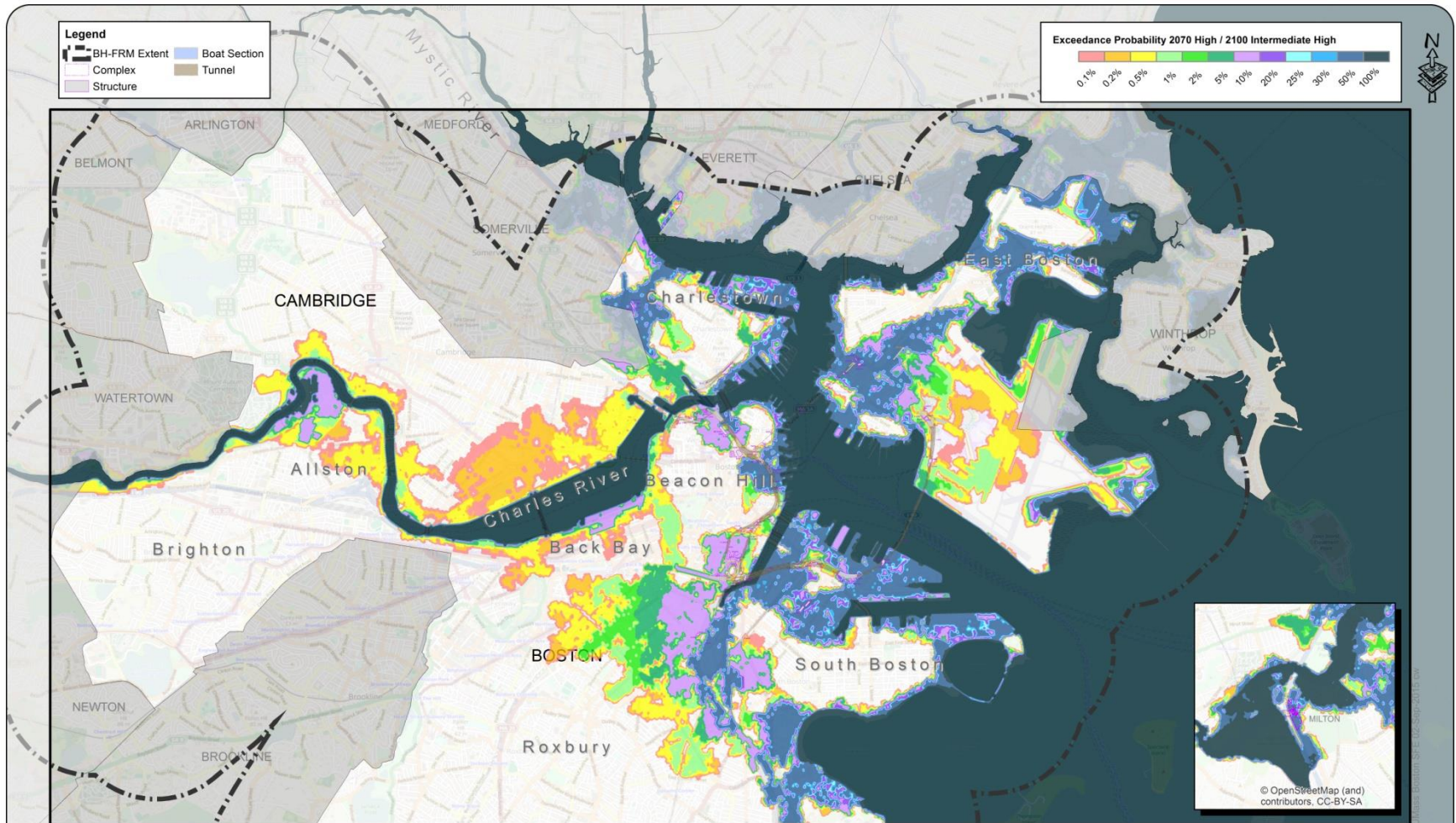
Example Results - Winds



Example Results - Hurricane



Exceedance Probability Maps

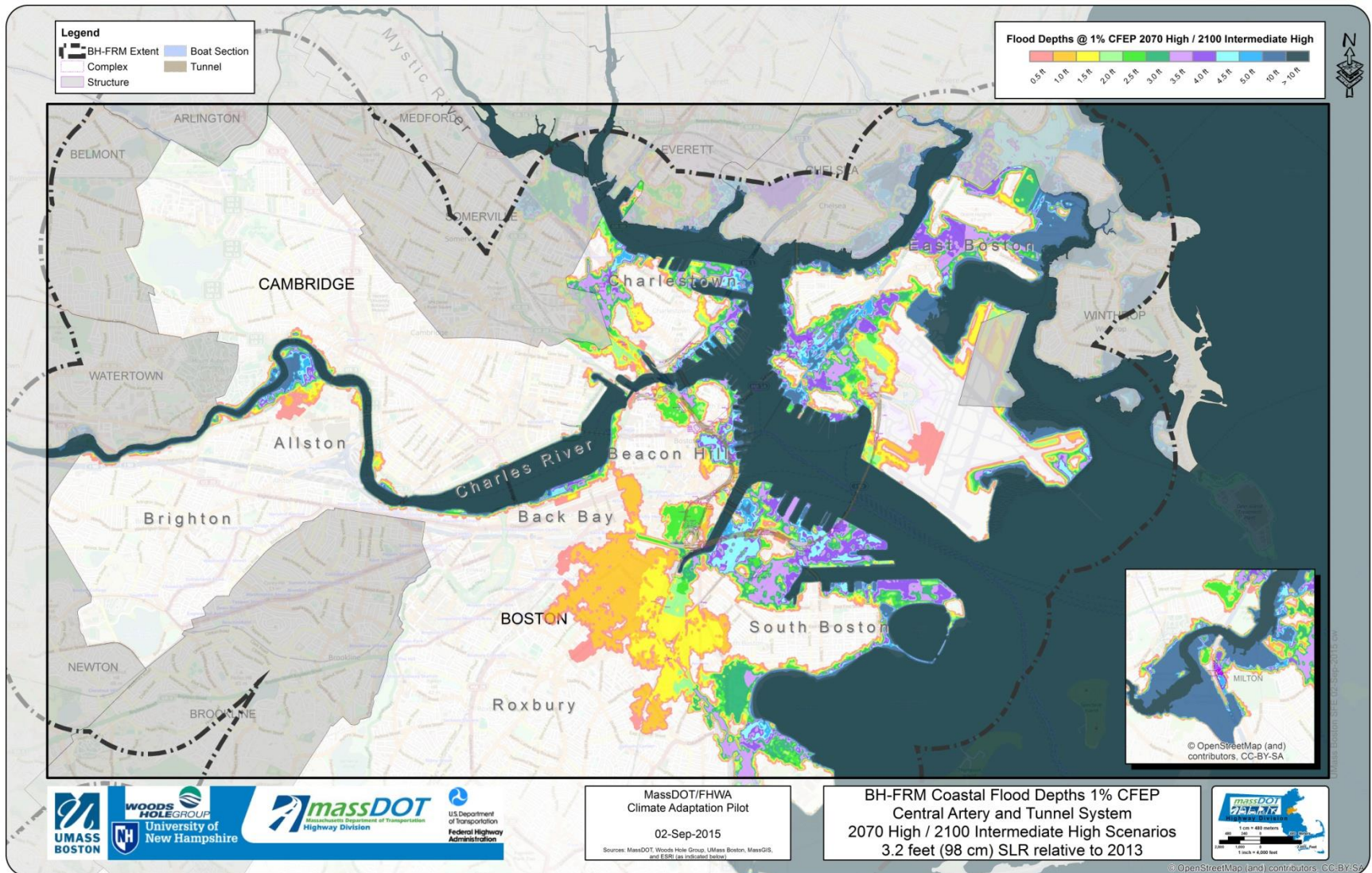


MassDOT/FHWA
Climate Adaptation Pilot
02-Sep-2015
Sources: MassDOT, Woods Hole Group, UMass Boston, MassGIS, and ESRI (as indicated below)

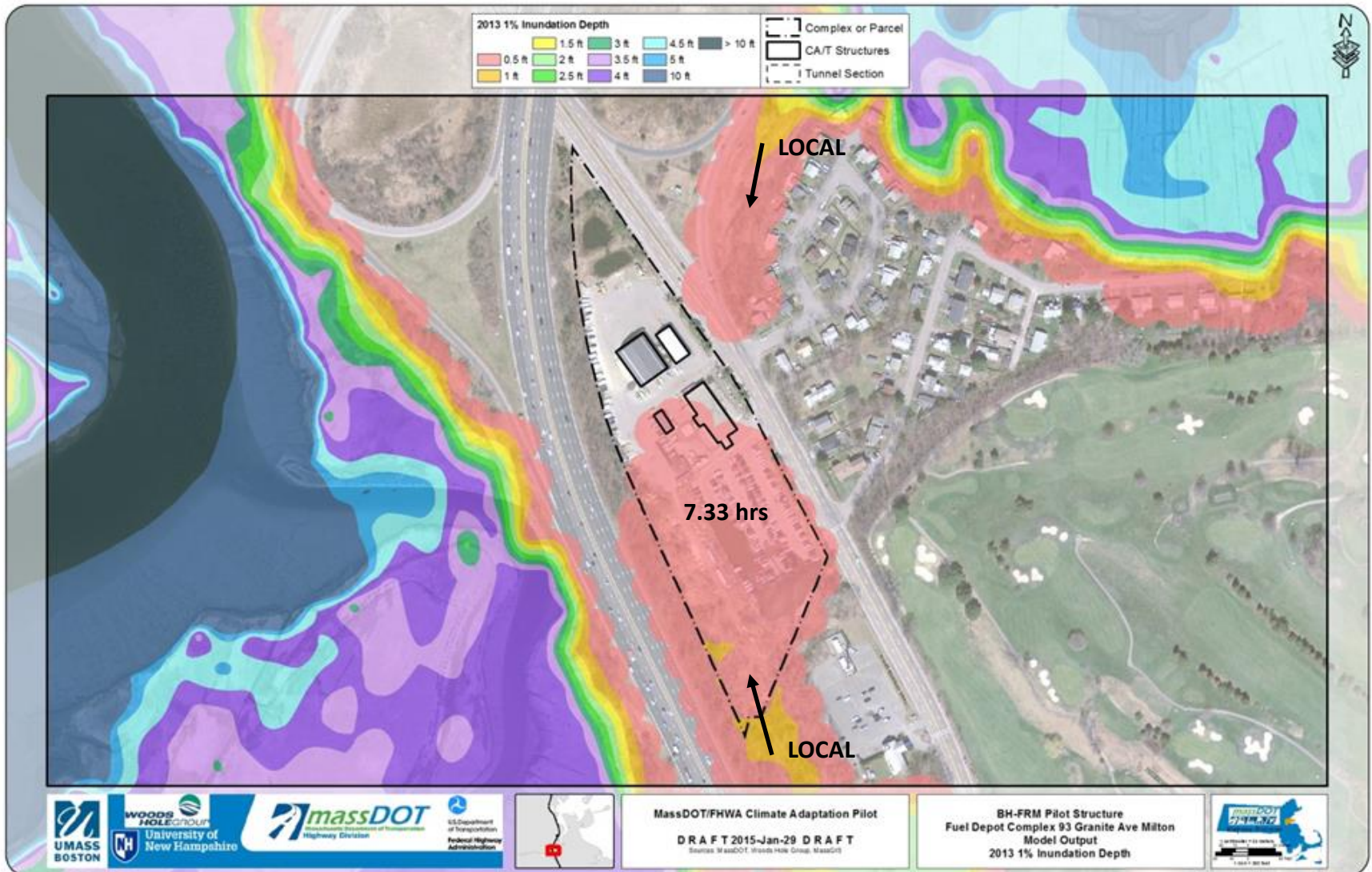
BH-FRM Coastal Flood Exceedance Probabilities
Central Artery and Tunnel System
2070 High / 2100 Intermediate High Scenarios
3.2 feet (98 cm) SLR relative to 2013



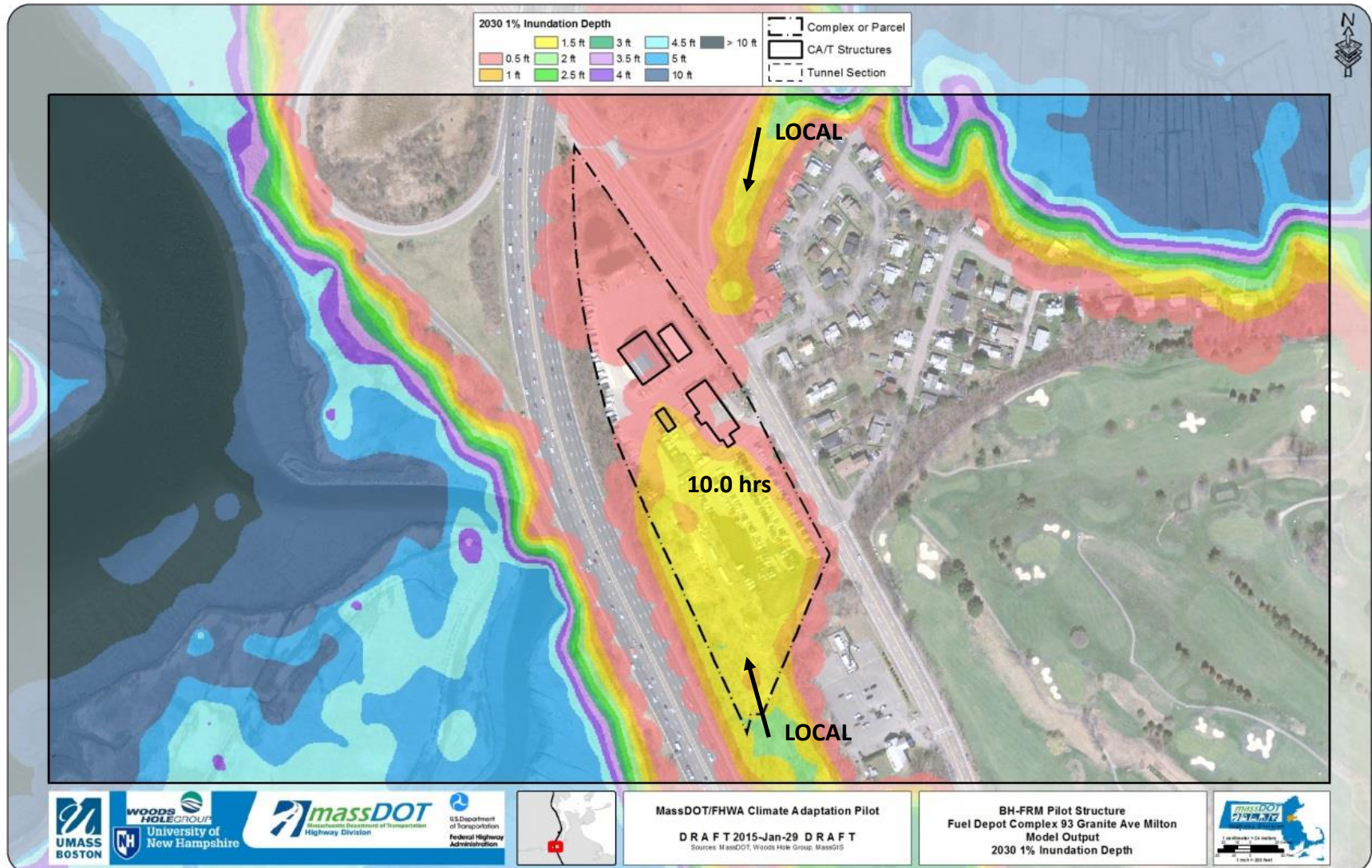
Depth of Inundation Maps



Example Assessment



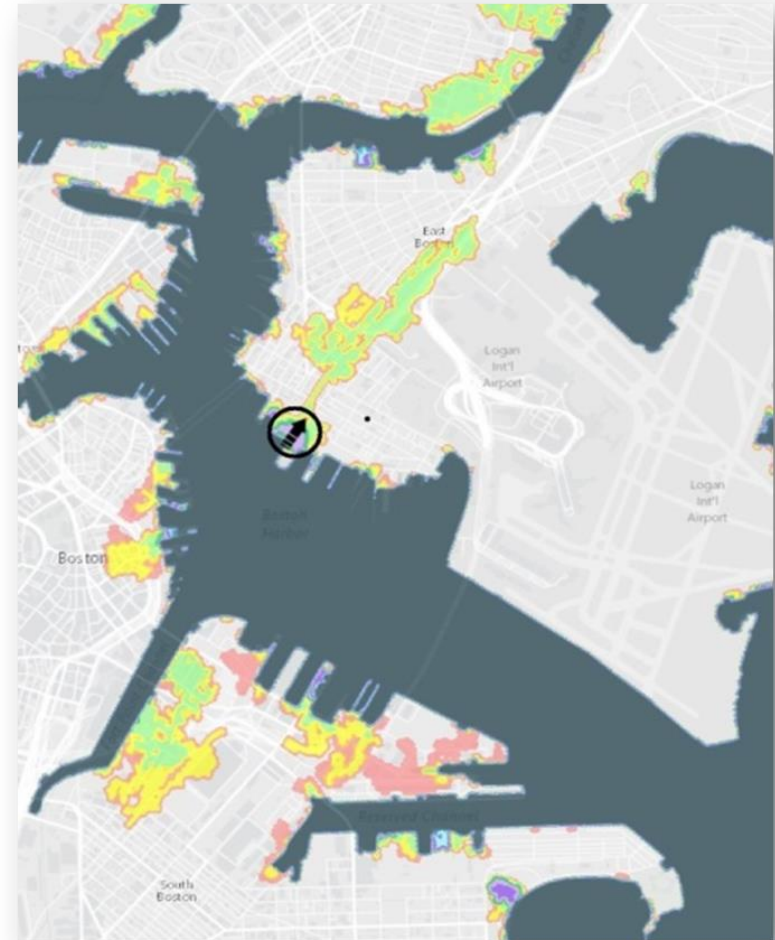
Example Assessment



Coastal Adaptation Options

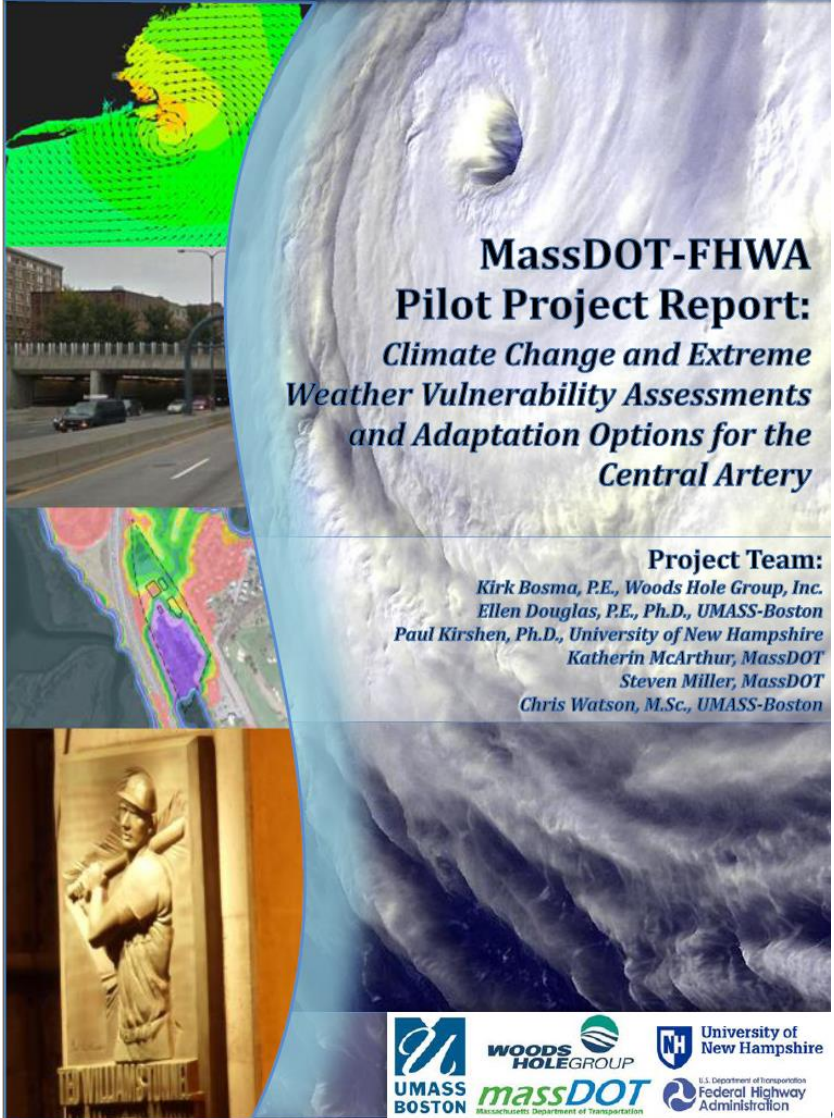
Retreat, Accommodate, or Protect

- Gray, Green, or Hybrid
- Local or Regional
- Now or Later
- Modular or Traditional
- Singular or Redundant
- Removable or Fixed
- By Probability
- By Consequence
- By Driver of Change
- By Community and Social
- By Partnerships






Summary

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



**MassDOT-FHWA
Pilot Project Report:
*Climate Change and Extreme
Weather Vulnerability Assessments
and Adaptation Options for the
Central Artery***

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