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

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Project Overview

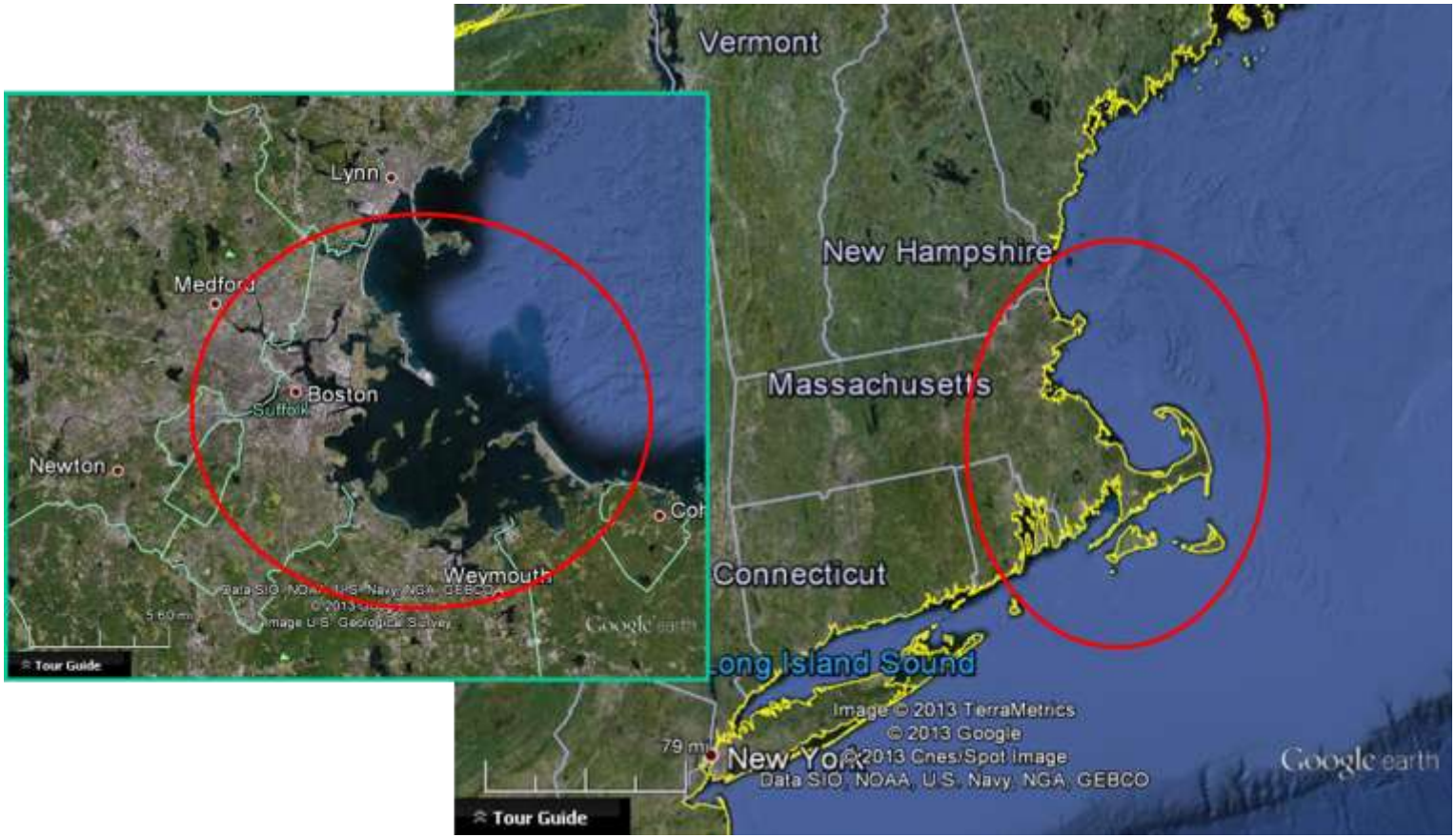
- The **Central Artery** is a critical link in regional transportation and a vitally important asset in the Boston metropolitan area. It is potentially vulnerable to flooding from an extreme coastal storm. It is 1 of 19 nationally co-sponsored through the FHWA Climate Resiliency Program.
- **Project Objectives:**
  - Assess vulnerability of Central Artery to sea level rise and extreme storm events
  - Investigate options to reduce identified vulnerabilities
  - Establish an emergency response plan for tunnel protection and/or shut down in the event of a major storm

Outside Committees

- Stakeholders: MassPort, MBTA, Cities of Boston and Cambridge, Executive Office of Environmental Affairs (DCR, CZM, DEP), Massachusetts and Federal Emergency Management Agencies, The Boston Harbor Association

- Technical Advisory: Woods Hole Oceanographic Institution, US EPA, USGS, ACOE, NOAA-reviewing sea level rise scenarios, and storm climatology for model input

Site Location



FHWA Pilot Project
Central Artery Overlay with Proposed Study Areas
Figure 2

Legend

Central Artery Facilities

- Administration Building
- Air Intake
- Electrical Substation
- Emergency Response Station
- Fan Chamber
- Low Point Pump
- Maintenance
- Operations Center
- Storm Water Pump
- Tunnel Drainage
- Vent Building
- D Street Facility

MHS Roads Boston Area

- Mainline
- Tunnel
- Viaduct

CAD Feature

- Facility
- Buildings

Other Feature

- Study Area

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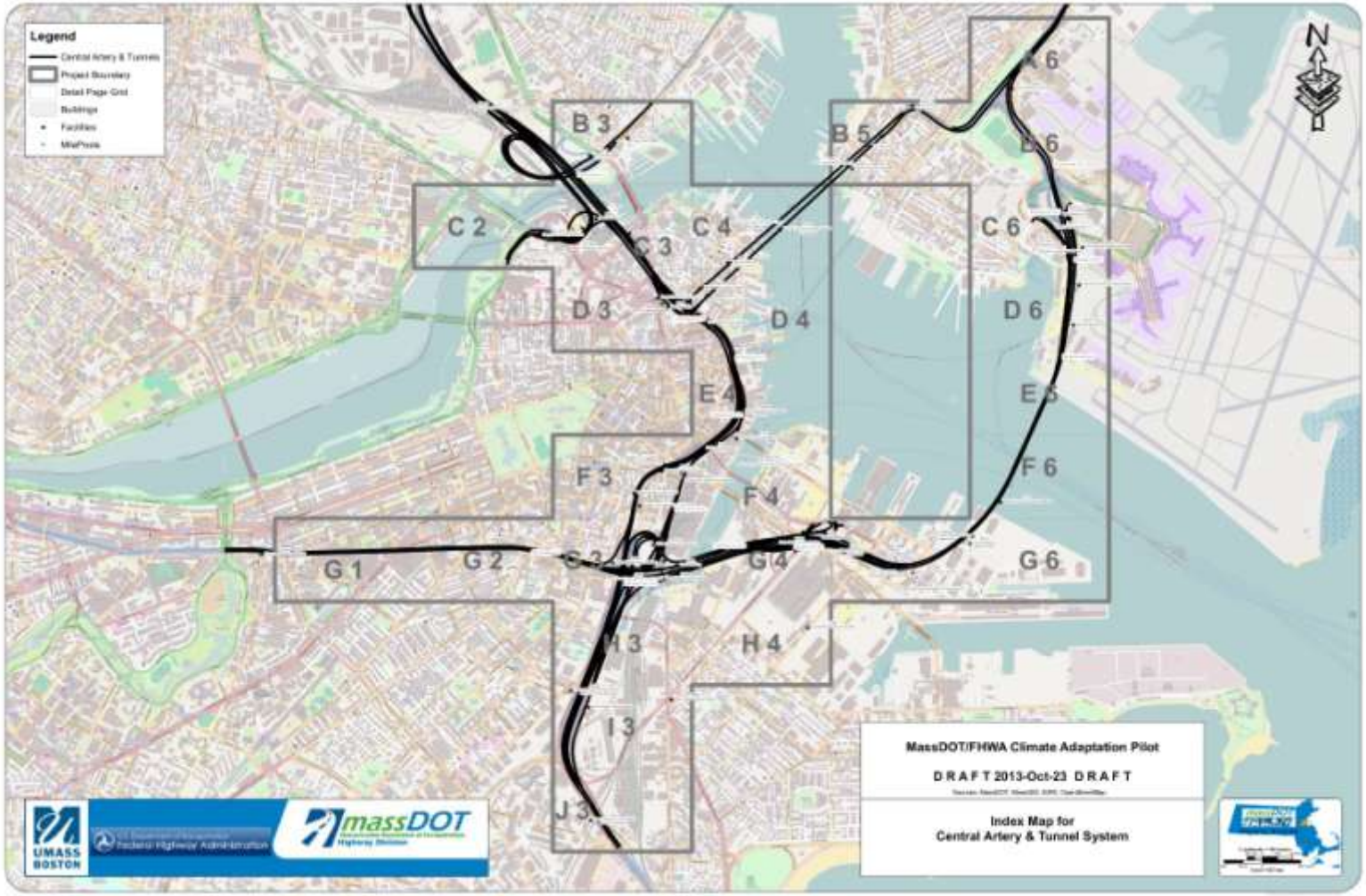

Central Artery / Tunnel (CA/T) System Boundaries

Why do we need a sophisticated approach?

- The risk is high
- TBHA inundation maps based on a “bathtub” approach do not reflect the dynamic nature of flooding
  - Bathymetric effects
  - Coastline geometry
  - Infrastructure
  - Frictional effects
  - Coastal processes (waves, tides, etc.)

- Flooding pathways can be significantly influenced by dynamic processes
- Achieve more detailed results to answer what is causing the flooding (e.g., increased river discharge, wave overtopping, storm surge, etc.)
- Test performance of engineering adaptations

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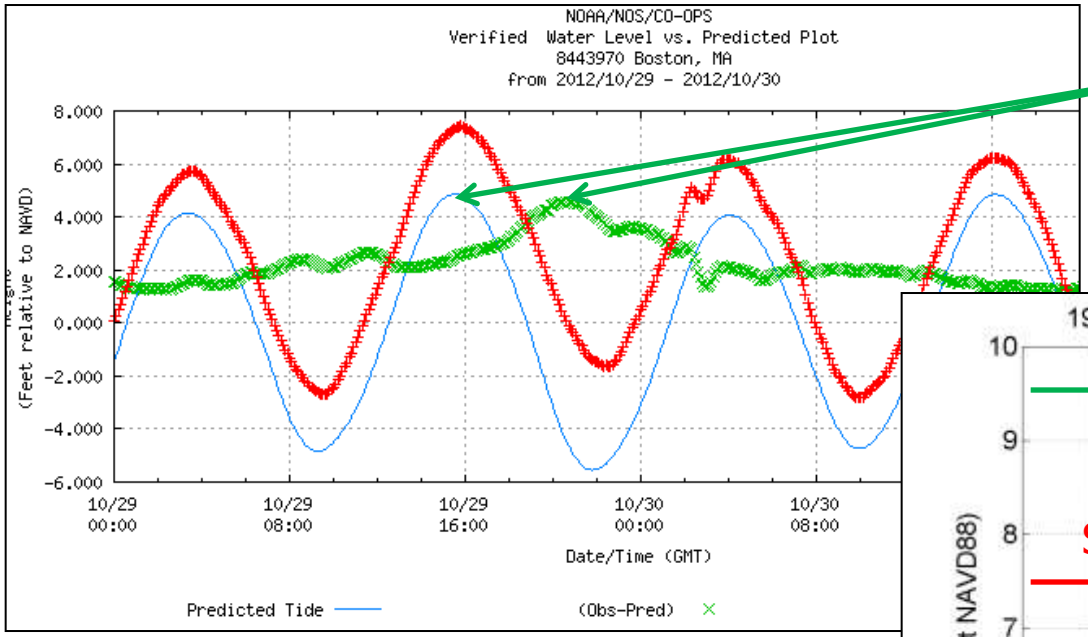
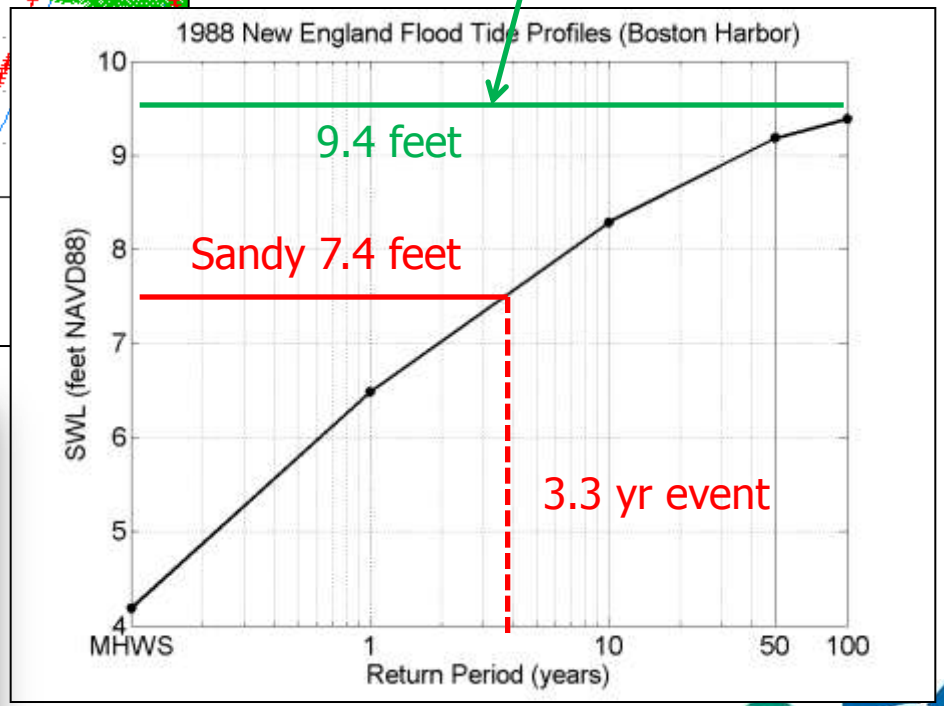


If peaks were simultaneous…



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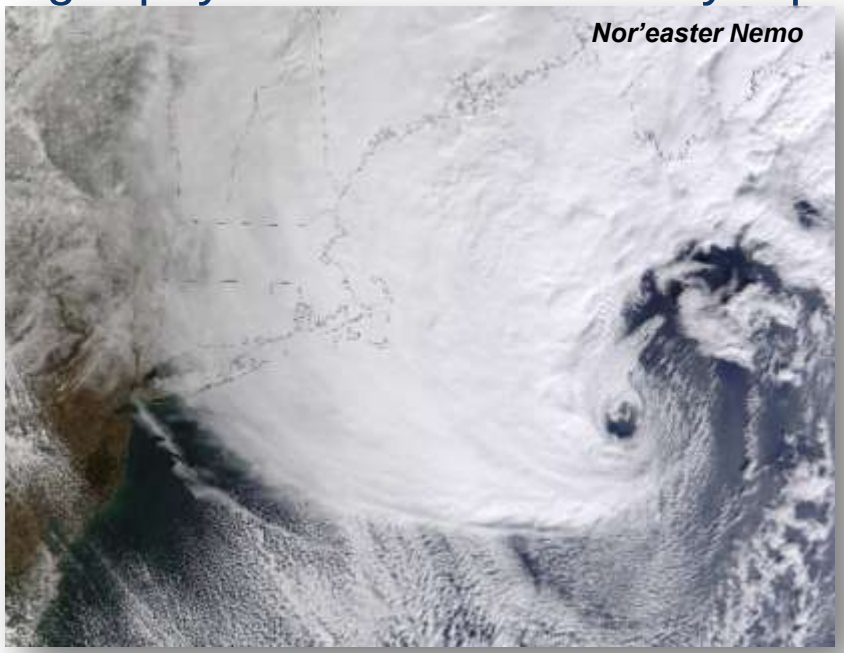
Hydrodynamic Modeling

- Includes relevant physical processes (tides, storm surge, wind, waves, wave setup, river discharge, coastline geometry, bathymetric effects, infrastructure, frictional effects, future climate scenarios (SLR))
- Covers a larger physical area to correctly represent the storm dynamics


Nor'easter Nemo

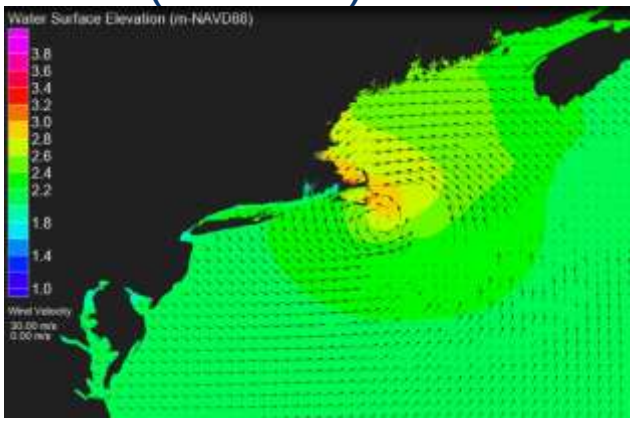
Required Input and Data Sources

Data Need	Source
LiDAR and topography	MassGIS, MassDOT, USGS, NOAA CSC, Site-specific surveys
Bathymetry	NOAA/NGDC, USGS, Site-specific surveys
Land cover	MassGIS, USGS
River flow and stage	BWSC, USGS, City of Cambridge
Historical high water marks	USGS, Gadoury (1979), NOAA Tides and Currents
Sea level rise scenarios	US National Climate Assessment (2012) Vermeer and Rahsmstorf (2009)
Flow control structure info.	Massachusetts DCR, USACE, MCZM
Storm climatology	Emanuel et al. (2006), Cheung et al. (2007), Vickery et al. (2007)

- Challenges
  - Urban model grid development
  - Extra-tropical and tropical storms
  - Tidal influence
  - Time alignment of peak discharge and peak storm surge
  - Simulation time for Monte Carlo approach

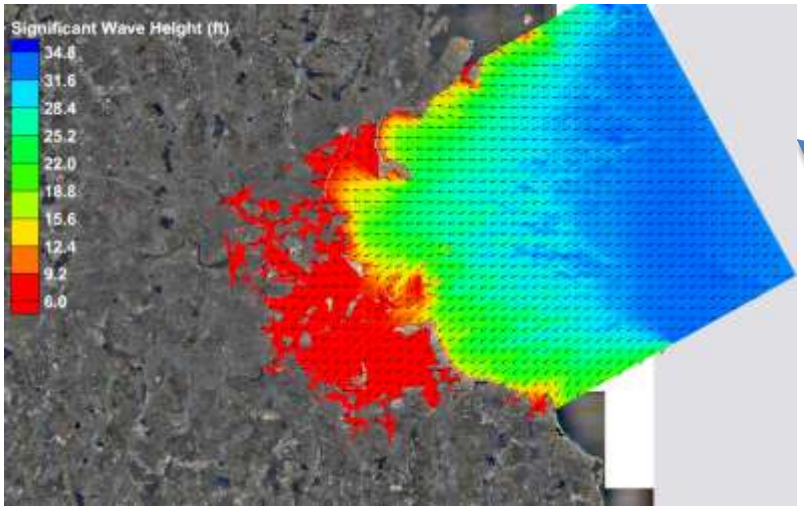
Hydrodynamic Modules

- Advanced Circulation Model for Oceanic, Coastal, and Estuarine Waters (ADCIRC)



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

- Simulating WAves Nearshore (SWAN)



- **Waves**
- **Wave Setup**

Tightly Coupled

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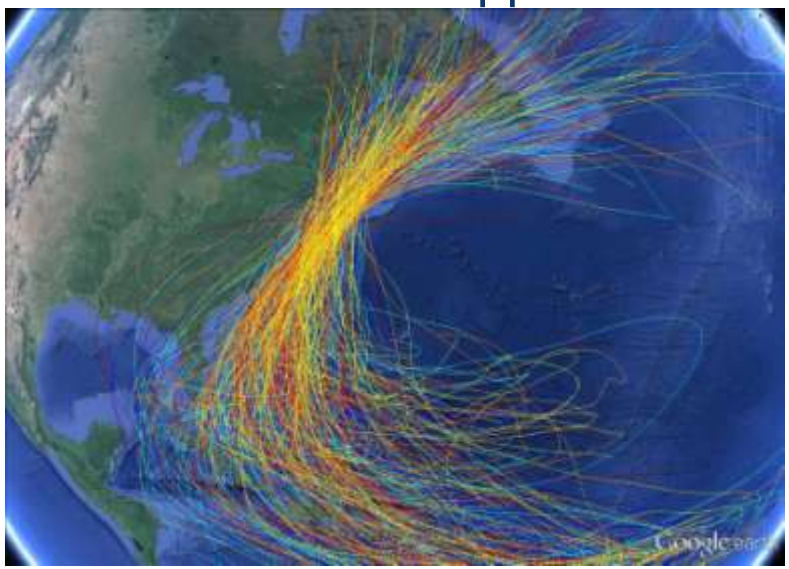
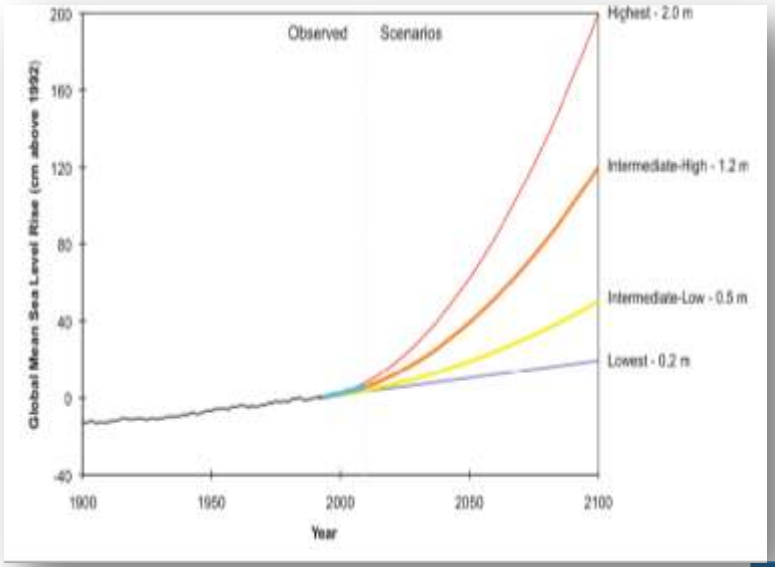
Simulation Scenarios

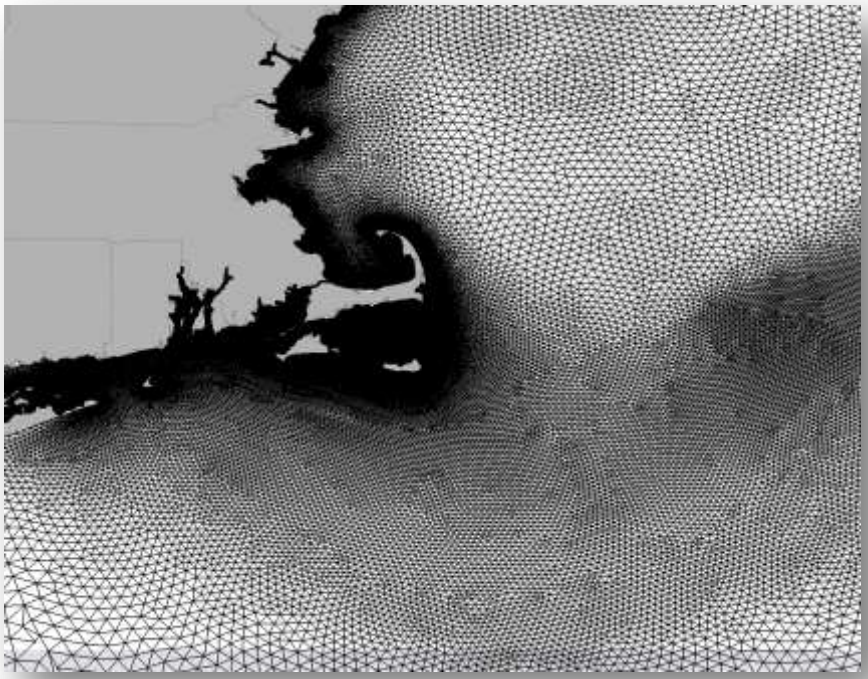
- Combined Surge and Sea Level Rise
- Present and future climate change scenarios
  - Simulate flooding associated with projections for 2030, 2070, 2100
- Robust tropical and extra-tropical storm sets
- Monte Carlo approach

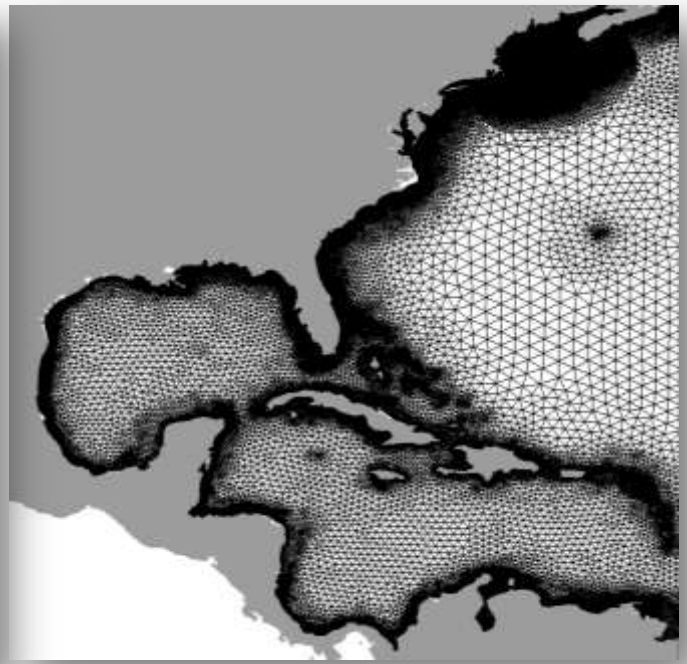




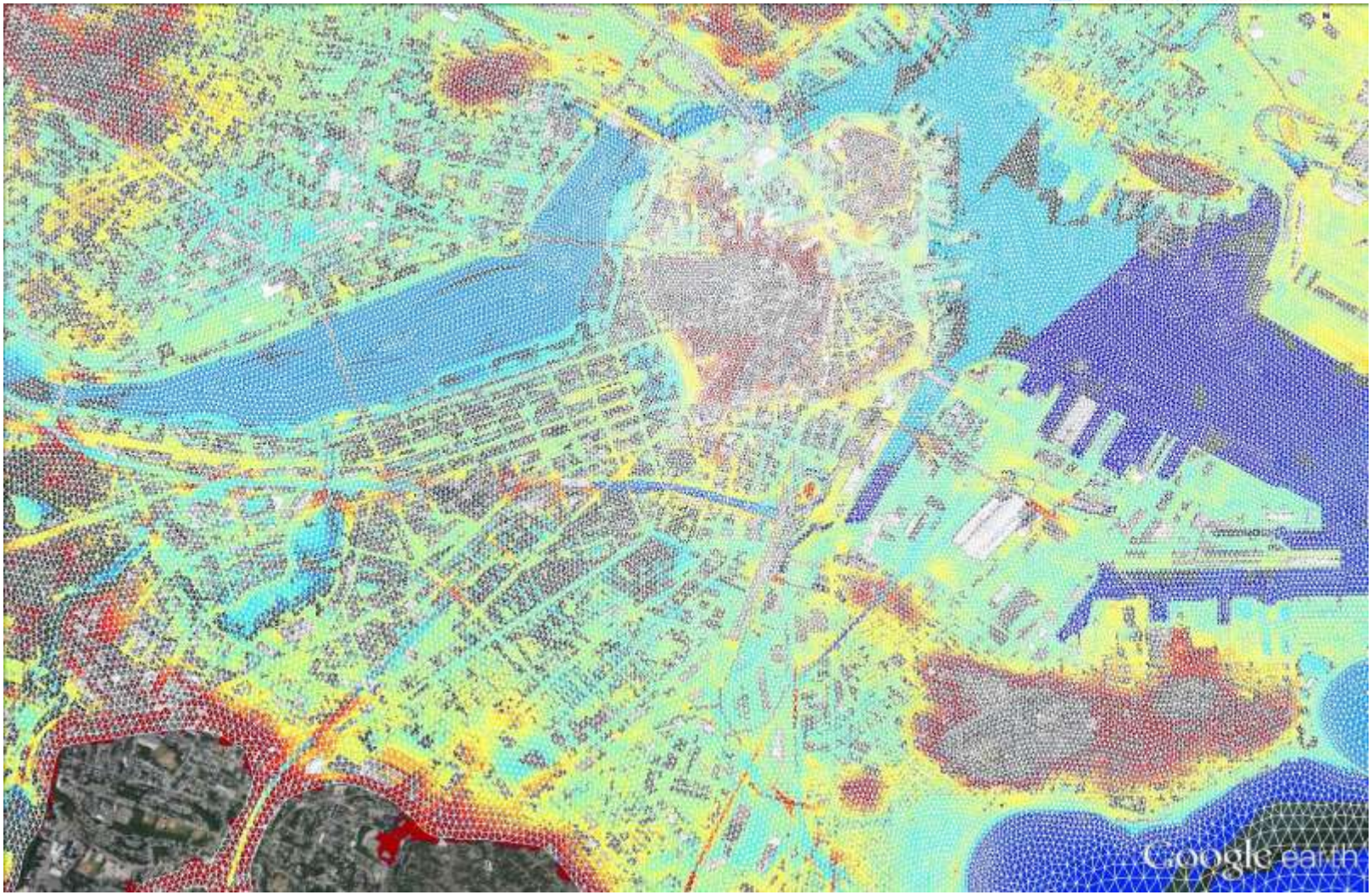
Grid Development

- 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 (Central Artery)
- Multiple high resolution urban subgrids coupled with coarser regional grid






Google earth



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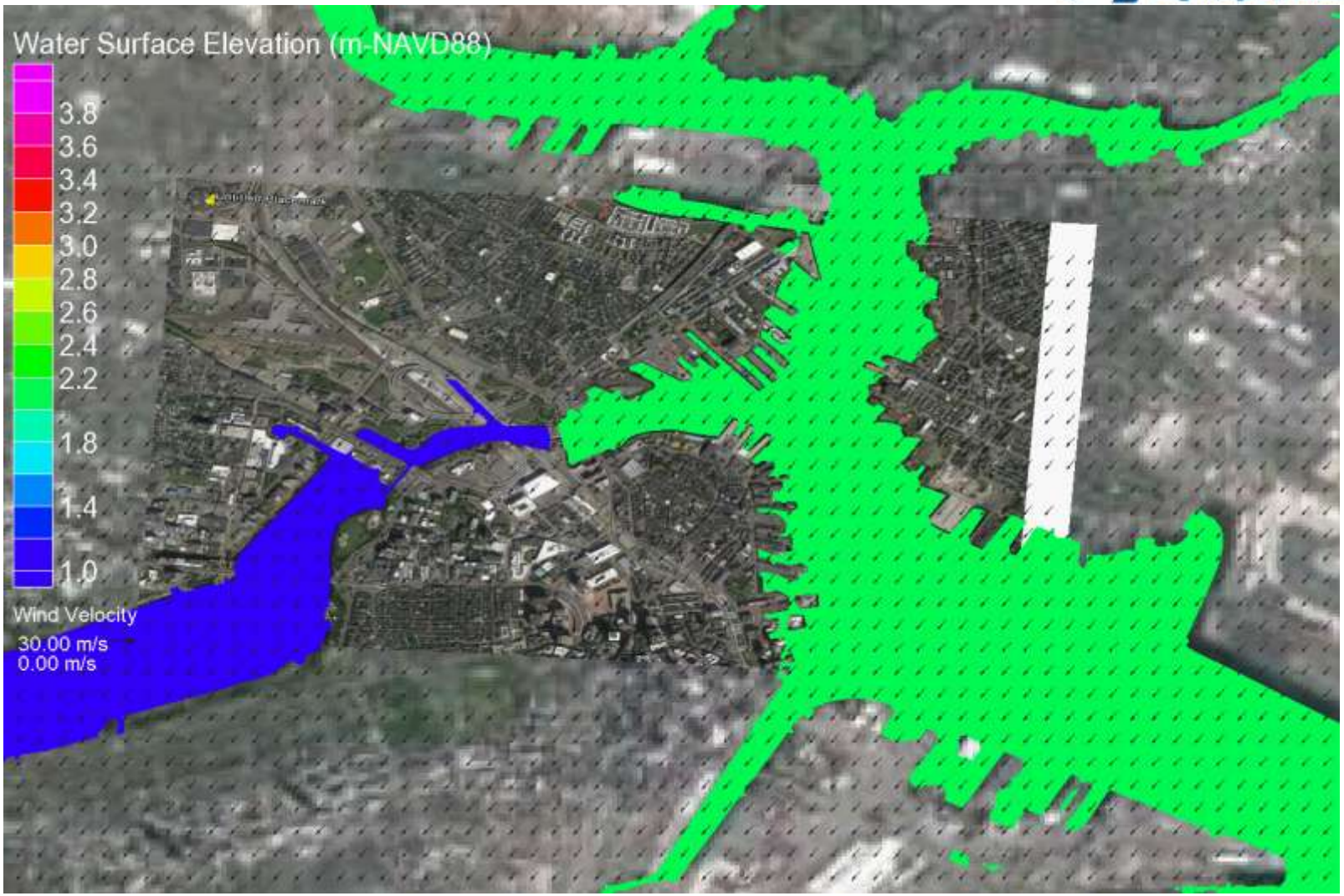

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Legend
CA/T
CA/T Survey Areas
Schraffts Lot & Ryan Playground
Border Street, East Boston
Beverly Street @ CRD & Zakim Bridge
Boat Sections near Greenway
Aquarium Station Area
Seaport Boulevard
MassDOT/FHWA Climate Adaptation Pilot
D R A F T 2014-Apr-30 D R A F T
Central Artery & Tunnel System
Proposed Elevation Survey Areas
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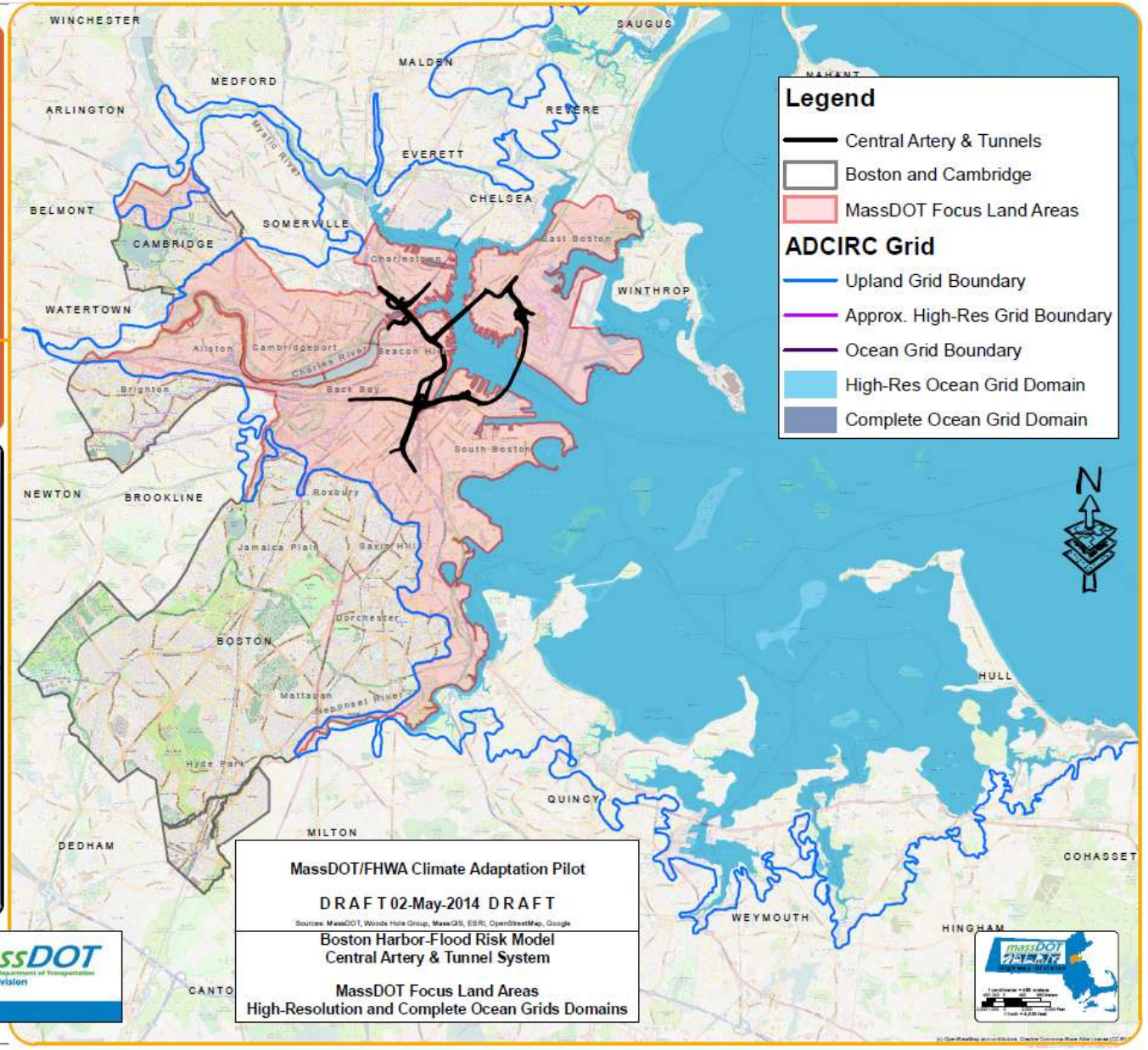

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D R A F T 02-May-2014 D R A F T

Sources: MassDOT, Woods Hole Group, MassGIS, ESRI, OpenStreetMap, Google

Boston Harbor-Flood Risk Model
Central Artery & Tunnel System

MassDOT Focus Land Areas
High-Resolution and Complete Ocean Grids Domains

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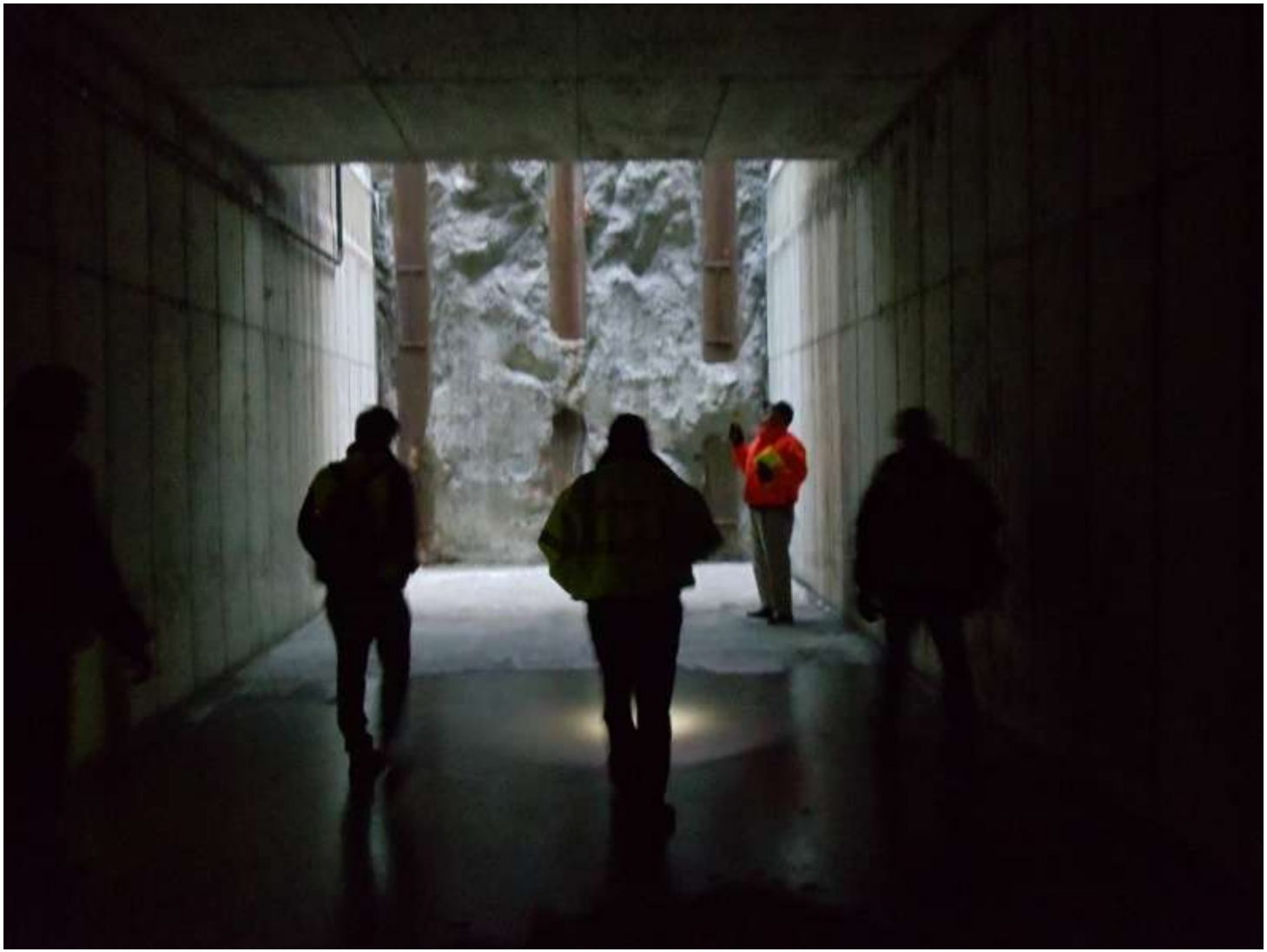
Hydrodynamic Model Results

- Cumulative distribution functions of water level (at 10s of thousands of locations)
- Detailed time-varying inundation maps
- Flood pathways and sources
- Current and future vulnerabilities
- Input to develop preparedness plans over time and scale
- Ability to test potential performance of engineering adaptations

Photo by John Minchilo, AP

Boston Harbor & Tip O'Neill Tunnel Exit/Entrance Ramps
http://www.flickr.com/photos/pictometry/6220376808/



Tip O'Neill Tunnel Entrance Ramp

Tip O'Neill Tunnel Exit & Entrance Ramps

Tip O'Neill Tunnel Exit & Entrance Ramps

Tip O'Neill Tunnel – Northernmost Portal

Vent Building 1

Vent Building 1 – Detail of Air Exchange Vent

Vent Building 4– Detail of 15KV Electrical Conduit