Hazardous Waste Site Vulnerability Assessment

By Katelyn Tarrio (with help Antonio Chidiac)

Introduction

- **Current** environmental hazards facing MA
  - Flooding
  - Hurricanes/storm surges
- **Future** climate change hazards facing MA
  - Exacerbation of flooding/hurricanes
    - Increased frequency
    - Increased severity
  - Sea level rise

Imperative to prevent additional waste site contamination spread:

→ Identify sites vulnerable to natural hazards

Flooded street in Marshfield, MA, after a winter storm January 27, 2015 (NBC News)

Research objectives

Part I : Vulnerability analysis

1. Assess **current** vulnerability of waste sites to natural hazards
2. Assess social impact of potential (current) waste site flooding
   - Water resources
   - Disadvantaged communities
3. Consider **future** vulnerability of waste sites to natural hazards

Part II : Climate Change Adaptation

4. Recommend remediation techniques

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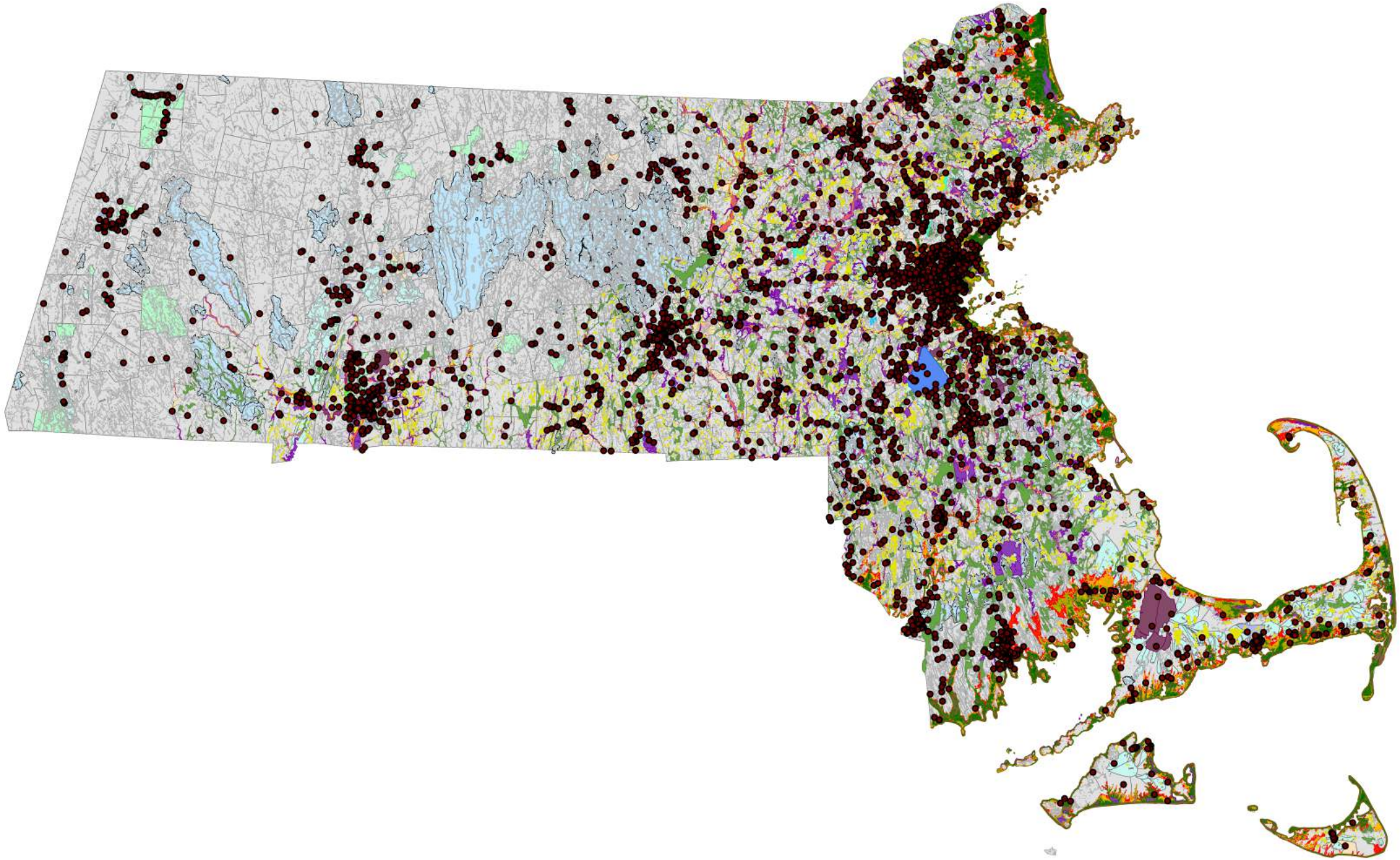
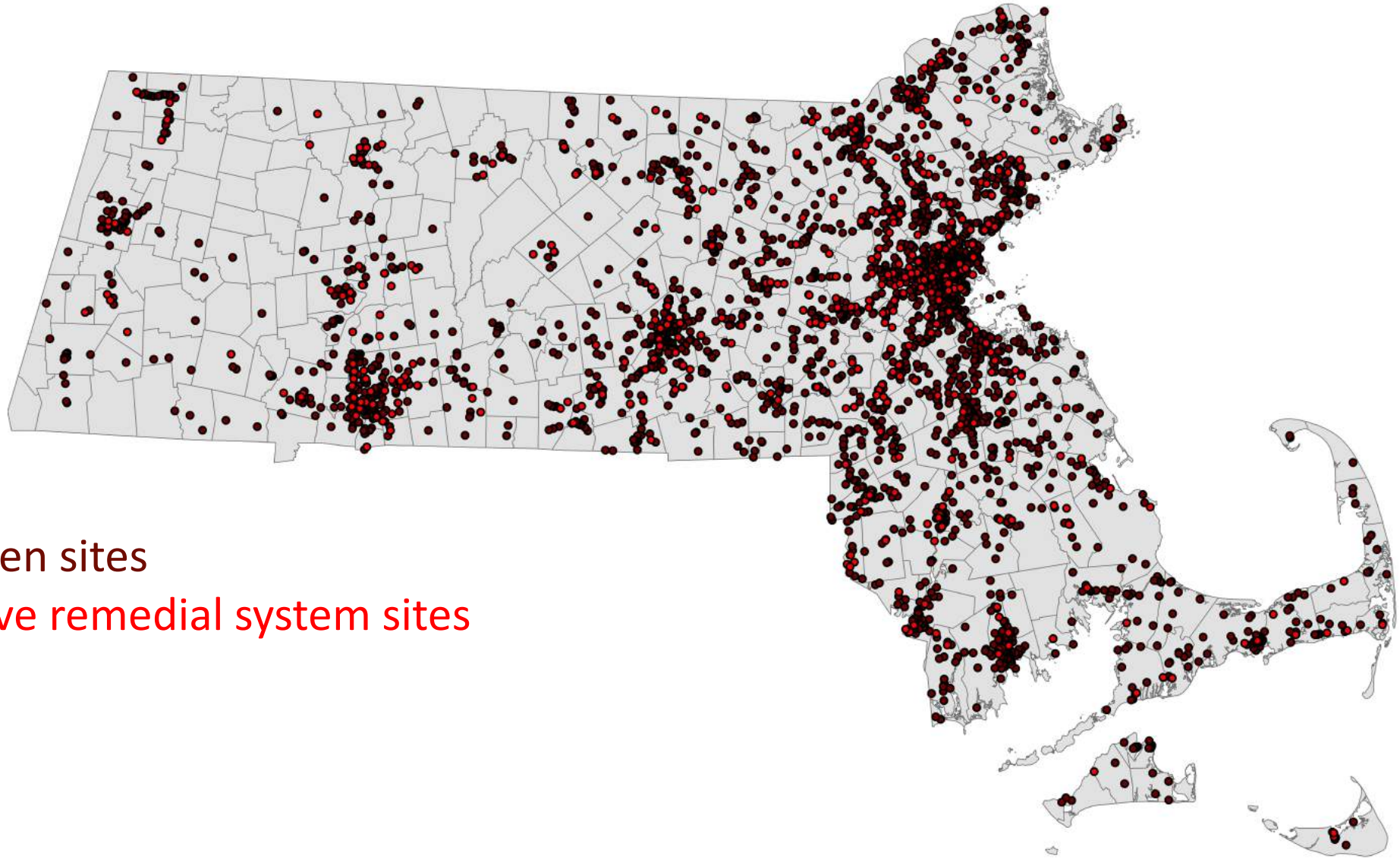
Methods – Current Vulnerability

1. Graph waste sites
2. Create buffer zones around sites
    - EPA standard: 50 feet
3. Calculate overlap with hazard areas:
    - **Flooding** (*FEMA* National Flood Hazard Layer)
    - **Hurricanes/storm surges** (*Army Corps of Engineers* Hurricane Surge Inundation Layer)
4. Assess vulnerability
    - Identify sites with:
        - High # of environmental risks
        - High # of active remediation systems



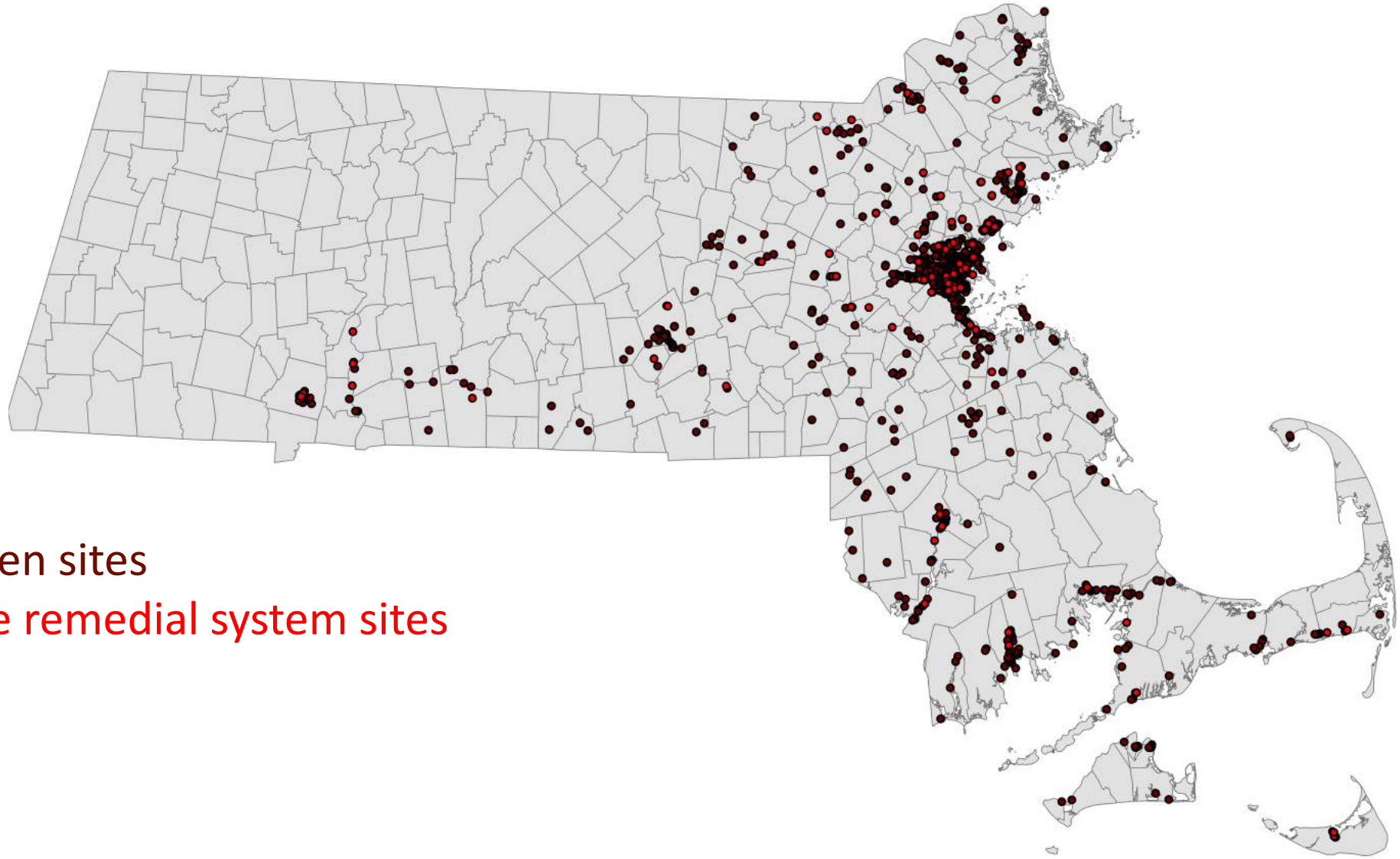
All sites



3772 Open sites

443 Active remedial system sites

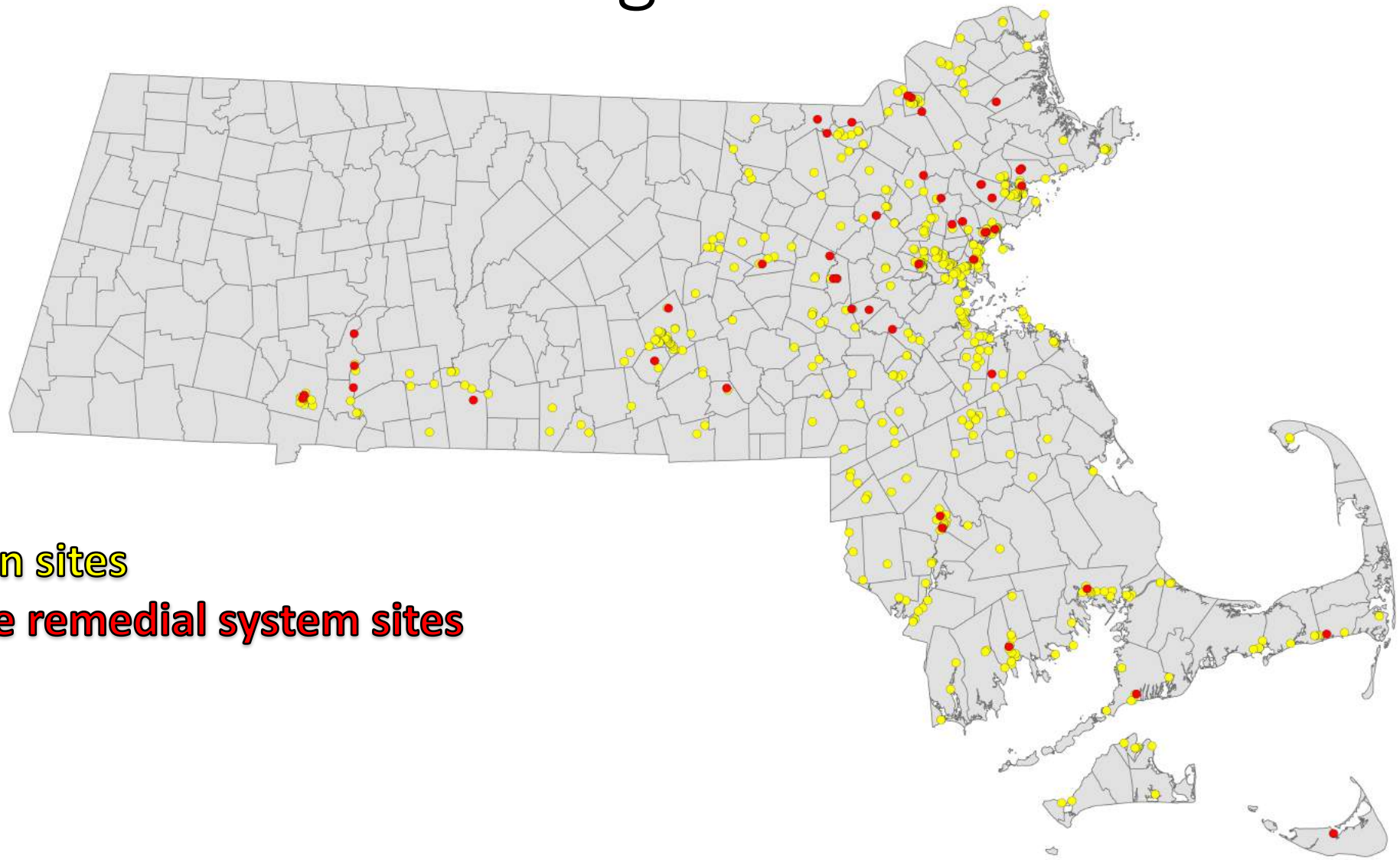
Sites at risk



1078 Open sites

89 Active remedial system sites

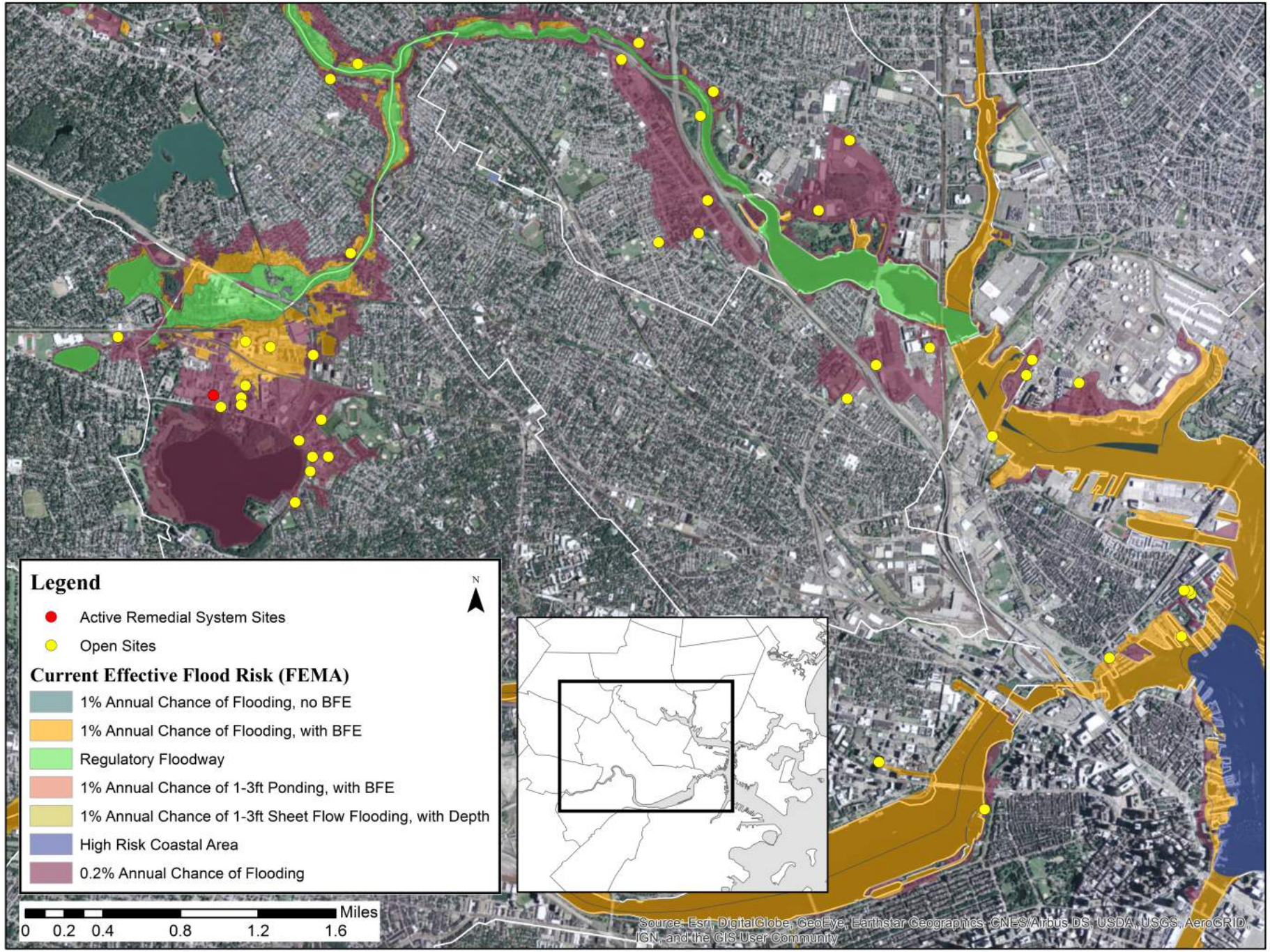
Sites at risk for flooding



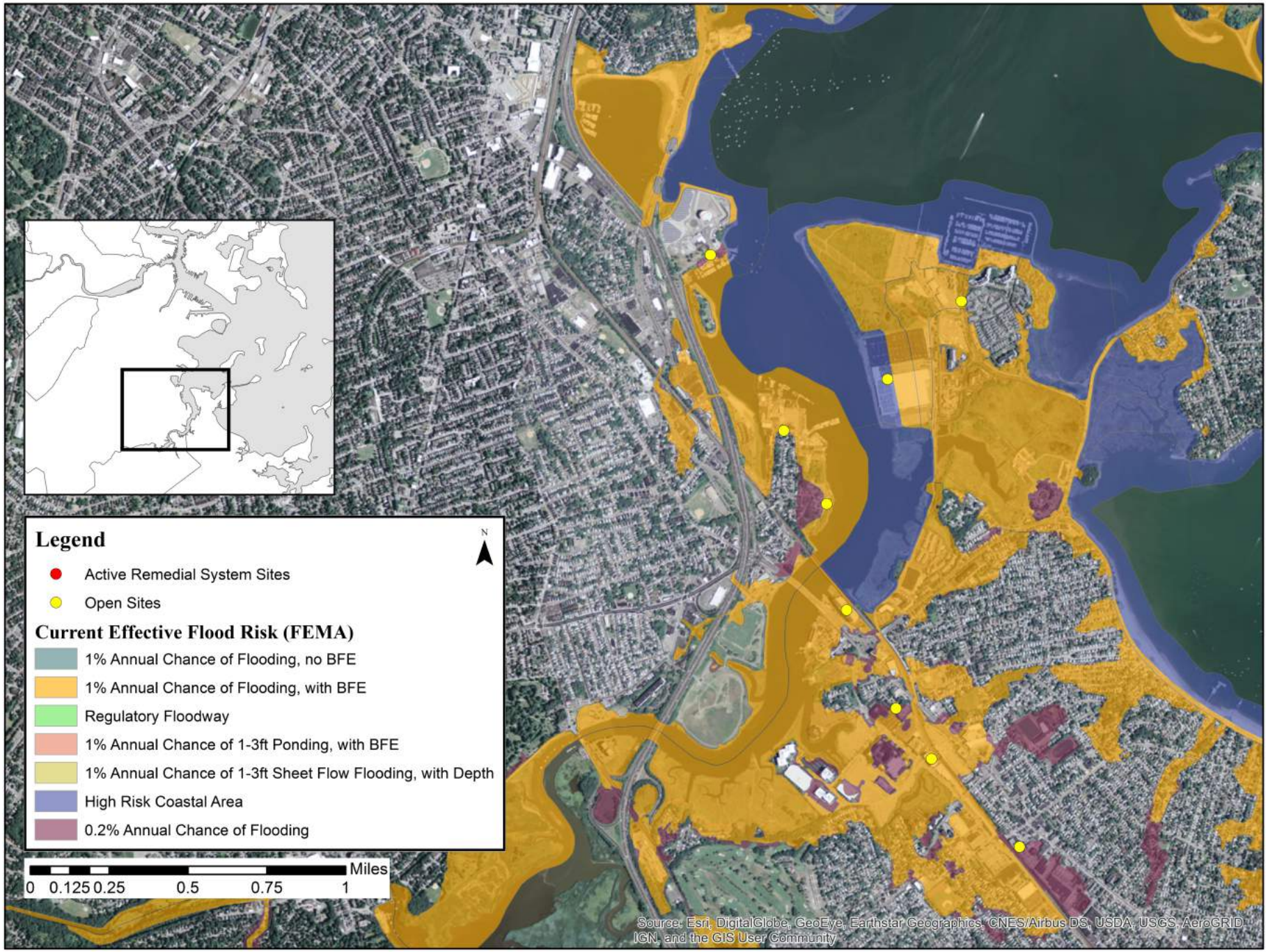
542 Open sites

50 Active remedial system sites

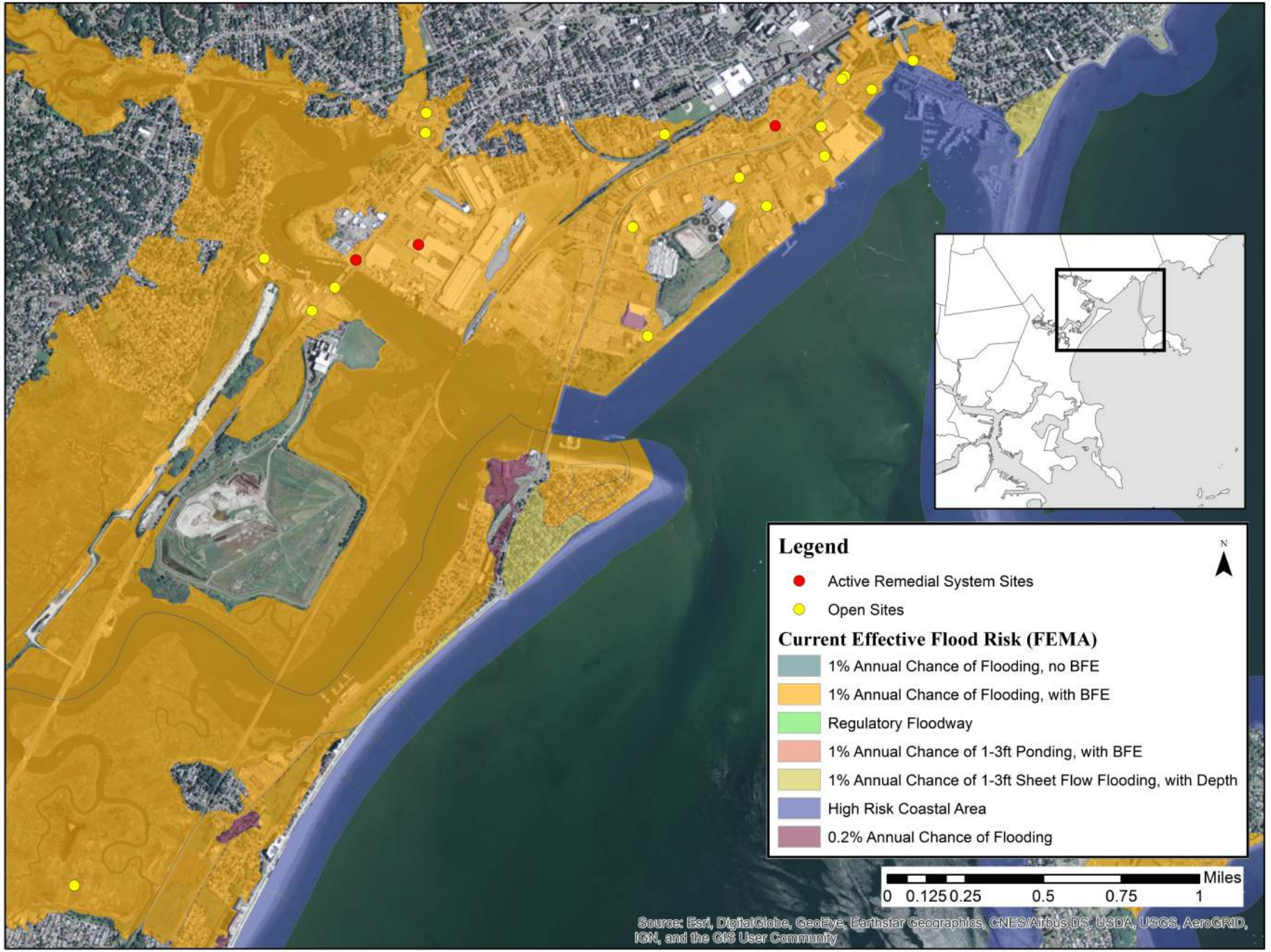
Cambridge, MA



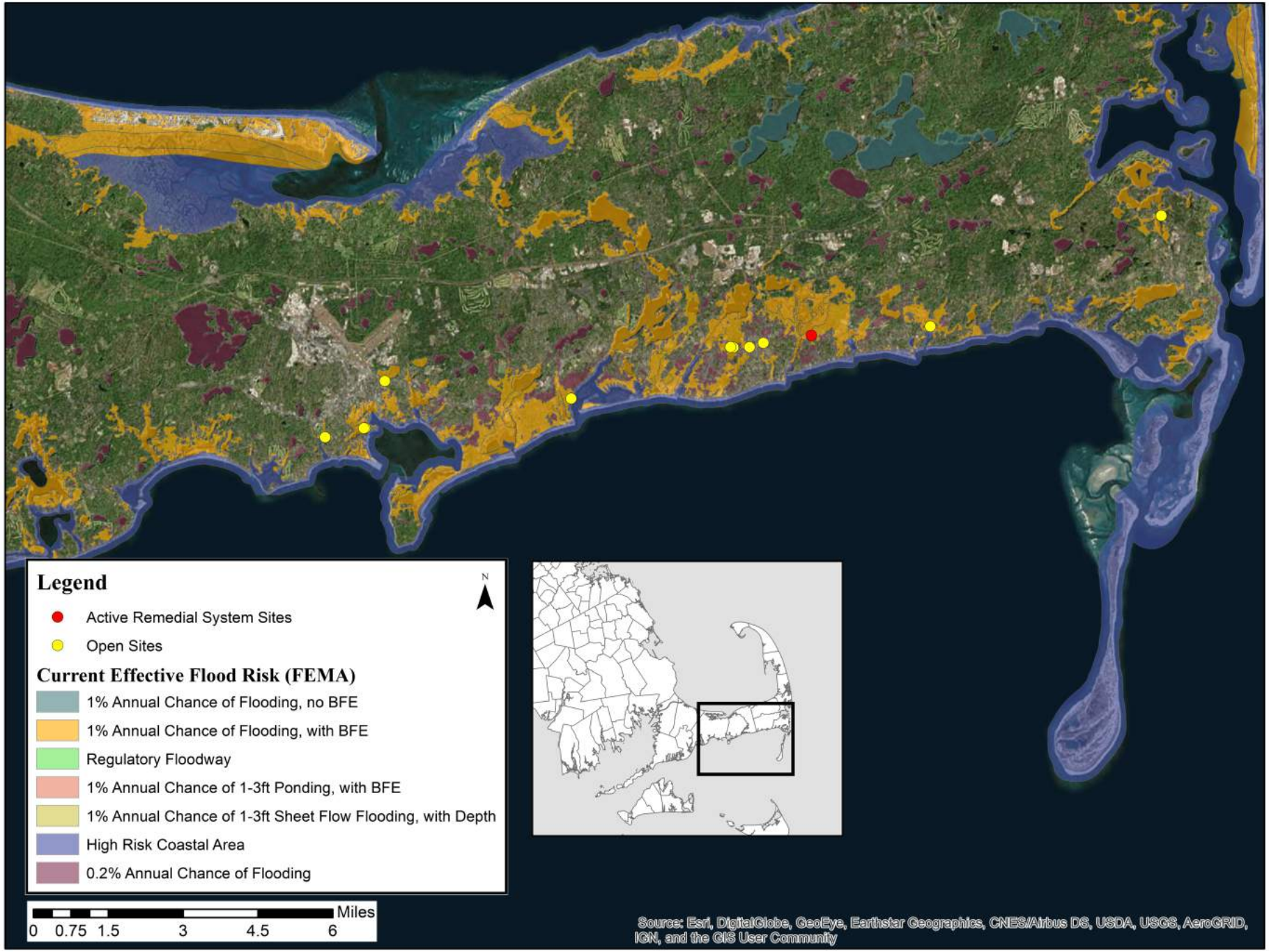
Marina Bay, Quincy MA



Revere, MA


Legend
N
Active Remedial System Sites
Open Sites
Current Effective Flood Risk (FEMA)
1% Annual Chance of Flooding, no BFE
1% Annual Chance of Flooding, with BFE
Regulatory Floodway
1% Annual Chance of 1-3ft Ponding, with BFE
1% Annual Chance of 1-3ft Sheet Flow Flooding, with Depth
High Risk Coastal Area
0.2% Annual Chance of Flooding
Miles
0 0.125 0.25 0.5 0.75 1
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Cape Cod, MA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Active Remedial System Sites
Open Sites
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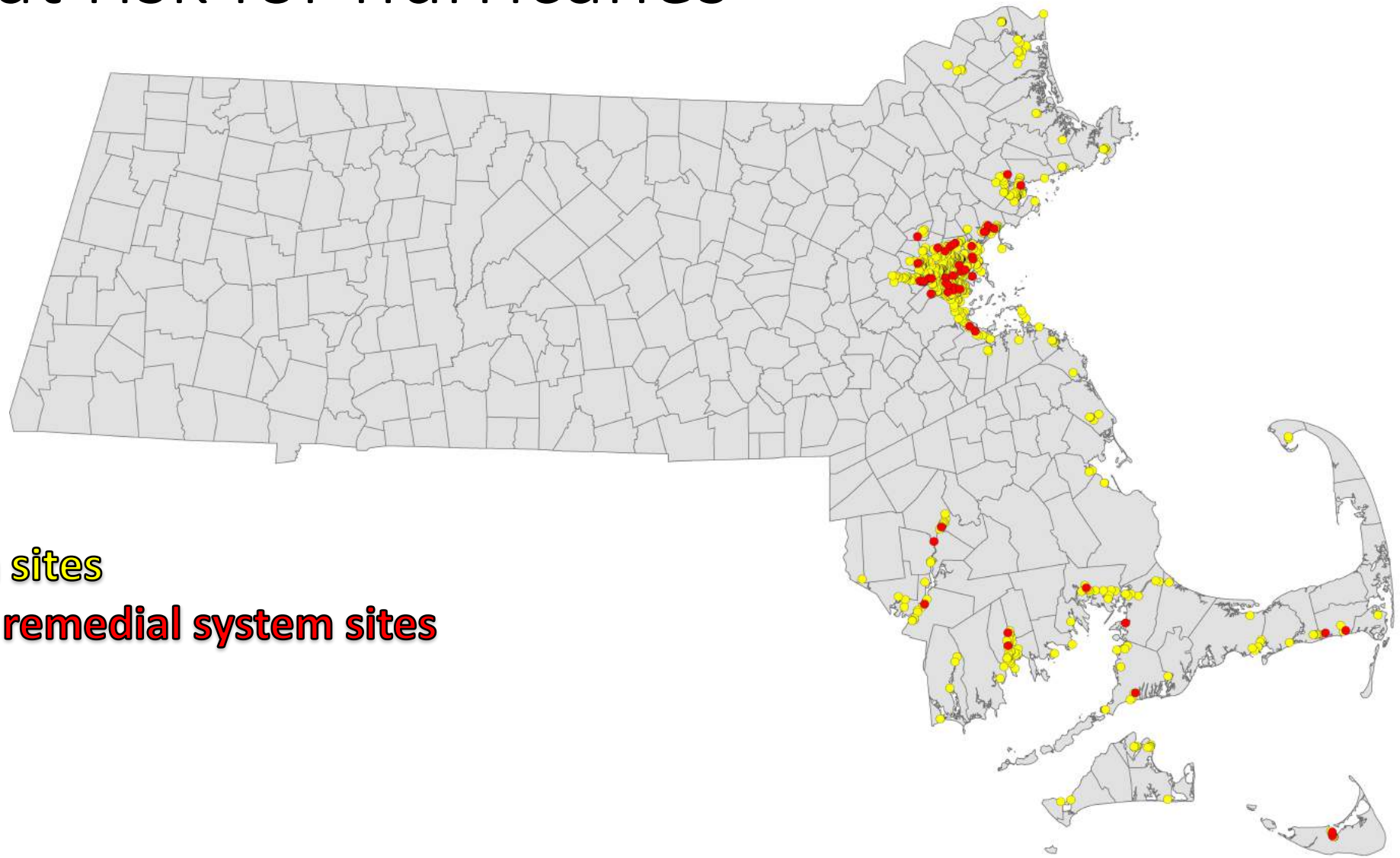
1% Annual Chance of 1-3ft Sheet Flow Flooding, with Depth
High Risk Coastal Area
0.2% Annual Chance of Flooding
N
Miles
0 0.75 1.5 3 4.5 6
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

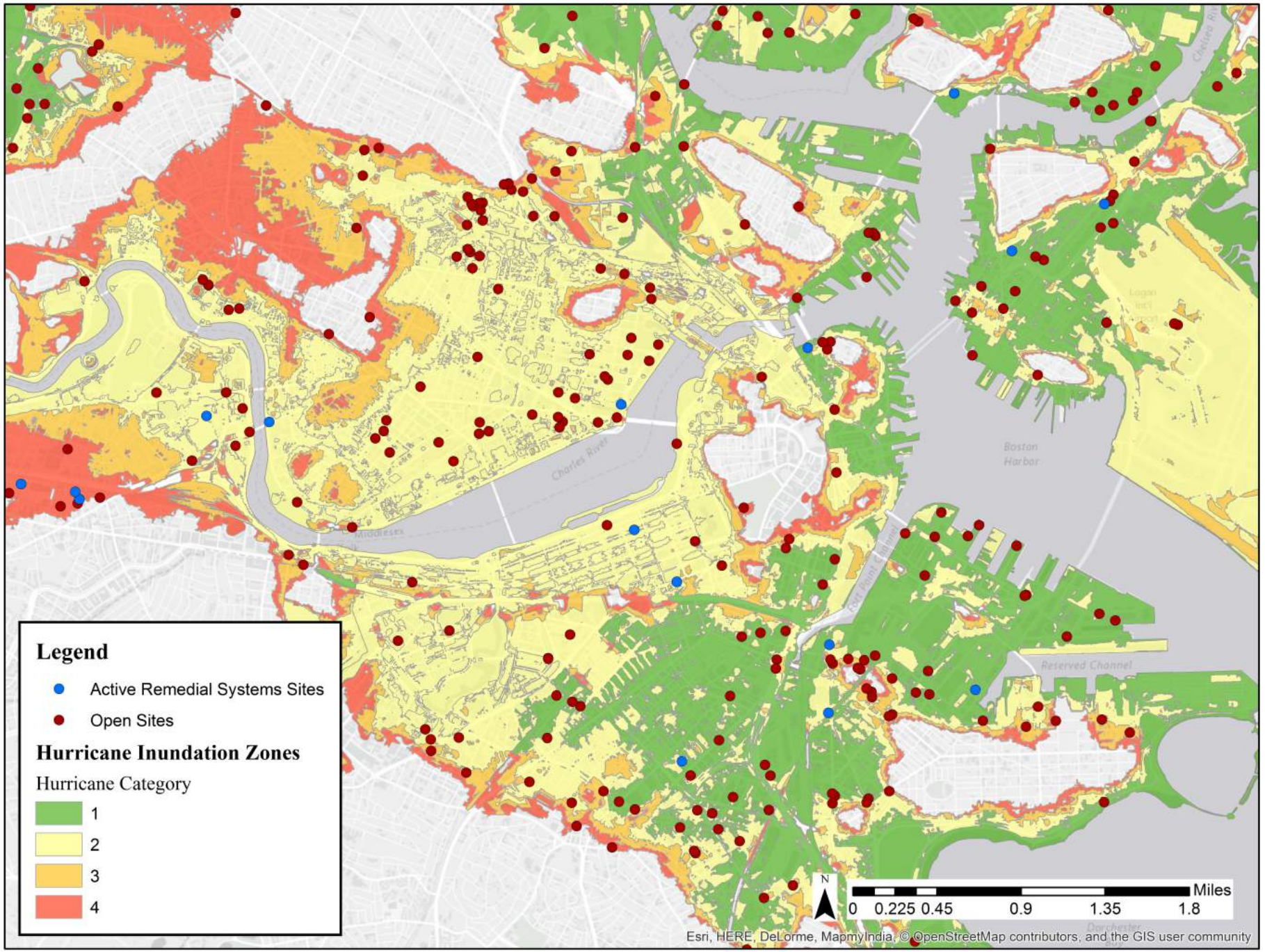
Sites at risk for hurricanes



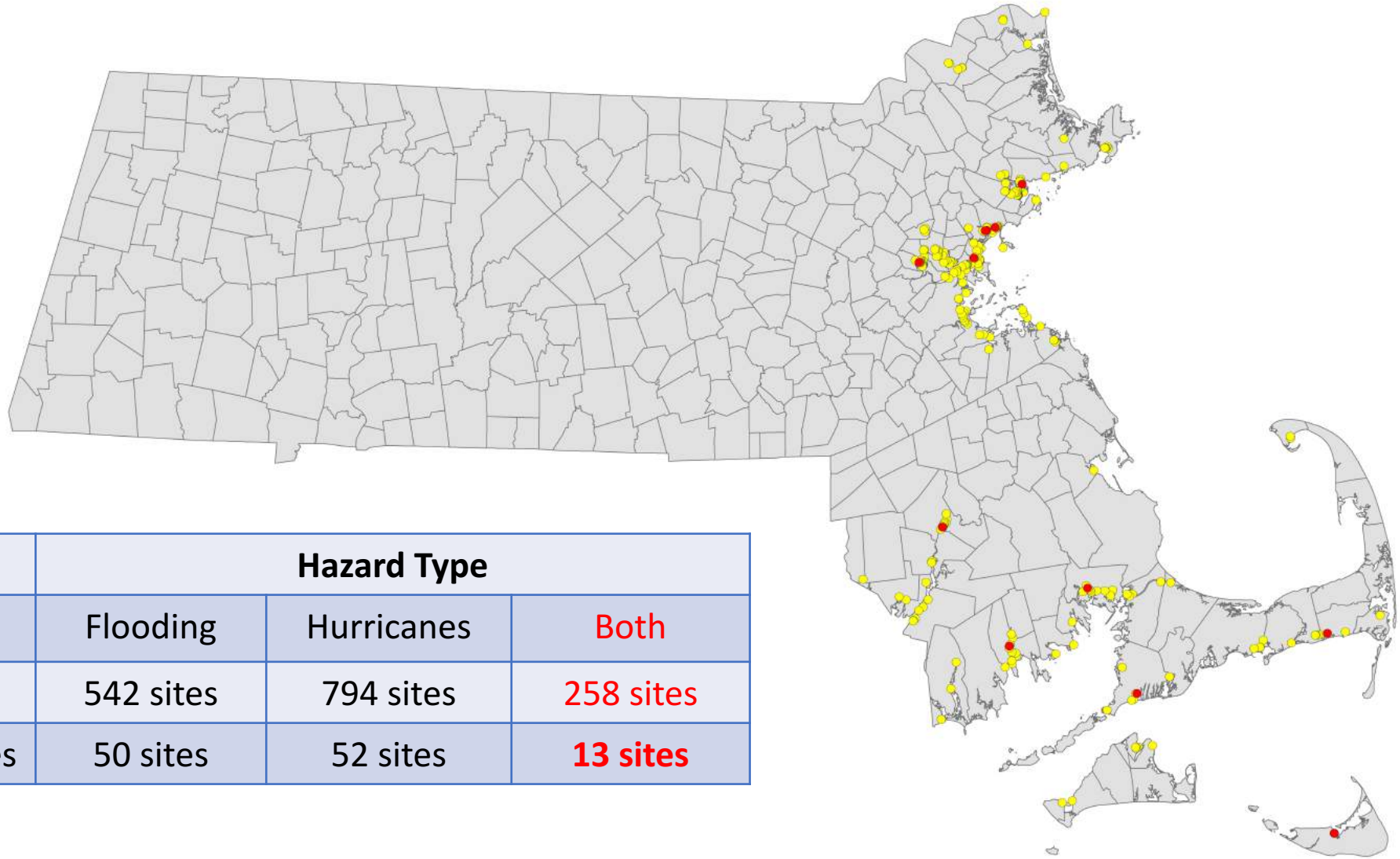
794 Open sites

52 Active remedial system sites

Boston, MA


Legend
Active Remedial Systems Sites
Open Sites
Hurricane Inundation Zones
Hurricane Category
1
2
3
4
N
Miles
0 0.225 0.45 0.9 1.35 1.8
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Current waste site vulnerability



	Hazard Type		
Site Type	Flooding	Hurricanes	Both
Open Sites	542 sites	794 sites	258 sites
Active Remedial Sites	50 sites	52 sites	**13 sites**

Priority sites: active remedial systems

Site name	RTN	GW Recover	SVE	Sparging	Dual phase	OHM type	# Remedies
NO LOCATION AID	3-0018094	0	1	1	0	Hazardous Material	2
GE RIVER WORKS	3-0000357	1	1	0	0	Oil	2
MBTA BUS TERMINAL	3-0002426	1	0	0	1		2
GLOBAL PETRO	3-0014835	1	0	0	0	Oil	1
REVERE COPPER PRODUCTS INC	4-0000815	1	0	0	0	Oil	1
MOBIL STATION 01 602 FMR	4-0000842	0	1	1	0	Oil	2
TUCK POINT CONDOMINIUM ASSOCIATION	3-0000234	1	0	0	1	Oil and Hazardous Material	2
SHELL SERVICE STATION	4-0014975	1	0	0	0		1
FORMER LIGHT PLANT FACILITY	4-0022172	1	0	0	0	Oil	1
SEWER MAIN REPLACEMENT PROJECT	4-0021801	1	0	0	0	Oil	1
FRANCONIA HURLEY LUMBERTOWN CORP	4-0014893	0	1	0	0	Oil	1
NO LOCATION AID	3-0018919	0	1	0	0	Oil and Hazardous Material	1
RTE 1A DRAINAGE SYSTEM	3-0024249	1	0	0	1	Oil	2

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1. Assess **current** vulnerability of waste sites to natural hazards
2. Assess social impact of potential (current) waste site flooding
   - Water resources
   - Disadvantaged communities
3. Consider **future** vulnerability of waste sites to natural hazards

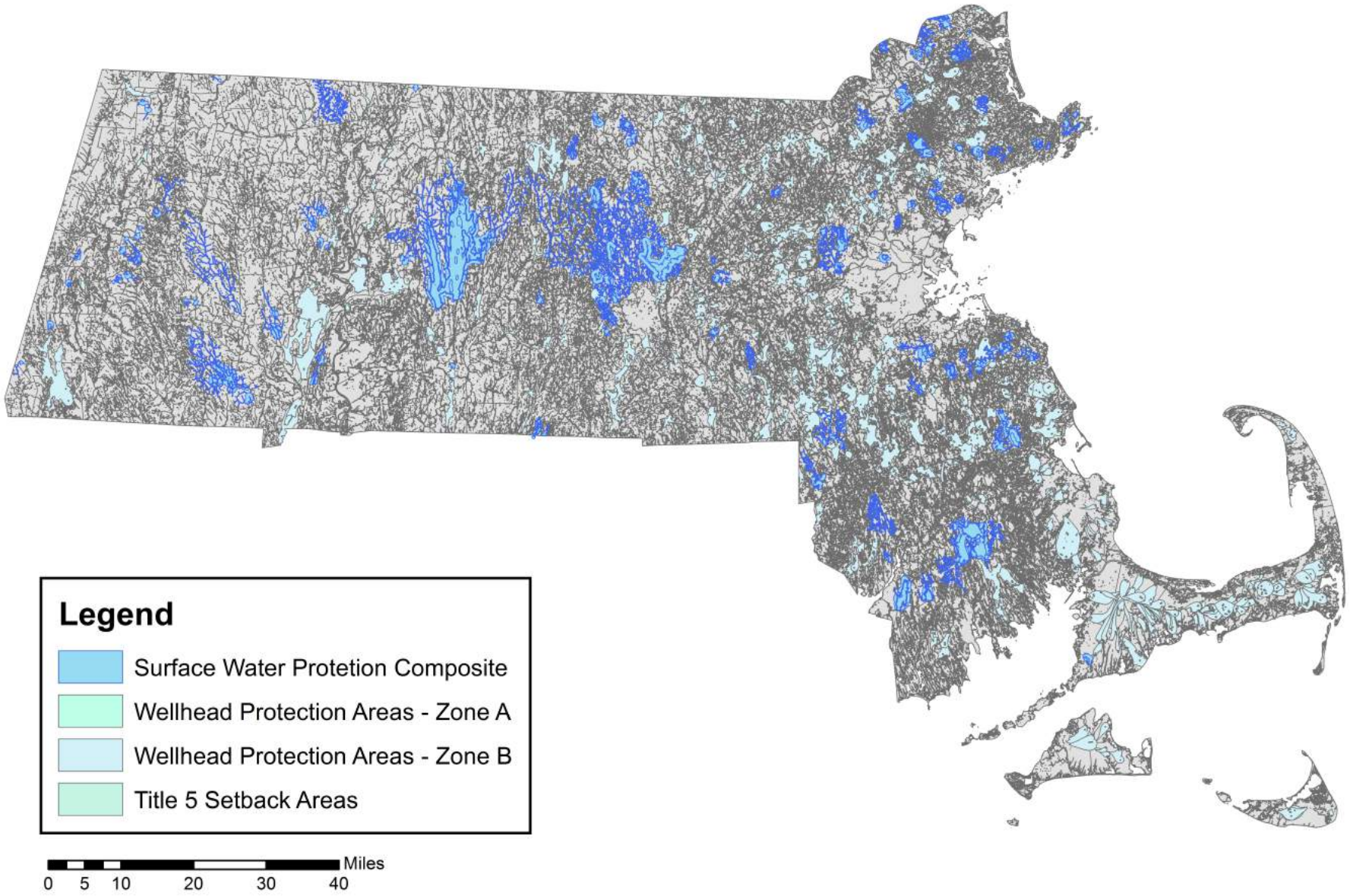
Part II : Climate Change Adaptation

4. Recommend remediation techniques

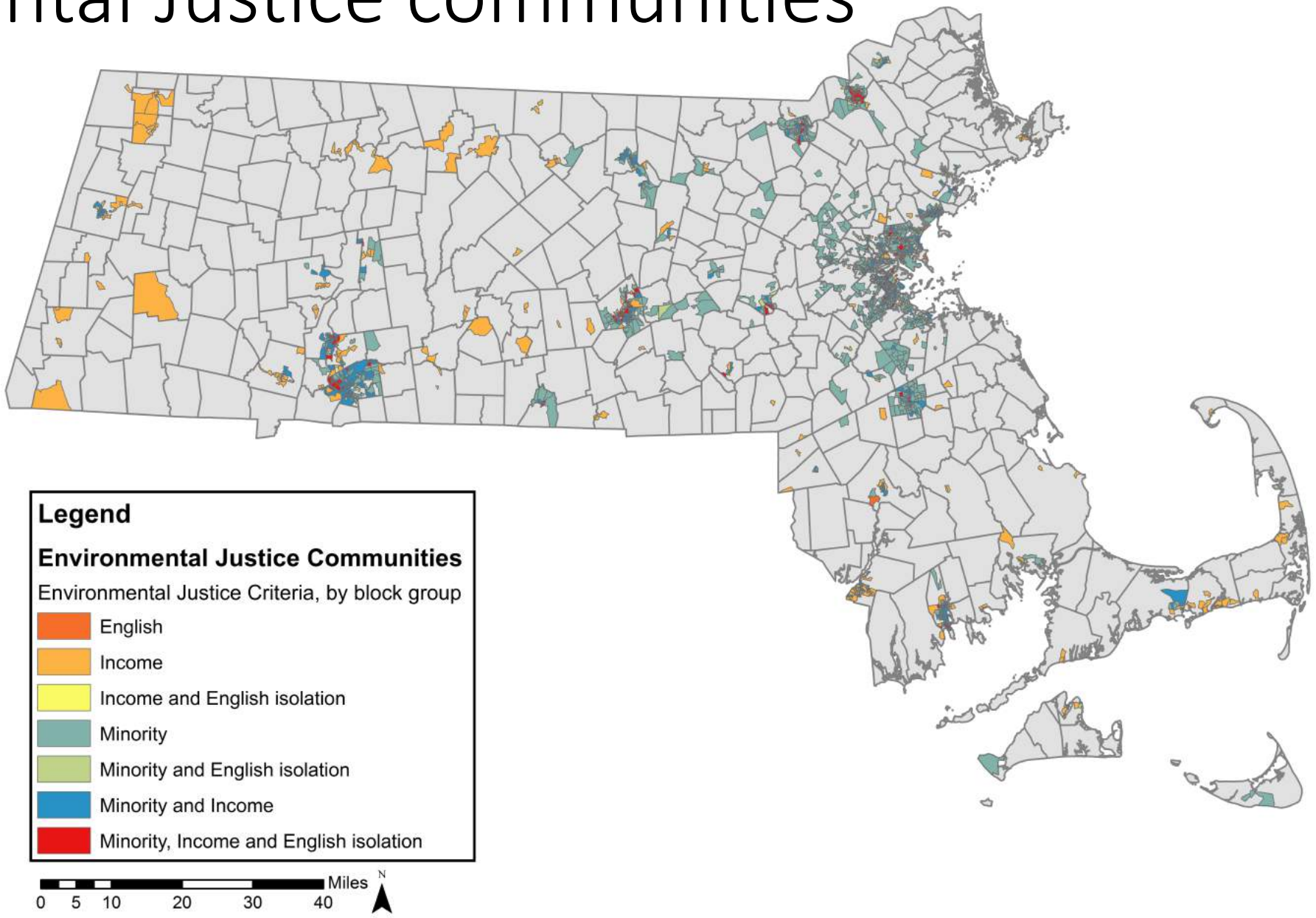
Methods – Social Vulnerability

1. Visualize overlap of sites at risk for hazards with social parameters:
    - **Water resources:**
        - Surface water supply protection areas (Zones A & B, reservoirs)
        - Wellhead protection areas (Zones 1 & 2)
        - Title 5 Setback areas
    - **Environmental Justice communities** (2010 *US Census*)
2. Assess vulnerability
    - Identify sites with:
        - Close proximity to water resources
        - Close proximity to the disadvantaged

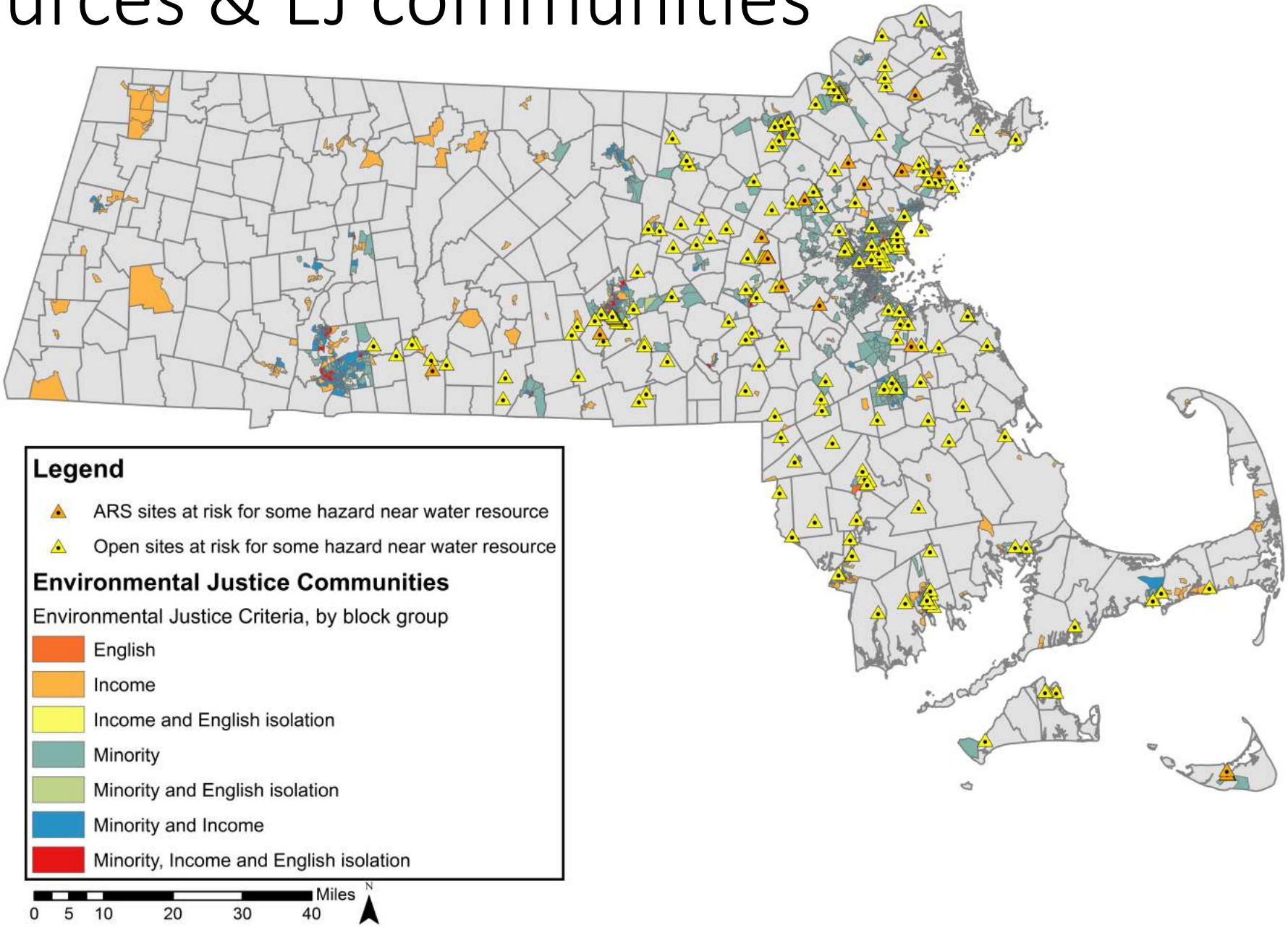
Water resources



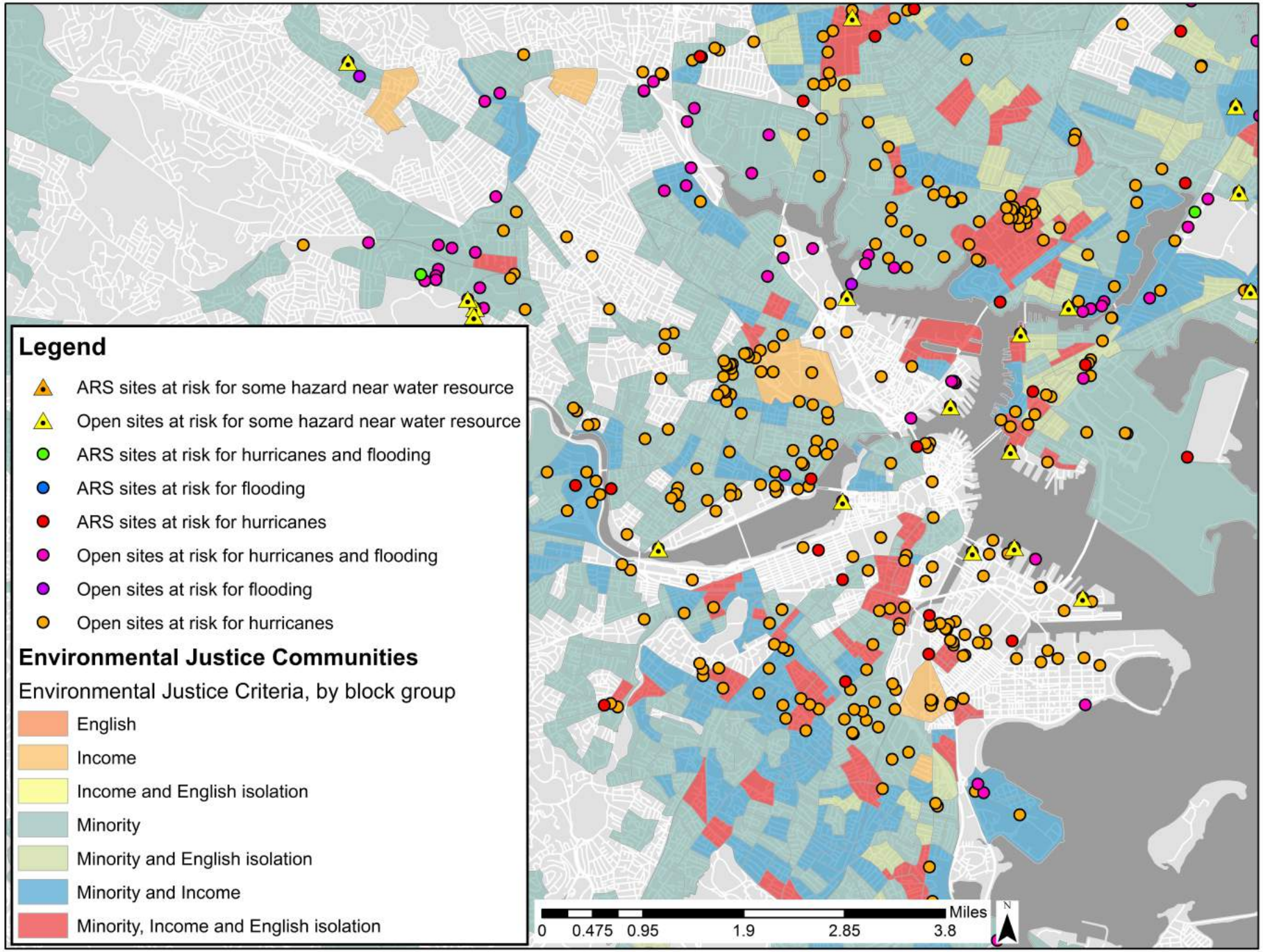
Environmental Justice communities



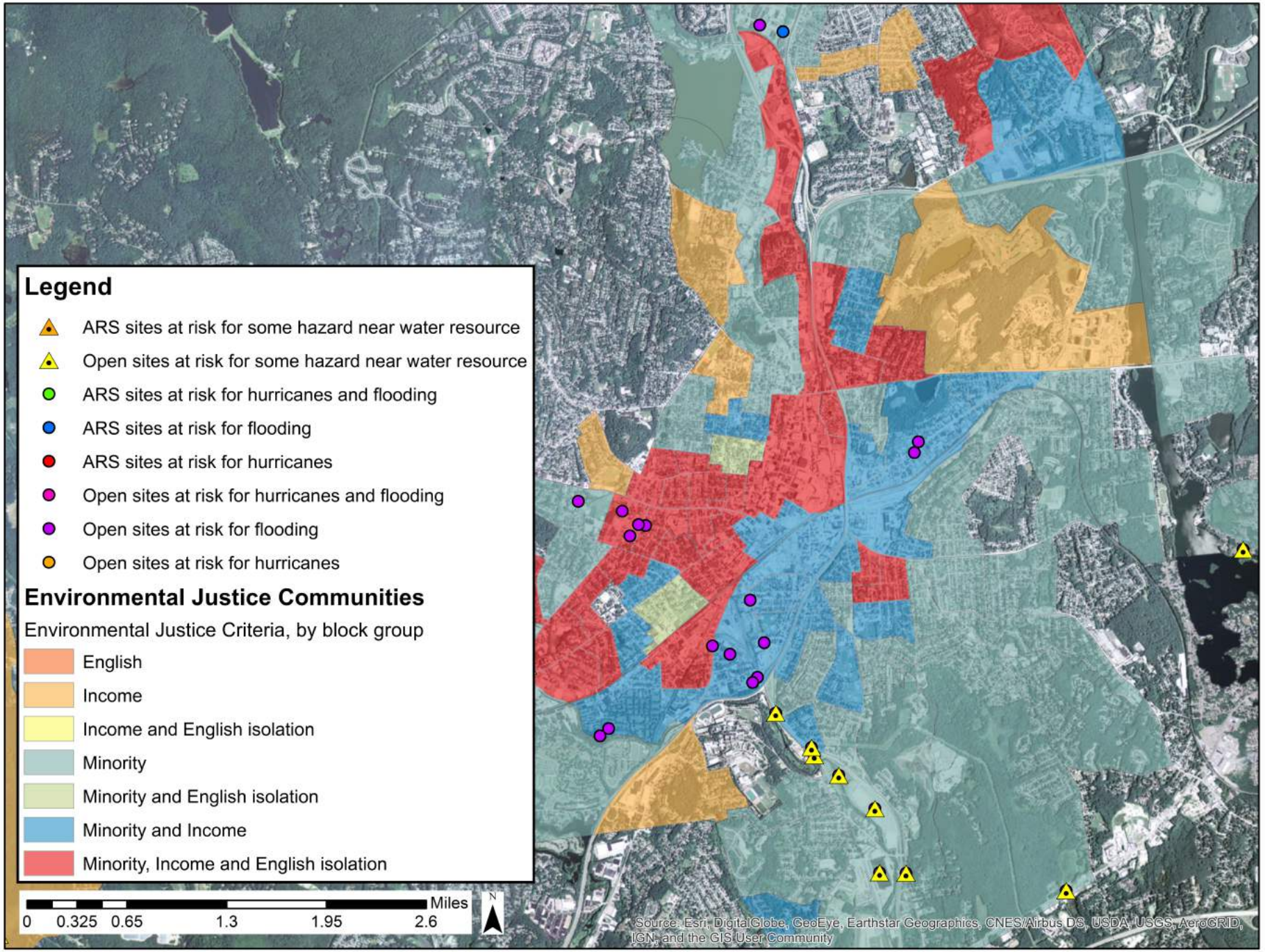
Water resources & EJ communities



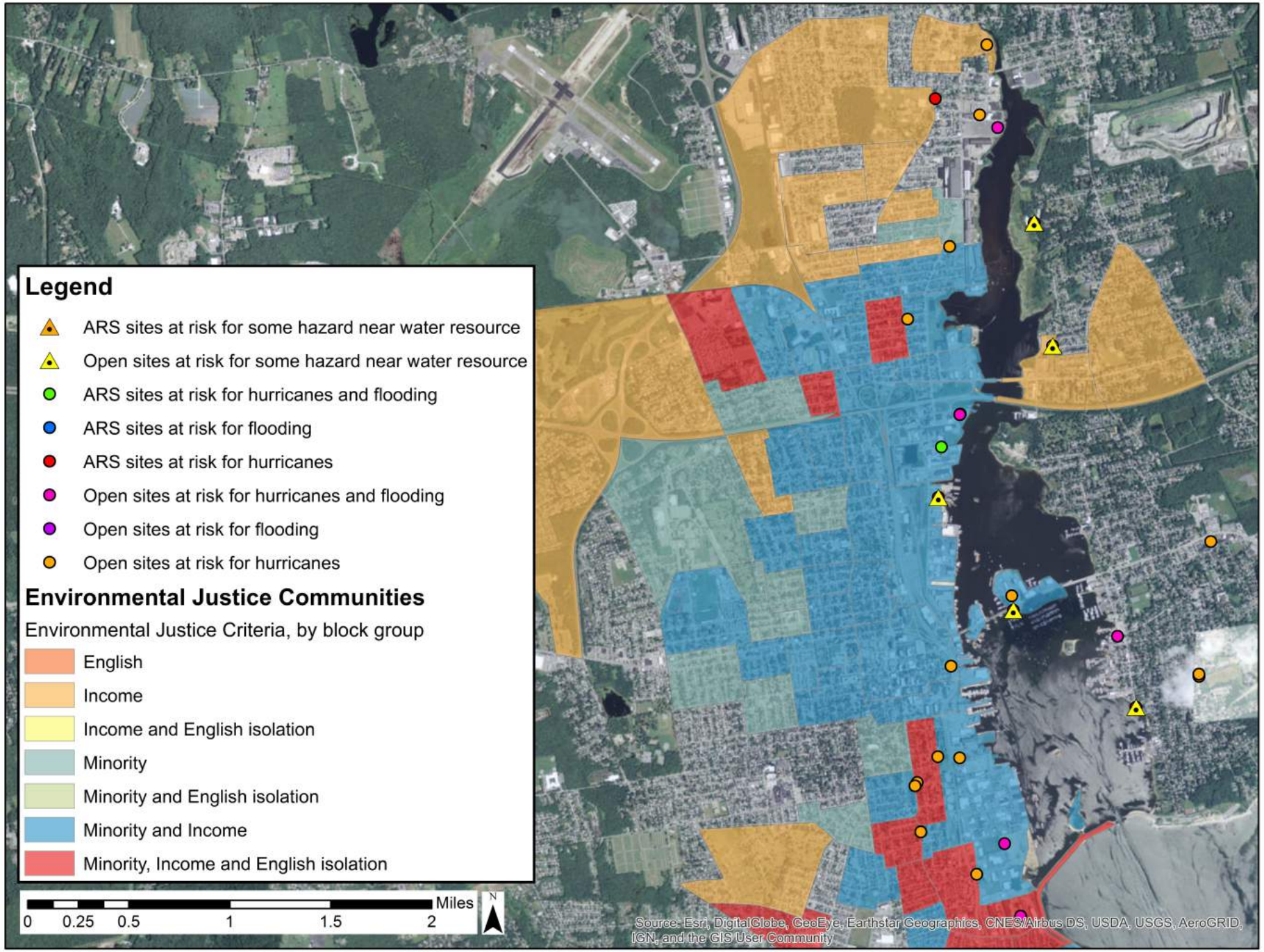
Boston, MA


Legend
ARS sites at risk for some hazard near water resource
Open sites at risk for some hazard near water resource
ARS sites at risk for hurricanes and flooding
ARS sites at risk for flooding
ARS sites at risk for hurricanes
Open sites at risk for hurricanes and flooding
Open sites at risk for flooding
Open sites at risk for hurricanes
Environmental Justice Communities
Environmental Justice Criteria, by block group
English
Income
Income and English isolation
Minority
Minority and English isolation
Minority and Income
Minority, Income and English isolation
0 0.475 0.95 1.9 2.85 3.8
Miles
N

Worcester, MA



New Bedford, MA



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Climate change & future vulnerability

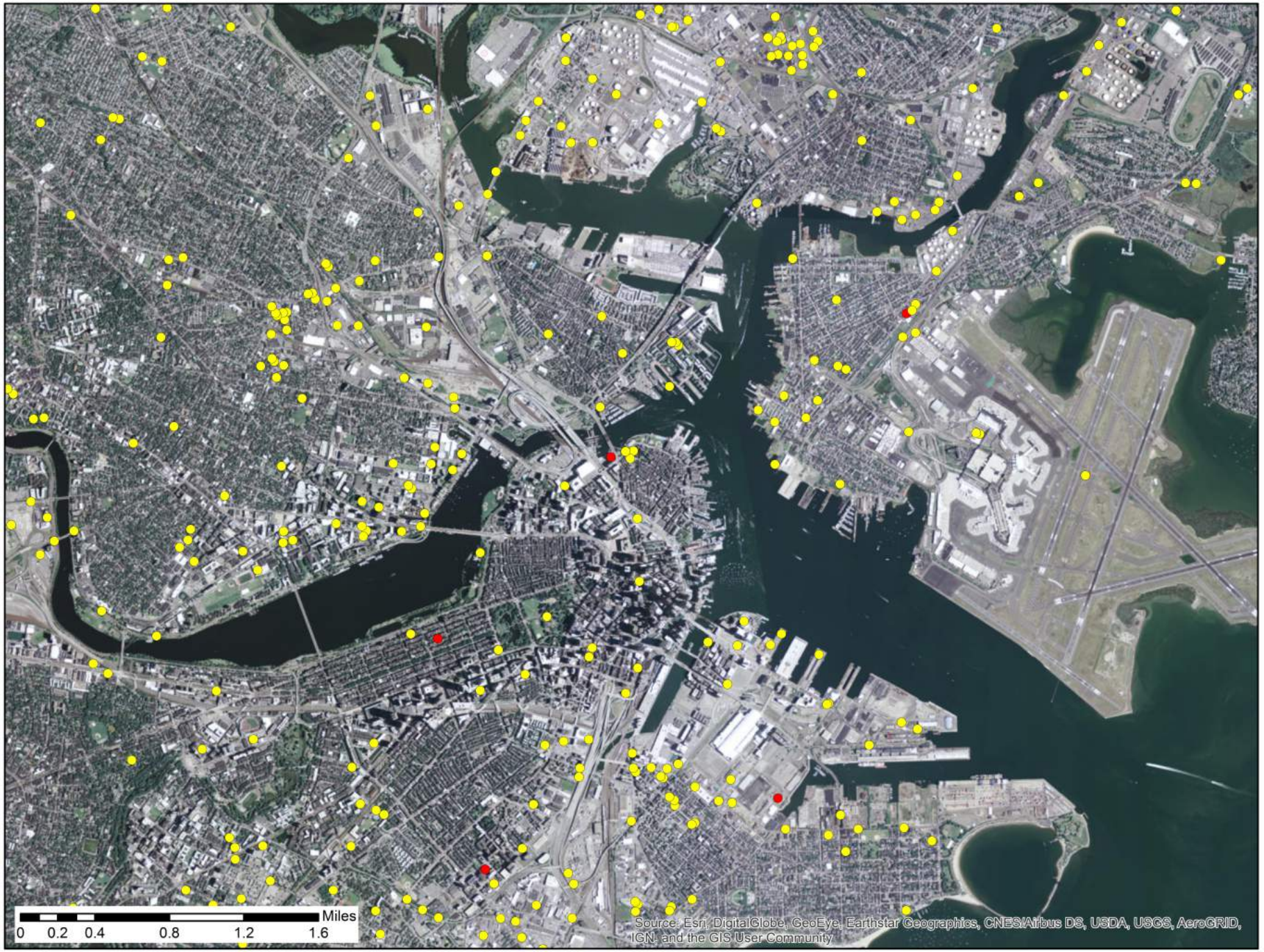
- Sea level rise:

	2030	2050	2100
Slow rise scenario	0.4 ft	0.8 ft	1.9 ft
Medium rise scenario	0.6 ft	1.3 ft	4.0 ft
Fast rise scenario	0.8 ft	1.9 ft	6.4 ft

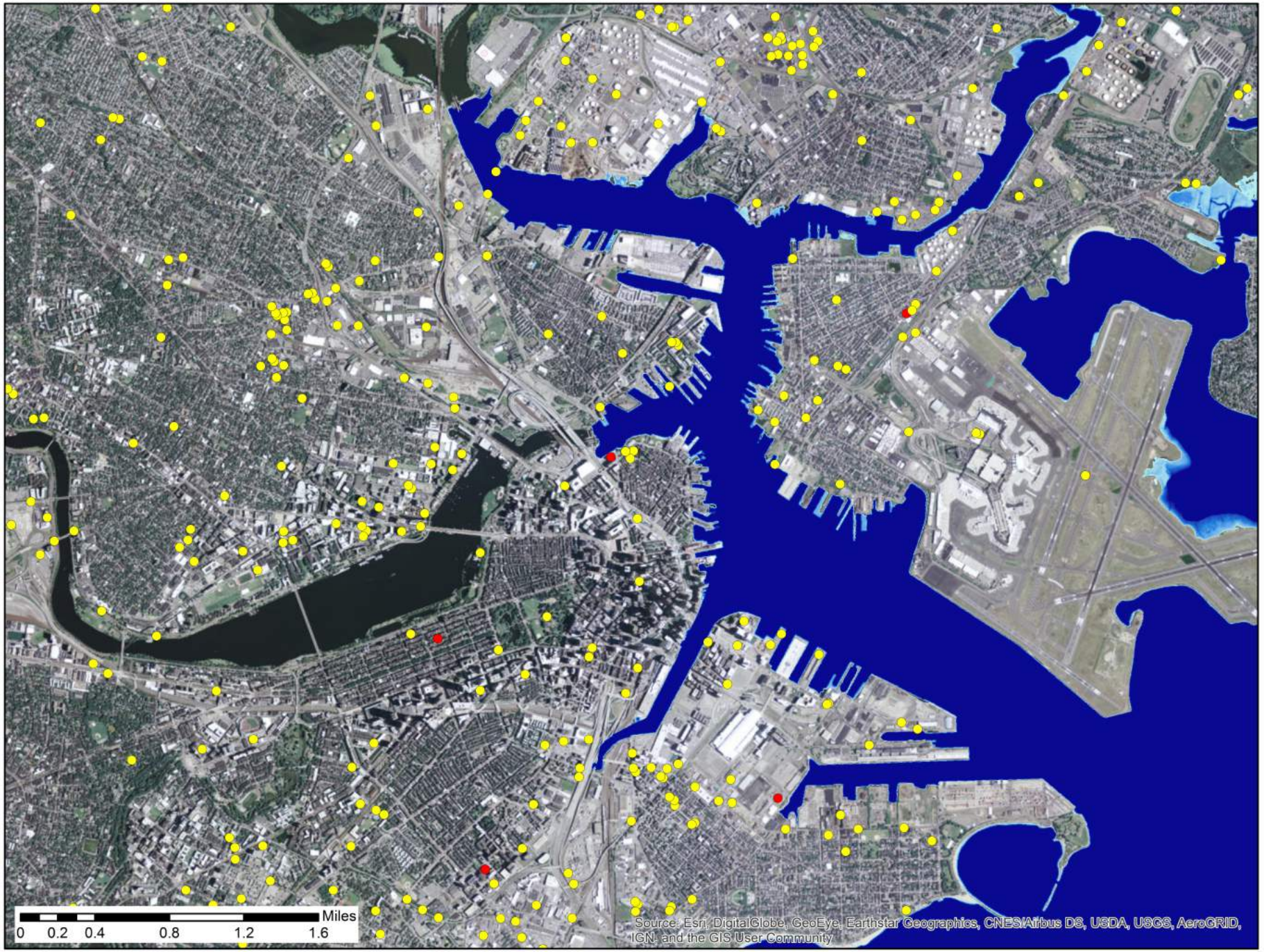
Localized projections from the 2014 National Climate Assessment

- Exacerbation of flooding/storms:
  - Increased frequency
    - 100 year flood possibly every 35 to 55 years
    - Greater occurrence of ponding
  - Increased intensity
    - Greater inundation extent
      - Floodplain expansion

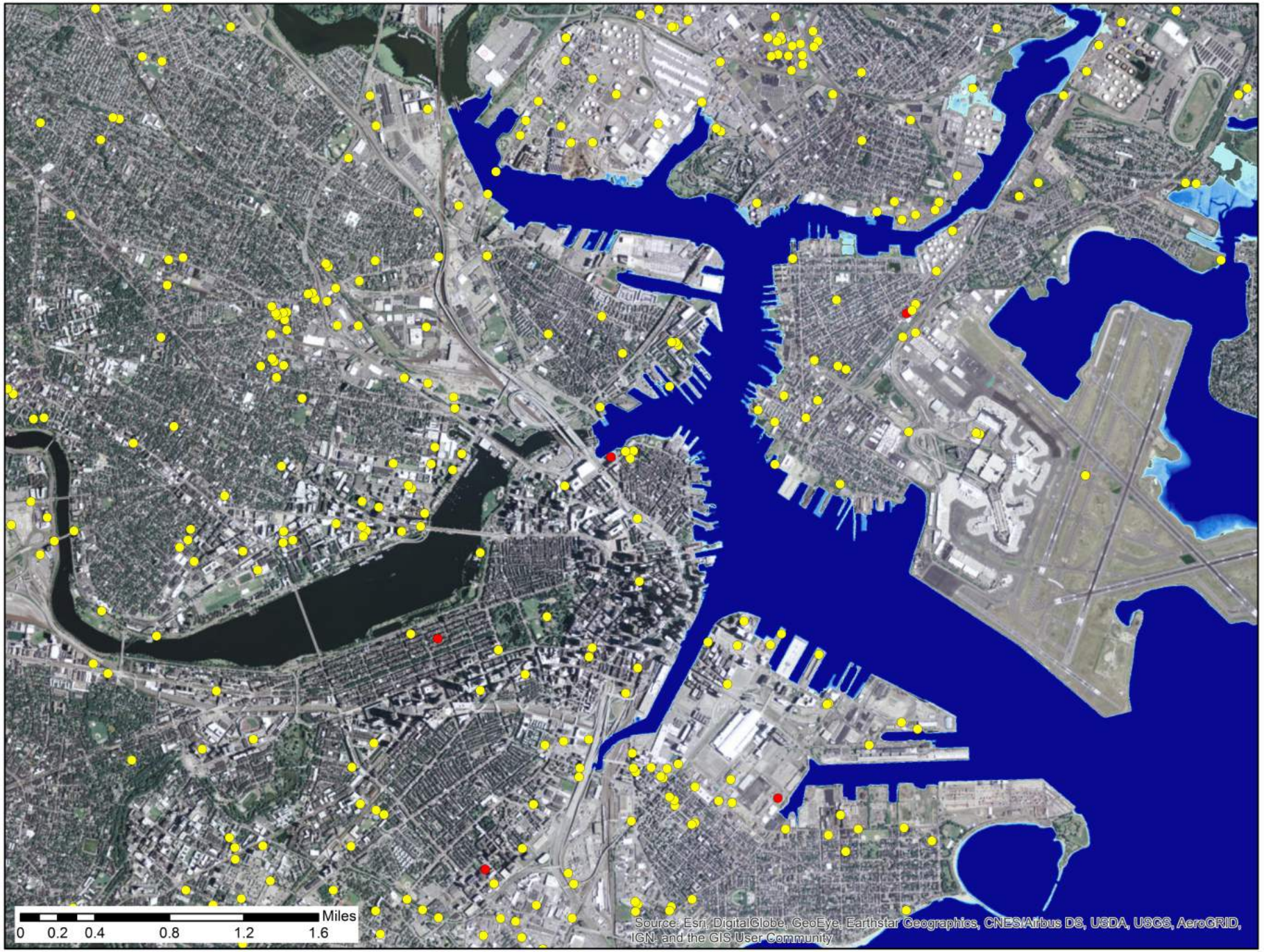
Boston, currently



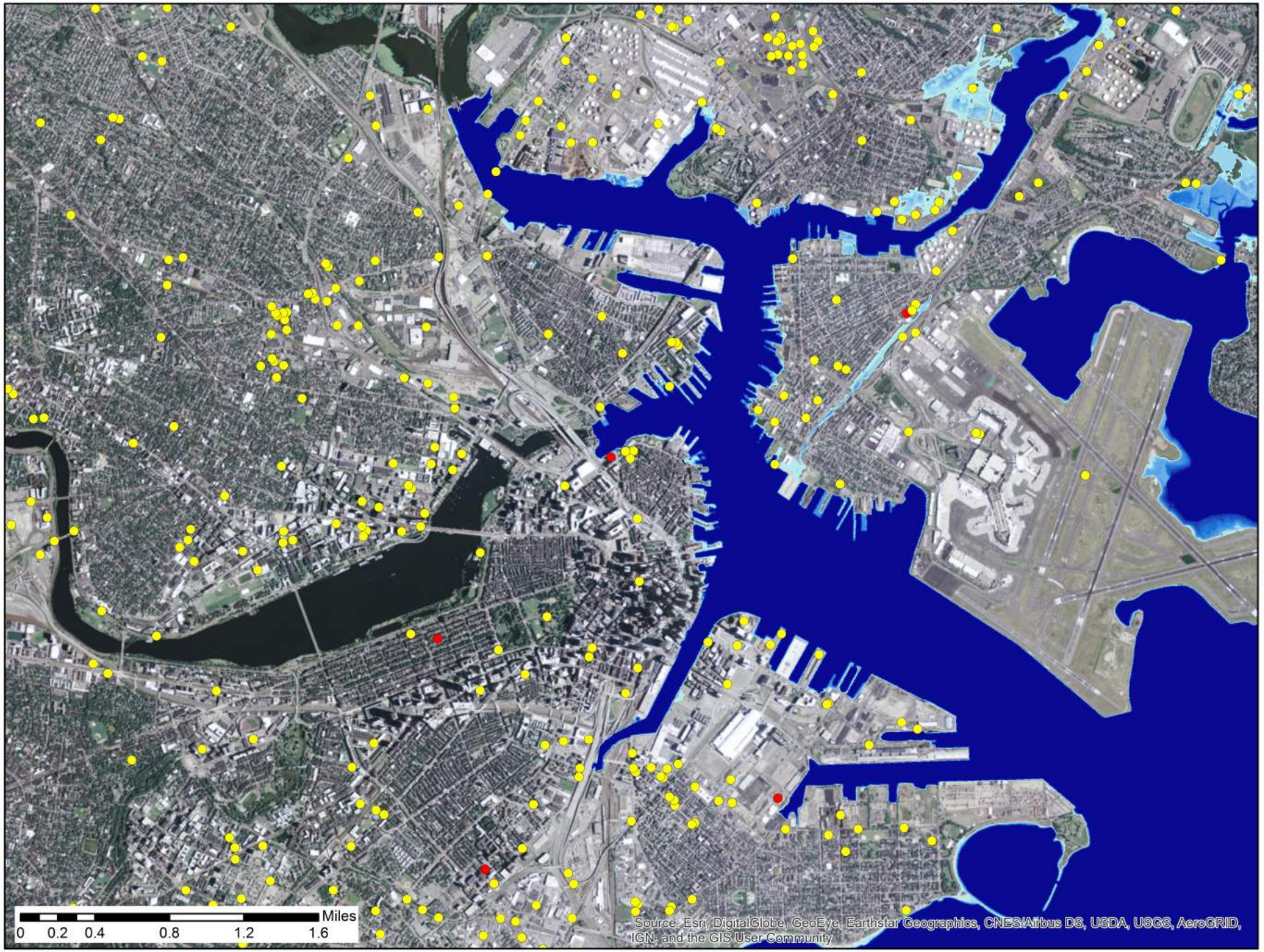
Sea level rise: 1 foot



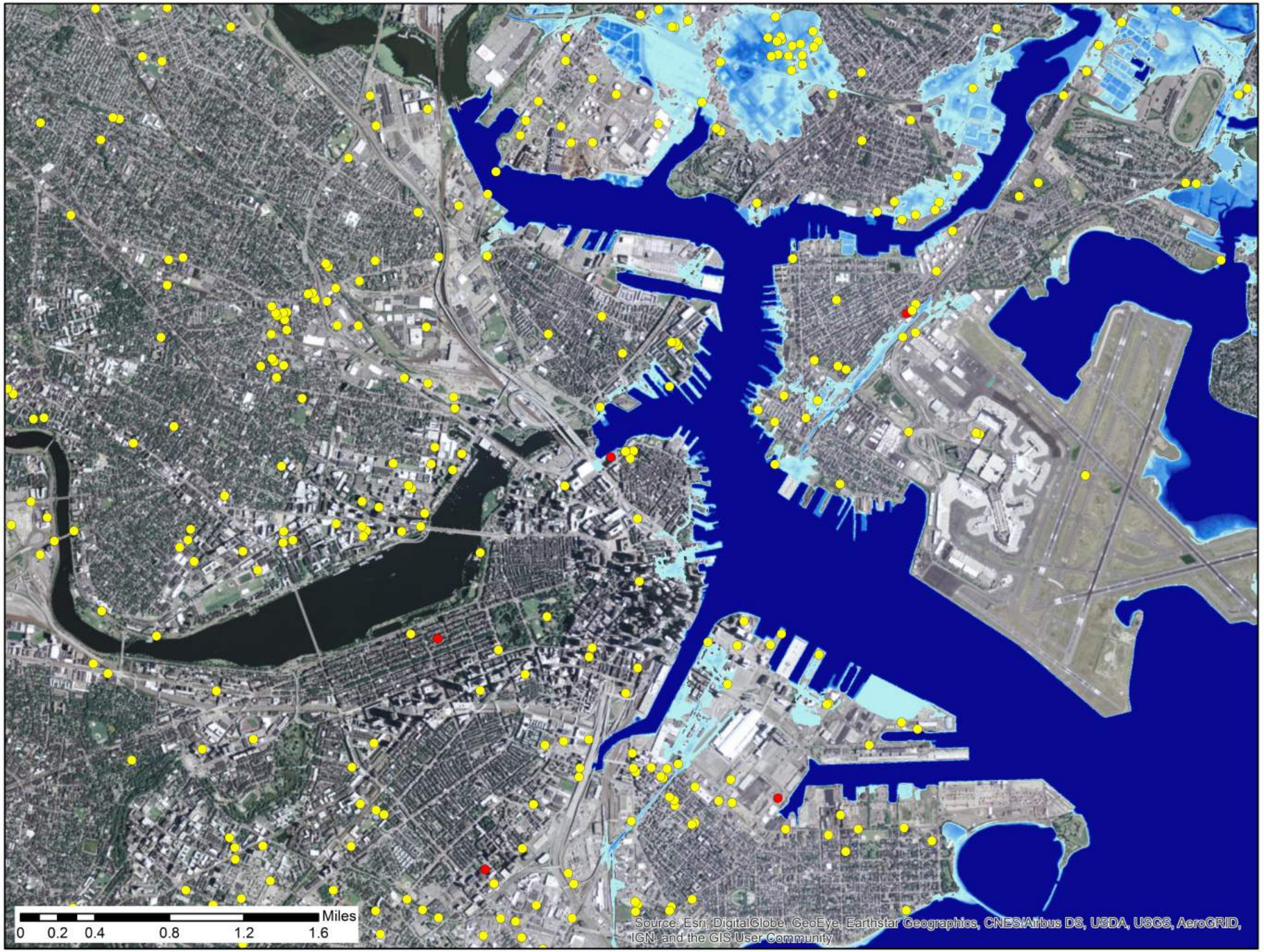
Sea level rise: 2 feet



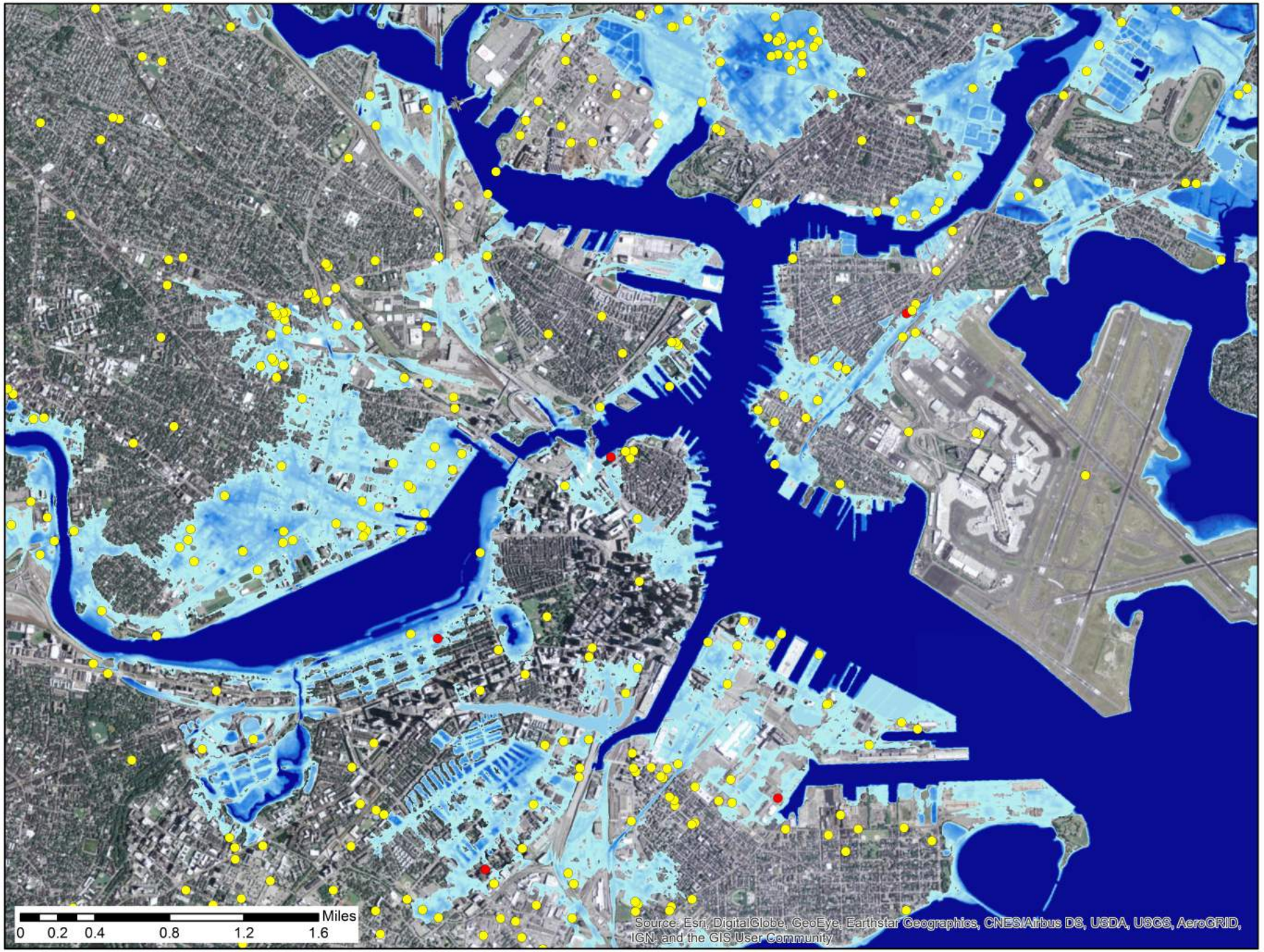
Sea level rise: 3 feet



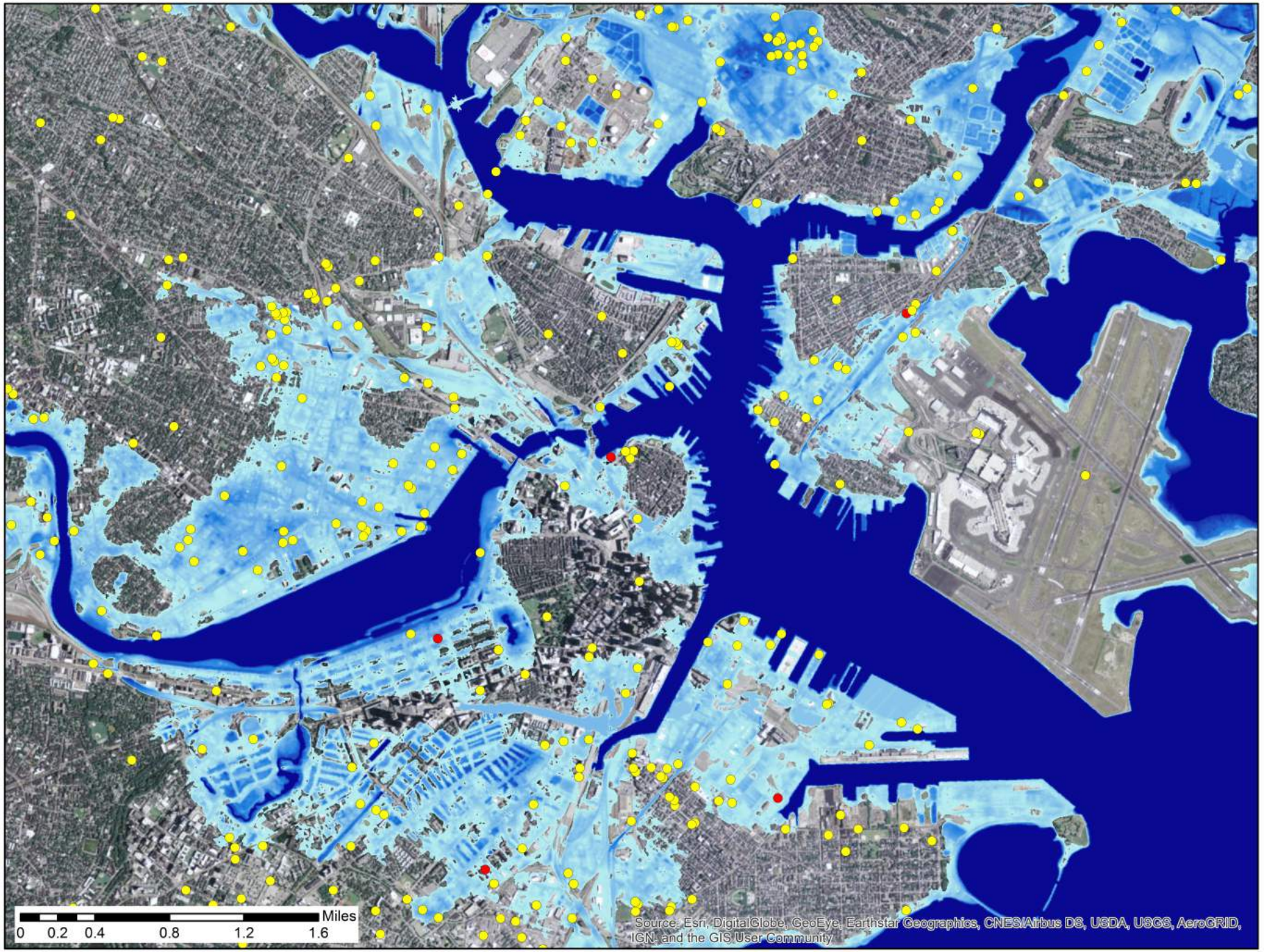
Sea level rise: 4 feet



Sea level rise: 5 feet



Sea level rise: 6 feet



Climate change & future vulnerability

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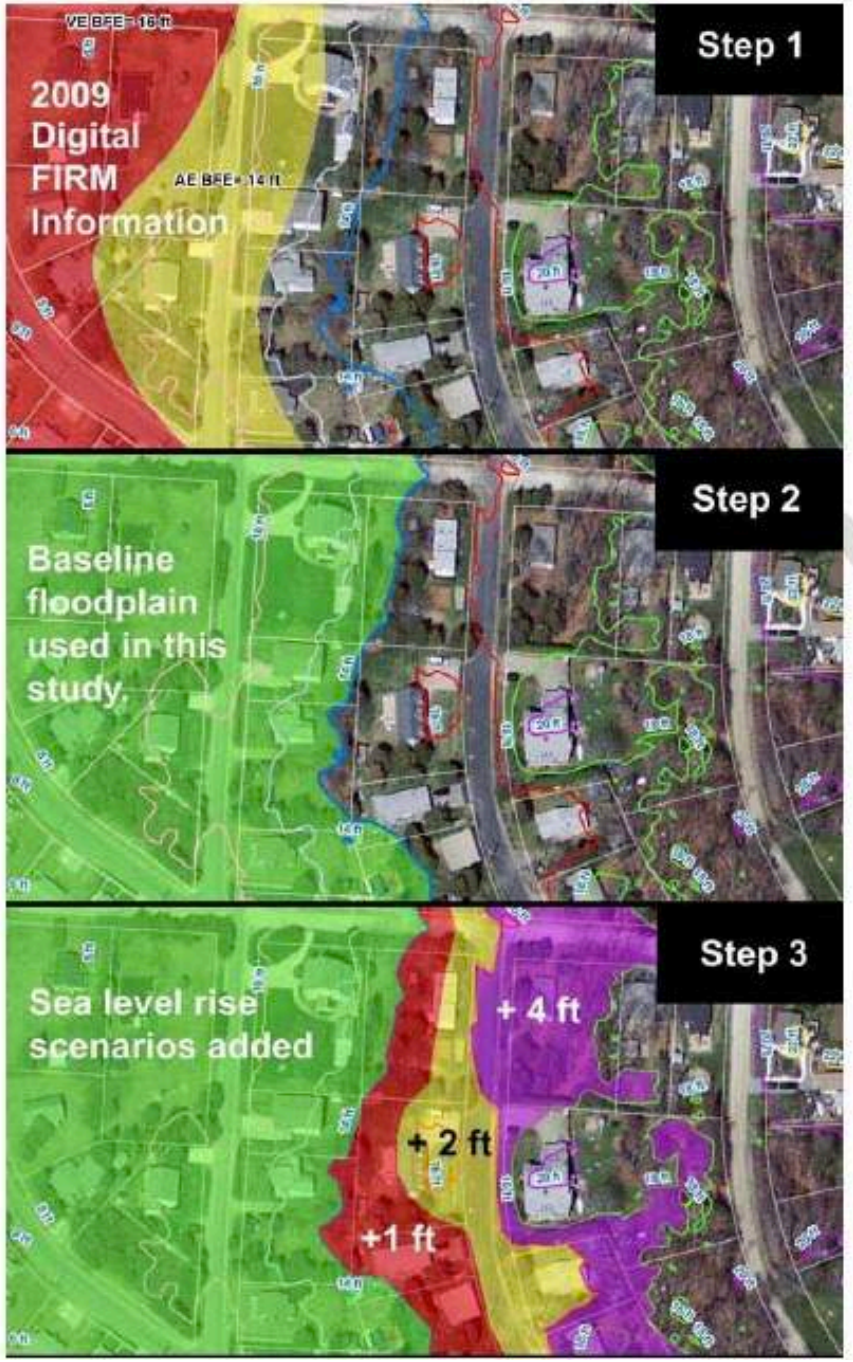
- Exacerbation of flooding/storms:
  - Increased frequency
    - 100 year flood possibly every 35 to 55 years
    - Greater occurrence of ponding
  - Increased intensity
    - Greater inundation extent
      - **Floodplain expansion**

Case study:

Projected Expansion of the Floodplain with Sea Level Rise in Wareham, Massachusetts

Buzzards Bay National Estuary Program and
Massachusetts Office of Coastal Zone Management



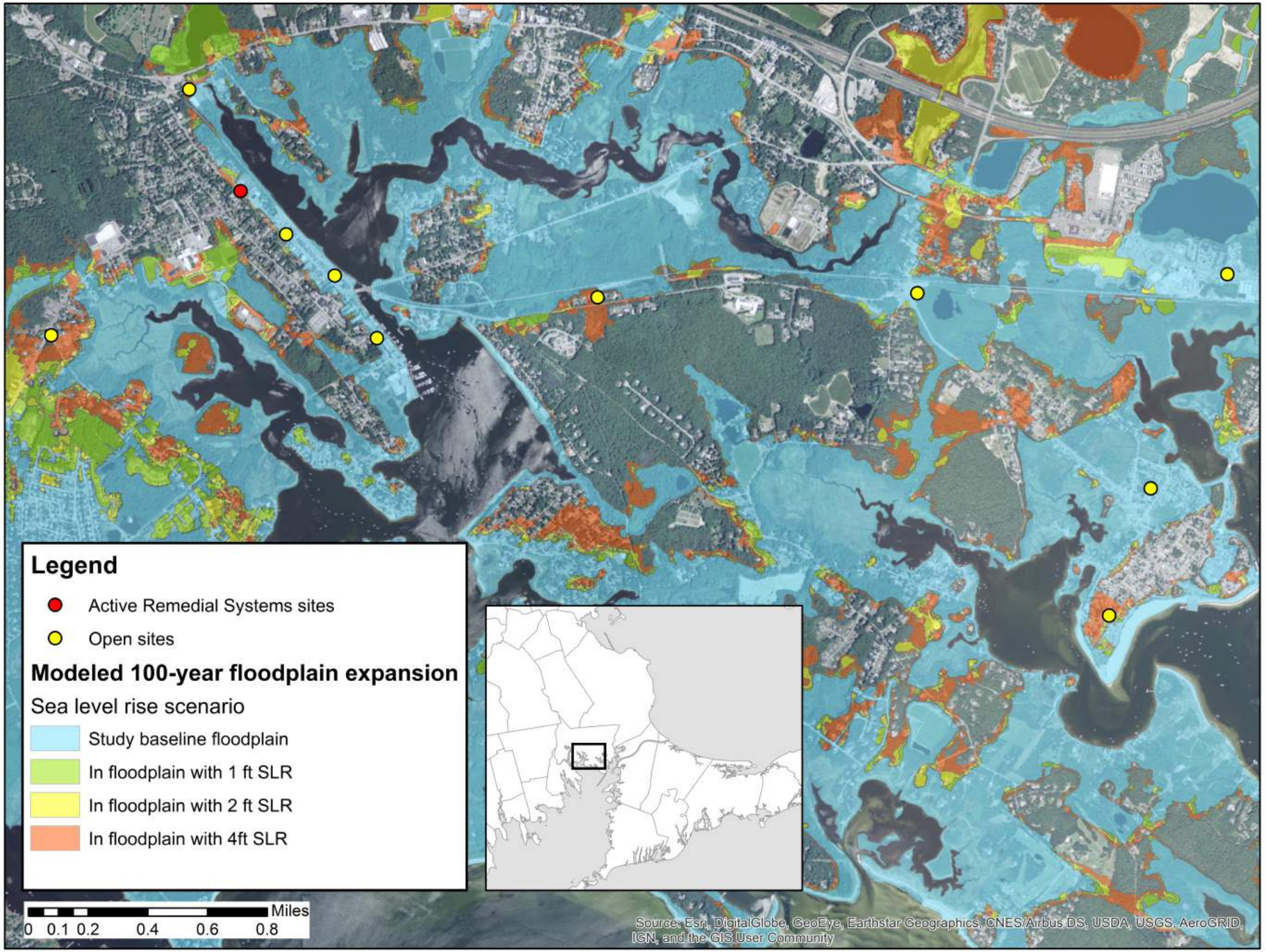
Comments

The baseline floodplain developed for this study was based on the base flood elevations and other information contained in the 2009 FIRM digital data set. At this site, the base flood elevation of the AE Zone or the 100-year storm was designated as 14-ft.

To ensure consistency of comparisons among the data sets, the baseline floodplain created for this study by precisely matched to the LiDAR contour elevations. In this case, the boundary was matched to the 14-ft LiDAR based contour line (blue line).

The process was continued for the +1-ft, +2-ft, and +4-ft sea level rise scenarios. If any portion of a house was in the new boundary, it was included in that sea level rise scenario. A house that crossed multiple boundaries was assigned to the lowest elevation.

Future vulnerability example: *Buzzards Bay Study – Wareham, MA (2013)*



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Remedy Vulnerability to Climate Change

Common Remedy Types*	Climate Change Scenarios							
	Flooding (Event)	Inundation (Chronic)	Extreme Storms	Large Snowfall	Wild Fires	Drought	Extreme Heat	Landslide (Precip)
Source In Situ								
SVE								
Solidification/Stabilization*								
In Situ Thermal Treatment								
Multi-phase Extraction								
Bioremediation								
Source Ex Situ								
Solidification/Stabilization*								
Physical Separation								
Recycling								
Surface Water Treatment								
Unspecified Off Site Treatment								
On-site Containment								
Groundwater In Situ								
Bioremediation								
Chemical Treatment								
Air Sparging								
Permeable Reactive Barrier								
Groundwater Ex Situ								
P&T								
Vertical Engineered Barrier								
Monitored Natural Attenuation								

Qualitative Vulnerability Analysis

* Most common remedy types based on Superfund Remedy Report

No known potential impacts

Minor impacts: Potential for temporary loss of remedy functionality or effectiveness, contaminant(s) remain contained

Moderate impacts: Potential for total loss of remedy functionality and effectiveness indefinitely, contaminant(s) remain contained

Major impacts: Potential for total loss of remedy functionality and effectiveness indefinitely, contaminant(s) release

Adaptation measures

- Site-specific
- Generally involve:
  - Raising/protecting electrical equipment
  - Using submerged pipes
  - Alert systems

	Climate Change Impacts					
	Temperature	Precipitation	Wind	Sea Level Rise	Wildfires	Potential Adaptation Measures for System Components
Groundwater Extraction or Containment System		◆				**Dewatering well system** *Installing additional boreholes at critical locations and depths to maintain target groundwater levels in the extraction/containment zone and reduce groundwater upwelling while not compromising the remediation system*
	◆	◆	◆	◆	◆	**Remote access** *Integrating electronic devices that enable workers to suspend pumping during extreme weather events, periods of impeded access, or unexpected hydrologic conditions*
	◆	◆	◆			**Well-head housing** *Building insulated cover systems made of high density polyethylene or concrete for control devices and sensitive equipment situated aboveground for long periods*
Aboveground Components of the Treatment System	◆	◆	◆	◆	◆	**Alarm networks** *Integrating a series of sensors linked to electronic control devices that trigger shutdown of the system, or linked to audible/visual alarms that alert workers of the need to manually shut down the system, when specified operating or ambient parameters are exceeded*
		◆	◆	◆		**Coastal hardening** *Building "soft" seawalls (through techniques such as replenishing sand and/or vegetation), jetties or groins to stabilize and shield a shoreline from erosion; in some cases, "hard" seawalls (such as those made of reinforced concrete) may be warranted*
	◆	◆		◆		**Concrete pad fortification** *Repairing concrete cracks, replacing pads of insufficient size or with insufficient anchorage, or integrating retaining walls along the pad perimeter*
					◆	**Fire barriers** *Creating buffer areas (land free of dried vegetation and other flammable materials) around the treatment system and installing manufactured systems (such as radiant energy shields and raceway fire barriers) around heat-sensitive components*
		◆		◆		**Flood controls** *Building one or more structures to retain or divert floodwater, such as vegetated berms, drainage swales, levees, dams or retention ponds*
	◆	◆	◆	◆	◆	**Power from off-grid sources** *Constructing a permanent system or using portable equipment that provides power generated from onsite renewable resources, as a primary or redundant power supply that can operate independent of the utility grid when needed*
		◆	◆	◆		**Relocation** *Moving the system or its critical components to positions more distant or protected from potential hazards; for flooding threats, this may involve elevations higher than specified in the community's flood insurance study)*

EPA Climate Change Adaptation Factsheet – Groundwater remediation systems

Adaptation resources

EPA Climate Change Adaptation Fact sheets:

- Groundwater remediation:
  - https://semspub.epa.gov/work/HQ/175851.pdf
- Landfills/containment as element of remediation:
  - https://semspub.epa.gov/work/HQ/175853.pdf
- Sediment containment remediation:
  - https://semspub.epa.gov/work/HQ/177110.pdf

Profile of three EPA Superfund sites' adaptation measures:

- https://clu-in.org/products/newsltrs/tnandt/view_new.cfm?issue=0514.cfm

Thank you!