Sea Level Rise and Coastal Flooding: A Case Study of Metro Boston

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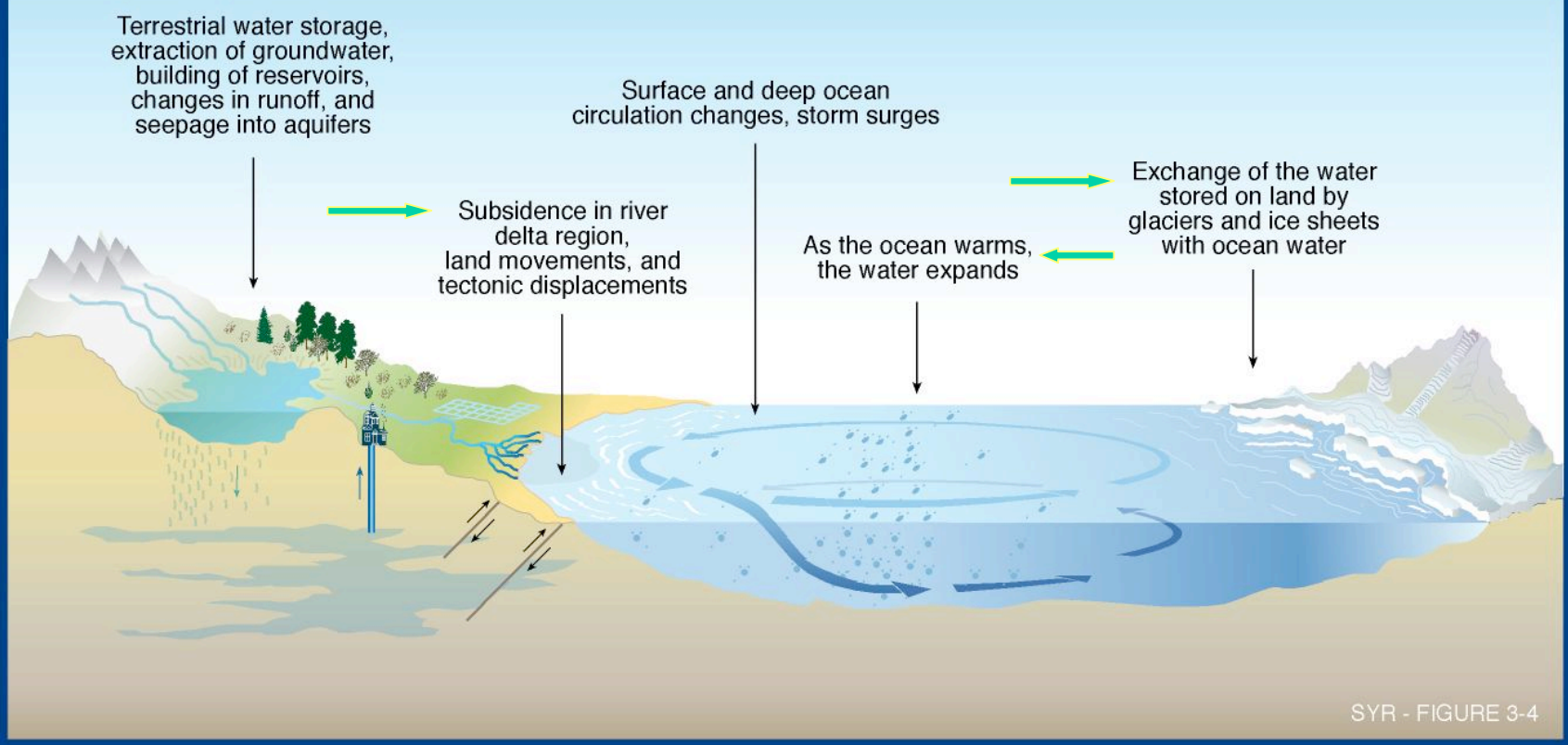
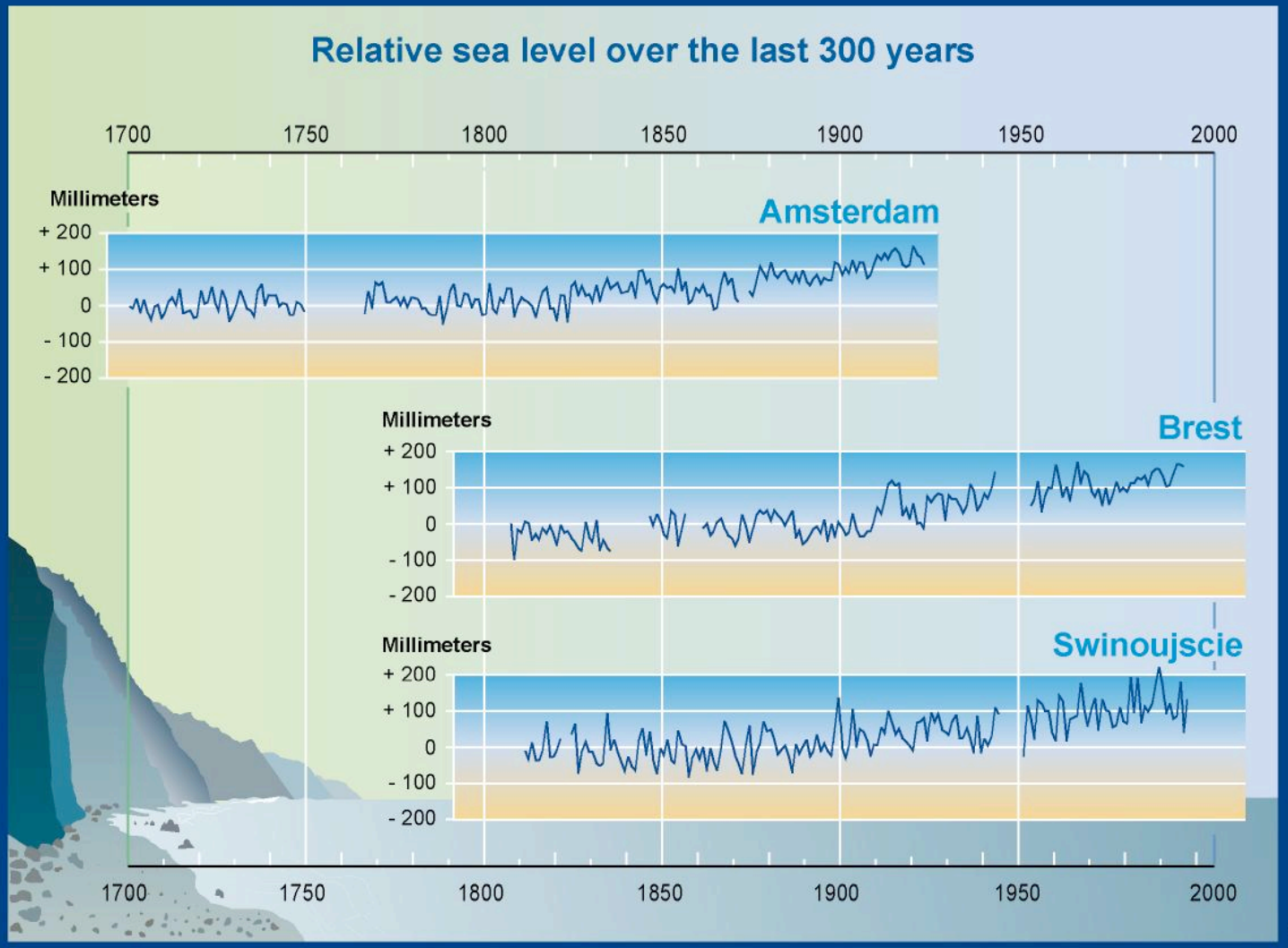
What causes the sea level to change?



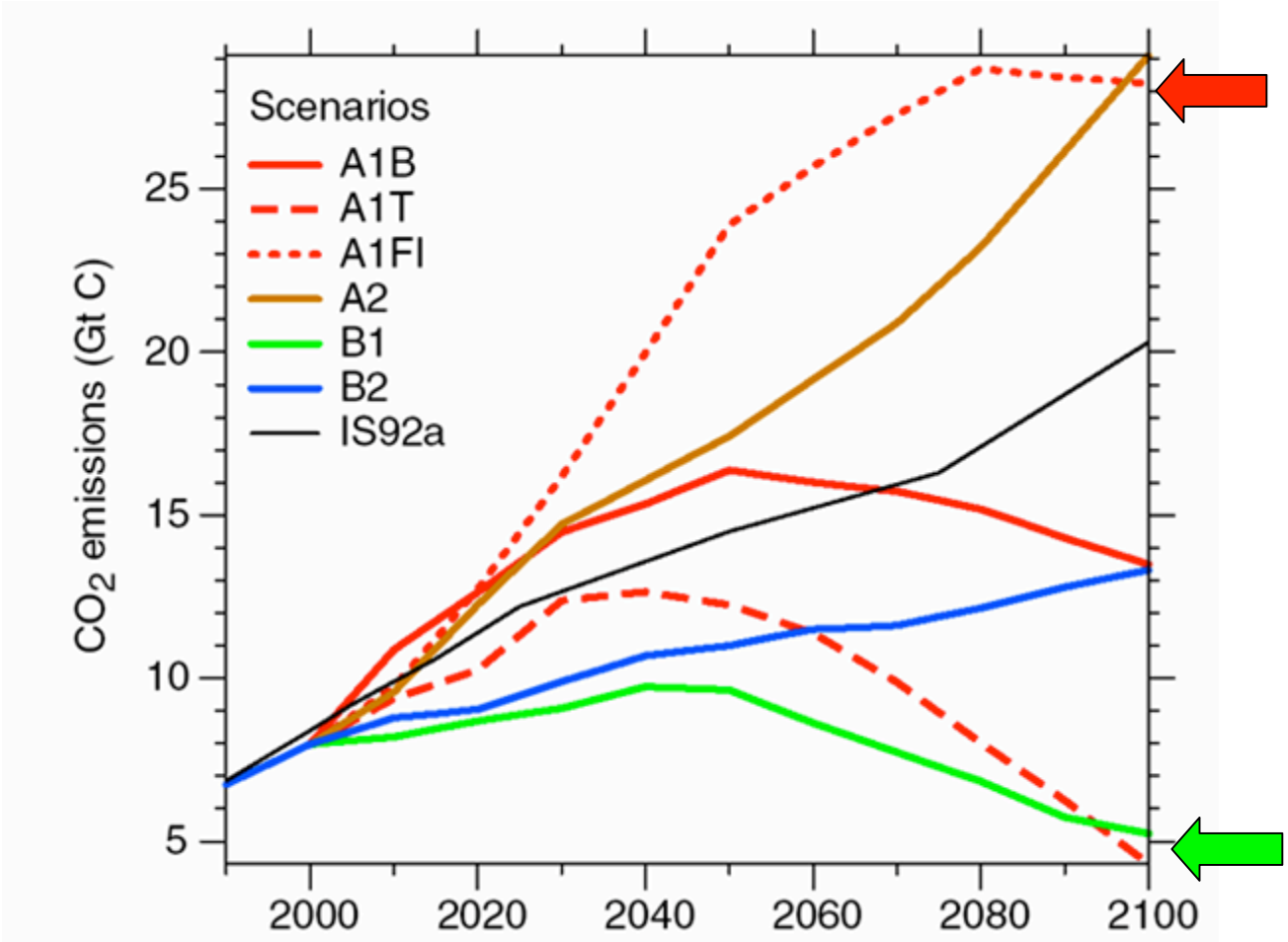
Sea Level Rise

- Eustatic sea level rise = thermal expansion and ice melt
- Subsidence = local rate of settling
- Relative sea level rise = eustatic sea level rise & subsidence
- Global historic eustatic sea level rise = ~1.8 mm/year, 1961-2003
- N Year Flood = land area that is flooded on the average 1 every N years or has probability of being flooded each year of 1/N % (eg note that 100 year flood has a 22 % of being equaled or exceeded in a 25 year period)

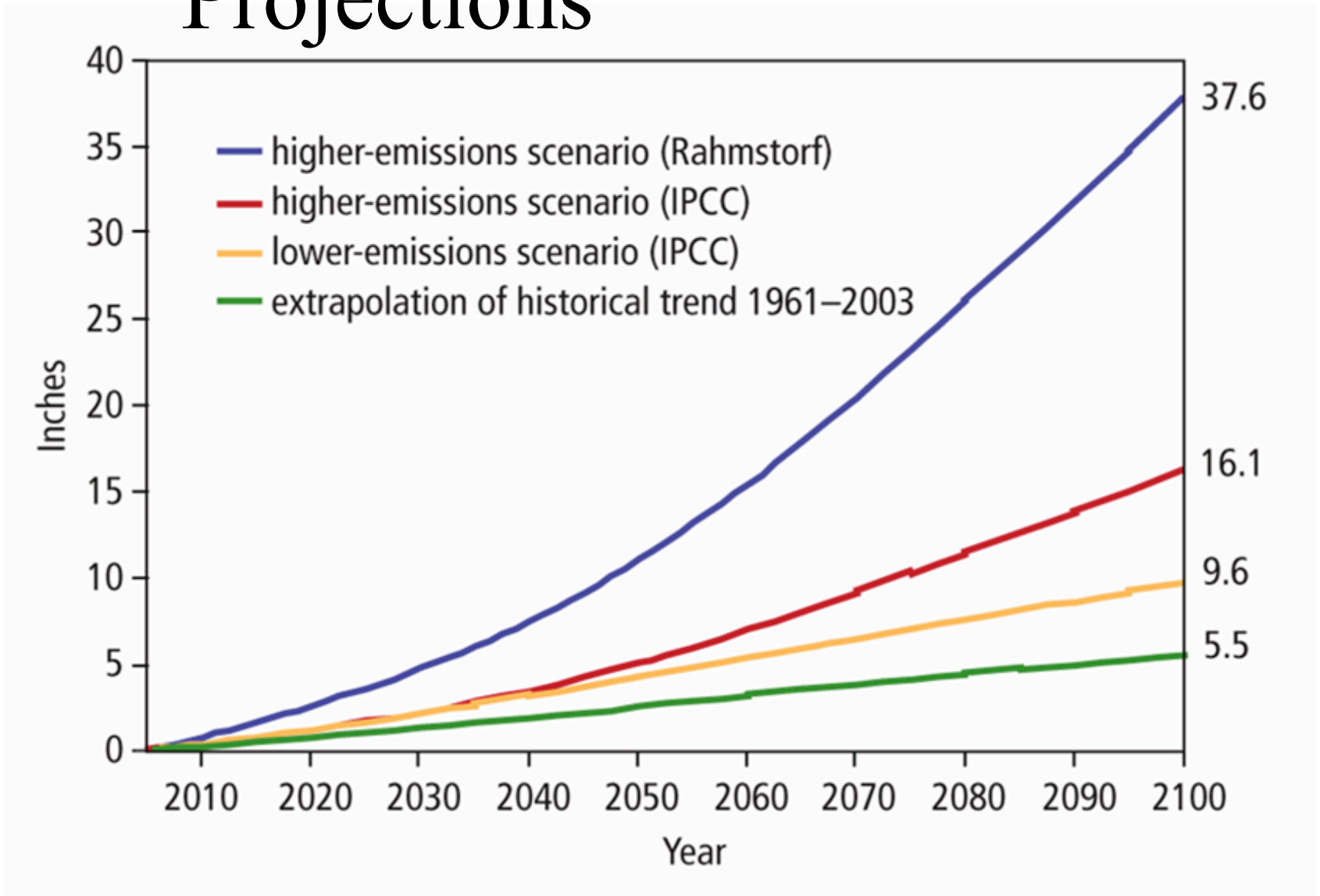


SYR - FIGURE 2-5

Emission Scenarios



Eustatic Sea Level Rise Projections



Increased Coastal Flooding under Climate Change

AP Photo/Michael Dwyer

-Higher sea levels

-More intense storms

-Changing Shorelines

-Higher Coastal Populations

Dr. Norbert Psuty

Estimates of Population (millions) in 1000 Year Floodplain in 1990 and 2080

Assumes low subsidence and population estimates, HadCM3 GCM

Region	1990 (baseline)	SRES scenarios (and sea-level rise scenario in metres)			
		A1FI (0.34)	A2 (0.28)	B1 (0.22)	B2 (0.25)
Australia	1	1	2	1	1
Europe	25	30	35	29	27
Asia	132	185	376	180	247
North America	12	23	28	22	18
Latin America	9	17	35	16	20
Africa	19	58	86	56	86
Global	197	313	561	304	399

From Nicholls (2004)


N
Pointer 40°38'53.33" N 71°08'37.04" W
Streaming 100%
Eye alt 679.71 mi

Northeast Climate Impacts Assessment

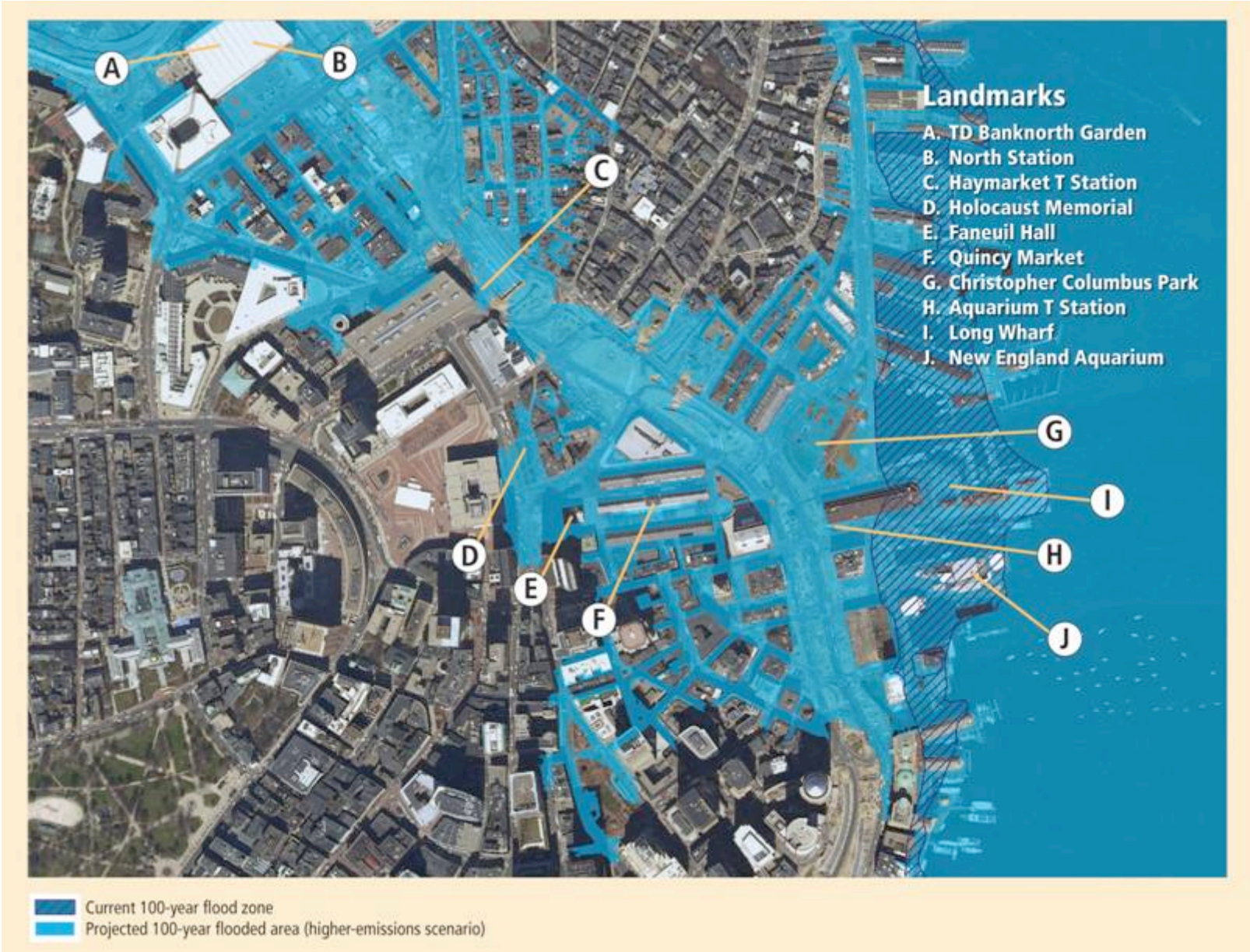
Table of Future Recurrence Intervals

		100-yr Storm Surge Elevation at MHHW (feet NAVD)				Recurrence Interval of 2005 100 -yr Anomaly (years)	
Station	Scenario	2005	2030	2050	2100	2050	2100
Boston	B1 (mid -range)	9.7	10.2	10.7	11.8	3	<<2
	A1FI (mid -range)	9.7	10.2	10.7	12.3	2	<<2
Woods Hole	B1 (mid -range)	10.0	10.2	10.5	11.1	51	21
	A1FI (mid -range)	10.0	10.2	10.5	11.6	46	9
New London	B1 (mid -range)	7.4	7.6	7.8	8.3	61	32
	A1FI (mid -range)	7.4	7.6	7.8	8.9	56	17
New York City	B1 (mid -range)	9.0	9.3	9.5	10.2	50	22
	A1FI (mid -range)	9.0	9.3	9.6	10.7	46	11
	Rahmstorf (mid -range)	9.0	9.5	10.1	12.5	24	<2
Atlantic City	B1 (mid -range)	7.7	8.7	9.5	11.6	4	<<2
	A1FI (mid -range)	7.7	8.7	9.6	12.1	4	<<2

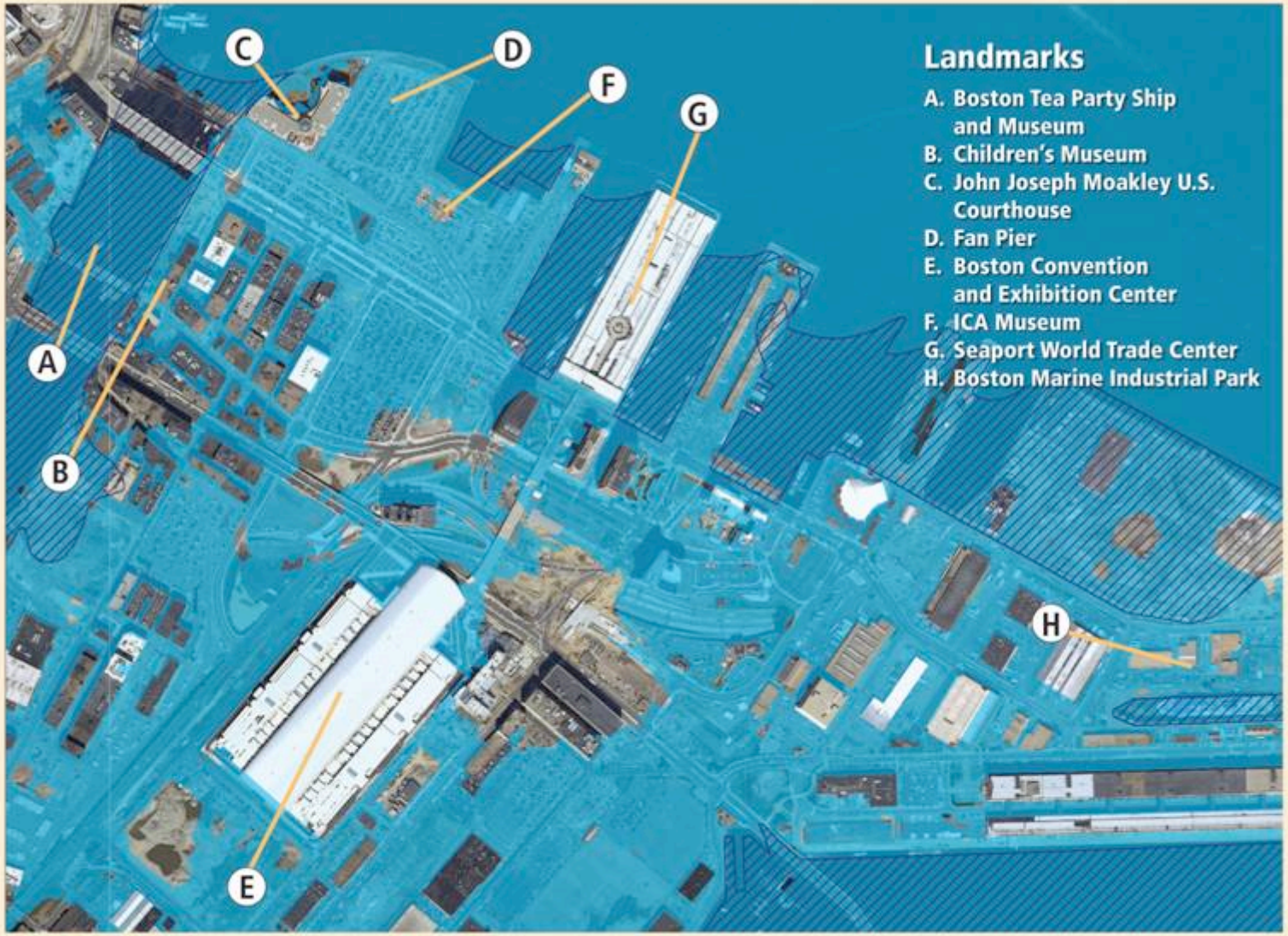
Estimated storm surge elevations for 2005, 2050 and 2100 for each site. Also included are the recurrence intervals in 2050 and 2100 for the 2005 100 -year storm surge elevation

Based on 7.06.07 table

Coastal Flooding in Boston under Present and High Emission Sea Levels

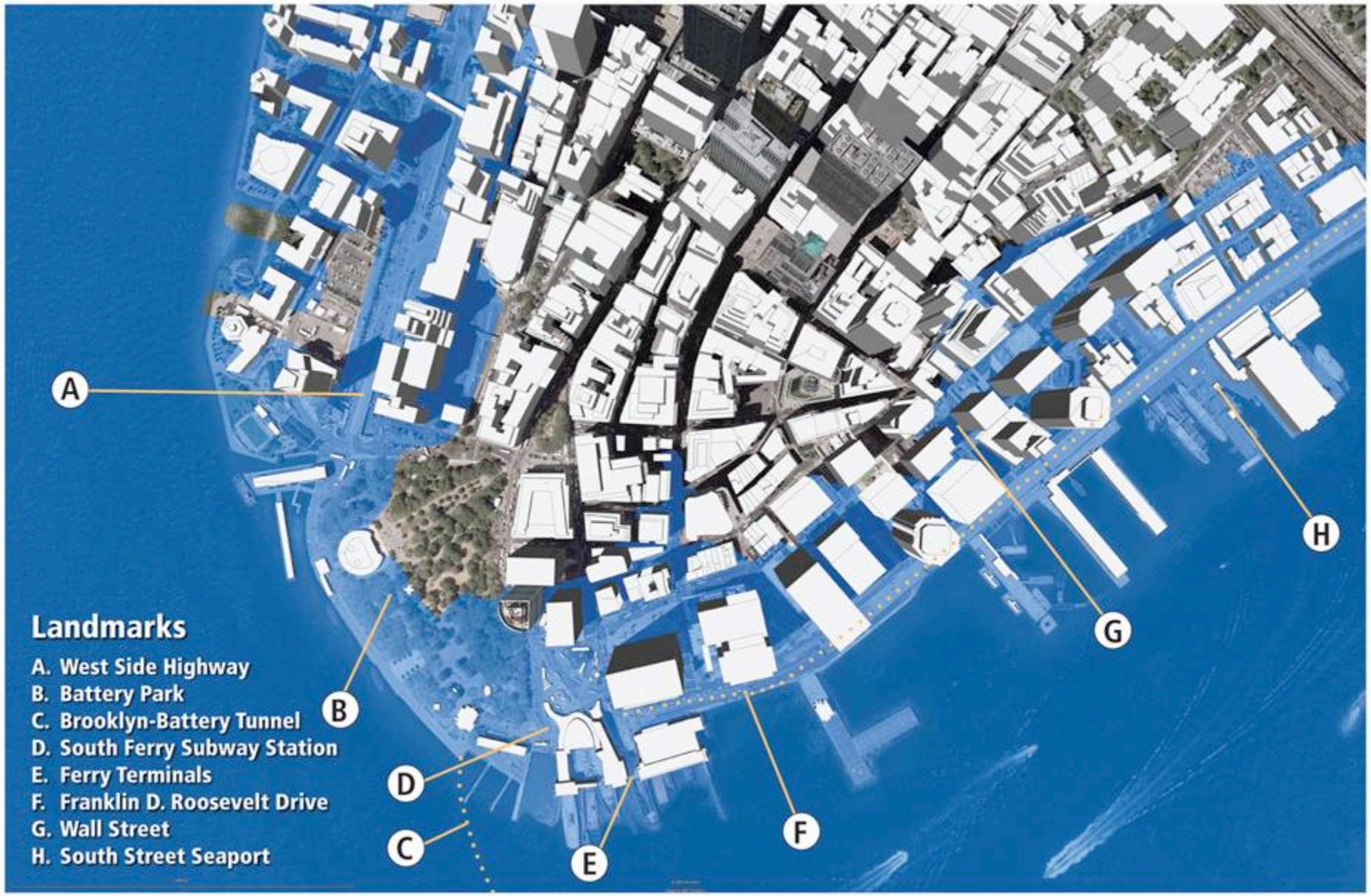


Source: NECIA/UCS, 2007 (see: www.climatechoices.org/ne/)



Source: NECIA/UCS, 2007 (see: www.climatechoices.org/ne/)

NYC Present 100 Year Flood and 2050 ~50 Year Flood under Both Emission Scenarios



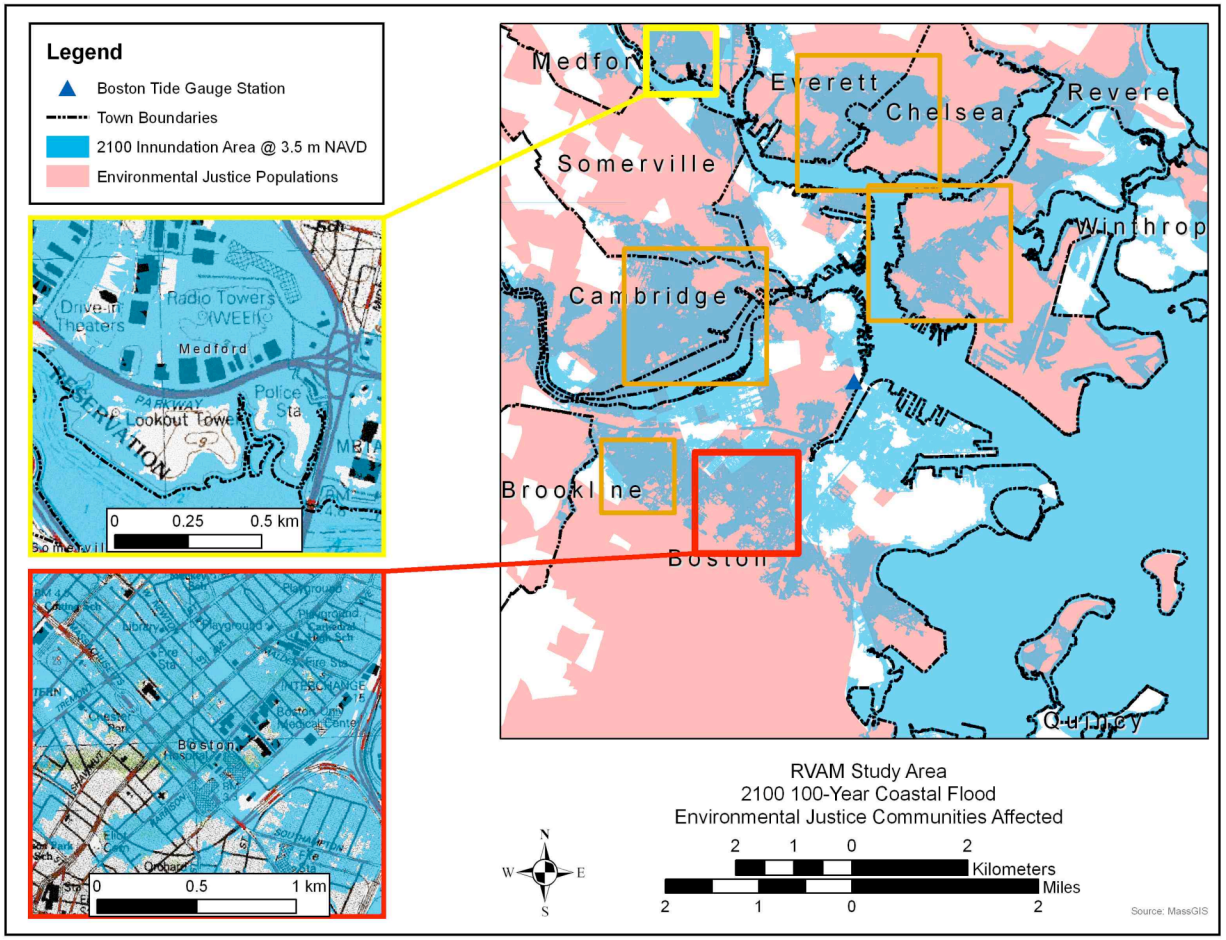
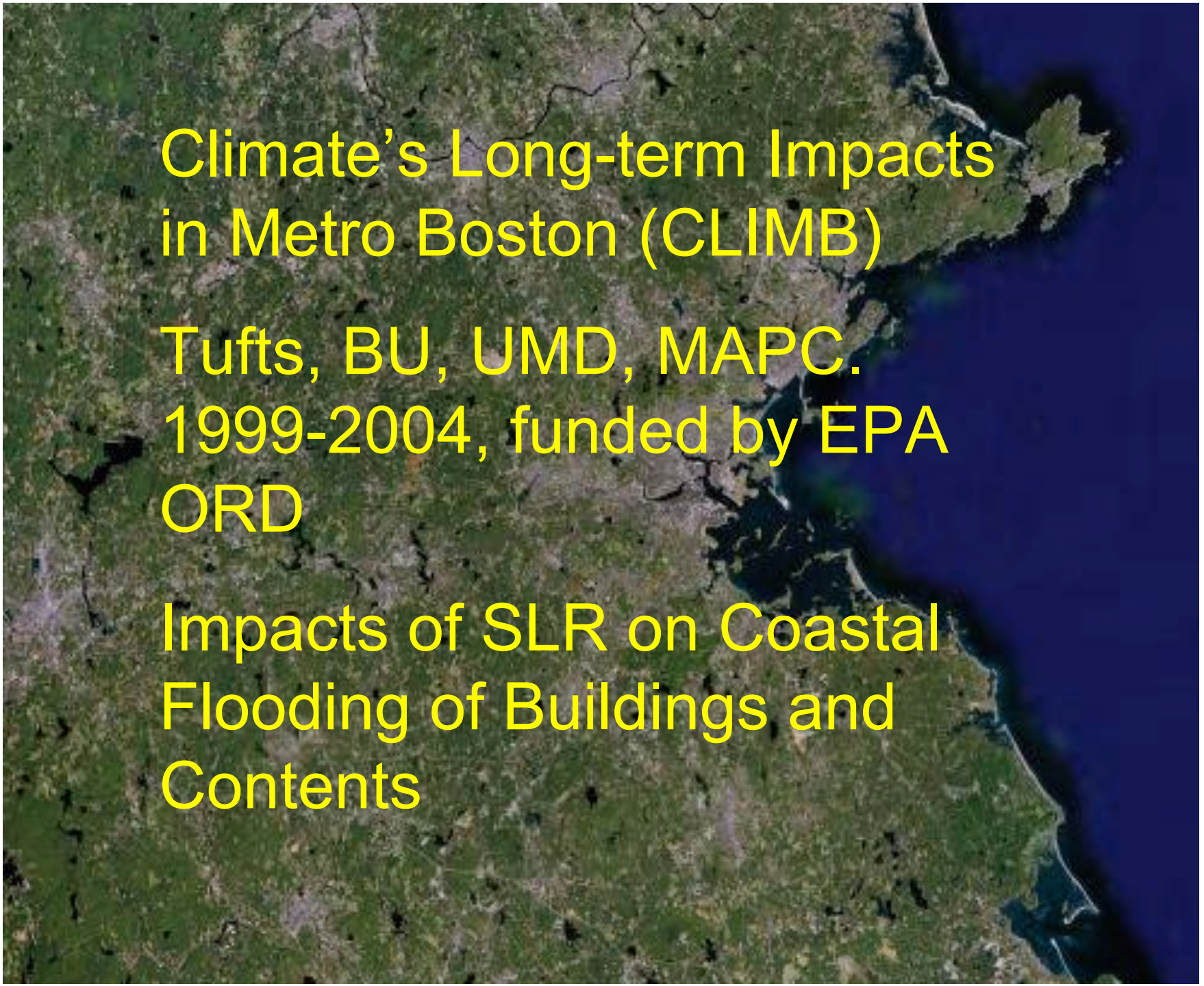
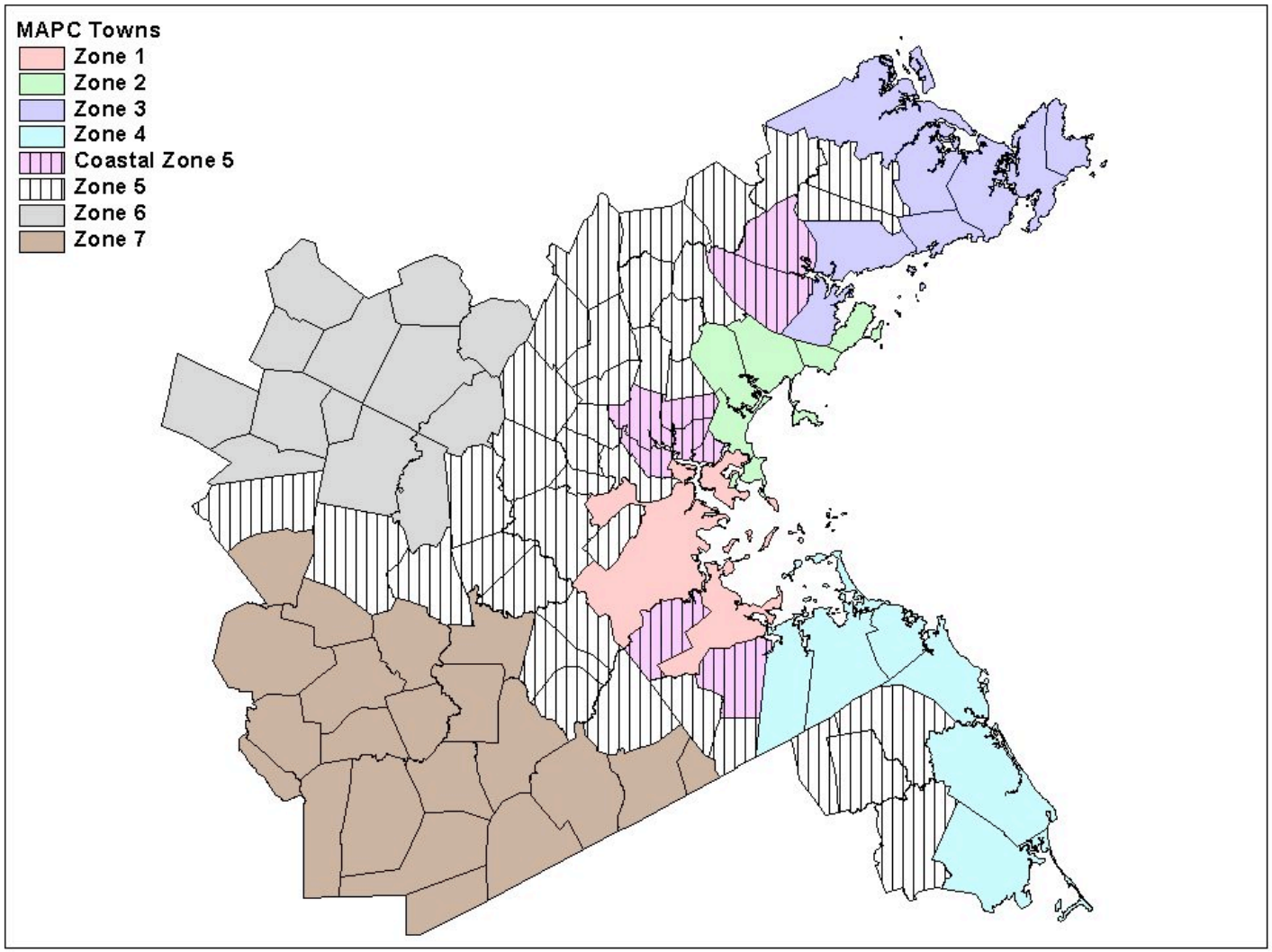


Figure 1: Preliminary identification of environmental justice populations vulnerable to coastal flooding events by the year 2100 (source: Watson, C. 2007. Assessing the vulnerability of Metropolitan Boston to increased coastal flooding due to sea level rise, unpublished Master's project paper, University of Massachusetts, Boston.)


Climate's Long-term Impacts in Metro Boston (CLIMB)
Tufts, BU, UMD, MAPC. 1999-2004, funded by EPA ORD
Impacts of SLR on Coastal Flooding of Buildings and Contents

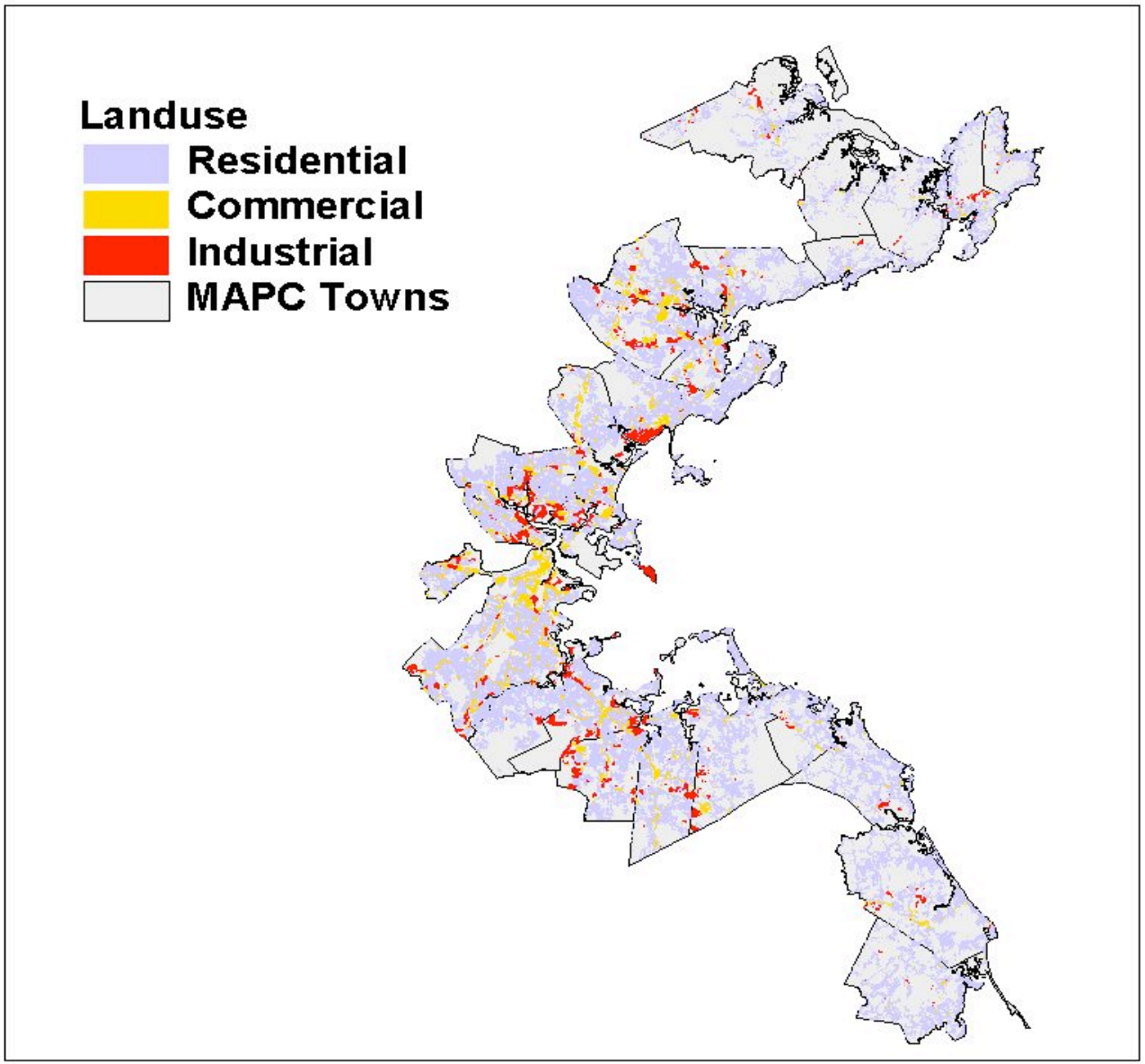
The MAPC Area



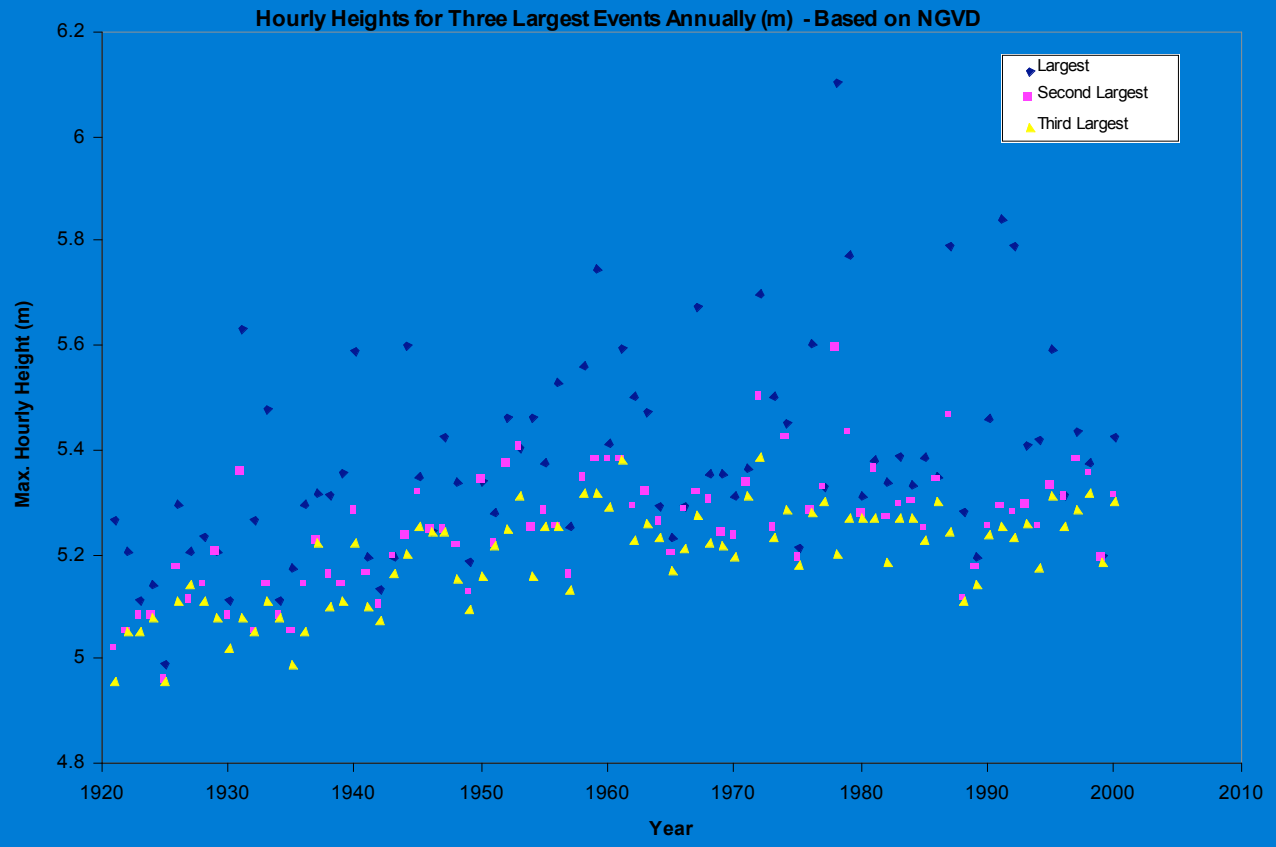
Study Area Overview

- 32 coastal municipalities in 5 zones
  - 1.2 million people
  - 110,000 hectares
    - Residential area = 40,000 hectares
    - Commercial area = 5,000 hectares
    - Industrial area = 3,000 hectares

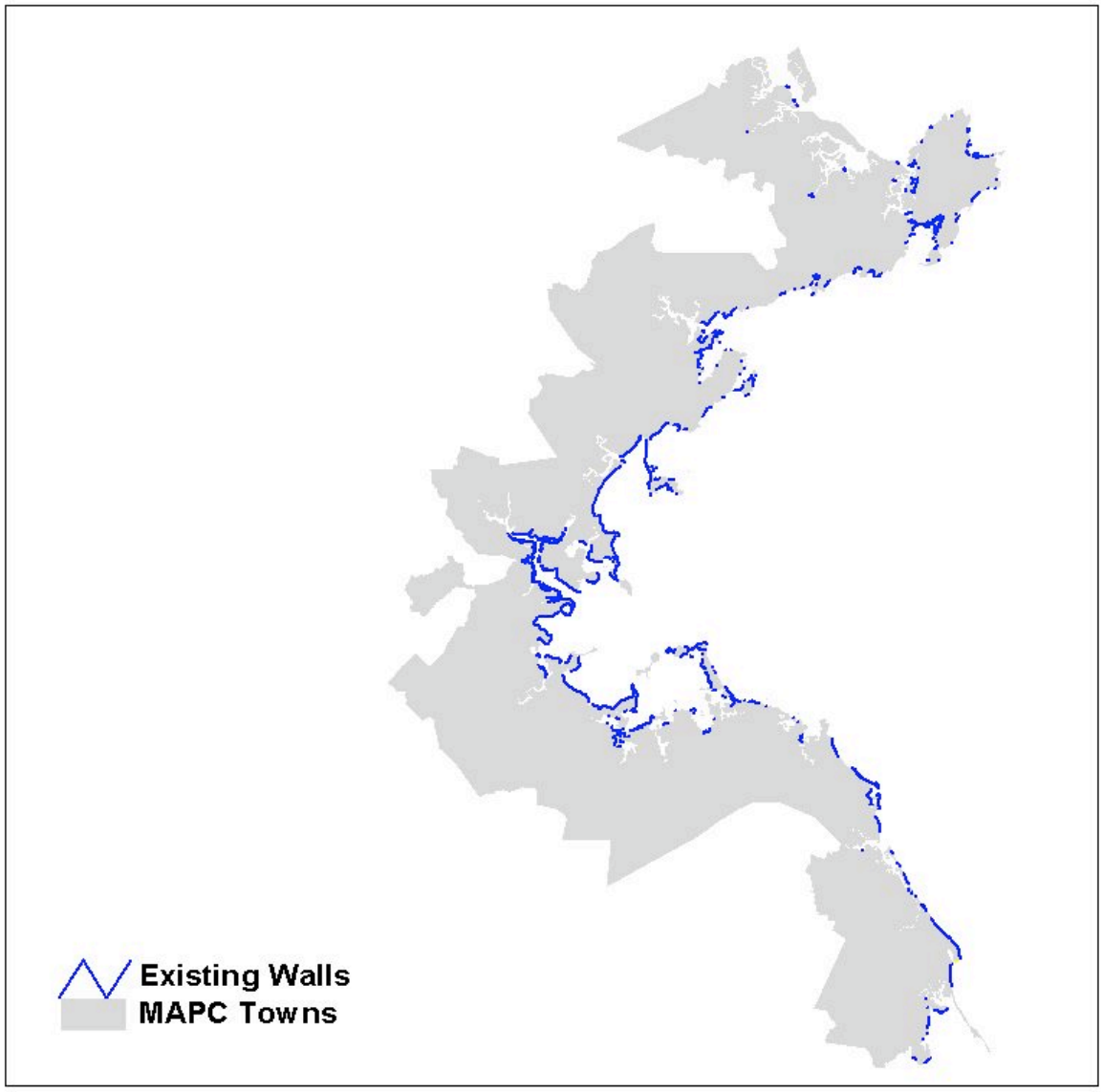
Current Landuse



NOS Gage Data - Boston

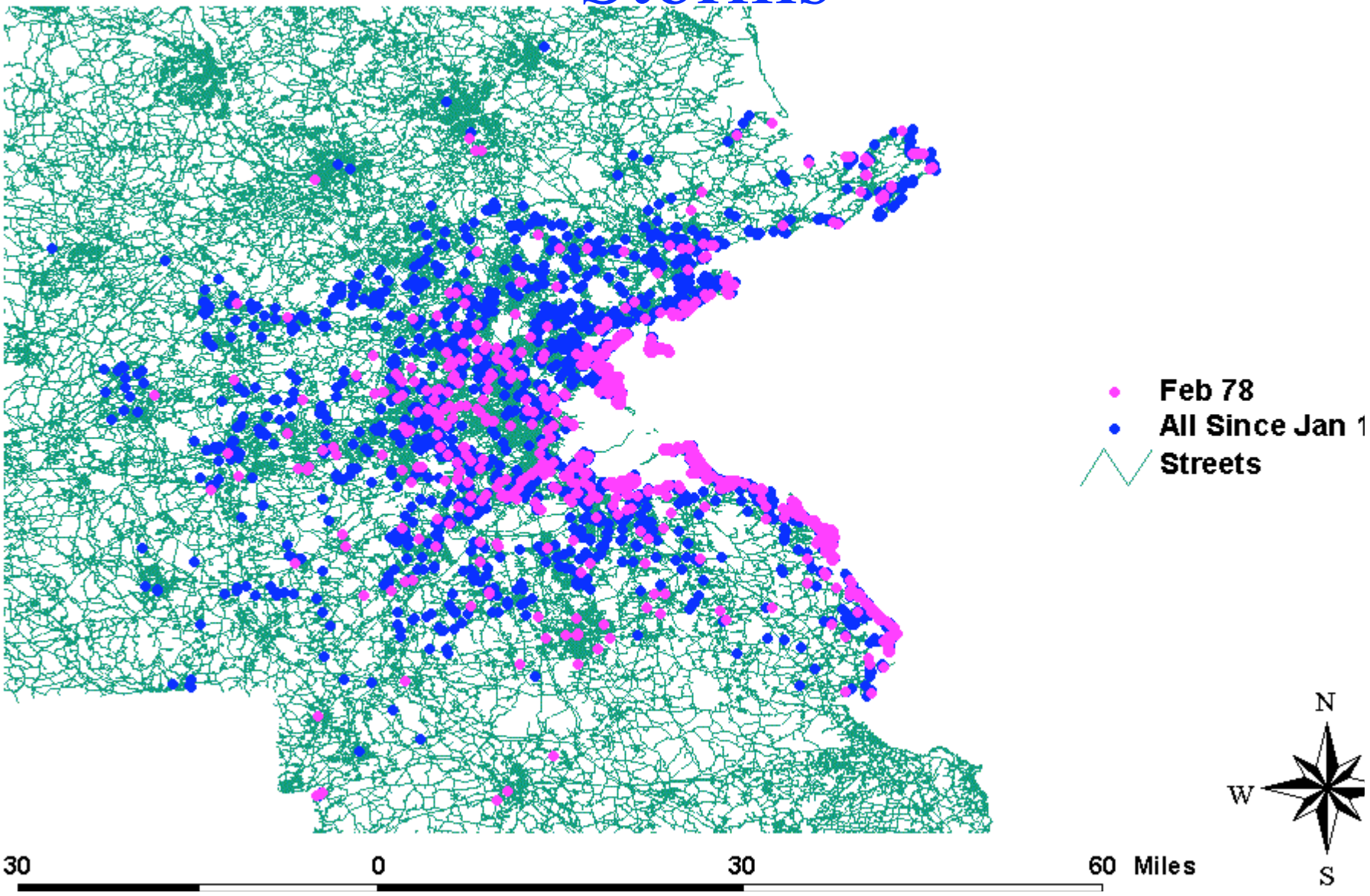


Current Coastal Protection

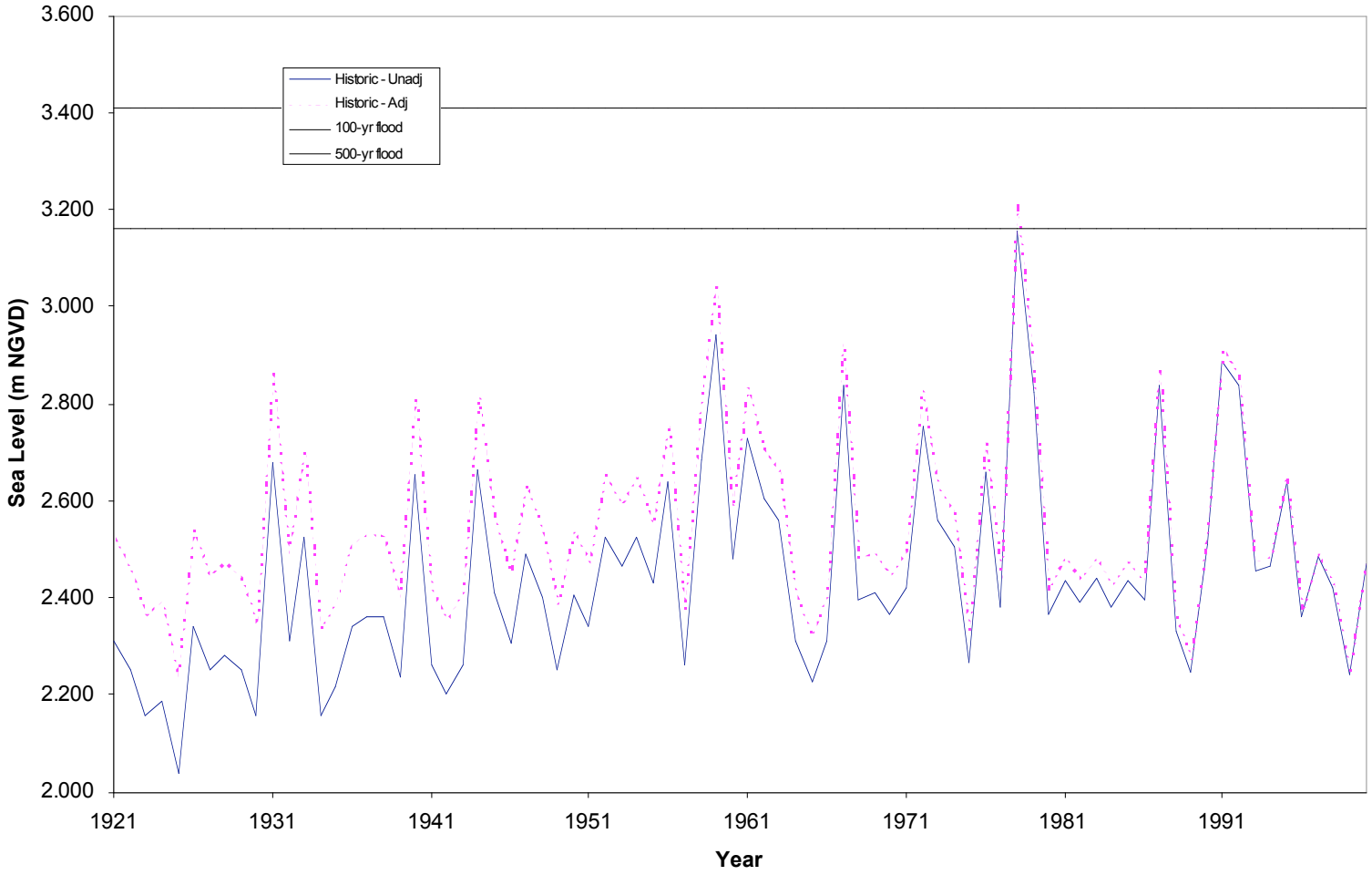


Current Coastal Protection

FEMA Reported Damages From Storms

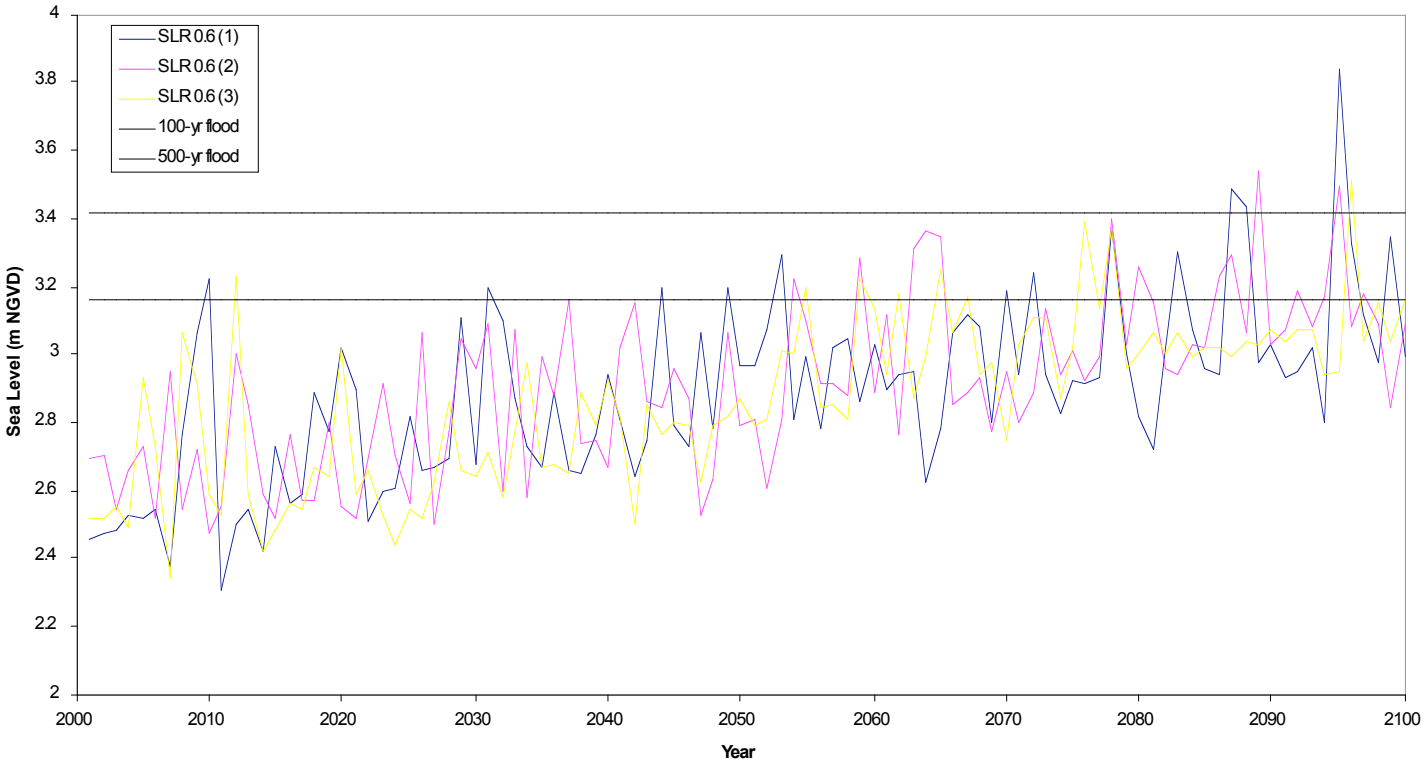


Maximum Annual Boston Sea Level; Measured and Adjusted



Storm Surge Flooding

Sample Bootstraps



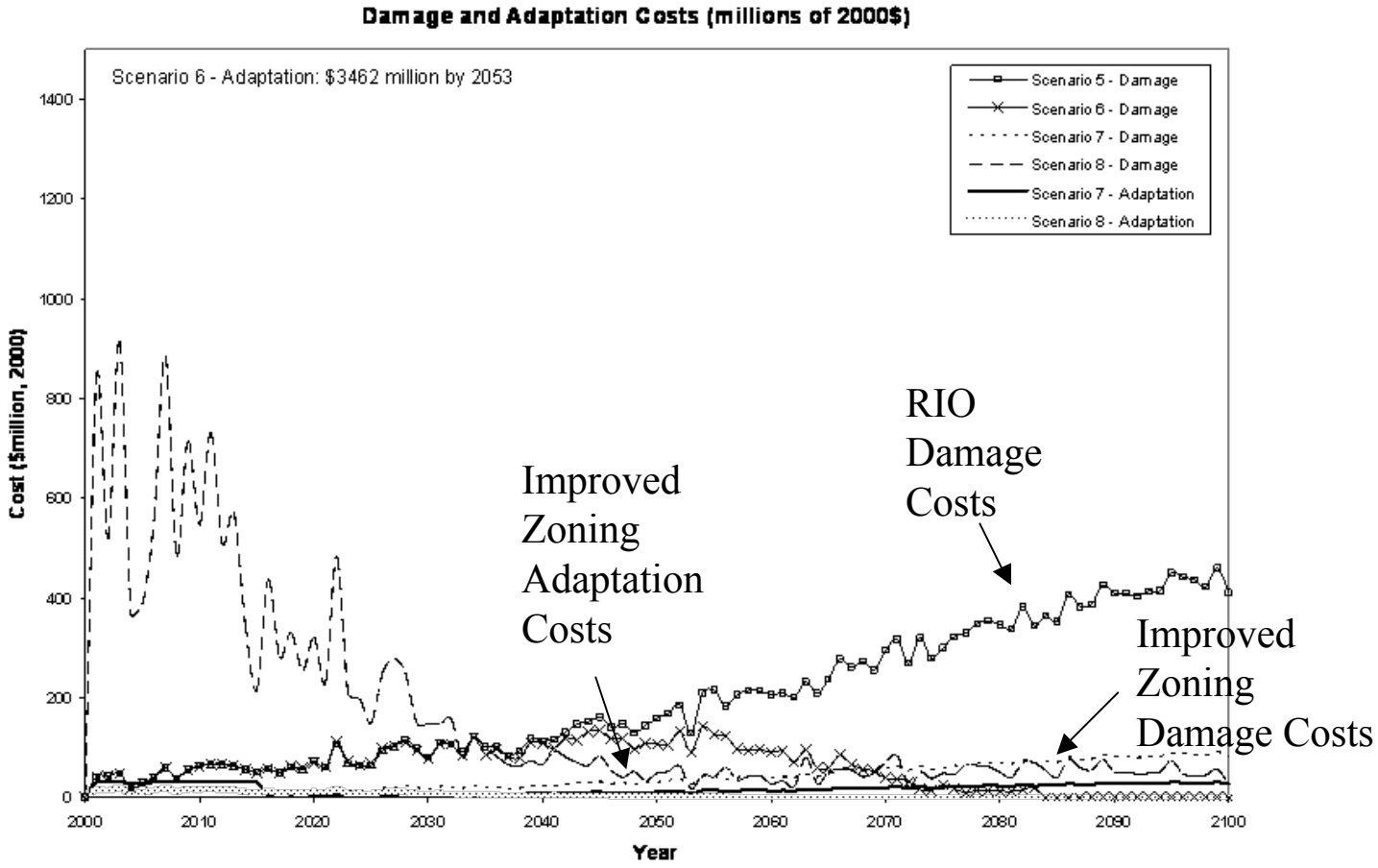
Adaptation

- **Do Nothing**
- **Protection** attempts to manage the hazard with "hard" structures such as seawalls and groins or “soft” measures such as beach nourishment.
- **Accommodation** allows human activities and the hazard to coexist through actions such as flood proofing.
- **Retreat** removes human activity from the hazard area which generally is accomplished by abandoning land as the sea rises.

Metro Boston Total Costs ($ million) of Damages and Adaptation (2000-2100)

Model Run	Residential	Commercial/ Industrial	Emergency	Adaptation	Total
Baseline - Growth, One Event	1205	4305	937	0	6447
Ride-It-Out - 0.6m SLR, One Event	3563	13525	2905	0	19993
Build-Your-Way-Out - 0.6m SLR, 1 Event	1091	3984	863	3462	9400
Green - 0.6m SLR, One Event	756	2697	587	1766	5806
Retreat – 0.6m SLR, One Event	5093	9142	2420	500	17155
Ride-It-Out – One meter SLR, One Event	6131	25014	5295	0	36440
Build-Your-Way-Out - One meter SLR, One Event	969	3613	779	3462	8823
Green - One meter SLR, One Event	1268	4959	1059	2897	10183
Retreat – One meter SLR, One Event	5564	9632	2583	546	18325

CZM in Metro Boston
Example of Proactive Adaptation



Source: CLIMB Study

Maine Sand Dune Rules (revised in 1993)

- “Prohibits new hardening structures (eg seawalls)
- Allows repair or maintenance of existing structures only if failing would cause unreasonable flooding hazards
- Does not allow any structure more than 50 percent damaged in a storm to be rebuilt unless permittee can demonstrate with clear and convincing evidence that building site will remain stable after allowing for 3 ft rise in sea level over 100 years.”

From Moser(2005)

Flood Insurance Reform and Modernization Act of 2007 (HR 3121, proposed)

- (C) EFFECTS OF GLOBAL WARMING- In updating and maintaining maps under this section, the Director shall--
- (i) take into consideration and account for the impacts of global climate change on flood, storm, and drought risks in the United States;
- `(ii) take into consideration and account for the potential future impact of global climate change-related weather events, such as increased hurricane activity, intensity, storm surge, sea level rise, and associated flooding; and
- `(iii) use the best available climate science in assessing flood and storm risks to determine flood risks and develop such maps.

Majority Supreme Court opinion (No. 05-1120, decided April 2, 2007) that the US Environmental Protection Agency has the authority to regulate greenhouse gases in automobile emissions.

SUPREME COURT OF THE UNITED STATES

No. 05–1120

MASSACHUSETTS, ET AL., PETITIONERS *v.* ENVIRONMENTAL PROTECTION AGENCY ET AL.

ON WRIT OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE DISTRICT OF COLUMBIA CIRCUIT

[April 2, 2007]

JUSTICE STEVENS delivered the opinion of the Court.

A well-documented rise in global temperatures has coincided with a significant increase in the concentration of carbon dioxide in the atmosphere. Respected scientists believe the two trends are related. For when carbon dioxide is released into the atmosphere, it acts like the ceiling of a greenhouse, trapping solar energy and retarding the escape of reflected heat. It is therefore a species—the most important species—of a "greenhouse gas."

Calling global warming "the most pressing environmental challenge of our time,"[1] a group of States,[2] local governments,[3] and private organizations,[4] alleged in a

as a landowner. The severity of that injury will only increase over the course of the next century: If sea levels continue to rise as predicted, one Massachusetts official believes that a significant fraction of coastal property will be "either permanently lost through inundation or temporarily lost through periodic storm surge and flooding events." *Id.*, ¶6, at 172.[20] Remediation costs alone, petitioners allege, could run well into the hundreds of millions of dollars. *Id.*, ¶7, at 172; see also Kirshen Decl. ¶12, at 198.[21]

Causation

EPA does not dispute the existence of a causal connection between man-made greenhouse gas emissions and


Thank you very much

- Tufts University, University of Maryland, Boston University

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Sea Level Rise

Projections:

- Canadian Climate Center (CCC)
  - 0.41 meter increase by 2100
  - Accounts for thermal expansion alone, not ice melt or subsidence
- The Hadley Center
  - 0.3 to 0.5 meter increase by 2100
  - Accounts for thermal expansion and ice melt, not subsidence
- Subsidence
  - 0.20 meter by 2100

- Relative Range

  - 0.61m to 0.70m

NOTE: new range is 0.38m (unlikely) to over one meter !