NASA-Rio UCCRN Training Partnership:

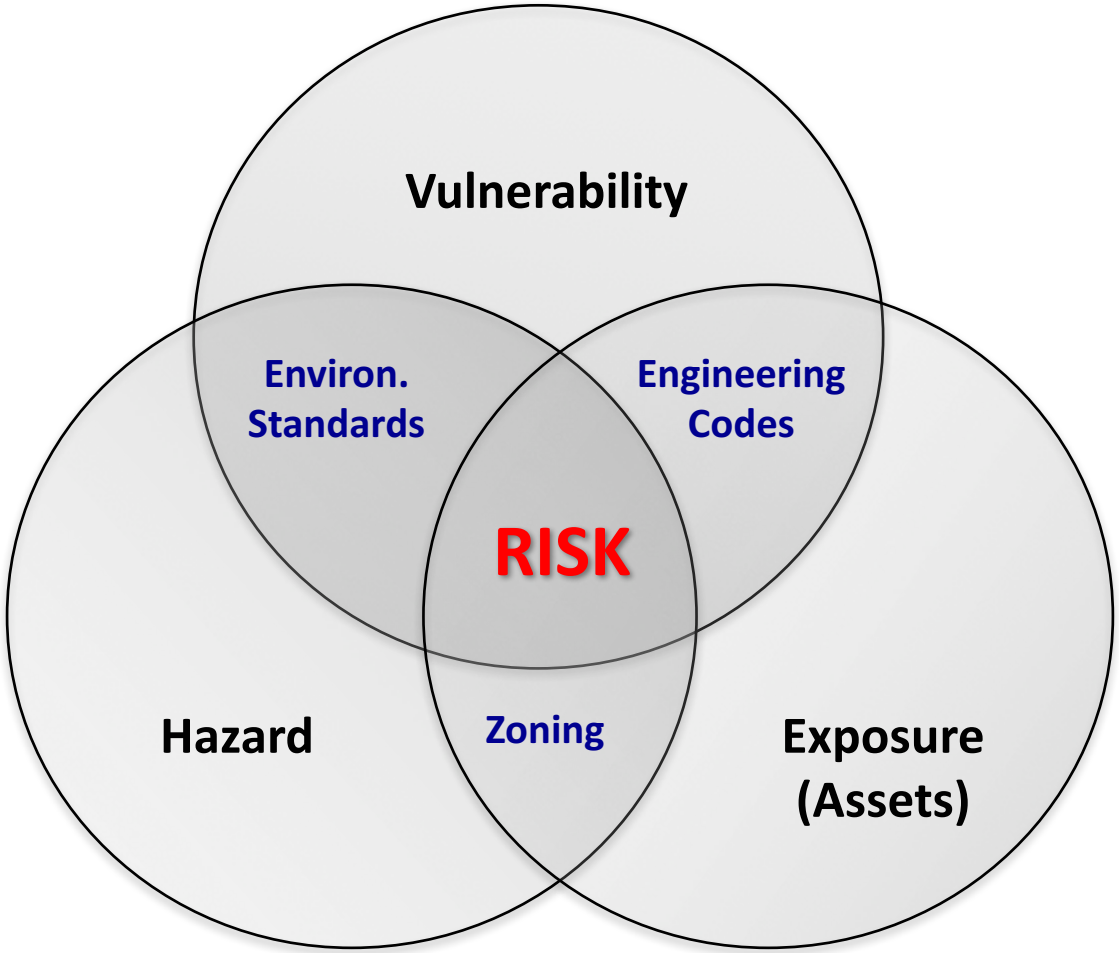
Columbia University/NASA Goddard Institute for Space Studies,
Day 2: Tuesday, November 15, 2016

Sculpture by Isaac Cordal in Berlin: Politicians discussing global warming

Sea Level Rise, Urban Heat Islands, and Water Quality

Klaus H. Jacob
jacob@ldeo.columbia.edu
Lamont-Doherty Earth Observatory &
Earth Institute/School of Professional Studies, Columbia University
M.S. Program in Sustainability Management

Some Risk Management Options:



NYC Climate Change Adaptation Before, During and Since 'Sandy'.

In Brief:

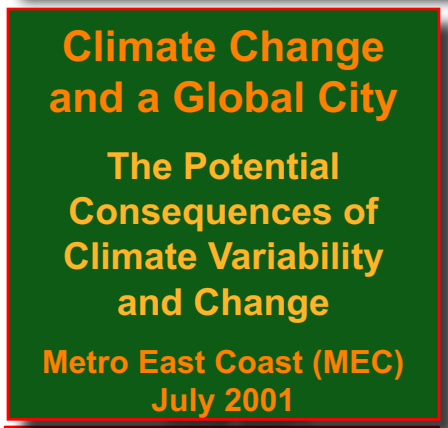
Before: Smart (YES, Many Good Studies; NYC-NPCC, ClimAID); Action (YES on CC Mitigation, Little on CC Adaptation)

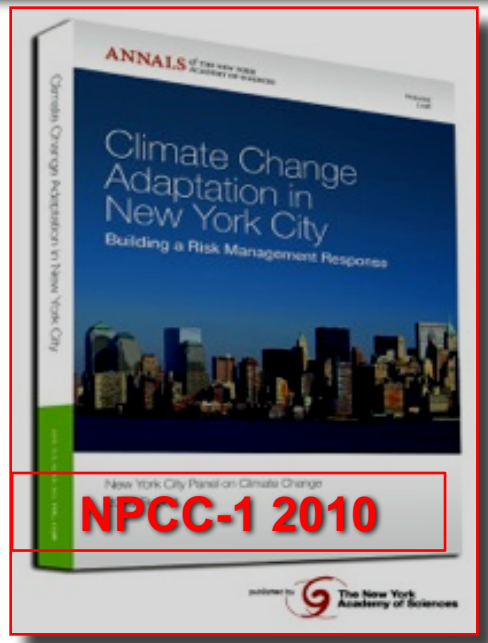
During: Some Very Good, Some Not So Good Response

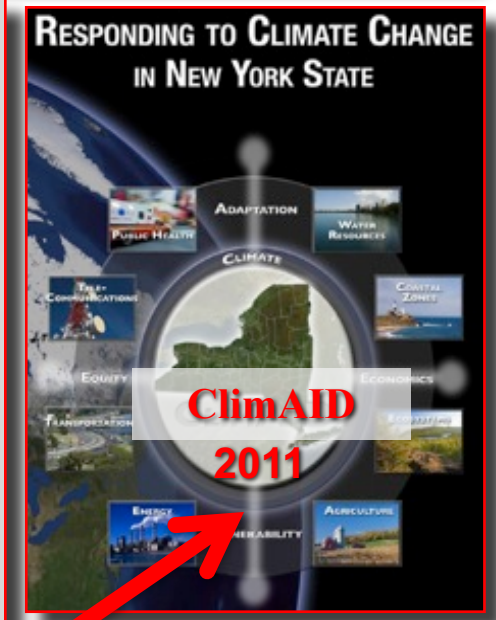
Since: Many New Plans (SIRR, 80%x2050, RBD, NY Rising, Some Action (Codes, Flood Maps, ……; modest $$$)

But Little on Long-term, Sustainable Resilience (≥ 2050s)

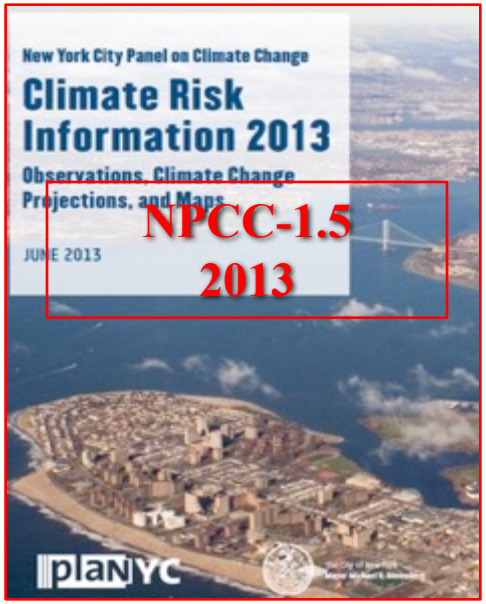
Many Excellent Studies & Reports, but Sparse Action & $$'s available todate

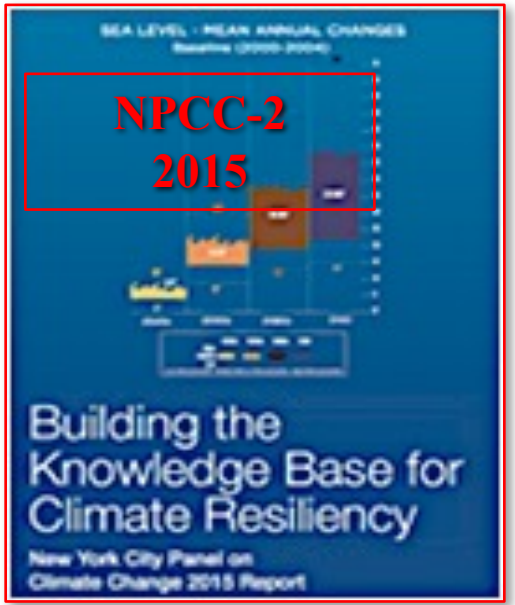


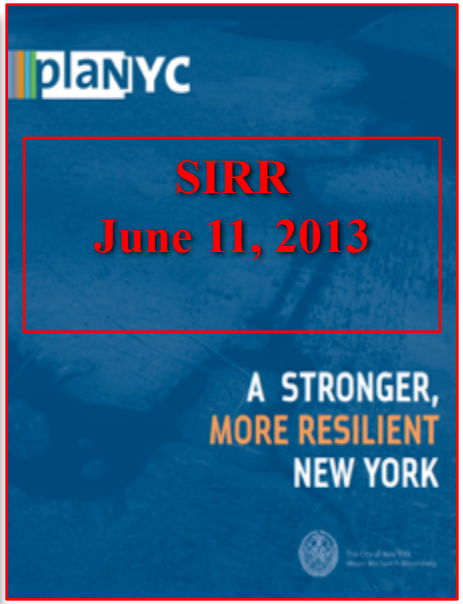


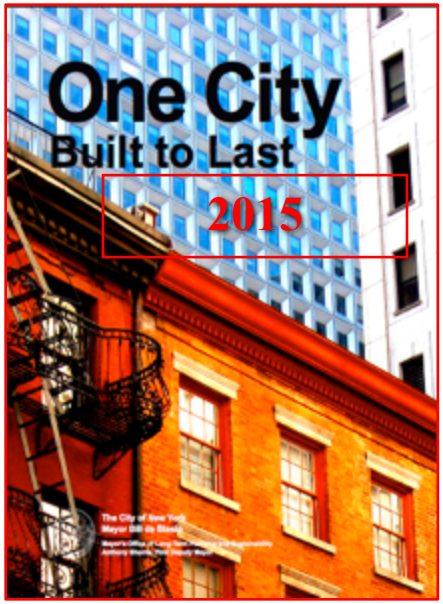


====> Sandy Oct 29-30, 2012



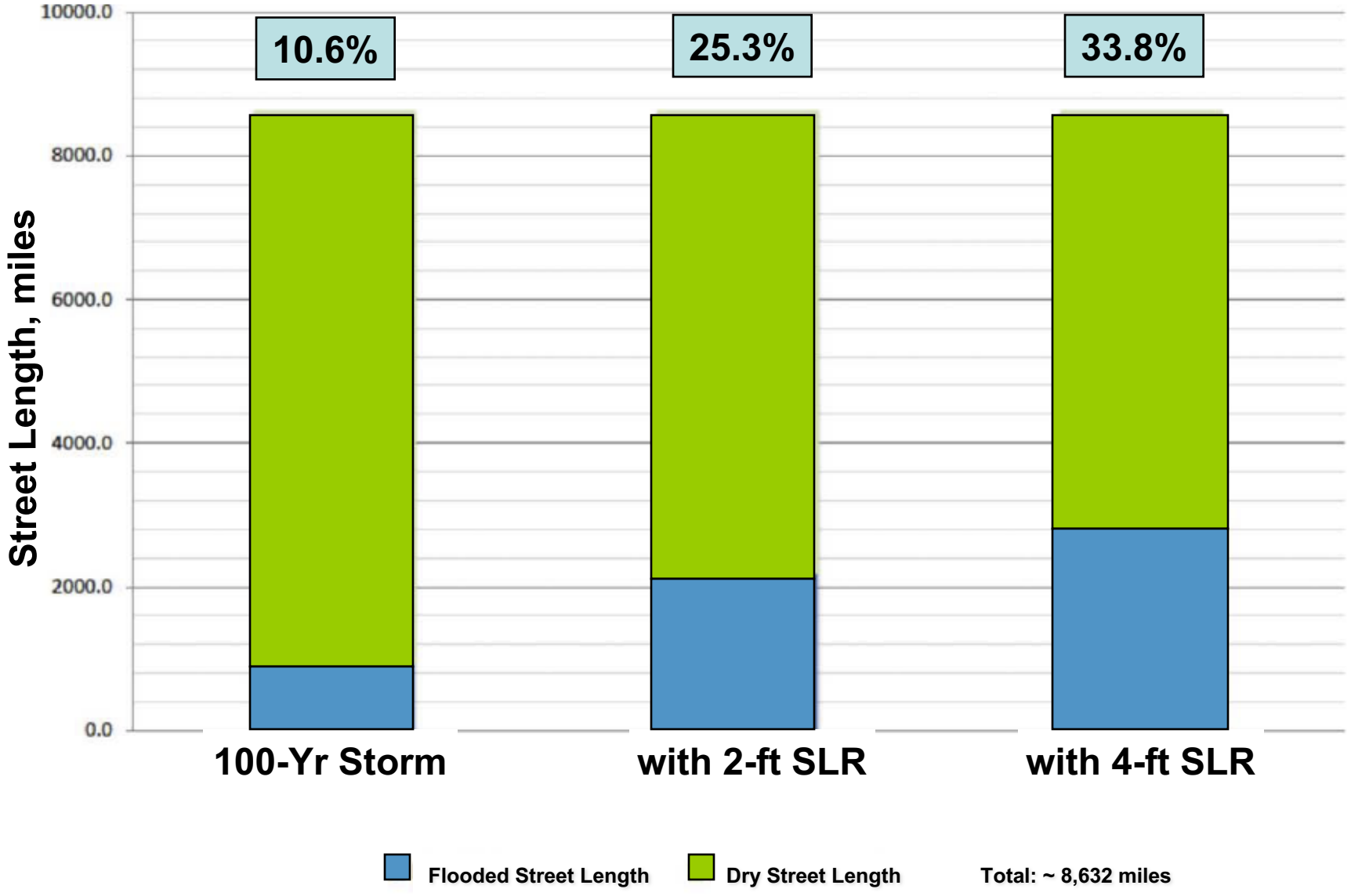




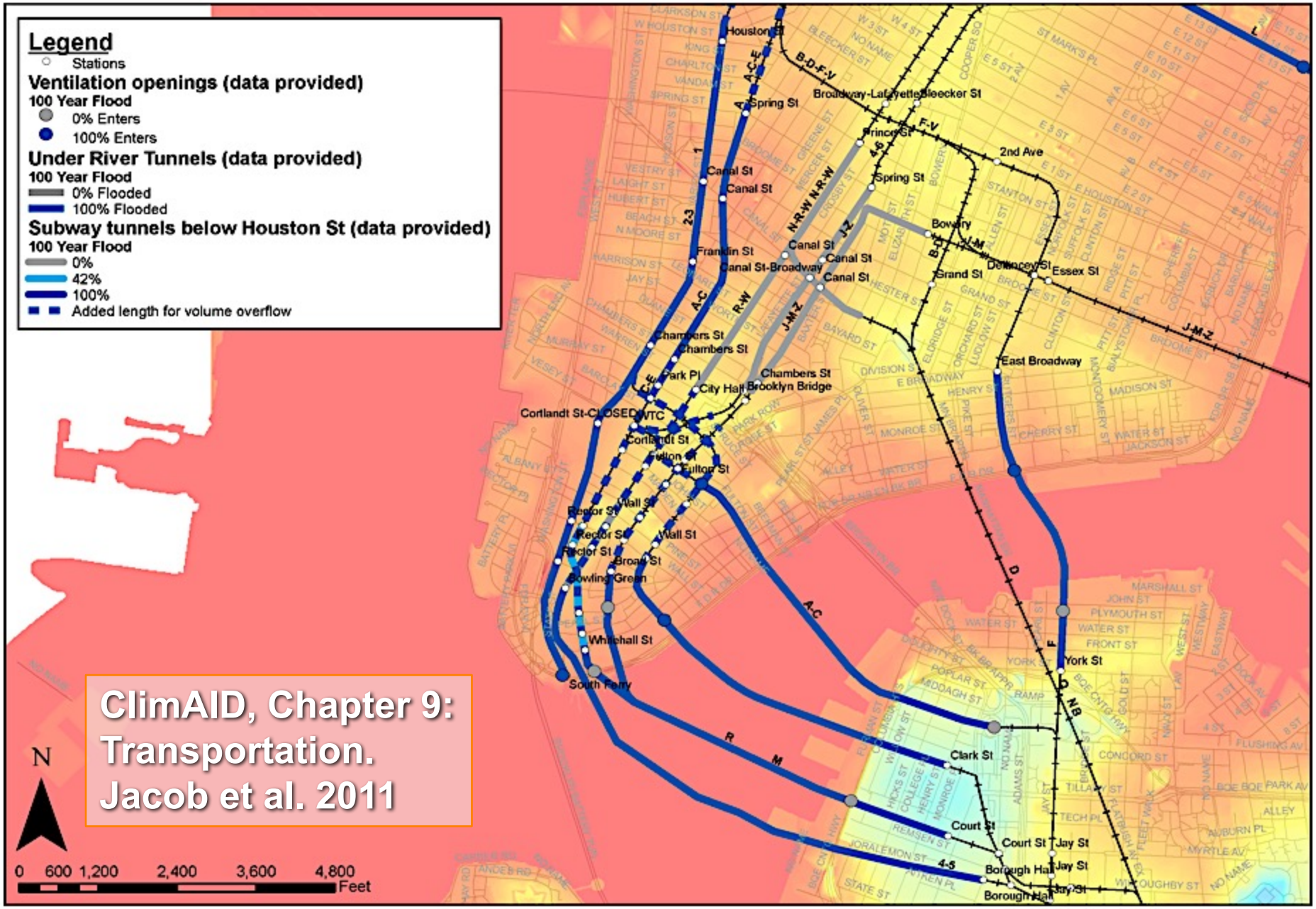


S1 100-y flood in 2000 (surge of ~ 8ft).
S2 100-y flood in 2040s, with +2ft SLR
S3 100-y flood in 2080s, with +4ft SLR
ClimAID, Chapter 9: Transportation. Jacob et al. 2011
9809 ft
© 2009 Tele Atlas
Image © 2009 DigitalGlobe
Image © 2009 Sanborn
Image © 2009 Bluesky
40° 44.955' N 73° 59.283' W elev 44 ft
NYCT - Grand Ave CMF
©2009 Google
Eye alt 29914 ft

NYC Street Length (miles) and % Flooded, for Three Flood Scenarios



Flooded Subway and Under-River Tunnels, Lower Manhattan, 1% Flood (length overflow)



ClimAID, Chapter 9: Transportation. Jacob et al. 2011

ClimAID Study: Chapter 9 – Transportation. (Jacob et al. December 2011)

- What is the expected **direct damage** from the 100yr flood to the transportation infrastructure ?

  ~ $ 10 Billion

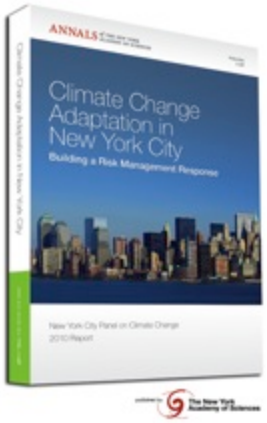
- **How long** will it take for the various components of infrastructure to have their **services restored** ?

  ~3 weeks (at ~ $ 4B/day =>)

- What will be **potential economic losses** from the transportation outages and extended restoration times ?

  ~ $ 60 Billion

NPCC-Recommended Adaptation Steps



1. Identify current & future climate hazards — 2010

2. Conduct Inventory of Built Assets — 2011

3. Characterize Risk of CC on Built Assets — 2012

"SANDY"

4. Develop Initial Adaptation Strategies — 2013

5. Identify Opportunities for Coordination

6. Link Strategies to Development Cycles

7. Implement Adaptation Plans

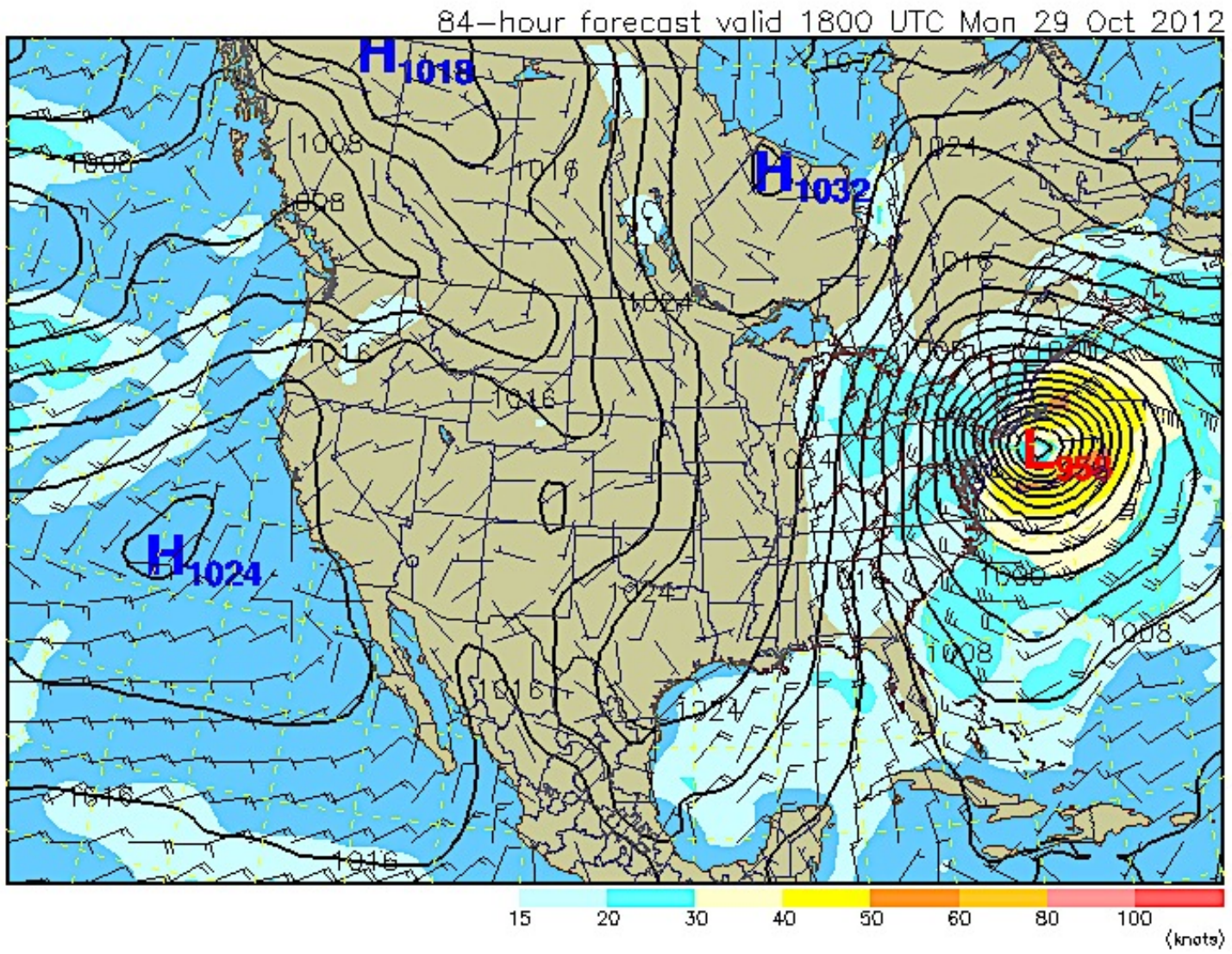
8. Monitor & Reassess

The 8 steps of adaptation

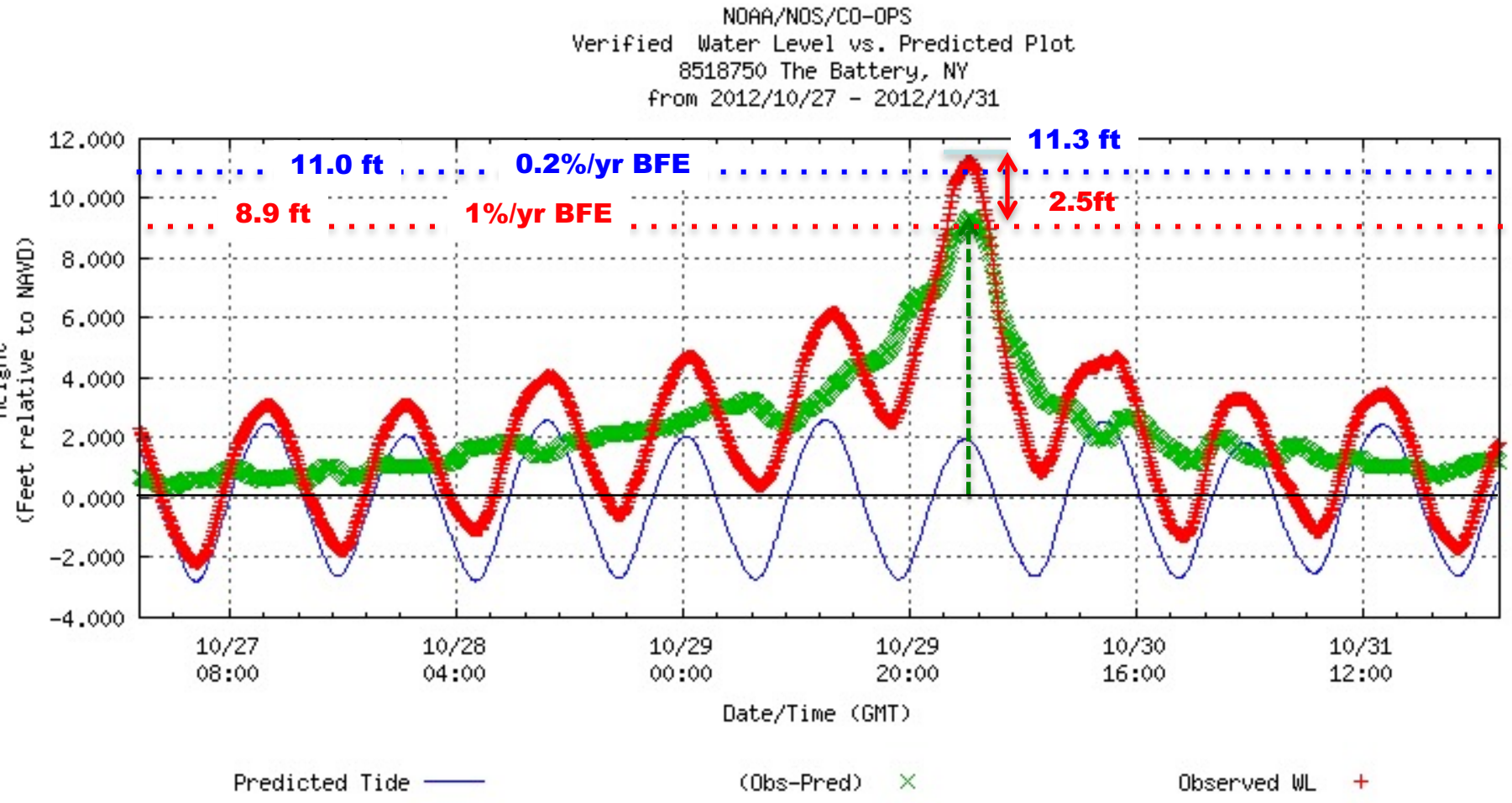
Pathways Flexible adaptation

http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.2010.05324.x/pdf

SANDY

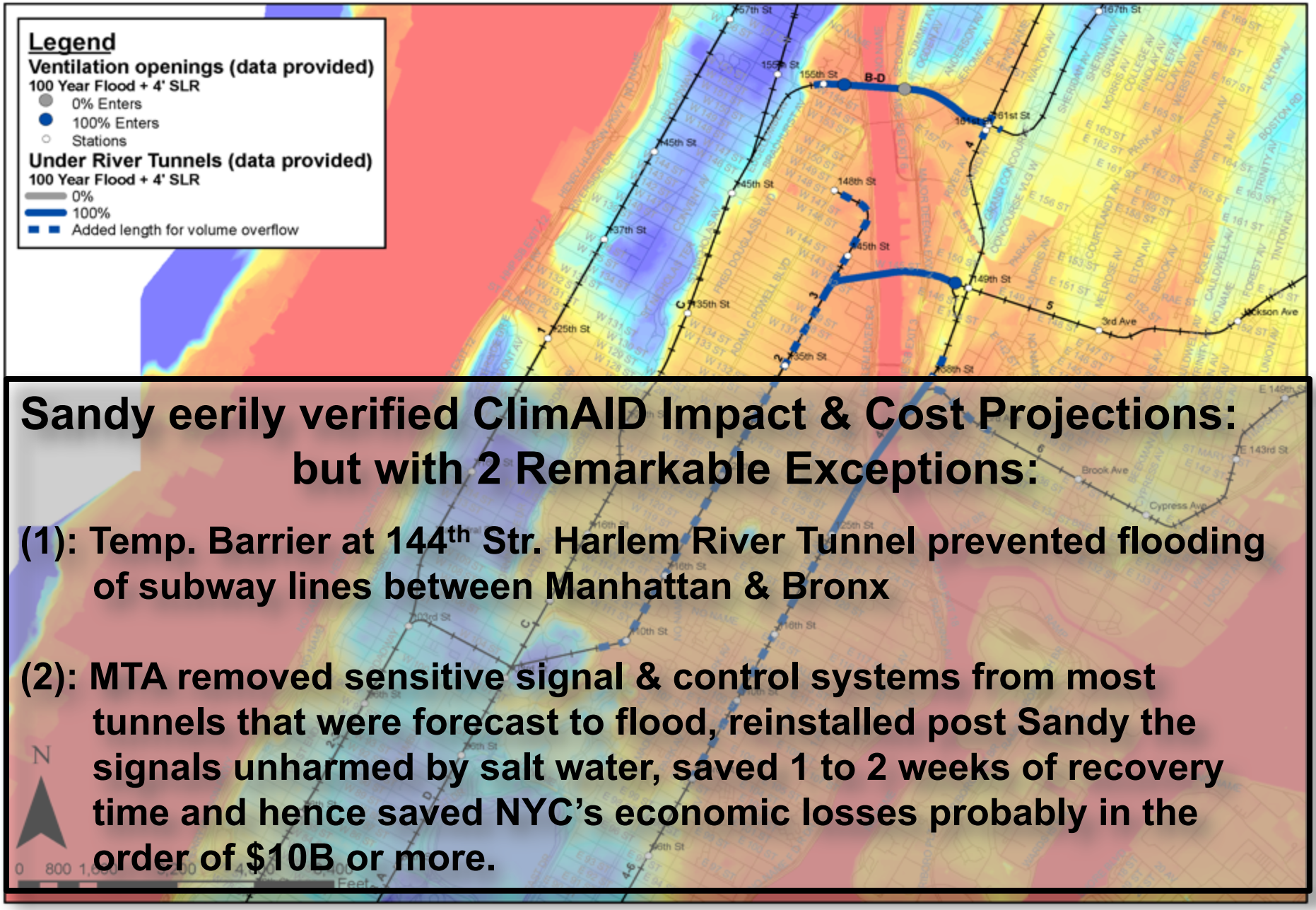

Sea-level pressure (mb) / surface wind speed (kts)
84–hour forecast valid 1800 UTC Mon 29 Oct 2012
H1018
H1032
H1024
L959
1008
1016
1024
1032
15
20
30
40
50
60
80
100
(knots)

SANDY Oct 29, 2012



MTA Storm Preparations, Downtown Subway Grates / 144th St Subw. Tunnel / Penn Station LIRR yard

Flooded Under River Tunnels, Harlem River Crossings, 1% Flood + 4' SLR (length overflow)



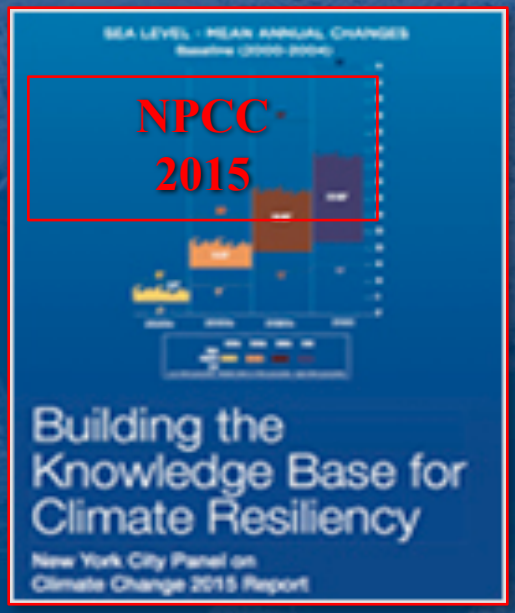
Sandy eerily verified ClimAID Impact & Cost Projections: but with 2 Remarkable Exceptions:

(1): Temp. Barrier at 144th Str. Harlem River Tunnel prevented flooding of subway lines between Manhattan & Bronx

(2): MTA removed sensitive signal & control systems from most tunnels that were forecast to flood, reinstalled post Sandy the signals unharmed by salt water, saved 1 to 2 weeks of recovery time and hence saved NYC's economic losses probably in the order of $10B or more.

The City and the Storm
Starting on p.17

SIRR
June 11, 2013



A STRONGER, MORE RESILIENT NEW YORK

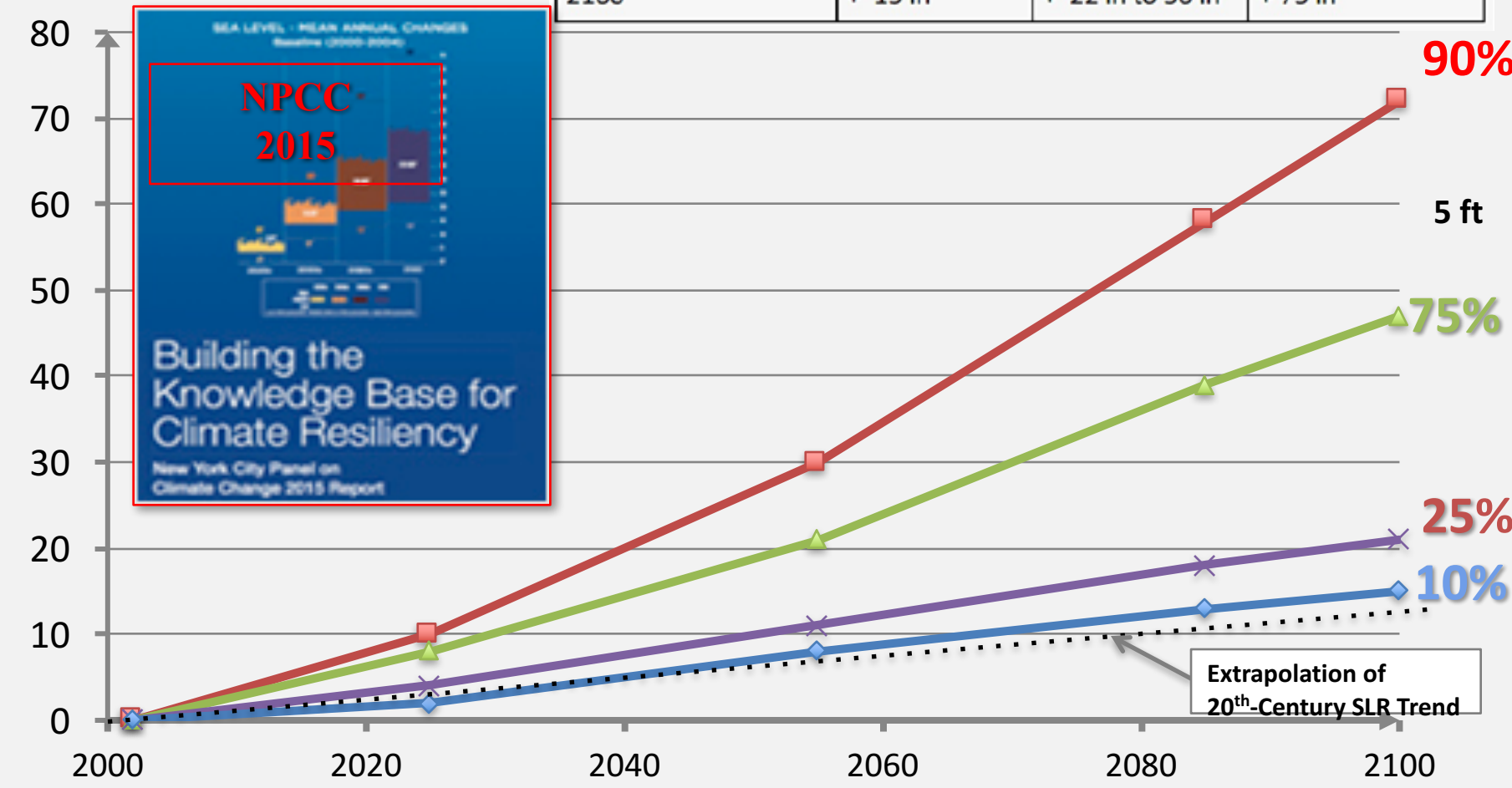
3 Basic Modes of SLR Adaptation:

- **Protection**
- **Accommodation**
- **(Strategic Relocation)**

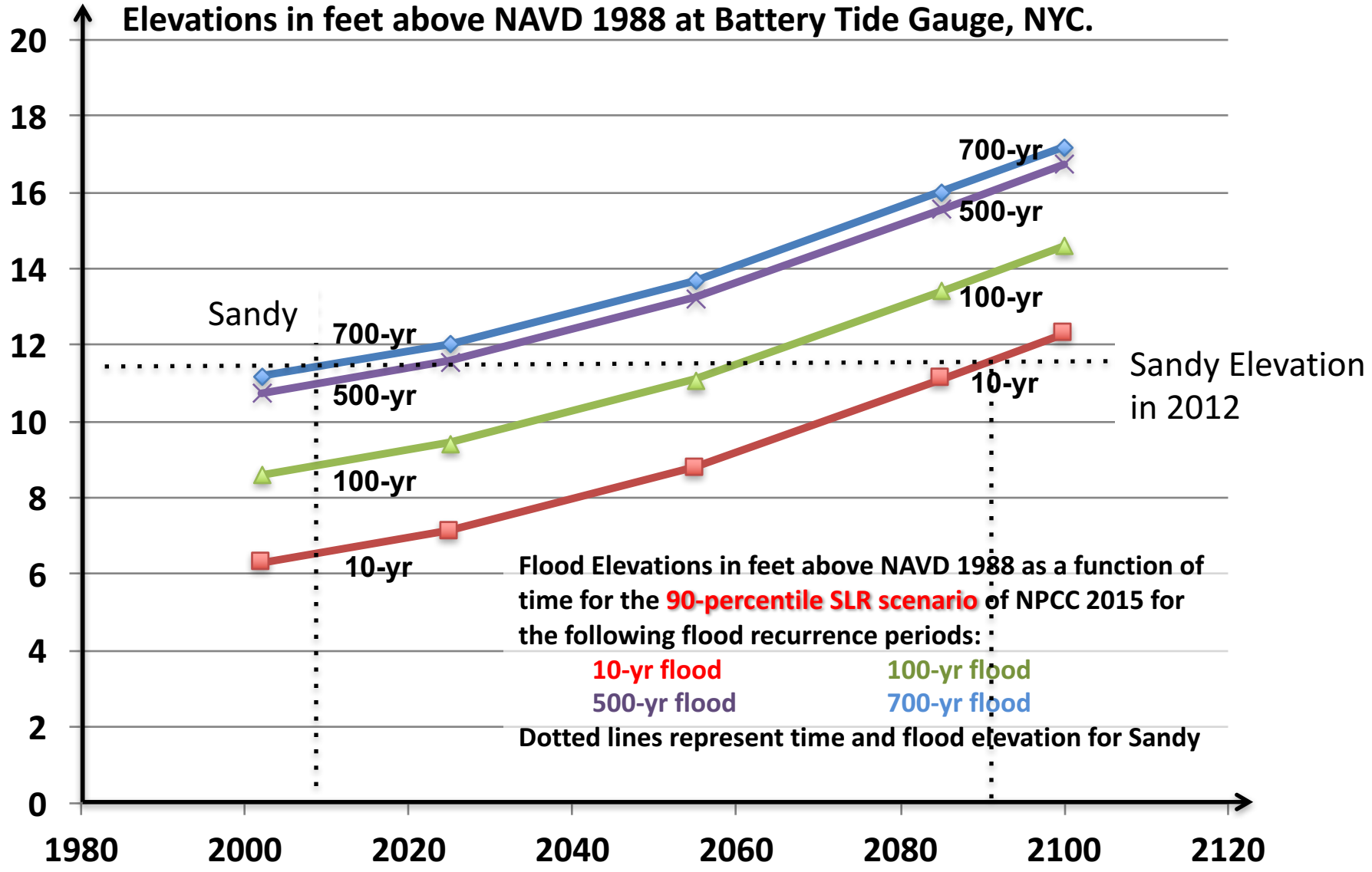
The City of New York
Mayor Michael R. Bloomberg

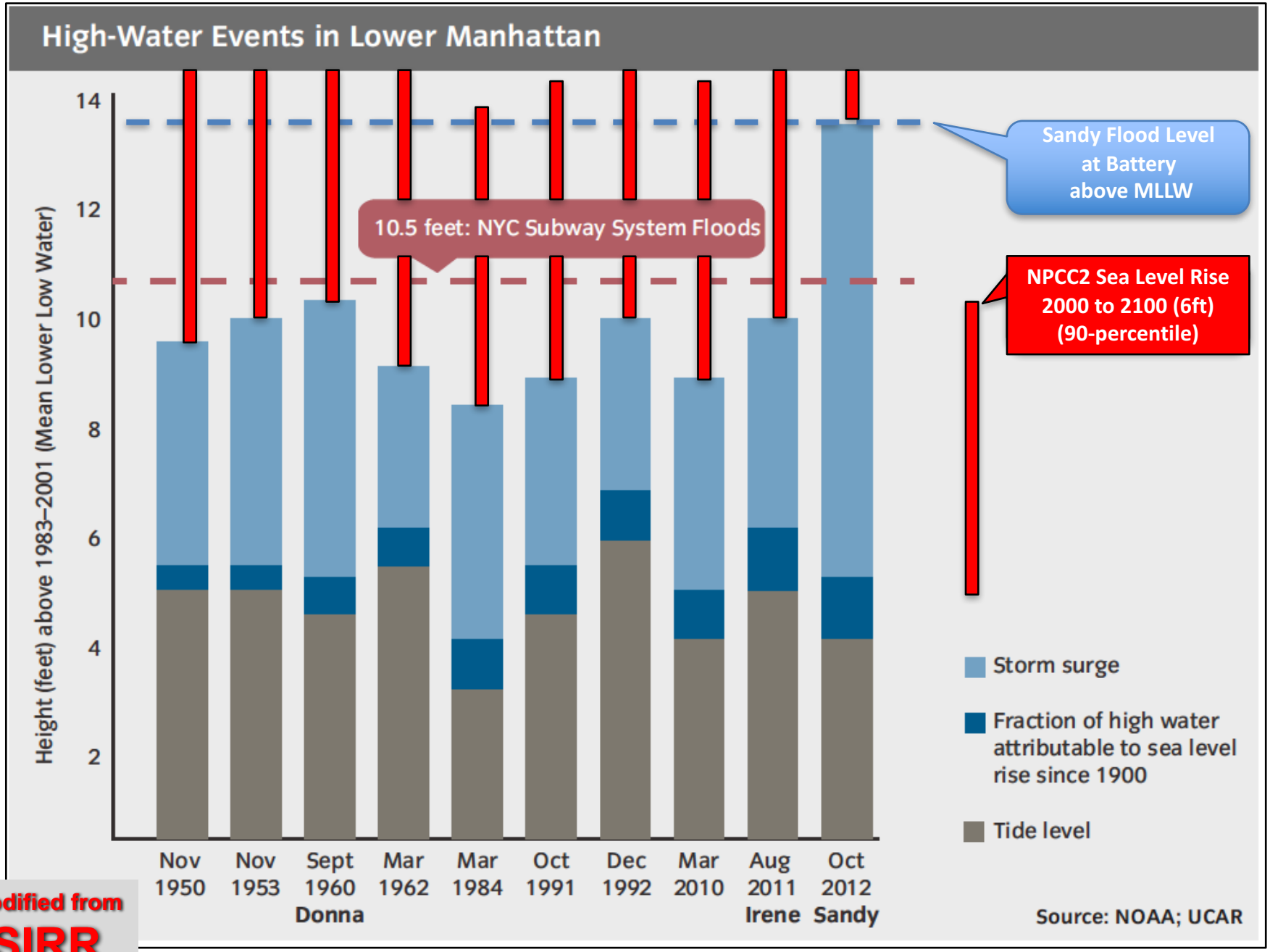
NPCC 2015 Sea Level Rise (SLR) Forecasts

Sea Level Rise Baseline (2000 – 2004)	Low-estimate (10th percentile)	Middle range (25th to 75th percentile)	High-estimate (90th percentile)
2020s	+ 2 in	+ 4 in to 8 in	**+ 10 in**
2050s	**+ 8 in**	+ 11 in to **21 in**	**+ 30 in**
2080s	+ 13 in	+ 18 in to 39 in	+ 58 in
2100	+ 15 in	+ 22 in to 50 in	+ 75 in



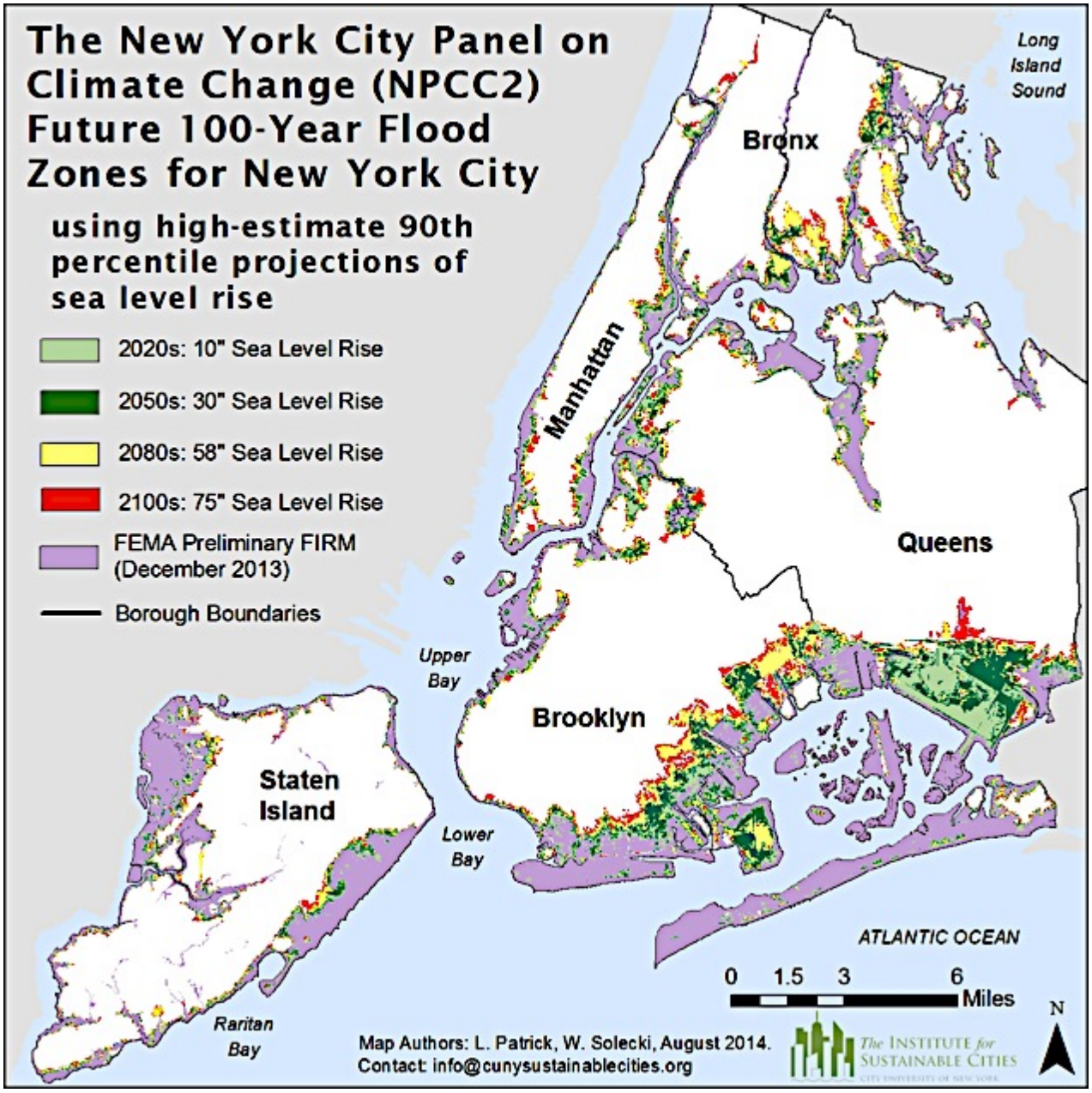
The elevations flooded in 2012 by a 700-yr event may be reached in 2090 by a 10-yr event: 70-fold risk increase!





Modified from SIRR June 2013

NPCC2 Future Coastal Flood Risk Maps



For low-lying areas like Red Hook in Brooklyn, Hospital Row in Manhattan and East Harlem, the plan calls for a system that could include portable flood walls

The plan recommends that a flood wall be built around Con Edison's Farragut substation on the East River, and a levee along the East Shore of Staten Island.

At narrow inlets such as Newtown Creek and the Gowanus Canal, the plan calls for movable gates in the water to keep a storm surge from reaching low-lying interior areas.

Figure 2. The Danube River in Germany was barely kept in check by a floodwall built by IBS Eng

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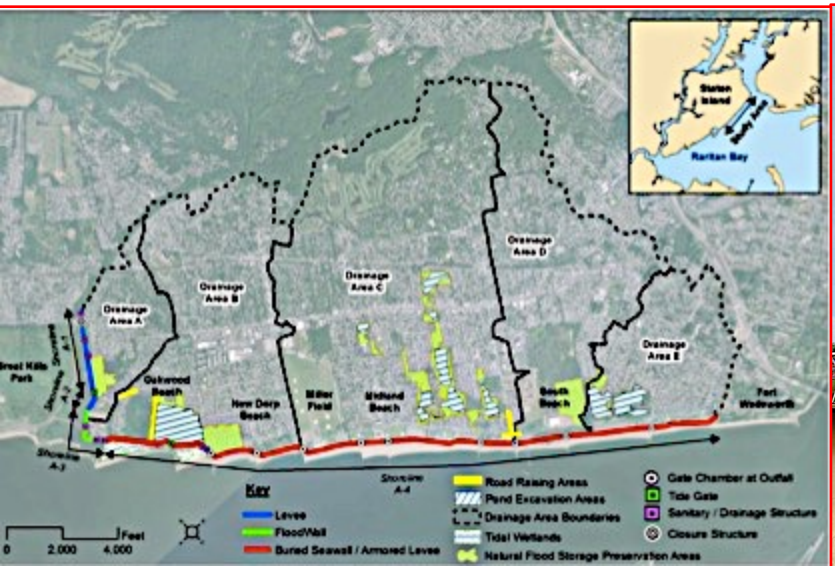

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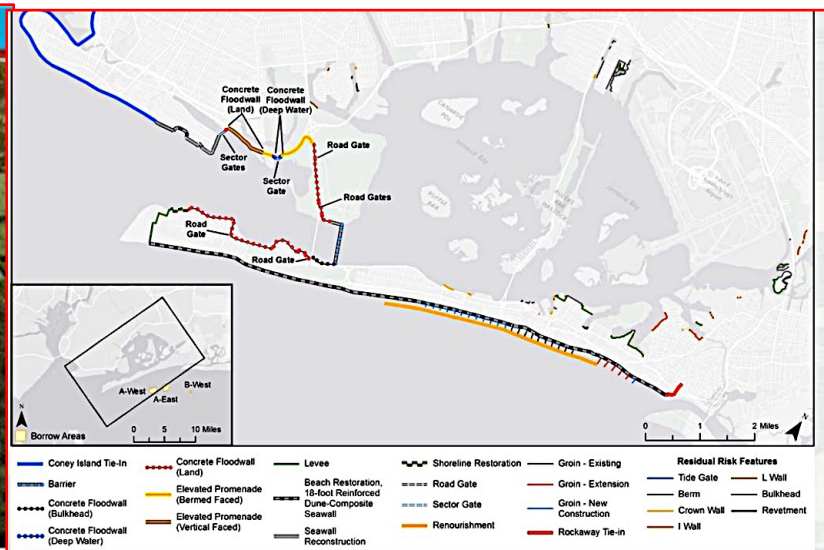
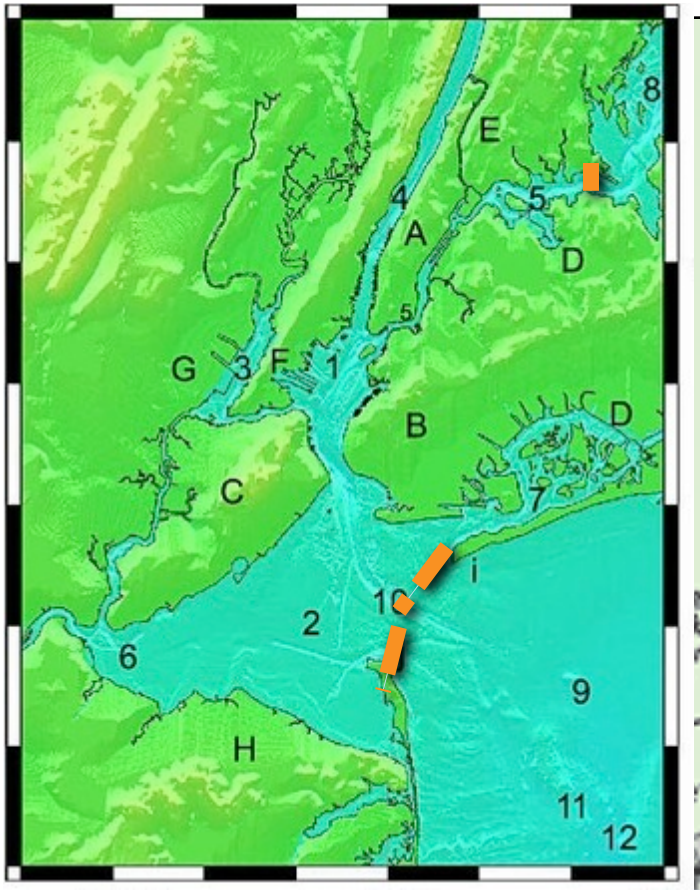


Creating a soft edge shoreline, Brooklyn Bridge Park, New York City

Source: Department of City Planning, City of New York City, 2011.

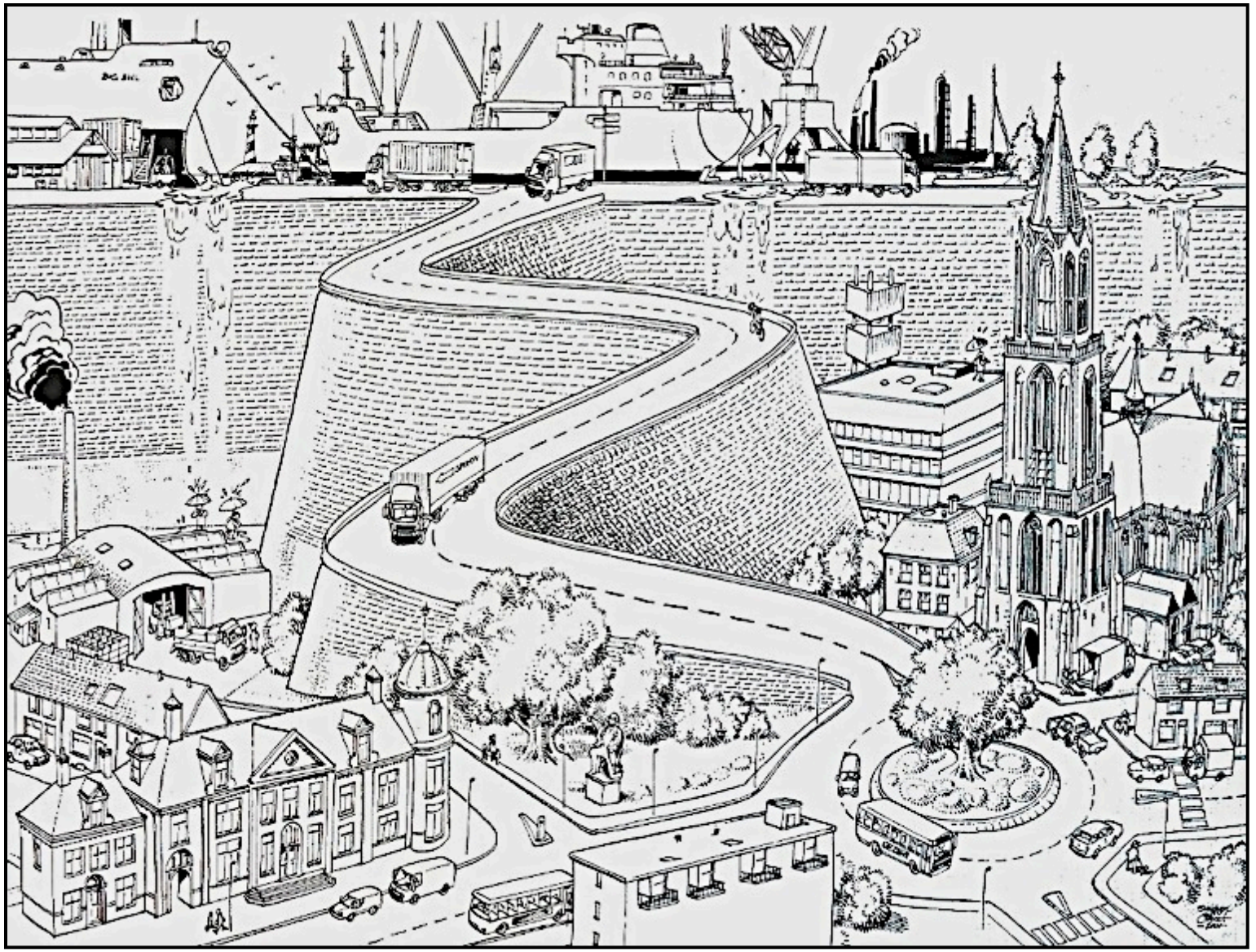
Proposed: 2 - 4 New York Barriers

Barriers Unsustainable. Why?



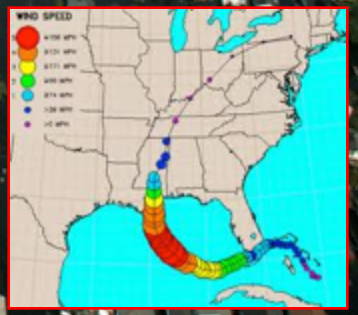
Some Propose NY Barriers:

This retractable storm surge barrier spans 3,000 meters across the Eastern Scheldt in the Netherlands.



A Dutch Cartoonist's View of SLR Defenses:
Is this what we plan for New Amsterdam?

Residual Risk: Katrina New Orleans, Aug 2005.

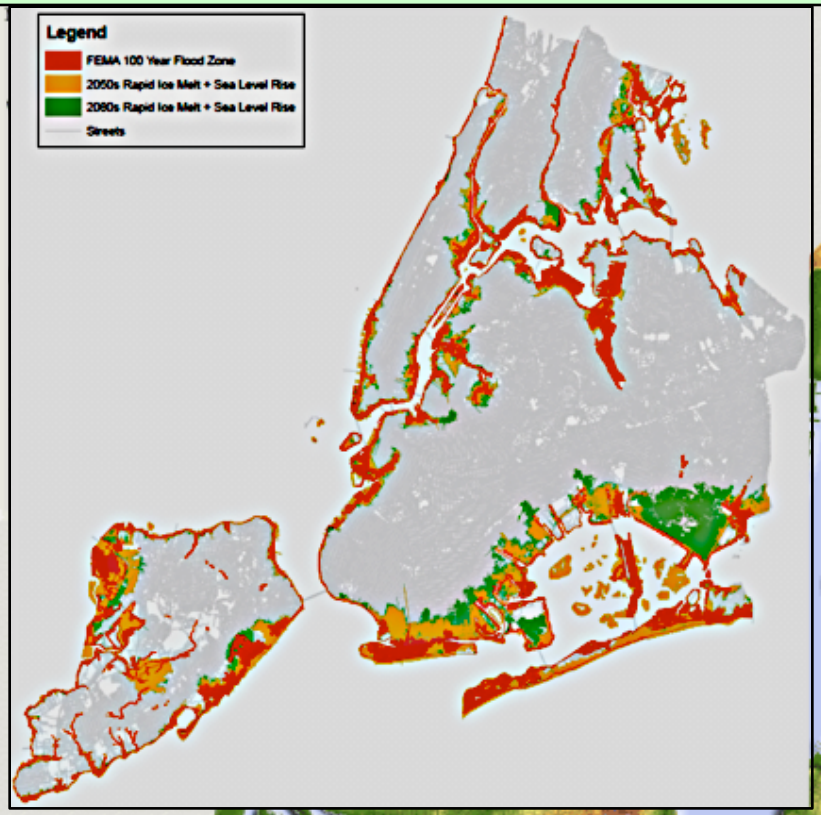


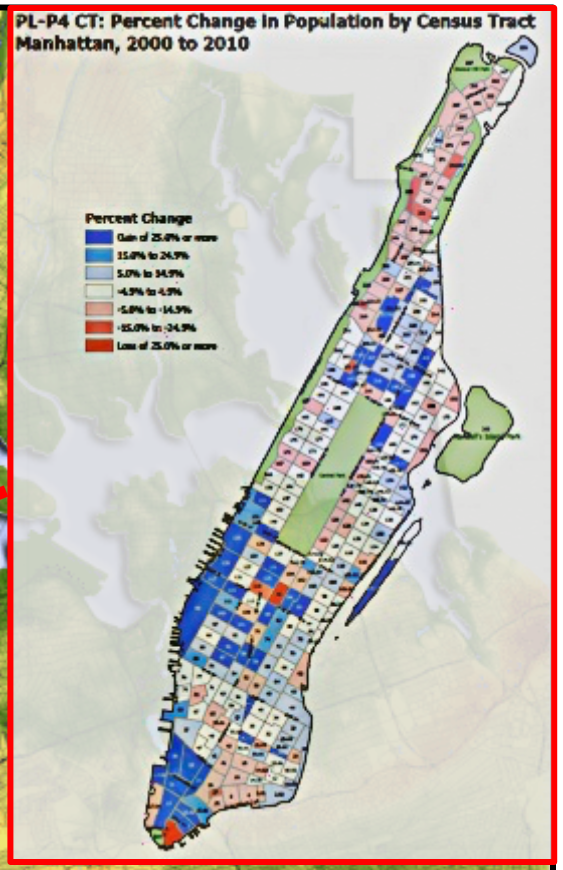
Sustainable Resilience:

- Sustainable design provides resilience now while minimizing liabilities for future generations => Intergenerational equity and justice.
- Plan for “Higher Ground”: avoid putting new assets into current and future flood plains near sea level. Migrate willing coastal communities that are at risk out of harm’s way to higher elevations. Create (National? /Local?) Fund for Community Transformation.
- Sustainable design
  => adaptive designs
  => floating structures, where feasible.

3 Basic Modes of Adaptation:

- **Protection**
- **Accommodation**
- **Strategic Relocation**





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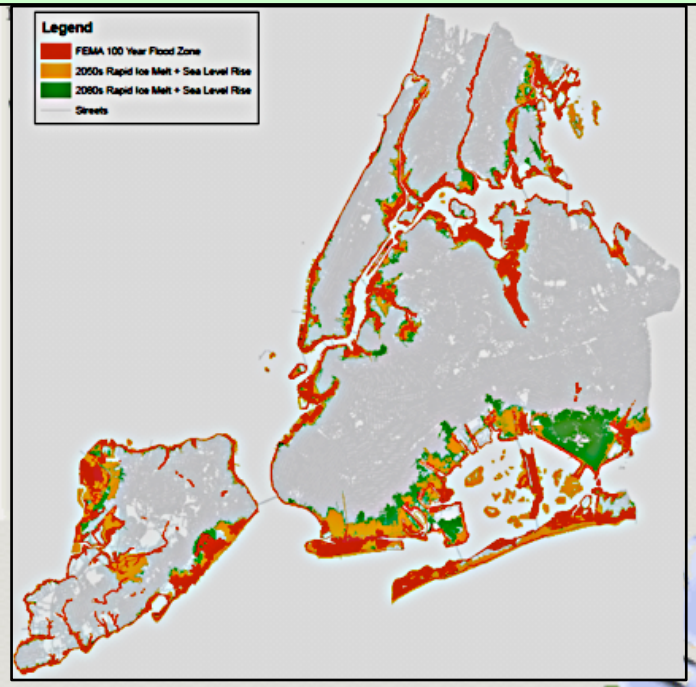
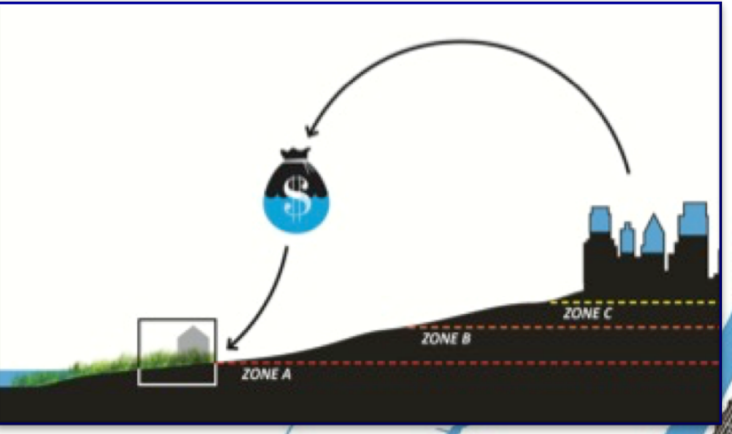
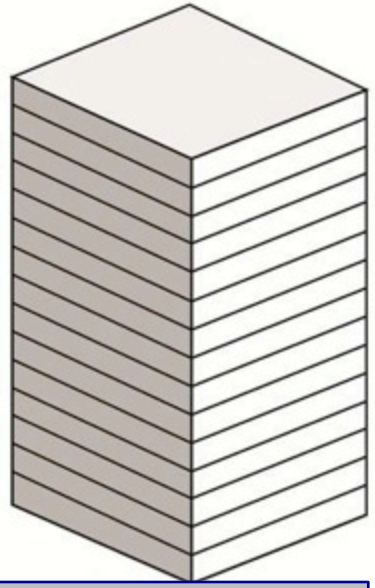






Possible Future Concept:
Transform Evacuation Zones A into Parks and Marshes and Raise the Floor Area Ratio in Non-Evacuation Zones

100 SQUARE FEET

Source: Susannah Drake, DLAND STUDIO PLLC,

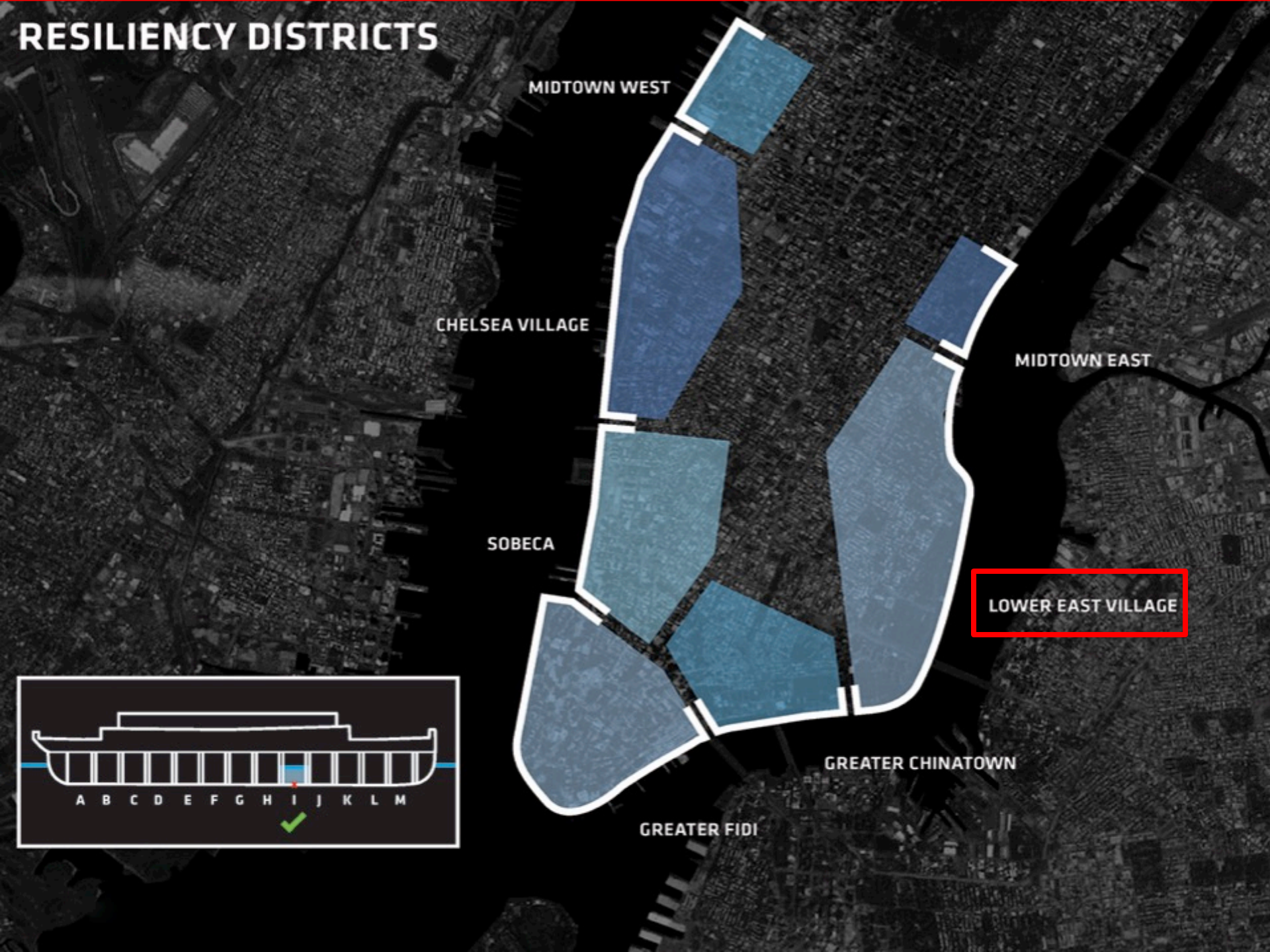
Oakwood Beach Community in Staten Island, NYC

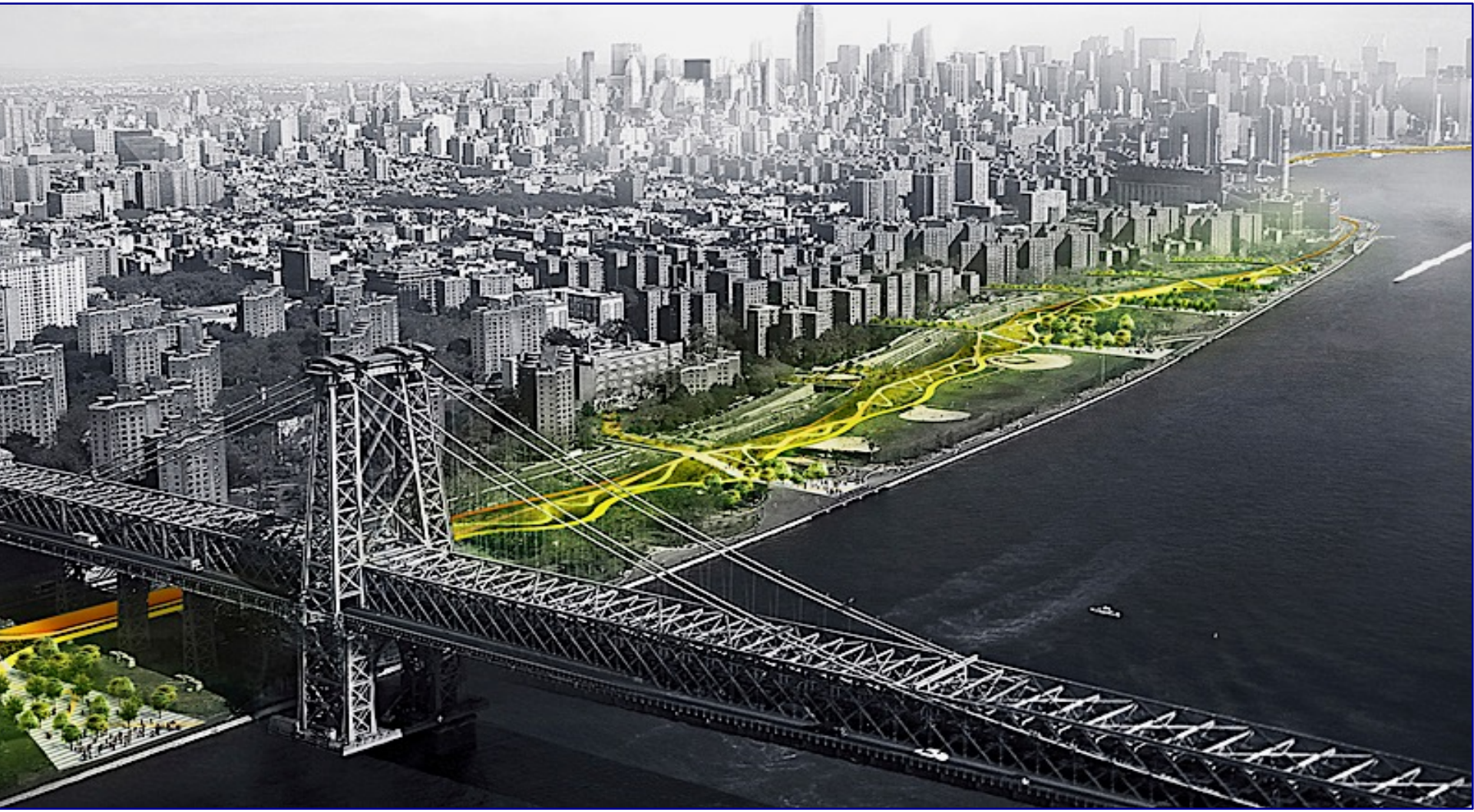
Rebuild by Design Competition (RBD): 48 Teams Applied, 10 Admitted, 6 Winners

BIG Team (Lower Manhattan BIG U)

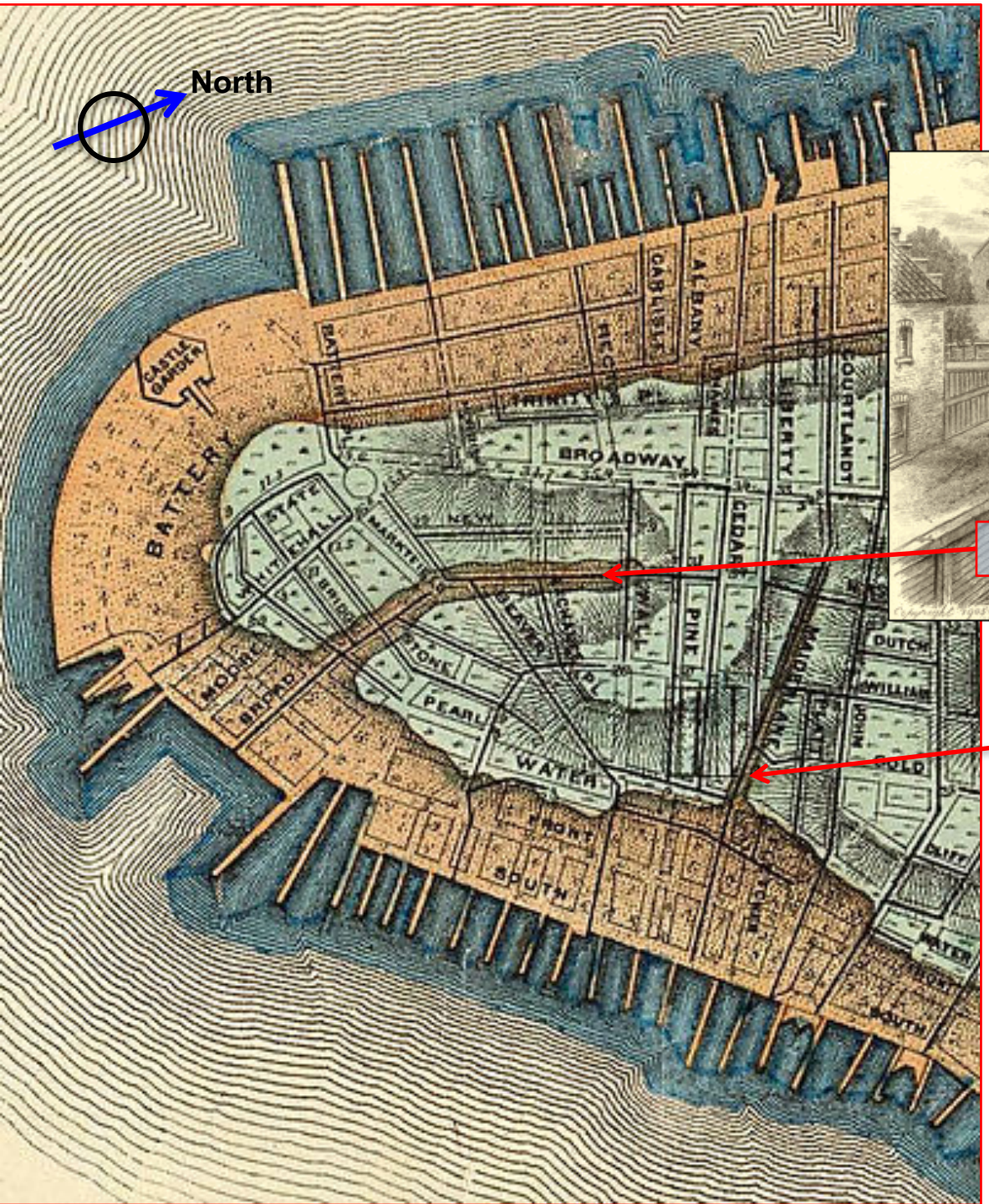
RBD: 48 Teams Applied, 10 Admitted , 6 Winners

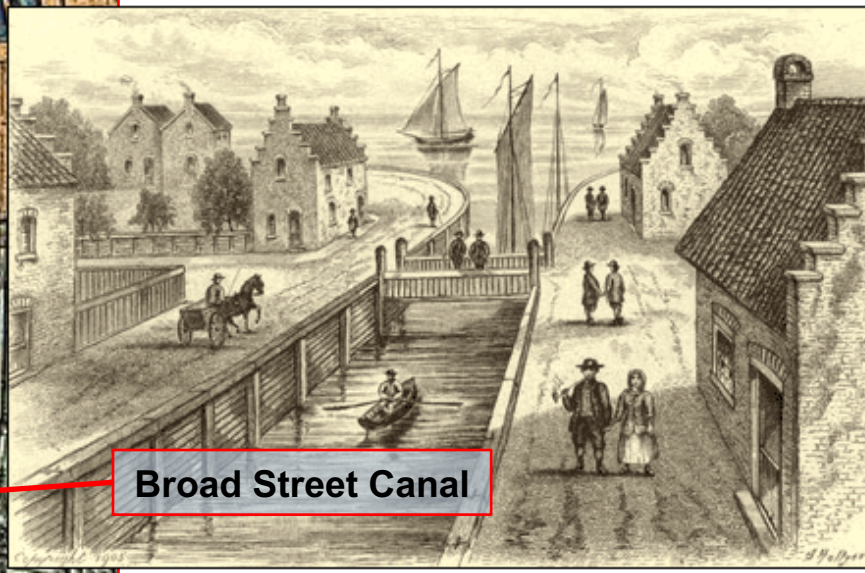
RESILIENCY DISTRICTS





Planned Berm and Park, Lower East Side of Manhattan





Broad Street Canal

Maiden Lane Inlet

New Amsterdam
ca 1660
REDRAFT
of
THE CASTELLO PLAN
NEW AMSTERDAM
in
1660
Broad Street Canal

In Modern Downtown Manhattan:

Can we have **Canals** again?

Amphibian **Water Taxis**? and **High Lines** crossing Canal- and Water Street?

Looking down on Ducks Floating on Wall Street ?!

Summary:

- **The NYC Metro Region is under *current* climate conditions vulnerable to extreme weather events.**

- **Climate Change, & especially Sea Level Rise in conjunction with coastal storms, will greatly amplify and accelerate these risks.**

- ***Protection* by Fixed-Height Structures (Levees, Barriers, Gates) is only effective for limited times & only postpones needed tough measures.**

- ***Accommodation*: living with water, submersible infrastructure and floating structures tend to provide more flexible adaptation paths.**

- ***Strategic Relocation* to higher elevations (vertically in place, or laterally to high ground) appears as the most sustainable adaptation strategy for long-term sea level rise (>2100), but ought to be incorporated in comprehensive planning NOW !! Financing !!**

- **NYC's SIRR & local and regional efforts (e.g. RBD, NY Rising) provide incremental, temporary resilience to about the 2050s. But more transformative, with time truly sustainable solutions are needed.**

Timing can be crucial !!.