NOAA CREST

Health Exposure, Socio-Economic Vulnerability, and Infrastructure at Risk to Current and Projected Coastal Flooding in New York City

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City College, CUNY

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CUNY CREST
SCIENCE & TECHNOLOGY TO SUSTAIN THE EARTH

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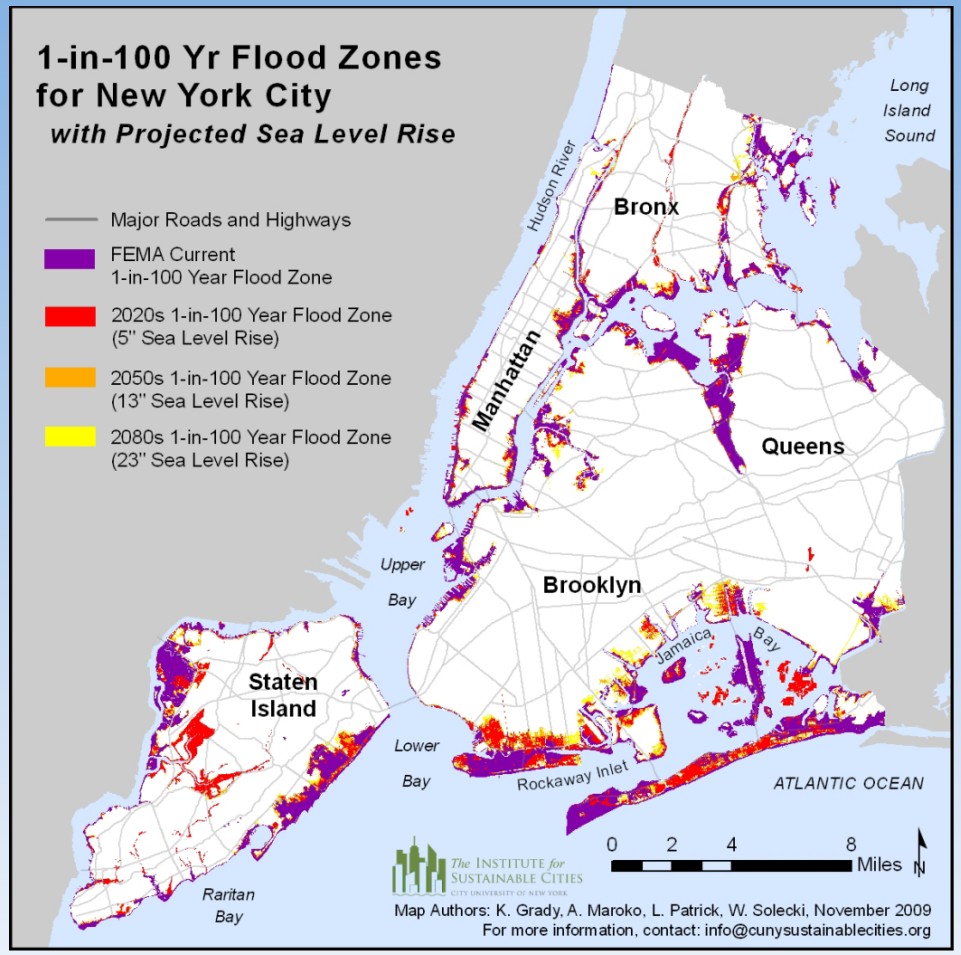
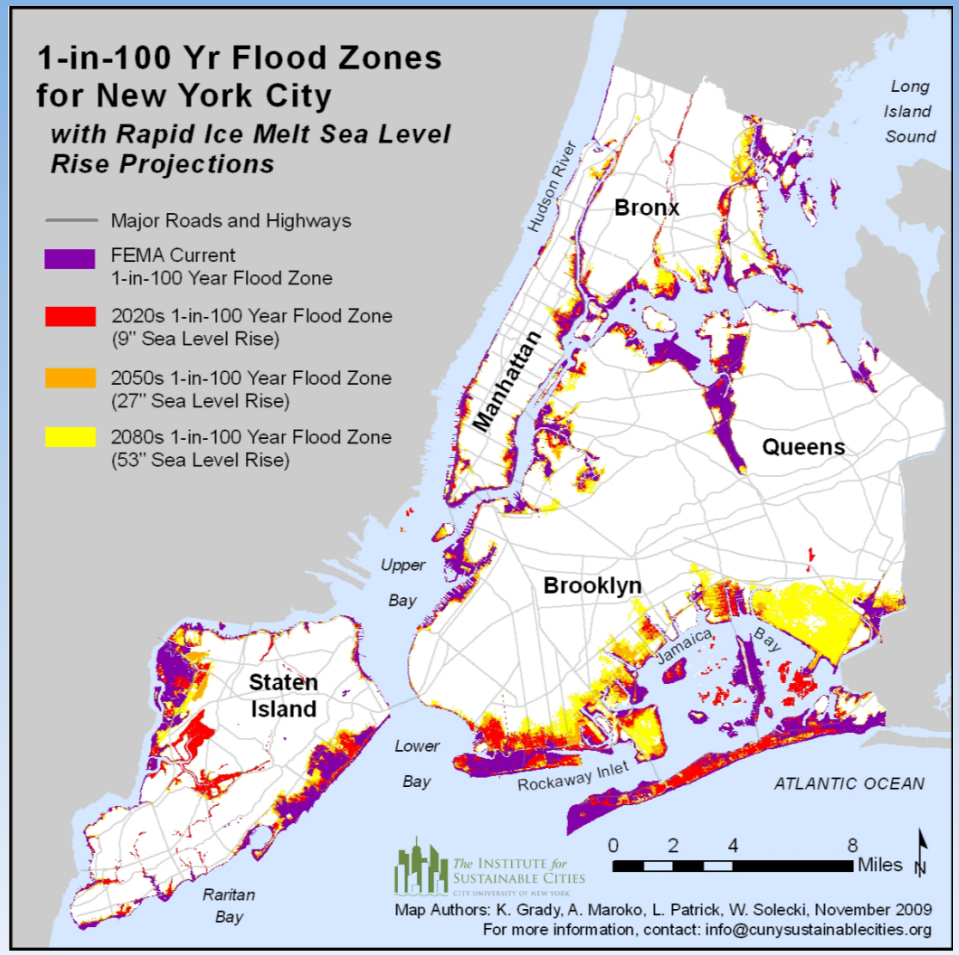
Introduction

This work uses a GIS-based methodology to develop and map a composite health exposure and infrastructure vulnerability index for New York City populations exposed to the current and predicted 100-year flood to assess overall flood risk at the intersection of exposure and vulnerability.

- Storms are not equal impact events!
- Social and physical geography interact to expose vulnerable populations to elevated risk.
- Due to sea-level rise, more communities are becoming vulnerable, existing communities are becoming more vulnerable and both are becoming less disaster resilient.
- The combination of social vulnerability, critical infrastructure at risk, and exposure to hazard provides a metric to rank neighborhood risk to flood hazards through an overall vulnerability index that characterizes site-specific levels of risk to flood hazard.
- Using recent publically available data at block group level resolution will allow planners and emergency managers to identify pockets of socially vulnerable populations.
- Overlapping socially vulnerable populations with physical hazard will identify communities that may require special attention, planning efforts and mobilization to respond to and recover from disasters and hazards.
- Flood Scenarios: FEMA ABFE Maps, Sandy Flooding, New York City Panel on Climate Change 2010 100-Year Flood Maps

Areas potentially at-risk to the 100-year flood in New York City due to model-based and rapid ice melt sea-level rise projections

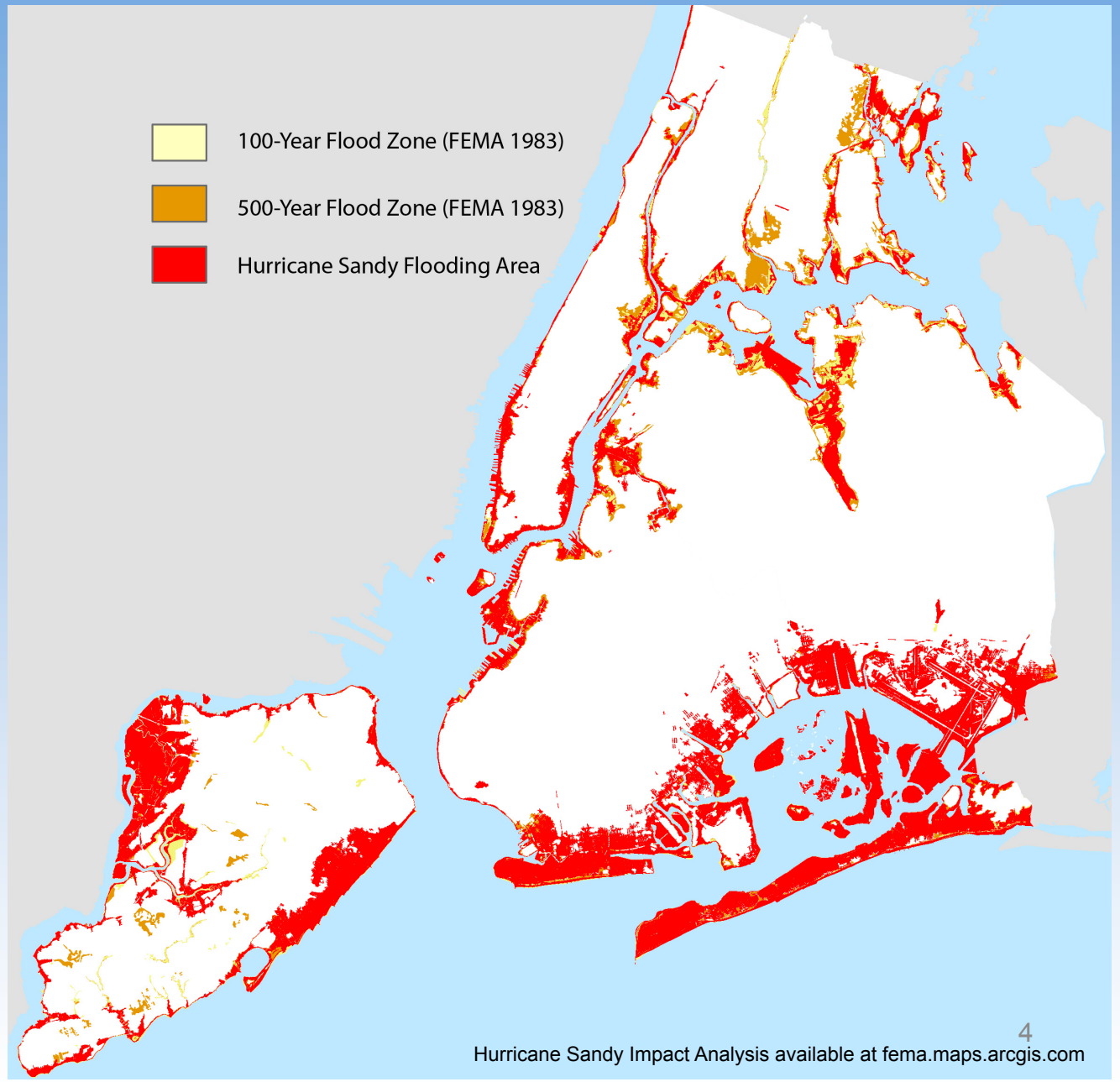




Source: Rosenzweig, C., Solecki W., Eds. 2010. Climate Change Adaptation in New York City: Building a Risk Management Response, New York City Panel on Climate Change 2010 Report. New York: New York Academy of Sciences.

FEMA 100 and 500-Year Flood Zones with Sandy Flooding

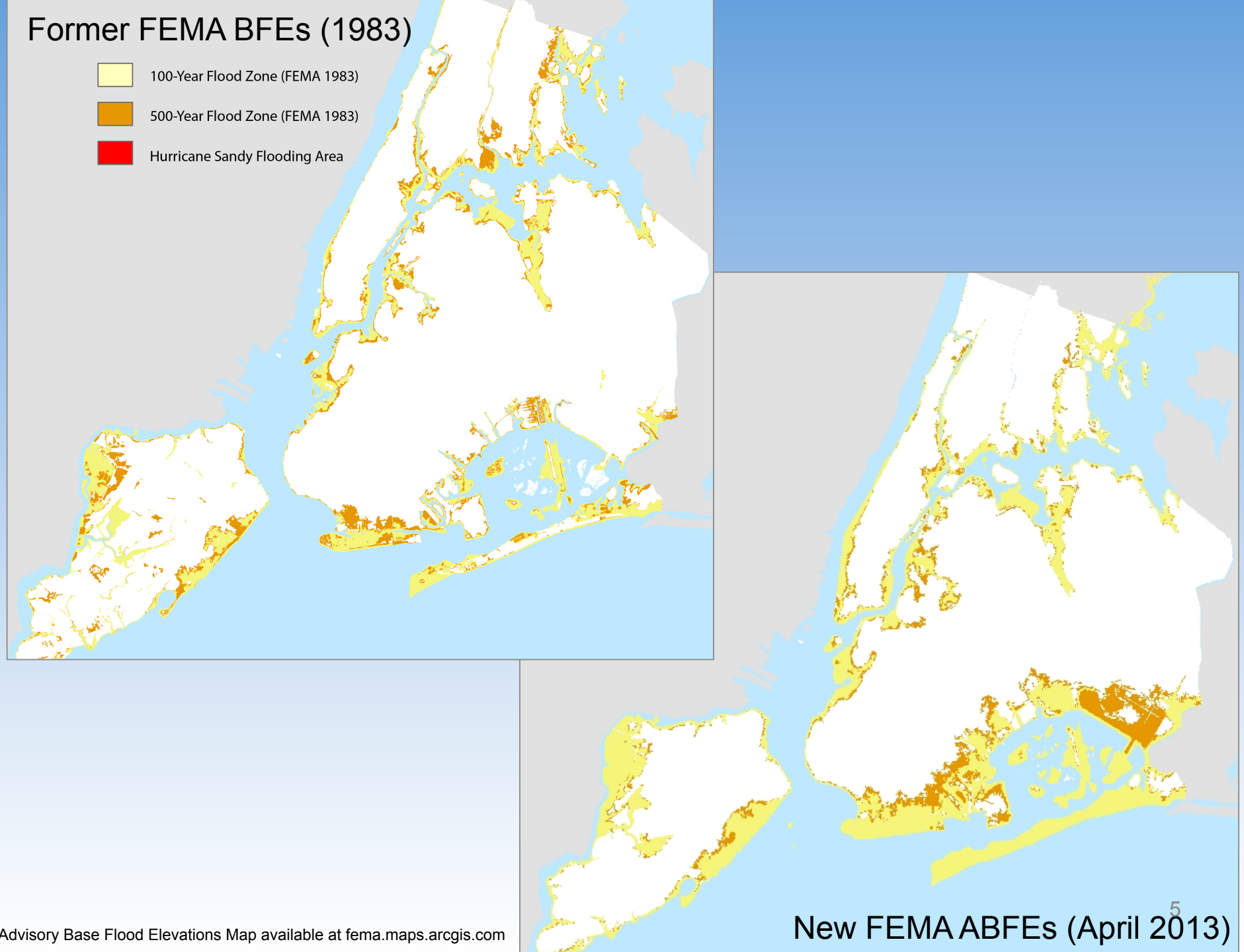
FEMA's projections of the 100-year and 500-year flood zones in NYC *with* field verified post-tropical storm Sandy flooding area



Field verified using:

- High water marks
- SS sensor data (USGS)

Hurricane Sandy Impact Analysis available at fema.maps.arcgis.com

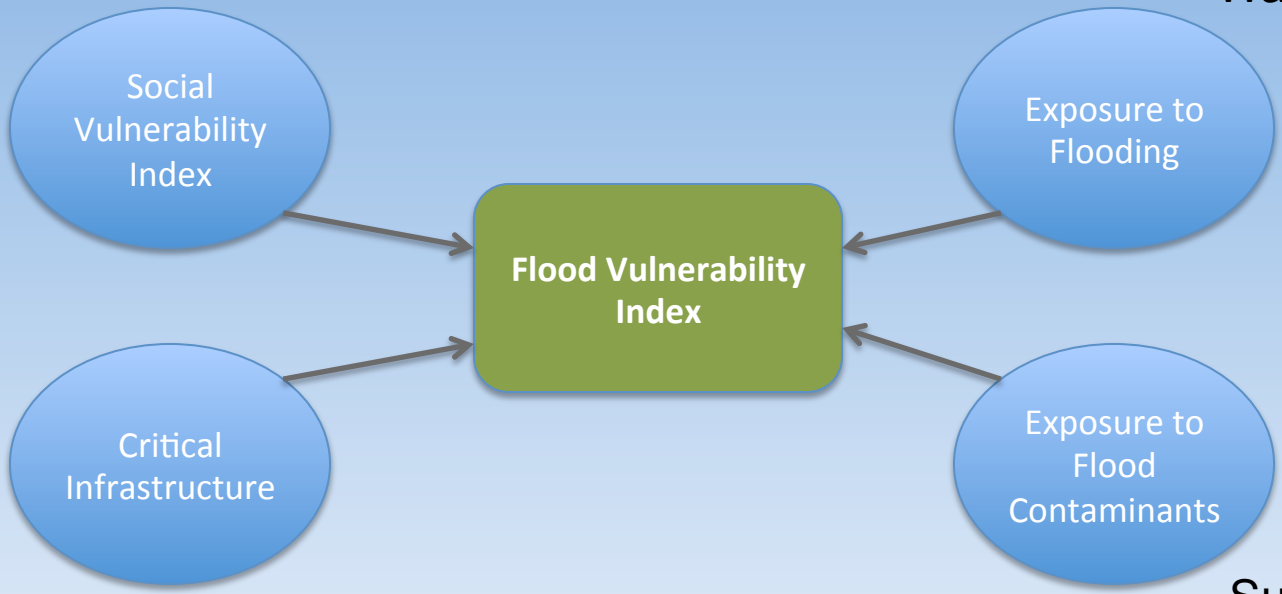


Advisory Base Flood Elevations Map available at fema.maps.arcgis.com

Flood Vulnerability Index Methodology

14 characteristics as indicators of social vulnerability

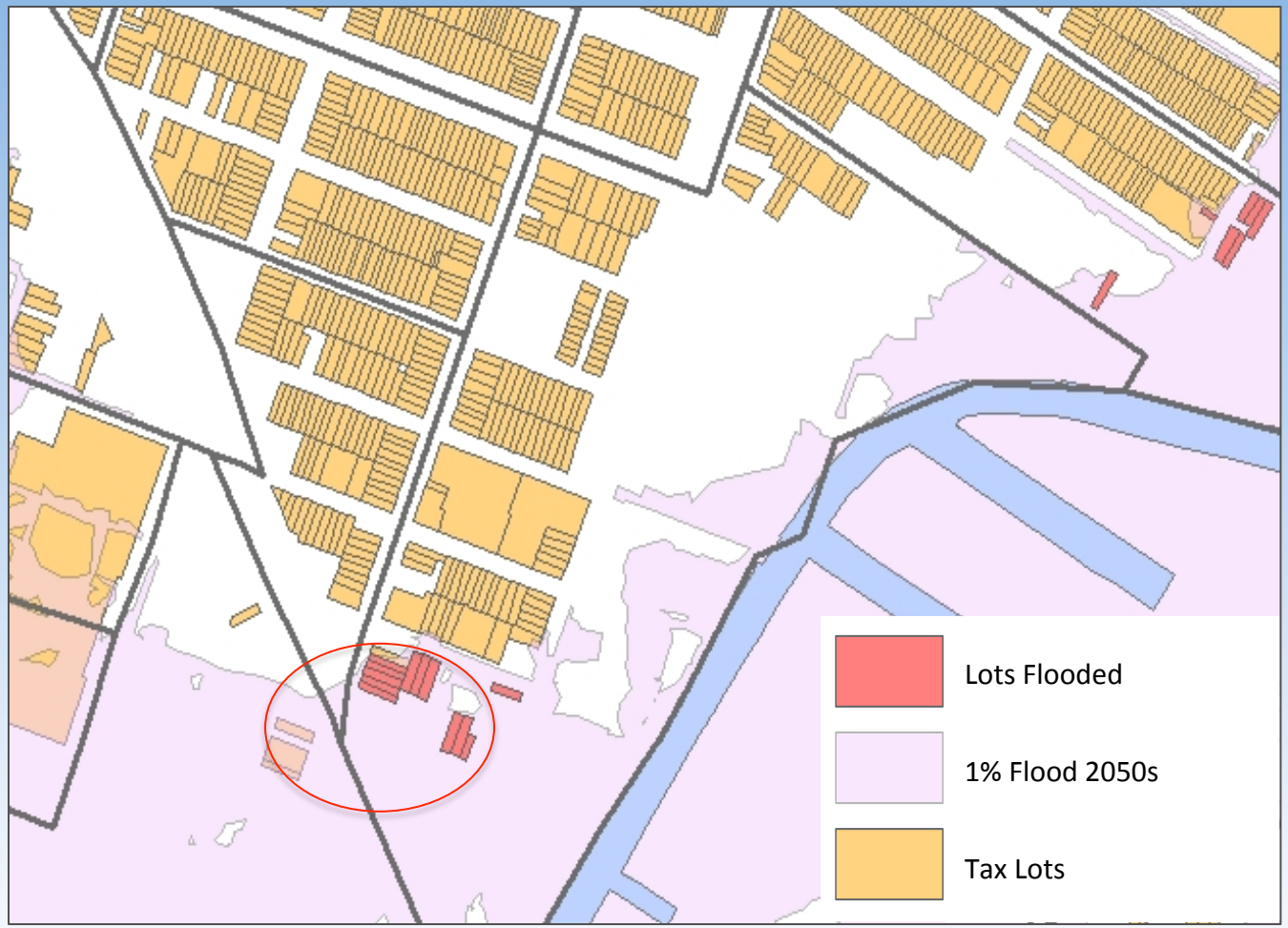
Wave Action
Water Depth



Emergency Services – police, fire, rescue
Hospitals, residential care
Schools
Hubs or power, telecommunications, utilities
Waste water treatment
Transportation

Superfund
TRI
Bulk Storage
SIMA

Calculating Population: Areal Weighting vs. Disaggregation



Block Group
Population: 1,121
Percent Flooded: 37

Tax Lots
Tax Lots: 144
Lots Flooded: 7

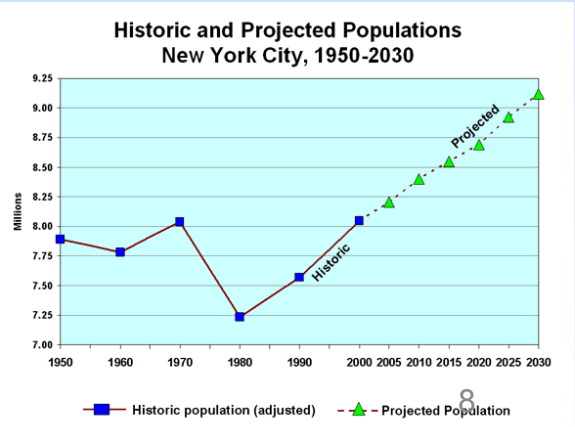
Population in Flood Zone
Areal Weighting: 419
Disaggregation: 74

Results: Land Area and Population Exposed to Current and Projected Flooding

Flood Scenario	Year	Flood Area mi^2	Population	Percent Change Flood Area	Percent Change Population
Post-Tropical Cyclone Sandy	2012	49.1	431,090	-	-
FEMA ABFE 100-Year Flood	2013	48.0	433,417	-	-
NPCC 1% Flood Zones With Model Based Sea-Level Rise	2020s	42.9	350,700	-11%	-24%
	2050s	46.2	401,847	8%	13%
	2080s	50.2	482,692	9%	17%
NPCC 1% Flood Zones With Rapid Ice Melt Sea-Level Rise	2020s	44.1	375,834	-8%	-15%
	2050s	53.1	534,191	20%	30%
	2080s	70.1	755,402	32%	29%

The U.S. Census Bureau forecasted that the population of New York State will increase by 2.6% by the 2030s.

New York City's population is expected to grow to 9.1 million persons by 2030.



Source: PlaNYC

Social Vulnerability Index Methodology

Construction Options

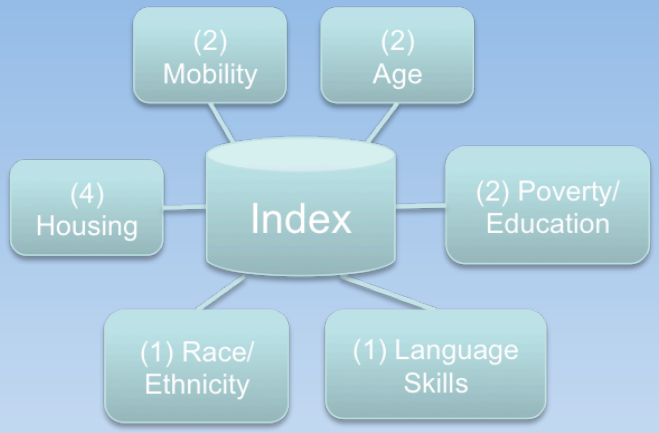
- Conceptual Design: Domains
- Structural Design: Deductive
- Analysis Scale: Census Tract, Block Group, and Tax Lot
- Indicators
- Transformation: Percentages, Per Capita
- Normalization: Max-Min linear scaling
- Weighting: Population Density
- Aggregation: Additive

ArcGIS Processes

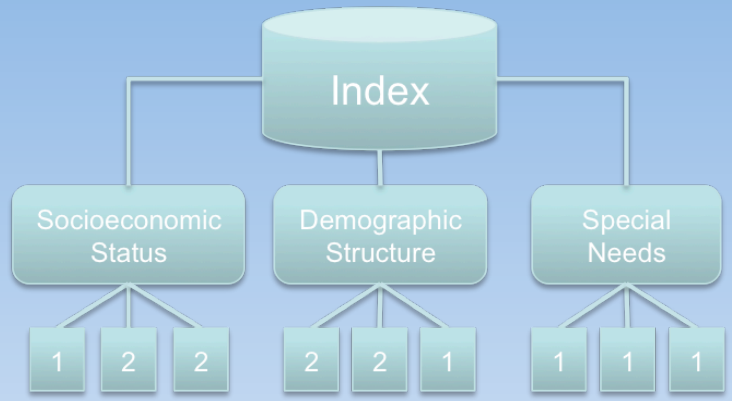
1. 2010 Census Variables
2. Transformation
3. Percentile Rank
4. 90^{th} percentile rank or higher
5. Aggregate
6. HVI Values 0 - 14

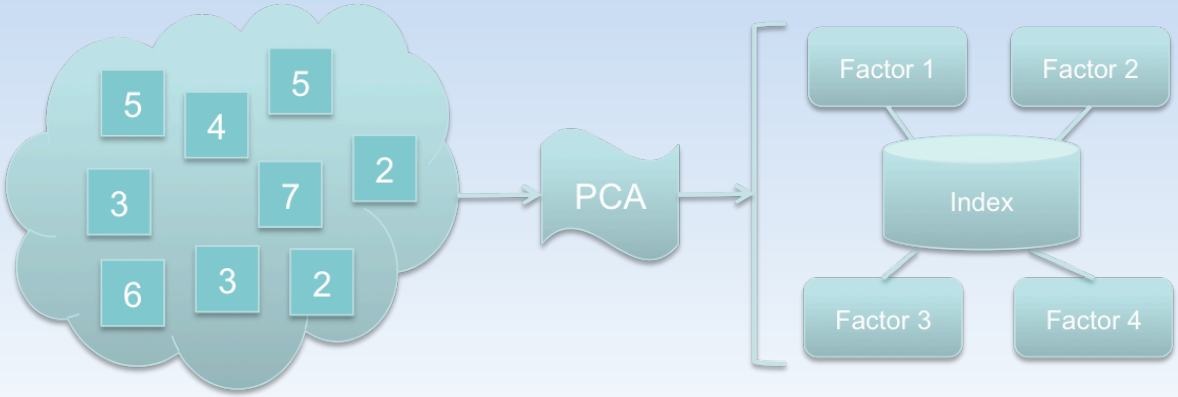
Social Vulnerability Index Structural Designs

Deductive Model



Hierarchical Model





Inductive Model

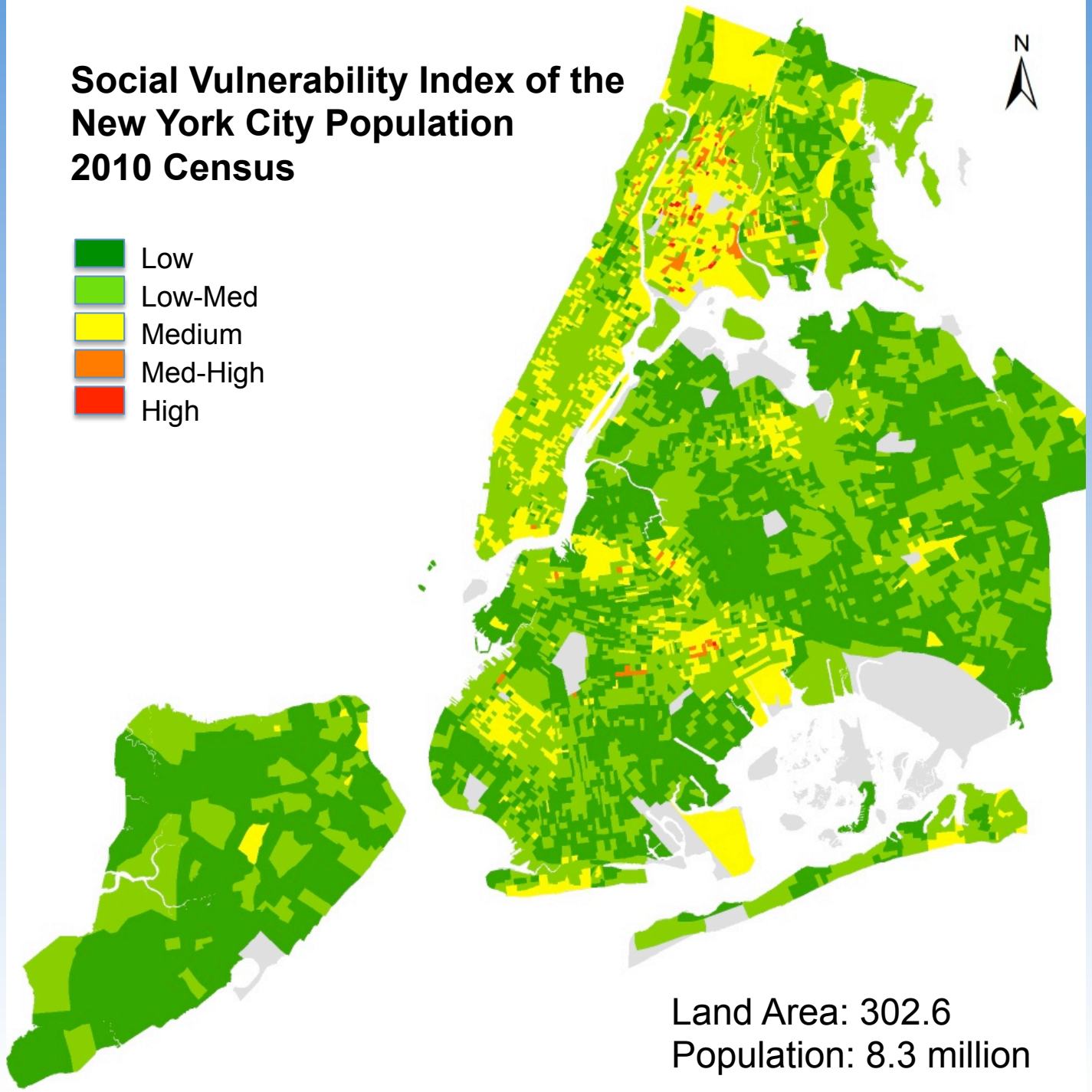
Adapted from Tate, E. 2012. Social vulnerability indices: a comparative assessment using uncertainty and sensitivity analysis. Natural Hazards 63:325-347.

Social Vulnerability Variables	Source	Unit	Description
Domain A: Socioeconomic Status			
1. Percent persons below poverty	ACS 5-Yr: 2006-2010	Block Group	Difficulty absorbing and recovering; lack of insurance, social safety nets, and entitlements programs.
2. Percent civilian unemployed	ACS 5-Yr: 2006-2010	Census Tract	Less financial resources, slower recovery .
3. Per Capita Income in the past 12 months	ACS 5-Yr: 2006-2010	Census Tract	Less financial resources, slower recovery .
4. Percent adults with no high school diploma	ACS 5-Yr: 2006-2010	Block Group	Lower education affects the ability to access and understand warning and recovery information.
Domain B: Household structure and disability			
5. Percent persons 65 years of age or older	2010 Census SF1	Block Group	Mobility constraints/concerns; lack of resilience.
6. Percent persons 10 years of age or younger	2010 Census SF1	Block Group	Movement out of harm's way. Time and money lost when daycare facilities are affected.
7. Percent male or female single householder with children under 18 years	ACS 5-Yr: 2006-2010	Census Tract	Limited finances to outsource child care. Affects resilience to and recovery from hazards.
Domain C: Minority Status and Language			
8. Percent Minority	2010 Census SF1	Block Group	Language and cultural barriers; Residences in high hazard areas; Access to post disaster funding
9. Percent persons 5 years of age or older who speak English less than well	ACS 5-Yr: 2006-2010	Block Group	Language and cultural barriers; Residences in high hazard areas; Access to post disaster funding
Domain D: Group Housing and Transportation			
10. Percent multi-unti structure	ACS 5-Yr: 2006-2010	Block Group	High density structures can complicate evacuation.
11. Percent Crowded Households	ACS 5-Yr: 2006-2010	Block Group	May lack shelter options when lodging becomes uninhabitable or too costly to afford.
12. Percent households without a vehicle	ACS 5-Yr: 2006-2010	Block Group	Ability to move out of harms way.
13. Percent persons in group quarters	2010 Census SF1	Block Group	Can be difficult to identify and measure; due to community invisibility can be ignored during recovery.

Adapted from Flanagan et al. 2011; Maantay et al. 2010; Cutter and Boruff 2003.

Source: 2010 US Census, American Community Survey Summary Files 2006 - 2010

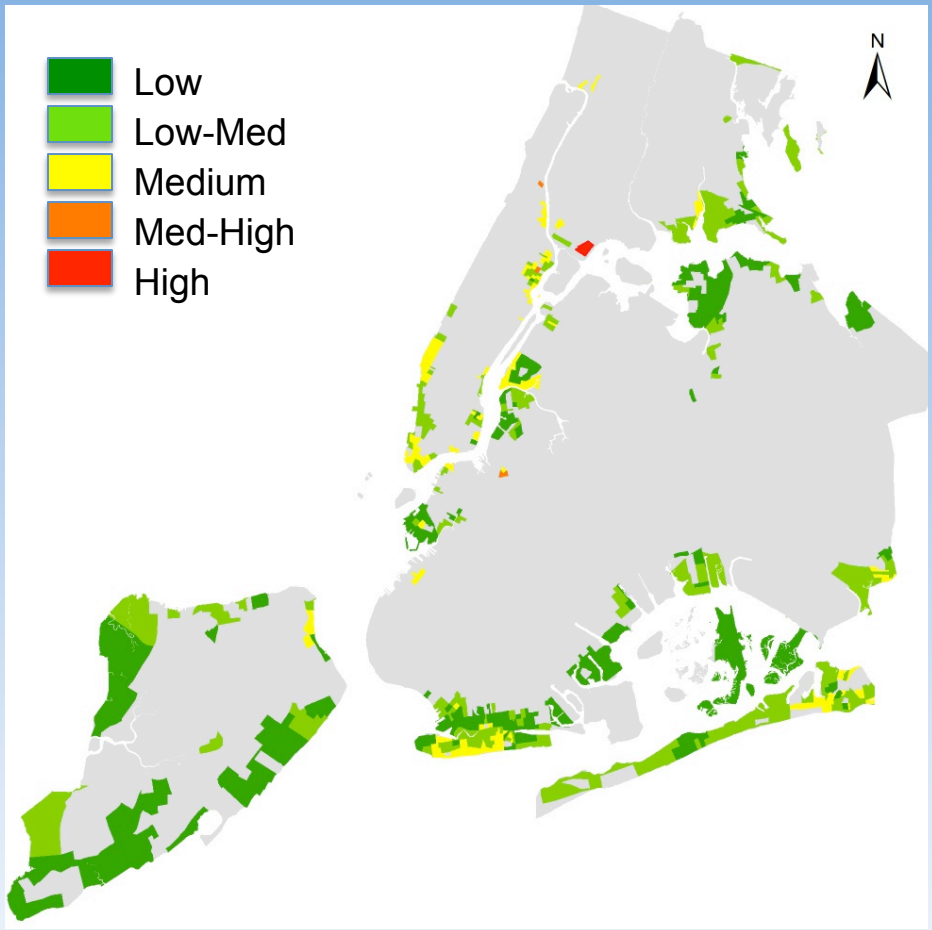
Social Vulnerability Index of the New York City Population 2010 Census



Land Area: 302.6
Population: 8.3 million

Social Vulnerability Index of Populations in the Projected 100-Year Flood Zone
with Model Based Sea-Level Rise Projections

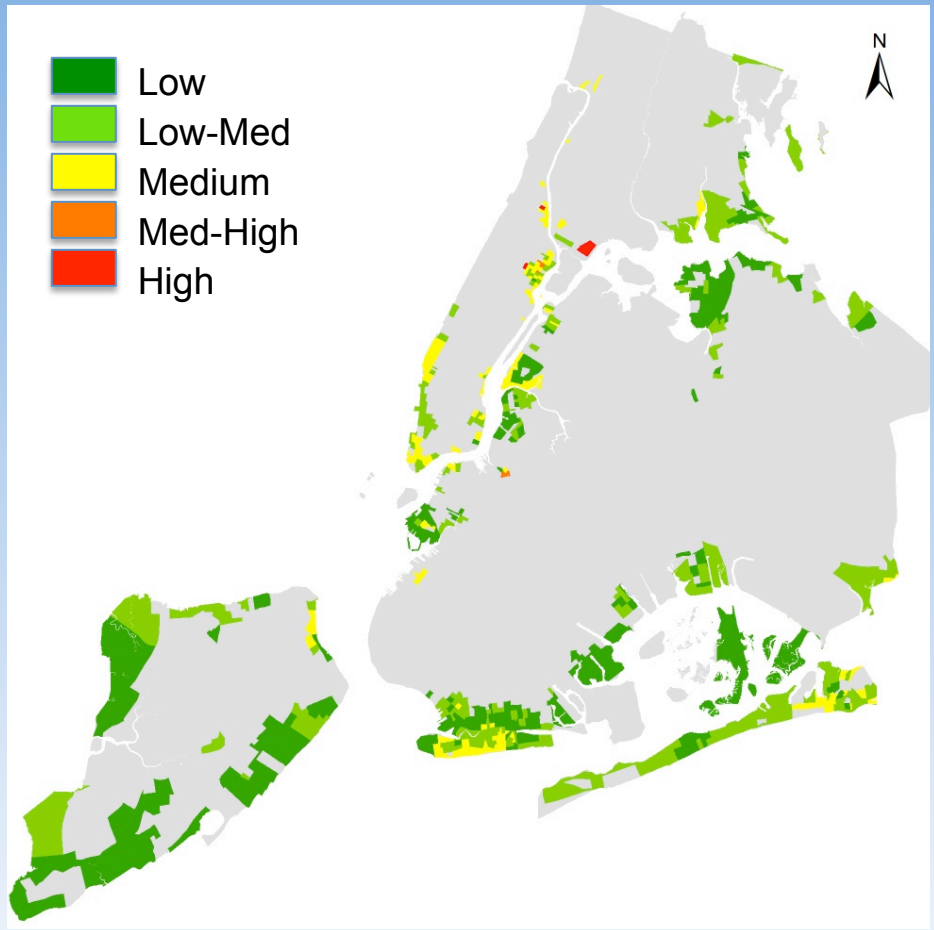
2020s, 5” sea-level rise



Flooded Area: 42.9 sq mi
Population in Flood Zone: 350,700

+8%
+13%

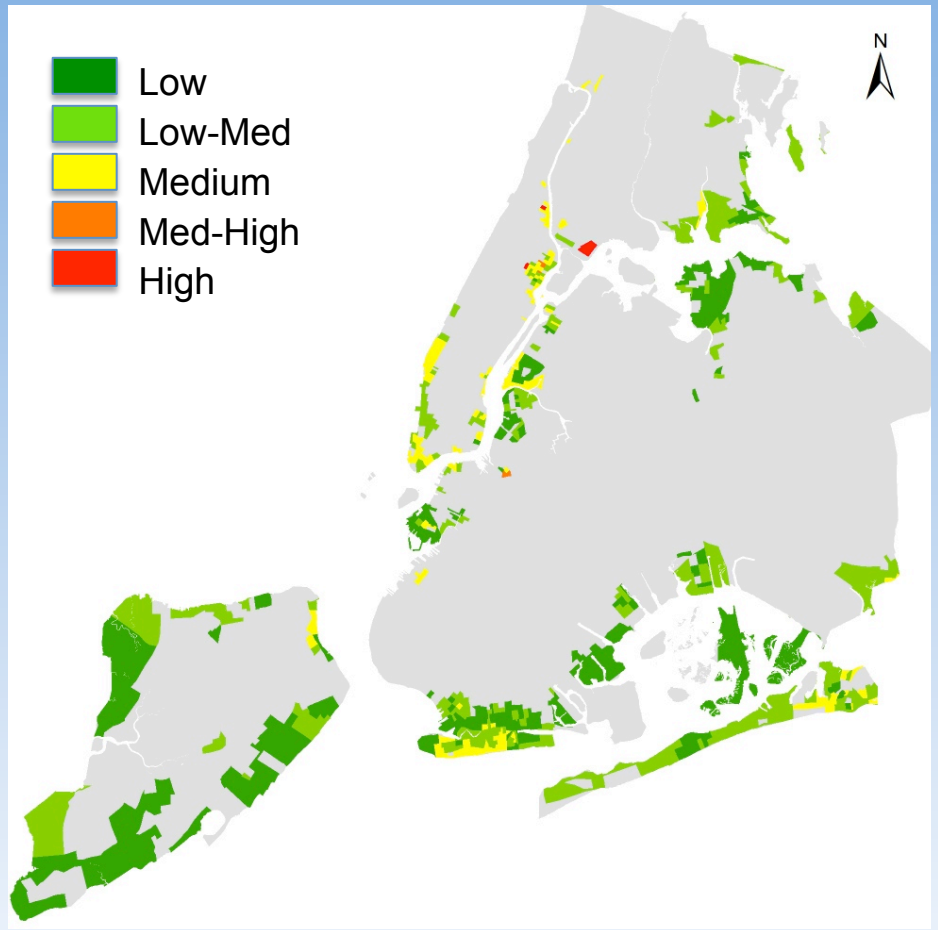
2050s, 13” sea-level rise



Flooded Area: 46.2 sq mi
Population in Flood Zone: 401,847

Social Vulnerability Index of Populations in the Projected 100-Year Flood Zone
with Model Based Sea-Level Rise Projections

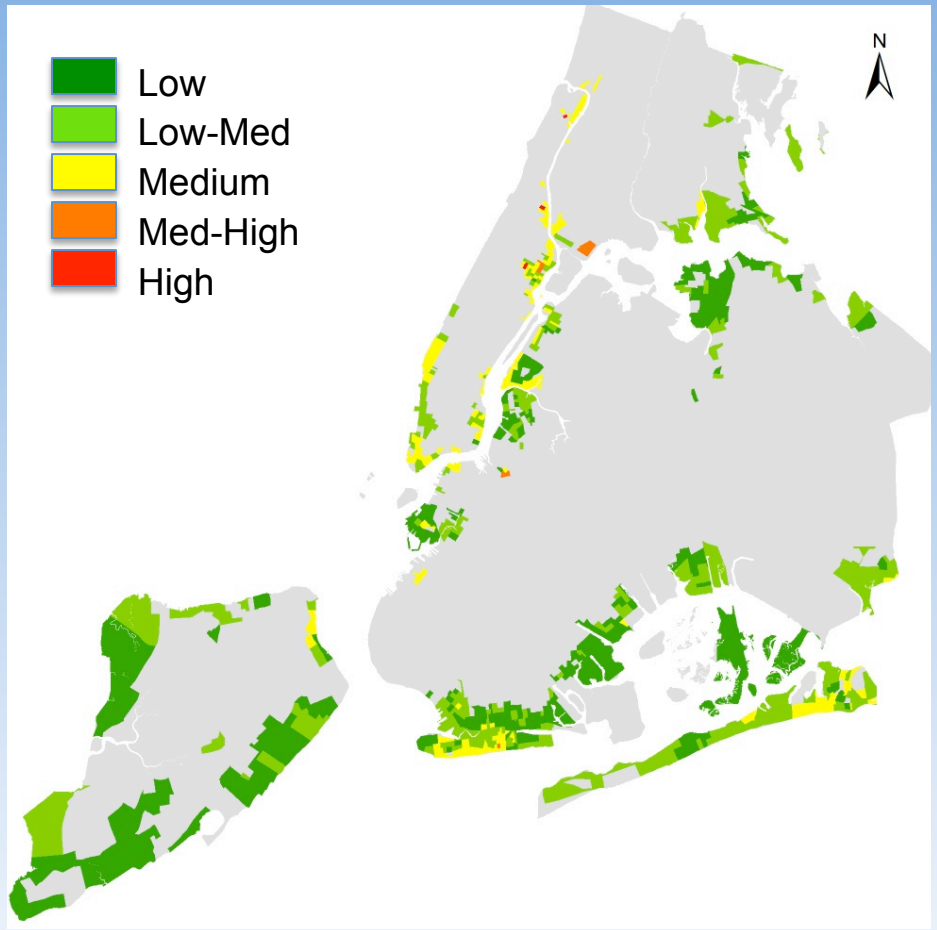
2050s, 13” sea-level rise



Flooded Area: 46.2 sq mi
Population in Flood Zone: 401,847

+9%
+17%

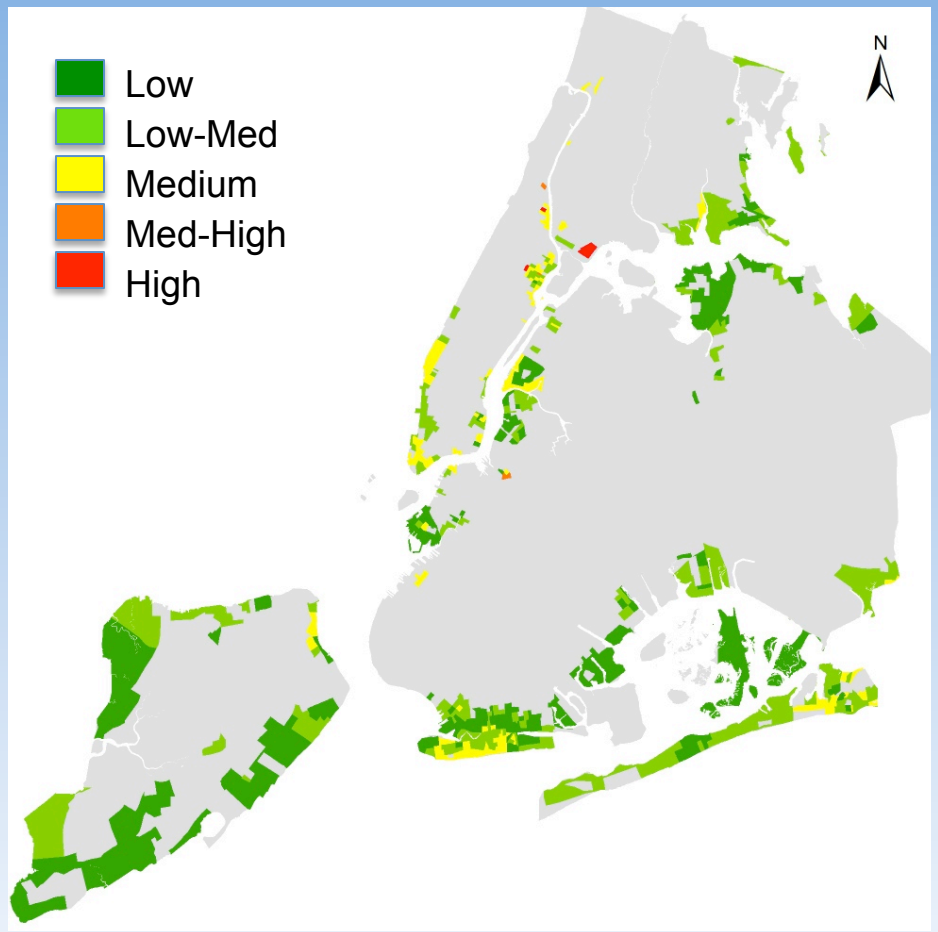
2080s, 23” sea-level rise



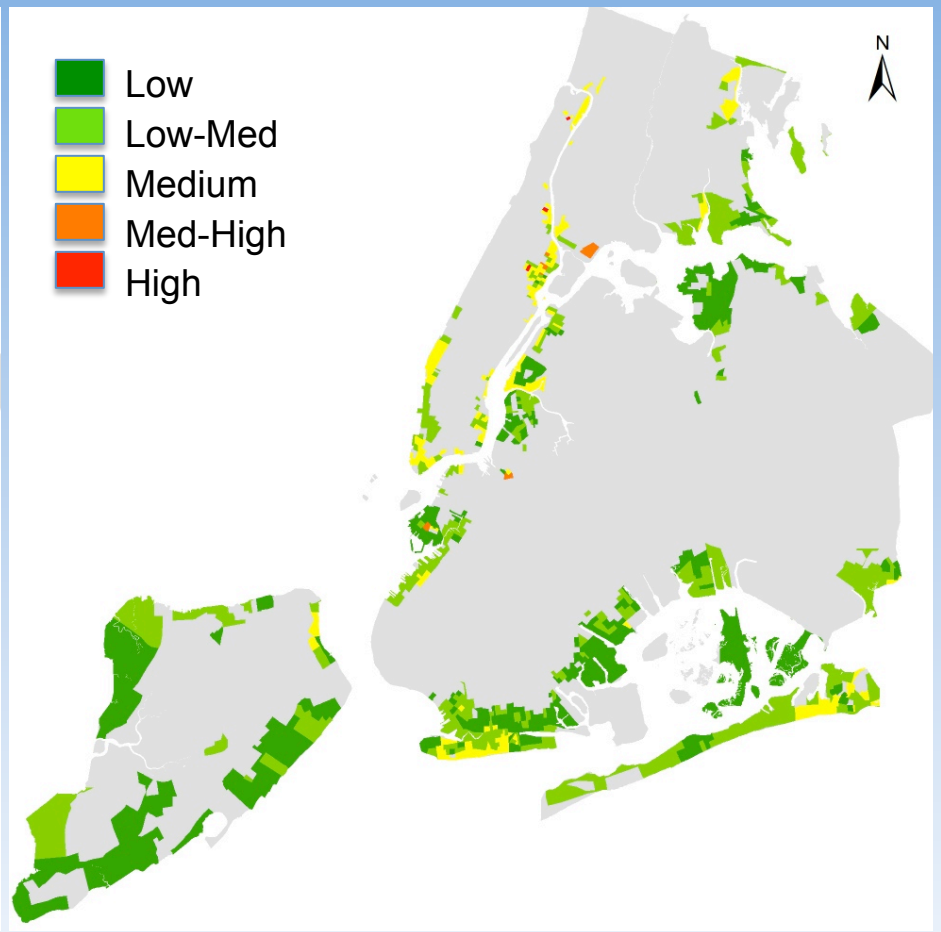
Flooded Area: 50.2 sq mi
Population in Flood Zone: 482,692

Social Vulnerability Index of Populations in the 100-Year Flood Zone
with Rapid Ice Melt Sea-Level Rise Projections

2020s, 9” sea-level rise



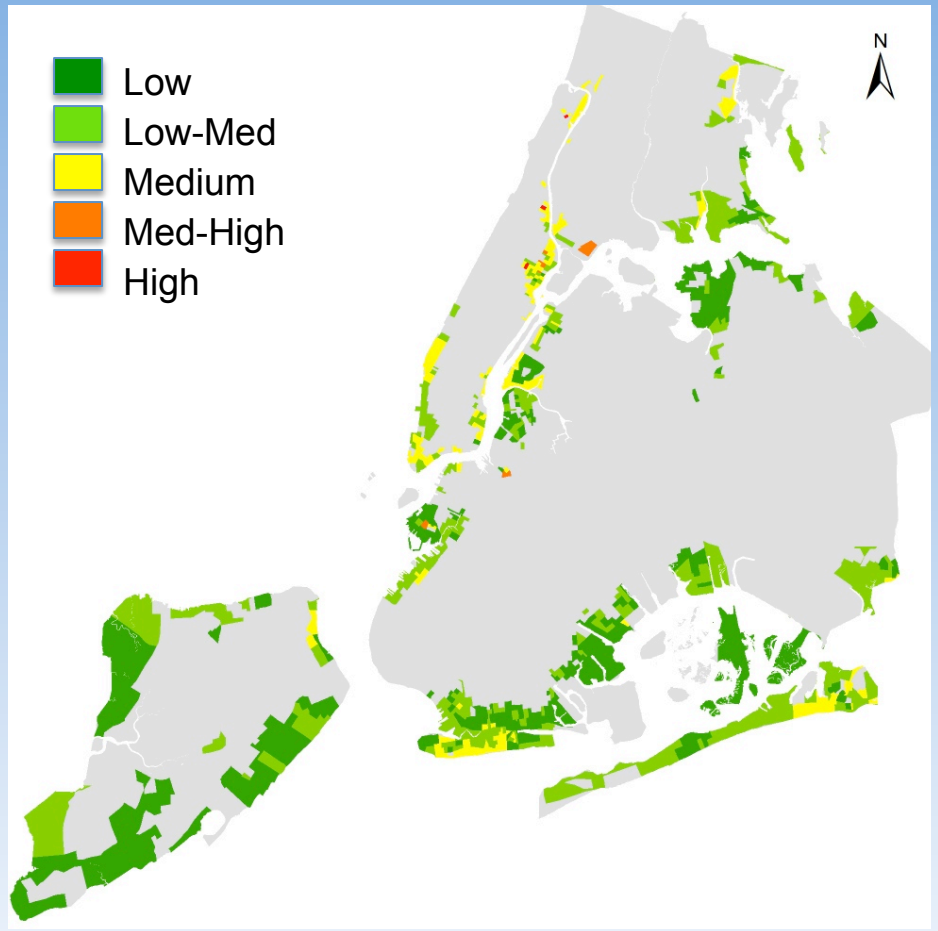
2050s, 27” sea-level rise



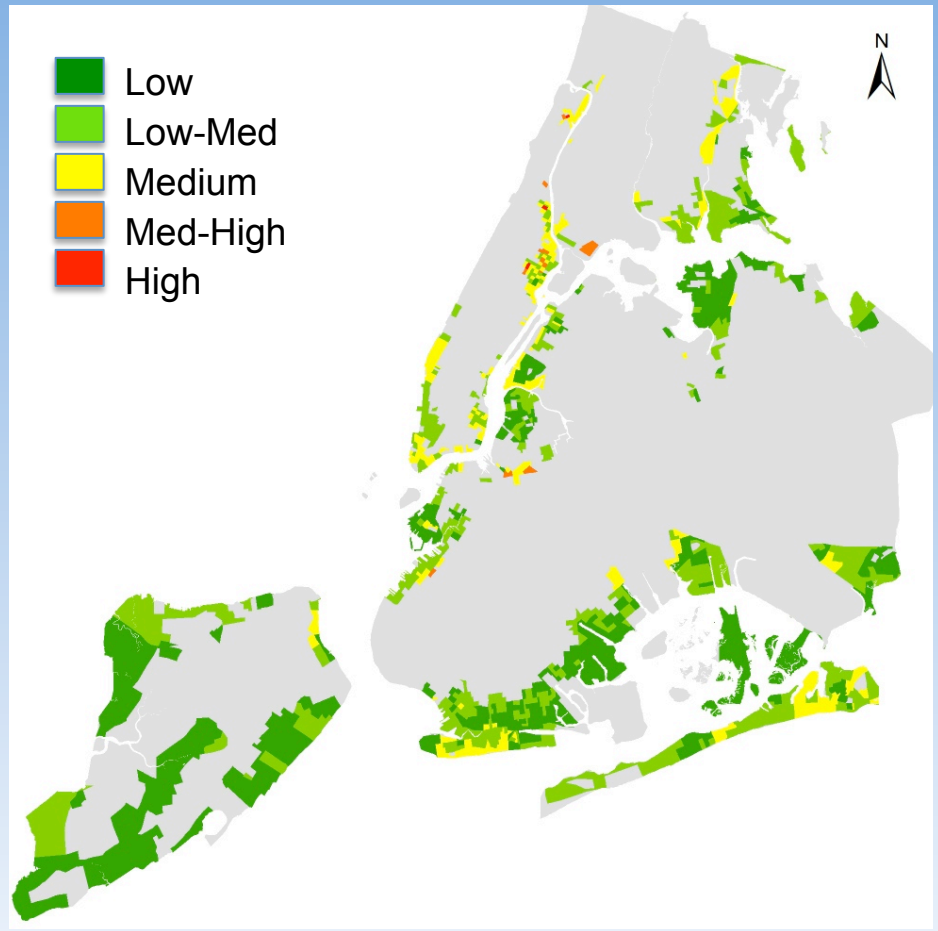
Flooded Area: 44.1 sq mi +20% Flooded Area: 53.1 sq mi
Population in Flood Zone: 375,834 +30% Population in Flood Zone: 534,191

Social Vulnerability Index of Populations in the 100-Year Flood Zone
with Rapid Ice Melt Sea-Level Rise Projections

2050s, 27” sea-level rise



2080s, 53” sea-level rise



Flooded Area: 53.1 sq mi
Population in Flood Zone: 534,191

+32%
+29%

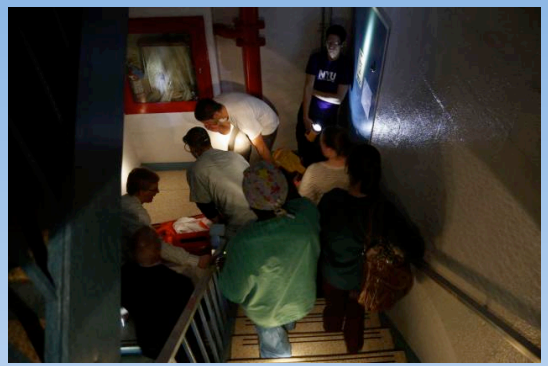
Flooded Area: 70.1 sq mi
Population in Flood Zone: 755,402

Next Steps

- Identify and rank areas at risk of greater flood exposure:
  - Higher water depth, zones of wave action
- Identify and rank areas proximal to sources of potential flood water contamination:
  - SIMA, Bulk/Major Oil storage, TRI, and National Priorities List (Superfund) sites, waste water treatment
- Identify and rank critical at risk infrastructure:
  - Emergency service, critical care services
  - Power stations, telecommunications, other utilities
  - Transportation

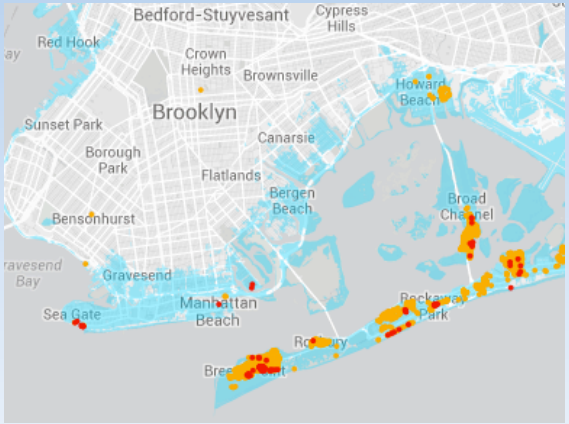
Critical Infrastructure at risk to flooding

Photograph by Iwan Baan
New York Magazine



NYU Langone Evacuation

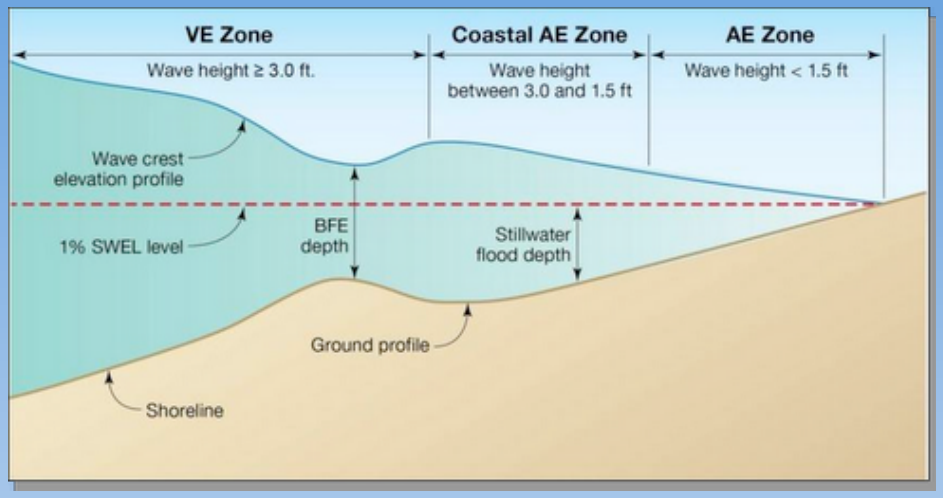
South Ferry Station



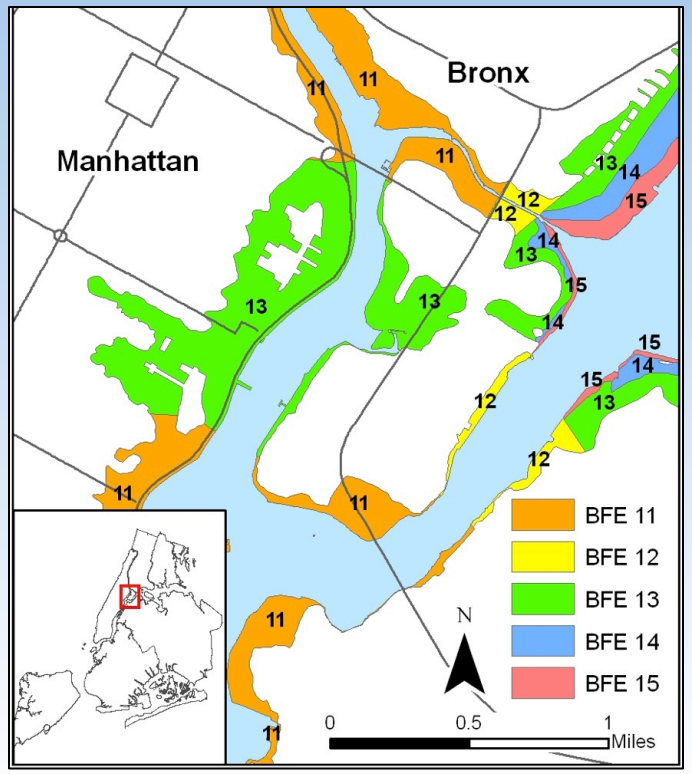
Limited Evacuation Routes

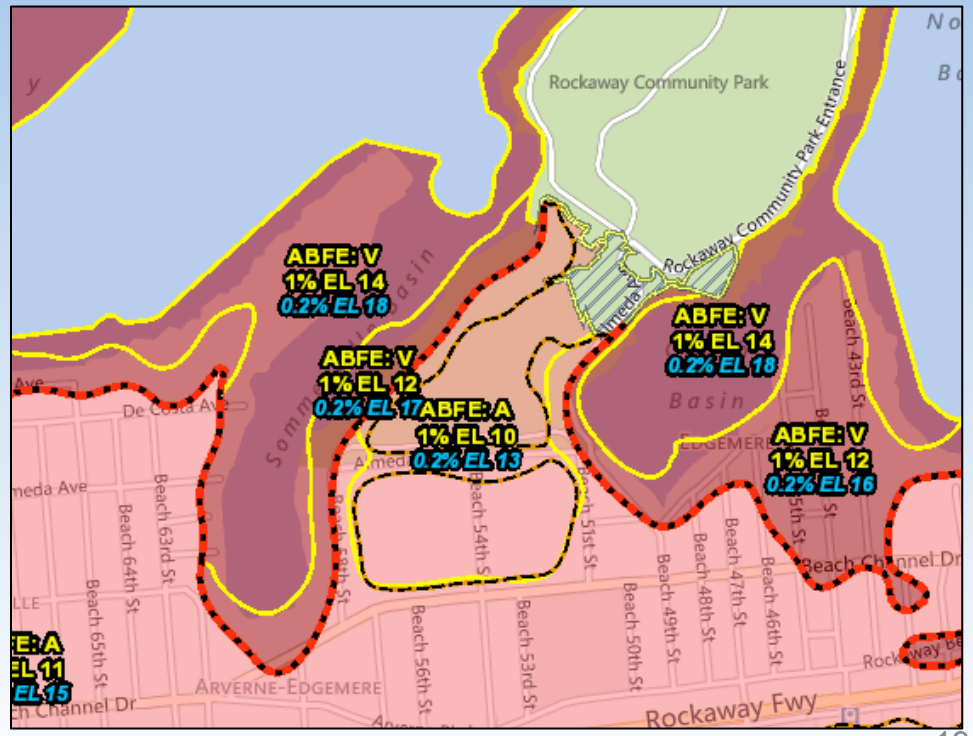
Breezy Point Fire, Queens

Degree of Exposure: Flood Height and Wave Action



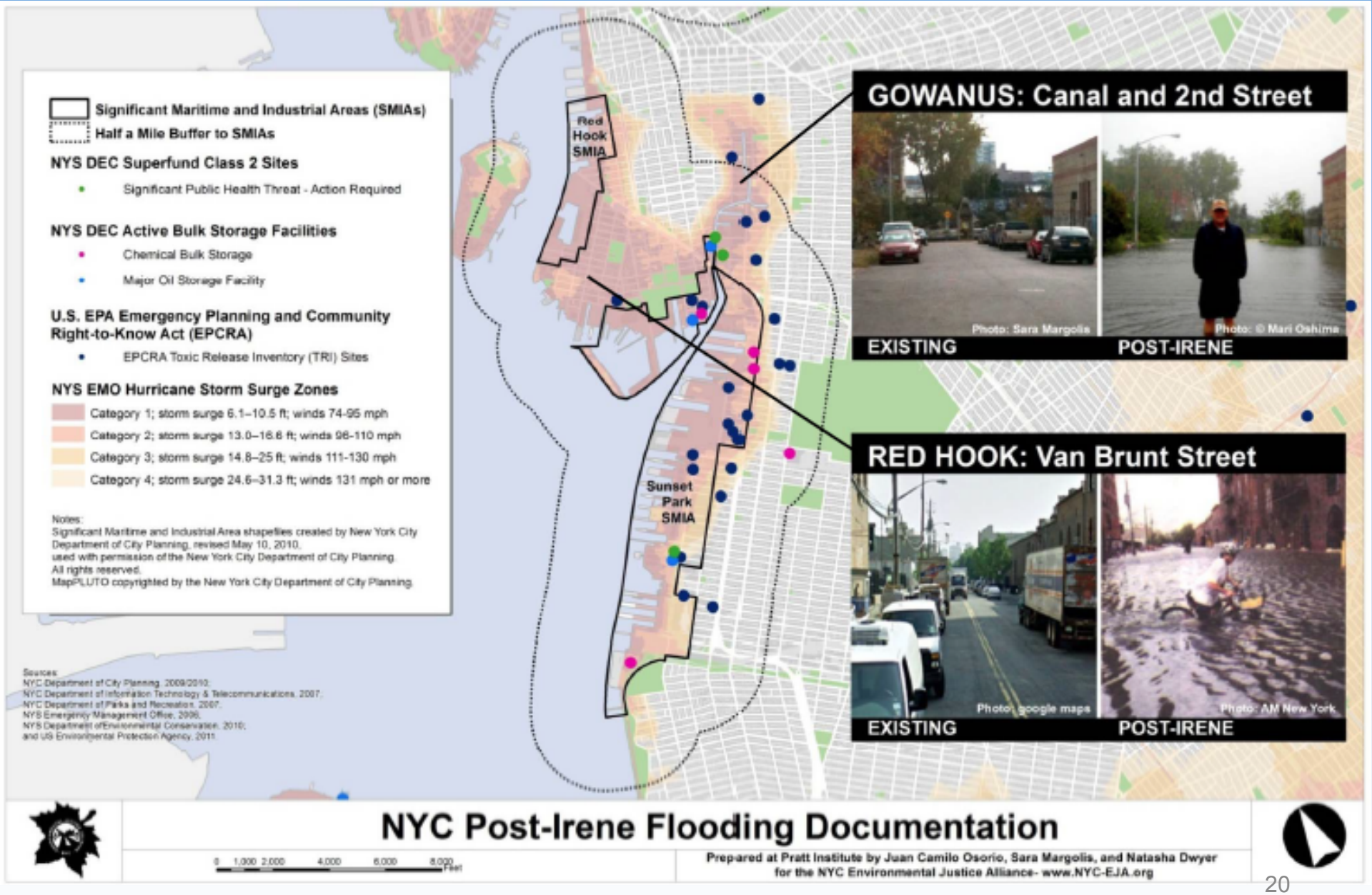
Source: FEMA Region 2, www.region2coastal.com





Source: FEMA Advisory Base Flood Elevations Map, April 11, 2013

Degree of Exposure: Hazardous Substances in Flood Waters



Source: New York City Environmental Justice Alliance, www.NYC-EJA.org

Conclusions

- Future sea-level rise will increase the risk of the 100-year flood, particularly under scenarios of potential population growth and distribution in the coastal and near-coastal zones.
- Due to sea-level rise, more communities are becoming vulnerable, existing communities are becoming more vulnerable and both are becoming less disaster resilient.
- A composite flood vulnerability index will identify and rank socially vulnerable populations at an elevated risk due to physical exposure to flooding, floodwater contamination, and proximity to at-risk critical infrastructure.
- Undertaking a composite flood vulnerability assessment and index should be a critical element in emergency and hazard management.