PHILADELPHIA IS A COASTAL CITY

Michael W. Tantala, P.E.
Tantala Associates, LLC, Engineers and Architects

PennDesign (Karen M'Closkey and Keith VanDerSys)

The City College of New York

(background) Matthew Cusick, Fiona's Wave, 2005

PHILADELPHIA

IS A

COASTAL CITY

1. my work with resiliency in other areas
2. the hazard and Philadelphia
3. Penn studio : *Testing the Waters : Philly Futures*
   (disaster, adaptation, or retreat)

On the Water | Palisade Bay

(with Guy Nordenson, Catherine Seavitt, *et al*)

Princeton University
School of Architecture

AIA
Latrobe Prize

imagines a "soft infrastructure" for the New York/New Jersey Upper Bay

develops interconnected infrastructures and landscapes which rethink the thresholds of water, land and city

mitigates potential damage from storms, new ground for recreation, ecologies, agriculture and urban development

MoMA

exhibition Rising Currents: Projects for New York's Waterfront, at The Museum of Modern Art, New York

the U.S. Pavilion at the 12th Venice Architecture Biennale

Model and Verification

Models were created to understand the consequences of flooding and its potential impact on infrastructure, ecosystems and coastal communities.

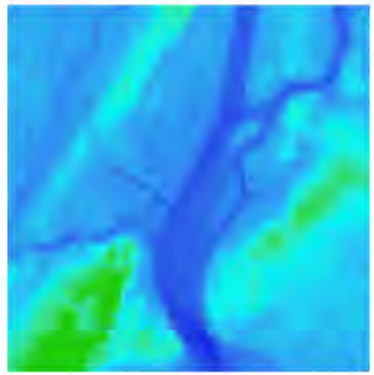


Fig. 9: GIS-generated bathymetric model of the Upper Bay. Deepest areas are indicated in green, shallowest areas in red.

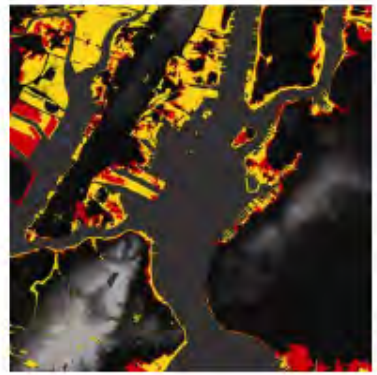


Fig. 10: GIS-generated inundation analysis of 100 and 500-year floodplains. The 100-year floodplain is indicated in yellow; the 500-year floodplain indicated in red.

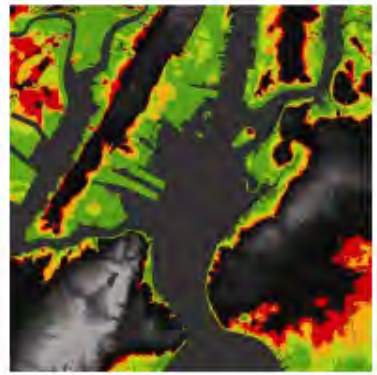


Fig. 11: GIS-generated inundation analysis of the SLOSH (Sea, Lake, and Overland Surges from Hurricanes) model. Category 1 and 2 hurricanes are indicated in green, Category 3 in orange, and Category 4 in red.

Fig. 12: Regional boundary domain, digital elevation model and simulated flood inundation zone using HAZUS-MH

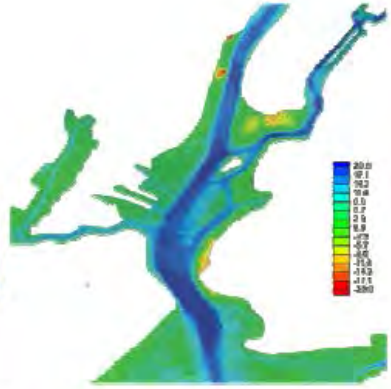


Fig. 13: ADCRIC computational hydrodynamic, finite element model with color scale rendered for elevation in meters

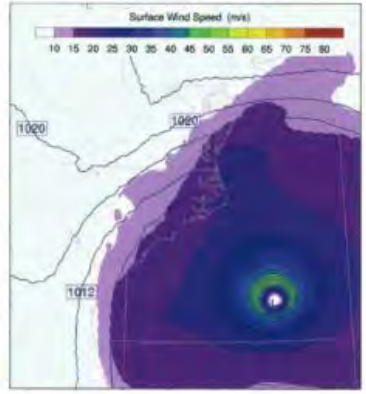


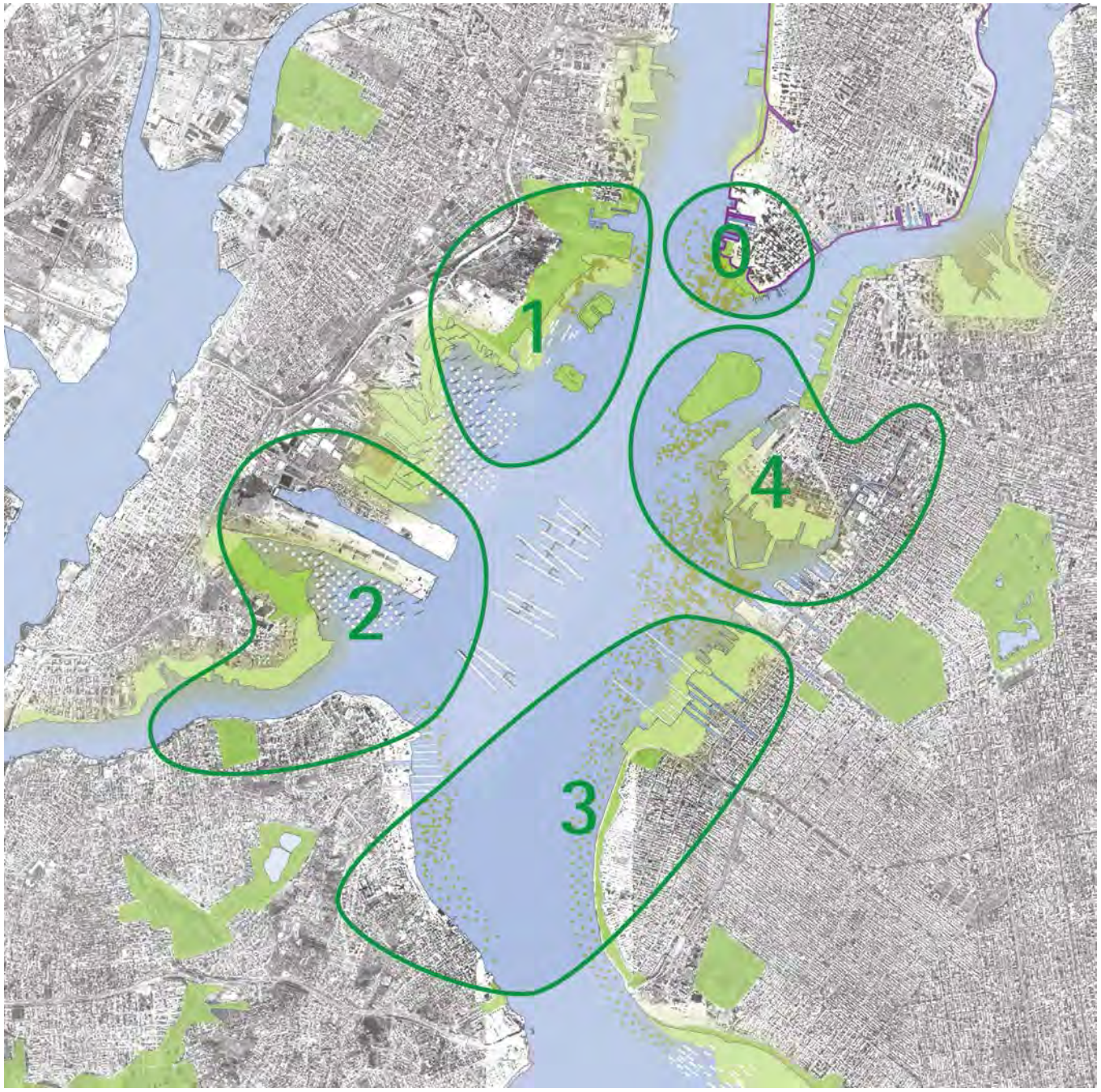
Fig. 14: Illustration of model initialization for "displaced" Hurricane Isabel. Color scale represents surface wind speed (m/s)

imagines a "soft infrastructure" for the New York/New Jersey Upper Bay

develops interconnected infrastructures and landscapes which rethink the thresholds of water, land and city

mitigates potential damage from storms but also provides new ground for recreation, ecologies, agriculture and urban development

"soft infrastructure" >



Structures of Coastal Resilience (SCR) Project

(with Guy Nordenson, Catherine Seavitt, *et al*)

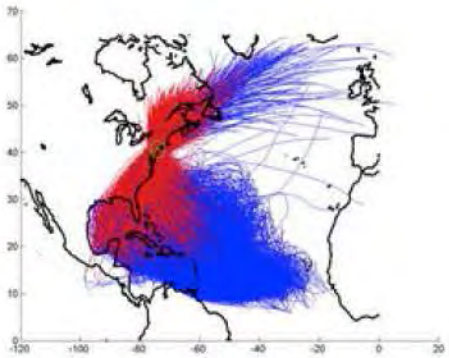
study and propose resilient designs for urban coastal regions in the North Atlantic

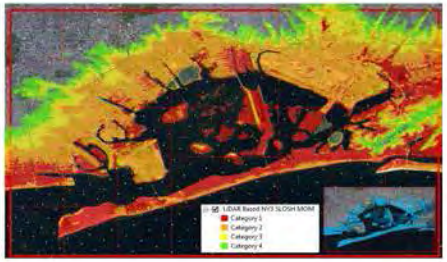
part of Federal and USACE

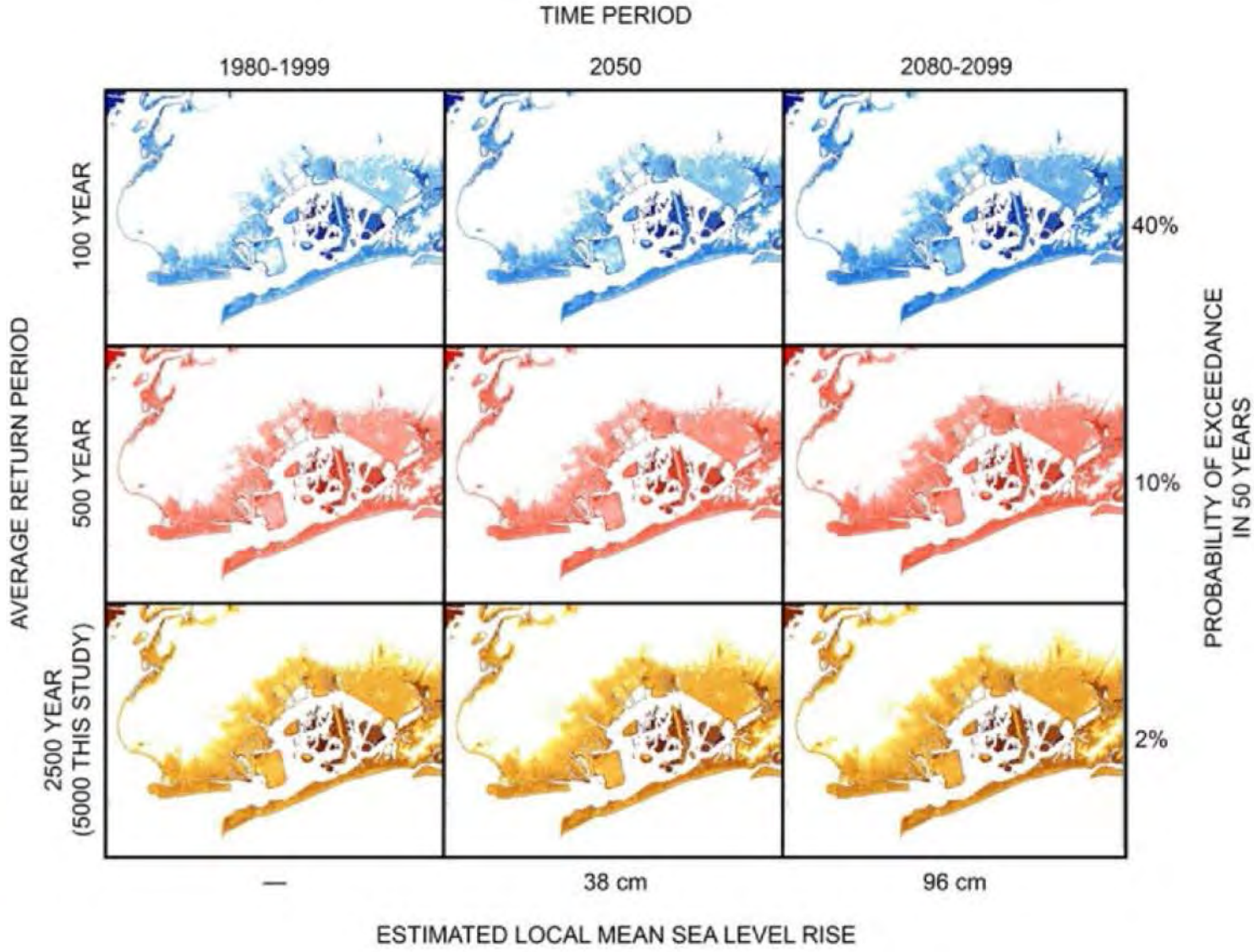
Includes structural, nonstructural, and 'natural and nature based features' (NNBFs)

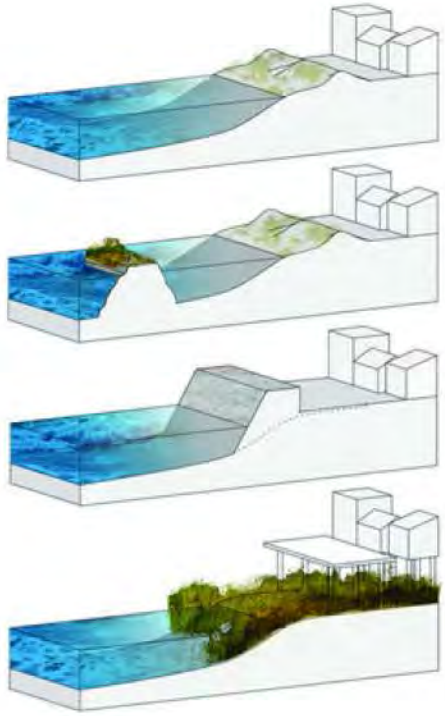
mapping of storm surge inundation with and without interventions


Boston/ Providence
Atlantic City
New York
Norfolk/Chesapeake Bay






TIME PERIOD
1980-1999
2050
2080-2099
AVERAGE RETURN PERIOD
100 YEAR
500 YEAR
2500 YEAR
(5000 THIS STUDY)
40%
10%
2%
PROBABILITY OF EXCEEDANCE
IN 50 YEARS
—
38 cm
96 cm
ESTIMATED LOCAL MEAN SEA LEVEL RISE



The three principles of attenuation, protection, and planning are central to the design approach and methodology that define the Structures of Coastal Resilience project.

The implications for flood resistant design are clear and can be summarized in three principles:

Attenuation and dissipation of wave energy offshore to reduce the demands on barriers and levees or wetlands where they exist or to building and structures where they do not;

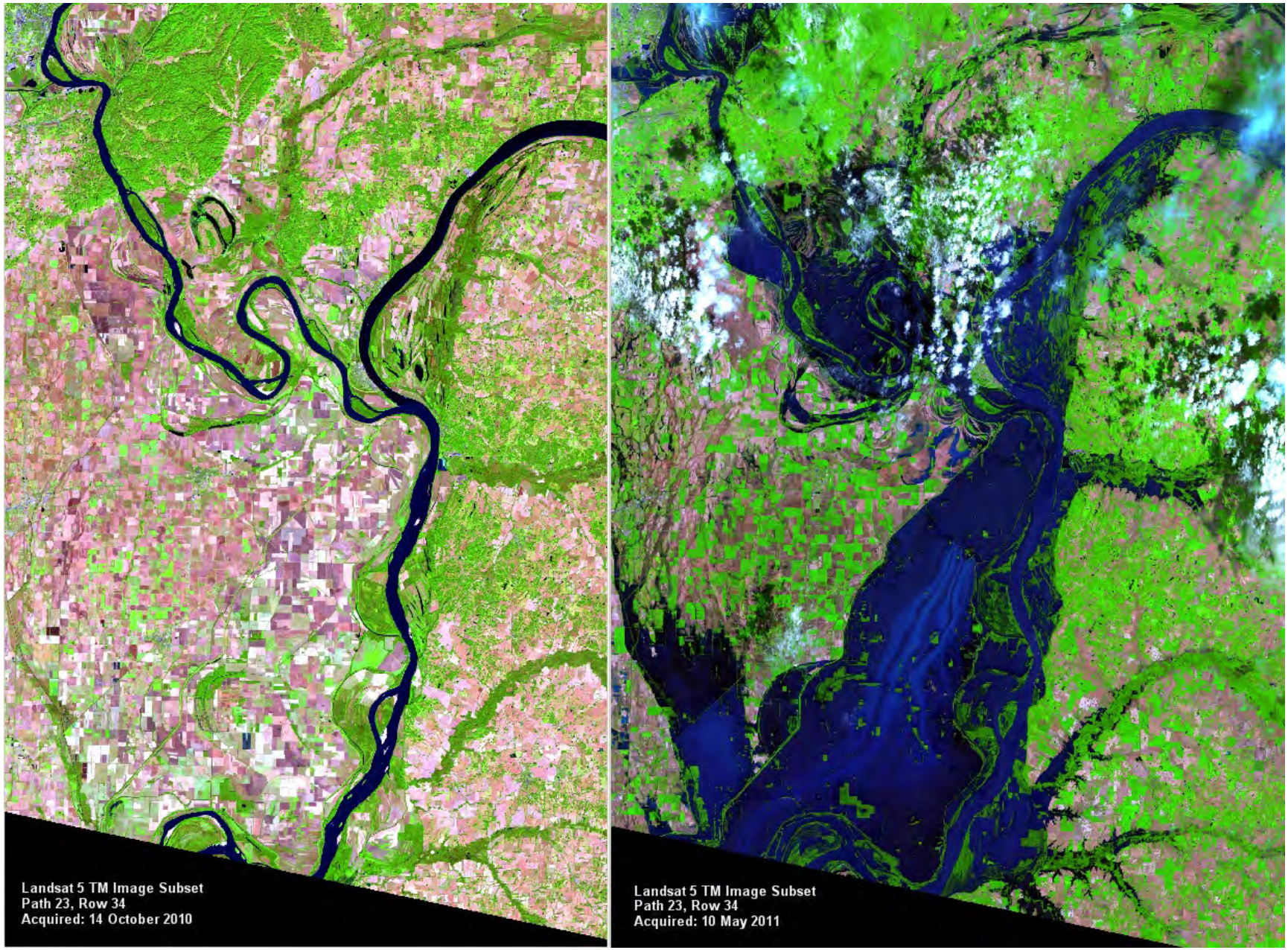
Protection with both flood structures and building code requirements knowing that some flooding will inevitably occur;

Planning for controlled flooding through urban and landscape flood plain management and design.

work with
remote sensing
of floods

delineation of
inundation,
areas and volumes

water recede
rates



Inundation Delineation: USGS Landsat images of Ohio/Mississippi River confluence before and during floods of 2011

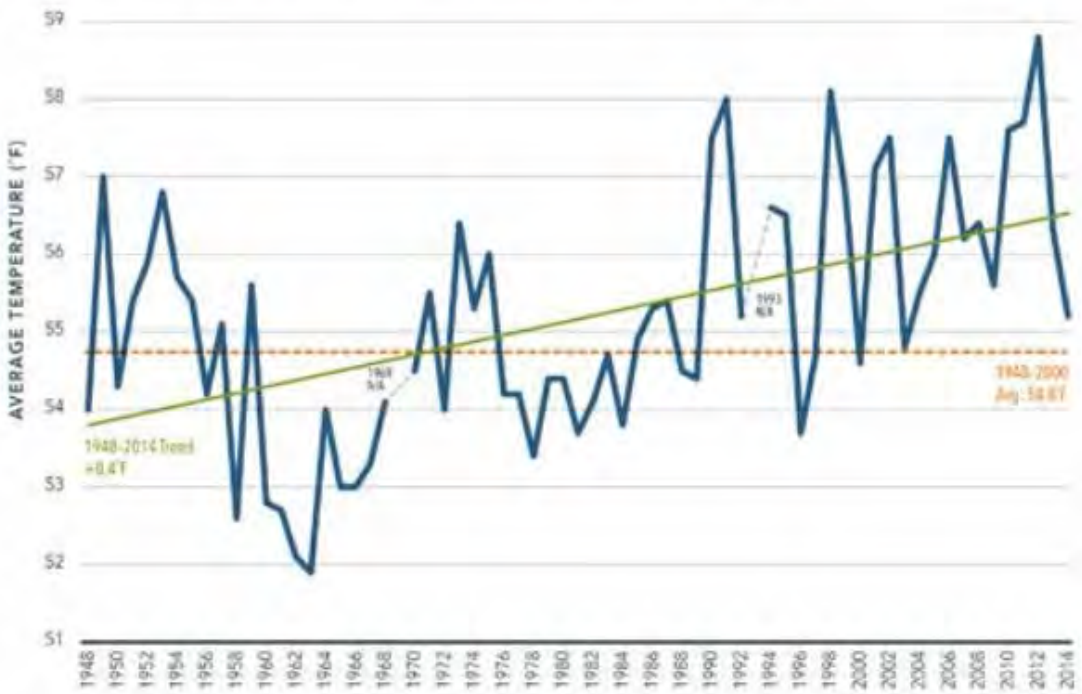
PHILADELPHIA

IS A

COASTAL CITY

- (although it is 60 miles inland from the Atlantic Ocean)
- it sits within the Delaware Estuary
- it faces significant challenges from climate change
- the next 30 years: 10x tidal flooding events increase (19/yr to 200/yr)

ANNUAL TEMPERATURE TREND FOR PHILADELPHIA, 1948–2014



The horizontal line represents the average temperature in Philadelphia from 1948–2000.[2]

HISTORICAL AND PROJECTED FUTURE TEMPERATURE INDICATORS FOR PHILADELPHIA

	OBSERVED (1950–1999)	PROJECTIONS FOR 2081–2099
Average summer temperature	84.5°F	89–93.7°F
Average number of days above 95°F	3	17–52
Average number of days above 100°F	0	2–16
Hottest 7-day average temperature	92°F	97–102°F

SOURCE: Useful Climate Information for Philadelphia: Past and Future

- *New Normals* past designs were based on past climate conditions
- Changing *Extremes* more frequent and severe

  snowiest winter, warmest summer, wettest day since 2010
- *Rising* Seas sea level rise raises levels in the Delaware & Schuylkill Rivers

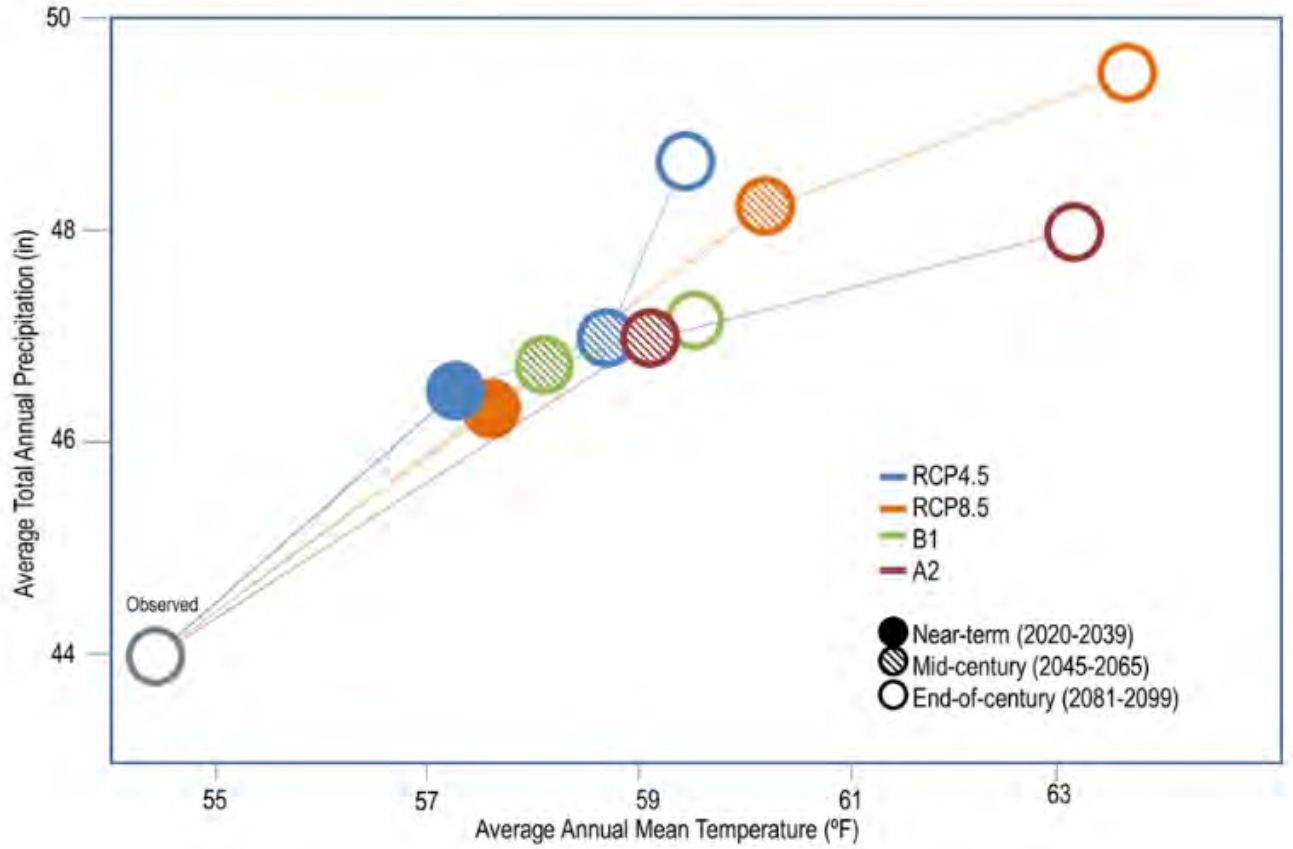
  increases depths and extent of flooding (storm surge)

  sea level rise 0.11 in / yr since 1900, one foot in 100 years!

(source: *Toward A Climate Ready Philadelphia* City of Philadelphia Mayor's Office of Sustainability and ICF International)

temperature
vs
precipitation

Figure 1 – Projected Changes in Average Annual Temperature and Total Annual Precipitation in Philadelphia

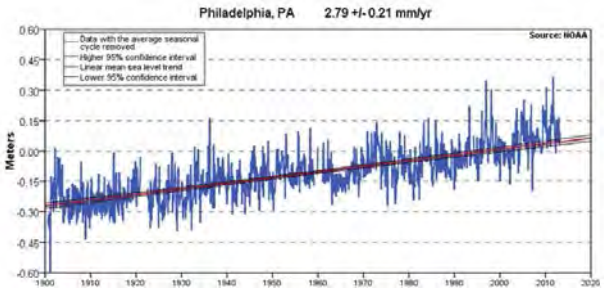


(source: *Toward A Climate Ready Philadelphia*
City of Philadelphia Mayor's Office of Sustainability and ICF International)

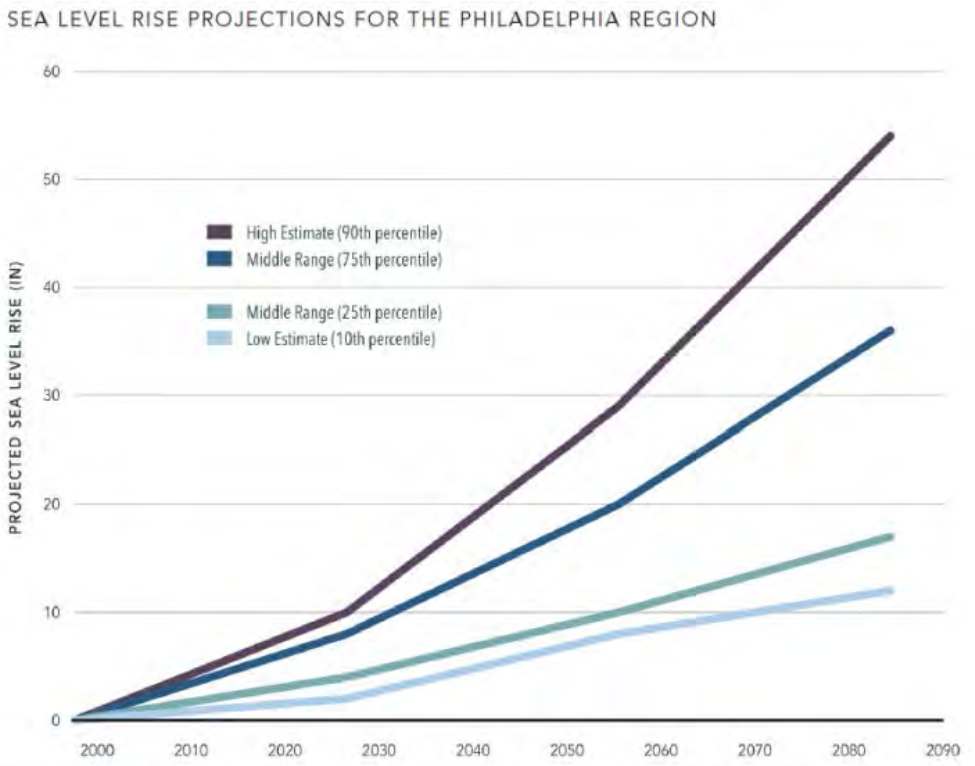
- Temperature increases → Precipitation increases
- various models, assumptions and predictions
- RCP = Representative Concentration Pathway (emissions scenarios)

RCP8.5	RCP6.0	RCP4.5
No intervention (business as usual)	Moderate	More aggressive intervention

Phila observed over 100 years mean sea level rise (SLR)



SLR future projections



Developed by scientists at Columbia University as part of the Consortium for Climate Risk in the Urban Northeast, and the Climate and Urban Systems Partnership.[9]

SEA LEVEL RISE PROJECTIONS FOR PHILADELPHIA

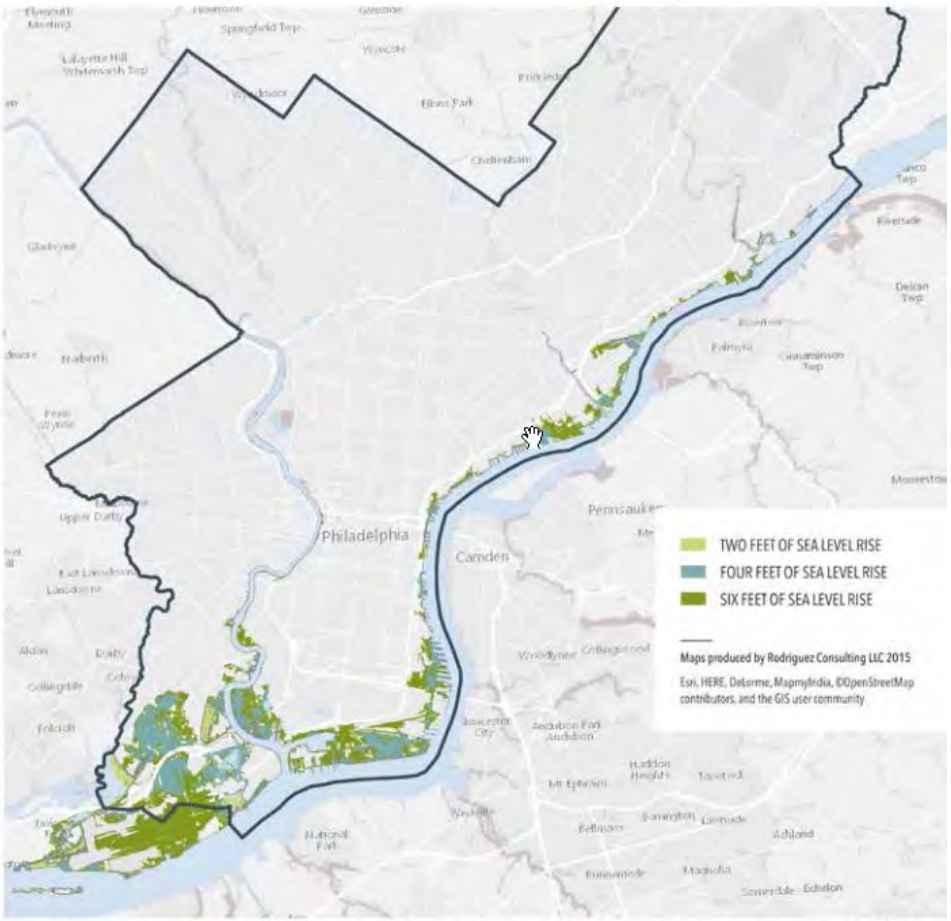
SOURCE	TIMELINE	SCENARIO			
		Low (10th%)	Mid (25th%)	Mid (75th%)	High (90th%)
CUSP	MID-CENTURY	< 1 ft (7-8")	< 1 ft (10")	2 ft (20")	3 ft (30")
	END-OF-CENTURY	1 ft (12")	1-2 ft (18")	3 ft (36")	4-5 ft (55")
		NCA Low	NCA Intermed-Low	NCA Intermed-High	NCA High
DOE	MID-CENTURY	< 1 ft	1 ft (2069)	1 ft (2045), 2 ft (2067)	<2 ft (2051)
	END-OF-CENTURY	< 1 ft	2 ft (2109)	4 ft (2100)	6 ft (2095)

(source: *Toward A Climate Ready Philadelphia* City of Philadelphia Mayor's Office of Sustainability and ICF International)

(source: *Toward A Climate Ready Philadelphia* City of Philadelphia Mayor's Office of Sustainability and ICF International)

SLR
(2', 4', 6')

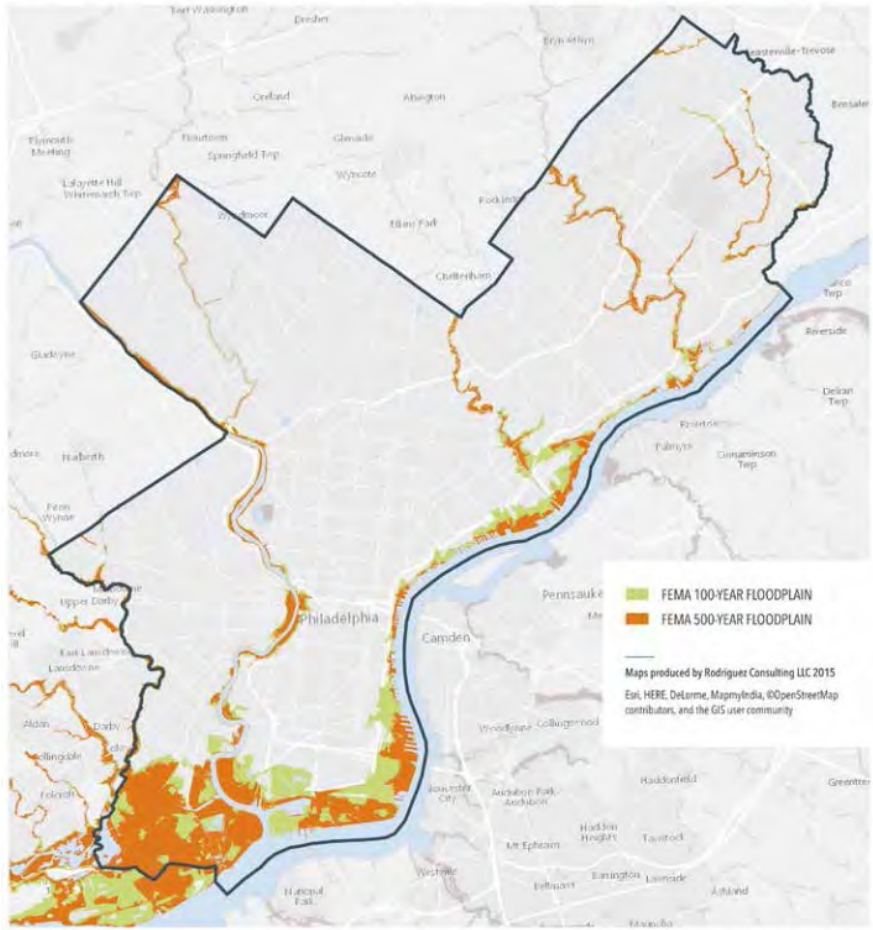
POTENTIAL INUNDATION FROM SEA LEVEL RISE



Areas in Philadelphia at risk of inundation under two feet of sea level rise, which is the expected sea level rise in 2050 under a scenario of moderate greenhouse gas emissions; four feet of sea level rise, which is the expected sea level rise in 2100; and six feet of sea level rise, which is the expected level in 2100 under a high-greenhouse-gas emissions scenario.

FEMA
(100 year and 500 year evenst)

POTENTIAL INUNDATION FROM 100- AND 500-YEAR FLOODS



Areas of Philadelphia at risk of inundation under a 100-year flood (a flood with a one percent chance of happening any year) and a 500-year flood (a flood with a 0.2 percent chance of happening any year).

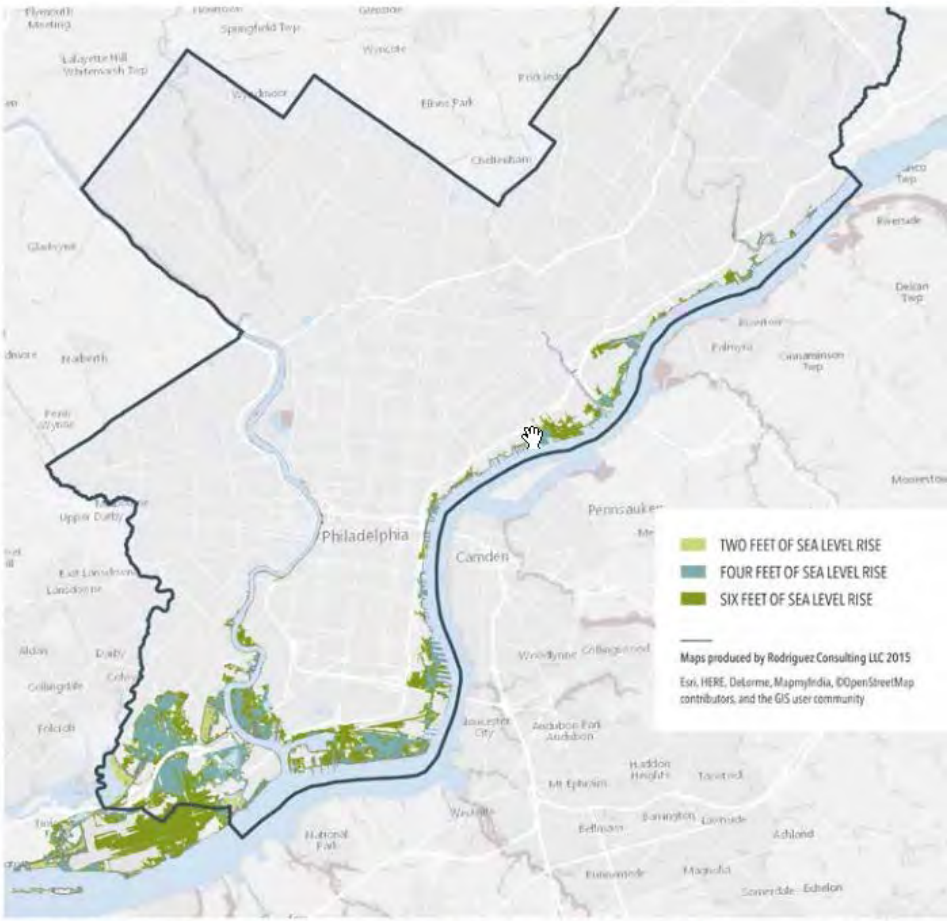
DELAWARE VALLEY dvrpc REGIONAL PLANNING COMMISSION

Waterfront Development in a Changing Climate
"Philadelphia is a Coastal City", Tantala, 2017.06.20

(source: *Toward A Climate Ready Philadelphia* City of Philadelphia Mayor's Office of Sustainability and ICF International)

SLR (2', 4', 6')

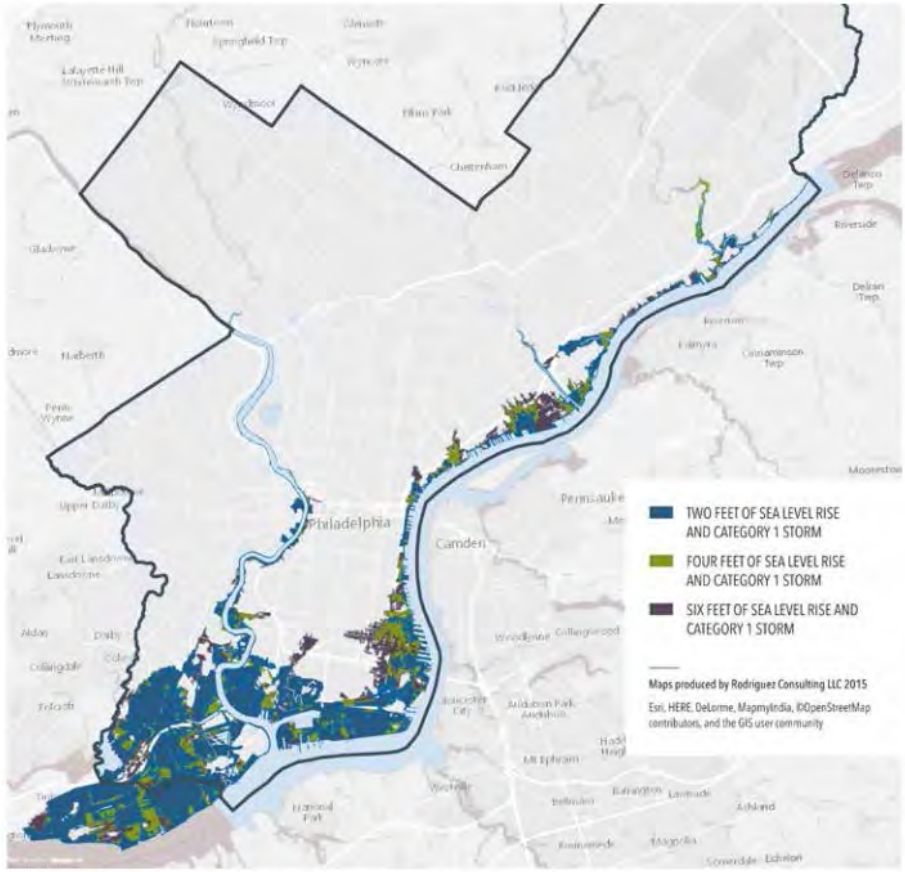
POTENTIAL INUNDATION FROM SEA LEVEL RISE



Areas in Philadelphia at risk of inundation under two feet of sea level rise, which is the expected sea level rise in 2050 under a scenario of moderate greenhouse gas emissions; four feet of sea level rise, which is the expected sea level rise in 2100; and six feet of sea level rise, which is the expected level in 2100 under a high-greenhouse-gas emissions scenario.

SLR and STORM (CAT 1 + 2', 4', 6')

POTENTIAL INUNDATION FROM SEA LEVEL RISE AND SEVERE STORM

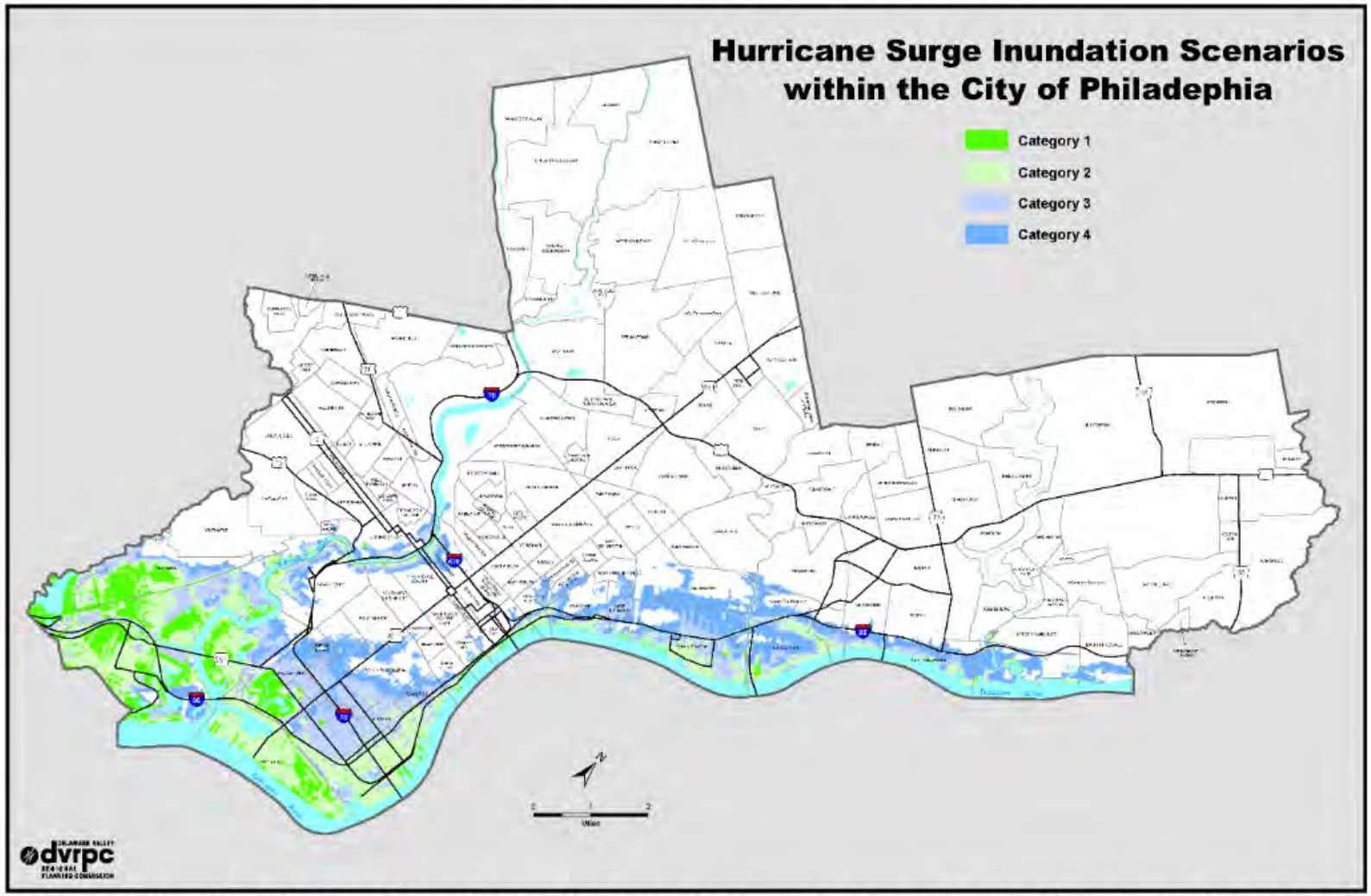


Areas in Philadelphia at risk of inundation by a Category 1 storm on top of two feet of sea level rise, which is the expected sea level rise in 2050 under a scenario of moderate greenhouse gas emissions; four feet of sea level rise, which is the expected sea level rise in 2100; and six feet of sea level rise, which is the expected level in 2100 under a high-greenhouse-gas emissions scenario. A Category 1 storm represents the most severe hurricane the region has ever experienced.

Storm Surge/Sea Level Rise Information courtesy of Energy Infrastructure Modeling and Analysis, Office of Electricity Delivery and Energy Reliability, U.S. Department of Energy. Original data produced by NOAA with analysis by ICF.

(source: *Toward A Climate Ready Philadelphia* City of Philadelphia Mayor's Office of Sustainability and ICF International)

Hurricane Surge Inundation Scenarios within the City of Philadelphia



Source: Hurricane Surge Inundation areas for category 1 through 4 hurricanes arriving at high mean water. The hurricane surge elevation data used to define these areas was calculated by the National Hurricane Center using the Sea Lake and Overland Surge from Hurricanes (SLOSH) Model. The SLOSH model hurricane surge elevations have an accuracy of +/- 20 percent. The hurricane surge inundation areas depict the inundation that can be expected to result from a worst case combination of hurricane landfall location, forward speed, and direction for each hurricane category.

(source: *Toward A Climate Ready Philadelphia* City of Philadelphia Mayor's Office of Sustainability and ICF International)

DIAGRAM OF THE PREPAREDNESS, DISASTER, AND RECOVERY PROCESS

PennDesign
Spring 2017 Architectural Studio

TESTING THE WATERS: Philly Futures

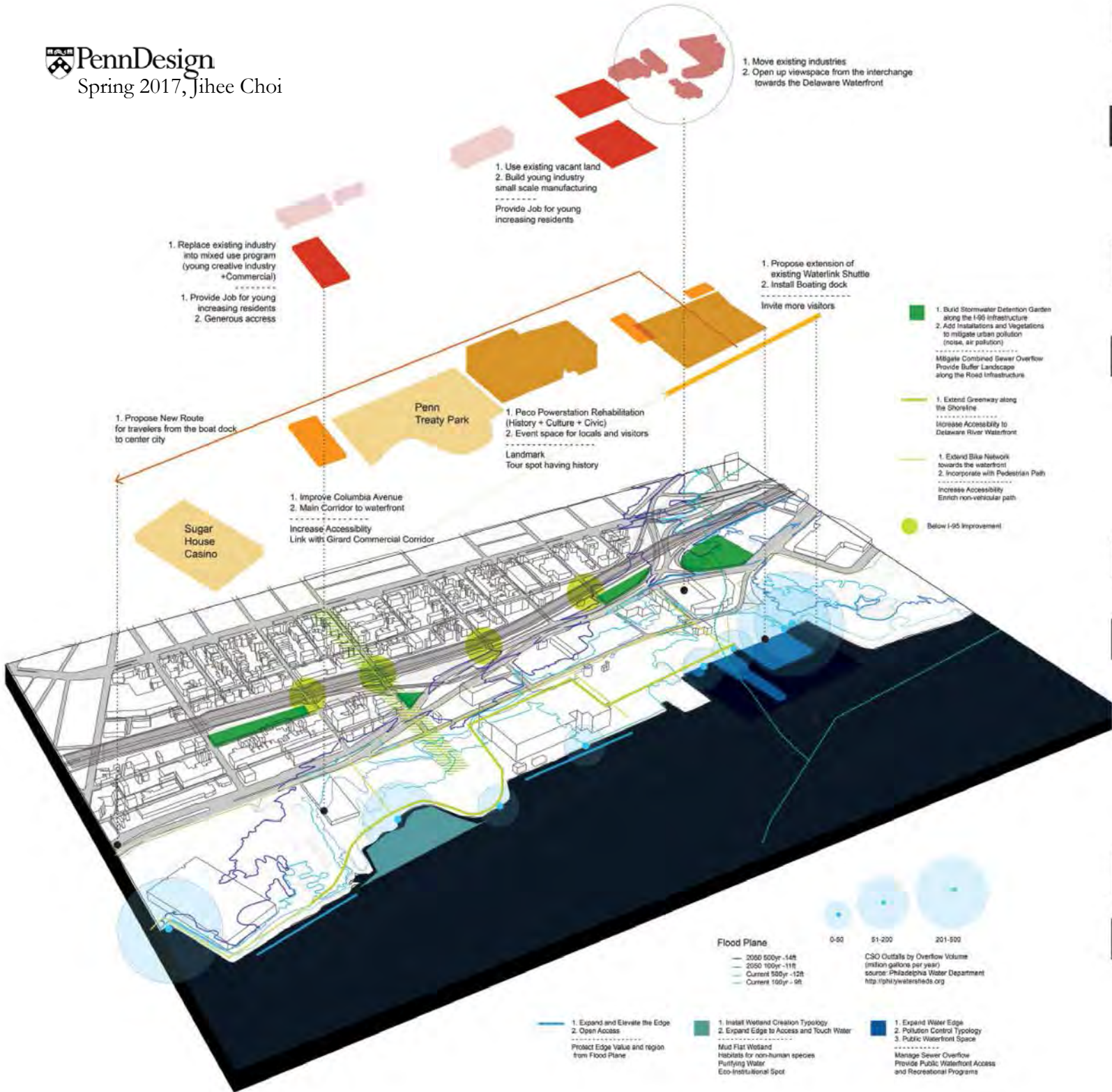
Nor'easter over Mid-Atlantic States, Getty Images

three scenarios—**disaster**, **adaptation**, or **retreat**

prioritize different ways of looking at the land-water transition zone

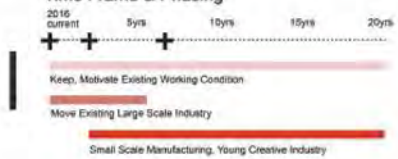
approaches for existing or proposed structures, infrastructures and land uses

PennDesign
Spring 2017, Jihee Choi



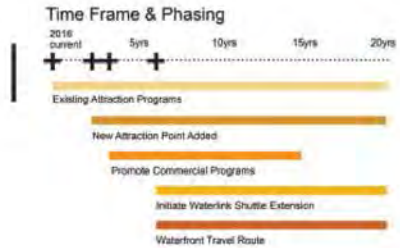
4. Working Waterfront

Time Frame & Phasing



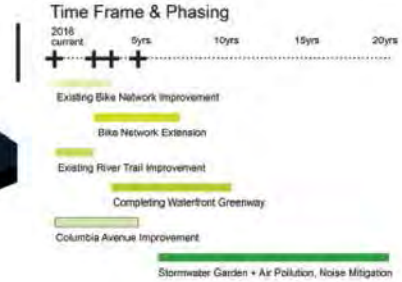
3. Enjoyable Waterfront

Time Frame & Phasing



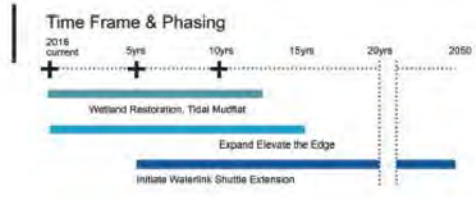
2. Urban Landscape

Time Frame & Phasing

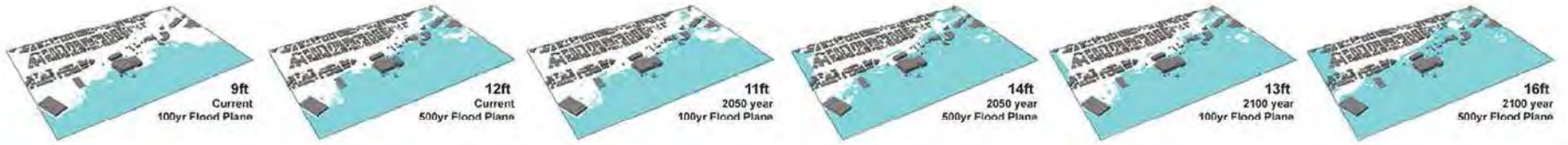


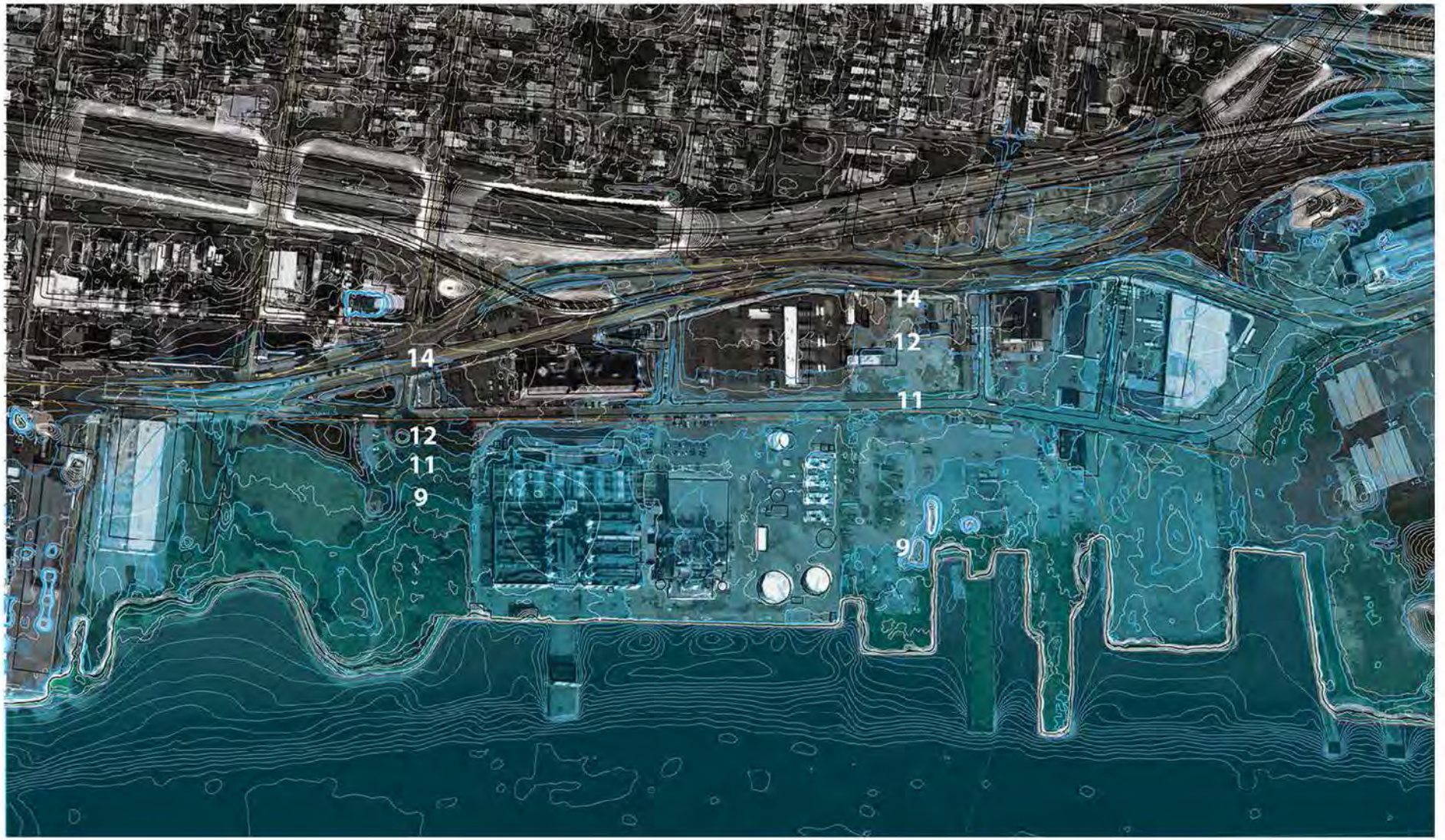
1. Update Shoreline

Time Frame & Phasing

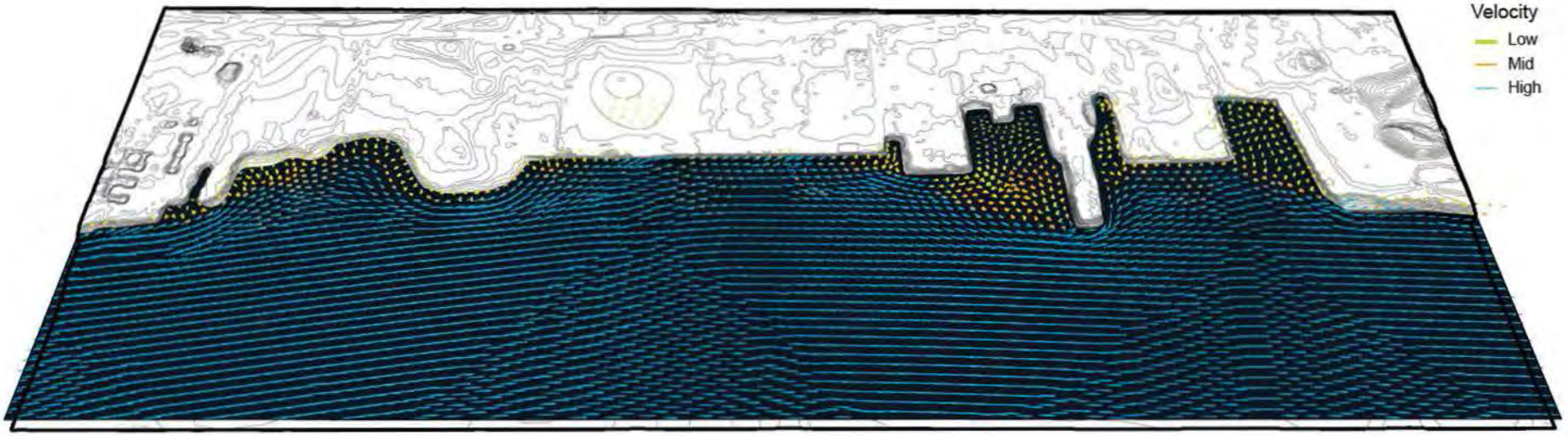


Risk Projection

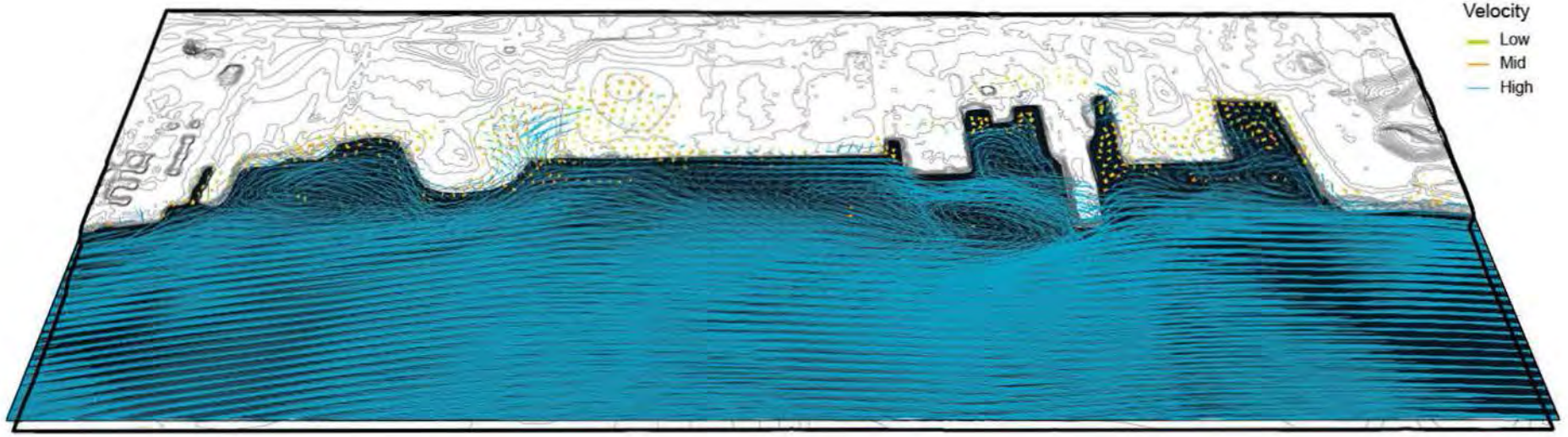




Simulation of Water Flow



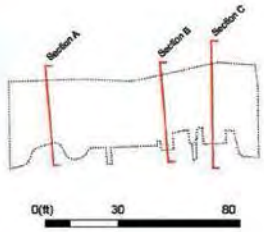
Simulation of Storm




N
0(ft) 100 300
1. Penn Treaty Park Wetland
2. Culture Platform
3. Berm Promenade 14 ft
4. Berm Promenade 12 ft
5. Pier Wetland
6. Recreation Center
7. Civic Center & Public Library
8. Grand Terrace
9. Pier Recreation Park
10. Parking Lot
11. Commercial
12. Mixed Use Building
13. Industry
14. Urban Detention Pond

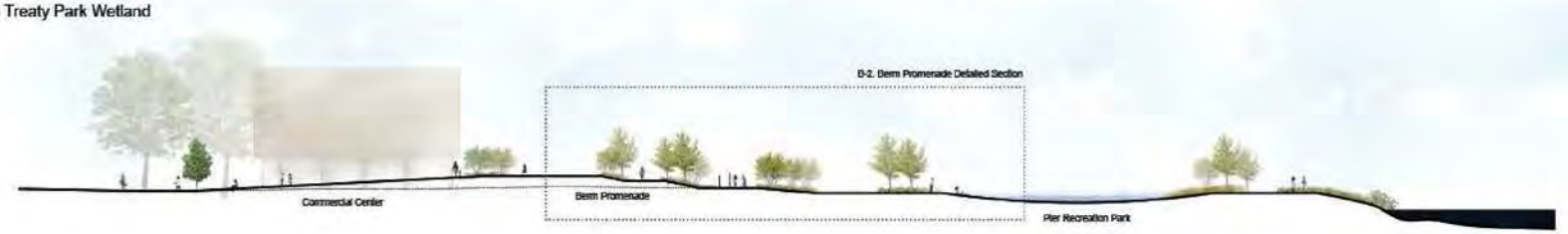
Sections

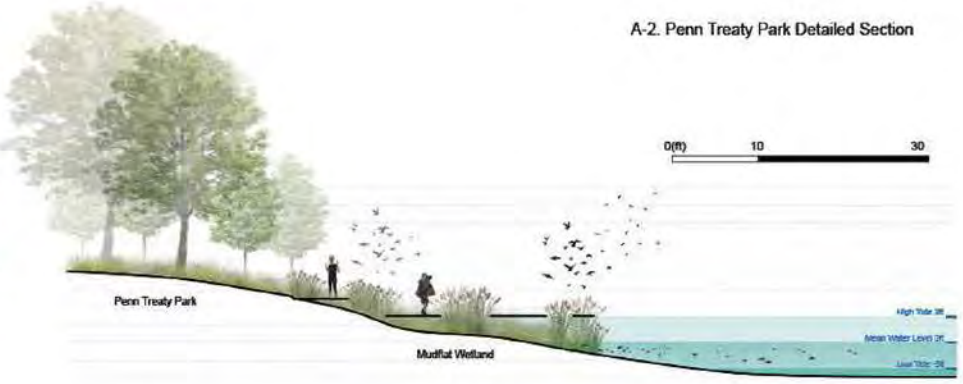
A. Penn Treaty Park Wetland



B. Penn Treaty Park Wetland

C. Penn Treaty Park Wetland






Berm Promenade, Dry condition


Penn Treaty Park Wetland, Low Tide -3ft


Berm Promenade, Flooding 12ft Level


Penn Treaty Park Wetland, High Tide 3ft

PHILADELPHIA IS A COASTAL CITY

Michael W. Tantala, P.E.
Tantala Associates, LLC, Engineers and Architects

PennDesign (Karen M'Closkey and Keith VanDerSys)

The City College of New York

(background) Matthew Cusick, Fiona's Wave, 2005