Hurricane Science and the "Hurricane X" Scenario

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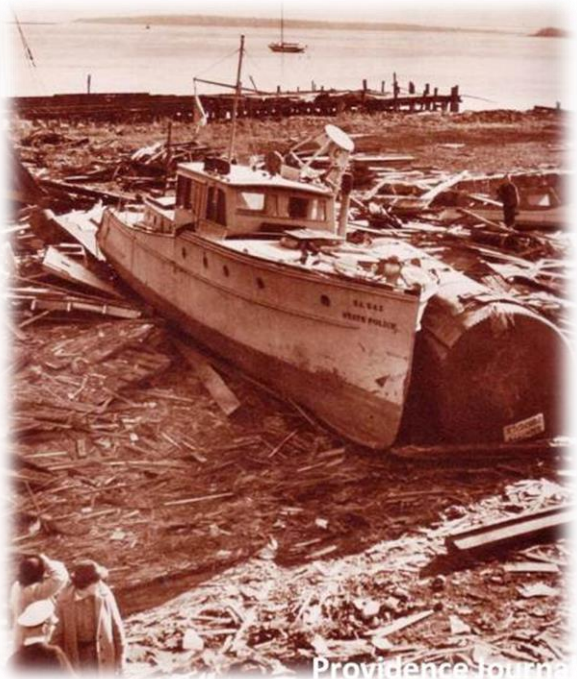
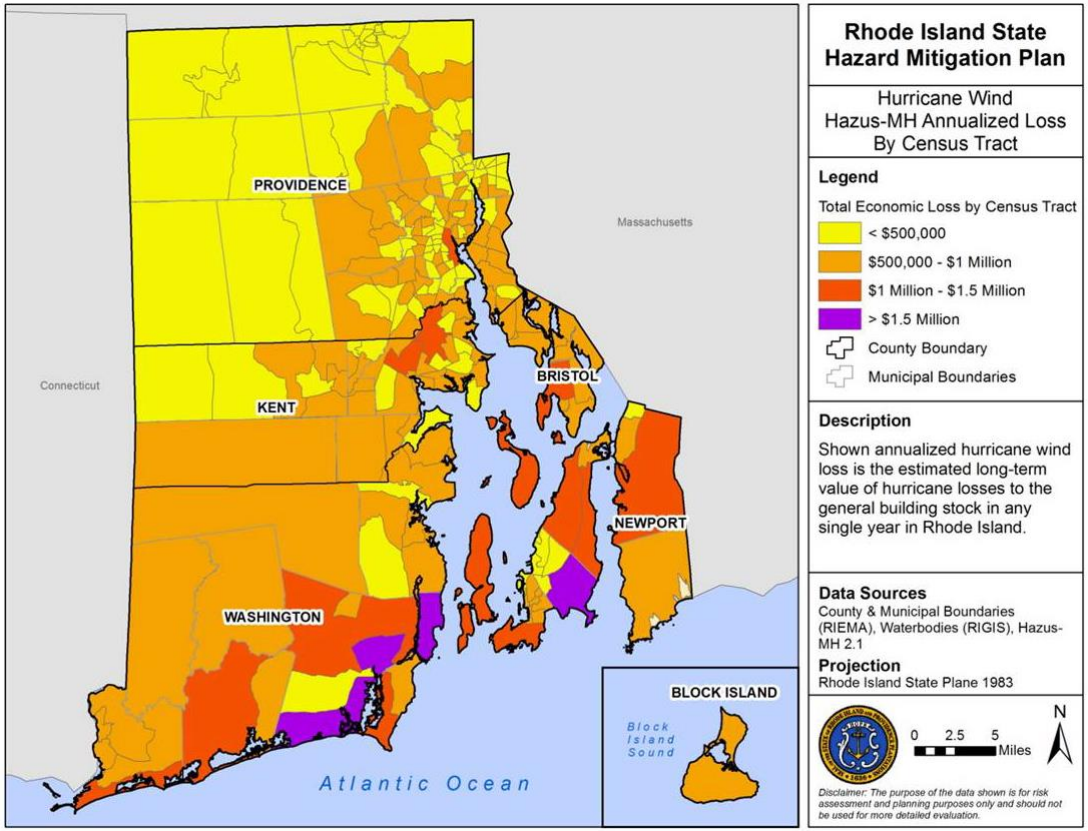
Rhode Island Hurricanes: Historical Record

- 37 hurricanes within 50 mi of RI since 1851
- ≈ 4 year return period
- ≈ 22.8% chance of hurricane per year



Rhode Island Hurricanes: Historical Record

- Annualized losses over $134 million* statewide [1].
- Hurricane of 1938 alone:
  - $2.3 billion* damage
  - 564 deaths
  - storm tide of 15.8 feet (@ high tide) at the Prov tide gauge [1].

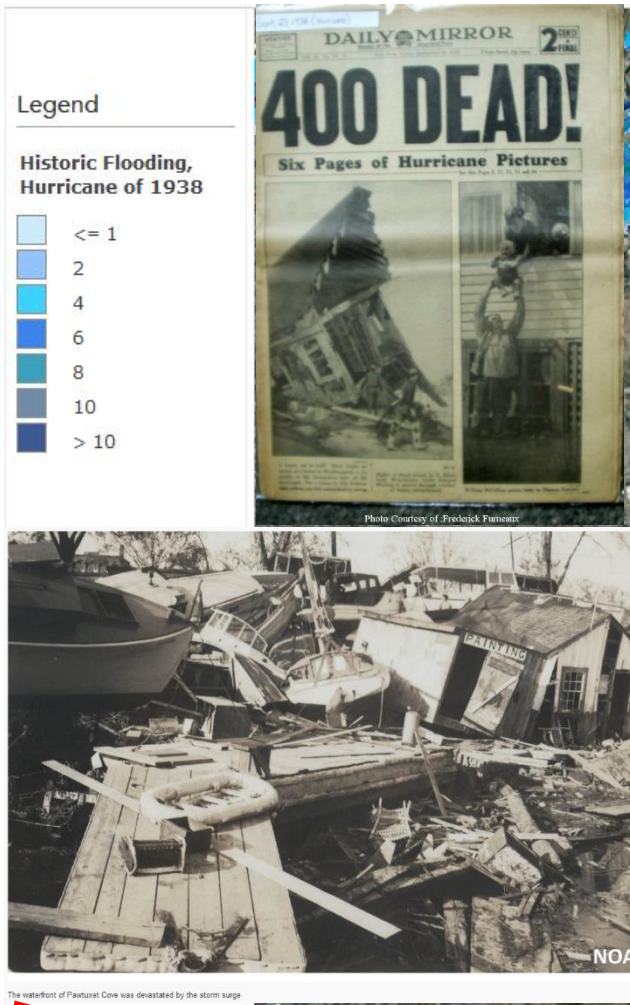


HAZUS MH
EARTHQUAKE • WIND • FLOOD

1. Rhode_Island_Emergency_Management_Agency, *Rhode Island Hazard Mitigation Plan*. 2014.

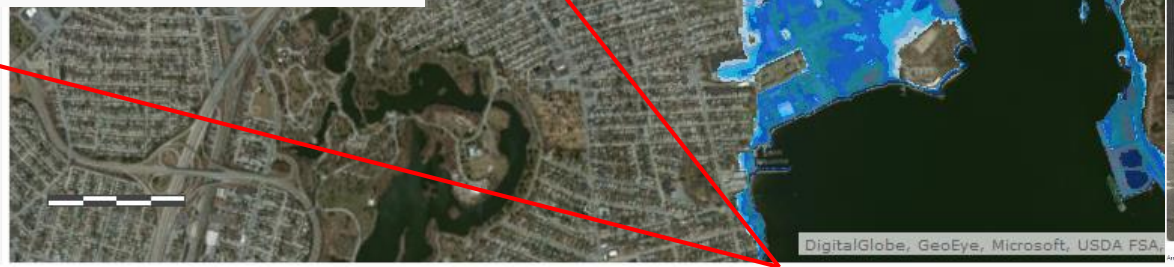
*(in 2012 dollars)

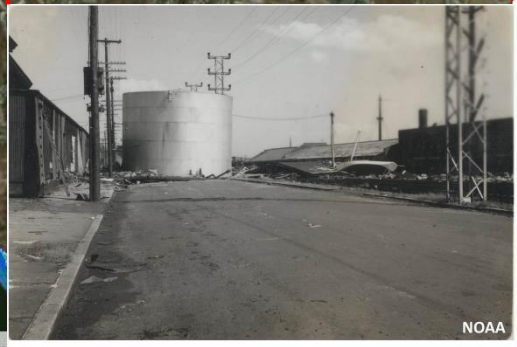
1938 Hurricane Flood Model (StormTools)



Weybosset Street in downtown Providence, RI just after the storm surge peaked

The waterfront of Pawtuxet Cove was devastated by the storm surge





Hurricane Impacts 101

Extra-tropical Transition (ET)

As hurricanes move into the mid-latitudes, they transition from:

Tropical

(feeding off latent ocean heat)

Extra-tropical

(feeding off a temperature contrast, or a front)

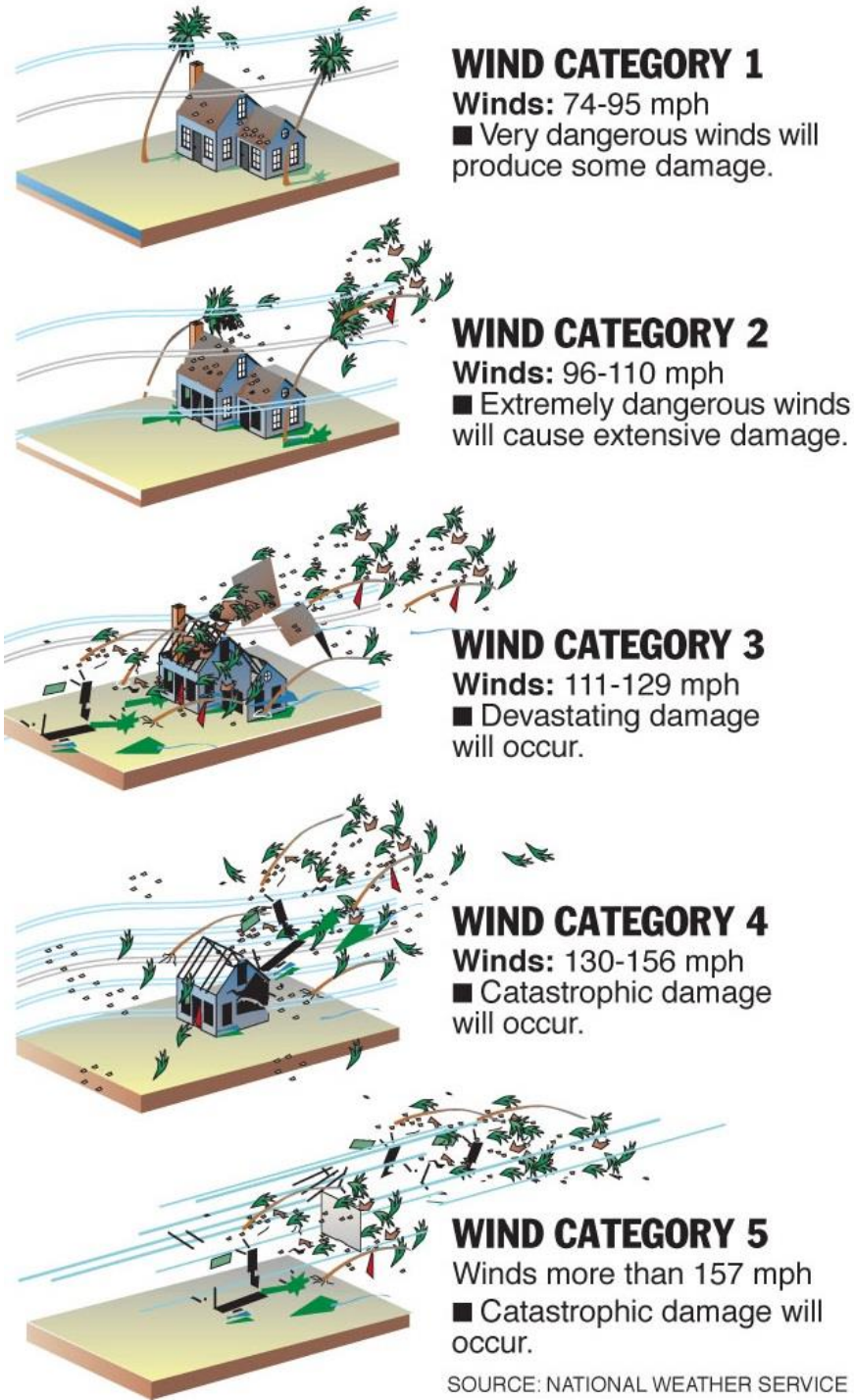
Can lead to:

- Larger diameter wind and rain fields
  - As with Hurricane Sandy
- Accelerated forward velocity
  - As with the 1938 Hurricane

Hurricane Impacts: **WIND**

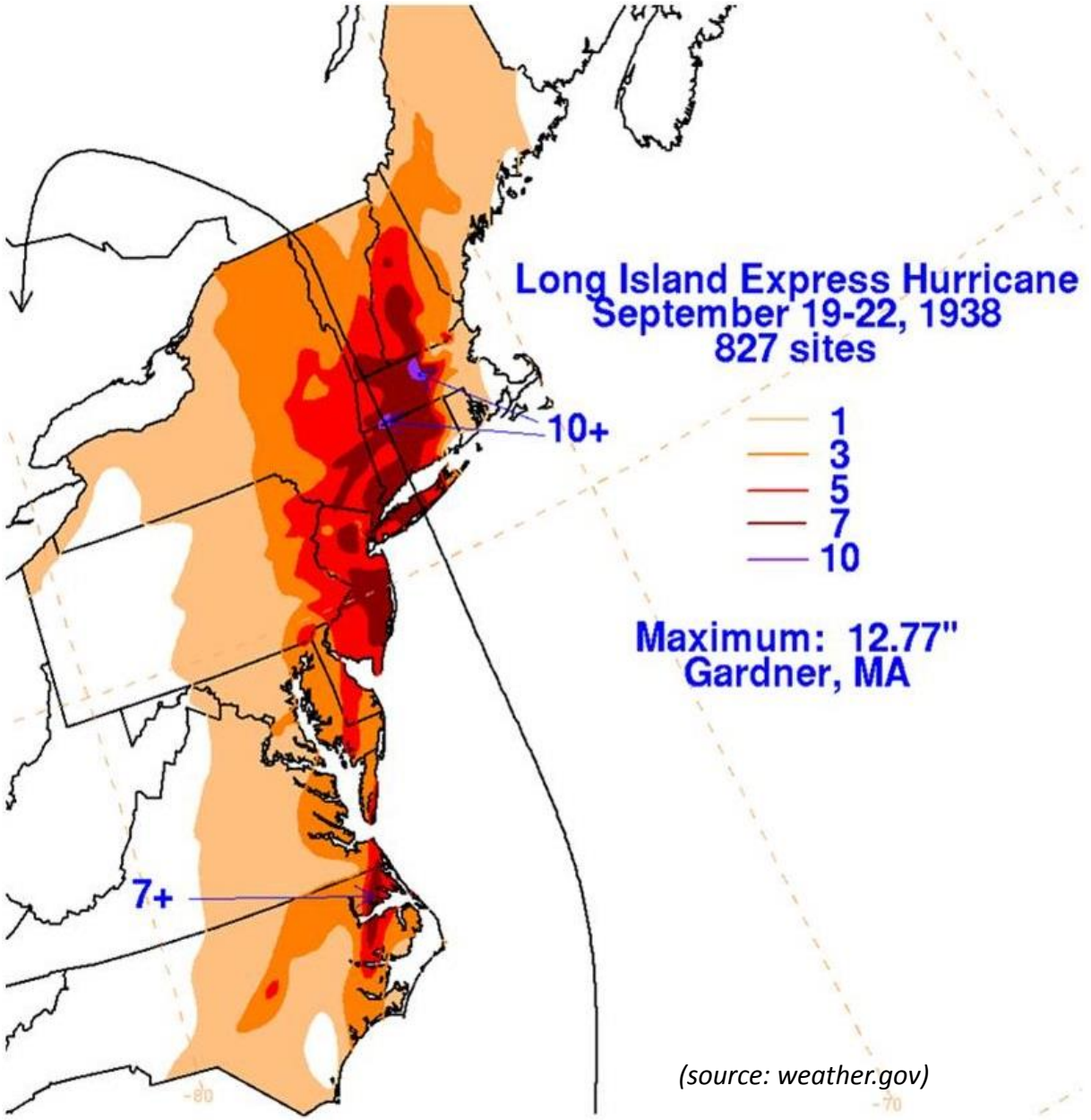
Saffir-Simpson Scale

Category	Winds (mph)	Destruction
1	74-95	Very dangerous winds will produce some damage
2	96-110	Extremely dangerous winds will cause extensive damage
3	111-129	Devastating damage will occur
4	130-156	Catastrophic damage will occur
5	>157	Catastrophic damage will occur



Hurricane Impacts:
RAIN

- 1938 hurricane produced **10 to 17 inches** of rainfall across Connecticut River Valley.
- Worst flooding ever recorded in this area

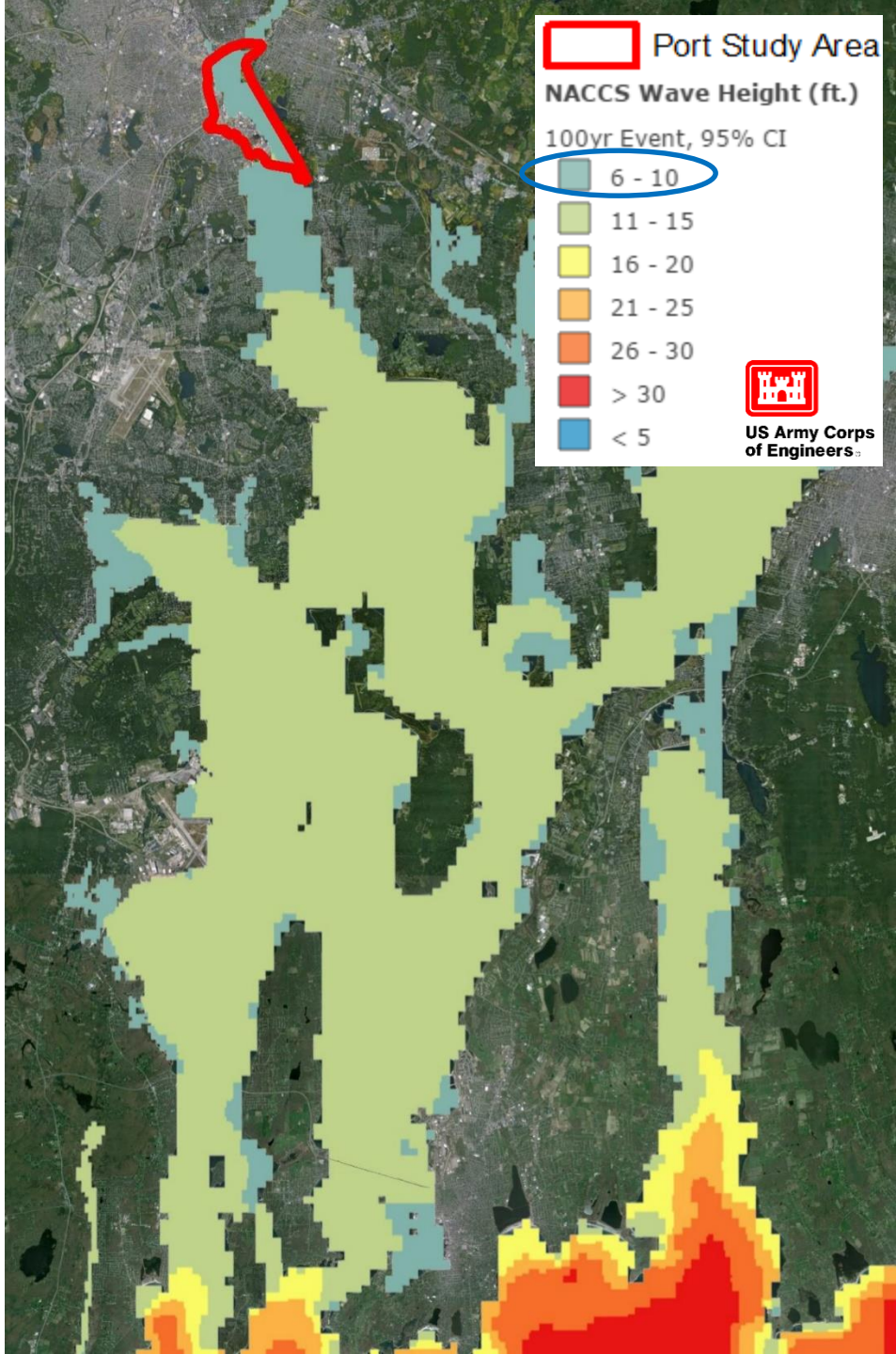


(source: weather.gov)

Hurricane Impacts: **WAVES**

- USACE N. Atlantic Coast Comprehensive Study (NACCS) used coupled wave and current models (ADCIRC and STWAVE) to produce simulated wave heights for a 100 year event

- Models indicate that Port of Providence could expect **<u>6 – 10 foot waves</u>** from such an event.

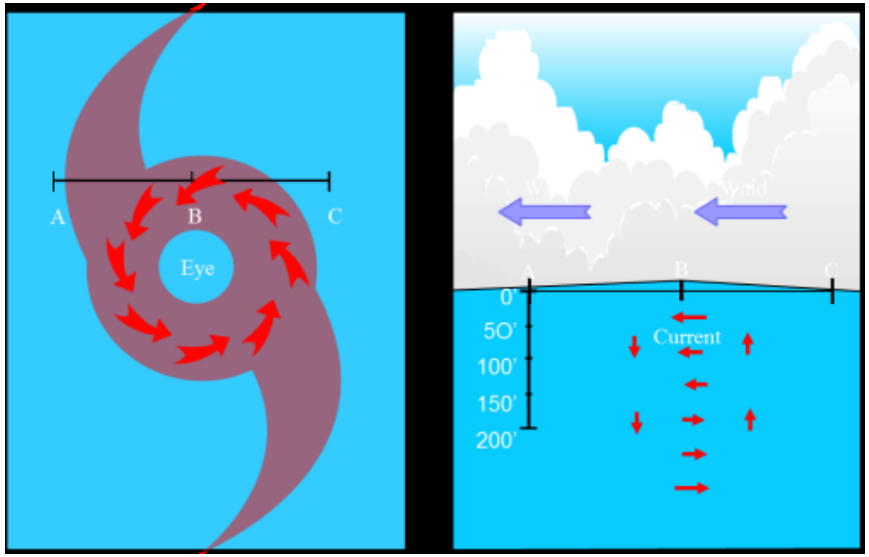


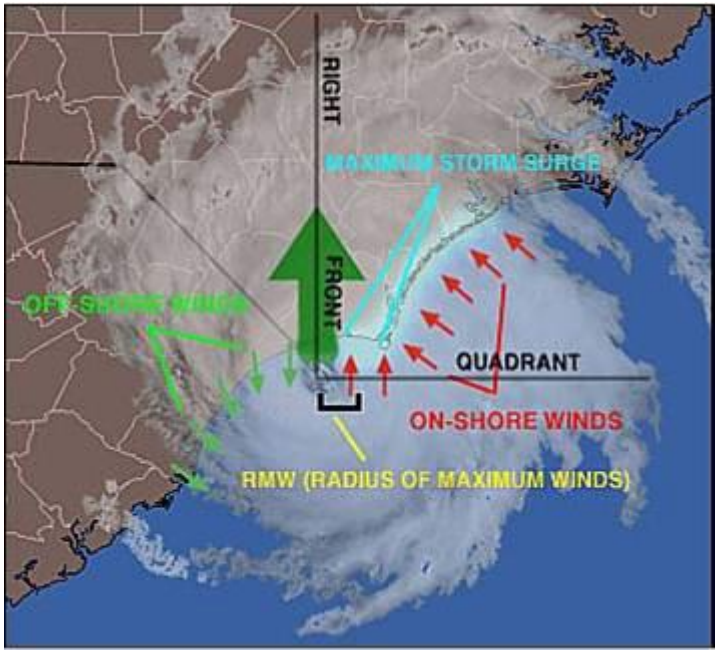
Hurricane Impacts: **STORM SURGE**

- Most powerful and destructive of coastal hurricane impacts
- An abnormal rise in sea level caused by two factors:
  1. **Inverted-barometer effect*:*** low pressure allows a “dome” of water to rise
  2. **Winds:** drive deep currents which are forced ‘upwards’ by coast bathymetry

Winds → Ocean Currents → Coastal Bathymetry → Rise in Water Level

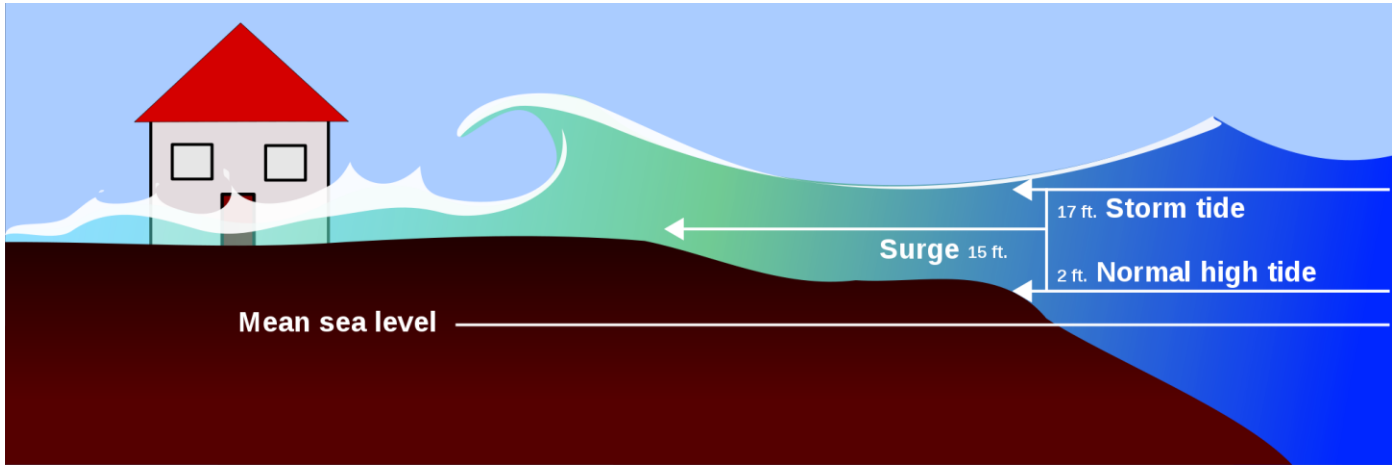
Images: NOAA Introduction to Storm Surge



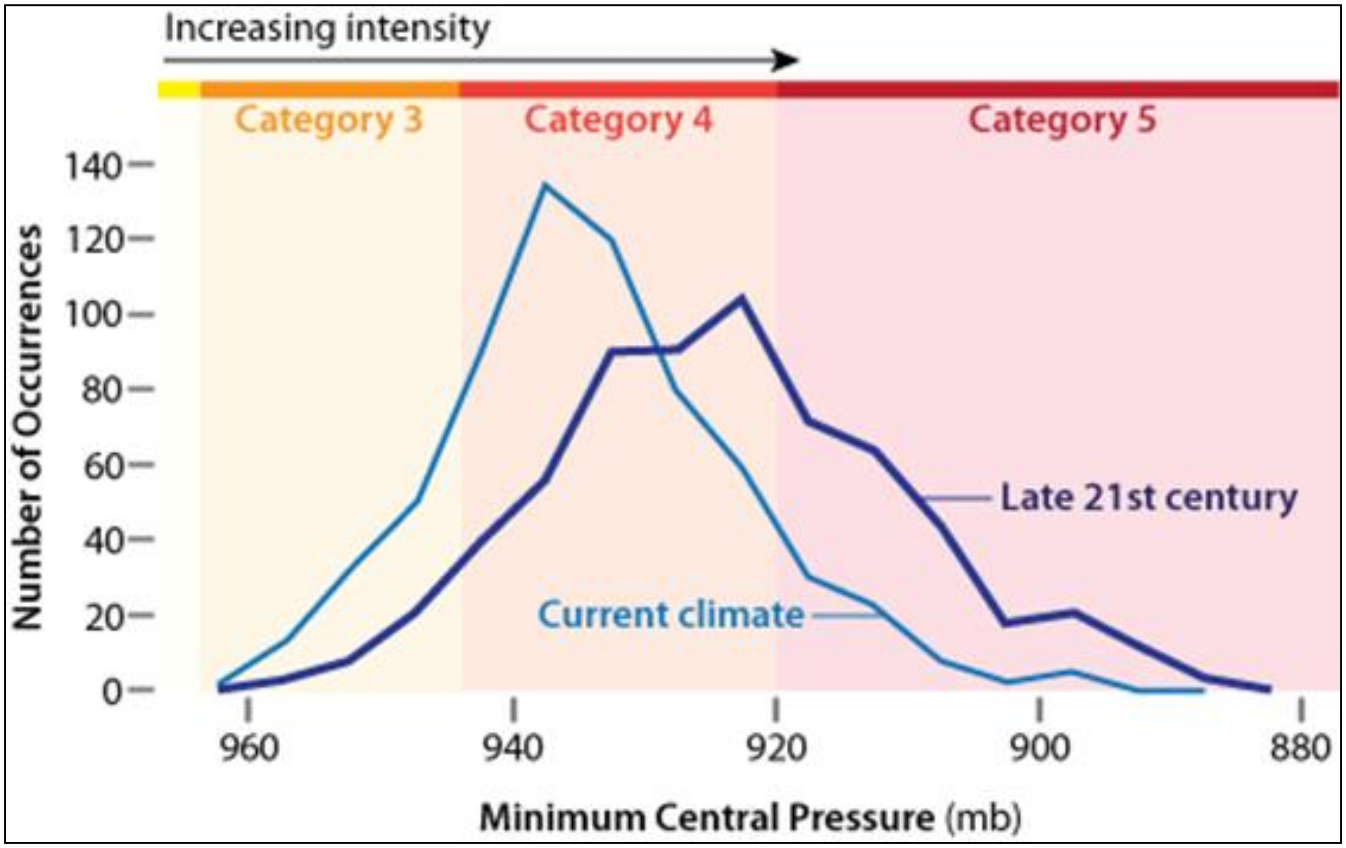


Hurricane Impacts: **STORM SURGE**

- Also driven by the forward speed of the storm
- May arrive ahead of the storm itself
- Can last 6 - 12 hours
- Storm surge + local tide cycle = **storm tide**
- Storm tide + wave action = actual water level



Hurricanes in a Changing Climate



- Change in Frequency: Uncertain
- Change in Intensity: **expect stronger & wetter storms**
  - Atlantic basin models:
    - Wind speeds ~ **4% stronger for every 1° C increase** in sea-surface temperature
    - **Rainfall increase near 20% by 2100** [1].

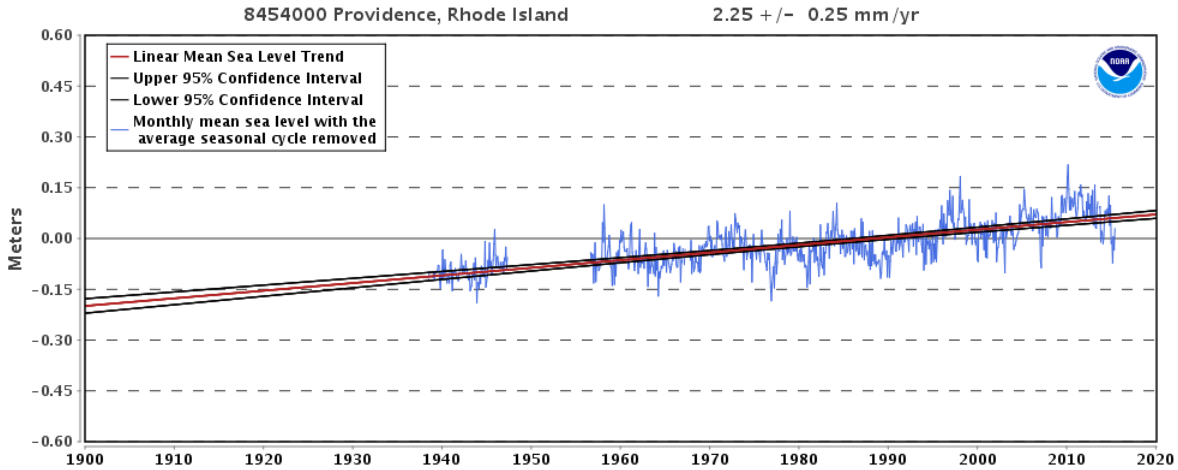
(Graph, Tom Knudson, NOAA GFDL)

Sea Level Rise (SLR)

Observed rate of SLR

Providence tide gauge:

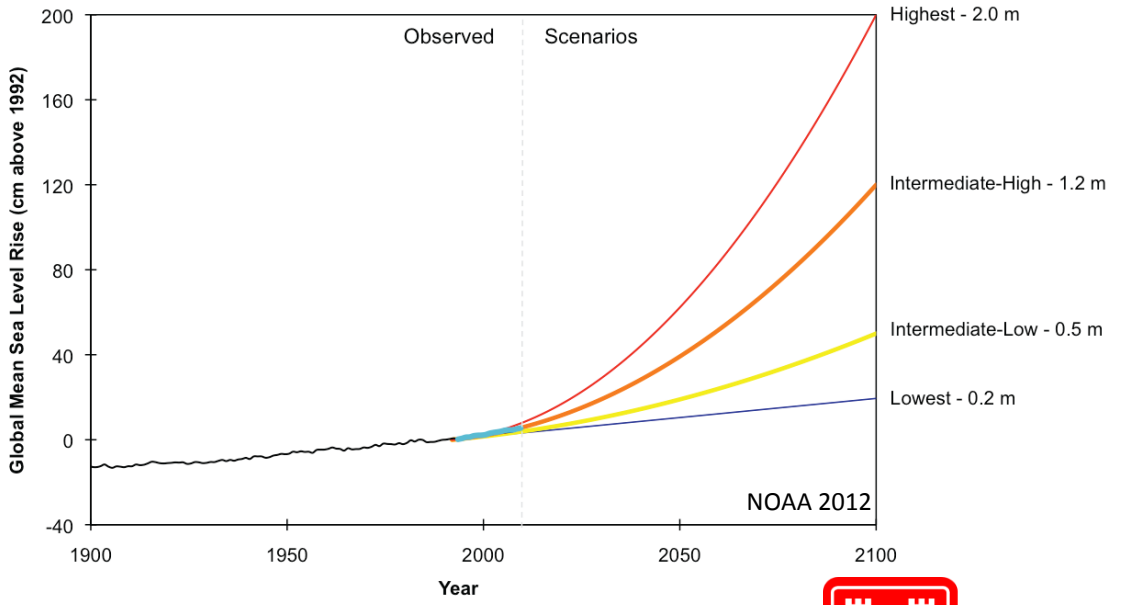
~ 0.1 inches per year



Projected SLR:

US National Climate Assessment (2012)

0.7 – 6.6 feet by 2100



NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

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Storm Surge in a Changing Climate

For the Northeastern US:
By 2050 the elevation of a 2005 100-year storm surge event may be equaled or exceeded at least every 30 years.

(Kirshen et al. 2008)

Photo: Kris Allred

A “Hurricane X” Storm Scenario
to consider in the workshop exercise that follows…

Hurricane "X" Storm Scenario

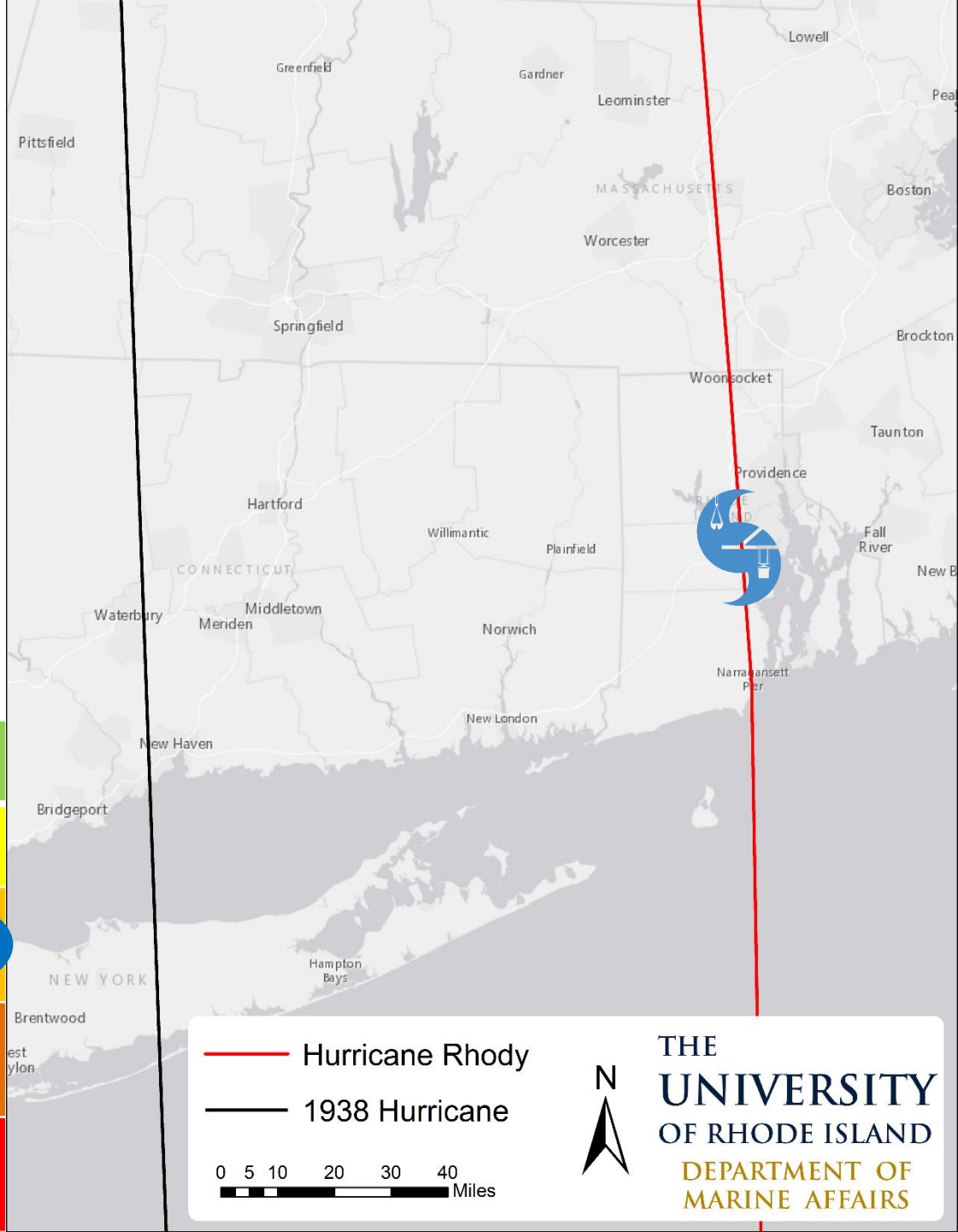
- Based on historical evidence
- Extreme, yet plausible storm scenario
- Category 3 Hurricane "X"
  - Landfall on August 3 at 11:00AM high tide
  - Tracking north at 40 mph and approaching Rhode Island from the south
    - For NE US, a Cat 3 Hurricane has a return period of ~ 60 years [1], or a 1.7% chance of impacting the region in a given year.

1. Ginis, I. *Predicting a Hurricane's Path of Destruction in Rhode Island*. 2006. Rhode Island Emergency Management Agency.

“Hurricane X”

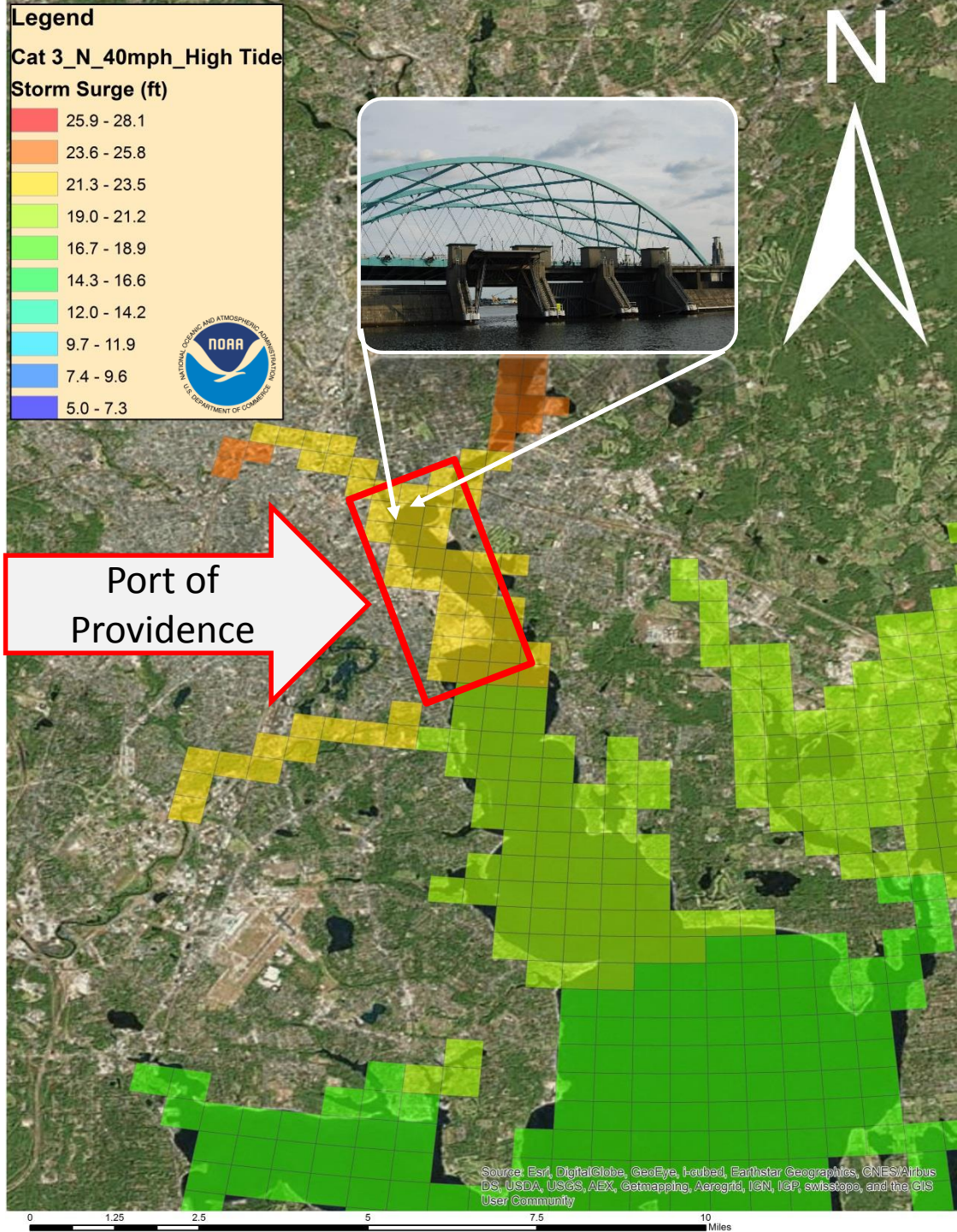
- ‘Direct hit’ for Providence
- Comparable to 1938 hurricane, but shifted ~ 80 mi East
- Comparable to Sandy without the ‘left hook’

1	74-95	some damage
2	96-110	extensive damage
3	111-129	Devastating damage
4	130-156	Catastrophic damage
5	>157	Catastrophic damage



“Hurricane X”

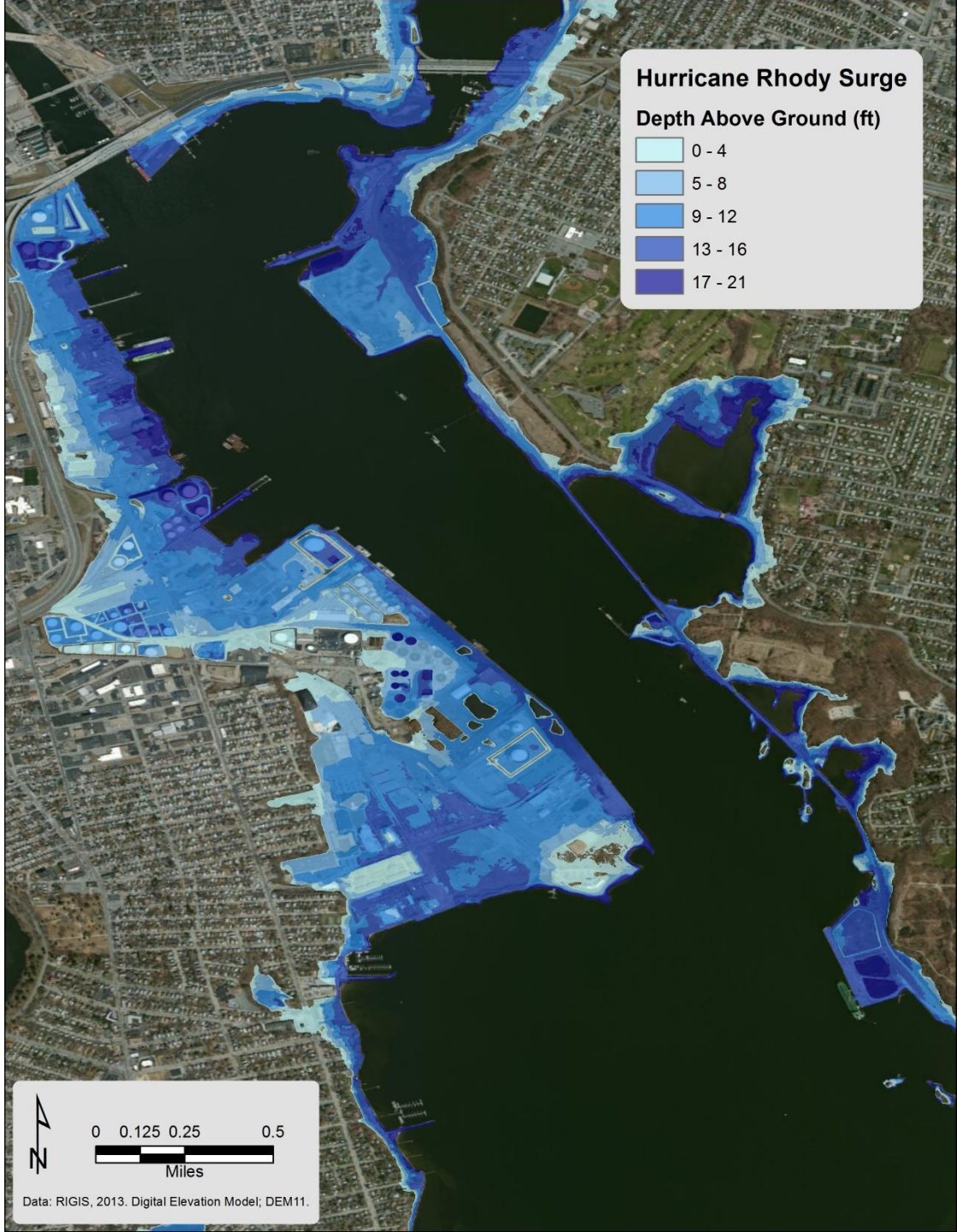
- Winds:
  ~ 111-129 mph
- Waves: ~ **6-10’**
- Storm Tide: ~ **21’**
  - SLOSH model
  - Does not overtop Fox Point Hurricane Barrier



“Hurricane X”

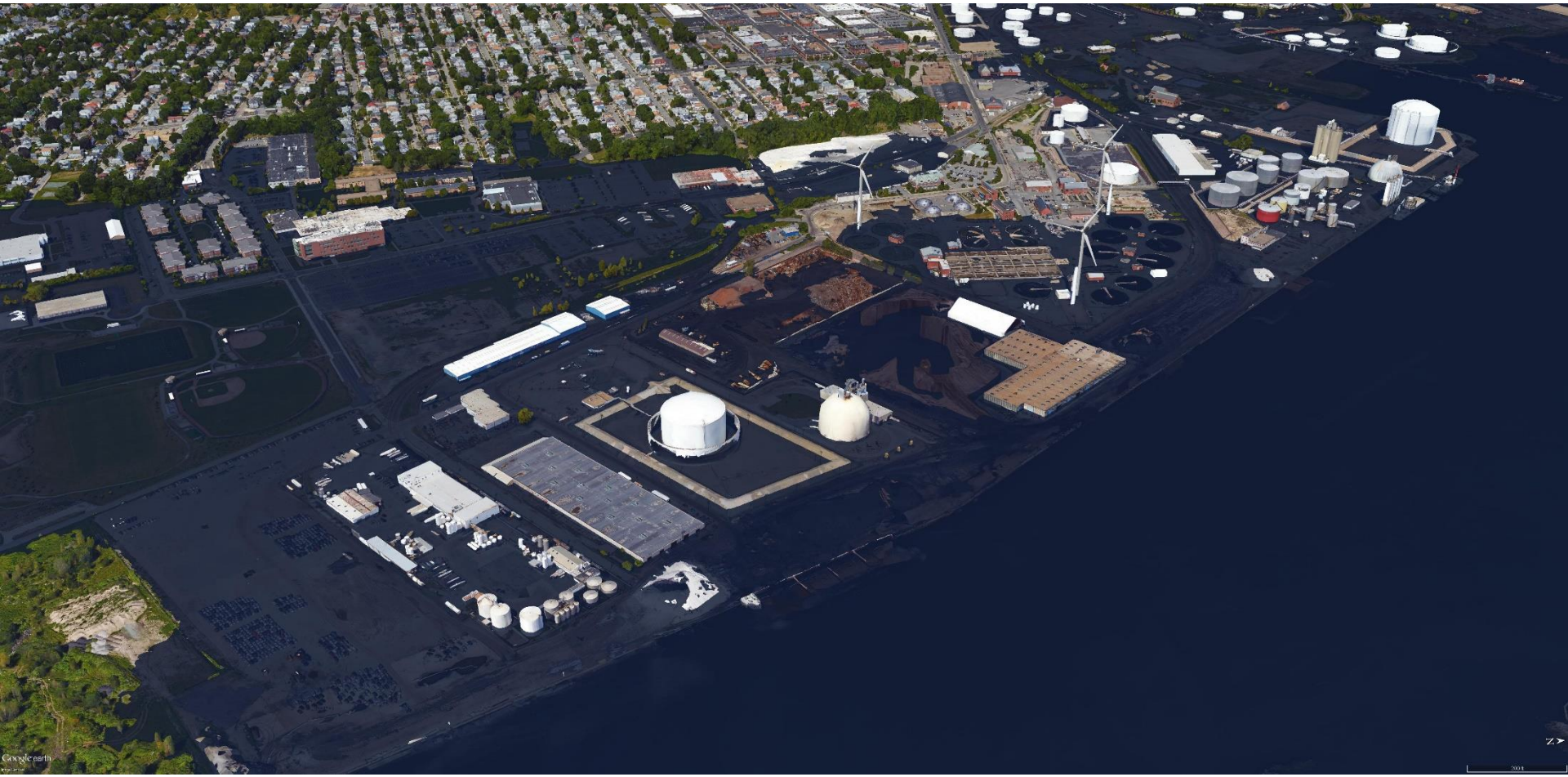
- GIS Visualization of 21 ft “bathtub” inundation
- Assumes Fox Point Barrier not overtopped
- Only shows passive level of sea
- Does not show expected 6-10’ wave action
- You have hard copies of this map at your tables

- Based on RIGIS, 2013 DEM derived from a 1-meter resolution digital elevation model originally produced as part of the Northeast LiDAR Project in 2011.



Hurricane "X"

ProvPort



See: http://www.portofprovidenceresilience.org/storm-scenario.html

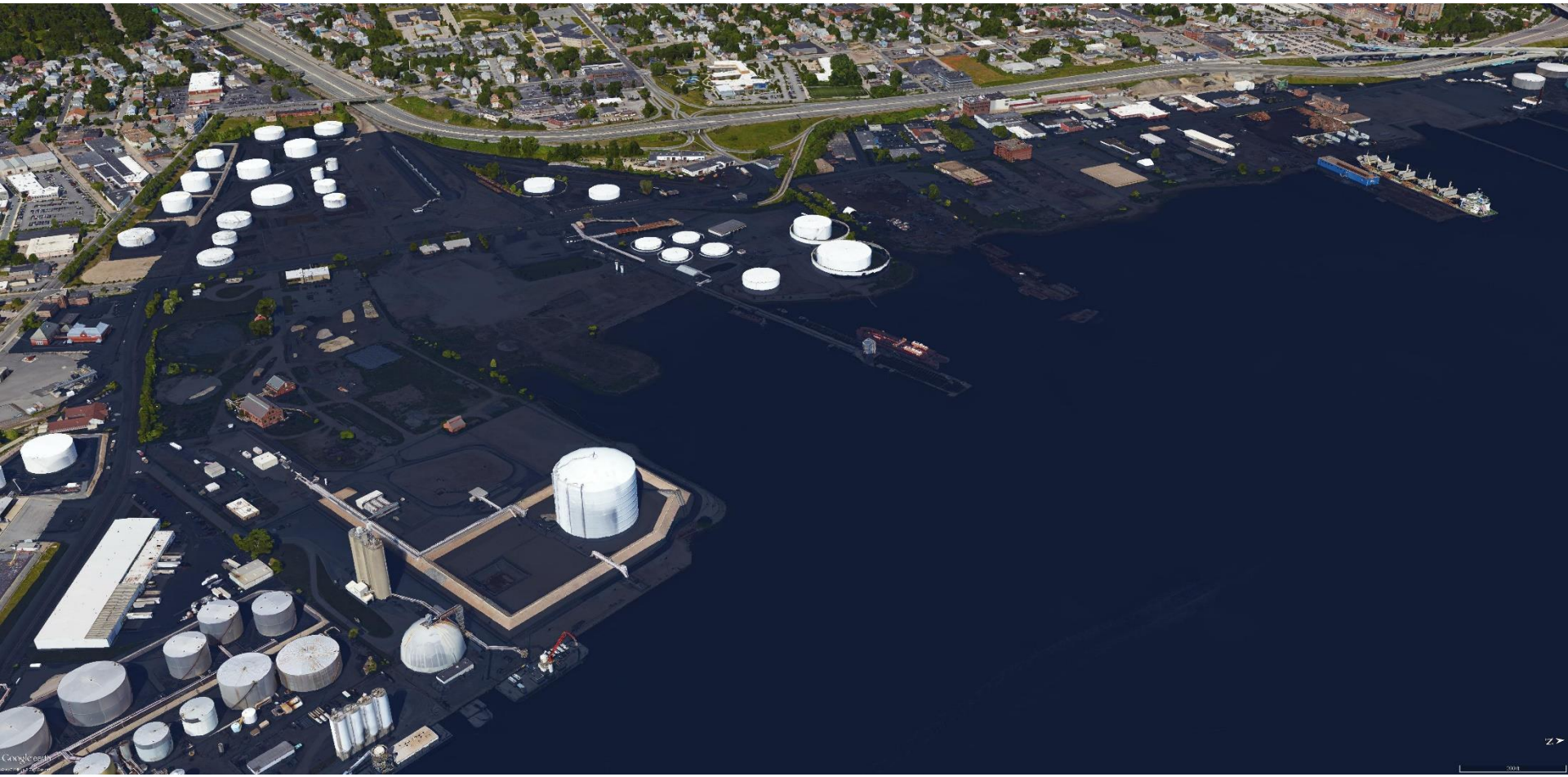
Hurricane "X"

Metals Recycling, Inc.

See: http://www.portofprovidenceresilience.org/storm-scenario.html

Hurricane "X"

Motiva



See: http://www.portofprovidenceresilience.org/storm-scenario.html

Hurricane "X"

Sprague

See: http://www.portofprovidenceresilience.org/storm-scenario.html

Workshop Exercise

Use maps provided

- At your tables with sticky cards, identify vulnerable areas & key consequences (i.e., what are storm's impacts) of concern:
  - **Weeks** after event (orange sticky notes)
  - **Months** after event (green sticky notes)
  - **Years** after event (yellow sticky notes)
- Report out top three vulnerabilities and consequences for each time frame (weeks, months and years after the storm.) (20 minutes)

Photo: Matt Conti