WAQUOIT BAY NATIONAL ESTUARINE RESEARCH RESERVE

The Fairhaven Star

HURRICANE STRIKES

Hundreds Homeless--Harbor View Wiped Out

Business Men's Association Discusses Traffic Hazards

An Appeal

Veterans, Legion and Red Cross Feed and Clothe Refugees

Many Boats Destroyed By Tide and High Water – Many Rescued By Police and Volunteers

Tax Collector Warns Motorists

Storm Settles Into Condemnery

25th Wedding Anniversary Celebrated By L. J. Renaude

Headline from the Fairhaven Star
Thursday, September 22nd, 1938

Hurricane Edition THE SUN Local and Shore News

Vol. 46. No. 39 WESTERLY, R. I., FRIDAY SEPTEMBER 23, 1938 Price Three Cents

Misquamicut Wiped Out; Napatree Point Gone; 50 Dead; Scores Missing

Westerly Paralyzed by Tropical Hurricane; Cottages at Charlestown Beach and Quonochontaug Washed Away; 4 Dead, 4 Missing In Stonington

List of Dead and Missing

Headline from the Fairhaven Star
Thursday, September 22nd, 1938

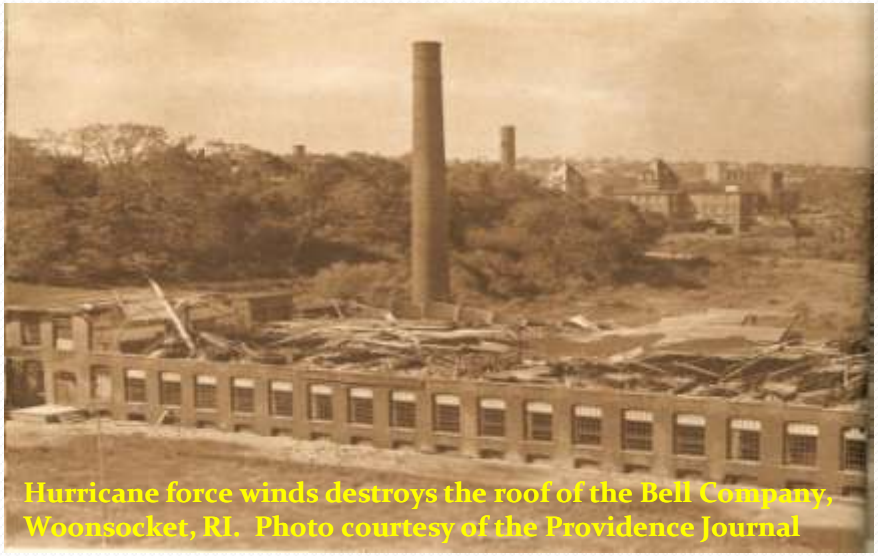
The Realities of Hurricanes on Cape Cod

David R. Vallee
Hydrologist-in-Charge
NOAA/NWS/Northeast River Forecast Center

Classic Hazards:

Damaging winds, flooding rains and devastating storm surge

Connecticut River Flooding, East Hartford, CT 9/24/1938.
Photo courtesy of the Connecticut State Archives.



Hurricane force winds destroys the roof of the Bell Company, Woonsocket, RI. Photo courtesy of the Providence Journal

Destruction from storm surge along Route 1A, Narragansett, RI.
Photo courtesy of the Providence Journal

An 11 to 13 foot storm surge devastates Pawtuxet Cove, Warwick, RI. Photo courtesy of the Providence Journal.

Common Characteristics

- Every system is undergoing a transition from pure Tropical to “Extra-tropical” (i.e.: winter storm-like) upon approach
  - Dramatic Jet Stream interactions
  - Rapid acceleration up the coast
  - Heavy rainfall usually focused along and west of the storm track
  - High winds focused east of the track
  - Storm surges focused east of the track with the greatest surge depths occurring on the upper reaches of south facing bays and inlets

Rapid Acceleration Northward

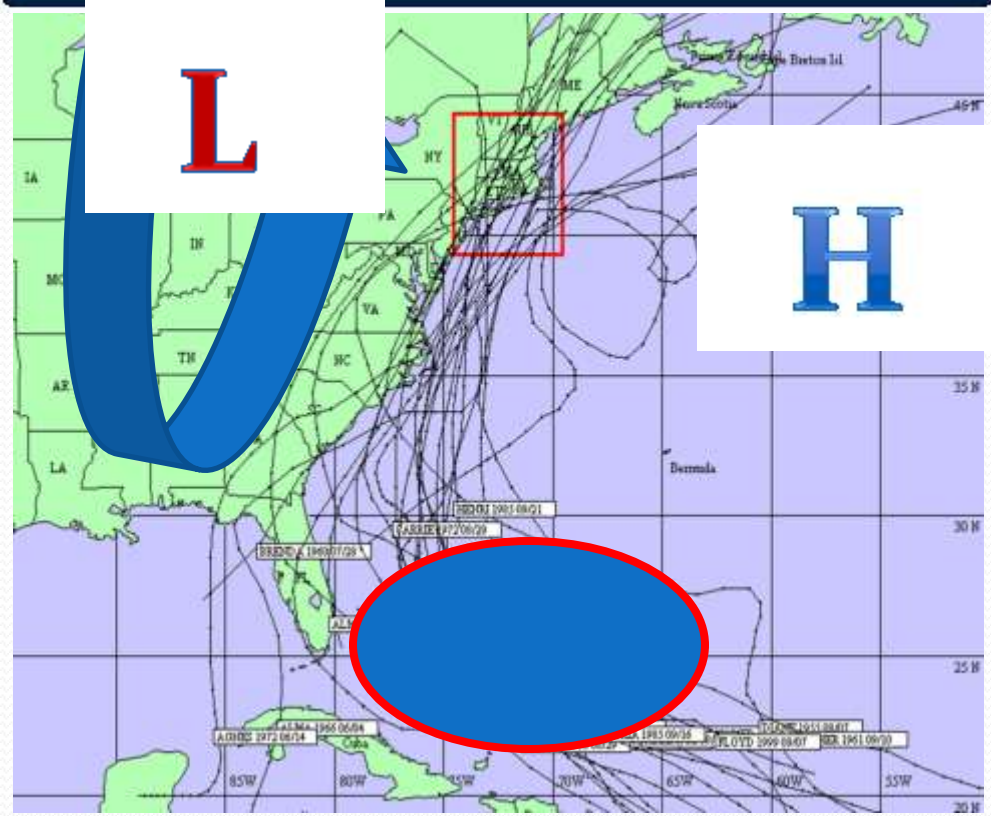
- Average forward motion for storms impacting New England: 33 mph
- The Great New England Hurricane of 1938 made the trip from Cape Hatteras, NC to Providence, RI in 8 hours!
  - Forward speed at landfall was at least 51 mph/82 km-hr and estimated as high as 60 mph/97 km-hr

Storm	Forward Motion
Atlantic Hurricane of 1944	29 mph
Carol – August 1954	35 mph
Edna – September 1954	46 mph
Diane – August 1955	15 mph
Donna – September 1960	24 mph
Gloria – September 1985	45 mph
Bob – August 1991	32 mph
Irene – August 2011	20 mph

Jet Stream Interactions

- Interactions with the Polar Jet Streams foster the rapid acceleration northward and northeastward
- Anomalous wintertime looking jet stream pattern
- These same interactions also lead to remarkable rainfall production in spite of the rapid forward motion
  - Complex interactions with synoptic scale cold fronts
  - Enhancements due to the development of coastal fronts
  - Onshore flow producing enhanced lift due to the topography of the Northeast

Anything with a name in the Bahamas is New England's Business!

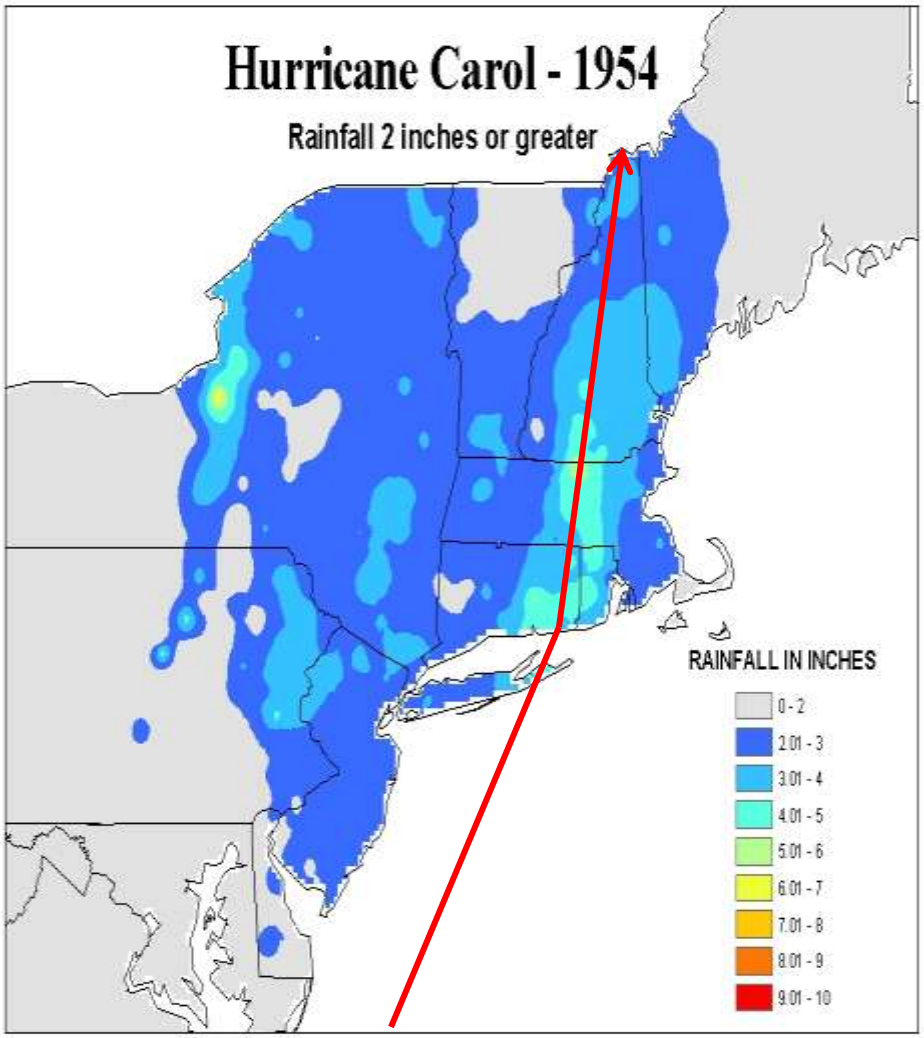


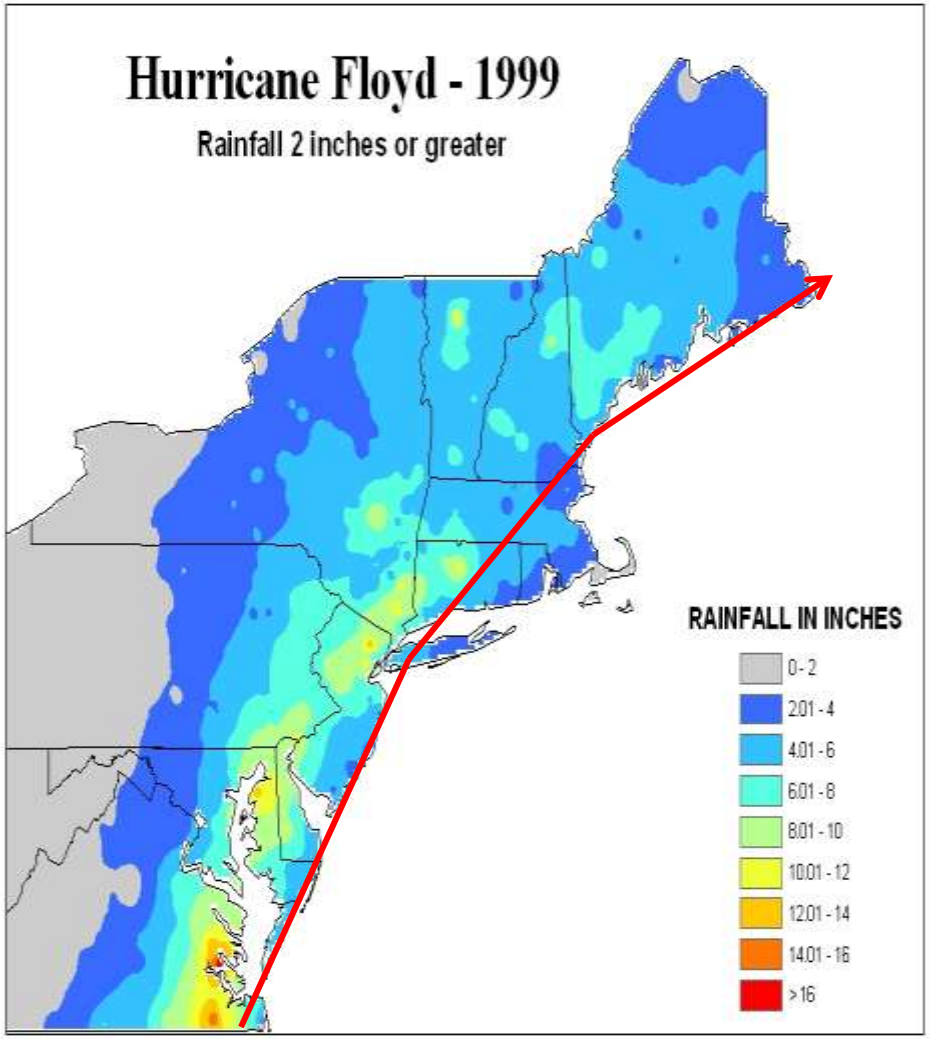
Heavy Rainfall Characteristics

- Two types of distributions
  - Right of Track
  - Left of Track
- Some systems "changed phase" as they turned and accelerated northeastward
- Nearly ½ of all our storms produced small stream/river flooding in the region!
- Average rainfall 6-8 inches
  - Blockbuster rains with some slower movers
    - Diane '1955 (15-20 inches)
    - Irene 2011 (10-16 inches)

Radar loop of Tropical Storm Irene's arrival in New England

Rainfall analyses for Carol & Floyd





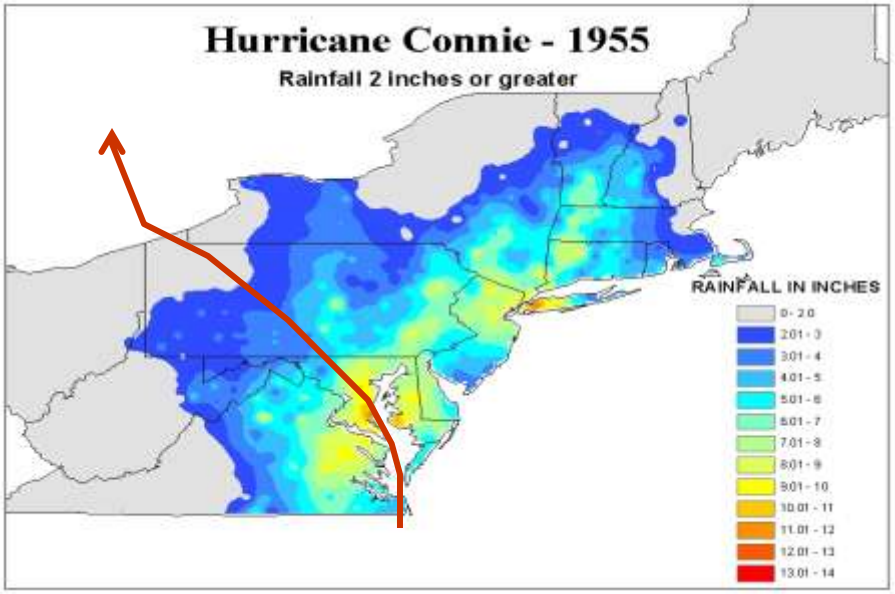
Historical Perspective

Connie & Diane's Widespread Flooding/Flash Flooding

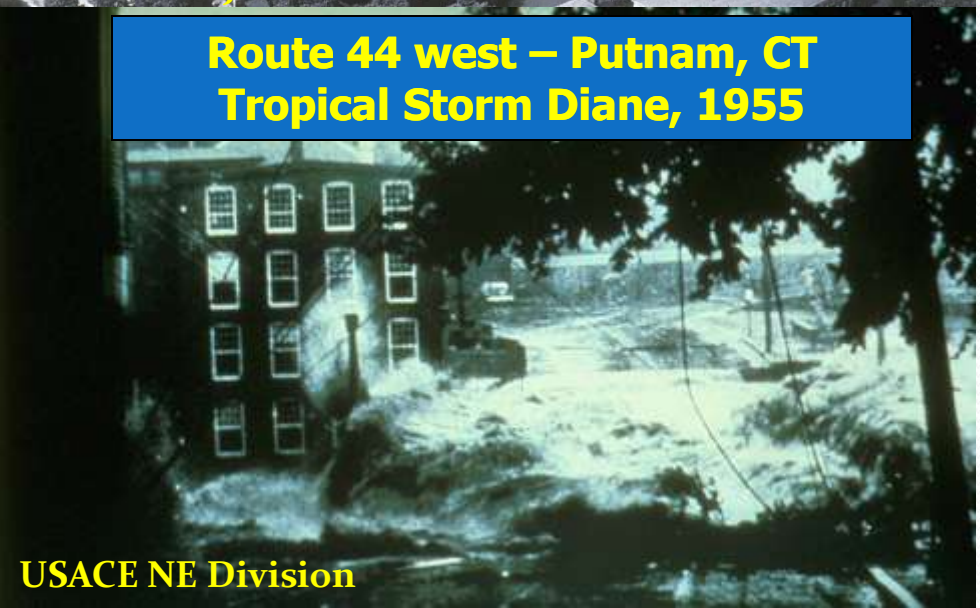
City of Woonsocket, RI – Diane 1955

Flooded downtown "social/business" district

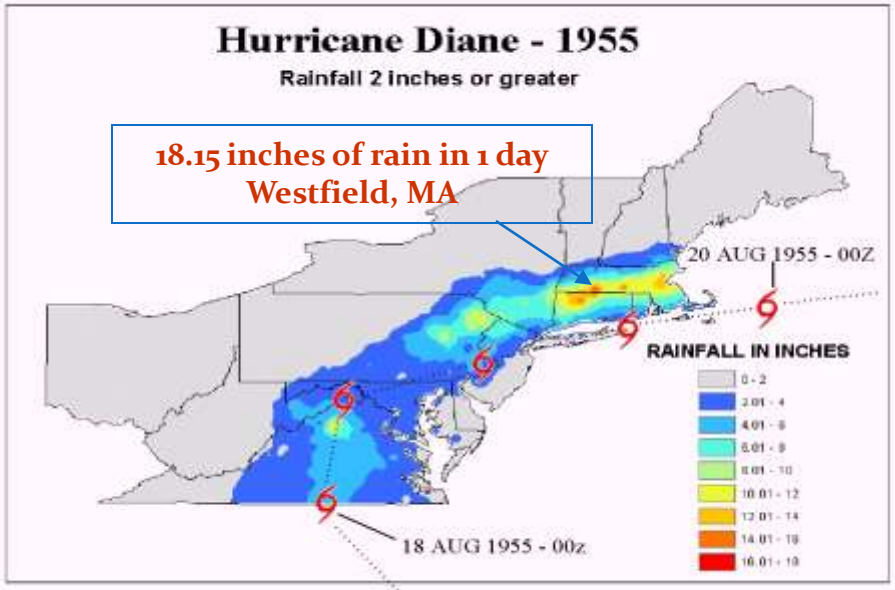
Providence Journal



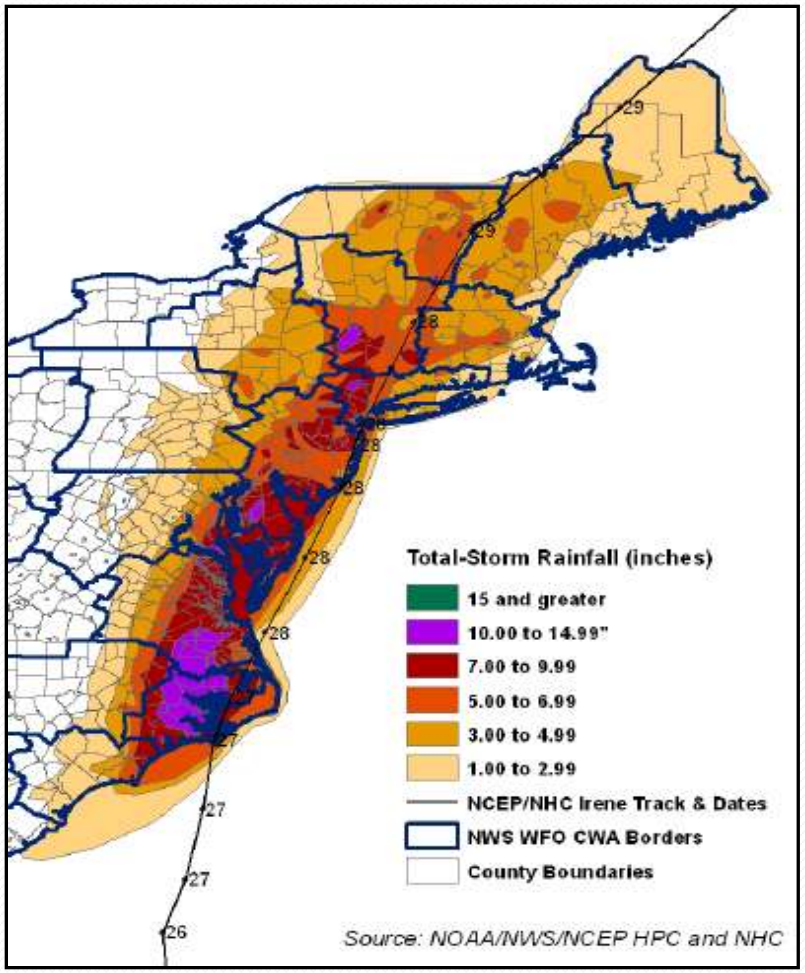
Route 44 west – Putnam, CT
Tropical Storm Diane, 1955



USACE NE Division



Irene – Devastated eastern NY and western NE



Prattsville, NY Damage
(Jimmy Vielkind/Times Union)

Flooding on Conway St., Buckland, MA
Photo: J. Brown

Behavior of the wind field

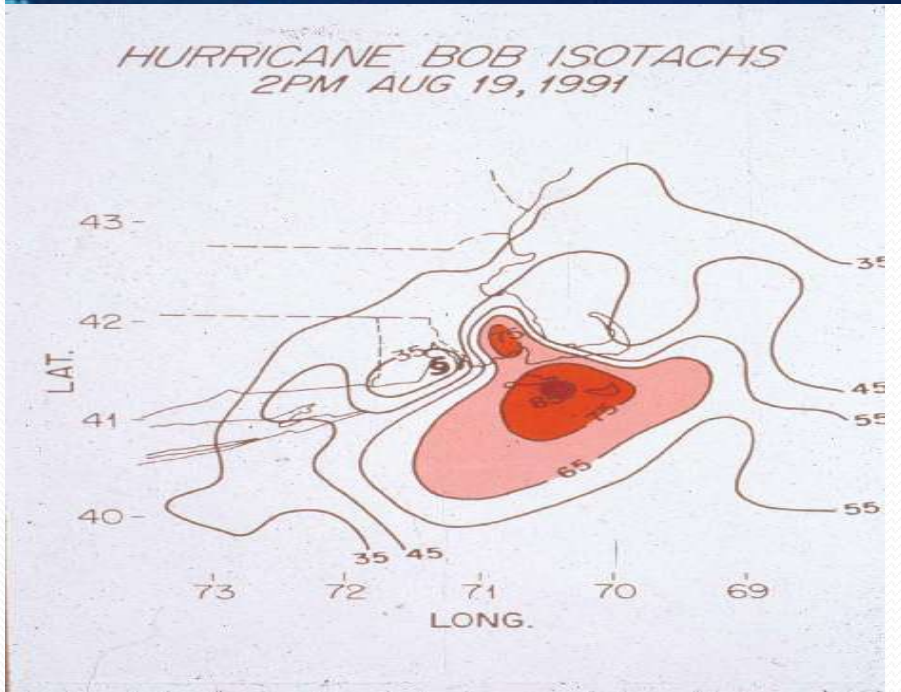
- Short duration of sustained tropical storm and hurricane force winds
  - Tropical Storm = 12 hours
  - Hurricane force = 3-6 hours
- High winds focused east of the track – enhanced by the acceleration toward New England
  - Acceleration dramatically adds to gust potential
- In 1938 the Blue Hill Observatory, Milton, MA elevation 629 ft recorded
  - 5 minute sustained wind of 121 mph
  - Peak instantaneous gust of 186 mph
- Other notable wind speeds from Hurricanes in the region
  - Hurricane Carol – T.F. Green Airport recorded 90 mph sustained wind with a peak gust of 105 mph
  - Hurricane Donna – peak wind gust 130 mph on Block Island
  - Hurricane Bob – peak wind gusts of 120 to 125 mph on Cape Cod

Hurricane Bob downed trees in Providence, RI
Source: Providence Journal

Hurricane Carol destroyed this home in Narragansett, RI
Source: Providence Journal

High Winds

- Radius of maximum winds (RMW) varied considerably
  - As small as 25 mi in Hurricane Bob 1991
  - As large as 50 nm in the Great New England Hurricane 1938
- Region is not built for strong southeast gales
  - Lowest frequency of occurrence is southeast
  - Prevailing winds northeast, southwest and northwest
  - Vegetation not built for southeast

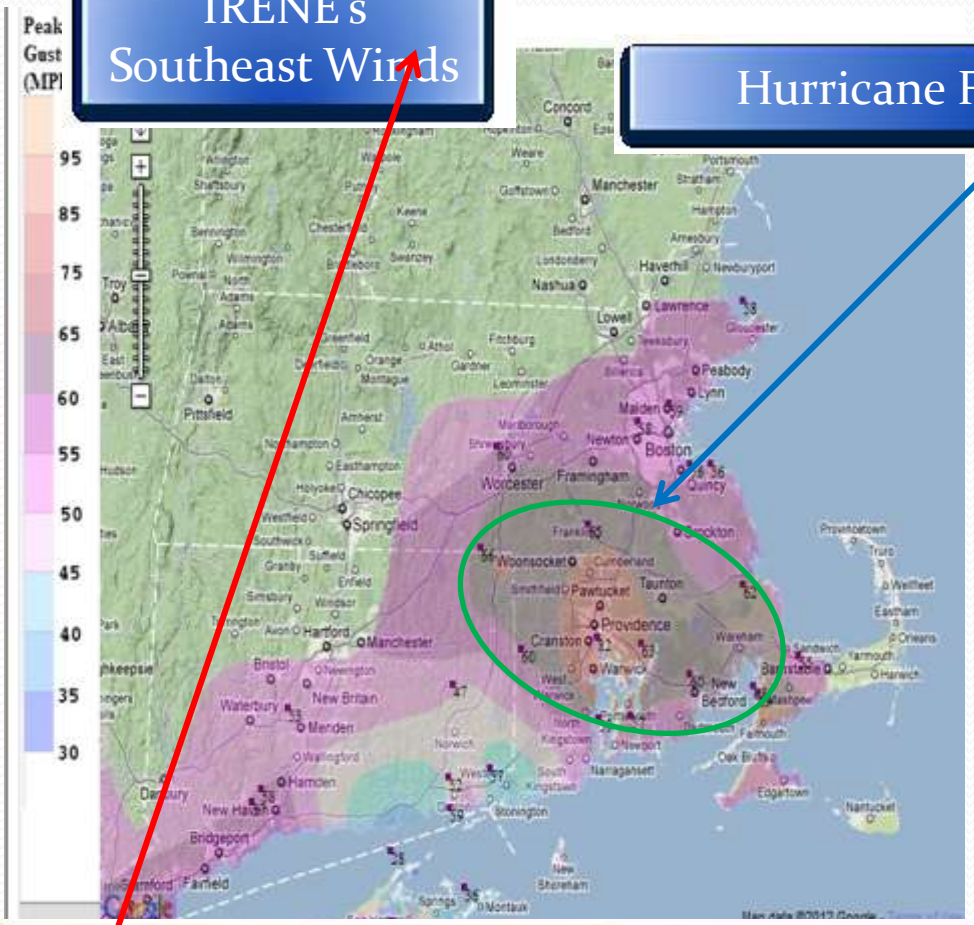


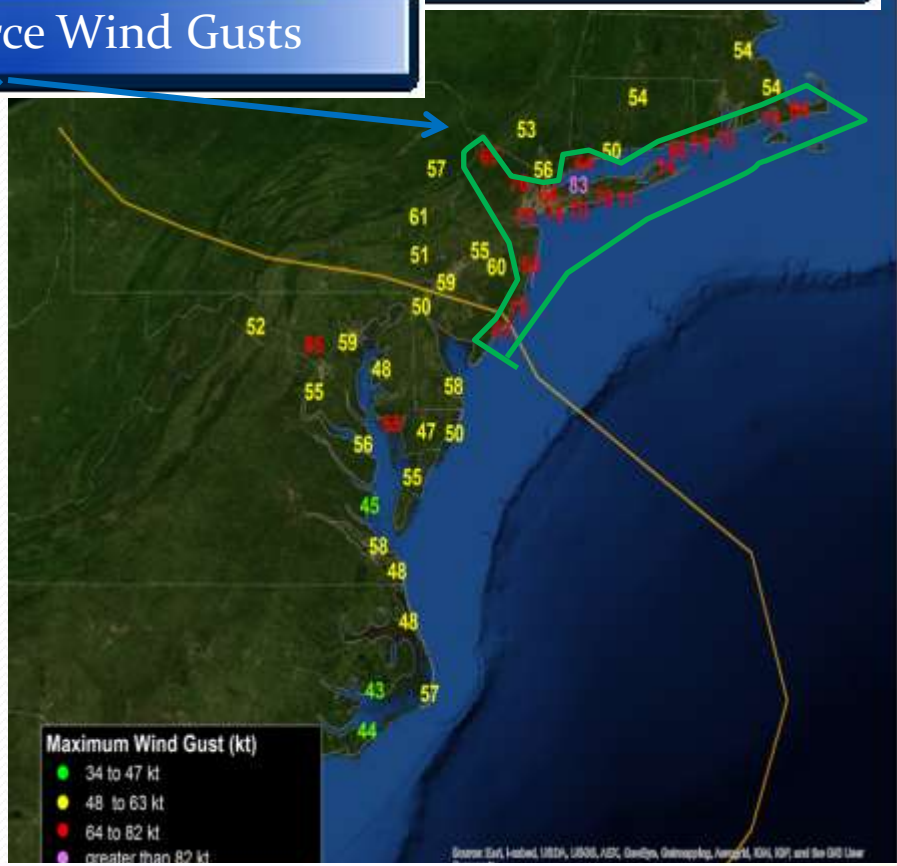
Irene's Winds vs. Sandy's Winds

IRENE's Southeast Winds

Sandy's Northeast Winds

Hurricane Force Wind Gusts



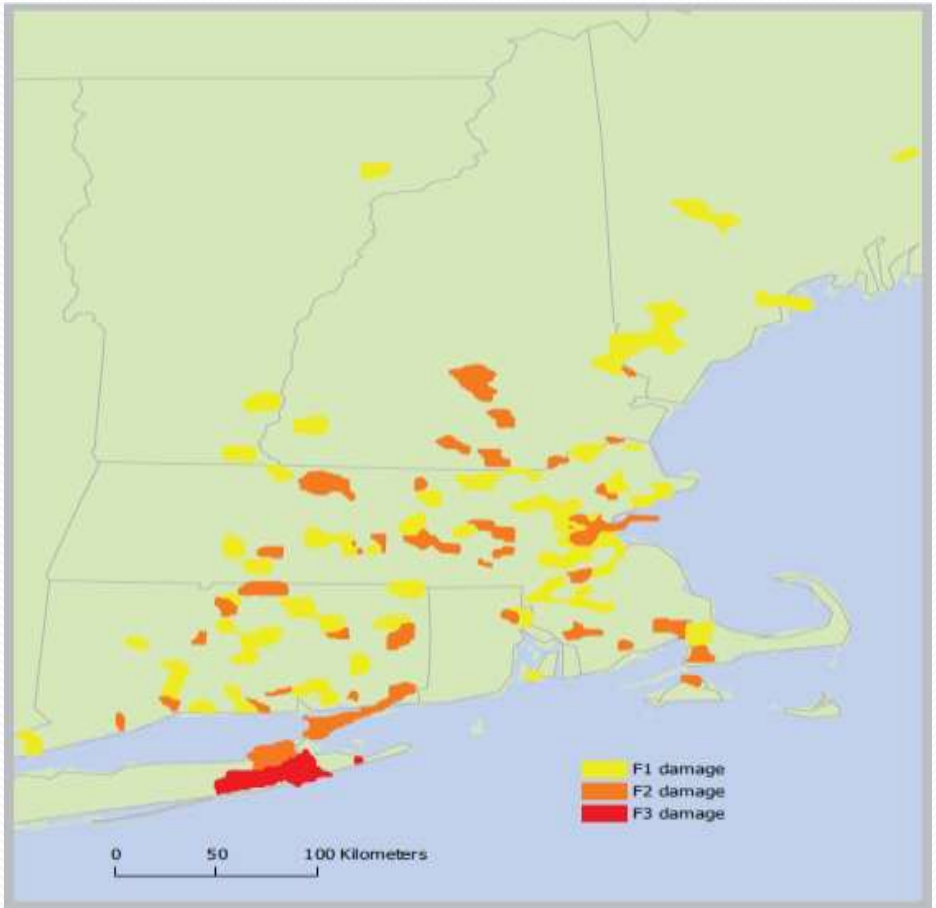


* Irene's winds were predominantly from the southeast

- Sandy's were mostly northeast except immediate south coast late Monday afternoon
- Difference between widespread damage vs. scattered shorter duration damage

1938 Wind damage

Similar to F1-F3 tornado

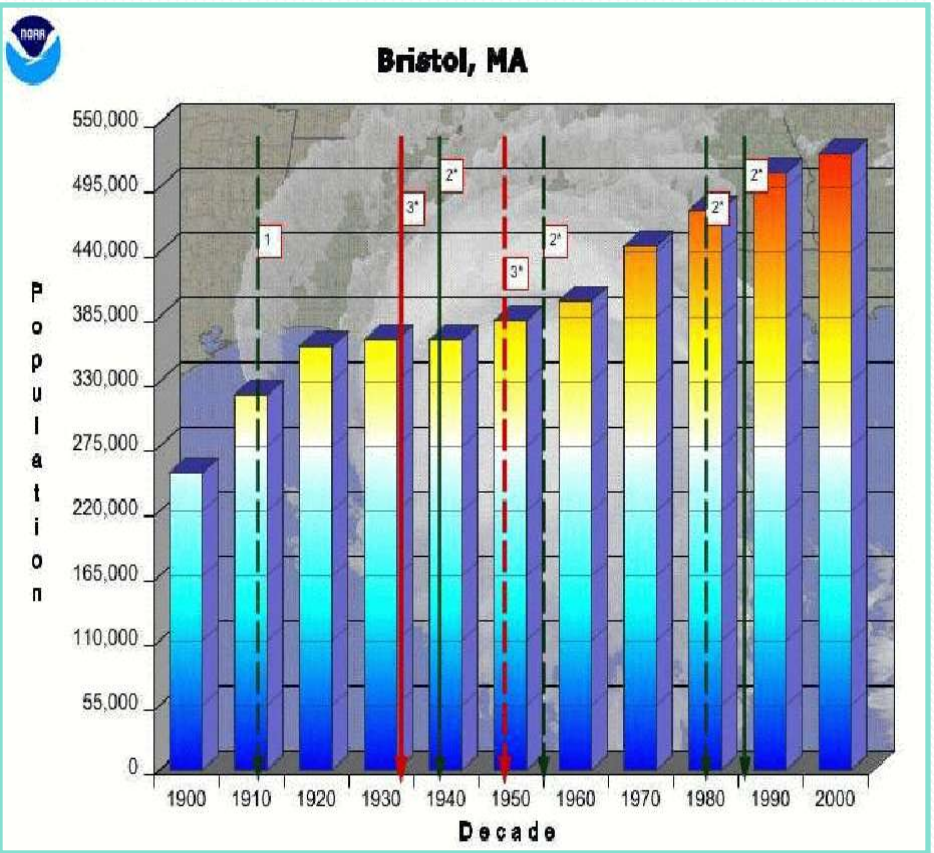


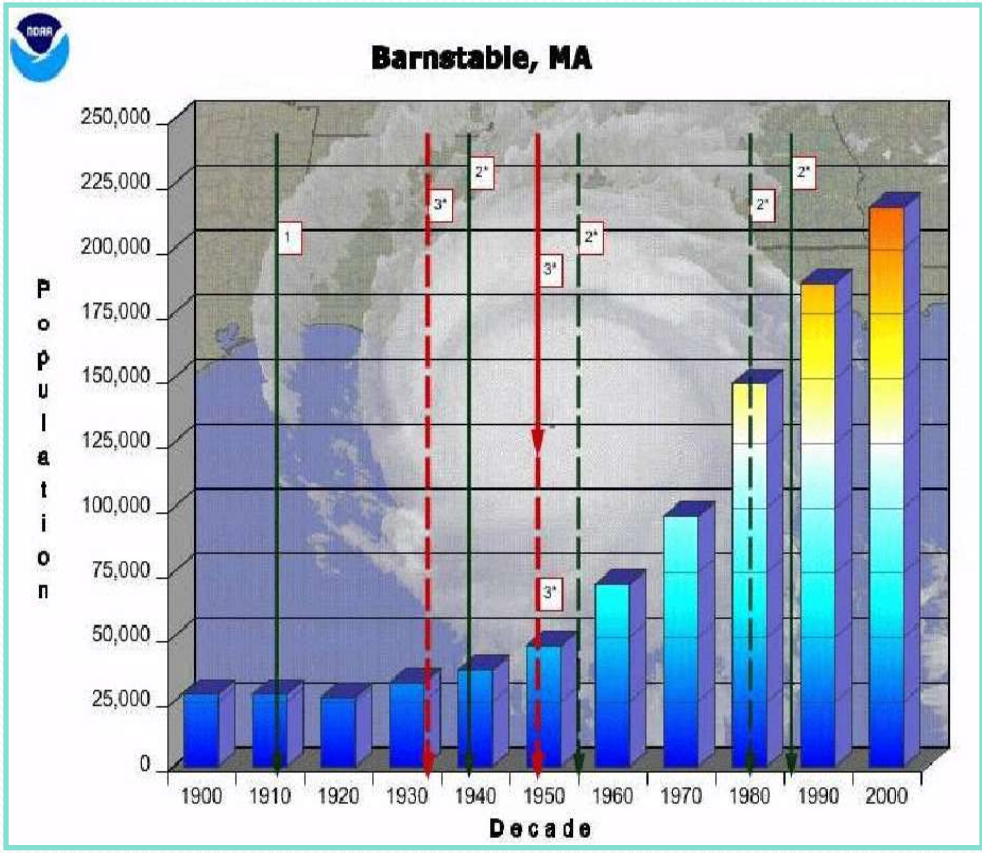
Degree of wind damage as a result of the 1938 Great New England Hurricane, as classified by the Fujita Scale (Source: Boose et al., 2001)

Tremendous wind damage in Windham, Connecticut following 1938

Deadly Storm Surge

- It can kill you & destroy coastal communities
- >50% of U.S. economic productivity - coast!
- Big population increase on our coast since '54

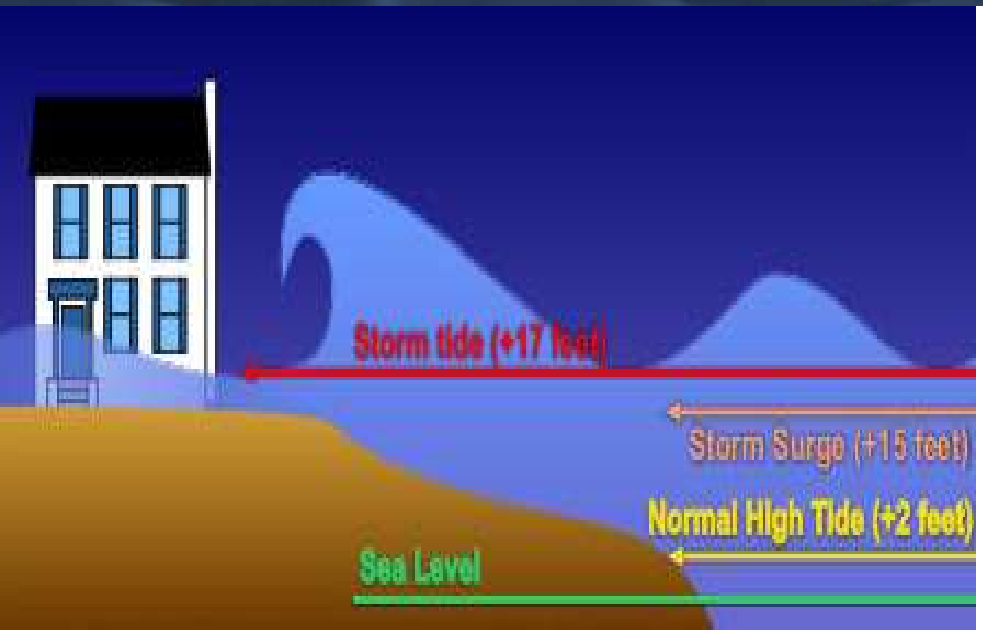


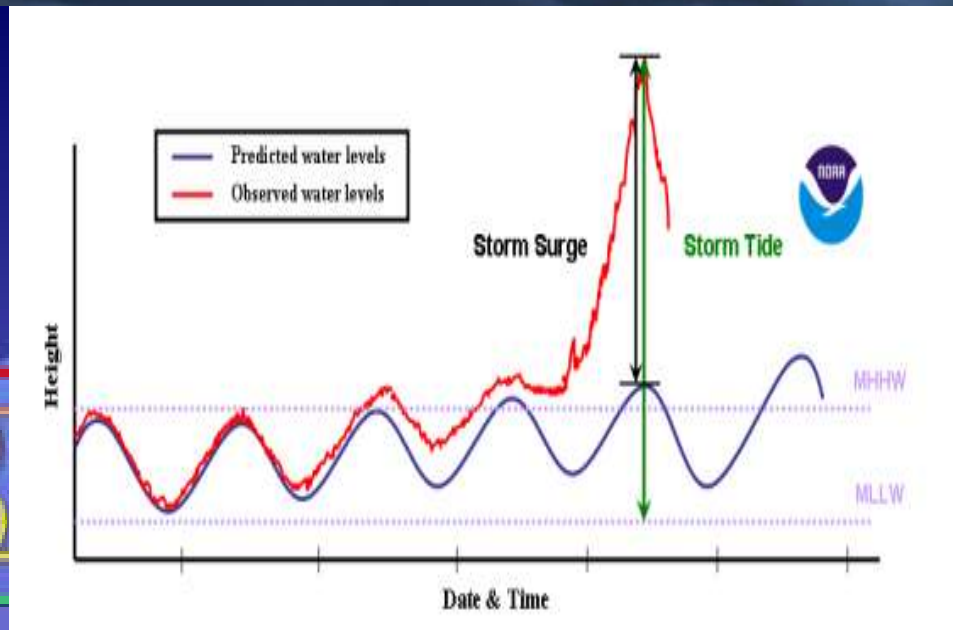


Examining Storm Surge

STORM SURGE is an abnormal rise of water generated by a storm, over and above the predicted astronomical tide.

STORM TIDE is the water level rise during a storm due to the combination of storm surge and the astronomical tide



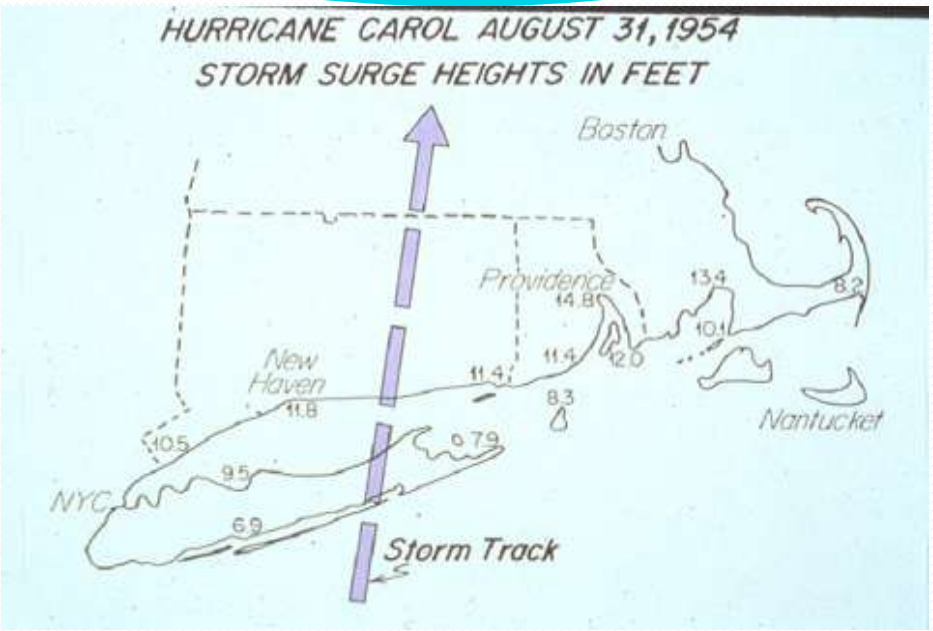


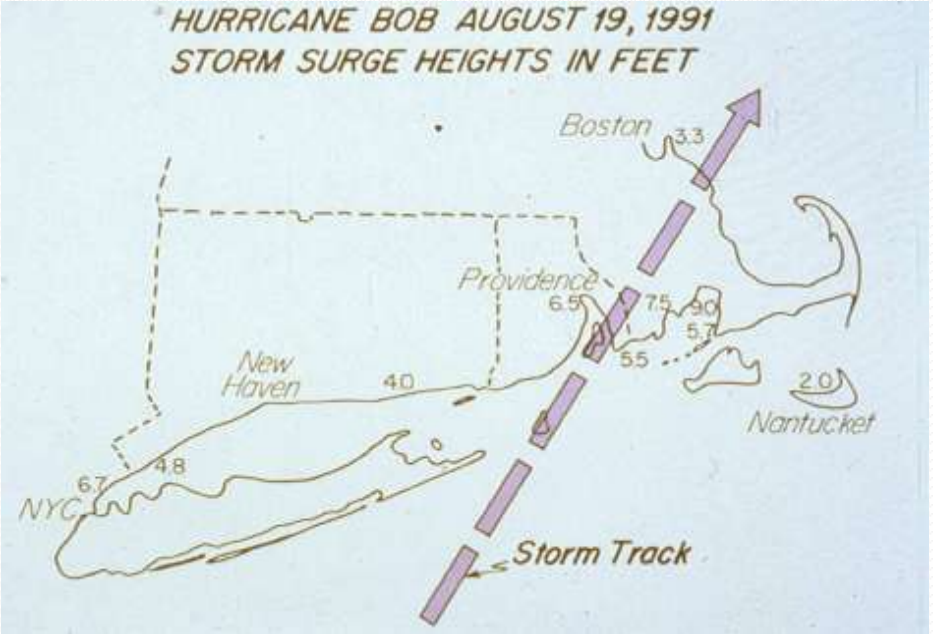
Storm Surge Characteristics

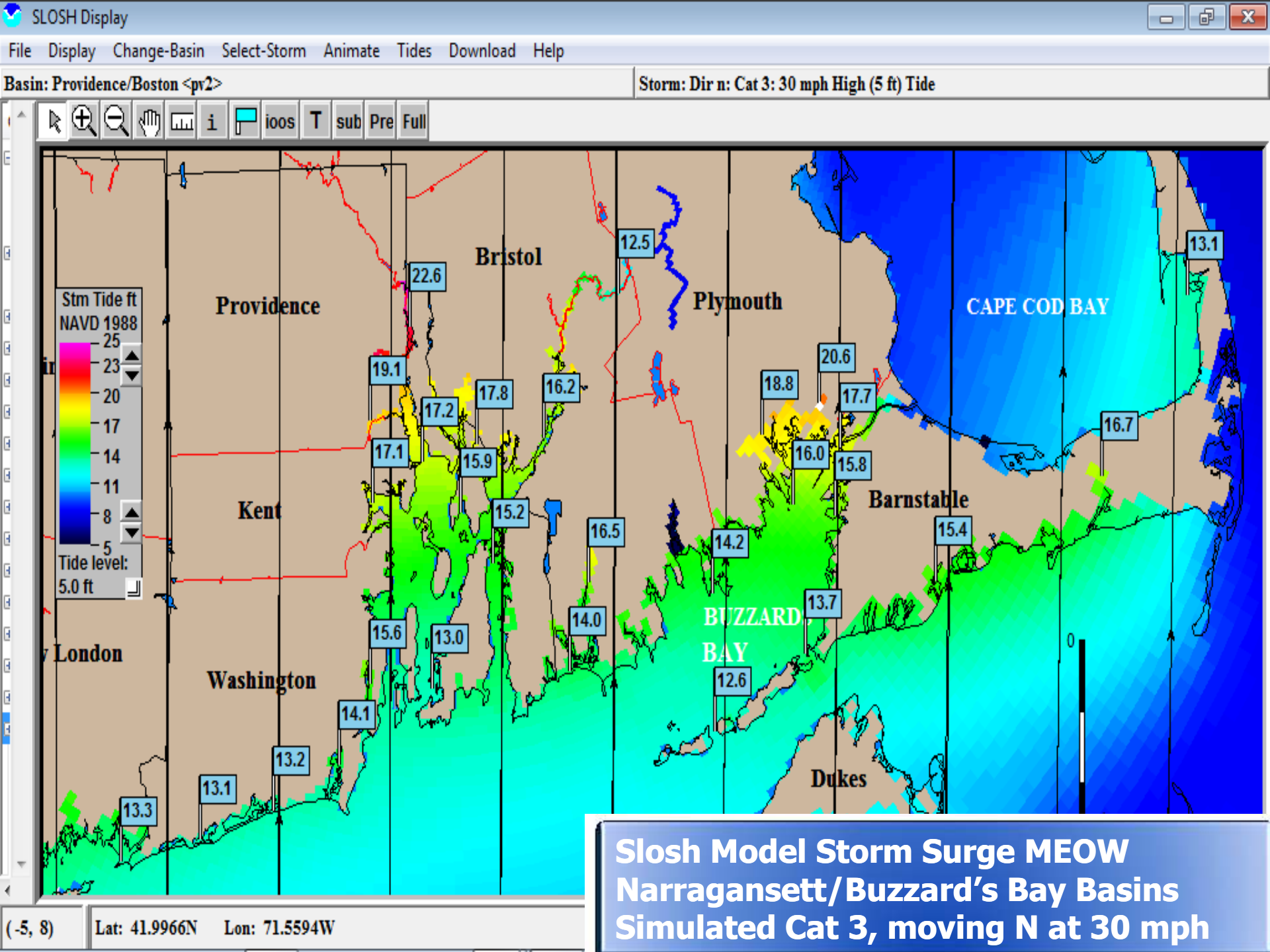
- Tremendous storm surges on south facing bays
  - Most significant "surge" occurs within one hour of landfall
- Wave run-up causes minor coastal flooding to commence ~ 6 hours before the eye arrives
  - In Sandy – 2012 it was more than 18 hours!
- Surges of 12 to 15 feet have been observed
  - Potential for 20-25 foot surges from Cat 3 storm exists for Buzzard's Bay, Massachusetts and the lower portions of Penobscot Bay in Maine
  - 10-14 feet for the south side of Cape Cod
  - 8 to 12 feet on the Cape Cod Bay side of Wellfleet & Truro

Angle of Approach and Forward Motion

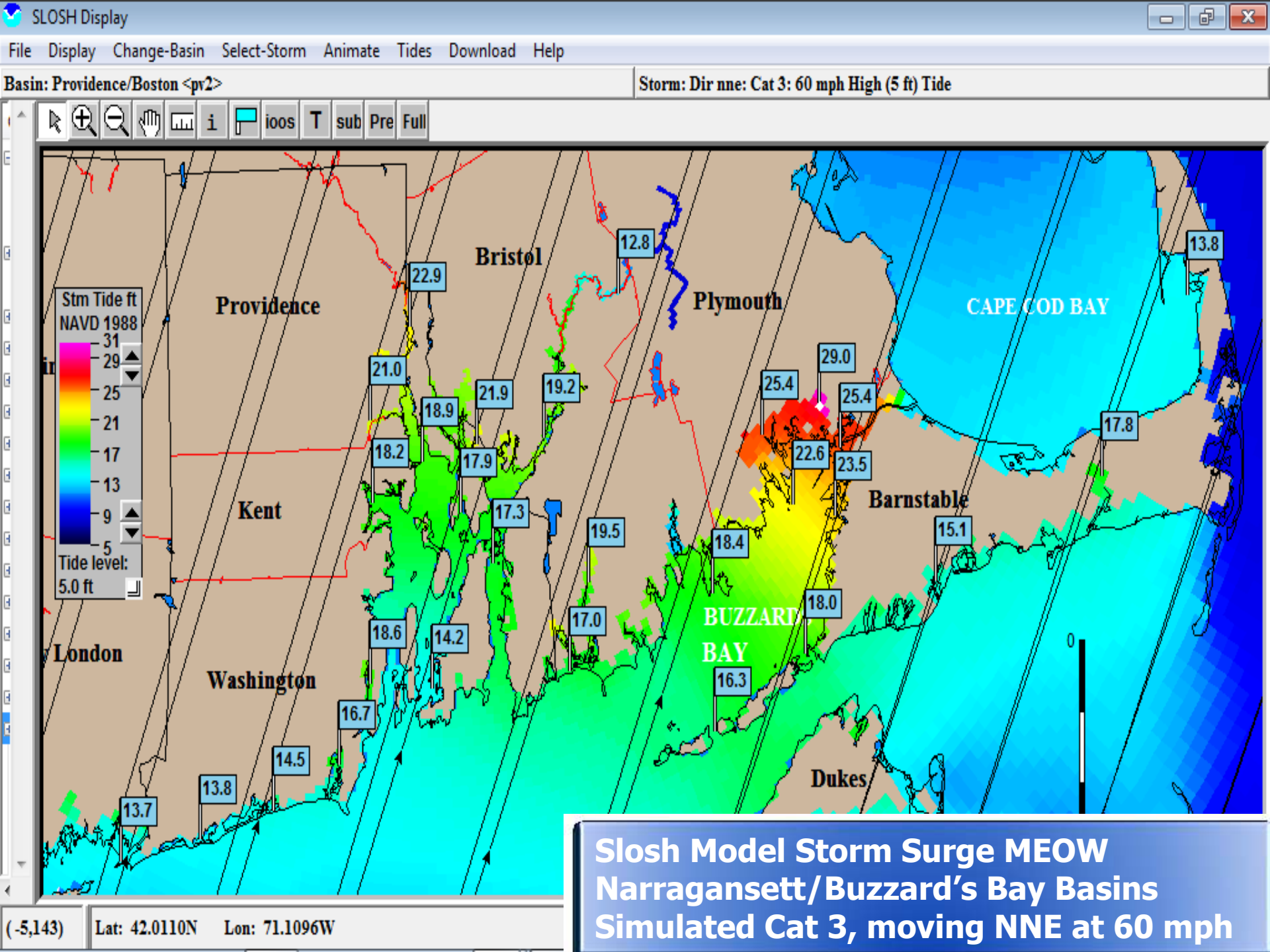
- Small changes greatly affect surge generation
  - Forward motion
  - Angle of approach
  - RMW significantly change where maximum surge occurs
- South coast will typically see less surge but significantly greater wave damage
- Upper bays and tidal rivers will see greater surge heights due to funneling but less wave related damage







Slosh Model Storm Surge MEOW
Narragansett/Buzzard's Bay Basins
Simulated Cat 3, moving N at 30 mph

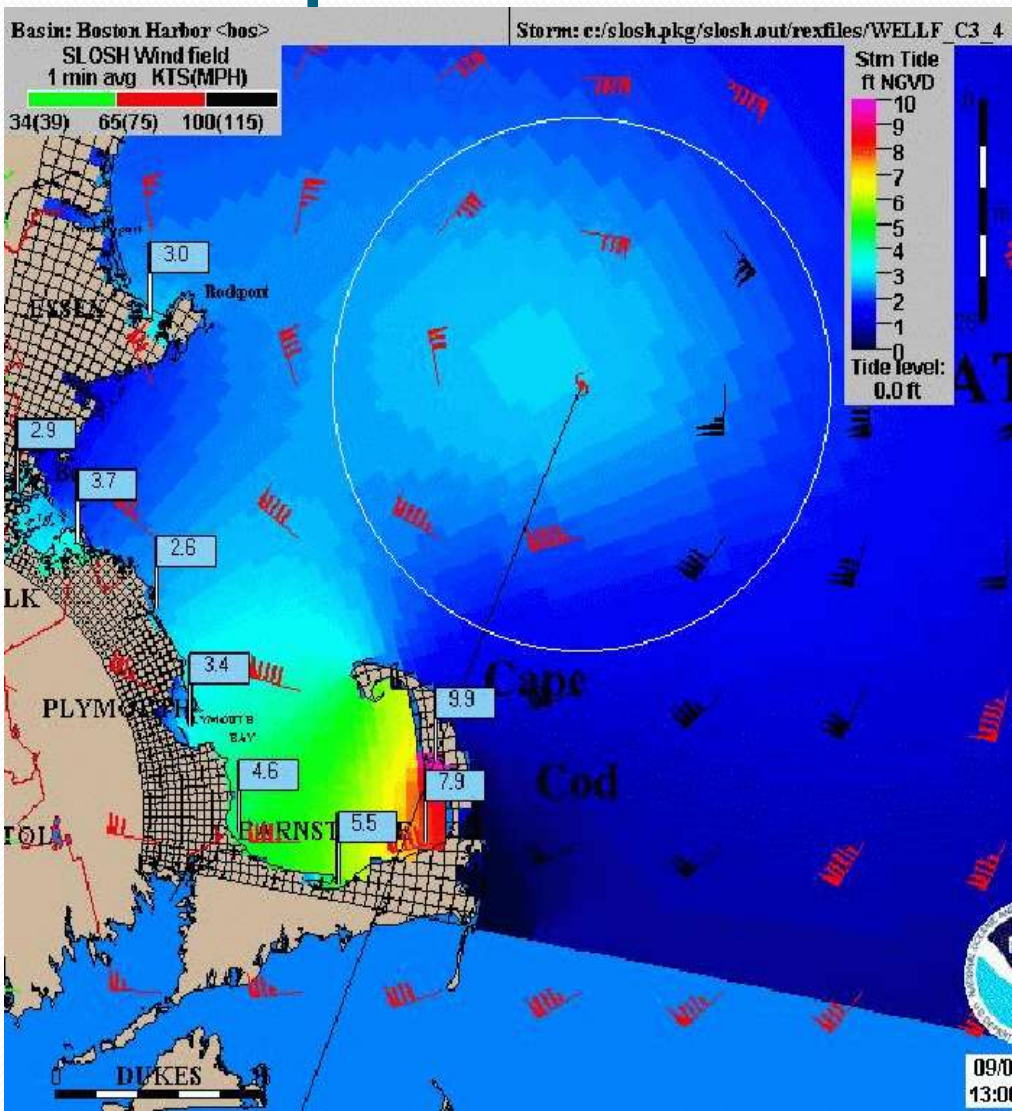


Slosh Model Storm Surge MEOW
Narragansett/Buzzard's Bay Basins
Simulated Cat 3, moving NNE at 60 mph

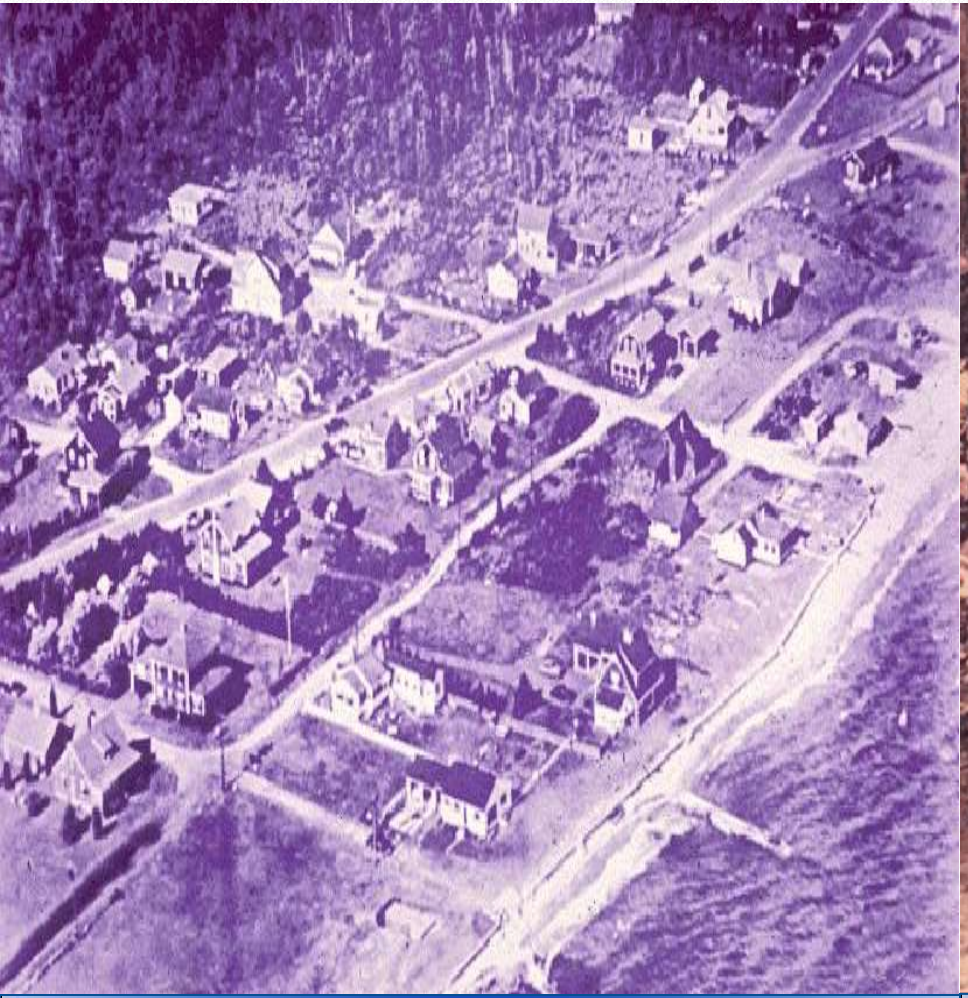
For Cape Cod Bay:

Max surge occurs after the center passes!

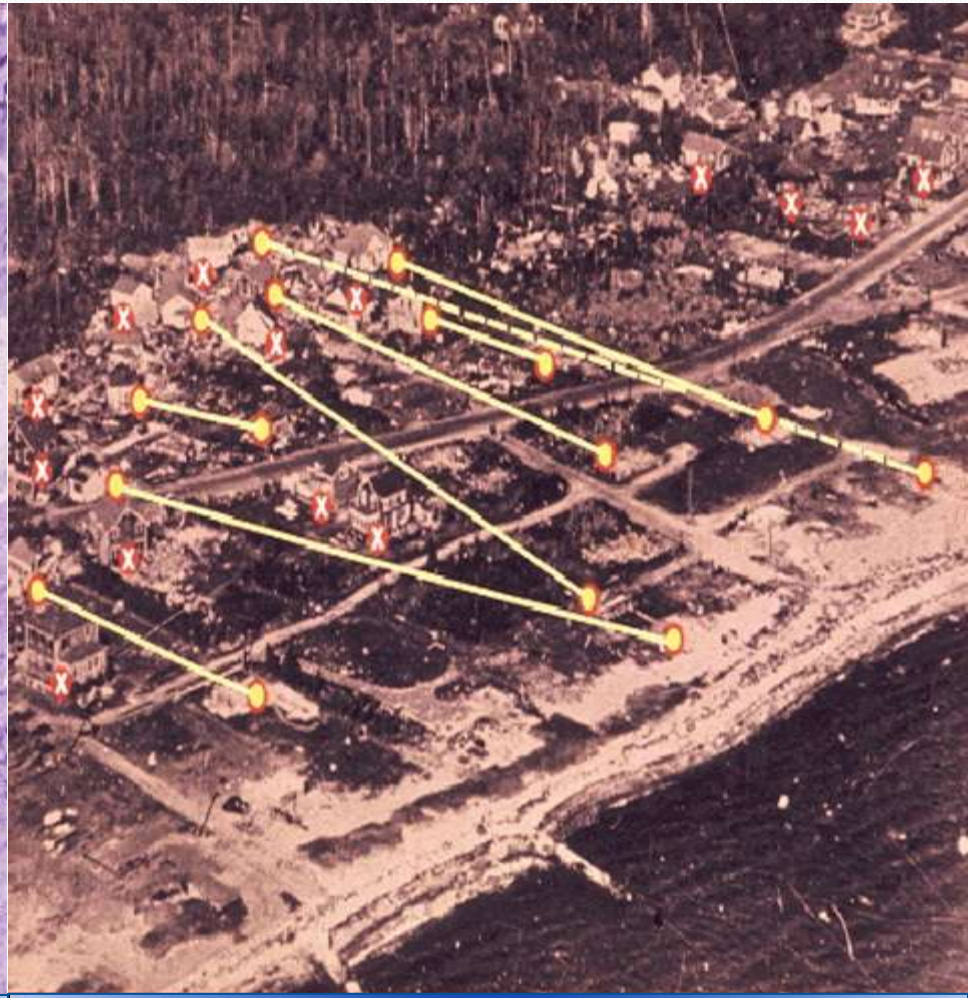
- Simulation for Hurricane Edna, 1954
- Note the surge of ~10 feet in Wellfleet Harbor - occurs nearly 1.5 hours after the eye reaches the south side of the cape!



Flavors of Surge Damage



Crescent Beach, MA - Before Hurricane Carol



Crescent Beach, MA - After Hurricane Carol

Flavors of Surge Damage

Wave and Surge Damage from Sandy along Atlantic Avenue, Westerly RI

The Great New England Hurricane of 1938 had it all!

Tremendous storm surge damage at the mouth of the Connecticut River, at Old Lyme

Route 1A – Scenic in Narragansett, RI the day after the Great New England Hurricane of 1938. Note the today destruction of the sea wall and roadway

Devastating storm surge damage flattens the beach-side village of Island Park, Portsmouth, RI

Powerful waves breaking over the sea wall at the U.S. Fishery Building during the 1938 Hurricane in Woods Hole, MA

Let’s take a trip to the Menauhant section of Falmouth, Massachusetts

Wondering what this might look like during an actual Storm Surge???

Hurricane Bob's Six Foot Storm Surge!

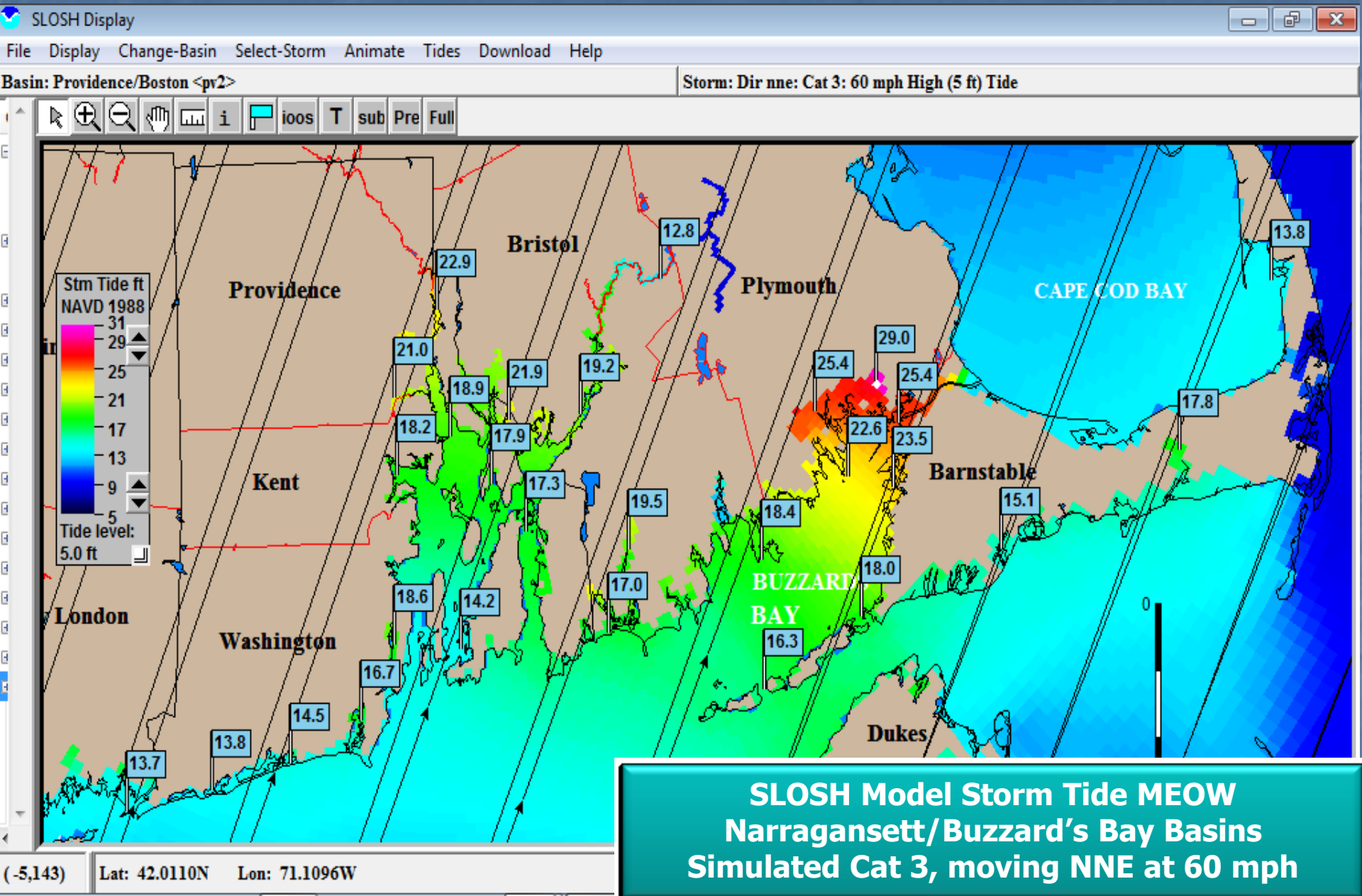
So What's The Real Potential?

As it is today…

So What's The Real Potential?

Upper Buzzards Bay Worst Case:

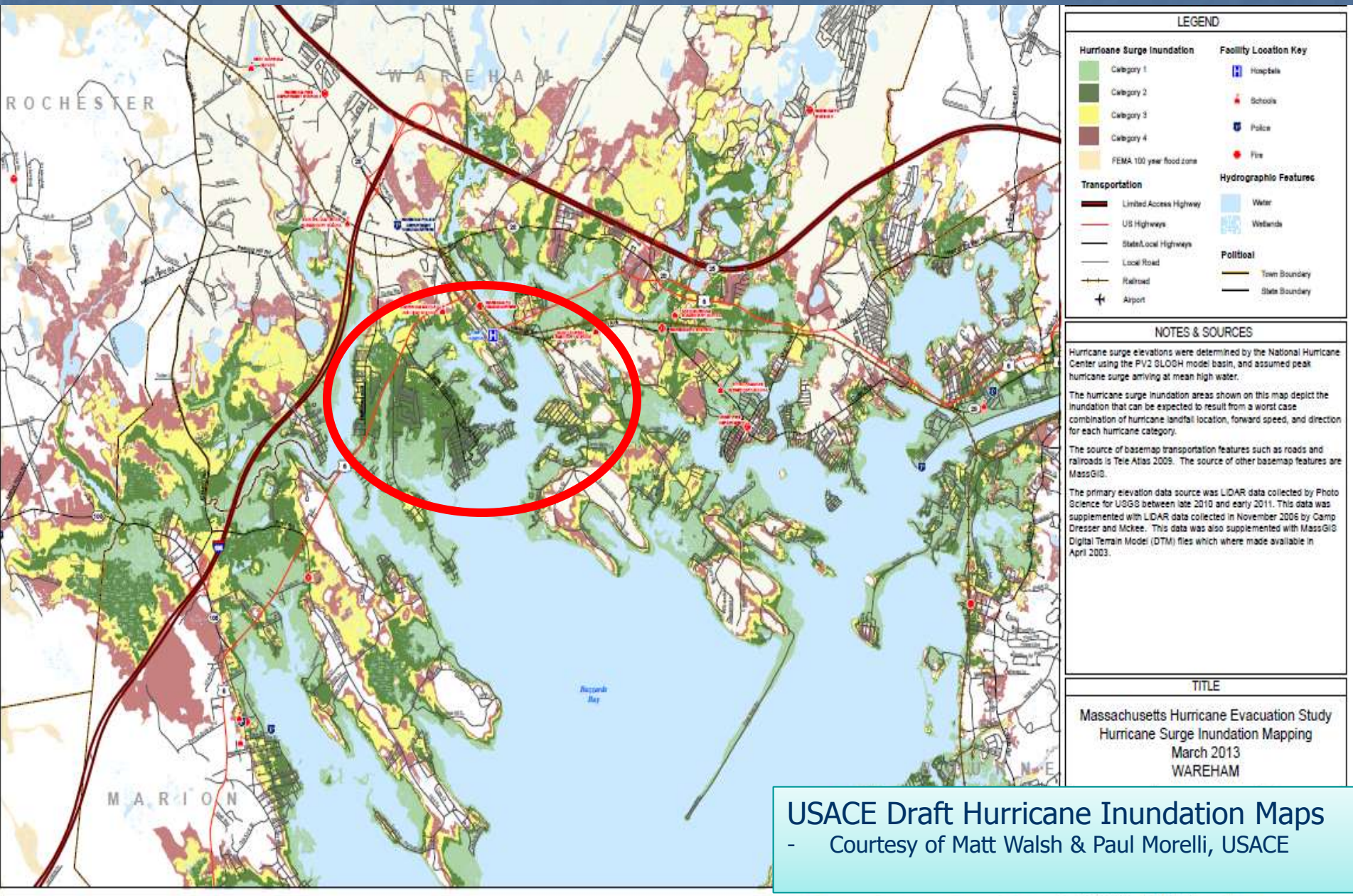
NNE Cat 3 moving at 60 mph



SLOSH Model Storm Tide MEOW
Narragansett/Buzzard's Bay Basins
Simulated Cat 3, moving NNE at 60 mph

Parkwood Beach, Wareham, MA
"My Miami of The North!"

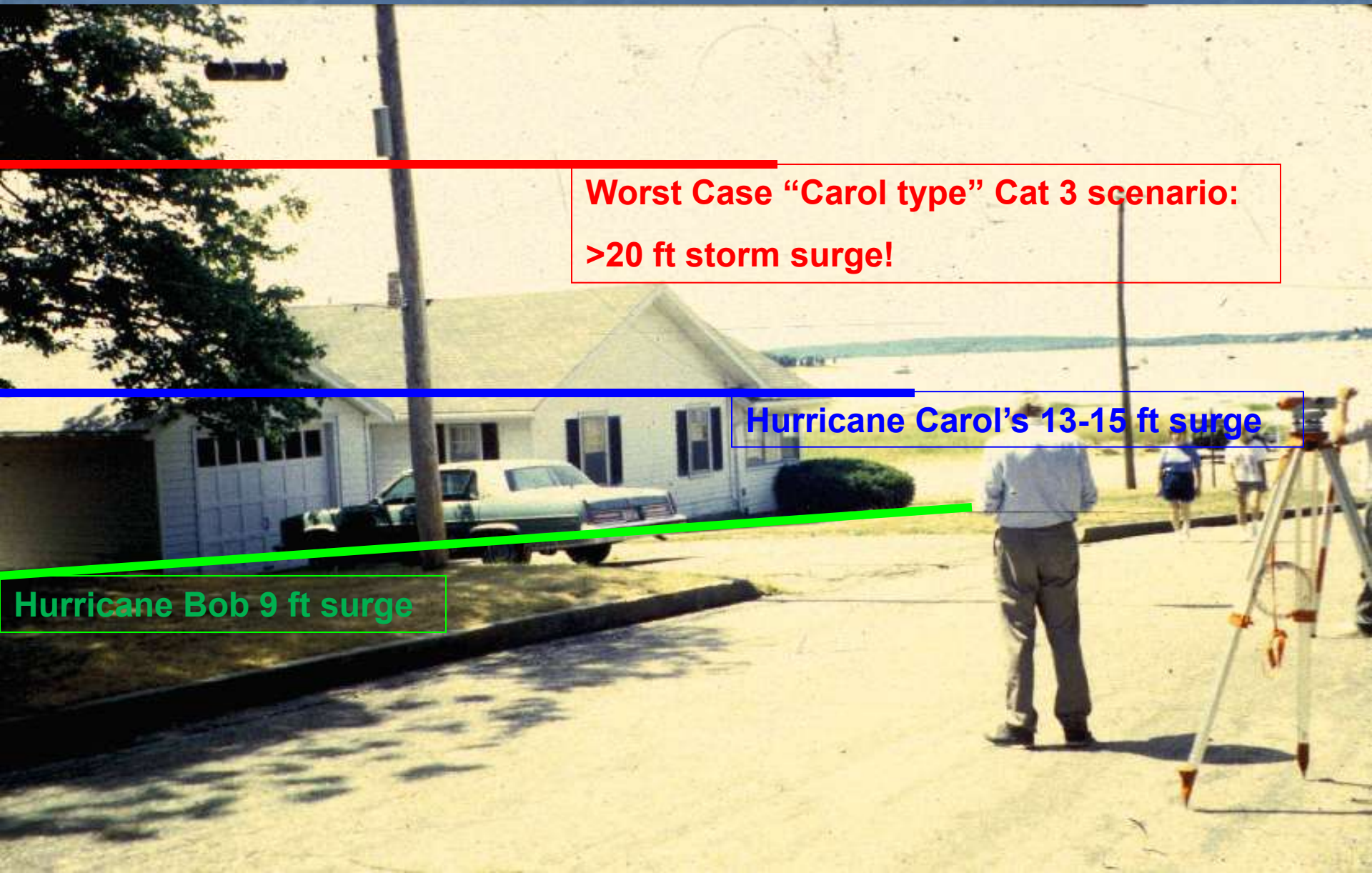
Upper Buzzards Bay Worst Case:
Potential Inundation in Wareham, MA



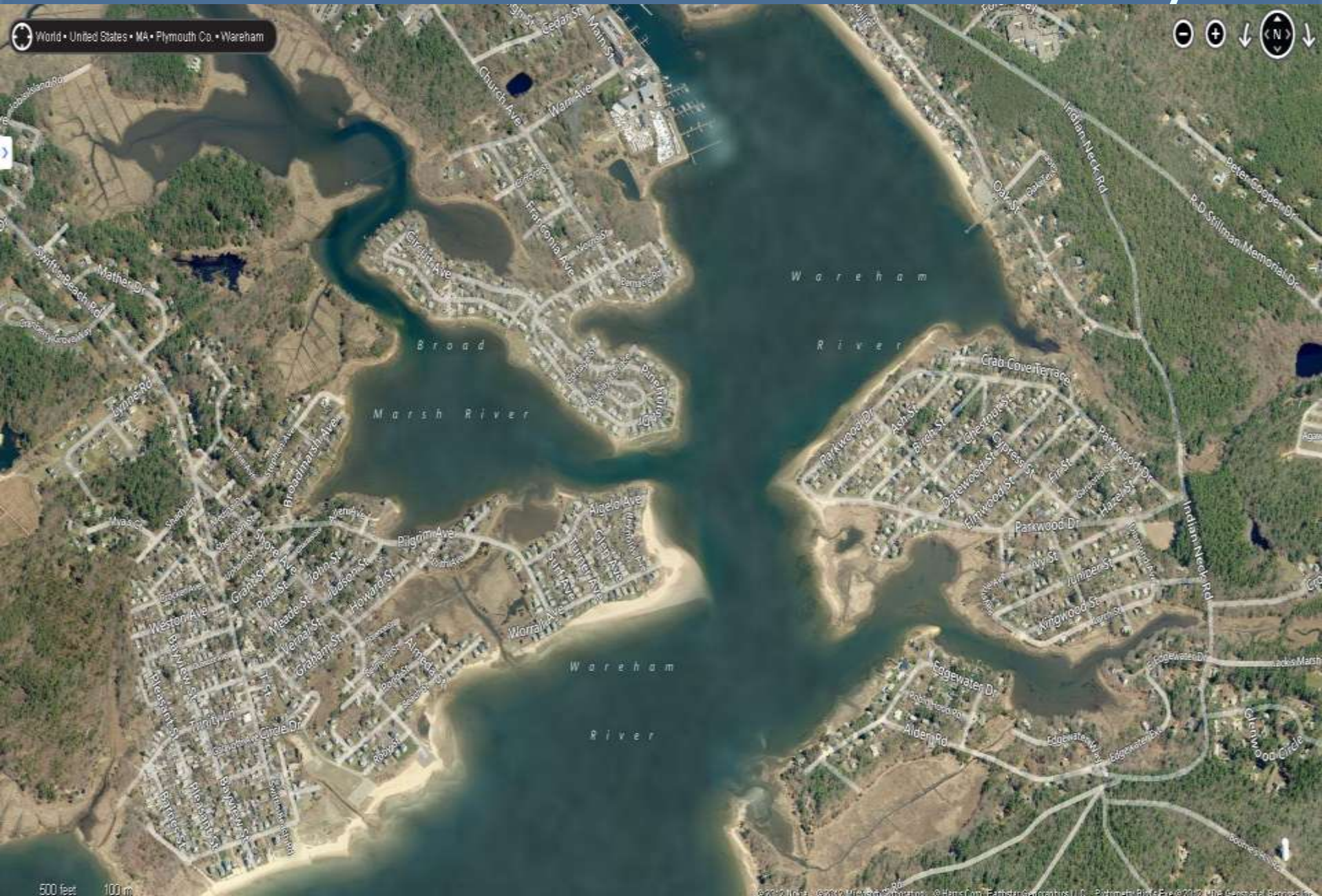
USACE Draft Hurricane Inundation Maps

- Courtesy of Matt Walsh & Paul Morelli, USACE

Tremendous potential for disaster



Swifts – Pinehurst – Parkwood today



Summary

- New England Tropical Cyclones have a particular behavior of their own
  - Driven by interaction with the westerlies
  - Desire to become Extra-tropical
- Potential for widespread severe wind damage
- Potential for devastating storm surges
  - 20 feet or more in the upper Sakonnet River and upper Buzzards Bay
- Explosive Jet interaction, coastal frontogenesis, and orographic enhancement can result in tremendous rainfall and flooding
- Acceleratory nature and the arrival of heavy rainfall well in advance of the storm:
  - Makes it a necessity to prepare well in advance

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