# UNDERSTANDING COASTAL GEOLOGIC HAZARDS
# SEA LEVEL RISE and CLIMATE CHANGE
# in
# RHODE ISLAND

## 2nd National Workshop on Subaqueous Soils

**9 August 2010**

**Jon C. Boothroyd, State Geologist,**
**Rhode Island Geological Survey and Department of Geosciences,**
**University of Rhode Island, Kingston, RI 02881,**
***jon_boothroyd@uri.edu***

RHODE ISLAND GEOLOGICAL SURVEY

COASTAL HAZARDS GROUP
GEOSCIENCES Univ RI

UNIVERSITY OF Rhode Island

COASTAL INSTITUTE

Sea Grant Rhode Island

CRMC
Coastal Resources Management Council

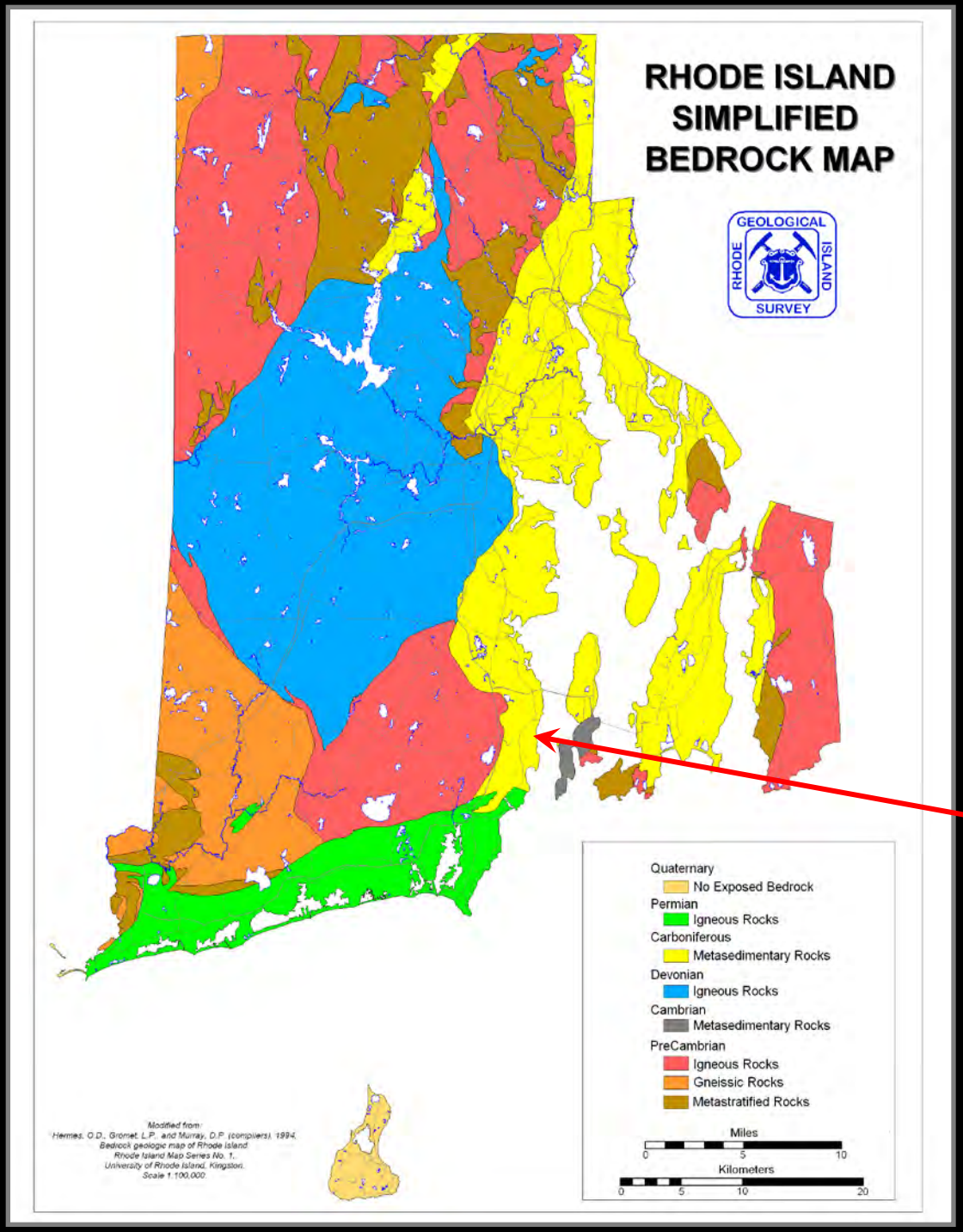
NRCS

RIGIS

US Army Corps of Engineers®
New England District

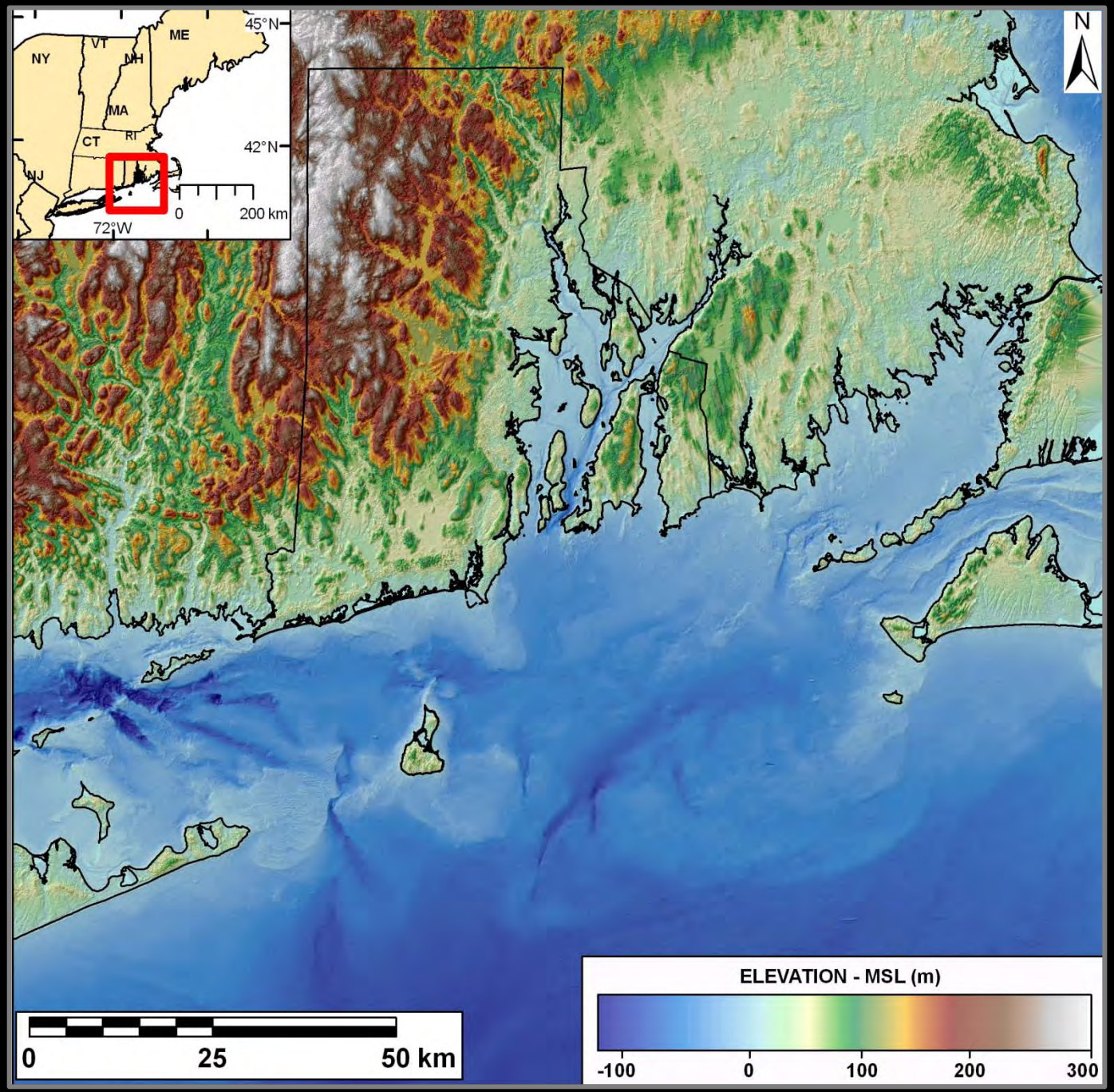
# *A Little Background Information*

- **Bedrock Geology**
- **Glacial Geology**


RHODE ISLAND
SIMPLIFIED
BEDROCK MAP
GEOLOGICAL
RHODE ISLAND
SURVEY
Quaternary
No Exposed Bedrock
Permian
Igneous Rocks
Carboniferous
Metasedimentary Rocks
Devonian
Igneous Rocks
Cambrian
Metasedimentary Rocks
PreCambrian
Igneous Rocks
Gneissic Rocks
Metastratified Rocks
Miles
0
5
10
Kilometers
0
5
10
20
Modified from:
Hermes, O.D., Gromet, L.P. and Murray, D.P. (compilers), 1994,
Bedrock geologic map of Rhode Island:
Rhode Island Map Series No. 1,
University of Rhode Island, Kingston,
Scale 1:100,000.

You are here

# Geomorphology of Southeastern New England

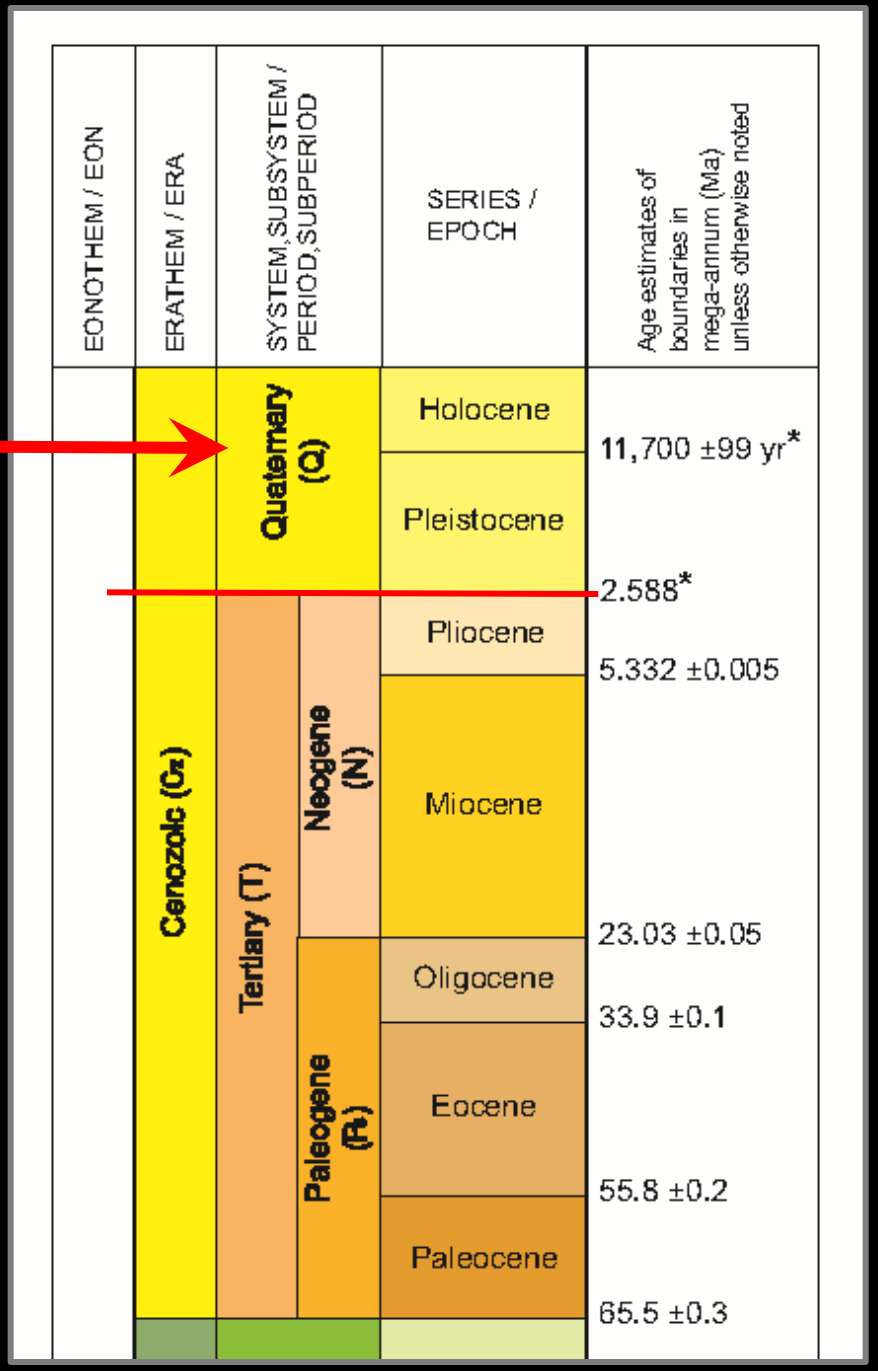


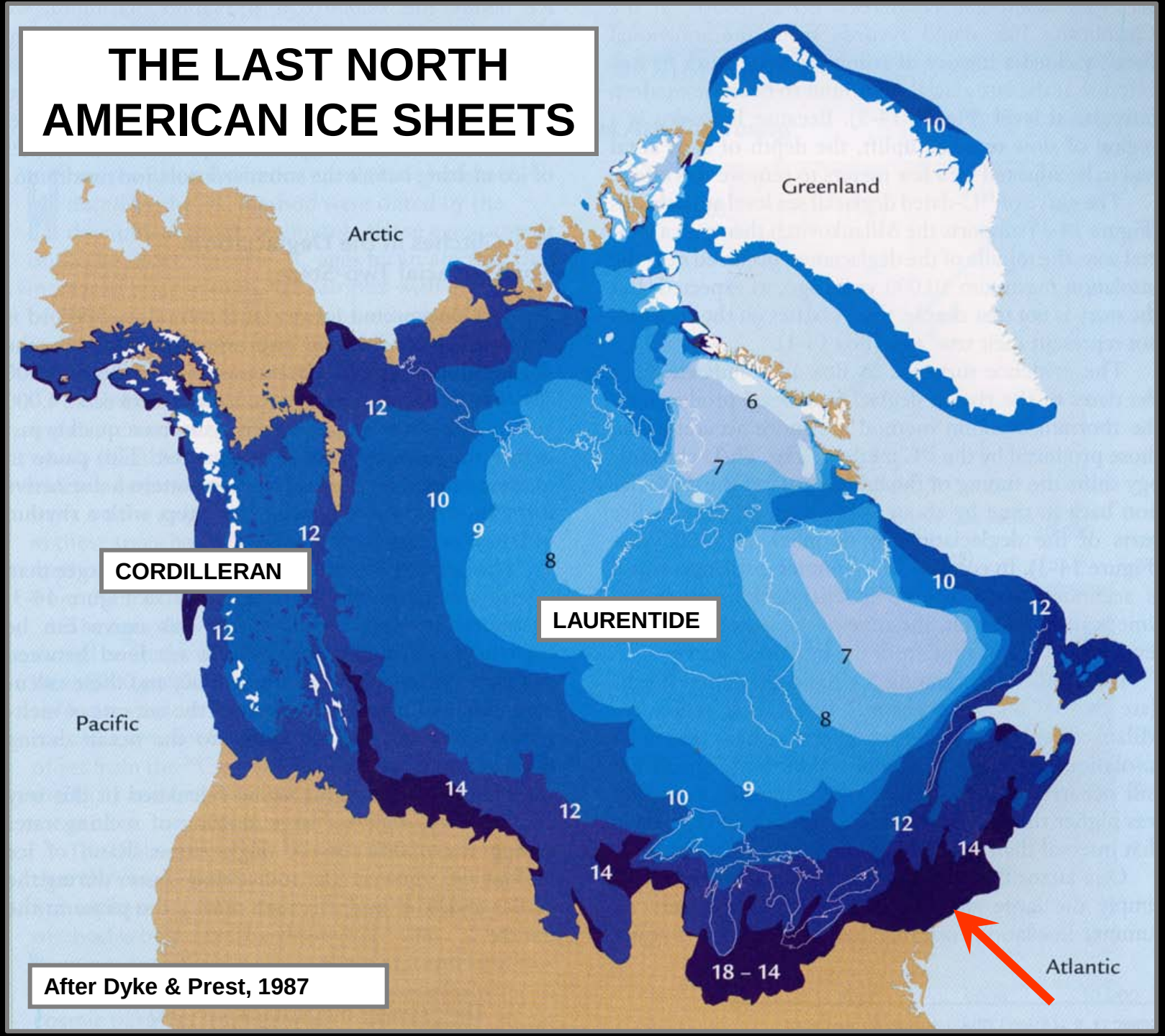
# Quaternary Geology Time Scales

- **QUATERNARY PERIOD - Last 2.6 million years of geologic time**
- **PLEISTOCENE EPOCH – All of Quaternary Period except last 11,700 years**
- **WISCONSINAN STAGE – Last glacial age of the Pleistocene (~70,000 years BP to 11,700 yrs BP)**
- **HOLOCENE EPOCH – Last 11,700 years (including now)**

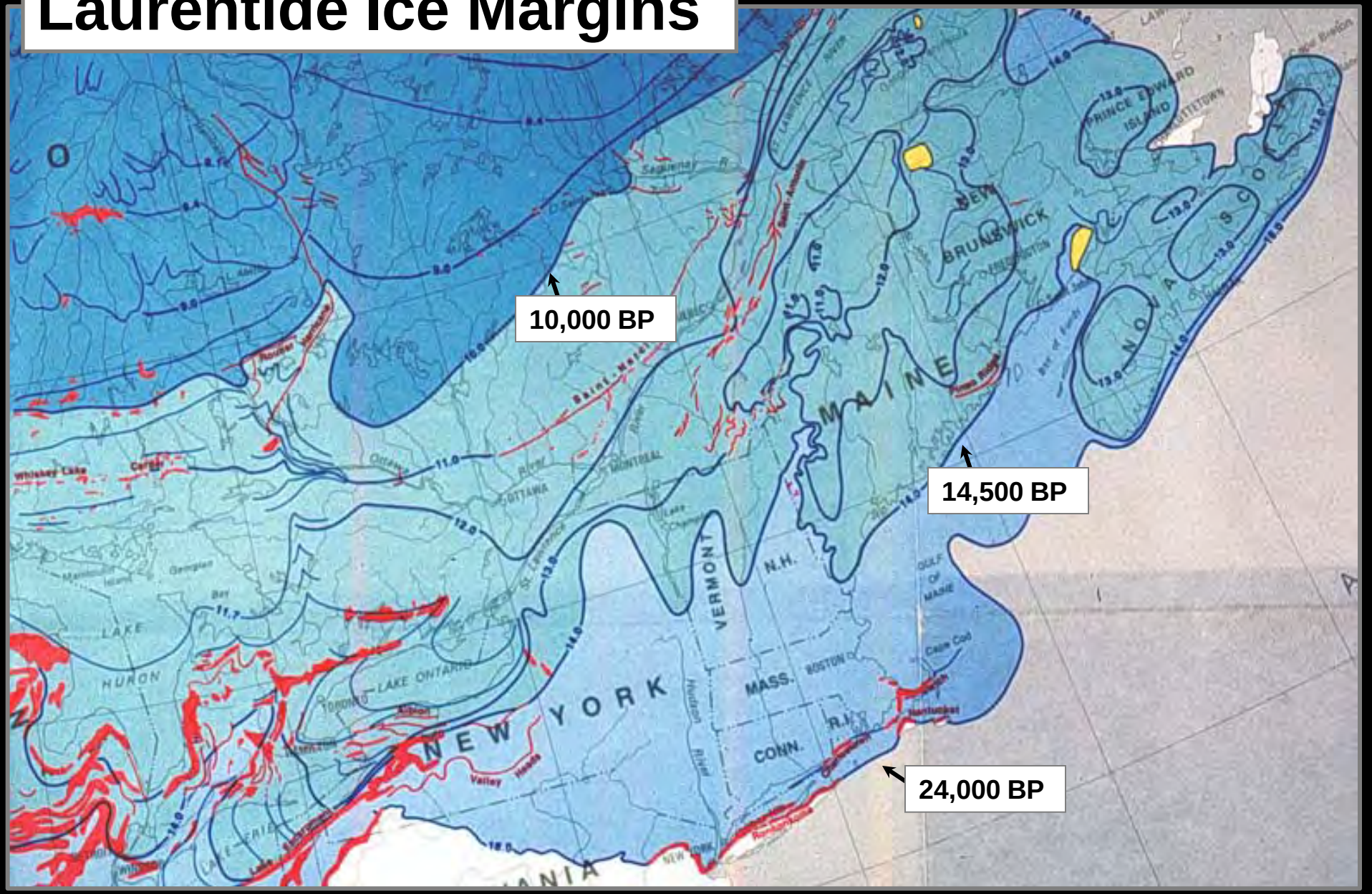
# Geologic Time Scale
# Cenozoic – Last 65.5 my

**Quaternary - Last 2.6 my**




THE LAST NORTH AMERICAN ICE SHEETS
Greenland
Arctic
Pacific
Atlantic
CORDILLERAN
LAURENTIDE
10
12
6
7
10
9
12
8
10
12
12
7
8
14
12
10
9
12
14
14
18 – 14
After Dyke & Prest, 1987

# Laurentide Ice Margins

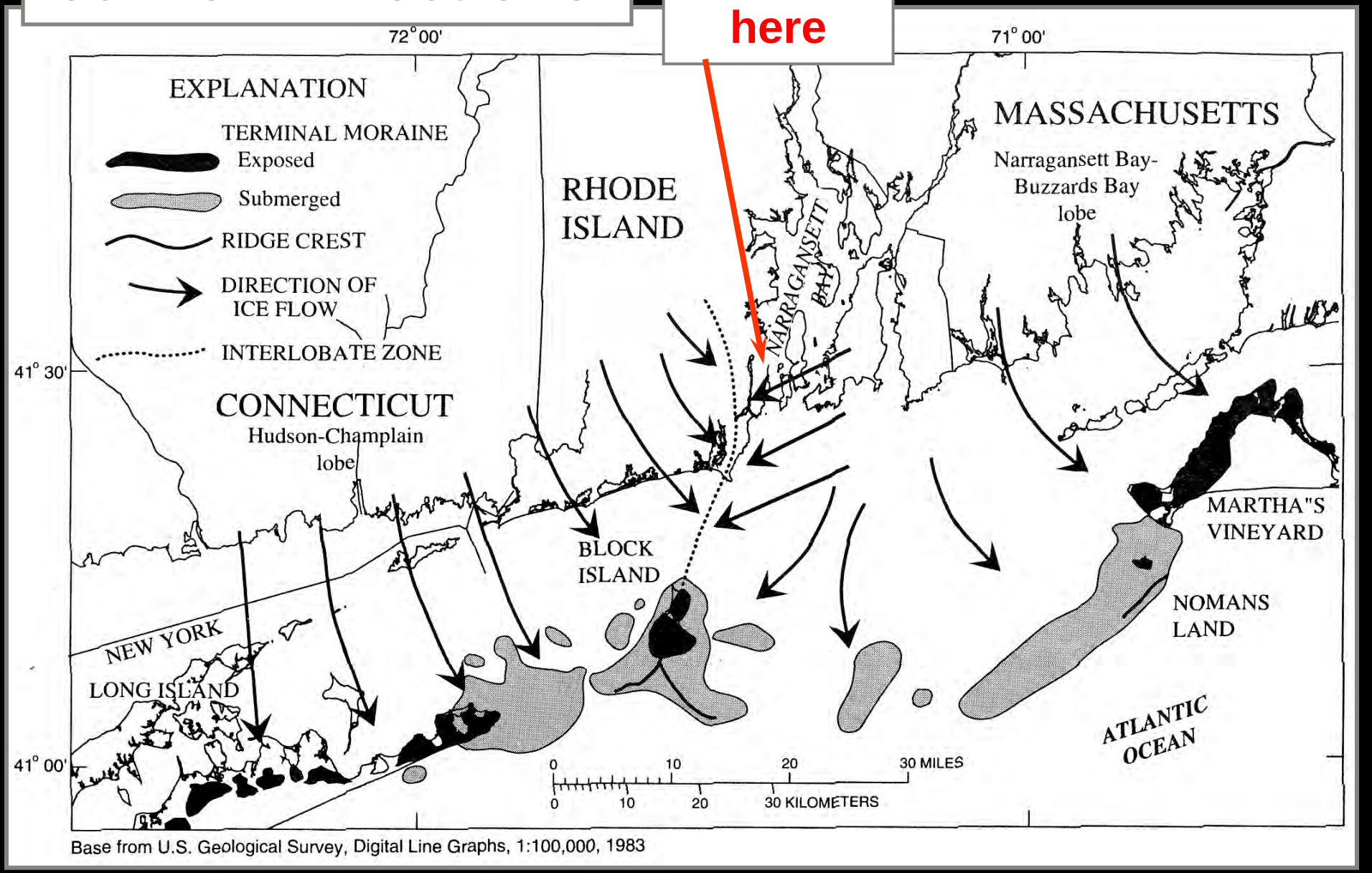



After Dyke & Prest, 1987

# MALASPINA GLACIER – Northeast Gulf of Alaska

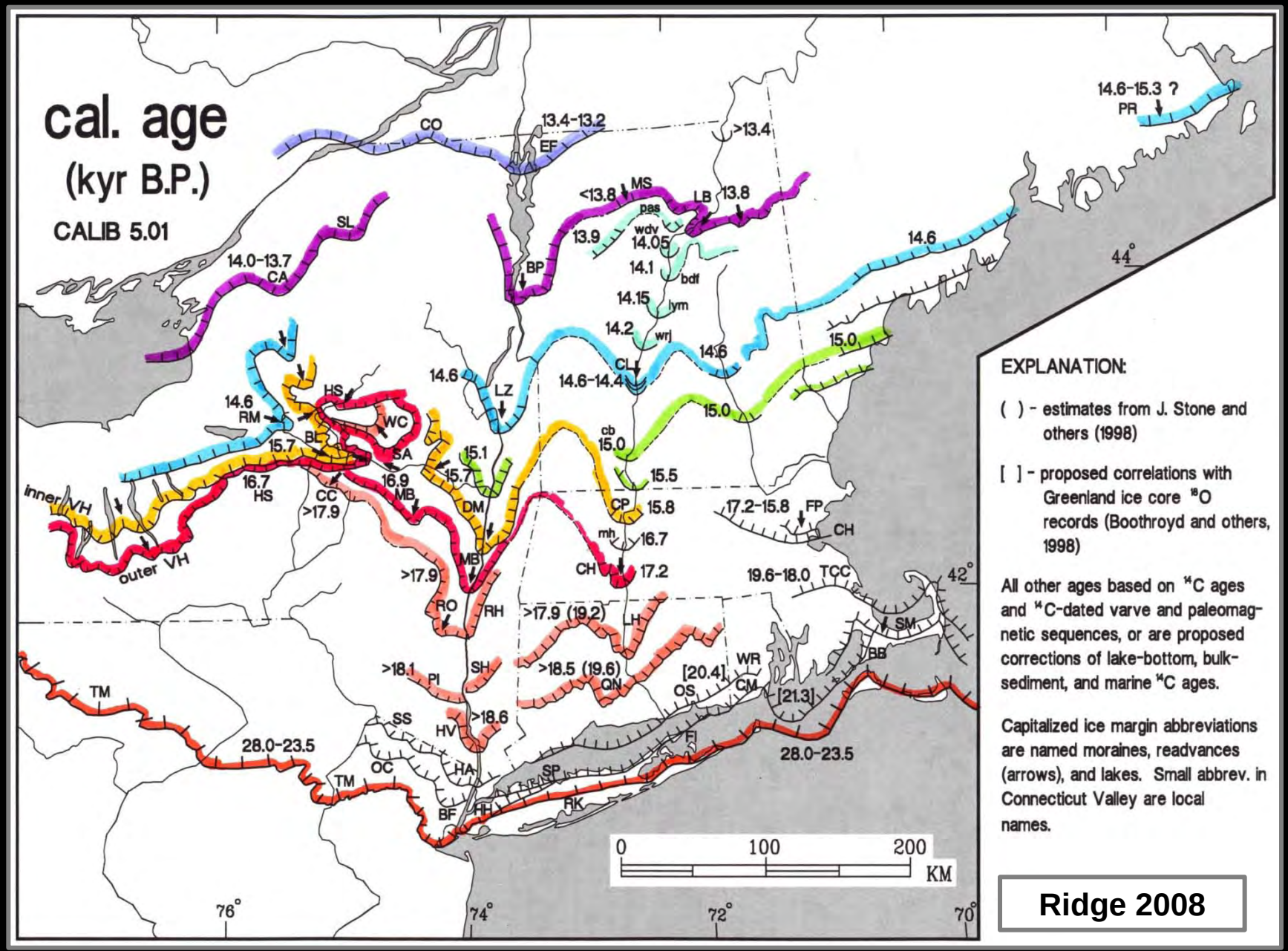
**An Analog "The size of Rhode Island"**

# Ice Flow Directions



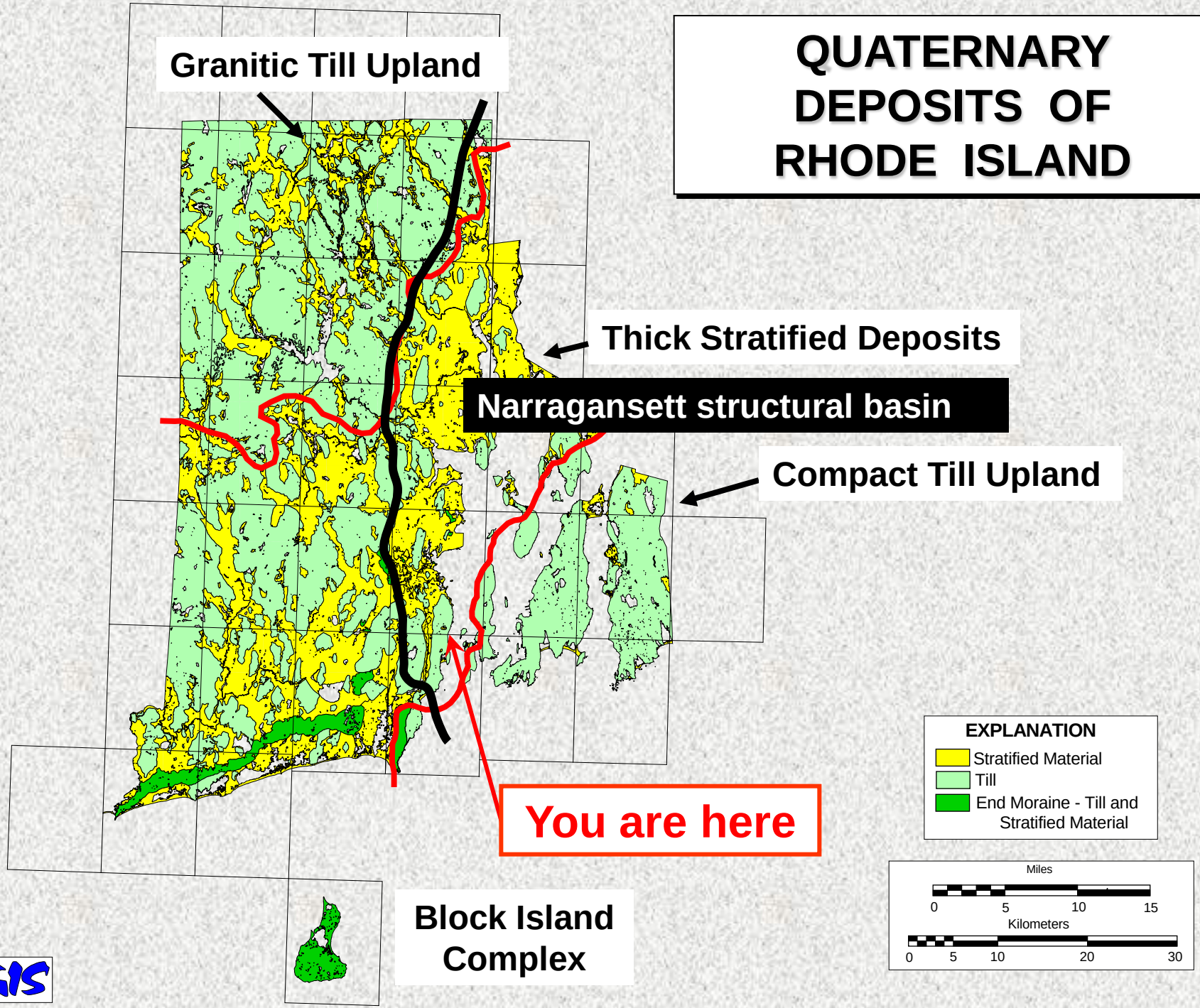

Stone and Sirkin, 1996

# New England Deglacial Ice Margins




**Ridge 2008**

# QUATERNARY DEPOSITS OF RHODE ISLAND



# GEOLOGIC FACIES -

Sediment with certain readily identifiable characteristics –

- Composition
- Color
- Particle size
- Sorting
- Stratification and structure
- Biologic content
- Plus others

May be discerned either in the field or laboratory.

# GEOLOGIC HABITATS -

Called **DEPOSITIONAL ENVIRONMENTS** by geologists

Places where geologic processes -

- Water
- Wind
- Ice
- Humans as agents

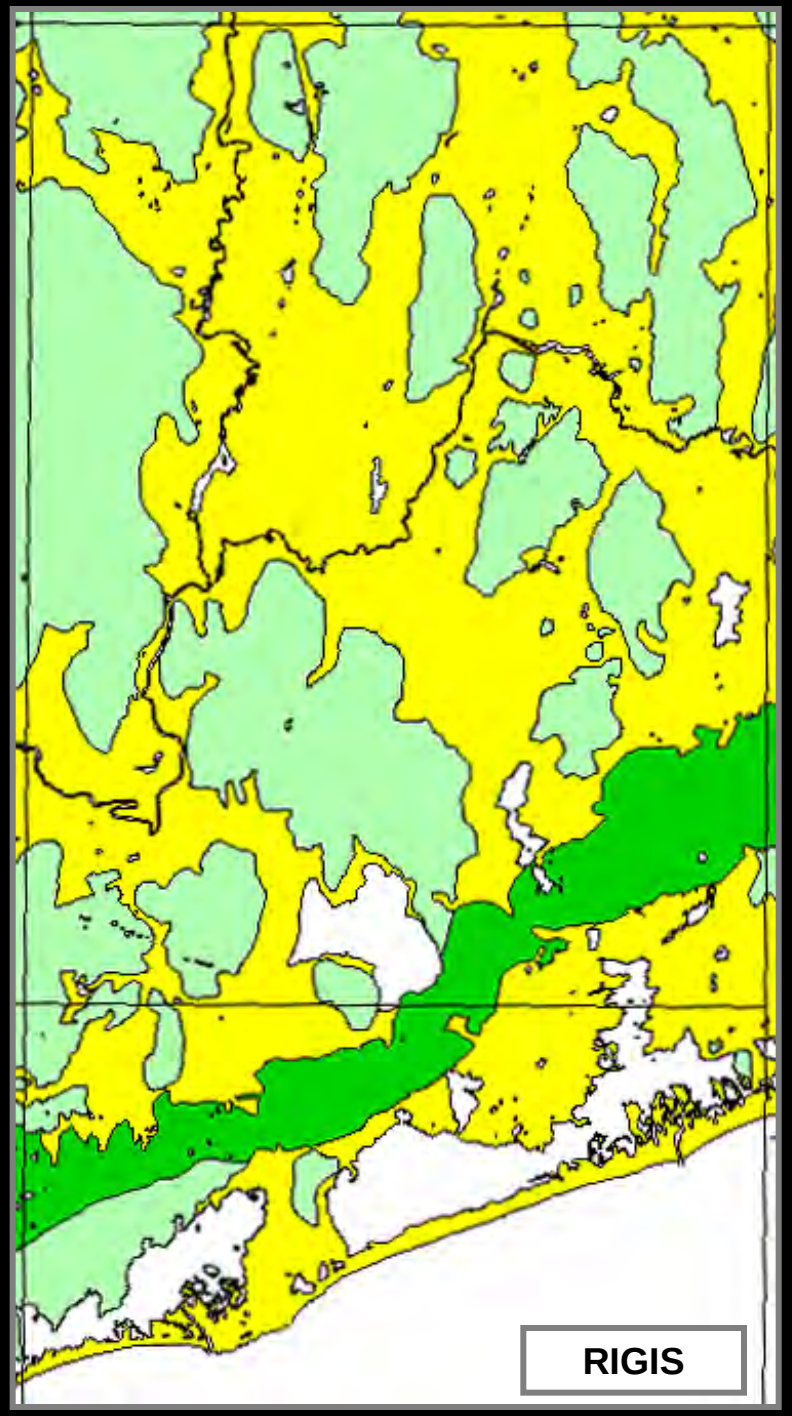
Deposit or modify geologic facies.

In a coastal setting, **GEOLOGIC HABITATS** may range from benthic habitats in 30 m water depth, through the intertidal zone, to the supratidal zone and perhaps across a barrier or upland habitat to the limit of storm-surge inundation.

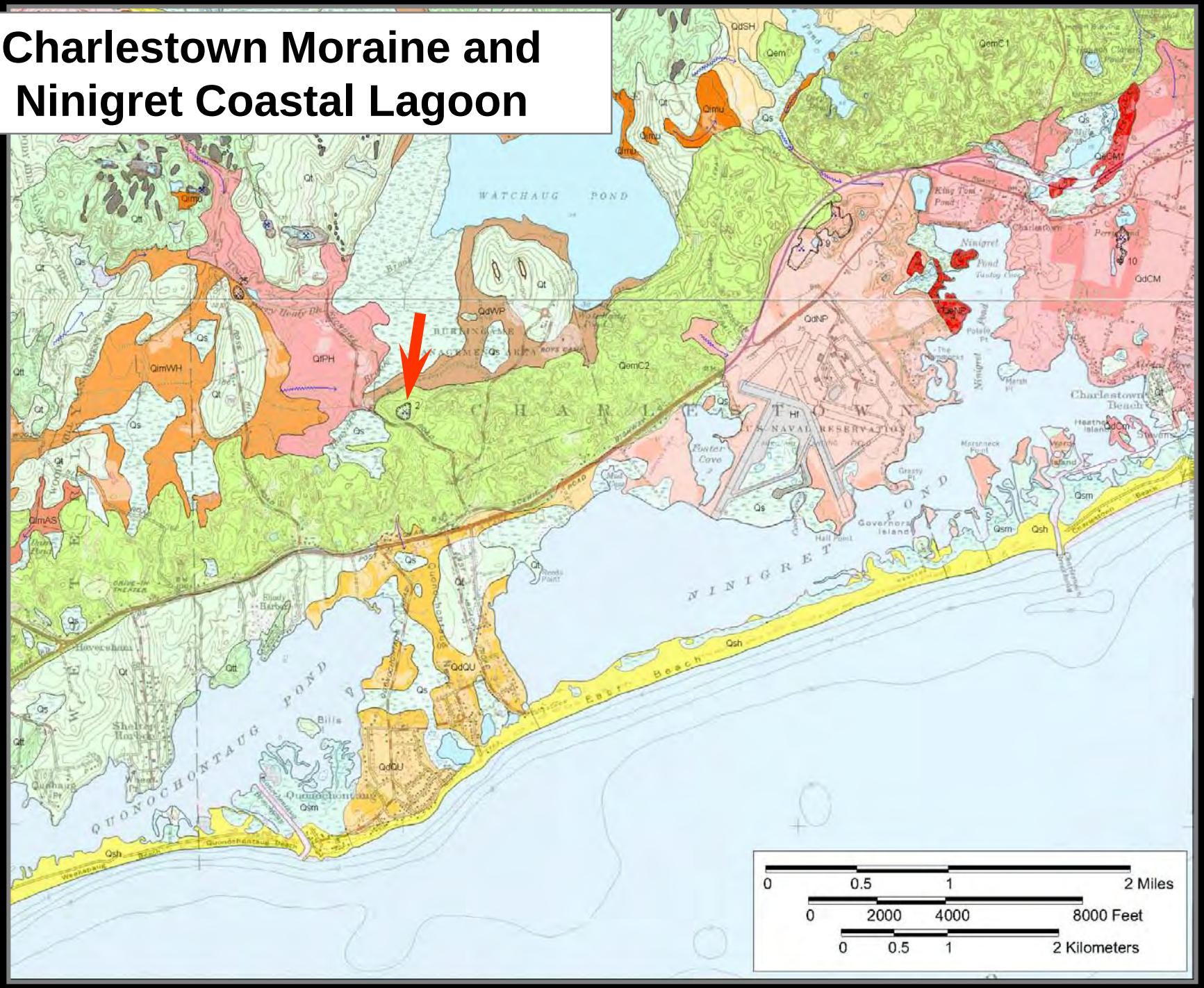
# Braided River on a Delta Plain

# Facies Deposited in a Glacial Lake Depositional Environment

# Quaternary Map Detail

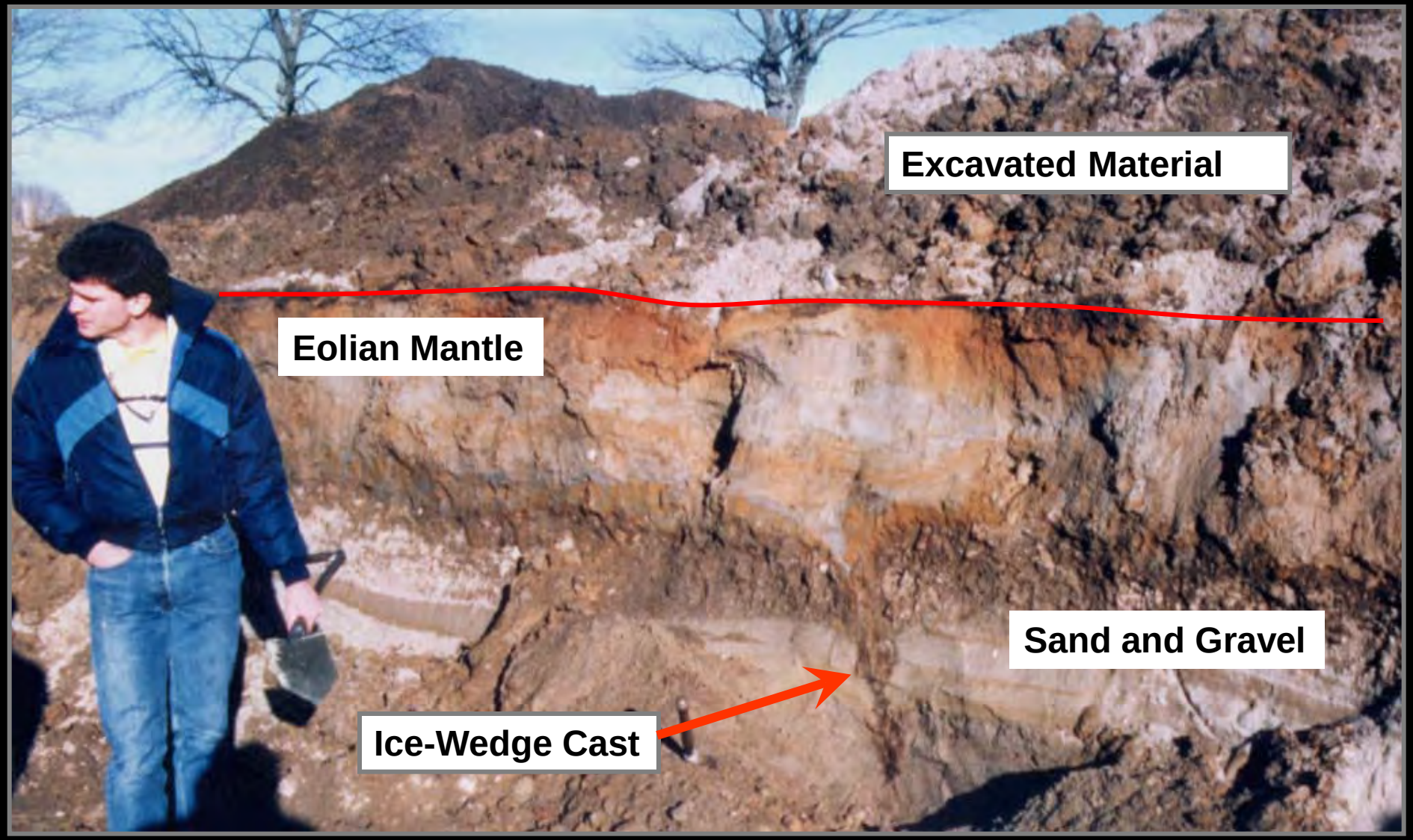
# Charlestown Moraine and Ninigret Coastal Lagoon



# Charlestown End Moraine

# Glacial and Post-Glacial Materials– Exeter RI

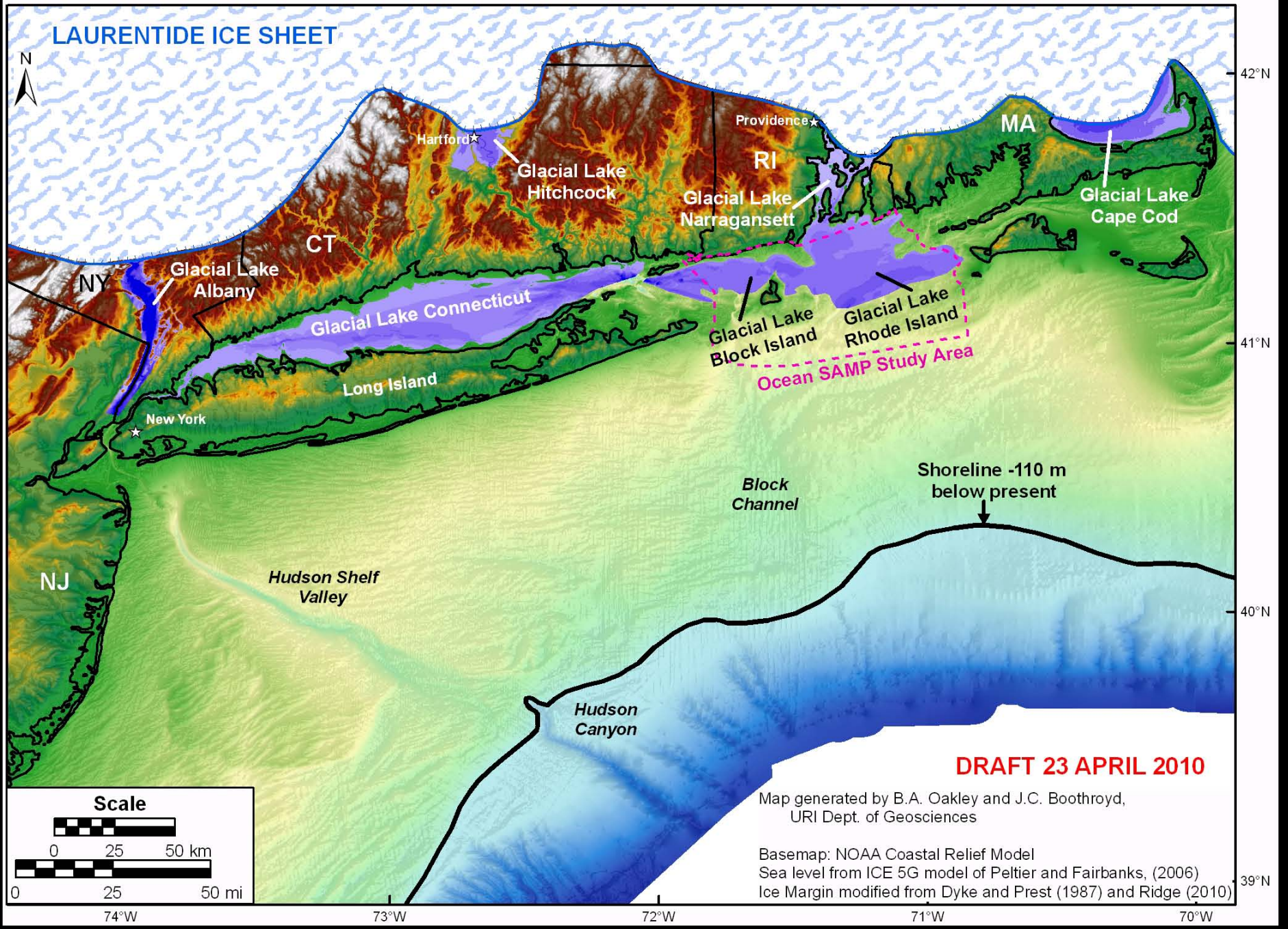
# Ice Wedge Cast – Exeter RI



# Ice Wedge Cast –
## Exeter RI

Eolian Mantle

# PALEOGEOGRAPHIC MAP OF THE SOUTHERN NEW ENGLAND CONTINENTAL SHELF 18,000 yBP

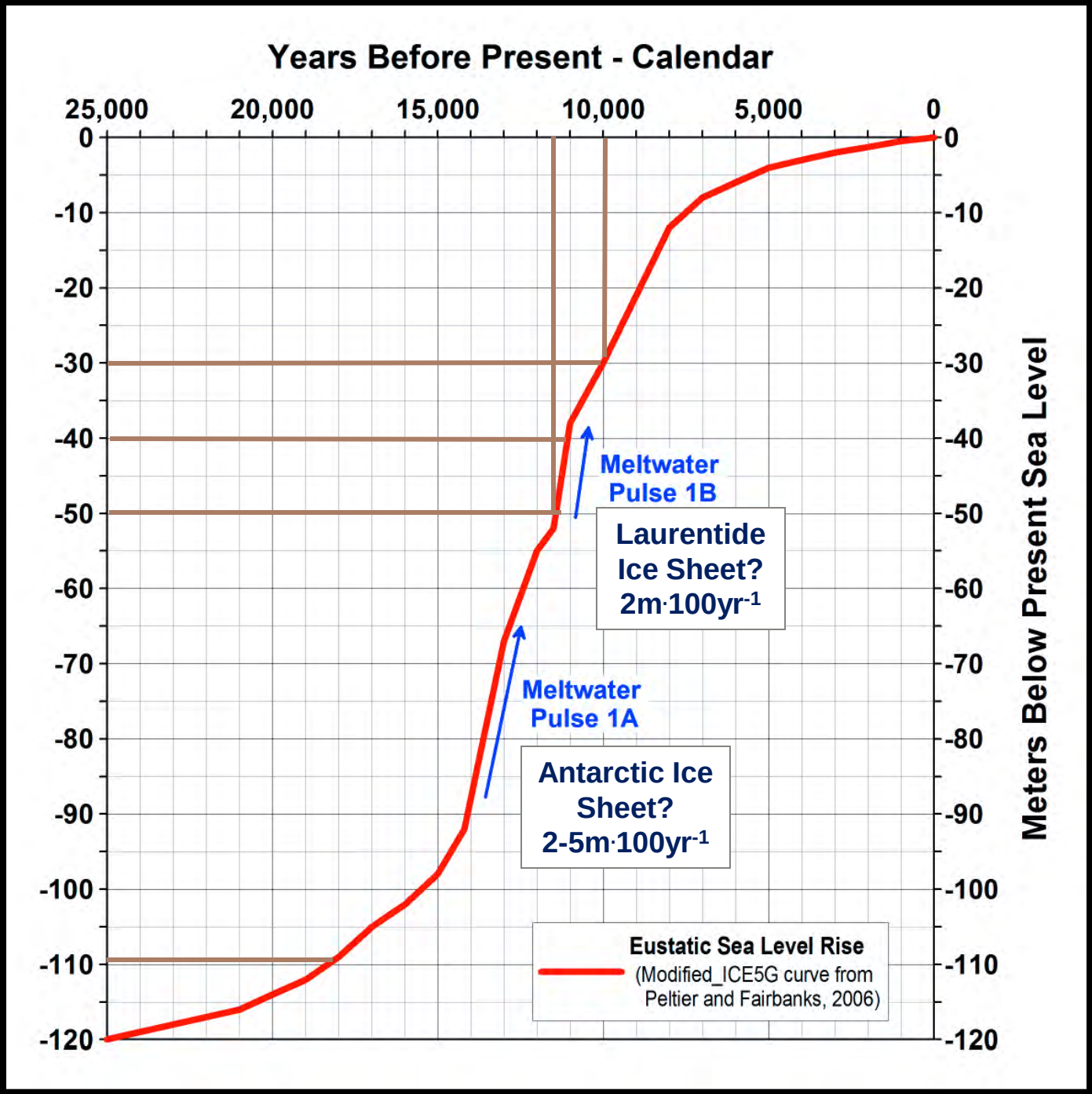



DRAFT 23 APRIL 2010

Map generated by B.A. Oakley and J.C. Boothroyd,
URI Dept. of Geosciences

Basemap: NOAA Coastal Relief Model
Sea level from ICE 5G model of Peltier and Fairbanks, (2006)
Ice Margin modified from Dyke and Prest (1987) and Ridge (2010)

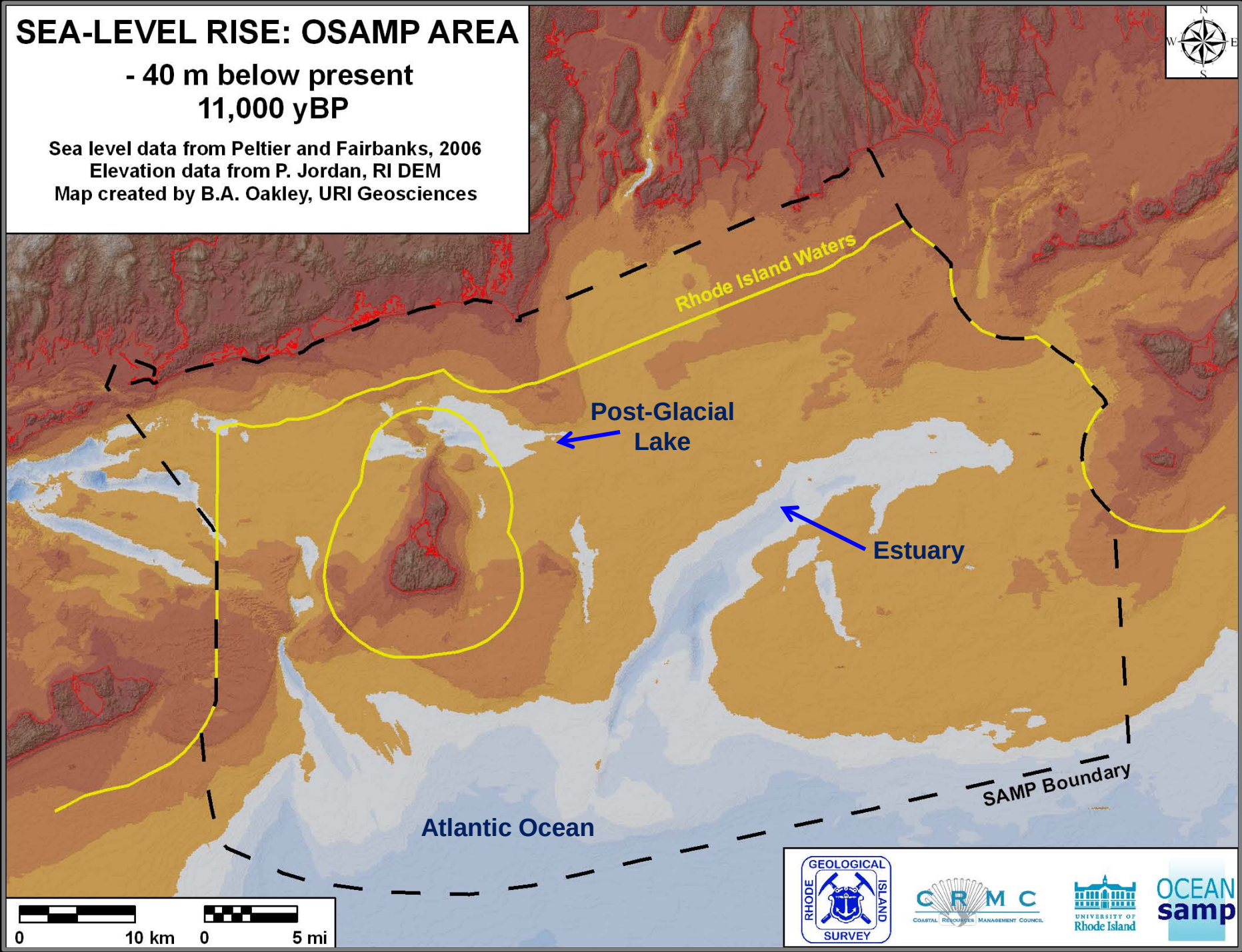
# Eustatic Sea-Level Rise



# SEA-LEVEL RISE: OSAMP AREA

## - 40 m below present
## 11,000 yBP

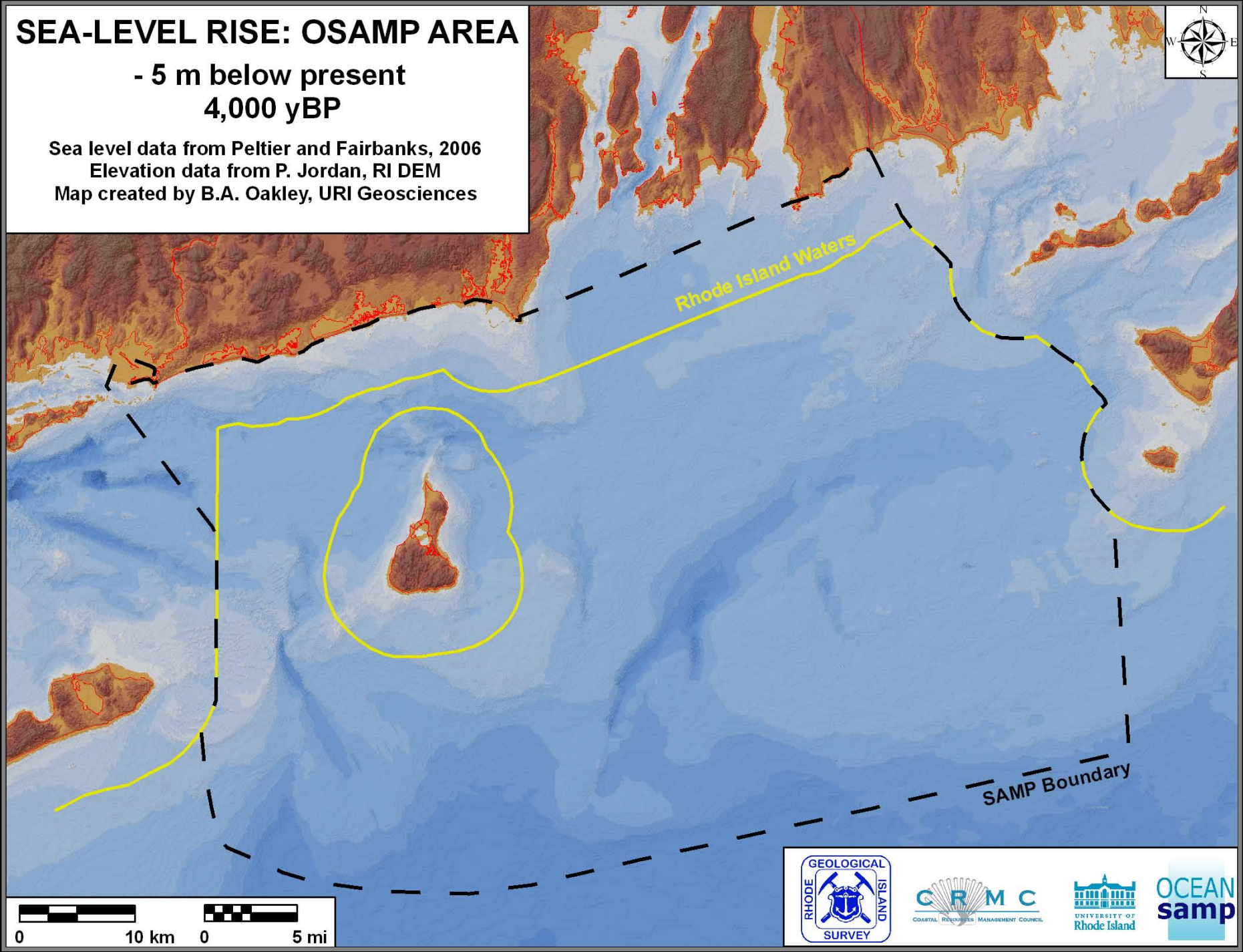
Sea level data from Peltier and Fairbanks, 2006
Elevation data from P. Jordan, RI DEM
Map created by B.A. Oakley, URI Geosciences



# SEA-LEVEL RISE: OSAMP AREA

## - 5 m below present
## 4,000 yBP

Sea level data from Peltier and Fairbanks, 2006
Elevation data from P. Jordan, RI DEM
Map created by B.A. Oakley, URI Geosciences




Now,
We Need to Consider
Coastal Processes Acting Today

# The Sea Is Rising – But…..

# *When Contemplating Rhode Island Coastal Geologic Hazards*

## One Must Consider:

- **Extratropical Cyclones (“Nor’easters”)**
- **Hurricanes (Tropical Cyclones)**
- **and ……. Sea Level Rise**

## *When Contemplating Rhode Island Coastal Geologic Hazards*

## Which Give Rise to these Processes:

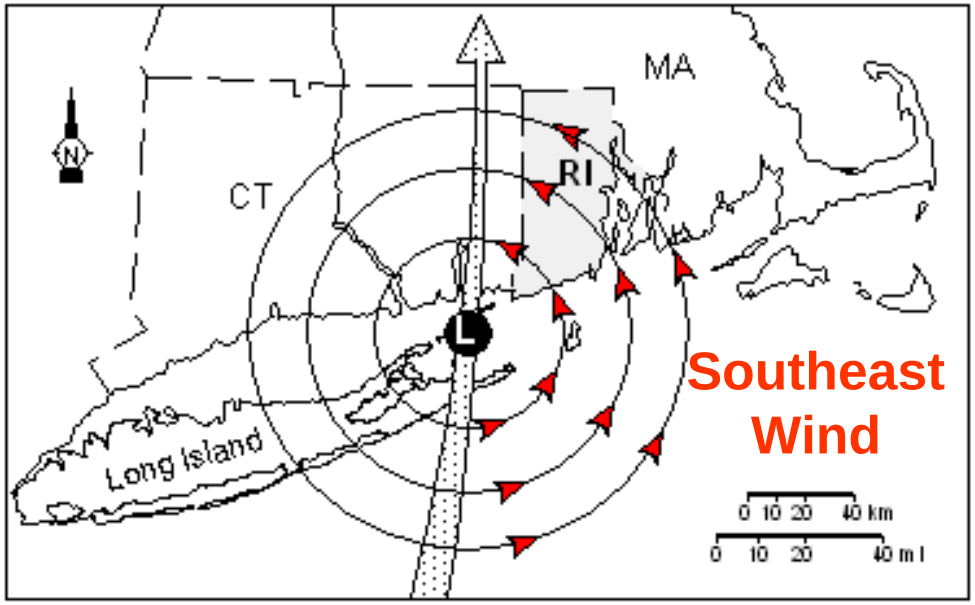
- **Frontal Erosion – from Breaking Waves and Swash**
- **Storm-Surge Overwash**
- **Elevated MHHW into the Future**

# *When Contemplating Rhode Island Coastal Geologic Hazards*

## The Scale of Processes are:

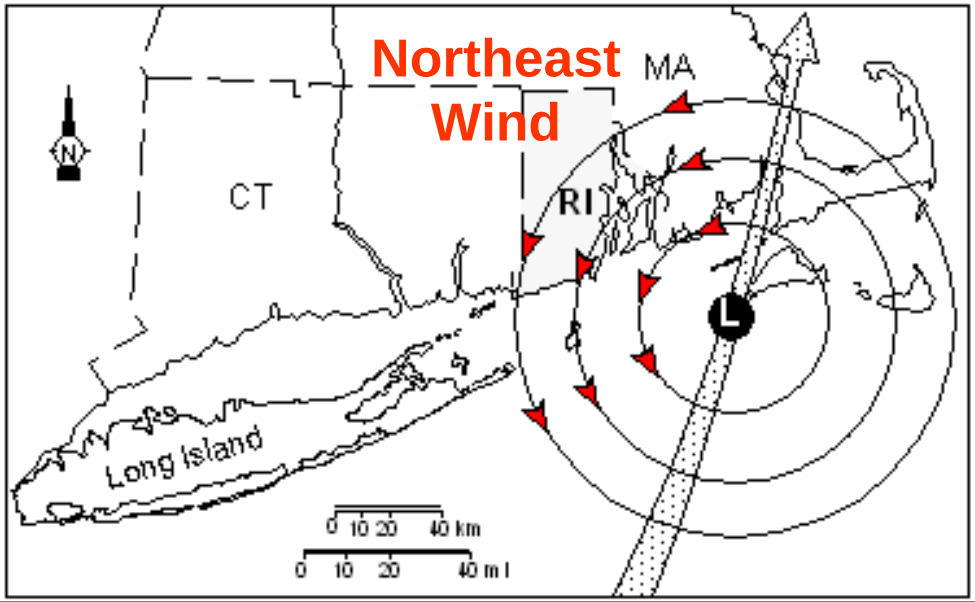
- **Breaking Waves –**
  **1 to 3+ meters at shoreline, much higher at first break**
- **Storm-Surge Overwash –**
  **30 cm to 3+ m water depth across shore zone**
- **Sea-Level Rise –**
  **2.7-3.3 mm/year at present;**
  **could increase to 1-1.5 cm/yr**

# HURRICANE and EXTRATROPICAL STORM PATHS and ASSOCIATED WIND PATTERNS




## PASSAGE TO THE WEST

- Maximum Onshore Wind
- Severe Storm-Surge Flooding

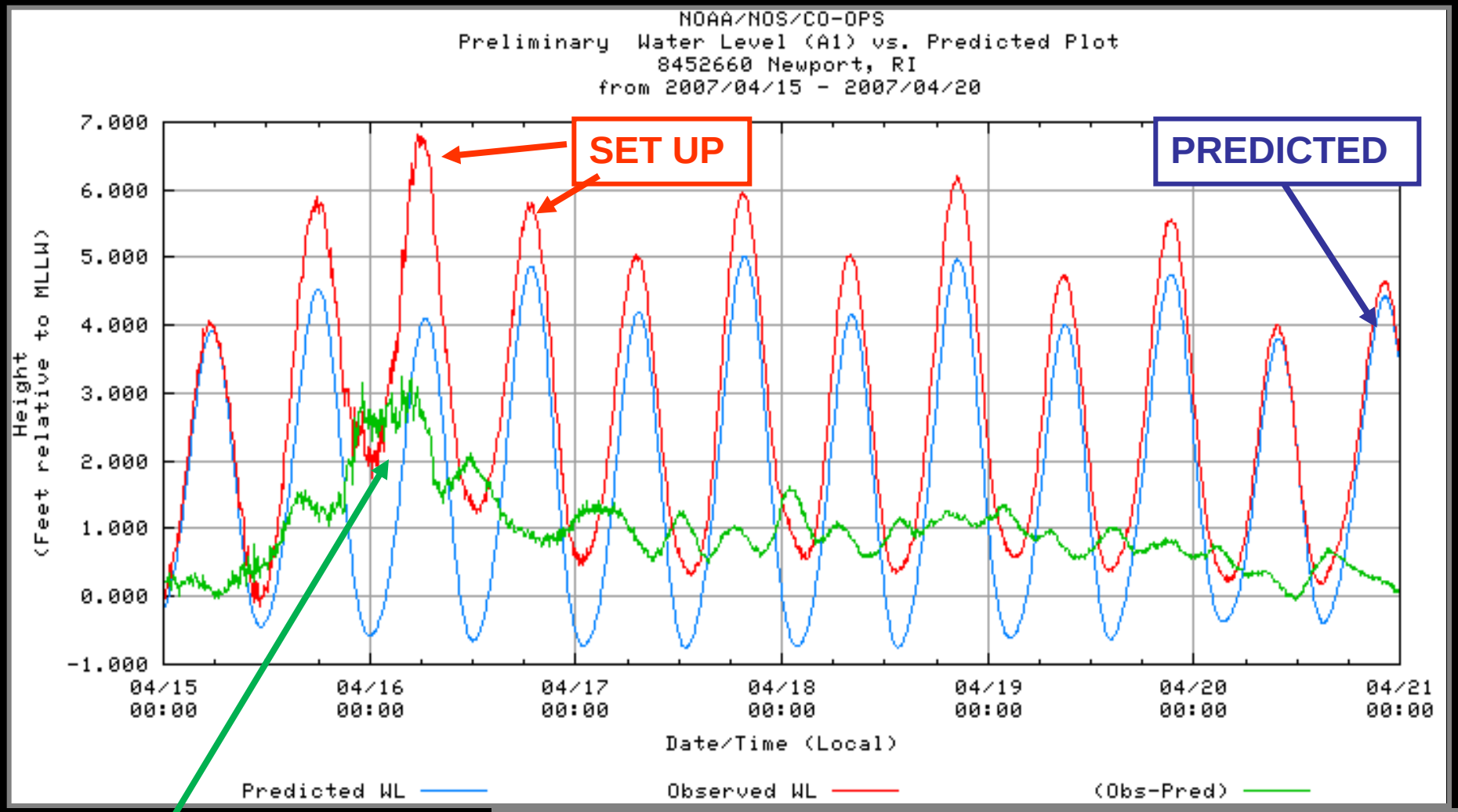



## PASSAGE TO THE EAST

- Offshore Wind
- Minimum Storm-Surge Flooding

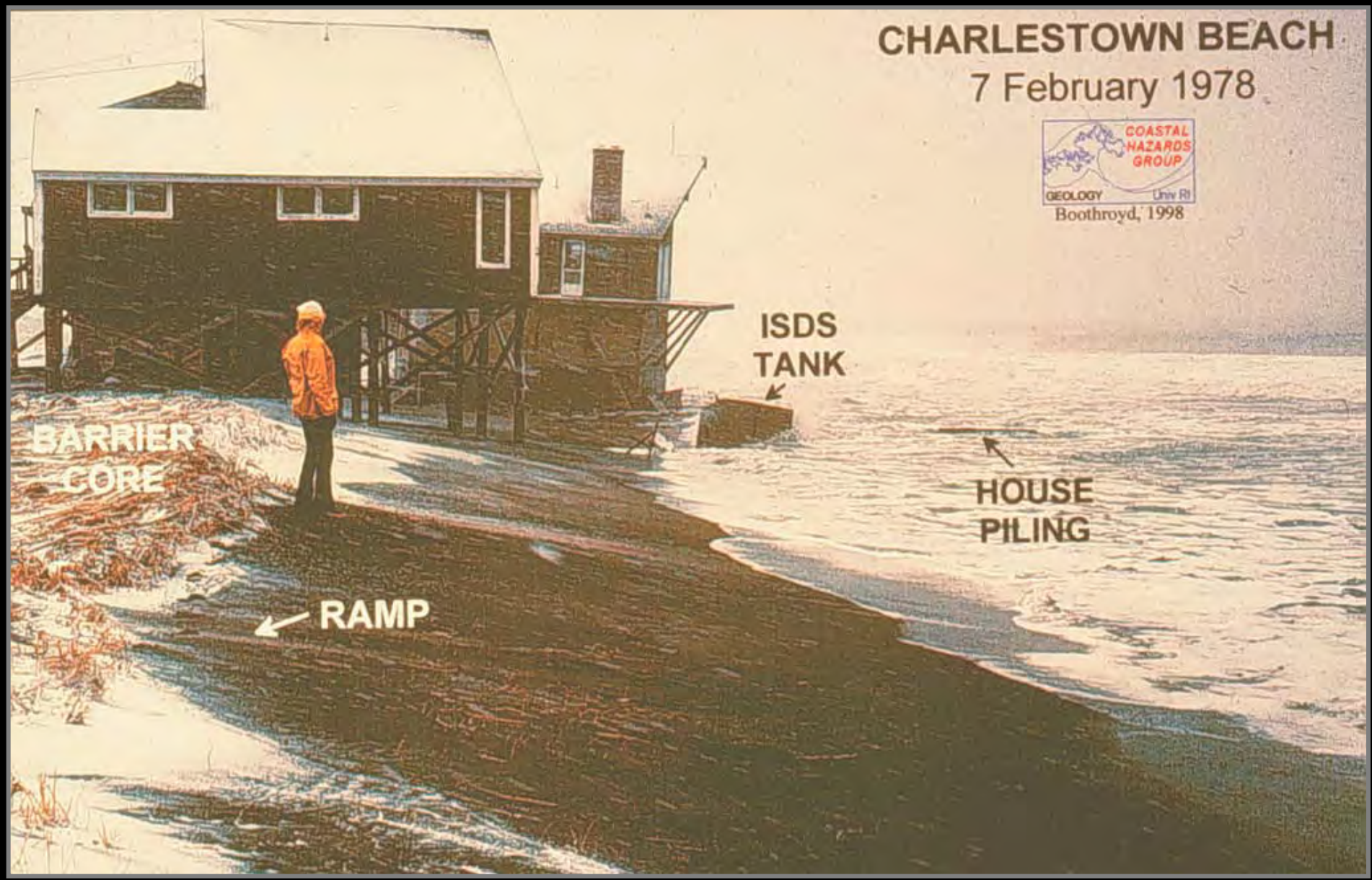
**From Wright and Sullivan, 1982**

# Patriots Day Extratropical Storm – April 2007
# Newport Tide Gauge




http://tidesandcurrents.noaa.gov/data_menu.shtml?stn=8452660%20Newport,%20RI&type=Tide+Data

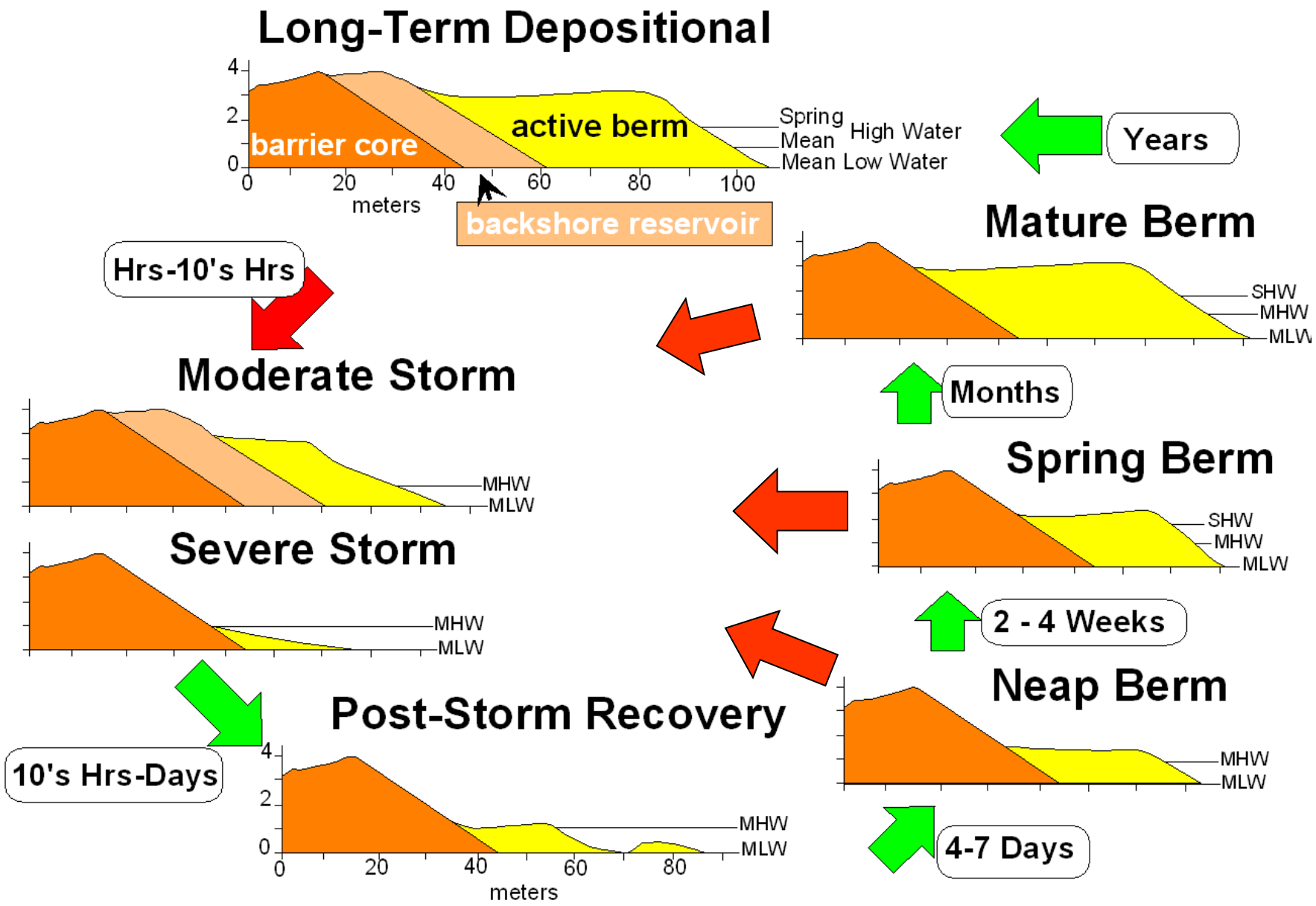
# Charlestown Beach – Blizzard 1978 – No Berm



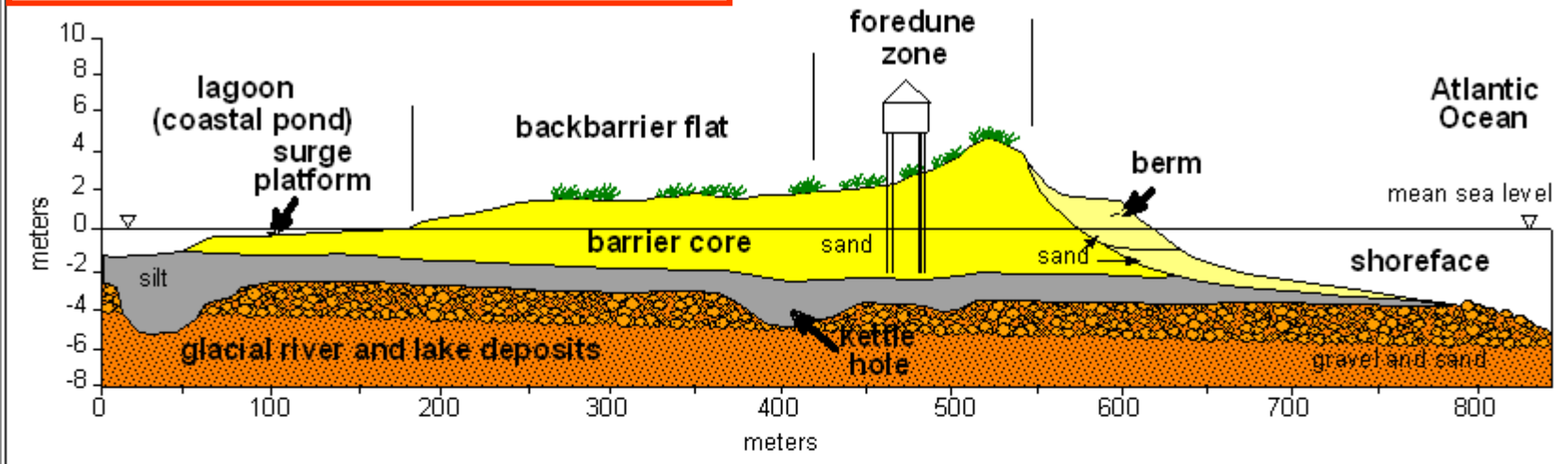
# Beach Cycles – RI Shore

COASTAL HAZARDS GROUP
GEOSCIENCES Univ RI

Boothroyd and Galagan, 1999



# Barrier Geologic Cross-Section




# Headland Geologic Cross-Section

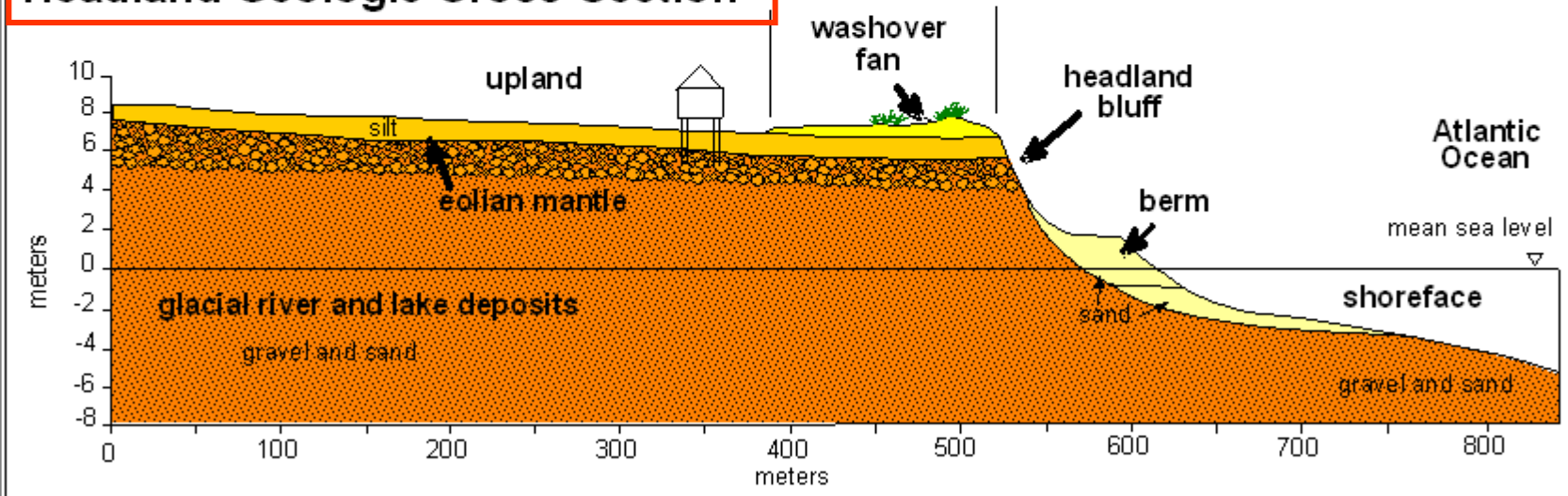
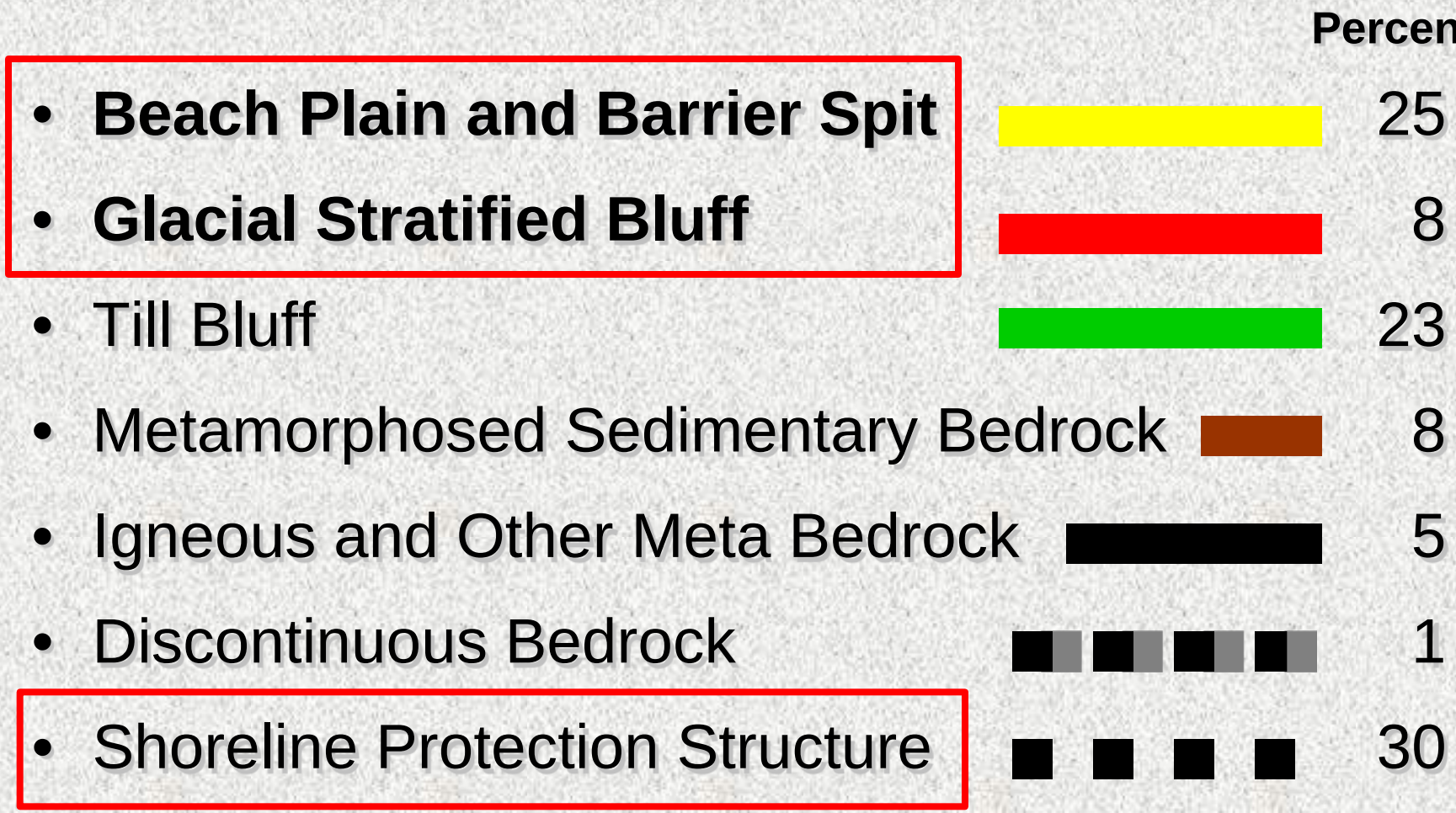



Figure 4-2

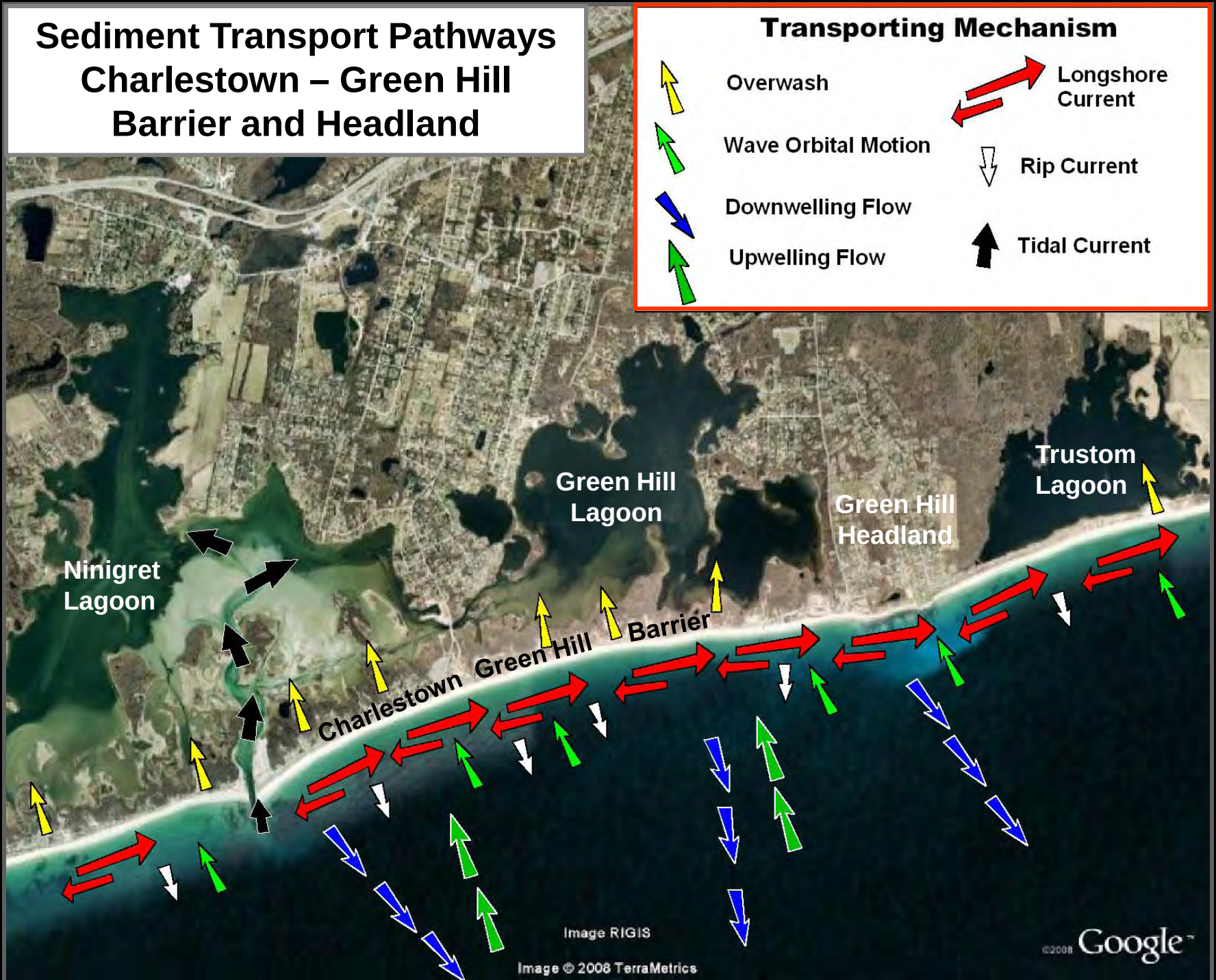
COASTAL HAZARDS GROUP
GEOLOGY Univ RI

Boothroyd & Galagan, 1998

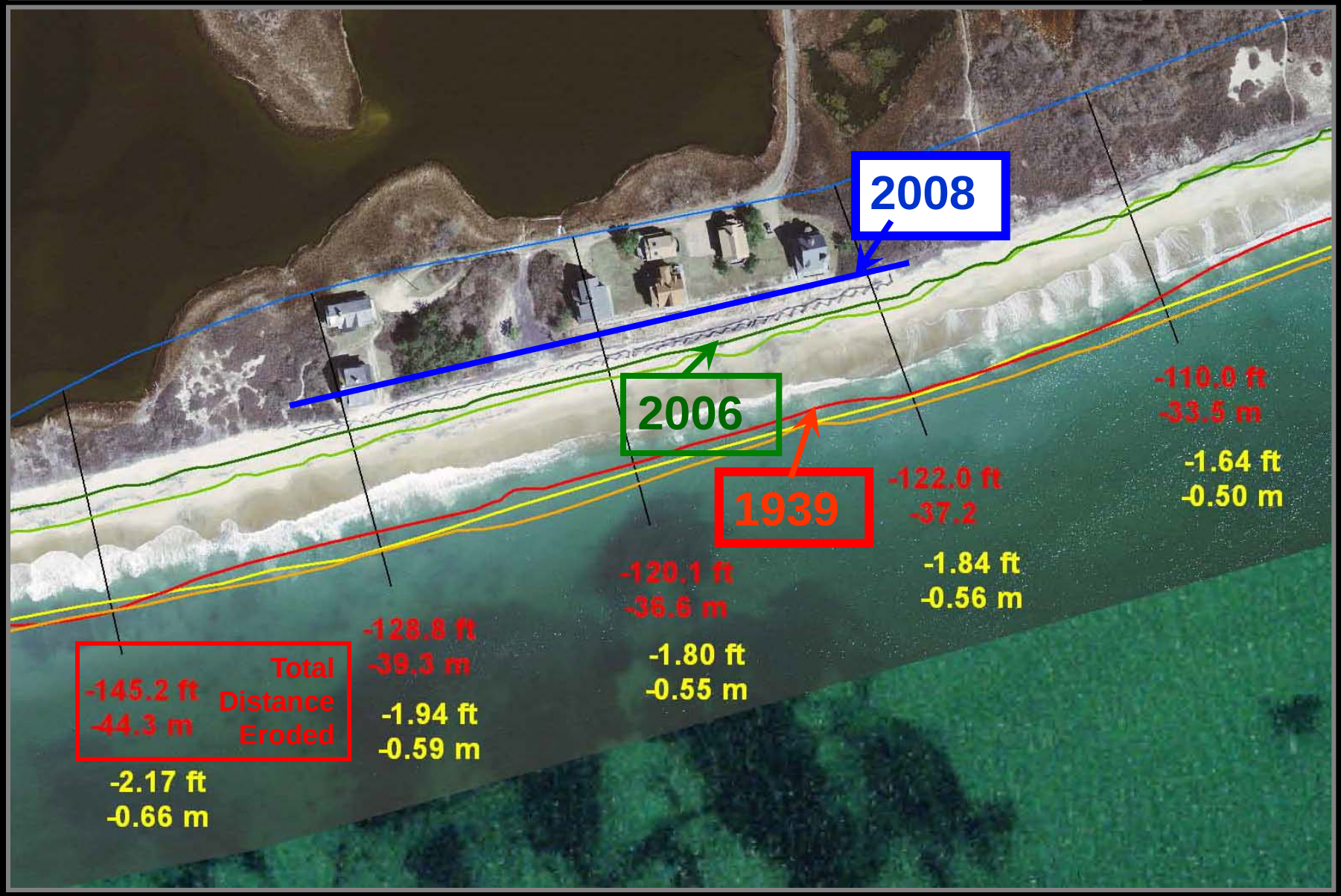
# GEOLOGIC SHORE ZONE TYPES



# Sediment Transport Pathways Charlestown – Green Hill Barrier and Headland



# Frontal Erosion 1939-2008 - Browning Cottages, Moonstone Barrier



# Frontal Erosion - Browning Cottages


BA Oakley

# Charlestown Beach – Overwash Processes

## Deposited 1 meter of sand in the road

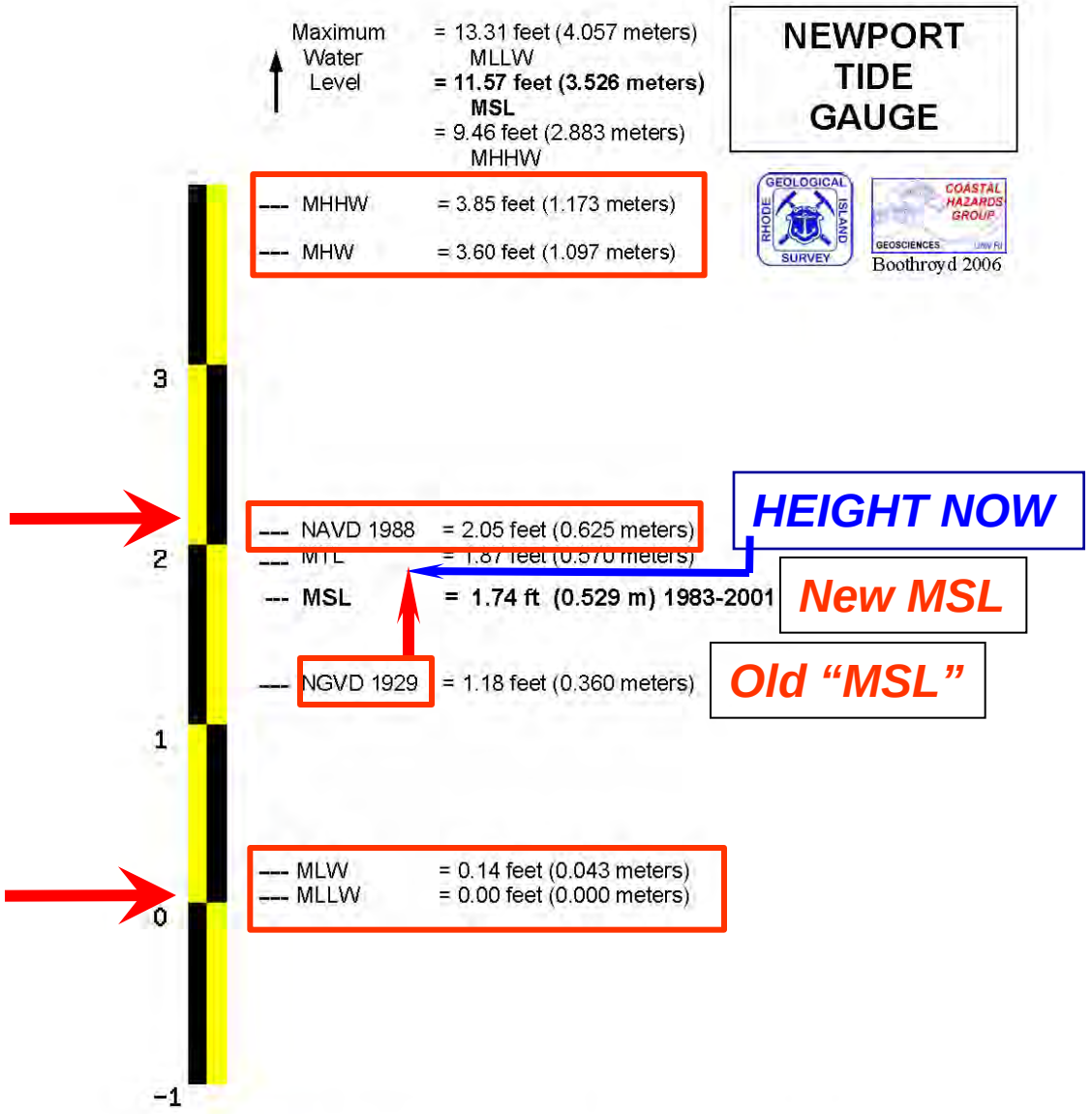
11 Dec 1992

# Charlestown Barrier – Hurricane Bob 1991
# Washover Fans

**Removal is a Bad Idea …….**
**Barriers Naturally Retreat**
**Landward and Upward**

Aug 1991

# Tidal Datums Newport

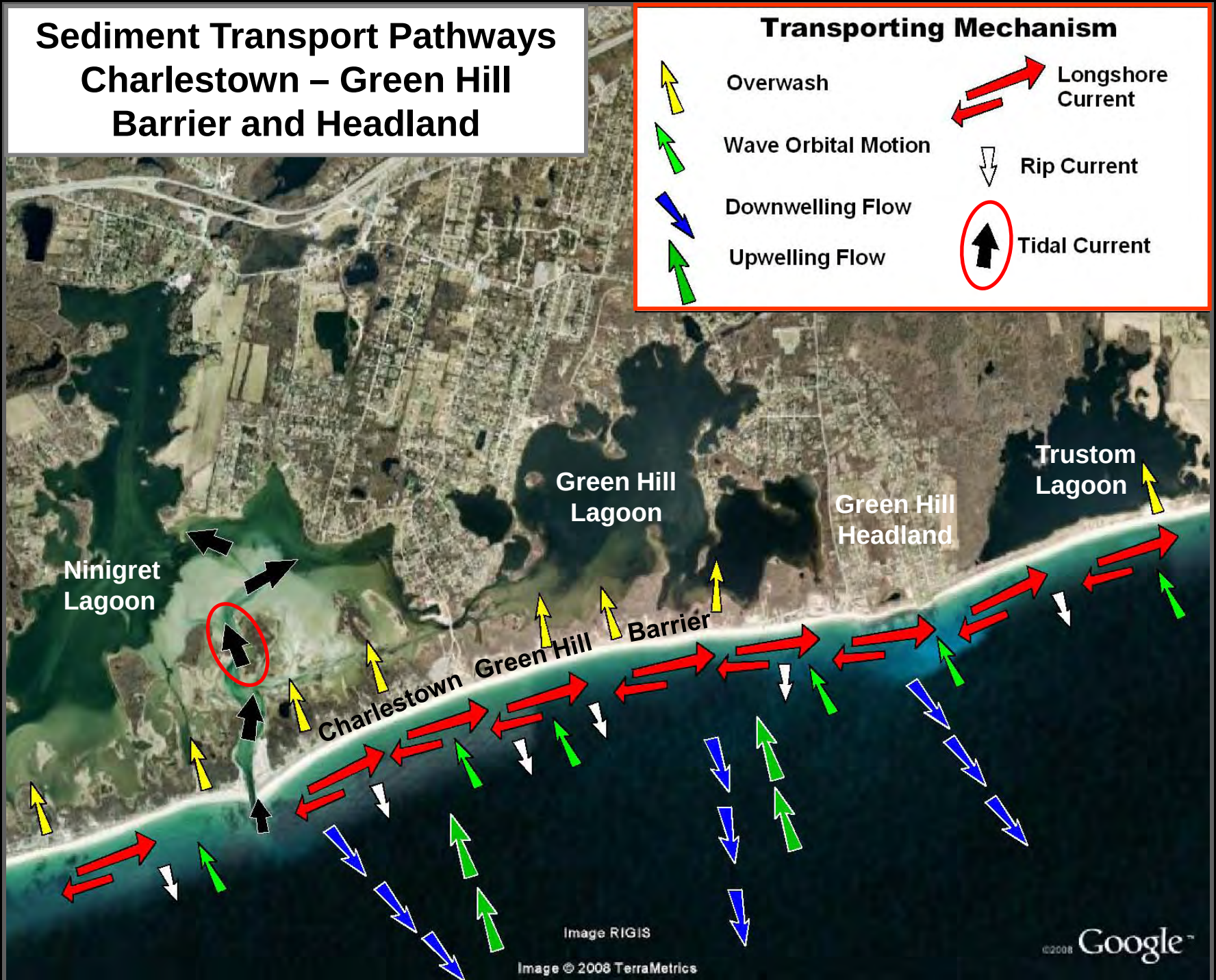



The NAVD 1988 and NGVD 1929 elevations related to MLLW were computed from Bench Mark, 845 2660 TIDAL 6, at the station.

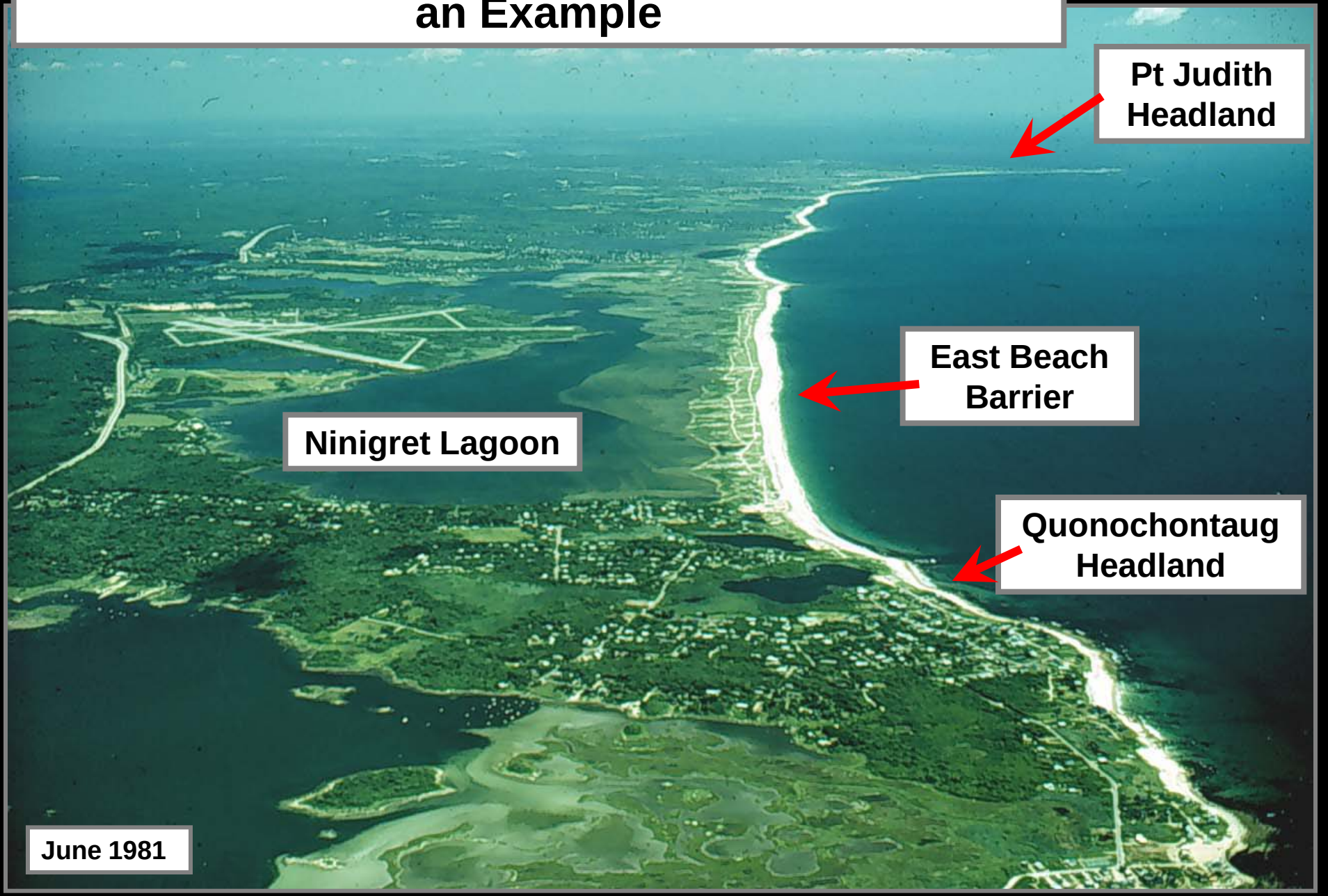
Displayed tidal datums are MEAN HIGHER HIGH WATER (MHHW), MEAN HIGH WATER (MHW), MEAN TIDE LEVEL (MTL), MEAN LOW WATER (MLW), AND MEAN LOWER LOW WATER (MLLW) referenced on 1983-2001 Epoch.

Adapted from: www.ngs.noaa.gov/newsys-cgi-bin/ngs_opsd.prl?PID=LW0493&EPOCH=1983-2001

# Sediment Transport Pathways Charlestown – Green Hill Barrier and Headland

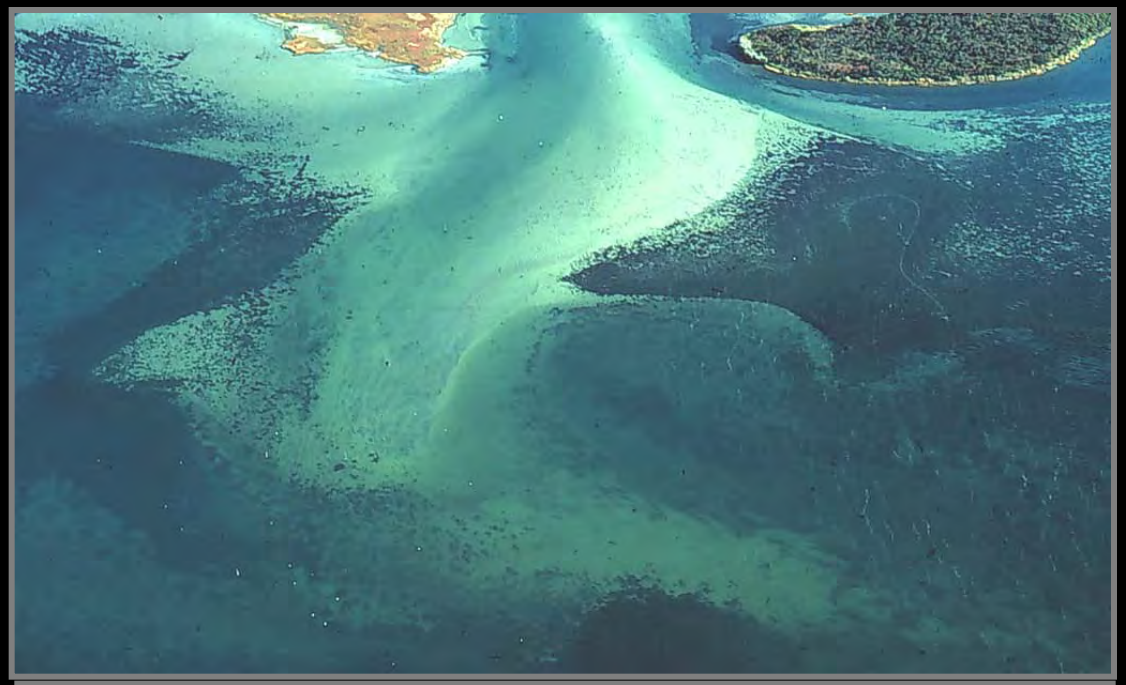


# Tidal-Current Deposition into Coastal Lagoons – an Example



# Ninigret Lagoon - 2004

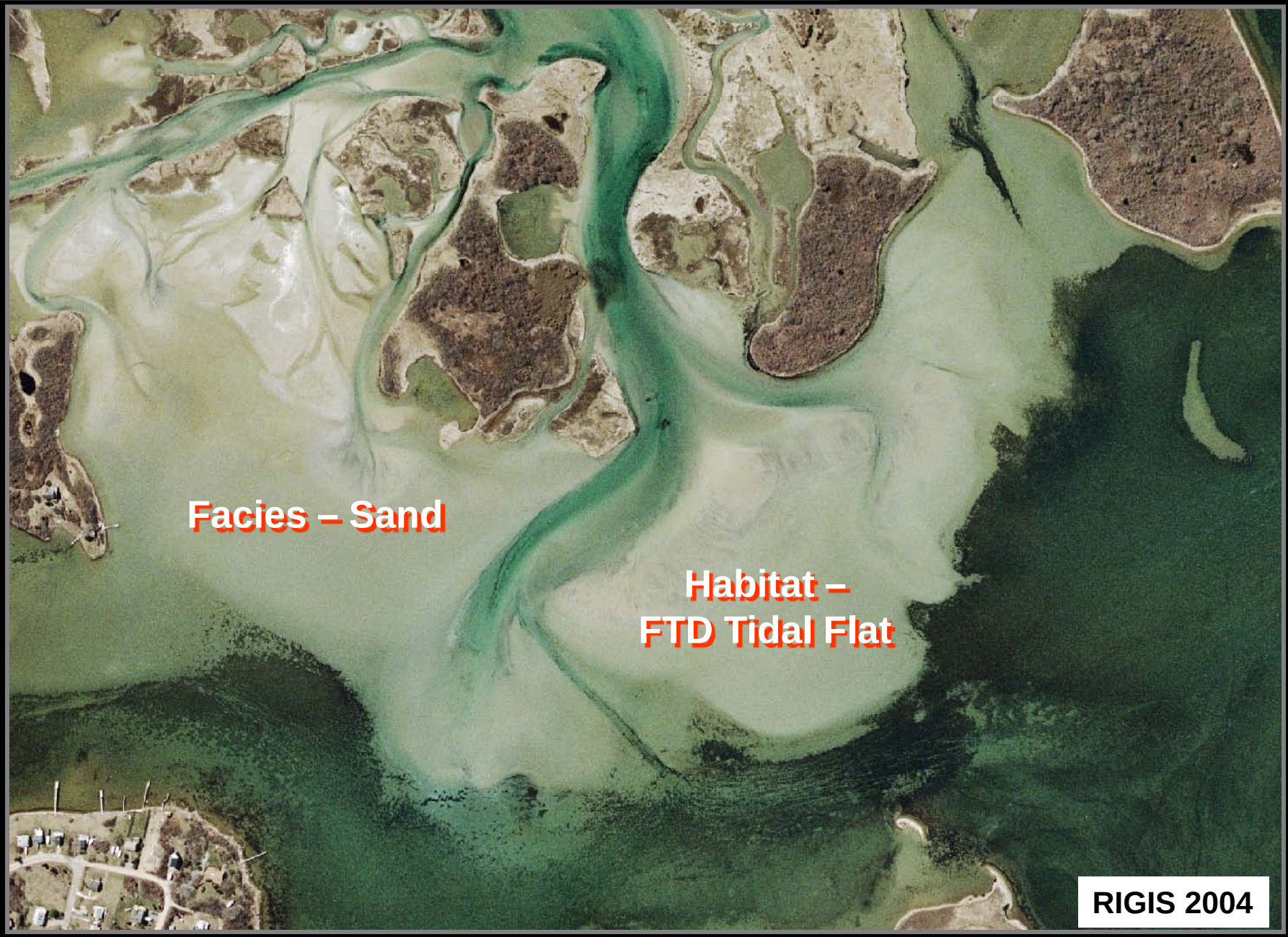
# Ninigret Flood-Tidal Delta - 1976



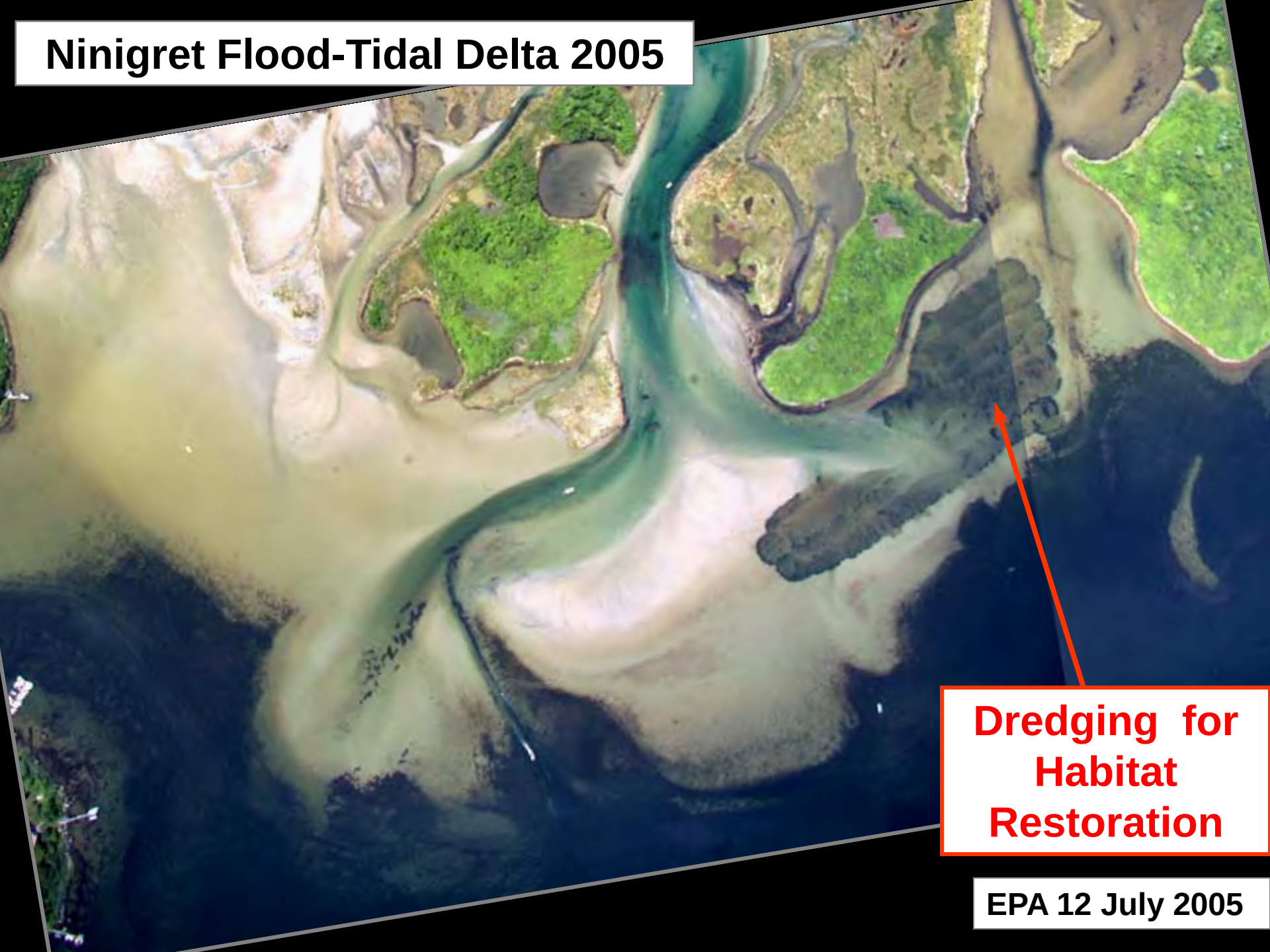
17 Oct 1978

24 Oct 1982

# Ninigret Flood-Tidal Delta 2004



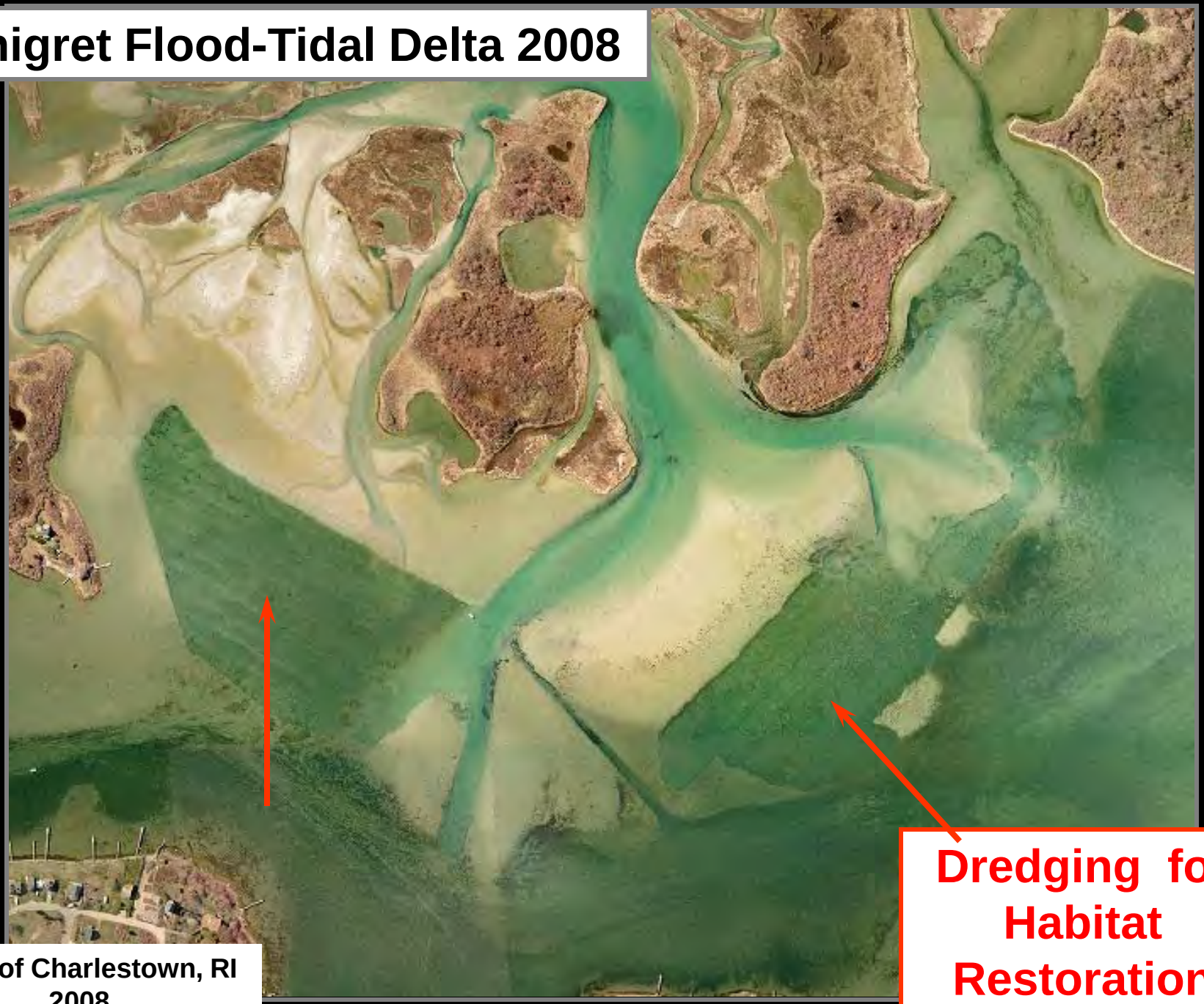
# Ninigret Flood-Tidal Delta 2005



**Dredging for Habitat Restoration**

EPA 12 July 2005

# Ninigret Flood-Tidal Delta 2008



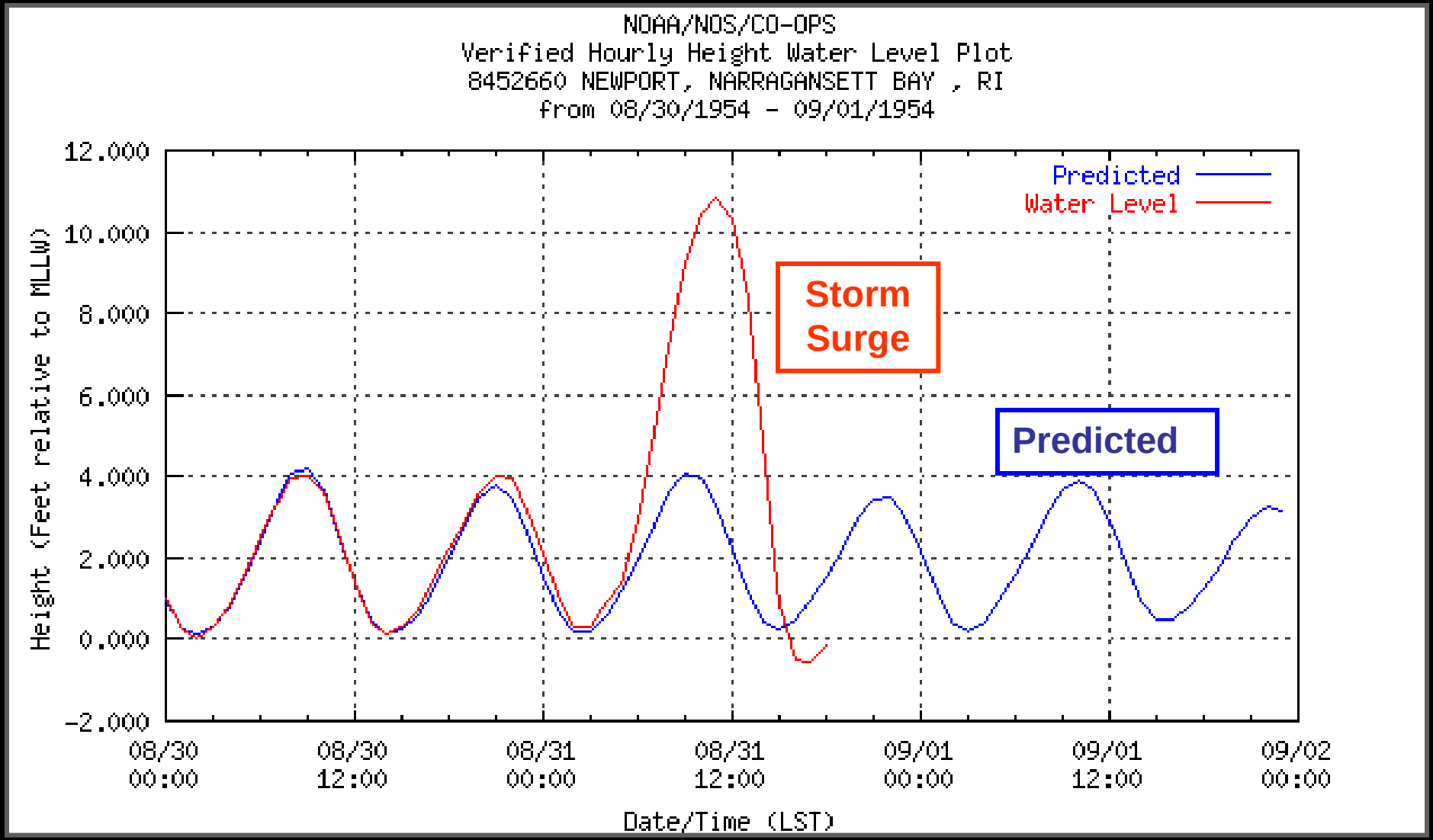
Dredging for Habitat Restoration

Town of Charlestown, RI
2008

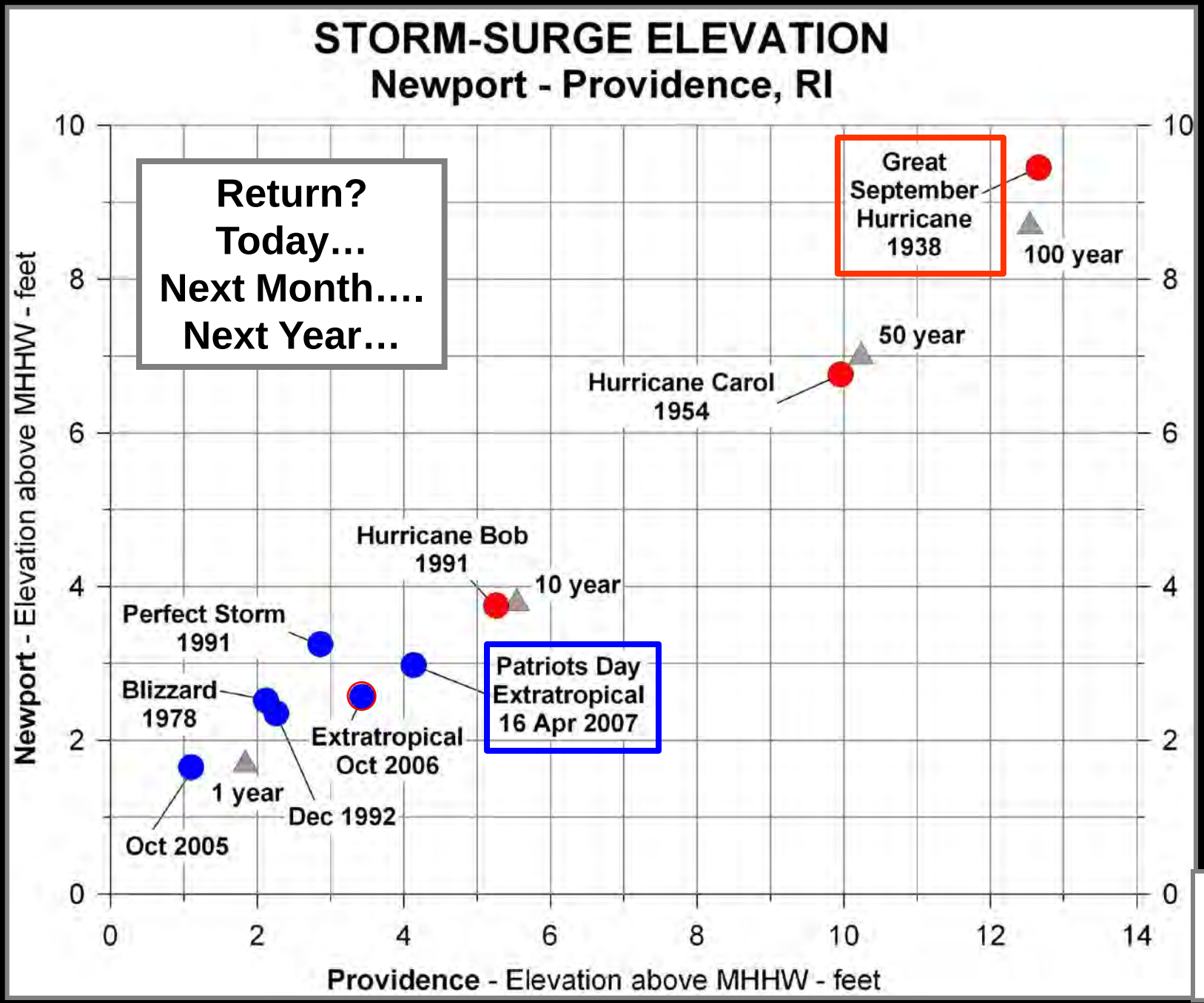
# Ninigret Flood-Tidal Delta - 2010


Really Big Storms

# Hurricane Carol - 1954



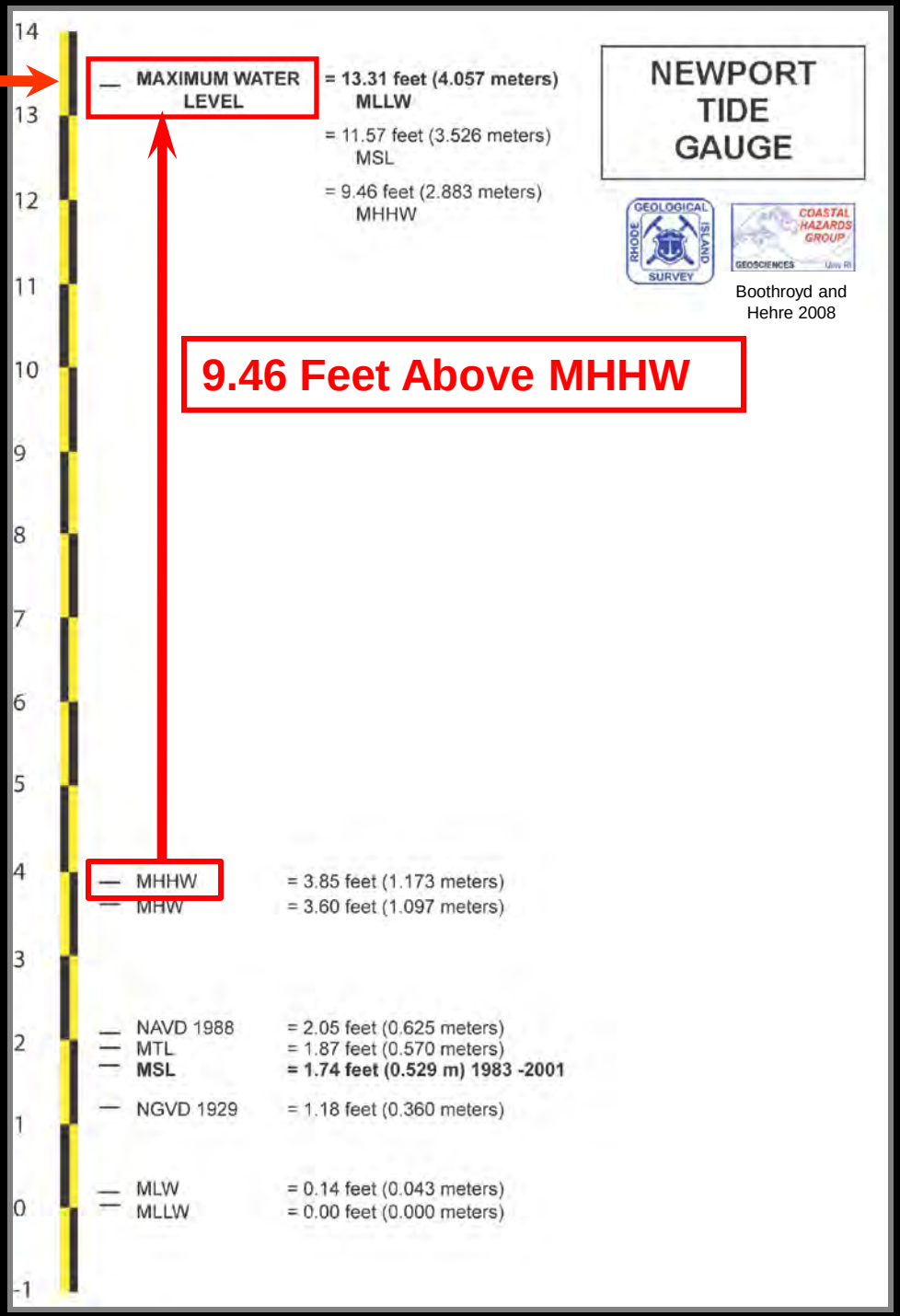

http://tidesandcurrents.noaa.gov/data_menu.shtml?stn=8452660%20Newport,%20RI&type=Tide+Data




Adapted from NOAA; USACE 1988; Hehre 2007

# How High will the Water Be?

## Tidal Heights Newport



# Charlestown Barrier


RE Hehre


N
W
E
S
2D
3D
Road
Aerial
25 feet
10 m
© 2010 Microsoft Corporation
Pictometry Bird's Eye © 2010 Pictometry International Corp
Pictometry Bird's Eye © 2010 MDA Geospatial Services Inc
bing
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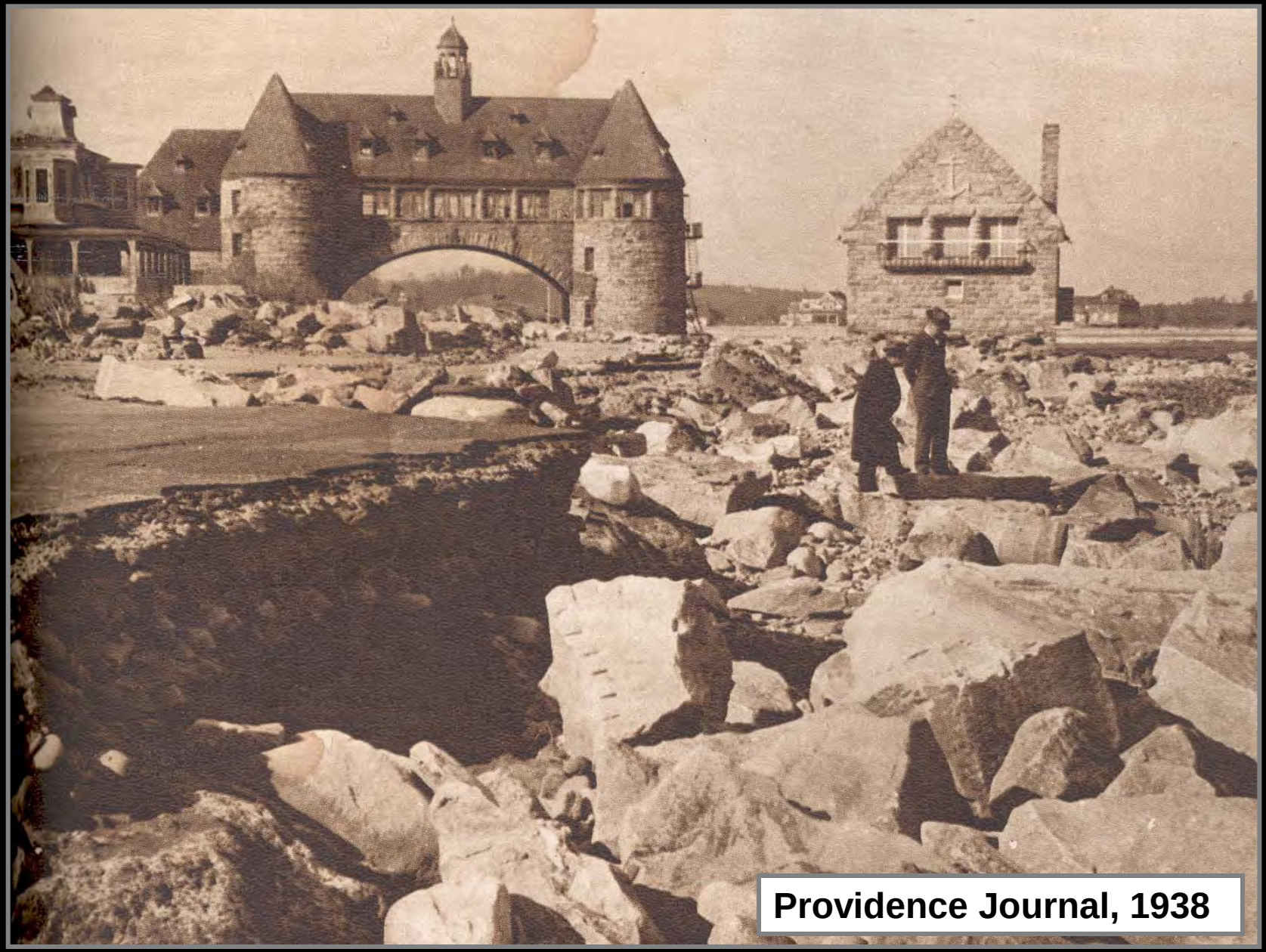
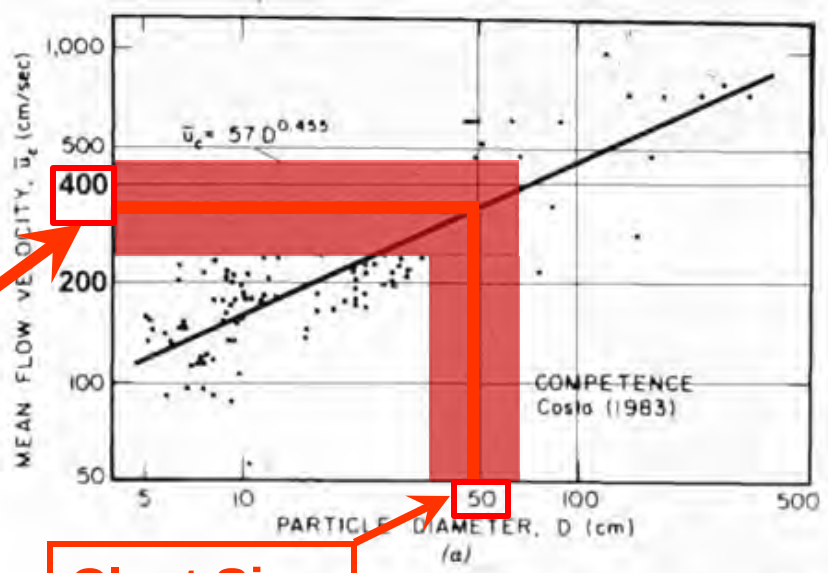
# The Towers – Narragansett Pier Headland - 1938



# CLAST MOVEMENT DIAGRAMS

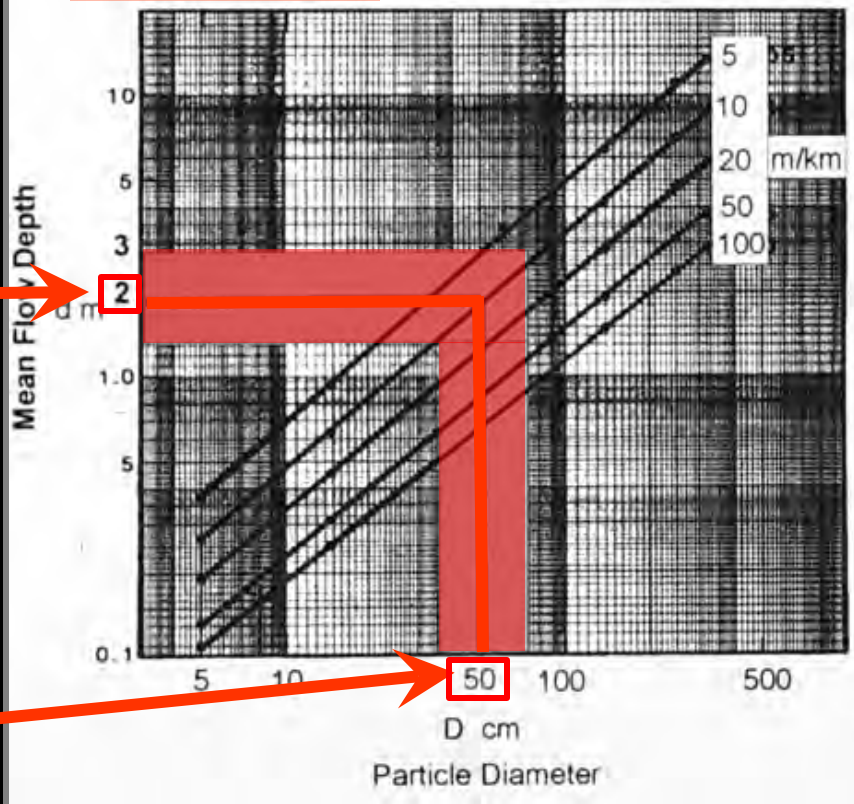
Velocity

Clast Size

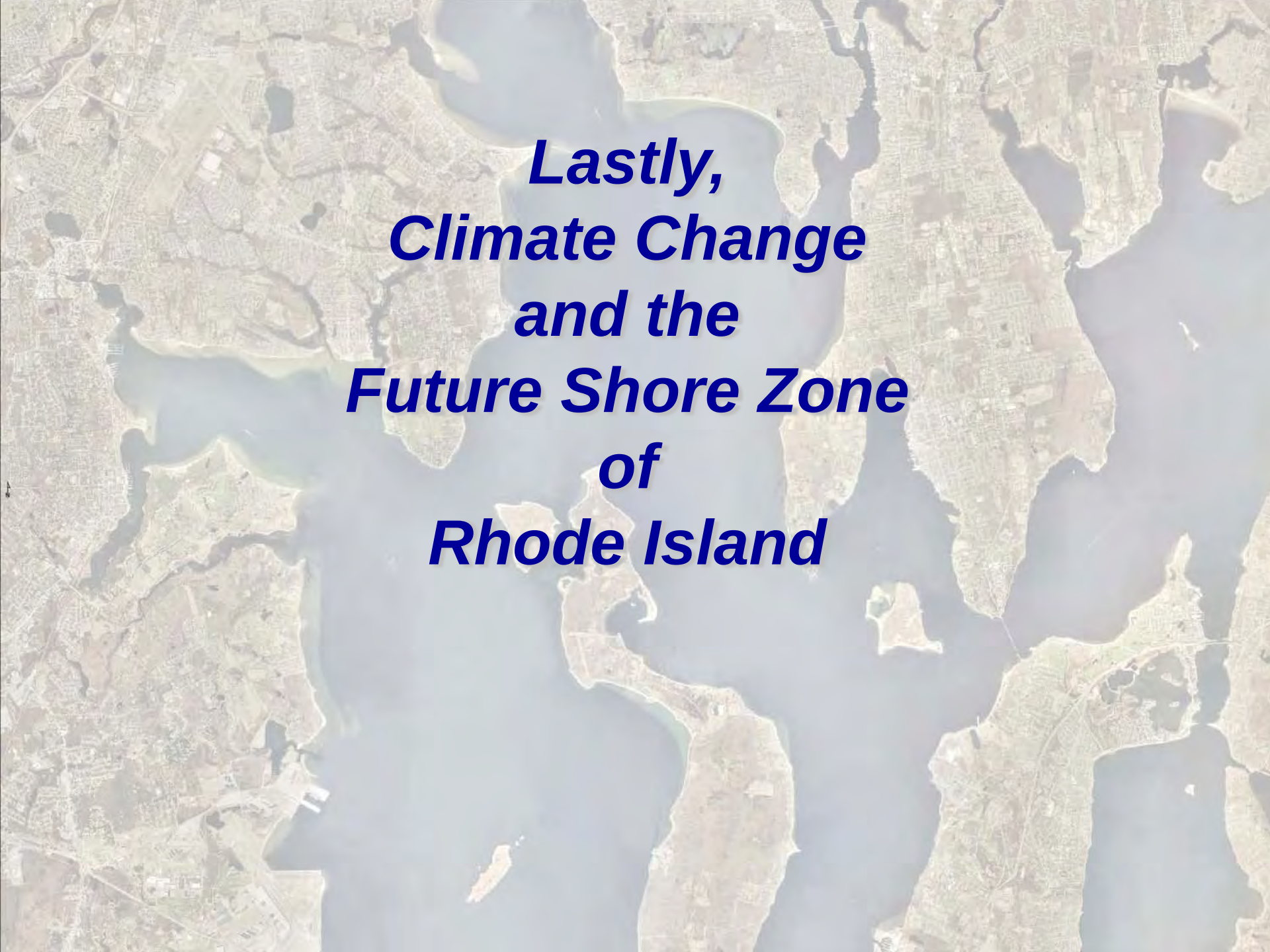


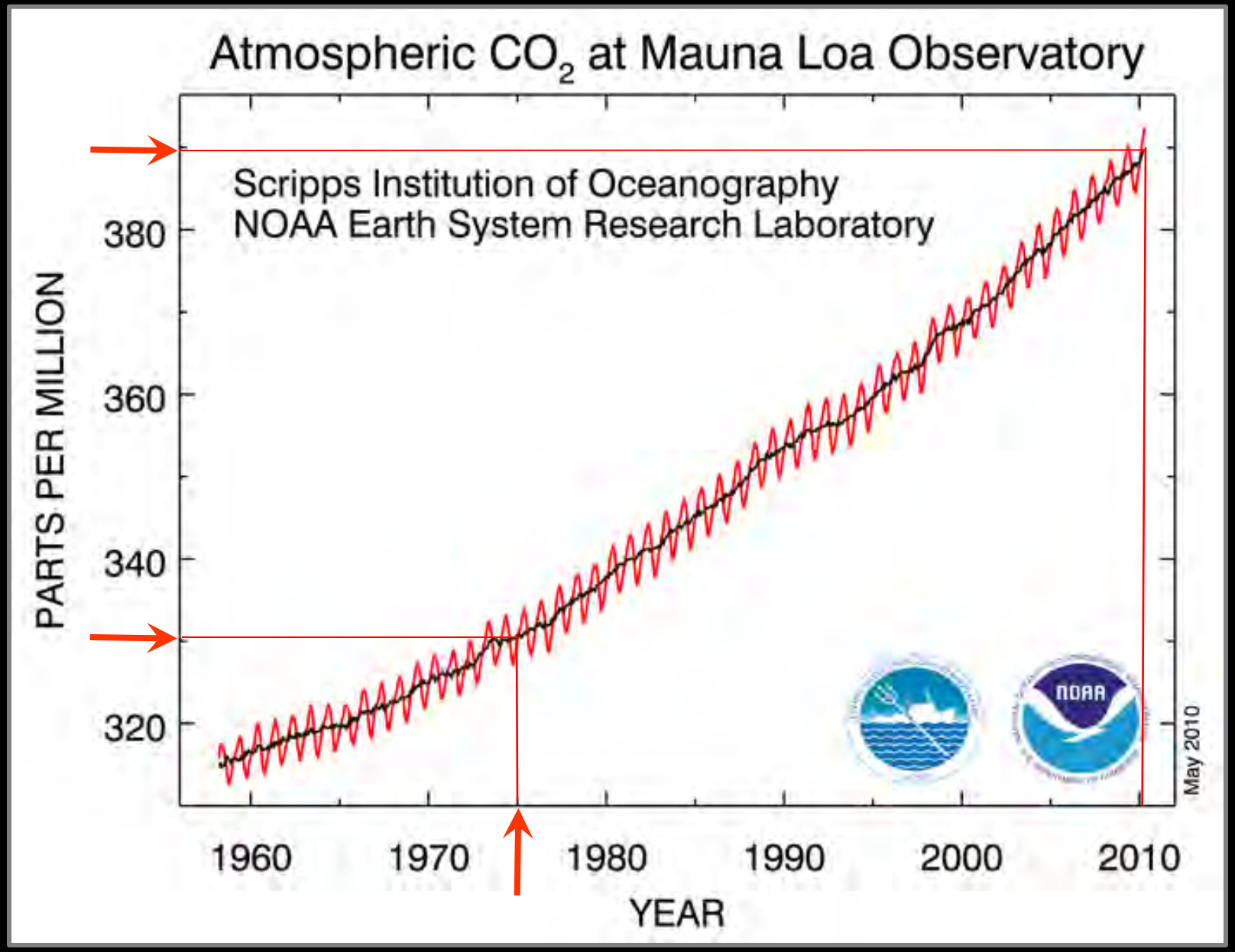

Depth

Clast Size




Costa, 1983

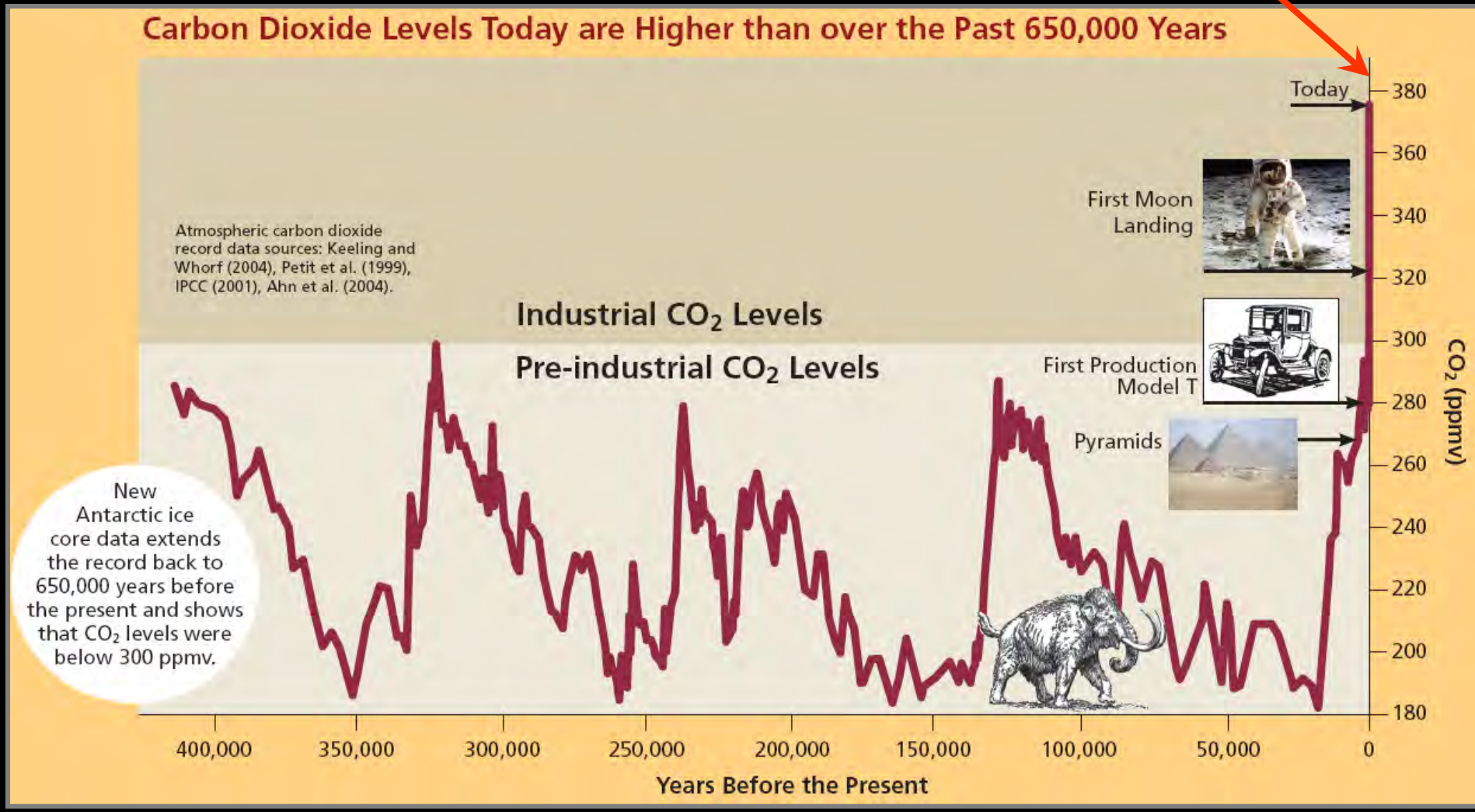

Lastly,
Climate Change
and the
Future Shore Zone
of
Rhode Island




http://www.esrl.noaa.gov/gmd/ccgg/trends/co2_data_mlo.html

# Carbon Dioxide - $CO_2$ – Levels
## A Cause for Concern

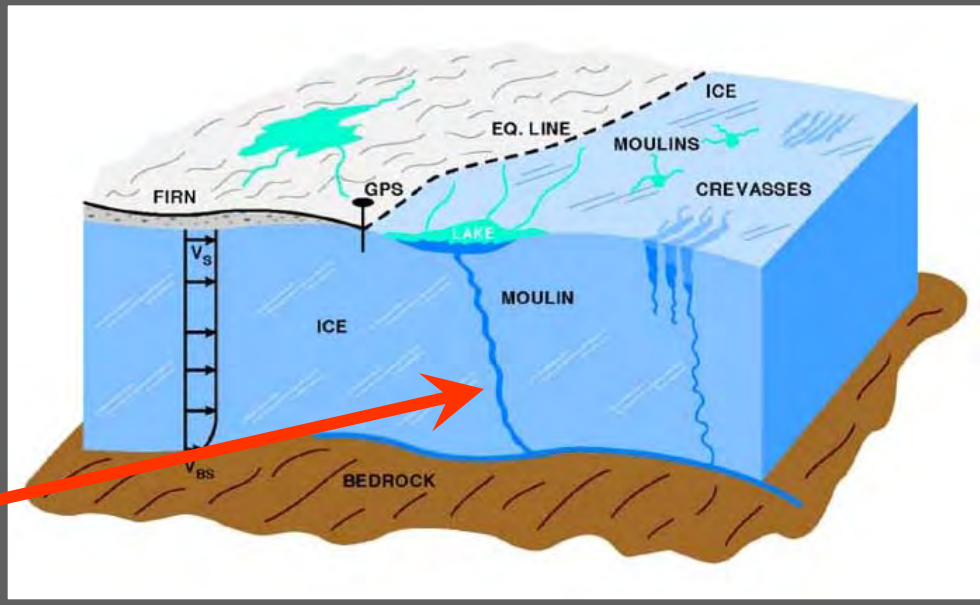
**Now 388+ ppm**




http://www.ucsusa.org/global_warming/science_and_impacts/science/past-present-and-future.html#3

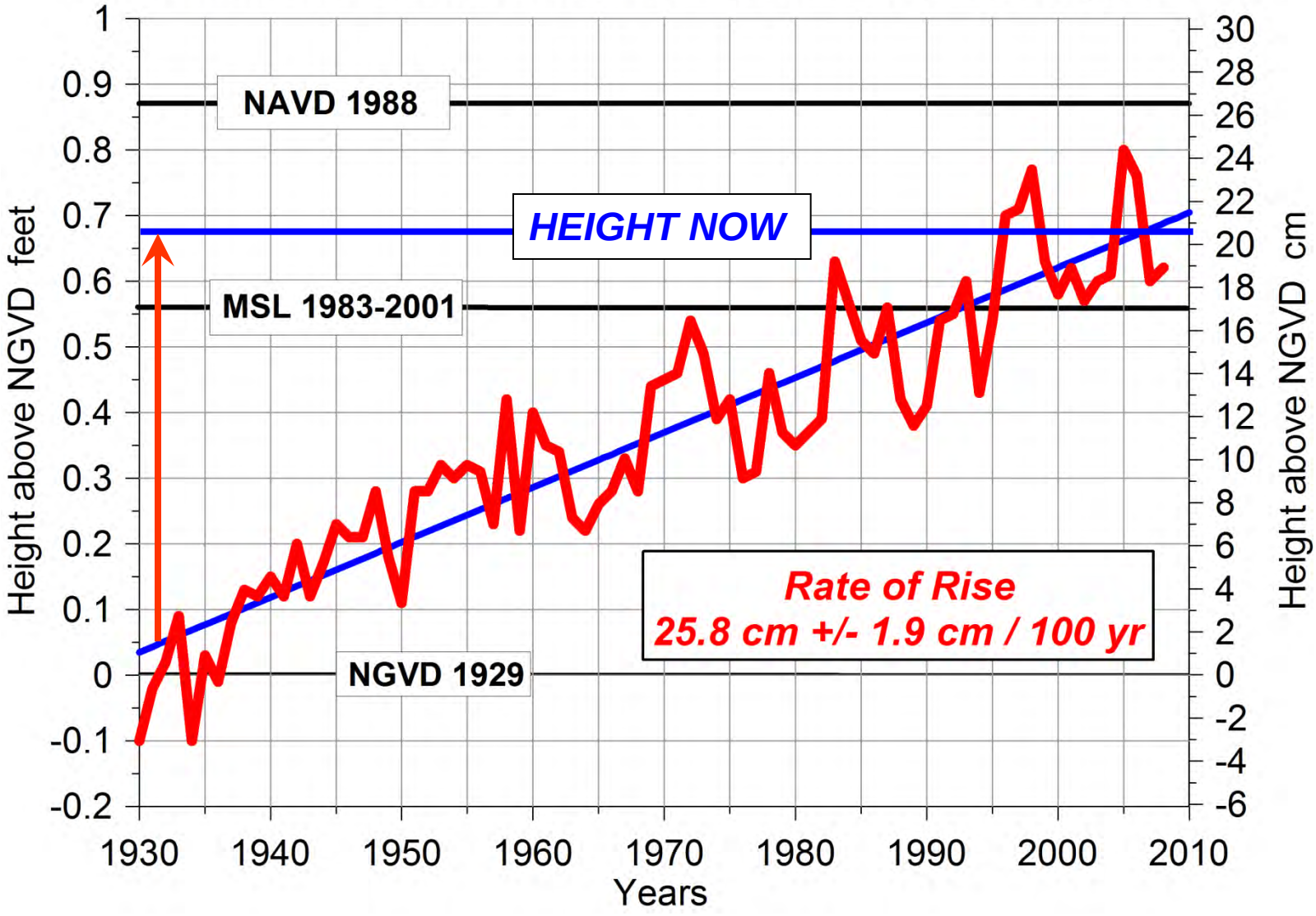
# Greenland Outlet Glaciers Changing from Polythermal to Warm Based

# A Key to Future Sea-Level Rise




Brathwaite, 2002

# HISTORIC SEA-LEVEL RISE - Newport, RI



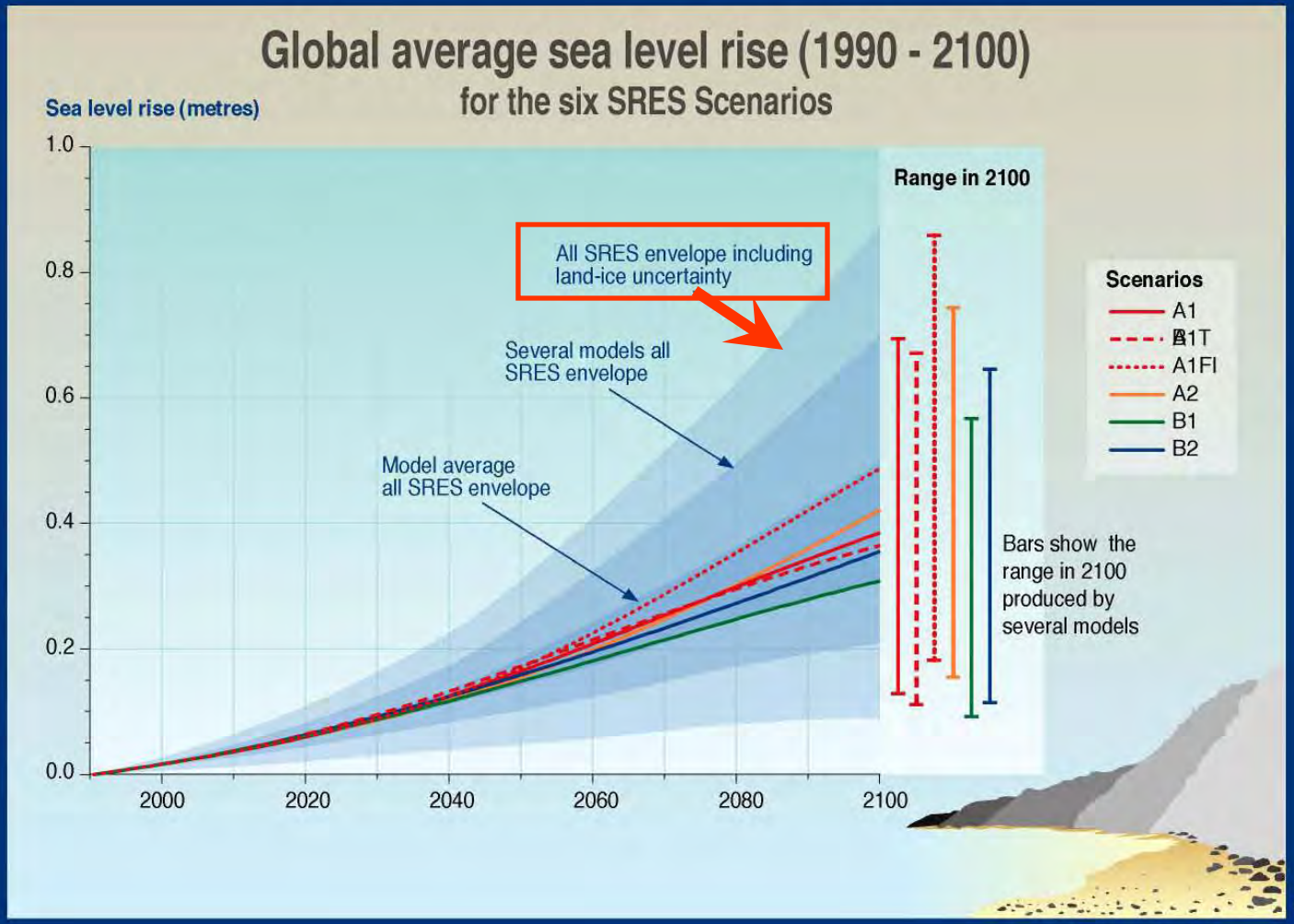

**Adapted from: http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8452660%20Newport,%20RI**

GEOLOGICAL SURVEY RHODE ISLAND

COASTAL HAZARDS GROUP GEOSCIENCES Univ RI

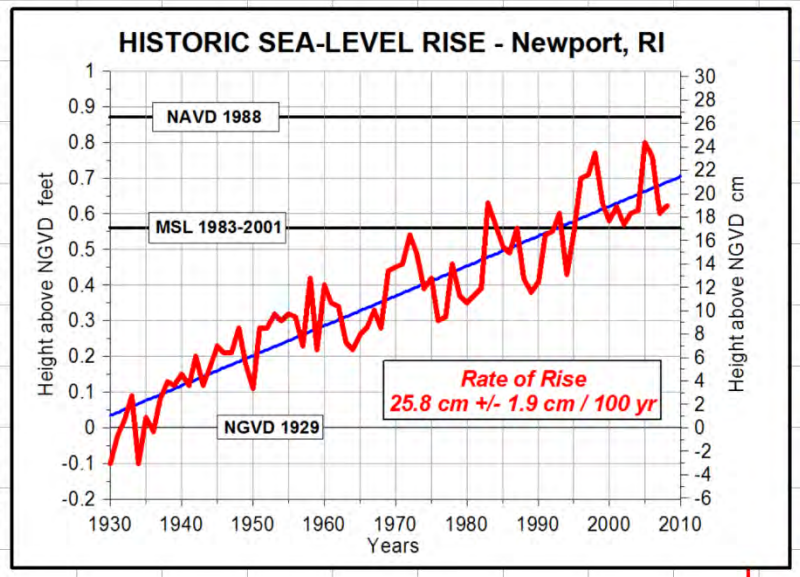
Boothroyd 2008

# IPCC Scenarios 2001




WG1 TS FIGURE 24

# ACCELERATED SEA-LEVEL RISE - Newport, RI

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**IPCC 2001**
Land Ice

**IPCC 2001**
Model Avg

HEIGHT NOW

HISTORIC TREND

MSL 1983-2001

NGVD 1929

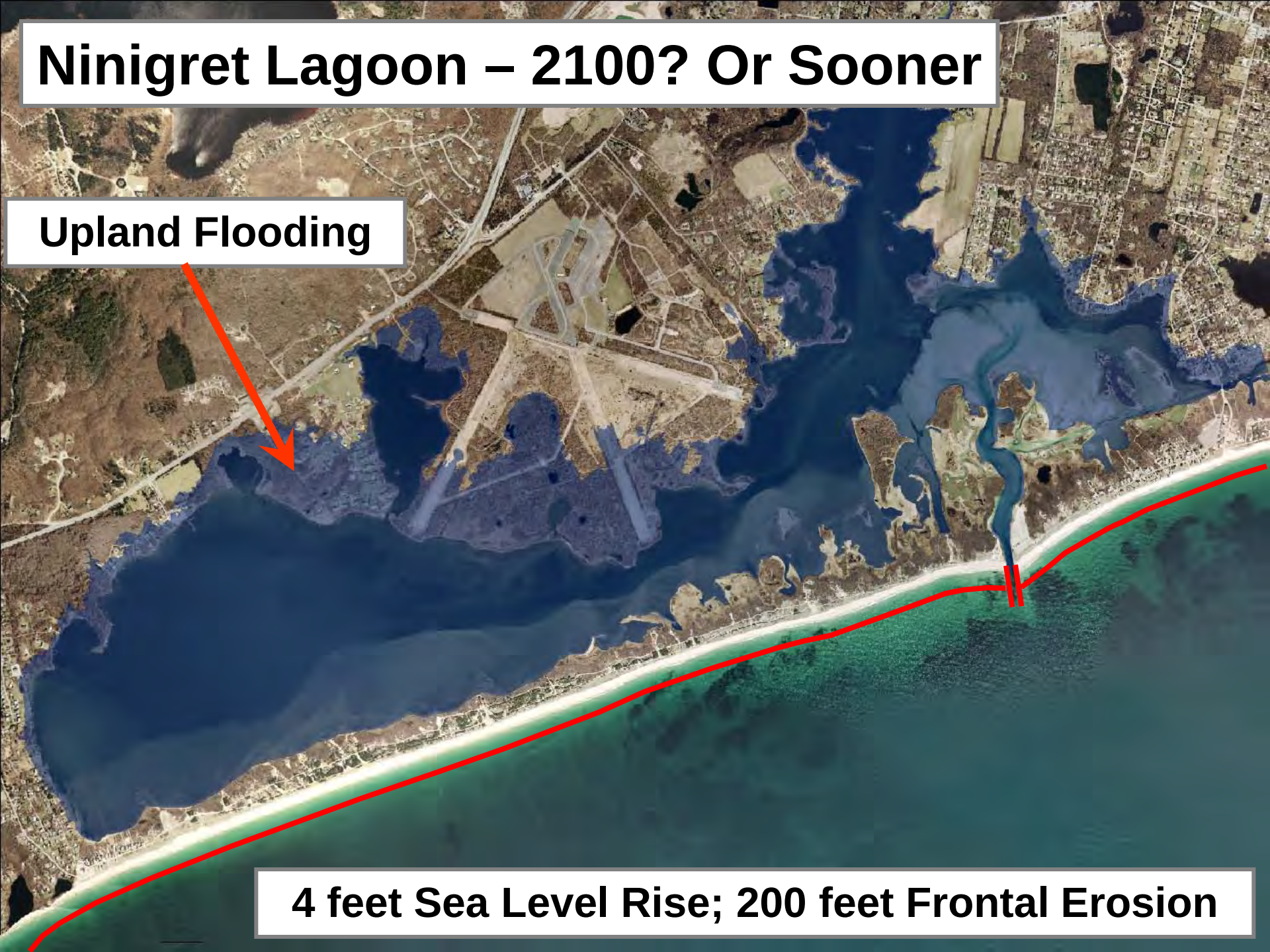
2008

Height above NGVD feet

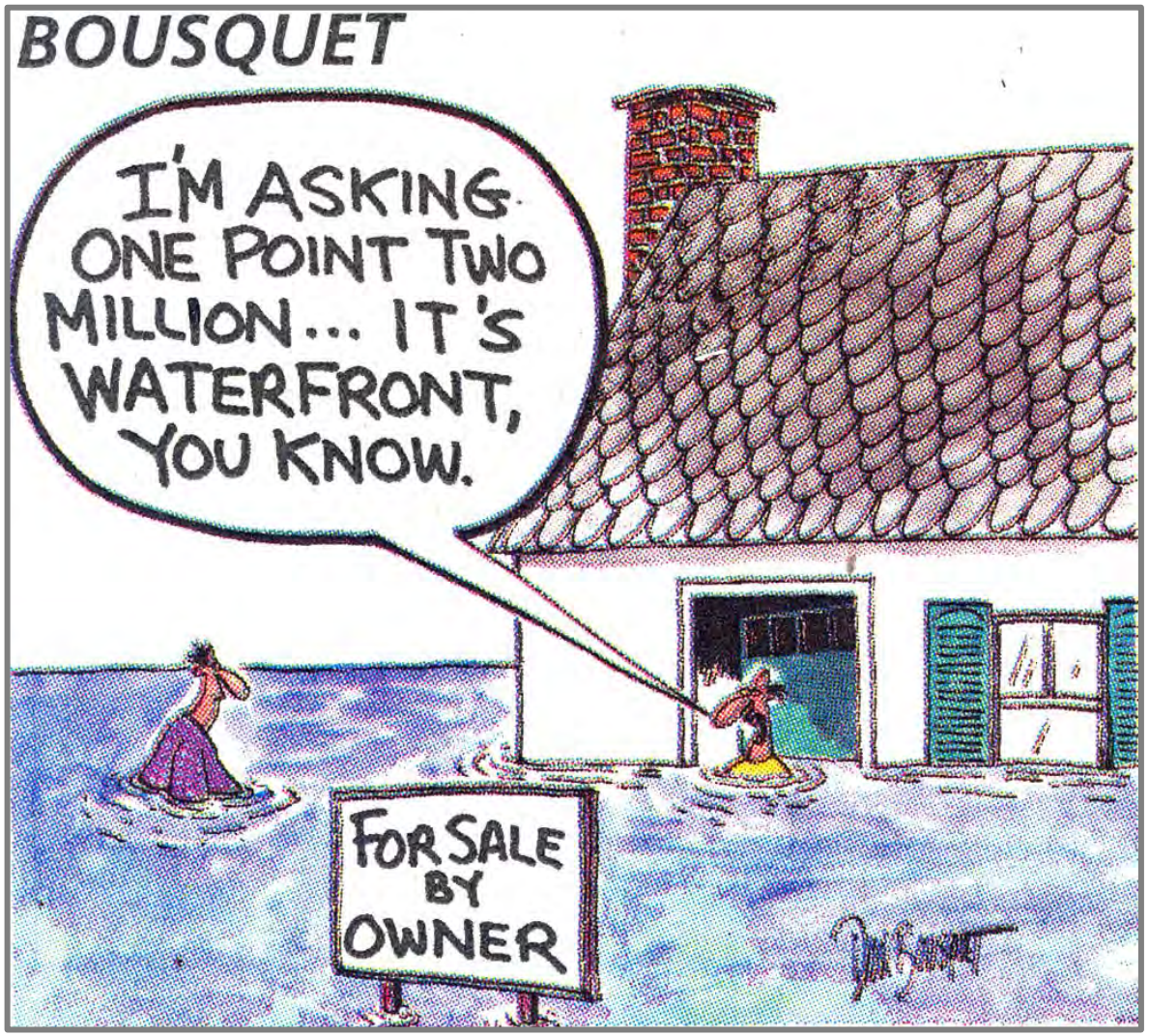
Height above NGVD cm

Years

# Ninigret Lagoon - 2004


Ninigret Lagoon – 2100? Or Sooner
Upland Flooding
4 feet Sea Level Rise; 200 feet Frontal Erosion

# Coastal Rhode Island – A Common View of the Future




Don Bousquet, June 2008

# Middlebridge, South Kingstown, Coastal Lagoon: A Common View of the Future

# End of Presentation

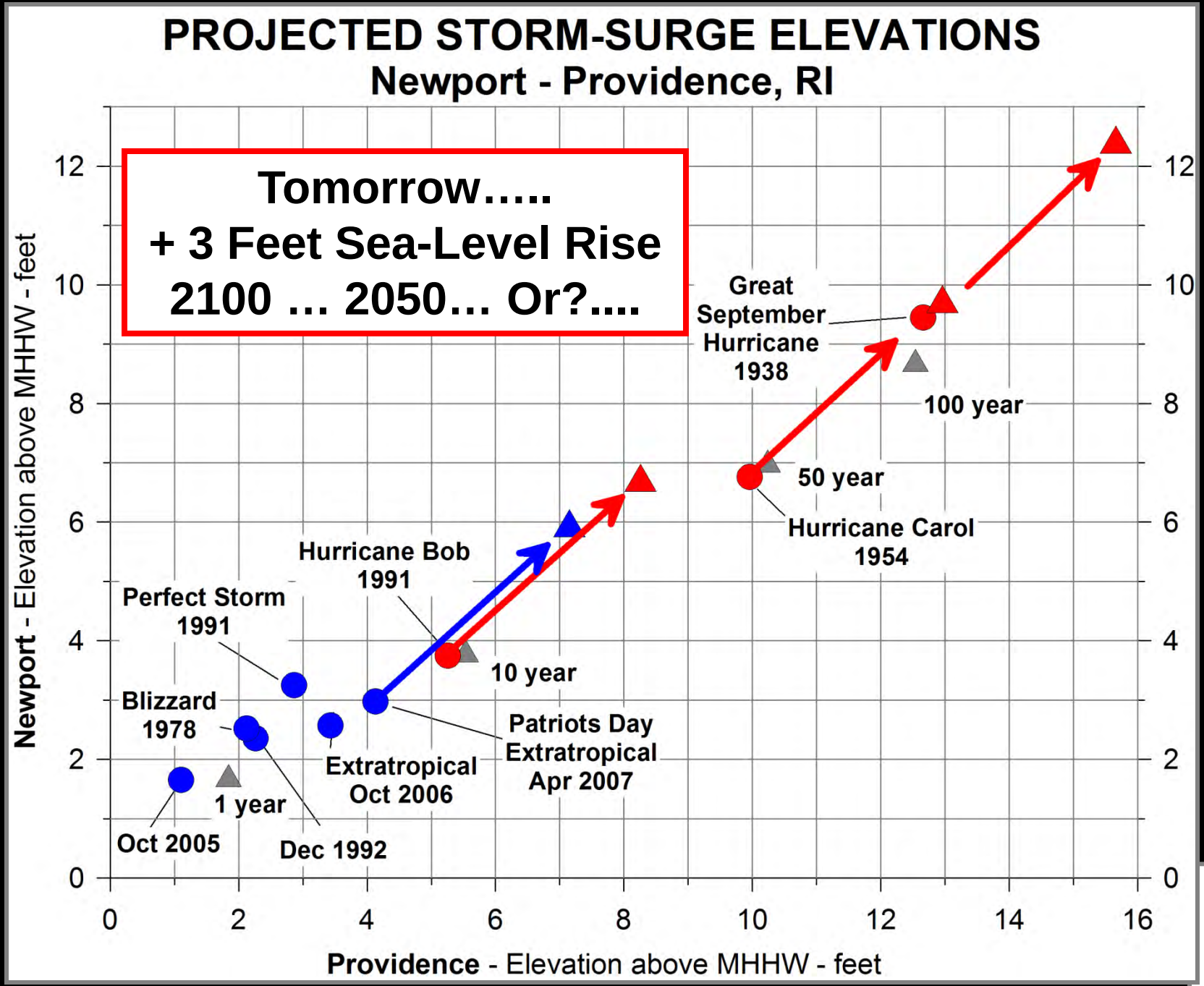
# South Kingstown Town Beach – South Kingstown RI

# South Kingstown Town Beach – South Kingstown RI


BA Oakley

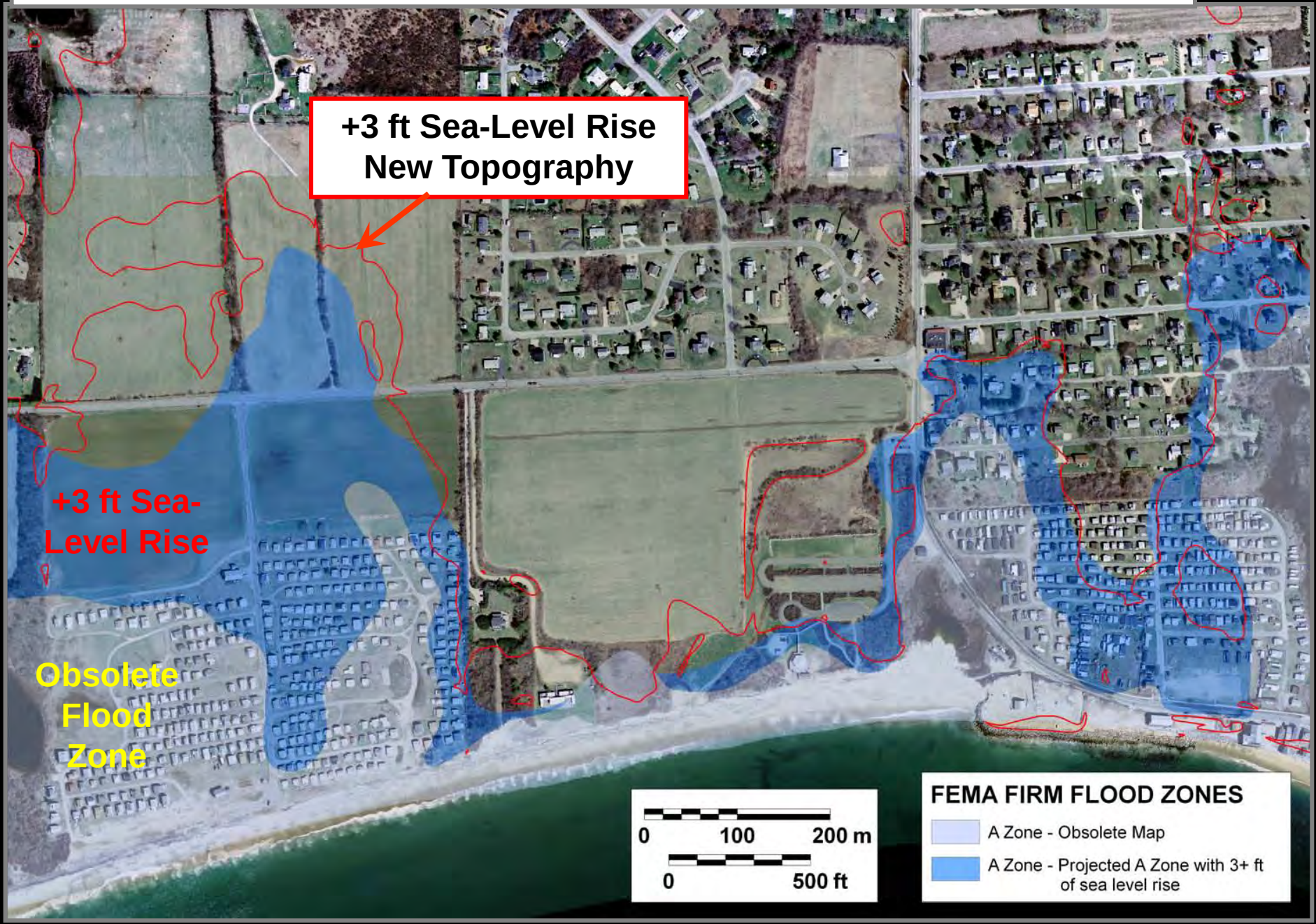
# South Kingstown Town Beach – South Kingstown RI

# South Kingstown Town Beach – South Kingstown RI

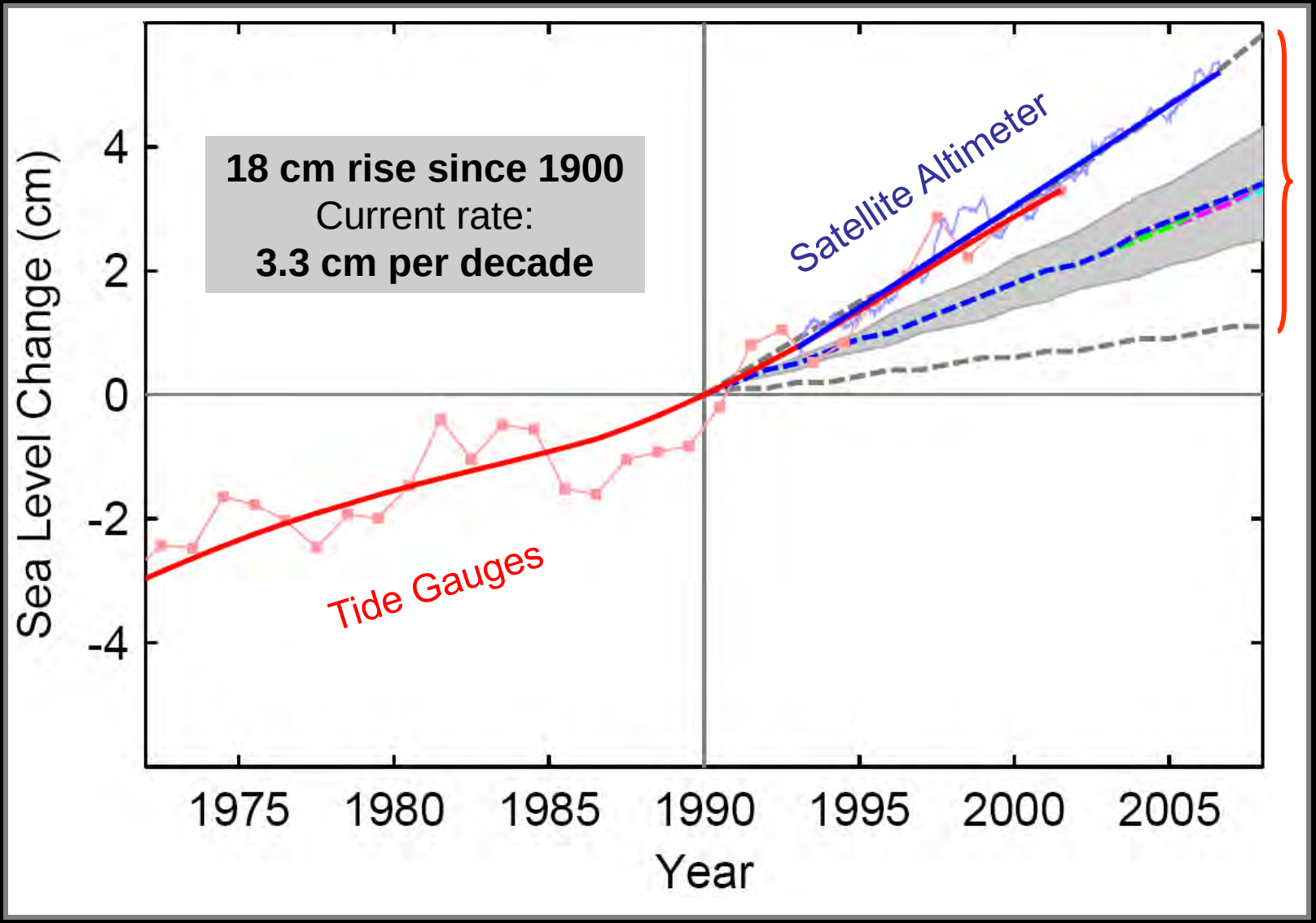



Adapted from NOAA; USACE 1988; Hehre 2007

# 100-Year Storm-Surge Inundation - Matunuck

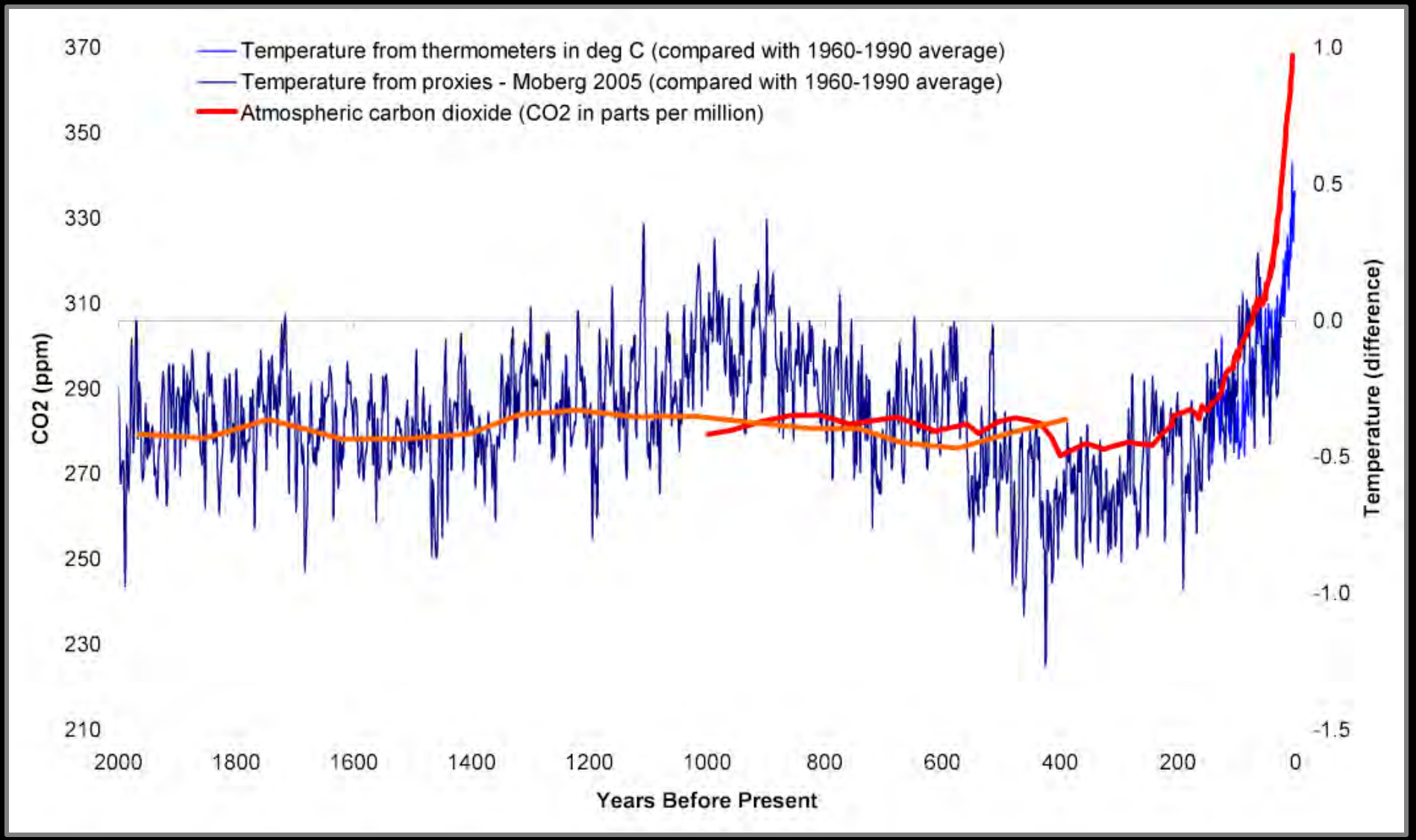


# Observed Global Sea-Level Rise

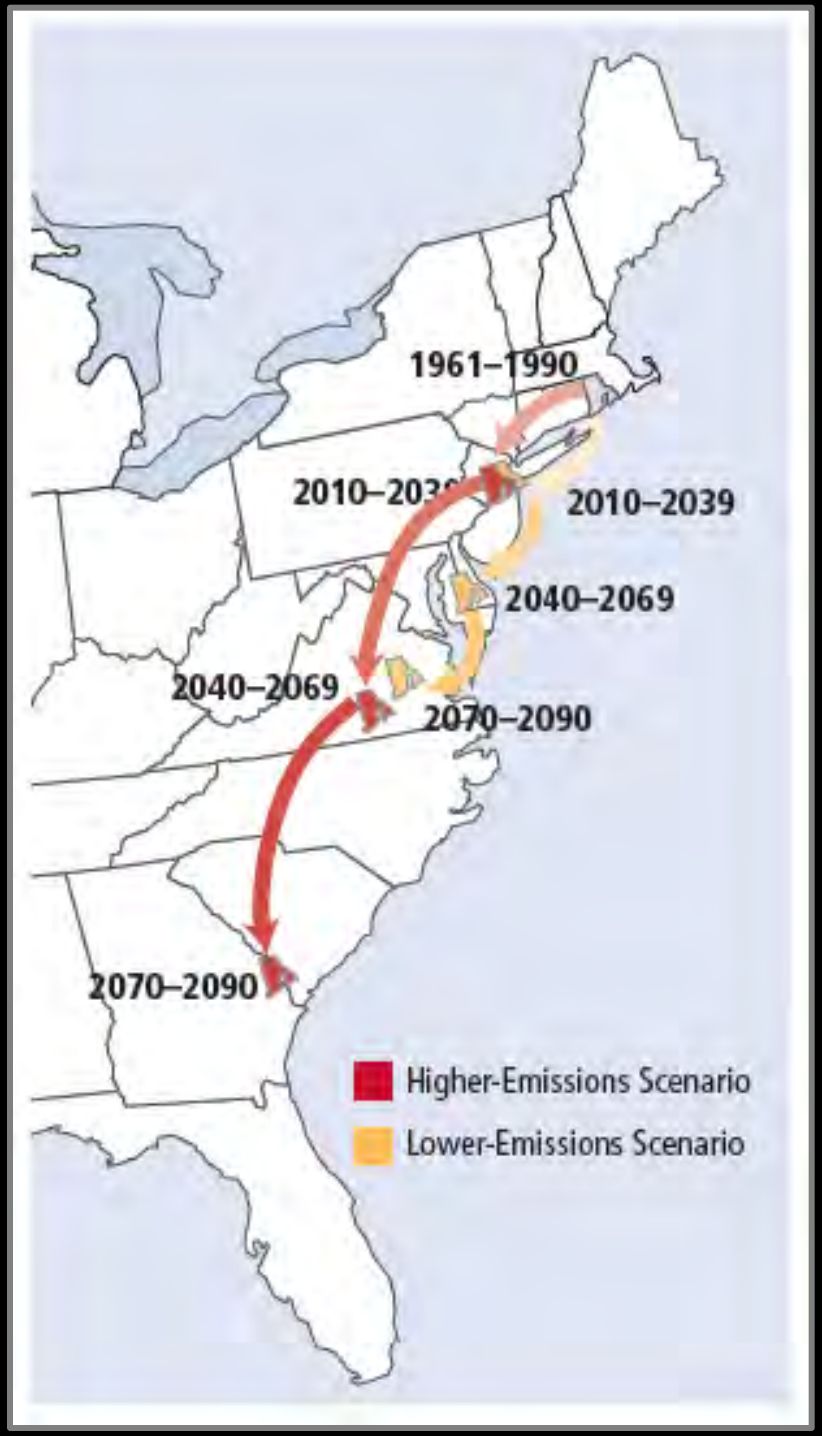



Rahmstorf, Cazenave, Church, Hansen, Keeling, Parker and Somerville (Science 2007)

# THE HOCKEY STICK




Moberg et al, 2005




# RHODE ISLAND POSSIBLE FUTURE CLIMATE

**Confronting Climate Change in the U.S. Northeast: Climate, Impacts, and Solutions, NECIA, 2007**

**http://www.northeastclimateimpacts.org/**

# SEDIMENT TRANSPORT PATHWAYS
# NARRAGANSETT
# COASTAL BARRIER

# NARRAGANSETT BEACH – Sand Transport Into Narrow River

# THE NARROWS – Flood-Tidal Delta and Narragansett Barrier Spit

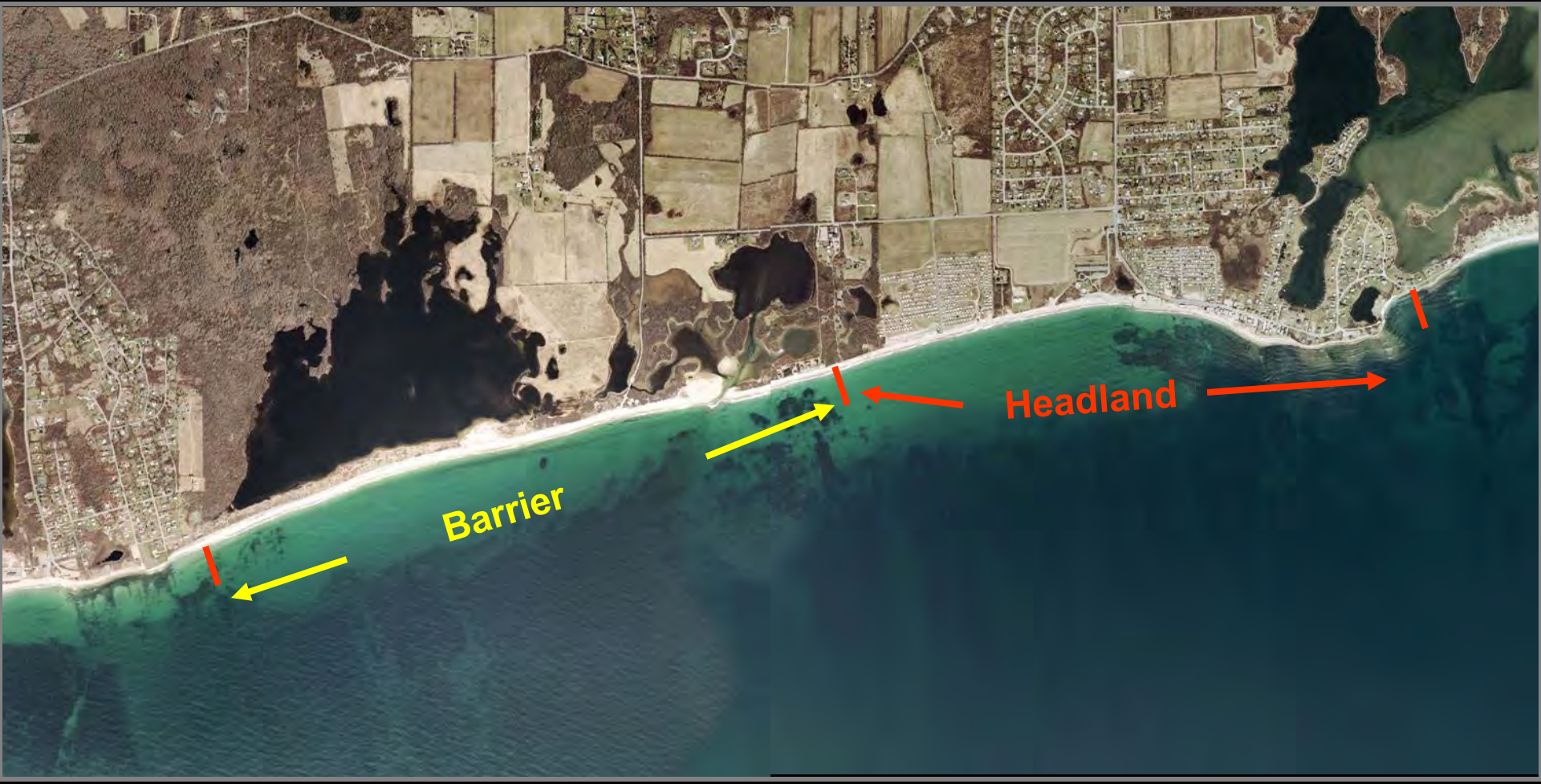
# NARRAGANSETT BEACH – Sand Transport Into Narrow River

# NARRAGANSETT BEACH – Narrow River Ebb-Tidal Delta

# Ninigret Flood-Tidal Delta - 1981

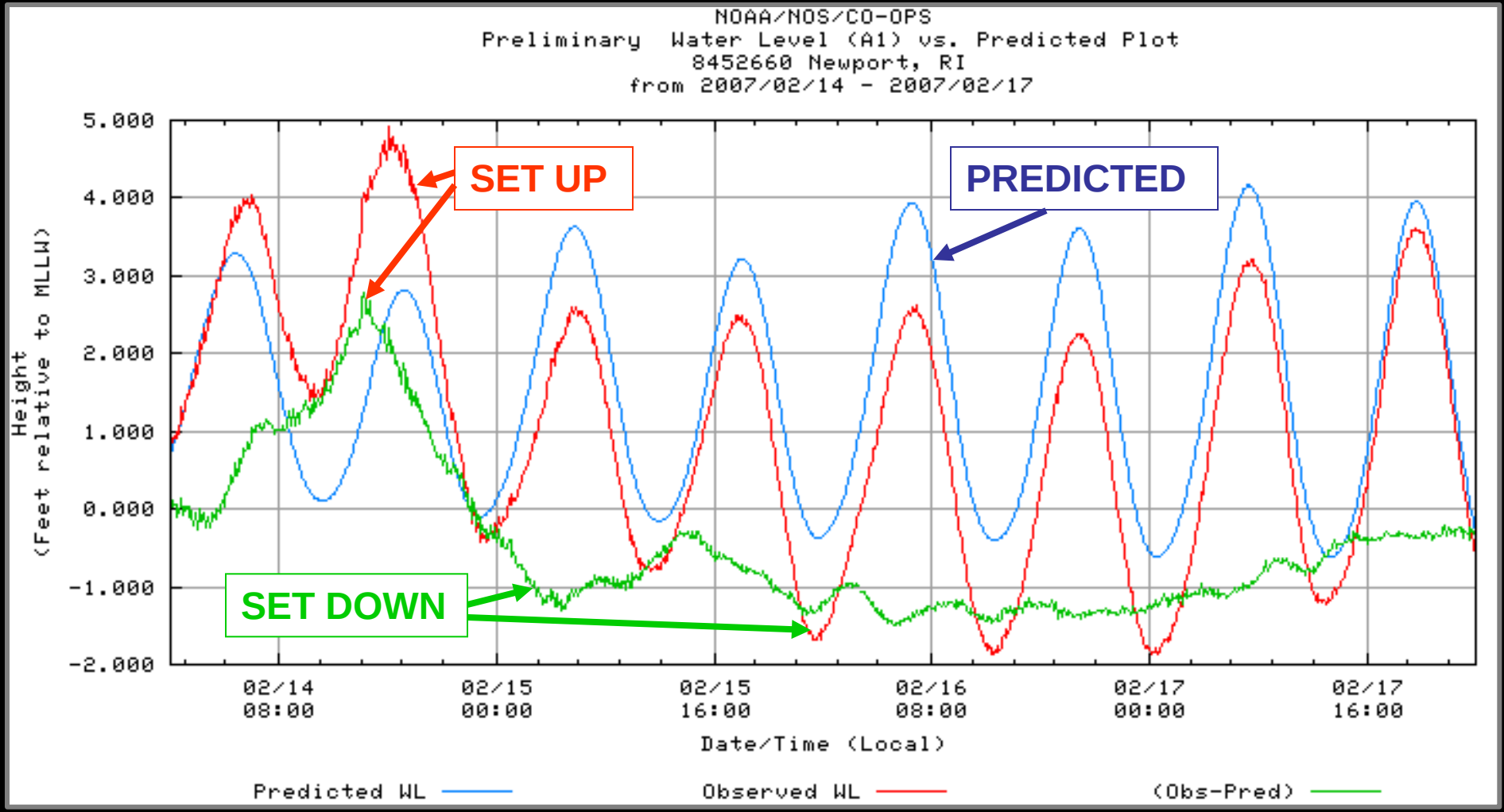
# Ninigret – Charlestown – East Beach Area

# Green Hill Headland to Matunuck Headland




RIGIS 2004

# Valentine's Day Extratropical - 2007

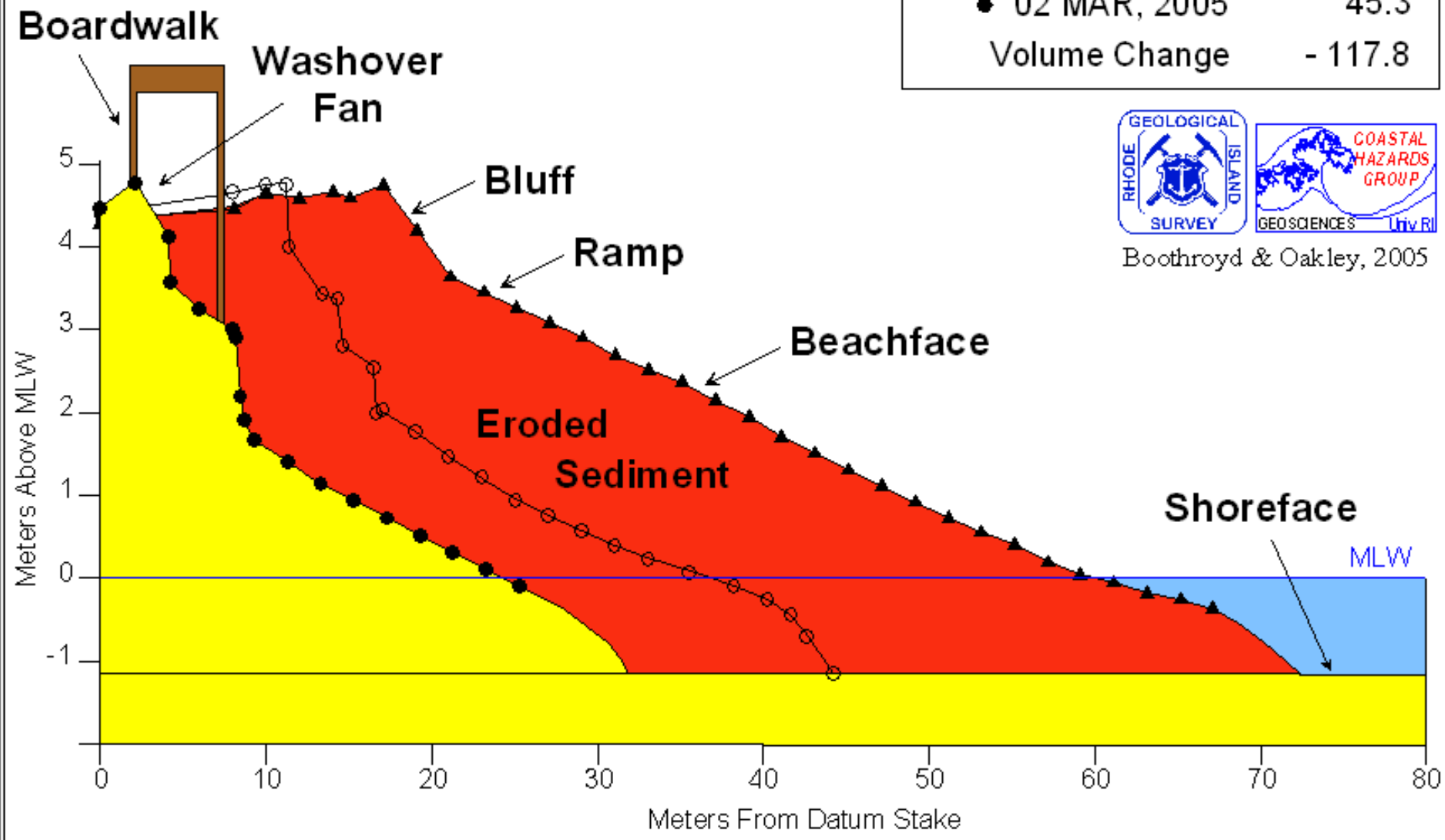



NOAA/NOS/CO-OPS

# South Kingstown Town Beach

## An Eroding Bluff Shoreline

| Profile Volume | $m^3\ m^{-1}$ |
|---|---|
| ▲ 20 AUG, 1996 | 163.1 |
| ○ 10 MAR, 1998 | 86.7 |
| ● 02 MAR, 2005 | 45.3 |
| Volume Change | - 117.8 |




GEOLOGICAL RHODE ISLAND SURVEY

COASTAL HAZARDS GROUP GEOSCIENCES Univ RI

Boothroyd & Oakley, 2005