

Bermuda Coastal Erosion Vulnerability Assessment

(Carried out for the Government of Bermuda)

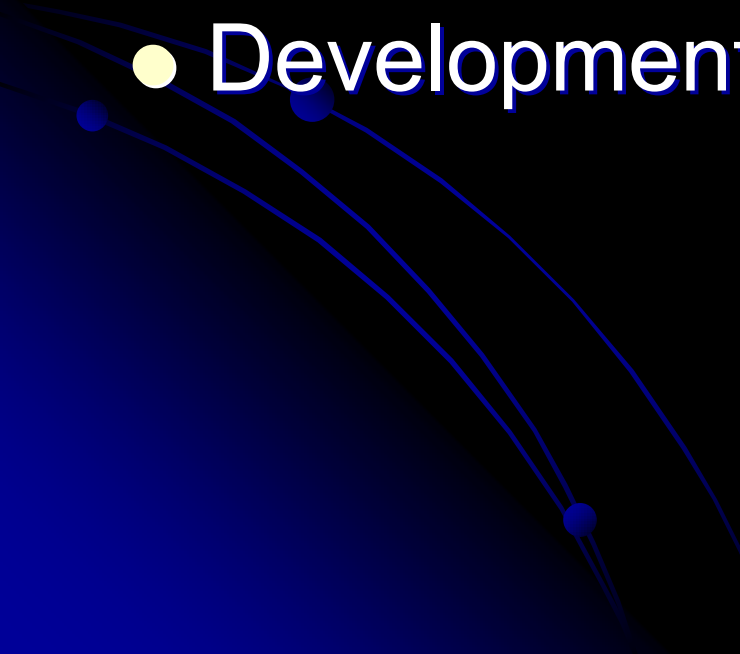
**Presented at the 2nd Annual GIS Conference:
Technological Applications for Coastal Protection**

by Dr. David A.Y. Smith, Managing Director, Smith Warner
International Ltd.

June 2006

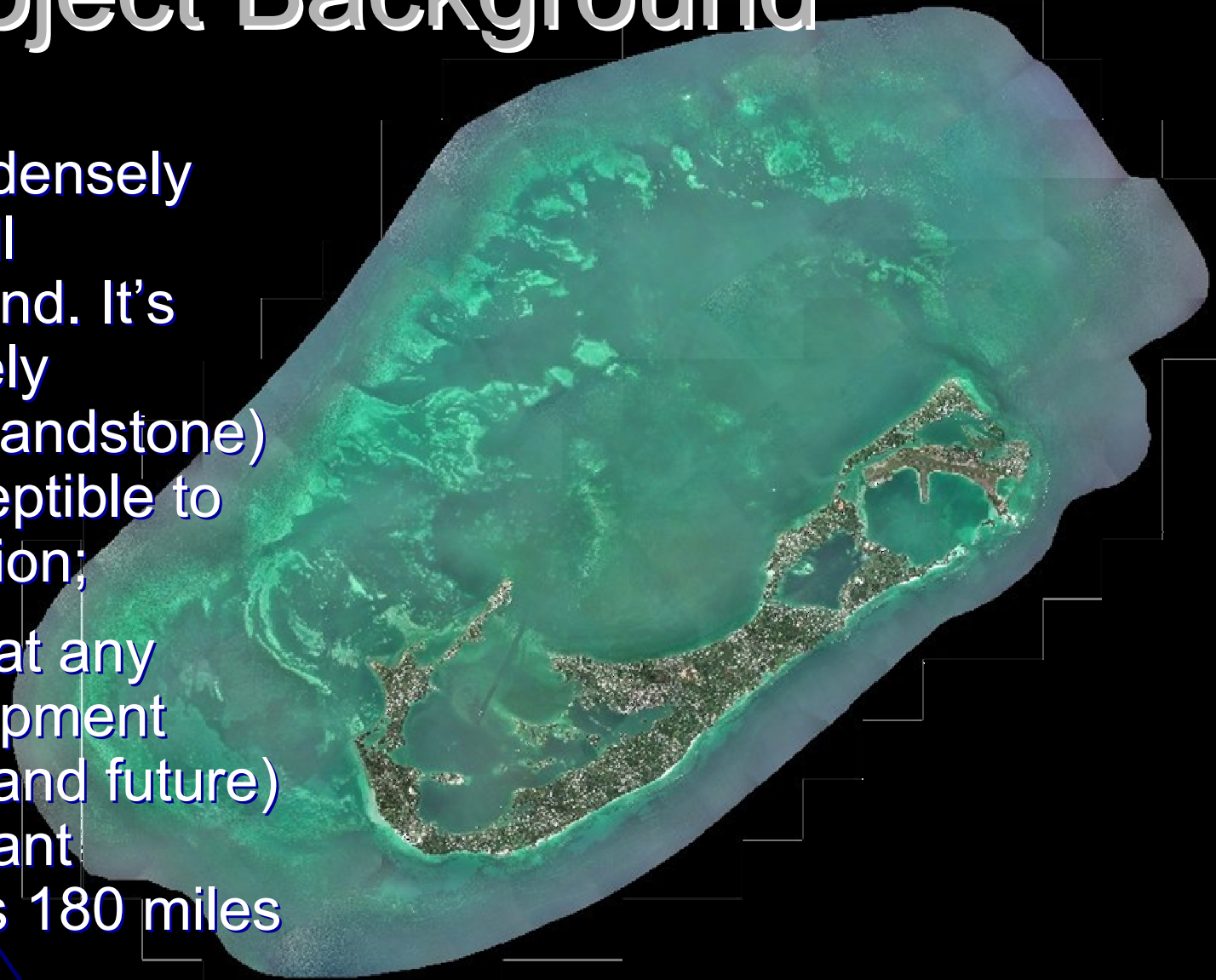


Presentation Outline

- Project background
 - Study objectives and methodology
 - Key Findings
 - Conclusions
 - Development Guidelines.
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Project Background

- Bermuda is a densely populated, well developed island. It's geology (loosely consolidated sandstone) makes it susceptible to shoreline erosion;
- This means that any coastal development (both existing and future) places significant pressure on its 180 miles of coastline;

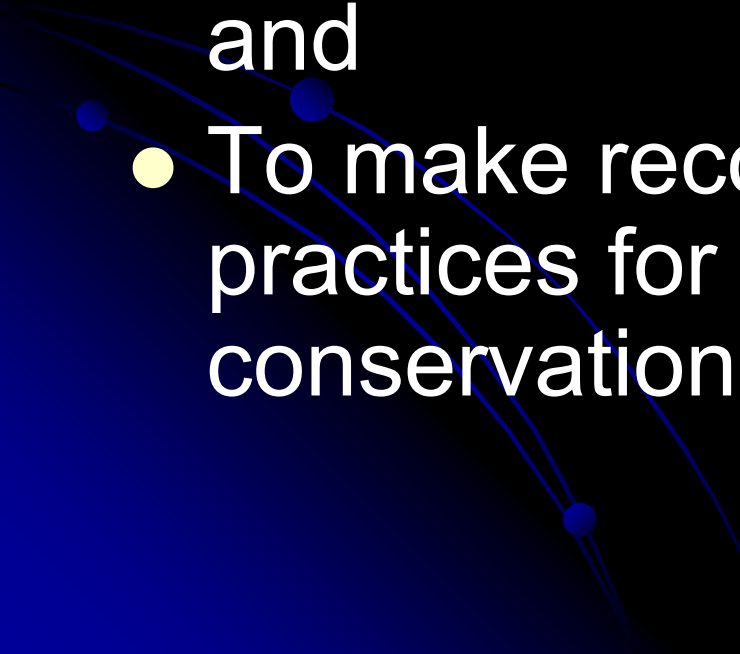


Project Background

- Shoreline protection and development have become important issues,
- Balance of shoreline protection & natural appearance of the coast.
- Bermuda Development Plan Review



Study **objectives** and methodology


- To synthesize the data that already exists in Bermuda about coastal erosion;
 - To determine which coastal areas in Bermuda are prone to erosion and which structures and landforms are most at risk; and
 - To make recommendations of best practices for coastal development and conservation.
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Study objectives and methodology

- Review and analysis of existing information & data gaps;
- Field investigations (initial data-gathering tour and a ground-truthing field visit).
- Inventory of the shoreline types, shoreline structures, forms of erosion, lithology.

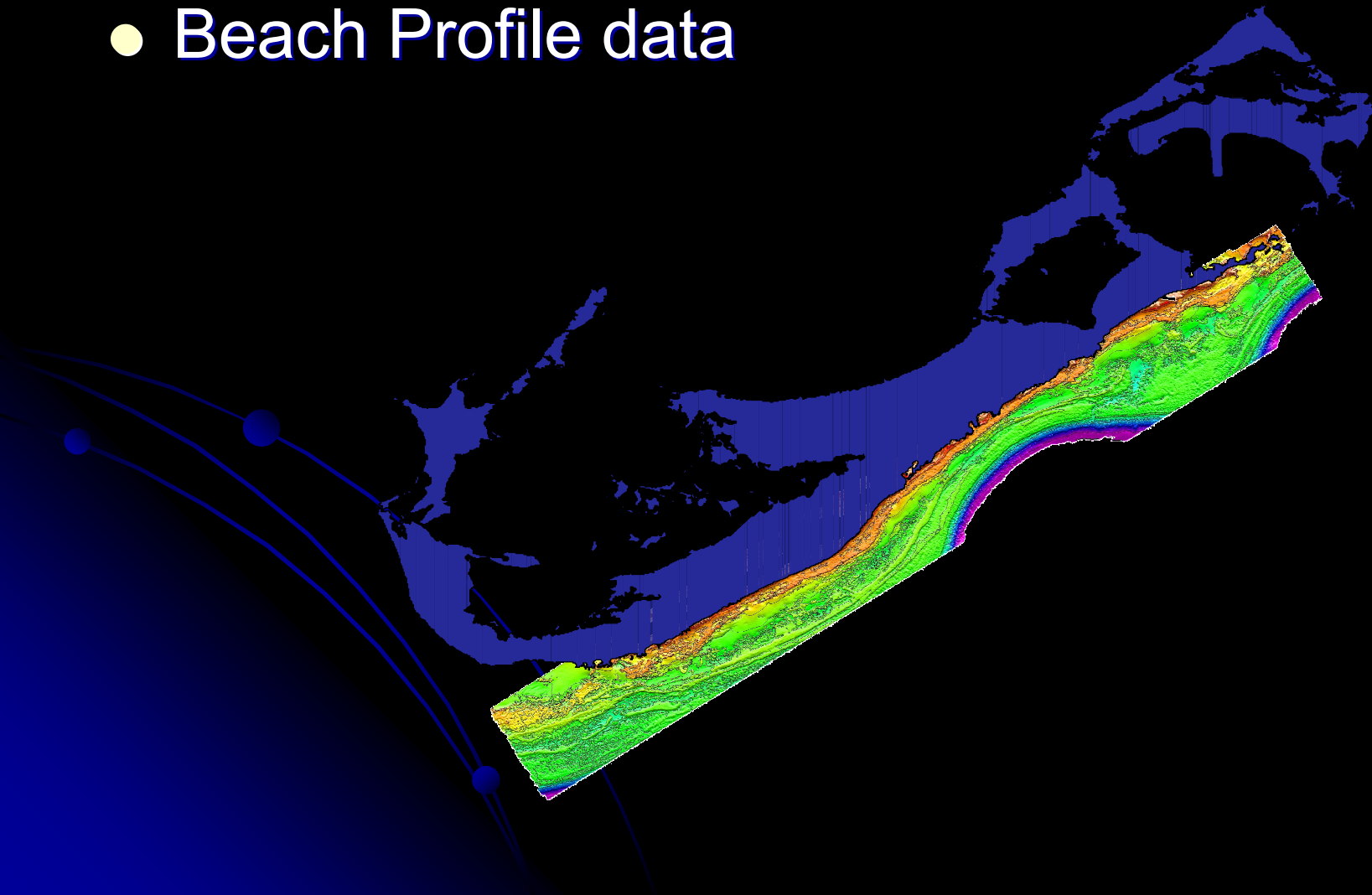


Study objectives and methodology

- Hurricane & Storm Analysis
 - Day to Day Wave Analysis
 - Coastal Processes Modeling
 - Geological Analysis
 - Vulnerability Assessment
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Findings – Data Gaps

- Bathymetry – South Coast
- Beach Profile data



Findings - Main Shoreline Types



Sandy shorelines



Flat rocky coastline



Low cliffs



High cliffs

Findings - Forms of Erosion



Dune erosion



Cliff erosion/spalling

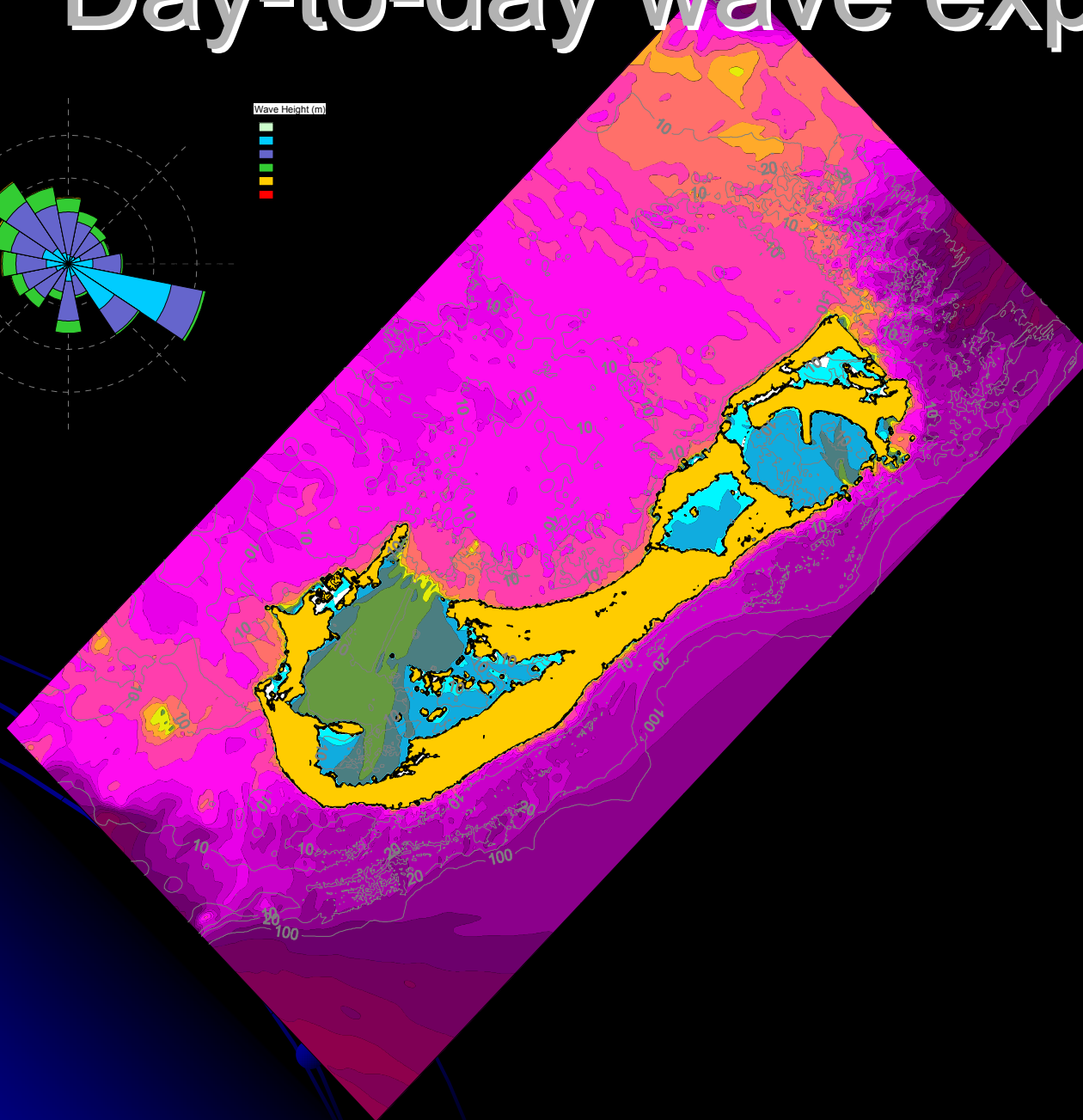
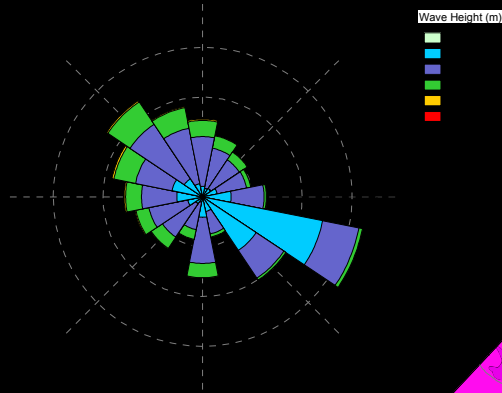


Horizontal/arch formation

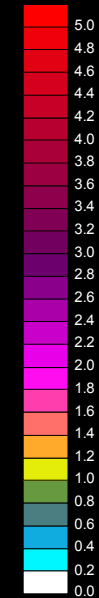


Bio-erosion

Day-to-day wave exposure



SWAN Results



Wave Height

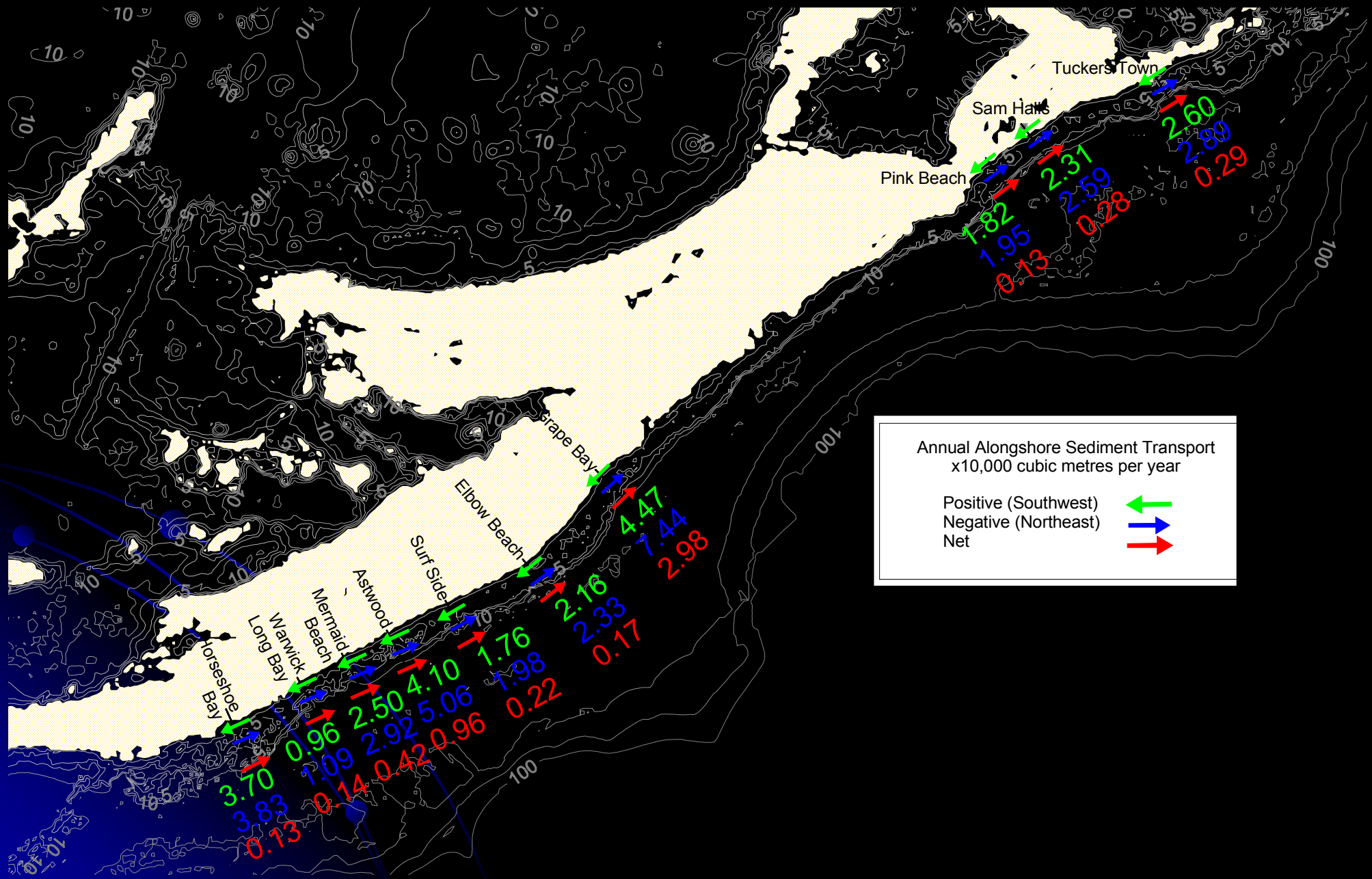
Water depth contours
shown in gray (m)

INVESTIGATION DETAILS

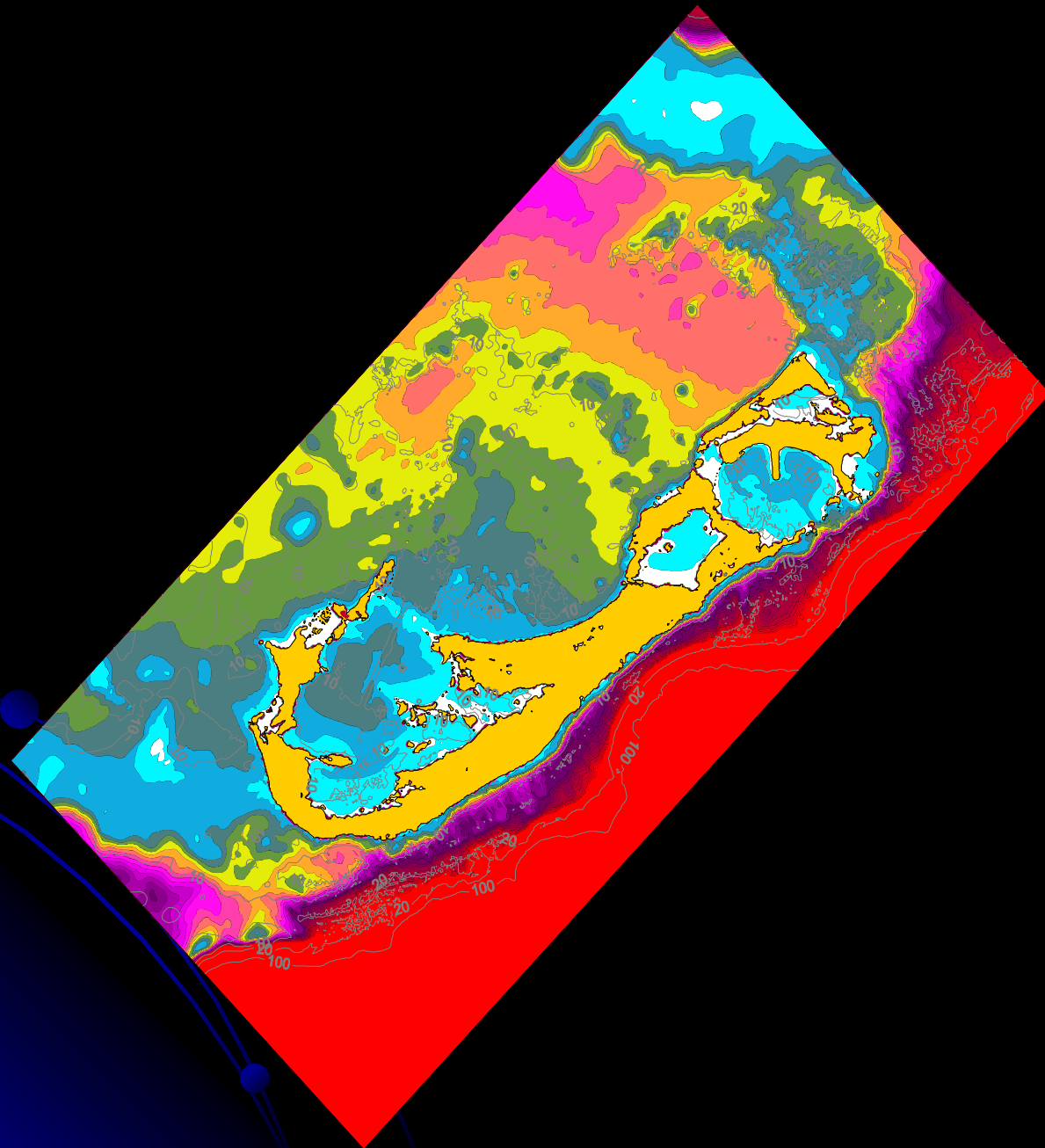
BERMUDA
Daily Wave Climate
(80th percentile Waves)
Maximum from All Directions



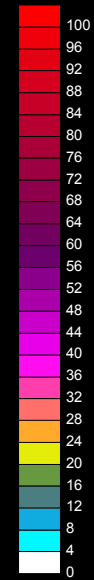
Sediment Transport



Extreme Wave Energy Exposure



SWAN Results



Wave Height Squared

Water depth contours
shown in gray (m)

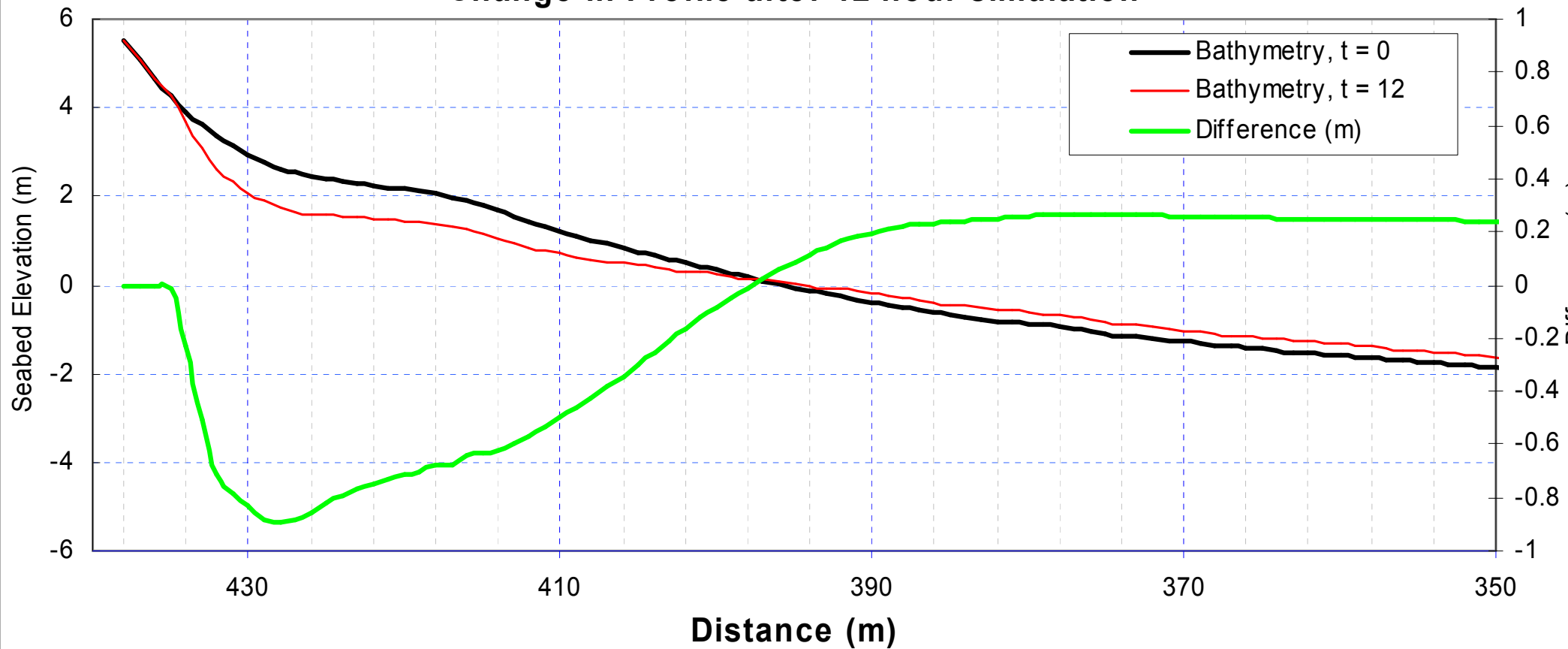
INVESTIGATION DETAILS

BERMUDA
150 yr Hurricane Event
Maximum from All Directions

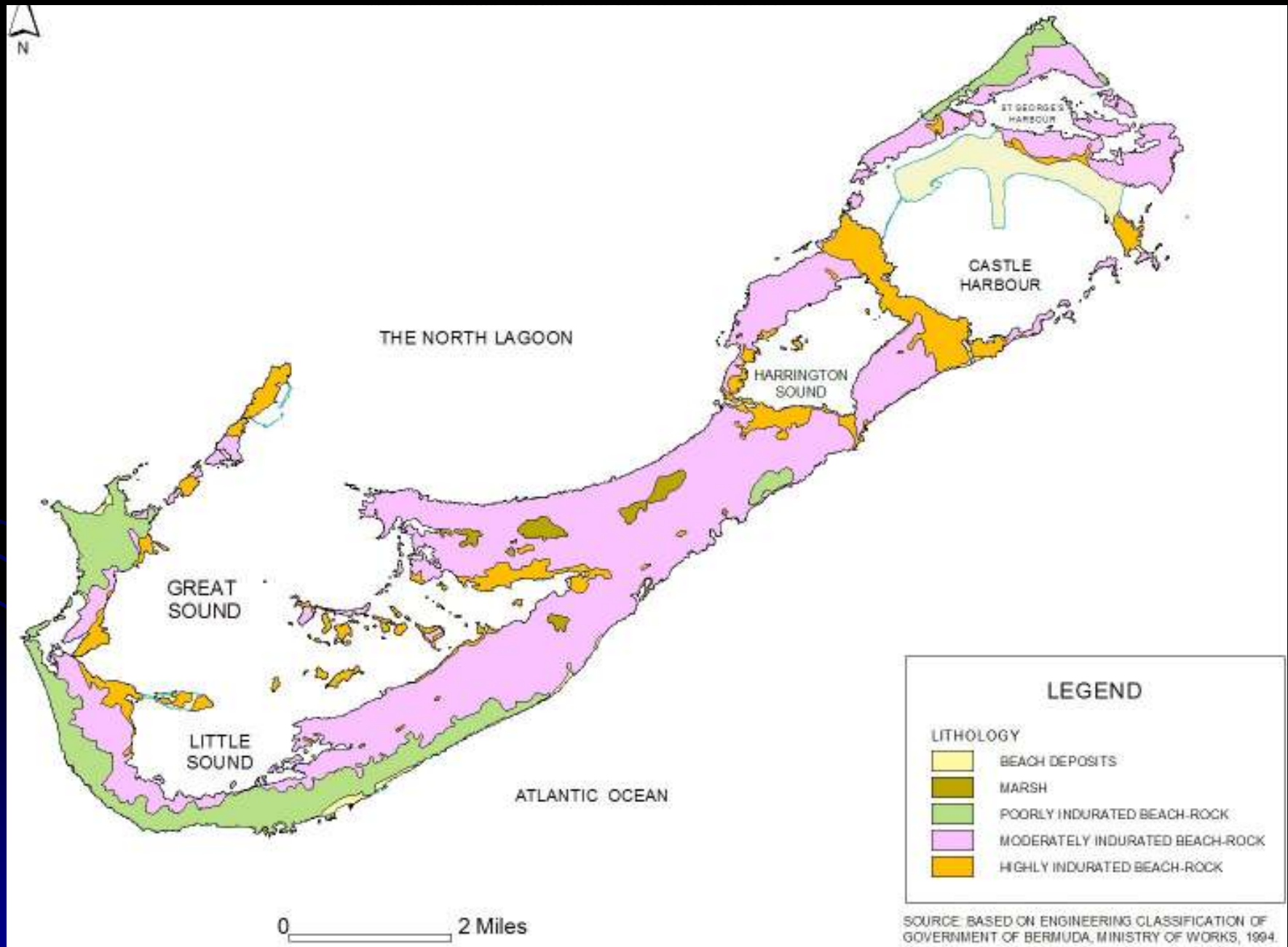


Beach Response to Hurricanes

Change in Profile after 12 hour simulation

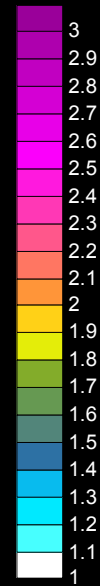
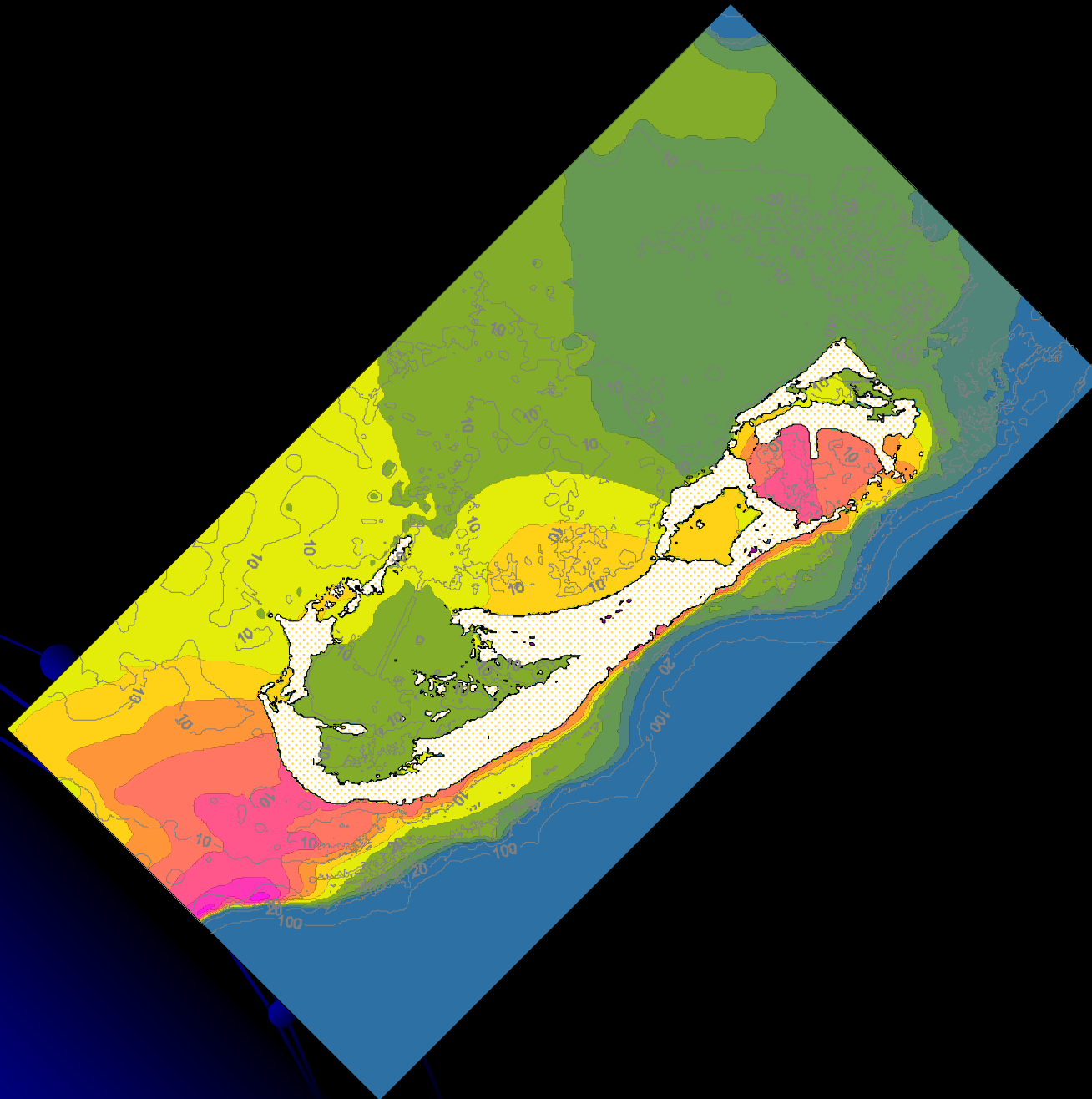


Geology



Storm Surge

SWAN Results



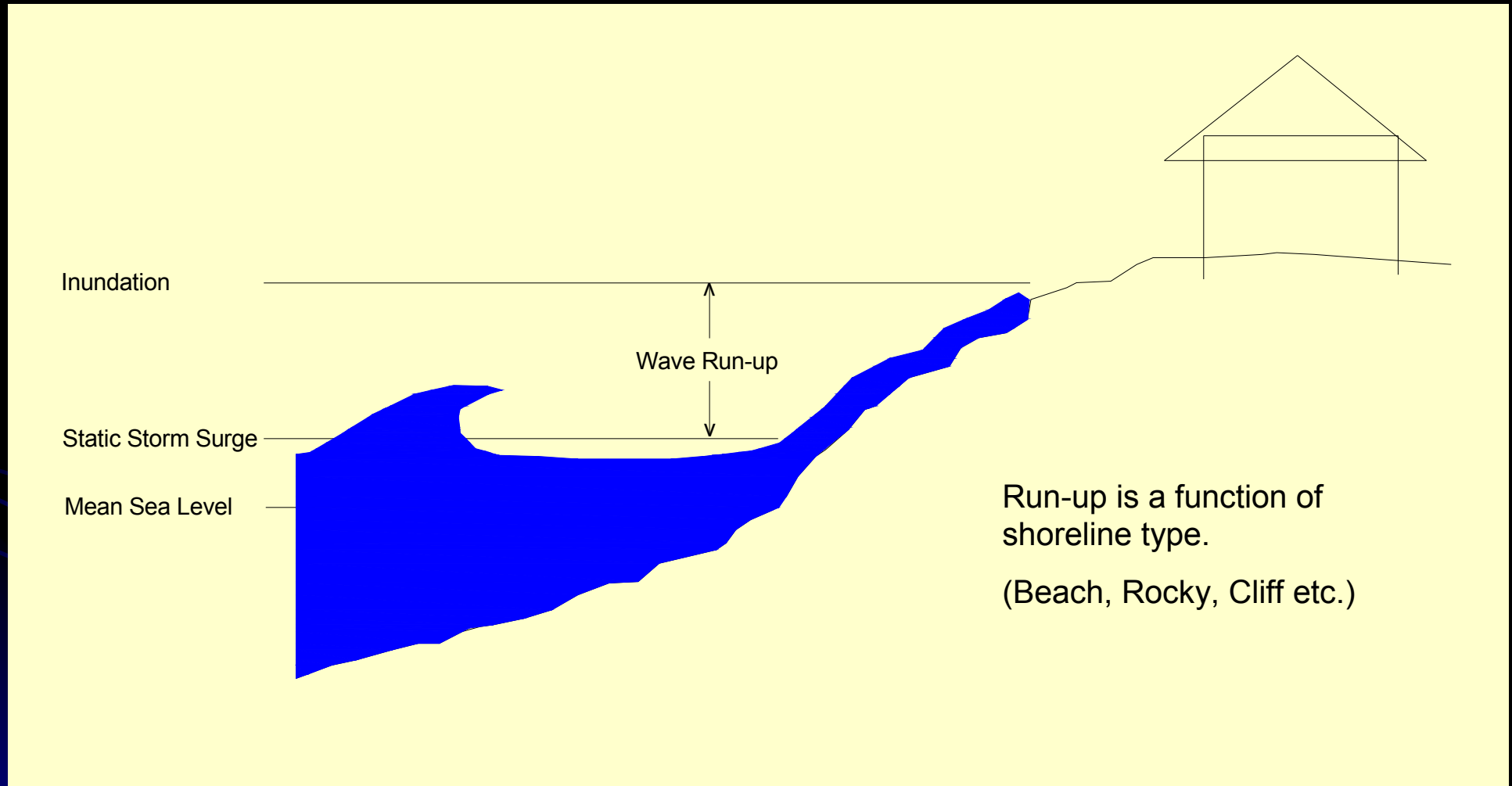
Static Storm Surge (m)

Water depth contours shown in gray (m)

INVESTIGATION DETAILS

BERMUDA
150 yr Hurricane Event
STATIC STORM SURGE
Maximum from All Directions

Wave Run-up & Inundation

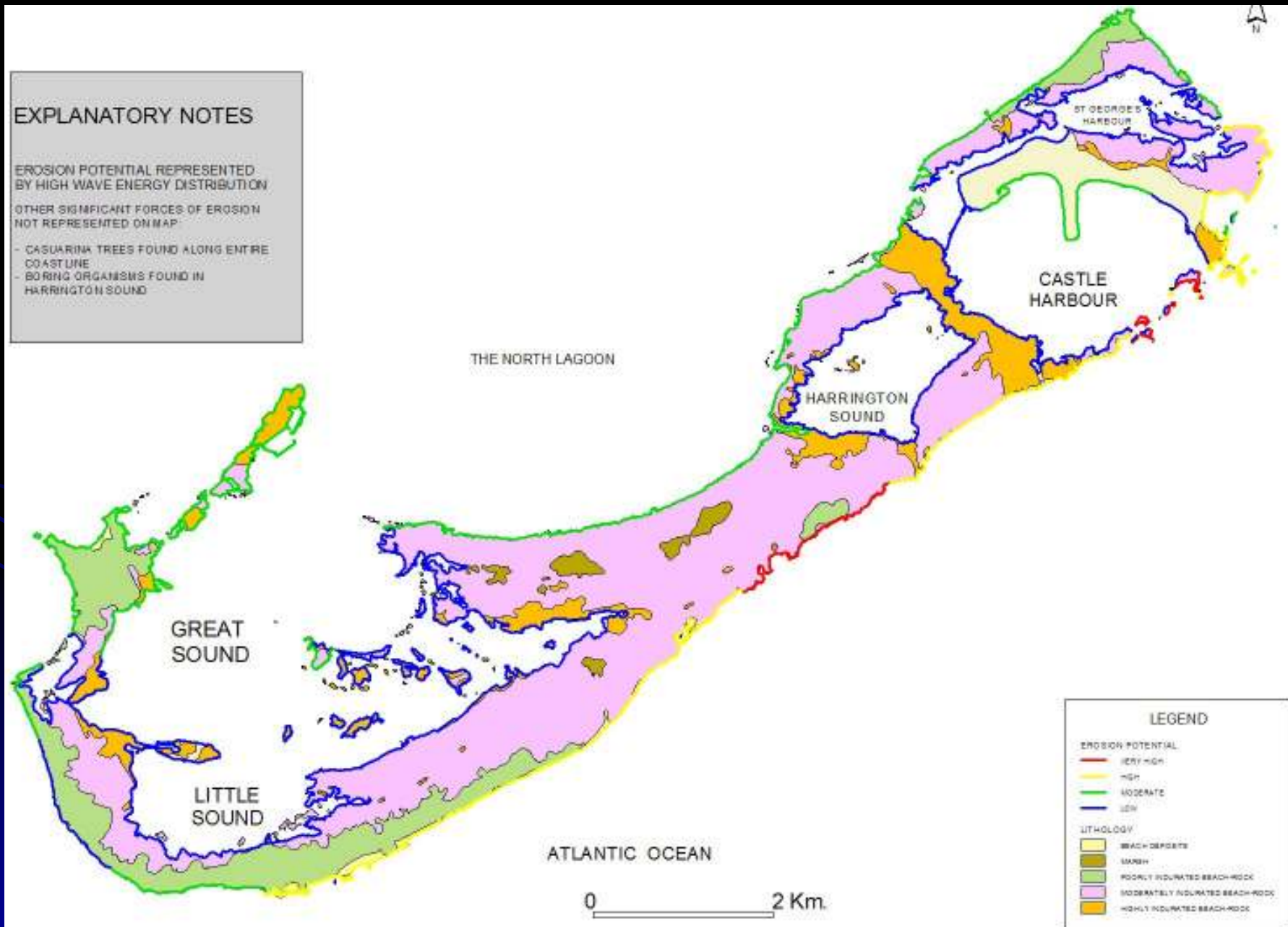


These have been calculated and tabulated for each shoreline division


Conclusions

- Storm waves are the main agent of erosion – less apparent yet potentially significant are the biological agents (marine borers and *Casuarina*).
- Day to day waves contribute minimally to the shoreline erosion.
- No dominant trend of alongshore sediment transport.
- Erosion vulnerability dependant on geology and exposure to wave energy.
- Findings have been incorporated into the Coastal Development Guidelines.

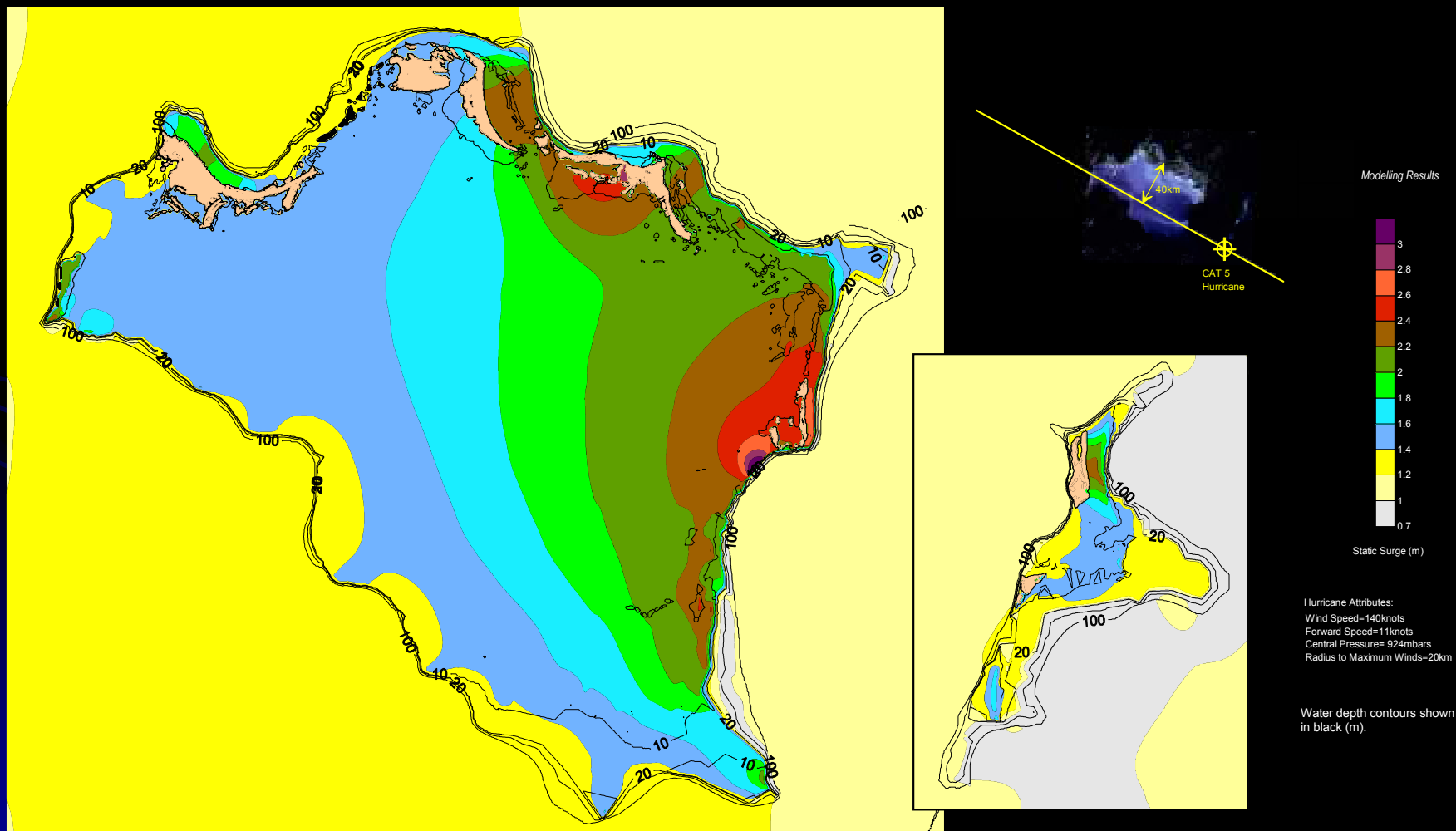
Storm and Erosion Vulnerability



Development Guidelines

- Consider the Bermuda image
 - Recommend appropriate shoreline protection
 - Suitable structures
 - Design considerations
 - Appropriate shoreline development
 - Inundation levels & setbacks
 - 'Community' approach
- 

Another Relevant Study: Storm Surge Mapping for Turks & Caicos Islands



Storm surge for Category 5 Hurricane coming from the east and passing south of TCI



Sub-Catchment (Provo, TCI)

1. Drainage pathways: light purple (and housing superimposed)
2. Sea: aquamarine
3. Low lying lands: light brown
4. Ridges: green, dark brown or deep purple.
5. A housing zone vulnerable to drainage induced flooding is ringed by a red circle.

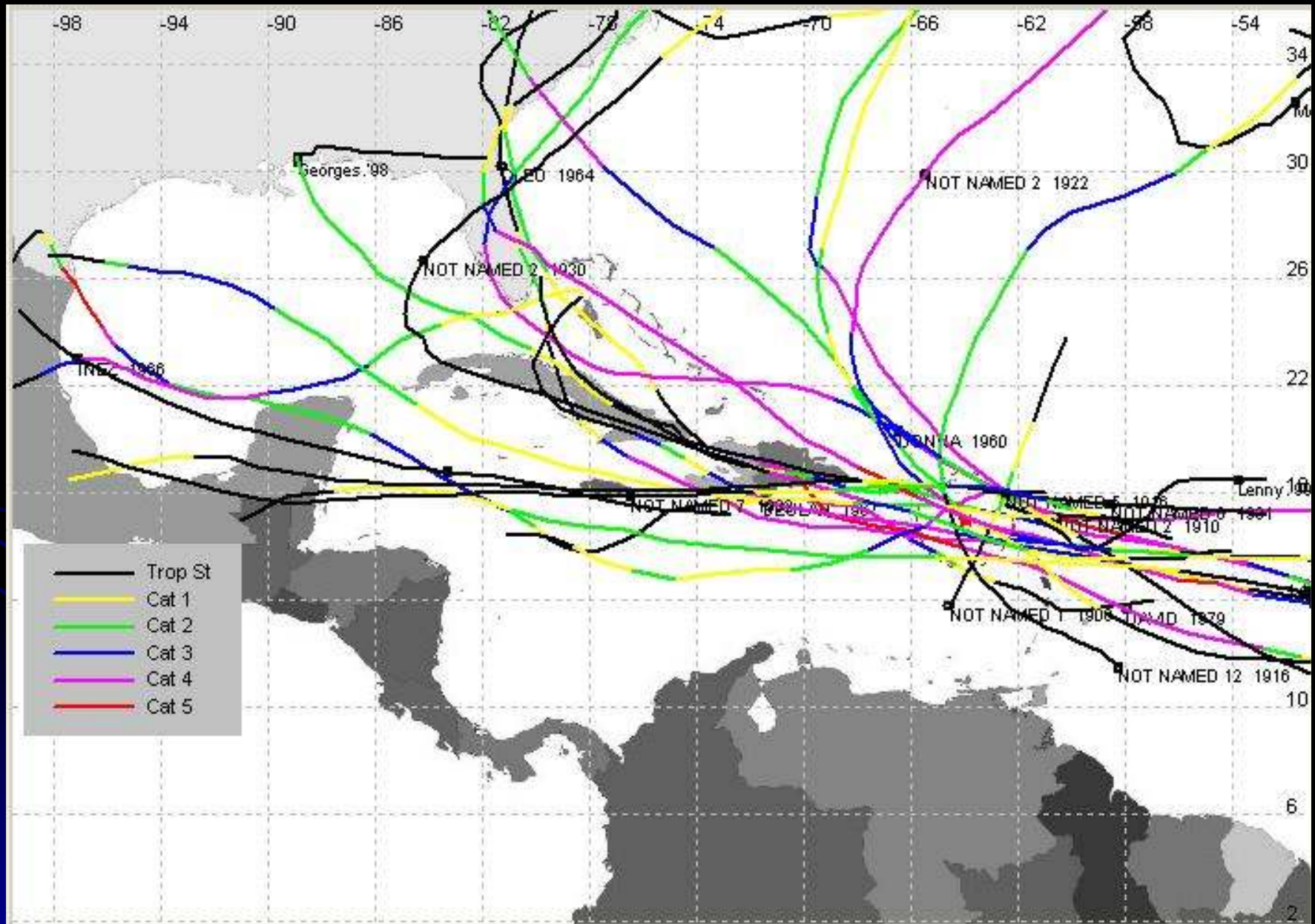
Hazards to Consider

- Hurricanes and Tropical Storms with the attendant effects of wind, storm surge, and flooding
- Droughts
- Earthquakes
- Fire
- Oil spills
- Environmental Health
- Environmental Degradation particularly sand mining;
- Border Security
- Accidents on land and sea, and in the air

Vulnerability Issues

- Multi-hazard exposure
- Low-lying topography and coastal settlements
- Increasing development in sensitive areas
- Destruction of natural protection— mangroves, coral reefs, beaches; inappropriate coastal structures
- High levels of flooding on all islands
- Increasing population with a growing component due to uncontrolled/illegal immigration
- Inadequate awareness of risk by all sectors of the population
- Multi-island jurisdiction
- Institutional capacity to handle the needs.

Hurricanes & the USVI



Lenny, 1999



Photo taken from <http://stormcarib.com/reports/1999/stcroix.shtml>