
STORM IMPACT MODELING ANALYSIS FOR THE RESTORATION OF GULF STATE PARK, AL

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APTIM – Numerical Modeling Lead
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OUTLINE

1. Introduction and motivation

2. Project goals

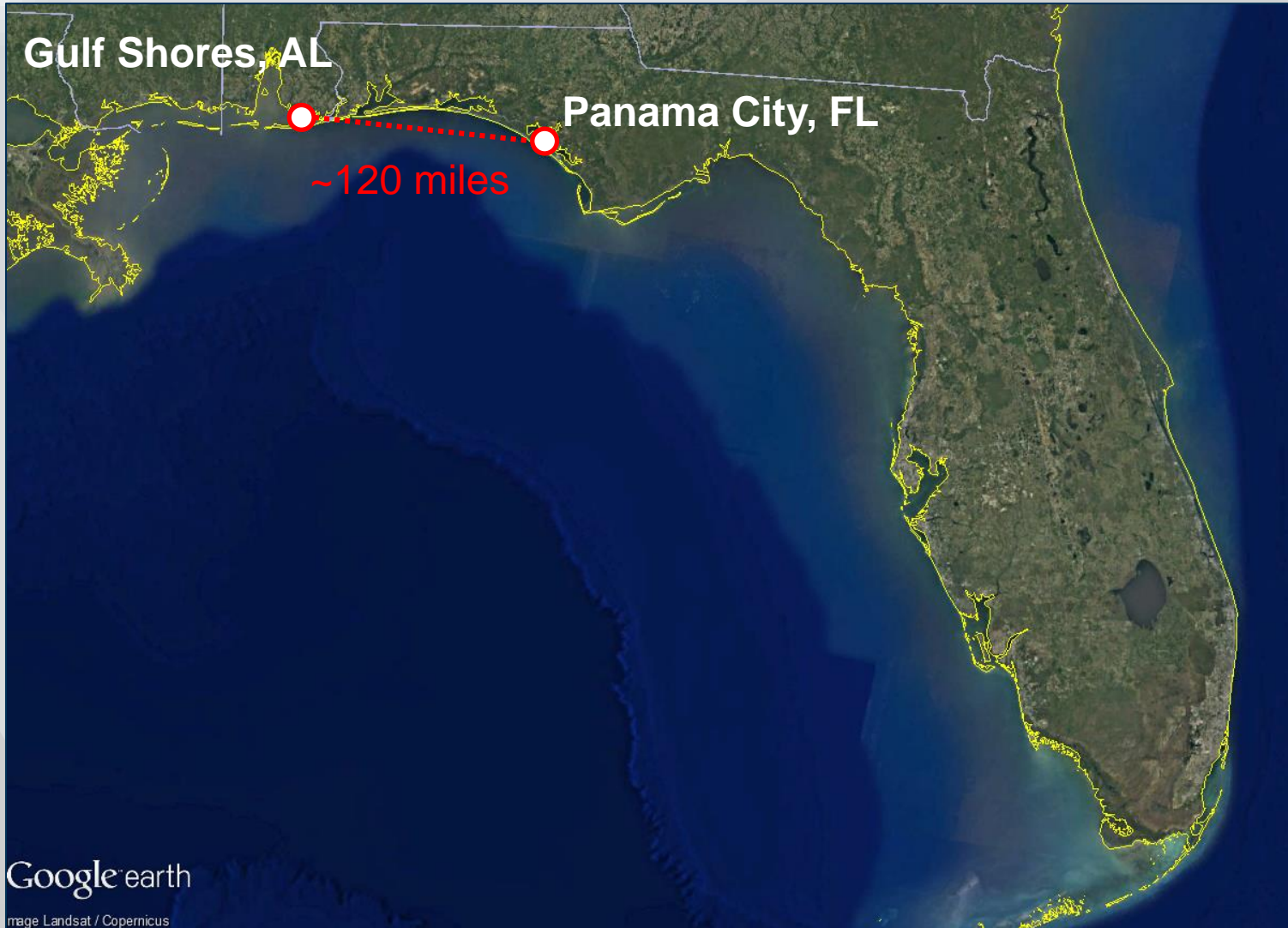
3. Modeling approach

SBEACH

XBEACH

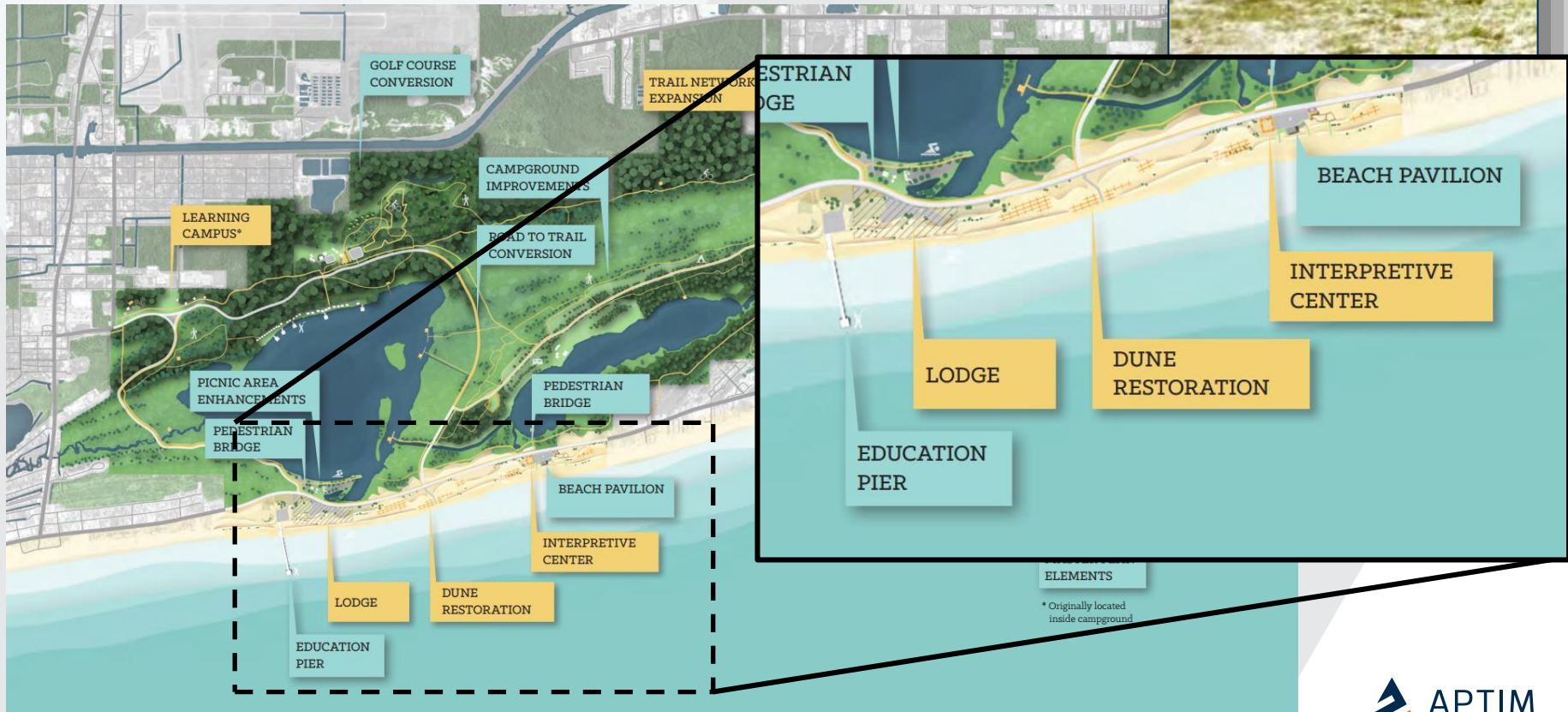
4. Conclusions

GULF STATE PARK (GULF SHORES, AL)



GULF STATE PARK

- 6,500 acres, developed in the 1930s
- Fishing pier, casino, cabins, golf course, hotel
- Approx. 2.3 M visitors/year (average of 6,300 per day!)



GULF STATE PARK: HURRICANE IVAN (2004)



Landfall as a Category 3 hurricane (105 kt)

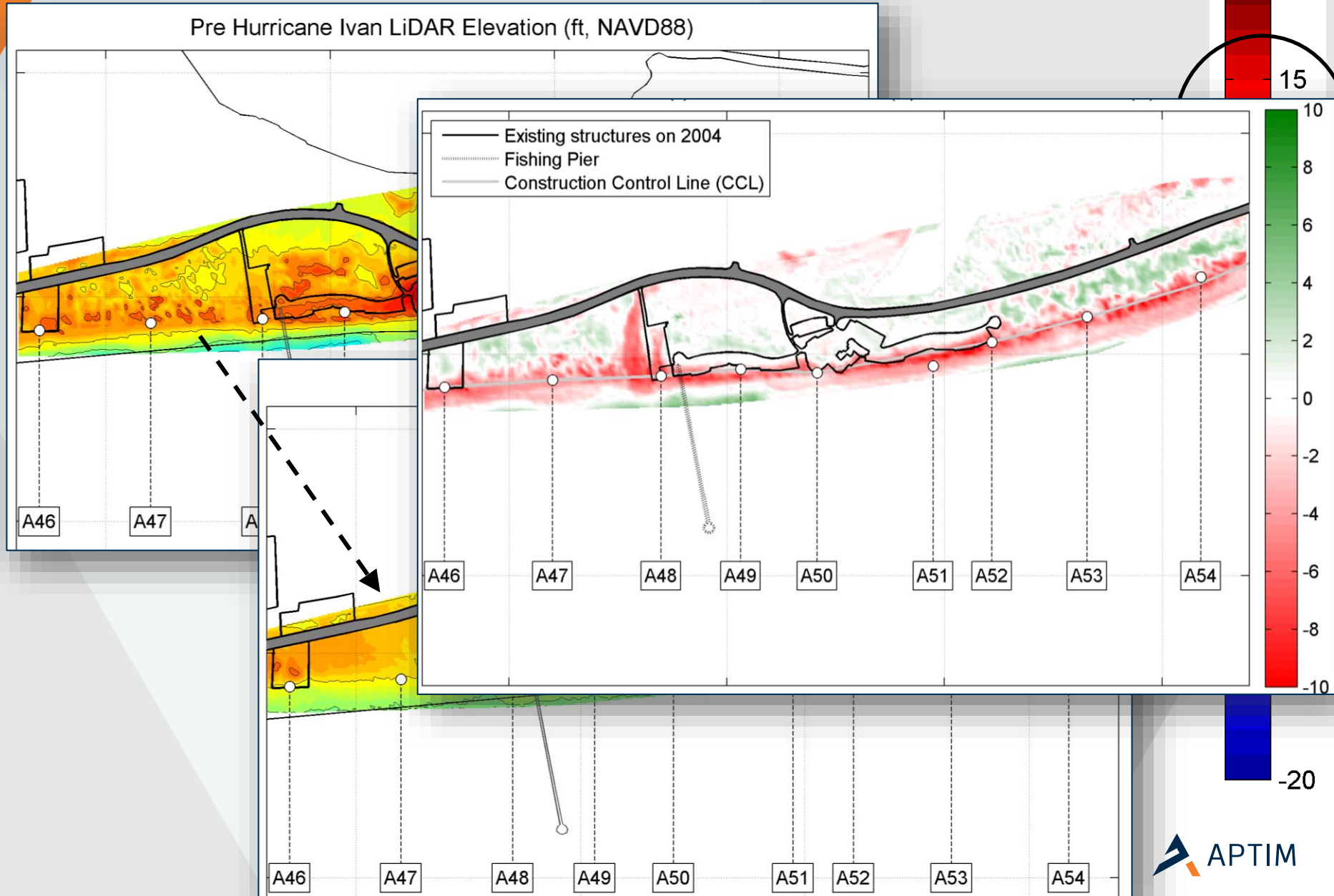
~85% of trees perished

10 -15 ft. storm surge

Cabins washed away, other buildings only frames left

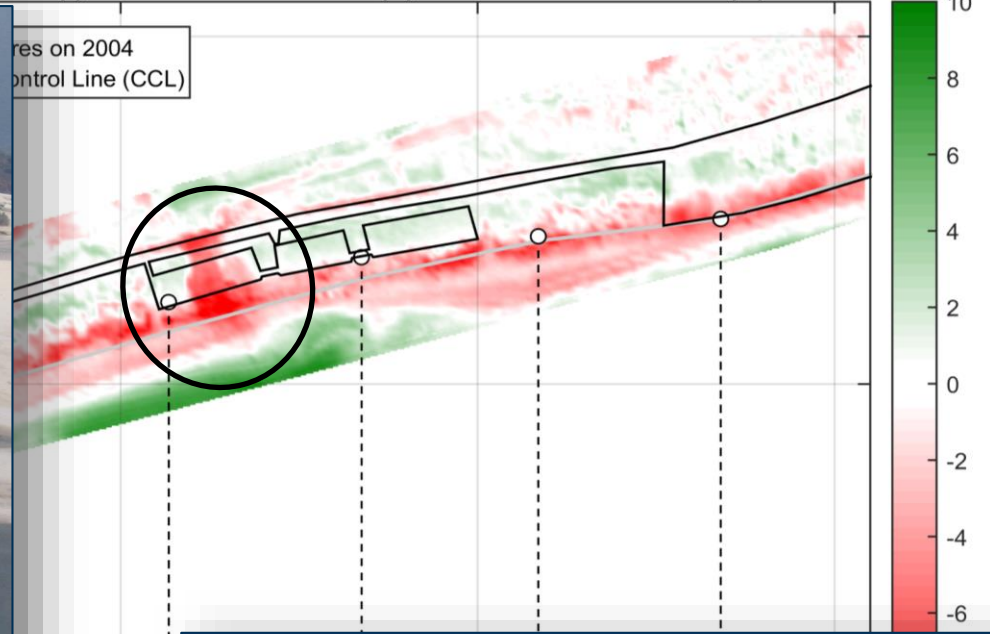
GULF STATE PARK: BEACH AND DUNE EROSION

Pre Hurricane Ivan LiDAR Elevation (ft, NAVD88)



GULF STATE P

LiDAR Erosion (-) and Sedimentation (+) After Hurricane Ivan (ft)



STUDY PURPOSE

Facilitate the redevelopment of Gulf State Park facilities (coastal aspects)

Anticipate response to storm events in the wake of Hurricane Ivan (2004)

Assess the level of protection achieved by proposed dune alternatives

SCOPE OF WORK / PROJECT TASKS:

- Design Storm Determination
- Pre- and Post-Development Conditions
- Cross-Shore Modeling
- Morphological Analysis and Three-Dimensional Modeling
- Wave Loads on Coastal Structures
- Hazard Vulnerability and Risk Analysis/Mitigation
- FEMA Modeling

APTIM'S MODELING APPROACH

Use models as tools to achieve project goals (means but not an end)

1. Identify the appropriate tool(s): processes vs. goals vs. effort
2. Look critically at model results:
 - compare with measurements
 - calibrate the key processes
 - take uncertainties/limitations into account

(model results) + (supplemental analysis) + (expert judgement)

Sound decisions

APTIM'S MODELING APPROACH

“Numerical models for simulating storm-induced beach changes”

SBEACH (1989; USACE) → 1D, cross-shore profile

Empirical relations: waves vs. beach profile changes (experiments performed in large wave tanks)

😊 : time effective, relatively simple to apply, reliable outcomes

😞 : 1-D (profile mode). For example, dune breaching cannot be captured

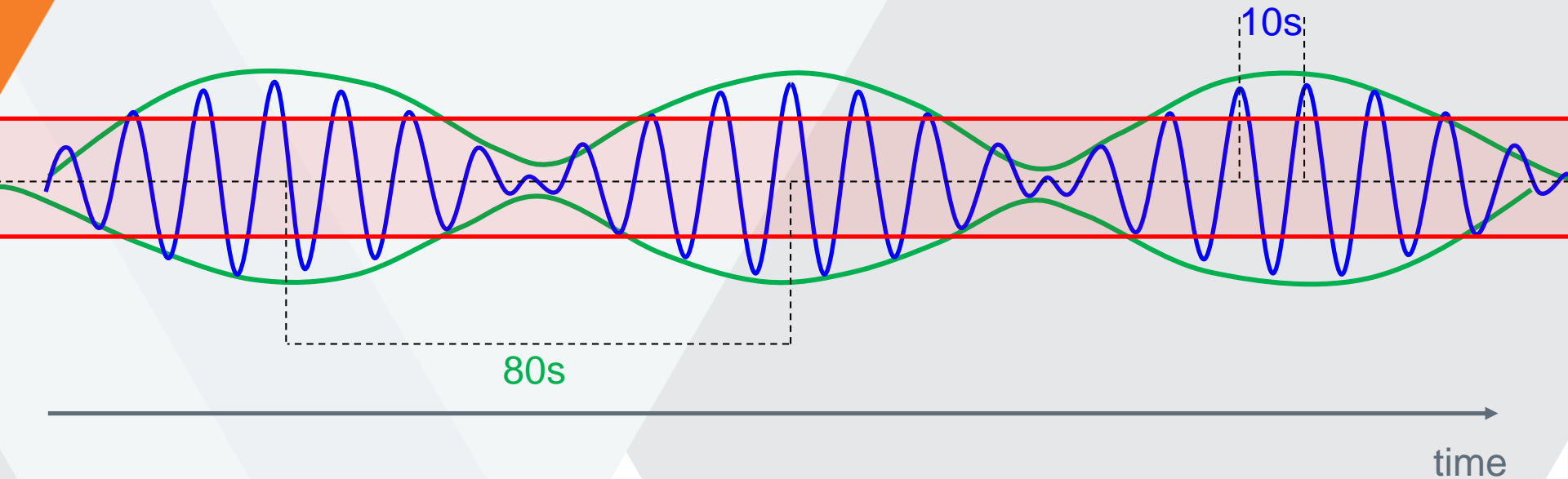
XBEACH (2009; USACE, USGS, Dutch Gov., EU) → “Plan-view”

Process-based model: short and long waves; wave set-up and unsteady currents; bed load and suspended sediment transport, dune face avalanching, bed update and breaching.

😊 : detailed processes in ‘plan-view’, alongshore dimension included

😞 : time demanding, more complicated setup

XBEACH'S CUTTING-EDGE



Delft3D-WAVE, SWAN, STWAVE, Mike21-SW, CMS-Wave ($H_s = H_s$)

Variations in hours or more

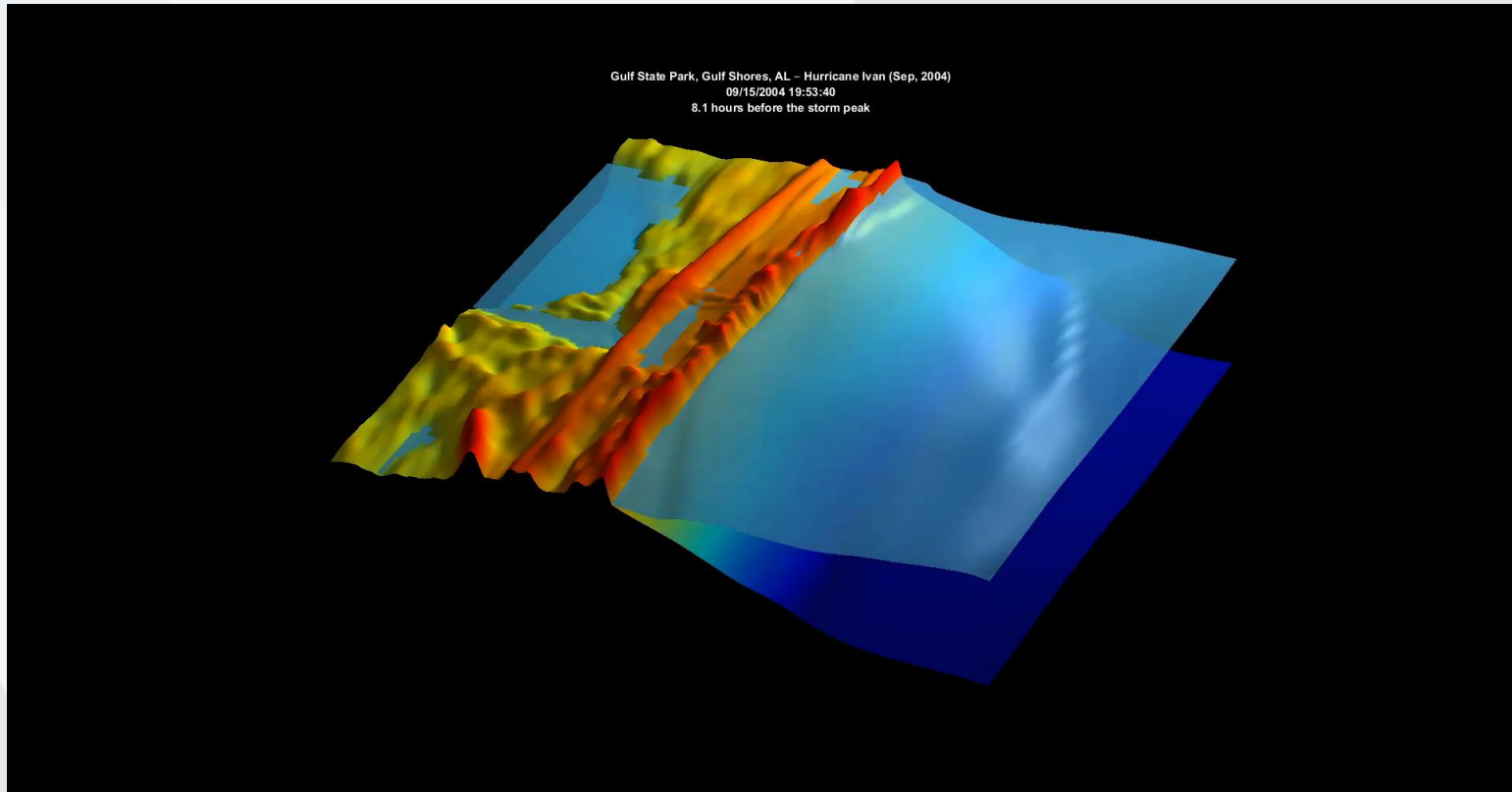
XBeach ($\overline{H_s} = H_s = H_s$) :

Variations in minutes or more (wave groups/sets)

- Infragravity waves ($30s < T < 5min$)
- Run-up & overwash

very relevant during storms


XBEACH DIFFERENTIAL

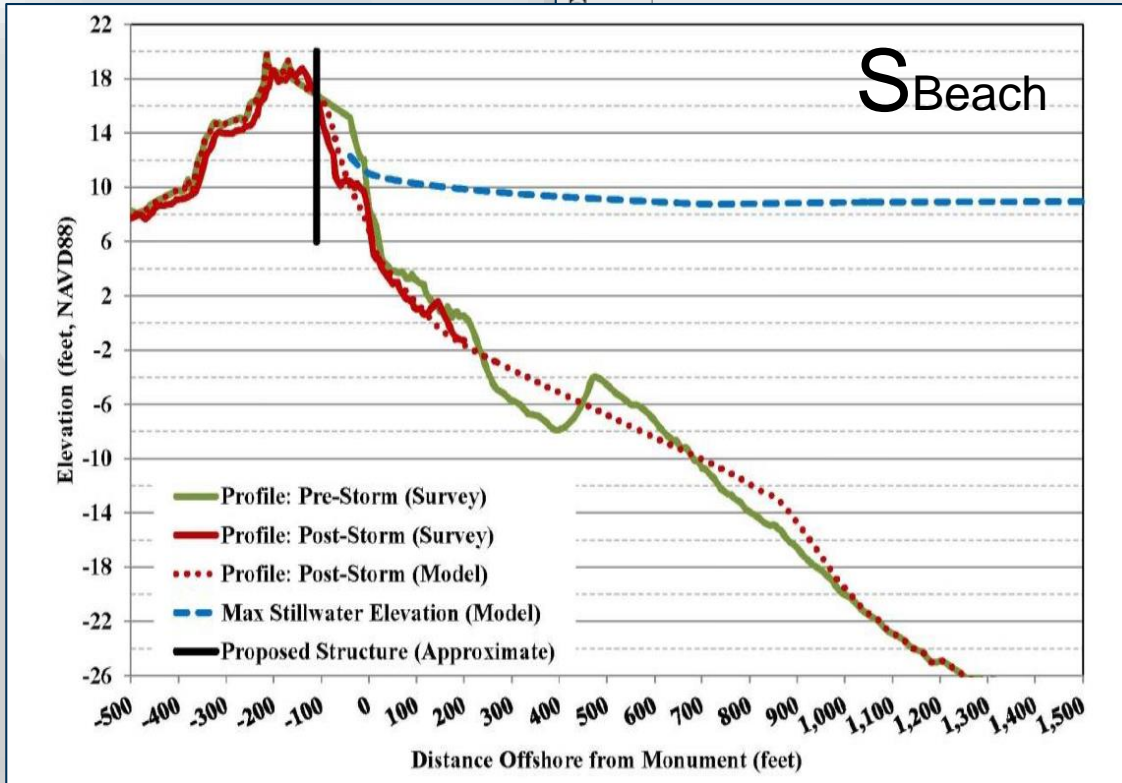
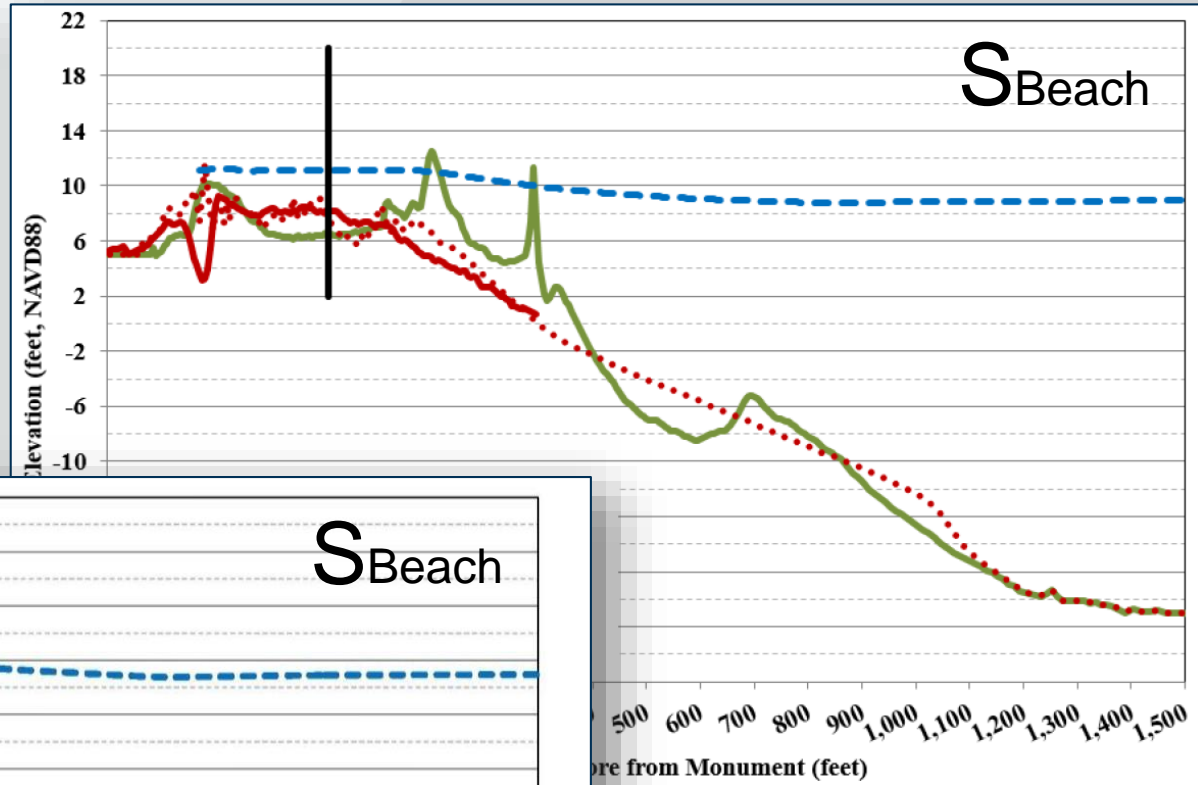


PROFILE CALIBRATION (SBEACH)

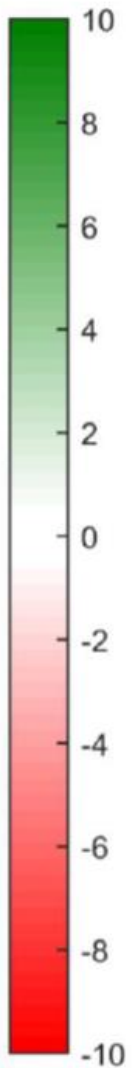
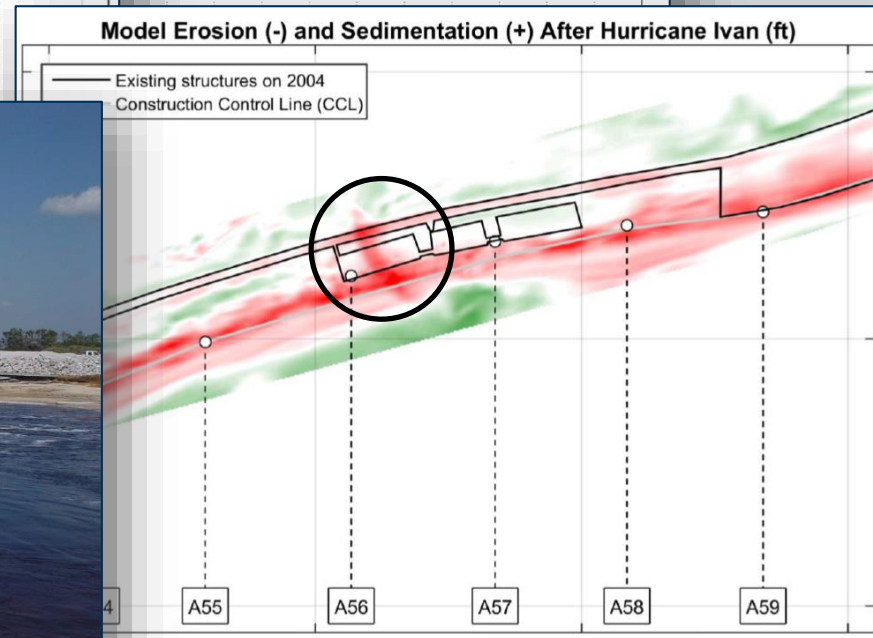
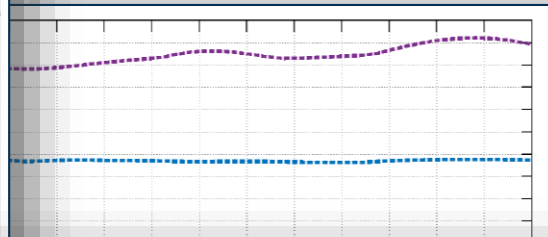
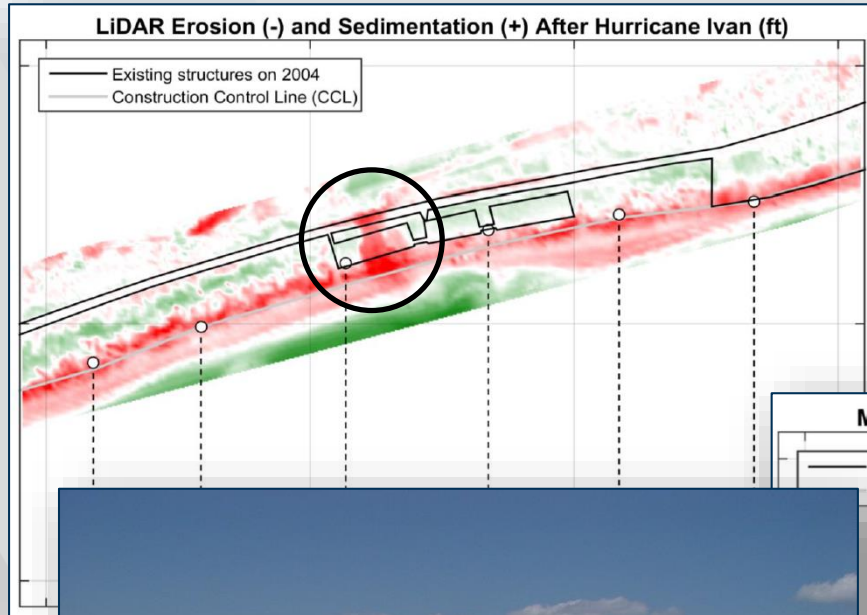
Pre-storm 

Post-storm 

Post-storm (model) 
(model)

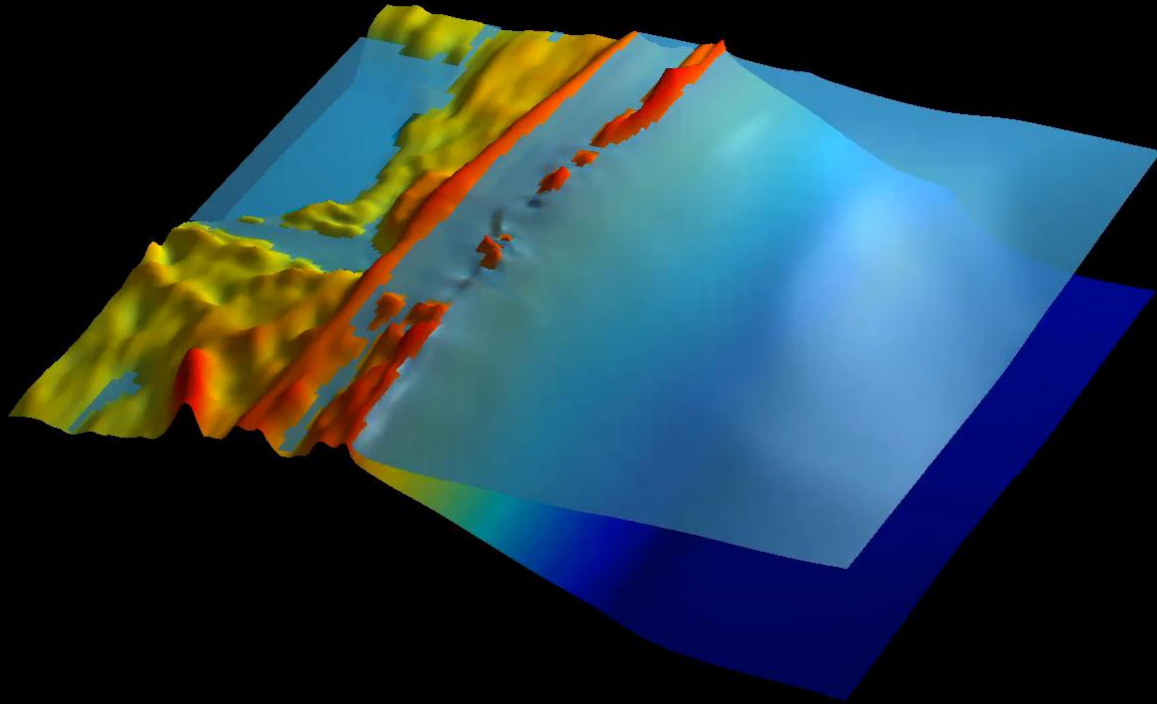


MAP CALIBRATION (XBEACH ONLY)



XBEACH CALIBRATION

Gulf State Park, Gulf Shores, AL – Hurricane Ivan (Sep, 2004)
09/15/2004 23:07:40
4.9 hours before the storm peak



PRODUCTION RUNS

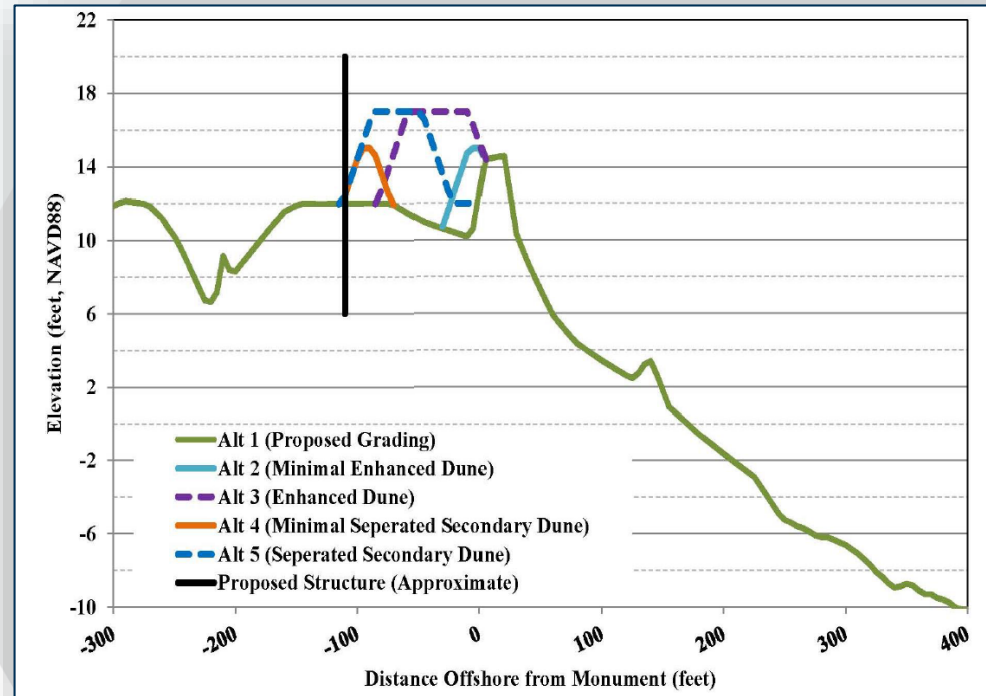
SBEACH: 20, 25, 30, 50 and 100
Year Storm events

XBEACH: 5, 10, 30, 50, 100
Year Storm events

Existing topo/bathymetry
+ Proposed site grading + structures
+ 4 dune alternatives
+ Dune cuts

Type of outputs:

- Extent of erosion from CCL
- Erosion + Scour (desktop analysis) near structures
- Breaching vulnerability near constructed areas
- Horizontal forces on structures
- Vulnerability and Risk Analysis/Mitigation
- Flood zone mapping (FEMA / CHAMP 2.0)



INTERPRETIVE CENTER

CONSTRUCTION PROGRESS – DEC. 2017

- Safe pedestrian connection to the park trail system
- Interpretive Porch containing interactive introduction to the park environment
- Sand & water play area for children
- Design setback to allow for dune regrowth
- Meeting space for organizations and educational events



Interpretive Center Construction Progress - Dec 2017

Source: www.MyGulfStatePark.com

LODGE

CONSTRUCTION PROGRESS – DEC. 2017



Source: www.MyGulfStatePark.com

CONCLUSIONS

(modeling tools) + (engineering analysis) + (expert judgement)

Better understanding of the system's response to extreme events

- Gives confidence to stakeholders regarding redevelopment plans

Developing and confirming design criteria

- Loads, siting, elevation of dunes and structures

Anticipate system's response to dune restoration alternatives

- Optimize performance, cost/benefit assessments
- Identify impacts to adjacent areas

THANK YOU!

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