Arrecife Condado

By:
Francisco Inserni, Esq., Arrecife Condado, Inc.
Alfredo Torruella, Ph.D., Principal, Caribbean Oceanography Group
Fernando Pagés Rangel, P.E., Director, Tetra Tech, Inc.

Interagency Meeting
November 4, 2015
San Juan, Puerto Rico

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Tt

Project: Arrecife Condado

- History
  - Community Based Initiative since 2008
  - Arrecife Condado, Inc.
- How it evolved
- Why it evolved

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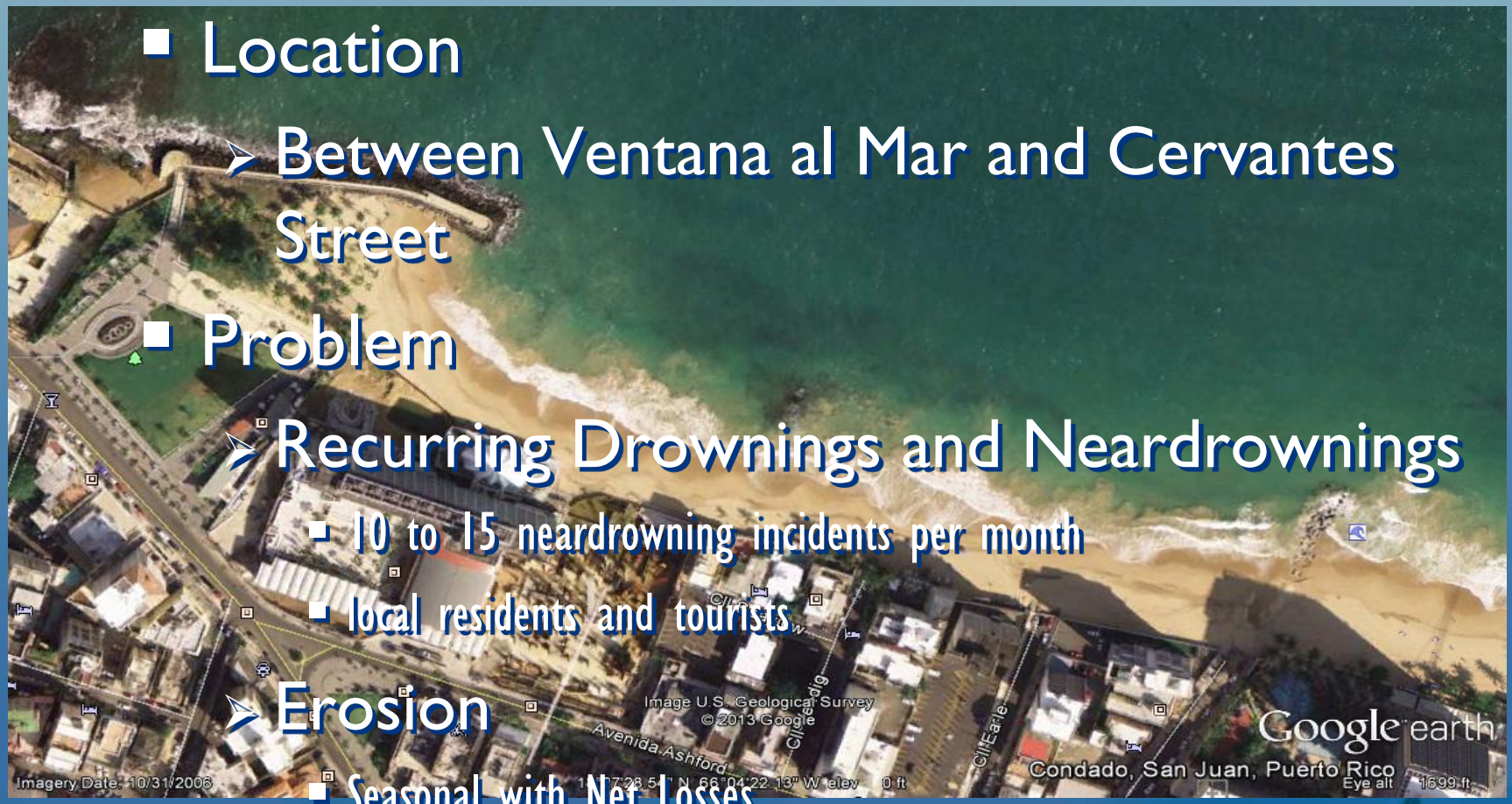
Project: Arrecife Condado

- Location
  - Between Ventana al Mar and Cervantes Street
- Problem
  - Recurring Drownings and Neardrownings
    - 10 to 15 neardrowning incidents per month
    - local residents and tourists
  - Erosion
    - Seasonal with Net Losses
    - Extreme Events Irreversible Losses



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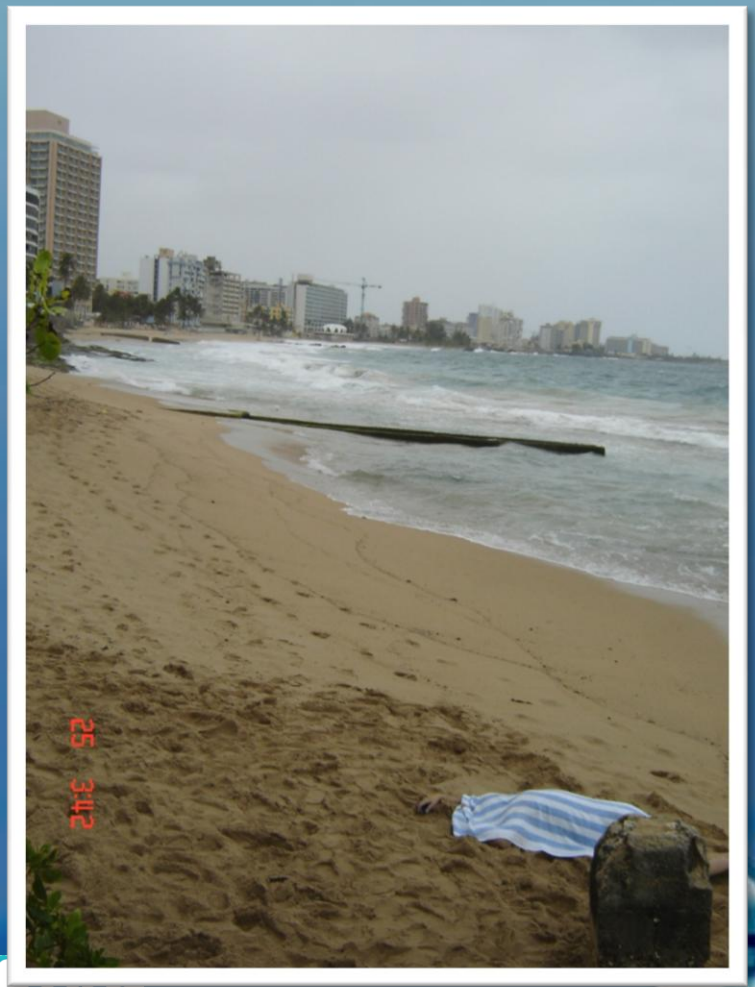
Deadly Tourist Attraction
January 25, 2005



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Beach Erosion in Front of La Concha

Photo by: Jose Suarez

December 30, 2010

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Project: Arrecife Condado

- Who's affected?
  - Local Beachgoers and Residents
    - > 150,000 people
  - Tourist in Condado and San Juan Areas
    - > 700,000 Per year
  - Commercial Businesses
    - Hotels & Guest Houses (over 20 in the area)
    - Water sports & recreation
    - Restaurants and bars

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Project: Arrecife Condado

- What's the Solution?
  - Mitigate Dangerous Currents
  - Mitigate Erosion
  - Marine Ecosystem Restoration
  - Create Recreational Opportunities
  - Create Educational Opportunities
  - Pilot Project for PR

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Who's Involved?

- Arrecife Condado, Inc.
  - Community Based Initiative - 2008
  - F. Inserni, W. Butler, M. Serbia
- Hotels
  - La Concha & Vanderbilt
- PR Agencies
  - Central Govt', SJ Municipality, SJ Bay Estuary Program, PR Tourism Co.

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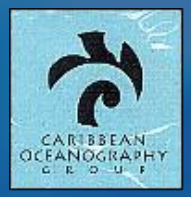
Who's Involved?

- Federal Agencies
  - NOAA, USFWS, USACE, USEPA
- Technical Advisors
  - Caribbean Oceanography Group
  - Tetra Tech, Inc.



Stakeholders

- Municipality of San Juan
- P. R. Department of Natural and Environmental Resources
- P. R. Environmental Quality Board
- P. R. Tourism Company
- S. J. Bay Estuary Program
- U. S. Army Corps of Engineers
- U. S. Environmental Protection Agency
- U. S. Fish & Wildlife Service
- National Oceanographic & Atmospheric Administration
- Puerto Rico Hotel & Tourism Association
- Puerto Rico Planning Board
  - Economic Development Administration
- Community and Environmental NGOs
  - Con-vive
  - Renace Condado

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What's been done to date?

- Biological Baseline Study
- Bathymetric Surveys (sea bottom topo)
- Field data collection for model calibration
  - Wave & Current Measurements
- Hydrodynamic Modeling – Mike 21
- Wave and Wind Climate Analyses
- Sediment Compatibility Analysis
- Conceptual Design and Layouts
- Private Investments > $100k

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Benthic Characterization and Mapping

- Sandy Bottom at Artificial Reef Location
- Patch Reef inside from 2.3m to 3.5m depth
- Turtle Grass

Figure 1. Benthic habitat map of the study area in the beachfront of La Concha Hotel, Condado.

Plate 1. Sandy bottom

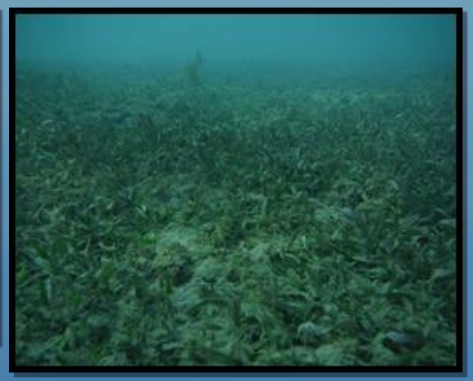

Plate 1. Turtle grass bed

Plate 1. Patch reef

Plate 1. Mixed school of doctorfishes (Acanthuridae) at the outer patch reef edge

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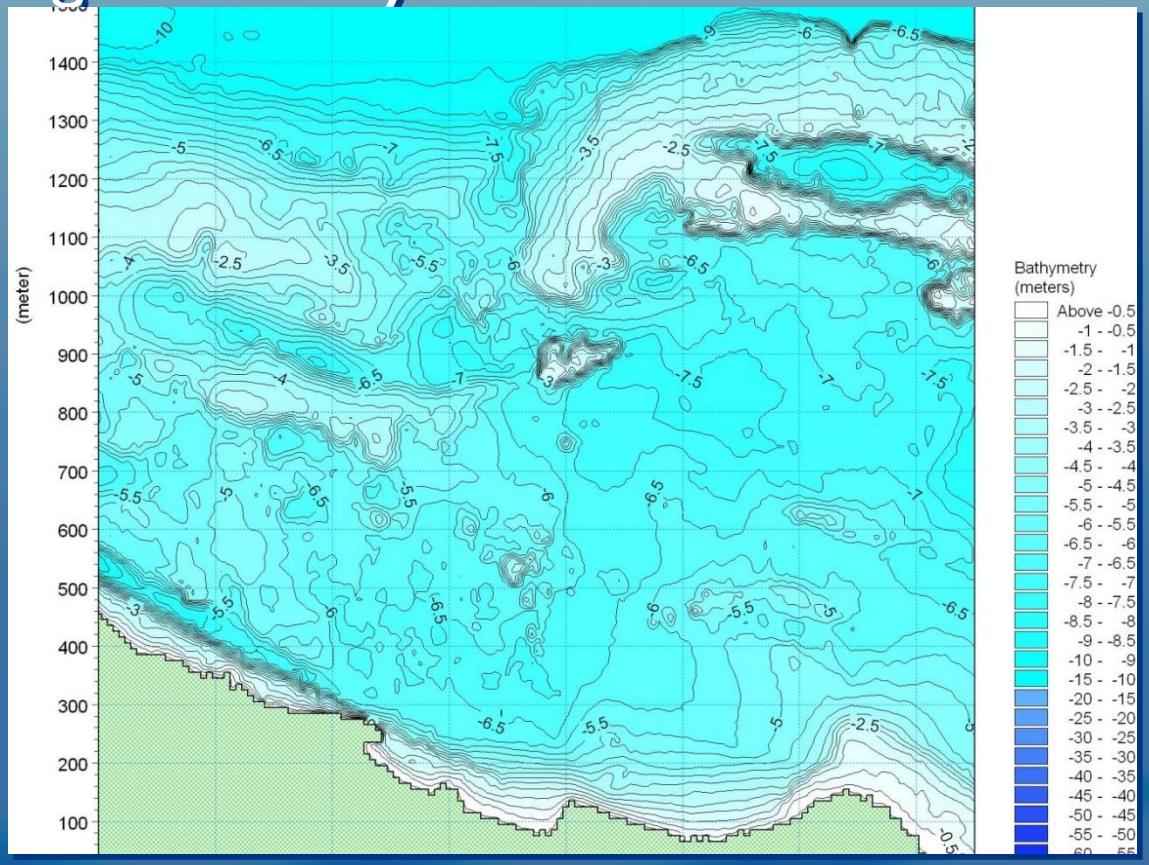
Existing Data and Studies

- Regional Bathymetric Data Available



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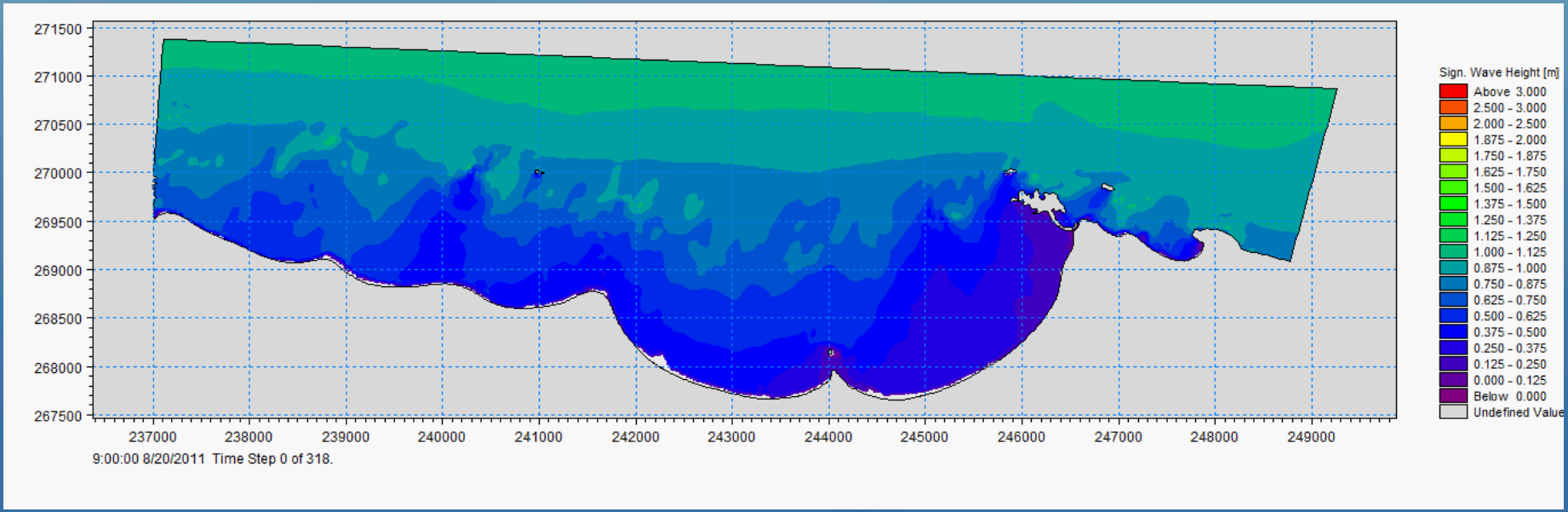
Existing Data and Studies

Regional Numerical Models Available



Jaime R Calzada, M.Sc, UPR
Dr. Alfredo Torruella, UPR

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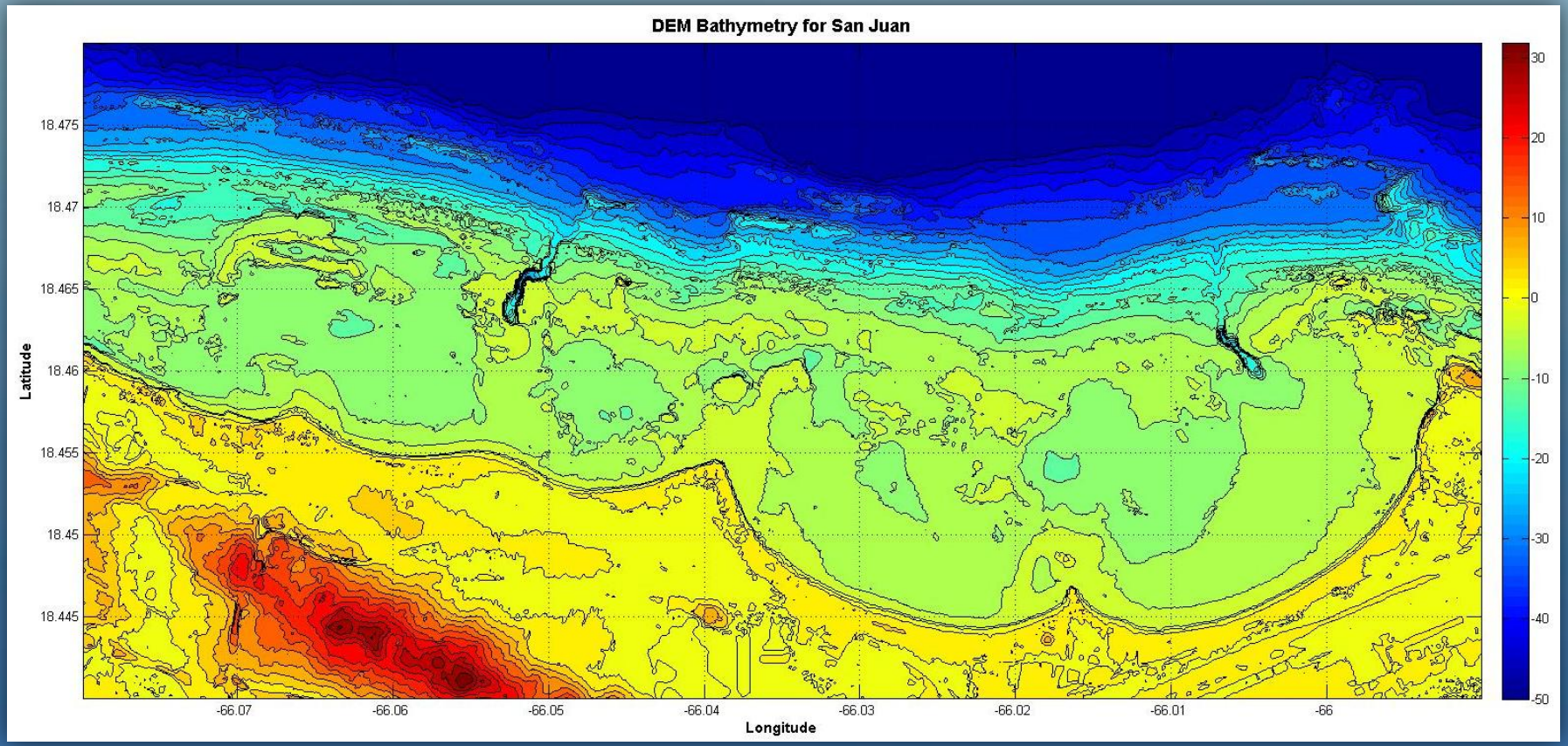
Regional Bathymetry



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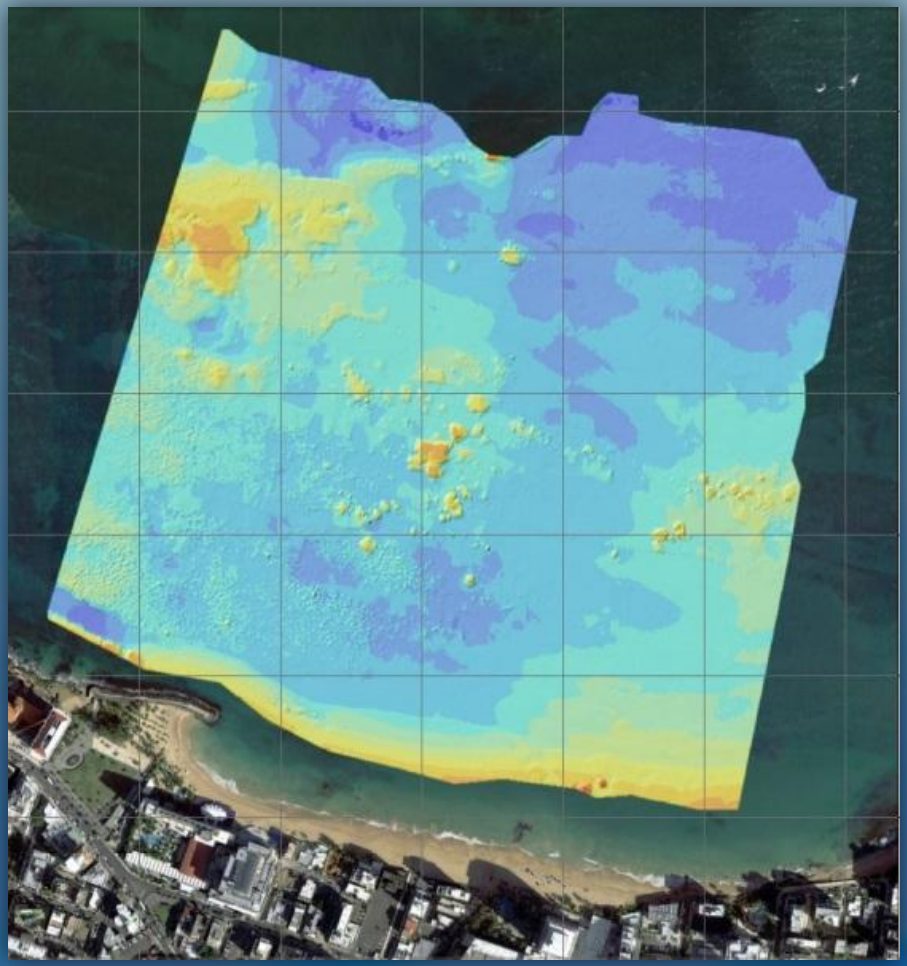
Site Bathymetry



High-resolution
Multi-Beam Sonar
by Tetra Tech, 2015

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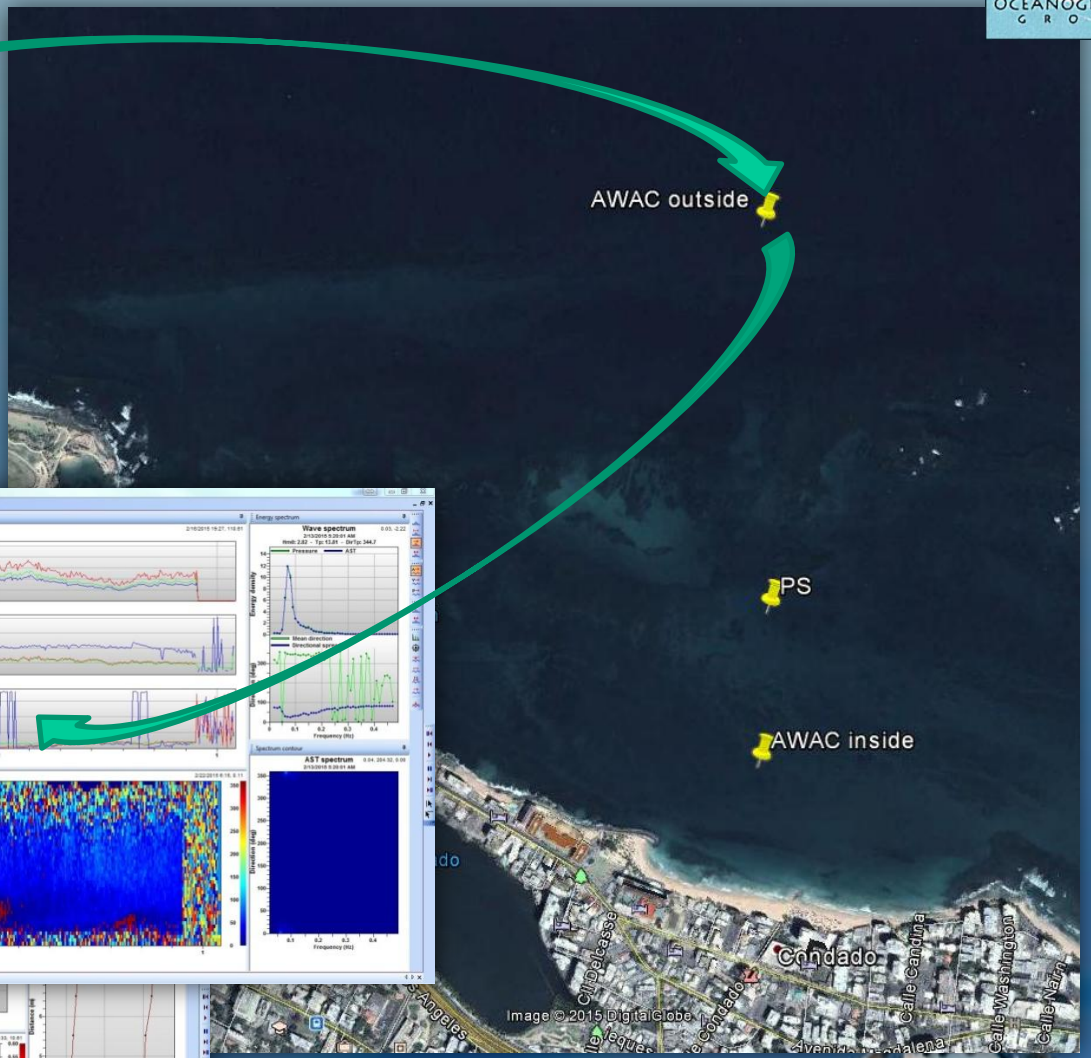
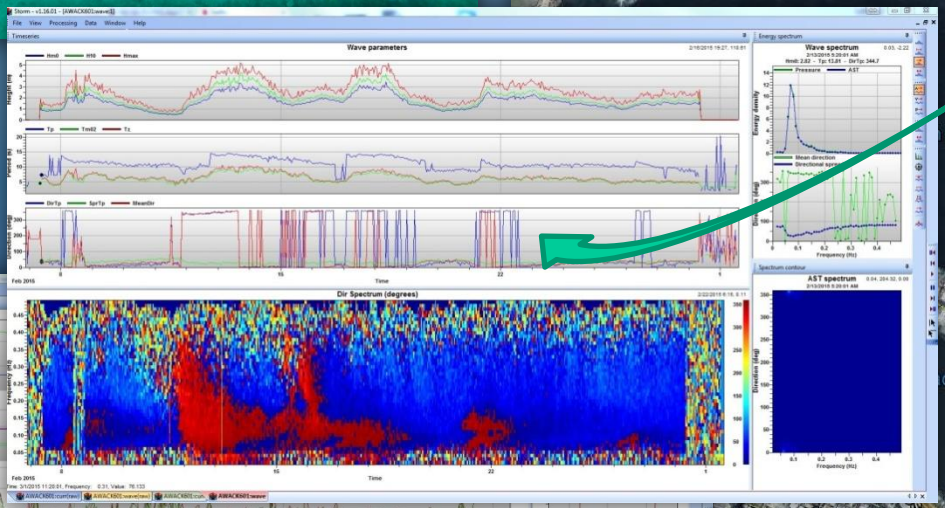
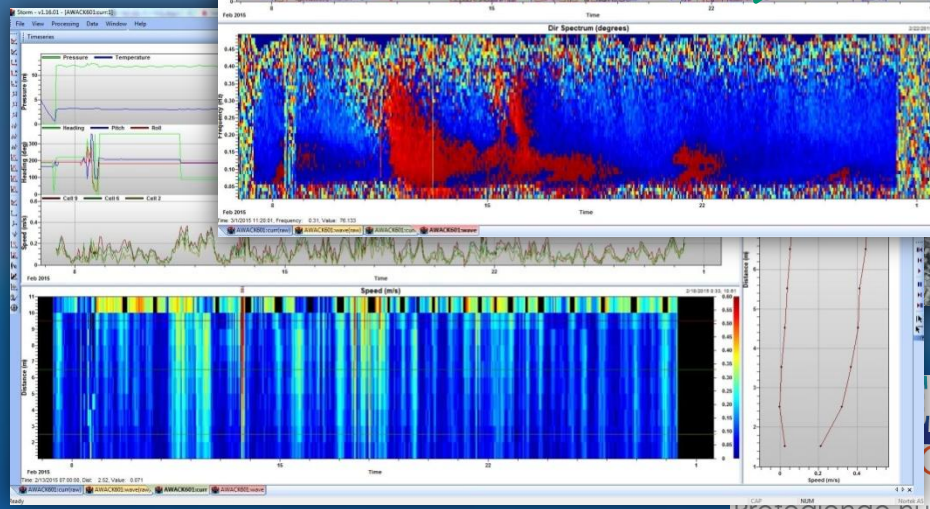
Model Calibration







CIEE Condado
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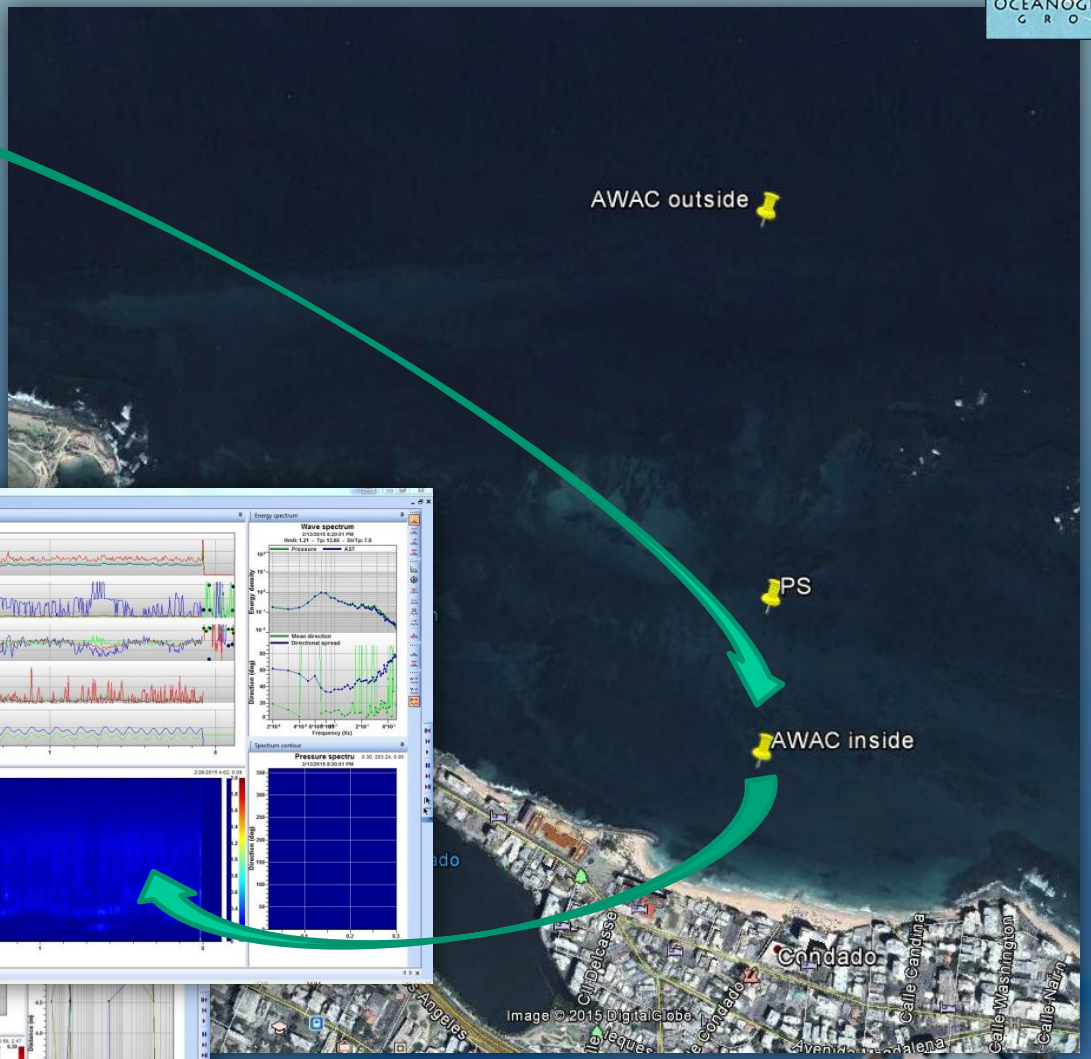
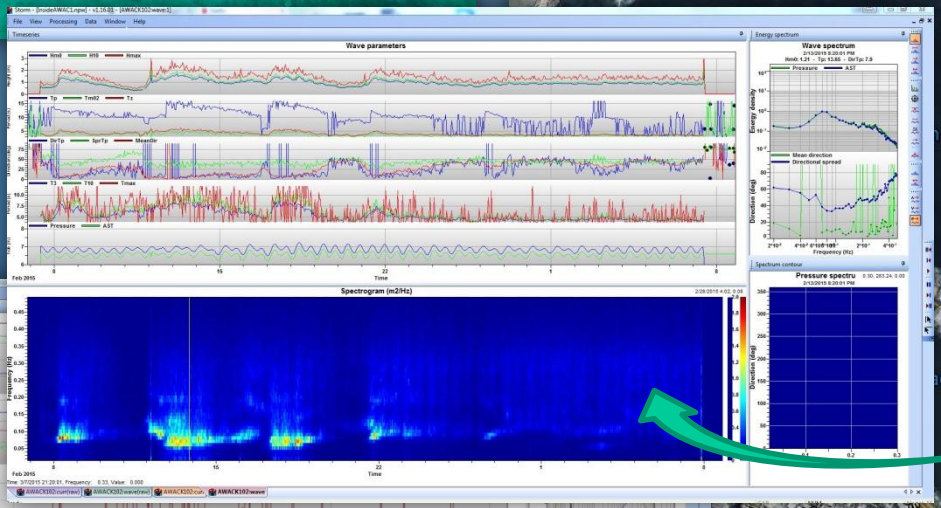
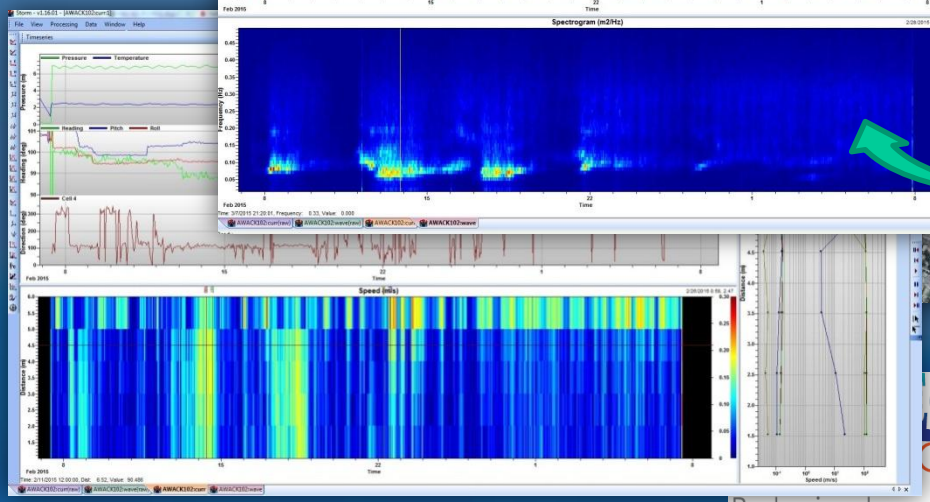
Model Calibration







Condado

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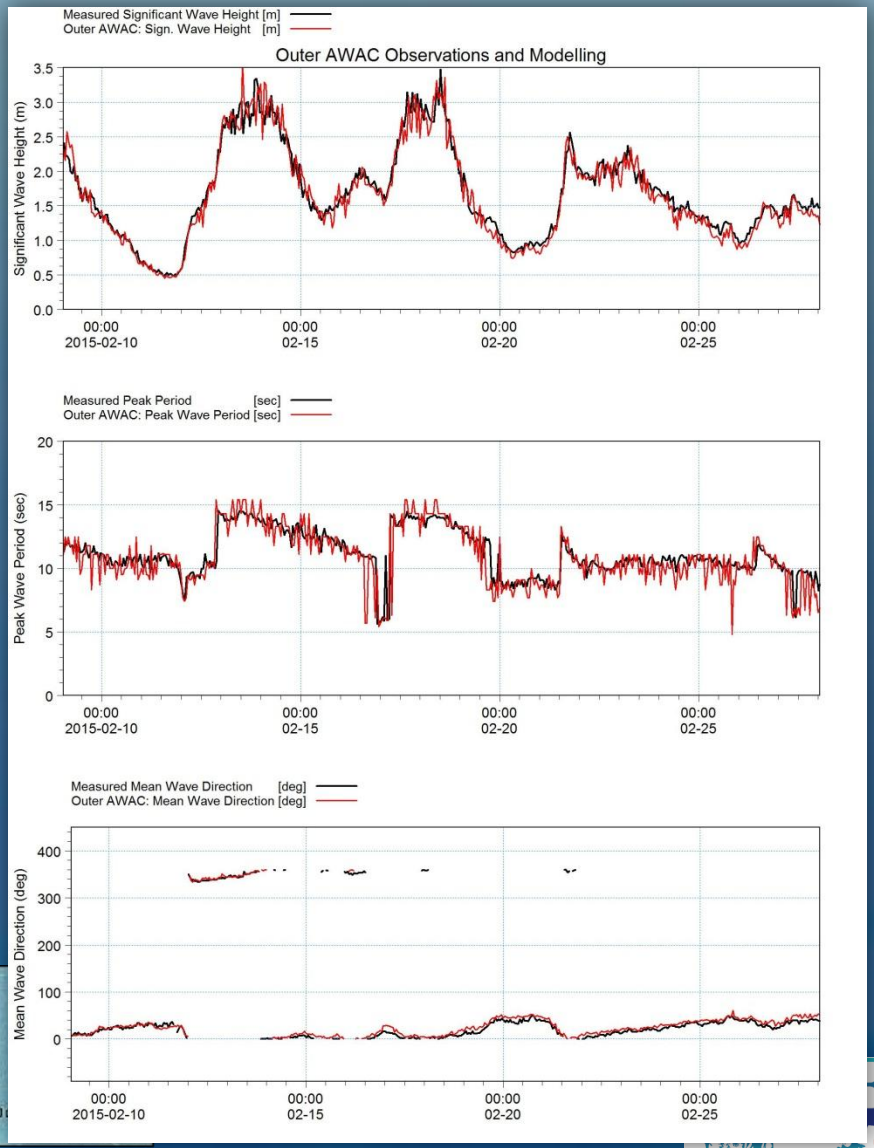
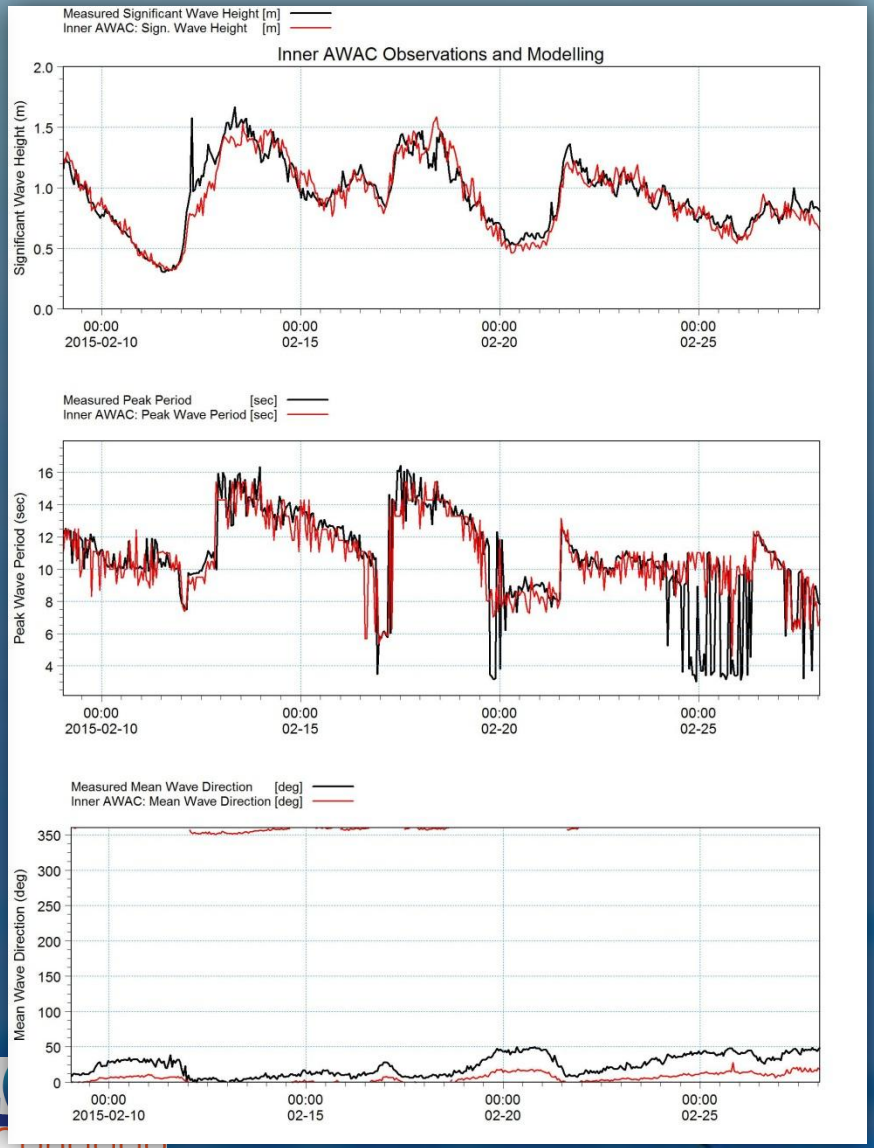
Model Calibration





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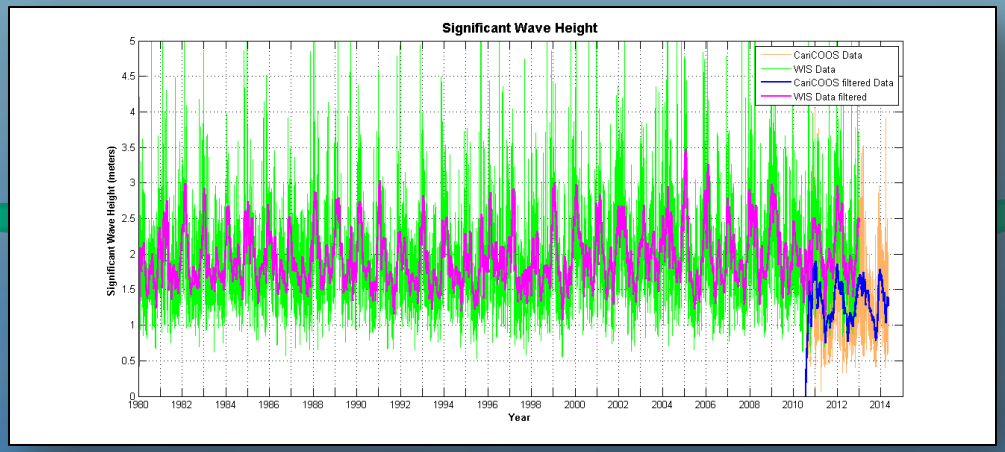
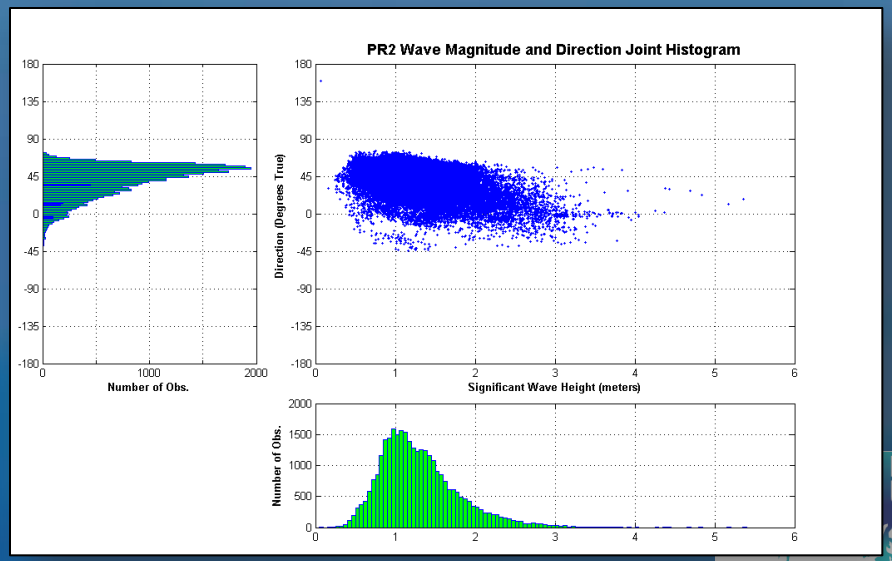
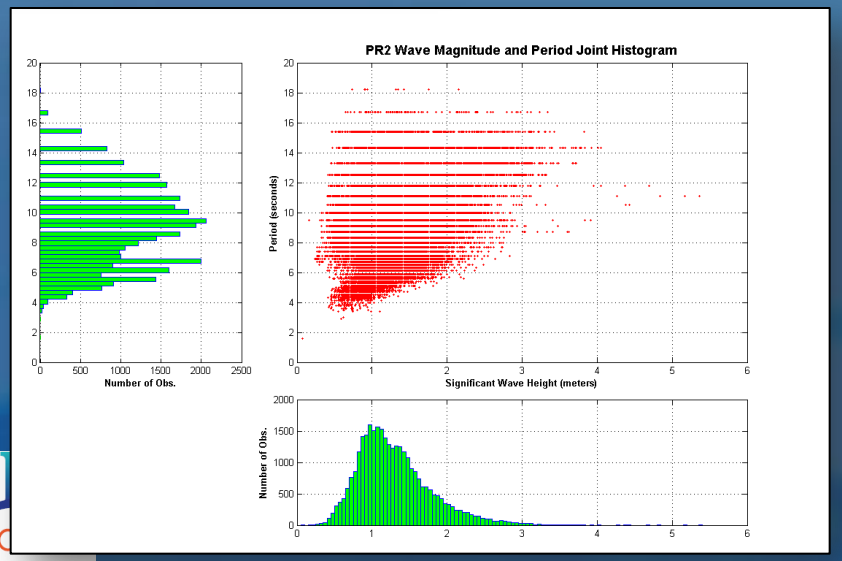
Wave Forcing
(from Wave & Wind Climate Analysis)







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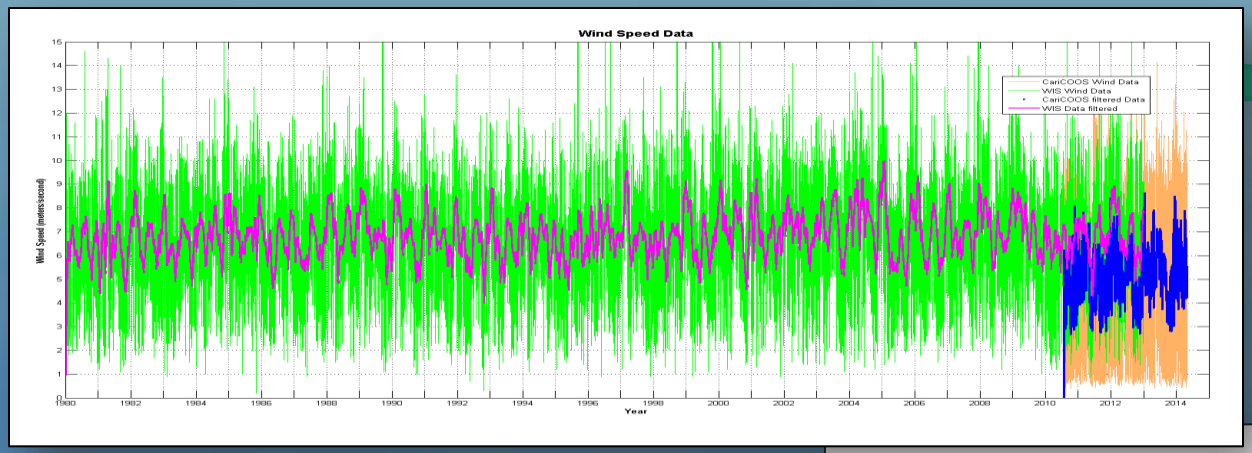
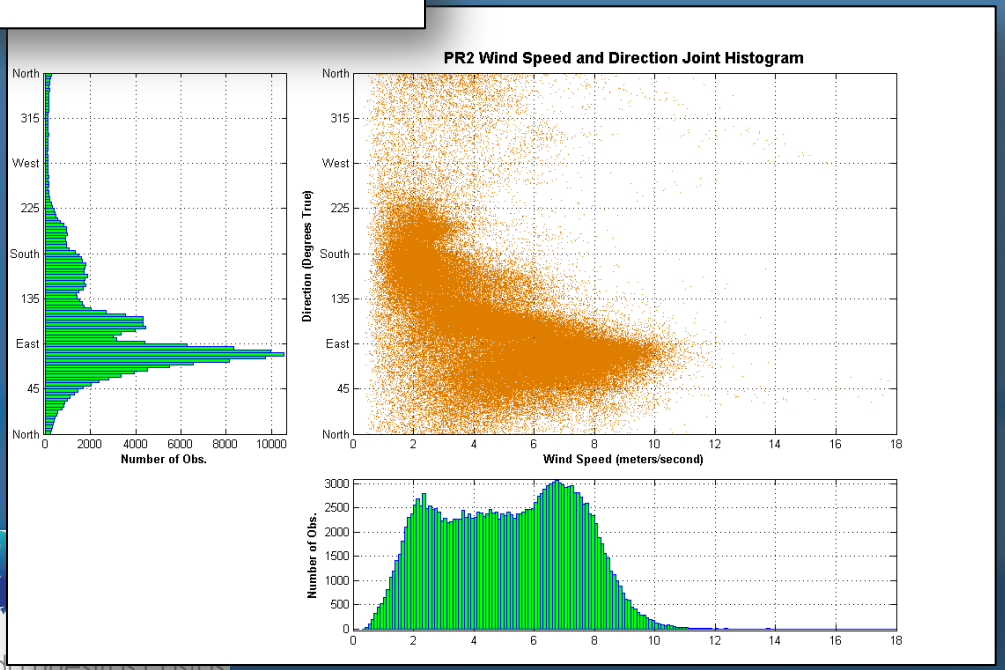
Wind Forcing
(from Wave & Wind Climate Analysis)





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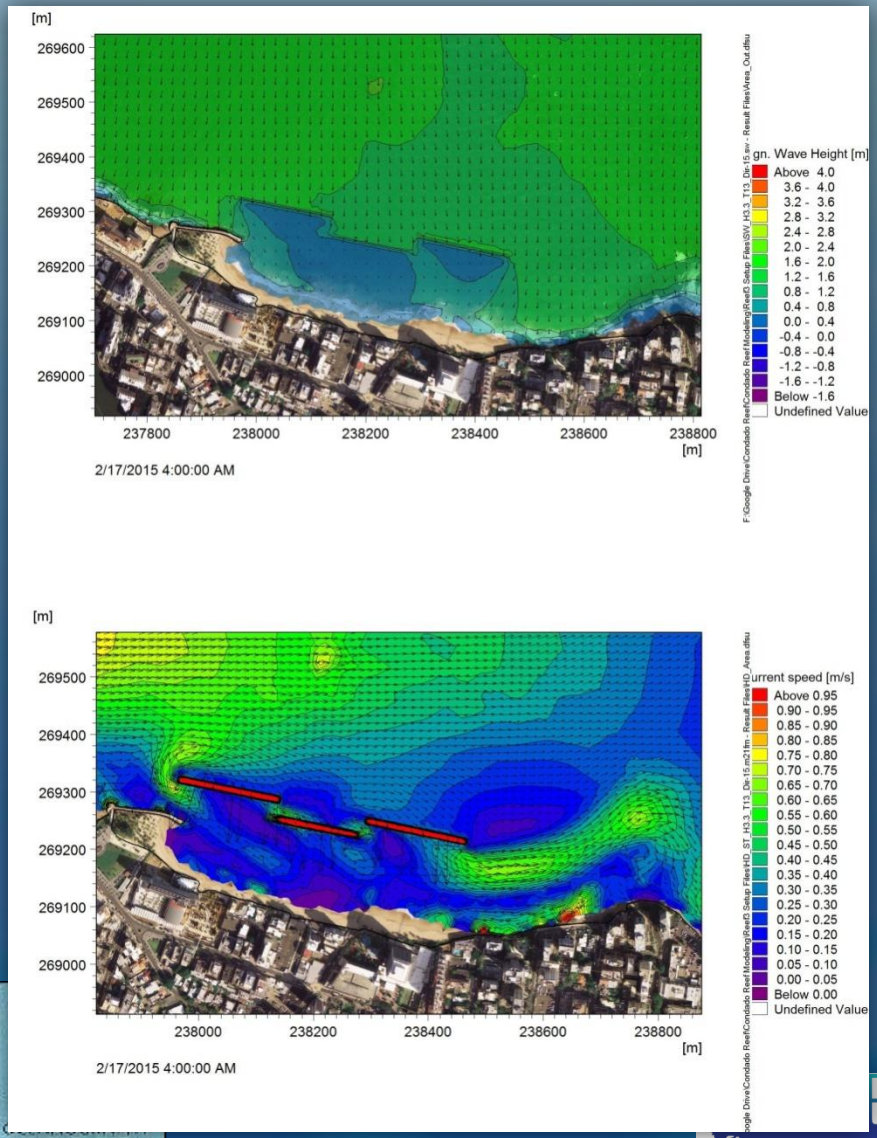
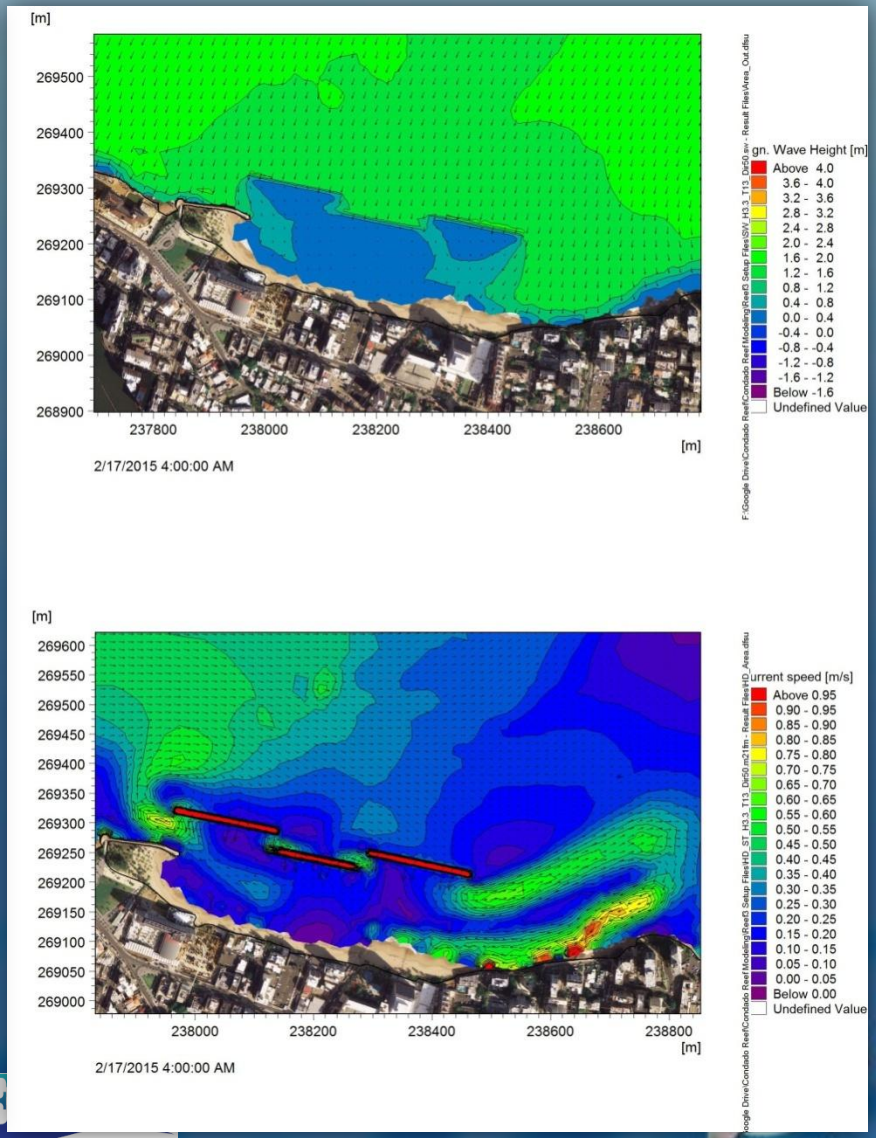
Artificial Reef Solutions





Hm_0 = 3.3 m, T = 13 s, Dir. = -15˚

Hm_0 = 3.3 m, T = 13 s, Dir. = 50˚

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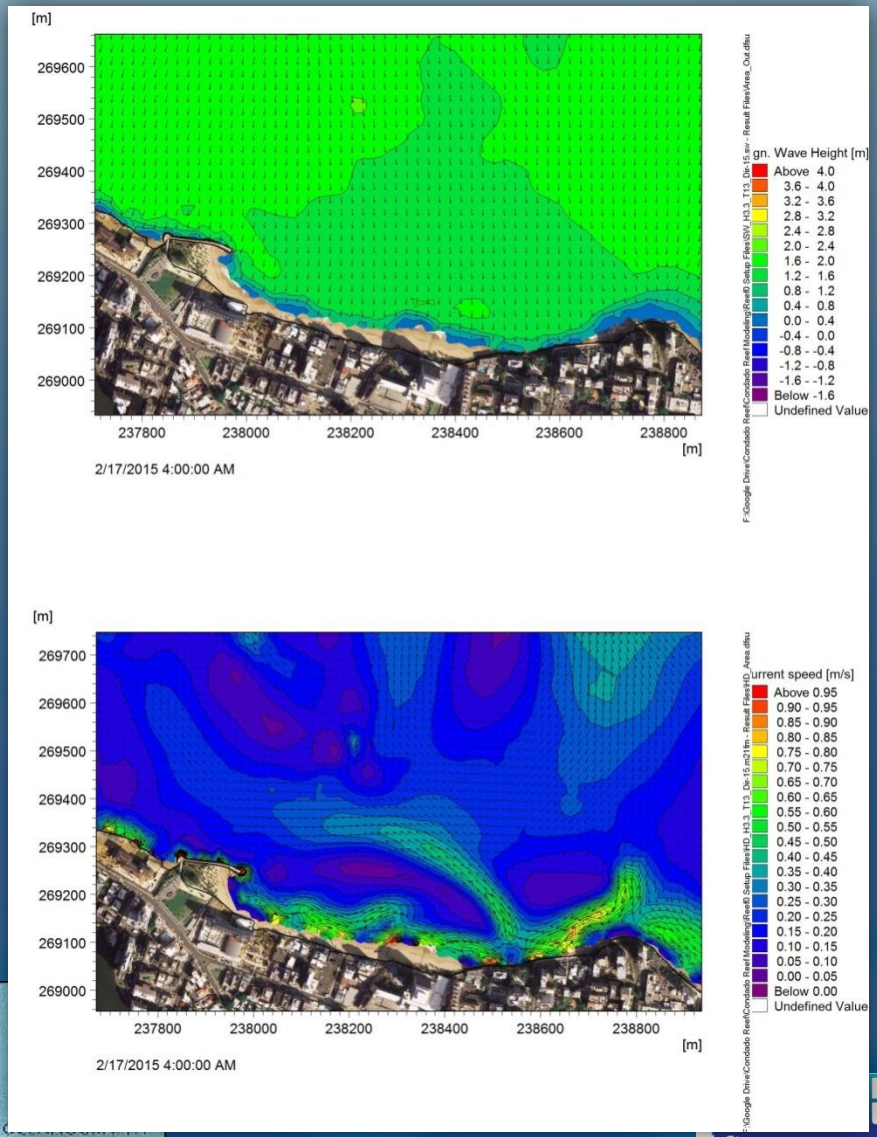
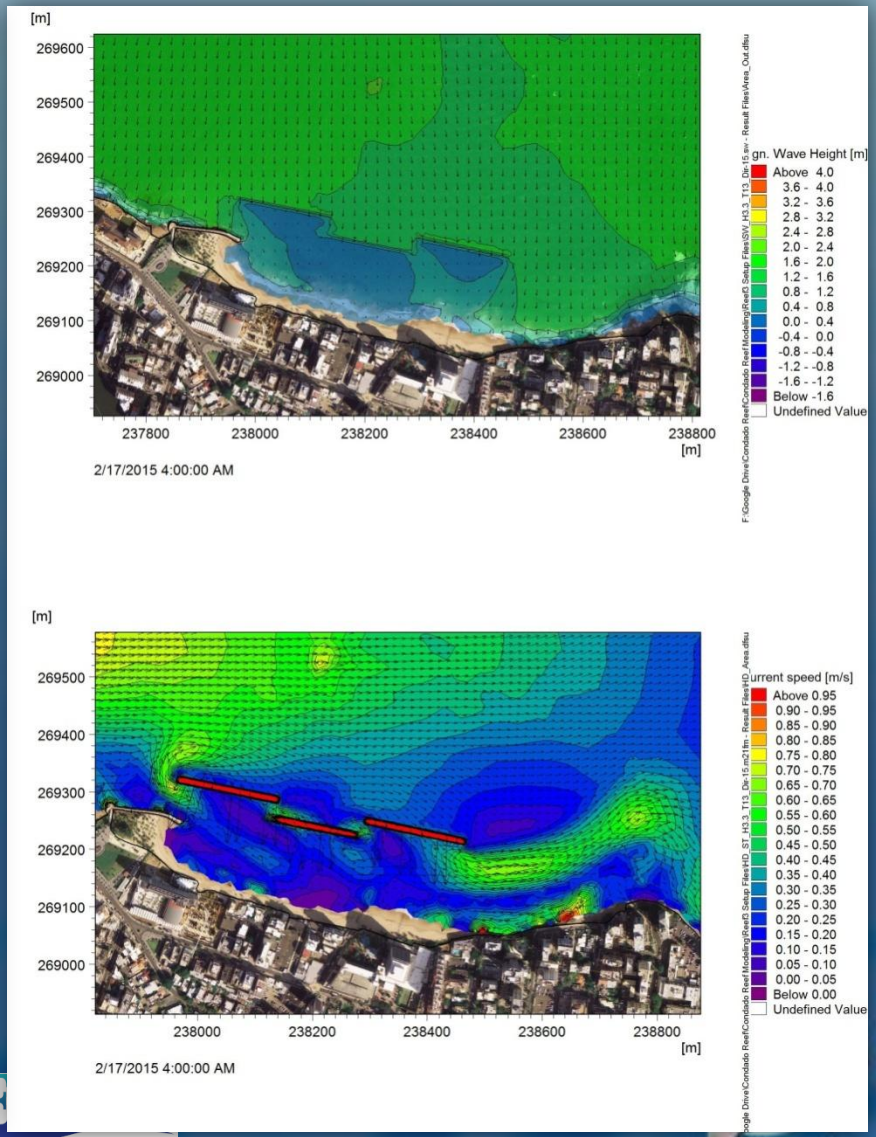
Evaluation of Results





Hm_0 = 3.3 m, T = 13 s, Dir. = -15˚

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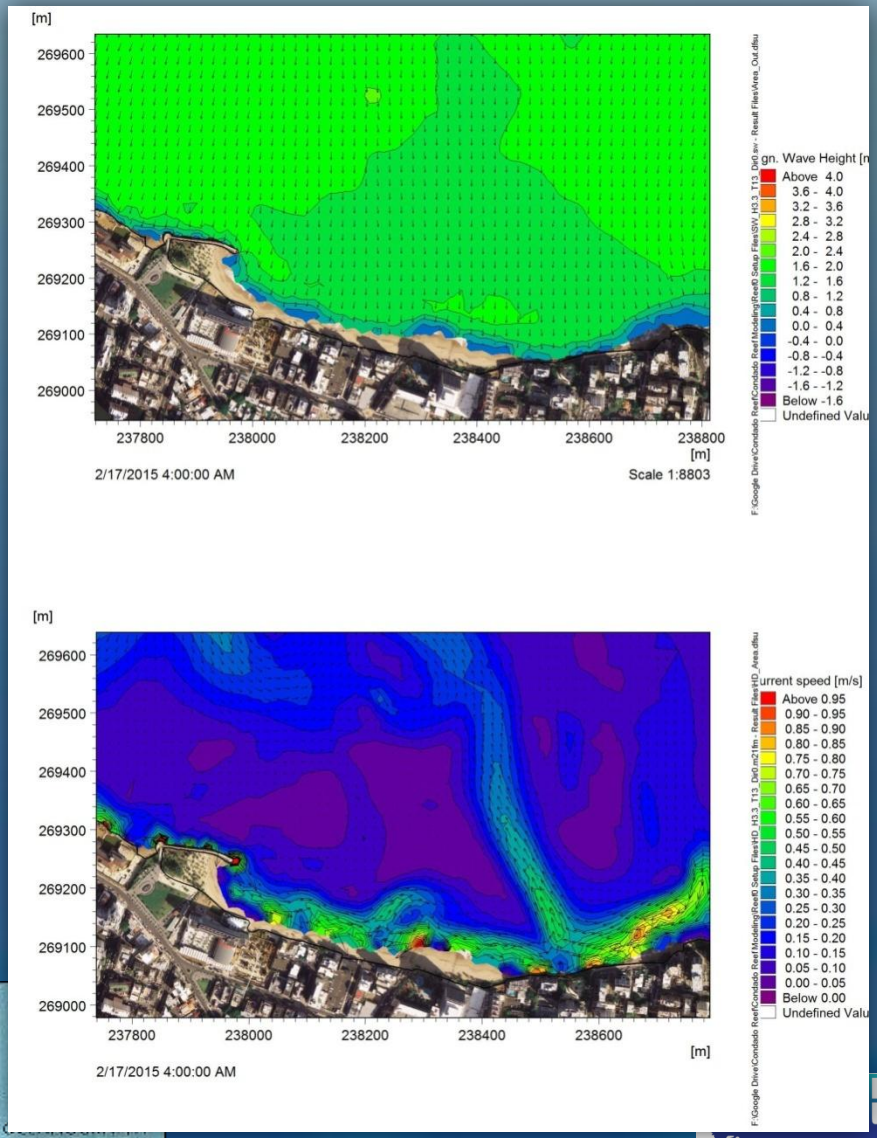
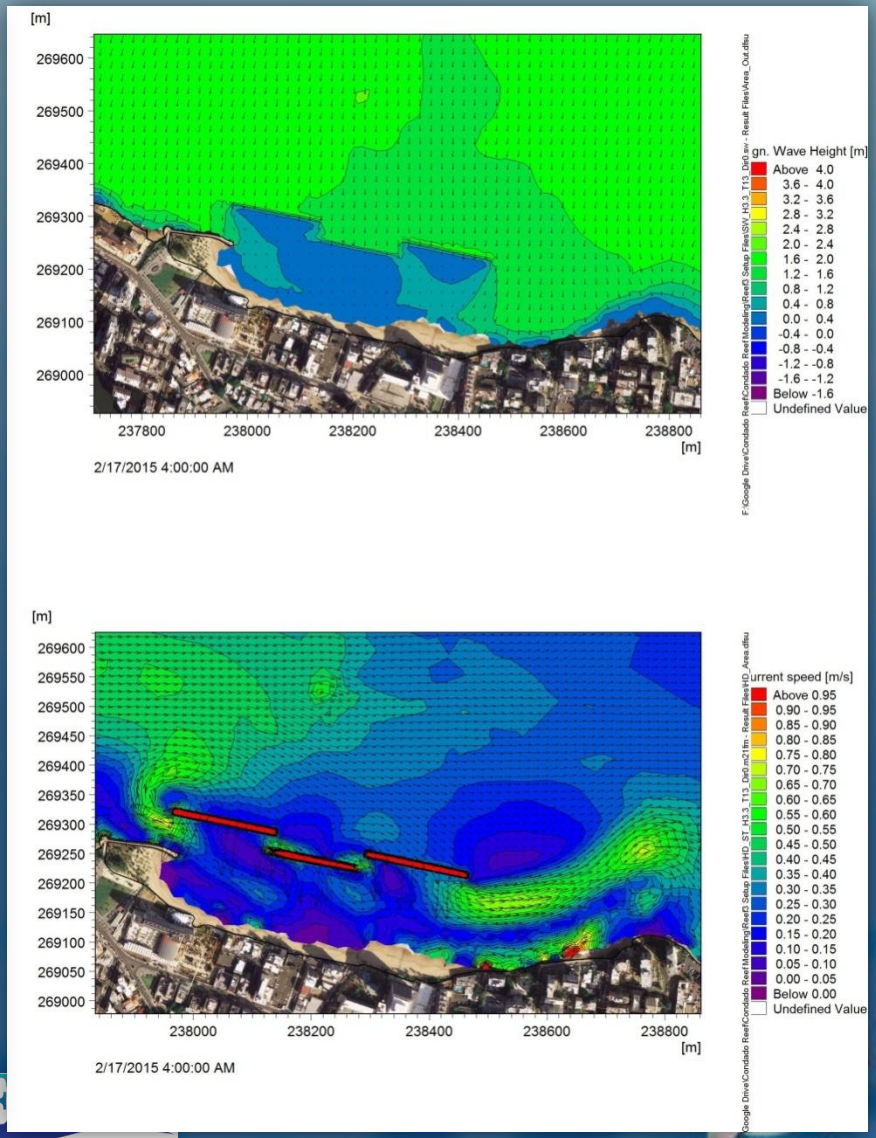
Evaluation of Results





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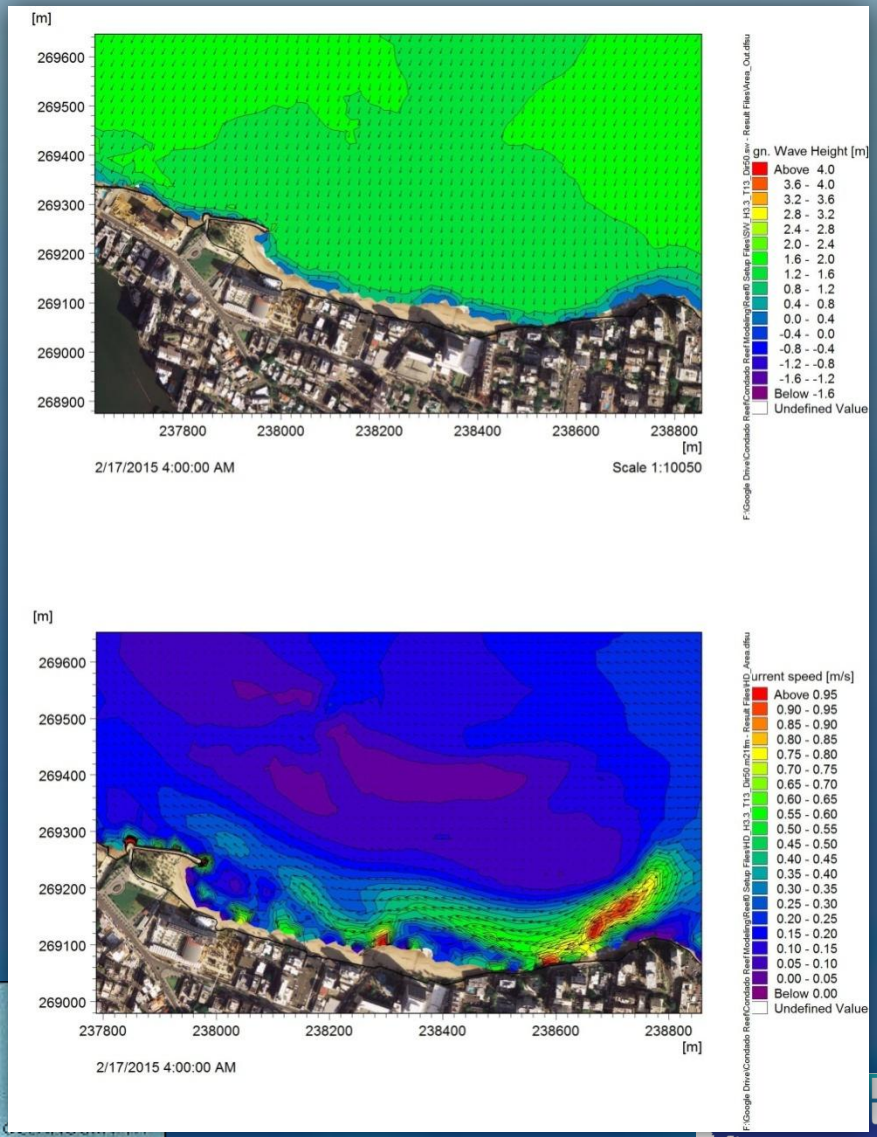
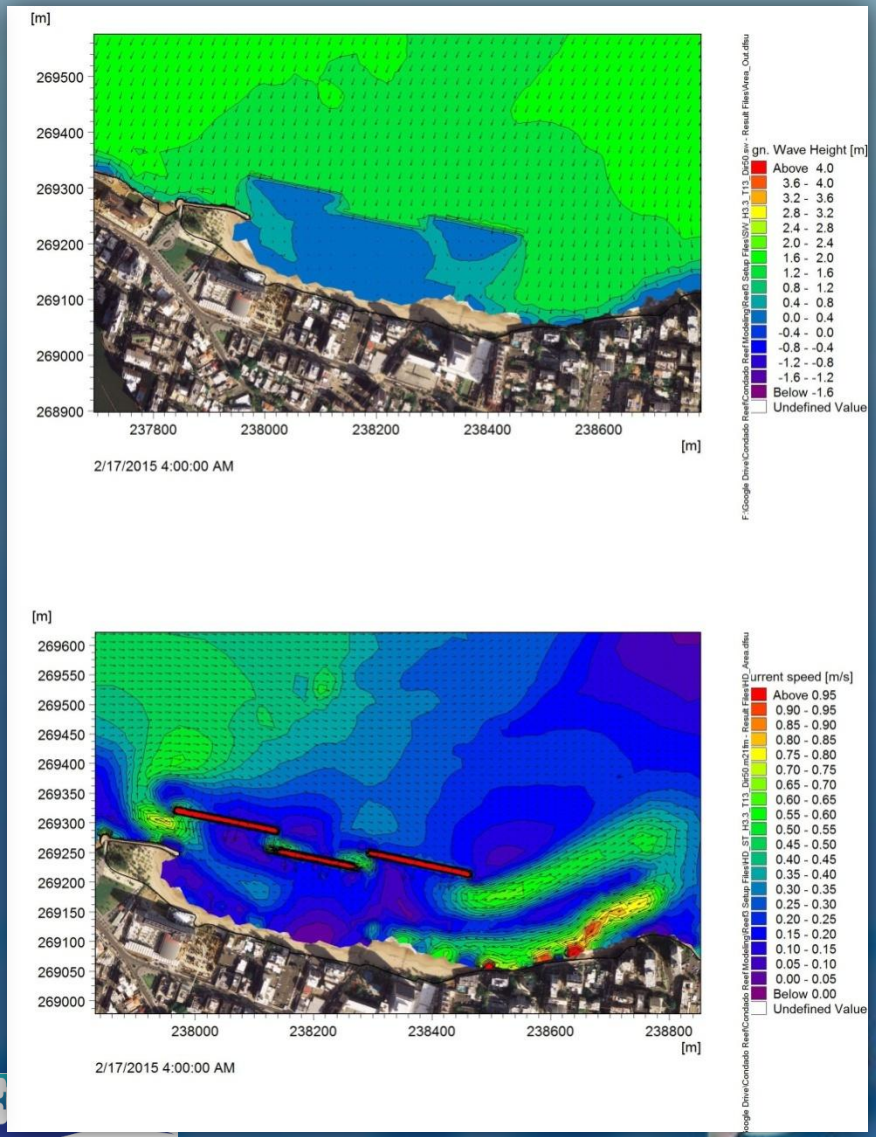
Evaluation of Results





Hm_0 = 3.3 m, T = 13 s, Dir. = 50˚

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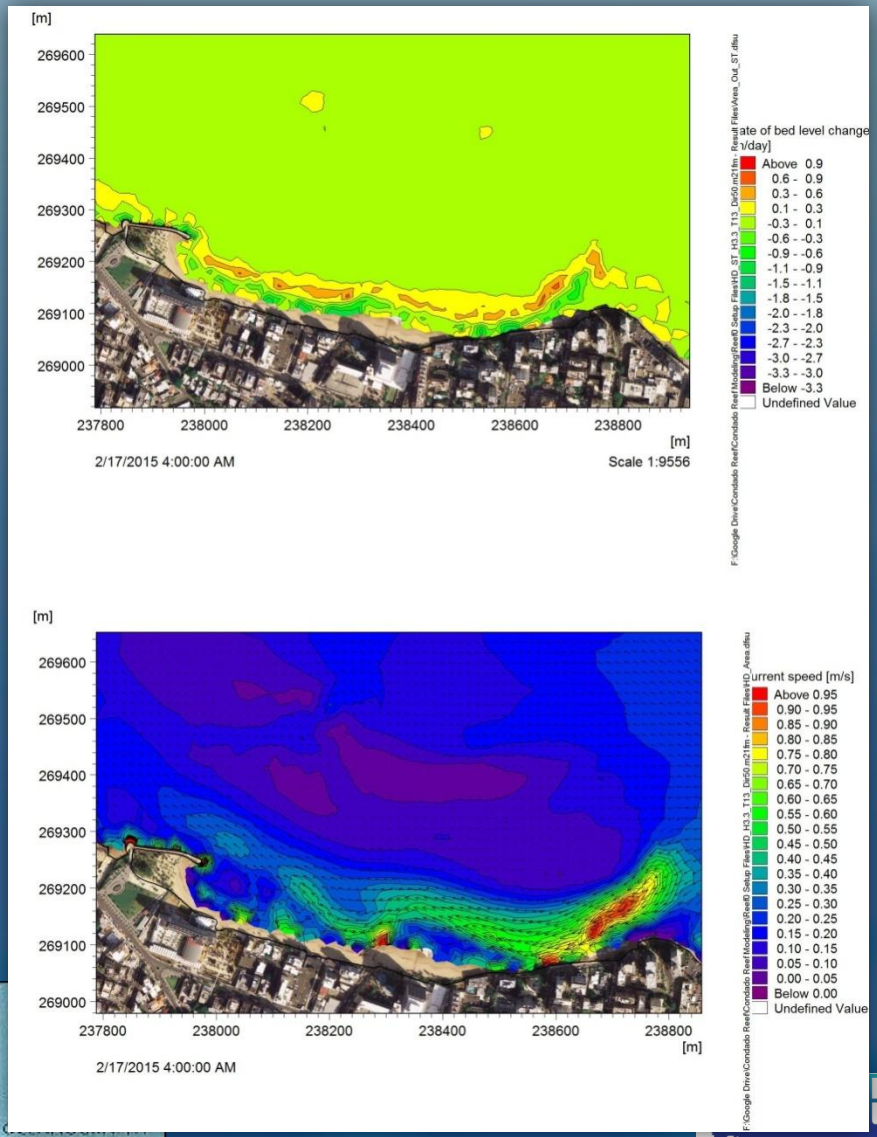
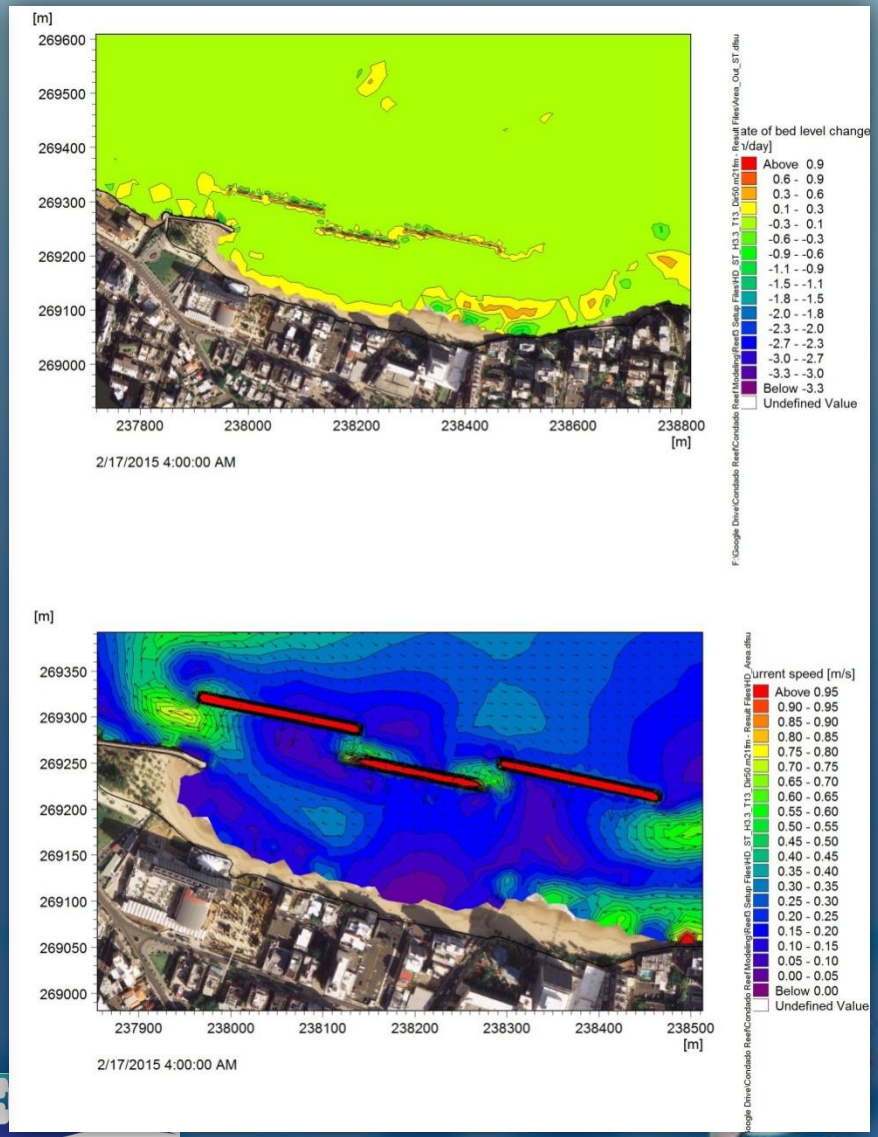
Evaluation of Results





Hm_0 = 3.3 m, T = 13 s, Dir. = 50˚

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Maiden Island 2010

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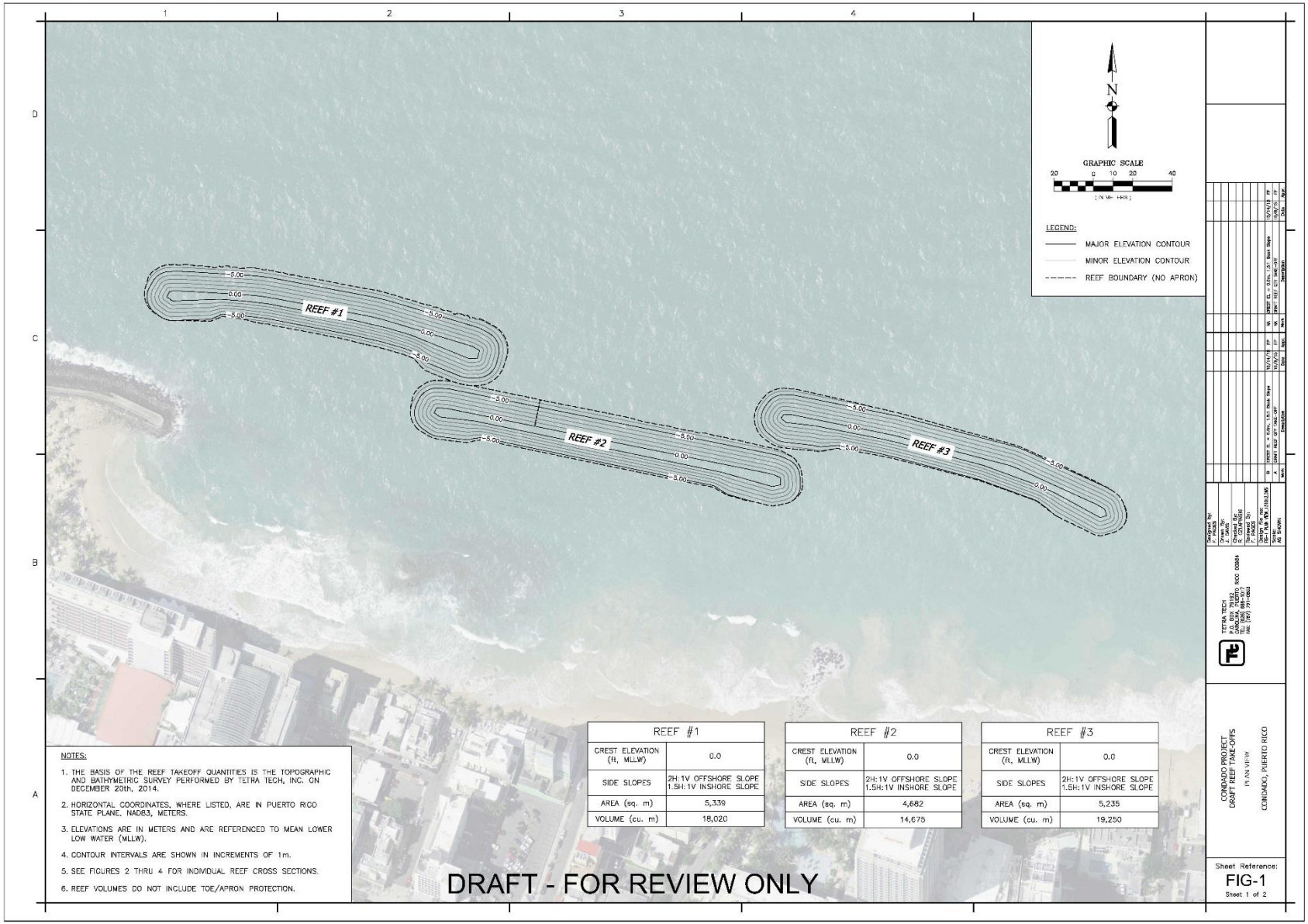
Conceptual Layout Plan

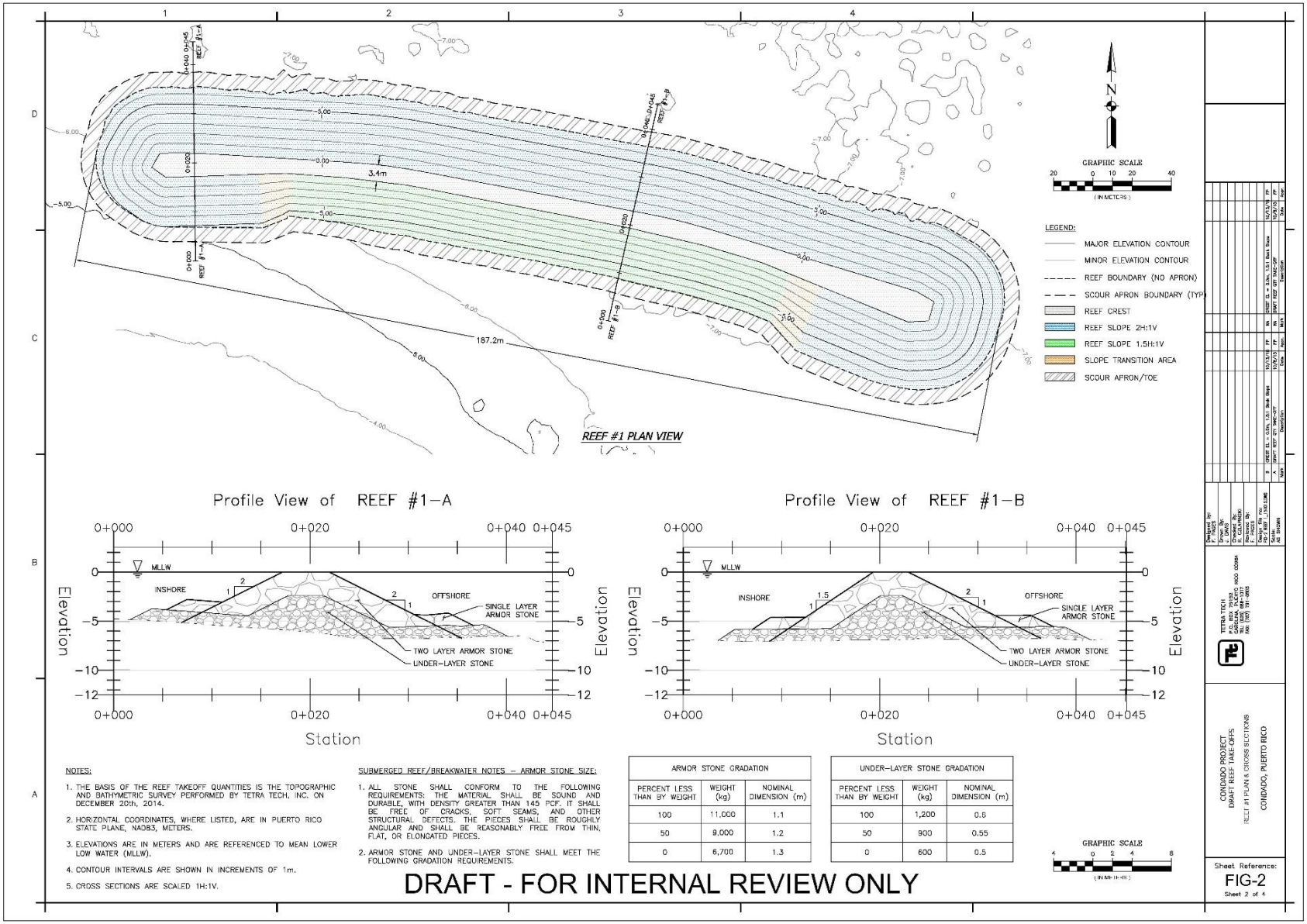


REEF #1	
CREST ELEVATION (ft, MLLW)	0.0
SIDE SLOPES	2H:1V OFFSHORE SLOPE 1.5H:1V INSHORE SLOPE
AREA (sq. m)	5,339
VOLUME (cu. m)	18,020

REEF #2	
CREST ELEVATION (ft, MLLW)	0.0
SIDE SLOPES	2H:1V OFFSHORE SLOPE 1.5H:1V INSHORE SLOPE
AREA (sq. m)	4,682
VOLUME (cu. m)	14,675

REEF #3	
CREST ELEVATION (ft, MLLW)	0.0
SIDE SLOPES	2H:1V OFFSHORE SLOPE 1.5H:1V INSHORE SLOPE
AREA (sq. m)	5,235
VOLUME (cu. m)	19,250

Conceptual Layout Plan



NOTES:

1. THE BASIS OF THE REEF TAKEOFF QUANTITIES IS THE TOPOGRAPHIC AND BATHYMETRIC SURVEY PERFORMED BY TETRA TECH, INC. ON DECEMBER 20th, 2014.
2. HORIZONTAL COORDINATES, WHERE LISTED, ARE IN PUERTO RICO STATE PLANE, NAD83, METERS.
3. ELEVATIONS ARE IN METERS AND ARE REFERENCED TO MEAN LOWER LOW WATER (MLLW).
4. CONTOUR INTERVALS ARE SHOWN IN INCREMENTS OF 1m.
5. CROSS SECTIONS ARE SCALED 1H:1V.

SUBMERGED REEF/BREAKWATER NOTES – ARMOR STONE SIZE:

1. ALL STONE SHALL CONFORM TO THE FOLLOWING REQUIREMENTS: THE MATERIAL SHALL BE SOUND AND DURABLE, WITH DENSITY GREATER THAN 145 PCF. IT SHALL BE FREE OF CRACKS, SOFT SEAMS, AND OTHER STRUCTURAL DEFECTS. THE PIECES SHALL BE ROUGHLY ANGULAR AND SHALL BE REASONABLY FREE FROM THIN, FLAT, OR ELONGATED PIECES.
2. ARMOR STONE AND UNDER–LAYER STONE SHALL MEET THE FOLLOWING GRADATION REQUIREMENTS.

ARMOR STONE GRADATION		
PERCENT LESS THAN BY WEIGHT	WEIGHT (kg)	NOMINAL DIMENSION (m)
100	11,000	1.1
50	9,000	1.2
0	6,700	1.3

UNDER–LAYER STONE GRADATION		
PERCENT LESS THAN BY WEIGHT	WEIGHT (kg)	NOMINAL DIMENSION (m)
100	1,200	0.6
50	900	0.55
0	600	0.5

DRAFT - FOR INTERNAL REVIEW ONLY

CONDADO PROJECT
DRAFT REEF TAKE-OFFS
REEF #1 PLAN & CROSS SECTIONS
CONDADO, PUERTO RICO

Sheet Reference:
FIG-2
Sheet 2 of 4

Conceptual & Final Design

- Hydrodynamic Modeling
  - Proven effectiveness in mitigating currents
  - Proven effectiveness in mitigating erosion
  - Maintains Water quality and circulation
- Artificial Reef Structural Stability
  - Void ratios, porosity
  - Wave forces
  - Settlement and scouring

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Conceptual Design

- Design Wave Height = 3 m
- Design Wave Period = 14 sec
- Three Sections approx. 150m at 0m mllw
  - Stone size ~ 1.1 – 1.3 m
  - Stone weight ~ 3.5 – 5.5 tons
  - 15k to 20k cubic meters each
  - Slope 2 to 1 offshore, 1.5 to 1 inshore
- Water depths approx. 5 – 7 m mllw

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Challenges of the Condado Artificial Reef

- Project Envisioned by Community Leaders in 2008
- Private Funding Support to Advance Studies/Design
- Need Government Agencies Endorsements
- Additional Funding for Project Development and Implementation

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Permitting

- USACE
  - Section 10 RHA
  - Section 404
- PR Joint Permit
  - Planning Board
  - PR Department Natural Resources
    - Submerged land lease
  - Environmental Quality Board
    - 401 Water Quality Certification

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Schedule

- Baseline Environmental & Oceanographic Studies, Conceptual Design
  - 8 months – Jan 2015 – August 2015
- Permitting
  - 8 -10 months – November 2015 – August 2016
- Final Design
  - 1.5 – 2 months – November 2015 – Jan. 2016
- Procurement & Construction/Installation
  - 4 – 6 months – Sept. 2016 – April-May 2017

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Construction Phase

- Identify specialized marine construction equipment (e.g., barges, cranes, access, etc.)
- Procurement of special construction material
  - Rock specifications (1-1.5 M rock w special gradation, clean, calcium carb content)
- Critical construction timeline with weather window
- Environmental monitoring requirements

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Quality Control - Quarries

- Reef compatible materials
- Boulder Measurements
- Drop Tests/Rough Handling
- Thoroughly Washed

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Quality Control - Quarries

- Selection of outer layer
- Keystones w/ holes and crevices
- Selective gradation to increase porosity
- Selective placement

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Quality Control – Staging Area

- Drop Test from Truck Bed
- Boulder Measurements

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Construction Phase

- Derrick Barge staged on site
- Load and transport barge to site
- Place (not drop) units into place

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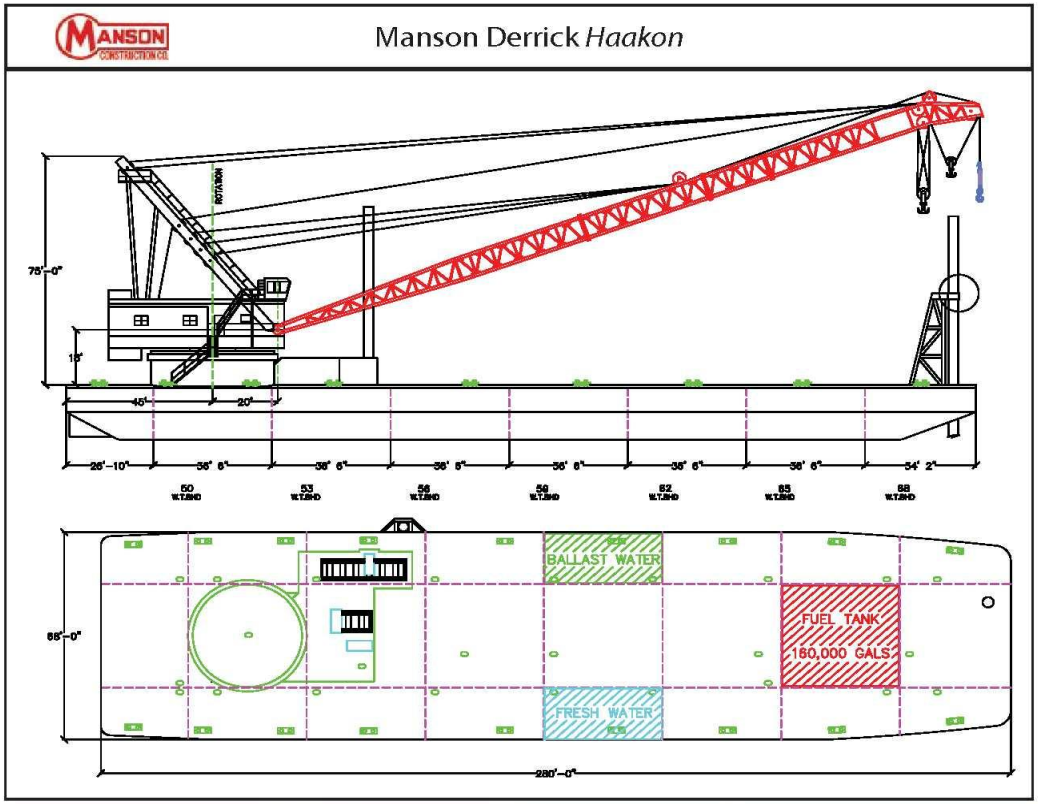
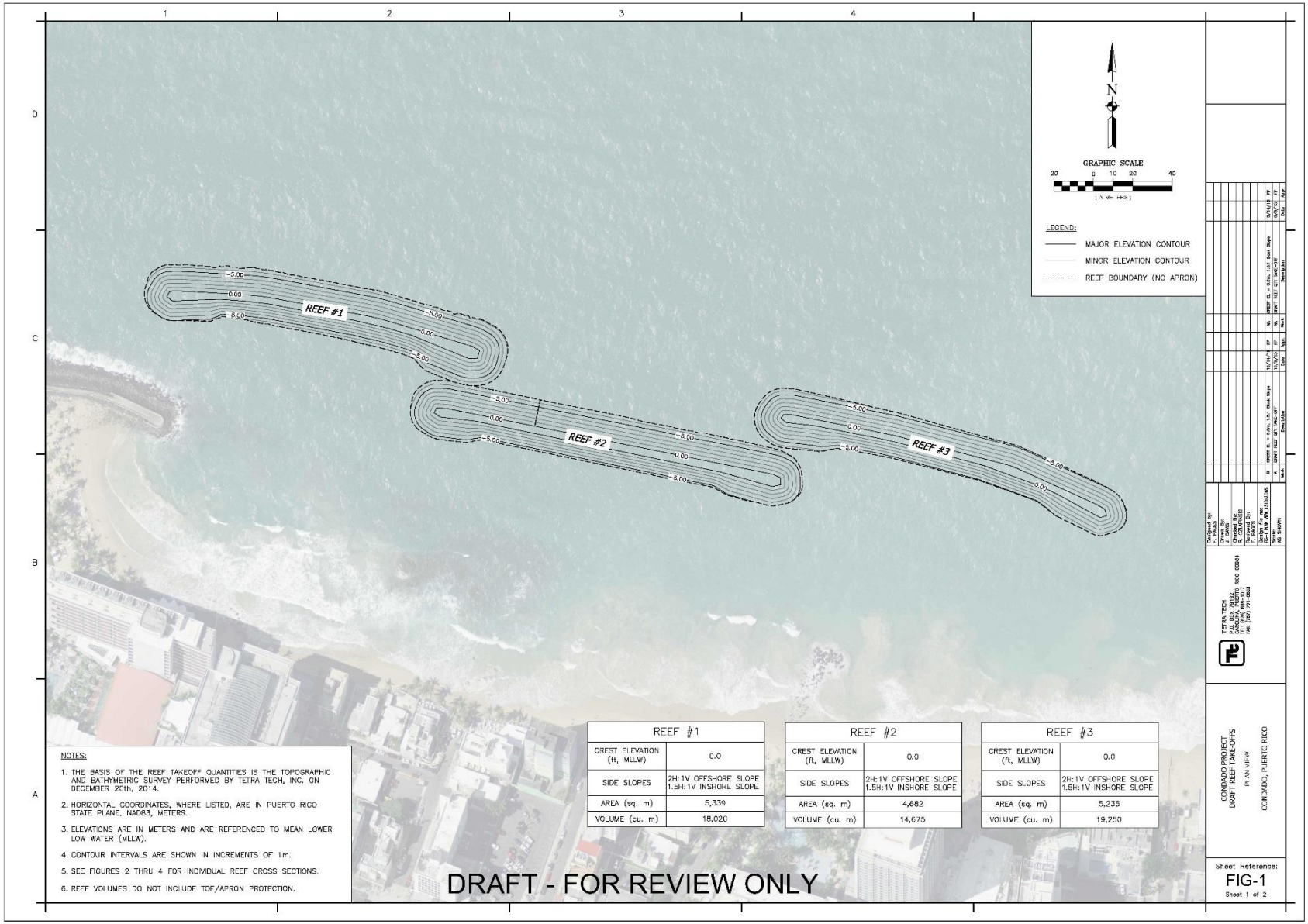
Construction Equipment

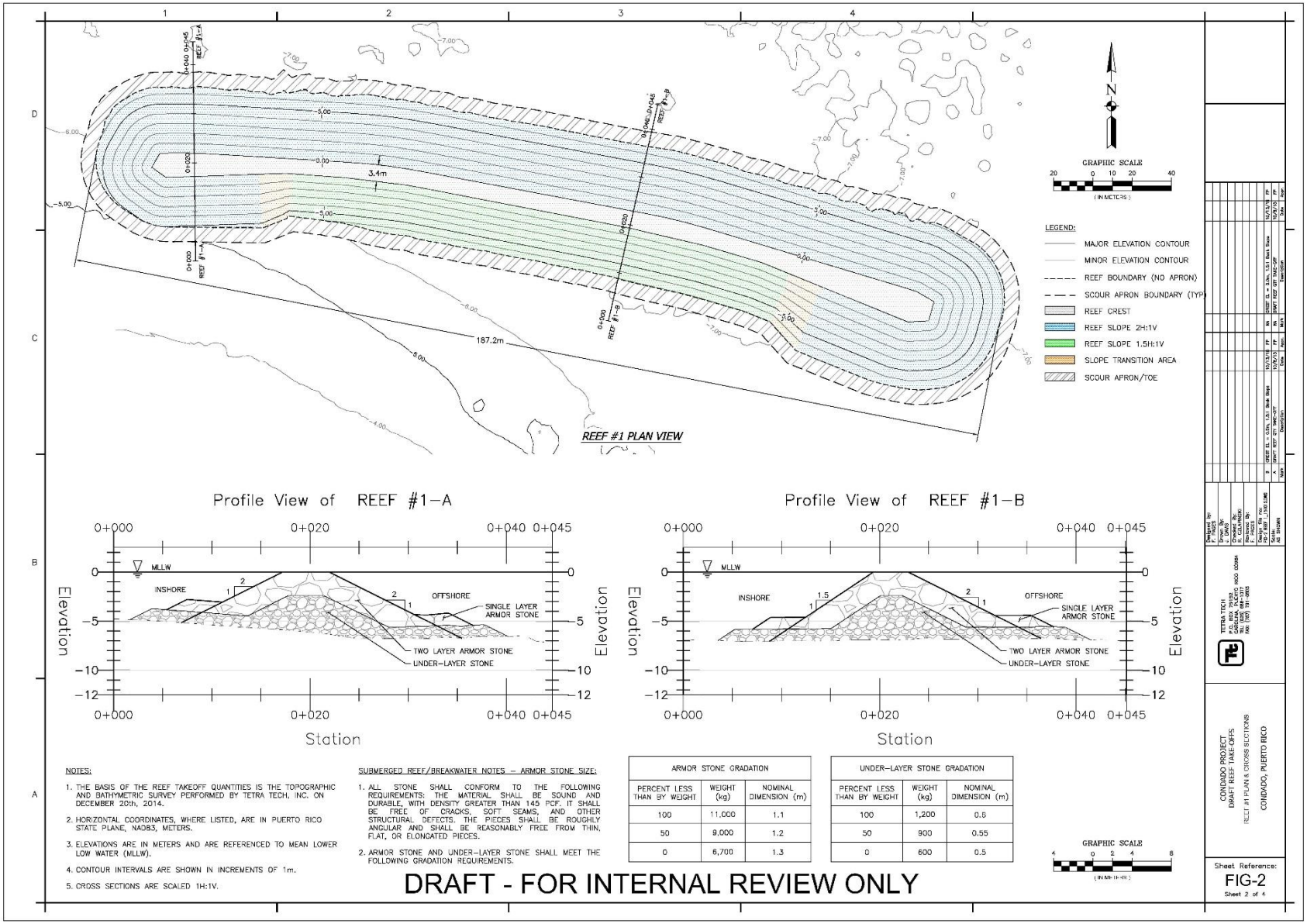


Principal Characteristics	
Length Overall	280'-0"
Beam Overall (Without Spuds & Fenders)	68'-0"
Barge Depth at Main Deck	18'-0"
Mean Draft	9'-0"
Distance Deck to Boom Heel	18'-0"
Boom Length to Main	210'-0"
Boom Length Main to Whip	16'-0"
Spuds	Two
Clamshell Bucket Capacity (Cu Yards)	15 Cubic Yards

Conceptual Layout Site Plan



Conceptual Layout Plan – West Section



NOTES:

1. THE BASIS OF THE REEF TAKEOFF QUANTITIES IS THE TOPOGRAPHIC AND BATHYMETRIC SURVEY PERFORMED BY TETRA TECH, INC. ON DECEMBER 20th, 2014.
2. HORIZONTAL COORDINATES, WHERE LISTED, ARE IN PUERTO RICO STATE PLANE, NAD83, METERS.
3. ELEVATIONS ARE IN METERS AND ARE REFERENCED TO MEAN LOWER LOW WATER (MLLW).
4. CONTOUR INTERVALS ARE SHOWN IN INCREMENTS OF 1m.
5. CROSS SECTIONS ARE SCALED 1H:1V.

SUBMERGED REEF/BREAKWATER NOTES – ARMOR STONE SIZE:

1. ALL STONE SHALL CONFORM TO THE FOLLOWING REQUIREMENTS: THE MATERIAL SHALL BE SOUND AND DURABLE, WITH DENSITY GREATER THAN 145 PCF. IT SHALL BE FREE OF CRACKS, SOFT SEAMS, AND OTHER STRUCTURAL DEFECTS. THE PIECES SHALL BE ROUGHLY ANGULAR AND SHALL BE REASONABLY FREE FROM THIN, FLAT, OR ELONGATED PIECES.
2. ARMOR STONE AND UNDER–LAYER STONE SHALL MEET THE FOLLOWING GRADATION REQUIREMENTS.

ARMOR STONE GRADATION		
PERCENT LESS THAN BY WEIGHT	WEIGHT (kg)	NOMINAL DIMENSION (m)
100	11,000	1.1
50	9,000	1.2
0	6,700	1.3

UNDER–LAYER STONE GRADATION		
PERCENT LESS THAN BY WEIGHT	WEIGHT (kg)	NOMINAL DIMENSION (m)
100	1,200	0.6
50	900	0.55
0	600	0.5

GRAPHIC SCALE

DRAFT - FOR INTERNAL REVIEW ONLY

CONDADO PROJECT
DRAFT REEF TAKE-OFFS
REEF #1 PLAN & CROSS SECTIONS
CONDADO, PUERTO RICO

Sheet Reference:
FIG-2
Sheet 2 of 4

Benefits of the Condado Artificial Reef

- Mitigate Erosion
  - Design & Installation of Artificial Reef and Beach Nourishment
- Mitigate Dangerous Rip Currents
  - Effective reduction of wave energy
- Create Habitat
  - Benthos, Sea Turtle Nesting
- Create Recreational Opportunities
  - Snorkeling, Diving, Surfing, Paddle Boarding, etc.
- Create Educational Opportunities
  - Monitoring, Research, Science Projects

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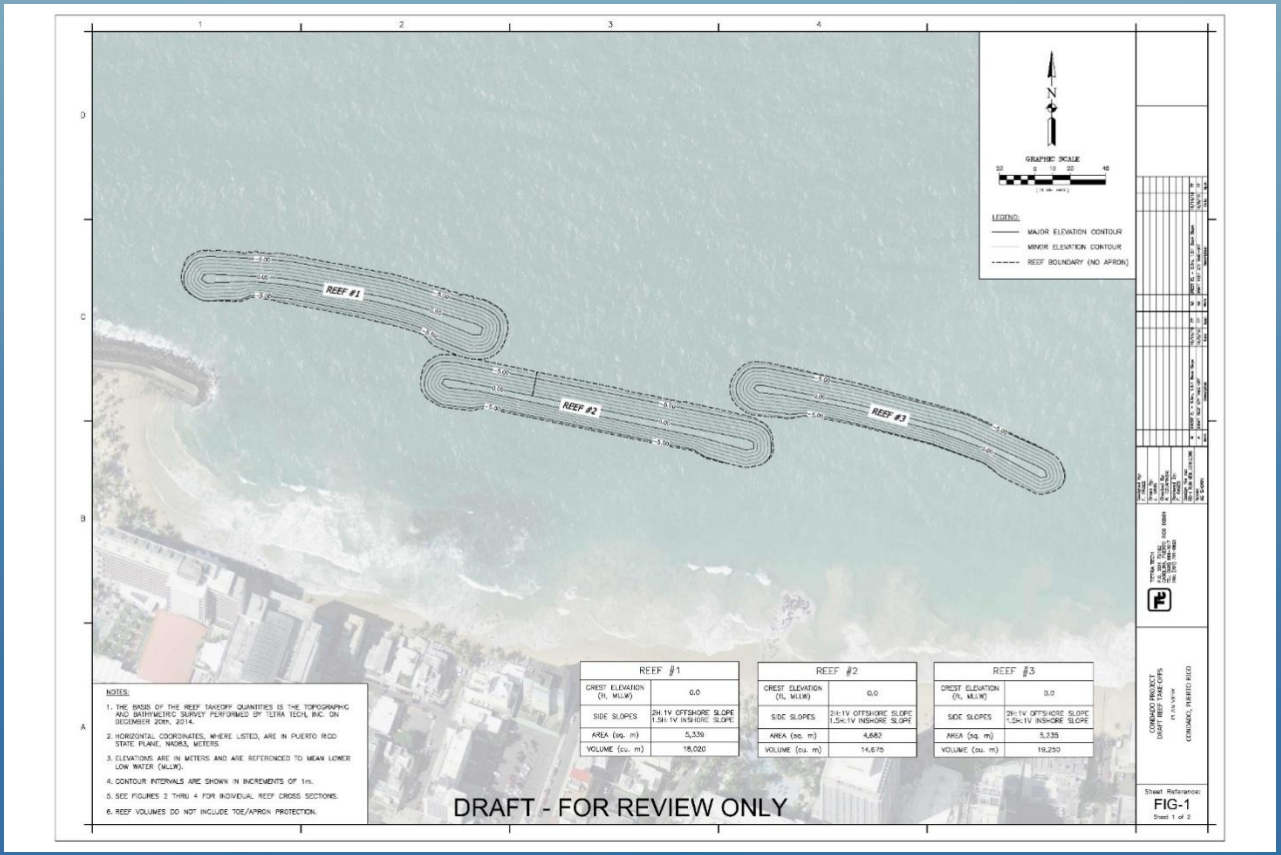
Questions?



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