Exhibit 2, Attachment A

St. John Marina - Numerical Modeling Analysis

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Numerical Modeling Analysis

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ST. JOHN MARINA

NUMERICAL MODELING ANALYSIS

01 GENERAL

This report provides a summary of the numerical modeling analysis conducted for the proposed St. John Marina in Coral Harbor, St John, Virgin Islands. The purpose of this analysis is to evaluate the potential effects of the marina on two reefs in its vicinity: the Pen Point and Harbor Point Reefs. More specifically, the analysis evaluates the potential for the proposed marina to result in increased sediment deposition at the reef locations. Background information reviewed consisted in data collected by Sea Diversified Inc. including ADCP current measurements, bathymetric survey, turbidity measurements and sediment samples sieve analysis. A circulation model was prepared to assess the flow patterns and characterize conditions that could potentially affect the reefs.

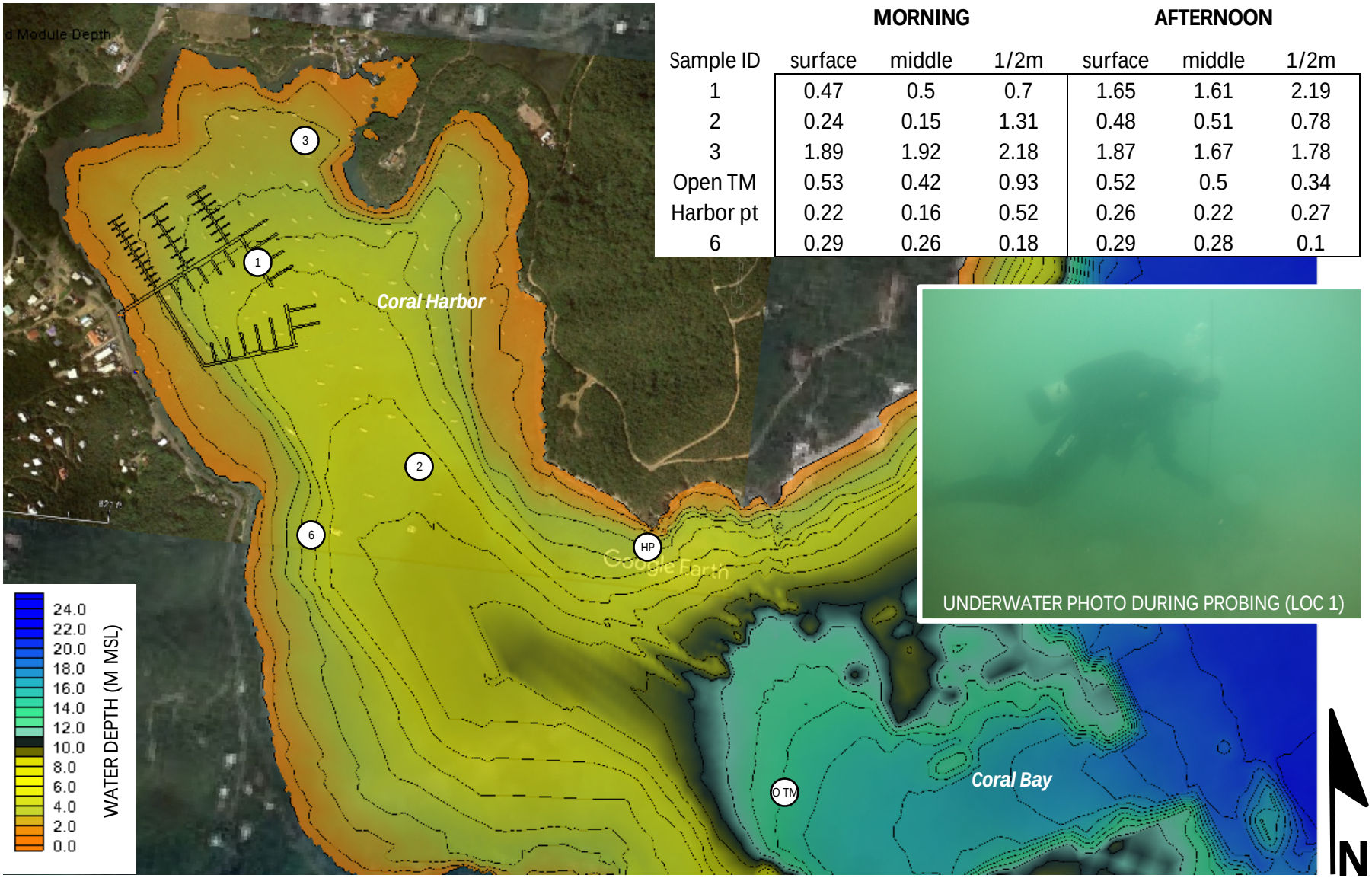
02 BACKGROUND DATA COLLECTION

02.01 TURBIDITY MEASUREMENTS

Turbidity measurements were collected by Bio-Impact Inc. on July 20th, 2019. Six locations within Coral Harbor were selected including the proposed marina location. The measurements were conducted once in the morning and once in the afternoon at all 6 locations and at three water depth: surface, mid-depth and 0.5m from bottom. The results and location of point measurements are presented in Figure 1. Overall the turbidity levels ranged around 2 NTU and lower. Location 3 and 1 showed the highest turbidity levels around 2 NTUs, while all other locations had levels lower than 1. Underwater photos from divers however, showed poor visibility within the proposed marina location (1), but this did not seem to affect turbidity readings significantly.

02.02 SEDIMENT SAMPLES

Several sediment samples were collected by Sea Diversified within the footprint of the proposed marina and at the location of the deployed ADCPs. For each location, 2 samples were collected and analyzed. The main factor likely to affect turbidity is the amount of silt present at any



	MORNING			AFTERNOON		
Sample ID	surface	middle	1/2m	surface	middle	1/2m
1	0.47	0.5	0.7	1.65	1.61	2.19
2	0.24	0.15	1.31	0.48	0.51	0.78
3	1.89	1.92	2.18	1.87	1.67	1.78
Open TM	0.53	0.42	0.93	0.52	0.5	0.34
Harbor pt	0.22	0.16	0.52	0.26	0.22	0.27
6	0.29	0.26	0.18	0.29	0.28	0.1

Figure 1: Coral Harbor - Turbidity Measurements

location because finer sediments, once disturbed will stay in suspension for a longer period of time, and thus could be carried away over longer distances. Figure 2 presents the results for the sieve analysis performed on all samples collected. The grain size distributions are presented in two ways (bar chart and log curves) in the exhibit, on the lower graph the percent passing sieve size #230 represents the amount of silt present within each sample (Yellow). The results indicate that the samples collected along the shoreline in shallower water contain the least amount of silt with levels ranging from 0 and 0.3% (NW and SW). Samples collected in deeper water contained silts levels ranging from 3% to 18% with sample SE containing the most. This indicates that finer particles (silt), once displaced tend to deposit in deeper water within the bay where they are less likely to be disturbed.

02.03 ADCP CURRENT METER

Sea Diversified Inc. deployed two Nortek ADCPs from July 16 to 20, 2019. The first gauge was located within the footprint of the proposed marina in approximately 4m of water depth and the second one towards the entrance of Coral Harbor in approximately 6m of water. The gauges collected current measurements at several depths (cells) along the water column and also measured wave heights.

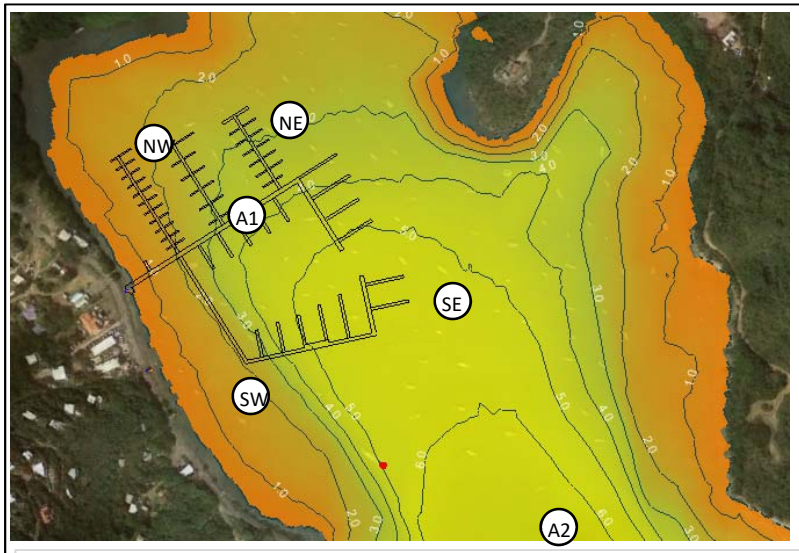
Results from the instruments indicate that the cell located near the water surface measured higher current velocities than all the cells beneath which covered most of the water column. The measurements also show that peak current velocities correlated well with the incoming and outgoing tides. This suggests that the limited tidal prism in the harbor (approx. 0.3m) mostly affects the very top layer of the water column. In general, measured current velocities beneath the surface layer indicate that overall there is little current through the water column.

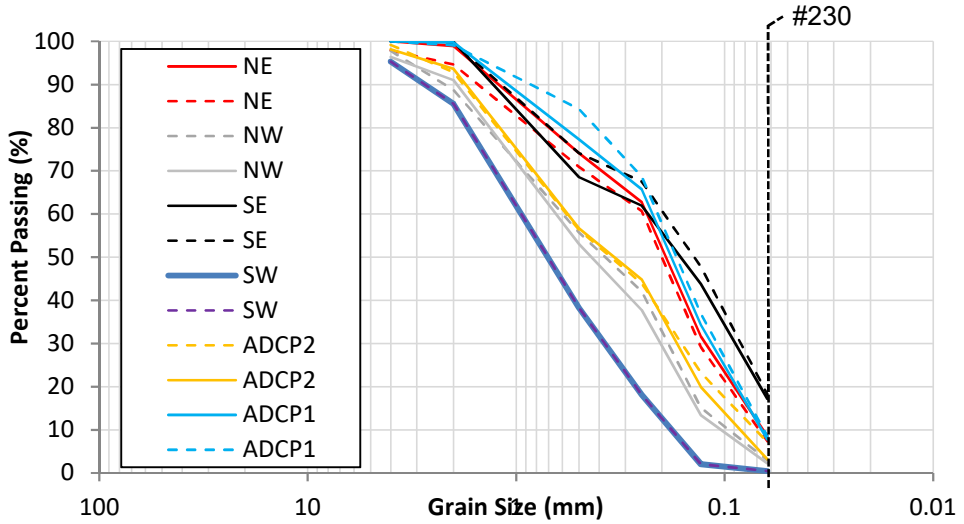
Figures 3 & 4 present the current measurement from the two gauges, a moving average was applied the data to highlight the main trend. The top graph represents the water level and each graph thereafter show the current velocity at increasing depth. Overall, when the current velocities are averaged over the depth at the gauge, the resulting current value was approximately 0.05 m/s for both gauges for the deployment duration. This indicates that there is no significant current in the bay in general.

03 NUMERICAL MODELING

03.01 MODEL DESCRIPTION & INPUTS

The Coastal Modeling System (CMS) suite of numerical models was used to perform detailed circulation modeling and help characterize flow patterns in Coral Harbor. CMS was developed by the US Army Corps of Engineers Coastal and Hydraulics Laboratory. The modeling system





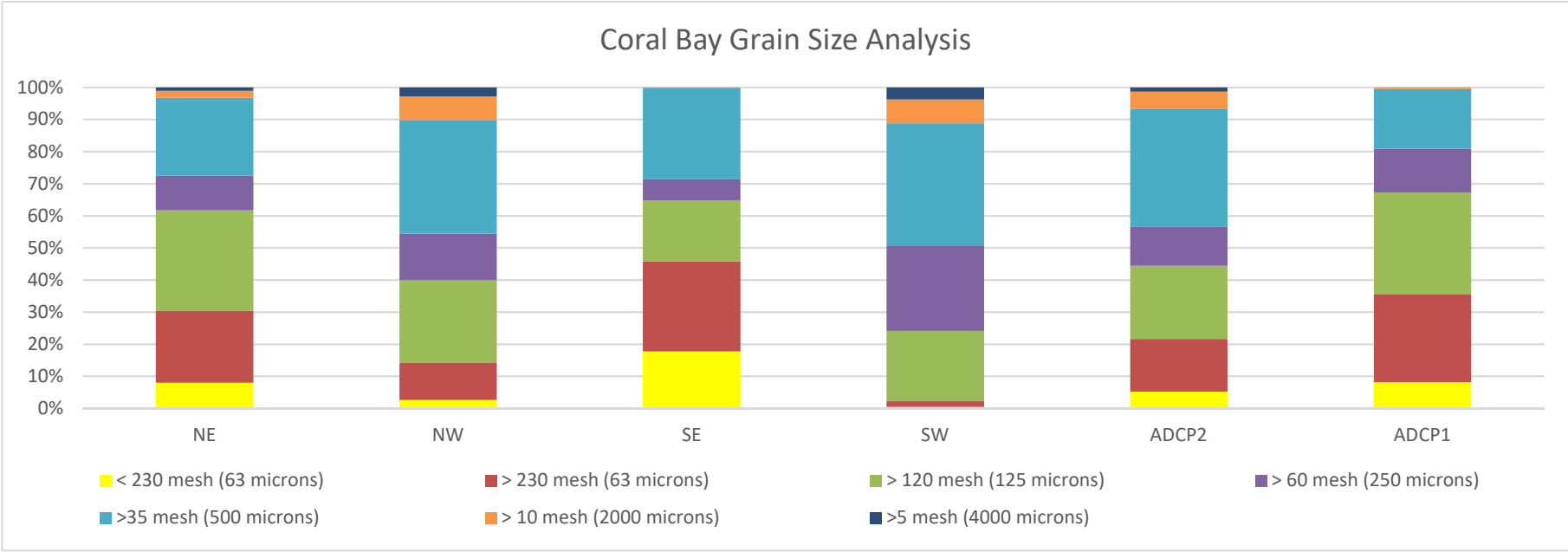


Figure 2: Coral Harbor – Sediment Samples Grain Size Distribution

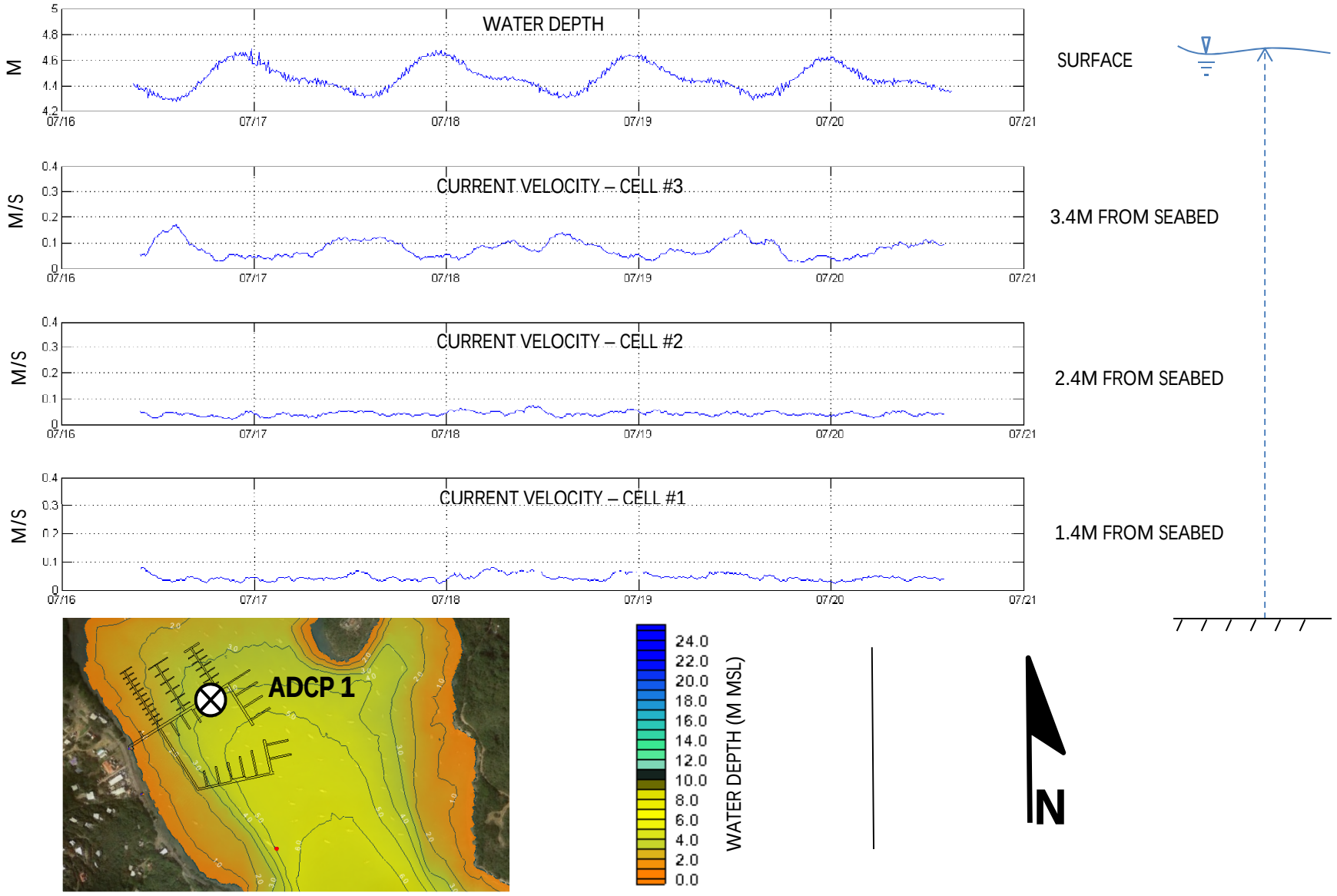


Figure 3: Coral Harbor – ADCP 1 Current Measurements

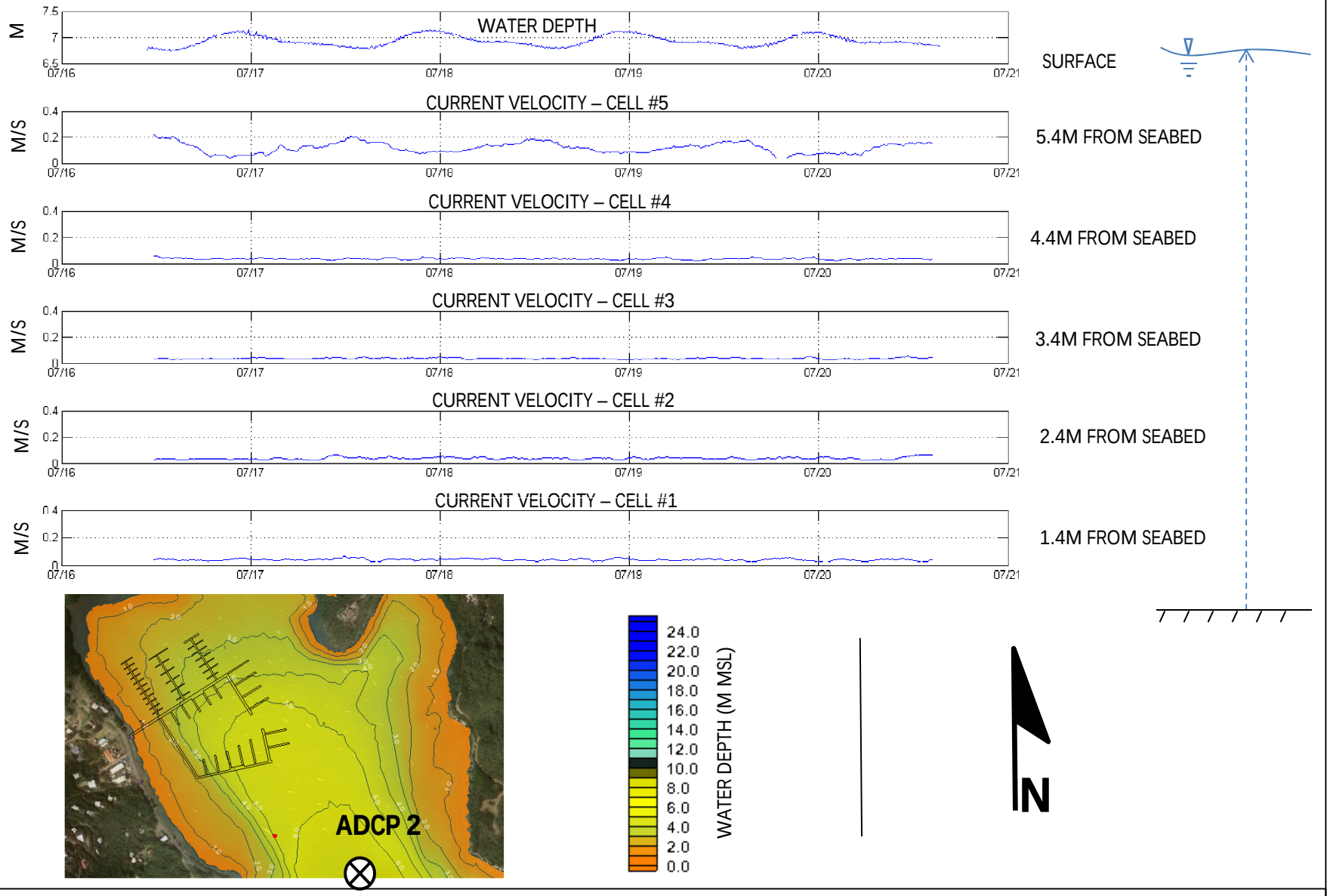


Figure 4: Coral Harbor – ADCP 2 Current Measurements

includes a 2-D wave spectral transformation phase averaged model suitable for coastal area modeling coupled with two dimensional, finite-difference numerical simulation of the flow, sediment transport and morphology. The model program allows for the creation of nested grids of varying resolution to allow higher definition in areas of interest. The model domain covered all Coral Bay with increased resolution for Coral Harbor and the proposed marina area. Figure 5 shows the CMS-Flow model grid with the nested cells varying in size from 8m in Coral Harbor to 64m for Coral Bay. This allows time dependent simulations of actual wave records while maintaining practical run time for long term simulations.

The numerical model inputs consisted in the recent bathymetric survey collected by Sea Diversified Inc. in July 2019 within the proposed marina area, bathymetry for the remainder of Coral Harbor was obtained from the most recent NOAA LIDAR data from 2011. Figure 6 shows the model domain with the input bathymetry. A full tidal cycle obtained from the nearest tide gauge in Lameshur Bay was used at the model open boundary as forcing, and several model runs were prepared with wave height input ranging from 0.5m to 2m.

03.02 MODEL RESULTS & VERIFICATION

The CMS model was initially setup to simulate waves only and then both waves and tide were used to help characterize the hydrodynamic patterns resulting from the combined forcing. Appendix A shows the model results for the waves only. In the figures, the lower quadrant shows a regional view of Coral Harbor and the main exhibit is a more detailed view of the proposed marina location for the corresponding simulated wave condition. Overall, the model results show that the marina location is fairly well sheltered from offshore waves. Additionally, the 1.5m offshore wave simulation resulted in wave heights similar to wave measured at the two ADCPs location (approx. 0.2-0.3m).

Appendix B presents the current model results for combined wave and tide simulations. The model simulates depth average current velocities, so velocities are representative of the whole water column. The results indicate that simulated current at the marina location are overall small in the order of magnitude between 0.01m/s to 0.08m/s for respective offshore waves of 0.5m and 2m. When comparing the depth averaged currents from the ADCPs to the simulated currents, the conditions for which the offshore waves were 1.5m result is the closest match. A review of the actual wave conditions for the nearest wave NOAA gauge (Station 41052 - South of St. John) shows that the offshore waves were on average close to 1.3 meters during the same time frame as the ADCP deployment. This suggests that the model could verify the current velocities with similar offshore wave conditions as simulated. Table 1 below presents a summary of the model results for wave and current velocity.

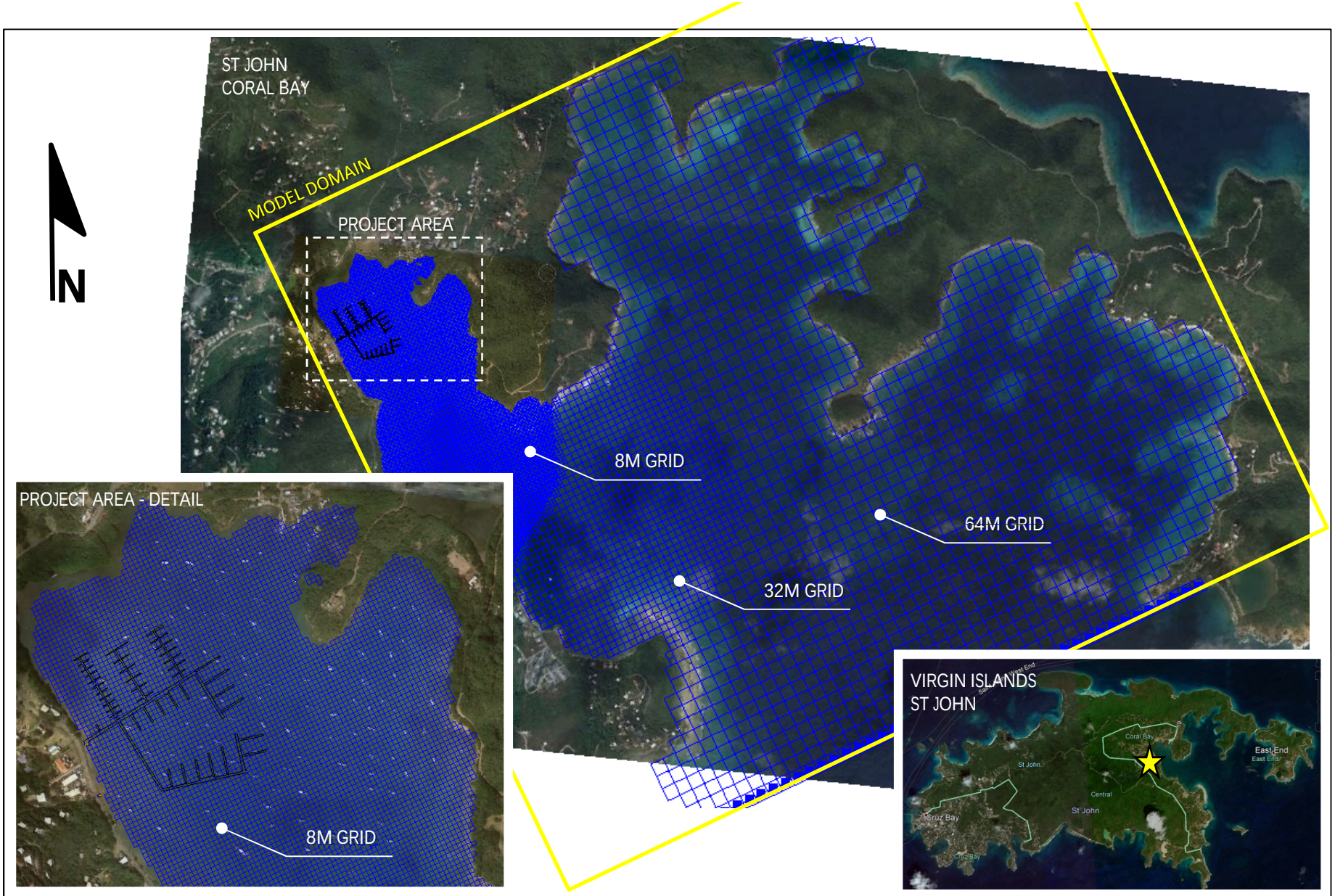


Figure 5: Coral Harbor – CMS Model Domain & Grid

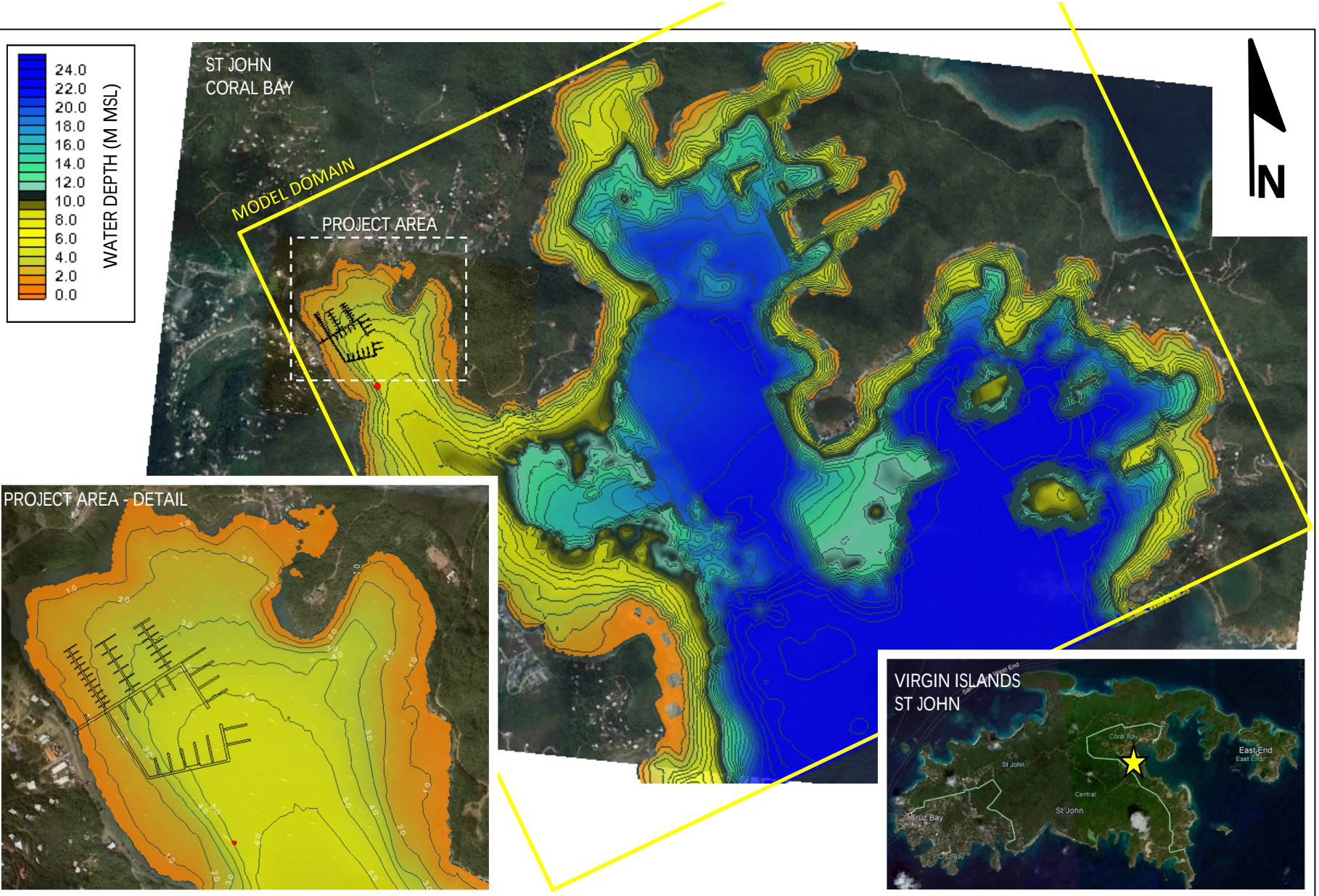


Figure 6: Coral Harbor – CMS Model Bathymetry

Table 1 – CMS - Model Results

	Offshore Wave Height	Wave Height @ Marina [m]	Current @ Marina [m/s]
	0.5m	0.1	0.01
	1m	0.2	0.03
ADCP measurement	1.3m	0.3	0.05
	1.5m	0.3	0.06
	2m	0.4	0.08

The model results seem to indicate that in addition to tidal fluctuations, wave heights may also affect the current magnitudes in the bay. The results suggests that incoming waves could generate a flow that follows the shorelines on either sides of Harbor Bay, and then returns offshore following the path along the higher depth in the center of the bay. While this assumption cannot be completely verified with the limited measurements, the similarity in magnitude between current simulated and measured provides reasonable level of validation for the model.

04 SUMMARY

The analysis of data collected in Coral Harbor combined with the numerical simulation allowed characterization of the hydrodynamic processes and their potential effects on turbidity and fine sediment deposition. The project is located in Coral Harbor, which is approximately 0.3 mile wide at the entrance and approximately 0.4 mile long. The overall significant width of the bay compared to its length and the small tidal range in the region result in water levels that rise and fall almost simultaneously throughout the bay during tidal exchanges. This explains the small current velocities measured and simulated. In addition, the grain size analysis suggests that finer sediments subject to disturbance from boating activities tend to settle in deeper water where they are less likely to be disturbed.

The analysis highlighted a potential correlation between waves and current in the bay. Based on the model results, the percent occurrence of certain current magnitude could be assessed from the analysis of wave events. Appendix C presents the annual time series of wave heights between 2014 and 2018 at Station 41052 offshore of St John. The percentage occurrence of wave was computed per bins of 0.5m for the 4-year period. These were then associated with their corresponding modeled current velocity and potential distances traveled by sediments were then computed following several assumptions:

- Sediments are disturbed mostly within the marina layout during boat docking maneuvers
- Sediments of interest are mostly medium and coarse silt with fall velocities of 0.1cm/s (Wentworth scale USGS).
- Disturbed sediments are assumed to reach the surface of water column.
- Most of the reefs are above 2 and 3 meters depth.

Using the fall velocity and predicted current velocities, several ranges for sediment deposition were determined, each carrying a specific probability of occurrence. The computations were conducted for 2 and 3 meters of water depth, corresponding to the deeper points along the reefs (Figure 9). Figures 7 & 8 present these results as color coded zones of probability for sediment deposition. The results suggest that sediments carried from the marina could reach Pen Point reef depth 8% of the time but only below 3m depth. The results show that Harbor Point reef would not be affected.

Overall, the analysis provides reasonable assurance that the proposed marina should not result in significant increase in turbidity at the two reef sites in its vicinity. For monitoring purpose, based on the modeling results, we suggest using an “Action Area” of approximately 120 meters around the proposed marina (see Figure 7, approx. 45 acres). This would cover the area where potential for sediment deposition down to 2 meter deep (most natural resources are above 2 meter depth) could occur from marina boating activities. The area also corresponds to wave and current conditions occurring 92% of the time.

Additionally the gauge results show current magnitude at the highest when the tide is descending, this means that currents occur mostly during flushing of Coral Harbor. This is

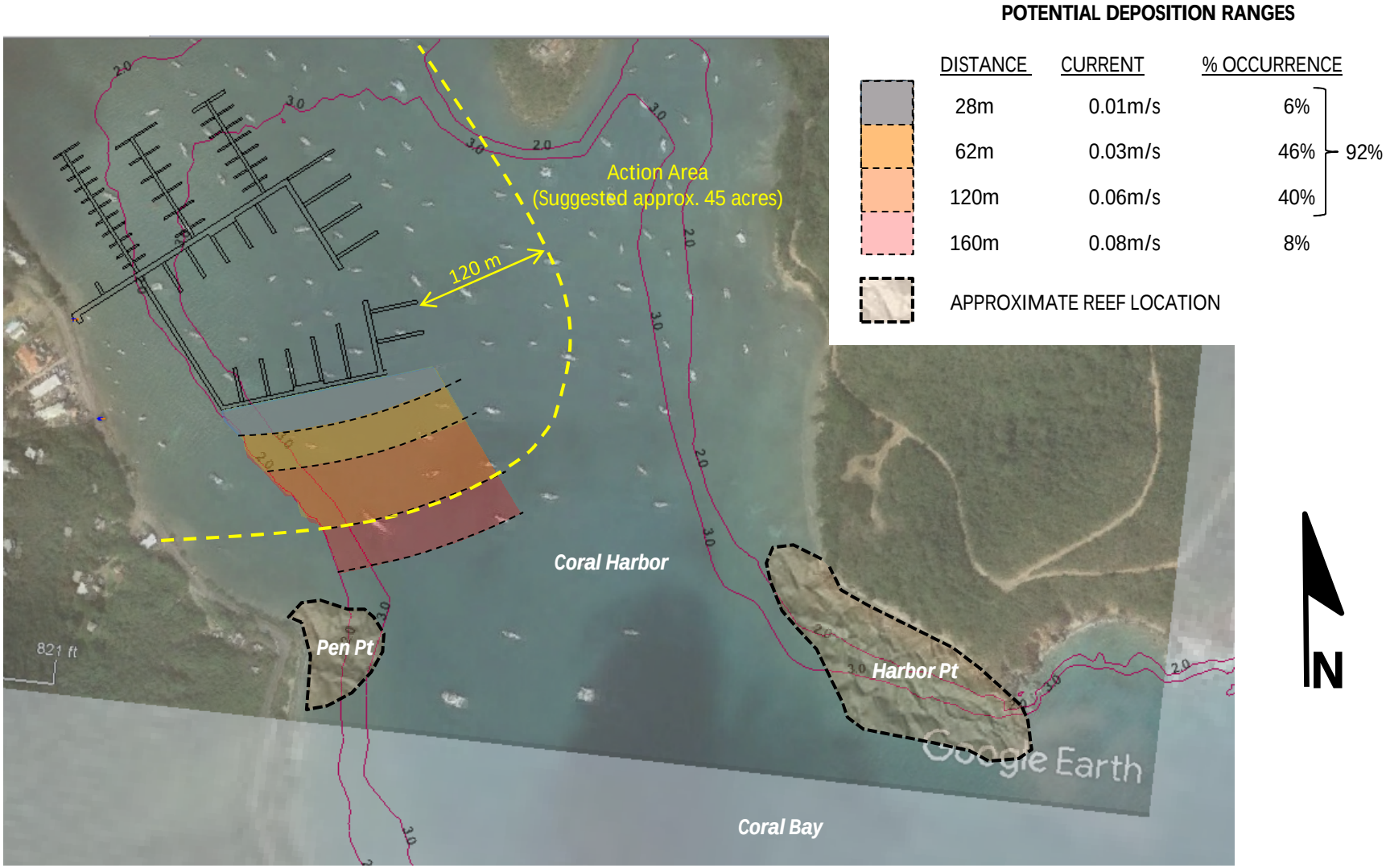


Figure 7: Coral Harbor – Potential Sediment Deposition Ranges to 2m depth

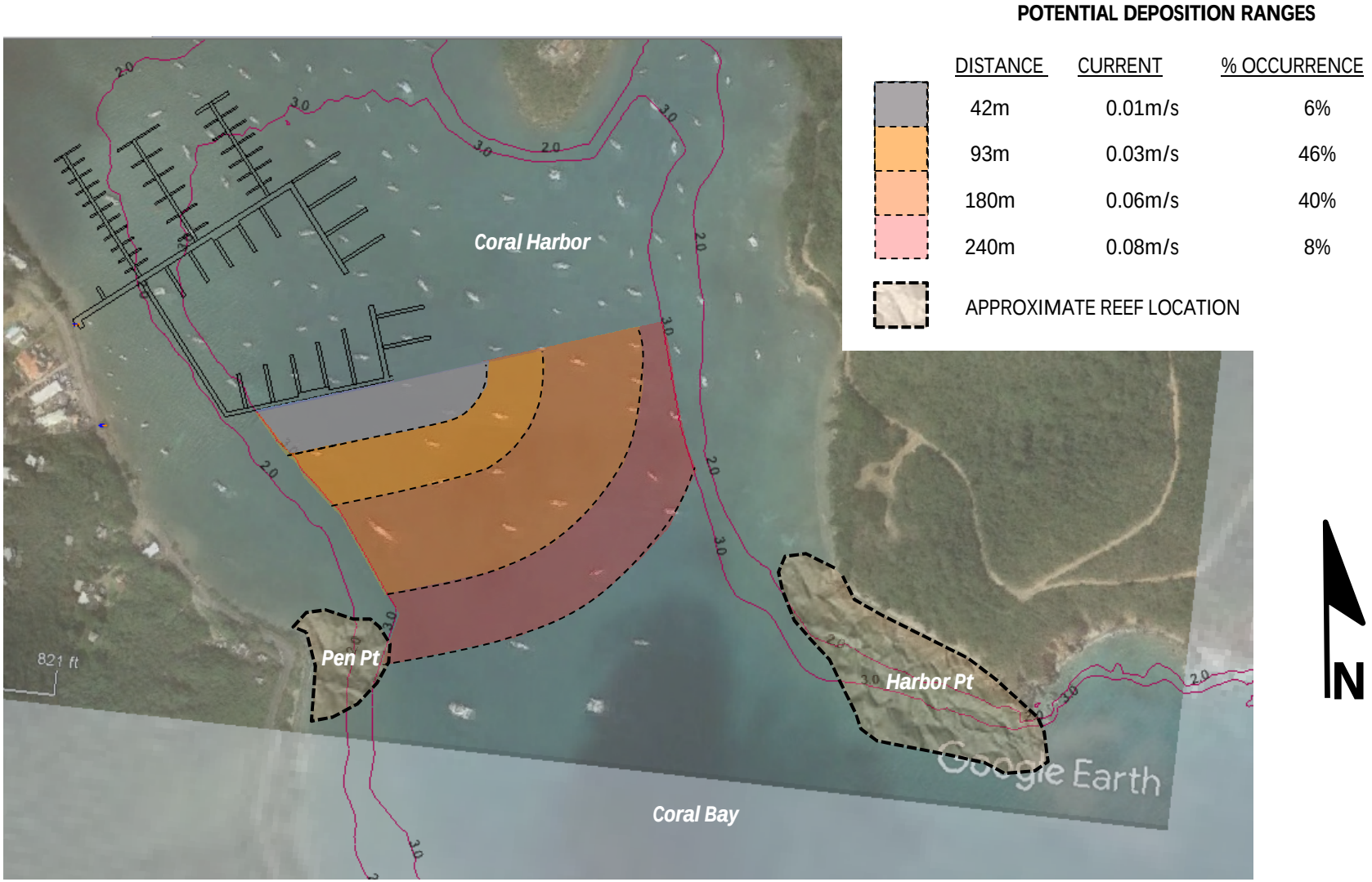


Figure 8: Coral Harbor – Potential Sediment Deposition Ranges to 3m depth

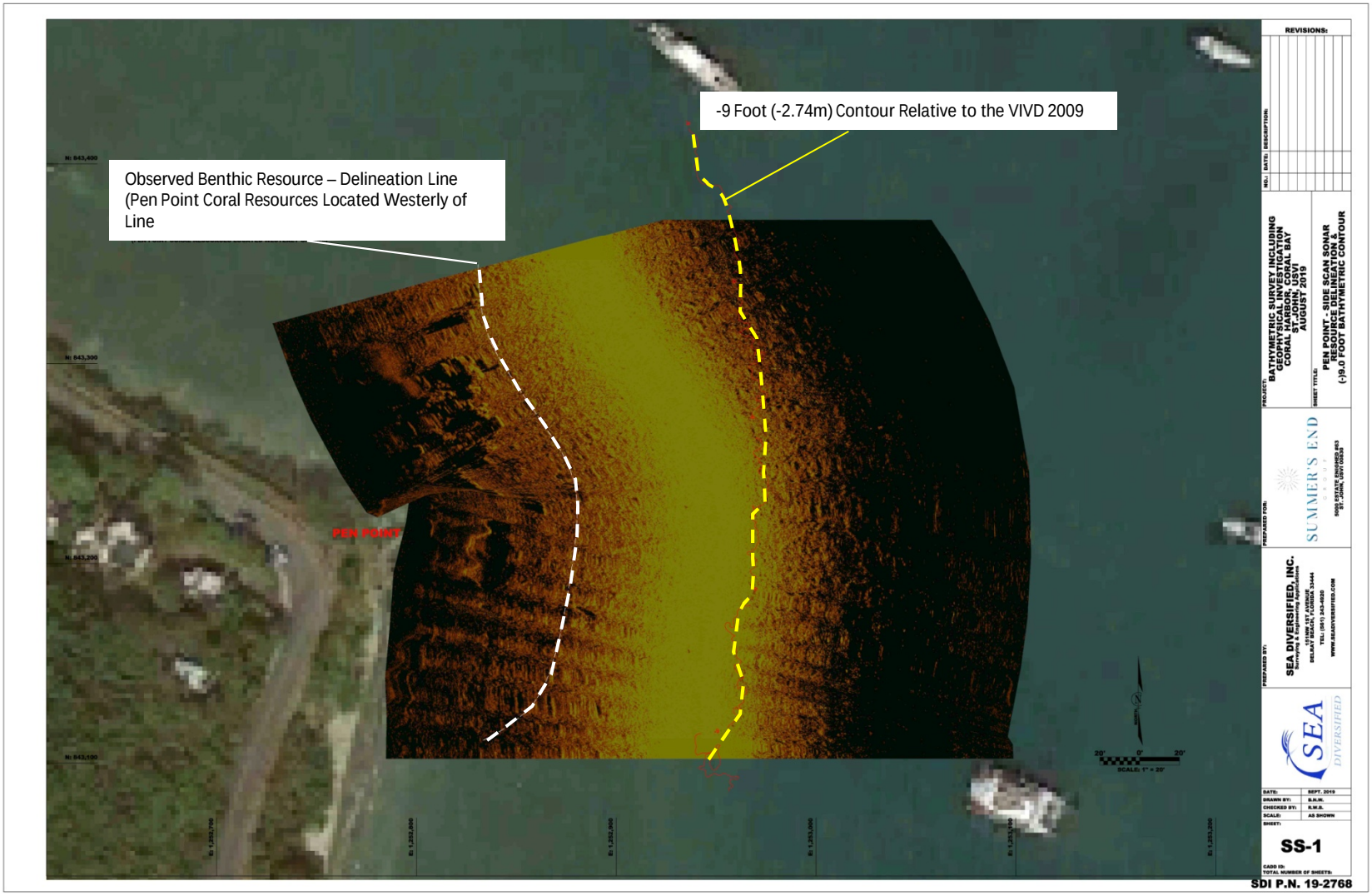


Figure 9: Coral Harbor – Sea Diversified Side Scan Sonar – Pen Point Reef

consistent with model results which show mostly flow going outside of the Harbor. Based on these observations, an increased turbidity at the marina would remain at the marina location or would migrate outside of the Harbor. The seagrass beds that could be affected are within the marina footprint area and possibly towards the south end of Coral Harbor within the 120m action area radius.

04 REFERENCES

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Buttolph, A. M., C. W. Reed, N. C. Kraus, N. Ono, M. Larson, B. Camenen, H. Hanson, T. Wamsley, and A. K. Zundel. 2006. Two-dimensional depth-averaged circulation model CMS-M2D: Version 3.0, Report 2: Sediment transport and morphology change. Coastal and Hydraulics Laboratory Technical Report ERDC/CHL TR-06-09. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

CLE Engineering, Inc., 2016, Environmental Conditions & Structural Calculations for Twin Dolphin Marina.

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APPENDIX A

CMS MODEL RESULTS

WAVE ONLY SIMULATIONS

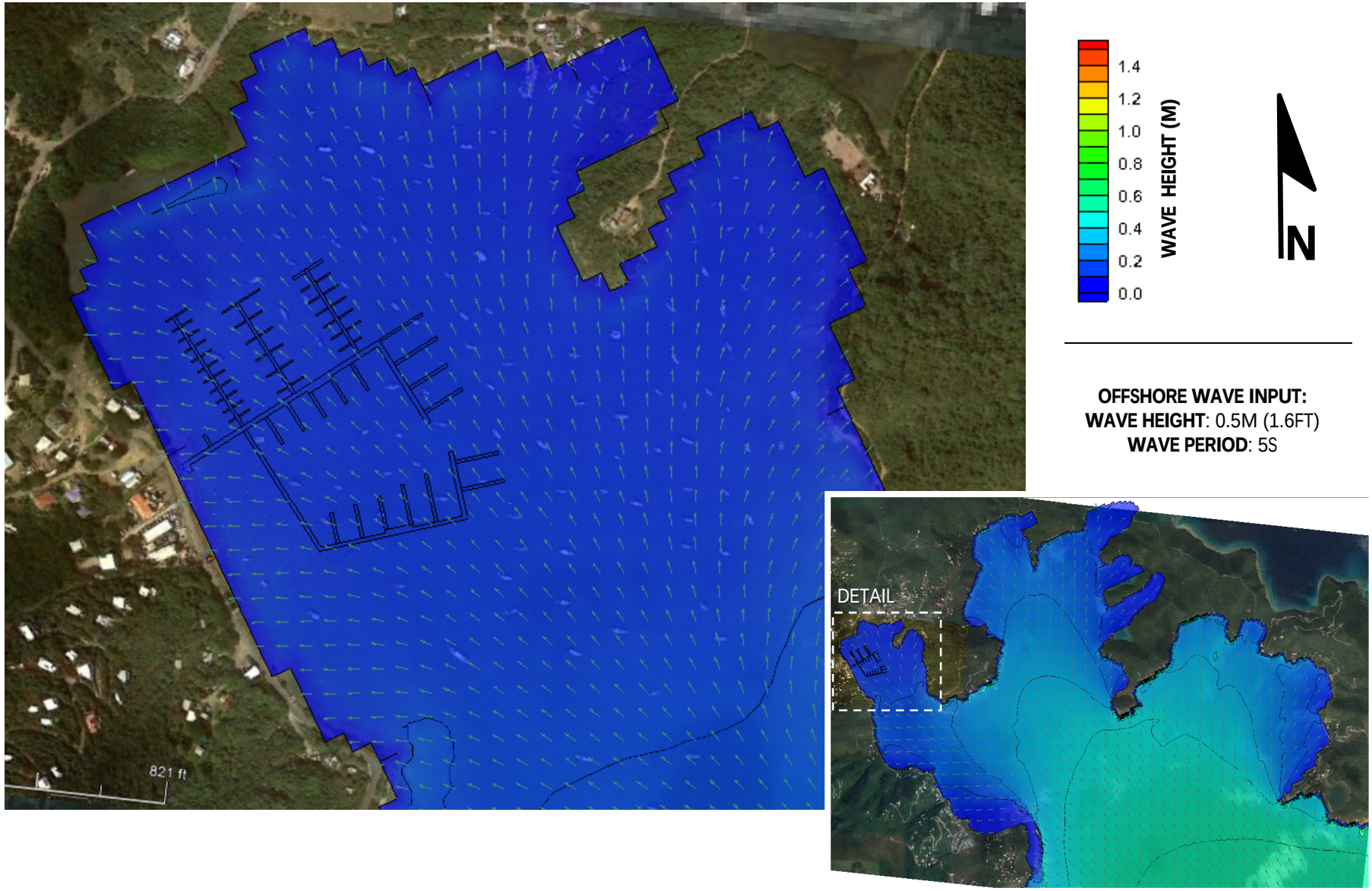


Figure A1: Coral Harbor – CMS-Wave Results – Hs=0.5m

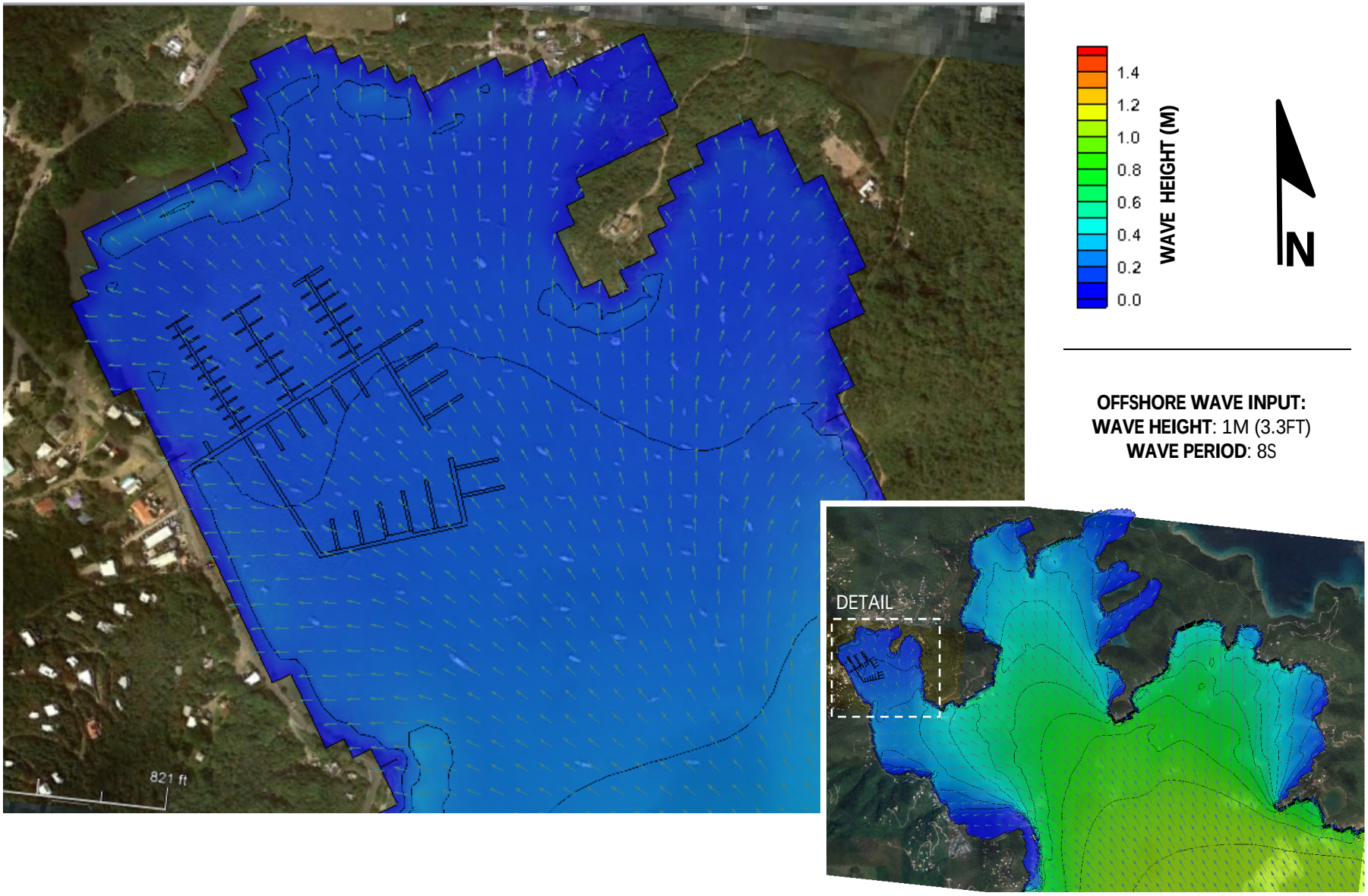


Figure A2: Coral Harbor – CMS-Wave Results – Hs=1m

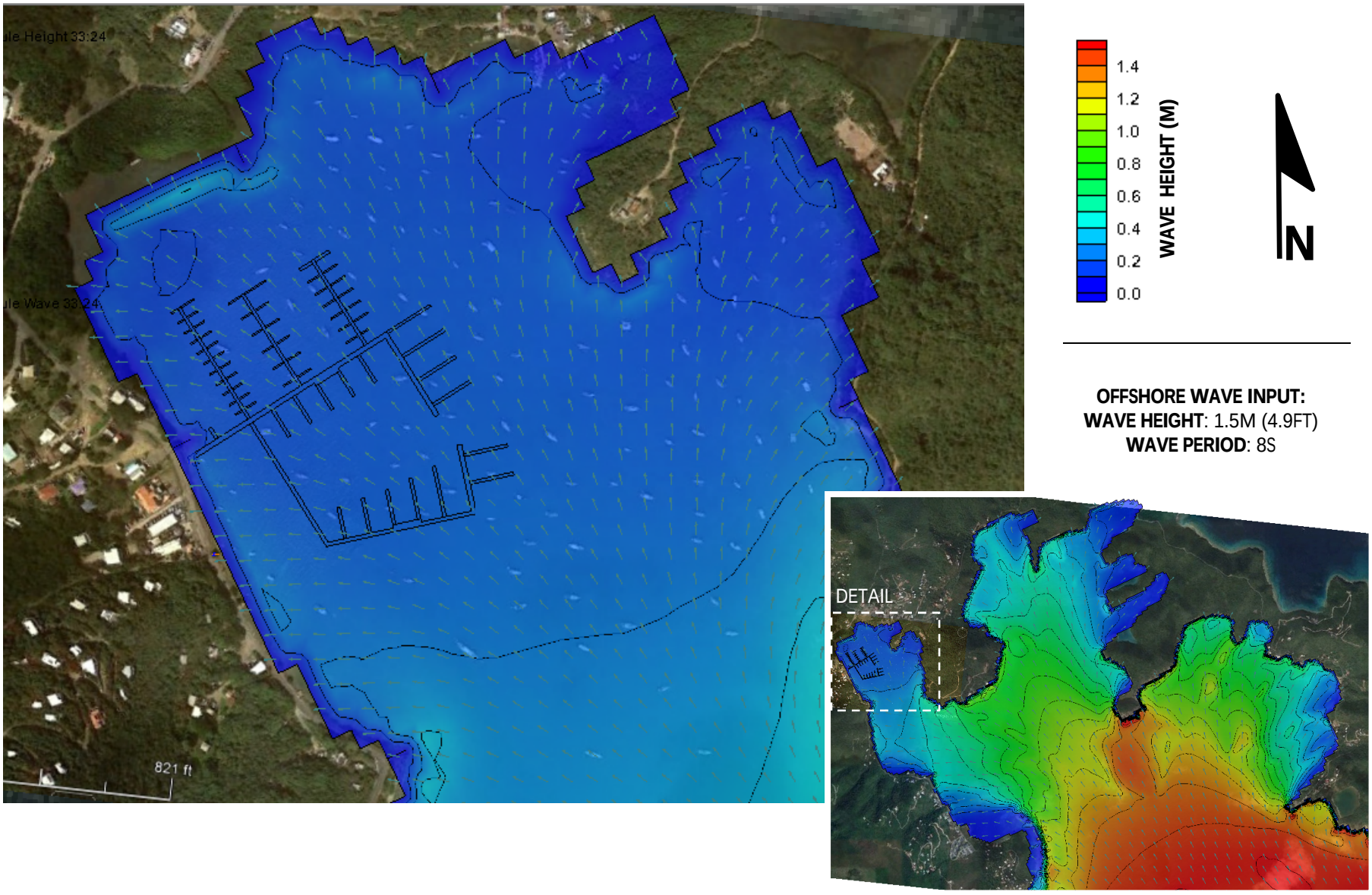


Figure A3: Coral Harbor – CMS-Wave Results – Hs=1.5m

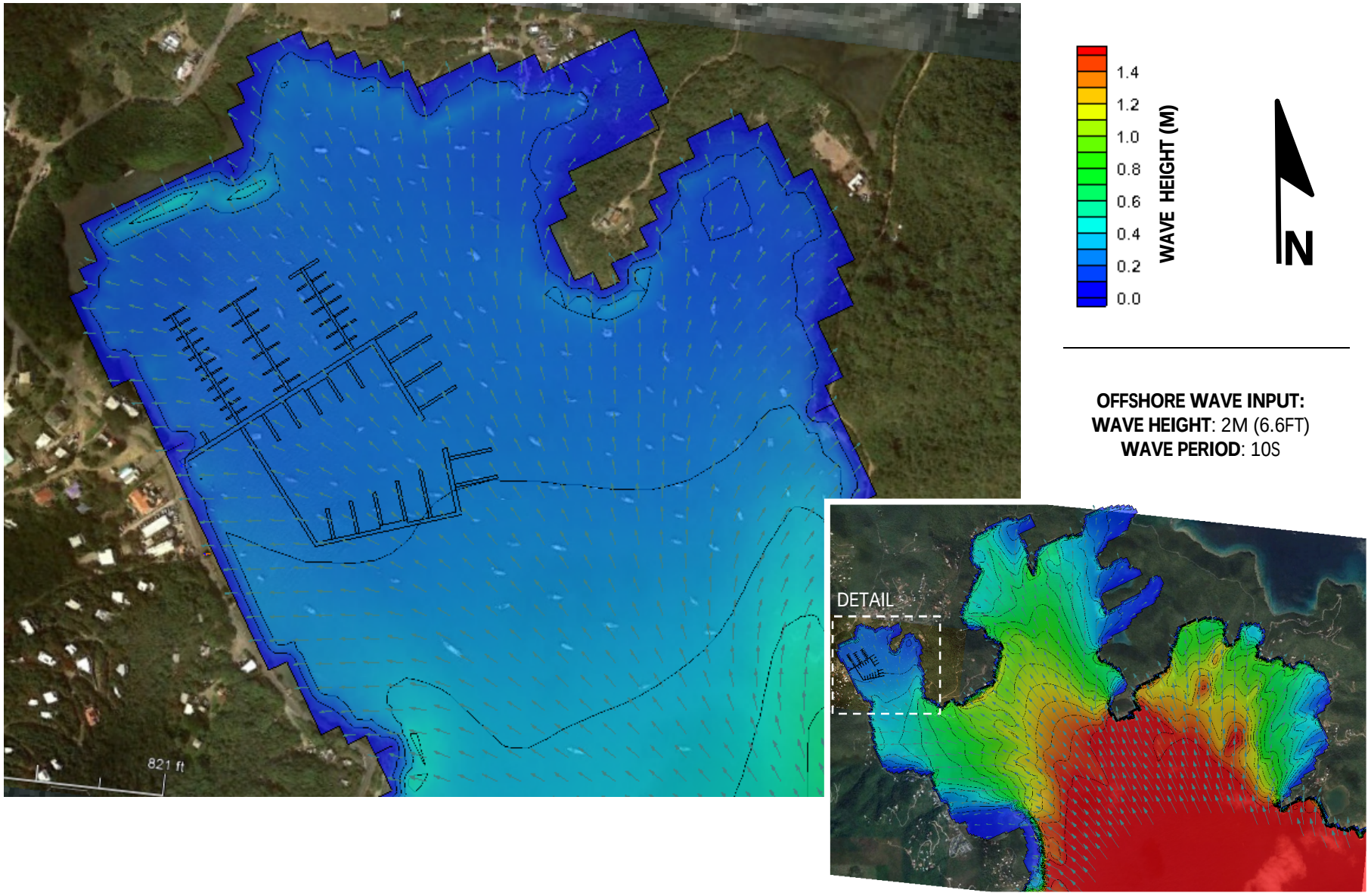


Figure A4: Coral Harbor – CMS-Wave Results – 2m

APPENDIX B

CMS MODEL RESULTS

WAVE & CURRENT SIMULATIONS

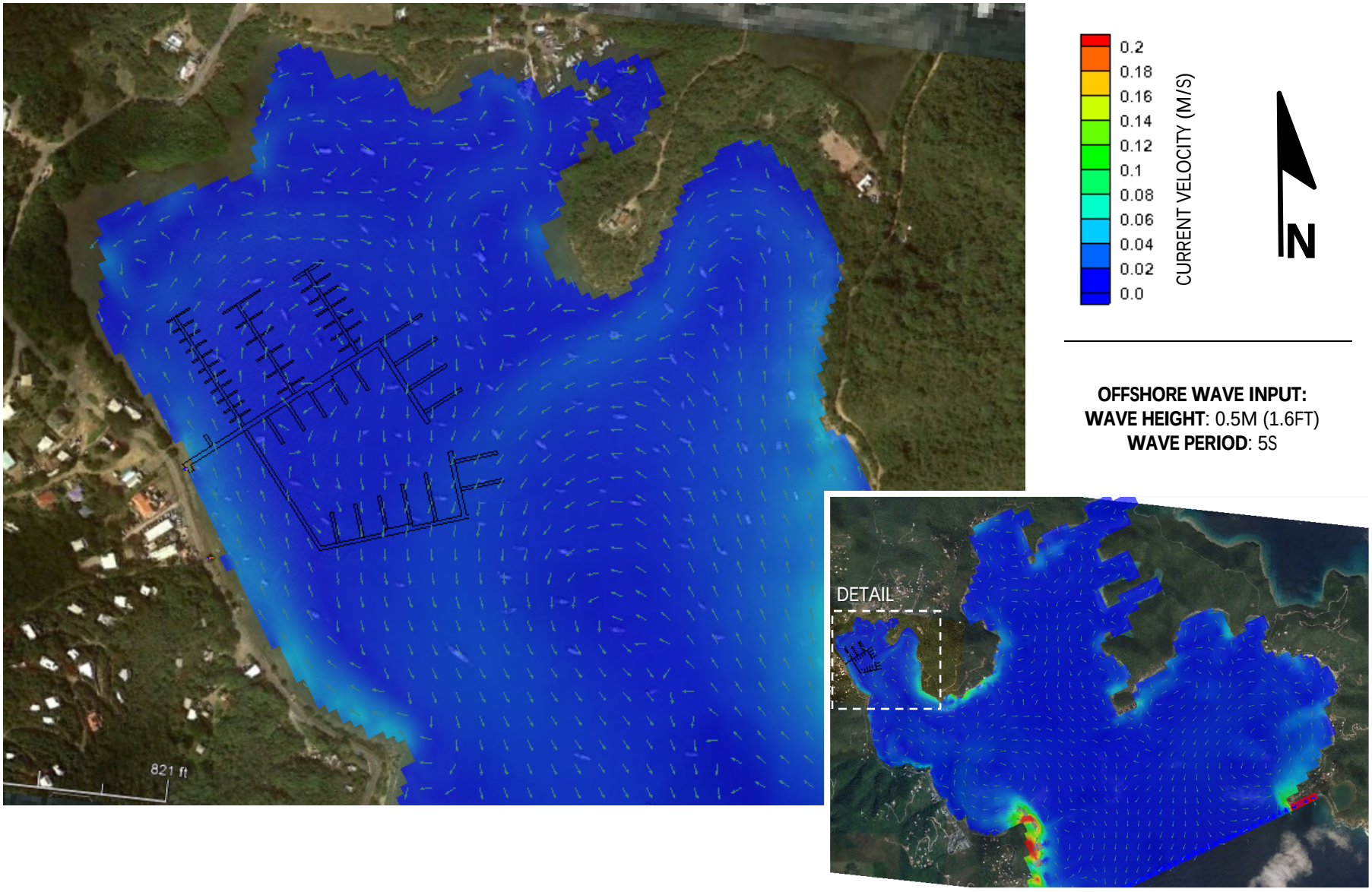


Figure B1: Coral Harbor – CMS-Flow Results – 0.5m

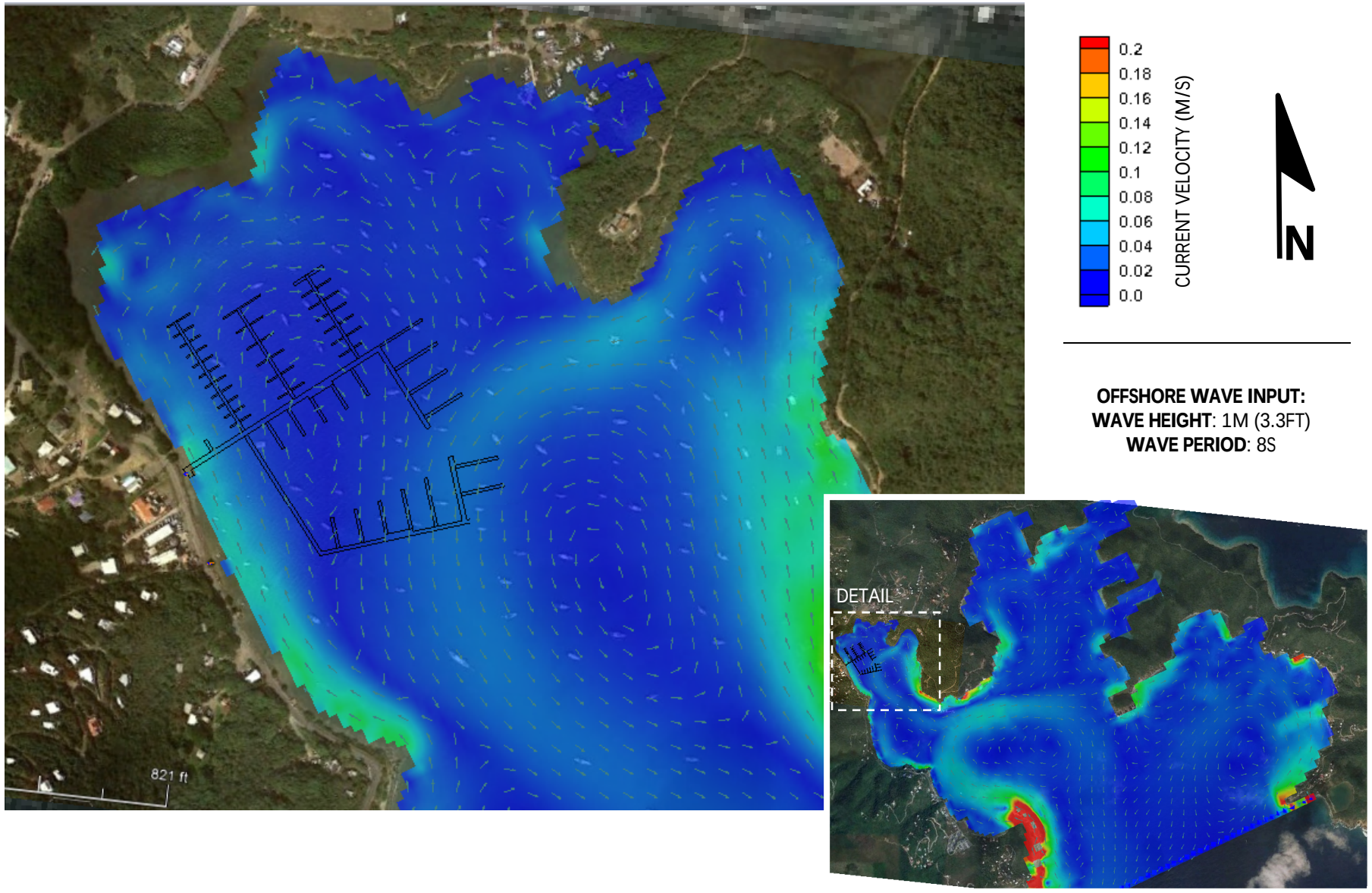
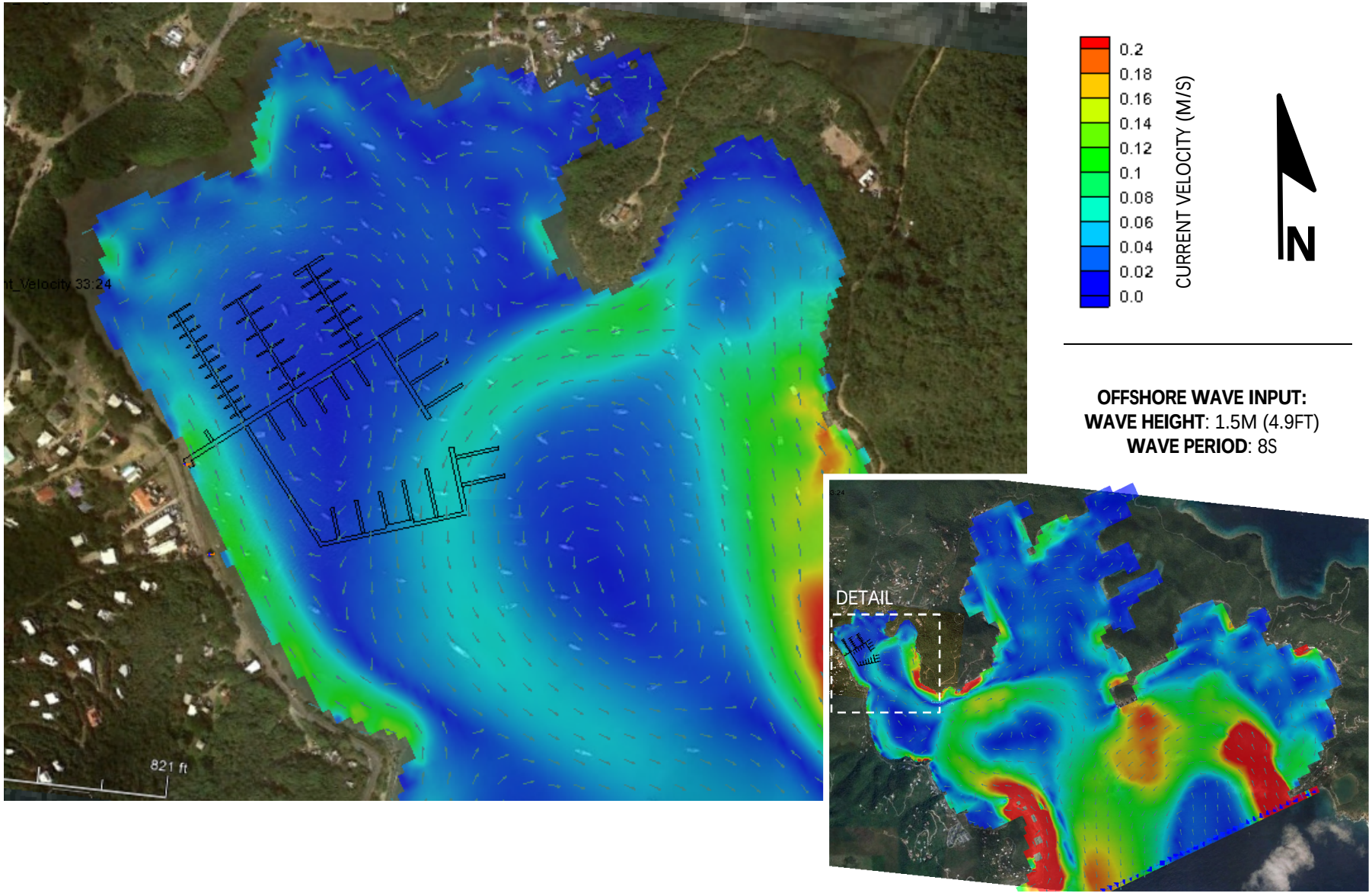


Figure B2: Coral Harbor – CMS-Flow Results – 1m



OFFSHORE WAVE INPUT:
WAVE HEIGHT: 1.5M (4.9FT)
WAVE PERIOD: 8S

Figure B3: Coral Harbor – CMS-Flow Results – 1.5m

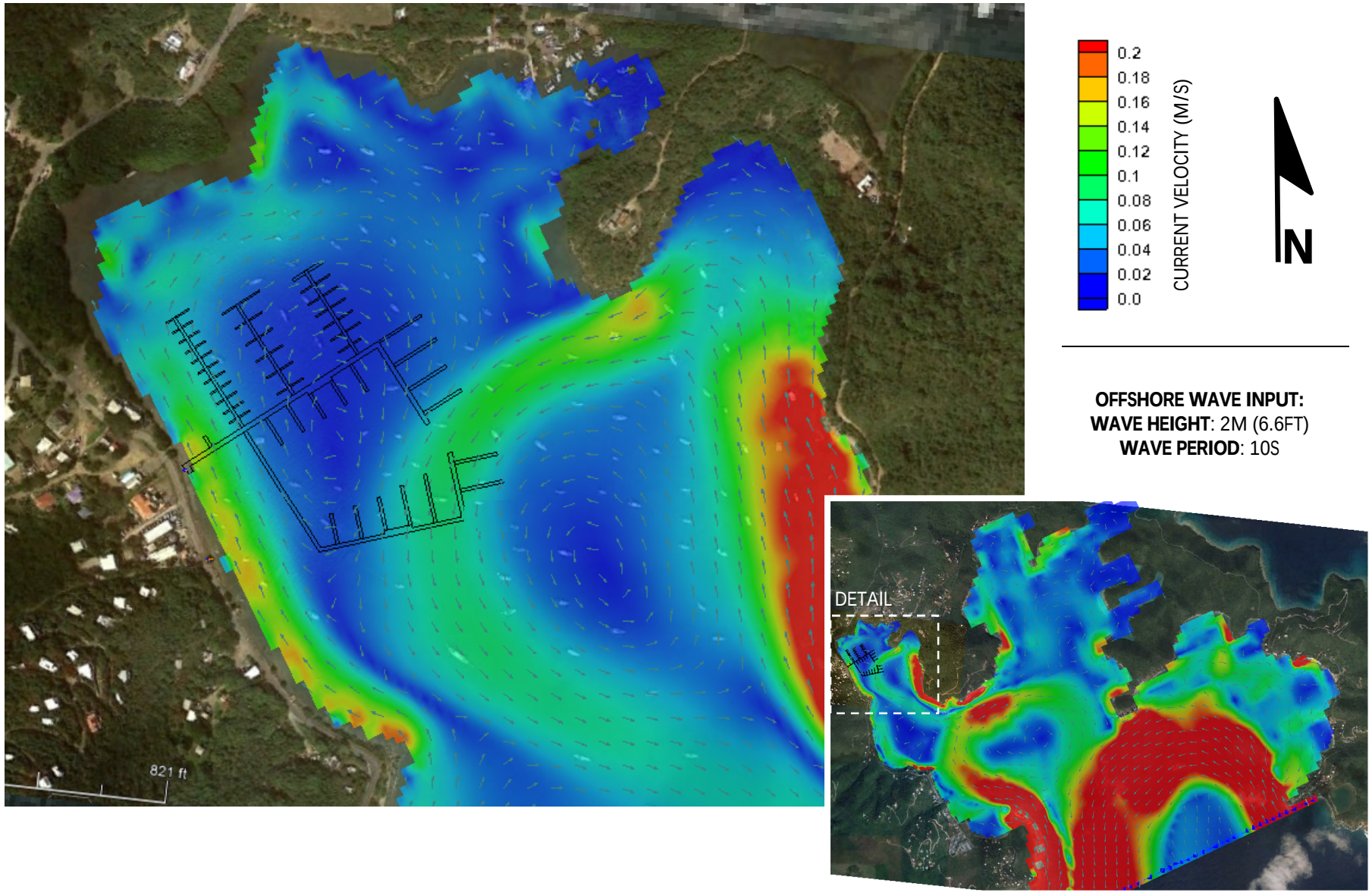


Figure B4: Coral Harbor – CMS-Flow Results – 2m

APPENDIX C

ST JOHN VIRGIN ISLANDS ANNUAL WAVE TIME SERIES

STATION 41052

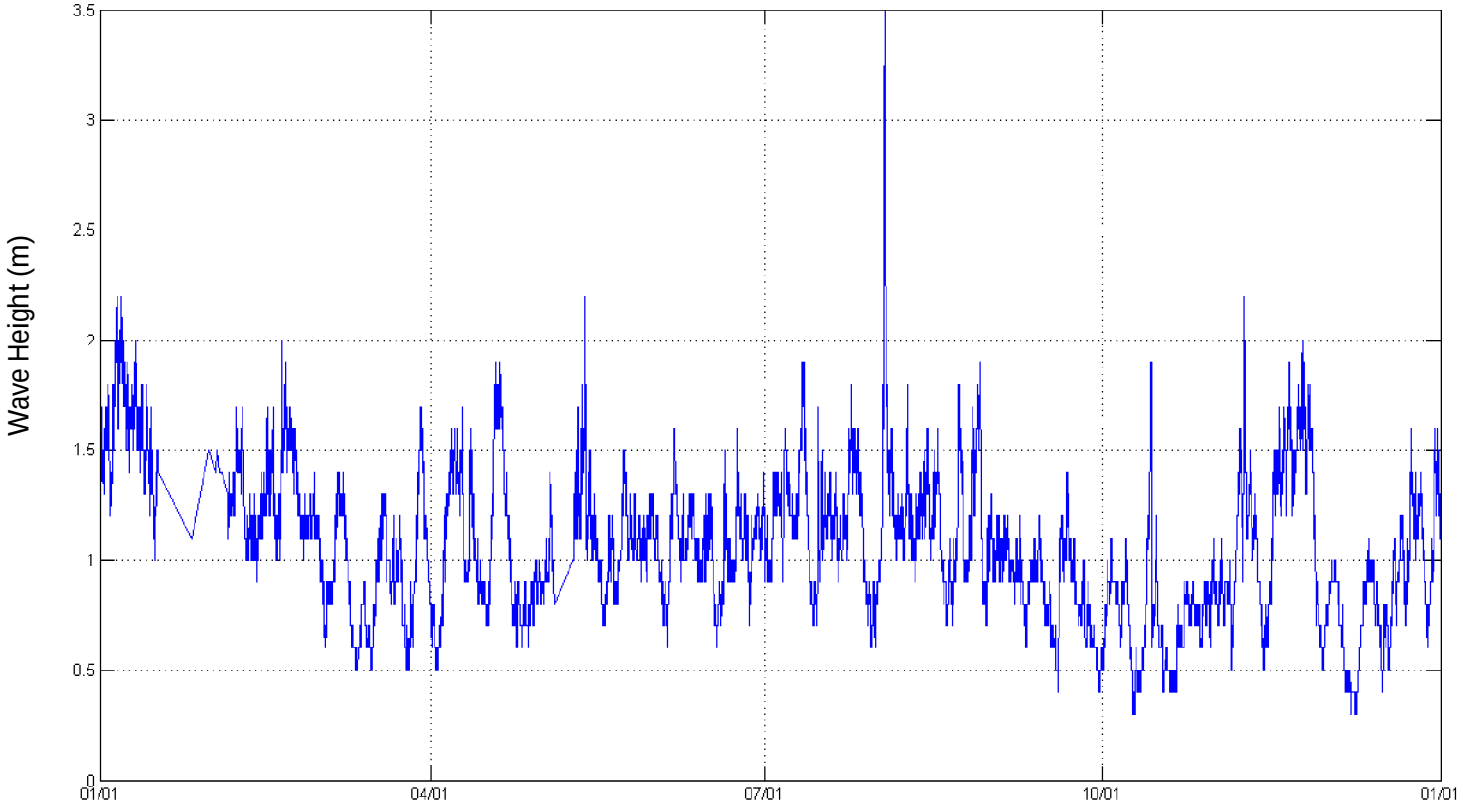


Figure C1: Coral Harbor – Offshore Wave Height 2014 – Station 41052

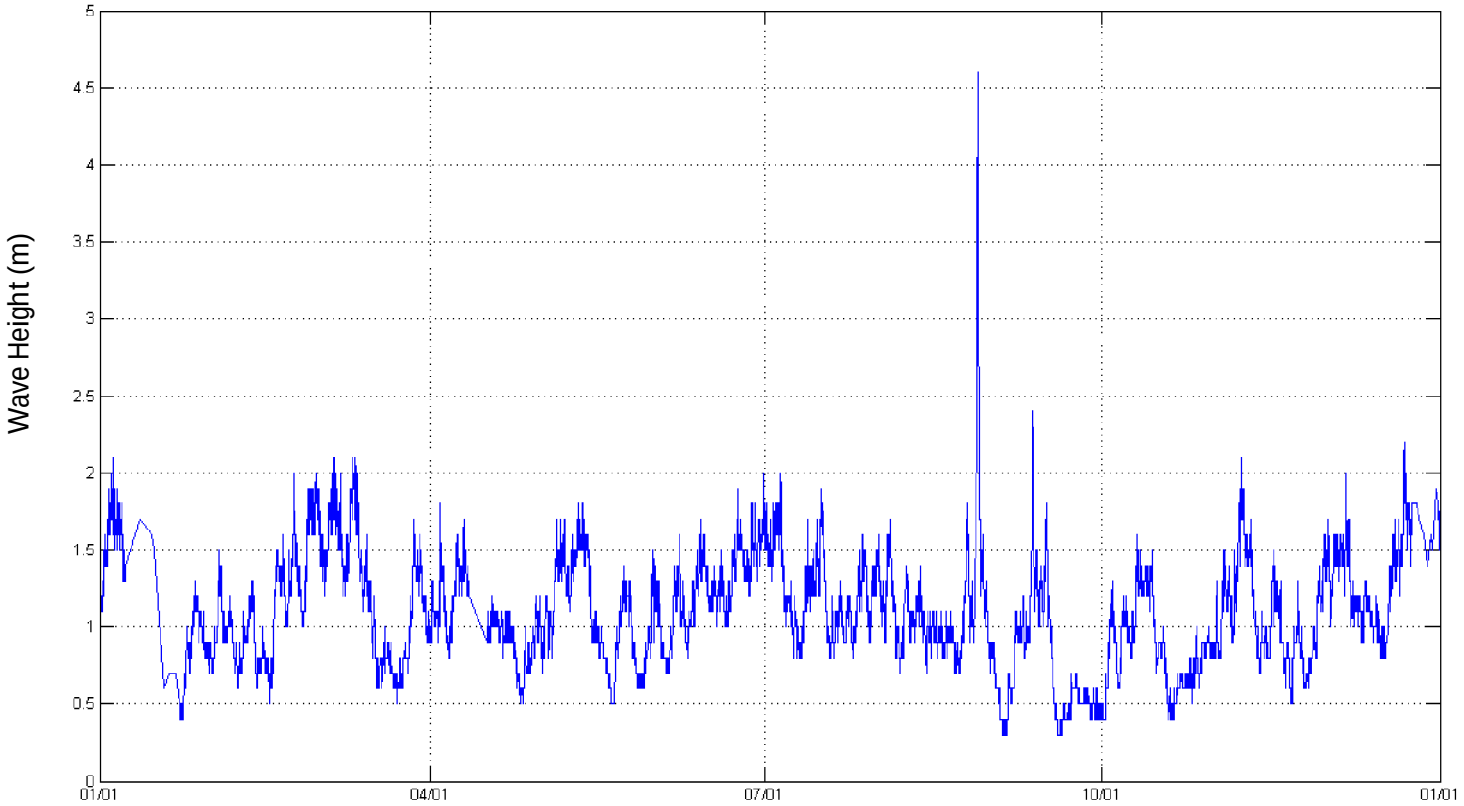


Figure C2: Coral Harbor – Offshore Wave Height 2015 – Station 41052

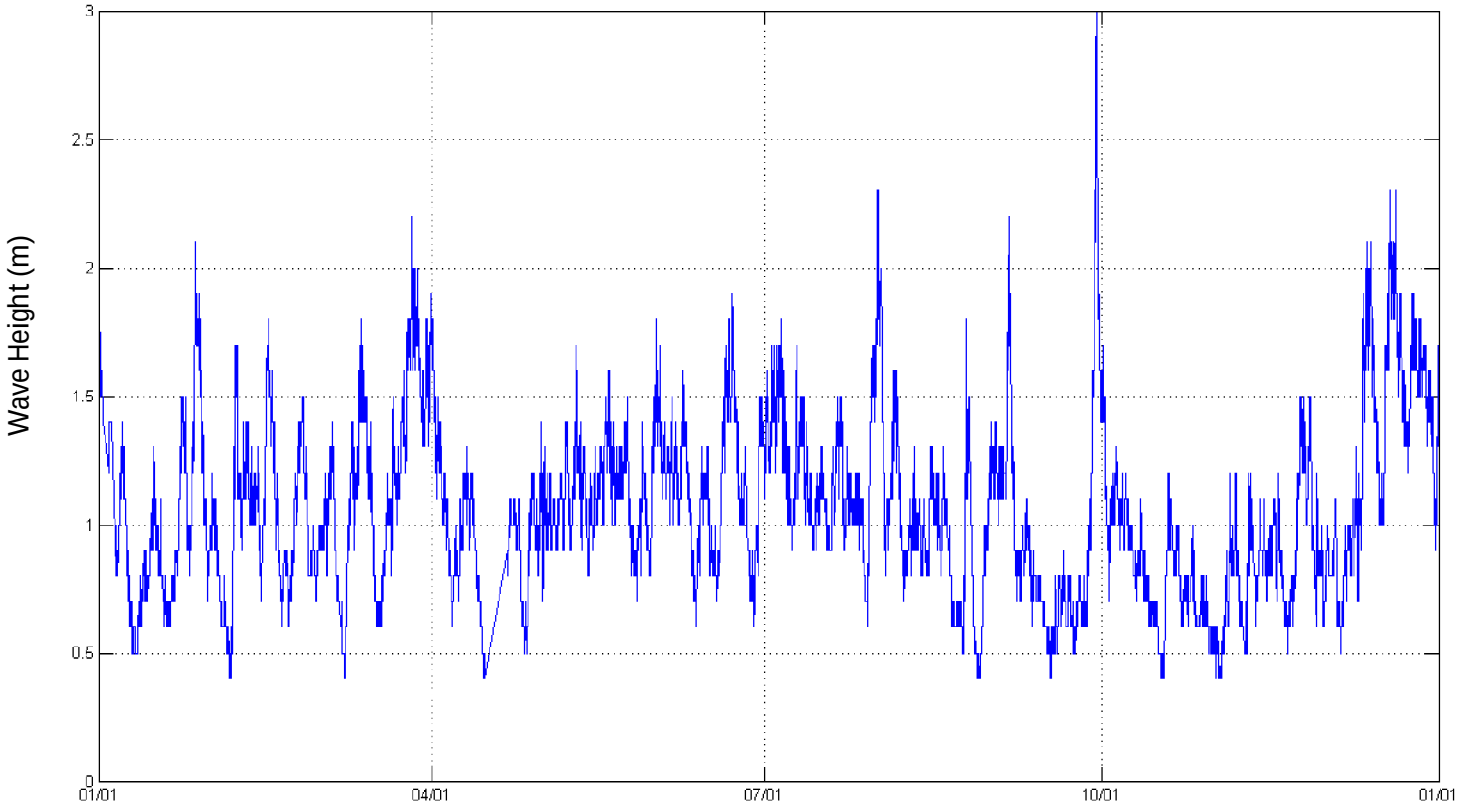


Figure C3: Coral Harbor – Offshore Wave Height 2016 – Station 41052

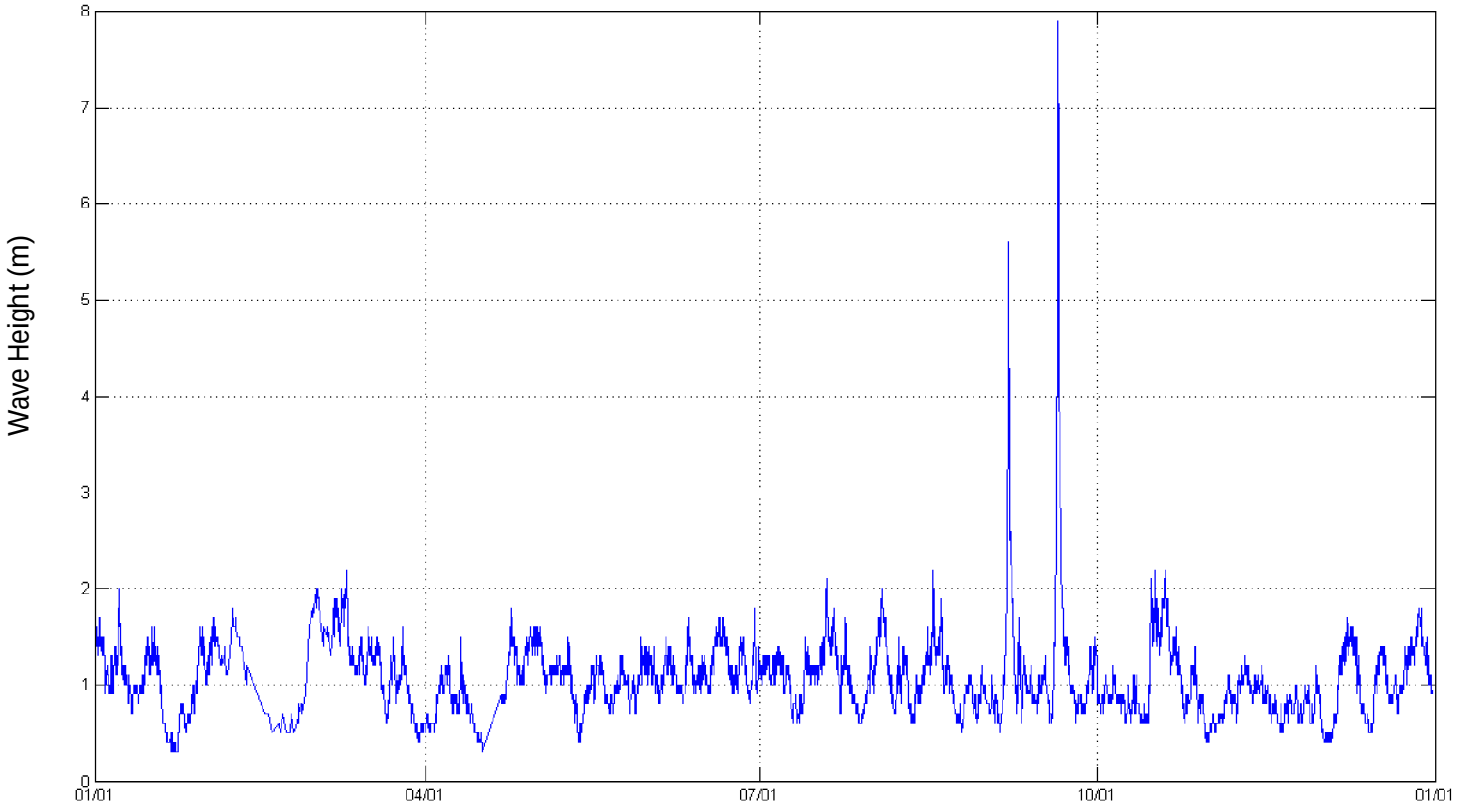


Figure C4: Coral Harbor – Offshore Wave Height 2017 – Station 41052

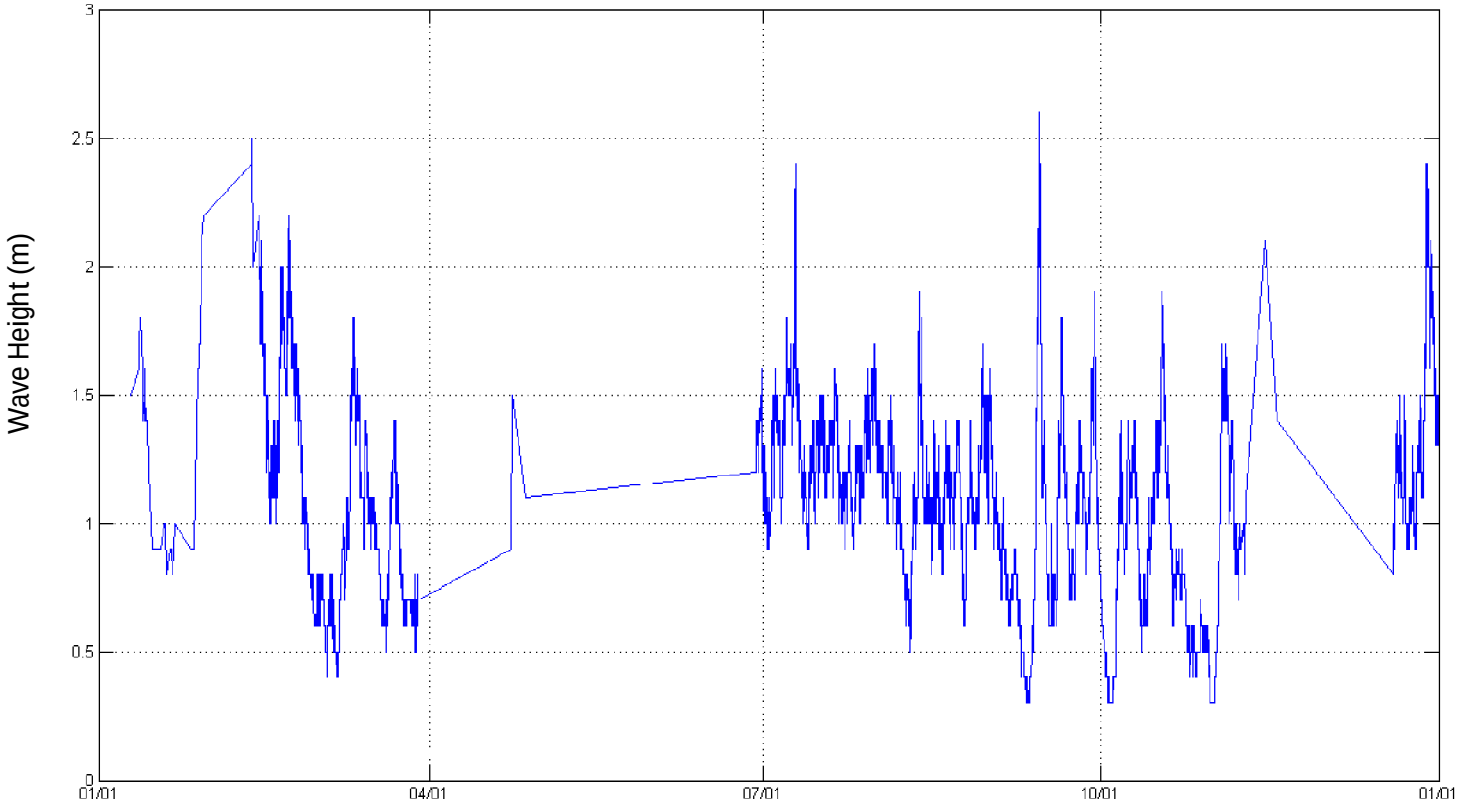


Figure C5: Coral Harbor – Offshore Wave Height 2018 – Station 41052