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June 12, 2018

Mr. Robert Weber, Coastal Program Manager
Town of Palm Beach Public Works Department
951 Old Okeechobee Road
West Palm Beach, FL 33401

Re: Proposal for the 2018 FDEP Beach Management Agreement Cell-Wide Hardbottom Monitoring and 2018 Hardbottom Map

Dear Mr. Weber:

Coastal Eco-Group is pleased to provide the Town of Palm Beach with the following proposal for the 2018 Environmental Monitoring Program based on the requirements of the Florida Department of Environmental Protection (FDEP) Beach Management Agreement (BMA). This proposal is being submitted to the Town on a Time and Materials – Not to Exceed basis for the services as described herein.

The scope and cost estimate contained herein have been collaboratively developed by professionals from the Coastal Eco-Group team. Teaming partners include Tetra Tech, Inc. and Nova Southeastern University. Ms. Cheryl Miller will serve as Project Manager and Principal Scientist for this effort.

This proposal has been divided into two tasks based on mapping and monitoring/reporting tasks of the BMA and the 2015 Mid-Town Beach Nourishment Project regulatory requirements. Task 1 is creation of the 2018 hardbottom map based on digitization of exposed hardbottom in aerial photography and nearshore hardbottom edge mapping of the entire BMA cell. Task 1 includes participation and presentation in public meetings for the BMA and an annual meeting with DEP. Task 2 is the Mid-Town regulatory project monitoring, BMA transect monitoring, and data analysis and reporting required by the BMA. Mid-Town is the only project with project monitoring for regulatory assurance in the BMA.

The specific scope of work to be implemented is described in the BMA, Appendix B– Cell-Wide Monitoring and Mitigation Plans. Language repeated directly from the BMA is shown in italics below.

Task 1. 2018 Hardbottom Edge Mapping and Creation of 2018 Hardbottom Map
A baseline benthic habitat map for the BMA was created in 2014 using aerial imagery from July and November 2014. Map creation included *in situ* verification of hardbottom edges.

Work performed under Task 1 involves digitization of exposed hardbottom in 2018 aerial photography using ArcGIS 10.6, including inter-observer QA-QC, following the standards used to develop the Town's historic hardbottom GIS database in the BMA. The nearshore hardbottom edge of the entire BMA cell (FDEP control monument R-76 to R-151) will be mapped by divers, and a final hardbottom map will be developed. These tasks correspond to the below BMA requirements.

Aerial photo survey and analysis of hardbottom distribution
Biannual aerial photography will be used to map the hardbottom along the BMA area twice a year and will serve as a data comparison for the in situ nearshore hardbottom edge mapping work in the summer. Having the additional aerial photo survey during the winter months will provide information on seasonal variability of hardbottom exposure. Department approved aerial photographic methods will be employed to collect aerial photography sufficient for analysis and delineation of hardbottom distribution within the cell. The acreage of exposed hardbottom in the specified zones of the cell area will be estimated and followed by a field verification of the outlined hardbottom areas, specifically on the shoreward edge (through the hardbottom edge mapping, as described in B.2.c.ii. below) and then the hardbottom will be digitally mapped using GIS. The acreage of exposed hardbottom in the specified zones of the cell area will be based primarily on aerial imagery that may be adjusted using diver observations conducted as close as possible to the imagery flight.

Nearshore Hardbottom Edge Survey
The nearshore hardbottom edge (western border of exposed hardbottom areas), or the position of the landwardmost visible border between sand and hardbottom defined by emergent biota, as well as the relief characteristics of the edge, will be mapped by a diver swimming with a differential global positioning system (DGPS). The diver shall tow a radio telemetry buoy with a DGPS antenna mounted on it. The buoy shall be on the shortest possible tether, such that the buoy is directly over the diver. The positioning system is a survey-grade DGPS which transmits continuous positions to ArcGIS or HYPACK hydrographic survey software on board the survey vessel with correction from a U.S. Coast Guard Navigational Beacon. The locator automatically acquires and simultaneously tracks GPS satellites and precisely measures code phase and Doppler phase shifts and then computes time, latitude, longitude, height, and velocity once per second. The positioning data is tracked using the positioning program. All data obtained are recorded on the computer's hard disk and copied to external storage at the end of each day.

The nearshore hardbottom edge is located in the intertidal/subtidal zone in Reaches 7 through 10 and portions of Reach 2. Due to the shallow water depths of these features, the nearshore edge in these areas will be mapped by qualified biologists using a handheld Trimble Geo 7x DGPS (or comparable) system. The field team will carry the Trimble unit as they walk/swim around the hardbottom feature at the sand/rock interface. The Trimble Geo 7x shall collect data every second during the edge mapping.

Task 2. Mid-Town Regulatory Transects and BMA Transect Field Survey and Annual Data Analysis/Report Development

Table 1 provides a list of the regulatory Mid-Town transects with transect lengths from the 2014 survey, and Table 2 provides the Mid-Town sediment transects. Table 3 lists the BMA transects and Mid-Town BMA extensions to be surveyed in 2018. If exposed hardbottom is observed seaward of the BMA transects listed in Table 3 during the 2018 survey, the transects will be extended to the length of exposed hardbottom, and sediment depth/line intercept monitoring shall be performed across the full cross-shore extent at the time of the 2018 survey. The seaward end of exposure in 2018 will be marked with a 6-inch PK nail, and DGPS coordinates will be recorded.

Table 1. Town of Palm Beach Mid-Town Regulatory Transects

Transect	Transect length (m)	Pre-Construction Survey
R-90	200	12/16/2014
R-91	200	12/16/2014
R-92	200	12/15/2014
R-93	200	12/15/2014
R-95 Breaker's (Artificial)	185	12/17/2014
R-97	75.2	12/15/2014
R-98	94	12/15/2014
R-99	95	12/16/2014
R-100	117	12/16/2014
R-101	107.3	12/16/2014

ENVIRONMENTAL MONITORING SURVEY METHODS

Transect Survey Methodology

During the monitoring event, the transect shall be set up (plotted) by a diver extending a measuring tape the distance of the transect, with each end secured to the end of the transect by a permanent pin. Sediment measurements shall be made, a video survey shall be conducted, and benthic quadrat sampling shall occur along the transect to measure the types and distribution of the benthic communities, as well as the relief and sedimentation features of the hardbottom. The sediment measurements shall be the first data collection event to occur following set up of the transect in order to have the least sediment disturbance. Video data and benthic quadrat surveys will follow sediment measurements. Transects include all data collections listed below, unless specified to be "sedimentation only" transects. If "sedimentation only" transects are specified, only that protocol shall be utilized.

Table 2. Town of Palm Beach Mid-Town Sediment Transects

Transect	Length of Transect (m)	Pin Locations	Sand Trough Locations
T14	200	0m (EB), 10m (EB), 50m (SR), 100m (EB), 145m (SR), 188m (SR), 200m (LR)	148 m - 188 m
T13	200	0m (LR), 70m (LR), 100m (EB), 140m (SR), 200m(LR)	150 m - 190 m
T9	194	0m (LR), 20m (SR), 50m (SR), 77m (SR), 177m (SR), 194m (LR)	80 m - 170 m
T8	56	0m (LR), 10m (LR), 56m (LR)	-
T7	62	0m (LR), 12m (LR), 48m (SR), 62m (LR)	-
T6	83	0m (LR), 12m (LR), 50m (SR), 83m (LR)	-
T5	78	0m (LR), 10m (LR), 50m (SR), 78m (LR)	-
T4	90	0m (LR), 10m (LR), 50m (SR), 90m (LR)	-

Table 3. BMA Transects, Offshore Stations, and Mid-Town BMA extensions

Transect	Length (m)	Date of Installation	Baseline Survey Date
R-80.5	150	6/22/2015	8/13/2015
R-83	156.8	6/22/2015	7/16/2015
R-88	172	10/30/2014	12/17/2014
R-90 ext.	82	10/20/2014	12/16/2014
R-91 ext.	108	10/3/2014	12/16/2014
R-92 ext.	125.6	10/17/2014	12/15/2014
Station R-92	22	6/22/2015	7/16/2015
R-93 ext.	3	10/17/2014	12/15/2014
R-94	281	10/29/2014	12/17/2014
Station R-94	22	6/22/2015	7/16/2015
R-95 Breaker's Natural	60	10/22/2014	12/17/2014
R-103	151	10/29/2014	12/17/2014
R-113	2.2	10/30/2014	12/18/2014
R-115	15.5	10/30/2014	12/18/2014
R-116	29.5	10/30/2014	12/18/2014
R-132	117	10/30/2014	12/18/2014
R-133	143	10/30/2014	12/18/2014
R-136	137	6/19/2015	7/16/2015
R-139	67	6/19/2015	7/16/2015
R-142	125.5	6/19/2015	7/15/2015
R-145	157.4	6/19/2015	7/15/2015

Sediment Measurements: Line Intercept and Sediment Depth Measurements.
In order to track changes in sediment cover over and across the hardbottom within the cell, line intercept and sediment depth measurements will be conducted along each transect. These surveys shall be conducted first, after the transect is set up, in order to measure undisturbed sediments. These surveys provide documentation of sediment cover and movement over the hardbottom, as well as information about where sediment accumulation is occurring over hardbottom.

i. *Interval sediment depth measurements document sediment movement and dynamics within each transect. Sediment depth shall be measured and recorded to the nearest centimeter, at every other meter mark (0m, 2m, 4m, etc.). For the measurement, a stainless-steel ruler, graduated in centimeters (0 cm to 30 cm), shall be pressed through the sediments until the ruler reaches surface of hard substrate or totally immersed in sand. Sand thickness of less than 0.5 cm will be recorded as 0, more than 0.5 cm but equal or less than 1 cm will be recorded as 1cm, etc. Measurements greater than 30 cm will be recorded as >30 cm. Measurements shall follow the entire length of the transect excluding sand patches over 0.5m that would be recorded in the line intercept survey, as described below. Measurements would be recorded in a table printed in waterproof paper, labeled in 2m increments with the transect number. For reporting purposes, results will be summarized in a Microsoft Excel format spreadsheet. Annual reports shall include average sediment depths for each transect, the entire monitoring area, and for zones 0-30m; 30m-60m; 60m- 100m; and 100m -150 (200) m, or more detailed if necessary.*

ii. *The line-intercept survey would be used to document larger areas of uninterrupted sand (patches and troughs over 0.5m measured width along the transect). Sediment dynamics within the monitoring area are characterized by changes in dimensions of such sand patches. The western and eastern edge of each sand patch/trough will be recorded during the line-intercept survey.*

Sediment depth will be measured at one point, in the middle of the patch, if the patch is 0.5 m to 1.5 meters wide, and at three points if the patch width is over 1.5 m (0.5m from each edge into the patch and in the middle of the patch). For reporting purposes, patches will be graphically displayed in a bar graph of each transect for the comparison of their dynamics over time.

Video Surveys of Transects
The video survey of the transect serves as an archived data set for reference or resolution of unclear data from the quadrat and sediment surveys. As mentioned above and prior to the survey, a measuring tape should be extended along the length of the transect, in order to clearly mark the location along the transect in meters for accurate video reference. The video of hardbottom along each transect will be taken using a digital camera, with the videographer swimming at a rate no faster than five (5) meters per minute, and holding the camera at a height of forty (40) centimeters above the hardbottom. A convergent laser guidance system shall be utilized to indicate the precise height of the camera at 40 cm from the bottom. Prior to commencement and at the end of each transect line documentation, an underwater display containing the transect number, depth, and date will be videotaped and integrated directly onto the digital video record; additionally, a 360^{o} panoramic view will be recorded both at the

beginning and at the end of each transect from the elevation of about 1m above bottom and at the angle about 30^o to the horizon. Geographic Positioning System (GPS) navigational coordinates (Florida State Plane Coordinate System, East Zone NAD 83) of the video transect locations will be overlaid on recent aerial photography and included in the project monitoring reports.

Quadrat Data Collection Along Transects

Benthic communities and their habitats will be characterized quantitatively using the quadrat method, which samples quadrat areas of habitat at certain points along a transect. The intent of the sampling is to sample the same quadrat areas in each annual survey to be able to document changes in communities over time.*

*The northeast corner of the quadrat will align with a particular meter mark of transect, and a nail will be installed to mark the location of this meter mark, in order to facilitate repeat sampling of the same quadrat in successive surveys. Quadrats shall be plotted avoiding areas of sand cover. Enough quadrats must be used to sample a 10 m2 sampling area for each 150 meters of transect. Quadrats 1.0 m2 or 0.5m2 in size can be used to sample the hardbottom community along each transect to make at least 10 m2 sampling area per transect** (if the larger quadrat sizes are selected, fewer samples will be required). Quadrats will be distributed along the transect to have at least 2.5m2 to 3.5m2 sampling area (enough to characterize) for the following zones 0-30m; 30m-60m; 60m- 100m; 100m to 150m (or up to200m if longer) and 200m- 300m (or up to 400m if longer).*

Quadrat monitoring includes the following measurements:

i. *Hardbottom relief measurements;*
ii. *Species documentation (this shall include functional groups including algae and benthic sessile organisms, % cover of these groups if >1%, and octocorals and stony coral specific measurements);*
iii. *Sediment depth; and*
iv. *Percent cover by sediments*

Datasheets will have a standardized layout similar to that used in BEAMR (Baron and Lybolt, 2006), and will simplify data collection and entry for statistical treatment.

Visual estimates of percent cover of all sessile benthos shall be pooled to 15 major functional groups. Functional groups are: sediments, macroalgae**, turf algae***, encrusting red algae****, sponges, hydroids, octocorals, scleractinian corals, tunicates, bare hard substrate, zoanthids, hydrocorals Millepora sp., sessile worms (including wormrock, Phragmatopoma spp.), bivalves, and bryozoans. Each functional group is given a percent cover value (0-100%, with a minimum of 1%; if less than 1%, the functional group or a species is simply listed) and the total cover of all functional groups is 100%. The macroalgae percent cover will be characterized by total cover, and percent cover by the dominant macroalgae (if a particular species/genus has >5% cover). All other macroalgae will be also identified at least to the genus level and listed. The quadrat in situ method is limited to organisms that can be visually recorded and identified in the field, similarly to all other non-invasive and non-consumptive methods of sampling.*

Each colony of octocoral and scleractinian coral will be identified, as well as the maximum height for octocorals, and the width for scleractinian corals will be measured to the nearest centimeter. The smallest size recorded is one (1) centimeter; for colonies less than one (1) centimeter the record would be <1cm. Octocorals will be identified to at least the genus level, and scleractinian corals will be identified to the species level. Abnormal conditions of each colony will be recorded (e.g., bleaching, disease, predation, etc.).

In addition to the species being recorded within the quadrats, all species of benthic invertebrates (identified to at least genus level) will be recorded within a 1 meter belt.

** Sediments characterized by circling of the descriptor, or giving short additional characterization (e.g., rubble, or circled descriptor sand and then + shell hash, etc.)*

*** Macroalgae include fleshy macroalgae and geniculate calcareous algae, e.g. Halimeda); non-geniculate calcareous branching red algae write separately*

**** Turf algae include all algae with thallium less than 10mm and forming dense cover*

*****Encrusting red algae recorded separately for non-calcareous and calcareous (% + %)*

A single Access database has been developed to manage all biological data collected for the BMA. Preparation of the data deliverables (Microsoft Access database of monitoring data and electronic library of raw monitoring data); and statistical analyses and annual report preparation according to BMA guidelines will be completed under this task.

Data Analysis and Product Development
Quantitative data on the major benthic biological components, e.g., percent cover, abundance, distribution by size, and species lists as well as a statistical evaluation and comparison (paired or multiple) of the data collected along the permanent transects will help to determine the amount of the hardbottom type and ecological functions over time. This will determine if the ecological functions of the hardbottom habitat are impacted by a beach nourishment project. This database would facilitate efficient QA/QC operations, data management, and will also be filed to a uniform GIS database. The results of these analyses will be included in the yearly reports due to the Department. The following are required.

i. *Multivariate Benthic Community Analyses and Univariate Analyses of Physical Habitat Data. A table of hardbottom types (according to the classification system for the BMA) will be maintained annually to evaluate and track the changes in communities over time. It will be used to determine 1) if the amount of each type of hardbottom is being maintained over time and the natural variability of the fluctuations of that type; and 2) if a loss is due to a project. Unanticipated project induced impacts will initiate compliance and enforcement action. Once natural variation can be conclusively determined within the cell, this information could be utilized for better resource management in future regulatory actions.*

ii. *Statistical Tests. The following includes a list of suggested statistical tests to be performed with each single survey dataset to compare between annual surveys as well as between annual survey and the Habitat Map of Hardbottom:*

a. *Percent Cover - Benthic Functional Groups. The simplest and one of the most effective statistical comparisons is provided by the estimations of % changes in cover, biodiversity, size class distribution, area of distribution, sediment cover, and sediment thickness. Changes expressed in percentages provide the clearest picture of the changes occurring in the hardbottom communities as a result of each nourishment or natural event. These results are to be presented in tabulated and graphical form. It is also important to understand that the statistical significance of change in the absolute value of a parameter or in %, does not necessarily reflect a critical threshold e.g. in sediment accumulation that can change the character of hardbottom community; such thresholds can be identified only experimentally.*

b. *Similarity Analyses.*

   i. *Non-Parametric Statistics using PRIMER-E (v6) (Clark and Gorley, 2006), such as the following listed below:*

      a. *Similarity matrix – Bray-Curtis and/or Euclidean Distance similarity matrices display similarity between samples for further analysis. This should be calculated between every pair of samples.*

      b. *Cluster analysis with Similarity Profile (SIMPROF) – Simple agglomerative, hierarchal clustering which creates a dendrogram from a similarity matrix to display significant differences.*

      c. *MDS ordination – A complex numerical algorithm based on a similarity matrix among samples (transects). This constructs a "map" of the samples which attempts to satisfy all the conditions imposed by the rank similarity matrix.*

      d. *Analysis of Similarity (ANOSIM) – Operate on a resemblance matrix and carry out an approximate analogue of the standard univariate 1- and 2-way ANOVA tests. Allows for the test of the null hypothesis that there are no assemblage differences between groups of samples specified by the factors. Generates a histogram and provides R-statistic and p-values.*

      e. *Similarity of Percentage (SIMPER) – Looks at the role of individual taxa in contributing to the separation (dissimilarity) between two groups of samples (e.g., Artificial vs. Natural).*

      f. *Second Stage Analysis (2STAGE) – Gives a succinct summary in a 2-d picture of the relationship between the multivariate sample patterns under various choices (e.g., a disturbance in the temporal patterns of controls vs. impact could be detected by a 2STAGE analysis). This includes resemblance, MDS and ANOSIM.*

   ii. *Parametric Statistics such as the following listed below:*

      a. *T-test – used to determine significant differences based on average percent cover, density, richness, etc. Paired, homoscedastic, and heteroscedastic. Provides p-value to compare to pre-determined alpha.*

      b. *ANOVA – A test of the statistical significance of the differences among the*

mean scores of two or more groups on one or more variables. In the event scores differ, non-parametric ANOVA or a generalized linear model may be utilized to account for the nature of this data.

c. *Shannon Diversity Index (H') – Measures diversity in categorical data. It is simply the information entropy of the distribution, treating species as symbols and their relative population sizes as the probability.*

d. *Pielou's Evenness Index (J') – A measure of biodiversity which quantifies how equal the populations are numerically. Based on Shannon Diversity Index.*

The report to be developed for the BMA study area will include 2018 aerial photography provided by the Town of Palm Beach with the summer 2018 hardbottom edge survey as an overlay; sediment analyses including bar graphs depicting sediment patch data and average sediment depths of transects and cross-shore zones; benthic community analysis and change, and statistical analysis of data. An annual monitoring summary presenting the 2018 survey results, interpretations, trends, and comparison to the baseline survey data will be submitted within 120 days of the completion of the 2018 survey. The final report will be submitted as a PDF file; two hard copies of the final 2018 report will be provided to the Town.

The commencement dates of the surveys will be reported to the FDEP approximately 7 days prior to beginning the work effort. All raw data (including shape files, copies of field data sheets, video and still photos) shall be provided to the Department in electronic format upon completion of the survey.

The total estimated cost of this proposal is **$199,523** and is submitted on a Time & Materials – Not to Exceed basis. The total cost of Task 1 is **$70,362**, and the total cost of Task 2 is **$129,161**.

Thank you for the opportunity to work with the Town of Palm Beach. Please contact me at 954-591-1219 or via email at cmiller@coastaleco-group.com if you have any questions regarding this proposal.

Sincerely,

Cheryl L Miller

Cheryl L. Miller
President, Principal Scientist
Coastal Eco-Group, Inc.