APPENDIX E – BIOLOGICAL MONITORING PROGRAM

Broward County Shore Protection Project
Proposal for Construction/Post-Construction
Nearshore Biological Monitoring Plan
June 26, 2003

1. Construction Monitoring of Nearshore Hardbottom: The CONSULTANT shall perform weekly visual assessments of sedimentation/siltation upon nearshore epibenthic communities seaward of the projected equilibrium toe of fill during fill placement activities. Visual observation of sedimentation/siltation impacts will be performed by qualified professionals led by a biologist with a M.S. degree or higher. Data on sedimentation/siltation impacts will also be collected using sediment collection pans installed at the fixed nearshore monitoring stations. Still photographic documentation of the epibenthic communities along each transect will be obtained. Health parameters of coral species that are visually identifiable such as disease, bleaching, excess sediment, and cyanobacterial or macroalgal growth over individual colonies will be used in conjunction with standing sediment levels measured in the collection devices at the fixed monitoring stations to trigger implementation of Best Management Practices (BMP) which include construction and/or extension of parallel berms on the beach in the areas of fill placement, cessation of sand pumping until the discharge plume dissipates, and/or shifting the dredge to an alternate sand source within the approved borrow sites. The behavioral stress responses and index values are the same as proposed for the offshore monitoring (bleaching, coral mucous production, and coral extension with index values of 0 to 4, where 0 represents no observation and 4 represents the maximum observed). *Siderastrea* spp. and *Solenastrea bournoni* will be used as the indicator species. Stress indicator "index values" will be assigned during aquaria testing by NSU, acting as Consultant to the COUNTY under a separate scope of work for the offshore monitoring. NSU will provide COUNTY and CONSULTANT with the stress indicator index values for both species for application in the nearshore construction monitoring. Histological tissues analysis and sediment measurement thresholds will not be implemented during nearshore hardbottom construction phase monitoring.

A total of 128 monitoring transects along the project area fill areas (DEP Control Monuments R-36 to R-43, R-51 to R-72, R-86 to R-92, and R-98 to R-128) will be established during the duration of project construction. Transects will be established at 500 foot intervals along the length of the project (referenced to DEP intermediate control monuments). The transects will run perpendicular to the shoreline and extend from the equilibrium toe of fill (or from hardbottom nearest seaward of the equilibrium toe of fill if no hardbottom is present at the ETOF) to a distance of 300 feet seaward contingent upon the reef topography along each transect. The west end of each transect will be marked with DGPS. If a turbidity or sedimentation violation/impact is documented at a particular transect during construction monitoring, the location will be added to the long-term post-construction monitoring. The 300 foot distance is proposed to address concerns for secondary turbidity/siltation impacts to hardbottom of higher diversity/stony coral coverage adjacent to the equilibrium toe of fill. During each weekly survey, six transects will be assessed for a total shore-parallel distance of approximately 3,000 linear feet. The locations of the transects during each survey will be determined by the section of beach where fill is being placed (i.e. the discharge pipe utilized at the time of the survey). A weekly construction observation report will be prepared and submitted to the State and Federal resource protection agencies.

2. Post-Construction Monitoring of Nearshore Hardbottom Epibenthic Communities: The CONSULTANT shall conduct post-construction monitoring of the nearshore hardbottom to

determine the impacts of beach renourishment upon the epibenthic communities within and adjacent to the projected equilibrium toe of fill. Using the GIS database and nearshore characterization sites investigated during 2001 baseline survey, a five-year post-construction nearshore monitoring program will be established to address resource protection agency and public stakeholder concerns that secondary impacts of sedimentation and turbidity extend beyond the equilibrium toe of fill. Nearshore monitoring surveys will be conducted in compliance with DEP permits for Segment III and Segment II independently due to the difference in construction schedules mandated by the State of Florida. A combination of cross shore digital video transects and an offshore gradient of biological monitoring stations will be used to assess potential changes in epibenthic community composition and biodiversity related to sedimentation generated from the advancement of the beach swash zone during fill equilibration.

Monthly surveys of Segment III will be conducted during Year 1 (one-year post-construction) and the first six months of Year 2 (two-year post-construction), and annual surveys will be conducted at the end of Year 2, Year 3 (three-year post-construction), and Year 5 (five-year post-construction). Monthly monitoring during the first eighteen months after project construction will provide comparative data that can be statistically analyzed by direct comparison to the 2001 summer baseline data set (where data exists) and also provide data regarding seasonal fluctuations in community composition and sand movement during adjustment to the equilibrium profile within Segment III. No pre-construction data set of winter conditions exists for statistical comparison. Monthly monitoring during the first eighteen months will also provide the information necessary for assessment of potential sedimentation and turbidity impacts and adequate short-term data to indicate changes in epibenthic community composition and survivability of stony corals within Segment III that will be used to determine whether Segment II construction may proceed.

Since the two beach project segments may be constructed at different times, post-construction monitoring may be staggered with monitoring in Segment III eighteen months ahead of Segment II. Segment III is scheduled for construction from November 2003 through May 2004, and Segment II is scheduled for construction from November 2005 to March 2006.

A. <u>Conduct Hardbottom Epibenthos Monitoring:</u> CONSULTANT shall conduct monitoring of nearshore hardbottom epibenthic communities along an offshore gradient to assess potential secondary and long-term impacts of sedimentation and turbidity upon epibenthic community composition and biodiversity. A combination of cross shore digital video transects and monitoring stations will be used. Transect locations were determined by examination of the impact areas and higher density stony coral areas using the 2002 GRR beach fill design and the 2001 nearshore characterization sites. The transects will commence at the location of the 2001 hardbottom characterization station (within or immediately adjacent to the area of equilibration impact) and extend offshore up to a distance of 300 feet (~ 90 meters) dependent upon the reef structure at each location. Monitoring stations will be positioned along the cross shore transects at specific intervals for organism density counts (# individuals/square meter for stony corals,

soft corals, sponges, tunicates, and hydroids/zoanthids). Transect and station locations will be permanently established for relocation purposes and DGPS positioning will be recorded at the time of establishment. Two or three monitoring stations will be located along each cross-shore transect dependent upon the reef structure at each location.

Methodology for transect monitoring will be repeated digital video sampling (using the Sony TRV-900, or equivalent equipment, in progressive scan mode) of the 1 meter wide transect at selected 20 meter sections of the offshore distance gradient along each transect. An estimation of percent cover for stony corals, soft corals, sponges, tunicates, hydroids/zoanthids, and macroalgae will be obtained using framegrabbing and random point counting software (PointCount'99). The methodology for data collection at the monitoring stations will be identical to the pre-construction baseline survey: a one-meter square quadrat will be repeatedly sampled at each location until a plateau in stony coral diversity is achieved with a maximum of 20 square meters sampled at any individual station. Estimates of percent cover will be performed for stony corals, soft corals, sponges, tunicates, hydroids/zoanthids, and macroalgae. Density counts (# individuals/square meter) will be performed for the faunal groups and data will be pooled and normalized to account for different sample areas. The stations will correspond to the 2001 baseline station locations with the addition of equilibrium offset stations.

Prior to commencement of project construction, the CONSULTANT shall permanently establish the transect locations and conduct a pre-construction baseline characterization of the equilibrium offset stations not investigated during the 2001 study. The east-west transect lines will run through each offset station and the station quadrats will extend north-south sequentially from the transect centerline so that no quadrat is sampled twice. Ecological diversity will be assessed using Shannon-Weaver diversity index. Community type, physical relief, and dominant species will be also be documented and described. As during the baseline survey, information regarding stony coral condition (disease, bleaching, sediment accumulation, and cyanobacterial or macroalgal growth) will be recorded. The investigators will document the biological communities at each station using still photography and qualitative panoramic video.

A total of thirty-four transects will be located throughout the project area: nineteen (19) in Segment II and fifteen (15) in Segment III. The following is a list of the transect locations with the proposed number of monitoring stations along each transect. Exact offset station locations will be adjusted in the field based upon reef topography.

Transect locations	Number of stations	Transect locations	Number of stations
Segment II		Segment III	
R34 (control)	2	R88	3
R37	2	R90	2
R38	3	R96 (control)	2
R38-250	3	R98 (control)	1
R39	2	R100	2
R40	3	R100.5	3
R40+250	2	R101	2
R41	2	R104	2
R42	2	R108	2
R46 (control)	2	R113	2
R52	3	R116	2
R54	3	R119	1
R58	2	R120	2
R60	2	R123	2
R65.5	2	R125	1
R66	3		
R71	3		
R72	2		
R74 (control)	2		

Forty-five (45) stations in Segment II and twenty-nine (29) stations in Segment III have been identified to accurately assess potential secondary and long-term post-construction impacts. In Segment II, twenty-six (26) of the stations were investigated during the summer of 2001, and nineteen (19) have been added along the offshore gradient. In Segment III, sixteen (16) sites were investigated during the baseline survey and thirteen (13) have been added along the offshore gradient. The distance of the 2001 characterization site from the equilibrium toe of fill determined the need for an additional offshore station. Therefore, in some locations in Segment II, there are a series of three stations while other areas only required two stations. In Segment III, a few of the 2001 characterization sites were located in excess of 100 feet offshore of the equilibrium toe of fill and therefore, only one site is suggested for monitoring.

Monitoring station data from each event will be compiled and incorporated into the GIS database for use in evaluating long-term project related impacts to nearshore epibenthic communities. This data shall include the raw data in Microsoft Excel format, graphic representations of the data, and still photographs. Statistical analysis of the data will be accomplished using parametric and non-parametric (ANOVA) techniques as appropriate. Detection of changes in community composition along the video transect samples over time will be done

using a paired comparison or Tukey's Test for Multiple Comparisons. Principle Components Analysis will be used to describe community patterns along the offshore gradient.

B. Conduct Nearshore Hardbottom Edge Mapping: The CONSULTANT shall map the position of the nearshore hardbottom edge using a diver/biologist propelled via scooter with DGPS antennae towed by the diver. The entire study area length surveyed during the summer of 2001 will be resurveyed for a total of 18.18 miles (R-31 to R-84 in Segment II, and R-86 to Dade County DEP control monument R-5) and will include the areas of mitigative reefs in the nearshore reef sand pockets. As during the mapping of the 2001 nearshore hardbottom edge, the DGPS buoy attached directly to the diver allows for the most exact positioning achievable at the time of the survey. The purpose of the survey to map the sand/hardbottom interface for verification of project related hardbottom impact and appropriate acreage of mitigative artificial reef habitat. Three hardbottom edge surveys will be conducted in compliance with State and Federal resource protection agency mandate: an immediate pre-construction survey, eighteen months and three years post-construction surveys. The eighteen month and three year post-construction nearshore hardbottom edge mapping will be conducted during the months of June through August to coincide with the timing and allow for direct comparison to the positioning and physical relief characteristics of the 2001 hardbottom edge. The monitoring of the nearshore hardbottom edge at the end of Year 3 will represent the final impact of fill equilibration upon the nearshore hardbottom edge and its associated biological communities. The hardbottom edge trackline from the surveys will be incorporated into the GIS database for direct comparison to previous surveys.

C. Direct and Secondary Impact Assessment of Sedimentation/Turbidity upon Nearshore Epibenthos: The CONSULTANT will compile the results of the above monitoring events to determine the overall direct and secondary impacts of beach project construction upon nearshore epibenthic communities. The CONSULTANT will analyze the epibenthic monitoring station data collected along the offshore gradient during the post-construction surveys and statistically compare the results to the baseline survey and previous surveys where applicable. All data and analyses conducted during this phase of the investigations will be included in monitoring reports prepared after Year 1 (includes results of monthly monitoring), Year 2 (includes results of monthly and annual monitoring), Year 3 (annual monitoring) and Year 5 (annual monitoring). Each report shall contain an analysis and discussion of current conditions and compare conditions to

- 1) the pre-construction baseline survey; and

- 2) any previous survey(s) where applicable. The annual reports will be cumulative so that the last annual report is the final report.

3. Post-Construction Biological Assessment of Fish Communities - Natural Nearshore Hardbottom and Mitigative Artificial Reefs: Principle Investigator: Dr. Richard Spieler. The CONSULTANT, working with NSU as a subconsultant, shall conduct a detailed assessment of the fish community on the natural nearshore hardbottom (3 year post-construction) and mitigative artificial reefs (four year post-construction) during the study period. The principal investigator, Dr. Richard Spieler has more than 30 years of experience in fish surveys and is experienced in the statistical techniques needed to complete the work. He has worked in Broward County for 10 years and has acquired the largest archive of fish distribution data for this area. All fish census takers are post-graduate biologists, certified AAUS scientific divers, trained in fish counting methods and directly supervised by Dr. Spieler.

The monitoring plan for fishes consists of two parts:

- 1) a comparison of the fish communities pre- and post-renourishment along the 18 mile (30 km) stretch of inshore coastline and at specific renourishment sites that could potentially be impacted by the beach renourishment;

- 2) a comparison of the fish assemblages associated with the mitigation reefs (limestone boulders) with surrounding natural hardbottom.

1) Comparison of the inshore hardbottom fish communities pre- and post-renourishment

During the months of June, July and August 2001, CONSULTANT accomplished an intensive inventory of the fishes associated with the first 95 ft (30 m) of inshore hardbottom using three censusing methods; each method has distinct advantages and disadvantages. All fishes on a 6.3 x 6.3 x 95 ft (2 x 1 x 30 m) transect, from west to east across the hardbottom, were identified and total length estimated, at 500 ft (152 m) intervals throughout the study area (200 total transects). At 1000 ft (305 m) intervals, CONSULTANT performed a point-count on the site with maximum rugosity within the first 95 ft (30m) of inshore hardbottom (100 total). CONSULTANT also performed a 20-minute rover-diver count within a 95 ft^2 ($30m^2$) area bordering the inshore edge of hardbottom at 1000 ft (305 m) intervals (98 total). DGPS coordinates were recorded at each site. In total 72,723 fish of 47 families were recorded (a more detailed description of the methods and results are available elsewhere; Spieler, 2001). Because these counts were concentrated on the first 95 ft (30m) of hardbottom, CONSULTANT has an excellent baseline portrait of the fish community, or communities, most likely to be impacted by beach renourishment.

CONSULTANT proposes to repeat these counts, using the same methods (transect-count and point-count) and at the same sites (DGPS determined), during the same timeframe (June and July) for four years post-mitigation. The resulting data will allow rigorous statistical comparisons of the Broward County nearshore fish communities at these sites before and after renourishment/mitigation. There would not be sufficient comparative value to warrant counting

the sites at other times during the year because baseline data is unavailable during those other times.

2) Comparison of the fish assemblages on mitigation reefs and natural hardbottom

Approximately 11.9 acres of artificial reef, consisting of 4 ft (1.25 m), or larger, diameter limestone boulders will be used to mitigate hardbottom burial. It is important to understand how well this mitigation functions as replacement for the lost hardbottom fish habitat. CONSULTANT proposes to survey twenty-five 6.3 x 6.3 x 95 ft (2 x 1 x 30 m) transects over the artificial reef areas and compare these to an equal number of transects on neighboring hardbottom. These transect will run west to east and be done every 500 ft (152m) along the long axis (north-south) of the mitigation reefs. In addition to transects, CONSULTANT will run fifty, 20-minute rover-diver counts over both natural hardbottom and artificial reefs (25 each). Although the presence/absence data obtained with rover-diver counts does not provide rigorously testable data, it does provide insight into the rare and refugal species that may be using the habitats. Because shallow water fish communities can differ between sites (e.g. north and south Broward County, Spieler 2001) it is important that the artificial reefs be compared to natural sites close by; but not so close to be significantly affected by the artificial reef. The actual no-effect distance is not known but for the purpose of this work, CONSULTANT will use 100 m, which appears reasonable from previous shallow water artificial reef work in Broward County (Spieler, 1998; Sherman, 2000; Spieler, 2000). CONSULTANT proposes to do these counts for four years, at the same DGPS sites, twice annually, during the summer and winter months, as there are seasonal changes in the shallow water fish communities in Broward County (Gilliam et al. 1995; Spieler, 1998; Sherman, 2000; Spieler, 2000). A more frequent count schedule (e.g., quarterly or monthly) would provide information on the rate of assemblage formation. However, this information is available from multiple other shallow-water, artificial reef studies in Broward County (Gilliam et al. 1995; Spieler, 1998; Sherman, 2000; Spieler, 2000). Results of the transect counts will allow CONSULTANT to compare the fish species, by size, numbers, and biomass, per unit area, between mitigation reefs and surrounding hardbottom. Results of the rover-diver counts will aid in determining the distribution of rare and refugal species between the two areas. These comparisons will, in turn, allow an evaluation of the quality of the mitigation reefs vis-à-vis natural hardbottom.

The CONSULTANT, working with NSU as a subconsultant, shall:

- 1) Conduct a detailed assessment of the fish community using the same methodology (see below) and at the same DGPS sites as previously counted (June, July 2001). This assessment will consist of a minimum of 30 transects and 30 point-counts at the R-monuments which correspond to the epibenthos monitoring sites. These counts will be repeated annually for three years after project construction and then again in Year 5;

- 2) Conduct a detailed assessment of the fish assemblages associated with 11.9 acres of mitigation artificial reef (limestone boulders) and neighboring hardbottom

at least 100 meters distant from any artificial reef. The assessment will consist of 50 rover-diver counts and 50 transects on a west-east axis at 500 ft intervals along the mitigation reefs and natural hardbottom (25 each). This assessment will be completed twice annually, during summer and winter months, for four years;

- 3) Transect counts: A 95 ft (30 m) line will be stretched out West to East, by compass, beginning at the nearshore edge of hardbottom. The diver shall swim above the transect recording all fish within 1 m either side and 1 m above the line (an imaginary 60 cubic meter tunnel). Species will be recorded as well as numbers and total length (by size class: <2, 2-5, 5-10, 10-20, 20-30, 30-50 and 50+ cm) as encountered. The diver will carry a 1 meter "T"-rod, with the size classes marked off, to aid in transect width and fish length estimation. Stretches of sand along the transect (absence of hard substrate) greater than 3 m will also be recorded. The transect normally takes approximately 10 minutes to complete but will not be time delimited. On completion of the fish count the diver will follow the line from beginning to end with a fiberglass surveyor's tape closely following the contours of the substrate. Comparison of the tape distance to the 30-m line will yield an estimate of gross rugosity;

- 4) Point counts: The point-count will be a modified Bohnsack and Bannerot (1986) method in which all the fish are counted in an imaginary cylinder, 15 m in diameter, from the substrate to the water surface. A 7.5-m line will be laid out prior to the count as an aid in estimating the cylinder circumference. For the first 5 minutes, only the species will be recorded. After the 5 minute species-count is completed, the number of fish per species and the minimum, maximum, and mean total length of each species will be recorded along with depth and bottom features. The diver will carry a 1-m rod with a ruler attached at one end of the rod in a T-configuration to aid in length estimation. In the published methodology (Bohnsack and Bannerot, 1986), the diver accomplishes the count by staying in the center of the cylinder and rotating about to record species and length. This will be modified to allow the diver to move around the cylinder because most of the fish are juveniles that often stay in depressions close to the substrate and are therefore hidden from the counter. Point-counts will be accomplished at previously (2001) recorded DGPS sites. These sites are 20 m north of, and parallel to, the transect line at a point estimated by the diver to have had maximum topographic relief; normally this was directly north of the east end of the transect. On completion of the fish count, the diver will follow the 7.5-m radius line from beginning to end with a fiberglass surveyor's tape closely following the contours of the substrate. Comparison of the tape distance to the radius line will yield an estimate of gross rugosity; and

- 5) Rover-diver counts: Rover-diver counts will consist of the diver recording the species encountered during a 20-minute interval. The diver is encouraged to look wherever he or she pleases in an attempt to record the maximum number of species.

No abundance or size data will be recorded. Rover-diver counts will be accomplished in an area bounded by: the transect line of the transect-count, the western edge of the artificial reef, and a 30-m line laid directly North of the eastern end of the transect line (essentially a 30-m square, but somewhat more or less depending on the reef edge). On natural hardbottom, 30-m lines will be laid North of both eastern and western ends of the transect line.

Data analysis will consist of parametric and non-parametric Analysis of Variance techniques (ANOVA) using Statistical Analysis Systems (SAS) or similar software and Multivariate Analysis using Primer software. Statistical analyses will primarily concentrate on comparisons of specific variables (i.e. number of species, number of fish by species and size class, biomass [based on total length estimates] and fish assemblage similarities [based on Bray-Curtis similarity indices]) between pre- and post-renourished sites or mitigation reefs and natural hardbottom. However, the extensive data sets of fish, invertebrate, and rugosity will permit enhanced site-specific recognition and impact resolution if desired.

Deliverables for this phase of the project include: all the raw data, and summary statistics of the raw data. CONSULTANT, working with NSU as a subconsultant, shall provide an annual report with statistical analyses that address:

- 1) a pre-and post-renourishment comparison of nearshore hardbottom fish by species, numbers, biomass, size class, and assemblage structure for the entire 18 miles of coastline potentially impacted by renourishment;

- 2) a pre- and post-renourishment comparison of nearshore hardbottom fish by species, numbers, biomass, size class, and assemblage structure for each renourishment site;

- 3) a comparison of fish, by species, numbers, biomass, size class, and assemblage structure that are associated with mitigation reefs and nearby natural hardbottom, overall and by specific mitigation reef. The annual reports shall be cumulative in analysis and discussion so that the last annual report is the final report. The CONSULTANT shall incorporate the fish monitoring data (Microsoft Excel format and still photographs) from each event into the GIS database for use in evaluating long-term project related impacts to nearshore fish communities.

4. Post-Construction Epibenthic Colonization of Nearshore Mitigative Reefs: The CONSULTANT shall conduct four years of post-construction monitoring of the epibenthic colonization of the mitigative artificial reefs to determine the replacement habitat value compared to the natural nearshore hardbottom. A pre-construction (Segment III) epibenthic survey of the mitigative artificial reefs will be conducted to establish the transects and baseline condition of the reef sites. Biannual surveys will be conducted during Year 1 (one-year post-construction) and Year 2 (two-year post-construction); and annual surveys will be conducted at the end of Year 3 (three-year post-construction) and Year 4 (four-year post-construction). The

early progressive colonization of shallow-water artificial reefs has been previously documented in south Florida (Cummings, 1990; Palm Beach County ERM, 2000). Biannual surveys are therefore recommended during the first two years post-construction to capture seasonal fluctuations in epibenthos recruitment/succession and to coincide with the fish counts. Post-construction monitoring of the mitigation may be staggered if the placement of the mitigative reefs in the two project segments occur at different times.

A. Conduct Post-Construction Epibenthos Monitoring: The methodology for data collection will be similar to the natural nearshore hardbottom epibenthic monitoring transects. A one-meter square quadrat will be repeatedly sampled along a 30 meter transect line and assessed for epibenthic organism density/percent cover. Twenty-five (25), 30-meter transects will be sampled from west to east over the 11.9 acres of nearshore mitigative reefs, and the locations will correspond to the twenty five (25) fish transects for direct correlation between fish populations and epibenthic communities. Transect locations will be permanently established for relocation purposes and DGPS positioning will be recorded. Estimates of percent cover will be performed for stony corals, soft corals, sponges, tunicates, hydroids/zoanthids, and algae. Density counts (# individuals/square meter) will be performed for the faunal groups. Gross rugosity measurements following the methodology described in Section 4 will be performed at each station for correlation between rugosity and epibenthic colonization (particularly stony coral settlement). Stony coral recruits will be identified and measured. Epibenthic organism density and community composition at the mitigative monitoring station sites will be statistically compared to the 2001 baseline characterization sites located in close proximity to the mitigation station sites.

Monitoring station data from each event will be compiled and incorporated into the GIS database for use in evaluating long-term project related impacts to nearshore epibenthic communities. This data shall include the raw data in Microsoft Excel format, graphic representations of the data, and still photographs.

B. Conduct Algal Recruitment/Sea Turtle Foraging Habitat Assessment: The mitigation monitoring program includes an assessment of algal recruitment with an emphasis upon replacement of preferred algal food species for sea turtles. Two stations, each consisting of three (3), 30 meter transects spaced at 1 meter intervals, will be established over a 0.5 acre area of the artificial reef site located in closest proximity to FDEP control monument R-66 in Fort Lauderdale. This site was chosen as the test site for replacement of preferred algal species because of its close proximity to the natural nearshore hardbottom where the highest number of juvenile green sea turtle sightings occurred in the summer of 2001 (R-52 to R-74). In Segment III, two control stations will be established over a 0.5 acre area of the artificial reef located between FDEP control monuments R-101 and R-104. Similar to the artificial reef epibenthos monitoring described in Section 4.A., transects will run from west to east over the reef, and the west and east ends will be permanently established. DGPS positioning of the transect ends will also be recorded. The 30 meter transects will be established following the rugosity of the boulders so that algal recruitment on both horizontal and

vertical surfaces will be assessed. Gross rugosity measurements will be performed by comparison to the 30-meter straight line transect.

The 30 meter transects will be documented using digital video sampling (Sony TRV-900, or comparable) in progressive scan mode. Macroalgae abundance will be assessed by percent cover using framegrabbing and PointCount'99 software. Species identification within the stations will be performed *in situ* by a second, qualified diver/biologist (M.S. degree or higher). The biologist will swim two, 1-meter corridors within the station and record a comprehensive taxonomic list of species present in the entire 60 square meter box. The algae surveys will be conducted on a semi-annual basis (spring/summer and fall/winter) for a period of 4 years in compliance with the FDEP permit.

Several studies have indicated diet selectivity in green sea turtles with the genera *Bryothamnion, Gracilaria,* and *Hypnea* and turf algae of the Family Gelidiaceae documented as food sources in Broward County nearshore waters (Wershoven and Wershoven 1990). The algae data collected during the County's 2001 study suggests that the red macroalgal community in the nearshore area between R-54 through R-72 often consists of a mat-like mix of species consisting of *Bryothamnion* sp., *Gracilaria* sp,, *Hypnea musciformis*, and *Dasya* sp. In certain areas, the algal community consists of a monoculture of *Bryothamnion* sp. on sand covered hardbottom with bottom cover ranging from 30 to 75%.

Target bottom coverages for these select red macroalgae species on the artificial reef test site in Fort Lauderdale have been established in the FDEP permit conditions. If these target bottom coverages are not achieved after one year of monitoring, transplantation of select algal species from the equilibrium toe of fill impact areas between R-52 and R-72 to the artificial reef test site will be performed to achieve the target abundance. If transplantation of select algal species is required, the transplanted algae will be monitored semi-annually in conjunction with the macroalgae recruitment assessment during the 4 year post-construction period.

C. Conduct Functional Habitat Assessment of Mitigation Reefs: The CONSULTANT shall compile all data collected during the monitoring of the mitigative reefs to conduct a comprehensive functional habitat assessment of the mitigation reefs and assess the overall replacement habitat value for impacted nearshore hardbottom habitat.

All data and analyses conducted during monitoring of the epibenthic communities on the mitigative reefs will be included in annual monitoring reports and submitted in conjunction with the nearshore fish mitigation monitoring reports described in Section 3. Each report shall contain an analysis and discussion of current conditions and compare conditions to

- 1) the pre-construction baseline survey; and

- 2) any previous annual survey(s) where applicable. The annual reports shall be cumulative in analysis and discussion so that the last annual report is the final

report. Annual reports will be submitted within ninety (90) days or sooner as required by the project permits after completion of the survey. The final report at the end of Year 4 will contain the final functional habitat assessment of the mitigation reefs.

5. Cumulative Effects Assessment and GIS Development: The CONSULTANT shall conduct a comprehensive evaluation of the post-construction biological monitoring data (epibenthos, fish, and mitigative reef) and imagery to determine the overall cumulative effects of project implementation. The GIS database will be used as the primary tool to analyze cumulative effects by overlaying data layers from post-construction monitoring events for comparison to the baseline and previous data sets. The CONSULTANT will identify the past, present, and reasonably foreseeable future conditions of the various resources which are directly or indirectly impacted by beach project construction. This task shall include research, review, and incorporation of positioning data and/or monitoring data from activities unrelated to beach project construction that have the potential to cumulatively affect the project area resources. These activities include, but are not limited to, fiberoptic cable or pipeline installations, water quality monitoring, and reef health monitoring in Broward County. The cumulative effects assessment will be prepared as a combination of the GIS database and a final written report prepared after completion of the four year post-construction monitoring program. A multimedia presentation utilizing GIS and PowerPoint will be prepared to present the findings of the cumulative effects assessment to regulatory agencies and public stakeholders.

EXHIBIT “A-1"

REVISIONS TO SCOPE OF SERVICES AND TIMETABLE (Term of agreement has been increased by one (1) additional year for a total of six (6) years.)

COUNTY is currently engaged in the design and implementation of a Shore Protection Project. The Project will consist of the placement of compatible sand on the beaches of Broward County in Segment II (between Hillsboro Inlet and Port Everglades) and in Segment III (from Port Everglades to the Miami-Dade/Broward County line). The Shore Protection Project will be constructed by a contractor selected through the COUNTY procurement process. Sand for the beach construction will be obtained from offshore borrow sources located adjacent to and between offshore reef community hard bottom. Before, during, and after the construction of the Project it will be required that the CONSULTANT monitor and assess the relative biological health and condition of the reef community offshore of and adjacent to the sand source borrow areas. This monitoring will be accomplished through Sedimentation Analysis, Coral Community and Fish Community Transect Analysis, Reef Edge Sediment Monitoring Surveys adjacent to borrow areas, and analysis of stress indicators for selected coral species at the Sediment Monitoring Survey Sites.

Beach renourishment construction is contemplated to take place beginning in the Spring of 2003 through October 2003 in Segment III and then continue in Segment II through February 2004 depending on construction schedules and anticipated production rates.

There are twenty-three (23) biological monitoring sites[1] and at each there is a sediment collector ringstand (Figure 11) containing three (3) replicate sediment collectors, in the area where the Project is to take place. Two additional sites will be established as per section 1 below.

CONSULTANT shall perform the following activities:

1. Upon receipt of a Notice to Proceed, CONSULTANT shall establish two (2) additional reef community monitoring sites (FTL5 and FTL 6, see Table 1) at the approximate locations indicated in Table 1. Exact locations of these sites will be determined by mutual agreement between COUNTY and CONSULTANT. CONSULTANT shall install sediment collector ringstands and stainless steel transect pins, identical to those at the existing twenty-three (23) locations. Additionally, CONSULTANT, shall install Sediment Monitoring Control Stations (FTL5SMC and FTL6SMC) at each location as described in the appropriate section below. Costs for this task and additional work are detailed in Exhibit “B-1", Item 10.

[1] See Table No. 1 attached hereto and made a part hereof.

2. Annual Site Visits. These annual site visits shall be conducted in September or October of each year of the Agreement. During each site visit, CONSULTANT shall perform the following:

2.1 Coral Community Transects. At each of the Twenty-five (25) reef monitoring sites (Table 1 and Figures 1 - 7) a permanent belt quadrant transect has been established. Each transect consists of Twenty-one (21), eighteen (18) inch long, one-half (0.5) inch diameter, stainless steel pins fixed in the bottom with marine, two-part epoxy or Portland Cement, exactly one (1.0) meter apart (+/- 1.0 cm) in a straight line. Transect analysis at each site will be consistent with methodology described by Dodge, et al. 1982[2]. A minimum of Thirty (30) square meters of bottom will be analyzed at each site. After field data collection the following calculations and analysis will be conducted for each transect data set:

2.1.1 Stony coral species density (colonies/m^2), diversity and evenness. Shannon-Weaver[3]

2.1.2 Diversity and evenness for percent live polyp coverage.

2.1.3 Density of octocoralia and porifera (colonies/m^2)

2.2 Fish Population Analysis. At each of the Twenty-five (25) reef monitoring sites, CONSULTANT shall conduct fish population assessments. Fish population assessments will be conducted as per methodology described in Bohnsack and Bannerot (1986)[4] and Bortone, et al, (1989)[5]. Two (2) Thirty (30) meter long transects for fish counts and one fifteen (15) meter diameter cylinder (stationary counts) will be conducted. The Thirty (30) meter transects will be established by adding ten (10) meters to the existing coral transect lines (these are already Twenty (20) meters long). A second transect for fish census will be conducted from one

---

[2] Dodge, R. E., A. Logan and A. Antonius. 1982. Quantitative Reef Assessment Studies in Bermuda: A Comparison of Methods and Preliminary Results. Bull. Mar. Sci., 32(3): 745-760.

[3] Shannon, C. E., and W. Weaver. 1948. The Mathematical Theory of Communication. Univ. of Ill. Press, Urbana. 117pp.

[4] Bohnsack, J. A. and S. P. Bannerot. 1986. A Stationary Visual Census Technique for Quantitatively Assessing Community Structure of Coral Reef Fishes. NOAA Technical Report NMFS 41. 15pp.

[5] Bortone, S. A., J. J. Kimmel, and C. M. Bundrick. 1989. A Comparison of Three Methods for Visually Assessing Reef Fish Communities: Time and Area Compensated. Northeast Gulf Science 10(2): 85-96.

end of the first line and perpendicular to the first line in a direction along the reef that will provide maximum topographical change. Populations of fishes will be counted one meter on either side of the transect line and two meters above the line. The center for the stationary counts will be established Seven and one-half (7.5) meters from the from the start point of the first line. Species counts will be to the lowest taxon that conditions allow and size (total length) estimates will be by class (0-2, 2-5, 5-10, 10-20, 20-50, >50 cm). Statistical analysis of the data will be done using parametric and non-parametric analysis of variance (ANOVA) techniques as appropriate. Costs for this task and additional work are detailed in Exhibit "B-1", items 2 and 3.

3. Sedimentation Analysis. CONSULTANT shall change out each ringstand sediment trap at each of the twenty-five (25) reef monitoring sites every sixty (60) days during the first five (5) years of the term of the Agreement, for a minimum of six (6) change-outs per year. Ten (10) additional sediment trap ringstands will be installed at Sediment Monitoring Survey sites (see section 4 below) adjacent to the sand source borrow areas and Monitored as per the methods in this section for twelve (12) sixty-day (60 day) collections starting sixty-days prior to commencement of beach renourishment construction. Analysis of trap contents will be conducted as per Standard Operating Procedures (SOPs) published and archived by Broward County (SOP No. ERO-019, and SOP No. ERO-037). Site locations are positively established and are reoccupied using DGPS latitude and longitude and/or range triangulation photographs. These location numbers and pictures shall be supplied to the CONSULTANT by COUNTY with the Notice to Proceed. Costs for this task and the additional work are detailed in Exhibit "B-1", items 1, 8, 9 and 11. Sediment analysis of the additional 10 sediment trap ringstands will only be for 6 collections in year three and 6 collections in year four.

4. Reef Edge Sediment Monitoring Surveys including Accumulated Sediment depth measurement and Observations of Sediment Stress on Indicator Coral Species.

   4.1 On the reef adjacent to each borrow area, when an adequate area or distance of reef substrate is present at the eastern and western edges of the borrow area in question (e.g. Borrow Area II has very little reef habitat on its' western side), CONSULTANT will establish, normal to the borrow orientation, 3 quadrats, one 10 meters from the reef edge, one 20 meters from the reef edge, and one 30 meters from the reef edge. Each quadrat will be 3 square meters in area (divided into 4 sub-quads, each 0.75 x 1 meter) and will have at least three centerline orientation pins along the east-west axis for occupation and re-occupation of the quadrat with a photo quadrat platform (Figures 8 & 9 and the pins shall be the same as described in section 2.1 above). The following list of borrow areas (see attached Figures 1-4) will have the indicated number of sediment monitoring sites: BA1 - 3 east, 3 west (numbered BA1SM1-6); BA2 - 3 east, 3 west (numbered BA2SM1-6); BA3 - 3 east, 3 west (BA3SM1-6); BA4 - 2 east, 2 west (BA4SM1-4); BA6 - 2east,

2 west (BA6SM1-4). Additionally, there will be 8 control sediment monitoring sites, three in the area at the BOCA permanent reef monitoring site (26^0 20.8030' N, 80^0 03.8830' W) north of the Boca Raton Inlet (BOCA-SMC1-3), and one each on the reefs at or adjacent to permanent reef monitoring sites FTL1, FTL2, FTL3, FTL5 and FTL6 (FTL1SMC, FTL2SMC, FTL3SMC, FTL5SMC, and FTL6SMC). This is a total of 34 sites. Once every week starting 8 weeks before construction, once every week during construction, and once every week for 8 weeks after construction CONSULTANT shall visit each of these sediment monitoring locations for each borrow area for qualitative biological assessment. CONSULTANT shall conduct photography of the substrate every other week and use these images as a record of each of the reef sites. All sites will be revisited, photographed and examined for cumulative sediment impact 6 months after construction and again one year after construction. Cost for the services in this section are detailed in Exhibit “B-1", items 4, 9, and 10.

4.2 At each quadrat that is 10 meters from the reef edge CONSULTANT shall establish two sediment accumulators (Figure 10) consisting of a stainless steel plate mounted on a concrete building block and cemented to the reef substrate (Figure 10). The orientation of the plate surface will be level and not follow the contour angle of the reef substrate at the deployment location. During each weekly visit the CONSULTANT shall measure the sediment depth in each accumulator plate to the nearest 0.5 mm. The first plate will be cleaned off at each weeks visit and the second plate will not, allowing a comparative measurement of accumulated sediment depth with week long sediment depth. Sediment depth will be measured and recorded as an average of 5 measurements at 5 locations on each of the plates. If any two of the week long plates (Plate #1) at any individual borrow area has an average measure of 1.5 mm depth of sediment per day or greater then the CONSULTANT shall notify the COUNTY within twenty-four (24) hours which Borrow Area(s) and which Sediment Monitoring Sites (SM’s) have met the above threshold. The COUNTY will then turn off that(those) Borrow Area(s) from usage for a week. Upon the next week’s remeasure of the week long plate (Plate #1), if the accumulated sediment is then less than an average of 1.5 mm per day, then usage of that borrow area can resume. Costs for the Sediment Monitoring Surveys are detailed in Exhibit “B-1", Item 4. Monthly cost for this service is calculated as follows: The CONSULTANT shall visit, on average, 7.5 sites (34 sites total) per day for 4.53 days per week and an average of 4.34 weeks per month (147.45 sites per month). Work for this service will start during YEAR 3 with 2 months survey of pre-construction conditions, continued monthly surveys during the construction of the beach, followed by two months of post construction surveys. When beach construction continues into YEAR 4 of this agreement then this service will continue during construction until construction is completed including 2 months of post-construction surveys. Assuming a good faith

effort by the CONSULTANT and based on a rate per site visit as listed in Exhibit “B-1", Item 4, and during any monthly billing cycle if CONSULTANT visits less than 75 Sediment Monitoring Sites due to weather conditions that prevent site visitations then CONSULTANT is only paid for the number of Sediment Monitoring Sites actually visited. If CONSULTANT visits 75 or more Sediment Monitoring Sites during the monthly billing cycle then CONSULTANT will be paid the entire monthly amount as calculated in Exhibit “B-1", Item 4.

4.3 CONSULTANT shall also install one additional sediment accumulator plate at each of the four (4) Sediment Monitoring Sites surrounding Borrow Area 6 (Figure 4). These four (4) (BA6SMC 1-4) Sediment Monitoring Sites will be visited every day (if dredge and fill construction is conducted with 2 dredges) or every other day (if dredge and fill construction is conducted using a single dredge) during the first twenty-eight (28) days of beach construction dredge and fill activity utilizing Borrow Area 6. The results of this daily or bi-daily sediment accumulator monitoring will be compared to the weekly sediment monitoring conducted during the same time period. CONSULTANT shall also make daily or bi-daily observations of stress indicators on coral species as described below. Assuming a good faith effort by the CONSULTANT and based on a rate per site visit as listed in Exhibit “B-1", Item 5, and during the first 28 days if of dredge operations CONSULTANT visits the four (4) Sediment Monitoring Sites around BA6 a cumulative total less than 56 times due to weather conditions that prevent site visitations then CONSULTANT will only paid for the number of Sediment Monitoring Sites actually visited. If CONSULTANT visits these sites 56 times or more during the twenty-eight (28) days then CONSULTANT will be paid the entire monthly amount as calculated and detailed in Exhibit “B-1", item 5. If bi-daily visits are required then the numbers of visits and payment will be adjusted appropriately.

4.4 At each of the Sediment Monitoring Sites (treatments and controls, 34 sites total, 3 quads per site, 4 sub-quads per site quad) CONSULTANT shall make weekly observations of stress indicators on coral species to determine the influence of sediment suspension and fallout on coral bleaching, coral mucus production and coral polyp extension. Stress indicator “index values” will be assigned by the CONSULTANT (i.e. 0 to 4 value for bleaching, or 0 to 4 value for mucus production, or a 0 to 4 value for polyp extension, where 0 represents no observed bleaching, mucus production, or polyp extension and 4 represents the maximum observed. A threshold value for each stress indicator will be determined during laboratory calibration experiments conducted prior to commencement of dredging activity for target stony coral species *Montastrea cavernosa* (great star coral) and/or *Solenastrea bournoni* (smooth star coral) and/or *Siderastrea spp*. (starlet corals) and/or octocoral species *Erythropodium caribaeorum* (encrusting gorgonian) and/or the

colonial anemone *Palythoa caribaeorum* (encrusting colonial anemone). Each quadrat will have at least two specimens to be monitored. These two specimens can be represented by any combination of two of the species listed above. CONSULTANT shall also develop laboratory and field protocols for histological analysis of coral tissues from these species to determine and/or measure tissue thickness, the presence or absence of mucus cells, and the presence or absence of zooxanthellae in comparison with or in correlation to developed stress indicator "index values". Histological tissue collection will commence at sediment monitoring sites for any borrow area that has accumulated daily average sediment values below 1.5 mm and visual observations have shown that two out of the three average stress indicator index values for any two of the borrow area sediment monitoring sites are above the laboratory determined threshold. Additionally, should sediment accumulation as described above in Section 4.2, not be enough to close a borrow area but should visual observations show that two out of three of the average stress indicator index values for any two of the borrow area sediment monitoring sites exceed the laboratory determined threshold then the CONSULTANT shall notify the COUNTY within twenty-four (24) hours which borrow area and which sediment monitoring sites have exceeded that threshold. This threshold level shall be adaptive and dependant upon both the initial calibration experiments and upon continuing tissue analysis of field collected specimens. The COUNTY will then turn off that (those) borrow area(s) from usage for one week. Upon the following week's remeasure of the appropriate sediment collector plates and observations of the stress indicator index values if the accumulated sediment in the weekly plate is less than an average of 1.5 mm per day and the stress indicator indices are less than the specified observational threshold then usage of the that borrow area can resume. Cost for these services are detailed in Exhibit "B-1", Items 12, 13, 14, and 15. Consultant billing for Item 12 will include development of coral stress indicator values and development and implementation of laboratory analysis of tissue samples. Monthly billing for field collection of coral tissue samples referenced in item 13 and 15 will only commence if the condition referenced above has been met for any portion of that month. If said conditions have not been met then CONSULTANT will not invoice for that service for that month.

5. Reef Damage Assessment Survey. If, during a Reef Edge Sediment Monitoring Survey, significant impacts to the reef community resource is evident due to construction activity, CONSULTANT shall immediately notify the Contract Administrator. Thereafter, upon receipt of written approval from the Contract Administrator, CONSULTANT shall immediately perform a Reef Damage Assessment Survey to discover and reveal the full areal extent of the irreversible loss. The Reef Damage Assessment Survey shall be completed within three (3) calendar days of receipt of the Contract Administrator's written notification unless CONSULTANT receives prior written permission from the Contract Administrator.

Performance of reef damage assessment activities prior to obtaining written approval from the Contract Administrator is at CONSULTANT's sole risk. Cost for this service is detailed in Exhibit "B-1", item 7.

6. Pipeline Corridor Surveys. After receipt of a written notice to proceed from the Contract Administrator, CONSULTANT shall conduct inspections of the sand discharge pipeline corridors along the reef hardbottom areas traversed by the pipeline (see Figures 3, 4, 5, & 7). There are eight proposed pipeline corridors, four (4) south of Port Everglades in Segment III and four (4) north of Port Everglades in Segment II. CONSULTANT will examine the reef habitat underneath each pipeline after the pipeline has been placed on the bottom and examine that same reef bottom habitat after the same day after the pipeline has been removed from that bottom location. CONSULTANT shall count and identify to species level all stony corals, octocorals, and sponge colonies visibly damaged or destroyed by the pipeline placement. CONSULTANT shall also video-document the impact of the pipeline placement on the reef habitat in each deployment area. CONSULTANT shall submit to the COUNTY a report of the examination findings for each pipeline corridor, including, but not limited to, species lists and video-documentation, within two weeks of field investigation of the area. Cost for this service is detailed in Exhibit "B-1", item 16.

7. Stony Coral Transplantation. The construction of the Shore Protection Project will result in the potential burial of 13.6 acres of nearshore habitat through impact of the construction toe of fill and the Equilibrium Toe of Fill (ETOF). Approximately 10.1 acres of this habitat is hardbottom substrate containing approximately 1000 stony coral colonies 15 centimeters diameter or larger.

   7.1 Part one (1) of Stony Coral Transplantation (move colonies to Cache Sites). Consultant shall locate approximately 1000 stony coral colonies 15 cm diameter or larger within the area of estimated ETOF impact, remove the colonies from the substrate, transport the colonies to designated "Cache Site(s)", transplant the colonies to the Cache Site(s), attach the colonies to the Cache Site, identifying each transferred colony by measuring and recording species and size, tag a subset of the transferred colonies (minimum of 25% of the colonies transferred) for monitoring, assess the condition of the tagged subset using digital images and detailed image analysis and provide a report on the size, species, condition, and distribution of all Cached colonies. Designated Cache Sites shall be within the range of depths of the areas from which the colonies are removed. Cost for this service is detailed in Exhibit "B-1", item 17.

   7.2 Part two (2) of Stony Coral Transplantation (move colonies to Mitigation Reef). As Mitigation for impact of the ETOF on the nearshore habitat the COUNTY will construct mitigation artificial reef boulders within the depth range of the impact area. CONSULTANT shall remove all cached colonies

from cache sites and transplant all colonies to mitigation reef sites nearest to the cache site where the colony was held. Colonies that were tagged in the Cache Sites shall remain tagged and shall continue to be monitored using digital images and image analysis. Cost for this service is detailed in Exhibit “B-1", item 17.

7.3 Part three (3) of Stony Coral Transplantation (monitoring of relocated colonies). After re-attachment of the transplanted colonies at the cache sites and at the mitigation reef sites CONSULTANT shall record the condition of the tagged colonies, take digital images of each tagged colony, analyze the health and condition of each tagged colony, assess the images of each tagged colony for growth and provide a report on the condition of each tagged colony and on the general success of the coral transplant portion of the mitigation program. Monitoring of the transplanted coral colonies shall take place six (6) months after transplantation to the Cache Sites, one year after transplantation to the Cache Sites, once prior to removal from the cache sites and every six (6) months for two (2) years after transplantation to the Mitigation Artificial Reef for a total of four (4) post-transplantation monitor events. Cost for this service is detailed in Exhibit “B-1", item 17. Reports of this coral transplant monitoring shall be submitted to COUNTY within sixty (60) days of completion of monitoring field work.

8. Reports

8.1 Annual Reports. Within Ninety (90) days, or sooner as required by the dredge and fill permit issued by the United States Army Corps of Engineers and the State of Florida Department of Environmental Protection, of the Annual Site Visit, CONSULTANT shall submit its Annual Report which contains the Sedimentation Analysis, Coral Transect Analysis, and Fish Transect Analysis. Each subsequent Annual Report shall compare results of analysis with the previous annual reports and with archival reports or assessments of the same reef monitoring sites or other reef monitoring sites as available or where appropriate, and the final contract report will discuss in detail the impact of the beach construction relative to any measured changes in the above parameters. These reports shall be of a style and content that would be appropriate for publication in a word processing format compatible as determined by COUNTY on a compact disc and in Adobe *.PDF format.

8.2 If CONSULTANT is required to perform a Reef Damage Assessment Survey as set forth above, CONSULTANT shall submit a Reef Damage Assessment Report within Two (2) days of completion of the Reef Damage Assessment Survey which shall document the full areal extent of the irreversible loss of the reef community resource.

8.3 Results of Sediment Monitoring Surveys of reef areas adjacent to sand borrow areas will be submitted to the COUNTY weekly during the beach construction period, the 60 day pre-construction period (s), and the 60 day post-construction period (s). The Sediment Monitoring Reports shall include results of weekly sediment depth measurements (average daily sediment accumulation in millimeters), results of stress index values for observed stony coral and octocoral species, and results of histological tissue analysis including, when appropriate, calculated correlation between or among stress indicator index values, examined histological tissue parameters, and measured sediment trap contents (milligrams/square centimeter/day; $mg/cm^2/day$). CONSULTANT shall also submit results of the daily or bi-daily monitoring of Borrow Area 6 within 24 hours of site visitations to the Sediment Monitoring Sites to COUNTY.

TABLE 1. BIOLOGICAL MONITORING SITES (NAD 83)

	SITE	DEPTH	LATITUDE	LONGITUDE	NORTHING	EASTING
1	JUL2	50	26 00.2593 N	80 05.3010 W	608306	955595
2	JUL1	35	26 00.3014 N	80 05.8134 W	608541	952788
3	HH2	15	26 00.6946 N	80 06.7572 W	610888	947605
4	JUL8	50	26 04.9957 N	80 05.0990 W	637007	956500
5	JUL7	25	26 04.9635 N	80 05.7321 W	636788	953038
6	JUL6	12	26 04.9120 N	80 06.2226 W	636457	950356
7	FTL6	18	26 08.9850 N	80 05.8070 W	661149	952461
8	FTL5	18	26 08.8710 N	80 05.7580 W	660460	952733
9	FTL4	18	26 08.2080 N	80 05.8440 W	656439	952289
10	FTL3	55	26 09.5183 N	80 04.6406 W	664424	958813
11	FTL2	40	26 09.5971 N	80 04.9522 W	664889	957106
12	FTL1	18	26 09.5343 N	80 05.7475 W	664478	952761
13	POMP6	52	26 14.5660 N	80 04.3980 W	695013	959921
14	POMP5	31	26 14.5660 N	80 04.7310 W	695000	958102
15	POMP4	19	26 12.7320 N	80 05.2010 W	683871	955613
16	POMP3	50	26 11.2141 N	80 04.3650 W	674708	960247
17	POMP2	40	26 11.3289 N	80 04.8039 W	675386	957843
18	POMP1	14	26 11.4356 N	80 05.2256 W	676016	955533
19	HB3	47	26 16.4255 N	80 03.8189 W	706301	963004
20	HB2	35	26 16.5350 N	80 04.2620 W	706947	960579
21	HB1	18	26 16.8357 N	80 04.5390 W	708758	959053
22	DB3	57	26 18.6828 N	80 03.5764 W	719986	964229
23	DB2	42	26 18.6280 N	80 04.0262 W	719637	961775
24	DB1	15	26 18.5869 N	80 04.3928 W	719373	959775
25	BOCA	30	26 20.8030 N	80 03.8830 W	732819	962462

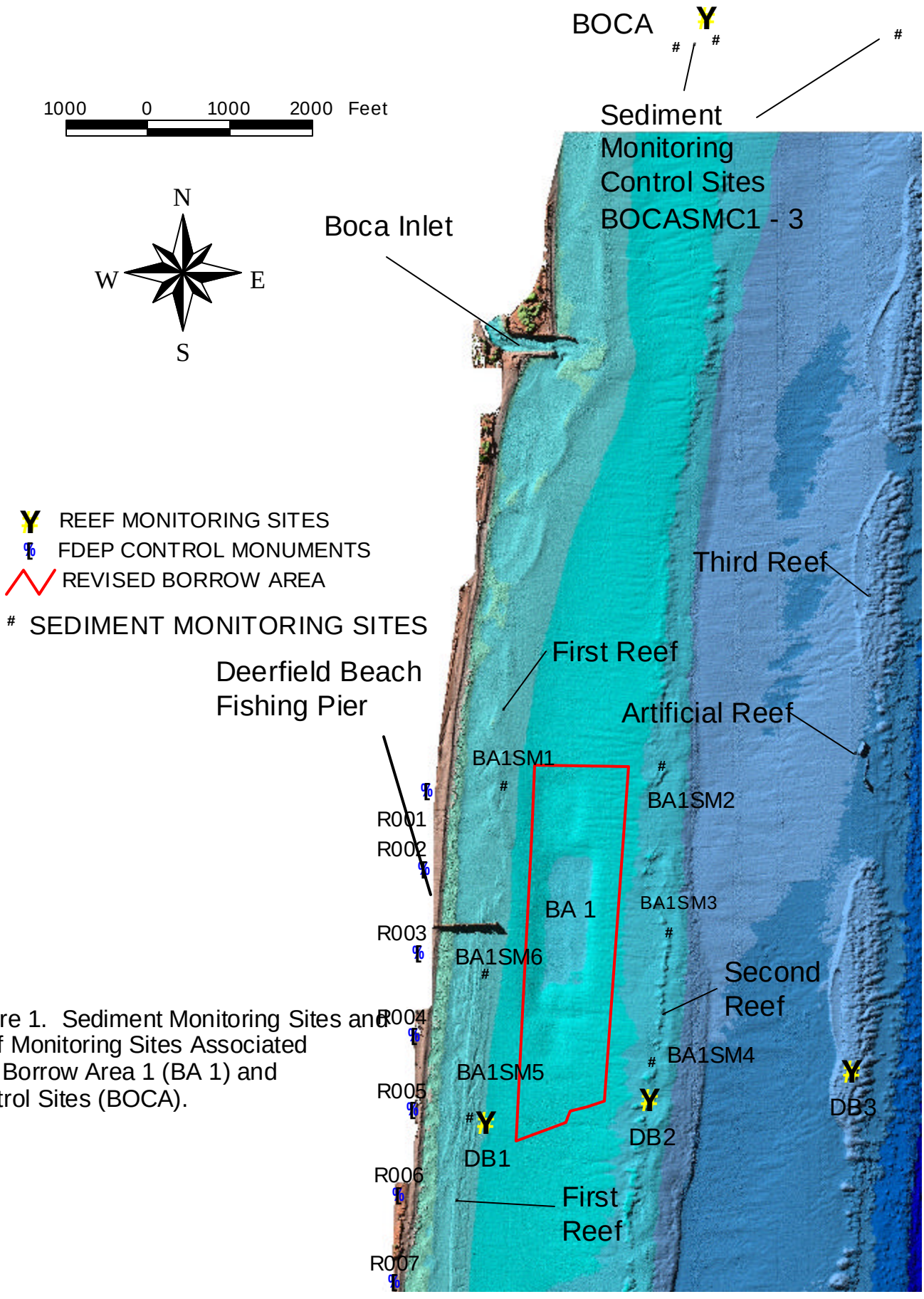


Figure 1. Sediment Monitoring Sites and Reef Monitoring Sites Associated with Borrow Area 1 (BA 1) and Control Sites (BOCA).

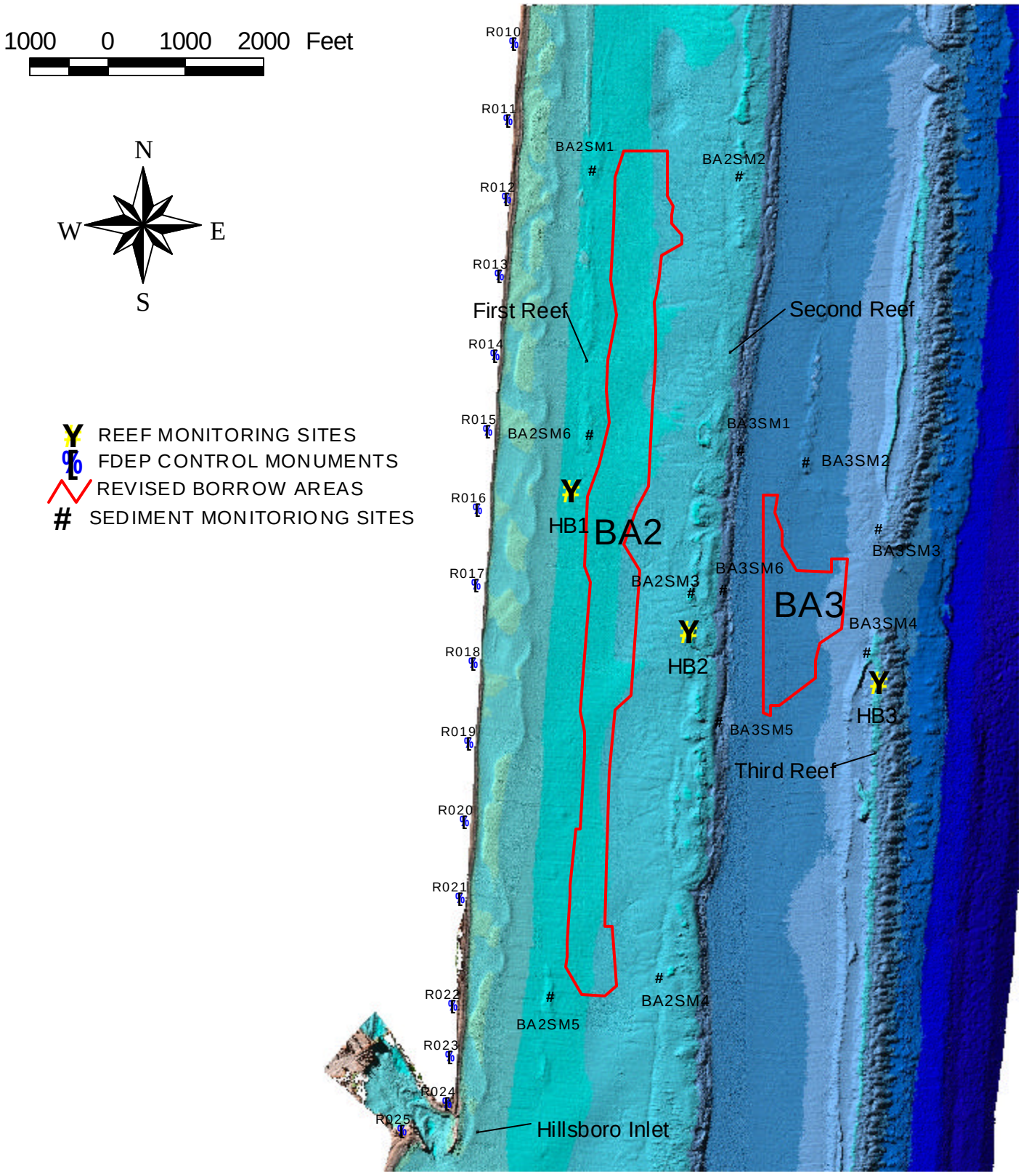


Figure 2. Sediment Monitoring Sites and Reef Monitoring Sites associated with Borrow Areas 2 and 3 (BA2 and BA3).

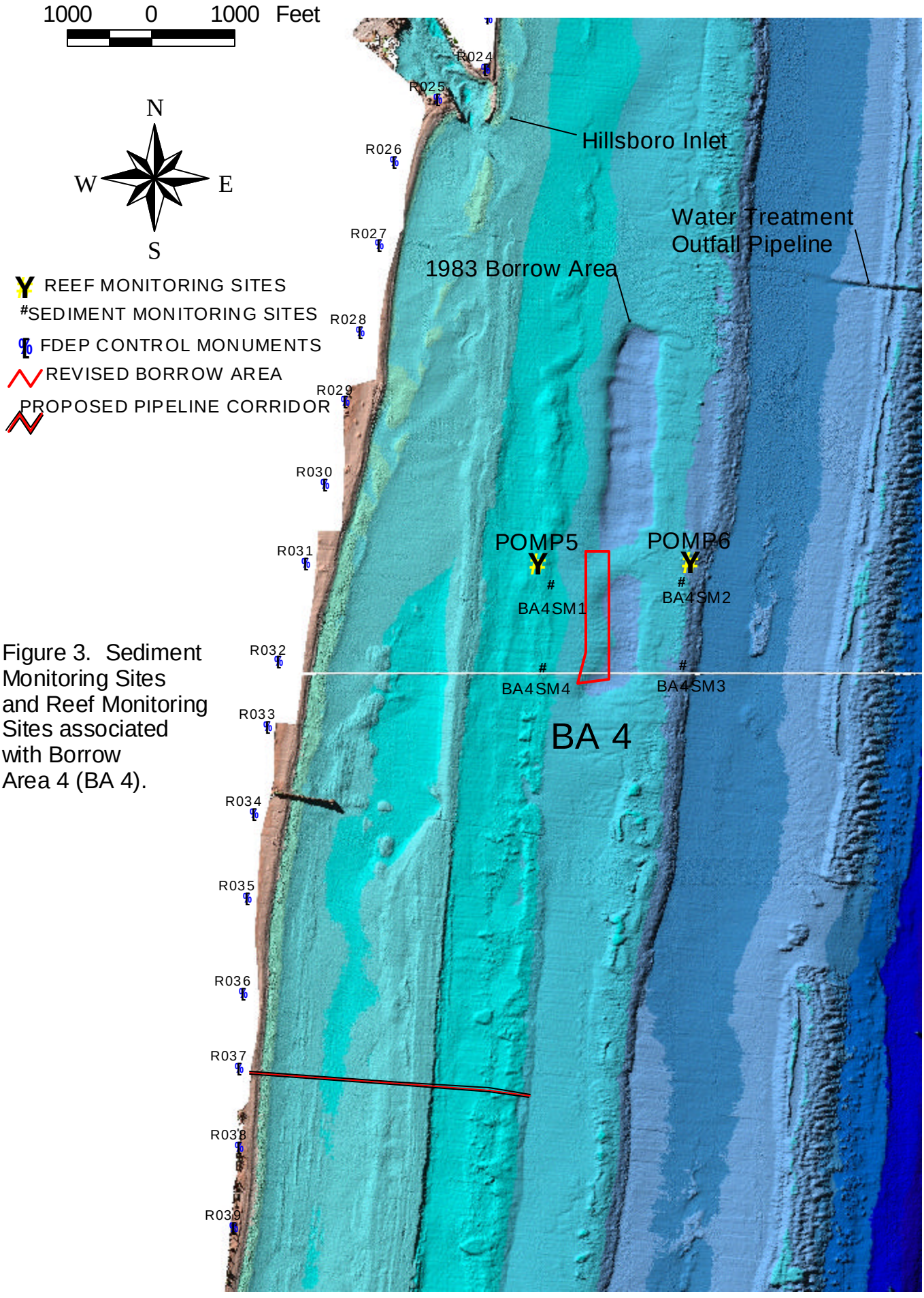


Figure 3. Sediment Monitoring Sites and Reef Monitoring Sites associated with Borrow Area 4 (BA 4).

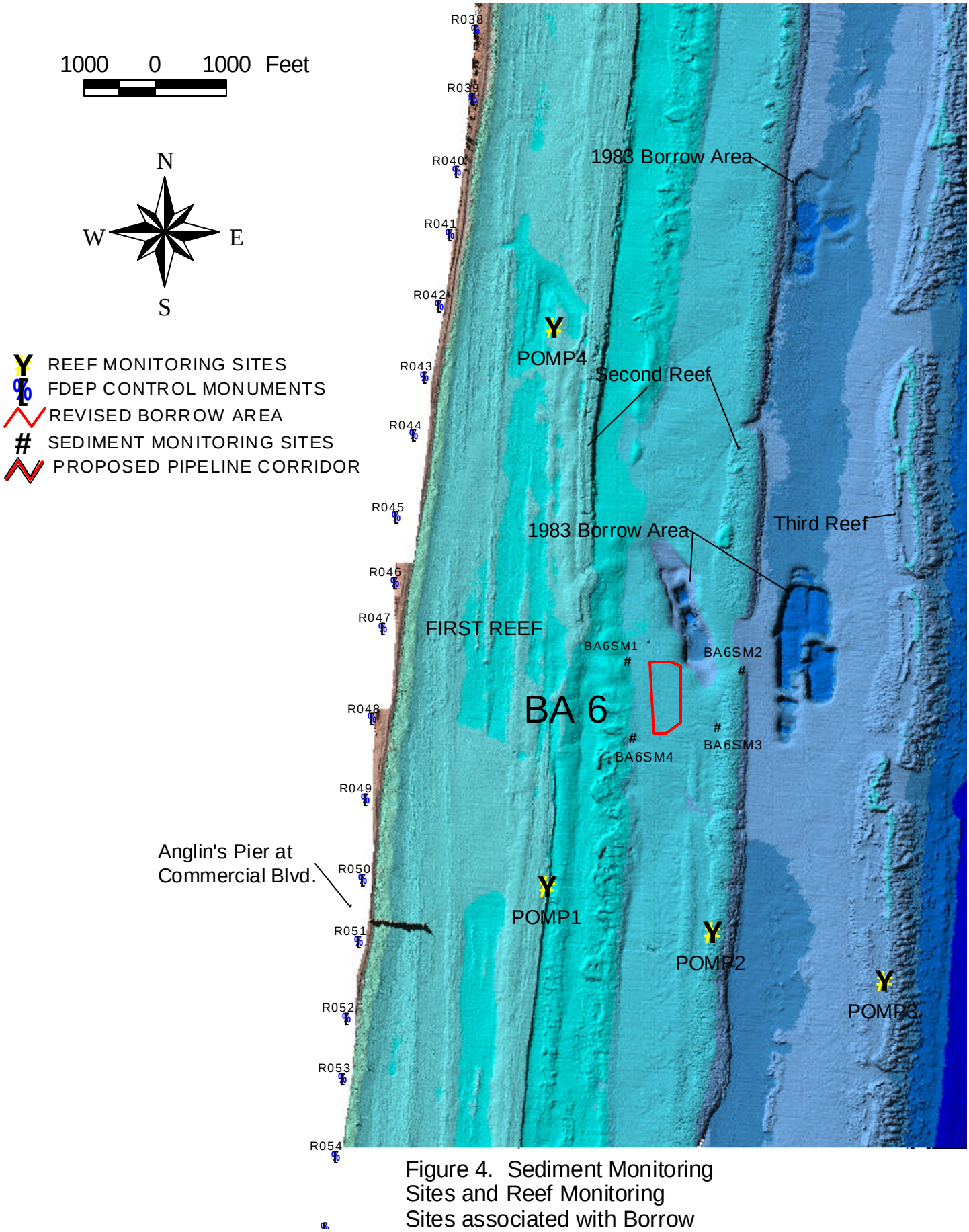


Figure 4. Sediment Monitoring Sites and Reef Monitoring Sites associated with Borrow Area 6 (BA 6).

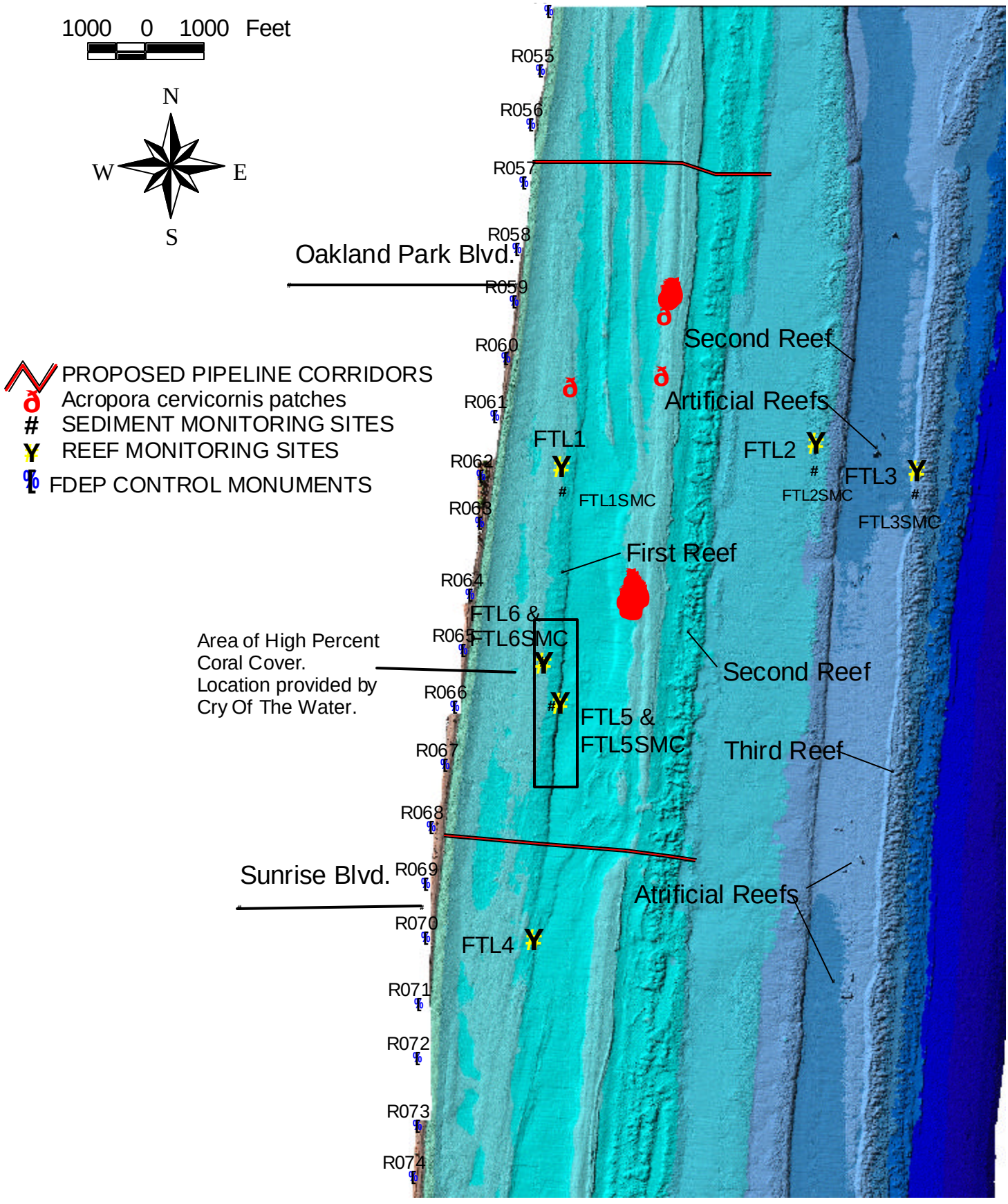


Figure 5. Sediment Monitoring Control Sites south of the Borrow Areas and Reef Monitoring Sites.

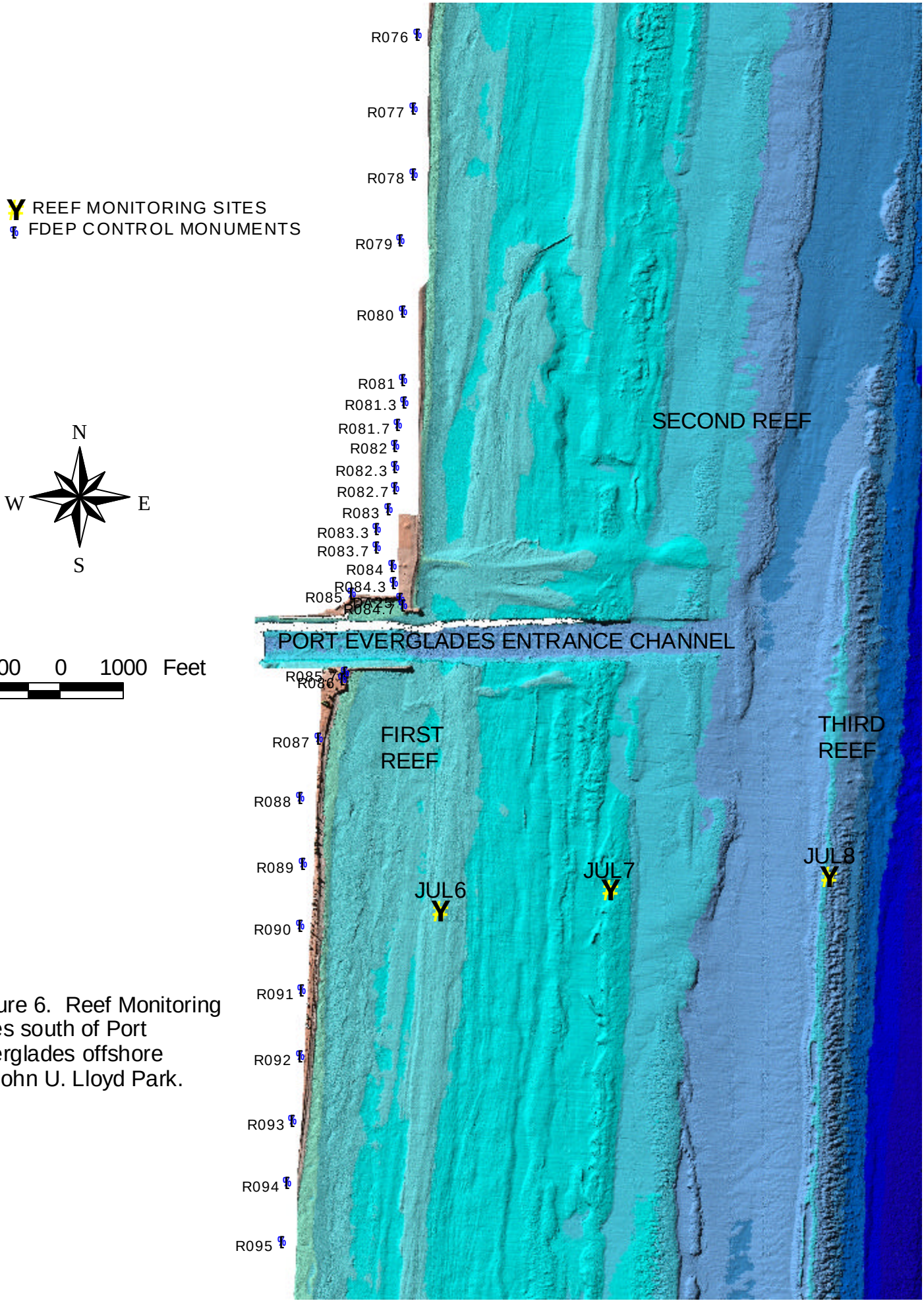


Figure 6. Reef Monitoring Sites south of Port Everglades offshore of John U. Lloyd Park.

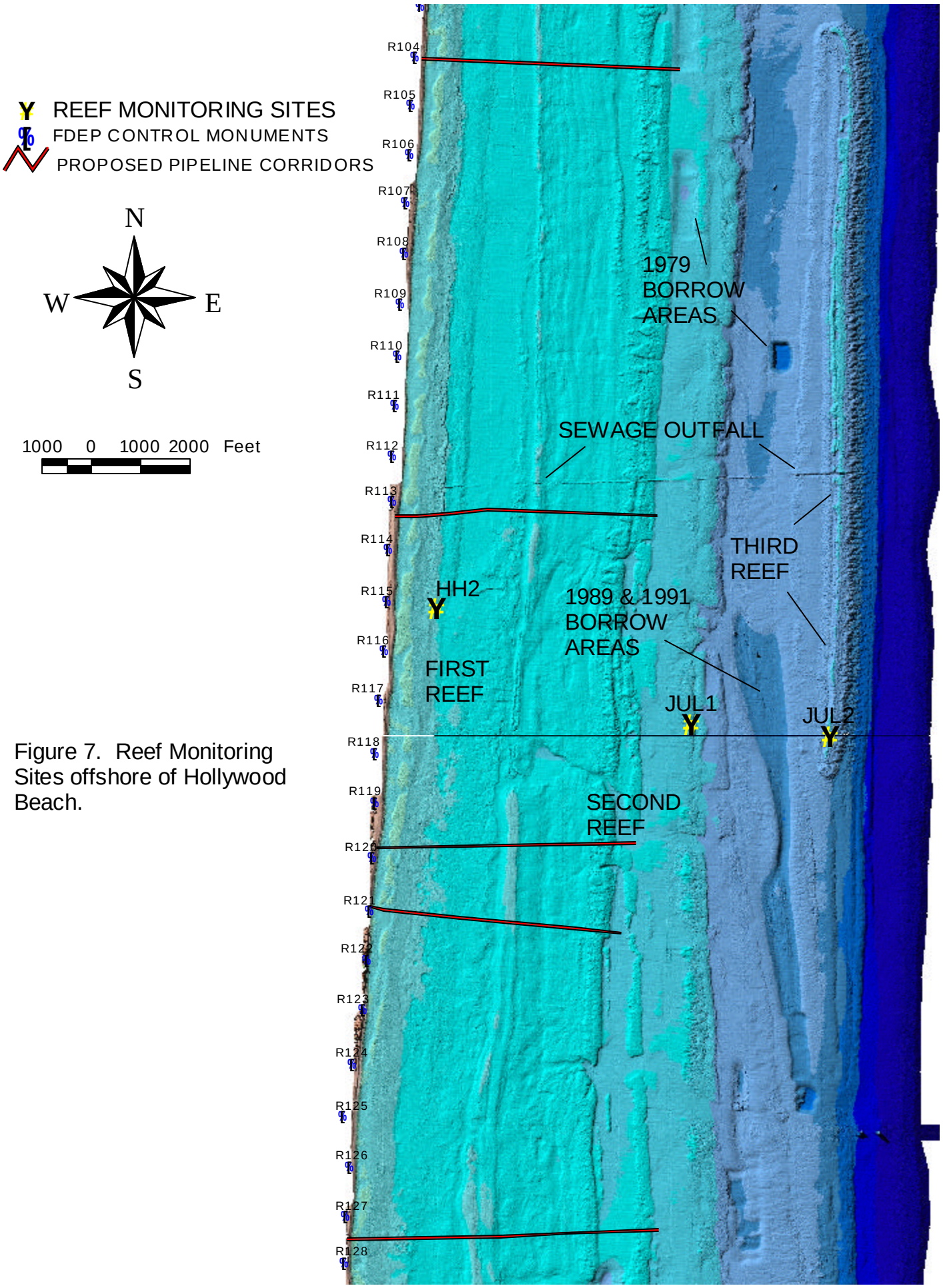


Figure 7. Reef Monitoring Sites offshore of Hollywood Beach.

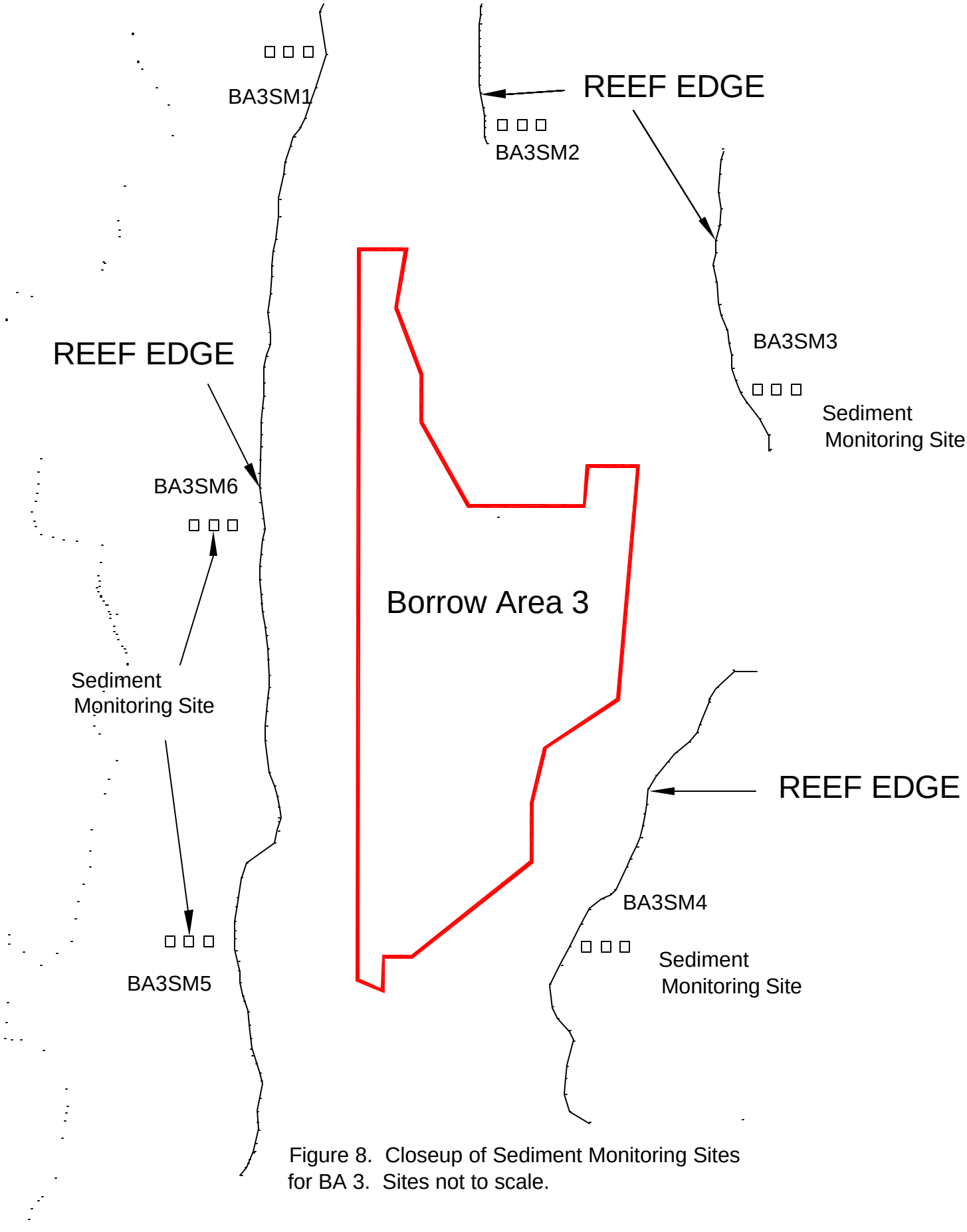


Figure 8. Closeup of Sediment Monitoring Sites for BA 3. Sites not to scale.

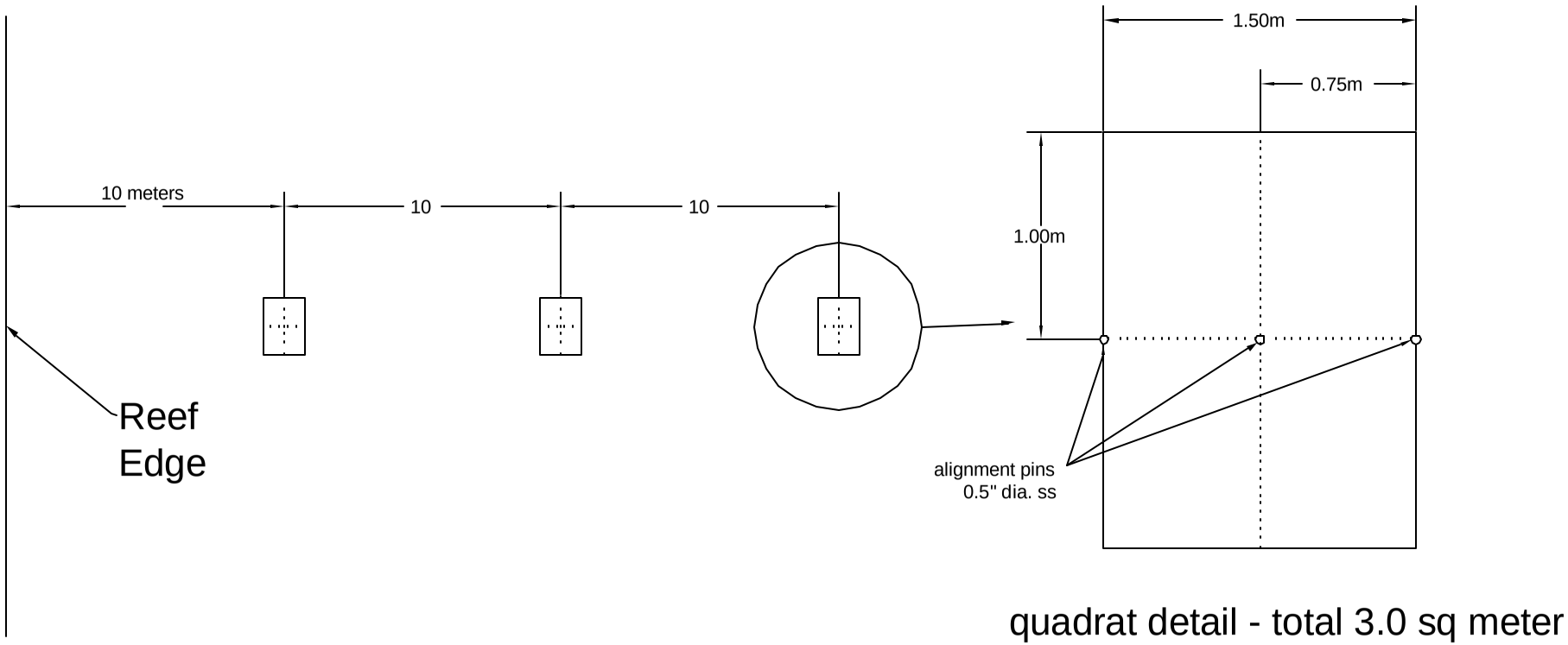


Figure 9. Typical Sediment Monitoring Site. Sediment trap ringstand and sediment collector plates will be located in proximity to quadrat that is ten meters from the reef edge.

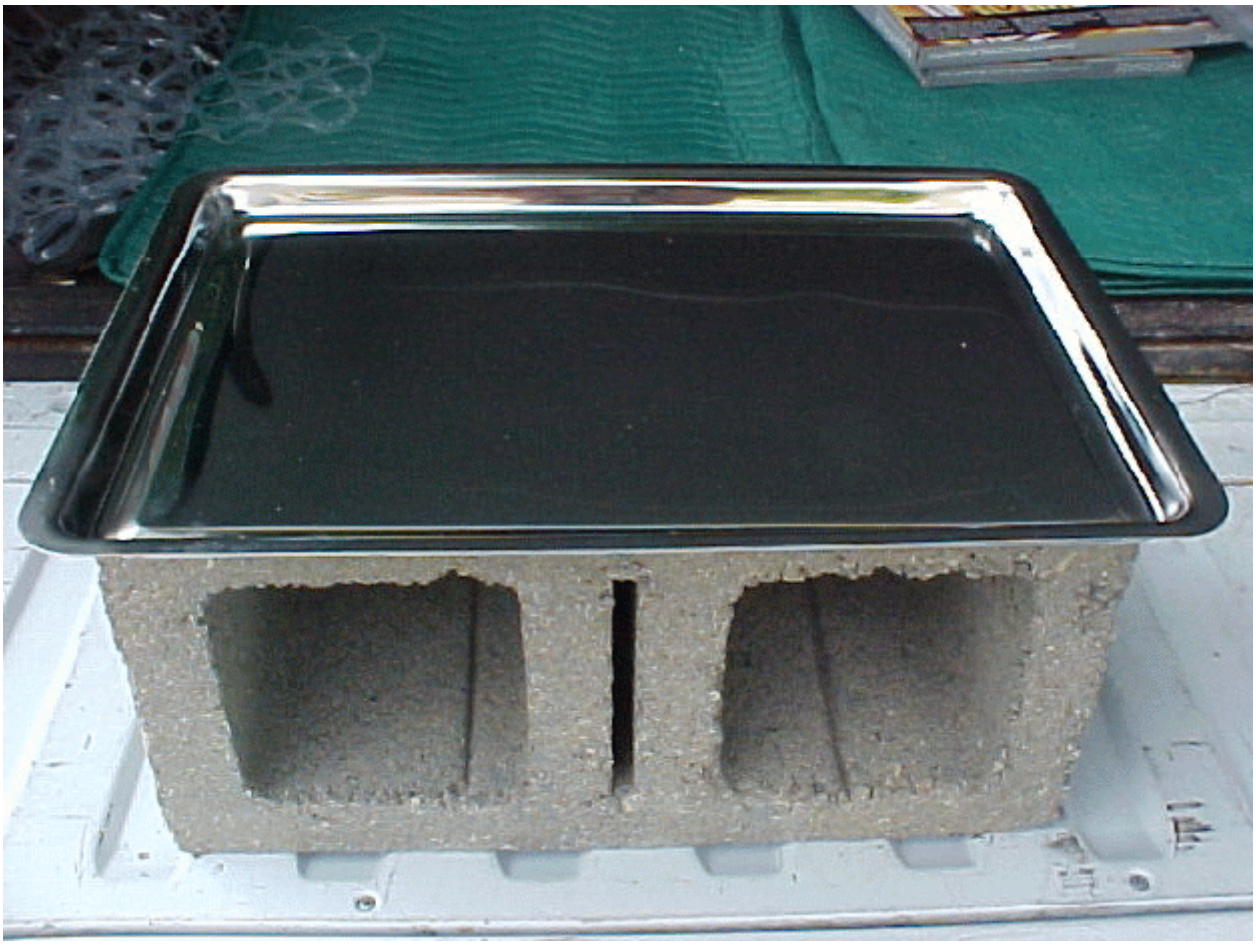
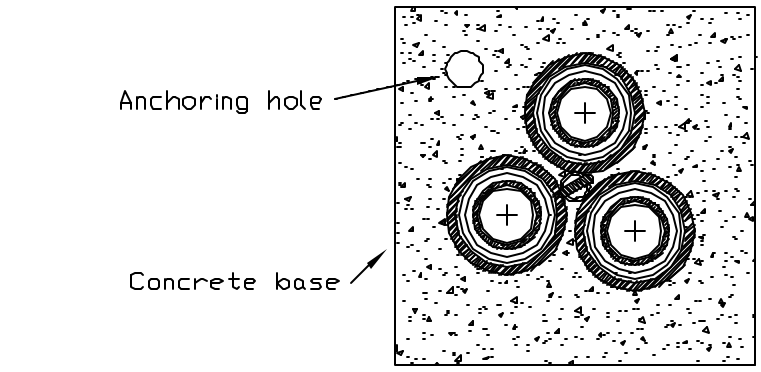
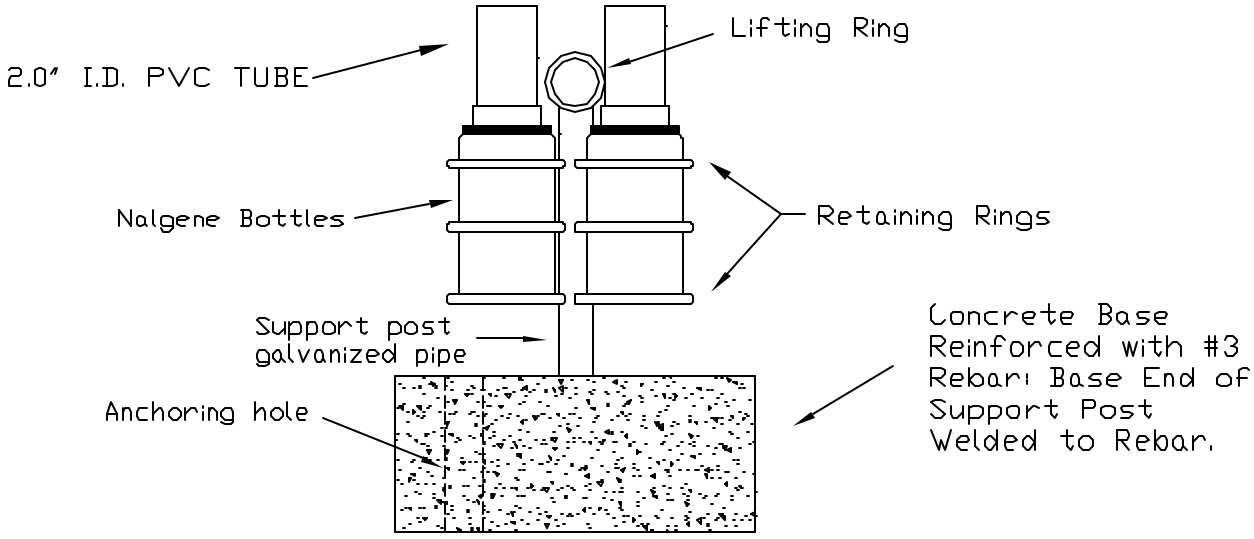


Figure 10. Sediment fallout collector for measurement of accumulated depth (mm) of sediment. Two units will be placed at each 10 meter quadrat location (10 meters from reef edge) at all sediment monitoring sites. The first unit will be used for measuring weekly sediment depth and the second unit will be used to measure overall accumulated sediment depth. Pan is constructed of stainless steel with 0.75 inch high perimeter edge and will be attached to block with marine epoxy. Block will be attached to the reef substrate using Portland cement.



TOP VIEW



PLAN VIEW

FIGURE 11 - SEDIMENT TRAP RINGSTAND