Tampa Bay Restored Oyster Reef Monitoring

Quality Assurance Project Plan

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This QAPP is effective for a period of five years from EPA approval date.

Element A1 - Title and Approval Sheet

Project Name: Tampa Bay Oyster Monitoring

U.S. Environmental Protection Agency

11/14/18	11/14/18
Felicia Burks Date	**Steve Blackburn** Date
National Estuary Program Project Officer	**EPA QAPP Officer**
Sustainable Communities and Watersheds Branch	

Tampa Bay Estuary Program

11/15/18	11/15/18
Gary Raulerson Date	**Ed Sherwood** Date
Project Manager	**Executive Director**
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Maya Burke Date	
Quality Assurance Officer	

Florida Wildlife Research Institute

19 Nov 2018	11/16/18
Ryan Moyer Date	**Kara Radabaugh** Date
Project Manager	**QA Officer**

Tampa Bay Watch

11/15/18	11/16/18
Serra Herndon Date	**Eric Plage** Date
Project Manager	**QA Officer**

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Element A3 – Distribution List

The following is a list of individuals and their respective organization that will receive a finalized, signed, and US EPA Region IV approved QAPP from the Tampa Bay Estuary Program and its subcontractor team, Florida Wildlife Research Institute and Tampa Bay Watch:

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Element A4 – Project/Task Organization

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Steven Blackburn EPA QAPP Approval Official US EPA Region IV	Responsible for administration from US EPA Region IV and QAPP review/approval
Gary Raulerson Project Manager Tampa Bay Estuary Program	Responsible for review/approval of QAPP, final report, development of management recommendations and all other deliverables
Maya Burke Project QA Officer Tampa Bay Estuary Program	Responsible for ensuring compliance with QAPP data and analysis protocols
Ryan Moyer Principal Investigator Florida Wildlife Research Institute	Responsible for FWRI component of oyster monitoring protocol, data summary and analyses, and final report.
Kara Radabaugh QAO, FWRI FWRI	Responsible for ensuring FWRI compliance with QAPP data and analysis protocols
Serra Herndon Principal Investigator Tampa Bay Watch	Responsible for TBW component of oyster monitoring protocol, data summary and analyses, and final report.
Eric Plage QAO, Tampa Bay Watch	Responsible for ensuring TBW compliance with QAPP data, and analysis protocols

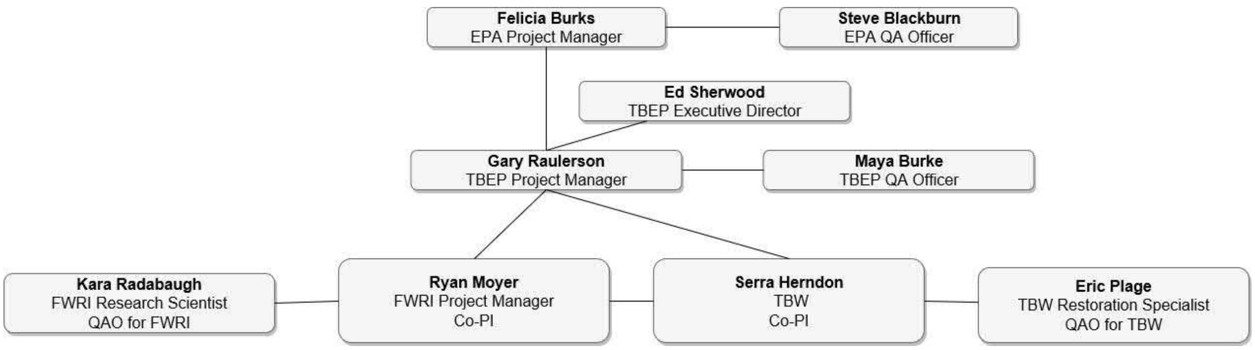

Figure 1. Organization chart for Tampa Bay oyster monitoring project.Element A5 – Problem Definition/Background

History and Status of Oysters in Tampa Bay

The eastern oyster (*Crassostrea virginica*) is the dominant and only reef-forming bivalve in Florida. Eastern oysters are ecosystem engineers and the reefs they build provide a variety of critical ecosystem services to coastal communities (Grabowski et al. 2012). Oyster reefs provide a nursery habitat or food source for wide variety of invertebrates, fish, and birds. Biomass, density, and species richness of fish and invertebrates are all greater on Florida oyster reefs than on unvegetated sand or mud bottoms (Tolley and Volety 2005). As filter feeders, oysters also remove organic matter and fine sediments from the water column. This increases water clarity and improves light conditions for seagrass and other benthic photosynthesizers (Booth and Heck 2009). Oyster reefs are commercially valuable to humans and are harvested for food and mined for shell, and indirectly valuable as they provide shoreline protection against erosion and fish-producing habitat (Grabowski et al. 2012).

Oyster habitat has declined by 85% or greater throughout the world (Beck et al. 2011), including in North America and in Florida's estuaries. Much of this loss can be directly attributed to poor water quality, as well as overharvesting and shell mining. Prominent causes for the decline of oysters in Florida include a direct loss of habitat due to dredge and fill construction, and loss of adequate substrate due to dredging, shell mining, or excess sedimentation. Altered hydrology is a significant problem in many areas of Florida. The channelization of surface water flow has led to estuarine salinities that are either too high (leading to increased predation or disease) or too low (leading to poor survival and reproduction) (Shumway 1996). A lack of suitable hard substrate is the primary factor limiting modern oyster distribution in Tampa Bay (Morrison et al. 2011), as the bay has relatively stable salinities in spite of widespread urbanization (Parker et al. 2013).

Oysters were once abundant in Tampa Bay, and numerous middens scattered on the shorelines of Tampa Bay are proof of the importance of this shellfish (and other estuarine resources) to indigenous populations (TBRPC 1989, Vojnovski 1995). Early European explorers of the Tampa Bay region reported on both the great extent of oyster beds (Ware 1966) and the excellent taste of oysters found in the mouths of Tampa Bay rivers (Pizzo 1968). Tampa Bay had a robust commercial oyster fishery in the late 1800s (Finucane and Campbell 1968) that continued through the mid-1900s in locations such as Papys Bayou, the Little Manatee River, and portions of Old Tampa Bay (Dawson 1953).

However, by 1900 there were already signs of declining oyster populations. Smeltz (1897) wrote of early depletion of oyster resources on the Gulf Coast from harvesting for human consumption, including Tampa Bay:

> "In 1876…oysters, oysters everywhere. How little did I then think that in less than twenty-five years every one of these bars would be partially or totally depleted."

Whitfield (1975) stated that dredging of "unproductive" live oyster reefs (generally for development fill) was legal until 1947. Based on shell production from leases, Estevez (2010) estimated that Tampa Bay once held nearly 2,000 acres of live oyster reefs and submerged shell middens but noted that significant amounts of oyster shell had been dredged from the bay bottom. By the 1970s, live reef extent had declined as a result of commercial harvest, shell mining, and dredging to an estimated 186-345 acres (Kaufman 2017). Recent mapping efforts estimate the current reef extent to be between 131 and 166 acres (SWFWMD 2016, Kaufman 2017). However, this estimate needs to be used with caution, since it provides no indication of on-the-ground condition of the oysters in the reefs (e.g., live or dead, density, or length), nor does it attempt to assess oysters on red mangrove prop roots, seawalls, within restoration projects or other areas not captured by aerial analysis. Drexler et al. (2014) determined that oysters on mangroves and non-natural substrates can provide similar ecosystem service benefits to natural reefs in Tampa Bay.

The widespread loss of oyster reefs and the many ecosystem services they provide has led to the implementation of a series of oyster restoration projects (by Tampa Bay Watch, Manatee County, and others in Tampa Bay) beginning in the early 2000s. Additionally, multiple coastal habitat restoration projects that have not had oysters as a primary focus have seen significant production of reefs or on red mangrove (*Rhizophora mangle*) prop roots (Brandt Henningsen, SWFWMD, personal communication). More recently, oyster restoration in near-shore areas has been recognized as a potentially important component in the creation of "living shorelines", an attempt to create resilience along generally urbanized shores by using more natural approaches to reduce erosion or mitigate other issues associated with sea level rise and climate change while providing a variety of ecosystem services (NOAA 2015).

Demonstration of Need

Several of the highest-ranked research needs identified during a survey conducted for the 2017 update to the Tampa Bay Estuary Program (TBEP) Comprehensive Conservation and Management Plan Update (CCMP) addressed the implementation of long-term monitoring of habitat restoration and mitigation projects. While habitat restoration projects generally have short-term monitoring requirements (for instance, ensuring some percentage of plant survivability, absence of exotic vegetation for 1-2 years, or live oyster coverage), there have only been sporadic longer-term assessments to understand and compare maturation trajectories of these areas compared to natural systems, including oyster restoration (Serra Herndon, TBW, personal communication). Projects are continually coming on-line in the Tampa Bay estuarine system, both conducted as required mitigation and as voluntary restoration efforts. It is essential to use data-driven monitoring to assess these projects to allow both adaptive management and application of "lessons learned" to future restoration projects.

The TBEP and its partners have been working to create restoration targets for oysters and other hard bottom habitats over the past several years, including current efforts to create a GIS-based oyster habitat suitability index that will aid in identification of locations to target for oyster restoration with increased likelihood of success (Kaufman 2017). As a component of this work, systematic and regular assessments of existing oyster restoration projects in comparison with natural reefs have been recognized as a significant need to better understand potential ecosystem benefits and identify new opportunities for oyster restoration projects. For projects where oysters have become incorporated within the study area, baseline assessments of oyster condition should be conducted. New projects should also be initiated to act as 'time zero' markers for assessment of a temporal series of restored oyster habitats.

The Oyster Integrated Mapping and Monitoring Program (OIMMP) is an effort led by the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute (FWRI) that seeks to compile information and foster communication among oyster mapping and monitoring programs across Florida. Tampa Bay Watch, a locally-focused non-profit that has conducted multiple oyster restoration projects (Figure 1), is attempting to initiate more regular monitoring on its project areas. Local municipalities such as Manatee County and the City of St. Petersburg have also recently been involved in oyster restoration and monitoring efforts.

This project will monitor newly created and established oyster restoration projects and other locations growing oysters in Tampa Bay (including natural reefs, red mangrove prop roots, and seawalls) to better understand factors influencing success or failure of the projects, including siting, timing, and preferred materials for varying conditions (e.g., sediment and wave energy).

Understanding the pattern of oyster larvae ("spat") release can be critical in identifying appropriate timing for deployment of oyster material to help ensure that the spat have an advantage for settlement above other biota, including the invasive Asian green mussel (*Perna viridis*)(Baker et al. 2007). The spat release pattern in Florida's estuaries is often bi-modal (e.g., Parker and Geiger 2011) and more precise information on signals for release could be useful to enhance Tampa Bay oyster restoration projects.

Element A6 – Project/Task Description and Schedule

A6.1. Objectives

This project will monitor newly created and established oyster restoration projects and other locations growing oysters in Tampa Bay (including natural reefs, red mangrove prop roots, and seawalls) to better understand factors influencing success or failure of the projects, including siting, timing, and preferred materials for varying conditions (e.g., sediment and wave energy).

Questions to be addressed include:

1. What variables impact oyster restoration project success in Tampa Bay?
2. Are there variations in restoration processes that are more or less likely to work in different parts of Tampa Bay?
3. Are realistic and useful short- and long-term goals being set for these projects?
4. What standardized monitoring protocols are appropriate to evaluate or estimate long-term success?

A6.2. Description of Work to be Performed

Monitoring phases include 1) site identification; 2) monitoring multiple restored and natural oyster reefs within Tampa Bay; 3) data analysis and management; and 4) creation of a final report and presentations detailing project findings and recommendations that include "lessons learned" and establishment of need for any iterative management actions within existing projects. A new Living Shoreline Creation Project at MacDill Air Force Base (AFB) that will create a series of oyster shell bars with an areal extent of approximately 0.11 ha (0.27 ac) will provide an opportunity for BACI (Before, After, Control, Impact) monitoring with a series of nearby well-established restored oyster reefs acting as additional impact sites.

A6.3. Project Phases

A6.3.1. Project Phase 1 – Site Identification

Site identification will include consideration of year of establishment (to ensure a broad range of project age), materials used (to assess as many standardized methods as possible), location (to try and understand potential differences between the upper and lower bay components), availability of nearby reference locations, and accessibility. Permission to conduct monitoring for selected sites will be negotiated with appropriate entities. Approximately eight study locations (differently-aged projects potentially located in close proximity to one another) will be selected.

Phase 1 deliverables will include:

- Map and list of monitoring sites
- Appropriate permissions from land managers for site access

A6.3.2. Project Phase 2 – Reef Monitoring

A6.3.2.1 Survey Data

<u>RTK Survey</u>

Baggett et al. (2015) suggested that survey data to be collected during oyster reef restoration monitoring should include maximal extent of entire reef, reef patch areas, and reef height. FWRI is the responsible entity for obtaining the physical characteristics data.

Field data are recorded within a preformatted RTK software application. All applicable data fields must be filled out for measurement. The objectives are to accurately describe the area and elevation of the oyster reef and surrounding associated area. All field and laboratory data sheets contain a space to record the initials of the persons entering, reviewing, and correcting data and dates of entry, review, and correction. Field data records include:

- Crew
- Date
- Location
- Weather
- Habitat type
- Latitude/Longitude
- Elevation

Reef Rugosity

The objective is to accurately describe the complexity of the reef as an indicator of habitat for invertebrates and fish (Frost et al. 2005). Field data and sampling logs are recorded on preformatted, waterproof data sheets. Accurate and complete field data should be recorded for each sample. All applicable data fields must be filled out for each sample collected. All field and laboratory data sheets contain a space to record the initials of the persons entering, reviewing, and correcting data and dates of entry, review, and correction. Field data records include:

- Crew
- Date
- Location
- Weather
- Chain Length
- Reef type (e.g., loose shell, bags, modules)

A6.3.2.2 Biological Characteristics

Using teams consisting of 2-3 field technicians, the project team will collect and record biological oyster data. Collected data will be measured at 10 randomly identified points per reef. Measurements to be made follow suggestions within Baggett et al. (2015) for universal metrics to be obtained at all oyster restoration projects. Primary equipment to be used includes pvc quadrats of varying sizes, calipers, and YSI or similar water quality measurement instrument. Measurements include:

- Density assessment
- Number of live and dead oysters
- Shell height in mm (25 live/dead oysters)(total of 250 per reef)
- Ancillary observations (wading bird observations, observed fish, macrocrustaceans)
- Water quality (DO, salinity, conductivity, temperature, pH)

Field data and sampling logs are recorded on preformatted, waterproof data sheets. Accurate and complete field data will be recorded for each sample. All applicable data fields must be filled out for each sample collected. The objectives are to accurately describe the sampling site and conditions at the time a sample is taken, and to record density, shell lengths, and ancillary observations collected in each sample. All field and laboratory data sheets contain a space to record the initials of the persons entering, reviewing, and correcting data and dates of entry, review, and correction. Field data records include:

- Crew
- Date
- Location
- Weather
- Water quality parameters (DO, salinity, conductivity, temperature, pH)
- Habitat type
- Visual survey data
- Additional comments

A6.3.2.3 Spat Settlement

From April to October (time of expected spat settlement), sets of clean oyster shell (6 per set) will be suspended using galvanized wire in the intertidal water column on T-shaped PVC "trees" (Volety 2001, Parker 2015). Shells will be removed and replaced on a monthly basis. Spat and other invertebrates on removed plates/shell will be enumerated in the laboratory and reported on a per cm^2 basis.

Field data and sampling logs are recorded on preformatted, waterproof data sheets. Accurate and complete field data should be recorded for each sample. All applicable data fields must be filled out for each sample collected. The objectives are to accurately describe the sampling site and conditions at the time a sample is taken, and to record density, shell lengths, and ancillary observations collected in each sample. All field and laboratory data sheets contain a space to record the initials of the persons entering, reviewing, and correcting data and dates of entry, review, and correction. Field data records include:

- Crew
- Date
- Location
- Weather
- Habitat type
- Ancillary observations

A6.3.2.4 Site Histories

TBW has been primarily responsible for oyster restoration implementation within Tampa Bay and will aggregate information regarding restoration at monitoring sites. Restoration site information gathered, as practicable and available, will include:

- Restoration plans and permits
- Type(s) and amounts of materials used
- Date(s) of installation
- Project costs, including information on volunteer hours
- Existing monitoring data (isn't there some sort of data mining category?)
- Maps and/or aerial photography of site (e.g., time series from Google Earth, geo-rectified historical photographs if available)

Phase 2 deliverables will include:

- Raw data from biological characteristics survey, spat collection, and reef survey
- Compiled historical information in appropriate electronic formats, including scanned *.pdf documents and, where feasible, data spreadsheets

A6.3.3 Project Phase 3 – Data Analyses and Management

The project team will input all data into Excel spreadsheets (or similar) and perform appropriate statistical analyses. Data QA (as described elsewhere in this document) will occur as a component of this phase.

Phase 3 deliverables will include:

- Data and results of statistical analyses for reef monitoring and spat settlement
- Processed survey data

A6.3.4. Project Phase 4 – Management Recommendations and Final Report

The project team will analyze all data collected and perform any appropriate statistical analyses. All information will be compiled into a final report incorporating the monitoring results to develop management recommendations for future oyster restoration in Tampa Bay.

Phase 4 deliverables will include:

- Management recommendations for future oyster restoration in Tampa Bay.
- Final project report.

A6.4 Project Schedule

All monitoring will occur during a 24-month consecutive period, beginning in early 2019. Survey data will be collected before construction of the MacDill reef and approximately two (2) years later). Data analyses will begin after initial acquisition but will primarily be completed during Quarters 9-11. Development of management recommendations will follow data analyses and will be completed by Quarter 12. Quarterly reports will be submitted to the EPA Program Officer (Felicia Burks).

Table 1. Timeline including activities for each Project Phase)

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
Phase 1 (Site Identification)	x	x										
Phase 2 (Field Monitoring)			x	x	x	x	x	x	x	x		
Phase 3 (Data Analysis)					x	x	x	x	x	x	x	
Phase 4 (Final Report)												x

A6.5 Project QA Records and Reports

TBEP QA Officer will request and review quarterly QA reports from project team leads (FWRI and TBW) for consistency and adherence to the approved QAPP. If any incidents are reported and/or if contractor is not following QAPP guidelines, the TBEP QA Officer and EPA QA Officer, if necessary, will discuss necessary changes with the project partner to ensure that the monitoring protocol is following the appropriate, approved methodology. The applicable data will be reviewed by the subcontractors and by TBEP to ensure there are no errors. If errors are detected due to a failure to adhere to approved QAPP guidelines, those affected samples will not be utilized.

Element A7 – Objectives and Criteria for Measurement Data

A.7.1 Quantitative and Qualitative Objectives

The primary task of this project is to assess the oyster restoration projects in Tampa Bay, with the ultimate objective being the use of the information to improve future projects. Metrics will include reef dimensions, densities, oyster larvae (spat) settlement rates, and water quality data. Recommendations may include preferred materials based on variables such as fetch, sediment, accessibility, and availability of natural spat source (i.e., nearby natural oyster reefs).

A7.2 Measurement Quality Objectives

The following table provides the QA targets for the YSI instruments (models Pro-DSS and Pro-2030) utilized by the FWRI Coastal Wetlands Research Program for water quality sampling:

Table 2. QA targets for YSI instrumentation used for water quality sampling.

Parameter	Instrument	Range	Accuracy	Resolution
Temperature	ProDSS	-5 to 70 °C (temperature compensation range for DO mg/L measurement: -5 to 50 °C)	±0.2 °C	0.1 °C or 0.1 °F (user selectable)
pH	ProDSS	0 to 14 pH units	±0.2 pH units	0.01 pH units
Dissolved Oxygen	ProDSS	0 to 500%, 0 to 50 mg/L	0 to 200%: ±1% of reading or 1% saturation, whichever is greater; 200 to 500%: ±8% of reading 0 to 20 mg/L: ±0.1 mg/L or 1% of reading, whichever is greater 20 to 50 mg/L: ±8% of reading	0.01 mg/L and 0.1%, or 0.1 mg/L and 1% (user selectable)
Salinity	ProDSS	0 to 70 ppt	±1.0% of reading or ±0.1 ppt, whichever is greater	0.01 ppt
Turbidity	ProDSS	0 to 4000 FNU	0 to 999 FNU: 0.3 FNU or ±2% of reading, whichever is greater 1000 to 4000 FNU: ±5% of reading	0.1 FNU
Temperature	Pro2030	-5 to 55°C (0 to 45°C; DO compensation range for mg/L)	±0.3°C	0.1°C

Dissolved Oxygen	Pro2030	0 to 500% air saturation, 0 to 50 mg/L	0 to 200% air saturation, ±2% of the reading or ±2% air saturation, whichever is greater; 200 to 500% air saturation, ±6% of the reading, 0 to 20 mg/L, ±2% of the reading or ±0.2 mg/L, whichever is greater; 20 to 50 mg/L, ±6% of the reading	0.1% or 1% air saturation, 0.01 or 0.1 mg/L (user selectable)
Salinity	Pro2030	0 to 70 ppt	±1.0% of the reading or 0.1 ppt, whichever is greater	0.1 ppt

Element A8 – Special Training Requirements/Certification Listed

Members of the project team are highly experienced in their specific areas of research and possess the following trainings and certifications.

- Professional Ecologist
- Certified GIS Professional(?)
- Advanced Degrees in Ecology, Biology, Oceanography, and Geology

Element A9 – Documentation and Records

A9.1 Data Reports

Copies of the most current approved QA Project Plan will be made and transmitted to Gary Raulerson for inclusion in the data collection of the project and copying for all team members.

Monitoring data and analyses will be collected, collated and kept by the respective monitoring agencies. Final data products will be included in the in the data collection package.

Copies of any grey literature will be made and transmitted to G. Raulerson for inclusion in the data collection of the project and copying for all team members

Historical data and information (maps, permits, etc.) obtained during the project will be archived in *.pdf format. Where practicable, data will be transcribed into spreadsheet format to enable comparison with current project data.

Quarterly status reports are due November 2018, January 2019, April 2019, July 2019, November 2019, January 2020, April 2020, July 2020, November 2020, January 2021, April

2021, and July 2021. The Draft and Final Implementation Plan Reports are due January 2021 and April 2021, respectively.

The final data products include:

- Summary of monthly fisheries monitoring data by hole (12 monthly summaries)
- Summary of seasonal benthic monitoring data by hole (2 seasonal summaries)
- Summary of bathymetric metrics by hole (1 summary)
- Final fisheries monitoring report, summarizing biological and water quality characteristics of each sampled hole
- Final benthic monitoring report, summarizing biological and sediment chemistry characteristics of each sampled hole
- Final bathymetric maps and data, summarizing physical characteristics of each sampled hole

A.9.2 Laboratory Analysis Turnaround Time

<u>Oyster Spat</u>
Oyster spat on shell will be enumerated in the laboratory within three months of collection. Until analysis, shells will be kept in a freezer.

<u>RTK Survey Data Analysis</u>
Survey Data will be analyzed within six (6) months of field collection.

A.9.3 Electronic Records Retention

Original copies of project records and reports will be retained at the generating agencies for a minimum of three (3) years following project completion. Electronic versions of raw (e.g., scanned field sheets), final data reports (e.g., Excel spreadsheets), and final reports will be kept indefinitely on the TBEP server which is regularly backed up. Final reports will also be hosted on the TBEP technical website.

Element B1 – Sampling Process Design (Rationale for Design)

B1.1 Type, number and matrix of samples slated for collection:

Researchers will measure ten (10) randomly located quadrats at each site from within each reef and four (4) randomly located in nearby natural reefs outside the restoration area to serve as a reference site. A minimum of eight (8) restored oyster reef locations will be selected for the study and samples will be collected during annual or bi-annual (2x per year) sampling events. More recent oyster restoration projects (defined as less than three years since installation at time of site identification) will be assessed twice per year, while older sites (greater than three years past deployment at time of site identification) will be assessed once per year. 1-m^2, 0.25-m^2, or 0.0625-m^2 quadrats will be used dependent upon rough density estimate (Baggett et al. 2014). Higher density sites will be assessed with smaller quadrats to reduce field time while obtaining appropriate data. Rugosity will be assessed at all random sites using the chain method (Frost et al. 2005).

Different sampling periodicity has been established for the oyster metrics, reef survey, and spat monitoring sampling portions of this study.

Survey data for each restored oyster reef nearby controls will be collected throughout the monitoring period, with timing based on availability of FWRI staff and equipment. Data collected will include elevation, area, and edge measurements.

Spat trees will be placed at six (6) restored oyster reefs located in different sections of Tampa Bay. Oyster shell collection and replacement for spat analysis will occur on a monthly basis from April to October, the known time frame for spat release in Tampa Bay (Parker et al. 2013).

All sites will be comprehensively surveyed at least one time during the project period. If a significant storm event occurs during the project period and budget is available, additional surveys will be conducted at a subset of the sites to aid in understanding site resilience.

B1.2 Rationale for the proposed sampling design

Biological Characteristics

The proposed sampling design consists of ten (10) replicate quadrats within each restored reef site which will allow for the calculation of basic summary statistics for oyster characteristics. The pooled reference samples from the restored reefs along with historic data from FWRI and TBW will provide comparable conditions for oyster reefs.

Oyster Spat

Duplicate pairs of spat "trees" will be placed at six (6) restored oyster reef sites throughout Tampa Bay to better understand potential seeding limitations during the oyster recruitment process. Sets of six (6) shells will be retrieved and replaced with clean shell on a monthly basis. Retrieved shells will be stored in a freezer until processed.

RTK Survey

Elevation profiles perpendicular to the shoreline will be created at each site. Within the new MacDill oyster restoration project footprint, a survey will be conducted less than one month prior to installation and approximately one (1) year post-installation to observe initial changes in elevation.

B1.3 Sample locations and frequency of sample collection at each location

The project will monitor approximately eight (8) restored oyster reef sites in Tampa Bay to assess their current ecological habitat value. Potential monitoring locations (Figure 1) include:

1. 2D Spoil Island: bagged shell installation by TBW began in Fall 2016 and an earlier component included deployed rock and rubble that has some oyster regeneration
2. Alafia Banks reefs: the intertidal zone contains a series of reef modules installed in 2011 protecting the islands that incidentally recruit oysters; this is an Audubon nesting sanctuary and it is recognized that no monitoring could occur from March 15 through August 31
3. Ballast Point: A series of domes were placed in 2006 among riprap to north and west of pier
4. Bayshore Boulevard: early demonstration project (mid-2000s) that included installation of a series of oyster domes
5. Cockroach Bay: early (1995 & 2008) Tampa Bay restoration projects with significant regeneration of red mangroves as an aggregation surface for oysters
6. Fantasy Island - project completed in 2017 that included both bags and domes
7. Ft. DeSoto campground: bagged shell deployed in 2006/2007
8. FWRI living shoreline project: Clam Bayou (Gulfport), DeSoto Park (McKay Bay), and seawalled areas within Tampa Bay. This is a new living shoreline project being conducted by FWRI and the information obtained (looking at different living shoreline approaches) will act as a supplement to this proposed project.
9. MacDill AFB: contains multiple differently-aged projects (2003-present) using different materials (bagged shell and reef modules) side by side, including the location of a “time zero” area included as a component in this application.
10. McKay Bay: multiple projects with bagged shell, the first of which was established in 2013 (work is continuing)
11. Perico Preserve: relatively new project (2016) with shell hash distributed at inlets and around rookery island
12. Robinson Preserve: relatively new restoration projects (2015-present) comprised of both bagged and loose shell as well as potential for red mangrove regeneration as an aggregation surface for oysters Fantasy Island: project completed in 2017 that included both bags and domes
13. Rock Ponds: new (2015/2016) SWFWMD coastal restoration project with observed oyster recruitment

Figure 1. Location of potential dredge holes to be studied.

Oyster characteristic data will be collected at approximately eight (8) oyster restoration sites (to be determined). Samples will be collected either annually or bi-annually (2 times per year). Based on understanding of rates of development of local oyster restoration reefs, annual data collections will occur at sites greater than three years old and bi-annual collections will occur at reefs less than three years old. Rugosity will be evaluated using the chain method (Frost et al. 2005) at each random plot.

Sampling sites will be randomly chosen from areas within the selected oyster reefs. Appropriate natural reef habitat outside of the restored areas will also be sampled.

Spat monitoring will occur at six restoration sites located throughout Tampa Bay. Oyster shells will be retrieved and replaced on a monthly basis.

FWRI staff will also prepare maps showing the sorted data, elevation contours, and reef boundaries.

Element B2 – Sampling Methods Requirements

B2.1 Sample collection procedures and methods

Biological Characteristics

Plots for assessment will be identified prior to field work by randomization programs available in ArcGIS or similar programs. For irregular sites, polygons will be drawn around identifiable reef areas and the program will randomly identify approximately twice the required number of survey sites (to allow for field issues). For areas with known quantities and layout of reef modules, the modules will be systematically numbered and randomly selected for analysis. To address the vertical component of the reef modules, the quadrat will be laid upon one-quarter of the top of the module (e.g., 12-3 pm of a clock face) and everything within that area will be enumerated on both the horizontal and vertical surfaces of the module (Figure 2). Higher density sites will be assessed with smaller quadrats to reduce field time while obtaining appropriate data. The use of 1-m^2, 0.25-m^2, or 0.0625-m^2 quadrats will be dependent upon rough density estimate during

Figure 2. Placement of quadrat to assess oyster density on reef module.

inspection the day of field work (Baggett et al. 2014). Total number of live and dead oysters will be counted within the quadrat, and XX measurements of shell height will be taken at each quadrat. Rugosity will be assessed at all random sites using the chain method (Frost et al. 2005).

Spat enumeration
T-shaped PVC "trees" will be installed at six (6) sites targeted for 1) understanding spat settlement and 2) low probability of equipment loss. The trees are situated at the densest location on the target reef. Prior to deployment, shells are cleaned by soaking with 5% bleach water for a minimum of 48 hours and scrubbed with a wire brush to remove any remaining algae and fouling organisms. Two pairs of six cleaned oyster shells (5-10 cm shell height) are strung with galvanized wire through pre-drilled holes and then suspended on each arm of the "T" just above the surrounding live oysters. On a monthly basis, the old sets of oyster shells are removed and clean oysters are placed at the site. Retrieved oyster sets are frozen until processing occurs.

Figure 3. Example of spat tree, photo courtesy GTM Research Reserve.

Reef Survey
Elevation surveys will be conducted using a Champion Instrument WR1 real-time kinematic global positioning system (RTK-GPS) with GLONASS enabled. In areas where cellular network coverage is available, the Florida Public Reference Network (PRN) service will be used in a single-rover setup for real-time position and elevation correction. The PRN services eliminate the need to establish a local GPS base station tied to a local benchmark and greatly improved the efficiency of field data collection. In areas where network services are not accessible, a base station will be setup and referenced to a local elevation benchmark, with the RTK-GPS operating in base-rover configuration. All measurements will be made only when the RTK achieves "fixed" status, and data collection will be facilitated by Carlson SurvCE software on a hand-held data collector (eGPS Inc. HC1) with Bluetooth connectivity to the RTK antenna. Data collection in "fixed" status allows for the highest precision mode, where multiple measurements are taken at 1-s intervals for 7 s at each point, and only measurements with acceptable Root-Mean-Square (RMS) errors accepted. Data collected will include position information in the x, y, and z vectors. The precision of, and RMS error thresholds for, each elevation measurement vary and are controlled by the following factors:

1) Number and location of satellite available of positioning. These are highly variable based on time of day, location of survey, and daily weather. Generally it impossible to achieve “fixed” survey status with fewer than eight satellites available to the RTK-GPS receiver.
2) Cellular network signal strength: the Trimble VRS Now H-Star services were accessed through cell phone communication. Trimble software requires solid communication to achieve TRK fixed status.
3) The bottom characteristics: a 5-cm diameter flat topo-foot will be used as a survey rod base. Therefore, the measured elevation will represent that of a 5-cm circle. The higher the rugosity and complexity of the survey point, the lower the precision.

Two approaches will be used to estimate survey uncertainties, particularly the accuracy of elevation measurements. For approach one, measurements will be conducted at the top and bottom of a temporary benchmark installed at each site. The height of the benchmark from the land/seafloor surface will be measured with a measuring tape and the RTK-GPS. The top-to-bottom elevation difference obtained by the RTK GPS should equal the measured height of the benchmark. Typical precisions are within 1 cm, and errors no larger than 2 cm will be considered acceptable. The second approach to determining survey uncertainties will involve repeated measurements of nearby survey elevation markers (benchmarks) certified by the National Geodetic Survey. Twenty measurements will be conducted at each survey benchmark over a 10-minute period. Horizontal survey data (x,y) will be measured and reported in the North American Datum 1983 (NAD83) Florida State Plane (west) coordinate system. Vertical data will be measured in the North American Vertical Datum 1988 (NAVD88). Vertical measurements in NAVD88 datum can be reference to local tidal datums using vDatum, a freely available software tool published by the National Oceanic and Atmospheric Administration. Based on corrections at the NOAA St. Petersburg tide station, a zero elevation in NAVD88 is 8.3 cm above the mean sea level (MSL) in Tampa Bay.

B2.2 Equipment needs

Biological Characteristics Equipment List:

- 1-m^2, 0.25-m^2, and 0.0625-m^2 quadrats
- Pencils
- Calipers
- Fine-linked chain
- Data sheets (Appendix B)
- GPS

Spat Assessment Equipment List

- PVC tree
- Rubber mallet
- Galvanized wire
- Clean oyster shell, pre-drilled, numbered, and on wire
- Data sheets (Appendix C)
- Pencils
- GPS

Reef Survey Equipment List

- Champion Instrument WR1 real-time kinematic global positioning system (RTK-GPS) with GLONASS enabled

B2.3 Support Facilities

FWRI and TBW both have appropriate boats that will be used to access several of the oyster restoration sites. FWRI laboratory space will be utilized to store and process oyster spat samples. Computer support is available at both facilities, including GIS and Excel applications for map processing and data entry.

B2.4 Individuals responsible for corrective actions in the field:

All field sampling and laboratory analysis will be conducted under the direction of a qualified principal investigator. Ryan Moyer (FWRI) and Serra Herndon (TBW) will be responsible for ensuring that data are collected according to the procedures detailed in this document. Any deviation for standard procedures will be documented and any corrective actions necessary will be reported to the TBEP Officer (Gary Raulerson; TBEP) in writing within 5 business days. Any corrective actions deemed necessary by the QA Officer will be documented in writing and the distribution list will be copied on all corrective actions.

B2.5 Process for preparation and decontamination of sampling equipment:

Not applicable

B2.6 Selection and preparation of sample containers – and specifies sample volumes:

Samples for spat analysis will be frozen in appropriate containers until analyzed.

B2.7 Requirements for Holding Times

Water Quality Sampling Methods

Water quality sampling (salinity, temperature, DO, conductivity, and pH) conducted during oyster monitoring will be in compliance with FDEP SOPs for in situ data as defined in the bullet points below:

- DEP-SOP-001/01 FQ 1000 Field Quality Control Requirements
- DEP-SOP-001/01 FS 1000 General Sampling Procedures
- DEP-SOP-001/01 FS 2000 General Aqueous Sampling
- DEP-SOP-001/01 FS 2100 Surface Water Sampling
- DEP-SOP-001/01 FT 1100 Field Measurement of Hydrogen Ion Activity (pH)
- DEP-SOP-001/01 FT 1200 Field Measurement of Specific Conductance
- DEP-SOP-001/01 FT 1300 Field Measurement of Salinity
- DEP-SOP-001/01 FT 1400 Field Measurement of Temperature

- DEP-SOP-001/01 FT 1500 Field Measurement of Dissolved Oxygen

Water Quality Field Sampling Procedures

Water quality sample collection will precede other data collection to avoid suspended sediments that may be disturbed as the result of benthic or fish collections. At each site, a surface reading (~0.2-m) of instrumental parameters (salinity/conductivity, temperature, dissolved oxygen, pH) are to be collected. Instrumental protocols followed include pre- and post-sampling bench calibrations as well as periodic field checks with standards such as air calibration checks for dissolved oxygen, and solutions of known conductivity and pH.

For station measurements, when probes are lowered to the proper depth (based on cable markings) and a stable reading obtained, data are recorded on physical data sheets. Field data forms proposed also include the identification of specific field instruments and results of field checks or calibrations of in situ instrumentation and any other information generic to the sampling crew and date. The proposed forms, together with custody sheets, incorporate the pertinent data elements required by FDEP (F.A.C. 62.160-240, February 23, 2012) for ambient sampling programs.

Electronic data are incorporated in the final data deliverable, but anomalous readings can be confirmed with the field data hard copy. Raw electronic files are archived as are the hard copies of field data sheets.

The water quality parameters to be measured in the field include temperature, salinity (conductivity), dissolved oxygen, and pH. Important pre-field calibration techniques are found in Section B7. Water quality instruments include:

- ProDSS Sonde (manufactured by YSI instruments, Yellow Springs, OH); and
- Two Pro2030 Sondes (manufactured by YSI instruments, Yellow Springs, OH).

All instruments will be calibrated at least every 4-6 weeks. Instruments will be recalibrated if calibrations checks fail to meet acceptance criteria. The ProDSS pH sensor will be replaced if calibration accuracy drifts or if mV readings begin to decline. Pro2030 DO membranes will be replaced regularly (approximately every 3 months). ProDSS sensors will be stored in tap water to prevent desiccation of sensor membranes. Pro2030 sensors will be stored in a plastic sleeve with a damp sponge. All quality control data shall be recorded in the calibration log. The procedure for collecting data using in situ physical chemistry recording units is provided below.

1) Before leaving the lab, check the battery charge on the display of the unit.
2) Keep the ProDSS probes immersed in water at all times. Exposure to air will dry out the membranes, which, in turn, will give false readings.
3) Once on station, turn the unit on and allow it to equilibrate for at least 2 minutes before taking the readings.
4) Water quality parameters will be recorded at 10 cm depth.

Secchi Disk Procedure

A Secchi disk provides an easy, economical and reliable measure of water clarity and light penetration. Turbidity and available light may be expected to have significant effects on the visual perception of fishes, and hence affect catchability. The Secchi disk used in this study is a 203-mm diameter disc with alternating black and white quarters. The purpose of the Secchi disk is to provide a measurement of visibility within the water column that integrates water clarity and ambient light level.

a) Locate an area that is free from turbidity generated by the boat or sampling operations. Local shadow effects caused by boat, shore vegetation, structures, or yourself should also be avoided. Remove sunglasses if worn.
b) Slowly lower disk into water using distance calibrated (meters and tenths) line. When the disk is lost to sight, note the point on the line at water surface.
c) Lower disk additional 0.2 - 0.3 m, then slowly begin to retrieve to surface. When the disk first becomes visible, again note point of line at surface. If this varies from the first measurement, average these two values and record to the nearest 0.1 m.
d) If disk settles on bottom before being lost to sight, record water depth and 'Y' in appropriate boxes on data sheet ('N' otherwise).

Filling Out Data Sheets

The success of any sampling program depends upon accurate and complete data being recorded for each sample. All applicable data fields must be filled out for each sample collected.
The objective of completing data sheets is to accurately describe the sampling site and conditions at the time a sample is taken and to record taxa, associated lengths, and number of fish and selected macroinvertebrates collected in each sample. The detailed methodology for filling out field data sheets associated with this project is provided in Appendix B.

Field Quality Control

Field quality control measures will be used to ensure that quality control in the field is adequately addressed. Activities include:

- Sampler training activities conducted by a single agency;
- Common sampling protocols;
- Standardized logging formats on waterproof paper;
- Instrument pre- and post-calibration against alternate methods or solutions;

Reef survey

Two approaches will be used to estimate survey uncertainties, particularly the accuracy of elevation measurements. For approach one, measurements will be conducted at the top and bottom of a temporary benchmark installed at each site. The height of the benchmark from the land/seafloor surface will be measured with a measuring tape and the RTK-GPS. The top-to-bottom elevation difference obtained by the RTK GPS should equal the measured height of the benchmark. Typical precisions are within 1 cm, and errors no larger than 2 cm will be considered acceptable. The second approach to determining survey uncertainties will involve repeated measurements of nearby survey elevation markers (benchmarks) certified by the National Geodetic Survey. Twenty measurements will be conducted at each survey benchmark over a 10-minute period. Horizontal survey data (x,y) will be measured and reported in the North American Datum 1983 (NAD83) Florida State Plane (west) coordinate system. Vertical data will be measured in the North American Vertical Datum 1988 (NAVD88). Vertical measurements in NAVD88 datum can be reference to local tidal datums using vDatum, a freely available software tool published by the National Oceanic and Atmospheric Administration. Based on corrections at the NOAA St. Petersburg tide station, a zero elevation in NAVD88 is 8.3 cm above the mean sea level (MSL) in Tampa Bay.

Element B3 – Sample Handling and Custody Requirements

Spat Monitoring

Oysters retrieved from trees will be checked for appropriate labels, put into labeled Ziploc bags or similar, and then placed in a cooler with ice prior to transfer to a freezer at the laboratory until spat enumeration. At all transfer points the labels will be inspected for legibility and correctness.

Element B4 – Analytical Methods Requirements

Analytical methods to be followed

The in-situ field measurements of water quality are collected using a YSI ProDSS or Pro2030 Sondes. Water quality parameters are recorded on field datasheets, which will be entered into excel upon return to the lab. At each site, physical water quality parameters at the surface (0.1-m) is recorded. The sonde readings are allowed to stabilize and then data is recorded.

Reef Survey

Elevation surveys will be conducted using a Champion Instrument WR1 real-time kinematic global positioning system (RTK-GPS) with GLONASS enabled. In areas where cellular network coverage is available, the Florida Public Reference Network (PRN) service will be used in a single-rover setup for real-time position and elevation correction. The PRN services eliminate the need to establish a local GPS base station tied to a local benchmark and greatly improved the efficiency of field data collection. In areas where network services are not accessible, a base station will be setup and referenced to a local elevation benchmark, with the RTK-GPS operating in base-rover configuration. All measurements will be made only when the RTK achieves "fixed" status, and data collection will be facilitated by Carlson SurvCE software on a hand-held data collector (eGPS Inc. HC1) with Bluetooth connectivity to the RTK antenna.

Spat Enumeration

The outside shells of each set (numbers 1 and 6) are discarded and spat and barnacles on the bottoms of shells 2-5 are counted using a dissecting microscope.

Validation information for non-standard methods

N/A

Individuals responsible for corrective action

Dr. Ryan Moyer and Ms. Serra Herndon will oversee field collections of the oyster characteristic data. Dr. Ryan Moyer will oversee the survey data collection.

Turnaround time for analysis and data deliverables

All physical and biology data will be processed within 6 months from the collection date. Final deliverables for data and final report will be completed within 6 months of the final field collection.

Element B5 – Quality Control Requirements

QC procedures and frequency for each sampling event, analysis, or measurement technique, as well as associated acceptance criteria and corrective actions:

Field staff is responsible for the proper completion and retention of field data sheets. Laboratory staff is responsible for completion, retention and filing of chain of custody forms and verification and tabulation of QC checks. Raw data are keypunched by field staff, laboratory analysts, and clerical staff. Keypunched data are validated (checked for data entry errors) and reviewed by the organization's QA officers for compliance with holding time and other QC requirements.

Quality Control on Field Measurements

All field instruments will be calibrated every 4-6 weeks. The instrument shall be recalibrated if the continuing calibration checks fail to meet acceptance criteria. The ProDSS pH sensor will be replaced if calibration accuracy drifts or if mV readings begin to decline. Pro2030 DO membranes will be replaced regularly (approximately every 3 months). All quality control data shall be recorded in the calibration log.

Table 3. Acceptable accuracy for calibration of sonde instruments.

Method No.	Parameter	Precision	Accuracy	MDL
SM 2550 B	Temperature	NA	± 1.0° C	NA
SM 4500-0 G	Dissolved Oxygen	10%	± 0.5 mg/L	0.5 mg/L
SM 4500-H+B	pH	NA	± 0.2	NA
SM12520 B	Salinity	10%	± 1.0 ‰	< 0.1 ‰

Quality Control on Laboratory Measurements

To quantify the effectiveness of the quality control procedures for enumeration of spat, repetitive measurements (*i.e.* recounting) will help determine the associated measurement error. Below is a list of QA procedures that are conducted and recorded on log sheets and in the electronic database.

High-quality dissecting microscopes are used for all identifications. A minimum of 10% of all samples counted by each technician is be recounted to monitor technician performance and provide feedback necessary to maintain acceptable standards. Resorts are conducted on a regular basis on batches of 10 samples and all results are documented and recorded on recount sheets and stored in a QA/QC database. The QC recount procedure is designed to provide effective and continuous monitoring of sorting efficiency. The minimum acceptable counting efficiency is within 90% of original count. Samples for recounting are randomly selected from a sample batch counted by a particular technician. The archived samples are retrieved and the recount sheet is filled in. The results of sample recounts may require corrective actions for specific technicians. Laboratory personnel and supervisors must be particularly sensitive to systematic errors (*i.e.,* consistent failure to achieve 90% accuracy), which may suggest the need for further training. Recount results below 90% require recounting of all samples in that batch and continuous monitoring of that technician to improve efficiency. Recount results are summarized for each technician on a QC recount summary sheet and recorded in the database.

Element B6 – Instrument/Equipment Testing, Inspection, and Maintenance Requirements

Instrument/equipment testing, inspection and maintenance will be done in accordance with FDEP and manufacturer requirements for field activities/sample collection and with laboratory protocols and SOPs as approved by NELAC for laboratory activities. Field equipment used for *in situ* measurements will have an initial verification and continuing calibration throughout the duration of the project. Field equipment will be factory calibrated at the time of deployment and operation and maintenance will be done in accordance with manufacturer's installation and maintenance guides.

Element B7 – Instrument/Equipment Calibration and Frequency

Instrument/equipment testing, inspection and maintenance will be done in accordance with FDEP and manufacturer requirements for field activities/sample collection and with laboratory protocols and SOPs as approved by NELAC for laboratory activities. The handheld GPS, survey equipment, conductivity meter, specific gravity meter and/or handheld refractometer used for *in situ* measurements will have an initial verification and continuing calibration throughout the duration of the project. Field equipment will be factory calibrated at the time of deployment and operation and maintenance will be done in accordance with manufacturer's installation and maintenance guides.

The Datasonde/YSI units must be calibrated routinely to assure the accuracy of their field readings. At a minimum, the units must be calibrated every 4-6 weeks. If during calibration, the readings in known solutions are outside the desired range of accuracy, the calibration interval should be reduced.

PRODSS calibration and maintenance:

General info

- Manuals are available at http://www.exowater.com/ with serial number
- Make sure cord does not get bent sharply, be careful when putting back in pelican case
- When taking out sensors, set them on a kim wipe to keep o-rings clean. Wipe off old grease, apply new on both o-rings and threads. Examine o-ring for cuts and nicks.
- Simple green and dishwashing soap may be used to clean sensors if grease accidentally gets on them.
- Close nut with fingers, then tighten with included tool
- Use WD40 on electronic connection from YSI to handheld device.
- "Restore default calibration" will return sonde to factory settings
- Keep sonde in wet cloth when outside as the housing acts as a greenhouse
- Sensors can be stored underwater, but if the sensor guard gets slimy with bacteria growth, clean it off and use a paintbrush to clean between sensors.

General calibration info

- Take off bottom part of the instrument cage when calibrating pH and salinity (can calibrate with less solution), but the bottom piece must be on to calibrate turbidity.
- In the calibration cup/sonde housing, the lowest line is the level to fill with pH, chlorophyll, and turbidity calibration solutions. The upper line is for the calibration of conductivity.
- Wait 30 seconds for all calibrations for the instrument to stabilize

DO calibration

- Leave DO coefficient alone; it was factory calibrated.
- Calibrate with 1/8 inch water, calibration cup partially tightened. Let sit 10-15 min. Verify barometer reading makes sense. On screen, go to "calibration," "ODO." "DO%" Let screen stabilize (no change for 40 seconds), then select "accept calibration"
- DO membrane is good for 2 years. It can be stored in saturated air, but soak for 2 hours to rehydrate before use. Enter coefficient by hand if a new membrane is ordered.

2 point turbidity calibration

- Put bottom back on sensor guard
- 2 rinses with DI water
- Pour DI water down the side of the calibration container to avoid bubbles in the container
- Look at sensor and wipe with kimwipe if needed
- Wait 30 seconds, set calibration to 0
- Repeat 2 rinses, fill with calibration solution and enter appropriate value. FNU=NTU

- Turbidity calibration solution is $300 per gallon because of microscopic polystyrene beads that are neutrally buoyant. The alternative calibration solution, formazin, is cheaper but it is a carcinogen and it must be very well mixed as it settles.

1 point conductivity calibration

- Remove bottom sensor guard
- 2 rinses with conductivity standard
- Pour standard down side of cup to higher line. tap to remove bubbles.
- On screen, go to "calibration," "specific conductivity." Use uS/cm units, enter 10,000 (or 50,000) to calibrate, depending on standard used

2 point pH calibration

- Remove bottom sensor guard
- Rinse with calibration solution 2 times, fill to bottom line
- Enter pH value from bottle (depends on temperature)
- Rinse with DI, then 2nd calibration solution and repeat.
- If cleaning pH sensor: pH connector has 2 o-rings; apply grease to connect. May be slightly wet while connecting, but it is better if they are not. To clean, soak in 1 M HCl (or vinegar) a few minutes, gently wipe with cotton swab. Soak in 1:1 tap water and bleach for 30 minutes. Soak sensor in saturated tap water for 30 min to leach out bleach. See manual for full instructions on cleaning sensor.

When done with calibrations, rinse with tap water 2 times and put enough tap water in the cap so that the pH sensor is submerged.

PRO2030 Calibration and maintenance

DO sensor should be changed every 2-3 months. Unscrew yellow DO membrane, verify that KCl solution is still present inside. Once the DO membrane has been removed, it cannot be placed back on. Check the gold/silver plating. If there is significant discoloration, use provided sand paper and gently clean sides. Rise, and gently clean bottom (sanding is normally not needed for every DO membrane change). Fill new DO membrane case with KCl 2/3 full, then screw on so cup over flows. Dab bottom with kimwipe to remove any droplets. Calibrate DO sensor.

Problem solving: Check DO plug for moisture. If present, clean with ethanol and air. Verify readings make sense; if sensor is unplugged, the unit should read 0% DO.

RTK Survey

Two approaches will be used to estimate survey uncertainties, particularly the accuracy of elevation measurements. For approach one, measurements will be conducted at the top and bottom of a temporary benchmark installed at each site. The height of the benchmark from the land/seafloor surface will be measured with a measuring tape and the RTK-GPS. The top-to-bottom elevation difference obtained by the RTK GPS should equal the measured height of the benchmark. Typical precisions are within 1 cm, and errors no larger than 2 cm will be considered acceptable. The second approach to determining survey uncertainties will involve repeated measurements of nearby survey elevation markers (benchmarks) certified by the National Geodetic Survey. Twenty measurements will be conducted at each survey benchmark over a 10-minute period. Horizontal survey data (x,y) will be measured and reported in the North American Datum 1983 (NAD83) Florida State Plane (west) coordinate system. Vertical data will be measured in the North American Vertical Datum 1988 (NAVD88). Vertical measurements in NAVD88 datum can be reference to local tidal datums using vDatum, a freely available software tool published by the National Oceanic and Atmospheric Administration. Based on corrections at the NOAA St. Petersburg tide station, a zero elevation in NAVD88 is 8.3 cm above the mean sea level (MSL) in Tampa Bay.

Element B8 – Inspection/Acceptance for Supplies and Consumables

Inspection/acceptance of supplies and consumables will be done in accordance with FDEP requirements for field activities and with laboratory protocols and SOPs as approved by NELAC for laboratory activities.

Sample bottles for oyster shell storage will be supplied by project team members and field staff will check that appropriate labels are affixed to each sample bottle.

Monitoring:

Ryan Moyer (FWRI) and Serra Herndon (TBW) will be in charge of purchasing consumable supplies for the sediment field collections and laboratory analysis and will inspect ordered supplies upon delivery for damage and to ensure compliance with requirements.

Element B9 – Data Acquisition Requirements for Non-Direct Measurements

Personnel throughout the Tampa Bay region with responsibilities for oyster restoration projects will be contacted to obtain background information. Restoration site information gathered, as practicable and available, will include:

- Restoration plans and permits
- Type(s) and amounts of materials used
- Date(s) of installation
- Project costs, including information on volunteer hours
- Existing monitoring data
- Maps and/or aerial photography of site (e.g., time series from Google Earth, geo-rectified historical photographs if available)

Element B10 – Data Management

The Coastal Wetlands Group at FWC FWRI and the Restoration team at TBW will be responsible for managing their data during this study. As a final deliverable, the data will be provided to the Tampa Bay Estuary Program in an acceptable format complete with metadata documentation. The data will undergo rigorous quality assurance and quality control protocols that include data entry, proofing, data corrections, reproofing, and verification programs that allow for the identification and research of potential outliers. All field data sheets will be scanned and provided as a deliverable as well.

GROUP C – ASSESSMENT AND OVERSIGHT

Element C1 – Assessments and Response Actions

Assessments will be conducted periodically and at milepost events. Periodic assessments include evaluation of completed tasks against schedule and budget.

Element C2 – Reports to Management

C1. Assessments and Response Actions

Reef characteristic and oyster assessment data will be reviewed by FWRI and TBW. Reef survey data will be reviewed by FWRI before submission to TBEP. Reports will be submitted quarterly, or as needed, to the TBEP and reviewed by Gary Raulerson. Missing data or QA problems will be reported to the TBEP and appropriate action will be determined by Gary Raulerson, Maya Burke, Ryan Moyer, and Serra Herndon. Data quality will be evaluated quarterly by TBEP staff.

Reports on the project status will be made to US EPA Region IV Project Manager, Felicia Burks, quarterly (February, May, August and November) for the duration of the project. These reports will be prepared by the TBEP Project Manager, Gary Raulerson, with input from the team members. When appropriate, TBEP Project Manager will include information or updates from partners and contractors on this project as supporting documentation. The reports will summarize completed and pending tasks, any quality assurance issues identified during the quarter and how they were resolved, task progress of any milestone events scheduled during the quarter, and identification and description of objectives achieved during the quarter. Any delays in data collection, validation or analysis will be summarized, with a description of implications and resolution, as appropriate.

C2. Reports to Management

The following reports will be provided to TBEP Project Manager:

- Quarterly status reports by FWRI and TBW
    - Quarterly reports will be reviewed by TBEP staff and a summary will be provided to EPA
- Draft final management and assessment report
    - Draft final reports will be reviewed by the entire project team, as well as other members of the Technical Advisory Committee, as appropriate
- Final management and assessment report
    - Final reports will be submitted to TBEP for inclusion and integration into the overall final project report

GROUP D – ASSESSMENT AND OVERSIGHT

Element D1 – Data Review, Validation and Verification

Data sheets are prepared prior to sampling and used as the checklist to ensure that all data are collected. Short discussions are undertaken at the beginning of each sampling event. See Appendices for sample data sheets.

The criteria used to review, verify and validate data will initially be the QA/QC sample results included in the laboratory report.

Element D2 –Validation and Verification Methods

Analytical data will be verified and validated per EPA Methods, laboratory SOPs and NELAC requirements. Data will be tabulated and queries performed to validate completeness of results and appropriate data ranges. Data will be scanned for anomalies by the use of scatterplots and histograms.

Task QA Managers will report their findings via email memos to the project manager, which, in turn, will contact the necessary project manager for conflict resolution and request immediate implementation of field corrective measures. Project personnel will update QA officer and project manager of the results of the new corrective action. All findings will be recorded in quarterly reports by the project manager.

Data collected on the checklist will be entered to a spreadsheet by a data manager. The data will be checked for transcription accuracy. Data results will be communicated to all team members and included in the data collection package as supporting documentation.

Element D3 – Reconciliation of Data to Project Objectives

If laboratory samples do not meet acceptance criteria, sample re-analysis will be required before laboratory data reports will be produced. The FWRI Analysis QA/QC Task Officer (Radabaugh) will be responsible for reconciling the data to the project data quality objectives.

APPENDIX A – References

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APPENDIX B – Example Oyster Biological Characteristics Field Data Sheet

Crew: ________ Date: ________ Start time: ________ End time: ________ Location: ________

Recorder: ________ Weather: ________

Plot #	Lat	Lon	Reef type	Quad size	# Live	# Dead	DO	Salinity	Cond	Temp	pH	General observations (fauna, etc)
Shell height (mm, 25 measurements per plot)												
												no length here

Plot #	Lat	Lon	Reef type	Quad size	# Live	# Dead	DO	Salinity	Cond	Temp	pH	General observations (fauna, etc)
Shell height (mm, 25 measurements per plot)												
												no length here

Plot #	Lat	Lon	Reef type	Quad size	# Live	# Dead	DO	Salinity	Cond	Temp	pH	General observations (fauna, etc)
Shell height (mm, 25 measurements per plot)												
												no length here

Plot #	Lat	Lon	Reef type	Quad size	# Live	# Dead	DO	Salinity	Cond	Temp	pH	General observations (fauna, etc)
Shell height (mm, 25 measurements per plot)												
												no length here

APPENDIX C – Example Spat Deployment and Retrieval Data Sheet

Crew: ____________ Date: ______________ Start time: ______

Recorder: ____________ Weather: __________________________

End time: ______ Location: ____________________

Site Name	Tree #	Lat	Long	Retrieve? (Y/N)	Comments