Quality Assurance Project Plan

Statewide Seagrass Monitoring Protocol Development Phase 2

June 19, 2012

Texas Parks and Wildlife Department
4200 Smith School Road
Austin, Texas 78744-3291

Effective Period: This Quality Assurance Project Plan (QAPP) is effective upon signature through August 31, 2013

A portion of this work to be performed for the Texas Commission on Environmental Quality under contract #582-12-22128

Questions concerning this quality assurance project plan should be directed to:

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A1. Approval Sheet

Texas Parks and Wildlife Department

6-20-2012

Patricia L. Radloff, Ph.D. — Date
Project Manager

6-21-2012

Angela Schrift — Date
Quality Assurance Project Officer

June 20, 2012

Cindy Hobson — Date
TPWD Quality Assurance Officer, FY 2012

Lower Colorado River Authority

6/20/12

Alicia Gill, Laboratory Manager — Date
Environmental Laboratory Services

6/20/12

Hollis Pantalion, Quality Assurance Officer — Date
Environmental Laboratory Services

Texas Commission on Environmental Quality

Office of Water
Water Quality Planning Division
Monitoring & Assessment Section

Laurie Curra, Manager Monitoring & Assessment Section	Date
Andrew Sullivan, SWQM Team Lead Surface Water Quality Monitoring Program	Date
Pat Bohannon, Project Manager Surface Water Quality Monitoring Program	Date
Robin Cypher, SWQM Project Quality Assurance Specialist Surface Water Quality Monitoring Program	Date

Office of Compliance and Enforcement
Field Operations Support Division

Stephen Stubbs, TCEQ Quality Assurance Manager Laboratory and Quality Assurance Section	Date
Daniel Burke, SWQM Program Quality Assurance Specialist Quality Assurance Section	Date

U.S. Environmental Protection Agency (EPA) – Region VI

____

Curry Jones, M.P.H., Section Chief Date
State and Tribal Programs Section
Assistance Programs Branch

____

Teresita Mendiola, Project Officer Date
State and Tribal Programs Section
Assistance Programs Branch

The TPWD Water Quality Program will secure written documentation from each project participant within 30 days, e.g. subcontractors, other units of government, contract laboratories, stating the organization's awareness of and commitment to requirements contained in this quality assurance project plan and any amendments or revisions of this plan. The Project Manager will maintain this documentation as part of the project's quality assurance records.

A2. Table of Contents

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List of Acronyms

AWRL	Ambient Water Reporting Limit
CMPSEA	Coastal Management Program seagrass study performed by TPWD
COC	Chain-of-Custody
DO	Dissolved Oxygen
EPA	U.S. Environmental Protection Agency
GPS	Global Positioning System
LCRA	Lower Colorado River Authority
LCS	Laboratory Control Standard
LOQ	Limit of Quantitation
MDL	Method Detection Limit
OP	ortho-Phosphate-phosphorus
PAR	Photosynthetically Active Radiation
QA	Quality Assurance
QAM	Quality Assurance Manual
QAO	Quality Assurance Officer
QAPO	Quality Assurance Project Officer
QAPP	Quality Assurance Project Plan
QC	Quality Control
RL	Reporting Level
RPD	Relative Percent Difference
SE	Standard Error
SI	Surface Irradiance
SOP	Standard Operating Procedure
SWQM	Surface Water Quality Monitoring
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TSS	Total Suspended Solids
TCEQ	Texas Commission on Environmental Quality
TPWD	Texas Parks and Wildlife Department
VSS	Volatile Suspended Solids

A3. Distribution List

Texas Parks and Wildlife Department
4200 Smith School Road
Austin, TX 78744

Patricia L. Radloff, Ph.D., Project Manager
Angela Schrift, Quality Assurance Project Officer
Cindy Hobson, TPWD Quality Assurance Officer
Adam Whisenant, Regional Biologist
Jennifer Bronson, Regional Biologist

Lower Colorado River Authority
Environmental Laboratory Services
P.O. Box 220, Austin, TX 78767

Gary Franklin
Hollis Pantalion

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P.O. Box 13087
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Andrew Sullivan, Team Leader, Surface Water Quality Monitoring Program (MC-234)
Pat Bohannon, Project Manager, Surface Water Quality Monitoring Program (MC-234)
Robin Cypher, SWQM Project Quality Assurance Specialist, Surface Water Quality Monitoring Program (MC-234)
Daniel Burke, SWQM Program Quality Assurance Specialist, Quality Assurance Team (MC-165)

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Suite 1200
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Curry Jones, MPH, Chief, State and Tribal Programs Section (6WQ)
Teresita Mendiola, Project Officer, State and Tribal Programs Section (6WQ)

A4. Project/Task Organization

This seagrass monitoring study is funded by the Texas Commission on Environmental Quality (TCEQ) through a contract with Texas Parks and Wildlife Department (TPWD). The project will test a coastwide seagrass monitoring program design using monitoring of seagrass condition and water quality indicators. Field work will be conducted by TPWD Principal Project Staff and Other Project Staff that have been trained by or are under the direct supervision of Principal Project Staff. Water and sediment chemistry analyses will be conducted by the Lower Colorado River Authority (LCRA). Seagrass, epiphyte and macroalgae biomass laboratory work will be conducted by TPWD Principal Project Staff or under their direct supervision.

Key organizations and personnel are identified in Figure 1. Figure 2 depicts project organization and lines of communication. TPWD Water Quality Program staff (Radloff, Hobson, Whisenant, Bronson) will manage the contract and are primarily responsible for deliverables. TPWD Coastal Fisheries Division staff will assist with the project. TPWD may invite individuals from interested organizations to participate in field work under the direct supervision of TPWD staff. Note that the TPWD Quality Assurance Officer (QA Officer) is a position that rotates annually among participating TPWD Divisions (Coastal Fisheries, Inland Fisheries, Wildlife and State Parks). For fiscal year 2012, the TPWD QA Officer is a member of the Water Quality Program staff (Hobson) and a principal staff member for this project.

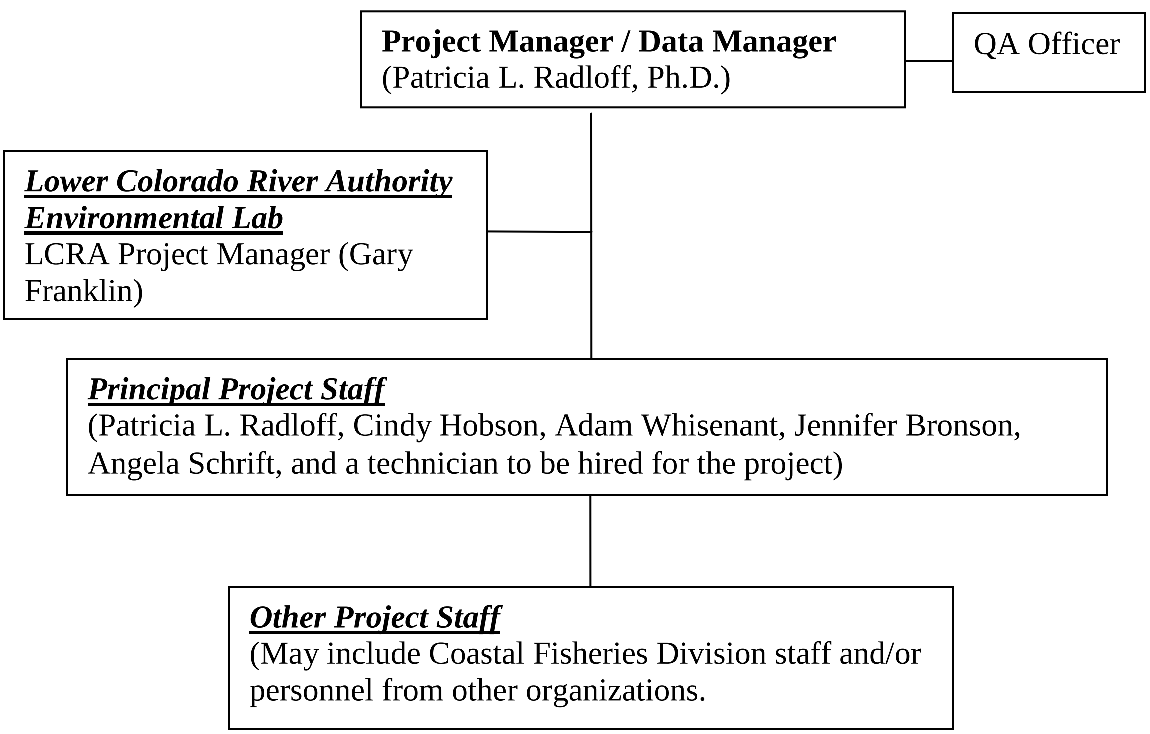


Figure 1. A4.1. Key organizations and personnel.

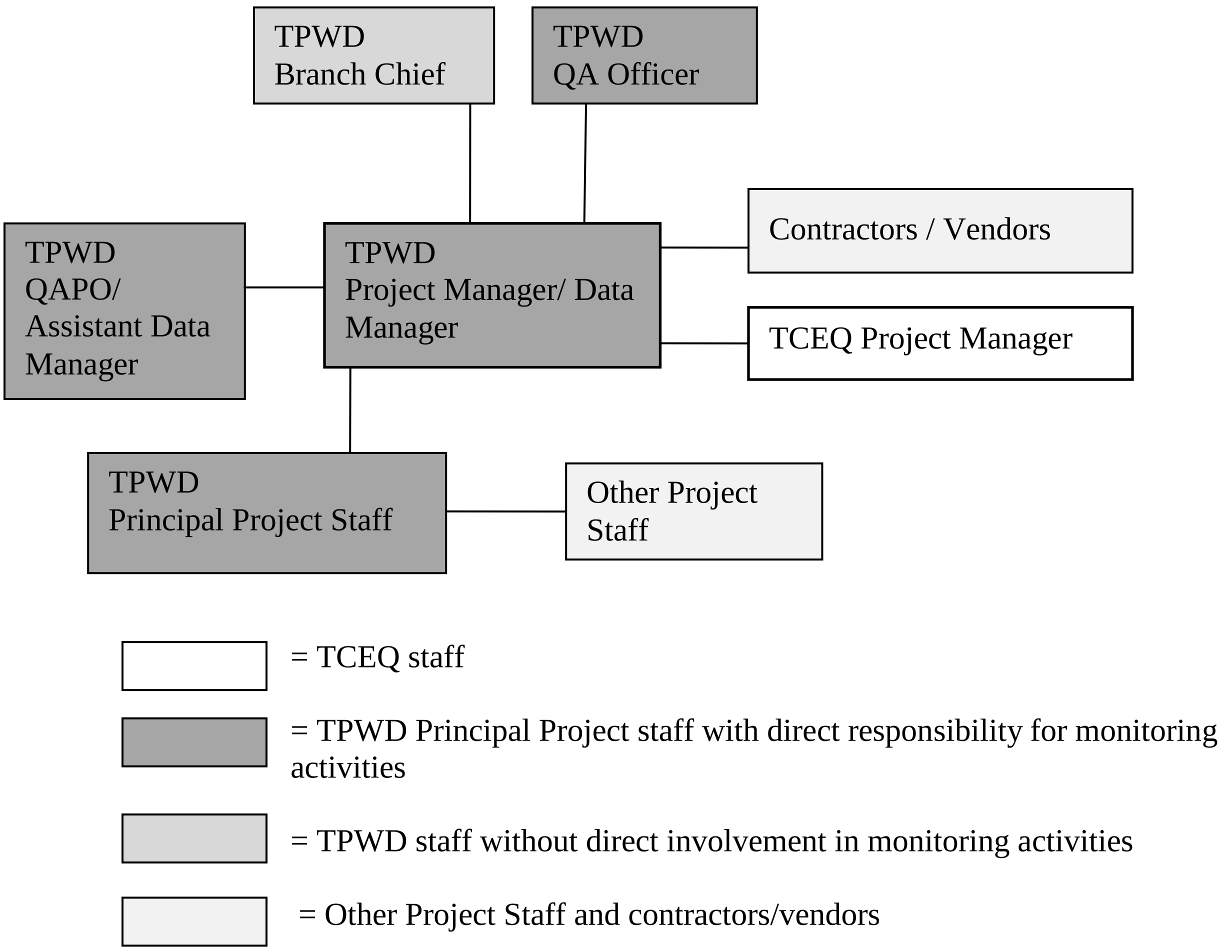


Figure 2. A4.2. Project organization chart.

Texas Parks and Wildlife Department

Patricia L. Radloff, Ph.D.
TPWD Water Quality Program Leader - Project Manager
Principal Project Staff
The Project Manager is responsible for ensuring that all project activities are performed, including planning, documenting project goals, preparation and approval of a Quality Assurance Project Plan (QAPP), and adherence to a QAPP, to ensure that data of known quality are collected. The project manager submits an annual project report to the TPWD QA Officer at an annual meeting of Project Managers, QAPOs, and relevant program managers and supervisory staff. The project manager coordinates assessments and confirms the implementation and effectiveness of corrective actions and documents such actions. The project manager and/or QAPO submit data to the Texas Commission on Environmental Quality in an approved format.

Angela Schrift
Quality Assurance Project Officer
Principal Project Staff
The primary duty of the Quality Assurance Project Officer (QAPO) is to assist the Project Manager in the development and implementation of the QAPP and in the performance and review of project quality assurance assessments. The QAPO is also responsible for recommending to the appropriate staff any modifications that may be needed to improve the effectiveness and efficiency of the TPWD quality system as a whole and for his or her assigned projects. The QAPO is required to attend the annual meeting of Project Managers and QAPOs. The QAPO also may conduct field monitoring and collect data for TPWD Water Quality Program activities, following procedures outlined in QAPP and any referenced Standard Operating Procedures (SOPs) and performing necessary field calibrations and other quality assurance measures as specified.

Adam Whisenant
TPWD Water Quality Program Regional Biologist
Principal Project Staff
Conducts field monitoring and collects data. Follows procedures outlined in QAPP and any referenced SOPs. Performs necessary field calibrations and other quality assurance measures as specified.

Jennifer Bronson
TPWD Water Quality Program Regional Biologist
Principal Project Staff
Conducts field monitoring and collects data. Follows procedures outlined in QAPP and any referenced SOPs. Performs necessary field calibrations and other quality assurance measures as specified.

Cindy Hobson
TPWD Quality Assurance Officer, FY 2012
TPWD Water Quality Program Coordinator

Principal Project Staff
The Quality Assurance Officer is responsible for review and approval of QAPPs. Relies on each Project Manager to be responsible for project quality assurance efforts. The QA Officer has authority to reject any environmental data that does not meet quality assurance standards, and reports directly to the Deputy Executive Director for Operations, or his or her designee, on quality assurance matters. Convenes an annual quality planning and assessment meeting involving project managers, QAPOs and other staff as appropriate. Conducts field monitoring and collects data. Follows procedures outlined in QAPP and any referenced SOPs. Performs necessary field calibrations and other quality assurance measures as specified.

Texas Commission on Environmental Quality

Daniel Burke
SWQM Program Quality Assurance Specialist
Assists the TCEQ SWQM QAS, Program Manager, and Project Manager on QA-related issues. Coordinates reviews and approves QAPPs and amendments or revisions. Prepares and distributes annual audit plans. Conveys QA problems to appropriate TCEQ management. Monitors implementation of corrective actions. Coordinates and conducts audits. Ensures maintenance of QAPPs and audit records for the SWQM program.

Robin Cypher
SWQM Project Quality Assurance Specialist
Serves as liaison between SWQM management and TCEQ QA management. Participates in the development, approval, implementation, and maintenance of written quality assurance standards (e.g., Program Guidance, SOPs, QAPPs, QMP). Serves on planning team for SWQM special projects and reviews QAPPs in coordination with other SWQM staff. Coordinates documentation and implementation of corrective action for SWQM.

Pat Bohannon
TCEQ Project Manager
The SWQM Project Manager is responsible for ensuring that the project delivers data of known quality, quantity, and type on schedule to achieve project objectives. Provides the primary point of contact between TPWD and the TCEQ; tracks and reviews deliverables to ensure that tasks in the work plan are completed as specified in the contract; reviews and approves the QAPP and any amendments or revisions and ensures distribution of approved/revised QAPPs to TCEQ participants; and responsible for verifying that the QAPP is followed by the TPWD.

Lower Colorado River Authority

Alicia Gill
LCRA Environmental Laboratory Services Manager
Responsible for overall performance, administration, and reporting of analyses performed by LCRA's Environmental Laboratory Services.

Hollis Pantalion
LCRA Environmental Laboratory Services QA Officer
Responsible for the overall quality control and quality assurance of analyses performed by LCRA's Environmental Laboratory Services. Monitors the implementation of the Quality Assurance Manual (QAM)/QAPP within the laboratory to ensure complete compliance with QA data quality objectives.

Gary Franklin
LCRA Environmental Laboratory Services Project Manager
Responsible for quality assurance of analyses performed by LCRA's Environmental Laboratory Services. Responsible for laboratory and field staff corrective action communication with the LCRA QAO. Oversees analysis of water and sediment samples. Reports results to TPWD on a regular basis.

A5. Problem Definition/Background

Seagrass beds serve as critical nursery habitat for estuarine fisheries and wildlife. Seagrasses provide food for fish, waterfowl and sea turtles. Seagrasses also contribute organic material to estuarine and marine food webs, cycle nutrients, and stabilize sediments. They are economically important based on their function in maintaining Gulf fisheries. Increasing coastal development threatens seagrasses.

Three state agencies signed the Seagrass Conservation Plan for Texas in 1999 (TPWD 1999), the Texas Commission on Environmental Quality (at that time the TNRCC), the Texas General Land Office, and the Texas Parks and Wildlife Department. The plan outlined needs in the area of seagrass research, management, and monitoring. In the 2000 Water Quality Standards revision, TCEQ adopted a seagrass propagation use, affording protection to seagrass statewide (30 TAC §307.5, TCEQ 2010). However, no monitoring protocol or procedure existed to determine whether the use was supported.

Shortly after publication of the Seagrass Conservation Plan, a Seagrass Monitoring Work Group began to meet regularly to develop a seagrass monitoring program for the state. The group continues to meet and is composed of academic, government and non-profit representatives. TPWD staff led development of a Strategic Plan for seagrass monitoring in Texas (TPWD 2003). An initial step toward developing a field protocol was an EPA-funded Regional Environmental Monitoring and Assessment Program (REMAP) study conducted by Dunton, Kopecky and Maidment (Dunton et al 2005). As follow-up to that work, the Coastal Bend Bays and Estuaries Program funded a project that led to a recommended framework for seagrass monitoring in Texas (Dunton and Pulich 2007; Dunton, Pulich et al. 2011). The recommended protocols were implemented in East Flats and Port Bay in a study a conducted by TPWD in collaboration with Dunton, Pulich and others (TPWD 2010).

This project is a sequel to the Phase 1 Seagrass Monitoring Protocol Development project led by TCEQ in 2010-2011 (TCEQ 2011). In Phase 1, several sites up and down the coast were monitored for a variety of environmental and biological parameters. For Phase 2, it is proposed that sampling be expanded to include many more sites under a tiered approach as used in other parts of the United States (Fourqurean, Durako et al. 2002; Neckles, Kopp et al. 2011) and as recommended by Dunton and Pulich (2007) and Dunton, Pulich et al. (2011).

A6. Project/Task Description

This project will incorporate a tiered sampling approach and probabilistic selection of permanent sampling stations. Tiered sampling allows resource managers to detect change in seagrass over a large area of interest, and collect sufficient information to infer cause-effect relationships for seagrass change (Neckles, Kopp et al. 2011). Tier 2 sampling represents the collection of a short list of basic seagrass condition parameters over a large area (bay scale, coastwide; Table 1). Probabilistic design allows the results to be extrapolated to the entire area of interest. Establishing permanent sampling stations that are returned to in subsequent years allows the use of powerful repeated-measures statistics, which in turn allows the detection of change in the area of interest with a limited number of samples. More intensive Tier 3 sampling measures environmental parameters and seagrass condition indicators in a much smaller area to identify causes for changes observed in Tier 2 in seagrass sampling (Table 2). Tier 1, coastwide seagrass mapping every 5-10 years, is a recommended component of seagrass monitoring in most programs, but is not a component of this project.

Table 1. A6.1. Definition of a Tier 2 station.

Description	Parameters – replicates	Info Derived
Rapid assessment One-time survey occurring in late summer/ early fall 2012	Seagrass percent coverage by species – 4 Seagrass canopy height – 4	Seagrass coverage over area of interest (coastwide, bay scale, other)

Table 2. A6.2. Definition of a Tier 3 station.

Description	Parameters – replicates	Info Derived
Intensive monitoring at an "index site" to evaluate factors affecting seagrass conditions A single Tier 3 station consists of three transects. Some measurements are made off-transect and others are made at 10 randomly selected quadrats along each transect. One-time survey occurring in late summer/early fall 2012	Datasonde (temperature, specific conductance, salinity, pH and dissolved oxygen (DO)) – 3 Secchi depth – 3 Photosynthetically-active radiation – 3 Water chemistry (ammonia-nitrogen, chloride, chlorophyll-*a*, total Kjeldahl nitrogen, nitrate-nitrogen, nitrite-nitrogen, sulfate, total phosphorus, total suspended solids, volatile suspended solids, ortho-phosphate-phosphorus, and pheophytin-*a*) – 3 Sediment (TOC, grain size) – 3 Sediment pore water ammonia-nitrogen – 30 Seagrass percent coverage by species – 30 Macroalgae biomass – 30 Seagrass biomass (above- and below-ground) – 9 Seagrass average number of leaves per shoot – 9 Seagrass shoot density – 9 Seagrass average leaf length and width – 9 Epiphyte load – 9	Seagrass condition and response to environmental factors Nutrient response indicators (macroalgae and epiphyte growth)

TPWD conducted a power analysis using seagrass data available from Phase 1 and other seagrass projects (Appendix A). Variance of the data for longest leaf length (as a surrogate for canopy height) and percent coverage by species suggests that 50 stations within an area of interest would suffice to detect 15% change.

TPWD will conduct Tier 2 monitoring, sampling seagrass coverage by species and canopy height at two scales: coastwide and bay scale. Coastwide Tier 2 monitoring at 50 randomly selected stations, if conducted annually or at regular intervals, would answer the question, "Is seagrass coverage increasing or decreasing over the entire Texas coast?" with ability to detect 15% or greater changes. For this project, the entire portion of the Texas coast which supports seagrass growth will be sampled using Tier 2 methodology. In addition to the 50 probabilistically-selected stations, staff will also sample the 14 fixed sites that were monitored as part of the Phase 1 Seagrass Monitoring project (Figure 3).

Tier 2 sampling in the bays, if conducted annually or at regular intervals, would answer the question, "Is seagrass coverage increasing or decreasing in this bay?" with ability to detect 15% or greater changes. Tier 2 monitoring at 50 stations will be conducted in one Texas bay. If TPWD resources permit, a second bay will also be sampled. This QAPP is written to include both bays, with the understanding that TPWD has a contractual obligation to sample only one bay.

Tier 3 sampling will be conducted at a representative site within one bay. If TPWD resources permit, a second bay will also be sampled. This QAPP is written to include both bays, with the understanding that TPWD has a contractual obligation to sample only one bay. If TPWD conducts Tier 3 sampling in a second bay, it is possible that not all Tier 3 parameters will be sampled, due to resource constraints.

Tier 3 sampling design is based on three transects which encompass the deep edge of the seagrass bed. Transects extend along the depth gradient to integrate differences in parameters that may be influenced by water depth. Water quality data that will be collected include ammonia-nitrogen, chloride, chlorophyll-*a*, total Kjeldahl nitrogen, nitrate-nitrogen, nitrite-nitrogen, sulfate, total phosphorus, total suspended solids, volatile suspended solids, ortho-phosphate-phosphorus, and pheophytin-*a*. Physicochemical measurements that will be collected include Secchi depth, photosynthetically-active radiation, specific conductance, salinity, dissolved oxygen, pH, and temperature. Sediment samples will be analyzed for total organic carbon, grain size, and sediment pore water ammonia-nitrogen. Seagrass condition indicators that will be studied include shoot density, above- and below-ground biomass, root-to-shoot ratio (ratio of below-ground biomass to above-ground biomass), number of leaves per shoot, leaf width, leaf length and leaf area index (product of shoot density, average leaf length, and average leaf width). Seagrass stressor indicators including macroalgal biomass and epiphyte biomass will also be measured.

All sampling will be conducted during the period August 1 – October 31, 2012, with most of the sampling occurring between August 1 and September 15.

Figure 3. A6.3. Phase 1 Seagrass Monitoring project sample sites.

Seagrass area (from Dunton and Pulich 2007)	Site ID	Site
1 – Galveston Bay	SM1.1	Christmas Bay
	SM1.2	West Bay at Galveston Island State Park
	SM1.3	West end of Galveston Island
2 – Matagorda Bay	SM2.1	Matagorda Peninsula
3 – San Antonio Bay	SM3.1	San Antonio Bay near Welder WMA
	SM3.2	Matagorda Island bay shore
4 – Mission Aransas	SM4.1	St. Charles Bay
	SM4.3	Mud Island
	SM4.4	Port Bay
5 – Corpus Christi Bay		
6 – Upper Laguna Madre	SM6.1	ULM north of JFK Causeway
	SM6.2	Nighthawk Bay
7 – Lower Laguna Madre	SM7.1	LLM near mouth of Arroyo Colorado
	SM7.2	Bay shore of South Padre Island
	SM7.3	South Bay

Amendments to the QAPP

Revisions to the QAPP may be necessary to reflect changes in project organization, tasks, schedules, objectives, and methods; to improve operational efficiency; and to accommodate unique or unanticipated circumstances. The TPWD Project Manager will prepare amendments to the QAPP as needed. Amendments are effective upon approval by both the TPWD and the TCEQ Project Managers, the LCRA Lab, and EPA. Amendments will be incorporated into the QAPP as attachments and distributed to personnel on the QAPP Distribution List.

Revisions to the Tier 2 SOP may be necessary to to improve operational efficiency or to accommodate unique or unanticipated circumstances. Changes to the Tier 2 SOP will take effect when the document is revised.

A7. Quality Objectives and Criteria

Performance specifications for field measurements, water and sediment quality parameters are outlined in Table 3.

Table 3. A7.1. Field, water and sediment quality parameter measurement performance specifications.

Parameter	Matrix	Units	Parameter code	Analytical method	Precision of LCS/LCSD (%RPD)	Bias of LCS (% Rec)	AWRL	Limit of Quantitation (LOQ)[1]	LOQ Check Sample % Rec.[2]	LCRA Lab MDL[3]
Field Parameters										
pH	water	standard units	00400	EPA 150.1 and TCEQ SWQM Manual, vol. 1	NA	NA	NA	NA	NA	NA
DO	water	mg L^{-1}	00300	EPA 360.1 and TCEQ SWQM Manual, vol. 1	NA	NA	NA	NA	NA	NA
Specific conductance	water	µS cm^{-1}	00094	EPA 120.1 and TCEQ SWQM Manual, vol. 1	NA	NA	NA	NA	NA	NA
Salinity	water	ppt	00480	SM 2520 and TCEQ SWQM Manual, vol. 1	NA	NA	NA	NA	NA	NA
Water temperature	water	ºC	00010	EPA 170.1 and TCEQ SWQM Manual, vol. 1	NA	NA	NA	NA	NA	NA
Secchi depth	water	meters	00078	TCEQ SWQM Manual, vol. 1	NA	NA	NA	NA	NA	NA
Surface irradiance	water	%	NA	Calculation	NA	NA	NA	NA	NA	NA
Light attenuation coefficient (*k*)	water	$meters^{-1}$	NA	Calculation	NA	NA	NA	NA	NA	NA
Photosynthetically-active radiation (PAR)	water	µmol photons sec^{-1} $meter^{-2}$	NA	QAPP	5%	NA	NA	NA	NA	NA
Days since last significant rainfall	NA	days	72053	TCEQ SWQM Manual, vol. 1	NA	NA	NA	NA	NA	NA

[1] Limit of Quantitation (LOQ), formerly known by the term "Reporting Level (RL)"
[2] Limit of Quantitation Check Sample Percent Recovery, formerly known by the term "Accuracy of RL (% Rec)"
[3] The MDL is a measure of method sensitivity and it is defined at 40 CFR Part 136 Appendix B as "the minimum concentration of a substance that can be reported with 99% confidence that the analyte concentration is greater than zero." MDLs can be operator, method, laboratory, and matrix specific. Due to normal day-to-day and run-to-run analytical variability, MDLs may not be reproducible within a laboratory or between laboratories. The regulatory significance of the MDL is that EPA uses the MDL to determine when a contaminant is deemed to be detected and it can be used to calculate a PQL for that contaminant. Where an MDL is specified, LCRA will report values observed at or above the MDL and accompanying quality assurance information.

Parameter	Matrix	Units	Parameter code	Analytical method	Precision of LCS/LCSD (%RPD)	Bias of LCS (% Rec)	AWRL	Limit of Quantitation (LOQ)[1]	LOQ Check Sample % Rec.[2]	LCRA Lab MDL[3]
Depth of measurement	water	meters	13850	TCEQ SWQM Manual, vol. 1	NA	NA	NA	NA	NA	NA
Total water depth	water	meters	82903	TCEQ SWQM Manual, vol. 1	NA	NA	NA	NA	NA	NA
Tide stage	water	1=Low 2= Falling 3=Slack 4=Rising 5=High	89972	TCEQ SWQM Manual, vol. 1	NA	NA	NA	NA	NA	NA
Conventional Parameters										
Ammonia-nitrogen	water	mg L^{-1}	00610	EPA 350.1	20	80-120	0.1	0.02[4]	70-130	0.0048
Chloride	water	mg L^{-1}	00940	EPA 300.0	20	80-120	5	5[4]	70-130	NA
Chlorophyll-*a*	water	µg L^{-1}	70953 - fluor	EPA 445.0	20	80-120	3	2[4]	NA	0.04
Total Kjeldahl nitrogen	water	mg L^{-1}	00625	EPA 351.2	20	80-120	0.2	0.2[4]	70-130	NA
Nitrate-nitrogen	water	mg L^{-1}	00620	EPA 300.0 Rev. 2.1 (1993)	20	80-120	0.05	0.02[4]	70-130	0.003
Nitrite-nitrogen	water	mg L^{-1}	00615	EPA 300.0 Rev. 2.1 (1993)	20	80-120	0.05	0.02[4]	70-130	0.003
Nitrate/nitrite-nitrogen	water	mg L^{-1}	00630	SM 4500-NO3-H	20	80-120	0.05	0.02[4]	70-130	NA
Sulfate	water	mg L^{-1}	00945	EPA 300.0	20	80-120	5	5[4]	70-130	NA
Total phosphorus	water	mg L^{-1}	00665	EPA 365.4	20	80-120	0.06	0.02	70-130	0.00249

[4] Limit of Quantitation is based upon an aqueous sample where no dilution is required due to matrix or sample quantity.

Parameter	Matrix	Units	Parameter code	Analytical method	Precision of LCS/LCSD (%RPD)	Bias of LCS (% Rec)	AWRL	Limit of Quantitation (LOQ)[1]	LOQ Check Sample % Rec.[2]	LCRA Lab MDL[3]
Total suspended solids	water	mg L^{-1}	00530	SM 2540 D	20	NA	4[3]	1	NA	0.5
Volatile suspended solids	water	mg L^{-1}	00535	EPA 160.4	20	NA	4[3]	1	NA	0.5
ortho-Phosphate-phosphorus	water	mg L^{-1}	00671 (fld filt <15 min)	EPA 365.1 EPA 300.0	20	80-120	0.04	0.04[4]	70-130	0.00249
	water	mg L^{-1}	70507 (lab filt >15 min)	EPA 365.1 EPA 300.0	20	80-120	0.04	0.04[4]	70-130	0.00249
Pheophytin-*a*	water	µg L^{-1}	32213 - fluor	EPA 445.0	NA	NA	3	2[4]	NA	0.04
Sediment Parameters										
Pore water ammonia-nitrogen	sediment pore water	mg L^{-1}	P1004	EPA 350.1	20	80-120	0.1	0.02[4]	70-130	0.0048
Grain size (clay, <0.002 mm)	sediment	% dry wt	49900	EPA 600/2-78-054	20	NA	NA	0	NA	NA
Grain size (silt, 0.002 to 0.05 mm)	sediment	% dry wt	49906	EPA 600/2-78-054	20	NA	NA	0	NA	NA
Grain size (sand, 0.05 to 2.0 mm)	sediment	% dry wt	49925	EPA 600/2-78-054	20	NA	NA	0	NA	NA
Grain size (gravel, > 2.0 mm)	sediment	% dry wt	80256	EPA 600/2-78-054	20	NA	NA	0	NA	NA
Total organic carbon	sediment	mg kg^{-1}	81951	EPA 9060	30	65-135	1500	1500	65-135	NA

REFERENCES AND NOTES:
EPA = U.S. EPA. Methods for Chemical Analysis of Water and Waste, revised March 1983, Manual #EPA-600/4-79-020. Washington, DC.; U.S. EPA.
TCEQ SWQM Manual, vol. 1 – Surface Water Quality Monitoring Procedures, Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment, and Tissue, 2008.
TCEQ SWQM Manual, vol. 2 – Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological Assemblage and Habitat Data, 2007
SM = American Public Health Association, *et al.* 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition. Washington, DC (*Note: The 21st edition may be cited if it becomes available*).

Methods listed are the preferred method of analysis. Other methods may be employed and the data will be accepted as long as the methods used: (1) meet the sensitivity requirements of the AWRLs, and (2) are contained in 40 CFR 136, the most current version of Standard Methods, or are another reliable procedure as described in this QAPP.

Field Measurements

Field measurements will be conducted as described in the TCEQ Surface Water Quality Monitoring Procedures Manual, Volume 1 (TCEQ 2008), with the exception of the measurement of photosynthetically-active radiation (PAR) which is described in Section B2.

Water and Sediment Quality Indicators

Water sample collection will be conducted as described in the TCEQ Surface Water Quality Monitoring Procedures Manual, Volume 1 (TCEQ 2008). Sediment sample collection will be conducted as described in Section B2.

Water and sediment quality samples will be analyzed by LCRA. The measurement performance specifications in Table 3 will be met for parameters analyzed by LCRA.

<u>Sensitivity</u>

Sensitivity is defined as “the capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest” and is presented for each measurement in Table 3.

<u>Reporting Limits</u>

Ongoing ability to recover an analyte at the laboratory Limit of Quantitation (LOQ) is demonstrated through analysis of a calibration or check standard at the LOQ. The LOQs for target analytes and performance limits at LOQs for this project are set forth in Table 3. However, the LOQ may be elevated due to dilution of sample to reduce sample matrix interferences, or if a reduced quantity of sample is received requiring a dilution to meet method quantity requirements. For this project, low levels of certain parameters may reasonably be anticipated. For these parameters, Table 3 lists laboratory Method Detection Limits (MDLs). As per definition, the MDL is a measure of method sensitivity and it is defined at 40 CFR Part 136 Appendix B as "the minimum concentration of a substance that can be reported with 99% confidence that the analyte concentration is greater than zero." MDLs can be operator, method, laboratory, and matrix specific. Due to normal day-to-day and run-to-run analytical variability, MDLs may not be reproducible within a laboratory or between laboratories. Where an MDL is specified, the laboratory will report values observed at or above the MDL and accompanying quality assurance information. TPWD will use best professional judgment in qualifying values below the LOQ for use in data analysis and reporting and will note where averaged or reported values include data below the LOQ. Measurements made below the LOQ but above the MDL will be flagged as such when reported to TCEQ and when published in the final report.

<u>Precision</u>

The precision of data is a measure of the reproducibility of a measurement when a collection or an analysis is repeated. It is strictly defined as the degree of mutual agreement among independent measurements as the result of repeated application of the same process under similar conditions. Performance limits for laboratory duplicates are defined in Table 3. Performance limits for field splits are defined in Section B5.

Bias

Bias is a statistical measurement of correctness and includes multiple components of systematic error. A measurement is considered unbiased when the value reported does not differ from the true value. Bias is verified through the analysis of laboratory control standards (LCS) prepared with certified reference materials and by calculating percent recovery. Results are plotted on quality control charts, which are calculated based on historical data and used during evaluation of analytical performance. Program-defined measurement performance specifications for LCS are specified in Table 3.

Accuracy

Accuracy is a measure of the overall agreement of a measurement to a known value; accuracy includes a combination of random error (precision error) and systematic error (bias). A measurement is considered accurate when the value reported does not differ from the true value. Accuracy is verified through the analysis of laboratory spikes and calibration control standards. Performance limits for laboratory spikes and calibration control standards for RLs are specified in Table 3. Field parameters measured under this QAPP are collected utilizing multiparameter probe instruments, following TCEQ Surface Water Quality Monitoring Procedures Manual, Volume 1 (TCEQ 2008). These instruments are calibrated prior to sampling utilizing standards of known values for pH, conductivity, and dissolved oxygen. The instruments are also checked against these standards following sampling, allowing for an assessment of accuracy. Accuracy of the temperature probe component of the instruments is checked periodically against a NIST traceable thermometer.

Representativeness

Site selection, the appropriate sampling regime, the sampling of all pertinent media according to TCEQ Surface Water Quality Monitoring Procedures Manual, Volume 1 (TCEQ 2008), and use of only approved analytical methods will assure that the measurement data represents the conditions at the site. See section B1 for a discussion of site selection criteria. TPWD understands that it may contribute data to TCEQ for use in the assessment process, without providing all the samples required for assessment.

Comparability

Confidence in the comparability of data sets for this project is based on the commitment of project staff to use only approved sampling and analysis methods and QA/QC protocols in accordance with quality system requirements and as described in this QAPP and in TCEQ Surface Water Quality Monitoring Procedures Manual, Volume 1 (TCEQ 2008). Comparability is also guaranteed by reporting data in standard units, by using accepted rules for rounding figures, and by reporting data in a standard format.

Completeness

The completeness of the data is basically a relationship of how much of the data is available for use compared to the total potential data. Ideally, 100% of the data should be available. However, the possibility of unavailable data due to accidents, insufficient sample volume, broken or lost samples, etc. is to be expected. Therefore, it will be a general goal of the project that 90% data completion is achieved.

Seagrass Condition and Stressor Indicators

Seagrass samples will be collected as described in Sections B1 and B2. Samples will be analyzed according to the specifications given in Table 4.

Sensitivity and expected ranges for biological parameters were developed based on data from previous seagrass studies (Table 4; TCEQ 2011; TPWD 2010). Reliable estimates of precision have not been developed for most of these biological parameters. For purposes of this study, precision for each biological parameter was estimated by first identifying potential sources of measurement error. Percentage error was identified for equipment and instruments used in processing samples, for example, the uncertainty associated with weighing samples was estimated using the limit of quantitation of the analytical balance. Percentage error for other potential sources was estimated based on best professional judgment. Precision was estimated by propagating all component sources of error that were identified for each biological parameter:

$$RMS = \sqrt{(error1)^2 + (error2)^2 + (error3)^2 \ldots}$$

Potential sources of error for the precision estimates (Table 4) are described below.

Percent coverage by species is defined as the percent of the total quadrat area that is obscured by a particular seagrass species when viewed from directly above. The sum of percent coverage for each species plus the percent of the total quadrat area that is bare is 100%. Two potential sources of error are difference in estimating percent coverage between observers, and difference in how well the quadrat area is cleared of macroalgae and debris before making the observation.

Shoot density is calculated by counting the number of shoots within a seagrass core, then dividing that number by the cross-sectional area of the corer to express density in number of shoots per square meter. Potential sources of error include differences in handling, cleaning and counting the sample between analysts, and uncertainty in exact corer dimensions.

Seagrass biomass is measured from analysis of seagrass cores collected in the field. Above-ground and below-ground material are separated in the lab and dried. Epiphyte growth (filamentous algae, diatoms, and other living organisms that attach to seagrass leaves) is removed from above-ground samples before drying. Weights are divided by the cross-sectional area of the corer to obtain biomass in grams per square meter. Potential sources of error include differences between analysts in cleaning samples, removing epiphyte growth and separating above-ground from below-ground material, not allowing sufficient drying time, uncertainty in weight measurements, and uncertainty in exact corer dimensions.

Leaf length, or canopy height, and leaf width are measured from shoots obtained in the same core samples used for biomass estimation. The longest leaf in each of five shoots is measured using a metric ruler with millimeter divisions. Along with shoot density, the leaf length and width are used to calculate a leaf area index. Potential sources of error include measurement differences between analysts, epiphyte growth on leaves, leaf tips broken off during handling, and uncertainty in length measurements. Another biological parameter derived from these five shoots in each core sample is the number of leaves per shoot. Potential sources of error include differences between analysts in counting leaves, leaves broken off during handling, and leaves pressed against and hidden by larger leaves.

Epiphyte biomass is measured by scraping material from seagrass shoots collected in the field. Epiphytes are scraped from both sides of seagrass leaves, and the area scraped is measured to allow epiphyte biomass to be expressed in milligrams per square centimeters. Epiphytes are scraped onto a pre-weighed glass fiber filter, on which they are dried and weighed to obtain epiphyte biomass. The scraped seagrass leaves are also dried and weighed to allow epiphyte biomass to be expressed in milligrams per gram of seagrass leaf. Potential sources of error include differences between analysts in efficiency of scraping epiphytes from the leaves, not letting material dry thoroughly in the oven, small pieces of the filter flaking off, and uncertainty in weight measurements. For expressing epiphyte biomass per unit leaf area, additional sources of error are those associated with measuring leaf length and width as described above. For expressing epiphyte biomass per unit leaf weight, for species other than *Thalassia*, there is an error associated with losing small pieces of thin seagrass leaves during weighing.

Macroalgal biomass is measured from algae samples collected from a square quadrat (0.25m on a side). Macroalgae is cleaned of epiphytes in the lab, dried and weighed, and the dry weight expressed in grams per square meter. Potential sources of error include not letting the macroalgae dry thoroughly, differences between staff in cleaning epiphytes from the macroalgae, uncertainty in exact quadrat dimensions, and uncertainty in weight measurements.

Table 4. A7.2. Seagrass condition and stressor indicator measurement performance specifications.

Analysis	Units	Parameter Code	Analytical method	Sensitivity	Precision	Expected range
Percent coverage by species	%	N/A	QAPP	1%[5]	10%	0-100%
Shoot density - 9 cm corer	shoots/m^2	N/A	QAPP	150	5%	150 - 22,000
Shoot density - 15 cm corer	shoots/m^2	N/A	QAPP	50	5%	50 - 6,000
Biomass (above-ground or below-ground) - 9 cm corer	g/m^2	N/A	QAPP	0.15	10%	0.5 - 400
Biomass (above-ground or below-ground) - 15 cm corer	g/m^2	N/A	QAPP	0.05	10%	0.5 - 400
Biomass - total - 9 cm corer	g/m^2	N/A	QAPP	0.3	10%	1 - 2,000
Biomass - total - 15 cm corer	g/m^2	N/A	QAPP	0.1	10%	1 - 2,000
RSR	N/A	N/A	QAPP	N/A	10%	0.5 - 25.0
Canopy height - *Thalassia*	cm	N/A	QAPP	0.1	5%	2 - 90
Canopy height - other than *Thalassia*	cm	N/A	QAPP	0.1	5%	2 - 60
Leaf length - *Thalassia*	cm	N/A	QAPP	0.1	5%	2 - 90
Leaf length - other than *Thalassia*	cm	N/A	QAPP	0.1	5%	2 - 60
Leaf width - *Thalassia*	mm	N/A	QAPP	0.5	25%	2 - 15
Leaf width - other than *Thalassia*	mm	N/A	QAPP	0.5	30%	1 - 3
LAI - *Thalassia*	m^2/m^2	N/A	QAPP	0.001	25%	0.02 - 5

[5] One shoot is the smallest quantity that can be detected by an observer, and will be assigned a percent coverage of 1%

Analysis	Units	Parameter Code	Analytical method	Sensitivity	Precision	Expected range
LAI - other than *Thalassia*	m^2/m^2	N/A	QAPP	0.001	35%	0.02 - 5
Number of leaves per shoot	integer	N/A	QAPP	1	5%	1 - 4
Epiphyte load - other than *Thalassia*	mg/cm^2	N/A	QAPP	0.01	50%	0 - 5
Epiphyte load - *Thalassia*	mg/cm^2	N/A	QAPP	0.01	30%	0 - 7
Epiphyte load - other than *Thalassia*	mg/g	N/A	QAPP	3	30%	0 - 300
Epiphyte load - *Thalassia*	mg/g	N/A	QAPP	3	10%	N/A
Macroalgal biomass	g/m^2	N/A	QAPP	0.002	10%	0 - 225

A8. Special Training/Certification

Personnel unfamiliar with sampling, field analysis, and/or laboratory methods will receive training. New field personnel will receive field training, which requires them to thoroughly review all sampling and field analysis procedures. During the training, experienced personnel will demonstrate procedures. Before actual sampling or field analysis occurs, new field personnel will demonstrate to the Project Manager (or designee) their ability to properly calibrate field equipment and perform field sampling and analysis procedures.

New TPWD laboratory personnel will undergo on-the-job training, which requires them to thoroughly review all methodologies and safety procedures prior to performing any lab work. During the training, personnel will be shown each laboratory procedure by an experienced staff member. New personnel will practice laboratory procedures under supervision of experienced staff prior to independent analysis of project samples.

A9. Documents and Records

In the field, data collected on site will be entered onto preprinted waterproof forms. Notes will be taken regarding date, time, personnel involved, weather conditions, samples collected and unique sample identification numbers. Deviations from standard sampling procedures or unusual occurrences will be noted.

Pertinent project documents and records will be retained as described in Table 5.

Table 5. A9.1. Project documents and records.

Document/Record	**Location**	**Retention (yrs)**	**Format**
QAPPs, amendments and appendices	TPWD Project Manager office/ Austin	5 years	Paper, electronic
QAPP distribution documentation	TPWD Project Manager office/ Austin	5 years	Paper, electronic
Field SOPs	TPWD Project Manager office/ Austin	5 years	Paper, electronic if available
Field equipment calibration/maintenance logs	TPWD Project Manager office/ Austin	5 years	Paper
Field instrument printouts	TPWD Project Manager office/ Austin	5 years	Paper, electronic
Field data sheets	TPWD Project Manager office/ Austin	5 years	Paper
Bench data sheets	TPWD Project Manager office/ Austin	5 years	Paper
Annual Project Report	TPWD Project Manager office/ Austin	5 years	Paper, electronic
Laboratory QA Manuals	Laboratory	5 years	Paper, electronic
Laboratory SOPs	Laboratory	5 years	Paper, electronic
Laboratory calibration records	Laboratory	5 years	Paper, electronic

Document/Record	Location	Retention (yrs)	Format
Laboratory instrument printouts	Laboratory	5 years	Paper, electronic
Laboratory data reports/results	Laboratory	5 years	Paper, electronic
Laboratory equipment maintenance logs	Laboratory	5 years	Paper, electronic
Corrective action documentation for laboratory	Laboratory	5 years	Paper, electronic

Laboratory Data Reports
Data reports from laboratories will report the test results clearly and accurately. The test report will include the information necessary for the interpretation and validation of data and will include the following:

- name and address of the laboratory
- name and address of the client
- a clear identification of the sample(s) analyzed
- identification of samples that did not meet QA requirements and why (e.g., holding times exceeded)
- date of sample receipt
- sample results
- field split results (as applicable)
- clearly identified subcontract laboratory results (as applicable)
- a name and title of person accepting responsibility for the report
- project-specific quality control results to include LCS sample results (% recovery), LCS duplicate results (%RPD), equipment, trip, and field blank results (as applicable), and RL confirmation (% recovery)
- narrative information on QC failures or deviations from requirements that may affect the quality of results

Laboratory Electronic Data
Data will be submitted electronically to TPWD as Microsoft Excel files in the format required by TPWD for acceptance into the project database.

B1. Sampling Process Design

Site Selection

Primary consideration is given to accessibility and safety for all project sampling sites.

Tier 2 Coastwide Sampling

Sets of coordinates have been generated probabilistically in order to obtain 50 suitable monitoring sites, along with extra sets of coordinates to take into account that some locations may not be suitable for Tier 2 monitoring. This is mostly due to the limitations of the seagrass coverage maps that are currently available, and that were used to generate the sampling coordinates. A decision point was whether to select coordinates based solely on the known seagrass abundance along the Texas coast (Figure 4) or to distribute coordinates more evenly along the coast (Figure 5). The former approach would result in almost all of the sampling points being located in the Laguna Madre and no sites north of San Antonio Bay. The latter approach distributes sampling sites throughout the seven major bay systems that support seagrass growth and would allow some points to be located as far north as the Galveston Bay system, which contains small but significant stands of seagrasses in West Bay and Christmas Bay. TPWD chose to use the latter approach so that the coastwide Tier 2 monitoring would not ignore upper coast areas like the Galveston Bay system, which historically sustained a higher acreage of seagrasses than is currently present. For the probabilistic draw, the seven major bay systems that sustain seagrass were divided into eight sections and 20 sets of coordinates were generated for each of the eight sections (Table 6). In addition to the 50 probabilistically-selected stations, staff will also sample the 14 fixed sites that were monitored as part of the Phase 1 Seagrass Monitoring project (Figure 3).

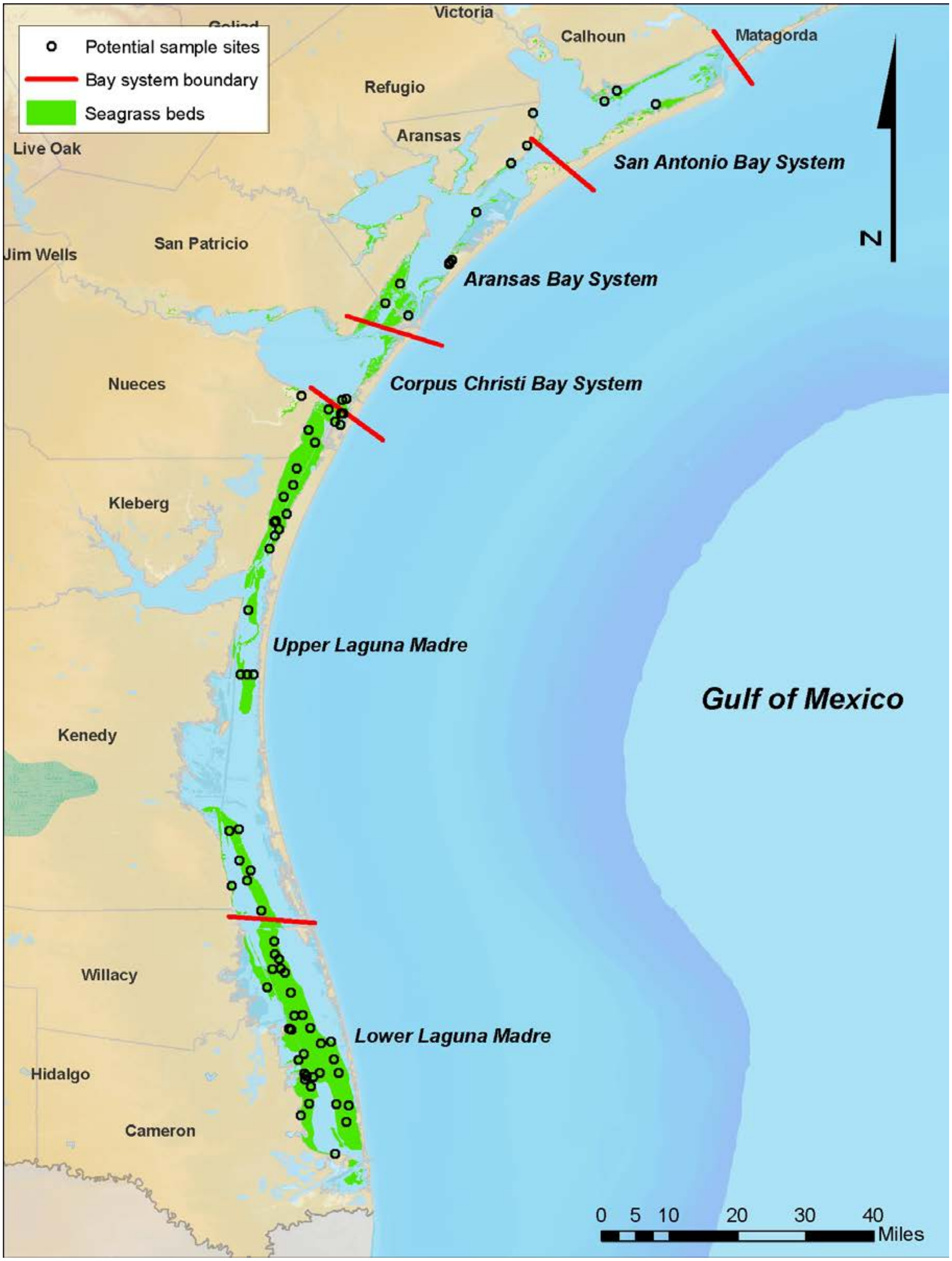


Figure 4. B1.1. Tier 2 coastwide sample locations based on seagrass abundance.
This sample reflects the total seagrass acreage, is heavily represented by the upper and lower Laguna Madre, and has no sites north of San Antonio Bay. 75 locations are provided (target of 50 samples with 25 extra to account for unsuitable sample sites).

Figure 5. B1.2. Tier 2 coastwide sample locations evenly distributed among the major bays.
Note that Matagorda Bay is divided into East and West Matagorda Bay, for a total of eight systems. 160 locations are provided with 20 samples per system (target of 50 samples with 110 extra to account for unsuitable sample sites).

Table 6. B1.3. Tier 2 coastwide sample locations evenly distributed among the major bays. Note that Matagorda Bay is divided into East and West Matagorda Bay, for a total of eight systems. 160 locations are provided with 10 samples per system (target of 50 samples with 110 extra to account for unsuitable sample sites). TPWD grids are one minute latitude by one minute longitude in size. They are sequentially numbered from west to east and north to south in each bay system and the Texas Territorial Sea. Each grid is identified by the latitude –longitude coordinates at the center. Each sample grid is divided into 144 sample gridlets that are five seconds latitude by five seconds longitude in size. Gridlets are sequentially numbered from west to east and north to south such that gridlet 1 is located in the upper left corner of the grid; gridlet 12 is located in the upper right corner of the grid, and gridlet 144 is located in the lower right corner of the grid.

Bay	TPWD grid	TPWD gridlet	Longitude	Latitude	Selection probability	Sampling weight
Galveston Bay	715	56	-95.2229	29.0438	0.03401	29.4
Galveston Bay	718	44	-95.1729	29.0451	0.03401	29.4
Galveston Bay	717	93	-95.1882	29.0396	0.03401	29.4
Galveston Bay	723	138	-95.2090	29.0174	0.03401	29.4
Galveston Bay	602	126	-94.9590	29.2188	0.03401	29.4
Galveston Bay	619	34	-94.9701	29.2132	0.03401	29.4
Galveston Bay	620	17	-94.9604	29.2146	0.03401	29.4
Galveston Bay	602	127	-94.9576	29.2188	0.03401	29.4
Galveston Bay	602	136	-94.9618	29.2174	0.03401	29.4
Galveston Bay	620	40	-94.9618	29.2118	0.03401	29.4
Galveston Bay	602	140	-94.9563	29.2174	0.03741	26.7
Galveston Bay	619	44	-94.9729	29.2118	0.03741	26.7
Galveston Bay	619	55	-94.9743	29.2104	0.03741	26.7
Galveston Bay	620	18	-94.9590	29.2146	0.03741	26.7
Galveston Bay	620	29	-94.9604	29.2132	0.03741	26.7
Galveston Bay	620	55	-94.9576	29.2104	0.03741	26.7
Galveston Bay	704	121	-95.1660	29.0688	0.03741	26.7
Galveston Bay	711	86	-95.1646	29.0563	0.03741	26.7
Galveston Bay	718	23	-95.1688	29.0479	0.03741	26.7
Galveston Bay	718	43	-95.1743	29.0451	0.03741	26.7
East Matagorda Bay	13	27	-95.6632	28.7799	0.03861	25.9
East Matagorda Bay	13	38	-95.6646	28.7785	0.03861	25.9
East Matagorda Bay	52	103	-95.7243	28.7215	0.03861	25.9
East Matagorda Bay	65	143	-95.7688	28.7007	0.03861	25.9
East Matagorda Bay	67	9	-95.7382	28.7160	0.03861	25.9
East Matagorda Bay	76	84	-95.8007	28.6910	0.03861	25.9
East Matagorda Bay	87	105	-95.8382	28.6715	0.03861	25.9
East Matagorda Bay	90	129	-95.9549	28.6521	0.03861	25.9
East Matagorda Bay	104	3	-95.9632	28.6326	0.03861	25.9
East Matagorda Bay	109	16	-95.5785	28.7979	0.03861	25.9
East Matagorda Bay	27	40	-95.8785	28.7451	0.04247	23.5
East Matagorda Bay	27	80	-95.8729	28.7410	0.04247	23.5

Bay	TPWD grid	TPWD gridlet	Longitude	Latitude	Selection probability	Sampling weight
East Matagorda Bay	52	84	-95.7174	28.7243	0.04247	23.5
East Matagorda Bay	67	50	-95.7479	28.7104	0.04247	23.5
East Matagorda Bay	76	118	-95.8035	28.6868	0.04247	23.5
East Matagorda Bay	77	35	-95.7854	28.6965	0.04247	23.5
East Matagorda Bay	78	9	-95.7715	28.6993	0.04247	23.5
East Matagorda Bay	96	66	-95.8590	28.6590	0.04247	23.5
East Matagorda Bay	103	3	-95.8799	28.6493	0.04247	23.5
East Matagorda Bay	104	17	-95.9604	28.6313	0.04247	23.5
West Matagorda Bay	134	128	-95.9563	28.6521	0.11628	8.6
West Matagorda Bay	134	129	-95.9549	28.6521	0.11628	8.6
West Matagorda Bay	450	91	-96.2410	28.4896	0.11628	8.6
West Matagorda Bay	450	92	-96.2396	28.4896	0.11628	8.6
West Matagorda Bay	457	4	-96.4451	28.4826	0.11628	8.6
West Matagorda Bay	468	27	-96.2632	28.4799	0.11628	8.6
West Matagorda Bay	477	43	-96.2910	28.4618	0.11628	8.6
West Matagorda Bay	491	71	-96.4021	28.4090	0.11628	8.6
West Matagorda Bay	493	71	-96.3688	28.4090	0.11628	8.6
West Matagorda Bay	498	98	-96.4146	28.3715	0.11628	8.6
West Matagorda Bay	134	117	-95.9549	28.6535	0.12791	7.8
West Matagorda Bay	450	93	-96.2382	28.4896	0.12791	7.8
West Matagorda Bay	467	128	-96.2729	28.4688	0.12791	7.8
West Matagorda Bay	468	28	-96.2618	28.4799	0.12791	7.8
West Matagorda Bay	485	119	-96.4021	28.4201	0.12791	7.8
West Matagorda Bay	485	132	-96.4007	28.4188	0.12791	7.8
West Matagorda Bay	485	133	-96.4160	28.4174	0.12791	7.8
West Matagorda Bay	485	134	-96.4146	28.4174	0.12791	7.8
West Matagorda Bay	488	128	-96.3563	28.4188	0.12791	7.8
West Matagorda Bay	489	40	-96.3451	28.4285	0.12791	7.8
San Antonio Bay	115	35	-96.5521	28.2965	0.00500	199.9
San Antonio Bay	131	92	-96.5896	28.2729	0.00500	199.9
San Antonio Bay	135	56	-96.7896	28.2604	0.00500	199.9
San Antonio Bay	222	115	-96.5243	28.3868	0.00500	199.9
San Antonio Bay	223	98	-96.5146	28.3882	0.00500	199.9
San Antonio Bay	245	117	-96.5882	28.3535	0.00500	199.9
San Antonio Bay	258	128	-96.6063	28.3354	0.00500	199.9
San Antonio Bay	259	5	-96.5938	28.3493	0.00500	199.9
San Antonio Bay	270	39	-96.6299	28.3285	0.00500	199.9
San Antonio Bay	285	36	-96.5340	28.3132	0.00500	199.9
San Antonio Bay	18	134	-96.7813	28.4340	0.00550	181.7
San Antonio Bay	171	127	-96.6910	28.2188	0.00550	181.7

Bay	TPWD grid	TPWD gridlet	Longitude	Latitude	Selection probability	Sampling weight
San Antonio Bay	173	42	-96.6590	28.2285	0.00550	181.7
San Antonio Bay	231	93	-96.5549	28.3729	0.00550	181.7
San Antonio Bay	232	45	-96.5382	28.3785	0.00550	181.7
San Antonio Bay	233	27	-96.5299	28.3799	0.00550	181.7
San Antonio Bay	242	135	-96.6465	28.3507	0.00550	181.7
San Antonio Bay	258	22	-96.6035	28.3479	0.00550	181.7
San Antonio Bay	268	86	-96.4479	28.3396	0.00550	181.7
San Antonio Bay	286	88	-96.5285	28.3063	0.00550	181.7
Aransas Bay	154	42	-96.8924	28.1118	0.00283	353.1
Aransas Bay	232	32	-97.1563	28.0465	0.00283	353.1
Aransas Bay	282	93	-97.1882	27.9729	0.00283	353.1
Aransas Bay	295	71	-97.0688	27.9590	0.00283	353.1
Aransas Bay	307	135	-97.0299	27.9340	0.00283	353.1
Aransas Bay	320	27	-97.1132	27.9132	0.00283	353.1
Aransas Bay	321	138	-97.0924	27.9007	0.00283	353.1
Aransas Bay	323	13	-97.0660	27.9146	0.00283	353.1
Aransas Bay	328	97	-97.1326	27.8882	0.00283	353.1
Aransas Bay	332	55	-97.0576	27.8938	0.00283	353.1
Aransas Bay	124	18	-96.9590	28.1313	0.00312	321.0
Aransas Bay	246	11	-97.1521	28.0326	0.00312	321.0
Aransas Bay	246	116	-97.1563	28.0201	0.00312	321.0
Aransas Bay	285	54	-97.0757	27.9771	0.00312	321.0
Aransas Bay	302	128	-97.1063	27.9354	0.00312	321.0
Aransas Bay	303	137	-97.0938	27.9340	0.00312	321.0
Aransas Bay	319	138	-97.1257	27.9007	0.00312	321.0
Aransas Bay	322	74	-97.0813	27.9076	0.00312	321.0
Aransas Bay	333	8	-97.0396	27.8993	0.00312	321.0
Aransas Bay	338	122	-97.0813	27.8688	0.00312	321.0
Corpus Christi Bay	55	136	-97.1285	27.8840	0.00369	270.8
Corpus Christi Bay	97	4	-97.0951	27.8493	0.00369	270.8
Corpus Christi Bay	97	17	-97.0938	27.8479	0.00369	270.8
Corpus Christi Bay	136	83	-97.1188	27.8076	0.00369	270.8
Corpus Christi Bay	137	90	-97.1090	27.8063	0.00369	270.8
Corpus Christi Bay	191	138	-97.1590	27.7507	0.00369	270.8
Corpus Christi Bay	235	38	-97.3313	27.6951	0.00369	270.8
Corpus Christi Bay	241	135	-97.2132	27.6840	0.00369	270.8
Corpus Christi Bay	242	36	-97.1840	27.6965	0.00369	270.8
Corpus Christi Bay	247	54	-97.3090	27.6771	0.00369	270.8
Corpus Christi Bay	55	7	-97.1243	27.8993	0.00406	246.2
Corpus Christi Bay	64	38	-97.1479	27.8785	0.00406	246.2

Bay	TPWD grid	TPWD gridlet	Longitude	Latitude	Selection probability	Sampling weight
Corpus Christi Bay	77	58	-97.1535	27.8604	0.00406	246.2
Corpus Christi Bay	77	79	-97.1576	27.8576	0.00406	246.2
Corpus Christi Bay	80	107	-97.1021	27.8549	0.00406	246.2
Corpus Christi Bay	81	136	-97.0951	27.8507	0.00406	246.2
Corpus Christi Bay	90	126	-97.2424	27.8354	0.00406	246.2
Corpus Christi Bay	93	50	-97.1646	27.8438	0.00406	246.2
Corpus Christi Bay	193	39	-97.1299	27.7618	0.00406	246.2
Corpus Christi Bay	235	51	-97.3299	27.6938	0.00406	246.2
Upper Laguna Madre	33	7	-97.2910	27.6160	0.00089	1123.2
Upper Laguna Madre	34	77	-97.2771	27.6076	0.00089	1123.2
Upper Laguna Madre	34	84	-97.2674	27.6076	0.00089	1123.2
Upper Laguna Madre	40	127	-97.2910	27.5854	0.00089	1123.2
Upper Laguna Madre	84	144	-97.3507	27.4340	0.00089	1123.2
Upper Laguna Madre	88	95	-97.3521	27.4229	0.00089	1123.2
Upper Laguna Madre	97	29	-97.3438	27.3965	0.00089	1123.2
Upper Laguna Madre	255	133	-97.3993	27.2340	0.00089	1123.2
Upper Laguna Madre	258	18	-97.4090	27.2313	0.00089	1123.2
Upper Laguna Madre	275	20	-97.4396	27.1646	0.00089	1123.2
Upper Laguna Madre	10	131	-97.2021	27.6688	0.00098	1021.1
Upper Laguna Madre	57	102	-97.3257	27.5382	0.00098	1021.1
Upper Laguna Madre	61	119	-97.3354	27.5201	0.00098	1021.1
Upper Laguna Madre	64	37	-97.2993	27.5285	0.00098	1021.1
Upper Laguna Madre	76	10	-97.3368	27.4826	0.00098	1021.1
Upper Laguna Madre	96	45	-97.3549	27.3951	0.00098	1021.1
Upper Laguna Madre	283	13	-97.4326	27.1313	0.00098	1021.1
Upper Laguna Madre	290	30	-97.4257	27.0965	0.00098	1021.1
Upper Laguna Madre	291	142	-97.4035	27.0840	0.00098	1021.1
Upper Laguna Madre	298	118	-97.4201	27.0535	0.00098	1021.1
Lower Laguna Madre	100	124	-97.3785	26.5354	0.00045	2230.8
Lower Laguna Madre	121	119	-97.3688	26.4868	0.00045	2230.8
Lower Laguna Madre	123	118	-97.3368	26.4868	0.00045	2230.8
Lower Laguna Madre	136	58	-97.3868	26.4604	0.00045	2230.8
Lower Laguna Madre	189	36	-97.3007	26.3632	0.00045	2230.8
Lower Laguna Madre	206	26	-97.3313	26.3299	0.00045	2230.8
Lower Laguna Madre	227	87	-97.2632	26.2896	0.00045	2230.8
Lower Laguna Madre	245	16	-97.2451	26.2646	0.00045	2230.8
Lower Laguna Madre	284	50	-97.2813	26.1771	0.00045	2230.8
Lower Laguna Madre	344	35	-97.2354	26.0799	0.00045	2230.8
Lower Laguna Madre	39	7	-97.4243	26.6993	0.00049	2028.0
Lower Laguna Madre	100	58	-97.3701	26.5438	0.00049	2028.0

Bay	TPWD grid	TPWD gridlet	Longitude	Latitude	Selection probability	Sampling weight
Lower Laguna Madre	128	90	-97.3924	26.4729	0.00049	2028.0
Lower Laguna Madre	155	111	-97.3465	26.4201	0.00049	2028.0
Lower Laguna Madre	181	78	-97.2757	26.3743	0.00049	2028.0
Lower Laguna Madre	201	74	-97.2813	26.3410	0.00049	2028.0
Lower Laguna Madre	234	78	-97.2924	26.2743	0.00049	2028.0
Lower Laguna Madre	264	2	-97.2313	26.2326	0.00049	2028.0
Lower Laguna Madre	274	53	-97.1938	26.2104	0.00049	2028.0
Lower Laguna Madre	293	19	-97.2743	26.1646	0.00049	2028.0

Tier 2 Bay Sampling

Since seagrass is known to be impacted by factors associated with human activity, one bay was identified that is less impacted by development pressure, San Antonio Bay, and one bay that has experienced impacts, Redfish Bay. Tier 2 bay sampling will be conducted in a similar manner to the coastwide Tier 2 monitoring. Fifty permanent stations will be established and monitored from a list of about 150 potential stations.

TPWD will conduct bay-scale Tier 2 sampling at 50 stations in Redfish Bay (Figure 6 and Table 7). As resources permit, bay-scale Tier 2 sampling will be conducted at 50 stations in San Antonio Bay (Figure 7 and Table 8).

Tier 3 Sampling

Tier 3 sampling will be conducted in Redfish Bay, and as resources permit, in San Antonio Bay. Transect locations for Tier 3 sampling will be selected based on reconnaissance of the areas early in the project.

Sample Frequency

Sampling for each component of this project (coastwide Tier 2, bay-level Tier 2, and bay-level Tier 3) will occur only once during the project, in late summer/early fall 2012.

Field Sampling Design

Tier 2 sample design is a set of discrete locations, determined as described above. Sample type and number are described in Table 9.

Tier 3 sample design is based on three 50 m transects that encompass the deep edge of the seagrass bed and extend across any depth gradient which may exist in seagrass beds that occur near shore. Seagrass condition and stressor indicators may be influenced by water depth, so using a transect-based design allows depth-related characteristics to be distinguished. Sample type and number are described in Table 10.

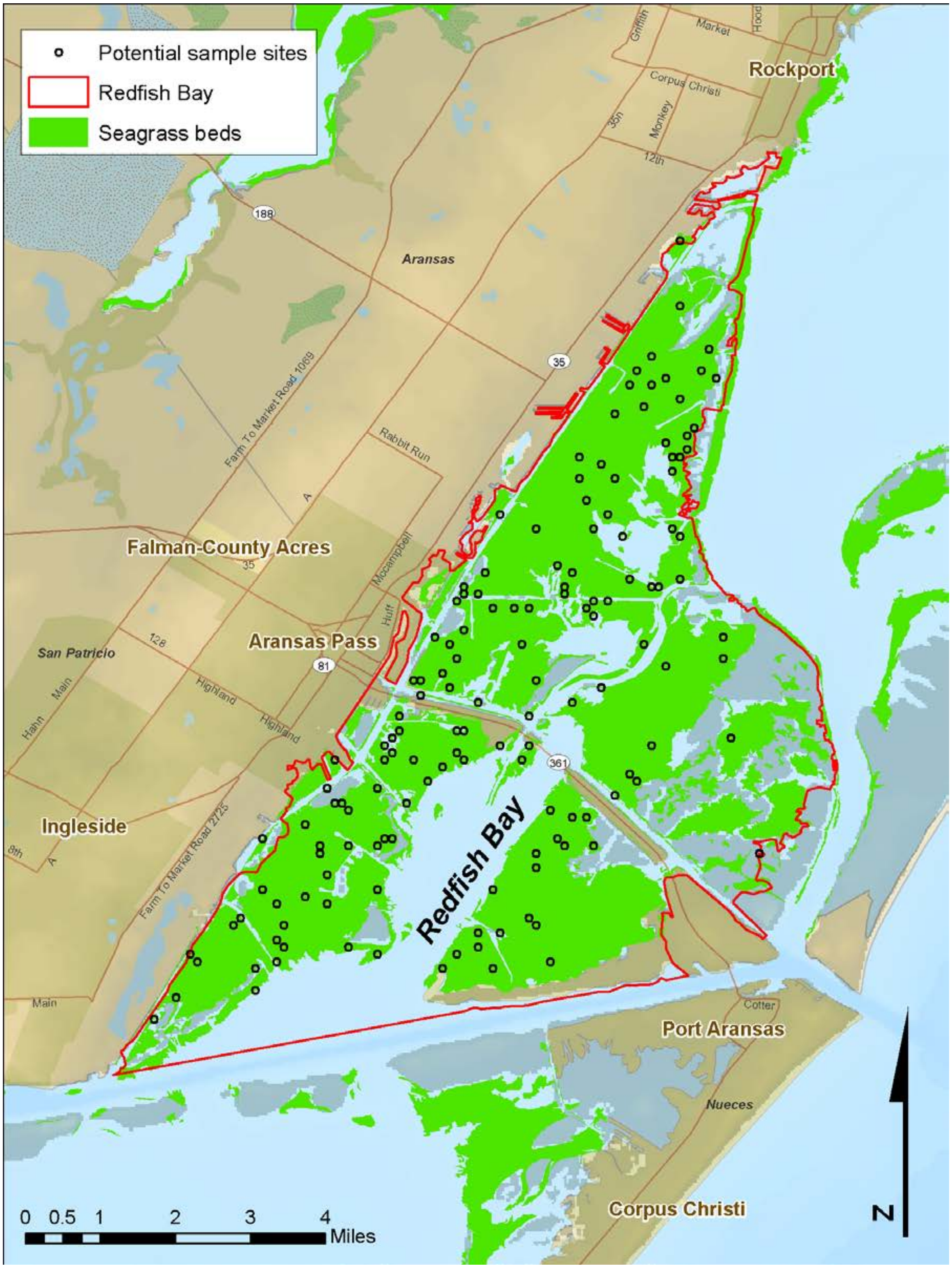


Figure 6. B1.5. Tier 2 sampling locations for Redfish Bay system based on seagrass abundance. 147 locations are provided (target of 50 samples with 97 extra to account for unsuitable sample sites).

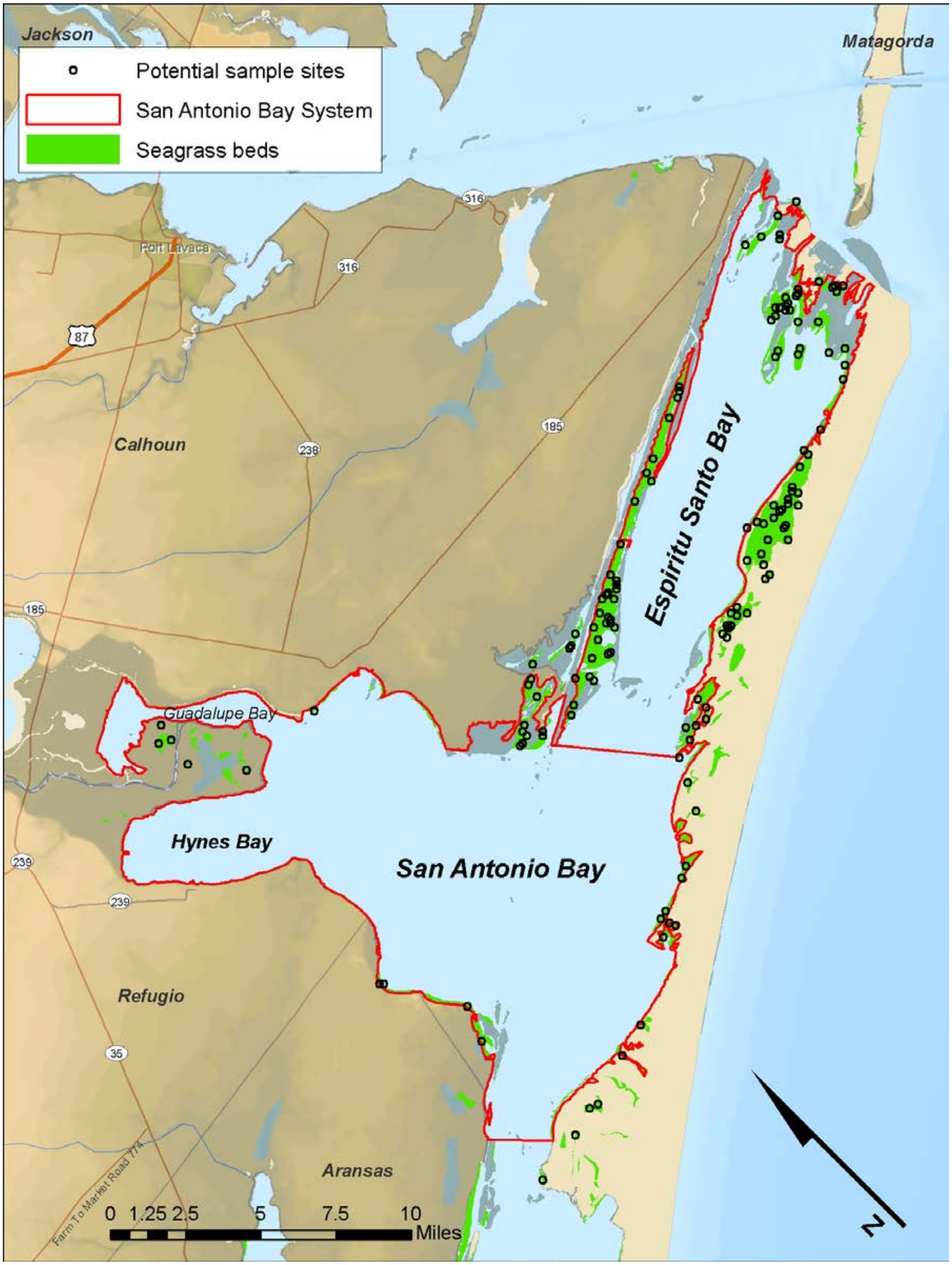


Figure 7. B1.6. Tier 2 sampling locations for San Antonio Bay system based on seagrass abundance. 150 locations are provided (target of 50 samples with 100 extra to account for unsuitable sample sites).

Table 7. B1.7. Tier 2 sampling locations for Redfish Bay system based on seagrass abundance. 147 locations are provided (target of 50 samples with 97 extra to account for unsuitable sample sites). TPWD grids are one minute latitude by one minute longitude in size. They are sequentially numbered from west to east and north to south in each bay system and the Texas Territorial Sea. Each grid is identified by the latitude –longitude coordinates at the center. Each sample grid is divided into 144 sample gridlets that are five seconds latitude by five seconds longitude in size. Gridlets are sequentially numbered from west to east and north to south such that gridlet 1 is located in the upper left corner of the grid; gridlet 12 is located in the upper right corner of the grid, and gridlet 144 is located in the lower right corner of the grid.

Bay	TPWD grid	TPWD gridlet	Longitude	Latitude	Selection probability	Sampling weight
Aransas Bay	274	135	-97.0799	27.9840	0.02124	47.1
Aransas Bay	294	95	-97.0854	27.9563	0.02124	47.1
Aransas Bay	294	138	-97.0924	27.9507	0.02124	47.1
Aransas Bay	295	80	-97.0729	27.9576	0.02124	47.1
Aransas Bay	303	61	-97.0993	27.9424	0.02124	47.1
Aransas Bay	303	76	-97.0951	27.9410	0.02124	47.1
Aransas Bay	303	97	-97.0993	27.9382	0.02124	47.1
Aransas Bay	304	17	-97.0771	27.9479	0.02124	47.1
Aransas Bay	310	120	-97.1174	27.9201	0.02124	47.1
Aransas Bay	311	143	-97.1021	27.9174	0.02124	47.1
Aransas Bay	312	128	-97.0896	27.9188	0.02124	47.1
Aransas Bay	312	144	-97.0840	27.9174	0.02124	47.1
Aransas Bay	313	51	-97.0799	27.9271	0.02124	47.1
Aransas Bay	313	123	-97.0799	27.9188	0.02124	47.1
Aransas Bay	319	20	-97.1229	27.9146	0.02124	47.1
Aransas Bay	319	69	-97.1215	27.9090	0.02124	47.1
Aransas Bay	319	116	-97.1229	27.9035	0.02124	47.1
Aransas Bay	319	138	-97.1257	27.9007	0.02124	47.1
Aransas Bay	320	11	-97.1021	27.9160	0.02124	47.1
Aransas Bay	320	25	-97.1160	27.9132	0.02124	47.1
Aransas Bay	320	28	-97.1118	27.9132	0.02124	47.1
Aransas Bay	320	30	-97.1090	27.9132	0.02124	47.1
Aransas Bay	321	17	-97.0938	27.9146	0.02124	47.1
Aransas Bay	321	26	-97.0979	27.9132	0.02124	47.1
Aransas Bay	321	94	-97.0868	27.9063	0.02124	47.1
Aransas Bay	322	81	-97.0715	27.9076	0.02124	47.1
Aransas Bay	322	117	-97.0715	27.9035	0.02124	47.1
Aransas Bay	322	121	-97.0826	27.9021	0.02124	47.1
Aransas Bay	327	142	-97.1368	27.8840	0.02124	47.1
Aransas Bay	328	2	-97.1313	27.8993	0.02124	47.1
Aransas Bay	328	134	-97.1313	27.8840	0.02124	47.1
Aransas Bay	330	16	-97.0951	27.8979	0.02124	47.1
Aransas Bay	330	119	-97.0854	27.8868	0.02124	47.1
Aransas Bay	331	106	-97.0701	27.8882	0.02124	47.1

Bay	TPWD grid	TPWD gridlet	Longitude	Latitude	Selection probability	Sampling weight
Aransas Bay	337	86	-97.0979	27.8729	0.02124	47.1
Aransas Bay	343	2	-97.0646	27.8660	0.02124	47.1
Aransas Bay	285	99	-97.0799	27.9715	0.03130	31.9
Aransas Bay	294	47	-97.0854	27.9618	0.03130	31.9
Aransas Bay	294	69	-97.0882	27.9590	0.03130	31.9
Aransas Bay	294	92	-97.0896	27.9563	0.03130	31.9
Aransas Bay	294	130	-97.0868	27.9521	0.03130	31.9
Aransas Bay	295	31	-97.0743	27.9632	0.03130	31.9
Aransas Bay	295	66	-97.0757	27.9590	0.03130	31.9
Aransas Bay	295	73	-97.0826	27.9576	0.03130	31.9
Aransas Bay	295	111	-97.0799	27.9535	0.03130	31.9
Aransas Bay	303	102	-97.0924	27.9382	0.03130	31.9
Aransas Bay	303	134	-97.0979	27.9340	0.03130	31.9
Aransas Bay	304	28	-97.0785	27.9465	0.03130	31.9
Aransas Bay	304	37	-97.0826	27.9451	0.03130	31.9
Aransas Bay	304	52	-97.0785	27.9438	0.03130	31.9
Aransas Bay	304	62	-97.0813	27.9424	0.03130	31.9
Aransas Bay	304	63	-97.0799	27.9424	0.03130	31.9
Aransas Bay	304	86	-97.0813	27.9396	0.03130	31.9
Aransas Bay	310	141	-97.1215	27.9174	0.03130	31.9
Aransas Bay	311	14	-97.1146	27.9313	0.03130	31.9
Aransas Bay	311	43	-97.1076	27.9285	0.03130	31.9
Aransas Bay	311	106	-97.1035	27.9215	0.03130	31.9
Aransas Bay	311	120	-97.1007	27.9201	0.03130	31.9
Aransas Bay	312	17	-97.0938	27.9313	0.03130	31.9
Aransas Bay	312	39	-97.0965	27.9285	0.03130	31.9
Aransas Bay	312	55	-97.0910	27.9271	0.03130	31.9
Aransas Bay	312	143	-97.0854	27.9174	0.03130	31.9
Aransas Bay	313	38	-97.0813	27.9285	0.03130	31.9
Aransas Bay	319	9	-97.1215	27.9160	0.03130	31.9
Aransas Bay	319	11	-97.1188	27.9160	0.03130	31.9
Aransas Bay	319	77	-97.1271	27.9076	0.03130	31.9
Aransas Bay	319	91	-97.1243	27.9063	0.03130	31.9
Aransas Bay	320	89	-97.1104	27.9063	0.03130	31.9
Aransas Bay	321	15	-97.0965	27.9146	0.03130	31.9
Aransas Bay	321	39	-97.0965	27.9118	0.03130	31.9
Aransas Bay	328	3	-97.1299	27.8993	0.03130	31.9
Aransas Bay	328	19	-97.1243	27.8979	0.03130	31.9
Aransas Bay	328	134	-97.1313	27.8840	0.03130	31.9
Aransas Bay	329	48	-97.1007	27.8951	0.03130	31.9
Corpus Christi Bay	54	96	-97.1340	27.8896	0.02770	36.1

Bay	TPWD grid	TPWD gridlet	Longitude	Latitude	Selection probability	Sampling weight
Corpus Christi Bay	54	118	-97.1368	27.8868	0.02770	36.1
Corpus Christi Bay	55	128	-97.1229	27.8854	0.02770	36.1
Corpus Christi Bay	55	141	-97.1215	27.8840	0.02770	36.1
Corpus Christi Bay	56	7	-97.1076	27.8993	0.02770	36.1
Corpus Christi Bay	56	66	-97.1090	27.8924	0.02770	36.1
Corpus Christi Bay	63	107	-97.1521	27.8715	0.02770	36.1
Corpus Christi Bay	64	38	-97.1479	27.8785	0.02770	36.1
Corpus Christi Bay	64	45	-97.1382	27.8785	0.02770	36.1
Corpus Christi Bay	64	64	-97.1451	27.8757	0.02770	36.1
Corpus Christi Bay	64	130	-97.1368	27.8688	0.02770	36.1
Corpus Christi Bay	64	133	-97.1493	27.8674	0.02770	36.1
Corpus Christi Bay	65	28	-97.1285	27.8799	0.02770	36.1
Corpus Christi Bay	66	81	-97.1049	27.8743	0.02770	36.1
Corpus Christi Bay	66	96	-97.1007	27.8729	0.02770	36.1
Corpus Christi Bay	67	20	-97.0896	27.8813	0.02770	36.1
Corpus Christi Bay	67	54	-97.0924	27.8771	0.02770	36.1
Corpus Christi Bay	67	135	-97.0965	27.8674	0.02770	36.1
Corpus Christi Bay	77	65	-97.1604	27.8590	0.02770	36.1
Corpus Christi Bay	77	83	-97.1521	27.8576	0.02770	36.1
Corpus Christi Bay	78	1	-97.1493	27.8660	0.02770	36.1
Corpus Christi Bay	78	38	-97.1479	27.8618	0.02770	36.1
Corpus Christi Bay	78	69	-97.1382	27.8590	0.02770	36.1
Corpus Christi Bay	79	143	-97.1188	27.8507	0.02770	36.1
Corpus Christi Bay	80	7	-97.1076	27.8660	0.02770	36.1
Corpus Christi Bay	80	114	-97.1090	27.8535	0.02770	36.1
Corpus Christi Bay	80	127	-97.1076	27.8521	0.02770	36.1
Corpus Christi Bay	92	31	-97.1743	27.8465	0.02770	36.1
Corpus Christi Bay	92	134	-97.1813	27.8340	0.02770	36.1
Corpus Christi Bay	93	43	-97.1576	27.8451	0.02770	36.1
Corpus Christi Bay	93	88	-97.1618	27.8396	0.02770	36.1
Corpus Christi Bay	94	17	-97.1438	27.8479	0.02770	36.1
Corpus Christi Bay	94	33	-97.1382	27.8465	0.02770	36.1
Corpus Christi Bay	95	23	-97.1188	27.8479	0.02770	36.1
Corpus Christi Bay	96	45	-97.1049	27.8451	0.02770	36.1
Corpus Christi Bay	96	49	-97.1160	27.8438	0.02770	36.1
Corpus Christi Bay	54	72	-97.1340	27.8924	0.03458	28.9
Corpus Christi Bay	54	107	-97.1354	27.8882	0.03458	28.9
Corpus Christi Bay	54	131	-97.1354	27.8854	0.03458	28.9
Corpus Christi Bay	54	135	-97.1465	27.8840	0.03458	28.9
Corpus Christi Bay	55	27	-97.1299	27.8965	0.03458	28.9
Corpus Christi Bay	55	47	-97.1188	27.8951	0.03458	28.9

Bay	TPWD grid	TPWD gridlet	Longitude	Latitude	Selection probability	Sampling weight
Corpus Christi Bay	55	92	-97.1229	27.8896	0.03458	28.9
Corpus Christi Bay	55	93	-97.1215	27.8896	0.03458	28.9
Corpus Christi Bay	56	110	-97.1146	27.8868	0.03458	28.9
Corpus Christi Bay	56	114	-97.1090	27.8868	0.03458	28.9
Corpus Christi Bay	56	137	-97.1104	27.8840	0.03458	28.9
Corpus Christi Bay	63	125	-97.1604	27.8688	0.03458	28.9
Corpus Christi Bay	64	63	-97.1465	27.8757	0.03458	28.9
Corpus Christi Bay	64	77	-97.1438	27.8743	0.03458	28.9
Corpus Christi Bay	64	131	-97.1354	27.8688	0.03458	28.9
Corpus Christi Bay	64	137	-97.1438	27.8674	0.03458	28.9
Corpus Christi Bay	64	141	-97.1382	27.8674	0.03458	28.9
Corpus Christi Bay	65	6	-97.1257	27.8826	0.03458	28.9
Corpus Christi Bay	65	61	-97.1326	27.8757	0.03458	28.9
Corpus Christi Bay	66	130	-97.1035	27.8688	0.03458	28.9
Corpus Christi Bay	66	143	-97.1021	27.8674	0.03458	28.9
Corpus Christi Bay	67	33	-97.0882	27.8799	0.03458	28.9
Corpus Christi Bay	77	91	-97.1576	27.8563	0.03458	28.9
Corpus Christi Bay	77	110	-97.1646	27.8535	0.03458	28.9
Corpus Christi Bay	77	121	-97.1660	27.8521	0.03458	28.9
Corpus Christi Bay	77	128	-97.1563	27.8521	0.03458	28.9
Corpus Christi Bay	78	86	-97.1479	27.8563	0.03458	28.9
Corpus Christi Bay	80	31	-97.1076	27.8632	0.03458	28.9
Corpus Christi Bay	80	61	-97.1160	27.8590	0.03458	28.9
Corpus Christi Bay	80	134	-97.1146	27.8507	0.03458	28.9
Corpus Christi Bay	92	44	-97.1729	27.8451	0.03458	28.9
Corpus Christi Bay	92	101	-97.1771	27.8382	0.03458	28.9
Corpus Christi Bay	93	7	-97.1576	27.8493	0.03458	28.9
Corpus Christi Bay	93	20	-97.1563	27.8479	0.03458	28.9
Corpus Christi Bay	93	52	-97.1618	27.8438	0.03458	28.9
Corpus Christi Bay	95	32	-97.1229	27.8465	0.03458	28.9
Corpus Christi Bay	95	54	-97.1257	27.8438	0.03458	28.9

Table 8. B1.8. Tier 2 sampling locations for San Antonio Bay system based on seagrass abundance. 150 locations are provided (target of 50 samples with 100 extra to account for unsuitable sample sites). TPWD grids are one minute latitude by one minute longitude in size. They are sequentially numbered from west to east and north to south in each bay system and the Texas Territorial Sea. Each grid is identified by the latitude –longitude coordinates at the center. Each sample grid is divided into 144 sample gridlets that are five seconds latitude by five seconds longitude in size. Gridlets are sequentially numbered from west to east and north to south such that gridlet 1 is located in the upper left corner of the grid; gridlet 12 is located in the upper right corner of the grid, and gridlet 144 is located in the lower right corner of the grid.

Bay	TPWD grid	TPWD gridlet	Longitude	Latitude	Selection probability	Sampling weight
San Antonio Bay	11	100	-96.7951	28.4549	0.03752	26.7
San Antonio Bay	16	11	-96.8021	28.4493	0.03752	26.7
San Antonio Bay	17	27	-96.7965	28.4465	0.03752	26.7
San Antonio Bay	34	50	-96.7813	28.4104	0.03752	26.7
San Antonio Bay	36	81	-96.7382	28.4076	0.03752	26.7
San Antonio Bay	76	2	-96.6479	28.3493	0.03752	26.7
San Antonio Bay	85	96	-96.6674	28.3229	0.03752	26.7
San Antonio Bay	85	107	-96.6688	28.3215	0.03752	26.7
San Antonio Bay	86	131	-96.6521	28.3188	0.03752	26.7
San Antonio Bay	100	79	-96.8076	28.2910	0.03752	26.7
San Antonio Bay	114	47	-96.5688	28.2951	0.03752	26.7
San Antonio Bay	114	48	-96.5674	28.2951	0.03752	26.7
San Antonio Bay	114	68	-96.5729	28.2924	0.03752	26.7
San Antonio Bay	115	3	-96.5632	28.2993	0.03752	26.7
San Antonio Bay	115	28	-96.5618	28.2965	0.03752	26.7
San Antonio Bay	115	55	-96.5576	28.2938	0.03752	26.7
San Antonio Bay	116	10	-96.5368	28.2993	0.03752	26.7
San Antonio Bay	129	72	-96.6174	28.2757	0.03752	26.7
San Antonio Bay	129	135	-96.6299	28.2674	0.03752	26.7
San Antonio Bay	130	70	-96.6035	28.2757	0.03752	26.7
San Antonio Bay	160	54	-96.6424	28.2438	0.03752	26.7
San Antonio Bay	171	118	-96.6868	28.2201	0.03752	26.7
San Antonio Bay	172	70	-96.6701	28.2257	0.03752	26.7
San Antonio Bay	173	38	-96.6646	28.2285	0.03752	26.7
San Antonio Bay	184	20	-96.6896	28.2146	0.03752	26.7
San Antonio Bay	184	39	-96.6965	28.2118	0.03752	26.7
San Antonio Bay	191	132	-96.7507	28.1854	0.03752	26.7
San Antonio Bay	192	96	-96.7340	28.1896	0.03752	26.7
San Antonio Bay	200	39	-96.7799	28.1785	0.03752	26.7
San Antonio Bay	212	109	-96.4326	28.4201	0.03752	26.7
San Antonio Bay	213	124	-96.4118	28.4188	0.03752	26.7
San Antonio Bay	213	144	-96.4007	28.4174	0.03752	26.7
San Antonio Bay	219	59	-96.4188	28.4104	0.03752	26.7

Bay	TPWD grid	TPWD gridlet	Longitude	Latitude	Selection probability	Sampling weight
San Antonio Bay	223	69	-96.5049	28.3924	0.03752	26.7
San Antonio Bay	227	106	-96.4368	28.3882	0.03752	26.7
San Antonio Bay	227	121	-96.4493	28.3854	0.03752	26.7
San Antonio Bay	227	123	-96.4465	28.3854	0.03752	26.7
San Antonio Bay	228	121	-96.4326	28.3854	0.03752	26.7
San Antonio Bay	231	115	-96.5576	28.3701	0.03752	26.7
San Antonio Bay	232	46	-96.5368	28.3785	0.03752	26.7
San Antonio Bay	232	100	-96.5451	28.3715	0.03752	26.7
San Antonio Bay	237	91	-96.4576	28.3729	0.03752	26.7
San Antonio Bay	237	101	-96.4604	28.3715	0.03752	26.7
San Antonio Bay	238	67	-96.4410	28.3757	0.03752	26.7
San Antonio Bay	238	132	-96.4340	28.3688	0.03752	26.7
San Antonio Bay	239	72	-96.4174	28.3757	0.03752	26.7
San Antonio Bay	254	103	-96.4410	28.3549	0.03752	26.7
San Antonio Bay	254	144	-96.4340	28.3507	0.03752	26.7
San Antonio Bay	257	64	-96.6285	28.3424	0.03752	26.7
San Antonio Bay	258	74	-96.6146	28.3410	0.03752	26.7
San Antonio Bay	258	92	-96.6063	28.3396	0.03752	26.7
San Antonio Bay	258	102	-96.6090	28.3382	0.03752	26.7
San Antonio Bay	258	104	-96.6063	28.3382	0.03752	26.7
San Antonio Bay	258	115	-96.6076	28.3368	0.03752	26.7
San Antonio Bay	259	13	-96.5993	28.3479	0.03752	26.7
San Antonio Bay	259	50	-96.5979	28.3438	0.03752	26.7
San Antonio Bay	268	44	-96.4396	28.3451	0.03752	26.7
San Antonio Bay	270	18	-96.6257	28.3313	0.03752	26.7
San Antonio Bay	270	60	-96.6174	28.3271	0.03752	26.7
San Antonio Bay	270	61	-96.6326	28.3257	0.03752	26.7
San Antonio Bay	270	85	-96.6326	28.3229	0.03752	26.7
San Antonio Bay	276	88	-96.5285	28.3229	0.03752	26.7
San Antonio Bay	276	104	-96.5229	28.3215	0.03752	26.7
San Antonio Bay	276	129	-96.5215	28.3188	0.03752	26.7
San Antonio Bay	277	100	-96.5118	28.3215	0.03752	26.7
San Antonio Bay	277	133	-96.5160	28.3174	0.03752	26.7
San Antonio Bay	277	140	-96.5063	28.3174	0.03752	26.7
San Antonio Bay	279	22	-96.4701	28.3313	0.03752	26.7
San Antonio Bay	279	25	-96.4826	28.3299	0.03752	26.7
San Antonio Bay	285	44	-96.5396	28.3118	0.03752	26.7
San Antonio Bay	285	107	-96.5354	28.3049	0.03752	26.7
San Antonio Bay	286	61	-96.5326	28.3090	0.03752	26.7
San Antonio Bay	287	34	-96.5035	28.3132	0.03752	26.7

Bay	TPWD grid	TPWD gridlet	Longitude	Latitude	Selection probability	Sampling weight
San Antonio Bay	287	49	-96.5160	28.3104	0.03752	26.7
San Antonio Bay	287	50	-96.5146	28.3104	0.03752	26.7
San Antonio Bay	25	1	-96.7993	28.4326	0.03752	26.7
San Antonio Bay	75	46	-96.6535	28.3451	0.03752	26.7
San Antonio Bay	75	56	-96.6563	28.3438	0.03752	26.7
San Antonio Bay	75	115	-96.6576	28.3368	0.03752	26.7
San Antonio Bay	85	21	-96.6715	28.3313	0.03752	26.7
San Antonio Bay	85	31	-96.6743	28.3299	0.03752	26.7
San Antonio Bay	85	55	-96.6743	28.3271	0.03752	26.7
San Antonio Bay	85	63	-96.6799	28.3257	0.03752	26.7
San Antonio Bay	85	64	-96.6785	28.3257	0.03752	26.7
San Antonio Bay	87	33	-96.6382	28.3299	0.03752	26.7
San Antonio Bay	87	98	-96.6479	28.3215	0.03752	26.7
San Antonio Bay	100	66	-96.8090	28.2924	0.03752	26.7
San Antonio Bay	114	35	-96.5688	28.2965	0.03752	26.7
San Antonio Bay	114	44	-96.5729	28.2951	0.03752	26.7
San Antonio Bay	114	68	-96.5729	28.2924	0.03752	26.7
San Antonio Bay	115	6	-96.5590	28.2993	0.03752	26.7
San Antonio Bay	116	8	-96.5396	28.2993	0.03752	26.7
San Antonio Bay	129	72	-96.6174	28.2757	0.03752	26.7
San Antonio Bay	129	118	-96.6201	28.2701	0.03752	26.7
San Antonio Bay	130	22	-96.6035	28.2813	0.03752	26.7
San Antonio Bay	130	87	-96.6132	28.2729	0.03752	26.7
San Antonio Bay	130	103	-96.6076	28.2715	0.03752	26.7
San Antonio Bay	135	106	-96.7868	28.2549	0.03752	26.7
San Antonio Bay	144	95	-96.6354	28.2563	0.03752	26.7
San Antonio Bay	151	101	-96.7938	28.2382	0.03752	26.7
San Antonio Bay	171	127	-96.6910	28.2188	0.03752	26.7
San Antonio Bay	184	45	-96.6882	28.2118	0.03752	26.7
San Antonio Bay	197	118	-96.8201	28.1701	0.03752	26.7
San Antonio Bay	199	77	-96.7938	28.1743	0.03752	26.7
San Antonio Bay	200	54	-96.7757	28.1771	0.03752	26.7
San Antonio Bay	212	139	-96.4243	28.4174	0.03752	26.7
San Antonio Bay	219	48	-96.4174	28.4118	0.03752	26.7
San Antonio Bay	222	120	-96.5174	28.3868	0.03752	26.7
San Antonio Bay	223	58	-96.5035	28.3938	0.03752	26.7
San Antonio Bay	223	79	-96.5076	28.3910	0.03752	26.7
San Antonio Bay	227	101	-96.4438	28.3882	0.03752	26.7
San Antonio Bay	227	114	-96.4424	28.3868	0.03752	26.7
San Antonio Bay	227	128	-96.4396	28.3854	0.03752	26.7

Bay	TPWD grid	TPWD gridlet	Longitude	Latitude	Selection probability	Sampling weight
San Antonio Bay	227	129	-96.4382	28.3854	0.03752	26.7
San Antonio Bay	227	139	-96.4410	28.3840	0.03752	26.7
San Antonio Bay	228	111	-96.4299	28.3868	0.03752	26.7
San Antonio Bay	228	122	-96.4313	28.3854	0.03752	26.7
San Antonio Bay	232	65	-96.5438	28.3757	0.03752	26.7
San Antonio Bay	238	8	-96.4396	28.3826	0.03752	26.7
San Antonio Bay	239	10	-96.4201	28.3826	0.03752	26.7
San Antonio Bay	239	96	-96.4174	28.3729	0.03752	26.7
San Antonio Bay	240	61	-96.4160	28.3757	0.03752	26.7
San Antonio Bay	240	87	-96.4132	28.3729	0.03752	26.7
San Antonio Bay	245	115	-96.5910	28.3535	0.03752	26.7
San Antonio Bay	246	53	-96.5771	28.3604	0.03752	26.7
San Antonio Bay	253	23	-96.4521	28.3646	0.03752	26.7
San Antonio Bay	254	1	-96.4493	28.3660	0.03752	26.7
San Antonio Bay	257	44	-96.6229	28.3451	0.03752	26.7
San Antonio Bay	257	63	-96.6299	28.3424	0.03752	26.7
San Antonio Bay	257	132	-96.6174	28.3354	0.03752	26.7
San Antonio Bay	258	23	-96.6021	28.3479	0.03752	26.7
San Antonio Bay	258	55	-96.6076	28.3438	0.03752	26.7
San Antonio Bay	258	139	-96.6076	28.3340	0.03752	26.7
San Antonio Bay	259	7	-96.5910	28.3493	0.03752	26.7
San Antonio Bay	259	14	-96.5979	28.3479	0.03752	26.7
San Antonio Bay	259	18	-96.5924	28.3479	0.03752	26.7
San Antonio Bay	259	29	-96.5938	28.3465	0.03752	26.7
San Antonio Bay	268	76	-96.4451	28.3410	0.03752	26.7
San Antonio Bay	270	59	-96.6188	28.3271	0.03752	26.7
San Antonio Bay	277	120	-96.5007	28.3201	0.03752	26.7
San Antonio Bay	277	129	-96.5049	28.3188	0.03752	26.7
San Antonio Bay	277	136	-96.5118	28.3174	0.03752	26.7
San Antonio Bay	277	137	-96.5104	28.3174	0.03752	26.7
San Antonio Bay	277	140	-96.5063	28.3174	0.03752	26.7
San Antonio Bay	278	68	-96.4896	28.3257	0.03752	26.7
San Antonio Bay	278	97	-96.4993	28.3215	0.03752	26.7
San Antonio Bay	278	133	-96.4993	28.3174	0.03752	26.7
San Antonio Bay	279	49	-96.4826	28.3271	0.03752	26.7
San Antonio Bay	286	42	-96.5257	28.3118	0.03752	26.7
San Antonio Bay	286	107	-96.5188	28.3049	0.03752	26.7

Table 9. B1.9. Sample design for a Tier 2 station, whether part of coastwide or bay-scale monitoring.

Parameter	Indicator	Analyzed by	Data Flow	Replicates
Seagrass coverage and species	Coverage estimated and species identified within a 0.25 m^2 quadrat	TPWD	TPWD retains original field sheets	4
Seagrass canopy height	Average of the longest leaf measured from five random shoots, by species. This is measured near the seagrass coverage quadrat for any seagrass species that has at least 20% coverage at that quadrat	TPWD	TPWD retains original field sheets	4

Table 10. B.1.10. Sample design for a Tier 3 station in a bay.
Work will be carried out in Redfish Bay and in San Antonio Bay, if resources allow.

Parameter	Indicator	Analyzed by	Data Flow	Transects	Replicates	Samples
Water and sediment quality indicators						
Instantaneous physicochemical monitoring	Dissolved oxygen, salinity, temperature, pH, specific conductance, Secchi depth	TPWD	TPWD retains original field sheets and instrument pre- and post-calibration records	3	1	3
Light attenuation coefficient (*k*) and percent surface irradiance (% SI)	PAR at surface and top of seagrass canopy (4 replicates = 1 sample)	TPWD	TPWD retains original field sheets	3	1	3
Water chemistry	ammonia-nitrogen, chloride, chlorophyll-*a*, total Kjeldahl nitrogen, nitrate-nitrogen, nitrite-nitrogen, sulfate, total phosphorus, total suspended solids, volatile suspended solids, ortho-phosphate-phosphorus, and pheophytin-*a*	LCRA	TPWD retains original field sheets. LCRA sends electronic and paper results and QA/QC information to TPWD.	3	1	3
Sediment chemistry	Sediment pore water ammonia-nitrogen	LCRA	TPWD retains original field sheets. LCRA sends electronic and paper results and QA/QC information to TPWD.	3	10	30
Sediment chemistry	Grain size, total organic carbon	LCRA	TPWD retains original field sheets. LCRA sends electronic and paper results and QA/QC information to TPWD.	3	1	3
Seagrass condition indicators						
Seagrass coverage and species	Coverage estimated and species identified within a $0.25m^2$ quadrat	TPWD	TPWD retains original field sheets	3	10	30
Seagrass morphology	Core sample yielding above-ground biomass, below-ground biomass, root:shoot ratio, leaf area index, leaf width, leaf length, number of leaves per shoot, and shoot density	TPWD	TPWD retains original field and bench sheets	3	3	9
Seagrass stressor indicators						
Epiphyte biomass	Weight of epiphytes scraped off seagrass leaves	TPWD	TPWD retains original field and bench sheets	3	3	9
Macroalgae biomass	Weight of macroalgae collected from 0.0625 m^2 quadrats along transect	TPWD	TPWD retains original field and bench sheets	3	10	30

B2. Sampling Methods

Tier 2

Tier 2 sampling will include measurement of seagrass coverage and canopy height. Procedures for conducting Tier 2 sampling are described in Tier 2 Sampling Standard Operating Procedures (Appendix B).

Tier 3

Tier 3 sampling will include physicochemical, water chemistry, sediment chemistry, and seagrass condition and stressor indicators. Measurements and sample collection will occur near or on three 50 m transects which run through the seagrass bed in the area of interest. Transects encompass the deep edge of the seagrass bed, and identical measurements and sample collection will occur at each transect as detailed below.

For each type of measurement, field staff will ensure that the site is not disturbed prior to sample collection. Measurements and sample collection for water chemistry, instantaneous physicochemical parameters, light, and Secchi depth will be made from the boat, near the deep end of each transect, before commencing biological and sediment measurements and sample collection (Figure 8, Figure 9).

Tier 3 Field Sampling Procedures for Water and Sediment Quality Indicators

Field sampling for water chemistry, Secchi depth, and physicochemical measurements will be conducted according to methods described in the *TCEQ Surface Water Quality Monitoring Procedures Manual* (Volume 1) (TCEQ 2008).

A water sample will be collected at each transect (Figure 8) to be analyzed for the following parameters: ammonia-nitrogen, chloride, chlorophyll-*a*, total Kjeldahl nitrogen, nitrate-nitrogen, nitrite-nitrogen, sulfate, total phosphorus, total suspended solids, volatile suspended solids, ortho-phosphate-phosphorus, and pheophytin-*a*. High density polyethylene containers will be used to collect water for analysis. When acidification is required, the containers will be acidified with concentrated sulfuric acid in the field or a pre-acidified container will be used to reduce the pH to less than 2. The acidified container will be marked with an “X” on the cap, designating that it is chemically preserved. Each container will be labeled per TCEQ SWQM labeling guidelines and chain of custody (COC). All samples will be placed in coolers immediately for preservation at 4°C ±2° and transport to the analytical laboratories within holding times. Coolers will be kept at least half full of ice.

Minimum sample volume, container types, preservation requirements, and holding time requirements may vary, depending on laboratory and field QA/QC measures. Typical requirements are given in Table 11.

Table 11. B2.3. Typical water and sediment chemistry sample storage, preservation and handling requirements.

Parameter	Matrix	Container	Preservation	Minimum Volume	Holding Time
TSS/VSS	water	high density polyethylene	<6º C	1000 mL	7 days
ortho-Phosphate-phosphorus	water	high density polyethylene	<6º C	100 mL	field filter <15 mins after collection; analyze within 48 hrs
Nitrate-nitrogen	water	high density polyethylene	<6º C	100mL	48 hrs
Nitrite- nitrogen	water	high density polyethylene	<6º C	100 mL	48 hrs
Ammonia-nitrogen, total Kjeldahl nitrogen (TKN), total phosphorus, nitrate-nitrogen plus nitrite-nitrogen	water	high density polyethylene	<6º C, pH<2 with H_2SO_4	100 mL	28 days
Chlorophyll-*a*, pheophytin-*a*	water	high density polyethylene	<6º C, dark	500 mL	filter at lab < 48 hrs; filter may be stored frozen up to 21 days
TOC	sediment	Whirlpak	<6º C	100 g	28 days
Grain size (texture)	sediment	Whirlpak	<6º C	100 g	28 days
Pore water ammonia-nitrogen	sediment	Whirlpak	<6º C	60 mL	30 days frozen

Dissolved oxygen, conductivity, salinity, pH and temperature will be measured in the field using pre- and post-calibrated datasondes. Secchi depth and total water depth will be measured at each transect.

Photosynthetically-active radiation (PAR) will be measured at each transect in order to calculate percent surface irradiance (% SI) and light attenuation coefficient (*k*). Measurements will be made in air and in water using an LI-193SA spherical quantum sensor (LI-COR Inc., Lincoln, Nebraska, USA) according to a procedure modified from Dunton and Jackson (TPWD 2010). The measurement in air will be made first. The sensor (inspected to insure it is dry) will be plugged into the LI-1400 data logger port programmed and labeled for "dry" (in air) measurement and positioned just above the water surface. Four PAR measurements will be sequentially read and recorded on the field form. Wet measurements will be made after completion of the dry measurements. The sensor will be moved to the data logger port programmed and labeled for "wet" (in water) measurement and lowered just below the surface. Four sequential measurements will be read and recorded. Then the sensor will be lowered until reaching the top of the seagrass canopy. Four sequential measurements will be read and recorded. Finally depth measurements will be made and recorded for each of the following: total water depth, distance from the surface of the water to the top of the seagrass canopy, and distance from the top of the seagrass canopy to the bay bottom. Potential sources of error in the measurement arise from taking data sequentially, rather than simultaneously, and from extraneous sources of reflected light, such as boats or clothing. Care will be taken to observe conditions such as clouds passing over the sun during the collection of PAR data, so that all measurements are taken under similar conditions. Care will be taken to avoid holding the sensor near sources of reflected light.

Light attenuation coefficient (*k*) will be calculated using the transformed Beer Lambert equation:

$$k = -[\ln(I_z/I_0)]/z$$

where *k* is the attenuation coefficient (m-1) and I_z and I_0 are irradiance (μmol photons m^{-2} s^{-1}) at depth z (m) and at the surface, respectively. Percent surface irradiance available at the seagrass canopy will be calculated as follows:

$$\% SI = (I_z/I_0) \times 100$$

where I_z and I_0 are irradiance (μmol photons m s^{-1}) at depth z (m) and at the surface, respectively.

Sediment will be collected at each transect for sediment pore water ammonia-nitrogen, grain size, and total organic carbon. One sample will be collected at each transect for grain size and total organic carbon. For sediment pore water ammonia-nitrogen, ten samples will be taken along, but about 5 m away from each transect line, to avoid disturbing the area where percent coverage is assessed.

Each sediment pore water ammonia-nitrogen sample will be collected at the same pre-determined random distance along the transect line where the 0.25 m^2 quadrats are placed for estimating seagrass percent cover. Samples will be collected separately using a 60 mL plastic syringe barrel. The syringe barrel is inserted straight down into the sediment with a twisting motion. Once the top of the barrel is within 1-3 cm of the bottom, the diver will seal the barrel with the palm of the hand to avoid loss of sample, and pull the corer up out of the bottom. The sediment core will then be dropped into a Whirlpak bag and placed on ice for transport to the lab.

A single sediment sample for grain size analysis will be collected and preserved in the same manner, at the approximate mid-point of the transect line. In this case, two cores will be collected in order to have enough material for the lab to process the sample (>100 mL). A single sediment sample (one core) for total organic carbon will be collected and preserved in the same manner.

Processes to Prevent Contamination

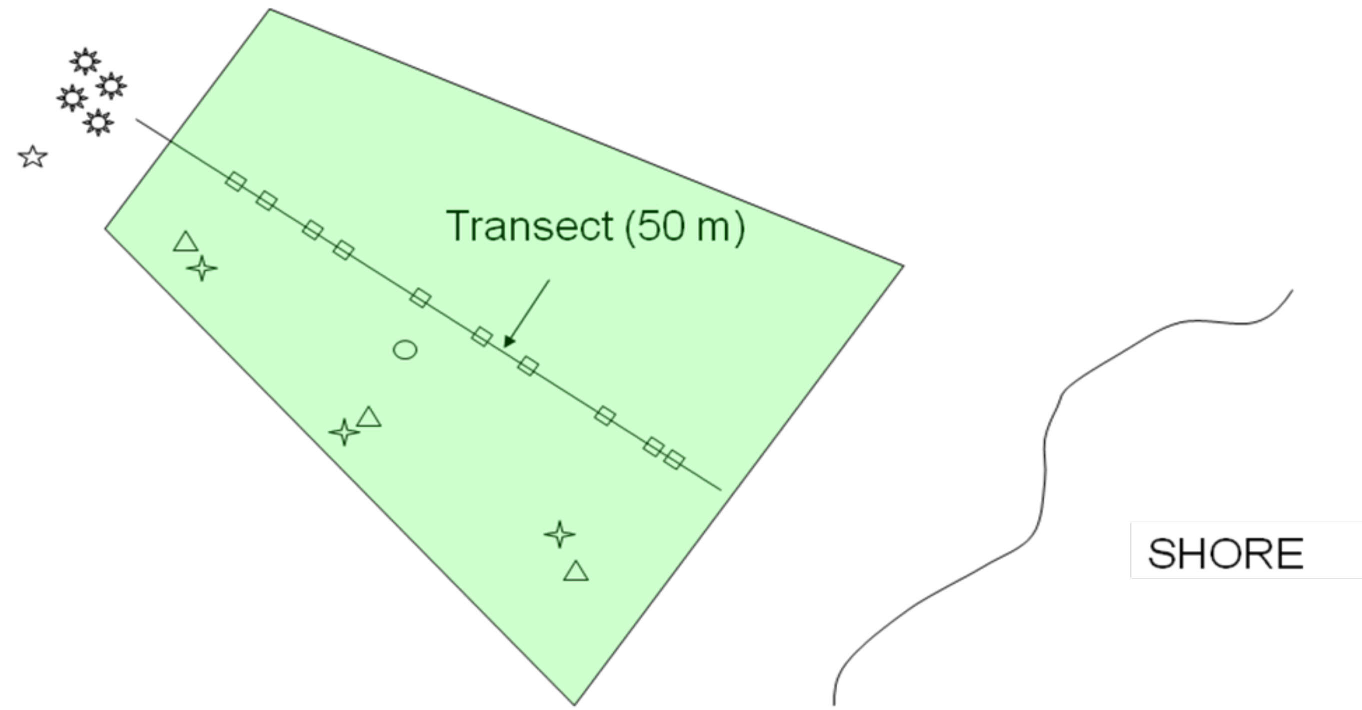
Procedures outlined in the TCEQ *Surface Water Quality Procedures Manual (Volume 1)* describe the necessary steps to prevent contamination of samples. This includes direct collection into sample containers. Field QC samples (identified in Section B5) are collected to verify that contamination has not occurred.

Tier 3 Field Procedures for Seagrass Condition and Stressor Indicators

Seagrass condition and stressor indicators will be collected using protocols modified from those developed by Dunton and Jackson as cited in a previous seagrass study (TPWD 2010). Seagrass condition indicators include seagrass percent coverage by species, seagrass biomass (total, above-ground, and below-ground), root-to-shoot ratio, shoot density, number of leaves per shoot, leaf length, leaf width, and leaf area index. Seagrass stressor indicators include macroalgae biomass and epiphytic algal biomass.

Tier 3 sample design consists of three 50 m transects which encompass the deep edge of the seagrass bed. Transects extend along the depth gradient to integrate differences in parameters that may be influenced by water depth. The transects will be temporarily marked with a PVC pole at each end, and a sinking meter tape stretched along the bottom between the two poles (the zero meter mark at the end nearest to shore). A floating line will be stretched between the two poles to assist in visualizing the location of the transect during sampling activities. The three transects will be located at least 50 m apart and will be selected to be representative of the seagrass bed in the area of interest.

Ten pre-determined random locations along the transect line will be marked before beginning (Figure 8). At each of the ten locations, a 0.0625 m^2 quadrat will be placed on the bottom along the sinking meter tape (Figure 9), and all macroalgal material within the quadrat will be collected, placed in a pre-labeled plastic bag, sealed, and then stored on ice for transport to the laboratory. Next, seagrass percent coverage by species will be estimated using a 0.25 m^2 quadrat placed at each of the ten locations along the transect line. The 0.25 m^2 quadrat area will be carefully cleared of macroalgae or other material which might obscure the view of the seagrass. A diver will examine the quadrat underwater to estimate percent coverage. Percent coverage is defined as the percent of the total quadrat area that is obscured by a particular species when viewed from directly above. The sum of percent coverage of all seagrass species, plus the percent of the quadrat that is bare, is 100%.



Seagrass core (biomass, leaf length and width, root-to-shoot ratio, leaf area index, number of leaves/shoot)
Light measurements
Instantaneous physicochemical, water chemistry, Secchi depth
Quadrats (seagrass coverage by species, macroalgae biomass, sediment pore water ammonia-nitrogen)
Sediment core (grain size and total organic carbon)
Seagrass shoots for epiphyte biomass
Seagrass bed (transect encompasses the deep edge of the seagrass bed)

Figure 8. B2.4. Schematic of field sampling design.

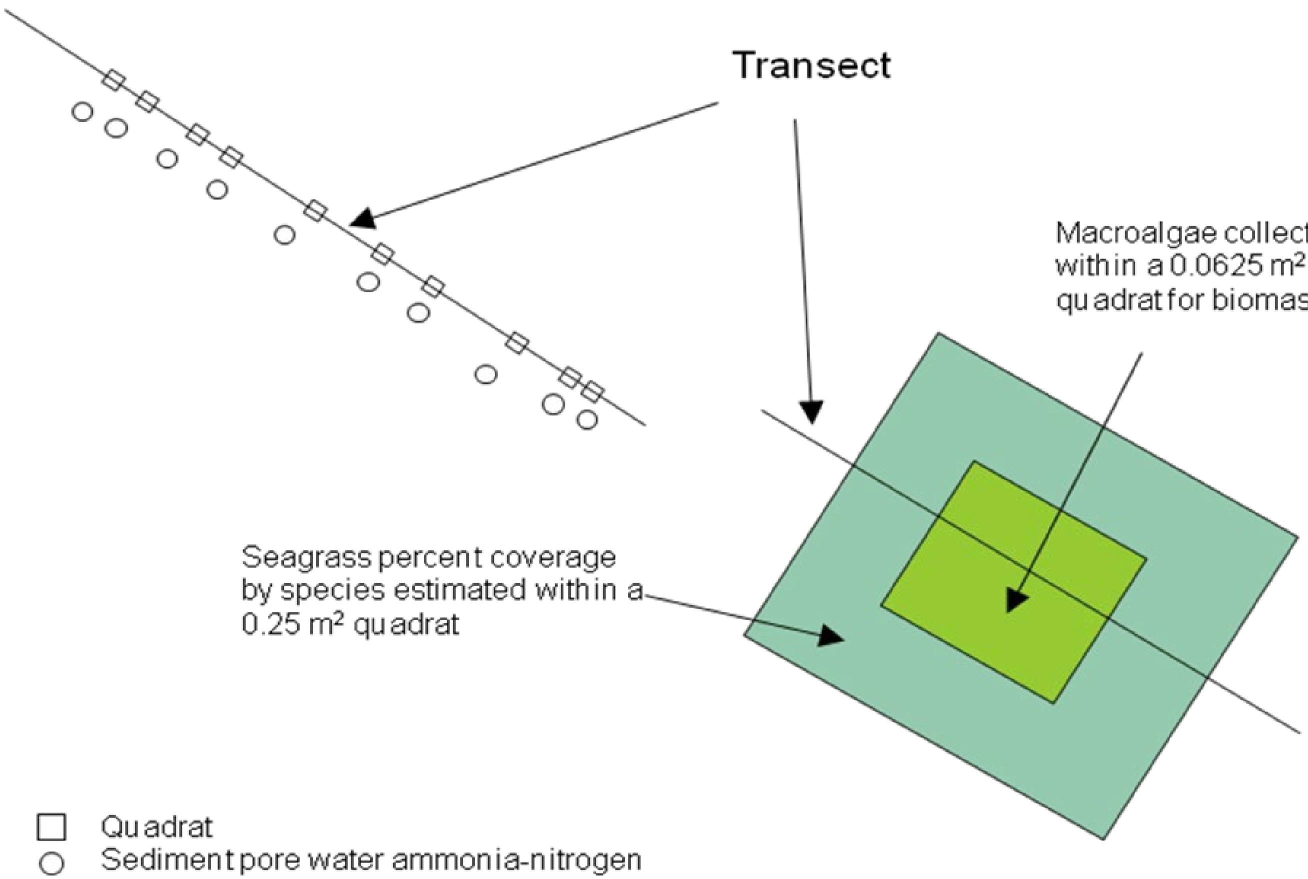


Figure 9. B2.5. Close-up of field sampling design showing quadrat.

Three seagrass cores will be taken on one side of the transect, within 25 m of the transect line. One core will be taken near the deep end of the transect, one near the midpoint of the transect, and one near the shallow end of the transect. A 15 cm inner diameter corer with a hole and rubber stopper on top (Figure 10) will be used to sample *Thalassia testudinum* (turtle grass; hereafter referred to as *Thalassia*, and a 9 cm inner diameter cylindrical corer (Figure 11) will be used to sample other Texas seagrass species: *Halodule wrightii* (shoal grass; hereafter *Halodule*), *Syringodium filiforme* (manatee grass; hereafter *Syringodium), Ruppia maritima* (widgeon grass; hereafter *Ruppia*), and *Halophila engelmannii* (star grass; hereafter *Halophila*).

Figure 10. B2.6. Seagrass corer (15 cm inner diameter) used for sampling *Thalassia*.

Figure 11. B2.7. Seagrass corer (9 cm inner diameter) used for sampling *Halodule, Syringodium, Ruppia and Halophila.*

For all species, the corer will be placed on the seabed. For *Thalassia* only, following placement of the large 15 cm corer on the seabed, the rubber stopper will be removed from the top of the corer. For all species, before pressing the corer into the sediment, the diver will feel carefully around the bottom of the corer to ensure that only seagrass belonging inside the radius of the corer is contained within. If seagrass from outside has been pulled under the corer, it will be removed. The diver will then press and twist the corer down into the sediment 10 to 15 cm. The stopper will be re-installed (15 cm corer only), and the corer rocked back and forth. The diver will then work one hand under the corer and remove it from the grass bed, making sure to keep a hand under the bottom to prevent loss of sample. After emptying material from the corer into the sieve, broken shoots will be removed since these will likely be exterior shoots cut by the corer tube. Samples will be placed in pre-labeled Ziploc bags on ice for transport to the lab.

Seagrass shoot samples will be collected near the deep end, mid-point, and shallow end of each transect, within 25 m of the transect line, for measuring epiphyte biomass. Rhizomes will be gently uprooted and the number of shoots counted to ensure that sufficient material will be available in the lab. For *Thalassia*, at least ten shoots will be needed; for other seagrass species, at least 20 shoots will be needed.

Documentation of Field Sampling Activities

Field sampling activities are documented on field data sheets. The following will be recorded for all visits:

1. Station location (latitude and longitude in decimal degrees)
2. Location
3. Sampling time
4. Sampling date
5. Sampling depth
6. Field personnel names
7. Values for all measured field parameters
8. Detailed observational data, including:
    a) water appearance
    b) weather
    c) days since last significant rainfall
    d) tide stage
9. Other observational data (*as applicable*), including:
    a) pertinent observations related to water quality or stream uses (e.g., exceptionally poor water quality conditions/standards not met; uses such as swimming, boating, fishing, etc.)
    b) unusual odors
    c) specific sample information (number of sediment grabs, type/number of fish in a tissue sample, etc.)
    d) missing parameters (i.e., when a scheduled parameter or group of parameters is not collected)
    e) algal blooms, fish kills, or pollution complaints

Recording Data

For the purposes of this section and subsequent sections, all field and laboratory personnel follow the basic rules for recording information as documented below:

1. Legible writing in indelible ink with no modifications, write-overs or cross-outs;
2. Correction of errors with a single line followed by an initial and date;
3. Close-out on incomplete pages with an initialed and dated diagonal line.

Deviations from Sampling Method Requirements or Sample Design, and Corrective Action

Examples of deviations from sampling method requirements or sample design include but are not limited to such things as inadequate sample volume due to spillage or container leaks, failure to preserve samples appropriately, contamination of a sample bottle during collection, storage temperature and holding time exceedance, sampling at the wrong site, etc. Any deviations will invalidate resulting data. Corrective action may include samples being discarded and if possible, re-collected.

B3. Sample Handling and Custody

Water and Sediment Quality Indicators and Seagrass and Stressor Condition Indicators

Chain-of-Custody

Proper sample handling and custody procedures ensure the custody and integrity of samples beginning at the time of sampling and continuing through transport, sample receipt, preparation, and analysis. A sample is in custody if it is in actual physical possession or in a secured area that is restricted to authorized personnel. The chain-of-custody form is used to document sample handling during transfer from the field to the laboratory and among subcontract laboratories. The following information concerning the sample is recorded on the chain-of-custody form.

1. Date and time of collection
2. Site identification
3. Sample matrix
4. Number of containers
5. Preservative used or if the sample was filtered
6. Analyses required
7. Name of collector
8. Custody transfer signatures and dates and time of transfer
9. Bill of lading (*if applicable*)

Sample Labeling

Samples are labeled on the container with an indelible marker. Label information includes:

1. Site identification
2. Date and time of sampling
3. Replicate number (if applicable)
4. Preservative added, if applicable
5. Designation of field-filtered, if applicable
6. Sample type

Sample Handling

The samples will be transported or shipped to the designated laboratory within the required holding times for the various parameters being analyzed. The sample custody will be transferred to the laboratory custodian and the samples left there for analyses.

Failures in Chain-of-Custody and Corrective Action

Failures associated with chain-of-custody procedures are immediately reported to the TPWD Project Manager. These may include delays in transfer, resulting in holding time violations; violations of sample preservation requirements; incomplete documentation, including signatures; possible tampering of samples; broken or spilled samples, etc. The TPWD Project Manager, in consultation with the QAPO, will determine if the procedural violation may have compromised the validity of the resulting data and how the issue will be resolved based on best professional judgment. Possible courses of action include, document and proceed; redo the entire sampling event; or selectively analyze the samples. Corrective action documentation is maintained by the TPWD.

B4. Analytical Methods

Water and Sediment Quality Indicators

Laboratory analysis techniques will be in accordance with the most recently published edition of *Standard Methods for the Examination of Water and Wastewater*, 40 CFR 136, or other reliable procedures as described in this QAPP.

Water and sediment chemistry samples will be analyzed by LCRA using methods described in Table 3.

Standards Traceability

All standards used in the field and laboratory are traceable to certified reference materials. Standards preparation is fully documented and maintained in a standards log book. Each documentation includes information concerning the standard identification, starting materials, including concentration, amount used and lot number; date prepared, expiration date and preparer's initials/signature. The reagent bottle is labeled in a way that will trace the reagent back to preparation.

Analytical Method Modification

Only data generated using approved analytical methodologies as specified in this QAPP will be submitted to the TCEQ.

Failures or Deviations in Analytical Method Requirements and Corrective Actions

Failures in field and laboratory measurement systems involve, but are not limited to, instrument malfunctions, failures in calibration, blank contamination, QC sample problems (i.e., poor spike recoveries), etc. In many cases, the field technician or lab analyst will be able to correct the problem (i.e., via re-calibration or re-analysis). If the problem is resolvable by the field technician or lab analyst, then they will document the problem on the field data sheet or laboratory record and complete the analysis. If the problem is not resolvable, then it is conveyed to the respective supervisor, who will make the determination. If the analytical system failure compromises the sample results, the data will not be reported to the TCEQ as part of this study. The nature and disposition of the problem is documented on the data report which is sent to the TPWD Project Manager. Corrective action documentation is maintained by the TPWD.

Seagrass Condition and Stressor Indicators

Seagrass and macroalgae samples will be analyzed in the laboratory for shoot density, above- and below-ground biomass, root-to-shoot ratio (ratio of below-ground biomass to above-ground biomass), number of leaves per shoot, leaf width, leaf length leaf area index (product of shoot density, average leaf length, and average leaf width), epiphyte biomass, and macroalgae biomass as described below, following procedures developed by Dunton and Jackson as cited in a previous seagrass study (TPWD 2010).

Macroalgae samples from each quadrat will be rinsed gently with tap water to clean. Rinsed samples will be placed into white lab sorting trays, and non-macroalgae material (seagrass, shells, sediment, etc.) will be removed (Figure 12). Samples will then be placed into a device designed to spin excess water from salad greens (Salad Spinner) and spun to drive off as much water as possible from the material. Samples will next be placed into pre-labeled aluminum foil envelopes for drying in the oven at 60°C. The top of the envelope will be left open to allow water vapor to escape.

Figure 12. B4.1. Close-up view of cleaned macroalgae in lab sorting tray.

Seagrass core samples will be rinsed gently with tap water to clean. Samples will be placed into white lab sorting trays, and non-seagrass material and dead plant material will be removed (Figure 13). Individual shoots will be counted using tally counters to maintain accuracy (Figure 14, Figure 15). Five shoots selected at random will be further examined for the calculation of leaf area index. For each shoot the number of leaves per shoot will be recorded. The length (to the nearest 0.1 cm) and width (to the nearest 0.5 mm) of the longest leaf of each shoot will be recorded. Leaf width will be measured at the midpoint of the leaf (halfway between the base and the top). Shoots will then be processed along with the rest of the sample. Above-ground tissue (leaves, sheaths, any floral parts) will be separated from below-ground tissue (roots and rhizomes) by cutting the leaf at the point where the green color fades to white. Above-ground tissue will be carefully cleaned of attached biota (such as epiphytes, hydrozoans, and polychaete worms) by scraping with a wet cloth, forceps, scalpel, or razor blade. Above-ground tissue and below-ground tissue will then be placed in separate pre-labeled and pre-weighed aluminum foil envelopes for drying in the oven at 60°C. The top of the envelope will be left open to allow water vapor to escape.

Figure 13. B4.2. Processing seagrass core samples in lab.

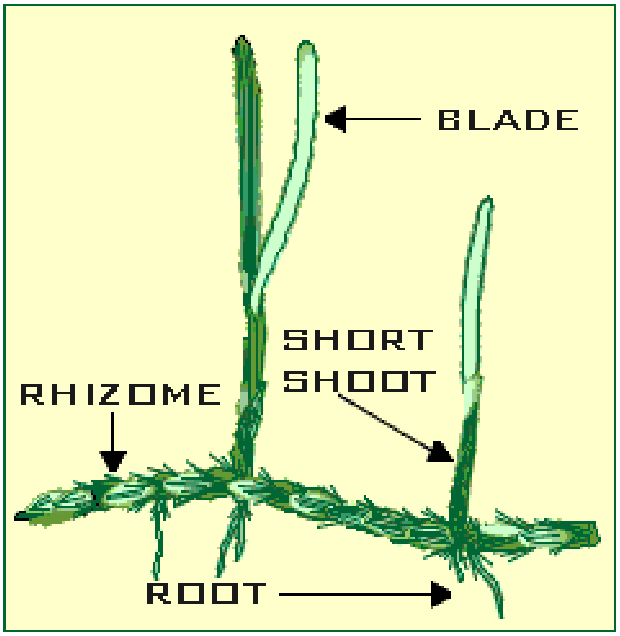


Figure 14. B4.3. Diagram illustrating typical seagrass plant morphology (University of Florida, 2011). For purposes of this project, the area labeled "blade" on the diagram will be consistently referred to as "leaf."

Figure 15. B4.4. Seagrass core sample in lab sorting tray prepared for cleaning and counting shoots.

For epiphyte biomass determinations, seagrass shoots must be processed within three days of collection. Epiphytes will be separated from the leaf surface by scraping with a scalpel, forceps, or razor blade. For *Halodule*, *Syringodium*, *Ruppia* or *Halophila*, at least twenty leaves of each sample (both sides of the leaf) will be scraped in this way. For *Thalassia*, a minimum of five leaves will be scraped. The same length is scraped on each leaf (e.g., 10 cm or 15 cm of each leaf is scraped). The length and width of the area scraped and the total number of leaves scraped will be recorded. Scraped material is collected on pre-weighed glass fiber filters. The collected epiphyte biomass sample and scraped seagrass leaves are then dried in separate pre-labeled aluminum foil envelopes in the oven at 60 °C. The top of the envelope will be left open to allow water vapor to escape.

Analytical Method Modification
Only data generated using approved analytical methodologies as specified in this QAPP will be submitted to the TCEQ.

B5. Quality Control

Water and Sediment Quality Indicators

Field Measurement Quality Control Requirements and Acceptability Criteria
The minimum Field QC Requirements are outlined in the *TCEQ Surface Water Quality Monitoring Procedures Manual* (Volume 1) (TCEQ 2008). Field instruments (for example, multi-parameter datasondes) will be calibrated against known standards, following the specified procedures, within 24-hours prior to sampling. Standards will not be used if they have expired (exceeded shelf life clearly labeled on standards container). If a field instrument does not pass pre-sampling calibration, it will not be used to collect data. Within 24 hours following sampling, field instruments will be checked against calibration standards to ensure that measurements are within required limits as specified in the *TCEQ Surface Water Quality Monitoring Procedures Manual* (Volume 1; TCEQ 2008). Data collected by instruments which do not meet the post-calibration check requirements will be flagged. Pre-sampling and post-sampling calibrations will be recorded.

Irradiance values will be compared with other sensors calibrated against a National Bureau of Standards (NBS) standard. Mean values of irradiance measurements will be provided from replicate sample measurements.

<u>Field Split</u> - A field split is a single sample subdivided by field staff immediately following collection and submitted to the laboratory as two separately identified samples according to procedures specified in the *TCEQ Surface Water Quality Monitoring Procedures Manual* (Volume 1) (TCEQ 2008). Split samples are preserved, handled, shipped, and analyzed identically and are used to assess variability in all of these processes. Field splits apply to conventional samples only and are collected on a 10% basis or one per batch, whichever is greater. The precision of field split results is calculated by relative percent difference (RPD) using the following equation:

$$RPD = (X1-X2)/((X1+X2)/2))*100$$

A 30% RPD criteria will be used to screen field split results as a possible indicator of excessive variability in the collection and analytical system. If it is determined that meaningful quantities of constituent were measured and analytical variability can be eliminated as a factor, than variability in field split results will primarily be used as a trigger for discussion with field staff to ensure samples are being handled in the field correctly. Some sample results or batches of samples may be invalidated based on the examination of all extenuating information. Professional judgment during data validation will be relied upon to interpret the results and take appropriate action.

Laboratory Measurement Quality Control Requirements and Acceptability Criteria
Detailed laboratory QC requirements and corrective action procedures are contained within the individual laboratory procedures. Minimum requirements are stated below. Lab QC sample results are submitted with the laboratory data report.

Limit of Quantitation (LOQ) - The laboratory will analyze a calibration standard (where applicable) at the LOQ concentration on each day samples are analyzed. All calibrations must meet the requirements of the analytical method or corrective action shall be implemented.

LOQ Check Sample – An LOQ check sample consists of a sample matrix (e.g. deionized water, sand, commercially available tissue) free from the analytes of interest spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. It is used to establish intra-laboratory bias to assess the performance of the measurement system at the lower limits of analysis. The LOQ check sample is spiked into the sample matrix at a level less than or near the LoQ for each analyte for each batch of samples analyzed.
The LOQ check sample is carried through the complete preparation and analytical process. LOQ check samples are run at a rate of one per analytical batch.
The percent recovery of the check standard is calculated using the following equation in which %R is percent recovery, SR is the sample result, and SA is the reference concentration for the check standard:

$$\%R = SR/SA * 100$$

Control limits are used to determine the acceptability of LOQ check sample analyses as specified in Table 3.

LCS - A LCS consists of analyte-free water spiked with the analyte of interest prepared from standardized reference material. The LCS is spiked into laboratory-pure water at a level less than or equal to the mid-point of the calibration curve for each analyte. The LCS is carried through the complete preparation and analytical process. The LCS is used to document the bias of the analytical process. LCSs are run at a rate of one per batch. Results of LCSs are calculated by percent recovery (%R), which is defined as 100 times the measured concentration, divided by the true concentration of the spiked sample.

The following formula is used to calculate percent recovery, where %R is percent recovery; SR is the measured result; SA is the true result

$$\%R = SR/SA * 100$$

Performance limits and control charts are used to determine the acceptability of LCS analyses. Project control limits are specified in Table 3.

Laboratory Duplicates - A laboratory duplicate is prepared in the laboratory by splitting aliquots of an LCS. Both samples are carried through the entire preparation and analytical process. LCS duplicates are used to assess precision and are performed at a rate of one per batch.

For most parameters, precision is calculated by the relative percent difference (RPD) of LCS duplicate results as defined by 100 times the difference (range) of each duplicate set, divided by the average value (mean) of the set. For duplicate results, X_1 and X_2, the RPD is calculated from the following equation:

$$RPD = (X_1 - X_2)/\{(X_1+X_2)/2\} * 100$$

Matrix spike (MS) - A matrix spike is an aliquot of sample spiked with a known concentration of the analyte of interest. Percent recovery of the known concentration of added analyte is used to assess accuracy of the analytical process. The spiking occurs prior to sample preparation and analysis. Spiked samples are routinely prepared and analyzed at a rate of 10% of samples processed, or one per batch whichever is greater. The MS is spiked at a level less than or equal to the midpoint of the calibration or analysis range for each analyte. Percent recovery (%R) is defined as 100 times the observed concentration, minus the sample concentration, divided by the true concentration of the spike.

The percent recovery of the matrix spike is calculated using the following equation in which %R is percent recovery, SSR is the observed spiked sample concentration, SR is the sample result, and SA is the reference concentration of the spike added:

$$\%R = (SSR - SR)/SA * 100$$

MS recoveries are plotted on control charts and used to control analytical performance. Measurement performance specifications for matrix spikes are not specified in this document.

Method blank - A method blank is an analyte-free matrix to which all reagents are added in the same volumes or proportions as used in the sample processing and analyzed with each batch. The method blank is carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination from the analytical process. The analysis of method blanks should yield values less than the reporting limit. For very high-level analyses, the blank value should be less then 5% of the lowest value of the batch, or corrective action will be implemented.

Additional method-specific QC requirements - Additional QC samples are run (*e.g.*, sample duplicates, surrogates, internal standards, continuing calibration samples, interference check samples) as specified in the methods. The requirements for these samples, their acceptance criteria, and corrective actions are method-specific.

Failures in Field and Laboratory Quality Control and Corrective Action
Sampling QC excursions are evaluated by the TPWD Project Manager, in consultation with the QAPO. Since differences in field duplicate sample results are used to assess the entire sampling process, including environmental variability, the automatic rejection of results based on control chart limits is not practical. Therefore, some professional judgment will be relied upon in evaluating results. Rejecting sample results based on wide variability is a possibility. Blank data are scrutinized very closely. Blank values exceeding the acceptability criteria may automatically invalidate the sample, especially in cases where high blank values may be indicative of contamination which may be causal in putting a value above the standard.

Laboratory measurement quality control failures are evaluated by the laboratory staff. The disposition of such failures is discussed in Section B4 under "Failures or Deviations in Analytical Methods and Corrective Actions." Corrective action documentation is maintained by the TPWD.

Seagrass Condition and Stressor Indicators
Mean values of seagrass condition (above- and below-ground biomass, shoot density, leaf width, leaf length, number of leaves per shoot), epiphyte biomass and macroalgae biomass measurements will be provided from replicate sample measurements.

B6. Instrument/Equipment Testing, Inspection and Maintenance

Field Equipment
All sampling equipment testing and maintenance requirements are detailed in the *TCEQ Surface Water Quality Monitoring Procedures Manual* (Volume 1) (TCEQ 2008). Sampling equipment is inspected and tested upon receipt and is assured appropriate for use. Equipment is maintained in working condition.

LCRA Laboratory
All laboratory tools, gauges, instruments, and equipment testing and maintenance requirements are contained within laboratory QAM(s). Testing and maintenance records are maintained and are available for inspection. Instruments requiring daily or in-use testing include, but are not limited to, water baths, ovens, autoclaves, incubators, refrigerators, and laboratory pure water. Critical spare parts for essential equipment are maintained to prevent downtime.

TPWD Laboratory

Analytical balances will be calibrated annually using standard weights. Oven thermometers will be checked annually using a NIST traceable thermometer.

B7. Instrument Calibration and Frequency

Field Equipment

Field equipment calibration requirements are contained in the *TCEQ Surface Water Quality Monitoring Procedures Manual* (Volume 1) (TCEQ 2008). Instruments not meeting post-calibration error limit requirements invalidate associated data. LI-COR light sensors are re-calibrated periodically to within ± 5% of NBS standards by LI-COR, Inc.

LCRA Laboratory

Detailed laboratory calibrations are contained within the QAM(s). The laboratory QAM identifies all tools, gauges, instruments, and other sampling, measuring, and test equipment used for data collection activities affecting quality that must be controlled and, at specified periods, calibrated to maintain bias within specified limits. Calibration records are maintained, are traceable to the instrument, and are available for inspection. Equipment requiring periodic calibrations include, but are not limited to, thermometers, pH meters, balances, incubators, turbidity meters, and analytical instruments. Calibration records are available for review.

TPWD Laboratory

Analytical balances are calibrated periodically using standard weights.

B8. Inspection/Acceptance of Supplies and Consumables

TPWD evaluates items and services received from suppliers upon delivery. These evaluations are based on defined acceptance criteria such as task specifications, product specifications, technical requirements, and quality requirements. The Project Manager or designee determines whether a product or service meets the established acceptance criteria.

TPWD will not use items or services that do not meet acceptance criteria. Corrective actions may range from repair or replacement of defective deliverables to re-award of procurements. State statutes, contract provisions, and TPWD Procurement procedures are the basis for initiating corrective actions.

B9. Non-Direct Measurements

No non-direct measurement sources will be required for this project.

B10. Data Management

Data collected by field staff will be recorded on field data sheets. Field data sheets will be scanned and stored electronically on the TPWD network, and backed up on a second drive on or other electronic medium such as a compact disk or DVD. Laboratory bench sheets will be scanned and stored in the same manner as field data sheets. Electronic data provided by LCRA will be stored on the TPWD network and backed up on a second drive or other electronic medium.

Original data sheet and electronic files will be maintained at the office of the Project Manager in Austin. The TPWD QAPO will validate data and verify that it meets quality requirements as set forth in this QAPP. Any data deemed unacceptable as set forth in this QAPP will not be used. The TPWD Project Manager/Data Manager will maintain data in a Microsoft Access database in Austin, and will report data to TCEQ at the end of the project in Microsoft Excel format, or other format agreed upon between the TPWD Project Manager and the TCEQ Project Manager. TPWD will upload data to EPA's Water Quality Exchange as resources allow.

Data Flow

Water and Sediment Quality Indicators and Seagrass Condition and Stressor Indicators

LCRA or Project Staff→ TPWD Project Manager/Data Manager and QAPO→ Data Manager (data entry) → QAPO (data entry QA review)→ TPWD Project Manager→TCEQ Project Manager

Data Errors and Loss

Data collectors have primary responsibility for ensuring that any errors in data are corrected or reported as a non-compliance or deficiency at the time of collection. Screening of data for completeness occurs at each step in the data flow process, and incomplete data (such as a date, or time, collector's name) is recovered as quickly as possible. If error or loss renders data unsuitable for use, a record will be made of the non-compliance or deficiency and the circumstances surrounding this occurrence.

Record Keeping and Data Storage

Original TPWD data sheets, laboratory bench sheets, and hard-copy printouts, as well as back-up electronic files, will be maintained in the office of the Project Manager in Austin. The Project Manager will enter data into a Microsoft Access database. Electronic files will be backed up on CDs, DVDs, flash drives, or a common network drive. All records will be maintained for a minimum of 5 years from date of collection.

Data Handling, Hardware, and Software Requirements

All specifications for computer hardware and software selected for TPWD's environmental programs are consistent with agency standards for performing all functions required to calculate, handle and otherwise manipulate data and produce reports, through time-tested applications.

C1. Assessment and Response Actions

The following table presents the types of assessments and response actions for data collection activities applicable to the QAPP.

Table 12. C1.1. Assessments and response requirements.

Assessment Activity	Approximate Schedule	Responsible Party	Scope	Response Requirements
Status Monitoring Oversight, etc.	Continuous	TPWD—all project staff	Monitoring of the project status and records to ensure requirements are being fulfilled	Update project group periodically
Annual Project Report	Once per year	TPWD Project manager	Brief description of pertinent aspects of the project including status, quality assessments performed, and any quality problems encountered.	Together with other annual quality meeting participants, determine what, if any, response actions are necessary

Corrective Action

The TPWD Project Manager is responsible for implementing and tracking corrective action procedures as a result of audit findings.

C2. Reports to Management

The Project Manager will submit the QAPP, including any revisions of the QAPP, to the TCEQ Project Manager. The Project Manager will also submit quarterly progress reports and a final report to the TCEQ Project Manager, as required by contract.

D1. Data Review Verification and Validation

All field and laboratory data will be reviewed and verified for integrity and continuity, reasonableness, and conformance to project requirements, and then validated against the data quality objectives, which are listed in Section A7. Only those data, which are supported by appropriate quality control data and meet the data quality objectives defined for this project, will be considered acceptable.

D2. Verification and Validation Methods

Data will be reviewed, verified and validated to ensure they conform to project specifications and meet the conditions of end use as described in Section A7 of this document.

Data review, verification, and validation will be performed using self-assessments and peer and management review as appropriate to the project task. The information to be reviewed, verified, and validated as appropriate (listed by task and responsible party in Table 13**)** is evaluated against technical and project specifications and checked for errors, especially errors in calculations, data reduction, and transcription. Potential errors are identified by examination of documentation and by manual or computer-assisted examination of corollary or unreasonable data. If a question arises or an error is identified, the manager of the task responsible for generating the data is contacted to resolve the issue. Issues which can be corrected are corrected and documented. If an issue cannot be corrected, the task manager consults with higher-level project management to establish the appropriate course of action, or the data associated with the issue are rejected. Reviews, verifications, and validations will be documented.

Data validation tasks to be addressed by project staff include, but are not limited to, the confirmation of data review, evaluation of field QC results, additional evaluation of anomalies and outliers, analysis of sampling and analytical gaps, and confirmation that all parameters and sampling sites are included in the QAPP. Any suspected errors or anomalous data must be addressed by the manager of the task associated with the data before data validation can be completed. The TPWD Project Manager validates that the data meet the data quality objectives of the project.

Table 13. D2.1. Data review, verification, and validation tasks.

Data to be Verified	Field Task	Vendor or Lab Task	Project Manager and/or QAPO
Field documentation complete	√		
Instrument calibration data complete	√	√	
Holding times not exceeded	√	√	
Sample preservation and handling acceptable	√	√	
Standards and reagents traceable	√	√	
Analytical sensitivity consistent with QAPP		√	√
Laboratory bench-level review performed		√	
QC samples analyzed at required frequencies	√	√	√
QC results meet performance and program specifications	√	√	√
Collection, preparation and analysis techniques consistent with SOPs and QAPP	√	√	√
Valid parameter codes			√
Results, calculations, transcriptions checked	√	√	
Corollary data agree	√	√	√
Nonconforming occurrences documented	√	√	√
Reasonableness check performed			√
Completeness and accuracy of the data sets will be verified			√

D3. Reconciliation with User Requirements

Data produced in this project will be analyzed and reconciled with project data quality requirements. Data meeting project requirements will be used by the TPWD for resource management and protection purposes and submitted to the TCEQ.

References

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Appendix A – Sample Size Analysis for Statewide Seagrass Monitoring

Sample Size Analysis for Statewide Seagrass Monitoring

Mark Fisher, Ph.D.

Tier-2 seagrass monitoring, as recommended in Dunton et al. (2011), utilizes fixed stations to be sampled annually as a single-factor repeated-measures design. Seagrass parameters are measured and recorded as the dependent variable, with time as the treatment. Each station will be sampled a repeated number of times during the course of the project, currently recommended at once per year at the same time each year. Data will be statistically analyzed to monitor change over time.

The advantage of this design is in its statistical power and efficiency. The number of stations required is a fraction of the number that would be required for a simple one-way design with randomly-selected stations (Vickers 2003). Specifically, this is because the within-station variance of repeated measures is typically lower than the between-station variance of a simple one-way design. The error variance associated with the treatment is smaller in the cast of repeated measures than that expected in a design using independent samples. Lower variance requires fewer samples to detect a treatment effect.

The disadvantage of this design is that it complicates the analysis of the data. Repeated-measures designs are more sensitive to violations in the model assumptions (e.g., normality, homogeneity of variance between transects and covariance within transects) (Littell 2006). Also, the repeated-measures design must be accounted for in the analysis in order to use the appropriate error term and degrees of freedom. If these data are analyzed as if they were from a simple one-way design, for example, then the probability of a Type II error (falsely accepting there has been no change in the measured parameters) is increased.

Sample size analysis is essential to ensure good study design. Too few samples diminish the usefulness of the results, while too many samples are a waste of resources. This can be a difficult decision, as there is often not enough information to determine the optimum number of samples. Also, different parameters may have different optimal samples sizes, and their conflicting requirements will need to be reconciled and compromised (Kish 1965).

Sample size requirements are dependent upon 4 factors: 1) variance of the parameters of interest, 2) effect size, 3) power, and 4) significance level (Quinn and Keough 2002). Of these, effect size, power and significance level are within direct control of the researcher, while variance is a property of the parameter of interest and is not directly controlled. However, a good study design can reduce the variability of samples.

Sample sizes are proportional to the variance between samples, where a population that is highly variable will require more samples than one that exhibits less variability to achieve the same level of precision. Precision is always dependent upon the sample size, with a large sample size producing estimates with greater precision than one with a smaller number of samples (Cohen 1988).

The effect size, or how large of a change we wish to detect, can be the most difficult step in a sample size analysis (Quinn and Keough 2002). The effect size is selected based on biological significance, where we want the study to identify a change in the seagrass population that is important to assess their overall condition. Often, there are no clear criteria for specifying a significant biological effect. A large effect requires fewer samples to detect than a small effect.

Power is the probability to detect a significant difference, if it exists. Power can be used *a priori* to design a sampling program in two ways—to determine a sample size with a given effect size, or to determine the effect size with a given sample size. By convention, power is set to a value of $1 - \beta = 0.8$ (Cohen 1988). Low power increases the probability of rejecting a false null hypothesis, i.e., a Type II error or a false negative. Power increases with an increase in sample size.

Finally, significance level, set by convention to $\alpha = 0.05$, is the probability of rejecting a true null hypothesis, i.e., a Type I error or a false positive. If α is set to a smaller value, then power will decrease, unless the sample size is increased. Similarly, if the significance level is set to a low value and power is increased, then the required sample size becomes very large. The convention of $\alpha = 0.05$ and $1 - \beta = 0.8$ is a balance between Type I errors and Type II errors, where Type I errors (false positives) are more serious and should be more stringently guarded against than Type II errors (false negatives) (Cohen 1988).

I based sample size requirements for tier-2 monitoring on the 2010 statewide Phase 1 seagrass survey results conducted by TCEQ and the TPWD CMPSEA seagrass survey in Port Bay and East Flats conducted by Contreras et al. (2011). Summary results for number of blades/plant, blade width and length of longest blade are presented in Table 1. The coefficient of variation (CV), which is the standard deviation as a percentage of the mean, allows comparison of the standard deviations from different species and surveys with different mean values.

The efficiency of the repeated-measures design is dependent upon the within-station correlation between successive measurements; a high correlation results in a small within-station variance, where a zero correlation results in a within-station variance that is equal to the between station variance with no efficiency gain (Keppel 1973). Neither the statewide nor the CMPSEA survey results could provide information on the annual within-station correlation of seagrass parameters.

A plot of power versus sample size for the number of blades/plant is shown in Figure 1. I used the CMPSEA values for *Halodule*, as the CV was among the highest observed; I discounted the values for *Ruppia* because of the extreme differences between the two surveys and the low number of observations. I also discounted values for *Syringodium*, as blades counts were either 1's or 2's. For correlation, I assumed a range of 0.4—0.7 and calculated the sample size needed for a paired t-test (same result as a single-factor repeated-measures design with only 2 measurements, i.e., a before/after design). Mean differences of 0.12, 0.25, 0.50 and 0.75 correspond to 5%, 10%, 20% and 30% changes. A sample size of $n = 50$ would be adequate to detect a 10% change in the number of blades/plant.

A plot of power versus sample size for mean blade width is shown in Figure 2. I used the statewide value for *Thalassia*, as the CV was this highest observed. All values for *Ruppia* were

1 mm and exhibited zero variability in both surveys. For correlation, I assumed a range of 0.4—0.7 and calculated the sample size needed for a paired t-test (same result as a single-factor repeated-measures design with only 2 measurements, i.e., a before/after design). Mean differences of 0.29, 0.58, 1.16 and 1.74 correspond to 5%, 10%, 20% and 30% changes. A sample size of n = 40 would be sufficient to detect a 10% change in the mean blade width.

A plot of power versus sample size for longest blade length is shown in Figure 3. I used the statewide value for *Thalassia*, as the CV was the second-highest observed. *Ruppia* exhibited the highest CV, but I discounted this result because of the low number of observations (n=8). For correlation, I assumed a range of 0.4—0.7 and calculated the sample size needed for a paired t-test (same result as a single-factor repeated-measures design with only 2 measurements, i.e., a before/after design). Mean differences of 0.6, 1.2, 2.4 and 3.6 correspond to 5%, 10%, 15% and 20% changes. A sample size of n = 50 would be sufficient to detect a 20% change in the longest blade length.

A plot of power versus sample size for species composition is shown in Figure 4. Variances for proportions are dependent upon the mean and is highest at p=0.5 (Cochran 1977). I used this value for sample size estimates. For correlation, I assumed a range of 0.4—0.7 and calculated the sample size needed for McNemar's correlated proportions (same result as a single-factor repeated-measures design with only 2 measurements, i.e., a before/after design). A sample size of n = 50 would be sufficient to detect a 20% change in the species composition.

A sample size of 50 coastwide stations would be adequate to detect a 10% change in blades/plant and mean blade width, and a 20% change in the longest blade length and in species composition.

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Table 1. Summary results from the 2010 statewide and CMPSEA seagrass surveys.

Parameter	Searass	Survey	n	Mean	S.D.	CV
Number of blades	*Halodule*	Statewide	85	2.3	0.55	24.1
		CMPSEA	205	2.51	0.66	26.3
	Thalassia	Statewide	15	2.66	0.31	16.2
		CMPSEA	61	2.88	0.66	22.1
	Syringodium	Statewide	20	1.9	0.31	16.2
		CMPSEA	24	1.21	0.41	34.3
	Ruppia	Statewide	8	2.62	0.52	19.7
		CMPSEA	21	6.57	5.90	89.8
Blade width, mm	*Halodule*	Statewide	85	0.99	0.05	5.4
		CMPSEA	205	1.02	0.11	11.1
	Thalassia	Statewide	15	5.8	1.13	34.2
		CMPSEA	61	6.24	1.14	22.6
	Syringodium	Statewide	20	1.5	0.51	34.1
		CMPSEA	24	1.13	0.30	27.0
	Ruppia	Statewide	8	1.0	0	0
		CMPSEA	21	1.0	0	0
Longest blade length, cm	*Halodule*	Statewide	85	11.9	4.14	34.9
		CMPSEA	205	19.0	7.48	39.4
	Thalassia	Statewide	15	12.8	5.87	45.8
		CMPSEA	61	32.4	17.25	35.9
	Syringodium	Statewide	20	20.6	7.58	36.8
		CMPSEA	24	29.3	10.5	35.9
	Ruppia	Statewide	8	6.8	3.90	57.8
		CMPSEA	21	9.4	4.22	45.1

Figure 1. Sample size vs power for mean differences in the number of blades/plant of 0.14 (5%), 0.28 (10%), 0.56 (20%) and 0.84 (30%). The reference line of power = 0.8 is the convention used.

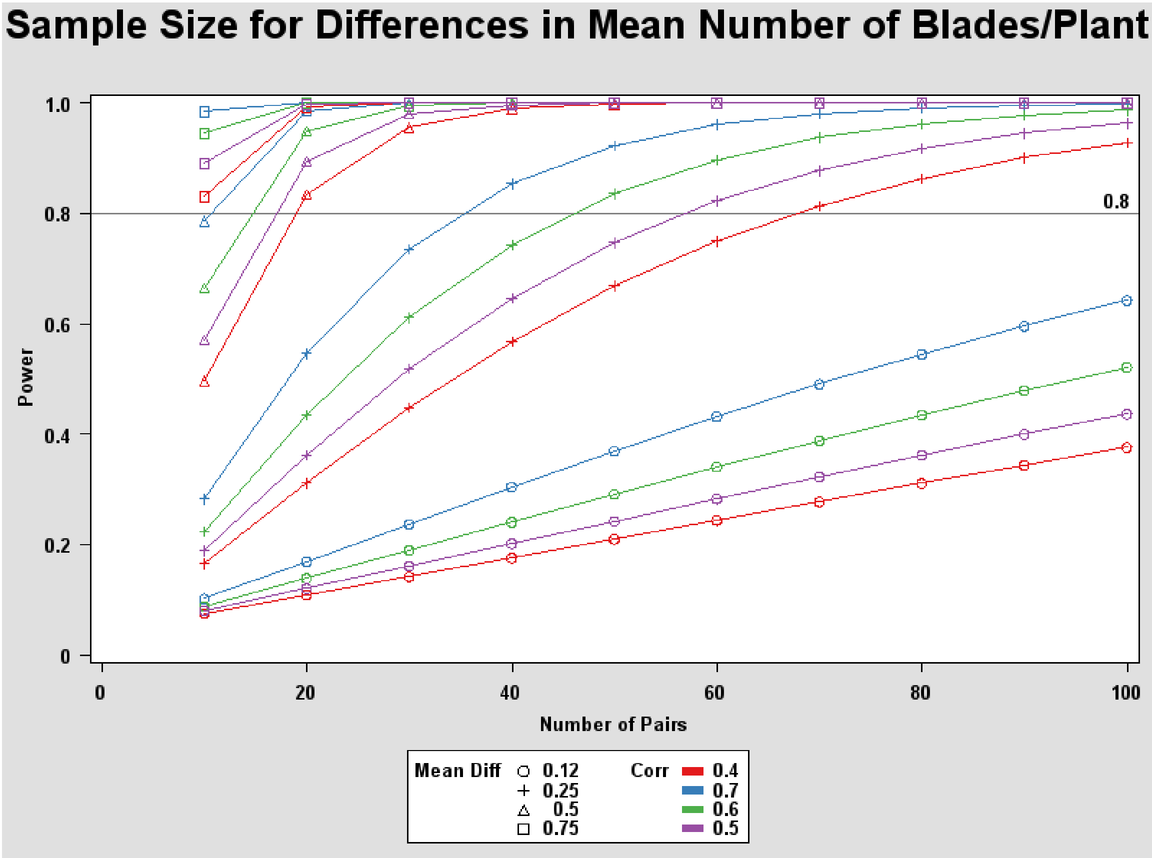


Figure 2. Sample size vs power for mean differences in the blade widths of 0.29 (5%), 0.58 (10%), 1.16 (20%) and 1.74 (30%). The reference line of power = 0.8 is the convention used.

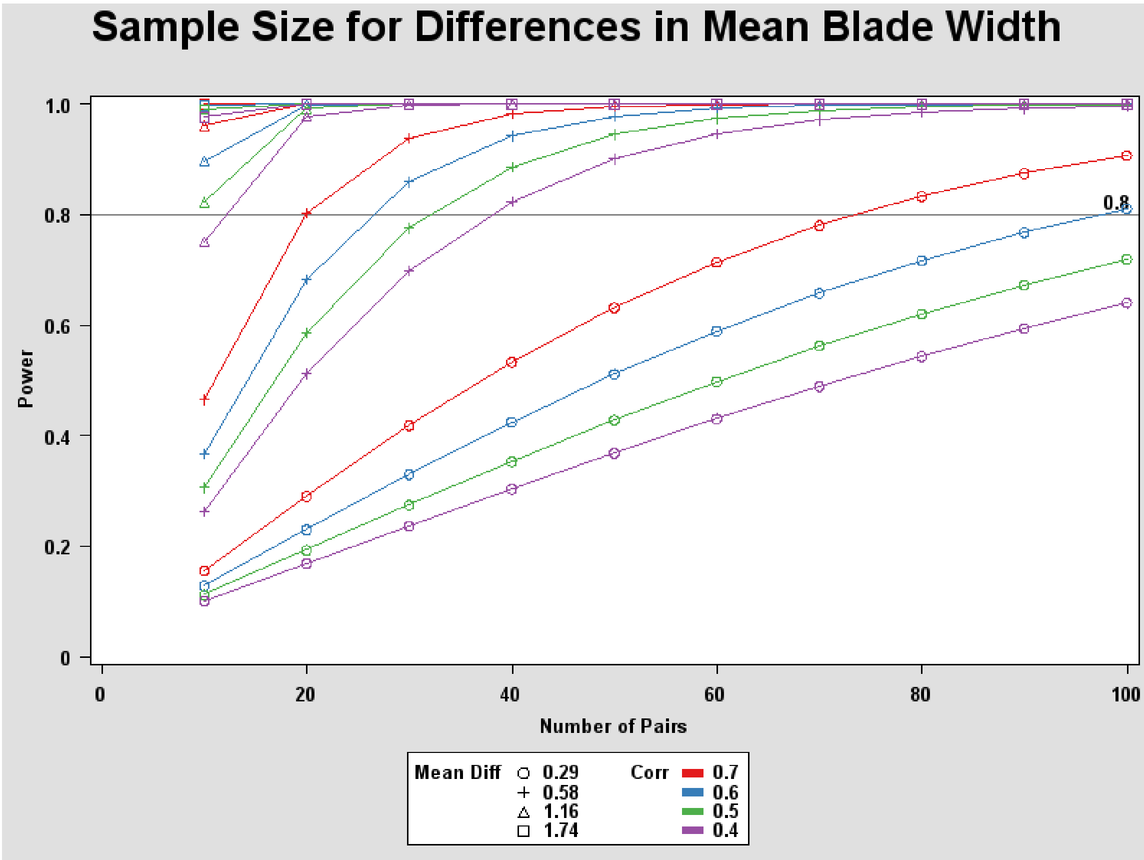


Figure 3. Sample size vs power for mean differences in the longest blade length of 0.6 (5%), 1.2 (10%), 2.4 (20%) and 3.6 (30%). The reference line of power = 0.8 is the convention used.

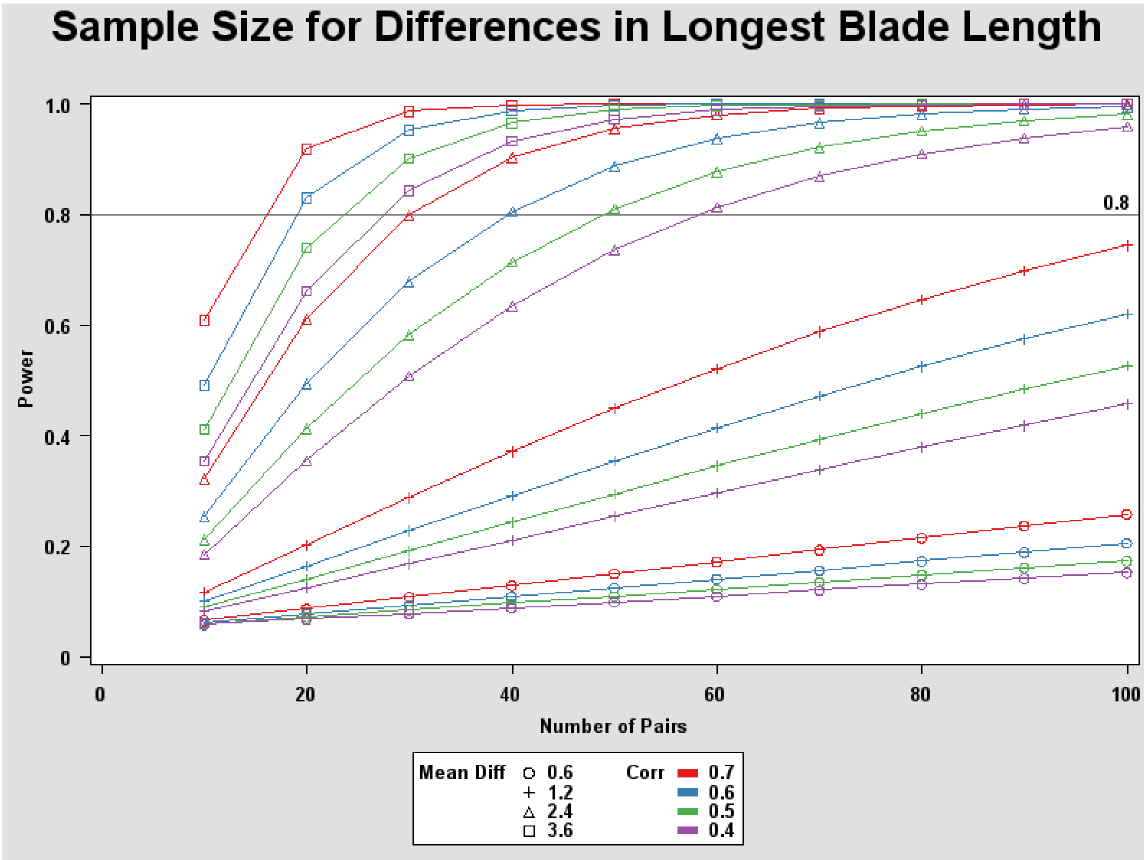
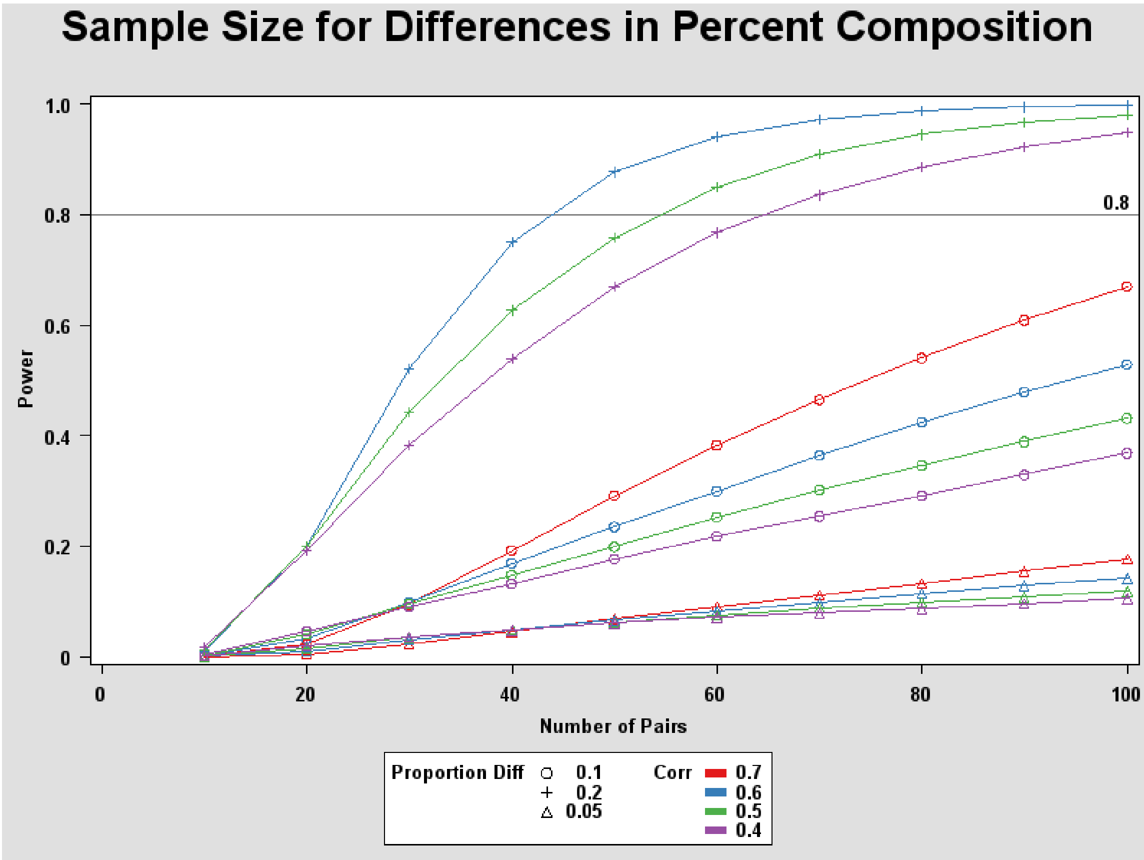


Figure 4. Sample size vs power for mean differences in the percent composition of seagrasses. The reference line of power = 0.8 is the convention used.



Appendix B – Tier 2 Sampling Standard Operating Procedures

Statewide Seagrass Monitoring Protocol Development Phase 2
Tier 2 Sampling Standard Operating Procedures

June 2012

Version 1.1

Introduction

The Statewide Seagrass Monitoring Protocol Development project uses a tiered approach to collecting seagrass condition information. Tier 2 seagrass sampling involves a short list of basic seagrass condition parameters collected over a specified area. This project will conduct Tier 2 sampling in Redfish Bay and along the Texas coast where seagrass is known to grow. If resources allow, sampling will also be conducted in San Antonio Bay.

This document describes how to complete the required measures for Tier 2 sampling. Additional details for the tiered approach, project design, principal staff, sampling period and sample sites can be found in the project's Quality Assurance Project Plan (QAPP).

Sample period

Tier 2 sampling period is August 1 – October 31, with most of the sampling occurring between August 1 and September 15.

Sample sites

Two areas will be sampled:

1. Coastwide - area in Texas where seagrass is known to occur
2. Redfish Bay

An additional area may be sampled:

1. San Antonio Bay

Sampling design

Each area has 50 randomly-selected coordinate sets (Appendix B - Table 1, Appendix B - Table 2, and Appendix B - Table 3) including extra sets of coordinates to use if some locations are unsuitable for monitoring. This is due to the limitations of the seagrass coverage maps that are currently available and that were used to generate the sampling coordinates. For each area, 50 coordinate sets will be established as permanent stations and be sampled for percent seagrass coverage by species and canopy height. The coastwide sampling includes an additional 14 stations (Appendix B - Table 4) previously monitored by TCEQ and TPWD for a total of 64 stations.

The pre-selected coordinates were generated using the TPWD Coastal Fisheries sampling grid system and the grid system will also be used to help establish permanent sampling stations. Each pre-selected coordinate set has been assigned a unique ID and is coupled with the TPWD grid and gridlet numbers.

Field work preparations

Prior to conducting field work, establish seagrass monitoring teams, prioritize coordinate sets, and prepare field equipment.

Establish seagrass monitoring teams

Seagrass monitoring teams should be established at least one month before sampling.

1. Coastwide Team(s) – Responsible for monitoring 50 permanent stations and 14 previously sampled stations. Coordination between teams working different areas will facilitate sampling efficiency.
2. Redfish Bay Team – Responsible for monitoring 50 permanent stations. May be able to sample the additional Coastwide stations that fall within Redfish Bay.
3. San Antonio Bay Team - Responsible for monitoring 50 permanent stations. May be able to sample the additional Coastwide stations that fall within San Antonio Bay.

Prioritize pre-selected coordinates

Permanent sampling stations will be established from the list of coordinate sets. To aid in establishing permanent sampling stations, seagrass monitoring teams will need to prioritize the pre-selected coordinates by presence of seagrass near the coordinates, ability to navigate by boat to the coordinates, and ability to safely sample near the coordinates.

At least one month prior to sampling, conduct a table top exercise with staff knowledgeable of each area to prioritize pre-selected sampling coordinates and eliminate coordinates that are known to be absent of seagrass, inaccessible by boat or unsafe. The first 50 coordinates will be given priority, and be designated as "priority coordinate sets." Remaining coordinates that have not been eliminated for reasons just described will be designated as "alternative coordinate sets." The alternative coordinate sets will be used when priority coordinate sets cannot be sampled.

Additional pre-field work preparations

Seagrass monitoring teams are responsible for preparing the field equipment and coordinating field work activities:

- Plan boat route to priority coordinate sets with priority given to navigation efficiency, time, and safety
- Use the grid system to identify priority and alternative coordinates that are in close proximity
- Prepare a list of priority coordinates – sorted by TPWD grid
- Prepare a list of alternative coordinates – sorted by TPWD grid
- Prepare maps with pre-selected coordinates labeled as priority or alternative
- Load pre-selected coordinates in handheld GPS units
- Identify boats for each team
- Assemble equipment - see equipment list
- Monitor weather

Field work steps

Establish permanent sampling stations

Navigate to pre-selected coordinates

Navigate to a priority coordinate set using a handheld GPS and maps with coordinate locations. Use the navigation function on the GPS to give the distance and direction to the selected coordinate set. Navigate to within 4 m (approximate accuracy for GPS) of the selected coordinate set. If you cannot get to within 4 m due to a safety hazard or errors associated with the GPS, navigating to within 10 m of the coordinate set is allowed.

Validate pre-selected coordinates

Each priority coordinate set must first be validated before establishing a permanent sampling station. This process is intended to ensure that the permanent sampling stations are located within seagrass beds, accessible by boat and are safe to sample.

Validate priority coordinate sets by conducting a preliminary survey. Coordinates are valid if:

- Visual observation suggests that seagrass coverage is relatively uniform in the sampling area, defined as a circle of radius 10 m around the boat (Appendix B - Figure 1).
- Visual observation indicates that seagrass is present at 50% coverage or more in the sampling area.
- There are no safety hazards or other considerations that would prohibit safe, effective seagrass sampling around the coordinates; for example, the coordinate set would be unsafe if it was within a narrow boat lane.

To ensure that the area contains 50% seagrass coverage or more and that seagrass coverage is relatively uniform within the sampling area, you may use a rake to sample the bottom, a viewing scope, or any other method as required by the location conditions (water depth and clarity).

If the priority coordinate set is validated using the criteria above, proceed to establish a permanent sampling station as described below. If the priority coordinate set does not meet the validation criteria, note the reasons why on the field data form and identify an alternative coordinate set as described in the next section.

Note: the 14 previously sampled stations (Appendix B - Table 4) have already been validated.

Identify an alternative coordinate set

If a priority coordinate set does not meet the validation criteria, navigate to an alternative coordinate set in the TPWD grid you are in or one nearby. Determine if the alternative coordinate set meets the validation criteria described above. If the alternative coordinate set meets the validation criteria, make note of it on the field data form and establish a permanent sampling station to replace the invalid priority coordinate set.

If no nearby alternative coordinate set can be validated, proceed to the next priority coordinate set. While navigating to the next priority coordinate set, continue to look for additional alternative coordinate sets. This process may have to be repeated several times until all of the invalid priority coordinate sets are replaced with alternative coordinate sets. In some circumstances, this may also require backtracking to areas already sampled to identify alternative coordinate sets.

Establish a permanent sampling station

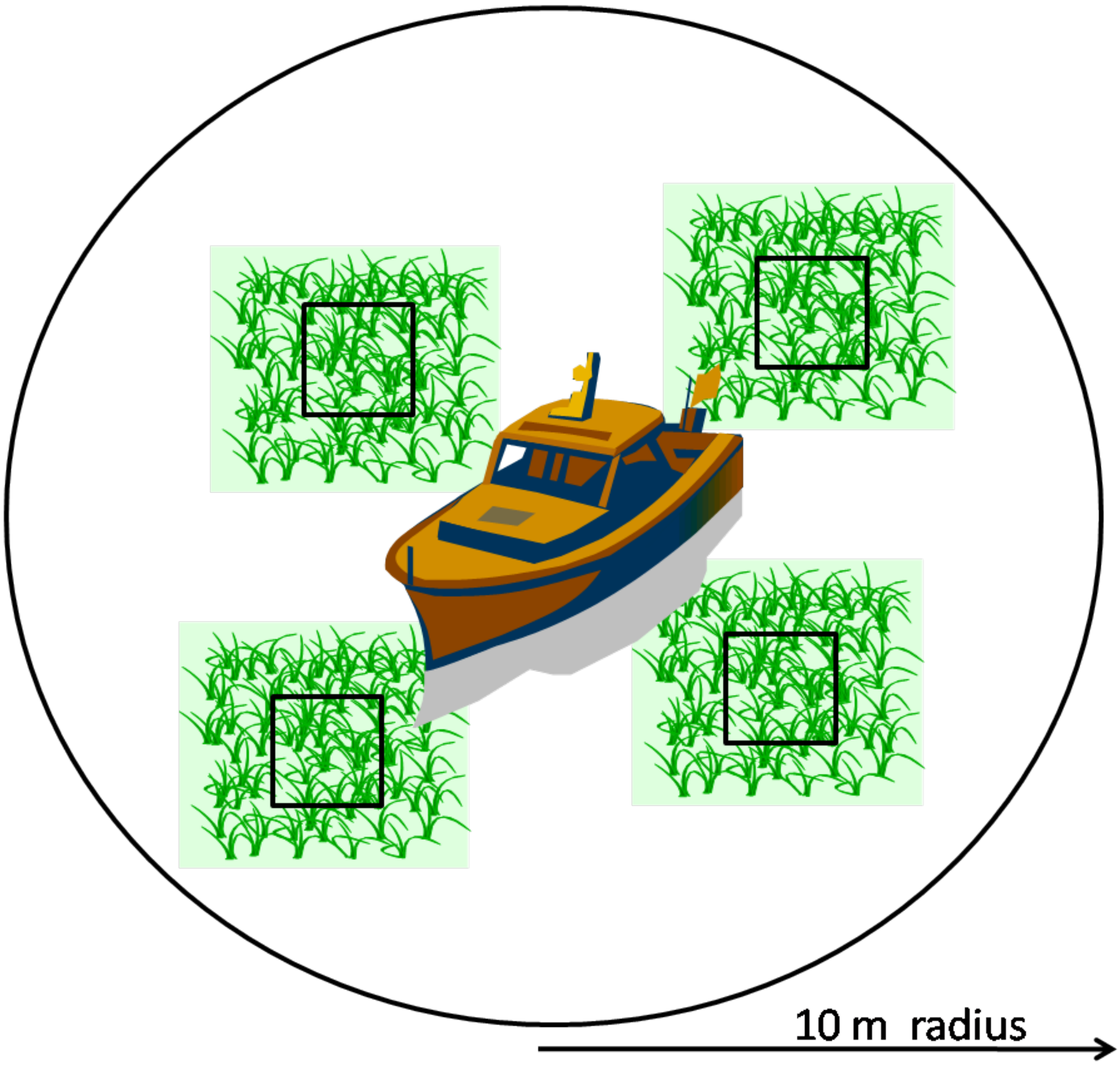
After a coordinate set is validated or when you arrive at one of the 14 existing stations, secure the location by anchoring (anchor, power pole, push pole, etc.) the boat (Appendix B - Figure 1). Maintain the boat in a single location and record the GPS position and Coordinate ID on the field data sheet and create a waypoint in the handheld GPS using the Coordinate ID. Use GPS map datum WGS 84 and record in decimal degrees (N00º.00000, W000º.00000). GPS waypoint name format is the two digit year, four digit Coordinate ID or Station ID (as given in Appendix B - Table 1 and Appendix B - Table 2). For example, a 2012 Redfish Bay sample at coordinate set 70 would be 12RF70.

Since we are establishing permanent stations, the GPS coordinates collected in the field this year will serve as the permanent sampling station coordinates, effectively replacing the pre-selected coordinates. This accounts for the up to 10 m difference that is allowed when validating coordinate sets. Using the first year permanent sampling station coordinates collected in the field will aid in returning to the stations if this work is repeated.

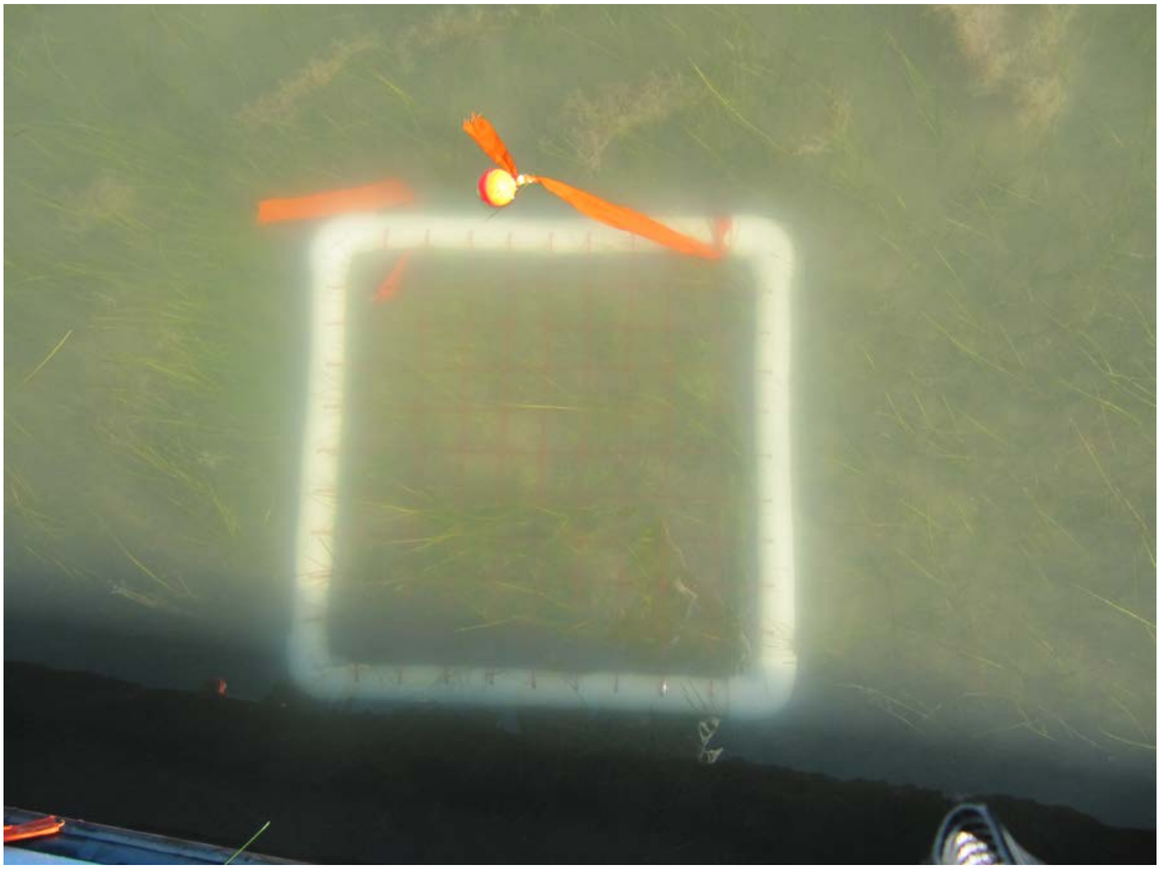
Record total water depth from boat to the nearest 0.01 m. Record other site information requested on the field form, including the unique ID (serial number, for example) of the GPS unit being used, the waypoint name stored in the GPS, latitude and longitude in decimal degrees, weather, water conditions, human use, and tide stage.

Estimate seagrass percent coverage

Once a permanent sampling station has been established, one team member will estimate the percent seagrass coverage by species. This is done by placing the 0.25 m^2 quadrat on the bay floor once each near the bow, starboard, stern and port sides of the boat within the 10 m sampling area (4 replicates, Appendix B - Figure 1). Depending on water depth and clarity, this may require the team member to use a viewing scope and/or snorkeling mask, or estimate coverage by feel within the quadrat. At a given station, use the method that allows the best view of the substrate within the quadrat. If wading is necessary, try to limit the amount the sea floor is disturbed so to maintain maximum visibility. Once the quadrat is in place (Appendix B - Figure 2), estimate percent coverage by species. Percent coverage is defined as the percent of the quadrat area that is obscured by seagrass when viewed from directly overhead. Record to the nearest 1% on the field data form. Percent coverage categories are *Halodule*, *Thalassia*, *Syringodium*, *Ruppia*, *Halophila* and Bare. Total of all species plus percent of the quadrat area that is bare should equal 100%. Before leaving the quadrat, collect seagrass shoots for measuring seagrass canopy height as described in the next section.



Appendix B - Figure 1. Sampling station area and quadrat placement for estimating seagrass coverage and measuring canopy height.

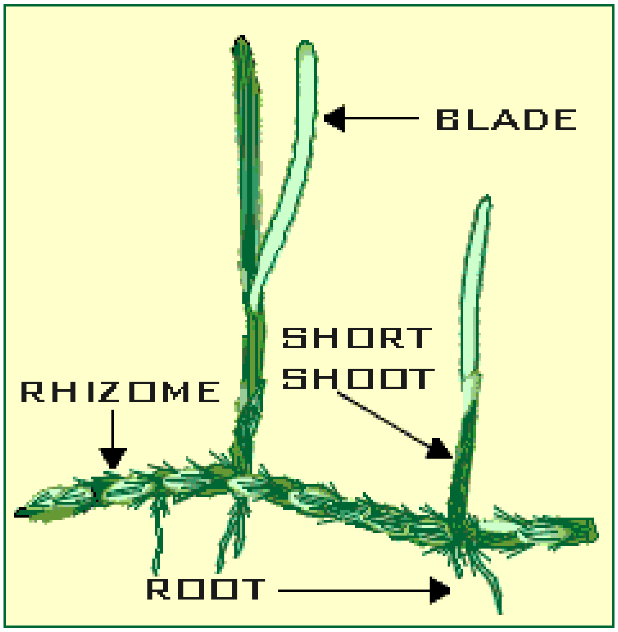


Appendix B - Figure 2. Quadrat for determination of percent coverage by seagrass species. Quadrat is 0.50 m by 0.50 m (0.25 m^2) and constructed of white PVC.

Measure seagrass canopy height

After estimating percent coverage by species in a quadrat, collect seagrass shoots from the quadrat location for measuring seagrass canopy height. The seagrass shoots can be given to the team members on the boat for measuring while the team member in the water moves to the next quadrat location. To collect seagrass shoots, gently uproot one or more rhizomes of seagrass. Bring the seagrass shoots to the boat and measure the total length of the longest leaf from five representative shoots, to the nearest 0.1 cm. A seagrass leaf is defined as the portion of the seagrass shoot that is green and above the sediment line (Appendix B - Figure 3). Do this for each quadrat location and record the measurements on the field data form in cm.

IMPORTANT: If more than one seagrass species is present in a quadrat, record leaf lengths as described above for each species that is at least 20% of the seagrass coverage.



Appendix B - Figure 3. Typical seagrass morphology.
For purposes of this project, the area labeled "blade" on this illustration is referred to as the "leaf." Diagram found at website of the Florida Medical Entomology Laboratory, University of Florida, Gainesville. Accessed 27 Jan 2011 at http://fmel.ifas.ufl.edu/habitat/seagrass_parts.shtml.

Data collection completion

For Redfish Bay, data collection is complete when 50 permanent sampling stations have been established and the associated seagrass percent coverage and canopy height data recorded.

Coastwide data collection is complete when 50 permanent sampling stations have been established and the associated seagrass percent coverage and canopy height data have been recorded for the 50 permanent sampling stations and the 14 existing stations.

Tier 2 seagrass sampling stations

Appendix B - Table 1. Tier 2 coastwide coordinate sets evenly distributed among the major bays.
160 locations are provided with 20 samples per bay system (target of 50 samples with 110 extra to account for unsuitable sample sites).

Coordinate ID	Bay	TPWD grid	TPWD gridlet	Longitude	Latitude
CW01	Galveston Bay	715	56	-95.2229	29.0438
CW02	Galveston Bay	718	44	-95.1729	29.0451
CW03	Galveston Bay	717	93	-95.1882	29.0396
CW04	Galveston Bay	723	138	-95.2090	29.0174
CW05	Galveston Bay	602	126	-94.9590	29.2188
CW06	Galveston Bay	619	34	-94.9701	29.2132
CW07	Galveston Bay	620	17	-94.9604	29.2146
CW08	Galveston Bay	602	127	-94.9576	29.2188
CW09	Galveston Bay	602	136	-94.9618	29.2174

Coordinate ID	Bay	TPWD grid	TPWD gridlet	Longitude	Latitude
CW10	Galveston Bay	620	40	-94.9618	29.2118
CW81	Galveston Bay	602	140	-94.9563	29.2174
CW82	Galveston Bay	619	44	-94.9729	29.2118
CW83	Galveston Bay	619	55	-94.9743	29.2104
CW84	Galveston Bay	620	18	-94.9590	29.2146
CW85	Galveston Bay	620	29	-94.9604	29.2132
CW86	Galveston Bay	620	55	-94.9576	29.2104
CW87	Galveston Bay	704	121	-95.1660	29.0688
CW88	Galveston Bay	711	86	-95.1646	29.0563
CW89	Galveston Bay	718	23	-95.1688	29.0479
CW90	Galveston Bay	718	43	-95.1743	29.0451
CW11	East Matagorda Bay	13	27	-95.6632	28.7799
CW12	East Matagorda Bay	13	38	-95.6646	28.7785
CW13	East Matagorda Bay	52	103	-95.7243	28.7215
CW14	East Matagorda Bay	65	143	-95.7688	28.7007
CW15	East Matagorda Bay	67	9	-95.7382	28.7160
CW16	East Matagorda Bay	76	84	-95.8007	28.6910
CW17	East Matagorda Bay	87	105	-95.8382	28.6715
CW18	East Matagorda Bay	90	129	-95.9549	28.6521
CW19	East Matagorda Bay	104	3	-95.9632	28.6326
CW20	East Matagorda Bay	109	16	-95.5785	28.7979
CW151	East Matagorda Bay	27	40	-95.8785	28.7451
CW152	East Matagorda Bay	27	80	-95.8729	28.7410
CW153	East Matagorda Bay	52	84	-95.7174	28.7243
CW154	East Matagorda Bay	67	50	-95.7479	28.7104
CW155	East Matagorda Bay	76	118	-95.8035	28.6868
CW156	East Matagorda Bay	77	35	-95.7854	28.6965
CW157	East Matagorda Bay	78	9	-95.7715	28.6993
CW158	East Matagorda Bay	96	66	-95.8590	28.6590
CW159	East Matagorda Bay	103	3	-95.8799	28.6493
CW160	East Matagorda Bay	104	17	-95.9604	28.6313
CW21	West Matagorda Bay	134	128	-95.9563	28.6521
CW22	West Matagorda Bay	134	129	-95.9549	28.6521
CW23	West Matagorda Bay	450	91	-96.2410	28.4896
CW24	West Matagorda Bay	450	92	-96.2396	28.4896
CW25	West Matagorda Bay	457	4	-96.4451	28.4826
CW26	West Matagorda Bay	468	27	-96.2632	28.4799
CW27	West Matagorda Bay	477	43	-96.2910	28.4618
CW28	West Matagorda Bay	491	71	-96.4021	28.4090
CW29	West Matagorda Bay	493	71	-96.3688	28.4090

Coordinate ID	Bay	TPWD grid	TPWD gridlet	Longitude	Latitude
CW30	West Matagorda Bay	498	98	-96.4146	28.3715
CW91	West Matagorda Bay	134	117	-95.9549	28.6535
CW92	West Matagorda Bay	450	93	-96.2382	28.4896
CW93	West Matagorda Bay	467	128	-96.2729	28.4688
CW94	West Matagorda Bay	468	28	-96.2618	28.4799
CW95	West Matagorda Bay	485	119	-96.4021	28.4201
CW96	West Matagorda Bay	485	132	-96.4007	28.4188
CW97	West Matagorda Bay	485	133	-96.4160	28.4174
CW98	West Matagorda Bay	485	134	-96.4146	28.4174
CW99	West Matagorda Bay	488	128	-96.3563	28.4188
CW100	West Matagorda Bay	489	40	-96.3451	28.4285
CW31	San Antonio Bay	115	35	-96.5521	28.2965
CW32	San Antonio Bay	131	92	-96.5896	28.2729
CW33	San Antonio Bay	135	56	-96.7896	28.2604
CW34	San Antonio Bay	222	115	-96.5243	28.3868
CW35	San Antonio Bay	223	98	-96.5146	28.3882
CW36	San Antonio Bay	245	117	-96.5882	28.3535
CW37	San Antonio Bay	258	128	-96.6063	28.3354
CW38	San Antonio Bay	259	5	-96.5938	28.3493
CW39	San Antonio Bay	270	39	-96.6299	28.3285
CW40	San Antonio Bay	285	36	-96.5340	28.3132
CW101	San Antonio Bay	18	134	-96.7813	28.4340
CW102	San Antonio Bay	171	127	-96.6910	28.2188
CW103	San Antonio Bay	173	42	-96.6590	28.2285
CW104	San Antonio Bay	231	93	-96.5549	28.3729
CW105	San Antonio Bay	232	45	-96.5382	28.3785
CW106	San Antonio Bay	233	27	-96.5299	28.3799
CW107	San Antonio Bay	242	135	-96.6465	28.3507
CW108	San Antonio Bay	258	22	-96.6035	28.3479
CW109	San Antonio Bay	268	86	-96.4479	28.3396
CW110	San Antonio Bay	286	88	-96.5285	28.3063
CW41	Aransas Bay	154	42	-96.8924	28.1118
CW42	Aransas Bay	232	32	-97.1563	28.0465
CW43	Aransas Bay	282	93	-97.1882	27.9729
CW44	Aransas Bay	295	71	-97.0688	27.9590
CW45	Aransas Bay	307	135	-97.0299	27.9340
CW46	Aransas Bay	320	27	-97.1132	27.9132
CW47	Aransas Bay	321	138	-97.0924	27.9007
CW48	Aransas Bay	323	13	-97.0660	27.9146
CW49	Aransas Bay	328	97	-97.1326	27.8882

Coordinate ID	Bay	TPWD grid	TPWD gridlet	Longitude	Latitude
CW50	Aransas Bay	332	55	-97.0576	27.8938
CW111	Aransas Bay	124	18	-96.9590	28.1313
CW112	Aransas Bay	246	11	-97.1521	28.0326
CW113	Aransas Bay	246	116	-97.1563	28.0201
CW114	Aransas Bay	285	54	-97.0757	27.9771
CW115	Aransas Bay	302	128	-97.1063	27.9354
CW116	Aransas Bay	303	137	-97.0938	27.9340
CW117	Aransas Bay	319	138	-97.1257	27.9007
CW118	Aransas Bay	322	74	-97.0813	27.9076
CW119	Aransas Bay	333	8	-97.0396	27.8993
CW120	Aransas Bay	338	122	-97.0813	27.8688
CW51	Corpus Christi Bay	55	136	-97.1285	27.8840
CW52	Corpus Christi Bay	97	4	-97.0951	27.8493
CW53	Corpus Christi Bay	97	17	-97.0938	27.8479
CW54	Corpus Christi Bay	136	83	-97.1188	27.8076
CW55	Corpus Christi Bay	137	90	-97.1090	27.8063
CW56	Corpus Christi Bay	191	138	-97.1590	27.7507
CW57	Corpus Christi Bay	235	38	-97.3313	27.6951
CW58	Corpus Christi Bay	241	135	-97.2132	27.6840
CW59	Corpus Christi Bay	242	36	-97.1840	27.6965
CW60	Corpus Christi Bay	247	54	-97.3090	27.6771
CW121	Corpus Christi Bay	55	7	-97.1243	27.8993
CW122	Corpus Christi Bay	64	38	-97.1479	27.8785
CW123	Corpus Christi Bay	77	58	-97.1535	27.8604
CW124	Corpus Christi Bay	77	79	-97.1576	27.8576
CW125	Corpus Christi Bay	80	107	-97.1021	27.8549
CW126	Corpus Christi Bay	81	136	-97.0951	27.8507
CW127	Corpus Christi Bay	90	126	-97.2424	27.8354
CW128	Corpus Christi Bay	93	50	-97.1646	27.8438
CW129	Corpus Christi Bay	193	39	-97.1299	27.7618
CW130	Corpus Christi Bay	235	51	-97.3299	27.6938
CW61	Upper Laguna Madre	33	7	-97.2910	27.6160
CW62	Upper Laguna Madre	34	77	-97.2771	27.6076
CW63	Upper Laguna Madre	34	84	-97.2674	27.6076
CW64	Upper Laguna Madre	40	127	-97.2910	27.5854
CW65	Upper Laguna Madre	84	144	-97.3507	27.4340
CW66	Upper Laguna Madre	88	95	-97.3521	27.4229
CW67	Upper Laguna Madre	97	29	-97.3438	27.3965
CW68	Upper Laguna Madre	255	133	-97.3993	27.2340
CW69	Upper Laguna Madre	258	18	-97.4090	27.2313

Coordinate ID	Bay	TPWD grid	TPWD gridlet	Longitude	Latitude
CW70	Upper Laguna Madre	275	20	-97.4396	27.1646
CW131	Upper Laguna Madre	10	131	-97.2021	27.6688
CW132	Upper Laguna Madre	57	102	-97.3257	27.5382
CW133	Upper Laguna Madre	61	119	-97.3354	27.5201
CW134	Upper Laguna Madre	64	37	-97.2993	27.5285
CW135	Upper Laguna Madre	76	10	-97.3368	27.4826
CW136	Upper Laguna Madre	96	45	-97.3549	27.3951
CW137	Upper Laguna Madre	283	13	-97.4326	27.1313
CW138	Upper Laguna Madre	290	30	-97.4257	27.0965
CW139	Upper Laguna Madre	291	142	-97.4035	27.0840
CW140	Upper Laguna Madre	298	118	-97.4201	27.0535
CW71	Lower Laguna Madre	100	124	-97.3785	26.5354
CW72	Lower Laguna Madre	121	119	-97.3688	26.4868
CW73	Lower Laguna Madre	123	118	-97.3368	26.4868
CW74	Lower Laguna Madre	136	58	-97.3868	26.4604
CW75	Lower Laguna Madre	189	36	-97.3007	26.3632
CW76	Lower Laguna Madre	206	26	-97.3313	26.3299
CW77	Lower Laguna Madre	227	87	-97.2632	26.2896
CW78	Lower Laguna Madre	245	16	-97.2451	26.2646
CW79	Lower Laguna Madre	284	50	-97.2813	26.1771
CW80	Lower Laguna Madre	344	35	-97.2354	26.0799
CW141	Lower Laguna Madre	39	7	-97.4243	26.6993
CW142	Lower Laguna Madre	100	58	-97.3701	26.5438
CW143	Lower Laguna Madre	128	90	-97.3924	26.4729
CW144	Lower Laguna Madre	155	111	-97.3465	26.4201
CW145	Lower Laguna Madre	181	78	-97.2757	26.3743
CW146	Lower Laguna Madre	201	74	-97.2813	26.3410
CW147	Lower Laguna Madre	234	78	-97.2924	26.2743
CW148	Lower Laguna Madre	264	2	-97.2313	26.2326
CW149	Lower Laguna Madre	274	53	-97.1938	26.2104
CW150	Lower Laguna Madre	293	19	-97.2743	26.1646

Appendix B - Table 2. Tier 2 coordinate sets for Redfish Bay system based on seagrass abundance. 147 locations are provided (target of 50 samples with 97 extra to account for unsuitable sample sites).

Coordinate ID	Bay	TPWD grid	TPWD gridlet	Longitude	Latitude
RF01	Aransas Bay	274	135	-97.0799	27.9840
RF02	Aransas Bay	294	95	-97.0854	27.9563
RF03	Aransas Bay	294	138	-97.0924	27.9507
RF04	Aransas Bay	295	80	-97.0729	27.9576
RF05	Aransas Bay	303	61	-97.0993	27.9424
RF06	Aransas Bay	303	76	-97.0951	27.9410
RF07	Aransas Bay	303	97	-97.0993	27.9382
RF08	Aransas Bay	304	17	-97.0771	27.9479
RF09	Aransas Bay	310	120	-97.1174	27.9201
RF10	Aransas Bay	311	143	-97.1021	27.9174
RF11	Aransas Bay	312	128	-97.0896	27.9188
RF12	Aransas Bay	312	144	-97.0840	27.9174
RF13	Aransas Bay	313	51	-97.0799	27.9271
RF14	Aransas Bay	313	123	-97.0799	27.9188
RF15	Aransas Bay	319	20	-97.1229	27.9146
RF16	Aransas Bay	319	69	-97.1215	27.9090
RF17	Aransas Bay	319	116	-97.1229	27.9035
RF18	Aransas Bay	319	138	-97.1257	27.9007
RF19	Aransas Bay	320	11	-97.1021	27.9160
RF20	Aransas Bay	320	25	-97.1160	27.9132
RF21	Aransas Bay	320	28	-97.1118	27.9132
RF22	Aransas Bay	320	30	-97.1090	27.9132
RF23	Aransas Bay	321	17	-97.0938	27.9146
RF24	Aransas Bay	321	26	-97.0979	27.9132
RF25	Aransas Bay	321	94	-97.0868	27.9063
RF26	Aransas Bay	322	81	-97.0715	27.9076
RF27	Aransas Bay	322	117	-97.0715	27.9035
RF28	Aransas Bay	322	121	-97.0826	27.9021
RF29	Aransas Bay	327	142	-97.1368	27.8840
RF30	Aransas Bay	328	2	-97.1313	27.8993
RF31	Aransas Bay	328	134	-97.1313	27.8840
RF32	Aransas Bay	330	16	-97.0951	27.8979
RF33	Aransas Bay	330	119	-97.0854	27.8868
RF34	Aransas Bay	331	106	-97.0701	27.8882
RF35	Aransas Bay	337	86	-97.0979	27.8729
RF36	Aransas Bay	343	2	-97.0646	27.8660
RF73	Aransas Bay	285	99	-97.0799	27.9715

Coordinate ID	Bay	TPWD grid	TPWD gridlet	Longitude	Latitude
RF74	Aransas Bay	294	47	-97.0854	27.9618
RF75	Aransas Bay	294	69	-97.0882	27.9590
RF76	Aransas Bay	294	92	-97.0896	27.9563
RF77	Aransas Bay	294	130	-97.0868	27.9521
RF78	Aransas Bay	295	31	-97.0743	27.9632
RF79	Aransas Bay	295	66	-97.0757	27.9590
RF80	Aransas Bay	295	73	-97.0826	27.9576
RF81	Aransas Bay	295	111	-97.0799	27.9535
RF82	Aransas Bay	303	102	-97.0924	27.9382
RF83	Aransas Bay	303	134	-97.0979	27.9340
RF84	Aransas Bay	304	28	-97.0785	27.9465
RF85	Aransas Bay	304	37	-97.0826	27.9451
RF86	Aransas Bay	304	52	-97.0785	27.9438
RF87	Aransas Bay	304	62	-97.0813	27.9424
RF88	Aransas Bay	304	63	-97.0799	27.9424
RF89	Aransas Bay	304	86	-97.0813	27.9396
RF90	Aransas Bay	310	141	-97.1215	27.9174
RF91	Aransas Bay	311	14	-97.1146	27.9313
RF92	Aransas Bay	311	43	-97.1076	27.9285
RF93	Aransas Bay	311	106	-97.1035	27.9215
RF94	Aransas Bay	311	120	-97.1007	27.9201
RF95	Aransas Bay	312	17	-97.0938	27.9313
RF96	Aransas Bay	312	39	-97.0965	27.9285
RF97	Aransas Bay	312	55	-97.0910	27.9271
RF98	Aransas Bay	312	143	-97.0854	27.9174
RF99	Aransas Bay	313	38	-97.0813	27.9285
RF100	Aransas Bay	319	9	-97.1215	27.9160
RF101	Aransas Bay	319	11	-97.1188	27.9160
RF102	Aransas Bay	319	77	-97.1271	27.9076
RF103	Aransas Bay	319	91	-97.1243	27.9063
RF104	Aransas Bay	320	89	-97.1104	27.9063
RF105	Aransas Bay	321	15	-97.0965	27.9146
RF106	Aransas Bay	321	39	-97.0965	27.9118
RF107	Aransas Bay	328	3	-97.1299	27.8993
RF108	Aransas Bay	328	19	-97.1243	27.8979
RF109	Aransas Bay	328	134	-97.1313	27.8840
RF110	Aransas Bay	329	48	-97.1007	27.8951
RF37	Corpus Christi Bay	54	96	-97.1340	27.8896
RF38	Corpus Christi Bay	54	118	-97.1368	27.8868
RF39	Corpus Christi Bay	55	128	-97.1229	27.8854

Coordinate ID	Bay	TPWD grid	TPWD gridlet	Longitude	Latitude
RF40	Corpus Christi Bay	55	141	-97.1215	27.8840
RF41	Corpus Christi Bay	56	7	-97.1076	27.8993
RF42	Corpus Christi Bay	56	66	-97.1090	27.8924
RF43	Corpus Christi Bay	63	107	-97.1521	27.8715
RF44	Corpus Christi Bay	64	38	-97.1479	27.8785
RF45	Corpus Christi Bay	64	45	-97.1382	27.8785
RF46	Corpus Christi Bay	64	64	-97.1451	27.8757
RF47	Corpus Christi Bay	64	130	-97.1368	27.8688
RF48	Corpus Christi Bay	64	133	-97.1493	27.8674
RF49	Corpus Christi Bay	65	28	-97.1285	27.8799
RF50	Corpus Christi Bay	66	81	-97.1049	27.8743
RF51	Corpus Christi Bay	66	96	-97.1007	27.8729
RF52	Corpus Christi Bay	67	20	-97.0896	27.8813
RF53	Corpus Christi Bay	67	54	-97.0924	27.8771
RF54	Corpus Christi Bay	67	135	-97.0965	27.8674
RF55	Corpus Christi Bay	77	65	-97.1604	27.8590
RF56	Corpus Christi Bay	77	83	-97.1521	27.8576
RF57	Corpus Christi Bay	78	1	-97.1493	27.8660
RF58	Corpus Christi Bay	78	38	-97.1479	27.8618
RF59	Corpus Christi Bay	78	69	-97.1382	27.8590
RF60	Corpus Christi Bay	79	143	-97.1188	27.8507
RF61	Corpus Christi Bay	80	7	-97.1076	27.8660
RF62	Corpus Christi Bay	80	114	-97.1090	27.8535
RF63	Corpus Christi Bay	80	127	-97.1076	27.8521
RF64	Corpus Christi Bay	92	31	-97.1743	27.8465
RF65	Corpus Christi Bay	92	134	-97.1813	27.8340
RF66	Corpus Christi Bay	93	43	-97.1576	27.8451
RF67	Corpus Christi Bay	93	88	-97.1618	27.8396
RF68	Corpus Christi Bay	94	17	-97.1438	27.8479
RF69	Corpus Christi Bay	94	33	-97.1382	27.8465
RF70	Corpus Christi Bay	95	23	-97.1188	27.8479
RF71	Corpus Christi Bay	96	45	-97.1049	27.8451
RF72	Corpus Christi Bay	96	49	-97.1160	27.8438
RF111	Corpus Christi Bay	54	72	-97.1340	27.8924
RF112	Corpus Christi Bay	54	107	-97.1354	27.8882
RF113	Corpus Christi Bay	54	131	-97.1354	27.8854
RF114	Corpus Christi Bay	54	135	-97.1465	27.8840
RF115	Corpus Christi Bay	55	27	-97.1299	27.8965
RF116	Corpus Christi Bay	55	47	-97.1188	27.8951
RF117	Corpus Christi Bay	55	92	-97.1229	27.8896

Coordinate ID	Bay	TPWD grid	TPWD gridlet	Longitude	Latitude
RF118	Corpus Christi Bay	55	93	-97.1215	27.8896
RF119	Corpus Christi Bay	56	110	-97.1146	27.8868
RF120	Corpus Christi Bay	56	114	-97.1090	27.8868
RF121	Corpus Christi Bay	56	137	-97.1104	27.8840
RF122	Corpus Christi Bay	63	125	-97.1604	27.8688
RF123	Corpus Christi Bay	64	63	-97.1465	27.8757
RF124	Corpus Christi Bay	64	77	-97.1438	27.8743
RF125	Corpus Christi Bay	64	131	-97.1354	27.8688
RF126	Corpus Christi Bay	64	137	-97.1438	27.8674
RF127	Corpus Christi Bay	64	141	-97.1382	27.8674
RF128	Corpus Christi Bay	65	6	-97.1257	27.8826
RF129	Corpus Christi Bay	65	61	-97.1326	27.8757
RF130	Corpus Christi Bay	66	130	-97.1035	27.8688
RF131	Corpus Christi Bay	66	143	-97.1021	27.8674
RF132	Corpus Christi Bay	67	33	-97.0882	27.8799
RF133	Corpus Christi Bay	77	91	-97.1576	27.8563
RF134	Corpus Christi Bay	77	110	-97.1646	27.8535
RF135	Corpus Christi Bay	77	121	-97.1660	27.8521
RF136	Corpus Christi Bay	77	128	-97.1563	27.8521
RF137	Corpus Christi Bay	78	86	-97.1479	27.8563
RF138	Corpus Christi Bay	80	31	-97.1076	27.8632
RF139	Corpus Christi Bay	80	61	-97.1160	27.8590
RF140	Corpus Christi Bay	80	134	-97.1146	27.8507
RF141	Corpus Christi Bay	92	44	-97.1729	27.8451
RF142	Corpus Christi Bay	92	101	-97.1771	27.8382
RF143	Corpus Christi Bay	93	7	-97.1576	27.8493
RF144	Corpus Christi Bay	93	20	-97.1563	27.8479
RF145	Corpus Christi Bay	93	52	-97.1618	27.8438
RF146	Corpus Christi Bay	95	32	-97.1229	27.8465
RF147	Corpus Christi Bay	95	54	-97.1257	27.8438

Appendix B - Table 3. Tier 2 coordinate sets for San Antonio Bay system based on seagrass abundance. 150 locations are provided (target of 50 samples with 100 extra to account for unsuitable sample sites).

Coordinate ID	Bay	TPWD grid	TPWD gridlet	Longitude	Latitude
SA01	San Antonio Bay	11	100	-96.7951	28.4549
SA02	San Antonio Bay	16	11	-96.8021	28.4493
SA03	San Antonio Bay	17	27	-96.7965	28.4465
SA04	San Antonio Bay	34	50	-96.7813	28.4104
SA05	San Antonio Bay	36	81	-96.7382	28.4076
SA06	San Antonio Bay	76	2	-96.6479	28.3493
SA07	San Antonio Bay	85	96	-96.6674	28.3229
SA08	San Antonio Bay	85	107	-96.6688	28.3215
SA09	San Antonio Bay	86	131	-96.6521	28.3188
SA10	San Antonio Bay	100	79	-96.8076	28.2910
SA11	San Antonio Bay	114	47	-96.5688	28.2951
SA12	San Antonio Bay	114	48	-96.5674	28.2951
SA13	San Antonio Bay	114	68	-96.5729	28.2924
SA14	San Antonio Bay	115	3	-96.5632	28.2993
SA15	San Antonio Bay	115	28	-96.5618	28.2965
SA16	San Antonio Bay	115	55	-96.5576	28.2938
SA17	San Antonio Bay	116	10	-96.5368	28.2993
SA18	San Antonio Bay	129	72	-96.6174	28.2757
SA19	San Antonio Bay	129	135	-96.6299	28.2674
SA20	San Antonio Bay	130	70	-96.6035	28.2757
SA21	San Antonio Bay	160	54	-96.6424	28.2438
SA22	San Antonio Bay	171	118	-96.6868	28.2201
SA23	San Antonio Bay	172	70	-96.6701	28.2257
SA24	San Antonio Bay	173	38	-96.6646	28.2285
SA25	San Antonio Bay	184	20	-96.6896	28.2146
SA26	San Antonio Bay	184	39	-96.6965	28.2118
SA27	San Antonio Bay	191	132	-96.7507	28.1854
SA28	San Antonio Bay	192	96	-96.7340	28.1896
SA29	San Antonio Bay	200	39	-96.7799	28.1785
SA30	San Antonio Bay	212	109	-96.4326	28.4201
SA31	San Antonio Bay	213	124	-96.4118	28.4188
SA32	San Antonio Bay	213	144	-96.4007	28.4174
SA33	San Antonio Bay	219	59	-96.4188	28.4104
SA34	San Antonio Bay	223	69	-96.5049	28.3924
SA35	San Antonio Bay	227	106	-96.4368	28.3882
SA36	San Antonio Bay	227	121	-96.4493	28.3854
SA37	San Antonio Bay	227	123	-96.4465	28.3854

Coordinate ID	Bay	TPWD grid	TPWD gridlet	Longitude	Latitude
SA38	San Antonio Bay	228	121	-96.4326	28.3854
SA39	San Antonio Bay	231	115	-96.5576	28.3701
SA40	San Antonio Bay	232	46	-96.5368	28.3785
SA41	San Antonio Bay	232	100	-96.5451	28.3715
SA42	San Antonio Bay	237	91	-96.4576	28.3729
SA43	San Antonio Bay	237	101	-96.4604	28.3715
SA44	San Antonio Bay	238	67	-96.4410	28.3757
SA45	San Antonio Bay	238	132	-96.4340	28.3688
SA46	San Antonio Bay	239	72	-96.4174	28.3757
SA47	San Antonio Bay	254	103	-96.4410	28.3549
SA48	San Antonio Bay	254	144	-96.4340	28.3507
SA49	San Antonio Bay	257	64	-96.6285	28.3424
SA50	San Antonio Bay	258	74	-96.6146	28.3410
SA51	San Antonio Bay	258	92	-96.6063	28.3396
SA52	San Antonio Bay	258	102	-96.6090	28.3382
SA53	San Antonio Bay	258	104	-96.6063	28.3382
SA54	San Antonio Bay	258	115	-96.6076	28.3368
SA55	San Antonio Bay	259	13	-96.5993	28.3479
SA56	San Antonio Bay	259	50	-96.5979	28.3438
SA57	San Antonio Bay	268	44	-96.4396	28.3451
SA58	San Antonio Bay	270	18	-96.6257	28.3313
SA59	San Antonio Bay	270	60	-96.6174	28.3271
SA60	San Antonio Bay	270	61	-96.6326	28.3257
SA61	San Antonio Bay	270	85	-96.6326	28.3229
SA62	San Antonio Bay	276	88	-96.5285	28.3229
SA63	San Antonio Bay	276	104	-96.5229	28.3215
SA64	San Antonio Bay	276	129	-96.5215	28.3188
SA65	San Antonio Bay	277	100	-96.5118	28.3215
SA66	San Antonio Bay	277	133	-96.5160	28.3174
SA67	San Antonio Bay	277	140	-96.5063	28.3174
SA68	San Antonio Bay	279	22	-96.4701	28.3313
SA69	San Antonio Bay	279	25	-96.4826	28.3299
SA70	San Antonio Bay	285	44	-96.5396	28.3118
SA71	San Antonio Bay	285	107	-96.5354	28.3049
SA72	San Antonio Bay	286	61	-96.5326	28.3090
SA73	San Antonio Bay	287	34	-96.5035	28.3132
SA74	San Antonio Bay	287	49	-96.5160	28.3104
SA75	San Antonio Bay	287	50	-96.5146	28.3104
SA76	San Antonio Bay	25	1	-96.7993	28.4326

Coordinate ID	Bay	TPWD grid	TPWD gridlet	Longitude	Latitude
SA77	San Antonio Bay	75	46	-96.6535	28.3451
SA78	San Antonio Bay	75	56	-96.6563	28.3438
SA79	San Antonio Bay	75	115	-96.6576	28.3368
SA80	San Antonio Bay	85	21	-96.6715	28.3313
SA81	San Antonio Bay	85	31	-96.6743	28.3299
SA82	San Antonio Bay	85	55	-96.6743	28.3271
SA83	San Antonio Bay	85	63	-96.6799	28.3257
SA84	San Antonio Bay	85	64	-96.6785	28.3257
SA85	San Antonio Bay	87	33	-96.6382	28.3299
SA86	San Antonio Bay	87	98	-96.6479	28.3215
SA87	San Antonio Bay	100	66	-96.8090	28.2924
SA88	San Antonio Bay	114	35	-96.5688	28.2965
SA89	San Antonio Bay	114	44	-96.5729	28.2951
SA90	San Antonio Bay	114	68	-96.5729	28.2924
SA91	San Antonio Bay	115	6	-96.5590	28.2993
SA92	San Antonio Bay	116	8	-96.5396	28.2993
SA93	San Antonio Bay	129	72	-96.6174	28.2757
SA94	San Antonio Bay	129	118	-96.6201	28.2701
SA95	San Antonio Bay	130	22	-96.6035	28.2813
SA96	San Antonio Bay	130	87	-96.6132	28.2729
SA97	San Antonio Bay	130	103	-96.6076	28.2715
SA98	San Antonio Bay	135	106	-96.7868	28.2549
SA99	San Antonio Bay	144	95	-96.6354	28.2563
SA100	San Antonio Bay	151	101	-96.7938	28.2382
SA101	San Antonio Bay	171	127	-96.6910	28.2188
SA102	San Antonio Bay	184	45	-96.6882	28.2118
SA103	San Antonio Bay	197	118	-96.8201	28.1701
SA104	San Antonio Bay	199	77	-96.7938	28.1743
SA105	San Antonio Bay	200	54	-96.7757	28.1771
SA106	San Antonio Bay	212	139	-96.4243	28.4174
SA107	San Antonio Bay	219	48	-96.4174	28.4118
SA108	San Antonio Bay	222	120	-96.5174	28.3868
SA109	San Antonio Bay	223	58	-96.5035	28.3938
SA110	San Antonio Bay	223	79	-96.5076	28.3910
SA111	San Antonio Bay	227	101	-96.4438	28.3882
SA112	San Antonio Bay	227	114	-96.4424	28.3868
SA113	San Antonio Bay	227	128	-96.4396	28.3854
SA114	San Antonio Bay	227	129	-96.4382	28.3854
SA115	San Antonio Bay	227	139	-96.4410	28.3840

Coordinate ID	Bay	TPWD grid	TPWD gridlet	Longitude	Latitude
SA116	San Antonio Bay	228	111	-96.4299	28.3868
SA117	San Antonio Bay	228	122	-96.4313	28.3854
SA118	San Antonio Bay	232	65	-96.5438	28.3757
SA119	San Antonio Bay	238	8	-96.4396	28.3826
SA120	San Antonio Bay	239	10	-96.4201	28.3826
SA121	San Antonio Bay	239	96	-96.4174	28.3729
SA122	San Antonio Bay	240	61	-96.4160	28.3757
SA123	San Antonio Bay	240	87	-96.4132	28.3729
SA124	San Antonio Bay	245	115	-96.5910	28.3535
SA125	San Antonio Bay	246	53	-96.5771	28.3604
SA126	San Antonio Bay	253	23	-96.4521	28.3646
SA127	San Antonio Bay	254	1	-96.4493	28.3660
SA128	San Antonio Bay	257	44	-96.6229	28.3451
SA129	San Antonio Bay	257	63	-96.6299	28.3424
SA130	San Antonio Bay	257	132	-96.6174	28.3354
SA131	San Antonio Bay	258	23	-96.6021	28.3479
SA132	San Antonio Bay	258	55	-96.6076	28.3438
SA133	San Antonio Bay	258	139	-96.6076	28.3340
SA134	San Antonio Bay	259	7	-96.5910	28.3493
SA135	San Antonio Bay	259	14	-96.5979	28.3479
SA136	San Antonio Bay	259	18	-96.5924	28.3479
SA137	San Antonio Bay	259	29	-96.5938	28.3465
SA138	San Antonio Bay	268	76	-96.4451	28.3410
SA139	San Antonio Bay	270	59	-96.6188	28.3271
SA140	San Antonio Bay	277	120	-96.5007	28.3201
SA141	San Antonio Bay	277	129	-96.5049	28.3188
SA142	San Antonio Bay	277	136	-96.5118	28.3174
SA143	San Antonio Bay	277	137	-96.5104	28.3174
SA144	San Antonio Bay	277	140	-96.5063	28.3174
SA145	San Antonio Bay	278	68	-96.4896	28.3257
SA146	San Antonio Bay	278	97	-96.4993	28.3215
SA147	San Antonio Bay	278	133	-96.4993	28.3174
SA148	San Antonio Bay	279	49	-96.4826	28.3271
SA149	San Antonio Bay	286	42	-96.5257	28.3118
SA150	San Antonio Bay	286	107	-96.5188	28.3049

Appendix B - Table 4. Tier 2 sampling locations for the 14 existing seagrass monitoring stations.

Station ID	Bay/Site	TPWD Grid	Closest TPWD gridlet	Longitude	Latitude
EX01	West Bay at GISP	620	31	-94.95810	29.21352
EX02	West end Galveston Island	684	114	-95.10922	29.10275
EX03	Christmas Bay	717	105	-95.18800	29.03849
EX04	Matagorda Peninsula	450	52	-96.24503	28.49303
EX05	San Antonio Bay near Welder WMA	270	76	-96.62881	28.32407
EX06	Matagorda Island bayshore	129	118	-96.61948	28.27019
EX07	St Charles Bay	99	37	-96.94905	28.14567
EX08	Mud Island	307	93	-97.02179	27.93940
EX09	Port Bay	247	77	-97.14429	28.02558
EX10	ULM north of JFK Causeway	7	113	-97.26089	27.66989
EX11	Nighthawk Bay	49	26	-97.26403	27.57942
EX12	Lower Laguna Madre near mouth of Arroyo Colorado	189	110	-97.31420	26.35368
EX13	Laguna Madre - bay shore of South Padre Island	306	79	-97.19077	26.14057
EX14	South Bay	374	125	-97.17722	26.03505

Tier 2 seagrass monitoring equipment list

Copy of QAPP
Copy of Tier 2 SOP
Seagrass percent coverage photo guide
Seagrass species ID guide
Field data forms on waterproof paper
Pens
Table of priority coordinate sets
Table of alternative coordinate sets
Maps
Handheld GPS – preloaded with priority and alternative coordinate sets
Digital camera
Rake
Aquaview scope
Push pole, power pole or anchor
6 ft PVC poles for permanent markers (coastwide and existing stations only)
PVC saw
PVC cutter
Rubber mallet
Depth measuring rod
PVC quadrat – 0.25 m^2
Meter stick for measuring canopy height to the nearest 0.1 cm
Mask and snorkel
Dive booties
Fins
Weight belt
Wet suit
Dive flags
First aid kit
Sunscreen
Life jackets

Seagrass percent coverage photo guide

Examples of percent coverage standards from the SeagrassWatch organization. Species depicted in this guide may differ from Texas species.
McKenzie, L.J., Campbell, S.J. & Roder, C.A. (2003) Seagrass-Watch: Manual for Mapping & Monitoring Seagrass Resources by Community (citizen) volunteers. 2nd Edition. (QFS, NFC, Cairns) 100pp.

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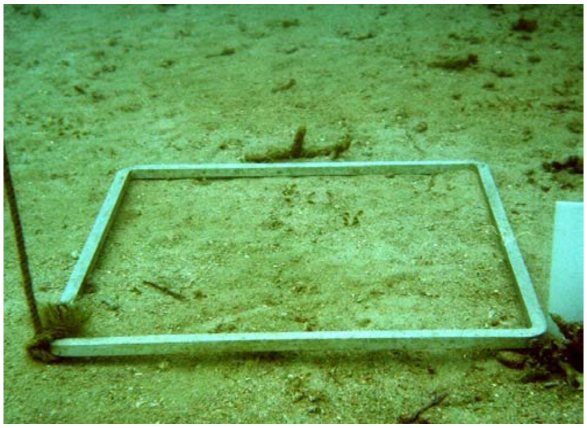

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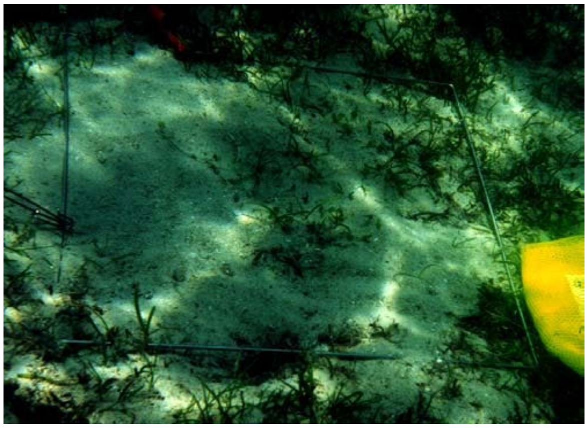

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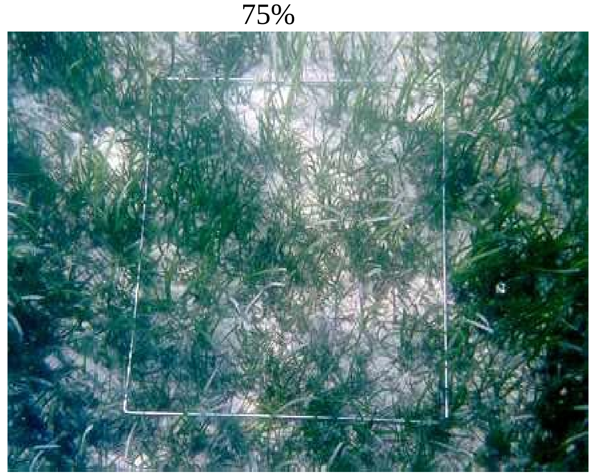

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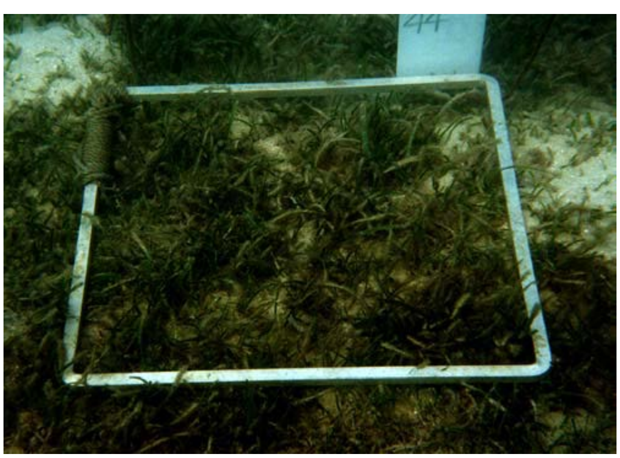

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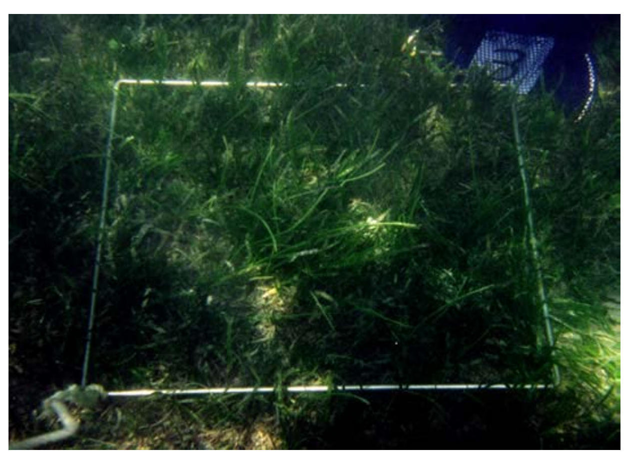

Field data form

Texas Statewide Seagrass Monitoring Program Tier 2 Field Data Form

Date	**Time**	**Personnel**

Station Validation

Bay	☐ priority ☐ alternative	Coordinate ID	TPWD Grid	TPWD Gridlet

A valid coordinate set has yes for each question. If no, then attempt an alternative coordinate set.	**Yes**	**No**
Is the seagrass coverage in a 10 m radius around the boat relatively uniform (visual check)?		
Is seagrass present at 50% coverage or more in the surrounding area (visual check)?		
Is site free of safety hazards that would prohibit safe sampling around the coordinates?		

If all three boxes are checked "yes", continue. If not, attempt alternative station and start new field data form

Notes

GPS unit unique ID	Waypoint name
Lat. (dd 00.00000)	Long. (dd 00.00000)

Weather (temp, wind, cloud cover, etc.)

Water conditions (color, odors, foam, algae, etc.)

Human use (angling, swimming, boating, etc.)

Tide stage (low, falling, slack, rising, or high)	Total water depth (nearest 0.01 m)

Seagrass Percent Coverage

Percent coverage of each seagrass species within 0.25 m^2 quadrat (total of all species plus bare should equal 100% for each replicate). Check box next to species if retained for ID. Record "V" for visual methods (eye, view scope) and "T" for touch.

	V/T	***Halodule***	✓	***Thalassia***	✓	***Syringodium***	✓	***Ruppia***	✓	***Halophila***	✓	**Bare**
Bow												
Starboard												
Stern												
Port												

Notes

Seagrass Canopy Height

Collect canopy height for all seagrass species with at least 20% coverage in the quadrat. Gently uproot seagrass rhizome. Measure the longest leaf from a shoot to the nearest 0.1 cm (record in cm). Repeat four more times for a total of five measurements. Collect data on all four sides of the boat.

Replicates	***Halodule***	***Thalassia***	***Syringodium***	***Ruppia***	***Halophila***
Bow – 1					
Bow – 2					
Bow – 3					
Bow – 4					
Bow – 5					
Starboard - 1					
Starboard – 2					
Starboard – 3					
Starboard – 4					
Starboard – 5					
Stern – 1					
Stern – 2					
Stern – 3					
Stern – 4					
Stern – 5					
Port – 1					
Port – 2					
Port – 3					
Port – 4					
Port – 5					

Notes