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Seagrass Survey

Lower Laguna Madre

Draft Report

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May 2023

EXECUTIVE SUMMARY

High intensity rainfall events in the Lower Rio Grande Valley drive flooding on relatively flat, slow-draining terrain and overwhelming the Valley's aging and inadequate drainage system. Floodwaters inundate large agricultural areas, improved pastures, and urban areas for long periods, extensively damaging crops, properties, and structures. Floodwaters block transportation arteries, interrupting economic activities, tourism, school attendance, and utility services, and increasing repair. Interruption of transportation routes also increases risk of loss of life by reducing access to critical emergency and rescue services.

Hidalgo County Drainage District Number 1 proposes modifying drainage to shift some water to the Raymondville Drain from the Main Floodway Channel during floods. The modification will not change the amount of water contributed by both drains which flow together to the Lower Laguna Madre.

Sampling on April 19 and 20, 2023 by Freese and Nichols, Inc. biologists found the following information about seagrass, water quality, and sediment over a 1,200-acre study area along the west shore of the Lower Laguna Madre about 5 miles south of Port Mansfield.

- Seagrass was present at 63 percent of the points sampled.
- Shoal grass was the seagrass seen most frequently in samples, present at 57 percent of the points sampled. Star grass was found at 10 percent of the sample points and Turtle grass was found at one point.
- Where present, Shoal grass covered from 1 to 25 percent of the bay bottom. The average percent cover of Shoal grass in samples where it was found was 6 percent.
- The length of Shoal grass leaves ranged from 2.5 to 7.5 inches and averaged 4.4 inches.
- Shoal grass was found most often in water less than 3.1 feet deep. Eighty-five percent of points with Shoal grass were shallower than 3.1 feet. Only 15 percent of points deeper than 3.0 feet had Shoal grass.
- Field water quality was generally within acceptable ranges with dissolved oxygen of 4.9 to 5.7 milligrams per liter, pH from 8.2 to 8.4 standard units, and temperatures below 77 degrees Fahrenheit. Salinities ranged from 27.7 to 29.8 practical salinity units.
- Macroalgae was present at 51 percent of the sample points, at times completely covering seagrass.
- Nutrient and chlorophyll α were below concentrations used by TCEQ to indicate nutrient enrichment in estuaries.
- Sediment grain size analysis showed sediment in the study area was predominantly sand with some clay and smaller amounts of silt and shell hash.
- Lack of adequate sunlight reaching the bottom in deeper water and areas of higher turbidity may be preventing growth of seagrass in parts of the study area.

Table of Contents

Page

List of Appendices

Figures

Page

Tables

Page

Acronyms and Abbreviations

°F	degrees Fahrenheit
µg/L	micrograms per liter (parts per billion)
CDT	Central Daylight Time
District	Hidalgo County Drainage District Number 1
FNI	Freese and Nichols, Inc.
mg/L	milligrams per liter
NOAA	National Oceanic and Atmospheric Administration
psu	practical salinity units
study plan	Lower Laguna Madre Seagrass Plan
su	standard units
TCEQ	Texas Commission on Environmental Quality
TPWD	Texas Parks and Wildlife Department
TSS	total suspended solids
UTMSI	University of Texas Marine Science Institute

1.0 INTRODUCTION

Flooding within the Lower Rio Grande Valley is primarily driven by high intensity rainfall events, falling on relatively flat, slow-draining terrain, overburdening the aging and inadequate drainage system in place throughout the Lower Rio Grande Valley. Floodwater inundates large areas used for row crop farming, improved pastures, and urban areas for long periods, resulting in extensive damage to crops, properties, and structures. Floodwaters block transportation arteries interrupting economic activities, tourism, school attendance, and utility services, and increasing the efforts of repair crews. Interruption of transportation routes also increases risk for loss of life due to limited egress and reduced access to critical emergency and rescue services. Flooding of sanitation facilities occurs periodically in many communities, contaminating water supplies and threatening the health and safety of the residents.

As a result of the relatively flat topography, most communities in the Lower Rio Grande Valley are affected by flooding to some degree. Communities within the Lower Rio Grande Valley that are particularly vulnerable to floods include McAllen, Edinburg, Lull, San Carlos, La Blanca, Elsa, Edcouch, La Villa, Raymondville, Lyford, Sebastian, and San Perlita. Other smaller rural communities are also affected. Flooding is compounded in Willacy County by surface runoff from Hidalgo County which must flow overland to the Laguna Madre. Both Raymondville and Lyford in Willacy County have local drainage conditions which result in receiving significant overland flow from rural areas to the west several days after flood producing rainstorms occur in the area.

The Hidalgo County Drainage District No. 1 (HCDD1) is developing a project to improve the existing regional storm water drainage system in Hidalgo and Willacy Counties, Texas. This drainage improvement project, known as the Raymondville Drain Project, is proposed to widen selected channels and ditches along the existing Raymondville Drain as well as evaluate the construction of new drainage system elements (i.e., detention ponds, storage channels, ditches, pond facilities, etc.) to provide additional drainage benefits in Hidalgo and Willacy Counties.

HCDD1 also proposes reducing the flow of water from the Main Floodwater Channel by approximately 1,100 cfs exclusively during flood conditions; this reduction would be accomplished by conveying water from the Main Floodwater Channel to the Raymondville Drain. Both drains meet about 0.8 miles west of the Lower Laguna Madre and flow together into the Lower Laguna Madre about five miles south of Port Mansfield in Willacy County, Texas. The proposed modifications to the Main Floodwater Channel and the Raymondville Drain will not change the amount of water currently conveyed to the Laguna Madre.

The HCDD1 is committed to protecting seagrass in the Lower Laguna Madre and commissioned a seagrass study by Freese and Nichols, Inc. (FNI) to describe the presence of seagrass over a 1,200-acre study area in the part of the Lower Laguna Madre receiving the combined flow from the Raymondville Drain and the Main Floodwater Channel. This report describes the results of the HCDD1's seagrass study conducted on April 19 and 20, 2023 by FNI.

The Lower Laguna Madre is a semi-enclosed, shallow, estuary along the south coast of Texas averaging a little more than 3.3 feet deep, and bordering Willacy and Cameron counties. The estuary was historically hypersaline but hydrological modifications like the Mansfield Ship Channel, the Gulf Intracoastal Waterway, and the Brownsville Ship Channel, combined with modified drainage patterns which deliver more freshwater to the estuary, have substantially reduced salinities.

The Lower Laguna Madre has become well-known for its extensive seagrass beds which covered an estimated 70,000 acres in 2009 (DeYoe et al., 2023), consisting of Turtle grass (*Thalassia testudinum*), Shoal grass (*Halodule wrightii*), Manatee grass (*Syringodium filiforme*), and Star grass (*Halophila engelmannii*). Onuf (1996) suggested that reduced salinities in the Lower Laguna Madre over recent decades may have contributed to reductions in Shoal grass and increases of Turtle grass and Manatee grass in the Lower Laguna Madre. Shoal grass still covers more of the Lower Laguna Madre bottom than the other species of seagrass.

Healthy seagrass beds are a critical part of the Lower Laguna Madre ecosystem. Seagrass beds shelter young fish and shellfish that are recreationally, commercially, and ecologically important. Tolan et al. (1997) found young anchovies and menhaden, both important prey for other fish and birds, dominated samples collected from seagrass beds. They also found juvenile Spotted Seatrout (*Cynoscion nebulosus*) and Red Drum (*Sciaenops ocellatus*) were found “almost exclusively” in Shoal grass (*Halodule wrightii*) seagrass beds in the Lower Laguna Madre. Sheridan and Minello (2003) found densities and biomass of fish, crabs, and shrimp were higher in Lower Laguna Madre seagrass beds than in areas of the Laguna Madre without seagrass. Overwintering waterfowl like Redhead Ducks (*Aythya americana*) in flocks that may number 60,000 birds, forage on seagrass of the Lower Laguna Madre (Cornell Lab of Ornithology, 2023). The highest concentration of Redhead Ducks in North America, about 300,000 birds, overwinter in the Laguna Madre and nearby waters (Michot et al., 2006). Recreational angling and waterfowl hunting which require healthy seagrass beds in the Lower Laguna Madre make important contributions to the local and state economy.

2.0 STUDY AREA

Sampling was conducted over a 1,200-acre area extending from the west shore of the Lower Laguna Madre east to the west side of islands created with dredged material placed along the west side of the Gulf Intracoastal Waterway (Figure 1). The study area extended from about 3.7 to 6.2 miles south of Port Mansfield. Sampling stretched into the channel formed by the confluence of the Main Floodway Channel and the Raymondville Drain. Water depths in the study area ranged from 1.2 to 5.6 feet with shallower water at the south end and deeper water towards the north end.

Table 1 reports the geographic coordinates of each sample point. Figure 2 shows the study area and the 84 sample points where data were collected. Sample Points 41 and 50 were so close to each other that they are not separated in Figure 2. In addition to seagrass samples, water quality and sediment grain size samples were collected at points 81 to 84.

Table 1
Sample Points

Sample Point	Latitude	Longitude	Sample Point	Latitude	Longitude
1	26.475810	–97.384535	43	26.483351	–97.403052
2	26.477633	–97.385688	44	26.486706	–97.404124
3	26.478518	–97.387886	45	26.489858	–97.405443
4	26.479482	–97.389979	46	26.486923	–97.407008
5	26.481658	–97.391382	47	26.482099	–97.408969
6	26.483308	–97.391102	48	26.481583	–97.409299
7	26.486615	–97.392430	49	26.481072	–97.406061
8	26.490008	–97.393868	50	26.476475	–97.399854
9	26.493246	–97.395397	51	26.475764	–97.399047
10	26.496131	–97.396748	52	26.474736	–97.398696
11	26.499593	–97.397921	53	26.471407	–97.398179
12	26.502658	–97.399400	54	26.473317	–97.393664
13	26.502396	–97.401764	55	26.474937	–97.391420
14	26.499293	–97.400350	56	26.478988	–97.392622
15	26.495616	–97.398857	57	26.483633	–97.394918
16	26.492758	–97.397940	58	26.487214	–97.397067
17	26.489575	–97.396477	59	26.489866	–97.398447
18	26.486325	–97.394916	60	26.493237	–97.399854
19	26.483475	–97.393652	61	26.49360	–97.391794
20	26.480370	–97.392099	62	26.496773	–97.393587
21	26.478321	–97.390735	63	26.486667	–97.389513

Sample Point	Latitude	Longitude	Sample Point	Latitude	Longitude
22	26.478908	–97.393259	64	26.483128	–97.388149
23	26.479363	–97.394801	65	26.480308	–97.386264
24	26.484046	–97.397029	66	26.478302	–97.384307
25	26.486250	–97.397912	67	26.480587	–97.387869
26	26.489521	–97.399406	68	26.480588	–97.390743
27	26.492671	–97.400672	69	26.481242	–97.393916
28	26.495861	–97.402061	70	26.480979	–97.395611
29	26.498827	–97.403584	71	26.480775	–97.396960
30	26.502233	–97.405190	72	26.480409	–97.399243
31	26.505416	–97.406435	73	26.481496	–97.401774
32	26.495792	–97.405066	74	26.483932	–97.399561
33	26.492933	–97.404037	75	26.485096	–97.398578
34	26.488790	–97.402503	76	26.487381	–97.399795
35	26.485730	–97.400822	77	26.488272	–97.398509
36	26.482369	–97.400096	78	26.487893	–97.396109
37	26.479501	–97.397871	79	26.487412	–97.39442
38	26.479338	–97.397507	80	26.487352	–97.391282
39	26.476520	–97.396543	81[1]	26.482897	–97.407879
40	26.473906	–97.398125	82[1]	26.488624	–97.401069
41	26.476421	–97.399851	83[1]	26.499099	–97.404794
42	26.480153	–97.40112	84[1]	26.478490	–97.399689

[1] Sample points for field water chemistry, water, and sediment grain size samples in addition to seagrass percent cover.

Figure 1. Lower Laguna Madre Seagrass Study Area
Google Earth Image from December 15, 2018

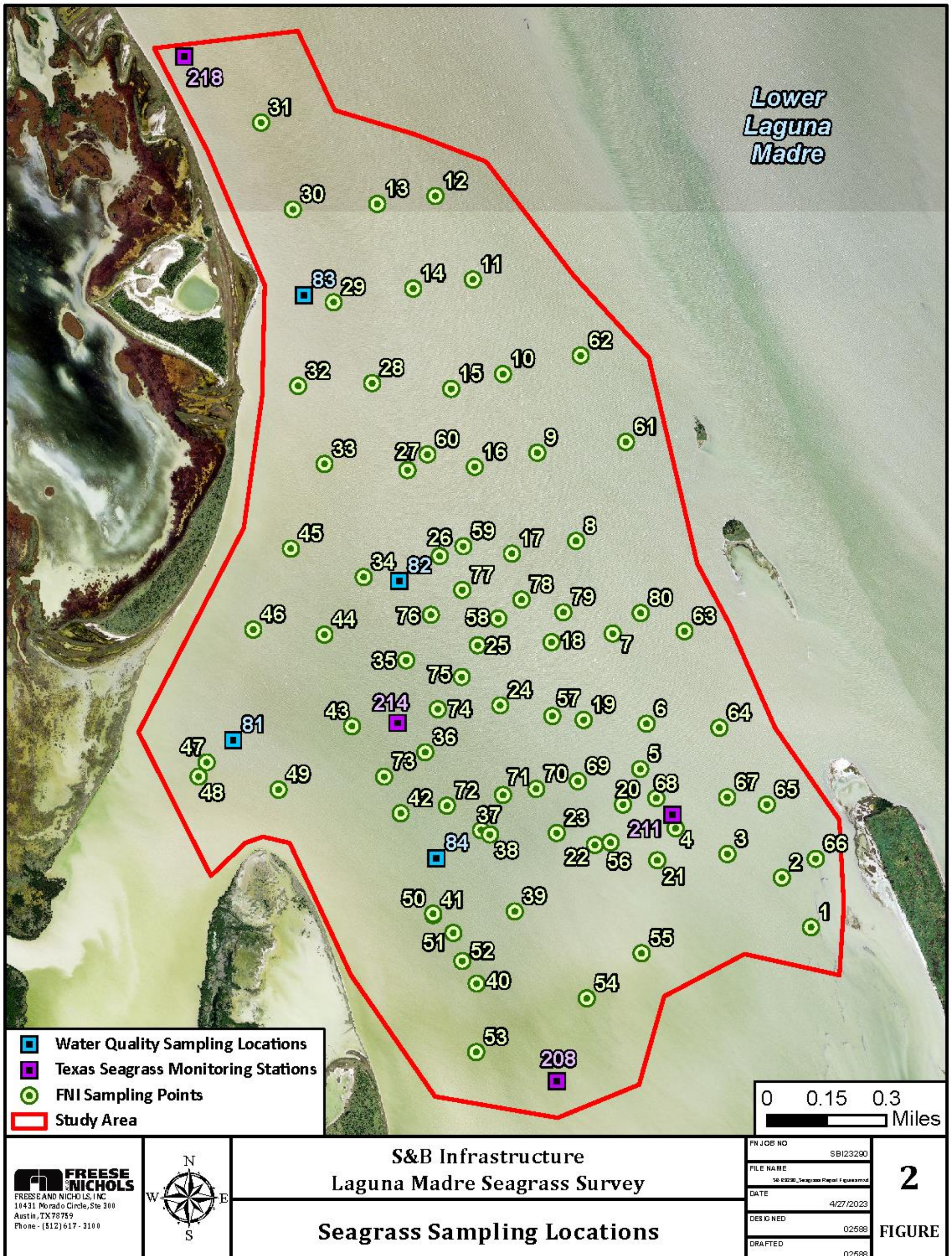

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Figure 2. Sample Points

Figure 3 shows the confluence of the Main Floodway Channel and the Raymondville Drain as they flow towards the Lower Laguna Madre. The blue arrow shows the direction water flows from the drains to the Lower Laguna Madre.

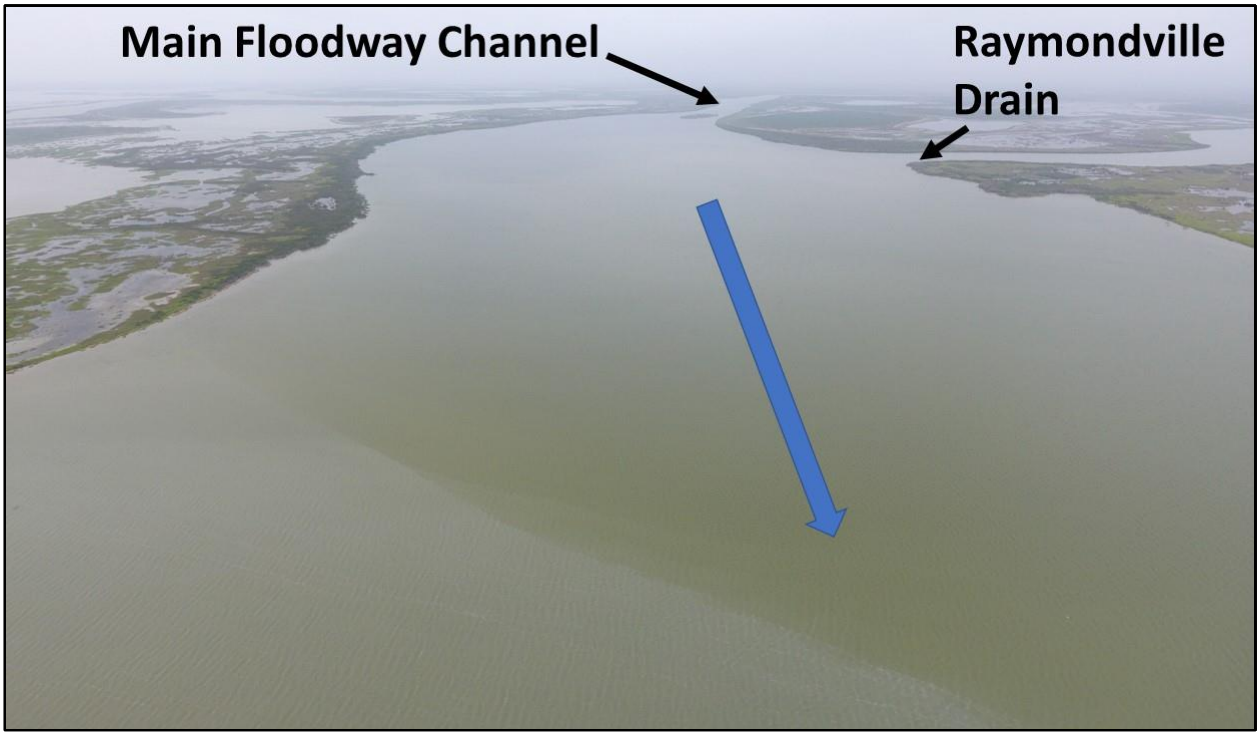

Figure 3. Confluence of the Main Floodway Channel and the Raymondville Drain
(Drone photo by FNI from altitude of 390 feet on April 20, 2023.)

Figure 4 shows the south end of the study area in the Lower Laguna Madre. The blue arrow shows where water flows from the drains to the Lower Laguna Madre.

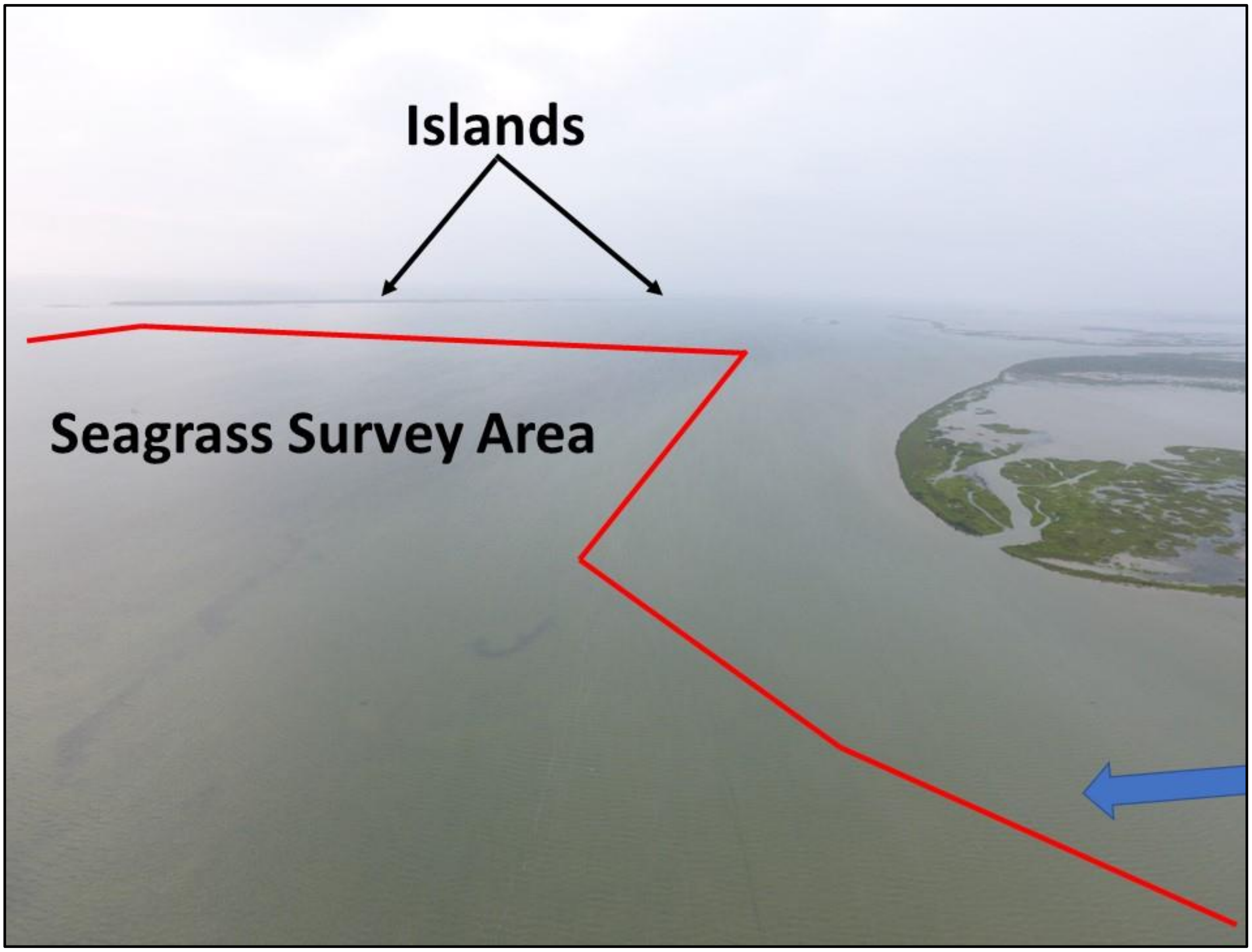

Figure 4. South End of Study Area in the Lower Laguna Madre
View to the south with mainland on the right and Lower Laguna Madre on the left.
(Drone photo by FNI from altitude of 390 feet on April 20, 2023.)

Figure 5 shows the north end of the study area in the Lower Laguna Madre. The blue arrow shows where water flows from the drains to the Lower Laguna Madre.

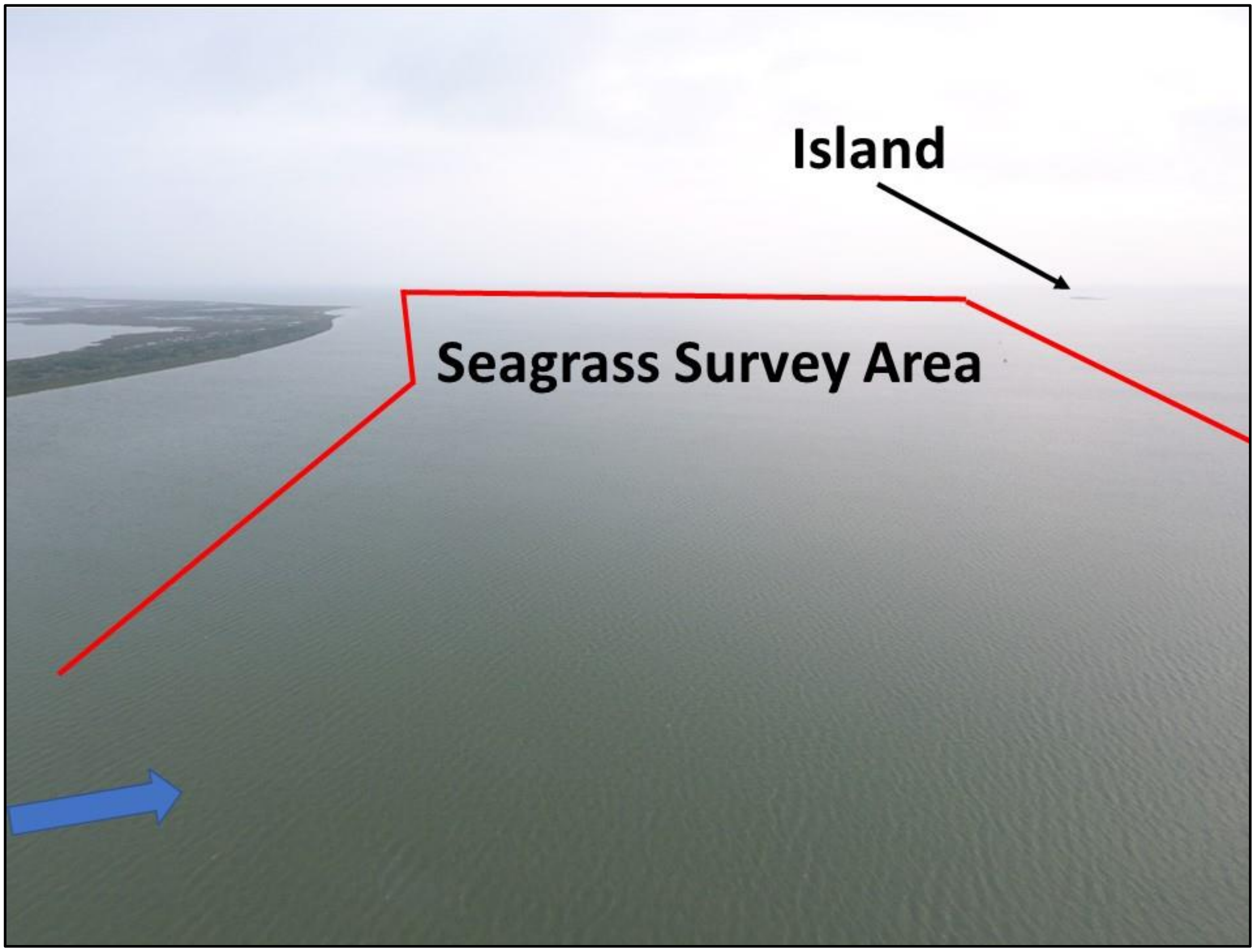

Figure 5. North End of Study Area in the Lower Laguna Madre
View to the north and Port Mansfield. Mainland on the left and the Lower Laguna Madre on the right.
(Drone photo by FNI from altitude of 390 feet on April 20, 2023.)

Seagrass wrack was floating throughout the study area. Most wrack consisted of green Shoal grass leaves with green Turtle grass leaves commonly observed.

The substrate throughout the study area consisted of mud, sand, and shell hash. There were no substantial visual differences in substrate across the study area. Clay and silt with some sand appeared to dominate the substrate with shell hash present in most samples. Some samples had substantially more shell hash than others. Samples in the area where the drains discharge to the Lower Laguna Madre may have had higher clay concentrations. Substantial organic matter was not observed in any sample and only one sample, Sample Point 37, had the detectable rotten egg odor of hydrogen sulfide. The sample with hydrogen sulfide had a thick layer of the red macroalgae, *Gracilaria/Gracilariopsis*.

Polychaetes, particularly the decorator worm, *Diopatra cuprea*, were common and observed in many samples. *D. cuprea* were observed with a green blade of Shoal grass attached to the exposed end of the polychaete's case in seven samples (Figure 6). Other invertebrates observed in samples included a ghost shrimp (Family Callianassidae), a grass shrimp (*Palaemonetes*), an unidentified shrimp, and the bivalves, stout tagelus (*Tagelus plebeius*), minor jacknife clam (*Ensis minor*), and Florida Cross-barred Venus (*Chione elevata*). Gastropods were not observed in any samples.

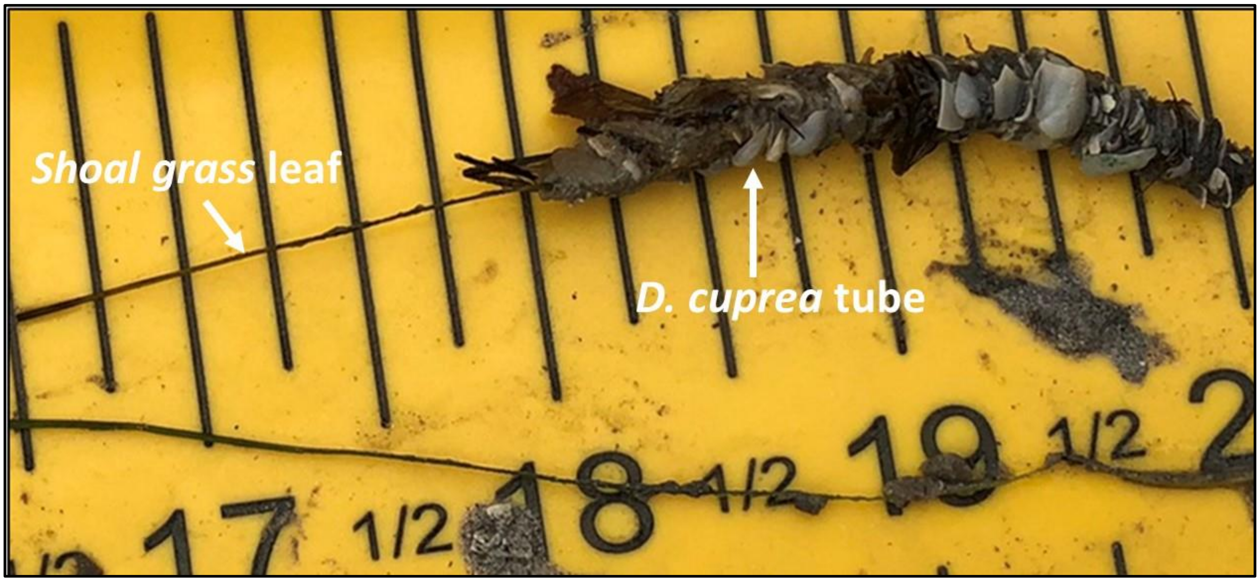

Figure 6. *D. cuprea* with Live Shoal Grass Leaf Attached to Exposed End of Case
(Ruler units are inches.)

Several boats with recreational anglers were observed in the study area throughout the day on April 19, 2023 and during the morning of April 20, 2023. Recreational anglers appeared to be fishing primarily in the south half of the study area. A series of crab traps which appeared to have recent labels extended from the Lower Laguna Madre into the channel formed by the confluence of the two drains.

3.0 METHODS

Samples and data were collected by FNI coastal biologists, Tom Dixon, David Buzan, and Avery Mottet, at 84 sample points, 80 sampling locations on April 19, 2023 and four sampling locations on April 20, 2023. The biologists used FNI's 20-foot long Majek shallow-draft boat.

The Lower Laguna Madre Seagrass Plan (study plan, Appendix A) included estimating percent seagrass cover at 80 points along five transects oriented from southeast to northwest using a 0.25 square meter quadrat divided with twine into 100 squares of approximate equal area. Turbidity within the study area prevented the biologists from observing the bay bottom and the quadrat on the bay bottom.

The biologists attempted to use the 0.25 square meter quadrat at Sample Points 1 and 2 by placing the quadrat on the bay bottom and feeling the seagrass within the quadrat. The presence of macroalgae on the bottom and the thin blades of the seagrass did not allow accurate estimates of seagrass cover to be made by touch with the quadrats. Although seagrass was present, percent seagrass cover was not obtained at Sample Points 1 and 2. In addition, seagrass percent cover was not measured at Sample Point 66. Since percent seagrass cover was not measured at Sample Points 1, 2, and 66, percent seagrass cover data are only available from 81 of the 84 points sampled.

To address the inability to see the quadrat and the bay bottom, biologists modified sampling by collecting one to four plugs of the bay bottom at each sample location with a post-hole digger. The post-hole digger collected sediment plugs that were 5 inches in diameter and 2 to 8 inches deep.

At each sample point, if the first sediment plug did not have visible seagrass blades or rhizomes, a second sediment plug was collected. If the second sediment plug did not have visible blades or rhizomes, a third sediment plug was collected (Figure 7).

The study plan required seagrass sampling at 80 points. The biologists sampled 84 points which were in a smaller area than proposed in the study plan. FNI biologists decided to stop sampling the north ends of the transects where water depths were greatest when at least two consecutive points along the same transect to the north were sampled without detecting seagrass. Water became shallower moving towards the south end of the study area and the biologists stopped sampling when it appeared the boat was disturbing the bay bottom.

In addition to trying to sample transects from the southeast to the northwest, the biologists tried to sample transects, not included in the study plan, from east to west in areas where seagrass seemed to be in the highest concentrations. The biologists also sampled selected points where it appeared submerged vegetation might be present. These points were identified from the boat as darker areas of water and were sampled to identify areas of maximum seagrass cover.

Figure 7. Three Sediment Plugs Collected at Sample Point 44
(Seagrass was absent from these plugs. One blade of Shoal grass was attached to a polychaete case.)

3.1 SEAGRASS PERCENT COVER

At each sample point, two biologists visually estimated the percent seagrass cover on each sediment plug independently of each other. Percent seagrass cover was estimated using this method at 81 of the 84 points sampled. Seagrass was present at Sample Points 1 and 2 but there are not estimates of percent seagrass cover at those two points. Percent seagrass cover was also not estimated at Sample Point 66. After estimating percent seagrass cover, the two biologists compared their results and reached consensus on the final value recorded for seagrass cover. The greatest difference in estimated seagrass cover between the biologists for any sample was 15 percent. If the sediment plug was covered with macroalgae, the percent seagrass cover was estimated after removal of the macroalgae (Figure 8).

The percent cover at each sample point was calculated based on the percent seagrass cover on each plug and the average of the seagrass cover on all the plugs collected at each point. For example, at Sample Point 39, three sediment plugs were collected, and each plug had a different amount of seagrass cover (Figure 9). The plug at the top of the photo did not have any seagrass, the plug in the middle of the photo was estimated to have 10 percent seagrass cover, and the plug at the bottom of the figure was estimated to have 20 percent seagrass cover. The seagrass cover value for Sample Point 39 was 10 percent, the average of the values for the three plugs.

Figure 8. Sediment Plug at Sample Point 21
(Plug with macroalgae in photo on the left. Plug without macroalgae on the right.)

Each sediment plug without seagrass was pushed apart and checked for the presence of seagrass rhizomes. Seagrass rhizomes were not found in any sediment plugs that did not have visible seagrass.

3.2 SEAGRASS BLADE LENGTH

Seagrass leaf length was measured by cutting a blade of seagrass at the level of the sediment from the center of the sediment plug and measuring it on a ruler to the nearest tenth of an inch. If more than one plug with seagrass was collected at a sample point, a seagrass blade was collected from only one of the plugs.

3.3 FIELD WATER QUALITY

Field water temperature (°F), pH (standard units [su]), salinity (practical salinity units [psu]), and dissolved oxygen (as milligrams per liter [mg/L] and percent saturation) were measured at a depth of 1 foot at each of four sample points (81 through 84), with a calibrated Hydrolab CMS5 water quality meter on April 20, 2023 between 07:50 and 08:50 CDT. Secchi disk transparency (feet) was measured at all seagrass sample points on April 19 and 20, 2023. Measurements of field water quality preceded collection of water and sediment samples.

Figure 9. Sediment Plugs at Sample Point 39

3.4 WATER QUALITY SAMPLES

Water samples were collected at the same points, depths (1 foot), and times as the field water quality measurements using sample bottle supplied by the laboratory. Sample protocols followed those in the Texas Commission on Environmental Quality Surface Water Monitoring Protocols (TCEQ, 2012).

Samples were analyzed by the Lower Colorado River Authority Environmental Laboratory for total suspended solids (TSS), ammonia nitrogen, nitrate and nitrite nitrogen, orthophosphorus, and chlorophyll α. Water samples were collected before collection of sediment samples at each sample point. A field duplicate water sample for submittal to the lab was collected at Sample Point 82 for quality control purposes. There is not a field duplicate of field water quality measurements. Water and sediment samples were delivered to the lab on April 21, 2023 at 09:58 CDT.

3.5 SEDIMENT SAMPLES

Sediment samples were collected with the post-hole digger at the same points and times as the field water quality and water samples. Sediment plugs were placed in a plastic tray and sediment was pushed into the sample bottle provided by the laboratory.

Samples were analyzed by the Lower Colorado River Authority Environmental Laboratory for sediment grain size. Sediment samples were collected immediately after water samples were collected. Sediment samples included the upper 2 to 3 inches of sediment since this was the approximate depth at which seagrass rhizomes were observed to penetrate the sediment. A field duplicate sediment grain size sample for submittal to the lab was collected at Sample Point 82 for quality control purposes.

3.6 PHOTOGRAPHY

The bottom of the bay was not visible at any sampling point because of the cloudiness of the water. Consequently, photographs of the bay bottom could not be taken. Photographs were taken of all sediment plugs collected at each location for assessment of seagrass cover. Photographs were also taken of the seagrass leaf blades that were measured. A total of 178 photos were taken of the sediment plugs, seagrass leaf blades, and selected organisms encountered at samples.

Drone photos were taken of the study area on April 20, 2023. Drone use was limited because high winds interfered with the ability to control the drone.

4.0 RESULTS

4.1 WEATHER

The nearest weather station with available data was at the Harlingen Valley International Airport, approximately 24 miles southwest of the study area. Data in this subsection were obtained from the Harlingen Valley International Airport weather station through the Weather Underground (2023) web page. When the biologists arrived at Port Mansfield on the afternoon of April 18, 2023, they attempted to boat to the work site but decided conditions were not safe and returned to the boat launch. Upon return to the boat launch, the biologists found a small craft advisory warning had been issued for the area. Winds were steady from the east-southeast at more than 20 miles per hour with gusts exceeding 30 miles per hour during the afternoon of April 18, 2023.

On April 19, 2023 when most of the seagrass data were collected, winds ranged from 7 miles per hour about 07:00 CDT when the biologists started work, up to 21 miles per hour by 13:52 CDT with gusts in the afternoon up to 26 miles per hour. Winds varied from the southeast to the south-southeast.

Total rainfall preceding sampling from April 1 through April 19, 2023 was 1.38 inches. The greatest daily rainfall total was 1.23 inches on April 7, 2023.

On April 20, 2023 when water and sediment samples were collected, winds were from the southeast at 10 miles per hour when the biologists left Port Mansfield at 06:52 CDT and 13 miles per hour when the biologists returned about 9:52 CDT.

4.2 WATER LEVEL AND CURRENTS

Preliminary water level data from the NOAA water level gage, 8778490, at Port Mansfield indicated water level ranged from 11.0 to 12.6 inches above mean sea level from April 19 through April 20, 2023 when seagrass sampling was conducted (Figure 10) (NOAA, 2023). Water level fluctuated less than 2 inches during the tidal cycles at the Port Mansfield water level gage during the study period.

There was no visible water flow from the combined drains into the Lower Laguna Madre.

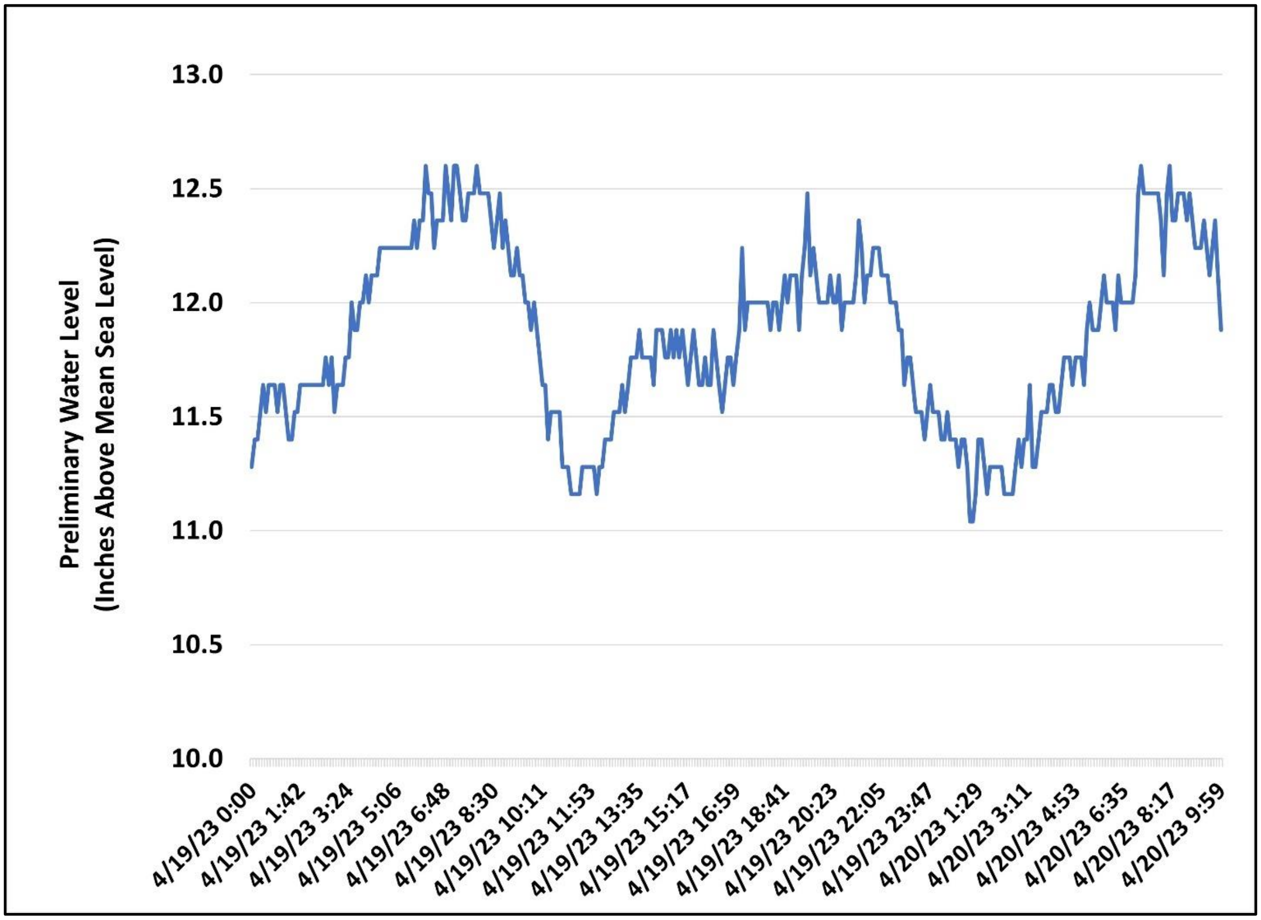

Figure 10. Water Level at the Port Mansfield Water Level Gage, 8778490

4.3 SEAGRASS

Three species of seagrass were observed in the study area: Shoal grass, Star grass (*Halophila engelmannii*), and Turtle grass (*Thalassia testudinum*). Estimated percent seagrass cover ranged from 0 to 25 percent at the 81 sample points where the percent seagrass cover was recorded (Table 2) (Figure 11). Seagrass was observed at 54 points with Shoal grass seen at 48 points (percent cover was not estimated at three of the points), Star grass (Figure 12) was seen at eight points, and Turtle grass, *Thalassia testudinum*, was found at one point, Sample Point 66. Shoal grass and Star grass were found together at three points and Shoal grass and Turtle grass were found together at Sample Point 66.

When present, Shoal grass covered from 1 to 25 percent of the bay bottom and averaged 6 percent cover in the 45 samples for which percent cover was recorded (Figure 13). Star grass percent cover ranged from 1 to 7 percent and averaged 3 percent (Figure 14). Percent cover of Turtle grass was not estimated at the point at which it was observed however percent cover was substantially less than 100 percent.

Table 2
Lower Laguna Madre Seagrass Data

Sample Point	Percent Seagrass Cover	Water Depth (feet)	Species	Leaf Blade Length (inches)	Substrate	Secchi Disk (feet)	Observations
1	[1]	1.7	Shoal grass	4.5	mud, sand	1.4	*Gracilaria/Gracilariopsis*
2	[1]	1.8	Shoal grass	5.0	mud	1.5	*Gracilaria/Gracilariopsis*
3	1	1.9	Shoal grass	3.3	mud, sand	1.6	
4	3	1.9	Shoal grass	2.5	mud, sand, shell	1.6	
5	5	2.2	Shoal grass	3.5	mud, sand	1.8	
6	7	2.7	Shoal grass	4.5	mud, sand	2.4	
7	2	3.6	Star grass	2.3	shell, mud	2.1	
8	1	4.8	Shoal grass	6.0	shell, mud	1.6	
9		5.3			shell, mud	1.4	
10	1	5.2	Shoal grass	3.8	shell, mud	1.5	
11		5.4			shell, mud	1.5	
12		5.6			shell, mud	2.1	
13		5.1			shell, mud	2.6	
14		4.8			shell, mud	2.6	
15		4.5			shell, mud	2.2	
16		5.0			mud, sand, shell	1.6	*Dictyota menstrualis*
17		4.4			shell, mud	1.7	*D. cuprea* with Shoal grass attached, unidentified red algae
18	25	3.4	Shoal grass	6.5	muddy	2.0	*Gracilaria/Gracilariopsis*
19	3	2.2	Shoal grass	2.8	mud, sand, shell	1.7	
20		2.1			shell, mud	1.3	*Gracilaria/Gracilariopsis*
21	4	2.3	Shoal grass	5.5	mud	1.9	*Gracilaria/Gracilariopsis*
22		1.9			mud, sand	1.5	*Gracilaria/Gracilariopsis*
23	8	2.2	Shoal grass	4.8	mud	1.4	*Gracilaria/Gracilariopsis*
24	16	2.8	Shoal grass	4.5	mud, shell	1.9	*Gracilaria/Gracilariopsis*
25		2.7			mud, shell	1.9	*D. menstrualis*

Sample Point	Percent Seagrass Cover	Water Depth (feet)	Species	Leaf Blade Length (inches)	Substrate	Secchi Disk (feet)	Observations
26	1	3.4	Star grass	4.3	mud, shell	2.2	*Gracilaria/Gracilariopsis*
27	1	4.3	Star grass		mud, shell	2.1	*D. menstrualis*
28	3	3.9	Shoal grass	3.0	mud, sand	2.2	
29	2	2.9	Shoal grass	3.3	mud, sand	1.7	
30		2.9			mud, sand	1.6	Callianassidae
31		4.1			mud, sand	2.1	*D. cuprea* with Shoal grass attached, *D. menstrualis*
32		3.5			mud, sand	1.6	*D. cuprea* with Shoal grass attached
33	1	3.5	Shoal grass	3.3	mud, sand	1.7	*Gracilaria/Gracilariopsis*
34		3.2			mud, sand	1.9	*D. cuprea* with Shoal grass attached, *D. menstrualis*, *Gracilaria/Gracilariopsis*
35	1	3.0	Shoal grass	2.5	mud, sand	1.8	
36	12	2.6	Shoal grass	6.0	mud, sand	2.1	*Gracilaria/Gracilariopsis*
37		2.2			mud, sand	1.7	*Gracilaria/Gracilariopsis, Cladophora,* hydrogen sulfide odor
38	8	2.6	Shoal grass	5.3	mud, sand	1.5	
39	10	2.6	Shoal grass	7.0	mud, sand	2.0	
40	7	2.2	Star grass	2.5	mud, sand	1.9	
40	9	2.2	Shoal grass	3.5	mud, sand	1.9	
41	1	2.6	Shoal grass	5.5	mud	1.9	*Gracilaria/Gracilariopsis*, *Ulva flexuosa*
42	7	2.5	Shoal grass	7.0	mud, sand	1.6	
43	20	2.5	Shoal grass	5.0	mud, sand	1.5	
44		3.0			mud, shell	1.5	*D. cuprea* with Shoal grass attached
45		3.7			mud, shell	1.6	*D. cuprea* with Shoal grass attached
46		3.0			mud, sand	1.2	
47		2.3			mud, sand	0.9	Stout tagelus, Minor jackknife clam, *Gracilaria/Gracilariopsis*
48		2.2			mud, sand	0.9	Stout tagelus, *Gracilaria/Gracilariopsis*
49	4	2.2	Shoal grass	4.8	mud, sand	1.0	*Gracilaria/Gracilariopsis*
50	20	2.4	Shoal grass	5.5	mud, clay, sand	1.7	
51	3	2.5	Shoal grass	4.5	mud, sand	1.9	*Gracilaria/Gracilariopsis*
52		2.7			mud, sand	1.9	*Gracilaria/Gracilariopsis*

Sample Point	Percent Seagrass Cover	Water Depth (feet)	Species	Leaf Blade Length (inches)	Substrate	Secchi Disk (feet)	Observations
53	25	2.4	Shoal grass	7.5	mud, sand	1.7	*Gracilaria/Gracilariopsis*, *U. flexuosa*
54	10	2.2	Shoal grass	4.5	mud, sand	1.7	*Cladophora*
55	3	2.1	Shoal grass	3.3	mud, sand	1.4	*Gracilaria/Gracilariopsis*
56	6	2.1	Shoal grass	4.8	mud, sand	1.4	*Gracilaria/Gracilariopsis*
57	1	2.8	Shoal grass	2.5	mud, sand	1.6	
58		3.5			mud, shell	1.6	
59	1	3.1	Star grass	2.3	mud, shell	1.4	
60		4.3			mud, shell	1.4	*D. cuprea* with Shoal grass attached, *D. menstrualis*
61		5.2			mud, shell	1.1	*Gracilaria/Gracilariopsis*
62		5.5			mud, clay, sand	1.3	
63		4.0			mud, clay, sand	1.1	
64	1	3.0	Shoal grass	3.0	mud, clay	1.1	*Gracilaria/Gracilariopsis*
65	2	2.9	Shoal grass	2.8	mud, clay	1.0	*Gracilaria/Gracilariopsis*
66		1.2	Turtle grass		mud, sand, shell	0.5	*Cladophora*
66	2	1.2	Shoal grass		mud, sand, shell	0.5	*Cladophora*
67	3	2.2	Shoal grass	3.0	mud, sand	1.0	
68	1	2.1	Shoal grass	2.8	mud, sand		*Gracilaria/Gracilariopsis*
69	2	2.4	Shoal grass	5.3	mud, sand	1.1	*Gracilaria/Gracilariopsis*
70	1	2.1	Shoal grass	5.5	mud, sand	1.1	*U. flexuosa*
71	1	2.3	Shoal grass	3.3	mud, sand	1.2	*Gracilaria/Gracilariopsis, Cladophora*
72	3	2.5	Shoal grass	4.0	mud, sand	2.2	*Gracilaria/Gracilariopsis*
73	5	2.6	Shoal grass	2.5	mud, sand	1.8	
74		3.0			mud, sand	1.5	
75	2	2.9	Shoal grass	4.3	mud, sand	1.1	*Gracilaria/Gracilariopsis*
76	7	3.6	Star grass	2.0	mud, sand	1.5	*Gracilaria/Gracilariopsis*
76	8	3.6	Shoal grass	6.8	mud, sand	1.5	
77	2	4.0	Shoal grass	3.5	mud, sand	1.3	*Gracilaria/Gracilariopsis*
77	4	4.0	Star grass	2.0	mud, sand	1.3	

Sample Point	Percent Seagrass Cover	Water Depth (feet)	Species	Leaf Blade Length (inches)	Substrate	Secchi Disk (feet)	Observations
78	2	4.0	Star grass		mud, sand, shell	1.1	*Gracilaria/Gracilariopsis*
79		3.9			mud, shell	1.1	
80		4.6			mud, clay, shell	1.1	
81		2.0			mud, clay	1.4	
82	20	2.5	Shoal grass		mud, sand	0.4	
83	1	3.0	Shoal grass		mud, sand	1.1	
84	1	2.0	Shoal grass		mud, sand	2.4	

[1] Seagrass was sampled at these points using the quadrat. Seagrass was present. Percent cover was estimated to be less than 50 percent by touch but was not visually estimated.

[2] Seagrass was observed but percent cover was not estimated.

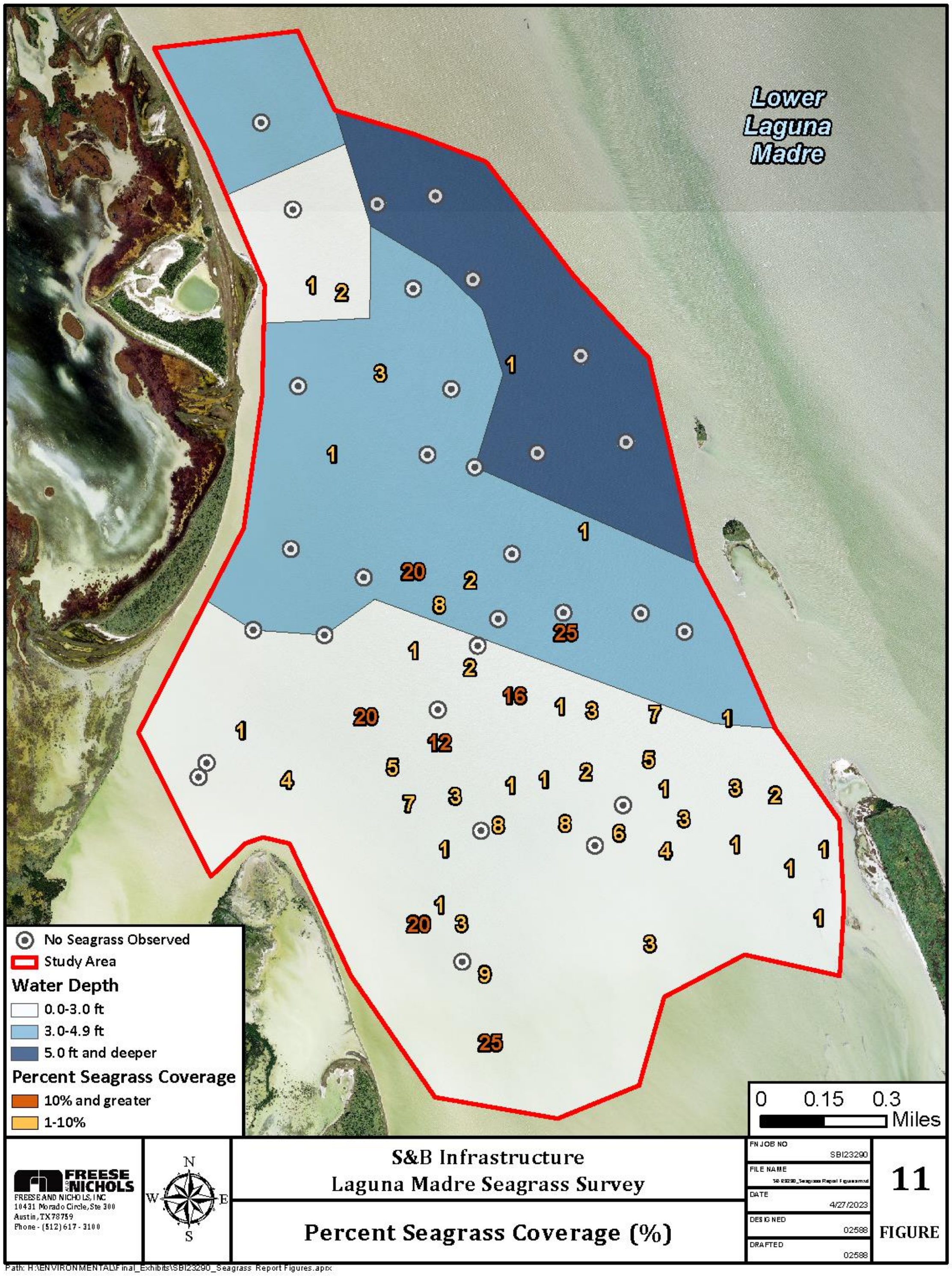

Figure 11. Percent Seagrass Cover

Figure 12. Star Grass at Sample Point 40

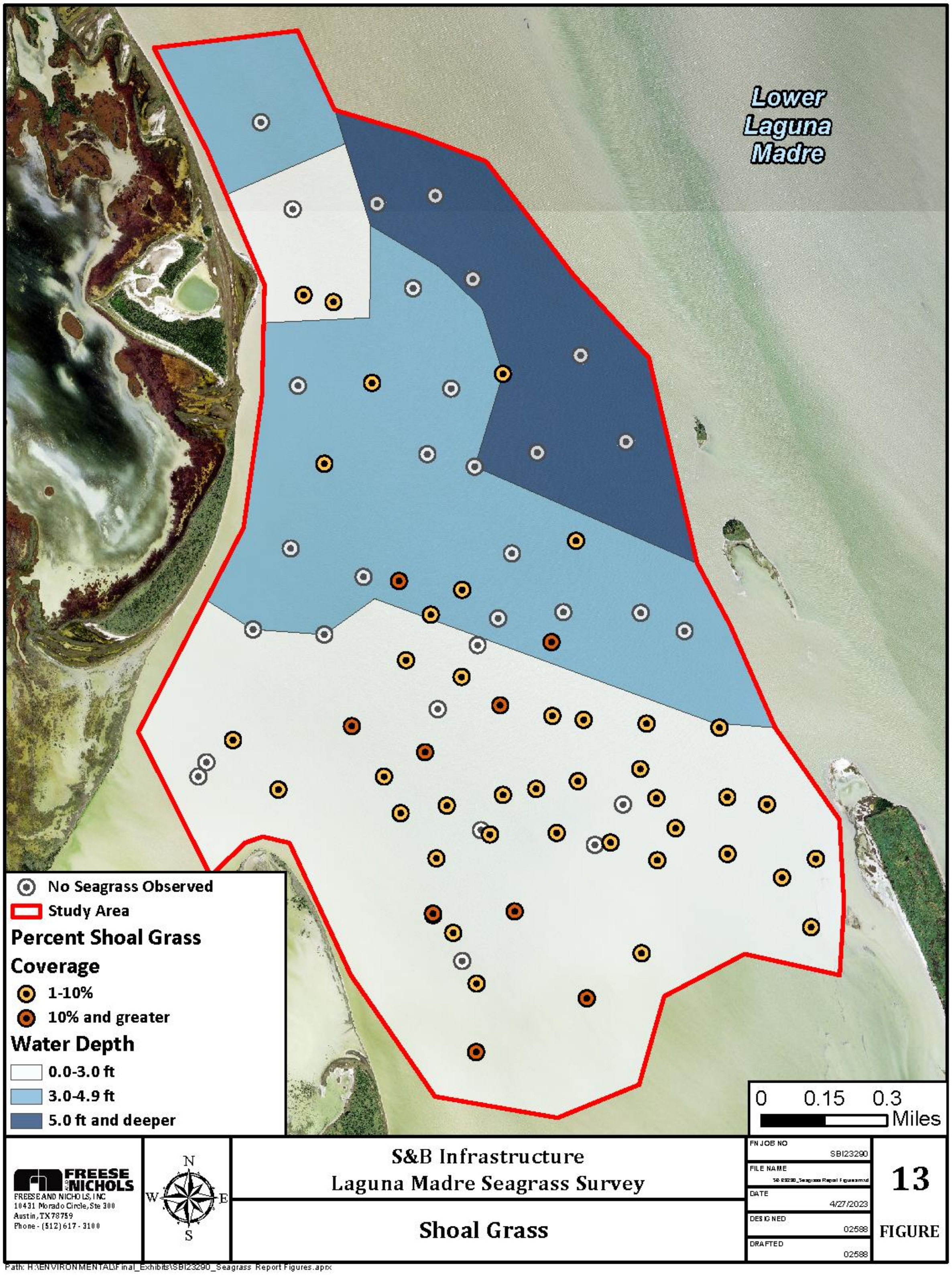

Figure 13. Shoal Grass Presence

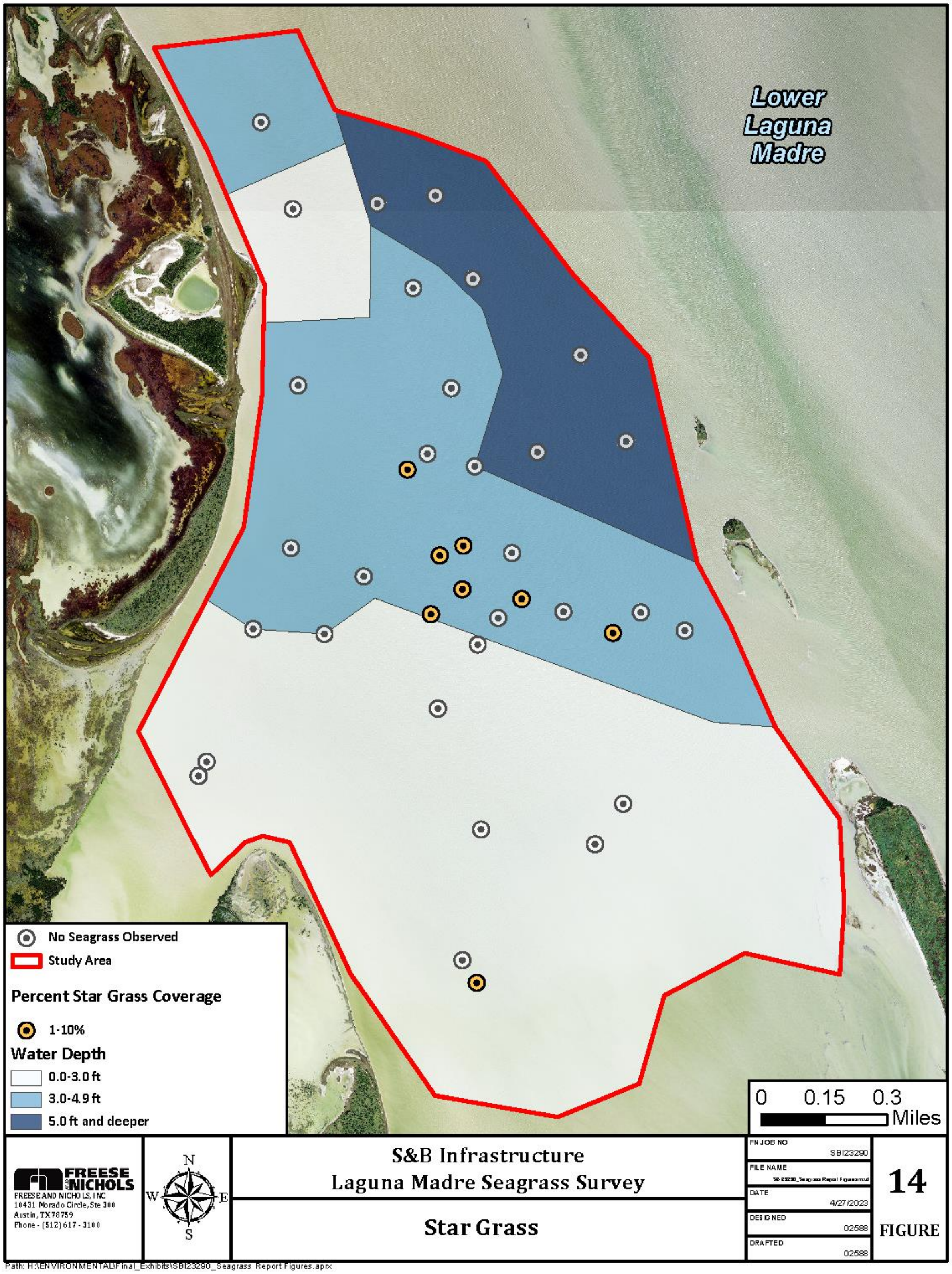

Figure 14. Star Grass Presence

The above-ground length of Shoal grass leaves ranged from 2.5 to 7.5 inches and averaged 4.4 inches from 44 samples. The above-ground length of Star grass stems and leaves, based on analysis of 6 specimens, ranged from 2.0 to 4.3 inches and averaged 2.5 inches. Measurements were not made of Turtle grass leaf blades.

The presence of seagrass appeared related to water depth. Only thirteen percent of samples from depths of 5.0 feet or deeper had seagrass while 78 percent of samples from depths of 3 feet or less had seagrass. Shoal grass was found most frequently in shallow water. Eighty-five percent of samples with Shoal grass were from water depths of 3 feet or less.

Star grass exhibited a different pattern in relation to depth. Seven of eight samples with Star grass were found at depths between 3.1 and 4.3 feet. Only one sample with Star grass was found at a depth less than 3.1 feet and no samples deeper than 4.3 feet contained Star grass.

4.4 MACROALGAE

Macroalgae were observed at 43 sample points. Kopecky and Dunton (2006) studied drift macroalgae in the Lower Laguna Madre and found drift macroalgae abundance was highly variable and these algae tended to accumulate in seagrass beds rather than bare areas. The red algae, *Gracilaria*/*Gracilariopsis*, was observed most often and was found at 33 sample points (Figure 15). AlgaeBase was checked to determine if the macroalgae was *Gracilaria* or *Gracilariopsis* (Guiry and Guiry, 2023). According to AlgaeBase, these two genera are distinguished by differences in specialized reproductive features. FNI biologists did not attempt to observe reproductive features on these algae and consequently this algae is referred to as *Gracilaria/Gracilariopsis* for this report.

Figure 15. Examples of *Gracilaria/Gracilariopsis*
Sample Point 37 (left photo) and Sample Point 49 (right photo)

Forked sea tumbleweed, *Dictyota menstrualis*, was observed at six sample points (Figure 16).

Figure 16. Forked Sea Tumbleweed, *D. menstrualis*, at Sample Point 34

The filamentous green algae, *Cladophora*, was observed drifting in the direction of the wind in the south end of the study area about 4 to 6 inches below the water's surface. These drifting aggregations of *Cladophora* were roughly spherical and ranged in diameter up to 4 inches. Where observed, there was about one aggregation of *Cladophora* per square foot of water surface area. Some of these aggregations were captured, primarily on filaments of *Gracilaria/Gracilariopsis*, but did not appear to be substantially covering any seagrass (Figure 17).

The green algae, *Ulva flexuosa*, was found at three sample points as solitary filaments about one to two inches long.

Figure 17. *Cladophora* Trapped on *Gracilaria/Gracilariopsis* at Sample Point 37

4.5 SEDIMENTS

Sediment grain size analysis showed the sediment was predominantly sand (greater than 82%) and clay (greater than 5%) at all sample points (Table 3). Sample Point 83 which was closest to the west shore of the Lower Laguna Madre was over 92% sand.

Table 3
Lower Laguna Madre Sediment Grain Size

Sample Point	Percent Sand	Percent Silt	Percent Clay	Percent Shell Hash
81	82.5	5.2	11.9	0.48
82	82.6	5.5	9.9	1.98

Sample Point	Percent Sand	Percent Silt	Percent Clay	Percent Shell Hash
82 (field duplicate)	82.6	6.6	8.2	2.61
83	92.6	1.2	5.0	0.15
84	82.9	6.4	9.2	1.55

4.6 WATER QUALITY

Water temperatures ranged from 75.7 to 79.9 degrees Fahrenheit (°F) from 08:00 CDT, April 19, 2023, through 10:00 CDT, April 20, 2023, at the National Oceanic and Atmospheric Administration (NOAA) Port Mansfield water level gauge (NOAA, 2023).

The Texas Commission on Environmental Quality (TCEQ) Surface Water Standards for the Lower Laguna Madre include a minimum daily average of 5.0 mg/L dissolved oxygen, a pH range of 6.5 to 9.0, and an instantaneous maximum temperature of 95°F (TCEQ, 2022a).

Water quality is summarized in Table 4. Dissolved oxygen, 4.9 mg/L, was below 5.0 mg/L at Sample Point 81. All pH measurements, 8.2 to 8.4, were within the water quality standards range of 6.5 to 9.0. Both dissolved oxygen and pH increased as points were sampled from 07:50 until 08:50 CDT. These increases in oxygen and pH may reflect increasing plant productivity from the seagrass, macroalgae, and microscopic algae in the area as exposure to daylight increased. As plant photosynthesis increases during the day, oxygen levels and pH tend to also increase until the sun begins to set.

Nitrogen as nitrite and nitrate and phosphorus as orthophosphate were below quantifiable concentrations in all samples. Nitrogen as ammonia was below TCEQ's screening level concentration of 0.10 mg/L in all samples. Chlorophyll α and TSS were highest at Sample Point 83 which was relatively close to the west shore of the Lower Laguna Madre.

Table 4
Lower Laguna Madre Water Quality

	81	82	82 (field duplicate)	83	84	TCEQ Comparison Values
Time (CDT)	07:50	08:26	08:26	08:50	08:13	
Depth (feet below the water surface))	1	1	Field tests were not duplicated	1	1	
Oxygen (mg/L)	4.9	5.6		5.7	5.3	5.0[1]
Oxygen (percent saturation)	71	82		83	77	
pH (su)	8.2	8.3		8.4	8.3	
Salinity (psu)	29.6	29.8		27.7	29.1	
Secchi Disk Transparency (feet)	1.4	0.4		1.1	2.4	
Temperature (°F)	76.6	76.5		76.7	76.3	95.0[2]
Seagrass (percent cover)	<1	20		1		
Nitrogen as ammonia (mg/L)	0.0180	0.0122	0.0136	0.0108	<0.008	0.10[3]
Nitrogen as nitrite and nitrate (mg/L)	<0.032	<0.032	<0.032	<0.032	<0.032	0.17[3]
Phosphorus as orthophosphate (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0	0.21[4]
Chlorophyll α (micrograms per liter [μg/L])	2.86	1.65	1.75	15.7	1.69	11.6[3]
Total suspended solids (mg/L)	23.6	13.9	13.5	38.6	11.6	

[1] The dissolved oxygen criterion is a 24-hour minimum average value (TCEQ, 2022a).

[2] The temperature criterion is an instantaneous value not to be exceeded (TCEQ, 2022a).

[3] Screening level values which if exceeded may indicate excessive nutrient levels. These are screening level values for Texas estuaries which should not be exceeded 20 percent of the time (TCEQ, 2022b).

[4] This is the nutrient screening value for total phosphorus. It should not be exceeded by orthophosphorus concentrations (TCEQ, 2022b).

5.0 CONCLUSIONS

Sampling on April 19 and 20, 2023 by Freese and Nichols, Inc. biologists found the following information about seagrass, water quality, and sediment over a 1,200-acre study area along the west shore of the Lower Laguna Madre about 5 miles south of Port Mansfield.

- Seagrass was present at 63 percent of the points sampled.
- Shoal grass was the seagrass species seen most frequently in samples, present at 57 percent of the points sampled. Star grass was found at 10 percent of the sample points and Turtle grass was found at one point.
- Where present, Shoal grass covered from 1 to 25 percent of the bay bottom. The average percent cover of Shoal grass in samples where it was found was 6 percent.
- The length of Shoal grass leaves ranged from 2.5 to 7.5 inches and averaged 4.4 inches.
- Shoal grass was found most often in water less than 3.1 feet deep. Eighty-five percent of points with Shoal grass were shallower than 3.1 feet. Only 15 percent of points deeper than 3.0 feet had Shoal grass.
- Field water quality was generally within acceptable ranges with dissolved oxygen of 4.9 to 5.7 mg/L, pH from 8.2 to 8.4 su, and temperatures below 77°F. Salinities ranged from 27.7 to 29.8 psu.
- Macroalgae was present at 51 percent of the sample points, at times completely covering seagrass.
- Nutrient and chlorophyll α were below concentrations used by TCEQ to indicate nutrient enrichment in estuaries.
- Sediment grain size analysis showed sediment in the study area was predominantly sand with some clay and smaller amounts of silt and shell hash.
- Lack of adequate sunlight reaching the bottom in deeper water and areas of higher turbidity may be preventing growth of seagrass in parts of the study area.

Texas Parks and Wildlife Department (TPWD), Texas Commission on Environmental Quality, and universities study seagrass in the Lower Laguna Madre. Texas Parks and Wildlife Department's (TPWD, 2023) Seagrass Viewer and the University of Texas Marine Science Institute's Texas Statewide Seagrass Monitoring Program (UTMSI, 2023) report the presence of seagrass in the study area. TPWD's Seagrass Viewer indicates the presence of seagrass in the study area based on photointerpretation of aerial photography (TPWD, 2023). The Texas Statewide Seagrass Monitoring Program has sampled seagrass at four points in and near this project's study area (see Figure 1) and data indicate seagrass presence and percent cover in the area varies between years and locations (Table 5).

Values in Table 5 include all data available online from the Texas Statewide Seagrass Monitoring Program at the time of this report. All values in Table 5 are for Shoal grass which was the only seagrass species found by that monitoring program. Station LLM218 may not have been sampled after 2011 because there were greater water depths in the north part of the study area where this station is located and seagrass may not receive enough light in these deeper waters to survive and be detected. Seagrass monitoring is not typically conducted in waters greater than five feet deep.

Table 5

Percent Seagrass Cover from the Texas Statewide Seagrass Monitoring Program

Sample Year	LLM208	LLM2011	LLM214	LLM218
2011	94	99	100	0
2012	13	13	56	No data
2013	80	93	100	No data
2014	98	100	95	No data
2015	98	90	0	No data
2016	No data reported			
2017	100	95	56	No data
2018	93	89	50	No data

Source: UTMSI (2023). UTMSI (2023) only found Shoal grass at these monitoring locations.

Table 5 indicates percent seagrass cover in the study area declined from 2011 to 2012. It is unknown why 2012 values are lower than the preceding and subsequent years. Wilson et al. (2013) stated conditions in the Lower Laguna Madre were generally better for seagrass in 2012 than in 2011 although they identified areas of the Lower Laguna Madre south of the study area in 2012 with little seagrass because of high turbidity and low water transparency. It's possible the study area was experiencing above-normal turbidity during 2012 which may have reduced seagrass cover that year.

Onuf (1996) described the presence of seagrass along the west side of the Lower Laguna Madre near Port Mansfield where this report's study area was located as "erratic." He attributed part of this pattern to the exposure of the west shore to prevailing winds from the southeast which resulted in more turbid water along the west shore. Macroalgae and Shoal grass were found at more than 45 percent of the stations with seagrass or macroalgae (Onuf, 1996). Star grass and Turtle grass were found at less than 20 percent of the stations in the Onuf (1996) study.

Onuf (2007) found seagrass distribution in the Lower Laguna Madre varied considerably from 1965 to 2000 and described the presence of Shoal grass, Manatee grass, and Star grass in the vicinity of this project's study area based on 1998 data. He found most areas without seagrass were deeper than four feet. According to Onuf (2007), Shoal grass probably covered more of the Lower Laguna Madre in the early 1960's than any other species of seagrass but has experienced reductions since then. He speculated that reductions in percent cover of Shoal grass over the years may have resulted from increased competition from Turtle grass and Manatee grass which appear to tolerate the moderated salinities of the Lower Laguna Madre which have occurred following the hydrological changes in the system.

Star grass was found at depths between 3.1 and 4.3 feet. Ralph et al. (2007) described Star grass as a "low light adapted" species of seagrass. Species distribution modeling (Bittner et al., 2020) suggests that light penetration to the bottom is the factor most influencing the distribution of Star grass. Morris et al. (2020) found Star grass at depths greater than 2 feet to more than 3 feet. Lee et al. (2007) found Star grass to have the lowest minimum light requirement of seagrasses and suggested the shape of the Star grass leaf may facilitate harvesting sunlight in low light environments.

UTMSI (2023) reported Shoal grass from its four sample points in the study area to have higher percent cover, averaging 73 percent from 2011 to 2018, than the percent cover estimated in this study which found the average Shoal grass cover to be 6 percent. Possible explanations for the difference between the two sets of data may be related to differences in sample methods, different observers, and the timing of sampling. This study was conducted at the beginning of the growing season for Shoal grass as the daylight period and water temperatures are starting to increase from winter. The UTMSI (2023) sampling is conducted beginning around July. Shoal grass cover may increase from the time this sampling was conducted until mid-to late summer when UTMSI typically samples in the area. Pulich (1985) found Shoal grass growth only increased after summer temperatures were reached.

Shoal grass was encountered most frequently in water shallower than 3 feet. A complex set of factors influence the distribution of seagrass. DeYoe et al. (2023) found most of this report's study area did not have seagrass with only the southern portion of the study area supporting Shoal grass ranging from 7 to 50 percent cover during a 2012 survey. DeYoe et al. (2023) also found substantial reductions in cover of Turtle and Manatee grasses in the southern portions of the Lower Laguna Madre following Hurricane Alex which struck the area in 2010. They attributed those changes to lowered salinities which allowed more competition between seagrass species and nutrient loading to the estuary from the hurricane-associated runoff. Increased nutrient loading may stimulate macroalgal growth and epiphytic algal growth, both of which can reduce light reaching seagrass.

One factor affecting study area observations includes increased light penetration to the bottom in the shallower waters of the south part of the study area. Shallower water allows more light to reach the bottom than deeper water, particularly greater than 4 feet deep, which is present in the north half of the study area. The south half of the study area may be more protected from wave generated turbidity since there is a more continuous line of dredged material mounds blocking the prevailing winds from the southeast across the Lower Laguna Madre (see Figure 3). This protection may reduce wave generated turbidity therefore allowing more light penetration to the bottom. The north half of the study area is not as protected by dredged material mounds and wave-generated turbidity may tend to be greater in this area, reducing light penetration to the bottom, and impacting the ability of seagrass to grow.

There are no proposed projects which would restore seagrass in the Lower Laguna Madre. Ecosystem Restoration Measure W-3 of the 2021 Coastal Texas Protection and Restoration Feasibility Study proposes restoring hydrological flushing of the Lower Laguna Madre that has occurred since the Port Mansfield Channel was dredged through Padre Island (USACE, 2021). This project may stabilize hydrological and water quality conditions in the Lower Laguna Madre which may in turn stabilize seagrass populations. However, restoration of seagrasses is not a direct, expected benefit of this proposed project.

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Appendix A

Lower Laguna Madre Seagrass Survey Plan

MEMORANDUM

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TO: Jackie Robinson and Evan Pettis, Texas Parks and Wildlife Department, Corpus Christi

CC: Aaron Petty, Freese and Nichols, Inc., Barbara Castille, Robert Bank, and James Kisiel, S&B Infrastructure

FROM: David Buzan

SUBJECT: Lower Laguna Madre Seagrass Survey

DATE: April 12, 2023

PROJECT: SBI23290

Hidalgo Drainage District 1 proposes modifying drainage patterns to shift some water to the Raymondville Drain from the North Floodway during flooding events. The modification will not change the amount of water contributed by both drains to the back bay complex of the Lower Laguna Madre or to the Lower Laguna Madre. The Drainage District is required to survey seagrass in the Lower Laguna Madre in the vicinity of the drains, and the District's engineers, S&B Infrastructure, hired Freese and Nichols, Inc. to survey seagrass in the area (Figure 1).

Figure 1. Draft Seagrass Study Area (red polygon). Red points represent seagrass monitoring stations sampled by the University of Texas Marine Science Institute's Texas Statewide Seagrass Monitoring Program. Google Earth Pro image is dated February 6, 2021.

Table 1 summarizes results of the Texas Statewide Seagrass Monitoring Program for the stations in the possible sampling area. The only seagrass species identified in the monitoring program is Shoalgrass, *Halodule wrightii*.

Table 1. Seagrass Survey Results as Percent Seagrass Cover from the Texas Statewide Seagrass Monitoring Program

Sample Year	LLM208	LLM2011	LLM214	LLM218
2011	94	99	100	0
2012	13	13	56	No data
2013	80	93	100	No data
2014	98	100	95	No data
2015	98	90	0	No data
2016	No data			
2017	100	95	56	No data
2018	93	89	50	No data

Draft Sample Plan

Sample Period: Approximately mid-April 2023, over a period not to exceed three days.

Sample Locations:
Figure 2 illustrates sample locations. Sampling is proposed at 80 sites: 4 sites (red points) sampled by the Texas Statewide Seagrass Monitoring Program and 76 sites at approximately equally spaced points along transects from south-southeast to north-northwest. Sample points are about 1,250 feet apart on seven transects oriented with north-south axes and about 1,000 feet apart from east to west.

Samplers: Sampling will be conducted by two or three Freese and Nichols, Inc. coastal ecologists using the Freese and Nichols, Inc. shallow draft boat.

Sampling Protocol (in order of data collection):

Seagrass
At each sample point, a 0.25 square meter quadrat will be used to estimate percent seagrass cover. The quadrat will be placed in the water near the boat at the designated sample points. The percent cover of each species of seagrass and bare area will recorded to the nearest 5 percent for each quadrat. The total seagrass cover and bare area for each quadrat will total 100 percent. The length of the photosynthetic part of randomly selected seagrass shoots from each quadrat will be measured (centimeters) to determine seagrass canopy height.

If a sample site does not have visible seagrass, a sediment plug will be collected with a post-hole digger and will be evaluated for the presence of live seagrass roots.

If the sample site does not have visible seagrass but visible seagrass is present within approximately 100 meters of the sample site, seagrass sampling will take place in the area with visible seagrass.

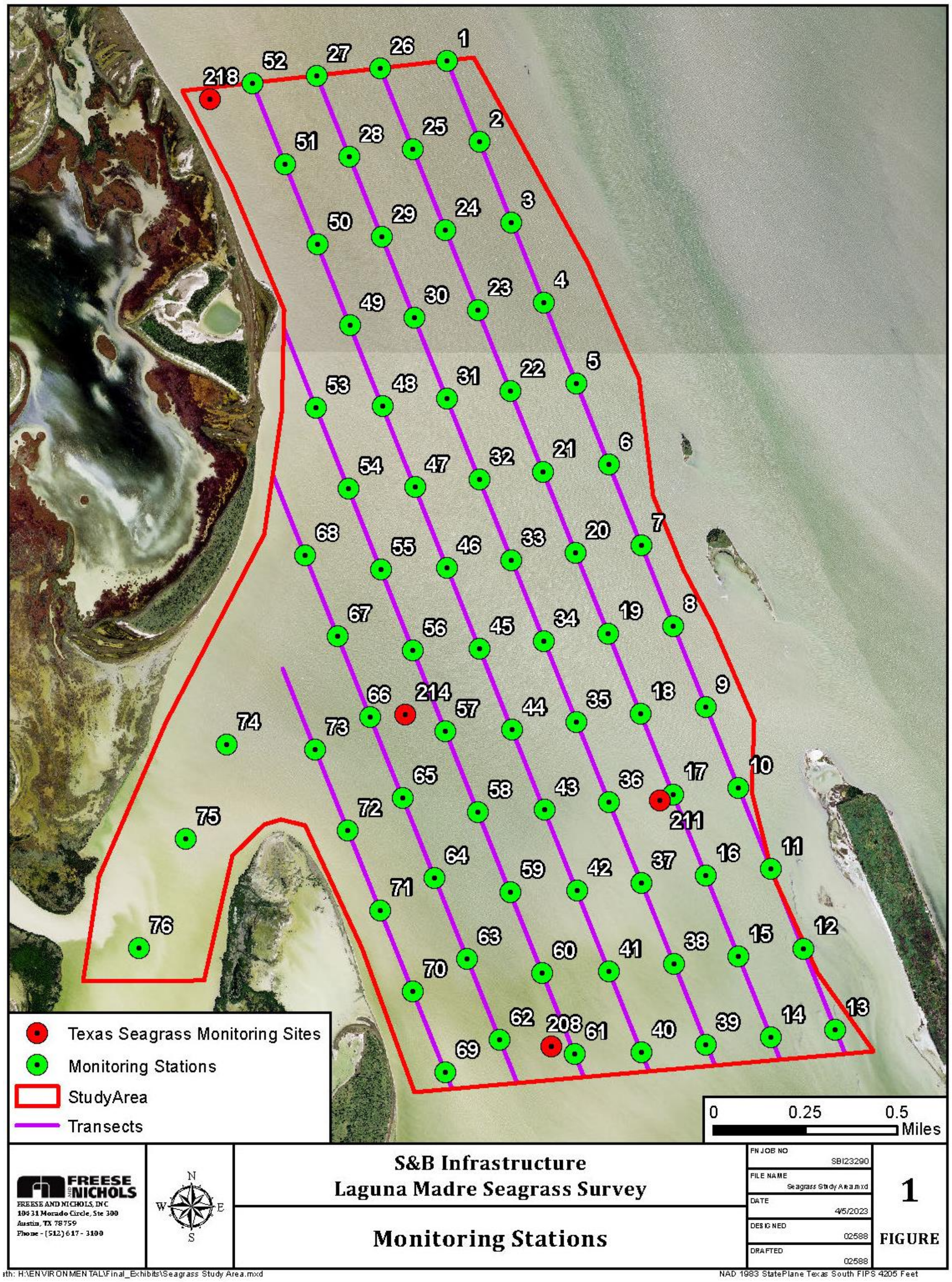

Figure 2. Proposed Sampling Locations. Red points are locations sampled by the Texas Statewide Seagrass Monitoring program on an approximate annual basis. The green points will be sampled by Freese and Nichols, Inc. in this study. Google Earth Pro image is dated February 6, 2021.

Field Water Quality

Field water temperature (°C), pH (standard units), salinity (practical salinity units), and dissolved oxygen (as milligrams per liter and percent saturation) will be measured at a depth of 1 foot at one location with a calibrated water quality meter at each of four sites. Secchi disk transparency (centimeters) will be measured at the same points.

Laboratory Water Quality

Water samples will be collected at the same points as the field water quality sampling. Samples will be analyzed for total suspended solids, ammonia nitrogen, nitrate and nitrite nitrogen, orthophosphorus, and chlorophyll α. A fifth water sample will be collected as a field duplicate of one of the other four water samples. This information will be used to understand the variability in water quality. Sediment will also be collected for sediment grain size analysis after the water samples are collected. These samples will be collected on the last day of sampling to minimize holding time before delivery to a NELAC-approved laboratory for analysis.

Field Observations

Observations will be recorded of weather conditions, currents, tides, and other conditions relevant to the presence of seagrass.

Photography

If water transparency permits, photos will be taken of selected sample quadrats. If weather conditions permit, drone imagery will be collected of the study area. Voucher photos will be taken of each seagrass species observed.

Quality Control

Percent Cover

Ten percent of all quadrats sampled for seagrass species and percent cover will be analyzed independently by two coastal ecologists. If percent cover of both analyses differs by more than 15 percent, samplers will conduct independent percent cover on each subsequent sample quadrat until percent cover analysis differs by less than 10 percent at four consecutive sample quadrats. This approach may not be feasible if water is turbid.

Water Quality

A fifth water sample will be collected as a field duplicate of one of the other four water samples. This information will be used to understand the quality of the laboratory analysis and variability in water quality.