A GUIDE TO LIVING SHORELINES IN TEXAS

TEXAS GENERAL LAND OFFICE
ESTABLISHED 1836

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

TEXAS COASTAL MANAGEMENT PROGRAM

ALLEN
ENGINEERING
AND SCIENCE

ABOUT THIS GUIDE

This guide is meant to be a one-stop educational resource for property owners on the use of living shorelines as alternatives to traditional shoreline stabilization techniques. The guide is intended to provide streamlined information on how to implement living shorelines and will outline the steps needed to design, permit, and construct a viable project.

The information provided is not meant to suggest that living shorelines are the correct or best option for every situation. It is important the reader understand that project sites can differ markedly from one to the next and the concepts described will need to be adapted to the conditions of each individual project site.

The Texas General Land Office (GLO) is committed to promoting ecologically and economically sound coastal management practices. The GLO hopes this information will help you build a living shoreline on your property that is resilient to coastal hazards and will protect your piece of Texas for generations to come.

ACKNOWLEDGMENTS

A Guide to Living Shorelines in Texas was created by the GLO in partnership with the Allen Engineering and Science Team, the Harte Research Institute, and with funding from a Texas Coastal Management Program Grant approved by the Texas Land Commissioner pursuant to National Oceanic and Atmospheric Administration Award No. NA17NOS4190139.

Front Cover Image: Tres Palacios Living Shoreline. Photo: Matagorda Bay Foundation

Galveston at Sunset. Photo: Texas General Land Office

CONTENTS

SECTION 1: INTRODUCTION TO LIVING SHORELINES 1
SECTION 2: INSTALLING A LIVING SHORELINE: A STEP-BY-STEP GUIDE 6
SECTION 3: LIVING SHORELINE CASE STUDIES 29
SECTION 4: PERMITTING A LIVING SHORELINE 42
SECTION 5: LIVING SHORELINE PLANTING GUIDE 50

APPENDIX A: HARTE RESEARCH INSTITUTE MODEL DETAIL 55
APPENDIX B: VISUAL SITE ASSESSMENT WORKSHEET 56
APPENDIX C: SOURCES CITED AND OTHER RESOURCES 57
APPENDIX D: FUNDING OPPORTUNITIES 58
APPENDIX E: GLOSSARY OF TERMS 59

Corpus Christi Bay. Photo: Texas General Land Office

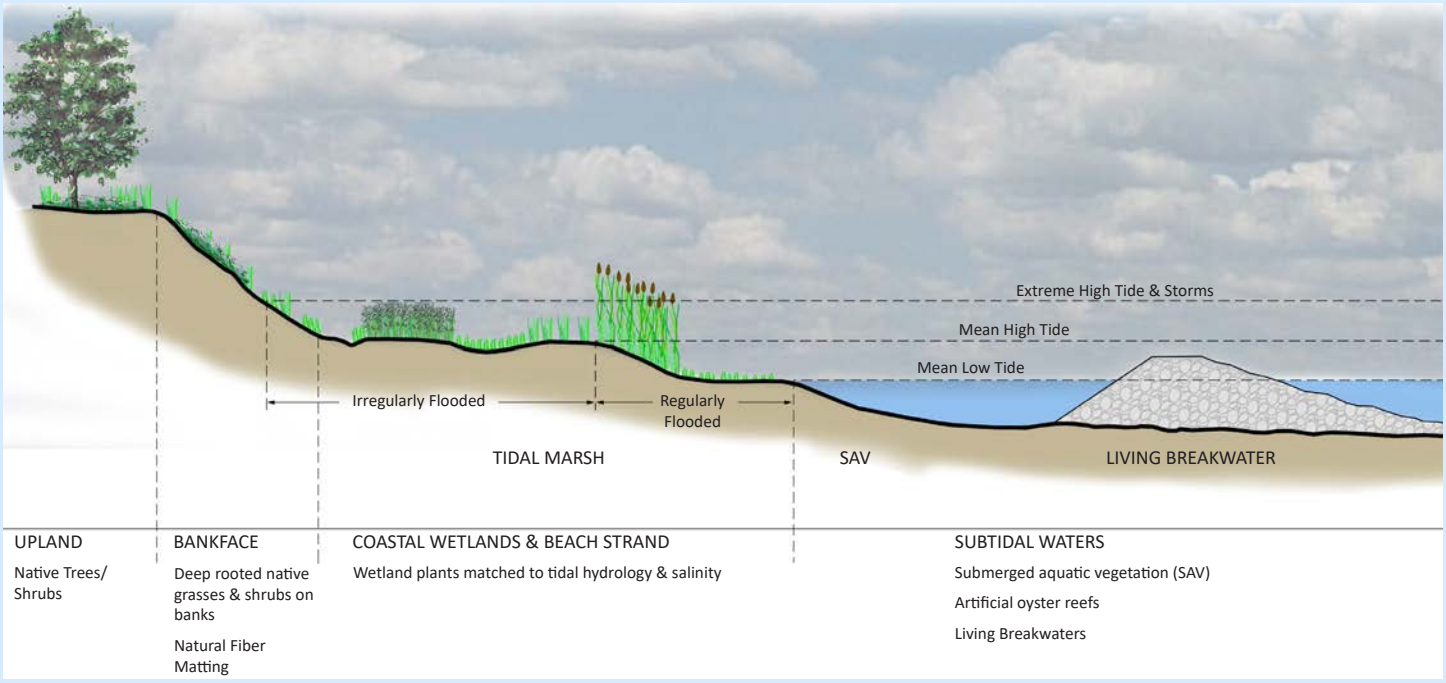
Great Blue Heron in Mangroves - South Padre Island. Photo: Texas General Land Office

INTRODUCTION TO LIVING SHORELINES

In today's dynamic coastal environment, property loss is a common concern for many coastal landowners. Unprotected shores are at the mercy of wind, wave and tidal energy and are vulnerable to storms, floods, and erosion. In fact, it is estimated the Texas coast is eroding at a startlingly rate of 4.1 feet per year.

Over the last century, a common response to erosion in Texas has been the wide-spread use of "hard" shoreline stabilization techniques such as concrete seawalls, bulkheads, and riprap. While these structures can reduce land loss, they can also have unintended negative consequences such as increased erosion on adjacent properties, habitat loss, and structure degradation over time.

Today, in the face of rising sea levels and increased storm intensities, it is more important than ever to find shoreline stabilization solutions that protect property and create habitat whenever possible.



Coastal Shoreline Continuum and Typical Living Shorelines Treatments. [1] Photo: Allen Engineering and Science

Retrofit Stabilization - Marsh Plantings with Riprap in Front of Wooden Bulkhead. Photo: Texas General Land Office

WHAT IS A LIVING SHORELINE?

Living shorelines incorporate substantial natural or nature-based features, potentially combined with hard structural components as approved by the Texas General Land Office, to provide shoreline protection and stabilization while maintaining shoreline ecosystem functions.

Living shorelines use natural or recycled materials, along with the strategic placement of plants and/or other organic material, to reduce erosion, protect property, create habitat, and enhance resiliency.

Living shorelines work best in low energy environments, such as bays and estuaries or other areas protected from large waves. The “ideal” living shoreline usually contains several natural components that work together such as:

- Upland native trees and shrubs
- Tidal marsh areas with a mixture of native vegetation
- Breakwaters or other energy reduction structures
- Submerged aquatic vegetation

Living Shorelines Reduce Wave Energy Even During Hurricanes. Driscoll-Rooke Park Living Shoreline. Pre-Harvey. Photo: Texas General Land Office

Living Shorelines Reduce Wave Energy Even During Hurricanes. Driscoll-Rooke Park Living Shoreline. Post-Harvey. Photo: Texas General Land Office

WHY USE A LIVING SHORELINE?

Living shorelines allow natural processes to take place. They help reduce erosion, decrease wave energy, and filter runoff. They can also naturally restore land by trapping sediments, which, over time, can build up and create shallow water habitat. Living shorelines are also highly sustainable and can provide effective property protection from hurricanes and storm surges.

While bulkheads and seawalls can help reduce erosion and be effective in the appropriate location, there are significant "downsides" to these vertical structures. The average hard structure has a lifespan of only 15 to 20 years. They also often have large construction and/or installation price tags with hidden maintenance expenses.

Bulkhead Failure Leads to Erosion and Land Loss Photo: Texas General Land Office

COMPARISON OF LIVING SHORELINES VERSUS HARD STRUCTURES

Benefits	Living Shorelines	Hard Structures
Reduce shoreline erosion	✓	✓
Deflect wave energy	✓	✓
Absorb wave energy	✓	✓
Minimal maintenance long term	✓	
Reduce storm surge and flood waters	✓	
Adapt to possible sea level rise	✓	
Increase recreational opportunities (fishing, wildlife viewing)	✓	
More potential for beach creation	✓	
Improve water quality	✓	
Maintain ecosystem functions (nutrient cycling, animal and plant habitat)	✓	
Create habitat for terrestrial and aquatic species	✓	
Enhance property aesthetics	✓	
Maintain the natural land/water connection	✓	

Boxes containing ✓'s indicate the method has this characteristic. A blank box means it does not. Note that these are general characteristics and may vary slightly with location.

Marsh Installation. Photo: Galveston Bay Foundation

HOW MUCH DO LIVING SHORELINES COST?

The cost of a living shoreline project will vary based on a variety of factors. With the wide array of living shoreline options and each project site being unique, it's difficult to calculate a "standard" linear foot cost for installation. Factors to consider in a project budget include:

- Permitting and surveying costs
- Engineering and design of the project
- Mobilization and demobilization associated with the construction of the living shoreline
- Accessibility and procurement of materials
- Annual or bi-annual project monitoring and maintenance

Keep in mind, living shorelines can be completed in phases as budgets allow. For example, a property owner can start a living shoreline project by planting marsh vegetation and add additional materials such as reef balls and breakwaters at a later date, if needed.

Here are some general cost estimates for the different living shoreline options (more on those next) typically used along the Texas coast.

COST ESTIMATES FOR LIVING SHORELINE OPTIONS [2, 3, 4, 5, 6, 7]

Living Shoreline Options	Material	Approximate Cost
Marsh Grass Plantings	Marsh plants	$2 - $3 per plug installed
Coir Logs	Coconut fiber coir logs	$5 - $6 per foot
Submerged Oyster Shell Bed	Bagged oyster shell	$5 - $20 per bag*
	Loose oyster shell	$20 - $60 per linear foot*
Reef Balls	Hollow structures often with special surfaces for attachment of shellfish	$45 per structure $100 - $200 installed
Articulated Mats or Blocks	Interwoven mats or individual concrete blocks	$10 - $18 per square foot
Breakwater	Riprap stone	$25 - $75 per ton $150 - $200 per linear foot installed
	Oyster shell	$20 - $60 per cubic yard*
	Vinyl Sheet Pile	$30 - $50 per linear foot

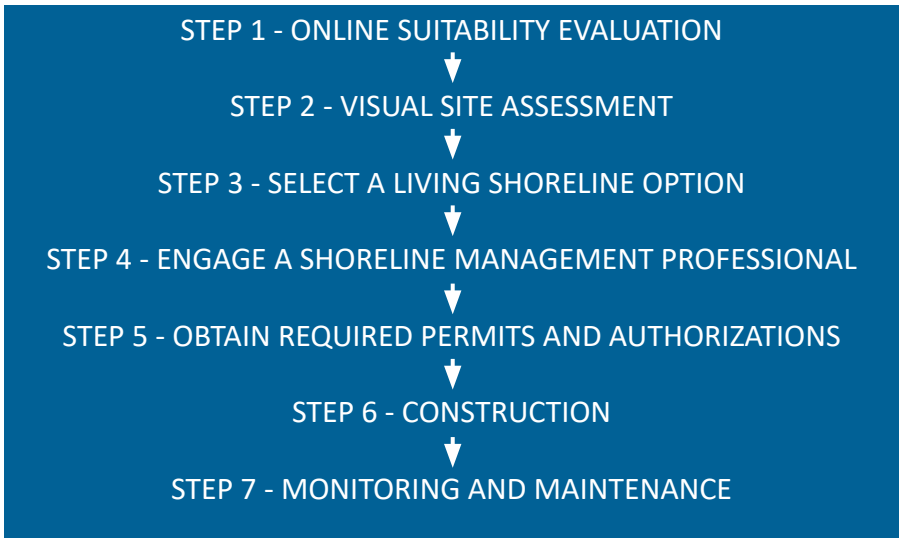
** Oyster shell is not commercially available in Texas and must be acquired from an oyster wholesaler. Oyster shell-based living shorelines will primarily be a building option for local governments, community groups, and nonprofit organizations.*

Segmented Breakwater with Marsh Plantings. Photo: AECOM

INSTALLING A LIVING SHORELINE: A STEP-BY-STEP GUIDE

While each property is unique and there is not a "one size fits all" living shoreline solution, there are steps you can follow to ensure the right living shoreline is implemented on your property.

The following graphic describes the general steps to take for planning and implementing a living shoreline.



General Process to Choose and Implement a Living Shoreline Option.

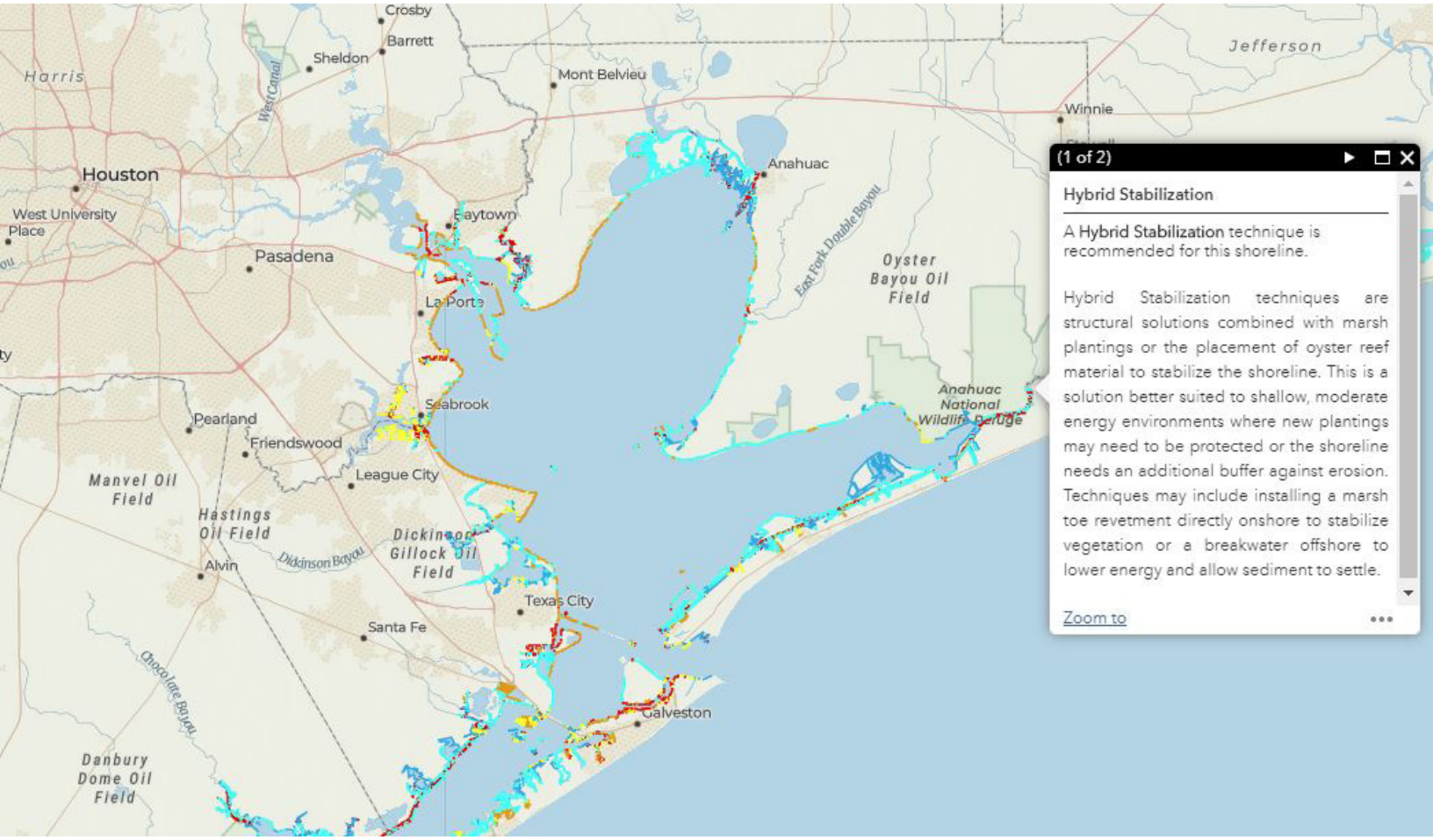
STEP 1: ONLINE SUITABILITY EVALUATION

The Harte Research Institute at Texas A&M University–Corpus Christi created the Living Shoreline Site Suitability Model (LSSM) as a first step to help you determine if your property is a good candidate for a living shoreline.

The tool allows you to enter your coastal property address and, based on your location, will provide a living shoreline recommendation. The recommendation will include a description of what the living shoreline option entails and a link back to this guide for more information and next steps.

It is important to note that this tool is **not** a substitute for a site assessment and some properties may not be suitable for a living shoreline based on the tool's prediction. However, we encourage all property owners to move on to the visual site assessment.

More information about the model and how it works can be found in **Appendix A** of this document. To access the tool, please visit https://gomaportal.tamucc.edu/GLO/LivingShorelines/. For help using this tool, email the Harte Research Institute at CMGL@tamucc.edu.



Sample output of the LSSM model. Photo: HRI

STEP 2: VISUAL SITE ASSESSMENT

Now it's time to do a visual site assessment and explore the specific conditions on your property. Information from this assessment will help you determine which living shoreline option to pursue. A helpful site assessment checklist is provided in **Appendix B.** The assessment factors you'll want to consider are listed below.

Wave Energy

Wave energy is a strong erosional force. Some wave energy is caused by natural forces like the lunar and wind-driven tides and other times it's caused by human activity such as boat wakes or scouring from adjacent hardened shorelines. While living shorelines typically perform better in low wave energy environments, projects in higher energy environments can still be constructed by incorporating nearshore breakwaters to reduce wave intensity.

- Does your property have low wave energy? For example, is it sheltered or far from boat traffic? Is it a mud or tidal flat? Is it a marsh?
- Does your property have moderate wave energy? Is there shell hash?
- Does your property have high wave energy? Does it border a shipping channel or have steep bluffs?

Type of Shoreline

Your property's shoreline type will help determine which living shoreline option is most practical.

- Is your shoreline a marsh, beach, tidal flat, or mud flat?
- Is your shoreline sand or fragmented shells?
- Does your shoreline have a hard stabilization structure in place? For example, do you have a bulkhead on your property?

Low Energy Shoreline - Mud Flat / Tidal Flat.
Photo: Texas General Land Office

Medium to High Energy Shoreline - Shell Hash.
Photo: Texas General Land Office

High Energy Shoreline - Steep Bluffs.
Photo: Texas General Land Office

Slope

The grade or steepness of your shoreline is very important in selecting a living shoreline option. Flat or gradual sloping shorelines are best for marsh plantings while steeper slopes might require a rock or structural alternative. Grading to flatten the land and prepare it for installation might be necessary if your property has a moderate to steep slope.

- Is the slope of your shoreline flat, gradual, moderate, or steep?

Erosion Rate

The rate of land loss, or erosion rate, is a key determinant in living shoreline site suitability. Sites with low erosion rates are generally more suitable.

- Does your property have a low rate of erosion? This would be true if your property has more erosion from sea level rise or subsidence over time.
- Does your property have a high rate or erosion? This would be true if your property has more erosion from high wave energy and high winds.

Water Depth

This refers to the depth of the water immediately in front of your shoreline. Water depth will impact your ability to plant native vegetation and can dictate whether a hybrid or structural component is necessary.

- Is your property adjacent to shallow water (less than 20 ft) or deep water (more than 20 ft)?

Fetch

Fetch is the distance over which the wave-generating wind blows. This has a direct effect on the size and energy of waves impacting your shoreline.

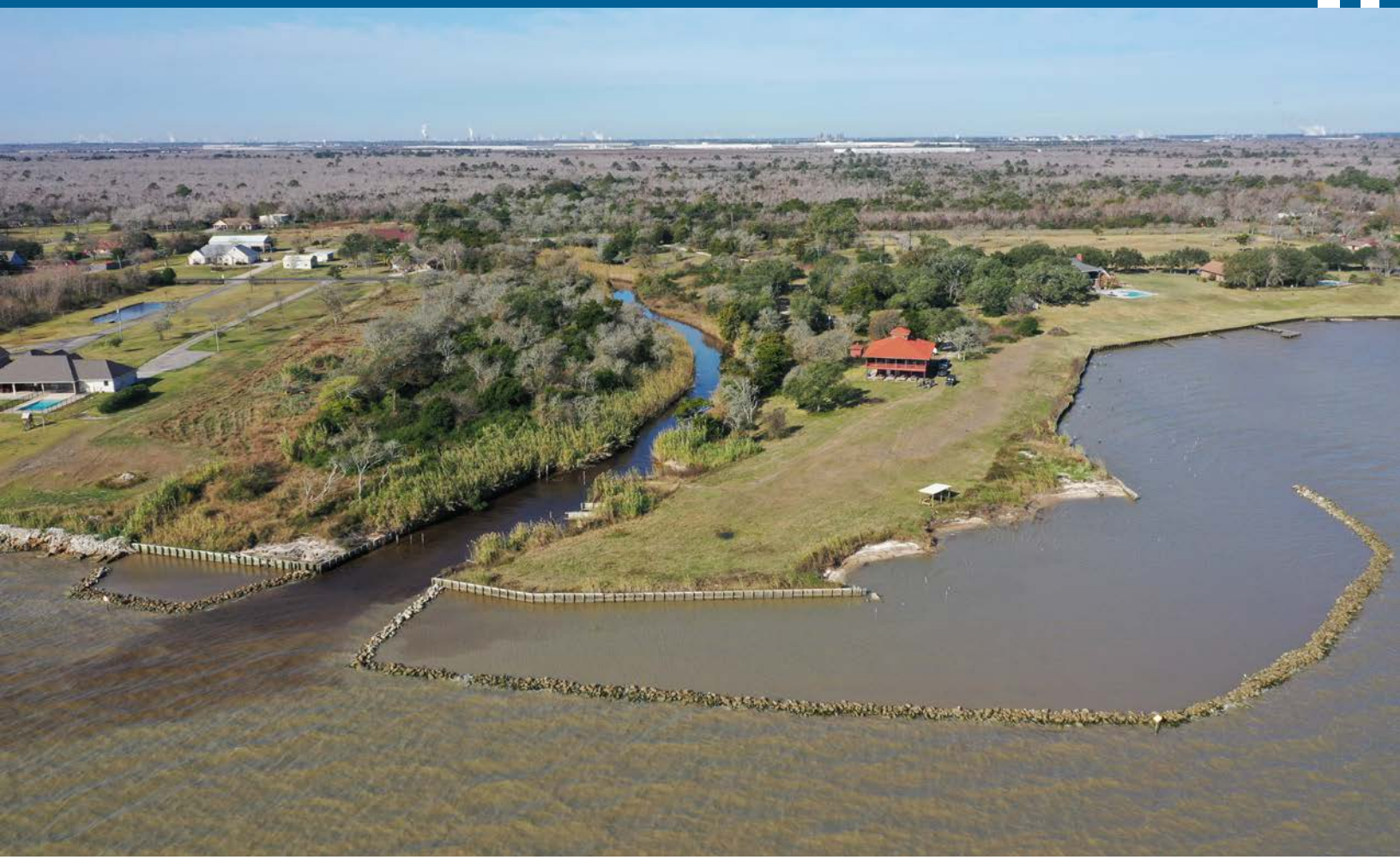
- Is there a long fetch across open water leading to your shoreline which creates more wave energy (typically greater than 0.5 miles)?
- Is there a shorter fetch of open water which reduces the amount of wave energy impacting your shoreline (less than 0.5 miles)?

Salinity

Freshwater mixing with gulf water produces a range in salinity from low salinity near the mouths of rivers to higher salinity near the barrier islands. The salinity of the water at your location will determine which vegetation will grow and thrive. In addition, if oysters will be part of your design, the salinity of the water at your site will be an important factor in determining their success.

- Is the water at your site saltwater, brackish (near a spot where freshwater and saltwater mix), or freshwater?

Seagrass. Photo: Texas General Land Office



Breakwater - Trinity Bay. Photo: Galveston Bay Foundation

Neighboring Property Conditions

What kind of conditions are present on your neighbor's property? This can have an impact on the living shoreline option you choose. For example, a bulkhead on your neighbor's property could be deflecting wave energy and sediment onto your property so you may need to adjust your design accordingly.

- Do the properties adjacent to yours have hard structures or a natural shoreline?
- What category of erosion are the properties experiencing: low, medium, or high?
- Do you know if your neighbors are interested in using living shorelines?

Personal Preference

It's important to think about what you want your completed project to look like and any amenities you'd like it to provide. You may want to think about factors such as:

- Appearance: Do you prefer more green (natural vegetation) or gray (stone, breakwater) structures?
- Water Access: Do you want to be able to access the water from your land?
- Existing Structures: Do you have structures on your property such as a pier, dock, or boat ramp?

STEP 3: SELECT A LIVING SHORELINE OPTION

Living shorelines are not one size fits all. The living shoreline you build will need to be customized to the specific conditions on your property. Luckily, living shorelines are highly versatile and can be designed to fit your site's individual needs.

The GLO has identified four broad categories of living shorelines commonly used along the Texas coast. The four categories include Soft Stabilization (Marsh Grass Plantings), Hybrid Stabilization (Breakwaters, Submerged Oyster Shell Beds, Reef Balls, Articulated Blocks or Mats, and Riprap), Retrofit: Soft Stabilization, and Retrofit: Hybrid Stabilization. Each type is associated with a specific set of conditions and implementation options designed to reduce erosion, protect the shoreline, and prevent land loss.

Using what you have learned about your property from both the online Living Shoreline Site Suitability Model and the visual site assessment, you can now start to determine which living shoreline option would be the best fit.

Marsh - Corpus Christi Bay. Photo: Texas General Land Office

Soft Stabilization

Soft stabilization living shorelines are non-structural in nature and usually involve planting marsh grasses along the existing shoreline.

MARSH GRASS PLANTINGS

Marsh grass planting involves the placement of native plants, such as native low marsh and high marsh species, along the existing shoreline. The plant's extensive root systems hold soil in place to help reduce erosion while plant shoots reduce wave energy and increase sediment deposition. A healthy salt marsh provides habitat for many species of plants and animals while maintaining the land/water connection. Marshes also improve water quality and provide recreational and educational opportunities.

Marsh plantings may be designed and constructed as stand-alone features or be incorporated as a component of a larger project. Marsh plantings can also include shoreline grading. **Note that some grading may be considered fill by the GLO and should be discussed during the planning phase.**

- **Materials:** You will need native, locally grown marsh plants appropriate for your site's salinity levels and specific site conditions including water depth, exposure to sunlight, and wave energy levels. You will also need a planting shovel or a plug planter as well as starter fertilizer.

Marsh Grass Planting. Photo: Coastal Bend Bays and Estuaries Program

- **Installation Technique:** Plugs of marsh grass are planted in bare or sparse areas. Shoreline grading may be needed to obtain appropriate elevations to provide a gradual slope for marsh creation or to enable a marsh to maintain its elevation with respect to sea level rise.

- **Durability and Maintenance:** Plants that are removed or die during the early stages of growth must be replaced immediately to ensure the undisturbed growth of the remaining plants. Removal of debris and selective pruning of trees is also a good maintenance practice to ensure sunlight reaches the plants. After significant growth has occurred, only periodic inspections may be necessary.

COIR LOGS

Though not common along the Texas coast, coir logs are also a soft stabilization option. Coir logs are natural fiber products designed to provide temporary stabilization to allow vegetation to establish landward of the log. Coir logs are most effective in low energy environments above the mean high tide line. To keep coir logs in place, they must be anchored to the ground. Any remaining anchoring material or stakes must be removed once the coir logs have degraded.

Coir Log Installation. Photo: Delaware Living Shorelines

Hybrid Stabilization

Hybrid stabilization living shorelines incorporate the materials used in soft techniques with hard features to provide additional erosion protection.

BREAKWATERS

Breakwaters are constructed nearshore, parallel to the shoreline, and function to break waves, reduce erosion, and promote sand and sediment accumulation landward of the structure. Breakwaters can consist of a variety of materials including rock rubble, concrete chunks, precast concrete forms, and reef. Low-profile breakwaters can be constructed in deep water and in high energy wave environments. Low-profile breakwaters, combined with landward marsh grass plantings, reduce wave energy while also providing habitat for plants and animals.

The breakwater structure can serve as habitat for filter feeders, such as oysters, whose presence improves water quality and further helps reduce wave action. Additionally, as sediment accumulates landward of the breakwater, the marsh grass roots anchor and retain the soil, building up the shoreline. The plantings also help dissipate wave energy and reduce erosion. Marsh grass plantings protected by a breakwater maintain a more balanced aquatic/terrestrial interface and provide recreational and educational opportunities.

- **Materials:** Rock rubble, reef (oyster/mussel shells)*, concrete chunks, precast concrete forms, or stone. Oyster shell reefs can be constructed with bagged or loose shell. Native marsh plants appropriate for salinity and site conditions should be used. Plugs of marsh grass can be planted in bare or sparse areas. Grading may be necessary to obtain appropriate elevations, to provide a gradual slope for marsh creation, or to enable a marsh to maintain its elevation with respect to sea level rise. Wildlife exclusion fencing may be necessary to avoid predation while plants develop.

Rock Rubble Breakwaters with Oysters Attached.
Photo: Texas General Land Office

Rock Rubble Breakwaters Protecting Area of Planted Seagrass (Under the Water) and Cordgrass Along the Bulkhead.
Photo: Texas General Land Office

Hybrid Stabilization

- **Installation Technique:** Low-profile breakwaters can be irregularly shaped or spaced in a specific pattern and involve placing low-profile stone, bagged concrete or man-made structures in the water to break wave energy. Native plants are added in areas of suitable depths to the marsh environment landward of the structure.

- **Durability and Maintenance:** Rock rubble and precast concrete forms are very durable, while oyster shell reefs will break down over time. The degradation of the shell bags is often a desired characteristic if they are being used to temporarily reduce wave energy while marsh grass plantings reestablish or oysters attach to the substrate.

  Plants that die during the early stages of the living shoreline project should be replaced immediately to ensure the undisturbed growth of the remaining plants and continued creation of the marsh substrate. Debris removal and selective tree pruning are also good maintenance practices to ensure that sunlight reaches the plantings. Once establishment has occurred, only periodic inspections may be necessary. Low-profile breakwater materials should also be replaced or re-installed if they are moved by a storm.

SHEET PILE BREAKWATERS

Another type of breakwater material is sheet pile or vinyl sheet pile. Sheet pile breakwaters may be made of PVC sheet piling, synthetic sheet piling, vinyl sheet piling, or other sheet piling brand name materials. The vinyl panes are driven into the ground, decreasing wave energy and creating a calmer area landward of the breakwater that promotes vegetative growth. Though a more affordable material, the two-dimensional shape of a sheet pile breakwater lacks the complex structure necessary to provide habitat. Therefore, a sheet pile breakwater alone is not considered a living shoreline. However, it may be used as part of a larger living shoreline project.

Breakwater of Precast Concrete Forms. Photo: Mott MacDonald

Vinyl Sheet Pile Breakwater. Photo: Texas General Land Office

Hybrid Stabilization

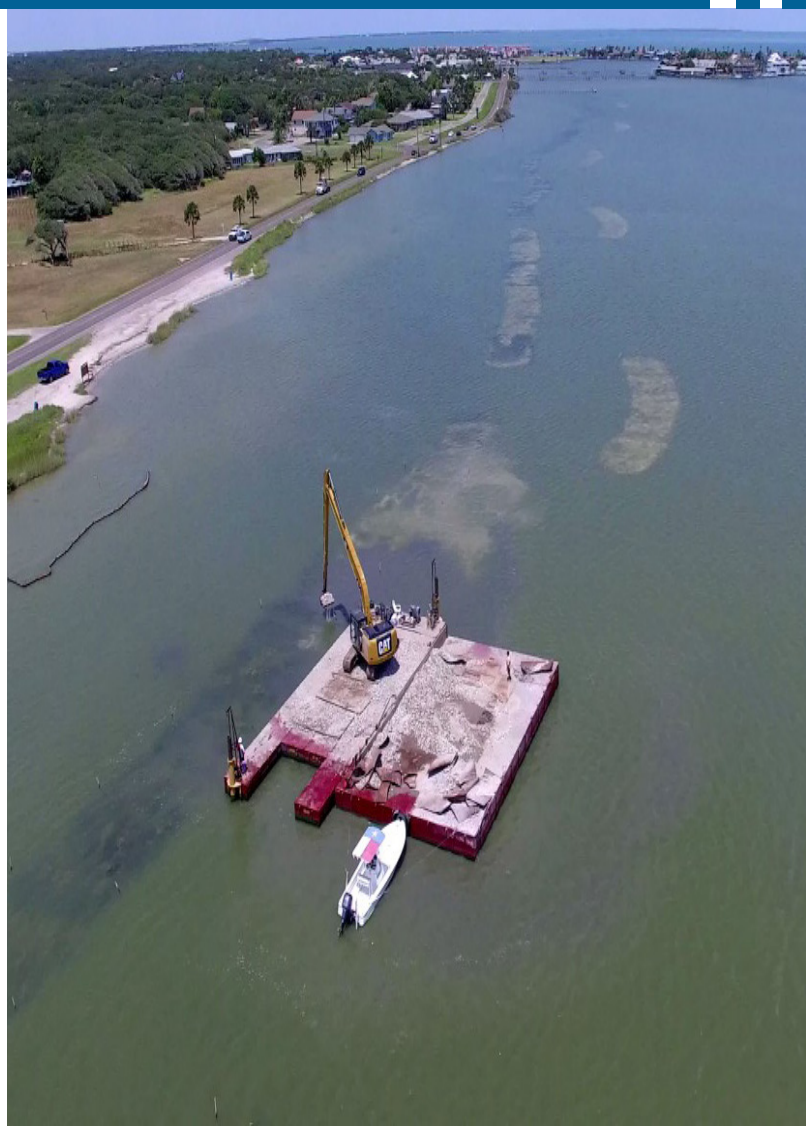
SUBMERGED OYSTER SHELL BEDS*

Submerged oyster shell beds can be created by placing a hard substrate, often recycled oyster shells or crushed concrete, limestone, or river rock on the seafloor and "seeding" them with oyster larvae. The larvae attach to the shells or rocks and begin to grow.

Submerged oyster shell beds can become valuable substrate for marine organisms and provide shelter and habitat for fish, crabs, and oysters. The structures can also dampen wave energy and increase sediment retention. Because shellfish are filter feeders, oyster/mussel reefs can improve water quality and, as the living breakwaters become colonized with marine species, provide recreational benefits such as fishing.

- **Materials:** Recycled oyster shells or crushed concrete, limestone, or river rock
- **Installation Technique:** Hard substrate is placed on the seafloor and "seeded" with oyster larvae. The larvae attach to the shells or rocks and begin to grow.
- **Durability and Maintenance:** Oyster shells and/or crushed concrete are very durable and will not break down over time. However, these materials can become covered in sediment due to settling or because of wave driven sedimentation over time. Changes in environmental factors can lead to die off of the live oysters so re-seeding might be required. Routine inspections are necessary and periodic additions of oyster shell or crushed concrete may be required to maintain function.

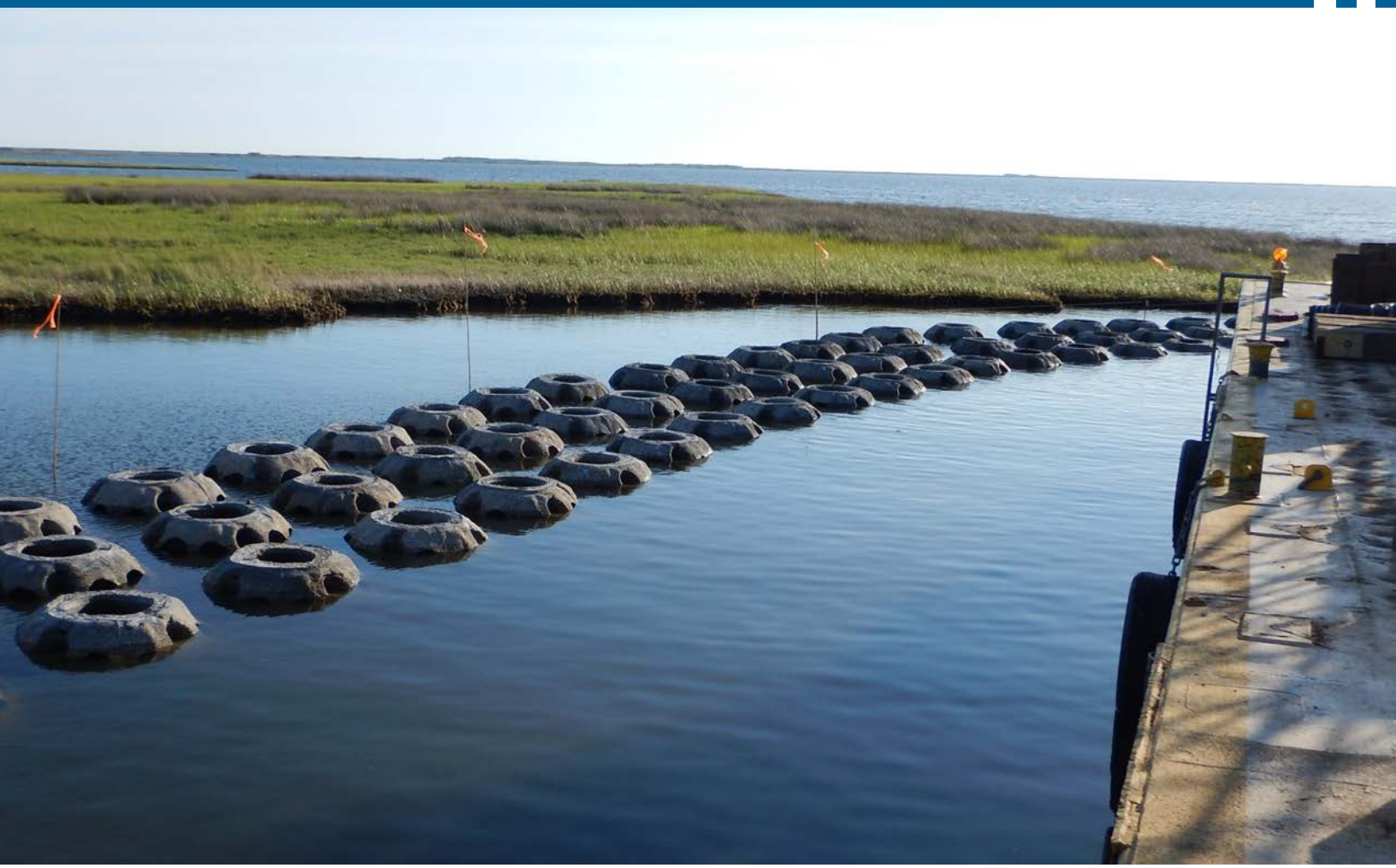
** Oyster shell is not commercially available in Texas and must be acquired from an oyster wholesaler. Oyster shell-based living shorelines will primarily be a building option for local governments, community groups, and nonprofit organizations.*



Submerged Oyster Shell Bed Installation Little Bay, Rockport, Texas. Photo: AECOM

Mesh Bag with Recycled Oyster Shells. Photo: Texas A&M University, Corpus Christi

Hybrid Stabilization



Reef Ball Installation. Photo: Mott MacDonald

REEF BALLS

Reef balls are nearshore structures designed to create oyster and fish habitat while reducing wave energy. These structures can become valuable hosts for marine organisms and provide shelter and habitat for fish, crabs, and other species. By reducing wave energy, the reef balls increase sediment retention for potential marsh creation. As these structures become colonized with marine species, they provide recreational benefits such as fishing and snorkeling.

- **Materials:** Reef balls are made from a pH-balanced concrete poured over fiberglass to create a hollow, porous structure typically in the form of an open-topped dome. The surface is textured to promote the attachment and growth of aquatic organisms.
- **Installation Technique:** Placed in shallow water environments to create a submerged breakwater. Structures are typically placed at predetermined intervals although space between structures is not always necessary due to the porous design which allows water flow-through.
- **Durability and Maintenance:** If sited properly, structures are extremely durable due to their design and the materials used in fabrication. Once placed, almost no general maintenance is required. Structures and placement may become altered in significant storm events.

Hybrid Stabilization

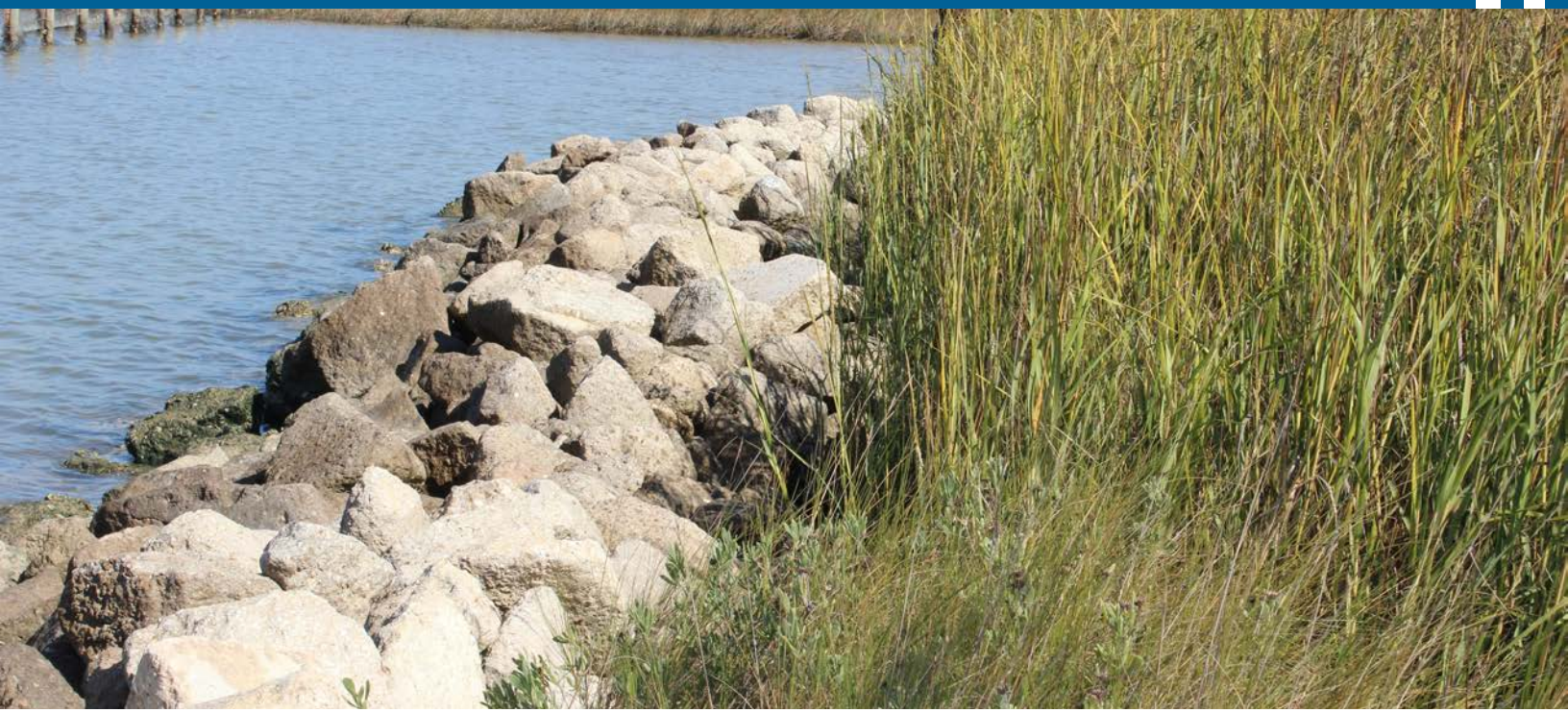
ARTICULATED BLOCKS OR MATS

Articulated blocks or mats alone are not considered a living shoreline, but they may be used as part of a larger living shoreline project. Mats are typically constructed as a flexible, interlocking matrix of concrete blocks that are uniform in shape and size, held together by a series of cables or installed as individual blocks. Articulated blocks or mats can contribute to the ecosystem by allowing vegetation to grow through the crevices, providing erosion control and creating habitat. Articulated mats may also be used in some situations to provide an extra layer of shoreline stabilization and erosion control.

- **Materials Needed:** Prefabricated articulated concrete mats or hand placed blocks.
- **Installation Technique:** Larger projects covering significant areas may require professional installation and the use of heavy machinery. Smaller projects such as residential shorelines can be installed by hand.
- **Durability and Maintenance:** If installed properly using anchor systems on shoreline slopes, the structures require very little maintenance and are highly durable. Debris should be routinely removed and plants may need to be periodically replaced.

Articulated Mats Stabilizing Vegetation as Part of a Living Shoreline Project. Photo: Texas General Land Office

Hybrid Stabilization



Riprap with Marsh Plants. Photo: Texas General Land Office

RIPRAP

Riprap alone is not considered a living shoreline, but it may be used as part of a larger living shoreline project. Riprap, sometimes called a revetment, is placed along the shoreline to break waves and reduce erosion. Riprap consists of stone or concrete of various shapes and sizes depending on the wave action and shoreline length at the project site. The GLO only allows a 3:1 ratio of riprap to height of shoreline. Ex. A shoreline that is 3' above the high-water mark (mean high tide) would be authorized to have a riprap width of 9'.

Riprap paired with marsh grass plantings can contribute to the ecosystem by providing habitat for oysters as well as small crab and fish species. It may also be used in some situations to provide an extra layer of shoreline stabilization and erosion control.

- **Materials Needed:** Stone or concrete
- **Installation Technique:** Riprap is placed along the shoreline at the water-land interface.
- **Durability and Maintenance:** Riprap is very durable and low maintenance. Tropical storm events may move smaller sized material. Debris may need to be removed from riprap periodically.

Riprap Only Shoreline. Photo: Texas General Land Office

Retrofit: Soft Stabilization

This technique may be recommended for lower energy environments where a hard structure such as a bulkhead, seawall, or riprap already exists. Here, the environment would support marsh plantings without an additional offshore structure being needed to protect the vegetation or shoreline. Marsh plantings located in front of the structure will provide an additional layer of protection, potentially increasing a bulkhead's life span by reducing wave energy and cutting down on scouring at the base of the bulkhead or seawall.

See the Materials Needed, Installation Technique, and Durability and Maintenance requirements listed under the Soft Stabilization section.

Marsh Planting. Photo: Galveston Bay Foundation

Retrofit: Hybrid Stabilization

Limestone Breakwater with Marsh Planting Installation - Before. Photo: Galveston Bay Foundation

Limestone Breakwater with Marsh Planting Installation - After. Photo: Galveston Bay Foundation

This technique may be recommended in moderate to higher energy environments. Here, there is an existing shoreline structure in place such as a bulkhead, seawall, or riprap. There may or may not be existing marsh plantings that need some additional protection from an oyster reef, articulated blocks or mat, breakwater, or riprap. Retrofits can potentially increase a bulkhead's life span by reducing wave energy and cutting down on scouring at the base of the bulkhead or seawall.

See the Materials Needed, Installation Techniques, and Durability and Maintenance requirements listed under the Hybrid Stabilization section.

NOT SUITABLE

Living shorelines are not always a suitable shoreline stabilization option. The shoreline may have too much wave energy, experience too much erosion, or be too deep to support plantings or other living shoreline options. This does not mean a living shoreline cannot be considered, but caution is encouraged and a site assessment performed by an expert is recommended.

IN ADDITION TO THIS GUIDANCE DOCUMENT, REFERENCES TO OTHER RESOURCES ON LIVING SHORELINES CAN BE FOUND IN ***APPENDIX C***

LIVING SHORELINE OPTIONS BASED ON YOUR PROPERTY'S CHARACTERISTICS

		Shoreline Type			Slope			Erosion Rate			Wave Energy			Water Depth			Salinity		
Category	**Option**	**Existing Bulkhead**	**Marsh**	**Beach Sand/ Shell Hash**	**Low**	**Moderate**	**High**	**Low**	**Moderate**	**High**	**Low**	**Moderate**	**High**	**Shallow**	**Moderate**	**Deep**	**Freshwater**	**Brackish**	**Salt**
Soft Stabilization	Marsh Vegetation Plantings	X	✓	•	✓	•	•	✓	•	X	✓	•	X	✓	•	X	✓	✓	✓
	Coir Logs	X	✓	✓	✓	✓	•	✓	X	X	✓	X	X	✓	X	X	✓	✓	•
Hybrid Stabilization	Submerged Oyster Shell Beds	•	✓	✓	✓	✓	✓	✓	✓	•	✓	✓	X	✓	•	X	X	✓	•
	Reef Balls	•	✓	✓	✓	✓	✓	✓	✓	•	✓	✓	✓	✓	✓	X	•	✓	•
	Articulated Mats or Blocks with Marsh Plantings	X	✓	✓	✓	✓	•	✓	✓	✓	✓	✓	•	✓	•	X	✓	✓	✓
	Breakwater with Marsh Plantings	✓	✓	•	✓	✓	✓	•	✓	✓	•	✓	✓	✓	✓	✓	✓	✓	✓
	Riprap with Marsh Plantings	✓	✓	•	✓	•	•	•	✓	X	•	•	X	✓	•	X	✓	✓	✓

✓	Best Management Strategy
•	Potential Management Strategy
X	Generally Not Recommended

ECOLOGICAL BENEFITS OF LIVING SHORELINES COMPONENTS

	Soft Stabilization		Hybrid Stabilization				
Benefit	**Marsh Grass Plantings**	**Coir Logs**	**Submerged Oyster Shell Beds**	**Reef Balls**	**Articulated Blocks or Mats**	**Breakwater**	**Riprap**
Creates plant and animal habitat	✓	✓	✓	✓	✓	✓	✓
Increases water filtration / water quality	✓		✓	✓		✓	
Promotes nutrient uptake	✓						
Retains sediment	✓	✓	✓	✓	✓	✓	✓
Reduces erosion	✓	✓	✓	✓	✓	✓	✓
Lessen wave energy	✓	✓	✓	✓	✓	✓	✓
Recreation opportunities	✓		✓	✓		✓	
Education opportunities	✓	✓		✓		✓	
Establishes a marsh	✓	✓				✓	
Denitrification	✓						
Carbon sequestration	✓						

✓	Benefits Provided

Aransas County Shoreline - Before
Photo: Mott MacDonald

Aransas County Conceptual Image - After
Photo: Mott MacDonald

STEP 4: ENGAGE A SHORELINE MANAGEMENT PROFESSIONAL

A successful living shoreline project often requires the involvement of a shoreline management professional with experience and expertise in designing and installing living shorelines. A professional will help you design your project, assist with the permitting process, provide a realistic schedule and budget and, if desired, install the living shoreline.

Although the GLO cannot make recommendations regarding firms or individual professionals to hire, we can provide example questions to ask when determining which professional to engage.

- What is your experience with living shorelines?
- How many similar projects have you completed and where are they located?
- Do you do project design, construction, or both? If only design, can you recommend an experienced contractor?
- Will you handle the permitting and will there be an extra fee for that service?
- What do you estimate the total cost of the project will be?
- If there are plantings, do you guarantee growth during the first year? (Usually they will not, as it's the property owner's responsibility to water the plantings.)
- What is the complete timeline for the project, including permitting?
- How will the payments be handled?
- Can you provide client references and recommendations?

Living shoreline design, permitting, and installation can be done without the help of a shoreline management professional. Just be sure to continue referencing this guide for installation tips to help the success of your project!

STEP 5: OBTAIN REQUIRED PERMITS AND AUTHORIZATIONS

Now it's time to start discussing permitting and authorization requirements with the GLO's Permit Service Center (PSC). Any structures or plantings located within GLO jurisdiction (generally all bay waters below mean high tide) will need a lease or easement from the GLO. A permit from the U.S. Army Corps of Engineers (USACE) will also be required, and potentially authorizations from other agencies.

The PSC offers **free**, streamlined assistance and can help you:

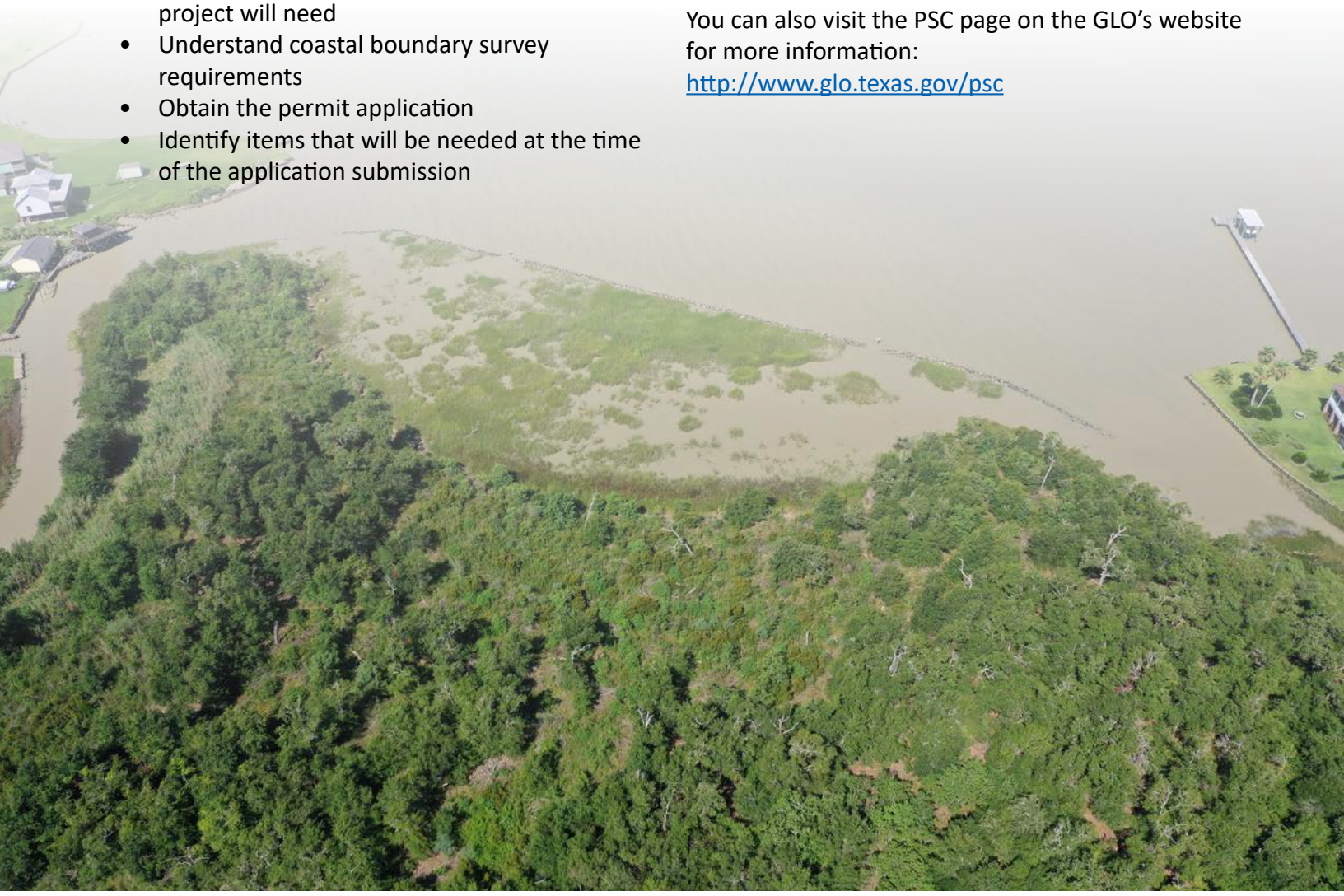
- Determine if your project location is under GLO jurisdiction
- Determine which leases or easements your project will need
- Understand coastal boundary survey requirements
- Obtain the permit application
- Identify items that will be needed at the time of the application submission

Coastal Boundary Survey Requirement

If the living shoreline will be located below mean high tide, which is the average daily tidal high water line in an area calculated over a period of time, a coastal boundary survey (CBS) to determine the extent of state-owned submerged lands at a property is required. The PSC can help determine whether a CBS is required for your property.

The living shoreline permitting process is described in greater detail in **Section 4: Permitting a Living Shoreline on the Texas Coast.** PSC contact information can also be found there.

You can also visit the PSC page on the GLO's website for more information:
http://www.glo.texas.gov/psc



Shipe Woods, Double Bayou. Photo: Galveston Bay Foundation

Riprap Breakwater Installation. Photo: Mott MacDonald

STEP 6: CONSTRUCTION

Construction can start once you receive written authorization from the GLO, the USACE, and any other required authorizing entity. The development and implementation of a living shoreline requires careful planning, sound engineering, and time for permitting and construction but, the long-term benefits of a living shoreline on your property are immeasurable. Keep your eye on the prize and your end goals in mind!

POTENTIAL FUNDING OPPORTUNITIES FOR INSTALLATION OF LIVING SHORELINES CAN BE FOUND IN ***APPENDIX D***

Construction of a Restored Marsh Habitat. Photo: Galveston Bay Foundation

Vegetative Monitoring. Photo: North Carolina Coastal Federation

STEP 7: MONITORING AND MAINTENANCE [8]

Even the most successful living shoreline will require some monitoring and maintenance over time. It is important to routinely monitor the living shoreline to make sure all the elements of the design are still operating as intended and providing the expected benefits.

Continually monitoring your location will allow you to spot problem areas before they become major issues. Long-term monitoring can be as simple as a visual inspection after major storms to identify areas requiring additional planting or where materials need to be replaced or reinforced. Some living shorelines may require monitoring as a component of their authorization.

Vegetation Monitoring

Vegetation monitoring will help identify vegetation that is not surviving or thriving. Photographs taken at regular intervals will help you track changes in your living shoreline over time. Or, you can select a 5 by 5-foot plot and estimate the percent cover of different plant species within the plot area. Reviewing your notes over time will help you discern trends and understand which species perform better or worse than others. You can also record other factors you observe such as invasive species, changes in water depth, amount of sunlight reaching the plants, or accretion of sediment.

If plants aren't thriving in certain areas, it could be a sign the soil is eroding beneath them or that the plants are not suitable for the site. The solution may be as simple as planting a different, more suitable plant species or installing a structural solution to lessen wave energy and slow erosion.

Materials Repair and Replacement

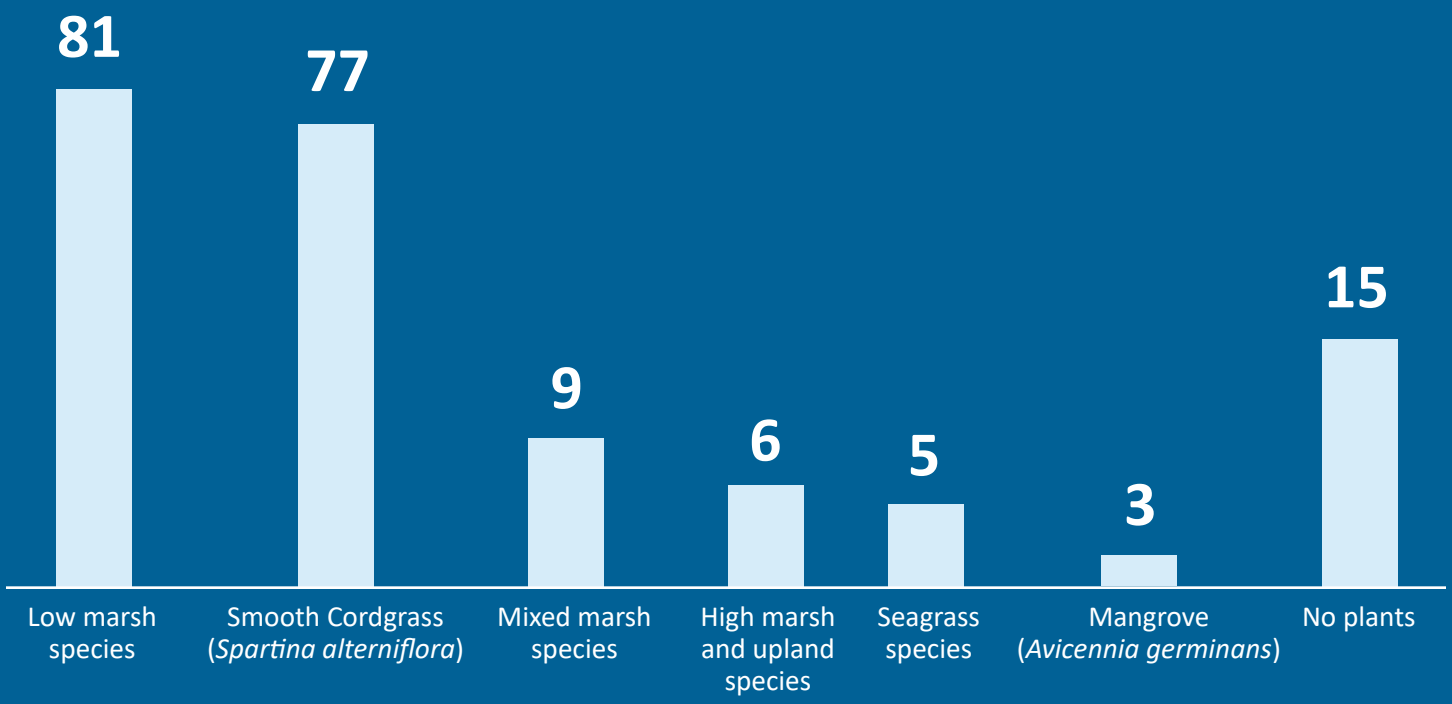
In areas with higher wave action, rock, oyster shell, or other stabilization methods may be used. It is important to monitor these features to ensure they do not become displaced. Maintenance of these features may include:

- Re-staking or reinstalling erosion control materials
- Rock or oyster bag replacement or readjustment
- Debris clean up

Vegetative Monitoring. Photo: Florida Sea Grant

Land and water animals love to feed on newly planted vegetation. Believe it or not, cows have even come down to graze on newly planted living shorelines! To keep unwanted animals out of the area for the first full growing season, a small fence or mesh enclosure is often effective.

The Number of Living Shoreline Projects Using Certain Plant Species in Texas



Tips for Minimizing Maintenance Needs

- Select native vegetation and ensure a reliable source of water if planting in a riparian area;
- Plant vegetation according to the planting season that is best for the species – avoid hurricane season and heat of the summer;
- Plant shrubs and trees during the rainy season if substantial water is required for survivability;
- Keep natural upland areas with native vegetation where possible to prevent landward erosion; and
- Minimize storm water runoff to the project area to prevent erosion.
- Large debris, such as logs, algae mats, and trash, should be periodically cleared from the site to protect wetland plants from being smothered.
- For beach and water access, keep a narrow path to the water unplanted to avoid trampling vegetation.
- Non-native invasive plants should be controlled and replaced with native wetland plants and shrubs.
- Trim any overhanging limbs that might be shading out marsh plants, especially during the early days of establishment.

Since 1987 there have been **114** living shoreline projects documented along the Texas coast.

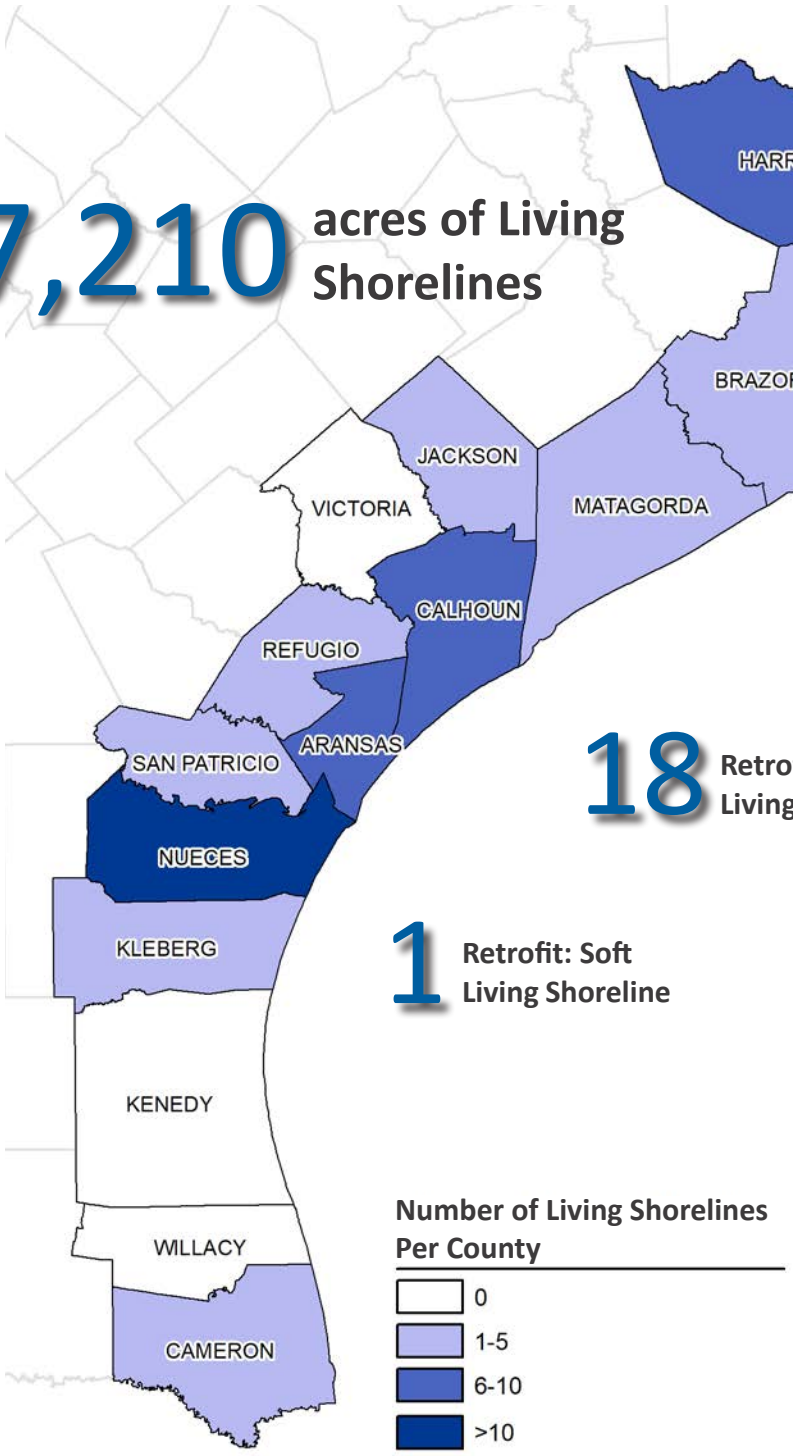
37,210 acres of Living Shorelines

64 Hybrid Living Shorelines

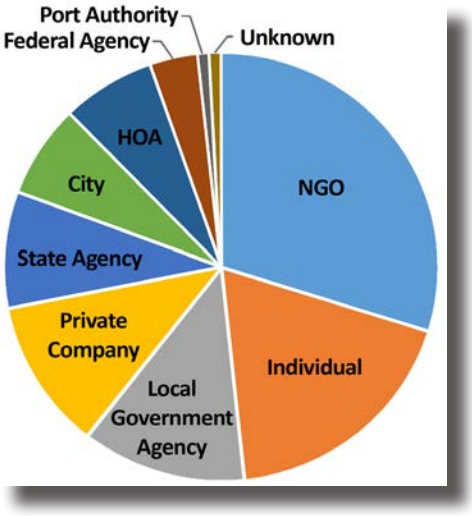
31 Soft Living Shorelines

18 Retrofit: Hybrid Living Shorelines

1 Retrofit: Soft Living Shoreline



Living Shoreline Owners



Living Shoreline with Marsh Planting and Breakwater. Photo: Texas General Land Office

TEXAS LIVING SHORELINE: CASE STUDIES

Every shoreline has its own unique features that influence how living shorelines are designed and implemented. This section presents living shoreline case studies from along the Texas coast that showcase the different ways living shorelines have been used to improve and protect property. We hope these examples provide ideas and inspiration to address your own shoreline issues.

Hybrid Stabilization

Riprap breakwater with marsh vegetation plantings

Shipe Woods Marsh Restoration

Chambers County

The Galveston Bay Foundation (GBF) purchased the 14-acre Shipe Woods complex in 1991 for conservation purposes. The property was experiencing erosion from wave action resulting in over 100 feet of shoreline marsh and forest loss. GBF used a hybrid living shoreline technique and installed a 225-foot riprap breakwater to create two acres of intertidal wetlands. The north end of the breakwater was left open, and two low spots were integrated into the structure to allow for water and wildlife movement.

Site Characteristics:

Shoreline Type: Existing salt marsh
Slope: High
Wave Energy: Low
Erosion Rate: Moderate
Fetch: Low
Water Depth: Shallow
Salinity: Low
Neighboring Property Conditions: Salt Marsh

Dimensions:

725 feet of riprap breakwater
2 acres of smooth cordgrass

Project Details:

Cost: $112,500
Permit: USACE Nationwide Permit 27
Timeline: Constructed 2013

Project Partners:

GBF, US Fish and Wildlife Service, RAE-NOAA, ERM Foundation, Cheniere Energy, Entergy

Photo: Galveston Bay Foundation

Photo: Galveston Bay Foundation

Photo: Galveston Bay Foundation

Hybrid Stabilization

Oyster reef balls with marsh vegetation planting

Oyster Lake Shoreline Protection

Brazoria National Wildlife Refuge, Brazoria County

The calm, shallow waters of Oyster Lake are separated by a narrow sand beach from the turbulent, deeper waters of West Bay. This narrow beach was experiencing erosion on both the West Bay and Oyster Lake sides. The Brazoria National Wildlife Refuge and Galveston Bay Foundation (GBF) worked together to install oyster reef balls on both sides of the beach to prevent further erosion and protect approximately 5,000 feet of coastline from land and habitat loss. The resulting oyster reef structures created 0.15 acres of fish habitat and volunteers planted 1.5 acres of marsh grasses behind the breakwaters.

Site Characteristics:

Shoreline Type: Existing salt marsh
Slope: Low
Wave Energy: Low
Erosion Rate: Low
Fetch: Low
Water Depth: Shallow
Salinity: High

Dimensions:

4,786 feet of oyster reef balls
1.5 acres of marsh grasses

Project Details:

Cost: $1,592,000
Timeline: 2013-2016: Phases One and Two

Project Partners:

GBF, Brazoria National Wildlife Refuge, and Ducks Unlimited

Photo: Galveston Bay Foundation

Photo: Galveston Bay Foundation

Photo: Galveston Bay Foundation

Hybrid Stabilization
Breakwater with marsh planting

Driscoll Rooke Covenant Park
Copano Bay, Refugio County

The Driscoll Rooke Covenant Park had lost a significant portion of its shoreline due to erosion from waves and recreational boat traffic. This land loss was endangering the park, public fishing pier, Copano Bay Drive, and nearby houses. The Copano Bay Soil and Water Conservation District (CCBSWCD) worked with the Coastal Bend Bays and Estuaries Program (CBBEP) to gently grade the eroding bluff, build a sheet pile breakwater, install an articulated mat, and plant marsh grasses. The resulting living shoreline created new wildlife habitat and provided a natural vegetative buffer against wave action. While many areas of the Bayside waterfront received substantial damage from Hurricane Harvey, the park's shoreline remained largely intact.

Site Characteristics:
Shoreline Type: Marsh
Slope: Low
Wave Energy: Moderate
Erosion Rate: Low
Fetch: Moderate
Water Depth: Deep
Salinity: Moderate

Dimensions:
500 feet of breakwater

Project Details:
Cost: $35,000 for design, $87,000 for construction
Timeline: Constructed 2003-2004

Project Partners:
CCBSWCD, CBBEP, City of Bayside

Photo: Coastal Bend Bays and Estuaries Program

Photo: Coastal Bend Bays and Estuaries Program

Photo: Coastal Bend Bays and Estuaries Program

Hybrid Stabilization

Riprap breakwater with marsh plantings

Loyola Beach

Baffin Bay, Kleberg County

In the early 2000s, the Loyola Beach shoreline began experiencing significant erosion from recreational boat traffic, particularly near the boat ramp. The Coastal Bend Bays and Estuaries Program (CBBEP) and the Texas A&M Kingsville Department of Environmental Engineering decided to use a hybrid living shoreline technique including installing riprap along the shoreline and planting marsh vegetation. The living shoreline preserves the beach, assists with ecosystem recovery, and costs roughly a third of a typical seawall.

Site Characteristics:

Shoreline Type: Existing boat ramp
Slope: Low
Wave Energy: Moderate
Erosion Rate: Moderate
Fetch: Moderate
Water Depth: Moderate
Salinity: High

Dimensions:

150 feet of shoreline riprap

Project Detail:

Cost: $50,000
Permitting: GLO lease and USACE permit
Timeline: Constructed 2003 (6 day install)

Project Partners:

Coastal Bend Bays and Estuaries Program, Texas A&M Kingsville

Photo: Coastal Bend Bays and Estuaries Program

Photo: Coastal Bend Bays and Estuaries Program

Photo: Coastal Bend Bays and Estuaries Program

Hybrid Stabilization
Breakwater with marsh plantings

Arturo Galvan Coastal Park
Laguna Madre, Cameron County

The City of Port Isabel observed that the beach at the Arturo Galvan Coastal Park in the Lower Laguna Madre was eroding due to high wave energy. A living shoreline consisting of a breakwater with marsh plantings was installed to reduce erosion while improving habitat and enhancing the park's attractiveness. The project required removing a vast debris field and completing beach nourishment to create a gently graded slope. Two low-crested rock breakwaters were installed to protect an intertidal area planted with native low marsh vegetation.

Site Characteristics:

Shoreline Type: Sandy beach and riprap
Slope: Low
Wave Energy: Moderate
Erosion Rate: Low
Fetch: Moderate
Water Depth: Deep
Salinity: High

Dimensions:

1,885 feet of rock breakwater

Project Details:

Cost: $800,000
Timeline:
2013-2015: Survey and project design
2015: Debris removal and construction

Project Partners:

City of Port Isabel, GLO

Photo: City of Port Isabel

Photo: City of Port Isabel

Photo: City of Port Isabel

Hybrid Stabilization
Breakwater with marsh plantings

Palacios Seawall Commission
Tres Palacios Bay, Matagorda County

This hybrid project included installing riprap and a concrete breakwater with marsh plantings to protect and enhance the pre-existing marsh habitat that was quickly eroding away. Large amounts of debris had to be removed from the shoreline to promote plant growth and improve aesthetics. The project and associated breakwater now protects approximately 2,800 feet of shoreline and 25 acres of natural and restored smooth cordgrass marsh that captures sediment, promotes recreational fishing, and supports oyster growth. Initiated in 1993, the marsh continues to remain healthy and productive despite storm damage.

Site Characteristics:

Shoreline Type: Existing docks/residential
Slope: Low
Wave Energy: Low
Erosion Rate: Moderate
Fetch: Low
Water Depth: Deep
Salinity: Moderate

Dimensions:

4,000 feet of concrete breakwater
600 feet of riprap breakwater
163 feet of articulated mat
8.4 acres of smooth cordgrass plantings
25 acres of smooth cordgrass protected

Project Details:

Cost: Unknown
Timeline: Constructed 1993-1995

Project Partners:

Matagorda County, Palacios Seawall Commission, Matagorda Bay Foundation

Photo: Matagorda Bay Foundation

Photo: Matagorda Bay Foundation

Hybrid Stabilization
Riprap breakwater

Pelican Island Shore Protection
Corpus Christi Bay, Nueces County

Located in Corpus Christi Bay with its northern shore on the Corpus Christi Ship Channel, Pelican Island is a vital habitat for colonial water birds. Erosion caused by wave energy from boat traffic had undercut a bluff on the northern shore of the island and was threatening to produce a breach across the island that would destroy critical bird habitat. The Port of Corpus Christi Authority (PCCA) wanted to stabilize the island's shoreline against further degradation so they installed a 2,200-foot revetment and breakwater.

In 2017, Hurricane Harvey made landfall just north of this project site. A post-storm inspection indicated no damage to the structure and showed that the structure performed it's intended goal to protect the upland habitat - no shoreline or habitat was damaged in the area protected by the breakwater.

Site Characteristics:

Shoreline Type: Marsh
Slope: Low
Wave Energy: High
Erosion Rate: Low
Fetch: Low
Water Depth: Moderate
Salinity: High
Neighboring Property Conditions: Ship traffic

Dimensions:

2,200 feet of breakwater

Project Details:

Cost: $1,200,000
Timeline: Constructed 2008-2009

Project Partners:

Port of Corpus Christi Authority, Mott MacDonald

Riprap Installation. Photo: Mott MacDonald

Riprap Installation. Photo: Mott MacDonald

Retrofit: Hybrid Stabilization

Bulkhead retrofitted with a breakwater and marsh vegetation planting

Trinity Bay Discovery Center

Trinity Bay, Chambers County

Galveston Bay Foundation's (GBF) Trinity Bay Discovery Center is a 17-acre conservation and education facility. Wind-driven waves had impaired an existing bulkhead on the property so the GBF established a living shoreline to reduce erosion, lessen wave energy, and restore marsh habitat. GBF installed a riprap breakwater and worked with volunteers to construct an oyster shell breakwater along the lower-energy northeastern shoreline. The breakwaters created approximately two acres of calm water habitat to allow intertidal marsh to re-establish. As of August 2019, over half an acre of this area had been planted with smooth cordgrass.

Site Characteristics:

Shoreline Type: Marsh
Slope: Low
Wave Energy: Moderate
Erosion Rate: Low
Fetch: Moderate
Water Depth: Deep
Salinity: Low

Dimensions:

780 feet of riprap breakwater
400 feet of oyster shell breakwater
0.5 acres of smooth cordgrass

Project Details:

Cost: $195,500
Permitting: GLO lease and USACE permit
Timeline: 2016: Coastal Boundary Survey
2017: Lease and permit acquired
2018-2019: Construction

Project Partners:

GBF, Texas Commission on Environmental Quality, US Fish and Wildlife Service, CCA Texas, NFWF/ Houston Wilderness

Photo: Galveston Bay Foundation

Photo: Galveston Bay Foundation

Photo: Galveston Bay Foundation

Retrofit: Hybrid Stabilization

Bulkhead retrofitted with a breakwater and marsh vegetation planting

Lafitte's Cove Subdivision

West Galveston Island, Galveston County

Canal-front property owners in the Lafitte's Cove subdivision were experiencing erosion and loss of critical salt marsh due to failing bulkheads and high wave energy from boat traffic in the canal. To prevent further erosion, residents installed a living shoreline breakwater in front of the failing bulkhead. This project also made innovative use of vinyl sheet pile to create a planted shelf, expanding the area for smooth cordgrass plantings in a narrow waterway. The property owners have introduced many of their neighbors to the benefits of living shorelines, which include resilience to hurricanes as the shoreline survived both Hurricanes Ike and Harvey.

Site Characteristics:

Shoreline Type: Marsh
Slope: Low
Wave Energy: Low
Erosion Rate: Low
Fetch: Low
Water Depth: Moderate
Salinity: High
Neighboring Property Conditions: Bulkheads

Dimensions:

180 feet of breakwater
0.06 acres of marsh plants

Project Details:

Cost: $34,880
Timeline: Constructed 2006

Project Partners:

GBF and US Fish and Wildlife Service

Photo: Galveston Bay Foundation

Photo: Galveston Bay Foundation

Photo: Galveston Bay Foundation

Retrofit: Hybrid Stabilization

Breakwater with marsh plantings

Clear Lake Forest Park Subdivision

Lake Pasadena, Harris County

The Clear Lake Forest Homeowner Association (HOA) noticed erosion along their natural shoreline due to failing bulkheads and moderate wave energy. To address the issue, the HOA decided to install a limestone breakwater with marsh planting. The north shore was graded to the lake edge, and the breakwater was installed. The south shore had an existing bulkhead, so the breakwater was installed in front. Limestone was chosen for the breakwaters as a slightly more attractive alternative to crushed concrete. Over 60 volunteers participated in planting 8,500 stems of smooth cordgrass, as well as seashore paspalum and marshy cordgrass landward of both the north and south breakwaters. In addition to receiving a 2011 Parks and Nature Areas award from the Houston Galveston Area Council, the living shoreline was able to withstand Hurricane Harvey with minimal damage.

Site Characteristics:

Shoreline Type: Existing bulkhead, upland turf vegetation
Water Depth: Deep
Salinity: Moderate

Dimensions:

640 feet limestone breakwater
0.03 acres of marsh plants

Project Details:

Cost: $120,000
Timeline: Constructed 2011

Project Partners:

Galveston Bay Foundation

Photo: Galveston Bay Foundation

Photo: Galveston Bay Foundation

Photo: Galveston Bay Foundation

Retrofit: Hybrid Stabilization

Existing bulkhead with breakwater installation and marsh planting

Copano Bay Living Shoreline

Copano Bay, Aransas County

This project was constructed to protect existing bulkheads and upland residential lots from erosion caused by high wave energy and to provide marsh habitat. Breakwaters were installed to protect the existing and newly planted marsh vegetation. Over time, oysters have colonized the breakwaters, contributing to the ecosystem's habitat and the structure's overall effectiveness. This shoreline took a direct hit from Hurricane Harvey in 2017 and the living shoreline proved to be highly efficient in protecting the upland areas. While homes and piers near the project were severely damaged, the marsh plants anchored the sediment around the living shoreline in place and the breakwater remained intact. Though some vegetation was lost to storm forces, the marsh grass is recovering and re-establishing.

Site Characteristics:

Shoreline Type: Existing bulkhead and marsh
Slope: Low
Wave Energy: Moderate
Erosion Rate: Low
Fetch: Moderate
Water Depth: Moderate
Salinity: Moderate

Dimensions:

880 feet of breakwater
0.3 acres of smooth cordgrass plantings

Project Details:

Cost: Unknown
Timeline: Constructed 2000 – 2002

Project Partners:

Belaire Environmental

Marsh Planting. Photo: Texas General Land Office

Rock Rubble Breakwater with Oysters Attached. Photo: Texas General Land Office

Marsh Planting. Photo: Texas General Land Office

Retrofit: Hybrid Stabilization

Breakwater with marsh plantings

Oak Island-Sullivan Project

East Bay, Chambers County

A property owner on Oak Island reached out to the Galveston Bay Foundation (GBF) for assistance in installing a living shoreline on his land to prevent further erosion from wave energy. Phase One involved erosion control fencing as a temporary breakwater to allow marsh grass to survive. Approximately 955 feet of fencing was installed, resulting in 0.03 acres of created marsh. In Phase Two, the landowner installed 320 feet of breakwater on his shoreline adjacent to his existing bulkhead. Additionally, a graded test area was installed upland of the breakwater and was protected by silt fence and erosion control matting. At the waterline, this graded area was planted with smooth cordgrass.

Site Characteristics:

Shoreline Type: Existing bulkhead
Slope: High
Wave Energy: Moderate
Erosion Rate: Moderate
Fetch: Moderate
Water Depth: Moderate
Salinity: Low

Dimensions:

955 feet of erosion control fencing; 320 feet of rock breakwater; 0.03 acres of marsh

Project Details:

Cost: Phase One: $14,304 / Phase Two: $10,429 for materials, $5,048 for construction
Timeline: 2008: Phase One; 2011: Phase Two

Project Partners:

Coastal Impact Assistance Program, US Fish and Wildlife Service

Marsh Planting. Photo: Galveston Bay Foundation

Shoreline Erosion. Photo: Galveston Bay Foundation

Marsh Planting. Photo: Galveston Bay Foundation

Living Shoreline. Photo: Galveston Bay Foundation

PERMITTING A LIVING SHORELINE ON THE TEXAS COAST

All living shoreline projects will require authorizations and permits in some capacity. This section provides guidance on how to navigate the permitting process.

Most submerged land in the bays and tidally influenced rivers belongs to the State of Texas and is managed by the GLO. Other entities that manage submerged land include navigation districts and municipalities. In addition, the U.S. Army Corps of Engineers (USACE) has jurisdiction over water and wetlands and Texas Parks and Wildlife Department (TPWD) regulations may also be applicable to some living shoreline projects.

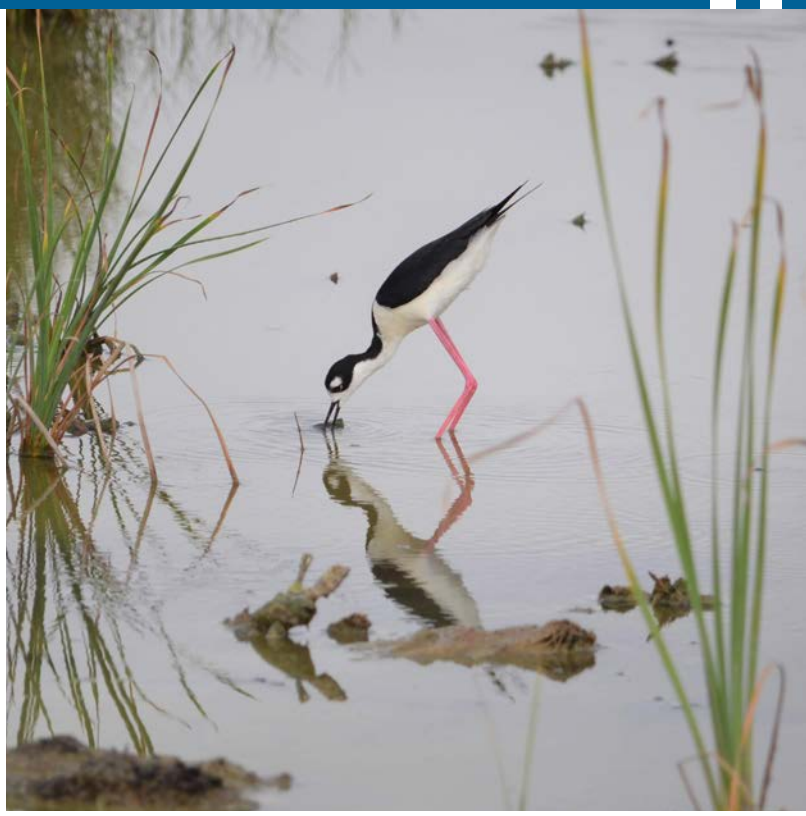
COASTAL PERMITTING STREAMLINED: THE TEXAS PERMIT SERVICE CENTER

The state and federal permitting requirements can appear daunting, but Texas provides **free** coastal permitting assistance through the GLO's two Permit Service Centers (PSCs). The PSCs are "one-stop shops" for projects that fall within the Texas coastal zone boundary (CZB). Applicants should work closely with PSC staff throughout the living shoreline development process.

The Upper Coast PSC in Galveston handles sites from the Louisiana border south to Live Oak Bayou. The Lower Coast PSC in Corpus Christi handles sites from the Colorado River south to the Rio Grande.
If you are unsure if your shoreline falls within the area of GLO jurisdiction, contact the PSC. If you are interested in a living shoreline project outside of the CZB, the PSC can provide you with contact information for the relevant agencies.

The PSC offers streamlined assistance with the following:

- The living shoreline authorization process, which involves the GLO, the USACE, and other state and federal agencies participating in the USACE permitting process.
- The Joint Permit Application Form (JPAF) that includes an application for the authorized use of state-owned submerged land from the GLO as well as an application for a USACE permit.
- The PSC may arrange for an applicant's project plan to be discussed at a Joint Evaluation Meeting (JEM). These are monthly meetings held by the local USACE office in coordination with other resource agencies to informally discuss proposed projects, answer questions, and provide guidance.
- PSC staff are familiar with local permitting requirements (if any) and can assist you in determining the appropriate office to contact.
- More information about the PSC can be found here: http://www.glo.texas.gov/psc



Black Necked Stilt Feeding. Photo: Texas General Land Office

PERMIT PROCESS OVERVIEW

Contact the PSC for the required application forms and information

↓

Consult with Contractor / Consultant (if needed) to Design Project

↓

Complete Application Forms, Drawings, etc. and Submit to PSC for Completeness Review.

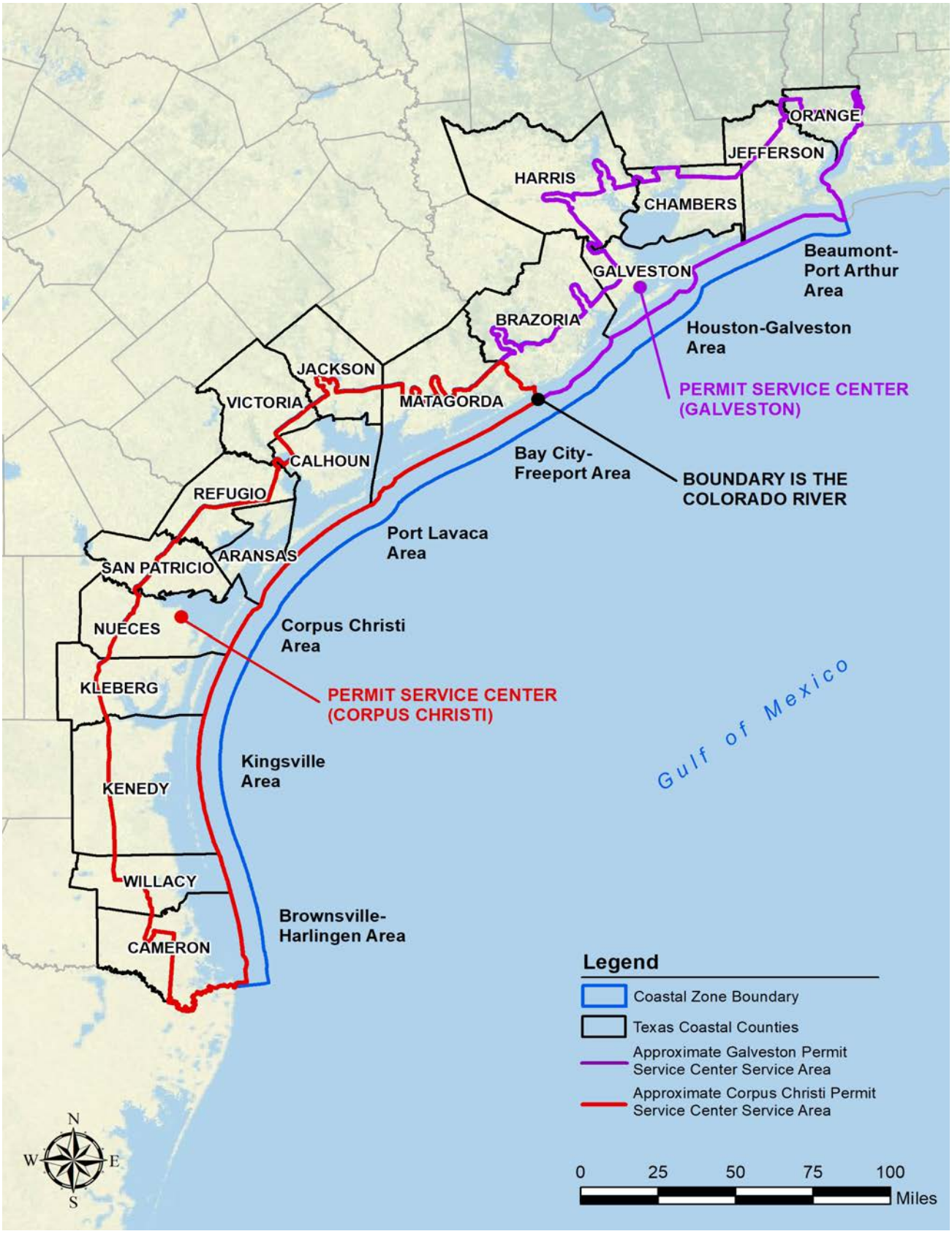
↓

PSC Reviews Submitted Documents and Forwards to USACE and/or GLO When Deemed Complete

↓

Construction Can Begin Once Applicant Has Received Authorization From All Required Agencies

PERMIT SERVICE CENTER AND COASTAL ZONE MAP



Permit Service Center and Coastal Zone Map. Photo: Allen Engineering and Science

Coastal Boundary Survey. Photo: Texas General Land Office

GLO AUTHORIZATION FOR THE USE OF STATE-OWNED SUBMERGED LAND

- A landowner who owns shoreline property and wishes to construct a living shoreline on state-owned submerged land must obtain authorization from the GLO.
- Time to process the state application depends on the complexity of the project. After completion of the coastal boundary survey (discussed below), most projects can be authorized within 90 days.
- Living shoreline projects typically do not require annual rent for the use of state land. Nominal rent may be required for other structures on state-owned submerged land. This does not apply to projects completed to satisfy mitigation requirements. Proposed projects with fill will be reviewed on a case by case basis and in accordance with the Texas Administrative Code (TAC). Please see TAC link for most up to date fee information https://texreg.sos.state.tx.us/public/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=31&pt=4&ch=155&rl=15

COASTAL BOUNDARY SURVEY REQUIREMENT

Texas law requires landowners planning coastal erosion response projects, including living shorelines, to obtain a coastal boundary survey (CBS). The CBS is a special survey to determine the boundary between private and state-owned submerged land.

- The CBS must be performed by a **Licensed State Land Surveyor (LSLS)**— a surveyor with special qualifications and state certification — and must be approved by the GLO.
- **A county surveyor of the county in which the land is located can also perform a CBS**.
- The GLO's Surveying Division will coordinate with the landowner and the surveyor to ensure the CBS is acceptable.
- The PSC can provide general information about the CBS requirement as well as information on Licensed State Land Surveyors.
- You can search for an LSLS in your county by visiting https://txls.texas.gov
- The CBS cost varies depending on the size and complexity of the survey needed.
- Approval of the CBS can take from 6 to 12 months.

FEDERAL PERMITTING

Most living shoreline projects will require a USACE permit to proceed.

- The PSC's JPAF includes an application for a USACE permit.
- The PSC will assist the applicant with the JPAF, screen the document for completeness, then submit to USACE for processing.
- Other state and federal agencies coordinate their review of an application as a part of the USACE permitting process. These agencies may include:
    - Texas Commission on Environmental Quality (TCEQ) – water quality certification
    - Texas Coastal Management Program (CMP) – consistency determination
    - U.S. Fish and Wildlife Service – consultation on endangered species (if needed)
    - National Marine Fisheries Service – consultation on essential fish habitat (if needed)
    - Texas Historical Commission – consultation on impacts to cultural resources (if needed)
- You do not need to contact these agencies unless so directed by PSC or USACE staff.

Marsh - Galveston East End. Photo: Texas General Land Office

TYPES OF USACE PERMITS FOR LIVING SHORELINES

The type of USACE permit required for a living shoreline depends on the project's location, design, and environmental impacts. A property owner should include permitting considerations in planning a project, as it can have a substantial effect on the cost and timing of the process.

- **Nationwide Permits (NWPs)**. The USACE issues "General Permits" that do not require individual review if certain criteria are met. Some living shoreline projects qualify as General Permits and are called "Nationwide Permits" (NWPs), which the USACE adopts every five years. The ability to use an NWP expedites scheduling and reduces cost.
- **Letters of Permission (LOPs)**. The USACE issues letters of permission (LOPs), which could authorize the construction of a living shoreline through an abbreviated procedure. LOPs are issued at the discretion of the USACE.
- **Individual Permits (IPs)**. Projects that do not fulfill the criteria for an NWP or an LOP must obtain an IP. These may require additional environmental studies and involves the issuance of a public notice. An IP may take from 12 to 18 months to obtain.

Restored Marsh Area. Photo: Galveston Bay Foundation

The three most commonly used NWPs for living shorelines include:

NWP 54
Provides that certain living shoreline projects can proceed expeditiously with an abbreviated environmental review.

NWP 27
Permits the construction of aquatic habitat, restoration, enhancement, and establishment activities with accelerated environmental review. Many living shorelines fit within this NWP.

NWP 13
Allows bank stabilization activities necessary for erosion control or prevention such as vegetative stabilization, bioengineering, and other structures that can form living shorelines.

TEXAS PARKS & WILDLIFE DEPARTMENT PERMIT REQUIREMENTS

Living shoreline projects that involve planting aquatic plants in state waters will require an Aquatic Introduction Permit (AIP) from TPWD.

- The applicant will submit the form directly to TPWD to obtain this permit.
- The form needs to be submitted at least 30 days prior to proposed introduction date.
- It generally takes about 30 days to obtain a TPWD AIP.
- TPWD does not require a fee for the AIP.
- The TPWD AIP form can be found here: https://tpwd.texas.gov/publications/pwdforms/media/pwd_1019_t3200_app_permit_stock_public_waters.pdf

If aquatic plants will be "borrowed" from another site, as opposed to purchasing from an approved Texas aquatic plant nursery, an Aquatic Resource Relocation Plan (ARRP) may be required by TPWD. This should be coordinated prior to submitting an application to the appropriate coordinator.

- The TPWD ARRP guidelines can be found here: https://tpwd.texas.gov/publications/pwdpubs/media/pwd_lf_t3200_1958_arrp_guidelines_packet.pdf

If the project will involve dredging marl, sand, gravel, shell, or mudshell in a streambed or navigable state waterway, the applicant must obtain a Marl, Sand, Gravel, Shell or Mudshell Permit from TPWD.

- The varying fees for these permits are described on the TPWD website.
- More information about the Marl, Sand, Gravel, Shell or Mudshell Permit can be obtained from the TPWD Sand and Gravel Permit Manager or found here: https://tpwd.texas.gov/faq/landwater/sand_gravel/#dig3

Texas City Prairie Preserve. Photo: Jerod Foster for The Nature Conservancy

LOCAL PERMITTING

Before planning a living shoreline, a property owner should check with the construction permitting department of the local municipality or county. While most coastal permitting is handled at the state and federal level, some jurisdictions have additional requirements. Local officials can provide guidance on how to comply with applicable regulations.

AGENCY CONTACT INFORMATION

GLO PERMIT SERVICE CENTERS

Upper Coast PSC
Office (409) 741-4057, Fax (409) 741-4010
Toll-free (866) 894-7664
TAMU-Galveston Campus
1001 Texas Clipper Road, Bldg. 3026, Rm. 912
Galveston, TX 77553
permitting.assistance@glo.texas.gov

Lower Coast PSC
Office (361) 886-1630, Fax (361) 888-9305
602 N. Staples St., Suite 240
Corpus Christi, TX 78401
permitting.assistance@glo.texas.gov

U.S. ARMY CORPS OF ENGINEERS

Regulatory Office in Galveston
Office (409) 766-3869
PO Box 1229, Galveston, TX 77553-1229
ceswg-pe-r@usace.army.mil

Regulatory Office in Corpus Christi
Office (361) 814-5847
ceswg-pe-r@usace.army.mil

TEXAS PARKS AND WILDLIFE DEPARTMENT

Coastal Introduction Permits

Upper Coast (Sabine – Matagorda Bays)
Justin Cournoyer
1502 FM 517 East
Dickinson, TX 77539
Office: (281) 534-0107
justin.cournoyer@tpwd.texas.gov

Lower Coast (San Antonio Bay – lower Laguna Madre)
Paul Silva
6300 Ocean Drive Mail Unit 5846
Corpus Christi, TX 78412
Office: (361) 825-3204
paul.silva@tpwd.texas.gov

Sand, Marl and Gravel Permits
Tom Heger, Permit Manager
4200 Smith School Road
Austin, TX 78744
Office: (512) 389-4583
tom.heger@tpwd.texas.gov

Coastal Planting. Photo: Coastal Bend Bays and Estuaries

LIVING SHORELINE PLANTS & PLANTING GUIDE

Marsh grasses are often the backbone of a living shoreline project. However, a wider variety of plants can be added to promote habitat diversity and create a more varied and attractive landscape. Native trees, shrubs, and grasses can also be used to hold soil in place, slow erosion, and add critical wildlife habitat, as well as beauty and value to your property.

Plant selection will depend on the project site conditions. It is important you become familiar with the types of plants suitable for your project site.

Plants can be obtained as transplants from borrow sites or purchased from local nurseries. If possible, purchase plants from a local nursery that does its own propagation from regionally obtained native stock or seed. If utilizing plants from a borrow site, try and select a site that has environmental conditions similar to your property – e.g. within the same bay system. When selecting plants, consult the supplier about whether the plant is appropriate for a saltwater, brackish, or freshwater environment and where in the marsh profile the plant will thrive. Note, the TPWD only allows native plant species to be introduced into state waters.

The following table lists plants commonly used in Texas living shoreline projects. The table also lists habitats that plants are most adapted to as well as their National Wetland Indicator Status, described below:

- Obligate (OBL) plants almost always occur in wetlands
- Facultative wetland (FACW) plants generally occur in wetlands more than 67 percent of the time
- Facultative (FAC) plants occur equally in wetlands and uplands
- Facultative upland (FACU) plants usually occur more than 67 percent of the time only on upland sites.

Sea oats. Photo: Leave Only Footprints

GRASSES, SEDGES AND RUSHES COMMON TO GULF OF MEXICO SHORELINES[9]

Scientific Name	Common Name	Adaptation	National Wetland Indicator Status
Distichlis spicata	Seashore saltgrass	Saline, Brackish, and Tidal Marshes	FACW
Cladium jamaicense	Sawgrass	Brackish and Tidal Freshwater Marshes	OBL
Eleocharis cellulose	Gulf coast spikerush	Brackish and Tidal Freshwater Marshes	OBL
Juncus effuses	Soft rush, Common rush	Tidal Freshwater Marsh	FACW, OBL
Juncus roemerianus	Black needlerush	Saline and Brackish Marshes	OBL
Muhlenbergia capillaris	Hairawn muhly	Dune	FACU
Muhlenbergia filipes	Gulfhairawn muhly	Brackish and Tidal Freshwater Marshes	FACU
Panicum amarum	Bitter panicum	Dune	FACU, FAC
Panicum virgatum	Switch grass	Tidal Freshwater Marsh	OBL
Paspalum vaginatum	Seashore paspalum	Brackish and Tidal Freshwater Marshes	OBL, FACW
Salicornia species	Glasswort	Saline and Brackish Marshes	FAC
Schizachyrium maritimum	Gulf bluestem	Dune	FAC
Schizachyrium littorale	Coastal bluestem	Dune	FACU
Schoenoplectus californicus	California bulrush	Tidal Freshwater Marsh	OBL
Schoenoplectus robustus	Saltmarsh bulrush	Saline and Brackish Marshes	OBL
Spartina alterniflora	Smooth cordgrass	Saline and Brackish Mrashes	OBL
Spartina patens	Marshay cordgrass, Saltmeadow cordgrass	Saline and Brackish Marshes	FACW
Spartina spartinae	Gulf cordgrass	Brackish and Tidal Freshwater Marshes	OBL, FACW
Sporobolus virginicus	Seashore dropseed	Saline Marsh	FACW
Uniola paniculata	Seaoats	Dune	FACU

Smooth cordgrass.
Photo: Texas Parks and Wildlife

Bitter panicum.
Photo: USGS

Saltmeadow cordgrass.
Photo: Marilee Lovit

Saw palmetto.
Photo: Kenny Braun

Seashore saltgrass.
Photo: Jim Wolford

Eastern baccharis.
Photo: Harry Rose

Black needlesrush.
Photo: iNaturalist

Hairawn muhly.
Photo: Meadow Farms

Seashore elder. Photo: West Florida Research and Education Center

FORBES AND WILDFLOWERS COMMON TO GULF OF MEXICO SHORELINES[9]

Scientific Name	Common Name	Adaptation	National Wetland Indicator Status
Borrichia frutescens	Sea oxeye daisy	Saline and Brackish Marsh	OBL, FACW
Canavalia rosea	Beach bean	Dune	FAC
Chamaecrista fasciculata	Partridge pea	Dune	FACU
Crinium americanum	Swamp lily	Freshwater Marshes	FACW
Helianthus debilis	Beach sunflower	Dune	FACU, FAC
Hymenocallis liriosme	Spider lily	Dune	FACU, FAC
Ipomoea imperati	Beach morning glory	Dune	FACU, FAC
Ipomoea pescaprae	Railroad vine, Goat's foot, Morning glory	Dune	FAC
Iris virginica	Iris	Dune	FAC
Sagittaria lancifolia	Bull tongue	Freshwater Marshes	FACW
Sesuvium portulacastrum	Sea purslane	Saline Marsh and Dune	FACW
Solidago sempervirens	Seaside goldenrod	Saline, Brackish, and Saline Marshes and Dune	FACW

Seaside goldenrod.
Photo: University of Waterloo

Southern blue flag iris.
Photo: Prairie Moon Nursery

Sea oxeye daisy.
Photo: Plant Creations

Spider lily.
Photo: Carolina Country

Bull tongue.
Photo: Wetlands Plant Inc.

Sea purslane.
Photo: Project Noah

TREES AND SHRUBS COMMON TO GULF OF MEXICO SHORELINES[9]

Scientific Name	Common Name	Adaptation	National Wetland Indicator Status
Argusia gnaphalodes	Sea lavender, Sea rosemary	Dune	FACU
Avicennia germinans	Black mangrove	Saline Marsh and Mangrove Swamp	OBL
Baccharis halimifolia	Eastern baccharis, Groundsel bush, Saltmyrtle	Saline and Brackish Marsh, and Tidal Freshwater Marshes	FAC, FACW
Celtis laevigata	Sugarberry, Hackberry	Saline Marsh, Dune	FACW, UPL
Chrysobalanus icaco	Cocoplum	Dune	FACW
Chysobalanus icaco	Seagrape	Dune	FAC
Conocarpus erectus	Buttonwood	Mangrove Swamp	FACW
Ilex cassine	Dahoon holly	Dune	FACW
Iva frutescens	Marsh elder, Jesuit's bark, High tide bush	Saline and Brackish	FACW
Iva imbricate	Seashore elder	Dune	FACW
Laguncularia racemosa	White mangrove	Mangrove Swamp	FACW
Lycium carliniamum	Salt matrimony vine	Saline Marsh, Dune	FACW
Magnolia grandiflora	Southern magnolia	Tidal Swamp	FAC
Myrica cerifera	Wax myrtle	Tidal Freshwater Marsh, Tidal Swamps, and Dunes	FAC, FAC
Morus rubra	Red mulberry	Saline marsh, Dune	FAC, FACU
Nyssa biflora	Blackgum, Swamp tupelo	Tidal Freshwater Marsh, Tidal Swamps, and Dunes	OBL
Persea palustris	Swamp bay	Tidal Swamp	FACW
Rhizophora mangle	Red mangrove	Mangrove Swamp	OBL
Saw palmetto	Serenoa repens	Brackish	FACW
Suriana maritima	Bay cedar	Dune	FACW
Taxodium distichum	Bald cypress	Tidal Swamp	OBL
Zizaniopsis miliacea	Giant cutgrass	Freshwater Marsh	FACU, FAC

For plant survival, it is important to educate yourself and to instruct contractors on proper planting strategy and spacing.

- Planting during the proper season is important to avoid temperature extremes to ensure plants thrive.
- In the coastal marsh environment, individual grass sprigs or plugs are typically planted approximately three feet apart.
- The root structure must be covered. Wave energy can dislodge the plants, so it is important to compact soil around the base of the stem.
- Plant as densely as one to two feet apart in higher energy environments. The higher the wave energy, the closer the plantings should be.

APPENDIX A
HARTE RESEARCH INSTITUTE MODEL DETAIL

The Living Shoreline Site Suitability model is an online map of the Texas coastline. In this map, the shoreline is divided into segments 55 yards long. When you click on a shoreline segment, a pop-up will appear with the recommended general living shoreline technique as determined by a decision tree model, a description of what that technique entails, and a link back to this guidebook for more information and potential next steps. You can either use the search tool to zoom in to your address or the area of interest, or just simply zoom in and out and pan using the buttons on the map and your mouse.

The model uses five factors to consider living shoreline use suitability:

- **Erosion Rate:** The erosion rate is the average horizontal retreat of the shoreline over time. This tool looks at long-term rates of shoreline change dating back to the 1950s as measured by the Bureau of Economic Geology. Shorelines with higher erosion rates are likely in a higher energy environment and need more protection.

- **Wave Energy:** The exposure to wave energy is estimated at each shoreline segment using wind speed and direction data from local tide gauges along with calculating wind fetch lengths every 22.5 degrees. Fetch length is the horizontal distance wind can blow over water to generate waves. Longer fetch lengths correspond to higher wave energies, thereby increasing shoreline erosion rates. Wave energy is strongest in the direction that the wind tends to blow most consistently or strongest – such as a shoreline with a long fetch length to the north that is exposed to strong northern winds when a cold front passes through.

- **Distance to Nearest Channel:** Shorelines near busy channels will likely experience erosion due to boat traffic, especially along larger or higher traffic channels. Therefore, the tool measures the distance from the shoreline to the nearest channel and classifies the channel as being small or large.

- **Shoreline Type:** The type of shoreline present along each segment of coast is identified to determine whether a beach, marsh, or existing shoreline armoring structure is present.

- **Water Depth and Nearshore Slope:** A bathymetry dataset is used to determine the water depth just offshore from the shoreline and the slope of the nearshore area up to 10 yards offshore. If the slope is too steep or the water too deep, a living shoreline technique may not be suitable since that shoreline may not support marsh plantings.

APPENDIX B
VISUAL SITE ASSESSMENT WORKSHEET FOR CONSIDERATION OF LIVING SHORELINES

Utilize this site assessment worksheet to better understand the conditions on your property that may affect the success of a selected living shoreline and also to assist you to better identify preferences for your living shoreline design.

1. Type of Shoreline: Natural, Armored, Marsh, Beach, Flat or other

   Comments: _____

2. Slope: No Slope, Gradual Slope, or Steep Slope, Bluff

   Comments:_____

3. Erosion Rate: No Erosion, Low Erosion, Moderate Erosion, or High Erosion

   Comments:_____

4. Wave Energy: Low Energy, Moderate Energy, or High Wave Energy

   Comments:_____

5. Fetch: Short fetch; Moderate fetch, or Long fetch

   Comments:_____

6. Water Depth Immediately Off-Shore: Shallow, Moderate or Deep

   Comments:_____

7. Salinity: Saline, Brackish or Freshwater

   Comments:_____

8. Neighboring Property Conditions
   a. What are the conditions on neighboring property's shorelines?
   b. Do they have a bulkhead or seawall or a more nature shoreline?
   c. Are they experiencing erosion? How severe?
   d. Are they interested in using a living shoreline to prevent erosion?

   Comments:_____

9. Do You Have a Personal Preference for Living Shoreline Features? For example, do you want the living shoreline to increase biodiversity, provide fish habitat, provide water access, reduce erosion, improve water quality, or look natural?

   If so, what?_____

10. Do You Have a Recreational Structure such as a Pier, Dock, or Boat Ramp to Consider When Selecting a Living Shoreline?

    If so, what?_____

APPENDIX C
SOURCES CITED AND OTHER RESOURCES

1. NOAA Habitat Conservation. Living Shoreline Planning and Implementation. http://www.habitat.noaa.gov/restoration/techniques/lsimplementation.html

2. Miller, Jon K., et. al. *Living Shorelines Engineering Guidelines*. **SIT-DL-14-9-2942**. February 2015. Revised February 2016. http://www.state.nj.us/dep/cmp/docs/living-shorelines-engineering-guidelines-final.pdf

3. Galveston Bay Foundation. *Living Shorelines: A Natural Approach to Erosion Control*. https://ewn.el.erdc.dren.mil/nnbf/other/11_Galveston_Bay_Foundation-Living_Shorelines.pdf

4. Florida Living Shorelines. http://floridalivingshorelines.com/

5. Gulf of Mexico Alliance, 2016. *Living Shorelines: A Technical Guide for Contractors in Alabama and Mississippi*. https://www.disl.org/assets/uploads/publications/LSGCGOMA2016.pdf

6. Mississippi Department of Marine Resources, 2013. *Alternative Living Shoreline Manual for Coastal Mississippi*. https://dmr.ms.gov/wp-content/uploads/2019/07/Alternative-Shoreline-Management-Guidebook.pdf

7. Alabama Department of Natural Resources and Mobile Bay National Estuary Program, 2014. *Living Shorelines: A Guide for Alabama Property Owners*. http://www.mobilebaynep.com/images/uploads/library/Living_Shorelines-10_30_14-Proof.pdf

8. The Nature Conservancy. Conservation Gateway. https://www.conservationgateway.org/ConservationPractices/Marine/crr/Documents/FINAL_CombinedProfilePages_7_12_2017.pdf

9. USDA-NRCS. The Plants Database: Plants for Gulf of Mexico Protection and Restoration. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/plantmaterials/technical/publications/?cid=stelprdb1044274

The growing popularity of living shorelines has led to the development of numerous online resources for interested property owners. The following resources may be particularly useful:

- **NOAA's Habitat Blueprint: Living Shorelines**
  https://www.habitatblueprint.noaa.gov/living-shorelines/

- **Galveston Bay Foundation's Living Shoreline Program**
  https://galvbay.org/work/habitat-restoration/

- **Gulf of Mexico Alliance's Living Shorelines in the Gulf Coast States: Texas Resource Guide**
  http://masgc.org/assets/uploads/documents/TX_Living_Shorelines_Singles.pdf

- **Restore America's Estuaries' Living Shoreline Academy**
  https://www.livingshorelinesacademy.org

APPENDIX D
FUNDING OPTIONS FOR LANDOWNERS, CITIES, LOCAL GOVERNMENTS AND NGO'S

Living shoreline projects cost money, and the larger the project, the higher the cost; therefore, additional financial resources to complete the project may be required. The following options are available even for land outside of GLO jurisdiction.

- Local governments can often issue bonds to finance shoreline protection projects like living shorelines. Bond issues generate capital that can finance a project and the bonds are paid off with tax revenue over a number of years.
- Bond issues sometimes cannot pay the entire cost of a project, but they can generate funding to plan a project and to provide a match for potential grant funding.
- Several of the federal coastal restoration funding programs resulting from the 2010 Deepwater Horizon incident can support living shoreline projects. Eligibility for and timing of grant opportunities varies by program.
    - Information about these programs in Texas is available at http://www.restorethetexascoast.org.
    - RESTORE Act programs, which distribute a portion of the Deepwater Horizon civil penalties to the Gulf States, provide funding for a wide range of environmental and economic restoration and recovery on the Texas Coast. In Texas, the RESTORE Act programs are administered by Texas Commission on Environmental Quality (TCEQ). https://www.restorethetexascoast.org/category/restore/
    - The National Fish and Wildlife Foundation (NFWF) distributes a portion of the criminal penalties from Deepwater Horizon to Texas and the other Gulf States for coastal restoration. https://www.restorethetexascoast.org/category/nfwf/
    - The Texas Natural Resource Damage (NRDA) Trustees for Deepwater Horizon are implementing a number of environmental restoration projects with funding from the settlement of the NRDA litigation over the incident. https://www.restorethetexascoast.org/category/nrda/
- State grant funding for living shoreline projects on the Texas coast comes primarily from two sources: The Texas Coastal Management Program (CMP) Grant Program and the Coastal Erosion Planning and Response Act (CEPRA) Coastal Resources Grant Program, both administered by the Texas General Land Office.
    - CMP grants are awarded annually
        - Local governments, institutions of higher learning, estuary programs, and nonprofit organizations are eligible applicants.
        - Grants require a 40% local match
        - Maximum CMP contribution to a project is $200,000
        - CMP regional "projects of special merit" can receive additional funding without a match requirement for large-scale projects with regional impacts
        - http://www.glo.texas.gov/coast/grant-projects/funding/index.html
    - CEPRA grants are awarded biennially
        - Any public or private entity is an eligible applicant.
        - Beach renourishment projects require a 25% match, all other projects require a 40% match.
        - CEPRA construction costs may be funded by GOMESA, which does not require a match. The GLO can provide more information.
        - http://www.glo.texas.gov/coast/grant-projects/funding/index.html
- Grant funding occasionally becomes available for living shoreline projects from the National Oceanic and Atmospheric Administration (NOAA) and from NFWF. You should check with these funders periodically to determine when funding may be available.
    - https://www.habitatblueprint.noaa.gov/living-shorelines/
    - http://www.nfwf.org/Pages/default.aspx

APPENDIX E
GLOSSARY OF TERMS

Armoring: Using physical structures to protect shorelines from coastal erosion; examples include seawalls and bulkheads.

Articulated Mat: Interlocking concrete blocks that hug the shoreline; an alternative to riprap, articulated mat also breaks up wave energy at the shoreline.

Beach: Shoreline type dominated by loose, unconsolidated sand.

Beach Nourishment: Placement of good-quality sand along a beach shoreline to increase the beach width and raise the elevation of the nearshore area.

Brackish: Water that is slightly salty; typically present in estuaries where river water and seawater mix.

Breakwater: Structures placed in the water, away from the shoreline but running alongside it, that break up wave energy away from the shore. This creates a calmer area between the breakwater and shoreline. Structures may include rock rubble, concrete, or oyster recruitment structures.

Bulkhead: A "wall" along the shore that protects the shoreline by making a hard barrier that waves hit and bounce back from.

Erosion: The loss of upland soil along a shoreline due to the action of water, ice, or wind. Indicators of erosion include bare soil areas, leaning and fallen trees, exposed tree roots, and dead tree stumps in the water.

FAC: Facultative - National Wetland Indicator Status that indicates a plant is equally likely to occur in wetlands and non-wetlands.

FACW: Facultative wetland – National Wetland Indicator Status that indicates a plant usually occurs in wetlands, but occasionally can be found in non-wetlands.

FACU: Facultative upland – National Wetland Indicator Status that indicates a plant usually occurs in non-wetlands, but occasionally can be found in wetlands.

Fetch: Distance that wind or waves travel across open water.

Fill: Soil or other material that replaces surface water with dry land or changes the bottom elevation of a surface water.

High-Energy Shoreline: Shorelines directly impacted by the effects of larger waves created by higher winds, longer fetches, and/or boat wakes.

Hybrid Living Shoreline: Living shoreline that uses a hard structures such as breakwater, riprap, etc. in combination with vegetative plantings.

Low Energy Shoreline: A shoreline protected from the effects of high winds, long fetches, and boat wakes resulting in less wave energy reaching the shoreline.

Low-Profile Breakwater: A breakwater that is located parallel to the shoreline and is generally below the surface at low tide.

Native Vegetation: Includes all the plant species that occur naturally in a particular habitat and provide essential habitat for native insects and animals.

Natural Fiber Material: Made of coir fiber, wood, straw, jute, or a combination of organic, biodegradable materials.

APPENDIX E
GLOSSARY OF TERMS

Natural Recruitment: The natural increase in animal or vegetation population within a habitat.

OBL: Obligate Wetland - National Wetland Indicator Status that indicates a plant almost always occurs in wetlands under natural conditions.

Reef Ball: A concrete structure made using a fiberglass mold which is placed to break wave action and provide habitat for oysters and other shelled organisms to grow.

Resilient: Ability to function under, and recover from, disturbance.

Riparian: Relating to wetlands adjacent to rivers and streams.

Riprap: Rock or chunky concrete material laid along the shoreline that breaks up wave energy at the shoreline can also be used in breakwater construction.

Submerged Aquatic Vegetation: Underwater vegetation including seagrasses such as shoal grass (*Halodule wrightii*) and turtle grass (*Thalassia testudinum*).

Seawall: A form of coastal defense structure, essentially a large bulkhead or retaining wall, that provides shoreline protection from waves but also retains soil.

Sediment: Naturally occurring materials that have been broken down by weathering and erosion. Finer, small-grained sediments are silts or clays. Slightly coarser sediments are sands. Even larger materials are gravels or cobbles.

Silt: Fine-grained material that can be easily carried and transported by moving water.

Storm Surge: The resulting temporary rise in sea level due to the action of wind stress on the water surface and low atmospheric pressure created during storms which can cause coastal flooding.

Subsidence: The gradual caving in or sinking of an area of land.

Substrate: An underlying material or substance, typically where plants grow.

UPL: Obligate Upland – National Wetland Indicator Status that indicates a plant almost always occurs in non-wetlands under natural conditions.

Wave Energy: The transport and capture of energy by ocean surface waves.