MARTIN ecosystems

Floating Breakwater White Paper

THE WATER INSTITUTE OF THE GULF
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SHORELINE PROTECTION | BANK STABILIZATION

INTRODUCTION

The Floating Breakwater product was researched and developed by Martin Ecosystems based in part off the Floating Island Technology family of products. Floating Island Technology was developed in Montana by an inventor with the assistance of two commercialization grants from the state of Montana, in conjunction with the Center for Biofilm Engineering at Montana State University. Since 2008, Martin Ecosystems began the manufacturing of several similar products. Today Martin Ecosystems manufactures products for several different markets such as Stormwater, Wastewater, and Erosion Control. Martin Ecosystems has continued to research and develop the line of products. This paper will present technical information on the Floating Breakwater.

INNOVATION SUMMARY

Martin Ecosystems has used the concept of biomimetics to develop a product referred to as Floating Breakwaters. The science of biomimetics employs nature as a model. With abundant time and variation, nature has evolved elegant and efficient mechanisms to address many problems common to humans. Floating islands, one of those naturally occurring mechanisms, serve to buffer their habitats against wind and wave energies. Martin Ecosystems has modeled natural floating islands to create a comparable product that can be introduced into rivers, bayous, lakes, ponds, and bays. The result is the Floating Breakwater (BFB), a biomimetic replication of peat-based wild floating islands, utilizing recycled plastics as the base material. Floating Breakwaters work to reduce and to potentially eliminate and reverse shoreline erosion.

Natural occurrences such as waves, hurricanes, and floods seemingly destroy ecosystems, but over time those ecosystems often recover and mature into diverse healthy environments. Without outside interference the processes of recovery are normal and inevitable. They include microbial colonization followed by the invasion of plant species and eventually wildlife. Time is usually the only requirement. However, the conditions, both naturally occurring and man-made, that are impacting coastlines and shorelines do not allow for this spontaneous recovery. To meet the challenges posed by the constant high energy environment and the human impact, intentional effort often must be directed toward environmental restoration. Floating Breakwaters (BFB) represent an environmentally efficient, systematic effort. The BFB protects the existing shoreline and has the potential to rebuild/restore the shoreline while encouraging plant growth and establishing a wildlife habitat.

Historically, the technology used for shoreline protection has included both structural and non-structural methods including seawalls, bulkheads, revetments, dikes, levees, and vegetation plantings. Each method has its place in the coastal lines of defense;

however, most of these structural technologies provide solid structure without the benefits of a soft, natural, life-sustaining foundation, and the non-structural or vegetation plantings offer a natural aesthetic appearance, without the structural component for support and longevity. Floating Breakwaters are unique because they provide both.

1.0 INNOVATION DESIGN

The Floating Breakwater creates a complete ecosystem. It is a floating structure manufactured with using layers of recycled Polyethylene terephthalate (PET) matrix sheets that are adhered together with Coast Guard approved urethane marine foam for buoyancy. The Floating Breakwater is encapsulated in a nylon netting system for anchoring and coated with spray polyurea armoring. Plant holes are also pre-cut in order to grow vegetation hydroponically.

The power behind BFB is rather simple. Each BFB provides a strong medium which protects new plant roots allowing them to establish and grow. The surface area of the matrix, along with that of the plants, serves to shear wave energies, protecting the shore line. (Figure 1)

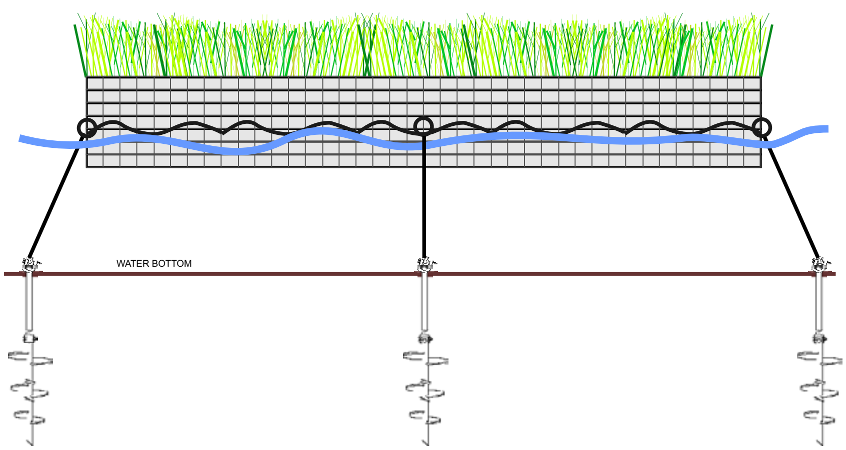


Figure 1

Martin Ecosystems has installed Floating Breakwaters in South Louisiana marshes and the BFBs have performed as anticipated resulting in significant plant growth, position maintenance, and visual reduction of wave and wind shearing (Photo 1).

Below, we identify the characteristics of the Floating Breakwater system that distinguish it from traditional shoreline protection measures. These elements not only make the BFBs unique but also provide the functionality of the product.

- Buoyant – The BFBs are designed as a floating system thus allowing them to accommodate anticipated and routine fluctuations in water levels, eliminate the risk of system settlement, and withstand wave forces.

- Lightweight – The BFBs are designed with semi-flexible material. They, therefore, result in smaller drafts, making the structure compatible with the shallow water present at the site.

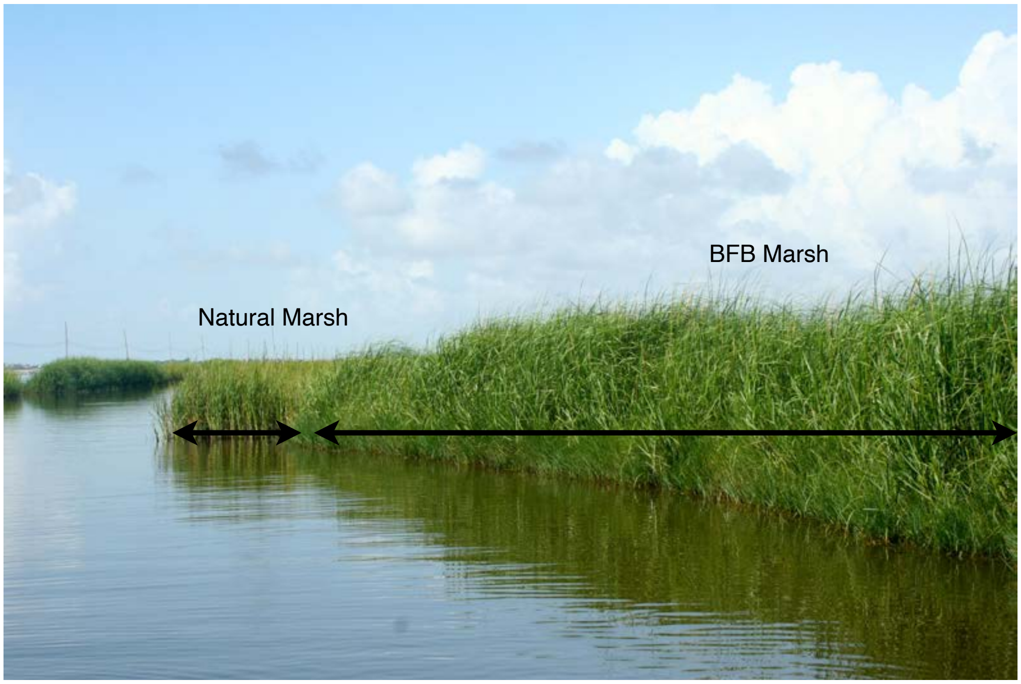
- Porous – The foundation of the BFBs is a porous matrix that allows transfer of water and organisms through the structure — a more natural flow than that created by a rigid, impermeable product.

- Self-Propagating – The underlying water column feeds vegetation that is originally planted and new seedlings are introduced to the BFB system through wildlife seed dispersal. As the vegetation and its root systems multiply, the surface area of the BFB system increases, providing increased wave and wind shearing capabilities. (Photo 2)

- Custom Designed Anchoring System – Martin Ecosystems has worked with a structural engineering firm to design an anchoring system that is uniquely suited for the conditions of coastal marshes.

Photo 1
Visual of BFB Wave Attenuation

Photo 2



In addition to the above mentioned unique characteristics of the Floating Breakwater, the BFBs have many other benefits. They create a riparian edge habitat that will sustain a variety of native vegetation and both water fowl and aquatic life. (PHOTO 3 & 4) The roots of the plant life expand the surface area of the BFB for microbial growth, thus also improving water quality. Finally, the BFBs are environmentally efficient, as they are made from recycled, non-toxic PET plastic.

Photo 3

Photo 4

Waterfowl and Blue Crabs have been found on, around, and under many of the BFBs at various project sites. They can't tell the difference-a testament to the BFBs ability to mimic natural marsh.

2.0 USES

Floating Breakwaters are an innovative tool for protecting and restoring wetlands and shorelines. It is a patented proven alternative to hard armor. They combine the look of natural vegetation with a recycled matrix to mechanically protect shoreline and wetlands from erosion. Floating Breakwaters are ideal in geographic regions where organic soils and/or sediments are too fine to withstand the weight of traditional heavy methods such as rock, concrete and/or rip rap. The floating nature of the BFB allows for an alternative choice. The strength and durability of the matrix material provides an ideal substrate for vegetative planting and establishment. This is in contrast to relying on earthen soils alone for planting where soils are not ideal. Joey Breaux, Coastal Advisor LA Association of Conservation Districts said, “BFBs are the thing to use in areas where stand-alone revegetation or earthen terraces won’t work due to extremely fluid, highly organic soils, as long as there’s firm substrate material to anchor into.”

The Water Institute of the Gulf endorsed the BFB in 2014 for shoreline protection and

Photo was taken 9 months after installation.
This photo depicts the tremendous ability of the BFB “marsh” to mimic natural marsh.
The BFB marsh is a brighter shade of green when compared to the natural marsh.

bank stabilization stating that it is “consistent with the goals and objectives of the 2012 Louisiana Coastal Master Plan. The innovation is relevant to the coastal program and the design, construction and performance measures illustrate that it is ready for implementation.”

3.0 SYSTEM PROPERTIES

Floating Breakwaters act as a floating wetland/floating island and function in the upper part of the water depth where much of the wave energy is concentrated. The structures effectively reduce wave height and energy in the lee of the structure by reflecting wave energy and dissipating kinetic wave energy of incoming waves. Energy losses result from breaking waves on the face of the structure and turbulent flow resulting from the interaction of the wave and the structure. BFBs offer some distinct advantages.

3.1 CONSTRUCTION

1. The Floating Breakwater is manufactured using 100% recycled polyethylene terephthalate, commonly referred to as PET plastic. The PET fibers are bonded together forming a non-toxic, non woven fibrous matrix. Matrix production processes consist of state-of-the-art computer controlled production lines emulating ISO 9000-2001 standards for quality management systems.

2. The matrix material has the advantage of having an open structure that is excellent for filtering, while also retaining a high tensile and tear strength. It is spray bonded with a special blend of self cross linking polymers which secure the product for greater water resistance and less breakdown. It will not biodegrade

and is nontoxic to fish. The matrix is water permeable, root friendly and ideal for vegetation. **Table 1** below lists the matrix material properties.

3. The matrix layers are adhered together using a marine foam which provides the buoyancy and flotation of the BFB. The Floating Breakwater has the buoyancy of 15 pounds per square foot. The urethane foam is a two (2) pound rigid foam formulated. It is a wholly water blown patented product formulated consisting of two parts, A Component (ASTM D 1638) and B Component (ASTM D 1638). **Table 1** below lists the foam material properties.

4. The Floating Breakwater is encapsulated on the top and all sides with a nylon netting system for anchoring. The number eighty-four (No. 84) nylon by four (4) inch square netting is double strand and provides secure anchoring points around the perimeter of the Floating Breakwater. A 3/8 inch twisted nylon border is sewn in and closed with a 1/2 inch twisted nylon rope. Stainless Steel Round Rings are added to the nylon border rope at design points for anchoring attachments. **Table 1** below lists the netting properties.

5. Spray polyurea coats the entire Floating Breakwater for strength and protection. The polyurea coating is perfect for marine environments because it is inert, it will not hydrolyze, leach or contaminate. It provides UV protection, contains no VOCs and is direct food contact approved. **Table 1** below lists the polyurea properties.

6. Plants are inserted into pre-drilled holes and grown hydroponically.

TABLE 1

Breakwater Property	Value
Thickness*	10 inches (5 Layers)
Weight (10” thick/18lb. buoyancy)	2 lb./ft2
Color	Brown
Plant Holes Size	3.5” diameter
Matrix Properties	**Value**
Matrix Tensile	40 lb./ in. (1 layer)
Matrix Tear	40 lb./ in. (1 layer)
Matrix Fiber Type	100% Recycled Polyethylene terephthalate (PET)
Matrix Binder System	Cross Linkable Water Based Latex
Binder Application	Spray/Thermal Bond

Foam Properties	Value
Foam Type	Two Part Polyurethane Marine Foam
Ecotoxicity	Not known to be toxic to aquatic organisms
Netting Properties	**Value**
Double Strand Nylon Netting	84 Nylon x 4in. square
Polyurea Properties	**Value**
VOC	0%
Tensile Strength (ASTM D638)	2000-2800 (lb/in)
Tear Strength (ASTM D624)	300-450 (lb/in)
Environmental	Food Contact Certified; will not leach
Ecotoxicity	Not known to be toxic to aquatic organisms;

3.2 DATA PERFORMANCE MEASURES

It was assumed that BFBs are most effective in short period (less than 3 second) and small wave height (less than 1 meter) wave environments or where vessel generated waves are common. Shorter period waves have most of their wave energy concentrated near the surface within the wave envelope. The wave environment at the previously mentioned Master Plan project sites meets these conditions. As a result, BFBs are an optimal solution for reducing wave energy.

The effectiveness of the BFB system is reflected in its transmission coefficient. The transmission coefficient is defined as the ration of the wave height of the transmitted wave in the lee of the structure to the incident wave height. Research has shown that transmission coefficients are a function of the ration of structure width to the wavelength, and if wavelength is greater than 0.45, then transmitted wave heights are reduced approximately 60%. Specific wave attenuation laboratory testing performed by Alden Labs of the matrix used to manufacture the BFBs indicate that wave heights may be reduced by 80% +/-4% for small amplitude waves (such as the 90% confidence waves anticipated at the project sites). Since BFBs include live plants (in effect, becoming a floating island), roots that penetrate the BFB and that are suspended in the water column will increase the effectiveness of the BFB over time. /-4%

For proposed Master Plan projects our design would involve installation of BFBs with 7.5' or 10' openings between each one depending on the width of the BFB. Small openings such as these do not produce significant wave energy in the lee of the structure if the gaps are limited to 50% of the wavelength. Our design allows for wave energy dissipation through diffraction and additional turbulence.

Recent research conducted by Bret Webb, Ph.D., PE at the University of South Alabama also confirms the above analysis and assumptions. The results demonstrated the following relationships:

- The transmission coefficient decreases as the ratio of breakwater width to wavelength (B/L) increases
- The transmission coefficient decreases as wave steepness increases
- The transmission coefficient is minimized when the water depth is 1.1 to 1.4 times larger than the deployment depth

The results of this research also suggest that BFB is most effective at attenuating short period waves, like wind chop. This was reinforced by the relationship to wave steepness, where short period waves are attenuated more effectively by the BFB. The results also suggest that the wave attenuating capabilities of the BFB are improved when the unit is slightly submerged.

Recommendations were to increase the prototype BFB size beyond 7.5 Ft. Martin Ecosystems has already begun to make this adjustment in quoting new projects. BFBs that are 10 feet in width are being discussed. This is one of the great advantages of the BFB. It is modular and can be manufactured in a variety of sizes and thicknesses to adjust for a variety of coastal conditions and environments. Deploying the BFB at Mean Tide Level (MTL) instead of Mean High Water (MHW) was the second recommendation in order to avoid increasing amounts of slack in the mooring system. Again, the BFB system allows for site specific design regarding deployment depths and anchoring. The final recommendation was to deploy the BFB in shallower waters to maximize wave attenuating capabilities. The shallow water deployment used in testing was 3.3 feet shown in the Figure 2 below. Research showed transmission coefficients were minimized when water depth was 1.1 to 1.4 times larger than the deployment depth. The effect of deployment depth on wave transmission was statistically significant at the 95% confidence interval. This would mean the ideal BFB (7.5'x20'x10") deployment depth is 3.3 feet in water depths of 3.6 feet to 4.6 feet. The BFB should be slightly submerged.

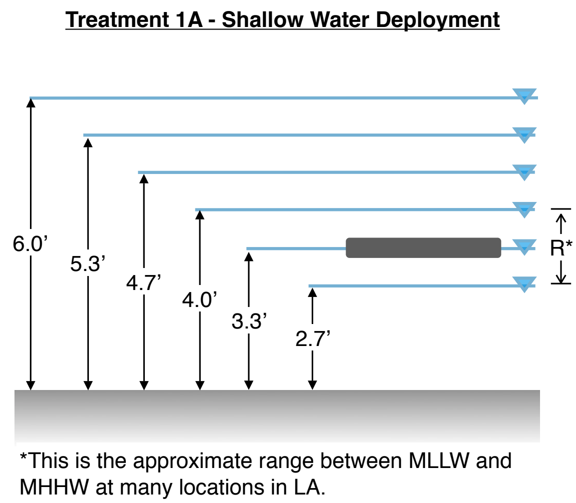


Figure 2

3.3 DURABILITY AND LONGEVITY

The design of the BFB system provides durability and longevity in the form of system strength, UV protection, wetting and drying tolerance, settlement tolerance, and resistance to wind and wave energy. In fact, the BFB has self-propagating characteristics that allow the BFB to continuously mature, quickly becoming an integrated feature of the shoreline. Consequently, the positive effect of the BFB system gradually radiates outward from the BFB reducing shoreline erosion and potentially reversing its effects.

- Strength -The BFB system design includes both matrix strength and anchoring strength. The strength of the Floating Breakwater is a result of the matrix material, netting and polyurea coating. Each layer of matrix material has a minimum tensile and tear strength of 20 pounds per inch, but it is the polyurea coating that provides the primary strength and durability. With a D Hardiness score of 50 and minimal loss due to abrasion, the polyurea creates a more sustainable product. The combination of these elements results in a semi-flexible, porous structure with significant strength to withstand wind and wave energies.

- UV Protection - Spray Polyurea provides UV protection with 50 mil coating in addition to the vegetation initially planted. The lateral spread of those plants over time add greater protection. The BFB vegetation will mature with every growing season and will soon cover the entire surface of the matrix shading it from the elements, including UV rays.

- Settlement – The unique floating feature of the BFB mitigates the risks associated with settlement or sinkage of the system.

3.4 VEGETATION

Floating Breakwaters provide hydroponic growth for native salt and fresh water vegetation. Plant roots grow through the matrix into the water column where they are provided a continuous source of nutrients for growth. Pre-drilled plant holes make planting the BFB timely and easy. (Photos 5-8)

Photos 5-8 demonstrate the BFBs ease in planting, as well as, their extraordinary ability to promote root growth, lateral spread, and plant growth.

3.5 ANCHORING AND INSTALLATION

Because BFBs float, anchoring is necessary to hold them in place. Each BFB is anchored in place using an engineered netting design. The entire Floating Breakwater is encapsulated with #84 twisted nylon x 4" square mesh net. The net has a break strength of 720 pounds per strand. Six stainless steel round rings are woven into the netting where they function as anchor points. Each round ring has a break strength of 18,000 pounds. The elongated BFBs require anchors attached along the length of the windward and leeward side of the BFB. The BFB is anchored in place using a 7' galvanized forget steel multi-helix scores anchor with an 8"-10"-12" flight.

As recommended, a 5' extension is used to penetrate Class 5 or 6 soils after going through the peat and organic silts of Class 7 and 8 soils. The holding capacity is as follows.

	Class 5 Holding (lb.)	Class 6 Holding (lb.)	Class 7 Holding (lb.)
8"-10"-12" anchor	39,000	32,000	26,000

Each stainless steel round ring is connected to the helical anchor using a 1/2 inch twisted nylon rope with a break strength of 6400 pounds.

Since our anchoring system accommodates for tidal variations and wave activity the result will be an extremely secure BFB system that displays some movement but does not pose a risk of breaking free. The movement associated with the BFBs provides a dynamic barrier between land and open water that buffers against wave erosion. As plants mature on the islands, with roots growing progressively deeper into the water column, the barrier provided by the islands becomes increasingly effective and the capacity to protect the shoreline continues to improve.

In addition to the above mentioned advantages, the BFBs have many other benefits. The fact that it is light weight makes it easy to install using limited heavy equipment and leaving minimal damage to existing marsh. Its modular design makes site specific design more efficient, timely, and cost-effective. Due to the floating nature, installation around pipelines is easier to accomplish.

4.0 ENVIRONMENTAL SAFETY

The matrix is manufactured with 100% recycled Polyethylene terephthalate (PET) plastic drinking bottles. Water Based Latex Resins are used in the matrix manufacturing process. No phenol-formaldehyde resins are used in the binding process. The matrix has been tested and was found to be non-toxic to aquatic life.

The polyester matrix fibers (PET) are non-reactive and resistant to attack by micro-organisms. PET is inert, won't biologically degrade and will not leach. PET is also inherently more UV resistant than other plastics, like polypropylene, because of its molecular structure.

The polyurea coating is perfect for marine environments because it is inert, it will not hydrolyze, leach or contaminate. It provides UV protection, contains no VOCs and is direct food contact approved.

5.0 IMPLEMENTED PROJECTS

CCA Louisiana-Isle de Jean Charles-Point au Chene, LA
Installed-September 2011 & April 2013
Water Depth-1' to 3'
(Shoreline Protection/Marsh Creation)

Shell Pipeline-Blue Hammock Bayou-Terrebonne Parish, LA
Installed-December 2012
Water Depth-3' to 7'
(Shoreline Protection/Marsh Creation)

LA Dept. of Ag-Soil & Water-Lake Hackberry and Bayou Decade, Terrebonne Parish, Madison Lands, Lafitte, LA, and Belle Isle, Franklin, LA
Installed-November & December 2011
Water Depth-1' to 3'
(Shoreline Protection/Marsh Creation)

LA Dept. of Ag-Soil & Water-Bayou Bienvenue, St. Bernard Parish, LA
Installed-March 2013
Water Depth-3' to 4'
(Shoreline Protection/Marsh Creation)

CCA Louisiana-LA Highway 1-Fourchon, LA
Installed - April 2015
Water Depth 3 1/2 '
(Shoreline Protection/Marsh Creation)

4.1 Isle de Jean Charles

The Isle de Jean Charles, Phase I project, installed in September of 2011, was a community project to protect the Isle de Jean Charles Road from further erosion. Today the BFB vegetation is thriving, the BFBs are demonstrating their effectiveness at breaking daily wave action, and they have created new habitats for birds, waterfowl and aquatic life. In addition, the BFBs passed a crucial test in 2012 by surviving Hurricane Isaac's 90 mph winds for over 24 hours and 5' storm surge. In April of 2013, phase II of this project was installed strategically placing the BFBs to protect approximately 70 acres of fragile marsh. Martin Ecosystems manufactured and installed both phases of this project in its entirety. In addition Martin Ecosystems educated volunteers with planting the vegetation. (Photos 9-11)

Photo 9

Photo 10

Photo 11

Photo 9 was taken at installation in September 2011.
Photo 10 was taken in September 2012, 3 days after Hurricane Issac made landfall.
Photo 11 was taken in 2016.

4.2 Blue Hammock Bayou

Martin Ecosystems and Shell Pipeline - GOM Installed 240 linear feet of Floating Breakwaters(BFB) in the pipeline just off of Blue Hammock Bayou on December 12, 2012. (Latitude 29◦18’17.58”N, Longitude 91◦2’17.16”W) Below are aerial photos (Photo 12) of the pipeline which show the islands installed across the canal in 3 different locations. Martin Ecosystems manufactured the project in its entirety.

Photo 12
BioHaven® Floating Breakwaters installed in pipeline canal to reduce further widening/ erosion

4.3 Lake Hackberry

In October 2011, the BFBs were installed in Lake Hackberry in water depths of 2’ to protect the levee of a private landowner that has repeatedly eroded away within a year of repair. Today the levee remains intact and the landowner gives full credit to the BFBs.

Photo 13
Floating Breakwaters protecting a levee from eroding away and exposing acres of marsh to erosion

4.4 Madison Lands

In Lafitte, at Madison Lands, BFBs were installed in December 2011 to protect a terracing project that had already lost the sacrificial terrace and was on the verge of losing more. The BFBs also survived Hurricane Isaac and as of February 2013, the vegetation has grown completely though the BFB and is rooted into the water bottom.

4.5 Bayou Bienvenue

Bayou Bienvenue is a remnant of a once great Mississippi River Delta Swamp. As recently as the 1960s, a freshwater cypress swamp extended from New Orleans eastward to Lake Borgne. More than a century of levee and canal construction converted this swamp into an open-water brackish marsh, with only cypress “ghosts”. The saltwater killed trees, eroded land, and destroyed tens of thousands of acres of wetlands that buffered local communities.

This project is intended to protect a small section of wetlands that are being eroded away. The small area of wetlands are the last line of defense to an even greater area of marsh. If the small area of marsh that we are trying to protect erodes away, wetlands behind it will become extremely vulnerable.

4.6 CCA Louisiana LA-1 Project

Installed in April of 2015, this was the first open water unprotected environment for Floating Breakwaters to be deployed. A total of 30 floating breakwaters (25’L x 7.5’W x 14 inch D) were installed.

In the winter of 2015, a cold front caused the anchor bushing to loosen due to constant pulling from waves. Some islands also split down the center due to plant hole pattern. A new anchoring design was engineered to repair the project and strengthen the anchoring using a netting system with six mooring lines. A total of 22 Floating Breakwaters were recovered and re-anchored using the new netting anchoring system. The new anchoring system was engineered to support a wave load of 40 pounds/ft2. This equates to supporting a load of 1044 pounds per mooring line. The re-designed Floating Breakwaters weathered a December 2016 cold front without any difficulty.

Photo 14

Photo 15 was taken at installation. Photo 16 was taken 8 months later. Vegetation again proves that the BFB is an effective medium for marsh vegetation to grow, spread, and thrive.

Photo 17
Mature BFBs form a protective “chain” in front of fragile marsh in Bayou Bienvenue

6.0 REFERENCES

Alden Labs Report, 2008. Hydraulic Testing Report.

Webb, B., 2014. Wave Transmission of the Martin Ecosystems Floating Breakwater.


Lake Laurier
Ferblanc, Bayou
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