



Vegetated EcoShield™ White Paper



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Innovation Summary

Erosion of shorelines, embankments and levee systems, either through natural effects or caused by human activities, is a serious problem for many areas around the world. Many attempts have been made over the years to prevent or control such erosion, resulting in the development of various devices and methods which attenuate wave action and reinforce the shoreline using bulkheads, concrete structures, mats, and similar means.

Natural occurrences such as waves, hurricanes, and floods may destroy ecosystems, as well as wave action attributable to boat traffic and other vehicles. 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 aquatic and wildlife species. In many areas, time is usually the only requirement for such recovery. However, the conditions, both naturally occurring and man-made, that are impacting shorelines and banks do not allow for this spontaneous recovery. To meet the challenges posed by the constant high-energy environment and human impact, intentional effort must be directed toward environmental restoration.

While such efforts have been successful to some degree, a primary goal in many areas is reformation and restoration of the shoreline to include native vegetation. In those instances, the objective is to reinforce the areas subject to erosion with plants which are typically native to the region. Consequently, an organic ecosystem can eventually be established that is resistant to erosive forces, but using means which do not detract from the natural beauty of the shoreline. These methods are sometimes referred to as "living shorelines", and they provide additional ecological habitat for aqueous as well as terrestrial biology. Living shorelines refers to management practices that use strategic placement of plants, stone, sand fill and other structural organic materials, such as oyster reefs, to provide shoreline stabilization and protection of marsh vegetation and habitat viability. Living shorelines may be used in appropriate areas as alternatives to bulkheads, rip-rap and other hard structures.

Because shoreline topography and conditions are so diverse, living shorelines must often be custom-designed for each location to be successful. According to most researchers, site-specific living shorelines must employ principles from each of the fields of ecology, geology, oceanography and engineering to develop effective projects.

To meet these needs, EcoShield™ provides one of the most environmentally efficient and systematic efforts to harness the natural processes of the coastal ecosystem. EcoShield™ protects the existing shoreline, while promoting plant growth and establishing a riparian edge for aquatic and wildlife habitat.

1.0 INNOVATION DESIGN

In 2014, the idea and design of EcoShield™ as a shoreline stabilization system and method was researched and developed by Martin Ecosystems. This paper will present technical information on the EcoShield™.

Vegetated EcoShield™ (Figure 1) is a patented, green infrastructure product that protects existing shorelines and stabilizes banks, while promoting vegetative growth and ultimately creating a “living shoreline”. Designed as a protective medium for vegetation to establish, grow, and spread, EcoShield™ compliments flood protection by reducing wave energies and extending the life of shorelines, levee systems, berms, and terraces. It is ideal for shoring up the embankments of waterways like the Gulf Intracoastal Waterway (GIWW) where banks have been compromised and saltwater intrusion threatens freshwater marshes. It also enhances the natural processes of the system by creating vegetative shorelines and creating coastal habitats for waterfowl, wildlife, and aquatic life.

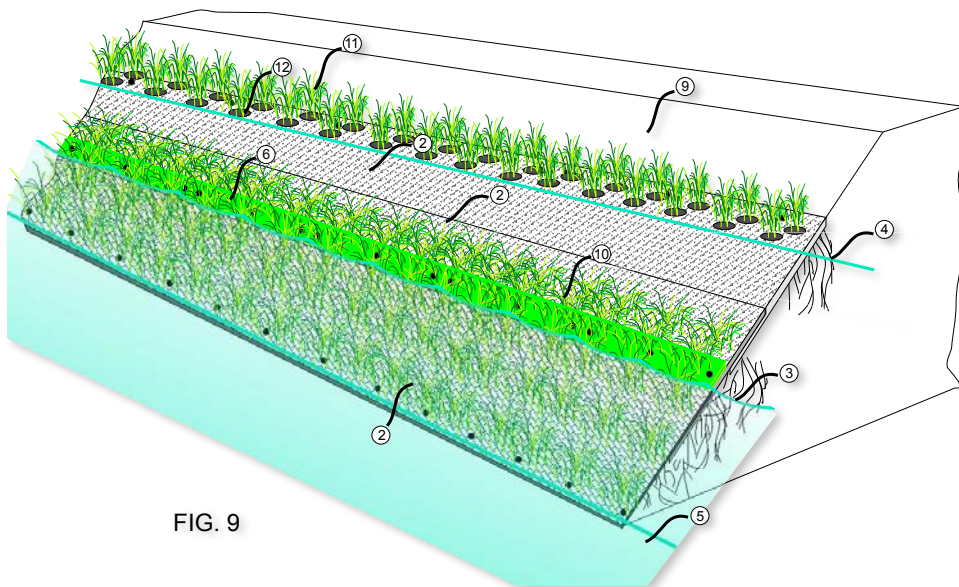


FIG. 9

EcoShield™ is assembled using layers of durable matrix that is made of non-toxic, recycled PET plastic. The matrix layers are anchored in place using rebar rods and wire coated mesh. Pre-planted matrix strips are also anchored near mean high water (MHW). Native grasses are planted in the top most matrix later to complete the ecosystem. The matrix 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.

Martin Ecosystems has installed EcoShield™ in South Louisiana along berms, levees, and a major waterway. It has performed as anticipated resulting in significant plant growth, position maintenance, wave attenuation and erosion reduction. (Photo 1)

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



- Semi-Flexible and Lightweight – EcoShield™ is designed with semi-flexible material. Therefore making it easy to install without the need for heavy equipment.
- Self-Propagating – The self-propagating nature of the EcoShield™ results from the fact that it functions as a complete ecosystem. The tidal water/waves feed the vegetation that is originally planted and new seedlings are introduced to the EcoShield™ through wildlife seed dispersal. As the vegetation and its root systems multiply, the surface area of the EcoShield™ increases, providing increased wave and wind shearing capabilities.
- Porous – The foundation of the EcoShield™ is a porous matrix that allows some transfer of water and organisms through the structure – a more natural flow than that created by a rigid, impermeable product.

- Custom Designed Anchoring System – Martin Ecosystems has worked to design an anchoring system that is uniquely suited for the conditions of coastal marshes.
- Potential to Restore the Shore Line – EcoShield™ will certainly reduce the extent and speed of shore line erosion. Previous applications suggest that EcoShield™ has the potential to reduce such destruction and/or to restore the shore line.

In addition to the above mentioned unique characteristics of the EcoShield™, it has many other benefits. First, EcoShield™ creates a riparian edge habitat that will sustain a variety of native vegetation and both water fowl and aquatic life. The matrix and plant roots expand the surface area of the EcoShield™ for microbial growth, thus also improving water quality. **EcoShield™ can be installed in multiple layers dependent on the slope of the project location.** The positioning of the EcoShield™ can be easily adjusted for debris and tidal activity. Finally, EcoShield™ is environmentally efficient, as it is made from recycled, non-toxic PET plastic.

2.0 USES

EcoShield™ is designed to reduce wave energies and extend the life of levee systems, berms, and terraces. It is ideal for shoring up embankments such as those of the Gulf Intracoastal Waterway (GIWW) where banks have been compromised and saltwater intrusion threatens freshwater marshes. EcoShield™ can be used where dirt is being used to create ridges and levees are being constructed. It can be manufactured in a variety of sizes suitable for a variety of shorelines and slopes. Vegetation planted can be of any type-freshwater or saltwater. This allows the project to be designed for the specific slope and location optimizing for greater success.

Levees and terraces make up a large portion of coastal restoration and protection projects, accounting for a sizable share of financial resources. They are some of our best lines of defense, yet they are not without problems. Scouring and erosive waves do take their toll. EcoShield™ should be designed into the initial construction project, in order to provide protection from erosion, allowing it to extend the life of the project while also reducing maintenance costs.

3.0 SYSTEM FUNCTIONS

3.1 CONSTRUCTION

EcoShield™ is made up of three components. The first component is a **Base Matrix Layer** of non-woven recycled Polyethylene terephthalate (PET) plastic. Each layer is 7.5'W x 90'L x 2" thick. The primary source of the matrix material is recycled water and soda bottles. No phenol-formaldehyde resins are used in the binding process. The tear strength is 2880 pounds/ square foot. Depending on the slope of the levee, berm or embankment, the matrix is secured onto the shoreline, levee base, or along a terrace, at the water's edge. This provides immediate protection from scouring and erosion. (Photo 2)

The second component of the Vegetated EcoShield™ is the **Pre-vegetated Matrix strip**. The same non-woven material is sent to a local coastal nursery where it is planted with a native grass and ground cover. Each strip is thirty (30") wide by fifteen (15') feet long. Martin Ecosystems recommends using Smooth Cord Grass and Seashore Paspalum in saltwater applications. Please note that other species of vegetation are acceptable. The pre-grown vegetation requires approximately 45 days to become established and ready for installation. The matrix strips are pre-grown off site and loaded onto a truck bed for transport to the installation site. Rebar rods along with coated wire mesh is used to secure the vegetated matrix strips in place. They are installed at the mean high water (MHW). (Photo 3)

The third component is the planting of three rows of **Native Grass** into layer 1 of matrix. (Photo 3)



Photo 2
Base layers installed



Photo 3
Pre-planted matrix strips and native grass

3.2 DATA PERFORMANCE MEASURES

Preliminary wave tank experiments performed by Chunyan Li, Ph.D., at Louisiana State University shows the effectiveness of the EcoShield™ is reflected in its ability to:

1. Reduce wave heights
2. Absorb wave energy reducing the breaking waves' impact for re-suspension
3. Provide cover protecting the water bottom from pounding waves
4. Reduce wave run up heights
5. Protect land beneath

The wave tank experiment showed wave reductions based on sensor measuring in front of EcoShield™ protected area compared to an unprotected area. The First Sensor (RED) depicts the wave measured on the side with EcoShield™ protection, while the Second Sensor (BLUE) was the bare side. The wave reduction is quite obvious because the EcoShield™ absorbed the incoming wave energy and the reflected wave was reduced causing the total wave height to be lower. This shows that EcoShield™ is definitely better than doing nothing. (Figure 2)

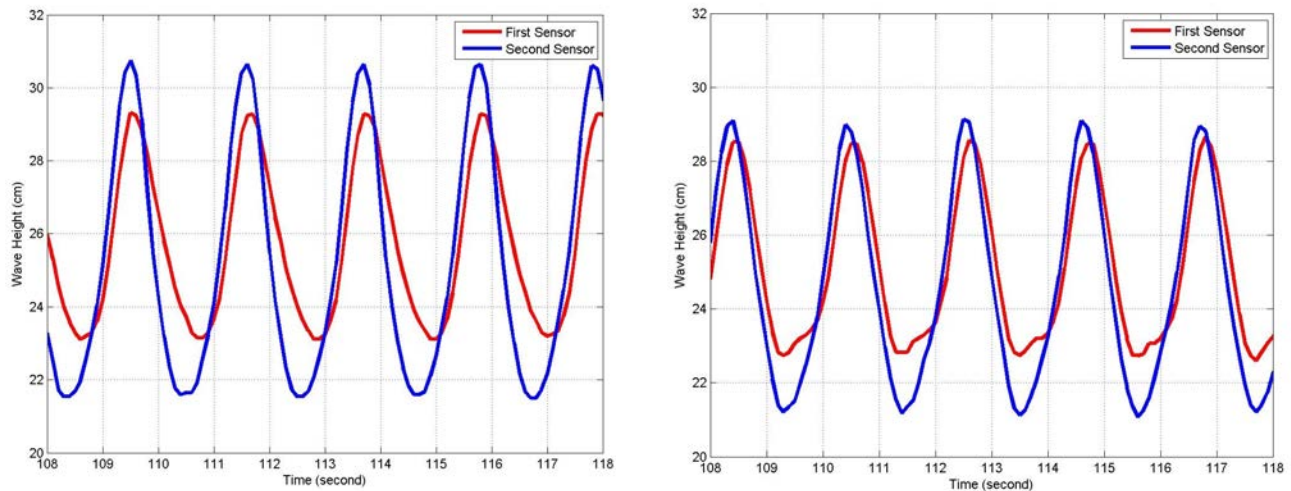


Figure 2
Wave reduction graphs

Below are a couple of Laser scans from the wave tank experiment. The image on the left is the original shape of the simulated beach or the control. The image on the right is the final shape after thirty (30) minutes of wave action. In this image EcoShield™ covered the left side facing the “beach” and the right side had no protection. This side is visibly eroded. (Figure 3)

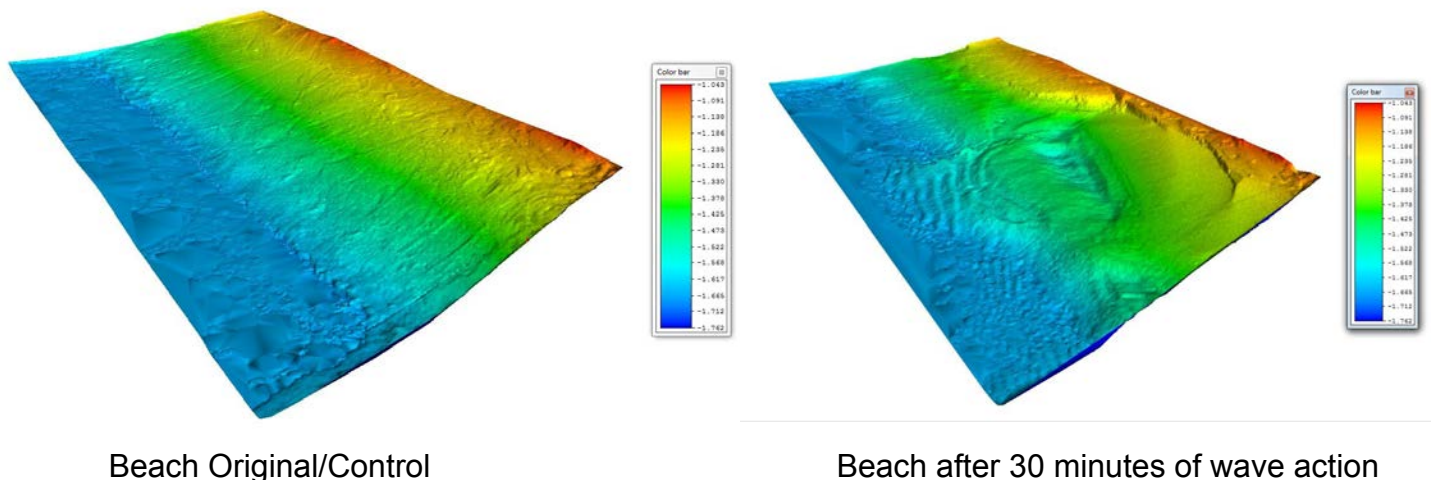


Figure 3
Laser scans -Control & After Wave Action

The combination of these preliminary results with the real world implemented projects have proven that the EcoShield™ product will prevent erosion. The project in Buras is a great example. Initially Martin Ecosystems installed only 660' of EcoShield™. The remaining 4020' of berm was unprotected. Due to heavy erosion of the unprotected berms, Plaquemine Parish requested that we install EcoShield™ on the remaining 4020' of eroding berm.

3.3. DURABILITY AND LONGEVITY

The design of the EcoShield™ provides durability and sustainability in the form of system strength, UV protection, settlement tolerance and resistance to wind and wave energy.

- **Durability-** The matrix material used in manufacturing EcoShield™ is made from polyester fibers from recycled PET plastic bottles. The polyester fibers have a high melting point of 260°C making it ideal for environments where heat resistance is desired. It also has good insulating properties for cold conditions.
- **Strength -** The EcoShield™ design includes both matrix strength and anchoring strength. The strength of the matrix results from the matrix material. Each layer of matrix material alone has a minimum tensile strength of 20 lbs. per inch. The anchoring is designed to hold the base layers and pre-planted matrix strips in place. The combination of these elements results in a semi-flexible, porous structure with significant strength to withstand wind and wave energies.
- **UV Protection -** The vegetation initially planted provides UV protection as well as, the lateral spread of those plants over time. The EcoShield™ 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 lightweight nature of the EcoShield™ material mitigates the risks associated with settlement of the system.
- **Resistance to Wind and Wave Energy -** The matrix material has shown to reduce wave heights, absorb wave energies, provide cover of the water bottom from pounding waves and reduce wave run up heights.

3.4 VEGETATION

Designed to create a natural vegetative buffer for minimizing erosive waves, the EcoShield™ product strengthens the success of newly planted vegetation by providing a protective medium. Pre-planted matrix strips (30" W x 15'L) are installed flush with the top matrix base layer typically just above Mean High Water (MHW). This location is project dependent. The pre-planted matrix strips also allow for success because they are pre-grown for a minimum of 45 days in ideal nursery conditions. This time allows the plants more time to establish, grow, and thrive transferring into greater project/planting success. Photos 4-8 show how the pre-vegetated matrix strips are planted and

delivered to the project site. As vegetation grows, spreads, and multiplies, the surface area increases, providing increased wave and wind shearing capabilities. This improves the outcomes of vegetation and vegetation plantings, as well as saves time by not having to replant again. The challenge of replanting has been noted using traditional vegetation methods, costing time and money.

Photos 4-8
Pre-vegetated Matrix Strips
Planted, Rolled, Loaded, Delivered, Installed



3.5 ANCHORING AND INSTALLATION

EcoShield™ is anchored in place using a combination of No. 3 rebar anchor staples and marine coated wire mesh. The coated mesh allows for vegetation to grow through while providing holding capacity. (Figure 4)

Finally, three rows of native grasses are planted into the top matrix layers to provide for additional vegetation and root anchoring. It is assumed that following a year of vegetative growth the EcoShield™ will have a significant amount of vegetative cover from the top most layer down the slope and into the water. (Figure 5 below)

Considerations for installation include the slope, soil settling or compaction, mean high tide, and energy environment. The ideal slope for the EcoShield™ product is a 1 on 5 slope. An adjustment of 25% for compaction may be required as settling of newly constructed levees or berms does occur over the initial 6 months. Placement of the pre-vegetated strip is important in order for the vegetation to survive. The placement should be mean high water. The Coastwide Reference Monitoring System (CRMS) can be used to assist with determining the appropriate location for each project. Finally consideration of energy environment is important. Four (4) layer EcoShield™ should be installed in high energy locations because it provides for additional erosion protection.

Figure 4
Anchoring components

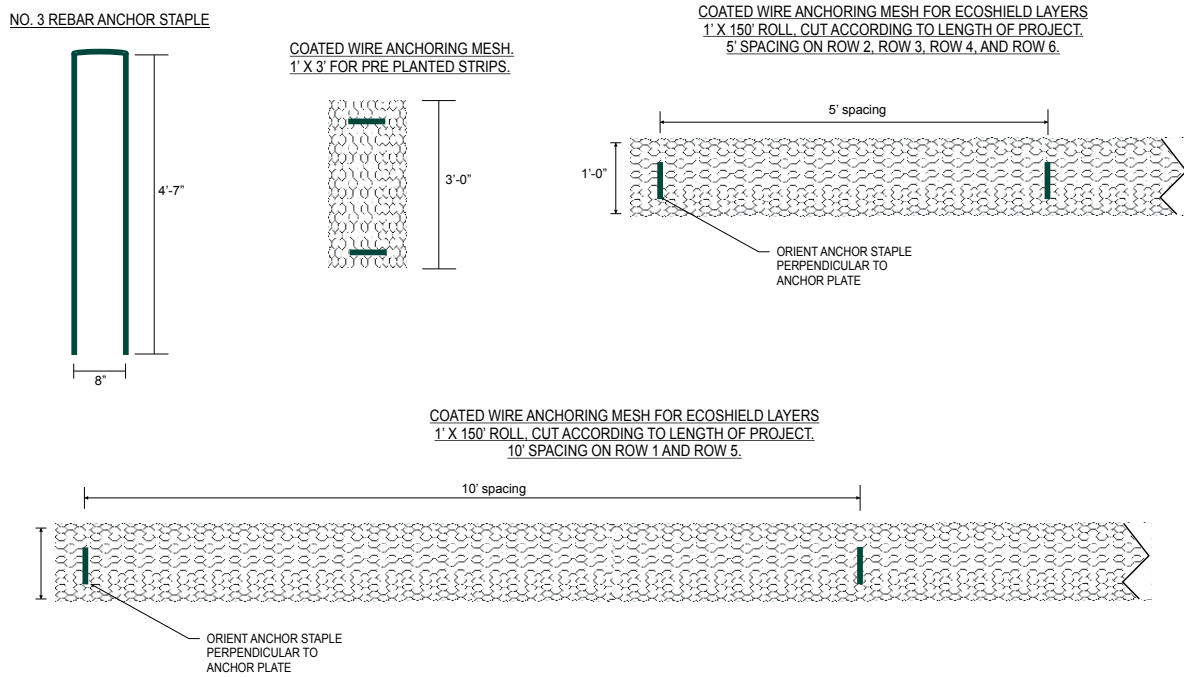
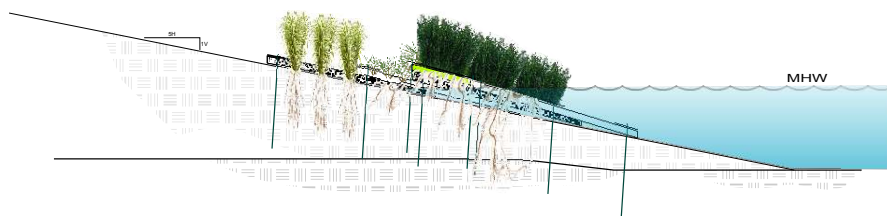


Figure 5
EcoShield after 1 year



EcoShield™ is porous and lightweight allowing for ease of timely installation. Heavy equipment is rarely required which also minimizes the installation footprint on existing critical areas. Very little maintenance is required as the self-propagating nature results in new seedlings being dispersed.

4.0 IMPLEMENTED PROJECTS

4.1 BURAS BOAT HARBOR

Finally, in 2014 Martin Ecosystems installed 4600' of EcoShield™ in Buras, LA for the Buras Boat Harbor Shoreline protection project. It should be noted that this environment was challenging as the EcoShield™ was installed with exposure to a large body of open water. (Photo 9) The project included the construction of new earthen berms and the protection of those berms. Initially, 600' of EcoShield™ was installed as a demonstration in order to determine if the EcoShield could protect the berm from daily erosive waves. Prior to the completion of the 600' installation, it was determined that the remaining exposed berm must be protected with EcoShield™ as well due to the quickness of the berm's erosion. Another 4000' of EcoShield™ was installed in order to protect both berms in their entirety. (Photos 10 & 11) Six months after installation, the EcoShield™ remains in place with healthy vegetation. (Photos 12-16) Plaquemine parish officials are pleased with the project to date and are excited about the potential

outcomes. The borrow material used to create the berms was not of great quality, yet the EcoShield™ is effectively protecting the shoreline of the berms. Daniel Duhon, the project engineer has said, "Due to the nature of the borrow material, I think the EcoShield™ served an important role in hardening the unstable material as it hardens and consolidates. If nothing was done to stabilize the new berm there was the potential to lose a significant portion of the seaward face of the berm due to wind and wave action." Martin Ecosystems has contracted Professor Chunyan Li of LSU School of the Coast & Environment to conduct an 18 month study of the effectiveness of this project.

Photo 9

Buras Boat Harbor Shoreline Protection Project
Ariel view of entire project including both berms protected



Photo 10 & 11
Buras Boat Harbor Shoreline Protection Project
Installation of EcoShield™ July 2014



Photo 12-14
Buras Boat Harbor Shoreline Protection Project
Ariel Photos taken 6 months after installation in 12/2014, at 2 years
and at 3 years



Photo 15 &16

Buras Boat Harbor Shoreline Protection Project
Ariel Photos of vegetative growth taken 6 months after installation
in 12/2014 and at 3 years.



4.2 DELTA FARMS GULF INTRACOASTAL WATERWAY

The America's WETLAND Foundation (AWF) brought together public and private partners to create the Gulf Intracoastal Waterway (GIWW) Shoreline Stabilization and Restoration Project in Lafourche Parish, LA. America's WETLAND Foundation contracted Martin Ecosystems to install 1 mile of EcoShield™ to protect the levee

Photo 17

EcoShield™ levee protection

where the embankment has been eroded. Since the installation of EcoShield™ in November of 2015, the landowner has not had to perform annual lifting or rebuilding of the levee as he has had to do previously. The levee remains in tact where EcoShield™ was installed.



4.3 BAYOU MONNAIE TERRACING PROTECTION

Earthen terraces were constructed by Ducks Unlimited to decrease fetch and turbidity while also lessening erosion, creating marsh habitat, increasing submerged aquatic vegetation (SAV) productivity, and restoring water quality.

Photo 18

EcoShield™ Terrace Protection



Earthen terraces are susceptible to erosion which is why Ducks Unlimited contracted Martin Ecosystems to install EcoShield™ along the sacrificial terraces to protect them. EcoShield™ was installed along the newly created terraces to determine what amount of protection they would provide to the earthen terraces compared to no protection.

Photo 19-22

EcoShield™



5.0 SIMILAR STRATEGIES

The beauty of EcoShield™ is that it is more cost-effective than traditional and even new strategies because it provides the structural support to protect from erosion, yet it is simplistic enough in its design and installation to install quickly and with little to no heavy equipment. In addition we can install it as the contractor shapes the levee or berm. This provides immediate protection from erosion and eliminates the need for the contractor to have to go back to continuously reshape the levee or berm.

Martin Ecosystems can install one thousand (1000') feet of EcoShield™ per day with an nine (9) man crew. At times the contractor may not be able to shape the toe of the berm or levee at the same pace that we install, but adjustments can be made for that.

The final strategy worth mentioning is comparing EcoShield™ to the cost of doing nothing. Many restoration and protection projects allow for the design and build of levees, ridges and banks, but they don't allow for the protection of these projects. We are spending millions of dollars building infrastructure, yet we are not protecting our investment. This scenario played out on our Buras project. The berms were designed to be built but not protected. After one weekend of thunderstorms and bad weather, the newly constructed berms were eroded back in some spots by five (5') to six (6') feet. This was when Plaquemine Parish asked us to install the additional 4000' of EcoShield™, thus protecting the entire front side of the berms. The cost of doing nothing on this project would have resulted in a quickly eroded berm.