The Pelican Cove Community Climate Change Adaptation Plan

Southwest Florida Regional Planning Council

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<u>SWFRPC and climate change planning</u>

The **Charlotte Harbor National Estuary Program** (CHNEP, www.chnep.org) and the **Southwest Florida Regional Planning Council** (SWFRPC, www.swfrpc.org) have completed significant fundamental work to address sea level rise and other climate change issues to date (Beever 2009 in Fletcher 2009).

In the late 1980’s the SWFRPC completed hurricane storm surge modeling and maps that have been used by the region and local governments to guide land use decisions, infrastructure investments, and conservation lands acquisition. This early work and resulting decisions have increased resiliency associated with sea level rise.

In 2003 the SWFRPC collaborated with local scientists and EPA’s Office of Atmospheric Programs, Climate Change Division, on the “Land Use Impacts and Solutions to Sea Level Rise in Southwest Florida” project. The project resulted in sea level rise projections by probability and year, along with maps that represent the near worst case scenario. Public participation was actively sought throughout the project; the progress and outputs of the project will be communicated to local governments, stakeholder groups and the public at large for use in developing coastal and land use planning, and avoidance, minimization, mitigation and adaptation of climate change impacts throughout the CHNEP study area.

Throughout 2008 the SWFRPC and CHNEP prepared a Regional Vulnerability Assessment for the counties shared by the two agencies. A database with climate effects and adaptation options forms the core of the assessment. The work was funded by EPA Region 4. As one of 6 Climate-Ready Estuary pilot programs, CHNEP and SWFRPC are partnering with the City of Punta Gorda to develop a city-specific Adaptation Plan, which will implement recently adopted city comprehensive plan policies related to climate change.

Information and technical assistance are provided from the Pelican Cove Condominium Association, the South Florida Water Management District, the Charlotte Harbor National Estuary Program, and the Intergovernmental Panel on *Climate Change* (IPCC 2013).

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Executive Summary

Pelican Cove and Southwest Florida are currently experiencing climate change. The natural estuarine peninsula setting of Pelican Cove coupled with extensive investment close to the coast have placed the community at the forefront of geographic areas that are among the first to suffer the negative effects of a changing climate. More severe tropical storms and hurricanes with increased wind speeds and storm surges have already severely damaged both coastal and interior communities of southwest Florida. Significant losses of mature mangrove forest, water quality degradation, and barrier island geomorphic changes have already occurred. Longer, more severe dry season droughts coupled with shorter duration wet seasons consisting of higher volume precipitation have generated a pattern of drought and flood impacting both natural and man-made ecosystems. Even in the most probable, lowest impact future climate change scenario predictions, the future for southwest Florida and Sarasota County will include increased climate instability; wetter wet seasons; drier dry seasons; more extreme hot and cold events; increased coastal erosion; continuous sea level rise; shifts in fauna and flora with reductions in temperate species and expansions of tropical invasive exotics; increasing occurrence of tropical diseases in plants, wildlife and humans; destabilization of aquatic food webs including increased harmful algae blooms; increasing strains upon and costs in infrastructure; and increased uncertainty concerning variable risk assessment with uncertain actuarial futures. Maintaining the status quo in the management of coastal and estuarine ecosystems in the face of such likely changes would result in substantial losses of ecosystem services and economic values as climate change progresses.

This adaptation plan provides alternative adaptation activities and projects that can addresses the potential effects of climate change within the Pelican Cove Community and the identified specific vulnerabilities relating to of 1) the shoreline and water quality to potential sea level rise and other coastal storm risks and how these risks may negatively impact the environment in the Little Sarasota Bay Watershed and the water quality in Clower Creek and Little Sarasota Bay; 2) from flooding and runoff caused by potential sea level rise and increased rain fall and storm activities including how these risks may negatively impact the environment in the Little Sarasota Bay Watershed and the water quality in Clower Creek and Little Sarasota Bay, as well as structures, grounds, and infrastructure at Pelican Cove; and 3) to the structures, grounds, and infrastructure from trees that are most susceptible to wet soils and high winds.

This report identifies the alternative adaptations that could be undertaken to address the identified climate change vulnerabilities for Pelican Cove community. These adaptations are presented without a prioritized order since the community will decide what adaptations it will choose to implement. Only the practical and positively received adaptations in each vulnerability area are fully developed for potential implementation. One of the utilities of this approach is that it provides a variety of adaptation options, which the community could select for implementation, adaptive management, and subsequent monitoring.

The Pelican Cove community has already undertaken a variety of affirmation adaptation actions that will assist in reducing the impacts from climate change and increasing resiliency to climate change effects. These include retaining a native vegetation relatively natural mangrove fringe shoreline, improvements of drainage systems in some areas, and removal and replacement of some potentially harmful invasive exotic trees.

After examination of the identified climate change vulnerabilities in the assigned areas of sea level, rise, flooding, water quality, and vegetation, coordination with the residents', committees, and staff of Pelican Cove, we have jointly identified 24 potential adaptation actions in 4 general categories of sea level rise, water quality improvement, flooding, erosion and run-off, and trees and vegetation improvement. These are listed in the report below.

The recommended adaptation options under consideration include options for sea level rise, options for water quality improvement, options for flooding and run-off from climate change, options for erosion, options for vulnerabilities to structures, grounds, and infrastructure, and options for plant s and tree species that can reduce negative impacts on the water quality in Clower Creek and Little Sarasota Bay based on their need for fertilizer, pesticide and irrigation.

The recommended options for sea level rise include a living shorelines composed of nine zones, sediment supplementation, dune/berm s parallel to the shoreline, within the Marina Harbor redesign (elevating docks, walkways, and decks, and/or floating docks) and increased ground floor elevations when rebuilding.

The recommended options for water quality improvement include sediment dredging (either spot dredging or removal of all anoxic silt, floating Islands, filter feeders structures (reef balls or similar structures, oyster strings, and cam bags),and pretreatment for drains.

The recommended options flooding and runoff from climate change include additional drainage swales with dunes, removal of silt from Clower Creek, removal of vegetation blocks from Clower Creek, and improved evacuation coordination

The recommended options to address erosion include improved run-off capture, removal of exotic plants on slopes and replacement with GeoWeb and native plant species, and improved vegetated swales.

The recommended options to address vulnerabilities to structures, grounds, and infrastructure from trees include removal of trees with low wind resistance and the utilization of native trees with high wind resistance in future tree replacements. The options examined to reduce negative impacts on the water quality in Clower Creek and Little Sarasota Bay by different plant species needs for fertilizer, pesticide and irrigation include favoring native vegetation species over exotics, selecting plants of coastal oak hammock uplands and flanking estuarine and creek transition zones; introduce some native tropical hardwood hammock specie; stabilizing exposed and eroding shore and backshore areas with marsh grasses and herbaceous marsh species in Zonal Shoreline Plantings; some changes in mangrove trimming, and some improvement in fertilizer management.

Introduction

The climate is changing. It has been changing since the formation of the atmosphere and the presence of water as vapor, liquid, and ice on the surface of the earth. Since the Pliocene and throughout the Pleistocene and Holocene (Current) Eras, global temperatures have risen and fallen with concomitant changes in air temperature and chemistry, hydrology, geomorphology, habitats, plant and animal species, sea level, and water temperature and chemistry. With the advent of human civilization and the recording of historical records, changes in the climate have changed human economy, human health, human infrastructure and human land use (Thomas 1974).

Climate change is currently occurring and more change is to be expected. The question for Southwest Floridians is not *whether* they will be affected by climate change, but *how much* they will be affected and in what ways including the degree to which it will continue, how rapidly change will occur, what type of climate changes will occur, and what the long-term effects of these changes will be (FOCC 2009).

Southwest Florida is particularly vulnerable to the effects of climate change. Topography is flat, naturally poorly drained and not very high above existing sea level. The majority of conservation lands and the regional economy have major investments within close proximity of the coast or lake water bodies. The savanna climate is naturally extreme, even without new perturbations.

Pelican Cove Condominium Association is a 75-acre gated community on Little Sarasota Bay in Sarasota, Florida, Originally the site was an old Florida landscape with towering palms, oaks, exotic fruit and nut trees, and a half mile panoramic view of the bay. During the 1930's the property was modified by the importation of melaleucas, Australian pines, sago palms and other exotic plantings. The property was developed during the 70's and early 80's, at the vanguard of ecologically oriented designs. Wherever possible the existing natural and exotic plant setting was left in place creating a close-to-nature habitat.

Pelican Cove is a coastal community and as such is vulnerable to the effects of hurricanes, tropical storms, and extra-tropical storms. Climate projections indicate increases in the strength and intensity of these storms as well as sea-level rise which will increase the likelihood of flood events. Pelican Cove is an environmentally friendly community and as such is concerned about the health of the Little Sarasota Bay Watershed and the water quality in Clower Creek and Little Sarasota Bay.

In view of the concerns noted above, Pelican Cove commissioned an Adaptation Study to provide a clear roadmap for addressing these issues. The purpose of this study is to prepare a course of action and design criteria that defines Pelican Cove's vulnerabilities in three important areas and provide methods to reduce potential damage to the environment, buildings, grounds and infrastructure due to impact from these events. The study includes three specific areas of concern which are: shoreline and water quality, drainage and erosion, and landscaping.

Shoreline and Water Quality: Pelican Cove's shoreline is vulnerable to the effects of climate change including not only sea level rise, but also such factors as elevated temperatures, and overland erosion and flooding from runoff from heavier rainfall events. In addition, our natural environment and property values are dependent on the health of the Little Sarasota Bay Watershed and the water quality in Clower Creek and Little Sarasota Bay. This report identifies specific vulnerabilities of the shoreline and water quality to potential sea level rise and other coastal storm risks and how these risks may negatively impact the environment in the Little Sarasota Bay Watershed and the water quality in Clower Creek and Little Sarasota Bay.

Drainage and Erosion: Pelican Cove is situated at a lower elevation than much of the surrounding properties and is vulnerable to overland erosion and flooding related to runoff from heavier rainfall events. The erosion and runoff may impact the health of the Little Sarasota Bay Watershed and the water quality in Clower Creek and Little Sarasota Bay. In addition, Pelican Cove's storm sewer system was designed to utilize sheet flow directly into the surrounding waterways. The potential sea level rise and storm surge associated with hurricanes, tropical storms and extra tropical storms increases vulnerabilities to flooding. This report identifies specific vulnerabilities from flooding and runoff caused by potential sea level rise and increased rain fall and storm activities including how these risks may negatively impact the environment in the Little Sarasota Bay Watershed and the water quality in Clower Creek and Little Sarasota Bay, as well as structures, grounds, and infrastructure at Pelican Cove.

Vegetation: Pelican Cove is a heavily forested community with many large mature trees and a heavy understory. The landscaping is vulnerable to wet soils and high winds associated with hurricanes, tropical storms, and extra tropical storms. In addition, the proximity to Little Sarasota Bay provides special concerns for runoff of chemicals or fertilizer that could impact the Little Sarasota Bay Watershed and the water quality in Clower Creek and Little Sarasota Bay. In addition, climate projections suggest possible changes in weather patterns that may alter the types of plants that thrive in our area. This report identifies specific vulnerabilities to the structures, grounds, and infrastructure from trees that are most susceptible to wet soils and high winds. It identifies plant and tree species at Pelican Cove that are causing a negative impact on the Little Sarasota Bay Watershed and the water quality in Clower Creek and Little Sarasota Bay based on their need for fertilizer, pesticide and irrigation.

The Pelican Cove Community Climate Change Adaptation Plan Includes Five Major Areas:
Shoreline adaptations for potential sea level rise and other coastal storm risks
Adaptations to protect and improve the water quality in Clower Creek and Little Sarasota Bay.
Adaptations to address flooding and runoff caused by potential sea level rise and increased rain fall and storm activities
Adaptations to address vulnerabilities to the structures, grounds, and infrastructure from trees that are most susceptible to wet soils and high winds
Identified plant and tree species that can reduce negative impacts on the water quality in Clower Creek and Little Sarasota Bay based on their need for fertilizer, pesticide and irrigation

Figure 1: The Pelican Cove Community with boundary marked in blue.

Residents and visitors alike benefit economically from the natural resources of the study area. The agriculture, championship fishing and tourism industries, for example, are directly related to the quality of the natural environment. Natural resources also provide jobs and industry earnings as well as other public and private benefits such as recharging groundwater aquifer water supplies and providing fish and wildlife habitat.

A functional environment provides clean drinking water for homes, soil and fertilizer for crops, and wading birds and other wildlife to complement a canoe trip through the mangroves. However, none of these resources are limitless, although they are often treated as such.

Tourists and residents are drawn to southwest Florida because of many natural amenities. Tourists demand clean beaches or they will seek other destinations with their vacation dollars. Likewise, residents are entitled to a healthy community, yet have a stewardship responsibility to ensure its health. The strength of the economy rests on the quality of the environment and nearly every household and occupation is in some way affected by the health of the ecosystem.

Conversion of natural landscapes to build environments has a cost in addition to that of permits, blueprints, materials and labor: loss of those "goods and services" that derive from natural ecosystems. Natural ecosystems directly or indirectly support a multitude of jobs, provide essential services for communities and make this a place to enjoy. Tourism, along with residential and commercial development, plays the dominant role in the coastal economies of Sarasota. Although the outputs of goods, services and revenues from all sectors of the economy are constantly changing, it is useful to understand the economic value associated with the current activities, amenities and nonuse satisfaction levels dependent on natural resources. Economic activities that are affected by environmental quality range from recreational fishing to construction. Natural habitats, water quality and freshwater flows are necessary to maintain the amenities and natural resources that sustain fishing, tourism, recreation and a multitude of other businesses. For example, agriculture requires that the water used for irrigation and livestock meet certain water quality standards. Mining operations require adequate quantities of water, but they are also charged with meeting state water quality regulations for any water they release. The quality and economic output of these activities is dependent on the extent and quality of the natural resources they consume.

The economy of Florida is one of the most vibrant in the country, but is also extremely vulnerable to climate change. Because so much of Florida's economy is natural resource-dependent, factors that affect local, regional and global climate will impact the state's future. This section will describe Florida's major economic sectors, from the estuaries to the inland areas, emphasizing those sectors' vulnerabilities to climate change.

Elements of an Adaptation Plan

Successful adaptation to climate change in estuaries and the lands adjacent to estuaries requires plans that respond to both the unique vulnerabilities and the priorities of the places they protect. Plans need to be flexible, to respond to changing conditions and information and to have realistic assessments of the degree of risk and cost that can be sustained. This document identifies the key elements of climate change adaptation planning for the three climate change effects identified by the Pelican Cove Community, and provides information and resources that can be used to adapt to those climate change effects and use in climate change adaptation. Each Community must select the best order and process to develop their adaptation plan.

There are two critical elements that an EPA approved adaptation plan must include for Climate ready Estuaries (CRE) recognition:

- Description of specific implementation actions
- Monitoring and evaluation of results

In addition, there are several other components that support the preparation of these two critical elements. The development of these may depend on the specific estuary's vulnerability and the extent to which these elements are either already in place or completed. These other recommended components include:

- An assessment of vulnerability;
- A summary of considerations used to set priorities and select actions; and
- Communication with stakeholders and decision makers.

An adaptation plan can be a stand-alone document or be incorporated as an additional or new element in an existing management plan. Regardless of where the adaptation plan is housed, some of the key considerations include:

- How the plan affects existing management goals;
- Additional climate change-induced goals and objectives beyond the existing management goals;
- Management actions associated with achieving those goals and objectives; and
- Steps required for implementation (including the associated tools and resources that can be deployed).

Finally, any climate strategy or plan needs to be seen as a living document‖ -one that allows for relatively easy revisiting and updating in response to changing conditions and lessons learned from monitoring and evaluation of results. Initial plans can be updated and enhanced as information changes regarding vulnerability, uncertainty, management priorities, technology, adaptation methods and costs.

Assessment of Significant Potential Climate Changes and Their Effects on the Pelican Cove Community

The Pelican Cove Community Climate Change Vulnerability Assessment (Beever and Walker 2017) describes the current climate of southwest Florida, the trends in climate change in Sarasota county, and the identified climate change vulnerabilities requested to be examined for the community. This document includes an assessment of significant potential effects of climate change in the three areas of sea level rise, flooding, and damages from trees and other vegetation on the human and native ecosystems of Pelican Cove, including consequences for human and natural resources resulting from and related to sea level rise, aquatic and atmospheric temperature rise, changes in rainfall patterns, increased storm intensity, waterbody acidification, and general weather instability. This overview identifies potentially critical vulnerabilities that will need to be addressed by adaptation or accommodation at Pelican Cove. A copy of the completed study can be found at the SWFRPC Pelican Cove Project Portal at
http://www.swflregionalvision.com/pelicancove.html
in the resources tab or directly at
http://swflregionalvision.com/content/pelicancove/The%20Pelican%20Cove%20Community%20Climate%20Change%20Vulnerability%20Assessment%20Final%2020170130.pdf

At the current measured rates of sea level rise for Litter Sarasota Bay, Pelican Cove can expect 1 foot of eustatic sea level rise above the current mean tide by the year 2131; 2 feet of eustatic sea level rise above the current mean tide by the year 2245; and 3 feet of eustatic sea level rise above the current mean tide by the year 2341. Many climate change models with strong scientific bases anticipate a rapid acceleration of sea level rise above the current measured rate, caused but more rapid melting of land based ice in glaciers and the polar zones, increased releases of Green House Gases from human activities, agricultural practices, and natural sources released from melting . This set of models predict faster sea level rise such that, Pelican Cove can expect 1 foot of eustatic sea level rise above the current mean tide by the year 2051; 2 feet of eustatic sea level rise above the current mean tide by the year 2085; and 3 feet of eustatic sea level rise above the current mean tide by the year 2120.

Storm surge events from tropical storms will increase due to the higher sea level stand combined with a higher severity of storms and impact Pelican Cove sooner than the eustatic sea level rise effects. All of Pelican Cove is within the Category 3 storm surge zone, approximately half of the community is in the Category 2 storm surge zone and all of the estuarine shoreline Bayhouse and Harborhouse is in the Category 1 storm surge zone for all directions of storm approaches with the exception of a storm crossing the state from east to west. Areas along Clower Creek within Pelican Cove are also in the Category 1 and 2 Strom Surge zones. The extent of these surges will reach further upslope and inland with the increased standing sea level. In addition rapid run-off from the urbanized impervious surfaces or the headwaters of Clower Creek will during rainy storms flood the riparian areas of Pelican Cove much more quickly even if the tide is low and wind fetch is blowing westward during a storm.

The existing drainage infrastructure of Pelican Cove depends upon rapid discharge to receiving waters. The stormwater drainage and treatment system of Pelican Cove reflects this old design that had limited detention/retention and quick discharge to tidal waters. The road system within Pelican Cove reflects a strong dependence upon the road surface shape to direct surface water run-off directed to central gutter groves, edge swales and small basin stormwater ponds. Much of the non-point stormwater discharge goes directly into Sarasota Bay, Clower Creek or the Harbor basin without much treatment other than grassed surfaces. In some areas there is no treatment before road and building runoff enters the estuary directly. This is particularly true at the terminus of roadways and through directed pipes entering the Yacht Basin.

Some portions of the roads hold water in shallow pools without drainage until the water reaches sufficient height to exceed the depression's depth or evaporation does its work. These were typically along road edges at junctures with parking slots. The grassed swale system behind Bayhouse Building #5B is a good functional feature. Unfortunately this type of stormwater treatment is not replicated and may not be possible in the Harborhouse area or in locations like Bayhouse Building #8 where there is insufficient distance between buildings and the Bay and a sharp drop-off to a rip-rap and Australian pine shoreline.

The area facing north in front of *Bayhouse Buildings #8 and #9*; and the west facing shoreline of Harborhouse #21 have the most exposure to wind fetch generated waves with subsequent erosion,. The south facing Bayhouse Buildings #7, #6, #5B and Bayhouse Buildings #2 and #1 are wee protected by the mangrove islands that stop wave action and calm wind effects coming from the south and west. The wider mangrove shoreline hedges are more robust on the south facing shoreline. Both the Yacht Basin and Clower Creek above the juncture with the Yacht Basin Channel are depositional environments accumulating significant silt deposits above the original channel bottoms.

Erosion occurs on-site from three basic causes wave action form the Bay, flow down Clower Creek, and run-off from land surfaces. The current areas of Bay-side erosion is the area not protected by flanking mangrove islands at *Bayhouse Buildings #8 and #9*; and the west facing shoreline of Harborhouse #21. These areas already have been hardened with rip-rap behind vegetation fringes. There is erosion between buildings #8 and #9 where4 there is a discontinuation of rip-rap and water running off the Pelican Point Drive coupled with excess water coming from misdirected irrigation sprinkler heads run down slope into the area near the mouth of Clower Creek. Erosion is also occurring from areas behind Bayhouse #9 at a very low wooden board barrier that is being over-watered above it and is not retaining soil as it appears it was intended to do.

From site inspection the area of Bayhouse Buildings #7, #6, #5B and Bayhouse Buildings #2 and #1 have approximately 8 feet of elevation above the high tide mark. The Bayhouse Buildings #8, #9, and #10 appear to have 5 feet of elevation above current high tide.

East of the road bridge Clower Creek is blocked by vegetation that has grown across the creek bed and a significant amount of fallen vegetation has fallen into the creek and/or tangled into the living vegetation. This includes both native mangroves and exotics like Brazilian pepper.

The vegetation of Pelican Cove reflects a canopy that is composed of an original coastal oak hammock uplands flanked by a mangrove shoreline that has been invaded by the typical invasive exotics that move into disturbed areas and then landscaped intentionally as a form of botanical garden with a wide diversity of non-native species disperse among the residential and common areas. There are 82 species of trees at Pelican Cove at this time. There are 29 (35.37 %) native tree species on-site with oaks and cabbage palm the most common. There are 52 (63.41%) species of non-native tree species.

Twenty-one tree species have the highest wind resistance. Seventeen of the trees with the best wind resistance are natives, Of the non-native trees with high wind resistance all are palms naturally adapted to high winds of their original home environment.

Fourteen tree species have medium wind resistance, 30 species have medium to low wind resistance, and 17 have low wind resistance. Only 2 of the species with the lowest wind resistance are native, the red cedar and laurel oak. The other 15 include some of the worst invasive plant exotics in Florida including Australian pine, melaleuca, and carrotwood

The vegetation understory is principally exotic species ranging from sod grasses to typical nursery landscaping species like hibiscus and periwinkles and several invasive exotic species including Brazilian pepper, wedelia, and exotic ferns as well as some toxic species like cats-eye and Devil's trumpet.

There are pockets of coastal hammock shrubs with sea grape, inkberry, sea ox-eye daisey, silver buttonwood, and palmettos found shoreward of the mangrove fringes in the Bayhouse and lower Clower Creek areas.

Maintaining the status quo in management of estuarine ecosystems would result in substantial losses of ecosystem services as climate change progresses. In the absence of effective avoidance, mitigation, minimization and adaptation, climate-related failures will appear in hydrology, water quality, fish and wildlife habitat, and community safety.

Changes in the climate will occur in the future even if mitigations, such as reductions in greenhouse gas emission, were to be implemented today. The stressors of air temperature and water temperature increases with subsequent changes in air quality and water quality can be expected to continue and the impacts of climate change variability and sea level rise, in particular, are inevitable. Climate change impacts from sea level are already evident in the growing demand for and costs of beach nourishment, increased coastal flooding, and more pronounced storm surges during tropical storm events.

Many of the anticipated consequences of climate change occur via mechanisms involving interactions among the stressors and variables. The magnitude of such interactive effects typically declines as each stressor or variable is better controlled, so enhanced adaptive management of traditional estuarine stressors has value as a management adaptation to climate change as well. The Pelican Cove Adaptation plan will provide suggested guidance in the three major areas of concern.

Among the consequences of climate change that threaten estuarine ecosystem services, the most serious involve interactions between climate-dependent processes and human responses to those climate changes In particular, conflicts will arise between sustaining natural coastal habitats and coastal private property, since current activities of protecting private shoreline property from erosion with hardening and placement of fill will become increasingly injurious to sub-tidal, littoral, and wetland habitats if continued as climate changes and sea level rises.

Florida is one of the most vulnerable areas in the world to the consequences of climate change, especially from increased hurricane severity, sea level rise, and climatic instability leading to drought and flood. Regardless of the underlying causes of climate change, global glacial melting and expansion of warming oceans are causing sea level rise, although its extent or rate cannot as yet be predicted with certainty.

Recommended Adaptation Options Under Consideration

After examination of the identified climate change vulnerabilities in the assigned areas of sea level, rise, flooding, water quality, and vegetation, coordination with the residents', committees, and staff of Pelican Cove we have jointly identified 23 potential adaptation actions in 4 general categories of sea level rise, water quality improvement, flooding and run-off, erosion, vulnerabilities from certain trees, and vegetation improvement. These are listed in the table below.

Table 1: Recommended Adaptation Options Under Consideration

1) Options for sea level rise

    a) Living shorelines of different design
    b) Sediment supplementation
    c) Dune/Berm Construction
    d) Within the Marina Harbor
        i) Redesign (Elevating Docks, Walkways, and Decks)
        ii) Floating Docks
    e) Increased Ground Floor Elevations When Rebuilding

2) Options for water quality improvement

    a) Sediment dredging
        i) Spot dredging
        ii) Removal of all anoxic silt
    b) Floating Islands
    c) Filter feeders
        i) Reef Balls or similar structures
        ii) Oyster Strings
        iii) Clam Bags
    d) Pretreatment for drains and improved run-off capture

3) Options Examined for Flooding, Runoff and Erosion From Climate Change

    a) Improved swales and additional drainage swales with coastal dunes
    b) Removal of exotics and replacement with GeoWeb and natives
    c) Removal of silt from Clower Creek
    d) Remove vegetation blocks from Clower Creek
    e) Improved Evacuation Coordination

4) Options Examined for Vulnerabilities to the Structures, Grounds, and Infrastructure from trees and identified plant and tree species that can reduce negative impacts on the water quality in Clower Creek and Little Sarasota Bay based on their need for fertilizer, pesticide, and irrigation

a) Removal of trees with low wind resistance
b) Utilize native trees with high wind resistance in future tree replacements
c) Favor native vegetation species over exotics.
d) Select plants of the original coastal oak hammock uplands and flanking estuarine and creek transition zones by a mangrove shoreline and a riparian creek.
e) Introduce some tropical hardwood hammock species
f) Stabilize exposed and eroding shore and backshore areas with marsh grasses and herbaceous marsh species in Zonal Shoreline Plantings
g) Changes in mangrove trimming
h) Continual improvement in fertilizer management

Shoreline adaptations for potential sea level rise and other coastal storm risks

The evaluation of the potential sea level rise and coastal storm risks for Pelican Cove is described in The Pelican Cove Community Climate Change Vulnerability Assessment (Beever and Walker 2017).

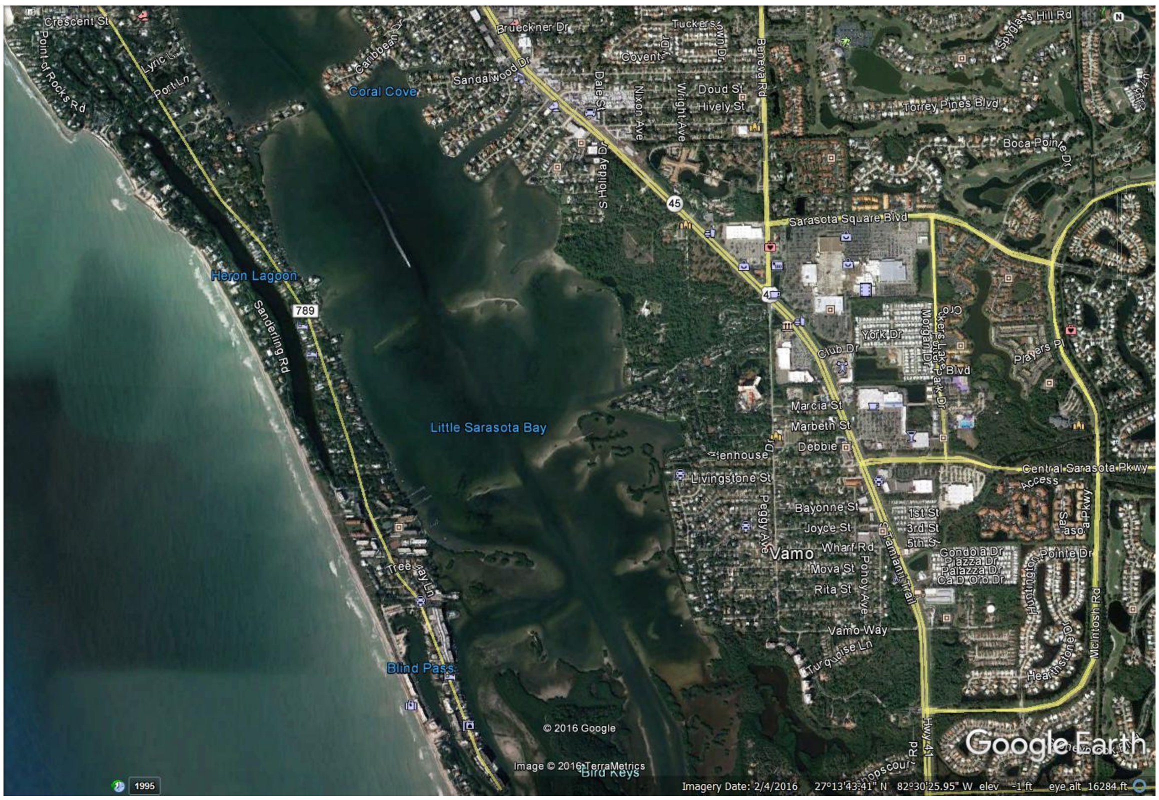


Figure 2: Actual Measured Current (2015) Rates of Sea Level Rise in Sarasota County Florida

At the current measured rates of sea level rise for Litter Sarasota Bay, Pelican Cove can expect 1 foot of eustatic sea level rise above the current mean tide by the year 2131; 2 feet of eustatic sea level rise above the current mean tide by the year 2245; and 3 feet of eustatic sea level rise above the current mean tide by the year 2341. The rate of sea level rise in Sarasota Bay and Little Sarasota Bay has increased 3.57% between 2014 and 2015

Location	Rate in MM/YR	Years to 1 foot	Years to 2 feet	Years to 3 feet
Sarasota	**2.76**	**111**	**221**	**321**
Worst Case Scenario	**9.09**	**34**	**67**	**101**

Location	Rate in MM/YR	Year at 1 foot	Year at 2 feet	Year at 3 feet
Sarasota	**2.76**	**2127**	**2237**	**2348**
Worst Case Scenario	**9.09**	**2050**	**2083**	**2117**

Table 2: Current rate of sea level rise and the projected worst case scenario for increased sea level rise rate for Sarasota and Little Sarasota Bay at the estimate future dates of occurrence.

Many climate change models with strong scientific bases anticipate a rapid acceleration of sea level rise above the current measured rate, caused by more rapid melting of land based ice in glaciers and the polar zones, increased releases of Green House Gases from human activities, agricultural practices, and natural sources released from melting . This set of models predict faster sea level rise such that Pelican Cove can expect 1 foot of eustatic sea level rise above the current mean tide by the year 2051; 2 feet of eustatic sea level rise above the current mean tide by the year 2085; and 3 feet of eustatic sea level rise above the current mean tide by the year 2120.

From existing data table from insurance certifications and site inspection the area of Bayhouse Buildings have approximately 8.4 feet of elevation above the high tide mark. Overall the community of Pelican Cove has a 1st floor elevation of 10.7 feet with a standard deviation of 2.3 feet. The highest 1st Floor elevation is 15 feet and the lowest at 8.4 feet.

Figure 3: Elevation in meters at Pelican Cove from LIDAR

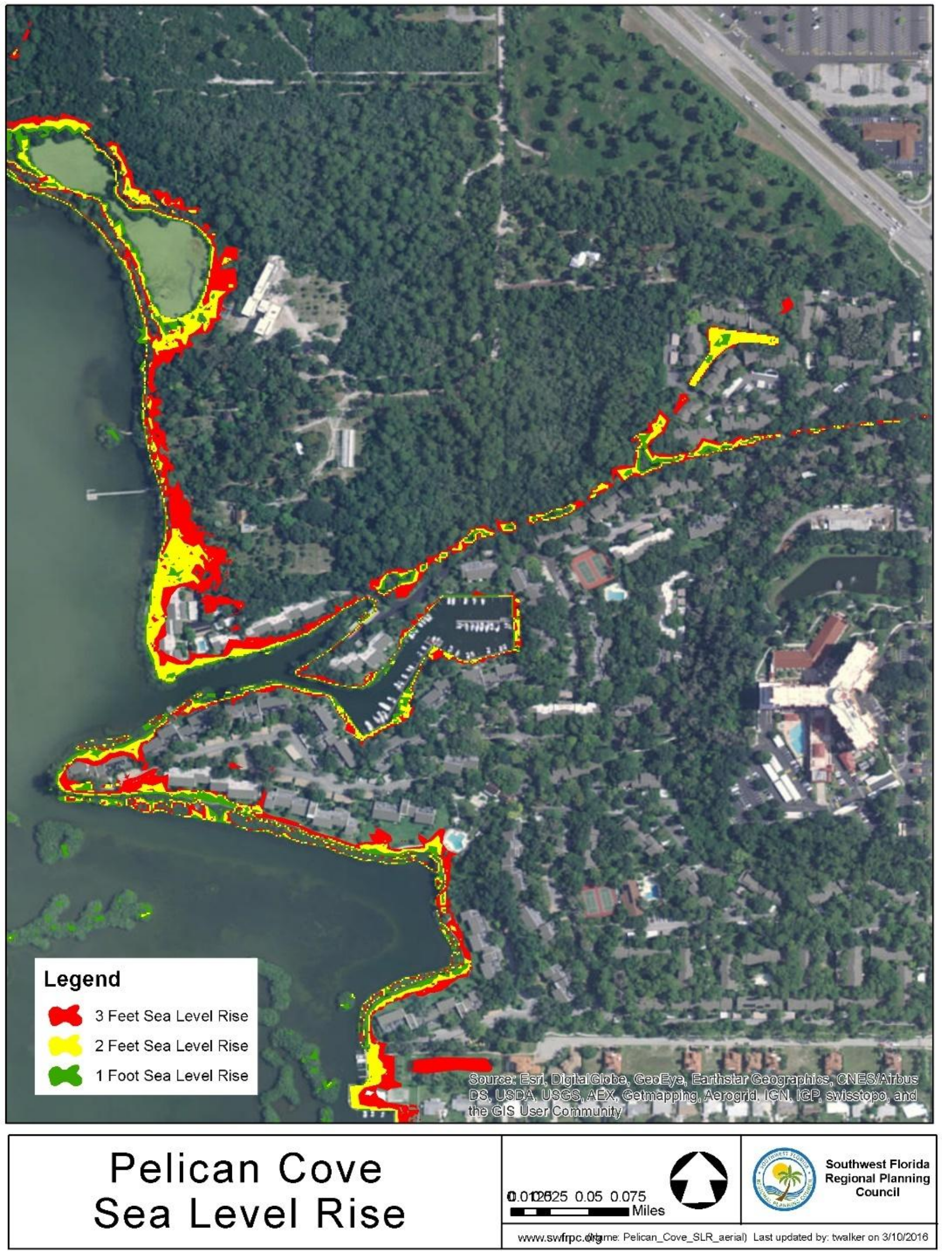


Figure 4: Sea Level Rise locations at 1 (green), 2 (yellow), and 3 feet (red) Elevations at Pelican Cove from LIDAR base.

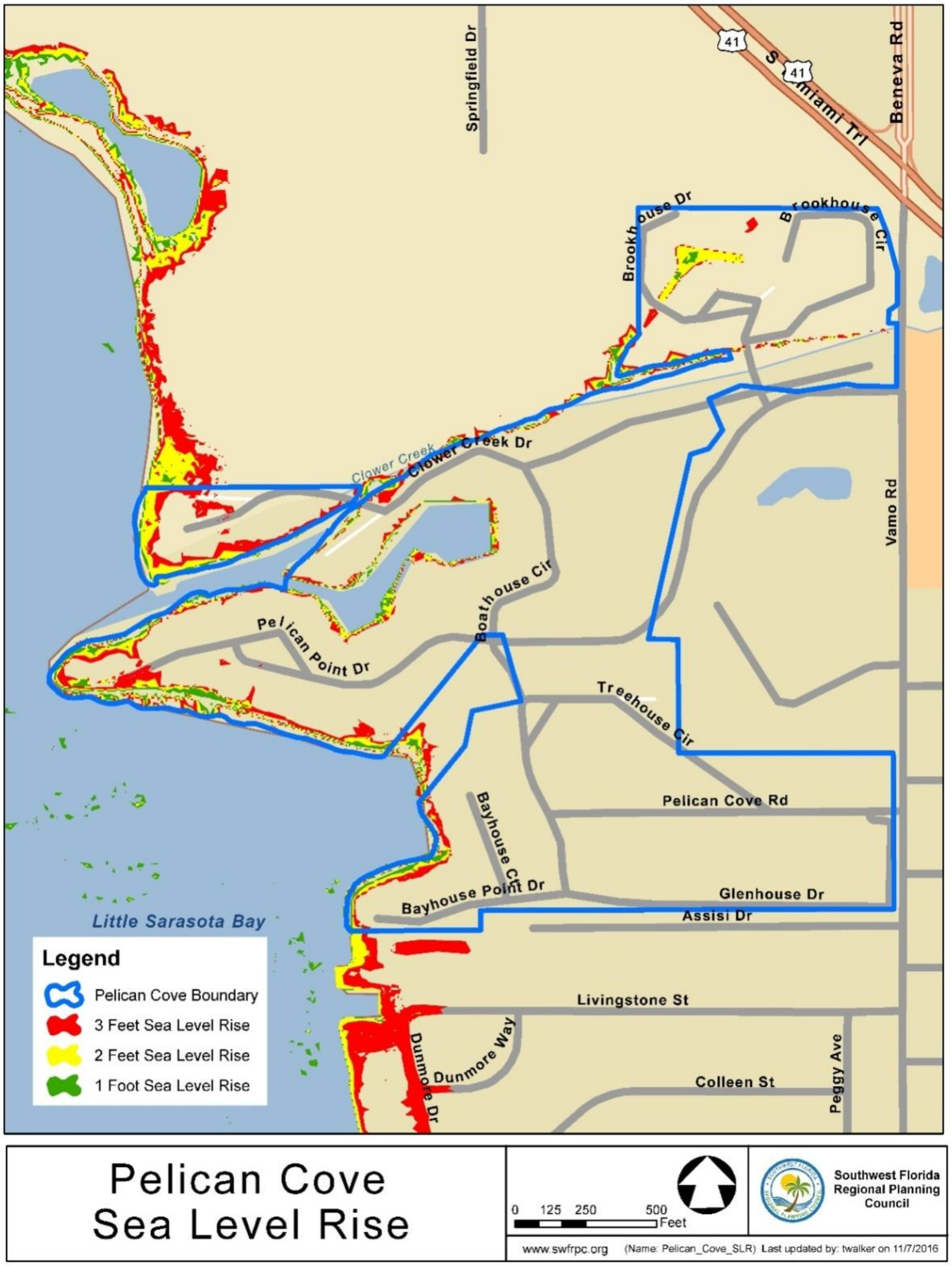


Figure 5: Sea Level Rise locations at 1 (green), 2 (yellow), and 3 feet (red) Elevations at Pelican Cove from LIDAR base with street map and boundary reference.

The existing shoreline on Little Sarasota Bay consists of a mangrove fringe retained in a hedge from along the entire shoreline including Clower Creek up to the Harbor Channel and Basin. This mangrove fringe is hedged at set heights that can be variable on different shorelines (Photographs 1 and 2). In locations along the more exposed shores of the point and the Far Harbor area rip-rap is located behind the mangrove fringe (Photograph 3) or within the mangrove fringe (Photograph 5).

Photograph 1: Mostly red mangrove hedge on Bayhouse Area South Cove shoreline facing northwest from the Wilbanks Area.

Photograph 2: Areas of mangrove hedge with black mangrove and silver buttonwood uplift trimming at the western point of the Bayhouse Area, Building #8.

Photograph 3: Rip-rap behind mangrove hedge along Clower Creek, Building #9 in Bayhouse Area

Photograph 4: View from dock below Buildings #17 Harborhouse looking west across Yacht Basin

Photograph 5: Large rip-rap on the south Yacht Basin shoreline backed by vertical concrete wall in the Harborhouse area.

Photograph 6: View east up Clower Creek showing convergence of the Creek and the Yacht Basin channel with Bayhouse Building #10 shoreline on south and Harborhouse shoreline, Building #19 on north.

Photograph 7: Mouth of Clower Creek as it enters Little Sarasota Bay

There are several different options available for infrastructure protection from sea level rise and coastal flooding. These range from bulkheads of various forms of hard materials to a soft natural shoreline. The current conditions at Pelican Cove are a form of hedge-modified soft living shoreline with rip-rap revetment in some locations. Based upon the long term commitment of the Pelican Cove Community to living with natures, the current site conditions, the most cost effective cost/benefit ratio, and planning for a maximum of three feet of sea level rise within the next 100 years a living shoreline is the best solution in the planning time-frame.

1) Living shorelines use natural shoreline features such as salt marshes, mangroves, seagrasses, other native plants and oyster reefs to preserve and build coastal habitats. Understanding the importance of natural shoreline stabilization techniques, how they work and the benefits of these alternatives play an important role in sustaining Florida's coast. Many shorelines along Florida's coasts have been stabilized using hardened structures such as sea walls, rip rap, groins and bulkheads. While hardened stabilizers are believed to prevent shoreline erosion, they can actually increase erosion and destroy native habitat. Natural stabilizers reduce coastal erosion and provide valuable habitat using native vegetation, sand and organic material. In Florida, local, county and statewide environmental agencies have begun to enhance, protect and re-create healthy coastal habitats. The Florida Department of Environmental Protection's Office of Coastal and Aquatic Managed Areas and other organizations have successfully restored many of Florida's natural coasts using living shorelines through habitat restoration projects. Florida is nationally known for its beautiful waterways and ecological diversity. Living shoreline initiatives are crucial to maintain these valued resources.

When planning a living shorelines project, there are several factors that restoration practitioners need to consider, including the permits and approval involved and the appropriate type of restoration for the habitat type. Here, we list the steps involved in planning and implantation.

1. **Site analysis:** Practitioners must determine which living shoreline stabilization is appropriate in a particular area; this analysis includes an evaluation of the bank erosion rate and elevation, wave energy, prevailing wind and wave direction, vegetation, and soil type. Design of restoration activities is done after the site analysis.
2. **Permit approval and legal compliance:** Compliance with all federal, state, and local laws, regulations, and permits for proposed restoration activities must be done prior to implementation. On June 1, the U.S. Army Corps of Engineers recommended a new general permit for natural shoreline defenses—*Proposed Nationwide Permit B. Living Shorelines*—which use natural materials such as plants, sand, and rocks to reduce erosion
3. **Site preparation:** This begins after appropriate permits are obtained from regulatory agencies. The site is cleared of debris and unstable trees, and failing seawalls and bulkheads can be removed. Any runoff issues should also be identified and addressed prior to material installation.
4. **Installation:** Typical living shoreline treatments include planting riparian, marsh, and submerged aquatic vegetation; installing organic materials such as bio-logs and organic

fiber mats; and constructing oyster reefs or “living breakwaters” that dissipate wave energy before it reaches the shore.

5. **Post-construction monitoring and maintenance:** This includes scientific monitoring of restored habitat to gather information on the success of the project for the purpose of improving the construction and implementation of future efforts. Maintenance activities include debris removal, replanting vegetation, adding additional sand fill, and ensuring that the organic and structural materials remain in place and continue to stabilize the shoreline.

Mangrove Fringe

Figure 6: An example diagram of a living shoreline profile.

The existing mangrove fringe along Little Sarasota Bay and Clower Creek can form a strong basis to build an improved living shoreline system. The lower wind and wave energy shorelines of South Cove and Clower Creek will have a different lower profile design than the high energy waves and fetch shorelines of the Point and Far Harbor.

Figure 7: Lower energy south shoreline area suitable for zonation planting, low dune swales, low energy living shoreline.

Figure 8: Higher energy north shoreline area suitable for zonation planting, and high energy living shoreline.

The pattern of the living shoreline would have nine (9) zones be from waterward to landward

<u>1) Man-made oyster bar.</u> Located between the low tide line and the existing navigation channel Native reef-building oysters play an important role in aquatic ecosystems. Oyster reefs can be enhanced or created at living shoreline sites as natural shoreline protective structures to dissipate wave energy, decrease coastal erosion, increase habitat for fish species, improve water quality, and provide protection for newly planted marsh grasses and submerged aquatic vegetation. The oyster bar design will be different ay different shorelines and may utilize oyster grids, oyster bags, loose shell, and/or oyster reef-balls. Small concrete oyster balls can be used at living shoreline sites to decrease wave energy while enhancing fish and oyster habitat. These hollow concrete structures provide a surface on which oysters colonize and form small living reefs, thus providing habitat and food for fish and other aquatic species. These structures also dissipate waves, decreasing coastal erosion and providing an area in which newly planted vegetation can grow.

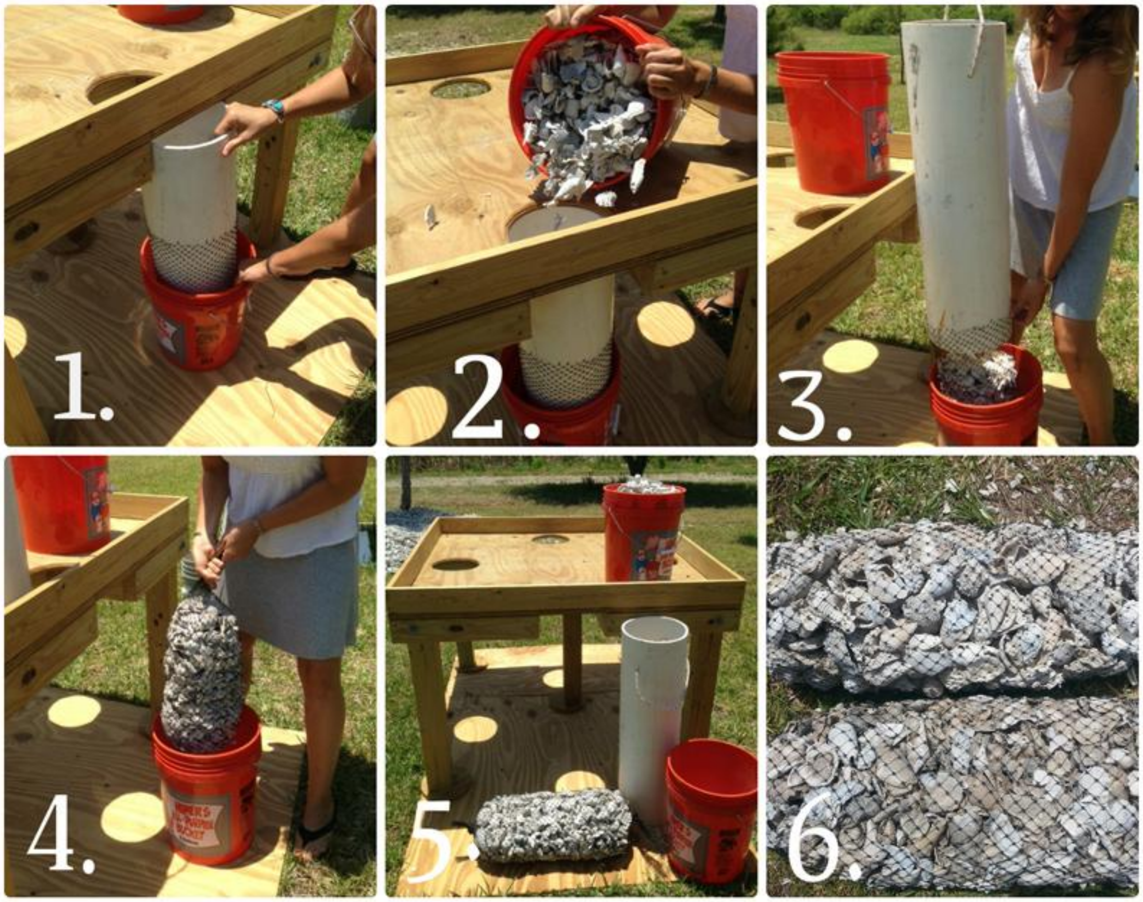


Figure 9; Citizen Volunteer filling oyster bags for living reef project City of Punta Gorda 2016.

Figure 10: Citizen Volunteer deploying an oyster screen into shallow waters of the Peace River for a living shoreline project, City of Punta Gorda.

Figure 11: One area of the completed living shoreline reef at the City of Punta Gorda. Poles mark the reef boundaries for navigation information and monitoring purposes.

In the oyster reef project for the City of Punta Gorda a total of nine reefs were installed, measuring approximately 4 m x 9 m each. The construction costs were approximately: $10,500 for restoration materials and supplies and $16,000 for a contractor with barge to assist in deploying the materials. The site where we stored the materials and the equipment needed to load the materials onto the barge were donated so they are not reflected in the costs. Citizen volunteers who constructed an assisted in deploying the oysters also reduced costs.

<u>2) Area of unvegetated bottom.</u> Located between the oyster bars and the smooth cordgrass or the mangrove fringe. This area has important habitat value in itself and may become colonized by submerge aquatic vegetation including seagrass. Seagrass beds dampen wave energy, stabilize sediments, improve water quality, and provide food and shelter for marine organisms. When used in conjunction with other living shoreline components such as marsh grasses, a natural shoreline buffer is created that reduces coastal erosion and stabilizes sediments via root growth.

<u>3) Smooth cordgrass, Spartina *alterniflora* (South Cove only).</u> Located in front of the mangrove fringe at the area between low and high tide where sediment allow clusters to be planted. They will spread naturally and may eventually be supplanted by mangroves.

Spartina alterniflora (smooth cordgrass or saltmarsh cordgrass) is a perennial rhizomatous deciduous grass which is found in intertidal estuarine shorelines. It grows 0.6 to up to 2.5 meters tall, and has smooth, hollow stems which bear leaves up to 20-60 cm long and 1.5 cm wide at their base, which are sharply tapered and bend down at their tips. The leaf blades are 1/4 to 3/5 inches wide. The leaves lack auricles and have ligules that consist of a fringe of hairs. The plant is deciduous; its stems die back at the end of each growing. *S. alterniflora* flowers are inconspicuous and are borne in greatly congested spikes; two to three inches long. It produces flowers and seeds on only one side of the stalk. The flowers are a yellowish-green, turning brown by the winter. It has rhizoidal roots, which, when broken off, can result in vegetative asexual growth. The roots can be are an important food resource for waterfowl.

Under favorable conditions, *S. alterniflora* can reach sexual maturity in three to four months. Mature plants produce seed in the fall. Seeds require soaking for approximately six weeks to germinate, with most seeds germinating in the spring. The seeds are short-lived (roughly 8 months), so the species does not have a persistent seed bank. Germination rates are variable.

While seeds are important for colonizing new areas, they appear to be unimportant in maintaining established stands. Studies in Rhode Island suggest that *S. alterniflora* seedlings are unable to survive under adult canopy, and seedling success increases with the size of bare patches. Therefore, the expansion of established stands is due to vegetative growth. In some areas, *S. alterniflora* has demonstrated the ability to rapidly colonize bare areas due to a high intrinsic growth rate and rapid propagation of stems via rhizomes. Estimates of lateral growth taken in Washington indicate that clones expand at approximately 0.5 to 1.7 m/yr. Found in areas of low to moderate wave energy, the species can colonize a broad range of substrates, ranging from sand and silt to loose cobble, clay, and gravel. The species can tolerate a wide range of environmental conditions, including: inundation up to 12 hours a day, pH levels from 4.5 to 8.5, and salinity from 10 to 60 ppt, although 10-20 ppt is optimal.

S. alterniflora is noted for its capacity to act as a substrate builder and stabilizer. It grows out into the water at the seaward edge of a salt marsh, and accumulates sediment and enables other habitat-stabilizing species, such as mussels, to attach and settle. This accumulation of sediment and other substrate-building species gradually builds up the level of the land at the seaward edge, and other -marsh species can move onto the new higher elevation. As the marsh accretes, *S. alterniflora* moves still further out to form a new edge. *S. alterniflora* grows in tallest forms at the outermost edge of a given marsh, displaying shorter morphologies up onto the landward side of the *Spartina* belt.

S. alterniflora is native to the Atlantic and Gulf of Mexico coast of the Americas from Newfoundland, Canada south to northern Argentina, where it forms a dominant part of brackish coastal salt marshes. In its native range, *Spartina alterniflora* exhibits varying growth forms in different salt marsh zones. A tall form occurs at the facing shoreline, along creek banks and drainage channels. Landward of the tall form, an intermediate form occurs, which grades into a stunted form at the marsh interior. In its native range, *S. alterniflora* typically exclusively dominates low salt marshes, growing from 0.7 m below mean sea level to approximately mean high water.

In its native habitat, *Spartina alterniflora* is valued. The species is highly productive, exporting approximately 1300 g/m^2 of detritus annually to the estuarine system. *S. alterniflora* is also highly regarded for erosion control, as well as fish and wildlife values in its native range. In these native habitats, some waterfowl and wetland mammals eat the roots and shoots of this plant. In addition, stands of *S. alterniflora* can serve as a nursery area for mangroves, and estuarine fishes and shellfishes. Because of their ability to trap sediment, *Spartina* species have been planted in many parts of the world for estuary reclamation.

Figure 12: Smooth Cordgrass, Big Panther Key, Pine Island Sound.

4) Existing mangrove fringe. Mangroves are woody plant communities that play an important role in stabilizing the shoreline. Through their extensive root system, mangroves trap sediment and nutrients and dissipate wave energy. Mangroves are found in estuarine tropical and subtropical environments and significantly decrease coastal erosion if used at living shoreline sites.

The value and central role of mangroves in the ecology of south Florida has been well established by numerous scientific investigations directed at primary productivity, food web interactions, listed species, and support of sports and commercial fisheries. The approximately 554,515 acres of mangroves remaining in central and south Florida are a unique and critical component of Florida's bay and estuarine ecosystems. They deserve special protection, because of the following functions:

a) Mangroves are important in recycling nutrients and the nutrient mass balance of the estuarine ecosystem. They are regarded as one of the tropical ecosystems with the highest primary and associated secondary biological production in the world.

b) Mangroves provide the, or one of the, basic food chain resources for arboreal life and nearshore marine life through leaves, wood, roots, and detrital materials. This primary production forms a significant part of the base of the arboreal, estuarine, and marine food web.

c) Mangroves have a significant ecological role as physical habitat and nursery grounds for a wide variety of marine/estuarine vertebrates and invertebrates. Many of these species have significant sports fishery and/or commercial fishery value.

d) Mangroves have a significant ecological role as habitat for a wide variety of above-surface wildlife including mammals, birds, reptiles, amphibians, and arboreal arthropods. This ecosystem is a Florida habitat unique in the continental United States.

e) Mangroves have a significant ecological role as habitat for endangered species, threatened species, and species of special concern. For several of these species the habitat is critical and vital to their continued survival.

f) Mangroves serve as storm buffers by functioning as wind breaks and through prop root baffling of wave action. Mangrove fine roots stabilize shorelines and fine substrates, reducing potential turbidity, and enhancing water clarity.

g) Mangroves improve water quality and clarity by filtering uplands runoff and trapping waterborne sediments and debris.

h) Unaltered mangroves contribute to the overall natural setting and visual aesthetics of Florida's estuarine water bodies.

i) Through a combination of the above functions, mangroves contribute significantly to the economy of the coastal counties of south Florida and the state of Florida.

Figure 13: Existing mangrove fringe at Pelican Cove at the South Cove Area.

Figure 14: Area of the mangrove fringe at Pelican Cove with mangrove hedging and uplift trimming.

<u>5) Middle tidal marsh (black needle rush (*Juncus roemerianus*) & other cordgrasses)</u> Marsh grasses dissipate wave energy, filter upland runoff, and improve habitat for fish and wildlife. Native grasses are planted in the water and at the mean high tide mark in the intertidal zone. Marsh grasses may be more successful if they are planted in the spring in areas where there is evidence of existing marsh, where there is less than 3 miles of open water, and where the prevailing winds will not cause destruction of the newly planted grasses.

Black needle rush occurs at an average elevation of 0.56 ± 0.22 meters (1.74 ± 0.72) feet with a minimum elevation of 0.00 meters or mean tide and a maximum elevation of 2.15 meters (7.4 feet). This wide range reflects that black needle rush is found in all marsh hydrogeomorphic settings of the CHNEP from waterfront fringing marshes to middle marsh peat platforms to the waterward edge of high marsh to the landward edge of high marsh. It is also important to understand that as the estuary proceeds up river and stream water courses the water surface gains elevation above sea level in accordance with the elevational gradient of the stream bed so the relative position of a marsh may be the same to relative water surface at a higher location than on the coastal shoreline. In both the Myakka River and Peace River black needle rush is supported on and most likely is responsible for the creation of peat mats that overlay sandier basement sediments evidencing a process of vegetative sourced land building.

Juncus roemerianus is a perennial moderate growing, bunch forming deciduous grass with green flowers in early spring, mid spring and late spring. It grows well in semi-shade, and prefers high levels of water. It is an erect plant and has a clump forming growth form, and has an ultimate height of 1.5 m / 4.9 ft. The leaves are green and tender in summer. Older stems are course and rigid. Leaves are terete, stiff and pungent. Inflorescence appear laterally; involucral bract terete and erect. Perianth usually brownish, 3-3.5 mm long; sepals longer and are more pointed than petals. It is composed of two types of plants based on flower morphology: one form produces perfect (bisexual flowers) and another form produces pistillate (unisexual) flowers. Seeds are dark and 0.6 mm long (May to October). This plant requires a minimum of 200 frost free days to grow successfully. It has no drought tolerance.

In the wild, black needlerush establishes from seed, rhizomes or vegetative divisions from storm derived flotsam. Pistillate-flowered plants produce more seed and seed with higher viability than perfect-flowered plants. Seed germination requires light and seeds will not germinate if covered. Seeds remain viable for over a year. Seeds will germinate when submerged or floating on water. Black needlerush seedlings are found mainly in areas with no or little associated vegetation. Seedlings are seldom found in mature stands of black needlerush or other marsh species. Black needlerush maintains itself in established stands though rhizome growth.

Where soil salinity is low and substrate is organic, black needle grass is robust with leaves reaching over 2.2 m in height. In high saline areas the plants are dwarfed often less than 0.3 m tall. *Juncus roemerianus* grows in soils ranging from a pH of 4 to 7. It is adapted to almost pure sand, clay, silt, loam, silty clay, sandy clay, clay loam, silt loam, sandy loam, silty clay loam and sandy clay loam soils, and prefers medium fertility. It also, grows in highly organic soils including peat soils. It has a high tolerance to anaerobic conditions and a high tolerance to $CaCO_3$.

Dense stands of black needlerush form deep fibrous root systems, which provide very good shoreline protection, filter suspended solids, uptake nutrients, and facilitate substrate oxidation. Ninety percent of the biomass of marsh plants, such as black needlerush, is not consumed by herbivores. Instead, marsh plant biomass is decomposed to microbial biomass. This microbial biomass is available to primary consumers which initiate food webs leading to commercially important fishes and crustaceans

With its range of salinity tolerances, black needlerush is used in tidal estuary restoration along the Atlantic and Gulf coasts. Seed and vegetative parts of black needlerush are utilized by waterfowl, muskrats, nutria, rice rat, marsh rabbit and non-game birds. More than 60 bird species use black needlerush dominated marsh at least seasonally.

Figure 15: Black needle rush marsh on the Myakka River.

Saltmeadow cordgrass, *Spartina patens***,** also known as salt marsh hay, is a species of cordgrass native to the Atlantic and Gulf coast of the Americas, from Newfoundland south along the eastern United States to the Caribbean and northeast Mexico. It can be found in marshlands in other areas of the world as an introduced species and often a harmful noxious weed. It is a hay-like grass found in the upper areas of brackish coastal salt marshes. It is a slender and wiry plant that grows in thick mats 30-60 cm high, green in spring and summer, and turns light brown in late fall and winter. The stems are wispy and hollow, and the leaves roll inward and appear round. Because its stems are weak, the wind and water action can bend the grass, creating the appearance of a field of tufts and cowlicks. Saltmeadow cordgrass produces flowers and seeds on only one side of the stalk. Flowers are a deep purple from June to October and turn brown in the winter months. Saltmeadow cordgrass is found in high marsh zones where it is covered at times by high tides. Specialized cells are able to exclude salt from entering the roots, preventing the loss of fresh water. This grass is, however, less tolerant of saltwater than some other marsh grasses. These grasses provide rich habitat for crustaceans, mollusks, and birds, and serve as a major source of organic nutrients for the entire estuary. Mats of saltmeadow cordgrass are inhabited by many small animals and are an important food source for ducks and Seaside Sparrows. Saltmeadow cordgrass marshes serve as pollution filters and as buffers against flooding and shoreline erosion. During the colonial era, towns scattered from Narragansett Bay to the Gulf of Maine were often settled based on their proximity to salt marshes due to the importance of saltmeadow cordgrass for fodder. It was harvested for bedding and fodder for farm animals and for garden mulch. Before hay was baled and stored under cover, it was used to top the hay stacks in the fields.

Baker's cordgrass, *Spartina bakeri*, also known as sand cordgrass, is a robust bunchgrass that can form clumps that are 18 to 20 feet in diameter and up to 3 to 4 feet tall. Its fine-textured, wiry leaves form a fountain spray pattern. The upper surfaces of the 1/4 in. wide leaves are dark green, but the lower surfaces are light green in color. Its long erect light-green leaves are almost completely rolled and tapered to sharp points making it look somewhat rush-like. The alternate leaves are sandpapery on the upper side. The leaves become tan and then brown in the autumn. It blooms from spring to fall. The obscure flowers of this plant may occur in the early spring but are relatively scarce. The inflorescence is 2-8 in. long, comprised of 3-14 branches that ascend near the axis; flowers are conspicuous, only on the undersides of the branches; spikelets flattened. The plant reproduces mainly by rhizomes. It has soil tolerances for extended flooding; acidic; slightly alkaline; sand; loam; clay and a high drought tolerance. Salt tolerance is for moderate salinities. It prefers full sunlight. This cord grass is frequently found growing in brackish marshes but also will extend into fresh marshes, hydric pine flatwoods, wet prairies, and lake and borrow pit lake margins and usually occurs in wetlands (estimated probability 67%-99%), but occasionally found in non-wetlands.The seeds are important wildlife food.

<u>6) High marsh plants.</u> Located landward in drier areas behind black rush and cordgrasses. Diverse plants with flowers and fruits like sea-ox-eye daisey, daisey fleabane, marsh-mallow, marsh pimpernel, saltwort, sea purselane, saltwort, star flower, etc.

High marsh communities are typically located on higher elevations above mean high water and are not regularly flooded by tides. The fully expressed high marsh ecosystem is expressed as a series of parallel banded associations with characteristic vegetation and structure. These patterns can repeat and be symmetric if elevational differences repeat in progression from the sea to uplands to sea on an island or peninsula. These bands follow an elevational gradient that often is reflected in changes in substrate associated with vegetation contributions, or lack thereof, to surface soils.

The mixed, or combined, high marsh is the most common form of salt marsh in southwest Florida.

Figure 16: Mixed meadow high marsh of saltmeadow cordgrass and sea ox-eye daisy, Deep Lagoon Preserve.

Batis maritima (Saltwort, Turtleweed, Beachwort, Pickleweed, Barilla, Planta de Sal, Camphire, Herbe-à-crâbes, and Akulikuli-kai,) is a species of evergreen low growing, yellow-green shrub with succulent leaves halophytic flowering plant, native to the coastal salt marshes of warm temperate and tropical. It is prostrate where colonizing new mud or sand, but once rooted, growing bushy 10-100 cm tall, 2 m in lateral extent, and 5 cm in basal diameter. Stems are usually multiple as sprouts from the root crown, and as they become tall and heavy, lie down and root along the stems forming loose mats. Weak roots with light-tan, corky bark form tap and lateral root systems. The bark is grayish white; stem wood is weak and brittle. The glabrous leaves are succulent, linear or narrowly oblanceolate and round or three- to four-angled in cross section. They are bright green, but can also take on a reddish color. The species is dioecious. Tiny, white to yellow-white male and female flowers occur on different plants. The flowers are small, produced in non-showy spikes, flowering from mid-summer to fall. In Florida, saltwort flowers in the spring and fruits in the summer. Flowering and fruiting occurs year round in Puerto Rico. Little is known about seed production or germination. Most effective reproduction of the species appears to be vegetative. Sprouting from the root crown occurs with and without disturbance. Layering is a constant process of prostrate stems. New plants can be started by cuttings and probably broken pieces of plants are carried to new habitat by water and machinery. Fruits are axillary drupaceous, yellow-green syncarps 1 to 2cm long, Some botanists divide *B. maritima* into five species, with *B. californica*, *B. fruticosa*, *B. spinosa* and *B. vermiculatus* split off, but this interpretation is not widely followed.

Batis has the ability to live in salty environments. When other plants are exposed to salty soil or water, they lose most of their stored water, but *Batis* has adapted to this environment and does not have these problems. To help it survive in this salty habitat, its fleshy leaves are covered with very fine hairs that reduce the amount of water the plant loses to the air. Saltwort is uncommon to abundant in low-laying areas near seashores. It grows in salt marshes, at the upper edge of tidal flats, at the edge of mangrove stands, and between scattered mangroves. It is recognized as a major colonizer after mangroves are destroyed by hurricanes. Although it is not a water plant, it can endure brief flooding and long periods of waterlogged soils. Saltwort grows slowly in soils with high salt concentrations and areas with seawater overwash where it suffers little competition from other plants. The species manages salts by sequestering them in cell vacuoles and eventually shedding the leaves. It also grows in soils without salt but is vulnerable to competition from non-halophytes. The soils are usually sandy, marly, or gravely. Deposits of wrack (dead plant material) by high tides have been shown to be beneficial to the species. Saltwort is intolerant of shade. The species is not seriously affected by insects, disease, or grazing. The species is not seriously affected by insects, disease, or grazing. Not many animals can eat it because it is too salty, but white-tailed deer eat *B. maritima* as part of their diet, treating it as a salt lick. Saltwort serves as the larval and adult hosts for the great Southern white and Eastern pigmy blue butterflies. *B. maritima* is becoming rare in some areas, and some scientists think it should be added to the United States endangered species list. *B. maritima* was used by Native Americans as a food; the roots were chewed (like sugar cane) or boiled into a beverage while the stems and leaves were eaten raw, cooked or pickled. Saltwort has unexpectedly turned out to be a nutritious food source. An analysis of its peppercorn-sized seeds has revealed that they are extremely nutritious, having high quantities of proteins, oils and starches. According to Massimo Marco from an article published by New Scientist, the seeds are extremely edible, having a nutty taste, and they can be added to salads, toasted, or even made into miniature popcorn. The oil is almost identical to safflower oil, which is used for cooking and in salad dressings, as well as for making margarine. The seeds also contain beneficial antioxidants such as tocopherols, which are thought to fight cancer.

Limonium carolinanum, (Sea lavender, canker root, ink root, marsh root, American sea lavender, seaside thrift, Marsh Rosemary) is a perennial plant growing up to 6 to 24 inches high; branching flower stalks support small, 1 1/4 inch, delicate purple flowers. Dark green, leathery, spoon-shaped leaves surround the base of the plant in rosettes. 5-25(-40) cm; petiole often narrowly winged distally, 0.1-20 cm, usually shorter than blade; blade usually elliptic, spatulate, or obovate to oblanceolate (rarely linear), 5-15(-30) × 0.5-5(-7.5) cm, leathery, base gradually tapered, margins usually entire, sometimes undulate, apex rounded or acute to retuse, cuspidate, cusp 1-3 mm, soon falling; main lateral veins ascending, obscurely pinnate. The leaves of the sea lavender grow upward along its stem in sheaths, forming a tubular envelope that surrounds the stem. The sheath causes the flower to appear alternately and delicately arranged. The entire plant turns brown in the fall and winter. Inflorescences: axes not winged, 10-60(-95) cm × 1-5 mm, glabrous; nonflowering branchlets absent; spikelets loosely to moderately densely aggregated along branches, internodes 0.5-10 mm; subtending bracts 2-6 mm, obtuse, surfaces and margins glabrous; flowers solitary or 2-3(-5) per spikelet. Flowers: Its branches produce small, fragrant, pale purple flowers along one side. Sea lavender flowers originate from basal leaves that rise up directly from the plant's roots. calyx whitish, obconic, 4-6.5(-7.5) mm; tube 2.5-5 mm, glabrous or densely pilose along ribs; lobes erect, to ca. 2 × 1 mm; petals lavender (rarely white), slightly exceeding calyx. Utricles 3-5.5 mm. $2n = 36$.There is more or less continuous variation in this polymorphic species. Seedling establishment is rare, and that populations spread primarily by vegetative means from horizontal rhizomes. Moisture: Moist Wet. Soil pH: 6-8.5.Soil type: Clay Loamy Sandy. Salinity: 0-30 ppt

Lycium carolinianum, (Christmas berry, Carolina desert-thorn, Carolina wolfberry), *is* a small shrub that is commonly found in the southeastern United States at the edge of salt marshes and on sandy shell mounds. This 6- to 10-foot-tall shrub has rigid branches that are sharply thorn-tipped. The tiny deciduous leaves of this plant are succulent and linear to oblanceolate in shape; green, alternate, simple, entire, evergreen, less than 2 inches. Leaf venation is absent or difficult to see. There is no fall color change The new branches may have 1-centimeter-long thick spines, or be unarmed; older branches, however, are spiny. The bisexual flowers are solitary in the leaf axils and are borne on slender flower stalks. Flowers are blue; white, yellow, or lavender and have purple streaks. They are summer flowering to fall flowering Flowers are bee pollinated. The flowers are followed by large, bright, lustrous red oval, 3 to 6 inches long, fleshy berries that ripen in late autumn or early winter. Birds love to eat the ripe berries. It resembles a tomato and was eaten raw or dried by Native Americans. It is relished by whooping cranes and other wild fowl. *Lycium carolinianum* contributes 21-52% of crane energy intake early in the wintering period Fruit can be eaten by humans raw or cooked. Rather pleasant eating, the fruit has a slightly salty taste. The fruit is a berry up to 12mm in diameter. Only the fully ripe fruits should be eaten. The fruit is a very rich source of vitamins and minerals, especially in vitamins A, C and E, flavanoids and other bio-active compounds. It is also a fairly good source of essential fatty acids, which is fairly unusual for a fruit. It is being investigated as a food that is capable of reducing the incidence of cancer and also as a means of halting or reversing the growth of cancers. The Christmas berry is very tolerant to salt spray and drought conditions. In addition to its native sandy dune habitat, Christmas berry can be found naturally along the edges of ponds, salty marshes and waterways. On a well-drained or wet site that receives full sun or partial shade. Plants drop leaves in dry weather as a drought avoidance mechanism, but the next wet period bring new leaves. Growth is thin and the plant forms an open canopy in the shade. Suckers regularly form at the base of the trunks, creating a multi-trunked thicket. New plants develop from secondary branches and the whole plant moves itself along the ground. It grows well in semi-shade, and prefers high levels of water. This plant requires a minimum of 250 frost free days to grow successfully. It has no drought tolerance. Lycium carolinianum grows in soils ranging from a pH of 5.5 (very acidic ranges from 5.2 to 5.5) to 9 (very alkaline ranges from 8.6 to 9). It is adapted to clay, silt, sand, loam, silty clay, sandy clay, clay loam, silt loam, sandy loam, loamy sand, silty clay loam and sandy clay loam soils, and prefers low fertility.

Salicornia is a genus of succulent, halophyte (salt tolerant) plants that grow in salt marshes, on beaches, and among mangroves. *Salicornia* species are native to North America, Europe, South Africa, and South Asia. Common names for the genus include glasswort, pickleweed, and marsh samphire**.** The common name glasswort came into use in the 16th century to describe plants growing in England whose ashes could be used for making soda-based (as opposed to potash-based) glass. The Salicornia species are small, usually less than 30 cm tall, succulent herbs with a jointed horizontal main stem and erect lateral branches. The leaves are small and scale-like and as such the plant may appear leafless. Many species are green, but their foliage turns red in autumn. The hermaphrodite flowers are wind pollinated, and the fruit is small and succulent and contains a single seed. *Salicornia* species can generally tolerate total immersion in salt water. They use the c4 pathway to take in carbon dioxide from the surrounding atmosphere. *Salicornia* species are used as food plants by the larvae of some Lepidoptera species including the *Coleophora* case-bearers *C. atriplicis* and *C. salicorniae* (the latter feeds exclusively on *Salicornia spp*). *Salicornia virginica* (American Glasswort, Pickleweed) is a halophytic perennial dicot which grows in various zones of intertidal salt marshes and can be found in alkaline flats. It is native to various regions of the Northern Hemisphere including both coasts of North America from Canada to Mexico. The plant is one of the *Salicornia* species being tested as biofuel crop as it is composed of 32% oil and being a halophyte can be irrigated with salt water. *S. virginica* is classified as an *Obligate Wetland* (OBL) species which: "Occurs almost always (estimated probability 99%) under natural conditions in wetlands".

Salicornia bigelovii is a species of flowering plant in the amaranth family known by the common names dwarf saltwort and dwarf glasswort. It is native to coastal areas of the eastern and southern United States, as well as southern California and coastal Mexico. It is an annual herb producing an erect, branching stem which is jointed at many internodes. The fleshy green to red stem can reach about 60 centimeters in height. The leaves are usually small plates, pairs of which are fused into a band around the stem. The inflorescence is a dense sticklike spike of flowers. Each flower is made up of a fused pocket of sepals enclosing the stamens and stigmas; there are no petals. The fruit is a utricle containing tiny fuzzy seeds. The southern part of the species range is represented by the Petenes mangroves of the Yucatan, where it is a subdominant plant associate in the mangroves.

Both species are occasionally sold in grocery stores or appear on restaurant menus as *Sea Beans*. These plants are gaining scientific attention for the potential to serve as an oil crop that can be grown in desert environments and maintained with water containing high levels of salts. It is the source of Salicornia oil. The plant is up to 33% oil. The oil contains up to 79% linoleic acid and is functionally similar to safflower oil. It can be used as cooking oil and a replacement for more valuable oils in chicken feed. Domestic animals can be fed the plant as forage. The plant could also be a source of biofuel. Since the plant is a halophytic coastline species which grows in saltwater, it can be irrigated with seawater, making it a potential crop for landscapes that can support few other crop plants.

Figure 17: Annual glasswort, Estero Bay Preserve Park.

Figure 18: Perennial glasswort, Shell Point Preserve

There are two sea-oxeye daiseys encountered in the marshes of the study area: *Borrichia frutescens* and *Borrichia arborescens*. *Borrichia frutescens*, sea daisy, also called sea-oxeye, is an evergreen shrub that sprouts bright yellow flowers in the spring and summer. Sea daisy is a low, erect, evergreen shrub, usually less than 4' tall. It spreads into a thick clump by rhizomes. The leaves are simple, opposite and elliptical in shape. They are about 1" to 4" long and are very thick, almost succulent. The margins are usually entire but might have coarse teeth. The leaves are covered with dense fuzz that causes the leaf surfaces to appear gray. Bright yellow flowers are at the ends of the branches, in heads about 1" across. Flower centers are darker yellow. Below the flowers are leaf-like, spiny bracts. The fruit is a flat, gray, angled four-sided achenes, about ½" long. Sea Oxeye requires full sun and is drought tolerant but will not bear over-watering or overfertilizing. It takes breakage and shearing well.

*Borrichia arborescens***,** sea ox-eye, also known as tree oxeye, silver sea ox-eye, oxeye daisy, sea daisy, seaside tansy, gull feed, clavelón de playa, and fleur-sorleil bord de mar, is an evergreen, low shrub usually 1 m or less in height with stem diameters of 1 cm, which forms mounds and mats. Older plants have numerous stems. The plants are supported by short rhizomes and a moderate number of lateral roots. The stems are gray with a white, brittle wood and a 3-mm pith. Twigs bear deep leaf scars. The foliage tends to be crowded at ends of twigs. The simple, opposite, sessile leaves are fleshy and yellow-green, light-green, or gray green, oblanceolate to spatulate, entire, and 3 to 8 cm long. The foliage is resinous and aromatic. Sea ox-eye flowers are usually solitary, terminal heads about 2.5 cm across on peduncles 2 to 5 cm long. The corolla and the ray florets are bright yellow and the disk florets are orange-yellow. The black achenes are 3 to 4 mm long with a pappus in the form of a dentate cup less than 1 mm long. The chromosome number is 2n = 28..*Borrichia x cubana* of southern Florida is believed to be a natural hybrid of sea ox-eye and *Borrichia frutescens* (L.) DC.

In addition to being in the landward side of high marshes natural sea ox-eyes can also grow immediately near the seashore on sandy substrates, usually within the influence of salt spray. Because the species is low in stature, grows slowly, and is intolerant of shade, it must occupy areas with low competition from other shading vegetation. It finds these conditions on headlands, seaside rocks, dunes, beach strands, low hammocks, and the edges of mangroves and brackish high marshes. Sea ox-eye will grow in more favorable conditions if artificially protected from shade competition. Almost any soil will do, including both acid and alkaline soils. Sea ox-eye tolerates both excessively drained and poorly drained conditions. Mean annual rainfall may range from 900 to 1500 mm. It is drought resistant.

Both sea ox-eyes bloom in spring and summer in Florida and throughout the year in Puerto Rico and the Caribbean. It is pollinated by insects. Seed dispersal appears to be by water (storm surges) and strong winds. Once established, plants widen by constant layering of the semiprostrate stems. New clumps probably are established by the rooting of broken stems moved by storms. Growth of sea oxeye is slow. Branch extension is about 10 to 30cm/year. Although, stems and branches die, as long as conditions remain favorable, clonal plants may live almost indefinitely.

Figure 19: Seas ox-eye daisy in mixed high marsh, Deep Lagoon Preserve, Caloosahatchee River.

Saltmarsh goldenrod, *Solidago sempervirens*, is a succulent, herbaceous perennial that reaches heights of 4–6 feet. Flowers are found in radiate heads, which make up a terminal, paniculiform inflorescence with recurved-secund branches. This species blooms in late summer and well into the fall. Its fruits are wind-dispersed achenes. *S. sempervirens* is a maritime plant, and is accordingly found along the ocean from Mexico north to Newfoundland. It is naturally found inland along the St. Lawrence Seaway and the Great Lakes, and has expanded its range further inland along roadsides over the past 30 years. It is highly tolerant of both saline soils and salt spray, and is usually found growing on coastal dunes and in salt marshes. *S. sempervirens* is a maritime plant with a high salinity tolerance. It is a poor competitor and very shade intolerant. *Solidago sempervirens* is native throughout eastern coastal North America from Newfoundland to Florida and the Bahamas. It is also native along the Gulf Coast and southward to Tobasco, Mexico. It has become naturalized in the Great Lakes regions and in the Azores. *S. sempervirens* grows naturally along roadsides, in pinewoods, coastal marshes, estuarine and bay shores and in dry to damp soils. It is a wetland species that has high saline soil and salt spray tolerance are produced below the terminal inflorescence but without the pyramidal shape. Flowering stems are from 18 inches to 10 feet tall. The mass of the inflorescence is made up of many secunds (arranged on one-side of the axis only) that are somewhat backward curving (recurving). Individual secund appear at the leaf axis. Flowering begins at the top of the inflorescence and works its way down. When laden with flowers, the stem is inclined to arch downwards at or near the ground. The flowers are quickly replaced by masses of fine white bristles known as pappi.

Seaside goldenrod pollen is too heavy and sticky to be blown far from the flowers, and is mainly pollinated by insects. It is a nectar plant for several butterfly species including the clouded sulphur, purplish copper, gray hairstreak, snout butterfly, silver bordered fritillary, pearl crescent, viceroy, wood nymph, monarch and eastern tailed blue.

Figure 20: Seashore goldenrod, Sanibel-Captiva Conservation Foundation.

Sea blite, *Sueda linearis*, is an annual herb found in the beaches, mangroves, and salt marshes of Florida, being most common in the southern part of the states. It is found in coastal plains from southern Canada, south to Florida and west to Texas. This annual plant appears in the spring, blooms in the summer, turns color in the fall and will die off in the late fall/early winter

Sea blite is a straggly, herbaceous annual with a waxy appearance. It may be reclining or erect, from 1' to 3' tall, and heavily branched. The leaves are simple, alternate, ½" to 2" long, and linear to elliptical. They are dark green and fleshy with a smooth, waxy surface and entire margins. Leaves generally lack a stem and are directly attached to the stem. The flowers are tiny, whitish, button-like blooms that appear from July to October. The fruit is a round sac containing many, glossy, black seeds. Sea blite has a succulent, somewhat woody stem that is pale green to almost white. This plant requires a salty environment and grows saltwater marshes, mangroves, and along beaches and dunes.

Native Americans in Florida used sea blite to add flavoring to foods and they ground the seeds into a flour to make bread. Both Native Americans and colonial settlers chewed the roots of the plant as a cure for diarrhea. Leaves were used to treat and bind wounds. Young leaves and stem tips are still used as culinary herbs today.

7) Salt tolerant grasses- *Distichlis spicata*, Key grass, *Monanthachloe littoralis, and* Seashore dropseed**,** *Sporobolus virginicus***.** On the slopes behind the marsh plant in salt grass, seashore dropseed and key grass. These salt tolerant grasses can be maintained as a lawn but they do not need water, fertilizer and are very salt tolerant.

Distichlis spicata is a species of grass known by several common names, including seashore saltgrass, inland saltgrass, and desert saltgrass. This grass is native to the Americas, where it is widespread. It can be found on other continents as well, where it is naturalized

Distichlis spicata thrives along coastlines and on salt flats and disturbed soils, as well as forest, woodland, montane, and desert scrub habitats. It can form dense monotypic stands, and it often grows in clonal colonies. Non-clonal populations tend to be skewed toward a majority of one sex or the other. The grass forms sod with its hearty root system. *Distichlis spicata* is a hardy perennial with rhizomes and sometimes stolons. It is an erect grass which occasionally approaches half a meter in height but is generally shorter. The solid, stiff stems have narrow leaves up to 10 centimeters in length, which may be crusted with salt in saline environments. Its rhizomes have sharp points which allow it to penetrate hard soils and aerenchymous tissues, which allow it to grow underwater and in mud. This plant grows easily in salty and alkaline soils, excreting salts from its tissues via salt glands.

Flowers are an inconspicuous yellow and bloom in mid-summer. This species is dioecious, meaning the male flowers and female flowers grow on separate individuals. The pistillate inflorescence may be up to 8 centimeters long, with green or purple-tinted spikelets. The staminate flowers look quite similar, thinner but larger overall and denser. The flower parts of both sexes may be bright pinkish-purple. Fruit in summer with a seed color is brown, Growth rate is slow. The active growth period is spring, summer, and fall. It has a high C: N ratio in its stems. Mature height is 1.1 feet. It has a long lifespan. It has a high tolerance to anaerobic conditions and $CaCO_3$. Root depth is 2 inches. The precipitation min/max is 5 inches/70 inches. pH min/max is 6.4/10. Temperature, Minimum is 35(°F). The number of Frost Free Days, Minimum is 80.The National Wetland Indicator status is FAC+, FACW+.

Under favorable soil and moisture conditions, studies have shown saltgrass favorable for pastures irrigated with saline water. The total dry matter yields were 9,081 kg/ha with a total protein production of 1,300 kg/ha. Saltgrass is grazed by both cattle and horses and it has a forage value of fair to good because it remains green when most other grasses are dry during the drought periods and it is resistant to grazing and trampling. It is cropped both when green and in the dry state; however, it is most commonly used the winter for livestock feed. Saltgrass along the Atlantic coast was the primary source of hay for the early colonists.

Key grass, *Monanthachloe littoralis*, is a perennial salt marsh grass with stolons or runners present, Stems are trailing, spreading or prostrate, Stems nodes are swollen or brittle, Stems are erect or ascending, Stems are geniculate, decumbent, or lax, sometimes rooting at nodes, Stems are caespitose, tufted, or clustered, Stems are terete, round in cross section, or polygonal, Stem internodes are hollow, Stems have an inflorescence less than 1 m tall, Stems, culms, or scapes exceeding the basal leaves, Leaves mostly cauline, Leaves conspicuously 2-ranked, distichous, Leaves sheathing at base, Leaf sheath mostly open, or loose, Leaf sheath smooth, glabrous, Leaf sheath and blade differentiated, Leaf blades very short, 0.5-2 cm long, Leaf blades subulate, needle-like, tip pungent, Leaf blades very narrow or filiform, less than 2 mm wide, Leaf blade margins folded, involute, or conduplicate, Leaf blades mostly glabrous, Ligule present, Ligule a fringe of hairs, Inflorescence terminal, Inflorescence solitary, with 1 spike, fascicle, glomerule, head, or cluster per stem or culm, Inflorescence a single spikelet, Flowers unisexual, Plants are dioecious, Spikelets pedicellate, Spikelets dorsally compressed or terete, Inflorescence or spikelets partially hidden in leaf sheaths, subtended by spatheole, Spikelet less than 3 mm wide, Spikelets with 2 florets, Spikelets with 3-7 florets, Spikelets solitary at rachis nodes, Spikelets unisexual, Spikelets disarticulating below the glumes, Glumes completely absent or reduced to cuplike structure, Lemma coriaceous, firmer or thicker in texture than the glumes, Lemma 8-15 nerved, Lemma glabrous, Lemma apex acute or acuminate, Lemma awnless, Lemma straight, Palea present, well developed, Palea membranous, hyaline, Palea about equal to lemma, Palea 2 nerved or 2 keeled, Palea keels winged, scabrous, or ciliate, Stamens 3, Styles 2-fid, deeply 2-branched, Stigmas 2, Fruit - caryopsis.

Seashore dropseed**,** *Sporobolus virginicus***,** is a rhizomatous perennial with lanceolate, spine-tipped leaf-blades growing 15-50 cm tall, erect, from creeping, hard, scaly rhizomes. *Sporobolus virginicus* is known by numerous common names including seashore dropseed, sacaton, marine couch, sand couch, coastal rat-tail grass, salt couch grass, saltwater couch and nioaka, Inflorescence dense, spikelike, up to 15 mm wide with short appressed branches and pale spikelets. Leaf- blades usually rolled inward, distinctly two ranked, 3-10 cm long and 1.5-4 mm broad; sheaths mostly overlapping, glabrous except for a few long hairs on either side of the collar The inflorescence is a contracted panicle, spicate, densely flowered; .Spikelets are straw-colored, grayish, or purple tinged, glabrous, shining .The panicle is shorter than many other Sporobolus spp., being not more than 7.5 cm long. Its flowers are green or purple from May to October and occasionally to December. It reproduces asexually by use of both stolons and rhizomes. It produces seed several times throughout the year. Fruit is a caryopsis. A caryopsis is a type of simple dry fruit, one that is monocarpelate (formed from a single carpel) and indehiscent (not opening at maturity) and resembles an achene, except that in a caryopsis the pericarp is fused with the thin seed coat. The caryopsis is popularly called a grain and is the fruit typical of the family *Poaceae* (or *Gramineae*).It has a wide range of soils, from clays to sands. It grows on highly saline marsh soils. It makes some growth all the year. It does best if the water level fluctuates from 5 cm above the soil surface to 15 cm below. Prolonged inundation kills it.

Figure 21: High Marsh Meadow Grasses (saltgrass, Key grass and seashore dropseed).

8) Low dune with back swale. Either formed by the existing path or built up slightly as a low berm that may be stabilized by a filter fabric.

Figure 22: Back swale located landward of the shell path at the south end of Pelican cove.

<u>9) Regular lawn or other upland plants currently present at Pelican Cove.</u> This area is the remainder of the exterior upland areas of Pelican Cove located at higher than the living shoreline planting zones. Future plantings should be made from available native plant species.

Figure 23 Existing Pelican cove lawn and vegetation are at greater than 5 foot elevation.

There are many benefits of living shorelines that are not provided by traditional shoreline hardening. These include

1. Stabilization of the shoreline.
2. Reduction of storm surges.
3. Protection of surrounding riparian and intertidal environment.
4. Detention of surface water run-off.
5. Improvement of water quality via filtration of upland run-off.
6. Retention of sediment and other particulates.
7. Transformation of nutrients to less harmful forms.
8. Decreases the amount of harmful nutrients and pollutants entering coastal waters.
9. Sequestration of carbon (some of the highest measurement of carbon sequestration in the world is in mangroves).
10. Creation of habitat for aquatic and terrestrial species.
11. Increases wildlife access to critical habitats, including feeding and nesting sites for water-fowl, waterbirds, other birds and nursery habitats for commercially and recreationally important species of shellfish and fishes.
12. Provides a natural buffer that absorbs wave energy and reduces coastal erosion.
13. Increases aesthetic value, enhances views, and creates a sense of place and privacy.
14. More cost efficient than structural stabilization in low-energy environments.

Living shoreline methods are the most cost effective and least expensive form of attenuating shoreline erosion, keeping pace with slower rates of sea level rise, and providing a aesthetically pleasing habitat that supports fisheries and wildlife while stabilizing sediments and improving water quality. Depending upon the design the construction costs for living shoreline projects and other stabilization methods vary depending on the shoreline length, level of protection needed, and the costs for materials and labor. Non-structural methods cost an average $50 - $100 per foot, such as supplementation nourishment and planted marshes. (Living Shorelines FAQ 2017). Other sources indicate a living shoreline installed cost of $361 per foot

Table 1. Cost Estimates for Shoreline Protection Products

Type of Erosion Control	Item	Cost range ($/unit)	Cost Installed ($/unit)	Comments
Vegetative Cover				
Wetland Plants	Smooth Cordgrass *Spartina alterniflora*	1.00-2.00/ft	2.50-4.50/ft	Based on 1-foot plant spacing
	Saltmeadow Cordgrass *Spartina patens*	0.60 -1.60/ft	1.30-3.50/ft	You will need to plant multiple rows for shoreline protection.
Dune Plants	Sea Oats *Uniola paniculata*	0.60 -1.60/ft	1.30-3.50/ft	
	Panic Grass *Panicum amarum*	0.60 -1.60/ft	1.30-3.50/ft	
Maintenance: Remove debris, prune trees, fertilize based on soil test and keep people out of the area as much as possible.				
Soft, non-structural stabilization				
Erosion control blankets	Straw blanket	0.29/yd^2		
	Coconut straw blend	0.52/yd^2		
	Coconut fiber	0.65/yd^2		
	Non-woven geotextiles	0.30-1.35/yd^2		
Maintenance: Straw and coconut fabrics are biodegradable and are used to aid with growth of new vegetation.				Geotextiles have very long life spans if they are buried. They are UV sensitive.
Shoreline Revetment	Riprap	18-35/yd^3	120-180/ft	Based on a 2:1 slope.
Maintenance: Typically very little, may need to add new rock over time.				
Offshore Breakwater	Oyster shell		45-55/yd^3	
	Oyster shell bag	5/bag		
	Oyster shell bag/spat	30/bag		
	Wave attenuation device		180-250/ft	
	Rock breakwater		125-200/ft	Based on a 2:1 slope.
	Wooden sills		65-100/ft	
Maintenance: Addition of oyster shell or rock over time. Wooden sills should be routinely inspected to determine overall condition.				
Hybrid Structures: Cost of shoreline or marsh planting + price of particular breakwater installed.				
Bulkheads	Vinyl	125-200/ft		Based on 4 to 8-foot height
	Vinyl with toe protection	210-285/ft		
	Wooden	115-180/ft		Includes labor and materials (earthwork and backfill)
	Wooden with toe protection	200-265/ft		
Maintenance: Scour typically happens to bulkheads so toe protection may be needed based on the site. Additional fill and vegetation may need to be installed over time.				

This table is a partial list of costs associated with shoreline protection products based on the Manufacturer's Suggested Retail Price and cost estimates from marine contractors. This list is to be used for the Northern Gulf of Mexico. Prices are subject to change. Some costs are based on assumptions, such as size, height or percent slope of erosion control structures. The following businesses and people provided information to develop this table: Carthage Mills, Spencer Rogers, Dauphin Island Construction, Bayside Seafood, Inc., Auburn University Shellfish Lab, Dune Doctors, Dolan Marine, Sea Horse General Contractors, Coastal Restoration, Inc., and Artificial Reefs, Inc.

Source: NOAA MASGP-07-031

2. Sediment Supplementation

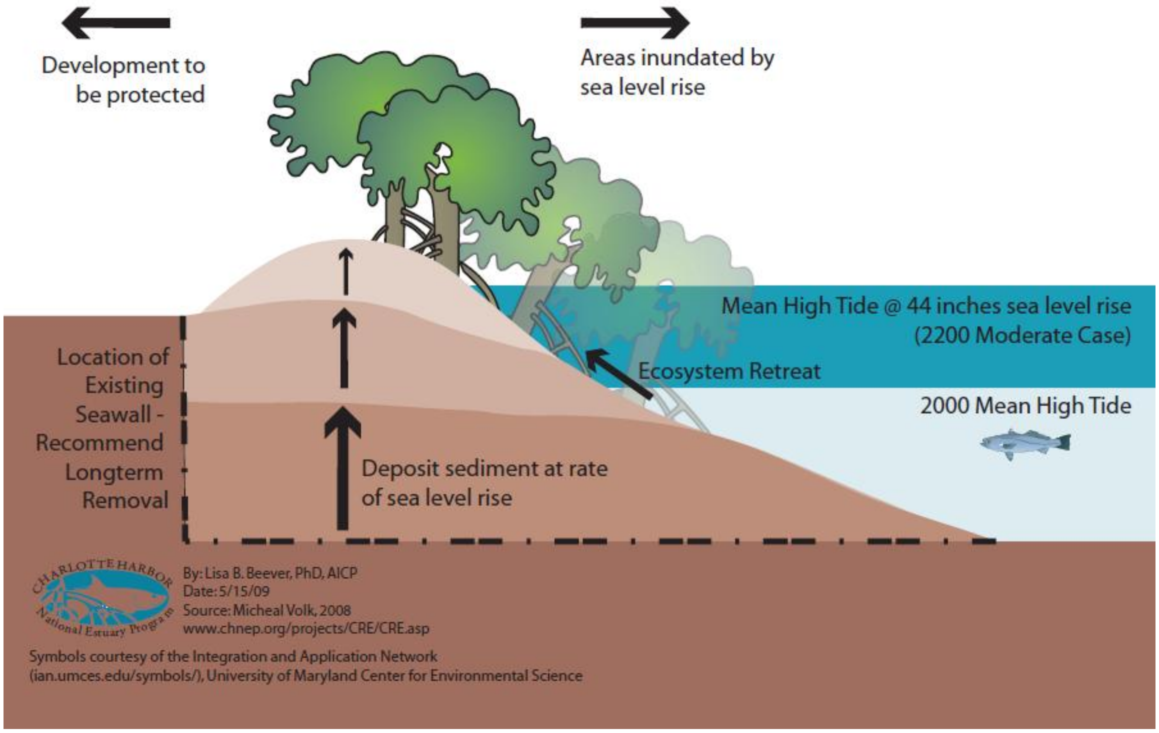


Figure 24: A method of gradual filling of areas in front of shoreline protection to keep pace with sea level rise. Based upon Volk 2008.

A second option is to maintain or establish ecosystems seaward of the existing shoreline, which can migrate up to the existing shoreline position. With this option, shoreline ecosystems may exist while maintaining an essentially static shoreline. The goals of a strategy such as this would be to maintain the same level of protection as would be gained through construction of a traditional protective structure such as a dike, to reestablish, maintain, and facilitate the adaptation of functional shoreline ecosystems, and to spread shoreline protection costs spread over a long period of time in keeping with rate of sea level rise. Several important issues created by this strategy, which could preclude its use, are available sediment sources, source of funding, and upland drainage issues. It should be noted that drainage of uplands will be an issue with any strategy protecting lands lower than the mean high tide.

An alternative that does not require an offshore berm is the placements of fill hydrologically at and behind the existing mangrove fringe at Pelican Cove at a rate equivalent to or slightly higher than the current rate of sea level rise. Utilizing the method of gradual sand filling to keep pace with sea level rise the current estimate for careful hydrologic sand placement would be in the neighborhood of 1.5 million for each mile of shoreline.

3. Dune/ Berm Construction

Naturally occurring sand dunes are wind-formed sand deposits representing a store of sediment in the zone just landward of normal high tides . Artificial dunes are engineered structures created to mimic the functioning of natural dunes. Dune rehabilitation refers to the restoration of natural or artificial dunes from a more impaired, to a less impaired or unimpaired state of overall function, in order to gain the greatest coastal protection benefits. Artificial dune construction and dune rehabilitation are technologies aimed at reducing both coastal erosion and flooding in adjacent coastal lowlands. The description of this technology originates from Linham and Nicholls (2010).

Dunes naturally occur along most undeveloped, higher energy sandy coastlines. Where they are present, their coastal defense role is two-fold:

1) They represent a barrier between the sea and land, in a similar way to a seawall

2) Dunes are 'dynamic', i.e. the dune/beach system interacts a great deal and is constantly undergoing small adjustments in response to changes in wind and wave climate or sea level. As such, dunes are able to supply sediment to the beach when it is needed in times of erosion, or store it when it is not (French, 2001).

The importance of dunes in coastal protection has been recognised and the construction of artificial dunes and rehabilitation of existing ones are potential technologies for adapting to climate change in the coastal zone.

At its simplest, artificial dune construction involves the placement of sediment from dredged sources on the beach or shoreline. This is followed by reshaping of these deposits into dunes using bulldozers or other means. As a result, dune construction is most frequently carried out at the same time as beach nourishment, because sand is readily available. Alternatively several Florida coastal communities are now purchasing sands from inland borrow pits and having in transported for placement on the coast.

There are a number of methods of dune rehabilitation. One such method is to build fences on the seaward side of an existing dune to trap sand and help stabilize any bare sand surfaces (USACE 2003). This method can also be used to promote dune growth after a structure has been created using bulldozers (Nordstrom & Arens 1998). Natural materials such as branches or reed stakes are commonly used for fence construction, because they break down once they have accomplished their sand-trapping objective (Nordstrom & Arens 1998).

Alternatively, vegetation planting can be used to stabilize natural or artificial dunes. This promotes the accumulation of sand from wind-blown sources around their stems – over time, this causes dune growth. Planting can be achieved by transplanting vegetative units from nursery stocks or nearby intact dunes (USACE, 2003). It can be undertaken at the community level using widely available tools. Over time, dune vegetation root networks also help to stabilize the dune. Typical species used include sea oats *Uniola paniculata*, bitter panicum *Panicum amarum*, gulf cordgrass *Spartina spartinae*, marshhay cordgrass *Spartina patens*, seashore paspalum *Paspalum vaginatum*, seashore dropseed *Sporobolus virginicus*, and railroad vine *Ipomoea pes-caprae*..

Sandy beaches are very important for dissipating wave energy. However, sandy beaches are in a constant state of flux, because they continuously react to constantly changing wave climates and sea levels. As such, the volume of sand held upon a beach is constantly fluctuating. During periods of low beach volume, the shoreline is susceptible to erosion and it is at these times, that sand dunes can be particularly valuable as a store of sediment which can be accessed in order to satisfy erosional forces. This compensates for the sand removed from a beach and helps to maintain wide, sandy beaches which will continue to dissipate incoming wave energy. The volume of erosion can be calculated using the Vellinga (1983) equation which requires knowledge of wave height, extreme water level and sediment fall velocity.

With careful management, dunes are able to offer a high degree of protection against coastal flooding and erosion. Dunes are naturally occurring features, and provided the construction/initiation of artificial dunes is completed in a sympathetic manner, they do not necessarily spoil the local landscape aesthetic. Sand dunes also provide a valuable coastal habitat for many highly specialized plants and animals. As such, sand dunes may be considered important both ecologically and recreationally.

Dunes have a reasonable sized footprint. This space requirement increases further if dunes are to be given sufficient room to adapt to SLR, thus avoiding coastal squeeze. It could be controversial to use land with development potential for dune creation and rehabilitation if the full benefits are not made clear.

Factors which are likely to influence the unit costs of dune construction are:

- Whether dredged material is required for dune construction/restoration or whether fences or vegetation can be used to promote sand accumulation
- Availability and proximity of appropriate clean dune construction material from nearby sites in Little Sarasota Bay and Clower Creek
- Dredger type, size and availability
- Costs to fence newly constructed dunes to prevent erosion
- Costs for planting new dunes with vegetation
- Frequency with which the dune needs to be artificially replenished or whether the structure naturally accumulates sand
- Project size and resulting economies of scale
- While dune construction using dredged sand may require specialized knowledge and equipment, rehabilitation and maintenance of naturally occurring and artificially created dunes is accomplishable at a community level.

- The application of fences to stabilize bare sand and encourage dune growth is possible using local, naturally occurring materials such as branches and reed sticks (Nordstrom & Arens, 1998). The measure therefore requires very little external provision of materials or guidance. Fencing can also prevent dune erosion caused by human access.
- As already mentioned, vegetation planting is frequently accomplished at the community level with subsequent maintenance also left to communities (Nordstrom & Arens, 1998). The success of this approach has been found to vary considerably with local commitment (Nordstrom & Arens, 1998). Local awareness raising campaigns could help local communities better understand the coastal protection role of dunes, which may promote local efforts to continue to preserve dunes.
- Once sufficient material for the creation of dunes is available, dune creation either through naturally occurring processes or through artificial placement, movement and reshaping of the material is another task achievable with limited technology requirements. The use of a bulldozer or other earth moving equipment is sufficient to undertake ad-hoc operations to reshape or repair dunes. Sediment may even be bulldozed from dune crests and placed in lower areas if the dune crest height exceeds design specifications (Nordstrom & Arens, 1998).
- Previous experience of artificial dune creation or rehabilitation projects has shown that one major barrier is the difficulty in convincing the public and municipal officials of the need for dune construction or heightening for a private community (Nordstrom et al., 2000).
- Dune grass planting costs between $250-$2,500/100m length for each visit; the lower cost estimates are for small schemes largely carried out by volunteers; the higher costs for large schemes undertaken by contracted operators. Costs for transplanting are dependent on labor costs, sources of transplants, extent of works, the need for ongoing management and the cost of ancillary works.
- Fencing costs are around $500-$2,500/100m frontage length, excluding costs of transplanting and on-going repairs. Fencing costs vary according to labor, type of material used, quality, length and spacing of posts, frequency of spurs, number of public access points, need for management and the cost of ancillary works.
- Dune construction costs are of similar range as beach nourishment costs.

The dune system adaptation need for the Pelican Cove shoreline would initially not need to any taller than 4 feet at the crest to account for potential sea level rise through the next 50 years. It will be useful for lower levels of strong surge resulting from tropical storms and weaker Category 1 hurricanes.

4. Elevating Piling Docks

Piling docks are constructed by driving pilings, generally robust wooden beams with a cylindrical appearance, into the lakebed. The decking is connected to the pilings to form a structurally sound and attractive dock. Estimates vary, but in general, homeowners should budget for between $20 and $40 per square foot for a basic piling dock and more for one with aesthetic features or high-end construction.

They are more expensive than floating docks due to the added difficulty of installation. Piling docks are permanent and durable if maintained properly. They also offer homeowners more options to customize the dock. Adding electrical for a boatlift or mooring system is a possibility here. It is recommended that future dock rebuilds at the Marina Basin should be constructed 3 feet higher than the current height to account for the range of future sea level rise rate for the next century.

5. Floating Docks

A floating dock is constructed by placing decking over airtight barrels or drums. These float and can accommodate a certain amount of weight on top of them. The amount of weight the dock can bear is influenced by the size and number of barrels used in construction along with the type and weight of the decking. A floating dock may cost between $20 and $35 per square foot, depending on the choice of decking.

Compared to other styles, a floating dock has advantages and disadvantages. These docks tend to be less expensive, and they can easily be removed from the water during the winter with a little planning. Their repair and upkeep tend to be manageable as well. Unfortunately, floating docks are less stable. They move with the flow of water, which makes them suited for use with water levels that rise and fall, but not with moving water, such as rivers and creeks.

Floating docks are a very good alternative for mooring areas since they adjust with the tidal range and sea level rise height. They are also useful for canoe and kayak launch platforms. Depending on design a floating dock can also be coupled with floating island water quality treatment features. Floating docks that are not solid metal are recommended for all active docking areas with sufficient mooring pilling heights to account for a 6 foot storm surge.

6. Increased Ground Floor Elevations When Rebuilding

The climate conditions, molds and insects of southwest Florida are very hard on human infrastructure and buildings. Repair and replacement in order to maintain building integrity are a regular and constant effort. Most wooden buildings have an effective half-life of about 70 years And younger more recently built wooden structures with dry-wall interiors have approximately half of that due to issues of moisture, rot an insect attack. When the time comes for rebuilding structures at Pelican Cove when they have reached the effective life consideration should be given to building to new higher ground living floor elevation commensurate with anticipated sea level rise within that century and if space is available selecting a new site at a higher existing elevation a anew foundation location. These issues will not be a matter of major consideration until the next century but long-term planning can provide significant improvements in energy efficiency, storm hardening, and wind protection.

Adaptations to protect and improve the water quality in Clower Creek and Little Sarasota Bay.

The potential sea level rise and increased rainfall and storm activities that will increase runoff and negatively impact Little Sarasota Bay Watershed and the water quality in Clower Creek and Little Sarasota Bay, as well as structures, grounds, and infrastructure at Pelican Cove are the result of change in air temperature and chemistry and changes in water temperature and chemistry that generates a climate instability that alters hydrology, results in geomorphic changes and impacts to the habitats and species of Little Sarasota Bay and the Clower Creek system. This section of the reports examines the Options Examined for Water Quality Protection From Climate Change.

The recommended options for water quality improvement include sediment dredging (either spot dredging or removal of all anoxic silt), floating Islands, filter feeders structures (reef balls or similar structures, oyster strings, and cam bags),and pretreatment for drains.

7. Sediment dredging of anoxic sediments can after their removal improve dissolved oxygen in enclosed water bodies such as the Harbor basin and Clower Creek. There are areas in the Harbor basin and in Clower Creek at and above the water control structures west of the bridge that have filled with sediments that are anoxic – lacking in oxygen. The Harbor Committee has a bottom survey of the Harbor and channel that indicates location where spot dredging should be done. These are associated with areas of drainage outfall to the basin and reflect the solids and silts that are transported and deposited by run-off. Hydrologic dredging is the best approach for soft silt removal. There is a location for silt deposit and control during dredging located in the parking area on the north side of the Harbor.

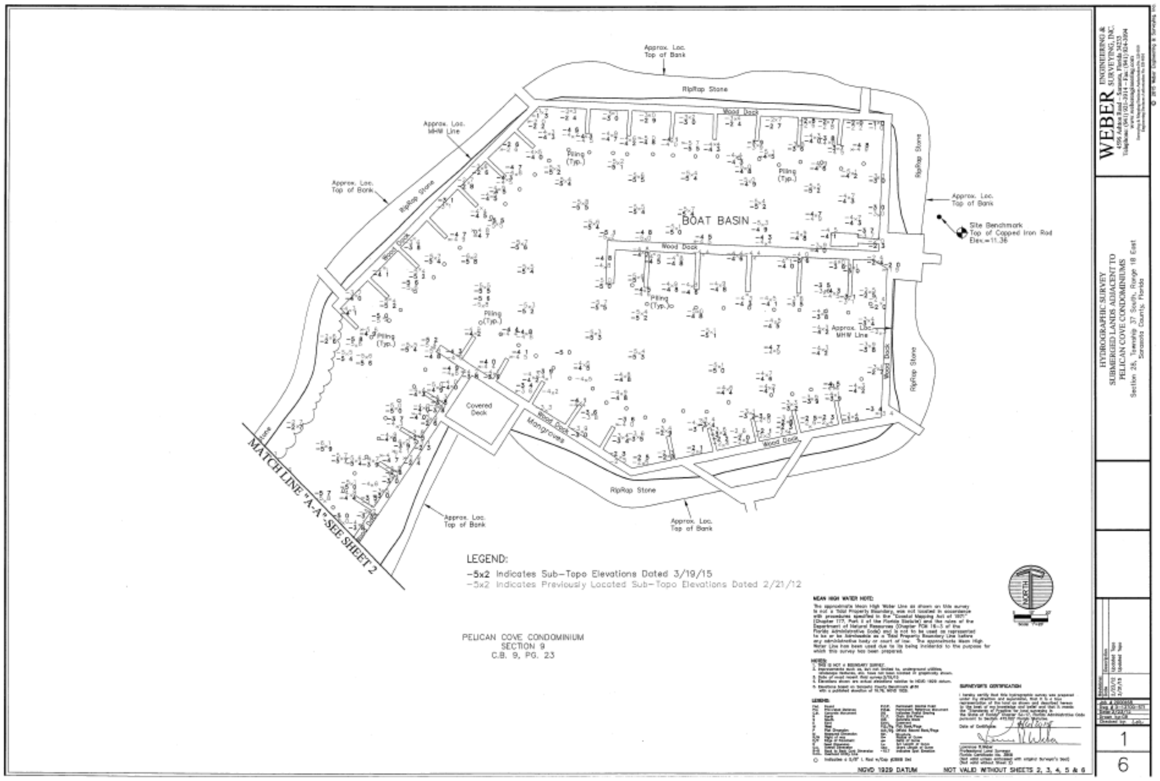


Figure 25:: Bathymetric Survey of the Marina Basin by Weber Engineering

Figure 26: Example of sediments in the Marina Basin at a location near a drain pipe discharge.

8. Floating Islands are a water quality improvement method that utilized man-made floating structures designed for the planting wetland plants that will root through into the waterbody. The patented floating plant mat consists of puzzle cut mats held together by nylon connectors. These mats may be assembled in any size or shape. After the mats are connected, plants are inserted into pre-cut holes. The plants may be any species of emergent aquatics. The mats can be attached to anchors or shoreline stakes. As plants grow, the excess nutrients in the water are taken up and stored in their tissues. Periodic harvesting of the mature plants prevents the stored nutrients from re-entering when the plants die and decompose. The floating wetland system provides an easy way to remove the entire plant and replant the mats to increase nutrient removal. This takes care of fluctuating water levels, produces oxygen, takes nutrients and pesticides out of the water, and provides habitat for wildlife utilization.

Most of the treatment of nutrient rich water within a wetland occurs in the thin aerobic layer at the surface of the soils within plant communities. This aerobic biofilm is a result of oxygen leakage from the plant roots at the soil-water interface. In an effort to more efficiently utilize the natural ability of macrophytes to extract and store nutrients from surface water, the designed floating mat system suspends native emergent plants and grasses. Expanding the root zone that is in contact with the water column increases the thickness of the aerobic layer, resulting in increased nitrification and accelerating the process in which nitrogen is cycled from the aquatic environment to the atmosphere. The greatly expanded root mass also facilitates increased uptake and storage of inorganic phosphorus in the plant tissues by creating more surface area for beneficial bacterial colonization. The periodic removal of mature macrophytes from the floating plant mat, prevents the accumulated nutrients from re-entering the aquatic ecosystem at senescence. Those plants are then composted at an upland location, allowing bacterial decomposition to release some of the organic phosphorus so it can be recycled and used as a fertilizer ingredient for growing soil mixtures. The foam and nylon parts of the floating plant mats are re-used to start a new cycle of plant growth and nutrient uptake., including nitrogen, phosphorous and depending on the plant chosen other pollutants including heavy metals, some pesticides, and some pharmaceuticals. This reduces the fuel for algae blooms in the waterbody, increases the dissolved oxygen concentration in the waterbody, reduces dissolved solids and increase water clarity.

Figure 27: Residential lake BEFORE floating islands and aerators

Figure 28: Residential lake AFTER floating islands and aerators

Figure 29: A recently planted floating island (7th Avenue North Lake, Naples, FL)

Figure 30: A mid-season floating island with a bird fence (6th Avenue North Lake, Naples, FL)

Figure 31: A late summer floating island (East Lake, Naples, FL)

There are at least 200 different native plant species that can be planted in floating islands depending on the salinity an temperature range of a water body.

In studies it has been shown that the BioHaven floating islands system when coupled with aeration is the most cost effective means to reduce phosphorous pollution.

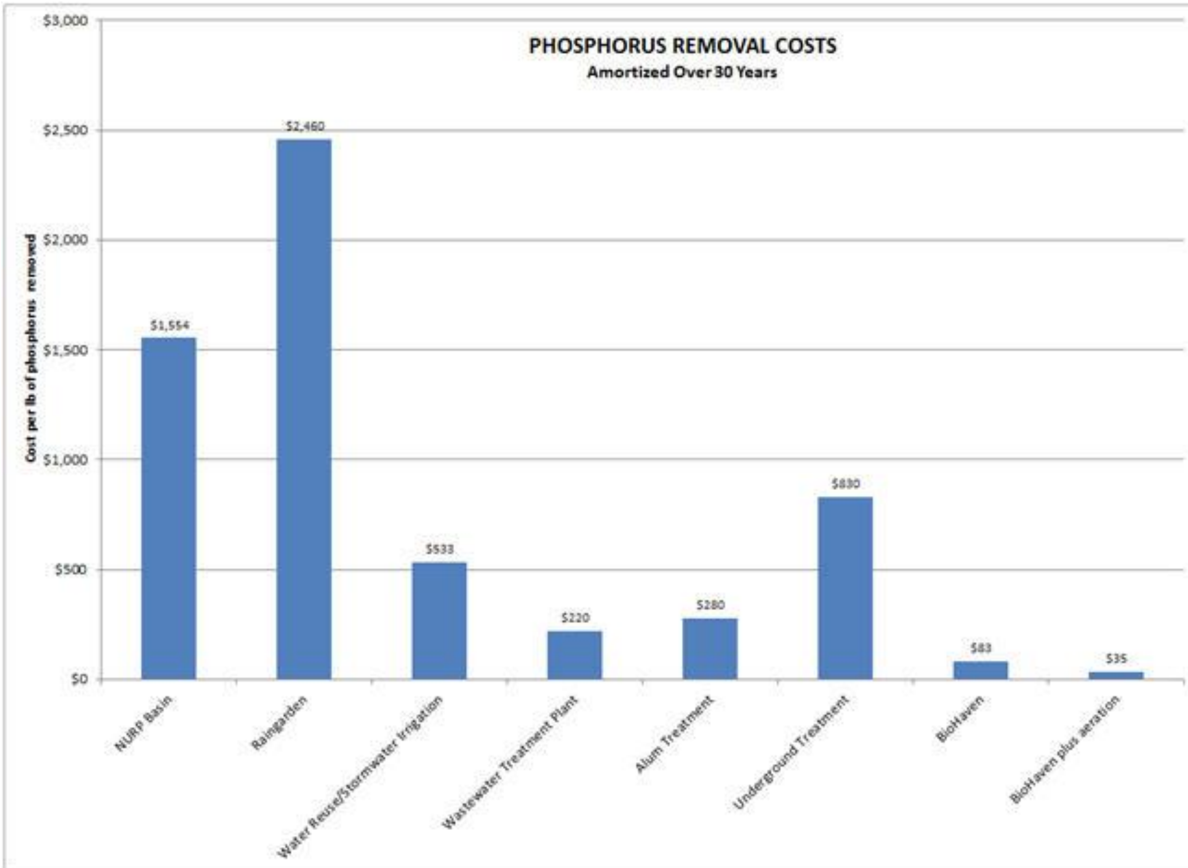


Figure 32: Phosphorous removal costs using different methods.

The BioHaven® Floating Island Design Specifications are recycled PET plastic matrix 8 inches thick with injected marine foam for buoyancy. There are built-in anchor points. A PVC frame with cable to connect island sections together. Planting holes on 8-inch centers are present through the first 2 layers, with 2.5 inch diameter circles. It can be custom shaped. The costs are $25/square feet for basic design. Costs range $25-30 per sq ft depending on customization

Sources for floating islands include:

Beemats Floating Wetlands
http://www.beemats.com/home.html

Aqua Biofilter
http://www.aquabiofilter.com/

BioHaven® floating islands
http://www.floatingislandinternational.com/products/biohaven-technology/

More information on the City of Naples Floating Islands Program can be found at:

City of Naples Lake Aerators and Floating Islands
http://www.naplesgov.com/index.aspx?NID=360
Bee Mats for the City of Naples
http://www.beemats.com/city-of-naples.html
BeeMats Video (mats are featured starting at 7.22)
https://www.youtube.com/watch?v=mu5dib32tew&feature=youtu.be
Naples Daily News Article
http://www.naplesnews.com/opinion/guest-commentary-those-new-islands-naples-city-lak
Martin Ecosystems is an environmental technology company that manufactures and supplies BioHaven® Floating Technology and EcoShield™.
http://www.martinecosystems.com/

9. Filter feeders are a sub-group of suspension feeding animals that feed by straining suspended matter and food particles from water, typically by passing the water over a specialized filtering structure. Filter Feeder Structures provide structure for aquatic animal organisms that filter water to obtain their food and in the process remove particles and nutrients from the water column. These organisms include oysters, clams, sea squirts, barnacles, sponges, gorgonians, soft corals, hydras, colonial tunicates, and some tube worms.

Over the last decade, scientific research has been conducted with respect to the ability of artificial reefs to produce or attract biomass, and the effectiveness of reef balls in replicating natural habitat and mitigating disasters. The use of reef balls as breakwaters and for beach stabilization has also been extensively studied.

The Reef Ball Foundation manufactures reef balls for open ocean deployment in sizes from 30 centimeters (1 ft) in diameter and 15 kilograms (33 lb.), up to 2.5 meters (8.2 ft) and 3,500 kilograms (8,000 lb.). Reef balls are hollow, and typically have several convex-concave holes of varying sizes to most closely approximate natural coral reef conditions by creating whirlpools. Reef balls are made from pH balanced micro silica concrete, and are treated to create a rough surface texture, in order to promote settling by marine organisms such as corals, algae, coralline algae, and sponges.

The Reef Ball Foundation was started in 1993 by Todd Barber, who founded the Reef Ball Development Group INC. with a goal of helping to preserve and protect coral reefs for the benefit of future generations. An avid scuba diver, Barber witnessed his favorite coral reef on Grand Cayman destroyed by Hurricane Gilbert, and wanted to do something to help increase the resiliency of eroding coral reefs. Barber and his father patented the idea of building artificial reef modules with a central inflatable bladder, so that the modules would be buoyant, thus making them easy to deploy by hand or with a small boat, rather than requiring heavy machinery. Over the next few years, with the help of research colleagues at University of Georgia, Nationwide Artificial Reef Coordinators and the Florida Institute of Technology, Barber and a small number of colleagues and business partners worked to perfect the design. Reef balls can be found in almost every coastal state in the United States, and on every continent including Antarctica. The Foundation has expanded the scope of its projects to include coral rescue, propagation and transplant operations, mitigation projects, mangrove restorations and nursery development. Reef Ball also participates in education and outreach regarding environmental stewardship and coral reefs. In 2001, The Reef Ball Foundation took control of the Reef Ball Development Group, and now operates all aspects of the business as a non-profit organization. By 2007, the foundation had deployed 550,000 reef balls worldwide.

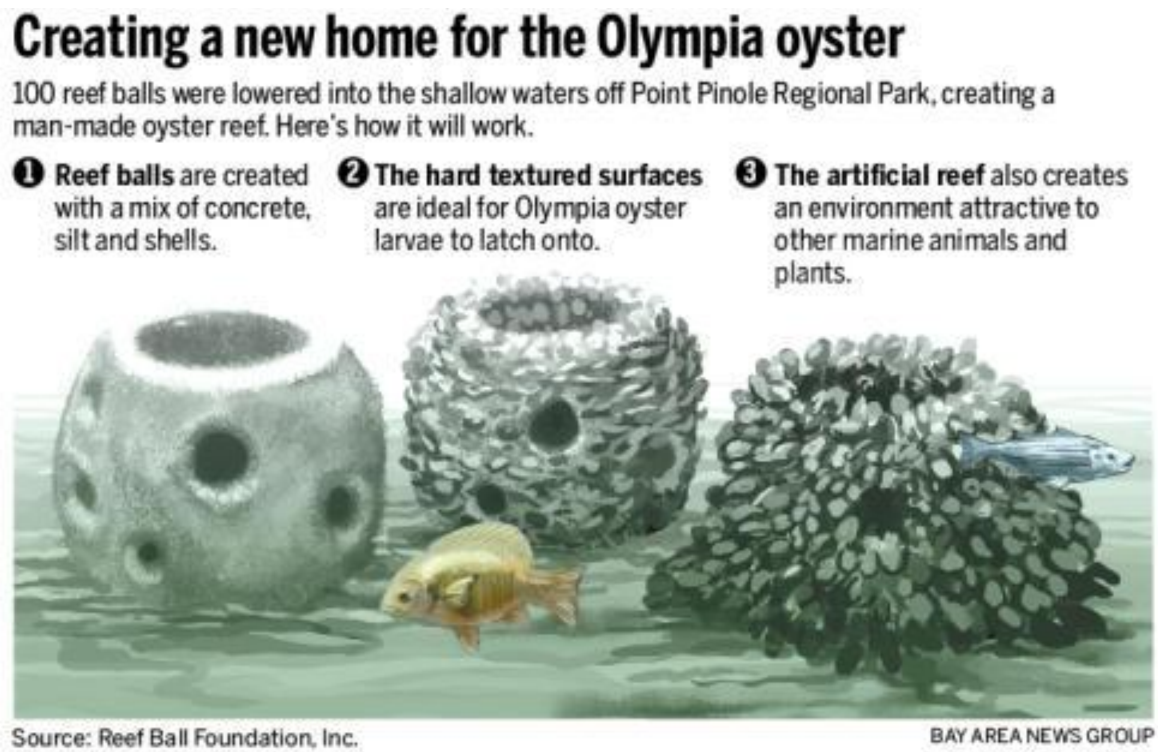


Figure 33: Diagram on how the Reef Balls work.

Figure 34: Examples of different reef ball designs and sizes.

Figure 35: A utilized Reef Ball with oysters and other benthic filter feeders from a canal in Punta Gorda Isles, Punta, Gorda, FL

Figure 36:: Homeowners in the residential area of Punta Gorda Isles paid for the installation of another 180 Reef Balls to be placed under 90 private docks

Mold Size-->	Oyster	Lo-Pro
Purchase	$719	$978
Reef Ball Foundation Grant	$443	$610
Mold Duplication Fee ***	$207 Oyster	$345

Mold Pricing Chart
Reef Ball Foundation: Getting Grants For Your Project
www.reefball.org/pricing.htm

Oyster Strings

The commercial farming methods of growing oysters are still generally traditional using the stake, hanging, long-line; broadcast methods and lattice-tray method. The string method is particularly amenable to use with docks in marinas and along residential shorelines. This method uses strings of empty shells as cultch collectors. Strings made of nylon or polyethylene twine are provided with spacers or knots of 10 cm interval at which the empty shells are held. The length of the string depends on the location of the oyster plot. In most cases these are located in an inter-tidal zone along the coastline with depths of 1–2 m. These strings are hung from the dock structures or fastened to bamboo or wooden framework at 25–30 cm apart. The advantages of the hanging method are that the productivity is higher; the oysters grow quickly; there is less mortality due to predators. This method can be applied in places where natural populations do not exist but favorable for growth of oysters or mussels.

Figure 37: Oyster String

Figure 38: Pulling up a oyster sting.

Figure 39: sets of oyster strings.

Mesh Bag Systems

A clam bag is a polyester mesh sewn in the shape of a bag The entry spout (about 8”) on one corner. There are various mesh sizes: Field nursery 3 and 4 mm; Grow-out bag¬ 9 to 12 mm There are several bag dimensions¬ Usually 4’ by 4’. They are planted as single bag or planted in belts of 5 to 10 bags Staked to bottom using a variety of materials including PVC pipe, pencil rod, Rebar (I do not recommend) and naturally occurring vegetations. The natural sediments serve as the bottom substrate.

The bags require serged seams to handle clam weight There are several clam bag manufacturers in Florida Fabric and thread suppliers can be found by checking the annual list of suppliers posted at http://shellfish.ifas.ufl.edu

Figure 40: Detail of the mesh bag

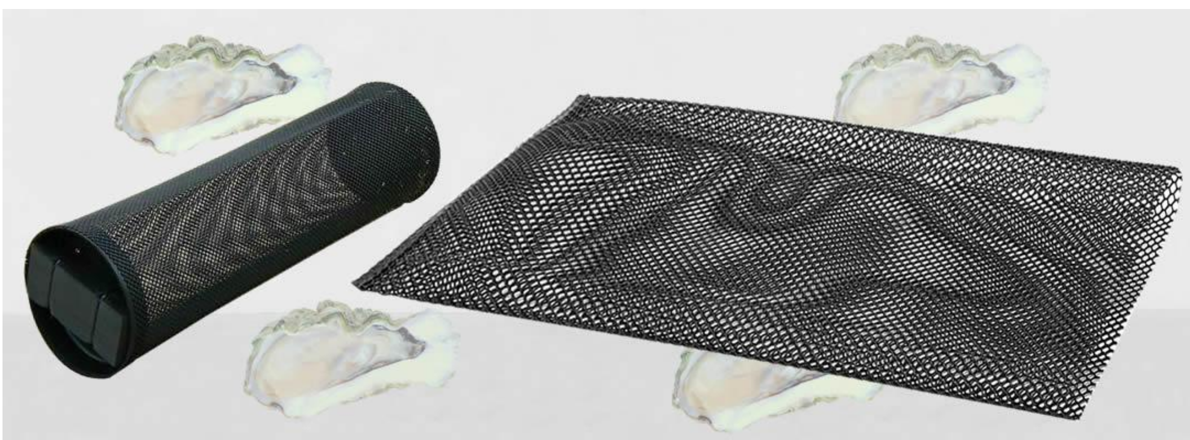


Figure 41: Examples of different mesh bag designs.

Figure 42: Clam bag deployed on sediment

2015 Clam Bag Suppliers

These suppliers are providing clam bags to Florida growers this year.
Contact suppliers directly for information on mesh and bag sizes, prices, and availability.

Island Bags
16710 SW 121st Lane
P.O. Box 86
Cedar Key, FL 32625
Contact: Carla and Ray Ermel
(352) 543-5231
(352) 949-1869 (cell)
isbags@att.net

M&R Seafood
P.O. Box 840
Cedar Key, FL 32625
Contact: Rick Viele
352) 543-9395
(352) 215-3121 (cell)
rickviele@bellsouth.net

Southern Belle Clam Bags
423 NE 833rd Street
Old Town, FL 32680
Contact: Faith van Orden
(352) 542-2508
(352) 542-5288 (cell)
ospreyf@bellsouth.net

Supertex Liberty Industries
312 W. Luther Avenue
Liberty, NC 27298
Contact: Sarah, Kat or Ed
(800) 790-1000 (office)
(800) 790-1003 (cell)
(336) 622-1002 (fax)
info@supertex-inc.com
www.supertex-inc.com

Southern Cross Seafarms
12170 State Road 24
Cedar Key, FL 32625
Contact: Brent Sanchez
(352) 543-5980
southerncrossclams@gmail.com
www.clambiz.com

Thread Supplier

Komar Alliance
370 East Maple Ave., Ste. 202
Langhorne, PA 19047
Contact: David Weitz
(800) 220-1529, ext. 8914
(251) 750-3590 (fax)
dweitz@komar.com

Fabric Suppliers

Jason Mills, LLC
440 South Main Street
Milltown, NJ 08850
Contact: Mike Lavroff
(732) 651-7200
(732) 651-7222 (fax)
info@jasonmills.com
www. jasonmills.com

Supertex Liberty Industries
312 W. Luther Avenue
Liberty, NC 27298
Contact: Sarah, Kat or Ed
(800) 790-1000 (office)
(800) 790-1003 (cell)
(336) 622-1002 (fax)
info@supertex-inc.com
www.supertex-inc.com

Summit Textiles
540 Gadsden Court
Spartanburg, SC 29302
Contact: Tom Howell
(864) 582-0400
(864) 573-8603 (fax)
thcortina@aol.com

Provided by:
University of Florida
Shellfish Aquaculture
Extension Program
P.O. Box 89
Cedar Key, FL 32625
Phone: (352) 543-5057
Email: LNST@ufl.edu
Website: shellfish.ifas.ufl.edu

This list is provided as a service of IFAS, University of Florida. We do not sponsor or endorse any of these suppliers above any others. These lists have been compiled as informational handouts to interested persons.

UF UNIVERSITY of FLORIDA
IFAS Extension

August 2015

10. Pretreatment for drains

Removing pollutants from stormwater runoff is an important component of any stormwater management plan. Stormwater pollution - sediment, trash and debris, nutrients, and metals - is one of the leading causes of water quality impairment. There are numerous technologies available for treating runoff - and the right system for the site should be selected based on local requirements, the target pollutants, and specific site characteristics. As no two projects are the same, there is no one size fits all answer.

Pelican Cove has installed 3 vaults to assist in the ability of the Cove to reduce the amount of pollutants (sediment) that flow into the Harbor. The boxes have a 6 cubic yard capacity.

Pelican Cove worked with the Southwest Florida Water Management District and the neighboring development to the south (Portofino) to create a drain that would run from our Glenhouse Drive to Portofino's catch basin. Also included in this project was the improvement of the rip rap area at the entrance of Little Sarasota Bay at the south boundary.

At the Pelican Cove Community pretreatment filters can be placed in existing features including the stormwater vaults, roof runoff - downspout, and gravity drain pipes.

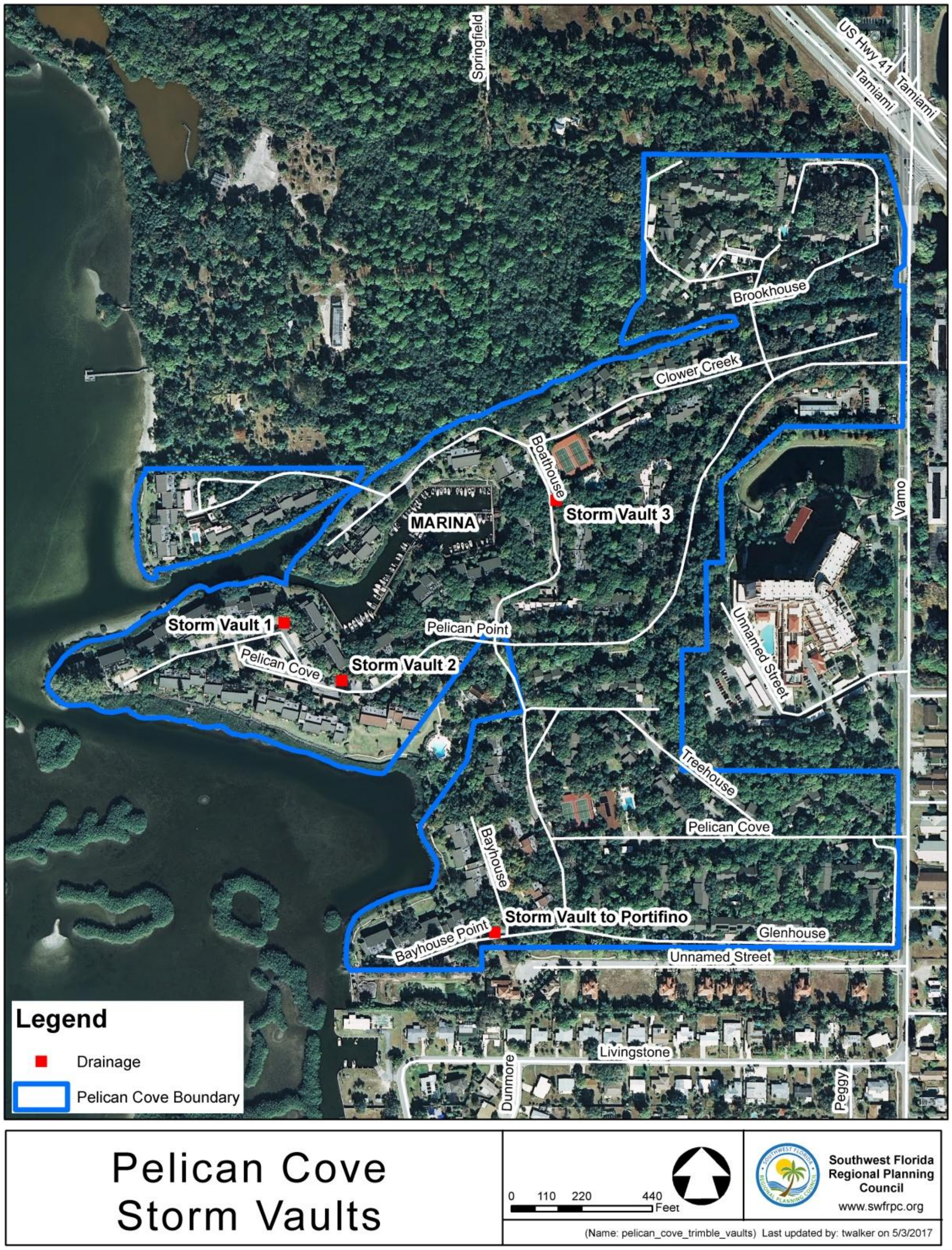


Figure 43: Location of existing Pelican Cove Storm Vaults

Filters can help you remove the most challenging pollutants from stormwater, including nutrients like phosphorus. There are many variables to consider when designing a stormwater filtration system. It’s critical to use a balanced approach that incorporates hydraulics, longevity, and performance. Filters are a recommended method to use with the new vault system that has been installed at Pelican Cove. A good example is the StormFilter system

StormFilter is a stormwater treatment device comprised of one or more structures that house rechargeable, self-cleaning, media-filled cartridges that trap particulates and absorbs pollutants such as dissolved metals, hydrocarbons, nutrients, metals, and other common pollutants found in stormwater runoff. The siphon actuated, high surface area cartridges draw stormwater evenly through the filter media, providing efficient, effective stormwater treatment, while the self-cleaning hood prevents surface blinding, ensuring maximum media contact, and prolongs cartridge life. The structures that house the StormFilter cartridges can be configured in a variety of ways to accommodate a wide range of flows, project specific footprints, and variable hydraulic conditions.

The filter media in the StormFilter cartridges can be customized to target site-specific pollutants. For example, in applications targeting phosphorus, Contech developed PhosphoSorb®, a unique filter media designed specifically for applications targeting high levels of phosphorus removal. The StormFilter is available in multiple cartridge heights to meet site-specific hydraulic needs and is available in different upstream configurations including downspout, catch basin, curb inlet, linear grate, infiltration, and dry well. StormFilter has been tested in the field and laboratory, and is performance verified by both the State of Washington Department of Ecology, Maine Department of Environmental Protection, Maryland Department of the Environment, Texas Commission on Environmental Quality, St. Louis Metropolitan Sewer District, Canada ETV and New Jersey Department of Environmental Protection, as well as other stormwater regulatory agencies. With over 120,000 worldwide installed cartridges, and twenty plus years of sustained performance, StormFilter is equipped to handle the most challenging stormwater scenarios.

How the StormFilter Treats Stormwater

- Stormwater enters the StormFilter through the inlet pipe.
- Stormwater passes through the filtration media and begins filling the cartridge’s center tube.
- When water nears the top of the cartridge, the float valve opens, and filtered water is allowed to drain at the design flow rate.
- A one-way check valve then closes, activating a siphon that draws polluted stormwater evenly through the filter media and into the center drainage tube.
- Filtered water then discharges out of the system through the under drain manifold.
- When the water level outside the cartridge approaches the bottom of the hood, air rushes through the scrubbing regulators, releasing the water column and breaking the siphon.
- The turbulent bubbling action agitates the surface of the filter media, promoting trapped sediment to drop to the vault floor. This patented surface cleaning mechanism helps restore the permeability of the filter surface between storm events.

There are many different StormFilter Media Options including:

- PhosphoSorb® - A lightweight media built from a Perlite base that removes total phosphorus (TP) by adsorbing dissolved-P and filtering particulate-P simultaneously.
- Perlite - Expanded volcanic rock. Its porous, multi-cellular structure and rough edges make it effective for removing TSS, oil, and grease.
- CSF® Leaf Media and Metal RX™ - A granular organic media created from deciduous leaves, CSF is most effective for removing soluble metals, TSS, oil, and neutralizing acid rain. MetalRx, a finer gradation, is used for higher levels of metal removal.
- Zeolite - A naturally occurring mineral used in a variety of water filtration applications, is used to remove soluble metals, ammonium, and some organics.
- Granular Activated Carbon - A micro-porous structure with an extensive surface area to provide high levels of adsorption. It is primarily used to remove oil and grease and organics such as herbicides and pesticides.
- ZPG™ - A proprietary blend of zeolite, perlite, and GAC to improve the performance of perlite and target organics, soluble metals, and other pollutants.

The StormFilter Configurations include vault, manhole, volume, peak diversion, catch basin, curb inlet, linear grate, infiltration well/dry well, and roof runoff - downspout. The StormFilter system fits into residential development stormwater quality retrofit applications providing pretreatment for Low Impact Development, infiltration, and rainwater harvesting and reuse systems

All StormFilter structures provide access for inspection, media replacement, and washing of the structure. StormFilter has been designed for predictable maintenance intervals ranging from 1 to 3 years. There are programs for cartridge replacement. Contech's Cartridge Replacement Program provides refurbished cartridges that are shipped to your site ready to install. Contech arranges for empty cartridges to be picked up and shipped back. Vacuum extraction of captured pollutants in the vault is recommended at the same time. Contech has created a network of Certified Maintenance Providers to provide maintenance on stormwater BMP's.

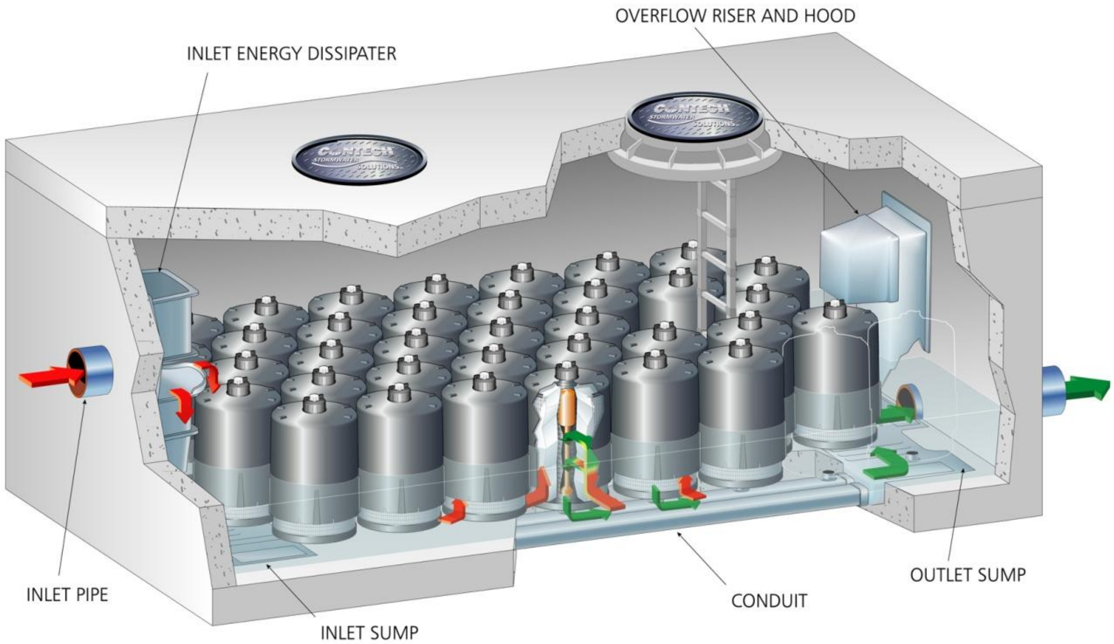


Figure 44: StormFilter System Diagram

Figure 45: StormFilter System installed in a vault.

Filterra is similar to bioretention in its function and application, but has been optimized for high volume/flow treatment and high pollutant removal. Its small footprint allows it to be used on highly developed sites such as landscaped areas, parking lots and streetscapes. Filterra is exceedingly adaptable and can be used alone or in combination with other BMPs. Stormwater runoff enters the Filterra system through a inlet opening and flows through a specially designed filter media mixture contained in a landscaped concrete container. The filter media captures and immobilizes pollutants; those pollutants are then decomposed, volatilized and incorporated into the biomass of the Filterra system's micro/macro fauna and flora. Stormwater runoff flows through the media and into an underdrain system at the bottom of the container, where the treated water is discharged.

Figure 46: Cross-section of a Filterra System

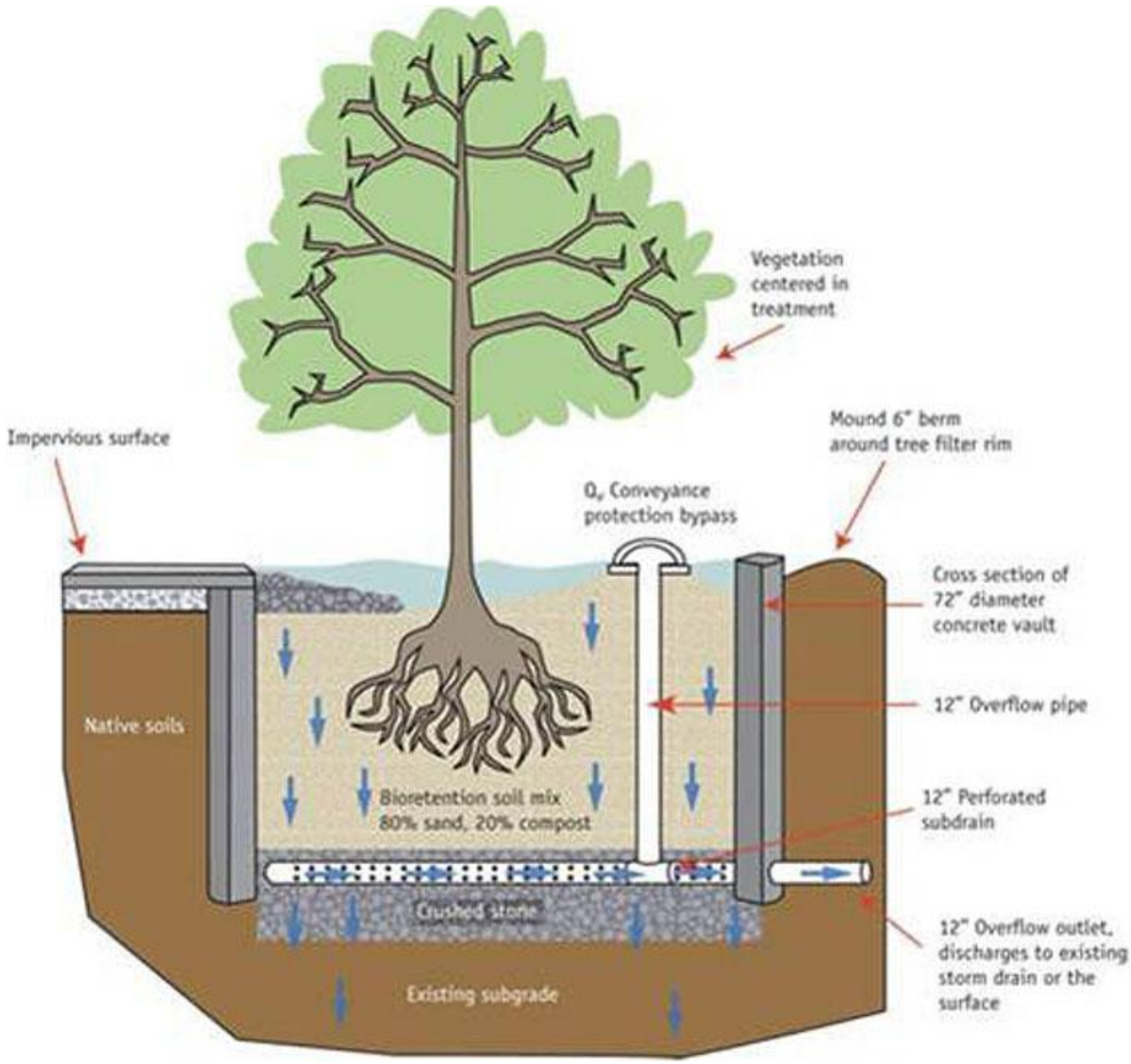


Figure 47: Diagram of the Filterra System

<u>The Jellyfish Filter</u> is a stormwater quality treatment technology featuring high surface area, high flow rate membrane filtration, at low driving head. By incorporating pretreatment with light-weight membrane filtration, the Jellyfish Filter removes a high level and a wide variety of stormwater pollutants. The high surface area membrane cartridges, combined with up flow hydraulics, frequent backwashing, and rinseable/reusable cartridges ensures long-lasting performance.

The Jellyfish Filter Treats Stormwater in the following steps

- Stormwater enters the Jellyfish through the inlet pipe or inlet grate, builds driving head, and traps floating pollutants behind the maintenance access wall and below the cartridge deck.

- Water is pushed down below the cartridge deck where a separation skirt around the cartridges directs oil, trash and debris outside the filtration zone, allowing sand-sized particles to settle in the sump.
- Water is directed to the filtration zone and up through the top of the cartridge into the backwash pool. Once the water has filled the backwash pool, clean water overflows the weir and exits via the outlet pipe.
- The membrane filters provide a very large surface area to effectively remove fine sand and silt-sized particles, and a high percentage of particulate-bound pollutants such as nitrogen, phosphorus, metals, and hydrocarbons while ensuring long-lasting treatment.
- After every storm peak, the filtered water in the backwash pool flows back through the hi-flo membrane cartridges into the lower chamber. This passive backwash extends cartridge life, keeping the membrane clean for future events.
- The draindown cartridge located outside the backwash pool enables water levels to balance.

The Jellyfish Filter can be can be configured in a variety of systems; manhole, catch basin, vault, fiberglass tank, or custom configuration. Typically, 18 inches (457 mm) of driving head is designed into the system. For low drop sites, the designed driving head can be less.

Jellyfish Filter cartridges are light weight, easy to use and reusable. Maintenance of the filter cartridges is performed by removing, rinsing and reusing the cartridge tentacles. Vacuum extraction of captured pollutants in the sump is recommended at the same time. Full cartridge replacement intervals differ by site due to varying pollutant loading and type, and maintenance frequency. Replacement is anticipated every 2-5 years. Contech has created a network of Certified Maintenance Providers to provide maintenance on stormwater BMP's.

Figure 48: Diagram of the Jellyfish Filter

Figure 49: Jellyfish Filter Vault Installation

Hydrodynamic separators were the initial underground water quality devices developed 20 years ago. Especially efficient on gross solids, trash and debris, they are an optimal choice for pretreatment systems.

Vortechs is a below-ground, engineered stormwater treatment device that combines swirl concentration and flow controls into a single treatment unit. Vortechs is ideal for capturing and retaining trash, debris, sediment, and hydrocarbons from stormwater runoff. The Vortechs system's large swirl concentrator and flow controls work together to create a low energy environment, ideal for capturing and retaining particles down to 50 microns.

Vortechs Treats Stormwater in the following process.

- Untreated stormwater enters the Vortechs swirl chamber through an inlet pipe.
- The swirling motion of the water within the chamber promotes gravitational separation of solids which settle on the chamber floor.
- Stormwater exits the swirl chamber, where a baffle wall traps floatables and hydrocarbons.
- Stormwater flows under the baffle wall into the flow control chamber which contains separate flow controls for peaks and low-intensity flows that are designed specific to project requirements.
- Treated stormwater flows to the outlet chamber and exits via the outlet pipe.

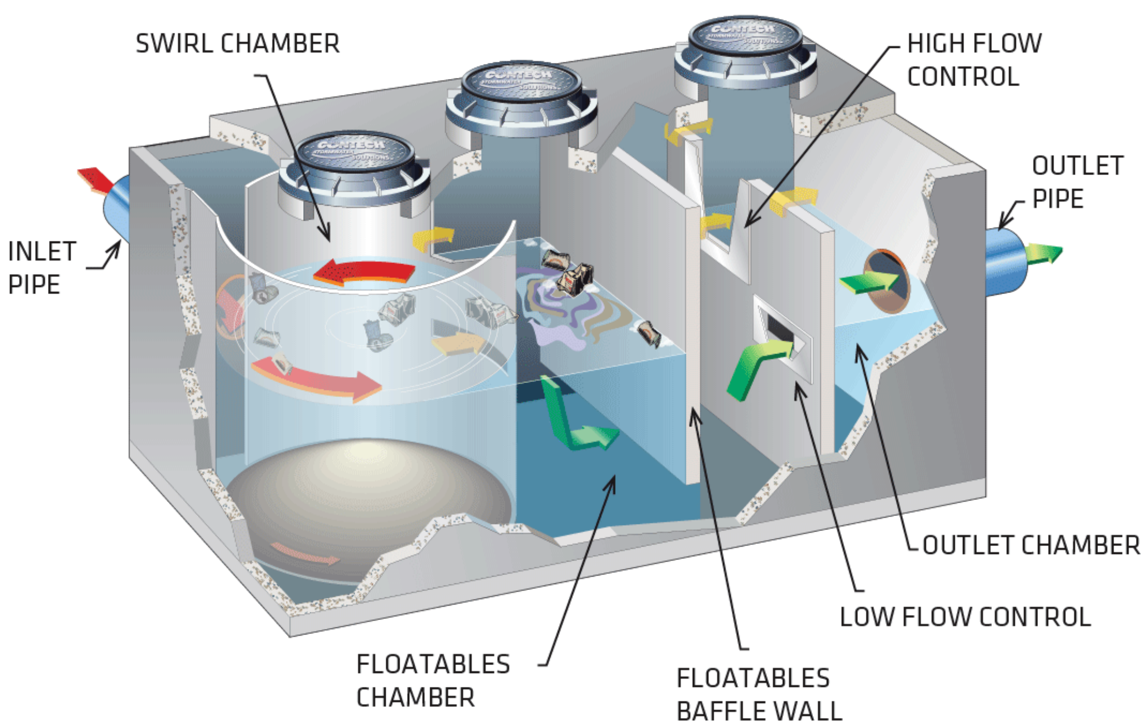


Figure 50: Diagram of the Vortechs system.

The VortSentry HS is a compact, below grade stormwater treatment system that uses helical flow technology to enhance gravitational separation of floating and settling pollutants from stormwater flows. The small footprint of the VortSentry HS makes it an effective stormwater treatment option for projects where space is at a premium.

The VortSentry HS accepts a wide range of pipe sizes to treat and convey a wide range of flows. The unique internal bypass weir allows flows exceeding the treatment capacity to be diverted within the unit eliminating the need for an external bypass structure.

VortSentry HS Treats Stormwater in the following process.

- Untreated stormwater enters the VortSentry HS through an inlet pipe or grate inlet.
- Low, frequently occurring storm flows are directed to the treatment chamber where a tangentially oriented downward pipe induces a swirling motion in the treatment chamber that promotes the separation of suspended solids. Trash and floating debris are also captured in the treatment chamber.
- Moderate storm flows are directed into the treatment chamber through a secondary inlet, which allows for capture of floating trash and debris. The secondary inlet provides for treatment of higher flows without significantly increasing the velocity or turbulence in the treatment chamber.
- Flow exits the treatment chamber through the outlet flow control, which manages the amount of flow that is treated and helps maintain the helical flow patterns developed within the treatment chamber.
- Flows exceeding the system's rated treatment flow are diverted away from the treatment chamber by the flow partition.
- Treated stormwater exits the VortSentry HS via the outlet pipe.

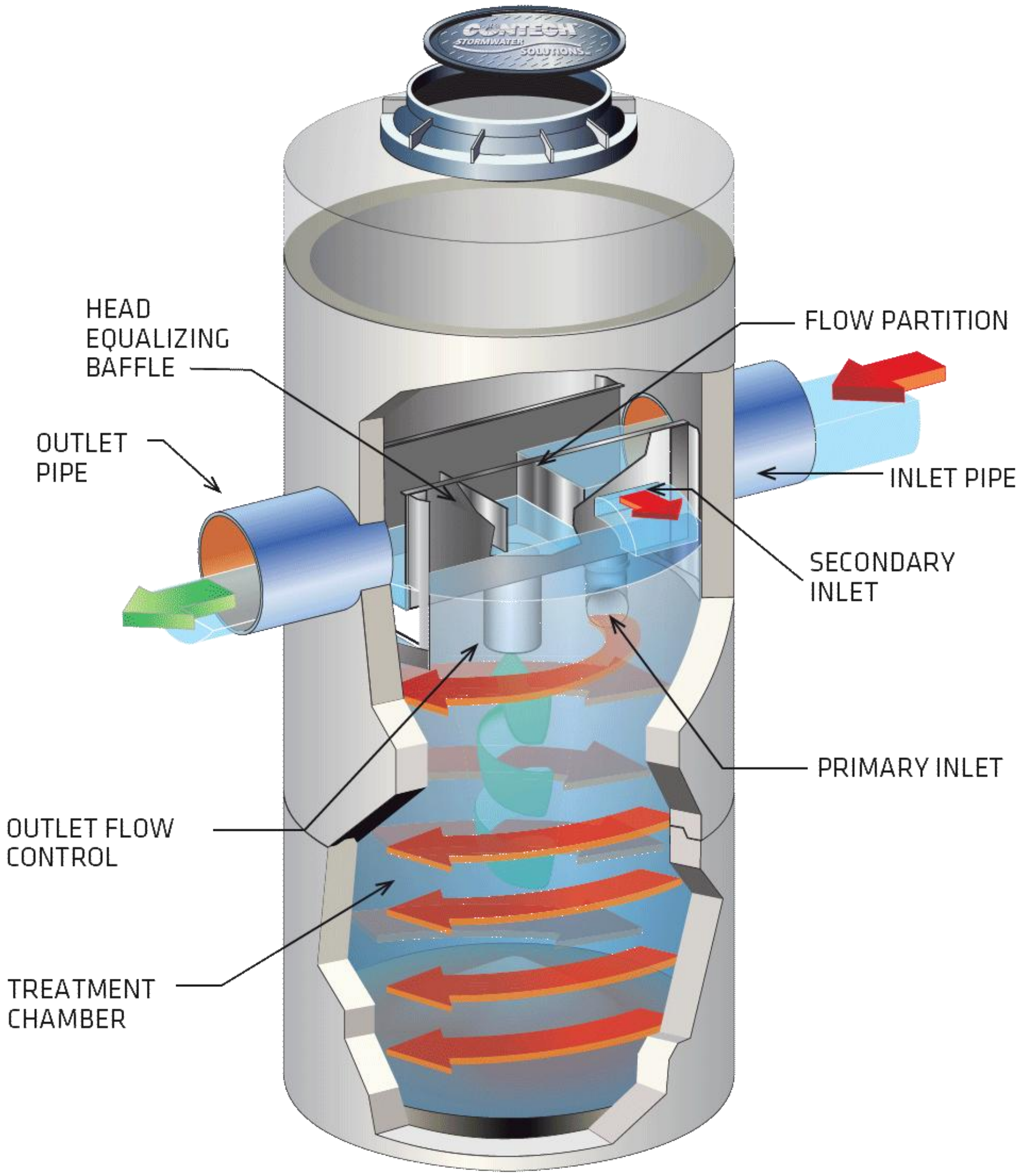


Figure 51: Diagram of the Vortsentry HS unit.

Figure 52: Installed Vortsentry HS unit

The CDS is a swirl concentrator hybrid technology that uses continuous deflective separation – a combination of swirl concentration and indirect screening to screen, separate and trap debris, sediment, and hydrocarbons from stormwater runoff. The indirect screening capability of the system allows for 100% removal of floatables and neutrally buoyant material debris 2.4mm or larger, without binding. CDS retains all captured pollutants, even at high flow rates, and provides easy access for maintenance.

CDS is used to meet trash Total Maximum Daily Load (TMDL) requirements, for stormwater quality control, inlet and outlet pollution control, and as pretreatment for filtration, detention/infiltration, bioretention, rainwater harvesting systems, and Low Impact Development designs.

The CDS Treats Stormwater in the following process

- Stormwater enters the CDS through one or multiple inlets and/or a grate inlet.
- The inlet flume guides the treatment flow into the separation chamber where water velocities within the chamber create a swirling vortex.
- Water velocities in the swirl chamber continually shear debris off the treatment screen, making it the only non-blocking screening technology available in a hydrodynamic separation system.
- The combination of swirl concentration and indirect screening force floatables and solids to the center of the separation chamber trapping 100% of floatables and neutrally buoyant debris larger than the screen aperture.
- Sediment settles into an isolated sump while floatables and neutrally buoyant pollutants are captured in the separation cylinder. All pollutants remain in these sections of the unit until they are removed during maintenance.

- Stormwater then moves under the hydrocarbon baffle, and the treated water exits the system. The baffle acts as a wall for hydrocarbon containment. It contains previously captured hydrocarbons and prevents the agitation of hydrocarbons when high-flows spill over the diversion weir.
- During high-intensity events, the internal diversion weir directs a portion of flows greater than the design storm around the treatment chamber and over an internal bypass weir.
- Treated stormwater exits the CDS via the outlet pipe.

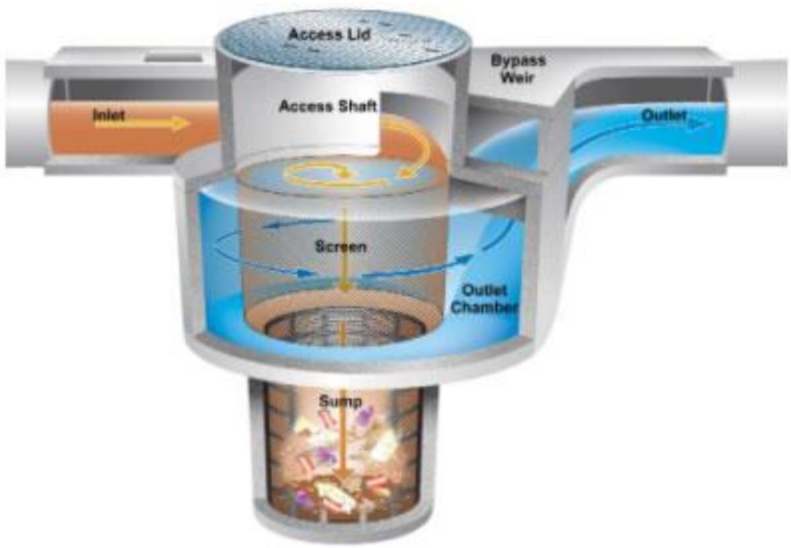


Figure 53: Diagram of the CDS treatment system

Information and contacts for these pretreatment systems can be found at
http://www.conteches.com/products/stormwater-management/treatment

Adaptations to address flooding and runoff caused by potential sea level rise and increased rain fall and storm activities

The recommended options flooding and runoff from climate change include additional drainage swales with dunes, removal of exotics and replacement with GeoWeb and natives removal of silt from Clower Creek, removal of vegetation blocks from Clower Creek, and improved evacuation coordination

11) Additional drainage swales with man-made dunes

A **swale** is a low depression of the land, especially one that is moist or marshy. The term can refer to a natural landscape feature or a human-created one. Artificial swales are often infiltration basins designed to manage water runoff, filter pollutants, and increase rainwater infiltration.[2]

The swale concept has also been popularized as a rainwater harvesting and soil conservation strategy by Bill Mollison, Geoff Lawton and other advocates of permaculture. In this context it usually refers to a water-harvesting ditch on contour.

Swales as used in permaculture are designed to slow and capture runoff by spreading it horizontally across the landscape (along an elevation contour line), facilitating runoff infiltration into the soil. This type of swale is created by digging a ditch on contour and piling the dirt on the downhill side of the ditch to create a berm or man-made dune. In arid dry season, vegetation (existing or planted) along the swale can benefit from the concentration of runoff. Trees and shrubs along the swale can provide shade which decreases water evaporation, however they increase transpiration, so their net effect on the hydrologic cycle is probably to reduce infiltration.

The term swale or "beach swale" is also used to describe long, narrow, usually shallow troughs between ridges or dunes, that run parallel to the shoreline

Vegetated swales are well suited as pretreatment structures for a volume reducing BMP such as upstream of an infiltration trench or bioretention area. They can also be used to convey water downstream from an SCM. The linear form factor of vegetated swales makes them well-suited to be placed in road and highway shoulders and medians. Vegetated swales can also be used in residential, commercial, or institutional developments along parking lot edges or islands, around buildings, or along driveways. Vegetated swales should be applied in linear configurations parallel to the contributing impervious cover, such as roads and small parking areas to allow for level spreading and not concentrating flow at one inlet and similarly to prevent a bottleneck or clogging at said single inlet. Standard vegetated swales may or may not have storage capacity, depending on design needs and the use of internal check dams or other structures. Water quality swales are differentiated from standard swales with the use of layered media below the vegetation, which acts like a bioretention cell to filter and infiltrate water. Water quality swale design must include design details on internal baffles or check dams. Sizing of water quality swales follows the protocol for bioretention. As storage in water quality swales fills, overflow occurs along the swale. Sizing of swale dimensions above the storage layers follows in water quality swales follows that of standard vegetated swales. Adequate overflow and spillway design must be in place to protect the surface and vegetation in water quality swales.

Designed to manage runoff primarily by reducing its velocity for increased treatment efficiency by a downstream practice, vegetated surfaces provide water quality pretreatment through filtering, biological uptake mechanisms, and subsoil cation exchange capacity. Subsoil can also provide a relatively small amount of runoff volume reduction especially when check dams are used. These attributes, in addition to low installation and maintenance costs, make the vegetated swale preferable to the traditional system of curb and gutter, storm drains, and pipes for managing stormwater runoff.

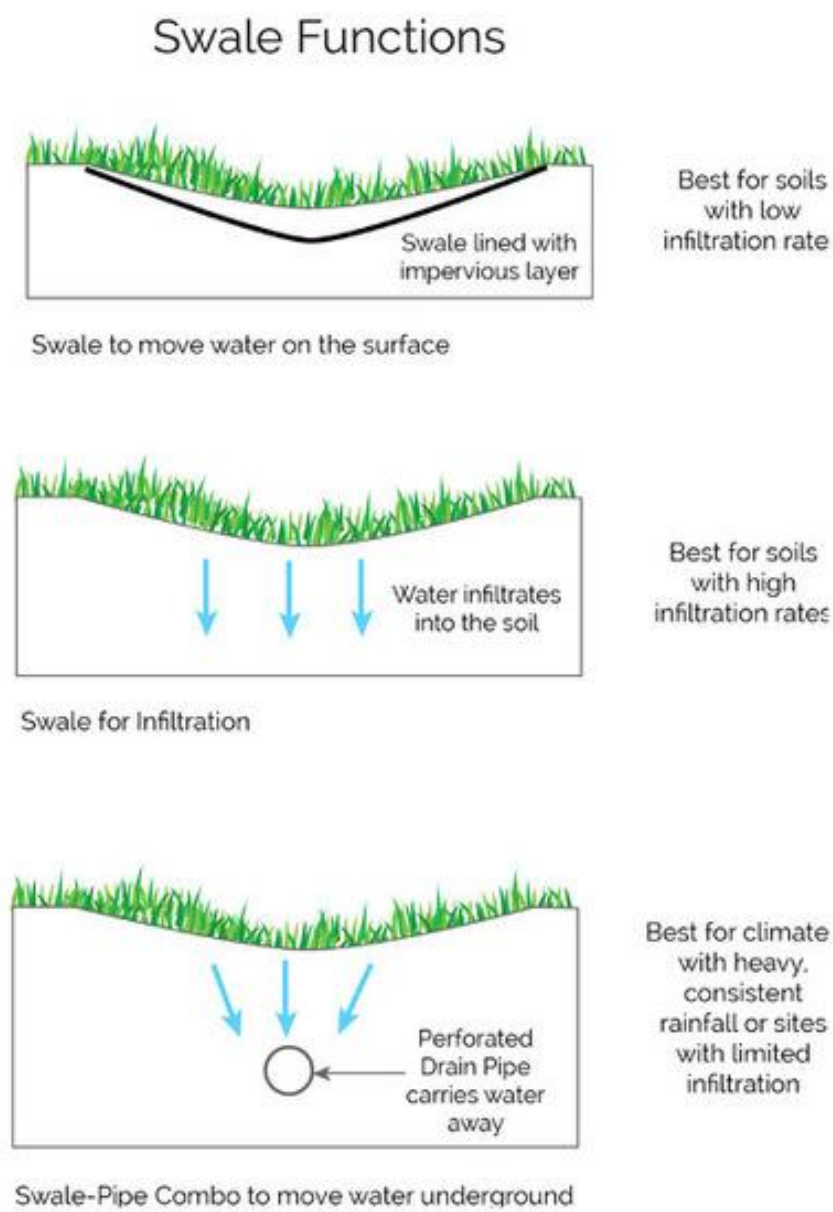


Figure 54: Swales can have different designs for different functions and treatment levels .

Figure 55: Existing swale at south end of South Cove Harbor. This is recommended to be replicated parallel to Little Sarasota Bay along all of South Cove and Far Harbor behind the mangroves and marsh living shoreline. Drainage from land surfaces would be directed in other swales into this coastal swale system.

Bioswales are landscape elements designed to concentrate or remove silt and pollution from surface runoff water. They consist of a swaled drainage course with gently sloped sides (less than 6%) and filled with vegetation, compost and/or riprap. The water's flow path, along with the wide and shallow ditch, is designed to maximize the time water spends in the swale, which aids the trapping of pollutants and silt. Depending upon the geometry of land available, a bioswale may have a meandering or almost straight channel alignment. Biological factors also contribute to the breakdown of certain pollutants.

A common application is around parking lots, where substantial automotive pollution is collected by the paving and then flushed by rain. The bioswale, or other type of biofilter, wraps around the parking lot and treats the runoff before releasing it to the watershed or storm sewer.

There are several classes of water pollutants that may be collected or arrested with bioswales. These fall into the categories of silt, inorganic contaminants, organic chemicals and pathogens.

- Silt - These structures slow the conveyance of Silt and reduce the turbidity of receiving waters.
- Organics - Many organic contaminants including Polycyclic aromatic hydrocarbons will volatilize or degrade over time and Bioswales slow the conveyance of these materials into waterways, and before they can affect aquatic life. Although not all organics will be captured, the concentration of organics is greatly reduced by Bioswales.
- Pathogens - are deprived of a host or from a nutrient supply long enough for them to become the target of a heterotroph.
- Common inorganic compounds are macronutrients such as phosphates and nitrates. Principal sources of these nutrients are excess fertilization, which can cause eutrophication in receiving waters. Plants surrounding these ponds absorb these nutrients.
- Metallic compounds such as mercury, lead, chromium, cadmium and other heavy metals are concentrated in the structures. Unfortunately, these metals slowly poison the surrounding soil. Regular soil removal is required in order to prevent metals from dissolving and releasing back into the environment. Some bioswales are designed to include hyperaccumulator plant species. These plants absorb but do not transform the metals. Cuttings from these plants often decompose back into the pond or are pruned by gardening services that do not know the compost they are collecting is poisonous.

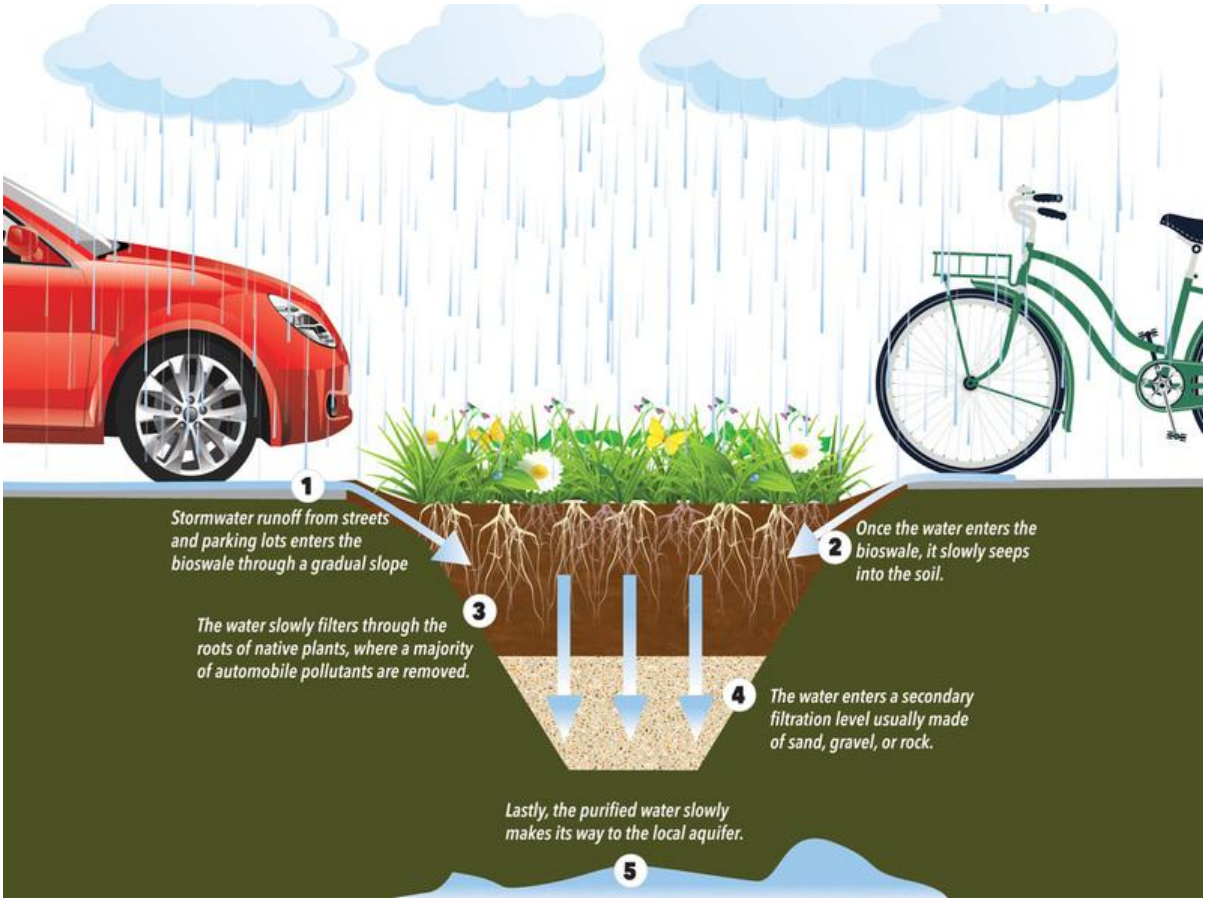


Figure 56: Bioswale diagram

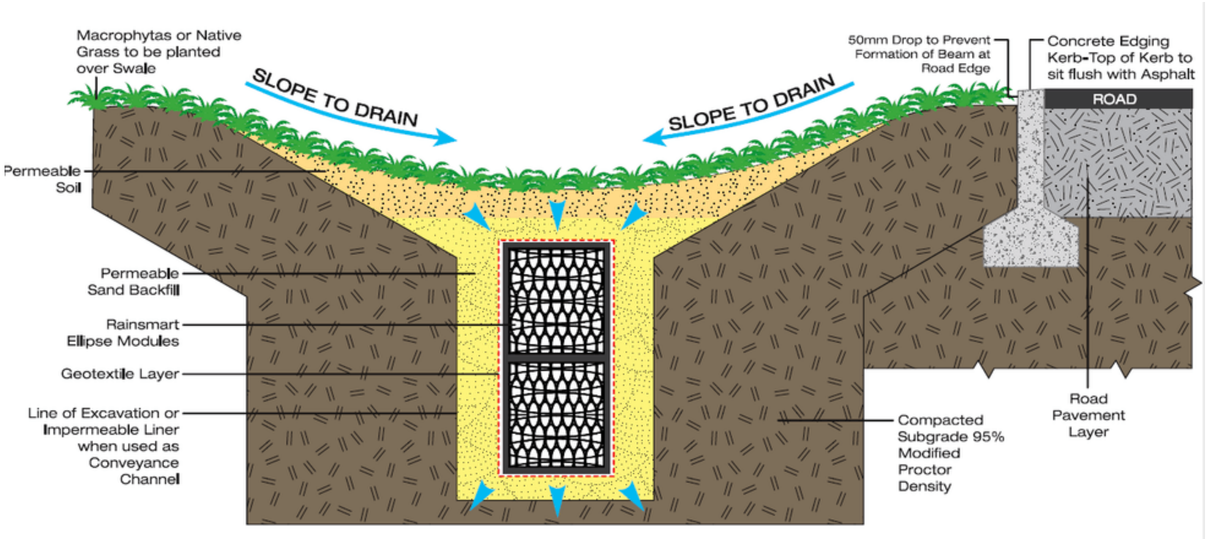


Diagram 57: Another form of Bioswale.

Figure 58: A Florida bioswale installation at Pahokee Marina and Campground.

Figure 59: Another Florida bioswale at Evergreen. Source APA Florida.

12) Removal of exotics and replacement with geoweb (a cellular confinement system CCS) and natives

At a number of locations in Pelican Cove areas of erosion from stormwater runoff have formed on slopes with bare soils and/or exotic vegetation cover. Several of these are located where volume flows or irrigation water from sprinkler heads runoff at low spots, others are at the discharge points of stormwater rain spouts and drains, a few are where the overflow from air conditioning units discharge.

Figure 60: Erosion Area behind unit on south side of Clower Creek Note pipe discharges.

Figure 61: Erosional area at the Harbor Marina with stone placed on runoff path.

Figure 62: Outfall pipe into the Harbor Marina. This is an area of sediment deposition within the basin.

Figure 63: Erosional area located at the Marina Basin. Note exposed soil.

Cellular confinement systems (CCS)—also known as geocells—are widely used in construction for erosion control, soil stabilization on flat ground and steep slopes, channel protection, and structural reinforcement for load support and earth retention. Typical cellular confinement systems are made with ultrasonically welded high-density polyethylene (HDPE) strips or novel polymeric alloy (NPA)—and expanded on-site to form a honeycomb-like structure—and filled with sand, soil, rock, gravel or concrete.

The three-dimensional lateral confinement of CCS along with anchoring techniques ensures the long-term stability of slopes using vegetated topsoil, aggregate or concrete surfacing (if exposed to severe mechanical and hydraulic pressures). The enhanced drainage, frictional forces and cell-soil-plant interaction of CCS prevents downslope movement and limits the impact of raindrops, channeling and hydraulic shear stresses. The perforations in the 3D cells allow the passage of water, nutrients and soil organisms. This encourages plant growth and root interlock, which further stabilizes the slope and soil mass, and facilitates landscape rehabilitation. Typical applications include: construction cut and fill slopes and stabilization; road and rail embankments; pipeline stabilization and storage facility berms; quarry and mine site restoration; channel and coastline structures. They can be built as an underlying mass or as a facing.

CCS provide steep vertical mechanically stabilized earth structures (either gravity or reinforced walls) for steep faces, walls and irregular topography. Construction of CCS earth retention is simplified as each layer is structurally sound thereby providing access for equipment and workers, while eliminating the need for concrete formwork and curing. Local soil can be used for infill when suitable and granular, while the outer faces enable a green or tan fascia of the horizontal terraces/rows utilizing topsoil. Walls also can be used for lining channels and in cases of high flow, it is required that the outer cells contain concrete or cementious slurry infill. CCS have been used to reinforce soft or uneven soil foundations for large area footings, for retaining wall strip footings, for load sharing of covers over pipelines and other geotechnical applications.

CCS is a green solution that makes civil infrastructure projects more sustainable. In load support applications, by reducing the amount and type of infill needed to reinforce soil, the usage of haul and earthmoving equipment is reduced. This in turn decreases fuel use, pollution and the carbon footprint, and at the same time minimizes on-site disruption from dust, erosion and runoff. When used for slope applications, perforated CCS provides excellent soil protection, water drainage and growth stratum for plants. The long-term design life of advanced CCS technology means that maintenance and the associated environmental costs are significantly reduced, as are long-term economic costs.

.A video showing a GEOWEB® Geocell Channel & Slope Installation (Full) can be found at https://www.youtube.com/watch?v=1oQp3QsUl3w

13) Remove Silt from Clower Creek and 14) Remove Vegetation Blocks from Clower Creek

Clower Creek above the juncture with the Yacht Basin Channel is a estuarine depositional environment accumulating significant silt deposits above the original channel bottoms. East of the Far Harbor road bridge Clower Creek is blocked by vegetation that has grown across the creek bed and a significant amount of fallen vegetation has fallen into the creek and/or tangled into the living vegetation. This includes both native mangroves and exotics like Brazilian pepper.

Clower Creek is significantly silted in with fines representative of a long period of upland run-off deposition. The salinity barriers below the bridge are filled to the control elevation with silt, providing little to no capacity for settling of more silt and turbidity.

Estuaries are very vulnerable to the effects of human activities and require careful management to keep them in reasonable shape. One of the biggest issues is sediment. Whether an estuary or estuarine creek fills in or remains deep depends on the balance between sediment entering and leaving the estuary, and on water inputs from rivers or from sea-level rise. Human activities have changed this balance in estuaries in various ways – mainly by increasing erosion and by changing water-flow patterns and sediment movements. For example, residential and/or marina developments trap fine sediment, and regular dredging may be required to prevent sediment accumulating. Water control structures like dams and salinity barriers can change both current patterns and the way sediment is carried in and trapped. Erosion can be caused by the clear of forests and vegetative cover and by construction projects such as new subdivisions; the fine particles in eroded material end up in estuaries. Overdosing on fine sediments can easily push the sedimentation balance towards irreversible infilling. This has happened in Clower Creek.

The Clower Creek watershed is about 85% developed, with over 40% commercial development. Stormwater from these commercial areas flows through a network of pipes and ditches to Clower Creek. *For basin details see: Little Sarasota Bay Water Quality Management Plan (2012).* In addition rapid run-off from the urbanized impervious surfaces or the headwaters of Clower Creek will, during rainy storms or tropical storm events, flood the riparian areas of Pelican Cove much more quickly even if the tide is low and wind fetch is blowing westward during a storm.

Figure 64: Watershed of Clower Creek. Note large amount of impervious surface and urbanization in the upper watershed.

Rain that falls on land that is in a natural state is absorbed and filtered by soils and vegetation as it makes its way into underground aquifers. However, in developed areas, "impervious surfaces" impede this process and contribute to polluted urban runoff entering surface waters. These surfaces include human infrastructure like roads, sidewalks, driveways and parking lots that are covered by impenetrable materials such as asphalt, concrete, brick and stone, as well as buildings another permanent structures. Soils that have been disturbed and compacted by urban development are often impervious aswell.52% of the land area within the Clower Creek Basin is covered by impervious surfaces.

These combination of factors have deposited significant amounts of silt in Clower Creek upstream of the two water control structures dams filling the Creek with silt to the lip of the dams and forming an alluvial silt deposit at the base of the most waterward dam with siltation extend to the confluence with the marina channel.

From records provided by Pelican Cove, the last full dredging of Clower Creek occurred in 1992 in a jointly funded cost sharing project with Sarasota County. A Clower Creek Capital Improvement Project (CIP) was formed. The total project cost in 1992 dollars was $220.000. Sarasota County contributed $137,000 to the project and the balance was obtained though an annual ad valorem assessment of $27 per year on approximately 486 Pelican Cove Units for 15 years. This means that the CIP expired after 2007.

Figure 65: Tidal side of Clower Creek begins at the two weirs. Note the egret walking on the silt in very shallow water.

Figure 66: Siltation in Clower Creek from sediment run-off in the watershed.

The vegetation clearing and removal of anthropogenic silts that is clogging Clower Creek is the responsibility of the Sarasota County Stormwater Environmental Utility (SEU) Sarasota County has had a stormwater management division since 1981 when the Aquatic Plant Control Department became part of the Department of Transportation. The department completed a master plan for the county in 1987 that identified the county's drainage basins and recommended the enactment of a stormwater utility fee as a dedicated funding source.

The Stormwater Environmental Utility (SEU) was established in 1989. Legal authority to establish a stormwater utility in Sarasota County was provided by Chapter 403 and Section 197.3632 of the Florida Statutes that allow communities to create stormwater benefit areas and charge special assessments. An inter-local agreement with the city of Sarasota was established in 1991, and later revised in 1997. It gave us responsibility for portions of the drainage system in the city of Sarasota, in addition to the parts in the unincorporated county.

The SEU states that the overall objectives or the drainage basins is to

. Reduce the threat of flooding to improve surface water quality and encourage appropriate development practices in the region.

- Reduce the threat of flooding by ensuring that the stormwater drainage system is properly operated and maintained.
- Reduce the threat of flooding by developing Basin Master Plans which will identify level of service deficiencies and cost effective solutions.
- Protect and improve our surface water quality by ensuring county compliance with federal and state regulations under the National Pollutant Discharge Elimination System (NPDES) Permit and other local, state and federal regulations.
- Mitigate the impacts of flooding and save money for the county residents by implementing activities in the Community Rating System (CRS) program to prevent and reduce flood losses and flood insurance cost.
- Protect existing property while encouraging appropriate community development by formulating and enforcing stormwater regulations for development.
- Maintain a customer service database to assure accuracy of parcel records and assessments.

Since the establishment of the stormwater utility, the SEU has worked on master plans for each of the 27 drainage basins in the County. After severe flooding in 1995, the work schedule was accelerated to complete all the master plans by the end of year 2001.

SEU started the first stormwater utility capital improvement projects in 1994 and began assessing drainage basins for Stormwater Improvement Assessments in 1995. The same year, SEU received the first NPDES permit issued in the state along with our joint applicants North Port, Venice, Sarasota, Longboat Key, and the Florida Department of Transportation.

Sarasota County reorganized the administrative divisions in 1999, and the Stormwater Management Division became part of the Public Works Business Center. This department was historically responsible for maintaining the county's drainage system.

The Stormwater Environmental Utility provides stable and dedicated funding for long-range planning and capital improvements to address existing as well as future concerns. It provides the ability to develop and implement a stormwater management plan to ensure the proper planning, construction, and operation and maintenance of stormwater systems. Sarasota County states that they are committed to providing responsive, courteous, quality service to all customers in the maintenance, repair, improvement, management and operation of the public stormwater management system.

The SEU will be the entity responsible for cleaning and restoring Clower Creek by removal of anthroprogenic sits and clogging vegetation Given the size of the project this will need to follow a path involving review of the Long Range Plan for the Watershed, development of a Capital Improvement Project for the restoration and implementation of the project with subsequent long term maintenance for continued Creek function.

The Master Planning Division will be responsible for the completion and updates of the Clower Creek drainage basin's master plan. The master planning crew inspects the existing stormwater system, identifies maintenance, repair, and replacement needs, develops a schedule for needed improvements, and estimates the costs of the needed improvements. During the assessment process, the team also identifies methods to reduce the pollutant load that enters the county's water supply and analyze current land use patterns to determine future stormwater management needs in the area. Basin Master Planning involves field survey work, inventorying the existing drainage system and researching historical drainage and flooding problems. Features, such as topography, soil type, and land uses, are considered during planning. Lakes, ponds, and wetlands are evaluated for possible storage areas for stormwater. The Master Planning Division engineers use a computerized modeling program based on the physical characteristics of each basin to determine the impacts of storms of varying intensity and the effects of different types of improvements on the level of stormwater service provided to the basins.

The Capital Improvements division will work with the Master Planning Division to identify and design the capital improvement project for cleaning Clower Creek and consults the Drainage Operations staff regularly to learn more about the current conditions of the project sites and determine if the operations staff will be able to repair and maintain the new projects after their completion. The capital improvements staff consults with the Public Works Business Center's Real Property Officer on projects involving easements and property acquisitions and with the County Attorney's Office and the Environmental Services Natural Resources Section to ensure that the construction projects comply with county regulations. The Road Program Construction Division of the Department of Public Works also cooperates with the Stormwater Management staff to administer the bidding, inspection, and accounting aspects of the capital improvement projects. Following the development of the CIP for Clower Creek the County will need to proved funding for implementation of the project. Sources for this funding may come from the SEU assessments, State revolving funds, Federal programs (although these appear to be in the decline), or alternative plans that might couple silt removal with manmade dune building or sediment supplementation.

Th project will likely involve hydrologic dredging and total removal of vegetation within the Creek channel but retaining vegetation on the bank littoral and above. Since the project will be removing and trimming mangroves, at least for some portion the mangrove impact permits will be needed.

Sarasota County is a delegated local government for the State of Florida's 1996 Mangrove Trimming and Preservation Act through the adoption of the local Mangrove Trimming and Preservation Ordinance. Since mangroves provide so many benefits to humans and the environment, they have special protections**.** The State of Florida developed a statewide law to protect Mangroves from unnecessary removal or destruction. The current Local Ordinance became Effective on Nov. 1, 2016. Typically mangrove removal is allowed in project that reduce flooding to protect public safety and prevent property damage from flooding.

In order to achieve the removal of silt and blocking vegetation in Clower Creek it is likely a new CIP will need to be formed. The process of achieving this project will not be an easy or quick one and may have to cycle through at least two fiscal years in order to meet all standard CIP requirements including hearings, legal advertisements, and project review re-designs,

The contact for coordinating this project with the SEU is Sarasota County Stormwater Environmental Utility, 1001 Sarasota Center Blvd, Sarasota, FL 34240, 941-861-5000 (a central contact center number).

15) Improve Evacuation Coordination

The existing conditions of Pelican Cove on a low-lying peninsula on Little Sarasota Bay with a active creek watershed makes it extremely susceptible to storm surge even at the lowest level of tropical storms and in all directions of storm landing.   The specifics of the flooding vulnerabilities and hurricane storm siege zones of Pelican Cove are detailed in the Pelican Cove Climate Change Vulnerability Assessment (Beever and Walker 2017).

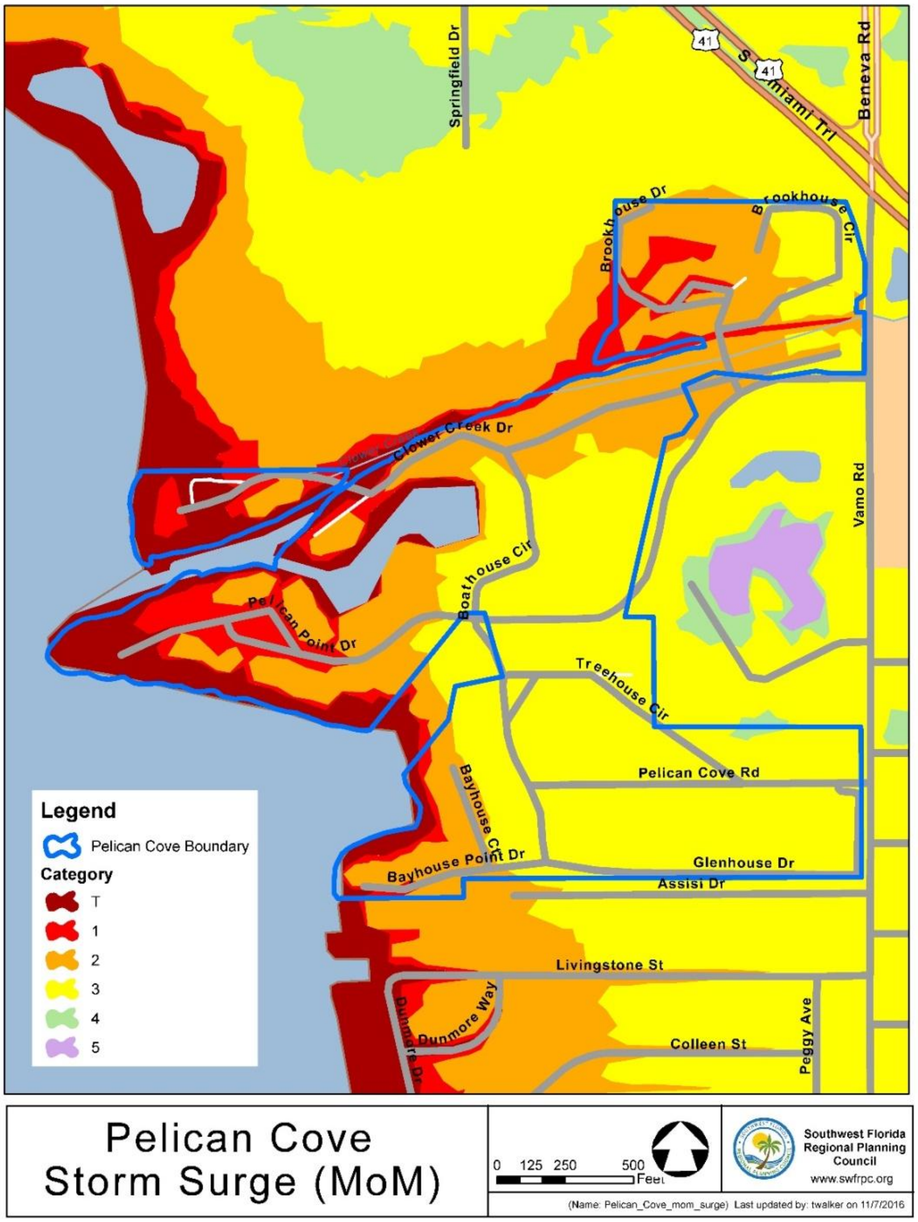


Figure 67: Storm Surge of a Worst Case Tropical Storm and Hurricane Path Storm

Pelican Cove has adopted a policy that during a tropical storm or hurricane of any level that all residents leave the property for the duration of the storm. This is a wise policy. The current is as follows

APPENDIX N

HURRICANE PREPAREDNESS

Pelican Cove units and common buildings are not built to current hurricane standards and should not be used as shelters by residents in a hurricane. **Although our 71 residential buildings are located in three different hurricane evacuation zones, PC Management will most likely extend evacuation orders to all residents. This will be disseminated via Pelican Cove's email blasts, bulletin boards, website** (http://www.pelicancovecondo.com/outside_home.asp) **and Comcast in-house closed circuit channel 195. Information on evacuation zones is available in the PC Office and on the Sarasota County website (http://www.scgov.net/EmergencyServices/allhazards.asp).** The hurricane season begins June 1st and ends November 30th. **Residents living here during hurricane season should develop a hurricane preparedness plan prior to June 1st that includes evacuation.**

- **The Sarasota County Hurricane Guide, available in the PC Office, includes information about hurricane preparedness plans, an evacuation map, hurricane shelters (including ones that take pets), persons with special needs, hurricane supply kits, emergency contacts, insurance information and re-entry procedures after a hurricane.**
- **The Pelican Cove Disaster Preparedness and Response Committee and a team of volunteers provide information and advice to residents about hurricane preparedness, to include conducting a hurricane information meeting each year.**
- If you will need assistance during an evacuation, it is important that you call Special Needs Registration at 861-5000. You must pre-register for this service - do not wait until the storm is here.
- If you have home health care service, plan ahead with your agency for emergency procedures. During an emergency, the Pelican Cove Staff will not be able to assist every individual.
- Second floor units should evacuate at the same time as the first floor units. A severe storm may damage the structural integrity of a building.
- Once a Hurricane **Watch** is announced, **the Association will implement its Hurricane Plan.** The Pelican Cove Office will be **secured for the storm** and staffed as long as it is deemed safe.
- **All recreational buildings and** pools will be prepared for the storm and deck furniture will be secured.
- **As soon as Sarasota County issues a tropical storm or hurricane warning, residents must remove all** outdoor objects: patio furniture, hanging pots, **potted** plants, grills, propane tanks, **hoses**, decorative items and other unsecured items. These must be moved inside to limit the amount of flying debris during hurricane season. If it is necessary for the Pelican Cove staff to remove such items, the owners will be fined $100, per storm, plus the costs of the removal of items as determined by Management.
- Boat and canoe/kayak owners are solely and completely responsible for the safety and security of their own vessels and must abide by the Hurricane Regulations in **The Rules We Boat By**.
- Residents should stay updated by watching the National Weather Channel (cable channel 31) or local television channels.

- **After a hurricane, there will be building damage information on the PC website. Unit owners not in residence may be instructed to call a special telephone number to find out specific information about their condo unit.**
- **Residents who have evacuated must be aware of Sarasota County re-entry procedures in effect, especially the need for valid credentials with a Pelican Cove address such as a drivers' license, utility bill, property tax bill or condo lease agreement.**
- **After a hurricane, Pelican Cove Board Emergency Powers may be implemented which includes the right to close the property for occupancy and contract for items or services as outlined in the Pelican Cove Disaster Preparedness and Response Plan.**
- Should the Association need to contact individual owners directly and their whereabouts are unknown, the Association will contact the person(s) designated as their Emergency Contact.
- The Association will make an effort to keep roads clear from debris.
- The Association will direct traffic and will open the South Gate if necessary.
- Upon re-entry, watch Pelican Cove's in-house closed circuit channel 195 or call one of the numbers listed in the hurricane guide. **Use Sarasota County website** for updates on the local conditions.

Figure 68; The Current Pelican Cove Hurricane Preparedness Plan

In discussions with the committees of the Pelican Cove Community updating the plan was thought to be a good idea. Among the ideas are to develop plans

- Invitation to the Sarasota County Emergency Management to do a pre-hurricane season presentation to the community prior to each year's season

- Plans to assist mobility-impaired residents who would have special evacuation needs to specialized facilities;

- Development of phone-trees within a building and within a community neighborhood. where individuals within the community arrange to contact each other to confirm their evacuation and to make sure none is left behind during evacuation or needs special help after the storm. These phone-trees are employed by the SWFRPC, FWC, and many other organizations among employees to make sure everyone is safe and OK during evacuation and after tropical storms.

- Assistance to those with pet evacuations to find faculties/locations where they will be able to evacuate with their pets.

- Have each resident/renter/visitor develop their personal/family emergency plan. Which includes the following. A link to help develop the plan is at https://www.ready.gov/make-a-plan

Personal/family emergency plan

Plan places where your family will meet, both within and outside of your immediate neighborhood. Use the Family Emergency Plan to decide these locations before a disaster.

If you have a car, keep a full tank of gas in it if an evacuation seems likely. Keep a half tank of gas in it at all times in case of an unexpected need to evacuate. Gas stations may be closed during emergencies and unable to pump gas during power outages. Plan to take one car per family to reduce congestion and delay.

Become familiar with alternate routes and other means of transportation out of your area. Choose several destinations in different directions so you have options in an emergency.

Leave early, typically 24 hours, enough to avoid being trapped by severe weather.

Follow recommended evacuation routes. Do not take shortcuts; they may be blocked.

Be alert for road hazards such as washed-out roads or bridges and downed power lines. Do not drive into flooded areas.

If you do not have a car, plan how you will leave if you have to. Make arrangements with family, friends or your local government.

Take your emergency supply kit unless you have reason to believe it has been contaminated.

Listen to a battery-powered radio and follow local evacuation instructions.

Take your pets with you, but understand that only service animals may be permitted in public shelters. Plan how you will care for your pets in an emergency.

Call or email the out-of-state contact in your family communications plan. Tell them where you are going.

Secure your home by closing and locking doors and windows.

Unplug electrical equipment such as radios, televisions and small appliances. Leave freezers and refrigerators plugged in unless there is a risk of flooding. If there is damage to your home and you are instructed to do so, shut off water, gas and electricity before leaving.

Leave a note telling others when you left and where you are going.

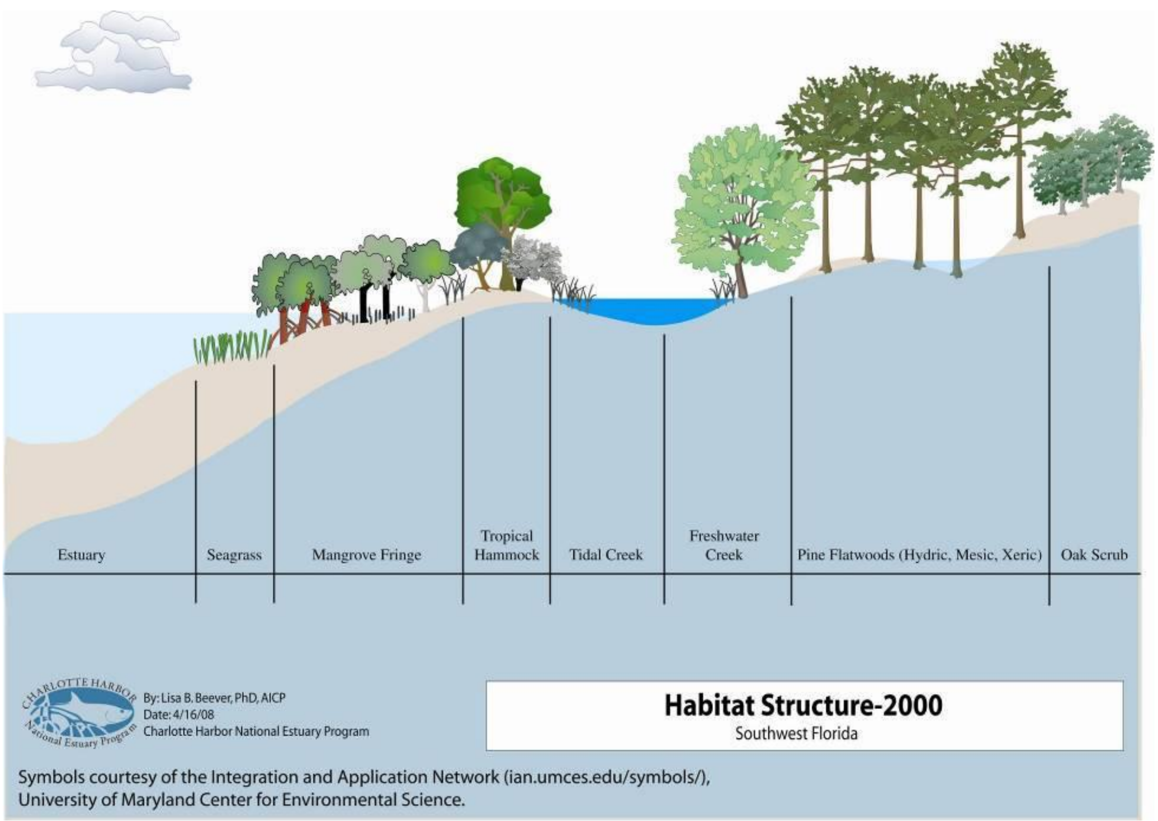
Wear sturdy shoes and clothing that provides some protection such as long pants, long-sleeved shirts and a cap.

Check with neighbors who may need a ride.

Adaptations to address vulnerabilities to the structures, grounds, and infrastructure from trees that are most susceptible to wet soils and high winds and identified plant and tree species that can reduce negative impacts on the water quality in Clower Creek and Little Sarasota Bay based on their need for fertilizer, pesticide, and irrigation

16) The recommended options to address vulnerabilities to structures, grounds, and infrastructure from trees include removal of trees with low wind resistance and the utilization of native trees with high wind resistance in future tree replacements.

The vegetation of Pelican Cove reflects a canopy that is composed of an original coastal oak hammock uplands flanked by a mangrove shoreline that has been invaded by the typical invasive exotics that move into disturbed areas and then landscaped intentionally as a form of botanical garden with a wide diversity of non-native species disperse among the residential and common areas. Some of the most problematic exotic trees were intentionally planted to act as privacy screening from adjacent properties and within the property. For example the mass planting of Australian Pines along Pelican Cove Road are used as a visual blockage of the Bay Village buildings.



There are 82 species of trees at Pelican Cove at this time. There are 29 (35.37 %) native tree species on-site with oaks and cabbage palm the most common. There are 52 (63.41%) species of non-native tree species.

Pelican Cove
Condominium

TREES AND PLANTS OF INTEREST NATURE WALK

Selected Trees, Palms, Plants and Other Points of Interest at Pelican Cove

Pelican Cove Condominium Association, Inc.
1615 Pelican Point Drive • Sarasota, FL 34231
Phone: (941) 966-5674 • Fax: (941) 966-6324

Updated: Grounds Committee 2009
e-mail: pelicancove@comcast.net

Key	Botanical Name	Common Name	Description	Max. Height	Color Span	Origin
1	Rhapis excelsa	Lady Palm	Evergreen / Moderate	Multi-stem 8'	Inconspicuous	China
2	Cycas circinalis	Queen Sago Palm	Evergreen / Tender	10' to 20'	Inconspicuous	Africa
3	Koelreuteria formosana	Golden Rain Tree	Deciduous / Hardy	50' x 30'	Yellow flowers/pink fruit	Australia
4	Beaucarnea recurvata	Pony Tail Palm	Evergreen / Moderate	15' to 25'	Inconspicuous	Mexican highlands
5	Cocos nucifera	Coconut Palm	Evergreen / Tender	50' to 80'	Inconspicuous	Pacific Islands
6	Spathodea companulata	African Tulip Tree	Deciduous / Tender	50'	Red/winter-spring	Africa
7	Cupanopsis anacardioides	Carrotwood Tree	Evergreen / Moderate	30' x 25'	Yellow orange fruit	Australia
8	Mangifera indica	Mango Tree	Evergreen / Tender	40' x 30'	Pinkish-white/winter	Native
9	Quercus virginiana	Live Oak	Semi-Deciduous / Hardy	60' to 100' x 80'	Inconspicuous	Native
10	Swietenia mahogoni	Mahogany	Semi-Deciduous / Tender	75' x 35'	Inconspicuous	Native
11	Acer rubrum	Fl. Red Maple	Deciduous / Hardy	70' x 35'	Red/late winter	Native
12	Delonix regia	Royal Poinciana	Deciduous / Moderate	40' x 40'	Orange-red/June-July	Madagascar
13	Bauhinia pinnata	Hong Kong Orchid	Semi-Deciduous / Moderate	35' to 40' x 30'	Purple/fall	China
14	Bursera simaruba	Gumbo Limbo	Semi-Deciduous / Tender	75' x 35'	Inconspicuous	Native
15	Jacaranda acutifolia	Jacaranda	Deciduous / Moderate	60' x 50'	Purple-blue/summer	So. America
16	Pinus elliottii	Slash Pine	Evergreen / Hardy	100'	Inconspicuous	China
17	Ficus Benjamina	Weeping Fig	Evergreen / Moderate	50' x 30'	Inconspicuous	China
18	Ficus lyrata	Fiddle Leaf	Evergreen / Tender	50' x 35'	Inconspicuous	Africa
19	Cinnamomum camphora	Camphor Tree	Evergreen / Hardy	50' x 35'	Black berries	China
20	Chrysalidocarpus lutescens	Areca Palm	Evergreen / Moderate	Multi-stem 20'	Inconspicuous	Madagascar
21	Livistona chenensis	Chinese Fan Palm	Evergreen / Hardy	25'	Inconspicuous	China/So. Japan
22	Chrysophyllum oliviforme	Satin Leaf Tree	Evergreen / Tender	25' x 30'	Yellow-white/fall	Caribbean
23	Quercus virginiana "QVTIA"	Highrise Oak	Semi-Deciduous / Hardy	60' to 80' x 40'	Inconspicuous	Native
24	Phoenix roebelenii	Pygmy Date Palm	Evergreen / Moderate	10'	Inconspicuous	India/Burma
25	Syagrus romanzoffianna	Queen Palm-Cocos Plumossa	Evergreen / Hardy	40'	Inconspicuous	So. Brazil/Argentina
26	Quercus laurifolia	Laurel Oak	Semi-Deciduous / Hardy	40' to 60' x 60'	Inconspicuous	Native
27	Neodypsis decaryi	Triangle Palm	Evergreen / Tender	25'	Inconspicuous	Madagascar
28	Citrofortunella mitis	Calamondin	Evergreen / Moderate	25' x 15' to 20'	White/early spring	China
29	Bougainvillea	Bougainvillea	Evergreen / Tender	15' to 20' x 15'	Many colors	So. America
30	Agave americana	Century Plant	Evergreen / Hardy	6' to 8'	Yellow green 20' spike/10 year	Native
31	Bismarckia noblis	Bismark Palm	Evergreen / Tender	30' x 60'	Inconspicuous	Madagascar
32	Quercus minima	Scrub Oak	Semi-Deciduous / Hardy	30'	Inconspicuous	Native
33	Ficus retusa	Cuban Laurel	Evergreen / Moderate	90' x 45'	Inconspicuous	India
34	Bucida "Shady lady"	Shady Lady	Evergreen / Tender	25' x 16'	Inconspicuous	Native
35	Carya glabra	Hickory Nut Tree	Deciduous / Hardy	70'	White/spring	Native
36	Laguncularia racemosa	White Mangrove	Evergreen / Moderate	60'	Inconspicuous	Native
37	Rhizophora mangle	Red Mangrove	Evergreen / Moderate	75'	White/fall	Native
38	Avicennia germinans	Black Mangrove	Evergreen / Moderate	25'	White/fall	Native
39	Psidium littorale	Cattley Guava	Evergreen / Tender	25' x 12'	White/red fruit edible	Brazil
40	Sabal palmetto	Cabbage Palm	Evergreen / Hardy	40'	Inconspicuous	Native
41	Tabebuia argentea	Tree of Gold	Deciduous / Tender	25' x 15'	Gold-yellow/spring	Paraguay/So. America
42	Callistemon viminallis	Weeping Bottlebrush	Evergreen / Hardy	20' x 20'	Red/spring-summer	Australia
43	Casuarina equisetifolia	Australian Pine	Evergreen / Hardy	50' to 70'	Inconspicuous	Australia
44	Podocarpus gracilior	Weeping Podacarpus	Evergreen / Moderate	30' x 25'	Inconspicuous	Africa
45	Brassia actinophylla	Schefflera	Evergreen / Tender	40' x 15'	Red/summer	Australia
46	Conocarpus erectus var.sericeus	Silver Buttonwood	Evergreen / Moderate	20'	Inconspicuous	No. America
47	Coccolobis uvifera	Sea Grape	Evergreen / Moderate	30' x 25'	White/spring	West Indies
48	Streelitzia uvifera	White Bird of Paradise	Evergreen / Tender	30'	White-dark blue/various	Africa
49	Hibiscus rosa - senensis	Anderson Crepe Hibiscus	Evergreen / Tender	18'	Pink/continuous	Asia
50	Eucalyptus Torelliana	Eucalyptus Tree	Evergreen / Moderate	35' x 20'	Small white/spring	Australia
51	Phoenix reclinata	Reclinata Palm	Evergreen / Hardy	Multi-stem 30'	Inconspicuous	Africa
52	Caryota mitis	Fish Tail Palm	Evergreen / Tender	25'	Inconspicuous	Asia
53	Kigelia pinnata	African Sausage Tree	Deciduous / Tender	40'	Maroon/continuous	Africa
54	Cassia fistula	Golden Shower Tree	Evergreen / Tender	30' x 15'	Yellow/spring-summer	Tropics
55	Quercus virginiana "SDLN"	Cathedral Oak	Semi-Deciduous / Hardy	60' x 40'	Inconspicuous	Native
56	Magnolia grandifolia "Bracken"	Brown Back Magnolia	Evergreen / Hardy	50' x 20'	White/spring	Native
57	Pinus palustris	Long Leaf Pine	Evergreen / Hardy	60'	Inconspicuous	Native
58	Ligustrum lucidum	Ligustrum Tree	Evergreen / Hardy	20' x 12'	Inconspicuous	Japan
59	Ilex attenuate "East Palatka"	East Palatka Holly	Evergreen / Hardy	35' x 15'	Inconspicuous	Native
60	Bambussa (spp.)	Bamboo	Evergreen / Moderate	Multi-stem 50'	Inconspicuous	Japan
61	Juniperus sillicicola	Red Cedar	Evergreen / Hardy	30'	Inconspicuous	Native
62	Dalbergia sisso	Indian Rosewood	Semi-Deciduous / Moderate	45' x 25'	Small yellow/spring	India
63	Magnolia grandiflora	Southern Magnolia	Evergreen / Hardy	60' x 80'	White/spring	Native
64	Washington robusta	Washington Palm	Evergreen / Hardy	80' to 100'	Inconspicuous	Mexico
65	Dipholis salicfollia	Willow Bustic	Evergreen / Tender	30'	White/spring	Native
66	Grevillea robusta	Silk Oak	Semi-Deciduous / Hardy	75' x 35'	Orange/spring	Australia
67	Syzigium cumini	Java Plum	Evergreen / Moderate	120' x 40'	White-purplish red fruit edible	India
68	Melaleuca leucadendron	Punk Tree	Evergreen / Hardy	50' x 20'	White/late spring	Australia
69	Ravenea rivularis	Majesty Palm	Evergreen / Tender	20'	Inconspicuous	Madagasgar
70	Callistemon	Rigid Bottlebrush	Evergreen / Hardy	25' x 20'	Red/spring-summer	Australia
71	Myrica cerifera	Wax Myrtle	Evergreen / Hardy	20' x 10'	Inconspicuous/blue green fruit	Native
72	Illex attenuate	Eagleston Holly	Evergreen / Hardy	25' x 8'	Inconspicuous	Native
73	Wodyetia bifurcate	Foxtail Palm	Evergreen / Tender	30'	Inconspicuous	Northern Australia
74	Serenoa repens	Saw Palmetto	Evergreen / Hardy	6'	Inconspicuous	Native
75	Datura arborea	Angel Trumpet	Evergreen / Moderate	20'	Various/spring-summer-fall	Tropics
76	Ardisia escallonioides	Marlberry Tree	Evergreen / Tender	25'	White/spring	Native
77	Peltaforum	Yellow Poincianna	Deciduous / Moderate	40' x 40'	Yellow/late winter	Madagasgar
78	Phoenix canariensis	Canary Island Date Palm	Evergreen / Hardy	40'	Inconspicuous	Canary Island
79	Acoelorrhaphe wrightii	Paurotis Palm	Evergreen / Hardy	Multi-stem 20'	Inconspicuous	Native
80	Araucaria excelsa	Norfolk Pine	Evergreen / Hardy	100' x 18'	Inconspicuous	Norfolk Island
81	Chorisia speciosa	Floss-Silk Tree	Deciduous / Tender	50'	Pink /fall	Argentina
82	Carissa macrocarpa	Natal Plum	Evergreen / Moderate	10'	White /spring-summer	South Africa

Table 3: Trees of the Pelican Cove Community

Twenty-one tree species have the highest wind resistance. Seventeen of the trees with the best wind resistance are natives. Of the non-native trees with high wind resistance all are palms naturally adapted to high winds of their original home environment.

Fourteen tree species have medium wind resistance, 30 species have medium to low wind resistance, and 17 have low wind resistance. Only 2 of the species with the lowest wind resistance are native, the red cedar and laurel oak. The other 15 include some of the worst invasive plant exotics in Florida including Australian pine, melaleuca, and carrotwood.

The following table specifies the wind resistance characteristics of the tree species of Pelican Cove.

Wind Resistance of the Trees of the Pelican Cove Community		
Botanical Name	Common Name	Wind Resistance

Acer rubrum	Florida Red Maple	Medium-Low Wind Resistance
Acoelorrhaphe wrightii	Parrotis Palm	Medium-High Wind Resistance
Agave americana	Century Plant	Medium-High Wind Resistance
Araucaria excelsa	Norfolk Pine	Lowest Wind Resistance
Ardisia escalloruoides	Marlberry Tree	Medium-High Wind Resistance
Avicennia germinans	Black Mangrove	Highest Wind Resistance
Bambussa (spp.)	Bamboo	Medium-Low Wind Resistance to Lowest Wind Resistance
Bauhinia pinnata	Hong Kong Orchid	Medium-Low Wind Resistance
Beaucamea recurvata	Ponytail Palm	Medium-Low Wind Resistance
Bismarckia noblis	Bismarck Palm	Medium-Low Wind Resistance to Lowest Wind Resistance
Bougainvillea (spp.)	Bougainvillea	Medium-High Wind Resistance
Brassia actinophylla	Schemera	Lowest Wind Resistance
Bucida "Shady lady"	Shady Lady	Medium-Low Wind Resistance
Bursera simaruba	Gumbo Limbo	Highest Wind Resistance
Callistemon rigidus	Rigid Bottlebrush	Medium-Low Wind Resistance
Callistemon viminauis	Weeping Bottlebrush	Medium-Low Wind Resistance
Carissa macrocarpa	Natal Plum	Medium-Low Wind Resistance
Carya glabra	Hickory Nut Tree	Medium-High Wind Resistance
Caryota mitis	Fish Tail Palm	Medium-High Wind Resistance
Cassia fistula	Golden Shower Tree	Lowest Wind Resistance
Casuarina equisetifolia	Australian Pine	Lowest Wind Resistance
Chorisia speciosa	Floss-Silk Tree	Lowest Wind

		Resistance
Chrysalidocarpus luteseens	Areca Palm	Medium-High Wind Resistance
Chrysophyllum olivifonne	Satin Leaf Tree	Medium-High Wind Resistance
Cinnamomum camphora	Camphor Tree	Medium-High Wind Resistance
Citrofortunella mitis	Calamondin	Medium-Low Wind Resistance
Coccoloba uvifera	Sea Grape	Highest Wind Resistance
Cocos nucifera	Coconut Palm	Medium-High Wind Resistance
Conocarpus erectus var. sericeus	Silver Buttonwood	Highest Wind Resistance
Cupamopsis anacardioides	Carrotwood Tree	Lowest Wind Resistance
Cyeas circinalis	Queen Sago Palm	Medium-Low Wind Resistance
Dalbergia sisso	Indian Rosewood	Medium-Low Wind Resistance
Datura arborea	Angel Trumpet	Medium-Low Wind Resistance
Delonix regia	Royal Poinciana	Medium-Low Wind Resistance
Dipbolis salicfollia	Willow Bustic	Medium-High Wind Resistance
Eucalyptus torelliana	Eucalyptus Tree	Medium-Low Wind Resistance
Ficus benjamina	Weeping Fig	Lowest Wind Resistance
Ficus lyrata	Fiddle Leaf	Medium-Low Wind Resistance
Ficus reclusa	Cuban Laurel	Medium-Low Wind Resistance
Grevillea robusta	Silk Oak	Lowest Wind Resistance
Hibiscus rosa-senensis	Anderson Crepe Hibiscus	Medium-Low Wind Resistance
Ilex attenuate "East Palatka"	East Palatka Holly	Highest Wind Resistance
Jacaranda acutifolia	Jacaranda	Lowest Wind Resistance
Juniperus sillicicola	Red Cedar	Lowest Wind Resistance

Kigelia pinnata	African Sausage Tree	Medium-Low Wind Resistance
Koelreuteria formosana	Golden Rain Tree	Medium-Low Wind Resistance
Laguncularia racemosa	White Mangrove	Highest Wind Resistance
Ligustrum lucidum	Ligustrum Tree	Medium-Low Wind Resistance
Livistona chenensis	Chinese Fan Palm	Highest Wind Resistance
lllex attenuate	Eagleston Holly	Highest Wind Resistance
Magnolia grandiflora	Southern Magnolia	Highest Wind Resistance
Magnolia grandiflora "Bracken"	Brown Back Magnolia	Highest Wind Resistance
Mangifera indica	Mango Tree	Medium-Low Wind Resistance
Melaleuca leucadendron	Punk Tree	Lowest Wind Resistance
Myrica cerifera	Wax Myrtle	Medium-Low Wind Resistance
Neodypsis decaryi	Triangle Palm	Medium-High Wind Resistance
Peltaphorum pterocarpum	Yellow Poinciana	Lowest Wind Resistance
Phoenix canariensis	Canary Island Date Palm	Highest Wind Resistance
Phoenix reclinata	Reclinata Palm	Highest Wind Resistance
Phoenix roe elenii	Pygmy Date Palm	Highest Wind Resistance
Pinus elliottii	Slash Pine	Medium-Low Wind Resistance
Pinus palustris	Long Leaf Pine	Medium-Low Wind Resistance
Podocarpus gracilior	Weeping Podocarpus	Highest Wind Resistance
Psidium littorale	Cauley Guava	Medium-Low Wind Resistance
Quercus laurifolia	Laurel Oak	Lowest Wind Resistance
Quercus minima	Scrub Oak	Highest Wind Resistance
Quercus virginiana "QVTIA"	Highrise Oak	Highest Wind

		Resistance
Quercus virginiana	Live Oak	Highest Wind Resistance
Quercus virginiana "SDLN"	Cathedral Oak	Highest Wind Resistance
Ravenea rivularis	Majesty Palm	Medium-Low Wind Resistance
Rhapis excelsa	Lady Palm	Medium-Low Wind Resistance
Rhizophora mangle	Red Mangrove	Highest Wind Resistance
Sabal palmetto	Cabbage Palm	Highest Wind Resistance
Serenoa repens	Saw Palmetto	Highest Wind Resistance
Spathodea companulata	African Tulip Tree	Lowest Wind Resistance
Streelitzia uvifera	White Bird of Paradise	Medium-Low Wind Resistance
Swietenia mahagoni	Mahogany	Medium-High Wind Resistance
Syagrus romanzoffianna	Queen Palm-Cocos Plumossa	Lowest Wind Resistance
Syzigium cumini	Java Plum	Medium-Low Wind Resistance
Tabebuia argentea	Tree of Gold	Lowest Wind Resistance
Washington robusta	Washington Palm	Lowest Wind Resistance
Wodyetia bifurcate	Foxtail Palm	Medium-High Wind Resistance

Table 4: Wind Resistance of Tree of the Pelican Cove Community

The most immediate adaptation needs for Pelican Cove in regard to trees is to address the trees with the lowest wind-resistance and the highest likelihood to topple or break to form projectiles. These are listed in the following table.

The problem tree species with the lowest wind resistance and the greatest danger to buildings, infrastructure, and access		
Araucaria excelsa	Norfolk Pine	Planned Removal and replace with alternate native
Brassia actinophylla	Schemera	Reduce or Remove only if threatening Structures and access

Cassia fistula	Golden Shower Tree	Reduce or Remove only if threatening Structures and access
Casuarina equisetifolia	Australian Pine	Planned Removal and replace with alternate native
Chorisia speciosa	Floss-Silk Tree	Reduce or Remove only if threatening Structures and access
Cupamopsis anacardioides	Carrotwood Tree	Planned Removal and replace with alternate native
Ficus benjamina	Weeping Fig	Reduce or Remove only if threatening Structures and access
Grevillea robusta	Silk Oak	Reduce or Remove only if threatening Structures and access
Jacaranda acutifolia	Jacaranda	Reduce or Remove only if threatening Structures and access
Juniperus sillicicola	Red Cedar	Reduce or Remove only if threatening Structures and access
Melaleuca leucadendron	Punk Tree	Planned Removal and replace with alternate native
Peltaphorum pterocarpum	Yellow Poinciana	Reduce or Remove only if threatening Structures and access
Quercus laurifolia	Laurel Oak	Reduce or Remove only if threatening Structures and access
Schinus terebinthifolius	Brazilian Pepper,	Planned Removal and replace with alternate native
Spathodea companulata	African Tulip Tree	Reduce or Remove only if threatening Structures and access
Syagrus romanzoffianna	Queen Palm	Planned Removal and replace with alternate native
Tabebuia argentea	Tree of Gold	Reduce or Remove only if threatening Structures and access
Washingtonia robusta	Washington Palm	Planned Removal and replace with alternate native

Table 5: Tree species with low wind resistance factor at the Pelican Cove Community

The most dangerous non-native trees with lowest wind resistance (Australian pines, melaleuca, Norfolk Pine) and therefore that have the highest potential for damage to buildings and infrastructure and to blocking road access safety and evacuation are located at the entrance road areas of Pelican Cove, at segments of the Bayhouse shoreline, portion of Clower Creek, and distributed as individual trees or tree copses throughout the community. : It is recommended that a schedule be developed and implemented, similar to the existing plan that have been developed for removal of melaleuca and laurel oaks to address removal and/or height reduction of these 17 species for the safety of the community during tropical storms and other high wind events. .

Allelopathy is a biological phenomenon by which an organism produces one or more biochemicals that influence the germination, growth, survival, and reproduction of other organisms. These biochemicals are known as **a**llelochemicals and can have beneficial (positive allelopathy) or detrimental (negative allelopathy) effects on the target organisms and the community. Allelochemicals are a subset of secondary metabolites, which are not required for metabolism (i.e. growth, development and reproduction) of the allelopathic organism. Allelochemicals with negative allelopathic effects are an important part of plant defense against herbivory. The production of allelochemicals are affected by biotic factors such as nutrients available, and abiotic factors such as temperature and pH. Allelopathy is characteristic of certain plants, algae, bacteria, coral, and fungi. Allelopathic interactions are an important factor in determining species distribution and abundance within plant communities, and are also thought to be important in the success of many invasive plants. Specific examples of negative allelopathy at Pelican Cove include Australian pine, melaleuca, and Brazilian pepper.

Some trees are growing under foundations and roadways causing structural damage. These locations, such as Bayhouse Court, will need a careful approach to tree/root removal that may need the filling of voids and resetting the foundation after root removal. Typically it is exotic Ficus and tree species that root laterally without a tap root the move under foundations.

Generally the approach in some coastal areas of Pelican Cove should be to retain root systems when the exotic trees are located in a coastal or erosional setting where trying to remove the root mass would destabilize slopes and potentially building. In some locations residents may object to the loss of perceived privacy provided by thick exotic trees Hedging of these trees to reduce height could create a situation where a number of the residents would object to the hedging of these trees. A better plan would be for the removal of the pines and replacing with native trees and understory plantings. Depending on the situation it would be possible to plant shade tolerant replacement species.

For each problem trees species, (Australian pine, melaleuca, Brazilian pepper, and carrotwood the grounds staff and grounds committee should develop a replace/removal schedule while emphases a priority of removing the worst species first the have the most imminent threat to structures and access to the Pelican Cove Community. For each problem tree species there are native tree species with better attributes and better wind resistance that are beautiful, functional, and can enhance the water quality conditions and wildlife habitat value of Pelican Cove.

The following is table with native tree substitutions for the tree species with the lowest wind resistance.

The problem tree species and the recommended native tree replacements		
Problem Tree	Native Replacement Tree	Plan for Problem Tree
Norfolk Pine, *Araucaria excelsa*	Willow Bustic, *Sideroxylon salicifolium*	Planned Removal and replace with alternate native
Schemera, *Brassia actinophylla*	White Ironwood, *Hypelate trifoliata*	Reduce or Remove only if threatening Structures and access
Golden Shower Tree, *Cassia fistula*	Sweet Acacia, *Acacia farnesiana*	Reduce or Remove only if threatening Structures and access
Australian Pine, *Casuarina equisetifolia*	Sea Grape, *Coccoloba uvifera*	Planned Removal and replace with alternate native
Floss-Silk Tree, *Chorisia speciosa*	Spicewood, *Calyptranthes pallens*	Reduce or Remove only if threatening Structures and access
Carrotwood Tree, *Cupamopsis anacardioides*	Buttonwood, *Conocarpus erecta* - both green and silver	Planned Removal and replace with alternate native
Weeping Fig, *Ficus benjamina*	Gumbo Limbo, *Bursera simaruba*	Reduce or Remove only if threatening Structures and access
Silk Oak, *Grevillea robusta*	Jamaican Caper, *Capparis cynophallophora*	Reduce or Remove only if threatening Structures and access
Jacaranda, *Jacaranda acutifolia*	Paradise Tree, *Simarouba glauca*	Reduce or Remove only if threatening Structures and access
Red Cedar, *Juniperus sillicicola*	Southern slash pine, *Pinus elliotti* var. densa or Longleaf Pine, *Pinus palustris*	Reduce or Remove only if threatening Structures and access
Punk Tree, *Melaleuca leucadendron*	Satin Leaf, *Chrysophyllum oliviforme*, or Florida Cupania, *Cupania glabra*	Planned Removal and replace with alternate native
Yellow Poinciana, *Peltaphorum*	West Indian Mahogany, *Swietenia mahagoni*	Reduce or Remove only if threatening Structures and

pterocarpum		access
Laurel Oak, Quercus laurifolia	Live Oak and Scrub Live Oak, *Quercus virginiana*	Reduce or Remove only if threatening Structures and access
Brazilian Pepper, Schinus terebinthifolius	Sea Grape, *Coccoloba uvifera*	Planned Removal and replace with alternate native
African Tulip Tree, Spathodea companulata	Wild Tamarind, *Lysiloma lastisiliquum*	Reduce or Remove only if threatening Structures and access
Queen Palm, Syagrus romanzoffianna	Cabbage Palm, *Sabal palmetto*	Planned Removal and replace with alternate native
Tree of Gold, *Tabebuia argentea*	Lignumvitae, *Guajacum sanctum*	Reduce or Remove only if threatening Structures and access
Washington Palm, *Washingtonia robusta*	Florida Thatch Palm, *Thrinax radiata* or Keys Thatch Palm, *Thrinax morrisii*	Planned Removal and replace with alternate native

Table 6: Tree replacement plan for tree species with low wind resistance factor at the Pelican Cove Community

The options examined to reduce negative impacts on the water quality in Clower Creek and Little Sarasota Bay by different plant species needs for fertilizer, pesticide and irrigation include favoring native vegetation species over exotics, selecting plants of maritime hammock uplands and flanking estuarine and creek transition zones; introduce some native tropical hardwood hammock specie; stabilizing exposed and eroding shore and backshore areas with marsh grasses and herbaceous marsh species in Zonal Shoreline Plantings; some changes in mangrove trimming, and some continual improvement in fertilizer management.

The vegetation understory in Pelican Cove is principally exotic species ranging from sod grasses to typical nursery landscaping species like hibiscus and periwinkles and several invasive exotic species including Brazilian pepper, wedelia, and exotic ferns as well as some toxic species like cats-eye and Devil's trumpet.

There are pockets of coastal hammock shrubs with sea grape, inkberry, sea ox-eye daisey, silver buttonwood, and palmettos found shoreward of the mangrove fringes in the Bayhouse and lower Clower Creek areas.

Pelican Cove has a progressive and nature-based Landscape Management Plan and its components are a significant improvement of standard southwest Florida subdivisions landscaping. The adaptation plan recommendations build upon the good practice currently implemented and are design o provide guidance toward a future community landscape that provides the structure, functions, and ambiance of the Pelican Cove Community that is more adapted to Florida and its future climate conditions. The basic principle for these adaptations is to Design With nature so as to provide a plant community that fits into in landscape, hydrogeomorphic and climactic setting. Another major goal is to have a landscape that provides self-maintenance with less needs for irrigation, pesticides, and fertilizer.

The additional principles/ polices suggested are

17) Favor native vegetation species over exotics.

In general Florida native plant species do not need irrigations, require no fertilizer, and do not need pesticides. The rare exemption for pesticides is when a new exotic plant disease enters Florida from the exotic palm trade that then attacks a related the native tree species. An example of this is the royal palm disease. native plants with those exotic disease problem are no recommended for future use.

18) selecting plants of maritime hammock uplands and flanking estuarine and creek transition zones;

By selecting plants of the maritime hammock uplands and flanking estuarine and creek transition zones Pelican Cove would be working with nature to provide the vegetation most able to survive and thrive in its current setting an conditions..Maritime Hammock Maritime Hammock - (synonyms: coastal hammock, maritime forest, tropical hammock). is characterized as hardwood forest lying just inland of a coastal waterbody (like Little Sarasota Bay. Live oak, cabbage palm, and red bay generally combine to form a dense, wind-pruned canopy whose streamlined profile deflects winds and generally prevents hurricanes from uprooting the trees. Other typical plants include American holly, southern magnolia, red cedar, sea grape, false mastic, paradise tree, lancewood, gumbo- limbo, strangler fig, poisonwood, wild olive, saw palmetto, beautyberry, poison ivy, coral bean, coontie, prickly ash, wild coffee, snowberry, myrsine, caper tree, marlberry, rouge-plant, and ferns. Typical animals include squirrel treefrogs, box turtles and gray squirrel. Migrating birds rely on these forests for food and shelter following trans-oceanic or trans-gulf migrations. Maritime Hammock occurs on old coastal dunes that have been stabilized long enough for the growth of a forest. Tree growth often begins in swales between old dune ridges where a higher moisture gradient exists. The isolated strips of tree growth gradually coalesce into a continuous forest. Humus buildup contributes to moisture retention, while the dense canopy minimizes temperature fluctuations by reducing soil warming during the day and heat loss at night. The generally mesic conditions and insular locations of well-developed Maritime Hammock communities inhibit natural fires, which occur no more frequently than once every 26 to 100 years. Nutrient recycling is generally accomplished by detrital organisms instead of by fire. Maritime Hammock is the terminal stage of succession in coastal areas.

Maritime Hammock is the prime resort and residential property on the west coast of Florida because of its relatively protected location along the coast. Although it originally occurred in virtually continuous bands with Coastal Strand, Maritime Hammock is now dissected into short strips by development and is rapidly disappearing as an endangered habitat. Maritime Hammock is reasonably resilient so long as the canopy remains intact and the landform stable. Removal of large exotic species should be conducted in phases to minimize canopy disruptions.

20) Introduce some native tropical hardwood hammock species to the landscape;

The current conditions at Pelican Cove will support some native tropical hardwood species. The problem tree replacement table indicates several which are better trees for the community with many positive attributes. As the climate continues to warm and southwest Florida shifts toward more tropical conditions from its subtropical state the northern boundary for tropical hardwood hammocks will continue to extend northward along the Gulf of Mexico shoreline.

The word “hammock” was first used by Native Americans of Florida to mean a cool and shady place. Later, settlers of Florida used the word “hummock” to indicate areas that were slightly higher in elevation from the rest of the land. Today, the term hammock is used in Florida to describe forest habitats that are typically higher in elevation than surrounding areas and that are characterized by hardwood forests of broad-leaved evergreens. Tropical hardwood hammocks occur in south Florida and along the Florida coastlines where danger from frost is rare and tropical trees and shrubs common to the Caribbean islands (West Indian origin) are able to survive.

Historically, tropical hardwood hammocks were found as far north as Cape Canaveral on Florida's east coast and up to the mouth of the Manatee River on the west coast. However, development pressure associated with growth of the South Florida human population has resulted in the conversion of many of these forests to urban and agricultural uses.

While few plant species are endemic to tropical hardwood hammocks, hammocks are critical habitat for West Indian species where the northernmost portions of their ranges extend into South Florida. Plants with their entire United States distribution in South Florida, and which are limited to tropical hardwood hammock habitats include Bahama strongbark (*Bourreria succulenta*), buccaneer palm (*Pseudophoenix sargentii*), crabwood (*Gymnanthes lucida*), Florida boxwood (*Schaefferia frutescens*), Florida oncidium (*Oncidium floridanum*), ghostplant (*Leiphiamos parasitica*), green thatch palm (*Thrinax radiata*), Key's nutrush (*Scleria lithosperma*), Key's tree cactus (*Pilosocereus robinii*), Krug's holly (*Ilex krugiana*), least halberd fern (*Tectaria fimbriata*), lignum vitae (*Guajacum sanctum*), mahogany mistletoe (*Phoradendron rubrum*), manchineel (*Hippomane mancinella*), milkbark (*Drypetes diversifolia*), pearlberry (*Vallesia antillana*), princewood (*Exostema caribaea*), red stopper (*Eugenia rhombea*), slender spleenwort (*Asplenium dentatum*), spicewood (*Calyptranthes pallens*), West Indian cherry (*Prunus myrtifolia*), West Indian mahogony (*Swietenia mahagoni*), wild dilly (*Manilkara jaimiqui* ssp. *emarginata*), and wild-tamarind (*Lysiloma latisiliquum*).

The canopy height of tropical hardwood hammocks varies according to substrate and climate. Typical canopy species of tropical hardwood hammocks include gumbo-limbo (*Bursera simaruba*), paradise tree (*Simarouba glauca*), pigeon-plum (*Coccoloba diversifolia*), strangler fig (*Ficus aurea*), wild mastic (*Sideroxylon foetidissimum*), and willow-bustic (*Sideroxylon salicifolium.* Other canopy trees include short-leaf fig (*Ficus citrifolia*) and wild-tamarind, West Indian mahogany. Some epiphytes also occur in the hammock canopy, including Spanish-moss (*Tillandsia usneoides*) and ballmoss (*T. recurvata*).

Common subcanopy and understory trees and shrubs include black ironwood (*Krugiodendron ferreum*), inkwood (*Exothea paniculata*), lancewood (*Ocotea coriacea*), marlberry (*Ardisia escallonoides*), poisonwood (*Metopium toxiferum*), satinleaf (*Chrysophyllum oliviforme*), and white stopper (*Eugenia axillaris*). Additional rockland hammock species include crabwood and spicewood. Coastal hammocks typically include saffron-plum (*Sideroxylon celastrinum*), Spanish stopper (*Eugenia foetida*), and sea-grape (*Coccoloba diversifolia*). Buttonwood (*Conocarpus erectus*) can often be found in hammocks along the interface with mangrove swamps and salt marshes. Additional subcanopy and understory species include Bahama strongbark (*Bourreria succulenta*), beeftree (*Guapira discolor*), darling-plum (*Reynosia septentrionalis*), Florida boxwood, green thatch palm, Jamaica caper (*Capparis cynophallophora*), Key's tree cactus, lignum-vitae, limber caper (*Capparis flexuosa*), manchineel, mayten (*Maytenus phyllanthoides*), milkbark, pearlberry, princewood, red stopper, torchwood (*Amyris elemifera*), and wild dilly. Species associated with aboriginal activity include red mulberry (*Morus rubra*) and soapberry (*Sapindus saponaria*), and those associated with wet areas in hammocks (such as sinkholes) include cocoplum (*Chrysobalanus icaco*), hackberry (*Celtis laevigata*), and pond-apple (*Annona glabra*). Several species, including Krug's holly, and West Indian cherry are limited in distribution to tropical hardwood hammocks on the Miami Rock Ridge. Subcanopy and understory species with extremely limited distributions include: bitterbush (*Picramnia pentandra*)--occurring only in coastal hammocks on the Miami Rock Ridge; Vines often associated with the hammock subcanopy include pull-and-hold-back (*Pisonia aculeata*), *Tournefortia hirsutissima*, and *T. volubilis*. Epiphytes found in the sub-canopy and understory include Florida peperomia (*Peperomia obtusifolia*) and resurrection fern (*Polypodium polypodioides*). In the lower portions of the understory, especially in wetter areas, epiphytes such as strap-leaved guzmania (*Guzmania monostachya*) and soft-leaved tillandsia (*Tillandsia variabilis*), can also be found.

The tropical hardwood hammock shrub and herb layer is mostly consisting of seedlings and saplings of canopy and subcanopy trees and shrubs. However, shiny-leaf wild-coffee (*Psychotria nervosa*) is not infrequently found in this layer, as well as herbs such as rouge plant (*Rivina humilis*), and false mint (*Dicliptera sexangularis*). Two species of native grasses can also be frequently found in this layer: bamboo grass (*Lasciasis divaricata*), and woods grass (*Oplismenus hirtellus*). Historically on the mainland, a variety of ferns and terrestrial orchids could be found, including Boston fern (*Nephrolepis exaltata*), Florida oncidium, and sword fern (*Nephrolepis biserrata*). Common trees and shrubs include American beautyberry (*Callicarpa americana*), coco-plum, common snowberry (*Chiococca alba*), coralbean (*Erythrina herbacea*), firebush (*Hamelia patens*), Florida trema (*Trema micrantha*), myrsine (*Rapanea punctata*), rough velvetseed (*Guettarda scabra*), and white indigoberry (*Randia aculeata*). In coastal areas, hammock edge species include blackbead

(*Pithecellobium keyense*) and limber caper (*Capparis flexuosa*). Vines associated with hammock edges include muscadine grape (*Vitis rotundifolia*), and greenbrier (*Smilax auriculata*). Typical airplant species include common wild-pine (*Tillandsia fasciculata*), giant wild-pine (*Tillandsia utriculata*), reflexed wild pine (*Tillandsia balbisiana*), and twisted wild pine (*Tillandsia flexuosa*). Herbs commonly associated with hammock edges include woods fern (*Thelypteris kunthii*), and pine fern (*Anemia adiantifolia*).

Many of the trees and plants found in tropical hardwood hammocks provide useful products for humans. For example, the ability of the gumbo limbo to sprout roots and produce a new tree from a fallen branch has been used to create living fences of gumbo limbo trees. The wood of the lancewood was used to make fishing poles. The lignum vitae, which is sometimes called the "wood of life," is one of the densest woods available. Its density, oily resin, and fine texture made it historically important for the production of ship propeller shafts, bearings, caster wheels, rollers, and washers. While many plants in tropical hardwood hammocks are useful to humans as a fishing tool of Native Flordians they can also be harmful. For example, the Jamaica-dogwood produces an oily resin that may cause severe skin irritation in humans.. Jamaica-dogwood (*Piscidia piscipula*), wild cinnamon (*Canella winterana*), are not recommended for the landscape of Pelican Cove.

19) Stabilize exposed and eroding shore and backshore areas with marsh grasses and herbaceous marsh species in Zonal Shoreline Plantings;

The stabilization of exposed and eroding shore and backshore areas with marsh grasses and herbaceous marsh species in Zonal Shoreline Plantings is discussed in the section on the proposed living shorelines.

20) Some changes in mangrove trimming practice;

There are several different types of mangrove fringe trimming. The Pelican Cove Community utilizes two of these. One is hedge trimming to a uniform height for all species.

Figure 69: Area of mangrove hedge trimming at South Cove area of Pelican Cove

The other method is selective uplifting of some mangroves to allow them to grow to a higher height with lateral branch trimming to allow a view.

Figure 70: Area of uplift trimming combined with hedging near the point at Pelican Cove.

Figure 71: Another example of limited uplift trimming coupled with hedging.

Estevez and Evans (1978 focused on loss of ecosystem function after pruning. There study looked at various types of pruning including uniform removal of the lower canopy from lower edge upward (undercutting), removal of the canopy from top down (hedging) and selective limb removal leaving the canopy intact (windows) on propagule production of red mangroves. The best remaining propagule production (reproduction) occurred with windows, the least with hedging, and in between values were found with undercutting

A Beever (1991) study in the Southwest Florida Aquatic Preserve found no net positive value of trimming to production of mangroves and demonstrated that primary production was reduced based upon the measured parameters. The study demonstrated the effects of mangrove hedging and improper trimming can be substantial, with losses of 8.6 tons of carbon/hectare/year when a 6 meter (20 foot) tall canopy is reduced to 1.5 meters (5 feet) in height. In an urbanized area where the majority of the shoreline could be subjected to hedging, this could result in a local loss of approximately 87% of the annual productivity of the mangrove ecosystem. A comparison of cut and adjacent natural mangrove fringes in seven of the eight Southwest Florida aquatic preserves was performed, utilizing standardized methods of measurement of mangrove productivity including standing crop and leaf parameters. Statistically significant reduction in net primary productivity export (83%), reduction of standing leaf crop (71%), reduction of flower production (95%), reduction of propagule production (84%), and reduction of leaf clusters (70%) resulted from the cutting of the 4.9 meter (16.1 feet) tall fringing red mangrove to 1.7 m (5.4 feet).. Similarly, reduction of net primary productivity export (72%), reduction of standing leaf crop (49%), reduction of propagule production (73%), and reduction of terminal branches (45%) resulted from cutting a 3.4 meter tall fringing white mangrove area to 1.3 m. Habitat utilization by associated large visible fauna was significantly reduced (79%) by mangrove trimming. For the parameters measured, no net positive benefit of mangrove trimming/cutting could be confirmed. The documented evidence of this study and existing literature indicate that mangrove cutting is deleterious to the estuarine environment; the mangrove trees themselves, and the fauna which depend upon mangroves for habitat and primary production (Beever 1996).

Parkinson et al. (1999) working in the Indian River Lagoon evaluated litter fall response of red mangroves to selective pruning using windowing over a 33 month period. They concluded that mean litter fall was not significantly different before and after pruning. However, they did note the invasion of the mangrove forest edge by Brazilian pepper, *Schinus terebinthifolius*, as a result of trimming, and cautioned that cumulative impacts of stress from repeated trimming could be detrimental.

There are final recommendations of the Science Subcommittee of the Mangrove Technical Advisory Committee (MTAC) established by the Florida Department of Natural Resources in 1994 (MTAC 1994) to provide technical guidance on mangrove trimming. Their final recommendation include:

I. For red mangrove trees of greater than 1 inch dbh [diameter breast high], black mangrove trees of greater than 8 inches dbh and white mangroves of greater than12 inches dbh no top trimming is recommended.

II. Selective removal of lateral branches in this and larger size classes can provide a view window. The combination of top trimming trees less than the specified dbh and uplifting trees of greater dbh and height creates a view window in a zone between the topped mangroves and the uplifted mangroves. Widow sizes can be up to 15 feet in vertical dimension and can be adjusted to site specifics by design and permit. This view window would be located site specific and can constitute100% of lateral limbs and branches in red mangrove forests, provided that no trunks greater than the specified dbh by species are topped trimmed.

III. Mangrove forests permitted for top trimming and thinning will not exceed 25 1. f. in width as measured from trunk to trunk. Mangrove forests of less than 0.5 acres continuous extent, irrespective of site boundaries, may be considered for all forms of alteration regardless of width as specified below.

IV. All species of mangrove trees greater than six feet in height and less than 20 feet in height may be reduced in extent to the point at which the trunk or branch diameter is one inch, provided no trunk is cut below six feet in height, and no branch is cut in the areas below six feet in height or above 20 feet in height.

It is often misunderstood that the final regulations on mangrove trimming instituted by the State of Florida in 1996 did not follow the recommendations of the above referenced committee. It is therefore not correct to state that there was, or is today, scientific support to allow all mangroves to be cut down to 2 m (6 feet) in height no matter the species, dbh or height (Lewis 2003).

The protection that mangroves provide from wind damage and storm surge is significant. The ecosystem service value of a mangrove fringe in southwest Florida has been calculated to be $3,609.57 per acre/year in 2013 dollars. The level of protection of the fringe depends upon its extent and height with tall fringes providing more protection particularly from wind damage.

It is recommended that Pelican Cove consider expanding it mangrove trimming windowing/ uplifting to all mangrove shorelines. This would over time increase the protection the mangrove fringe provides for the community and increase the health of the mangrove fringe itself. The number of trees uplifted can be variable. It is recommended that the mangrove hedge be allowed to grow to a height at the actual viewshed height needed, rather than a set height at a size below what is needed for view.

Figure 72: An improved mangrove windowing and hedge design in southwest Florida

21) Continual improvement in fertilizer management

The Pelican Cove community has a advanced and progressive approach to landscape management. The Pelican Cove Landscape Management Policy adapted in 2008 speaks to the use of fertilizer and pesticides in the landscape. The Fertilizer Management Policy state that Pelican Cove will continue to meet or exceed all Sarasota County and State of Florida Codes and/or regulations regarding the use of fertilizer, types allowed, application guidelines and certification requirements. A low maintenance zone of landscape plants appropriate to preventing and/or reducing fertilizer runoff will be maintained around the Brookhouse Ponds, Clower Creek, the Harbor area and the Bay. The policy on Pest Management Practices states Pelican Cove will continue to utilize Best Pest Management practices and limit as much as possible all applications or pesticides. We will use "weed and feed" products only when absolutely necessary, and in limited areas.

At this time the local government fertilizer ordinance for Sarasota County is stricter and more protective than the State of Florida standard. There have been repetitive annual attempts by the Florida legislature to preempt or eliminate strict local government fertilizer standards This behavior can be expected to continue. It is recommended that the Pelican Cove Community commit to the better standards for fertilizer management irrespective of any weakening that may be made in future state actions.

The critical recommendations that need to be retained or followed to protect water quality in southwest Florida are:

A. **Timing of Application**
No Applicator shall apply Fertilizers containing nitrogen and/or phosphorus to Turf and/or Landscape Plants during the "rainy season" (defined as July 1 through September 30 of each calendar year).

B. Fertilizer Content and Application Rate
1) No Fertilizer shall be applied to Turf and/or Landscape Plants within Southwest Florida that contains more than 2% phosphorous or other compounds containing phosphorous, such as phosphate, per guaranteed analysis label (as guaranteed analysis and label are defined by Chapter 576 Florida Statutes, such definition incorporated herein). The use of no phosphorus Fertilizer is strongly encouraged, as Florida soils typically contain sufficient phosphorus for a healthy native or man-made landscape
2) Fertilizer applied to Turf and/or Landscape Plants within the Southwest Florida must contain no more than 20% total nitrogen, with at least 70% as Slow Release Nitrogen per guaranteed analysis label (as guaranteed analysis and label are defined by Chapter 576 Florida Statutes, such definition incorporated herein).
3) Fertilizer applied to Turf and/or Landscape Plants within Southwest Florida must be slow release, granulated fertilizer. Blended fertilizer shall not be applied.
4) Fertilizers should be applied to Turf and/or Landscape Plants at the lowest rate necessary without exceeding the maximum weight per application. Fertilizer shall not be applied at a rate greater than one (1) pound of nitrogen per 1000 square feet per application. No more than four (4) pounds of nitrogen per one thousand (1000) square feet shall be applied to any Turf/landscape area in any calendar year.

The above provisions are also applicable to and regulate the application of pesticide/Fertilizer mixtures, including, but not limited to, "weed and feed" products.

C. **Total Yearly Applications**
While single Fertilizer applications in the fall and spring will often suffice, Fertilizers shall not be applied more than six (6) times during any one calendar year to a single area. A Controlled Release Landscape Management Plan is strongly recommended.

D. **Impervious surface**
Fertilizer shall not be applied, spilled, or otherwise deposited on any impervious surfaces. Any Fertilizer applied, spilled, or deposited, either intentionally or accidentally, on any impervious surface shall be immediately and completely removed. Fertilizer released on an impervious surface must be immediately contained and either

legally applied to Turf or any other legal site, or returned to the original or other appropriate container.

E. **Buffer Zones**
No Fertilizer shall be applied within 25 feet of any pond, stream, water course, lake, retention areas, drains and drainage ditches or canal, or in any designated wetland or within 25 feet of any wetland as defined by the Florida Department of Environmental Protection (Chapter 62-340, F.A.C. defines Florida Wetland as "Those areas that are inundated or saturated by surface water or ground water at a frequency and a duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils").

F. **Mechanical Application**
Spreader deflector shields are required when fertilizing by use of any broadcast spreaders. Deflectors must be positioned such that Fertilizer granules are deflected away from all impervious surfaces and water bodies, including wetlands.

Conclusions

The focus of this climate change adaptation plan for the Pelican Cove Community is to identify and define the recommended adaptations that can be undertaken by the community to address the climate change events likely to occur within the next 50 year period. The adaptations identified were selected to fit with the existing practices, culture, and capabilities of the Pelican Cove Community and its commitment to a natural approach that lives with its landscape, Little Sarasota Bay, and Clower Creek.

The adaptations selected for recommendation were developed in coordination with committees, residents and staff of the Pelican Cove Community in an open process driven by their input. T the greatest extent possible we looked for adaptations that are consensus based, pragmatic, and fit into current planning efforts. The adaptations are all implementable or in some aspects like the exotic removal and fertilizer management landscape are currently being implemented. We looked for adaptations that are cost conscious and that favor "No Regrets Actions". The adaptations can be incorporated into ; not separated; from existing efforts and plans of the Community and to a large extent the adaptations reflect a redesign that incorporate the principles of Design With Nature to achieve protection, water quality, and climate change survival improvements.

All the proposed adoptions are recommendations. After the Community decides what adaptations they will choose to implement then a monitoring plan can be developed for the implementation of each adaptation witch identifies what will be monitored, who will do the monitoring and hen the Community knows it has achieved its goals and success. Since it is unknown at this time which adaptation will be selected to be implemented the development of the monitoring program would be premature.

The recommended adaptation options under covered in this report include options for sea level rise, options for water quality improvement, options for flooding and run-off from climate change, options for erosion, options for vulnerabilities to structures, grounds, and infrastructure, and options for plant s and tree species that can reduce negative impacts on the water quality in Clower Creek and Little Sarasota Bay based on their need for fertilizer, pesticide and irrigation.

The recommended options for sea level rise include a living shorelines composed of nine zones, sediment supplementation, dune/berm s parallel to the shoreline, within the Marina Harbor redesign (elevating docks, walkways, and decks, and/or floating docks) and increased ground floor elevations when rebuilding.

The recommended options for water quality improvement include sediment dredging (either spot dredging or removal of all anoxic silt, floating Islands, filter feeders structures (reef balls or similar structures, oyster strings, and cam bags),and pretreatment for drains.

The recommended options flooding and runoff from climate change include additional drainage swales with dunes, removal of silt from Clower Creek, removal of vegetation blocks from Clower Creek, and improved evacuation coordination

The recommended options to address erosion include improved run-off capture, removal of exotic plants on slopes and replacement with GeoWeb and native plant species, and improved vegetated swales.

The recommended options to address vulnerabilities to structures, grounds, and infrastructure from trees include removal of trees with low wind resistance and the utilization of native trees with high wind resistance in future tree replacements. The options examined to reduce negative impacts on the water quality in Clower Creek and Little Sarasota Bay by different plant species needs for fertilizer, pesticide and irrigation include favoring native vegetation species over exotics, selecting plants of coastal oak hammock uplands and flanking estuarine and creek transition zones; introduce some native tropical hardwood hammock specie; stabilizing exposed and eroding shore and backshore areas with marsh grasses and herbaceous marsh species in Zonal Shoreline Plantings; some changes in mangrove trimming, and continual improvement in fertilizer management.

The Recommended Adaption fo Climate Change at Pelican Cove Are:

1) Recommended adaptations for sea level rise

    a) Living shorelines of different design
    b) Sediment supplementation
    c) Dune/Berm Construction
    d) Within the Marina Harbor
        i) Redesign (Elevating Docks, Walkways, and Decks)
        ii) Floating Docks
    e) Increased Ground Floor Elevations When Rebuilding

2) Recommended adaptations for water quality improvement

   a) Sediment dredging
      i) Spot dredging
      ii) Removal of all anoxic silt
   b) Floating Islands
   c) Filter feeders
      i) Reef Balls or similar structures
      ii) Oyster Strings
      iii) Clam Bags
   d) Pretreatment for drains and improved run-off capture

3) Recommended adaptations Examined for Flooding, Runoff and Erosion From Climate Change

   a) Improved swales and additional drainage swales with coastal dunes
   b) Removal of exotics and replacement with GeoWeb and natives
   c) Removal of silt from Clower Creek
   d) Remove vegetation blocks from Clower Creek
   e) Improved Evacuation Coordination

4) Recommended adaptations Examined for Vulnerabilities to the Structures, Grounds, and Infrastructure from trees and identified plant and tree species that can reduce negative impacts on the water quality in Clower Creek and Little Sarasota Bay based on their need for fertilizer, pesticide, and irrigation
   i) Removal of trees with low wind resistance
   j) Utilize native trees with high wind resistance in future tree replacements
   k) Favor native vegetation species over exotics.
   l) Select plants of the original maritime hammock uplands and flanking estuarine and creek transition zones by a mangrove shoreline and a riparian creek.
   m) Introduce some tropical hardwood hammock species to the landscape
   n) Stabilize exposed and eroding shore and backshore areas with marsh grasses and herbaceous marsh species in Zonal Shoreline Plantings
   o) Some changes in mangrove trimming
   p) Continual improvement in fertilizer management

The recommended adaptations are not mutually exclusive of each other and implementation of one adaptation option does not interfere with or preclude implementation of another adaptation simultaneously or at a later date.

An excellent idea of this combination concept has been developed by Mr. David Schowalter a member of the Harbor Committee. It is a combination floating dock canoe/kayak launch with a floating island perimeter and bivalve strings beneath. Properly designed and implemented this can address sea level rise and water quality issues in the Marina Harbor together .

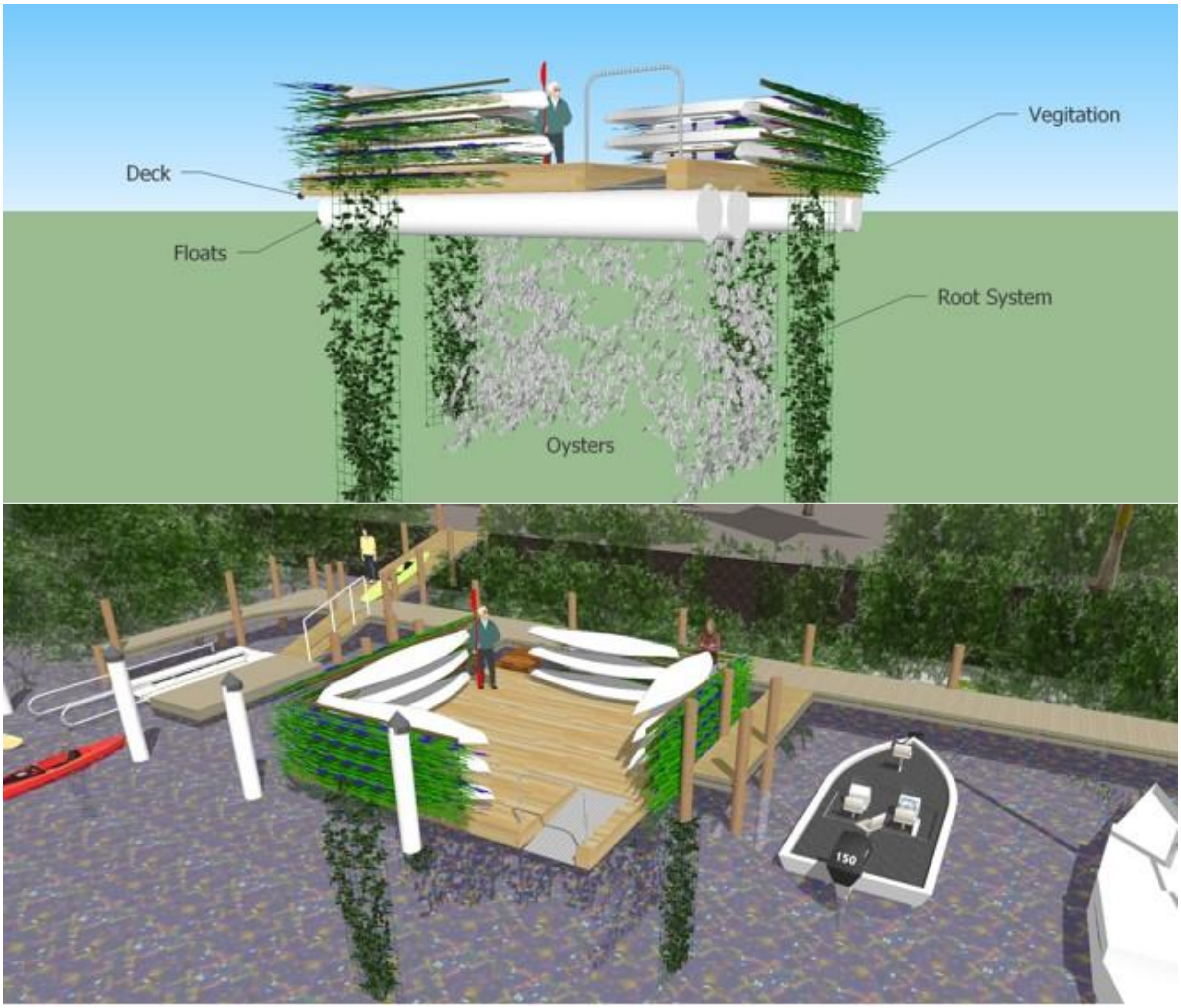


Figure 73: The David Schowalter Florting Canoe/Kayak Launch Water Quality Enhancer.

The identified adaptations do not constitute a cultural change for the Pelican Cove Community but rather a continuation of a progressive nature-based approach undertaken by the Community City to improve and enhance its community, ambiance and standard of living.

This plan will need to be a "living document," utilizing adaptive management techniques that allows for updating in response to changing conditions and lessons learned from monitoring and evaluation of results.

The methods developed in this project can be used as a framework to develop climate change adaptation plans for other coastal communities in Florida and around the Gulf Coast.

This adaptation plan of recommended options completes the first phase of climate change adaptation for the Pelican Cove Community. The next step will be the consideration of which options the Community chooses to implement and how to secure the secure the funding and resources to implement the selected options. Depending on the project there are external funding sources from governments, non-governmental organizations, and foundations specifically interested in some of the adaptations. It is unlikely that any project would be fully funded by others. Some of the options such as removal and replacement of some of the exotic tree species, hurricane preparedness planning, and aeration to improve dissolved oxygen are currently ongoing. Some of the others can be implemented gradually with the assistance of volunteers to reduce costs. In all cases the recommended adaptation options constitute non-regrets action since they will improve the safety of Pelican Cove while improving it ambiance and natural functions.

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https://www.youtube.com/watch?v=mu5dib32tew&feature=youtu.be
Naples Daily News Article
http://www.naplesnews.com/opinion/guest-commentary-those-new-islands-naples-city-lak
Martin Ecosystems is an environmental technology company that manufactures and supplies BioHaven® Floating Technology and EcoShield™.
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