Coastal Erosion Control on Airport Road in Cedar Key, Florida
Integration of Ecologically Sustainable Mitigation Strategies

Produced by: Carrie Schuman, Justin Caron, and Russell Anderson

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Executive Summary

The purpose of this paper is to address the effectiveness of armoring the area around Airport Road in Cedar Key with a living shoreline and the various effects such a technique would have on the protection of the upland properties, economy, and tourist development.

Over the course of the last two millennia, Cedar Key has gone through many changes due to both nature and human activity. However, the city and her people have continued to rely on their close proximity to the ocean as a means of industry, sustenance, and transportation. Living shorelines represent mankind's unique ability to learn from nature to both build and protect infrastructure. Comprised of mainly natural materials such as living oyster bars, sand, marsh grasses, and mangroves, living shorelines offer an opportunity to effectively armor man made infrastructure, while supporting natural fish habitat and a natural aesthetic (NOAA 2015).

Cedar Key is well aware of the need to adequately protect the property of both the property and the County (FDEP 2016). Additionally, living shorelines are now finally being considered as a technique to combat sea level rise and erosion and as a viable alternative to the previously used hard armoring techniques such as seawalls and riprap (NOAA 2015). Living shorelines (LSLs) may include design elements from along this spectrum but tend to favor those along the green side. Biological design elements that may be included in living shorelines construction include natural materials such as sand and fiber coir logs, and living components including coral reefs, oysters, marsh vegetation, and mangroves (NOAA 2015). While there are many vegetation types and other organisms that may be effective when constructing living shorelines, only those pertinent to the Cedar Key region are discussed below.

LSL designs are meant to provide shoreline protection with regards to 1) wave energy attenuation, 2) storm surge, and 3) sediment loss (Myszewski and Alber 2016). This may be important over time due to more gradual increases in sea level rise, and in response to catastrophic storm events such as hurricanes, which are only expected to rise in intensity over time in response to globally changing climatic conditions (Webster et al. 2005).

Members of the Cedar Key community have been involved in a participatory decision making process with regards to narrowing down desired options to address shoreline erosions and impacts at both the Airport Road site as well as an additional location in town at G Street. This process was initiated after a prior meeting in 2016 that established that the community was interested in discussing solutions to shoreline erosion. Hurricane Hermine also occurred within this timeframe, further highlighting the need to address impacts associated with catastrophic storm events.

Living shorelines may provide more significant levels of shoreline protection than beach nourishment projects with lower cost and maintenance needs. The shoreline of Airport Road also has components that can inform what would be useful elements of an LSL design for that area. A cursory look along the road revealed the presence of *Spartina alterniflora* (smooth cordgrass), *Juncus roemerianus* (black needle rush), *Iva frutescens* (marsh-elder), and *Batis maritima* (saltwort) suggesting all can grow there if the right conditions are established. Oyster reefs offshore suggest the additional use of oysters as wave breaks is possible.

Introduction and Background

Cedar Key is a small town comprised of a series of islands on Florida's north western Gulf Coast. This area known as the "Big Bend" follows along the westward curve of Florida's western coast and the start of the panhandle. This region supports ecosystems found in few other places across the globe. The primary characteristics that make this area unique are the lack of siliclastic sands and low wave energy (Hine et al. 1988). While normally coasts directly bordering the open ocean are comprised of sandy beaches with strong to moderate wave action, the lack of both of these factors have allowed the majority of the Big Bend region to become vegetated with marsh that is buffered by natural oyster bars as opposed to sandy barrier islands (Hine et al. 1988, Hine 2009).

The City of Cedar Key has a long history stemming back at least 2,500 years where several Native American tribes relied on the Gulf of Mexico's rich bounty of oysters, mullet, and other seafood. Just before the start of the American Civil War, Cedar Key marked the western end of the Florida Railroad which connected the Gulf of Mexico to the Atlantic coast in Fernandina Beach (Turner 2003). Following the Civil War, Cedar Key became known for several industries, which once again, relied on the region's abundant natural resources. These included pencils made from the many cedar trees in the area, and brushes made from the fibers of the native cabbage palm (Fishburne 1997).

As the timber industry slowed and manufacturing plants were destroyed by a series of hurricanes, many of the people of Cedar Key turned to fishing in the waters of the Gulf of Mexico. While this industry proved fruitful for a period of years, in 1994 the people of Florida passed a constitutional amendment banning gillnetting in nearshore waters (Anderson 2002). With their livelihood taken from them, the resilient people of Cedar Key gradually switched to the aquaculture of clams (Colson and Sturmer 2000), and recently oysters. Today, Cedar Key represents one of the largest supplier of aquacultured clams in Florida, and exports their products across the world.

Over the course of the last two millennia, Cedar Key has gone through many changes due to both nature and human activity. However, the city and her people have continued to rely on their close proximity to the ocean as a means of industry, sustenance, and transportation.

Living shorelines represent mankind's unique ability to learn from nature to both build and protect infrastructure. Comprised of mainly natural materials such as living oyster bars, sand, marsh grasses, and mangroves, living shorelines offer an opportunity to effectively armor man made infrastructure, while supporting natural fish habitat and a natural aesthetic (NOAA 2015).

The purpose of this paper is to address the effectiveness of armoring the area around Airport Road in Cedar Key with a living shoreline and the various effects such a technique would have on the protection of the upland properties, economy, and tourist development.

Airport Road is a stretch road owned by Levy County along the edge of Cedar Key. Bordering the stretch of road there are nine upland property owners (Appendix 2). While the Big Bend region of Florida generally has low wave action, extreme high tides and storms make this region

extremely vulnerable to tidal surge (FEMA 2011). Most recently, during Hurricane Hermine in September 2016, tidal surge flooded over the roadway, destroying portions of it in the process. In order to combat this flooding, the roadway, and upland marsh area were recently patched with poured concrete (Figure X).

Cedar Key is well aware of the need to adequately protect the property of both the property and the County (FDEP 2016). Additionally, living shorelines are now finally being considered as a technique to combat sea level rise and erosion and as a viable alternative to the previously used hard armoring techniques such as seawalls and riprap (NOAA 2015). This is partially due to the UF/IFAS partnership with property owners along nearby Joe Rain's Beach to create a model living shoreline which has allowed the people to see both its implementation and ability to prevent against the loss of property (Clark and Barry 2016).

Over the course of research for this project, we have consulted with a wide variety of stakeholders about their thoughts and opinions of a living shoreline being used to protect Airport Road. The stakeholders were made up of the upland property owners along airport road, city commissioners, local business owners, and private citizens. While there is community support for living shorelines to be used in projects such as this, there is still open discussion on the exact form of living shoreline that would be the most beneficial to the people of Cedar Key.

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Biological/Ecological Considerations of Living Shoreline Designs

Coastal armoring and shoreline protection can be categorized along a spectrum of grey to green infrastructure, grey represents man-made or built components such as seawalls, riprap, and bulkhead. Green represents constituents of a natural quality (Fig 1). Gray engineering materials can be categorized as "hard", while green materials may be designated as "soft." However, some more natural components such as rock and oyster reefs may represent harder shoreline structures.

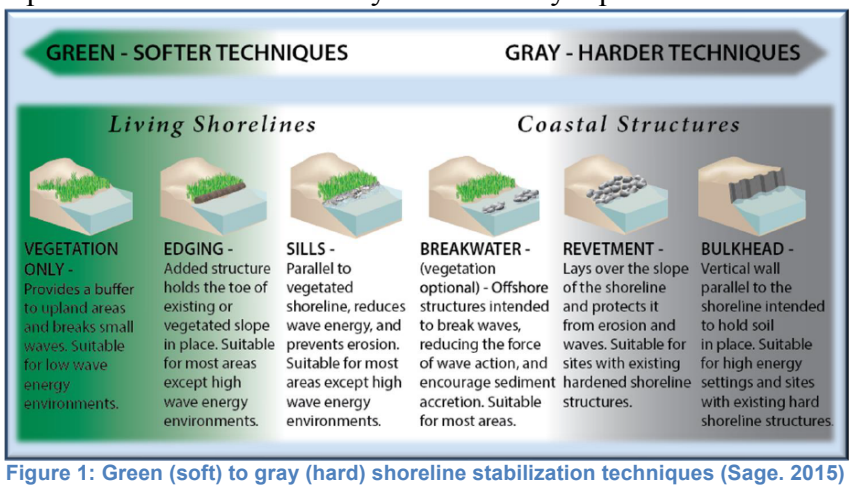

Figure 1: Green (soft) to gray (hard) shoreline stabilization techniques (Sage. 2015)

Living shorelines (LSLs) may include design elements from along this spectrum but tend to favor those along the green side. Biological design elements that may be included in living shorelines construction include natural materials such as sand and fiber coir logs, and living components including coral reefs, oysters, marsh vegetation, and mangroves (NOAA 2015). While there are many vegetation types and other organisms that may be effective when constructing living shorelines, only those pertinent to the Cedar Key region are discussed below.

Coastal Protection Properties of LSLs

LSL designs are meant to provide shoreline protection with regards to 1) wave energy attenuation, 2) storm surge, and 3) sediment loss (Myszewski and Alber 2016). This may be important over time due to more gradual increases in sea level rise, and in response to catastrophic storm events such as hurricanes, which are only expected to rise in intensity over time in response to globally changing climatic conditions (Webster et al. 2005).

Individual constituents that may be used in constructing LSL have often been shown to provide positive benefits with regards to the three facets of coastal protection. Oyster reefs have been suggested to reduce wave energy by 25% (Garvis 2012). In addition, constructed and natural oyster reefs have been shown to decrease rates of the shoreline loss behind them, but the degree to which this occurs may depend on tidal energy and orientation/method of oyster placement (Meyer et al. 2007). Piazza et al. (2005) found a reduction in shoreline loss in low energy environments as compared to non-cultched locations, but no significant difference when wave energies were high. A study comparing constructed versus natural reefs suggest that constructed reefs may have the ability to outcompete their natural counterparts (Stricklin et al. 2010). Most of these studies do not suggest a complete halt to erosion processes, suggesting oyster reefs should be paired with re-vegetation and other elements in order to gain stabilization benefits.

Salt marsh vegetation, a common component of LSLs with species of *Spartina* frequently employed in plantings, may have significant capacity to attenuate wave energy. Möller et al. (2014) simulated storm surge conditions and estimated salt marsh vegetation reduced waves by 60%. Other studies have resulted in similar findings (Knutson 1982, Shepard et al. 2011). Leonardi et al. (2016) examined the effects of extreme weather events on rates of salt marsh erosion and found 1) a linear response relative to wave energy with no threshold where erosion accelerated, and 2) salt marshes do not tend to collapse due to extreme weather. In fact, they suggested it was moderate storms that led to more salt marsh diminishment, while intense events contributed only 1% to recorded erosion rates.

Mangroves especially have advantageous effects with regard to protecting from extreme storms. Mangrove-protected villages in India both experienced less damage to homes and crops, and resulted in less death than those that lacked them during cyclone events (Das & Vincent 2009, Badola & Hussain 2005). They may positively counteract storm surges by slowing water, decreasing wave altitude, and reducing surge flooding (McIvor et al. 2012 a, Zhang et al. 2012). The degree of these outcomes may depend on factors like tree height, density, and diameter; forest width; storm size and speed; and other environmental variables (McIvor et al. 2012 b).

Typically the best results with regards to shoreline protection occur when vegetation is combined with some kind of hard protective structure in the form of breakwater or sills. This finding was supported when examining multiple LSL projects in Virginia (Duhring et al. 2008). Also when assessing wave energy reminiscent of boat wakes, Manis et al. (2015) found a combination of *Crassotrea virginica* and *Spartina alterniflora* was more effective than either constituent alone.

The above habitats also have the advantage relative to hard structure of gaining elevation over time allowing them to meet the challenge of rising seas. Within suitable tidal conditions, oyster reefs have the ability to outpace SLR by adding height through the addition of shell and sediment (Rodriguez et al. 2014, Ridge et al. 2015). Kirwan et al. (2016) actually suggest that the vulnerability of salt marsh to SLR has been overestimated, and that most marshes are accreting at speeds similar to or exceeding historical SLR rates. While not all mangroves accrete sediment, many do, and do so on par with SLR projections (Alongi 2008). However, sea level rise is not the only expected impact from climate change and these additional anticipated effects certainly may complicate the picture.

LSL Compared to Grey Engineered Designs

Hard coastal armoring structures often may provide some level of protection and may be the only reasonable option in cases of particularly high wave energy (NOAA 2015). However, many of these structures are also associated with negative repercussions such as increased scouring and erosion that leads to destabilization, decrease of localized biodiversity, and loss of sensitive coastal habitat (Davis et al. 2006, NOAA 2015). Seawalls appear to be most impacting according to a recent meta-analysis (Gittman et al. 2014), indicating 23% decrease in biodiversity and 45% fewer organisms relative to natural shorelines. Riprap and breakwaters may be slightly better options with regards to providing complex habitat that support species in ways similar to native habitat but the effects are variable and more study is needed.

Living shorelines also have the potential to outperform man-made structures during storm events. When examining damage during Hurricane Irene to bulkheads, marsh, and marsh paired with sills, Gittman et al. (2014) found a large percentage of the former were damaged at survey sites, while the two latter protection strategies showed little ill effect.

Some solutions may combine a mixture of grey and green engineering when appropriate. Concrete breakwaters combined with marsh plantings of *Spartina alterniflora* were used in a LSL installed at Saw Grass Point in Dauphin Island, Alabama in 2004. The breakwaters proved positive substrate for oyster settlement, and no salt marsh erosion occurred behind them (Swann 2008). The use of sills combined with marsh habitat appear to increase marsh height and vegetation recovery time post-hurricane events, and experience less habitat loss and erosion in general when compared to marshes unprotected by sills (Burke 2005, Gittman et al 2014).

There are some trade-offs when implementing LSLs as opposed to grey structures. One primary difference when using green infrastructure to protect a coastline as opposed to built armoring structure, is the timeline along which that protection may occur. While seawalls, riprap, and other man-made barriers may be constructed over short time scales, living shorelines may take several years to be fully established and for benefits such as coastal protection and ecosystem service enhancement to be fully realized (Davis et al. 2006, Gittman et al. 2016). However, LSLs may ultimately be more cost effective and provide protective and ecological benefits for a longer period of time (NOAA 2015).

Ecological benefits of living shoreline designs

On their own, the living components often used in living shoreline designs have been documented to provide a wealth of additional ecosystem services beyond just shoreline protection. Oysters are keystone species that have often been referred to as ecosystem engineers, as they greatly shape the surrounding environment through multiple processes (Grabowski et al. 2012). Oysters are filter-feeders and thus may facilitate nutrient removal and carbon sequestration (Grabowski et al. 2012, Kellogg et al. 2013). Filtration also improves water clarity leading to more available light in wavelengths used for photosynthesis which greatly benefits submerged aquatic vegetation (SAV) (Thayer et al. 1978). The presence of oyster reefs have been suggested to aid in the expansion of seagrass coverage (Sharma 2016).

Reef-forming species of oysters, such as *Crassostrea virginica*, provide increased habitat for macroinvertebrates and juvenile fish. This may lead to enhanced fisheries (Scyphers et al. 2011). Peterson et al. (2013) quantified the expected increased production of fish and large mobile crustaceans as 2.6 kg yr^{-1} for every 10 m^2 increase of restored reef. The three-dimensional structure of reefs may also support the entrainment of freshwater (Kaplan et al. 2016) which may be important for maintaining important trophic interactions and abiotic dynamics in a system.

Vegetation may provide some similar benefits to oysters including positive benefits to water quality and maintenance of fisheries (Barbier 2011). Salt marsh vegetation and mangroves have been identified as important pathways within blue carbon (coastal carbon capture and storage) pathways (Barbier 2011, Mcleod et al. 2011). Mangrove trees often are utilized in different parts of the world for their wood used as both fuel and for building (Brander et al. 2012).

Cedar Key Specific Results

While conditions specific to a region may dictate the degree to which the above levels of coastal protection and positive ecological effects occur with regards to oysters, mangroves, and salt marsh vegetation (Gedan et al. 2010), there is evidence suggesting positive outcomes to using them within the Big Bend region. A 1993 extratropical storm that brought with it a storm surge on the order of 3 meters in the Waccasassa Bay region, deposited sediments along the shoreline and resulted in no discernable erosion as opposed to sandy coastlines where opposite pattern might be expected (Goodbred and Hine 1995). Mangroves on the Gulf Coast of South Florida were able to reduce wave amplitude and the total area inundated by storm surge during Hurricane Wilma, a 2005 Category 3 storm (Krauss et al. 2009, Zhang et al. 2012) and Hurricane Charley (Krauss et al. 2009).

One local consideration with regards to the inclusion of mangroves in LSL designs, is that while they offer strong advantages with regards to armoring against storm surges, they may have vulnerabilities that make them a less dependable addition to coastal protection schemes. While there is evidence their range has fast been increasing along Florida coastlines, often displacing salt marsh in the process (Cavanaugh et al. 2014), a figure from Alongi (2008) delineates Florida mangroves as among the most vulnerable to effects of climate change. Mangrove presence is also regulated by freeze events (Cavanaugh et al. 2014), and while temperatures in many parts of Florida have currently hovered above this threshold, this doesn't preclude the possible occurrence of future freezes with enough magnitude or length to reduce mangrove coverage.

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Living Shorelines Policy and Legal Framework

Introduction

There are a variety of techniques that a homeowner or municipality may use to armor the shoreline bordering their home or business. Each of these techniques has their own unique advantages and disadvantages. As explained in the previous section, this large range of armoring techniques varies from hard coastal armoring with the use of materials such as rip rap or a concrete sea wall extending along the border of the property, to soft armoring techniques that use natural ecosystems such as grassy plants and mangrove trees to buffer the force of waves. Living shorelines offer a third option that combines several aspects of the many different armoring techniques in order to provide protection to the coastal upland property. These living shorelines use nature as a guide to effective armoring through the use of oyster reef, geo-textile tubes, and natural plantings. The use and installation of a living shoreline by a private homeowner or collective group must go through a unique permitting processes which involves every level of government including local, state, and federal.

In the study of armoring the Gulf of Mexico side of Airport Road in Cedar Key, Florida, we have determined that a form of living shoreline would prove to be an effective technique to protect both the Levy County roadway, and the upland properties. The following is a policy analysis and proposal which involves an in depth analysis of the permitting and regulatory process of both small and large scale living shorelines as an option on Airport Road, potential implications of the various techniques that may be used, and a proposal of the various funding techniques that may be used for armoring projects along this shoreline.

I. Regulatory Framework of Permitting Process

Due to the unique character of the Gulf of Mexico, permitting any sort of coastal armoring technique, which involves placing some type of material in a waterway, eventually makes it through all levels of government. This bureaucratic structure is necessary to ensure that all proper measures are taken. However, this often times serves as an impediment to the development of new process that may appear to be more complicated than previous techniques such as concrete seawalls. The regulations governing living shorelines and other armoring techniques stem from the City of Cedar Key, the Florida Department of Environmental Protection, and the Army Corps of Engineers.

A. Local Government Authority, the City of Cedar Key

The City of Cedar Key has an interest in protecting the citizens and property within the boundaries of the city. In recent years, Cedar Key has moved away from hard armoring techniques such as seawalls, and favored the use of living shorelines as a means of coastal protection. The city has effectively prohibited the construction of new seawalls and bulkheads within the city limits through its comprehensive plan and ordinance 10.04.00.[i]

This ordinance prohibits the construction of bulkheads and seawalls, except where it is necessary to protect an existing structure. Additionally, the city has included in this ordinance that

variances will not be granted in regards to the permitting of seawalls. This prohibition makes it crucial for homeowners to use alternative armoring techniques, such as living shorelines, to protect their property.

B. State Government Authority

In the 1950's, the United States Congress passed the Submerged Lands Act granting and codifying the State's ownership of submerged lands below navigable bodies of water.[ii] The State of Florida, in its capacity as the sovereign, has authority over all submerged lands under navigable bodies of water in Florida. The title to all submerged bottom lands are vested in the Board of Trustees of the Internal Improvement Trust Fund.[iii] This submerged land is held in a trust for all of the people of Florida, and may not be used exclusively by an individual, absent a lease or other permissive document from the State. The Florida Department of Environmental Protection is authorized to permit and regulate construction over these state owned lands.

C. Federal Government Authority

The federal government receives its original authority over navigable bodies of water from the United States Constitution. The Commerce Clause, Found in Article 1, Section 8 of the U.S Constitution gives the federal government authority to regulate interstate commerce.[iv] In addition to this, the Rivers and Harbors Appropriation Act of 1899 forbids building any obstructions, which includes filling in water with material, in navigable waters of the United States and gives authority to regulate to the United States army Corps of Engineers. [v] The Army Corps of Engineers is granted further permitting authority over navigable bodies of water through the Clean water Act.[vi]

II. Permitting Process of Living Shorelines

The following is an analysis of the permitting application process through the various governmental entities and the requirements for creating a living shoreline on a piece of property. Each governmental entity has unique requirements for living shorelines. This can cause a homeowner to experience frustration while attempting to navigate these various levels of bureaucracy. However, these entities, the Army Corps of Engineers and the Florida Department of Environmental Protection, have worked together to streamline this process for small scale living shorelines that are less than 500 linear feet in length.

A. Permitting of Small Scale Living Shorelines

The Army Corps of Engineers has issued a series of nationwide permits (NWPs) to permit certain approved activities under the purview of their jurisdiction. These permits authorize certain activities based on the Army Corp's jurisdiction under Section 404 of the Clean Water Act and Section 10 of the River and Harbors Act of 1899 when the activities are expected to cause no more than minimal or individual effects.[vii] The purpose of these broad, permissive permits are to streamline the process at the federal level when there will be another governmental entity reviewing the specific individual permit applications.

There are several NWP's that the Army Corps of Engineers has issued that are applicable to the implementation of living shorelines. These applicable NWP's are the NWP 13-Bank Stabilization, NWP 27- Aquatic Habitat, Restoration, Establishment, and Enhancement Activities, State Programmatic General Permit- SPGP V, and the new NWP B 54- Living Shorelines[viii]. Each of these NWPs represent the Army Corp's permits that have been granted for these specific activities. A full break down of these requirements stemming from each of the NWP's can be seen in *Appendix 1.*

While NWP 13 and NWP 27 apply more so to large scale living shorelines extending longer than 500 linear feet, the Army Corps has issued the SPGP V in order to avoid duplication and streamline the permitting process for small scale living shorelines that are expected to have no more than a minimal impact on the environment and are considered minor work in the waters of the United States. Approved project types under this permit now include living shorelines per the Florida Administrative Code[ix]. These small scale living shorelines must meet certain requirements such as extending no longer than 500 linear feet, removing invasive species, and others as seen in *Appendix 1.*

For a graphic version of the comparison of the permitting entities please see Appendix 1.

B. SPGP V Green Light, Yellow Light, Red Light Policy

The SPGP V is effectively a grant of power to the State of Florida from the Army Corp to complete the initial, and sometimes final review of a permit application. This green light, yellow light, red light policy is a ranking method that judges the potential impacts that the requested project would have on the environment. This permit application for a small-scale living shoreline is submitted directly to the Florida Department of Environmental Protection (FDEP) rather than the Army Corp for initial review.

If the FDEP believes that the project will have no more than a minimal adverse effect on the environment and the project meets the requirements for a small-scale living shoreline, they will approve project and the project is considered "exempt" from requiring a permit. If they believe the project may have some form of adverse effect on the environment, the FDEP then forwards the application to the Army Corp for review, which is the yellow light. Similarly, if the FDEP believes there is a high likelihood of adverse impact, they will forward the application to the Army Corp and continue to do a review separately.

C. NWP B54 Living Shorelines

This permit was approved in early 2017. The NWP B 54 is intended to complement NWP 23 and 27 in order to permit a broad authorization to the use of living shorelines as a form of bank stabilization. In addition to the two existing NWPs, this permit authorizes certain structures to be used and for the discharge and dredging of materials when used for the purpose of living shorelines as long as the permit applicant follows the specific regulations imposed by NWP B 54. This new NWP should make the permitting process and implementation of small-scale living shorelines more effective for the average small scale coastal armoring project.

III. Potential Living Shoreline Funding Techniques

As with any coastal armoring technique, cost is a factor in determining the best type of living shoreline. The cost of coastal armoring techniques can be broken up into several categories. These factors include the initial cost of the project, how long the project will continue to be effective, and the cost to make repairs overtime.

Living shorelines are often more affordable than traditional hard armoring techniques that use materials such as poured concrete or granite boulders. Additionally, the replacement cost and general maintenance of living shorelines represent a lower cost than traditional techniques due to the natural materials used.

Despite the lower cost of living shorelines compared to other armoring techniques, there is still a significant cost associated with any form of property protection. The following is a proposal of several funding techniques that the City of Cedar Key, or the individual property owners may use to implement a living shoreline. Some of these funding proposals may be used singly, or in conjunction with one another.

1. Individual Funding vs. Group Funding.

I. Private Funding

A. Individual Funding

One option that the individual landowners could potentially use to fund the installation and maintenance of a living shoreline is the simplest one; they self fund the project themselves. With this approach, each individual landowner would be tasked with deciding on which coastal armoring technique best suits their interest and funding such projects. Following with traditional property rights, this would allow the individual to be responsible for protecting their own private property.

While this is currently the situation being used across much of Cedar Key and Airport Road, this method is both costly and may even be counterproductive to the long- term preservation of the upland properties in the face of sea level rise. Some of the problems associated with this piece by piece armoring include a higher cost for individual projects, and the loss of property due to an adjoining property owner's lack of, or ineffective armoring technique on their own property. A piece of property does not exist in a bubble, and everything that occurs on one property affects those adjoining, and sometimes, non adjacent properties. This example has been seen quite clearly on nearby Joe Raines Beach, the site of the UF/ IFAS model living shoreline.

On this stretch of beach running along G street in Cedar Key, Florida, long shore drift has carried dry sand that once armored a coastal property, several parcels down and has since filled in a canal to the point of inaccessibility.[x] The cause of this steady erosion over the past several decades is believed to have once again, started several parcels away in the opposite direction where the shoreline had become vegetated. This vegetation gradually slowed the longshore drift of sediments, accreting the land in that particular, vegetated area, whereas the non-vegetated shoreline on Joe Raines Beach continued to have sand erode, eventually to the degree where the beach was non existent even during average high tides.

A situation like this could arise on Airport Road in Cedar Key if individuals were to task themselves with armoring their property separately from the adjoining landowners. In addition to this, the individual armoring of several individual parcels is often far more expensive than one larger project. This is true even more so on a small island community such as Cedar Key, where contractors must travel in order to reach the construction site.

The focus of this project is focused on the stretch of Airport Road that includes nine individual parcels that face the Gulf of Mexico along the County owned road. However, six out of these nine property owners live full time in a location other than Cedar Key, as referenced by *Appendix 2*. This lack of full time investment into a property, could potentially cause a lack of congruency among armoring techniques of those trying to protect their home, and those trying to protect a vacation house, rental, or investment property.

This image shows the properties that would benefit from a living shoreline along Airport Road, Cedar Key. See Appendix 2 and 3 for ownership identification.

Figure 2: Intervention Beneficiary Properties

B. Collective Funding

One option that a collective group of property owners could take either with, or in the absence of governmental funding is to create a homeowner's association (HOA). HOA's in the State of Florida are governed by Chapter 720 of the Florida Statutes. The definition under these governing laws is,

" A Florida Corporation responsible for the operation of a community or mobile home subdivision in which voting membership is made up of parcel owners or their agents, or a combination thereof, and in which membership is a mandatory condition of parcel ownership, and which is authorized to impose assessments, that if unpaid, may become a lien on the parcel…"[xi]

While ordinarily an HOA includes many if not all of the aspects of home maintenance within the community, this organization could be created for the sole purpose of protecting the stretch of road as whole, as opposed to individual armoring. A HOA could be used for the purpose of funding and maintaining a living shoreline on Airport Road for several reasons. In general the HOA would form a collective body to implement the best form of a living shoreline for all property owners along this stretch of shoreline. This would not only be more aesthetically pleasing than a patch work of armoring techniques, but would also reduce the risk of different armoring making each adjoining property owner's technique less effective, for example one owner installing a seawall, which degrades the next's living shoreline, which then degrade the next's dry, sandy beach, etc.

Additionally, forming an HOA for the purpose of creating and maintaining a living shoreline would provide a steady stream of funding for the maintenance and repair of a living shoreline. Oftentimes HOA's in other situations will collect a set amount of fees from each member monthly, quarterly, or yearly. These funds may be used for general upkeep of the "common areas", but also may be kept in a reserve in for emergency purposes.

When applied to living shorelines, the dues held in reserve, may be used to repair or replace a living shoreline following a major storm event such as Hurricane Hermine. This option would not only allow for the guaranteed continual maintenance of the entire piece of shoreline, but would also limit the cost to the individual property owners following these major storm events when they have also experienced other costly damage from the storm. In addition to this, the HOA would create a source of revenue that is collected evenly from all property owners, whether they are full time residents of Cedar Key, or only temporary. Similarly, the covenants and restrictions would attach to the property rather than the owner, ensuring long term protection of the shoreline.

2. Public Funding

In addition to or in combination with private funding, the homeowners along Airport Road could potentially seek several forms of public funding with the purpose of implementing a living shoreline. This public funding could come from a variety of sources ranging from the city, county, and even state level of government. In addition to this, there are other funding sources

such as the RESTORE funds, which could potentially be used for purposes such as this. While obtaining public funding for a living shoreline on only Airport Road may be difficult due to it small-scale, the likelihood of obtaining funds increases as the size or scope of the project does. For example, a wide spread policy endorsing and seeking to implement living shorelines across the entire City of Cedar Key, would potentially attract more attention, and money, than a localized project.

The following is a short summary of public funding techniques that could potentially be used for implementing living shorelines along Airport Road, and Cedar Key in general.

I. Taxation

A. Taxation of Homeowners

Dependent Special Taxing Districts.

General law in Florida has authorized municipalities, such as the City of Cedar Key, to create special districts through the passage of a local ordinance.[xii] These Special Districts can collect a tax from a unique area, carved out of the entire city, for a specific purpose.[xiii] While there is a statutory framework laid out for municipalities seeking to create such a district, this could potentially allow the City of Cedar Key to map out an area of the city where they would like to create such a district, and devote the funding towards the implementation of sustainable, and environmentally friendly coastal armoring techniques such as living shorelines.

B. Taxation of Tourists

Another form of taxation would focus on taxing the tourists and transient renters that visit Cedar Key, but are not full time residents. This option, which would spread the cost out over the entire county, with an emphasis on tourism, is a form of a hospitality tax. Currently Levy County has a Tourist Development Tax on accommodations at the rate of 2%.[xiv]

Levy County as a whole, has a transient rental rate of 2%.[xv] This Tourist Development Tax is a local tax option imposed on rentals or leases of accommodations in hotels, motels, apartments, rooming houses, mobile home parks, RV parks, condominiums, or timeshares for a term of six months or less. [xvi] The revenue received from these sources may be used for capital construction of tourism related facilities, tourist promotion, and beach and shoreline maintenance.[xvii]

Cedar Key currently represents a large portion of the hotels and transient rentals within the county. Due to the fact that these taxes may be used for beach and shoreline restoration, and Cedar Key represents a large draw of tourists to both Levy County and the Nature Coast, the City Commission or the people of Cedar Key could reach out the Board of County Commissioners and the Levy County Tourist Development Council to obtain a portion of these funds collected for the purpose of creating living shorelines across Cedar Key. The use of Tourist Development Tax funds for the purpose of creating living shorelines may additionally increase tourism, as they represent a more aesthetically pleasing, and natural form of armoring as opposed to more traditional, hard armoring techniques.

II. RESTORE Funds

RESTORE funds represent a unique source of income to the counties along the Big Bend region of Florida. The Resources and Ecosystems Sustainability, Tourist Opportunities and Revived Economies of the Gulf Coast States Act (RESTORE) Act, dedicates 80% of all the administrative and civil penalties accrued following the Deepwater Horizon oil spill in 2012 to gulf restoration.[xviii] These funds may be used for a variety of purposes, which include the restoration and protection of natural resources, ecosystems, fisheries, marine and wildlife habitats, beaches, and coastal wetlands of the Gulf Coast region, and coastal flood protection and related infrastructure.[xix] Currently Levy County has 10 established projects that will be using RESTORE funds over the fifteen year period. However, there is potentially the option that additional projects such as the funding of living shorelines along the developed coast of Levy County could occur.

Federal and State of Florida Permitting Requirements for Living Shorelines.
See Appendix 1.

Permitting Entity	**Florida Department of Environmental Protection**	**Army Corps. of Engineers**	**Army Corps. of Engineers**	**Army Corps of Engineers**
	DEP Exempt Permit	Army Corps of Engineers Proposed	Army Corps of Engineers Nationwide Permit 13- Bank Stabilization	Army Corps of Engineers Nationwide Permit 27- Aquatic Habitat, Restoration, Establishment, and Enhancement Activities
Regulatory Basis	Florida Administrative Code, 62-330.051	Nationwide Permit B –Living Shorelines		
Length of Shoreline	Length of LSL must be < 500 feet	Length of LSL must be < 500 feet (unless district manager waives based on a no more than minimal adverse environmental effects)	Activity must be < 500 feet (unless district engineer waives)	Not addressed
Water ward Extension	Inner toe of Breakwater may not be more than 10 feet water ward of the MHWL (Mean High Water Line)	Structure and fill area may not extend more than 30 feet of the MHWL (unless district engineer waives this based on a no more than minimal adverse environmental effects	Activity may not exceed an average of one cubic yard per running foot placed along the bank below the ordinary high water mark or the high tide line (unless waived by the district engineer)	Not addressed
Height	Top of Breakwater may not exceed the MHWL	Not addressed	No material is of a type, or is placed in any location, or in any manner, that will impair surface water flow into or out of the U.S.	Not addressed
Relationship to submerged Aquatic Vegetation (SAV)	Breakwater may not be placed within three feet in any direction of existing submerged grass or marsh.	Not addressed	Not addressed	Not Addressed
Tidal exchange	Breakwater must include “tidal channels” or openings in the seawall at least every twenty feet. These opening must be at least three feet long	No more than a minimal adverse impact on water movement between the body of water and the shore and no more than a minimal adverse impact on the movement of aquatic organisms	No more material than is absolutely necessary for erosion protection.	May not substantially disrupt the necessary life cycle movements of indigenous aquatic species, including migratory species, unless the primary purpose is to impound water
Relationship to Spawning areas	Not Addressed	Not Addressed	Not Addressed	Activities in spawning areas, during spawning season must be avoided to the maximum extent possible Activities in the waters of the U.S. that serve as breeding areas

				Activities in the waters of the U.S. that serve as breeding areas for migratory birds must be avoided to the maximum extent practicable
Relationship to migratory birds	Not addressed	Not addressed	Not addressed	No activity may occur in areas of concentrated shellfish populations unless the activity is directly related to a shellfish harvesting activity authorized by NWPs 4 and 48, or is a shellfish seeding or habitat restoration activity authorized by NWP 27
Relationship to existing shellfish beds				The construction of oyster habitat over unvegetated bottom in tidal waters is permitted
Construction Materials	Must be composed predominantly of natural oyster shell clutch (clean and fossilized oyster shell) or *other stable, non-degradable materials* such as oyster reef, reef balls, unconsolidated boulders, clean concrete rubble, rip rap, rock sills, or triangular concrete forms.	Must be composed of coir logs/mats, stone, oyster shell, native wood, or other structural materials of proper weight that may be anchored	Material may not be placed in a manner that will be eroded by normal or expected high flows	Not addressed
	No form of fill may be used for construction on anything except the breakwater	Discharges, fill, and reef structures must be the minimum necessary to establish and maintain a living shoreline	Not addressed	Activities authorized by this NWP include, but are not limited to: the removal of accumulated sediments; the installation, removal, and maintenance of small water control structures, dikes, and berms, as well as discharges of dredged or fill material to restore appropriate stream channel configurations after small water control structures, dikes, and berms, are removed
Fill Material	Not addressed	No discharge or fill may be used in special aquatic sites (unless waived by the district engineer)	Activity may not involve discharges of dredged or fill material into special aquatic sites (unless waived by district engineer)	The construction of small nesting islands; the construction of open water areas;
Special aquatic areas	Oyster shell cultch must be in mesh bags with holes < three inches and be must be properly anchored.	Not addressed	Not addressed	Not addressed
	Turbidity Curtain: If a turbidity curtain is necessary to ensure survival of plantings and curb wave action, one may be used on a temporary basis for the length of the growing season	Not addressed	Not addressed	Not addressed

Invasive and exotics	All exotic and invasive species must be removed before completion of the LSL		Invasive plant species may not be used for bioengineering or vegetative bank stabilization	
	Plantings may not extend further than 10 feet water ward of the MHWL	Not addressed	Not addressed	Additional activities allowed are: Shellfish seeding; activities needed to reestablish vegetation, including plowing or disking for seed bed preparation and the planting of appropriate wetland species; re-establishment of submerged aquatic vegetation in areas where those plant communities previously existed; re-establishment of tidal wetlands in tidal waters where those wetlands previously existed; mechanized land clearing to remove non-native invasive, exotic, or nuisance vegetation; and other related activities.
	Not addressed	Living shoreline must be properly maintained	If a temporary fill is used, upon its removal the area must be revegetated	Not addressed
	Not addressed	Not addressed	Not addressed	If the Secretary of the Army or his representative ever determines the project has interfered with navigation, or future operations of the United States require its removal, it shall be done at the owners expense.
NAVIGATION				
	Not addressed	Not addressed	Not addressed	Any safety lights and signals prescribed by the U.S. Coast Guard, must be installed and maintained at the permittee's expense on authorized facilities in navigable waters of the U.S.
	Not addressed	Not addressed	Not addressed	The permitted must submit a pre-construction notification to the district engineer prior to commencing any activity
NOTICE				

Table 1: Federal and State Florida Living Shoreline Permitting Requirements

Airport Road Properties Cedar Key, FL
See Appendix 2: Map Key

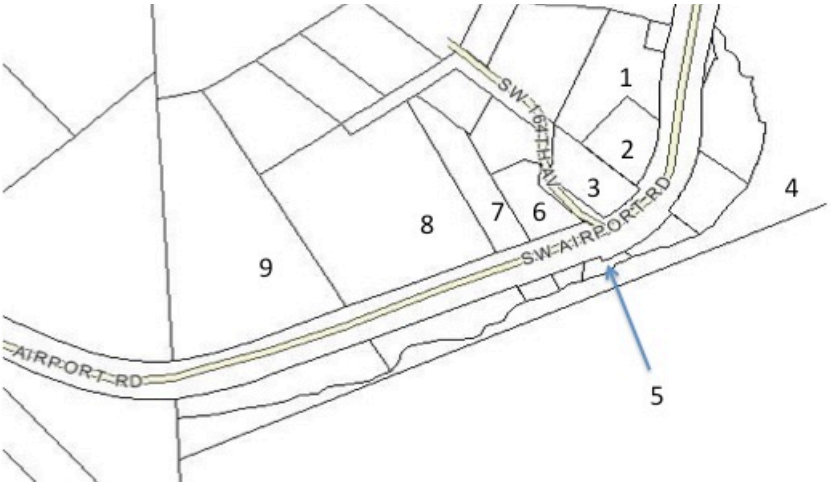

Figure 2: Airport Road Properties

Property Owners Along Airport Road, Cedar Key FL

1. Parcel Number: 0891700000 Owner: Bobby Wilder Trustee/Margaret Wilder Trustee Physical Address: 16401 SW Airport Rd., Cedar Key Mailing Address: PO BOX 202, Cedar Key, FL 32625 Submerged Lands: N/A		6. Parcel Number: 0892300100 Owner: Alice Phillips Physical Address: 16439 SW Airport Rd., Cedar Key, FL Mailing Address: PO BOX 701, Cedar Key, FL 32625 Submerged Lands: Hard to tell
2. Parcel Number: 0891700100 Owner: Lanier Municipal Supply Co., Inc. Physical Address: 16411 SW Airport Rd. Cedar Key, FL Mailing Address: PO BOX 127, Lakeland, GA 31635 Submerged Lands: N/A		7. Parcel Number: 0892100000 Owner: Milton Stubbs Physical Address: 16453 SW Airport Rd., Cedar Key, FL Mailing Address: 1224 NW 22nd St., Gainesville, FL 32605 Submerged Lands: Hard to tell
3. Parcel Number: 0892200000 Owner: Barbara Jackson Trustee/ Joseph Kirk Jr. Residual Trust Physical Address: 16425 SW Airport Rd., Cedar Key, FL Mailing Address: PO BOX 5048, Ovilla, TX 75154 Submerged Lands: Yes		8. Parcel Number: 0892500000 Owner: Sarah Schulz/Richard Schulz Family Trust Physical Address: 16467 SW Airport Rd., Cedar Key, FL Mailing Address: 2959 Daniels St., Marianna, FL 32446 Submerged Lands: N/A
4. Parcel Number: 0042401400 Owner: Robin Jocelyn Physical Address: Underwater... Mailing Address: PO BOX 736, Cedar Key, FL 32625 Submerged Lands: Yes...LOTS...		9. Parcel Number: 0042300000 Owner: Pope and Margaret Griffin Trust Physical Address: 16495 SW Airport Rd., Cedar Key Mailing Address: 1389 S Shore Dr., Fleming Island, FL 32003 Submerged Lands: Hard to tell
5. Parcel Number: 0892600000 Owner: Steven and Brenda Jones Physical Address: 13172 SW 164 Ave., Cedar Key, FL Mailing Address: 206 Heron Shores, McCormick, SC 29835 Submerged Lands: Yes		

Table 2: Airport Road Property Owners

(Section 2) Endnotes

[1] City of Cedar Key Land Development Code, Chapter 4, Ord. 10.04.00 Bulkheads and Seawalls.
[1] § 43 U.S.C.A. § 1311

[1] Fla. Stat. § 253.12

[1] U.S. Const. art. I, § 8, cl. 3

[1] 33 U.S.C.A . §1
[1] 33 U.S.C.A . §1344
[1] Army Corps of Engineers, DoD, *Proposal to Reissue and Modify Nationwide Permits*, Federal Register
[1]Army Corps of Engineers. 2017 NWP 54 2017. December 2016. http://www.usace.army.mil/Portals/2/docs/civilworks/nwp/2017/NWP_54_2017_final_Dec2016.pdf?ver=2017-01-06-125514-560. Accessed 20 March 2017
[1] Chapter 62-330(12)(e) of the Florida Administrative Code
[1] Dr. Mark Clark, Dr. Savanna Barry. Whats happening at Joe Raines Beach?". University of Florida IFAS. Nature Coast Biological Station 08/2016. https://ncbs.ifas.ufl.edu/whats-happening-joe-raines-beach. Accessed 10 March 2017
[1] Fla. Stat. §720.301
[1] Florida Department of Economic Oppurtunity. "Introduction to Special Districts." http://www.floridajobs.org/community-planning-and-development/special-districts/special-district-accountability-program/florida-special-district-handbook-online/introduction-to-special-districts#Dep. Accessed 18 March 2017.
[1] Fla. Stat. §189.02
[1] Florida Department of Revenue. "County Local Option Transient Rental Tax Rates Grouped by Administration (Tourist Development Tax Rates)" http://www.floridarevenue.com/Forms_library/current/dr15tdt.pdf. Accessed 20 March 2017
[1] Id.
[1] Id.
[1] Fla. Stat. §125.0104(3)(c)
[1] "About the RESTORE Act". *Restore the Gulf, Gulf Coast Ecosystem Restoration Council* https://www.restorethegulf.gov/history/about-restore-act. Accessed 24 March 2017
[1] "The Restore Act 2012- Levy County. *Levy County Commission.* http://www.levycounty.org/restoreact.aspx. Accessed 20 March 2017

Socio-Economic and Sustainable Development
Considerations for Shoreline Impact Mitigation on Airport Road

Developing Resilient Coastlines for Cedar Key

This paper has thus far demonstrated the ecological benefits and regulatory considerations of living shorelines for Cedar Key, Florida. While still a relatively new strategy for development along the nature coast, the 'Airport Road Shoreline Impact Mitigation Project' would not be the first sustainable shoreline project in Cedar Key. Joe Raines Beach has served as a testing ground for University of Florida and community stakeholders and serves as a local example of 'vegetated shoreline supported by natural breakwater' (Clark, M. Barry, S. 2016) provided by Eastern Oyster (*C. virginica*).

A 'vegetated shoreline with natural breakwater' design is a favored option amongst those stakeholders engaged in this project to date (fig.11). While the conditions at Joe Raines and Airport road differ in factors related to elevation, position, and composition, physical capacity towards vegetative stabilization for erosion impact mitigation are similar. The management of these spaces allows us to compare the sites by function, use, and recovery when impacted.

Figure 5 shows the stabilization efforts at Joe Raines Beach, where fig. 4 shows the (county sponsored) hardening solution. While these images are stark in their contrast, it is important to consider the level of public and private collaboration that has taken place to date, respective to each site. Joe Raines beach is a far more established project as of 2017.

Notice in fig. 7 the poured sections of concrete on Airport Road are beginning to erode, despite being in place for less than 3 months. Figure # shows those areas of Airport Road buffered by living shorelines with an Oyster breakwaters. The accretion of vegetation and shell materials within this space serves a critical function in buffering those sections from erosion.

Figure 4: AirPort Road. 2017. Cedar Key, FL

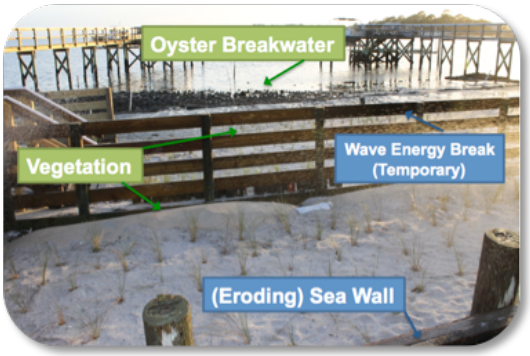

Figure 5: Joe Raines Beach. 2017. Cedar Key, FL

Figure 6: Airport Road Living Shoreline. 2017.

Figure 7: Airport Road Tide Induced Erosion. 2017.

Socioeconomic Considerations

When considering coastal resiliency and impact mitigation projects, it is important to recognize the financial limitations experienced by semi-rural 'working waterfront' communities. Allotting public funds for ecosystem service projects comes with a degree of uncertainty. In section 2 'Regulatory Policy and Legal Frameworks' context was provided (sub-section 3) as to funding options for consideration. These mechanisms can help to insulate public and private stakeholders by dividing economic burdens. This strategy would also help to foster community networks for future resiliency-centered collaborations and decision making activities.

Living shorelines can help to prevent coastal erosion, create estuarine habitat (NOAA 2015). They can also facilitate the adoption of and support towards establishing a 'blue-green economy' (LSECities). The 'nature coast' of Florida is burgeoning economy heavily reliant on coastal resources to sustain industry and livelihoods (USACityFacts). The community works hard to protect their resources, but recognize the need to insulate themselves from the risks associated with environmental, biological, and climate challenges (Purcell, K. 2013).

Cedar Key lives and breathes by the benefits provided from Gulf of Mexico and is blessed with a rich environment for Oyster and Clam production. The rationality of shellfish aquaculture is simple. The opportunity costs outweigh the marginal costs yielding benefits to the harvesters, investors, consumers, and community at large. The rich history of Cedar Key is one that has always been adaptive in its management strategies. The benefits of shellfish aquaculture have provided comparable advantages for those leasing a claim to submerged lands near Cedar Key.

This is especially true since the proverbial 'collapse' of the Oyster beds in the Apalachicola basin (Florida Sea Grant 2012). Globally, more than 80% of wild oyster populations have disappeared over the last 200 years (Beck, M.). Despite these heavy losses, a renewed taste for oysters and clams have resulted in an intensification of commercial scale interests in the region. These increasing pressures are coupled with increasing demands for resources and demonstrated vulnerabilities to coastal weather and climate impacts.

For the risk averse, investing in ecological services that come with uncertainty can pose a significant issue. However, these projects support jobs, education, experience with alternative engineering models, and provide a foundation for community networking and engagement.

Those early adopters and the risk neutral should not see investing in coastal erosion as an antecedent to economic growth or as an adverse selection. Instead these opportunities can build resiliency within the community, while protecting private and public property from storm surge.

Empowering Stakeholders and Increasing Capacity

In creating success and resiliency across our coastlines, it is paramount that state representatives, research professionals, and commercial interests recognize and respect the voice and decision making power of community stakeholders. The legacies of interactions between individuals and groups through financial capital, traditional markets, and social networks should be seen as resources for empowering citizens to choose the direction of erosion prevention strategies along their coasts. Dynamic opportunities for locals and visitors to interact with projects such as Joe Raines beach, G Street, and the Airport Road project help to normalize sustainability and contextualize mitigation and adaptation to those previously unfamiliar (or unexposed) to the theory in practice.

Public engagement helps to generate interest and volunteerism, thereby increasing labor and output capacity at a reduced cost. Demonstrated success in these projects comes with a sense of pride for those who helped manifest its origins. In doing so, those who were once neutral or averse can see a realized benefit from the time, labor, and capital investment. Successful projects also demonstrate new models for the representatives and interest, thereby further catalyzing restoration and mitigation principles along coastlines.

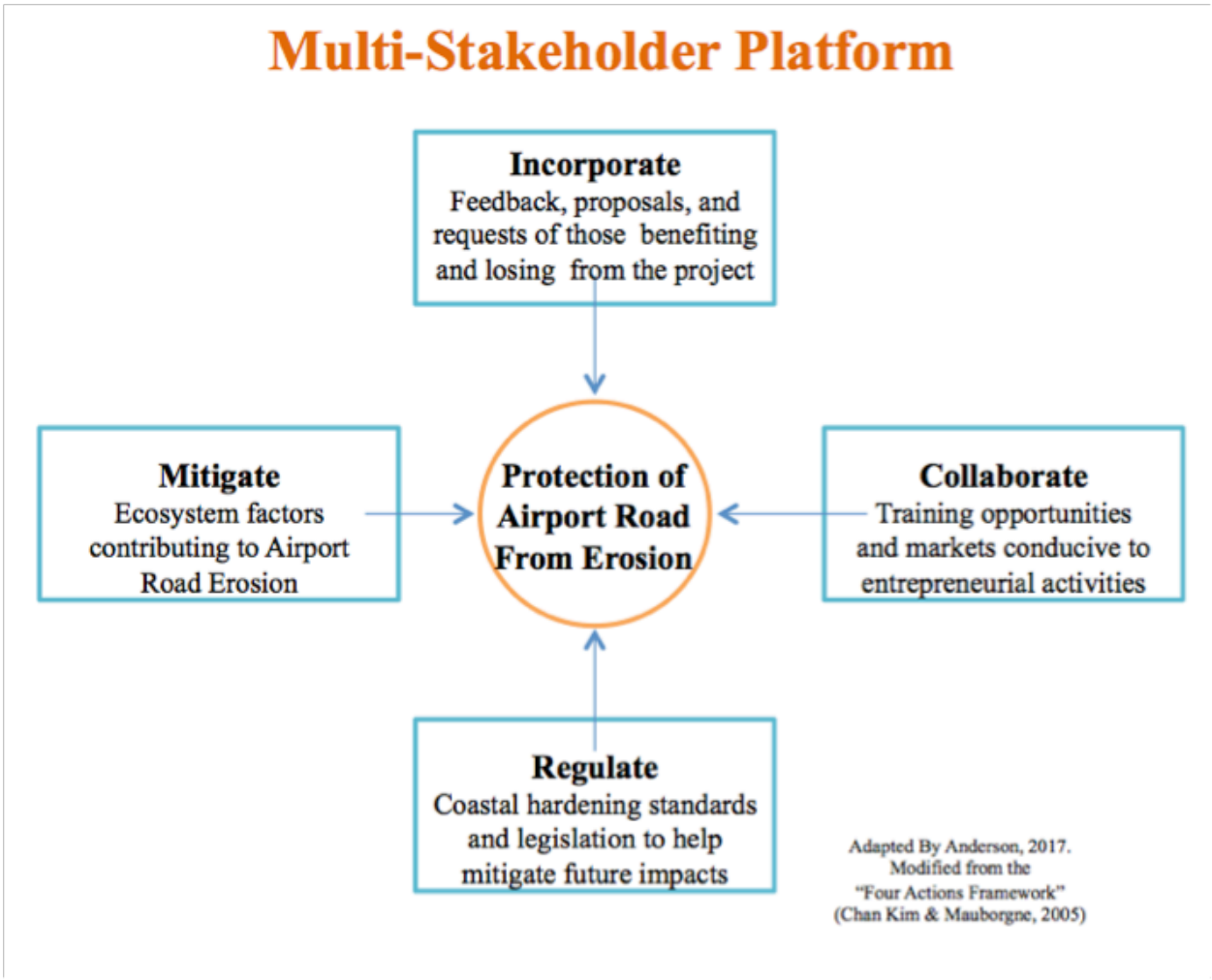

Figure 8: MSP for Cedar Key Airport Road Living Shoreline

To gauge success of this project, stakeholder meetings and advanced coordination would be necessary for mapping improvements in use and function metrics. This should include understanding: levels of employment, rates of volunteerism, funding mechanisms solicited, collaborations, etc. Most importantly, capturing the success of the buffering mediums comprising the living shoreline (Schang, Z. et al. 2014).

The best strategy for management of the site would be adaptive in the capacities to change goals/direction. By creating meaningful engagement opportunities and flexibility in its represented stakeholder composition at any given time (Stankey, G. et al 2005), we can empower communities to engage with research initiatives. These interactions can also help de-stigmatize the stereotypes placed between the 'academic' and 'blue collar' communities (Connor, M. 2010).

Dynamic Planning for Growth and Development

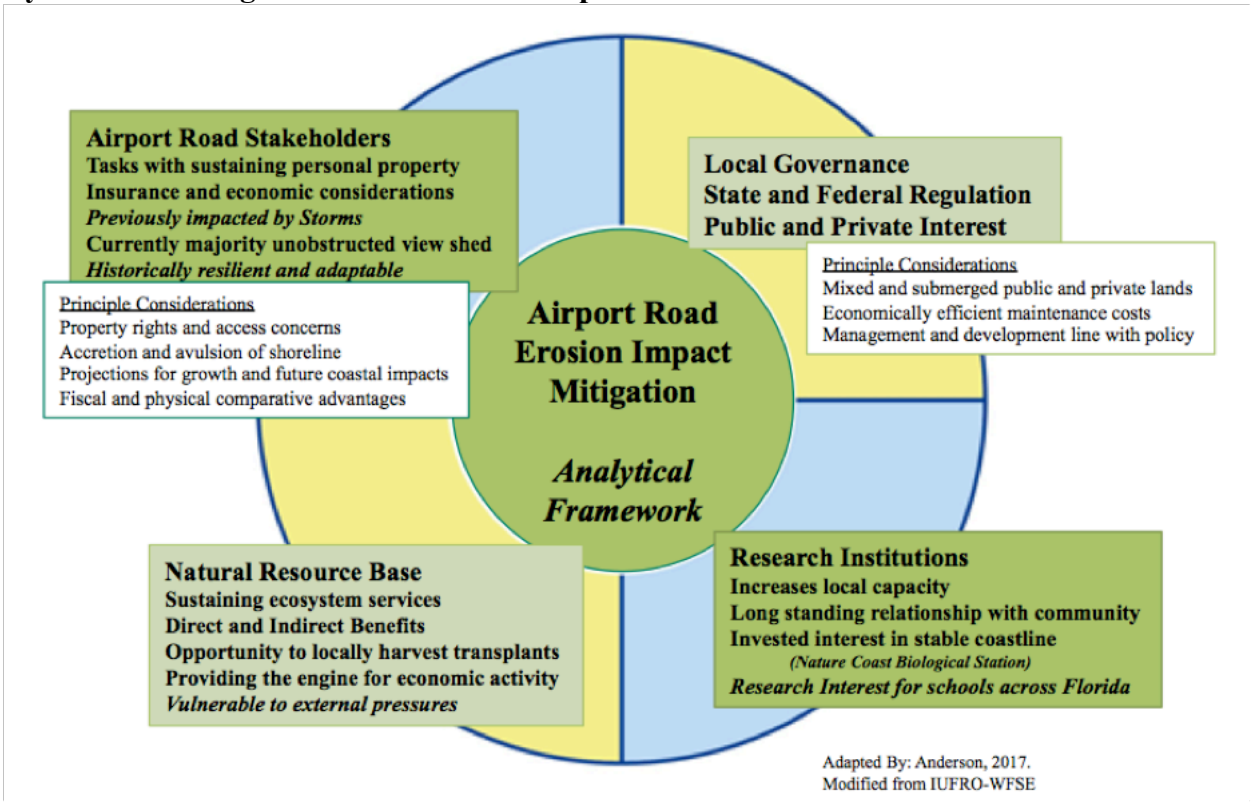

Figure 9: Cedar Key Contextual-Conceptual Framework

Figure 9 provides a framework to understand how society, environment, regulation, and stakeholder preferences shape our capacities on Airport Road. It is important to understand the spectrum of actors and agencies involved in the development process and the principle considerations of each party (NRLI, 2015). For residents living on Airport road, development of the space is cause for accessibility concerns. For property managers and citizens, a view shed obstructed by mangroves presents challenges (Cedar Key News. 2015). We also have to consider the level of investment each party would be expected to contribute and how that may affect project goals and capacities (Dain, J. 2015).

By partnering with the University of Florida on this erosion mitigation project, local and district representatives have an opportunity to capitalize on a knowledge and resource base that includes legal, biological, ecological, and social support structures. By way of the "Nature Coast Biological Station", U. of Florida has positioned themselves as a locally accessible resource for those seeking information on how to improve their shorelines and coastal resiliency against tidal erosion damage and storm surge impact mitigation services.

In comparing project options, stakeholders can get a sense of the rate of functionality over time. Function and rate of degradation towards eventual obsolescence can also help create a foundation for determining comparative advantages between systems. As a dynamic coast and a site prone to significant storm surge (Weather.com. 2016) we must also anticipate changes in ecosystem services over time (Schang, Z. et al. 2014). This eventual transformation over time will be based on the evolution of site, including species recruitment and rate of recruitment.

In section 1, we introduced the idea of coastal hardening. Using figure # and Table # as reference, we can compare the social and environmental benefits across the references 'Grey To Green' mitigation activities.

	'Business as usual'	'Grey scale' hardening	"Green scale' hardening	'Mixed' Grey & Green
Economic Development	(-) Post-impact remediation ($15k+) (+) Limited engagement means limited expense	(+) Initial construction and engineering (-) Routine maintenance and Beach renourishment	(+) Initial construction and engineering (+) Training resource (-) Initial and maintenance investments required	(+) Initial construction and engineering (+) Training resource (-) Initial and maintenance investments required
Ecosystem Services	As provided by natural accretion and avulsion rates	No added benefits to ecosystem services. Potential negative impacts through avulsion.	(+) Greatest rate of ecosystem and biological services (-) Potential for loss of services during weather event (-) 6 mo. establishment time	(+) High rate of ecosystem and biological services (+) More insulated from tidal and storm surge impacts (-) 6 months establishment
Social Welfare	(-) Minimal impacts	(+) Temporal insulation from storm surge	(+) Improved function and ecosystem services	(+) Improved function and ecosystem services
Private Property	(-) Fiscal liabilities for damages (-) Insurance Premium Concerns	(+) Temporal insulation from storm surge (-) Costs of installation, maintenance, and renourishment	(+) Vegetated erosion control (+) Stabilization supports fiscal insulation (-) Private investment required	(+) Vegetated erosion control (+) Stabilization supports fiscal insulation (-) Private investment required
Public Property	Administrative Management Physical Maintenance	Administrative Management Physical Maintenance Cost of renourishment inputs	Administrative Management Physical Maintenance (+) Can obtain vegetation transplants from adjacent public lands	Administrative Management Physical Maintenance (+) Can obtain vegetation transplants and shell midden from adjacent public lands

(+)=Considered to be positive outcomes, (-)= Considered to be challenges or demonstrated concerns

Table 2: Socio-Economic and Development Considerations for Coastal Erosion Mitigation

Referenced in the following sections, stakeholders have been engaged in a planning and visioning process related to stabilizing Airport Road. These activities have been lead by Dr. Savanna Barry, of the University of Florida (Cedar Key News. 2017). Information developed within this reference paper is centered on the preferences of those within the community that have participated in that process thus far. As we work together to stabilize Airport road, it will take the combined efforts of researchers, industry, and community to balance economic and ecologic sustainable development towards erosion impact mitigation.

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Results and Discussion

Members of the Cedar Key community have been involved in a participatory decision making process with regards to narrowing down desired options to address shoreline erosions and impacts at both the Airport Road site as well as an additional location in town at G Street. This process was initiated after a prior meeting in 2016 that established that the community was interested in discussing solutions to shoreline erosion. Hurricane Hermine also occurred within this timeframe, further highlighting the need to address impacts associated with catastrophic storm events. Proceedings are being funded by the Suwannee Water Management District and the Florida Department of Environmental Protection Coastal Management Program.

A recent key meeting, framed as a Cedar Key Shoreline Visioning Workshop, was held on March 3, 2017. The event was facilitated by two University of Florida faculty and Natural Resource Leadership Institute (NRLI) members, John Dain (NRLI Director) and Wendy-Lin Bartels (NRLI team member), who specialize in conflict management.

The workshop focused on identifying ways the community currently uses both locations and what shoreline stabilization techniques would support similar continued use. Airport road was identified as the only way to access the local Cedar Key Airport by car. In addition, locals use the site for activities that include biking, kayaking, fishing, walking their dogs, and accessing the beach.

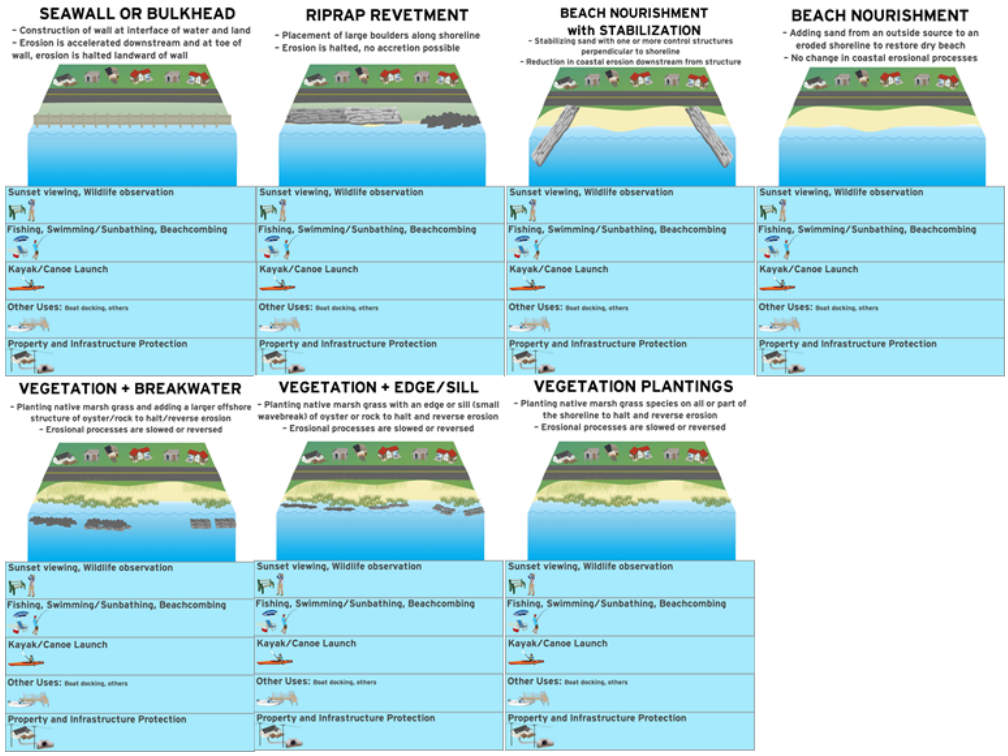

Fig 10: Posters shown to participants at the Cedar Key Shoreline Visioning Workshop in March 2017. The list of possible human uses were omitted.

Participants were shown posters similar to those in Figure X depicting a variety of possible solutions for shoreline protection that ranged from grey to green infrastructure. Attendees were

then taken on a field trip in order to see examples of all elements, ask clarifying questions, and discuss the implications of each. After discussing the options at length, facilitators led a voting process where community members indicated their least favorite options using a circle sticker, and their favorite as indicated by a star; green was used to denote preference for G street, while red was used for Airport Road. Two options were clearly favored (Fig 3). These included beach nourishment with stabilization and the vegetation and breakwater option.

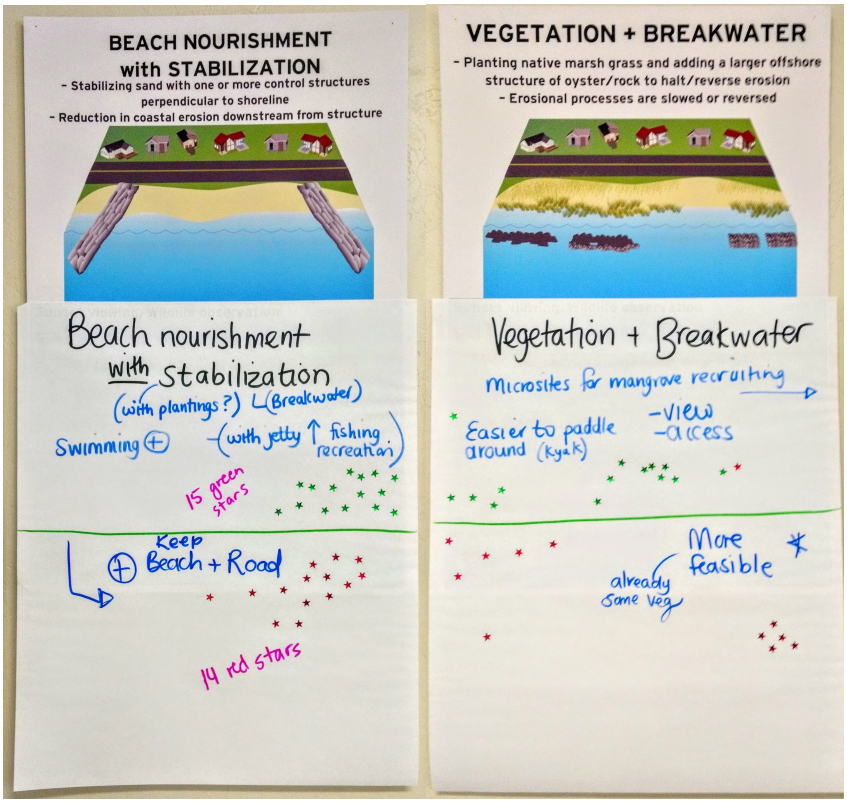

Fig 11: Two favored shoreline protection solutions identified by attendees of the Cedar Key Shoreline Visioning Workshop in March 2017, as denoted by the stars. Red stars indicated options specific to Airport Road location.

Based on these recent results paired with personal anecdotes about the failure of harder infrastructure such as seawalls and bulkheads during past storms in the regions, it is clear that greener engineering solutions have some possible utility for the Cedar Key community. However, it seems likely that there may be some trade-offs with regards to balancing human use with shoreline protection capacity.

Presumably beach nourishment paired with stabilization is an attractive option due to the preservation or enhancement of recreational opportunities associated with a sand beach. However, as sand is dynamic and may need regular replenishment even with stabilization, beach nourishment projects require long-term maintenance. The Army Corp of Engineers lifecycle for renourishment projects is typically 50 years. The utility of beach nourishment can be diminished if renourishment does not occur. Fixed structures used to stabilize these projects need to be carefully planned with regards to their utility in managing sand movement (Marine Board 1995).

Living shorelines may provide more significant levels of shoreline protection than beach nourishment projects with lower cost and maintenance needs. The shoreline of Airport Road also has components that can inform what would be useful elements of an LSL design for that area. A cursory look along the road revealed the presence of *Spartina alterniflora* (smooth cordgrass), *Juncus roemerianus* (black needle rush), *Iva frutescens* (marsh-elder), and *Batis maritima* (saltwort) suggesting all can grow there if the right conditions are established. Oyster reefs offshore suggest the additional use of oysters as wave breaks is possible.

A more contentious part of the Airport Road vegetative community is mangrove trees. Both *Rhizophora mangle* (red mangrove) and *Avicennia germinans* (black mangrove) are common in the Cedar Key area. Though mangroves may represent a superior form of natural shoreline protection especially with regards to storm surges, as noted in prior sections, residents have voiced concerns over the impact these species have on shoreline access and the viewshed associated with local homes and tourist lodging.

However, the movement of mangroves into areas currently dominated by salt marsh species can be expected with increased warming due to climate change. If a salt marsh environment is considered far superior to mangrove habitat by Cedar Key citizens, mangroves may need to be actively managed at that location. This could occur in the form of seedling removal before trees become established or the trimming and shaping of mangroves. In some locations mangroves have been trimmed to resemble hedges, which may preserve desired views, but also preserve valuable root systems that bolster coastlines and provide valuable habitat and refuge for local aquatic species.

It may be advisable to develop an adaptable mangrove management plan. As the effects of sea level rise and global warming continue to escalate, residents may find they wish to increase the resiliency of the Airport Road site to shoreline impacts. This may mean favoring the presence of a mangrove system alongside the roadway. While deliberately planting mangroves may not be recommended due to their potential vulnerability to hard freezes, an option to foster their natural migration into this site at at future points might be valuable.

Regardless of the method of erosion control chosen by the community, the actions of property owners along Airport Road must be coordinated in order to create a more successful project. While portions of the shoreline are considered submerged lands and will be used by the local community and the general public, nearby homeowners have the ability to enact piecemeal solutions to protect their property that may have inclement effects on collective long-lasting shoreline protection. But as the site is used by multiple stakeholder groups, the specifics of possible funding mechanisms will need to be carefully negotiated throughout the process, perhaps looking towards some of the options we have outlined above.

It is also clear that the decision-making process needs to be carefully managed in order to foster stakeholder buy-in and long term investment of resources, volunteer capacity, etc. However, Cedar Key has already shown itself as a community with a great deal of versatility and interest in pursuing smart, sustainable solutions that will help them maintain their invaluable working waterfront.

Conclusions and Recommendations

Steps that are important in allowing Cedar Key residents to come to consensus about a shoreline stabilization strategy for Airport Road:

- Continuing participatory process allowing community members to identify shoreline erosion control options that will best suit current needs.

- Specifically reaching out to airport road property owners in an effort to engage collective solutions to erosion control and to balance their actions with additional stakeholder groups.

If a living shoreline is identified as the desired outcome for shoreline stabilization at the Airport Road site, we recommend:

- Establishing a pre, during, and post project monitoring plan that not only considers biological changes but perhaps takes into consideration additional socio-economic considerations such as changes in use and access.

- Working closely with experts in the legal and permitting process that may also be able to suggest if and how adaptable elements of a shoreline design might be implemented.

The actions that can be taken in the implementation stage of a living shoreline are:

- Determining areas of greatest concern that should be points of focus. Considerations with regards to project impact, funding needs, and permitting process should be including.

- Identifying sites adjacent to targeted locations with vegetation zonation that can be mimicked effectively in a living shoreline design.

- Working with University of Florida IFAS and Sea Grant programs to provide information on environmental conditions of adjacent sites that may need to be recreated in order to successfully establish vegetation.

- Determining if elevation needs to be raised at any particular sites, and if fill can be derived from other local activities.

- Creating or tapping into existing partnerships with the local community, schools, non-profits, and other organizations that can provide volunteer labor that will both decrease project costs and increase local social capital and investment in project success. This can take the form of community planting and oyster shell bagging events.

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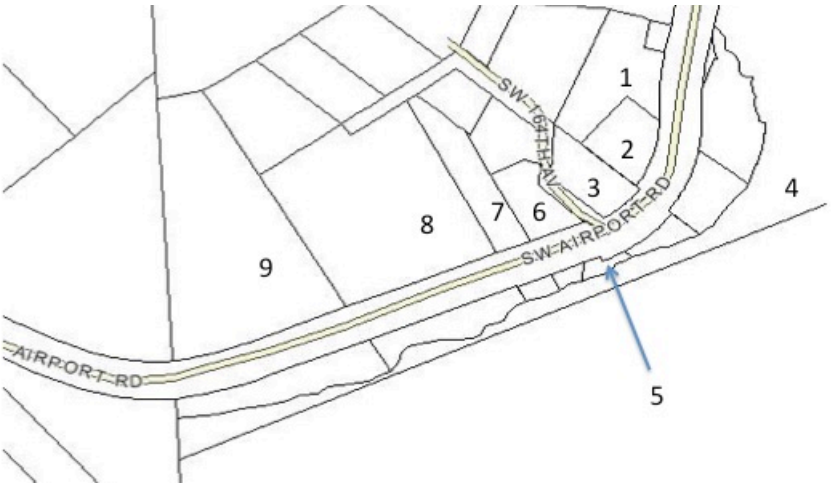
Appendix 2 - Map Airport Road Properties Cedar Key FL



Appendix 3 - Property Owners Along Airport Road, Cedar Key FL

1. Parcel Number: 0891700000		6. Parcel Number: 0892300100
Owner: Bobby Wilder Trustee/Margaret Wilder Trustee Physical Address: 16401 SW Airport Rd., Cedar Key Mailing Address: PO BOX 202, Cedar Key, FL 32625 Submerged Lands: N/A		Owner: Alice Phillips Physical Address: 16439 SW Airport Rd., Cedar Key, FL Mailing Address: PO BOX 701, Cedar Key, FL 32625 Submerged Lands: Hard to tell
2. Parcel Number: 0891700100		7. Parcel Number: 0892100000
Owner: Lanier Municipal Supply Co., Inc. Physical Address: 16411 SW Airport Rd. Cedar Key, FL Mailing Address: PO BOX 127, Lakeland, GA 31635 Submerged Lands: N/A		Owner: Milton Stubbs Physical Address: 16453 SW Airport Rd., Cedar Key, FL Mailing Address: 1224 NW 22nd St., Gainesville, FL 32605 Submerged Lands: Hard to tell
3. Parcel Number: 0892200000		8. Parcel Number: 0892500000
Owner: Barbara Jackson Trustee/ Joseph Kirk Jr. Residual Trust Physical Address: 16425 SW Airport Rd., Cedar Key, FL Mailing Address: PO BOX 5048, Ovilla, TX 75154 Submerged Lands: Yes		Owner: Sarah Schulz/Richard Schulz Family Trust Physical Address: 16467 SW Airport Rd., Cedar Key, FL Mailing Address: 2959 Daniels St., Marianna, FL 32446 Submerged Lands: N/A
4. Parcel Number: 0042401400		9. Parcel Number: 0042300000
Owner: Robin Jocelyn Physical Address: Underwater... Mailing Address: PO BOX 736, Cedar Key, FL 32625 Submerged Lands: Yes...LOTS...		Owner: Pope and Margaret Griffin Trust Physical Address: 16495 SW Airport Rd., Cedar Key Mailing Address: 1389 S Shore Dr., Fleming Island, FL 32003 Submerged Lands: Hard to tell
5. Parcel Number: 0892600000		
Owner: Steven and Brenda Jones Physical Address: 13172 SW 164 Ave., Cedar Key, FL Mailing Address: 206 Heron Shores, McCormick, SC 29835 Submerged Lands: Yes		

Erosion Control on Airport Road. 2017. Cedar Key, FL