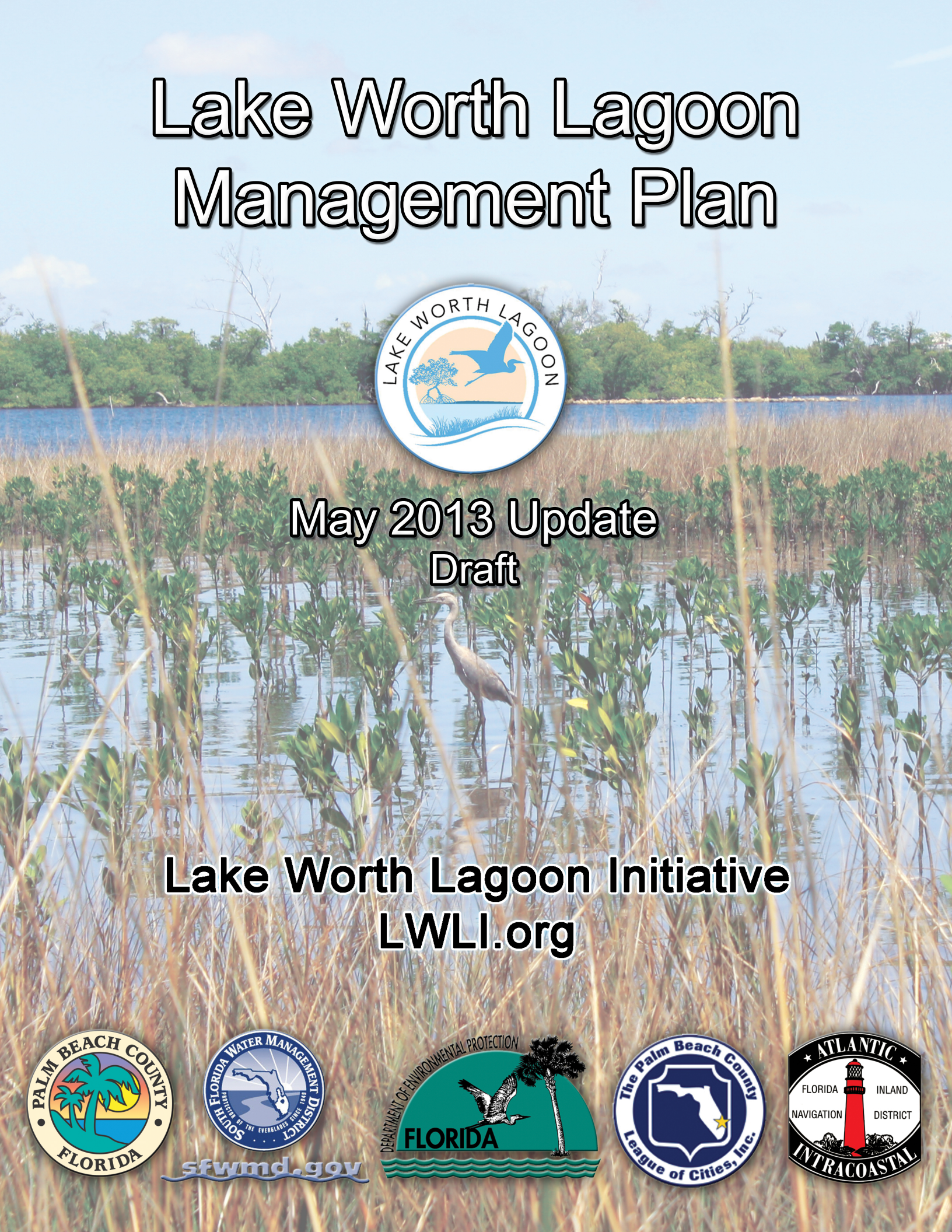
Lake Worth Lagoon Management Plan



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EXECUTIVE SUMMARY

Significant progress has been made since the Lake Worth Management Plan (Plan) was revised in 2008. Many tasks and projects defined in the 2008 Plan have been and are currently being implemented by various groups and agencies. This third update of the Plan summarizes accomplishments during the 2008-2012 timeframe. The five primary programmatic areas identified in 2008 remain in effect to guide the next five years of goals and objectives for restoring the lagoon. These areas are summarized below.

- **Water and Sediment Quality Program**
- **Habitat Restoration and Enhancement Program**
- **Public Use and Outreach Program**
- **Interagency Planning and Coordination**
- **Funding**

Several Action Plans (APs) proposed in 2008 have been merged, modified or eliminated, while new actions have been added based on revised information and newly identified priorities. This update encompasses 23 APs - 7 of them appearing in this Plan for the first time.

ACCOMPLISHMENTS FROM 2008-2012

In the past five years, many goals and objectives of the 2008 Plan have been implemented under the leadership of the Palm Beach County Department of Environmental Resources Management (ERM), in partnership with state agencies, local municipalities and interested stakeholders.

The Lake Worth Lagoon Initiative (Initiative), a multi-agency effort to increase awareness, support and funding assistance for projects to improve and protect the natural resources within the watershed was established in 2008. The Initiative has successfully promoted interagency coordination and commitment to the Lake Worth Lagoon (LWL) restoration and protection.

Since 2008, $15.9 million has been allocated and matched by $10.4 million to provide $26.3 million towards restoration projects. Twelve habitat enhancement and restoration projects have created over 70 acres of habitat: mangrove, spartina, maritime hammock, seagrass beds, oyster and artificial reefs. Grant funding has been provided by FIND, FDEP, the Florida Fish and Wildlife Conservation Commission (FWC), The National Wildlife Federation (NWF), the U.S. Fish and Wildlife Service (USFWS), Loxahatchee River District, and various municipalities around the Lagoon.

Water Quality (WQ) projects included the creation of a new monitoring plan and the expansion of the WQ monitoring network by adding twelve (12) new stations. A five years WQ baseline analysis was conducted and it is included in this management plan update. Three stormwater treatment projects have been implemented treating runoff from an area of 526 acres. The use of pollution control devices, stormwater ponds, wetland treatment, and treatment swales has

significantly reduced the amount of nutrients, sediments, and heavy metals entering LWL. Two projects have also been implemented to reduce septic loading in this estuary.

All the Public Outreach (PO) goals (PO1-4) identified in the 2008 Plan have been implemented. ERM hired a full-time LWL public outreach coordinator and the Initiative PO Working Group was formed in 2009. Over the past five years Working Group members have developed public awareness programs to involve and inform residents, visitors, and decision-makers about the LWL ecosystem through specific outreach materials. Citizen engagement efforts have focused on lagoon cleanups, volunteer habitat restoration projects, and community presentations.

Goals for the Next Five Years

Water and Sediment Quality Program

APs to improve and monitor WQ, and to reduce wastewater, stormwater and sediments are outlined in Chapter 4. Goals for this program are:

- Continue the water quality ambient monitoring program in the LWL for baseline purposes and trend analysis.
- Increase focus on decreasing inputs of suspended materials, and nutrients from point and nonpoint sources.
- Identify and reduce anthropogenic loadings of fecal contaminants and other pathogens Increase additional sanitary sewer, wastewater, and stormwater retrofit projects
- Manage sediments.

Habitat Enhancement and Restoration Program

The targets within the next five years are to restore seagrass, tidal marsh, oyster reef, artificial reef, and protect and enhance the lagoon's existing mangrove and seagrass areas. These goals will be accomplished through a series of capital projects (Appendix C) and monitored as outlined in a series of specific APs. Goals for this program include:

- Restore and enhance seagrass beds, oyster habitat, emergent mangrove wetlands, coastal hammock habitat, and protective upland buffer zones.
- Add Living Shorelines to vertical seawalls to reduce wave-generated sediment resuspension and provide additional upland and hardbottom habitat.
- Construct artificial reefs that provide juvenile, intermediate and adult habitats required by the life cycle of estuarine and marine dependent fish and invertebrate species.
- Evaluate the status and protect sea turtles, manatees, and other endangered, threatened, and rare species, and species of special concern using the LWL.

Public Use and Outreach Program

The Public Use and Outreach Program is committed to creating an engaged constituency of

citizens who understand both the environmental, recreational and economic value of the LWL, and actively participate in restoring and protecting it. Though all the 2008 APs have been implemented, more needs to be done to raise public awareness. Goals for this program are:

- Strengthen LWL brand awareness.
- Increase citizen participation in water quality protection and habitat restoration efforts within the community.
- Expand LWL education and engagement opportunities for youth in Palm Beach County.
- Promote lagoon ecotourism opportunities to various audiences including local residents, school groups, convention and out-of-town guests.
- Expand interaction through social media.

Interagency Planning and Coordination

In the 2013 revision of the Plan, stakeholders representing state, local and federal government, and members of the scientific community actively participated in its development. The most successful restoration projects have been completed through partnerships with engaged stakeholders. It is the goal of this management plan and its programmatic activities to continue and expand these partnerships. Goals are:

- Build partnerships with government agencies, municipalities and stakeholders for the implementation of the management plan.

Funding

Based on very preliminary estimates, the cost to implement all of the APs is estimated to be in excess of $81 million. Palm Beach County continues to pursue funding and in-kind support to finance restoration projects in the LWL. The LWL Partnership Grant Program (LWLPGP) and FIND's Waterways Assistance Program (WAP) have been matched with local funding to complete the majority of the restoration and water quality projects to date. The financing strategy includes pursuing dedicated and variable funding sources at federal, state, and local levels, as well as potential private and non-profit sources. The major objectives of the financing strategy are:

- Re-establish the LWLPGP.
- Secure funding in State agencies' (line item) budget.
- Secure Federal Legislative authorization and funding for restoration project support through the U.S. Army Corps of Engineers.
- Aggressively pursue state and federal grant partnerships for lagoon improvement.
- Maintain existing levels of local funding sources to provide matching funds to accomplish more with public dollars.
- Promote public-private partnerships with the potential for bottom-line benefits for

LWL businesses, Trusts, environmental organizations and others.

- Establish a LWL Restoration Fund (subset of the Pollution Recovery Trust Fund) to receive state fines levied for LWL watershed impacts to be applied towards lagoon restoration

Maintaining and continuing the Lagoon restoration progress will be challenging in the future. Emergent issues such as sea level rise and climate change, associated gaps in scientific knowledge, and the required funding to implement the APs will require commitment and partnerships. Adoption of the Plan through a formal Resolution by its contributors will provide a confirmation that consensus is essential for securing future resource allocation and grant funding. This pledge will confirm that partners are willing to work together cooperatively and commit funding and resources to the Plan. Broad community support and a united effort by environmental managers in government and industry will assure attainable and realistic goals within the next five years.

1. INTRODUCTION

This document represents the third update of the Lake Worth Lagoon Management Plan (Plan), encompassing the years 2008-2012. The Plan was significantly revised and formally re-adopted in 2008, setting forth specific, measurable goals for the Lagoon improvement in five areas: Water and Sediment Quality, Habitat Restoration Enhancement and Monitoring, Public Use and Outreach, Interagency Planning and Coordination, and Funding. The 2008 Plan presented a comprehensive series of actions to assist with its implementation. A total of 29 Action Plans (APs) were proposed. Each AP contained a background of the issue being addressed, a step by step strategy on how to implement the plan, the cost, the schedule, and the expected benefits.

In this third update, several APs proposed in the 2008 Plan have been merged, modified or eliminated, while new actions have been added based on revised information and newly identified priorities. These modifications reflect new or emerging issues for the Lagoon management. New actions are underlined in the Index of Action Plans at the beginning of the document; merged, modified or retired actions also are noted in the Index. This update encompasses 23 APs - 7 of them appearing in this Plan for the first time.

ACCOMPLISHMENTS FROM 2008-2012

In the past five years, many goals and objectives of the 2008 Plan have been implemented under the leadership of Palm Beach County Department of Environmental Resources Management (ERM), in partnership with state agencies, local municipalities, and interested stakeholders.

One of the most recent and significant achievements for the Lake Worth Lagoon (LWL) is the establishment of the Lake Worth Lagoon Initiative (Initiative). The Initiative, a multi-agency effort to increase awareness, support and funding assistance for projects to improve and protect the natural resources within the watershed was established in 2008. The Initiative has successfully promoted interagency coordination and commitment to the LWL restoration and protection. Palm Beach County (PBC) and the South Florida Water Management District (SFWMD) adopted Resolutions to support the establishment of the Initiative and adoption of the Plan. The Initiative has an informal Steering Committee that meets quarterly and is represented by members from the following organizations:

- Palm Beach County Board of County Commissioners
- Palm Beach County League of Cities
- Florida Inland Navigation District
- South Florida Water Management District Governing Board
- Florida Department of Environmental Protection

Individual Working Groups made up of multi-agency and stakeholder participants meet quarterly to cover three main areas of focus: Water Resources, Habitat Restoration and Public Outreach. Accomplishments in the five main Program areas are outlined below:

Water and Sediment Quality Program

Local governments and agencies have made significant investments each year in pollution prevention and stormwater improvements outlined in the 2008 Plan. Accomplishments of APs targeted specifically to improve and monitor the Lagoon water quality (WQ), and to reduce wastewater (WW), stormwater (SW), and sediments (SE), are outlined below:

- ERM in cooperation with the SFWMD completed a new LWL Monitoring Plan and expanded the water quality monitoring network by adding twelve (12) new stations (2008 AP: WQ-1).
- Data collected are currently stored in **DBHYDRO** the SFWMD environmental database which stores hydrologic, meteorologic, hydrogeologic and water quality data. This database is the repository source of the LWL up-to-date environmental data to be shared with local governments, State agencies and stakeholders (2008 AP: WQ-1).
- A formal interagency review of the Monitoring Plan Network was conducted for optimization (2008 AP: WQ-1).
- A five year baseline data analysis was conducted and is included in Chapter 2 this Plan update (2008 AP: WQ-1).
- ERM in cooperation with the Florida Department of Health (DOH) in Palm Beach County developed an ArcGIS map of septic systems (Appendix A) that discharge to the Lagoon and its associated watershed (2008 AP: WW-1).
- Two existing septic sewer systems previously discharging in the LWL were replaced with sanitary sewer systems. Detention areas were constructed, and swales re-graded and replaced. All sewage generated in a 65-acre area of Westgate in West Palm Beach, and a 7.5 acres area in The Town of Hypoluxo are now conveyed to wastewater treatment plants. Improved swales and retention areas results in cleaner water runoff, and the elimination of the septic systems protect LWL from sewage discharges (2008 AP: WW-2).
- Three stormwater retrofit projects were completed from 2008 to 2012. The Cities of West Palm Beach, Lake Worth, and Boynton Beach implemented several pollution reduction stormwater projects ranging from baffle boxes, drainage and sanitary pipe replacements, exfiltration systems and lake detention systems. Combined these projects are treating runoff from 526 acres of older urban areas filtering contaminants before they reach the LWL (2008 AP: SW-2).
- Monitoring of the sediment trap constructed as part of the C-51 Sediment Management Project was conducted from 2007 to 2010. Results showed an accretion of material during the three year study period averaging 4,649 cubic yards per year. Project partners included the SFWMD and the City of West Palm Beach (2008 AP: SE-2, SE-3).
- Implemented a Sediment Sourcing study, with emphasis on the C-51 Canal, to determine sources of total suspended solids (TSS) as well as the relative importance of the different components of TSS in attenuating light. The study identified potential sediment sources

within the basin based on land use data and water quality samples. This information should be evaluated to target specific Best Management Practices to reduce loads of sediments and nutrients entering LWL (2008 AP: SE-2).

- Conducted a pilot project to effectively cap fine-grained silt sediments (muck) from stormwater discharges of the nearby C-51 drainage canal and prevent their re-suspension in the water column. This project was a cooperative effort between PBCERM, SFWMD, and the Town of Palm Beach (2008 AP: SE-3).

Habitat Restoration and Enhancement Program

Significant lagoon improvements have been made through stormwater treatment and habitat restoration projects. Since 1998, the Florida Legislature has appropriated $16.7 million for the Lake Worth Lagoon Partnership Grant Program (LWLPGP), which has been matched with over $59.5 million in local and federal funds to construct over 44 projects totaling $76 million to improve water quality and habitat.

Since 2008, $15.9 million has been allocated and matched to provide $26.3 million for projects. Mangrove, spartina, maritime hammock and seagrass habitats were created and restored, oyster and artificial reefs were constructed, and stormwater management systems were put in place throughout the watershed that remove pollutants from the water before discharging to the Lagoon. A complete list of projects and accomplishments is summarized in **Appendix B**.

The 2008-2012 projects include:

- 12 Habitat Restoration and Enhancement Projects protecting and creating over 70 acres of habitat
- 3 Stormwater Projects Treating 526+ Acres of Runoff
- 2 Septic to Sanitary Sewer Projects taking septic systems offline
- 2 Public Boardwalks providing access to habitat restoration projects
- 8 Monitoring Projects

Financial Summary 2008-2012:

Total cost of projects implemented:	$26.3 Million
Total grant/state funds:	$15.9 Million
Total matching funds - local sponsors:	$10.4 Million

Some of the exemplary enhancement and restoration projects completed in the last five years include:

- **South Cove Natural Area** has brought life to the urban waterfront in central LWL by filling a dredged hole with 150,000 cubic yards of sand to cap muck sediments, and create 3.5 acres of seagrass habitat and 2 acres of mangrove/cordgrass islands. The sand

was stabilized by rock, which provides 1 acre of oyster reef. Fish and wading birds are utilizing the new habitat. A 550' boardwalk provides access to view the islands (2008 AP: HE-1, HE-2, HE-5, SE-3).

- **John's Island Oyster Reef** provides over 10 acres of oyster habitat in the central LWL. Over 15,000 tons of limestone rock was placed to form reef pods to optimize water flow and oyster recruitment along the reef edges (2008 AP: HE-1).
- **Ibis Isle** project restored over 8 acres of productive mangrove and salt marsh habitat by entombing thick muck sediments with a sand cap. Over 40,000 cubic yards of sand was placed using an electric conveyor and sand shooter, which systematically layered the sand cap without displacing the muck deposits. The sand is stabilized by limestone rock, which provides 1 acre of oyster reef. The new wetland is thriving with seagrass, wading birds, horseshoe crabs, oysters and fish (2008 AP: HE-1, HE-2, HE-3).
- **Boynton Beach/Ocean Ridge Mangrove Preserves and Breakwaters** enhancement project was designed to protect 35 acres of existing mangroves, including a mangrove fringe that has slowly eroded from boat wakes. 4,000 tons of limestone rock, stretching for 2,236 linear feet, provide shallow water artificial reef habitat that is ideal for oysters and other attaching organisms. A mangrove planter was also constructed behind the wave breaks to provide additional habitat (2008 AP: HE-2).
- **Phil Foster Park Artificial Reef** consists of discrete piles of limestone boulders and prefabricated reef modules placed in 6-10 feet of water to provide an 800-foot-long snorkel trail. These unique structures contain tunnels, ledges and cavities for fish, octopus, seahorse and other sea life. The accessibility to sea life make this a popular place for snorkelers (2008 AP: HE-2, HE-5).
- **Snook Islands Phase II/Bryant Park Wetlands** collectively provide over 11.7 acres seagrass, 1.2 acres mangroves and 0.5 acre oyster habitat in the central LWL. The project restores habitat by filling a dredged hole, capping muck sediments and providing the sand substrate necessary for seagrass recruitment. Five new mangrove islands will be created and linked by a series of oyster reefs. This project is a continuation of the very successful 100 acre habitat restored in Snook Islands Phase I (2008 AP: HE-1, HE-2, HE-4, SE-3).

These environmental enhancement and restoration projects have been accomplished through the efforts of and cooperation with many funding partners: Palm Beach County, the Florida Inland Navigation District (FIND), the Florida Department of Environmental Protection (FDEP), Florida Department of Transportation (FDOT), SFWMD, LWLPGP, and municipalities including City of West Palm Beach, Town of Palm Beach, City of Lake Worth, City of Riviera Beach, City of Boynton Beach and Town of Ocean Ridge.

Public Use and Outreach Program

The Public Outreach Use and Outreach Program is committed to creating an engaged constituency of citizens who understand both the environmental, recreational and economic

value of the Lagoon, and actively participate in restoring and protecting it. All the APs (PO1-4) identified in Chapter 6 of the 2008 Plan have been implemented, but more needs to be done to raise public awareness. Accomplishments of Public Outreach (PO) are outlined below:

- Established the Initiative (LWLI.org) was created in 2008 to facilitate stakeholder partnerships (2008 AP: PO-1).
- Developed the LWL logo and tagline: *Discover a Local Treasure* in cooperation with the PO Working Group (2008 AP: PO-2).
- Hired a full-time PO coordinator (2008 AP: PO-2).
- Developed public awareness programs to involve and inform the residents, visitors, and decision makers about the LWL ecosystem (2008 AP: PO-2). These programs include:

    a. 15 volunteer cleanups within and around the lagoon.
    b. Two Oyster Reef Restoration Projects with the help of over 250 volunteers.
    c. Several "Adopt-A-Spot" groups to clean up lagoon sites four times a year. Examples include Munyon Island and the Snook Islands Natural Area.
    d. The Initiative website, www.LWLI.org.

- Developed new educational programs and materials that emphasize the ecology of the LWL ecosystem and ways to help to preserve it（2008 AP: PO-2). These include:

    a. The Lake Worth Lagoon Educator's Guide, Lake Worth Lagoon: Discover a Local Treasure 16-page Newspaper in Education in partnership with the School District of Palm Beach County and the Palm Beach Post
    b. Produced a 45-minute video "Lake Worth Lagoon: Discover a Local Treasure" covering history, ecology, and restoration efforts.
    c. Created the Lake Worth Lagoon Speakers Bureau webpage which includes a listing of 11 agencies and organizations willing to provide formal presentations on various topics.
    d. Hosted the 2010 Lake Worth Lagoon Speakers Series with nine presentations, free and open to the public, at various locations through Palm Beach County.
    e. Participated in numerous community events to increase public awareness of the lagoon including the "Eco-Treasures" exhibit hosted at the City of West Palm Beach's Lakefront Pavilion, the Palm Beach County Boat Show, City of Lake Worth Earth Day, and West Palm Beach e4 Sustainability Summit.
    f. Conducted three large-scale boat tours (2009, 2010, 2011) and multiple smaller tours for elected officials, government agency representatives, and community partners to showcase lagoon restoration projects.

- Promoted passive public use of and access to the LWL through the creation of a *"Paddling Treasures"* brochure that highlights kayak launch locations and points of interests (2008 AP: PO-3).

- Advertised and promoted several public access features including the City of West Palm Beach's Municipal Docks, Munyon Island Dock, Snook Islands Natural Area public use components (boardwalk, fishing pier, and kayak launch structure), and the South Cove Natural Area public use components (2008 AP: PO-3).
- Expanded the Pollution Prevention Initiatives and the Florida Yards & Neighborhood Program to include LWL watershed. New educational products developed include the *Protect and Conserve Palm Beach County's Water and Environment* brochure, and Florida-Friendly school curriculum for 3rd through 5th grades (2008 AP: PO-4).

Interagency Planning and Coordination

The main goal of the 2008 management plan and its programmatic activities was to coordinate with other agency and local government plans or programs. Key policy leaders representing Federal, State, and local government, members of the scientific community, businesses and other stakeholders have actively participated in the development of the document and its APs.

Coordination with Federal, State and local government agencies has facilitated grant funding partnerships with FIND, FDEP, the Florida Fish and Wildlife Conservation Commission (FWC), The National Wildlife Federation (NWF), the U.S. Fish and Wildlife Service (USFWS), Loxahatchee River District, and various municipalities around the Lagoon. Accomplishments of these partnerships are outlined below:

- The establishment of the Initiative in 2008 has fostered the partnering of government agencies, municipalities and stakeholders for the implementation of the Plan, coordinated funding requests and discussions of lagoon management issues
- Successful completion of habitat restoration and water quality improvement projects (**Appendix B**) over the last five years has been a result of partners' coordination to acquire funding, overcome permitting issues and develop constituent support.
- PBC, FWC and USFWS hosted a Living Shorelines Workshop on April 20, 2010. Living Shorelines provide an alternative to seawalls and armoring by reducing shoreline erosion and providing wetland habitat. The workshop, organized by the Initiative Habitat Working Group, was well attended with more than 120 participants.
- A partnership with USFWS was developed in 2011 future construction of Living Shorelines. A small grant was given to ERM to develop and design these shoreline projects.
- Agency partnering has facilitated beneficial re-use of LWL sediments. Cooperation between State/Federal permitting agencies and County environmental managers has resulted in dredged materials being re-used for restoration. In the case of South Cove Natural Area construction, dredged materials from ICW maintenance dredging and marina projects, was utilized for wetland restoration and provided significant project cost savings.

- FWC partnered with PBC and acted as the State sponsor in applying for federal funding through the USFWS. FWC supports LWL restoration projects through a coordinated grant application process. Several grant applications have been submitted in cooperation with FWC on various habitat projects.
- Coordinated mitigation efforts has resulted in improved projects and cost savings. Since ERM specializes in wetland restoration, permitting agencies have encouraged collaboration to incorporate multiple mitigation needs into suitable restoration projects to promote overall habitat restoration success throughout the Lagoon. Examples include FDOT – PBC cooperation to construct Snook Island's II/Bryant Park Wetlands. These projects incorporate the mitigation needs associated with LWL bridge replacement projects.

Funding

Since 2008 ERM has pursued several avenues to secure funding or-in kind support to finance restoration and monitoring projects in the LWL. The LWLPGP had received funding between 1998 and 2008, however due to State budget cuts, the Florida Legislature has not been able to appropriate funding for this program since then. The financing strategy has not changed since the last Plan update. The goal is still to increase funding directed toward LWL management through Federal, State and local government grants and partnerships, private-public partnerships with non-governmental organizations (NGOs), and grants from privately managed trusts. Accomplishments of the Funding APs from 2008 to 2012 are outlined below:

- Aggressively pursued state and federal partnerships funding and received a total of $15.9 million, which was matched by $10.4 million in local funding for a total of $26.3 million.
- Applied for grants in partnership with NGO's.
- Maintained existing levels of expenditures for cost-effective projects contributing to the restoration goals.
- Evaluated programs and redirected resources to accomplish more with public dollars.

ISSUES AFFECTING THE LAKE WORTH LAGOON

Population increases, altered hydrology and large-scale freshwater releases from regional canals are still the main stressors for potential habitat loss and degradation of water quality in the LWL. Efforts to improve water quality and the water management strategies planned as a result of the Comprehensive Everglades Restoration Plan (CERP) have also evolved. Priorities have changed due to the economic situation. Many restoration and monitoring projects that could have directly or indirectly affected the health of the ecosystem have been scaled back or reduced to reflect the new economic reality. A new approach is required in the LWL. Development of long-term strategies and evaluation of the Lagoon's health is central to the success of restoration efforts, enabling communities to measure return on investment, and helping resources managers redirect their efforts when necessary. The habitat and monitoring programs formulated by the Initiative

still need broad community support. A united effort by environmental managers in government and industry is essential to reflect new issues such as sea level rise and climate change, associated gaps in scientific knowledge, and the required restoration to implement the APs while still considering current and future uses of the lagoon.

The following chapter summarizes progress made in the Lagoon protection and restoration from 2008 to 2012, noting ongoing monitoring and newly identified challenges. Important trends in the key issue areas identified in the Plan and its partners are presented here.

2. STATE OF THE LAKE WORTH LAGOON

Florida coastal lagoons and estuaries are extremely important ecosystems, as they support unique and important fish and wildlife populations. The following sections will provide a summary of information acquired since 2008 on seagrass, mangroves, oyster and artificial reefs, sea turtles, manatees, sediments, and water quality. A brief introduction to climate change and its potential effects on the LWL is also included. Full reports are available on www.LWLI.org.

Seagrass Background and Current Status

Seagrasses act as ecological engineers in coastal waters (Wright and Jones 2006), providing valuable ecological services to the marine environment (Orth et al. 2006, Costanza et al. 1997). These services include provision of physical habitat structure/shelter, alteration of water flow, nutrient cycling, organic carbon production and export, sediment stabilization, enhancement of biodiversity, trophic transfers to adjacent habitats, and food web structure (Hemming and Duarte 2000; Orth et al., 2006). Seagrasses are an important food source for endangered megafauna, such as green sea turtles and manatees, and provide critical habitat for many commercially and recreational important fishery species. Species such as drums (Sciaenidae), sea bass (Serranidae), porgies (Sparidae), grunts (Haemulidae), and snappers (Lutjanidae) use seagrass meadows as nursery grounds (Beck et al. 2001; SAFMC, 2011). Within LWL, seagrass beds also provide valuable refuge for juvenile fish such as red drum (*Sciaenops ocellaturs*), grouper (*Epinephelus* spp.), snook (*Centropomus undecimalus*), and spotted seatrout (*Cynoscion nebulosus*) (Crigger et al., 2005).

Due to the global importance of seagrass habitats to key ecological services, seagrasses can be considered “coastal canaries,” global biological sentinels of increasing anthropogenic influences in coastal ecosystems (Orth et al. 2006). Large-scale losses of seagrasses are being reported worldwide due to the cumulative effects of multiple stressors, including sediment and nutrient runoff, physical disturbance, invasive species, disease, commercial fishing practices, aquaculture, overgrazing, algal blooms, and global warming, causing declines at scales of square meters to hundreds of square kilometers (Orth et al. 2006). *Halophila* species, which are the dominant species in the Lagoon, are particularly sensitive and experience rapid turnover from season to season.

The earliest evaluation of seagrass in the LWL was compiled from a 1940 aerial survey and documented 4,271 acres of seagrass (PBCERM & FDEP 1998). In 1975, a resource inventory found that only 161 acres of seagrass remained in LWL. While there is uncertainty about the accuracy of methods used, the results indicate a substantial loss of seagrass. The loss was thought to be a result of extensive dredging and filling, sewage disposal outfalls that directly discharged to LWL, degraded water quality, and changes in salinity (PBCERM 1998). The impacts were inevitable due to the rapidly expanding population surrounding the estuary and the limited technology associated with wastewater treatment plants. During the 1950s, an estimated ten million gallons per day (MGD) of raw sewage was discharged in the Lagoon resulting in

bacterial and nutrient pollution. By 1970, seven major waste water treatment plants had been constructed, discharging 18.49 MGD of secondarily treated sewage effluent. The volume was reduced to 2.98 MGD by 19884, largely as a result of the NPDES program administered by the U.S. Environmental Protection Agency (USEPA) (PBCERM & FDEP 1998).

In 1990, the LWL natural resource inventory performed by Dames & Moore and ERM included detailed in-water surveys which provided the most complete information to date. The survey indicated that there were 2,110 acres of seagrass present, or approximately half of the extent of seagrass in 1940 (PBCERM 1990), but a substantial increase of 1,949 acres when compared to results of the 1975 survey (Braun 2006).

In 2001, true color aerial photographs were interpreted to determine seagrass coverage in LWL. While this did not include extensive in situ ground truthing, the goal was to develop a methodology to generate baseline data for future large scale monitoring. The total 2001 seagrass coverage was determined to be 1,646 acres, or approximately 21.2% of the Lagoon (PBCERM 2008a). The coverage varied throughout the three segments of the Lagoon (**Table 1**).

Although the methods of analysis were markedly different between the 1990 and 2001 surveys, there appears to be a loss of seagrass coverage over the 11-year period. The 2001 survey did not include extensive in-water ground truthing, therefore sparse seagrass beds, or those located in areas with poor water visibility, were not mapped (PBCERM 2008a).

The most recent aerial mapping of seagrass was conducted in 2007. This mapping effort implemented the same methodologies that were utilized to map and classify the 2001 seagrass coverage. This allowed for the first true large-scale trend comparison between any two years. Results of the 2007 mapping showed that seagrass beds covered at least 1,688 acres, or 21.74%, of the Lagoon. This is a 2.5% (42 acre) increase over the 2001 calculation of 1,647 acres and is probably not a significant increase given the resolution of the aerials (PBCERM 2008b). Much of the increase can be attributed to the presence of patchy seagrass beds throughout the LWL. As in 2001, the seagrass coverage varied throughout the three segments of the Lagoon in 2007. Approximately 65%, or 1,090 acres, of seagrasses were identified in the northern segment (Little Lake Worth just north of PGA Blvd to Flagler Memorial Bridge); 12%, or 205 acres, were identified within the central segment (Flagler Memorial Bridge to Lake Ave. Bridge); and 23%, or 393 acres, were mapped within the southern segment (Lake Ave Bridge to Ocean Ave Bridge in Boynton Beach) (**Table 1**).

Habitat Type	North	Central	South	Lagoon-wide
2001 Seagrass Acres				
Patchy Seagrass	13	1	0	14
Continuous Seagrass	1136	195	302	1,633
All Seagrass	1149	196	302	1,647
2007 Seagrass Acres				
Patchy Seagrass	21	21	10	52
Continuous Seagrass	1069	184	383	1,636
All Seagrass	1090	205	393	1,688
Change 2001-2007				
Patchy Seagrass	+8	+20	+10	+38
Continuous Seagrass	-67	-11	+81	+3
Net Change All Seagrass	-59	+9	+91	+41
Percent Change	**-5.1%**	**+4.4%**	**+23.2%**	**+2.5%**

Table 1: 2001 vs. 2007 Seagrass Acreage and Percent Change by LWL Segment

When comparing 2001 to 2007, a 59 acre decrease was noted for the northern segment, a 9 acre increase was noted for the central segment, and a 91 acre increase was noted for the southern segment (PBCERM 2008b). Although useful for detecting temporal and spatial trends, the results may underestimate seagrass coverage, especially in the central and southern segments of the Lagoon. These two areas typically have poor water visibility, and the most dominant species (*Halophila*) found within these two segments are diminutive in their size. Additionally, the aerial mapping efforts were designed to detect large scale changes, and therefore only identified seagrass beds that were 0.25 acres or greater in size. **Table 2** summarizes the results of all five seagrass mapping efforts in LWL.

Year	Seagrass (Acres)	% Change[3]
1940[1]	4,271[2]	-
1975	161	(96%)
1990	2,110	1,210%
2001[4]	1,646	(22%)
2007[4]	1,688	2.5%

Table 2. Historical Seagrass Coverage in Lake Worth Lagoon

[1]Arbitrary date reflects conditions prior to intense urbanization; conditions allow for maximum coverage of seagrass.

[2]Acres is the maximum allowable area of seagrass given pre-WWII conditions.

[3]Due to gross differences in survey methods, these values should only be used to indicate an order of magnitude change.

[4]2001 and 2007 utilized the same methodology to calculate acres

In the last five years, 15 acres of additional seagrass habitat in the central LWL has been created as a result of County restoration projects (Table 3). In 2012, PBCERM attempted to map seagrass coverage Lagoon-wide using the same methodologies used in 2001 and 2007, but was unsuccessful. The LWL Basin experienced an above average rainy season (May through October) in 2012, with an overall total rainfall of approximately 64.7 inches recorded at Palm Beach International Airport. In August 2012, Tropical Storm Isaac produced a 1-in-100-year rainfall event within Palm Beach County's C-51 Basin that received nearly 15 inches of rain over a 72-hour period. This resulted in a record flow of 10,300 cubic feet of water per second from the C-51 control structure into the LWL. The heavy rainfall and stormwater discharges resulted in poor water clarity, a condition not favorable for aerial seagrass mapping. ERM will attempt to obtain Lagoon-wide seagrass coverage in 2013 with a revised methodology relying more heavily on groundtruthing.

Project Name	Location	Year Completed	Acres
South Cove Natural Area	Central	2012	3.50
Snook Islands Phase II	Central	2013	7.17
Bryant Park Wetlands	Central	2013	4.54
Total			15.21

Table 3. Restoration Projects Resulting in Seagrass Acreage, 2008-2012

Fixed Transect Seagrass Surveys

With the exception of 2006, ERM has conducted annual monitoring along nine fixed transects located across the length of the LWL since 2000. The transects are located in areas where the Lagoon bottom increases in depth by one to two feet within 50 to 100 feet of the edge of an existing seagrass bed and are in close proximity to construction projects funded by the LWLPG Program or some other water or habitat improvement project. As water quality in the Lagoon improves, seagrass beds are expected to expand to greater depths and increase in density and diversity.

Variations in seagrass presence and cover at the permanent stations have occurred throughout the 12-year survey period (**Figure 1**). Annual monitoring data indicate that large-scale events, such as the extreme freshwater discharges associated with tropical storms and hurricanes, may be the largest contributor to overall seagrass trends in the Lagoon. The 2005 and 2006 surveys showed major decreases in seagrass cover at most of transects following the active storm seasons of 2004 and 2005. The loss of seagrasses is believed to be a result of increased turbidity and suspended sediments caused by runoff from the hurricanes, discharges from Lake Okeechobee and burial/scour from wave action.

Recovery of seagrass populations was observed during the 2007 annual monitoring with record high levels of seagrass cover and density, followed by slight decreases in 2008 and 2009. The 2007, 2008, and 2009 surveys documented expansion of seagrass beds into deeper water at the transect locations. The 2010 survey revealed a reduction in seagrass cover compared to the 2007

through 2009 surveys, which may represent a response to typical rainfall patterns from mid 2009 through 2010 following drought conditions between 2007 through 2009. Dense *Lyngbya* and filamentous mat algal overgrowth, which were likely related to pulses of high rainfall in March and April 2010, also contributed to the loss of seagrass cover and retraction of bed edges in 2010.

Overall seagrass frequency of occurrence in 2011 was the third highest recorded during the entire monitoring period, just short of the overall high cover recorded in 2007. Similar to the 2007 survey, which followed a very dry "wet season", the 2011 survey was preceded by a very dry "dry season." The 2012 survey data continued to support the temporal pattern of seagrass cover associated with south Florida's hydrologic regime. Declines in overall seagrass abundance and cover were observed in July 2012, with overall seagrass abundance most closely resembling the June 2010 survey.

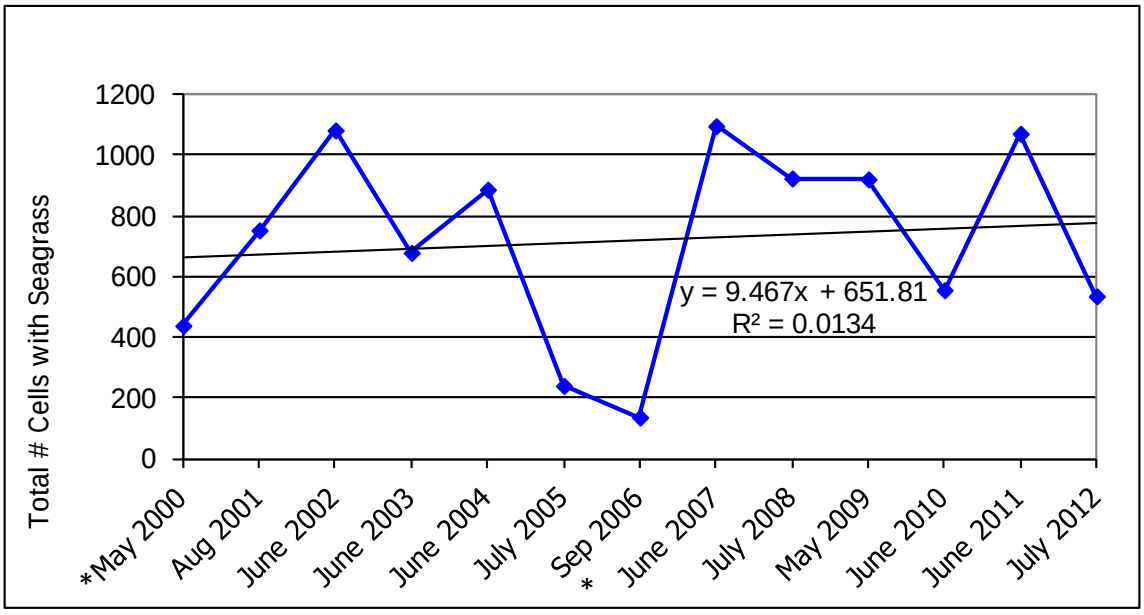


Figure 1. Total number of cells with seagrass for all stations, all transects and all years. *Note: May 2000 survey was only Transects 1 through 5. Survey in 2006 only included 4 of 9 transects.

A strong negative correlation between muck substrate and seagrass abundance has been documented over the course of the annual surveys (**Figure 2**). Muck and silty sand were the least common substrate types associated with seagrass, while sand and shelly sand supported the majority of stations. This finding highlights the importance of ERM's restoration projects to cap muck sediments and restore seagrass habitat in the LWL.

Annual surveys at the nine transects provide only a snapshot of seagrass cover and health at the time of the survey; however, the long-term dataset allows for the evaluation of temporal trends and general patterns in seagrass cover in response to large-scale environmental disturbances, such as hurricanes, and small-scale habitat factors, such as sediment characteristics.

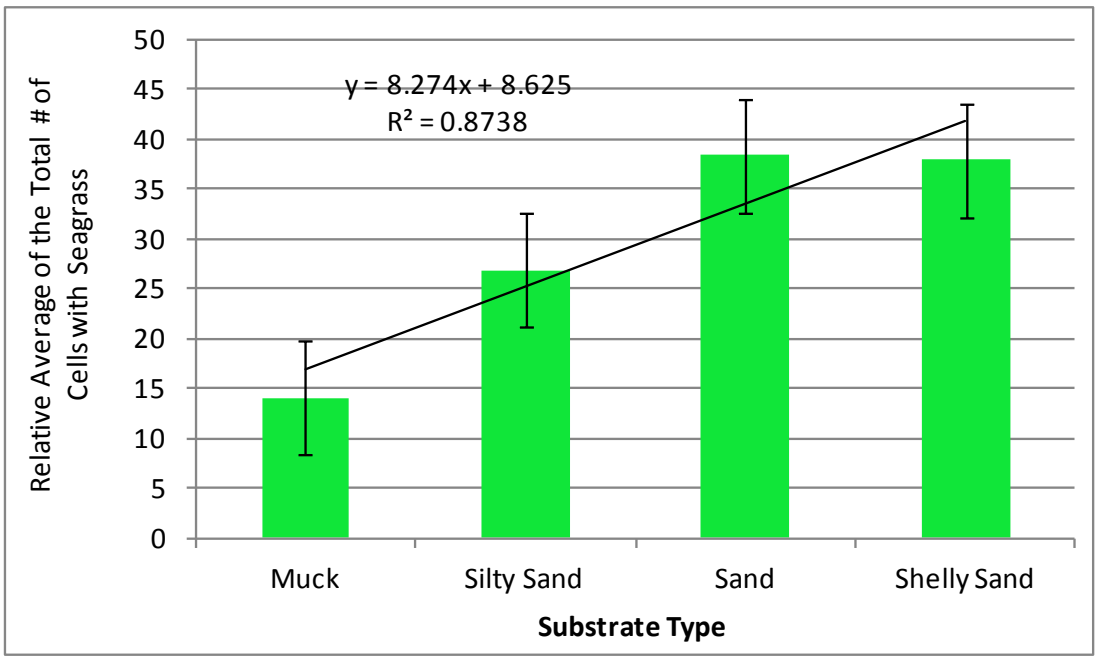


Figure 2. Relationship between substrate type and total average frequency of seagrass occurrence during 2000-2012.

SFWMD/CERP Monitoring Program

CERP was developed with the goal of restoring more natural freshwater discharges to the Northern Estuaries, including the Lagoon, by providing more stable and desirable conditions (e.g., lowered salinity variability) amenable to the re-establishment of floral and faunal communities. The restoration of a more natural hydrology is expected to improve the spatial and structural characteristics of SAV and its associated biological communities. Seagrass populations in LWL have been much reduced in distribution via the inflow of suspended sediments and fluctuating salinity resulting from current water management practices.

In December 2009 the Restoration Coordination & Verification (RECOVER) team, lead by the SFWMD, developed a monitoring protocol capable of detecting seagrass changes in both short and long term spatial and temporal scales. The original scope of work included monitoring seagrass at five permanent stations within the Lagoon, located north and south of both the C-17 and C-51 Canals. In spring of 2011, RECOVER went through a Monitoring Reduction and Optimization exercise which resulted in a reduction of monitoring stations (from 5 to 4) and frequency (from bimonthly to twice a year).

RECOVER monitoring efforts within the Lagoon have shown an increase in the presence of seagrass at all four stations from 2010-2012. Coverage patterns displayed typical seasonal trends, increasing in early spring, peaking in late summer, followed by decreases/die-off during

the winter months. Although total seagrass percent occurrence remained relatively stable at the northern lagoon sites, the two sites near the C-51 Canal experienced significant decreases in September 2012. These decreases are most likely a result of increased discharges and runoff associated Tropical Storm Isaac.

Status of *Halophila johnsonii* in the Lake Worth Lagoon

Johnson's seagrass (*Halophila johnsonii*) is the first marine plant species to be listed under the Endangered Species Act (**Figure 3**). Johnson's seagrass has the most limited known geographic distribution of any seagrass in the world (NOAA 2002). Its distribution is disjunct and patchy and limited to the east coast of Florida, from Sebastian Inlet south to central Biscayne Bay. The largest known contiguous distribution of Johnson's seagrass has been documented inside the Lagoon and Lake Worth Inlet. Of the 10 areas established as critical habitat in Florida, two are within the LWL (**Figure 4**). It often grows in a patchy, non-contiguous distribution in the intertidal zone, but can be found to a depth of 9 feet (NOAA 2002). Johnson's seagrass has been found in coarse sand and muck substrates, and in areas with turbid waters and high tidal currents. Johnson's seagrass appears to be more tolerant of salinity, temperature, and desiccation variation than other Florida species.

Figure 3. Picture of Johnson's Seagrass (ERM)

Despite its diminutive size and patchy distribution, studies indicate that Johnson's seagrass provides similar ecological and economic benefits to larger species, including its role as a refuge and nursery for fish and invertebrates and in sediment stabilization. Its small size and rapid turnover rate lends to its importance in detritus and nutrient cycling. Endangered green sea turtles and West Indian manatees are known to feed on *Halophila* species and this genus may represent a significant component of their diet (NOAA 2002).

The continued existence and recovery of Johnson's Seagrass may be limited due to habitat alteration by a number of human and natural perturbations, including dredging, storm action and

sedimentation and degraded water quality. The Recovery Plan for Johnson's Seagrass was published in 2002. The Recovery Plan calls for research on basic reproductive biology and life history of the species, as well as general management and coordination among responsible local, state, and Federal agencies, to guide conservation decisions.

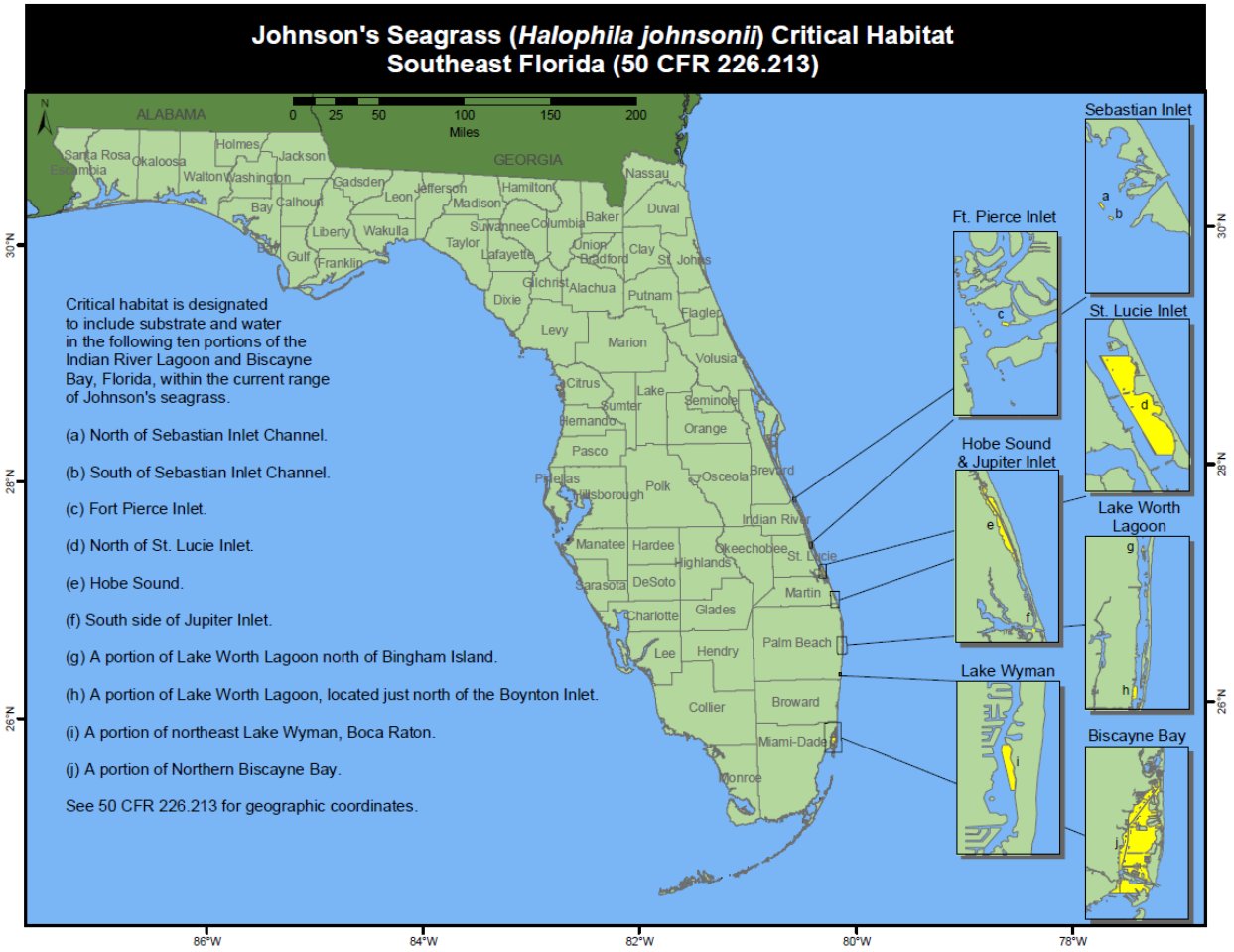


Figure 4. Map of Crital Habitat for Johnson's Seagrass

One of the specific actions set forth in the Recovery Plan was to "initiate a range wide mapping and monitoring program." A brief summary of this program is summarized below.

Johnson's Seagrass Distribution and Abundance Surveys and Monitoring of Populations in the Southern Range

(Florida Fish and Wildlife Conservation Commission, Florida Fish and Wildlife Research Institute and Juliet Christian)

One of the actions set forth in the Johnson's Seagrass Recovery Plan (2002) was to "initiate a range wide mapping and monitoring program." Since 2006, the Johnson's Seagrass Recovery Team has been monitoring *Halophila johnsonii* (Johnson's seagrass) in the southern half of the species' range, which extends from the Jupiter Inlet south to Virginia Key in Biscayne Bay.

Monitoring occurs annually during the summer. For the purpose of this Plan, only data specific to the LWL is considered here. In LWL eight sites have been established. Of the four seagrass species observed between 2006 and 2012, *H. wrightii* and *H. johnsonii* were observed most frequently---50% and 38% of all quadrats surveyed, respectively (**Figure 5**). Frequencies of occurrence, densities and abundances of the species varied substantially from site to site, as well as annually. Monitoring will continue annually through 2015.

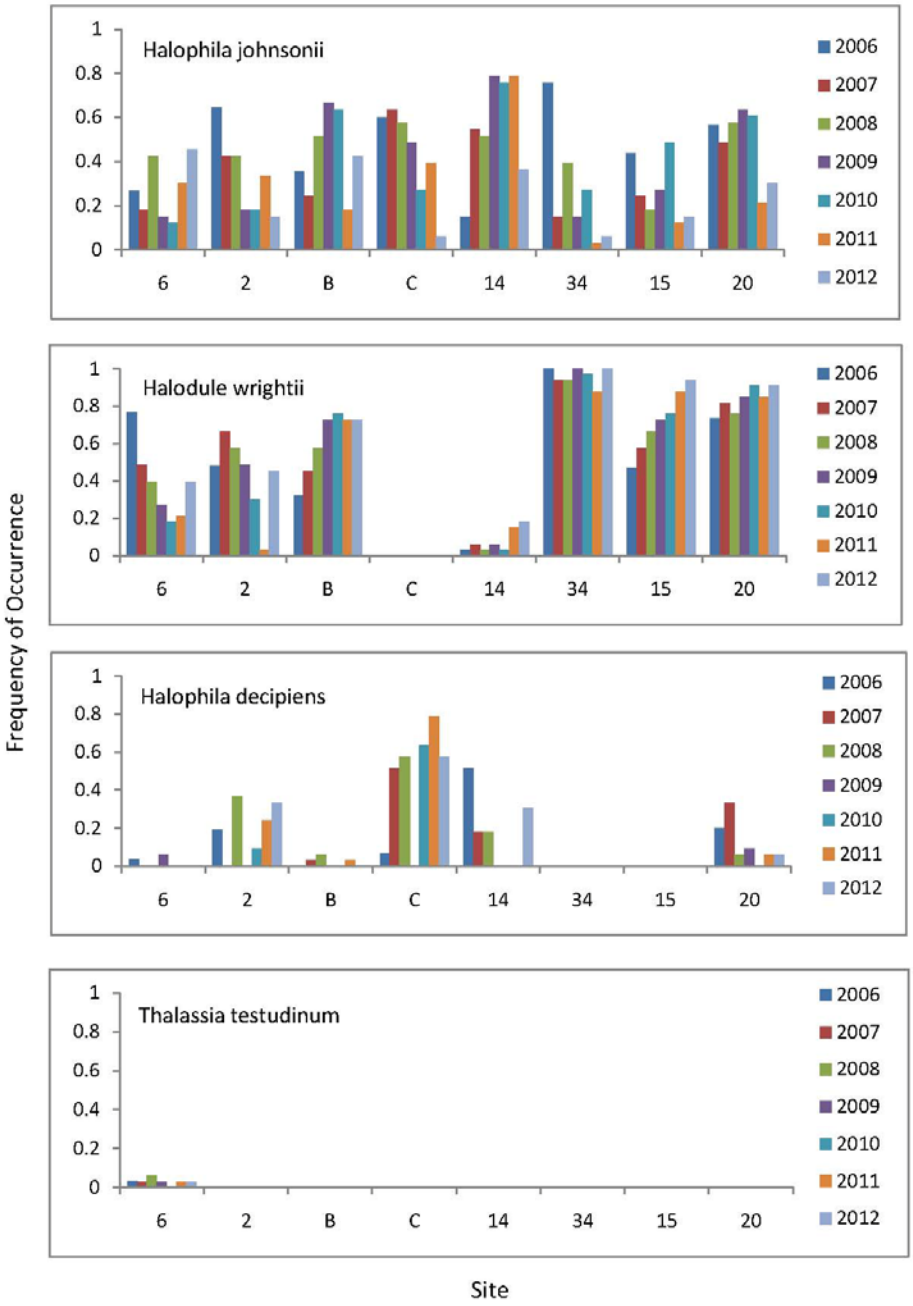


Figure 5. Annual frequency of occurrence for four seagrass species in the LWL. Sites are arranged from north to south (left to right). Data provided by FWC/FWRI.

Additional Seagrass Research in the Lake Worth Lagoon

Biodiversity of submerged aquatic vegetation in Lake Worth Cove, a protected region of Lake Worth Lagoon, Florida

(Thomas C. Chesnes, Palm Beach Atlantic University; Scott Duncan, John D. MacArthur Beach State Park; Kathryn Swick, Palm Beach Atlantic University; Charles Jabaly, Florida Park Service)

Study Summary

A portion of northern LWL is protected, located within the boundaries of John D. MacArthur Beach State Park, including the nearly 40 hectare, semi-enclosed Lake Worth Cove (**Figure 6**). In an ongoing project conducted by a variety of stakeholders, including university faculty, undergraduate research assistants, park staff, scientists and volunteers, nondestructive field surveys of submerged aquatic vegetation were initiated within the Cove in 2010.

All seven of Florida's seagrass species were found in the Cove, including the federally threatened species *Halophila johnsonii* (Johnson's seagrass) as well as *Ruppia maritima* (widgeon grass), a species which has never been documented within the Cove and rarely documented within the lagoon remote from freshwater sources. Within a particular two-hectare zone in the southern cove, all seven species were present. The dominant seagrass was consistently shoal grass, *Halodule wrightii*, with estimated coverage peaking near 24% in the summer sample. Johnson's seagrass was found during all sampling periods, with a maximum coverage estimate near 3.5% in the summer survey. Drift algae was more frequently encountered during the spring surveys, covering nearly 10% of the Cove during this time. The most common drift algae encountered was *Acanthophora spicifera*.

Lake Worth Cove has the highest seagrass diversity of any area in LWL and, along with the Indian River Lagoon, has the greatest seagrass diversity of any estuary in the Western Hemisphere. This diversity may be due to the semi-enclosed morphology of the estuary, and likely influenced by the variety of sediment types, depths, and currents found within the cove. The protected nature of the area and the natural resource management efforts of the Florida Park Service likely enhance the community makeup and integrity of the submerged habitats. In many other natural areas, the biodiversity and value may not be yet documented, nor even known. Under current developmental pressure, the remnant natural areas within LWL are threatened. The ecological loss of these patches within urban landscapes would far outweigh the temporary economic benefit.

Figure 6. Location of John D. MacArthur Beach State Park in the northern Lagoon. Notice the lack of natural shoreline in the lagoon outside of the park. (Aerial images from ERM)

Mangrove Communities

Mangroves serve very important functions in the ecology of the LWL. They recycle nutrients and the nutrient mass balance of estuarine ecosystems. Mangrove leaves, wood, roots, and detrital material provide essential food chain resources, and provide habitat for many wildlife endangered and threatened species and species of special concern. They also serve as storm buffers, stabilizing shorelines and fine substrates with their roots, thereby reducing potential turbidity and enhancing water clarity.

The coverage of mangrove habitat in the Lagoon continues to increase as a result of restoration efforts. In 2007, aerial photography of the LWL was acquired to map the extent of essential fish habitats, including mangroves, and determine large-scale historical trends. After acquiring the aerial photographs, individual habitat boundaries were defined according to signatures apparent on the photography. Groundtruthing methodologies were then applied to verify photographic signatures with actual field conditions. Including restoration projects completed since the 2007 survey, the Lagoon is estimated to contain approximately 295 acres of mangroves (**Figure 7**), which represents an 8% increase since 1985 (**Table 4**).

Year	Mangrove (Acres)	Increase (Acres)	Percent increase from 1985[1]
1985	273	-	-
2001	278	5	1.8%
2007	283	5	3.7%
2012	295	12	8.1%

Table 4. Historical Mangrove Coverage in Lake Worth Lagoon

[1]Due to differences in survey methods, these values should only be used to indicate an order of magnitude change.

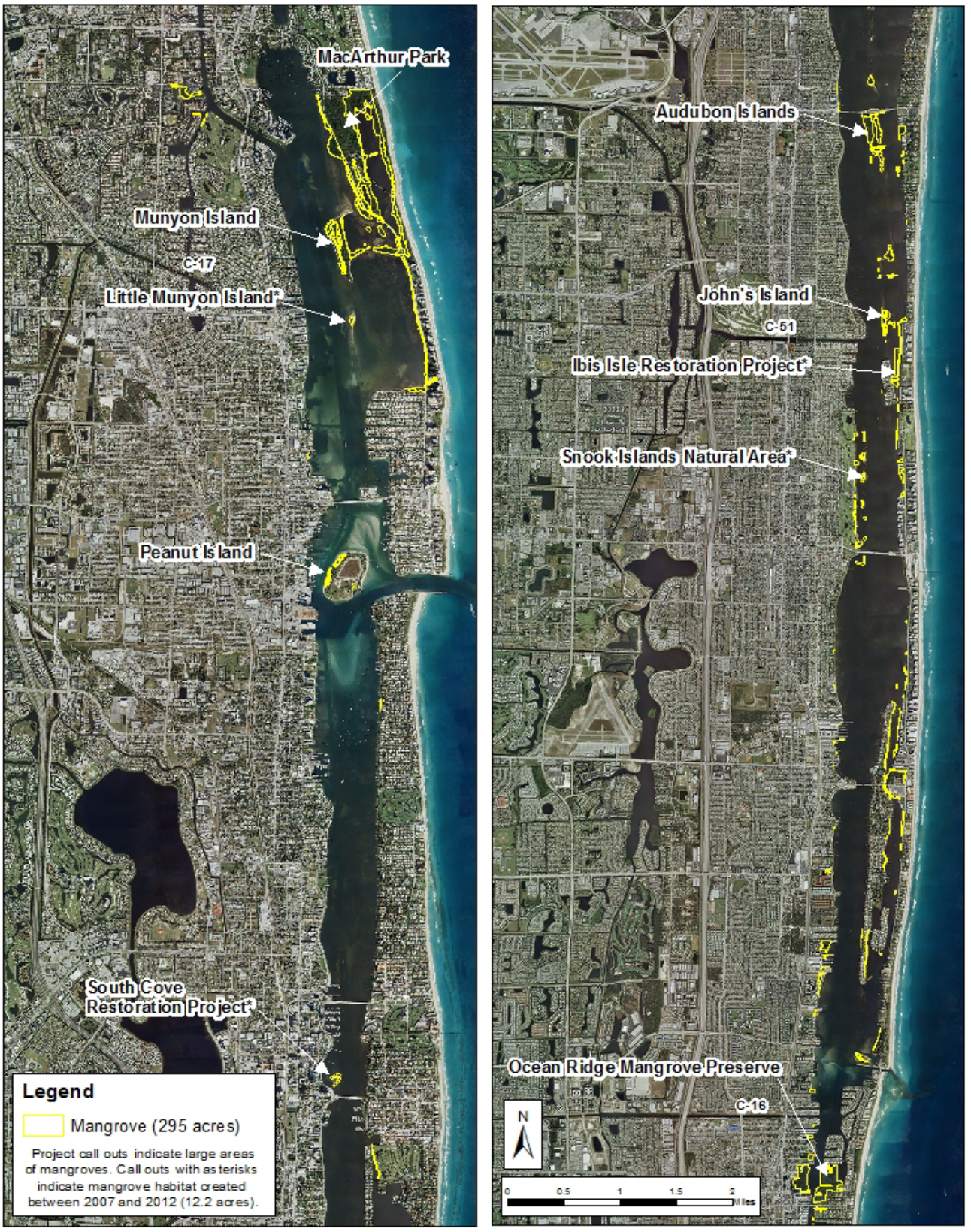


Figure 7. Mangrove Communities in LWL

Between 1985 and 2007, increases in mangrove habitat were observed within the north (33.1 acres) and central (5.8 acres) Lagoon, which can be partly attributed to ERM restoration projects, including Munyon Island, Peanut Island, John's Island, and Snook Islands. The removal of exotics and the protection and natural recruitment of mangroves along the shoreline of John D. MacArthur Beach State Park are also believed to increase the mangrove habitat in the north segment of the LWL. A decrease of mangrove habitat was observed in the South LWL (-3.6 acres). Between 2008 and 2012, increases in mangrove habitat were observed primarily in the north (0.9 acre) and central (11.3 acres) Lagoon and are a direct result of restoration efforts (**Table 5**).

Project Name	Location	Year Completed	Acres
Little Munyon Island	North	2009	0.92
Ibis Isle Restoration	Central	2010	6.94
South Cove Natural Area	Central	2012	1.79
Snook Islands Natural Area*	Central	2013	2.12
Bryant Park Wetlands	Central	2013	0.44
Total			12.21

Table 5. Restoration Projects Resulting in Mangrove Acreage, 2008-2012

*Snook Islands Phase I had just been completed at the time of the 2007 habitat mapping project; therefore, the entire mangrove habitat was not accounted for. This calculation includes 1.38 acres from Phase I and 0.74 acre from Phase II.

Oyster Reefs

Oysters provide numerous ecological benefits including habitat diversity, erosion control and improvement of water quality. Restoration and enhancement of natural oyster reefs and the creation of additional oyster reefs are important components of ERM's mission to restore and manage the LWL ecosystem. In the last five years, restoration projects have resulted in the addition of nearly 13 acres of oyster reefs in the south and central LWL. Details about these projects can be found in **Table 6**.

Monitoring projects are necessary to determine the health and productivity, not only of existing natural oyster beds, but to determine the success of artificially created oyster beds. AP EM-4 was implemented by maintaining and increasing the current monitoring efforts of the oyster population in the Lagoon. Two monitoring studies, one by FWC as part of the CERP/ RECOVER Monitoring and Assessment Plan, and the second by ERM in cooperation with Harbor Branch Oceanographic Institute (HBOI) at Florida Atlantic University (FAU), have been conducted. Both efforts are summarized in the following section.

Project Name	Location	Year Completed	Acres
Boynton Beach/Ocean Ridge Mangrove Riprap Project	South	2009	0.26
Lantana Preserve and Bicentennial Park Volunteer Oyster Projects	South	2009	0.04
Ibis Isle Restoration	Central	2010	0.80
South Cove Natural Area	Central	2012	1.00
Johns Island	Central	2012	10.00
Snook Islands Natural Area	Central	2013	0.45
Bryant Park Wetlands	Central	2012	0.06
Total			12.61

Table 6. Restoration Projects Resulting in Oyster Acreage, 2008-2012

Northern Estuaries Oyster Monitoring Program

(Dr. Melanie Parker, FWC Fish and Wildlife Research Institute)

In 2005, scientists from FWC initiated an oyster monitoring program in several east coast estuaries, which included LWL, Loxahatchee River, and the St. Lucie Estuary, as a component of CERP. The main objective of that oyster program is to conduct long-term monitoring in order to document the response of oysters, *Crassostrea virginica*, to changes in the magnitude and timing of freshwater flow into each estuary as related to CERP activities. Several aspects of oyster ecology were monitored including spatial and temporal variations in the abundance of settled oysters, recruitment of juvenile oysters, and distribution and frequency patterns of the oyster disease *Perkinsus marinus* (dermo). Three separate oyster reefs were selected as study locations within the central LWL (**Figure 8**).

In order to assess settled oyster densities, bi-annual surveys are conducted at each of the three LWL monitoring stations in the spring and fall of each year. Results show that live oyster densities varied substantially from 2008 through spring 2012 (**Figure 9**). The highest mean live oyster densities (665 oysters m^{-2}) were recorded in fall 2008, but were preceded in the spring by the lowest mean recorded densities (111 oysters m^{-2}) for the period from 2008 through spring 2012. Average densities from 2009 through 2011 were relatively stable, generally falling between 400 to 450 oysters m^{-2}, with the only exception occurring in spring 2010 (248 oysters m^{-2}). In spring 2012, mean live density was lower (146 oysters m^{-2}) and more similar to the mean density measured in spring 2008.

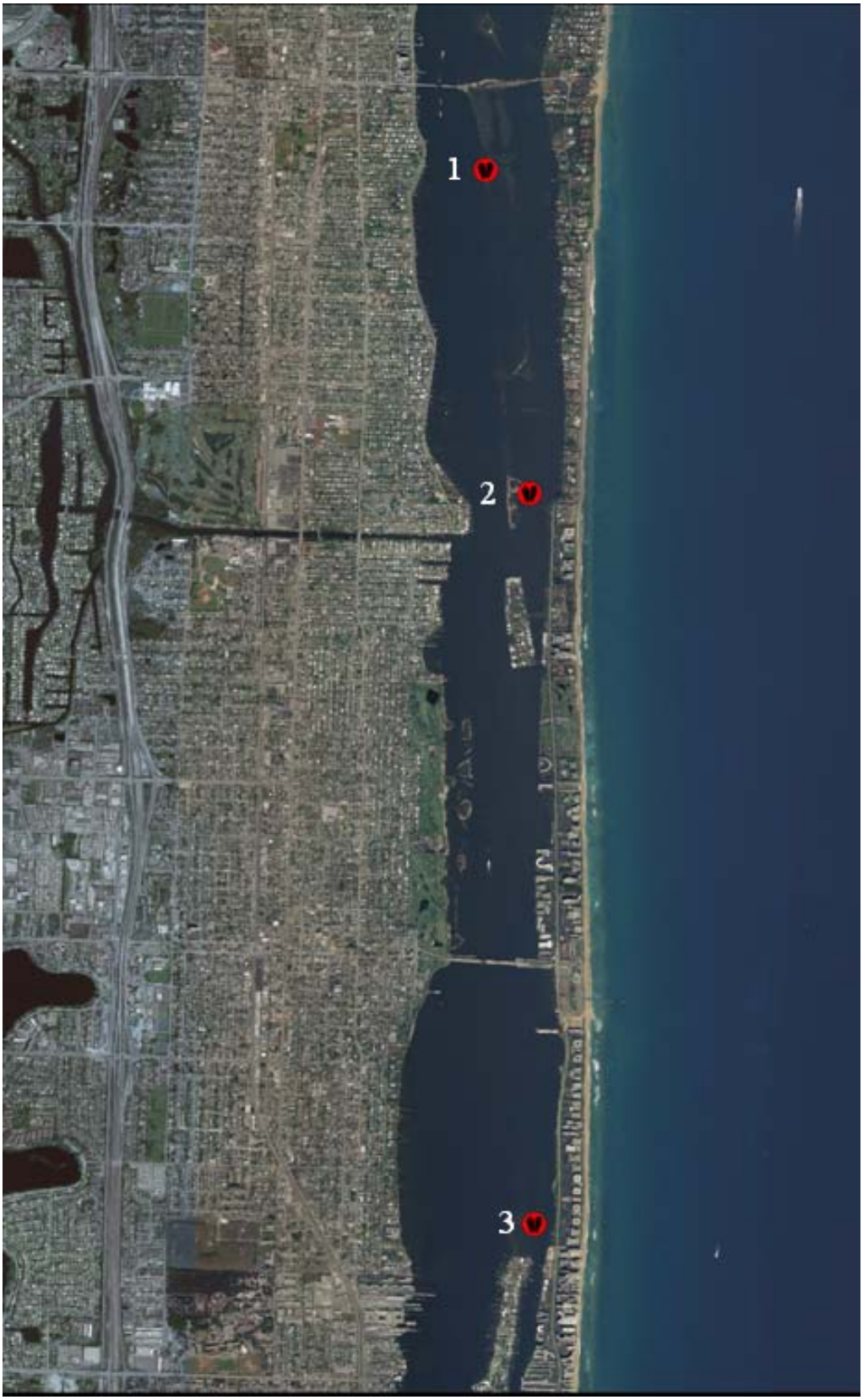


Figure 8. FWC oyster monitoring stations in LWL

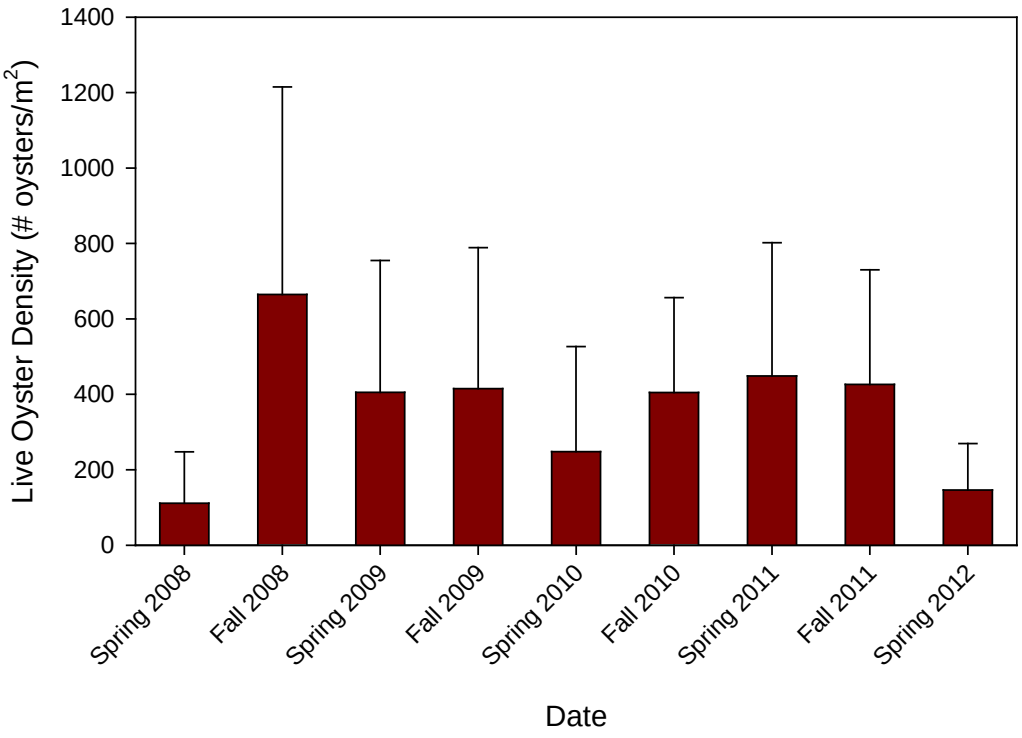


Figure 9. Mean number (±S.D.) of live oysters present during the spring and fall surveys in LWL from 2008 – 2012.

The substantial increase in live oyster density measured in fall 2008 was the result of a successful recruitment event that occurred from April through October 2008. The influence of those new oyster recruits is demonstrated by a comparison of live oyster shell heights. Mean shell height of live oysters during most surveys ranged from 29 to 35 mm, but the mean shell height in fall 2008 was only 19 mm (**Figure 10**). This suggests that a larger majority of the live oysters measured in fall 2008 were smaller, recently settled juveniles.

Juvenile oyster recruitment was monitored at all three stations in LWL on a monthly basis. Three replicate spat monitoring arrays were deployed at each station for a period of approximately 28 days and then collected and returned to the FWC laboratory for processing. Larval recruitment is reported as the mean number of spat (settled juvenile oysters) counted per shell each month. With the exception of 2008, recruitment occurred continuously from May through December (**Figure 11**). Recruitment also began in April in 2012, but the duration of the season has yet to be determined. Mean annual recruitment also varied among years, with the highest rates measured in 2010 and 2012 (5.1 and 6.0 spat/shell/month, respectively). It is worth noting that the mean annual recruitment rate for 2012 is the highest measured to date despite the fact that there are likely several more months remaining in the season.

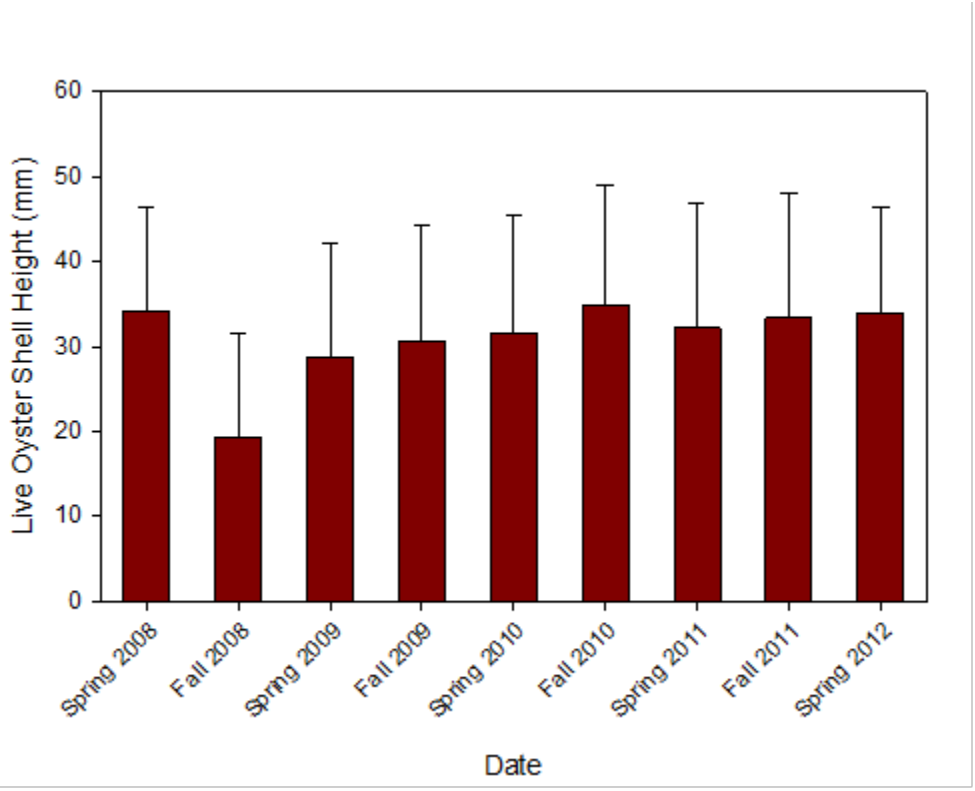


Figure 10. Mean shell height (±S.D.) of live oysters present during the spring and fall LWL from 2008 – 2012.

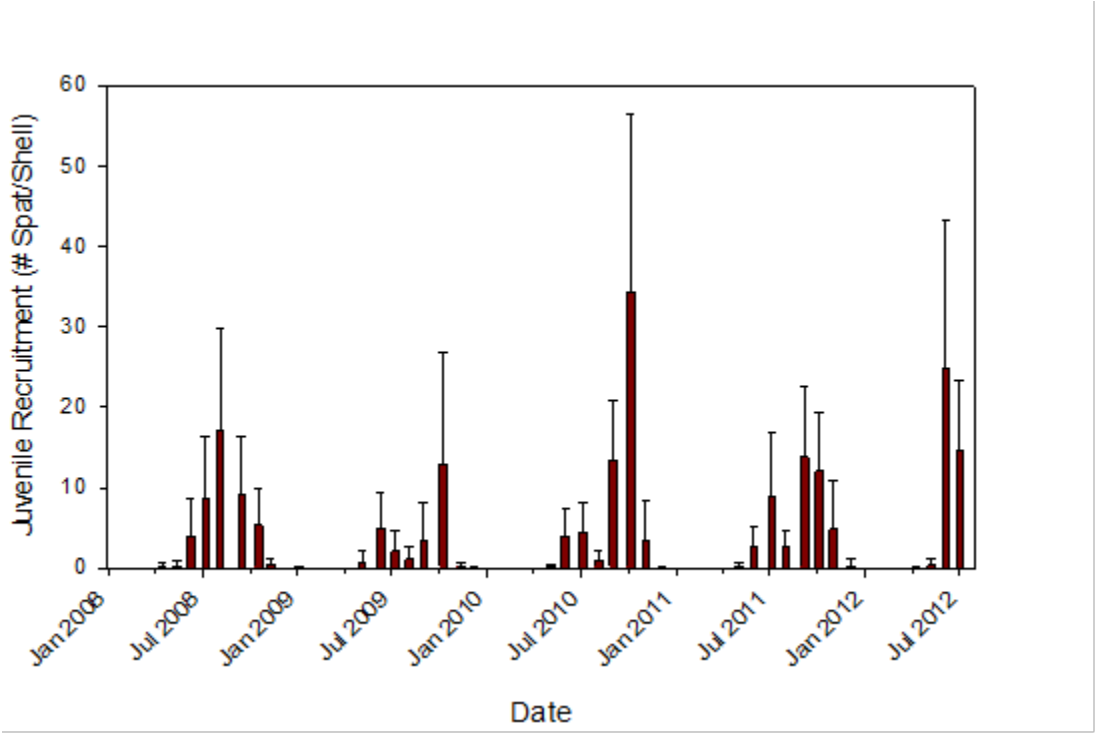


Figure 11. Mean number (±S.D.) of oyster spat collected per shell each month in LWL from 2008 – 2012.

Live adult oysters were collected monthly from each station in LWL for determination of the prevalence and intensity of the oyster disease, *Perkinsus marinus* (dermo). Dermo infection was

present in all months, except May 2009, in oysters collected from LWL. When present, infection prevalence ranged from 7 to 93% of the collected oysters (**Figure 12**). Parasite density (infection intensity) was ranked using the Mackin scale (**Table 7**), which ranges from 0 to 5, where 0 indicates no infection detected and 5 indicates a heavy parasitic load. Despite the persistent presence of dermo in oysters collected from LWL, infection intensity levels remained low to moderate with mean scores never exceeding a rank of 2 (**Figure 13**).

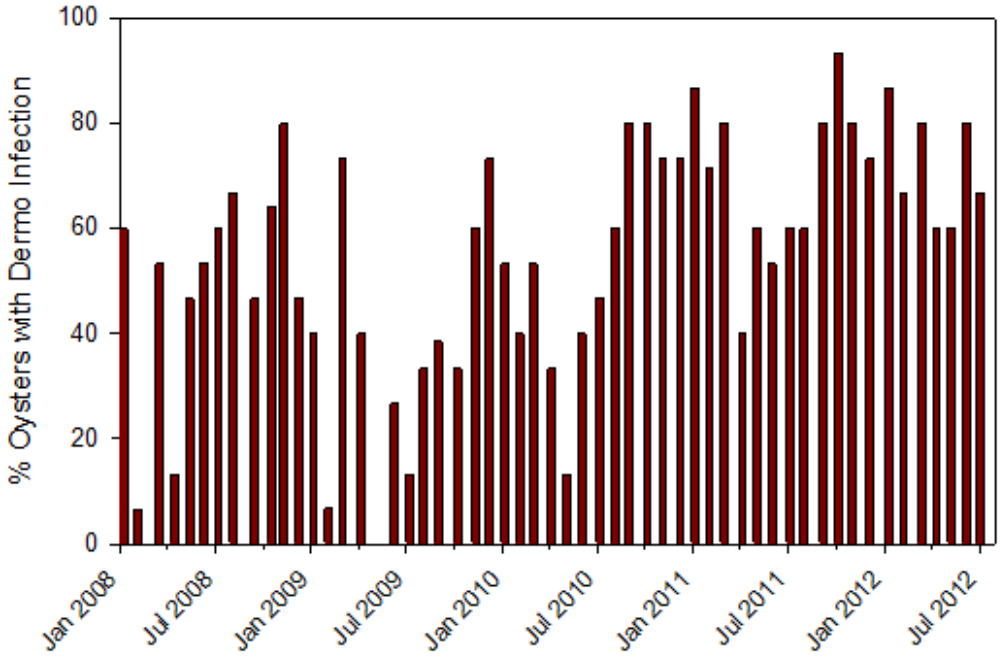


Figure 12. Monthly prevalence (%) of oysters infected with *Perkinsus marinus* (dermo) in Lake Worth Lagoon from 2008 – 2012.

Stage	Category	Cell Number	Notes
0	Uninfected	No cells detected	
0.5	Very light	<10 cells in entire preparation	
1	Light	11-100 cells in entire preparation	Cells scattered or in localized clusters of 10-15 cells
2	Light-moderate		Cells distributed in local concentrations of 24-50 cells; or uniformly distributed so that 2-3 cells occur in each field at 100X
3	Moderate	3 cells in all fields at 100X	Masses of 50 cells may occur
4	Moderate heavy	Cells present in high numbers in all tissues	Less than half of tissue appears blue-black macroscopically
5	Heavy	Cells in enormous numbers	Most tissue appears blue-black macroscopically

Table 7. Mackin scale showing different stages of *Perkinsus marinus* (dermo) infection intensity.

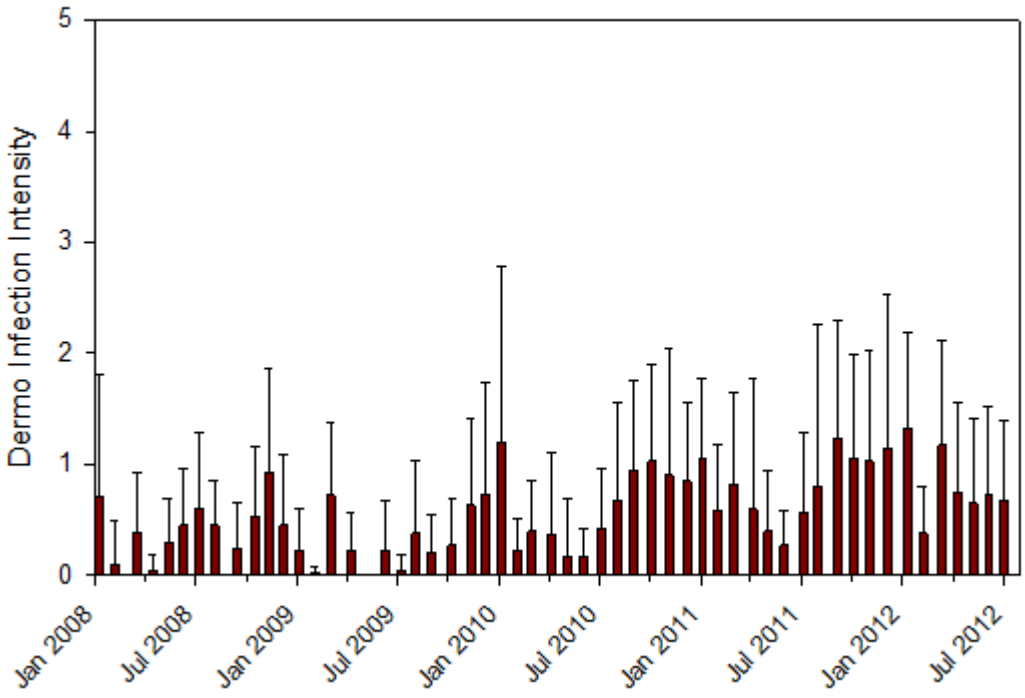


Figure 13. Monthly mean infection intensity (±S.D.) of oysters infected with *Perkinsus marinus* (dermo) in LWL from 2008 – 2012.

Survey of Select Oyster Populations

(Dr. John Scarpa and Dr. Susan E, Laramore, Harbor Branch Oceanographic Institute at Florida Atlantic University)

In 2008 ERM in cooperation with HBOI initiated a two year study to determine the health and productivity of three additional oyster reef sites, and the potential for expanding reefs at or near these locations. The report presented the findings from monthly monitoring from March 2008 to February 2010 of two natural oyster reefs located in the northern and central LWL, and one artificially created oyster habitat in the central Lagoon. The sites chosen by ERM were a natural bed located at John D. MacArthur Beach State Recreation Park located in the estuary off the northern end of the LWL, a natural bed located at Ibis Isle in the central Lagoon, and a created bed centrally located at the Snook Islands Natural Area in the central LWL (**Figure 14**).

Objectives

The major objective of this study was to determine the health and productivity of each site. This was accomplished by monitoring changes in: 1) environmental and water quality parameters, 2) size and density of adult oysters, 3) physiological condition and reproductive potential of adult oysters, 4) recruitment of larval oysters, 5) growth of newly set oysters, and 6) prevalence and intensity of oyster diseases, with emphasis placed on Dermo (*Perkinsus marinus*) and MSX (*Haplosporidum nelsoni*).

Figure 14: Satellite view of north and central portion of the Lake Worth Lagoon detailing the MacArthur, Ibis Isle and Snook Island sampling sites.

Results

Water Quality Parameters

No variation was seen between the northern and central sites in regards to temperature or other environmental parameters measured, except for salinity. Salinity varied significantly between sites, with the two central sites experiencing wide variation in salinity. Differences were especially apparent in summer, when salinities at the central sites (Ibis Isle and Snook Island) were 10-15 ppt lower than at the northern MacArthur site. MacArthur had the highest average salinity and Ibis Isles the lowest salinity of the three sites (**Figure 15**).

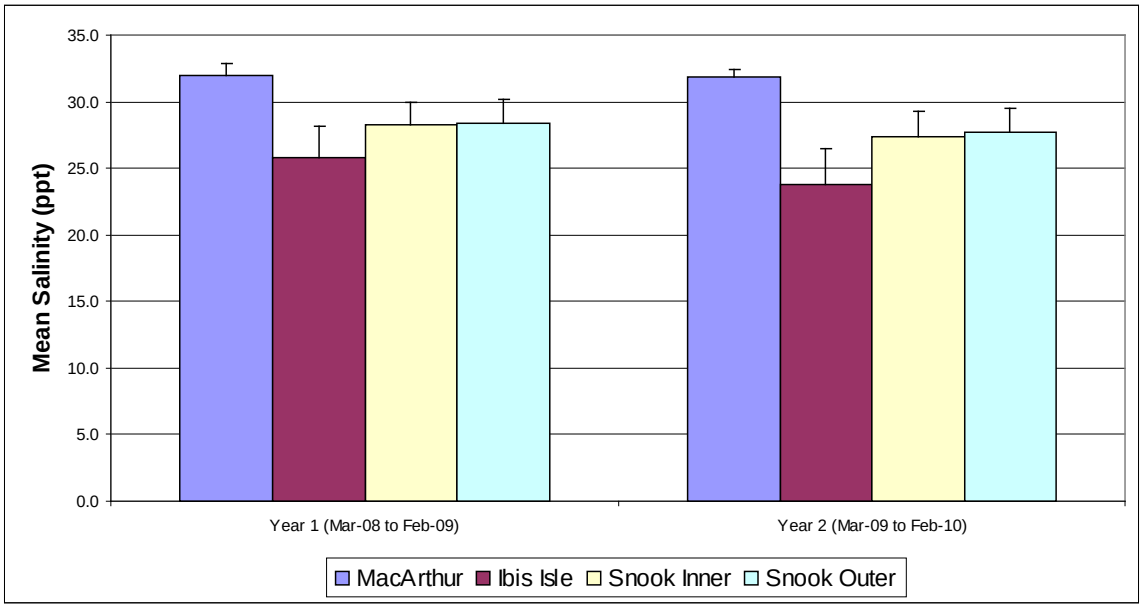


Figure 15. Annual average salinity (±SE) at oyster monitoring sites in Lake Worth Lagoon from March 2008-February 2010.

Adult Oyster Density

Live oyster density was significantly greater at Ibis Isles compared to MacArthur for both years of the study, and significantly greater compared to Snook Island in year one (**Figure 16**). Densities were higher in fall than in spring at all sites. Oyster density at Snook Island showed no vertical distribution differences between the base and middle of the riprap, but oysters were rarely found at the top of the island.

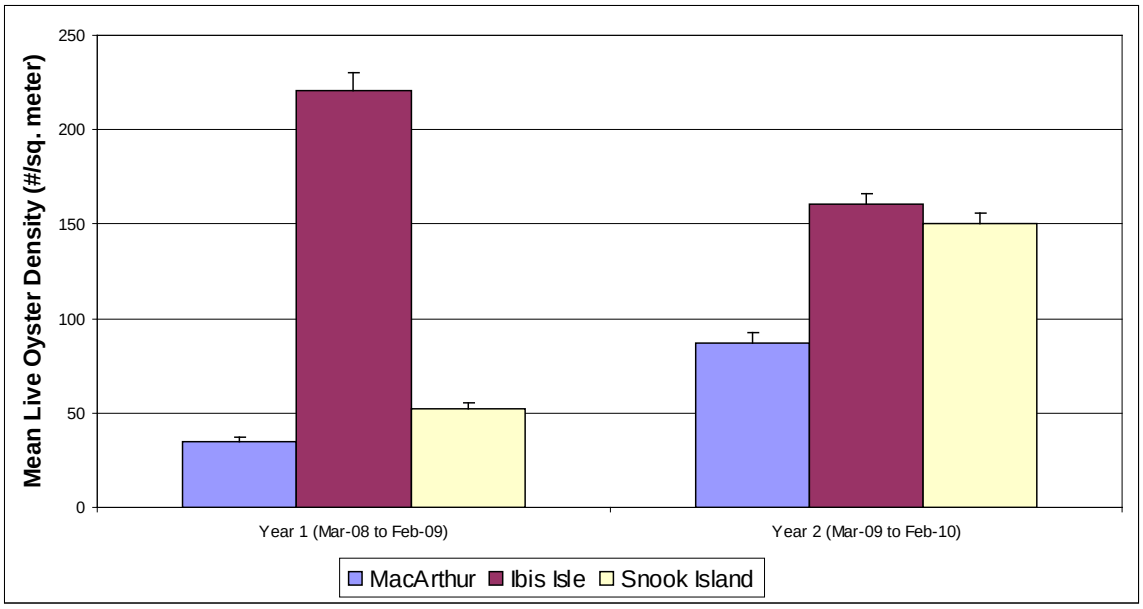


Figure 16. Average annual oyster density (±SE) of sampling sites in Lake Worth Lagoon from March 2008 to February 2010.

Physiological Condition

Oysters at Snook Island had the highest condition index (CI) in year one, while oysters at MacArthur had the highest CI in year two (**Figure 17**). CI was high at all sites during the winter. Low CI's were seen in the spring of year one at both MacArthur and Snook Island.

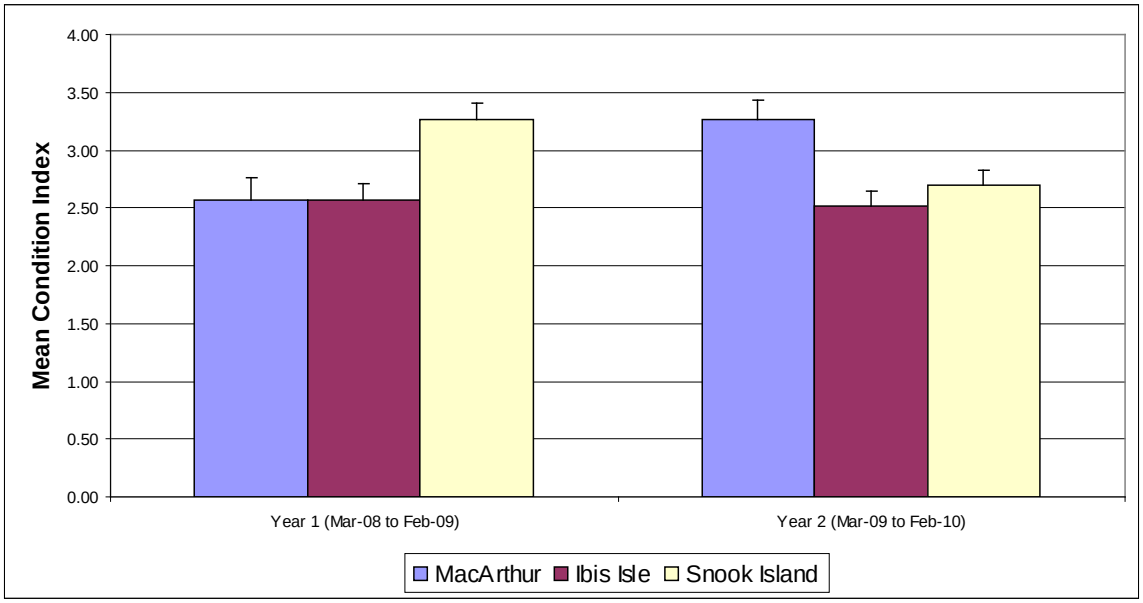


Figure 17. Average annual (±SE) condition index (CI) of oysters sampled from sites in Lake Worth Lagoon from March 2008 to February 2010.

Reproduction

Oysters were reproductively active at all sites, except during the winter. In year two only oysters at Snook Island had two reproductive peaks, one in the spring and another in the fall. Reproductive peaks occurred only in the fall at both Ibis Isles and MacArthur in year two.

Disease

Dermo (*Perkinsus marinus*) was present year round at all three sites. Annual prevalence was similar, although levels were slightly lower at Snook Island (**Figure 18**). Prevalence was lowest at all sites during the winter and low at the central sites concurrent with low salinity events. Intensity, as defined on a 0-5 Mackin scale, ranged from 0-4.5. Average annual intensities ranged from 0.85-1.2, with MacArthur having the highest annual intensities and Snook Island the lowest. No MSX (*Haplosporodium nelsoni*) was found at any of the sites.

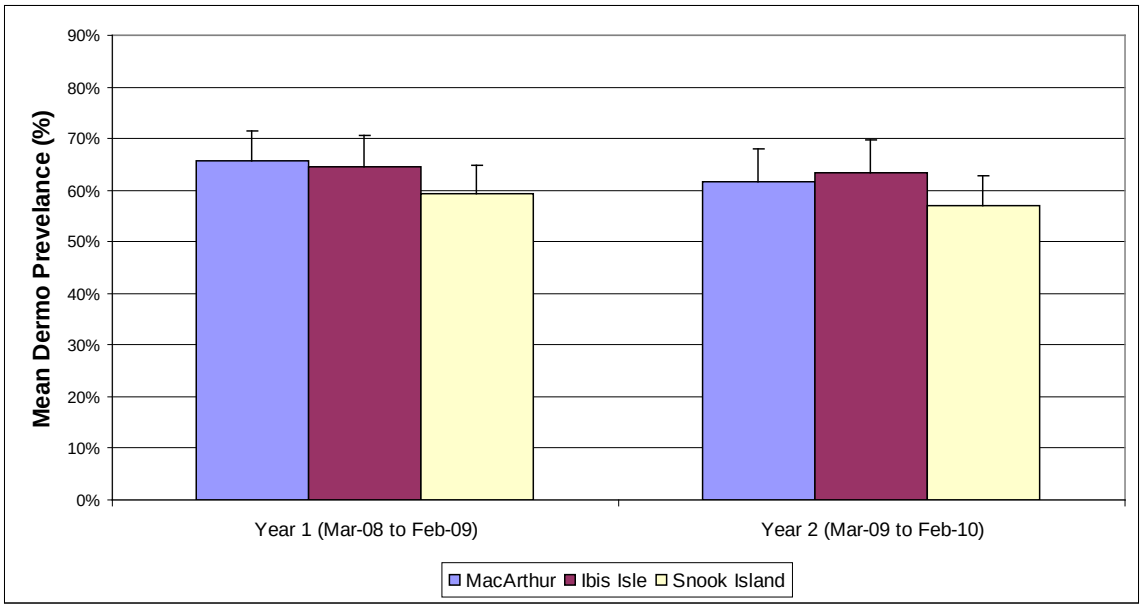


Figure 18. Annual average (±SE) Dermo prevalence at sampling sites in the Lake Worth Lagoon from March 2008 to February 2010.

Larval Recruitment

The highest larval recruitment occurred at Snook Island and the lowest at MacArthur (**Figure 19**). Bi-annual recruitment peaks occurred only at Snook Island. Larval recruitment occurred from late spring/early summer through fall at all sites, and followed the same pattern as reproductive activity. Level of recruitment appeared to be related to adult oyster density.

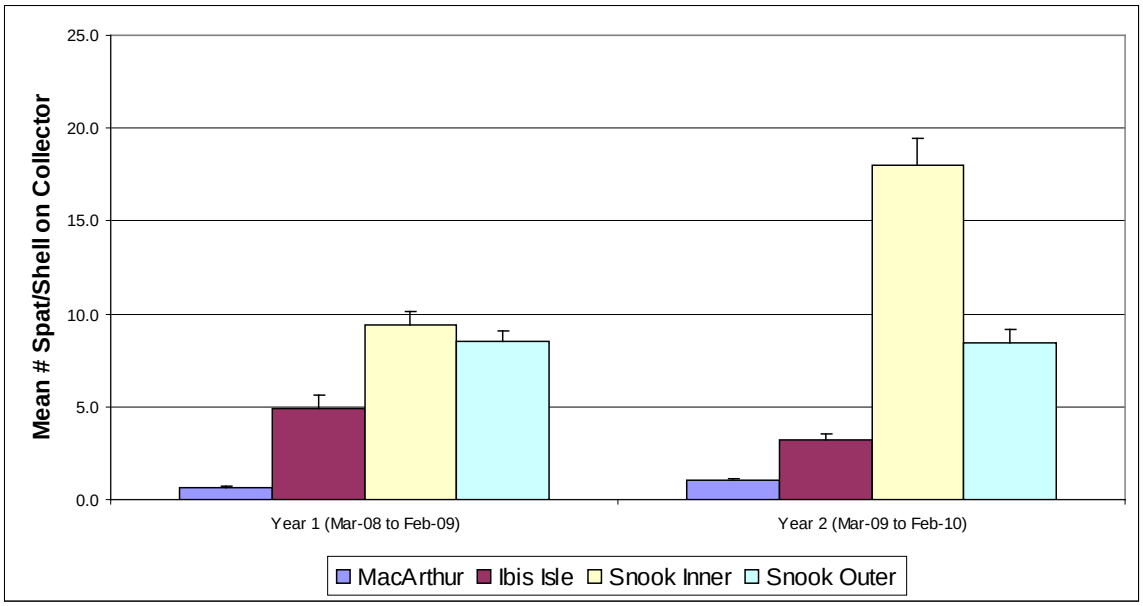


Figure 19. Average annual (±SE) number of spat collected at sampling sites in the Lake Worth Lagoon from March 2008 to February 2010.

Juvenile growth

Growth, as defined by shell height, was highest at Ibis Isles in year one and at MacArthur in year two (**Figure 20**). Growth was lowest at Snook Island both years.

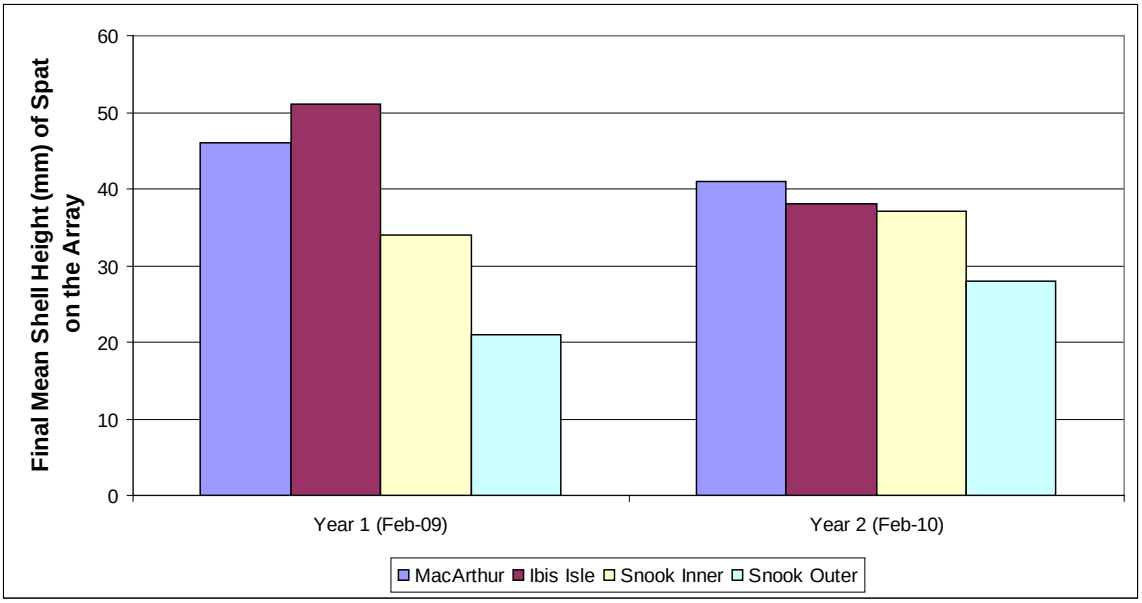


Figure 20. Final annual mean shell height of juvenile oysters on shell arrays at sampling sites in Lake Worth Lagoon.

Conclusions

Oyster densities on Florida's west coast (Caloosahatchee River) are much higher than all east coast sites, including the LWL. In all other parameters measured (i.e., reproductive activity, juvenile growth, and condition index) LWL oysters are comparable to those of other Florida east and west coast oysters within year to year variability. Based on these studies further oyster reef restoration projects within LWL should be successful whether projects considered are large, such as the Snook Island project, or small in scope, such as envisioned in the Living Shoreline projects.

All three sites monitored over the past two years have healthy oysters present. Although the natural oyster bed at MacArthur is subjected to less salinity pressure it had the lowest density and recruitment. Still, oysters at MacArthur had as high or higher CI and juvenile growth than oysters in the central lagoon. The natural oyster beds at Ibis Isle had the highest density and single-month recruitment, but the site is substrate limited. The artificially constructed Snook Island environmental enhancement area had the highest annual recruitment (twice that of Ibis Isle and ten times that of MacArthur), but oyster density was only one-fifth to three-quarters that of Ibis Isle though twice as high as at MacArthur, indicating this site may be substrate limited. Although no oysters grew on the top of the vertical structure it is recommended that the height not be decreased due to the eventual wear and movement of rock at the base of the island.

The LWL is a productive system with patches of healthy oyster beds that provide the recruitment necessary to seed large (Snook Island) and small restoration projects, as long as other environmental factors (salinity, hydrology, food availability) and substrate type (hard bottom, mud) are considered. Based on this two year monitoring study additional restoration projects should not only be successful, but would improve water quality, provide erosion control and increase habitat for associated species, such as other invertebrates, fish and birds.

Artificial Reefs in LWL

Artificial reefs within the LWL create new marine life communities and provide nursery habitat for many marine/estuarine species. Generally these reefs are placed in locations where little productive habitat exists such as dredge holes. Dredge holes within the Lagoon can be as deep as 35 ft. making these ideal locations for artificial reefs by increasing their habitat value. The reef structures are built from a variety of materials: limerock boulders, demolition concrete, old barges, and prefabricated modules. These reefs replace habitat that has been lost because of coastal development, and while being different compared to shallow water softbottom, mangrove and seagrass habitats also altered by development, reefs supply the physical structure that provide shelter and increase productivity of the Lagoon. Juvenile fish of reef species are always present in varying numbers which suggests the reefs may be serving as nurseries for offshore populations.

These reefs are monitored by staff and by a group of volunteer divers, the Palm Beach County Reef Research Team (RRT). Since 1991, this group has monitored marine life on the County's reefs, both natural and artificial, and continues to provide valuable data for management decisions and scientific research. Funding for the costs associated with this monitoring has been provided by FWC's Artificial Reef Program Monitoring Grants since 1996. The majority of monitoring occurs offshore but the Team has monitored two Lagoon reefs extensively. The remainder have had limited, opportunistic surveys conducted.

Thirteen artificial reef sites have been constructed to date (**Figure 21**), the majority of them deployed in the northern portion of the LWL.

Kelsey Park Reef is a 2 acre site (10' deep) located 1.75 miles north of the Lake Worth Inlet on the west side of the Lagoon. This reef was constructed between 2004 -2008 and contains concrete materials from the demolition of the old Forest Hill High School, limestone boulders, and 18 concrete modules placed by the Riviera Beach Maritime Academy.

Monitoring: In a site visit in 2006, the most numerous fish observed were grunts (*Haemulon plumieri*), porkfish (*Anisotremus virginicus*), tomtate (*Haemulon aurollneatum*). The limerock boulders were covered with a dense mat of algae hydroid, but benthic invertebrates were numerous, including many tunicates and sponges.

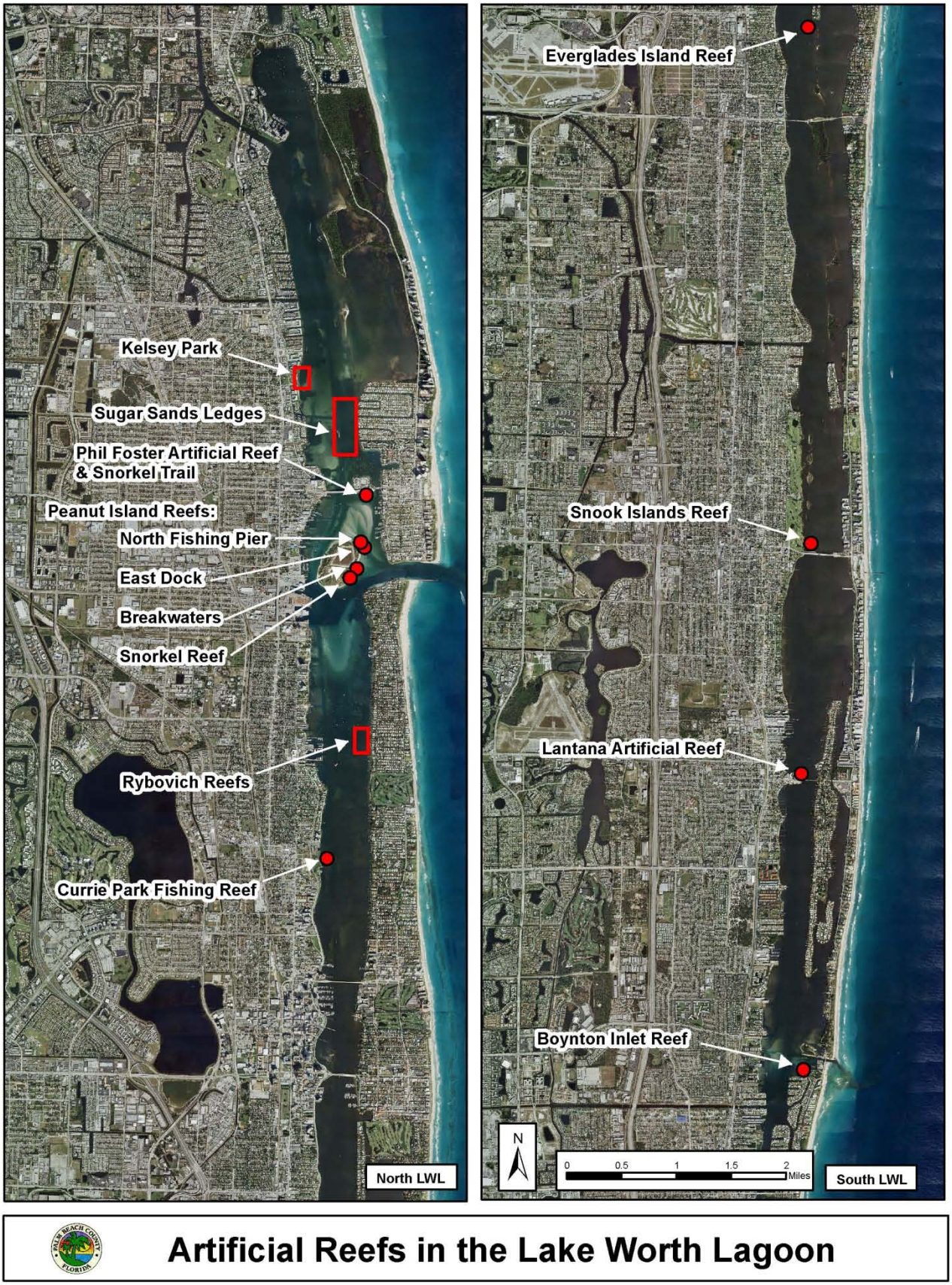


Figure 21. Map of Artificial Reefs in the LWL

Sugar Sands Ledges is a 6 acre site located in a 26' deep dredged hole, 0.25 mile north of the Blue Heron Bridge and east of the ICW. Multiple deployments from 1991-99 include pyramid modules, limestone boulders & ledges, which provide habitat complexity and a diverse fish assemblage.

Monitoring: Sugar Sands Ledges has been monitored by the RRT since 1997. Overall, 34 families and 138 species were counted in 24 monitoring events between 1997 and 2010. Haemulidae (grunts) were the dominant species present in these counts (averaged 71%-88%). Other families present in great numbers were Scaridae (parrotfish-13 species) and Serranidae (sea bass-18 species). Snook were recorded on almost every dive and are regularly seen densely packed beneath the ledges.

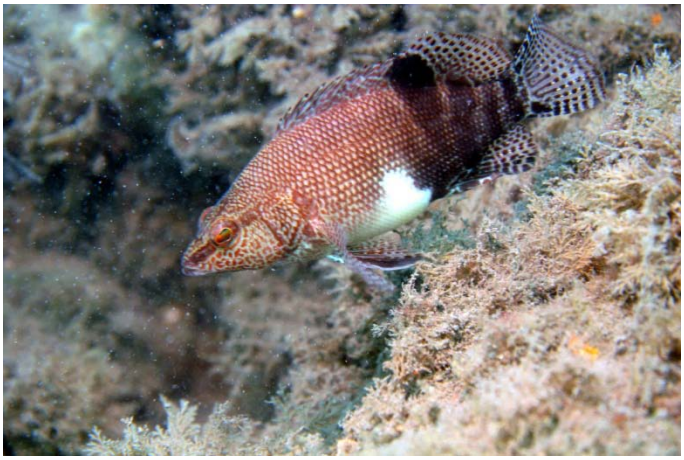
Several sponges, tunicates, and other benthic invertebrates inhabit the limerock boulders as well as the ledges. Hard corals, such as blushing star coral (*Stephanocoenia intersepts*), diffuse ivory bush coral (*Oculina diffusa*), and massive starlet coral (*Siderastrea siderea*) are present. Benthic monitoring in 2010 recorded a total of 42 taxa, including 2 more species of hard corals (**Figure 22**).

Figure 22. Pictures of various fish recorded at Sugar Sands Ledges

Rybovich Reef is a 2 acre site located 1.5 miles south of the Lake Worth Inlet and was constructed between 1991-2004. The reef consists of a variety of materials including concrete, pyramids, reefballs (deployed by RRT) concrete ledges, Jersey barriers, trommel screens, limerock boulders and a 60' barge, which provide an interesting and complex habitat in 29' water depth with maximum relief of 13'(**Figure 23a**).

Monitoring: Rybovich Reef has been monitored by the RRT since 1995. Nineteen monitoring events have been completed between 1995 and 2006, and a total of 38 families and 121 species of fish were reported. Haemulidae (grunts) (**Figure 23b)** were the dominant species present (67%-78% of the counts). Other families represented by a great number of species were: Serranidae (sea bass-13 species) and Scaridae (parrotfish-10 species). Snook were recorded on every dive in numbers over 8 times higher than counts on Sugar Sands Ledges. Snook are regularly seen schooling beneath the shelter of the trommel screens. Snappers, an important commercial/recreational fish family, are regularly observed at Rybovich Reef. Of the 11 species of snapper reported, 80% of the total counted individuals were Gray (mangrove) snapper (*Lutjanus griseus*).

Photo by Jennifer Podis
Figure 23 (a)



Belted Sandfish (*Serranus subligarius*)
Photo by Linton Creel, PBCRRT
Figure 23 (b)

Blue Heron Bridge (BHB) site is known as the "Muck Diving Capital of the US". The area is a very unique underwater environment frequented by SCUBA divers from around the world, particularly underwater photographers. Because of Palm Beach County's proximity to the Gulf Stream, this dive site has documented 686 species of marine mollusks with over 100 Opisthobranch species, 5 of these endemic to this site - **Figure 24 (a)** (**b) -** and documented for the first time in the United States (Anne Dupont, personal communication – Selected Opisthobranch Mullusks from Florida Waters, www.jaxshells.org/opis.htm).

Photo by Anne Dupont
Pipehorse (*Acentranura dedritica*)
Figure 24 (a)

Photo by Anne Dupont
Nudibranch *(Hoplodoris hansrosarum)*
Figure 24 (b)

Between 2008 to 2013, over 300 roving diver surveys have been conducted at the BHB by local and visiting divers and snorkelers and reported to the R.E.E.F. database. A total of 66 families and 301 species of fish were recorded. The families with the greater numbers of species observed at this site are: Serranidae (sea bass) with 27 spp., Gobiidae (goby) with 18 spp., Labridae (wrasse) with 15 spp., Haemulidae (grunt) with 14 spp., and Scaridae (parrotfish) with 14 spp. Unusual sightings include Sea robins (Triglidae), Star gazers (Uranoscopidae), and Pipefish/Seahorses (Syngnathidae). There are several families of fish where one or more species were documented that have not been reported for any other location within the Lagoon. These families are: Conger eels (Congridae), Frogfish (Antennariidae), Sand flounder (Paralichthyidae), Jawfish (Opistognathidae) and Flying gurnard (Dactylopteridae.

Phil Foster Snorkel Reef is a 0.6 acre snorkel reef constructed south of the BHB in August 2012 and consists of limerock boulders and prefabricated modules placed in discreet reef pods at an 8' depth. A monitoring event conducted 1 month after installation documented 11 families and 26 species of fish, and 3 months later documented 26 families and 63 species of fish. Two species each of grunt and snapper were in schools of greater than 100 individuals. The reef is expected to become as diverse as BHB over time.

Peanut Island is located at the mouth of the Lake Worth Inlet and has 4 separate reef sites. The fishing pier and east dock sites contain concrete tetrahedrons, modules and caprock deployed in 2000 and 2011. Major enhancements occurred on the Island in 2005, including creation of the 10' deep snorkel reef which is protected by limestone and granite boulders. Between 2006 and 2012, 6 breakwaters were added on the east and south sides of the island. These multiple structures encompass 1.7 acres in depths ranging from 2'- 4'.

Monitoring: The snorkel reef was monitored in 2007, 2008, and 2012. A total of 26 families and 63 species of fish were recorded. Haemulidae (grunt) and Scaridae (parrotfish) were represented by the most species with 11 and 10 species respectively. Unusual sightings included a black grouper (*Mycteroperca bonaci*) juvenile.

During the 2007 site visit only two years after the limerock boulders were installed, five hard coral species and a gorgonian were observed. Unusual sightings included spaghetti worms (*Eupolymnia crassicornis*) and an unidentified octopus. The site visit in September 2012 documented 12 different species of corals. Several of these corals have attained larger sizes, such as 30 cm for boulder brain coral (*Colpophyllia natans*) and 20 cm for symmetrical brain coral (*Diploria strigosa*). Other species of note were several sponges, urchins, clams, and tunicates. Due to the proximity to the inlet, this area is bathed semidiurnally by clear Gulf Stream waters, which make this a unique and diverse reef.

2 corals – Peanut Island Snorkel Reef (Photo by Todd Moore)

Currie Park Reef is a 0.01 acre site located 2.6 miles south of the Lake Worth Inlet. The reef consists of 100 tons of limerock boulders, deployed at 5' depth under the pier.

Central LWL contains 2 artificial reefs located at Everglades and Snook Islands.

Everglades Island Reef is 0.1 acre site located 5.75 miles south of the Lake Worth Inlet. The 18' deep fishing reef was deployed in February 2011 and consists of an 87' barge and 1,100 tons of concrete ledges with 8' of relief.

Snook Islands Reef is a 0.05 acre site located 5 miles north of the South Lake Worth Inlet. The fishing reef was deployed in April 2011 and consists of 700 tons of concrete bridge material with an approximate 4' relief in 12' water depth.

South LWL contains 2 artificial reefs located in Lantana and Boynton Beach.

Lantana Reef is a 0.5 acre site located 3 miles north of the South Lake Worth Inlet. The fishing reef was deployed in 2002-2003 and consists of 250 tons of concrete box culverts, 20 reef balls and 500 tons of limerock boulders at a 10' depth.

Boynton Inlet Reef is a 0.7 acre site located inside the South Lake Worth Inlet adjacent to Ocean Inlet Park. This reef was deployed in 1994 and consists of 900 tons of limerock boulders at a 10' depth. Additional rock (500 tons) was added in 2002.

Monitoring: A monitoring event on August 12, 2011, documented 13 species and 9 families of fish. Although juvenile goliath groupers (*Epinephelus itajara*) have been observed here, the most numerous fish observed were sergeant majors (*Abudefduf saxatilis*), and the most numerous species in one family were Haemulidae (grunt). Benthic invertebrates were dominated by algae hydroid (*Thyroscyphus ramosus*), the boring sponge, *Cliona delitirx*, and turf alga.

For more information about artificial reefs in the Lagoon is available online at the PBCERM Artificial Reef web page and the PBCRRT website.

Sea Turtles

Estuaries can be important developmental habitat for subadult sea turtle population. Because sea turtles can function as an indicator species of habitat conditions, it is important to know the characteristics of the sea turtle population utilizing the LWL. Information on the size, recruitment, diet, habitat preference, genetic stock and health can be used to learn how the Lagoon is used by turtles and as a measure of restoration success. Fibropapillomatosis (FP), a potentially deadly disease affecting primarily green sea turtles in polluted estuarine waters, has been documented at a high frequency in the LWL though at a lower levels than found in Indian River Lagoon (IRL) and Mosquito Lagoon sea turtle populations.

Since March 2005 ERM has contracted a non-profit organization to conduct 18 surveys of sea turtles in LWL. The primary objectives of this on-going study are to:

- Obtain baseline data on species abundance, size frequencies and sex ratios.
- Determine the Catch per Unit Effort (CPUE) at specific sites.
- Document the prevalence of FP.
- Collect esophageal and anterior stomach contents to evaluate feeding preferences between algal or seagrass species.
- Obtain blood samples for genetic, sex ratio and disease analysis.
- Determine habitat preference of sea turtles by collecting GPS waypoints to mark sighting and capture locations.

For the period from March 2005 to September 2011, there were 560 observations of sea turtles spotted on 713.28 km of visual transects in the LWL. Of those, 555 were juvenile green turtles and only 5 were loggerhead. The vast majority of sightings were in the north Lagoon, east of Little Munyon Island. **Figure 25** depicts a map of all sea turtle observations (all species and all size classes resulting from aerial survey, stranding reports, and inwater surveys) since 1990, overlaid with seagrass, dredge hole locations, and bathymetry contours. The cluster of observations (green circles) are in the vicinity of the best seagrass beds in the Lagoon.

The study has found that juvenile green turtle abundance in North LWL was 2.29 sightings/km hour while South LWL was only 0.03 sightings/km hour. The North LWL abundance is markedly higher than similar surveys conducted in IRL, the Florida Keys, and PBC nearshore reefs.

Captures were made using tangle net, dip net or rodeo methods and 83 green turtles (including 1 recapture) were captured, sampled and tagged. A tagged turtle from another research project was also documented. The relatively high tangle net CPUE was 2.38 turtles/km net hour, but still somewhat less than recorded in the South and central IRL (3.23 and 3.32 CPUE, respectively). Six turtles have been recaptured with one (#XXY519) captured three times over a 5 year period. When last captured this turtle had nearly doubled in length and weighed five times more. At this time however, there are insufficient samples to calculate growth rates for turtles in LWL.

For more information see Assessment of Marine Turtles in Lake Worth Lagoon Phase III 2005-2011.

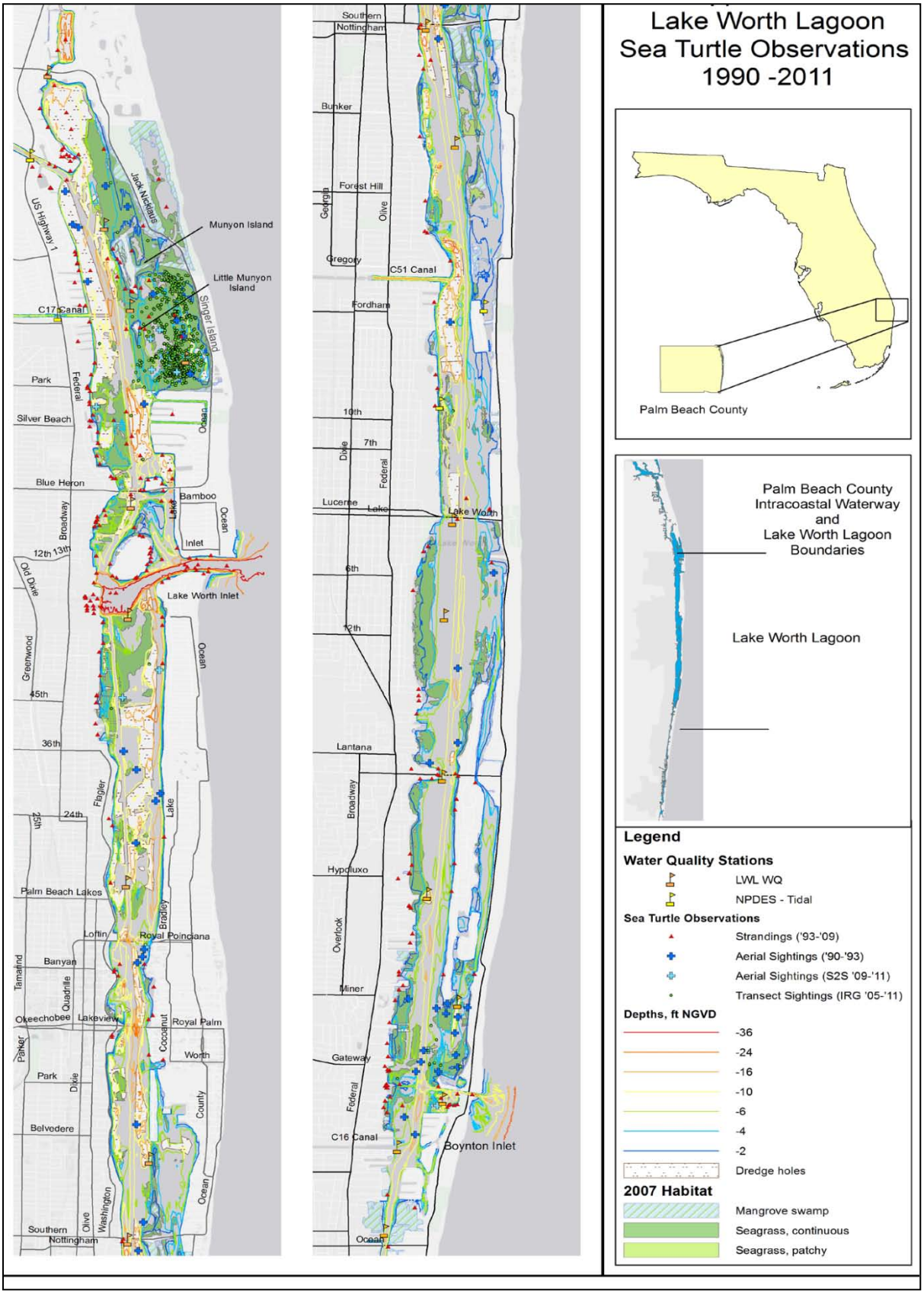


Figure 25. Map of locations of all sea turtle observations

The size of the turtles in the Lagoon ranged from newly recruited 26.8 cm Standard Straight Carapace Length (SCL) to 62.3 cm with a mean of 42.4 cm (**Figure 26**). This size is similar to nearshore reef turtles in St. Lucie and Indian River County but somewhat smaller than IRL and Key West turtles (44.0 and 53.1, respectively).

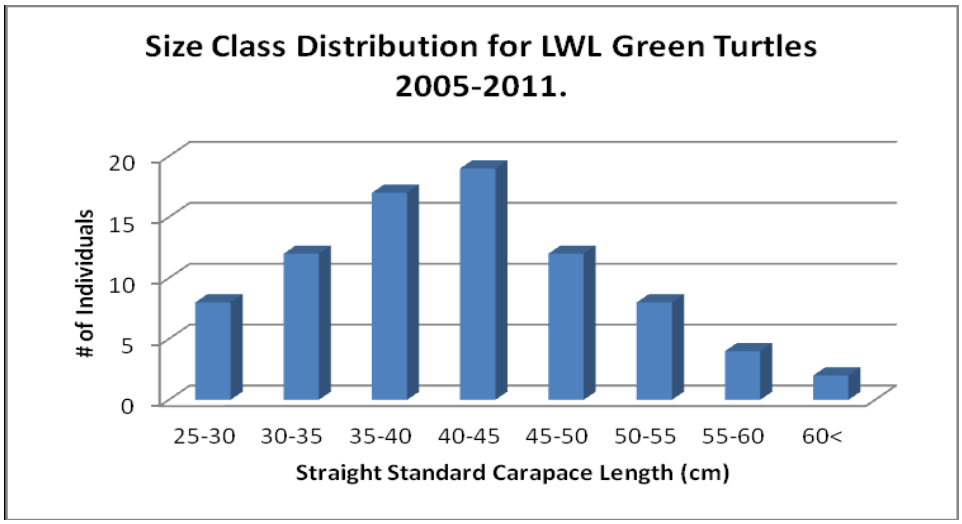


Figure 26. Size class distribution for green turtles captured in Lake Worth Lagoon 2005-2011 (n=84)

Overall, FP was observed in 47% of the green sea turtles captured (**Figure 27**). This is lower than what has been observed in South and Central IRL (54.6% and 55.2%, respectively). There appears to be a slightly decreasing (but non-significant) trend in FP rate but an increasing (but non-significant) trend in FP severity. Seven of the 39 turtles with FP were so severely affected that they were sent to rehabilitation facilities. In addition, three of the captures have required transfer to a rehabilitation facility for monofilament or boat-related injuries.

The findings of the dietary analysis indicated that turtles selectively feed primarily upon three species of seagrass: turtle grass (*Thalassia testudinum),* manatee grass *(Syringodium filiforme),* shoal grass *(Halodule wrightii,),* and eat very little algae. Turtle grass was found most often in nearly >85% of the samples, followed by manatee grass found in 52.4% of the samples. These two species are the least prevalent seagrass in the Lagoon and are indicative of better water quality and substrate conditions, suggesting that sea turtles are most likely to be found in similar conditions. Mitochondrial DNA results indicate that LWL turtles originate from beaches throughout the Western Hemisphere including Florida, Cuba, Mexico, Costa Rica and the South Atlantic (**Figure 28**).

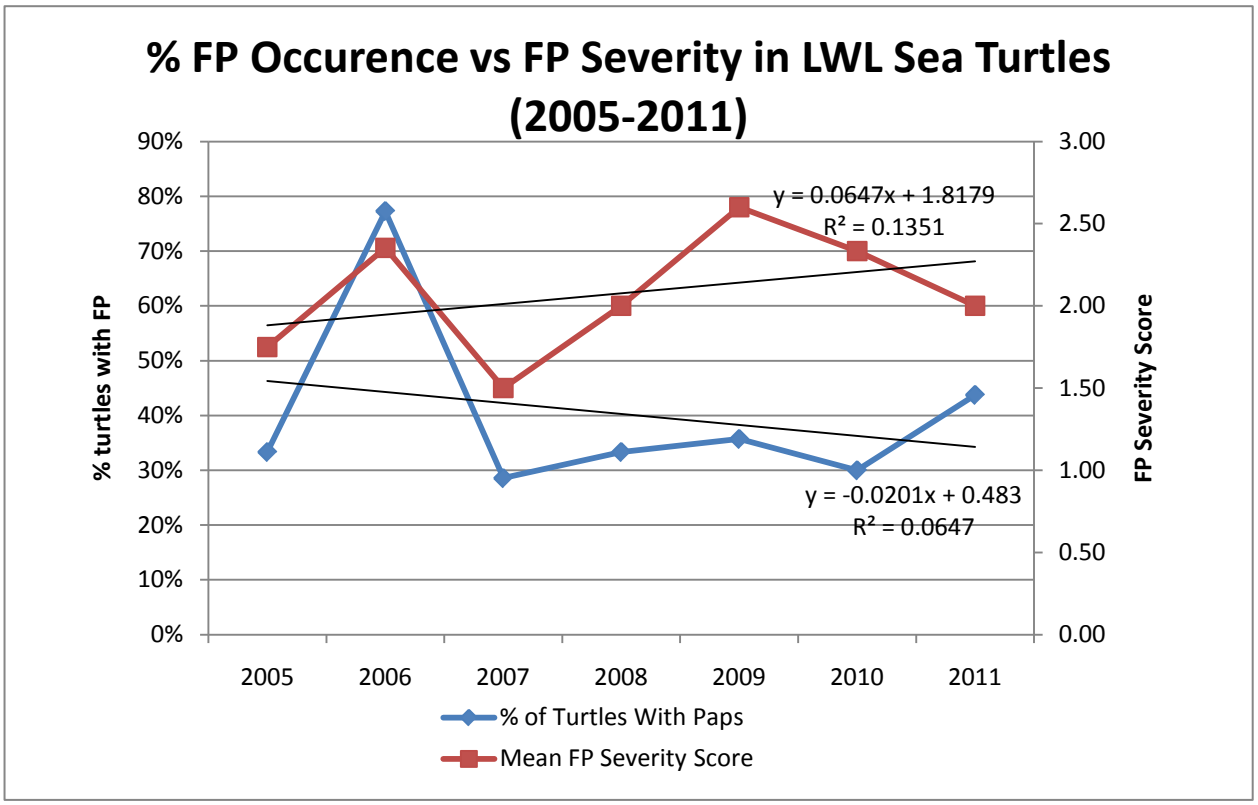


Figure 27. Trend in FP rate of occurrence vs. severity in LWL Sea Turtles 2005-2011

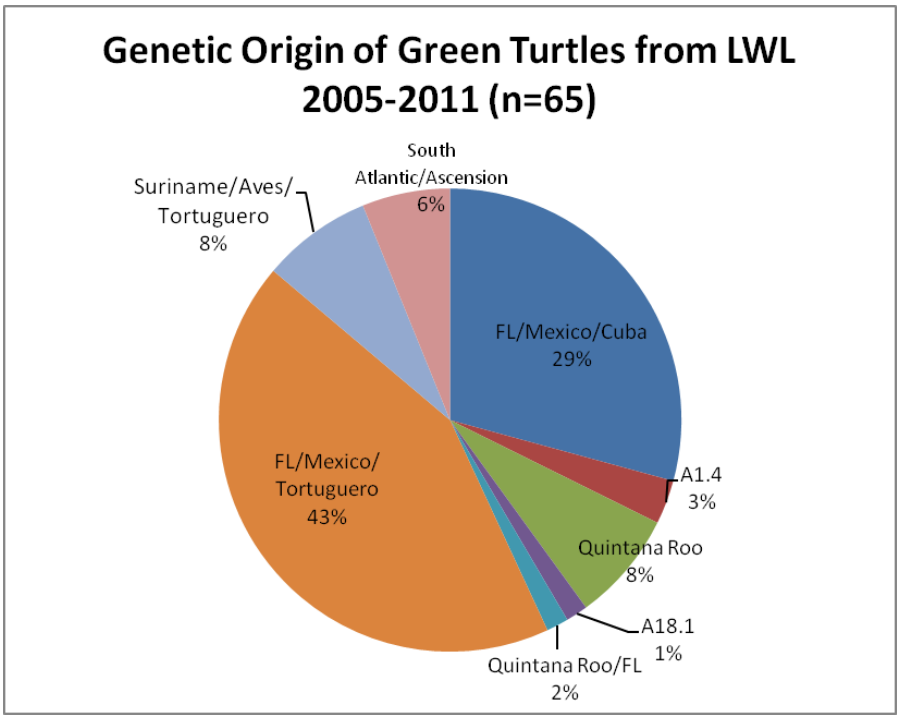


Figure 28. Natal beach origin of green turtles captured in Lake Worth Lagoon 2005-2011.

Results from this on-going research are summarized below:

- Sea turtle captures and sightings are more prevalent during spring and summer months.
- Sea turtles are frequenting areas that support dense and diverse seagrass and algae.
- Lagoon sea turtles are feeding almost exclusively on seagrass, whereas IRL sea turtles tend to feed on seagrass and algae.
- CPUE is slightly lower than in the IRL.
- Nearly half of the turtles in the Lagoon have FP though the rate and severity is slightly lower than in the IRL.
- LWL turtles come from nesting beaches throughout the Western Hemisphere, some of which are over 5,000 miles away.

LWL is used as important developmental habitat by juvenile green sea turtles to a much greater extent than expected. Because sea turtles can function as an indicator species to habitat health and water quality, the high FP rate could have important implications and inferences about the water quality in LWL. It is important to promote community understanding on the significance of the Lagoon to sea turtles, the relationship of LWL to the sea turtle rookeries throughout the Atlantic, and the importance of restoring and maintaining LWL habitat. An educational campaign focused on the relationship between sea turtles, high quality seagrass beds and good water quality is underway. Interesting questions that remain include gathering information on seagrass habitat quality at sea turtle "hotspots", determining the migration and emigration rate, growth rates, and the connectivity of the Lagoon to nearshore reefs and other adjacent developmental habitats such as IRL, Florida Bay, and the Florida Keys.

Manatees

Many habitat restoration projects built in the past five years were designed to benefit the endangered Florida subspecies of the West Indian Manatee (*Trichechus manatus latirostris*). Although manatees are observed year-round in the Lagoon, an average of 500 manatees are present during the winter months as they congregate near the warm-water discharges of the Florida Power & Light (FPL) Riviera Power plant. A synoptic survey performed by FWC in December 2010 confirmed that 812 manatees were gathered at the power plant. The FPL discharge is one of the more important warm water refuges on the East coast. The northern segment of the Lagoon provides a particularly important habitat where the most expansive and diverse seagrass beds are located (ERM 2006, Sea to Shore Alliance 2011). These seagrass beds are an important food source for manatees given the limited seagrass beds in Broward County (also an important warm water refuge).

A specific Action Plan (HE-3) was developed in the 2008 Plan to implement and increase protection for the manatees in PBC. The PBC Manatee Protection Plan (MPP) was approved by the PBC in August 2007. The MPP provides guidance to PBC and municipalities in developing

policies and guidelines for comprehensive manatee protection in local waterways. The following is a summary of "Priority" initiatives undertaken by PBC to ensure effective implementation of the MPP and the AP.

MPP Implementation

The MPP was incorporated in the County's Comprehensive Plan in 2008. The City of West Palm Beach and Boynton Beach have also adopted the MPP in 2008 and 2009 respectively. The MPP includes a comprehensive summary and analysis of manatee, boating and marine facility data with much of the information depicted on GIS maps. It also includes a boat facility siting plan which consists of shoreline maps with boat facility siting categories depicted and permitting criteria defined. This information has been provided to local, State and Federal permit reviewers and interested parties to utilize for planning, development and permitting of future marine facilities.

Funding

A dedicated funding source of $1,000,000 per year was established in 2007 to implement the goals and objectives of the MPP. The account is funded by the County's Ad valorem taxes and as such, due to the economic downturn, the budget for this program has been reduced to $750,000 since 2011 with $525,000 annually allocated to habitat restoration, $75,000 annually to outreach and studies, and $150,000 for the increased waterway speed zone law enforcement.

Data Collection

As recommended by the MPP, ERM continued its existing seagrass monitoring program, obtained relevant data from on-going studies conducted by the SFWMD, FWC, the Loxahatchee River District, and worked with SFWMD to expand seagrass monitoring at the patch scale as part of the monitoring required to evaluate the effects of the CERP. These data have been incorporated into ERM's GIS database and are used in assessing long-term trends. In addition, ERM obtains and reviews manatee synoptic and mortality data provided by FWC and provides that information to stakeholders.

Studies:

The MPP recommends that new or updated information be gathered to reflect current conditions. The following studies were completed in the last five years:

- **Updated Boat Activity Study (FWC 2009)**
- **Updated Manatee Aerial Survey Study (January 2009 to March 2011)**
- **Boater Speed Zone Compliance Study (November 2011 to March 2013)**

Some of the conclusions from the aerial survey study include:

- 4,869 manatees were observed during 52 flights. Approximately ten times as many manatees are utilizing LWL compared to 20 years ago. Aerial surveys conducted from 1990 to 1993 documented 2,461 animals.
- The highest numbers observed were in December 2010 (812) and February 2010 (505), which are much higher than the highest numbers observed in the 1990's (245 in 1992)
- There was a distinct seasonal pattern with the vast majority observed during the coldest months between late December and mid-February.
- Summer (mid-May through August) had somewhat higher counts than spring and fall which had the lowest counts.
- Non-winter counts were highest in Central and South LWL where there are more shallow areas that may be favorable for mating herds.
- Areas supporting the most manatees (in order of importance) are North LWL, South LWL, and South ICW. The higher counts are related to seagrass beds, proximity to warm water (FPL and ocean inlets), and travel to and from Broward County. It is not clear whether a relatively small number of manatees are resident to LWL or selectively migrate here in the summer. Additional radio tagging and photo identification of summer manatees may help answer that question.
- Interestingly, the number of manatees observed in the nearshore ocean was similar to that seen in South LWL and South ICW and is likely a result of manatees avoiding the record cold inshore water temperatures while traveling in the winter.
- Winter manatee distribution was dependent on whether the FPL warm water discharge was operating. A temporary water heater was installed in 2009 and operated intermittently causing manatees to disperse over larger areas seeking warm water. Secondary warm water sites included ship berths at the Port of Palm Beach, dredge holes immediately south of FPL, near Peanut Island and around Munyon Island when temperatures warmed.
- LWL is an important winter warm water refuge. Manatee use of LWL has increased considerably providing another important reason for making the restoration of habitat and water quality a high priority.

Education and Awareness

Outreach efforts included: working with the FIND and FWC to develop a new colored manatee and boat safety zones brochure for PBC; distributing various brochures on manatees and speed zone maps; redesigned manatee posters for the educational kiosks at local boat ramps (12 locations), and promote educational contacts via the **Law Enforcement (LE) Program** to increase awareness and compliance with manatee speed zones countywide. Educational material have been displayed and utilized at numerous boating and environmental events. Press releases through the County Public Affairs Department have also been issued at the beginning of each manatee season. ERM also actively participates in the Miami-Dade/Broward/Palm Beach

Manatee Awareness Group (MAG). This multi-agency group is comprised of governmental agencies, educational institutions and community organizations, and provides technical assistance, information sharing, educational support and coordination of law enforcement, wildlife management and public outreach. In cooperation with the Marine Animal Rescue Society (MARS) and FWC, several workshops titled "Marine Mammal Protection and Rescue Basics" were organized between 2009 and 2012. Participants were trained in handling marine mammal strandings and manatee rescues. These workshops were well attended by US Coast Guard staff, US Coast Guard Auxiliary members, local law enforcement, lifeguards, and FWC staff.

Additional Manatee Outreach Accomplishments:

- Lake Worth Lagoon: Discover a Local Treasure, 16-page publication – published 2010. Includes manatee information and an activity for students to graph manatee population data. Reached 30,000 5th and 8th grade students during the 2010-11 and 2011-12 school years.
- Lake Worth Lagoon Educator's Guide – published in 2011.
- Lake Worth Lagoon Brochure – published in 2011.
- ERM Environmental Times Newsletter.
- Distributed aerial survey data on a bi-weekly basis over the two-year study period to over 400 stakeholders and law enforcement agencies.
- LWL E-News sent to over 1000 people on a quarterly basis.
- LWL Speakers Bureau.
- Online Narrated Ibis Isle Presentations.
- New Lake Worth Lagoon Discover a Local Treasure 45 minute video.
- Eco-Treasures Exhibit at City of West Palm Beach Lake Pavilion.
- Lake Worth Lagoon Table Top Display Board for community events.

Law Enforcement

The County has funded additional on-water law enforcement in the County's waterways between $150,000 and $200,000 per year. From 2008 to 2011, ten law enforcement agencies participated in the LE Program. Officers logged more than additional 8,859 hours, over 13,600 educational contacts, 3,553 manatee zone warnings, and 828 manatee zones citations since January 2008, when the program started. The increased law enforcement presence improves speed zone compliance and reduces risks to both manatees and boaters. For the 2011-2012 season, eight law enforcement agencies participated: Tequesta, Jupiter, West Palm Beach, Lantana, Boynton Beach, Boca Raton, the Palm Beach Sheriff's Office, Riviera Beach, and FWC. Detailed statistics are provided below (**Table 7**). This program has significantly increased manatees and speed zones awareness.

	07-'08	08-'09	09-'10	'10-'11	11-'12	Total
Total Citations	255	362	239	292	232	1380
Manatee Zones Citations	153	199	151	188	137	828
Educational Contacts	789	1326	3276	4868	3341	13600
Written warnings	293	539	815	856	730	3233
Verbal Warnings	274	542	1047	1389	918	4170
Manatee Zone Warnings	165	410	872	1273	833	3553
TOTAL HOURS	1000	1656	2341	2193	1669	8859

Table 8. 2008-2012 Law Enforcement Summary

In addition, to these efforts, ERM facilitated several "Operation Mermaid" in cooperation with the Palm Beach Sheriff's Office (PBSO) and FWC, along with other federal and local law enforcement agencies. These agencies patrolled the county waterways as part of this large-scale effort to remind boaters to slow down for migrating manatees. Law Enforcement agencies also assisted in several manatee rescues and releases during the manatee season. ERM coordinated assistance to FWC for these rescue and release efforts when needed.

The Manatee LE Program has received a 2012 National Association of Counties (NACO) Achievement Award. The NACO award recognizes new and innovative methods to carry out county services and programs.

Habitat Restoration

Continuous efforts to support existing and future programs to preserve, enhance, restore manatee habitat, and water quality within the County have been made. Several projects to improve water quality in PBC's waterways and enhance habitat for manatees have been completed since 2008. These include:

- **South Cove Natural Area**
- **Ibis Island Restoration**
- **John's Island Oyster Reef**
- **Limestone Creek Restoration**
- **Jupiter Ridge Natural Area**

Details about these projects can be found in Appendix B. Additional habitat restoration projects are planned and will be constructed over the next five years.

Vessel Registration

According to PBC Vessel Registration statistics reported by the Florida Department of Highway Safety and Motor Vehicles; the annual number of registered boaters in the County has decreased by approximately 13% or 5,782 registered boats from 2008 to 2011. As of 2008 there were 45,294 registered boats in the County. In 2011, the number has decreased to 39,512 (**Figure 29**). This decrease is likely due to the economic conditions in the last few years.

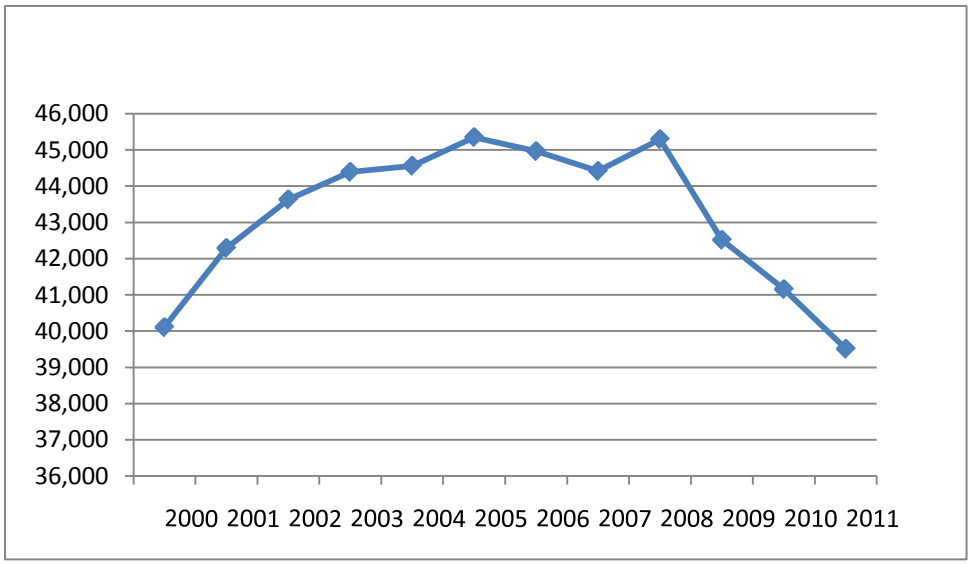


Figure 29. Boater registration in PBC from 2000 to 2011

Manatee Mortality

Information on manatee mortality within PBC is derived from FWC's manatee salvage and rescue program, which records information on the location, time of year, and cause of manatee deaths. Since 1978 manatee mortality in PBC has averaged 6.3 deaths per year with 34% attributed to watercraft. Since the approval of the MPP in 2007, overall mortality has increased with a total of 42 manatee deaths (11.4 per year), however watercraft-related mortality has declined to 26%. The higher overall mortality rate is related to cold stress associated with the record cold winters in 2010 and 2011 (**Figure 30**).

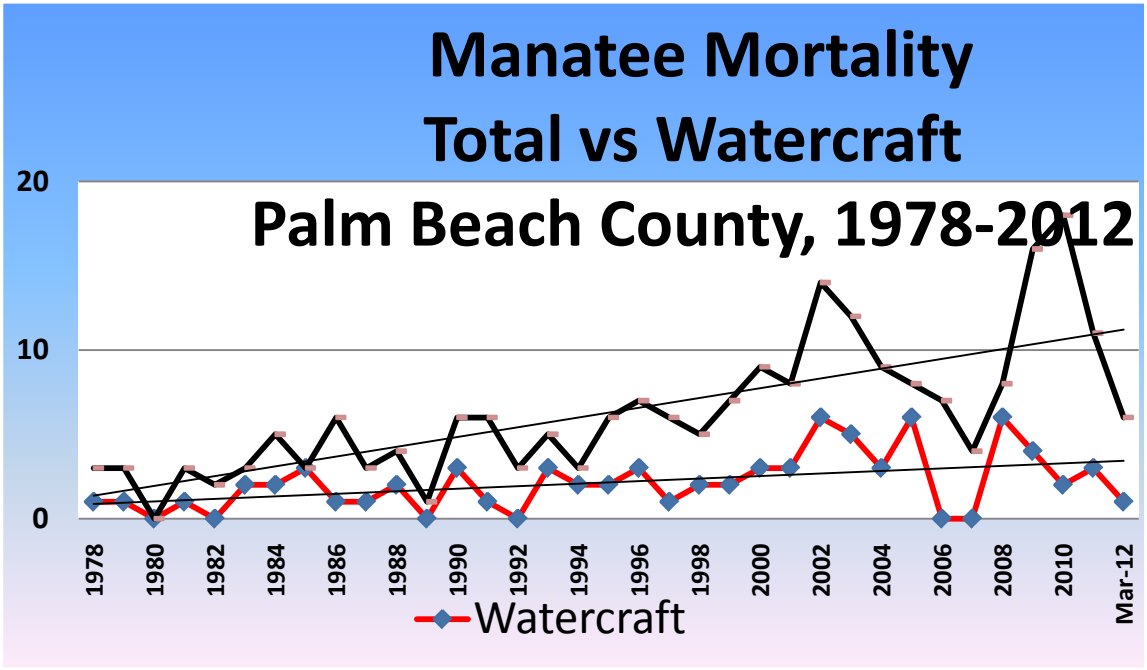


Figure 30. Summary of total manatee mortality vs. watercraft from 1974 to 2012 in Palm Beach County

The goal for the next five year period is to further reduce watercraft mortality. To accomplish this goal, ERM will work with LE agencies and local municipalities to increase public education efforts and enhance law enforcement patrols. Vigilant monitoring for speed zone compliance near manatee hot spots is also recommended. More details about manatees' status and trends, and the County's MPP can be found on the PBCERM manatee web page.

Water Quality

All surface waters in PBC, including LWL, are classified as Class III waters with few exceptions. Water quality within the lagoon has been significantly degraded by various drainage, dredging, and development projects in the past. These projects have caused significant alterations in the timing, distribution, quality and quantity of fresh water that enters the coastal waterways. Water quality within the coastal waters, canals, and freshwater lakes of PBC are mainly affected today by nonpoint sources of pollution including stormwater runoff. Large volumes of freshwater discharges into the Lagoon, primarily through the C-17, C-51, and C-16 canals, can cause extreme salinity fluctuations which can be harmful to many aquatic organisms, such as oysters and seagrasses unable to tolerate excessive freshwater inflows.

While salinity fluctuations are a problem with freshwater discharges, a major threat to the recovery of the LWL is excess suspended sediments. Suspended sediments increase turbidity and thereby decrease the amount of sunlight that reaches the bottom; nutrients cause proliferation of phytoplankton in the water column further deteriorating water clarity. As sediments fall out of suspension, they accumulate on the bottom, sometimes forming a silty layer over previously natural sediments which affect the flora and fauna.

At present, water quality within the Lagoon is highly variable and it is best in the vicinity of the inlets, where the water bodies are subjected to tidal flushing and enhanced circulation. This section provides a summary of the information available on the current state of, factors affecting, and initiatives to monitor and improve water quality within LWL.

Water Quality Monitoring Network

The LWL monitoring network implemented in October 2007 consisted of twenty-two (22) sites (**Figure 31**). Several parameters have been analyzed on a monthly basis including: dissolved oxygen (DO), pH, salinity; Kjeldahl nitrogen (TKN), ammonia nitrogen (NH_4), nitrite-nitrate nitrogen (NOx), total phosphorus (TP) and orthophosphorus (OPO_4), turbidity, and chlorophyll-a. Metals such as arsenic (As), copper (Cu), cadium (Cd), and lead (Pb) were initially collected and later dropped due to their low concentrations present in the water, and the associated high costs for these samples. Two high-frequency in-situ sondes (multi-parameter sampling units) were deployed to augment the monitoring network - most recently to document salinity near the C-51.

The WQ Monitoring Network is a partnership between the SFWMD and ERM. It is providing an estuary-wide assessment of the chemical and physical conditions of LWL. ERM collects monthly grab-samples and delivers them to the SFWMD lab for analysis. The WQ network will continue to provide policy-makers and the public with estimates of the status of the County's inshore coastal resources with statistical confidence. Data collected are currently stored in **DBHYDRO,** the SFWMD environmental database which stores hydrologic, meteorologic,

hydrogeologic and water quality data, and shared with local governments, State Agencies and stakeholders.

Water quality data from 2007-2012 period of record (POR) were analyzed by SFWMD and compared to data from 2001-2005 to evaluate spatial and temporal trends in LWL. The resulting baseline will be used to describe the relationships between indicators of natural and anthropogenic stress and marine resource, and to quantify the impacts of stormwater discharges on biological resources, such as seagrasses and oyster beds.

An Analysis of Water Quality In Lake Worth Lagoon: 2007-2012

(Zhiqiang Chen, Ph. D., South Florida Water Management District)

Objectives

The objectives of this water quality update in the LWL are:

a) To assess overall water quality status for data collected from 2007-2012 and identify differences in water quality between segments of the lagoon;
b) To identify temporal trends in water quality from 2007-2012;
c) To compare water quality data collected from 2007-2012 to water quality data collected during a previous period of record from 2001-2005.

Study area

LWL can be divided into three segments (north, central, and south) based on hydrological factors including water quality, circulation, and physical characteristics. The boundaries of these segments have been slightly modified from the 1998 Plan. These new management units reflect the currently adopted segments of the Palm Beach County Manatee Protection Plan (PBCMPP, 2008).

There are three major fresh water inflows from the watershed discharged to the lagoon estuary via regional canals **(Figure 31)**. The Earman River Canal (C-17, S44) discharges to the northern segment of the lagoon (LWN). The West Palm Beach Canal (C-51, S155) discharges to the central segment (LWC). The Boynton Beach Canal (C-16, S41) discharges to the southern segment (LWS). These discharges carry large influxes of nutrients, suspended and dissolved organic matter, contaminants, and toxins, all of which affect the flora and fauna within the Lake Worth Lagoon (PBCMPP, 2008).

Figure 31. Water quality monitoring stations at the Lake Worth Lagoon and three canals discharging freshwater to the system. Six stations were sampled from 2001-2005 (yellow circles) and eighteen (18) stations were sampled from 2007-2012 (yellow and red circles).

Materials and Methods

Two data sets were analyzed for the 2013 update (**Table 9**). The first data set was generated using samples collected monthly and analyzed by FDEP. The second data set consists of data from samples collected monthly by PBC and analyzed by the South Florida Water Management District's NEELAC certified analytical laboratory. The former covers period from June 2001 to December 2005, and the latter from July 24, 2007 - July 24, 2012. During the interim between these two periods (i.e.,2006), sampling was reduced (i.e. fewer number of stations, less frequently sampled) thus was not used in this study. The two periods of record chosen for this analysis provide data to maximize statistical rigor.

Three analyses were conducted on these water quality data. First, overall status of water quality were evaluated for data collected from 2007-2012. Descriptive statistics and statistical box plots were used to summarize water quality status and show spatial and temporal variations. In addition, a one-way analysis of variance (ANOVA) was applied to evaluate statistical differences in water quality among northern, central and southern segments of the lagoon. Second, water quality trends (2007-2012) were tested utilizing the nonparametric Seasonal Kendall Trend test (Helsel et al. 2006), where each month was treated as an individual season. This selection of each month as a season is because 1) samples were collected monthly, and 2) the selection of a month as a season supported a more statistically robust trend analyses, compared to analyzing for wet/dry months as seasons. When multiple samples were collected within a given month and a given segment, arithmetic means were calculated for the trend analysis. Third, to examine differences in water quality between two sampling periods and the three segments, a two-factor ANOVA was conducted. The factors were "period" with two levels and "segment" with three levels. To be consistent, only data at those stations sampled during both periods of record (**Table 9**) were used in the two factor ANOVA. Statistically significant differences between main effects and interaction between periods and segments were evaluated using the Student-Newman-Keuls procedure following Winer (1971). Because water quality data in coastal waters are commonly not normally distributed (Doering, 1996; Doering and Chamberlain, 1999), nonparametric analyses were used. Both the one way ANOVA and the two way ANOVA were performed on ranked data. In all statistical tests probability (p) values of less than 0.05 were used to indicate the significance level.

The selected water quality parameters were salinity, chlorophyll *a* (Chl *a*), total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS) and Secchi Disk Depth (SDD). In the 2001-2005 data set, SSD was not available and TSS data were insufficient for analysis; therefore turbidity was evaluated instead. These parameters have been analyzed in previous reports (PBCMPP, 2008). Water quality data collected before 2006 were provided by Palm Beach County. Data collected after 2006 and daily freshwater inflows from three canals (e.g. C-16, C-17 and C-51) were downloaded from the water quality data base managed by the South Florida Water Management District (DBHYDRO). Monthly and yearly averages were calculated from

these daily freshwater inflows. To maximize all latest available data (up to July 2012), a water year was defined as the time from July 1 of one year to June 30 of the next year (e.g. July, 2007-June, 2008 represents WY 2008 for these analyses). The definition is different from calendar year and slightly different from the commonly used water year definition (May, 1 to April 30), but the differences among these methods are expected to be minor.

Periods	Segment	Stations
2007-2012	Lake Worth North	LWL-1*, LWL-2, LWL-3*, LWL-4, LWL-5, LWL-6, LWL-7
	Lake Worth Central	LWL-8, LWL-9*, LWL-10, LWL-11*
	Lake Worth South	LWL-12, LWL-13*, LWL-14, LWL-15, LWL-16, LWL-17, LWL-18*
2001-2005	Lake Worth North	LWL-1, LWL-3
	Lake Worth Central	LWL-9, LWL-11
	Lake Worth South	LWL-13, LWL-18

Table 9. Lagoon segments and associated stations for two periods: 2001-2005 and 2007-2012. The stations with * in 2007-2012 are stations sampled for both periods, and were used for the comparison of water quality between two periods (see Table 11)

Results

Freshwater inflows

Annual (water year from July 1 to June 30 of next year) average freshwater inflows to the lagoon ranged from 200 to 1000 cfs with an overall average of about 600 cfs (**Fig. 32**). The inflows to the central LWL from the C-51 accounted for more than 60% of the total flows with another 25% from C-17 to the north LWL and ~15% from the C-16 to the south LWL. On average, freshwater flows to the Lagoon were lower (Mann-Whitney U-Test, $p<0.05$) during the period from 2007-2012 (~450 cfs), especially in 2011 (~220 cfs) and 2012 (~320 cfs), relative to flows during 2001-2005 (~720 cfs).

Water quality status

Table 10 shows the overall statistics of selected water quality parameters for all three segments for the period from July 2007 through July 2012. The LWN segment had higher salinity, lower concentrations of nutrient, chlorophyll *a*, and TSS relative to the LWC and LWS segments. The pattern appears to suggest there were clearer waters in the LWN with lower light attenuation and a deeper photic depth. However, Secchi Disk Depth in the LWN was shallower than in the LWC and the LWS. This apparent inconsistency may be related to the bathymetry of the segments. The northern segment has a median depth of 1.3 m, which is shallower than median depths in the central (2.8 m) and southern (1.6 m) segments. Results of the one way ANOVA further revealed that all water quality parameters in the LWN were significantly ($p<0.001$) different from those in LWC and LWS (**Table 10**).

There were also some differences between the LWS and LWC. Salinity in the LWC was significantly ($p<0.001$) lower, and nutrient concentrations and TSS significantly higher relative to levels in the LWS (**Figure 33**). The differences are likely due to the higher freshwater inflows from C-51 to the LWC (**Figure 32**). No significant differences in chlorophyll *a* concentrations and SSD were found between the central and southern segments (**Figure 33 and Table 10**).

To compare with "baseline" concentrations of water quality in the lagoon, a reference condition approach was applied. Data at IRL04 (27.01131,-80.0982836, the closest station in the Indian River Lagoon) were also shown in **Table 10**. We assume that the conditions at that station would represent a typical condition with fewer impacts by freshwater inflows and anthropogenic activities. Indeed, a nearby station was selected by the Loxahatchee River District as a reference site too. Salinity in LWL was relatively lower, while concentrations of TN, TP and Chl *a* were higher (all about as twice as IRL's concentrations). No significant differences in Secchi disk depth and TSS were observed.

Water quality trends from 2007-2012

Water quality showed strong inter-annual variations from water year 2008-2012 in all three segments (**Figure 33**). For example, the lowest salinity and the highest TN and TP concentrations were observed in 2010, when the highest annual freshwater inflow for the period occurred (**Figure 32**). Seasonal Kendall Trend tests of monthly data averaged within each segment identified no significant trends for most water quality parameters except TP and TSS (**Table 11**). Decreasing trends were observed for TP in the LWN and TSS in the LWS. This apparent lack of long-term trends may be related to the limited period of record (nearly about 5 years with relatively higher values in the middle year (2010) of the period) or relatively stable conditions in last 5 years (relatively dry conditions, **Figure 32**).

Parameters	Statistics	Segments			IRL04
		LWN	LWC	LWS	
Salinity	minimum	14.80	6.93	0.36	30.10
	maximum	38.00	36.60	38.00	38.10
	median	33.4***a***	30.8***c***	32.8***b***	35.10
	average	32.55	29.05	30.30	34.10
	standard deviation	3.66	6.18	6.37	1.88
Chlorophyll *a*	minimum	1.00	1.00	1.00	0.50
	maximum	31.00	38.00	45.00	5.00
	median	2.00***b***	4.00***a***	4.00***a***	2.00
	average	3.22	5.00	5.69	1.75
	standard deviation	3.03	4.66	5.24	1.04
TN	minimum	0.12	0.22	0.08	0.09
	maximum	1.07	1.13	1.23	0.37
	median	0.30***c***	0.40***a***	0.37***b***	0.19
	average	0.33	0.48	0.42	0.20
	standard deviation	0.14	0.21	0.22	0.07
TP	minimum	0.004	0.014	0.006	0.010
	maximum	0.087	0.098	0.222	0.033
	median	0.022***c***	0.039***a***	0.03***b***	0.014
	average	0.024	0.041	0.036	0.014
	standard deviation	0.012	0.014	0.023	0.005
Secchi Disc Depth	minimum	0.5	0.4	0.5	0.9
	maximum	4.8	4.2	3.3	2.8
	median	1.2***b***	1.4***a***	1.3***a***	1.6
	average	1.4	1.5	1.5	1.6
	standard deviation	0.6	0.7	0.6	0.5
TSS	minimum	1.5	1.5	1.5	1.50
	maximum	59.0	37.0	43.0	22.00
	median	6.0***c***	8.0***a***	7.0***b***	8.00
	average	7.8	9.9	9.1	8.47
	standard deviation	7.3	6.4	6.9	6.05

Table 10. Statistics of selected water quality parameters and results of one way ANOVA followed by the Student-Newman-Keuls test to evaluate significant differences between three segments using data collected from July 2007-July 2012. The analysis was conducted on ranked data. Letters indicate statistical difference between segments with the same letters indicating no difference. For a comparison, water quality data from Indian River Lagoon, namely at station IRL04(27.01131,-80.0982836) are also shown in the table.

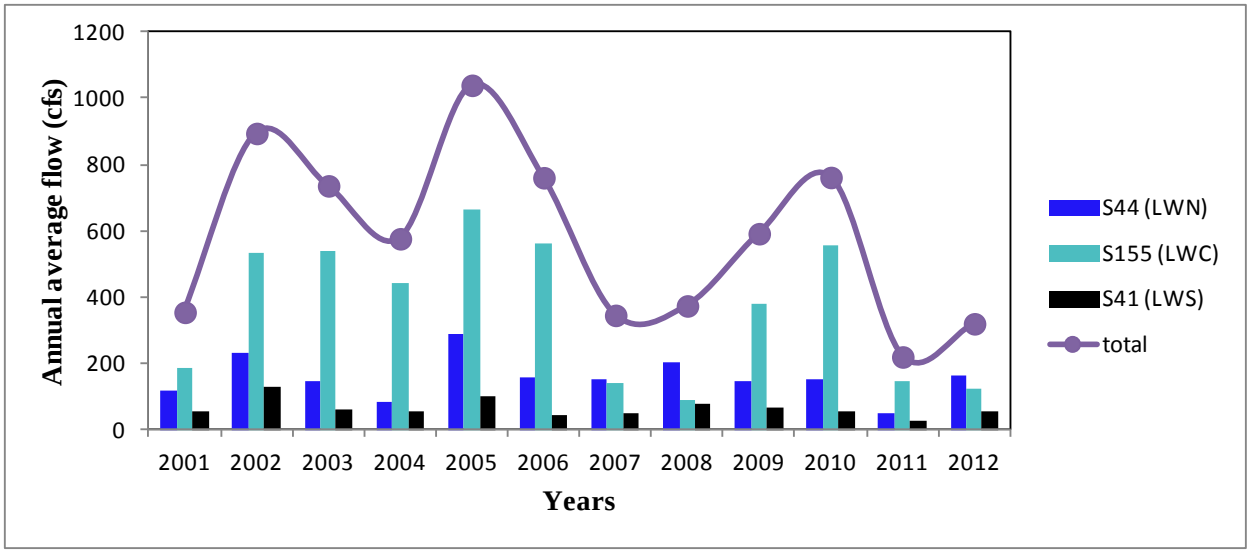


Figure 32. Average Annual flows (cfs) from the Earman River Canal (C-17, S44) to the North lagoon, the West Palm Beach Canal (C-51, S155) to the central lagoon, and the Boynton Beach Canal (C-16, S41) to the southern lagoon from water year 2001 (July 1, 2000-June 30, 2001) through water year 2012 (July 1 2011 to June 30, 2012).

Parameters	Segments		
	LWN	LWC	LWS
Salinity	no	no	no
Chlorophyll *a*	no	no	no
TN	no	no	no
TP	Decreasing	no	no
TSS	no	no	Decreasing
Secchi Disk Depth	no	no	no

Table 11. Temporal trends (2007-2012) of selected water quality parameters from Seasonal Kendall Trend test of monthly data averaged over stations within each segment

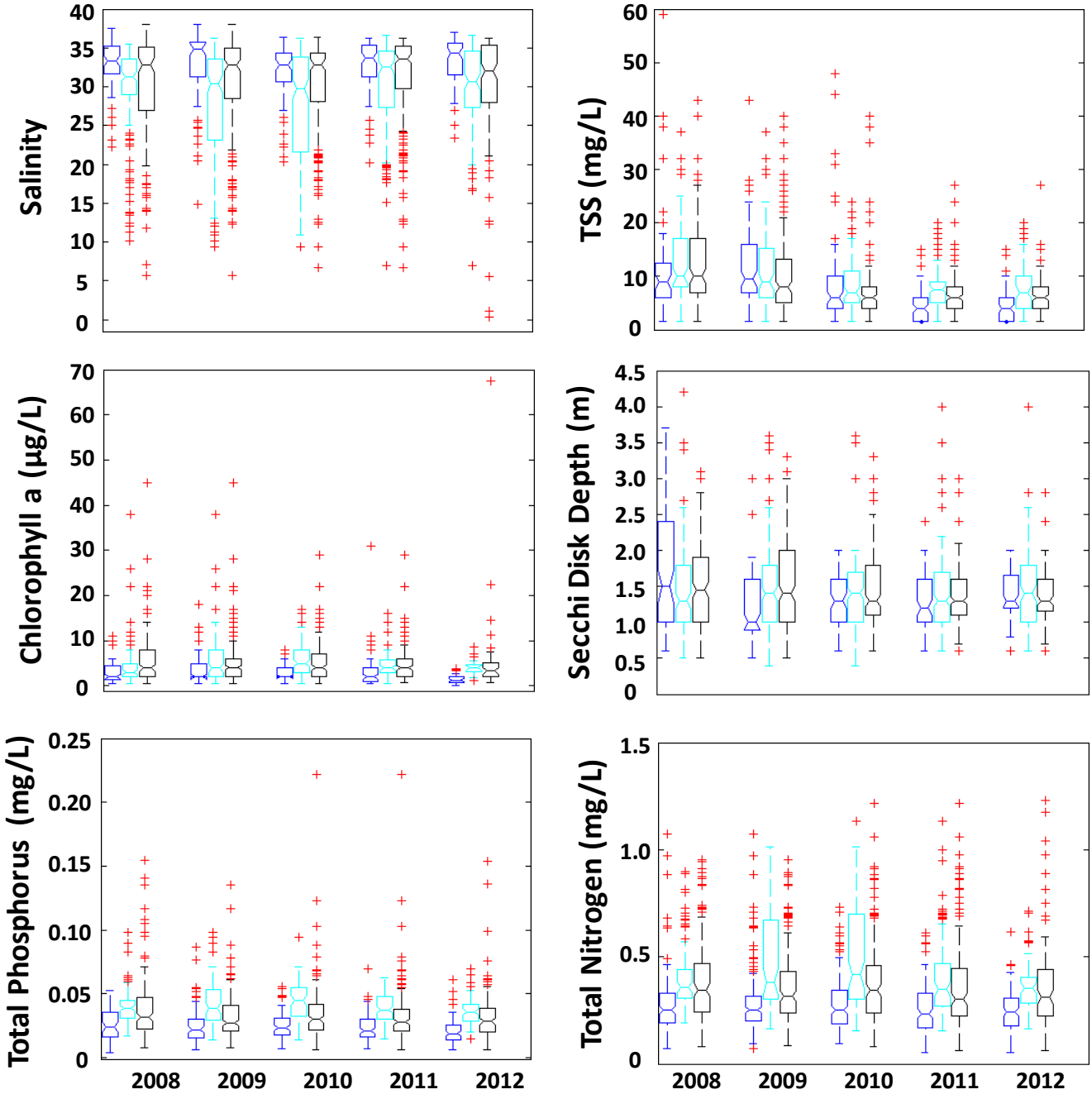


Figure 33. Time series of whisker box plots of selected water quality parameters in three segments of LWL (LWN (first in series; dark blue), LWC (second in series; light blue), LWS (third in series; black) from water year 2008-2012.

Water quality changes from period of 2001-2005 to period from 2007-2012

Table 12 shows some statistics and results of two way ANOVAs for salinity, TN, TP, Chl *a* and turbidity between the two periods of record (June, 2001-December, 2005 and July, 2007-July, 2012). These results indicate that in general, differences in water quality between the two periods varied with segment; interaction between segments and periods were statistically significant for most parameters except TP and TN. When compared with 2001-2005, data from 2007-2012 showed the following differences:

- Salinity was significantly higher in LWC and LWS; no significant difference was observed in LWN;
- Both TN and TP concentrations were significantly lower for all segments ;
- Chl *a* was lower in LWC; no significant differences were observed in LWN and LWS;
- Turbidity was higher in the LWN segment and lower in the LWC with no difference in the LWS.

In addition, there were same spatial distributions of water quality parameters between these two periods (**Table 12**). For example, the north lagoon had relatively higher salinity, and lower concentrations of nutrient and turbidity than the south and central segments during both periods.

The differences shown in **Table 12** may be in part due to the difference in freshwater inflows. For example, lower salinity in the central and south lagoons in 2001-2005 is consistent with relatively larger freshwater inflows during that period than in 2007-2012 (**Figure 32**). The differences may be also due to differences in analytical methodology used during the two PORs. For example salinity differences between the two PORs for different segments is the result of several extreme values observed from 2001-2005. Both minimum and maximum salinity values for the first POR are significantly different from those in the new data set. More importantly, these extremes appear to be beyond a normally expected range (highest salinity up to 47) for Lake Worth Lagoon. Caution should be taken when comparing these two data sets. We hope that the existing monitoring program will continue in the future, using consistent sampling and analytical methodologies that will enable users to conduct data analyses to test for longer term water quality trends.

Water quality Parameter	Segments	Periods	
		2001-2005	2007-2012
Chlorophyll *a*	LWN	4.44(4.98)***a***	3.52(4.25)***a***
	LWC*	5.67(8.79)***b***	4.00(5.27)***b***
	LWS	5.27(8.32)***b***	4.00(5.94)***b***
TPO4*	LWN*	0.05(0.03)***a***	0.03(0.01)***a***
	LWC*	0.08(0.03)***b***	0.04(0.01)***b***
	LWS*	0.07(0.04)***b***	0.04(0.02)***b***
Turbidity	LWN*	2.0(1.0)***a***	2.5(1.5)***a***
	LWC*	6.2(3.2)***b***	4.5(2.1)***b***
	LWS	4.3 (3.1)***c***	3.4(2.0)***c***
Salinity	LWN	31.1(6.7)***c***	32.0(3.1)***c***
	LWC*	23.1(8.7)***a***	29.3(5.9)***a***
	LWS*	27.7 (7.9)***b***	30.7(5.3)***b***
TN*	LWN*	0.43(0.22)***a***	0.29(0.10)***a***
	LWC*	0.77(0.39)***c***	0.43(0.19)**c**
	LWS*	0.64(0.33)***b***	0.39(0.17)***b***

Table 12. Results of two way ANOVA of water quality as a function of time period (2001-2005 or 2007-2012) and three segments (North, Central and South; only for those common stations in Table 1) in Lake Worth Lagoon. Arithmetic means (+standard deviations) are shown. A two-way ANOVA was conducted on ranked data followed by Student-Newman-Keuls procedure to evaluate significant differences between main effect and interaction between segments and periods. Asterisks (*) indicate statistical differences between periods, while letters indicate statistical difference between segments within each period with the same letters suggesting no difference.

According to Dr. Chen analysis, it appears that WQ between the two POR has generally improved or remained stable (with the exception of turbidity in the north LWL), and that the improvement could be primarily related to a reduction in freshwater discharge. The north LWL has the best WQ, followed by the south and then central LWL.

Optimized WQ network

Monitoring the health of LWL is central to the success of the restoration and protection of the lagoon. An effective monitoring program provides the data necessary to assess the status and trends in the health and abundance of the lagoon's resources and habitats. The data are also used to evaluate the effectiveness of management strategies, the direct or indirect effect on the health of the ecosystem, and to indicate if the restoration goals in other APs have been met. Continuing the monitoring is an important goal of the management plan. A formal interagency review of the monitoring plan was conducted by SFWMD through an optimization study in 2011. Results of this evaluation concluded that 4 sites could be eliminated without compromising the information collected. Monthly water quality monitoring will continue at 14 fixed locations (**Figure 34**); 4 other stations are also collected to comply with NPDES requirements bringing the total stations sampled to 18.

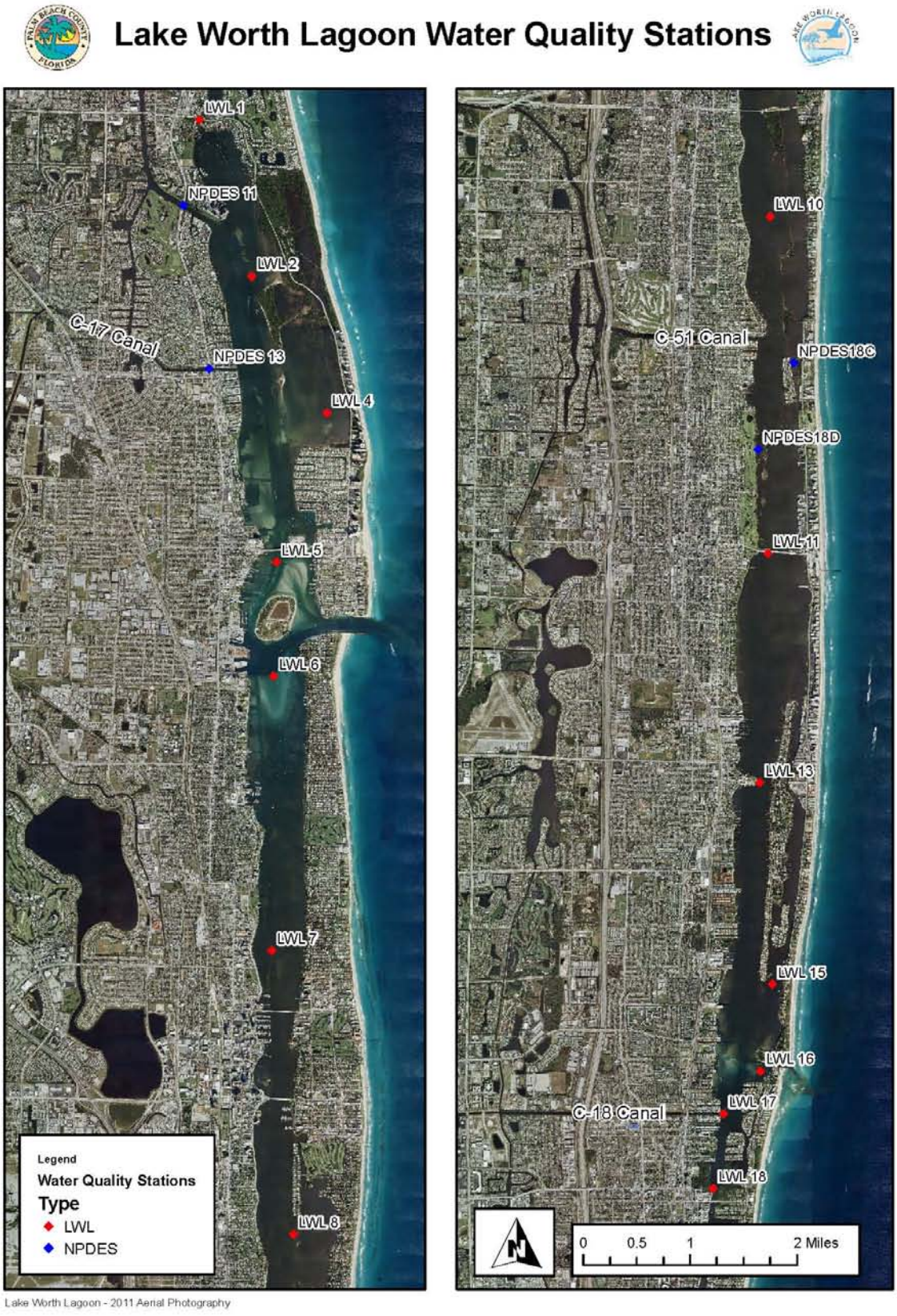


Figure 34. LWL Sampling Site Locations of optimized network

Central Lake Worth Lagoon Salinity

The John's Island Salinity Monitoring Project was initiated in April 2009 to study salinity changes due to stormwater releases from salinity control structures in the Central LWL. The primary monitoring site Southeast of John's Island (**Figure 35**) was selected due to its proximity to SFWMD's S-155 spillway and adjacent to PBC estuarine restoration projects. ERM staff has deployed and maintained one multi-parameter in-situ sonde at this location continuously from April 2010 to present.

Figure 35. John's Island Salinity Monitoring Site

The graph depicted below represents the full period of record (4/21/2010-1/28/2013). The green line shows salinity measured at the monitoring location on the SE side of John's Island; the red line shows flow in cubic feet per second (cfs) for SFWMD's S-155 structure; and the blue line shows precipitation measured at Palm Beach International Airport (PBIA). There are some gaps in the salinity data due mostly to equipment failures and scheduling conflicts; these gaps can be seen as long straight segments on the graph (**Figure 36**).

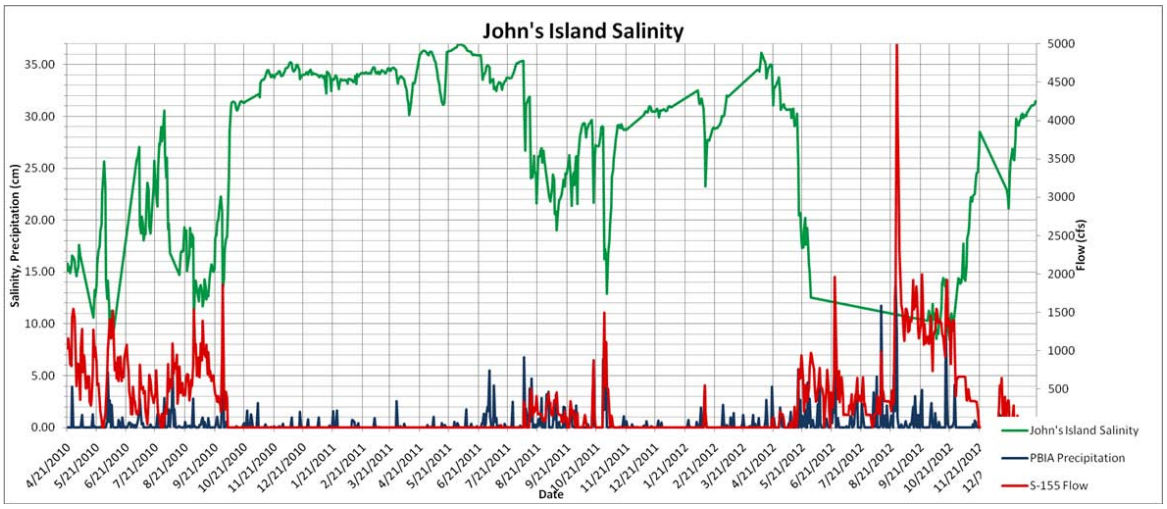


Figure 36. Salinity, rainfall and flow for POR 2012-2013

Overall there are several trends in the data that clearly show the close relationship between rainfall within the drainage basin, discharge events at the S-155 structure, and salinity levels in the central Lake Worth Lagoon. As expected, the wet season typically brings increased rainfall totals and eventually leads to associated stormwater releases from the S-155. Immediately following each release a corresponding drop in salinity has been observed and sustained until S-155 flow slows/stops. Local rainfall without associated S-155 discharge events appears to have little significant impact on salinity levels. This is apparent in the 2011 dry season data where multiple rainfall events occurred without associated S-155 discharge, while salinity remained high during the same period.

LWL Sediment Sourcing Study

(Trefry, J.H., Trocine, R.P., and Bennett, H. Department of Marine & Environmental Systems. Florida Institute of Technology)

Stormwater runoff is a major source of sediment input to the LWL that negatively impacts water quality and estuarine habitats. To address this environmental stressor a monitoring study began in July 2008 to assess sediment sources that are eventually discharged through the C-51 Canal, which delivers water from the Everglades Agricultural Area and Lake Okeechobee. The C-51 contributes approximately half of the freshwater inflow to the LWL. This joint project was in cooperation with the Florida Institute of Technology (FIT), ERM and the SFWMD. The objective of this study was to help improve water quality and benthic habitats in LWL by determining sources of muck sediments that enter the estuary via the C-51 Canal. Such information can be used to develop strategies that reduce sediment loading to LWL. This is one of the APs (SE-2) described in the 2008 Plan that has been completed.

The study area included the area of LWL within about 2 km of the terminus of the C-51 Canal as well as the entire length of the C-51 Canal and nine upstream canals that were separated from the C-51 Canal by a water control structure. The areas of interest for the sediment sourcing aspects of this study were as follows: (1) C-51 east basin, (2) C-51 west basin and (3) areas west of the C-51 west basin (**Figure 37 and 38**).

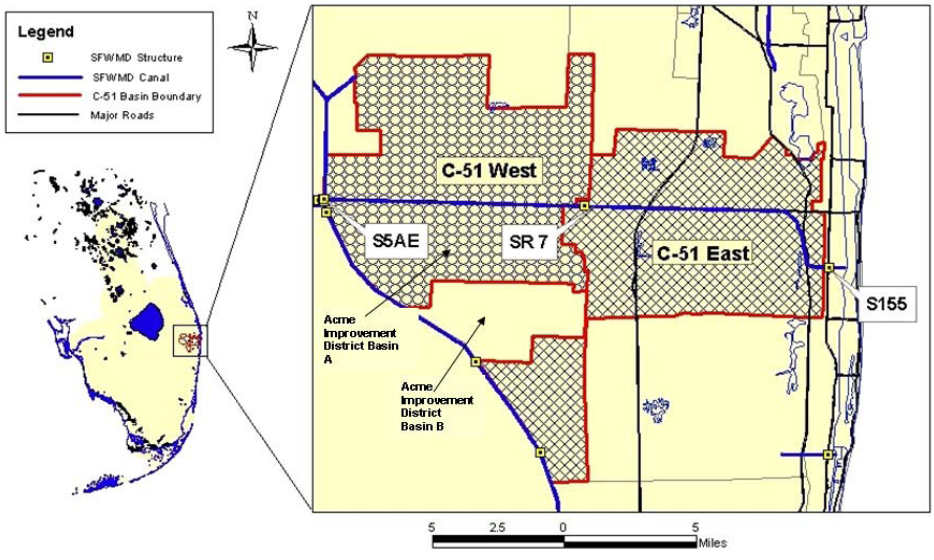


Figure 37. Maps showing overview of study area that includes the C-51 Canal and basin and Lake Worth Lagoon.

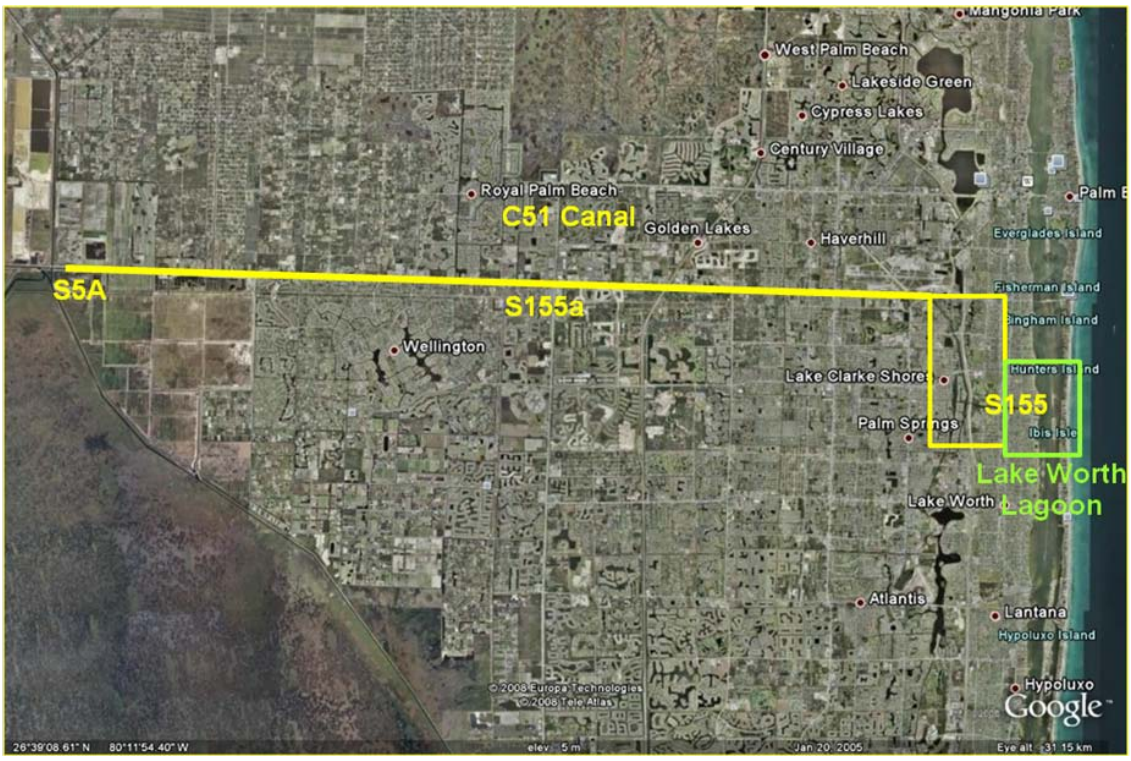


Figure 38. The approximate locations of three water control structures, S5A, S155A and S155 are labeled on the maps.

Results from this study showed that organic matter makes up 19% of the sediment composition in the LWL and 65% of this organic matter is derived from terrestrial (on land) sources. Sod probably contributes <10% of the inorganic fraction of the muck sediment but it probably contributes 30-50% of the sediment found in tributary canals in the C-51 east basin (e.g., the E1-E4 canals). Sediment inputs from the C-51 east basin and the M1 and Wellington Canals in the C-51 west basin collectively seem to contribute <30% of the inorganic matter. A large fraction of the inorganic component (>70%) seems to be derived from source areas west of Loxahatchee in the western reaches of the C-51 basin and farther west. In addition, data from DBHYDRO for 2004 to 2009 show that 25% of the water flow into LWL is from the C-51 east basin and the remaining 75% is from C-51 west, L8 and other canals west of the C-51 west basin. Analysis of data generated from samples collected will be used to develop management strategies to reduce sediment loading, and for the development and prioritization of Best Management Practices (BMPs) to reduce pollution.

This study is part of a larger, ongoing effort to BMPs that decrease sediment and organic matter loading to LWL. Within the context of this larger goal, several recommendations for future consideration are presented in this report, many of which have been previously proposed or initiated. The recommendations include the following: (1) Re-engineer or expand the S155 structure to avoid opening at the bottom, (2) continue the practice of dredging muck sediments from the C-51 Canal, (3) decrease flow at the S155A structure, (4) establish an *in situ* turbidity

monitoring system, (5) increase public awareness about the impacts of discharging lawn cuttings and debris into the canal, (6) increase the database on the chemical composition of sediments in the C-51 basin and, more importantly, west of the C-51 basin to Lake Okeechobee, (7) identify sources of metals found at elevated levels in LWL sediments, (8) determine if construction of S155A structure has decreased sediment input to LWL since 2000.

A synopsis of the study is summarized below:

The first task of the sediment sourcing effort was to determine the composition of bottom sediments from LWL and to create a characterization, or fingerprint, that could be used to identify upstream sources of sediment to the lagoon. Surface sediments (top 2 cm) were collected at 19 locations in LWL near the terminus of the C-51 Canal. Three sediments cores also were collected from LWL for age dating and chemical analysis to investigate possible shifts in sediment composition over the past several decades. The average thickness of muck sediments determined at the 19 stations sampled in LWL was ~60 cm. Chemical results for 15 elements in 19 surface sediments from LWL and 20 samples from the three sediment cores showed that concentrations of individual metals varied by 3- to 5-fold among stations.

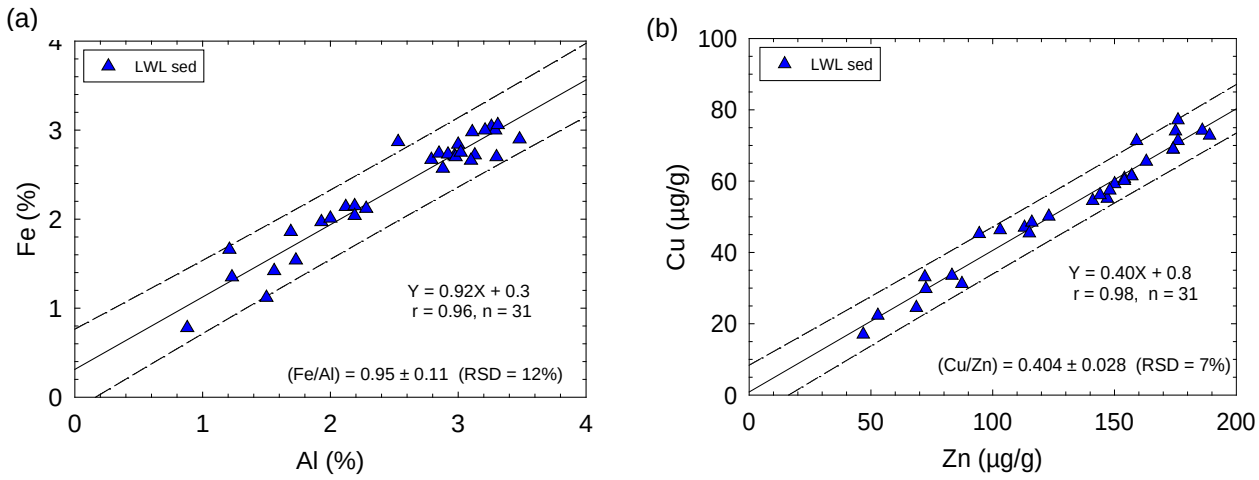


Figure ES1. (a) Iron (Fe) versus aluminum (Al) and (b) copper (Cu) versus zinc (Zn) graphs using data for bottom sediments from Lake Worth Lagoon (LWL). Solid lines and equations are from linear regression analysis. Dashed lines show 95% prediction intervals. Calculated Fe/Al and Cu/Zn ratios are shown with relative standard deviations (RSD).

Such variability in metal concentrations is common in coastal marine sediments and can most often be explained by natural variations in sediment grain size, mineralogy and organic matter content. For sediments from LWL, the finer-grained material was richer in metal-bearing clay minerals whereas the coarser grained sediment contained metal-poor quartz sands and carbonate shell fragments. Concentrations of sediment trace metals were ratioed to concentrations of aluminum (Al), thereby normalizing differences in metal values that result from variations in grain size, mineralogy and/or organic matter (**Figure ES1a**).

Next, surface sediments and data for muck depth were collected at 33 locations in the C-51 Canal. The average muck depth at these 33 stations was ~50 cm with maximum values >150 cm. Results from additional probe measurements showed hard or sandy bottom at >30 disconnected locations because the presence of fine-grained, organic-rich sediments was patchy, yet found along the complete length of the C-51 Canal. The thickest deposits were found in the area where the C-51 Canal turns east at its junction with the E4 Canal.

Values for the same metal/metal ratios identified from analysis of LWL sediments were determined for sediments from the C-51 Canal. Data for the Cr/Fe ratio, for example, showed that all stations, except C120 and C118 at the western end of the C-51 Canal, had higher values than found for sediments from LWL (**Figure ES2a**). The Cr/Fe plot, and other plots, suggested that sediments from the western extent of the C-51 Canal are needed in sizeable proportions to yield the various metal/metal ratios found for LWL sediments. Example results for the Cu/Zn ratio showed a relatively good match between sediments in the C-51 Canal and LWL as the canal sediments cumulatively acquire and record metal concentrations of sediments introduced from various tributary canals as they are carried toward LWL.

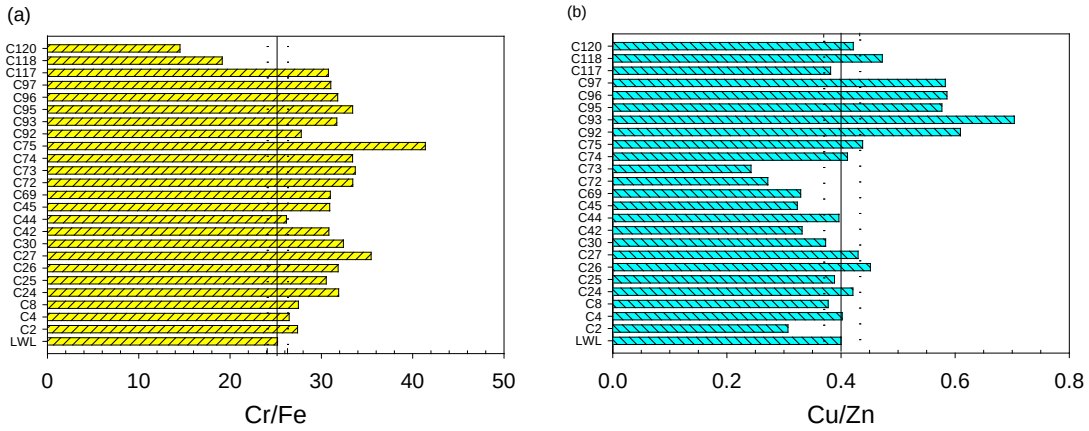


Figure ES2. (a) Cr/Fe and (b) Cu/Zn ratios for sediments from the C-51 Canal and the mean value (solid vertical line) ± 1 standard deviation (vertical dashed lines) for bottom sediments from Lake Worth Lagoon (LWL)

The suite of samples used to identify sources of sediments to LWL was as follows: suspended sediment samples from nine upstream canals, bottom sediments from these stations (except for three locations where only sand was present) and samples of fresh sod from sod farms and distributors in the C-51 drainage basin. The results showed, for example, that sod had much higher ratios for Cu/Zn and As/Al than found for LWL sediments (**Figure ES3**) and thus sod was not likely to play a large role as a source of sediment to LWL relative to sediments from the western portion of the C-51 basin and farther west as described in the report.

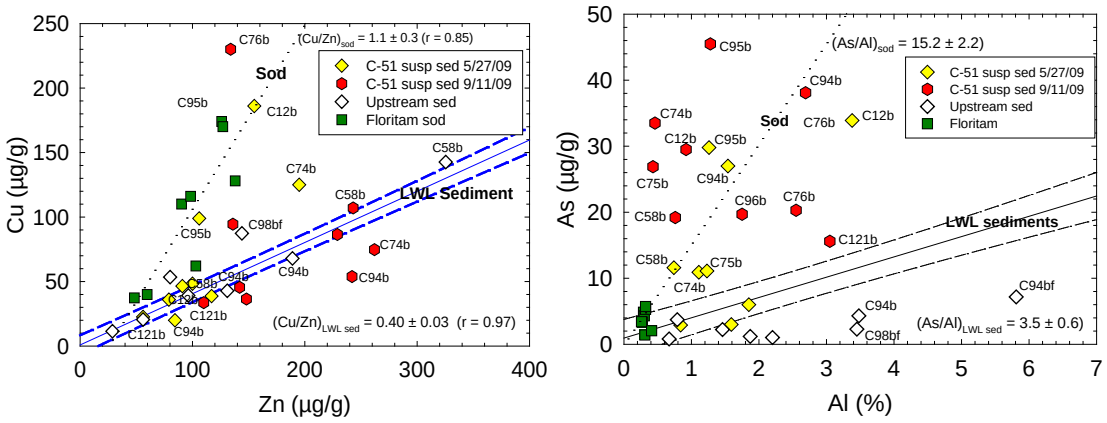


Figure ES3. Plots for (a) Cu versus Zn and (b) As versus Al with data for bottom and suspended sediments from upstream locations in the C-51 basin as well as for Floritam sod. Solid lines and dashed-line 95% prediction intervals are from a linear regression analysis using metal data for bottom sediments from Lake Worth Lagoon (LWL). Dashed lines without prediction intervals are from data for Floritam sod.

Organic matter made up an average of 19% of the dry sediment mass in LWL and gave the muck sediments their characteristic black color and high oxygen demand. Sources of this organic matter were determined using stable carbon isotopes. The results show that an average of 65% of the organic matter in LWL sediments was derived from terrestrial sources (i.e., land derived) and 35% was produced through primary production in LWL.

Sourcing of inorganic matter (clays and other aluminosilicate minerals) was carried out using data for the various metal/metal ratios for LWL sediments and upstream source materials. One common observation in the source samples was that the RSD was >20% for ~77% of the values because of the high variability in composition of the samples due to low concentrations of suspended solids and variability in the composition of the source material during this study. The ratios were characterized as being very high, very low or closer to values for LWL sediments and a series of refinements and calculations were carried out using the ratio data.

Calculations using the various metal/metal ratios support the following statements: (1) sod probably contributes <10% of the inorganic fraction of the muck sediment in LWL, (2) sod probably contributes 30 to 50% of the sediment found in tributary canals in the C-51 east basin such as the E1 to E4 series of canals, (3) sediment inputs to LWL from the C-51 east basin (the E1 to E4 canals mentioned above) seem to account for <30% of the inorganic matter found in LWL sediments, and (4) a large fraction of the inorganic component of the sediment in LWL seems to be derived from areas west of Loxahatchee in the western reaches of the C-51 west basin and farther west. Data for water flow from 2004 to 2009 (DBHYDRO database) show that ~25% of the water discharge into LWL from the C-51 Canal is from the C-51 east basin and that the remaining 75% is from the C-51 west basin, the L8 Canal and other areas to the west. This trend is consistent with results from the sediment sourcing study.

Data for metals also can be used to make an assessment of the degree of contamination in bottom

sediments from the C-51 Canal and LWL. The first assessment was made using the State of Florida sediment quality guidelines. No data points exceeded the state guidelines for As **(Figure ES4a**) and 6 of 72 data points exceeded the guidelines for Cr. In contrast, more than 40 of 72 data points for Cu, Pb and Zn exceeded the state guidelines (e.g., Cu in **Figure ES4b**). To assess possible adverse effects to bottom-dwelling organisms, another set of guidelines that set an Effects Range Low (ERL) and Effects Range Median (ERM) were applied. No metal values exceeded the values for the ERM and no values for silver exceeded the ERL. However, 13, 23 and 40 of the 72 data points for lead, zinc and mercury, respectively, exceeded values for the ERL.

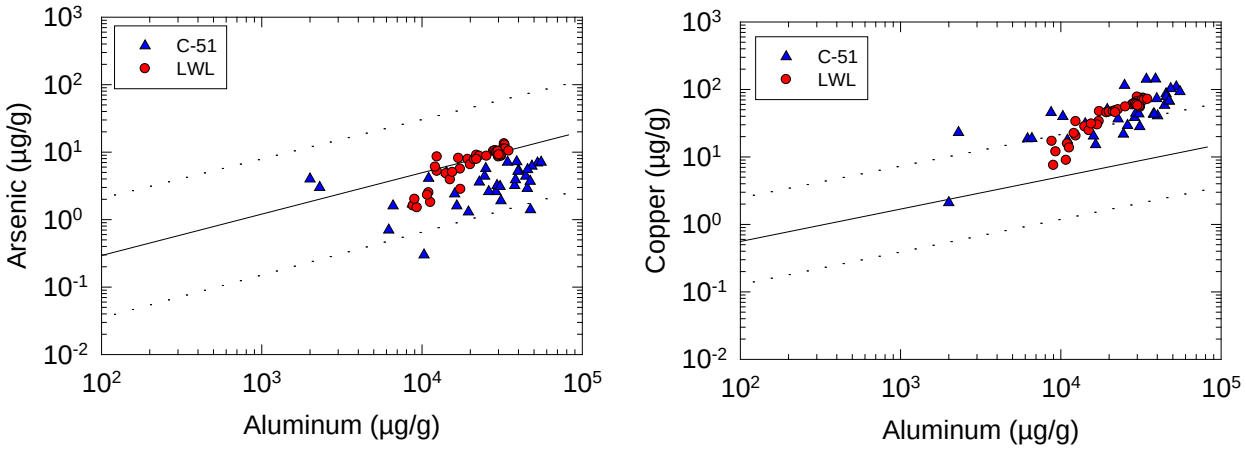


Figure ES4. Aluminum versus (a) arsenic and (b) copper for bottom sediments from the C-51 Canal and Lake Worth Lagoon (LWL). Regression line with 95% prediction interval is from State of Florida sediment quality guidelines. Data points that plotted above the upper prediction interval are considered to have an anthropogenic input of metal.

The main conclusions of this study are as follows:

- Sediments in Lake Worth Lagoon (LWL) within 2 km of the terminus of the C-51 Canal have very uniform ratios for Fe/Al, Cr/Al, Cr/Fe, Cu/Al, Cu/Fe, Cu/Zn, Mn/Al, As/Al, As/Fe, Mg/Al, Mg/Fe, Zn/Al, and Zn/Mg. This uniformity over the past several decades most likely results from a dominant common source for the sediment and/or good mixing of incoming sediments during transport to and burial in the lagoon. These ratios define, or provide, a distinct fingerprint for LWL sediments.

- Data for total suspended solids (TSS) versus turbidity in LWL and the C-51 Canal are highly correlated ($r>0.95$) and an equation has been derived to calculate TSS from turbidity.

- Organic matter makes up 19% of the sediment composition in LWL and, based on stable carbon isotopes, 65% of this organic matter is derived from terrestrial (on land) sources.

- Sod probably contributes <10% of the inorganic fraction of the muck sediment in LWL.

- Sod probably contributes 30-50% of the sediment found in tributary canals in the C-51 east basin (e.g., the E1-E4 canals).

- Sediment inputs from the C-51 east basin and the M1 and Wellington Canals in the C-51 west basin collectively seem to contribute <30% of the inorganic matter found in LWL.

- A large fraction of the inorganic component of the sediment in LWL (>70%) seems to be derived from source areas west of Loxahatchee in the western reaches of the C-51 basin and farther west.

- Data from DBHYDRO for 2004 to 2009 show that 25% of the water flow into LWL is from the C-51 east basin and the remaining 75% is from C-51 west, L8 and other canals west of the C-51 west basin.

- Concentrations of Cu, Pb and Zn in sediments from LWL exceeded the State of Florida sediment quality guidelines for >40 of 72 samples.

- No concentrations of metals in sediments from LWL exceeded the upper Effects Range Median value for adverse effects to bottom-dwelling organisms.

- Concentrations of Pb, Zn and Hg exceeded the values set for Effects Range Low for 13, 23 and 40 of 69 samples, respectively.

Recommendations

Capture sediment and organic matter at the S155 structure by re-engineering the present structure or creating an additional adjacent structure.

The S155 structure, like many similar structures in Florida, was designed to move water and sediment from upland areas to coastal lagoons and bays. Many of these structures, including S155, open at the bottom and thus allow sediments to flow more easily into adjacent coastal lagoons. If the present S155 structure could be re-engineered to facilitate flow over the top or if another nearby structure could be designed to trap sediments, this modification would greatly limit sediment loading to LWL. Regular removal of sediment from the upstream side of the structure would be required.

Continue the practice of monitoring and dredging C-51 Canal sediment trap in the area where the C-51 Canal turns east and passes under the US 95 highway and in other areas.

Palm Beach County dredged about 100,000 cubic yards of muck from the C-51 Canal in the area where the canal turns east. This process removed sediment that could have been carried into LWL and also created a 13 acres sediment trap that can capture future incoming sediment. The dredged site and trap are being monitored to determine the amount of new sedimentation. This monitoring process and future dredging of the trap should be continued. In addition, other sites along the C-51 Canal and adjacent canals should be considered for dredging including, for example, the E4 Canal. Dredging should certainly be one component of the overall management

strategy.

Decrease flow at the S155A structure.

If, as this study suggests, a large fraction of the sediment being carried to LWL originates west of the S155A structure, then decreasing flow at the S155A structure by diverting water into upstream agricultural and other areas would lessen the burden of freshwater and sediment on LWL. This stated goal of Palm Beach County and the South Florida Water Management District is strongly supported.

Establish *in situ* turbidity monitoring stations at several locations along the C-51 Canal.

More real-time data on sediment transport are needed. One method for obtaining such data is to establish monitoring sites with *in situ* turbidity sensors. Possible locations for such sensors include just upstream and downstream of the S155 structure, upstream and downstream of the S155A structure, in the L-8 Canal and other canals west of the C-51 basin. This data could be used to help make real-time management decisions regarding choices for water diversion.

Increase public awareness about impacts of discharging lawn cuttings and other organic and inorganic matter into the C-51 Canal and other canals.

Disposal of grass cuttings and other vegetation, as well as soil and debris, into the C-51 Canal and adjacent canals were observed during this study. The obvious detrimental impact of these practices may be minimized by including pertinent information in ongoing public outreach efforts.

Increase the data base on composition of sediments in upland canals of the western area of the C-51 west basin and in other areas to the west.

More data are needed on the chemical composition of sediments in areas west of those locations investigated during this study. These areas include several canals west of the C-51 west basin as well as other areas including Lake Okeechobee. Such information could be used to develop a more robust model of sediment sourcing for LWL. Samples should include bottom sediments with analysis of the fine-fraction and suspended sediments.

Increase the data base on composition of sediments in upstream canals of the C-51 east basin.

More chemical data also are needed to enrich the data set for source sediments from upstream canals in the C-51 east basin. This effort should focus mainly on the fine-fraction of bottom sediments because this material is easier to collect in quantity and may better represent the material that is being transported to LWL from this sub-basin.

Identify sources of selected metals that are found at elevated concentrations in the bottom sediments of LWL and the C-51 Canal.

Concentrations of metals such as mercury, silver, lead, copper and zinc were elevated in sediments of LWL and the C-51 Canal. A study should be initiated to determine the sources of these metals so that inputs to the canal and Lagoon may be reduced.

Determine if construction of the S155A structure during the past decade has decreased inputs of sediment into LWL.

Installation of the S155A structure since 2000 may have helped decrease sediment loading to LWL by trapping material at the structure with water flow over the top. This may be difficult to show but one method that may prove successful is high resolution (every 0.5 cm) sectioning and age-dated of well-chosen sediment cores from LWL.

Manage Sediments in the Lake Worth Lagoon - Monitoring Results from the C-51 Canal Sediment Management Project

C-51 Canal Monitoring Results

The C-51 Canal is considered a major water conveyance system, providing both flood protection and water supply, and responsible for the greatest freshwater discharges to LWL. Freshwater inflows affect turbidity, salinity and nitrogen levels in the Lagoon with a positive correlation between proximity to the C-51 and declined water quality in the lagoon. To help reduce the amount of potential suspended sediment discharge in LWL, ERM, in partnership with SFWMD and the City of West Palm Beach, implemented the C-51 Canal Sediment Management Project in 2006.

As a result of the project, approximately 101,500 cubic yards of muck was removed from a 0.66 mile section of the C-51 Canal. In addition, a 13.1 acre sediment trap was created in a widened section of the canal immediately west of I-95 where conveyance canals from the south, west and north meet prior to the canal's easterly projection to the control structure. The trap was dredged to an average depth of -15.5 feet NAVD (range of -13.5 to -19.5 feet NAVD) in an effort to capture and confine sediments and reduce the amount discharged into the Lagoon.

From 2007-2010, the County conducted annual survey events to monitor sediment accretion and erosional trends within the project area and evaluate the effectiveness of the sediment trap. During the first two years of the study (2007–2009), there was a net accretion of sediments in all reaches of the C-51 Canal, and the most significant increase occurred within the sediment trap. Of the four reaches monitored, the sediment trap showed the greatest accretion of material during the three year study period with an average of 4,649 cubic yards per year (**Figure 39**). The net volume of sediments accreting within the sediment trap far exceeded the net volume of erosion from other reaches indicating there were other contributing areas beyond the limits of the study. During the last year of the study (2009-2010), all reaches of the canal experienced a loss of sediments with the greatest losses occurring within the segment of the canal adjacent to and immediately upstream of the S-155 Control Structure.

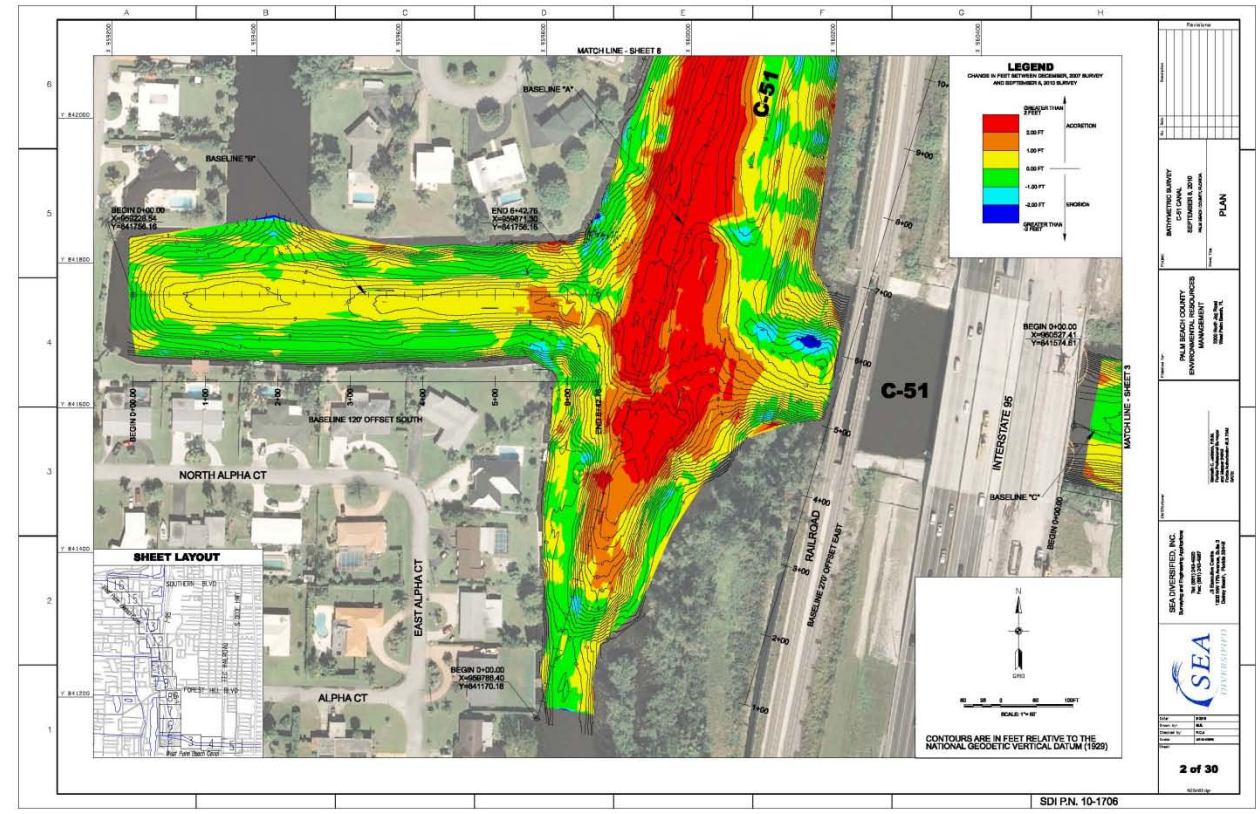


Figure 39. C-51 Sediment Trap Bathymetry, 2007-2010

The volume/rate of and number of consecutive discharge days from the S-155 Control Structure has a direct correlation with erosion and accretion trends throughout the study area. During the first two years, there was recorded discharge through the structure less than 50% of the days, with limited times of consecutive daily discharge. During this period there was documented sediment accretion in all segments of the canal (**Figure 40**). For the last year of the study, data indicates the structure discharged over 75% of the days with consecutive daily discharges for almost the entire last half of the period (178 days). During this period, all segments of the study area, including the sediment trap, experienced a loss of sediments. It is evident that increased flow volume/rate and duration of discharge through the structure directly relate to the net accretion or erosion of sediments within the upstream areas of the canal. In that the sediment trap experienced relatively minimal sediment loss during the period of excessive discharge from the structure, it is apparent the sediment trap is functioning as intended.

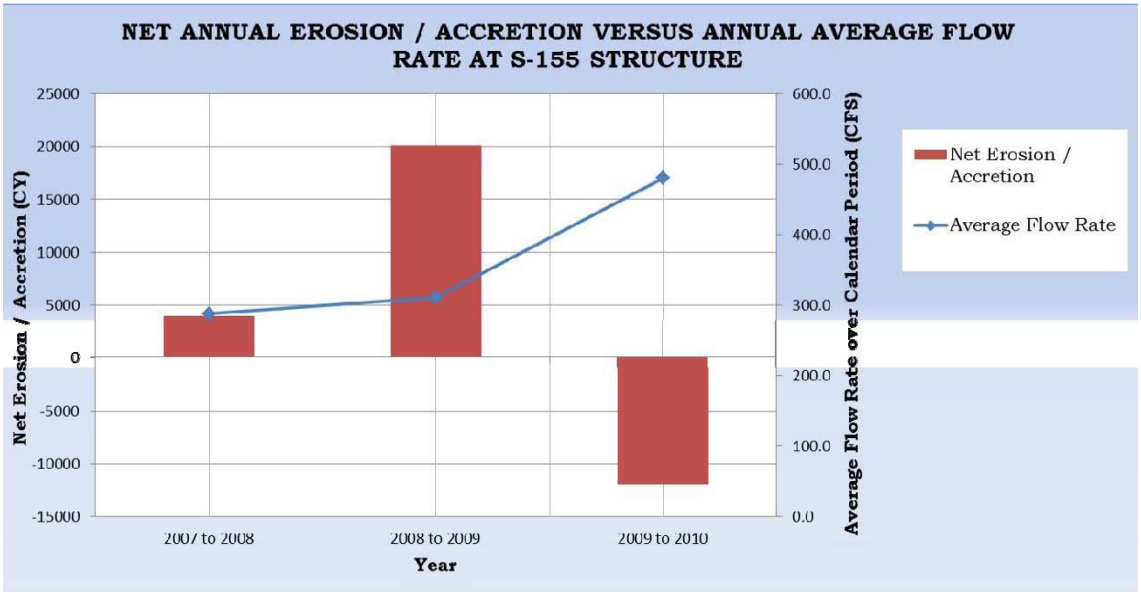


Figure 40. Net Annual Erosion/Accretion versus Annual Average Flow Rate at S-155 Structure

The final report recommendations, following the three year monitoring period, suggest continued monitoring surveys to better understand the movement of sediments through the C-51 Canal, including the extent and rate of sediment accretion within the sediment trap and degree of sediment loss through the S-155 structure into the LWL. Evaluation of sediment erosion and accretion trends, relative to discharge rates/volumes at the S-155 structure would also assist in understanding the characteristics of sediment transport during varying times of structure operation, and the estimation of future dredging requirements. Annual monitoring, which is consistent with the previous study, would be appropriate however, interim check survey immediately before and after extreme discharge events at the structure may provide valuable information regarding the extent of sediment loss to LWL during such events.

It appears that annual dredging prior to the start of the rainy season of sediments just upstream of the S-155 and in the trap could be a have a major benefit to the Lagoon by significantly reducing the amount of fine sediments discharged every year.

PBC, the SFWMD and the City of West Palm Beach have an existing Interlocal Agreement for sediment management within the C-51 Canal (sediment trap) and LWL. The tri-party agreement addresses future sediment trap monitoring and maintenance, which is further discussed in Action Plan SW-1 *Reduce Discharge of Freshwater and Total Suspended Solids.*

Muck/Sediment Thickness Study

The LWL sediment thickness study was performed to investigate, map and quantify the horizontal and vertical extent of the reported sediment/muck deposits within areas centered about the C-51discharge canal. The study area ranged from the northern most site at 12 Oaks to the southern extremity at Bryant Park, and included the areas of Currie

Park, South Cove, Palm Beach Atlantic University, Everglades, Ibis Isles, Snook Islands, and Blossom's Hole (**Figure 41**). Field data collection commenced on March 31, 2009 and was completed on September 21, 2009.

Two hundred forty-one (241) sediment probes, eighty-four (84) Ponar grab sediment samples, and twenty-nine (29) vibracore samples were collected (**Table 13**). Horizontal locations of the probes and samples were established using GPS, and bathymetric survey information was collected using an automated hydrographic survey system. Digital photography was used to document the characteristics of the sediment retrieved from both the Ponar grab and the vibracore samples. Details on the methodology can be found in the full report.

Upon completion of the field data collection activities, sediment samples were sent to a laboratory for grain size analysis. The final report included a sediment analysis with sediment probe, grain size analysis, and vibracore data. Isopach charts of upper sediment thickness were also created for each of the fifteen (15) sites.

Figure 41. Map of areas investigated

SITE INDEX

2	12 OAKS SITE
3	12 OAKS SITE
4	CURRIE PARK SITE
5	CURRIE PARK SITE
6	SOUTH COVE SITE
7	PALM BEACH ATLANTIC UNIVERSITY SITE
8	PALM BEACH ATLANTIC UNIVERSITY SITE
9	EVERGLADES WEST SITE
10	EVERGLADES EAST SITE
11	BLOSSOM'S HOLE SITE
12	BIG ISLES (NORTH) SITE
13	BIG ISLES (SOUTH) SITE
14	SNOOK ISLANDS SITE
15	SNOOK ISLANDS SITE
16	BRYANT PARK SITE

Project Site	Area (Acres)	# Probes	# Sediment Samples	Dates of Probes and Samples	# of Vibracore Sample	Dates of Vibracore Sample
12 Oaks (Monastery)	90.7	28	6	6/17/09	4	9/21/09
Currie Park	78.8	12	5	5/7/09	3	9/17/09-9/21/09
South Cove	27	28	13	4/22/09 – 6/15/09	6	9/17/09-9/18/09
Palm Beach Atlantic University	77	43	11	6/10/09-6/15/09	0	n/a
Everglades West	17	25	3	4/27/09-5/27/09	0	n/a
Everglades East	29.9		8			
Blossom's Hole	18	10	4	4/27/09	0	n/a
Ibis Isles North	24.8	38	9	3/31/09-6/9/09	14	9/10/09
Ibis Isles South	22.6	20	8	3/31/09-4/9/09		
Snook Islands	37.9	28	12	4/23/09-5/27/09		
Bryant Park	30	10	5	4/23/09-5/27/09	2	9/21/09
Totals	453.7	242	84		29	

Table 13. Summary of probes, Ponar grab samples, and vibracore samples

Summary

The results of the muck/sediment thickness study indicate much of the original bottom in the study area is overburden with a thick semi-fluid muck layer. Analysis of the data shows a strong correlation between the relative depths of water and the thickness of the muck layer, as well as the type of material present. Analysis of each of the nine sites can be found in the full report. In general terms, holes or deeper areas contained thicker layers of muck sediment. Sites having the thickest muck layers include South Cove (thickness of 12 feet in depth of -20' NAVD) and Snook Islands (thickness of 12 feet in depth of -13' NAVD). The isopach map for Snook Islands is shown in **Figure 42**.

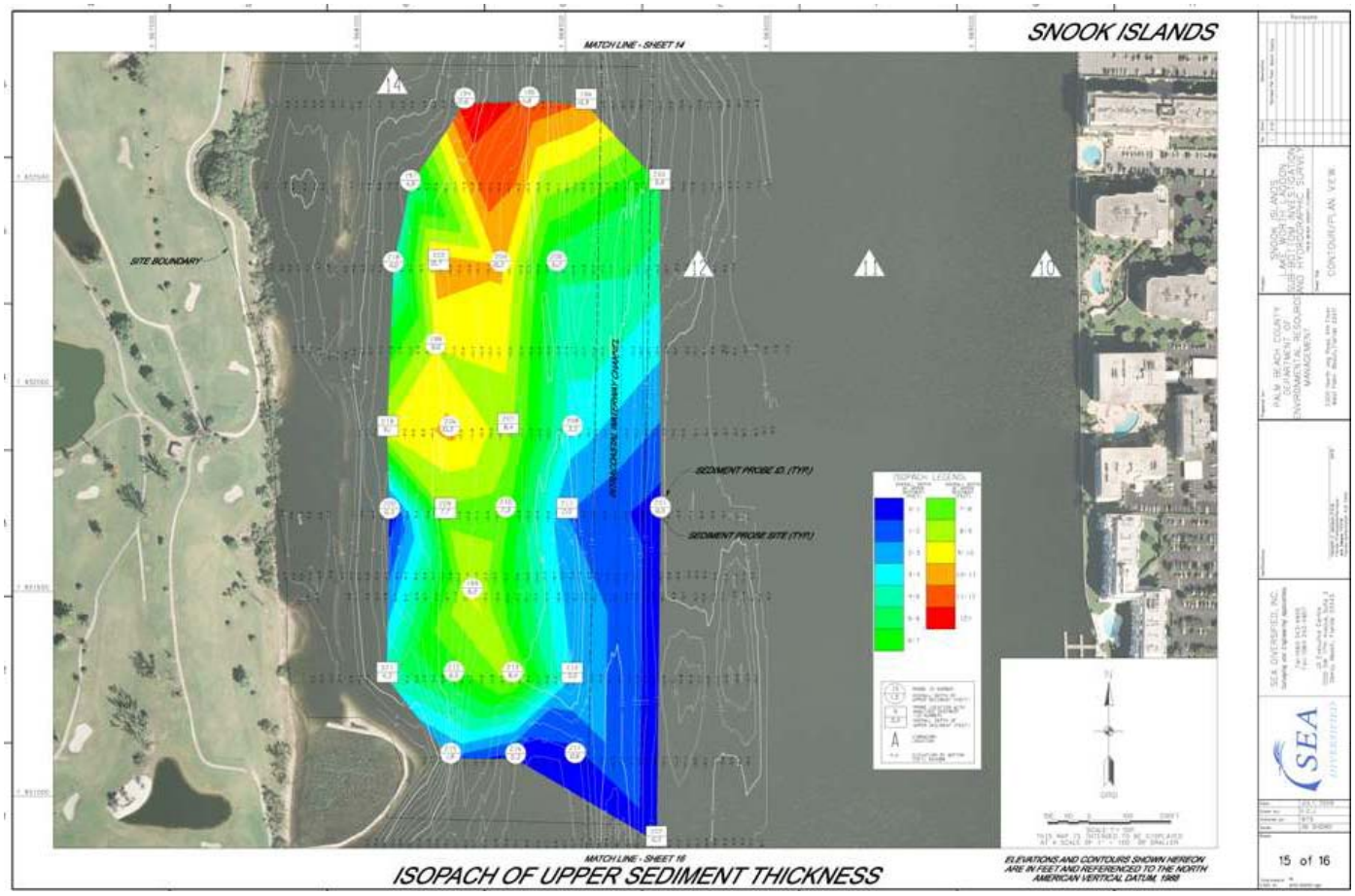


Figure 42. Isopach map of Snook Islands site.

Additionally, within each site the thicker layers of muck corresponded to a higher percentage of fines within the sediment analyzed. Overall, sites closest to the C-51 discharge had the highest percentage of fines. Average percentage of fines for Ibis Isle North, Ibis Isle South, and Snook Islands, was 72, 56, and 54 respectively, and within those areas the highest percentage of fines was generally found in the thickest muck.

Climate Change and the LWL

Climate change refers to the complex environmental changes caused by increasing emissions of CO_2 and other greenhouse gases to the atmosphere (Bjork *et al*., 2008). Due to its peninsular geography, low topography, and abundant population, Southeast Florida is considered one of the most vulnerable areas to climate change (SFRCC, 2012). Climate change presents a significant threat to fish, wildlife and natural ecosystems and will likely exacerbate and couple with many existing threats, including habitat loss, nonnative species, and water pollution (FWC, 2011). Of the major climate change impacts recognized by scientists, four are expected to directly affect Florida: sea level rise, increased intensity of storms, extreme fluctuations in rain and warmer temperatures (FWC, 2009; FWC, 2011).

The effect most recognized in terms of the potential scale of its impact on the ecology and economy of Southeast Florida is sea level rise (SLR) (FWC, 2011). Projections are that by 2030 sea level could be 3 to 7 inches higher than it is now, and by 2060 sea level could be 9-24 inches higher, with sea level continuing to rise into the future (**Figure 43**) (SFRCC, 2012). As the level of the sea rises, estuaries and other coastal systems are affected. Within estuaries, sea level rise will result in the disappearance of seagrasses, mangroves and salt marshes at their deeper, more waterward edge (W. Gray, FFWCC, personal communication, September 10, 2012). The habitats will expand at their upland edge as long as the vegetative species can grow faster than the rising sea level and the path is not obstructed by a manmade structure (e.g. seawall, roads, wall, etc.). Flooding and inundation from storms is also made worse by sea level rise and will most likely affect low lying natural systems, such as mangrove and tidal marsh wetlands (SFRCC, 2012). Flood waters piled on top of raised sea level travel farther inland, especially during extreme weather events, which may significantly alter salinity levels.

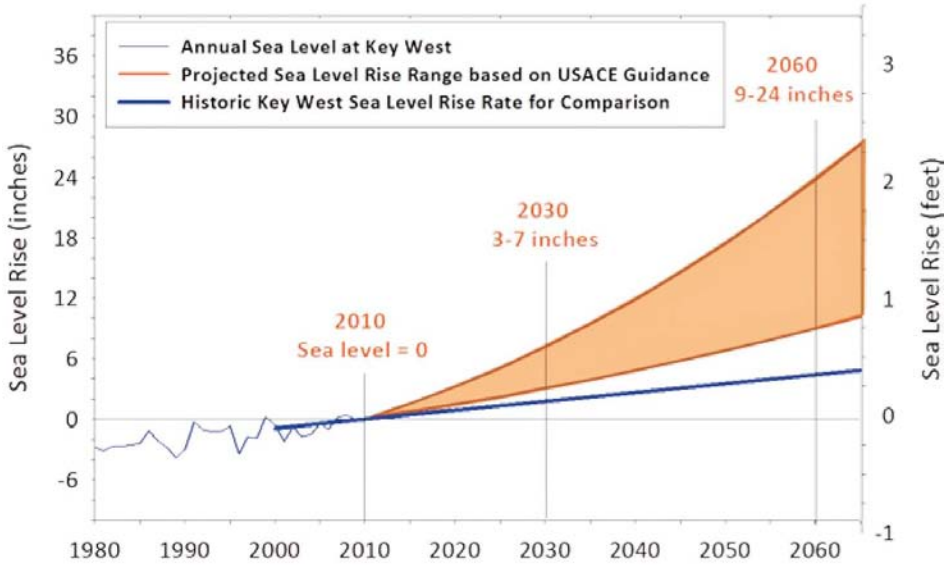


Figure 43. Unified Southeast Florida Sea Level Rise Projection for Regional Planning Purposes (Regional Climate Action Plan)

Climate change is likely to cause less frequent, but more intense tropical storms and hurricanes, with tendencies for flooding and drought (Björk *et al.*, 2008; FWC, 2011; W. Gray, FFWCC, personal communication, September 10, 2012). The significant amount of rainfall and stormwater discharge generated by such storms can significantly increase sediment loading, which may result in smothering of benthic resources, such as seagrasses and oysters, and proliferation of algal blooms. The increased turbidity can remain long after the storm subsides, decreasing light availability for seagrasses. Extreme fluctuations in rainfall can reduce water quality and alter salinity gradients, both of which negatively affect estuarine species.

Increasing air and water temperatures are known to result in latitudinal shifts in species distribution, with tropical species expanding their range further north (FWC, 2011). The success with which species are able to adapt to temperature changes will depend on rate and intensity of changes, but also on the level of competition for potential space and resources. In seagrasses, for example, temperature stress will result in distributions shifts and altered growth rates (Björk *et al.*, 2008). When temperatures reach the upper thermal limit for individual species, the reduced productivity will cause plants to die. Elevated temperatures may also increase the growth of algae, which can outcompete seagrass and reduce the available sunlight needed for seagrass growth.

The Environmental Protection Agency (EPA) has developed a comprehensive overview of climate change stressors and projected impacts on estuarine systems (USEPA, 2009). While many of the actions to address climate change will likely occur on the national level, additional baseline data for the LWL is essential to evaluating changes and understanding the vulnerabilities of this ecosystem and its species. The timing of projected impacts is unpredictable; therefore regular monitoring is important to detecting changes as they occur. While not all of these changes will directly affect day-to-day management of the LWL, many of the changes will require consideration of adaptation strategies and adjustments to management strategies. In January 2010, the Southeast Florida Regional Climate Change Compact (Compact) was entered into by Palm Beach, Broward, Miami-Dade and Monroe Counties. The main objective of the Compact is "to integrate climate adaptation and mitigation into existing decision-making systems and to develop a plan that can be implemented through existing local and regional agencies, processes and organizations" (SFRCC, 2012).

One of the goals of Southeast Florida's first Regional Climate Action Plan is to "implement monitoring, management, and conservation programs designed to protect natural systems and improve their capacity for climate adaption". The actionable recommendations directly applicable to long-term management of the LWL are (SFRCC, 2012):

- Develop a vital signs status and trends monitoring program for biological monitoring. Parameters could include rate of sea level rise, landscape-level vegetation patterns, water temperature, pH, and occurrence and range of invasive plant and animal species. [Recommendation NS-1]

- Maintain or restore multiple areas of habitat and large-scale connectivity to facilitate native species population stability and habitat shifts. [Recommendation NS-5]

- Coordinate and implement invasive exotic species prevention and control efforts to minimize the diversity and abundance of habitat-homogenizing exotic plants and animals by emphasizing prevention of new invasions and early detection/rapid response to nascent invasions. [Recommendation NS-6]

- Coordinate “living shorelines” objectives to foster use of natural infrastructure (e.g. reefs, native vegetation and mangrove wetlands) instead of or in addition to grey infrastructure (e.g. bulkheads). [Recommendation NS-7]

- Advocate for federal and state funding for applied monitoring and climate related science [Recommendation NS-10]:

    - Identify economic and physical linkages between marine systems (e.g. reefs and mangroves) and hazard risk/damage claim reduction

    - Monitor coastal marsh vegetation tolerance to changing salinity, depth and other climate variables.

    - Improve data on estuarine bathymetry and use appropriate models to identify habitats at risk.

    - Develop refined climate projections, hydrologic and ecological models to aid in planning.

- Support regulatory requirements that provide for ecologically beneficial uses of clean, dredged materials. [Recommendation NS-11]

- Maintain/restore urban tree canopy. [Recommendation NS-14]

To effectively prepare Southeast Florida for the likely impacts of climate change, cooperation is vital, not only among the Compact Counties, but also among the municipalities, local, regional, state, and federal agencies serving this area.

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3. GOALS FOR THE LAGOON

MISSION AND GOALS

The mission of the Plan is to restore, conserve and manage the LWL ecosystem and to build and promote partnerships through the implementation of a scientifically sound, community supported management plan. The new 2013 Action Plans present proposed activities for the next five years with the projected funding and expenditures when applicable. The Action Plans are the core of the Plan implementation. The five programmatic areas identified in 2008 remain in effect to guide the new Action Plans. These areas are: Water and Sediment Quality, Habitat Restoration and Enhancement, Public Use and Outreach, Interagency Planning and Coordination, and Funding. Goals identified in the 2008 management plans have been expanded and revised accordingly and they are summarized below:

Water and Sediment Quality Program

- Continue the water quality ambient monitoring program in the LWL for baseline purposes and trend analysis.
- Increase focus on decreasing inputs of suspended materials, and nutrients from point and nonpoint sources.
- Identify and reduce anthropogenic loadings of fecal contaminants and other pathogens Increase additional sanitary sewer, wastewater, and stormwater retrofit projects
- Manage sediments

Habitat Restoration and Enhancement and Restoration Program

- Restore and enhance seagrass beds, oyster habitat, emergent mangrove wetlands, coastal hammock habitat, and protective upland buffer zones.
- Add Living Shorelines to vertical seawalls to reduce wave-generated sediment resuspension and provide additional upland and hardbottom habitat.
- Construct artificial reefs that provide juvenile, intermediate and adult habitats required by the life cycle of estuarine and marine dependent fish and invertebrate species.
- Evaluate the status and protect sea turtles, manatees, and other endangered, threatened, and rare species, and species of special concern using the LWL.

Public Use and Outreach Program

- Strengthen LWL brand awareness.
- Increase citizen participation in water quality protection and habitat restoration efforts within the community.
- Expand LWL education and engagement opportunities for youth in Palm Beach County.

- Promote lagoon ecotourism opportunities to various audiences including local residents, school groups, convention and out-of-town guests.
- Expand interaction through social media.

Interagency Planning and Coordination

- Build partnerships with government agencies, municipalities and stakeholders for the implementation of the management plan.

Funding

- Re-establish the LWLPGP.
- Secure funding in State agencies' (line item) budget.
- Secure Federal Legislative authorization and funding for restoration project support through the U.S. Army Corps of Engineers.
- Aggressively pursue state and federal grant partnerships for lagoon improvement.
- Maintain existing levels of local funding sources to provide matching funds to accomplish more with public dollars.
- Promote public-private partnerships with the potential for bottom-line benefits for LWL businesses, Trusts, environmental organizations and others.
- Establish a LWL Restoration Fund (subset of the Pollution Recovery Trust Fund) to receive state fines levied for LWL watershed impacts to be applied towards lagoon restoration

The vision for the Lagoon and its management is attainable. At the core of this effort is the overall goal to improve and maintain this ecosystem. Today's challenges call for a new direction, one that involves all the stakeholders and secures commitments to the APs. As the Initiative strives to maintain the momentum in these fiscally challenging times, the need to rely on partnerships to leverage our limited resources, has never been more important.

UPDATED ACTION PLANS

The 2008 Plan presented a comprehensive series of actions to assist with its implementation. A total of 29 APs were proposed. Each AP contained a background of the issue being addressed, a step by step strategy on how to implement the plan, the cost, the schedule, and the expected benefits. The first task of the 2013 management plan was to review each of the 29 APs proposed in 2008, and to determine whether they should be kept and continue implementation on an ongoing or as needed basis, dropped from the plan because the action was determined to be completed or was no longer relevant, or revised the action item to reflect current conditions, knowledge and needs.

In this third update, several APs proposed in 2008 have been merged, modified or eliminated, while new actions have been added based on revised information and newly identified priorities. These modifications reflect new or emerging issues for the Lagoon management like Climate Change and sea level rise. New actions are underlined in the Index of Action Plans at the beginning of the document; merged, modified or retired actions also are noted in the Index. This update encompasses 23 Action Plans – 7 of them appearing in this Plan for the first time.

4. WATER AND SEDIMENT QUALITY

OVERVIEW

The recovery of the LWL ecosystem after decades of adverse impacts has been greatly increased since wastewater treatment technologies and reduction of point sources of pollution have been implemented. The rebound in water quality and ecological health of the LWL is even more significant in light of the strong population growth. The various restoration projects implemented in the LWL have offset to some degree the amount of pollutant loading from these sources, but the drainage that the Lagoon receives from its watershed is still significant, especially during storm events. Stormwater impacts, primarily suspended sediments, are believed to be the primary threat to the Lagoon. Local governments and agencies are already making significant investments each year in pollution prevention and stormwater improvements but a lot more needs to be done. Action Plans targeted specifically to improve and monitor the Lagoon water quality (WQ), and to reduce wastewater (WW), stormwater (SW), and sediments (SE) in the next five years, are outlined below and in Appendix C.

SUMMARY OF ACTIONS FOR WATER AND SEDIMENT QUALITY:

WQ-1 Water Quality Monitoring
Action Plan updated

~~WQ-2~~ Reduce the Occurrence of Municipal Sewer overflows
Action Plan on Hold – seeking partner sponsorship

WQ-3 Install Additional Sewage Pump-out Facilities for Recreational Boaters and Live-aboard Vessels
Action Plan updated

~~WQ-4~~ Improve Fueling and Bilge-Pumping Practices Among Recreational Boaters
Action Plan incorporated into WQ-3

WW-1 Identify Septic and Municipal Wastewater Loading to Lake Worth Lagoon
Action Plan updated

WW-2 Provide Additional Sanitary Sewer Connections to Priority Areas
Action Plan updated

SW-1 Reduce Discharge of Freshwater and Total Suspended Solids
Action Plan Updated

SW-2 Implement Best Management Practices on Golf Courses near the Lake Worth Lagoon
Action Plan Updated

SW-3 Identify and Increase Stormwater Retrofit Projects
Action Plan updated

~~SE -1~~ Substrate Characterization
Action Plan implemented and completed

~~SE -2~~ C-51 Basin and Lake Worth Lagoon Sediment Sourcing Study
Action Plan implemented and completed

SE -3 Manage Sediments in Lake Worth Lagoon
Action Plan updated

ACTION PLAN *Water & Sediment Quality*

WQ-1

Water Quality Monitoring

ACTION:
Continue monthly water quality monitoring of the Lake Worth Lagoon (LWL) at 14 fixed stations. Conduct trend analysis in five years and compare data to currently developed baseline.

BACKGROUND:
All the steps highlighted in the 2008 WQ-1 AP have been successfully implemented. The improved water quality monitoring program was expanded in 2007, with a total of twenty-two (22) sites of which 18 were actively monitored in the LWL within the past 5 years. A Monitoring Plan was created and the data stored in the centralized SFWMD Water Quality (WQ) database DBHydro, to be shared with local governments, State agencies and stakeholders. A formal interagency review of the Monitoring Network was conducted through an optimization study in 2011. Results of this evaluation concluded that four sites could be eliminated without compromising the information collected. In addition to monthly sampling, salinity data were also collected by high-frequency in-situ sondes for POR 2010-2012. Summary results are included in Chapter 2.

Monitoring the health of LWL is central to the success of the restoration and protection of the lagoon. An effective monitoring program provides the data necessary to assess the status and trends in the health and abundance of the lagoon's resources and habitats. Monitoring program data are used to evaluate progress towards restoration and protection goals of the Plan. The data are also used to evaluate the effectiveness of management strategies, the direct or indirect effect on the health of the ecosystem, and to indicate if the restoration goals in other APs have been met. Continuing the monitoring is an important goal of the management plan. Monthly water quality monitoring will continue at 14 fixed locations through a cooperative partnership between ERM, which collects the samples, and the SFWMD, which analyzes the samples and posts results on DBHydro.

STRATEGY:

STEP 1 Identify willing partners to assist in the long-term funding of the LWL WQ Monitoring Network.
Potential Partners: ERM, SFWMD, DEP

STEP 2 Conduct a 5 year evaluation in 2017 to determine status and trends and assess whether water quality and habitat projects have significantly impacted the lagoon's resources and habitats.
Potential Partners: ERM and SFWMD

STEP 3 Conduct a second interagency review of the Monitoring Network for further optimization.
Potential Partners: ERM and SFWMD

SCHEDULE:
Step 1 will be completed by FY'2014. Step 2 will be completed in 2017 and Step 3 will be initiated in 2017.

COST:
Annual costs for staff, equipment, material, and laboratory analysis are estimated at approximately $135,000 per year.

EXPECTED BENEFITS:
Determine current status of WQ and nutrient levels and provide data to evaluate impacts of measures to improve WQ in the LWL (i.e. TMDL, NNC, BMAP, BMPs). WQ results can be correlated with changes in SAV, oyster and sea turtle.

MONITORING ENVIRONMENTAL RESPONSES:
Data will be collected, analyzed and integrated with existing monitoring program.

REGULATORY NEEDS:
None anticipated. Although not mandated by the legislature, the data can be used in verification of other potential impairments such as Numeric Nutrient Criteria, TMDLs, BMPs, etc. that have not yet been verified due to lack of relevant data. In addition, the baseline developed from this monitoring program will provide information to evaluate impacts of both CERP and non-CERP related projects to the LWL and its wateshed.

FUNDING:
Monitoring is currently conducted through a partnership between the SFWMD and ERM based upon availability of resources. Additional funding sources may be needed in the future. ERM is committed to collect the samples for the next 5 years.

POTENTIAL PARTNERS AND FUNDING SOURCES*:

ERM, SFWMD, FDEP, Local governments

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals

ACTION PLAN *Water & Sediment Quality*

WQ-3

Install Additional Sewage Pump-out Facilities for Recreational Boaters and Live-aboard Vessels

ACTION:
Assist local governments in obtaining funding through the Florida Clean Vessel Act grant program to construct sewage pump-out facilities at publicly and privately marinas in the Lake Worth Lagoon (LWL).

BACKGROUND:
The Florida *Clean Marina* Program is a voluntary designation program under the Department of Environmental Protection (DEP) with a proactive approach to environmental stewardship. Participants receive assistance in implementing Best Management Practices (BMP) through on-site and distance technical assistance, mentoring by other *Clean Marinas* and continuing education. To become designated as a *Clean Marina*, facilities must implement a set of environmental BMP designed to protect Florida's waterways. These BMP address critical environmental issues such as sensitive habitat, waste management, storm water control, spill prevention and emergency preparedness. Designated facilities and those facilities seeking designation receive ongoing technical support from the Florida *Clean Marina* Program and the *Clean Boating* Partnership. Of the twenty clean marinas in Palm Beach County, thirteen are located on the LWL. Six have received the designation between 2008 and 2012. Three of them have added pumpout stations.

Human waste and associated pathogens can severely impact water quality and public health when discharged directly to water bodies. Providing more pump-out facilities will help reduce waste loads while encouraging boaters to become more responsible stewards of the LWL.

STRATEGY:

STEP 1 Identify and create a GIS map of potential future Clean Marinas
Potential Partners: FDEP, local governments, ERM and Marine Industries Association (MIA)

STEP 2 Encourage participation in the Clean Vessel Act grant program, Florida's Clean Marina program, which provides financial assistance to older marinas for installing sewage pump-out systems.
Potential Partners: FDEP, local governments, ERM, PBC Parks and Recreation Dept., MIA

STEP 3 Construct pump-out facilities or contract for portable systems.
Potential Partners: Local governments, marina owners, MIA

STEP 4 Identify the busiest marinas for outreach and educational purposes. Provide educational materials to boaters explaining the importance of pump-out facilities or portable systems and how to use them. Disseminate educational materials to boating clubs in the region making them aware of facilities.
Potential Partners: Local governments, local boating clubs, Lagoon Keepers, ERM, PBC Parks and Rec., MIA, West Palm Beach Fishing Club

STEP 5 Encourage registered boat owners to install fuel overfill protection devices and fuel-water and oil-water separators in automatic bilge pumps.
Potential Partners: FDEP, U.S. Coast Guard Auxiliary, MIA, Lagoon Keepers

STEP 6 Promote educational materials and "Clean boater pledge" to recreational boaters.
Potential Partners: FDEP, U.S. Coast Guard Auxiliary, Lagoon Keepers, in cooperation with ERM, PBC Parks and Rec.

SCHEDULE:
DEP will enlist the organizations listed above to evaluate on-going programs and material, and develop a plan to implement the steps outlined.

COST:
Installation and construction costs vary depending on type of equipment selected. According to FDEP, costs for stationary or portable pump-out units range from approximately $2,000 to $6,000. Costs for a portable toilet waste station may vary from $1,100 to $1,800. State grants could pay up to 75 percent of the construction costs. In addition, construction and maintenance costs could be recouped by charging boaters a minimal user fee. If DEP funds are utilized, a maximum charge of $5.00 per service can be requested by these marinas for the next five years.

Costs to develop and distribute educational materials will be determined based on format selected, but should be accomplished through existing resources or available grants.

EXPECTED BENEFITS:
Providing sewage pump-out services for boaters will help reduce pathogens as well as nitrogen and solids in the LWL.

MONITORING ENVIRONMENTAL RESPONSES:
Use of the pump-out stations through sales' receipts can be tracked to determine effectiveness. Receipts will be submitted to the FDEP's Clean Marina program.

REGULATORY NEEDS:
None anticipated, with the exception of the FDEP authorization. These facilities are

typically given a deminimus exemption.

FUNDING:
FDEP, Florida's Clean Vessel Act grant program, Florida's Clean Marina program, Palm Beach County Boater Registration, Pollution Recovery Trust Fund (PRTF)

POTENTIAL PARTNERS AND FUNDING SOURCES*:

FDEP, Local governments, ERM, PBC Parks and Rec., MIA, FIND

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals

ACTION PLAN *Water & Sediment Quality*

WQ-5

Provide a Pump-out service to Live-aboard Vessels and Other Boat Owners

ACTION:
Provide sewage removal from vessels within the Lake Worth Lagoon (LWL) to live-aboard vessels through a pump-out boat.

BACKGROUND:
While no significant progress has been made on this AP since 2008, its importance cannot be overlooked. Pump-out boats can make a difference in maintaining water quality in LWL. Human waste and associated pathogens can severely impact water quality and public health when discharged directly to water bodies. A pump-out boat is a boat that pulls up to other boats and empties their waste tank into a holding tank on the pump-out boat. The pump-out boat takes the waste to a fixed unit on a dock or shore area and unloads the waste into sewer lines. Providing this service would help reduce waste loads while encouraging boaters to become more responsible stewards of the LWL.

Martin County has been very successful in establishing a County program that provides a free pump-out service to customers. The pump-out boat was purchased with grants from the Florida Department of Environmental Protection (FDEP) Clean Vessel Act grant program (as part of the Clean Marina Program), and the Florida Inland Navigation District (FIND). The grants paid for 75% of the initial start-up costs. Below are the highlights of this program:

- The pump-out boat is stationed in one of the marinas in Manatee Pocket Bay. Customers can arrange for service either by VHS marine radio channel or cell phone.
- Waste is transported to a county operated wastewater treatment facility.
- There is no charge for this service; however donations are accepted to help defray the cost of operating this program.

Since the inception of this program in 2000, approximately 165,000 gallons of raw sewage have been safely disposed through this operation.

STRATEGY:

STEP 1 Obtain a funding commitment from potential partners for the implementation of this program.
Potential Partners: MIA, FIND, PBC or Municipalities

STEP 2 Apply for FDEP grants to offset start-up costs.
Potential Partners: Applicants

STEP 3 Identify a public or municipal marina to dock the pump-out boat and bid out contract for services.
Potential Partners: Applicants

STEP 4 Provide educational materials to boaters explaining how to use this new service and the importance of pump-out boats. Disseminate educational and cruising guide materials to boating clubs in the region.
Potential Partners: MIA, FDEP, PBC, Local governments, local boating clubs, Lagoon Keepers

SCHEDULE:
Interested parties will apply for the FDEP reimbursement grant once a commitment to the program has been finalized by the sponsoring Partner. The organizations listed above will be enlisted to evaluate educational materials and to implement the steps outlined.

COST:
The annual cost to run this program is estimated to be $70,000/year. This amount includes a full-time contractor to run the service, and the associated costs for docking fees.

EXPECTED BENEFITS:
Providing sewage pump-out service for boaters will help reduce pathogens as well as nitrogen and solids in the LWL.

MONITORING ENVIRONMENTAL RESPONSES:
Disposal receipts can be tracked to determine pump out volume. Receipts will be submitted to the FDEP's Clean Marina program.

REGULATORY NEEDS:
None anticipated.

FUNDING:
FDEP, Florida's Clean Vessel Act grant program, Florida's Clean Marina program, Palm Beach County Vessel Registration Fee, FIND grant program, PRTF.

POTENTIAL PARTNERS AND FUNDING SOURCES*:

FDEP, MIA, PBC, FIND, Local governments

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals

ACTION PLAN *Water & Sediment Quality*

WW-1

Identify Septic and Municipal Wastewater Loading to Lake Worth Lagoon and associated watershed

ACTION:
Identify and evaluate loading rates associated with sewage spills, septic systems, small wastewater treatment plants, and the potential loading from expanded land application of reclaimed water within the area surrounding the Lake Worth Lagoon (LWL).

BACKGROUND:
Nutrient levels and bacteriological contamination within the LWL continue to be a priority in this AP. By identifying the sources and locations of potential nutrient and bacteriological contamination, strategies can be developed to assess impacts, evaluate reduction options and implement improvements when justified. Some progress has been made on this AP since 2008. Two facilities discharging raw sewage into the LWL were discovered and required to connect to the existing sanitary sewer systems. The AP will continue to focus on wastewater discharges and disposal associated with the following:

- Direct releases of untreated sewage as a result of an aging sewer infrastructure system and storm related events.

- Seventeen (17) small domestic wastewater treatment plants operating within the area and the two that are authorized to discharge treated effluent directly to the LWL via the Spanish River.

- Areas around the LWL that remain on septic systems for wastewater treatment and disposal with no sewer option.

- Increased use of reclaimed water and treated effluent for landscape irrigation within the area surrounding the LWL, including direct discharge into stormwater management lakes.

In 2009 the Department of Health (DOH), at request of the Florida Legislature, conducted a study that inventoried locations of known septic tanks in each County using their existing databases associated with septic tank permitting, as well as information gathered from the collection systems for wastewater treatment plants regulated by the Department of Environmental Protection (DEP). This study was a snapshot intended to be used as part of a larger management program for septic systems. The management program was established in 2008; however the scope of the program was reduced in 2012

with the emphasis on protecting Florida's springs within specific counties. The DOH's inventory was used to produce a relational database with individual septic tank locations identified. Additional work would be useful to refine the GIS map around the LWL to validate and update the wastewater disposal information. Reclaim water use locations need to be mapped. Additionally, stormwater management lakes receiving reclaimed water and reclaimed water land application sites need to be mapped. Correlations between water quality, domestic wastewater treatment plants, septic tanks and reclaimed water use and their effects on the environment need to be studied. Currently FDEP and SJRWMD are working on a project to understand the possible effect of reclaimed water application to the environment regarding Nitrogen. This study could provide useful information potentially applicable to the LWL.

Bacteriological contamination at some level is common in all surface waters. Sources of the contamination include stormwater contaminated with wildlife and domestic animal waste, releases of untreated sewage from the aging sewer infrastructure system through leaking/broken pipes and overflows, and the release, either directly or indirectly, from wastewater plants, septic systems and the pathogenic contamination of reclaimed water. The AP calls for a review of current knowledge regarding the environmental impacts of these sources and identification of the appropriate actions to be taken. The actions may include additional source tracking and/or epidemiological studies to quantify the human health risks associated with the levels of contamination within the LWL. Once problem areas or sources have been identified, it may be appropriate to survey for a variety of traditional and alternative indicators, including bacteriological source tracking, sucralose, coliphage testing (for the presence of viruses and indication of recent fecal pollution) and direct pathogen monitoring for viruses and parasites as the sampling technology allows.

STRATEGY:

STEP 1 Update ArcGIS files to show areas where sanitary sewer has been installed, areas where only septic tanks are in use and mixed areas where sanitary sewer has been installed and the use of septic tanks is being phased out. Also map areas where reclaimed water is being land applied within the watershed. Compile data into spatial database.
Potential Partners: ERM, FDOH, PBCHD, FDEP, PBC Utilities, and Municipalities

STEP 2 Implement a bacteriological assessment of the LWL and associated watershed to identify areas where contamination levels are above surface water quality standards or at levels classified as "Poor" under the U.S. Environmental Protection Agency's Healthy Beaches Program.
Potential Partners: ERM, FDOH, PBCHD, PBC Utilities, HBOI/FAU, EPA, and Municipalities

STEP 3 Evaluate sources that discharge wastewater directly or indirectly into LWL, quantify levels, and develop reports detailing sewage spills, wastewater plant

discharges and estimated septic system discharges and land application of reclaimed water usage within the LWL area.
Potential Partners: ERM, FDEP, FDOH, PBCHD, PBC Utilities, and Municipalities

STEP 4 Generate recommendations, based on steps 1-3, for sewer utilities to upgrade or replace aging sewer infrastructure and expand sewer coverage into areas with large concentrations of septic systems. Generate recommendations for land applied reclaim water in specific areas where it is a contributing factor for pollution.
Potential Partners: ERM, DOH, PBCHD, PBC Utilities, FDEP

SCHEDULE:
Step 1 – 6 Months from Project Initiation.
Step 2 – 24 Months from Project Initiation.
Step 3 – 18 Months from Completion of Step 1.
Step 4 – 6 to 12 Months from completion of Steps 2 and 3.

COST:
Step 1: $25,000. Labor
Step 2: $225,000. Labor, Equipment, Materials, and Laboratory Support.
Step 3: $45,000. Labor and Materials.
Step 4: $10,000. Labor and Materials.
Total Cost: $305,000.

EXPECTED BENEFITS:
Assess the nutrient and bacteriological contamination levels within the LWL, identify sources contributing to the contamination and identify potential corrective actions where needed. Ultimately, these sources can be reduced and/or eliminated reducing nutrient and bacteriological/pathogenic input to receiving water bodies thus improving the overall quality of the LWL and reducing public health risks.

MONITORING ENVIRONMENTAL RESPONSES:
Data will be collected, analyzed and integrated with the existing water quality monitoring program.

REGULATORY NEEDS:
Not applicable.

FUNDING:
Funding sources need to be identified. The Pollution Recovery Trust Fund (PRTF) and DEP grants or loans could be considered for some of these steps. NOAA FACE monitoring program has funded some monitoring and analysis at SLWI and expansion of that work should be considered.

POTENTIAL PARTNERS AND FUNDING SOURCES*:

PBC, FDEP, DOH, PBCHD, EPA, SFWMD, HBOI/FAU, NOAA FACE Program, Local Municipalities.

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals

ACTION PLAN *Water & Sediment Quality*

WW-2

Provide Additional Sanitary Sewer Connections to Priority Areas

ACTION:
Provide sanitary sewer connection to a regional wastewater treatment plant to priority areas of Lake Worth Lagoon (LWL) and its watershed now served by septic systems or small domestic wastewater treatment plants.

BACKGROUND:
Many homes constructed around LWL still use septic systems for wastewater treatment and disposal. Many of these homes were built during the 1950's, prior to centralized sanitary sewer availability in the area. Other communities adjacent to the LWL do not have wastewater treatment plants and are not located near central sewer lines, or have elected to remain on septic systems. In addition, several small condominium and homeowner associations operate and maintain private wastewater treatment plants. While septic systems and small wastewater plants provide sewage treatment to a degree, elimination of the effluent streams offers an additional reduction of nutrient and bacteriological loadings to the LWL. While the nitrogen and bacteriological loading associated with domestic wastewater is a concern, so are other chemicals including phosphates and "emerging contaminants" such as pharmaceuticals and metabolites within these waters.

Older septic systems dominate in the largely residential communities bordering the shore of LWL, and efforts to convert portions of these neighborhoods to sanitary sewer service are underway. Several communities are either converting to sanitary sewer or have plans to make the conversion. Conversion from septic to sewer service can be costly, with residential hookup fees as high as $7,000 or more with sewer and water hookups. These fees are even higher for condominiums and homeowner associations looking to connect versus continuing to operate their small wastewater plants. The need for financing options such as interest-free loans, or low cost and cost-sharing grants to assist residents in areas slated for conversion is an issue. PBC Water Utilities Department offered a 20 years low monthly Deferred Payment Plan (DPP) option to property owners for the connection costs in the recently completed Westgate project (Appendix B). Monthly fees range between $27.21 and $46.58 for single family homes. These costs are included in the monthly water and wastewater bill.

Additionally, the availability of regional sewer service can allow higher density development in environmentally sensitive areas, or in municipalities that don't want high-rise condominiums, an issue local governments must consider in their long-term

planning.

Alternatives to traditional septic systems exist and can be put into use when sanitary sewer in the environmentally sensitive area surrounding the LWL cannot be used. Such a program exists within the Florida Keys which requires Performance-Based systems which meet secondary and advanced secondary treatment standards. The Department of Health (DOH) is currently conducting a legislatively mandated study to develop cost-effective, passive strategies for nitrogen reduction for onsite sewage treatment and disposal systems. This project is scheduled to be completed in 2015 and may provide cost-effective nitrogen reduction strategies that will improve environmental and public health protection.

STRATEGY:

STEP 1 Review data from GIS geodatabase for locations of the small wastewater treatment plants, areas with sanitary sewer, and areas with only septic systems in conjunction with a review of the surface water quality data as well as data from Florida's Healthy Beaches program to determine if correlations exist.
Potential Partners: ERM, PBCHD, PBC Utilities, and Municipalities

STEP 2 Utilize the technical working group established by the Palm Beach County Water Resources Task Force to prioritize problem areas for feasibility analysis of conversion from septic to sanitary sewer.
Potential Partners: FDEP, PBC, DOH, HBOI/FAU, FDEP, Municipalities

STEP 3 Monitor progress in the project area and determine whether further research is needed:
a. Track construction of new sanitary sewer lines and service within the LWL area.
b. Assess opportunities for the removal of small wastewater plants or additional connections to these plants from near-by septic systems.
d. Identify areas where additional research is needed to quantify level of impacts, to confirm human fecal contamination, and to trace sources or associated human health risks (hot spots).
e. Obtain funding and conduct studies to confirm impacts.
g. Evaluate alternatives to centralized sanitary sewer systems in environmental sensitive areas.

STEP 4 Identify and secure funding for eliminating septic systems and small wastewater plant systems contributing to poor water quality.
Potential Partners: All Partners.

STEP 5 Increase educational outreach in problem areas to encourage proper operation and maintenance of septic systems, and encourage hook-up to central service where it is available.

SCHEDULE:
PBC to convene working groups as noted above during 2013-2014.

COST:
To be determined.

EXPECTED BENEFITS:
Reduced nutrient and bacteriological loading to the LWL and increased treatment of existing wastewater streams. Ultimately, these sources can be reduced and/or eliminated reducing nutrient and bacteriological input to receiving water bodies thus improving the overall water quality of the LWL and reducing public health risks.

MONITORING ENVIRONMENTAL RESPONSES:
Data will be collected, analyzed and integrated with existing PBC and PBCHD Healthy Beaches water quality monitoring program.

REGULATORY NEEDS:
Not applicable.

FUNDING:
Funding sources need to be identified.

POTENTIAL PARTNERS AND FUNDING SOURCES*:

PBC, FDEP, DOH, HBOI/FAU, EPA, NOAA FACE Program, Local Municipalities, SFWMD.

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals

ACTION PLAN *Water & Sediment Quality*

SW- 1

Reduce Discharge of Freshwater and Total Suspended Solids

ACTION:
Reduce large volumes of freshwater and suspended sediment discharges through the C-51 Canal.

BACKGROUND:
The purpose of the Loxahatchee River Watershed Restoration Project *(formerly known as North Palm Beach County - Part 1)* is to capture, store and treat excess water that is currently discharged to the LWL and use that water to enhance the Loxahatchee River and Slough and provide for water supplies to the City of West Palm Beach Grassy Waters Preserve. While significant progress has been made on the planning side for this CERP project since 2008, a state-federal initiative to speed up planning for key CERP projects was approved in October 2011. This new initiative re-focused a lot of projects on the Central Everglades Planning Project (CEPP), with a goal to deliver within two years a finalized plan for a suite of restoration projects in the central Everglades, not in the LWL (www.evergladesplan.org). For this reason this AP was revised and updated to reflect this new reality. However, several efforts to benefit the LWL that are not part of CERP are still planned.

In 2012, the State of Florida and the U.S. Environmental Protection Agency reached a consensus on a new strategy for improving water quality in the Everglades. Under this strategy, SFWMD is implementing a technical plan to complete six projects that will create more than 6,500 acres of new STAs and 110,000 acre-feet of additional water storage through construction of flow equalization basins (FEBs). FEBs provide a more steady flow of water to the STAs, helping to maintain desired water levels needed to achieve optimal water quality treatment performance. This flow diversion and water storage that includes the L-8 Reservoir should decrease flow from the C-51 canal, which is still the most significant source of freshwater to the LWL. The SFWMD, LWDD, PBC and affected municipalities are evaluating additional water storage options that may involve the construction of the C-51 Reservoir, for which cost benefit analyses are being conducted. Reducing flow, nutrient and suspended sediment loads to LWL will maximize the potential growth of such valued ecosystem components (VECs) as oysters (*Crassostrea virginica*), and seagrasses (represented by *Halophila decipiens*, *H. johnsonii*, and *Halodule wrightii*). These species are key estuarine components currently present in LWL but impacted by anthropogenic stressors.

STRATEGY:

STEP 1: Quantify reduction of rate and/or volume of freshwater to the LWL from the six projects and new STAs through modeling and share results with LWL stakeholders.
Potential Partners: SFWMD, ERM

STEP 2: Assess sediment loads to the LWL from inflow structures C-17, C-51, and C-16 and other available stormwater structures.
Potential Partners: SFWMD, ERM

STEP 3: Utilize deployed in-situ sondes salinity data to establish a correlation with flows and VECs.
Potential Partners: SFWMD, ERM

STEP 4: Resume annual surveys of the C-51 Canal and sediment trap to correlate discharge rates at the S-155 and determine sediment trap maintenance schedule.
Potential Partners: SFWMD, ERM, City of WPB

STEP 5: Conduct a feasibility study and create options for sediment reduction prior to entering the LWL. Options include creation of new sediment traps, canal dredging above the S-155 structure, and stormwater treatment facilities.
Potential Partners: SFWMD, ERM

SCHEDULE:
Steps 1 will be implemented by 2013. Step 2 will be initiated in 2013. Step 3 is currently on-going. Step 4 will be initiated by October 2013.

COST:
The total cost of the six FEBs projects with all its components is estimated to be $800 million; the proposed Steps 1 through 3 and step 5 is cost for staff time estimated at $5,000/year. The annual cost for Step 4 is estimated to be $20,000. A new C-51 dredging/sediment trap project is estimated to be $3 million.

EXPECTED BENEFITS:
Improve the quality of water released to tide by promoting establishment, maintenance, and sustenance of a healthy, well-balanced assemblage of estuarine flora and fauna. Reservoirs, aquifer storage and recovery units, and storm-water treatment areas (STAs) planned as part of FEBs are expected to reduce loadings of nutrients, solids and contaminants to the LWL.

MONITORING ENVIRONMENTAL RESPONSES:
Monitoring of water quality, salinity, SAV, oyster health in the lagoon, and in the C-51

Canal and at the site of implemented FEBs, will allow an evaluation of this focused approach to improving water quality and TSS in the LWL.

REGULATORY NEEDS:
Permits required by FDEP or SFWMD and USACE.

FUNDING:
Funding for FEBs is contingent upon yearly State annual appropriations. Other sources of funding will be pursued.

POTENTIAL PARTNERS AND FUNDING SOURCES*:

SFWMD,USACE, ERM, FDEP, PBCWU, LWDD, HBOI/FAU and municipalities.

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals

SW- 2 *Water & Sediment Quality*

Implement Best Management Practices on Golf Courses near the Lake Worth Lagoon

ACTION:
Encourage Golf Courses located near the Lake Worth Lagoon (LWL) to implement Best Management Practices (BMPs) to minimize pollution and reduce stormwater runoff.

BACKGROUND:
A typical 18-hole golf course requires three to four tons of various germicides, herbicides, and pesticides every year to keep the green and fairways healthy, to combat weeds, and kill insects. The nitrogen and phosphorus in the fertilizers mix with rainwater and eventually flow via runoff to the nearest waterbody. The high nutrient content in the water can stimulate the growth of algae. There are 13 golf courses adjacent or close to the LWL. Engaging these golf courses in practicing BMPs is one the goals of this action plan.

In January 2007, Florida Department of Environmental Protection (FDEP), in collaboration with the Florida Golf Course Superintendents Association, the University of Florida and many private sector partners, released an updated edition of *Best Management Practices for the Enhancement of Environmental Quality on Florida Golf Courses*. The manual aims to develop guidelines for minimizing pollution and conserving Florida's water resources. It provides the superintendent or golf course operator with sound management strategies to maintain the golf course in a positive manner with respect to environmental protection, water quality protection, and conservation. It is also intended to provide elected officials, regulators, developers, and others with an overview of golf course management practices and how they relate to environmental issues. A comprehensive program of BMPs should include a combination of components that are properly selected, designed, operated, and maintained. BMP options should be screened for feasibility based on the following factors:

- Physical and technical limitations,
- Operational and management limitations,
- Pollutant reduction/water conservation effects,
- Profitability/cost considerations,
- Other benefits or disadvantages, and
- Public acceptance.

While no progress has been made since 2008, there is a renew interest by stakeholders to work on some of the following steps.

STRATEGY:

STEP 1 Provide Golf Courses along the LWL with the BMP manual developed by FDEP and encourage them to adopt it and implement the following BMPs' priorities:

1. To correct any identified existing water quality/quantity problems.

2. To minimize water quality/quantity problems resulting from land use and operations.

3. To improve the effectiveness of existing BMPs implemented.

4. To seek additional improvement of BMPs based on new, quantifiable information.

Responsible parties: LWL Outreach Advisory Committee (OAC)

STEP 2 Monitor the environmental effects of implemented BMPs along the LWL.
Responsible parties: Participating Golf Courses with FDEP assistance

STEP 3 Develop new BMPs or revise existing implemented BMPs to further improve water quality, and reduce stormwater runoff to the lagoon.
Responsible parties: Participating Golf Courses with FDEP assistance

SCHEDULE:
Step 1 will be implemented during 2008. Step 2 will be initiated after BMPs implementation according to FDEP guidelines. Step 3 will be initiated after monitoring results are available.

COST:
Initial costs would be minimal since this manual is available on-line and can be duplicated on CD. Since most golf courses already have routine maintenance programs, this action could help to direct expenditures to areas where specific problems have been identified, and seek funding for maintenance and upgrades to these systems. Additionally, an aggressive preventive maintenance program may prove most cost-effective in the long run.

REGULATORY NEEDS:
None anticipated. In the event that these BMPs are adopted by rule, as provided by Subsection 403.067(7)(c)1, Florida Statutes (F.S.), certain protection from liabilities may be established through the voluntary implementation of BMPs that have been verified by FDEP to be effective in protecting water quality.

FUNDING:
To be determined.

EXPECTED BENEFITS:

Improved BMP's and pollution prevention standards will reduce the amount of fertilizer, pesticide, and nutrients being introduced into the LWL through stormwater runoff and provide increased water quality conditions.

POTENTIAL PARTNERS AND FUNDING SOURCES:

FDEP, IFAS, SFWMD, Environmental Education Centers, Lagoon Keepers

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals

ACTION PLAN *Water & Sediment Quality*

SW- 3

Identify and Increase Stormwater Retrofit Projects

ACTION:
Identify and increase the number of stormwater retrofit projects to benefit water quality of Lake Worth Lagoon (LWL).

BACKGROUND:
Stormwater pollution is one of the most significant threats to LWL. Much of the urban and coastal area surrounding the lagoon was developed before the 1980's when stormwater treatment standards began to be required. As a result, much of the stormwater discharged is untreated. Because of the density of development, the lack of vacant land is a major limiting factor in the ability to treat stormwater. The coastal basin is particularly challenging, but has a direct impact on the lagoon. As a result, more innovative and expensive treatment technologies are required. Since 2008 $6.8 million in LWLPGP grants were matched by $8.0 million in local funds to construct over $14.8 million in restoration and water quality projects. Three stormwater treatment projects have been implemented within the LWL watershed treating runoff from more than 526 acres that was previously untreated and discharged directly to the LWL. The use of pollution control devices, stormwater ponds, wetland treatment, and treatment swales has reduced the amount of nutrients, sediments, and heavy metals entering LWL.

In PBC, NPDES stormwater regulations require that local governments are issued NPDES stormwater permits to reduce to the maximum extent possible the discharge of pollutants both into and from municipal separate storm sewers to "Waters of the U.S." This is accomplished through the implementation of an approved stormwater management plan, which addresses the various aspects of how pollutants reach municipal storm sewers. This action plan calls for identifying areas and outfalls that are not part of the NPDES Municipal Separate Storm Sewer System (MS4) permit, and that are not currently mapped in Map Direct database from FDEP. Some of these outfalls have little or no treatment before discharging to LWL or a receiving water body that discharges to LWL. Identifying potential treatment solutions, and identifying funding sources for the construction of the most effective stormwater treatment projects is a priority for this AP.

STRATEGY:

STEP 1 Identify and collect ArcGIS compatible data of existing outfalls not currently mapped that discharge to the LWL or receiving water body in the watershed and integrate them with Map Direct. Develop spatial coverage of areas with no stormwater treatment and produce LWL maps depicting outfalls with

natural resource coverage and land use.
Potential Partners: ERM, FDEP, SFWMD, PBC NPDES Program

STEP 2 Prioritize stormwater basins in need of retrofits based on size of drainage basin, loading, proximity to the lagoon, potential for pollutant reduction, cost, impacts to natural resources, and other factors.
Potential Partners: ERM, FDEP, SFWMD, PBC NPDES Program

STEP 3 Identify and provide funding mechanisms and grant opportunities to implement retrofits in high priority locations.
Potential Partners: ERM, PBC NPDES Program, FDEP, SFWMD

STEP 4 Allocate funds to targeted stormwater retrofit projects in high priority locations.
Potential Partners: ERM, FDEP

SCHEDULE:
Steps 1 through 2 will be implemented by 2013. Step 3 to be completed by 2014. Step 4 will be completed after Step 3.

COST:
The anticipated cost of the ArcGIS coverage of stormwater outfalls and project prioritization is $50,000. The potential cost of constructing a major municipal stormwater treatment system is $5 million. This number was based on the City of West Palm Beach Stormwater Master Plan.

EXPECTED BENEFITS:
Improve water quality by treating stormwater before entering LWL. Reduction in TSS, nutrients, and metals is anticipated.

MONITORING ENVIRONMENTAL RESPONSES:
Data will be collected, analyzed and integrated with existing water quality monitoring program.

REGULATORY NEEDS:
Permits are required by SFWMD after FDEP review.

FUNDING:
Funding sources to be determined. Potential grants and program: Florida Section 319 Grants, TMDL Water Quality Restoration Grants; Potential Stormwater Utility Development; PRTF

POTENTIAL PARTNERS AND FUNDING SOURCES*:

SFWMD, ERM, FDEP, Municipalities, PBC NPDES Program, EPA

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals

ACTION PLAN *Water & Sediment Quality*

SE-3

Manage Sediments in Lake Worth Lagoon

ACTION:
Implement new projects for capping of muck sediments in Lake Worth Lagoon (LWL) to create sandy submerged bottom habitat, potential oyster or seagrass habitat, or emergent mangrove habitat, or to prevent resuspension of fine-grained sediments.

BACKGROUND:
All the steps highlighted in the 2008 SE-3 AP have been successfully implemented. In 2010, ERM completed the 8-acre Ibis Isle Restoration Project which successfully capped 30,000 cubic yards of muck sediments immediately east of the C-51 Canal. The planted cordgrass and mangroves have prospered and recruitment of oysters, seagrass and additional mangroves has occurred. Since completion, the project has provided foraging habitat for manatees and at least 44 different species of wading birds and shorebirds, as well as spawning habitat for horseshoe crabs. The capping technique developed during the Ibis Isle project will be used to complete the 22-acre Grassy Flats Restoration Project immediately south of Ibis Isle. The Grassy Flats Project will capture and contain approximately 30,000 cubic yards of additional muck sediments and result in seagrass habitat and two intertidal islands consisting of mangrove, tidal marsh, tidal flat, and oyster habitats.

Muck sediments continue to blanket large areas of the LWL, covering the bottom with an anaerobic substrate inhibiting seagrass growth and negatively impacting the diversity of the benthic community. These fine-grained sediments are easily resuspended by wind and wave action, increasing turbidity and attenuating light penetration, thereby further impacting the lagoon environment. Dredge holes created during the process of shoreline development often contain large volumes of muck sediments at times deep as 10 feet. Muck also covers expansive shallow bottom areas in the central lagoon. Capping of muck will contain these sediments to prevent their resuspension and can provide habitat for seagrass, oysters, and/or mangroves.

STRATEGY:

STEP 1 Identify funding and sand sources for Grassy Flats project. Construct project and implement monitoring program.
Potential Partners: PBC, USFWS, FWC, FIND, USACE, LWLPGP, FDEP

STEP 2 Identify additional potential sites for sediment capping and initiate permitting. Candidate sites shall include dredge holes with low habitat value as well as thinner deposits or depressions where elevations may be increased for

recruitment of seagrass.
Potential Partners: ERM, HBOI/FAU

STEP 3 Implement additional sediment capping projects in LWL.
Potential Partners: ERM

SCHEDULE:
STEP 1 to be completed during 2012-2013. **STEP 2** to be completed by 2014.

COST:
$2.6 million

EXPECTED BENEFITS:
Conversion of muck deposits to suitable habitat for environmental restoration. Habitat includes seagrass, oysters, mangroves, and cordgrass. Capping of fine-grained muck deposits will reduce resuspension of material directly improving water quality.

MONITORING ENVIRONMENTAL RESPONSES:
Both pre- and post-construction monitoring (water clarity, seagrass coverage, benthic invertebrates) will be required to assess the positive impact of the project.

REGULATORY NEEDS:
Environmental Resource Permits will be required from USACE and SFWMD or FDEP.

FUNDING:
Funding sources to be determined. Potential funding mechanisms include SFWMD, FDEP, NMFS, FIND and USACE

POTENTIAL PARTNERS AND FUNDING SOURCES*:

SFWMD, USFWS, EPA, USACE, NMFS, PBC, LWLPG, FIND, FWC, FDEP (SEFCRI), HBOI/FAU

*Listed Agencies have not committed funds and are subject to Agencies' budget approval

5. HABITAT RESTORATION ENHANCEMENT AND MONITORING

OVERVIEW

The restoration and protection of the diverse habitats within the LWL is crucial to the lagoon's health. Increasing and preserving the quantity, quality and diversity of these communities are the long-term goals of this management plan, which are accomplished through the individual APs for habitat creation and monitoring of system status. In the 2008-2012 timeframe, great progress has been made with the implementation of the Habitat APs, over 70 acres of wetland habitat have been created, protected and restored within the lagoon through the completion of 12 habitat restoration projects: 14 acres of oyster reef, 41 acres of mangrove/spartina, 11 acres of seagrass, and 5 acres of artificial reef habitat.

The Habitat Restoration and Enhancement program goals for the 2013-2017 timeframe strive to increase habitat acres at the same magnitude of the previous decade. The overall target within the next five years is to continue restoration of 14 habitat acres/year or 70 acres over 5 years. In addition to creation, restoration and protection of the lagoon's existing mangrove and seagrass resources, submerged lands and wetland acquisitions remain a part of the overall restoration plan. These goals will be accomplished through a portion of 35 specific projects that are outlined in **Appendix C**. The proposed projects include creation of: intertidal wetlands, oyster reefs, artificial reefs, seagrass habitat through dredged hole filling and living shorelines.

Updating the PBC Manatee Protection Plan remains one of the Action items in the revised Plan, and is included for the reason that habitat restoration is a key component of the manatee plan. Monitoring is also an important component of the *Habitat Restoration and Enhancement* program and has been incorporated in a series of specific Action Plans. A summary of these plans for Habitat Enhancement (HE) and Environmental Monitoring (EM) is outlined in the following paragraph:

SUMMARY OF ACTIONS FOR HABITAT RESTORATION ENHANCEMENT AND MONITORING IN LWL

HE - 1 Expand Oyster Reef Habitat – *Updated*
HE - 2 Restore, Create and Protect Mangrove and Spartina Habitats – *Updated*
HE - 3 Implement Palm Beach County Manatee Protection Plan – *Updated*
HE - 4 Develop Seagrass Restoration Target and Restore Habitat – *Updated*
HE - 5 Expand Reef Habitats – *Updated*
HE - 6 Acquisition of Submerged and Intertidal lands in Lake Worth Lagoon – *Updated*
HE - 7 Enhance Resilience and Sustainability to Climate Change – *New*
EM - 1 Implement Sea Turtle Monitoring– *Updated*
EM - 2 Develop a Fish Monitoring Program – *Updated*
~~EM -~~ 3 Develop a SAV Monitoring Program – *Action Plan incorporated into HE-4*

ACTION PLAN *Habitat Restoration Enhancement and Monitoring*

HE-1

Expand Oyster Reef Habitat

ACTION:
Increase the Lake Worth Lagoon (LWL) oyster population through enhancement of impacted habitat.

BACKGROUND:
All the steps highlighted in the 2008 HE-1 AP have been successfully implemented. A five acre oyster reef pilot project was constructed in central Lake Worth Lagoon in 2009, with an additional 5 acres to be placed in 2013. This newly created oyster reef habitat adjacent to John's Island, consists of limestone boulders placed in discrete piles with open space to allow water flow. The reef has colonized with oyster spat and continues to develop and support a thriving oyster and fisheries community. Other restoration projects constructed with an oyster reef component include Boynton Beach/Ocean Ridge Riprap, Ibis Island Restoration, Lantana Oyster Reefs, South Cove Natural Area, Snook Island's II and Bryant Park Wetlands Restoration. Since 2008, a total of 14 acres of oyster reef has been added to LWL.

Step 3 of the 2008 AP was accomplished with the development and implementation of an oyster monitoring plan designed to track oyster recruitment and health on natural and created oyster reefs within the lagoon. ERM, in cooperation with Harbor Branch Oceanographic Institute (HBOI) at Florida Atlantic University, initiated a two year study to determine the health and productivity of three reef sites (2 natural/1 created), and the potential for creating additional oyster reef habitat in these locations. The oyster monitoring study set a solid framework for future monitoring and concluded, in part, that the LWL is a productive system with patches of healthy oyster beds that provide the recruitment necessary to seed large and small restoration projects (detailed in Chapter 2). It had been hypothesized that LWL is substrate limited. This study further concluded that the addition of substrate to provide oyster reef in LWL should be successful, improve water quality, provide erosion control and increase habitat for associated species. In the future, consideration should also be given to expanding mollusk restoration activities to other species to diversify the restoration effort.

STRATEGY:

STEP 1 Identify new project sites for optimum oyster reef placement
Potential Partners: ERM, HBOI/FAU

STEP 2 Create additional oyster habitat
Potential Partners: ERM

STEP 3 Identify willing partners to assist with conducting and expanding the LWL Oyster Monitoring program
Potential Partners: ERM, SFWMD, FWC, HBOI/FAU

SCHEDULE:
Step 1 will be initiated in 2013. Step 2 material placement will be implemented upon completion of Step 1. Step 3 oyster monitoring protocols have been established but needs funding and agency participation to build upon the established baseline.

COST:
Construction of 14 acres oyster reef over 5 year period: $3.5 million
Staff time involved in project design and management: $350,000
Oyster Monitoring Program costs: $75,000/year

EXPECTED BENEFITS:
Habitat enhancement, water quality improvements and erosion control by the placement of material to promote oyster recruitment in substrate limited areas of LWL. The oyster reefs will add high quality complex habitat in the lagoon, which supports oyster recruitment and associated species such as other invertebrates, fish and birds.

MONITORING ENVIRONMENTAL RESPONSES:
Annual monitoring will be conducted by ERM and FWC staff to assess aerial extent and health of oysters on deployed substrate.

REGULATORY NEEDS:
Permits for construction are required by FDEP or SFWMD and USACE. Legislation to streamline the permitting process, for Government sponsored limited restoration or enhancement projects (including living shorelines), is currently being evaluated for inclusion in the Statewide Environmental Resource Permit rule as a Restoration General Permit. Some of the habitat restoration/enhancement projects may qualify for the USACE Nationwide Permit #27. Steps are being considered by USACE to streamline the permitting for "Living Shoreline" shoreline stabilization projects.

FUNDING:
Funding will be sought by PBC.

POTENTIAL PARTNERS AND FUNDING SOURCES*:

ERM, SFWMD, FDEP, NOAA / NMFS, FWC, FIND, USACE, HBOI/FAU.

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals

ACTION PLAN *Habitat Restoration Enhancement and Monitoring*

HE- 2

Restore, Create and Protect Mangrove and Spartina Habitats

ACTION:
Increase mangrove coverage within the Lake Worth Lagoon through implementation of projects to create new mangrove and spartina wetlands and to protect and enhance existing resources.

BACKGROUND:
The lagoon supports approximately 295 acres of mangroves, 11 acres of which have been added since 2007 through the construction of habitat restoration projects. This represents an 8% increase in overall mangrove habitat since 1985.

Steps 1 and 2 outlined in the 2008 HE-2 AP have been successfully completed, with the mapping of mangrove resources and the construction of five habitat restoration projects which contained intertidal wetland components: Peanut Island Spartina, Ibis Isle, Bryant Park Islands, Snook Islands II and South Cove Natural Area. An additional 30 acres have been enhanced and protected through construction of wave attenuating breakwaters at Boynton Beach/Ocean Ridge.

While no significant progress has been made on Step 3 of the 2008 AP, the new restoration trend "Living Shorelines" provides a habitat component and is a shoreline protection alternative to armoring. Living Shorelines can be created by installing plant material, oyster shells, earthen material and riprap. These materials can be placed to create shoreline planters and restore shoreline habitat lost to bulkheads or armoring. The Living Shorelines concept is a good strategy to take to municipalities as they consider shoreline protection in response to climate change.

STRATEGY:

STEP 1 Design and permit priority habitat restoration projects identified in Table C-1.
Potential Partners: ERM, SFWMD, FDEP, USACE

STEP 2 Establish Interlocal Agreements with municipalities or land owners to restore and create mangrove/spartina habitats and Living Shorelines within their jurisdiction, and protect these habitats through education.
Potential Partners: ERM, FDEP, League of Cities, Municipalities: North Palm Beach, Lake Park, Riviera Beach, Palm Beach Shores, West Palm Beach, Palm Beach, South Palm Beach, Lake Worth, Lantana, Hypoluxo, Manalapan, Boynton Beach, and Ocean Ridge

STEP 3 Identify funding and construct projects to create intertidal habitat.
Potential Partners: ERM, FDEP, FIND, FWC, USACE, NOAA, USFWS

SCHEDULE:
Step 1 was initiated with the identification of priority restoration projects. Conceptual design and permitting will be initiated in 2013, with the cooperation of municipalities. **Step 2** will be initiated for projects identified in Table C-1. Letters will be sent to appropriate municipalities to request partnership and project support through an Interlocal Agreement with Palm Beach County.
Step 3 Permitted projects will be constructed based on municipal support and funding.

COST:
Design and permitting: $250,000/year/project = staff time and permit fees
Construction costs: $2,000,000/year
Monitoring/maintenance $100,000/year

EXPECTED BENEFITS:
- Habitat and nursery grounds for invertebrates and fisheries with important recreational and commercial value.
- Roosting and nesting sites for wading and overwintering birds.
- Shoreline protection and reduced re-suspension of sediments
- Mangroves trap and cycle organic materials and nutrients within the estuarine ecosystem
- Water quality/clarity improvements through filtration of runoff & sediment trapping
- Mangroves contribute to the economy of our coastal communities
- Manatee refuge and habitat.

MONITORING ENVIRONMENTAL RESPONSES:
Progress in implementing mangrove habitat restoration will be monitored by ERM.

REGULATORY NEEDS:
Permits for construction are required by FDEP or SFWMD and USACE. Legislation to streamline the permitting process, for Government sponsored limited restoration or enhancement projects (including living shorelines), is currently being evaluated for inclusion in the Statewide Environmental Resource Permit rule as a Restoration General Permit. Some of the habitat restoration/enhancement projects may qualify for the USACE Nationwide Permit #27. Steps are being considered by USACE to streamline the permitting for "Living Shoreline" shoreline stabilization projects.

POTENTIAL PARTNERS AND FUNDING SOURCES*:

PBC, FIND, SFWMD, USACE, FDEP, FWC, NOAA, USFWS, EPA.

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals

ACTION PLAN *Habitat Restoration Enhancement and Monitoring*

HE-3

Implement Palm Beach County Manatee Protection Plan

ACTION:
Continue to increase manatee protection in and around the Lake Worth Lagoon (LWL) and update the Palm Beach County Manatee Protection Plan (MPP) in 2014.

BACKGROUND:
All the steps highlighted in the 2008 HE-3 AP have been successfully implemented. Significant outreach efforts included working with the Florida Inland Navigation District (FIND) and FWC to develop a new colored manatee and boat safety zones brochure for PBC; redesigned manatee posters for the educational kiosks at 12 local boat ramps, and promote educational contacts via the Manatee Law Enforcement (LE) Program (Chapter 2) to increase awareness and compliance with manatee speed zones countywide. New educational material has been also created and displayed at numerous boating and environmental events. Several press releases were also prepared and distributed through the County Public Affairs Department on manatee issues and manatee season awareness. Several marine mammals' workshops were also organized from 2009 to 2012 in cooperation with the Marine Animal Rescue Society (MARS) and FWC.

In 2007 a dedicated funding source was established to set-up a grant program for LE per Step 3 of the 2008 AP. The PBCMPP commits the County to annually provide funding for additional on-water law enforcement in the County's waterways. The grant is funded by the County's Ad valorem taxes and due to the economic downturn, the annual budget for the LE program has been reduced from $200,000 to $150,000. The MPP was incorporated in the County's Comprehensive Plan. The County also encouraged local municipalities to adopt the MPP into their respective Comprehensive Plans. The City of West Palm Beach and Boynton Beach have adopted the MPP on December 15, 2008 and on December 1, 2009, respectively.

Continuous efforts to support existing and future programs to preserve, enhance, restore manatee habitat, and water quality within the County have been made. The BCC has allocated between $525,000 and $700,000 annually to habitat restoration projects. Five habitat restoration projects to improve water quality in PBC's waterways and enhance habitat for manatees have been completed and several are being designed and should be completed in the next 5 years.

STRATEGY:

STEP 1 Continue and expand upon public education efforts through more aggressive outreach to LE agencies, boaters, fishermen, shoreline residents, restaurants, marinas, boat rentals, and the general public. Support construction and operation of the proposed manatee education center at the FPL Riviera Beach plant scheduled to be constructed in 2014.
Potential Partners: ERM, FWC, SFWMD, DEP, municipalities, environmental education centers, Lagoon Keepers, FPL.

STEP 2 Work with local governments, FWC, and local marine law enforcement units to provide more effective enforcement of boating speed and entry restrictions within the manatee protection zones by adding more municipalities to the LE program, and encouraging LE agencies to increase multi-agency manatee details like "Operation Mermaid" in PBC and adjacent Counties.
Potential Partners: ERM, FWC, PBSO, local law enforcement agencies, local governments

STEP 3 As the budget or grant opportunities allow, return funding to the LE grant program to 2007 levels for local and State law enforcement marine patrol units working in PBC for the enforcement of manatee zones and public education.
Potential Partners: ERM

STEP 4 Continue SAV and WQ monitoring. Conduct additional studies identified by FWC and USFWS which may include assessment of potential secondary warmwater refugia and radio tagging or photo monitoring of summer manatees to determine if there is a resident LWL population.
Potential Partners: ERM, FWC, USFWS, FPL, research organizations

STEP 5 Identify potential manatee habitat creation opportunities within the lagoon that may be permitted, and constructed within a 5 year period (See HE-2).
Potential Partners: ERM

STEP 6 Update MPP in 2014 and distribute for public review and comment.
Potential Partners: ERM, FWC

SCHEDULE:

Step 1 needs to expand to other local environmental action groups and utilize marine mammals stranding networks to recruit volunteers. Local boat rentals, marinas, schools and businesses will be also asked to participate in the outreach efforts. Work with FPL on the proposed manatee education and viewing center to significantly improve awareness of the importance of LWL to manatees. Step 2 has been initiated by PBSO and by 2013 manatee details will increase by 50%. ERM will continue with local law enforcement agencies to plan a series of actions to encourage adjacent Counties to participate in these operations. Step 3 will be pursued by ERM for the 2014-2015

manatee season. Step 4 and 5 will be initiated in 2013. Step 6 will be initiated by late 2013 with the goal of adoption by the BCC by the end of 2014.

COST:
The LE grant program will cost approximately $150,000 to $200,000/year. An additional $75,000-$100,000 is allocated to studies and public outreach. Habitat creation and restoration projects that benefit manatee and manatee habitat are allocated $525,000 per year, however it could be increased to $700,000 and return to the 2007 funding level.

EXPECTED BENEFITS:
Continued implementation of a coordinated manatee protection plan and boat facility siting component will provide a more unified, countywide approach to manatee conservation. Enforcement of waterway speed zones will increase protection of manatees and vital seagrass habitats within the lagoon. Increased public awareness of the lagoon's natural resources and the usage of these habitats by the manatees will improve their protection, as well as the habitats they depend upon. Habitat restoration projects will provide additional manatee food sources and improve water quality in the lagoon.

MONITORING ENVIRONMENTAL RESPONSES:
Annual statistics issued by FWC will be used to monitor manatee mortality in the LWL. These statistics will be combined with an inventory of existing boat slips and number of registered boats in an annual report that evaluates change over time. This report will also highlight outreach efforts from local communities on manatee protection and education, special projects and awards and summarize habitat restoration progress.

REGULATORY NEEDS:
None anticipated.

FUNDING:
The MPP implementation will be funded through annual allocations by the BCC.

POTENTIAL PARTNERS AND FUNDING SOURCES*:

PBC, FWC, USFWS, PBSO, Municipalities, FDEP, FIND, FPL

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals

ACTION PLAN *Habitat Restoration Enhancement and Monitoring*

HE-4

Develop Seagrass Restoration Target and Restore Habitat

ACTION:
Develop a seagrass restoration target that incorporates restoration of lagoon sediments and elevations, as well as water quality improvements, to promote subsequent increases in areal extent of seagrasses. Increase seagrass habitat within the Lake Worth Lagoon through implementation of restoration projects. Monitor the increase in seagrass to refine target.

BACKGROUND:
In 2007, seagrass covered at least approximately 1,688 acres or 22% of the LWL, based on aerial photographic interpretations. Of the seven seagrass species found in the Lagoon, *Halophila johnsonii* is one of the most abundant in terms of area of coverage. *H. johnsonii* is the only marine plant designated as a federally threatened species, and several designated critical habitat areas for this species are found in the Lagoon.

This Action Plan includes the development of a Seagrass Restoration Target (formerly 2008 Plan Action Plan HE-4), seagrass habitat restoration, and continued implementation of a Submerged Aquatic Vegetation (SAV) Monitoring Program (formerly 2008 Action Plan Plan EM-3).

Target: The restoration target entails setting an average maximum depth for each lagoon segment at which seagrass will recruit and grow. Methods to establish the target were proposed by Braun (2006) and resulted in an estimate of approximately 2,100 acres of potential seagrass habitat, a 25% increase over 2007. This project provides a framework for setting future targets; however, the methods need to be validated and data needs to be updated in order to arrive at a more accurate target.

Steps 1 and 2 of the 2008 HE-4 Action Plan have not been completed, but are integrated into **STEP 1** of this Action Plan. Participants of the Lake Worth Lagoon Initiative Habitat Working Group met in 2012 to share information on the status of SAV monitoring. The participants (ERM, SFWMD, FDEP, FWC and Palm Beach Atlantic University) will complete **STEP 1**. Step 3 of the 2008 HE-4 Action Plan was not accomplished, but is integrated into **STEP 8** in this Action Plan. The group will work together to continue implementation of **STEP 8**. Once established, the target elevation and acreage will be refined as additional data becomes available.

Restoration: Since 2008, an additional 11 acres have been added through the construction of two habitat restoration projects, each containing a seagrass component: South Cove Natural Area and Snook Islands II Restoration. Additional seagrass habitat restoration will be accomplished through the construction of projects outlined in Appendix C-1,

which includes constructing wave breaks, filling select dredge holes and restoring bottom sediments and elevations to promote seagrass recruitment. **STEPS 2 through 6** of this Action Plan allow for the identification, design, coordination, permitting, solicitation of funding, and construction of these projects. Monitoring of new projects is designated in **STEP 7**.

Monitoring*:* A sound monitoring program is essential to understanding temporal, short-term and long-term spatial changes, both on a landscape and bed/patch scale, and temporal changes in seagrass cover within the LWL. Step 1 of the 2008 EM-3 Action Plan has been completed. Monitoring protocols have been established in the LWL by ERM (annual fixed monitoring of 9 transects and aerial mapping every 5 years), SFWMD (annual monitoring of 4 beds), FWC/FWRI (annual monitoring of 8 transects), and Palm Beach Atlantic University (monitoring of 50 zones in Lake Worth Cove at MacArthur State Park). Steps 2 and 3 are ongoing and have been incorporated as **STEP 8** of this Action Plan. ERM continues to monitor the nine fixed transects on an annual basis. Aerial photographs of the Lagoon to document large-scale trends in seagrass were last acquired in 2007. The next flight is scheduled for the spring of 2013.

STRATEGY:

STEP 1 Propose a target elevation and acreage for seagrass restoration in each lagoon segment based on existing information. Share the target with Federal, State, and local governments and stakeholders.
Responsible parties: ERM, SFWMD, FDEP, FWC, USFWS, and NOAA

STEP 2 Identify sites within the Lagoon for restoration/creation using the agreed upon seagrass target (see Appendix C-1).
Responsible parties: ERM

STEP 3 Develop conceptual design for each of the priority seagrass habitat restoration projects identified in Appendix C-1.
Responsible parties: ERM

STEP 4 As necessary, establish Interlocal Agreements with municipalities, to restore and create habitat within their jurisdiction, and protect the habitat through education.
Responsible parties: ERM, SFWMD, FDEP, League of Cities and Municipalities, including North Palm Beach, Lake Park, Riviera Beach, Palm Beach Shores, West Palm Beach, Palm Beach, South Palm Beach, Lake Worth, Lantana, Hypoluxo, Manalapan, Boynton Beach, and Ocean Ridge

STEP 5 Obtain permits for priority seagrass habitat restoration projects identified in Appendix C-1.
Responsible parties: ERM, SFWMD, FDEP, USACE

STEP 6 Identify funding and construct projects to restore/create seagrass habitat.
Responsible parties: ERM, FDEP, FIND, FWC, USACE, NOAA, USFWS and municipalities

STEP 7 Develop and implement project-specific monitoring programs to document areal increase in seagrass habitat as result of restoration projects.
Responsible parties: ERM, SFMWD, FDEP, HBOI/FAU

STEP 8 Continue long-term monitoring programs, which include landscape and bed/patch surveys, to document spatial and temporal changes in seagrass cover and correlate trends with water quality and sediment parameters.
Responsible parties: ERM, SFWMD, FDEP, FWC, PBAU, HBOI/FAU

SCHEDULE:
STEP 1 is anticipated to begin in 2013. **STEP 2** can occur concurrently with **STEP 1**, as priority projects have already been identified (Appendix C-1). Additional projects may be identified at the completion of **STEP 1**. Conceptual design for those projects already identified as priority will be initiated in 2013, followed by completion of **STEP 4,** when necessary, and **STEP 5**. **STEP 6** will primarily be dependent on funding. **STEP 7** will begin upon completion of construction. **STEP 8** will be ongoing, but contingent on funding. The next landscape (aerial) surveys is scheduled for 2013 and for every 5 years thereafter, while bed/patch surveys are scheduled annually (ERM, FWC) and bi-annually (SFWMD).

COST:
- Construction of up to 15 acres of seagrass habitat over the next five years is estimated at $3,500,000. Staff time involved in project design, permitting, management, and post-construction monitoring is estimated at $450,000.
- The estimated cost for the fixed transect monitoring program is $30,000 annually, and the estimated cost for the aerial mapping is $140,000.
- Annual costs for staff, subcommittee meetings, and materials to establish target elevation and acreage are estimated at approximately $50,000.

EXPECTED BENEFITS:
Restoration of seagrass habitat will provide food, substrate, and shelter for thousands of species of flora and fauna, including commercially and recreationally important fish, manatees, and sea turtles, and also help stabilize sediments and maintain water clarity. Monitoring allows managers to quantify the coverage of seagrass within the Lake Worth Lagoon, as well as identify problems and design solutions to protect seagrass resources. The restoration target provides an effective management tool to determine where restorative and protection efforts of seagrass should be focused in the Lagoon.

MONITORING ENVIRONMENTAL RESPONSES:
Progress in implementing seagrass habitat restoration will be monitored by ERM. Project-specific monitoring will be conducted by ERM, while the long-term monitoring programs will be conducted by ERM, SFWMD, FDEP, and FWC.

REGULATORY NEEDS:
Permits for construction are required by FDEP or SFWMD and USACE. Legislation to streamline the permitting process, for Government sponsored limited restoration or enhancement projects (including living shorelines), is currently being evaluated for inclusion in the Statewide Environmental Resource Permit rule as a Restoration General Permit. Some of the habitat restoration/enhancement projects may qualify for the USACE Nationwide Permit #27. Steps are being considered by USACE to streamline the permitting for "Living Shoreline" shoreline stabilization projects.

FUNDING:
Funding will be sought by ERM.

POTENTIAL PARTNERS AND FUNDING SOURCES*:

PBC, SFWMD, FDEP, FWC, FIND, PBAU, USACE, USFWS, NOAA, EPA, HBOI/FAU

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals

ACTION PLAN *Habitat Restoration Enhancement and Monitoring*

HE-5

Expand Reef Habitats

ACTION:
Increase fisheries and benthic habitat in Lake Worth Lagoon (LWL) through additional artificial reefs while enhancing impacted areas.

BACKGROUND:
All the steps highlighted in the 2008 HE-5 AP have been successfully implemented. Since 2008, six projects were constructed to add over 4.5 acres of new artificial reef habitat in LWL. These reefs provide nursery habitat and conduits for fisheries movement and shelter throughout the lagoon. Additionally, these habitats provide recreational opportunities for fishermen, snorkelers and divers in protected accessible conditions, compared to the offshore reefs. The new LWL artificial reefs are located at: Peanut Island, Riviera Beach, Everglades Island, Phil Foster and Boynton Beach/Ocean Ridge.

Artificial Reef monitoring continues at representative sites in the lagoon: Sugar Sands Reef, Rybovich Reef and the Blue Heron Bridge Reef, for which details are provided in Chapter 2.

STRATEGY:

STEP 1 Identify additional locations, especially artificially-deepened areas for artificial reef placement in LWL.
Potential Partners: ERM, HBOI/FAU

STEP 2 Develop, permit and construct new artificial reefs.
Potential Partners: ERM

STEP 3 Continue and expand monitoring of existing and new artificial reefs.
Potential Partners: ERM, PBC Reef Research Team, FWC, Environmental Education Centers

SCHEDULE:
The placement of artificial reef materials for habitat enhancement in the Lagoon is an on-going endeavor.

COST:
Construction of 1 acre/year at $ 200,000/year, plus staff time involved in project design and management.

EXPECTED BENEFITS:
Placement of artificial reef material promotes settlement of epifaunal organisms which in turn promotes fisheries nurseries within the Lagoon that also benefits nearby ocean reef systems. Existing Lagoon artificial reefs can have as much as 80% of fish on the reef representing the juvenile class and are important developmental refuges for fish that have value to the commercial and recreational fisheries. These artificial reefs add high quality complex habitat the lagoon and they support a wide variety of species.

MONITORING ENVIRONMENTAL RESPONSES:
Regular monitoring already occurs with the Sugar Sands Ledges and Rybovich Reef using the Reef Research Team. ERM will be monitoring the other artificial reefs within the Lagoon.

REGULATORY NEEDS:
Permits for construction are required by FDEP or SFWMD and USACE. Legislation to streamline the permitting process, for Government sponsored limited restoration or enhancement projects (including living shorelines), is currently being evaluated for inclusion in the Statewide Environmental Resource Permit rule as a Restoration General Permit. Some of the habitat restoration/enhancement projects may qualify for the USACE Nationwide Permit #27. Steps are being considered by USACE to streamline the permitting for "Living Shoreline" shoreline stabilization projects.

FUNDING:
Funding is available through the County Vessel Registration Fee and additional funding will be sought.

POTENTIAL PARTNERS AND FUNDING SOURCES*:

ERM, FWC, Environmental Education Centers, FIND, FDEP, WPB Fishing Club, dive shops, HBOI/FAU

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals

ACTION PLAN *Habitat Restoration Enhancement and Monitoring*

HE-6

Acquisition of Submerged and Intertidal Lands in Lake Worth Lagoon

ACTION:
Acquisition and conservation of privately owned submerged and intertidal lands within the Lake Worth Lagoon (LWL).

BACKGROUND:
Over the past five years the County acquired 26 acres of mangrove wetlands along the ICW within the Ocean Ridge Natural Area North and South parcels. In addition, the County has been successful in leasing 108 acres of intertidal and submerged lands owned by the City of Lake Worth that contain seagrasses, mangroves and oyster reef habitats. The acquisition of other submerged parcels of land, most notably the seagrass area within Riviera Beach, has been less successful. Several attempts were made to find willing sellers however, due to multiple ownerships of the same privately owned submerged lands for Condominiums, agreements between sellers was difficult to achieve.

Increasing and preserving the quantity, quality and diversity of the lagoon's mangrove and seagrass habitats, through acquisition of "at risk" privately owned submerged lands, is still one of the long-term goals of this management plan. Fifty-six (56) parcels of privately owned submerged lands have been identified within the LWL, totaling 218 acres. Some of these parcels were subject of permit applications for development during the 2008-2012 timeframe. These submerged lands are primarily located within three municipalities of the County: the City of Riviera Beach, the Town of Palm Beach, and the City of Lake Worth. The majority of these parcels have been identified as areas that either support existing healthy seagrass beds, or provide valuable estuarine habitats with great potential for restoration.

Twenty-eight (28) parcels located in the City of Riviera Beach adjacent to Singer Island, are the highest priority for acquisition and conservation. These 154 acres of submerged parcels include the most abundant area of seagrass habitat within the LWL and in Palm Beach County. This area is adjacent to John D. MacArthur Beach State Park and is critical to fish and wildlife. It provides nursery grounds for juvenile fish and shellfish, as well as feeding areas for many types of birds and animals including manatees and green sea turtles. This region has been documented as a very important developmental habitat for juvenile green sea turtle with the number of turtles observed similar to other important habitats in Florida. DNA analysis has indicated that juveniles were born on beaches throughout the Caribbean and from as far away as Ascension Island in the South Atlantic.

A previous attempt to purchase these parcels in 1997 was not successful; however it did generate significant support from the community with $103,100 collected from voluntary contributions, and the donation of an approximate three-acre parcel of submerged land containing valuable seagrasses to Palm Beach County. This critical habitat will be the focal point of a larger plan to acquire submerged lands for preservation and enhancement of existing habitats within the LWL. If these acquisitions are successful, Palm Beach County and/or State will develop a long-term management plan to preserve these valuable estuarine habitats.

STRATEGY:

STEP 1 Survey property owners to determine number of willing sellers. Identify and obtain funding and develop an acquisition schedule.
Potential Partners: ERM

STEP 2 Estimate total acquisition costs based on pre-appraisals projections.
Potential Partners: ERM, PBC Property & Real Estate Management (PREM)

STEP 3 Notify property owners of the intent to acquire their property.
Potential Partners: ERM, PREM

STEP 4 Send letter and maps to all permitting agencies recommending that acquisition of these properties be considered as partial mitigation for unavoidable impacts when evaluating permits.
Potential Partners: ERM, PREM,FDEP

SCHEDULE:
Step 1 is contingent upon the successful identification of a secure funding source. Step 2 and 3 are contingent upon Step 1. If a funding source for Step 1 is obtained, Step 2 will be implemented within two months. Step 3 will be implemented between 1 to 2 years. Step 4 will be implemented after all the previous steps have been completed.

COST:
Acquisition costs for each parcel need to be evaluated.

EXPECTED BENEFITS:
The purchase of submerged lands will increase and preserve in perpetuity critical habitats utilized by the estuarine species in the LWL.

MONITORING ENVIRONMENTAL RESPONSES:
Information obtained by the monitoring of valued ecosystem species such as seagrasses, sea turtles and manatees, will be analyzed and integrated with existing monitoring programs.

REGULATORY NEEDS:
None anticipated.

FUNDING:
Funding sources need to be identified.

POTENTIAL PARTNERS AND FUNDING SOURCES*:

ERM, USFWS, NOAA / NMFS, FWC, local Municipalities

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals

ACTION PLAN *Habitat Restoration Enhancement and Monitoring*

HE-7

Enhance Resilience and Sustainability to Climate Change

ACTION:
Enhance resilience to climate change within the Lake Worth Lagoon (LWL) through Living Shorelines and other adaptation approaches. Monitor the response of the LWL and its species to climate change.

BACKGROUND:
Climate change presents a significant threat to fish, wildlife and natural ecosystems and will likely exacerbate and couple with many existing threats, including habitat loss, nonnative species, and water pollution. Preparing for the future impacts of climate change is an emerging concern for the LWL and involves proper planning, implementation of adaptive measures, and long-term monitoring.

Of the major climate change impacts recognized by scientists, the most recognized in terms of the potential scale of its impact on the ecology and economy of Southeast Florida is sea level rise (FWC, 2011). Sea level rise will result in the disappearance of seagrasses, mangrove, and salt marshes at their deeper, more waterward edge. Where unobstructed, the habitats will expand at their upland edge as long as the species can grow faster than the rising sea level. Upland migration of estuarine species in the LWL will be severely limited as approximately 87% of the LWL shoreline is hardened, and there is a concern that more erosion, storm damage and flooding as a result of sea level rise will lead to more intense armoring of shorelines.

Living shorelines are an alternative adaptive strategy recommended by the Southeast Florida's Regional Climate Action Plan to both reduce ecological impacts, and enhance resilience to climate change. As a softer alternative or addition to hardened shorelines, living shorelines incorporate natural elements, such as limerock and native vegetation, and mimic natural slopes to facilitate migration upland. Eleven "climate-smart" living shoreline projects have been identified within the LWL, and six will be constructed over the next five years. At completion, 10,000 linear feet of living shoreline will provide a vegetative buffer for the land, improve water quality, and provide essential habitat for many species of fish and wildlife (see Action Plan HE-2).

The Southeast Florida's Regional Climate Action Plan also recommends the development of a biological monitoring program to study parameters, such as rate of sea level rise, landscape-level vegetation patterns, water temperature, pH, and occurrence and range of invasive plant and animal species. Many organizations and Universities are currently monitoring climate changes on a regional or state level; however, partnerships can be

established to study the effects on a micro-scale. Small scale approaches offer the opportunity to evaluate 'keystone species' through specific monitoring studies, identify areas less affected by climate change, which can be used as a 'seed source' for recovery or destination of climate-sensitive migrant species, and evaluate restoration techniques. The public should be encouraged to actively participate in programs, such as the National Phenology Network's *Nature's Notebook* project, which monitors the influence of climate on specific plants and animals.

STRATEGY:

STEP 1 Identify, design and obtain permits for living shoreline projects identified in Table C-1.
Potential partners: ERM, HBOI/FAU, SFWMD, FDEP, USCAE

STEP 2 Establish Interlocal Agreements with municipalities or landowners to create living shorelines within their jurisdiction, and protect these habitat through education.
Potential partners: ERM, State, municipalities, private landowners

STEP 3 Identify funding sources and construct 10,000 linear feet of living shoreline.
Potential partners: PBC, FDEP, SFWMD, FWC, USFWS, EPA, NOAA

STEP 4 Monitor living shorelines and other adaptation and restoration projects (existing 295 acres of mangroves), to evaluate their response to climate change.
Potential partners: ERM, HBOI/FAU, and other universities

STEP 5 Establish partnerships to monitor effects of climate change on keystone species and identify areas less affected by climate change and identify funding for monitoring.
Potential partners: ERM, HBOI/FAU, FWC, USFWS, EPA, NOAA

STEP 6 Encourage public participation in monitoring climate change in the LWL through existing programs.
Potential partners: ERM, FAU Center for Environmental Studies

SCHEDULE:
STEP 1 was initiated with the identification of projects. Conceptual design and permitting will begin in 2013, with the cooperation of municipalities and private landowners. **STEP 2** will occur once a design has been agreed upon. **STEP 3** will be dependent on municipal support and funding. **STEP 4** will begin at the completion of each individual project. **STEP 5** and **STEP 6** can occur concurrently with other steps.

COST: Cost for each step needs to be further evaluated.

EXPECTED BENEFITS:

- Shoreline protection and enhanced resilience to effects of sea level rise and other effects of climate change.
- Water quality/clarity improvements through filtration of runoff & sediment trapping.
- Habitat and nursery grounds for invertebrates and fisheries with important recreational and commercial value.
- Roosting and nesting sites for wading and overwintering birds.

MONITORING ENVIRONMENTAL RESPONSES: Progress in implementing living shoreline and other restoration and adaptation projects and their response to climate change will be monitored by ERM. Partnerships with local Universities and organizations will be also be established.

REGULATORY NEEDS: Permits for construction will required by FDEP or SFWMD and USACE. Legislation to streamline the permitting process, for Government sponsored limited restoration or enhancement projects (including living shorelines), is currently being evaluated for inclusion in the Statewide Environmental Resource Permit rule as a Restoration General Permit. Some of the habitat restoration/enhancement projects may qualify for the USACE Nationwide Permit #27. Steps are being considered by USACE to streamline the permitting for "Living Shoreline" shoreline stabilization projects.

FUNDING: Funding will be sought by PCERM and partners.

POTENTIAL PARTNERS AND FUNDING SOURCES*:

PBC, SFWMD, FDEP, FWC, FIND, HBOI/FAU, USACE, USFWS, NOAA, EPA, FAU

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals

ACTION PLAN *Habitat Restoration Enhancement and Monitoring*

EM-1

Implement Sea Turtle Monitoring

ACTION:
Monitor the health of the sea turtle population utilizing Lake Worth Lagoon (LWL) by continuing to perform annual monitoring events for an additional 5 years.

BACKGROUND:
Sea turtles are considered an indicator species of ecosystem value. Baseline data on the sea turtle populations utilizing LWL were collected between 2005-2011 and it was learned that many more turtles than expected were observed, the lagoon seagrass beds provide important developmental juvenile green turtles, and turtles from nesting beaches throughout the Western Hemisphere use LWL (see Chapter 2). To determine the distribution and health of the sea turtle population in LWL changes in response to habitat restoration and water quality improvements, the following questions remain:

- Does Catch Per Unit Effort (CPUE) of sea turtles increase over time?
- What is the growth rate of turtles in LWL?
- Is the occurrence and severity of fibropapillomatosis (FP) reduced over time?
- Are there unique habitat characteristics in the Little Munyon Island sea turtle "hotspot"??
- How long are turtles resident in the lagoon and do they utilize other nearby developmental habitats (nearshore reefs and adjacent lagoons) during this period?

STRATEGY:

STEP 1 Continue to implement the revised 2012 sea turtle netting study scope of work for the next five years. Study will continue to capture and tag new turtles and provide information on CPUE and FP rate and severity change over time. More data from recaptured turtles is required in order to calculation growth rate and determine where migrants originate.
Responsible parties: ERM

STEP 2 Conduct seagrass surveys to determine differences in habitat quality between "hotspots" and nearby areas used less frequently by turtles and use findings to guide restoration.

STEP 3 Continue to collect water quality data and consider expanding parameters to. evaluate constituents (such as arginine) that may possibly be linked to FP
Responsible parties: ERM

STEP 4 Explore development of a sonic or radio tagging program to evaluate short term

patterns of habitat utilization, nearshore reef habitat use, and residence time in LWL.

Responsible parties: PBCERM, universities, environmental education/ research centers

STEP 5 Continue an educational campaign promoting understanding of the importance of sea turtles. Promote community participation in maintaining LWL health and protection of sea turtles, similar to beach programs.

Responsible parties: ERM

SCHEDULE:
Step1 and Step 2: Annual survey to be conducted 1 week every summer. Step 3 and 5 will be implemented as part of the Action Plans PE-1 and WQ-1, contingent upon available funding. Step 4 will depend on receiving research approvals from FWC and NMFS.

COST:
Annual costs for contractor staff, equipment, and blood and dietary sample analysis are estimated at approximately $15,000 per year. Cost for Step 4 tagging will depend on the type of tag permitted.

EXPECTED BENEFITS:
By comparing changes in the sea turtle population in the LWL to the 2005-11 baseline, the impacts of water quality improvement and habitat restoration projects on sea turtle health can be documented.

MONITORING ENVIRONMENTAL RESPONSES:
Data is collected and analyzed in accordance with FWC and NMFS permits and guidelines. LWL data will be compared to the LWL baseline and similar lagoon systems, such as the Indian River Lagoon and Mosquito Lagoon.

REGULATORY NEEDS:
Although not required by any regulatory or construction activities, this study may document sea turtle habitat preferences and population distribution that should be included in LWL management decisions.

FUNDING: Funding is available in the Pollution Recovery Trust Fund (PRTF) and the Sea Turtle License Plate Grants. Additional funding sources will be investigated.

POTENTIAL PARTNERS AND FUNDING SOURCES*:

ERM, FWC, Sea Turtle License Plate Grants Program, USFWS, PRTF

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals

ACTION PLAN *Habitat Restoration Enhancement and Monitoring*

EM-2

Develop a Fish Monitoring Program

ACTION:
Develop a long-term, comprehensive database on fish and selected invertebrate species inhabiting the Lake Worth Lagoon (LWL).

BACKGROUND:
A quantitative fish assessment has never been conducted in the LWL. Baseline data on fish needs to be gathered in order to assess changes over time and allow managers to identify problems, opportunities and design solutions. Tracking the health of the lagoon's fish population is an important component for the on-going restoration.

Steps outlined in the AP 2008 EM-2 Develop a Fish Monitoring Program were not achieved due to the costs to establish and maintain a meaningful lagoon wide data set. The comprehensive sampling protocol, originally proposed in partnership with the Fish and Wildlife Research Institute's Fisheries Independent Monitoring Survey (FIMS), would require monthly sampling over a 1-2 year period to establish and monitor the relative abundance of fish in the system. While the aggressive sampling plan would quantify some LWL fish populations and provide information about status and trends, is not feasible at this time.

The LWL has heterogeneous habitat types; therefore, previously proposed net sampling may not be applicable in habitats likely to support higher species diversity. A fish monitoring plan that incorporates multiple methodologies is proposed to gather LWL fish data. Additionally, project specific survey methods need to be established to record baseline data and demonstrate the increase in fish associated with habitat creation projects. This information will be useful to demonstrate habitat utilization and project success, which will facilitate the acquisition of grants and foster partnerships.

Many of the resident fishes and invertebrates in LWL live in association with the relatively small amount of hard substrate present. The hard substrate is varied and includes: rocks exposed at inlets, jetties, channel edges, artificial reefs, bridges, dock pilings/supports and seawalls. In these areas traditional net sampling either by hand or tow is difficult, therefore the methodology needs to be adjusted.

A list of specific monitoring and research objectives needs to be formulated and prioritized. A preliminary list of objectives includes:

1. Compile a current species list and compare it to anecdotal records.
2. Document the fish species and size classes utilizing restored lagoon habitats (seagrass, mangrove, oyster reef, and artificial reef).
3. Document the fish species and size classes utilizing existing lagoon habitats

(sand flats, muck bottom, seawalls, riprap, piers, dredge holes),

4. Evaluate the effects of large scale storm water discharges on local fish populations.
5. Evaluate fish health and concentrations of toxic compounds such as mercury.
6. Evaluate the extent of movement of certain species between habitat types with a focus on linkages between restored and natural lagoon and offshore habitats.
7. Document the catch per unit effort of key economically-important species.

To compile a species list and estimate fishing effort, the following strategies could be used:

- Literature search and review of WPB Fishing Club records.
- Creel survey to estimate the catches made by small scale or recreational fishermen through interviews and inspection of individual catches at fishing areas and boat ramps.
- Volunteer angler surveys (mail or email).
- Angler website to report catches in LWL and create on-going virtual "fishing tournament"

For those projects assessing change, consideration should be given to using the BACI (Before-After Control-Impact) experimental design when designing the surveys. Reference areas will need to be selected and monitored with similar methods to have a meaningful comparison. Ideally there would be pre-restoration sampling conducted at select restoration sites to get a better understanding of the extent of change. Sampling methods will depend on the question being asked and the habitat being sampled. A listing of potential fish sampling methods that have been suggested includes:

- Visual sampling using divers' surveys, potentially limited by high turbidity, low visibility and currents in LWL. This method is currently used to monitor LWL artificial reefs close to inlets where visibility is less limited (see Chapter 2.
- Remote visual sampling: 1) using underwater cameras deployed from surface vessels and moved around the sampling sites; or 2) using fixed cameras with 360° view with video feed to remote shore stations. Cameras have better detection/resolution than humans.
- Siene or trawl net surveys, however these methods have limited use when sampling diverse habitats in an urbanized estuary.
- Net enclosed areas using visual counts or dip net.
- Hook-and-line sampling, a time-intensive method for the amount of data collected and affected by biases due in part upon the type of gear and bait used.

To better understand the relationship between restored habitats and nearly natural habitats, it is important to document movement of fish between estuarine and ocean habitats. Expansion of the existing Florida Atlantic Coast Acoustic Telemetry (FACT) network to include the LWL would be important in creating a more complete picture. FACT already includes receivers at Lake Worth Inlet, reefs north of the inlet, Loxahatchee River and Indian River Lagoon.

STRATEGY:

STEP 1 Develop a prioritized list of research questions and define the most appropriate sampling method to answer them. Since restoration is the main focus in the management plan, sampling at restored projects should be the highest priority for fish monitoring. This monitoring should include comparisons with control or reference sites.
Potential Partners: FWC, PBCERM, PBAU, WPBFC, HBOI/FAU, NOVA, FIU

STEP 2 Apply the best methodology at the selected locations for regular sampling.
Potential Partners: FWC, ERM, PBAU, WPBFC, HBOI/FAU

STEP 3 Conduct monthly/quarterly sampling (depending on support level/funding).
Potential Partners: FWC, ERM, NOVA, FIU, WPBFC, NMFS

STEP 4 Prepare annual reports that summarize the data from the LWL study area(s). The report will include a summary of overall sampling effort, species composition and abundance from the study area, and more detailed data summaries such as catch rates, size distribution, spatial and temporal distribution for more abundant species and species of economic importance.
Potential Partners: FWC, ERM

STEP 5 Seek funds for an underwater video camera and passive acoustic tag receivers to monitor restoration project sites. Conduct baseline and quarterly monitoring to determine habitat utilization.
Potential Partners: ERM, FWC, HBOI/FAU, PBAU

SCHEDULE:
Step 1 will be initiated when Potential Partners agree on methods and participation effort. Step 2 and 3 are contingent upon Step 1.

COST:
The estimated annual cost for this monitoring program is $120,000. The estimated costs are based on monthly sampling including three full-time staff personnel, boat and vehicle fuel, travel time, nets, boat/vehicle repairs and upkeep, and expendable routine supplies.

EXPECTED BENEFITS:
Quantify LWL fish population and establish a monitoring program that will provide more comprehensive information about status and trends. Its implementation will allow managers to identify problems and design solutions to preserve and enhance fish stocks in the LWL.

MONITORING ENVIRONMENTAL RESPONSES:
The information will assist managers in monitoring the health and the abundance of fisheries within the LWL. Monthly or quarterly monitoring will be incorporated in annual reports that will be used for restoration purposes.

REGULATORY NEEDS:
None anticipated.

FUNDING:
TBD

POTENTIAL PARTNERS AND FUNDING SOURCES*:

ERM, FWC, NOAA / NMFS, WPB FISHING CLUB, PBAU, HBOI/FAU

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals

6. PUBLIC USE AND OUTREACH

OVERVIEW

The Public Outreach (PO) Program is committed to creating an engaged constituency of citizens who understand both the environmental, recreational and economic value of the LWL, and actively participate in restoring and protecting it. All the Action Plans (PO1-4) identified in the 2008 Plan have been implemented.

The Initiative was created in 2008 to facilitate stakeholder partnerships. ERM hired a full-time LWL public outreach coordinator and the Initiative Public Outreach Working Group was formed in 2009. Over the past five years Working Group members have developed public awareness programs to involve and inform residents, visitors, and decision makers about the LWL ecosystem through specific LWL outreach materials. Citizen engagement efforts have focused on lagoon cleanups, volunteer habitat restoration projects, and community presentations. Working Group members have led multiple volunteer lagoon cleanups annually while volunteers have donated time to help build oyster reef habitat and plant mangrove forests. The Initiative also hosted three large-sale boat tours (2009, 2010, 2011) showcasing lagoon restoration projects to elected officials, government agency representatives, and community partners.

Passive use and access to the LWL was also promoted. A "Paddling Treasures" brochure was created, highlighting kayak launch locations and points of interests. In addition, numerous project fact sheets, kiosk posters, newsletter articles and media press releases advertised and promoted several public access features including.

PBC Florida Yards & Neighborhood Program, one of the 2008 APs, incorporated the LWL watershed map into local presentations. New educational materials highlighting the connection between land and water were developed, specifically the Protect and Conserve Palm Beach County's Water and Environment brochure and a Florida-Friendly school curriculum for 3rd through 5th grades.

For the next five years, Public use and Outreach goals will be accomplished through specific new APs listed below:

SUMMARY OF ACTIONS FOR PUBLIC USE AND OUTREACH

PO – 1 Lake Worth Lagoon Brand Awareness - *New*
PO – 2 Citizen Participation in Environmental Protection and Restoration - *New*
PO - 3 Youth Education and Engagement - *New*
PO - 4 Florida-Friendly Landscaping - *New*
PO - 5 Ecotourism - *New*
PO - 6 Website and Social Media - *New*

ACTION PLAN *Public Use and Outreach*

PO-1

Lake Worth Lagoon Brand Awareness

ACTION:
Strengthen LWL brand awareness and its effectiveness.

BACKGROUND:
Anecdotal information suggests most citizens refer to the LWL as the Intracoastal Waterway. Increasing public awareness that LWL is Palm Beach County's largest estuary system, composed of natural resources worth protecting, is an important public outreach goal. To increase awareness of the lagoon and the Initiative, the Initiative Public Outreach Working Group designed and selected a LWL logo and tagline (Discover a Local Treasure) in year 2009. The logo and tagline is incorporated into the LWLI.org website design, Initiative brochure, LWL: Discover a Local Treasure Newspaper in Education publication, LWL 45-minute video, and posters displayed at waterway kiosks along the lagoon. There is a need to build upon these efforts and strengthen LWL brand awareness and its effectiveness.

STRATEGY:

STEP 1 Consistently use the LWL logo, tagline (Discover a Local Treasure), and set colors on the website, publications, signage, public presentations, working group meetings, etc.
Potential Partners: All LWL Public Outreach Working Group Participants

STEP 2 Develop sub-brand taglines (complimenting the "Discover a Local Treasure" tagline) to reach specific audience segments such as boaters, anglers, and environmentalists.
Potential Partners: PBC Convention and Visitors Bureau (PBCCVB) along with Marine Industries Association of PBC (MIA), ERM, SFWMD, TDC

STEP 3 Increase local brand awareness by encouraging local businesses, organizations, and municipalities to display the LWL logo and tagline. For example, consider creating a LWL pledge and a pledge plaque to display in their store or office.
Potential Partners: MIA along with PBCCVB, Loxahatchee Group of the Sierra Club, PBC League of Cities

STEP 4 Develop a 5 year brand awareness plan that focuses efforts on one industry at a time, such as marine industries, restaurants, homeowners associations.
Potential Partners: MIA along with PBCCVB

SCHEDULE:
Step 1 is ongoing.
Step 2 to be completed in 2015.
Step 3 to be completed in 2018.
Step 4 to be developed in phases as resources allow.

COST:
To be identified.

EXPECTED BENEFITS:
Increasing local brand awareness (for example, the public's ability of to recall and recognize the LWL logo) will draw attention to the lagoon, increase community awareness of the Initiative's efforts, and engage new community partners.

MONITORING ENVIRONMENTAL RESPONSES:
Not applicable.

REGULATOR NEEDS:
Not applicable.

FUNDING:
Actions require participating LWL Public Outreach Working Group members to devote time and individual resources. Funding may be sought if a LWL pledge and plaque program is developed to engage new businesses, organizations, and municipalities in brand awareness and outreach efforts.

POTENTIAL PARTNERS AND FUNDING SOURCES*:

LWL Public Outreach Working Group Participants, PBCCVB, MIA, ERM, SFWMD, Loxahatchee Group of the Sierra Club, PBC League of Cities

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals.

ACTION PLAN *Public Use and Outreach*

PO-2

Citizen Participation in Environmental Protection and Restoration

ACTION:
Increase citizen participation in water quality protection and habitat restoration efforts within the community and at home.

BACKGROUND:
Existing public outreach efforts aim to build a constituency of informed citizens who actively participate in the lagoon's protection, restoration and enhancement. Educational publications, including the LWL E-News, presentations through the LWL Speakers Bureau, the 2012 LWL 45-minute video, and volunteer events such as International Coastal Cleanup engage citizens and provide opportunities for residents to learn more about the lagoon. While thousands of citizens are reached annually through these efforts, the county's large population of 1.3 million means there is a constant need to increase citizen participation in water quality protection and habitat restoration efforts within the community and at home.

STRATEGY:

STEP 1 Encourage participation in the Initiative working groups.
Potential Partners: All LWL Public Outreach Working Group Participants

STEP 2 Continue and expand public presentations to increase understanding of individual actions that can be taken to protect the lagoon and the watershed.
Potential Partners: LWL Speakers Bureau Participants

STEP 3 Continue to encourage citizen participation in lagoon cleanups (through existing programs such as the Solid Waste Authority's Adopt-a-Spot Program, International Coastal Cleanup, and the Great American Cleanup) and fish and wildlife habitat restoration projects
Potential Partners: Keep Palm Beach County Beautiful (KPBCB), Solid Waste Authority of PBC (SWA), and ERM along with FDEP/John D. MacArthur Beach State Park, PBC Parks and Recreation Department

STEP 4 Encourage citizen participation in public decision-making processes that impact the LWL and its watershed.
Potential Partners: All LWL governmental stakeholders along with LWL

Public Outreach Working Group Participants

STEP 5 Promote citizen science opportunities (participatory field work by volunteers) such as the Great Backyard Bird Count.
Potential Partners: Audubon Society of the Everglades along with ERM

STEP 6 Propose a "LWL Awareness Month" proclamation to the Palm Beach County Board of County Commissioners and to local municipalities along the lagoon.
Potential Partners: ERM along with PBC League of Cities

STEP 7 Identify and promote micro-volunteering activities that are designed to take between 10 seconds to 30 minutes to complete at home or via internet. For example, email a public official or friend to share information about the Initiative.
Potential Partners: UF/IFAS PBC Cooperative Extension Service along with ERM and Florida Federation of Garden Clubs District X

STEP 8 Host a Initiative Symposium once every 5 years to summarize accomplishments and identify actions for future improvements.
Potential Partners: ERM along with SFWMD, FIND, FDEP, PBC League of Cities

SCHEDULE:
Steps 1, 2, 3, 4, and 5 are ongoing.
Step 6 to be completed in 2015.
Step 7 to be completed in 2016.
Step 8 to be completed in 2018.

COST:
The 2018 LWL Symposium is expected to cost approximately $10,000.

EXPECTED BENEFITS:
Increasing citizen participation will build a constituency of informed citizens who actively participate in the lagoon's protection, restoration and enhancement.

MONITORING ENVIRONMENTAL RESPONSES:
Lagoon site counts for the Great Backyard Bird Count will be recorded annually.

REGULATOR NEEDS:
Not applicable.

FUNDING:
TBD

POTENTIAL PARTNERS AND FUNDING SOURCES*:

ERM, SFWMD, FIND, FDEP, KPBC, SWA, FDEP/John D. MacArthur Beach State Park, PBC Parks and Recreation Department, Audubon Society of the Everglades, PBC League of Cities, UF/IFAS PBC Cooperative Extension Service

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals.

ACTION PLAN *Public Use and Outreach*

PO-3

Youth Education and Engagement

ACTION:
Expand LWL education and engagement opportunities for youth in Palm Beach County.

BACKGROUND:
Existing public outreach efforts aim to build a constituency of informed youth who recognize LWL as the county's largest estuary, are familiar with the plants and animals that live there, and actively participate in the lagoon's protection, restoration and enhancement. LWL curriculum is now included for 5th and 8th grade students throughout the county. The LWL: Discover a Local Treasure publication reached more than 30,000 students in the 2010-2011, 2011-2012, and 2012-2013 school years. Teacher resources highlighted on www.LWLI.org include the LWL Educator's Guide (1998, 2010), lagoon posters, and more. Recognizing it will take years to build a new generation of lagoon stewards there is a need to expand lagoon education and engagement opportunities for youth in Palm Beach County.

STRATEGY:

STEP 1 Continue and expand resources to help K-12 teachers engage students in lagoon education and outdoor learning. Examples include curriculum integration, teacher trainings, and field experiences.
Potential Partners: FDEP/John D. MacArthur Beach State Park along with ERM, UF/IFAS Palm Beach County Cooperative Extension Service Gulfstream Council Boy Scout & Girl Scouts of America Environmental Merit Badge Program

STEP 2 Continue service learning opportunities for youth, such as lagoon cleanups and mangrove planting projects.
Potential Partners: KPBCB, SWA, ERM, LagoonKeepers.org along with LWL Public Outreach Working Group Participants

STEP 3 Continue service learning opportunities for youth, such as lagoon cleanups (through existing programs such as the Solid Waste Authority's Adopt-a-Spot Program, International Coastal Cleanup, and the Great American Cleanup) and mangrove planting projects.
Potential Partners: ERM along with FDEP/John D. MacArthur Beach State

Park, SFWMD, UF/IFAS Palm Beach County Cooperative Extension Service

STEP 4 Assemble a youth engagement action team within the larger Initiative Public Outreach Working Group.
Potential Partners: UF/IFAS PBC Cooperative Extension Service

STEP 5 Expand resources to inspire youth outside school settings to learn about the lagoon and enhance environmental stewardship.
Potential Partners: UF/IFAS PBC Cooperative Extension Service along with FDEP/John D. MacArthur Beach State Park

STEP 6 Implement a "create a Lake Worth Lagoon mascot" contest for youth in Palm Beach County.
Potential Partners: Florida Federation of Garden Club District X

SCHEDULE:
Steps 1, 2, and 3 are ongoing.
Step 4 to be completed in 2015.
Step 5 and 6 to be completed as resources allow.

COST:
TBD

EXPECTED BENEFITS:
Increasing youth education and engagement will build a new generation of lagoon stewards who actively participate in the lagoon's protection, restoration and enhancement.

MONITORING ENVIRONMENTAL RESPONSES:
Not applicable.

REGULATOR NEEDS:
Not applicable.

FUNDING:
Funding sources need to be identified.

POTENTIAL PARTNERS AND FUNDING SOURCES*:

FDEP/John D. MacArthur Beach State Park, ERM, UF/IFAS PBC Cooperative Extension Service, KPBCB, SWA, ERM, LagoonKeepers

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals.

ACTION PLAN *Public Use and Outreach*

PO-4

Florida-Friendly Landscaping

ACTION:
Support and enhance citizens' protection of and connection to their watershed and the LWL through Florida-Friendly outreach and programming.

BACKGROUND:
The Florida Yards and Neighborhoods and Green Industries Best Management Practices (GI-BMP) pPrograms were developed in response to the increasing problem of nonpoint source water pollution. The programs focus on reducing stormwater runoff from landscaped areas. Runoff can carry nutrients and chemicals, polluting Florida's lakes, canals and coastal water (including LWL). Homeowners and professionals learn about appropriate use of fertilizers and pesticides, water conservation, and how to minimize stormwater. In Palm Beach County, the programs are coordinated by UF/IFAS Palm Beach County Cooperative Extension Service.

STEP 1 Increase awareness of Florida-Friendly Principles by promoting Florida-Friendly events and incorporating the principles into LWL presentations, website, etc.
Potential Partners: UF IFAS/PBC Cooperative Extension Service along with Palm Beach County Soil and Water Conservation District and Loxahatchee Group of the Sierra Club

STEP 2 Continue and expand public presentations to increase understanding of individual actions that can be taken to protect the lagoon and the watershed. Actions include certifying GI-BMP professionals, creating a Florida-Friendly Yard and adopting Florida-Friendly principles at home, in the workplace, and in the community.
Potential Partners: UF IFAS/PBC Cooperative Extension Service

SCHEDULE:
Steps 1 and 2 are ongoing.

COST:
Staff costs to be determined

EXPECTED BENEFITS:
Increasing participation in the Florida-Friendly Yards Program will engage homeowners in watershed protection. Implementation of Florida-Friendly landscaping techniques will improve the quality of stormwater and reduce the amount of nutrients, pesticides, sediments, and organic materials, entering LWL.

MONITORING ENVIRONMENTAL RESPONSES:
WQ monitoring

REGULATOR NEEDS:
Not applicable.

FUNDING:
Funding will be sought

POTENTIAL PARTNERS AND FUNDING SOURCES*:

UF IFAS/PBC Cooperative Extension Service, Palm Beach County Soil and Water Conservation District, Loxahatchee Group of the Sierra Club, LWL stakeholders

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals.

ACTION PLAN *Public Use and Outreach*

PO-5

Ecotourism

ACTION:
Connect residents and travelers with LWL destinations and outdoor activities as a means to increase awareness, appreciation and environmental stewardship for LWL.

BACKGROUND:
There are many existing recreational opportunities for residents and visitors to enjoy LWL. The Snook Islands Natural Area in the City of Lake Worth and the South Cove Natural Area in the City of West Palm Beach are just two examples of environmental restoration projects that include boardwalks and other public-use components. Phil Foster Park, a Parks and Recreation Department facility located in Riviera Beach on the west side on the lagoon, offers boating, fishing snorkeling, and diving opportunities. On its southern shoreline, the park provides access to a unique lagoon habitat enhancement project, the Phil Foster Park Artificial Reef and Snorkel Trail. An area immediately adjacent to the snorkel trail under the Blue Heron Bridge is well known to scuba divers for the variety of sea life found there. Additional amenities are provided at John D. MacArthur Beach State Park and the numerous municipal parks found along the lagoon. Limited resources, such as the brochure Paddling Treasures: A Guide to LWL and the Loxahatchee River Estuary exist. There is a need to connect residents and travelers with lagoon destinations and outdoor activities as a means to increase awareness, appreciation and environmental stewardship for LWL.

STEP 1 Promote lagoon ecotourism opportunities to various audiences including local residents, school groups, convention and out-of-town guests.
Potential Partners: PBCCVB along with ERM, PBC Parks and Recreation Department, PBCMPO, MIA, PBC League of Cities, PBPPC

STEP 2 Expand LWLI.org to include a web page that highlights lagoon ecotourism and the PBCCVB "Eco-Adventures" web page.
Potential Partners: PBC ERM along with PBCCVB

STEP 3 Combine lagoon ecotourism information from multiple sources into one. Sources include PBCCVB, ERM, PBC Parks and Recreation Department, PBMPO, and municipalities.
Potential Partners: PBCCVB along with ERM, PBC Parks and Recreation Department, PBCMPO, MIA, PBC League of Cities, Palm Beach Pack and Paddle Club (PBPPC)

STEP 4 Promote lagoon ecotourism in a manner that makes it easy for a person to distinguish between commercial and self-guided opportunities and categorizes opportunities by activity (paddling, bird watching, boating, water taxi etc.).
Potential Partners: PBCCVB along with MIA, PBC League of Cities, PBPPC, Audubon Society of the Everglades

STEP 5 Encourage local businesses and organizations to "link to" the PBCCVB "Eco-Adventures" web page, for lagoon ecotourism information.
Potential Partners: PBCCVB along with MIA, PBC League of Cities, PBPPC

STEP 6 Promote the environmental education component of lagoon ecotourism with assistance from businesses, organizations, the media, and via word-of-mouth.
Potential Partners: PBCCVB along with MIA, PBC League of Cities, PBPPC

SCHEDULE:
Step 1 is ongoing.
Step 2 to be completed in 2014.
Steps 3 and 4 to be completed in 2015.
Step 5 to be completed in 2016.
Step 6 to be completed in 2017.

COST:
Staff costs to be determined

EXPECTED BENEFITS:
Connecting residents and travelers with LWL destinations and outdoor activities will increase awareness, appreciation and environmental stewardship for LWL.

MONITORING ENVIRONMENTAL RESPONSES:
Not applicable.

REGULATOR NEEDS:
Not applicable.

FUNDING:
Funding will be sought

POTENTIAL PARTNERS AND FUNDING SOURCES*:

PBCCVB along with ERM, PBC Parks and Recreation Department, PBCMPO, MIA, PBC League of Cities, PBPPC

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals.

ACTION PLAN *Public Use and Outreach*

PO-6 Website and Social Media

ACTION:
Expand interaction through social media, capturing a broad audience and connecting community members to www.LWLI.org.

BACKGROUND:
The Initiative website (www.LWLI.org) was launched in year 2009 and is a public outreach tool used to share general lagoon information and Initiative Steering Committee and Working Group information with the public. Components of the website also include news and events, documents and resources, teacher resources, and the LWL speakers' bureau. Now that the website is established, there is an opportunity to expand interaction through social media, capturing a broad audience and connecting community members with the Initiative.

STEP 1 Increase links between LWLI.org and other partners including local municipalities along the lagoon, tourism and outdoor recreation sites, non-profit organizations, and local businesses.
Potential Partners: All LWL Public Outreach Working Group Participants

STEP 2 Expand LWLI.org to become a comprehensive website that will provide a "one-stop-shop" experience to learn about the lagoon. This includes combining information from multiple sources, highlighting news stories, and posting Initiative Working Group meeting announcements, agendas, and other relevant documents.
Potential Partners: ERM along with SFWMD

STEP 3 Secure the Initiative's ideal account name on various social media sites. Important social media sites at this time include FaceBook, Twitter, YouTube, Pinterest, and FourSquare.
Potential Partners: ERM

STEP 4 Monitor Initiative website and social media statistics over time.
Potential Partners: ERM

STEP 5 Assemble a social media/website action team within the larger Initiative Public Outreach Working Group.
Potential Partners: ERM along with SFWMD

STEP 6 Determine a social media administrator to build the Initiative's social media

presence, coordinate calendar management, and monitor conversations and uploads.

Potential Partners: ERM along with SFWMD

SCHEDULE:

Steps 1 and 4 are ongoing.
Step 2 to be developed in phases as resources allow.
Step 3 to be completed in 2013.
Step 5 to be completed in 2015.
Step 6 to be completed in 2015.

COST:

Staff costs to be determined

EXPECTED BENEFITS:

Expanding interaction through the website and social media will broaden the reach of public outreach efforts and connect community members to the Initiative.

MONITORING ENVIRONMENTAL RESPONSES:

Not applicable.

REGULATOR NEEDS:

Not applicable.

FUNDING:

Funding will be sought

POTENTIAL PARTNERS AND FUNDING SOURCES*:

LWL Public Outreach Working Group, ERM, SFWMD

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals.

7. INTERAGENCY PLANNING AND COORDINATION

PARTICIPATING AGENCIES AND THEIR ROLE

This chapter addresses the role of key agencies and stakeholders, and how they integrate their efforts with the lagoon's restoration. The most successful restoration projects have been completed through partnerships with state, local and federal government, members of the scientific community, businesses and engaged stakeholders. **Appendix B** summarizes the contributions that different agencies have provided to improvements the LWL over the past 5 years.

PALM BEACH COUNTY

The Coastal and Conservation Element of the PBC Comprehensive Plan directs ERM, along with other County's Departments to protect the wildlife and natural. ERM has developed an environmental enhancement program designed to restore estuarine shorelines, improve their productivity and offset the negative effects of development. Coordination with other agency programs will achieve mutual restoration goals, and the cost-sharing of expenses associated with restoration monitoring, applied research, and management. Those plans and programs that are described below are currently in the forefront of LWL management.

South Lake Worth Inlet Management Plan

The South Lake Worth Inlet, also known as the Boynton Inlet, separates the Town of Manalapan located on Palm Beach Island to the north from the Town of Ocean Ridge to the south. This inlet is the southern and smaller of the two inlets connecting LWL with the Atlantic Ocean. The South Lake Worth Inlet Advisory Committee was created to advise the Board of County Commissioners on improvements, operations, maintenance, and enhancement of the inlet and adjacent property and to assist in the development, coordination, and public review of the Inlet Management Plan. The purpose of the Management Plan was to evaluate the erosive impact of the inlet on adjacent beaches, and to recommend corrective measures to mitigate identified impacts. Navigation improvements and other issues were also included in the plan.

Recommended projects in the SLWI Management Plan included creation of an interior sand trap with regular maintenance dredging, replacement of the sand transfer plant, rehabilitation of the north and south inlet jetties, and replacement of the Bird Island seawall. These projects were successfully completed in 2011 with the interagency coordination and funding partnership of PBC, FDEP, FIND and the City of Boynton Beach. With the adoption of the Management Plan and the successful restoration of the inlet facilities, the Board of County Commissioners voted to sunset the South Lake Worth Inlet Advisory Committee on September 28, 2010. The decision was approved by the

Florida Legislature on June 2, 2011. Future projects include continued maintenance dredging of the sand trap, Boynton Boat Club Channel, and ICW navigation channel.

Agricultural and Green Industry Best Management Practices (BMPs)

Best Management Practices (BMPs) for nonpoint source pollution from agricultural areas are authorized under the Florida Watershed Restoration Act. BMPs are designed to provide industry guidance for various agricultural activities to promote water quality and conservation objectives. There are currently a number of published BMPs that are applicable to agricultural practices within PBC. The state BMP rule is administered by the Florida Department of Agriculture and Consumer Services (FDACS). Farmers and growers in PBC that voluntarily enroll, implement and maintain verified FDACS BMPs receive a "presumption of compliance" relating to stormwater runoff from FDEP and SFWMD. Throughout Florida, several innovative cost-share programs exist for nurseries and agricultural operations utilizing effective BMPs. In addition, the SFWMD and FDACS have partnered with local organizations to create BMP cost-share programs in surrounding areas. In areas with adopted basin management action plans (BMAPs), and some other designated areas, producers who implement BMPs avoid having to conduct costly water quality monitoring. BMP participation demonstrates agriculture's commitment to water resource protection, and helps maintain support for this alternative approach. For more information visit the FDACS Office of Agricultural Policy web page.

Palm Beach Soil & Water Conservation District (PBSWCD) joined efforts with USDA/Natural Resources Conservation Service (NRCS) to introduce and implement wise use of land, water conservation, water quality and related conservation resources through the implementation of the USDA Farm Bill programs, which are administered by NRCS. The District assists NRCS in promoting Farm Bill cost-share programs to local growers which can reduce their costs of implementing a variety of conservation practices as well as promote agricultural production. PBSWCD also manages parcels owned by PBC in the Ag Reserve. The properties are leased for agricultural production and PBSWCD works with the lessees to implement BMPs.

In addition to agricultural BMPs, PBC promotes Green Industry BMPs, or GI-BMP program, developed through a partnership between DEP and the University of Florida. The mission is to equip green industry professionals with quality, research-backed education intended to protect our ground and surface waters through environmentally safe landscaping practices. The Green Industry includes landscape maintenance professionals, designers, arborists, landscape architects, and designers. These individuals can positively impact water quality through appropriate fertilization, maintenance, and other landscape practices.

To further emphasize the importance of this education, Florida Statute 526.1562 states that all commercial fertilizer applicators must have a license from FDACS by January 1,

2014. Successful completion of the GI-BMP training program is a prerequisite for obtaining this license. Many non-commercial Green Industry applicators or other workers are required to pass the training by local ordinances or voluntarily participate in the program to better serve their clients.

In PBC, nearly 600 individuals have successfully completed this training since the program's inception in 2007. A minimum of six GI-BMP classes are offered each year in order to equip a large local green industry to safely care for green spaces in the LWL watershed. Implementation of the various programs identified above should improve the quality of water in PBC.

Palm Beach County Metropolitan Planning Organization

The PBC Metropolitan Planning Organization (MPO) was mandated by the Federal Highway Act of 1973 to provide a cooperative transportation planning and decision-making process. The process encompasses all modes of transportation and covers both short and long-range planning. Five new water taxi dock facilities in the Lagoon are components of larger projects assisted by grants from the federally funded Ferry Boat Discretionary (FBD) Program, which is part of the U.S. Department of Transportation, Federal High Administration (FHWA) discretionary grant program, administered by the MPO. The docks will link PBC cities in the LWL and grant recipients will seek interested vendors and coordinate operations and marketing. MPO has contributed up to $547,163 to municipalities and County for these water taxi docks.

MPO Grants for the Lake Worth Lagoon

Project	Recipient	Grant Award	Completed
Flagler Drive Docks	City of West Palm Beach	$100,000	February 2009
Currie Park, North Flagler Drive	City of West Palm Beach	$100,000	November 2009
Boynton Harbor Marina	Boynton Beach CRA	$20,253	October 2010
Snook Islands	Palm Beach County ERM	$130,000	February 2012
Riviera Beach Municipal Marina	City of Riviera Beach	$196,910	Under Construction
Total		$547,163	

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

The SFWMD is a regional governmental agency that oversees the water resources in the southern half of Florida, including all or part of 16 counties from Orlando to the Florida Keys serving a population of more than 7.7 million residents. The SFWMD mission is to manage and protect the water resources of the region by balancing and improving water quality, flood control, natural systems, and water supply. The SFWMD is responsible for the routine (and emergency) operations and maintenance of the Central and Southern Florida Flood Control (C&SF) Project. The C&SF Project was authorized by Congress in 1948 and constructed by USACE over the next two decades. The C&SF Project is one of the world's largest water management systems; it includes 1,978 miles of canals, 2,873 miles of levees, and 573 water control structures. In Palm Beach County 110 miles of canals, 200 miles of levees, 11 water control structures, 80 project culverts, 6 pump stations, 34 boat ramps, and 210 berm gates are operated and maintained by SFWMD, including many that the SFWMD built. Drainage districts and local governments are responsible for operating and maintaining the sub-regional, secondary stormwater management systems connected to the C&SF Project.

Modernization of the C&SF Project to address its unintended harm to the region's water resources was the "driving force" for the development of the CERP authorized by Congress in the Water Resources Development Act of 2000 (WRDA 2000). CERP provides a framework and guide to restore, protect, and preserve the water resources of central and southern Florida, including the Everglades. The goal of CERP is to capture fresh water that now flows unused to the Atlantic Ocean and the Gulf of Mexico and redirect it to areas that need it most. Most of the water made available by CERP will be devoted to environmental restoration; the remaining water will benefit water users by enhancing water supplies for the south Florida economy. Needed improvements to the C&SF Project will be implemented as part of CERP. Structural and operational modifications to the C&SF Project will improve the quality of the environment; improve protection of the aquifer; improve the integrity, capability, and conservation of urban and agricultural water supplies; and improve other water-related purposes.

The SFWMD is also the lead agency for implementing the Everglades Forever Act (EFA) which was passed by the Florida Legislature in 1994. The EFA authorized the Everglades Construction Project (ECP) one of the largest public works projects in the nation and considered to be the first major step in Everglades restoration. The EFA required the SFWMD to acquire land, design, permit, and construct a series of Stormwater Treatment Areas (STAs) to reduce phosphorus levels from stormwater runoff and other sources before entering the Everglades Protection Area (EPA). In addition to the ECP, the EFA directed the SFWMD to implement a regulatory source control program requiring land owners to reduce phosphorus in their stormwater runoff on-site prior to off-site discharge.

In addition to its role in the EFA and federal partnership for CERP, the SFWMD has shared jurisdiction as the local sponsor in other water resource projects, some of which are designed to complement CERP projects. Authorized by Congress in 1996, the West Palm Beach Canal/Stormwater Treatment Area 1-East Project (STA-1E) detains and treats stormwater runoff from the western portion of the C-51 basin that is collected in the West Palm Beach (C-51) Canal. The treated water is discharged into Water Conservation Area 1 (WCA-1), also known as the Arthur R. Marshall Loxahatchee National Wildlife Refuge. A Periphyton Stormwater Treatment Area (PSTA) demonstration project was conducted within the eastern portion of Cell 2 of STA-1E to test a methodology to reduce phosphorus concentrations to levels lower than expected for emergent vegetation.

While the goals and objectives developed for CERP and EFA continue to be sound, process improvements and project enhancements have been implemented as necessary to ensure success. The SFWMD has been an important partner for implementing the Lagoon management plan. The Everglades restoration and water quality treatment projects implemented as part of the CERP and EFA will ensure that LWL benefits by receiving clean water in the right amounts and at the right time. The SFWMD has also provided funding to Palm Beach County for salinity modeling, water quality monitoring, sediment transport studies, C-51 sediment trap construction, habitat restoration, and public outreach.

CERP Components That Benefit Lake Worth Lagoon

The Water Resources Development Acts in 1992 and 1996 provided the USACE with the authority to re-evaluate the performance and impacts of the C&SF Project and to recommend improvements and/or modifications to the project, in order to restore the South Florida ecosystem and to provide for other water resource needs. The result of this re-evaluation, also known as the Restudy, is the foundation for CERP; a multibillion dollar Federal and State program to restore the South Florida ecosystem, while providing flood control and enhancing water supplies. As envisioned in WRDA 2000, CERP implementation will take at least 30 years. The major components of the plan include surface water storage reservoirs, water storage areas, aquifer storage and recovery wells, water quality treatment areas, removal of more than 500 miles of canals and levees that are barriers to natural sheet flow, new infrastructure to move water to meet restoration goals, wastewater reuse facilities, and C&SF Project operational changes. The purpose of the Loxahatchee River Watershed Restoration Project *(formerly known as North Palm Beach County - Part 1)* is to capture, store and treat excess water that is currently discharged to the LWL and use that water to enhance the Loxahatchee River and Slough and provide for water supplies to the City of West Palm Beach Grassy Waters Preserve. This project should improve water clarity and quality, and lead to a healthier ecosystem in the County's coastal waters by regulating and reducing pollutant laden freshwater discharges to the estuary. More information about the Loxahatchee River Watershed Restoration Project can be found at www.evergladesplan.org.

In October 2011, a state-federal initiative to speed up planning for key CERP projects was approved. Now under way, the Central Everglades Planning Project (CEPP) has set a goal to deliver within two years a finalized plan for a suite of restoration projects in the central Everglades to prepare for congressional authorization as part of CERP. These restoration projects will be constructed on land already in public ownership to allow more water to be directed south to the central Everglades, Everglades National Park, and Florida Bay while protecting coastal estuaries. The CERP components included in CEPP include the Everglades Agricultural Area Storage Reservoir, Decompartmentalization of Water Conservation Area 3, Everglades National Park Seepage Management, and Everglades Rain Driven Operations. The USACE is leading this planning effort in partnership with the SFWMD.

Non-CERP Projects That Benefit Lake Worth Lagoon

The ECP was developed over 10 years through a collaborative process involving extensive public input, state and federal legislation and litigation. The scope and timeframes of the comprehensive ECP were incorporated into the 1994 Everglades Forever Act, which recognized constructed wetlands are the best available means to achieve the interim water quality goals of Everglades restoration. The objectives of the ECP are:

- Reduce the phosphorus levels in water entering the northern Everglades ecosystem to a target of 10 parts per billion.
- Improve the volume, timing and distribution of water entering the Everglades.
- Reduce the volume of harmful discharges to sensitive estuarine systems, including the Caloosahatchee estuary, the St. Lucie estuary and Lake Worth Lagoon,
- Reduce the volume of poor quality water discharged to Lake Okeechobee from special drainage districts adjacent to the lake,
- Improve the flood protection in the C-51 West basin located in central Palm Beach County,
- Restore more desirable water levels in the 25,000-acre Rotenberger Wildlife Management Area, and
- Provide a source of clean water for the 35,500-acre Holey Land Wildlife Management Area.

The STAs are constructed wetlands that use biological processes to reduce the level of nutrients, and improve the volume and timing of water entering the Everglades. Four STAs in western Palm Beach County (STA-1E, STA-1W, STA-2, and STA-3/4) provide an effective treatment area of 43,300 acres, treating runoff from the Everglades Agricultural Area and urban runoff in the western C-51 Basin. More information about the STAs can be found on the SFWMD STA web page.

In 2012, the State of Florida and the U.S. Environmental Protection Agency (USEPA) reached a consensus on a new strategy for improving water quality in the Everglades. Based on months of scientific and technical discussions, water quality improvement projects will be expanded to achieve the ultra-low phosphorus water quality standard established for the Everglades. Under this strategy, SFWMD is implementing a technical plan to complete six projects that will create more than 6,500 acres of new STAs and 110,000 acre-feet of additional water storage through construction of flow equalization basins (FEBs). Flow equalization basins provide a more steady flow of water to the STAs, helping to maintain desired water levels needed to achieve optimal water quality treatment performance.

The strategy also includes additional source controls – where pollution is reduced at the source – in areas of the eastern Everglades where phosphorus levels in stormwater runoff have been historically higher. In addition, a robust science plan will ensure continued research and monitoring to improve and optimize the performance of water quality treatment technologies.

Design and construction of the treatment and storage projects will be completed in three phases over a 12-year timeframe, with completion set for 2024.

The SFWMD has been working with PBC, the Lake Worth Drainage District, and the City of Fort Lauderdale regarding the C-51 water quality and quantity reservoir planning and development. Known as the C-51 reservoir, this project is being analyzed by SFMWD and a coalition of utilities as a potential public water supply source. Under the right conditions, the C-51 reservoir could potentially store water currently lost to tide and deliver it to recharge wellfields. Similar to the L-8 project, it is a viable concept that could be used to effectively meet future water supply demands and ensure the LWL benefits by receiving clean water in the right amounts and at the right time.

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

FDEP is currently coordinating with PBC, SFWMD, local governments and other stakeholders to assess the lagoon under the state's Impaired Waters Rule (62-303, FAC) and to development Total Maximum Daily Loads (TMDL) for verified water quality impairments. As TMDLs are established, FDEP will continue to coordinate with these entities on the development of Basin Management Action Plans (BMAP) to meet TMDL goals.

Total Maximum Daily Load

While in general, surface waters in PBC meet many of the applicable water quality standards for their respective classifications, improvements are needed in some areas. In 2002, Florida adopted the Impaired Waters Rule (IWR), Florida Administrative Code 62-303, which provides the methodology to determine impaired waters for which a TMDL

must be established. TMDLs establish the maximum amount of a pollutant that a water body can assimilate without exceeding water quality standards. Pursuant to the IWR, water bodies that do not meet applicable water quality standards are designated as "impaired waters." The FDEP has established requirements necessary to remove a water body from impaired status. According to the IWR, when a body of water has been verified impaired by FDEP, it can only be removed from the verified list (delisted), when a TMDL is developed, or when new pollution control measures have been implemented providing reasonable assurance, or new water quality data indicate that the water body is no longer impaired. As additional data is gathered and analyzed that documents the effectiveness of restoration efforts in the LWL, some water bodies and segments will be delisted while others may be added to the list. Assessments are made approximately 3 to 4 times a year by the IWR Run database. The verified impaired listing and delisting are completed on a 5 year cycle, which also set a priority for TMDL development. The current verified list of impaired waters is from the second cycle and was adopted in 2010.

During the next few years, data collection and analysis will be done to establish TMDLs for impaired water bodies in PBC, and to establish loading allocations of pollutants needed to meet TMDLs. As such, developments of TMDLs are an important step toward restoring our waters to their designated uses. Implementation of TMDLs refers to any combination of regulatory, non-regulatory, or incentive-based actions that attain the necessary reduction in pollutant loading. Non-regulatory or incentive-based actions may include development and implementation of Best Management Practices (BMPs), pollution prevention activities, and habitat preservation or restoration. Regulatory actions may include issuance or revision of wastewater, stormwater, or environmental resource permits to include permit conditions consistent with the TMDL. These permit conditions may be numeric effluent limitations or, for technology-based programs, requirements to use a combination of structural and non-structural BMPs needed to achieve the necessary pollutant load reduction. (From http://www.dep.state.fl.us) .

Table 14 lists the current (Cycle 2) verified impaired water bodies affecting the Lake Worth Lagoon.

Planning Unit	Water Segment Name	Parameters of Concern from IWR	Concentration Causing Impairment	Comments
C-17	C-17 Segment	Dissolved Oxygen and Nutrients (Chlorophyll a)	< 5.0 mg/L (Dissolved Oxygen) >20 µg/L (Chlorophyll a)	BOD was found to be the causative pollutant to DO exceedences. Chlorophyll a exceeded the listing threshold in 2005 and 2006.
C-51	Pine Lake	Dissolved Oxygen, Nutrients (TSI) and Fecal Coliform	< 5.0 mg/L (Dissolved Oxygen) TSI > 60 (Nutrients) ≤400 cfu/100ml (Fecal Coliform)	BOD was found to be the causative pollutant to DO exceedences. TSI annual mean exceeded the threshold in 2008
C-51	Lake Clarke	Fecal Coliform	≤400 cfu/100ml (Fecal Coliform)	
C-51	C-51 East	Dissolved Oxygen and Fecal Coliform	< 5.0 mg/L	BOD was found to be the causative pollutant to DO exceedences.
C-51	C-51 West	Nutrients (Chlorophyll a)	>20 µg/L (Chlorophyll a)	Chlorophyll a exceeded the listing threshold in 2007.
C-16	Boynton Canal	Dissolved Oxygen and Nutrients (Chlorophyll a)	< 5.0 mg/L (Dissolved Oxygen) >20 µg/L (Chlorophyll a)	BOD was found to be the causative pollutant to DO exceedences. Chlorophyll a exceeded the listing threshold in 2002, 2004, 2007 and 2008.
C-16	E-4 Canal	Dissolved Oxygen and Nutrients (Chlorophyll a)	< 5.0 mg/L (Dissolved Oxygen) >20 µg/L (Chlorophyll a)	BOD was found to be the causative pollutant to DO exceedences. Chlorophyll a exceeded the listing threshold in 2008.
Intracoastal	Lake Worth Lagoon (North, Central and Southern Section)	Mercury (in fish tissue)	Exceeds DoH Threshold (> 3.7 mg/kg	FDEP has proposed a Statewide TMDL for Mercury.

Table 14. Lake Worth Lagoon Basin IWR FDEP Adopted Verified List (Cycle 2)

The determination of the impairment for these listed water bodies may change as additional water quality data becomes available. ERM provides support to the TMDL program as a water quality data provider. The TMDL process will draw additional attention and resources to improve water quality where needed.

Environmental Resource Permitting

FDEP has been partnering with governmental entities to draft language for Chapter 62-

330 F.A.C., Environmental Resource Permitting. Legislation to streamline the permitting process for Government sponsored restoration or enhancement projects may be simplified through issuance of a Restoration General Permit under 62-330.631 Noticed General Permit to Governmental Entities for Limited Environmental Restoration or Enhancement Activities. These limited activities may include, but are not limited to, Living Shorelines, Artificial Reefs, seagrass and mangrove habitat restoration. This is a step in the right direction towards partnering in efforts to restore LWL.

Palm Beach County National Pollutant Discharge Elimination System (NPDES)

The NPDES Municipal Separate Storm Sewer System (MS4) permit is a federal program designed to eliminate stormwater pollutant discharges to receiving waters of the United States. The NPDES stormwater regulations require that local governments are issued NPDES stormwater permits to reduce to the maximum extent possible the discharge of pollutants both into and from municipal separate storm sewers to "Waters of the U.S." This is accomplished through the implementation of an approved stormwater management plan, which addresses the various aspects of how pollutants reach municipal storm sewers. The Stormwater Management Plan (SWMP) includes the following individual program components: maintenance of stormwater structural control; stormwater treatment projects; roadway maintenance activities; flood control projects; municipal solid waste facilities; pesticide, herbicide and fertilizer application; illicit connections and discharges; high risk industrial facilities; and construction activities. In addition to these individual program components, water quality monitoring is performed. The water quality monitoring is conducted within the receiving water bodies over time to determine the effectiveness of the Stormwater Management Plan. Other important aspects of the NPDES Program include regulatory prohibition of stormwater discharges to the stormwater system and the public education efforts that are part of several individual program components.

In 2011, the third 5-Year NPDES MS4 permit was issued to Palm Beach County's forty co-permittees. PBC has a cooperative program now involving forty co-permittees, the FDEP and the USEPA. Northern Palm Beach County Improvement District (NPBCID) acts as lead permittee for the PBC group. A Steering Committee was formed in 1991 to coordinate and facilitate joint activities within the PBC MS4 NPDES program. Mock•Roos, Inc. acts as staff to the Steering Committee, assisting with the administration of the program. The group maintains the PBC MS4 NPDES program website for sharing information.

The third term permit contained additional requirements related to TMDLs. For water bodies or water body segments with a FDEP established TMDL with a Basin Management Action Plan (BMAP) the permittees must comply with the adopted provisions of the plan. For FDEP or EPA established TMDLs without a BMAP, monitoring stormwater discharges from a representative stormwater outfall in the water

body segment are required. The stormwater monitoring data will be used to assess the SWMPs effectiveness in reducing the pollutant(s) of concern and whether additional BMPs are necessary.

Numeric Nutrient Criteria for Lake Worth Lagoon

USEPA and FDEP both have numeric nutrient criteria (NNC) processes ongoing at the time of this update. Thus, the future NNC for the LWL estuary and its watershed remains uncertain. The following text provides a synopsis of where both the federal and state NNC processes are to date. The USEPA has both Phase 1 and Phase 2 rulemaking as part of a consent decree reached in the settlement of a federal lawsuit. Information is available on the EPA Nutrients Water Quality Standards for the State of Florida web page.

The LWL would potentially be influenced by the Phase 2 portion of the federal rulemaking that includes South Florida Canals ("flowing freshwaters" south of Lake Okeechobee, as well as south of the Loxahatchee River watershed) and all Florida estuarine and coastal waters. Currently, the USEPA is scheduled to propose NNC for Phase 2 waters on November 30, 2012 and promulgate a final rule by September 30, 2013. Information is available on the EPA Federal Nutrient Water Quality Standards for the State of Florida's Estuaries, Coastal Waters, and South Florida Inland Flowing Waters (Coastal Rule) web page.

The FDEP completed its own numeric nutrient standards rulemaking in February 2012 and the rules were upheld by a Division of Administrative Hearing judge in June 2012. The FDEP standards cover most freshwaters statewide [i.e.,., lakes, streams, and springs (nitrate only)] and several South and Southwest Florida estuaries where appropriate scientific information was available to develop numeric interpretations of the current narrative nutrient criteria. Information is available on the FDEP Numeric Nutrient Criteria Development web page. This includes many areas within the boundaries of National Estuary Programs on the state's west coast (e.g., Charlotte Harbor). Other South Florida estuaries covered under the FDEP rule include the 10,000 Islands, Florida Bay, Biscayne Bay, and estuaries with current State adopted TMDLs (e.g., St. Lucie Estuary).

FDEP's nutrient standards have been submitted to USEPA and the federal review process is ongoing. Potentially USEPA could approve FDEP's rule and withdraw their federal rulemaking process. However, USEPA has not made a decision at this time, and the future interactions between the state and federal rules remain unknown. Should USEPA approve FDEP's current nutrient standards rule, many estuaries, such as those listed above, would have NNC in place. However, some of the state's estuaries would be part of a future rulemaking schedule. FDEP's nutrient standards under review by USEPA state:

F.A.C. 62-302.532 (3) The Department shall establish by rule or final order estuary

specific numeric interpretations of the narrative nutrient criteria for TN and TP for Perdido Bay, Pensacola Bay (including Escambia Bay), St. Andrews Bay, Choctawhatchee Bay, and Apalachicola Bay by June 30, 2013, subject to the provisions of Chapter 120, F.S. The Department shall establish by rule or final order the estuary specific numeric interpretation of the narrative nutrient criteria for TN and TP for the remaining estuaries by June 30, 2015, subject to the provisions of Chapter 120, F.S.

The "remaining estuaries" referenced for NNC completion by June 30, 2015 includes the LWL. FDEP prepared a draft report in 2010 summarizing information that could be used to support development of NNC for the Lagoon and held public meetings to present their initial work. FDEP anticipates that it will reinitiate NNC development for the Lagoon's waters after it completes adoption of NNC for west panhandle estuaries (currently scheduled to be presented at the November 2012 Environmental Regulation Commission meeting).

FLORIDA INLAND NAVIGATION DISTRICT (FIND)

Long Range Dredged Material Management Plan for the Intracoastal Waterway in Palm Beach County

FIND is an Independent Special State Taxing District and the "local sponsor" for the continued management and maintenance of the Atlantic Intracoastal Waterway Project in Florida. In this capacity FIND is responsible for providing dredge material sites for the Waterway pursuant to s.374.984, Florida Statutes According to its 1989 Long Range Dredged Material Management Plan. FIND has identified 6 upland sites and 2 beach placement sites to provide for the management of maintenance material periodically dredged from the waterway channel. The plan is aimed to enhance the water quality of the lagoon by removal of these sediments, and to prevent their further re-suspension by properly disposing of the materials in approved areas for beneficial re-use. ERM coordinates with FIND to manage some of the sites for environmental enhancement purposes and to identify suitable beach deposit sites (for beach compatible dredge material) to augment the County's shoreline protection efforts.

Waterway Assistance Program and Cooperative Assistance Program

FIND's Waterway Assistance Program (WAP) is a grant program established by the Florida Legislature and the District for the purpose of financially cooperating with local governments to alleviate problems associated with the Atlantic Intracoastal Waterway and associated waterways within the District. The program is authorized by Section 374.976, Florida Statutes, and is administered under the provisions of Chapter 66B-2, Florida Administrative Code.

Waterway related projects must be located on natural, navigable waterways within the District. Eligible waterway related projects include navigation channel dredging, channel

markers, navigation signs or buoys, boat ramps, docking facilities, fishing & viewing piers, waterfront boardwalks, inlet management, environmental education, law enforcement equipment, boating safety programs, beach re-nourishment, dredge material management, environmental mitigation, and shoreline stabilization.

Eligible local governmental agencies include municipalities, counties, port authorities and special taxing districts within the twelve counties of the District. FIND has funded and provided lands for many restoration projects in the LWL through the WAP program including Peanut Island, Munyon Island, and Snook Islands Natural Area. FIND has also provided WAP grants for construction of many public waterway access facilities to provide public access to the LWL.

FIND's **Cooperative Assistance Program** is a grant program established by the Florida Legislature and the District for the purpose of financially cooperating with state and regional governments to alleviate problems associated with the Atlantic Intracoastal Waterway and associated waterways within the District. The program is authorized by Section 374.976, Florida Statutes, and is administered under the provisions of Chapter 66B-1, Florida Administrative Code. Eligible state and regional governmental agencies seeking to develop waterway improvement projects within the twelve counties of the District (Miami-Dade to Nassau Counties) can apply for funding assistance. A list of projects funded by FIND is included below.

Florida Inland Navigation District—Waterways Assistance Program Projects in Lake Worth Lagoon 2008-2012

PROJECT NAME	PROJECT NUMBER	PROJECT SPONSOR	GRANT AMOUNT	TOTAL COST
S. Lake Worth Inlet Sand Trap & Boat Channel Dredging	PB-07-127	Palm Beach County	$233,220.00	$897,000.00
John's Island Oyster Reef Project	PB-08-132	Palm Beach County	$200,000.00	$680,000.00
Snook Islands Public Use Facilities	PB-08-133	Palm Beach County	$639,575.00	$1,279,150.00
South Cove Restoration& Boardwalk	PB-10-148	Palm Beach County	$1,000,000.00	$4,388,000.00
Bryant Park Wetland Restoration & Boat Ramp Facility	PB-11-153	Palm Beach County	$255,000.00	$625,000.00
John's Island Oyster Reef Project-Ph B	PB-11-154	Palm Beach County	$406,250.00	$812,500.00
Jaycee Park Environmental Education	PB-BB-09-136	City of Boynton Beach	$77,045.00	$154,090.00
Lake Park Harbor Marina Breakwater - Phase I	PB-LP-08-130	Town of Lake Park	$62,254.00	$124,508.00
Lake Park Harbor Marina Breakwater - Phase II	PB-LP-09-138	Town of Lake Park	$349,292.00	$698,585.00
Anchorage Park Improvements	PB-NPB-08-131	Village of North Palm Beach	$200,000.00	$700,000.00
Lake Worth Inlet Sand Transfer Plant Renovation	PB-PB-09-139	Town of Palm Beach	$300,000.00	$2,248,000.00
Municipal Marina Remediation - Phase I	PB-RB-09-141	City of Riviera Beach	$475,000.00	$950,000.00

Municipal Marina Construction	PB-RB-10-150	City of Riviera Beach	$850,000.00	$4,270,366.00
Municipal Marina Construction	PB-RB-11-158	City of Riviera Beach	$1,500,000.00	$3,500,000.00
City Commons & Waterfront Park - Phase V	PB-WPB-08-134	City of West Palm Beach	$1,000,000.00	$2,000,000.00
City Commons & Waterfront Project - Phase V-2	PB-WPB-09-142	City of West Palm Beach	$150,000.00	$300,000.00
Currie Park Boating Improvement	PB-WPB-09-143	City of West Palm Beach	$233,800.00	$467,600.00
City Commons Kayak/Paddle Boat Launch - Phase I	PB-WPB-10-151	City of West Palm Beach	$30,000.00	$60,000.00
		Total	**$7,961,436***	

UNITED STATES ARMY CORPS OF ENGINEERS (USACE)

The USACE has a long history of maintaining the nation's waterways, but only in the last two decades has the Corps taken its knowledge of routing water and applied it towards ecosystem restoration. The Jacksonville District of the U.S. Army Corps of Engineers oversees the planning, design, construction and management of ecosystem restoration projects in Florida, Puerto Rico, and other U.S. territories in the Caribbean Islands.

The majority of ongoing restoration projects are located in south Florida, including CERP and the Central and Southern Florida projects. A key component of successful ecosystem restoration is the use of interagency teams during the planning process and continued communication during execution. The Ecosystem Branch is proud to be the Jacksonville District's representative on the South Florida Ecosystem Restoration Task Force and utilizes this position to continue to inform other agencies regarding ongoing activities.

USACE has the authority, provided by Section 1135 and Section 206 of the Water Resources Development Act of 1986, as amended, to plan, design and construct fish and wildlife habitat restoration measures. The Corps has partnered with PBC to construct many restoration projects within the LWL through the Section 1135 program including, Munyon Island, Peanut Island, Snook Islands and John's Island Restoration Projects. PBC has attempted to initiate additional projects through this program, but the program currently lacks funding.

Lake Worth Inlet (Palm Beach Harbor) Navigation Project

The USACE, Jacksonville District is preparing the Lake Worth Inlet Navigation Project Pilot Feasibility Study. The study is a cooperative effort between the USACE and FDEP, with input from PBC-ERM, which contains the results of the Value Engineering (VE) Workshop that was performed June 18-22, 2012. VE analysis was incorporated into the development and validation of the proposed Tentatively Selected Plan (TSP). The following aspects of the navigation project were considered: mitigation options, disposal options, advanced channel maintenance issues, jetty stabilization issues.

The Port of Palm Beach is the fourth busiest container port in Florida and eighteenth busiest in the continental United States. Based on modern vessel sizes, the port is operating with insufficient channel width and depth, currently at 300' and 33', respectively. The current feasibility study is executed under the USACE Accelerated Feasibility Study Pilot Program. This program tests streamlined applications of planning principles while completing a feasibility study on an accelerated schedule. A number of alternative options that address problems and needs have been identified and evaluated. Optimization of benefits, costs and risks will result in the determination of a proposed TSP with the following components:

- Widening and deepening of the entrance channel, ocean-side settling basin, interior channel and turning basin.
- Bulkhead stabilization and/or berth deepening to three existing wharfs
- Environmental mitigation for seagrass and hardbottom impacts

West Palm Beach Canal (C-51)/Stormwater Treatment Area-1 East (STA-1E)

West Palm Beach Canal/Stormwater Treatment Area-1 East (STA-1E) detains and treats stormwater runoff from the western portion of the C-51 basin that is collected in the West Palm Beach (C-51) Canal. The treated water is discharged into Water Conservation Area 1 (WCA-1), also known as the Arthur R. Marshall Loxahatchee National Wildlife Refuge.

The C-51 canal is a component of the Central and Southern Florida Project. The C-51 basin is located in Palm Beach County, Fla., and extends from the edge of WCA-1 on the west, almost to the Atlantic Ocean on the east. The drainage area of the basin is approximately 164 square miles. STA-1E is located between WCA-1 and the western end of the C-51 canal.

In 1996, Congress authorized the U.S. Army Corps of Engineers to modify the C-51 flood control project to additionally act as a stormwater treatment area, by building an STA that would reduce phosphorous discharge levels to 50 parts per billion (ppb). The Corps began construction in June 2000. STA-1E was turned over to the South Florida Water Management District (SFWMD) for operation and maintenance in October 2005. However, the Corps retained control of the eastern flowway (Cells 1 and 2) to operate the Periphyton Stormwater Treatment Area (PSTA) demonstration project.

The Corps is scheduled to remove the PSTA demonstration project beginning in the fall of 2012. Deconstruction is expected to take approximately seven months to complete. Once the deconstruction has been completed, SFWMD will begin their re-vegetation process, which is expected to take approximately 18 months. At that time, Cell 2 will be

restored to operational condition and will be brought back on-line to continue the removal of phosphorus from the water.

Palm Beach Harbor (PBH) Lake Worth Access Channel Expansion

The USACE, Jacksonville District has prepared a Draft Environmental Impact Statement (DEIS) for the PBH Lake Worth Access Channel Expansion, Section 107 Small Navigation Project. The study is a cooperative effort between the USACE and FIND, with the support of PBH.

The purpose of the study is to consider modifying the Federal navigation project of PBH to provide navigation access for larger and deeper-draft vessels to interior berthing, testing, and repair facilities located adjacent to PBH in Lake Worth. Existing depths in the proposed Lake Worth main access channel area are presently limited to the 10-foot deep Federal ICW channel that runs north and south from the Port. The need for this deepening project comes from the recent growth in larger/deeper-draft vessels requiring deeper water depths to safely navigate the interior area.

The study involves an analysis of a deepened access channel from the existing ten-foot depth, in one-foot increments to a 16-foot depth. Each alternative depth considered includes a one-foot required and one-foot allowable over-depth. All alternative depth main access channels have a bottom width of 125 feet for about 0.7 miles north and 4.5 miles south of the PBH project limit. Adding an appropriate depth access channel would enable larger vessels access to commercial repair and berthing facilities in the vicinity of PBH and improve operational efficiencies at other commercial and educational training facilities along Lake Worth.

Issues: The DEIS will consider impacts on seagrasses, protected species, health and safety, water quality, aesthetics and recreation, fish and wildlife resources, cultural resources, energy conservation, socio-economic resources, and other impacts identified through scoping, public involvement, and interagency coordination.

Coordination: The proposed action is being coordinated with the USFWS and the National Marine Fisheries Service under Section 7 of the Endangered Species Act, with the USFWS under the Fish and Wildlife Coordination Act, and with the State Historic Preservation Officer.

Lake Worth Inlet Management Plan

The Lake Worth Inlet, also known as the Palm Beach Inlet, is a man-made inlet that separates Palm Beach shores to the north from the Town of Palm Beach to the south. The inlet is the northernmost and larger of two inlets connecting LWL with the Atlantic

Ocean. The original inlet creation, subsequent expansion and deepening, and the federal role in the Lake Worth Inlet have been a result of local navigation interests and the Port of Palm Beach District. Federal participation in the maintenance of the inlet channel and jetty structures began in 1934 and continues today. The USACE assumed responsibility for maintenance of the inlet under authorization of the River and Harbor Act of 1935. In 1993, the Town of Palm Beach agreed to undertake preparation of the Lake Worth Inlet Management Plan in cooperation with the State of Florida. The *Lake Worth Inlet Management Plan (Applied Technology and Management, Inc.*, 1995) has been adopted (1997) by the State in accordance with the Beaches and Shore Preservation Act (Chapter 161, F.S.). Inlet management issues are addressed through a tri-party cooperative agreement between Palm Beach County, the Town of Palm Beach and the Port of Palm Beach. The goals of the *Lake Worth Lagoon Management Plan* need to be coordinated with the *Lake Worth Inlet Management Plan* through the intergovernmental coordination process.

The Lake Worth Inlet is dredged on an annual basis, with the last dredging event to occur January 2013, removing approximately 380,000cy3 from the inlet, north turning basin and settling basins, to be deposited in the onshore and nearshore disposal areas, south of the inlet.

ADDITIONAL INTERGRATED PROGRAMS

FWC Role in Lagoon Management

FWC's mission statement is, "Managing fish and wildlife resources for their long-term well-being and the benefit of people." As the manager of all fish and wildlife resources in the state of Florida, FWC plays a critical role in management of the LWL including law enforcement, research, restoration, and management. FWC Law Enforcement monitors the waters of the LWL for boating and wildlife violations. Multiple FWRI programs conduct monitoring in the LWL, including seagrass and oyster monitoring. The marine and estuarine subsection of HSC has fostered a partnership with PBC ERM and has provided assistance in seeking funding for large scale restoration projects such as South Cove and Grassy Flats. Multiple representatives from FWC participate in the Initiative. As part of the Initiative, FWC was a partner in the first Living Shorelines Symposium which was held in 2010. FWC will continue to participate in this initiative and provide expertise, data, and resources when possible. Additional FWC Programs currently on-going in the Lagoon include:

Great Florida Birding and Wildlife Trail

The Great Florida Birding and Wildlife Trail (GFBWT) is a program of the Florida Fish and Wildlife Conservation Commission. At its core is a network of nearly 500 sites throughout Florida selected for their excellent birdwatching, wildlife viewing or

educational opportunities. This 2,000-mile, self-guided highway trail is designed to conserve and enhance Florida's wildlife habitats by promoting birding and wildlife viewing activities, conservation education and economic opportunity. John D. MacArthur Beach State Park is a viewing location on the GFBWT.

Coastal Wildlife Conservation Initiative

The Coastal Wildlife Conservation Initiative (CWCI) is a FWC-led multi-agency strategy to address threats to coastal wildlife and habitats, while considering human interests and uses of Florida's coastal areas. The goal is a statewide, cooperative process to:

- Protect coastal wildlife populations,
- Conserve and manage coastal ecosystems, and
- Achieve balance between conservation and opportunities for recreation, commercial activities, and responsible development.

More than 100 of Florida's species of greatest conservation need depend on coastal areas for some part of their life cycle. But coastal ecosystems and wildlife face ever-increasing numbers of threats, and wildlife needs and human activities are often in conflict as a result. Florida has many agencies, programs, laws, regulations and organizations that in some way work towards coastal conservation, but most operate independently of each other. In creating a partnership network, the CWCI can help to leverage existing resources to advance coastal conservation goals statewide.

The key components of CWCI are:

- Partnership Network – include participation by partners and stakeholders
- Education and Outreach – raise awareness about human impacts to wildlife on beaches
- Habitat Management – directly benefit wildlife and habitat conditions
- Habitat Preservation – utilize land acquisition options and explore alternatives to designate coastal areas for different levels of recreational activities
- Research Needs – identify information gaps, existing efforts, and implementation plans
- Regulations – compile and evaluate existing regulatory programs, and identify areas of overlap
- Voluntary Programs – encouraging shoreline softening and best management practices
- Incentive-Based Programs – incorporate habitat conservation plans, green building/blue beaches designations

Florida's State Wildlife Action Plan and State Wildlife Grants

Florida's State Wildlife Action Plan (Action Plan) is an action plan for conserving all of the state's wildlife and vital natural areas for future generations. It outlines what native wildlife and habitats are in need, why they are in need and, most importantly, what we are going to do about it. The Action Plan was part of a nation-wide effort by all 56 states and U.S. territories to develop action plans and qualify for federal funding. Completed in September 2005, the Action Plan was approved by the U.S. Fish and Wildlife Service in December 2005.

One of the programs of the Action Plan, the Florida's State Wildlife Grants Program (SWG), is supported by the federal State Wildlife Grants Program, which provides annual funding to every state and territory. This is a matching grants program, which provides financial support for projects that address conservation needs identified in the State Wildlife Action Plan. During 2011, the FWC coordinated with partners to develop revised implementation goals for 2012-2017 to align with priorities identified in the 2011 revised Action Plan. At a minimum, these goals will direct the use of FWC resources including SWG funding. Ideally these goals will guide conservation efforts outside the realm of SWG, provide opportunities for partners to work together and help leverage resources to conserve Florida's fish and wildlife. Projects aimed at monitoring and adaptation as it pertains to climate change are currently major goals of the program. The LWL, on the front line of climate change is an excellent location to further climate change research and to experiment with innovative techniques to adapt to climate change.

Monofilament Recovery and Recycling Program

The Monofilament Recovery & Recycling Program (MRRP) is a statewide effort to educate the public on the problems caused by monofilament line left in the environment, to encourage recycling through a network of line recycling bins and drop-off locations, and to conduct volunteer monofilament line cleanup events. The program was initiated with funding from the FWC Advisory Council for Environmental Education and involves partnerships as the key to its success. Cooperation with stakeholders and partners in the LWL could grow this program further.

Municipal Government Comprehensive Plans

The submerged area and shoreline of the LWL is divided among the geographical jurisdictions of various governmental units. Most of the comprehensive plans developed by municipalities surrounding the estuary were supportive of the restoration efforts, and consistent with the County’s Comprehensive Plan. The LWLPGP is a great example of local municipalities actively participating in the LWL restoration. A number of waterfront redevelopment projects currently proposed around the lagoon included direct or indirect benefits and improvements to the estuarine system.

The extreme north section, including Little Lake Worth, is in unincorporated Palm Beach County. The Port of Palm Beach District has jurisdiction over the northern inlet area. The following thirteen municipalities also include portions of the Lake Worth Lagoon: *North Palm Beach, Lake Park, Riviera Beach, South Palm Beach, Palm Beach Shores, Hypoluxo, West Palm Beach, Manalapan, Palm Beach, Boynton Beach, Lake Worth, Ocean Ridge, Lantana.*

Port of Palm Beach

The Port of Palm Beach (PPB) has recently updated their Master Plan (PPB2012) with new goals, objectives and policies intended to further the overall objectives of the 2008 Plan, and help maintain the environmental quality of the area.

The PPB continues its environmental improvements of the harbor by far exceeding all stormwater requirements when improving its cargo laydown areas and slips. The PPB continues to maintain and clean the stormwater systems, conduct testing of the stormwater runoff and maintain the eight stormwater outfalls which service the surrounding area/streets of Riviera Beach and the Port's property.

Future harbor improvements of the Lake Worth Harbor are currently being studied in conjunction with the USACE within a managed environmental context. The harbor expansion and channel improvement could have impacts on natural resources of the harbor. Resource impacts requiring mitigation could include impacts to seagrasses, hardbottom and benthic habitat, manatees, and temporary water quality degradation due to construction activities. The PPB and USACE, recognize the impacts due to expansion, and will continue to actively participate in the lagoon's restoration efforts. The PPB has already demonstrated a significant commitment through its lease of the Peanut Island shoreline to PBC for restoration and recreational purposes, and by providing some of the funding for this project. The Port's 2012 Master Plan has committed to exploring options that will minimize adverse effects on the ecosystem.

Existing operations and future improvements continues to assist in the protection of the manatee, which congregates in areas adjacent to the PPB due to warm water outfalls from the Riviera Beach power plant. Manatees also feed and rest in this area. The Port's 2012 Master Plan update reinforces the Port's commitment to the safety and wellbeing of these species.

Drainage Districts

In PBC, permitting and operational jurisdiction of the classified surface waters of the State, including canals and/or natural water courses, is held by the SFWMD and various drainage districts authorized by Chapter 298, F.S. PBC will ensure that a Drainage Plan for the unincorporated area of the County is adopted. The Drainage Plan and the Future

Land Use Plan will be coordinated so that development is consistent with drainage facility capacity and the adopted level of service standards. This development will be accomplished through a cooperative effort between the County, the local drainage districts and the SFWMD.

Flood control in PBC is dependent on a complex, integrated system of canals, waterways and flood control devices operated by the SFWMD, 20 drainage districts, and thousands of privately owned canals, retention/detention lakes and ponds. The county's drainage system is designed to handle excess surface water in three stages. The "neighborhood or tertiary drainage systems" made up of community lakes, ponds, street and yard drainage grates or culverts, ditches and canals flow into the "local or secondary drainage system", made up of canals, structures, pumping stations and storage areas and then into the "primary flood control system" consisting of South Florida Water Management District canals and natural waterways and rivers; ultimately reaching the coast.

Three primary drainage basins located in eastern Palm Beach County drain into the LWL. The three drainage basins are: the C-17/Earman River in the northern portion; the C-51/West Palm Beach Canal in the central portion; and the C-16/Boynton Beach Canal in the southern portion of the Lagoon. Inflows to C-17 are by various canals under the management of Northern Palm Beach County Improvement District and local municipalities. Inflows to C-16 basin are by various LWDD canals. Inflows to the C-51 are by:

Lake Worth Drainage District (LWDD)
Acme Improvement District
Indian Trail Improvement District
Loxahatchee Groves Water Control District
Pine Tree Water Control District
Seminole Water Control District

8. FUNDING

Palm Beach County continues to pursue funding and in-kind support to finance restoration projects in the LWL. The LWL Partnership Grant Program (LWLPGP) and FIND's Waterways Assistance Program (WAP) have been matched with local funding to complete the majority of the restoration and water quality projects to date. The financing strategy includes pursuing dedicated and variable funding sources at federal, state, and local levels, as well as potential private and non-profit sources. The major objectives of the financing strategy are:

- Re-establish the LWLPGP
- Secure funding in State agencies' (line item) budget
- Secure Federal Legislative authorization through the Water Resources Redevelopment Act (WRDA) for restoration project support through the U.S. Army Corps of Engineers
- Aggressively pursue municipal, state and federal grant partnerships for Lagoon improvement
- Maintain existing levels of local funding sources to provide matching funds to accomplish more with public dollars
- Promote public-private partnerships with the potential for bottom-line benefits for LWL businesses, Trusts, environmental organizations and others
- Establish a LWL Restoration Fund (subset of the Pollution Recovery Trust Fund) to receive state fines levied for watershed impacts to be applied towards lagoon restoration

LAKE WORTH LAGOON PARTNERSHIP GRANT PROGRAM

Since 1998, the Florida Legislature has supported restoration and enhancement of the LWL by appropriating over $16.7 million for the LWLPGP. Local sponsors have provided over $59.5 million in matching funds, a 78% match. 44 projects totaling over $76 million have been constructed to improve water quality and habitat in the lagoon.

In the 2008-2012 timeframe, $6.8 million in LWLPGP grants were matched by $8.1 million in local funds to construct over $14.9 million in restoration and water quality projects. There has been a drastic decline in state funding with only a $500,000 legislative appropriation to the LWLPGP in 2008, which has caused a reduction in projects' construction as state and federal funds are sought to extend limited local funds.

FLORIDA DEPARTMENTS OF ENVIRONMENTAL PROTECTION AND TRANSPORTATION

Partnerships with FDEP and FDOT have enabled PBC to stretch local dollars. In 2008-2013, the State has contributed over $6.5 million, which has been matched by over $0.9 million in local funds to construct over $7.4 million in additional habit restoration and

mitigation projects.

FLORIDA INLAND NAVIGATION DISTRICT'S WATERWAYS ASSISTANCE PROGRAM

FIND's Waterway Assistance Program (WAP) is a grant program established by the Florida Legislature and the District for the purpose of financially cooperating with local governments to alleviate problems associated with the Atlantic Intracoastal Waterway and associated waterways within the District. In 2008-2012, FIND granted over $2.1 million in WAP funds, matched by local dollars to construct $4 million in LWL habitat and public use projects. FIND also provided over $5.2 million in grant funds, matched by over $10.2 million in local funds, to construct municipal public use facilities, marinas and waterfront enhancements (program details and projects listed in Chapter 7)

LOCAL FUNDING

Local funding sources are provided through Municipal Governments and PBC Manatee Protection Program and Vessel Registration Fee Program covered in Chapter 7.

The 2008-2012 projects include:

- 12 Habitat Enhancement Projects protecting and creating over 80 Acres of habitat
- 3 Stormwater Projects Treating 526+ Acres of Runoff
- 2 Septic to Sanitary Sewer Projects taking septic systems offline
- 2 Public Boardwalks providing access to habitat restoration projects
- 8 Monitoring Projects

Financial Summary 2008-2012:

Total cost of projects implemented:	$26.3 Million
Total grant/state funds:	$15.9 Million
Total matching funds - local sponsors:	$10.4 Million

PROJECTS SUMMARY

Habitat Enhancement

Twelve habitat enhancement and restoration projects have been implemented with grant funding provided through the LWLPG, FIND, FDEP, FDOT and local matching funds. These projects have provided vital habitat such as oysters, mangroves, seagrasses, which are essential to system sustenance and recovery. Some of the exemplary restoration projects, already discussed briefly in Chapter One, include:

- South Cove Natural Area

- John's Island Oyster Reef
- Boynton Beach/Ocean Ridge Mangrove Preserves
- Phil Foster Park Artificial Reef and Snorkel Trail
- Ibis Isle Restoration

Artificial Reefs

Artificial reefs were constructed at three locations within LWL to provide habitat for fish and invertebrates and recreational opportunities for fisherman, snorkelers and divers. These reefs provide shelter, feeding and spawning habitats for juvenile and mature estuarine organisms to utilize. These structures also form a substrate for many water filtering invertebrates thereby improving water quality within the lagoon.

Water Quality Projects

Water quality projects included the creation of a new LWL Monitoring Plan and the expansion of the water quality monitoring network by adding twelve (12) new stations. This effort is a cooperation between ERM and the SFWMD. Data collected are currently stored in **DBHYDRO** the SFWMD environmental database to be shared with local governments, State Agencies and stakeholders. A five years WQ baseline analysis was conducted and it is included in this management plan update.

Stormwater Treatment

Three stormwater treatment projects have been implemented within the LWL watershed treating more than 526 acres of runoff that previously discharged directly to the LWL. The use of pollution control devices, stormwater ponds, wetland treatment, and treatment swales has significantly reduced the amount of nutrients, sediments, and heavy metals entering LWL.

- City of Boynton Beach Regional Federal Highway Stormwater Improvements
- City of West Palm Beach Stormwater Improvements
- City of Lake Worth 2nd Ave North Baffle Box

Septic loading

Septic loading continues to be a problem in LWL as many coastal communities have not converted to centralized sewer systems. Two projects have been implemented to reduce septic loading in this estuary:

- The Town of Hypoluxo's Comprehensive Plan calls for removal of all septic tanks throughout the Town. In 2004, the project removed 99 septic tanks east of U.S. 1 in Hypoluxo and connected the single family homes to the municipal sewer

line. Over sixty of these homes are directly on the Lake Worth Lagoon or a canal leading to it. Some of these homes had septic tanks within 10 feet of the water. The last 28 homes in Hypoluxo using septic systems were connected to sanitary sewer in 2008.

- The Westgate/Belvedere CRA Infrastructure Improvements Project (Phases IV- V and VI) has benefited the Lake Worth Lagoon and continues to do so with improvements to the C-51 basin. Improvements to the approximately 150-acre basin include replacement of the existing septic sewer system with a sanitary sewer system and construction of water retention areas. Approximately 500 homes were converted to sanitary sewer.

Monitoring Studies and Resource Mapping

The LWLPGP also funded the following studies, which are detailed in chapter 2:

- LWL Sediment Sourcing
- C-51 Canal & Sediment Trap Survey
- LWL Substrate Characterization
- Inshore Sea Turtle Survey
- Seagrass Mapping
- Fixed Transect Seagrass Surveys
- Oyster Monitoring
- Water Quality Monitoring

The LWLPGP has been a critical component of many projects and partnerships, yet more funding will be necessary for restoration and monitoring to continue. One of the limitations of the LWLPGP is that this program is not backed by a dedicated funding source, and is dependent upon legislative approval each year.

CONCLUSIONS

Since its inception in 1998, the Plan has successfully guided a collaboration of stakeholders in recognizing the status of the Lagoon and making significant progress towards habitat restoration, system recovery and resource balance. The formation of the Initiative in 2008 provided a catalyst for further coordination among a larger group of agencies, local governments, non-profit groups and the public.

The 2013 Plan is a product of that much larger web of collaboration, providing a more comprehensive view of the Lagoon's status and presenting specific Action Plans that build on the successes to date. Adoption of the Plan through a formal Resolution by its contributors will provide a confirmation of that consensus that is essential for securing future resource allocation and grant funding.

A RESOLUTION OF THE _____
IN SUPPORT OF THE 2013 LAKE WORTH LAGOON MANGEMENT PLAN

WHEREAS, the Lake Worth Lagoon restoration efforts have been underway since 1998 and the State of Florida designated the lagoon a priority water body in the 2004 Florida Statutes Chapter 373.453; and

WHEREAS, in 2008, the Lake Worth Lagoon Initiative (LWLI) was established to provide interagency coordination with the purpose of seeking awareness, support and legislative funding assistance for projects that will improve and protect the natural resources within the watershed; and

WHEREAS, the LWLI provides partnerships between government agencies and stakeholders that incorporate and combine funding acquisition support, outreach and technical expertise, increase stakeholder and public awareness; and

WHEREAS, the 2013 Lake Worth Lagoon Management Plan Update (LWLMP) is a revision to the 1998 & 2008 LWL Management Plans, which outline actions and projects to restore the ecological health of the water body; and

WHEREAS, the _____ desires to support the 2013 LWLMP, which provides for the following elements:

Continue construction of priority environmental enhancement and restoration projects, increase stakeholder participation, increase partnering efforts for funding support and acquisition, complete Action Plans, increase public awareness and outreach efforts, and prioritize and combine data collection efforts to assess project successes and guide future management decisions; and

NOW THEREFORE, BE IT RESOLVED BY _____:

Section 1: The foregoing recitals are hereby adopted and ratified.

Section 2: This Resolution shall take effect immediately upon adoption.

PASSED and ADOPTED this _____day of _____, 2013.

GLOSSARY

Algae - Aquatic, non-flowering plants that lack roots and use light energy to convert carbon dioxide and inorganic nutrients, such as nitrogen and phosphorus, into organic matter by photosynthesis. Common algae include dinoflagellates, diatoms, seaweed, and kelp.

Anoxic - A condition in which dissolved oxygen is absent.

Baffle Box - A box attached to a stormwater drain that collects debris and sediments.

Bathymetry - The physical shape of a basin which contains water, with special attention to the contours of depth; bathymetric maps of lakes are analogous to topographic maps of mountains.

Benthic - Relating to the community of animals living in and on the bottom sediments of a body of water.

Best Management Practice (BMP) - A practice or combination of practices that provide the most effective and practicable means of controlling point and nonpoint pollutants at levels compatible with environmental quality goals.

Community - Populations of plants and/or animals living in a common habitat.

Drainage Basin - The land that surrounds a body of water and contributes freshwater, either from streams, groundwater or surface water runoff, to that body of water.

Dredge-and-Fill - Commonly refers to the removal of bottom sediments (dredging) to construct and maintain canals and ship lanes, and the use of dredged material (spoil) as fill for development.

Ecosystem - A community of living organisms interacting with one another and their physical environment, such as mangroves, salt marshes or estuaries. The Lake Worth Lagoon system is considered a sum of these inter-connected ecosystems.

Effluent - The outflow of water, with or without pollutants, usually from a pipe.

Epifauna - benthic fauna living on the substrate (as a hard sea floor) or on other organisms.

Estuary - A semi-enclosed coastal water body which has free connection to the open sea and within which seawater is measurably diluted with freshwater.

Eutrophication - The process of nutrient enrichment in a water body. In marine systems eutrophication results principally from nitrogen and phosphorus inputs from human activities, such as sewage disposal and runoff from uplands. Such input stimulates algal

blooms and bacteria growth, which contribute to depletion of oxygen in water, and anoxic conditions, and eventually leads to fish kills.

Exotic Species - Any introduced plant or animal species that is not native to the area and may be considered a nuisance.

Goal - A general statement describing what is to be achieved in the future. Goals reflect a consensual vision for a specific or general resource.

Habitat - The specific place or environment where a particular plant or animal lives. An organism's habitat must provide all the basic requirements for life and should be free of harmful contaminants. Typical habitats of the Lake Worth Lagoon include mangroves, beaches, marshes, oyster reefs, mudflats, seagrass beds, unconsolidated sediments and the water column.

Hydrologic - Pertaining to hydrology, the physics of water movement. A "hydrologic model" is a type of computer simulation which takes into account the known behavior of water in the form of mathematical formulas and allows one to mimic the movement of water in a river, lake or estuary.

Intracoastal Waterway (ICW) - A federally constructed and maintained deepwater channel (12 feet) that runs north and south in the Lagoon constructed to create safe passage for water-based commerce. The Atlantic ICW extends from Key West to Maine.

Invertebrates - Animals without backbones, examples include insects, worms, crustaceans, mollusks and sponges.

Lagoon - A shallow body of water which is separated from the sea by a sand bar, barrier beach or coral reef where salt water from the sea and fresh surface water runoff from the land meet and mix.

Loading - The total amount of material entering a system from all sources.

Mangrove - A tropical, aquatic tree which forms dense thickets in tidal regions. Mangroves offer an important habitat and food source for fish, shellfish and crustaceans.

Marsh - A wetland where the dominant plants are grasses and sedges, as opposed to a swamp, where woody plants like shrubs and trees are the dominant vegetation.

Muck - Fine-grained sediments that contain a significant amount of clay and silt and about ten percent organic matter. Its primary source is runoff from upstream deposits. Muck is easily resuspended to increase turbidity in the water column. The resuspension can lead to decline in seagrasses by reducing light penetration of the water column.

Nonpoint Source Pollution (NPS) - Pollution that is generated over a relatively wide area and may be discharge into surface waters through storm drains. Nonpoint source pollution includes stormwater runoff, leaking septic systems and overboard waste

discharged from boats and ships.

Nutrients - Any substance required by organisms for normal growth and maintenance. Mineral nutrients usually refer to inorganic substances derived from soil and water. Excessive amounts of nutrients, including nitrogen and phosphorus, may result in excessive growth of algae, leading to oxygen depletion and water quality degradation.

Photosynthesis - The synthesis of chemical compounds with the aid of radiant energy and especially light; formation of carbohydrates in the chlorophyll-containing tissues of plants exposed to light.

Point Source Pollution - Pollution that originates at a particular place, such as a sewage treatment plant, effluent outfall pipe or other discharge pipes into a water body. Point source pollution is generally the byproduct of a process such as wastewater treatment, manufacturing, or similar activities.

Resource - A substance or object required by an organism for normal maintenance, growth and reproduction. If the resource is scarce relative to demand, it is referred to as a limited resource. Non-renewable resources (such as space) occur in fixed amounts and can be fully utilized; renewable resources (such as food) are produced at a fixed rate, with which the rate of exploitation attains equilibrium.

Retrofit - To reconstruct an existing system with new capabilities.

Riprap or Riprap Revetment - Large boulders or clean concrete rubble, generally one to three feet in diameter, commonly used to stabilize shorelines or reinforce the face of vertical seawalls.

Runoff - The portion of precipitation that travels over land and ultimately reaches surface streams and other receiving watersheds. Runoff often carries pollutants such as oils, fertilizers and pesticides and is frequently a major component of nonpoint source pollution. See Stormwater.

Salinity - The dissolved inorganic salts in seawater expressed in grams of salt per kilogram of seawater as parts per thousand (ppt) or practical salinity units (psu).

Seagrasses - A flowering plant that lives underwater. Like land plants, seagrasses produce oxygen. The depth at which seagrasses are found is limited by water clarity because they require light to grow. They are important to ecosystems as they help maintain water clarity by trapping sediments, stabilizing the bottom with their root system, and providing a nursery habitat for fish, shellfish and crustaceans.

Septic Tank - A domestic wastewater treatment system commonly used in areas not served by central sewer systems.

Spoil - Sediments removed during dredging. Spoil may be deposited underwater or on islands created specifically for spoil disposal.

Stakeholder - One who has an interest in the restoration, conservation, and management of the Lagoon.

Storm Drain - A system of gutters, pipes and ditches used to carry stormwater from the land to streams, ponds or other surface waters. Storm drains carry a variety of harmful substances including stormwater, chemicals, organics such as lawn clippings, oil and grease, and suspended sediment.

Stormwater - The portion of the precipitation that travels over land and ultimately reaches surface streams, canals and other receiving watersheds. Stormwater often carries pollutants such as oils, fertilizers and pesticides and is frequently a major component of nonpoint source pollution. See Runoff.

Submerged Aquatic Vegetation (SAV) - Rooted vegetation that grows underwater in shallow zones where light penetrates.

Suspended Solids - Organic or inorganic particles that are suspended in and carried by the water. The term includes sand, mud, and clay particles as well as solids in wastewater.

Turbidity - Cloudiness of water from suspended fine solids. As the cloudiness increases, so does the turbidity. Clear water indicates low turbidity and may be associated with good water quality.

Wastewater - Water contaminated with the by-products of domestic, commercial, agricultural or industrial uses.

Wastewater Treatment - Processes that help remove solids, nutrients and other pollutants from water before it is discharged or reused.

Watershed - A region bounded at the periphery by physical barriers that cause water to part and ultimately drain to a particular body of water.

Water Column - The water, lake, estuary or ocean which extends from the bottom sediments to the surface. Water columns contain dissolved and particulate matter and are habitat for plankton, fish and marine mammals.

Wetland - Land where the water table is usually at or near the surface. Some wetlands contain water year-round; others may remain relatively dry for months, becoming moist only during periods of heavy rain. Wetlands are vital habitats for many species of plants and animals; they are protected by local, state and federal regulations.

ACRONYMS

ANOVA	Analysis Of Variance
AP	Action Plan
AREEC	Artificial Reef and Environmental Enhancement Committee
BMAP	Basin Management Action Plan
BMP	Best Management Practices
C&SF	The Central and Southern Florida Project
CEPP	Central Everglades Planning Project
CERP	Comprehensive Everglades Restoration Plan
CI	Condition Index
CPUE	Catch per Unit Effort
CRA	Community Redevelopment Authority
CWCI	Coastal Wildlife Initiative
DBHYDRO	SFWMD's hydrologic, meteorologic, hydrogeologic and water quality database
DEIS	Draft Environmental Impact Statement
DEP	Department of Environmental Protection
DO	Dissolved Oxygen
DOH	Department of Health
DPP	Deferred Payment Plan
ECP	Everglades Construction Project
EFA	Everglades Forever Act
EM	Environmental Monitoring
EPA	Environmental Protection Agency
ERL	Effects Range Low
ERM	Effects Range Median
F.A.C	Florida Administrative Code
F.S.	Florida Statutes
FACT	Florida Atlantic Coast Telemetry
FAU	Florida Atlantic University
FBD	Ferry Boat Discretionary Program
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FDOH	Florida Department of Health
FDOT	Florida Department of Transportation
FEB	Flow Equalization Basin
FHWA	Federal Highway Administration
FIT	Florida Institute of Technology
FWC	Florida Fish and Wildlife Conservation Commission
FIND	Florida Inland Navigation District
FP	Fibropapillomatosis
FPL	Florida Power & Light

FWRI	Fish and Wildlife Research Institute
FY&N	Florida Yards & Neighborhoods Program
GFBWT	Great Florida Birding and Wildlife Trail
GI-BMB	Green Industries Best Management Practices
GIS	Geographical Information Systems
HBOI	Harbor Branch Oceanographic Institute
HJ	*Halophila johnsonii* "Johnson's Seagrass"
ICW	Intracoastal Waterway
IRG	Inwater Research Group, Inc.
IRL	Indian River Lagoon
IWR	Impaired Waters Rule
KPBCB	Keep Palm Beach County Beautiful
LE	Law Enforcement
LWC	Lake Worth Lagoon Central
LWDD	Lake Worth Drainage District
LWL	Lake Worth Lagoon
LWLI	Lake Worth Lagoon Initiative
LWLMP	Lake Worth Lagoon Management Plan
LWLPGP	Lake Worth Lagoon Partnership Grant Program
LWN	Lake Worth Lagoon North
LWS	Lake Worth Lagoon South
MAG	Manatee Awareness Group
MARS	Marine Animal Rescue Society
MIA	Marine Industries Association
MP	Management Plan
MPO	Metropolitan Planning Organization
MPP	Manatee Protection Plan
MRRP	Monofilament Recovery & Recycling Program
MSX	*Haplosporodium nelsoni*
NAVD	North American Vertical Datum
NGO	Non-Governmental Organization
NNC	Numeric Nutrient Criteria
NOAA	National Oceanic & Atmospheric Administration
NOAA FACE	National Oceanic & Atmospheric Administration Florida Area Coastal Environment
NOAA NMFS	National Oceanic & Atmospheric Administration National Marine Fisheries Service
NPBC-CERP	North Palm Beach County Comprehensive Everglades Restoration Plan
NPBCID	Northern Palm Beach County Improvement District
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NWF	National Wildlife Federation
OAC	Outreach Advisory Committee

PBC	Palm Beach County
PBCCVB	Palm Beach County Convention and Visitors Bureau
ERM	Palm Beach County Environmental Resources Management Department
PBCHD	Palm Beach County Health Department
PBCMPO	Palm Beach County Metropolitan Planning Organization
PBCMPP	Palm Beach County Manatee Protection Plan
PBCRRT	Palm Beach County Reef Research Team
PBCSWD	Palm Beach Soil & Water Conservation District
PBCWU	Palm Beach County Water Utilities Department
PBH	Port of Palm Beach Harbor
PBPCC	Palm Beach Pack and Paddle Club
PBSO	Palm Beach Sheriff Office
PIR	Project Implementation Report
PO	Public Outreach
POR	Period of Record
PPB	Port of Palm Beach
PREM	Property & Real Estate Management
PRTF	Pollution Recovery Trust Fund
RECOVER	Restoration Coordination & Verification
RSD	(Standard Deviation/Mean) x 100%
SAV	Submerged Aquatic Vegetation
SDD	Secchi Disk Depth
SE	Sediments
SEFCRI	Southeast Florida Coral Reef Initiative
SFRCC	South Florida Regional Climate Compact
SFWMD	South Florida Water Management District
SH	Shell Height
SIRWCD	South Indian River Water Control District
SJRWMD	St. Johns River Water Management District
STA	Storm-Water Treatment Areas
SW	Storm Water
SWA	Solid Waste Authority
SWMP	Stormwater Management Plan
TBD	To Be Determined
TDC	Tourist Development Council
TKN	Kjeldahl nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSP	Tentatively Selected Plans
TSS	Total Suspended Sediments

UF/IFAS	University of Florida / Institute of Food and Agricultural Sciences
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VE	Value Engineering
VEC	Valued Ecosystem Components
WAP	Waterways Assistance Program
WPB	West Palm Beach
WRDA	Water Resources Redevelopment Act
WQ	Water Quality
WW	Waste Water

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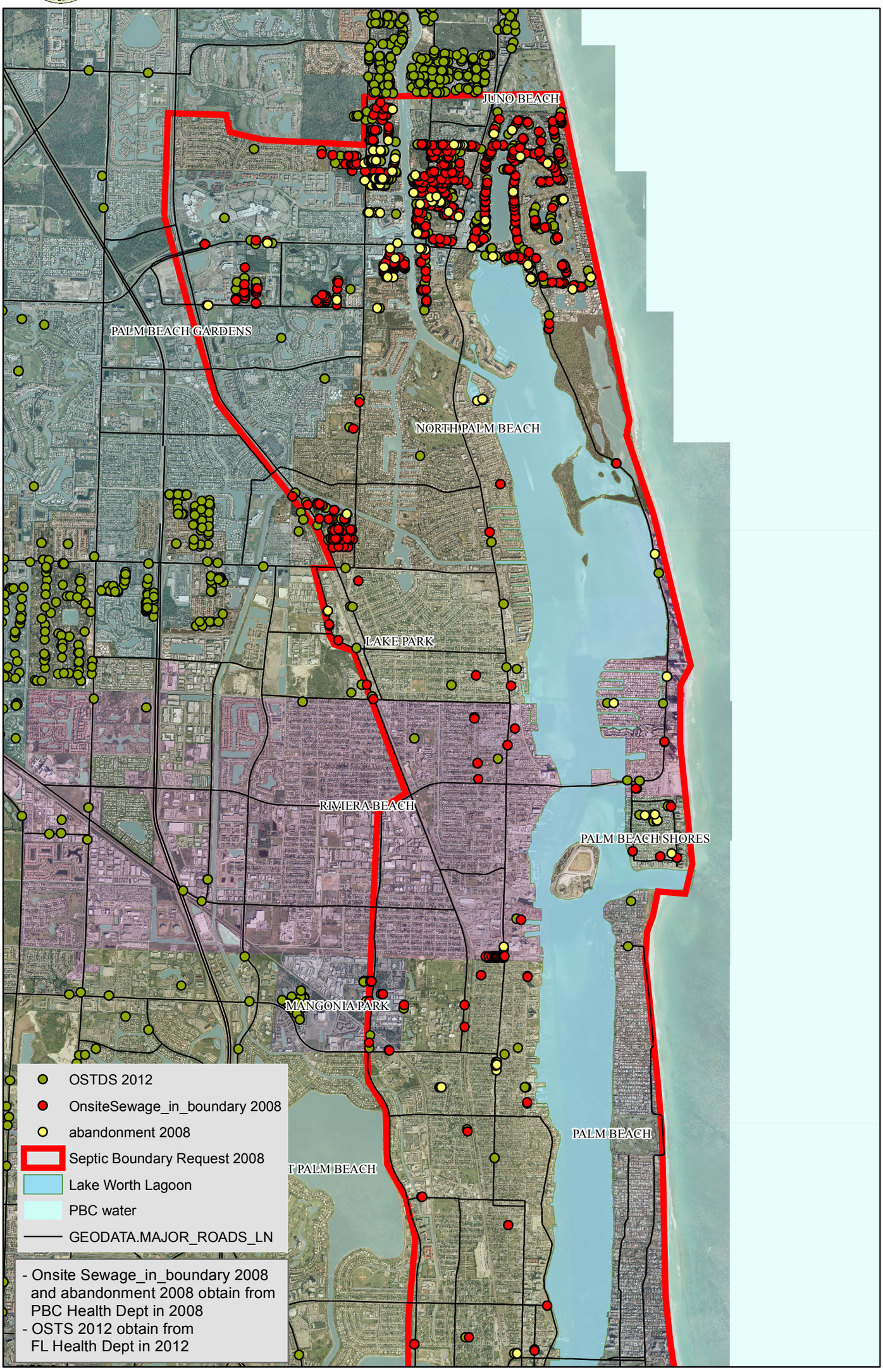
APPENDICES

Septic and Package Plant Mapping
North Lake Worth Lagoon



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Palm Beach County
Department of Environmental
Resources Management

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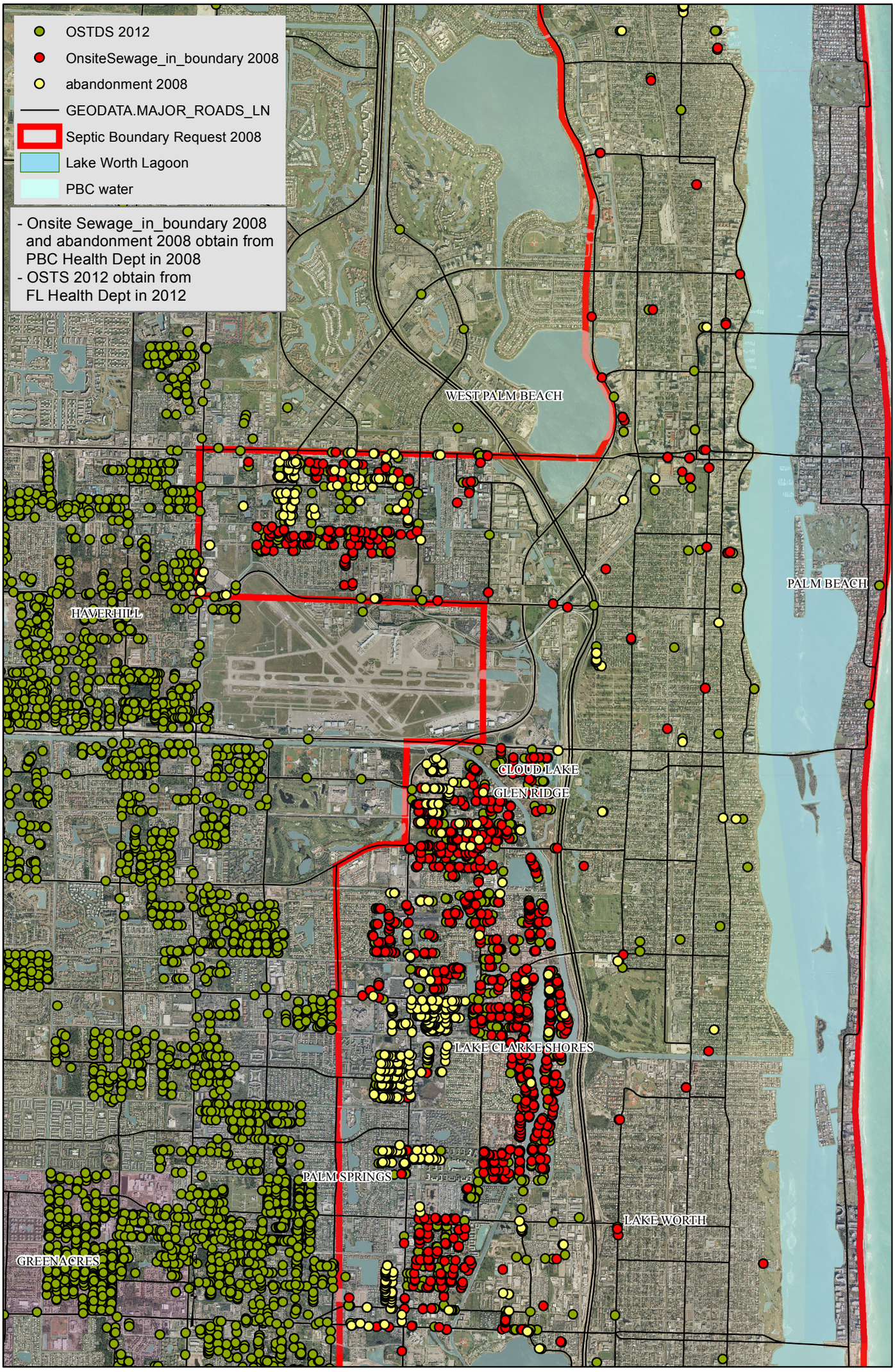
Septic and Package Plant Mapping
Central Lake Worth Lagoon and
Chain of Lakes: Pine Lake and Lake Clarke



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Department of Environmental
Resources Management

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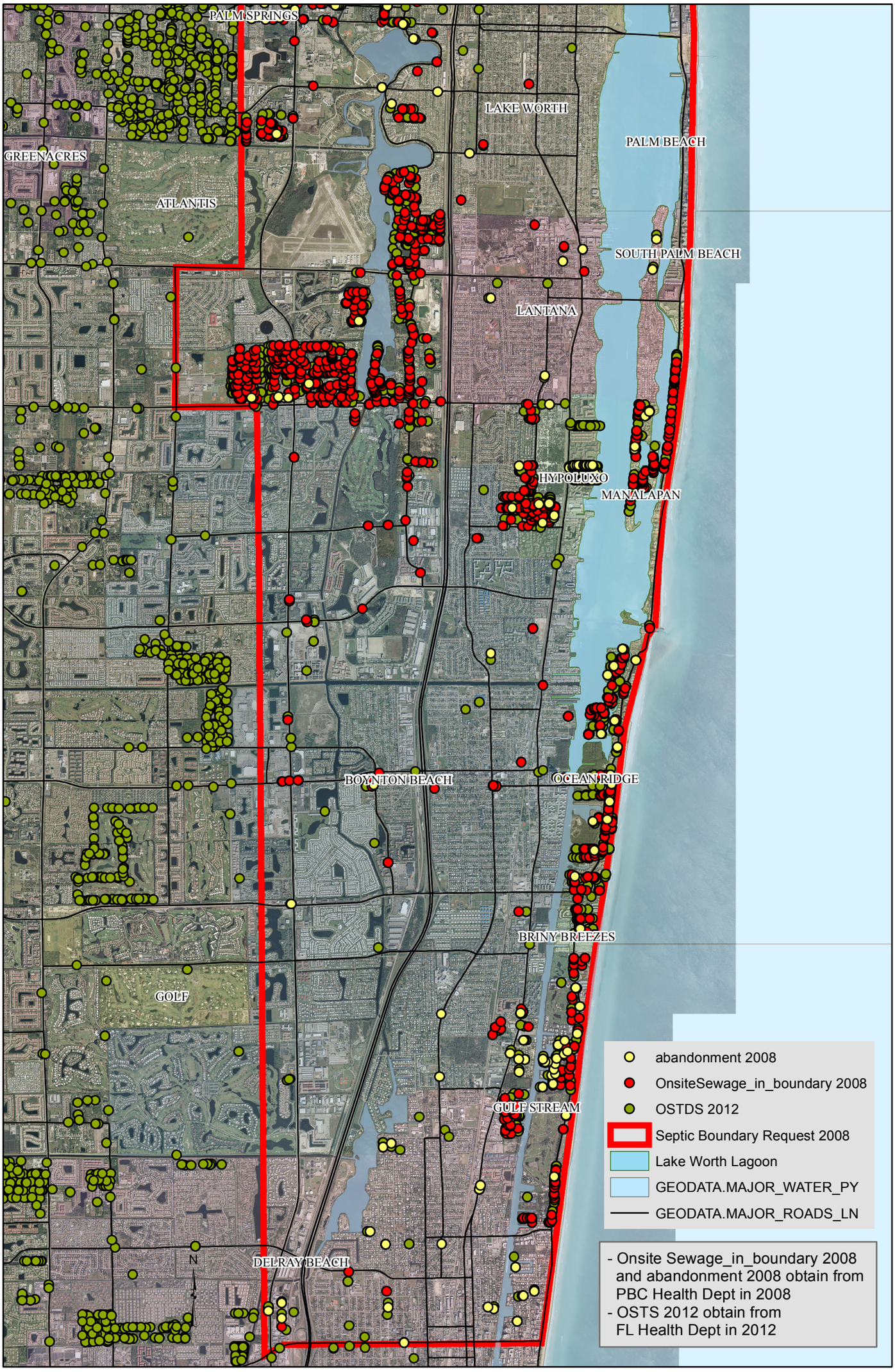
Septic and Package Plant Mapping
South Lake Worth Lagoon and
Chain of Lakes: Lake Osborne, Lake Ida, and Lake Eden



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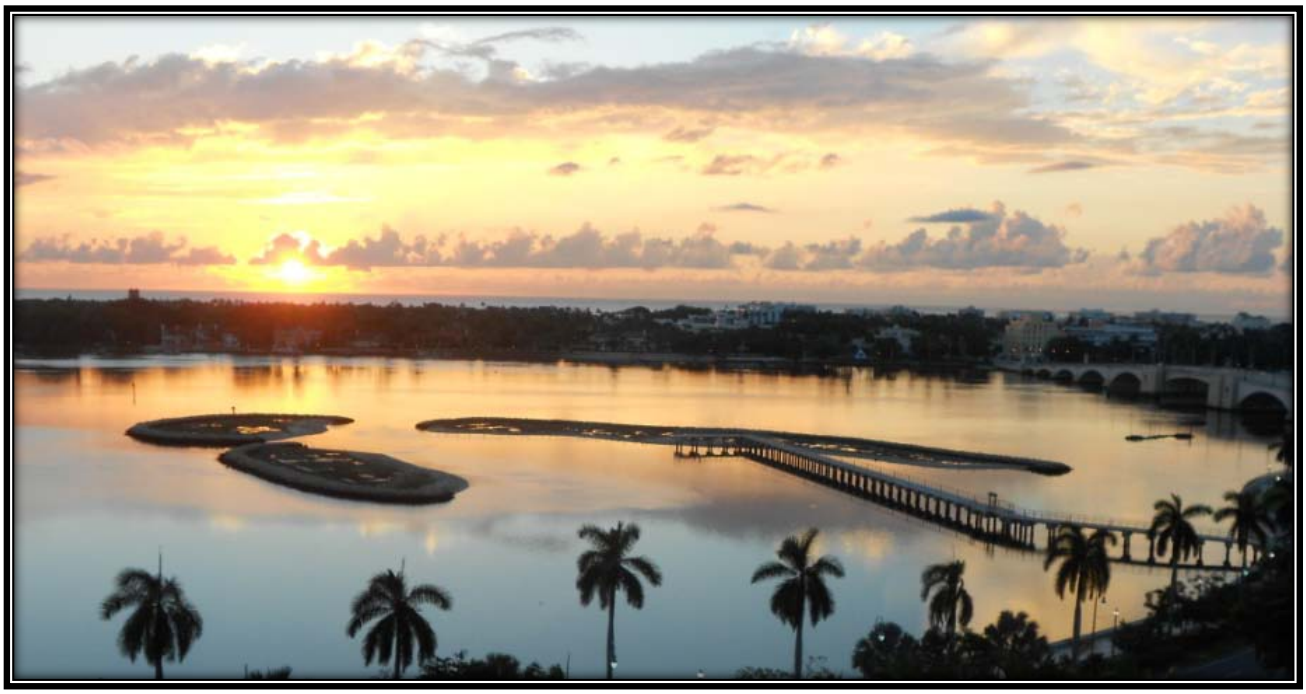
Appendix B

Lake Worth Lagoon Habitat Restoration and Stormwater Projects



Palm Beach County
Department of Environmental Resources Management
2300 North Jog Road
West Palm Beach, Florida 33411

1.0 LWL Completed Projects 2008 - 2013

Table 1: Grant Projects, Awards, Local Match Dollars, and Total Project Costs.

Year Completed	Project Name	Lake Worth Lagoon Partnership Grant Funding	Additional Funding	Total Project Cost
2008	Peanut Island Breakwater Reefs	-	$47,000 (PBC)	$47,000
2009	Boynton Beach/Ocean Ridge Mangrove Preserves and Breakwaters	$330,000	$330,000 (PBC)	$660,000
2009	Hypoluxo Shores Sewer Project	$366,297	$366,297	$732,594
2009	Little Munyon Island	-	-	-
2009	Peanut Island Lagoon/Shoreline Restoration	-	$79,180	$79,180
2008	Riviera Beach Artificial Reef	$13,605	$13,605 (PBC)	$27,210
2010	Boynton Beach Federal Highway Stormwater Improvements	$750,000	$775,040	$1,525,040
2010	Ibis Isle Restoration	$477,000	$378,000 (PBC) $400,000 (SFWMD)	$1,255,000
2010	Lantana Volunteer Oyster Reef Restoration	-	$2,360 (PBC)	$2,360
2010	West Palm Beach Stormwater Improvements	$1,100,000	$1,675,000	$2,775,000
2011	Everglades Artificial Reef	-	$60,000	$60,000
2011	Lake Worth 2nd Avenue North Outfall Water Quality Improvements	$145,606	$145,606	$291,212
2012	John's Island Oyster Reef	$265,000	$671,250 (PBC) $606,250 (FIND)	$1,542,500
2012	Peanut Island Breakwaters and Reef Improvements	-	$170,242	$170,242
2012	Phil Foster Park Artificial Reef and Snorkel Trail	-	$82,170	$82,170
2012	Snook Islands Natural Area Public-Use Facilities	-	$988,040 (PBC) $559,575 (FIND	$1,547,615
2012	South Cove Natural Area	$1,015,000	$1,485,000 (PBC) $1,000,000 (FIND)	$3,500,000
2012	Westgate Infrastructure Improvements	$1,608,331	$1,850,199	$3,458,530
2013	Snook Islands Wetlands Restoration Phase II	-	$3,600,000 (FDOT)	$3,600,000

Figure 1: North Lake Worth Lagoon Completed Projects 2008-2013

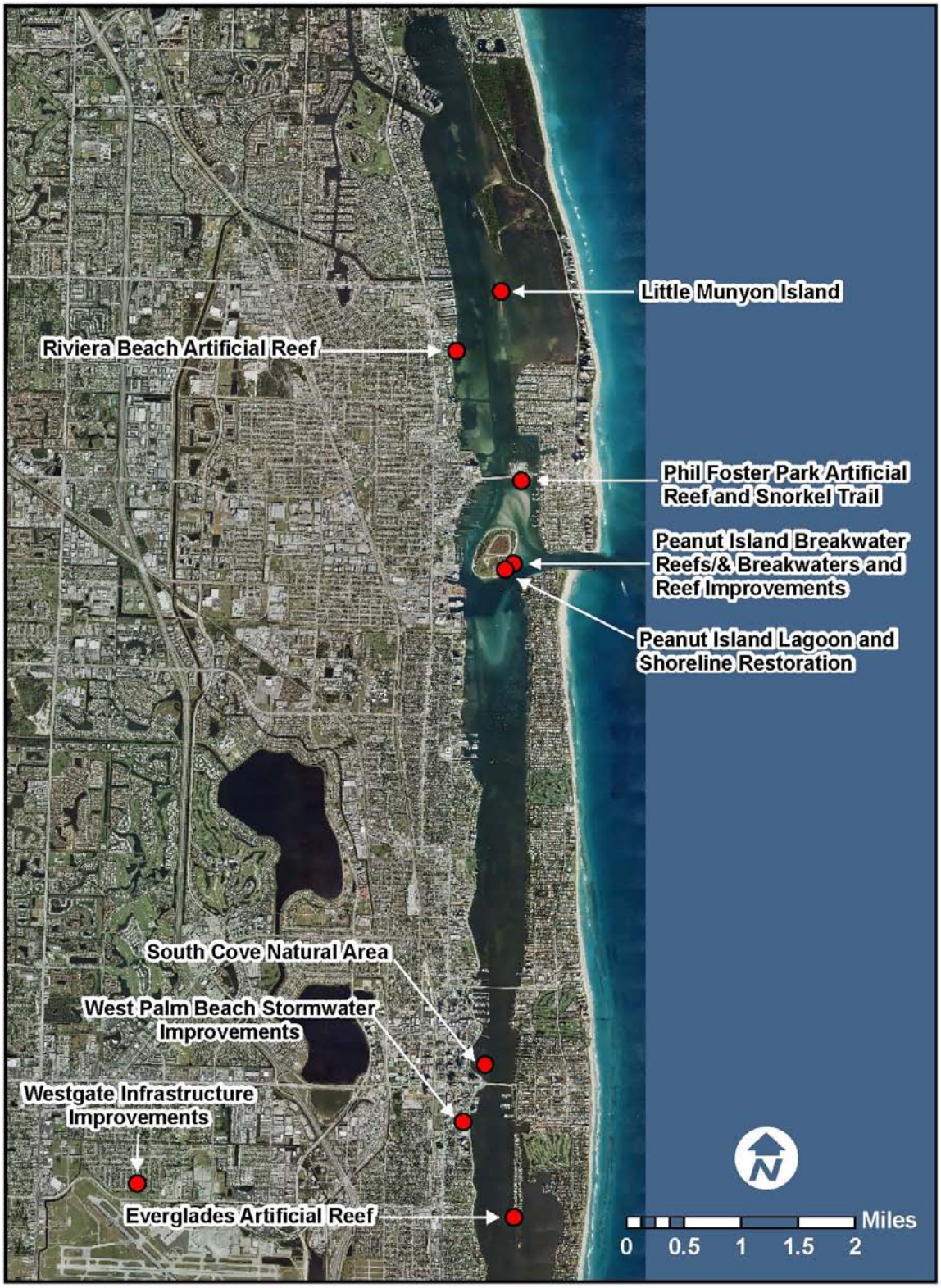
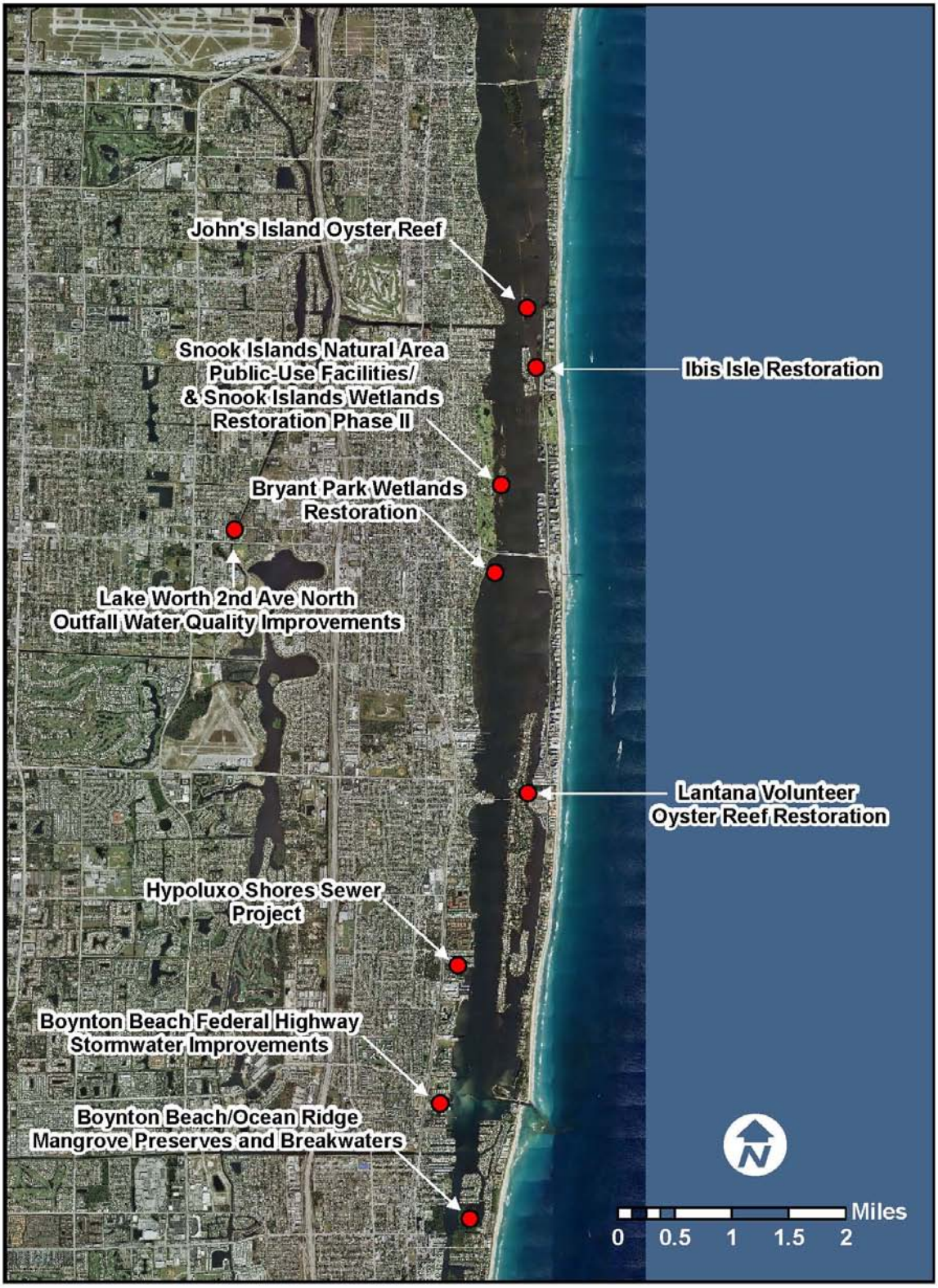


Figure 2: South Lake Worth Lagoon Completed Projects 2008-2013



Peanut Island Breakwater Reefs (2008)

Local Sponsor Palm Beach County
Total Project Cost $47,000

Limestone rock (500 tons) was used to construct three breakwaters on Peanut Island's shoreline. One breakwater was constructed on the east side of the island and two smaller structures were installed on the southeastern shoreline. The structures not only slow beach erosion and provide shoreline protection, they also provide reef habitat. The breakwater reefs are very popular with snorkelers and provide a variety of restored habitats for fish, invertebrates, and birds.

Boynton Beach/Ocean Ridge Mangrove Preserves and Breakwaters (2009)

Local Sponsor Palm Beach County
LWL Partnership Grant $330,000(FY06)
Palm Beach County MATCH $330,000
Total Project Cost $660,000

Limestone boulders were placed along the shoreline to serve as a wave break. Gaps were left in the wave breaks to provide adequate flushing of the mangroves. To provide additional habitat, a mangrove planter was constructed behind the wave breaks. The project was designed to protect 35 acres of existing mangroves, including a mangrove fringe that has slowly eroded from boat wakes. Mangroves provide important habitat for many species of fish and wildlife and improve water quality. The rock, by nature of its makeup and location, also provides shallow water artificial reef habitat which is ideal for oysters and other attaching organisms. Partners include City of Boynton Beach and the Town of Ocean Ridge.

Hypoluxo Shores Sewer Project (2009)

Local Sponsor Town of Hypoluxo
LWL Partnership Grants $366,297 ($400,000/FY07)
Town of Hypoluxo MATCH $366,297
Total Project Cost $732,594

The Town of Hypoluxo's Comprehensive Plan calls for removal of all septic tanks throughout the Town. In 2004, the project removed 99 septic tanks east of U.S. 1 in Hypoluxo and connected the single family homes to the municipal sewer line. The septic systems were more than 50 years old and some of these homes had septic tanks located just 10 feet from the edge of the Lagoon. Due to the shallow groundwater level in the project area, a vacuum sewer system was designed as an alternative to a conventional gravity sewer system. The last 28 homes in Hypoluxo using septic systems were connected to sanitary sewer between 2008 and 2009. By eliminating septic loading to the Lagoon, a reduction in pollutants such as metals, nutrients, and oxygen depleting compounds is expected.

Little Munyon Island (2009)

Local Sponsor Rybovich Marina

Located just south of Munyon Island, this project includes a 1.4 acre privately-owned island, 7.5 acres of privately-owned submerged lands, and 10.3 acres of State-owned submerged lands. Construction was completed in 2009 to offset resource impacts associated with the expansion of Rybovich Marina in West Palm Beach and included the removal of exotic vegetation, planting of native plants, and construction of a 1,525 ft long wave break wall to enhance seagrass growth. The privately-owned submerged land is protected by a conservation easement and will be deeded to the State of Florida when the area has achieved success as determined by the Florida Department of Environmental Protection and the US Army Corps of Engineers.

Peanut Island Lagoon/Shoreline Restoration (2009)

Local Sponsor Palm Beach County
Total Project Cost $79,180

Sand was dredged from the Peanut Island boat docks and fishing pier and reused onsite to stabilize the beach and prevent further erosion of the walking path. The sand was also used to re-contour the snorkeling lagoon and create 0.4 acres of intertidal *Spartina* (salt marsh cordgrass) habitat which stabilizes the shoreline, increases nutrient uptake, and provides important wildlife habitat.

Riviera Beach Artificial Reef (2009)

Local Sponsor Riviera Beach Maritime Academy
LWL Partnership Grant $13,605(FY07)
Palm Beach County MATCH $13,605
Total Project Cost $27,210

The Riviera Beach Maritime Academy Artificial Reef Building Program provides high school students the opportunity to learn about artificial reef construction. Students built and deployed 20 prefabricated rebar and concrete artificial reef habitats - also known as rice cakes - in the Lagoon. The reef provides valuable habitat for fish and shellfish.

Boynton Beach Federal Highway Storm Water Improvements (2010)

Local Sponsor	City of Boynton Beach
LWL Partnership Grant	$750,000(FY07)
City of Boynton Beach MATCH	$775,040
Total Project Cost	$1,525,040

A storm water management system for neighborhoods within a 57-acre area using a combination of ex-filtration trenches, curb inlets, manhole structures, conveyance piping, grassed swales, baffle boxes, valley curb grates and catch basins that collect storm water to be disposed of via a centralized ex-filtration system. The project retains storm water onsite and treats it before it reaches the Lagoon. The project also reduces freshwater discharges, which in large quantities can negatively affect the Lagoon's water quality and wildlife by dumping pollutants, and decreasing salinity to a dangerous level for species like the eastern oyster – consequences that propagate all the way up the food chain and beyond.

Ibis Isle Restoration (2010)

Local Sponsor	Palm Beach County
LWL Partnership Grant	$477,000(FY07)
Palm Beach County	$378,000
SFWMD	$400,000
Total Project Cost	$1,255,000

Existing muck deposits were capped with clean sand along Ibis Isle, providing substrate and habitat improvements. The sand cap was placed and contoured to create 8.3 acres of mangrove, cordgrass and 0.8 acres of oyster habitat. The project creates a refuge for fish and wildlife and provides subsequent water quality improvements by reducing re-suspension of sediments into the water column. Partners include the Town of Palm Beach and the South Florida Water Management District. Since project completion, the Ibis Isle Restoration has had an influx of native wildlife: the number of bird species observed post-construction has doubled from the pre-construction count, and includes the American oystercatcher (*Haematopus palliatus*), a species of special concern; fishes, including snook, mullet, flounder, catfish, and pufferfish; and invertebrates including horseshoe crabs, fiddlercrabs, nerite snails, eastern oysters, and marsh mussels.

Lantana Volunteer Oyster Reef Restoration (2010)

Local Sponsor Palm Beach County
Total Project Cost $2,360

To increase oyster habitat and promote public awareness, Palm Beach Count y, the Town of Lantana, and the West Palm Beach Fishing Club implemented a Volunteer Oyster Reef Restoration Project. More than 160 volunteers filled 1,400 netted bags with 24 tons of fossilized shell and placed them along the Lantana Nature Preserve shoreline.

A follow-up project, organized by an Eagle Scout candidate, assembled 25 volunteers to place 250 oyster bags a along 60-feet of seawall at the Town of Lantana's Bicentennial Park.

West Palm Beach Storm Water Improvements (2010)

Local Sponsor City of West Palm Beach
LWL Partnership Grants: $1,100,000 ($1,100,000/FY07)
City of West Palm Beach MATCH $1,675,000
Total Project Cost $2,775,000

Pollution Control Devices

Storm water pollution control devices (PCDs) were installed to reduce the amount of trash, oils, greases and suspended solids entering the Lagoon. PCDs have been reported to remove 75-90% of total suspended solids, 45-70% of nutrients (phosphorous and nitrogen) and 75-90 % of heavy metals. The project enhances the quality of water running off the 451-acre watershed before it enters the Lagoon.

Everglades Artificial Reef (2011)

Local Sponsor	Palm Beach County
FDOT	$50,000 (plus donated reef material)
City of Lake Worth	$10,000 (plus donated reef material)
Total Project Cost	$60,000

A fishery habitat was created within a portion of an old dredge hole. Although historically the Lagoon is generally four to five feet deep with a biologically productive bottom, the project area was relatively deep water (10-20 ft), devoid of any seagrass or hard bottom resources. Concrete slabs were stacked on top of concrete piles, making unique ledges used by snook, species of snapper, and other fish. Additionally, an 80 foot long barge was cleaned and placed within the southern portion of the site with costs covered by the City of Lake Worth. Partners include Florida Department of Transportation, City of Lake Worth, and Town of Palm Beach. The reef will provide food, shelter, protection, and spawning areas for hundreds of fish species and other marine and estuarine organisms. It will also provide alternate areas for use by divers and anglers, reducing user pressures on natural reef systems.

Lake Worth 2nd Ave North Outfall Water Quality Improvements (2011)

Local Sponsor	City of Lake Worth
City of Lake Worth MATCH	$145,606
LWL Partnership Grant:	$145,606 (FY08)
Total Project Cost	$291,212

A nutrient separating baffle box was installed to improve the water quality of storm water discharging from an 18-acre drainage basin. Previously, this storm water outfall received no pre-treatment prior to discharge. The baffle box will reduce the quantity of pollutants by filtering out particles, debris, and hydrocarbons from the storm water flow, preventing these contaminants from entering the Lagoon. The baffle box is anticipated to reduce total suspended solids (TSS) by 90%.

Nutrient Separating Baffle Box

Photo Credit: Suntree Technology Inc.

John's Island Oyster Reef (2012) - Phase I and II

Local Sponsor	Palm Beach County
LWL Partnership Grant	$265,000
Palm Beach County	$671,250
FIND	$606,250
Total Project Cost	$1,542,500

Small limestone boulders were placed to create almost 10 acres of oyster reef habitat. The addition makes a significant contribution to intertidal habitat and water quality improvements. Boulders were placed in discrete piles with open spaces between each pile. The open space provides an edge between the sand and rock, allowing fish and invertebrates easy entry to the rock structures and water flow. Water flow is important to oyster health by delivering oxygen and food, and for settlement of oyster spat. Project partners included the Town of Palm Beach and Florida Inland Navigation District. Just north of the Ibis Isle Restoration Project, this site is also known for foraging American oystercatchers and osprey.

Peanut Island Breakwaters and Reef Improvements (2012)

Local Sponsor	Palm Beach County
Total Project Cost	$170,242.00

The project was designed to improve the tidal flow within the snorkeling reef system and provide increased shoreline protection and reef habitat on the island's east shore. The existing rock infrastructure was modified by removing rocks that impeded tidal flow, and re-used them to build reef breakwaters along the adjacent beach. The reef system is extremely popular with snorkelers due to the clear oceanic water, fish, coral, and other reef resources that it provides.

Phil Foster Park Artificial Reef and Snorkel Trail (2012)

Local Sponsor Palm Beach County
Total Project Cost $82,170

This artificial reef is spread across a two-acre area just south of Phil Foster Park in Lake Worth Lagoon. This location was selected due to its proximity to the Lake Worth Inlet and clear oceanic water. The reef consists of discrete piles of limestone boulders and prefabricated reef modules placed in 6 to 10 feet of water. Six hundred tons of rock was used to build the 800 foot-long snorkel trail. The various shaped piles are separated with a trail of smaller boulders.

Six concrete reef modules, two tons each, were deployed between the piles of rock. These unique structures contain tunnels, half bowls, indents, interior cavities and ledges. The design of the rock reef includes ledges and small habitat spaces for fish, octopus, and other types of sea life.

Snook Islands Natural Area Public-Use Facilities (2012)

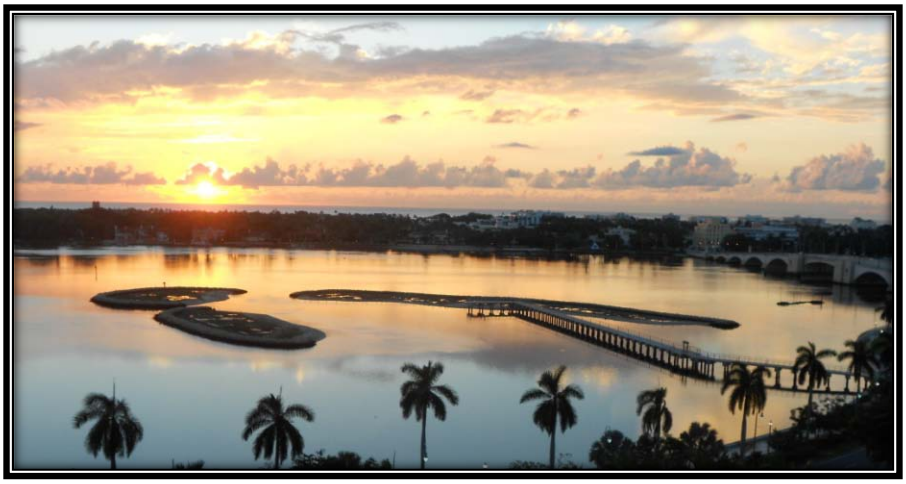
Local Sponsor Palm Beach County
FIND $559,575
Palm Beach County $988,040
Total Project Cost $1,547,615

The Snook Islands Natural Area, completed in 2005, restored 100 acres of wetland habitat in the Lake Worth Lagoon. The new facilities allow visitors to view wildlife, fish, and explore the lagoon waters. Public-use components includes a boardwalk with observation platform, fishing pier, kayak launch structure, day-use docks, boat trailer parking, bike racks, benches, and informational kiosks. Public use facility project partners include Florida Inland Navigation District, and the City of Lake Worth.

South Cove Natural Area (2012)

Local Sponsor	Palm Beach County
LWL Partnership Grants	$1,015,000 ($415,000/FY08;$600,000/FY07)
Palm Beach County	$1,485,000
FIND	$1,000,000
Total Project Cost	$3,500,000

A deep dredge hole was filled and raised to elevations for recruitment of seagrass, and to create a series of mangrove islands. The project created mangrove (2 ac), seagrass (3.5 ac), and oyster habitat (1 ac). Fisheries and wildlife benefit from increased food supplies, nursery areas, and water quality improvements. Public-use components include an elevated boardwalk, observation deck, and an informational kiosk. Project partners include the City of West Palm Beach and the Florida Inland Navigation District. Since the project's completion, it has already seen a natural recruitment of wildlife, including oyster spat on the rock revetment, wading and shore birds (including a resident osprey), schools of mullet, and hermit and fiddler crabs.



Westgate
Infrastructure Improvements (2012) - Phase IV, V, and VI

Local Sponsor	Westgate Community Redevelopment Agency
LWL Partnership Grants	$1,608,331 ($1,080,383/FY07; $400,000/FY06; $127,948/FY05)
Westgate CRA MATCH:	$1,850,199
Total Project Cost	$3,458,530

The remaining septic tanks were replaced with a sanitary sewer system, retention areas were constructed, swales re-graded and replaced in the last three phases of this project. A 6.85 central lake was constructed to provide additional storm water storage capacity. A water fountain and littoral planting for fisheries were also added. All sewage generated in the 65-acre area is conveyed to a wastewater treatment plant. Improved swales and retention areas result in cleaner water runoff and the elimination of the septic system protects the Lagoon from sewage discharges. Fewer pollutants such as metals, nutrients, oxygen depleting materials and sediments are expected. Project partners included Palm Beach County.

Snook Islands Wetlands Restoration Phase II (2013)

Local Sponsor Palm Beach County
FDOT $3,600,000
Total Project Cost $3,600,000

The Snook Islands Phase II project included the construction of two mangrove islands and oyster reefs. Fish and wildlife habitat created include 0.45 acre oyster reef, 0.74 acre red mangrove, and 7.17 acres of seagrass habitat. Overall, the project will improve habitat for birds using the open areas of shoreline and mudflats, fish, and other wildlife. Project partners include the Florida Department of Transportation and the City of Lake Worth. This project completes the original Snook Islands Natural Area that was constructed in year 2005. All together, Snook Islands is a hot-spot for birders and anglers alike: species of wading and shorebirds are common, and the American oystercatcher has been known to breed and raise young there. Mullet, snook, and other fish species are also prevalent.

2.0 Lake Worth Lagoon Monitoring Efforts

The main objective of monitoring is to determine if habitat restoration and stormwater improvement projects are improving the health of the Lagoon. Projects have monitored physical conditions such as sediments and biological measurements like the abundance of seagrass, mangroves, fishes, benthic organisms and sea turtle use of the Lagoon. Survey and monitoring reports for the following projects are found in Chapter 2.

Monitoring projects include:

- Sediment Sourcing
- C-51 Sediment Sourcing Survey
- Substrate Characterization
- Inshore Sea Turtle Survey
- Water Quality Monitoring
- Seagrass Mapping and Transect Monitoring
- Oyster Monitoring

LAKE WORTH LAGOON MANAGEMENT PLAN APPENDIX C-1 TABLE

HABITAT RESTORATION AND ENHANCEMENT PROJECTS SUMMARY

Project # Action Plan	Project Name	Project Type	Project Area	Comments	Project Cost	Status
1 HE-1, HE-2 HE-7	Little Lake Worth Living Shoreline	Mangrove planter Oyster habitat	100-200 linear ft projects	Place rock along bulkheads for mangrove planter or oyster habitat Need homeowner approval	$30,000-$60,000	
2 HE-4, HE-5, SE-3	Little Lake Worth Dredged Hole	Filling/Capping Seagrass Artificial Reef	40 acre dredge hole (ave -25') contains muck sediment. Approx. 500,000 cy3 capacity 2-4 acre artificial reef	Substrate and habitat to support SAV, stone crab, fisheries and water quality improvements. Low maintenance/monitoring.	$5,500,000 to $10,000,000 fill costs-depends on sand source $500,000 reef	
3 HE-2	Little Lake Worth Floating Mangrove or spartina Islands	Mangrove or spartina	0.25 acre	Provide habitat & nutrient uptake	$30/sf = $326,700	
4 HE-4, HE-5, SE-3	Turtle Cove Dredged Hole	Filling/Capping Seagrass Artificial Reef	40 acres dredged hole (ave -17') contains >10' muck sediments. Approx. 500,000cy3 capacity 20 ac seagrass habitat 2-4 acre artificial reef	Substrate and habitat to support SAV, stone crab, fisheries and water quality improvements. Low maintenance/monitoring.	$5,500,000 to $10,000,000 fill costs-depends on sand source $500,000 reef	
5 HE-1, HE-2 HE-7	Monastery Living Shoreline	Mangrove Planter Oyster Habitat	900 linear ft	Mangrove planters will stabilize shoreline and provide habitat. Requires Interlocal Agreement with owner	$270,000	
6 HE-1, HE-2, HE-4	MacArthur Park Islands	Mangrove Islands Seagrass Breakwater-oyster and art reef	54 ac area (500,000 cy3 capacity) 30 ac seagrass, 20 ac mangrove 4 ac artificial reef	Mangrove Islands will provide habitat & breakwater for seagrass enhancement	$10,000,000	
7 HE-1	Earman River Oyster Habitat	Oyster habitat	500 linear feet along Anchorage Park	Requires Interlocal Agreement with Village of NPB	$75,000	

LAKE WORTH LAGOON MANAGEMENT PLAN APPENDIX C-1 TABLE

HABITAT RESTORATION AND ENHANCEMENT PROJECTS SUMMARY

Project # Action Plan	Project Name	Project Type	Project Area	Comments	Project Cost	Status
8 HE-4 HE-6	Singer Island Seagrass Sanctuary	Acquisition Conservation Seagrass	Up to 154 acres of land for acquisition (147 submerged acres, 7 upland acres), 6,100 ft. shoreline.	This submerged area contains the densest and healthiest seagrass beds in the Lake Worth Lagoon.	Based on Appraisal TBD	
9 HE-1, HE-2 HE-7	Kelsey Park Living Shoreline	Mangrove planter Oyster habitat	600 linear ft	Place rock or planter along bulkhead Need Interlocal Agreement with Town of Lake Park	$180,000	
10 HE-1, HE-2 HE_7	Lake Park Marina Living Shoreline	Mangrove planter Oyster habitat	600 linear ft	Place rock or planter along bulkhead & pier outside of current fishing sites Need Interlocal Agreement with owner	$180,000	
11 HE-4, HE-5	Lake Park Breakwater	Breakwater Seagrass	5-10 acres of seagrasses	Place a rock breakwater between the channel & bulkhead to protect seagrass shoal	$400,000	
12 HE-5	Phil Foster Park Fishing Reef	Artificial reef	Artificial reef site 0.5 acres Along 400' of seawall	Artificial reef site located off of west seawall in 10' of water	$100,000	
13 HE-4, HE-5, SE-3	Peanut Island shoal	Seagrass Habitat Artificial Reef Water Quality	~30 acre flood shoal, remove ~100,000 cy3. of sand, add reef habitat	Improve tidal flushing to northern LWL; provides habitat and recreational opportunities. Sand will be used to fill dredged hole sites for additional seagrass enhancement.	$1,100,000	
14 HE-5	Peanut Island Reefs	Artificial Reef	2-3 acres off SE Peanut	Highly productive reef site	$400,000 – 600,000	
15 HE-5	Snorkel Reef	Artificial Reef	2 acres SE of Port of Palm Beach		$400,000	
16 HE-2, HE-7	PB Country Club Living Shorelines	Mangrove Planter	1500 linear ft	Mangrove planters will stabilize shoreline and provide habitat. Requires Interlocal Agreement with PBCC	$450,000	In design phase

LAKE WORTH LAGOON MANAGEMENT PLAN APPENDIX C-1 TABLE

HABITAT RESTORATION AND ENHANCEMENT PROJECTS SUMMARY

Project # Action Plan	Project Name	Project Type	Project Area	Comments	Project Cost	Status
17 HE-1, HE-2 HE-7	West Palm Beach Currie Park Living Shoreline	Mangrove Planter Oyster Habitat	2000 linear ft.	Mangrove planters/riprap will be constructed waterward of seawall. Project will attenuate waves/wakes. Requires Interlocal Agreement with City of WPB.	$600,000	
18 HE-1, HE-2 HE-7	Good Samaritan Living Shoreline	Mangrove Planter Oyster Habitat	700 linear ft	Mangrove planters/riprap will be constructed waterward of seawall. Project will attenuate waves/wakes. Requires Interlocal Agreement with landowner	$210,000	
19 HE-1, HE-2 HE-7	Town of Palm Beach Bradley Park- Living Shoreline	Mangrove Planter Oyster Habitat	180 linear ft.	Mangrove planter will be constructed waterward of seawall. Interlocal Agreement with Town of Palm Beach executed 7-10-07. Project postponed until Flagler Bridge replacement 20xx	$200,000	In scoping/design phase
20 HE-5	Flagler Bridge Reef	Artificial reef	<1 acre hole.		$200,000	
21 HE-1, HE-2, HE-4, SE-3, HE-7	Palm Beach Atlantic Univ. Islands Living Shoreline	Mangrove Islands & Planter Filling/Capping Seagrass/Oyster	<3 acre area	Mangrove Islands & planter will provide habitat and wave attenuation. Filling/capping mucks will provide substrate for SAV. Requires Interlocal Agreement with PBA	$300,000 / fill $400,000 oyster/mangrove	In scoping/design phase
22 HE-4, SE-3	Bingham Dredged Hole	Filling/Capping Seagrass	9 ac dredged hole; ave -12'; 60,000cy3 capacity	Previously filled with material from Palm Harbor Marina; capacity remains	$1,200,000	
23 HE-1,HE-4	Town of Palm Beach Oyster Reefs	Oyster Reef Seagrass Habitat	4 acre area of primarily submerged habitat between Southern Blvd north to Everglades Island. 2 acre oyster reef	Increased oyster and seagrass habitat will benefit water quality, bird and fisheries resources.	$400,000	
24 HE-5	Southern Boulevard Bridge Reef	Artificial reef	3 acre hole	Located in the vicinity of significant resources but away from inlets.	$250,000	

LAKE WORTH LAGOON MANAGEMENT PLAN APPENDIX C-1 TABLE

HABITAT RESTORATION AND ENHANCEMENT PROJECTS SUMMARY

Project # Action Plan	Project Name	Project Type	Project Area	Comments	Project Cost	Status
25 HE-1, HE-2	Bingham Islands	Exotic vegetation removal Mangrove/Oyster habitat	2 acre area of primarily 50% submerged and 50% existing high quality mangrove habitat.	Increased oyster, mangrove and seagrass habitat will benefit water quality, bird and fisheries resources. Located in an area of significant resources.	$350,000	
26 HE-1, SE-3	Forest Hill Dredged Hole	Filling/Capping Seagrass	6 ac dredge hole; ave -16'; 60,000cy3 capacity	Previously filled with material from Palm Harbor Marina; capacity remains	$1,200,000	
27 HE-1, HE-4, SE-3	Sloan's Curve Sands	Muck Capping Seagrass Islands/breakwater	100 acres	Create a sandy productive area, protected by breakwaters/oyster habitat.	$10,000,000	
28 HE-1, HE-4, SE-3	Ibis Isle West	Muck Capping Seagrass Islands	Filling a substantial hole north of Snook Islands, south of C-51 canal along the west side of ICW	A continuation of the original Snook Islands project, and involve a large quantity of fill w/ breakwaters.	$5,000,000	
29 HE-1, HE-2, HE-4, SE-3	Grassy Flats	Filling and capping Mangrove Island(s) Oyster/Seagrasses	12 acres total 10 ac SAV 2 ac mangrove/spartina/oyst	Cap muck sediments with sand shooter Bring elevations up to support SAV. Rock placement to provide oyster habitat and mangrove islands.	$3,000,000	Permitted
30 HE-1, HE-2, HE-4, SE-3	Tarpon Islands	Filling/ capping Mangrove Island(s) Oyster/Seagrasses	Approximately 80-100 acres	Utilize fill material on site and bring elevations up to support SAV. Rock placement to provide oyster habitat and mangrove islands.	$10,000,000	
31 HE-1, HE-2 HE-7	Bryant Park Living Shoreline	Mangrove Planter Oyster Habitat	2,600 linear ft of shoreline 2,100 linear ft of bulkhead rock	Riprap bulkhead and eroded shoreline, rock provides mangrove planters and oyster habitat	$1,410,000	Permitted

LAKE WORTH LAGOON MANAGEMENT PLAN APPENDIX C-1 TABLE

HABITAT RESTORATION AND ENHANCEMENT PROJECTS SUMMARY

Project # Action Plan	Project Name	Project Type	Project Area	Comments	Project Cost	Status
32 HE-1, HE-2 HE-7	Jewel Cove Living Shoreline	Oyster habitat Spartina Planter	1,100 linear ft shoreline 365 linear ft rock	Exotic plant removal, install native plants. Riprap will provide habitat and shoreline protection	$440,000	Permitted
33 HE-2	Lantana Nature Preserve	-Mangrove/Spartina -Exotic removal -Enhanced Flushing	2 acre mangrove area	Mangrove planting, exotic removal. Excavate sediments in mosquito ditches to increase flushing to mangroves.	$75,000 exotic removal & planting $50,000 enhance flushing	
34 HE-5	Lantana Bridge Reef	Artificial Reef	42 Acres reef north of Ocean Ave Bridge	Will need to get town of Lantana permission. 15' dredge hole close to ICW	$100,000	
35 HE-2	Ocean Ridge Natural Area	Dredge channels for tidal flushing to mangroves	Ocean Ridge Natural Area (ORNA) North and South .	ORNA North includes City of Boynton Beach mangroves	$200,000	

APPENDIX C-2 TABLE

STUDIES AND MONITORING PROJECTS SUMMARY

Project #/ Priority Action Plan	Project Name	Project Type	Status	Project Area	Comments*	Project Cost
1 EM-1	Implement Sea Turtle Monitoring Goals for LWL	Monitoring	The netting survey has been ongoing since March 2005. Additional sampling events will be scheduled annually for the next four years as funding is made available.	Little Munyon Island and Bird Island	Monitor the health of the sea turtle population utilizing LWL by continuing to perform annual netting events for 5 years.	$14,000/yr $70,000/5yr
2 EM-2	Develop a Fishery Monitoring Program	Monitoring	To be implemented. Develop a long-term, comprehensive database on fish and selected invertebrate species inhabiting the LWL.	All three segments of the Lake Worth Lagoon	FWC/FWRI will contribute $75,000 in staff & services. The remaining $75,000 is contingent upon grant funds.	$150,000/yr $750,000/5yr
3 HE-4	Develop a SAV Monitoring Program	Monitoring	Current SAV Monitoring: PBCERM- annual fixed transects and aerial mapping/5yr; SFWMD-bi-annual of 4 beds; FWC/FWRI annual fixed transects; PBAU-50 zones at MacArthur Beach State Park .	All three segments of the Lake Worth Lagoon.	Continue agency monitoring efforts to detect SAV changes in both short- and long term spatial and temporal scales. Develop a SAV restoration target.	$100,000/yr $500,000/5yr $140,000/5yr for aerial mapping
4 HE-1	Monitor Oyster Reef Habitat in LWL	Monitoring	A baseline for LWL oysters has been established through an ongoing monitoring program headed by FWC since January 2005. PBCERM/HBOI/FAU completed a study on natural vs. created reef, which established a monitoring framework for future monitoring.	All three segments of the Lake Worth Lagoon.	Document the aerial extent of the oyster population in LWL and on artificial substrate (walls, pilings, rock).	$75,000/yr $375,000/5yr
5 HE-1, HE-2, HE-4, HE-5	Post Construction Project Monitoring	Monitoring	Establish monitoring program to determine success of constructed restoration/enhancement projects.	All three segments of the Lake Worth Lagoon.	Monitor the project success and re-establishment of resources.	$100,000/yr $500,000/5yr

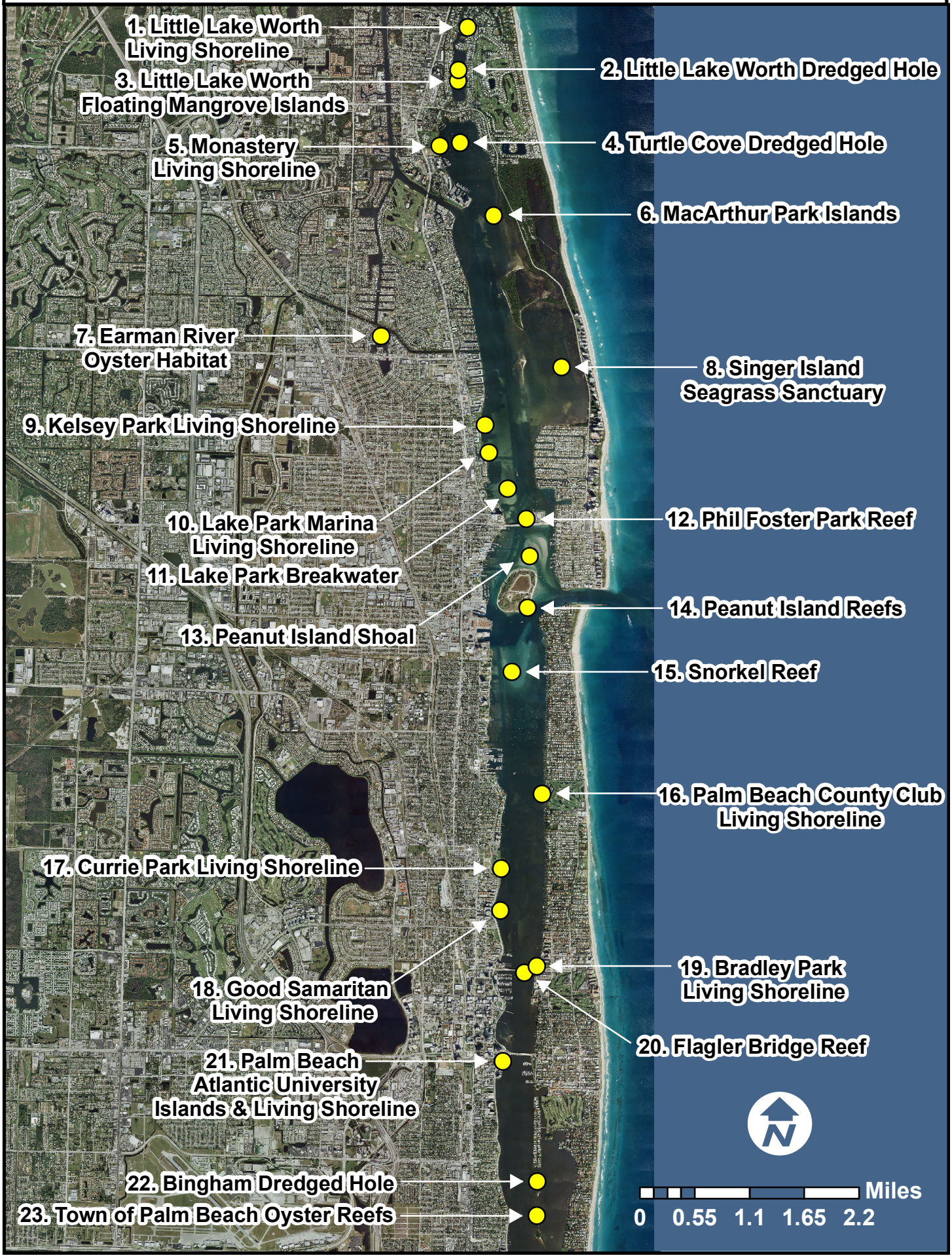
TABLE C-3 TABLE

WATER AND SEDIMENT QUALITY PROGRAM

Project Name	Project No. & Priority	Activity or Product	ESTIMATED COST	POTENTIAL* PARTNERS	STATUS
WATER QUALITY	WQ - 1	Continue water quality monitoring of LWL at 14 fixed stations. Conduct trend analysis in 2017.	$135,000/yr $675,000/5yr	PBCERM, SFWMD, local governments	PBCERM/SFWMD have an on-going cooperative monitoring effort since 2007. Trend analysis conducted in 2012.
	WQ – 3	Install Additional Sewage Pump-out Facilities for Recreational Boaters and Live-aboard Vessels. Encourage participation in FDEP's Clean Marina Program	Stationary or portable pump-out units range from $2,000 to $6,000. Costs for a portable toilet waste station may vary from $1,100 to $1,800.	FDEP, Local governments, PBCERM, Marine Industries Association	To be implemented
WASTE WATER TREATMENT	WW – 1	Update ArcGIS files of septic systems and sanitary sewer coverage within the watershed. Implement a bacteriological assessment of the LWL watershed	$150,000 for update to Environmental Health Database $75,00 for bacteriological assessment	PBCDOH/ERM/Utilities, FDEP, EPA, Local Municipalities	DOH created a septic tank location map, which needs to be refined with GIS. To be implemented
	WW – 2	Provide Additional Sanitary Sewer Connections to Priority Areas of Lake Worth Lagoon.	Conversion from septic to sewer service range from $2,500-$6,500 plus monthly service fees	FDEP, PBC, DOH, FAU/HBOI, Municipalities	To be implemented
STORMWATER TREATMENT AND SEDIMENTS	SW – 1	Reduce Discharge of Freshwater and Total Suspended Solids in the Lake Worth Lagoon through the C-51 Canal.	Construction of FEBs =$800M Quantify f flow reduction/sed loads = $5,000 C-51 survey = $20,000 C-51 sed trap dredging = $2.7M	SFWMD, PBCERM, PBCWU, USACE, FDEP, LWDD, Municipalities	To be implemented.
	SW – 3	Identify and create ArcGIS map of outfalls discharging to LWL watershed. Prioritize stormwater retrofits, identify funding, implement retrofits.	$50,000 to create ArcGIS maps/prioritization $5M to construct municipal stormwater treatment system	SFWMD,PBCERM, FDEP, Municipalities, PBC NPDES Program	To be implemented
	SE – 3	Manage Sediments in Lake Worth Lagoon Identify funding & sand sources for Grassy Flats Identify/prioritize/permit capping projects	$2,600,000 for Grassy Flats Identify/ perm ˙t additional capping projects $20,000 staff	SFWMD, USFWS, EPA, USACOE, PBC, LWLPGP, FIND, FDEP	Grassy Flats permitted & ready to construct pending funding

*Listed Agencies have not committed funds and are subject to Agencies' budget approvals

North Lake Worth Lagoon Projects 2013-2017



South Lake Worth Lagoon Projects 2013-2017