TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 Introduction and Purpose of Study

1.1 Introduction

Applied Technology & Management (ATM) was been contracted by the City of Boynton Beach (City) to assess the current conditions of the South Lake Worth Inlet (also known as the Boynton Inlet) with respect to improving boater safety and water quality in the Lake Worth Lagoon. The intent of this study is to determine possible inlet modifications to address these two concerns

Water quality in the Lake Worth Lagoon is a long standing and well-known issue. Additionally, South Lake Worth Inlet is not maintained as a "navigable inlet" and often poses dangerous navigation conditions, especially to inexperienced boaters. The primary focus of this investigation is to look at options that would not only improve water quality in the lagoon but would also address critical navigation safety issues related to the current inlet configuration.

1.2 Study Approach

With improvements to lagoon water quality and navigation safety as the primary goals of the study, a full range of alternatives from "No Action" to significant widening and deepening of the inlet were developed to assess potential benefits and related negative impacts. Key assessment parameters used to rank alternatives included: 1) Improvements to Navigation Safety; 2) Improvements to Lagoon Water Quality; 3) Permit-ability; 4) Environmental Impacts; 5) Other Secondary Impacts; 6) Construction Cost and Timeline; and, 7) Overall Effectiveness of Achieving Goals.

An important element to this study was the solicitation of stakeholder input. There are a variety of stakeholders who hold an interest in the inlet. They include Palm Beach County's (PBC) Department of Parks & Recreation and Department of Environmental Resource Management (ERM), local municipalities, Florida Department of Transportation (FDOT), South Florida Water Management District (SFWMD), Lake Worth Drainage District (LWDD), several environmental organizations, local property owners, boaters, business owners, and various other user groups. As previously mentioned, efforts were made to gain upfront input from stakeholders regarding the perceived concerns with the inlet and lagoon, as well as feasibility of various alternatives. These included meetings with PBC ERM, Parks & Recreation, and representatives from the Marine Industries Association.

ATM researched and obtained all readily available data, studies, and publications relative to the inlet. Information from the Corps of Engineers, the University of Florida, studies and engineering reports from PBC ERM, in-house studies performed by ATM (seagrass), reports and statistical data from the Florida Inland Navigation District (FIND) and the Marine Industries Association (MIA), and other sources were gathered in support of this study.

ATM deployed and collected *in-situ* tidal stage and current data for a period of eight days for use in model calibration. While in the field, it was noted that another instrument had been deployed and further investigation discovered that NOAA was performing a data collection effort for an unrelated study. Contact with the office of Dr. John Proni was made in an attempt to collect additional tidal current data for modeling use. While data was not available at the time of this study, it is envisioned that future communications may yield information that will be of value relative to the results of this study. If so, an addendum to this study could be developed to reflect any additions or edits.

To assess navigation safety, boating incident reports from PBC Central Records and Florida Fish & Wildlife Conservation Commission (FWC) were collected. Additionally, interviews with PBC Marine Enforcement Unit officers, as well as PBC's Chief of Ocean Rescue and several lifeguards were held.

A key component of the study process included holding two workshops. The first was held on August 8, 2007 at the City of Boynton Beach, during which ATM presented the proposed scope of work, solicited input, and fielded questions from attendees. A Workshop Survey Form was provided to all participants, requesting input on existing concerns, ranking of those concerns, and opinions on favorability of various approaches to modifying the inlet (physical and management changes). Appendix A contains copies of the survey forms received from the workshop, as well as in the mail and from an internet posting on ATM's home page.

The content and format of this report was established not only to provide background on the inlet's history and current issues, but also to summarize work efforts undertaken (modeling, research, etc.) to assess the inlet and potential physical and management alternatives aimed at improving safety and lagoon water quality. Section 2.0 briefly summarizes the history of the inlet and provides a description of the physical characteristics of the inlet. Section 3.0 is written to provide a comprehensive listing of the environmental and safety issues associated with the inlet as they stand today. While the primary focuses of the study were related to lagoon water quality and navigation safety, there are other issues related to the inlet that must be addressed. These "secondary issues" are summarized in Sections 4.0 and include topics such as beach management, public access, boating statistics and economics. Sections 5.0 & 6.0 discuss lagoon flushing and wave modeling studies that were undertaken as part of the overall studies, highlighting the results of up to six inlet modification alternatives. Sections 7.0 through 9.0 summarize and evaluate all of the alternatives (structural and non-structural) evaluated for the inlet, providing conclusions and recommendations based on a ranking of alternatives approach.

Through the ranking process, viability of each alternative is defined along with associated advantages and limitations.

The end result of this study is not an exhaustive and detailed review and assessment of every alternative, rather an overall comprehensive range of alternatives. Through the ranking process, favorable approaches to modifying and/or managing the inlet in a manner that would accomplish the goals of the study presented themselves. Those alternatives that were deemed favorable are highlighted and recommended for further detailed investigation and implementation.

2.0 Inlet History and Current Inlet Conditions

2.1 Inlet History

The following is a historical summary of the South Lake Worth Inlet re-written from a report titled, "*History of Palm Beach County Inlets*", obtained from Palm Beach County's Department of Environmental Resource Management (PBC ERM).

South Lake Worth Inlet was originally constructed primarily as a measure to improve the declining water quality in the Lake Worth Lagoon. At that time it was also deemed necessary for shipping and transportation. Prior to construction of the South Lake Worth Inlet, the Legislature of Florida created a special taxing district (the South Lake Worth Inlet District) whose Board of Commissioners was authorized to construct and maintain an inlet.

The U.S. Army Corps of Engineers issued a permit for construction of the inlet in 1924 and construction commenced in 1925. After completion of the jetties and the channel bulkhead, the final cut opening the lagoon to the ocean was made in March 1927. The original channel was approximately 130 feet wide and averaged 8 feet deep. Soon after the initial opening of the inlet, sand impounded on the north jetty began to spill into the channel and form a large flood shoal inside the lagoon. The impounded sand along the north jetty and the formation of the flood shoal led to erosion on the south side of the inlet and consequently the construction of a 2,000-foot long seawall known as the "McCormick wall" in 1932. Soon after, a series of groins were built in front of the seawall by the same property owner in an attempt to protect the seawall from undermining.

The volume of sand entering the lagoon was high enough to necessitate raising the elevation of the jetties from +5 feet Mean Low Water (MLW) to +12 feet MLW and installing a fixed sand bypassing plant, accomplished in 1936 and 1937, respectively. Despite these modifications, interior shoaling remained a problem causing decreases in tidal flow and hazardous navigation conditions and requiring continuous maintenance dredging.

To help reduce the interior shoaling along the north side of the inlet, a training wall and weir were constructed in 1953. The University of Florida performed an engineering study of the inlet that resulted in the extension of the north and south jetties, the relocation and upsizing of the fixed sand transfer plant, and the construction of the south training wall in 1967. These modifications would improve the hydraulic efficiency of the inlet and decrease interior shoaling rates. The jetty extensions added 410 feet to the north jetty and 68 feet to the south jetty. The ends of the jetties were constructed with a deck elevation of around +7 ft referenced to the National Geodetic Vertical Datum (NGVD).

Since then, only minor modifications such as the construction of a small spur and sealing of portions of the north jetty (1971) have been made. According to the County's inlet summary report, the existing A1A fixed span bridge over the inlet was reconstructed in 1974. Additional communications with FDOT and their construction contractor indicate no plans for major rehabilitation or replacement of the bridge in the near future. Improvements to the bridge's eastern handrail system are underway and will not have any impact on the clearance or function of the bridge.

It is known through personal communications with the County that the original excavation and several maintenance dredging events of the inlet were difficult and required blasting of base rock to complete. Since the original cut was made there has been only one attempt to remove more of the base rock resulting in removal of only a small but problematic high spot near the inlet mouth.

In 1996 the South Lake Worth Inlet District was abolished and the County now operates the sand transfer plant and manages the inlet. The latest inlet construction project occurred in 1998 when 8 "t-head" groins were installed south of the inlet to help retain a minimum beach section immediately downdrift of the inlet. The shoreline to the south of the inlet is maintained as a Federal Beach Nourishment project with the County serving as the local sponsor.

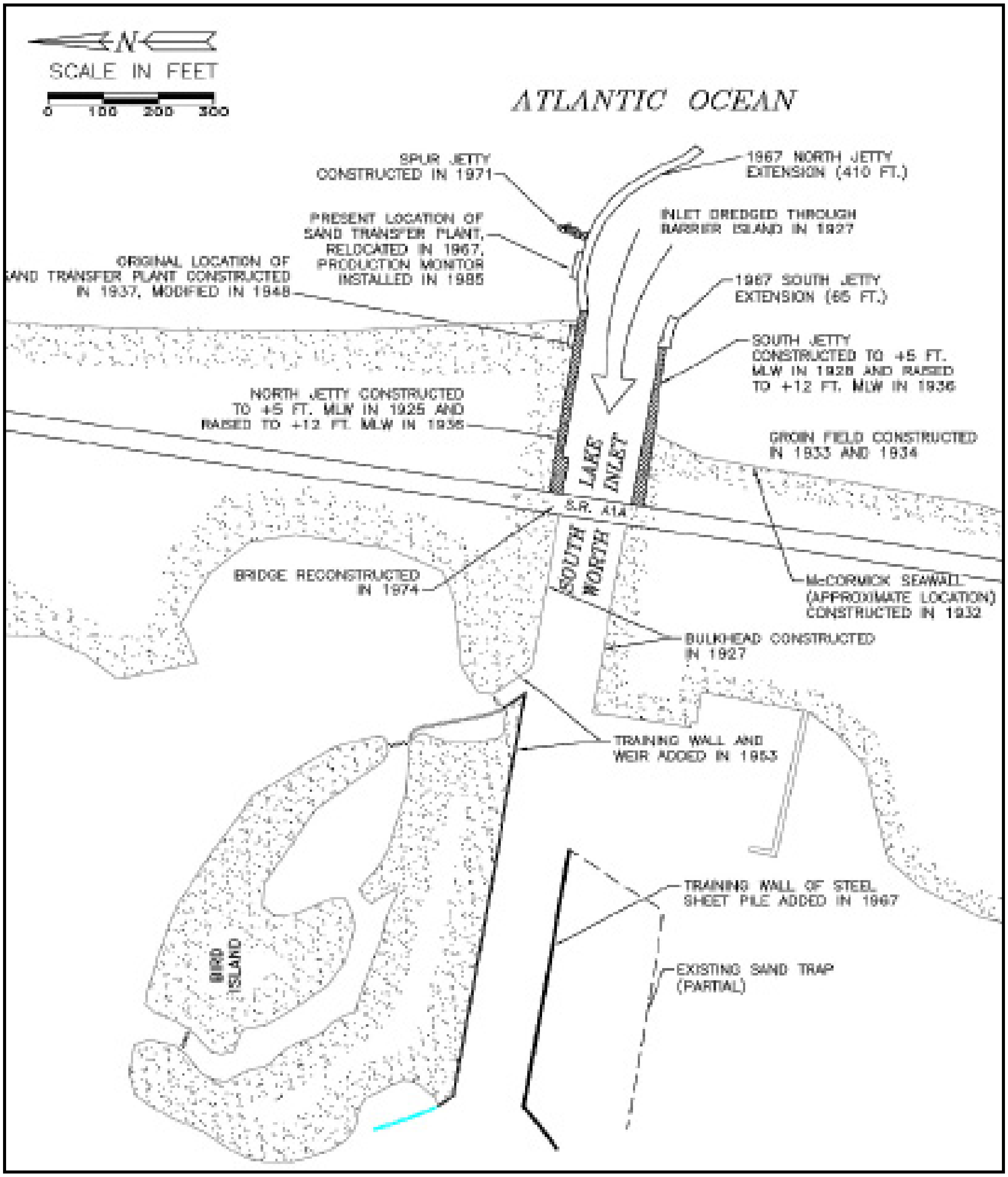


Figure 1 – Overview of Improvements to South Lake Worth Inlet (source: PBC ERM)

2.2 Current Inlet Configuration

Today South Lake Worth Inlet remains close to its original configuration (Figure 2). The inlet is stabilized by two rock and rock-filled crib jetties. The south jetty was 370 feet long, but lost ~10 ft of the outer end after the hurricane season of 2004. The north jetty is around 770 feet long and also suffered damage and loss of around 10 ft of the outer end during the 2004 hurricane season.

The navigable channel width varies from 125 feet wide west of the bridge to around 110 feet wide at the bridge, then down to less than 100 feet wide near the mouth of the inlet east of the bridge (Figure 3). Both sides of the channel passing through the barrier island are protected by vertical sheetpile walls. Bird Island is located inside the Lake Worth Lagoon and immediately adjacent to the north side of the channel and is protected by 840 feet of vertical wall. Opposite Bird Island is the 615-foot long training wall (also a vertical structure).

Because of the continuous lengths of vertical structures that line this relatively narrow channel, vessel wake reflection becomes problematic especially during peak usage. Multiple inbound and outbound vessels over a short period of time set up a series of reflected waves whose peaks and troughs merge across the full width of the channel. This creates difficult navigation conditions that force boaters to perform constant steering corrections to counter wave (and current) forces.

As can be seen in Figure 4, the depths within the channel also vary appreciably. The controlling water depth is between 8 and 10 feet. Average bottom elevations are around -11 feet NGVD west of the bridge. Near the mouth of the inlet there are deep pockets greater than 20 feet deep and remnant submerged ledges of -8 feet NGVD or less in the center of the channel. Along the south side of the inlet east of the bridge and roughly 15 feet from the north side of the south jetty structure, there is a near vertical ledge with less than 4 feet of water. This submerged ledge effectively reduces the navigable width of this section of the channel to less than 100 feet.

The State Road A1A bridge is a single-span steel beam structure. It connects the Towns of Manalapan and Ocean Ridge and serves as an emergency evacuation route. The lowest structural member restricts clearance beneath the bridge to approximately 18 feet above the mean water line. This limits the maximum vessel size that can pass through the inlet.

Recent communications with PBC ERM indicate that plans to repair and improve both jetties and the north training wall along Bird Island are near completion. At the time of this study, however, the schedules for permitting approval and construction were not available.

Figure 2 – Current Inlet Configuration

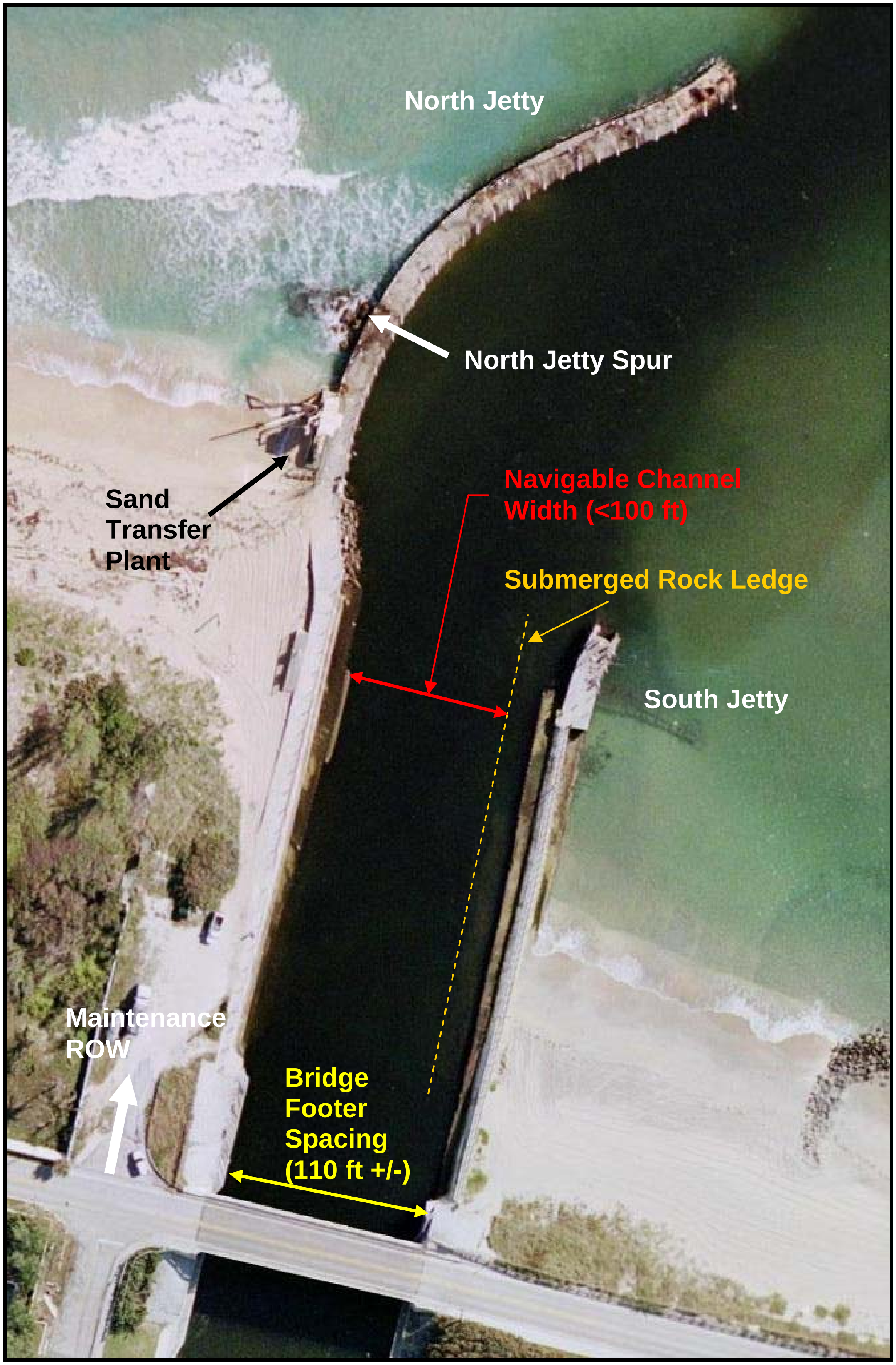


Figure 3 Inlet Mouth

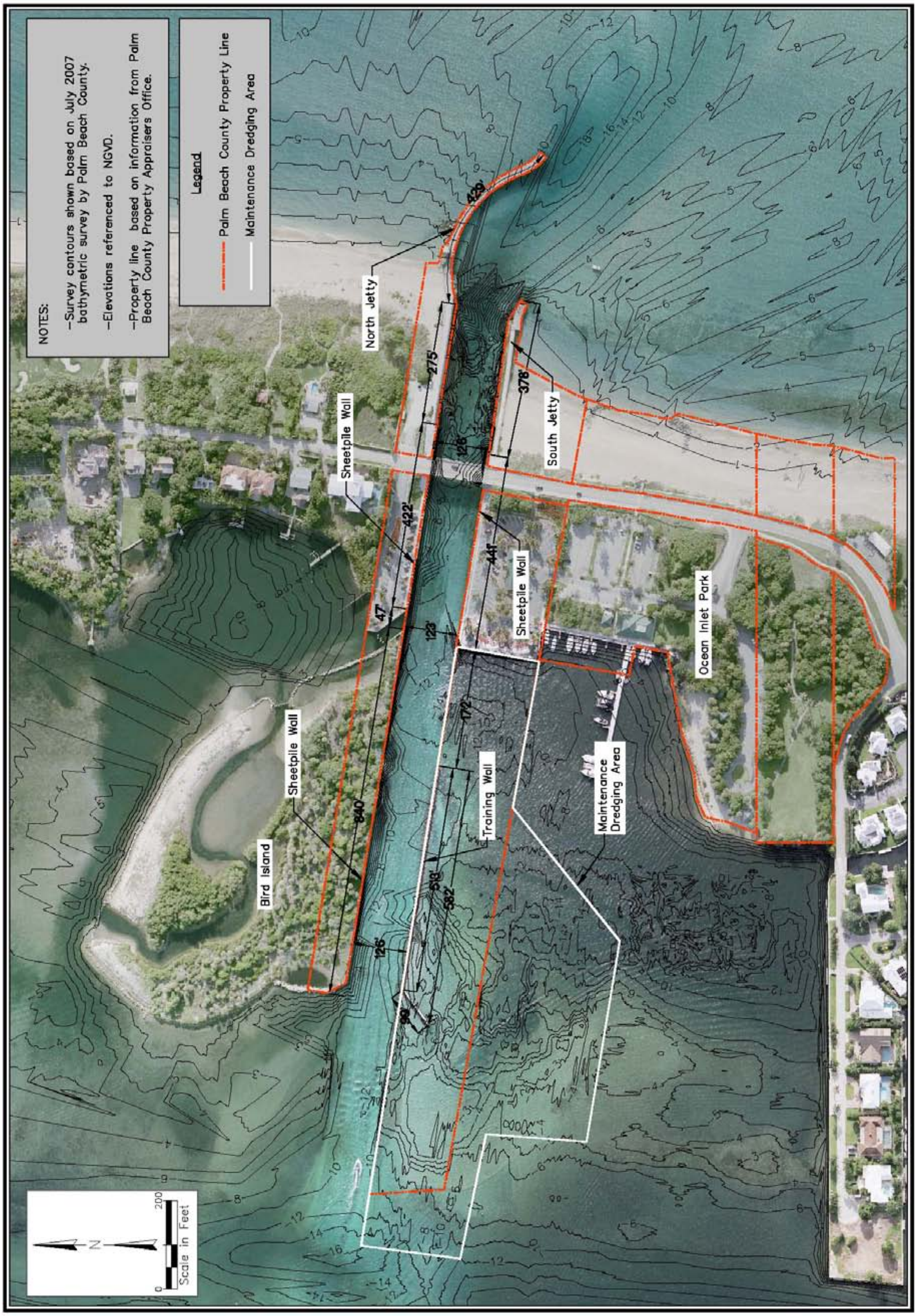


Figure 4 – South Lake Worth Inlet Survey

2.3 County and Contiguous Property Ownership

Palm Beach County owns and maintains 11.4 acres surrounding the inlet roughly as shown in Figure 5 below. Ocean Inlet Park has 1,100 linear feet of Intracoastal Waterway frontage and 600 ft of guarded ocean beach. The park is open from sunrise to sunset and fishing on the jetties is permitted 24-hours. Additionally, the park has the following facilities:

- 24-slip marina, including 3 lifts for PBC Sheriff's Marine Enforcement Unit vessels
- Approximately 216 Free Public Parking Spaces (26 on the north side of the inlet and 190 on the south side)
- Ocean Overlook
- Playground
- Seating Pavilion
- Family Picnic Shelters, Tables and Grills
- Restroom Facilities
- Outdoor Showers
- Ocean Inlet Grill and Snack Bar

Along the north side of the inlet, the County maintains an 80-ft right-of-way for access to the north jetty and fixed bypass plant. The 80-ft ROW continues west along the parking area and out onto Bird Island. The remainder of Bird Island is privately owned and was in the recent past an Audubon bird sanctuary. Public access is restricted to Bird Island.

South of Ocean Inlet Park is the Town of Ocean Ridge. Residents on both sides of the inlet have shared experiences and concerns over the management of the inlet and beaches.

Figure 5 – Approximate Property Boundaries

3.0 Key Environmental and Safety Issues

3.1 Environmental Issues

Coastal lagoons and estuaries are highly productive ecosystems that provide habitat for a diverse array of plant and animal life. The Lake Worth Lagoon (LWL), extending 21 miles along the eastern portion of Palm Beach County, is recognized as one of Florida's important estuaries. During the past 100 years, human activities have profoundly affected the LWL. The LWL has been transformed from a relatively natural freshwater lake to an estuarine lagoon that has been heavily impacted by the urban, commercial, and industrial development that now encircles it. The LWL has over 70 linear miles of shoreline and in an assessment conducted in the late 1980's, Palm Beach County reported that over 65% of the natural shoreline vegetation had been replaced by seawalls, bulkheads, and/or shoreline armoring.

Ecological surveys in the LWL have documented a great diversity of marine life. Over 250 species of fish are known to occur in the Lagoon and in the vicinity of its inlets. Thirteen plant species and 27 animal species designated as endangered, threatened, rare, or species of special concern are either known to occur or are likely to occur in the LWL. Field surveys have documented the presence of five species of seagrass, including the threatened Johnson's seagrass (*Halophila johnsonii*), various species of macroalgae, oyster habitat, corals, and sponges.

3.1.1 Lake Worth Lagoon Water Quality

The LWL receives freshwater from a variety of sources, including rainwater, groundwater, and drainage from various canals, ditches, and other man-made conveyances. Large scale freshwater releases come from local channels such as the Earman River (C-17) canal, the Palm Beach Canal (C-51) and the Boynton Beach (C-16) canal.

According to water quality studies conducted by Florida Department of Environmental Protection (FDEP) the C-16 canal which is in the southern portion contained levels of nutrients, dissolved oxygen, and iron that do not meet applicable water quality standards designated by the Federal Clean water Act. According to this act, under Section 303(d), the area is considered to be "impaired waters".

3.1.2 Lagoon Resources

3.1.2.1 Seagrass

It is widely recognized that seagrasses are an excellent indicator of environmental conditions in estuarine ecosystems, primarily because their existence, abundance, and vitality are directly related to water quality. Elevated turbidity levels reduce light penetration, which is often the limiting factor for the survival of seagrasses. Elevated levels of nutrients result in an imbalance of plant life, typically favoring the abundance and growth of algae and negatively affecting seagrasses. The presence, abundance, and vitality of rooted marine life are often limited by salinity regimes. Fluctuations in salinity due to modifications in the volume, timing, and/or delivery of fresh water into estuarine systems have a significant effect in determining the composition and health of seagrass and other benthic floral and faunal communities.

In the southern portion of the lagoon continuous seagrass beds can be found on the western shore. This extends from Lake Worth Avenue south to South Lake Worth Inlet. Approximately 300 acres are found in the southern portion which comprises 18.5% of the total lagoon seagrass acreage. Lagoon-wide research has shown that within an 11-year period there has been a notable decline in seagrass coverage and they have been showing signs of stress due to low water quality (PBC ERM, 2003).

Fixed transects have been documented throughout the Lake Worth Lagoon since 2000, with the exception of 2006. In 2007, seagrasses were in an improved condition when compared with recent years, though this improvement can be largely attributed to moderate lagoon-wide recovery following significant impacts during the 2004 and 2005 hurricane seasons. While not covered under the lagoon-wide monitoring, seagrass mapping in the immediate vicinity of the inlet has been periodically documented in detail as a requirement for maintenance dredging by the County. Figure 6 is included for reference as it depicts the results of seagrass mapping efforts from 2002 and 2003. The County is in the process of developing plans for another maintenance dredging event for the inlet and may perform an updated seagrass mapping effort in the near future.

Demonstrating the importance of seagrass as a key habitat and valuable resource in the local ecosystem, planning and permitting success weighs heavily on the impact to this resource. From PBC ERM website (http://www.co.palm-beach.fl.us/erm/enhancement/seagrasses.asp):

"Recent studies analyzing such factors as nutrient cycling, raw materials, and support for recreational and commercial fisheries, provide a conservative estimate of the economic value of seagrasses at $20,500/acre/year. Using this value, Palm Beach County's seagrass resource would have an economic value of $51,455,000 per year. It should be noted that Chapter 376.121, F.S., deals with liability for damage to natural resources and requires compensation for seagrass and mangrove habitat loss at $1 per square foot ($43,560/acre). ERM believes this is a resource well worth protecting."

3.1.2.2 Mangroves

Mangroves also play an important role in an estuarine environment. Four critical roles they play are: 1.) Providing valuable habitat for various fish and shellfish species during critical development stages (larval, juvenile); 2.) Serving as important nesting habitat for various bird species; 3.) Naturally trapping and filtering waterborne nutrients and other pollutants and runoff; and, 4.) Naturally protecting shorelines against erosion and storm impacts.

Compared to more than fifty years ago, very little natural shoreline with mature mangrove forests exist today. Development has led to significant "hardening" of the lagoon shorelines through construction of bulkheading, concrete sea walls, rock revetments, etc. to protect upland properties. In 1975 it was estimated that 87% of the lagoon's original mangroves had been replaced, leaving only 267 acres (PBC ERM, Understanding the Lake Worth Lagoon). Today there are multiple environmental restoration projects underway throughout the lagoon, such as the Snook Islands restoration project, the Ocean Ridge Natural Area, Bird Island Sanctuary, Peanut Island restoration, Munyon Island and many others.

3.1.2.3 Oysters

Oysters are considered a keystone species because they form large clusters of biogenic reefs. Oysters filter water removing pollutants and sediments from the water. This allows for greater water quality immediately downstream, which in turn results in greater light penetration, promoting the growth of submerged vegetation. It also assimilates the organic matter providing food for benthic organisms. In the entire LWL system, a healthy population of approximately 5-acres of oyster reef exists. A majority of these reefs are found in the central area of the lagoon. It appears that the species is not recruitment limited, but limited by the lack of appropriate substrate. There are projects in effect that are attempting to increase these beds in the central area where it may be more suitable, but not currently within the southern portion. Other areas in the lagoon may be suitable but those areas have yet to be identified.

Potential changes to the inlet, especially those that significantly change tidal prism and lagoon salinity are likely to have an effect on oyster success.

3.1.2.4 Manatees

The endangered Florida subspecies West Indian Manatee (*Trichechus manatus latirostris*) is observed year-round within the LWL. The majority of the population congregates in the northern section of the lagoon during the winter months, when surrounding water temperatures decline. Canals and discharge points, such as the powerplant in Riviera Beach become gathering points for manatees looking for warmer waters.

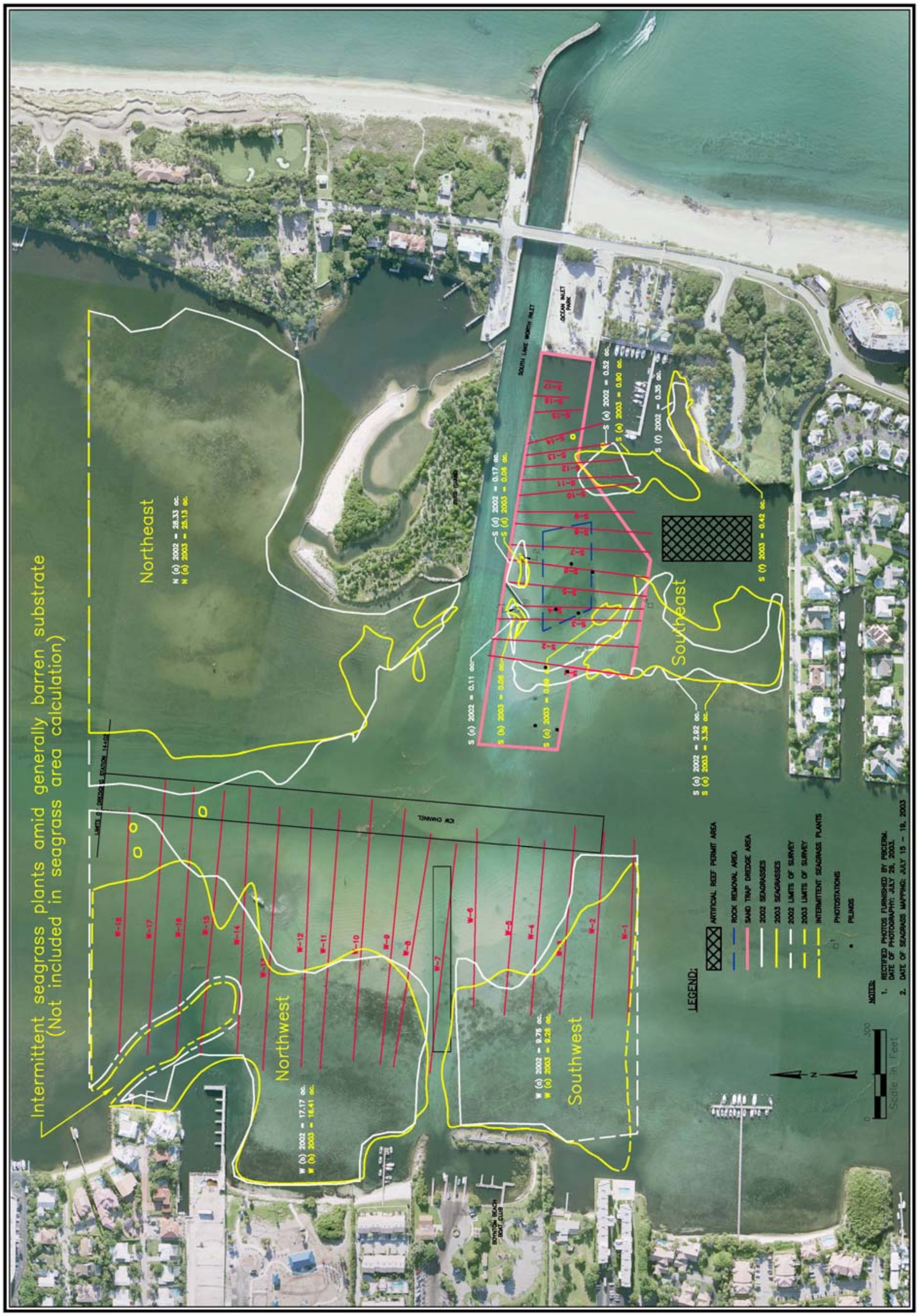


Figure 6 – South Lake Worth Inlet Seagrass Survey (2002 & 2003)

In 2007 the Manatee Protection Plan (MPP), was approved by the Florida Fish and Wildlife Commission (FWC). This state-approved planning document contains manatee data, strategies, and management actions aimed at protecting manatees from watercraft and other human-related impacts in a specific region or county.

Manatees are affected both directly and indirectly by the quality of water in which they live (MPP 2007) which might be directly affected through the release of pathogens and pollutants associated with stormwater runoff and waste water discharges. Additionally, the distribution and abundance of the manatee's primary forage (submerged aquatic vegetation) is related to salinity and other water quality patterns (MPP 2007). Thus, manatees are indirectly affected when seagrasses are impacted by runoff and stormwater discharges. Improving the flushing within the lagoon may help improve the health of the manatee.

Portions of the southern Lake Worth Lagoon are in an area were boater and manatee densities are greatest. According to the MPP, during the warm season (April-November), manatees and calves are most abundant within the south Lake Worth Lagoon, followed by the north Lake Worth Lagoon and the Intracoastal Waterway south of Delray Beach (MPP 2007).

Also according to the MPP, "*The potential for manatee avoidance of watercraft is dependent, in part, on the physical parameters of the waterway. All other factors being equal, narrow, constricted waterways have the greatest potential for manatee/watercraft collisions. In relatively wide areas, such as the Lake Worth Lagoon, manatees can more easily disperse away from the congested ICW. Conversely, in narrow areas such as Lake Worth Creek and ICW South, manatees have little opportunity to avoid areas congested with boat traffic. Consequently, there is a higher likelihood of boat and manatee interaction in narrow waterways compared with relatively wide waterbodies*."

Figures 7 and 8, taken from the MPP, depict cumulative manatee abundance and speed zone watercraft mortality for the entire lagoon, respectively. The highest mortality rates for manatees have occurred around Jupiter Inlet, Lake Worth Inlet, and ICW South. South Lake Worth Inlet has been designated as an area with high manatee abundance, yet has experienced low watercraft mortality. Proposed physical changes that will occur in the inlet and associated changes to boating traffic volumes would ultimately require a review of the MPP.

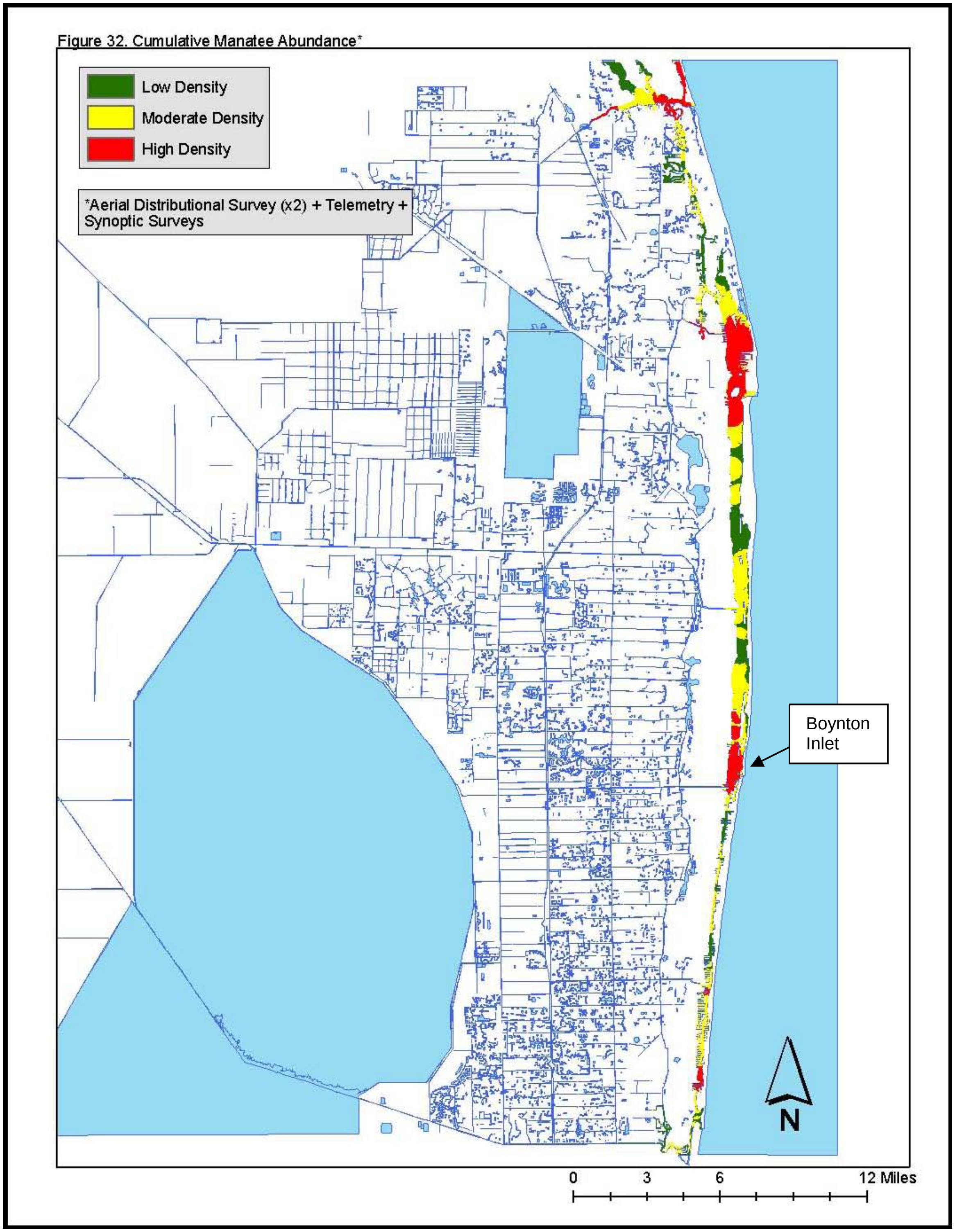


Figure 7 – MPP Cumulative Manatee Abundance

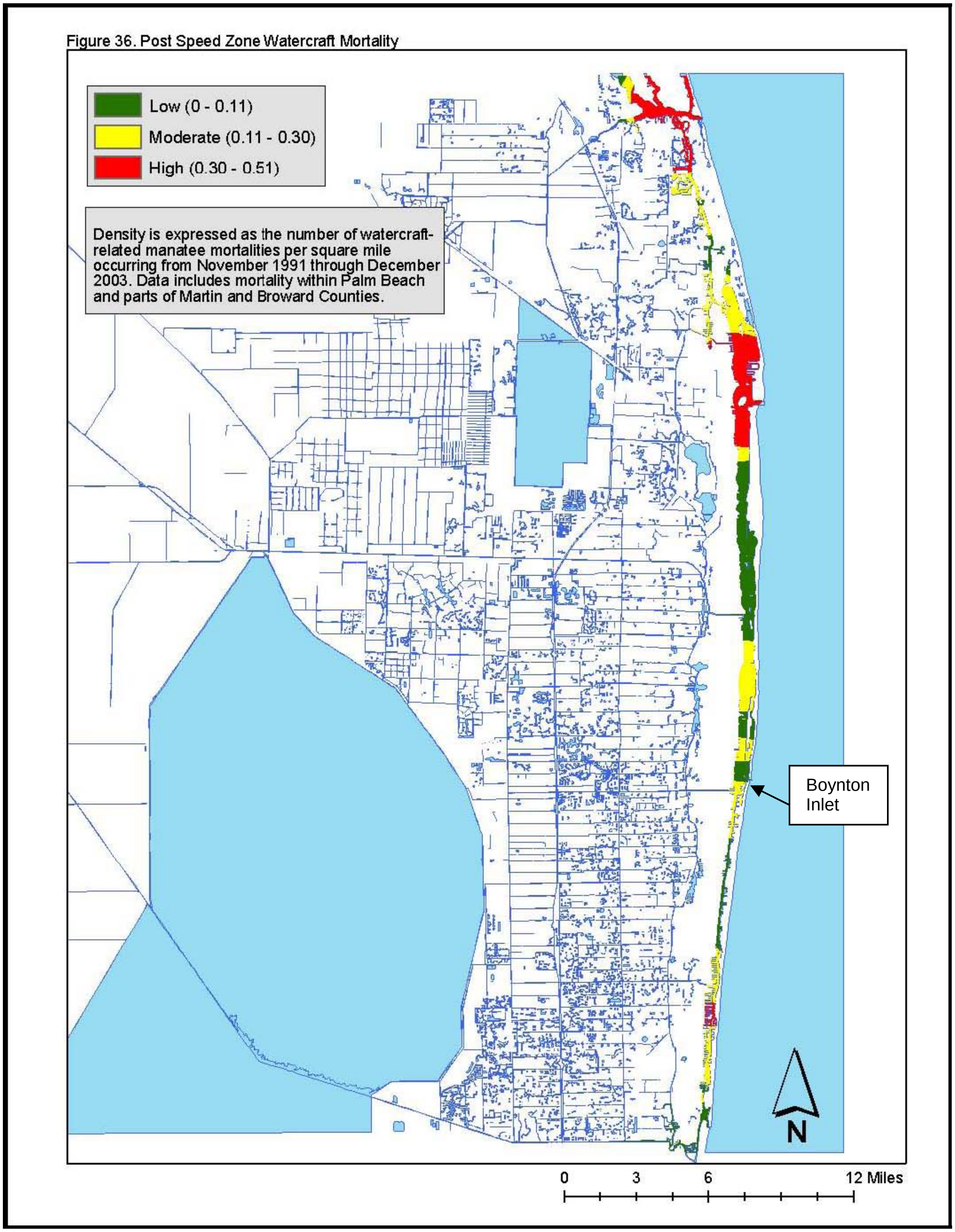


Figure 8 – MPP Post Speed Zone Watercraft Mortality

3.1.2.5 Sea Turtles

Estuaries can be important development habitat for sub-adult sea turtle populations. Sea turtles have been documented in the lagoon, however, not much is known of the sea turtle population in Lake Worth Lagoon. The health of the lagoon is reflected in the health of the sea turtles. Considered an indicator species, sea turtles in the Indian River Lagoon and Mosquito Lagoon have been well-documented. Green sea turtles in these areas have shown high occurrences of Fibropapillomatosis (FP), a viral infection which leads to tumor growths. Palm Beach County ERM is currently conducting research to assess the occurrences of FP in Lake Worth Lagoon. Current data obtained from their study shows that they are affected as well.

The widening of the inlet would improve the flushing in limited areas of the lagoon around the inlet. This potential benefit may help improve the health of the subadult species within the area. However, an increase in the nutrient load outside of the inlet may have potentially negative effects on offshore habitat and turtle populations.

3.1.3 Ocean Resources

Reefs and exposed hardbottom adjacent to and offshore of the inlet are important habitats that may also be affected by changes to the inlet. Both resources are subject to monitoring and have been the topics of various research and study efforts. From Appendix A of the Draft Lake Worth Lagoon Conceptual Ecological Model, written as part of the Coastal Everglades Restoration Plan (CERP):

"Coral reef systems are highly oligotrophic, and potentially vulnerable to changes resulting from nutrient enrichment. Reef development is typically slow and occurs over geologic time scales, so impacts to reefs may cause ecological problems that require long time frames for recovery. The areas near North and South Lake Worth Inlets (i.e., Palm Beach and Boynton Inlets) are unique and important resources for the State of Florida. The extensive hard coral systems present within a few kilometers of the shoreline provide habitat for many marine species of socio-economic value to tourism and local fisheries. These reefs represent the most northward extension of tropical reefs on the east coast of the United States, and transition into worm reef/limestone habitat near the Jupiter Inlet (Japp and Hallock 1990). The recreational and commercial importance for this area of northern Palm Beach County cannot be overstated, and the health of Florida's reef system is of special concern. The quantity and quality of water discharged from the Lake Worth Lagoon has effects on near-shore habitats near the ocean inlets of the Lake Worth Lagoon, and changes to the water management strategies as a result of Comprehensive Everglades Restoration Plan (CERP) activities may alter the current conditions. Alteration of flows delivered to C-16, C-17 and C-51 will directly affect the transport of sediments to near-shore reef areas, as well as light penetration through alteration of watercolor and clarity. These factors may directly or indirectly affect the health of corals through a variety of mechanisms. Decreasing the volume of fresh water "put to tide" through existing water conveyances will most likely be beneficial to the overall health of these hardgrounds. System-wide effects expected as a result of the implementation of the CERP include decreased nutrient and sediment transport to these tropical reefs, and decreased color, which will improve the light regime needed by symbiotic zooxanthellae found in many sessile invertebrates (e.g., stony corals, octocorals, sponges and tunicates). Indirectly, these reef animals will benefit from an expected decrease in overgrowth by macro-algal species that readily respond to increased nutrients"

As they support a greater diversity and number of floral and faunal species, consideration must be given to impacts on resources that may already be stressed or are currently clear of the inlet's current sphere of influence. Specifically, the plume of brackish water exiting the inlet during the ebb tidal flow extends offshore, spreading lagoon waters over nearshore bottoms. Changes to the exchange of waters and associated offshore impacts will have to be considered against potential improvements to lagoon water quality. It is beyond the scope of this work to quantitatively assess this potential - hence discussion in later sections will remain qualitative in nature.

3.2 Safety Issues (Navigation)

There are multiple issues related to navigation and boating safety. Weather and boater inexperience are two critical elements contributing to boating incidents – both of which are beyond the control of this study. Improved boater education and ready awareness of weather conditions are two ways to combat these elements.

South Lake Worth Inlet currently suffers from a variety of natural forces and man-made obstacles that make navigation potentially hazardous, even during relatively mild weather conditions. The following sections describe each of these factors and how they affect navigation safety.

3.2.1 Tides and Tidal Currents

Typical of many barrier island inlets in Florida, tidal current velocities follow the relative rise and fall of bay (or in this case lagoon) and ocean water elevations, the levels of which are mostly driven by the phasing of the sun and moon. Because of the large tidal prisms and relatively small connecting points (inlets) between interior lagoons and the ocean, tide driven currents can reach velocities high enough to create hazards to navigation especially for inexperienced boaters. Current velocities through the South Lake Worth Inlet are especially hazardous during a falling tide (ebb) where the rate of flow induces standing waves in the mouth of the inlet that are several feet high. Coupled with incoming waves, timing of ingress and egress through the inlet becomes critical.

Ocean tides in the vicinity of South Lake Worth Inlet (Lake Worth Pier) range from 2.8 feet up to 4.4 feet for typical and spring tides, respectively. The lagoon tidal range (predicted for the Intracoastal Waterway in Ocean Ridge) is between 2.5 feet and up to 4.0 feet for typical and spring tides, respectively. (Source: Tides and Currents Pro software version 2.5)

From the NOAA website (www.tidesandcurrents.noaa.gov) tidal datums at Boynton Beach based on:

LENGTH OF SERIES: 36 MONTHS
TIME PERIOD: November 1970 - October 1973
TIDAL EPOCH: 1983-2001
CONTROL TIDE STATION: 8723170 MIAMI BEACH (CITY PIER)

Elevations of tidal datums referred to Mean Lower Low Water (MLLW), in METERS:

HIGHEST OBSERVED WATER LEVEL (10/23/1973)	= 1.446
MEAN HIGHER HIGH WATER (MHHW)	= 0.849
MEAN HIGH WATER (MHW)	= 0.798
* NORTH AMERICAN VERTICAL DATUM-1988 (NAVD)= 0.703	
MEAN TIDE LEVEL (MTL)	= 0.422
MEAN SEA LEVEL (MSL)	= 0.410
MEAN LOW WATER (MLW)	= 0.045
MEAN LOWER LOW WATER (MLLW)	= 0.000
LOWEST OBSERVED WATER LEVEL (06/12/1970)	= -0.365

* Elevation does not meet the quality control standards of the NOS.
Therefore, caution should be used when using this elevation.
National Geodetic Vertical Datum (NGVD 29)

Tidal currents that pass through the inlet are based on hydraulic head differences between ocean and lagoon water surface elevations. ATM deployed an acoustic current meter (Nortek EZ-Q) for a period of nine days (August 28th to September 6th, 2007) to obtain time-series stage and current readings for use in calibrating a numerical flushing model. The meter was installed on an existing rail system located on the northern bulkhead approximately 150 feet west of the bridge and roughly 6 feet off of the bottom (Figure 5).

In general, tides are semi-diurnal in this area, yielding two highs and two lows in a 24-hour period. Recorded tides confirmed that there is a diurnal inequality for tidal flow through the inlet.

Tidal current measurements obtained during the course of this study revealed current velocities that ranged near zero feet per second (fps) to a peak of around 10.2 fps (Figure 10) on the outgoing (ebb) tide. Measured tide ranges were between 2.08 and 3.54 feet.

Additionally, the distribution of tidal currents across the inlet is not symmetrical. Due to the orientation of the channel and jetties, tidal currents are higher along the north side of the inlet channel. This exacerbates already difficult conditions and vessels tend to compensate for this by trying to navigate in the center of the channel during ingress and egress. This is not possible with two-way traffic through the inlet and passing vessels within the mouth of the inlet is an undesirable task for any boat captain.

Figure 9 – Instrument Location (Image from Google Earth)

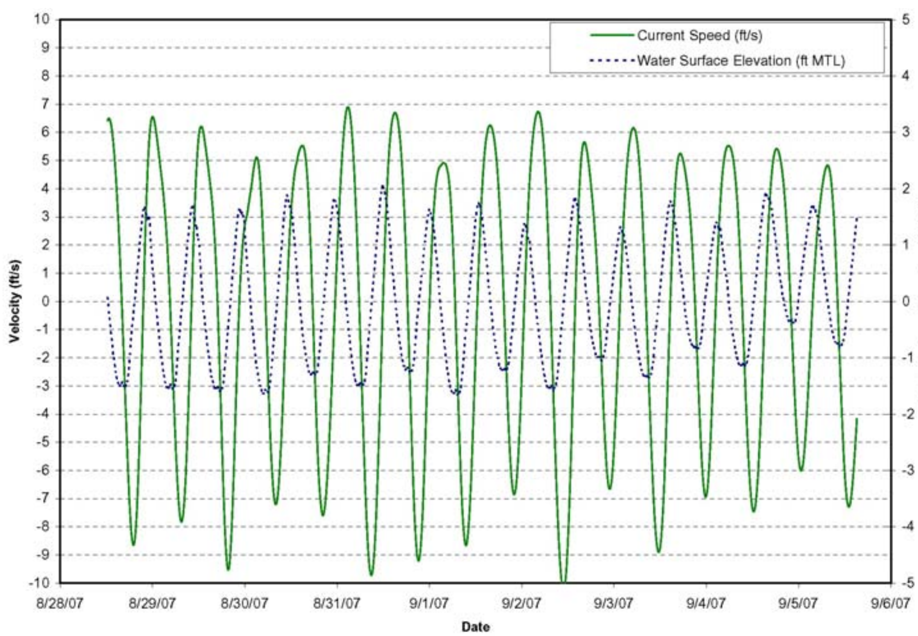


Figure 10 – Recorded WSEL and Tidal Currents (South Lake Worth Inlet)

3.2.2 Winds and Waves

The National Climatic Data Center (NCDC) maintains records of historic wind data. The West Palm Beach International Airport site was utilized for this study, and is in close proximity to Boynton Inlet. The geographical variability of long-term winds, is not likely to vary from the airport site to Boynton Inlet; thus, the long-term wind patterns observed at the airport station site are valid for the project site.

A ten year record of hourly wind data from 1996 through 2005 was analyzed to determine the long-term, prevailing conditions. Figure 11 presents a wind rose of the data. The wind speeds are 15 knots or less 83% of the time and are primarily from the east, which accounts for approximately 14% of the time. The overall mean wind speed for the period of the 10-year record is 7.9 knots.

Although the wind rose shown in Figure 11 does not show seasonal data, the wind conditions are known to vary by season. During the summer season, the winds are typically from the southeast. Based on the data, winds are from the east-southeast through the south-southeast a total of 23.7% of the time, the mean wind speed is approximately 9.6 knots. During the winter season, the winds are generally from the northeast though the east, and these winds occur 24.6% of the time. The mean winds speed for winds from the northeast through the east is approximately 10.3 knots.

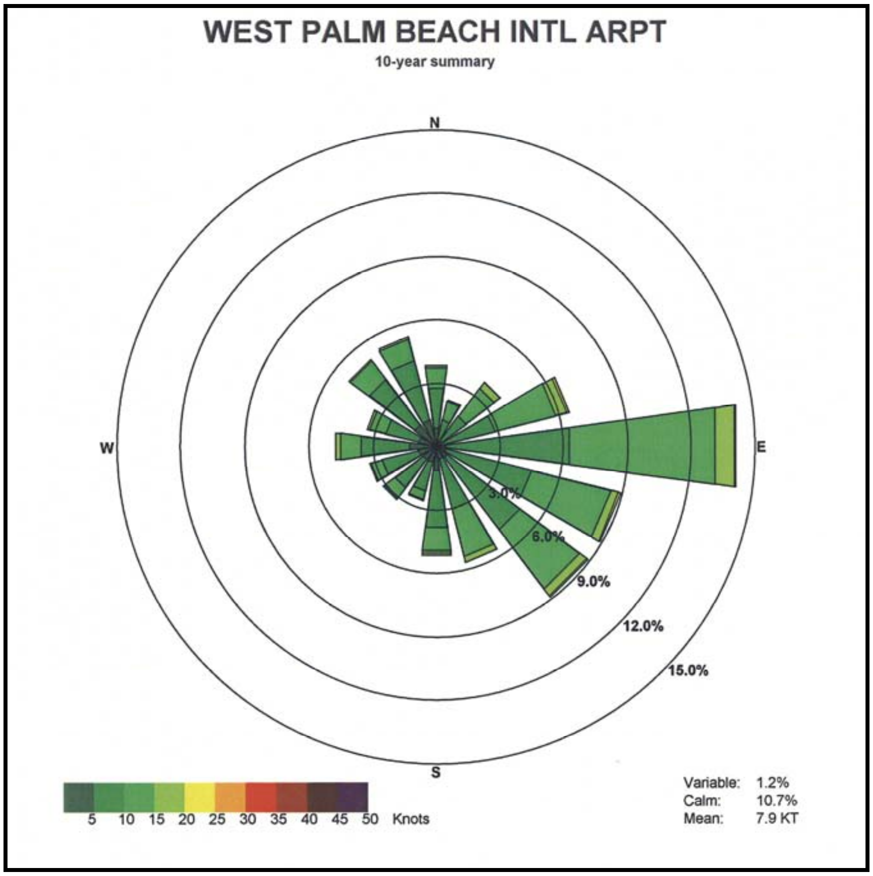


Figure 11 – Wind Rose for West Palm Beach (NCDC website)

The U.S. Army Corps of Engineers updates and published the Wave Information Study (WIS) database. This database is a comprehensive record of long-term wind and wave data, and data from WIS Station 462 (79.9167°W and 26.5°N) were used for this study. The station is located offshore of the project area at a depth of approximately 880 feet. WIS data are generated from using recorded winds to hindcast wave heights. The WIS data record from 1990 through 1999 was utilized to characterize the wave conditions in the nearshore water adjacent to Boynton Inlet.

The wave records are deepwater wave values, and because the water depths adjacent to the inlet are generally 20 to 60 feet, the WIS data were transformed to an appropriate depth. For this study, only shoreward propagating waves were analyzed, and a depth of 35 feet was selected as a suitable depth for the ocean in the vicinity of the inlet. Figures 12 and 13 present histograms of the wave data. The x-axis for each of the graphs is the meteorological wave direction, or the direction the wave is propagating from, and y-axes are the wave height (in feet) and wave period (in seconds). The bold-face numbers on the blocks in the histogram are the percentages of occurrence for waves within the given band. Based on the histogram for wave period (Figure 13), the wave period is generally 3.7 seconds from the NNE thorough SE directions, and occurs approximately 50% of the time. Approximately, 9.8% of the waves from the NE have a wave period of 4.5 seconds, which is significant when looking at waves from the other directions in the 4 to 5 second period range. This is consistent with on-site observations that NE waves typically have a slightly longer period than waves coming from the east or southeast, which is likely due to the sheltering effect of the Bahamas to the east and southeast directions.

There are swell conditions to note when examining Figure 13. When examining the wave data for the 56.3° to 78.8° degree band (ENE direction), approximately 6.4% of the waves have a period of 9 to 14 seconds. This is greater occurrence than waves from the ENE with periods of 5 to 9 seconds; thus, there are two sea states that commonly occur, waves with periods of 5 seconds or less (characterized as wind waves) and waves with periods of 9 to 14 seconds (characterized as swell). Similarly, looking at the wave periods for the 78.8° to 101.3° band (E direction), there are swell conditions with wave periods of 6.3 second and 11.8 seconds.

A histogram of the wave heights versus wave direction is shown in Figure 12. For the shoreward propagating waves, approximately 70% of the waves are 3 feet or less, and approximately 87% of the waves are 4 feet or less. The histogram shows that the wave heights are generally larger for waves propagating from the northeast. Waves from 33.8° through 78.8° (NE and ENE) 5 feet or less account for 42.3% of the record; whereas, waves 5 feet or less from 78.8° through 123.8° (E and ESE) account for 28.3% of the record.

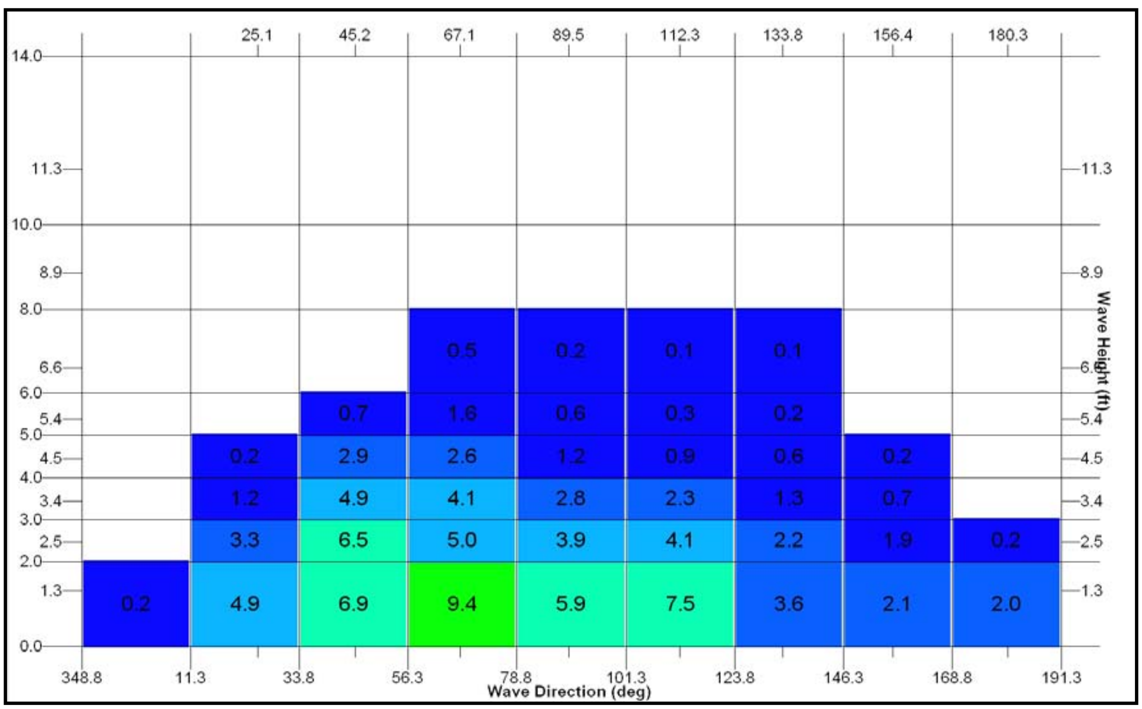


Figure 12 – Wave Occurrence (Direction versus Height)

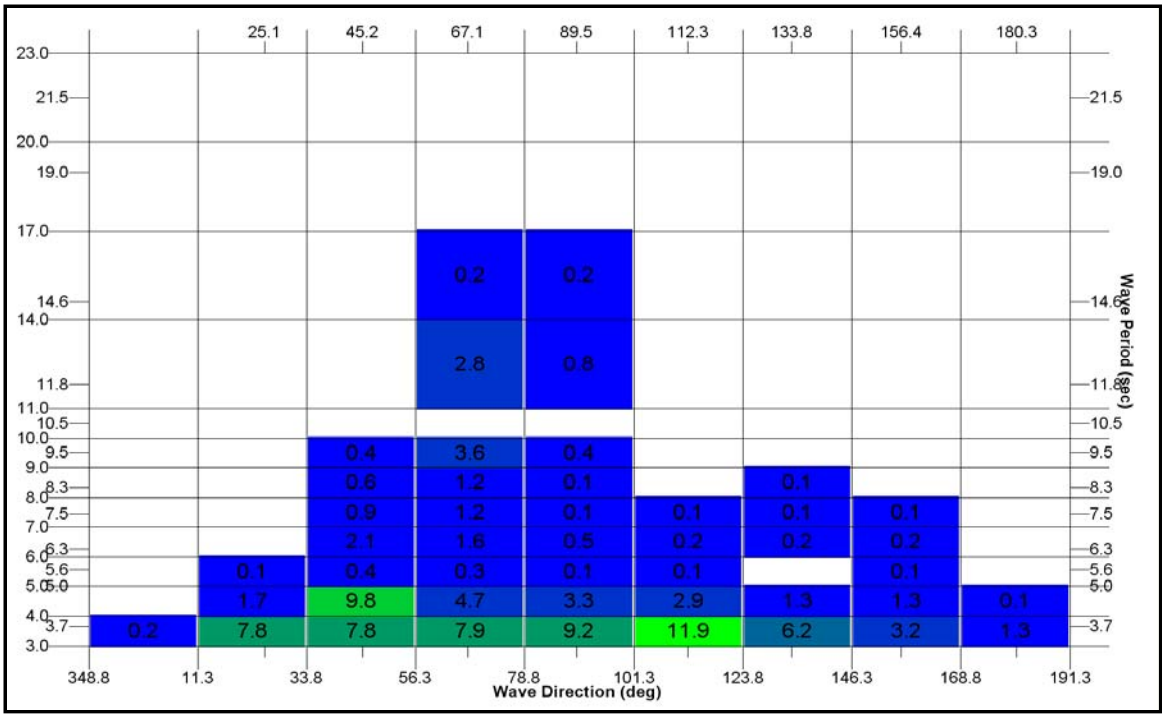


Figure 13 – Wave Occurrence (Direction versus Period)

3.2.3 Channel Dimensions

The total length of the inlet's constricted channel from its intersection with the ICW to the end of the north jetty is approximately 2,400 feet. As previously mentioned, the navigable channel width through South Lake Worth Inlet varies from 125 feet wide west of the S.R. A1A bridge to around 110 feet wide at the bridge, then down to less than 100 feet wide near the mouth of the inlet east of the bridge (refer back to Figure 3). The width of the eastern end of the channel is effectively reduced by a submerged rock ledge that was left after excavation along the south side of the inlet. The width of the ledge is around 15 feet and there is minimal water depth here.

From the South Lake Worth Engineering Alternative's Analysis produced by CP&E in July, 1998:

"The South Lake Worth Inlet contains two significant rock ledges that affect navigation seaward of the bridge. The first rock ledge is immediately seaward of the north and south jetty, has a typical elevation of -9 feet NGVD. The second rock ledge is along the south jetty and has an elevation of -5 to -6 ft NGVD. Both ledges contribute to spatially non-uniform flows which may contribute to the unsafe navigation conditions which exist at the inlet."

The County is currently is the permitting stages for additional inlet modifications, including installation of new sheetpile immediately seaward of the existing sheetpile walls on the north and south side, further reducing the effective channel width by several feet on each side.

Typical channel width design for two-way boat traffic for a straight channel requires at least five times the design vessel beam. For this discussion, it is assumed that the design vessel beam would be based on the largest vessel currently utilizing the inlet and not a projection of the future potential of the inlet if it were widened and the bridge restriction were lifted. The widest beam known to transit the inlet is approximately 22 feet – representative of either the *Lady K* or *Sea Mist III* head boats.

Navigation channels with bends, high currents, and peak traffic issues, such as those at South Lake Worth Inlet require additional width beyond the minimum five times design vessel beam requirement. The channel bend at the mouth of the inlet is roughly 35 degrees to the south. Currents through this section of the channel typically peak between 6-9 feet per second. These velocities are very high for a "navigable" waterway and create standing waves that can be greater than 2 ft in height. Adding a relatively high volume of boat traffic during peak holiday weekends, the recommended minimum channel width for the inlet's current configuration and use would be more than 150 feet – over 50 feet wider than it is now.

3.2.4 Ebb Shoal

Similar to most coastal inlets, the extent of the ebb shoal is expansive relative to the size of the inlet. At the South Lake Worth Inlet the ebb shoal formation is well-formed and nearly continuous, connecting from north to south across the inlet. It is a dynamic formation, constantly changing in response to tidal currents and wave forces. Sand is naturally bypassed along the full length of the ebb shoal formation both to the north and south, with a net southerly bypass rate estimated to be between 90,000 and 104,000 cy/yr (Olsen, 1990; CP&E, 2004).

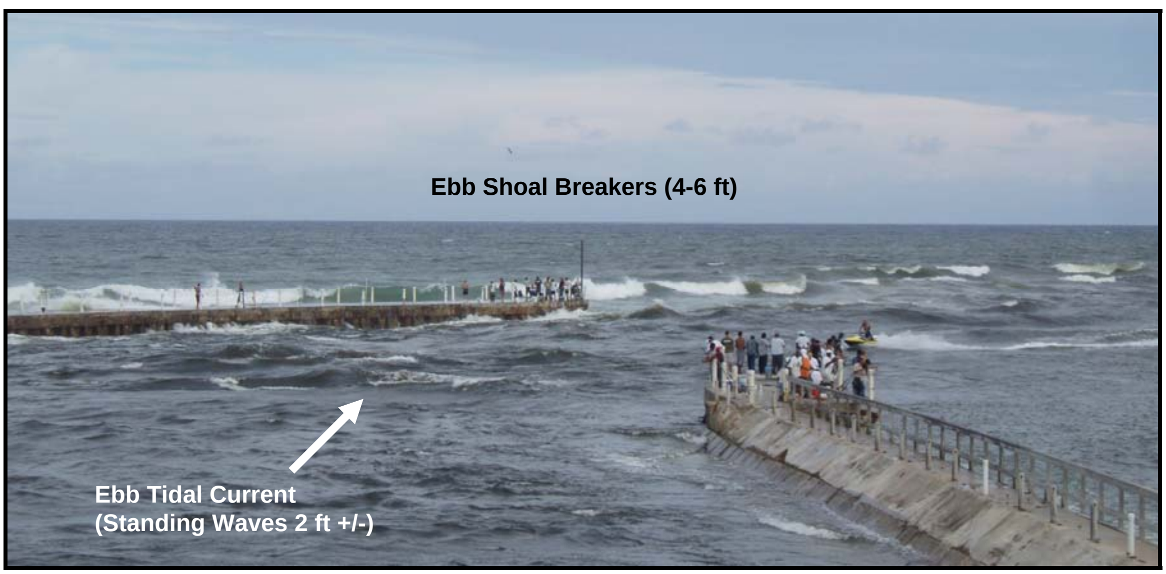
In a technical report submitted to the Palm Beach County Board of County Commissioners in 1990, Olsen Associates documented that the influence of the South Lake Worth Inlet extends from approximately 4,000 feet north to 2,500 feet south of the inlet cut (Olsen, 1990). The report estimated the holding capacity of the ebb shoal to be between 1.6M and 3.0M cy.

The ebb shoal outside of the South Lake Worth Inlet can be both a blessing and a curse for users of the inlet. The shoal formation naturally protects the shoreline from increased wave attack by knocking down incoming waves and shielding the shoreline from otherwise erosive forces. The breaking waves on the ebb shoal, however, present one of the most challenging and hazardous conditions for boating.

As evidenced in the photographs below, breaking waves on the ebb shoal bar are not conducive to safe navigation, especially to inexperienced boaters who are unaware of the sea conditions or do not know how to time ingress and egress between sets of breakers. The results have been numerous capsizing incidents, where boaters had to be rescued by lifeguards, PBC Marine Enforcement officers, FWC Marine Patrol units, and other responders.

The controlling depth of the ebb shoal bar varies temporally and spatially, but generally ranges from 4 to 8 feet deep. Larger vessels with deeper drafts will occasionally have to find the break in the ebb shoal bar, or time ingress and egress with the tides and waves to avoid bottoming out or running aground on the shoal. Referring to the general depths along the ebb shoal, Captain Alan Lebrun of the *Lady K* stated that he has to time the approaches depending on tides and waves, but there is always a way to get across the shoal (personal communication August 8, 2007).

Photograph Taken 5/9/07 – Ebb Shoal Breaking Waves / Incoming Tide / NE Swell



Photograph Taken 10/2/07 – Ebb Shoal Breaking Waves / Outgoing Tide / NE Swell

3.2.5 Line of Sight

Line of sight through South Lake Worth Inlet is restricted by both jetties. The elevation of the top of the north jetty is around +7 ft NGVD and with the extension angled to the south it effectively blocks the line of sight to the east for most small boats exiting the inlet. It is not until after clearing the south jetty and making the initial turn to the south that boaters begin to be able to visually assess conditions (i.e., presence of other boats in the area and sea state). Larger vessels with towers or flying bridges can see over the north jetty and have an advantage in being able to plan further ahead compared to smaller, lower vessels. Both fishing and diving charter boat captains (Capt. Alan Lebrun of the Lady K and Capt. Lynn Simmons of Splashdown Divers) say that they are able to wait in the pocket behind the north jetty and hold until they have good conditions to leave the inlet. Both vessels have elevated cockpits enabling them to see incoming wave sets and time their departure accordingly.

The line of sight will be further diminished in the future after completion of the County's plans for rehabilitation of the north jetty. The finished elevation of the jetty will increase from +7 ft NGVD to +9.5 ft NGVD. This increase should not affect larger vessels but would further reduce the visual range for smaller vessels whose operators are at deck level (typically near water level for most vessels).

3.2.6 Navigation Aides

South Lake Worth Inlet is not an official navigation channel by U.S. Coast Guard or any other standards. Typically, red and green lighted markers on top of floating buoys (cans) or mounted to fixed piles mark the navigable sections of a channel. Channel markers are important for keeping vessel traffic in safe corridors through shallow areas and are especially important at night where lighting allows boaters to remain within the channel limits without any other visual cues.

3.2.7 Boating Trends and Statistics

In 2006, Department of Motor Vehicle records indicated 28,892 registered, Class 1 - 5, recreational vessels in Palm Beach County. Growth in the popularity of recreational boating has occurred at a rate of approximately 3% per year between 2000 and 2006 (DMV). The largest contingency of vessels is between 16 and 26 feet (Class 1 vessels) with 21,674 or 75% of the total number of registered vessels. Reasons supporting the popularity of this vessel class include the generally mild weather conditions in the area, price range, and trailer-ability. A survey performed by FIND in 2006 found that (of those surveyed) 41% of all boats are stored at home on a trailer, 35% are at a private wet slip, and 23% are stored at a commercial facility.

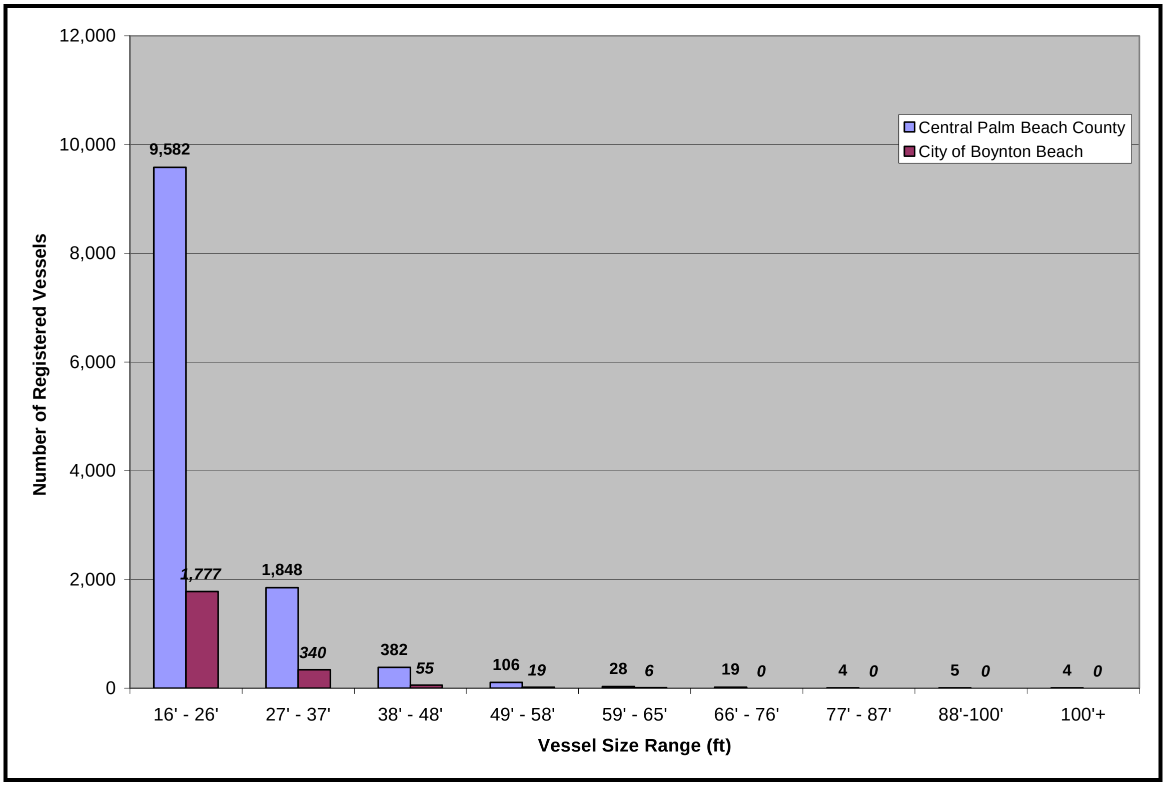


Figure 14 – 2006 Boat Registrations for Localities Surrounding South Lake Worth Inlet

Boat registration data from the Florida Department of Motor Vehicles (DMV) was collected and analyzed by zip codes (Figure 14). Registrations with zip codes from central Palm Beach County that would utilize South Lake Worth Inlet as a point of ingress and egress were tallied, along with a separate breakout of registrations from the City of Boynton Beach for reference. From the data, there are roughly 11,978 vessels registered in central Palm Beach County and 2,197 registered in the City of Boynton Beach. The largest vessel registered in central Palm Beach County is 117 feet long, while the largest registered in the City of Boynton Beach is only 65 feet long. These are privately-owned vessels and do not include commercial vessels such as the aforementioned charter vessels. It is felt that that most vessels under 50 feet can use the inlet, while vessels that are between 50 and 65 feet would be marginal and most vessels over 65 feet would not likely use the inlet. This is mostly due to the existing bridge height restriction.

Utilizing 2006 aerial photography and listings from other sources, ATM counted private and public boat slips along the ICW between the Linton Boulevard bridge crossing (south) up to the Southern Boulevard (north) crossing. Total private slips associated with single family homes and/or townhomes/condos were estimated to be around 2,475. Public marinas within this reach of the ICW offer roughly 320 wet slips and 475 dry racks for vessels. Private Yacht Clubs offered around 175 wet slips and 270 dry racks. Lastly, there were approximately 40 empty lots either with an existing dock or capable of berthing vessels. Appendix B provides a summary of those findings broken down between bridge spans from south to north.

Boat traffic through the inlet is a function of several factors: 1.) The total number of vessels that can reasonably access the inlet; 2.) Weather; and, 3.) Weekend and Holiday peaks. DMV registration data gathered for all recreational vessel classifications with zip codes around South Lake Worth Inlet indicated close to 12,000 registered vessels that potentially use South Lake Worth Inlet. This does not include commercial vessels using the inlet or vessels that are not registered in the State of Florida. It is estimated that of the 12,000 registered potential users, several hundred would have limited or no access through South Lake Worth Inlet due to the limited bridge clearance.

The generally mild weather conditions in South Florida support year-round boating. Calm summer months allow users relatively safe and easy ocean conditions, while winter weather patterns tend to limit the volume of ocean-going vessels. However, breaks in rough weather during the winter often result in peak usage, especially from recreational fishermen (stipulated to be the largest user classification for South Lake Worth Inlet).

Peaks in inlet use occur when good weather is coupled with holiday weekends such as Memorial Day, Independence Day, and Labor Day. While a boating traffic study was not a part of this scope, it is estimated that between 500 and 1,500 vessels utilize the inlet for ingress and egress during any given day, peaking at a rate of around 5 to 10 boats per minute. During busy (weekend, holiday) days, the majority of vessels tend to exit the inlet during morning hours and return during the afternoon hours resulting in vessel congestion around and through the inlet during those times. Studies performed by the University of Miami and highlighted in the PBC MPP indicate that most boat departures occur between 8 and 10am.

Recreational boating continues to grow in popularity, adding more vessels every year at a rate of around 3%. This growth rate is expected to hold into the near future, potentially adding in excess of 1,500 additional vessels to the total number that currently utilize the inlet over the next five years. A higher usage rate may be expected to yield a higher number of boating incidents.

The Florida Fish & Wildlife Conservation Commission (FWC) produces annual boating accident statistics for the state, broken down by County. Between 2005 and 2006, Palm Beach County was ranked second in the state for number of reportable incidents, second to Monroe County which covers all of the Florida Keys. Fifty-one accidents, leading to 29 injuries and 5 fatalities were reported for PBC in 2005 and 65 accidents, leading to 41 injuries and 1 fatality were reported in 2006. The portion of these associated with South Lake Worth Inlet could not be extracted as the commission does not store and catalog the reports in a manner that allows for this analysis.

Communications with officers from the PBC Marine Enforcement Unit (MEU) identified that the majority of boating incidents they respond to are related to vessels crossing the ebb shoal bar during adverse sea conditions. Breaking waves along the bar either caused by local weather patterns (wind-driven chop) or from swells generated well offshore (northeasters) can catch vessel operators off guard. Most problems occur when smaller vessels are unaware of sea conditions and attempt to cross the bar, only to stall or try to turn back. Loss of power and/or attempting to turn around in the area just outside of the inlet mouth has led to capsizing of vessels on numerous occasions. The officers did note that crossing the ebb shoal is not just an issue leaving the inlet, but also coming back into the inlet when timing, speed, and positioning relative to wave faces is important to vessel stability.

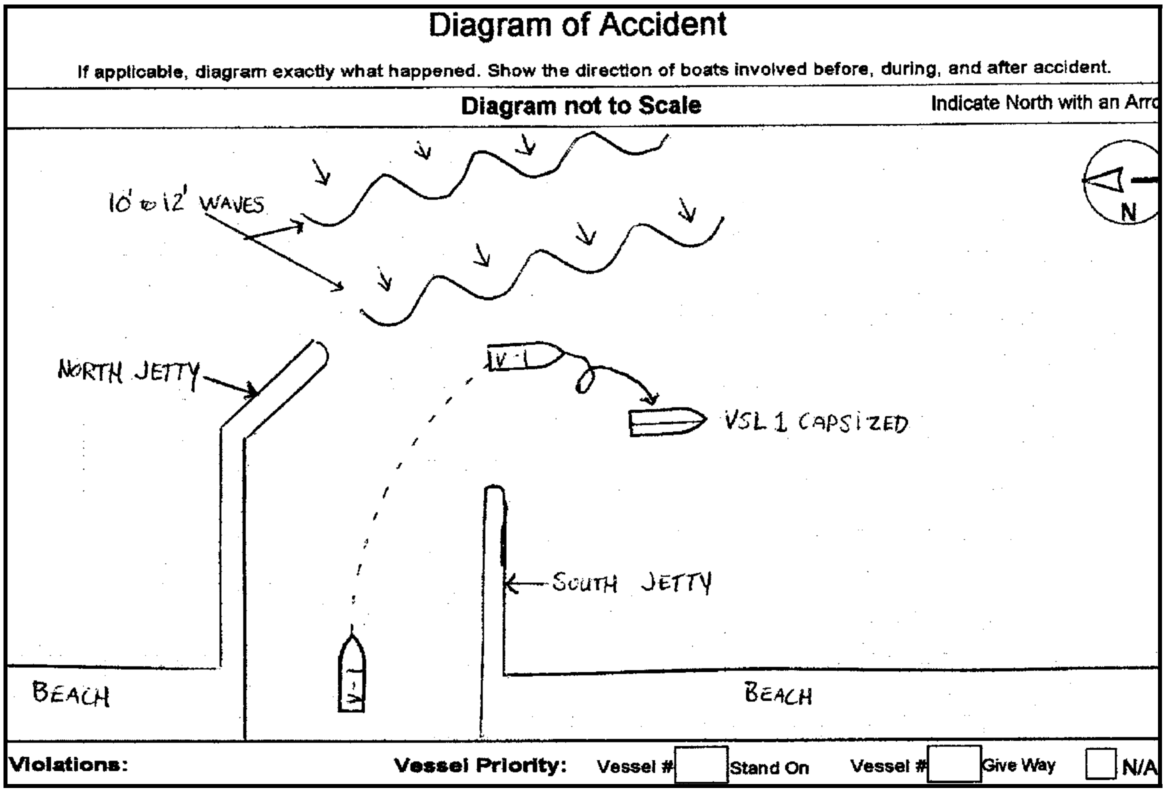


Figure 15 – Copy of Florida Boating Accident Investigation (Date of Incident 05/09/2007)

Boating incidents reported by the Sheriff's MEU are recorded and kept on file at the County's central records office. Figure 15 above is taken directly from an accident report filled out by the Palm Beach County Marine Enforcement Unit as one example of incidents related to adverse conditions at the inlet. In the case above, a 20-ft open fisherman attempted to leave the inlet when wave conditions were 10 to 12 feet – conditions exceeding a small craft advisory. After exiting and attempting to turn south, the vessel was broadsided, capsized and the occupants were ejected into the water.

Reports written and filed by PBC Sheriff's over the past three years (2004 – 2007) confirm at least 8 boating incidents directly related to the inlet. A number of records were destroyed and it could be assumed that several of those were boating incident reports related to South Lake Worth Inlet.

An article published in the *Sun-Sentinel*, on May 2, 2007 entitled *"Danger on Our Waters"* stated that "Boynton Beach Inlet logged about 21 accidents" between 2002 and 2006. During that same time period, Hillsborough Inlet logged about 36 incidents. The source of these statistics was confirmed through the author of the article (Leon Fooksman) to come from the State's Fish and Wildlife Commission.

The County's Ocean Rescue South District was contacted and provided the following statistics for the inlet:

Table 1 – Ocean Rescue Statistics for South Lake Worth Inlet

Year	Total Attendance	Boat Rescues	Boat Rescues (Passengers)	Boat Assists	Boat Assists (Passengers)
2004	242,201	1	3	9	15
2005	207,285	3	6	13	10
2006	216,296	2	6	12	20
2007*	150,817	5	8	5	6

* - Stats from January - July

As can be seen from the table, 2007 is shaping up to be one of the "busier" years for county lifeguards at the inlet. There is no clear pattern to the numbers, however it is obvious that they are significant and a reason for concern.

Further inquiries and communications with local lifeguards confirmed that the majority of boating incidents occur on the ebb shoal bar. There were also concerns voiced about people who climb down to the lower ledge within the inlet and end up being swept off the ledge and into or out of the inlet. This highlights a separate (non-boating) issue as the current handrail system is not safe and does not deter people from gaining access to this dangerous area.

4.0 Secondary Issues Related to Inlet Management

4.1 Sediment Transport and Beach Management

Natural and man-made inlets are barriers to sediment transport and have been the source of significant controversy and engineering management studies. The South Lake Worth Inlet has been studied over the years resulting in multiple inlet and sand management programs. The following summarizes the most important aspects of those studies when considering modifications to the inlet.

4.1.1 Palm Beach County Inlet and Beach Management Programs

Beginning in the late 1960's, the County procured coastal engineering consultants such as Olsen Associates and Coastal Planning & Engineering to evaluate South Lake Worth Inlet and develop management programs focused on ways to effectively bypass sand and alleviate downdrift shoreline losses.

Olsen Associates first established estimates of the inlet's sediment budget in 1990. Coastal Planning & Engineering updated the inlet's sediment budget in 2004 as reflected in Figure 16. The following table summarizes key littoral budget estimates from the CP&E report.

Table 2 – South Lake Worth Inlet Sediment Budget

Component Number/Name	1997 – 2002 Rate (cy/yr)
Q1 S. Net Drift @ R146	200,000
Q2 Updrift Beach	11,000
Q3 Ebb Shoal Volume	19,000
Q4 Flood Shoal Volume	6,900
Q5 Natural Bypassing	104,000
Q6 Mechanical Bypassing	60,000
Q10 Offshore Dredging (Nourishment)	164,000
Q13 S. Net Drift @ R159	222,000

(Source: CP&E, 2004)

From north to south, a net of approximately 200,000 cy/yr of sand is transported into the inlet's sphere of influence. Approximately 11,000 cy/yr is stored by the updrift (northern) shoreline, 19,000 cy/yr is stored in the ebb shoal, 6,900 cy/yr is stored in the flood shoal, 104,000 cy/yr is naturally bypassed along the ebb shoal to the southern shoreline, and 60,000 cy/yr is

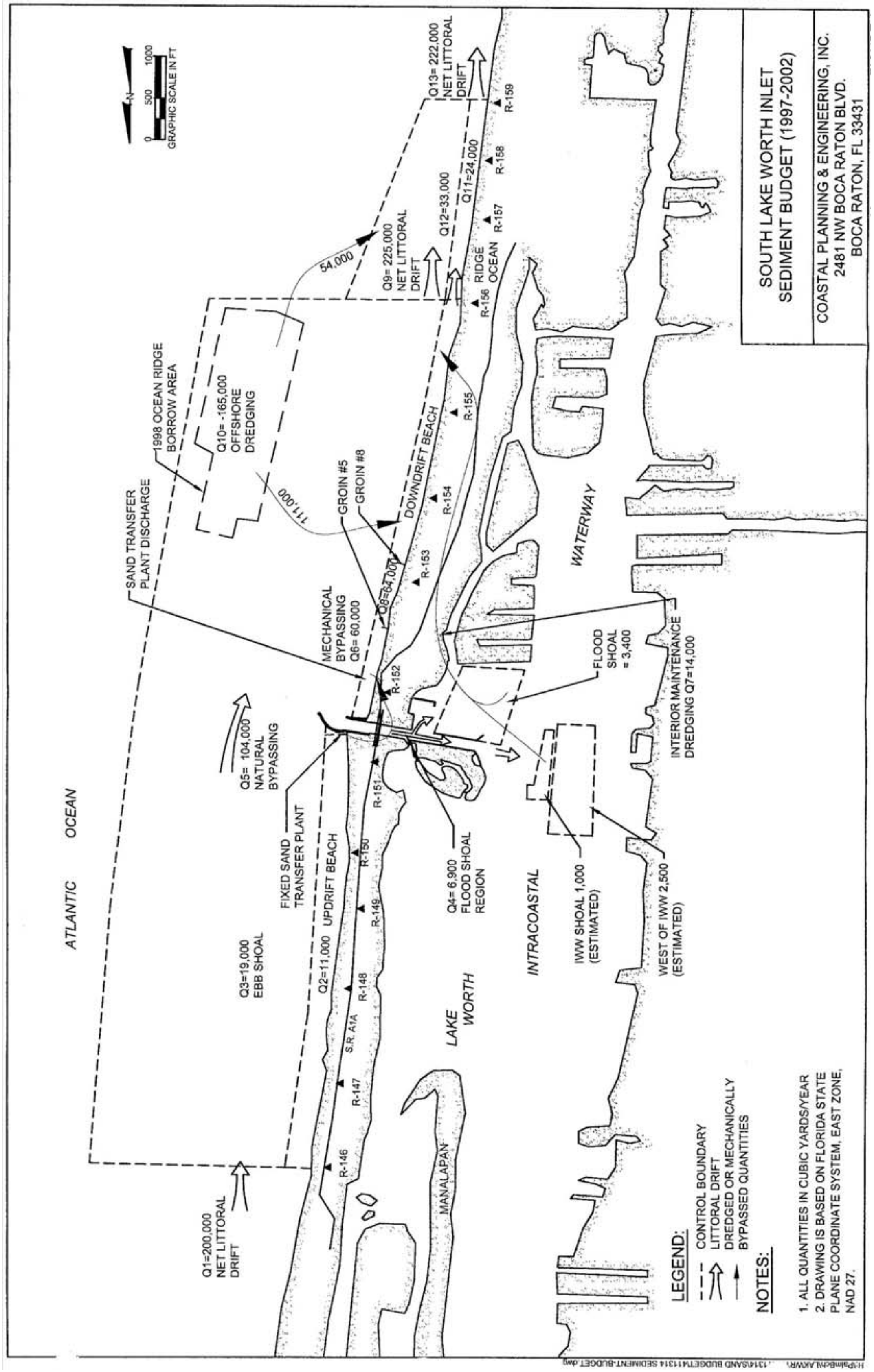


Figure 16 – South Lake Worth Sediment Budget (CP&E, 2004)

mechanically bypassed to the southern shoreline (balanced sediment equation: Q1–(Q2+Q3+Q4+Q5) ≈ 0).

On average, periodic dredging of the offshore borrow area and the interior maintenance area results in an additional 179,000 cy/yr of material placed along the shoreline south of the inlet. Nourishment does not occur on an annual basis, rather typical nourishment cycles occur once every five to ten years. According to the CP&E study, approximately 783,000 cy of material was removed from the offshore borrow area in 1998 along with 41,640 cy of material and an additional 9,000 cy of rock (to deepen the trap) from the interior sand trap in 2002.

4.1.2 Interruption of Littoral Processes and Potential Changes to Ebb and Flood Shoals

Inlets are barriers to longshore sediment transport resulting in shoreline and shoal patterns that require monitoring and special management considerations. Inlet tidal shoals are dynamic features, always changing in response to the naturally varying environmental conditions and anthropogenic influences. Daily ebb and flood tidal currents, cyclical changes in peak tidal fluctuations, seasonal variations in weather patterns, unpredictable extreme weather events, etc. are the most significant natural forces that shape and reshape inlet shoals. Significant artificial / anthropogenic sources of inlet shoal changes include structural influences, mechanical bypassing, and other maintenance dredging events. Effective beach management practices attempt to avoid and/or compensate for artificially-induced changes to sediment transport patterns.

Changes to an inlet can result in substantial changes to a shoreline system, the most extreme responses leading to “sand starvation” of downdrift beaches and shoreline erosion. One important aspect of this study is to evaluate the impact of any proposed inlet modification on beach management requirements. Based on studies of inlets in the Gulf, Pacific and Atlantic, stability curves relating inlet cross-sectional area to ebb-tidal delta (shoal) area have been developed by the Corps of Engineers. Figure 17 below represents the finding of the studies as a graph that can be used to estimate ebb shoal growth induced by a change in the inlet cross section.

Example: A threefold increase in the inlet cross-sectional area from 1,000 to 3,000 square feet (similar to a 200-ft widening of South Lake Worth Inlet) can increase the area of the ebb-tidal shoal by more than three times.

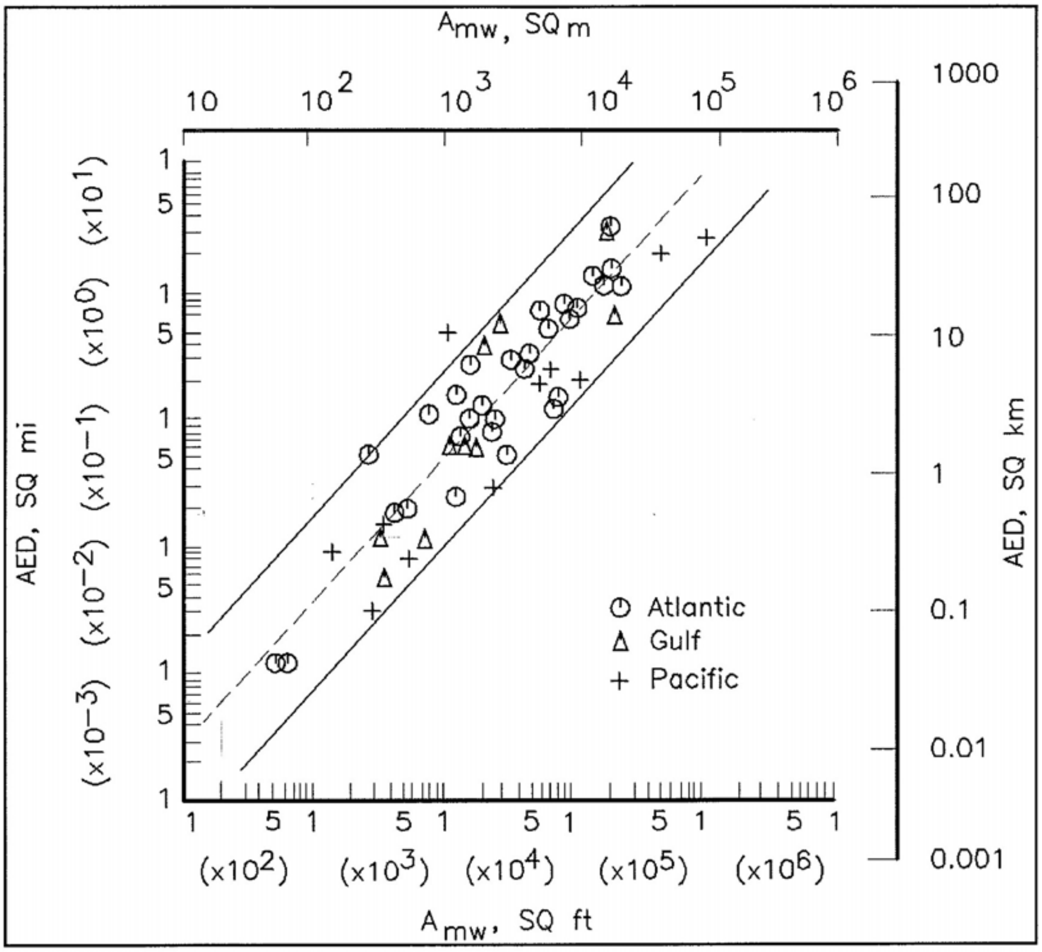


Figure 17 – A_{mw} versus ebb-tidal delta area (AED) (Vincent and Corson 1980)

According to the 1990 Inlet Sand Management Plan by Olsen Associates, the ebb shoal volume is estimated to be between 1.6M and 3.0M cy. If the ebb shoal were to grow three times in size, the holding capacity could conceivably grow to more than 9.0M cy. This estimate represents a significant reduction or deficit to the existing sediment budget and does not include growth of the flood shoal which would also occur to a lesser degree. Obvious concerns stemming from the growth of the ebb and flood tidal shoals are the loss of sediment to the downdrift beaches that would otherwise have bypassed naturally.

The growth of the ebb tidal shoal resulting from a change in the inlet cross sectional area and tidal prism would occur over a period of years. According to the South Lake Worth Inlet Management Program Update (CP&E, 2004) it is estimated that the natural bypass rate of the ebb shoal is on the order of 104,000 cy per year. At this rate it would take over 50 years for the ebb shoal to reach an equilibrium capacity of 9,000,000 cy, (growing 6M cy larger from 3M to 9M cy) during which time steady recession of the beaches south of the inlet would occur without improvements to mechanical bypassing, periodic dredging of the sand trap and shoals, and/or dedicated beach nourishment.

4.2 Maintenance Dredging

Currently a "scheduled" maintenance dredging program for the channel, sand trap, ebb and flood shoals does not exist. Periodic dredging of the sand trap has been performed under contract by the County to help bypass additional sand to the south. This has typically occurred every 6 or 7 years bypassing on the order of 40,000 to 50,000 cy of sand per event.

Maintenance dredging of the access channel to the Boynton Beach Boat Club launch typically occurs in concert with excavation of the sand trap or when the navigable water depths become problematic, averaging one to two thousand cubic yards once every 6 or 7 years according to the County. The access channel dimensions are 940 ft long by 30 ft wide.

Since the extension of the north jetty, the ebb shoal has not been dredged for navigation or beach nourishment. There are no plans for maintenance dredging of the ebb shoal bar.

4.3 Inlet Closures and Water-Based Businesses

As highlighted in several workshop survey forms, local business owners are concerned about the amount of time that the inlet would be restricted or closed to navigation. The additional travel time and distance to use either Boca Inlet or Lake Worth Inlet cannot be afforded by most charter businesses and the loss of business to other restaurants, marinas, etc. would have an economic effect locally. For this reason, the length of time that the inlet would be restricted or closed becomes an important stakeholder ranking criteria. Later in this study, estimates of construction time and the degree of inlet closure for each alternative will be discussed.

4.4 Public Access

Public access, especially public access to waterfront areas (beaches, ICW, fishing piers, etc.), has become a sensitive topic. Palm Beach County has recently undertaken efforts to secure waterfront property for public access through grants and the issuance of bonds to secure/improve county property, public water access, and assist public boating facilities. Ocean Inlet Park is an important and valuable piece of "public" property given its location and amount of ocean and Intracoastal Waterway frontage. Additionally, it is one of the few ocean access points in Palm Beach County with free parking for over 200 cars.

A variety of users frequent Ocean Inlet Park, including fishermen who often crowd the north and south jetties, beach goers, marina tenants, park users (picnic areas, playgrounds, etc.), surfers, etc. The Palm Beach County Sheriff's Marine Enforcement Unit has an office on the park grounds and retains three slips for their water operations. County Lifeguards also keep an inflatable and a jet ski within the marina for ocean rescues. Conflict between user groups sometimes occurs, more often between jetty fishermen and recreational vessels trying to catch bait near the mouth of the inlet.

Other nearby public access points are maintained by the County and the City of Boynton Beach. The County does offer additional public access points to the beach through Ocean Hammock Park with approximately 24 parking spaces on the west side of S.R. A1A

The City of Boynton Beach owns and operates the Oceanfront Park just over a mile south of the inlet. Oceanfront Park is a paid parking facility with 255 parking spaces, over 1,100 feet of ocean shoreline, restrooms, showers, picnic and play areas. Additionally, in an effort to bolster waterfront activity and entertainment, the Boynton Beach CRA is beginning to focus on improving the old Two Georges Marina, recently renamed "Boynton Harbor Marina"

4.5 Boating Industry and Economics

According to marine industry studies, the 2006 economic impact of the waterways in Palm Beach County consists of $1.9B in business volume, $688M in personal income and 16,505 jobs (FIND, 2006). This was an increase of more than $1.1B in business volume, $412M in personal income, and over 9,000 jobs from 1999. The same studies indicate that if the waterways were not maintained there would be significant economic losses to the region.

Additional marine industry economic estimates from the Marine Industry Association website (http://www.marinepbc.org/pages/impact.htm) are as follows:

"A recent study by MIAPBC indicated that the marine industry has an annual direct economic impact of $1.35 billion in Palm Beach County, a 112% increase since 1999, when a similar study was performed.

There are 110 acres of marinas and boatyards in Palm Beach County with a combined appraised value of $48 million. The 2,794 boat slips in Palm Beach County have a total appraised value of $87 million.

The $1.35 billion direct annual income is generated by:

- *$2.1 billion in gross business volume*
- *$751 billion in personal income*
- *19,928 jobs*
- *$436 million in boat slips*

The current market value of a boat slip in Palm Beach County is $94,235, an increase of 204% from the 1999 study. Applying this average to the 4,633 boat slips in Palm Beach County results in an overall total of $436 million in boat slips in the county. Marinas and boatyards equal a combined appraised value of $78.4 million in Palm Beach County.

Other marine related business sectors include:

Service Activities	*$487.1 million*
Retail Trade	*$269.0 million*
Wholesale Trade	*$266.2 million*
Manufacturing	*$154.8 million*
Used Boat Sales	*$117.2 million*
Construction	*$55.0 million*
Finance Activities	*$4.1 million*
Transportation	*$1.8 million*

It was beyond the scope of this work to model or study the economic impacts of the South Lake Worth Inlet. While not specifically studied, a significant portion of this industry relies on access to the open ocean through each of the four inlets in the County (Jupiter Inlet, Lake Worth Inlet, South Lake Worth Inlet and Boca Inlet). The South Lake Worth Inlet provides ocean access to nearly 16 miles of more than 46 miles of Intracoastal Waterway (ICW) running through the County. While not exactly a linear extraction, mostly due to the limited clearance of the bridge crossing South Lake Worth Inlet, this stretch of the ICW represents more than 33% of its total length in the County. One-third of the annual marine industry economic contribution would be

$633M in business volume alone. While this oversimplifies the complex nature and distribution of marine-related businesses and economics, the discussion is only intended to begin to understand the magnitude of economic influence that an inlet such as the South Lake Worth Inlet can have on a region.

A second economic element related to the performance of the inlet is land value and real estate tax revenues collected by the County. While there is no fixed formula for computing a return on inlet investment, it can be stipulated that an improved inlet, especially one that would allow for safer passage of more (and larger) vessels would tend to increase property values. A privately-owned piece of property with deepwater access that can berth a large vessel is more valuable than a similarly sized property with limited access, hence would generate a higher tax base.

More focused and detailed studies would be required to ascertain the true economic influence that South Lake Worth Inlet has on the local economy. It is stipulated that the results would be in the hundreds of millions in business volume, plus additional economic drivers, including real estate values/property taxes and economic spinoffs (dollars staying in the communities).

4.6 Storm Surge and Flooding

Coastal communities in South Florida have contended with hurricanes for many years. In addition to damage caused by high winds and waves, storm surge and flooding are highly problematic along low-lying coastal areas. Sustained winds and waves act to force water onto the shoreline through inlets and into backbay areas, holding above-average water surface elevations for the period of time until winds and seas die down allowing for piled up water to recede.

Federal (FEMA) flood insurance requirements establish limits on wave propagation (V-Zones) and base flood elevations. Properties within designated flood prone areas must either pay for additional flood insurance, or exceed elevation requirements shown on Flood Insurance Rate Maps (FIRMs).

Storm surge elevations within backbay areas, such as the Lake Worth Lagoon are highly influenced by the geometry of the inlets. Smaller inlets such as the South Lake Worth Lagoon do not allow as much water to enter the lagoon as other inlets. A significant change in the cross-sectional area of the inlet may increase the storm surge potential and flood elevations of the lagoon. Such a change would have far-reaching effects on property insurance and would require further investigation to be conclusive.

4.7 Bridge Clearance and Maintenance

Based on phone interviews with the Florida Department of Transportation and the contractor currently responsible for the S.R. A1A bridge crossing South Lake Worth Inlet there are no current plans to rehabilitate, remove or replace the bridge. The current limitation on bridge clearance will remain an issue unless the bridge is either remove or replaced. Anticipated costs for removal and replacement of the bridge are discussed later in this report. Maintenance costs, especially for a drawbridge would be considerable and would have to be weighed against other factors such as navigation safety and possible economic benefits associated with allowing larger vessels access through the inlet.

4.8 Emergency Evacuation

Currently, State Road A1A serves as an evacuation route for the Towns of Manalapan and Ocean Ridge. Modifications to the inlet will have to consider impacts to evacuation routes and public safety.

5.0 Inlet Hydrodynamics and Lake Worth Lagoon Flushing

The Environmental Fluid Dynamics Code (EFDC) model was used to evaluate inlet hydrodynamics and estuary circulation. EFDC is a general purpose modeling package for simulating three-dimensional flow, transport and biogeochemical process in surface water systems including: rivers, lakes, estuaries, reservoirs, wetlands and near shore to shelf scale coastal regions. The EFDC model was originally developed at the Virginia Institute of Marine Science for estuarine and coastal applications and is considered public domain software. For a complete description of the model and complete summary of data input and results, please refer to Appendix C.

For this study a total of five alternatives or scenarios reflecting various levels of inlet modification were modeled. Table 3 below briefly describes each of the modeled alternatives and Section 7 of this report provides additional detail on each alternative. It should be noted that only those alternatives that would result in a change to the hydraulics of the inlet were examined. Other alternatives, such as just shifting the jetties, would not substantially change the potential rate of water exchange through the inlet (the primary factor affecting the exchange is the inlet cross-section between the vertical bulkheads in the inlet's throat).

Table 3– Simulated Alternatives

Alternative	Description
1	Existing configuration with channel excavation to -15 ft NGVD
2	Existing configuration with channel excavation to -20 ft NGVD.
3	150-ft wide channel (add 50' to existing) with bottom @ -20 ft NGVD
4	300-ft wide channel (adds 200' to existing) with bottom @ -10 ft NGVD.
5	300-ft wide channel (adds 200' to existing) with bottom @ -20 ft NGVD.

Key results from the modeling are summarized in the following sections and tables.

5.1 Simulated Currents

The peak simulated current velocities are shown in Table 4. The alternatives show decreasing velocities with increasing inlet cross-sectional area, as shown in Figure 18.

All of the alternatives would provide an inlet with a stable cross-section. Typically, if inlet currents are too high, they will scour sediments and enlarge the inlet cross-section, and if currents are too low, sediments will deposit in the inlet throat and reduce the inlet cross-section. However, unlike inlets cut through sediments, South Lake Worth Inlet is cut through rock, and high velocities will not cut the inlet gorge deeper or wider. In regard to the minimum desired velocity, a peak velocity of 1.1 m/s is considered sufficient to maintain an inlet cross-section and avoid deposition of sediments in the inlet. Alternative 5 shows the smallest velocities at 1.2 m/s (i.e., the most desirable from a navigation safety perspective), but these velocities are still sufficient to scour sediments from the inlet throat.

Inlet stability should also consider the impact of sand deposited in the inlet from a storm event on the currents. For some inlets, a reduction in inlet cross-section will result in a decrease in inlet currents. If an event sufficiently reduces the inlet cross-section, and the resulting currents are too low, this can potentially lead to instability with the gradual reduction in cross-section leading to further reduced currents until the inlet closes. As shown in Figure 18, if any of the alternative inlet configurations is constructed, a subsequent reduction in the inlet cross-section will cause the current velocities to increase. This means that if any of the alternatives were constructed, and then a storm event deposits a volume of sand in the inlet throat (reducing the cross-sectional area to as small as that for the existing conditions), the current velocities will increase, scouring the sand from the inlet throat. It should be noted that cross-sections smaller than the existing conditions were not evaluated. At some point, a reduction in cross-section in area will lead to a reduction in velocity (near the left end of the x-axis in Figure 18).

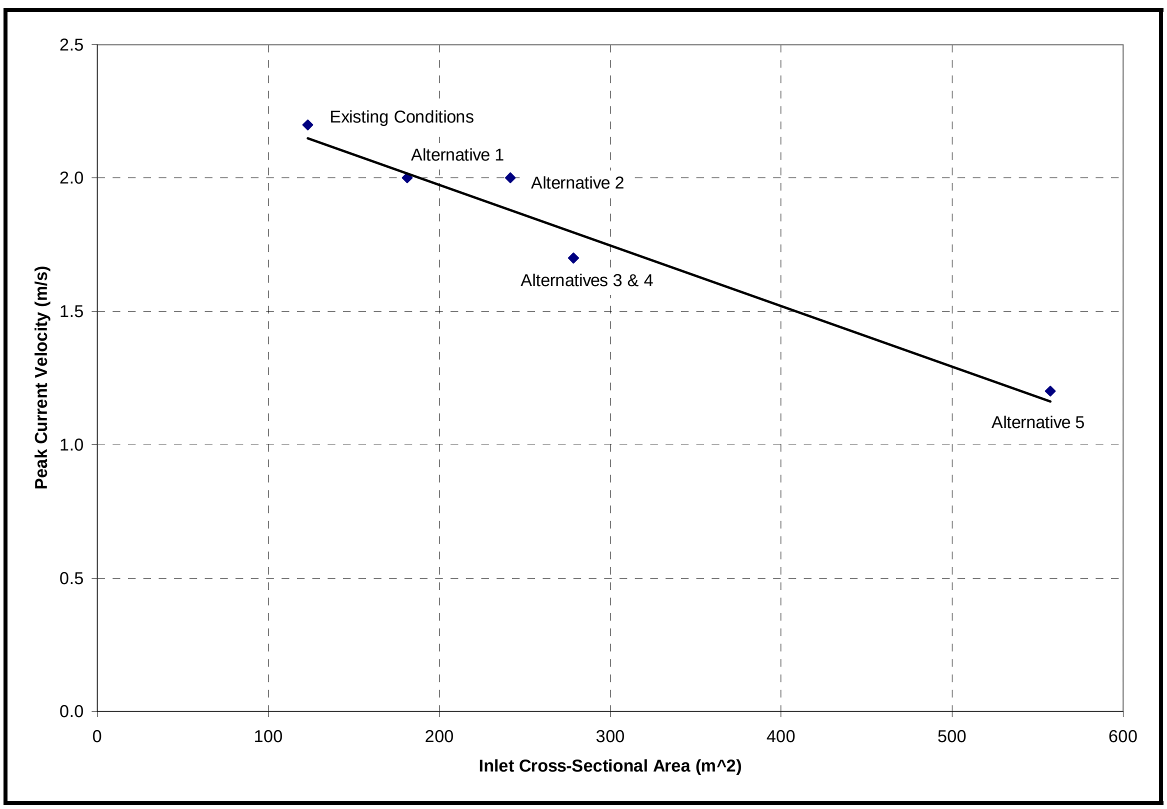


Figure 18 – Tidal Current Velocity Versus Inlet Cross-Sectional Area

Table 4 – Simulated Current Velocities

Scenario	Ebb Current (m/s)	Flood Current (m/s)	Ebb Current Change (%)	Flood Current Change (%)
Existing	2.1	2.2	-	-
Alternative 1	1.9	2.0	-10%	-9%
Alternative 2	1.8	2.0	-14%	-9%
Alternative 3	1.7	1.7	-19%	-23%
Alternative 4	1.5	1.7	-29%	-23%
Alternative 5	1.0	1.2	-52%	-45%

5.2 Simulated Tidal Prisms

The simulated tidal prisms are summarized in Table 5. The tidal prism is the volume flux of water through the inlet on each incoming or outgoing tide. For this study, the tidal prisms were averaged over a 9 day simulation period (the same simulation period used for the model calibration). The results indicate that the alternatives will increase the tidal prism passing through the inlet, with Alternative 5 causing the greatest increase (133% for the flood tide prism).

Table 5 – Simulated Tidal Prisms

Scenario	Ebb Tidal Prism (m^3)	Flood Tidal Prism (m^3)	Ebb Tidal Prism Change (%)	Flood Tidal Prism Change (%)
Existing	4.0E+06	-3.6E+06	-	-
Alternative 1	5.4E+06	-4.8E+06	37%	34%
Alternative 2	6.6E+06	-5.9E+06	66%	64%
Alternative 3	7.6E+06	-6.9E+06	92%	93%
Alternative 4	7.1E+06	-6.6E+06	80%	84%
Alternative 5	8.9E+06	-8.4E+06	126%	133%

5.3 Simulated Water Exchange Rates

Two changes can improve the water quality in the estuary: (1) reduction of the pollution load entering the estuary, and (2) reduction of pollutant concentrations in the estuary by increasing the exchange of estuary waters with the ocean. This study evaluates the potential increased exchange rate that would result from the proposed inlet modifications.

The exchange rate was evaluated by simulating the transport of a tracer dye initially placed throughout the region behind the inlet (Refer to Appendix C, Figure 5-11). This region extends from the Lantana Bridge (north of the inlet) to the Little Club golf course (south of the inlet). The hydrodynamic model was used to simulate the transport of this tracer over time, and the percentage of the initial tracer mass remaining within the initial placement area was calculated after four days simulation time. It should be noted that these simulations were for the same period as the calibration, and therefore it represents tidal exchange rates during spring tide conditions. The exchange rates are lower during neap tide conditions.

For the existing inlet configuration, the simulated dye distributions after 1 day and after 4 days are shown in Figures 5-12 and 5-13 of Appendix C. At present, the estuary behind the inlet flushes relatively slowly, with 52 percent of the water exchanged after 4 days.

The tracer dye distribution after 4 days is shown for the five alternatives in Figures 5-14 through 5-18 of Appendix C. The simulated exchange rates are tabulated in Table 6. The results show that the alternatives would increase the exchange rate significantly. Alternatives 2, 3 and 5 would all increase the percent exchange after 4 days to 70% or more. These rates represent a 21 to 35 percent increase in the exchange rate, as compared to the existing conditions. This increase in exchange rate will dilute pollutants in the estuary in the vicinity of the inlet. Given that the estuary is moderately polluted from watershed pollution sources, and Canal C-16 is an impaired waterbody, the increase exchange and dilution of the pollutants will result in improvements to the estuary water quality. However, quantification of the impact on any particular variable of concern (e.g., dissolved oxygen, nitrogen, etc.) would require a detailed water quality model that includes estimates of pollution loading from the water shed and simulation of water quality kinetics in the estuary.

Table 6 – Simulated Exchange Rates

Scenario	Percent Initial Mass Remaining after 10 days	Percent Exchanged
Existing	48%	52%
Alternative 1	37%	63%
Alternative 2	29%	71%
Alternative 3	27%	73%
Alternative 4	37%	63%
Alternative 5	30%	70%

5.4 Simulated Tide Levels

The simulated tides near the shoreline immediately west of the inlet are shown in Figure 19. The spring tide ranges are summarized in Table 7. The results indicate that the inlet alternatives will allow a greater tidal range in the estuary. Alternative 5 has the greatest impact, with the high spring tide reaching 3 cm (~0.1 ft) above the existing high tides. The more pronounced effect is that low tide extends 9 cm (~0.3 ft) lower for Alternative 5 than the existing conditions. The results of this analysis show that the inlet impacts to the tide range in the estuary are relatively small, but they are not insignificant. If the results showed that the changes were insignificant, then one could reasonably assume that the potential impacts to storm surge levels in the estuary would also be insignificant. Based on this analysis, conclusions regarding potential impacts to storm surge levels cannot be drawn. There is a potential that enlargement of the inlet may have some impact on coastal storm surge levels, and further detailed storm surge studies may be required by FEMA prior to inlet construction of a project that enlarges the inlet.

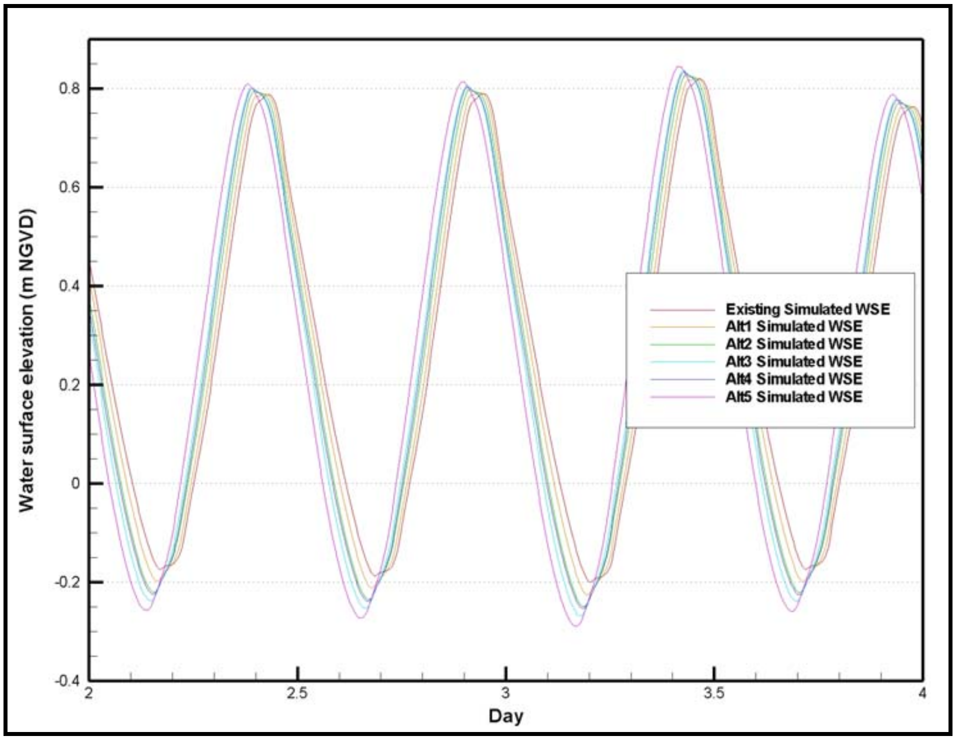


Figure 19 – Simulated Tides

Table 7 – Simulated Spring Tide Levels

Scenario	High Tide (m NGVD)	Low Tide (m NGVD)	Range (m)	Change in Range (%)
Existing	0.82	-0.20	1.02	-
Alternative 1	0.82	-0.23	1.05	3%
Alternative 2	0.83	-0.25	1.08	6%
Alternative 3	0.84	-0.27	1.11	9%
Alternative 4	0.83	-0.25	1.09	7%
Alternative 5	0.84	-0.29	1.13	12%

6.0 "Operational" Wave Modeling

For this wave study, the Bouss-2D wave model was selected, a local-scale wave model based on the Boussinesq equations for wave propagation. The Bouss-2D model is capable of modeling wave refraction, shoaling, diffraction, reflection and breaking, as well as incorporating wave-current interaction and non-linear waves. Given the scale, geometry and the magnitude of the tidal flows at South Lake Worth Inlet, the Bouss-2D model is the most appropriate wave model for this study. For a complete description of the model and complete summary of data input and results, please refer to Appendix C.

Several alternative inlet configurations were evaluated by the numerical models in order to determine the combination of widening and deepening of the inlet needed to adequately reduce current magnitudes. Table 8 presents the alternative inlet widths and depths.

Table 8 – Description of Alternatives

Alternative	Description
1	Existing configuration with channel excavation to -15 ft NGVD
2	Existing configuration with channel excavation to -20 ft NGVD.
3	150-ft wide channel (add 50' to existing) with bottom @ -20 ft NGVD
4	300-ft wide channel (adds 200' to existing) with bottom @ -10 ft NGVD.
5	300-ft wide channel (adds 200' to existing) with bottom @ -20 ft NGVD.
6	Dredging of Ebb Shoal to -8 ft. NGVD

Because the purpose of the study is to evaluate project alternatives that will improve boater safety, a wave height was selected that is representative of conditions that present dangerous situations, but are not elevated enough to deter boaters. Selecting a wave height that occurs frequently or typical summer conditions, would not provide a basis to evaluate project alternatives on the basis of improved safety. Likewise, modeling storm conditions would not accurately represent the conditions when boaters are typically navigating through the inlet. For the selected wave periods, a wave height of 4.5 feet is a typical elevated wave state based on the WIS data and site observations. A 4.5-foot wave would not be considered operationally safe, and also would not be considered as a storm condition. The wave periods and wave height were as parameters to develop JONSWAP wave spectra for model input. Table 9 provides a summary of the wave conditions used to evaluate the project alternatives.

Table 9 – Wave Model Cases

Direction	Peak Wave Period	Significant Wave Height
ENE	9.5 sec.	4.5 ft.
E	6.3 sec.	4.5 ft.
ESE	6.3 sec.	4.5 ft.

South Lake Worth Inlet has strong tidal currents that result in significant wave-current interaction. The most significant wave-current interaction occurs at a peak current and when the current is opposing the wave direction, which occurs at the peak flow of the ebb tide. The results from the hydrodynamic model for the peak ebb flow condition were utilized as input into the Bouss-2D model.

Alternatives 2 through 6 were simulated to evaluate the changes to the existing wave conditions in the vicinity of the inlet. For each of the alternatives, the geometry of the inlet was revised, and the ebb currents predicted by the hydrodynamic model were used as input. For Alternative 6, the existing currents were used since the hydrodynamic model was not applied to Alternative 6. When analyzing the model results, the following generalizations should be noted:

- Waves will refract such that the wave crest will become more aligned with the bottom contours;
- When waves encounter a localized current, the wave crest will bend such that the crest will wrap towards the area with higher currents; and,
- As waves enter shallow water, they will shoal, which results in increased wave heights.

Because of the dynamic nature of the model and the spatial variation of the results, a simplified tabular summary of the results is not practical. Instead general trends related to changes in wave height are summarized for each alternative.

6.1 Alternative 2 – Channel Deepening (to -20’ NGVD)

The first alternative assessed was a 10-ft deepening of the existing inlet channel configuration, increasing the average bottom elevation from -10 feet referenced to the National Geodetic Vertical Datum (NGVD) to an average of -20 feet NGVD. For the ENE and E scenarios, this alternative generally shows reduction in wave heights in the vicinity of the inlet. For the E alternative, there generally is a 10 to 20% reduction at the limits of the proposed excavation; however, there is an area of increased wave height (up to 10%) adjacent to the inlet entrance. For the E scenario, there generally are model-predicted decreases in wave heights in the vicinity of the inlet, which could provide increased boater safety. However, for the E case and ESE case there are increases in wave height in the close vicinity of the inlet entrance. For the E case, the increase of wave height is up to 10% and is in a localized area, but the increase for the ESE case could be up to 40%. These increases are generally due to localized changes in the tidal currents and the bending of waves toward the current.

6.2 Alternative 3 – Channel Widening (50-ft Southerly Expansion) – 10' Deepening

This alternative widens and deepens the inlet to 150-ft overall width and -20 ft NGVD bottom elevation, with a subsequent offset of the existing southern shoreline and jetty 50 ft to the south. Analysis of the results shows general increases in the wave heights in the areas adjacent to the inlet entrance, but these increases are generally small (Appendix C, Figure 5-23). For the ENE case, the increase in wave heights in the vicinity of the inlet entrance is 10% or less, which could be considered insignificant for wave heights. In the inlet there is a decrease in wave heights of up to 30%, but generally on the order of 20%. For the E case, the increase in wave heights in the vicinity of the inlet is up to 30% in a localized area where the model-predicted alternatives wave heights are on the order of 7 feet for the 4.5-foot offshore wave condition. This increase is due to the change in tidal currents, and the acceleration of the tidal flow from the deeper inlet channel to the shallower depths outside of the proposed dredge area.

The predicted change in tidal flow outside of the inlet significantly impacts the waves for the ESE case. Comparing the wave vectors for the model-predicted existing conditions and project alternative, there are significant changes in the wave patterns (Appendix C, Figure 5-23). Due to the change in the ebb tidal currents, the wave crests are bending towards the ebb tidal flow. The predicted tidal flows through the inlet have decreased, but the hydrodynamic model results show a general increase in currents in the areas adjacent to the inlet entrance, which is likely a result of the larger tidal prism. As a result of the wave focusing, and orientation of the entrance channel, there is a model-predicted increase of wave heights up to 40% in the channel where the model-predicted alternatives wave heights are on the order of 7 feet for the 4.5-foot offshore wave condition.

6.3 Alternative 4 – Channel Widening (200-ft Southerly Expansion) – No Deepening

Under this scenario the inlet width is increased from its current configuration by roughly 200 ft to an average of 300 feet wide. The average bottom elevation is maintained at -10 ft NGVD.

Like Alternative 3, the hydrodynamic model predicts a decrease in tidal flow velocity through the inlet, but the tidal flow in the areas adjacent to the inlet generally shows an increase. The increase in the tidal flow in these areas can be attributed to a larger tidal prism. The model-predicted wave heights generally increase up to 10% in the adjacent areas, but this increase can be considered as insignificant; however, there are localized areas of larger increases in wave heights (Appendix C, Figure 5-24). The increased wave heights in the inlet are primarily due to the widening of the inlet, where there currently is land.

The wider inlet allows for more waves to enter the inlet as shown for the E and ESE cases (Appendix C, Figure 5-24). For the E case, there would generally be an increase of up to 20% in the entrance channel. Likewise, the model results for the ESE show an increase of up to 40% in the entrance of the inlet. The increases in the inlet are likely due to the model boundary for this scenario, and may not be realized.

6.4 Alternative 5 – Channel Widening (200-ft Southerly Expansion) – 10' Deepening

This alternative is the same as Alternative 4, except the bottom elevation is increased from an average of -10 ft NGVD to -20 ft NGVD, significantly increasing the cross-sectional area of the inlet resulting in increased tidal prism and decreased average current velocities in the inlet.

The model results for Alternative 5 are presented in Figure 5-25 of Appendix C. Because the only difference between Alternatives 4 and 5 is a larger cross sectional area, the same discussion for Alternative 4 applies to this alternative. Compared to the results for Alternative 4, the areas of decreased wave heights adjacent to the entrance and the areas of increased wave heights are more exaggerated. This is due to differences in the hydrodynamic model predicted currents, and the increased tidal prism.

There is generally a decrease of model-predicted wave heights of up to 30% in the area adjacent to the entrance channel for all three wave scenarios (Appendix C, Figure 5-25). The model results show significant increases inside the inlet, and are likely a result of increased energy propagating into the inlet and downdrift shoreline. Because the magnitude of the ebb currents has decreased, the wave current interaction has decreased resulting in more wave energy reaching the inlet entrance and adjacent shoreline.

6.5 Alternative 6 – Dredging of Ebb Shoal to -8 ft NGVD

Alternative 6 reflects an attempt to deal with the single largest cause of boating incidents documented for South Lake Worth Inlet. Breaking waves on the shallower portions of the ebb shoal bar have been the reason for the majority of boating incidents recorded. For this reason, an option to increase the average water depth over the ebb shoal through excavation was investigated. This is not an uncommon practice for inlet management and has been successfully implemented at a number of inlets in the region, including Boca Inlet and Hillsborough Inlet who share similar boating issues.

This scenario was not modeled utilizing the flushing models as the changes to the ebb shoal would have no impact on the flushing of the Lake Worth Lagoon. For the wave modeling analyses, it was assumed that the general tidal current velocities would not significantly change for this alternative. Dredging the ebb shoal generally increases the wave energy in the vicinity of the inlet as shown in Figure 5-26 of Appendix C. For the ENE case, the model results show general increases to the wave heights in the vicinity of the inlet up to 10%, which can be considered insignificant. Under the E and ESE conditions, there are areas of localized decreases in model-predicted wave heights. The decreases are less than 20%. The model results do show significant increases in wave height along the shoal area and landward of the shoal. These increases are due to less wave breaking and dissipation of wave energy at the shoal, and a greater amount of wave energy is able to propagate over the shoal and into the shoreline. Under the ESE condition, dredging of the shoal allows a greater amount of wave energy into the inlet entrance.

7.0 Summary of Alternatives

The goal of this study is to identify and evaluate the full range of potential structural and non-structural alternatives and their associated benefits (and detriments) to inlet performance. In general, the study bracketed the range between a No Action / "Status Quo" approach up to an aggressive widening and deepening of the inlet. The widening and deepening alternative was expanded to a point that was felt sufficient to understand the range of influence on lagoon water quality and navigation safety – the two chief factors by which this study is measured.

The following provides brief descriptions of each proposed structural and non-structural alternative for the inlet. Figure 20 at the end of this section graphically displays proposed physical modifications to the inlet. Alternatives for bridge modifications are addressed independently as all structural options outlined below may incorporate any number of bridge options. Additionally, the bridge structure only influences the maximum vessel size and does not affect lagoon water quality and/or navigation safety.

7.1 Structural Alternatives

7.1.1 No Action – Status Quo

The No Action or Status Quo approach offers no changes to the inlet, yielding no improvements or negative impacts to the environment and/or navigation safety. It is assumed that certain maintenance and improvements to the existing structures (jetties, bulkheads, bridge, etc.) would occur as scheduled by the County and FDOT.

Currently, County plans include several improvement projects to the inlet's jetties, bulkheads, and sand transfer plant. The largest changes will be the installation of new bulkhead along the north and south jetties, as well as along the entire length of Bird Island. Construction will consist of installation of new sheetpile walls immediately seaward of the existing walls, encroaching into the channel by several feet. New piles will be driven along the north jetty and a new concrete deck will be constructed to support a new sand transfer plant. The new transfer plant will utilize a 900 horsepower electric motor capable of bypassing around 250 cy per hour to the discharge point 700 feet south of the inlet. Although detailed plans were not available at the time of this study, it is understood that the location of the bypass plant will not change.

Communications with FDOT indicate that there are no plans for either rehabilitation or replacement of the existing A1A bridge in the near future. Minor construction is occurring that will replace the handrails along the perimeter of the bridge crossing. This work will have no bearing on this study as it will not affect the current performance of the bridge.

The proposed work by the County and DOT are not seen to materially affect the current performance of the inlet and therefore deemed Status Quo for this study.

7.1.2 Channel Deepening – Modeled Alternatives 1 and 2

Deepening of the existing channel by an additional 5 and 10 feet (to -15 ft and -20 ft NGVD) was investigated primarily to evaluate effects on lagoon flushing. Existing channel depths (averaging around -10 ft NGVD) are adequate for most vessels that currently gain access through the inlet. However, increases in bridge clearance may increase the maximum vessel length and draft potential of the inlet.

It has been well-documented that the existing substrate is rocky in nature and difficult to remove. Excavation quantities for the proposed deepening efforts are estimated to be on the order of 42,000 and 85,000 cubic yards for the proposed 10- and 20-foot increases in average bottom elevations, respectively. It is assumed herein that the full width of the channel may not be excavated as proposed and that a five-foot minimum offset for excavation would be required to avoid undermining or destabilizing the existing structures. This assumption would have to be validated in the future through detailed engineering and geotechnical investigations prior to implementation.

7.1.3 Channel Widening (50' Southerly Expansion – 10' Deepening) – Modeled Alternative 3

To evaluate the effect of a marginal increase in channel width, a 50-foot shift in the southern boundary of the inlet, including the existing bulkhead and jetty is proposed. It was determined through discussions with the County that expansion cannot occur to the north due to the already restricted property dimensions, location of the current maintenance access point to the bypass plant, and relatively large magnitude of structuring (i.e., size of north jetty, presence of bypassing plant, etc.) along the north side. All expansion alternatives presented in this study therefore translate to the south side of the inlet.

As discussed in Section 3.2.3, typical widths for two-way traffic for a straight channel require at least five times the design vessel beam. Navigation channels with bends, high currents, and peak traffic issues, such as those at South Lake Worth Inlet require additional width beyond this minimum requirement.

An increase in the existing controlling width of 100 feet by 50 feet would expand the nominal width of the inlet to approximately 150 feet. For the vessels currently utilizing the inlet, 150 feet would be a recommended controlling width for the inlet leaving appropriate spacing for vessels with beams up to 22 feet.

As it was beyond the scope of this study to evaluate the stability of any of the existing structures, it cannot be assumed that the bulkhead and bridge support/footers on the north side of the inlet would be suitable for continued use. This is not likely when considering a larger bridge structure is required to span the widened inlet.

Expansion of the inlet to the south by 50 feet and deepening by 10 feet would require the following:

- removal of approximately 500 linear feet of existing bulkhead along the south side of the inlet and construction of a new bulkhead of matching length;
- removal of approximately 10,000 cy of upland and existing sandy beach within the 50-ft expansion zone (loss of approximately 0.7 acres of upland property);
- removal of the existing south jetty and construction of a new jetty;
- removal of existing bridge and construction of a wider bridge; and,
- excavation of approximately 94,000 cy of mostly rock bottom to attain an average bottom elevation of -20 feet NGVD.

It should be noted here that the training wall was assumed to remain in place under this alternative.

7.1.4 Channel Widening (200' Southerly Expansion – No Deepening) – Modeled Alternative 4

To evaluate an aggressive approach to increasing the flushing capacity of the inlet, thereby significantly improving potential water quality within the Lake Worth Lagoon, a 200-ft widening of the inlet from 100 to 300 feet in nominal width was evaluated. A potential secondary benefit of such an increase in cross-sectional area is a reduction in current velocities significant enough to affect navigability of the inlet.

As with the 50-ft widener, the shift would occur along the south side of the inlet. Expansion of the inlet to the south by 200 feet would require the following:

- removal of approximately 650 linear feet of existing bulkhead and construction of roughly 500 feet of new bulkhead;
- removal of approximately 45,000 cy of upland within the 200-ft expansion zone (loss of approximately 2.7 acres of upland property);
- removal of the existing south jetty and construction of a new jetty;
- removal of existing bridge and construction of a wider bridge; and,
- excavation of approximately 66,000 cy of rocky bottom to attain bottom elevation of -10 feet NGVD.

It should be noted that current state-of-the-art bridge designs do allow for a 300' +/- single span structure, however, it would come at a relatively high cost compared to other design solutions. This is discussed in more detail in section 7.1.7 below.

7.1.5 Channel Widening (200' Southerly Expansion – 10' Deepening) – Modeled Alternative 5

Adding to the 200-ft widening outlined in the previous alternative, a concurrent deepening of the channel by 10 feet from an average of -10 feet NGVD to an average of -20 feet NGVD was investigated. This option is primarily an evaluation of the sensitivity of tidal exchange to changes in depth and was not envisioned to have a tangible impact on navigation safety, except for a potential minor reduction in current velocities.

The structural requirements for an expansion of the inlet to the south by 200 feet are outlined above. The deepening associated with this alternative would required excavation of an additional 226,000 cy of mostly rock substrate (total estimated for this alternative is 292,000 cy of rock and 45,000 cy of sand).

7.1.6 South Jetty (Southerly Shift)

A shift in the south jetty seaward of the bridge is presented as an alternative to address navigation safety. A southerly shift in the jetty's current location by 50 feet or more would provide additional space for maneuvering through one of the most difficult spots in the inlet – still barely meeting a minimum 150-ft wide channel recommended for navigation. Additionally, the shift would also lessen the degree of turning required, improve lines of sight, and may reduce current velocities within the widened channel section.

This option would not necessarily require reconstruction of the existing bulkheads or bridge, but would require removal of the existing jetty structure, construction of a new jetty, and excavation of approximately 10,000 cy of sand and rock (for a 50-ft shift).

7.1.7 Bridge Considerations

Currently the bridge has a limiting clearance of approximately 18 feet at Mean Sea Level (MSL). This is not considered a navigation safety hazard, rather a restriction to navigation that limits the size and type of vessels that can transit the inlet. Specifically, vessel types that are commonly restricted from the South Lake Worth Inlet include nearly all classes of sailboats, (50-ft plus) sportfishers with fixed outriggers and flying bridges, and general yachts that exceed 60 feet in length. There have been many observed cases of contact between bridge and vessel superstructures resulting in damage to VHF antennae, radar arrays, bimini tops, fiberglass hard tops, etc.

For every inlet modification alternative proposed in this study there are a range of bridge replacement options. Three options that can potentially reduce or remove the height restriction of the inlet include: removal of the bridge without replacement, replacement with a drawbridge, and replacement with a higher fixed-span bridge.

The "no bridge" option would be the easiest to implement and would cost the least amount if changes were to be made. There are many inlets in South Florida that do not have bridge crossings, however, S.R. A1A is a highly utilized road that is recognized as an emergency evacuation route.

A new drawbridge is perhaps the most complex solution. It would alleviate the height restriction, however, it is felt that the limited standby area and likely bridge opening schedule would not suit this inlet. Inbound vessels would have to wait in the open ocean, potentially having to contend with rough weather conditions and other vessels attempting to transit during the opening. This is potentially a more dangerous scenario that what exists today. Additionally, the cost for construction and maintenance would be high relative to other bridge options. If not properly maintained, the drawbridge may present issues/obstacles for both boat and car traffic if inoperable.

A new fixed-span bridge is seen as a middle-of-the-road alternative compared to the other bridge options. Any change to the inlet geometry would likely require replacement of the bridge. A single span bridge could be designed with a greater clearance than what is currently in operation, however, it would cost on the order of $50M to $100M and require special planning and consideration of FDOT rights of way, maximum allowable inclines, and other transportation planning issues. On the other hand, a fixed-span bridge with multiple supports that are spaced wide enough for vessel navigation should be considered, with the same clearance and ROW issues previously outlined. If feasible, the minimum clearance requirement for the bridge should be raised.

7.2 Non-Structural Alternatives

Non-structural alternatives can be implemented in concert with or independent of structural alternatives and include the following.

7.2.1 Ebb Shoal Dredging and Bypassing

Breaking waves on the ebb shoal have been identified as the primary reason for inlet-related boating incidents. Controlling water depths over the ebb shoal can be as low as 4 to 6 feet, inducing relatively small waves (4 ft high or less) to break when passing over the top of the shoal. Periodic maintenance dredging of the ebb shoal bar would help alleviate this condition during marginally poor sea conditions. It is thought that by maintaining a minimum controlling depth of 8 feet over the ebb shoal that the inlet's navigability would improve significantly, except during periods of sustained high winds where local offshore sea conditions include wave heights exceeding 5-6 feet. Per statistical wave data for the area, wave heights between 3 and 4 feet occur on average 17.3% of the time (Figure 12). Similarly, wave heights between 5 and 6 feet occur roughly 3.4% on average. Increasing the controlling water depth on the ebb shoal to 8 feet could potentially improve navigation conditions as much as 14% on average.

However, it is important to note that small craft advisories in Florida are locally issued under different marine conditions. This means that while conditions may be improved by dredging the ebb shoal bar, this will not make overall boating conditions safer. Typically when offshore wave heights exceed 5 to 6 feet small craft should be advised not to navigate through the inlet or in open ocean waters.

7.2.2 Navigation Lighting and Channel Markers

Improvements to lighting, especially on the outer ends of both jetties, as well as the ends of the western ends of the training wall and Bird Island wall would assist in night-time operations. Dedicated channel markers are not seen as necessary for the inlet as the inlet structures themselves are the channel boundaries. Lagoon areas outside of the inlet throat may experience shoaling to a degree and problematic shoals should be marked appropriately.

7.2.3 Adverse Conditions Warning System

Situational awareness is probably the most important element for boating safety. Planning a boat trip should begin with an understanding of the local weather and sea conditions both at the time of expected departure and through the duration of the trip. Weather conditions can quickly deteriorate and catch boaters unprepared.

Marine forecasts continuously updated and published online by NOAA for stretches of coastline are valuable. Additionally, VHF weather channels and newer satellite-fed radio and television streams, announcing local weather and sea conditions are available and should be monitored. Inlet conditions in Palm Beach County can be seen through web-cam sites operated by the County (http://www.co.palm-beach.fl.us/webcams/slwi/), although the clarity of the images do not always provide an accurate picture of poor conditions and occasionally the system is not operating correctly.

An adverse conditions warning system would be a potential benefit to inlet users. The warning system would simply consist of signage and a set of flashing lights at the western entrance of the inlet. When a local small craft advisory is issued for the area, the lighting system could be activated. Signage would explain that when activated, the flashing lights mean that conditions are hazardous and vessels operators should take caution and/or avoid traversing the inlet. The same warning system could be linked to the County web-cam site with a warning message flashing on the screen. This type of system would likely deter smaller vessels and help inform boaters who may otherwise attempt a trip without being cognizant of sea conditions.

7.2.4 Boater Education

There are numerous boater education programs supported by the U.S. Coast Guard / Coast Guard Auxiliary, State of Florida, Palm Beach County, national organizations such as the National Marine Manufacturer’s Association, GrowBoating.org, DiscoverBoating.com, Marine Industries Association, etc. The U.S. Coast Guard and Coast Guard Auxiliary offer boater safety courses and inspections. The Florida Fish & Wildlife Conservation Commission provides a great deal of information for boating safety, as well as educational grants to municipalities, counties and other organizations under the Florida Boating Improvement Program. NMMA and other private marine industry associations provide free consumer safety information and links to other boating safety programs.

Increased boater education may be accomplished by focusing on inlet users. Specifically, the City-owned boat ramp immediately west of the inlet is highly utilized by local boat owners. Providing pamphlets or flyers on boating safety, along with explanations of how to assess sea conditions before going out on the water and how to avoid problems navigating inlets may result in fewer inlet-related incidents. Similar educational material can be provided to local boat owners through the various marinas, boat dealers, and dry stack facilities in the area. If the adverse conditions warning system is implemented, it should be formally announced and advertised as a tool for boaters.

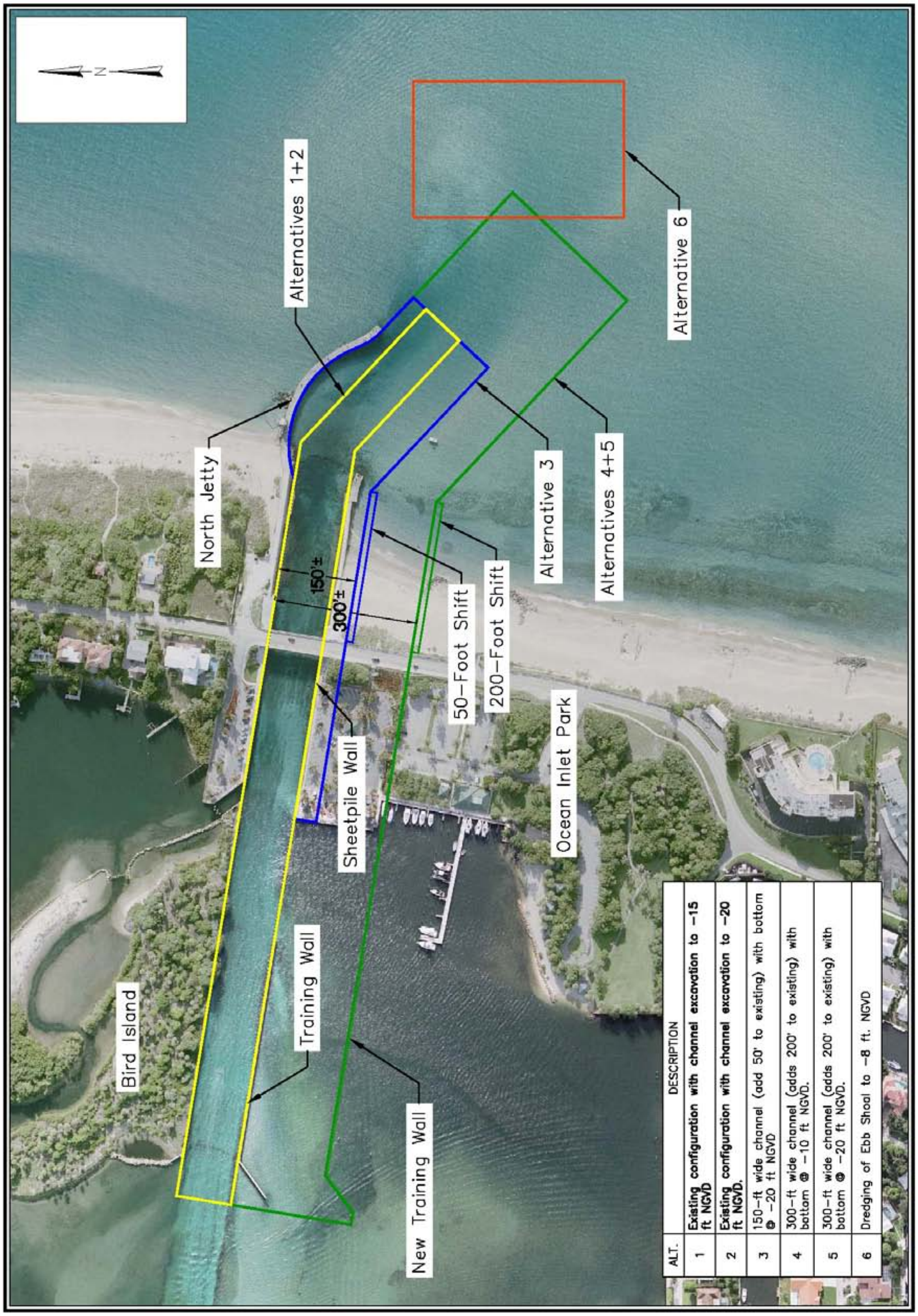


Figure 20 – South Lake Worth Inlet Structural Alternatives

8.0 Ranking of Inlet Modification Alternatives

In order to evaluate all of the potential alternatives for modifying the inlet, a method of weighting or ranking each alternative is necessary. The following criteria were established for ranking inlet modification alternatives as described in Section 7.0:

8.1 Navigation Safety

The inlet's current configuration is not adequate for safe navigation. The limited width, restricted line of sight, and presence of the ebb shoal are three factors that pose threats to boaters who use the inlet even though it is not officially a navigable inlet. One of the primary focuses of this study is to try to determine how the inlet can be made safer for vessels and as such this is one of the criteria used to rank the alternatives.

8.2 Lagoon Water Quality

Water quality in the Lake Worth Lagoon has become a topic of concern over the past few years with increasing awareness of pollution and programs being established to both study and enhance the Lake Worth Lagoon estuary. This issue is acknowledged as being one of the catalysts for this study and the results of the alternatives assessment will be ranked according to the level of improvement to the lagoon's water quality afforded by each alternative.

8.3 Permit-Ability

Implementation of any alternative will require permitting approvals. Any proposed modification to the inlet will induce some level of change or impact to the environment and operating conditions of the inlet. The permit-ability of each option is ranked in order of the level of difficulty anticipated. Some cases may not require extensive review and approval for permitting while others may not be feasible from a permitting perspective. Those that are not deemed permit-able may be eliminated for this reason alone.

8.4 Environmental Impacts

Outside of the impacts to lagoon water quality and related to permit-ability are the environmental impacts associated with each alternative. Direct impacts to upland and marine resources, as well as indirect impacts will take place – some positive and some negative. For instance, improvements to water quality within the lagoon through an increase in the width and depth of the inlet will have direct impacts associated with the removal of additional beach and hardbottom habitats plus an increase in the amount of lagoon water (sediments, runoff, nutrients, etc.) finding its way offshore. Care must be taken to consider the various types of habitats that will be directly and indirectly impacted and to balance benefits with negative impacts to avoid a net reduction in overall environmental quality.

8.5 Other Secondary Impacts

Public access and loss of County-owned property are two chief concerns that fall under this category. Additionally, impacts to sediment transport patterns that would, in turn, affect significant shoreline responses (erosion) would fall also under this category. Lastly, storm surge (flooding) and emergency evacuation are included under this topic as secondary impacts.

8.6 Costs and Construction Timeline

As with any large scale public project, cost and timing are critical issues. Order-of-magnitude construction cost estimates are outlined under Table 10, along with estimates for required construction time. It is envisioned that all alternatives would not result in a complete closure of the inlet to boating traffic. However, prolonged restrictions on access may be required and could potentially have a negative impact on local business owners who rely on the inlet.

8.7 Overall Effectiveness

The overall effectiveness of each option is to achieve the goals of the study without creating insurmountable issues. This ranking is computed by taking an average of all other ranking criteria.

Table 10 – Construction Estimates

Direct Inlet Modification Alternatives	Construction Cost Range		Estimated Time
Alternative Desc.	**Low**	**High**	**of Construction**
Alternative 1: 5-ft Channel Deepening (-15')			
Mobilization/Demobilization	$250,000	$500,000	30 days
Excavation	$840,000	$1,680,000	90 days
	Total	**$2,180,000**	**4 months**
Alternative 2: 10-ft Channel Deepening (-20')			
Mobilization/Demobilization	$250,000	$500,000	30 days
Excavation	$1,700,000	$3,400,000	180 days
	Total	**$3,900,000**	**7 months**
Alternative 3: 50-ft Widening w/10-ft deepening (-20')			
Mobilization/Demobilization	$600,000	$1,200,000	30 days
bulkhead demolition	$150,000	$250,000	60 days
south jetty demolition	$108,000	$180,000	60 days
bridge demolition	$500,000	$1,000,000	60 days
upland / beach excavation	$50,000	$100,000	30 days
rock excavation	$1,880,000	$3,760,000	90 days
new bulkhead	$600,000	$875,000	90 days
new south jetty	$750,000	$1,500,000	180 days
	Total	**$8,865,000**	**16 months**
Alternative 4: 200-ft Widening (-10')			
Mobilization/Demobilization	$600,000	$1,200,000	30 days
bulkhead demolition	$195,000	$325,000	60 days
south jetty demolition	$108,000	$180,000	60 days
bridge demolition	$500,000	$1,000,000	60 days
training wall demolition	$61,500	$123,000	30 days
upland / beach excavation	$225,000	$450,000	30 days
rock excavation	$1,320,000	$2,640,000	120 days
new bulkhead	$600,000	$875,000	90 days
new south jetty	$750,000	$1,500,000	180 days
north jetty extension (325 lf)	$1,500,000	$2,500,000	180 days
new training wall	$369,000	$615,000	90 days
	Total	**$11,408,000**	**18 months**
Alternative 5: 200-ft Widening w/10-ft Deepening (-20')			
Mobilization/Demobilization	$600,000	$1,200,000	30 days
bulkhead demolition	$195,000	$325,000	60 days
south jetty demolition	$108,000	$180,000	60 days
bridge demolition	$500,000	$1,000,000	60 days
training wall demolition	$61,500	$123,000	30 days
upland / beach excavation	$900,000	$1,800,000	30 days
rock excavation	$5,840,000	$11,680,000	180 days
new bulkhead	$600,000	$875,000	90 days
new south jetty	$750,000	$1,500,000	180 days
north jetty extension (325 lf)	$1,500,000	$2,500,000	180 days
new training wall	$369,000	$615,000	90 days
	Total	**$21,798,000**	**20 months**
Alternative 6: 50-ft Shift in S. Jetty			
Mobilization/Demobilization	$250,000	$600,000	30 days
south jetty demolition	$108,000	$180,000	60 days
upland / beach excavation	$15,000	$30,000	30 days
rock excavation	$140,000	$280,000	60 days
new south jetty	$750,000	$1,500,000	180 days
	Total	**$2,590,000**	**10 months**

9.0 Viable Alternatives and Recommendations

In order to evaluate each alternative and rank all according to the criteria established for this study, a quantitative approach employing a ranking matrix was developed. Each alternative was reviewed and given a ranking between zero and six – with zero representing a highly unfavorable condition, three representing a neutral or no change condition, and six representing a highly favorable condition. Intermediate numbers represent varying degrees of favorability.

Table 11 outlines the results of the ranking of the inlet modification Alternatives 1 through 6. For this study the options for the bridge are not included in the ranking analysis as it has no direct bearing on the water quality and a relatively small influence on the navigation safety of the inlet. The following sections highlight specific discussion points that led to the ranking of each alternative. Additional discussion sections are provided to address the bridge and other non-structural alternatives developed as part of this study. Lastly, the importance of stakeholder support cannot be understated for this project. It is anticipated that the results of this study will be presented to all stakeholders and that in order for any project to move forward support from key stakeholders will have to be gained through close and continued communication and coordination efforts.

9.1 No Action – Status Quo

The No Action or Status Quo option does not require any changes, hence does not induce any changes to the current state of the inlet and surrounding areas. For this reason it does not accomplish any of the goals of the study. The alternative, however, ranks well in terms of cost and ability to implement.

9.2 Channel Deepening – Modeled Alternatives 1 & 2

In an attempt to improve flushing without having to reconstruct the existing inlet structures, a deepening approach was taken. Alternatives 1 and 2 modeled during this study propose to deepen the existing bottom from roughly -10 ft NGVD to -15 ft and -20 ft NGVD, respectively.

The results of the hydrodynamic modeling indicate that the average peak current velocities for Alternative 1 (-15 ft NGVD) would be around 1.9 m/s (6.2 fps) for the ebb and 2.0 m/s (6.6 fps) for the flood tide cycle. The same results for Alternative 2 (-20 ft NGVD) indicate a small decrease in peak ebb velocity to 1.8 m/s (5.9 fps) and no change in peak flood. Because of the relatively narrow channel width, deepening of such a small cross-section does not significantly alter the hydraulic characteristics of the inlet. The reductions in peak velocities also do not significantly enhance maneuverability and safety in the inlet.

Changes to water quality in the lagoon through the inlet can be accomplished through increases in the amount of water exchange during each tidal cycle. For this reason, changes in tidal prism were quantified. The overall water exchange through the deepened inlet will result in a 34%-37% increase in the tidal prism for Alternative 1 and 64%-66% increase in tidal prism for Alternative 2. However, the relationship between tidal prism and flushing is not linear. As indicated by the hydrodynamic model, Alternative 1 would increase flushing by 9% over the existing conditions (from 52% volume exchange in 4 days for existing conditions to 65% for Alternative 1 conditions). Alternative 2 would result in a 19% improvement in flushing over the existing conditions (up to 71% volume exchanged in 4 days).

While the relative improvements in flushing are seen to be significant, only qualitative judgments can be made. More detailed studies focused on specific pollutants would be required to quantify net improvements and their expected improvements to lagoon water quality. The model utilized for the flushing analysis in this study can be expanded and/or adapted to evaluate specific water quality parameters. However, this would only be recommended for viable alternatives (those not ruled out for other reasons and are possible to implement) as it is involves a higher level of effort (time and cost).

As described in Section 4 of this report, increases in cross-sectional area and tidal prism for inlets tend to increase the size and therefore the storage potential of the associated ebb and flood shoals. Alternatives 1 & 2 would have this effect, the extent of which may or may not be manageable through adjustments to the operation of the fixed bypass plant alone.

Per Table 10, the estimated construction costs for Alternatives 1 & 2 are $2.18M and $3.10M, respectively. Alternative 1 is expected to require a 4 month construction window (not including permitting) to complete while Alternative 7 is projected to require 7 months to complete.

9.3 Channel Widening (50' Southerly Expansion – 10' Deepening) – Modeled Alternative 3

As described in Section 7.1.3, widening the inlet by 50 feet to the south was evaluated as a minimum offset for navigation safety, with a 10-ft deepening (to -20 ft NGVD) of the channel to enhance flushing. The results indicate the following hydraulic changes:

- Reduction in average peak ebb and flood current velocities to 1.7 m/s (5.6 fps);
- Increase in tidal prism by 92%-93% over the existing conditions; and,
- Increase in volume of water exchanged in four days by 21% over existing conditions (change from 52% for existing to 73% for Alternative 3). (Note that this represents only a 2% improvement over deepening of the existing channel to -20 ft NGVD).

Wave modeling results indicate that wave heights will generally decrease within the deepened channel areas generally by 20%, while localized increases in wave height by as much as 30% may occur during the peak ebb flow at the end of the channel cut. The increase is directly attributed to the steep transition from -20 ft NGVD (in the channel) up to surrounding elevations that would be close to -10 ft NGVD which would force currents to accelerate vertically, “jacking” waves above their typical peak heights. This means that for a wave that would typically be 4 feet in height, would grow to more than 5 feet. This localized effect is critical and may present issues to navigation safety if the end of the cut is located beyond the sheltering effect of the end of the north jetty (as modeled).

The proposed cross-sectional area for Alternative 3 is roughly 3,000 sf (150 ft wide by 20 ft deep) and following the example set in Section 4 of this study, could potentially more than triple the current size of the ebb shoal. This cannot be countered through the fixed bypass plant, even with the proposed improvements. Instead, a focused strategy to either bypass sand from the ebb shoal as it grows will be required or additional material will have to be pumped in from offshore borrow sites. This would increase the volume and/or frequency of required nourishment cycles, an activity managed by the County and partially funded by the Federal Government. If the ebb shoal were not excavated, the growth in shoal area would eventually present additional navigation issues.

The estimated cost of this alternative is approximately $8.86M and is estimated to take 16 months to complete. Compared to Alternative 2, this is over $5.76M and will take 9 months more to accomplish (for only a 2% gain in flushing). This does not include the time and expense for replacing the bridge which would otherwise remain in place under Alternatives 1 and 2.

From a permitting standpoint, Alternative 3 will be more difficult to permit than Alternatives 1 and 2. In general, the larger the physical change, the more impacts to existing environmental resources (seagrass, hardbottom, etc.) and management and higher level of difficulty in permitting. A relatively small loss in County-owned property and public access would also result from the southerly expansion of the inlet. As there is obvious real estate and public access value in the property, this is an issue that must be discussed with local stakeholders before ruling out.

The biggest gain associated with Alternative 3 is the added width that would provide much needed clearance and improved sight lines for vessels navigating through the inlet.

9.4 Channel Widening (200’ Southerly Expansion – No Deepening) – Modeled Alternative 4

To help understand the range of solutions, a maximum expansion scenario comprised of widening the inlet by 200 feet was evaluated. Widening by this amount would enlarge the inlet to a point that would offer more than enough space for safe navigation of two-way traffic, but was also felt to be wide enough to lower currents to a point that would be more manageable while at the same time having a significant impact on flushing in the lagoon.

The results of the flushing analyses for this case are as follows:

- Reduction in average peak ebb and flood current velocities to 1.5 m/s (4.9 fps) and 1.7 m/s (5.6 fps), respectively;
- Increase in tidal prism by 80% to 84% over the existing conditions (note that this is a decrease from Alternative 3 by 11%-12%); and,
- Increase in percent of water exchanged by 63% over the existing conditions (note that this is a 10% decrease in the water exchange by Alternative 3).

General results from the wave modeling indicate overall reductions in wave heights at the mouth of the inlet, except in areas where the existing conditions are dry land and the proposed Alternative 4 conditions reflect water (within the 200-ft expansion area). Noteworthy are the increases in wave heights experienced within the entrance channel during E and ESE wave cases where wave heights within the throat of the channel increase between 20% and 40%. While an increase in the throat would be expected, the results of the model are felt to be conservatively high and may be influenced by model boundary conditions.

The increase in cross sectional area is the same as that of Alternative 3 at 3,000 sf +/- (300 ft wide by 10 ft deep). The same issues and ramifications exist for the ebb shoal as outlined for Alternative 3 above, perhaps to a lesser degree as the overall tidal prism is slightly smaller for Alternative 4 (due to a relatively higher friction effect associated with the channel cut geometry).

While the increase in flushing compared to the existing conditions is desirable, the results are inferior compared to those of Alternative 3 – widening the inlet by 50 feet and deepening by 10 ft (to -20 ft NGVD). The cost of Alternative 4 is estimated to be around $11.41M, roughly $2.55M more than Alternatively 3. At 18 months the estimated time of construction is only 2 months more than what is estimated for Alternative 3.

The additional width of the inlet would require the loss of roughly 2.7 acres of County property, as well as the removal of the existing training wall and the construction of a replacement wall. Environmental impacts required for construction of this alternative would be extensive and difficult to permit for the following reasons: 1) hardbottom, seagrass and other direct impacts would occur within the 200-ft offset, 2) the existing sand trap falls within the 200-ft offset and would have to be relocated, resulting in increased impacts for a new sand trap, 3) the potential growth of the ebb shoal induced by the increase in tidal prism would require special consideration by beach planners, and 4) there is a potential for increased impacts to offshore reef through the increased discharge of lagoon waters through the inlet.

9.5 Channel Widening (200' Southerly Expansion – 10' Deepening) – Modeled Alternative 5

The most aggressive modification proposed for this study involves a 200-ft southerly expansion and a deepening of the existing and expanded inlet cut to an average bottom elevation of -20 ft

NGVD. While the added depth does not notably improve the navigation safety conditions over that of "Alternative 4" for the current vessel types that utilize the inlet, modifications to the bridge may allow for larger vessels to access the lagoon. Refer to section 9.6 below for a discussion on bridge height limitations and potential issues associated with increasing the maximum vessel size that can access the lagoon through the inlet.

The results of the flushing analyses for this case are as follows:

- Reduction in average peak ebb and flood current velocities to 1.0 m/s (3.3 fps) and 1.2 m/s (3.9 fps), respectively;
- Increase in tidal prism by 126% to 133% over the existing conditions; and,
- Increase in percent of water exchanged by 70% over the existing conditions (note that this is a 3% decrease in the water exchanged by Alternative 3).

The reduction in average peak current velocities to less than 4 fps is significant improvement from a navigation safety perspective, yet it is high enough to be self scouring (greater than 3.0 fps) and will not close due to sedimentation.

The wave modeling generally shows decreases in wave heights across the mouth. However, more wave energy is shown to propagate into the throat of the inlet and onto the southern shoreline. Because the southern stretch of shoreline is protected by the ebb shoal, continuously nourished by sand bypassing, and reinforced or protected by the groin field, this is not felt to be a concern unless the ebb shoal bar were drastically reduced allowing large waves to reach shore.

The cross-sectional area of this alternative is the largest of all at 6,000 sf (300 ft wide by 20 feet deep). It is felt that the level of change to the ebb shoal that may result from this will be a challenge, presenting significant issues in planning, permitting, and managing. Environmental impacts and other beach management concerns are the same as those outlined under Alternative 4.

The estimated cost for this alternative is high at $21.8M and will require approximately 20 months to complete. Note that as with all of these examples, the removal of the existing bridge is included, however, the cost and time to construct a new bridge is NOT included.

While Alternative 5 would be one of the safest inlet configurations by far, there are many challenges that would arise in trying to implement this option.

9.6 Ebb Shoal Dredging – Modeled Alternative 6

Through reviews of available records and interviews with first responders such as the County's lifeguards and Sheriff's Marine Enforcement Unit, the largest cause of boating incidents at the inlet are associated with breaking waves on the ebb shoal bar. While offshore conditions may be manageable for small craft, the controlling water depths over the ebb shoal bar are shallow enough to induce waves that are 4 ft +/- and greater in height to begin breaking. Inexperienced boaters, and occasionally even experienced boaters, can easily be caught off guard and unaware of the conditions over the bar.

For this study, it is felt that a small increase in water depth would greatly assist during marginal wave conditions (wave heights up to 4 ft +/-). The wave model study assessed an increase in the average bottom elevation to approximately -8 ft NGVD with positive results. Per statistical wave data for the area, wave heights between 3 and 4 feet occur on average 17.3% of the time (Figure 12). Similarly, wave heights between 5 and 6 feet occur roughly 3.4% on average. Increasing the controlling water depth on the ebb shoal to 8 feet could potentially improve navigation conditions as much as 14% on average.

While this is an improvement to navigation safety, it will not improve conditions when wave heights begin to exceed 5-6 feet. These are conditions when small craft advisories are in effect for offshore boating and attempts to exit the inlet should not be made.

It will also require logistical consideration in terms of implementation. Ideally, ebb shoal dredging could be combined with other (county and federal) nourishment programs to provide an added benefit to local beaches. It is estimated that roughly 100,000 cy of sand would be excavated and available for nourishment from the ebb shoal if a portion of the bar were reduced to -8 ft NGVD.

Lastly, the increase in average water depth over the ebb shoal will reduce the effective dissipation of wave energy approaching the shoreline. This is not seen to present concerns about increased erosion as the section beach that would be impacted (south of the inlet) is continuously nourished through bypassing sand from the north (fixed plant) and is protected by the groin field that extends south of the influence of the bypass bar.

9.7 Shift in South Jetty (50-ft Southerly Shift)

In an attempt gain a minimal buffer for navigation through seaward entrance of the inlet (east of the bridge, a 50 ft shift offset of 380 feet of channel/jetty is proposed. This will widen the channel to roughly 150 feet wide – the minimum recommended for two-way vessel traffic given the current vessel sizes that utilize the inlet. The offset will not only provide more room for navigation but will also improve line of sight for smaller vessels.

The estimated cost of essentially shifting the jetty (tearing out the old, digging the additional channel width, and building a new structure) is roughly $2.59M and will require an estimated 10 months to construct.

Table 11 - Alternatives Ranking Matrix Summary

	Ranking Criteria (Scale 0 to 6: 0 being highly unfavorable, 3 being neutral or no change, and 6 being highly favorable)							
	Permit-ability	**Environmental Impacts**	**Lagoon Water Quality Impacts**	**Safety**	**Cost/ Time**	**Overall Effectiveness**	***Total Points***	***Ranking***
Physical (Structural) Options:								
Inlet								
Status Quo	6	3	3	3	6	1	***22***	***1***
Inlet Deepening (5')	2	3	4	4	3	3.2	***19.2***	***2***
Inlet Deepening (10')	2	4	4	4	2	3.2	***19.2***	***2***
Inlet Widening (50' w/10' deepening)	2	2	3	5	2	2.8	***16.8***	***4***
Inlet Widening (200' w/out deepening)	1	1	5	6	1	2.8	***16.8***	***4***
Inlet Widening (200' w/10' deepening)	1	1	5	6	1	2.8	***16.8***	***4***
Shift in South Jetty (50')	2	2	3	5	3	3	***18***	***3***
Maintenance Dredging of Ebb Shoal	3	2	3	6	2	3.2	***19.2***	***2***

This alternative will have some permitting challenges associated with the widening and impacts to resources. It will not have any improvements to lagoon water quality as it does not alter the hydraulic characteristics of the inlet. Lastly, it should induce only minor changes in wave fields and not have any impact on sediment transport patterns.

9.6 Bridge Considerations

Currently there are no plans to rehabilitate or replace the bridge crossing South Lake Worth Inlet. As such, all plans that would require a modification to the bridge would require close coordination with FDOT to develop such plans. Without any plans on the horizon for the bridge there is not likely any dedicated funding source and approvals are seen to be very difficult to obtain.

If a project were to move forward that included a modification to the bridge, there are several approaches that could be taken. The first would be removal of the bridge without replacement. This is the least costly method and would provide unrestricted access to vessels. The biggest drawbacks would be the disruption of traffic, public access, and alteration to an emergency evacuation route utilized by the local residents in the Towns of Ocean Ridge and Manalapan.

The second option would be replacement of the bridge with a drawbridge. Boca Inlet is an example of this, however, the standby area is well-protected and currents are lower through that inlet. The high currents and direct exposure would create a difficult and dangerous situation for vessels waiting to enter from offshore. Additionally, drawbridges are relatively expensive when compared to similarly sized fixed bridges, and can be prone to mechanical failure and disruption of traffic if not properly maintained.

The third option is construction of a higher, fixed span bridge. There are limitations to a single span bridge and the gain in elevation clearance would require reconsideration of the existing FDOT rights of way. Even if the height limitation of the bridge were removed, there are practical limitations to the maximum vessel size that would be able to enter and traverse this section of the Lake Worth Lagoon. Those limitations would be dictated by limiting water depths inside of the lagoon itself. The ICW is maintained to an average bottom elevation of roughly -10 ft NGVD and access to most private slips and public marina facilities are depth-limited with less than 10 ft being common.

Another issue related to increasing the maximum vessel size would be increased pressure to deepen existing access channels to accommodate larger vessels in both privately-owned slips and public marina facilities. Compared to the current demand for public slips and trends that are privatizing docking facilities, there is a shortage of spaces available for public use. This yields a third issue – a potential shift to favor larger slips. Development along the Lake Worth Lagoon is nearly 100% saturated with no real potential for a new large public marina facility to be built. As such, if existing facilities were to redevelop to accommodate larger vessels within the same property limits, the total number of slips would have to drop, further reducing an already limited supply.

In contrast, however, there are potentially significant economic benefits associated with improvements to access through the South Lake Worth Inlet. As described in Section 4.5 the estimated economic benefit of the marine industries in Palm Beach County is on the order of $1.9B (FIND, 2006). Improvements to access through the inlet would increase this. Furthermore, increases in real estate value and related tax bases would also likely be realized with improvements to access.

9.7 Non-Structural Alternatives

Non-structural alternatives listed earlier in this study include the following:

- Adverse Conditions Warning System;
- Additional Navigation Aides; and,
- Boater Education Programs.

Since these are not seen to have any adverse impacts, do not require permitting, and do not cost a great deal (relative to structural alternatives) they should be easy to implement and should be investigated further.

Periodic ebb shoal dredging is another non-structural alternative that is felt to have benefits to navigation safety and beach management. Because the County owns the surrounding property and manages the inlet and adjacent beaches, this option should be pursued further through appropriate County representatives (ERM and others). The best approach would be to incorporate the ebb shoal maintenance into the periodic beach nourishment program, accomplishing both an increase in safety and providing an additional source of beach sand outside of the dedicated offshore borrow site.

9.8 Stakeholder Feedback

The City of Boynton Beach held a public workshop on August 8, 2007 to provide brief background and introductory remarks regarding the goals of the study. The workshop also solicited public feedback and comments on the inlet in the form of open dialogue and a survey form. The survey form was comprised of a series of directed questions regarding the current condition of the inlet and desirable changes to the inlet. A series of tables were also included that allowed respondents to rank various issues (navigation safety, lagoon water quality, etc.) and possible inlet modifications (improved lighting, widening, deepening, etc.) in accordance with their perceived level of importance.

The survey form was made available immediately following the August workshop and was also posted on ATM's web-site. As of October 8, 2006, only eight completed survey forms were received. While this is not enough to perform any valuable statistical analyses, general points from the surveys are as follows:

- Navigation Safety was consistently ranked as an issue of importance for the inlet.
- Lagoon Water Quality varied from low to high as an issue of importance.
- Bridge Clearance ranked between low and medium as an issue and proposed modifications to the bridge were seen as Undesirable or Neutral.
- Beach impacts and maintenance of the inshore/offshore bars ranked medium to high in importance and maintenance of the bars was generally ranked as desirable.
- Proposed improvements to navigation lighting were generally seen as desirable.
- Proposed widening and deepening of the inlet was generally seen as neutral or undesirable (only one response was desirable for this action).

A second workshop presenting the findings of the study to members of the Inlet Steering Committee was held on November X, 2007 during which the results of the studies herein were made. Feedback on the results and recommendations were solicited with the following key issues being raised:

-

9.9 Funding Alternatives

There are several funding sources that could potentially grant support to an inlet improvement project. The largest single source may come from the Florida Inland Navigation District's Waterway Assistance Program, having supported over $18M in improvements to navigation over the years (http://www.aicw.org/wap/wap.htm). Other potential sources of funds may be the National Boating Infrastructure Grant Program (http://myfwc.com/boating/grants/bigp.htm) and the state's Florida Boating Improvement Program (http://myfwc.com/boating/grants/fbip.htm). Lastly, there is a federally-backed Recreational Boating Safety program that would be administered through the U.S. Coast Guard (http://www.uscgboating.org/grants/state/rbs.htm).

It should be noted that this study was funded by the South Florida Water Management District through a grant to the City of Boynton Beach.

9.10 Recommendations

In general, this study looked at a full range of potential inlet modifications, ranging from small to large in scale and complexity. Each alternative was developed with one of two key goals in mind: 1) improve lagoon flushing and water quality and 2) improve navigation safety through the inlet.

As a whole, the results of the study did indicate that structural improvements could be implemented that would improve both the water quality of the lagoon and the safety/navigability of this inlet. Increases in the channel width and depth produced the greatest benefits. This study further suggests that there would be significant economic benefits to these alternatives and these net economic benefits may be on the order of or even exceed project costs.

Major structural alternatives, however, represent major capital projects and other significant hurdles. The major issues identified within this study include the following:

> *Environmental Impacts*: Improvement to the lagoon may come at an even greater cost corresponding to increases in nutrient loads to nearshore reefs. The net environmental benefit of improving a degraded waterbody (lagoon) over impacting a fairly untouched resource (offshore reef) is not fully understood at this time and therefore is a concern.
>
> *Coastal Impact*: Channel improvements would result in increased potential for sand storage by ebb shoal ranging on the order of several million cubic yards of sand. This is a potential for a major impoundment of sand within the shoal system that has the potential for significant downdrift impacts. The existing federal project and sand bypassing regime is likely insufficient to make up this loss to the downdrift coastal system
>
> *Bridge issues*: With the exception of the deepening only scenarios, all structural modifications requiring a widening of the inlet will require a new bridge. Given that FDOT currently has no plans for replacing the existing S.R. A1A bridge, this is a lengthy and costly undertaking to be added.
>
> *Loss of Park Property and Public Access*: The property surrounding the inlet is owned and operated by Palm Beach County. The loss of property for any inlet expansion would come at a cost to valuable real estate and public access.
>
> *Costs* – Overall costs associated with significant alterations to the inlet are high and there currently are limited funding sources available.

Collectively these issues represent a significant impediment to the approval and implementation of any major inlet modification.

A matrix was developed using a scale from 0 to 6 to rank each inlet modification alternative according to favorability (0 being highly unfavorable, 3 being neutral or no change, and 6 being highly favorable. Six ranking criteria were evaluated, including: Permit-ability; Environmental Impacts; Lagoon Water Quality Impacts; Safety; Cost/Time; and, Overall Effectiveness. As shown in Table 11 each alternative was ranked according to each of the six criteria, then the total for each alternative was added together to formulate an overall ranking of viability. Based on the results of the ranking matrix outlined in Table 11, structural alternatives fall into the following order from highest ranked (more viable) to lowest ranked (less viable):

1. No Action/Status Quo – This option ranked high simply because it does not suffer from having to seek permitting or funding approvals, and implementation is a forgone conclusion. However, this option does nothing to accomplish the goals of the study, hence was penalized on overall effectiveness.

2. Deepening Alternatives 1 & 2 and Ebb Shoal Dredging – Three options ranked the same, including both deepening alternatives and the ebb shoal dredging option. Both deepening Alternatives 1 & 2 share similar challenges with slightly different advantages and disadvantages. Both would present nearly identical permitting issues mostly related to additional impact to existing hardbottom resources in and around the inlet. Alternative 1 requires less money and time to implement but does not provide the flushing improvement that Alternative 2 offers. Lastly, neither deepening alternative really addresses navigation safety issues. Maintenance dredging of the ebb shoal would perhaps be the single most important improvement to the inlet for navigation safety. The difficulties of maintenance dredging really present themselves in permitting and funding.

3. Shift in South Jetty (50-ft Southerly Shift) – The shift in the southern jetty would not achieve an improvement in water quality, but would provide for a safer inlet for boating. The cost versus benefit of this option should be carefully weighed as the amount of money and time to construct is not insignificant, and the majority of recorded boating incidents occur on the ebb shoal bar rather than in the throat of the inlet.

4. Widening/Deepening Alternatives 3, 4 & 5 – All three widening and deepening alternatives present varying degrees of difficulty in permitting. They also require a change to the existing bridge, removal and replacement of the southern bulkhead and jetty, and loss of County property. All three of these alternatives rank high in improvements to lagoon water quality and navigation safety, which satisfy the primary goals of this study. The overall effectiveness of these options are offset by the downsides in other potential environmental impacts, permitting, as well as costs and time required for construction.

By this measure alone, maintaining the status quo does rank high but does not achieve any of the desired improvements. Based solely on achieving improvements to lagoon water quality and navigation safety, the widening and deepening alternatives would rank highest. However, the associated direct impacts to hardbottom and seagrass (including protected *johnson* species), as well as potential indirect impacts to nearshore reefs linked to increases in discharge of nutrients and other pollutants from the lagoon, are a cause for concern at this point in time. Inlet management is a continuous process and although major modifications may not be viable at this time, at some future point in time, if lagoon water quality improves through ongoing stormwater management and discharge / treatment controls, then such alternatives may become viable.

In terms of water quality, this study re-iterates findings of previous studies regarding the status of the lagoon – namely, the key to improvement in water quality is treatment and control of source inputs. The use of the inlet as a practical means of water quality improvement is questionable given the potential for impacts to the nearshore hardbottom environment. The model which forms of the basis of this study may be used to further address water quality issues in the lagoon through future applications.

Regarding safety and navigability, there are a number of implementable options. South jetty relocation is conceptually viable, though the high cost may not justify the limited benefit. Ebb shoal dredging is also viable but requires a funding and maintenance commitment by several parties, most notably Palm Beach County. The results of the ebb shoal dredging are also short-term and would require an ongoing commitment – the cost of which is not insignificant.

If cost and time were unrestricted, then a combination of deepening the existing channel (Alternative 1 or 2), the 50-foot southerly shift in the south jetty, and limited excavation of the ebb shoal would provide a solution with improvements to lagoon flushing and navigation safety. The level of change in lagoon flushing would be marginal and the increase in discharge outside the inlet and onto nearshore reefs would need to be investigated further. The cost benefit of the shift in the south jetty would also need to be better defined as investigations did not indicate this area to be the source of biggest concern for navigation. Regardless, the existing width of the channel is too narrow for safe two-way traffic and would benefit from a 50-ft minimal expansion.

Non-structural options highlighted in Sections 7.2.2 – 7.2.4 are all seen as viable and implement-able. Improvements to lighting, especially on the outer ends of both jetties, as well as the western ends of the training wall and Bird Island wall would assist in night-time operations. Dedicated channel markers are not seen as necessary for the inlet as the inlet structures themselves are the channel boundaries. Lagoon areas outside of the inlet throat may experience shoaling to a degree and problematic shoals should be monitored and marked appropriately.

An adverse warning system consisting of clear signage and flashing (yellow) lights to warn boaters of “adverse boating conditions” is relatively cheap and easy to install at the inlet. Lights and signs should be posted at the western entrance to the inlet to warn boaters before they enter the constricted area within the throat. The warning system should be tied to locally issued small craft advisories. When a small craft advisory is issued, then the flashing lights should be turned on. Signage would explain that when activated, the flashing lights mean that conditions are hazardous and vessels operators should take caution and/or avoid traversing the inlet. Additionally, the warning system can be linked to a simultaneous warning message posted on the County's inlet web cam.

Increased boater education may be accomplished by focusing on inlet users. Specifically, the City-owned boat ramp immediately west of the inlet is highly utilized by local boat owners. Providing pamphlets or flyers on boating safety, along with explanations of how to assess sea conditions before going out on the water and how to avoid problems navigating inlets may result in fewer inlet-related incidents. Similar educational material can be provided to local boat owners through the various marinas, boat dealers, and dry stack facilities in the area. If the adverse conditions warning system is implemented, it should be formally announced and advertised as a tool for boaters.

Implementation of any plan is a process that needs to be understood. The time it may take to permit, design, bid and initiate contracts for construction will vary depending on the overall complexity and size of the project. Before any action is taken, open dialogue with the Inlet Steering Committee and the landowners must be initiated. Palm Beach County's Parks & Recreation Department is the "property owner", and the County's Department of Environmental Resource Management is responsible for maintaining the inlet and beaches. Thus any proposal that would impact either the property or the operation of the inlet must be reviewed and approved by the County. The Inlet Steering Committee includes representatives from various municipalities and County organizations. The committee was organized as a collective body of representatives who have a vested interest in the inlet. Feedback from the committee on the results of this study was received during the November 2007 workshop.

The permitting process is likely to be the longest lead item leading to construction and for any of the inlet expansion options (Alternatives 1 – 5) as it would require filing a Joint Coastal Permit application (JCP). Key regulatory agencies that are likely to be involved in this process include Florida Department of Environmental Protection, Florida Fish and Wildlife Conservation Commission, State Historic Preservation Officer, Environmental Protection Agency, National Marine Fisheries, and the U.S. Army Corps of Engineers. The application process for a complex project such as this would require extensive studies, dedicated funding sources, and could take several years to complete without any guarantee of approval. Similarly, maintenance dredging of the ebb shoal would also require filing a JCP, but would not likely require extensive studies and approval is more likely than for other, more impactive, structural alternatives.

The City of Boynton Beach may choose a single option or combination of alternatives outlined herein for further investigation and should initiate a path forward by presenting this decision to the Inlet Steering Committee.

References:

ASCE Manuals and Reports on Engineering Practice No. 50. *Planning and Design Guidelines for Small Craft Harbors*. 1994.

American Sportfishing Association. Data & Statistics. Internet Source (www.asafishing.org/asa/statistics.htm).

University of Florida. *Hydraulic Study for South Lake Worth Inlet*. Coastal Engineering Laboratory. College of Engineering. April 1964.

Coastal Everglades Restoration Plan. *Draft Lake Worth Lagoon Conceptual Ecological Model. Appendix A*. January, 2004.

Coastal Planning & Engineering, *South Lake Worth Inlet Engineering Alternatives Analysis.* July 1998.

Coastal Planning & Engineering, *South Lake Worth Inlet Management Program.* September 1998.

Coastal Planning & Engineering, *South Lake Worth Inlet Management Program Update.* January 2004.

Florida Fish & Wildlife Conservation Commission. Boating Incident Reports (2005 – 2006)

Florida Inland Navigation District. *Update of the Economic Analysis of the District's Waterways in Palm Beach County*, December 2006.

Marine Industries Association of Palm Beach County. *Economic Impact of The Marine Industry in Palm Beach County*. Internet Source (www.marinepbc.org/pages/impact.htm).

Olsen Associates. *South Lake Worth Inlet Sand Management Plan. Technical Report.* December 31, 1990.

Palm Beach County Department of Environmental Resource Management, *Seagrass Monitoring in Lake Worth Lagoon. Final Cumulative Report for 2000 – 2004.* March 2005.

Palm Beach County Department of Environmental Resource Management. *Cumulative Report of Seagrass Monitoring Conducted During 2001, 2002 & 2003..* October 31, 2003.

Palm Beach County Department of Environmental Resource Management. *Understanding the Lake Worth Lagoon*. Pamphlet.

Palm Beach County Department of Environmental Resource Management. *Lake Worth Lagoon Monitoring Project. Final Report.* Revised November 2003.

Palm Beach County Department of Environmental Resource Management. *Lake Worth Lagoon Management Plan Revision.* May 2007.

Palm Beach County Department of Environmental Resource Management. *Palm Beach County Manatee Protection Plan.* July 2007.

Palm Beach County Department of Environmental Resource Management. *History of Palm Beach County Inlets.* Web Document. http://www.co.palm-beach.fl.us/erm/enhancement/Images/PDF_Documents/history_inlets.pdf

Recreational Boating and Fishing Foundation. *Understanding the Relationship Between Recreational Boating and Fishing Participation: A National Survey. Quick Facts.* Internet Source (www.rbff.org).

Sun-Sentinel. *Danger on Our Waters.* Article, May 2, 2007. Writer: Leon Fooksman.

USACE, EM 1110-2-1615. *Hydraulic Design of Small Boat Harbors*. 1984.

USACE, EM 1110-2-1100. *Hydrodynamics of Small Inlets*. 2006.

Villanueva, M. *Palm Beach County Boat Study*, University of Miami, Boating Research Center. 1994.

Personal Communications:

D/S Tom McElroy, Palm Beach County Sheriff's Marine Enforcement Unit officer, October 2, 2007. (Telephone)

D/S Travis Keene (#6343), Palm Beach County Sheriff's Marine Enforcement Unit officer, October 2, 2007. (In person)

Palm Beach County Lifeguard (Ocean Inlet Park), October 2, 2007. (In person)

Captain Phil Wotton, Palm Beach County Ocean Rescue South District, October 24, 2007 (Telephone and e-mail)

Don May, Chief of Ocean Rescue, Palm Beach County, October 17, 2007. (Telephone)

Mr. Sandy Daniel, FDOT Contractor, October 8, 2007. (Telephone)

Florida Fish & Wildlife Conservation Commission, Mollyann Williams, October 9, 2007. (Telephone)

Captain Amy Tolderlund, Vice President Marine Industries Association Palm Beach County, October 23, 2007. (In person)