1. Introduction

Lee County faces a daunting planning dilemma: how to balance the phenomenal growth of its boating population with conservation and management of its estuarine resource. Estero Bay is the focus of the Phase 1, Regional Waterway Management System for Lee County; a collaborative effort by the Lee County Division of Natural Resources, the West Coast Inland Navigation District, and the University of Florida Sea Grant Program, to apply the latest science and technology to the region's waterway management issues.

The waters and adjoining shore ecosystems of Estero Bay are attractive, unique, varied, and vulnerable to boating pressures. Estero Bay, the location of Florida's first Aquatic Buffer Preserve, is fringed by expanding commercial and residential developments. The Bay serves as a mecca for boating enthusiasts; increased boat traffic and upland development create problems that are manifested in declining water quality and stressed habitat conditions, such as boat wake that washes away soil and sand supporting mangrove roots or boat contaminants that accumulate due to low tidal exchange within enclosed canal systems.

The pressures brought to bear on Estero Bay offer a glimpse of the challenges that are faced along the entirety of coastal Lee County. The quandary faced by private citizen users, planners, and elected officials is how to sustain and protect this coastal ecosystem without isolating people from nature. The Florida Sea Grant approach is to devise and use methods that allow for the simultaneous use and protection of coastal waters, while still maintaining the economic vitality of coastal communities. This approach is embodied in the report, which evaluates the human ecosystem (boat user) and waterway system (environment) jointly, concurrently, and spatially.

The report focuses on the technical aspects of waterway management and provides a planning tool and decision options to stabilize channel conditions in order to avoid further deterioration of bay resources. A detailed, comparative analysis of water depth and boat draft relations, within Estero Bay, provides a comprehensive overview of channel conditions and the geographic distribution and severity of waterway restrictions. Two planning options are illustrated: (1) normal low tide conditions and (2) below normal (winter Cold Front) conditions. Data for a third option is presented: (3) adjusting waterway maintenance standards to the variable draft capability of restricted boats. The scientific approach presented in the report ensures a rational and objective method of waterway management.

In situations where dredging is selected as an appropriate management option, the prescribed dredge depth and width will depend on a number of factors, including regulatory and historical precedents, potential environmental impacts, draft characteristics of the present boat population, and cost. Designated controlling depths that have been established via permitting from the Florida Department of Environmental Protection (FDEP) may set practical limits to upstream dredge projects. A central tenet
of the Florida Sea Grant approach is that maintained, signed channels discourage resource depletion by encouraging boaters to stay within the channels and away from environmentally sensitive shoal areas. This approach also promotes safe navigation.

Cost, including spoil disposal, is another factor that influences the depth-to-dredge decision. Some restricted waterways are secondary access channels for which there is a clear public need to fully subsidize the maintenance of the waterway. Other waterways are residential canal systems where the maintenance cost should be borne by local citizen users. The Geographic Information System developed for the project provides the necessary information to identify where public/private partnerships may be required to cost-share local waterway restoration or improvement.

Estimated dredging requirements are provided for “trafficsheds”\(^3\) that contain waterway restrictions (Appendix D). The 20-foot wide improvement footprint used in the study conforms with the WCIND “surgical” approach to maintenance dredging adopted for regional waterway management in southwest Florida in order to minimize environmental impacts to bay resources.

2. Background

The Phase 1 Regional Waterway Management System for Lee County provides the scientific base and information necessary to meet the waterway management needs of waterfront neighborhoods on and near Estero Bay, in a region extending from the Collier County line northwest to Boweditch Point, including Hurricane Bay and the navigable portions of the Imperial River, Spring Creek, Estero River, Mullock Creek, Ten Mile Canal, and Hendry Creek. The Phase 1 area includes approximately 112 miles of navigable waterways, 6123 boats, 9624 moorings, 3270 shore facilities, and 1514 boating-related signs. Information is presented on boats, channels, and potential dredging required to provide boats with waterway access from berths to secondary channels and, ultimately, to deep, open water—the point at which a vessel is no longer restricted to a channel\(^4\).

The report is based on regional (1:24,000) and large-scale (1:2400) mapping of water depth, boat and facility characteristics, signage, and habitat. A detailed analysis

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\(^3\)The term trafficshed is used to define an area that contains a concentration of boats that use a common channel, exclusive to the trafficshed, to gain access to secondary access channels and, ultimately, to deep, open water. Secondary access channels generally correspond to the "Minor Boating Channels" shown on A Boaters Guide to Lee County, published by the Lee County Environmental Services Division.

\(^4\)For the purpose of this report, deep, open water—defined as a function of vessel draft—begins at that location in the transit of a vessel, from its berth, beyond which the vessel is no longer restricted to a channel because of environmental or depth limitations. Deep, open water for some vessels may occur within Estero Bay and for others in the Gulf. The location of what is considered deep, open water also can be associated with the aggregated draft characteristics of a trafficshed or a boating region.
delineates and quantifies, at ½ ft resolution, levels of boat accessibility to open bay waters and the location and extent of channel depth restrictions.

The methodology and objectives of the Lee County Project stem from a pilot study (Antonini and Box, 1996) conducted by Florida Sea Grant (FSG) and the West Coast Inland Navigation District (WCIND). The pilot study, designed for southwest Florida waterways, was a test application of a management system that is consistent with municipal, county, Florida Department of Environmental Protection (FDEP), and WCIND goals of facilitating safe boating and reducing boating impacts on natural resources. The design criteria are: (a) fit channel maintenance to boat draft needs; (b) minimize impacts on bay habitats; (c) prioritize and evaluate management alternatives on a regional scale; and (d) identify information products, for boaters and shore residents, that encourage environmental awareness by users of neighborhood waterways and boat access channels.

Results from the pilot study, and from follow-up studies in other areas (Antonini et al., 1998; Swett et al., 1999), prompted the Lee County Board of Commissioners to authorize the evaluation of Lee County waterways. The Phase 1 results presented in this report provide the County with a rationale and method for implementing a Regional Waterway Management System for Estero Bay and its tributaries containing the following elements: (a) documentation of existing depths; (b) establishment of maintenance dredging requirements according to user draft specifications; (c) placement of signs to conform with boat density and traffic patterns; (d) management of boat traffic based on detailed knowledge of boat distributions and travel routes; (e) siting of habitat restoration to protect waterways; (f) regional scale permitting to accommodate water-dependent uses and to minimize environmental impacts; and (g) educating the public, using waterway maps and guide materials, to instill stewardship and best boating practices. A Memorandum of Agreement (MOA), signed by the FDEP, FSG, and the WCIND (September 26, 1997), provides the required, state-approved framework for a Regional Waterway Management System that is needed to implement the study results (Appendix A).

3. Information Base

Florida Sea Grant conducted three separate types of on-the-water surveys in order to obtain: (1) tide-corrected depths of waterway access channels (January–July 1999); (2) the location and characteristics of boats, moorings and related facilities (January–May 1999); and (3) the location and characteristics of signs (June–July 1999). Shoreline, generalized land use/land cover characteristics, mangrove and sea grass information was obtained from the South Florida Water Management District (SFWMD) and the Florida Marine Research Institute (FMRI). One-meter resolution, 1994-95 U.S. Geological Survey digital orthophoto quarter quadrangles (DOQQ) in JPEG format were obtained from the Florida Resources and Environmental Analysis Center (www.labins.org).
This report presents boat, channel, signage, and habitat information for four boating regions located within the Lee County Phase 1 project area (Figure 1). The division of the project area into boating regions is based on the primary routes that boats are assumed to travel to reach Gulf waters through Matanzas Pass, Big Carlos Pass, and Big Hickory Pass. Boats are assigned to a primary route to facilitate the analysis of channel and boat restrictions.

South Estero Bay (Region 1) includes boats from the Collier County line to Big Carlos Pass. The majority of boats (1656) in Region 1 are routed to Big Carlos Pass and New Pass, however, 50 boats located in the vicinity of Big Hickory Pass are routed through that pass. Central/North Estero Bay (Region 2) includes boats on Hendry Creek, Mullock Creek, Ten Mile Canal, and the Estero River. The primary destination designated for boats in Region 2 is Big Carlos Pass. Big Carlos Pass Vicinity (Region 3) includes boats located on Estero Island, from Fairview Isles to Big Carlos Pass. Matanzas Pass Vicinity (Region 4) includes boats on Estero Island from Indian Bayou to Matanzas Pass, and the area surrounding Hurricane Bay. The majority of surveyed boats and channels within these regions are associated with trafficshes. A traffished is defined as a boat source area with a navigable channel that provides access to a secondary channel5 (Figure 1). Secondary channels ultimately lead to deep, open water--the point at which a vessel is no longer restricted to a channel.

Boat and channel characteristics are reported for individual trafficshes. Special consideration also is given to situations where primary and secondary channels provide access to two or more trafficshes or to boats that are not located within a traffished. This situation occurs in every boating region, but is particularly notable in the Matanzas Pass Vicinity (Region 4), where one-third of all boats have direct access to secondary channels and, thus, are not associated with a particular traffished.

The following presents a general overview of key site conditions.

a. Trafficshes. The study identifies 47 trafficshes in the Lee County Phase 1 project area. Eleven trafficshes are located in Region 1, from the Collier County line to Big Carlos Pass; three within Region 2: Central/North Estero Bay; four within Region 3, from Fairview Isles to Big Carlos Pass; and twenty-nine in Region 4, from Indian Bayou to Matanzas Pass. Table 1 and Figure 2 present regional and summary data on the distribution of boats by boating region and boat source area, and Appendix D provides details for each traffished.

b. Boats. The boat census observed 6123 boats6 berthed on Phase 1 Lee County water bodies or stored on salt-water accessible parcels (Table 2).

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5Secondary channels generally correspond to the "Minor Boating Channels" shown on A Boaters Guide to Lee County, published by the Lee County Environmental Services Division.
6This total excludes 24 derelict vessels located in the Lee County Phase 1 Project area. A derelict vessel is defined to include 1) vessels identified and marked by the DEP and 2) vessels, though not marked by the DEP, determined by Sea Grant personnel to be abandoned at the time of the boat census. Derelict condition is included in the Derelicts GIS database.
Boat types are reported as speed, open utility (bass, skiff, john, pontoon), recreational fishing, sail, row (kayak, canoe), power cabin and trawler, other (ferry, safety, law enforcement, US Coast Guard, excursion, etc.), and personal watercraft. The characteristics collected for each boat include: facility, mooring type, length, age, make and model, draft (including draft adjustment capability), and the date the boat was surveyed.

c. **Facilities.** There are approximately 3270 boating facilities in the region.\(^7\) Facilities are reported as residential (single-family, multi-family), marina (including boatyard, yacht club), motel (including hotel, restaurant, shop), anchorage, government, other (vacant commercial properties, office buildings, or locales such as skating rinks or bowling alleys, etc.) (Table 3).

d. **Moorings.** The region includes 9624 "moorings", which are defined as boat locations that are either occupied (6123) or vacant (3501).\(^8\) Mooring types are reported as anchorage, beached or blocked, dry stack or hoist, mooring, ramp, seawall, trailer, and wet slip.

e. **Signage.** There are 1514 boating-related signs in the region: hazard warning (17), navigation guide (598), private ownership (470), resource protection (128), speed regulation (283), government (15), and other (3). All signs in the water and along the waterfront, visible to the boater, are included in this inventory. Signage information includes site (bridge, dock, land, seawall, other, water), type (e.g., buoy, float, other, piling, structure), message, status (non-permitted, permitted, unknown), and condition (damaged, ok).

f. **Site.** Site characteristics include the general distribution of biological features within the water body; namely mangrove areas and sea grass beds (Figure 3). Mangrove forests are found along nearly all undeveloped shoreline in the

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\(^7\)The facility count was based on a cross-tabulation of the facility type, the parcel identification number (PID), a unique numerical identifier in the property ownership spatial database of Lee County assigned to each boat and mooring, and the parcel owner name. The facility counts should be regarded as estimates. In some instances, boats and moorings were designated as belonging to a single-family residence, however, there was no corresponding subdivision into single-family residences within the county property ownership spatial database. An example of this is a mobile home park. In these instances, unique identifiers were generated and assigned to these boats and moorings based on the judgment of the project staff. The project's analyst accomplished this by deciding to which parcel a boat or mooring belonged. The adjacency to the parcel of the boat or mooring was the primary criteria for transferring the parcel information. This type of problem is symptomatic of discrepancies between the two databases, which introduced a level of inaccuracy in assigning a facility designation to a parcel.

\(^8\)The PID was assigned to relate boats and moorings to parcel ownership information contained in the Lee County Property Appraiser spatial database. As in the case of relating facility type with parcel ownership, so too there are a number of factors that limit the utility of relating boats and mooring to parcel information. One factor is the 1-meter resolution digital orthophoto quadrangle (DOQs) obtained from the United States Geological Survey (USGS), which was utilized as the base map for the project. The DOQs provided the most consistent representation of physical features, such as shoreline, and land use/land cover for the project area. Boats and moorings were surveyed in the field utilizing GPS and, if necessary, their mapped positions were adjusted to the image base map. In order to transfer PID numbers to each boat and mooring, the image base map was overlaid with the property ownership spatial database. The degree of spatial correspondence between physical features from the base map and the property ownership database required some interpretation when assigning the correct PID to a boat or a parcel.
Phase 1 study area, excluding the upper reaches of some rivers, where salinity is relatively low. Mangroves cover most islands in the study area, except where removed by human activity. Sea grass is extensive in the study area, especially in the Central/North Estero Bay and Matanzas Pass Vicinity boating regions, where many channels pass through sea grass beds.

4. Field Surveys

a. **Depths.** Boat channels were identified by interpretation of section aerials and by field reconnaissance methods. Permitted and non-permitted channel markers were used for orientation wherever present. Field inspection guided final channel alignment. In some cases, it was necessary to perform multiple transects where shoaling was present. Personnel from the Lee County Division of Natural Resources and local boaters provided information about existing channel conditions for specific locations. When the depth survey was completed, county field staff examined maps of the surveyed boat channels to verify their location and the logical consistency of depth measurements.

A total of 22,859 depth points were recorded for all channel centerlines and approaches to boating facilities. A Trimble Pro XR Differential Global Positioning System (DGPS) with a beacon receiver was used to obtain the geographic position of each depth feature. Positions and measurements were logged using a Trimble TSC1 data logger and were plotted on 1:2400-scale section aerials in the field.

Depths are referenced to the navigation datum; mean lower low water (MLLW). Tide gauges were installed at six locations (Figure 4) during the data collection period, January–July 1999, and observers recorded supplemental tide data as needed. The University of Florida Department of Coastal and Oceanographic Engineering provided computer programs with which to correct depths to MLLW. (Depths in some Bayside Estates canals, isolated from tidal waters by a weir, are referenced to the “normal” water level maintained there, rather than to MLLW; the water was at approximately the desired level when the canals were sounded, so depths shown are as measured, with no further correction. On the Imperial River, upstream from the railroad bridge in Bonita Springs, depth is influenced more by stream discharge, which varies with precipitation, than by tides. Depths measured in that reach can not be meaningfully related to MLLW in the tidal waters downstream and in the channels leading to open water, so channel restriction analyses for the 28 boats surveyed there were begun at the railroad bridge.)

b. **Boats, Facilities, and Signs.** The positions and attributes of boat and waterway features were surveyed using a Trimble Pro XR DGPS with a beacon receiver and a TSC1 data logger. An Advantage range finder (Laser Atlanta Optics, Inc.) was used to determine the offset from the observer’s location to the position of
the surveyed feature. Information about the feature and its location also were plotted on 1:2400-scale section aerials.

c. **Data Editing.** A series of integrity checks was carried out on depth measurements, tide records, and all boat, facility and signage features. The logical consistency of attribute values and the accuracy of feature positions were ascertained. Discrepancies were verified in the field and corrected.

5. **Printed Data Products**

Printed data products provided to Lee County consist of thematic information portrayed at both trafficshed (1:2400) and regional (1:24,000) scales. The trafficshed-scale thematic information is contained in three 63-page atlases and the regional scale information in one 5-page atlas. All atlases contain an index of page numbers that overlies an aerial photo mosaic of the study region.

a. **Trafficshed-Scale Atlases**

1. **Bathymetry** - 22,859 soundings for channel centerlines and adjacent shoals. Depths are corrected to MLLW and presented at 0.5-ft resolution.

2. **Channel Depths, Boat Drafts, and Signage** - 22,859 soundings, presented in six depth categories (≤ 1 ft, 1.5 or 2.0 ft, 2.5 or 3.0 ft, 3.5 or 4.0 ft, 4.5 or 5.0 ft, and > 5.0 ft); boat draft (6123 vessels) presented in six draft categories (same units as depths); Signs (1514) presented in six categories: speed regulation, hazard warning, resource protection, navigation guide, private ownership, government.

3. **Analysis - Channel Restrictions,** defined as the difference between a channel segment depth and the maximum draft of vessels located up-channel, and portrayed in seven restriction classes (no restriction, 0.0 ft, 0.5 ft, 1.0 ft, 1.5 ft, 2.0 ft, and ≥ 2.5 ft); and Boat Restrictions (6123 boats, excluding derelict vessels), defined as the difference between boat draft and the controlling center-line depth and portrayed in seven restriction classes (same units as Channel Restrictions).

b. **Regional Scale Atlases**

1. **Bathymetry** – 22,859 soundings that pertain to channel centerlines and adjacent shoals. Depths are corrected to MLLW and presented at 0.5-ft resolution as color-coded symbols in four generalized depth ranges (≤ 2 ft, > 2 ft and ≤ 4 ft, >4 ft and ≤ 6 ft, and > 6 ft).

2. **Boats** – 6123 boats presented as color-coded symbols in four generalized draft categories (≤ 2 ft, > 2 ft and ≤ 4 ft, >4 ft and ≤ 6 ft, and > 6 ft).

3. **Facilities** - the distribution of wet and dry slips per facility. A facility is defined as the land use to which a slip is associated and includes the following categories: anchorage, government, industrial, marina, yacht club, boat yard, residence (single family or multi-family), motel, hotel, restaurant, or shop. A color-coded symbol,
graduated in size, indicates the number of slips per facility and is presented in six categories (1 slip, >1 to 5 slip, >5 to 10 slips, >10 to 50 slips, >50 to 100 slips, and >100 to 300 slips).

4. Signs - 1514 signs presented as color-coded symbols in message classes (e.g. bridge clearance, channel mark, crime watch, danger/hazard, shoal, etc.).

5. Mangroves and Sea Grass - the map shows the approximate location of mangroves and sea grass in the Phase 1 project area. The Florida Marine Resources Institute (FMRI) provided the mangrove and sea grass map data. The original sources of the mangrove coverage were (a) the U.S. Fish and Wildlife Service Wetlands Inventory, interpreted from 1:80,000 scale color infrared photographic prints obtained in 1972-73, and (b) mid-1980’s 1:56,000 color infrared prints and transparencies from the National High-Altitude Aerial Photography Project. FMRI personnel interpreted sea grass coverage from 1:40,000 scale aerial photographs made in 1990-94.

6. Geographic Information System (GIS) Data Files, Metadata, and Software Application

The present contract between FSG and Lee County, which is funded through the WCIND, includes delivery of GIS data files and corresponding metadata. The GIS database for the Phase 1 Lee County Regional Waterway Management System includes eight files: boats, boating access channels, access channel depths, derelict vessels, moorings, signage, trafficsheds, and the Map Atlas index. They have been provided to the County on a CD-ROM in ARC/INFO export format and as ArcView 3.X shapefiles. The metadata have been provided, consistent with federal standards for reporting GIS data descriptions.\(^9\)

During implementation of the South Sarasota County Regional Waterway Management System (Antonini et al., 1998), the WCIND commissioned the development of a customized ArcView (ESRI, Inc.) application to produce print copies of one or more atlas pages. This application was modified to include atlas pages for the Phase 1 project area and has been delivered to Lee County and to the WCIND. The application re-creates the printed atlases, which include the following layers, themes, and attributes, at the pre-defined 1:2400 (1in = 200 ft) scale:

(a) A background black-and-white image that consists of U.S. Geological Survey (USGS) digital orthophoto quarter quadrangles. The orthophotos have a spatial resolution of 1-meter and were derived from 1994-1995 color infrared photography.

(b) Water depth (0.5 ft increments adjusted to MLLW datum).

(c) Boat draft, presented as color-coded symbols in six draft classes: ≤ 1 ft, 1.5 or 2.0 ft, 2.5 or 3.0 ft, 3.5 or 4.0 ft, 4.5 or 5.0 ft, and > 5.0 ft.

\(^9\)A data dictionary describes each file and includes detailed information on identification, data quality, spatial data organization referencing, entities and attributes, distribution and metadata references.
Channel center-line depth, accurate to 0.5 ft and corrected to mean lower low water (MLLW), presented as color-coded symbols in six classes: ≤ 1 ft, 1.5 or 2.0 ft, 2.5 or 3.0 ft, 3.5 or 4.0 ft, 4.5 or 5.0 ft, and > 5.0 ft.

Signage (speed regulation, hazard warning, resource protection, navigation guide, private ownership, government).

Channel restrictions portrayed in seven classes: no restriction, 0.0 ft, 0.5 ft, 1.0 ft, 1.5 ft, 2.0 ft, and ≥ 2.5 ft.

Boat accessibility portrayed in seven restriction depth classes: no restriction, 0.0 ft, 0.5 ft, 1.0 ft, 1.5 ft, 2.0 ft, and ≥ 2.5 ft.

Upon starting the application, the user is presented with a view (page) showing an index of the study region that includes general land use/land cover and a variation of the USGS quarter quadrangle grid. Each individual index tile represents 1/16th of a quarter quadrangle and is labeled with a corresponding atlas page number. The user is able to select and print pages at the pre-defined 1:2400 scale. This application requires ArcView 3.X, running under Windows 95, 98, NT, or 2000, and access to the appropriate computer and plotting hardware. Further details are contained in the user notes found on the application CD-ROM.


The WCIND met with the FDEP Deputy Secretaries in September 1997 and discussed the state’s adoption of the waterway management methodology described in this report. The FDEP, at that meeting, signed a Memorandum of Agreement (MOA), wherein the agency states that it will work as a partner with FSG and the WCIND in implementing a regional waterway management system in WCIND waters (Appendix A). Since Lee County has taken the initiative by sponsoring these waterway evaluations, the county is well positioned to implement the study’s results by proposing to the FDEP an ecosystems-type approach to waterway management, including needed maintenance dredging, habitat restoration, and boat traffic management.

8. Results of the Lee County Project: Phase 1

a. Boats

The Lee County Phase 1 project area contains 6123 small-craft vessels (excluding 24 derelict vessels), which are in the water or on adjacent salt-water accessible upland parcels (Table 2). The majority consists of speed boats (24 percent), open utility (24 percent), and recreational fishing (23 percent); followed by sail (9 percent), kayak/row canoe (7 percent), and power cabin/trailer-types (6 percent). There are relatively few personal water craft (3 percent) at adjacent waterfront locations.
b. Trafficsheds

The term trafficshed is used to define an area that contains a concentration of boats that use a common channel, exclusive to the trafficshed, to gain access to deep, open water. This term refers to a unit of segmentation that was created to facilitate waterway management objectives. Segmentation into trafficsheds permits data generalization and reduction for GIS analysis and subsequent management recommendations.

The Lee County Phase 1 project area includes 47 defined trafficsheds. (Appendix D presents maps showing the location of each trafficshed.) Overall, 81% (4979) of surveyed boats belong to trafficsheds while 19% (1144) have direct access to secondary channels. Ninety-six percent (2951) of all boats from the Collier County line to Fairview Isles (Regions 1, 2, and 3) are situated within trafficsheds, whereas one-third (1016) of all boats from Indian Bayou to Matanzas Pass (Region 4) have direct access to secondary channels and are situated outside of defined trafficsheds (Table 1 and Figure 2). Sixty-two percent of all boats are found in one-fourth (12) of Phase 1 trafficsheds: Imperial River (934), Fish Tale Marina (466), Bayside Estates (350), Mullock Creek (321), Spring Creek (302), Siesta Isles (302), Fairview Isles (262), Mid-Island Marina (237), Estero River (165), Imperial Shores (163), Compass Rose (154), and Salty Sam’s Marina (147); 91 percent of all restricted boats are situated in trafficsheds that contain 15 or more boats (Appendix B).

c. Accessibility

Boat accessibility refers to the difference between a boat’s draft and the MLLW depth of the shallowest downstream channel segment that the boat must traverse to gain access to a secondary channel and, ultimately, deep water—the point at which a vessel is no longer restricted to a channel. Four levels of restrictions are denoted:

(a) Somewhat restricted (0.0 ft or 0.5 ft deeper).
(b) Restricted (1.0 ft or 1.5 ft deeper).
(c) Severely restricted (2.0 ft or 2.5 ft deeper).
(d) Blocked (3.0 ft or more deeper).

Forty-eight percent (2924) of all boats experience some degree of restriction. Of the restricted boats, 1913 (65 percent) are somewhat restricted and only experience problems within 0.5 ft of MLLW; 721 boats (25 percent) are restricted by 1.0 - 1.5 ft; 200 (7 percent) are severely restricted by 2.0 - 2.5 ft; and 90 (3 percent) are blocked by shoals ≥ 3.0 feet. A summary of the analytical results is presented in Table 4. Figure 5 shows a sample of the mapped results, which appear in the 63-page analysis atlases described on page 5.

The boats in the Phase 1 area may be grouped into three draft categories: shallow (0.5 to 1.5 ft); medium (2.0 to 3.5 ft); and deeper draft (4.0 ft and greater). Fifty percent (3034) of all boats have shallow drafts, 42 percent (2551) have medium drafts,
and 9 percent (538) have deeper drafts. Of all restricted boats, 39 percent have shallow drafts, 49 percent have medium drafts, and 12 percent have deeper drafts (Table 5).

Some boats—those propelled by outboards or inboards with out-drives—are capable of varying their draft by partially raising or lowering the outboard unit of the propulsion system. The accessibility analysis for these boats included two options: (a) normal running conditions, with the lower unit fully extended; and (b) shallow water running, with the lower unit partially raised, for temporary shoal operation (see Table 6). Seventy-three percent (2146) of the restricted boats have the ability to raise their lower outboard units (Table 6). These are concentrated at the lower end of the restriction levels, meaning that raising the lower unit by 0.5-1.0 ft would effectively eliminate, or substantially reduce, the restriction problem. The majority (98 percent) of the restricted boats with "variable draft" capability are in the 1.0 ft (139), 1.5 ft (806), 2.0 ft (770), 2.5 ft (253), and 3.0 ft (143) draft categories (Table 7).

d. Spatial Distribution of Restricted Access Boats

Restricted boats are unevenly distributed among the four Phase 1 boating regions. Regions 1 (South Estero Bay) and 2 (Central/North Estero Bay) include 37 percent of all boats (2248), but contain 61 percent (1777) of all restricted boats. In contrast, Regions 3 (Big Carlos Pass Vicinity) and 4 (Matanzas Pass Vicinity) contain 63 percent (3877) of all boats and 39 percent (1147) of all restricted boats (Table 8). Twenty-five percent of South Estero Bay restricted boats are limited solely by shallows located within common waterways, while 27 percent are limited solely by shallows within trafficsheds and 48 percent by restrictions located both within trafficsheds and common waterways. The majority of restricted boats in Big Carlos Pass Vicinity (97 percent) and Matanzas Pass Vicinity (58 percent) are limited by channel restrictions contained solely within trafficsheds.

Of the 1144 boats that are not located in trafficsheds (Figure 1), 147 are restricted solely by channel segments associated with secondary channels. The majority (112) is located in Matanzas Pass Vicinity, while five restricted boats are located in Big Carlos Pass Vicinity. Thirty restricted boats are located in South Estero Bay, 15 of which are routed to Big Carlos Pass and 15 to Big Hickory Pass.

Eight trafficsheds account for 75 percent (2205) of all 2924 restricted boats (Appendix B). Four of the eight trafficsheds are located in South Estero Bay and Central/North Estero; together, they account for nearly 50 percent of all restricted boats. The eight trafficsheds are (number of restricted boats listed in parentheses): Imperial River (798), Mullock Creek (259), Spring Creek (258), Siesta Isles (249), Bayside Estates (192), Fairview Isles (187), Estero River (141), and Imperial Shores (121).

An additional fifteen trafficsheds, each with 15 or more restricted boats, account for 16 percent of all restricted boats: Hendry Creek (54), Fish Trap Bay 2 (47), Salty Sam's Marina (44), Getaway (43), Mid-Island Marina (41), Compass Rose (40), Port Carlos Cove (39), Mobile Home Park (28), Bonita Beach (26), Pelican Landing (19),
Palermo Circle (17), El Sol (15), Fish Tale Marina (15), Laguna Shores (15), and McLaughlin Blvd. (15).

Ninety-one percent of all restricted boats are situated in these 23 trafficsheds, ten of which are in Matanzas Pass Vicinity, seven in South Estero Bay, and three apiece in Central/North Estero Bay and Big Carlos Pass Vicinity. The relative proportions of restricted boats at the twenty-three locations are shown by graduated dots on Figure 6.

e. Channel Restrictions

There are approximately 112 statute miles of waterways in the Lee County Phase 1 Project area. A total of 22,859 soundings were used to construct channel depth segments. The principal travel routes, which include some secondary channels and all trafficsheds channels, consist of approximately 105 miles of waterways. These principal travel routes were analyzed to determine the location and extent of restrictions (shoals) that impede boat traffic. Results of the analysis are presented in Tables 9a, 9b, and 9c. A sample of the mapped results (which appear in the trafficshed-scale atlases described on page 5) is shown in Figure 5.

Boat traffic is restricted on approximately 37 percent (38.7 mi.) of the principal travel route waterways. However, 48 percent of the restricted channel length (18.4 mi.) only impedes vessel transit by less than or equal to 0.5 feet at MLLW. The remaining 52 percent of restricted channel length consists of 13.9 mi. that restrict by 1.0 or 1.5 ft, 5.1 mi. that restrict by 2.0 to 2.5 ft, and 1.3 mi. that restrict by 3 ft or greater at MLLW (Table 9).

Fifty-two percent (20.0 miles) of the restricted channel length is found in the eight trafficsheds that contain 75 percent of all restricted boats (see 7d. Spatial Distribution of Restricted Boats). The sums of restricted channel lengths for these trafficsheds are: Imperial River (4.7 mi), Mullock Creek (4.0 mi), Spring Creek (3.0 mi), Siesta Isles (0.4 mi), Bayside Estates (1.1 mi), Fairview Isles (1.9 mi), Estero River (4.1 mi), and Imperial Shores (1.0 mi).

An additional 15 trafficsheds, with 15 or more restricted boats, contain 16 percent of all restricted channels (see 7d. Spatial Distribution of Restricted Boats). The sums of restricted channel lengths for these trafficsheds: Hendry Creek (2.5 mi), Fish Trap Bay 2 (0.5 mi), Salty Sam’s Marina (0.08 mi), Getaway (0.2 mi), Mid-Island Marina (0.06 mi), Compass Rose (0.2 mi), Port Carlos Cove (0.4 mi), Mobile Home Park (0.1 mi), Bonita Beach (0.3 mi), Pelican Landing (0.7 mi), Palermo Circle (0.3 mi), El Sol (0.2 mi), Fish Tale Marina (0.06 mi), Laguna Shores (0.2 mi), and McLaughlin Blvd. (0.2 mi) (Appendix C).

Twenty-two percent (8.7 mi.) of restricted channel segments are associated with secondary waterways that are located outside of trafficsheds and that provide service to a higher volume of boat traffic (Table 9b and Figure 7). Restrictions on secondary channels in Matanzas Pass Vicinity account for 12 percent (4.8 mi.) of all restricted segments and for 56 percent of secondary channels restrictions. However,
approximately one-third of these restrictions are related solely to 66 deep-draft (≥ 8 ft.) commercial fishing boats (e.g. shrimpers) docked north of the Matanzas Pass anchorage.

Channel restrictions on the secondary waterways of South Estero Bay account for 7 percent (2.9 mi.) of all restricted segments and 33 percent of restricted secondary channels. The principal channel restrictions, of greater than 1 foot, occur along a stretch that begins at the mouth of the Imperial River, passes through Fish Trap Bay and Intrepid Pass, and ends before the southern entrance to Hogue Channel (Figure 7). Additional restrictions occur where Hogue and Broadway Channels meet.

Ten percent (0.9 mi.) of secondary waterway restrictions occur in Central/North Estero Bay, in the vicinity of the confluence of Hendry and Mullock Creeks. These restrictions are 1 foot or less and could be accommodated by the 81 percent of upstream boats with variable draft capability. Boat traffic is restricted by 1/10th mile of secondary channels in Big Carlos Pass Vicinity (Figure 7).

f. Relation of Boat Accessibility to Channel Restriction

As stated in section d, above, 23 trafficsheds contain 91 percent of all restricted boats and 60 percent of the projected dredge for all restricted channels. The boat-channel relations for these locations are shown in Figure 8. Imperial River stands out from the remaining trafficsheds in terms of combined relative totals, followed by Mullock Creek, Spring Creek, Estero River, Fairview Isles, and Bayside Estates. As a group, these 6 trafficsheds account for 63 percent of restricted boats and 43 percent of estimated total dredge for the Phase 1 project area. For some locations, such as Siesta Isles, Salty Sam’s Marina, Mid-Island Marina, and Bonita Beach, estimated dredge requirements are low relative to concentrations of restricted boats. (For trafficshed-specific information on restricted boat counts and channel lengths (ft), see Appendixes B and C).

g. Projected Dredging Requirements

Dredging requirements are projected for all trafficsheds (Appendix D). Estimates are based on a 20-foot wide improvement footprint, which conforms with the WCIND “surgical” approach to maintenance dredging adopted for regional waterway management in southwest Florida in order to minimize environmental impacts to bay resources. This improvement footprint, along with the 5 ft margin setbacks for channel markers, is consistent with the WCIND standard of 30 ft wide navigation channels.

Tables 10 and 11 present an analysis for all trafficsheds and secondary channels in the study region. The ratio of Total Dredge (Tables 10 and 11, right-hand column) to Restricted Boats (Tables 10 and 11, left-hand column) gives a lumped per-boat dredge volume that is applicable within the trafficshed. For example, under the Normal Clearance option (Table 10), Imperial River, with 798 restricted boats and an estimated total dredge of 16,398 yd³ (within the trafficshed), would have a per-boat
dredge requirement of approximately 21 yd$^3$, whereas Mid-Island Marina would have an approximate per-boat dredge value of 3.4 yd$^3$. This ratio is an aggregated value that can be expected to vary within a trafficshed, since restricted boats and channel segments are spatially distributed. Estimates of required dredging were calculated using two scenarios:

i) Normal (MLLW = 0 ft datum) Depth Clearance (Table 10); and

ii) Additional Depth Clearance, which requires a 1 ft clearance between lowest point of boat and channel bottom (Table 11).\textsuperscript{10} Dredging amounts are in cubic yards and assume a base channel width\textsuperscript{11} of 20 ft.

Under Scenario (i) Normal Clearance, the amount of dredge required for a 100-ft channel segment restricted by 1.5 ft, is equal to the restriction amount, multiplied by a 20-ft base channel width, divided by 27 (27 ft$^3$ per yd$^3$), or approximately 111 cubic yards.

\[
\frac{[100 \text{ ft} \times 1.5 \text{ ft} \times 20 \text{ ft}]}{27 \text{ ft}^3 \text{ per yd}^3}
\]

Given the above assumptions, the depth of dredge equals the restriction level of the channel, e.g., a 0.0 ft channel restriction level requires no dredging, whereas a channel with a 2.5 restriction level would require a 2.5 ft depth cut.

Under Scenario (ii) Additional Depth Clearance, the same obstruction would require approximately 185 cubic yards:

\[
\frac{[100 \text{ ft} \times (1.5 \text{ ft} + 1.0 \text{ ft}) \times 20 \text{ ft}]}{27 \text{ ft}^3 \text{ per yd}^3}
\]

In this case, restricted channel segments would be dredged to the restriction level plus an additional foot, e.g., a somewhat restricted segment (0.5 ft restriction) would be dredged to 0.5 + 1.0 = 1.5 ft.

\textsuperscript{10}This may be considered an extended application of the FDEP Rule for Aquatic Preserve Waters, which requires, in non-man-made canals or previously un-dredged portions of coastal streams, a 1 ft clearance at the dock between the lowest point of the boat hull or fixed drive unit (whichever is lower) and any submerged bottom lands or tops of sea grasses.

\textsuperscript{11}There is great variation in channel width within the canals and waterways of Lee County. To account for the variation, a base channel width of 20 feet was used to calculate estimated dredge volumes for all restricted channel segments. This 20-foot base channel width, or improvement footprint, will accommodate the majority of recreational boats when two pass abreast of each other. There are locations, however, when a restricted channel will require either a width greater than 20 feet or can only accommodate a narrower width. For example, the marked channels within Estero Bay require a minimum width of 30 feet to accommodate the channel and the placement of navigation aids. To determine an estimated dredge volume that accounts for a wider or narrower channel, simply multiply the estimated dredge volumes contained in the report by the ratio of the required width and the base channel width. For instance, to adjust estimated dredge volumes to account for a required dredge width of 30 feet, multiply the estimated dredge volume within the report by a factor of 1.5 (30 feet / 20 feet). Conversely, to adjust for a 15 ft channel, use a factor of 0.75.
A comparison of the results between Normal (approximately 142,084 yd$^3$) and Additional (approximately 293,675 yd$^3$) shows that twice the amount of spoil would need to be removed, overall, to achieve the additional depth clearance. The top 23 trafficsheds which, combined, contain 91 percent of all restricted boats, represent 60 percent of the dredging needs of the Phase 1 area. Figure 9 shows the locations of these trafficsheds, which are represented on the map by graduated-size dots. The top six restricted trafficsheds account for 43 percent (61,407 yd$^3$) of projected dredging requirements for Normal Clearance (Imperial River, Estero River, Fairview Isles, Bayside Estates, Mullock Creek, and Hendry Creek); and they account for 47 percent (138,624 yd$^3$) for Additional Clearance (Imperial River, Estero River, Mullock Creek, Spring Creek, Hendry Creek, and Fairview Isles).

**h. Signage**

The study region contains 1514 boating-related signs. Forty percent (603) are in Matanzas Pass Vicinity, 35 percent (527) are in South Estero Bay, 13 percent (200) are in Central/North Estero Bay, and 12 percent (184) are in Big Carlos Pass Vicinity. Fifty-two percent of all signs (794) are in trafficsheds. Of all signs, 598 are navigation-type, 470 are categorized as private ownership, 283 post speed regulations, 128 are for resource protection, 17 are for hazard warning, 15 are related to government facilities, and 3 are classified as other. The most common type of sign is “piling” (48 percent) followed by those on structures (41 percent). Tables 12a and 12b detail this information.

**9. Special Management Considerations Warranted in Estero Bay**

Much of Florida's distinctive character lies in the beauty of its natural features, especially its coastlines. Only through careful preservation and management of these resources can the public's continued enjoyment of such activities as boating, swimming and fishing be ensured. To protect these distinctive natural features for the enjoyment of future generations, the Florida Legislature created aquatic preserves. The first aquatic preserve was established in Estero Bay in 1966.

As part of the Department of Environmental Protection's system of Aquatic and State Buffer Preserves, a stringent water quality classification, as identified in section 62-302.700 of the Florida Administrative Codes, governs all activities within Estero Bay. The aquatic preserve status is designed to promote conservation-oriented use. Permission may be authorized by the state regulatory agency (FDEP), on a case-by-case basis, to carry out water-dependent activities that must have access to sovereign lands and waters, because the activity requires it (e.g., recreation, transportation) and where the use of state land or water is an integral part of the activity. Examples of such cases include: public navigation projects, maintaining existing navigation channels; creating and maintaining commercial or industrial docks, piers, or marinas; creating or maintaining private docks for water access by riparian owners; and maintenance dredging for navigation right-of-way to docks.
A rational management policy for regulating public waterways must balance the needs of users with a careful consideration of natural resources and environmental limitations. An adequate and effective policy will require detailed information, such as boater characteristics or manatee use, in order to make sound management decisions.

10. Conclusions and Recommendations

The waterway management needs of Lee County are uniquely defined by the geography of boat source areas (tracsheds) and the secondary channels that service the tracsheds; there are waterways with many boats and areas with few boats. The relations of boat draft to controlling channel depth determine the degree of boat accessibility and channel restrictions. An understanding of these relations is fundamental to developing and implementing rational waterway management policy. The results of this study argue in favor of prioritizing channel improvements based on greatest need; they also highlight conditions within Phase 1 Lee County waters that should guide region-wide bay water use policies. A rational waterway planning policy must address both user needs and environmental limitations.

a. Short-term

1. The Phase 1 study results indicate that the greatest problems of boat access and channel restrictions occur in a relatively few tracsheds. The tracsheds that contain the greatest numbers of restricted boats are Imperial River, Mullock Creek, Spring Creek, Siesta Isles, Bayside Estates, Fairview Isles, Estero River and Imperial Shores; they account for 75 percent of the boat access problems and 52 percent of the channel restrictions. Lee County should concentrate initial waterway management efforts at these locations. Another fifteen waterways (Hendry Creek, Fish Trap Bay 2, Salty Sam’s Marina, Getaway, Mid-Island Marina, Compass Rose, Port Carlos Cove, Mobile Home Park, Bonita Beach, Pelican Landing, Palermo Circle, El Sol, Fish Tale Marina, Laguna Shores, and McLaughlin Blvd) account for an additional 16 percent of the boat access problems and 16 percent of the channel restrictions. In some cases, such as Siesta Isles, Bonita Beach, Mid-Island Marina, Salty Sam’s Marina, Mobile Home Park, and Fish Tale Marina, relatively short segments of channel restrictions impede relatively large numbers of boats: the high benefit-to-cost ratio is an incentive to make channel improvements at these locations.

2. Several secondary access channels serve two or more tracsheds and are heavily used by boaters to transit the Phase 1 project area or to gain access to Gulf waters. The high volume of boat traffic traversing these arteries makes them strong candidates for maintenance dredging. These secondary channels impact 1613 boats (55 percent) and account for 22 percent of the total length of restricted channels.

3. Additional assessment of the needs and operating habits of the deep-draft commercial shrimp boats that dock on the north side of Matanzas Pass should be considered in relation to secondary channel restrictions.
4. The waterway inventory information in the project’s GIS database has value and application beyond the bay water planning and management results presented in this report. This information should be reformatted and provided to shoreline residents and boaters in the watersheds targeted for waterway improvements, as Waterway Maps, showing channel center-line depths, boat facilities, and natural resource conditions. (The WCIND and FSG have produced similar maps of anchorages.) This information can sensitize users to the environmental conditions of the waterways and provide a basis for instilling stewardship and responsible boating practices.

5. Lee County should consider implementing these recommendations under the Memorandum of Agreement (MOA) for Regional Waterway Systems Management (Appendix A). This MOA is designed to offer local governments and local waterfront community organizations a mechanism to effect regional waterway improvements within an ecosystem, place-based management approach. The MOA provides an avenue for pursuing region-wide permit review and project applications. A proposal should be submitted to the FDEP that is countywide in coverage and comprehensive in scope. The proposal should be based on the results of this project covering Phase 1 county waters and on the results from Phases 2 and 3, which are currently in progress.

b. Long-term

6. Lee County and the WCIND have an investment in this Regional Waterway Management System. This system should be maintained and enhanced in order to respond to the county’s growing needs for rapid assessment and comprehensive geographic analysis of its bay water resources.

7. The Regional Waterway Management System can be strengthened by linkage to the county’s upland databases, which will facilitate response to more complex issues that transcend land-water boundaries. For example, sediment sources could be identified and their relative contribution to waterway shoaling quantified. This would allow for a more equitable distribution of maintenance dredging costs among those charged with waterway maintenance and those who contribute to shoaling.

8. The Regional Waterway Management System database should be updated periodically with countywide boat information. The WCIND has developed a preliminary plan based on revising the annual Vessel Registration Form. This plan, to incorporate information on boat type, draft and location onto the form, offers a systematic updating method that should be pursued through the County Tax Collector’s Office and the State Division of Motor Vehicles.

9. The bathymetric surveys should be updated, as needed, to identify shoaling conditions of the waterways. The WCIND is collaborating, through Florida Sea Grant, with the National Oceanic and Atmospheric Administration (NOAA) Marine Chart Division in a program to redesign coastal charts for recreational waterway users. There
are opportunities for Lee County to partner with this federal charting agency and thereby share survey information on a periodic basis.

10. The appropriate County department should be provided with the GIS equipment, software, and training to carry out waterway inventory and analysis, in order to respond to routine customer requests for information and technical services. The Florida Cooperative Extension Service and State University System should continue to provide institutional and professional support.

11. A measure of the success of the regional waterway management program is whether technical results are translated into meaningful benefits for local communities. A program that includes a strong boater education component will best address the diverse management needs of Estero Bay. The Lee County Marine Agent, a recently created extension education position that is jointly funded by Lee County and the University of Florida Sea Grant Program, is a timely resource for the dissemination of Project results at the local, community level. The Marine Agent can work with interested waterfront communities to help maintain their waterways, providing assistance in the form of project data, technical support, workshops, and field site inspections. Networking the community with permitting agencies and contractors, in order to develop community-based strategies to restore and maintain waterway resources, will increase the effectiveness of the Marine Agent. Boaters can play an active, critical role in determining whether to boat in a given area, what type of boating should occur, and what level of intervention is necessary.
References

