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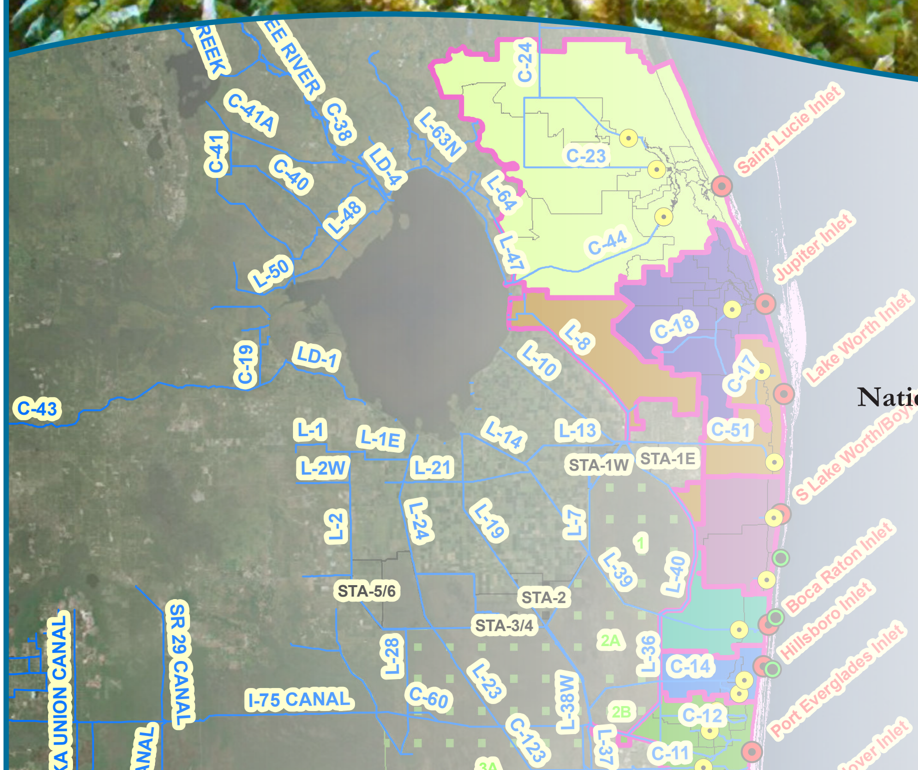
Watershed Scale Planning to Reduce Land-Based Sources of Pollution (LBSP) for the Protection of Coral Reefs in Southeast Florida

An Overview and Data Gap Assessment

January 2015



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Key data for understanding current watershed conditions were obtained from NOAA's Florida Coral Reef Tract (FCRT) project, NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML), SFWMD DBHydro and AHED databases, FDEP's STORET database, University of Florida's GeoPlan Center, NSU mapping data, and databases from the four counties in the study area.

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List of Relevant Acronyms

AFSIRS	Agricultural Field Scale Irrigation Requirements Simulation
AOML	NOAA's Atlantic Oceanographic and Meteorological Laboratory
ArcNLET	ArcGIS based septic tank nitrogen loading model
BOD	Biochemical Oxygen Demand
CBASE	Current Base Condition
C&SF	Central and Southern Florida
CEPP	Central Everglades Planning Project
CERP	Comprehensive Everglades Restoration Program
cfs	Cubic Feet per Second
CRE	Caloosahatchee River Estuary
CWA	Clean Water Act
CWNS	Clean Watersheds Needs Survey
DO	Dissolved Oxygen
ERM	Palm Beach County Division of Environmental Resources Management
ERP	Environmental Resource Permit
F.S.	Florida Statutes
F.A.C.	Florida Administrative Code
FACE	Florida Area Coastal Environment Program
FAS	Floridan Aquifer System
FCRT	Florida Coral Reef Tract
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
FEB	Flow Equalization Basin
FLUCCS	Florida Land Use, Cover, and Forms Classification System
GIS	Geographic Information System
ICA	Inlet Contributing Area
IRL	Indian River Lagoon
IRL-SPIR	Indian River Lagoon – South Final Integrated Project Implementation
IWR	Impaired Waters Rule
LBSP	Land-Based Sources of Pollution
LEC	SFWMD Lower East Coast
LOER	Lake Okeechobee and Estuary Recovery
LOFT	Lake Okeechobee Fast Track
LOP2TP	Lake Okeechobee Watershed Construction Project, Phase II
LOPA	Lake Okeechobee Protection Act
LORSS	Lake Okeechobee Regulation Schedule Study
LOSA	Lake Okeechobee Service Area
LOWSM	Lake Okeechobee Water Shortage Management
LWC	Lake Worth Central
LWL	Lake Worth Lagoon
LWN	Lake Worth North
LWS	Lake Worth South
NEEPP	Northern Everglades and Estuaries Protection Program
NERSM	Northern Everglades Regional Simulation Model
NOAA	National Oceanic and Atmospheric Administration

NSM	Natural System Model
NSU	Nova Southeastern University
OPTI	Reservoir Optimization Model
PBC	Palm Beach County
PD&E	Process Development and Engineering
PIR	Project Implementation Report
RECOVER	Restoration Coordination and Verification
RSM	Regional Simulation Model
RWPPB	River Watershed Protection Plan Base
RWQMP	Research and Water Quality Monitoring Program
SAV	submerged aquatic vegetation
SEFCRI	Southeast Florida Coral Reef Initiative
SFER	South Florida Environmental Report
SFWMD	South Florida Water Management District
SFWMM	South Florida Water Management Model
SJRWMD	St. John's River Water Management District
SLRWPP	St. Lucie River Watershed Protection Plan
SLE	St. Lucie Estuary
SLT	St. Lucie Tributary Monitoring Program
STA	Stormwater Treatment Area
SWIM	Surface Water Improvement and Management
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
UEC	SFWMD upper east coast
UF-	University of Florida
UF–IFAS	University of Florida–Institute of Food and Agricultural Sciences
USFWS	US Fish and Wildlife Service
USGS	U.S. Geological Survey
USNRCS	US Natural Resources Conservation Service
VEC	Valued Ecosystem Component
WaSh	Watershed Hydrology and Water Quality Model
WBID	Waterbody Identification (Number)
WCA	Water Conservation Area
WCD	Water Control District
WRAC	Water Resources Advisory Commission
WRDA	Water Resources Development Act
WSE	Water Supply/Environmental Regulation Schedule

Executive Summary

This project provides an assessment framework for evaluating the impacts of land-based sources of pollution (LBSP) on the coral reef ecosystem in southeast coastal waters Martin, Palm Beach, Broward, and Miami-Dade counties. Rapid population growth and intense increases in land development in this region over the past 50-100 years have put the coral reef ecosystem and supporting estuarine habitats under significant stress. Pollutants from these land-based human activities include nutrients (e.g. Nitrogen and Phosphorus), sediments, pathogens pharmaceutical and personal care products, and other LBSPs. These pollutants are discharged to the southeast Florida coastal ecosystem in large part in stormwater runoff (both urban and agricultural) and wastewater effluent and the management of stormwater and wastewater in southeast Florida affects the pollutants loads and ecosystem impacts.

The purpose of this document is to assist the National Oceanic and Atmospheric Administration (NOAA) and other Southeast Florida Coral Reef Initiative (SEFCRI) partners in tackling the problems associated with LBSP by identifying sources of pollution, data availability and gaps, and sources of information from past planning and management activities in southeastern Florida. This report creates a watershed-based framework for understanding and assessing the pollutant sources and loads, and uses nine coastal inlets in the region as the basis for defining the contributing watersheds. This report will provide a roadmap for future LBSP-related data collection and pollution reduction efforts in southeast Florida.

This document is organized into sections as follows:

1. Introduction
2. Overview of Project Area
3. Inlet Contributing Areas
4. Watershed Assessment and Planning Data Needs
5. Information Collection and Compilation Process
6. Discussion of Documented Levels of LBSP Impacts in Each ICA
7. Summary of Data and Data Gaps
8. Conclusions and Recommendations

This project mapped the linkage of land-to-inlet by delineating watersheds or inlet contributing areas (ICAs) to the nine inlets in SE Florida. Because the topography is extremely flat and the area is threaded with highly managed water canals, normal watershed delineation tools were not useful; therefore, the project used the hydraulic database (AHED) developed by the South Florida Water Management District (SFWMD) to identify the ICA boundaries. Flow directions and flow rates in the waterways often depend on the hydrological conditions at the given time; this study focused on the contributing areas associated with the “normal” or average condition. For the Intracoastal Waterway portions of the ICAs, published volumes of tidal prisms for each inlet were used to approximate the surface areas within each inlet. The salinity control structures (SCS), which represent the most upstream extent of salinity intrusion in each estuary, were also identified.

There are nine inlets in the study area that connect the Intracoastal Waterway with the Atlantic Ocean in the vicinity of the Southeast Florida coral tract (see Figure ES-1). These ICAs are as follows, from north to south:

1. St. Lucie Inlet
2. Jupiter Inlet

3. Lake Worth Inlet
4. Boynton / South Lake Worth Inlet
5. Boca Raton Inlet
6. Hillsboro Inlet
7. Port Everglades Inlet
8. Baker's Haulover Inlet
9. Government Cut Inlet

Watershed-based management is an effective approach for reducing pollutant loads that is documented and supported by the Environmental Protection Agency (EPA). The ICAs represent watersheds where watershed-based management could be implemented. EPA's Handbook describes nine elements that should be included in the structure of a watershed-based management plan. These elements are recommended for effective watershed management and required for any project to be eligible for funding under the Clean Water Act Section 319 grant program to reduce nonpoint source pollution.

Watershed planning begins with whatever information and data are available at the time. Additional data can be incorporated into the management plan as it is revised over time. Key data for understanding current watershed conditions falls into several key categories: geographic information, water quality data, flow data, and watershed mechanics (hydrology, geology, natural resources). The data for this project were obtained from NOAA's Florida Coral Reef Tract (FCRT) project, NOAA'S Atlantic Oceanographic and Meteorological Laboratory (AOML), SFWMD, Florida Department of Environmental Projection's (FDEP) STORET DATABASE, University of Florida's GeoPlan Center, Nova Southeastern University, and databases from the four counties in the study area.

These ICAs differ in the degrees of watershed assessment and planning efforts undertaken to date. The areas contributing to the St. Lucie Inlet, Jupiter Inlet and the Lake Worth inlets have clearly been the focus of more extensive watershed-based assessment and pollutant source assessment than the other ICA's. This report documents these data sources and assessments as a starting point for future efforts.

Wastewater management is a major element of watershed-based LBSP management. About 300 million gallons per day (mgd) of secondary treated wastewater effluent is discharged to the coral reef ecosystem one to three miles offshore via six ocean outfalls in the southeast Florida region. Current Florida law requires the ocean outfalls to be essentially phased out by 2025. Wastewater in the region is managed through a combination of onsite septic systems, small package plants, and centralized wastewater sewer and treatment systems. County maps of estimated and confirmed wastewater treatment for each parcel are presented in the report.

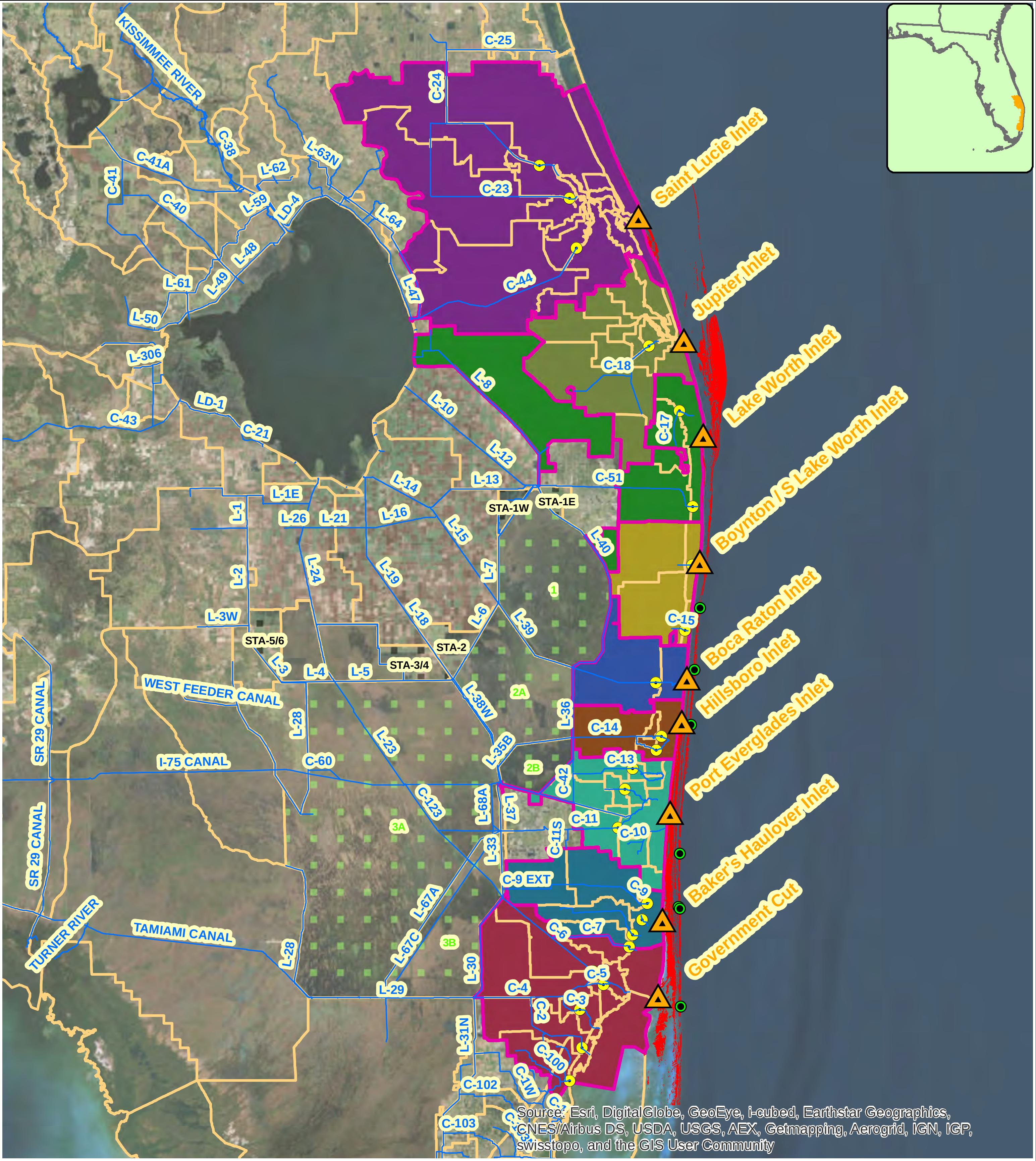
To compare the potential LBSP contribution from each ICA, a summary of land uses and a rough calculation of nutrient pollutant loads in each ICA are presented this report. The calculation used the land use runoff coefficients developed by SFWMD in the St. Lucie River Watershed Protection Plan and applied them across the entire SEFCRI region. This approach is only an approximate method, but is a useful first step in ranking loads from LBSP.

Data availability and data gaps for LBSP planning are assessed and presented in the report. Basic water quality data for parameters (nitrogen, phosphorus, sediments, and salinity) relevant to LBSP were used. Data useful for estimating LBSP loads to the estuarine systems were evaluated from flow and water concentration measurements at the identified salinity control points, since they represent the input locations to estuaries. Estuarine responses to LBSP loads were estimated using monitoring data extracted from the Impaired Waters Rule (IWR) database maintained by FDEP for connected surface water bodies. The extracted data were evaluated in terms of the number of stations, number of measurements, and period of record.

In addition to water quality and flow monitoring data, we examined the information assembled for this project and identified a host of relevant information that can be used to evaluate runoff, infiltration, tidal flushing of pollutants in the estuaries, and pollutant loading from wastewater discharges. Some of these data were developed for specific areas of the SEFCRI Region but can be applied to other areas as a means of developing preliminary analyses.

As a result of the assessment of existing information in the region, this report makes the following recommendations for next steps:

- In the short term, begin to fulfill the elements in a watershed-based management plan by:
  - Holding ICA-specific focus groups to identify impacted receiving waters and identify known LBSPs;
  - Prioritizing major known problems using local knowledge and information in this report;
  - Extrapolating known information from the well-studied ICAs to the others (for example, the pollutant loads estimated in this report can be used); and
  - Identifying potential funding sources and partners.
- In the long term, make changes to monitoring strategies to:
  - improve the precision of these land use based pollutant load estimates for each ICA; and
  - increase the sampling intensity in the estuarine sampling programs in each ICA
- In the long term, develop simple models to help frame the pollutant sources and magnitudes, specifically:
  - Develop estuarine models of nutrient and sediment transport;
  - Develop hydraulic models of the entire southeast coast and estuaries to better understand the how polluted freshwater impacts the coral reefs; and
  - Perform a qualitative assessment or develop a simple shallow groundwater model of the southeast coast to better understand how shallow groundwater impacts coral reefs.



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1 in = 16 miles

- Inlets
- Domestic Wastewater Outfalls
- Salinity Control Structures
- Canals
- SW Treatment Areas
- Conservation Areas
- Watersheds
- Inlet Contributing Areas
- Coral Reefs

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Horsley Witten Group
Sustainable Environmental Solutions

Inlet Contributing Areas in SE Florida

Date: 12/8/2014

Figure ES-1

1. Introduction

The purpose of this document is to provide National Oceanic and Atmospheric Administration (NOAA), the Southeast Florida Coral Reef Initiative (SEFCRI), and coral reef conservation partners with a baseline assessment of available data, as well as planning and assessment reports that are useful and necessary in the effort to reduce loads from land-based sources of pollutants (LBSP) to the Southeast Florida coral reef ecosystem. Valuable work has been performed to date by others in reviewing and summarizing the complicated issue of LBSP in southeast Florida as it pertains to the coral reef tract and supporting habitats. Two key documents that lay a foundation for this project are the Land Based Sources of Pollution Local Action Strategy Combined Projects 1 & 2 (Trnka, et al., 2006) and a Literature Review and Synthesis of Land-Based Sources of Pollution Affecting Essential Fish Habitats in Southeast Florida (Gregg, 2013). Our report provides a summary of LBSP information, including assessment and planning reports as well as data, organized by the inlet contributing areas (ICAs), or watersheds, that drain to the coral reef tract. It also identifies gaps in data, assessment and planning for LBSP reduction in the SEFCRI ICAs. The purpose for organizing the data and information according to ICA is to provide a starting point for watershed-based planning and to assist NOAA and SEFCRI in prioritizing LBSP reduction projects and funding that will be pursued.

The U.S. Coral Reef Task Force was established in 1998 to lead U.S. efforts to preserve and protect coral reef ecosystems. It includes leaders of 12 Federal agencies, seven U.S. States, Territories, and Commonwealths, and three Freely Associated States. The Task Force has been working to research and monitor the health of the coral reefs in Florida and elsewhere. A significant decline in certain species of corals has been observed, and efforts are underway to understand the reasons for the decline and to protect the remaining coral communities. NOAA is a partner in the Task Force and a leader in the Southeast Florida Coral Reef Initiative. NOAA is focusing significant effort toward understanding and assessing the LBSPs that are contributing to the decline of coral reef health in southeast Florida.

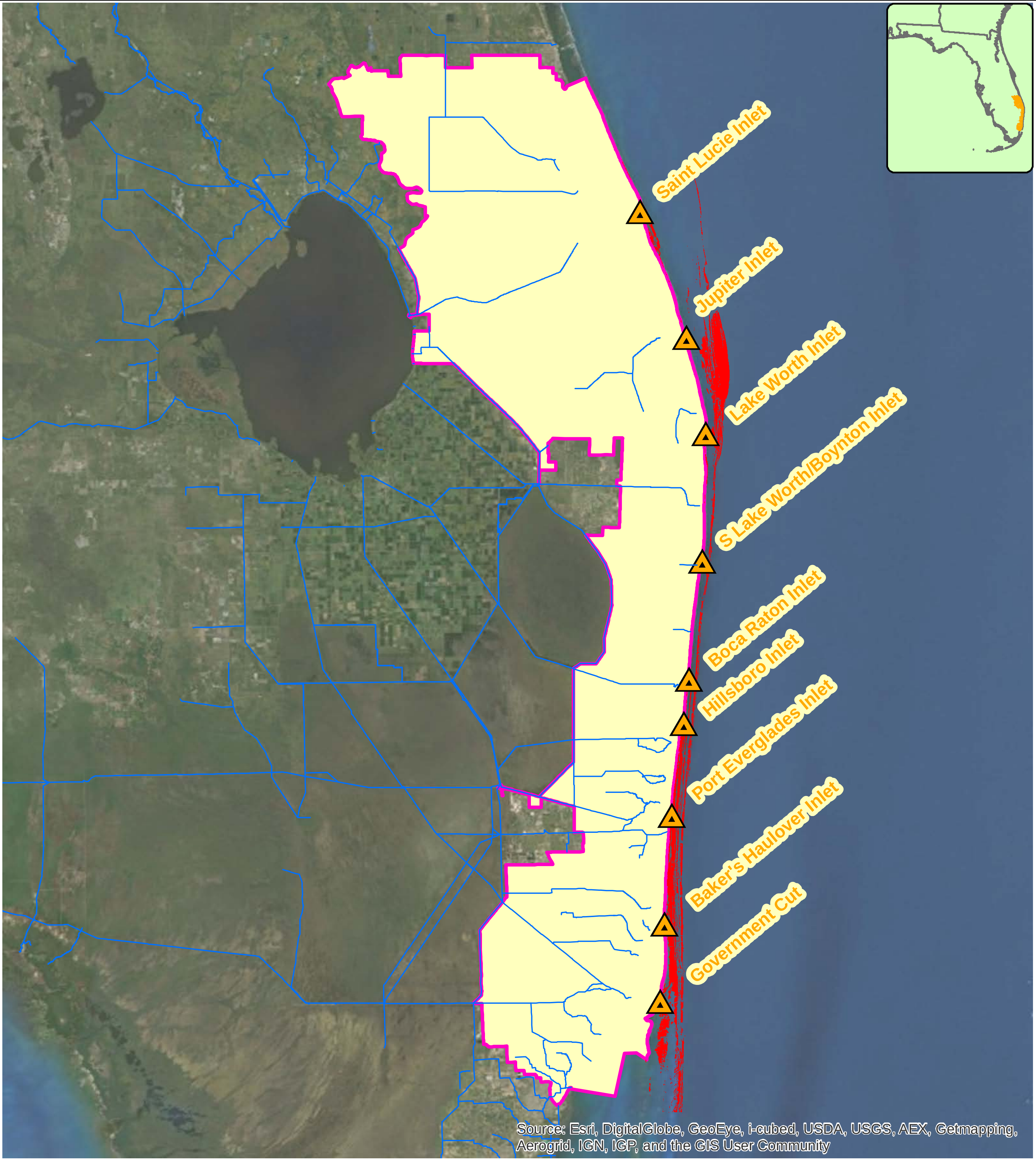
Rapid population growth and intense increases in land development in Southeast Florida are putting the coral reefs and the supporting estuarine ecosystems under significant stress. Pollutants from the human activities on land are known to have a severely detrimental effect on coral reefs. In particular, these pollutants include nutrients (nitrogen and phosphorus), pharmaceuticals, herbicides/pesticides/salinity, carbon dioxide, temperature, turbidity, sedimentation, and disease/pathogens/viruses/bacteria (Trnka, et al., 2006). The loads and concentrations of these pollutants that are carried to the estuaries and coral reef tract are likely to be dependent on whether it is a wet or dry season and the size of an individual precipitation event. In addition, the resulting impact from the pollutant on the receiving water and the reef ecosystem is likely to be dependent on the season. However, as is noted by the creation of the SEFCRI Water Quality Monitoring Project, the link between pollutant loading from LBSPs and the resulting impacts to the southeast Florida reef tract is still not clearly defined because there are simply not yet enough data and monitoring locations to document such links (Boyer, et. al., 2011). In addition, when pollutants of concern are part of the natural cycle in the ecosystem, as is the case with most LBSPs, it is difficult to trace them back specifically to their original sources. Instead, we must recognize the natural balance in the environment and be able to identify the pollutant concentrations that far exceed natural concentrations, and then make educated estimates of the pollutant loads contributed by land uses and other direct pollutant sources.

The coral reef tract in Southeast Florida is well characterized in Chapter 5, The Coral Tract of Continental Southeast Florida (Miami-Dade, Broward, and Palm Beach Counties, USA) of Coral Reefs of the USA (Riegl and Dodge, 2008). It is comprised of three reefs parallel to the coastline separated by sandy plains. The reef ecosystem includes the reefs themselves, as well as the estuarine environment that supports the fish and invertebrate communities on the reef. The biggest human induced threats to the southeast Florida reefs are: pollution, which promotes algal blooms and benthic cyanobacteria; coastal construction, which causes sedimentation on the reefs; and dredging projects, which also cause sedimentation and direct destruction to the reefs and supporting estuarine habitat (Riegl and Dodge, 2008). In addition, long-term discharges of large volumes of fresh water into the estuarine receiving waters via water management canals has also been shown to reduce the salinity in the estuarine receiving waters and cause episodes of significant damage and die-off in the estuarine ecosystems that support these coral reefs.

The purpose of this document is to assist NOAA and its partners in identifying what data exist and what level of planning and management activities have been undertaken to address LBSP that threaten coral reefs off the coast of southeastern Florida, and the estuarine ecosystems that support them. The web of research, data collection, regulation, water management and land use planning in Southeast Florida is complicated. This is due to a variety of factors. Many government agencies at the municipal, county, regional and state level participate in this 'web' in varying ways. The ICA land area that drains to the Southeast Florida Coral Reef tract is a very large area, covering approximately 2,500 square miles (30 miles east to west and 80 miles north to south), with a diversity of land uses and water management goals. Water in southeast Florida is highly managed with a network of major and minor canals to meet a variety of often-competing uses. The South Florida Water Management District uses a network of major canals, pump stations, flood mitigation projects, and water quality treatment projects to meet its mission "to manage and protect the water resources of the region by balancing and improving water quality, flood control, natural systems and water supply."

The study area is defined by inlet contributing areas (ICAs), or the area of land draining to an inlet under normal (average) hydrologic conditions. There are nine inlets in the study area that connect the Intracoastal Waterway with the Atlantic Ocean in the vicinity of the Southeast Florida coral tract (see Figure 1-1). These are as follows, from north to south:

1. St. Lucie Inlet
2. Jupiter Inlet
3. Lake Worth Inlet
4. Boynton / South Lake Worth Inlet
5. Boca Raton Inlet
6. Hillsboro Inlet
7. Port Everglades Inlet
8. Baker's Haulover Inlet
9. Government Cut Inlet



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1 in = 15.8 miles

Inlets

Canals

Inlet Contributing Areas

Coral Reefs

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ICA Study Area in SE Florida

Date: 7/3/2014

Figure 1-1

These inlets exchange water between the Intracoastal Waterway and the Atlantic Ocean, and deliver pollutants to the coral reef system. In reality, the Intracoastal Waterway is an initial receiving body in the ICAs, connecting all the ICAs to each other to a certain degree. However, the movement, exchange and mixing of water and pollutants in the Intracoastal Waterway and through the inlets to the Atlantic Ocean are not yet fully understood. Furthermore, they are complicated by intense weather conditions that can change wind, flow direction, and mixing for some interim period associated with a storm. This is an important gap in the available information for assessing and managing pollutant impacts on the Southeast Florida coral reef tract and the estuarine habitat that supports it.

This document is organized into sections as follows:

1. Introduction.
2. Overview of Project Area - Describes the general project area.
3. Inlet Contributing Areas - Describes the process by which the ICAs were delineated, and presents the ICA boundaries.
4. Watershed Assessment and Planning Data Needs - A General Discussion - Provides an overview of a watershed assessment and a watershed management plan, and describes the data that are needed to perform these tasks.
5. Information Collection and Compilation Process - Describes the process undertaken for this report to collect and compile data and assessment and planning documents for each ICA.
6. Discussion of Documented Levels of LBSP Impacts in Each ICA - Provides an overview of what impairments are observed or anticipated, and what LBSPs exist in each ICA.
7. Summary of Data and Data Gaps - Summarizes the body of currently available data and reports in the context of watershed assessment and management, and identifies major data and information gaps.
8. Conclusions and Recommendations - Provides a summary of the data gaps and basic prioritization of data and planning needs, presented as a list of recommended next steps.

2. Overview of Project Area

A. Description of Project Setting

South Florida's complex system of waterways is part of a vast management area from Orlando in the north, through Lake Okeechobee, to Miami in the south. Lake Okeechobee lies about 30 miles west of the Atlantic Ocean and 60 miles east of the Gulf of Mexico. The lake consists of a broad and shallow depression in bedrock and has a surface area of approximately 730 miles. Land levels around the lake fluctuate from 10 ft to 50 ft above sea level. Levees, pumping stations and other lake level-control structures surround the lake to respond to drought, flood conditions and water demands (USFWS, 1999).

The managed system of canals and waterways in South Florida provides habitats for the region's birds and wildlife and also provides ecosystem services such as flood control and water supply. The project area examines nine ICAs in South Florida in an effort to understand how water managed throughout the ICAs contributes to the ecosystem health of near shore coral reef systems. The inlets considered as part of the project area are listed below in order from the northernmost inlet, St. Lucie, to the southernmost, Government Cut.

1. St. Lucie Inlet
2. Jupiter Inlet
3. Lake Worth Inlet
4. Boynton / South Lake Worth Inlet
5. Boca Raton Inlet
6. Hillsboro Inlet
7. Port Everglades Inlet
8. Baker's Haulover Inlet
9. Government Cut Inlet

Coral ecosystems in southern Florida are vast, extending from as far north as the St Lucie Inlet on the Atlantic Ocean coast to the Dry Tortugas in the Florida Keys. These coral ecosystems depend on the health of the saltwater in which they reside. Water management efforts throughout the ICAs include practices of changing and managing flow and pushing freshwater from Lake Okeechobee into the ICA canals and inlets. As a result of moving freshwater throughout the ICAs and pollutant runoff into canals, changes in seawater chemistry may result in subsequent negative impacts on coral ecosystem health. It is the intent of this project to understand if and where water quality is monitored throughout the ICAs and present data gaps where more research, monitoring, and analysis might be needed to understand the effects of pollution and flow management on the Atlantic Ocean's coral ecosystems in South Florida.

B. Inlet Contributing Areas

The ICA is the watershed that drains from the land to the estuary and then out to the ocean through the inlet to the coastal waters. The ICAs to nine southeast Florida inlets were delineated to provide a framework for determining sources and loads of pollution via the inlets to the adjacent coral reefs. These ICA boundaries represent the normal hydrologic condition over time. However, ICA boundaries can shift as a result of extremely wet or dry conditions and the intensive management of the engineered hydrologic system in southeast Florida. This section describes the method used for delineation and presents maps of the final ICA areas.

1. Delineation of ICAs

The typical method of watershed delineation uses topographic information like contours or ground surface elevations to trace the drainage of water down the watershed from the highest point to the outlet. In urban areas, these flow paths are sometimes altered by existing stormwater infrastructure that change the natural drainage pattern and redirect flow through drainage pipes. In contrast, in southeast Florida, the slopes are so minimal and there is such an extensive canal drainage network, that the flow of water in a watershed is mostly governed by hydraulics, that is, the canals, the hydraulic structures, and the associated pumps and structures that move water through the network. Fortunately, the South Florida Water management District (SFWMD) has an extensive hydraulic database that captures much of this information.

The ICAs were delineated using the WATERSHED feature class in the SFWMD's ArcHydro Extended Database. The ICA boundaries were modified based on the flow direction in the HYDROEDGE feature class, published reports for the Saint Lucie watershed, and technical input from SFWMD personnel, including in particular Kevin Carter and Kenneth Konyha. The conservation areas to the western side of the study area (located in south central Florida) and some areas near Lake Okeechobee were excluded since that water either flows to Lake Okeechobee or to the Everglades.

The coastal portion of the ICAs encompassing the Intracoastal Waterway required special consideration in this delineation process. In many cases, the land in the ICA drains via an estuary to the Intracoastal Waterway before exiting to the ocean through one of the nearby inlets. In those cases, it is often unclear which inlet is the primary discharge point from the ICA to the coastal waters. This study used published volumes of tidal prisms (Banks, et al., 2008) for each inlet to approximate the surface area of water in the Intracoastal Waterway associated with each inlet. The tidal prism represents the amount of water moving through the inlet by tidal action. It should also be noted that strong winds from the north or south affect the direction of flow to inlets as water mounds up on the downwind end of the estuaries under these conditions.

The direction of flow in the canals and the corresponding ICA can change based on three principal hydrologic conditions: extremely wet conditions where the canal water is pumped into stormwater storage/treatment areas; normal flow conditions with minimal canal management; and extremely dry conditions where canal water is used to augment ground water supplies. Because the wet and dry conditions are less frequent events, it is likely that they have only a small effect on the average annual flow and nutrient loads. This study therefore focused on the ICAs associated with the "normal" condition. However, it must be recognized that some of these more infrequent hydrologic events, rather than average annual conditions, can have a significant effect on the receiving estuary that supports that coral reef system. In particular, significant influxes in fresh water from the canal system can be detrimental to the estuarine and nearshore coastal ecosystems. These unusual events must be looked at individually.

2. Identification of Salinity Control Structures

Salinity Control Structures (SCSs) were also identified for each ICA. The SCSs represent the most upstream extent of salinity intrusion in the estuary associated with the inlet and are important to manage saltwater intrusion in the water management canals.

HW visually identified the SCSs from maps displaying the STRUCTURES feature class in the SFWMD's ArcHydro Extended Database. These structures were then verified with technical input from SFWMD personnel.

3. ICA Maps

HW developed a series of maps showing the location of the nine inlet contributing area (ICAs) in southeast Florida in relation to the local geography and relevant water quality features. The WATERSHED and HYDROEDGE layers are from SFWMD's AHED database. Also shown are the SCSs and the domestic wastewater outfalls that discharge treated wastewater from nearby communities into the coastal waters. According to the Ocean Outfall Act (2008), these wastewater discharges will be phased out from 2015 to 2025. Stormwater treatment areas (STAs) and water conservation areas (WCAs) are displayed to the west of the ICAs; water from these areas rarely enters the ICAs.

Figure 2-1 shows the overall location of the nine ICAs in southeast Florida. In the electronic (pdf) version of this map, the WATERSHEDS layer can be turned on and off to show the watershed boundaries. Figures 2-2 to 2-10 show each individual ICA. In the electronic (pdf) versions of these maps, the HYDROEDGE layer can be turned on and off to show the existing canal details along with their flow directions.

The ICA boundary shapefile and the SCS point shapefile are both available through the NOAA Coral Reef Information System (CoRIS) as a result of this project.

C. Overview of Land Uses and LBSPs in the Project Area

Freshwater from both Lake Okeechobee and basins within the ICAs influences transport of contaminants, water quality, and aquatic habitat in the project area estuaries and inlets themselves. Land use in the eastern section of the project area varies somewhat, but in general, land closer to the Atlantic coast is urbanized, while land use further inland is designated for crop and animal agricultural production, as well as wetlands and forests. Animal agriculture is not as widespread as land used for crop production.

1. Crop and Animal Agriculture

The northernmost ICAs near Lake Okeechobee in the project area including St. Lucie, Jupiter, Lake Worth – and to some extent Boynton – exhibit significantly more agricultural land use. Forests and wetland areas also make up a large portion of these northern ICAs, especially Jupiter Inlet. Freshwater flows from inland agricultural production areas via ICA canals and estuaries and eventually to the coastal inlets. Crop fields and animal production can contaminate inland waterways by way of nutrient deposition in groundwater or runoff. Inlets are at risk of contamination from excess nutrients, such as nitrogen and phosphorous, which are transported throughout the ICA.

In addition to nitrogen and phosphorous, pathogens (indicated as a potential threat by the presence of fecal coliform bacteria) are another pollutant that makes its way into waterways. Fecal coliform bacteria come from the digestive tract of warm-blooded animals and have been used as an indicator for the potential of human pathogens in water. Pathogens and associated viruses can enter the water from many sources, including poorly maintained agricultural operations, stormwater runoff, and poorly functioning septic systems.

2. Urban Areas

Coastal ICAs in the project area are mainly urbanized with minimal agriculture, wetland and forest land use designations. The southern ICAs in the project area - Boca Raton, Hillsboro, Port Everglades, Baker's Haulover, and Government Cut – devote a very small portion of land use to agriculture. While this indicates that nutrient transport and contamination from agricultural production may be lower, some of the northern ICAs will likely still experience contamination from stormwater runoff due to an increase in impervious surfaces such as rooftops and pavement for sidewalks, parking lots, roads and highways. In addition to stormwater runoff, contamination from leaking sewer lines and combined sewer overflows during heavy rain events can contribute to waterway contamination in urban areas of the ICAs.

The distribution of land use categories within each ICA is mapped in Figures 2-11 through 2-19 and presented in Table 2-1, and the percentage of total ICA land area occupied by each land use category is presented in Table 2-2.

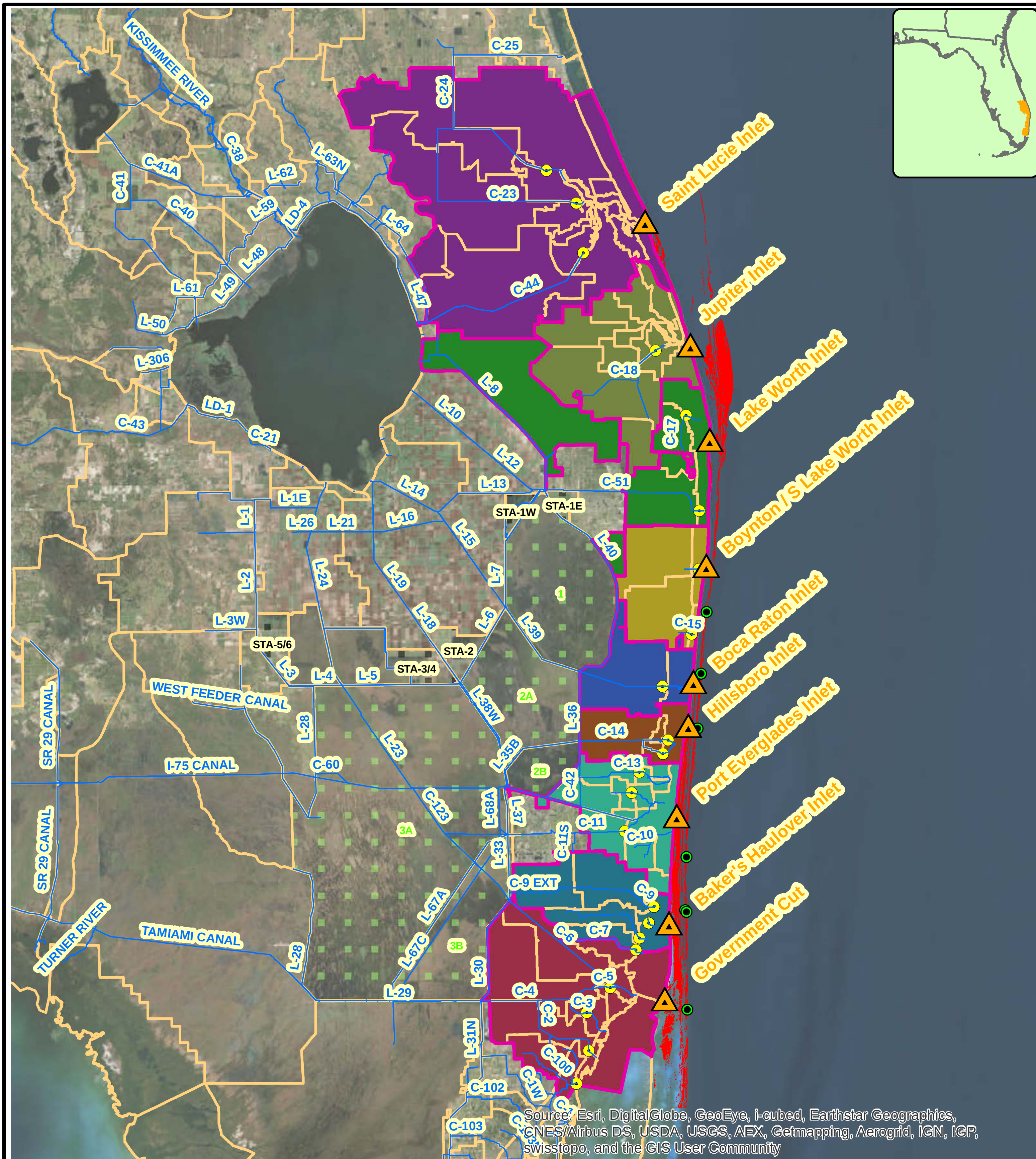
As demonstrated in Tables 1 and 2, urban land accounts for nearly half (46%) of land use across the project area. Crop agriculture (20%) is far more predominant than animal agriculture (0.3%). Among ICAs, crop agriculture is most prevalent in the St. Lucie ICA (49%) with the next highest percentage in the Boynton ICA (10%). The St. Lucie and Government Cut ICAs have the most water/wetlands at 28% and 22%, respectively, out of a total of 601 square miles of wetlands in the project area.

Table 2-1. ICA Area (Square Miles)

ICA Name	Urban/ Trans	Crop Agriculture	Animal Agriculture	Water/ Wetlands	Open/ Forest	Total
St Lucie Inlet	176.3	430.4	3.3	167.4	99.7	877.2
Jupiter Inlet	69.1	27.2	0.4	118.1	67.6	282.5
Lake Worth Inlet	143.2	27.4	1.7	95.0	50.5	317.9
Boynton / South Lake Worth Inlet	108.1	14.5	1.1	16.7	3.8	144.1
Boca Raton Inlet	84.8	6.6	0.5	14.5	6.3	112.7
Hillsboro Inlet	71.4	0.0	0.0	7.3	1.6	80.3
Port Everglades Inlet	148.7	1.0	0.1	18.9	5.3	174.0
Baker's Haulover Inlet	132.0	1.6	0.0	32.0	5.3	170.9
Government Cut	224.6	4.2	0.0	131.1	11.9	371.7
SUM	**1158.2**	**513.0**	**7.1**	**601.0**	**252.0**	**2531.3**

Table 2-2. ICA Area (Percent of Total)

ICA Name	Urban/ Trans	Crop Agriculture	Animal Agriculture	Water/ Wetlands	Open/ Forest	Total
St Lucie Inlet	20.1	49.1	0.4	19.1	11.4	100.0
Jupiter Inlet	24.5	9.6	0.1	41.8	23.9	100.0
Lake Worth Inlet	45.1	8.6	0.5	29.9	15.9	100.0
Boynton / South Lake Worth Inlet	75.0	10.1	0.8	11.6	2.6	100.0
Boca Raton Inlet	75.2	5.9	0.4	12.9	5.6	100.0
Hillsboro Inlet	88.9	0.0	0.0	9.1	1.9	100.0
Port Everglades Inlet	85.5	0.6	0.1	10.8	3.1	100.0
Baker's Haulover Inlet	77.3	0.9	0.0	18.7	3.1	100.0
Government Cut	60.4	1.1	0.0	35.3	3.2	100.0



Legend

N

1 in = 16 miles

- Inlets
- Domestic Waste-water Outfalls
- Salinity Control Structures
- Canals
- SW Treatment Areas
- Conservation Areas
- Watersheds
- Inlet Contributing Areas
- Coral Reefs

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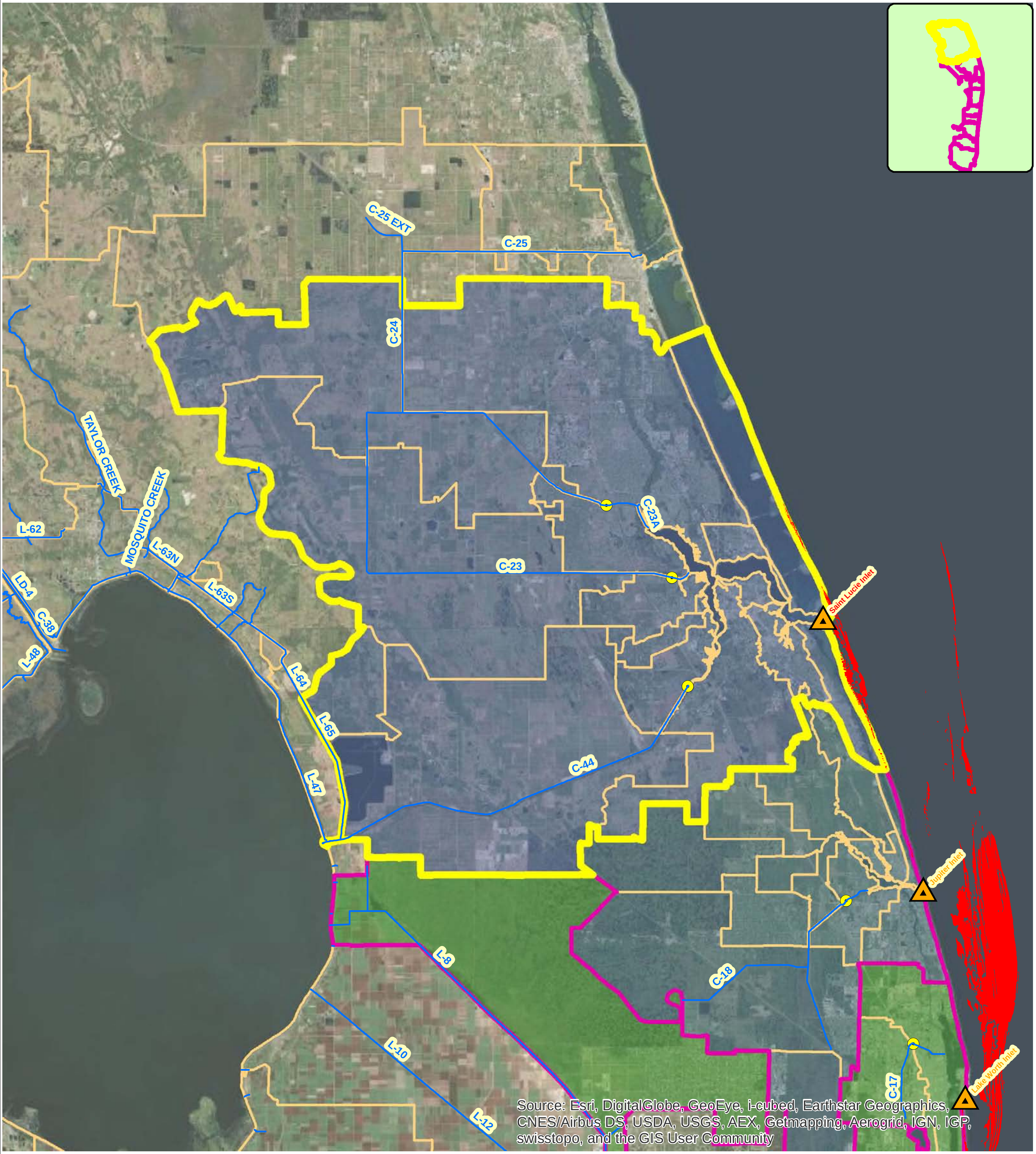
Inlet Contributing Areas in SE Florida

Date: 11/25/2014

Figure 2-1

Path: C:\Shared\Projects\13107 TO 4.7 Southeast Florida LBSP\GIS\Maps\141125_ICAs_Overall_Small_13107.mxd



Legend

N

1 in = 7.3 miles

- Inlets
- Domestic Wastewater Outfalls
- Salinity Control Structures
- Canals
- Flow Lines
- SW Treatment Areas
- Conservation Areas
- Watersheds
- Inlet Contributing Areas
- Coral Reefs

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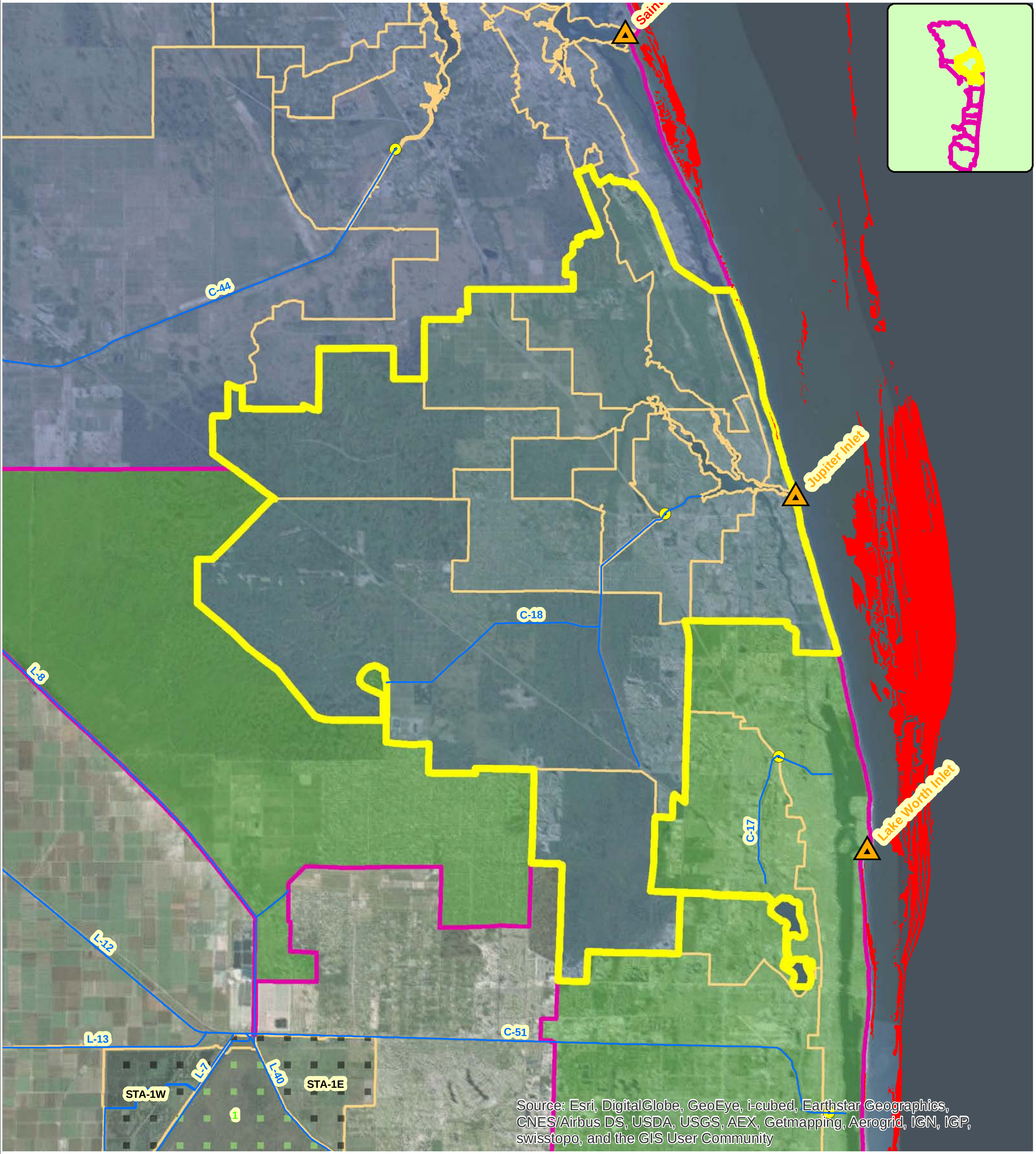
St Lucie Inlet

Date: 11/25/2014

Figure 2-2



Legend

N

1 in = 4.3 miles

- Inlets
- Domestic Waste-water Outfalls
- Salinity Control Structures
- Canals
- Flow Lines
- SW Treatment Areas
- Conservation Areas
- Watersheds
- Inlet Contributing Areas
- Coral Reefs

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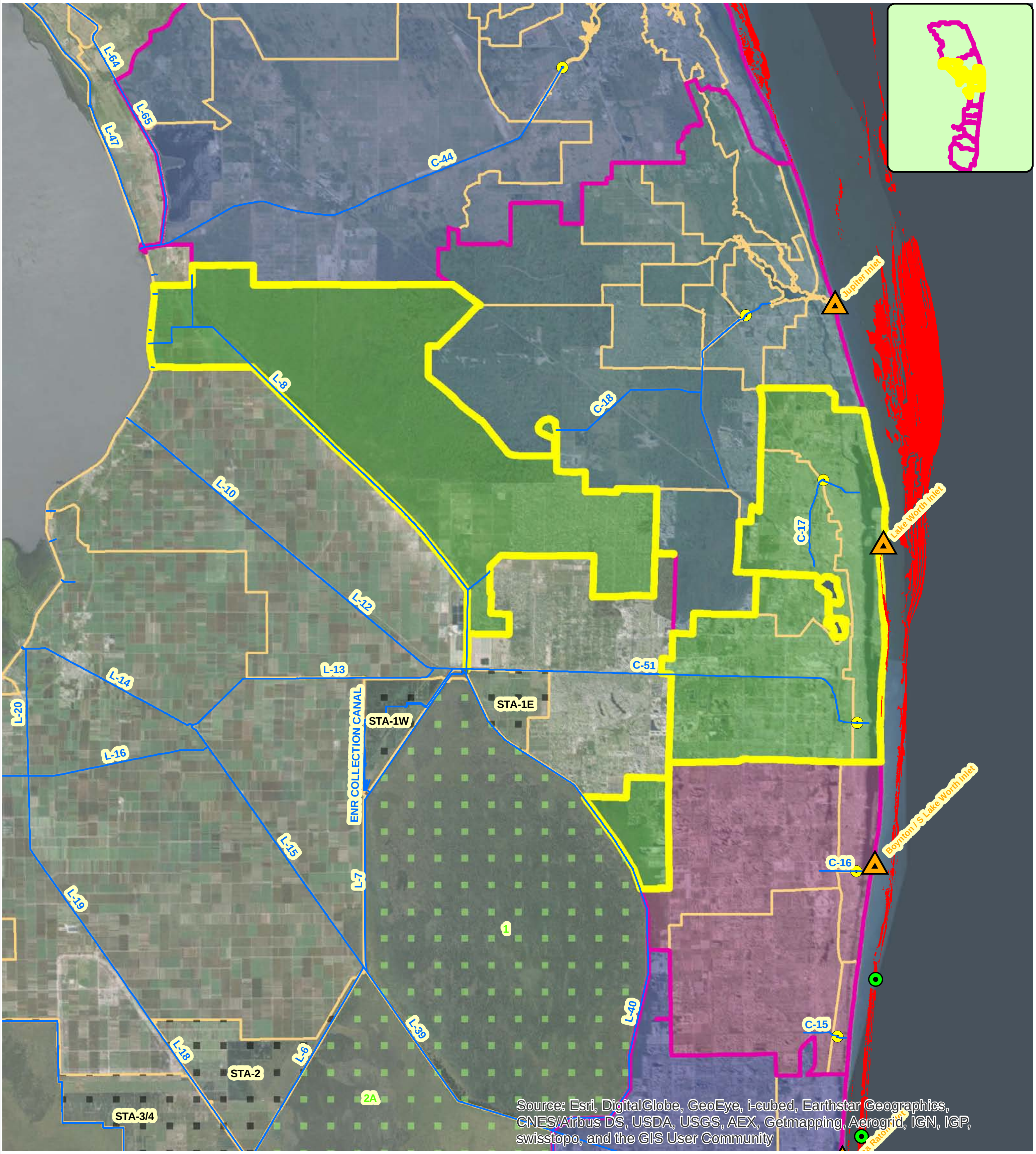
Jupiter Inlet

Date: 11/25/2014

Figure 2-3



Legend

N

1 in = 6.3 miles

- Inlets
- Domestic Wastewater Outfalls
- Salinity Control Structures
- Canals
- Flow Lines
- SW Treatment Areas
- Conservation Areas
- Watersheds
- Inlet Contributing Areas
- Coral Reefs

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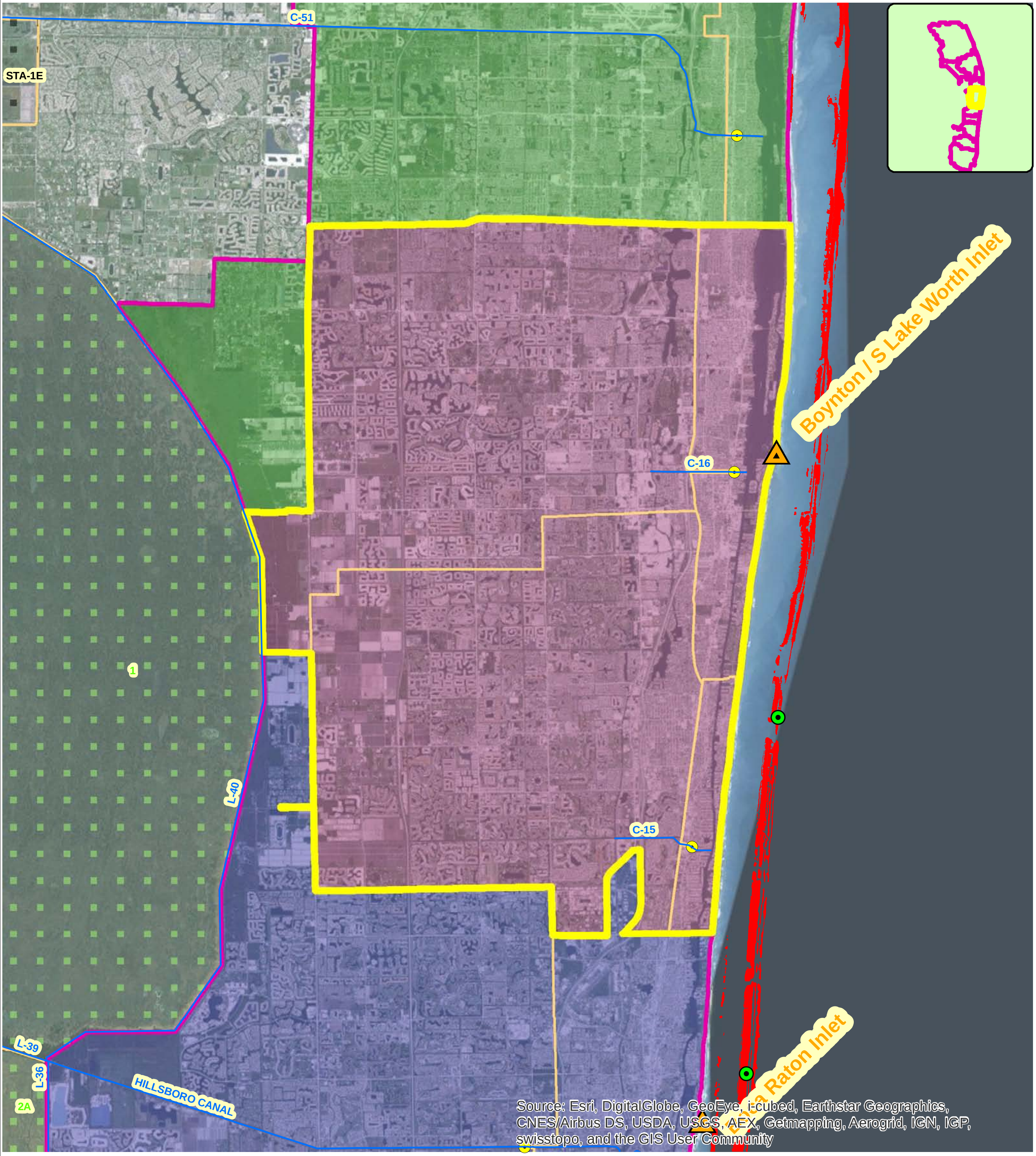
Lake Worth Inlet

Date: 11/25/2014

Figure 2-4



Legend

N

1 in = 2.8 miles

- Inlets
- Domestic Waste-water Outfalls
- Salinity Control Structures
- Canals
- Flow Lines
- SW Treatment Areas
- Conservation Areas
- Watersheds
- Inlet Contributing Areas
- Coral Reefs

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Boynton / South Lake Worth Inlet

Date: 11/25/2014

Figure 2-5

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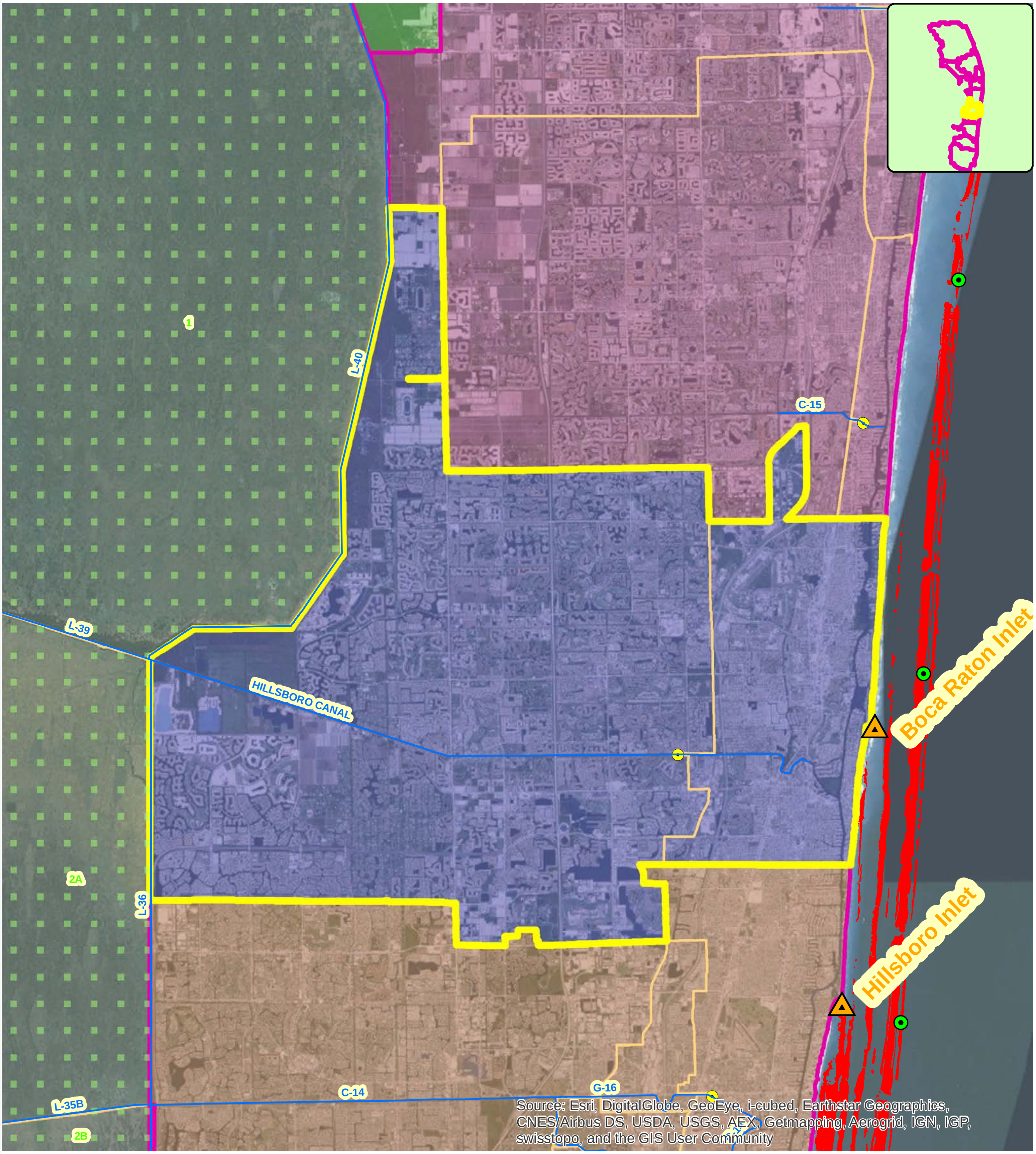

Legend

N

1 in = 2.5 miles

- Inlets
- Domestic Waste-water Outfalls
- Salinity Control Structures
- Canals
- Flow Lines
- SW Treatment Areas
- Conservation Areas
- Watersheds
- Inlet Contributing Areas
- Coral Reefs

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Boca Raton Inlet

Date: 11/25/2014

Figure 2-6

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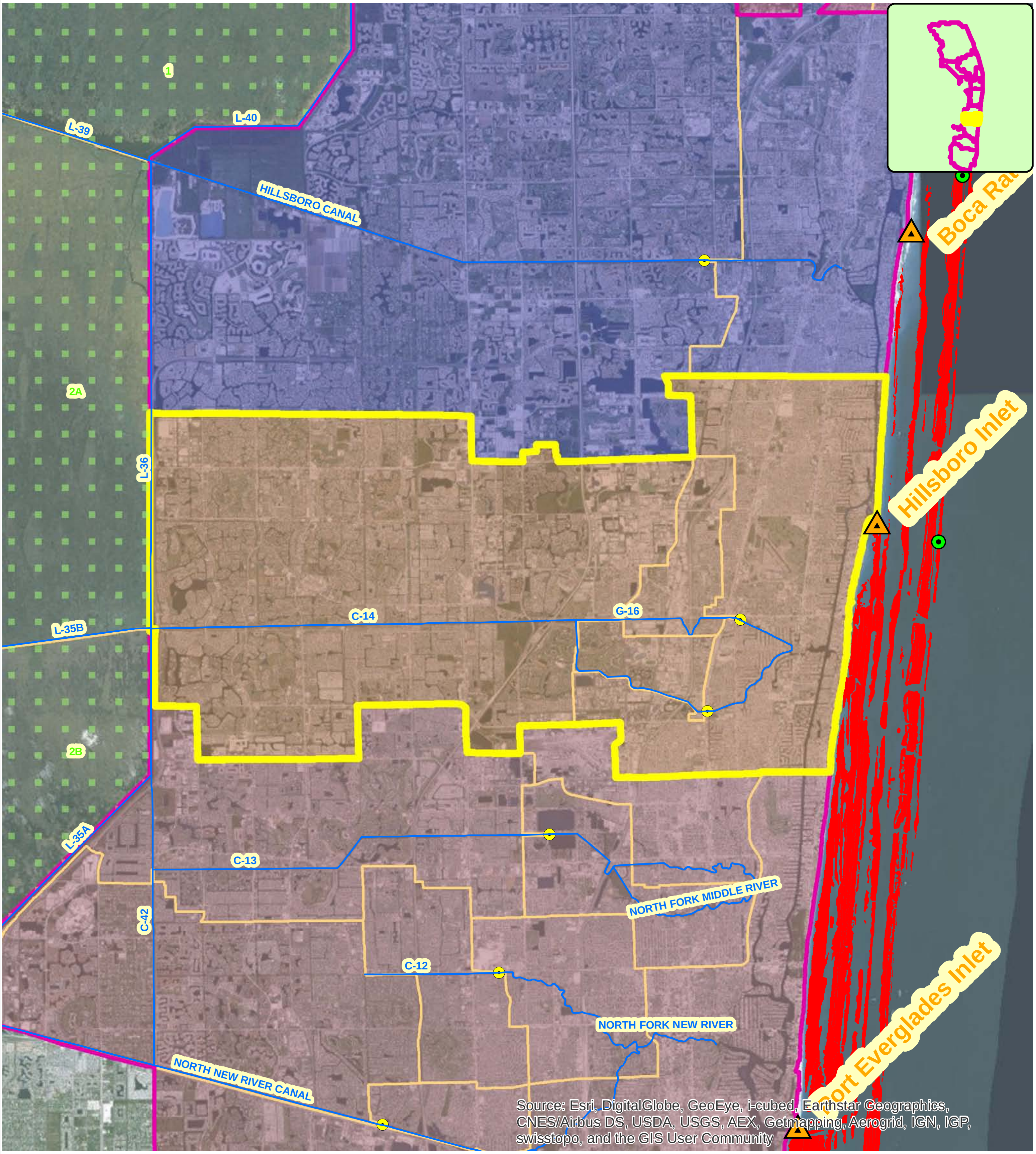

Legend

N

1 in = 2.4 miles

- Inlets
- Domestic Wastewater Outfalls
- Salinity Control Structures
- Canals
- Flow Lines
- SW Treatment Areas
- Conservation Areas
- Watersheds
- Inlet Contributing Areas
- Coral Reefs

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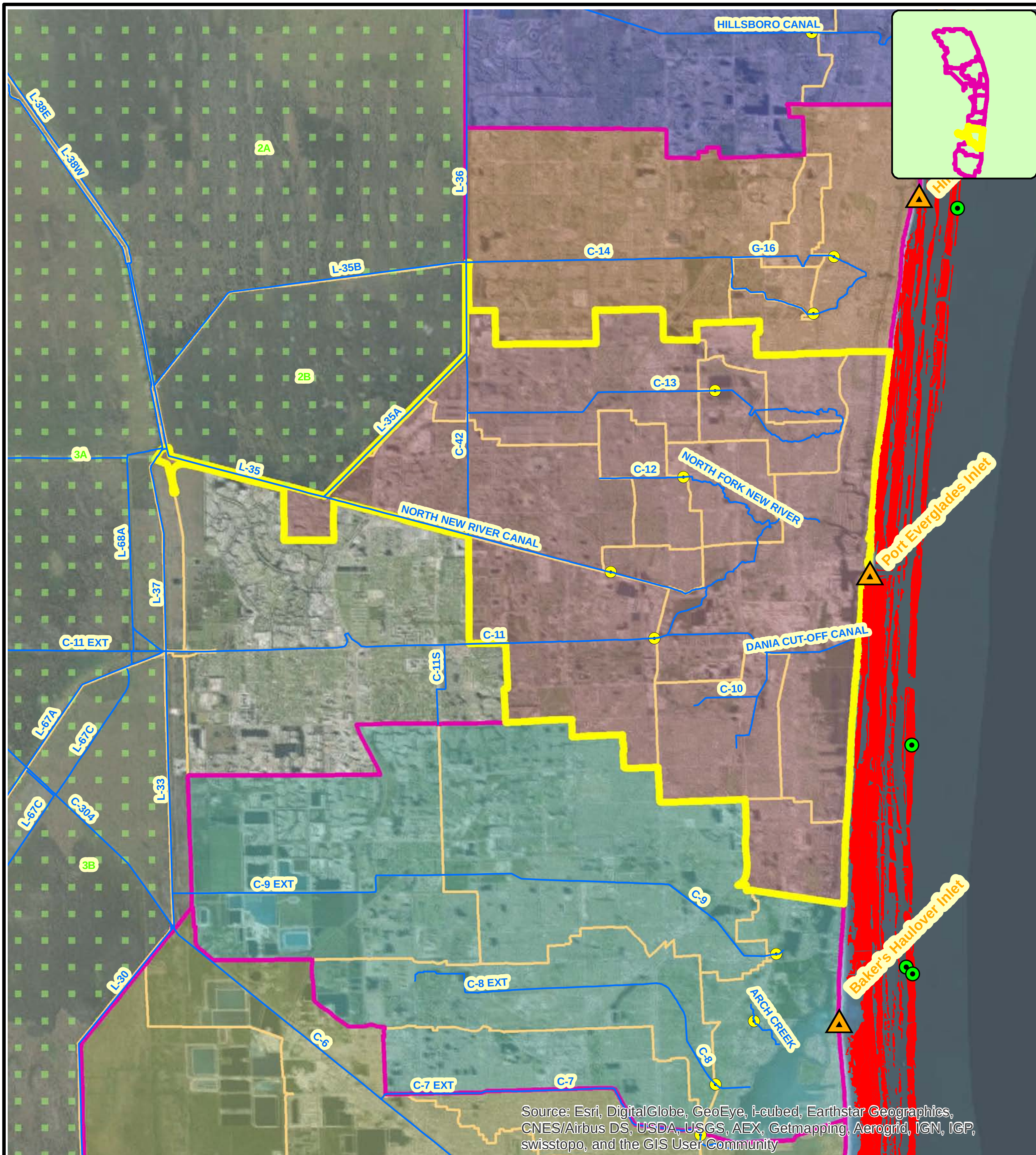
Hillsboro Inlet

Date: 11/25/2014

Figure 2-7



Legend

N

1 in = 3.8 miles

- Inlets
- Domestic Wastewater Outfalls
- Salinity Control Structures
- Canals
- Flow Lines
- SW Treatment Areas
- Conservation Areas
- Watersheds
- Inlet Contributing Areas
- Coral Reefs

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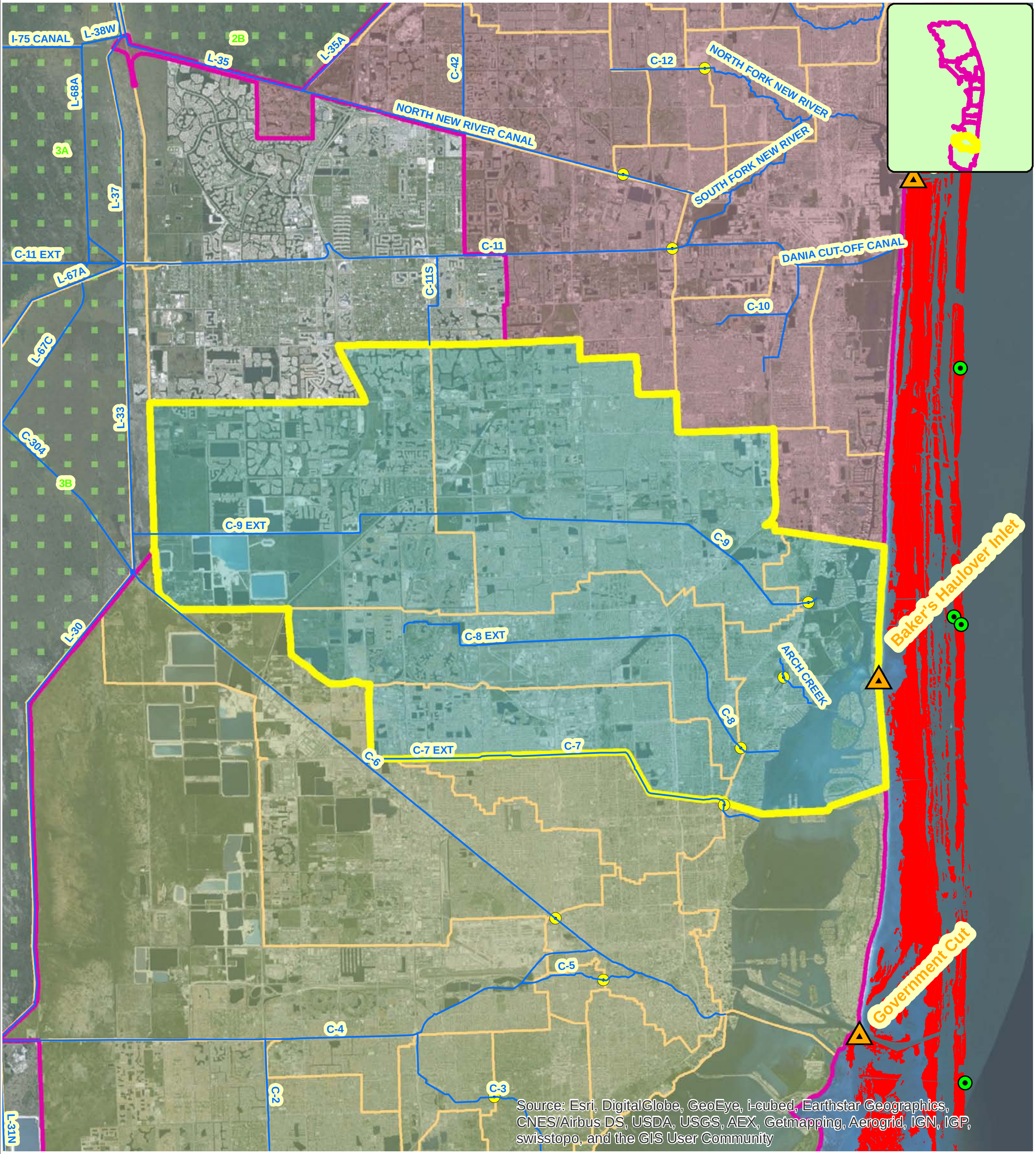
Port Everglades Inlet

Date: 11/25/2014

Figure 2-8



Legend

N

1 in = 3.4 miles

- Inlets
- Domestic Waste-water Outfalls
- Salinity Control Structures
- Canals
- Flow Lines
- SW Treatment Areas
- Conservation Areas
- Watersheds
- Inlet Contributing Areas
- Coral Reefs

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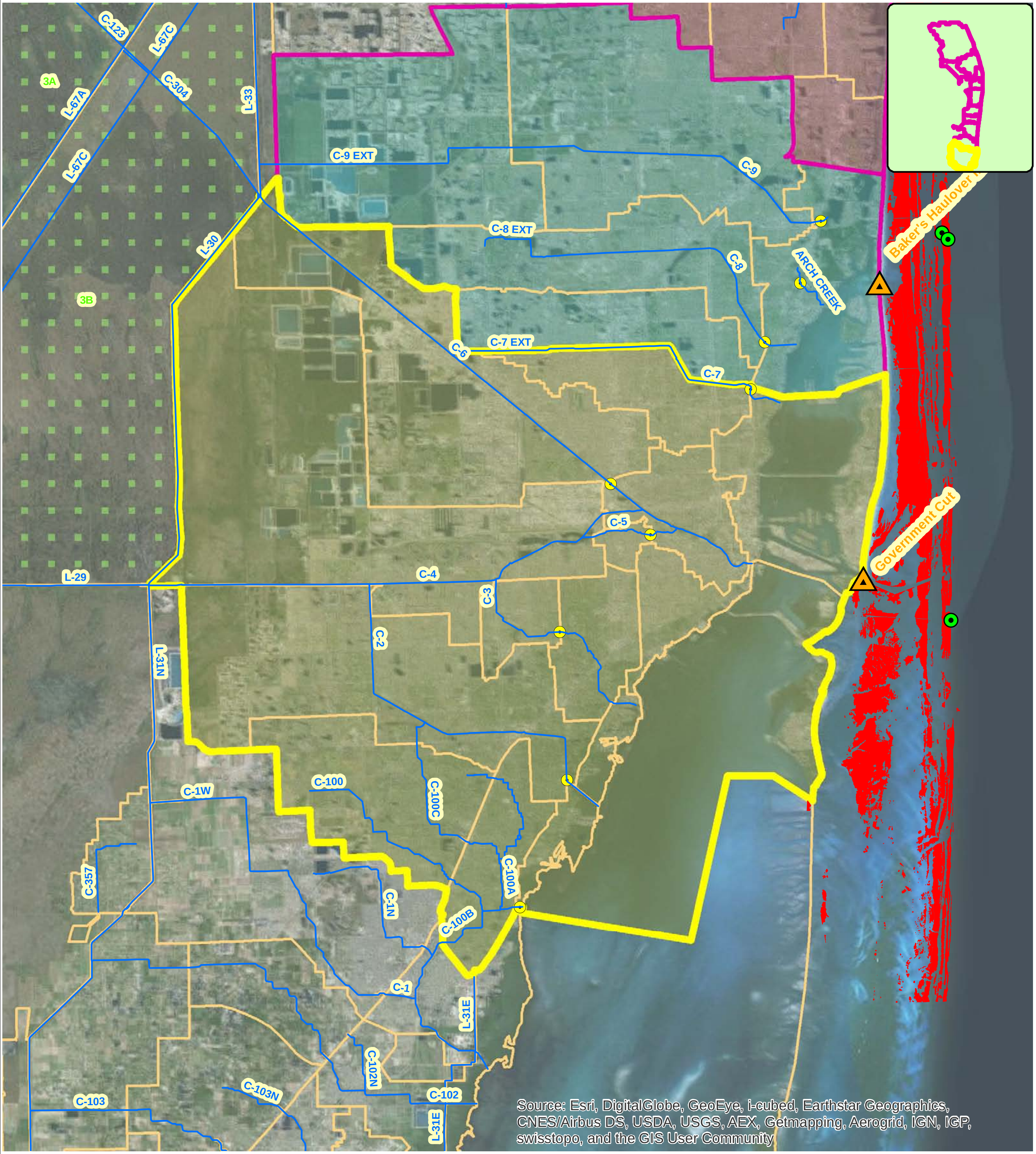
Baker's Haulover Inlet

Date: 11/25/2014

Figure 2-9



Legend

N

1 in = 4.1 miles

- Inlets
- Domestic Wastewater Outfalls
- Salinity Control Structures
- Canals
- Flow Lines
- SW Treatment Areas
- Conservation Areas
- Watersheds
- Inlet Contributing Areas
- Coral Reefs

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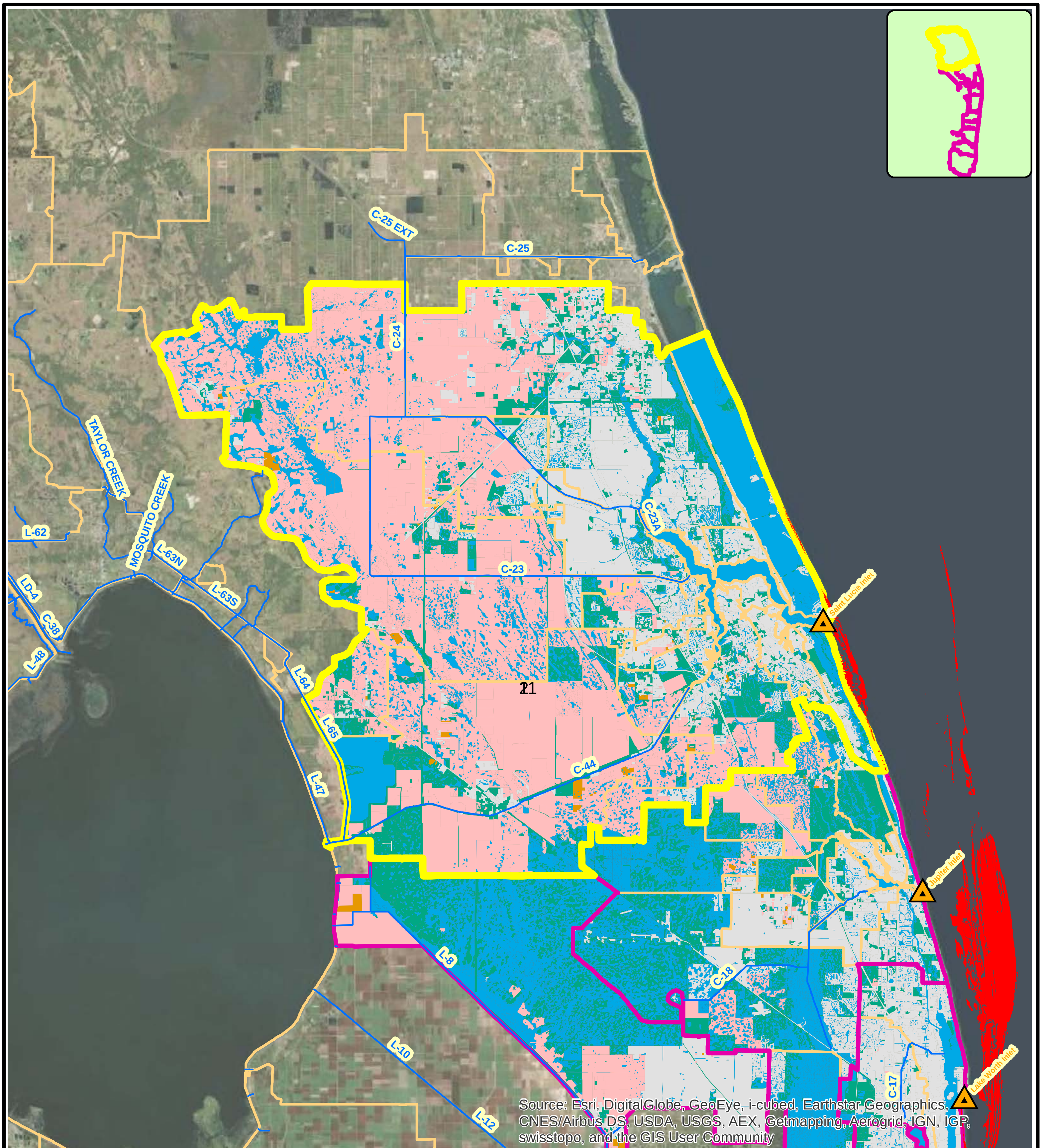
Government Cut

Date: 11/25/2014

Figure 2-10



Legend

N

1 in = 7.3 miles

- Inlets
- Canals
- Watersheds
- Inlet Contributing Areas
- Coral Reefs
- Urban/Trans.
- Animal Agric.
- Crop Agric.
- Open/Forest
- Water/Wetlands

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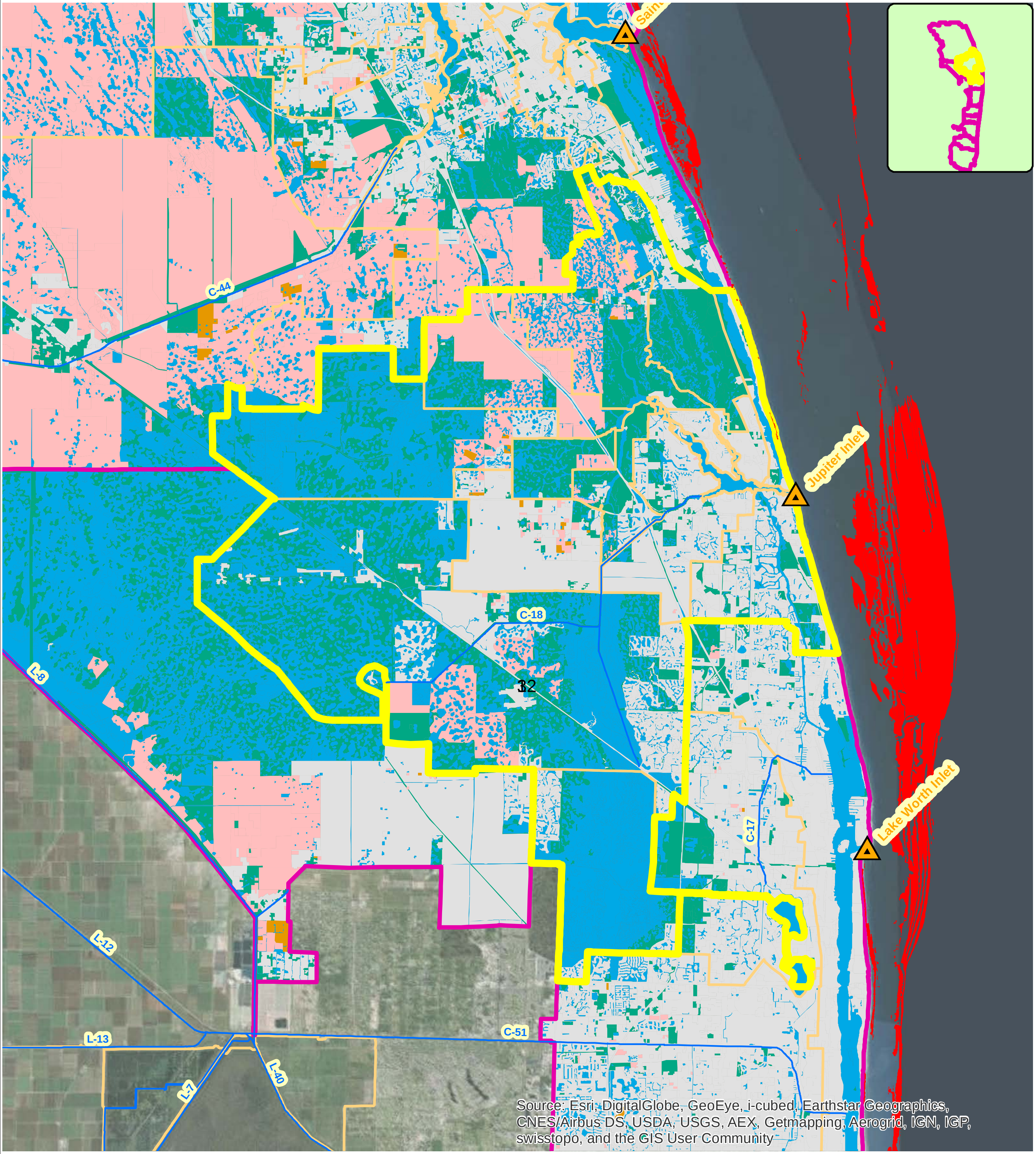
St Lucie Inlet - Land Uses

Date: 11/25/2014

Figure 2-11



Legend

N

1 in = 4.3 miles

- Inlets
- Canals
- Watersheds
- Inlet Contributing Areas
- Coral Reefs
- Urban/Trans.
- Animal Agric.
- Crop Agric.
- Open/Forest
- Water/Wetlands

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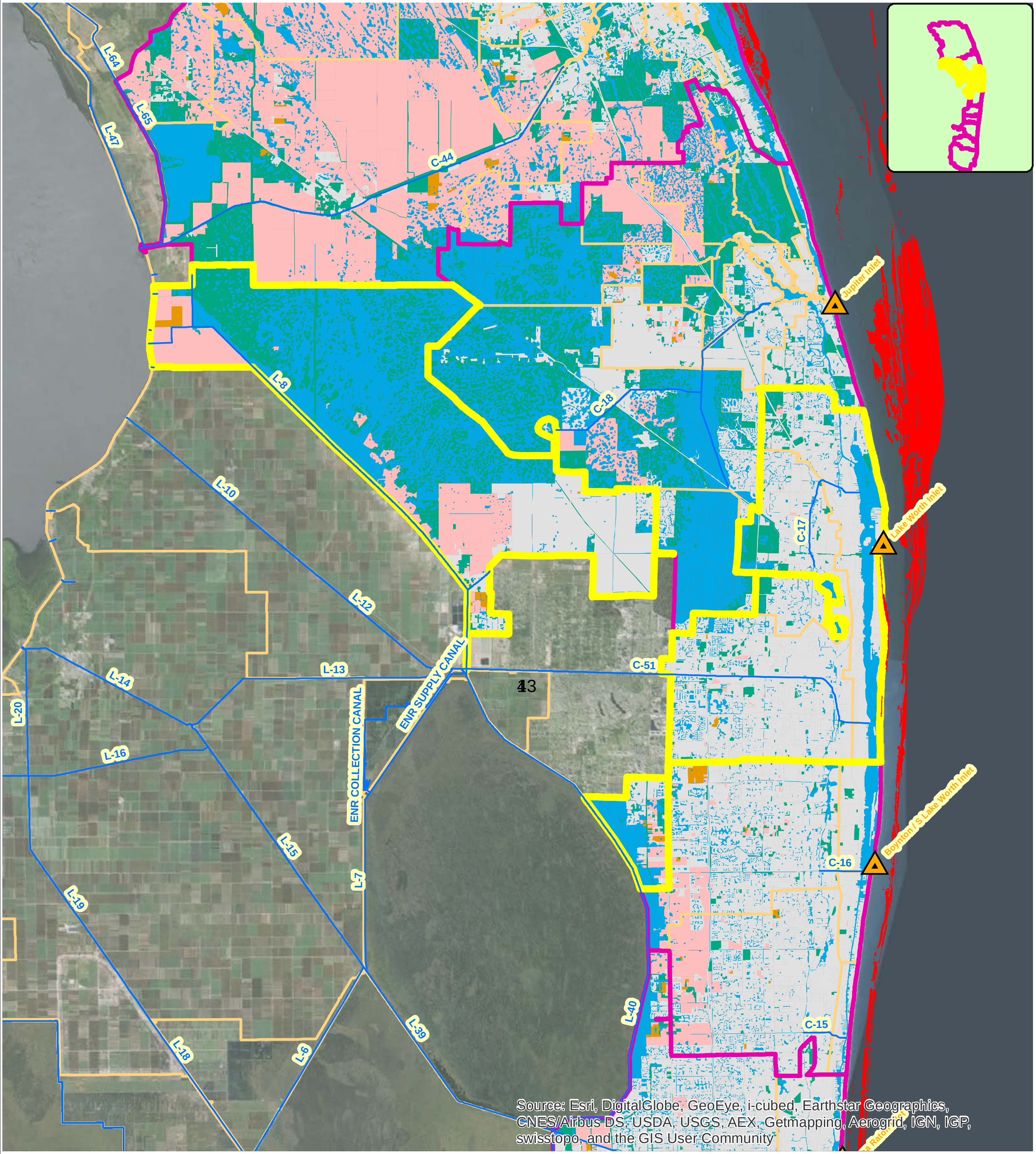
Jupiter Inlet - Land Uses

Date: 11/25/2014

Figure 2-12

Path: C:\Shared\Projects\13107 TO 4.7 Southeast Florida LBSP\GIS\Maps\141125_Landuse_Small_13107.mxd



Legend

N

1 in = 6.3 miles

- Inlets
- Canals
- Watersheds
- Inlet Contributing Areas
- Coral Reefs
- Urban/Trans.
- Animal Agric.
- Crop Agric.
- Open/Forest
- Water/Wetlands

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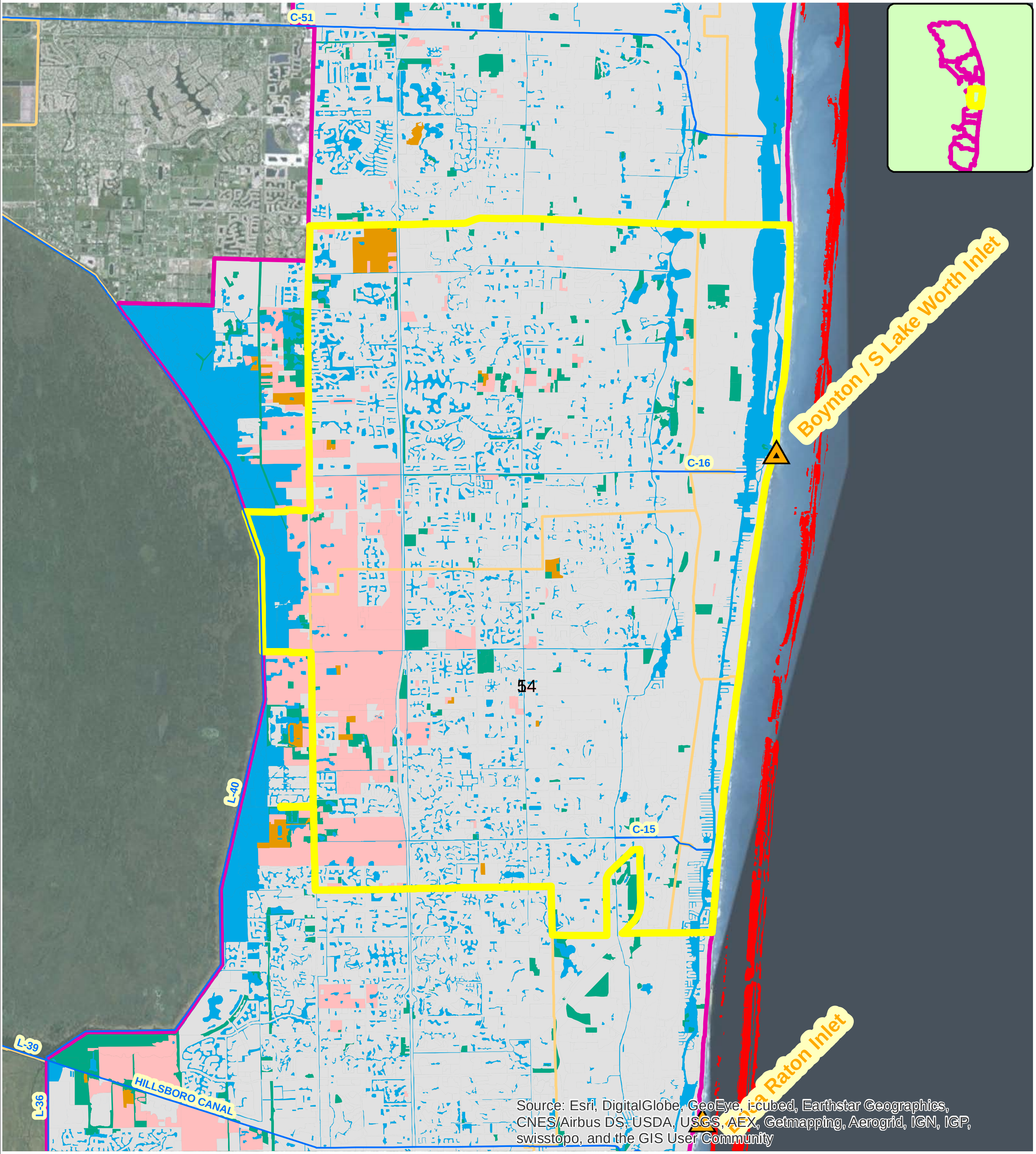
Lake Worth Inlet - Land Uses

Date: 11/25/2014

Figure 2-13

Path: C:\Shared\Projects\13107 TO 4.7 Southeast Florida LBSP\GIS\Maps\141125_Landuse_Small_13107.mxd



Legend

N

1 in = 2.8 miles

- Inlets
- Canals
- Watersheds
- Inlet Contributing Areas
- Coral Reefs
- Urban/Trans.
- Animal Agric.
- Crop Agric.
- Open/Forest
- Water/Wetlands

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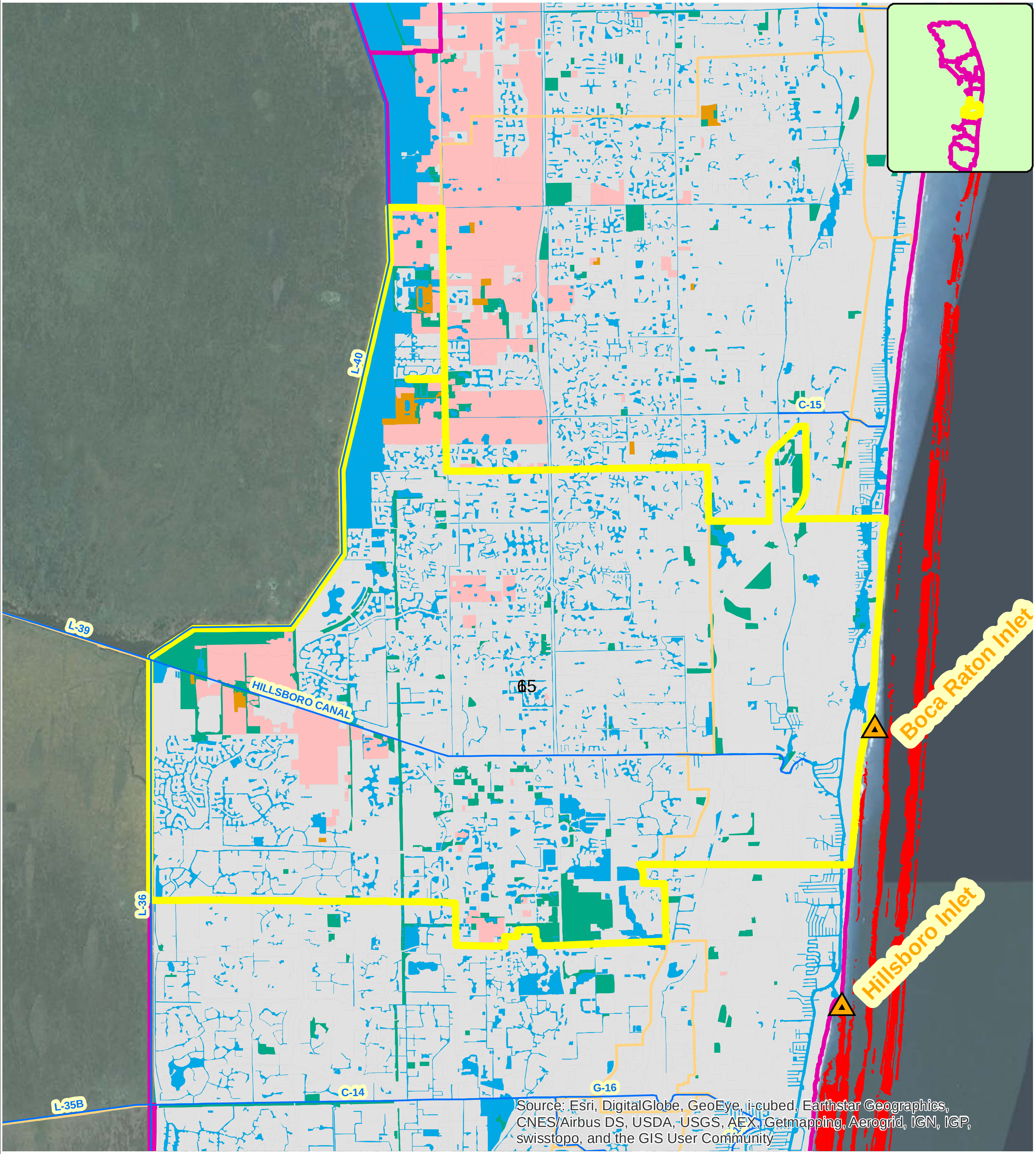
Boynton / S Lake Worth Inlet - Land Uses

Date: 11/25/2014

Figure 2-14

Path: C:\Shared\Projects\13107 TO 4.7 Southeast Florida LBSP\GIS\Maps\141125_Landuse_Small_13107.mxd



Legend

N

1 in = 2.5 miles

- Inlets
- Canals
- Watersheds
- Inlet Contributing Areas
- Coral Reefs
- Urban/Trans.
- Animal Agric.
- Crop Agric.
- Open/Forest
- Water/Wetlands

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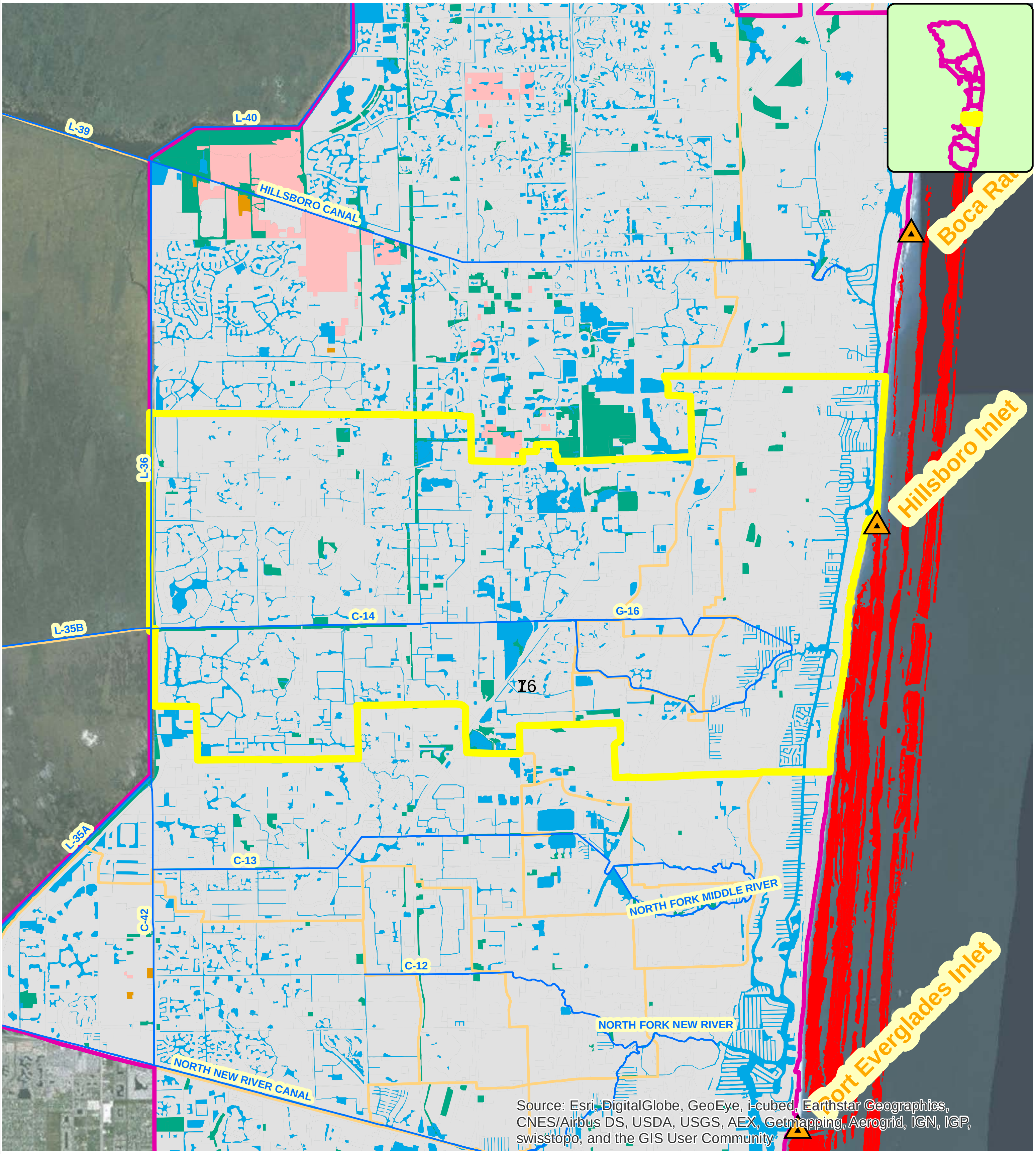
Boca Raton Inlet - Land Uses

Date: 11/25/2014

Figure 2-15



Legend

N

1 in = 2.4 miles

Inlets	Urban/Trans.
Canals	Animal Agric.
Watersheds	Crop Agric.
Inlet Contributing Areas	Open/Forest
Coral Reefs	Water/Wetlands

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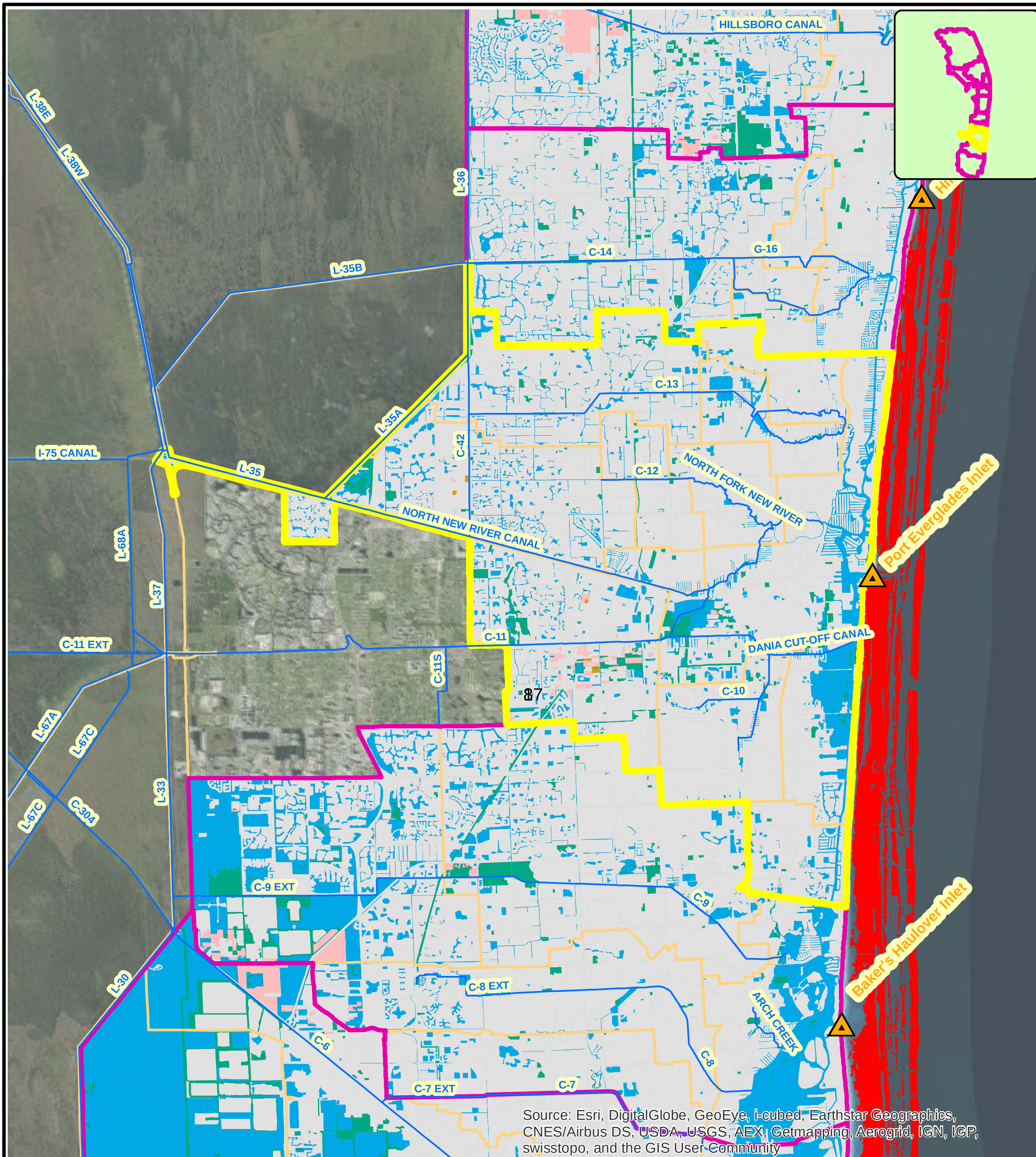
Hillsboro Inlet - Land Uses

Date: 11/25/2014

Figure 2-16



Legend

N

1 in = 3.8 miles

- Inlets
- Canals
- Watersheds
- Inlet Contributing Areas
- Coral Reefs
- Urban/Trans.
- Animal Agric.
- Crop Agric.
- Open/Forest
- Water/Wetlands

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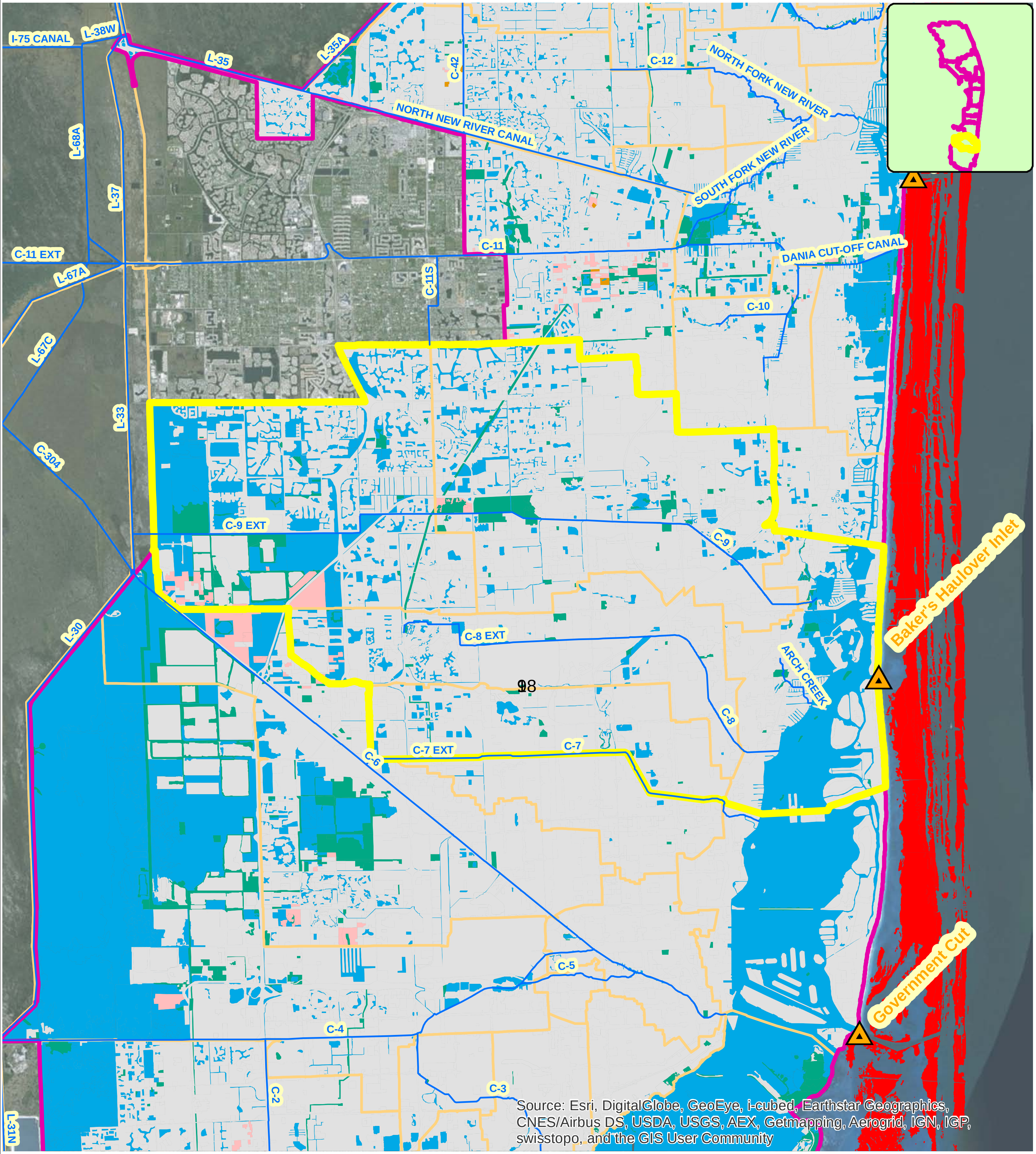
Port Everglades Inlet - Land Uses

Date: 11/25/2014

Figure 2-17



Legend

N

1 in = 3.4 miles

- Inlets
- Canals
- Watersheds
- Inlet Contributing Areas
- Coral Reefs
- Urban/Trans.
- Animal Agric.
- Crop Agric.
- Open/Forest
- Water/Wetlands

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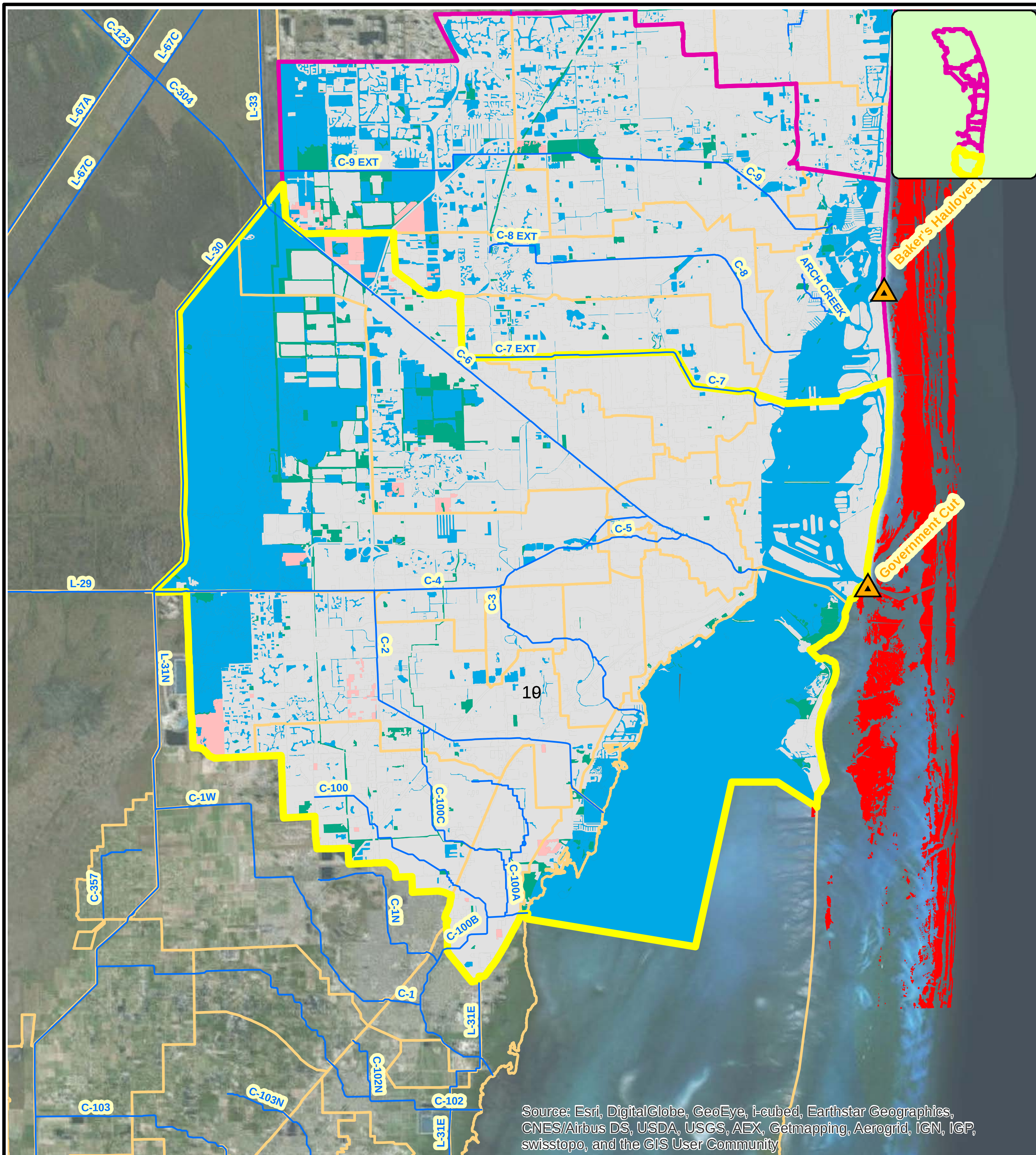
Baker's Haulover Inlet - Land Uses

Date: 11/25/2014

Figure 2-18



Legend

N

1 in = 4.1 miles

Triangle	Inlets	Grey	Urban/Trans.
Blue line	Canals	Orange	Animal Agric.
Tan outline	Watersheds	Pink	Crop Agric.
Magenta outline	Inlet Contributing Areas	Green	Open/Forest
Red	Coral Reefs	Blue	Water/Wetlands

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Government Cut - Land Uses

Date: 11/25/2014

Figure 2-19

Path: C:\Shared\Projects\13107 TO 4.7 Southeast Florida LBSP\GIS\Maps\141125_Landuse_Small_13107.mxd

3. Water Management in Each ICA

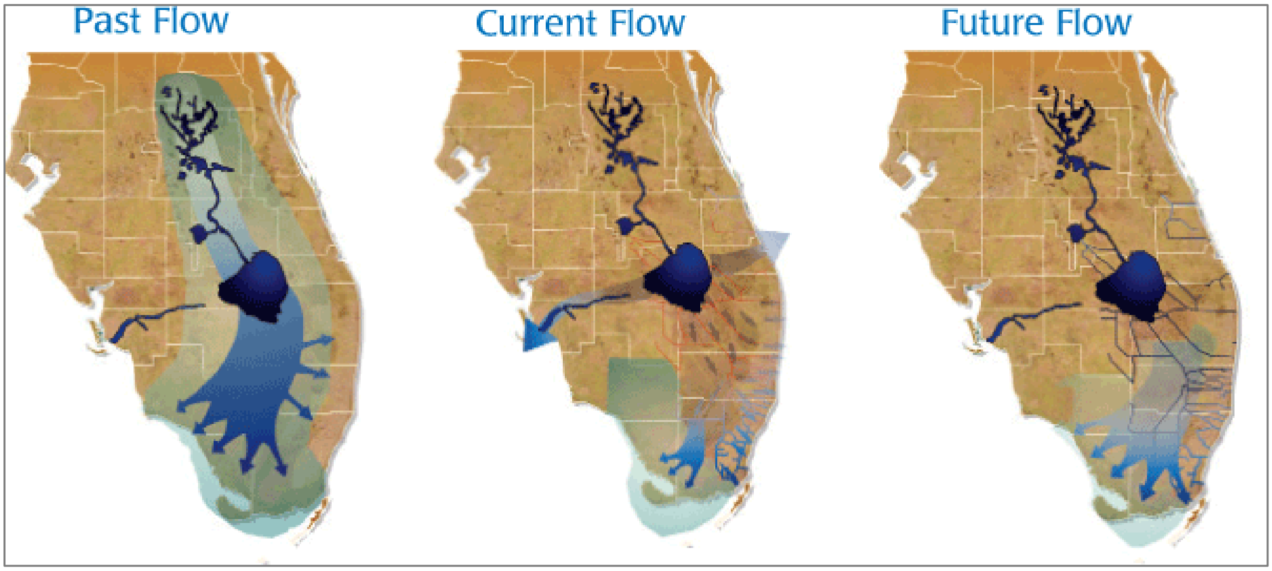
South Florida's waterways include some of the most unique ecological systems in the world. As with many other vibrant ecosystems, the region has attracted significant development and population growth. Canals and water control structures were built to accommodate increased urban and agricultural land development – more development increases water demand. As a result, flow is managed from Lake Okeechobee and throughout the ICAs. The level of management, monitoring, and land use differs among ICAs.

The construction of water management structures has disrupted natural water flow patterns and timing, contributed to the loss of fifty percent of Florida's wetlands, and degraded water quality. In addition, development has reduced the ecological diversity of the region resulting in unintended consequences such as fewer wading birds, deteriorated lake and estuary health, and habitat decline for native species. Understanding that increased development in South Florida has degraded the environment, many agencies have been working together to better manage water quality and quantity throughout the region.

One major effort is the Comprehensive Everglades Restoration Plan (CERP) (USACE and SFWMD, 2010), which when fully implemented will revitalize South Florida's water resources and natural ecosystems. More specifically, CERP management efforts address South Florida's water quality, quantity, timing and distribution through infrastructure and operational changes including: improvements to surface water reservoirs, changes to aquifer storage and recovery practices, constructed stormwater treatment wetlands for flood management and storage, operational changes in management, underground seepage management, removing structures such as canals and levees to restore historic flow to wetlands. These types of infrastructure and operational changes will attempt to capture, treat, and redistribute water in an effort to revitalize South Florida's natural ecosystem.

The schematic in Figure 3-1 developed by the US Army Corps of Engineers (USACE) and SFWMD presents the relative flow volumes and flow direction of water in South Florida. The Past Flow schematic represents natural conditions before major human development in the region. Current Flow represents the current flow under the highly mechanized water management system. Future Flow represents the goal of the CERP to better balance ecosystem needs, ecosystem services and human needs in South Florida.

Figure 3-1. Depiction of Historic Flow and Future Flow with Implemented CERP Projects (USACE & SFWMD, 2010)



Ultimately, the region needs to maintain balanced and optimal flow to address demand for ecosystem services (e.g., water supply, flood management, drought management, recreation, and freshwater, estuarine and near shore marine habitats) and ensure that flow conditions in bays and estuaries sustainably support aquatic life. It is not likely that water in South Florida can be managed to natural flow conditions. However, the implementation of proposed flow and water quality improvement programs should balance the demands of the growing population with the needs of a sustainable South Florida environment, including specifically the coral reef ecosystem.

A. Management in the St. Lucie ICA[1]

The St. Lucie ICA is approximately 877.2 square miles in size, almost half of which (49.1%) is comprised of crop agriculture. It is by far the largest ICA in the project area. (See Table 2.1 for a more detailed breakdown of land uses within the ICA). Current and ongoing efforts to manage water quality and flow in the St. Lucie ICA are both collaborative and comprehensive in comparison to other Florida ICAs. As with the entire project area, water in the St. Lucie ICA is transported through a canal system. The major canals within the St. Lucie ICA include C-24, C-23, and C-23A with nearby C-25 flowing into C-24, directly north, but outside of the St. Lucie ICA. Canal C-44 transports water throughout the southern section of the ICA in combination with flows from L-65 and L-64 and to some extent, L-47.

The C-24 canal, also known as the Diversion Canal, drains a primarily agricultural sub-basin into the North Fork, and the C-23 canal drains a combination of residential and agricultural land. C-24 is the primary canal for the St. Lucie River Basin (FDEP, 2000). The C-44, also known as the St. Lucie Canal, from Lake Okeechobee carries water east into the South Fork. When Lake Okeechobee water levels get too high, water is released into the canal/river system (SFWMD, 1999).

[1] Information for each ICA is adapted from "Canals in South Florida – A Technical Support Document. Appendix C: Primary Water Management Features" (SFWMD)

There are many structures controlling the interconnected flow of water in the St. Lucie ICA. The C-24, C-25, and C-23 canals are all interconnected, with three major water control structures on the C-24 canal. These structures, the G-81, G-79, and S-49, are used for flow alteration during flood events, surface water supply, and ground water recharge to avoid saltwater intrusion. The G-81 structure can transfer operations between C-24 and C-25 if necessary (FDEP, 2000).

B. Management in the Jupiter ICA

The Jupiter Inlet is the connector between the Loxahatchee River and the Atlantic coast. The Jupiter ICA is approximately 282.2 square miles in size, and the largest land use sector is water and wetlands, at approximately 41.8% of the ICA, followed by urban and transportation uses covering 25% of the ICA and open forest covering 23.9% of the ICA. (See Table 2.1 for a more detailed breakdown of land uses within the ICA). Canal C-18 controls flow within the Jupiter ICA and out to the Jupiter Inlet. The C-18 basin area is approximately 105.8 square miles, and is an extension of the Southwest Fork of the Loxahatchee River. Primary functions of the C-18 canal and control structures are flood protection, water supply, and water table maintenance. Those control structures can also be used to augment flows in the Northwest Fork of the Loxahatchee River. Water is supplied to the Northwest Fork of the Loxahatchee River from C-18 by way of the G-92 structure and canals of the South Indian River Water Control District.

As a result of its geography, the Jupiter Inlet experiences issues related to saltwater intrusion into the freshwater floodplain, especially in cases of reduced freshwater flow and sea level rise. There are ongoing efforts throughout the ICA to monitor nutrients, flow and other water quality indicators and manage saltwater encroachment and habitat restoration and preservation.

C. Management in the Lake Worth ICA

The Lake Worth ICA is approximately 317.9 square miles in size, and is the second largest ICA in the project area. The largest land use in the ICA is urban and transportation, which comprises 45.1% of the ICA. (See Table 2.1 for a more detailed breakdown of land uses within the ICA). Canals C-17, C-51, and L-8 transport water and regulate flow within the Lake Worth ICA in coastal West Palm Beach and Palm Beach County. Excess water in the C-17 basin is discharged to tidewater in the lntracoastal Waterway, which also controls water surface elevations in C-17. For the most part, rainfall is the only water supply source in this basin. C-17 is part of the West Palm Beach canal and is aligned from north to south. Inflows to C-17 are by various canals and managed locally. Two important tributaries are the city of West Palm Beach canals that drain the lands in the basin south of 45th Street.

Canal C-51 is the part of the West Palm Beach Canal that lies east of L-40. East of Congress Avenue the canal extends to the south and then to the east, connecting to the lntracoastal Waterway east of Lake Clarke. The L-8 canal connects Lake Okeechobee to Water Conservation Area (WCA)-1 to regulate flow into or out of the lake. Excess water can be discharged from the L-8 basin to Lake Okeechobee, to tidewater, or to WCA-1.

Water quality and water quantity management in the Lake Worth ICA are handled in part by the SFWMD and Palm Beach County Environmental Resources Management (ERM), with support from Florida Department of Environmental Protection (FDEP) and the Lake Worth Lagoon Initiative. Flow and water quality monitoring efforts are ongoing within the Coastal Ecosystems Section of the SFWMD.

D. Management in the Boynton / South Lake Worth ICA

The Boynton Inlet is located off the coast of Boynton Beach and directly south of Palm Beach. It transports water from inland sources such as the Boynton Canal through the Intracoastal Waterway and into the Atlantic Ocean. The Boynton ICA is approximately 144.1 square miles in size, the majority of which is comprised of urban and transportation land uses (75% of the ICA). (See Table 2.1 for a more detailed breakdown of land uses within the ICA).

Canals C-16 and C-15 control flow within the Boynton ICA. C-16 is an extension of the Boynton Canal in the Lake Worth Drainage District (LWDD). C-15 is an extension of a LWDD lateral canal flowing west to east canal. The Boynton Canal ends and C-16 begins at the Lake Ida Canal. Flow in the canal is to the east with discharge to the Intracoastal Waterway. Water supply to the basin is from local rainfall and by pumping from WCA-1.

E. Management in the Boca Raton ICA

The Boca Raton ICA is approximately 112.7 square miles in size, the majority of which is comprised of urban and transportation land uses (75.2% of the ICA). (See Table 2.1 for a more detailed breakdown of land uses within the ICA). The major canal within the Boca Raton ICA is L-39, also known as the Hillsboro Canal, with nearby L-36 and L-40 flowing into the Hillsboro Canal. The L-39 levee is adjacent to the canal on the north side and forms the southwestern boundary of WCA-1. The Hillsboro Canal is also one of four primary canals, in addition to North New River Canal, Miami Canal, and West Palm Beach Canal that facilitate runoff removal and irrigation water supply for the Everglades Agricultural Area (Abtew, et, al., 2013). The Hillsboro Canal accepts west to east flows and is the primary discharge point to the Boca Raton Inlet.

F. Management in the Hillsboro ICA

The Hillsboro ICA is approximately 80.3 square miles in size, and is the smallest ICA in the project area. The majority of the ICA is comprised of urban and transportation land uses (88.7%). (See Table 2.1 for a more detailed breakdown of land uses within the ICA). The major canals within the Hillsboro ICA are C-14 and G-16. To the west, L- 35B (west), L-35A (southwest) and L-36 (north) also regulate flow into the Hillsboro ICA and Hillsboro Inlet. The L-35B canal connects the North New River Canal to C-13 and C-14. The canal is immediately north of L-35B and runs west to east making an open channel connection to the North New River Canal at its west end and connecting to C-14 at its east end.

G. Management in the Port Everglades ICA

The Port Everglades ICA is approximately 174.0 square miles in size, the majority of which is comprised of urban and transportation land uses (85%). (See Table 2.1 for a more detailed breakdown of land uses within the ICA). The major canals within the Port Everglades ICA which run east to west are C-13, C-12, C-11, and C-10. To the west, canals C-42, L-35, and L-35A also control flow in the Port Everglades ICA. North Fork New River and North New River Canal and the Dania Cut-Off Canal also provide flow regulation throughout the ICA. The canals and control structures in the C-13 basin provide flood protection and drainage, supply water, and intercept and control seepage.

H. Management in the Baker's Haulover ICA

The Baker's Haulover ICA is approximately 170.9 square miles in size, the majority of which is comprised of urban and transportation land uses (77.3%). (See Table 2.1 for a more detailed breakdown of land uses within the ICA). The major canals within the Baker's Haulover ICA that regulate flow are C-7, C-8, and C-9. All three of these major canals have extensions in the Baker's Haulover ICA. In addition, Arch Creek also controls flow throughout the ICA. The C-8 Canal is located in northeastern Miami-Dade County. C-8 begins in the east of the Palmetto Expressway, flows east, and discharges to Biscayne Bay. The portion of the C-8 basin west of the Palmetto Expressway exhibits poor drainage and as such, imposes development restrictions. The C-7 canal also flows east with discharge to Biscayne Bay. During low flow periods, water is diverted to the C-6 basin. Water is subsequently diverted from C-6 to the C-7 and C-9 basins as needed to maintain the optimum flow in the canals in those basins.

I. Management in the Government Cut ICA

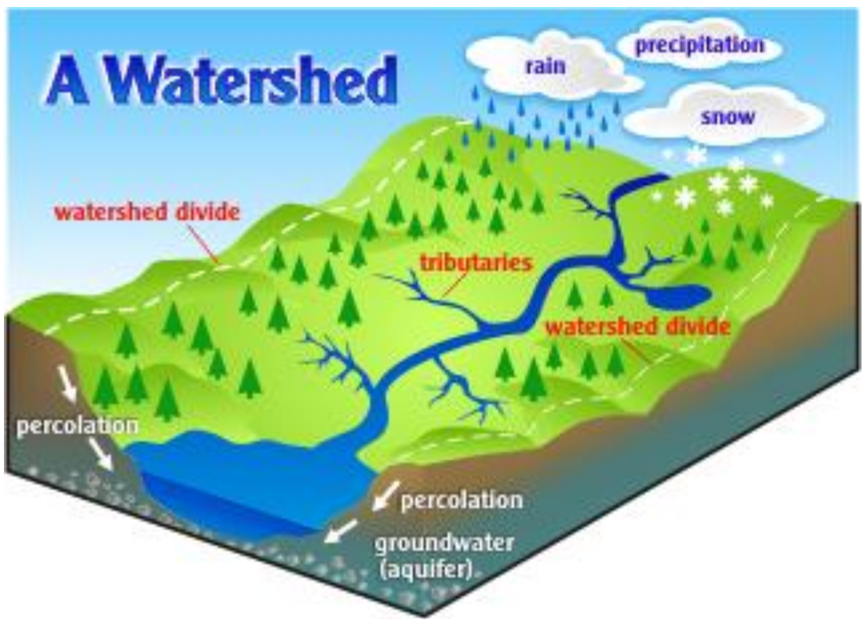
The Government Cut ICA is approximately 371.7 square miles in size, the majority of which is comprised of urban and transportation land uses (60.4%). (See Table 2.1 for a more detailed breakdown of land uses within the ICA). From north to south and east to west, the following major canals are within the Government Cut ICA and regulate flow to the Government Cut Inlet: L-30, C-7, C-7 Ext, C-6, L-29, C-4, C-5, C-2, C-3, C-100, C-100C, C-100A, and C-100B. The C-6 canal, also known as the Miami Canal, starts at the intersection of L-30 and L-33. The L-33 canal runs north-south along the eastern boundary of the ICA and connects to C-6 at L-30. Normal flows are from C-6 to the borrow canal. The C-6 canal runs southeast and discharges to Biscayne Bay. The major canals C-6 and C-4 C-6 and C-4, discharge excess water from Water Conservation Areas to tidewater.

4. Watershed Assessment and Planning Data Needs

A. What is a Watershed?

"A watershed is the area of land where all of the water that is under it or drains off of it goes into the same place" (EPA, 2012). Watersheds of different sizes can be nested inside one another, such that several small subwatersheds comprise a larger watershed, and so on and so forth. Pollutants that originate on the land within a watershed are carried to the receiving water in surface water and groundwater. A watershed is the perfect unit of analysis for land-based sources of pollution, because what happens on the land eventually impacts the receiving water.

Figure 4-1. A Watershed. A watershed is the area of land where all of the water that is under it or drains off of it goes into the same place (EPA, 2012).



In the SEFCRI project area, we have delineated the watersheds that drain to each of the nine inlets along the Atlantic coastline (Section 3 of this report). To differentiate them from watersheds of a different scale (larger or smaller) and to alleviate confusion about the varying naming conventions for a watershed unit used by different agencies (e.g., basin, watershed, subwatershed, catchment), we are calling each watershed in this study area an inlet contributing area (ICA). However, this section of the report discusses the topic of watershed-based planning in general, and therefore continues with the generic use of the term watershed.

B. Watershed-Based Management Approach

A watershed-based management approach is a logical and effective approach to reducing pollutant loads that are affecting the southeast Florida coral reef tract and the marine and estuarine habitats that support it. A watershed-based management approach directs that you first assess the pollution problems and threats, then identify the upstream and upgradient sources of the pollution, and develop management options to reduce or treat the pollutant source. EPA strongly encourages the use of a watershed management approach for protecting and restoring the nation's waters. EPA's goal is to manage each watershed so the water quality of the receiving waters supports their designated uses under the applicable water quality standards for the long term. In other words, these plans aim for sustainable solutions. The watershed planning goal of natural resource managers is similar to EPA's goal of sustainable solutions for maintaining designated uses, but can be more focused on pollutants and sources that affect specific managed resources such as coral reef, hard bottom, seagrass, mangrove or oyster habitats.

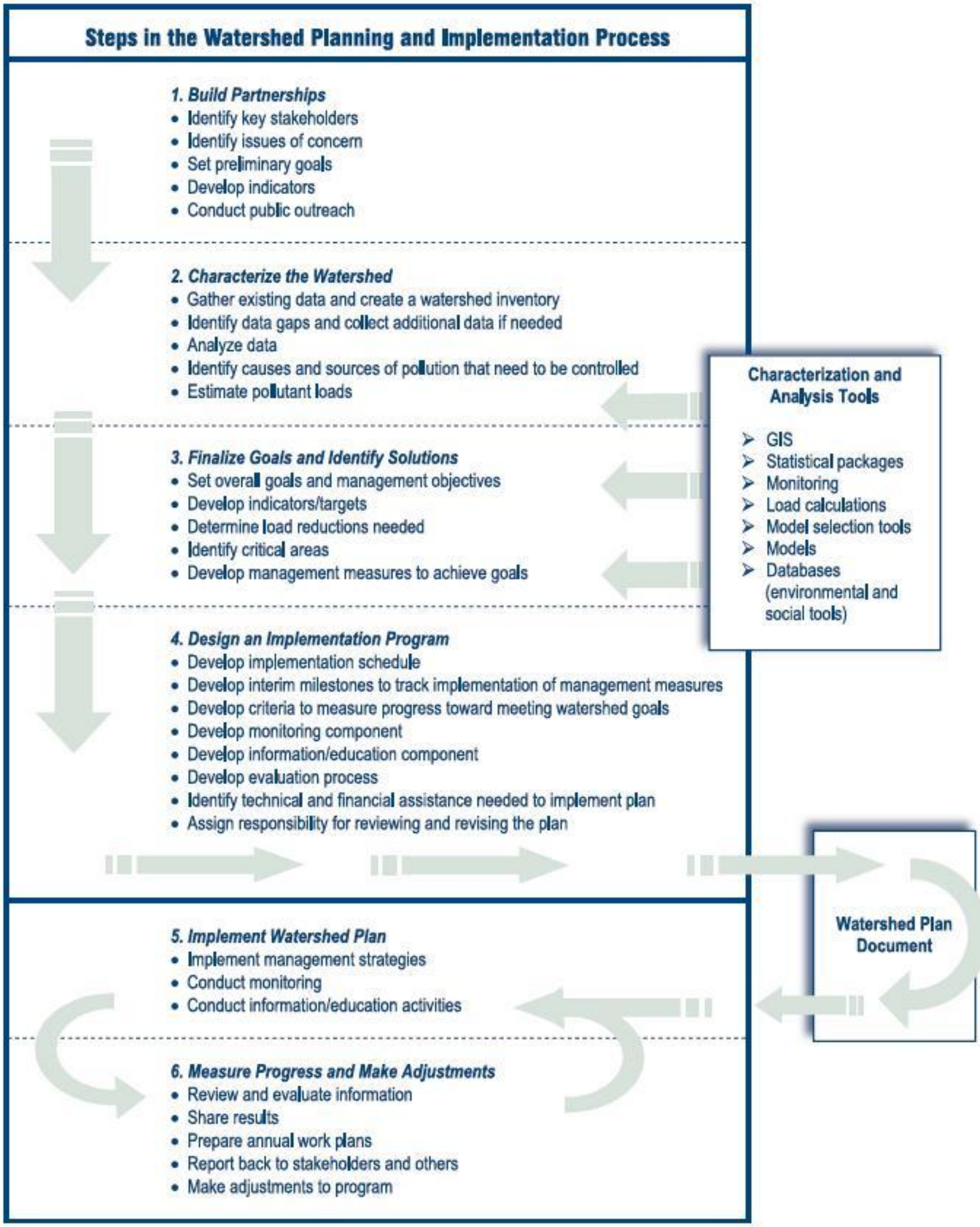
EPA's *Handbook for Developing Watershed Plans to Restore and Protect our Waters* (EPA, 2008) describes in detail the watershed-based planning and management approach. It lays out six major steps in the watershed management planning process, as presented in Figure 4-2. Importantly, this process is continuous, iterative and adaptive. Steps 5 and 6 are looped so that watershed managers continue to update and revise the watershed plan as needed based on measured successes and failures. These plans are not intended to be static documents that are completed and placed on a shelf. They are supposed to evolve in the hands of the partnerships and stakeholders in the watershed so that it can be updated, improved and revised to adjust to new information and changing conditions. However, this process requires time, effort and dedication among those that implement the plan so that successes can be measured and maintained, and shortcomings can be addressed.

EPA's Handbook also describes nine elements that should be included in the structure of a watershed management plan. EPA requires these elements for any project funded by the Clean Water Act Section 319 grant program to reduce nonpoint source pollution and restore impaired waters. These nine elements include:

a. Identify the causes of water body impairment and sources of pollution.
b. Estimate pollutant loads and expected load reductions from management efforts.
c. Describe the management measures that will achieve reductions.
d. Estimate funding and technical assistance needs to implement management measures.
e. Describe the public education component to encourage continuous participation in the plan.
f. Define a schedule for implementation.
g. Describe interim measureable milestones to assess whether implementation is occurring.
h. Identify reasonable criteria to evaluate improvements in water quality and watershed health.
i. Describe a monitoring program to measure progress against the criteria.

Our document herein supports *Step 2 Characterize the Watershed* of the six steps of watershed management planning for the nine ICAs in the SEFCRI region. It also supports elements *a* and *b* in the nine elements of a watershed plan. This document presents the boundaries of the ICAs, the equivalent of watershed boundaries, to frame the watershed planning effort. It also provides a summary of the available data and information, as well as a summary of the watershed-based assessment and planning efforts that have been undertaken to date for each of the nine ICAs in the SEFCRI study area.

Figure 4-2. Steps in the Watershed Planning and Implementation Process (from EPA, 2008, Figure 2.3)



C. Scale for Assessment and Planning

Watershed management plans can be developed at varying scales, and like watersheds, can even be nested inside one another. A watershed plan can be developed for a large watershed, for several subwatersheds within that watershed, and then even on a site specific basis to address small individual water bodies such as small stream reaches, ponds, or neighborhoods.

D. Tools for Assessment and Planning

A variety of assessment and analytic tools exist for varying levels of detailed watershed analyses. Every analysis is limited by the robustness of data and assumptions that are incorporated into the analysis. However, a lot of valuable knowledge can be gained even from a very basic approach to watershed assessment. The most basic assessment approach is a land-use based loading analysis for a given pollutant of concern. This approach uses a spreadsheet to calculate annual average pollutant loads from different land-use types based on a pollutant loading coefficient. Ideally, a pollutant loading coefficient would be calibrated to the specific watershed, but it is common practice to borrow data from similar watersheds and environments as a first cut at the calculation. More detailed watershed pollutant loading models are integrated with GIS and take into account additional watershed characteristics such as the location of land-uses in the watershed, flow rates, and seasonality or event-specific conditions. In addition, these models sometimes work in conjunction with or have an integrated tool that evaluates hydrodynamics of the receiving water body (mixing and dilution), chemical and biological transformation of the pollutants in the receiving water, and other more complex systems. Obviously, more data are required to utilize the more complex tools effectively.

Below is a list of common publicly accessible watershed assessment and analysis tools:

- Watershed Treatment Model (Center for Watershed Protection)
- BASINS - Better Assessment Science Integrating Point and Non-Point Sources (EPA)
- WAM - Watershed Assessment Model (EPA)
- SWMM - Stormwater Management Model (EPA)
- WARMF - Watershed Analysis Risk management Framework (EPA)
- NSPECT - Nonpoint Source Pollution and Erosion Comparison Tool (NOAA)
- MapShed – Map version of Generalized Watershed Loading Function (GWLF) model (PennState)

E. Data Needs for Assessment and Planning

The watershed assessment and management planning process can begin with whatever information and data are available at the time. Collection of additional data can be incorporated as part of the management plan so that the plan is revised over time as more information becomes available and more data are collected. Key data for watershed assessment, the process of understanding the current watershed conditions, generally falls into several key categories: Geographic Information, Water Quality Data, Flow Data, and Watershed Mechanics (hydrology, geology, natural resources).

Examples of the data that might be included in each of these categories as they relate to the SEFCRI region include:

Geographic Information:

- ICA boundaries
- Land uses
- Wastewater discharges (deep well injection and ocean outfalls)
- Septic system locations (or general service areas)
- Hydrologic connections (canals, natural streams, wetlands, Intracoastal Waterway, inlets)

Water Quality Data:

- Nitrogen
- Phosphorus
- Sediment
- Fecal Coliform, e coli
- Sediment
- Turbidity
- Salinity
- Key Monitoring Locations for Water Quality Data:
  - Inlets
  - Discharges of large canals into Intracoastal Waterway
  - Ambient stations throughout estuaries in Intracoastal Waterways
  - Along the coral reef tract
  - Discharges from specific land use types
  - Intermittent stations in canals downgradient of specific land use types and known pollutant sources

Flow and Hydrodynamics:

- Discharges from major canals into Intracoastal Waterways
- Exchange and flushing between Intracoastal Waterway and Atlantic Ocean
- Exchange between different segments of the Intracoastal Waterway
- Groundwater flow and location of discharge (shallow and deep) to estuaries and the ocean
- Key Monitoring Locations for Flow and Hydrodynamics:
  - Discharges of large canals into Intracoastal Waterway (coincident with water quality stations)
  - Inlets
  - Ambient stations throughout estuaries in Intracoastal Waterways
  - Along the coral reef tract
  - Discharges from specific land use types (coincident with water quality stations)
  - Intermittent stations in canals downgradient of specific land use types and known pollutant sources (coincident with water quality stations)

Watershed Mechanics

- Rainfall data (annual, seasonal, event specific, design storms (1-yr, 2-yr, 10-yr storms, etc.)
- Flow direction in canals over time
- Interaction between canals and shallow groundwater
- Discharge of various aquifer systems in relation to coral reef tract, Intracoastal Waterway
- Geology and soils
- Soil infiltration rates

5. Information Collection and Compilation Process

A. Introduction

Information and data were collected for this project from a variety of organizations. In accordance with our scope of work, HW relied heavily on NOAA to either provide information to us directly in the form of electronic reports and files or to point us to websites and databases for various projects and organizations that contain relevant reports and information. We were also provided with an introduction to key individuals and agencies working in the SEFCRI region during a trip to the region in January 2014. We then followed up via email and telephone conversation with individuals, as needed. HW also engaged assistance from a local contractor[2] familiar with the relevant agencies in the SEFCRI region to investigate and obtain available data primarily from local county governments. This project was not a data collection project, but rather an effort to compile and organize readily available data and provide information in a format that would be useful for performing pollutant loading and source assessments in each of the nine ICAs in the SEFCRI region.

B. Sources of Data

The primary data for this project were obtained from NOAA and SEFCRI partners. These data were collected by them and provided to HW for this LBSP project. The Florida Coral Reef Tract (FCRT) project conducted by the Biogeography Branch of NOAA's Center for Coastal Monitoring and Assessment provided a significant portion of these data. In addition, the NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML) provided data on inlet hydraulics including inflow and outflows and monitoring of water quality in the coastal waters near the coral reefs and wastewater outfalls.
The SFWMD has an extensive database on the hydraulics and water quality of the engineered hydrologic system in southeast Florida. The Advanced ArcHydro Extended Database (AHED) contains hydraulic data on watersheds, canals, control structures, and monitoring locations. The DBHYDRO database contains monitoring data for flow, stage, water quality, and weather.

The STOrage and RETrieval (STORET) database maintained by FDEP also contains data on flow, stage, water quality, and weather, as well as data from volunteer and municipal sources. Some of the six counties in the study area (Broward, Martin, Miami-Dade, Okeechobee, Palm Beach, and St. Lucie) also maintain separate databases for flow, stage, water quality, and weather for their monitoring sites. There is some repetition between the DBHYDRO, STORET, and the county databases.

In addition to the above sources, HW supplemented missing GIS data from the extensive Florida Geographic Data Library maintained at the University of Florida's GeoPlan Center. Geographic data on boundaries, land use, surficial geology, habitat, and topography were downloaded. The Nova Southeastern University provided geographic data on coastal benthic habitat including coral reefs. Septic service areas were obtained from the county parcel databases.

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[2] HW engaged the services of Katharine Tzadik, who was formerly the Environmental Project Coordinator for the Coral Reef Conservation Program at the Florida DEP.

C. Types of Data

This project was compiled using multiple types of information. Technical reports, geographic (GIS) data, and numerical data were obtained from state, federal, scientific, and consultant sources. These data are organized into two Excel files, one for text files, and one for geographic files. These files act as source libraries for this project and accompany this report. These files include the following searchable columns:

- Title/Description. A title and detailed description of the data.
- Folder. Relative folder location under main data directory.
- Filename. Name of the file for this data source.
- Source. Identifies where the data came from, which is not necessarily same as the entity that created the original data.
- ICA. Identifies the ICA(s) to which the data apply.
- Collected By. Identifies who collected or gathered the data. Normally FCRT, NOAA, or HW.

These two libraries can be utilized to locate text- or geographic-based information related to the ICAs. A simple search on the Key Word column allows the user to locate all instances of the search word. Alternatively, a slightly more sophisticated approach using the Excel Filter function can highlight only those records of interest (others are filtered out). Once a record is located, the file path and name gives the location of the file relative to the Excel file.

D. Limitations on Data Collected

Most of the data were collected by NOAA and SEFCRI partners for this LBSP project. Additional secondary data and information were collected by HW to fill in gaps or supplement existing data. We followed up on leads and suggestions from NOAA staff or those that we met with during our January 2014 project trip to the region. All of these data are secondary data and contain the accuracy and reliability limitations inherent in the source data. HW did not perform any primary data collection for this project.

6. Documented Levels of LBSP Impacts in Each ICA

A. Impaired Waters and TMDLs

This section provides a basic summary of the documented levels of LBSP impacts in each ICA, as evidenced by water quality assessments, planning level nutrient loading calculations and planning documents. Each ICA has been the focus of varying degrees of assessment and planning efforts (The most relevant assessment and planning documents for each ICA are further documented in Section 7). Under the Section 303(d) of the Clean Water Act (CWA) and the Florida Impaired Waters Rule (IWR), the state of Florida is required to identify and assess impaired surface waters throughout the state. This assessment is presented most recently in the 2014 Integrated Water Quality Assessment Report (FDEP, 2014a). For those waters that are impaired, meaning they do not meet the water quality standards to support their designated use, the state is directed to develop a Total Maximum Daily Load (TMDL) to restore the water quality to the required standard[3]. TMDLs address individual pollutants, so a water body that is impaired by more than one pollutant could require multiple TMDLs. Table 6-1 presents the TMDLs that have been approved within each of the 9 ICAs. According to an FDEP status map of TMDLs in Florida (FDEP, 2014b), there are no additional TMDLs currently under development or included in the 2-year work plan within the SEFCRI Region. Beyond the set of waters for which a TMDL has been developed, there is a much larger set of water bodies that have been verified as impaired, but are still awaiting development of a TMDL. Table 6-2 presents a summary of the number of verified impaired water bodies in each ICA[4].

Table 6-1. Approved TMDLs in the 9 ICAs

ICA	WBID	CLASS	WATERBODY NAME	POLLUTANTS
Saint Lucie Inlet	3197	3F	C-24	TN, TP, and BOD
Saint Lucie Inlet	3200	3F	C-23	TN and TP
Saint Lucie Inlet	3218	3F	C-44	TN, TP, and BOD
Saint Lucie Inlet	3194A	3F	TENMILE CREEK	Fecal Coliform
Saint Lucie Inlet	3194	3M	ST LUCIE RIVER (NORTH FORK)	Fecal Coliform
Saint Lucie Inlet	3194	3M	ST LUCIE RIVER (NORTH FORK)	TN, TP, and BOD
Saint Lucie Inlet	3210A	3M	ST LUCIE CANAL	TN and TP
Saint Lucie Inlet	3194B	3M	ST LUCIE RIVER (NORTH FORK)	TN, TP, and BOD
Saint Lucie Inlet	3211	3M	BESSEY CREEK	TN and TP
Saint Lucie Inlet	3193	3M	ST LUCIE RIVER	TN and TP
Saint Lucie Inlet	3210	3M	ST LUCIE RIVER (SOUTH FORK)	TN and TP
Jupiter Inlet	3226C	2	LOXAHATCHEE RIVER (SOUTHWEST FORK)	Fecal Coliform
Hillsboro Inlet	3271	3F	POMPANO CANAL	TN and TP
Hillsboro Inlet	3270	3F	C-14 (CYPRESS CREEK CANAL/POMPANO CANAL)	Fecal Coliform
Hillsboro Inlet	3264A	3F	E-1 CANAL	Fecal Coliform

[3] This report did not evaluate whether the water quality standards applicable to each water body are protective of coral reefs and the associated supporting marine and estuarine habitats.

[4] As part of the development of this report, HW has created a shapefile based on 2014 FDEP Impaired Waters data that links WBIDs to ICAs, so that the specific impaired waters can be identified.

ICA	WBID	CLASS	WATERBODY NAME	POLLUTANTS
Port Everglades Inlet	3277C	3F	NORTH NEW RIVER CANAL	Fecal Coliform
Port Everglades Inlet	3274	3M	C-13 EAST (MIDDLE RIVER CANAL)	Fecal Coliform
Port Everglades Inlet	3281	3F	C-11 (EAST)	Fecal Coliform
Port Everglades Inlet	3277A	3M	NEW RIVER CANAL (SOUTH)	Fecal Coliform
Port Everglades Inlet	3276	3F	C-12	Fecal Coliform
Port Everglades Inlet	3273	3F	C-13 WEST (MIDDLE RIVER CANAL)	Fecal Coliform
Port Everglades Inlet	3277E	3M	DANIA CUTOFF CANAL	Fecal Coliform
Port Everglades Inlet	3276A	3M	NEW RIVER (NORTH FORK)	Fecal Coliform
Baker's Haulover Inlet	3285	3F	C-8/BISCAYNE CANAL	Fecal Coliform
Government Cut	3290	3F	C-6/MIAMI CANAL	Fecal Coliform
Government Cut	3288	3M	C-6/MIAMI RIVER	Fecal Coliform
Government Cut	3287	3F	C-7/LITTLE RIVER	Fecal Coliform
Government Cut	3288B	3M	C-6/MIAMI RIVER (LOWER SEGMENT)	Fecal Coliform
Government Cut	3288A	3M	WAGNER CREEK	Fecal Coliform
Government Cut	3226G4	3M	LAS OLAS ISLES FINGER CANAL SYSTEM	Fecal Coliform

Source: 2014 Integrated Water Quality Assessment Report (FDEP, 2014a)

Table 6-2. Summary of Verified Impaired Water Bodies Identified in the 9 ICAs

ICA	Nutrients	Sediment	Bacteria	Other
St. Lucie Inlet	27	2	12	25
Jupiter Inlet	26	1	8	15
Lake Worth Inlet	24	1	5	15
South Lake Worth/ Boynton Inlet	16	0	1	7
Boca Raton Inlet	10	0	2	6
Hillsboro Inlet	5	0	4	10
Port Everglades Inlet	3	0	14	19
Baker’s Haulover Inlet	0	0	9	10
Government Cut	1	0	10	23
TOTAL	**112**	**4**	**65**	**130**

Source: 2014 Integrated Water Quality Assessment Report (FDEP, 2014a)

B. Basin Management Action Plans

In Florida, each TMDL is implemented through a Basin Management Action Plan (BMAP). A BMAP generally includes an analysis of the existing pollutant loads to the impaired water, the sources of those loads, and actions that need to be taken to reduce those pollutant loads to an acceptable level. Therefore, BMAPs are important and useful resources for understanding LBSPs in a given watershed.

Figure 6-1 presents FDEP's status update (FDEP, March 2014) for BMAP adoption. According to this figure, there are two BMAPs pertaining to the SEFCRI region: one under development for Lake Okeechobee and one that has been approved for the St. Lucie River and Estuary Basin. The upper section of the Lake Worth ICA (WBID 3233A) is included in the Lake Okeechobee Basin BMAP area. The development of the Lake Okeechobee BMAP is in progress and the boundaries are still tentative (FDEP, 2014c). The St. Lucie River and Estuary Basin BMAP includes the St. Lucie and Jupiter ICAs and was adopted in May 2013. No BMAPs are in development or have been adopted in the remaining ICAs to the south.

C. Aquatic Preserve Management Plans

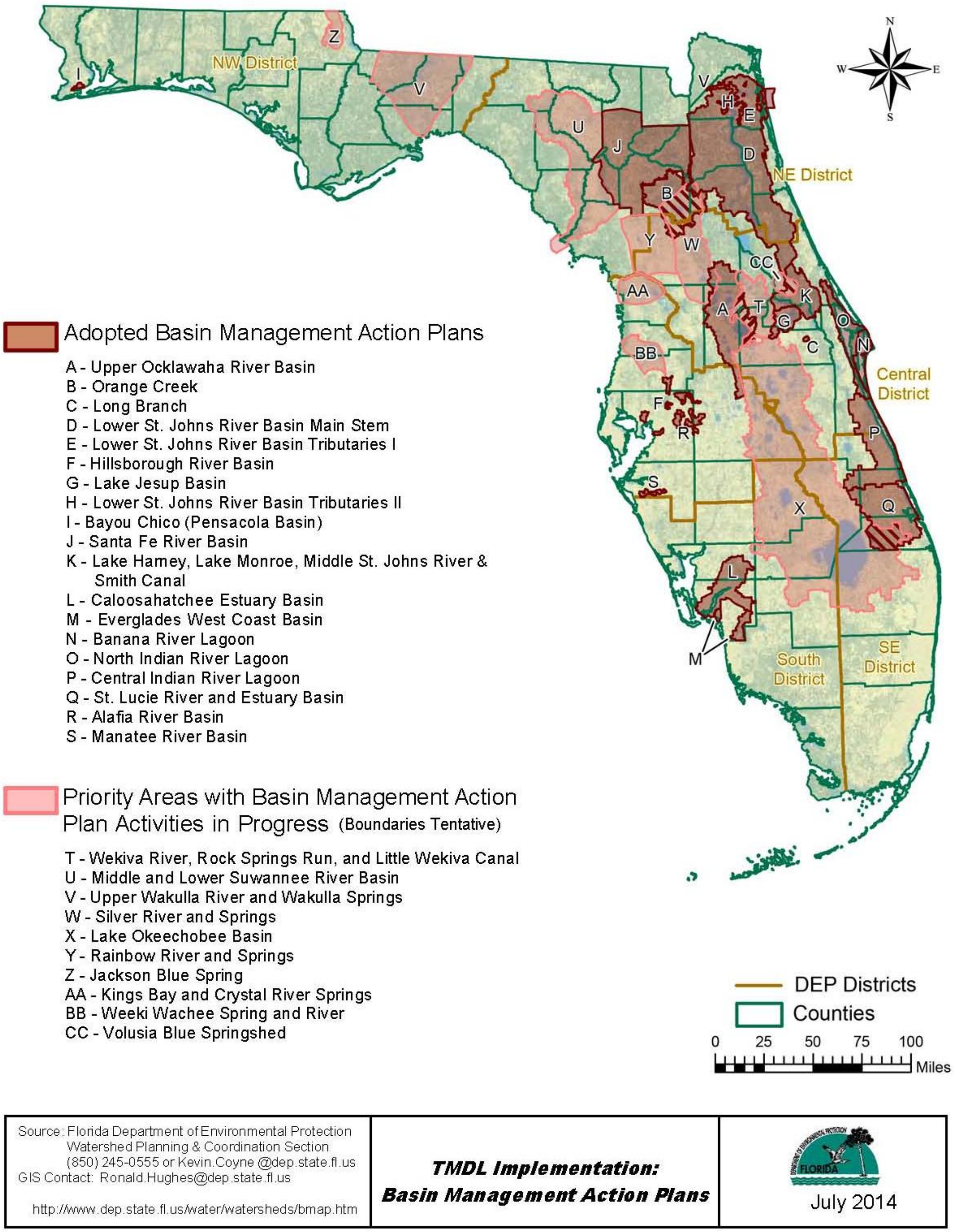
The SEFCRI Region includes a number of Florida Aquatic Preserves, which have specially designated protective status, water quality standards and management plans. These Aquatic Preserves are managed by the FDEP Office of Coastal and Aquatic Managed Areas (also referred to as the Florida Coastal Office) (http://www.dep.state.fl.us/coastal/). In particular, this region includes the Biscayne Bay Aquatic Preserves, the North Fork St. Lucie Aquatic Preserve, the Loxahatchee River-Lake Worth Creek Aquatic Preserve and the Jensen Beach to Jupiter Inlet Aquatic Preserve within the Indian River Lagoon Aquatic Preserves.

These preserves were established through the 1975 Florida Aquatic Preserve Act so that "their aesthetic, biological, and scientific values may endure for the enjoyment of future generations." The management policies and criteria within the Aquatic Preserves are governed by Florida Administrative Code (F.A.C) Chapter 18-20, Florida Aquatic Preserves, except for the Biscayne Bay Aquatic Preserve, which is governed by F.A.C. Chapter 18-18, Biscayne Bay Aquatic Preserve. These Aquatic Preserves are afforded special water quality protections that prohibit water quality degradation, in accordance with section the Florida Surface Water Quality Standards (F.A.C. Chapter 62-302.700).

A major hurdle for these aquatic preserves is that the preserves do not include the contributing land area that drains to the water bodies being protected. In the SEFCRI Region, these drainage areas are fairly heavily developed, and the population is increasing. A great strength of these Management Plans is that they can focus directly on habitat protection for the animals and plants that are vital in supporting coral reef ecosystem health. These Aquatic Preserves can play an important role in management, planning, and coordination among local, county, and state staff implementing the plans for aquatic preserve restoration and protection.

The **Biscayne Bay Aquatic Preserves** is a combination of two areas located on the north and south end of Biscayne Bay, just outside the Biscayne National Park, near Miami. The northern section of the preserve includes part of Baker's Haulover Inlet and Government Cut. The website provides the following summary of water quality and LBSP challenges facing the preserve:

Insert Figure 6-1. TMDL Implementation: Basin Management Action Plans (FDEP, 2014c)



"Water quality has improved substantially in the last 30 years in the northern part of Biscayne Bay in particular, and water quality generally meets or exceeds local, state and federal standards for recreational uses and propagation of fish and wildlife. However, past development, hydrologic changes, water management practices and adjacent land uses have contributed to loss of wetland and seagrass communities has contributed to physical and ecological changes in water quality. Biscayne Bay still receives a considerable amount of nutrients, trace metals, organic chemicals and particulates from storm water runoff, canal discharge, and other sources. Specific water and sediment quality related problems include turbidity, nutrients, sewage and contaminants. Other water quality concerns have to do with the quantity of fresh water received by Biscayne Bay currently from natural sheetflow, groundwater and inputs from tributaries - albeit often in the form of pulsed, point source discharges. Timing and distribution of this much needed freshwater also adds to water quality concerns."

The **North Fork St. Lucie Aquatic Preserve** Management Plan for 2009-2019 (FDEP, 2009) includes a delineation of the contributing drainage area for purposes of identifying pollutant loads. The drainage area is coincident with the St. Lucie ICA delineated in this report. The plan includes maps of nitrogen and phosphorus loading from each WBID polygon within the drainage area (pages 66-67).

The **Loxahatchee River – Lake Worth Creek Aquatic Preserve** is located within the Jupiter ICA. The drainage area can be assumed to be coincident with the Jupiter ICA boundaries, although a watershed map was not readily available on the preserve website. The Management Plan is old (FDNR, 1984) but the website has the following description of management and LBSP challenges facing the preserve:

"Because of the rapid residential / urban growth and input of agricultural drainage canals, the health of the Preserve has been affected. The C-18 canal causes massive amounts of freshwater to drain into the river basin and forces saltwater into the North Fork of the river, thereby altering the historical natural communities. The preserve does play host to a vast array of plant and animal species, but many are threatened by the extensive development and the freshwater drainage of the C-18 canal. Major issues in the Preserve include leaching of pollutants from local septic tanks which contributes to a documented decrease of dissolved oxygen in the River. The local state park and the Loxahatchee River Control District also provide on-site management and education about the River."

The **Indian River Lagoon Aquatic Preserve** is actually a group of four Aquatic Preserves in Indian River Lagoon which will now be managed under one Management Plan (FDEP, 2014d). This area includes the areas of Indian River Lagoon that are within the delineated ICAs the St. Lucie and Jupiter inlets, as well as areas to the north. Water quality management in this Management Plan is addressed by BMAPs, including the St. Lucie River and Estuary BMAP described above.

D. Estimated LBSP Loads

A useful way to compare the relative contribution to impairments in each ICA is to calculate the pollutant loads based on land-uses in each ICA. In Section 3 of this report, we presented a summary of land uses in each ICA. In this section, we have developed a rough calculation of nutrient pollutant loads in each ICA simply for purpose of comparison among ICAs. The calculation used the land use runoff coefficients developed by SFWMD in the St. Lucie River Watershed Protection Plan (SFWMD et al., 2009) and applied them across the entire SEFCRI region. This approach is an approximate method but is a first step in ranking loads from land-based sources of pollution. The calculation is simple: The area of land within each land use is multiplied by the applicable land use coefficient and then summed together to obtain the estimated total annual pollutant load for each land use in all the ICAs. Because we had grouped land uses together into broader categories than the St. Lucie report, we calculated the area-weighted land use coefficients for these new broader categories for each ICA. These land-based loads exclude loads from septic systems. However, with further effort, this calculation could be revised to incorporate an estimate of septic system loads. The total phosphorus (TP) and total nitrogen (TN) loads from land uses in each ICA are presented below in Tables 6-3 and 6-4.

Table 6- 3. Summary of Estimated TP Loads (lb/yr) from Land Uses in Each ICA

ICA	Phosphorus Loads (lb/yr)					
	Animal Agric	Crop Agric	Open/Forest	Urban/Trans	Water/Wetlands	TOTAL
St. Lucie Inlet	7,458	449,242	22,448	152,820	11,042	**643,011**
Jupiter Inlet	1,131	26,931	10,625	51,197	9,857	**99,741**
Lake Worth Inlet	2,537	17,221	7,036	122,891	7,392	**157,076**
Boynton/S. Lake Worth Inlet	1,980	36,562	753	115,695	720	**155,710**
Boca Raton Inlet	574	14,426	1,360	89,946	724	**107,031**
Hillsboro Inlet	0	17	383	84,380	306	**85,087**
Port Everglades Inlet	123	1,707	1,497	163,014	803	**167,143**
Baker's Haulover Inlet	0	2,241	1,114	139,282	1,695	**144,331**
Government Cut	0	8,714	2,374	228,868	7,386	**247,342**
TOTAL	**13,803**	**557,062**	**47,591**	**1,148,092**	**39,924**	

Table 6- 4. Summary of Estimated TN Loads (lb/yr) from Land Uses in Each ICA

ICA	Nitrogen Loads (lb/yr)					
	Animal Agric	Crop Agric	Open/Forest	Urban/Trans	Water/Wetlands	TOTAL
St. Lucie Inlet	23,623	1,819,762	152,259	679,810	133,752	**2,809,205**
Jupiter Inlet	3,130	105,167	85,241	243,382	115,715	**552,635**
Lake Worth Inlet	10,928	99,548	64,087	553,964	87,526	**816,053**
Boynton/S. Lake Worth Inlet	8,788	98,200	6,339	469,325	9,401	**592,053**
Boca Raton Inlet	3,845	42,716	10,462	366,496	9,179	**432,698**
Hillsboro Inlet	0	56	2,890	328,222	4,021	**335,189**
Port Everglades Inlet	770	5,029	10,199	657,174	10,505	**683,677**
Baker's Haulover Inlet	0	8,024	9,395	571,334	21,263	**610,017**
Government Cut	0	24,422	20,694	961,622	91,701	**1,098,439**
TOTAL	**51,083**	**2,202,925**	**361,566**	**4,831,329**	**483,063**	

E. Wastewater

Wastewater in the SEFCRI Region is managed through a combination of onsite septic systems, small package plants and centralized wastewater sewer and treatment systems. The Statewide Inventory of Onsite Sewage Treatment and Disposal Systems in Florida (Earthsteps, LLC and GlobalMind, 2009) provides county maps of estimated and confirmed wastewater treatment on a parcel by parcel basis. These maps are presented in Figure 6-2 through 6-5.

Clearly there are more septic systems in use in Martin County, in the northern SEFCRI Region, than in the southern, more developed counties. However, septic systems are used throughout the region and warrant an evaluation as a potential nutrient source in all the ICAs.

Approximately 300 million gallons per day (mgd) of secondary treated wastewater effluent is discharged to the ocean, approximately one to three miles offshore, via six ocean outfalls in the SEFCRI region (FDEP 2010). Current Florida law requires the ocean outfalls to be either phased out of use or the treatment of wastewater to advanced water treatment standards will be required for ocean outfall discharge in the next 10 years. The following succinct summary of the ocean outfall law is provided in the Miami-Dade County Water and Sewer Departments (MDWSD) Compliance Plan (MDCWSD, June 28, 2013):

"In 2008, the Florida Legislature approved and the Governor signed a law requiring all wastewater utilities in southeast Florida utilizing ocean outfalls for disposal of treated wastewater to reduce nutrient discharges by 2018, cease using the outfalls by 2025, and reuse 60% of the wastewater flows by 2025. The statute was amended in 2013 to provide greater flexibility to meet the reuse requirements and to allow continued use of the outfalls for managing peak sewage flows not to exceed 5% of the annual baseline flows. The statute requires the affected utilities to submit a preliminary compliance plan by July 1, 2013.

In addition, the FDEP 2010 Annual Report on implementation of the phase out also provides valuable summary information. Figure 6-6 is excerpted from the report and shows the location of the ocean outfalls. Tables 6-5 and 6-6, also excerpted from the report, are helpful summary tables identifying the permittees discharging through each outfall, and the nutrient concentrations being discharged.

Figure 6-2. Martin County Wastewater Methods Estimations

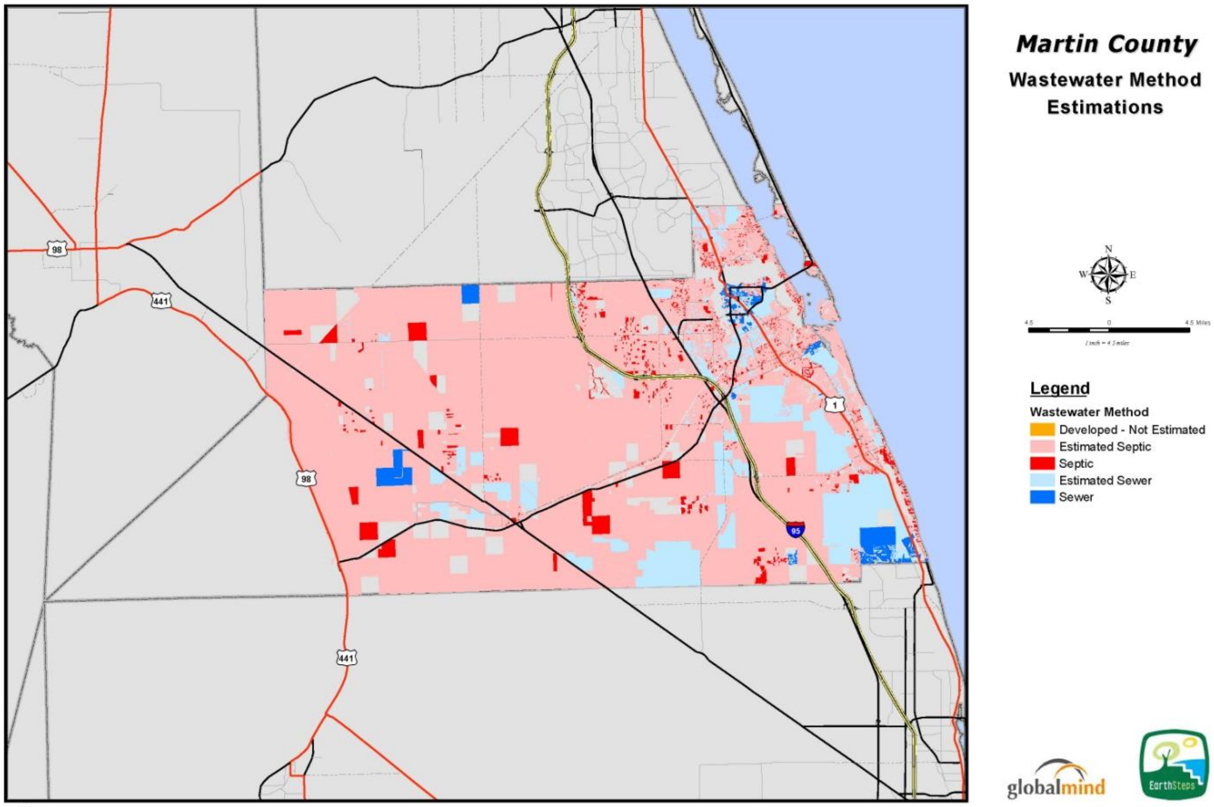


Figure 6-3. Palm Beach County Wastewater Methods Estimations

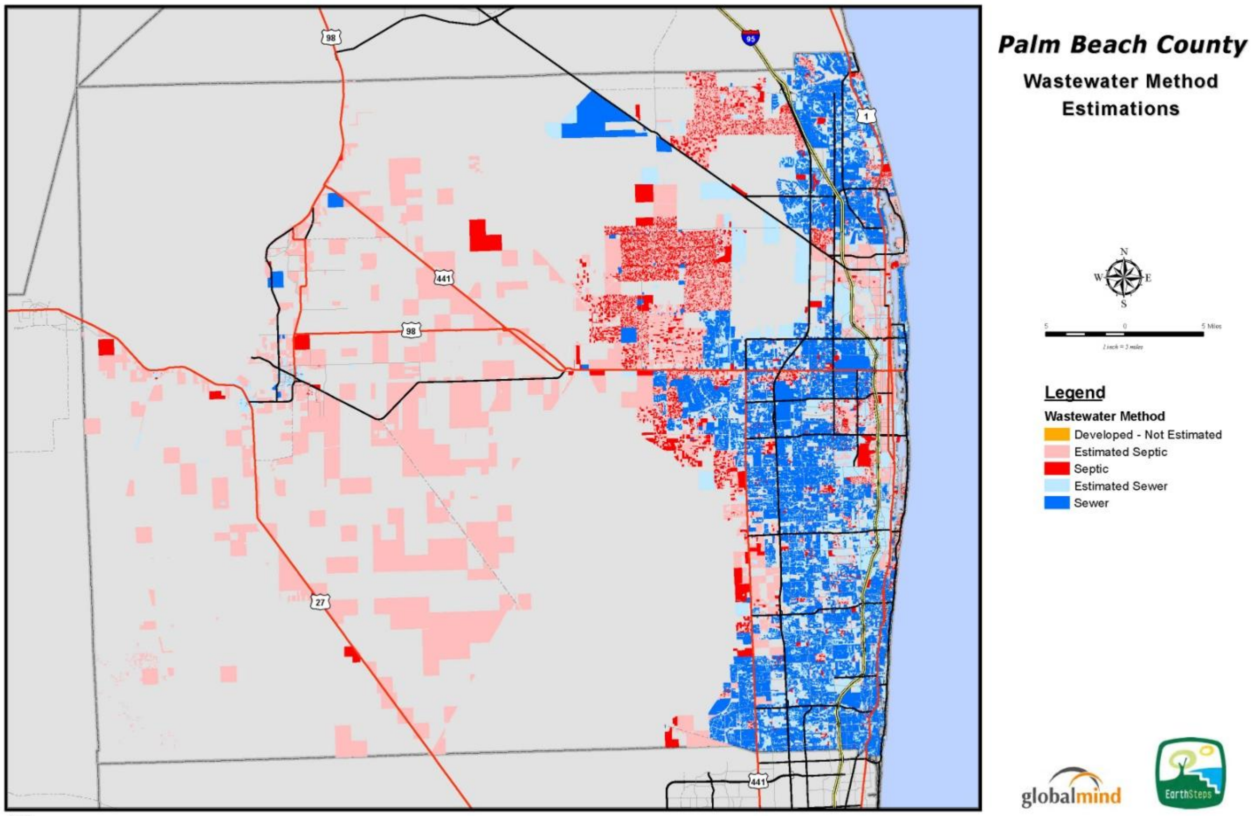


Figure 6-4. Broward County Wastewater Methods Estimations

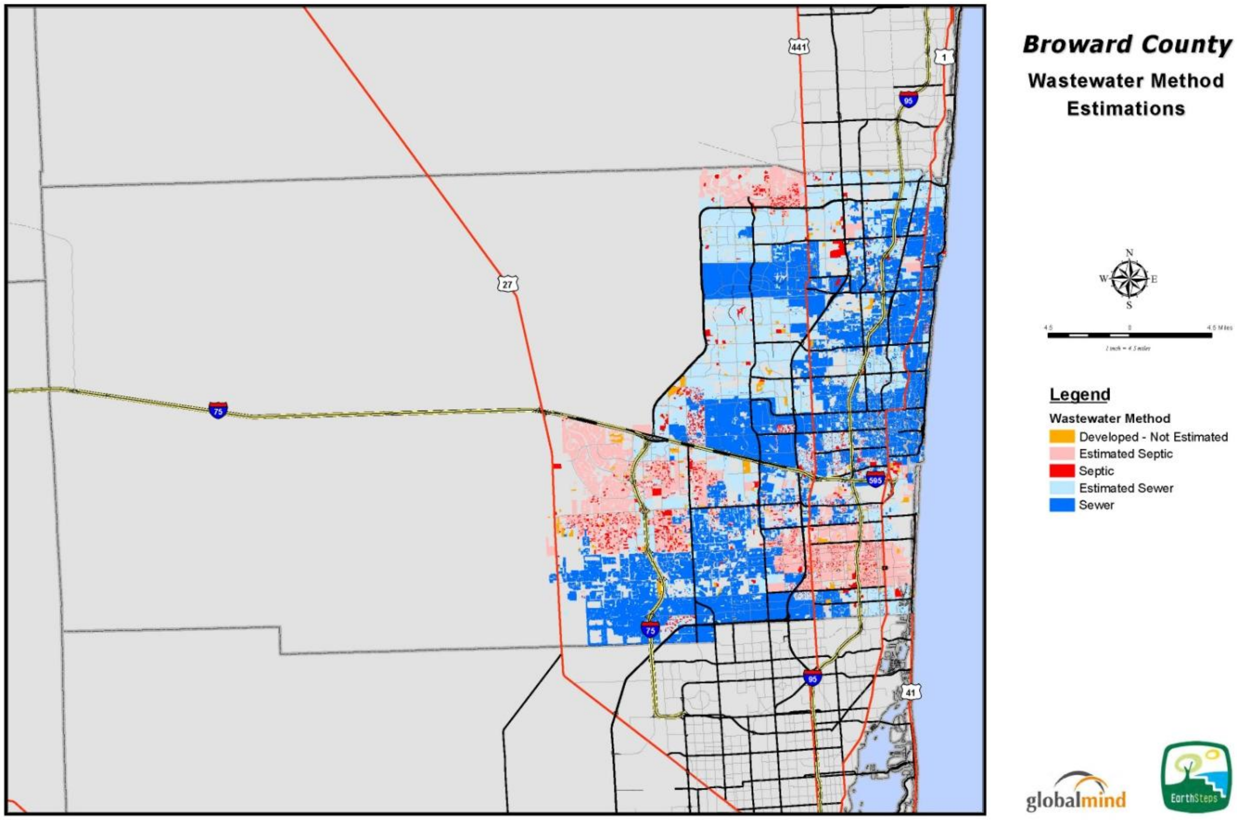


Figure 6-5. Miami-Dade County Wastewater Methods Estimations

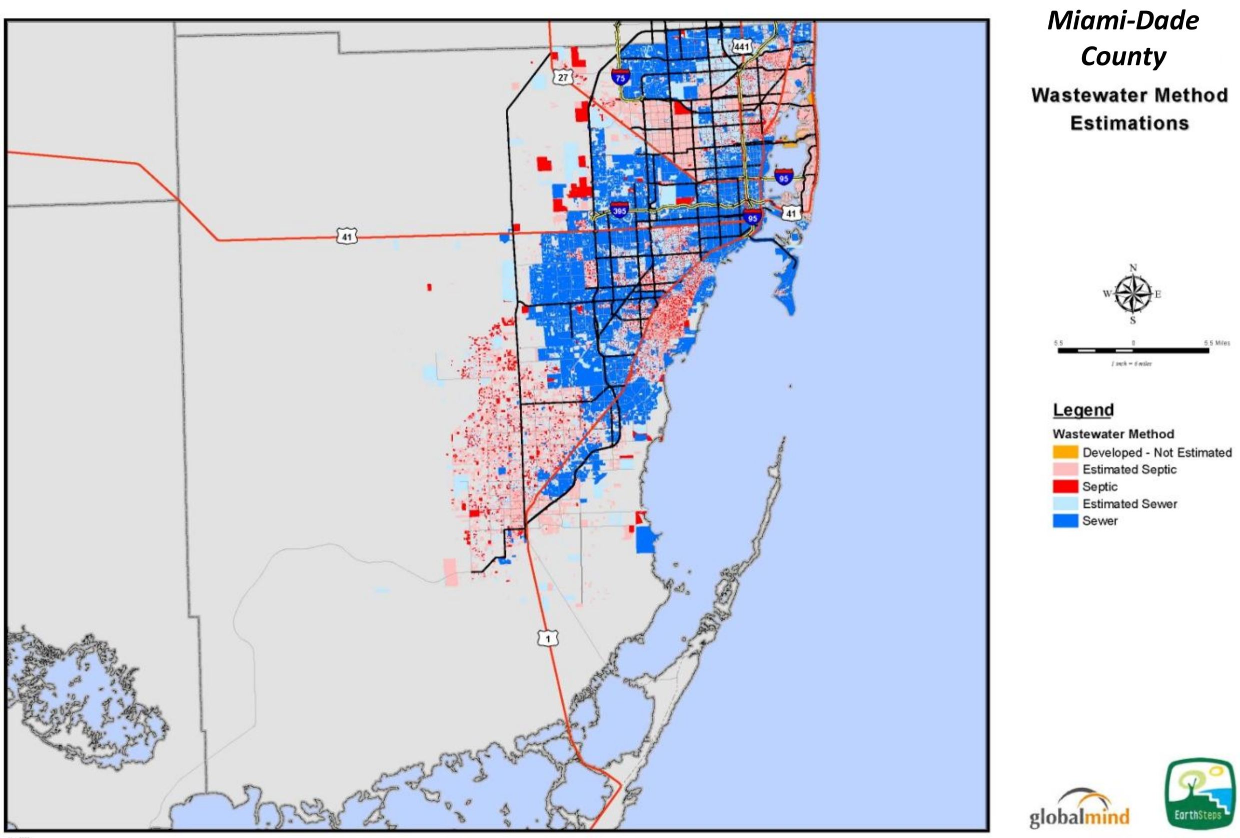


Figure 6-6. Location of Existing Ocean Outfalls in Florida

Table 6-5. Existing Ocean Outfalls, Treatment Facilities and Permit Holders

Ocean Outfall Name	Treatment Facility Name	Permit Holder
Boynton/Delray Beach *(See note)*	South Central Regional Wastewater Treatment Facility	South Central Regional Wastewater Treatment and Disposal Board
Boca Raton	City of Boca Raton Wastewater Treatment/ Water Reclamation Facility	City of Boca Raton
Broward	Broward County North Regional Wastewater Treatment Plant	Broward County Office of Environmental Services
Hollywood	Hollywood Southern Regional Wastewater Treatment Facility	City of Hollywood
	Cooper City Wastewater Treatment Facility	City of Cooper City
	Town of Davie Wastewater Treatment Facility	Town of Davie
Miami North	MDWASD North District Wastewater Treatment Plant	MDWASD
Miami Central	MDWASD Central District Wastewater Treatment Plant	MDWASD

Source: (FDEP, 2010)

Note: "Currently, the facility disposes of its treated wastewater through deep injection wells or for irrigation reuse. The Boynton/Delray Beach ocean outfall currently is used only to handle peak flows during wet weather, during mechanical integrity testing of its deep wells, or as an emergency backup disposal method." (FDEP, 2010)

Table 6-6. Baseline Nutrient and Target Nutrient Loadings for Existing Wastewater Facilities Discharging Through an Ocean Outfall

Wastewater Facility	Actual AADF* (mgd)	Baseline N Load (lb/day)	Target N Load (lb/day)	Baseline P Load (lb/day)	Target P Load (lb/day)
South Central Regional Wastewater Treatment Facility *(see note)*	12.9	1895	323	164	108
City of Boca Raton Wastewater Treatment/ Water Reclamation Facility	10.3	1591	257	69	86
Broward County North Regional Wastewater treatment Plant	37.4	7027	936	550	312
Hollywood Southern Regional Wastewater Treatment Facility	36.7	4836	918	387	306
Cooper City Wastewater Treatment Facility	1.5	197	37	16	12
Town of Davie Wastewater Treatment Facility	1.9	260	48	21	16
MDWASD North District Wastewater Treatment Plant	81.0	10951	2028	1119	676
MDWASD Central District Wastewater Treatment Plant	114.8	17354	2872	1651	957
Totals	**296.5**	**44111**	**7419**	**3977**	**2473**
Totals (tons/day)		**22.06**	**3.71**	**1.99**	**1.24**
Reduction (tons/day)		**18.35**		**0.75**	

*AADF = Actual Annual Daily Flow
Source: (FDEP, 2010)

Note: "Currently, the facility disposes of its treated wastewater through deep injection wells or for irrigation reuse. The Boynton/Delray Beach ocean outfall currently is used only to handle peak flows during wet weather, during mechanical integrity testing of its deep wells, or as an emergency backup disposal method." (FDEP, 2010)

F. General Planning Efforts

1. St. Lucie ICA

The St. Lucie Inlet ICA (877.2 square miles) is characterized by impairments for total phosphorus (TP), total nitrogen (TN) and biological oxygen demand (BOD) across six different WBIDs within the ICA. A majority (56% according to the BMAP (FDEP, 2013), 49.5% according to the land use maps presented in this report) of the drainage area is agricultural use, and 14% falls into the land use category of Urban and Built-up lands (20.1% in the category of urban and transportation according to the land use maps presented in this report). As a result, the primary sources of pollutants contributing to the impairments are agricultural and urban stormwater, water from Lake Okeechobee, and groundwater. Lake Okeechobee water is addressed through a separate BMAP to remediate water quality in that water body, so the BMAP for the St. Lucie Estuary focuses on stormwater sources that originate within the ICA itself.

According to the BMAP (FDEP, 2013), the stormwater sources can be categorized into three basic groups: Municipal Separate Storm Sewers Systems (MS4s) regulated by the NPDES Program, other stormwater programs not regulated as MS4s, and agricultural runoff. The largest agricultural land uses at the time of the BMAP assessment were cow and calf operations and citrus production, although citrus production has fallen off in recent years, resulting in land being less intensely farmed or being converted to other uses. The BMAP includes reduction requirements for each of these land use categories, with specific BMPS identified for regulated MS4s and other municipal stormwater programs, as well as agricultural producers regulated by FDACS. The project types that will be implemented to meet these TN, TP and BOD load reductions include structural BMPS, nonstructural BMPs, street sweeping, public education and agricultural management BMPs.

2. Jupiter ICA

The Jupiter ICA corresponds to the Loxahatchee Planning Unit identified in the 2003 FDEP Basin Status Report for the St. Lucie and Loxahatchee (FDEP, 2003). This Planning Unit is described in detail on pages 74-79. Unless otherwise noted, the information provided below is derived from the 2003 FDEP Basin Report. Although this document includes both the St. Lucie ICA and the Jupiter ICA, the level of management planning since 2003 in the Jupiter ICA is less significant than in the St. Lucie where a BMAP was recently adopted.

The Jupiter ICA is approximately 282.2 square miles in area. Almost half (41.8%) of the ICA is wetland and approximately 24.5% is urban and transportation area. Another quarter of the ICA (23.9%) remains in open/forest land and another small area 9.6% is in crop agriculture (source: land use maps in this report). This ICA also contains the first designated Wild and Scenic River in Florida, the Northwest Fork of the Loxahatchee River. All waters in the Planning Unit are designated as Class III except the C-18 Canal, which is Class I due to its connection to the West Palm Beach Water Catchment Area to the south, which is used for potable water supply.

Size of ICAs

ICA	*Area (Sq. Mi.)*
St. Lucie	*877.2*
Lake Worth	*317.9*
Government Cut	*371.7*
Jupiter	*282.2*
Port Everglades	*174.0*
Bakers Haulover	*170.9*
South Lake Worth/ Boynton	*144.1*
Boca Raton	*112.7*
Hillsboro	*80.3*

At the time of the 2003 Basin Status Report, there were four wastewater treatment facilities in the planning unit that are identified as the most significant of 23 permitted WWTFs. These are Seacoast's PGA's Domestic WWTF (12 mgd), The Loxahatchee River District's WWTF (9 mgd), the Jupiter Water Treatment Plant Reverse Osmosis facility discharge (2 mgd), and the Village of Tequesta Water Treatment Plant Reverse Osmosis discharge (1.2 mgd).

The 2003 Basin Report identified the major concern for this Planning Unit as the reduction in freshwater flows in the Loxahatchee River and the upstream transition of the salinity wedge, which has resulted in die off of cypress trees and replacement by mangroves. Other contributing causes of the salt water intrusion into the estuary are the dredging in 1947 to permanently open the Jupiter Inlet and sea level rise (USGS, 2013). Several projects have been developed in response, including the Pal Mar and

Corbet Hydropattern Restoration Project, and the C-51 and L-8 Reservoir Projects (part of CERP) that will make more water available to the Palm Beach Water Supply and therefore allow more water to remain in the Loxahatchee River system.

Most subsequent planning and assessment studies appear to have focused on the North Fork Loxahatchee River with the goal of reducing salinity intrusion up the estuary. An appendix in the 2007 South Florida Environmental Report presented the 2006 Flow Restoration Project for the North Fork of the Loxahatchee River, prepared jointly by FDEP, SFWMD, the Loxahatchee River District and the Florida Park Service (FDEP et al., 2007). In summary, the Preferred Restoration Flow Scenario is a variable dry season flow between 50 cfs and 110 cfs, with a mean monthly flow of 69 cfs over Lainhart Dam, while providing an additional 30 cfs of flow from the downstream tributaries.

A 2013 USGS study, Assessment of Groundwater Input and Water Quality Changes Impacting Natural Vegetation in the Loxahatchee River and Floodplain Ecosystem, Florida (Open File Report 2007-1304) (USGS, 2013), looked at the question of whether groundwater was a significant source of freshwater to the Loxahatchee River and how that might be influencing the health of freshwater species such as cypress. The report concluded that episodic events such as hurricanes may play a significant role in pushing saline waters up into the estuary contributing to die off, and should be studied more.

3. Lake Worth ICA

Lake Worth Lagoon has been the subject of extensive management planning, including the adoption of the Lake Worth Lagoon Management Plan in 1998, the first update in 2008 and the second update recently in 2013. "Population increases, altered hydrology and large scale freshwater releases from regional canals are still the main stressors for potential habitat loss and degradation of water quality in the Lake Worth Lagoon" (LWLI, 2013. Page 7). The contributing area for Lake Worth Lagoon inlet is a total of approximately 317.9 square miles. It is largely wetland (29.9% of the ICA) and upland forest and open space (15.9% of the ICA) in the upstream areas of the ICA, and very heavily developed and impervious (45.1% of the ICA) in the lower portion of the ICA. Implementation of the management plan since the 2008 Update of the Lake Worth Lagoon Management Plan included a five-year water quality baseline analysis, implementation of three large stormwater treatment projects to treat runoff from 526 acres, and two projects to reduce septic system loading to the estuary by removing septic systems and replacing them with sanitary sewer systems and treatment at centralized wastewater treatment facilities.

The 2013 Lake Worth Lagoon Management Plan Update includes a summary of the five-year baseline water quality assessment performed by the Lake Worth Lagoon Initiative. This summary is described in Chapter 2 of the 2013 Update. The lagoon was divided into three assessment areas, the North Lagoon that receives freshwater inflows from the Earman River Canal (C-17, S44), the Central Lagoon that receives freshwater inflows from the West Palm Beach Canal (C-51, S155) and the Southern Lagoon that receives freshwater inflows from the Boynton Beach Canal (C-16, S41). (Note: The Southern Lagoon and contributing area together essentially comprise the Boynton / South Lake Worth ICA described in this document.) Six water quality stations were sampled from 2001-2005 and 18 stations were sampled from 2007-2012. Below is an excerpt from the 2013 Update to the Lake Worth Lagoon Management Plan:

"When compared with 2001 – 2005, data from 2007-2012 showed the following differences:

- *Salinity was significantly higher in Lake Worth Lagoon Central [LWC] and Lake Worth Lagoon South [LWS],; no significant difference was observed in Lake Worth Lagoon North [LWN].*
- *Both TP and TN concentrations were significantly lower for all segments.*
- *Chlorophyll-a was lower in Lake Worth Lagoon Central [LWC]; no significant differences were observed in LWN and LWS.*
- *Turbidity was higher in the LWN segment and lower in the LWC with no difference in the LWS.*

In addition, the north lagoon had relatively higher salinity, and lower concentrations of nutrient and turbidity then the south and central segments during both periods…. According to Dr. Chen's (SFWMD) analysis, it appears that the water quality between the two Periods of Record has generally improved or remained stable (with the exception of turbidity in the north LWL) and that improvement could be primarily related to a reduction in freshwater discharge (page 63)".

In addition, a sediment analysis in the C-51 canal conclude that most of the sediment originated from west of the S155 structure, and suggested that the S155 structure be re-engineered to allow water to flow over instead of under the structure. This would allow sediment to be captured behind the structure rather than delivered to the estuary, and this sediment could then be regularly removed. It also supports the Palm Beach County and SFWMD goals of reducing the flow of water through the S155 structure by diverting water for other uses upstream of the S155 structure. (LWLI, 2013. Page 73-75).

The 2013 Update to the LWL Management Plan also focuses heavily on restoration efforts aimed at ecosystem habitat, including in particular seagrass, oysters, and mangroves. It also includes explicit goals to enhance resilience of the coastline in the face of climate change, including the protection and use of living shorelines. The Lake Worth Lagoon Initiative website hosted by Palm Beach County (http://www.co.palm-beach.fl.us/erm/lakes/estuarine/lake-worth-lagoon/) provides access to all of the latest and ongoing assessments, monitoring efforts, outreach and events, and planning processes.

4. Boynton / South Lake Worth ICA

Boynton Inlet is the southern of two inlets within Lake Worth Lagoon. The overview of water quality analyses and management efforts described above as part of the 2013 Update to the Lake Worth Lagoon Management Plan apply to the Boynton / South Lake Worth Inlet as well. The Boynton / South Lake Worth Inlet ICA is approximately 144.1 square miles in total area. It is particularly developed and impervious, with 75% urban and transportation land, 11.6% water and wetlands and 10.1% crop agriculture (according to the land use tables presented herein).

In addition, the NOAA FACE Program has included several studies of note that focus particularly on the Boynton Inlet. The Boynton Inlet Flow Measurement Study (Stamates, 2013) estimated the flux of certain nutrients through the Boynton Inlet into the coastal ocean. The study observed that the ebb tidal phase transports more water out of the inlet than is returned on the flood tide (page 10). The difference is comprised of freshwater inputs from canals, precipitation, and direct runoff. The study also observed tidal impacts from north and south winds, noting that winds from the north can push water south inside LWL, exaggerating the ebb tide and reducing the flood tide through Boynton Inlet, and winds from the south can push water north in LWL away from the Boynton Inlet reducing the ebb tide and increasing the flood tide (page 11).

The Boynton-Delray Coastal Water Quality Monitoring Program report (Carsey et al., 2011) presents results from a series of six monitoring cruises in 2007 and 2008 in the vicinity of the Boynton inlet, Lake

Worth Lagoon and the Boynton-Delray Wastewater ocean outfall discharge. This report provides the best available current data on the near shore ocean water quality, and includes vertically stratified sampling (surface, middle, bottom) at 18 locations. This report provides an estimate of the flux of various nutrients out of the Boynton Inlet into the near shore ocean water.

5. Boca Raton ICA

The Boca Raton ICA is the second smallest ICA in the southeast Florida study area, at 112.7 square miles in area, and is located entirely in the developed corridor of the eastern shoreline of Florida. It is characterized by urban development and impervious cover. According to the maps presented in this report, 75.2% of the ICA is urban and transportation land use, 12.9% is open water and wetlands, and 5.9% is crop agriculture. This suggests that pollutant loads associated with stormwater runoff from urban areas will be a significant concern in this ICA. The FACE Program has performed some water quality sampling in the Boca Raton Inlet and within the adjacent area of the Intracoastal Waterway as part of the Florida Inlets Program, but the final report on this effort is not yet available (http://www.aoml.noaa.gov/themes/CoastalRegional/projects/FACE/Inlets.htm).

6. Hillsboro ICA

The Hillsboro ICA is the smallest of the nine ICAs in the southeastern Florida region, with a total of 80.3 square miles. Like the Boca Raton ICA, it is located entirely in the developed corridor of the eastern shoreline of Florida. It is characterized by urban development and impervious cover. According to the maps presented in this report, 88.9% of the ICA is urban and transportation land use, 9.1% is open water and wetlands, and 1.9% is open space or forest. There is basically no agriculture in this ICA. This suggests that pollutant loads associated with stormwater runoff from urban areas will be a significant concern in this ICA. The FACE Program has performed some water quality sampling in the Hillsboro Inlet and within the adjacent area of the Intracoastal Waterway as part of the Florida Inlets Program, but the final report on this effort is not yet available (http://www.aoml.noaa.gov/themes/CoastalRegional/projects/FACE/Inlets.htm).

7. Port Everglades ICA

The Port Everglades ICA, approximately 174.0 square miles in area, is characterized by significant development, as well as by the fact that the Port Everglades Inlet is one of the busiest shipping channels in Florida. According to our land use mapping, a significant majority of the ICA (85.5%) is urban and transportation land, and 10.8% is open water and wetlands. Less than 1% is agricultural land.

In support of SEFCRI, the NOAA FACE Program performed an intensive assessment of flow and nutrient flux through the heavily trafficked shipping channel that is the Port Everglades Inlet. This study (Stamates, et al., 2013) observed the flow profile to function in a two tiered system, with varying ebb and flood tide flows at the surface and in deeper water based on differences in the flow velocities at these two depths. It also included a water quality monitoring component to look at pollutant fluxes through the channel at these two depths in the profile to try to understand the flux of pollutants out of the Intracoastal Waterway into the near shore ocean and toward the coral reef tract. There is significant variation in the flows and an increase in the ebb tide flows during significant rainfall events, as evidenced by an example using a 6.2 cm (2.4 inches) rainfall event on December 18, 2009.

8. Baker's Haulover ICA

Baker's Haulover Inlet is located at the north end of Biscayne Bay within the northern section of the Biscayne Bay Aquatic Preserves, north of Biscayne National Park. The ICA is characterized by a significant percentage of open water and wetlands (18.7%) and a majority of urban and transportation land use (77.3%). This area is included within the Biscayne Bay Aquatic Preserves Management Plan (FDEP, 2012). While the water quality in the Preserves is relatively healthy, the Preserves face pressure and threats from the ICA that falls outside of the boundaries of the Preserves. An excerpt from the Management Plan presents a summary of the water quality issues facing this area:

Water quality has improved substantially in the last 30 years, particularly in northern Biscayne Bay. Water quality now generally meets or exceeds local, state and federal standards for recreational uses and propagation of fish and wildlife. However, past development, hydrologic changes, water management practices and adjacent land uses have contributed to loss of wetland and seagrass communities, which has contributed to physical and ecological changes in water quality. Biscayne Bay still receives a considerable amount of nutrients, trace metals, organic chemicals and particulates from storm water runoff, canal discharge, and other sources. Specific water and sediment quality related problems include turbidity, nutrients, sewage main breaks and residual and persistent contaminants. Other water quality concerns have to do with the quantity of fresh water currently received by Biscayne Bay from natural sheetflow, groundwater, and inputs from tributaries—albeit often in the form of pulsed, point source discharges that bring with it debris, contaminants, yard and pet waste, and nutrients from fertilizers. (FDEP, 2012; page 90).

9. Government Cut ICA

Government Cut is also located north of Biscayne National Park, within the Biscayne Bay Aquatic Preserves. The ICA is approximately 371.7 square miles in area. The main inlet is just east of downtown Miami, directly east of the outlet of the Miami River, which connects the Miami Canal from Lake Okeechobee to Biscayne Bay. The Miami River has well documented levels of water and sediment contamination, including elevated bacteria and low dissolved oxygen concentrations, and was recently the subject of an historic dredging effort ushered by the Miami River Commission (www.miamirivercommission.org) to improve shipping access up the river. The Commission is now guiding the implementation of the Miami River Greenway as well as efforts to improve water quality through improved stormwater management. The contributing area to the Miami River and the Government Cut ICA generally includes significant areas of highly urbanized land, including industrial, commercial and residential development. Land use in this ICA is characterized by a majority of urban and transportation land use (60.4%) along with a large proportion of open water and wetlands (35.3%).

Government Cut is the primary opening to the Atlantic Ocean from this ICA, however, because the southern portion of this ICA was derived from the boundary of the northern section of the Biscayne Bay Aquatic Preserve, there are additional openings through Biscayne Bay south of Government Cut, making this ICA unique within the SEFCRI region (See Figures in Section 1 and 2 for reference). The portion of the Government Cut ICA that is actually in Biscayne Bay itself is included within the Biscayne Bay Aquatic Preserves Management Plan (FDEP, 2012).

7. Summary of Data and Data Gaps

The purpose of this section is to present a summary of the data and information that we have identified to support the evaluation of LBSPs in the ICAs that contribute to the SEFCRI Region, and then identify key gaps that need to be filled. The most basic water quality parameters that are relevant for evaluating LBSPs in an ICA are nitrogen, phosphorus, sediments, and salinity. Nitrogen and phosphorus affect algae growth, dissolved oxygen fluctuation and decline, as well as water clarity. Sediments also affect water clarity and can physically cover benthic organisms like corals, oysters and seagrass. Salinity is important to consider since some ICAs are subject to fluctuations of salinity resulting from large inflows of fresh water into the estuaries from the upstream canals.

A. Data for Estimating Pollutant Input Loads

The nutrient, sediment, and salinity loads to the estuarine systems can be estimated from flow and water concentration measurements at select inputs to the estuaries. For this evaluation, HW evaluated the data collected by SFWMD at control structures within the study area. In most cases, only the loads delivered from the upstream areas over the salinity control structures were considered. In the case of the St. Lucie Estuary, the structure (S-308) sometimes directs Lake Okeechobee water into the ICA via the C-44 canal, so it represents an intermittent load input to the ICA. A total of 25 structures with 49 water quality stations were evaluated.

Flow and water quality data collected at the salinity control structures were extracted from the SFWMD DBHydro database and assessed to define the period of record and frequency of measurement for these data. Continuous flow-weighted sampling of water quality is the preferred sampling method for accurate calculation of loads; this type of data had been collected only in the St. Lucie Inlet. Time-weighted sampling or intermittent grab samples of water quality are less desirable but significantly easier to collect. These data have been collected at the other eight ICAs.

Generally flow data is reported daily while most water quality data is reported monthly, with the exception of flow-weighted measurements, which are reported every two weeks. The period of record ranges from 1952 to 2014 for flow and 1979 to 2014 for water quality samples and sondes. The salinity data are mostly from 1985 to 2014, with a few sites dating back to 1961. Table 7-1 summarizes the data extracted from the DBHydro database for each ICA.

Table 7-1. Summary of Data Extracted from DBHydro Database for each ICA

ICA NAME	Name	Collection Method	Structure	Variable	Frequency	Period
St. Lucie	S308_S	Flow	S308	Flow	Daily	1996-2014
St. Lucie	S48_S	Flow	S48	Flow	Daily	1963-1970, 1999-2014
St. Lucie	S49_S	Flow	S49	Flow	Daily	1961-2014
St. Lucie	S80_S	Flow	S80	Flow	Daily	1952-2014
St. Lucie	C23S48	Autosampler	S48	N, P, TSS	Monthly, weekly after 1997	1979-1997, 1997-2014
St. Lucie	C24S49	Autosampler	S49	N, P, TSS	Monthly, weekly after 1997	1979-1997, 1997-2014
St. Lucie	C44S80	Autosampler	S80	N, P, TSS	Monthly, weekly after 1997	1979-1997, 1997-2014
St. Lucie	C23S48	Surface Water Grab	S48	N, P, TSS	Monthly, weekly after 1997	1979-1997, 1997-2014
St. Lucie	C24S49	Surface Water Grab	S49	N, P, TSS	Monthly, weekly after 1997	1979-1997, 1997-2014
St. Lucie	C44S80	Surface Water Grab	S80	N, P, TSS	Monthly, weekly after 1997	1979-1997, 1997-2014
St. Lucie	S308C	Surface Water Grab	S308C	N, P, TSS	Monthly, weekly after 1997	1979-1997, 1997-2014
Jupiter	S46_S	Flow	S46	Flow	Daily	1961-2014
Jupiter	C18S46	Surface Water Grab	S46	N, P, TSS	Monthly	1979-2014
Lake Worth	S155_S	Flow	S155	Flow	Daily	1939-1014
Lake Worth	S44_S	Flow	S44	Flow	Daily	1977-2014
Lake Worth	C17S44	Surface Water Grab	S44	N, P, TSS	Monthly	1979-2014
Lake Worth	C51S155	Surface Water Grab	S155	N, P, TSS	Monthly	1979-2014
S. Lake Worth/ Boynton	S40_S	Flow	S40	Flow	Daily	1984-2014
S. Lake Worth/ Boynton	S41_S	Flow	S41	Flow	Daily	1983-2014
Boca Raton	G56_S	Flow	G56	Flow	Daily	1978-2014
Hillsboro	G57_S	Flow	G57	Flow	Daily	1990-2014
Hillsboro	S37A_S	Flow	S37A	Flow	Daily	1962-2014
Hillsboro	G57	Autologger	G57	SCOND	Monthly & quarterly	1961-2014
Hillsboro	S37A	Autologger	S37A	SCOND	???	1961-2014
Hillsboro	G57_H	Stage	G57	Stage	Daily	1988-2014
Hillsboro	G57_T	Stage	G57	Stage	Daily	1991-2014
Port Everglades	G54_S	Flow	G54	Flow	Daily	1978-2014
Port Everglades	S13_P	Flow	S13	Flow	Daily	1957-2014
Port Everglades	S13_S	Flow	S13	Flow	Daily	1957-2014
Port Everglades	S33_S	Flow	S33	Flow	Daily	1962-2014
Port Everglades	S36_S	Flow	S36	Flow	Daily	1961-2014
Port Everglades	S13	Autologger	S13	SCOND	???	1992-2014
Baker's Haulover	G58_C	Flow	G58	Flow	Daily	1987-2014
Baker's Haulover	S28_S	Flow	S28	Flow	Daily	1962-2014
Baker's Haulover	S29_S	Flow	S29	Flow	Daily	1959-2014
Baker's Haulover	S28	Autologger	S28	SCOND	???	1985-2014
Baker's Haulover	S29	Autologger	S29	SCOND	???	1985-2014
Government Cut	G93	Flow	G93	Flow	Daily	1991-2014
Government Cut	S123_S	Flow	S123	Flow	Daily	1979-2014
Government Cut	S22_S	Flow	S22	Flow	Daily	1959-2014
Government Cut	S25_C	Flow	S25	Flow	Daily	1978-2014
Government Cut	S26_P	Flow	S26	Flow	Daily	2005-2014
Government Cut	S26_S	Flow	S26	Flow	Daily	1978-2014
Government Cut	S27_S	Flow	S27	Flow	Daily	1960-2014
Government Cut	S123	Autologger	S123	SCOND	Monthly & quarterly	1985-2014
Government Cut	S22	Autologger	S22	SCOND	???	1985-2014
Government Cut	S25	Autologger	S25	SCOND	???	1985-2014
Government Cut	S26	Autologger	S26	SCOND	???	1985-2014
Government Cut	S27	Autologger	S27	SCOND	???	1985-2014

B. Measurements for Evaluating Estuary Response to LBSPs

Measurements of nutrients, sediment, and salinity were extracted from the Impaired Waters Rule (IWR) database maintained by FDEP for their five-year assessment of water quality and preparation of the required Impaired Waters Report in accordance with Clean Water Act Section 305(b). The IWR database includes both GIS locations and numeric data in a user-friendly Microsoft Access database. These data only include samples from connected surface water bodies. The majority of the data in the IWR database come from the STORET database, which includes data from multiple state and municipal sources. The IWR database also includes data from the following sources: legacy STORET (pre-1998), USGS, SFWMD (DBHydro), St. Johns River Water Management District, and Florida Department of Agriculture and Consumer Services (FDACS). In preparing the IWR database, FDEP excludes duplicate data from the multiple sources.

HW identified sample points from the GIS database that are located downstream of the salinity control structures, with the assumption that these would best represent the estuarine areas. The selected GIS points were joined to the raw database tables and exported to a separate database. The exported data were then filtered to extract only those parameters relevant to nutrients, sediment, and salinity. These parameters included those listed in Table 7-2.

These extracted data were then assessed to determine the number of stations, number of measurements, and period of record for each parameter of interest within each ICA. Most of these data were collected in the period from 1985 to 2014, but some extend back to 1968, and a select few data extend back to 1930. Table 7-3a summarizes the data points extracted from the IWR database for each ICA. There are clearly more data points in the St. Lucie ICA than any other ICA in the study area.

Ideally, an error analysis is needed to estimate the number of sampling points required for accurate estimation of water quality conditions at any point in space and time. In general, a higher error tolerance is acceptable for variable parameters; otherwise, the number of samples required becomes excessive. For example, chemical parameters like total phosphorus or total nitrogen with low coefficients of variation (~10%) would require about 4 samples to give +/-10% error associated with the mean value. Biological parameters like chlorophyll-a have higher coefficients of variability (~30%) and would require about 9 samples for a 20% error tolerance. Similarly, variable parameters like bacteria have high coefficients of variation (~50%) and would require about 11 samples for a 30% error tolerance.

For purposes of comparison, Table 7-3b summarizes the number of data points in each ICA and also expresses the number as a percentage of data points in the St. Lucie ICA. The potential gaps in data are identified as those sites with a percentage of less than 25% and are highlighted in pink in the Tables. Figures 7-1 to 7-9 present the monitoring locations for the data extracted from the DBHydro and IWR databases within each ICA.

Table 7-2. Water Quality Parameters Relevant for Evaluating LBSPs in an ICA

Parameter Type	Parameter Code	Parameter Name
Nutrient	BOD	Biochemical Oxygen Demand 5-Day (mg/l)
Nutrient	CBOD	Carbonaceous Biochemical Oxygen Demand 5-Day (mg/l)
Nutrient	CHLA	Chlorophyll (µg/l)
Nutrient	DO	Dissolved Oxygen (mg/l)
Nutrient	DOSAT	Oxygen Percent Saturation (%)
Nutrient	NH4	Nitrogen Ammonia as N (mg/l)
Nutrient	NIORG	Nitrogen Inorganic as N (mg/l)
Nutrient	NO2	Nitrite Nitrogen as N (mg/l)
Nutrient	NO3O2	Nitrate Nitrite (mg/l)
Nutrient	ORGN	Nitrogen Organic as N (mg/l)
Nutrient	TKN	Nitrogen Kjeldahl as N (mg/l)
Nutrient	TN	Nitrogen Total as N (mg/l)
Nutrient	POD	Phosphorus, Dissolved Organic as P (mg/l)
Nutrient	PORD	Phosphorus, Dissolved Orthophosphate as P (mg/l)
Nutrient	PORTH	Ortho Phosphate as PO4 (mg/l)
Nutrient	TORTH	Phosphorus in Total Orthophosphate as P (mg/l)
Nutrient	TP	Phosphorus Total as P (mg/l)
Cond/Sal	COND	Specific Conductance (µmhos/cm)
Cond/Sal	SALIN	Salinity (g/kg or ppt)
Sediment	TSS	Total Suspended Solids (TSS), mg/l
Sediment	TURB	Turbidity (NTU)
Sediment	SD	Secchi Depth (ft)

Table 7-3a. Summary of Data Points Extracted from IWR Database for Each ICA

Parameter	Inlet Contributing Areas								
	St. Lucie	Jupiter Inlet	Lake Worth	Boynton/ South Lake Worth	Boca Raton	Hillsboro	Port Everglades	Baker's Haulover	Government Cut
	Number of Measurements by ICA								
Nutrients	326,732	133,779	24,597	10,530	24,825	8,842	117,355	99,575	261,582
Conductivity/Salinity	123,152	47,575	6,883	3,517	7,297	2,506	42,885	62,518	167,950
Sediments	58,558	30,112	2,641	1,101	3,088	1,222	15,315	13,918	39,093
Dissolved Oxygen (mg/L)	78,259	26,169	4,646	2,406	4,465	1,476	23,173	32,260	87,541
Nitrogen Total as N (mg/L)	26,333	12,248	2,276	858	1,841	888	9,207	1,300	3,764
Phosphorus Total as P (mg/L)	24,713	12,254	2,668	980	3,343	1,096	14,933	10,672	27,355
Total Suspended Solids, TSS (mg/L)	13,168	8,492	352	160	44	0	212	354	801
	Number of Stations by ICA								
Nutrients	4,552	1,997	603	336	341	114	1,379	424	1,323
Conductivity/Salinity	906	452	116	60	70	23	332	123	385
Sediments	1,068	428	104	56	51	12	203	90	222
Dissolved Oxygen (mg/L)	555	242	68	37	39	11	160	61	205
Nitrogen Total as N (mg/L)	481	185	64	35	27	10	111	35	111
Phosphorus Total as P (mg/L)	498	205	71	39	40	13	158	56	189
Total Suspended Solids, TSS (mg/L)	216	90	19	12	5	0	8	23	41

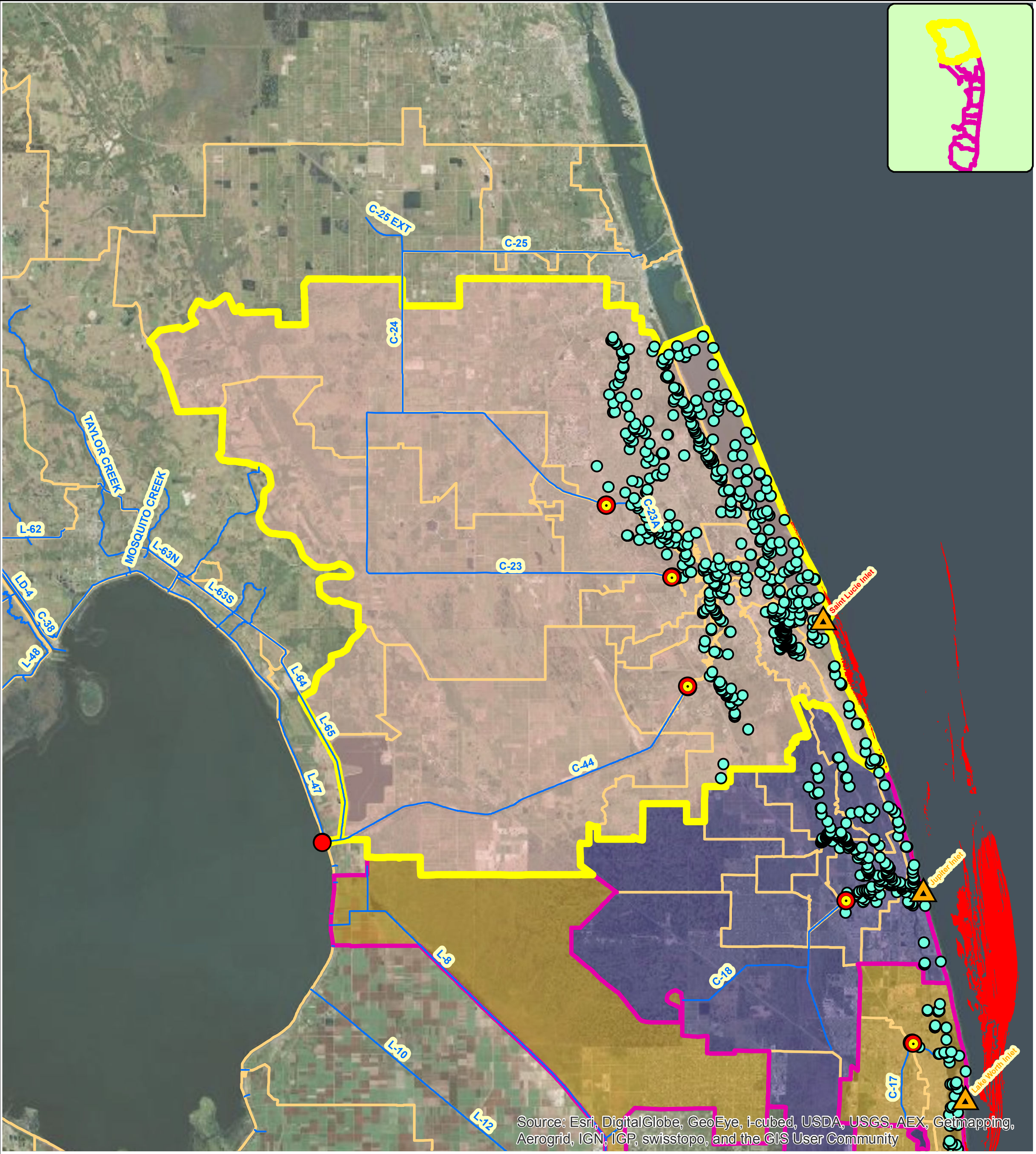
Note: Colored cells represent <25% of the number of data points for the St. Lucie ICA

Table 7-3b. Summary of Data Points Extracted from IWR Database, Compared to St. Lucie ICA

Parameter	Inlet Contributing Areas								
	St. Lucie	Jupiter Inlet	Lake Worth	Boynton/ South Lake Worth	Boca Raton	Hillsboro	Port Everglades	Baker's Haulover	Government Cut
	Number of Measurements by ICA (% SLI)								
Nutrients	100.0	40.9	7.5	3.2	7.6	2.7	35.9	30.5	80.1
Conductivity/Salinity	100.0	38.6	5.6	2.9	5.9	2.0	34.8	50.8	136.4
Sediments	100.0	51.4	4.5	1.9	5.3	2.1	26.2	23.8	66.8
Dissolved Oxygen (mg/L)	100.0	33.4	5.9	3.1	5.7	1.9	29.6	41.2	111.9
Nitrogen Total as N (mg/L)	100.0	46.5	8.6	3.3	7.0	3.4	35.0	4.9	14.3
Phosphorus Total as P (mg/L)	100.0	49.6	10.8	4.0	13.5	4.4	60.4	43.2	110.7
Total Suspended Solids, TSS (mg/L)	100.0	64.5	2.7	1.2	0.3	0.0	1.6	2.7	6.1
	Number of Stations by ICA (% SLI)								
Nutrients	100.0	43.9	13.2	7.4	7.5	2.5	30.3	9.3	29.1
Conductivity/Salinity	100.0	49.9	12.8	6.6	7.7	2.5	36.6	13.6	42.5
Sediments	100.0	40.1	9.7	5.2	4.8	1.1	19.0	8.4	20.8
Dissolved Oxygen (mg/L)	100.0	43.6	12.3	6.7	7.0	2.0	28.8	11.0	36.9
Nitrogen Total as N (mg/L)	100.0	38.5	13.3	7.3	5.6	2.1	23.1	7.3	23.1
Phosphorus Total as P (mg/L)	100.0	41.2	14.3	7.8	8.0	2.6	31.7	11.2	38.0
Total Suspended Solids, TSS (mg/L)	100.0	41.7	8.8	5.6	2.3	0.0	3.7	10.6	19.0

Note: Colored cells represent <25% of the number of data points for the St. Lucie ICA

In addition to water quality and flow monitoring data, we examined the information assembled for this project and identified a host of relevant information that can be used to evaluate runoff, infiltration, tidal flushing of pollutants in the estuaries, and pollutant loading from wastewater discharges. Some of these data were developed for specific areas of the SEFCRI Region but can be applied to other areas as a means of developing preliminary analyses. For example, the Boynton Inlet Flow Measurement Study (Stamates, 2013) presents a detailed study of flow and tidal exchange at the Boynton Inlet. This study can be useful in understanding how water at other inlets is being exchanged, and provides a basis for exploring which ICA is exchanging the most significant pollutant loads with the ocean. In addition, detailed land use loading coefficients for nitrogen and phosphorus were developed for the St. Lucie River and Estuary Watershed Protection Plan and BMAP (including both the St. Lucie and Jupiter ICAs). These coefficients can be applied across the entire study region to develop a preliminary estimate and comparison of pollutant loading, as we have done in this report. Ultimately, these coefficients should be developed for each individual ICA in the region. These key data and data sources are summarized in Table 7-4.



Legend

N

1 in = 7.3 miles

Inlets

Canals

Watersheds

Inlet Contributing Areas

Coral Reefs

Domestic Waste-water Outfalls

Salinity Control Structures

DBHydro Load Stations

IWR Receiving Water Stations

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St Lucie Inlet
Monitoring Locations

Date: 1/23/2015

Figure 7-1

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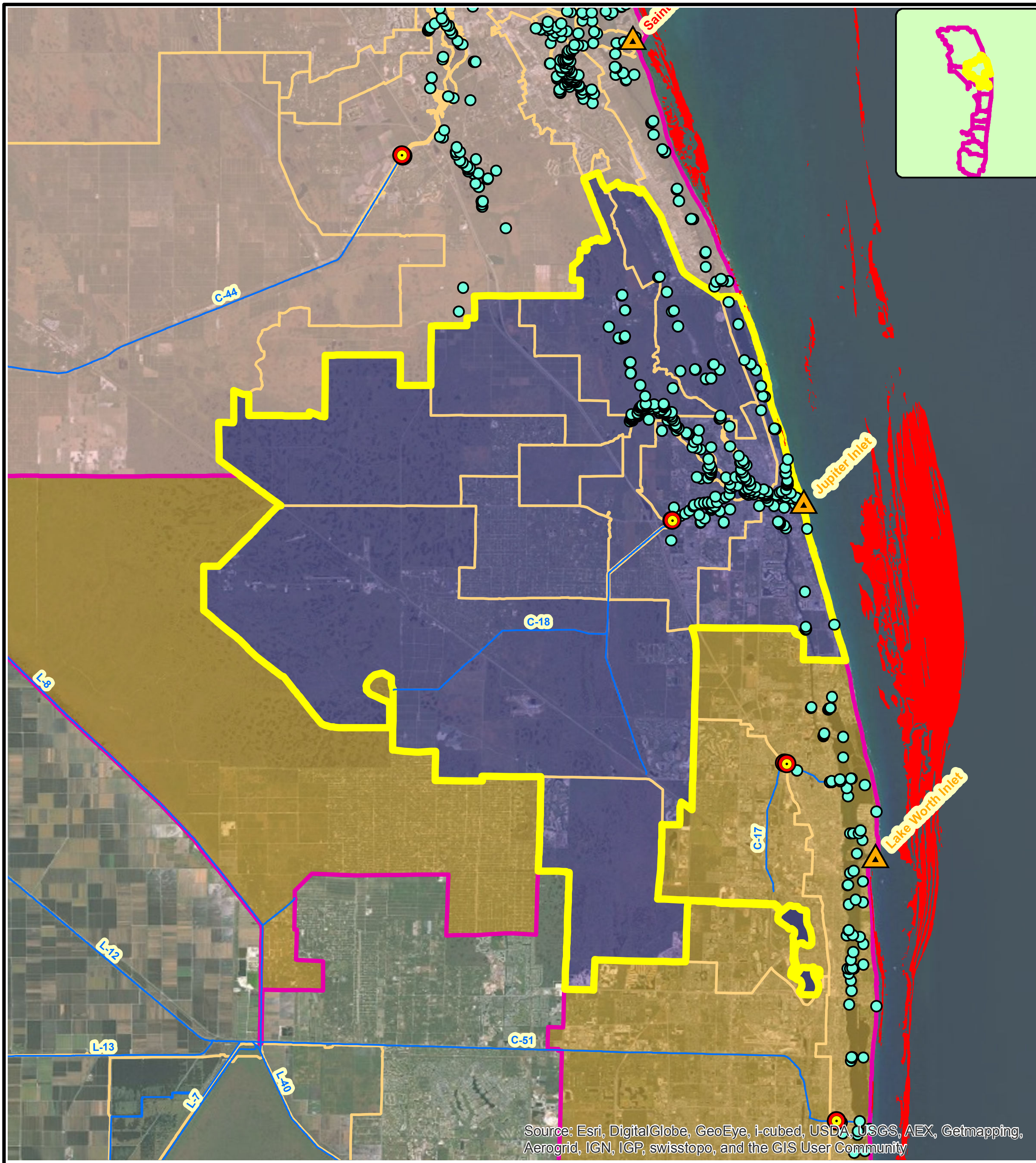

Legend

N

1 in = 4.3 miles

- Inlets
- Canals
- Watersheds
- Inlet Contributing Areas
- Coral Reefs
- Domestic Wastewater Outfalls
- Salinity Control Structures
- DBHydro Load Stations
- IWR Receiving Water Stations

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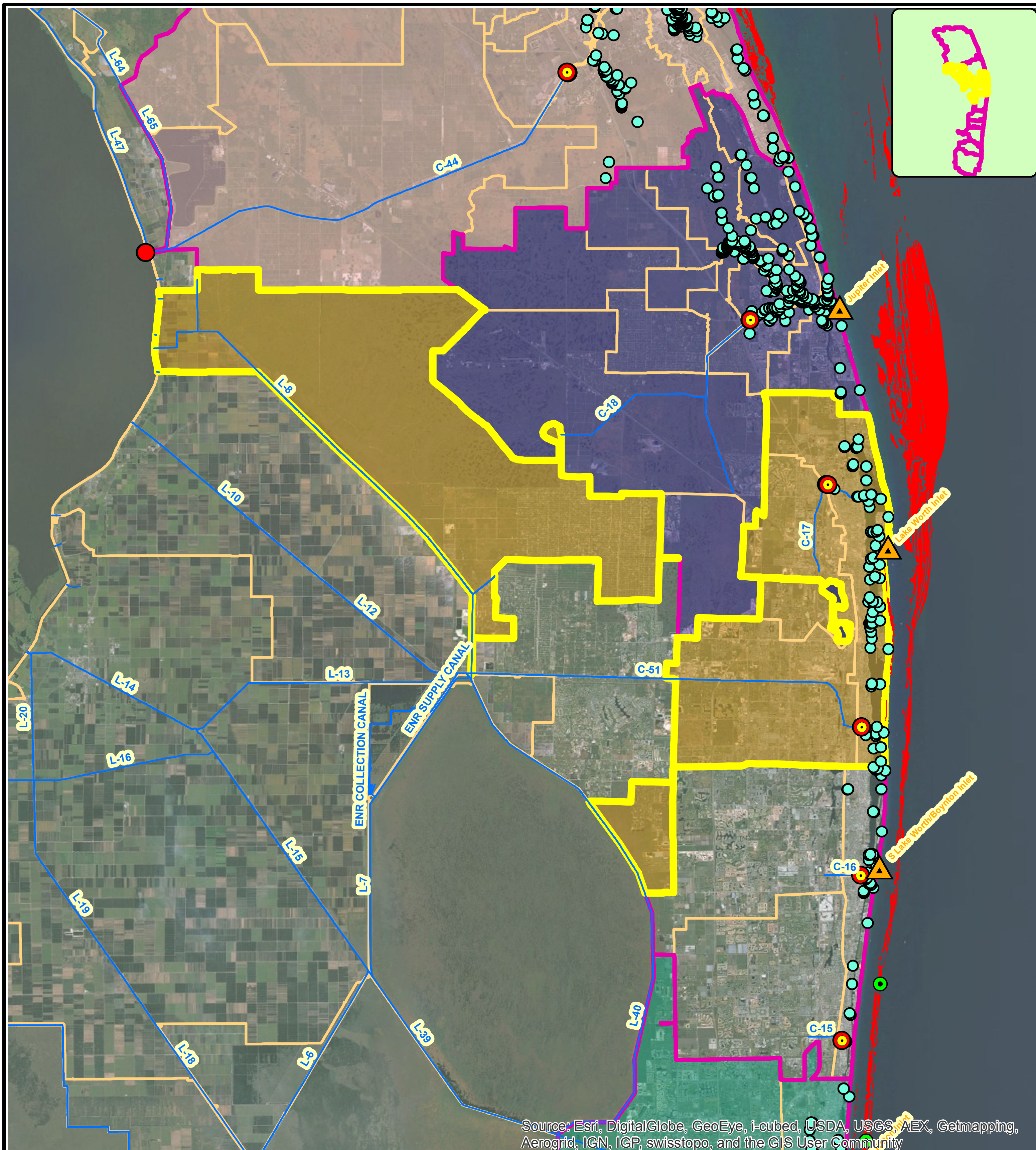
Jupiter Inlet
Monitoring Locations

Date: 1/23/2015

Figure 7-2



Legend

N

1 in = 6.3 miles

- Inlets
- Canals
- Watersheds
- Inlet Contributing Areas
- Coral Reefs
- Domestic Wastewater Outfalls
- Salinity Control Structures
- DBHydro Load Stations
- IWR Receiving Water Stations

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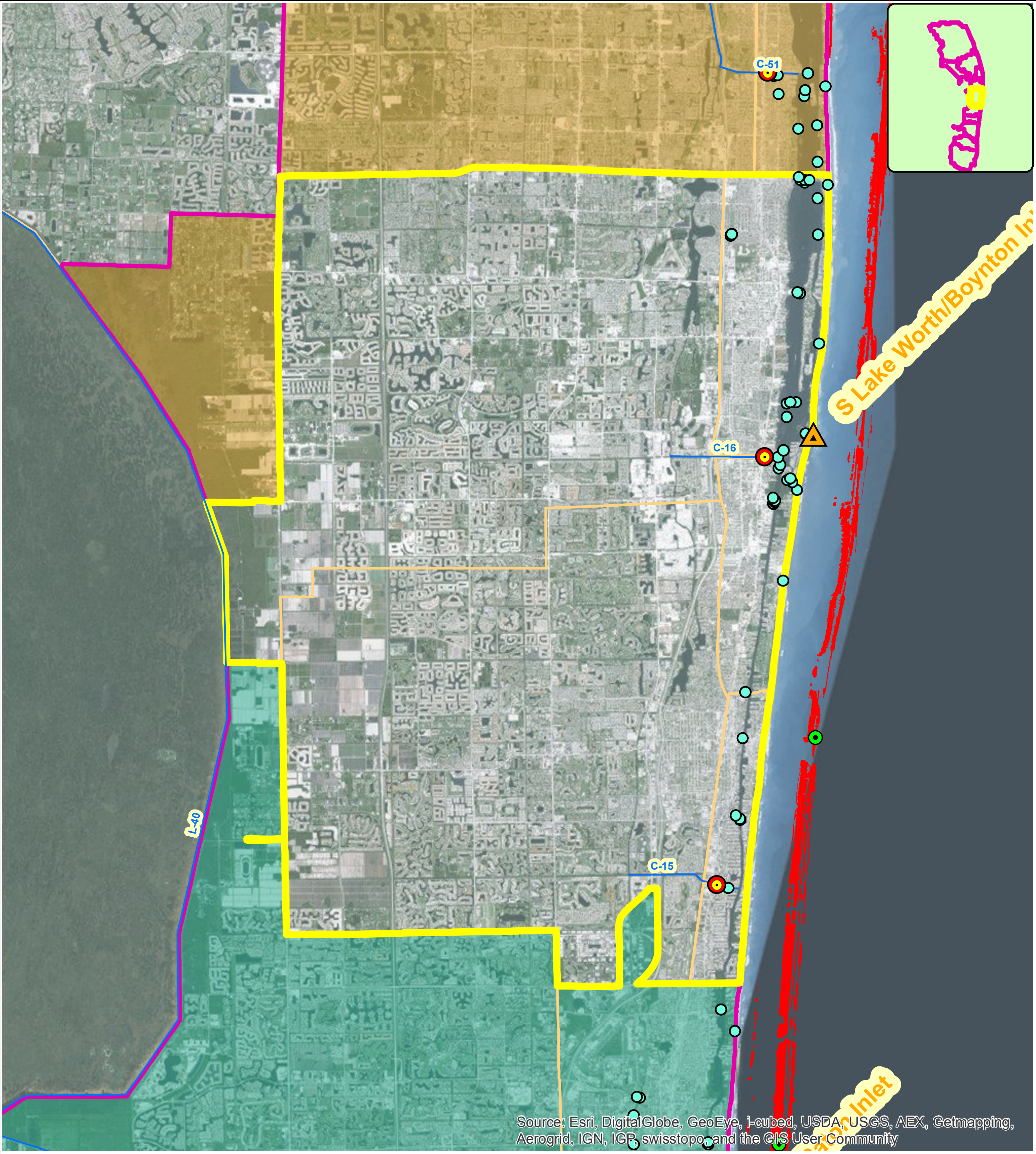
Lake Worth Inlet Monitoring Locations

Date: 1/23/2015

Figure 7-3



Legend

N

1 in = 2.4 miles

- Inlets
- Canals
- Watersheds
- Inlet Contributing Areas
- Coral Reefs
- Domestic Wastewater Outfalls
- Salinity Control Structures
- DBHydro Load Stations
- IWR Receiving Water Stations

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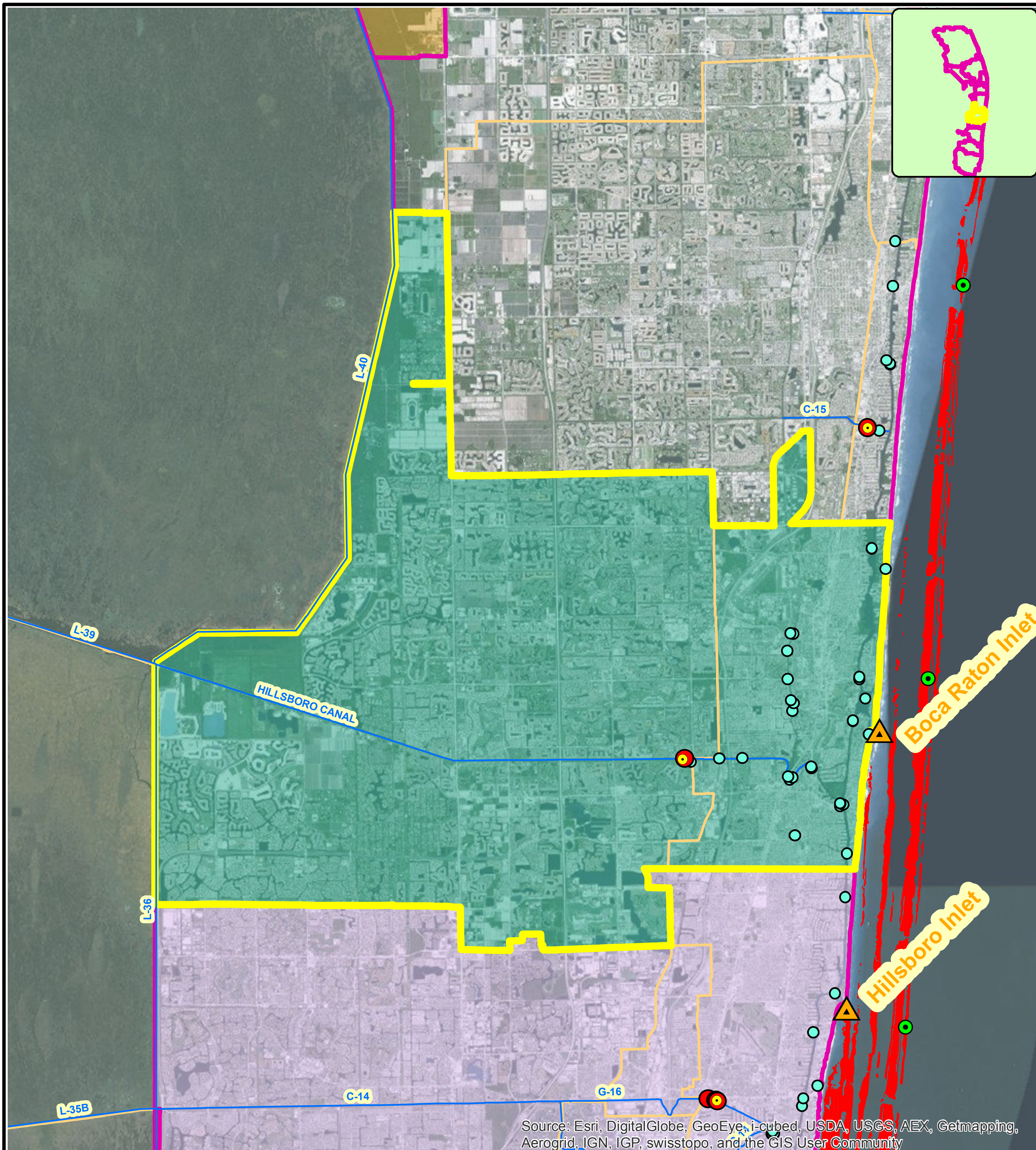
Boynton / S Lake Worth Inlet Monitoring Locations

Date: 1/23/2015

Figure 7-4



Legend

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1 in = 2.5 miles

- Inlets
- Canals
- Watersheds
- Inlet Contributing Areas
- Coral Reefs
- Domestic Wastewater Outfalls
- Salinity Control Structures
- DBHydro Load Stations
- IWR Receiving Water Stations

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Boca Raton Inlet
Monitoring Locations

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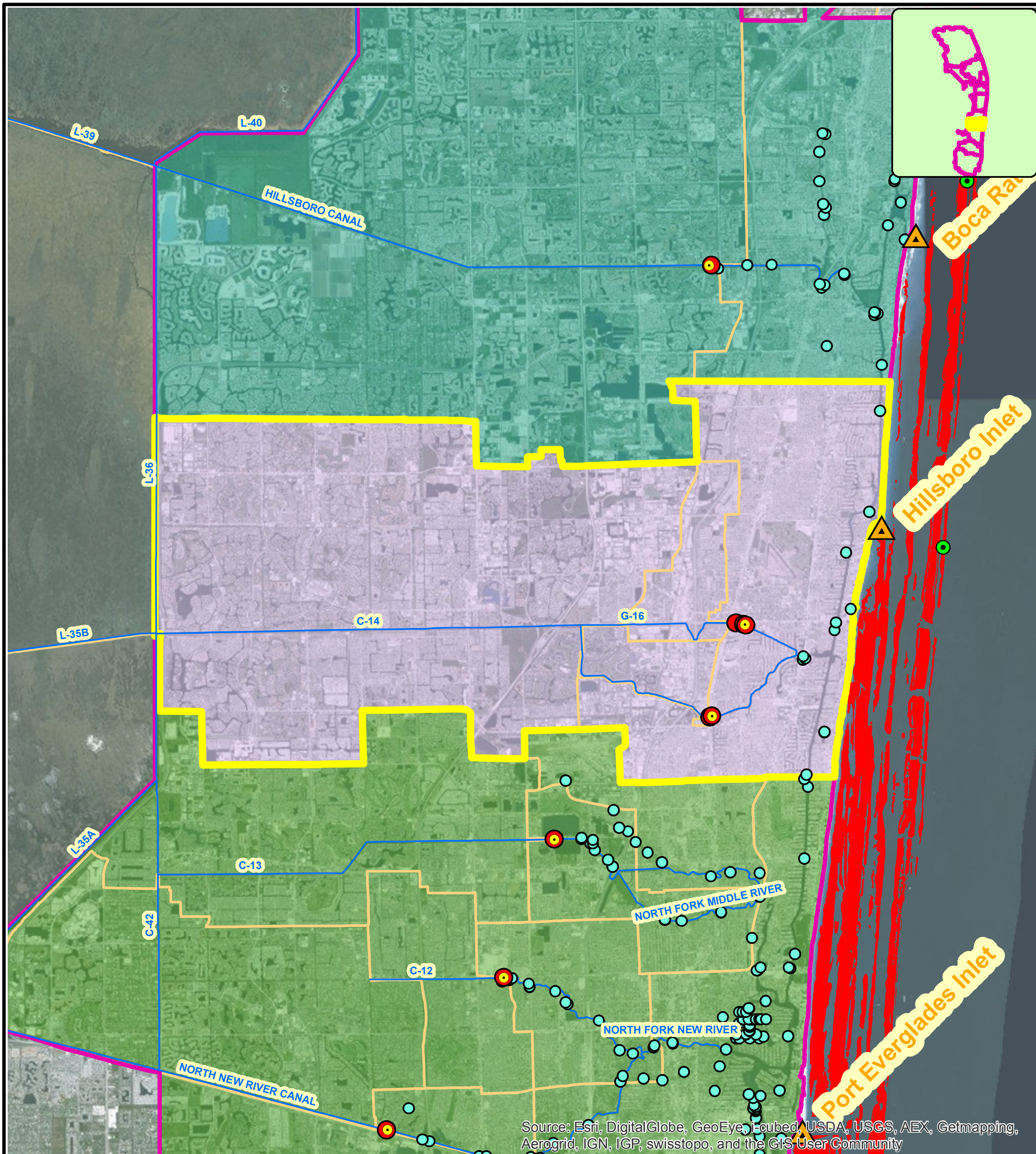
Figure 7-5



Legend

N

1 in = 2.4 miles

- Inlets
- Canals
- Watersheds
- Inlet Contributing Areas
- Coral Reefs
- Domestic Wastewater Outfalls
- Salinity Control Structures
- DBHydro Load Stations
- IWR Receiving Water Stations

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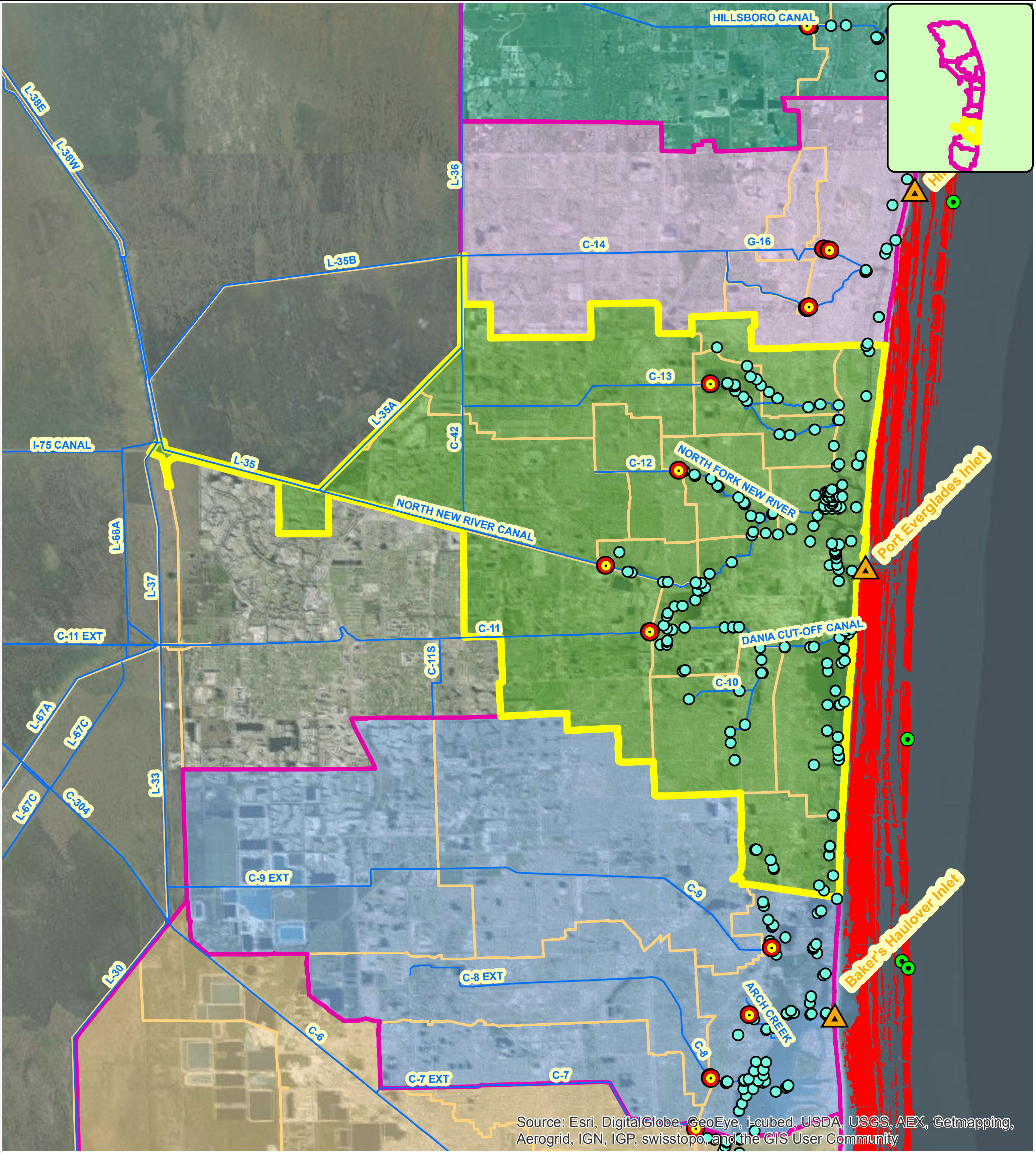
Hillsboro Inlet
Monitoring Locations

Date: 1/23/2015

Figure 7-6



Legend

N

1 in = 3.8 miles

- Inlets
- Canals
- Watersheds
- Inlet Contributing Areas
- Coral Reefs
- Domestic Wastewater Outfalls
- Salinity Control Structures
- DBHydro Load Stations
- IWR Receiving Water Stations

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Port Everglades Inlet Monitoring Locations

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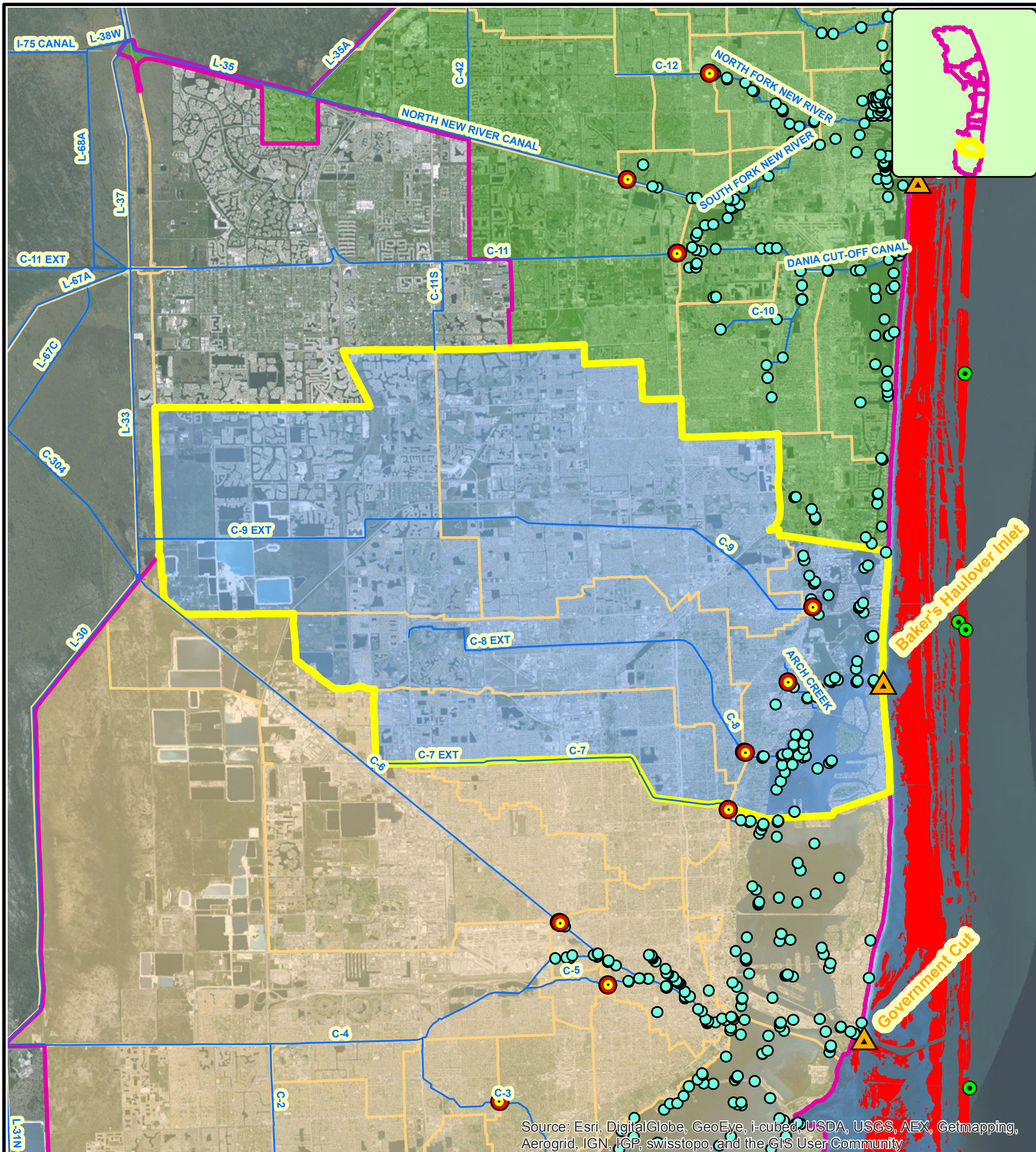
Figure 7-7



Legend

N

1 in = 3.4 miles

- Inlets
- Canals
- Watersheds
- Inlet Contributing Areas
- Coral Reefs
- Domestic Wastewater Outfalls
- Salinity Control Structures
- DBHydro Load Stations
- IWR Receiving Water Stations

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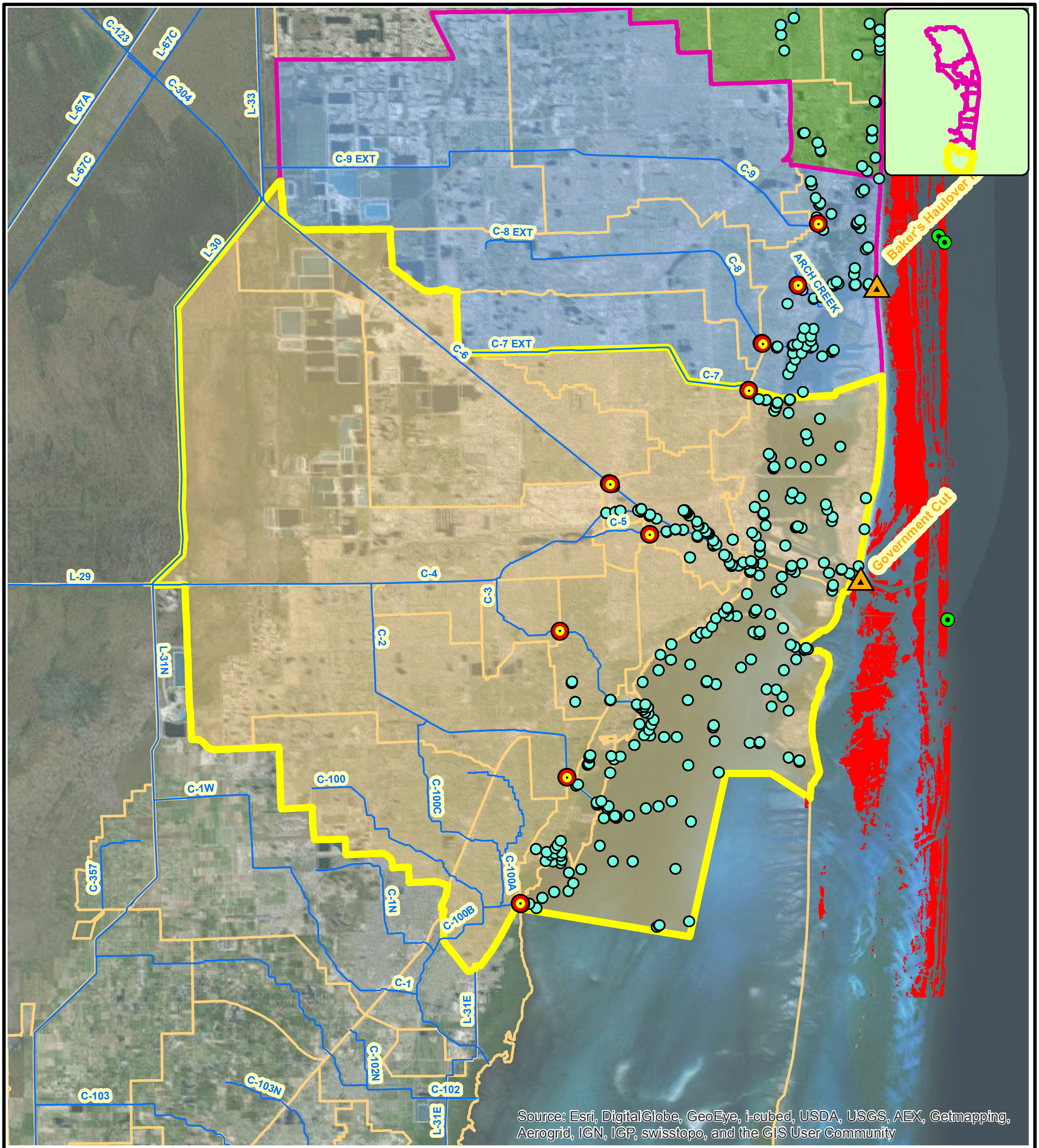
Baker's Haulover Inlet Monitoring Locations

Date: 1/23/2015

Figure 7-8



Legend

N

1 in = 4.1 miles

- Inlets
- Canals
- Watersheds
- Inlet Contributing Areas
- Coral Reefs
- Domestic Wastewater Outfalls
- Salinity Control Structures
- DBHydro Load Stations
- IWR Receiving Water Stations

Path: C:\Shared\Projects\13107 TO 4.7 Southeast Florida LBSP\GIS\Maps\150123_ICAs_WQStations_Small_13107.mxd

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Government Cut Monitoring Locations

Date: 1/23/2015

Figure 7-9

Table 7-4. Summary of Relevant Reports and Information Applicable Across ICAs

DESCRIPTION	DATA SOURCE
Rainfall	
Daily, Monthly, Seasonal, Annual, etc.	http://www.sfwmd.gov/portal/page/portal/xweb%20weather/rainfall%20historical%20%28daily%29
Land Use Pollutant Loading Rates	
St. Lucie BMAP Land Use Loading Rates for Nitrogen and Phosphorus	SFWMD, 2013. St. Lucie BMAP Model February 2013. Excel file.
Flow	
Reports on measured inlet/outlet flows	NOAA Technical Reports OAR AOML 38 through 42
Annual flows (acf) for Lake Okeechobee, St. Lucie Canal, St. Lucie Estuary.	SFWMD, 2014. South Florida Environmental Report. March 1, 2014. Table on Page 4 of Volume 1 – Summary Report.
Flow and salinity data and modeling	Wand and Hu, 2006. Modeling Freshwater Inflows and Salinity in the Loxahatchee River and Estuary. SFER 2006. Appendix 12-1.
Water Quality Monitoring at Outlet of Major Canals	
Total Maximum Daily Load (TMDL) for nutrients and dissolved oxygen (DO) for the St. Lucie basin: WBIDs (WaterBody Identification) 3193 (St. Lucie River Lower Estuary), 3194 (North Fork St. Lucie River), 3194B (North St. Lucie Estuary), 3197 (C-24 canal), 3200 (C-23 canal), 3210 (South St. Lucie Estuary), 3210A (South Fork St. Lucie River), 3211 (Bessey Creek), and 3218 (C-44 Canal).	FDEP, 2008. TMDL Report - Nutrient and Dissolved Oxygen TMDL for the St. Lucie Basin. October.
Salinity, dissolved ammonium, nitrate + nitrite, DIN, SRP.	LaPointe et al. , 1997. Nutrient thresholds for bottom-up control of macroalgal blooms on coral reefs in Jamaica and southeast Florida. Limnology and Oceanography. 42. 1119-1131. Table 1. Page 1123.
A study was conducted in 2007 to quantify the flux of nutrients and other materials through the Boynton Inlet (Carsey et al., 2012) and this project is a component of that study.	Stamates, S.J., 2013: Boynton Inlet flow measurement study. NOAA Technical Report, OAR-AOML-43, 13 pp.
Examines water quality, nutrients, etc. Study looks at options to improve water quality in the lagoon and would also address navigation safety issues in the inlet.	Applied Technology Management, Date Unknown. South Lake Worth Inlet Fact Finding Study. City of Boynton Beach.
Website with historical and updated information on the Boynton / South Lake Worth Inlet. Website discusses an ongoing water quality study initiated in the Boynton Inlet in 2007.	FL Coalition for Preservation, 2014. South Lake Worth Inlet Current Status Update (website: http://www.preservationfla.org/lakeworth.php).
Data gathered included nutrients (silicate, orthophosphate, ammonium, nitrite+nitrate), isotope ratios of nitrogen, the presence or absence of selected biological indicators (Escherichia coli, enterococci, and total coliform), and physical parameters that included pH, salinity, total suspended solids, and turbidity.	Carsey, Thomas and Jack Stamates, et al. November 2012. Boynton Inlet 24-Hour Sampling Intensives, June and September 2007. NOAA technical Report OAR AOML-40.
Samples were analyzed during 2007 and 2008 for a variety of nutrients and related parameters. Conductivity / temperature / depth was also measured. Synchronal ocean current data was measured by nearby acoustic Doppler current profiler (ADCP) instrument.	Carsey, Thomas and C. Featherstone, et al. August, 2011. Boynton Delray Coastal Water Quality Monitoring Program. NOAA Technical Report OAR-AOML-39.
Salinity, dissolved ammonium, nitrate + nitrite, DIN, SRP. Table 1. Page 1123.	LaPointe et al., 1997." Nutrient thresholds for bottom-up control of macroalgal blooms on coral reefs in Jamaica and southeast Florida." Limnology and Oceanography. 42. 1119-1131.
FACE Outfalls Survey Cruise-2006. Data from Boynton-Government Cut inlets. Nutrients, pH, Chlorophyll, CTD, velocity, etc.	Carsey, T, H Casanova, C Drayer, C Featherstone, C Fischer, K Goodwin, J Proni, A Saied, C Sinigalliano, J Stamates, P Swart, and J-Z Zhang. 2010. FACE Outfalls Survey Cruise - October 6-19, 2006. NOAA Technical Report OAR-AOML-38.

DESCRIPTION	DATA SOURCE
Water Quality Monitoring within Estuaries of ICAs	
TMDL calculations for nutrient reductions based on concentrations of chlorophyll-a, dissolved oxygen (DO), and/or biochemical oxygen demand (BOD),and total phosphorus (TP), total nitrogen (TN), and BOD (March 2009) in 9 water bodies.	FDEP, 2013. St. Lucie River and Estuary Basin Management Action Plan.
Study of anthropogenic land-based nitrogen (N) sources and effect on HAB growth near reefs. Macroalgal tissue data along seven transects from Jupiter to Deerfield Beach. Tables 1 and 2. Pages 1110-1111. Results relevant for all ICAs.	Lapointe, B. et al., 2005. Macroalgal blooms on southeast Florida coral reefs II. Cross-shelf discrimination of nitrogen sources indicates widespread assimilation of sewage nitrogen.
Water quality monitoring data (e.g., salinity, seagrass) and analysis conducted by Miami-Dade County's Department of Environmental Resources Management (also known as Permitting, Environment, and Regulatory Affair or PERA).	NOAA and FDEP, 2013. Biscayne Bay Aquatic Preserve Management Plan.
Water Quality Monitoring Near Southeast Florida Coral Reefs	
Study of anthropogenic land-based nitrogen (N) sources and effect on HAB growth near reefs. Macroalgal tissue data along seven transects from Jupiter to Deerfield Beach. Tables 1 and 2. Pages 1110-1111. Results relevant for all ICAs.	Lapointe, B. et al., 2005. Macroalgal blooms on southeast Florida coral reefs II. Cross-shelf discrimination of nitrogen sources indicates widespread assimilation of sewage nitrogen.
Coral Reef Water Quality Survey Data (1995-2011)	Carsey, Thomas and C. Featherstone, et al. August, 2011. Boynton Delray Coastal Water Quality Monitoring Program. NOAA Technical Report OAR-AOML-39.
Study of anthropogenic land-based nitrogen (N) sources and effect on HAB growth near reefs. Macroalgal tissue data along seven transects from Jupiter to Deerfield Beach. Tables 1 and 2. Pages 1110-1111. Results relevant for all ICAs.	Lapointe, B. et al., 2005. Macroalgal blooms on southeast Florida coral reefs II. Cross-shelf discrimination of nitrogen sources indicates widespread assimilation of sewage nitrogen.
Hydrodynamics	
Tidal prism, flow measurements, identification of 6 coastal wastewater outfalls, coral reef habitat data.	Banks, B and B. Reigl, et al., 2008. The Reef Tract of Continental Southeast Florida (Miami-Dade, Broward and Palm Beach Counties). In B.M. Riegl and R.E. Dodge (eds.), Coral Reefs of the USA, Springer Science + Business Media B.V. 2008.
Tidal prism data for coastal Atlantic waters.	Powell, et al. 2006. Morphodynamic Relationships for Ebb and Flood Delta Volumes at Florida's Tidal Entrances. Ocean Dynamics, 56: 295–307.
Presentation on regional hydrologic and hydrodynamic modeling utilized in southeast Florida.	SFWMD and USGS, 2008. Hydrologic & Hydrodynamic Modeling. Presentation from 2008 Conference: "Greater Everglades Ecosystem Restoration Planning, Policy and Science Meeting For Everglades Restoration 2050 - Advancing the Science to Achieve Success." Naples, FL.

C. Summary of Data in Assessment and Management Reports

Each ICA has received differing degrees of watershed assessment and management efforts in recent years. These documents provide a starting point for future LBSP assessment and management, and provide an indication of the level of effort that has been expended on a watershed-wide (ICA-wide) basis to evaluate LBSPs comprehensively. This list is not inclusive of every local and smaller-scale assessment and restoration effort, but rather includes larger scale comprehensive reports for each ICA and a comparison among ICAs of the extent to which water quality, flow and habitat have been assessed and management plans have been developed. Table 7-5 provides a tally of the topics addressed by these documents. Some documents address more than one topic and have been included in the tally for each applicable topic. It demonstrates in a cursory manner the extent to which watershed-based assessment and management in the northern ICAs (St. Lucie, Jupiter, and Lake Worth) has far exceeded the other ICAs to the south.

The detailed list of these documents is presented in Appendix B. For each document, we have presented the title, author, and a brief description of the document as it pertains to the identification and management of LBSPs in the ICA. These documents are presented in chronological order from oldest to newest in order to provide the reader with a sense of how the assessment and management planning process has evolved in each ICA.

Table 7-5. Tally of Planning and Management Reports in Each ICA

ICA	Water Quality Assessment and Management	Flow Assessment and Management	Habitat Assessment and Management
St. Lucie	10	2	2
Jupiter	7	5	4
Lake Worth	7	5	4
South Lake Worth/ Boynton	8	3	1
Boca Raton	2	1	0
Hillsboro	1	1	0
Port Everglades	1	2	0
Baker's Haulover	1	0	1
Government Cut	1	0	1

D. Data Gaps

The following is a list of data gaps that emerged from the information collected and assessed in this section:

- Significant assessment and management effort has been expended in the northern ICAs, particularly in the St. Lucie ICA and Jupiter ICA. As presented in Tables 7-1 and 7-3 and Figures 7-1 through 7-9, there are many more water quality and flow data points in these ICAs than in the more southern ICAs. In the St. Lucie ICA, in particular, there are many more water quality data points in both the estuary (receiving waters) and at the salinity control points (discharge from land area), allowing for more detailed assessment and prioritization of LBSPs.

- There has been more effort expended toward watershed based planning and management in the St. Lucie, Jupiter, Lake Worth ICAs than in the more southern ICAs. When these documents are examined more closely (see Appendix B), it is clear that the St. Lucie and Jupiter ICA's are the subject of more advanced watershed-based water quality management planning than the other ICAs. More effort should be focused on the southern ICAs in the project area on watershed based assessment and management to reduce pollutant loads from LBSPs that are affecting the estuaries within each ICA.

- Significant water quality data collection has been conducted in the St Lucie ICA for water quality in the estuaries and nutrient loads at the salinity control structures or other canal discharge locations ICA. What level of sampling is necessary to bring the other ICAs up to an adequate level of monitoring? An error analysis is needed to estimate the number of sampling points required for accurate estimation of water quality conditions at any point in space and time.

- Land-based loading coefficients have been developed and calibrated for the St Lucie ICA. While these numbers can be used to provide a working estimate of land-based pollutant loading in the other ICAs, as has been calculated in this report, it is reasonable to expect that these loading coefficients differ somewhat among the ICAs. Land-based loading coefficients calibrated to each ICA are needed to understand and prioritize LBSP in each ICA.

- The St Lucie Estuary has a hydrodynamic model to quantify the outflow of water and nutrients to the ocean. The NOAA FACE Program has performed some initial studies to evaluate the flow and exchange of pollutants through several of the inlets, including Boynton / South Lake Worth Inlet, the Boca Raton Inlet, the Hillsboro Inlet, and the Port Everglades Inlet. However, in general, very little is known about the exchange of pollutants in water (both fresh and saline) between the ICA estuarine systems and the marine environment in the vicinity of the reef tract. More information about the flushing rates of the estuaries through the inlets and the loads of pollutants that enter the exit the estuaries through the inlets would be helpful in better understanding the loading capacities in the estuarine systems and the sources of pollutants (land-based or ocean-based).

- The influence of groundwater flow and groundwater discharge on water quality in the reef tract and estuaries of southeast Florida is largely unknown. Assessments are needed to answer a number of management questions such as: Where is groundwater discharging to the estuaries and ocean? What are the magnitude and variability of groundwater discharges in the ICAs of southeast Florida? What nutrients and other pollutants are contained in these groundwater discharges? Is septic system discharge reaching this groundwater flow regime? What impacts are aging sanitary sewer systems having on groundwater quality in the ICAs?

8. Conclusions and Recommendations

This report provides basic information to identify the boundaries of the nine ICAs that discharge to the Atlantic Ocean through the nine inlets in southeast Florida. It also provides land use mapping and readily available information to evaluate the principal sources of nutrient and sediment contamination to the receiving water bodies in these ICAs, as well as sources of water quality data to evaluate the extent of the water quality impairments in each the waters of each ICA. Finally, this report helps to identify, on a broad scale, the gaps in field data that are necessary for better characterizing pollutants and pollutant sources and to prioritize future water quality improvement efforts.

Although significant effort has been dedicated toward watershed-based planning and management in the St. Lucie and Jupiter ICAs, there is still much to do in the other ICAs, and there are some global gaps in the understanding how land-based sources of nutrients and sediment are delivered to the estuaries and the near-coastal coral reefs and what the target levels of contamination should be for healthy coral reef ecosystems in southeast Florida.

As discussed earlier in this report, the US EPA's Nine Elements of a Watershed Plan (EPA, 2008) are a well-recognized guide to developing a watershed-based management plan. EPA's guidance for developing watershed-based plans to address land based sources of pollution (LBSP) provides a critical path for identifying problem sources of contamination and finding solutions. EPA's nine elements can provide a useful framework for evaluating what work has been completed and what work remains in each ICA in southeastern Florida. For reference, the nine elements are as follows:

j. Identify the causes of water body impairment and sources of pollution.
k. Estimate pollutant loads and expected load reductions from management efforts.
l. Describe the management measures that will achieve reductions.
m. Estimate funding and technical assistance needs to implement management measures.
n. Describe the public education component to encourage continuous participation in the plan.
o. Define a schedule for implementation.
p. Describe interim measureable milestones to assess whether implementation is occurring.
q. Identify reasonable criteria to evaluate improvements in water quality and watershed health.
r. Describe a monitoring program to measure progress against the criteria.

This report assists in fulfilling elements "a" (identify causes) and "b" (quantify pollutant loads and required reductions) of the nine elements. But as evidenced by the information, data and management efforts that we have compiled in the nine ICAs within our study area, additional elements of the planning process have been developed in some ICAs already. In particular, the St. Lucie and Jupiter ICAs already have Basin Management Action Plans that address all of the nine elements to a certain degree and do not require additional watershed plans. For the other seven ICAs, most of the nine elements of a watershed based plan remain to be developed, or have been developed for a subsection of the watershed, but not for the full ICA. The Florida Aquatic Preserves, which are located wholly or partially within a delineated ICA (Government Cut, Baker's Haulover, Jupiter and St. Lucie ICAs) have Management Plans that address some of the elements of the Watershed Based Plan to reduce LBSPs, but only for that specific subsection of the ICA, and often with only limited focus on the LBSP and water quality aspects of the aquatic preserve.

The most difficult steps towards developing fully-fledged watershed plans are steps "a" (identify causes) and "b" (quantify pollutant loads and required reductions). Following these two initial steps, step "c" of describing the management measures to achieve pollutant reductions is the next most important and challenging piece of the watershed based plan.

The following section is a concise list of recommendations for next steps in fleshing out EPA's elements "a" and "b" to develop watershed based plans to reduce LBSP impacts in the nine ICAs in southeastern Florida for the protection of the coral reef tracts:

- Considerable effort is necessary to accurately estimate the nutrient and sediment loads to a receiving water and the sources of those loads. Although the SFWMD does monitor flows and water quality entering the receiving waters of each ICA through their salinity control structures, most of the concentration measurements are time-based measurements rather than flow-based measurements, and these are not adequate for accurate load estimates. Fortunately, we can extrapolate some data and analysis from the more extensive data analysis that has already been performed in the St. Lucie ICA. Current load measurements could be used to roughly calibrate the St. Lucie export coefficients for nutrients and sediment to each ICA. This approximation will enable the calculation of loads and identification of their sources in each ICA. In the long term, the recommendation is to improve the precision of these land use based pollutant load estimates for each ICA.

- For responses in the estuarine waters, there is a large disparity in the sampling intensity of water quality with the estuaries. Although significant sampling and modeling efforts have occurred in the St. Lucie and Jupiter estuaries, there has been much less effort in the estuaries of the other seven ICAs. The dynamics of four of the nine inlets has been studied by NOAA in their FACE program. Estuarine sampling and inlet dynamics are necessary to determine quantify water quality impacts and determine the transformation and movement of pollutants through the estuary to the near-coastal waters. Because each estuary is unique in terms of loading, volume, and flushing rates, there is little opportunity for extrapolation from the prior work, although some simplified estuarine model might be developed. The recommendation is perform a statistical study to determine the required sampling intensity, make adjustments in the sampling programs in each ICA to achieve the desired sampling intensity, and develop simple estuarine models of nutrient and sediment transport.

- For responses in the near-coastal waters, there are almost no data in FDEP's IWR databases or elsewhere that we could identify for this project. NOAA has made some measurements of the nutrient dispersal around the six offshore wastewater discharge points and a number of monitoring cruises along the southeastern coast. There was no available information of the mixing of the inlet loads with the coastal waters. This is probably because this type of effort can be data intensive and lengthy. However, the long-term recommendation is to develop a simple hydraulic model of the entire southeast coast and estuaries to better understand the interaction of freshwater and marine waters and how LBSP loads are delivered to the near-coastal coral reefs.

- The specific influence of nutrient loads from groundwater on water quality in the reef tract and estuaries of southeast Florida appears to be largely unknown based on our data compilation effort. Nitrogen is a common contaminant that can be transported long distances with little attenuation via groundwater. Nitrogen sources of concern include septic systems, intensive landscaping, and agriculture. The long-term recommendation is to perform a qualitative assessment or develop a simple shallow groundwater model of the entire southeast coast to better understand the interaction of shallow groundwater and coastal waters and how nitrogen loads in shallow groundwater are delivered to the near-coastal coral reefs.

- Even without extensive data to document exact LBSP impacts and sources, many known problems can be identified and remedies developed based on first-hand knowledge from those most familiar with the ICA, including environmental managers, practitioners, land owners, and other watershed stakeholders. It is never too early to begin the effort of addressing major known problems. The data and information collected in this report can serve to inform this effort. Therefore, the recommendation is to immediately begin to hold focus groups to discuss each ICA individually, to identify known LBSPs within the ICA, to identify receiving waters within the ICA that are experiencing pollution problems, and to begin to prioritize areas to focus on first. Discussions should also include potential management options to reduce the identified LBSPs in specific areas, as well as potential funding source and partners. All of these elements of the discussion will help the group to identify certain immediate actions or priorities to be addressed, even while the effort to collect additional data and perform additional data analysis for a watershed based plan continues. These actions will begin to fulfill elements "c" through "i" of the nine elements in a comprehensive watershed-based management plan.

9. References

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Appendix A - Library of Information

We have developed two directories in Excel format to track all of the documents and GIS data that we have collected to date for this project. Each document or GIS file is cross-referenced to the ICA or ICAs to which is pertains. These reports and GIS files have been organized into a stand-along folder, with subfolders, that serves as the library for this report and for continued efforts to assess and manage LBSPs in the SEFCRI Region. The Excel file directories include reference to the sub-folders where each document is filed, as well as direct hyperlinks to the document or GIS data file. These two directories of documents and GIS data files are presented in Tables A-1 and A-2.

In each table, the ICAs are referenced by the following codes:

1	Saint Lucie Inlet
2	Jupiter Inlet
3	Lake Worth Inlet
4	Boynton/South Lake Worth Inlet
5	Boca Raton Inlet
6	Hillsboro Inlet
7	Port Everglades Inlet
8	Baker's Haulover Inlet
9	Government Cut Inlet

Appendix B - Relevant Planning and Management Documents in Each ICA

Table B-1 Relevant Planning and Management Documents – St. Lucie

Document title	Date	Author(s)/ Agency	Document Overview
Basin Status Report - St. Lucie and Loxahatchee	February 2003	FDEP	This document is first step in FDEP's TMDL Program compliance. It is a preliminary evaluation of water quality and ecological health in the study area. Specific data not included.
Water Quality Assessment Report - St. Lucie and Loxahatchee	2004	FDEP	This document presents the Clean Water Act Section 303(d) listing of verified impaired waterbodies in the St. Lucie and Loxahatchee watersheds. Impaired water bodies that do not support their designated use require a TMDL. This assessment follows from the Basin Status Report and provides a basis for Basin Management Action Plans to restore impaired waters. Assessment is structured into 8 Planning Units, and includes a summary of water quality assessment. Specific data not included.
Lake Okeechobee Watershed Construction Project Phase II Technical Plan	2008	SFWMD	A Phase II component of the Lake Okeechobee Watershed Construction Project (LOWCP) was added in the 2007 Northern Everglades and Estuaries Protection Program (NEEPP) legislation. The legislation requires the SFWMD, in collaboration with the FDEP and the FDACS to develop a detailed technical plan that focuses on projects and initiatives designed to reduce phosphorus loadings to the Lake and to provide additional storage capacity north of the Lake in order to better manage lake water levels and help reduce the need for releases to the estuaries. That plan – also a requirement of the NEEPP - was submitted to the Florida Legislature on February 1, 2008.
TMDL Report: Nutrient and Dissolved Oxygen TMDL for the St. Lucie Basin	2008	FDEP	This report provides information on the development of TMDL targets for the St. Lucie Basin. The basin is subdivided into water body identification units (WBID) as detailed in the report. There are nine impaired WBIDs that this TMDL addresses for dissolved oxygen (DO), nutrients, and biochemical oxygen demand (BOD). Although there are other WBIDs that contribute significant flows to the St. Lucie Estuary, these WBIDs are not considered in this TMDL because they already have TMDLs associated with them, are scheduled for TMDL development in the future, or have significant water improvement projects underway within their boundaries.

Document title	Date	Author(s)/ Agency	Document Overview
St. Lucie River Watershed Protection Plan (SLRWPP)	2009	SFWMD, FDEP, FDACS	The SLRWPP was developed in response to state legislation, which authorized the Northern Everglades and Estuaries Protection Program (NEEPP). The primary goal is to restore and protect surface water resources by addressing not only the water quality but also the quantity, timing, and distribution of water to the natural system. Three main components of the plans are: 1) a Watershed Construction Project, which identifies water quality and storage projects to improve hydrology, water quality, and aquatic habitats within the watershed; 2) a Watershed Pollutant Control Program that is a multi-faceted approach to reducing pollutant loads by improving the management of pollutant sources within the watershed; and 3) a Watershed Research and Water Quality Monitoring Program to monitor progress of the programs and the health of the estuaries. The intent of the protection plan is to identify strategies for addressing and better understanding local watershed influences and inflows on the health of the river and estuary.
Summary Highlights of St. Lucie River Watershed Protection Plan Update	2012	SFWMD, FDEP, FDACS	This is a summary of state mandated reporting. The full updated document is included as Appendix 10-1 in the South Florida Environmental Report, submitted to the Florida Legislature in March 2012. Full report cited below. This report highlights significant watershed improvements as of 2012 as they relate to management strategies for water quality improvement. More specifically, this document lists efforts to improve water quality by reducing nutrient loadings to meet the Total Phosphorus (TP) and Total Nitrogen (TN) TMDL targets. Water storage plans for 2012-2014 are also discussed in this document in brevity.
Appendix 10-1: St. Lucie River Watershed Protection Plan Update. (2012 South Florida Environmental Report)	2012	Eds. Lesley Bertolotti and Pinar Balci (SFWMD)	This report fulfills the legislative update requirement for the three-year update to the SLRWPP and focuses on the coordinating agencies' progress since 2009 toward meeting the plan's goals. It also defines current and proposed nutrient reduction and storage projects that will require funding for implementation and identifies the lead agencies for implementing each activity or project.

Document title	Date	Author(s)/ Agency	Document Overview
			Supporting information is included as attachments: • ***Attachment A:*** SLRWPP new project/activity sheets • ***Attachment B:*** Revised nutrient loading rates and reduction factors associated with Best Management Practices (BMPs) and technologies • ***Attachment C:*** Assumptions for BMP implementation rates • ***Attachment D:*** An overview of the St. Lucie River Watershed and Estuary monitoring efforts
St. Lucie River and Estuary Basin Management Action Plan (BMAP)	2013	St. Lucie River and Estuary Basin Technical Stakeholders Div. of Environmental Assessment and Restoration (FDEO), Bureau of Watershed Restoration (FDEP)	This report was prepared as part of a statewide watershed management approach to restore and protect Florida's water quality. It was developed by St. Lucie River and Estuary Basin stakeholders. FDEP identified nine segments with waterbody identification (WBID) numbers in the St. Lucie River and Estuary Basin as impaired by nutrients. The report includes TMDL calculations for nutrient reductions based on concentrations of chlorophyll-a, dissolved oxygen (DO), and/or biochemical oxygen demand (BOD) in each of the WBIDs. In March 2009, the FDEP adopted the St. Lucie Basin TMDL for total phosphorus (TP), total nitrogen (TN), and BOD. This report lists the TMDLs and pollutant load allocations adopted by rule for the WBIDs in the St. Lucie River and Estuary Basin. TMDL loads in upstream WBIDs were calculated based on achieving the same target concentrations (0.72 milligrams per liter [mg/L] for TN and 0.081 mg/L for TP) as in the St. Lucie Estuary. The TMDLs were used as the basis for the BMAP targets and allocation calculations.
2014 South Florida Environmental Report-Executive Summary, Volume I, Chapter 10 – Coastal Priorities.	2014	SFWMD	This brief chapter serves specifically as the annual report for the Caloosahatchee River Estuary (CRE) and St. Lucie River Watershed Protection Plans under the NEEPP, and summarizes estuary monitoring and associated research that link watershed freshwater inflow to ecological patterns and trends including: • Wet and dry extremes for rainfall and freshwater inflows into the St. Lucie Estuary and subsequent releases from Lake Okeechobee.

Document title	Date	Author(s)/ Agency	Document Overview
			• Specific TN and TP loading numbers for the watershed including the tidal portion of St. Lucie Estuary (SLE) and the CRE. • TN and TP loading from Lake Okeechobee to SLE and CRE. • TN, TP, and chlorophyll concentrations for TMDL reporting for 2013 in CRE, upper SLE, and St. Lucie inlet. • Salinity concentrations in relation to local oyster habitat health. • Watershed construction projects and studies being conducted to improve water quality hydrology, aquatic habitat health, etc.
Indian River Lagoon System Management Plan (DRAFT)	June 2014	FDEP	The Plan is an ecosystem based management plan and describes water quality and natural community function and species diversity in the context of the ecosystem science, management , education and outreach, and public use within the Indian River Lagoon System. It also includes an administrative plan. The Plan includes a compilation of 4 Aquatic Preserves (APs): • Banana River AP • Indian River - Malabar to Vero beach • Indian River - Vero Beach to Ft. Pierce • Jensen Beach to Jupiter Inlet The Jensen Beach to Jupiter Inlet AP includes area of the Indian River Lagoon within the St. Lucie and Jupiter ICAs. The Appendices also include an overview of et legal codes governing the APs, a species list, a description of the public involvement process, a summary of the goals, objectives, and strategies for management to the AP, budget and major accomplishments since approval of the previous individual management plans.

Table B-2. Relevant Planning and Management Documents – Jupiter Inlet

Document title	Date	Author/Authoring Agency	Document Overview
Loxahatchee River Lake Worth Creek Aquatic Preserve Management Plan	June 12, 1984	FDEP	This AP Management Plan is somewhat outdated, but provides a basic overview of the resource management under prior development conditions, as well as management objectives at the time. The website for this AP provides a clear map of the AP for reference, and a link to this water quality monitoring summary document that provides a summary of water quality data and data sources for the Indian River Lagoon and Loxahatchee River system.
Basin Status Report - St. Lucie and Loxahatchee	February 2003	FDEP	This document is first step in FDEP's TMDL Program compliance. It is a preliminary evaluation of water quality and ecological health in the study area. Specific data not included.
2006 South Florida Environmental Report, Appendix 12-1: Modeling Freshwater Inflows and Salinity in the Loxahatchee River and Estuary	2006	Yongshan Wan and Gordon Hu, SFWMD	This appendix describes the hydrologic and salinity models applied in the Northwest Fork of the Loxahatchee River Restoration Plan. The Loxahatchee Watershed (WaSh) model was developed to simulate freshwater flow from each of the tributaries into the Northwest Fork. The WaSh model is based on restructuring HSPF (Hydrologic Simulation Program – Fortran) into a cell-based system with the addition of a groundwater model and a full dynamic channel routing model (Wan et al., 2003). The model is capable of simulating surface water and groundwater hydrology in watersheds with high groundwater tables and dense drainage canal networks. The Loxahatchee River Hydrodynamics/Salinity (RMA) model was developed to simulate the influence of freshwater flows on salinity conditions in the Loxahatchee River and Estuary. The RMA model is based on the RMA-2 and RMA-4 and was calibrated against field data from five locations and provided salinity predictions for many other sites where field data are not available. Tide/salinity data collected since 2002 have provided a field database for the investigation of the impact of freshwater inflow on the salinity regime in the Northwest Fork.

Document title	Date	Author/Authoring Agency	Document Overview
			To perform long-term predictions of daily salinity, a Long-Term Salinity Management Model (LSMM) was developed to predict salinity and calculate several other performance parameters under various ecosystem restoration scenarios. Field data, regression analyses, and results from multidimensional hydrodynamic computer models were integrated into the LSMM as a system simulation and management tool. This salinity management model is applied to predict daily salinity from for the simulation period from 1965 to 2003 under the base condition and various restoration scenarios. (excerpted from Executive Summary)
Restoration Plan for the Northwest Fork of the Loxahatchee River	2006		The Loxahatchee River Watershed drained through Loxahatchee and Hungryland Slough to the Northwest Fork. The permanent opening of the Jupiter Inlet in 1947, along with sea level rise, has resulted in significant saltwater encroachment where a saltwater tolerant, mangrove-dominated community has moved into the freshwater, bald cypress-dominated floodplain. The watershed has been permanently altered by the construction of canals for drainage. The C-18 Canal and S-46 Structure were constructed in the 1960s, which diverted flows from the Northwest Fork to the Southwest Fork for flood control purposes. Currently, reduced amounts of freshwater flows into the Northwest Fork, especially in the dry season, do not push back saltwater that adversely impacts the freshwater floodplain ecosystem. This Plan discusses data collection and analyses used to develop and evaluate restoration flow alternatives. In summary, the Preferred Restoration Flow Scenario is a variable dry season flow between 50 cfs and 110 cfs, with a mean monthly flow of 69 cfs over Lainhart Dam, while providing an additional 30 cfs of flow from the downstream tributaries. Implementation of the Northwest Fork Loxahatchee River Restoration Plan with its Preferred Restoration Flow Scenario is being achieved through

Document title	Date	Author/Authoring Agency	Document Overview
			important interagency plans and projects, which are currently underway within the watershed.
2009 System Status Report Loxahatchee River Estuary Water Quality Results Executive Summary	2009		Water quality monitoring sites within the Loxahatchee River Estuary are shown in the map. The 2009 System Status Report (SSR) provides an in-depth assessment of the monitoring data provided by the Restoration Coordination and Verification (RECOVER) Monitoring and Assessment Plan (MAP) in conjunction with historical data and data from non-MAP sources. These monitoring data on the status and trends of physical (e.g., hydrology), chemical (e.g., nutrients), and biological (e.g., wading birds) parameters are assessed to establish pre-Comprehensive Everglades Restoration Plan (CERP) reference conditions and ultimately determine whether the goals and objectives of the CERP are being met. The goal of the SSR is to provide a synthesis of data for each of the four geographic regions (Lake Okeechobee, Northern Estuaries, Greater Everglades and the Southern Coastal Systems) as well as the ecosystem as a whole.
Loxahatchee River National Wild and Scenic River Management Plan Update	2010	FDEP, SFWMD	The 2010 Loxahatchee River National Wild and Scenic Management Plan contains an overview of enacting legislation and policy, government agency authority and responsibilities, a description and assessment of natural and cultural resources within the river area, preservation objectives, strategies and tasks and progress to date. The managing agencies responsible for implementing the plan embrace adaptive management practices and recognize the multi-agency effort to conserve the river's resources which necessitate the need for plan updates every five years. These updates maintain the protection and enhancement objectives from the original plan while updating the strategies and tasks to fit current conditions and activities occurring within the National Wild and Scenic Loxahatchee River.
Presentation Summary of 2011 Datasonde Monitoring	2011	Loxahatchee River District	Summarizes automated data monitoring efforts in the Loxahatchee River. Data points summarized include: annual average rainfall, flood control releases, downstream estuary health (e.g., salinity), supplemental flow for

Document title	Date	Author/Authoring Agency	Document Overview
			upstream river segments (i.e., freshwater habitats avoided significant harm), saline waters migrated upstream following testing.
Presentation Summary of 2013 Loxahatchee River Water Quality	2013	Loxahatchee River District	Summarizes water quality data collection in the Loxahatchee River basin. Data points summarized include: nitrogen, phosphorous, chlorophyll a, fecal coliform, and flow.
Loxahatchee River - RiverKeeper Database 1991 - 12/31/2013 (EXCEL format)	2013	Riverkeeper	Data collected throughout Loxahatchee River basin. Includes measurements included but not limited to: DO, salinity, fecal coliform, nitrogen, phosphorous, temp, pH, etc.
Assessment of Groundwater Input and Water Quality Changes Impacting Natural Vegetation in the Loxahatchee River and Floodplain Ecosystem, Florida	2013	USGS	Drainage patterns within the Loxahatchee River basin have been altered significantly due to land development, road construction (e.g., Florida Turnpike), and construction of the C-18 and other canals. These activities along with sea level rise have resulted in significant adverse impacts on the ecosystem over the last several decades, including increased saltwater encroachment and undesired vegetation changes in the floodplain. The problem of saltwater intrusion and vegetation degradation in the Loxahatchee River may be partly induced by diminished freshwater input, from both surface water and ground water into the River system. This project attempted to assess the seasonal surface water and groundwater interaction and the influence of the biogeochemical characteristics of shallow groundwater and porewater on vegetation health in the Loxahatchee floodplain. The hypothesis tested are: (1) groundwater influx constitutes a significant component of the overall flow of water into the Loxahatchee River; (2) salinity and other chemical constituents in shallow groundwater and porewater of the river floodplain may affect the distribution and health of the floodplain vegetation.
Indian River Lagoon System Management Plan (DRAFT)	June 2014	FEDP	The Plan is an ecosystem based management plan and describes water quality and natural community function and species diversity in the context of the ecosystem science, management , education and outreach, and public use within the Indian River Lagoon System. It also includes an administrative plan. The Plan includes a compilation of 4 Aquatic Preserves (APs): • Banana River AP

Document title	Date	Author/Authoring Agency	Document Overview
			• Indian River - Malabar to Vero beach • Indian River - Vero Beach to Ft. Pierce • Jensen Beach to Jupiter Inlet The Jensen Beach to Jupiter Inlet AP includes area of the Indian River Lagoon within the St. Lucie and Jupiter ICAs. The Appendices also include an overview of et legal codes governing the APs, a species list, a description of the public involvement process, a summary of the goals, objectives, and strategies for management to the AP, budget and major accomplishments since approval of the previous individual management plans.

Table B-3. Relevant Planning and Management Documents – Lake Worth Inlet

Document title	Date	Author/Authoring Agency	Document Overview
Basin Status Report - Lake Worth Lagoon - Palm Beach Coast	July 2003	FDEP	This document is first step in FDEP's TMDL Program compliance. It is a preliminary evaluation of water quality and ecological health in the study area. Specific data not included.
Water Quality Assessment Report, Lake Worth lagoon - Palm Beach Coast	2006	FDEP	This document presents the Clean Water Act Section 303(d) listing of verified impaired waterbodies in the Lake Worth Lagoon and Palm Beach Coast Basin. Impaired water bodies that do not support their designated use require a TMDL. This assessment follows from the Basin Status Report and provides a basis for Basin Management Action Plans to restore impaired waters. Assessment is structured into 9 Planning Units, and includes a summary of water quality assessment. Specific data not included.
Lake Worth Lagoon–Palm Beach Coast Basin Lakes, Rivers, Streams, and Aquifers	2006	FDEP	The Watershed Monitoring Section administers the Status Monitoring Network, which oversees the statewide sampling of surface and ground water. This report summarizes the 2006 Status Monitoring Network results for the Lake Worth Lagoon–Palm Beach Coast Basin.
Final Project Report for the Palm Beach 2007 Habitat Mapping Project	2007	Avineon Inc. (Contractor)	Under contract for Palm Beach County’s Environmental Resources Management (ERM) department, Avineon conducted the 2007 mapping efforts to enable ERM to determine the aerial extent selected estuarine habitats existing within the county. Avineon completed and delivered a final geodatabase to the County depicting seagrass, unvegetated bottom, tidal flats, algae beds, mangrove swamp, oyster bars/reefs, cordgrass (spartina sp.), and shoreline. This report summarizes the project results and explains the methodology used to produce the project deliverables. It also contains references to additional reports that were delivered during the course of the project.
Lake Worth Lagoon Management Plan Revision	2008	Palm Beach County ERM	The Lake Worth Lagoon Management Plan (LWLMP) was adopted in 1998. Tasks and projects originally defined in the plan were and are currently being implemented by various groups and agencies. This first revision of the LWLMP encompasses the 1998-2007 timeframe. It provides a look back at the progress made in implementing the original goals and

Document title	Date	Author/Authoring Agency	Document Overview
			priorities, and a look ahead at strategies and restoration projects. A current status of the lagoon is included, along with Action Plans for future projects. Information in the plan has been synthesized with visual aids and specific Action Plans scheduled for the next 5 years. Each Plan summarizes the topic, presents management objectives, and suggests a series of actions with strategies to address those objectives. Anticipated costs and schedules are included, along with the expected benefits. The topics include: Water and Sediment Quality Program, Habitat Restoration and Enhancement and Restoration Program, Public Use and Outreach Program, Interagency Planning and Coordination, Funding
Lake Worth Lagoon Watershed and Stormwater Loading Analysis	2009	Taylor Engineering for SFWMD	An overview of the water quality in the LWL watershed and a characterization of the types and magnitude of selected pollutant concentrations in stormwater runoff — event mean concentrations (EMCs) —from contributing land uses that discharge to the LWL. The report recommends that the SFWMD should develop an EMC dataset target and budget for the cost expected to meet that target. After the first rainy season sampling effort, assessment of the EMC dataset produced by the effort to date and the project cost to date will provide the basis to reassess those targets and make recommendations to revise the collection methodology for the two following years.
Survey of Select Eastern Oyster Populations in Lake Worth Lagoon (Presentation) Report	2010	John Scarpa and Susan Laramore Harbor Branch Oceanographic Institute, Florida Atlantic University	Presentation to describe project and project report. The project measures and compares growth, abundance, reproductive effort, and health of the Eastern oyster, Crassostrea virginica (Gmelin, 1791) at selected sites in Lake Worth Lagoon.
Lake Worth Lagoon Management Plan	2013	Lake Worth Lagoon Initiative	Update to the 2008 LWLMP. Many goals and objectives of the 2008 Plan were implemented under the leadership of the Palm Beach ERM in partnership with state agencies, local municipalities and interested stakeholders. The Lake Worth Lagoon Initiative (Initiative), a multi-agency effort to

Document title	Date	Author/Authoring Agency	Document Overview
			increase awareness, support and funding assistance for projects to improve and protect the natural resources within the watershed was established in 2008. The Initiative has successfully promoted interagency coordination and commitment to the Lake Worth Lagoon (LWL) restoration and protection.
Wet Season Freshwater Inflows to Lake Worth Lagoon (Presentation)	Oct 2013	Presentation by: Yongshan Wan, Ph.D. P.E. Section Leader - Coastal Ecosystems Section, SFWMD	Presentation to the Palm Beach County Board of County Commissioners Workshop. Discusses Lake Worth Lagoon drainage basin delineation and land use characteristics; 2013 wet season rainfall/runoff characteristics and discharges into LWL; and how much Lake Okeechobee water was discharged into LWL during 2013 wet season.
Freshwater Discharges to Lake Worth Lagoon (Presentation)	Oct 2013	Robert Robbins, Palm Beach ERM	Presentation "Takeaway Points": • SFWMD is doing what it can to reduce discharges. • 'System' lacks water storage. • Too much freshwater kills seagrasses and oysters. • Seagrasses and oysters can recover. • Muck sediments are left behind. • Muck smothers most living organisms. • C-51 Sediment Trap helps. • Reducing discharges will also reduce sediments.
Freshwater Inflows and Water Quality in Lake Worth Lagoon	Nov 2013	Presentation by: Zhiqiang Chen, Ph.D. Senior Scientist, Coastal Ecosystems Section Applied Sciences Bureau, SFWMD	Presentation to Water Resources Working Group Lake Worth Lagoon Initiative. Discusses water quality in LWL inlets and canals; Data from 3 monitoring stations. Looking at freshwater flow impacts on water quality.

Table B-4. Relevant Planning and Management Documents – South Lake Worth/Boynton Inlet

Document title	Date	Author/Authoring Agency	Document Overview
Basin Status Report - Lake Worth Lagoon - Palm Beach Coast	July 2003	FDEP	This document is first step in FDEP's TMDL Program compliance. It is a preliminary evaluation of water quality and ecological health in the study area. Specific data not included.
NOAA's Florida Area Coastal Environment (FACE) Program	Program began in 2004	NOAA	The FACE program is designed to understand the many controlling oceanographic and coastal environmental factors that influence Florida public health and coastal biota, and to provide this knowledge to the area's environmental regulators, resource managers, utility operators, and to the public. The broad objectives of the studies include: • Quantify the sources of selected nutrients and microbial contaminants into critical areas of interest within the FACE purview. • Measure relevant physical parameters such as ocean currents and meteorology with which the chemical measurements must be interpreted. • Determine the likely exposure of coral reef resources to those nutrients. According to the FACE Program website, the study area of FACE covers 467 km of coastline in Miami-Dade to Brevard counties. The area includes six treated wastewater plants with ocean outfalls: Miami Central, Miami North, Hollywood, Broward, Boca Raton, and South Central, which together contribute ~1 million cubic meters (284 millions of gallons) per day to the coastal waters of the region. In addition, this coastal area receives substantial fresh water discharged through coastal inlets. The FACE study area is the home of nearly 5.5 million people (U S Census Bureau, 2006) and supports an economy heavily dependent on a healthy offshore environment.
Water Quality Assessment Report, Lake Worth lagoon - Palm Beach Coast	2006	FDEP	This document presents the Clean Water Act Section 303(d) listing of verified impaired waterbodies in the Lake Worth Lagoon and Palm Beach Coast Basin. Impaired water bodies that do not support their designated use require a TMDL. This assessment follows from the Basin Status Report

Document title	Date	Author/Authoring Agency	Document Overview
			and provides a basis for Basin Management Action Plans to restore impaired waters. Assessment is structured into 9 Planning Units, and includes a summary of water quality assessment. Specific data not included.
Active NPDES Chain of Lakes and SFWMD Sampling Sites	2009	Palm Beach County ERM	Palm Beach County ERM monitors the water quality within estuaries, lakes, and canals containing both fresh and salt water. Presently there is over 20 years of data that ERM has collected on the water quality in Palm Beach County. All of the water quality data that is generated is provided to the EPA and FDEP's statewide water quality database, FL STORET. This data is used in the biannual assessment of water quality conditions throughout Florida and the determination of impaired water bodies. The map provides the location of monitoring sites.
Palm Beach County Chain of Lakes report	2009	Palm Beach County ERM	The Chain of Lakes is located on the western slope of the Atlantic Coastal Ridge in Palm Beach County and run north and south for approximately 30 miles. The northern most portion starts at Belvedere Road in West Palm Beach to Lake Ida Road in southern Boynton Beach and has been divided into four water body segments for this water quality monitoring project. This water quality monitoring program was designed to provide information to the managers to achieve the lakes management goals. Monitoring began in January 2006 and continues today. Thirteen monitoring stations are sampled bi-monthly for a wide variety of parameters, including field measurements. The report finds that in general, the Chain of Lakes show increasing nutrient loadings as indicated by the TSI trends. Lake Ida and Pine Lake are currently listed as impaired for nutrients (TSI) by the Florida Department of Environmental Protection. Increases in organic nitrogen concentrations were observed in all lakes, while concentrations of total phosphorus declined.
South Lake Worth (Boynton) Inlet Fact Finding Study	2009	City of Boynton Beach and Applied Technology and Management	Applied Technology & Management (ATM) was 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

Document title	Date	Author/Authoring Agency	Document Overview
			this study was 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. • 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 was 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.
Boynton-Delray Coastal Water Quality Monitoring Program Report	Aug 2011	NOAA's Atlantic Oceanographic and Meteorological Laboratory Miami, Florida	This report discusses a sequence of six cruises in the vicinity of the Boynton-Delray (South Central) treated-wastewater plant outfall plume, the Boynton Inlet, and the Lake Worth Lagoon, Palm Beach County, Florida. The sampling cruises took place on June 5-6, 2007; August 28-29, 2007; October 18-19, 2007; February 14 and 18, 2008; May 19-20, 2008; and July 11-13, 2008. Water was sampled at 18 locations at the surface, middle, and near the seafloor (where there was sufficient depth) for a total of 45 samples; these samples were analyzed for a variety of nutrients and related parameters. The water sampling unit contained a conductivity-temperature-depth (CTD) instrument from which data were obtained at each sampling site. Synchronal ocean current data were measured by a nearby acoustic Doppler current profiler (ADCP) instrument.
The Florida Area Coastal Environment Program supports science-based water quality management	2012	Thomas Carsey and Jack Stamates (NOAA FACE Program Primary Investigators)	Chapter 3 from book – *Tropical Connections: South Florida's marine environment.*
Boynton Inlet Flow Measurement Study	2013	NOAA's Atlantic Oceanographic and Meteorological Laboratory	An Acoustic Doppler profiler was installed on the north seawall of the Boynton Inlet on February 20, 2007 and remained operational through August 2008. The system measured a profile of velocities across the inlet and also measured the water level above the instrument. Data from this

Document title	Date	Author/Authoring Agency	Document Overview
		Miami, Florida	system were calibrated by regressing the velocity data with data from an independent, down-looking acoustic Doppler profiler which was repeatedly transected across the channel during flood and ebb tidal phases. The down-looking Doppler system was also used to measure the bathymetric profile of the channel at the location of the measurement system. This information was used to generate estimates of the channel flux at 15-minute intervals. These flux measurements were integrated over flood and ebb tidal periods to estimate the tidal prism of the inlet. Comparisons of these tidal prism estimates with wind data collected at Lake Worth pier showed that the north component of the wind velocity was correlated with the Boynton Inlet tidal prism.

Table B-5. Relevant Planning and Management Documents – Boca Raton Inlet

Document title	Date	Author/Authoring Agency	Document Overview
Florida Inlets Program		NOAA, FACE Program	While not significant shipping ports, the inlets at Boca Raton and Hillsboro are significant drains of surface runoff from high population districts and of canal water through the Intracoastal Waterway. NOAA has conducted a study of those inlets, including a series of experiments at both inlets consisting of 1) four sampling and current measurement intensives using a small boat with down-looking ADCP instrumentation, and 2) biweekly sample analysis of water from the inlet over the course of a year. These data are currently being employed to provide estimates of the fluxes of materials through these inlets into the coastal ocean.
Boca Raton Annual Water Quality Report, 2012	2012	City of Boca Raton Utility Services Department	Drinking water and source water protection annual report. The City of Boca Raton Utility Services Department continues to remain in the forefront of new and emerging water treatment technology as well as alternative water supply technologies in support of water conservation. To promote environmental stewardship and public awareness, the Utility Services Department offers public outreach and education programs. These programs are offered to local schools, homeowners associations, civic groups, and through other venues. Some of the programs include tours of the Water Treatment Facility, Water Conservation programs, Water Pollution programs, and Water Quality programs.

Table B-6. Relevant Planning and Management Documents – Hillsboro Inlet

Document title	Date	Author/Authoring Agency	Document Overview
Florida Inlets Program		NOAA, FACE Program	While not significant shipping ports, the inlets at Boca Raton and Hillsboro are significant drains of surface runoff from high population districts and of canal water through the Intracoastal Waterway. NOAA has conducted a study of those inlets, including a series of experiments at both inlets consisting of 1) four sampling and current measurement intensives using a small boat with down-looking ADCP instrumentation, and 2) biweekly sample analysis of water from the inlet over the course of a year. These data are currently being employed to provide estimates of the fluxes of materials through these inlets into the coastal ocean.

Table B-7. Relevant Planning and Management Documents – Port Everglades Inlet

Document title	Date	Author/Authoring Agency	Document Overview
Florida Inlets Program		NOAA, FACE Program	Project: An acoustic Doppler current profiler was installed on the south side of the Port Everglades Inlet to measure the velocity of the water flow at levels starting near the surface and reaching down to near the channel bottom. Volume estimates will be used to estimate the total seaward flux of certain substances measured by the Florida International University group during the study.
Port Everglades Flow Measurement Study	2013	NOAA's Atlantic Oceanographic and Meteorological Laboratory Miami, Florida	Port Everglades is a major seaport, as well as a connection of the Intracoastal Waterway to the Atlantic Ocean. To calculate the mass flux through the inlet, NOAA initiated the Port Everglades Shipping Channel (PESC) Study. To measure the flow through the inlet, a 300-kHz HADCP (Teledyne RD Instruments) was installed in February, 2009, on the south side of the Port Everglades inlet. In addition to the HADCP, a number of meteorological instruments have been installed on the south side of the inlet. The instrumentation includes: wind speed and direction, relative humidity, dew point, barometric pressure, and rain parameters. The instrumentation has the designation as Buoy PVGF1 of NOAAs National Data Buoy Center, and of station PVGF1 of NOAA's CREWS/ICON coral reef monitoring program. Measurements of chemical concentrations were conducted by FIU for the estimation of chemical fluxes through the inlet.

Table B-8. Relevant Planning and Management Documents – Baker's Haulover Inlet

Document title	Date	Author/Authoring Agency	Document Overview
Biscayne Bay Aquatic Preserves Management Plan	February 2013	FDEP	This Management Plan includes areas in eth Baker's Haulover ICA as well as the Government Cut ICA. The Plan is an ecosystem based management plan and describes water quality, habitat loss, obstacles in natural resource management, public access and economic uses. It also includes an administrative plan.

Table B-9. Relevant Planning and Management Documents – Government Cut

Document title	Date	Author/Authoring Agency	Document Overview
Biscayne Bay Aquatic Preserves Management Plan	February 2013	FDEP	This Management Plan includes areas in the Baker's Haulover ICA as well as the Government Cut ICA. The Plan is an ecosystem based management plan and describes water quality, habitat loss, obstacles in natural resource management, public access and economic uses. It also includes an administrative plan.