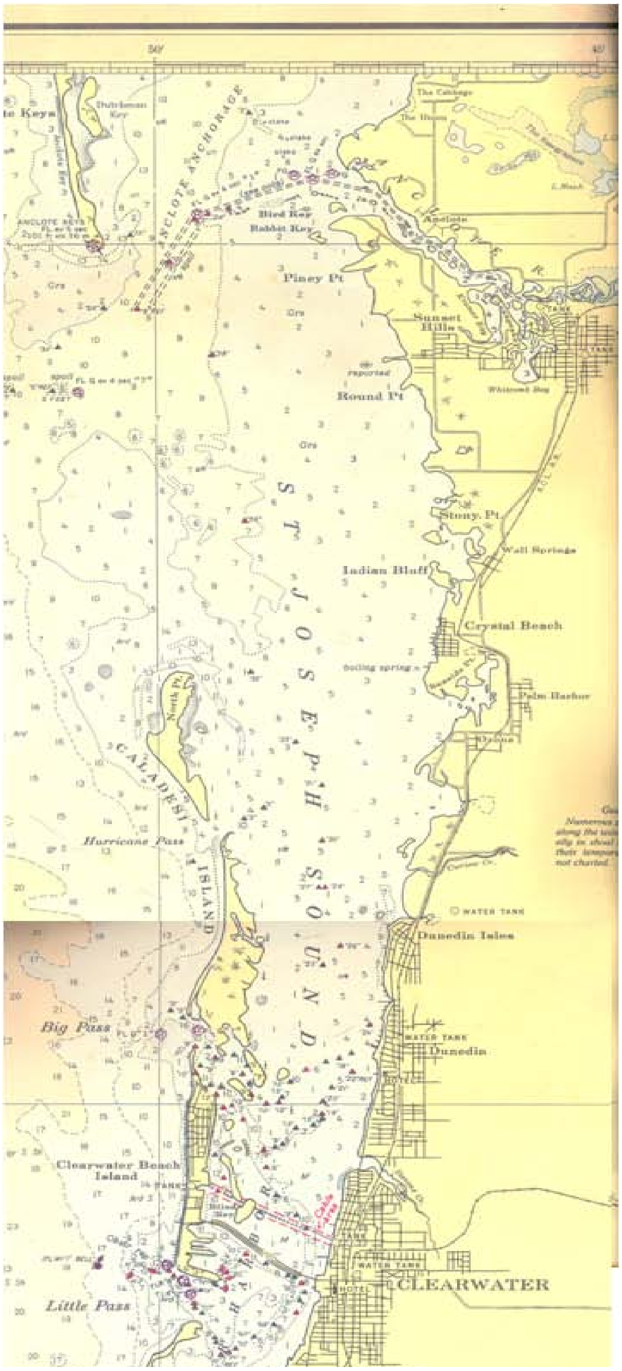

State of the Resource Report for Clearwater Harbor and Saint Joseph Sound

Prepared for:
Pinellas County
Department of
Environment and Infrastructure

Pinellas County
ENVIRONMENT AND INFRASTRUCTURE

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December, 2011

Foreword

This document is provided in fulfillment of Task 7 of the Comprehensive Conservation and Management Plan for Saint Joseph Sound and Clearwater Harbor; Contract No: 089-0222-P.

Acknowledgements

This report would not have been completed without contributions from a number of local scientists and water resource managers. Janicki Environmental, Inc. would like thank project managers Kelli Hammer Levy and Melissa Harrison of Pinellas County and Kris Kaufman of the Southwest Florida Water Management District for their oversight and insights into the successful completion of this report. The stakeholder group provided immeasurable contributions to the success of this project. The stakeholder group included representatives of the City of Tarpon Springs, City of Dunedin, City of Clearwater, City of Largo, Pinellas County, Florida Department of Environmental Protection, the United States Environmental Protection Agency, and the Southwest Florida Water Management District. Cooperative funding for this project was supplied by Pinellas County, the Southwest Florida Water Management District, and the United States Environmental Protection Agency. Janicki Environmental would also like to acknowledge the contributions of their sub-consultants on this project for their contributions. Specifically, Kathy Anamisis, Pam Latham, Doug Robison, and David Tomasko of Atkins Global are acknowledged for their contribution to the sections of the report detailing the state of the resources for land use, seagrass, and environmental lands. Additionally, Ann Hodgson and Ann Paul of the Audubon of Florida's, Florida Coastal Islands Sanctuaries program contributed Chapter 5.7 of the State of the Resource Report concerning birds.

Executive Summary

The Pinellas County Department of Environment and Infrastructure (PCDEI), in cooperation with the U.S. Environmental Protection Agency (EPA), the Southwest Florida Water Management District (SWFWMD), in partnership with the cities of Clearwater, Largo, Dunedin, and Tarpon Springs, is developing a ***Comprehensive Conservation and Management Plan for Clearwater Harbor and St. Joseph Sound***. This area includes the northernmost portion of Pinellas County's Gulf Coast shoreline and contains some of the most extensive natural areas and environmental preserves in southwest Florida. However, northwestern Pinellas County is also one of the most densely populated areas in all of Florida. The Comprehensive Conservation and Management Plan (CCMP) is being developed to provide a unique management strategy to protect and restore the valued natural systems that make this area so valuable and attractive to residents and visitors. By assessing existing data, integrating various existing management strategies, and identifying knowledge and information gaps, the CCMP will set forth a foundation and a path forward to integrate natural resource protection efforts and focus future work on those areas where the greatest yields can be gained. To that end, this document, the ***State of the Resource Report for Clearwater Harbor and St. Joseph Sound,*** establishes the scientific foundation and rationale from which to proceed in developing the CCMP for Clearwater Harbor and St. Joseph Sound, collectively referred to as the CHSJS. There are three watersheds within the CHSJS (Figure 1):

- St. Joseph Sound (SJS)
- Clearwater Harbor North (CHN)
- Clearwater Harbor South (CHS)

The northern boundary of the CHSJS is the Pinellas–Pasco County Line though for pollutant loading calculations, the Anclote watershed was included within the geographic boundary (Figure 1). Other limits of the estuary are primarily defined by bridges including the Dunedin Causeway separating Clearwater Harbor North from St. Joseph Sound, and the Memorial Causeway separating Clearwater Harbor South from Clearwater Harbor North. The southern extent of Clearwater Harbor South is defined by the Walsingham Causeway Bridge.

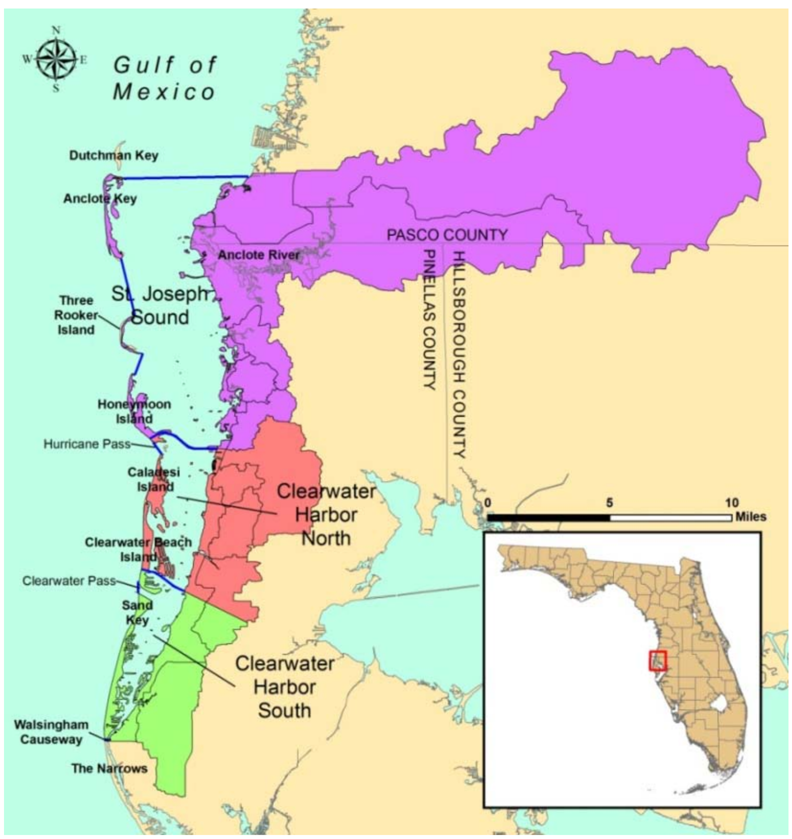

Figure 1. CHSJS location map.

The St. Joseph Sound watershed includes the Anclote River basin which extends north and east into Pasco County. The Pasco County portion of this watershed was only evaluated with respect to pollutant loading because of its influence on St. Joseph Sound. Data analysis and management recommendations for the Anclote River are restricted to those areas within Pinellas County. The remainder of the St. Joseph Sound watershed lies within the City of Tarpon Springs, the City of Dunedin, and unincorporated Pinellas County. The Clearwater Harbor North and Clearwater Harbor South watersheds encompass all or parts of the municipalities of Dunedin, Clearwater, Largo, Belleair, Belleair Bluffs, Belleair Beach, Belleair Shores, and Indian Rocks Beach as well as unincorporated Pinellas County.

A stakeholder group composed of representatives from state, regional, county, municipal, and public citizen groups has been formed as part of the development of the CCMP. Through regular meetings and workshops, the stakeholders have identified key resources of concern and management issues that have become the focus of the CCMP. These key resources and issues include:

- Watershed Hydrology and Estuarine Circulation
- Water Quality
- Seagrasses
- Fish, Birds, Turtles, and Marine Mammals
- Freshwater and Saltwater Wetlands and Native Uplands
- Managed Lands

For each of the key resources, data are identified, described and analyzed; and management goals and targets are identified. Goals and targets for the key resources provide an essential framework for the CCMP.

The State of the Resource Report is organized as follows:

- Chapter 1 summarizes the extent and history of the CHSJS.
- Chapter 2 characterizes the physical features of the CHSJS estuary.
- Chapter 3 characterizes the physical features of the CHSJS watershed.
- Chapter 4 describes analysis of natural resources in the CHSJS watershed.
- Chapter 5 describes analysis of natural resources in the CHSJS estuary.

Estuaries are among the most highly productive biological systems on earth. The CHSJS estuary is a major focus of the CCMP because of its natural resources and economic value to the region. Estuarine health and productivity is driven by the combination of nutrient delivery, sediment delivery, circulation, emergent vegetation, submerged aquatic vegetation, and the balance of benthic and pelagic food webs. Circulation prevents water stagnation and increases mixing, although it can also increase turbidity and therefore decrease water clarity. Long residence times of water in an estuary allow organic detritus to contribute nutrients to the food chain, but can also lead to reduced dissolved oxygen concentrations. Therefore, estuarine water quality and overall productivity relies on a delicate balance of inputs, nutrient uptake and cycling, and mediating influences such as residence times. In the sub-tropical estuaries of the CHSJS, water quality conditions are partially related to the expression of phytoplankton which contribute to overall productivity, but can also contribute to deleterious conditions and harmful algal blooms if allowed to proliferate. Phytoplankton concentrations (as measured by chlorophyll *a* concentrations) are thought to be limited by nutrient concentrations or nutrient loads to the estuary from the watershed.

High phytoplankton concentrations can also reduce light availability and thus affect the health and success of seagrass in the study area. Currents, wind speed, and sediment type also play a role in the health and success of seagrass in the study area. The health of seagrass contributes to the area being highly prized for recreational fishing. Water quality also impacts the temporal and spatial extent of water column habitat availability for those organisms whose survival and reproductive strategies are dependent on specific water quality conditions (e.g., specific salinity ranges, dissolved oxygen requirements, and water clarity).

To provide context to the current state of the resources in the CHSJS, a brief history of the area is provided. In the early 20th century, the City of Clearwater became incorporated and was known principally as an agricultural port city. Tarpon Springs was also among the first urban centers in the area and was one of the largest sponge ports in the United States. The town of Dunedin was another early seaport and trading center, and at one time was home port to the largest commercial fleet of ships in the state. By 1920, the U.S. Army Corps of Engineers (Corps) had already finished major construction on Florida's Atlantic portion of the Intracoastal Waterway (ICW) and was developing plans for the Cross Florida Barge Canal. In 1910, Congress appropriated $29,000 to dredge and maintain a 7-by-100-foot channel from Tampa Bay into Boca Ciega Bay and a 5-by-50-foot channel on to Clearwater Harbor as part of the Gulf of Mexico ICW. The Corps completed this work in 1920, however enlargement of the channel that extended from Clearwater Harbor North through St. Joseph Sound to the Anclote River was not completed until 1962.

Exponetially increasing immigration and settlement in Pinellas County followed improvements to infrastructure; especially land-based transportation. A 135 % increase in the population in Pinellas County between 1950 and 1960 was the largest increase ever recorded in the County and was followed by commensurate increases in residential development in each of the next three decades (Figure 2). Environmental impacts due to land development activities led to the establishment of regulatory agencies in the early 1970s. During this same period, portions of northeastern Pinellas County and northwestern Hillsborough County were leased for wellfield development in response to saltwater intrusion into local water supplies. In 1975, the Local Government Comprehensive Planning Act was enacted by the Florida Legislature and in the late 1970s, Pinellas County began identifying environmentally-significant lands with the intent of "…adopting the necessary and appropriate regulatory land use designations to preserve their environmental significance."

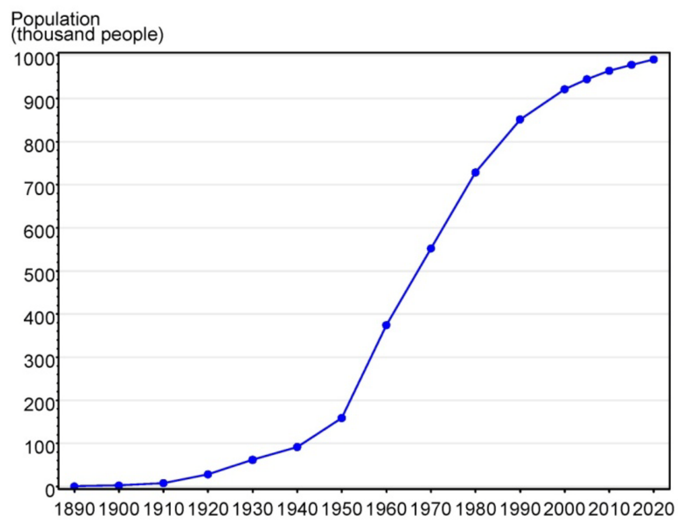

Figure 2. Pinellas County permanent population - historical, current and projected future. (Pinellas County Planning Department, 2010

To provide baseline information on the extent of natural resources in the study area such as wetlands, native uplands and seagrasses, historical aerial photographs circa 1940 were obtained from the National Archives and Records Administration in Washington D.C. These photographs are the earliest record available with complete coverage throughout the CHSJS. The photographs were digitized and geo-rectified so that the areal extent of local natural resources could be estimated. Comparisons were then made to more recent aerial surveys of land use and seagrasses conducted by SWFWMD.

Below is a summary of the natural resource value assessments conducted as part of the State of the Resource Report.

Land Use

Historically, the CHSJS watershed was dominated by pine flatwoods, dry prairie, forested and unforested freshwater wetlands, and near the coast, salt marsh and mangrove habitats. Based on an analysis of historical aerial photography it was determined that in 1942 about 65% of the watershed remained in one of these types of "native lands". Thirty four percent of the watershed in 1942 was classified as developed lands, dominated by agriculture. Other non-native land uses included residential, commercial and municipal development within the watershed. In many areas agricultural development had supplanted native uplands and wetlands, consequently altering the natural surface water and groundwater systems of the watershed. Since the 1940s, urban and residential development increased dramatically replacing historical agricultural areas and destroying more native uplands and wetlands. Today less than 20%, 10%, and 5% of historical native lands remain in St. Joseph Sound, Clearwater Harbor North, and Clearwater Harbor South, respectively. Natural areas in the CHSJS are now limited primarily to the northeast portion of the St. Joseph Sound watershed and within public lands including the barrier island state parks. Increased urban and residential development has increased impervious land surface and other features that are associated with adverse stream impacts including reduced stream stability, habitat degradation, water quality degradation, and a loss of biological diversity. The dramatic losses to uplands and wetlands in the three watersheds of the CHSJS have also consequently reduced available habits for threatened and endangered species including the gopher tortoise, colonial waterbirds, Bald Eagle, and Red Cockaded Woodpecker.

Given the extensive loss of both native uplands and wetlands to urban and residential land uses, it was considered unreasonable to expect that the CCMP should set a goal of restoring land to the historical acreage circa 1942. Therefore, current acreages for uplands, forested wetlands, non-forested wetlands, mangroves, and salt marshes were documented and should be considered minimum acceptable acreages for each habitat type within the watershed. In the CCMP document, several strategies will be outlined and prioritized to increase the extent of these habitat types to the largest practical extent with a focus on restoring the balance of habitat types based on the historical balance of habitats estimated from the 1940s photographs. The current acreages for each habitat type in the mainland portion of the CHSJS are as follows:

	St. Joseph Sound	Clearwater Harbor North	Clearwater Harbor South	Total Acres
Uplands (acres)	1,500	517	241	2,258
Forested Wetlands (acres)	1,567	252	23	1,842
Non-Forested Wetlands (acres)	536	137	86	759
Mangroves (acres)	209	3	24	236
Saltwater Marshes (acres)	448	3	2	454

Coastal island wetland habitats (i.e., those not associated with the mainland) were historically and remain dominated by mangrove forests. While some salt marsh habitat remains, the current habitat ratios are similar to their historical proportions. The current acreages for mangrove, and saltwater marshes along coastal island habitats are:

	St. Joseph Sound	Clearwater Harbor North	Clearwater Harbor South	Total Acres
Mangroves (acres)	153	390	24	567
Saltwater Marshes (acres)	77	13	0	90

Seagrasses

Seagrass communities are keystone indicators of estuarine health in sub-tropical systems such as Clearwater Harbor and St. Joseph Sound. Seagrass health and success depends on good water quality and water clarity making seagrasses useful indicators of ecosystem health. Seagrasses support a complex trophic food web and a detritus-based food chain, as well as provide sediment and nutrient filtration, sediment stabilization, and breeding and nursery areas for finfish and shellfish. A vast array of estuarine and marine organisms relies upon seagrass habitats for a portion or all of their life cycles. The canopy structure of the seagrass bed provides protection and cover for fish in their fry and juvenile stages, essentially serving as a nursery ground. Primary production within seagrass beds also provides food for recreationally and commercially important fish species and serves as a trophic foundation for the ecosystem. Seagrass meadows are also a direct food source for the West Indian manatee (*Trichechus manatus*), green sea turtle (*Chelonia mydas*), and ecologically important invertebrates such as the variegated sea urchin, *Lytechinus variegates*. Therefore, seagrass meadows support a complex trophic food web and a detritus based food chain.

Sediment deposition can have either positive or negative consequences for seagrasses depending on the volume, timing and quality of the sediments. Since seagrasses live in the shallow, protected coastal waters that are directly proximal to the shore and watershed, seagrasses are highly susceptible to nutrient and sediment inputs. Nutrient assimilation and recycling is another of the many ecosystem services that seagrass communities provide. Seagrasses filter nutrients and contaminants, which helps improve water quality and support adjacent habitats and fisheries. They allow for organic-matter accumulation and nutrient regeneration and recycling, which support primary production and sustain food webs. They can also serve as sinks for nitrogenous loads from watershed sources. Anthropogenic nitrogen loads can lead to excessive algae growth, which adversely affects light penetration to submerged seagrasses.

Historical aerial photography was used to develop a historical seagrass coverage for the open bay segments of the CHSJS using the same National Archive aerial photographs of 1942 that were used for the land use change analysis. Seagrass extent in the western portion of St. Joseph Sound, for which no 1942 National Archive photographs were available, was digitized from aerial photographs taken in 1957. These data were then used to estimate the historical areal extent of seagrasses within the open bay segments of the CCMP. These estimates were then compared to recent surveys conducted by the SWFWMD after adjusting for non-restorable areas, such as dredging of the Intracoastal Waterway and other dredge and fill projects.

Current seagrass areal extents are 83%, 79% and 73% of historic estimates for St. Joseph Sound, Clearwater Harbor North and Clearwater Harbor South, respectively (Figure 3). Clearly Clearwater Harbor South has lost the largest proportion of seagrasses relative to historic estimates. However, St Joseph Sound lost more acreage than the other segments. It should be noted that the seagrass numbers presented here are different from those reported by the Southwest Florida Water Management District in that these do not include areas west of the barrier islands or seagrass acreage within the Anclote River

Despite these historical losses, seagrass acreage has been trending upward since 1999 throughout Clearwater Harbor and there have been substantial recent gains in St. Joseph Sound. The most recent seagrass mapping efforts, completed in 2010, indicate that in St. Joseph Sound, seagrass cover in 2010 was 15% higher than in 1999, an increase of 1,680 acres (Figure 4; Table 1).

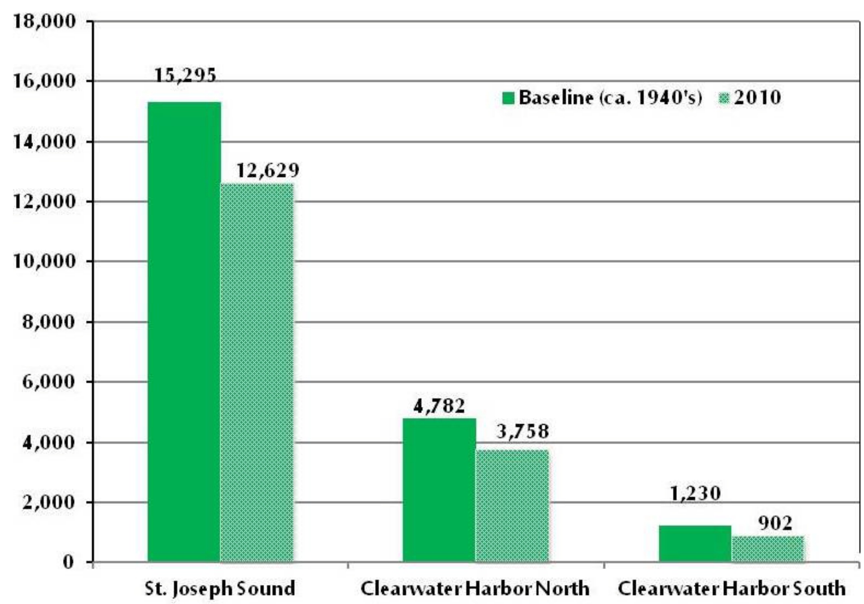

Figure 3. Comparison of historical and 2010 seagrass acreages for each CHSJS estuarine segment.

In Clearwater Harbor North, seagrass acreage increased 56%, from 2,416 acres in 1999 to 3,758 acres in 2010. Seagrass cover in Clearwater Harbor South increased 66%, from 545 acres to 902 acres between 1999 and 2010. These substantial increases in seagrass acreage are concurrent with improved water quality between 1999 and 2010 relative to conditions in the early 1990s.

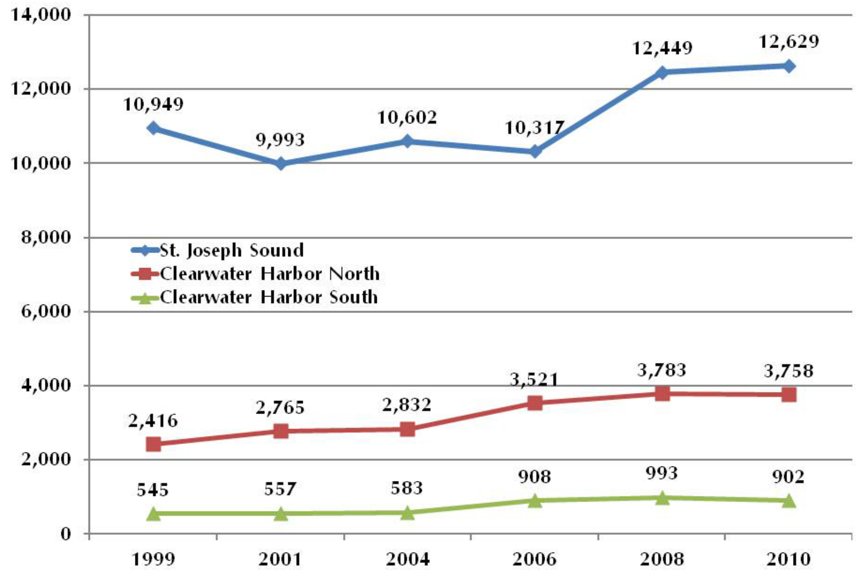

Figure 4. Change in seagrass areal extent between 1999 and 2010 for each CHSJS estuarine segment.

Table 1. Seagrass acreage within each segment for all years.

Segment	Adjusted 1942 Baseline	1999	2001	2004	2006	2008	2010
St. Joseph Sound	15,295	10,949	9,993	10,602	10,317	12,449	12,629
Clearwater Harbor North	4,782	2,416	2,765	2,832	3,521	3,783	3,758
Clearwater Harbor South	1,230	545	557	583	908	993	902

Note: *The numbers reported above do not include seagrass acreage west of the barrier islands or in the Anclote River and are therefore different from the seagrass acreages reported by the Southwest Florida Water Management District.*

In Clearwater Harbor North and South, historical seagrass estimates were used to develop seagrass areal extent targets. Given the recent trajectory in seagrass acreage in these segments, the historical acres were thought to be reasonable estimates of the potential gains. Large areas of seagrass loss in St. Joseph Sound appear to be due to physical disturbances such as barrier island migration, the dredging of the ICW and its associated impacts on current velocities, and depth and wave energy, as well as the potential effects of episodic biological perturbations and grazing events as described in Chapter 5. Given these considerations, it was deemed unrealistic to develop a target for St. Joseph sound that is based on historical conditions. Consequently, the seagrass areal target acreage for St. Joseph Sound is an average of the two most recent surveys. Therefore, the segment-specific seagrass targets for the CHSJS estuary are:

The segment specific seagrass acreage targets are:

Segment	Acreage Target
St, Joseph Sound	12,539 acres
Clearwater Harbor North	4,782 acres
Clearwater Harbor South	1,230 acres

Note: *The numbers reported above do not include seagrass acreage west of the barrier islands or in the Anclote River and are therefore different from the seagrass acreages reported by the Southwest Florida Water Management District.*

Water Quality

Hydrologic processes have a significant effect on the ecology of the estuary. Transport of nutrients and sediments to coastal waters of the CHSJS estuary is largely determined by the amount of rainfall over monthly, seasonal, and annual time periods. Rainfall directly impacts surface water flows, is a significant source of directly deposited nitrogen and phosphorus from the atmosphere, and can increase the amount of suspended solids in adjacent waterbodies through sediment erosion and transport to surface waters.

The timing, volume, and distribution of freshwater inflows to Clearwater Harbor and St. Joseph Sound are affected by land use and hydrologic alterations that have occurred in the watershed, as well as by precipitation patterns. Extensive alteration to the watershed's hydrologic features has changed how freshwater is delivered to the receiving water. Channelization of coastal streams and destruction of coastal wetlands has increased peak flow rates and velocities, and reduced opportunities for pollutant removal and groundwater recharge. Higher peak flows and reduced attenuation has also increased the potential for channel and coastal erosion. The CHSJS watershed receives approximately 127 cm (i.e. 50 inches) of rainfall annually with nearly half of the total occurring over four months between June and September (Figure 5).

The largest source of freshwater inflow into the CHSJS estuary is the Anclote River. Both natural and anthropogenic factors influence discharges in the Anclote River. Well fields for potable water supply have operated in the Anclote River watershed for decades, and significant pumping of groundwater for public supply has resulted in river flows that

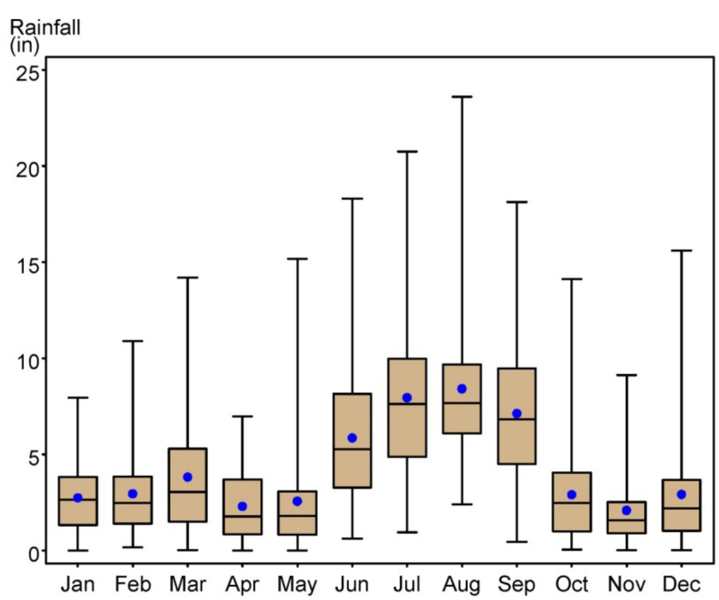

Figure 5. Distribution of monthly rainfall at City of Tarpon Springs rain gage over a 75 year period of record.

are estimated to have been reduced by 29%. Local resource managers recognized that existing levels of pumping were not sustainable, and developed the Northern Tampa Bay New Water Supply and Ground Water Withdrawal Reduction Agreement, which was implemented in 1998. Through the recovery plan regional groundwater withdrawals would be reduced from 158 million gallons per day (mgd) in 1998 to 90 mgd in 2009. Minimum flow criteria were developed for the river by the SWFWMD in 2007. Reductions in wellfield pumping resulted in a measureable increase in river flows. A 2009 re-evaluation of impacts on the Anclote River due to groundwater withdrawals suggested that if the 2008 pumping rates and well rotation schedule were continued, flow in the Anclote River would recover to the SWFWMD minimum flow thresholds.

The remaining freshwater sources are smaller creeks and small magnitude coastal springs including Klosterman Creek, Curlew Creek, Cedar Creek, Spring Branch, Stevenson Creek, Smith Creek, McKay Creek and Wall Spring. While these tributaries deliver a much lower volume of freshwater than the Anclote River, they remain ecologically import and contribute significant amounts of freshwater, nutrients and sediments to the estuary. Direct runoff from coastal lands, direct precipitation to the estuary as well as direct discharge from stormwater outfalls also contribute freshwater and nutrients to the estuarine waters.

Hydrologic loadings often result in high nutrient loading to the estuary which drives primary production and may result in subsequent eutrophication. Increases in sediment loads are another consequence of heavy rainfall and may be associated with increased concentrations of heavy metals and organic contaminants that bind to sediment particles. Suspended solids can also impact light attenuation in the water column and can negatively impact submerged aquatic vegetation as well as benthic invertebrates and fish species. Total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS) and biochemical oxygen demand (BOD) are four of many "pollutants" measured to evaluate water quality. These pollutants are measured in streams and estuarine waters throughout the CHSJS as concentration by the PCDEI. Pollutant concentrations are expressed as milligrams per liter of water (mg/L). Phytoplankton concentrations are an often used indicator of the system response to nutrient pollution. In freshwater, TP is commonly the nutrient that governs phytoplankton concentration while TN generally limits phytoplankton concentrations in the estuarine waters. The CHSJS soils are generally rich in phosphorus and TN is recognized as the limiting nutrient. Phytoplankton concentrations are typically estimated by measuring the concentration of chlorophyll *a* (the photosynthetic pigment in phytoplankton). Chlorophyll *a* concentrations are reported in micrograms per liter (μg/L). Chlorophyll *a* concentrations in the CHSJS estuary have been improving (i.e. decreased concentration) since 1992. Also, nutrient concentration trends (both TN and TP) at many stations within the tributaries to the estuaries have been improving (i.e. decreasing concentration) over that time.

A pollutant loading model was developed for the State of the Resource Report to estimate the mass (load) of four principal "pollutants" delivered via freshwater inflow to the CHSJS estuary. Pollutant loading estimates use the volume of water delivered to the estuary with either measured or estimated concentration of these pollutants in the watershed to derive a mass delivered via freshwater discharge. Pollutant loading estimates are an integral part of the Florida Department of Environmental Protection's (FDEP) Total Maximum Daily Loads (TMDL) program that attempts to define the assimilative capacity of waterbodies it deems impaired due to excessive nutrient pollution. While TMDL's have been expressed as both concentrations and loads, the calculation of loading estimates has played an integral role in assigning regulatory nutrient pollution thresholds in nearby Tampa Bay. Estuarine biological processes respond in system specific manner to both the concentration of nutrients in the water and to the mass of nutrients delivered. The differences in response to loads or concentrations include factors such as dilution, water residence times, and the complex interactions between the mass delivered and nutrient assimilation and recycling from biological processes.

Pollutant loading model estimates were generated for a 23 year period from 1985 through 2008 for each sub-basin of the CCMP study area. Since loads are a function of rainfall, higher rainfall years will generally have higher loads. Therefore loads can be more variable than concentrations across years because of the effects of rainfall. For example, the St Joseph Sound segment had much higher than typically loadings for the years of 1998 and 2003 when rainfall amounts and subsequent river flows from the Anclote River were much higher than typical. This variability was not observed to the same extent in Clearwater Harbor North or Clearwater Harbor South due to the lesser contribution of freshwater flows to these segments. Total loads are a combination of both point sources (e.g., wastewater treatment plants and industrial facilities) and non-point sources (e.g., stormwater runoff and agriculture or pasture lands). In the CHSJS, non-point source loads contributed the majority of the total loads delivered to the estuary when excluding direct deposition due to rainfall.

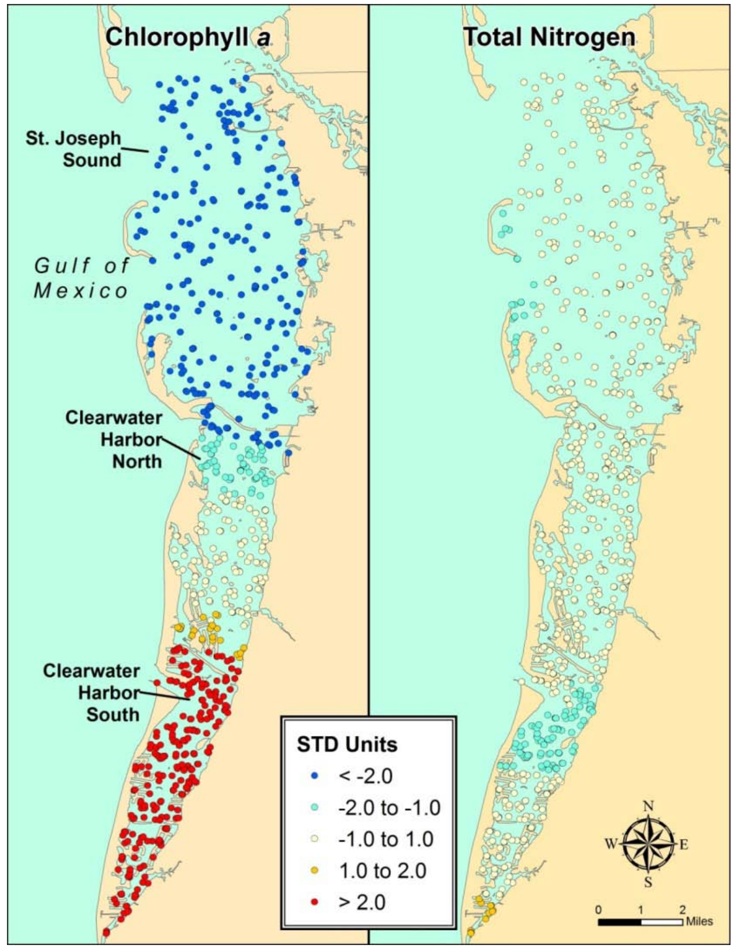

Figure 6. Spatial distribution of chlorophyll *a (left)* and TN *(right)*. *Red* dots indicate significant clustering of higher than average values and blue dots indicate statistically lower than average values.

The calculation of loadings per acre (i.e. load/acre/year) was used to compare "unit area loads" or "yields" to identify sub-basins which contributed, on average, the highest yield of pollutants. Stevenson Creek in Clearwater Harbor North had among the highest unit area loads for hydrologic load, TN load, TP load and BOD load. However, both Spring Branch and Smith Bayou sub-basins had higher yields of TSS than Stevenson Creek. Despite this finding, while the marine segment of the Stevenson Creek watershed is identified by FDEP as impaired for nutrients, the CHN estuary does not show signs of impairment. In fact, all of the open bay segments of the CHSJS are meeting their designated full aquatic life uses according to FDEP. In summary, while there are issues related to pollutant loadings and concentrations in many of the CHSJS tributaries, pollutant loadings to the CHSJS estuary are not currently sufficient to cause impairment in the open estuary as evidenced by improving chlorophyll *a* concentrations and recent increases in seagrass areal extent in all estuarine segments.

Descriptive and quantitative statistical analyses suggested that neither nutrient concentrations nor nutrient loadings alone were confident predictors of the chlorophyll *a* concentrations used as an indicator of estuarine health. While within segment analysis did not reveal a direct link between nutrients and phytoplankton concentrations, descriptive plots suggested a north/south gradient in chlorophyll *a* concentrations that appeared to be principally a function of residence times. The direct influence of tidal exchange with the Gulf of Mexico is most pronounced in St. Joseph Sound and least pronounced in Clearwater Harbor South. The increased residence time of water in the Clearwater Harbor South segment seemingly allows for a higher concentration of phytoplankton for a given level of nutrient concentration as shown in Figure 6. In this plot the chlorophyll *a* concentration and total nitrogen values are standardized to that they are on the same scale (i.e., units of standard deviation from their long term average). Therefore, blue filled circles represent lower than average concentrations and red filled circles indicate higher than average concentrations.

For the purposes of the CCMP, the estuary water quality goal was established to ensure that water quality conditions in the estuary are protective of two critical indicators of estuarine health – seagrasses and dissolved oxygen. Given the results of analysis described above, and the fact that seagrasses are currently stable or improving throughout the CHSJS estuary it was concluded that recent water quality conditions are sufficient to maintain full aquatic life uses in the estuary. Therefore, a reference period approach was used to establish management targets and thresholds used to monitor water quality in the estuarine open bay waters of the CCMP. The reference period was defined as the 2003-2009 time period.

Target chlorophyll *a* and water clarity (% transmissivity) values for each CHSJS estuarine segment were defined by the overall average of the annual geometric means for each constituent during the reference period. A threshold value for these constituents was defined as a value would indicate that water quality was significantly higher than that observed over the reference period. The threshold value was calculated based on statistical theory that if water quality in any year was not different from reference period conditions, its geometric mean value would be lower than the reference period mean +1.95 standard deviation with at least 95% confidence. Therefore, the threshold values can be used to test the sample geometric means for the three parameters for compliance with the established targets and thresholds. Any sample geometric mean higher than these values would then be considered an excursion for that water quality constituent.

The proposed chlorophyll *a* targets and thresholds are:

	Target	Threshold
• St. Joseph Sound	1.9 µg/L	3.1 µg/L
• Clearwater Harbor North	3.5 µg/L	5.4 µg/L
• Clearwater Harbor South	4.8 µg/L	7.6 µg/L

The proposed percent light transmittance targets and thresholds are:

	Target	Threshold
• St. Joseph Sound	90%	83%
• Clearwater Harbor North	82%	75%
• Clearwater Harbor South	74%	62%

Threshold values for TN concentrations and TP concentrations were calculated in a similar manner and are presented below. These targets and thresholds were developed as management criteria and are proposed to be used to evaluate water quality with respect to not allowing for degradation of water quality from that observed over recent time period (i.e. 2003-2009) when the open bay estuarine segments were fully meeting their designated uses. Within this context, an excursion is defined as an annual geometric average for a particular constituent that exceeded the threshold value. The annual geometric mean should be derived strictly from water quality sampling conducted according to Pinellas County's probabilistic water quality sampling design in designated strata "W1", "W2" , and "W3" corresponding to St. Joseph Sound, Clearwater Harbor North and Clearwater Harbor South, respectively. These thresholds are not to be considered as end of pipe criteria for point source discharges within the CCMP for regulatory purposes. Further, a single excursion of the threshold value does not necessarily mean that there has been significant degradation of water quality. The use of minimum detection limits other than those used by Pinellas County will also affect compliance with these criteria. The analyses of Chapter 5.2 of the State of the Resource Report suggests that there have been times when estuarine water quality values for chlorophyll *a*, TN, TP, and transmittance have historically exceeded the proposed threshold values and yet the estuarine waters were meeting full aquatic life uses according to FDEP. However, in keeping with the spirit of EPA's anti-degradation policy given the special nature of these estuarine waters, the threshold values were chosen as the appropriate management level criteria for these segments.

With respect to pending numeric nutrient criteria proposed by the EPA, The CCMP nutrient thresholds may be considered as site specific criteria for these waterbodies under the constraints and assumptions described above. While EPA has stated that the numeric nutrient criteria must be expressed as concentrations others, including DEP, have argued that the estuarine numeric criteria can and should be expressed as loadings. Therefore, both concentration - and loading-based TN and TP criteria are proposed. Pollutant loading-based thresholds have also been derived using the same methods described above for concentrations, using the geometric averages from the reference period and the standard deviation associated with the estimate of the population of geometric mean values.

The proposed TN and TP concentration-based numeric criteria are:

	TN Criterion	TP Criterion
• St. Joseph Sound	0.66 mg/L	0.05 mg/L
• Clearwater Harbor North	0.61 mg/L	0.05 mg/L
• Clearwater Harbor South	0.58 mg/L	0.06 mg/L

The proposed TN and TP loading-based criteria are:

	TN Criterion	TP Criterion
• St. Joseph Sound	493 tons/yr	85 tons/yr
• Clearwater Harbor North	124 tons/yr	17 tons/yr
• Clearwater Harbor South	58 tons/yr	7 tons/yr

In addition to the quantitative targets and thresholds described above, there were several natural resource components identified where qualitative goals were developed due to a lack of information necessary to develop numerical targets. These resource components include: sediment quality, benthos, fishes, dolphin, turtles, manatee and birds. For these resource components, descriptive analyses were conducted to describe available information and qualitative goals were developed to guide management activities associated with the natural resources of concern. Many of these value natural resources rely heavily on wetland habitats, sea gasses and water quality for which quantitative targets have been developed as described above.

Benthos

There was a paucity of information on sediment quality in the study area so a baseline characterization of sediment quality was performed as part of this study. While collecting information on sediment quality, macroinvertebrate collections were also performed to provide a baseline characterization of benthic macroinvertebrates in the CHSJS estuary. The location of the samples characterized by their sediment grain size categories are provided in Figure 7. The benthic macroinvertebrate samples contained between 10 and nearly 100 taxa with abundances from 10 to 1,100 individuals per sample. Relative abundances in St. Joseph Sound were frequently higher than those observed in both Clearwater Harbor North and South and the lowest abundances tended to occur in Clearwater Harbor South.

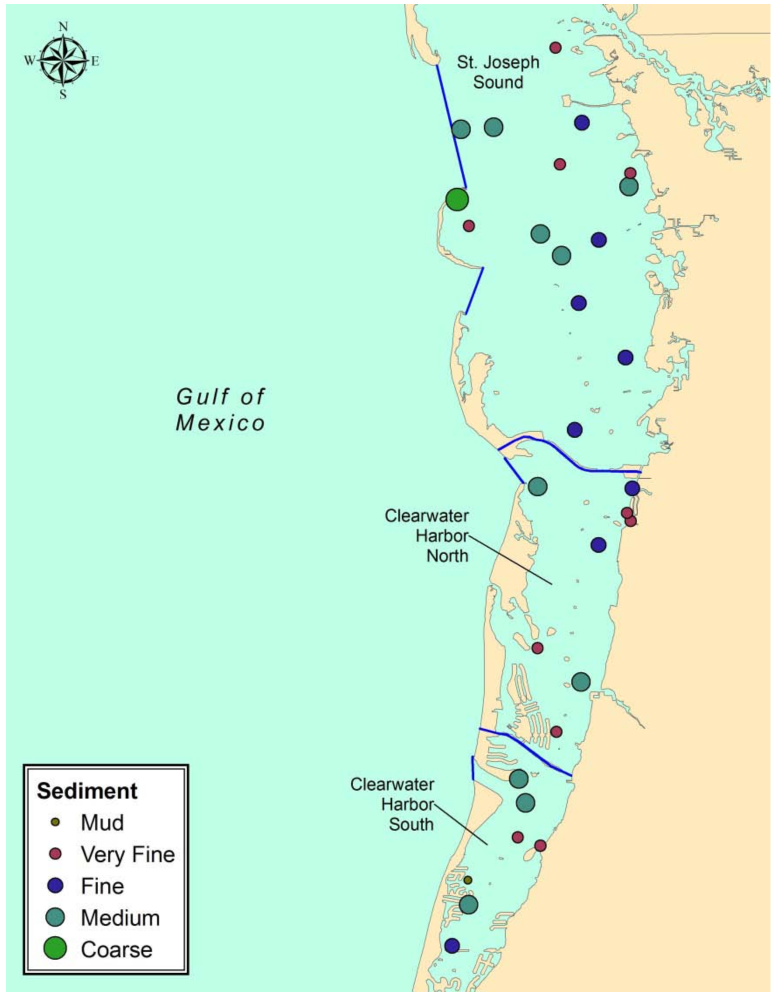

Figure 7. Distribution of sediment grain size from benthic samples collected in September 2009.

The limited availability of data for the CHSJS estuary precludes establishing quantitative goals or targets for either benthic community integrity or sediment quality. Therefore, the proposed goals for benthic community integrity or sediment quality were to minimize the extent of contaminated and/or hypoxic benthic sediments; to develop a benthic sampling program designed to provide a baseline characterization of sediment quality and the benthic invertebrate community, and to establish sediment quality targets, similar to those developed for the Tampa Bay estuary, that maintain the sediment quality necessary for a diverse benthic community.

Fishes

The CHSJS estuary supports a diverse assemblage of fishes and invertebrates occupying a mosaic of seagrass, mangrove and hard bottom habitats. The close proximity of the Gulf of Mexico to the west and a significant freshwater source, the Anclote River, to the east contribute to a dynamic and productive estuarine system. Several large barrier islands, Anclote Key, Three Rooker, Honeymoon and Caladesi Islands, and Sand Key provide a buffer from the Gulf and create calm, shallow waters behind them. Strong tidal currents flow through the passes between these islands scouring the bottom and creating deeper areas through which large fishes, sea turtles and marine mammals move between the Gulf and the estuary. The passes also transport into the estuary, planktonic fish and invertebrate larvae that are spawned offshore and along the beaches. Since the early 1970s, numerous studies have characterized the fish and invertebrate community of the study area including several masters' theses on Anclote River estuarine fish assemblages and more recent surveys by the Florida Wildlife Research Institute (FWRI). Based on these studies as well as other information, stressors to fish populations with the CHSJS estuary were identified as: impacts to nursery areas (e.g., prop scarring of seagrasses, mangrove losses); fishing pressure; water quality degradation, red tide events, and cold stress.

The FWRI collects information on fishing pressure using creel surveys. There were 3 different types of anglers recorded in this data; charter anglers, private boat anglers, and shore anglers. Clearwater Municipal Marina experienced the highest amount of charter boat pressure while private vessel anglers exhibited greater pressure at sites within St. Joseph Sound, and Clearwater Harbor. Areas that experienced a higher than average number of shore anglers were near, or on, passes or channels and also at the Clearwater Pier/Big Pier 60.

FWRI's Molluscan Fisheries Program has monitored the status of the Bay Scallop population in St. Joseph Sound since 1994 and has tracked recruitment by scallop spat since 1997. From 1994-2006, adult scallop abundances ranged from 0.2 to 47.4 scallops per $600m^2$, but from 2007-2009 abundances more than tripled to 138-174 scallops per $600m^2$ (Stephenson and Geiger, 2010). Scallop population restoration efforts involving the rearing and release of scallop spat collected between 1999 and 2006 may have contributed to the increased scallop abundance observed in more recent years.

The limited availability of fisheries data for the CHSJS estuary precludes establishing quantitative targets. However, the proposed goals for the preservation and protection of fish stocks include: maintaining the current extent of seagrasses and shoreline habitat (i.e., fisheries habitat) in the estuary; leveraging existing fish research efforts to provide a more quantitative estimate of the relative abundance of fishes over various habitat types within the study area; encourage participation in existing creel surveys to obtain accurate information on angler pressure; facilitating research into the utilization of the estuarine segments by the bay scallop, and public education to reduce anthropogenic stressors on fish habitat such as prop scarring.

Megafauna

Bottlenose dolphins, Florida manatees, and five species of sea turtles utilize the CHSJS area; all of which are federally protected under the Endangered Species Act. These species are often referred to as "charismatic megafauna" due to their large size and common appeal among humans which tends to invoke a connection with nature and the marine environment. As a result of this connection, these species have been successfully used to promote public awareness and conservation of coastal resources. While there are limited data available for analysis, a characterization of the ecology of these species, natural and anthropogenic stressors and management issues is an important part of the CCMP. Much of the existing information on marine mammals and sea turtles in the CHSJS system comes from research programs at the Florida Fish and Wildlife Conservation Commission (FWC), Mote Marine Laboratory, and the National Marine Fisheries Service (NMFS), though collaborative efforts between these and various other agencies have provided information as well. Florida has state-wide programs exist to monitor and assess the status of marine mammal and sea turtle populations and to conduct research on the biology and ecology of these species. This information is useful for the management of these natural resources and can be applied to populations that use the estuarine and coastal habitats of Clearwater Harbor and St. Joseph Sound.

The Florida manatee, *Trichechus manatus latirostris*, is another common marine mammal species found in the shallow, coastal waters of Clearwater Harbor and St. Joseph Sound. Manatee are especially abundant near warm waters at power plants and springs during the winter.

Sea turtles utilize the western shorelines of the barrier islands as nesting sites and deposit eggs above the high tide line, westward of the primary dunes. Sea turtles have high site fidelity, returning to the same beaches year after year to nest and the barrier islands associated with the project area have management plans aimed at protecting the nesting sea turtles and their eggs from harm. Three species, the green (*Chelonia mydas*), loggerhead (*Caretta caretta*) and leatherback sea turtle (*Dermochelys coriacea*) use the beaches to nest; however, loggerhead sea turtles are the most common species utilizing the barrier islands of the CHSJS.

Management goals for these species should focus on the protection of the habitat, including water quality, seagrass, and shorelines and sustainable fish populations for bottlenose dolphins. Public education regarding the human interactions with these animals among the boating and fishing community will continue to be an important part of the management strategy for these species and should be emphasized in the future. Facilitating future research into causes of sea turtles and manatee strandings, protecting crucial habitats within the estuaries, and continued monitoring are recommended.

Birds

A unique assemblage of colonial waterbirds (pelicans, wading birds, gulls, terns, and skimmers) and shorebirds use the Clearwater Harbor and St. Joseph Sound (CHSJS) region of peninsular Florida. Located on the Atlantic Flyway, these waterways, beaches, and shorelines are extremely important stopover and over-wintering sites for birds that nest further north, some as far as the Arctic tundra, but retreat south in the winter to find their fish, shellfish, insect, and invertebrate prey. At least twenty-five bird species, including several taxonomic groups of colonial waterbirds and territorial birds (oystercatchers, plovers, and willets), breed in CHSJS coastal habitats (Table 5-21). Eleven of these species are federally or state-listed as "endangered", "threatened", or as "species of special concern" and many birds that occur in the region are listed on non-regulatory management lists. In 2009, 5,331 pairs (all species combined) nested on islands in the system. This count did not include colonies of Least Terns and Black Skimmers that nested on scattered beaches and rooftops in this region of Pinellas County. Because of the species richness and abundance of the region's avifauna, BirdLife International and the National Audubon Society Audubon of Florida have recognized the CHSJS area as highly valuable for its avifauna by inclusion of two of its regions, "Clearwater Harbor-St. Joseph Sound" and the "Gulf Islands GEOPark", in the Important Bird Areas (IBAs) of Florida.

Additionally, thousands of ducks, hundreds of Common Loons and grebes, and thousands of shorebirds also use CHSJS waters and shores as overwintering habitats. A small group of songbird species nest uniquely in the CHSJS mangroves, coastal hammocks, and shorelines, while many others over-winter here or stop during their fall and spring migrations. Several raptor species (Bald Eagles, Osprey, owls), commonly called "birds of prey", nest regionally, while others follow migrating flocks of shorebirds and ducks seasonally.

Bird habitats in CHSJS include forested areas (patches of mangroves, coastal hammocks, or pine flatwoods remaining on barrier islands, some natural mangrove islands, and mangroves and coastal hammock communities on some islands created when the Intracoastal Waterway (ICW) was dredged); beaches on barrier islands and dredged spoil material islands; and coastal marshes. The dominant types of nesting habitats within the CHSJS study area include arboreal (tree), beach, and coastal marshes. Many species of colonial waterbirds use arboreal habitats for nesting including: Brown Pelican, Double-crested Cormorant, the herons and egrets, White Ibis, and Roseate Spoonbill. Colonies of birds nesting in trees generally occur only on small islands that have no resident mammalian predators and are off-shore, separated by open water and deep channels with tidal currents that discourage mammals from swimming to them. Colonial waterbirds will not nest on islands if mammalian predators are present. Three of the larger barrier islands (Honeymoon Island, Caladesi Island, and the northern section of Clearwater Beach) still have relatively undisturbed mangrove forests, coastal hammock communities, salt marshes, beaches, and pine flatwoods. Conversely, most of Clearwater Beach and Sand Key are highly developed and the beach-front communities of condominiums, hotels, and residences on Clearwater Beach, Belleair Shores, Belleair Beach, and Indian Rocks Beach have displaced most native vegetation and shallow water shorelines.

Management and conservation activities conducted by Audubon's Florida's Coastal Islands Sanctuaries (FCIS) program, the Florida Park Service, Florida Department of Environmental Protection Pinellas Aquatic Preserves, Pinellas County, and the cities of Clearwater, Belleair Beach, and Indian Rocks Beach, other cooperating agencies, and regional volunteers (Tampa Bay Regional Planning Council's Agency on Bay Management, Clearwater Audubon Society, Suncoast Chapter of the Florida Native Plant Society, Keep Pinellas Beautiful, and boating groups, among others) are addressing some management needs but more work needs to be undertaken.

The following actions which should be continued or added to on-going activities for the protection of the birds of the CHSJS estuary include population estimation, colony protection, public education, predator control, cooperation among law enforcement agencies, habitat management, taking measures for climate change, fishing line accumulation, coordination with public agencies, and protecting nesting islands from erosion.

The information contained in this State of the Resource report includes a comprehensive summary of the key natural resource elements that will be used to guide development of a Comprehensive Conservation and Management Plan for Clearwater Harbor and St. Joseph Sound. The CCMP document will establish a process for achieving the goals and objectives developed from the analysis presented in the State of the Resource report and outline specific management actions to conserve, protect and monitor the ecological integrity of this incredible environmental asset that is Clearwater Harbor and St. Joseph Sound.

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1.0 Introduction

The Pinellas County Department of Environment and Infrastructure (PCDEI), in cooperation with the U.S. Environmental Protection Agency (EPA), the Southwest Florida Water Management District (SWFWMD), and partners the Cities of Clearwater, Largo, Dunedin, and Tarpon Springs, is developing a ***Comprehensive Conservation and Management Plan for Clearwater Harbor & St. Joseph Sound*** (CCMP). The objective is to create and implement a plan that addresses the comprehensive set of environmental issues facing the Clearwater Harbor and St. Joseph Sound (CHSJS) estuary.

The CHSJS CCMP will serve as a blueprint to guide future decisions and actions and address a wide range of environmental protection issues including water and sediment quality, nutrient management, habitat protection and restoration, fish and wildlife protection, and land use change. An effective CCMP will establish priorities for watershed management activities, research, and funding for the estuary. It is anticipated that all of these efforts will be carried out through partnerships between federal, state, and local agencies with assistance from private and nonprofit sectors and citizens.

The CHSJS CCMP will be based on the scientific characterization of the estuary and its watershed presented in this **State of the Resource Report**. This report provides insight into the current and former nature of the CHSJS area, specifically with respect to the status of natural resources and water quality in the estuary and its watershed. This area has long been subject to significant development pressures yet retains some incredibly valuable natural resources.

Both this report and the CCMP will be developed and approved by the partners identified above. The development and implementation of a management plan for these resources, using information presented in this State of the Resource report, will help ensure the protection and enhancement of local ecological communities.

1.1 Objective

The CHSJS estuary and watershed are collectively referred to in this document as the CHSJS. The resource management Action Plans to be developed for the CCMP will address both activities in the estuary and watershed-based activities that profoundly affect the receiving waters. Thus, a comprehensive understanding of the CHSJS estuary and watershed is essential to the development of the CCMP.

The CHSJS has extensive natural resource components which require protection and stewardship. An evaluation of the current status and recent trends of these resources is a critical element of the resource protection process and is the focus of this document. Further, the purpose of the State of the Resource report is to provide a comprehensive assessment of the current status of the resources, and to define the critical environmental requirements for these resources. Information is provided for each estuary segment and its associated watershed. The resources addressed include physical features of the estuary and its watershed, hydrology, water quality, biota, and protected land and water. The process for developing resource management goals and quantitative targets for critical natural resources is defined. The quantitative goals and targets will provide an essential framework for the CHSJS CCMP.

The report is organized as follows:

- Chapter 1 defines the geographical extent of the CHSJS and provides a brief history of this area.
- Chapter 2 provides a characterization of the CHSJS estuary, including physical features such as estuarine circulation and existing protected areas of land and water.
- Chapter 3 provides a characterization of the CHSJS watershed, including physical features such as surface water hydrology, land use, and soils.
- Chapter 4 describes the critical natural resources in the CCMP estuary, including water quality, seagrasses, emergent vegetation, benthos, fisheries, birds, and charismatic megafauna (e.g., mammals and sea turtles); quantitative water quality goals, including proposed numeric nutrient criteria, seagrass targets, and nutrient loading goals are presented; a summary of existing management plans for preserved lands within the estuary is also provided;
- Chapter 5 describes the CHSJS watershed, including a land use change analysis; tributary water quality are nutrient loading are reviewed; a summary of existing management plans for preserved lands both within the watershed is also provided.

1.2 Geography

The CHSJS is located on the northwest coast of Pinellas County in west-central Florida (Figure 1-1). It extends from the Anclote River watershed south to the Walsingham Causeway at "The Narrows." The entire watershed lies within the Gulf Coastal Lowlands physiographic province which is characterized by generally low elevation and poorly drained soils with many wetland areas, and contains barrier islands, lagoons, estuaries, coastal ridges, and relict spits and bars, with intervening coast-parallel valleys (White, 1970).

The estuarine waters of St. Joseph Sound and Clearwater Harbor are bounded to the east by the mainland and to the west by the Gulf of Mexico and several barrier islands including, from north to south - Anclote Key, Three Rooker Bar, Honeymoon Island, Caladesi Island, Clearwater Beach Island, and Sand Key (Figure 1-1). Honeymoon Island and Caladesi Island are state parks and remain in a generally natural state but Clearwater Beach Island and Sand Key are highly developed.

The CHSJS encompasses all of some or several local government jurisdictions. To the north, the St. Joseph Sound watershed includes the Anclote River basin which extends north and east into Pasco County. The remainder of this watershed is within the City of Tarpon Springs, the City of Dunedin, and unincorporated Pinellas County (Figure 1-2). The Clearwater Harbor North and Clearwater Harbor South watersheds (Figures 1-3 and 1-4, respectively) encompass all or parts of the municipalities of Dunedin, Clearwater, Largo, Belleair, Belleair Bluffs, Belleair Beach, Belleair Shores, and Indian Rocks Beach as well as unincorporated Pinellas County.

The barrier islands that bound the estuaries to the west have been formed by physical processes including winds, tides, waves, and sea-level rise, interacting with the geologic and geomorphic setting. This portion of the coast is a low-energy system that includes wave-dominated and tide-dominated sections (Davis and Elko, 2003). Anthropogenic activities such as dredge and fill development, channel dredging, shoreline hardening, beach renourishment, and construction of causeways have also influenced the physical features of the islands.

The barrier islands interrupt the gently sloping west Florida continental shelf. In addition to the very low topographic gradient, the estuary has a somewhat irregular bottom configuration. This is due to widespread patches of exposed limestone bedrock and the presence of local sand bars with varying orientations (Davis and Elko, 2003). The barrier islands differ in age, origins, and morphology and reflect the combination of overall low-energy conditions and the relationship between wave-dominated and tide- dominated conditions. Of the undeveloped islands, the oldest barrier island is Caladesi Island, thought to be at least 2,000 years old. The youngest is Three-Rooker Bar, only about 25 years old (Davis and Elko, 2003).

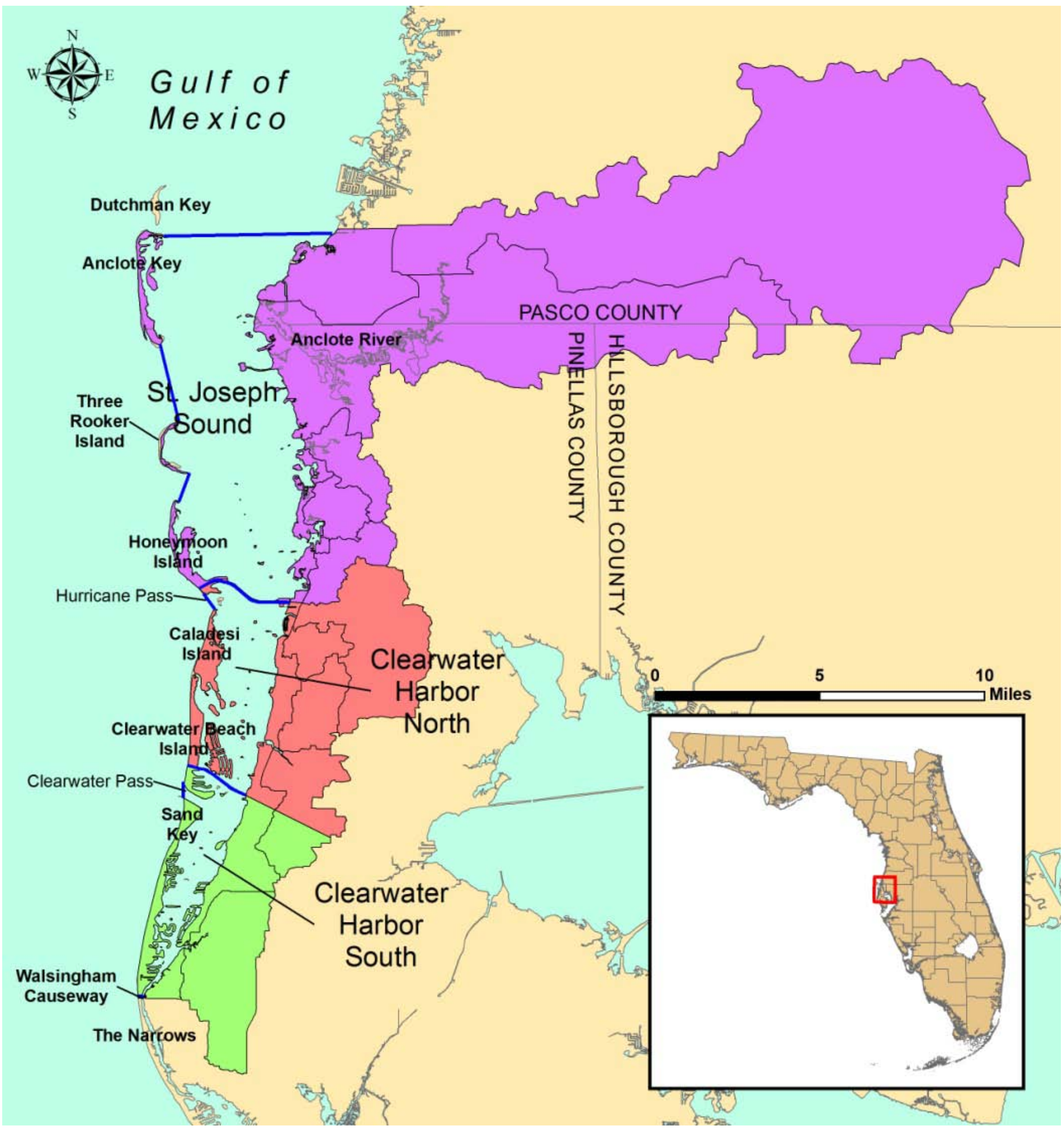


Figure 1-1. CHSJS location map.

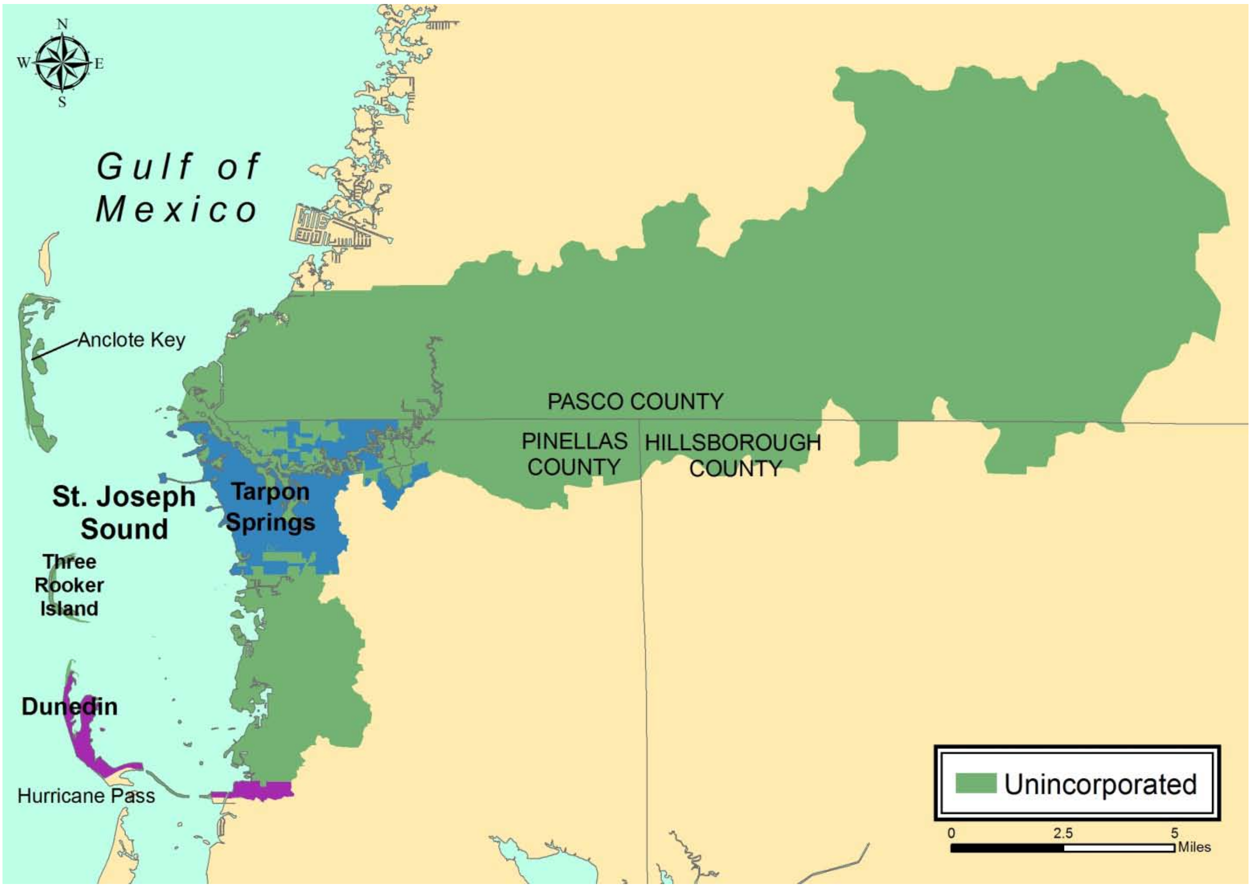


Figure 1-2. St. Joseph Sound political jurisdictions.

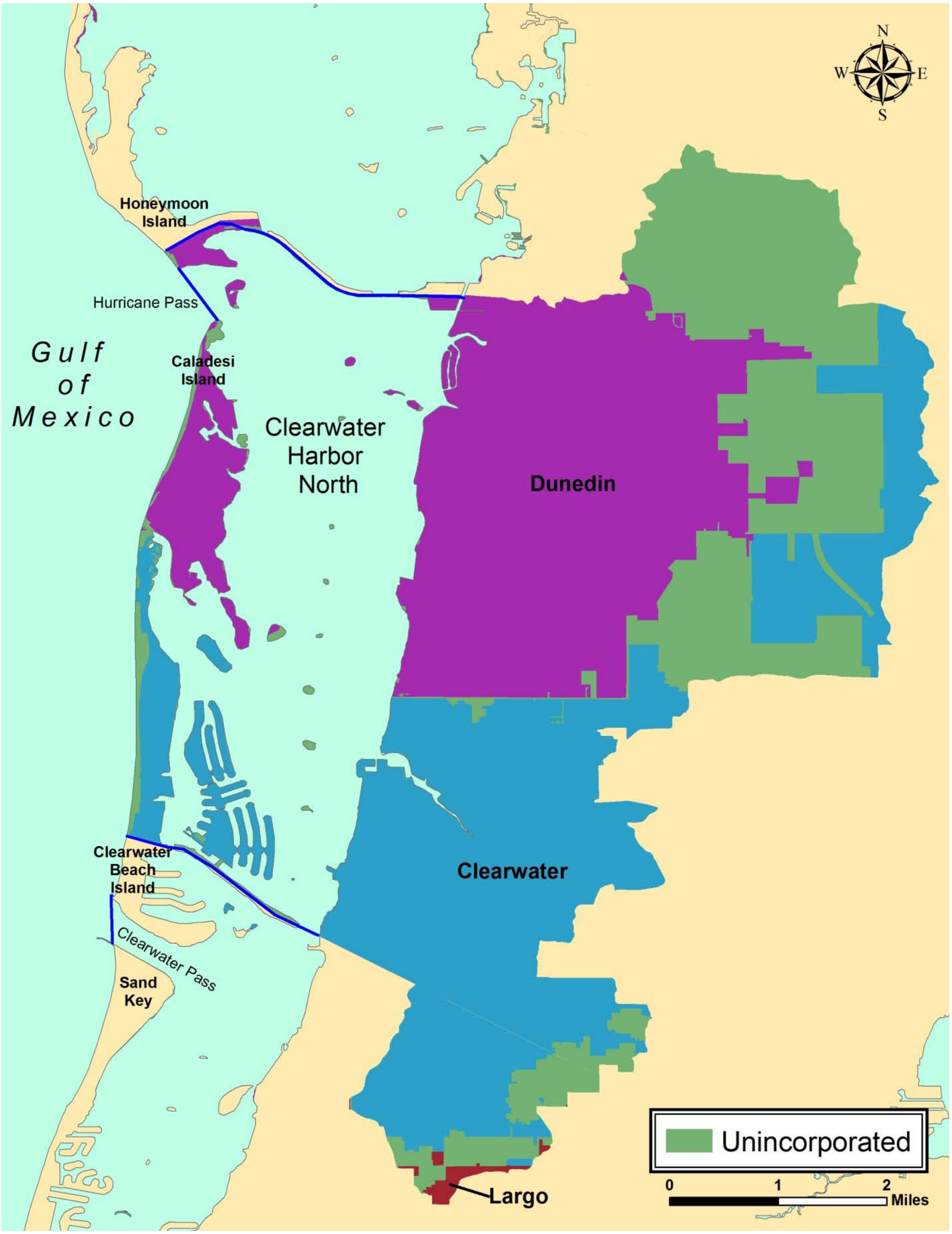


Figure 1-3. Clearwater Harbor North political jurisdictions.

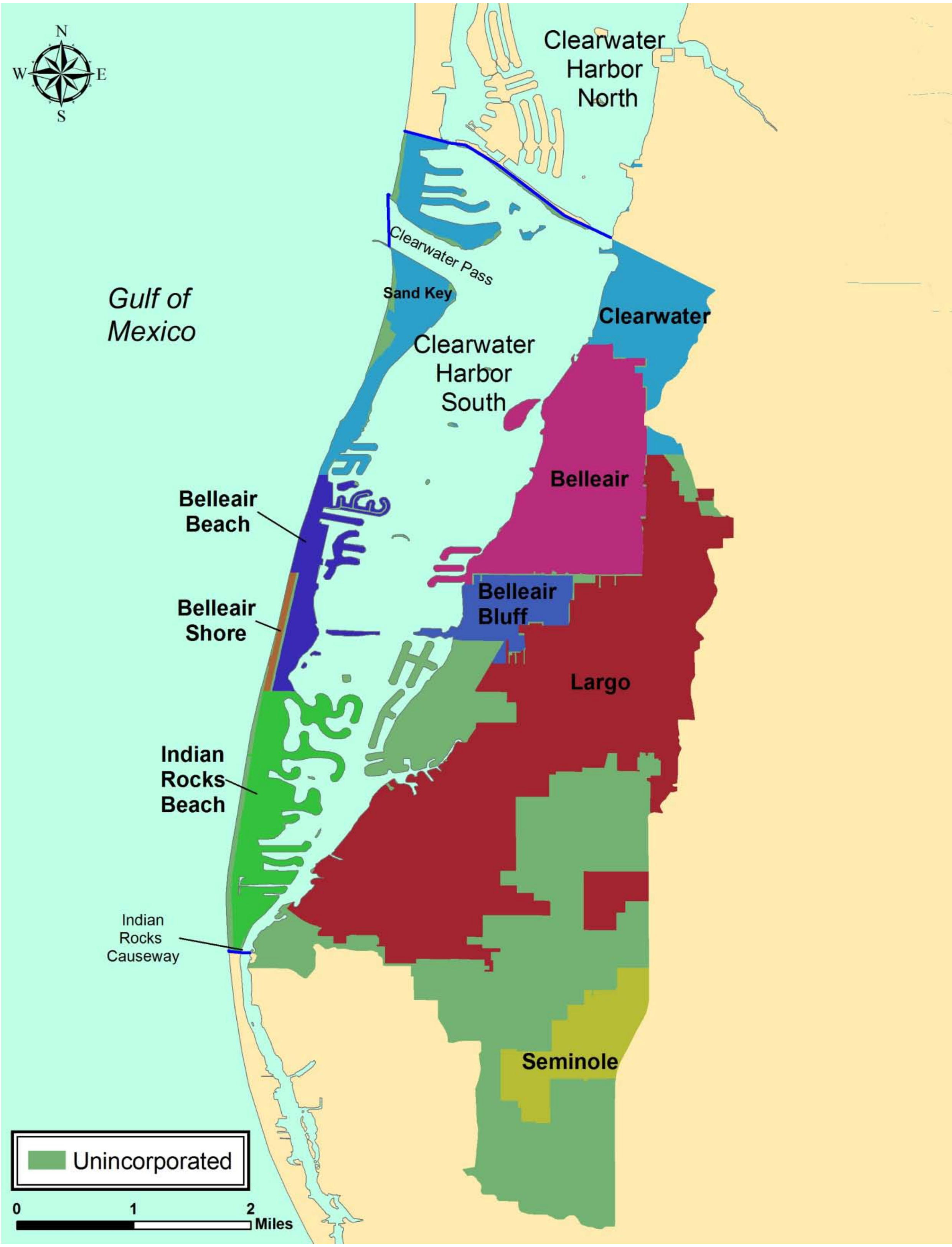


Figure 1-4. Clearwater Harbor South political jurisdictions.

1.3 History

- Early History

Before settlement by Europeans, the CHSJS had been occupied for more than 10,000 years by aboriginal cultures. From the Paleoindian to the Safety Harbor periods, the prehistory of the area is manifested in a variety of archaeological site types. These include aboriginal mounds, middens, cemeteries, quarries, camps and villages, and ceremonial sites (Babb et al., 2006).

The last prehistoric society in the area before the Spanish occupation was called the Tocobaga, also known as the Safety Harbor culture. Tocobaga was the dominant culture in the area from about A.D. 900 until about 1567, ending with the arrival of the Spanish explorers Panfilo de Narvaez (1528) and Hernando DeSoto (1539). By the 18th century, the Tocobaga had been virtually destroyed after years of exposure to European diseases, Spanish colonization efforts, and warfare between Spain and England (Estabrook, 1992).

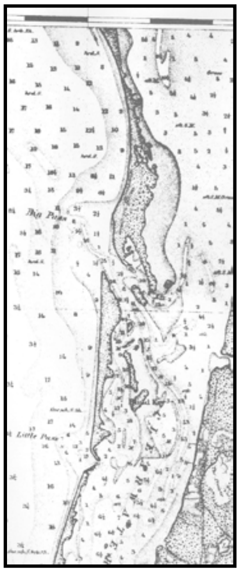
By 1800 most inhabitants were Seminole Indians who started arriving in Florida from Georgia and Alabama ca. 1750. The Spanish maintained a mission in nearby Safety Harbor until Spain traded Florida to Great Britain in 1763 in exchange for control of Havana. The earliest European settlements were mainly fish camps along the Gulf of Mexico shoreline. Around 1832, Count Odet Philippe of France moved to what is now Safety Harbor and established the St. Helena Plantation, bringing citrus to the region. He also persuaded other settlers to move to the area (WebCoast, 2010). Citrus remained a growing agricultural crop until the "great freeze" of 1895 severely damaged the industry locally. Citrus remained an important industry, but after another major freeze in 1962, many growers sold their property to developers.

- Changes to the CHSJS Estuary

The Clearwater Harbor and St. Joseph Sound estuary and its passes are dynamic waterbodies that have undergone numerous changes from both natural phenomena and anthropogenic activities. Major alterations that have occurred to these waterbodies over the past century are summarized below.

Two navigable passes in the CHSJS currently allow tidal interaction between the estuaries and the Gulf of Mexico: Hurricane Pass and Clearwater Pass (Figure 1-1). Dunedin Pass was historically navigable but is now closed. St. Joseph Sound is more open to the Gulf of Mexico at the north end of the CHSJS.

Historically, Honeymoon and Caladesi Islands were one land mass (known as Hog Island), until one of the most severe hurricanes ever reported for the west coast of Florida formed Hurricane Pass in 1921. Development activities in the estuary, including the construction of Dunedin Causeway, caused tidal flow in St. Joseph Sound to be redirected towards Hurricane Pass. The tidal flow helped maintain Hurricane Pass' stability, allowing it to become the main inlet for St. Joseph Sound (PCCMD, 2010).



Clearwater Pass separates Clearwater Beach Island and Sand Key, and provides a connection for tidal exchange between Clearwater Harbor and the Gulf of Mexico. Originally named Little Pass, Clearwater Pass was opened by strong storms in 1848 and was widened by the 1921 hurricane. The pass was frequently dredged from the 1930s to the 1970s, however it began to narrow and deepen between 1962 and 1973. Sediment movement threatened the existing bridge, as support pilings began to scour at the base. To stop further erosion, a rock jetty was constructed on the south side of the channel in 1975 and has helped stabilize Clearwater Pass (PCCMD, 2010).

Dunedin Pass, previously known as Big Pass, was historically navigable and was the main inlet for St. Joseph Sound prior to the hurricane of 1921 which opened Hurricane Pass to the north. The 1879 U.S. Coast & Geodetic Survey chart to the left shows a wide pass at the time. The combination of the hurricane and significant changes in tidal circulation in St. Joseph Sound led to the destabilization of Dunedin Pass (PCCMD, 2010).

Following the 1921 hurricane, Dunedin Pass migrated over one-half mile to the north as the spit on the north end of Clearwater Beach Island extended. Construction of the Clearwater Memorial Causeway in 1926, and of the Dunedin Causeway and Gulf of Mexico Intracoastal Waterway in 1962, redirected tidal flow away from Dunedin Pass. This allowed sediment to accrete in the channel, restricting navigation.
Shoaling became a regular problem in the 1970s and the channel soon narrowed to about 150 feet wide and less than 6 feet deep. In 1985, Hurricane Elena's 8-foot waves eroded the stabilizing shoal at the mouth of Dunedin Pass and rendered the pass non-navigable (USDC, 2006). Without the protection of the shoal, tidal flow was not sufficient to maintain the inlet. The pass shoaled in and totally closed in 1988 (PCCMD, 2010). As a result of the pass closure it is now possible to walk from Clearwater Beach Island to Caladesi Island.

The passes, and overall near-shore water depth, were important factors in the area's growth, as early settlers were dependent on water-borne traffic. Until the railroad extended through the region, boats were the only practical method for moving any quantity of material or people. As population and trade grew, it was recognized that dedicated in-shore shipping channels that shielded ships from rough seas would greatly facilitate access for larger vessels and encourage more trade. The U.S. Army Corps of Engineers (Corps) had already finished Florida's Atlantic portion of the Intracoastal Waterway (ICW) in the early 1900s. They were also developing plans for the Cross Florida Barge Canal and were nearly finished with the Caloosahatchee River/Lake Okeechobee Cross Florida Waterway.

In 1910, Congress appropriated $29,000 to dredge and maintain a 7-by-100-foot channel from Tampa Bay into Boca Ciega Bay and a 5-by-50-foot channel on to Clearwater Harbor as part of the Gulf of Mexico ICW. Legislation in 1919 provided for enlarging channel dimensions to 8-by-100 feet from Tampa Bay to Boca Ciega Bay. The Corps completed this work in 1920, however completion of a channel enlargement that extended from Clearwater Harbor north through St. Joseph Sound to the Anclote River was not accomplished until 1962 (Alperin, 1983).

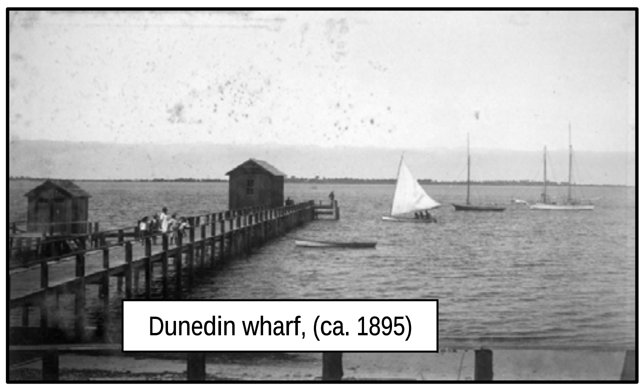
Some of the most striking changes to the estuaries came about when land was "created", displacing the estuarine habitat and altering circulation patterns. During the 1950s, large-scale dredge and fill projects were conducted in Clearwater Harbor. In 1955, the Pinellas County Commission formed the Pinellas County Water and Navigational Control Authority in order to regulate dredge and fill operations.

Although St. Joseph Sound has escaped significant dredge and fill development, there are extensive finger fill residential areas at Paradise Keys north of the Memorial Causeway. Also, Clearwater Harbor south of Belleair has abundant finger fill areas. Many large dredge and fill developments were completed in the 1950s – 1960s, prior to the enactment of environmental protection legislation. The watersheds have also changed significantly over the years, converting from mainly agricultural land to urban. Both the mainland and the barrier islands south of Caladesi Island are highly urbanized, and coastal development and shoreline hardening have further affected the estuaries.

While urban development on the mainland and barrier islands continued, Clearwater Harbor and St. Joseph Sound were provided additional protection through the creation of the Pinellas County Aquatic Preserve in 1972. The estuaries were designated Outstanding Florida Waters in 1979 along with all State sovereign submerged lands within the County boundary. One of the most recent development activities on Clearwater Harbor is the recently opened City of Clearwater Downtown Boat Slips project, located at the base of Memorial Causeway. Facilities include 126 public slips and other docking opportunities (City of Clearwater, 2010a).

- **Changes to the CHSJS Watershed**

The first settlements of Europeans included Clearwater, Dunedin, and Tarpon Springs. Commerce in the towns was supported mainly by agriculture (citrus, vegetables, and cotton) and fishing. These originally small outposts have grown into the single urban landscape of today.



Dunedin wharf, (ca. 1895)

The City of Clearwater was founded in the 1830s as the Seminole War-era Fort Harrison, located on the bluffs south of downtown. Clearwater developed into an agricultural port by the 1850s and was incorporated in 1915 (City of Clearwater, 2010b). Tarpon Springs was also among the first urban centers in the area. It had a population of 52 when it was incorporated in 1887, 11 years after it was founded. A few years later the sponge harvesting industry was initiated and the town grew rapidly after that. By 1900, Tarpon Springs was the largest sponge port in the U.S. The town of Dunedin was another early seaport and trading center, and at one time was home port to the largest commercial fleet of ships in the state. It was named in 1882 and was incorporated in 1899.

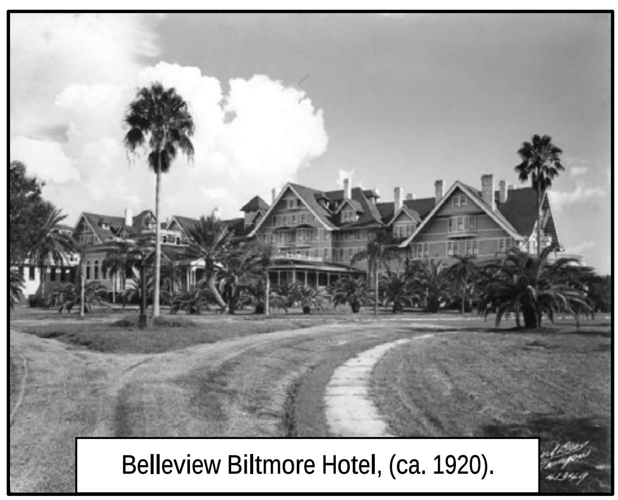
Key to the continuing growth of the area were significant improvements to land-based transportation. As inland regions of Florida developed it became increasingly important to have access to non-coastal areas. In 1888, the first railroad came south from Ocala, through Tarpon Springs and Dunedin, and on to St. Petersburg. The Orange Belt Railway, as it was known, was organized by Peter Demens who later went bankrupt. This allowed first the Plant Railway and then the Atlantic- Coastline Railroad to acquire the rail facilities. The railway carried large volumes of goods and passengers overland and helped to accelerate local growth.

Other transportation improvements that encouraged urban growth included a two-mile long wooden bridge from Seminole Street to Clearwater Beach. The bridge, built in 1916, had a hand-cranked rotating swing bridge section to allow boat passage. Prior to this, the popular tourist destination was accessible only by boats and ferries. On November 11, 1927, Memorial Causeway was dedicated. The new causeway extended from Cleveland Street to the beach and had a double-lift bridge to accommodate ship traffic on the ICW.

The major east/west connector, Gulf-to-Bay Boulevard, also was opened in 1927. The original bridge was replaced in the 1950s, and in 2005 a new much higher Clearwater Memorial Causeway opened to replace the former bridge (City of Clearwater, 2010b). Other causeways to the barrier islands (Figure 1-1) include the Dunedin Causeway which connects the mainland to Honeymoon Island. The current structure was constructed in 1963 and is the demarcation between St. Joseph Sound and Clearwater Harbor. Farther south, the Belleair Causeway extends from Belleair Bluffs to the beach at Belleair Shores. The Belleair Causeway was originally constructed in 1950 as a toll bridge and was recently rebuilt as a high vertical clearance fixed span. The Walsingham Causeway was built in the early 1960s and is the southern limit of Clearwater Harbor.

Besides agriculture and fishing, the tourist trade was a significant economic force in the areas from the earliest days. Florida developer Henry Plant built several large resorts in the region including the Belleview Biltmore Hotel, which opened in 1897 on bluffs overlooking the harbor. Tourism remains one of the major sources of local income in the CHSJS.

The rate of urban growth in the CHSJS accelerated rapidly during the Florida Land Boom from 1921 until the "bust" of 1926. However, development continued, with returning World War-II military veterans later boosting the area's population. During this period much of the remaining agricultural land was sold for development.


Belleview Biltmore Hotel, (ca. 1920).

Although accurate records of historical population growth for the CHSJS alone are not available, all indications are that the trend in population mirrors that of Pinellas County as a whole.

Figure 1-5 below shows the County's estimated permanent population from 1890 to the present, with the highest rates of increase occurring between the 1950s and 1970s. Projected future growth has slowed significantly in recent years due to the already highly urbanized character of most of the County.

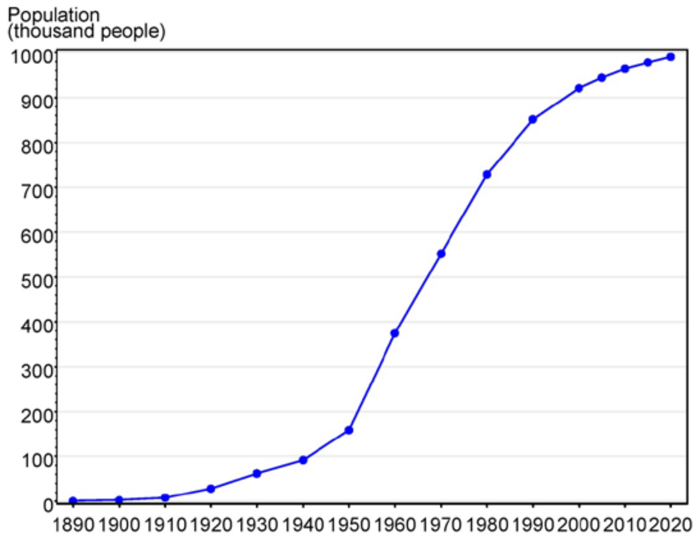


Figure 1-5. Pinellas County permanent population – historical, current and projected future. (Pinellas County Planning Department, 2010.

Although industrial uses within the CHSJS are limited, Progress Energy owns and operates the Anclote Electric Power Plant located at the mouth of the Anclote River in Pasco County. The plant is a two-unit oil-fired steam facility whose first unit began commercial service in 1974, and its second unit followed in 1978 (Progress Energy, 2010). It has a power producing capacity of 1,011 megawatts of electricity. Although plant operation could potentially be very detrimental to local biota significant work has been completed to reduce impacts to marine species.

Once-through cooling water for the plant is diverted from the Anclote River through an intake canal and passed through bar racks and intake screens to remove marine organisms and trash. After passing through the boiler the water is pumped through condensers to remove excessive heat and flows into the plant's discharge canal. The discharge canal opens to the Gulf of Mexico north of the river mouth. The plant's NPDES permit does not require reporting flow rates through the plant, however mean flow for the period 2/1/2003 through 1/31/2004 was reported to be approximately 2,100 million gallons per day (mgd) (FDEP, 2004).

The plant also has dilution pumps and cooling towers which are used on an as needed basis for additional heat removal to achieve thermal discharge limitations. The dilution pumps transfer water directly from the intake canal to the discharge canal to mix with and cool the warmer plant discharge water. However, in the past dilution pump usage was severely limited due to the regulatory agency assumption that no zooplankton survived entrainment through these pumps. To test this assumption, FPC performed a study of the survival of zooplankton entrained through the pumps in 1995, in conjunction with the renewal of the plant NPDES permit. Study results showed a mean overall survival through the dilution pumps of 87% (Melton and Serviss, 2000). This information resulted in approval for increased usage of the dilution pumps for control of thermal discharges, and allowed a reduction in operation of the cooling towers, which cause near total mortality of entrained zooplankton due to mechanical and chemical stressors.

2.0 Physical Characterization of the CHSJS Estuary

This chapter contains a summary of physical characteristics of the CHSJS including geographic boundaries, estuarine bathymetry, and estuarine circulation. The chapter is organized by estuarine segment from north to south (St. Joseph Sound, Clearwater Harbor North, and Clearwater Harbor South). The extent of the CHSJS estuarine waterbodies are defined principally by bridges as described in Chapter 1 with Dunedin Causeway separating Clearwater Harbor North from St. Joseph Sound and the Memorial Causeway separating Clearwater Harbor South from Clearwater Harbor North. The southern extent of Clearwater Harbor South is defined by the Narrows and the Indian Rocks Causeway bridge. The Intracoastal Waterway is a dredged channel running the length of the estuary. Spoil islands resulting from this dredging activity exist through the estuary but are principally located in the northern half of the CHSJS. These islands currently support offshore native habitats and recreational activities and are an important management feature of the CHSJS. The entire CCMP estuarine area is included in the Pinellas County Aquatic Preserve. The following sections discuss the geographic extent, bathymetry, and circulation of the estuarine segments of the CCMP.

2.1 Geographic Extent

Below is a brief discussion of the geographic extent of the estuarine segments.

2.1.1 St. Joseph Sound

The St. Joseph Sound estuary occupies approximately 18,000 acres within Pinellas County and is bounded to the north by the Anclote Anchorage at the mouth of the Anclote River and to the south by Dunedin Causeway (Figure 2-1). Several barrier islands including Anclote Key, Three Rooker Key, and Honeymoon Island mark the western boundary of the sound. They are the northernmost barrier islands on the west coast of peninsular Florida south of the Panhandle region.

Large passes between these barrier islands provide significant tidal interaction with the Gulf of Mexico. Much of the eastern shoreline of the estuary has been hardened by seawall and rip-rap, such as can be seen along Klosterman Bayou. In contrast, the western shorelines along the barrier islands have remained largely in a natural state. Anclote Key and Three Rooker Bar are accessible only by boat. The natural areas on the barrier islands provide major public recreation features including Honeymoon Island State Recreation Area and Anclote Key Preserve State Park.

2.1.2 Clearwater Harbor North

Clearwater Harbor North occupies approximately 5,876 acres and is substantially narrower and less connected to the Gulf of Mexico than St. Joseph Sound. Hurricane Pass, in the northern region of Clearwater Harbor North (Figure 2-2) provides the only direct tidal interaction with the Gulf of Mexico. Clearwater Harbor North is bounded to the west by Caladesi Island and Clearwater Beach Island and to the east by mainland Florida and the cities of Dunedin and Clearwater. The great majority of the estuary's shoreline is hardened by seawall and rip-rap to accommodate coastal development and to prevent erosion of the shoreline, including much of the barrier islands. Large areas of the bay bottom have been dredged and filled to create residential canal developments that extend into the estuary. Major public recreation features in Clearwater Harbor North include Caladesi Island State Park and Clearwater Beach.

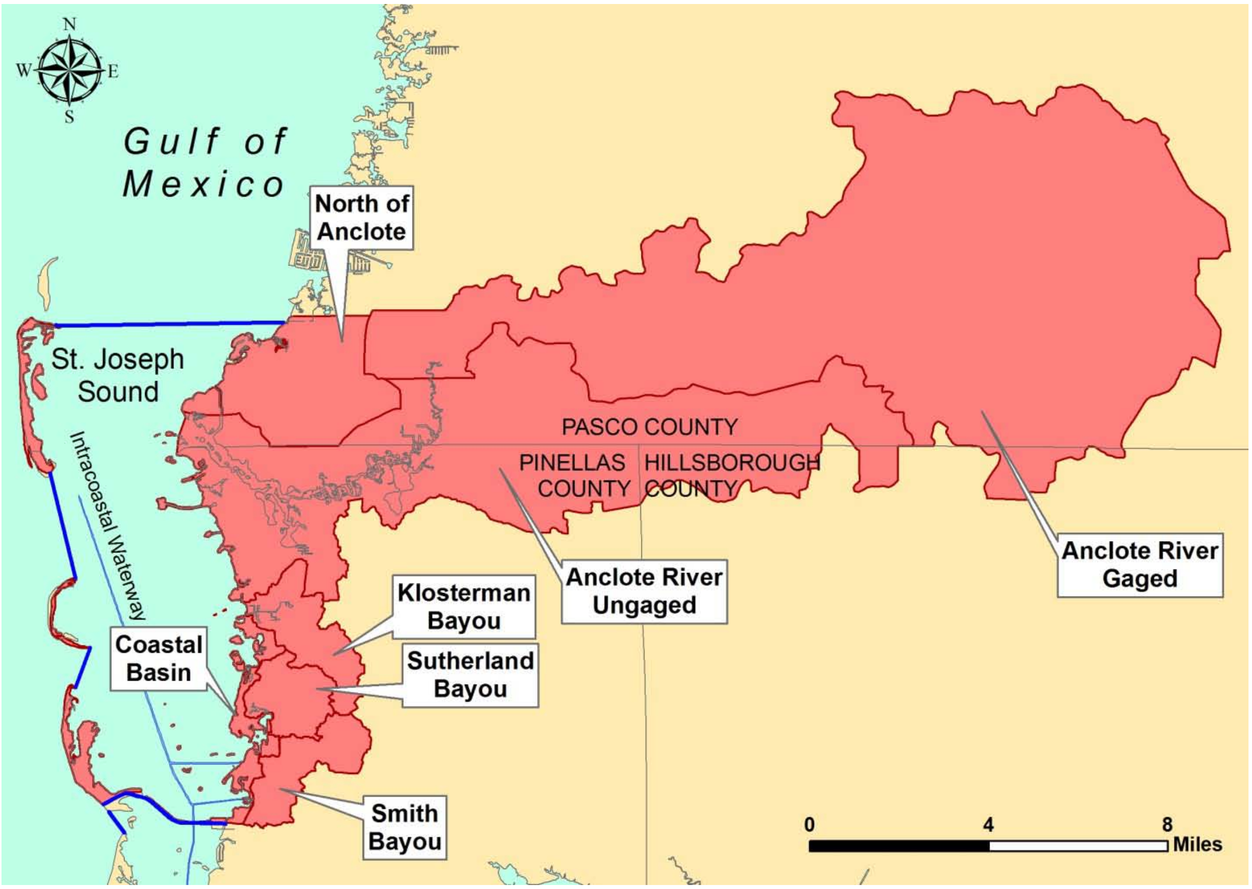


Figure 2-1. St. Joseph Sound extent.

2.1.3 Clearwater Harbor South

Clearwater Harbor South is the smallest (3,831 acres) and least tidally connected of the three bay segments with tidal exchange occurring principally through Clearwater Pass in the northern portion (Figure 2-3). The construction of the Clearwater Memorial Causeway, much of which involved filling the bay bottom to allow road construction, has restricted the connection between Clearwater Harbor North and Clearwater Harbor South with north/south tidal exchange limited on the eastern and western sides of the causeway.

From Clearwater Pass at the north end of this segment, the segment quickly narrows from approximately 2 kilometers (km) across to less than 0.2 km in width at The Narrows where it connnects to Boca Ciega Bay via a dredged channel that serves as the Intracoastal Waterway. Much of the southern extent of Clearwater Harbor South from Belleair to Indian Rocks Beach has been filled to create residential canal developments that form its western boundary along Sand Key

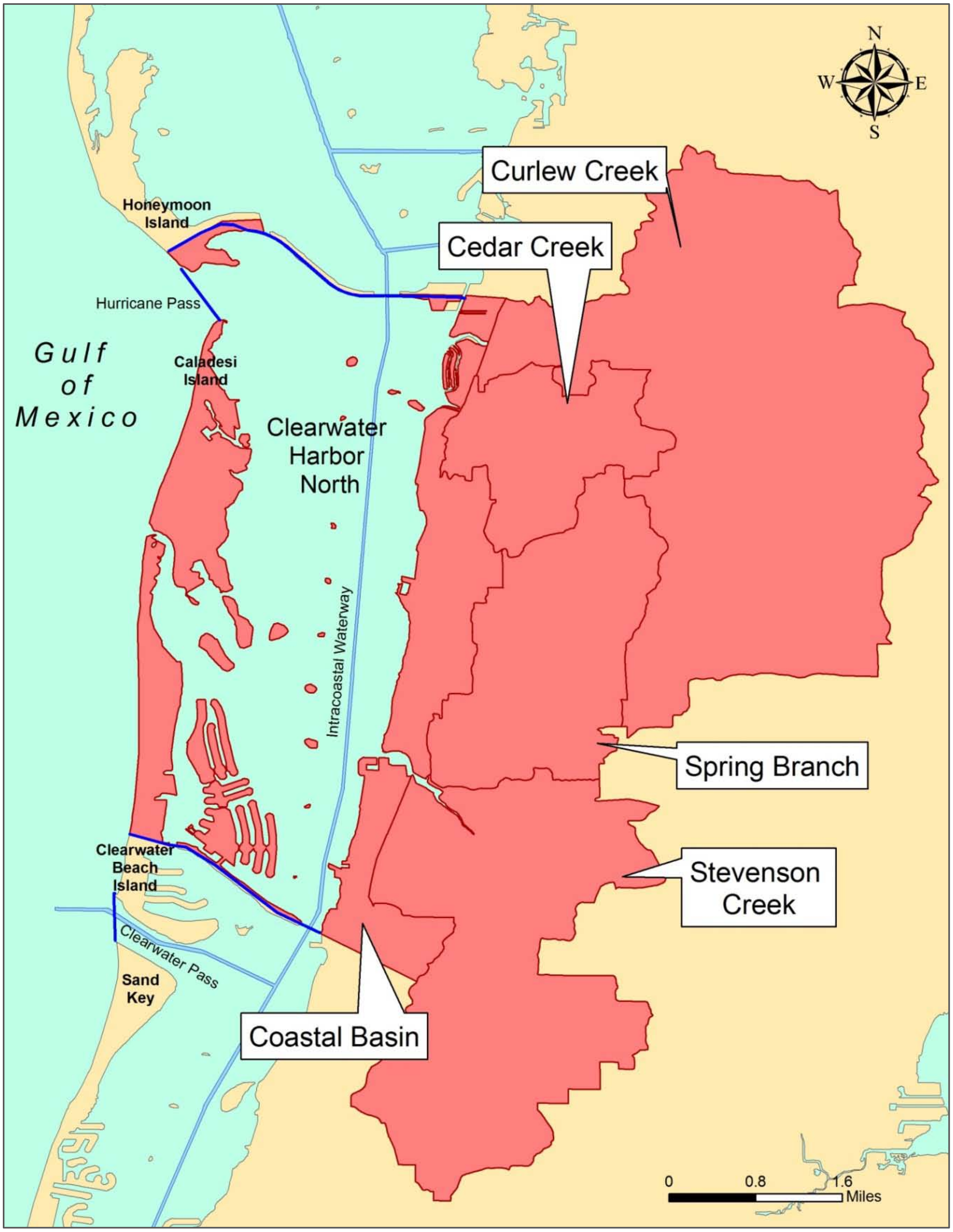


Figure 2-2. Clearwater Harbor North extent.

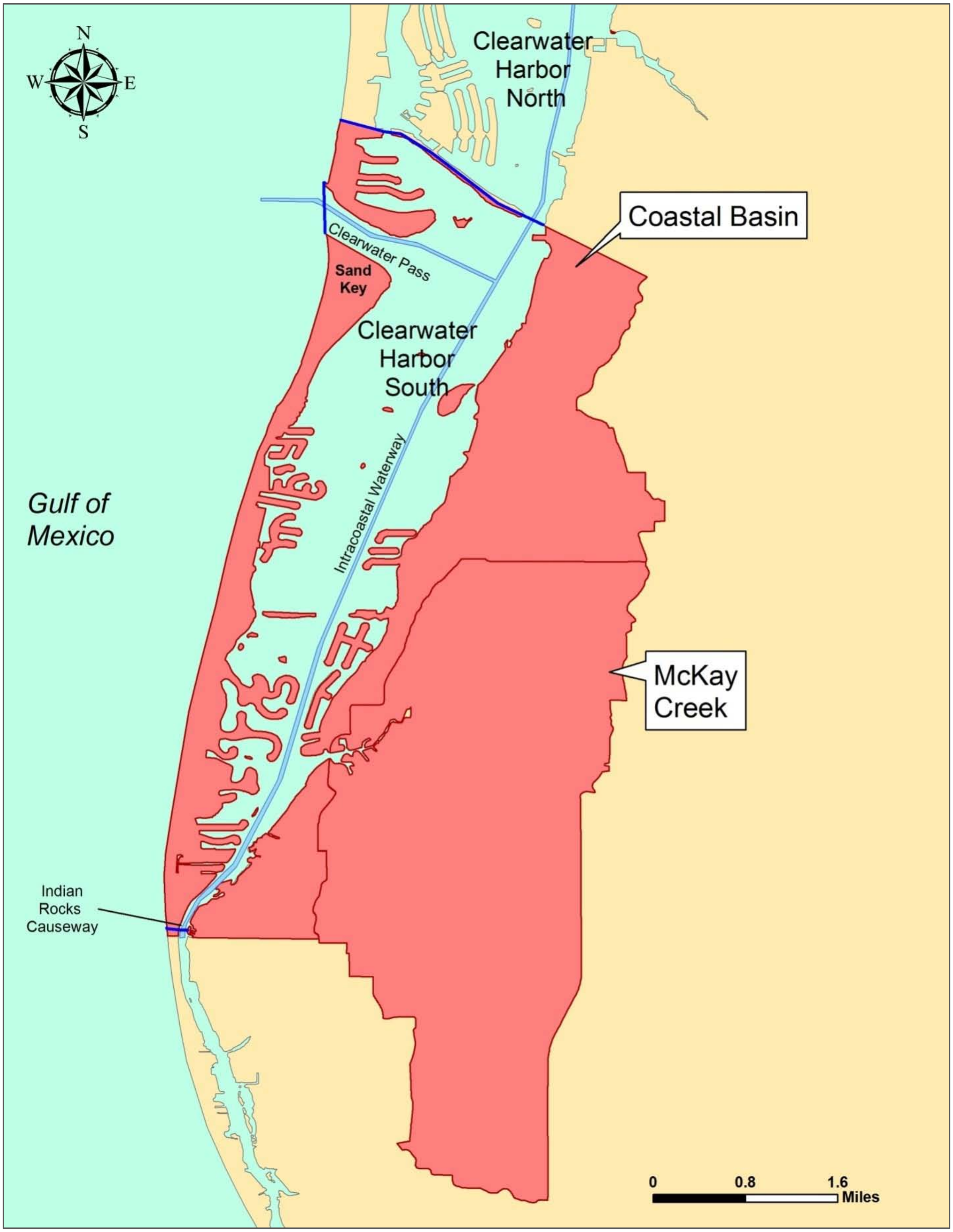


Figure 2-3. **Clearwater Harbor South extent.**

2.2 Bathymetry

The U.S. Geological Survey's Florida Shelf Habitat (FLaSH) point dataset provides the data used to characterize the bathymetry of the CHSJS (Robbins et al., 2007). These data are expressed as a Mean Lower Low Water (MLLW). The CHSJS estuary is a relatively shallow waterbody with an average depth of 1.4 meters (m), including navigation channels.

2.2.1 St. Joseph Sound

Water depths in St. Joseph Sound are the deepest of the three bay segments, although its average depth is only 1.5 m deep. Depths in St. Joseph Sound vary from less than 1 m within a wide area of shallow water along the eastern shoreline to 2-4 m deep in a more expansive area in the northern portion of the Sound, between Honeymoon Island and Anclote Key (Figure 2-4). The deepest waters in St. Joseph Sound reach in excess of 4 m in the northern portions and a maximum depth of around 5.8 m at the northern end of Anclote Key. Navigation channels of the ICW run north-south through the estuary, providing navigation features for recreational and commercial vessels as do dredged channels within the tidal tributaries draining the surrounding watershed.

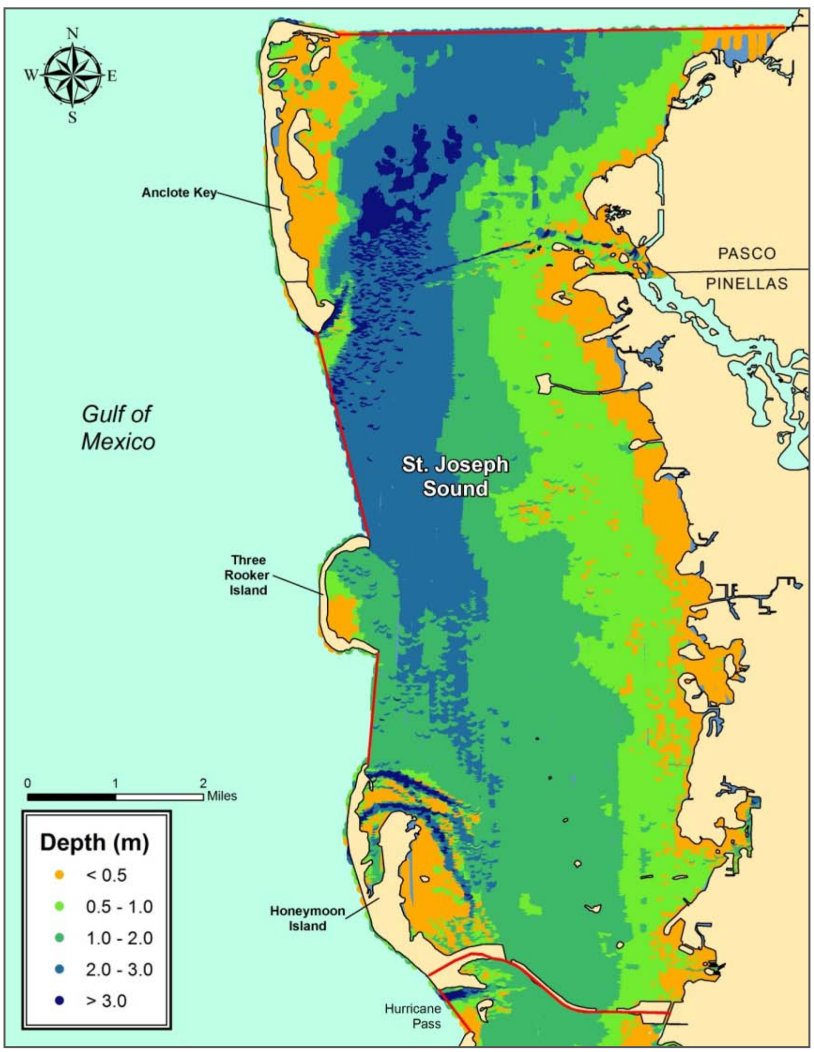


Figure 2-4. St. Joseph Sound bathymetry.

2.2.2 Clearwater Harbor North

Clearwater Harbor North is typically less than 2 m deep with an average depth of 1.1 m (Figure 2-5). The deepest areas range between 4 and 7 m in depth and are found in dredged areas including the navigation channels along the seawalls of the residential canal developments near the now closed Dunedin Pass and in the Intracoastal Waterway beneath the Clearwater Memorial Causeway. The closure of Dunedin Pass likely had a dramatic effect on bathymetry and circulation in Clearwater Harbor North. The closure of Dunedin Pass resulted in Hurricane Pass being the only direct source of coastal water exchange with the Gulf though St. Joseph Sound still contributes greatly to the overall flushing and residence times in the northern portion of this segment.

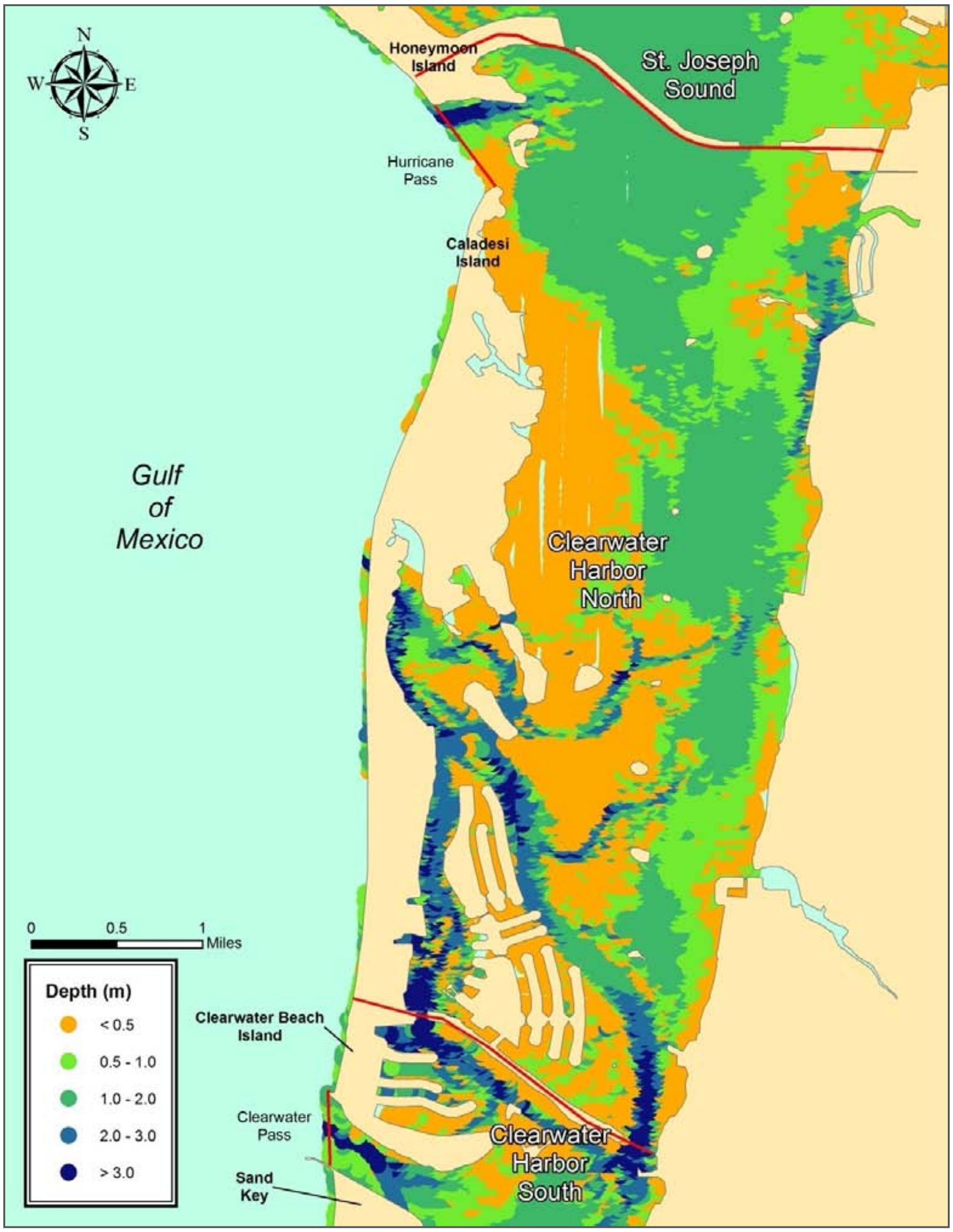


Figure 2-5. Clearwater Harbor North bathymetry.

2.2.3 Clearwater Harbor South

Clearwater Harbor South is slightly deeper on average than Clearwater Harbor North with a mean depth of 1.4 m and much of this segment ranging from 1-2 m in depth (Figure 2-6). Shallower areas less than 1 m are restricted to the shorelines and the southernmost portion of the bay segment. Deeper waters 2-3 m in depth, which are not associated with navigation channels, are found centrally in the widest portion of the bay segment near Belleair and along the Clearwater Memorial and Belleair Causeways where spoil was dredged during construction of the roadways. The deepest area of Clearwater Harbor South is found in Clearwater Pass where depths reach 7.0 m. As in St. Joseph Sound, deeper areas also exist within the ICW and tributary dredged channels.

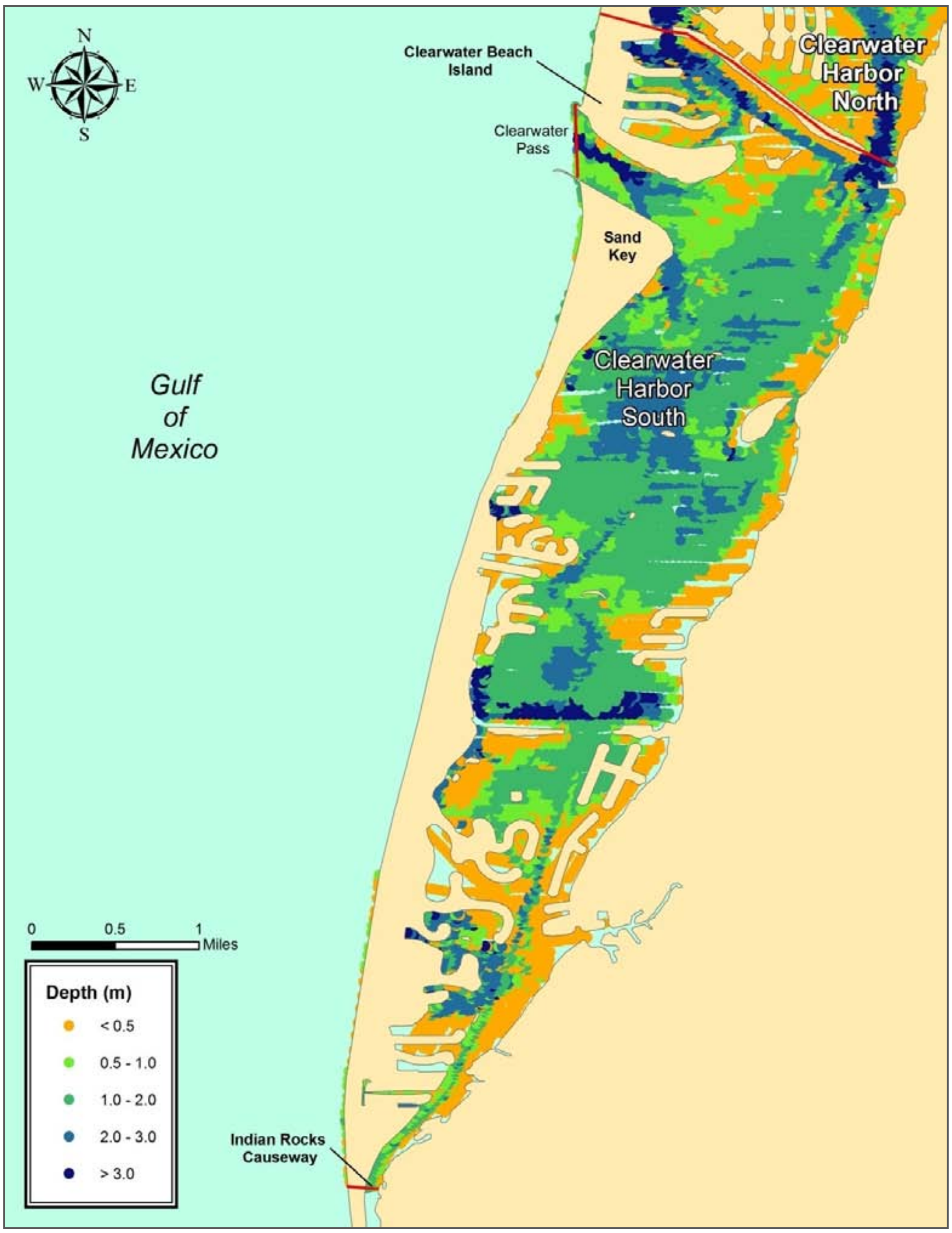


Figure 2-6. Clearwater Harbor South bathymetry.

2.3 Circulation

Circulation patterns in Clearwater Harbor and St. Joseph Sound are functions of various physical factors, including freshwater inflows, wind forcing, bathymetry, and connections to the Gulf of Mexico to the west. The barrier islands along the western boundaries of Clearwater Harbor limit connectivity to the Gulf of Mexico, while St. Joseph Sound is largely open to the Gulf. A generalized discussion of circulation in the Gulf is provided immediately below, followed by a discussion of the physiographic characteristics of the CHSJS system which impact exchange with the Gulf. Finally, a hydrodynamic model developed for the system, and used to estimate residence time within the three segments of the CHSJS system is described.

Tidal circulation on the west Florida shelf results in cross-shelf movement of water parcels in an elliptical pattern, with no net displacement over a tidal cycle (Weisberg et al., 1996). Simulations of tidal circulation (He and Weisberg, 2002a) suggest that residual tidal circulation is small in the CHSJS region, with residual circulation directed to the southwest. During summer, when winds are typically from the southeast, tidal levels are higher than during winter, when winds are typically from the northeast.

Wind and tidal action, in concert with density effects related to freshwater inflow, are the primary forcing mechanisms for circulation in the CHSJS region. The tidal range in the area (i.e., the vertical difference between the lowest and highest tides on a given day) is relatively low. Tides in the CHSJS area are "mixed", with approximately equal "diurnal" (one low water and one high water per day) and "semidiurnal" (two low waters and two high waters per day) influences. As a result, two unequal low and two unequal high tides usually occur each day. The mean diurnal tidal range for the 1996-2005 period is 0.8 m as measured at Clearwater Beach, and this is approximately half the range (2.1 m) between the annual minimum and maximum tidal elevations (Mukai et al., 2001).

Fresh water enters Clearwater Harbor and St. Joseph Sound from several streams, including Stevenson Creek, Cedar Creek, Spring Branch, Curlew Creek/Bee Branch, Rattlesnake Creek, Wall Spring, and Klosterman Creek, as well as from the Anclote River near the northern boundary of the study area. Fresh water inflow to the coastal areas north of the Anclote Anchorage, from sources including the Pithlachascotee, WeekiWachee, and Chassahowitzka rivers, may also be transported southward into the Anclote Anchorage and CHSJS system. Transport of freshwater southward along the coast is dependent on wind-induced circulation, and is most likely when winds are from the north, as is typical during the winter.

The exchange of water with the Gulf of Mexico through Clearwater Pass, Hurricane Pass, and the western and northern boundaries of St. Joseph Sound provides for flushing of the CHSJS system. It is expected that waters in the southern portion of the system do not exchange as often with the Gulf as do those in the northern portion, as there are only two passes into Clearwater Harbor, whereas St. Joseph Sound has a long common boundary with the Gulf of Mexico. The effects of the longer residence times expected in the southern portion of the system on water quality are likely to be of concern when examining potential pollutant loading scenarios. The effects of pass closures and openings on exchange with the Gulf also play a role in determining the water quality conditions within the system, especially in Clearwater Harbor.

Janicki Environmental previously developed a hydrodynamic model of the west-central Gulf coast and the Anclote Anchorage (Janicki Environmental, 2003) for use in evaluation of potential effects of a desalination facility near the Anclote River. More recently, a revised Gulf Coast Shelf Model (GCSM) has been developed by Janicki Environmental (2008) using the Environmental Fluid Dynamics Code (EFDC) (Tetra Tech, 2002), a hydrodynamic model supported by EPA. The GCSM grid and bathymetry (Figure 2-7) was used to run the EFDC model with inputs of freshwater inflows along a large portion of the west coast of Florida. The output from this model was used to provide salinity, temperature, and water elevation boundary conditions to the more refined model grid of the Lower Withlacoochee River, as described in Janicki Environmental (2008).

For the CHSJS CCMP, a refined grid was developed for St. Joseph Sound and Clearwater Harbor (Figure 2-8), so that the refined grid model can be used to evaluate the effects of morphological and freshwater loading changes on residence time and salinity within the CHSJS system. More detailed descriptions of the two models, the large spatial scale GCSM and the more refined spatial scale Clearwater Harbor/St. Joseph Sound Model, are provided in Appendix A, including calibration results for the models.

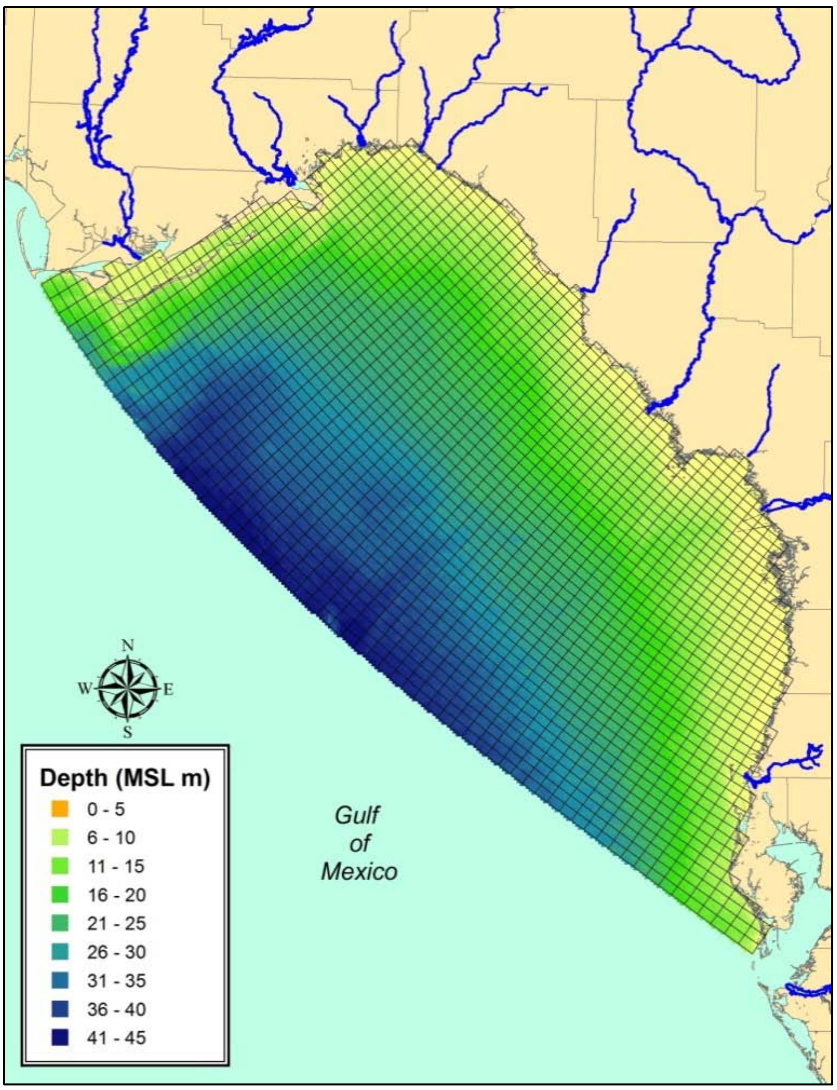


Figure 2-7. **Gulf Coast Shelf Model grid and bathymetry.**

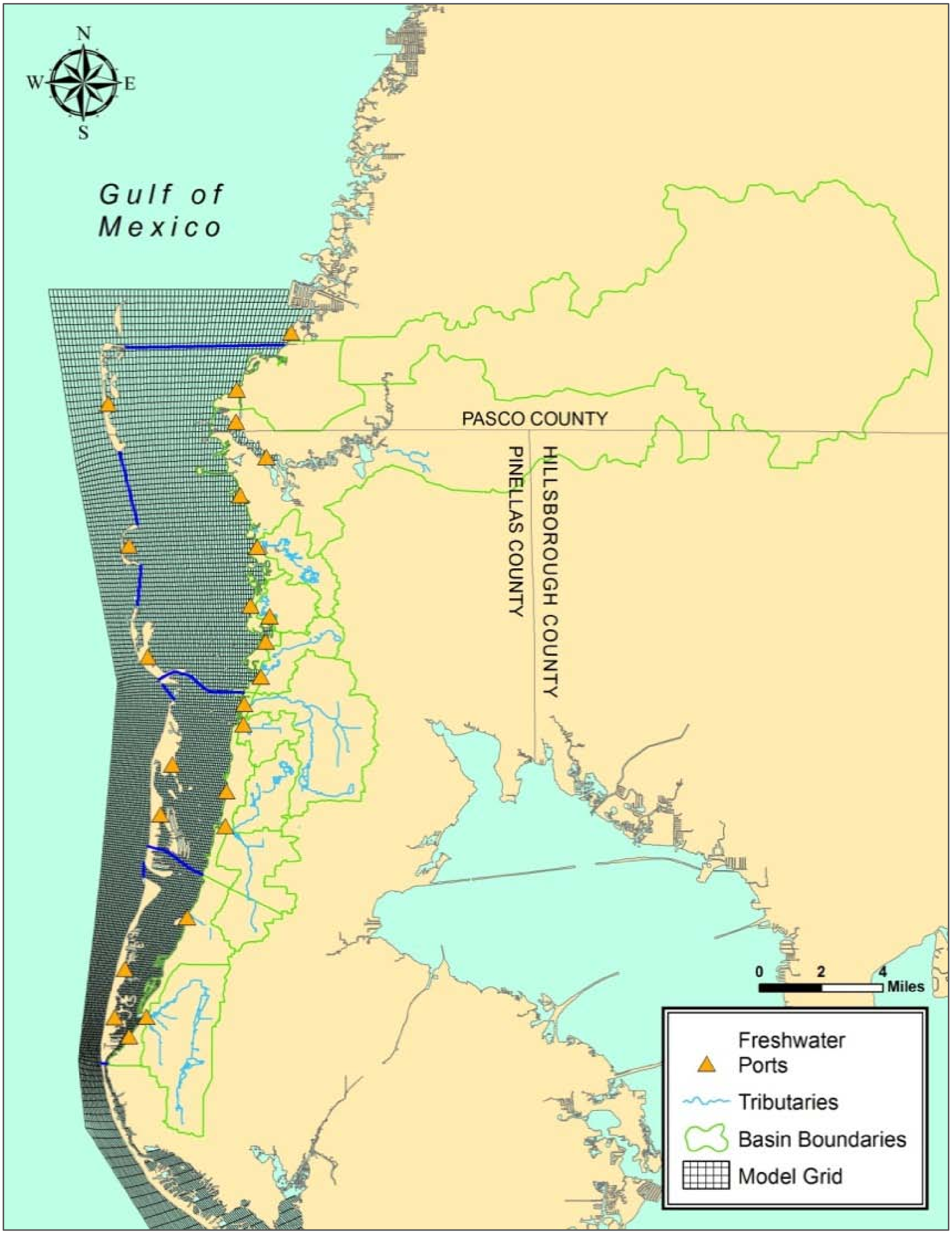


Figure 2-8. Clearwater Harbor/St. Joseph Sound grid system with locations of freshwater inflows (ports).

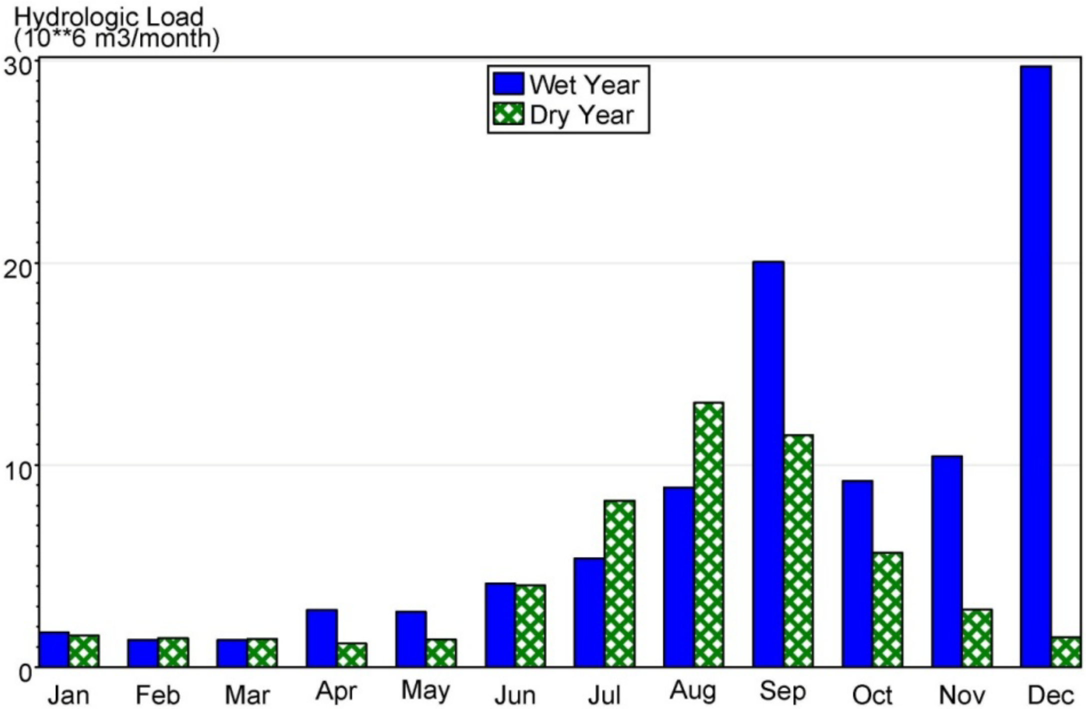


Figure 2-9. Monthly hydrologic loads during wet (1997) and dry (1999) years.

The refined grid model for CHSJS was used to compare expected salinity distributions during a wet year and during a dry year. An exceptionally wet year (i.e. 1997) and an exceptionally dry year (1999) were modeled to include extremes of hydrologic conditions observed over recent history. This allowed for efficient model simulations while maintaining robust predictions across a wide range of conditions expected in the estuary. January of each year was used to "spin up" the EFDC model. A spin-up period is required for the model to adjust from initial condition specifications to a more realistic representation of the system based on the hydrodynamics of the system. A one month spin up period is appropriate based on previous experience in using this model in other Gulf Coast systems as cited above.

Monthly median salinity values were derived from the hourly model output for each scenario, and are provided in Appendix B. The monthly watershed hydrologic loads during the wet and dry years are provided in Figure 2-9. The resultant daily median salinities for each month (excluding January due to spin up period as described above) are provided as box and whisker plots in Figures 2-10 through 2-15 below.

As shown in Figure 2-9, the first half of both the dry year (1999) and the wet year (1997) had very similar hydrologic loads from the watershed. During July and August, hydrologic loads were greater during 1999 than in 1997, and the modeled salinities were responsive to these differences, being higher during July and August during the dry year of 1999 than they were during the same months of 1997. During the last four months, the wet year hydrologic loads were greater than those during the dry year, especially during November and December. During these months, the simulated salinity values were several parts per thousand lower during the wet year than during the dry year, more so in Clearwater Harbor North and Clearwater Harbor South than in St. Joseph Sound. This is as expected, as the tidal influence in St. Joseph Sound is greater than in the two Clearwater Harbor segments, as discussed more below with respect to residence times.

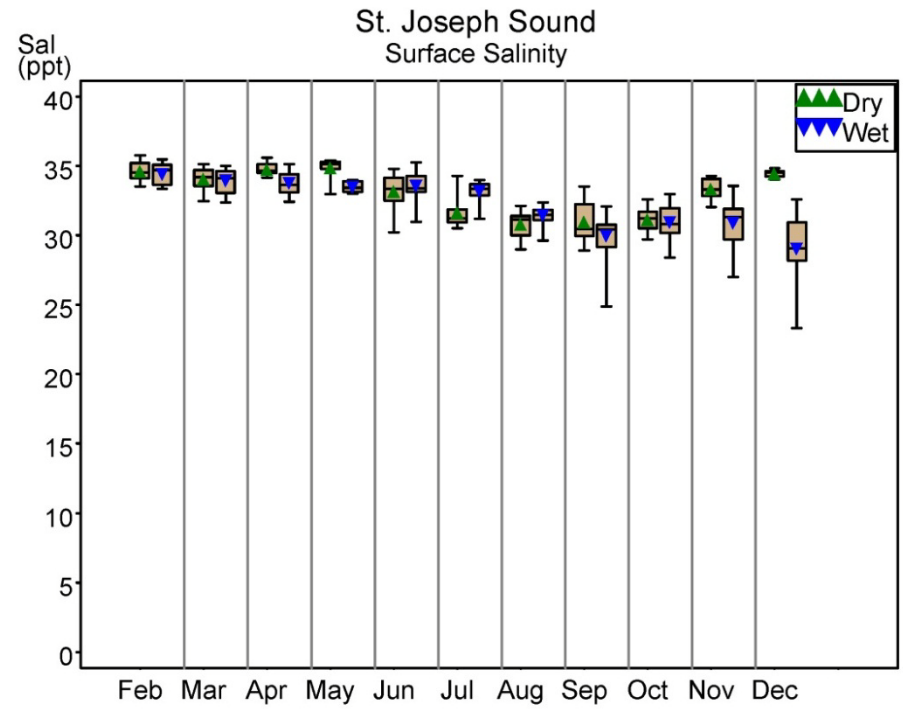


Figure 2-10. Comparison of wet and dry year surface salinities by month in St. Joseph Sound.

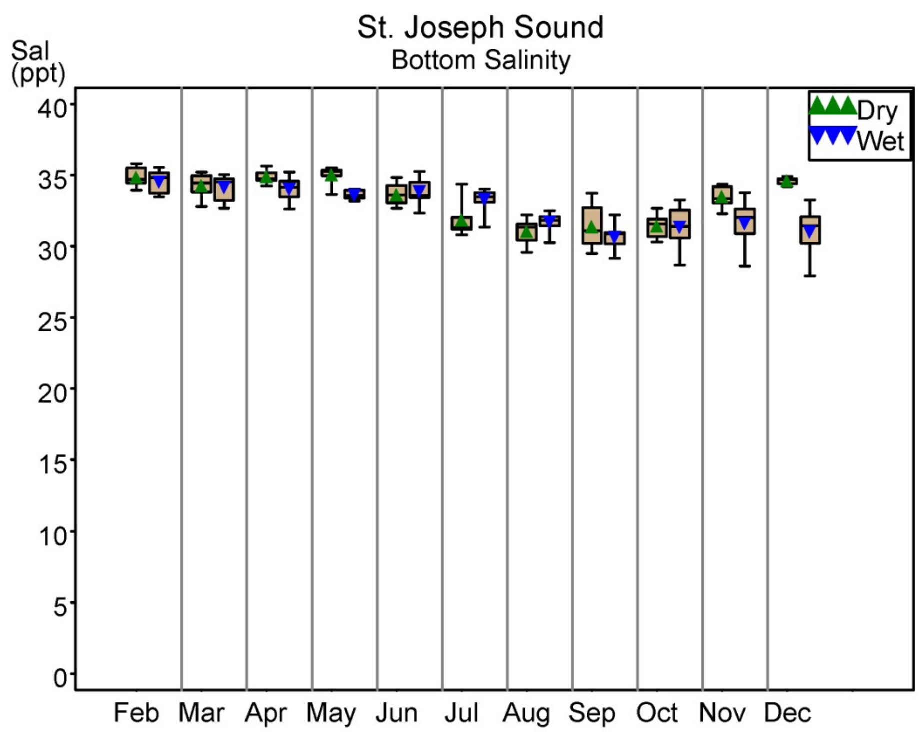


Figure 2-11. Comparison of wet and dry year bottom salinities by month in St. Joseph Sound.

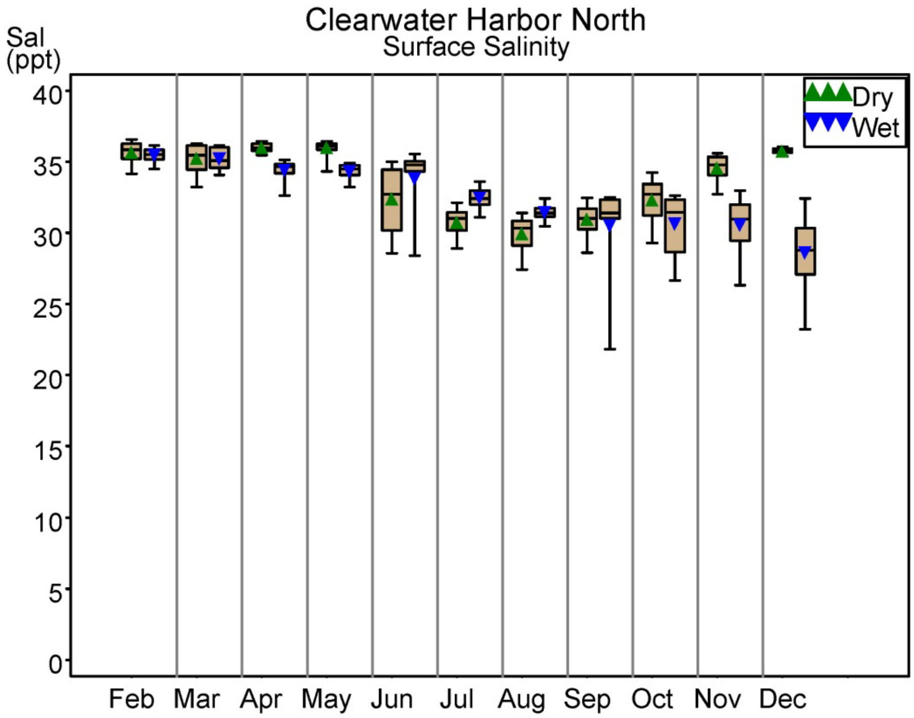


Figure 2-12. **Comparison of wet and dry year surface salinities by month in Clearwater Harbor North.**

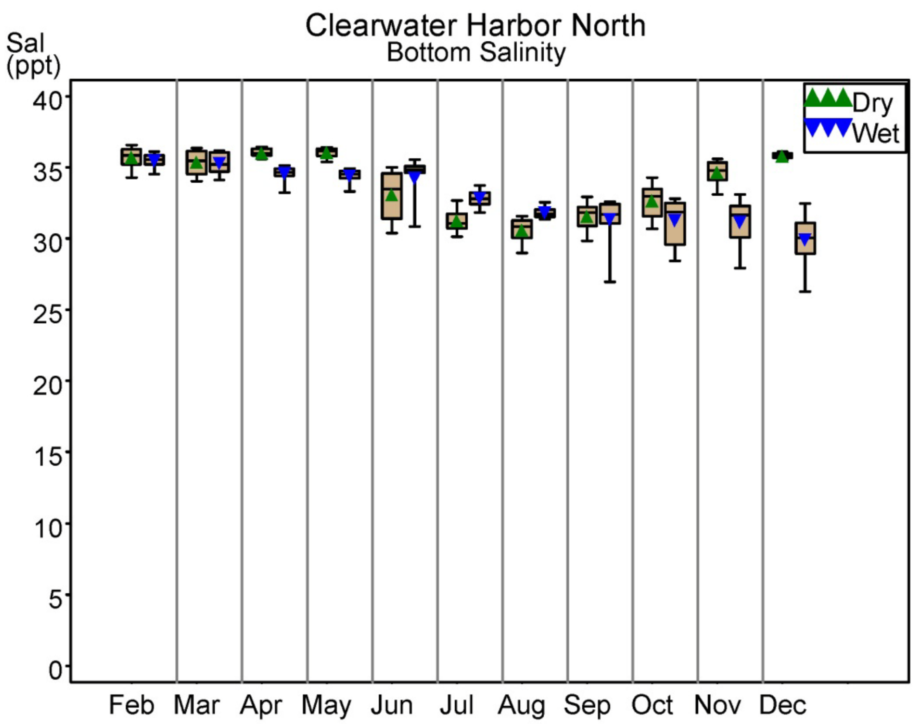


Figure 2-13. **Comparison of wet and dry year bottom salinities by month in Clearwater Harbor North.**

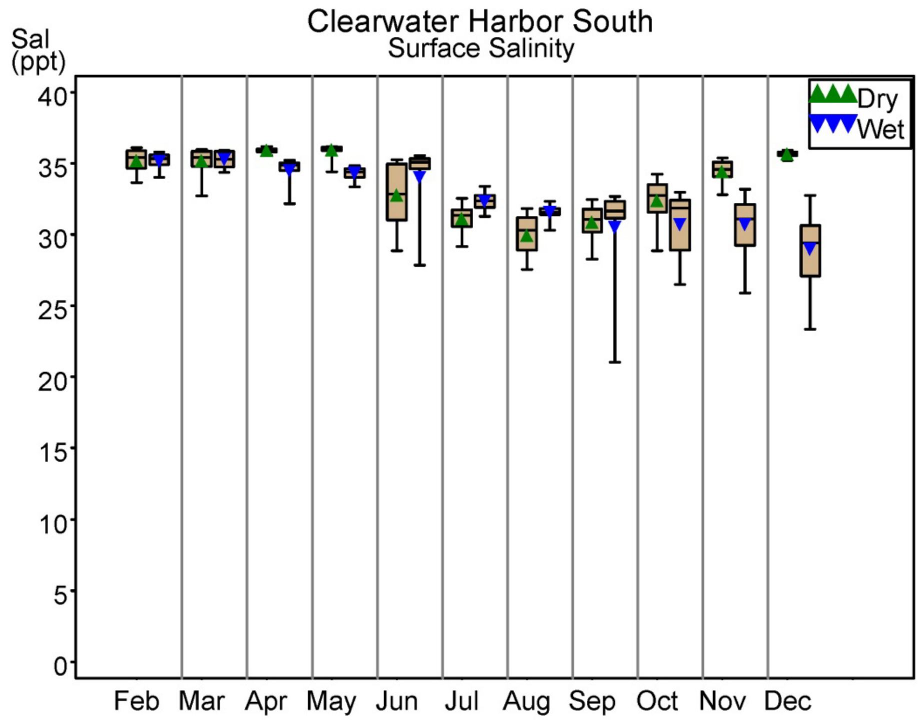


Figure 2-14. **Comparison of wet and dry year surface salinities by month in Clearwater Harbor North.**

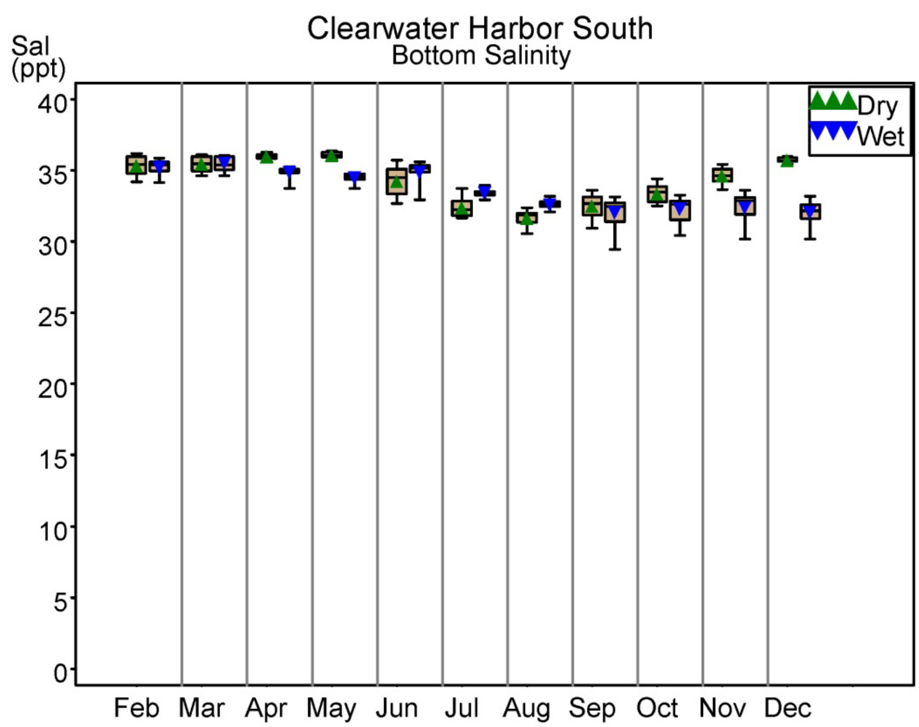


Figure 2-15. **Comparison of wet and dry year bottom salinities by month in Clearwater Harbor South.**

Median monthly surface salinities for each segment in November of the wet year (1997) and the dry year (1999) are provided in Figures 2-16 through 2-18. The effects of the greater hydrologic loads during November 1997 are evident in the salinity distributions, with less saline water in the segments during the wetter November of 1997. All of the monthly median salinity maps, for February-December of both years, are provided in Appendix B.

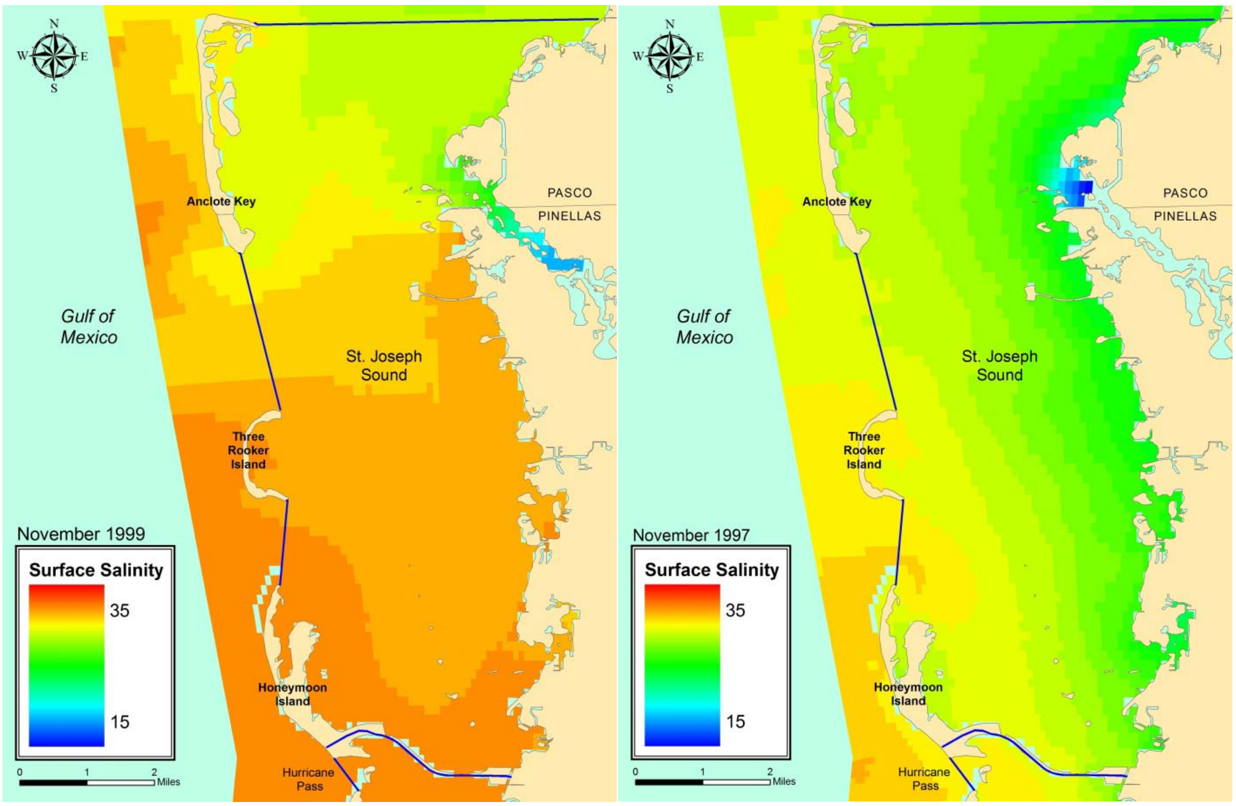


Figure 2-16. Modeled November surface salinity in St. Joseph Sound for wet year (1997) and dry year (1999).

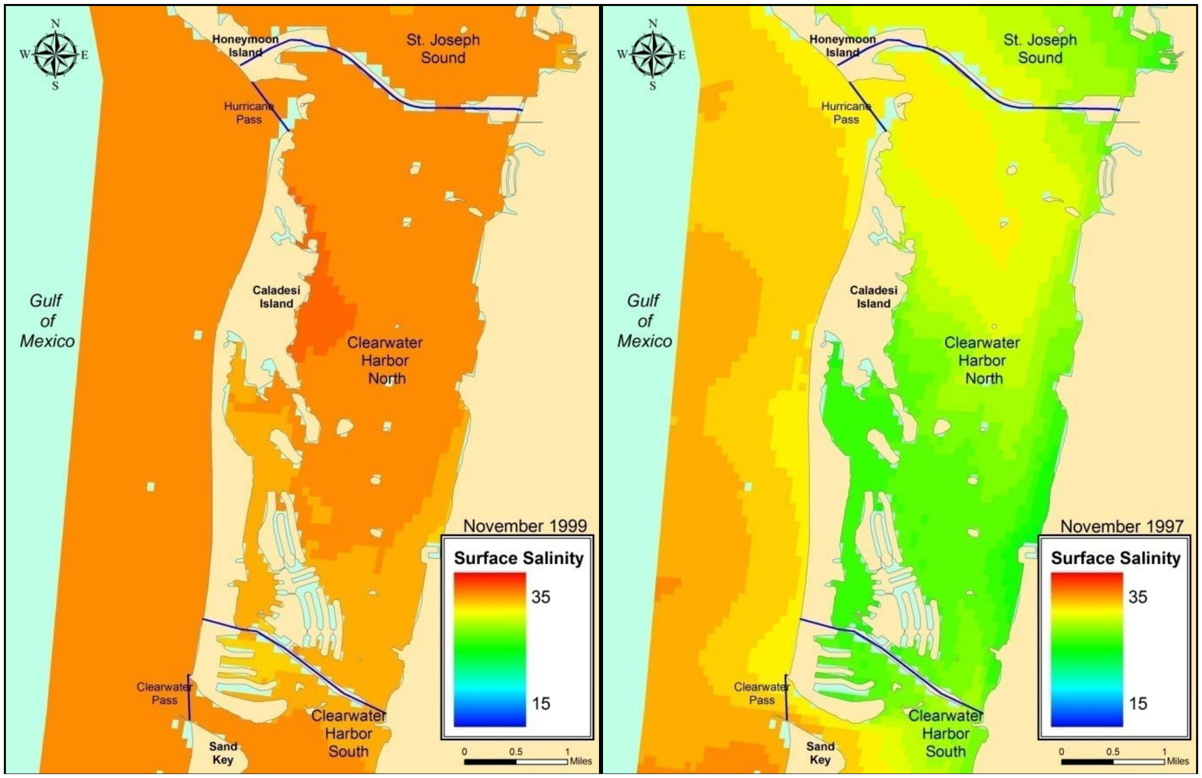


Figure 2-17. **Modeled November surface salinity in Clearwater Harbor North for wet year (1997) and dry year (1999).**

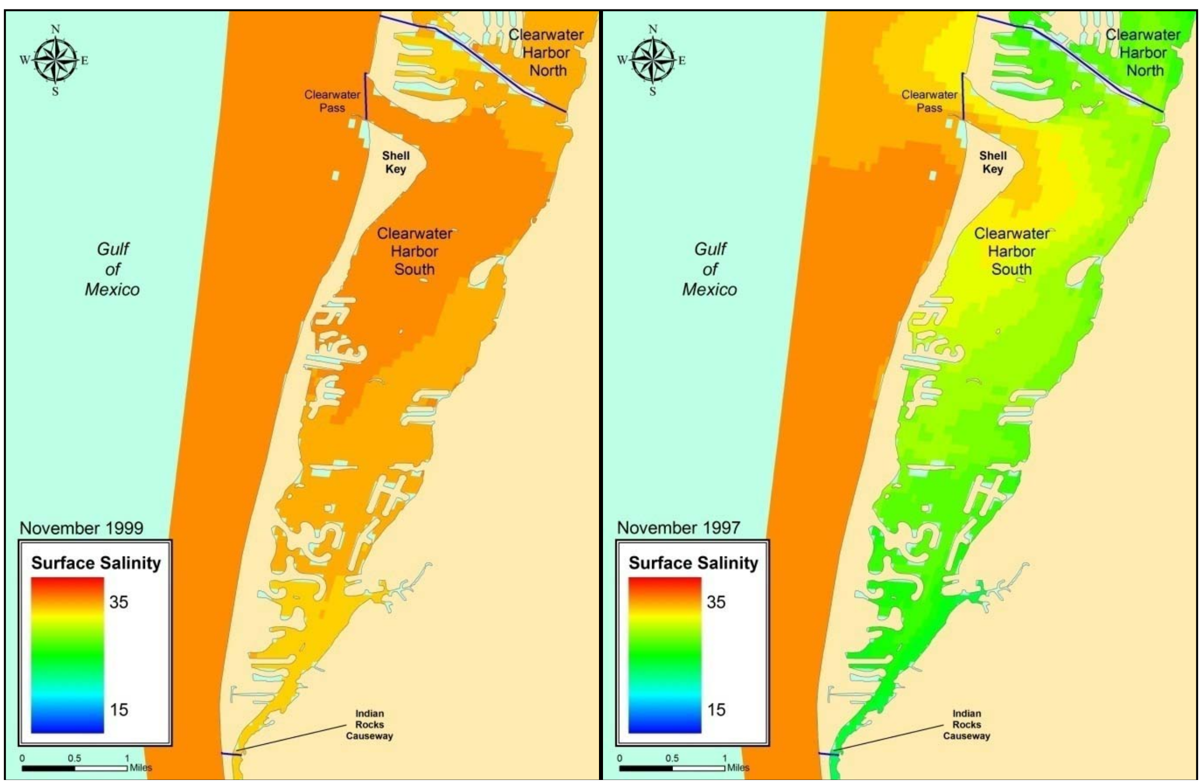


Figure 2-18. **Modeled November surface salinity in Clearwater Harbor South for wet year (1997) and dry year (1999).**

The Clearwater Harbor/St. Joseph Sound hydrodynamic model was also used to develop monthly-specific mean velocity vectors during the wet year (1997) and during the dry year (1999). Monthly mean horizontal velocity vectors were derived from the hourly model output for each scenario, with maps of the surface velocities (representing the top quarter of the water column) provided in Appendix C. January of each year was part of the spin-up period for the model, and so results are not displayed for January.

As shown, the first half of both the dry year (1999) and the wet year (1997) had very similar hydrologic loads from the watershed. During the last four months, the wet year hydrologic loads were greater than those during the dry year, especially during November and December. Based on the surface velocity vectors (Figures 2-19 and 2-20), the differences in hydrologic loads do not greatly impact the circulation in the model domain, with all months showing similar mean flows out of Clearwater Pass and Hurricane Pass, and similar northward mean current velocities throughout Clearwater Harbor.

Typical winter (October-March) Florida Gulf coast shelf water movement is to the southeast, with summer (April-September) water movement along the coast to the northwest. In the less restricted St. Joseph Sound, this pattern is seen, with the summer (June, Figure 2-19) average movement to the north and the winter (November, Figure 2-20) average movement to the south. It is notable that despite the large differences in watershed hydrologic loads during the wet and dry years, especially in November and December, surface circulation patterns are not very different, indicating the importance of the tidal influence and estuarine morphology on circulation in the CHSJS system.

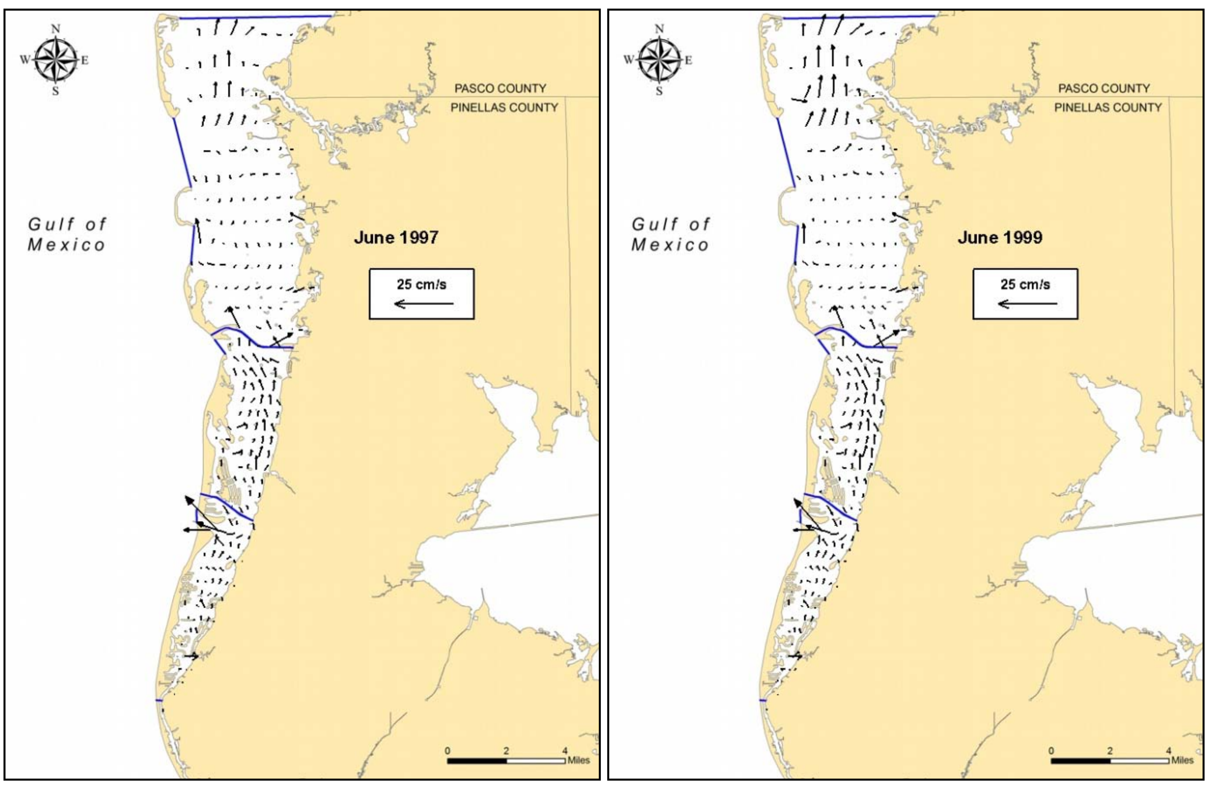


Figure 2-19. Modeled June (summer) surface velocities in Clearwater Harbor and St. Joseph Sound, for wet year (1997) and dry year (1999).

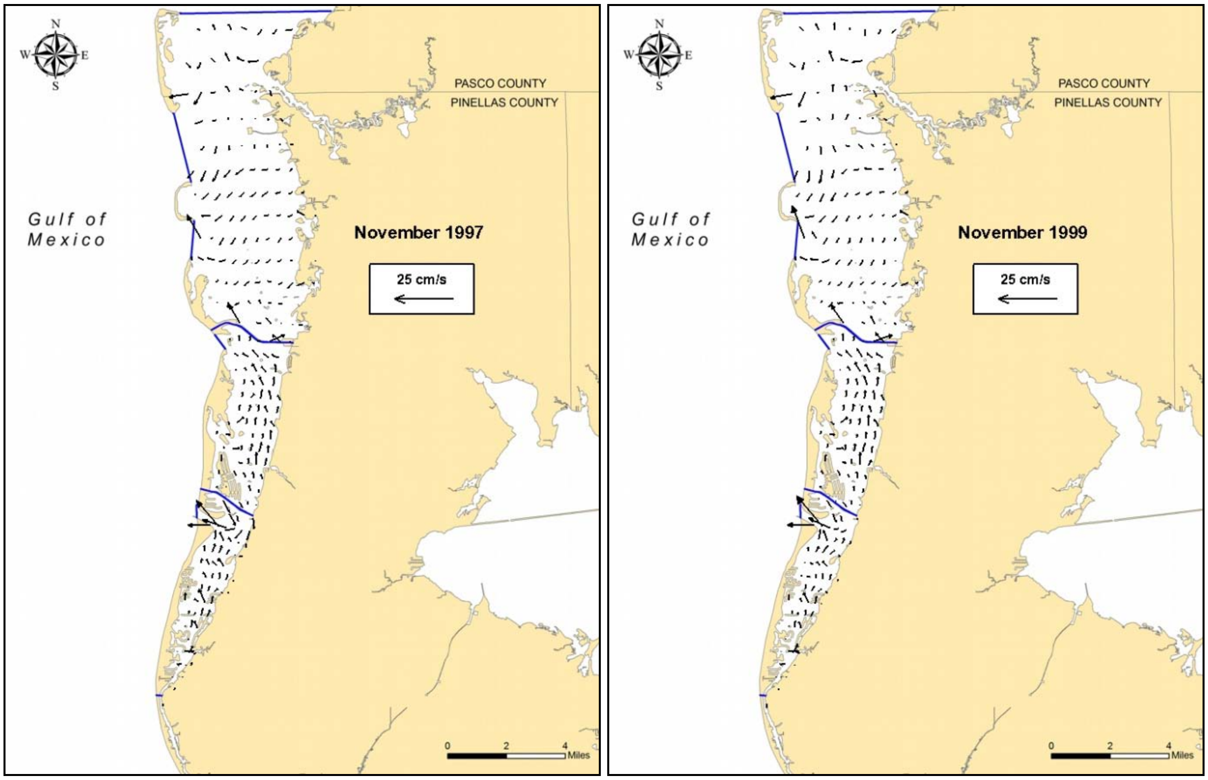


Figure 2-20 Modeled November (winter) surface velocities in Clearwater Harbor and St. Joseph Sound, for wet year (1997) and dry year (1999).

Residence times in the three segments of the system were estimated using the Clearwater Harbor/St. Joseph Sound hydrodynamic model. The hydrologic loadings from the watersheds of the three segments as developed for this project were examined to select a relatively wet year and a relatively dry year. The Clearwater Harbor/St. Joseph Sound hydrodynamic model was then run for these two years separately, using the watershed hydrologic loads for the years.

Residence time is defined here as the length of time required to reduce the mass of a tracer in a given segment to approximately 36% of the initial as in Hagy et al. (2000). The monthly hydrologic loads from the watershed to each segment were apportioned to daily loads based on watershed-specific daily rainfall amounts. Residence times were estimated for each month for both the wet year and the dry year. The wet year selected was 1997, when the total annual hydrologic load to the segments from the watershed (98 million m^3) was almost twice as much as during 1999 (54 million m^3), the dry year selected.

Residence times were estimated by initializing the concentration of a tracer in all three segments at the beginning of each month, so that given the water surface elevation output from the model for each grid cell and the concentration within each cell, the total mass of the tracer at the beginning of the month and the end of the month was determined. The monthly reduction in tracer mass was then translated to a daily tracer loss fraction for the month, which in turn was used to estimate when the tracer mass in each segment reached $e^{-1}$of its original mass as in Hagy et. al. (2000).

As estimated for this analysis, the residence times are averages for the entire segment. Within a segment, residence times at particular locations will be different. This is especially evident in Clearwater Harbor South, where the northern end of the segment is likely to have shorter residence times than does the southern end of the segment, due to the proximity of the northern portion to Clearwater Pass. Similarly, the interior portions of Clearwater Harbor North likely have longer residence times than do both the southern and northern portions of the segment, which are adjacent to Clearwater Pass and Hurricane Pass, respectively.

The results of this analysis for each segment are provided in Table 2-1 below. As seen in the comparison of the monthly values, some months during the wet year may have longer residence times than the same month during the dry year. The flows for a given month during each of the two years may be very similar, but the total over the entire year results in the designation of wet or dry. As expected, wet years result in shorter residence times, although the differences were not dramatically different given the differences in hydrologic loads. For example, in December the watershed hydrologic load to the entire system was approximately 20 times greater in 1997 than in 1999. However, the residence times during this month for the dry year compared to the wet year were only 45% longer in Clearwater Harbor South, 21% longer in Clearwater Harbor North, and 27% longer in St. Joseph Sound. Clearly, exchange with the Gulf of Mexico plays a dominant role in circulation and residence time within the CHSJS system, especially in the two northern, more open segments.

Table 2-1. Estimated residence times (in days) for each month and segment during a wet year (1997) and dry year (1999).

Month	Clearwater Harbor South		Clearwater Harbor North		St. Joseph Sound	
	Dry Year	Wet Year	Dry Year	Wet Year	Dry Year	Wet Year
January	10.0	10.5	8.8	9.8	5.3	5.4
February	14.0	15.1	10.8	10.8	6.2	5.6
March	10.7	15.3	10.4	12.5	4.2	5.5
April	13.5	14.1	10.6	12.3	6.5	5.7
May	13.7	15.9	11.3	12.4	6.2	6.5
June	13.2	13.4	14.6	11.7	4.7	5.6
July	13.3	13.3	13.8	12.3	5.4	6.1
August	13.6	13.5	13.4	11.8	6.2	6.9
September	12.5	11.4	10.7	10.1	6.3	4.8
October	13.2	12.8	9.4	9.9	6.8	6.3
November	16.2	12.0	9.6	9.1	7.5	6.0
December	13.9	9.6	11.4	9.4	5.2	4.1
Average	13.2	13.1	11.2	11.0	5.9	5.7

2.4 Environmental Lands

This section provides a summary of the current status of environmental lands within the project area estuaries, as well as issues critical to the management of these lands. Environmental lands in Pinellas County include publicly-owned preserves, other managed environmentally sensitive lands, and passive recreation parks. Environmental lands can be differentiated from active recreation parks (e.g., ball fields) and other open space in that they: support the sustainability of natural resources, watersheds, and natural habitat; provide resource-based recreational opportunities; and promote a healthy environment and community.

Within the estuarine boundaries of CHSJS study area, several environmental lands are owned and managed by the Florida Department of Environmental Protection (FDEP) and Pinellas County. There are no federally owned/managed environmental lands in the project area.

Pinellas County is unique in the State of Florida in that all submerged lands and tidal waters within the County boundaries are designated as an Aquatic Preserve pursuant to Chapter 258, Florida Statutes, adding to already designated environmental lands. The Pinellas County Aquatic Preserve includes approximately 350,000 acres of submerged lands.

2.4.1 Data Description

An inventory of environmental lands in the project area estuaries was conducted by reviewing SWFWMD's 2007 land use data and local government property appraiser databases. Based on these data, there are nine designated environmental lands in the Clearwater Harbor and St. Joseph Sound estuarine study area. The estuarine environmental lands in the project area are listed in Table 2-2, which also provides the owner, managing entity, size, and estuary location for each of these environmental lands. The environmental lands are presented in Figure 2-21.

Table 2-2. Environmental lands in the Clearwater Harbor and St. Joseph Sound.

Name	Owner	Managing Entity	Total Acres	Estuary
Anclote Key Preserve State Park	State of Florida	FDEP	12,177	St. Joseph Sound
Honeymoon Island State Park	State of Florida	FDEP	2,810	St. Joseph Sound
Caladesi Island State Park	State of Florida	FDEP	2,470	Clearwater Harbor
Fred Howard Park	Pinellas County	Pinellas County	155	St. Joseph Sound
Wall Springs Park	Pinellas County	Pinellas County	198	St. Joseph Sound
Sand Key Park	Pinellas County	Pinellas County	95	Clearwater Harbor
Mariners Point Management Area	Pinellas County	Pinellas County	76	St. Joseph Sound
Anclote Islands Management Area	Pinellas County	Pinellas County	160	St. Joseph Sound
King Islands Management Area	Pinellas County	Pinellas County	25	Clearwater Harbor

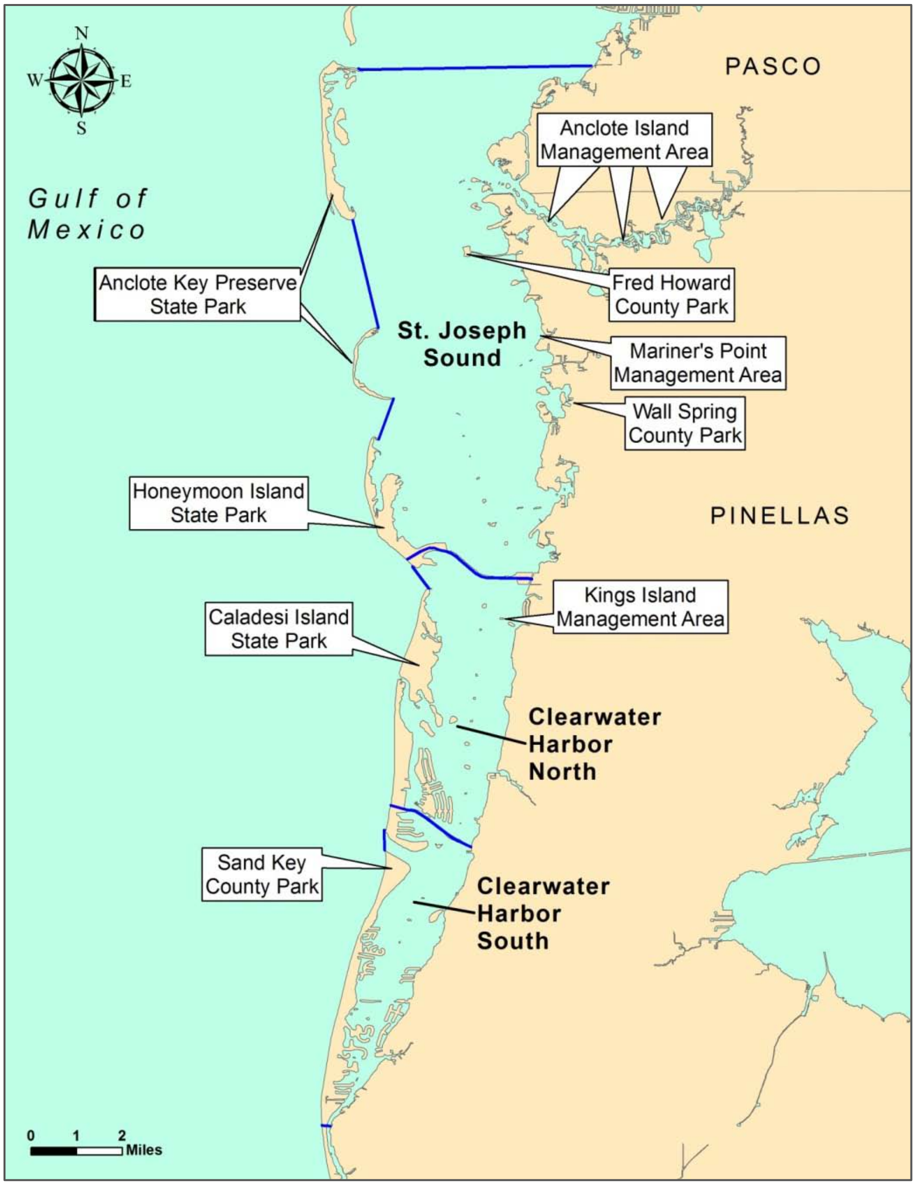


Figure 2-21. Location of environmental lands in the CHSJS area.

2.4.2 State Parks

Anclote Key, Honeymoon Island, and Caladesi Island are three of Florida's few remaining intact, undeveloped barrier islands. While none of these barrier islands has been designated as an Area of Critical State Concern, as defined in Section 380.05, Florida Statutes, they have been effectively preserved as State Parks. The Pinellas County Aquatic Preserve contains portions of three County parks. As such, all waters are classified as Class III by FDEP.

The FDEP Division of Recreation and Parks is responsible for the maintenance and management of the three State Parks, and has developed Unit Management Plans for each. These plans include detailed information regarding existing conditions in the parks as well as management issues, goals and programs. The sections that follow are brief summaries of the existing conditions in the three State Parks.

Anclote Key Preserve State Park - comprises approximately 437 acres of uplands located in the Gulf of Mexico, three miles offshore near Tarpon Springs in western Pasco and Pinellas Counties. It consists of several barrier islands of varying size and shape. Besides the island of Anclote Key there is North Anclote Key, which is almost contiguous with the north end of Anclote Key. Another Island is Three Rooker Island, about three miles south of Anclote Key. Three Rooker Island and the southern tip of Anclote Key are in Pinellas County, while the remainder of Anclote Key, as well as North Anclote Key, are in Pasco County. When the submerged lands are included, the entire preserve encompasses over 12,000 acres.

Anclote Key itself was acquired by trade with the U.S. Government for state land in the J. N. "Ding" Darling National Wildlife Refuge. In July 1988, Three Rooker Island was added, and in July 1996, the lighthouse on Anclote Key and the small lot that it occupies was donated by the U.S. Government. Two small mangrove islands (Dutchman Key and North Keys) just landward of Anclote Key have been identified for acquisition (FDEP, 2001). Access to the preserve is by boat only. Development is restricted to the minimum necessary for user safety and natural resource interpretation. Public outdoor recreation is the designated single use of the property. There are no legislative or executive directives that constrain the use of this property (FDEP, 2001).

Longshore drift is predominately northward at the latitude of Anclote Key (Johnson and Barbour 1990), and a new barrier island (Anclote Bar) has formed about two miles north of the preserve. Anclote Bar essentially marks the northern terminus of barrier island development on the west coast of Florida. From this new island north to the Ochlockonee River drainage is open coastal estuary with no barrier islands (FDEP, 2001).

Anclote Key Preserve State Park contains seven distinct natural communities:

- Beach dune,
- Coastal strand,
- Maritime hammock,
- Mesic flatwoods,
- Marine tidal marsh (predominantly *Spartina alterniflora,*
- Marine tidal swamp (mangroves), and
- Marine unconsolidated substrate (mud and sand flats).

In addition to native plant communities, the park contains limited ruderal areas (e.g., areas altered by human activities) that have little native vegetation and have often been replaced by weedy or exotic species.

Designated species are those which are listed by the Florida Natural Areas Inventory (FNAI), U.S. Fish and Wildlife Service (USFWS), Florida Fish and Wildlife Conservation Commission (FWC), and the Florida Department of Agriculture and Consumer Services (FDACS) as endangered, threatened or of special concern.

Three Rooker Island is a very significant nesting site for shorebirds (herein defined to include larids) on a statewide basis, ranking among the top five sites (Douglass, 1997). In addition to 5,000 laughing gull nests, American oystercatcher, black skimmer, least tern and snowy plover nests have been recorded on the island (Schnapf, 1997). Three Rooker Island is an important wintering site, and is used by piping plovers and a myriad of other species. However, there is now so much human use of this small island that nesting and resting birds are seriously threatened. As an indication of the intensive recreational use, the preserve has received requests from food vendors for permits to supply food service there. Attempts to have the area declared a Critical Wildlife Area by the FWC in 1995 were not successful. Recent attempts to post the nesting sites against trespassing have met with more success. In addition to shorebirds, southern bald eagle and osprey nests occur in slash pine trees and snags on Anclote Key.

Atlantic loggerhead sea turtles are known to crawl up on the beach at Anclote Key during nesting season (Brewer, 1997), but nesting has not been adequately monitored. Raccoons, which are responsible for most sea turtle nest predation on carrier islands to the south, are also present on Anclote Key. West Indian manatees, utilizing the Anclote River and the warm water refuge provided by the springs in Whitecomb Bayou, also use seagrass beds in the park.

Honeymoon Island State Park - is located in Pinellas County about four miles northwest of downtown Dunedin, and about two miles from the mainland shoreline. The island has been accessible from the mainland via highway State Road 586 and the Dunedin Causeway since 1965. St. Joseph Sound lies between the island and the mainland. A small mangrove island, Grassy Key, lies off the eastern shore of Honeymoon Island (FDEP, 2007b).

Acquisition of the barrier island began in 1974, after the failure of an extensive commercial development scheme of high-density dwellings (Luisi, 1999). Initially, funds from the 1972 sale of general obligation bonds were used. Later purchases were made with funds from the Land Acquisition Trust Fund. Currently the park contains approximately 2,810 acres. The park is the location of the administrative office for the following parks: Egmont Key State Park, Skyway Fishing Piers State Park, Caladesi Island State Park, and Anclote Key Preserve State Park (FDEP, 2007b).

At Honeymoon Island State Park, public outdoor recreation is the designated single use of the property. There are no legislative or executive directives that constrain the use of this property. Honeymoon Island State Park is a favorite destination for beach recreation and nature study. It consistently ranks among the top five most visited parks in the Florida State Parks system (FDEP, 2007b).

Honeymoon Island State Park contains nine distinct natural communities in addition to rural and developed areas. Natural communities include:

- Beach dune,
- Coastal strand,
- Maritime hammock,
- Mesic flatwoods,
- Marine grass bed,
- Marine mollusk reef (oyster *Ostrea frons*),
- Marine tidal marsh (*Spartina alterniflora*),
- Marine tidal swamp (mangroves), and
- Marine unconsolidated substrate (mud and sand flats).

Honeymoon Island is a very significant feeding and wintering site for shorebirds. It is ranked second among 27 sites in biological importance to wintering shorebirds on the southeast coast of the U.S., and is ranked third in the State of Florida (Sprandel et al., 1997). It is located due south and in close proximity to Three Rooker Island, which is consistently ranked among the top five shorebird nesting sites in the State by biologists of the FWC. A large number of piping plovers, a state- and federally-listed threatened species, forage and rest at Honeymoon Island. The island also supports several species of nesting shorebirds, including Wilson's plover and two threatened species, the least tern and the snowy plover, as well as a species of special concern, the American oystercatcher (FDEP, 2007b).

In addition to the four listed species of shorebirds noted above, 34 other designated bird species have been documented in the park. Six designated reptile species, and one designated mammal species have been documented. As for plants, four designated species have been discovered in the park. The park is noted for its large number of osprey nests. The hiking trail which traverses the northern half of the island, passes in close proximity to several of the nests, without apparent harm (FDEP, 2007b).

Atlantic loggerhead sea turtles nest on the beach. Raccoons, which are responsible for most sea turtle nest predation on barrier islands, are also present on Honeymoon Island. West Indian manatees, utilizing the Anclote River and the warm water refuge provided by the springs in Whitecomb Bayou, also use seagrass beds in the park. Manatees have been seen in the shallow seagrass beds north of the park manager residences (FDEP, 2007b).

Caladesi Island State Park - is located in Pinellas County about two miles and west of the town of Dunedin. The park is accessible by private boat or watercraft, and a ferry service is provided from nearby Honeymoon Island State Park, at the western terminus of State Road 586. The entrance to Honeymoon Island State Park is five miles west of U.S. Highway 19. Technically, Caladesi is no longer an island. Dunedin Pass, that once separated it from Clearwater Island to the south, has in recent years filled with sand, joining the two islands. Visitors can now reach the park by walking north from Clearwater Beach (FDEP, 2007a).

Currently the park contains approximately 2,470 acres. The initial acquisition was a donation by the City of Dunedin in 1966. From 1967 through 1969, additional acquisitions were made using funds for the Land Acquisition Trust Fund and the Federal Land and Water Conservation Fund. The last acquisition was a donation in 1983. Public outdoor recreation and conservation of the property are the sole designated uses. There are no legislative or executive directives that constrain the use of this property. Caladesi Island is a favored destination for boaters, tourists and a popular site for beach recreation. An annual survey of U.S. recreational beaches by the University of Maryland's Laboratory for Coastal Research, consistently places Caladesi Island in the top ten (e.g., in both 2006 and 2007 the ranking was number 2). The beach ranking is based on 50 criteria including width, softness of sand, water temperature, pollution and crowding. The park is a component of the Florida Greenways and Trails System (FDEP, 2007a).

Caladesi Island is one of Florida's few remaining intact, undeveloped barrier islands and less than ten percent of the uplands have been disturbed to provide visitor and support facilities. Further disturbance has been in the form of invasive exotic plants and by a network of small canals dug throughout the mangroves for mosquito control in the late 1960 and early 1970s. The island is three-quarters of a mile wide at its broadest point. In length, it stretches about four miles; the length includes three small satellite mangrove islands. Cultural resources are evident in the remains of a Pre-Columbian burial mound, a shell scatter site and of a nineteenth century homestead (FDEP, 2007a).

Caladesi Island State Park contains nine distinct natural communities in addition to ruderal and developed areas. Natural communities include:

- Beach dune,
- Coastal strand,
- Maritime hammock,
- Mesic flatwoods,
- Shell mound,
- Marine grass bed,
- Marine mollusk reef (oyster *Crassostrea virginica*),
- Marine tidal marsh (*Spartina alterniflora*),
- Marine tidal swamp (mangroves), and
- Marine unconsolidated substrate (mud and sand flats).

2.4.3 County Parks

Three Pinellas County parks border the CHSJS estuarine area. The primary designated use of Pinellas County parks is public recreation; however, the County also strongly promotes natural resource conservation and public environmental education at its park facilities. The following provides a brief summary of the three County parks.

Fred Howard Park - consists of 155 acres and is located on the Gulf of Mexico. The park was named in honor of Fred H. Howard, former Mayor of Tarpon Springs, and was dedicated in April 16, 1966. Howard Park's location provides access to the Gulf of Mexico by a 1-mile long causeway. The white sandy beach is a very popular north county swim area. The causeway is also used for sunbathing, fishing and exercising.
The park was constructed when access to the barrier islands was much more limited, thus providing convenient access to the Gulf and a swimming beach for the citizens of Tarpon Springs. The park was created from spoil material dredged from surrounding sub-tidal areas prior to the enactment of the federal environmental regulations in the 1970s that now restrict dredge and fill activities.

Remnants of historical habitats still remain, and second growth habitats have established, within park boundaries, including:

- Long leaf and slash pine flatwoods,
- Turkey oak - long leaf pine sandhill,
- Coastal scrub,
- Marine grass bed,
- Marine tidal marsh,
- Marine tidal swamp, and
- Salt barrens.

(http://www.pinellascounty.org/park/06_howard.htm)

Wall Springs Park - consists of 195 acres, and includes a historic spring once used as a spa and bathing area from the turn of the 20th century until the mid-1960s. Pinellas County began acquiring the Wall Springs property in 1988, with the initial purchase of approximately 63 acres which included the spring and surrounding area. The County has continued to acquire additional property since their initial purchase. The park now includes boardwalks, nature trails, playground, a 35-foot observation tower, bike racks, drinking fountains, restrooms, parking lot, and access to the Pinellas Trail. (http://www.pinellascounty.org/park/21_wall_springs.htm)

Wall Springs is a major spring with mean annual freshwater discharges of 4.2 million gallons per day. The spring run, which discharges to tidal waters of St. Joseph Sound, is a rare freshwater/estuarine habitat. Other habitats contained within the park boundaries include:

- Spring-run stream,
- Clastic upland lake,
- Marine tidal swamp,
- Marine tidal marsh,
- Mesic flatwoods,
- Xeric hammock,
- Upland mixed forest,
- Unconsolidated substrate,
- Marine mollusk reef, and
- Marine grass bed.

Sand Key Park - consists of 95 acres located on the northern end of the barrier island of Sand Key. The park was opened to the public in 1984, and comprises two components: a beachfront on the Gulf of Mexico, and a park area along Clearwater Harbor. Sand Key Park houses the base of operations for the artificial reef program, an interdepartmental cooperation program to build a reef in the Gulf. Sand Key Park's natural communities include a beach where sea turtles annually deposit eggs. The nearby Clearwater Aquarium takes responsibility for these nests and keeps statistics. In July 2002, the media chronicled 84 hatchlings from a rare Kemp's Ridley Sea Turtle making their way to the Gulf of Mexico. A salt marsh with viewing benches further enhances the park, where heron, roseate spoonbill, great horned owl, anhinga, and common moorhen nest and feed. The park has nine boardwalks leading to the beach. (http://www.pinellascounty.org/park/15_Sand_Key.htm)

2.4.4 County Management Areas

County management areas are smaller, publicly-owned parcels that have been acquired, and are managed, primarily for environmental conservation purposes. These areas do not have restroom facilities such as restrooms or public educations displays, nor do they provide any active recreational amenities.

Mariners Point Management Area - is a 76-acre tract located in Tarpon Springs. The Pinellas County Board of County Commissioners acquired the property in 1990. The site was historically composed of a mosaic of emergent tidal wetlands and wet pine flatwoods that drained via sheetflow to St. Joseph Sound. While the site has never been developed, hydrologic impacts have occurred primarily to improve drainage of adjacent developed parcels.

Hydrologic modifications include the dredging of a freshwater marsh and a canal to St. Joseph Sound, and the construction of a stormwater culvert and sump in the southeastern corner of the property.

The area supports a diverse array of natural communities, including tidal swamp dominated by mangroves, tidal marshes dominated by rushes, and flatwoods dominated by pines and saw palmetto. Also supported are extensive sandhills, a unique upland community dominated by longleaf pine, oaks, wiregrass, and hogplum. Disturbance has resulted in ruderal areas and has encouraged the spread of invasive exotic species, including Brazilian pepper, punktree, guineagrass, and air-potato. The spread of other exotics, such as carrotwood and camphor tree, has been promoted by surrounding landscaping in nearby residential areas. Rare species that utilize the area include gopher tortoises and bald eagles.
(http://www.pinellascounty.org/park/managedlands/pdf/MPMA.pdf)

Anclote Islands Management Area - is a cluster of intertidal islands and riparian wetlands in the Anclote River, comprising a total land area of approximately 160 acres. The management area was acquired through a number of land purchases from the mid-1990s to 2004 by the Pinellas County Board of County Commissioners. Elevations range up to several feet above sea level, with many portions of the management area permanently inundated. The dominant soil types are mucks and fine sands that support tidal swamp and tidal marsh communities. The tidal swamps consist primarily of red and black mangroves, but also support buttonbush, glasswort, cordgrass, needlerush, and sea purslane. The tidal marshes are dominated by black rushes, but also support bulrushes, cordgrass, and saltwort. These communities provide habitat for a wide variety of saltwater fishes and wading birds. Because this management areas has not been heavily disturbed, exotic species are not as predominant a problem as at some other natural areas.
(http://www.pinellascounty.org/park/managedlands/pdf/AIMA.pdf).

King Islands Management Area is an approximate 25-acre parcel in Clearwater Harbor North, immediately west of the City of Dunedin. This management area is composed of two mangrove islands and surrounding submerged lands. This parcel was dedicated to the Pinellas County Board of County Commissioners by a private entity. Audubon has been surveying and managing Kings Island West (aka Dunedin Sand Key West) since the early 1990s. Before then it was posted by the island's owners.
(http://www.pinellascounty.org/park/managedlands/pdf/KIMA.pdf)

3.0 Physical Characterization of the CHSJS Watershed

Watershed characteristics profoundly impact estuarine health. This chapter describes the watershed characteristics of the CHSJS. Land use, soils, hydrology, and physical features all influence estuarine water quality, circulation, and the biological communities both within the watershed and in the downstream estuary. Each of the estuarine segments of the CHSJS CCMP has a watershed that delivers freshwater and a suite of water quality constituents that can significantly influence the receiving waterbody depending upon the magnitude and timing of delivery.

Each segment's watershed is in turn comprised of several individual watershed sub-basins which can be drastically different from adjacent sub-basins in terms of land use and hydrology. In general, the watersheds of Clearwater Harbor North and Clearwater Harbor South are highly urbanized as illustrated by the land use summary in Table 3-1, while the St. Joseph Sound watershed remains over 50% undeveloped and includes the largest areas of freshwater wetlands in the CHSJS. Development in the southern segments of the CHSJS is comprised principally of high density residential and commercial/institutional land uses with large areas of impervious surface. The intensive levels of development, in concert with widespread modifications to the surface water hydrologic system, have significant consequences regarding hydrologic and pollutant loadings to the estuary.

Table 3-1. Percent land use type for each segment watershed based on SWFWMD 2007 land use coverage.

Land Use	St. Joseph Sound	Clearwater Harbor North	Clearwater Harbor South
High Density Residential	13	56	60
Medium Density Residential	10	9	3
Low Density Residential	3	2	1
Commercial/Institutional	6	17	16
Industrial	1	0	1
Agriculture	0	0	0
Pasture	16	0	0
Open Land	9	8	14
Upland Forest	13	2	<1
Freshwater Wetlands	21	2	1
Fresh water	6	2	3
Saltwater Wetlands	2	2	<1

A summary of the land use codes that comprise the categories in Table 3-1 as well as the event mean concentrations and season specific soil runoff coefficients are provided in Appendix D. The following sections describe land use characteristics for each segment's watershed, with more detailed accounting of land use types and hydrologic features within each of the watershed sub-basins. Each segment's watershed consists of several sub-basins with individual water features that provide freshwater inflows to the estuary. An understanding of watershed characteristics at this localized level allows for the development of effective, site-specific management alternatives.

The following describes each of the named sub-basins within the St. Joseph Sound watershed.

3.1 St. Joseph Sound Watershed

The St. Joseph Sound watershed is approximately 132 square miles (84,416 acres) in area and includes portions of mainland Pinellas and Pasco Counties and the eastern portions of offshore barrier islands. The watershed is bounded to the east by the western boundaries of the Lake Tarpon and Tampa Bay watersheds, to the north by the Pithlachascotee River watershed, to the west by St. Joseph Sound, and to the south by the Clearwater Harbor North and Tampa Bay watersheds. The St Joseph Sound watershed includes seven named sub-basins (Figure 3-1):

- Anclote River Gaged – 74 square miles,
- Anclote River Ungaged – 40 square miles,
- North of Anclote River – 7.7 square miles,
- Klosterman Bayou – 3.2 square miles,
- Sutherland Bayou – 2.4 square miles,
- Smith Bayou – 2.9 square miles, and
- Coastal– 4.2 square miles.

- **Land Use**

Dominant land uses in the St. Joseph Sound watershed include residential (26%), freshwater wetlands (21%), and pasture (16%), as shown in Table 3-2. Land uses include residential and commercial in the southern and western potions of the watershed, especially in the part of the watershed within Pinellas County. Mixed natural, rural, and agricultural land uses predominate

Table 3-2. 2007 land use percent coverage in St. Joseph Sound sub-basins.

Land Use	Anclote River	Klosterman Bayou	Sutherland Bayou	Smith Bayou	Coastal Basin
High Density Residential	11	33	20	51	8
Medium Density Residential	9	5	47	19	16
Low Density Residential	3	4	8	6	2
Commercial/Institutional	6	8	10	14	2
Industrial	1	1	0	1	1
Pasture	17	0	1	0	0
Open Land	8	28	6	2	22
Upland Forest	14	5	3	1	9
Freshwater Wetlands	23	10	2	4	1
Fresh water	6	6	3	2	11
Beaches	0	0	0	0	7
Saltwater Wetlands	1	0	0	0	21

Figure 3-1. St. Joseph Sound watershed and contributing sub-basins.

in the east and north, especially in that portion of the Anclote watershed in Pasco County (Figure 3-2). The barrier islands are generally undeveloped. The comparison of land use changes that is discussed in the following chapter includes only the Pinellas County portion of the St. Joseph Sound watershed.

- **Soils**

The nature of the soils within a watershed can have a significant influence on both the quantity and quality of water that leaves the watershed and is ultimately delivered to the estuary (Gordon et al., 1992). In terms of quantity, the rate of infiltration varies among soil groups and as a result affects the amount of runoff leaving a watershed. In addition to topography, the timing of the delivery of runoff is also highly dependent upon the soil characteristics such as sediment size. In terms of quality, the chemical nature of the soils is a significant factor affecting the chemistry of both interstitial and surface waters.

Soils are classified by the U.S. Department of Agriculture's National Resources Conservation Service (USDA , 1993) into specific hydrologic soil groups based on the properties of the soil and the likelihood of rainfall either being infiltrated or resulting in runoff. Hydrologic soil groups are defined as:

- A - Low runoff potential, high infiltration,
- B - Moderately low runoff potential, moderately high infiltration,
- C - Moderately high runoff potential, moderately low infiltration, or
- D - High runoff potential, low infiltration.

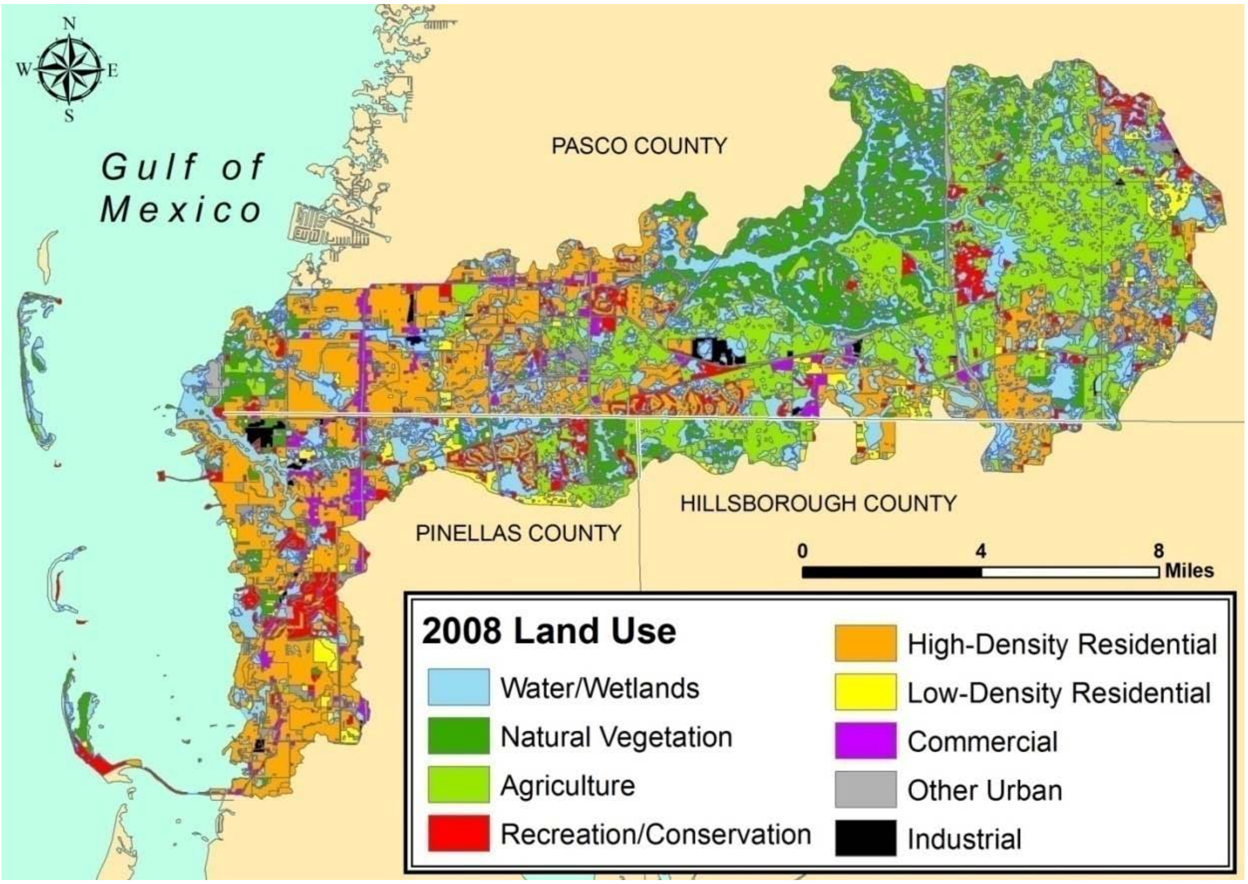


Figure 3-2. 2008 Land use/cover in the St. Joseph Sound watershed (SWFWMD, 2010).

Dual hydrologic group classifications occur when, for example, wet soils that are typically well-drained (i.e., groups A and B) are influenced by a high water table (within 60 cm of the surface). In such cases the soil is considered to have high runoff potential.

The extent of the various hydrologic soil groups can be seen in Figure 3-3. The extent of these soils within each of the sub-basins that comprise the St. Joseph Sound watershed is summarized in Table 3-3. Soils in the St. Joseph Sound watershed are generally sandy and well-drained except in the coastal lowlands. The majority of soils within the Pinellas County portion of the watershed, including the Klosterman Bayou, Sutherland Bayou, and Smith Bayou sub-basins, are Group A soils consisting primarily of Astatula Fine Sand (86% of the watershed) (Figure 3-3).

Group B/D soils and the poorly drained Groups C and D are much less common (2-7% each) and consist of tidal, frequently flooded and urban-fine sand complexes. These soils are more commonly found in the eastern Pinellas portion of the Anclote River sub-basin. Coastal areas of St. Joseph Sound consists of a mosaic of well-drained and poorly drained soils and is not characterized by any one soil group. Soils forming the mostly undeveloped barrier islands including Anclote Key and Honeymoon Island are primarily either Group C or D which consist of Canaveral Fine Sand beaches or frequently flooded intertidal Estero and Bessie Muck.

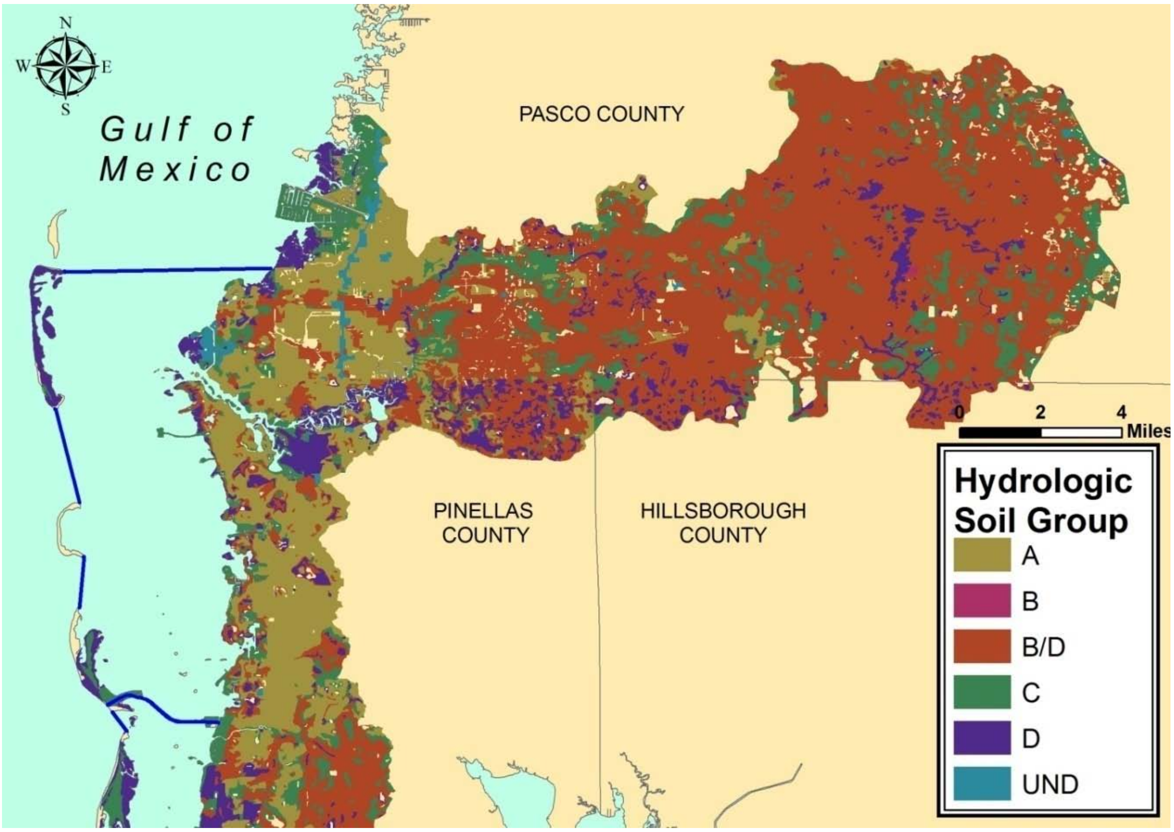


Figure 3-3. Hydrologic soil groups in the St. Joseph Sound watershed (SWFWMD, 2010).

The same soil distribution observed for the Pinellas County extent of the St. Joseph Sound watershed is also characteristic of soils within the Pasco County and Hillsborough County portions of the Anclote River watershed which also drains to this segment. Well-drained Group A soils constitute the majority (52%) and poorly drained Groups C and D constituting only a small percentage of the watershed (5-7%). However, the Pasco/Hillsborough portion of the Anclote River watershed is largely composed of Group B/D soils which represent a greater percentage of the overall watershed (37%) when considering areas of the St. Joseph Sound watershed beyond Pinellas County. Group B/D soils in this part of the upper Anclote River watershed consist largely of Sellers Mucky Loamy Fine Sand and frequently flooded Chobee Soils. High sandy ridges along the Anclote River provide good drainage. Despite the well-drained soils in the St. Joseph Sound watershed, few natural soil drainage patterns exist there today due to urbanization. The Group A and B soils are most common in all of the sub-basins comprising the St. Joseph Sound watershed (Table 3-3). The SJS Coastal sub-basin has the greatest relative extent of Group D soils. This results from the relatively high water table and extensive wetlands in this sub-basin.

Table 3-3. Hydrologic soil group coverage within the St. Joseph Sound watershed sub-basins.

Hydrologic Soil Group	Anclote River	Klosterman Bayou	Sutherland Bayou	Smith Bayou	Coastal Basin
A	15	72	84	61	12
B/D	64	12	8	24	14
C	13	7	6	8	31
D	8	9	2	7	43

- **Managed Lands**

The CHSJS contained within Pinellas County contains several public areas managed by the county, state, water management district, or municipalities. The preservation and maintenance of these undeveloped lands is especially important in a developed region like the CHSJS. Included are lands in or adjacent to the estuary such as recreational parks, (Fred Howard, Honeymoon Island, Wall Spring, and Sand Key, among others) and dedicated habitat management areas (Anclote Islands and Mariner's Point) as shown in Figure 3-4. The entire submerged estuary is also an Aquatic Preserve. There are also parks within the watershed interior (Hammocks, Walsingham, and others) as well as management areas (Ozona and Jerry Lake) (Figure 3-5). A description of each management land area and their management priorities are provided in subsequent sections.

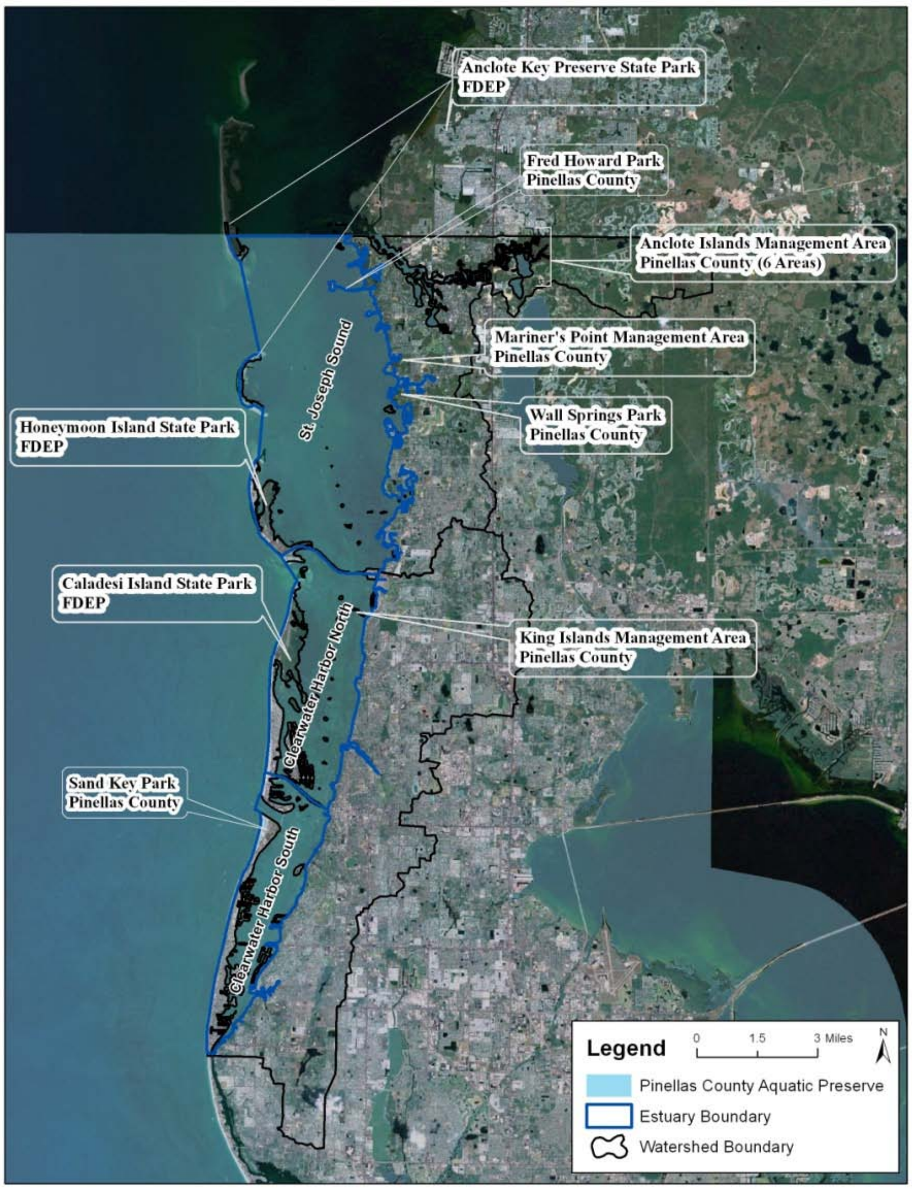


Figure 3-4. Public managed lands in the CHSJS estuary.

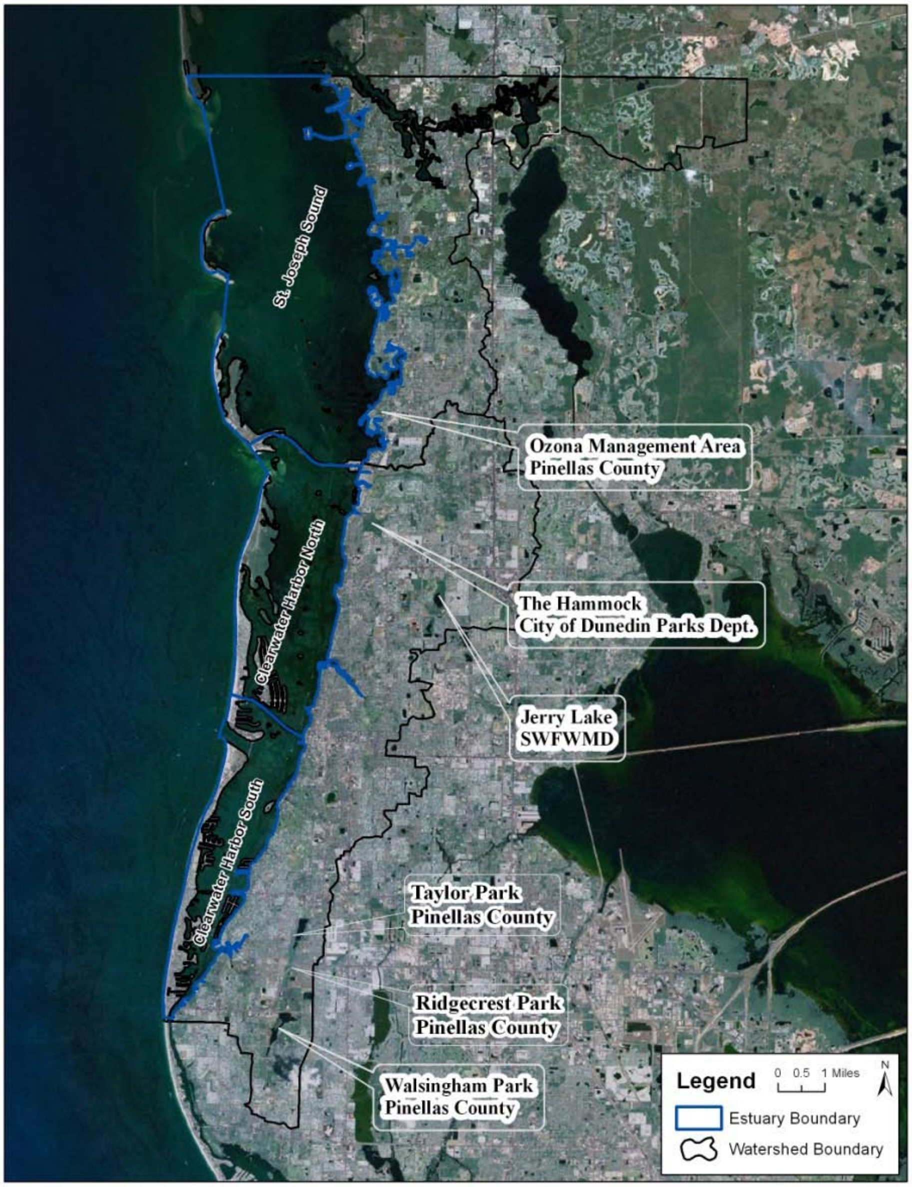


Figure 3-5. Public managed lands in the CHSJS watershed.

A sub-basin-level characterization of land use and hydrologic features in the St. Joseph Sound watershed is provided in the following sections. The extent of natural and altered stream reaches was assessed for each sub-basin within all segments. Stream channels were classified as "stream/river" or "canal/ditch" using the data and definitions of the National Hydrography Dataset (NHD) (USGS, 2000). A stream/river is defined as *"A body of flowing water."* A canal/ditch is defined as *"An artificial open waterway constructed to transport water, to irrigate or drain land, to connect two or more bodies of water, or to serve as a waterway for watercraft."*

3.1.1 Anclote River

The Anclote River is the largest sub-basin in the CHSJS watershed and is the only significant freshwater tributary to St. Joseph Sound. The balance of freshwater inflow to the sound is conveyed via overland flow or small coastal channels and ditches. The Anclote River mouth is located at the

Pinellas County-Pasco County boundary but the majority of the river sub-basin is located in Pasco County. The distance from the mouth of the Anclote River to its headwaters near the community of Land O' Lakes at US 41 is approximately 24 miles.

The Anclote River sub-basin consists of three sub-basins – Gaged Anclote River, Ungaged Anclote River, and North of Anclote River, as shown in Figure 3-1. One 2nd magnitude spring (Crystal Beach Spring) is located about 1,000 feet offshore of the Anclote River mouth in the Gulf of Mexico (Scott et al., 1977).

The Gaged Anclote River sub-basin includes an area of approximately 74 square miles (47,343 acres) upstream of USGS stream gage #02231000 (Anclote River near Elfers) and, except for a small area in the southeast corner of the sub-basin, is entirely in Pasco County (Figure 3-6).The dominant land uses in the gaged Anclote River sub-basin include freshwater wetlands (28%), pasture (23%), and upland forest (18%). Based on the NHD GIS coverage, the gaged Anclote River sub-basin contains 43.1 miles of streams/river and 32.0 miles of canals/ditches, as defined above in Chapter 3.1. Although many river reaches remain in a natural state, many small creeks have been channelized for agricultural or urban purposes. The FDEP WBID delineations are also displayed on Figure 3-6 with the color of the WBID labels indicating impairment for fecal coliform (brown) or nutrients of dissolved oxygen (red). Black numbers WBID labels indicate no impairment.

Very little urban activity exists in the central and northern parts of the sub-basin, which contain large areas of undeveloped uplands and wetlands. However, the extreme western portion of the sub-basin is urbanized and includes parts of the communities of New Port Richey and Elfers. Urban land uses have also increased in the southeast section of the sub-basin over the past years as well.

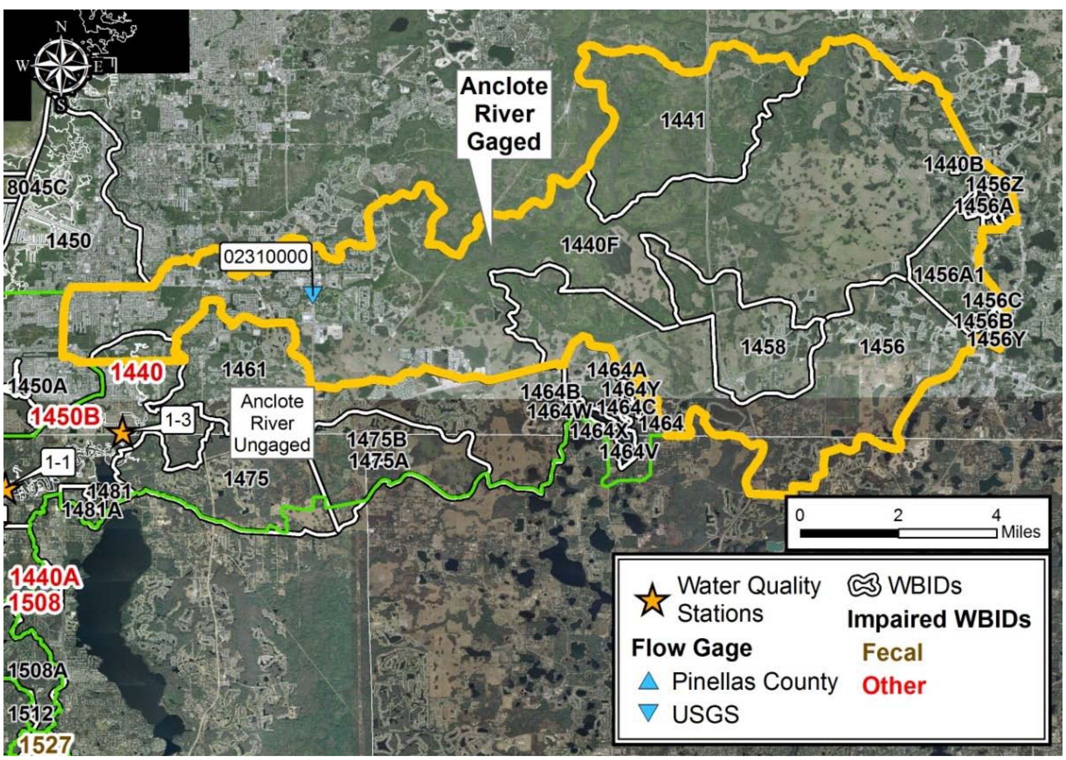


Figure 3-6. 2008 aerial photograph of the gaged portion of the Anclote River Basin (SWFWMD, 2010).

The ungaged portion of the Anclote River sub-basin includes the area downstream of the USGS gage (Ungaged Anclote River - 40 square miles or 25,810 acres, and North of Anclote River – 7.7 square miles or 4925 acres), as shown in Figure 3-7. Pinellas County water quality monitoring sites FDEP WBID boundaries and the USGS stream gage site are also shown. Those WBID numbers displayed in red indicate that a TMDL has been established for this WBID based on either Nutrient of dissolved oxygen impairment. These impairments are discussed in detail in Chapter 4 of the report.

Residential land uses are prevalent in this part of the Anclote River sub-basin. Urbanization is well-established in the coastal and western part of the watershed, but the new residential development Trinity has pushed the urban boundary to the east. The ungaged river sub-basin includes the City of Tarpon Springs south of the river near its mouth. The river channel from Tarpon Springs to the Gulf of Mexico is dredged and allows many commercial and recreational boaters to utilize the waterbody. Based on the NHD GIS coverage, the ungaged Anclote River sub-basin contains 11.4 miles of streams/river and 22.4 miles of canals/ditches, as defined above in Chapter 3.1. This reflects the generally urban nature of the basin.

The North of Anclote River sub-basin is the most densely developed, with 70% urban land use. The sub-basin includes portions of Holiday and Beacon Square, just south of New Port Richey. Based on the NHD GIS coverage, this sub-basin contains 4.5 miles of streams/river and 2.9 miles of canals/ditches, as defined above. Like the ungaged sub-basin the area's surface hydrology is highly altered for urban use.

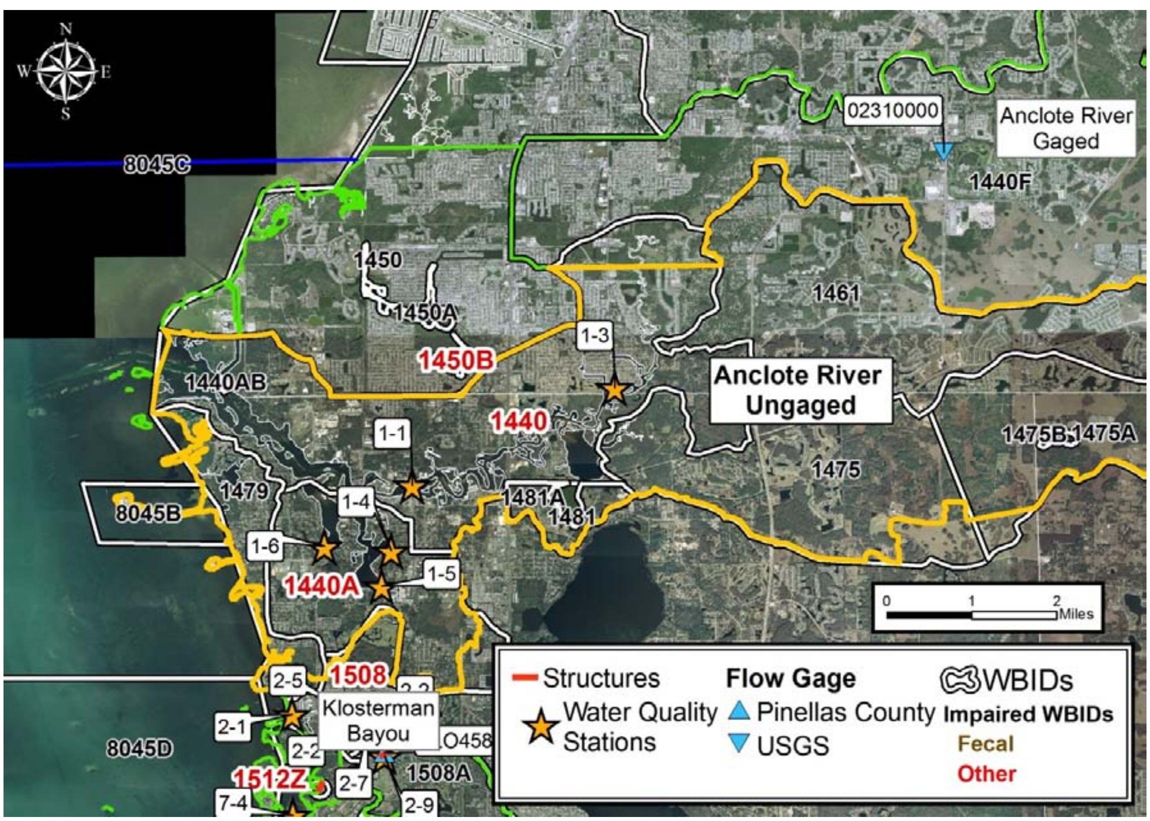


Figure 3-7. **2008 aerial photograph of the ungaged portion of the Anclote River sub-basin in the St. Joseph Sound watershed (SWFWMD, 2010).**

Managed lands in the Anclote River sub-basin include Fred Howard County Park - a recreational fill area in the sound, and the Anclote Islands Management Area which is located just south of the county boundary east of US Route 19.

Figure 3-8 presents a ground-level view of the mouth on the Anclote River. Figure 3-9 shows an upstream view of the Anclote River at the Alternate US Route 19 bridge.

Figure 3-8. Ground-level view of the mouth of the Anclote River.

Figure 3-9. Upstream view of the Anclote River at the Alternate US Route 19 bridge.

3.1.2 Klosterman Bayou

Klosterman Bayou is located just south of the Anclote River sub-basin and is bounded to the south by Sutherland Bayou. Its 3.2-square mile (2,067-acre) sub-basin contains a small (2.5 mile long) coastal stream draining residential and golf course areas and becomes tidally influenced upstream of Alternate US Route 19 (Figure 3-10). Figure 3-10 also shows PCDEM water quality sampling sites and stream gages, and any water control structures. The marine portion of the bayou and creek is heavily altered and channelized. The primary land uses in the watershed are residential (42%) and recreational areas (%), with golf courses, including Innisbrook, Highlands Lake, and Copperhead Lake, covering approximately one quarter of the sub-basin area. Based on the NHD GIS coverage, the sub-basin contains 1.1 miles of streams/river and 0.1 miles of canals/ditches, as defined above in Chapter 3.1.

This sub-basin is also the location of the County's William Dunn Water Reclamation Facility. This treatment plant provides reclaimed irrigation water to the golf courses and has no direct discharge to the bayou. The highly urbanized nature of the sub-basin and potential point source contributions, have impacted the bayou's water quality. FDEP published a Total Maximum Daily Load (TMDL) report for Klosterman Bayou in 2008. The estuarine waterbody was deemed impaired for nutrients, DO, and fecal coliform bacteria (FDEP, 2008a,b). Although there are several potential contributors to the degraded water quality, on-going investigations have not definitively identified the most significant sources of pollutants. These water quality impairments are discussed further in Chapter 4. Ground-level photographs of the sub-basin are presented in Figures 3-11 and 3-12.

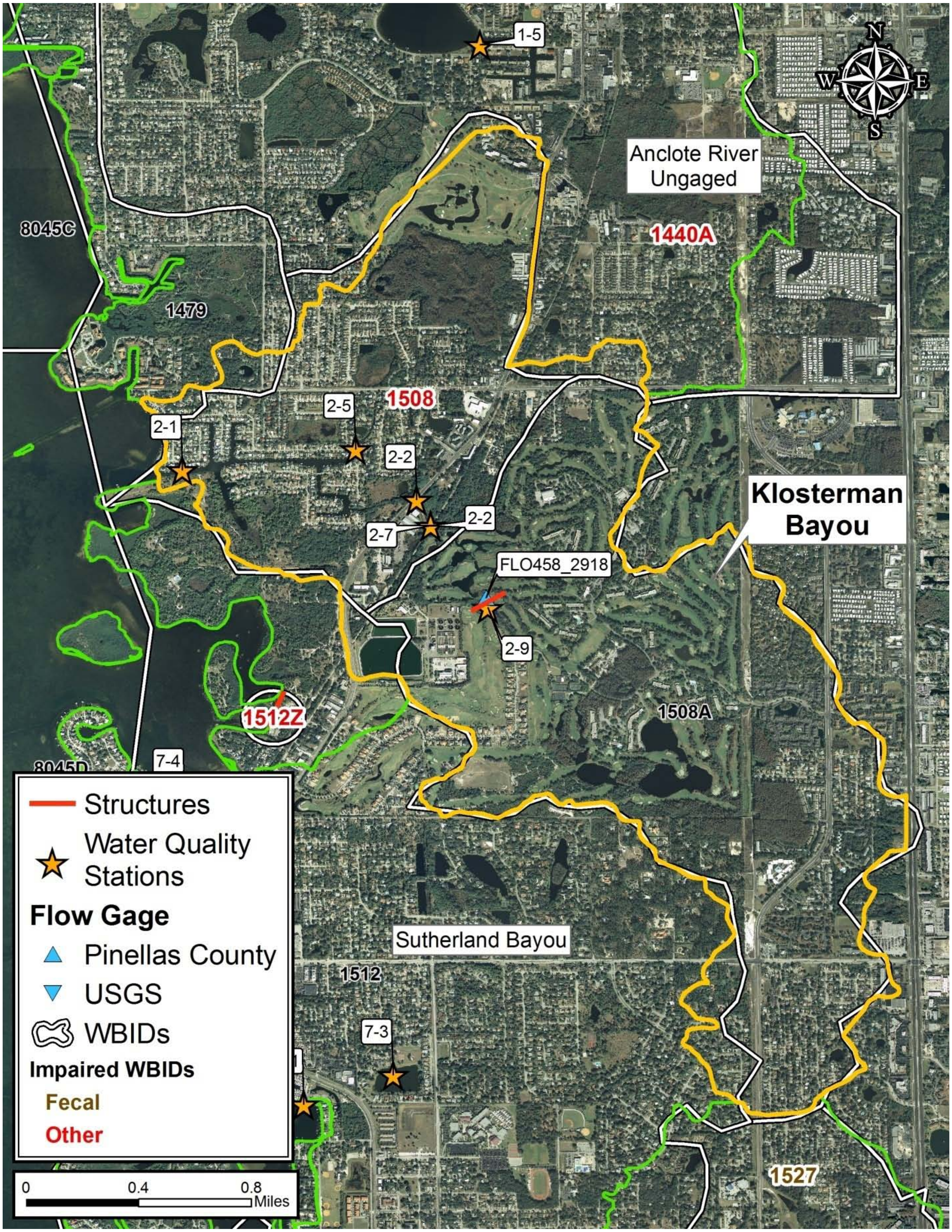


Figure 3-10. 2008 aerial photograph of the Klosterman Bayou sub-basin in the St. Joseph Sound watershed (SWFWMD, 2010).

Figure 3-11. Klosterman Bayou PCDEM water quality monitoring site 2-1.

Figure 3-12. Klosterman Bayou near PCDEM water quality monitoring site 2-5.

3.1.3 Sutherland Bayou

The Sutherland Bayou sub-basin is located just south of the Klosterman Bayou sub-basin and is bounded to the south by the Smith Bayou sub-basin and is north of the community of Ozona. A 2008 aerial photograph of this 2.37 square mile (1,516 acre) sub-basin (Figure 3-13) illustrates that the sub-basin is built-out. The figure also shows PCDEM water quality monitoring sites and water control structures. Residential areas, including a portion of the community of Palm Harbor, comprise 75% of the area in this sub-basin. Based on the NHD GIS coverage, this sub-basin contains 0.1 miles of streams/river and 0.1 miles of canals/ditches, as defined above.

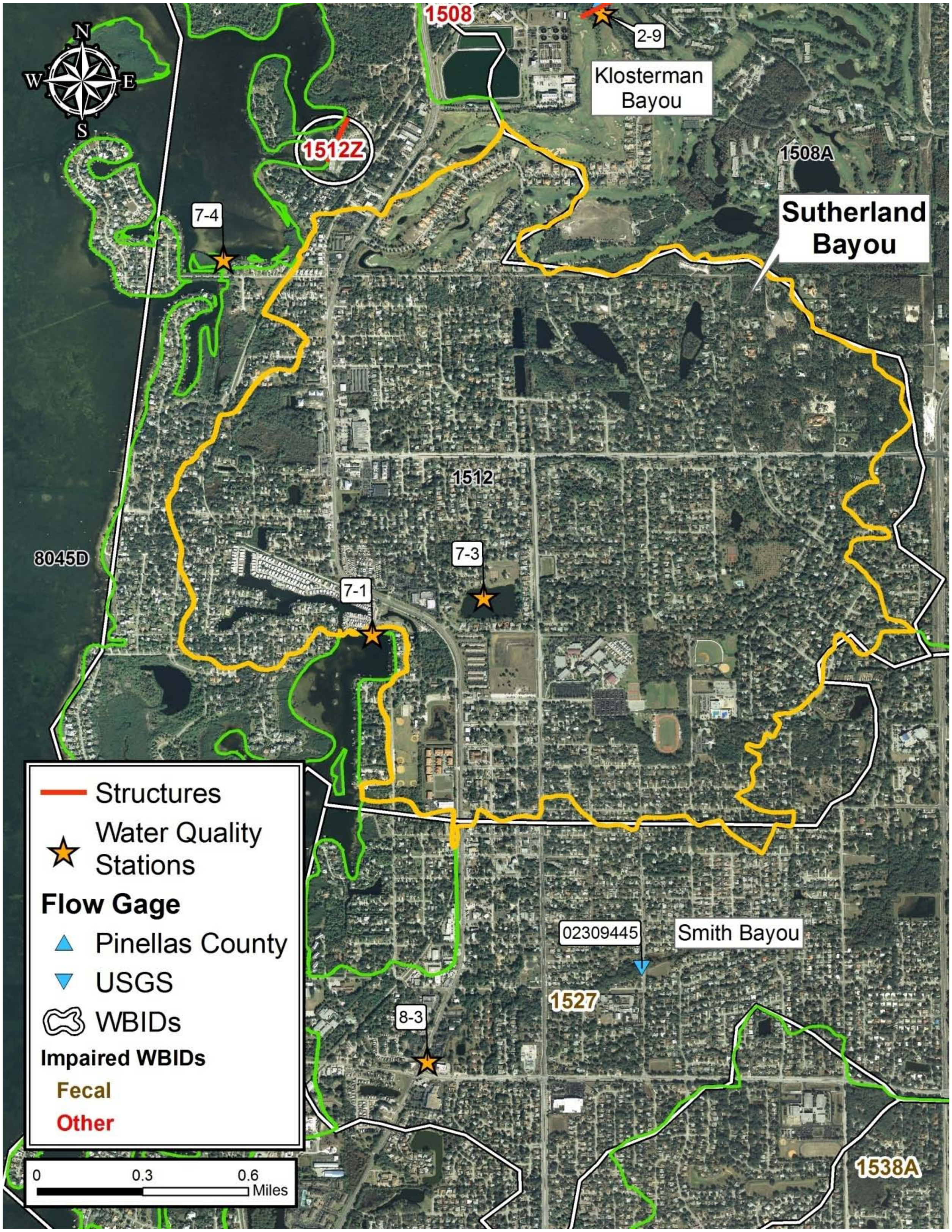


Figure 3-13. 2008 aerial photograph of the Sutherland Bayou Basin sub-basins in the St. Joseph Sound watershed (SWFWMD, 2010).

Figure 3-14 presents a ground-level view of one of the PCDEM water quality sampling sites on Sutherland Bayou. Crystal Beach, the coastal sub-basin adjacent to Sutherland Bayou sub-basin contains significant shoreline development including residential finger canals. The high density of residential land uses along the coast makes this area a high hazard area for hurricanes.

Figure 3-14. Sutherland Bayou near PCDEM water quality monitoring site 7-1.

3.1.4 Smith Bayou

The 2.9-square mile (1,841-acre) Smith Bayou sub-basin is the southern-most sub-basin within the St. Joseph Sound watershed and is bounded to the south by the Curlew Creek sub-basin. Smith Creek (also known as Bee Branch), the primary tributary draining this sub-basin, originates in an unnamed wetland near the intersection of Nebraska Avenue and Riviere Road, a distance of about 3 miles from the bayou. Based on the NHD GIS coverage, the Smith Bayou sub-basin contains 4.5 miles of streams/river and 0.3 miles of canals/ditches, as defined above in Chapter 3.1. This particular classification may not adequately reflect the length of stream channel that has been channelized for urban drainage, although much of the stream channel does maintain a tree canopy.

This sub-basin includes part of the community of Ozona and is highly developed, with mainly urban land uses - 75% residential and 14% industrial land uses in 2008. There is a small percentage of freshwater wetlands (~4) in the sub-basin with the remaining land use made up of freshwater and open land. An aerial and ground-level photograph of the sub-basin are presented in Figure3-15, which shows PCDEM water quality monitoring sites, and Figure 3-16.

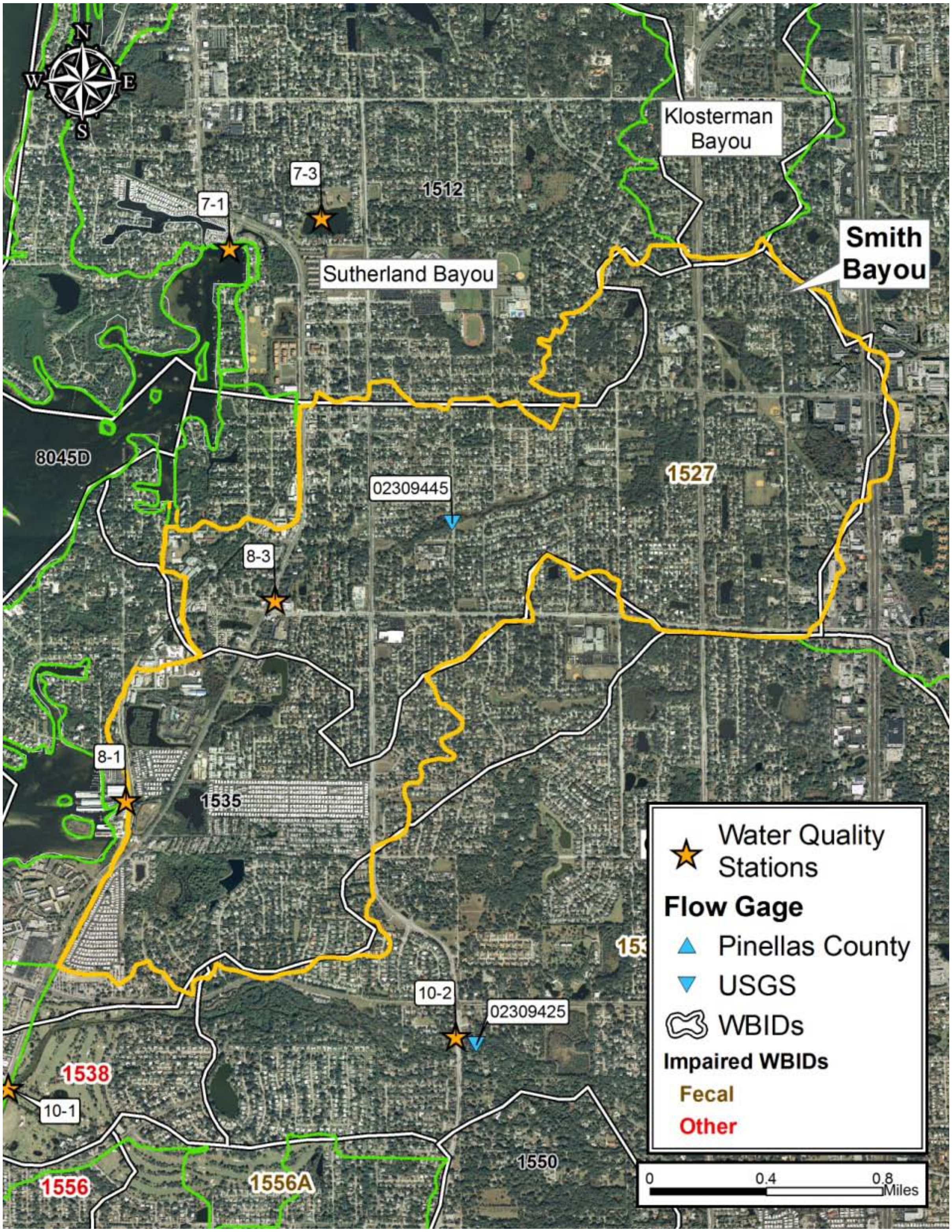


Figure 3-15. **Smith Bayou 2008 aerial photograph sub-basins in the St. Joseph Sound watershed (SWFWMD, 2010).**

Figure 3-16. Smith Bayou near PCDEM water quality sampling site 8-1.

3.1.5 SJS Coastal Subbasin

The SJS Coastal sub-basin contains areas that drain directly to the Sound and with no significant water features except for Health Spring/Wall Spring (Figure 3-17), a 3rd magnitude spring, located in Wall Spring County Park, west of US Alt 19 north of Crystal Beach (Scott et al., 1977). Flows from the spring ranged from 0.0 to over 16 cubic feet per second (cfs) (Scott et al., 1977). The spring run discharges to Boggy Bayou between Klosterman Bayou and Sutherland Bayou. FDEP has identified Wall Spring as nutrient impaired. Based on the NHD GIS coverage, the sub-basin contains 0.9 miles of streams/river and 0.3 miles of canals/ditches, as defined above in Chapter 3.1.

Figure 3-17. Wall Spring discharge to Sutherland Bayou.

The SJS Coastal sub-basin includes mainland coastal areas, spoil islands in the sound, Honeymoon Island, Anclote Key, and Three Rooker Bar. The sub-basin includes portions of the communities of Ozona, Palm Harbor, and Crystal Beach, none of which are incorporated. The entire mainland shoreline between Klosterman Road and the Dunedin Causeway is included in the SJS Coastal sub-basin. As seen in Figure 3-18, the mainland portion of the SJS Coastal sub-basin is urbanized, in contrast to the generally pristine and undeveloped barrier islands. PCDEM sampling sites, and County and USGS stream gage locations are also shown.

Together, these small sub-basins constitute a diverse area that include residential development(26%), open lands (22%), and saltwater wetlands (21%). The islands total 2.5 square miles (1,600 acres) and the mainland coastal sub-basins contain 1.7 square miles (1,066 acres). The Coastal SJS sub-basin supports stands of mangroves and represents the northern extreme of their habitat, based on their temperature tolerance.

Public environmental lands include Fred Howard County Park, Wall Springs County Park, Honeymoon Island State Park, and Anclote Key Preserve State Park. Several photographs of contributing land areas that comprise the SJS Coastal sub-basin are presented in Figures 3-19 through 3-22.

Figure 3-18. 2008 aerial photograph of the SJS Coastal sub-basin.

Figure 3-19. Ground-level view of Anclote Key.

Figure 3-20. Ground-level view of Three Rooker Bar.

Figure 3-21. Ground-level view of several spoil islands in St. Joseph Sound.

Figure 3-22. Oblique aerial view of Honeymoon Island.

3.2 Clearwater Harbor North Watershed

The Clearwater Harbor North (CHN) watershed is approximately 26 square miles (16,793 acres) in area. The watershed extends east from the harbor's shoreline and includes incorporated areas in the Cities of Clearwater and Dunedin. The Clearwater Harbor North watershed also includes several small spoil islands and the eastern half of Caladesi Island. (Figure 3-23). The watershed is bounded to the east by the Tampa Bay watershed, to the north by the St. Joseph Sound watershed, to the west by the Clearwater Harbor estuary, and to the south by the Clearwater Harbor South watershed. The Clearwater Harbor North watershed is comprised of 5 sub-basins:

- Curlew Creek (10.5 square miles)
- Cedar Creek (1.9 square miles)
- Spring Branch (3.3 square miles)
- Stevenson Creek (6.0 square miles)
- Coastal (4.5 square miles).

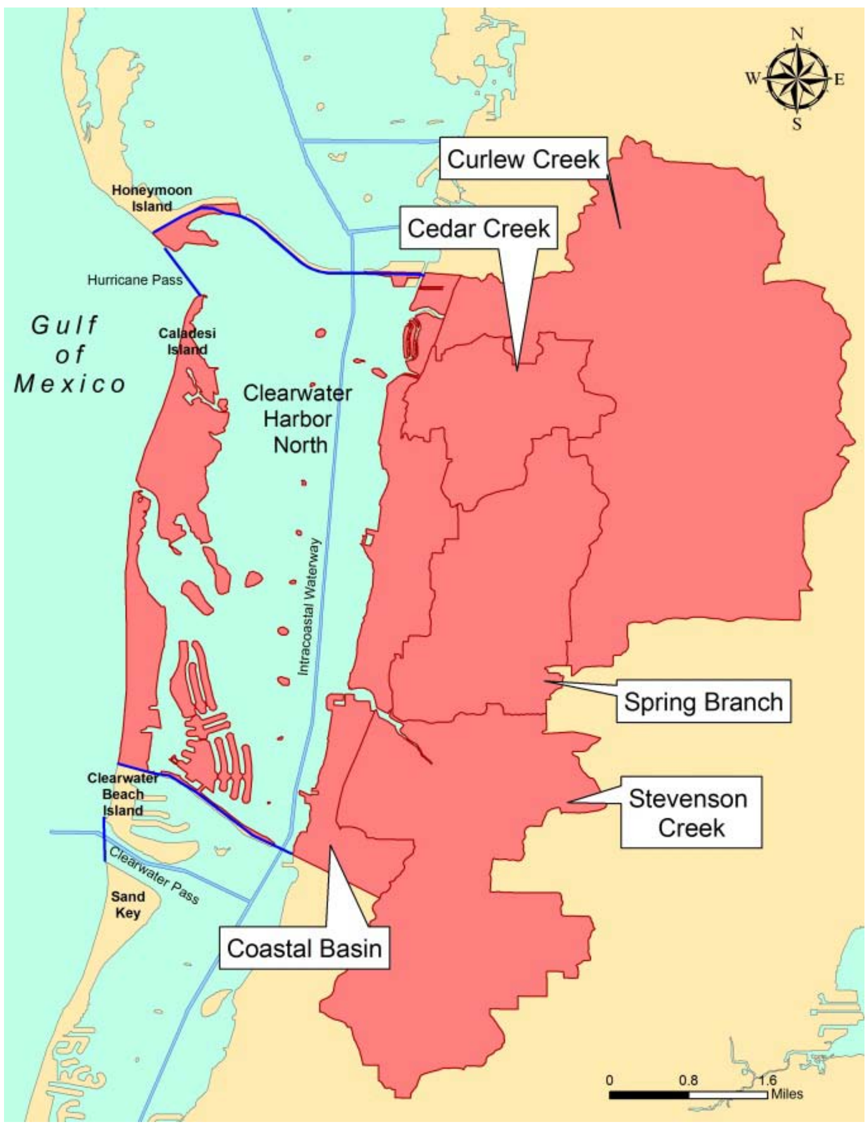


Figure 3-23. Clearwater Harbor North watershed and contributing sub-basins.

- **Land use**

Existing land use both on the mainland and barrier islands (with the exception of Caladesi Island) is predominantly urban with only isolated parcels of natural land. The predominant land uses are residential and commercial (which together comprise at least 63% of the total land use in every sub-basin), with little industrial, agricultural, or open space (Figure 3-24). There is very little vacant land left to develop in the watershed and in general re-development of land is the only remaining opportunity for urban growth. The land use breakdowns for each sub-basin within the Clearwater Harbor North watershed are provided in Table 3-4.

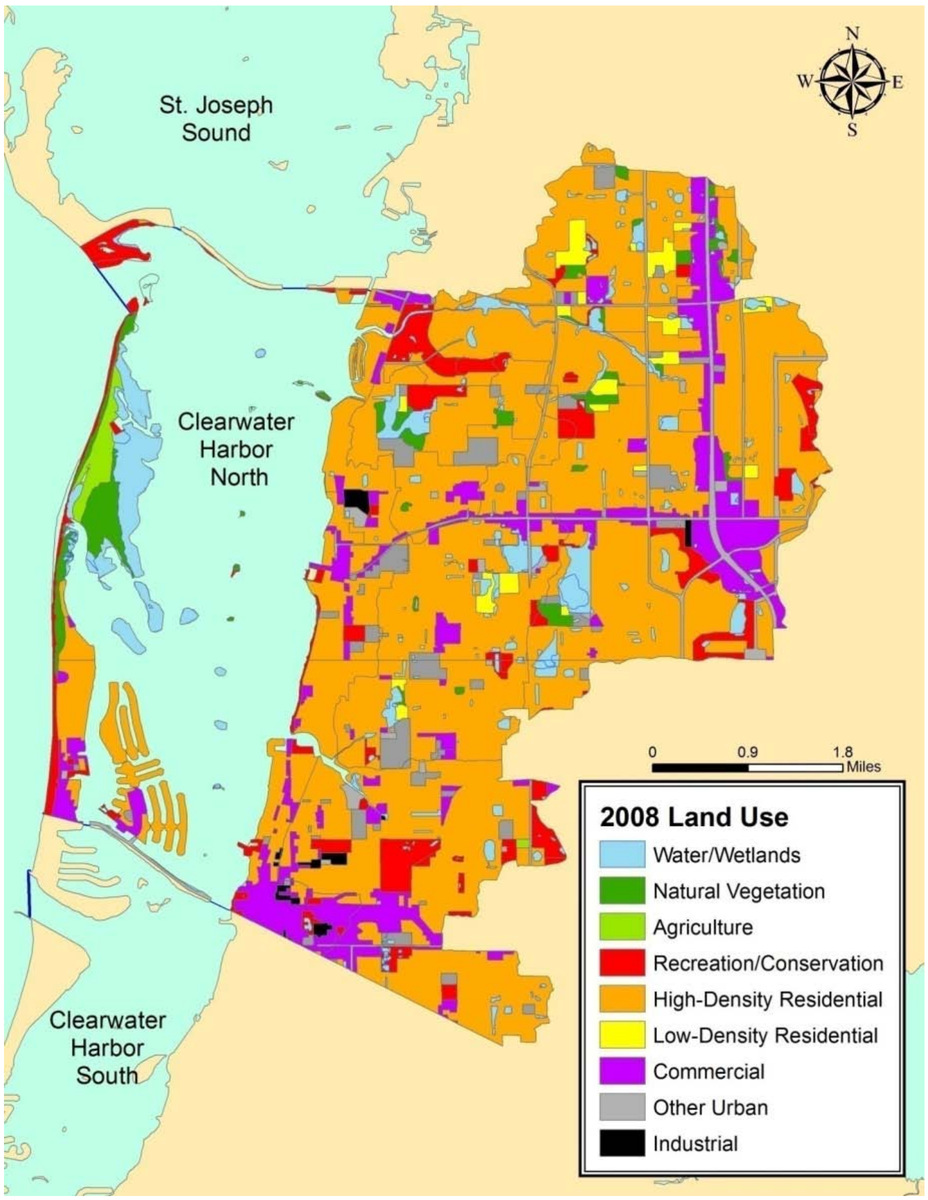


Figure 3-24. 2008 Land use/cover in the Clearwater Harbor North watershed (SWFWMD, 2010).

Table 3-4. 2008 land use percent coverage in Clearwater Harbor North sub-basins.					
Land Use	**Percent Coverage**				
	Curlew Creek	**Cedar Creek**	**Stevenson Creek**	**Spring Branch**	**Coastal Basin**
High Density Residential	50	40	70	72	46
Medium Density Residential	14	27	0	0	2
Low Density Residential	3	1	0	3	0
Commercial/Institutional	19	13	19	14	17
Industrial	<1	0	1	0	1
Agriculture	0	0	0	0	0
Open Land	6	8	8	3	14
Upland Forest	2	5	0	1	4
Freshwater Wetlands	3	5	12	4	2
Fresh water	3	1	0	4	0
Beaches	0	0	0	0	0
Saltwater Wetlands	0	<1	0	0	14

- **Soils**

Soils in the Clearwater Harbor North watershed consist primarily of the poorly drained Group D (33% of the watershed), Group B/D (29%) and Group C (15%) soils and less of the well-drained Group A soils (22%), as shown in Figure 3-25. Astatula Fine Sand is the dominant well-drained soil in this watershed and it is also the dominant Group D soil in the form of a poorly drained Urban Land-Astatula complex.

Urban development within the Clearwater Harbor North watershed has converted much of the Myakka, Immokalee and Pomello Fine Sands into poorly drained Urban Land-Fine Sand complexes. Group B/D soils are primarily Myakka and Immokalee Fine Sand and are the dominant soils found in the Curlew Creek sub-basin along with well-drained Group A Astatula Fine Sand. The coastal zone of Clearwater Harbor North and Stevenson Creek consist of poorly drained Groups C and D soils (Urban land, Arents-Urban Land and Urban Land-Astatula complexes). Spring Branch and Cedar Creek are similar but also contain some areas of well-drained Astatula Fine Sand.

Similar to the barrier islands in St. Joseph Sound, the northern part of Caladesi Island is primarily either Group C Canaveral Fine Sand beaches or Group D frequently flooded intertidal Estero and Bessie Muck. South of Caladesi, Clearwater Beach has largely been developed into Group D Urban Land. As with most of the CHSJS, few natural soil drainage patterns exist presently in the Clearwater Harbor North watershed due to the intense level of urbanization. The soil breakdown for each sub-basin within Clearwater Harbor North is provided in Table 3-5.

A sub-basin level characterization of land use and hydrologic features in the Clearwater Harbor North watershed is provided in the following sub-sections.

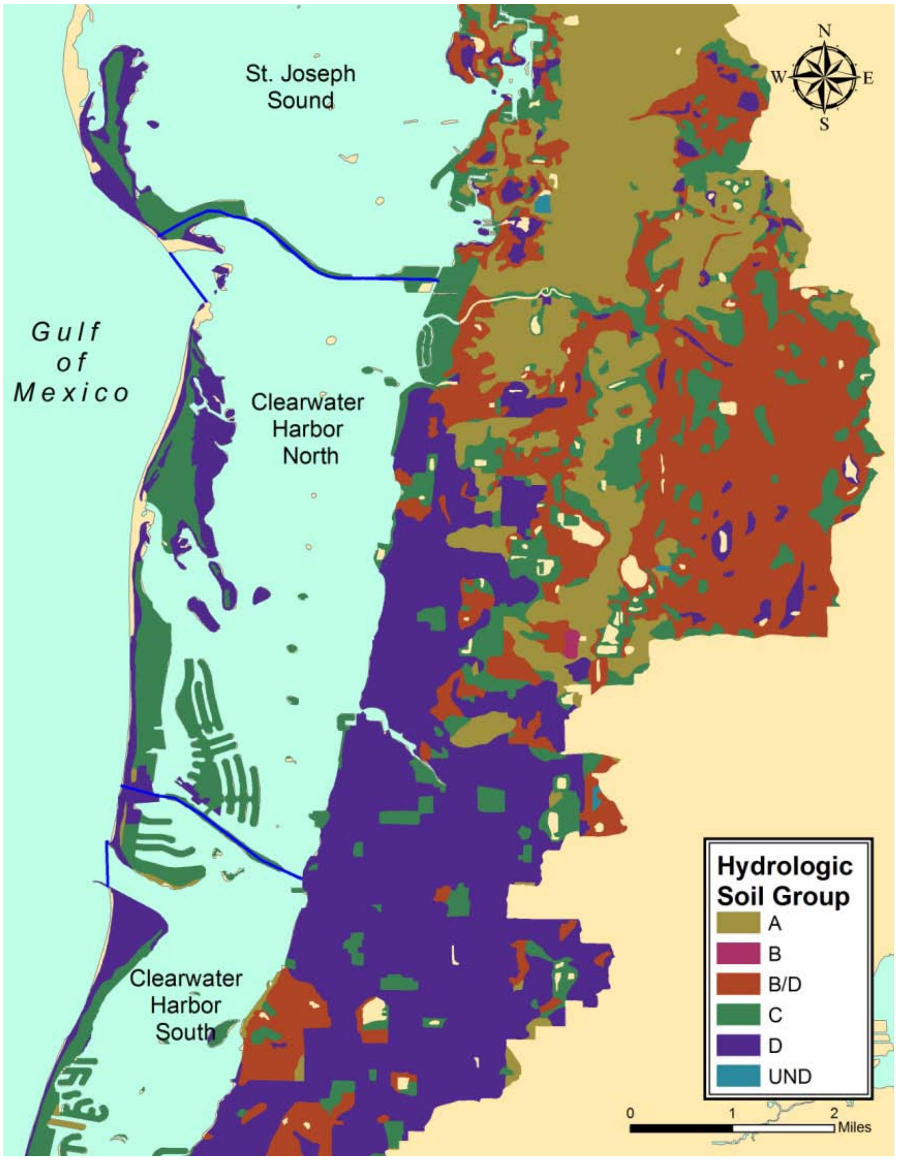


Figure 3-25. Hydrologic soil groups in the Clearwater Harbor North watershed (SWFWMD, 2010).

Table 3-5. Hydrologic soil group percent coverage by sub-basin in Clearwater Harbor North.

Hydrologic Soil Group	Percent Coverage				
	Curlew Creek	Cedar Creek	Stevenson Creek	Spring Branch	CHN Coastal
A	27	31	2	24	2
B/D	53	37	6	24	2
C	17	12	11	20	46
D	3	20	81	32	50
Notes:	1) Because of the nature of much of the watershed all dual HSC soils (A/D, B/D) were assigned an HSG of D. 2) Coastal Zone includes mainland direct runoff areas, spoil islands, Clearwater Beach Island, and Caladesi Island.				

3.2.1 Curlew Creek

Curlew Creek is one of the larger coastal stream sub-basins (10.5 square miles (6,697 acres) in the CHSJS. It is the northernmost sub-basin in the Clearwater Harbor North segment watershed. The creek extends for about six miles, originating west of Clubhouse Drive West and discharging to the Harbor just south of the Dunedin Causeway. Based on the NHD GIS coverage, the sub-basin contains 9.2 miles of streams/river and 1.1 miles of canals/ditches, as defined above in Chapter 3.1. Like Smith Bayou, Curlew Creek still generally follows its historical alignment but its channel and floodplain have been altered to facilitate urban drainage. A tree canopy has been maintained, however.

With the exception of a few open areas and golf courses the sub-basin is highly developed with mainly residential land use, with commercial uses lining the major roads. Dominant land uses include high density residential (50%), freshwater wetlands (28%), and commercial or institutional lands (19%).

The Curlew Creek sub-basin is east and south of Ozona, and is bounded to the east by the Lake Tarpon Outfall Canal and to the east by Keene Road, except along the steam channel as it approaches the coast south of the Dunedin Causeway. About one quarter of this sub-basin is within the City of Clearwater. Public land includes the City of Dunedin's Curlew Creek Park located about one mile east of the causeway.

Curlew Creek Channel "A" is located at the headwaters of the Curlew Creek riparian system in Pinellas County, Florida. This stream segment flows northward from Evans Road to the stream crossing at Belcher Road. Portions of Curlew Creek Channel "A" have been subject to channel erosion and sediment accumulation in the channel. Measures are being implemented to address these issues and to improve instream habitat, reduce excessive sedimentation, and reduce flood hazards (Suncoast News, 2007).

An aerial photograph of the sub-basin is presented in Figure 3-26, which also shows PCDEM water quality monitoring sites (at Keene Road and Bayshore Blvd.) and a USGS stream gage at Keene Road. Two ground-level photographs of Curlew Creek are shown in Figures3-27 and 3-28.

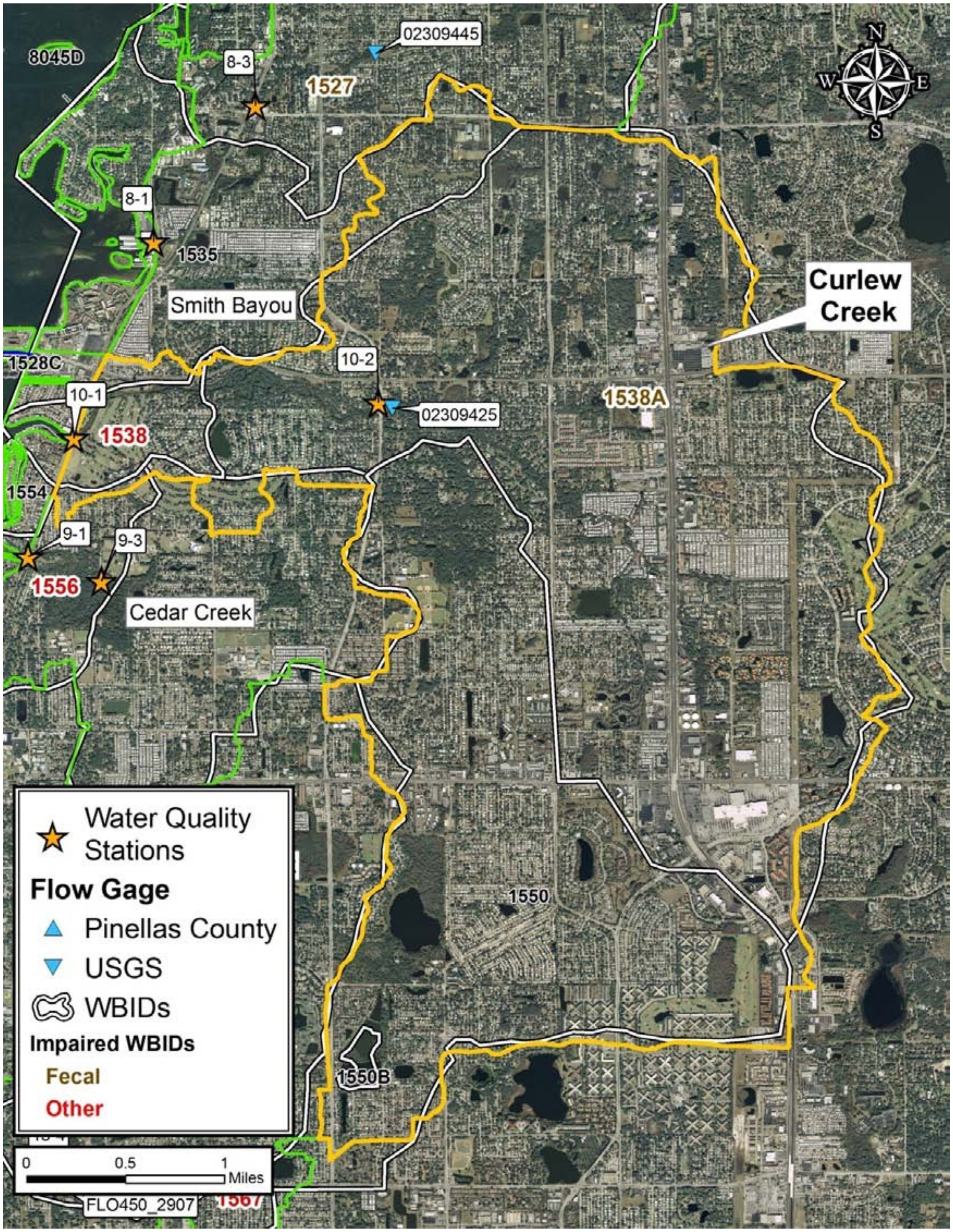


Figure 3-26. Curlew Creek 2008 aerial photograph (SWFWMD, 2010).

Figure 3-27. Curlew Creek near PCDEM water quality monitoring site 10-1.

Figure 3-28. Curlew Creek near PCDEM water quality monitoring site 10-2.

3.2.2 Cedar Creek

Cedar Creek is a small (1.9 square miles or 1,233 acres) sub-basin just south of Curlew Creek and is mainly in the City of Dunedin. Its headwaters are in an area northwest of the intersection of Solon Avenue and Brae Moor Drive, and the creek channel is about two miles long. This sub-basin is highly developed with mainly residential land use (68%), some freshwater wetlands (17%) and commercial land uses (13%) mainly along the major roads. Based on the NHD GIS coverage, the sub-basin contains 1.2 miles of streams/river and 0.6 miles of canals/ditches, as defined above in Chapter 3.1. Figure 3-29 presents an aerial and ground-level photograph of the sub basin with PCDEM water quality monitoring sites, and Figure 3-30 shows a ground-level view of the sub-basin.

The City of Dunedin's Hammock Park is located in the Cedar Creek sub-basin. The city has incorporated a restoration plan for hydrated wetlands in the park and Lake SueMar into its flood control master plan (Suncoast News, 2007). Other public environmental land includes Pinellas County's King Islands Management Area, located just offshore of the Cedar Creek sub-basin. The two islands have an area of 25 acres and were formed from dredged spoil material. The islands were acquired by the County in 1994 and active management began in 2008. They support seagrass meadows, tidal swamp, and diverse bird populations (PCDEM, 2010).

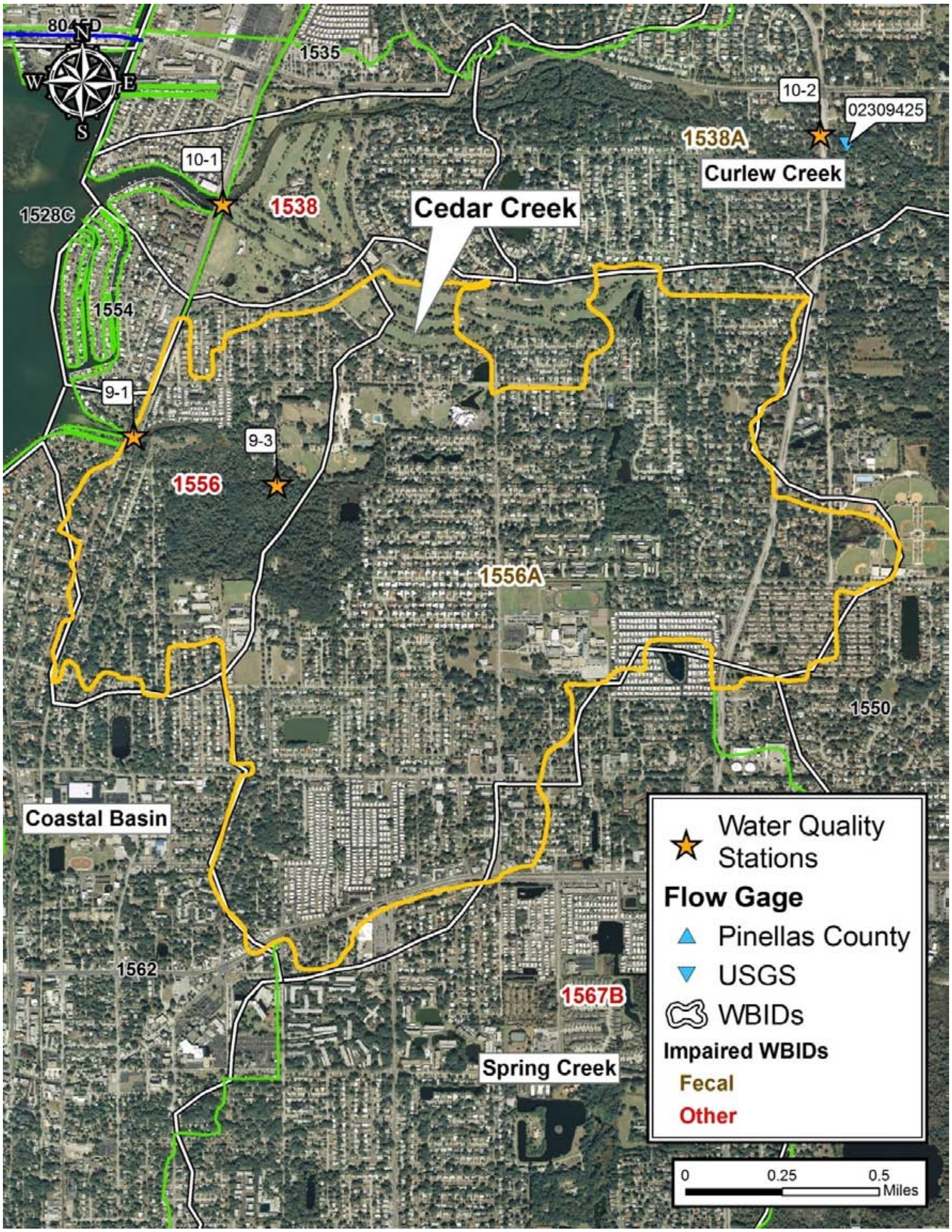


Figure 3-29. Cedar Creek 2008 aerial photograph (SWFWMD, 2010).

Figure 3-30. Cedar Creek in the Hammock City Park.

3.2.3 Stevenson Creek

Stevenson Creek is located just south of the Curlew Creek sub-basin. It originates just south of Druid Road and flows south to north about three miles to the Harbor. It is the largest (6 square miles or 3,859 acres) and most urbanized of any sub-basin in the City of Clearwater and includes the eastern portion of the city's downtown area. This sub-basin is bounded to the west by the CHN Coastal sub-basin and to the east by Old Tampa Bay watershed.

This sub-basin also contains portions of the City of Dunedin and unincorporated Pinellas County. With the exception of a few open areas and golf courses the sub-basin is highly developed with mainly residential land uses (70%), and commercial (19%) along the major roads. Much of the urban development occurred prior to requirements for stormwater management so runoff from very little of this sub-basin is provided peak flow attenuation or water quality treatment. Based on the NHD GIS coverage, this sub-basin contains 1.9 miles of streams/river and 2.2 miles of canals/ditches, as defined above in Chapter 3.1. Like other local sub-basins the NHD classification does not fully account for stream reaches with channel alterations.

FDEP completed draft TMDL for Stevenson Creek in 2008. This waterbody was identified as being impaired for nutrients and DO (FDEP, 2008c). FDEP concluded the major sources of nutrients included urban runoff and reuse water from a municipal wastewater treatment plant.

The City of Clearwater completed a watershed management plan for Stevenson Creek and Spring Branch in 2001 (City of Clearwater, 2001a) and has implemented regional water quality and flood protection projects in the sub-basin including the Glen Oaks, Lake Bellevue, and Turner Street improvements. The tidal reach of the creek has a restoration plan as well, including muck dredging, exotic vegetation removal, and mangrove planting.

An aerial photograph of the Stevenson Creek sub-basins presented in Figure 3-31, which also shows PCDEM water quality monitoring sites, a stream gage site on the grounds of the Clearwater Country Club north of Drew Street, and a other water control structures. Two ground-level photographs of Stevenson Creek are presented in Figures 3-32 and 3-33.

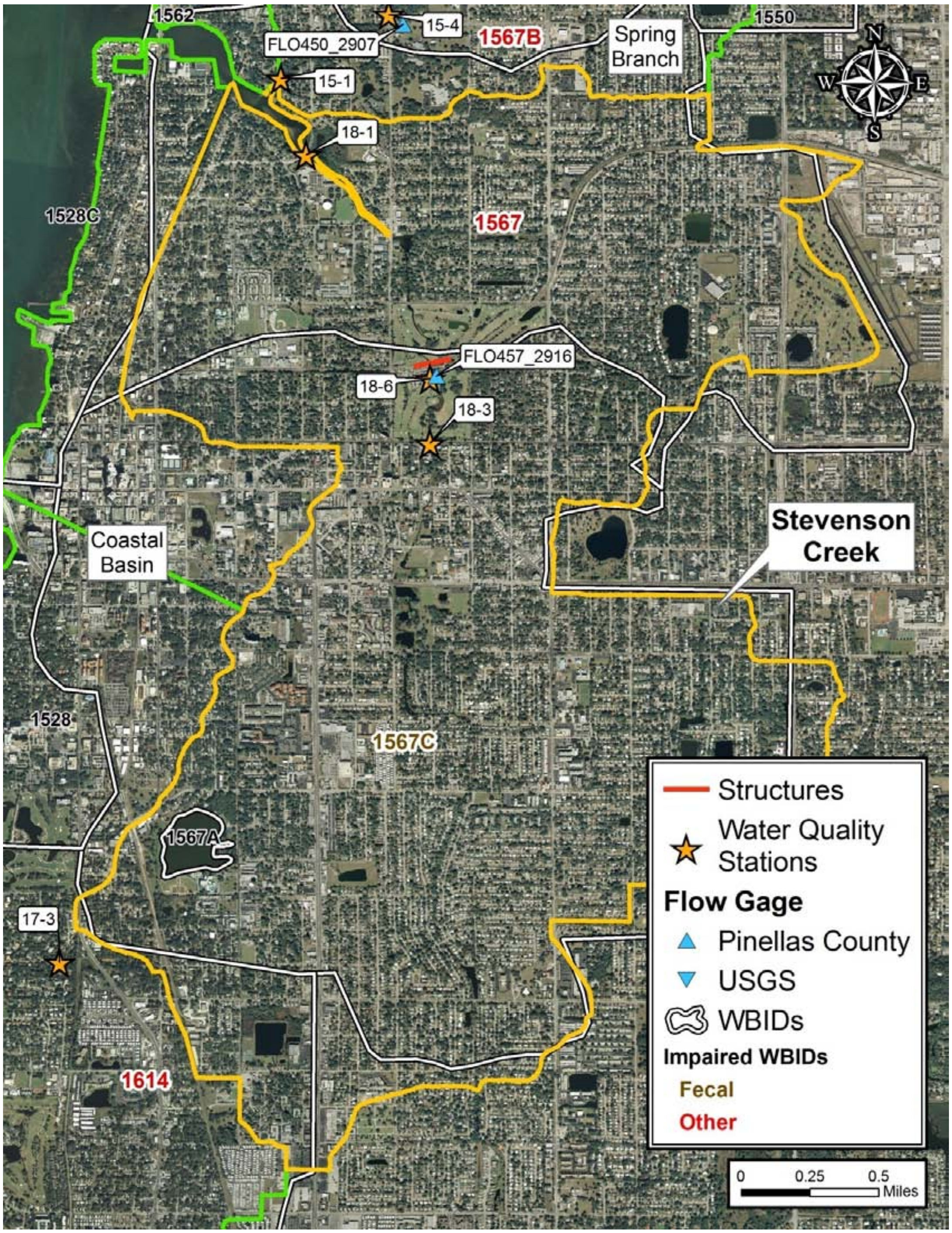


Figure 3-31. Stevenson Creek 2008 aerial photograph (SWFWMD, 2010).

Figure 3-32. Stevenson Creek near PCDEM water quality monitoring site 18-1.

Figure 3-33. Stevenson Creek near PCDEM water quality monitoring site 18-6.

3.2.4 Spring Branch

Spring Branch is located just south of the Curlew Creek sub-basin. Spring Branch is a tributary to Stevenson Creek. It flows southwest two miles and discharges into Stevenson Creek near its mouth. Like Stevenson Creek, the 3.3-square mile (2,136 acre) sub-basin is highly developed with mainly residential land use (75%), with commercial (14%) along the major roads and 10% freshwater wetlands. An aerial photograph of the basin that also shows PCDEM water quality monitoring sites and stream gage is presented in Figure 3-34 and a ground-level photograph is presented in Figure 3-35. Based on the NHD GIS coverage, this sub-basin contains 1.6 miles of streams/river and 2.2 miles of canals/ditches, as defined above. This relatively high proportion of canalized stream channel reflects the sub-basin's urban nature.

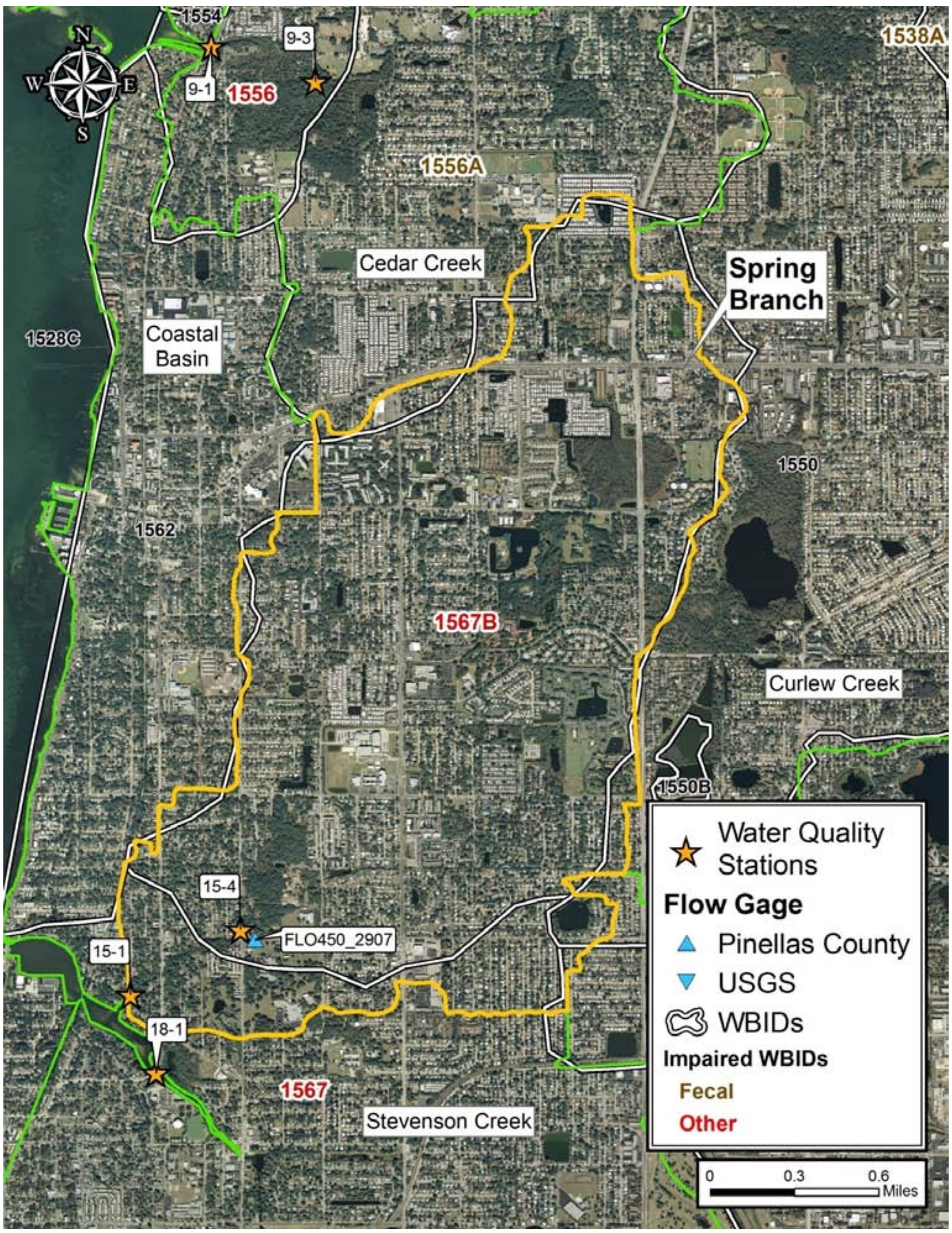


Figure 3-34. Spring Branch 2008 aerial photograph (SWFWMD, 2010).

Figure 3-35. Spring Branch near PCDEM water quality monitoring site 15-1.

3.2.5 CHN Coastal Subbasin

The CHN Coastal sub-basin contains coastal areas that drain directly to Clearwater Harbor North. There are no significant freshwater inputs. The sub-basin contains the great majority of coastal land in the watershed, including mainland shoreline, spoil islands, Caladesi Island, and Clearwater Beach Island. The only saltwater wetlands in the Clearwater Harbor North watershed are supported in the CHN Coastal sub-basin.

The mainland coastal areas, including downtown Clearwater and Clearwater Beach Island are highly urbanized, in contrast to the generally pristine Caladesi Island. The land uses of this diverse sub-basin include residential (48%), commercial (17%), open land (15%), and saltwater wetlands (14%).

Caladesi Island State Park is located in the CHN Coastal sub-basin. The park is relatively undeveloped, unlike Clearwater Beach Island to the south. Although Caladesi and Clearwater Beach Islands are named separately, longshore transport of sand has closed the pass that in the past separated the two land masses.

Much of the shoreline is hardened due to the extensive waterfront development and finger fill style residential areas, typified by Island Estate north of the Clearwater Causeway. The CHN Coastal sub-basin is unusual in that it contains some significant topographic relief, with bluffs overlooking the estuary north of the Clearwater Causeway. Based on the NHD GIS coverage, this sub-basin contains 2.8 miles of streams/river and 6.6 miles of canals/ditches, as defined above, and is consistent with the dense urbanization within the coastal areas.

Public environmental lands in the CHN Coastal sub-basin include Caladesi Island State Park. The park is accessible only by walking along the beach north from Clearwater Beach island, or by ferry. An aerial photograph that shows PCDEM water quality sampling sites and water control structures is shown in Figure 3-36. A ground-level photograph of the sub-basin is presented in Figure3-37.

Figure 3-36. CHN Coastal sub-basin 2008 aerial photograph (SWFWMD, 2010).

Figure 3-37. CHN Coastal sub-basin near Dunedin Causeway.

3.3 Clearwater Harbor South Watershed

The Clearwater Harbor South (CHS) watershed is approximately 16 square miles (10,225 acres) in area and includes portions of mainland and the eastern portions of the barrier islands west of the harbor (Figure 3-38). The watershed includes all or portions of the jurisdictions of unincorporated Pinellas County and the incorporated Cities of Belleair, Belleair Beach, Belleair Bluffs, Belleair Shore, and Indian Rocks Beach.

In general, the Clearwater Harbor South watershed is even more intensely urbanized than the CHN watershed, including the barrier islands. The watershed is bounded to the east and south by the western boundary of the Tampa Bay watershed, to the north by the Clearwater Harbor North watershed, and to the west by the barrier island Sand Key extending from Clearwater Pass south to the Narrows. The Clearwater Harbor South watershed is comprised of two sub-basins:

- McKay Creek (8.8 square miles) and
- Coastal Zone (7.2 square miles)

- **Land use**

The Clearwater Harbor South watershed, including the barrier island Sand Key, is highly urbanized. Very little natural or open land remains on either the mainland or on the barrier island of Sand Key (Figure 3-39). Percent coverage of land use is provided in Table 3-6. Dominant land uses in this segment watershed include high density residential (60%) and commercial/institutional (22%). Freshwater wetlands make up between 12% and 28% of each sub-basins land use. Although the current land use coverage shows 12–18% undeveloped land in the CHS sub-basins this is mainly coastal or beachfront land that is undevelopable.

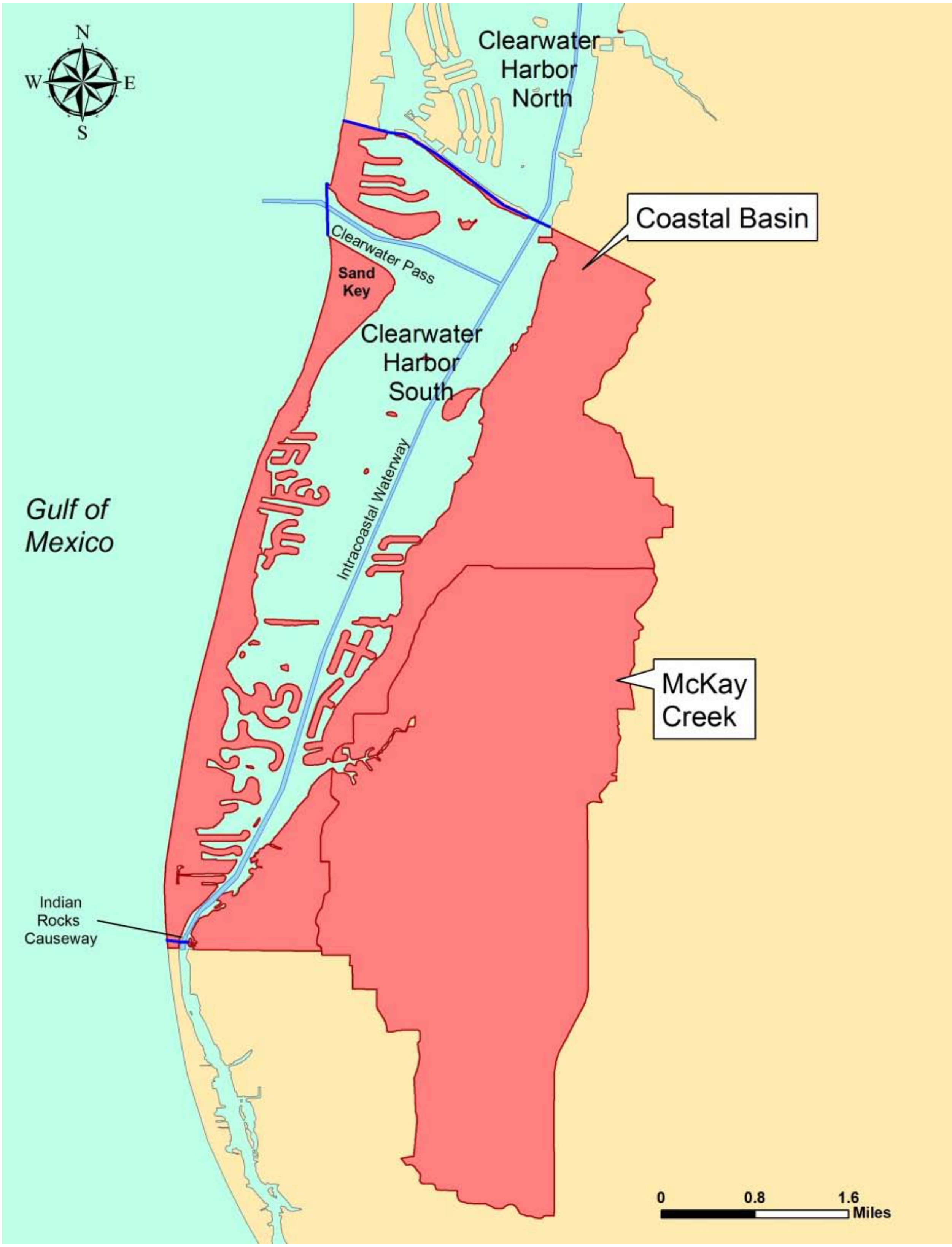


Figure 3-38. Clearwater Harbor South watershed and contributing sub-basins.

Table 3-6. 2008 land use percent coverage in Clearwater Harbor South sub-basins.		
Land Use	**Percent Coverage**	
	McKay Creek	**Coastal Basin**
High Density Residential	60	57
Medium Density Residential	4	3
Low Density Residential	2	0
Commercial/Institutional	14	22
Industrial	0	2
Agriculture	0	0
Open Land	12	14
Upland Forest	1	0
Freshwater Wetlands	2	0
Fresh water	5	0
Saltwater Wetlands	0	1

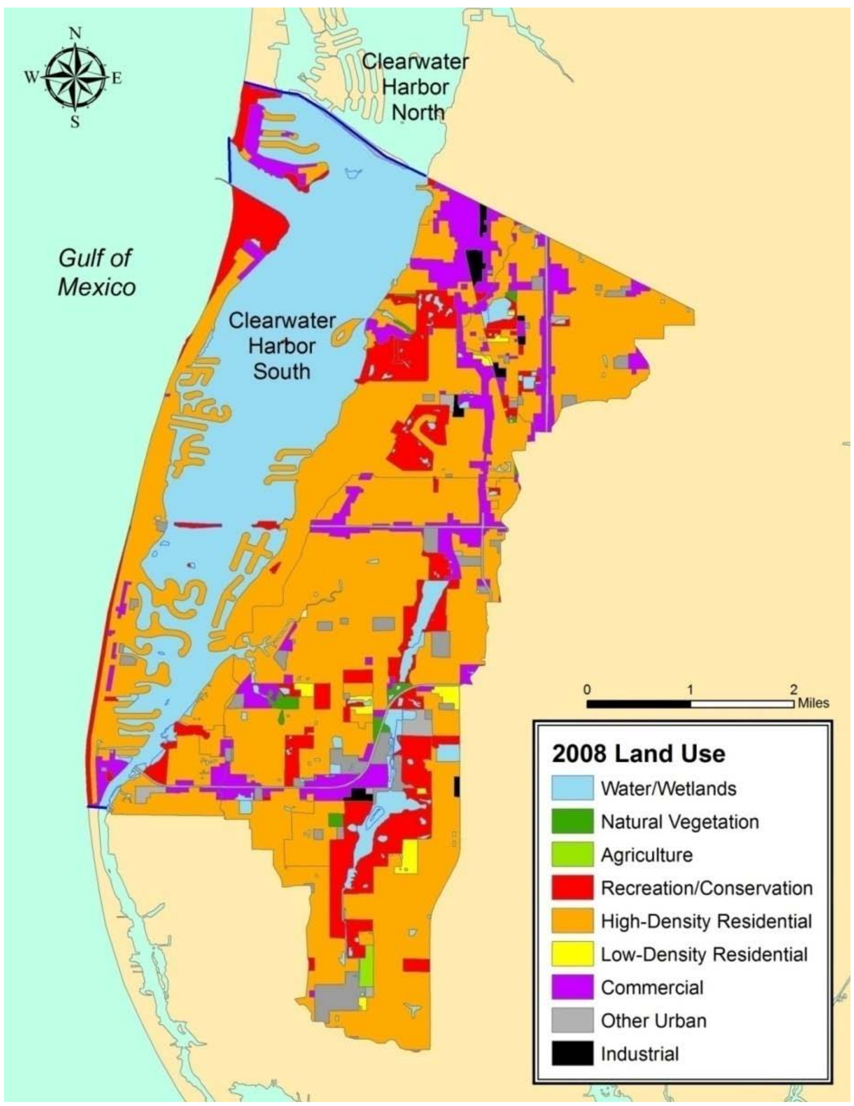


Figure 3-39. 2008 Land use/cover in the Clearwater Harbor South watershed (SWFWMD, 2010).

- **Soils**

The soils of Clearwater Harbor South are very similar to those found throughout the CHSJS characterized by primarily poorly drained Group D (31% of the watershed), Group B/D (33%) and Group C (9%) soils and less of the well-drained Group A soils (27%), as shown in Table 3-7.

Table 3-7. Hydrologic soil group percent coverage by sub-basin in Clearwater Harbor South watershed.

Hydrologic Soil Group	Percent Coverage	
	McKay Creek	Coastal Basin
A	10	6
B/D	43	20
C	13	35
D	34	39

The McKay Creek sub-basin and the coastal zone of Clearwater Harbor South are largely Groups B/D and D poorly drained Myakka Fine Sand, Urban Land or a complex (Figure 3-40). In addition, the McKay Creek sub-basin also has areas of Immokalee Fine Sand (Group B/D) and well-drained Astatula Fine Sand (Group A). Sand Key is similar to the more developed barrier islands within the greater CHSJS watershed in that it has primarily Group C and D soils with Canaveral Fine Sand beaches and Arents-Urban Land complex. Astatula Fine Sand is the dominant well-drained soil here (Group A) with poorly drained soils consisting of Myakka and Immokalee Fine Sands (Group B/D), Arents-Urban Land complex, Pomello and Canaveral Fine Sands (Group C) and Urban complexes of Astatula and Myakka Fine Sand (Group D).

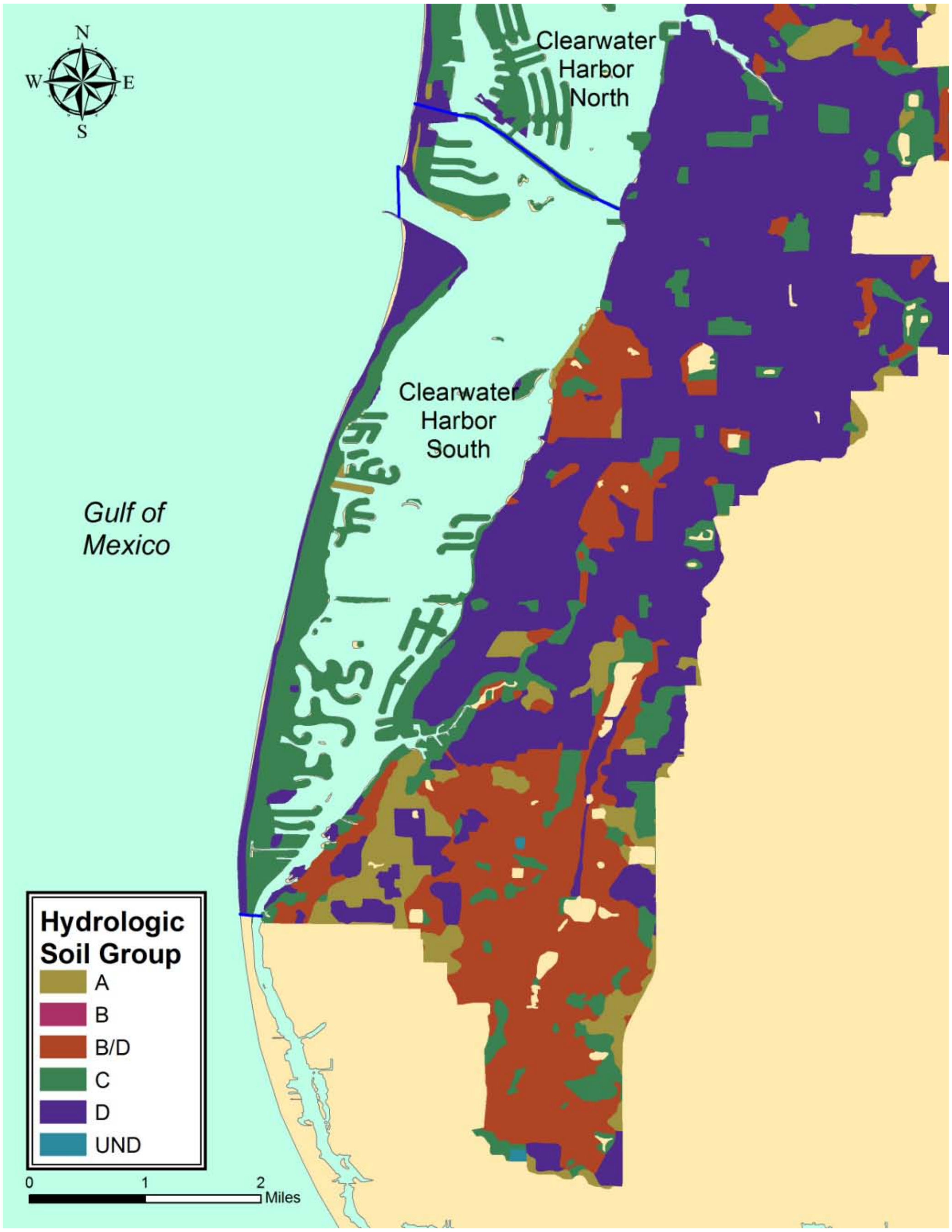


Figure 3-40. Hydrologic soil groups in the Clearwater Harbor South watershed (SWFWMD, 2010).

A sub-basin-level characterization of land use and hydrology in the Clearwater Harbor South watershed is provided in the following.

3.3.1 McKay Creek

McKay Creek with its tributary Church Creek is the southernmost named water feature in the CHSJS and the only mainland sub-basin in the Clearwater Harbor South watershed. McKay Creek flows about seven miles from an unnamed lake south of 86th Avenue to discharge into the Harbor. The 8.8-square mile (5,628 acres) sub-basin is highly urbanized, with residential land uses (66%) and commercial (14%) comprising 80% of the land use. Open lands constitute 12% of the sub-basin land use with remaining land use types less than 5%. Based on the NHD GIS coverage, the sub-basin contains 0.9 miles of streams/river and 6.0 miles of canals/ditches, as defined above, and is consistent with dominant urban uses. An aerial photograph of this sub-basin is presented in Figures 3-41, which also shows PCDEM water quality monitoring sites. Ground-level photographs of McKay Creek and Church Creek are provided in Figures 3-42 and 3-43, respectively.

There are three County parks in the McKay Creek sub-basin – Taylor Park, Ridgecrest Park, and Walsingham Park. These parks help preserve some of the few undeveloped inland areas in the sub-basin.

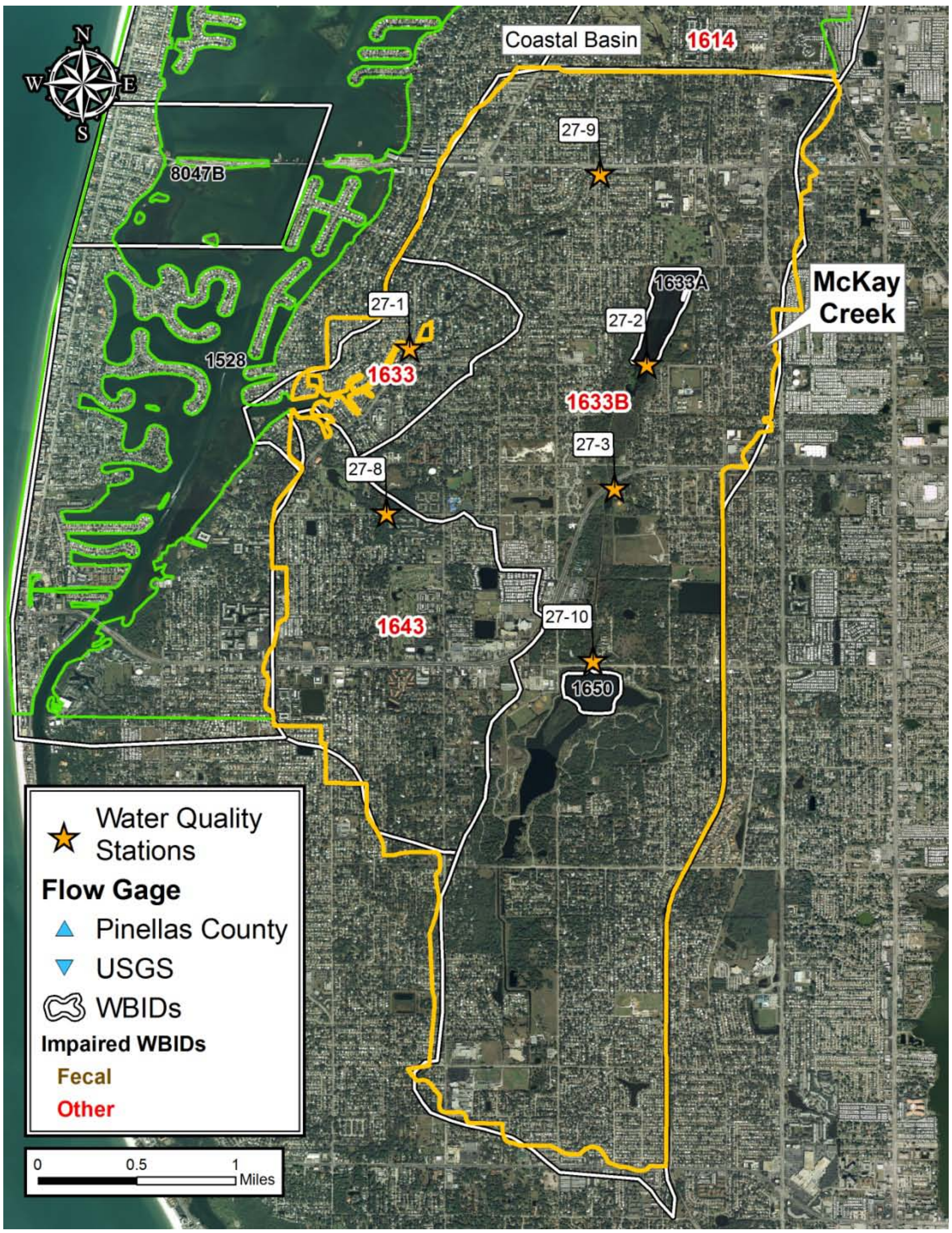


Figure 3-41. **McKay Creek 2008 aerial photograph (SWFWMD, 2010).**

Figure 3-42. McKay Creek near PCDEM water quality sampling site 27-1.

Figure 3-43. Church Creek near PCDEM water quality sampling site 27-8.

3.3.2 CHS Coastal Subbasin

The CHS Coastal sub-basin contains 7.2 acres of coastal areas that drain directly to Clearwater Harbor South. This sub-basin is highly urbanized, with residential and commercial lands comprising 79% of the basin and open lands contributing 14% of the total area. Freshwater inputs from this sub-basin are minimal. Sand Key has no significant water feature and drains directly to Clearwater Harbor South. The 1.9-square mile (1,223 acre) island is highly urbanized, with 91% of the land use comprised of residential or commercial uses. Because of the lack of defined surface water features in the CHS watershed, proportionally more area is within the Coastal sub-basin than the other two watersheds. Based on the NHD GIS coverage, this sub-basin contains 0.6 miles of streams/river and 1.2 miles of canals/ditches, as defined above in Chapter 3.1.

An aerial photograph of the sub-basins presented in Figure 3-44 that shows two PCDEM water quality monitoring sites, on Rattlesnake Creek at the Belleview Biltmore Resort and one farther upstream, as well as water control structures. A ground-level photograph is presented in Figure 3-45.

Figure 3-44. CHS Coastal sub-basin 2008 aerial photograph(SWFWMD, 2010).

Figure 3-45. **CHS Coastal sub-basin photograph near Memorial Bridge and Clearwater Beach Island.**

3.4 Hydrology of the CHSJS

Hydrologic processes that occur in the watershed have a significant effect on the circulation and ecology of the estuary. The timing, volume, and distribution of freshwater inflows to Clearwater Harbor and St. Joseph Sound are determined by land use and hydrologic alterations that have occurred in the watershed, as well as by precipitation patterns. This section summarizes surface water features and hydrology for the three CHSJS segment watersheds.

Characteristics of most of the stormwater runoff reaching the CHSJS estuary are affected by man-made stormwater management features. Extensive alteration to the watershed's hydrologic features has greatly changed how freshwater is conveyed to the receiving water. Channelization of coastal streams increases peak flow rates and velocities, which in turn reduce opportunities for pollutant removal and groundwater recharge. Higher peak flows and reduced attenuation also increases the potential for channel and coastal erosion.

Stormwater management systems are now required to moderate runoff flow rates and afford some level of water quality treatment. However much of the watershed was developed prior to the enactment of current stormwater rules and thus are not subject to such requirements.

3.4.1 St. Joseph Sound

The major surface water feature in the St. Joseph Sound watershed is the Anclote River, which is described above. The balance of freshwater inflow to the estuary is conveyed via overland flow or small coastal channels and ditches. Named tributaries are shown in Figure 3-1 and include the Anclote River (Gaged, Ungaged, and North of Anclote River), Klosterman Bayou, Sutherland Bayou, and Smith Bayou. Direct runoff to the estuary is from the CHS Coastal sub-basin.

Precipitation and streamflow data were used to characterize the entire CHSJS. Precipitation data used for loading estimates were obtained from a rain gage at the City of Tarpon Springs municipal wastewater treatment plant (WWTP). As shown in Figure 3-46, annual rainfall had a range of over 50 inches during the site's 75-year period of record, but most annual values fell between 40 and 60 inches per year for an overall average annual value of 51.6 inches.

Monthly precipitation follows the typical regional seasonal pattern with highest monthly rains occurring during the months of June through September (Figure 3-47). A spring freshette occurs during the month of March as well. Peak monthly precipitation values exceed 15 inches during half the months including all four wet season months, and minimum values are at or nearly at zero in all eight months of the dry season.

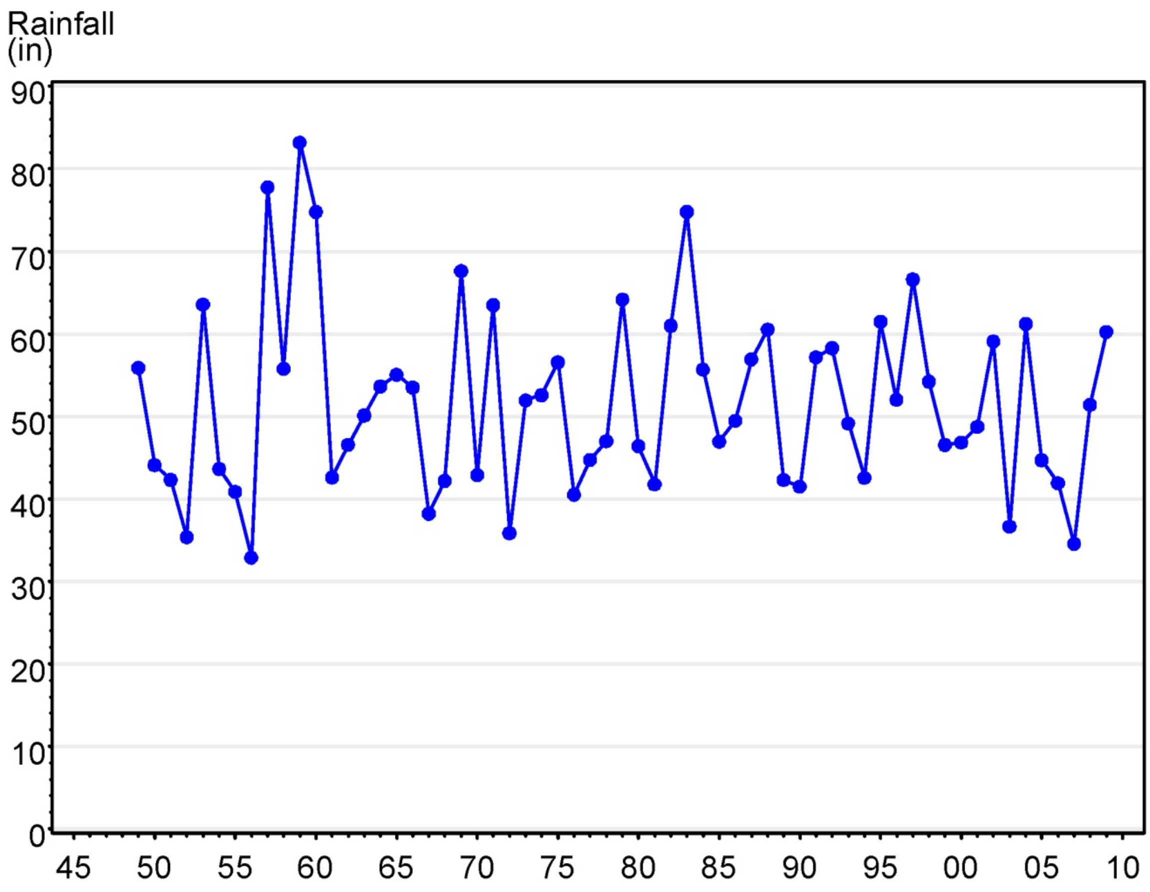


Figure 3-46. Annual precipitation at City of Tarpon Springs WWTP, 1948 - 2009.

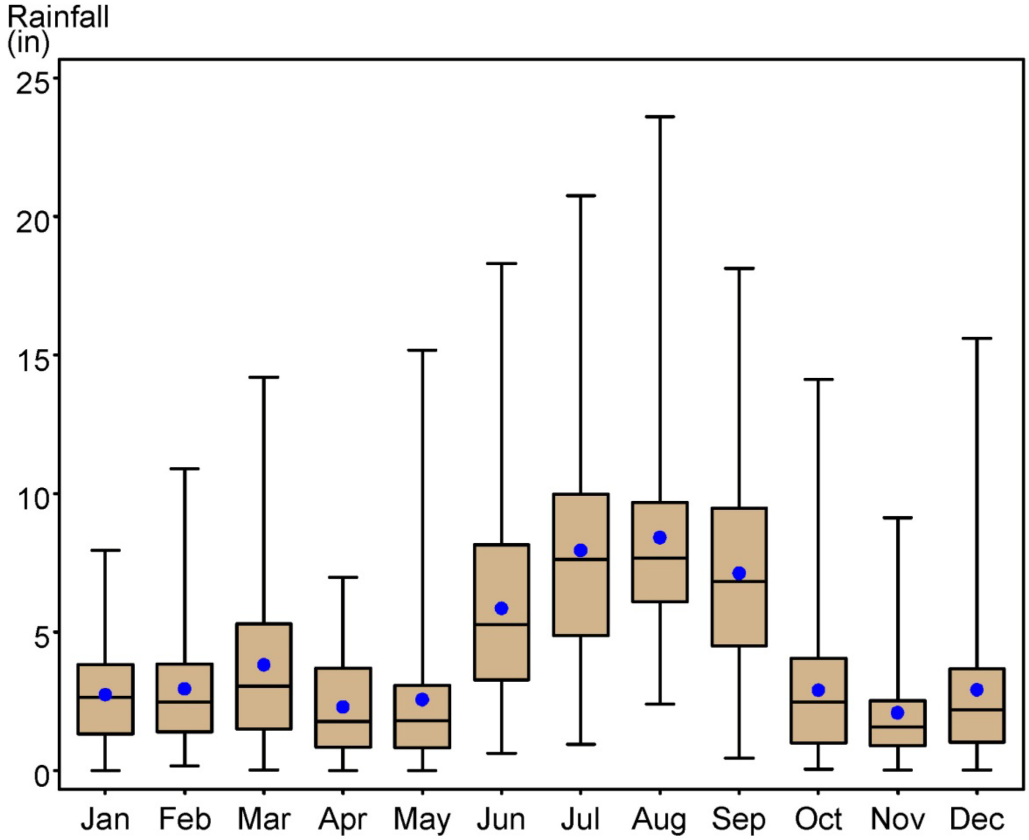


Figure 3-47. Monthly precipitation at City of Tarpon Springs WWTP rain gage.

Recorded streamflow, or discharge, expressed as daily average flows in cubic feet per second (cfs), were available from a total of seven sites within the CHSJS. Four of the gages are operated by the U.S. Geological Survey (USGS) or a cooperator, and three of the gages are operated by PCDEM.

Of these, one USGS gage (on the Anclote River) and one County gage (on Klosterman Creek) are located in the St. Joseph Sound watershed. As can be seen in Table 3-8, only the Anclote River gage has a significant period of record (64 years). The Anclote River sub-basin is also by far the largest sub-basin in the watershed, however the USGS gage (#02310000 near Elfers) is 16 miles upstream of the river mouth and its recorded discharge represents only about 60%of the total river flow. The gage with the next longest period of record is Curlew Creek (10 years), in the Clearwater Harbor North watershed. These data were used to estimate hydrologic and pollutant loads to the estuaries.

Annual average flows at the Anclote River gage ranged from under 10 cfs to over 200 cfs (Figure 3-48),with most values in the 30 to 1000 cfs range. Although relatively modest flows by some standards these flows have a significant influence on circulation, flushing, and water quality in St. Joseph Sound. Monthly flows at the Anclote gage mirror the rainfall pattern, with higher flows occurring between June and September (Figure 3-49). Although average flows are higher during the summer (approaching 200 cfs), extreme monthly flows for March and December are also very high (near 600 cfs). Mean monthly flows for the dry season are frequently less than 50 cfs.

Table 3-8. Surface water discharge gages in the CHSJS.					
Gage Number	**Water Body**	**Receiving Water Body**	**Owner**	**Period of Record**	**Subbasin Area (square miles)**
02310000	Anclote River	St. Joseph Sound	USGS	05-01-46 to present	75.2
02309445	Bee Branch	St. Joseph Sound	USGS	06-30-00 to 09-30-03	1.13
02309425	Curlew Creek	St. Joseph Sound	USGS	08-09-99 to present	4.09
FLO458_2918	Klosterman Bayou	St. Joseph Sound	Pinellas County	06-01-06 to current	1.69
FLO450_2907	Spring Branch	Clearwater Harbor	Pinellas County	06-01-06 to current	3.16
FLO457-2916	Stevenson Creek	Clearwater Harbor	Pinellas County	06-01-06 to current	3.60

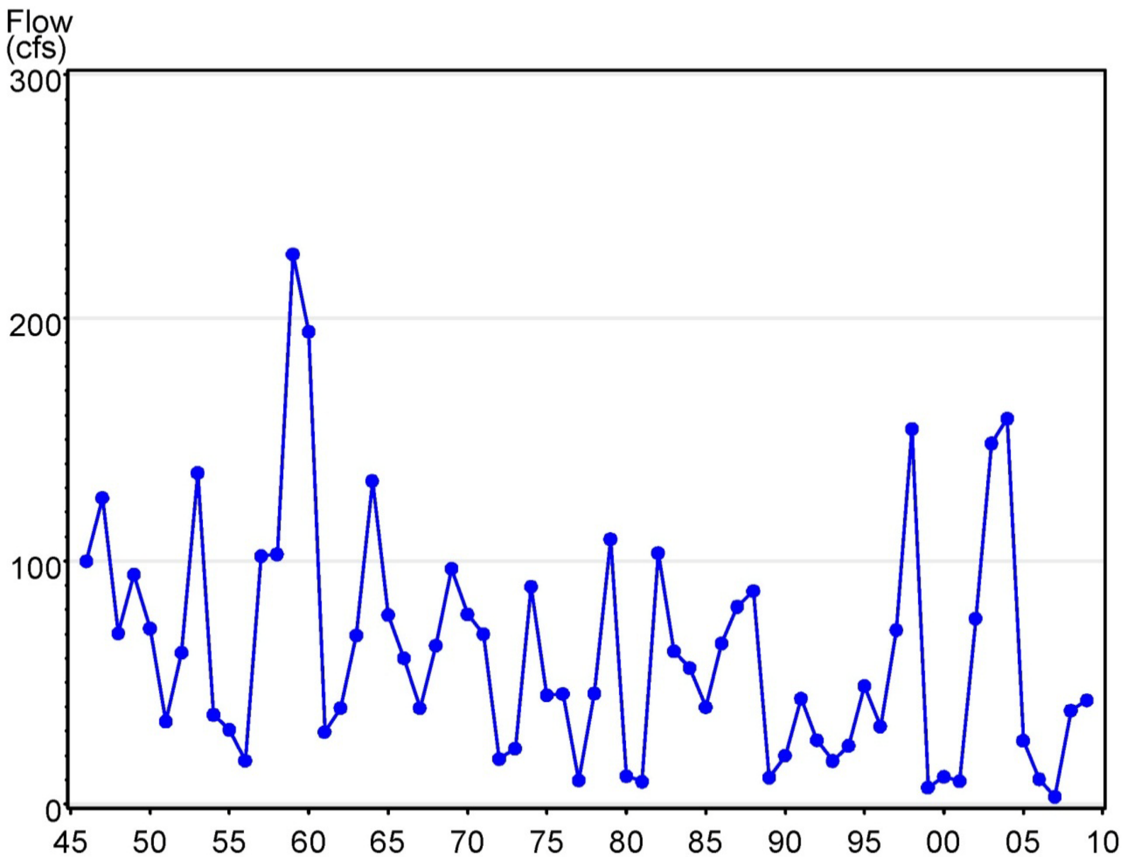


Figure 3-48. Annual mean flows at USGS gage 02310000, Anclote River near Elfers.

Both natural and culturally-derived factors influence discharges in the Anclote River. The river responds relatively directly to variability in rainfall, with high rains bringing increases in river flow rates. However, wellfields have operated in the Anclote River watershed for decades, and significant pumping of groundwater for public supply has resulted in river flows that are estimated to have been reduced by 29% as measured at the USGS gage (Heyl et al., 2010). Mean annual flow for the period of record was 63.3 cfs, but mean annual flow for the period 2004 through 2008, was 47 cfs (Heyl et al., 2010).

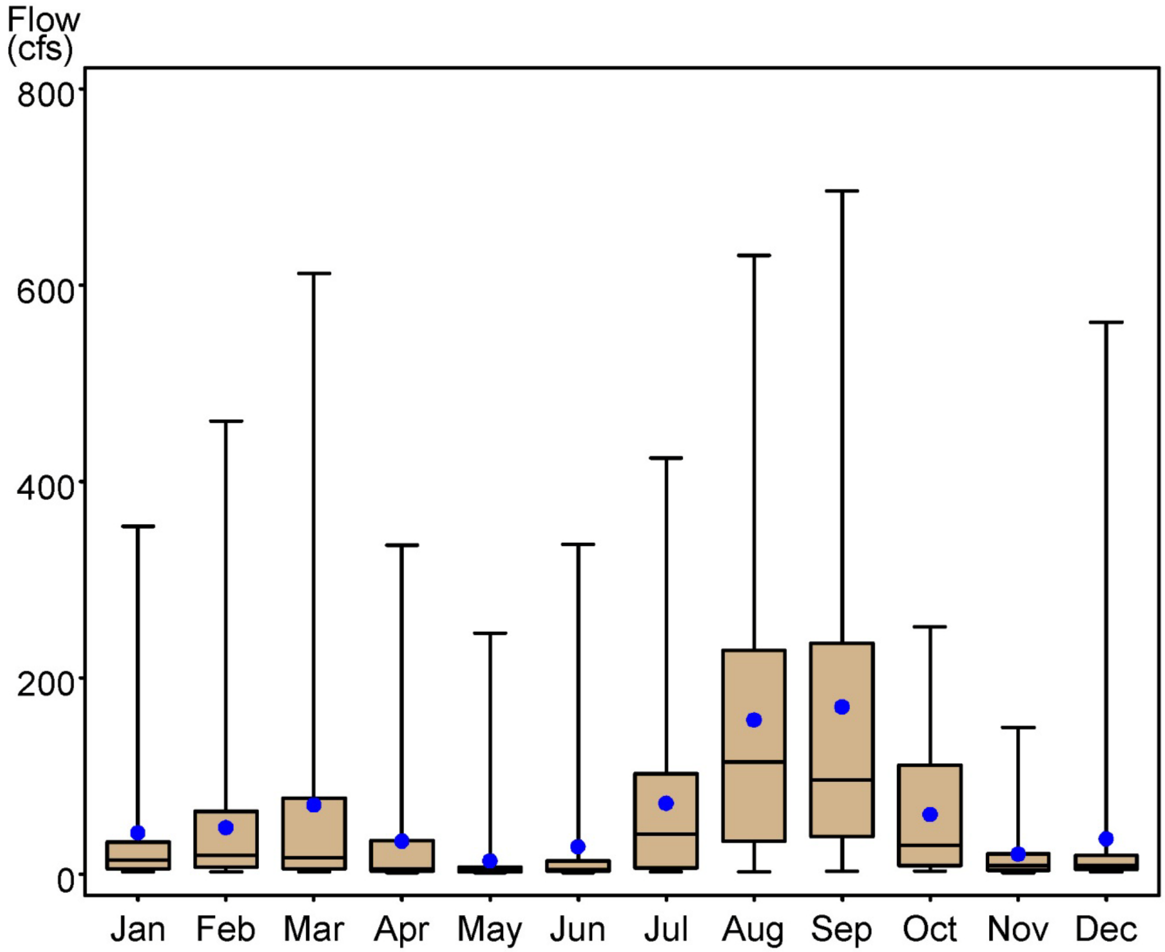


Figure 3-49. Monthly mean flows at USGS gage 02310000, Anclote River near Elfers.

Local resource managers recognized that existing levels of pumping were not sustainable, and developed the *Northern Tampa Bay New Water Supply and Ground Water Withdrawal Reduction Agreement*, which was implemented in 1998. Through the recovery plan regional groundwater pumpage would be reduced from 158 million gallons per day (mgd) in 1998 to 90 mgd in 2009 (Heyl et al., 2010). Minimum flow criteria were developed for the river by SWFWMD in 2007. Cutbacks in wellfield pumping resulted in a measureable increase in river flows. A 2009 re-evaluation of impacts on the Anclote River due to groundwater withdrawals suggested that if the 2008 pumping rates and well rotation schedule were continued, flow in the Anclote River would recover to levels within the SWFWMD minimum flow thresholds (Heyl et al., 2010).

Ensuring that adequate and timely freshwater flows from the Anclote River reach St. Joseph Sound is crucial to sustaining the local estuarine communities, which depend on the volume and timing of those flows for the protection of critical habitat. Increasing demands for potable water supply must be balanced with the requirements of the natural system. The CHSJS CCMP will address these issues by building on the SWFWMD minimum flow work to develop freshwater inflow targets for the estuary.

The other stream gage in the St. Joseph Sound watershed is Pinellas County's gage FLO458_2918 (Klosterman Creek, just south of the Anclote River sub-basin). Dry season monthly mean flows are frequently less than 0.5 cfs, and monthly mean wet season flows are usually3 to 4 cfs (Figure 3-50).

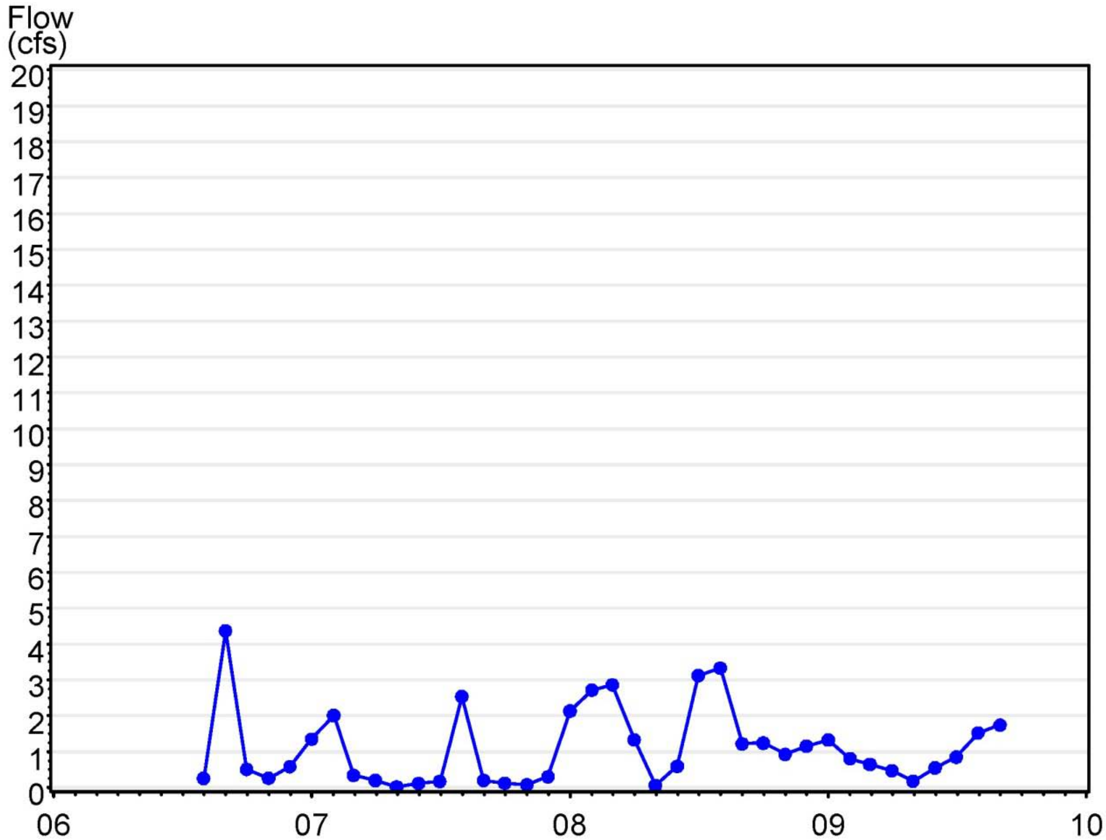


Figure 3-50. Monthly mean flows at Pinellas County gage FLO458_2918, Klosterman Creek.

3.4.2 Clearwater Harbor North Watershed

The Clearwater Harbor North watershed drains to the estuary through several small creeks. Named tributaries to the estuary include (from north to south) Curlew Creek, Cedar Creek, Spring Branch, and Stevenson Creek. Direct runoff reaches the estuary from the CHN Coastal sub-basin via overland flow or small coastal channels and ditches.

In contrast to the larger flows of the Anclote River, freshwater inflows to the Clearwater Harbor North segment are small, although still ecologically important. Curlew Creek, at the north end of Clearwater Harbor (USGS gage 02309425), has annual average flows ranging from 11 to 24 cfs (Figure 3-51), with wet season and dry season monthly mean flows in the range of 10 cfs and 30 cfs, respectively (Figure 3-52). Bee Branch/Smith Creek (USGS gage #02309445, essentially a drainage ditch in Palm Harbor, had annual average flows ranging from 1.5 to 4.2 cfs over its short period of record (Figure 3-53). Monthly flows range from near 5 cfs in July and August to 1.0 or less in many dry months (Figure 3-54).

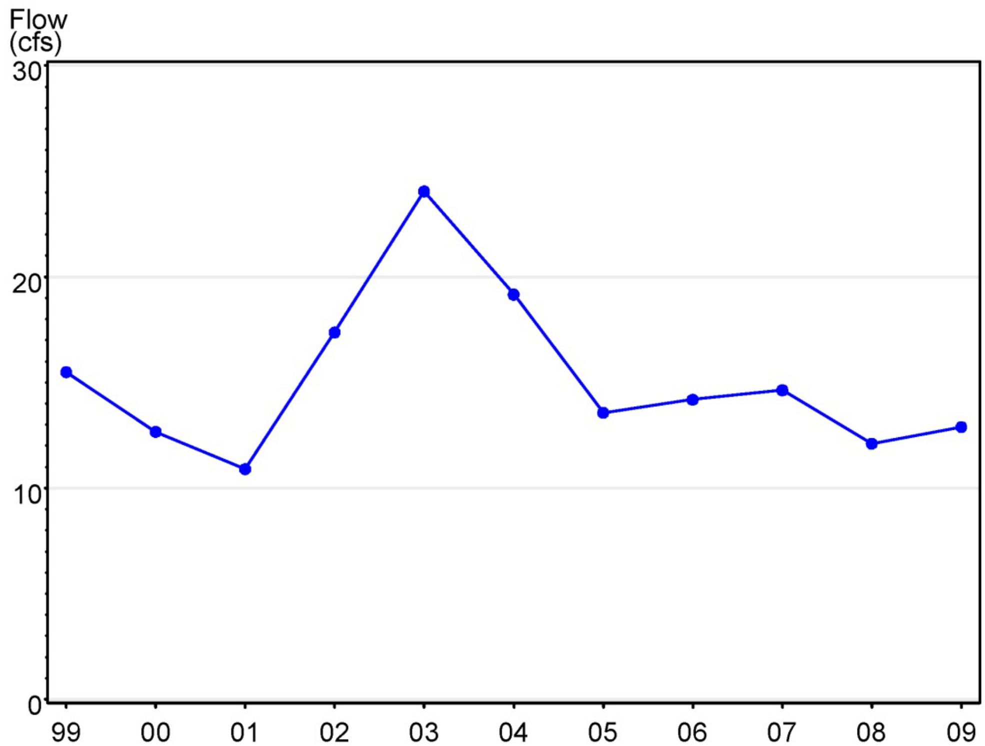


Figure 3-51. **Annual mean flows at USGS gage 02309425 Curlew Creek near Ozona**

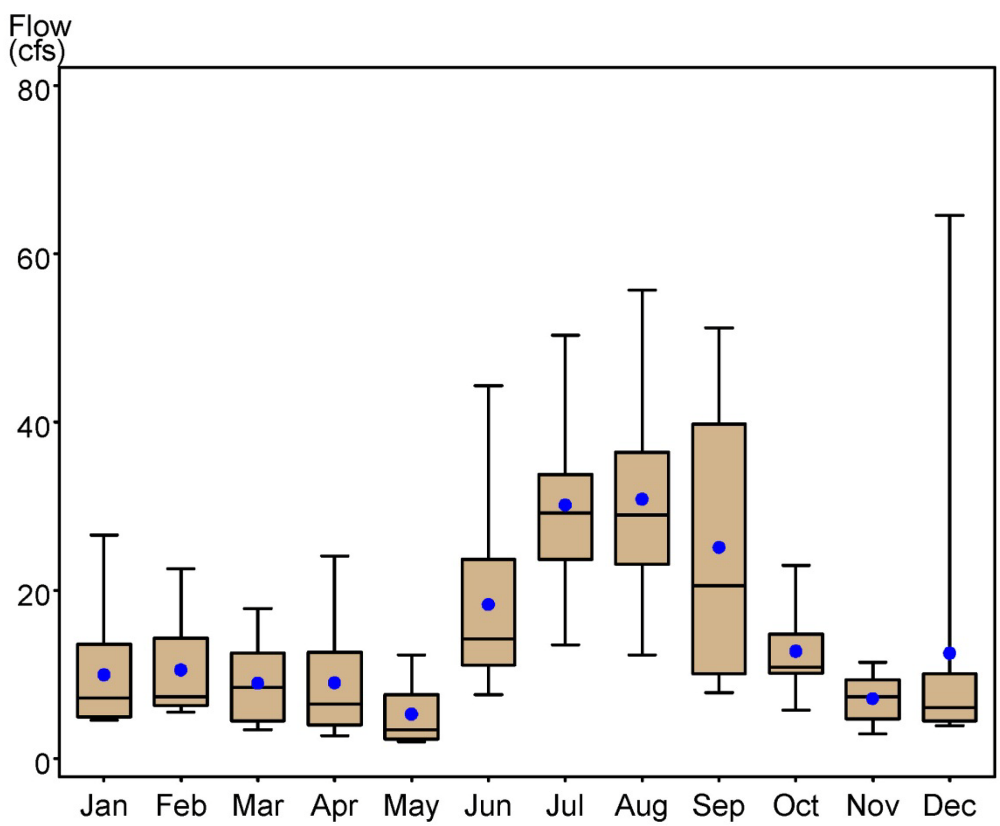


Figure 3-52. **Monthly mean flows at USGS gage 02309425 Curlew Creek near Ozona.**

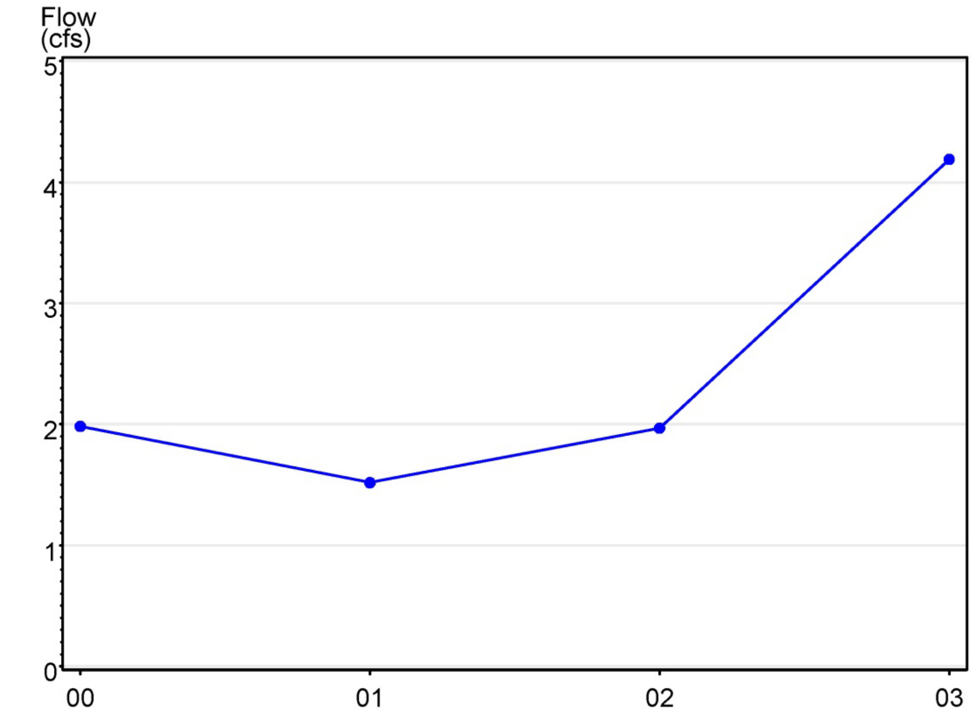


Figure 3-53. **Annual mean flows at USGS gage 023109445 Bee Branch at Palm Harbor.**

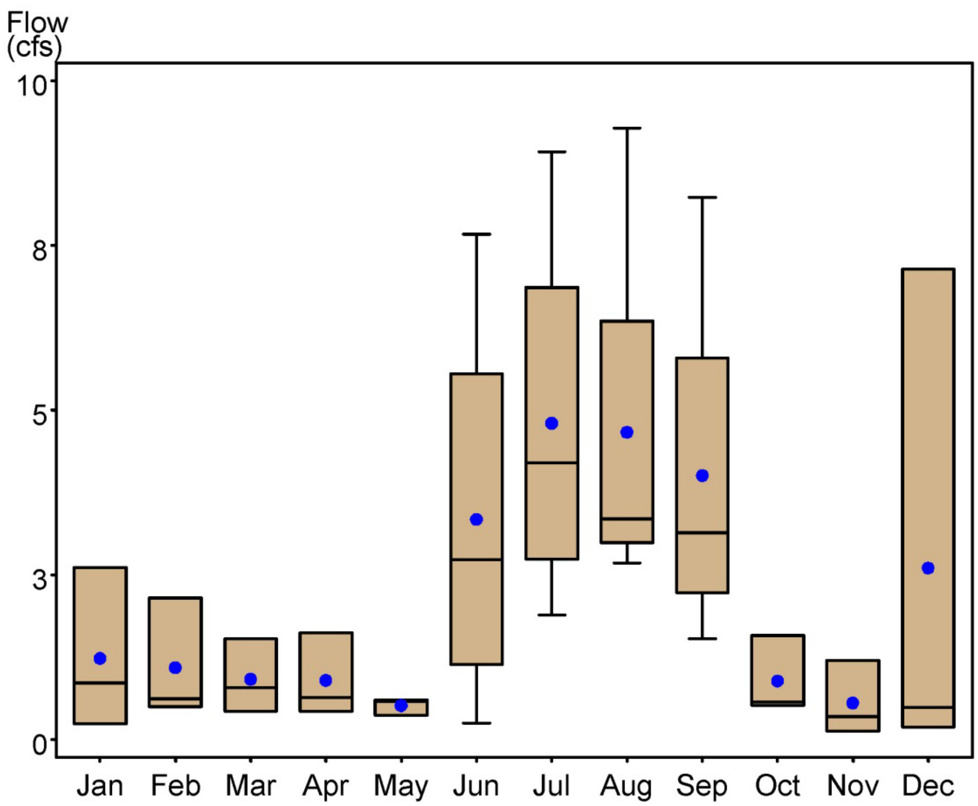


Figure 3-54. **Monthly mean flows at USGS gage 023109445 Bee Branch at Palm Harbor.**

Gage FLO458_2907 (Spring Branch, a tributary to Stevenson Creek) often has dry season monthly mean flows of less than 1 cfs, but maintained flows over 2 cfs in the 2007-8 dry season, with monthly mean wet season flows typically in the 3 to 6 cfs range (Figure 3-55). PCDEM gage FLO458_2916 (Stevenson Creek, entering Clearwater Harbor north of Memorial Causeway) has reported dry season monthly mean flows ranging from less than 1 cfs up to 6 cfs, with at least one monthly mean wet season flow exceeding 10 cfs most years (Figure 3-56).

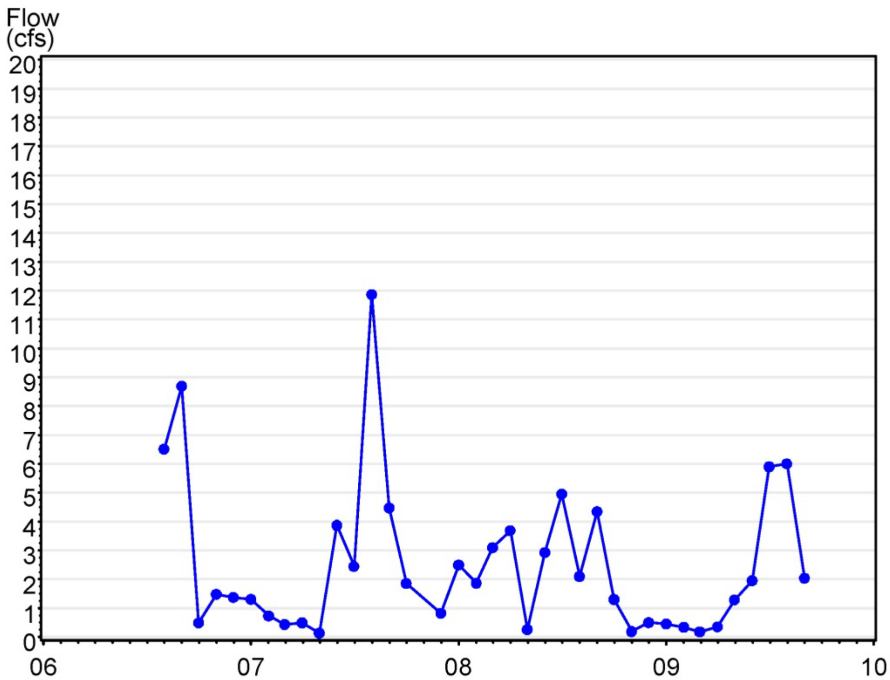


Figure 3-55. Monthly mean flows at Pinellas County gage FLO458_2907, Spring Branch.

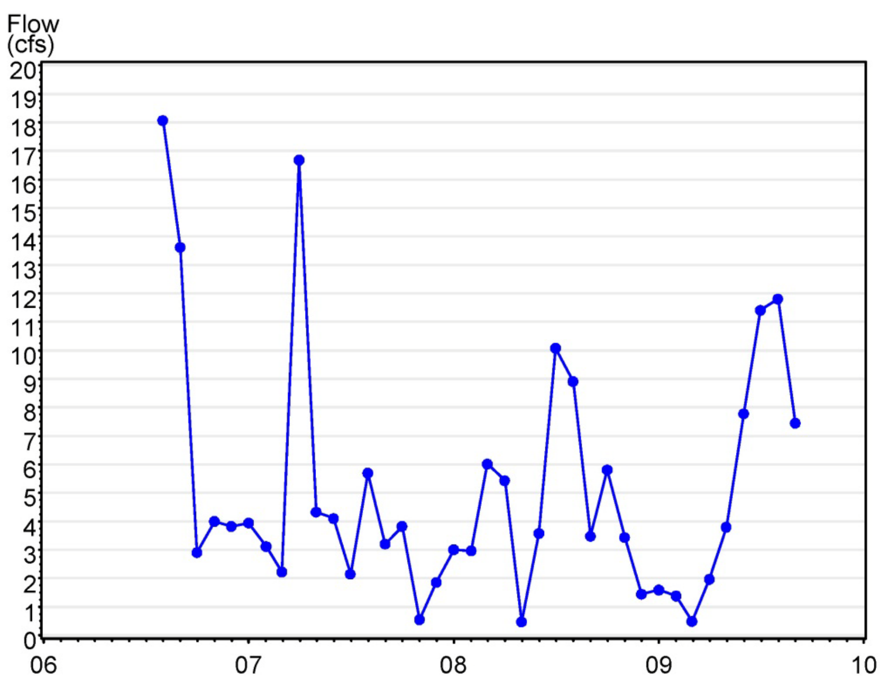


Figure 3-56. Monthly mean flows at Pinellas County gage FLO458_2916, Stevenson Creek.

3.4.3 Clearwater Harbor South Watershed

Clearwater Harbor South is the smallest watershed and includes only McKay Creek with its tributary Church Creek as a freshwater tributary. The remaining freshwater inflow is conveyed via overland flow or small coastal channels and ditches in the Coastal sub-basin. There are no streamflow gaging stations in the watershed. The small area contributing freshwater inflows, highly urbanized land use, and the presence of Clearwater Pass greatly affects circulation, residence time, water quality and salinity, and other estuarine features.

A tool used to compare the relative amount of stormwater runoff that a basin generates per acre of area is called the unit area flow, or unit discharge, expressed in cfs/unit area. Unit discharges can be used to identify sub-basins with the most significant hydrologic alterations or most intensive urbanization. In general higher unit discharges point to more channelization or more impervious surface. The three County gaged sub-basins (Klosterman Creek, Spring Branch, and Stevenson Creek) have unit discharges of 0.66, 0.80, and 1.43 cfs/mi^2, respectively. All three have relatively flat terrain, but land use plays a significant role in the different values. Both Stevenson Creek and Spring Branch have very little open space and pervious area. Klosterman Creek, on the other have, is over 40% open space (25% golf course with less coverage of upland forest and wetlands). These pervious areas promote groundwater recharge and peak flow attenuation, as well as pollutant uptake.

3.5 Environmental Lands

Environmental lands in Pinellas County include publicly-owned preserves, other managed environmentally sensitive lands, and passive recreation parks. Environmental lands can be differentiated from active recreation parks (e.g., ball fields) and other open space in that they: support the sustainability of natural resources, watersheds, and natural habitat; provide resource-based recreational opportunities; and promote a healthy environment and community. However, active recreation parks can also include remnants of native habitats, as well as provide other important hydrologic functions such as surface water storage and treatment, and groundwater recharge. For the purposes of this document, active recreation parks that possess such natural resource values are considered to be environmental lands.

Within the watershed boundaries of CHSJS area, environmental lands and active recreation parks are owned and managed by Pinellas County, SWFWMD, and the City of Dunedin. There are no federally owned/managed environmental lands in the project area watersheds.

This section provides a summary of the current status of environmental lands within the project area watersheds, as well as any relevant management issue with these lands. This section does not address those estuarine environmental lands described in Chapter 2.

3.5.1 Data Description

An inventory of environmental lands in the project area estuaries was conducted by reviewing SWFWMD's 2007 land use data, as well as local government property appraiser databases and website information. In addition, the Florida Natural Areas Inventory database was reviewed to identify publicly-owned lands that have natural resource value, and are being managed at least partially for conservation purposes.

Based on these data, six designated environmental lands and/or active recreation parks with natural resource values, were identified in the Clearwater Harbor and St. Joseph Sound watersheds. Of the six environmental lands identified, four are owned and managed by Pinellas County, one is managed by SWFWMD, and one is owned and managed by the City of Dunedin.

Table 3-9 provides a summary of these lands including: managing entity; total land area; land area within each of the two respective watersheds; and significant habitats and/or features. Figure 3-57 shows the location of these six environmental lands.

Table 3-9. Summary of environmental lands in the Clearwater Harbor and St. Joseph Sound watersheds.

Name	Managing Agency	Acres Total and Watershed			Significant Habitats/Features
		Total	Clearwater Harbor	St. Joseph Sound	
Taylor Park	Pinellas County	156.5	156.5	0	Includes a 53-acre freshwater lake, flatwoods; connected to Pinellas Trail.
Ridgecrest Park		23.0	23.0	0	Includes a 5-acre freshwater lake; passive recreation amenities.
Walsingham Park		350	353	0	Sections of remnant scrubby flatwoods, and mesic flatwoods; paved trails throughout.
Ozona Management Area		8	0	8	Mangrove forest with open water ponds important to wading birds; pine flatwoods and live oak hammock are also present.
Jerry Lake	SWFWMD	81	80	0	Natural lake and surrounding mixed hardwood floodplain forest.
The Hammock	City of Dunedin	88	82	0	Primarily hardwood swamp and cabbage palm hammock; adjacent to Highlands Park, which is used for active recreation.

3.5.2 Existing Conditions

Pinellas County

Taylor Park is located in the City of Largo, but is owned and managed by Pinellas County. The park consists of 156.5 acres, including a 53-acre created freshwater lake with excellent fishing. Small boats can be launched from a concrete boat ramp. Development of this park began in 1958. Its facilities include group picnic shelters, playground equipment, and restrooms. It also offers a softball diamond and a large, open playing field which are very popular with the local residents and children. A 1.8-mile running/exercise trail was added in May 1982. In late 1990, access to the nearby Pinellas Trail was completed. Remnants of native habitats include pine flatwoods and freshwater wetlands and aquatic habitats associated with the lake.

Figure 3-57. Location of environmental lands in the Clearwater Harbor and St. Joseph Sound watersheds.

Ridgecrest Park is located in the City of Largo, but is owned and managed by Pinellas County. This 23-acre park was first acquired and developed in 1958, and includes a 5-acre freshwater lake where fishing is permitted. In addition to picnic facilities, the park offers two play areas with a variety of playground equipment, restrooms, and a softball field. Remnants of native habitats include pine flatwoods, freshwater wetlands, and aquatic habitats associated with the lake.

Walsingham Park is situated on 354 acres, divided by 100-acre Walsingham Lake, one-quarter mile west of the Pinellas Trail. There are entrances on Walsingham Road and on 102nd Avenue North. The park provides passive and active recreational amenities for approximately 700,000 visitors to this park each year. Visitors picnic and enjoy recreation such as hiking, jogging, cycling, a 6-mile trail, a 10-station fitness area, bird-watching, observing many plant species, fishing and/or boating. Boating is restricted to rowing, sailing, or electric engines - combustion engines are not permitted. Walsingham Reservoir was created from a natural lake to provide an irrigation water supply for citrus farming in part of Pinellas County. Five habitat areas have been delineated within the boundaries of Walsingham Park: botanical gardens, pine flatwoods, oak scrub, Walsingham Reservoir (with detention ponds, swales and wetlands), and cleared areas. Wildlife includes: snakes, tortoises, turtles, hawks, mottled ducks, herons, wrens, thrashers, warblers; as well as butterflies comprised of swallowtails, sulphurs, gulf fritillary, Carolina satyr, and white peacock.

Ozona Management Area is an 8-acre conservation area located in unincorporated Pinellas County. Aerial photographs from the 1920s indicate former freshwater marshes and surrounding flatwoods and sandhill communities in this area. Prior to 1942, a ditch was dredged to connect this area to the Gulf of Mexico providing a means of salt water ingress to the formerly freshwater wetland system. Road improvements and coastal development that included mangrove removal followed. The Pinellas County Board of County Commissioners acquired the parcels that comprise this property between 1989 and 2001 and the area is managed by Pinellas County. Tides play a minimal role in the hydrology, which is regulated primarily by elevation changes in stormwater control structures. Low-lying areas within the region flood frequently. Elevation ranges up to 10 feet above sea level, though higher elevations are attributed to fill material associated with residential development. Mowing, dumping of trash, ditching, and filling have encouraged the extensive spread of invasive exotic species, including Brazilian pepper, punk tree, guinea grass, and air-potato. The spread of other exotics, such as carrot wood and camphor tree, has been promoted by surrounding landscaping. Remaining native habitats and plant communities include: pine flatwoods, oak hammock, tidal swamp (mangrove), and, salt barren.

Since assuming management of this area in 1998, the County has focused its efforts primarily on controlling exotic species through the use of chemical treatment and planting bays, cedars, hollies, ferns, and rushes. Volunteers have devoted many hours to removing exotics by hand. As with all small natural areas surrounded by development, control of exotics will be an on-going challenge. Though natural communities of this region would have burned naturally, reintroduction of fire is not currently a viable management strategy at the Ozona Management Area due to its small size and proximity of residential areas. Additional efforts at this management area may include improving the hydrology, and planting native vegetation.

Southwest Florida Water Management District

Jerry Lake is a natural 31-acre lake located within the City of Dunedin. The lake and approximately 50 acres of undeveloped mixed hardwood forest on the north and south sides of the lake are owned by SWFWMD. Jerry Lake and its forested floodplain are identified as a major drainage feature in the Pinellas County Comprehensive Plan Drainage Element, and function as an urban flood detention area. Jerry Run flows into the northeastern end of the lake. The lake also receives stormwater runoff from adjacent residential development on the east and west sides of the lake. There is no documentation on the ecological condition of the lake and adjacent floodplain forest. There are no public recreational facilities on the lake or the adjacent open space.

City of Dunedin

Hammock Park, also known as "The Hammock", is an 88-acre natural area and passive recreational park owned and managed by the City of Dunedin. The park has five miles of nature trails, three picnic shelters, an observation platform, rest rooms and a playground area. This relatively small park has been largely preserved from the impacts of adjacent development, and contains a wide variety of vegetation and wildlife. There are five distinct native habitats represented in the park: mangroves, salt marsh, pine flatwoods, oak hammock/hardwood forest, bay heads, and, sand pine/scrub oak.

4.0 State of the CHSJS Watershed Resources

This chapter summarizes the information on a number of critical resources including:

- Watershed water quality status and trends,
- Watershed water quality management issues,
- Watershed loadings to the CHSJS estuaries,
- Watershed water quality targets and numeric nutrient criteria, and
- Watershed land use and habitat change.

As an initial step in characterizing the watersheds of the CHSJS, critical resources were identified, natural and anthropogenic stressors to the resources were identified, and a list of potential management activities was compiled to help guide the development of the final CCMP. These lists were then formulated into a list of critical questions that became the analytical pathway for establishing watershed water quality targets. Where the data allow, quantitative targets for resource protection and restoration are presented. Where the data do not allow defensible quantitative targets to be proposed qualitative targets are presented. Both the quantitative and qualitative targets will provide critical context and input to the CCMP development process.

4.1 Watershed Water Quality

Water quality is a primary determinant of conditions related to freshwater habitat availability and health. Water quality impacts the temporal and spatial extent of water column habitat availability for those organisms whose survival and reproductive strategies are dependent on specific water quality conditions (e.g., dissolved oxygen requirements, water clarity, and phytoplankton production). In order to be consistent with the other sections of the report, data and analyses are presented and discussed by segment (St. Joseph Sound, Clearwater Harbor North, and Clearwater South). In this section, the following topics are presented:

- description of water quality sampling,
- analysis of ambient water quality data,
- summary of Impaired Waters Rule evaluations of waterbodies,
- summary of loading estimates from the watershed, and
- background on regulatory developments pertaining to nutrient criteria.

4.1.1 Data Description

The County conducts routine water quality monitoring throughout the project area including the open-segments of Clearwater Harbor and St. Joseph Sound and the tributaries to these coastal waters (Figure 4-1). Water quality sampling for CHSJS tributaries is based on a fixed-station design and include 32 fixed stations located in ten tributary basins (Figures 4-2 – 4-4). These basins include, from north to south:

- St. Joseph Sound (SJS)
    - Anclote River
    - Klosterman Bayou
    - Sutherland Bayou

- Smith Bayou

- Clearwater Harbor North (CHN)
  - Curlew Creek
  - Cedar Creek
  - Spring Branch
  - Stevenson Creek

- Clearwater Harbor South (CHS)
  - Rattlesnake Creek
  - McKay Creek.

Detailed figures including aerial photography for each basin was provided in Chapter 3 and included FDEP waterbody identifiers and PCDEM water quality monitoring locations.

Figure 4-1. Location of tributaries in the CHSJS watershed.

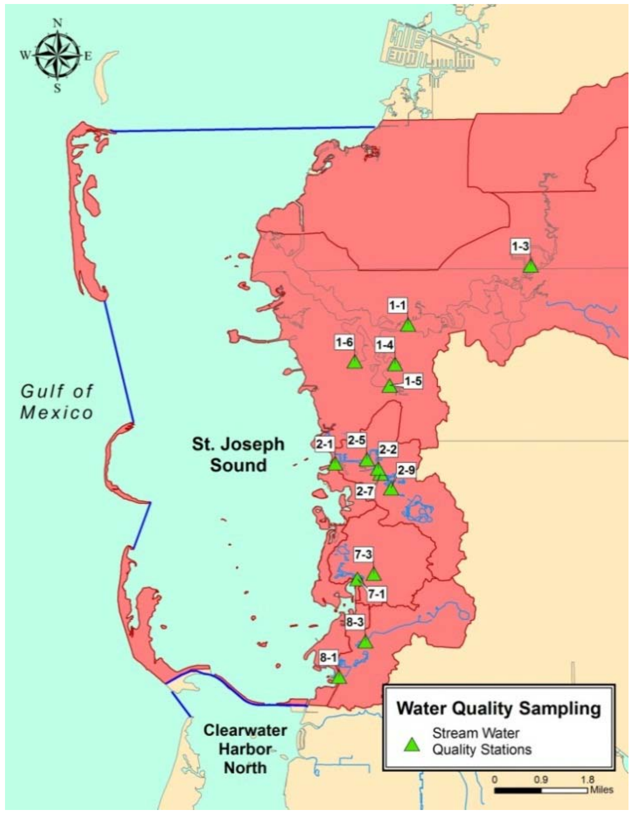


Figure 4-2. Location of tributary water quality sampling stations in SJS watershed.

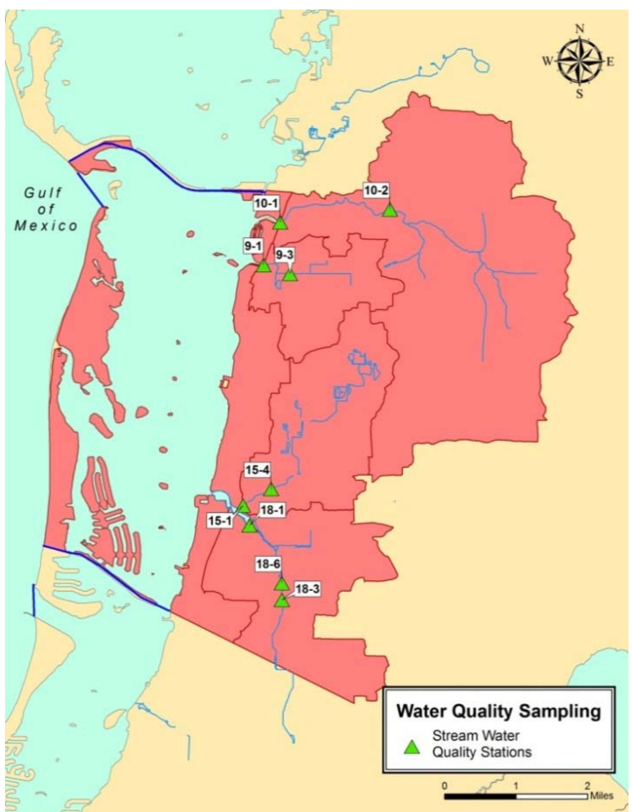


Figure 4-3. Location of tributary water quality sampling stations in CHN watershed.

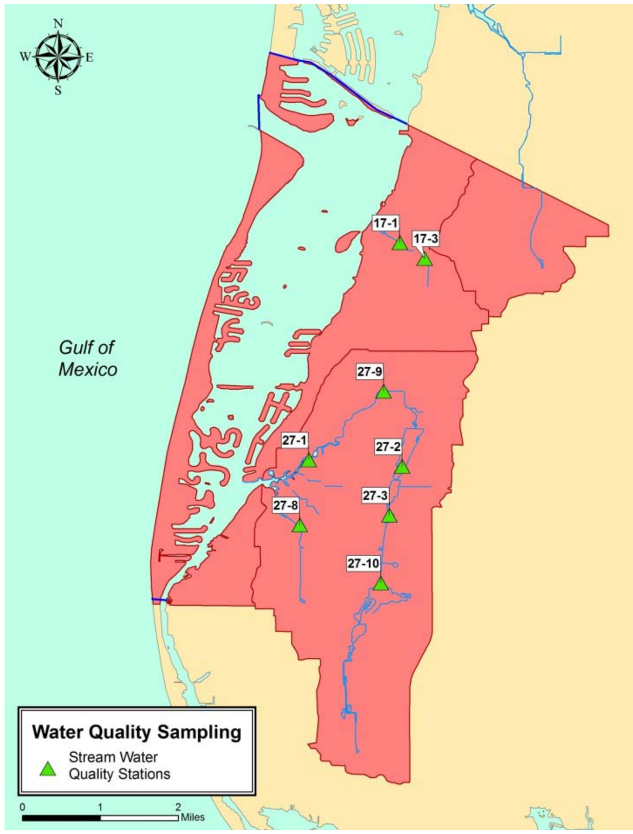


Figure 4-4. **Location of tributary water quality sampling stations in CHS watershed.**

The purpose of this aspect of the monitoring program is to develop estimates of pollutant loadings using grab-sample nutrient concentrations and flow velocity measurements. After a review of the sampling program in 2002, several tributary sampling stations were moved upstream to assure that they are above the tidal head and are not being influenced by estuarine water quality. All moved stations were renamed according to FDEP standards. While fixed-station data are limited with respect to generalizing information to the waterbody of interest, they are very useful for detecting changes in nutrient concentrations over time.

During each sampling event, water quality parameters measured *in situ* included: water temperature (^{O}C), salinity (ppt), conductivity (ms/μm), pH (su), and dissolved oxygen (DO mg/L). Grab samples were collected for laboratory analysis of biochemical oxygen demand (BOD mg/L), total suspended solids (TSS mg/L), chlorophyll *a* (μg/L), total nitrogen (TN mg/L), total phosphorus (TP mg/L), turbidity (NTU), and fecal coliform (# colonies/100 ml). All field collections were performed according to FDEP standard operating procedure and laboratory analysis was performed to NELAC standards.

4.1.2 Watershed Water Quality Status and Trends

All ten of the tributaries have at least one WBID that has been designated as impaired by the FDEP. The impairment status is discussed in detail in Chapter 4.1.4. These impairments are related to principally to dissolved oxygen, fecal coliforms and chlorophyll *a* concentrations exceeding state standards.

As with other analyses presented in this document, tributary water quality data are presented by segment, as described above. To better understand the past and current state of water quality in the tributaries, timeseries plots of the annual average and box and whisker plots of all samples are presented for chlorophyll *a*, fecal coliform, TN, TP, and salinity. For DO, the timeseries plot is a summary of the percent of DO measurements in a year that are less than 4 mg/L for estuarine stations or less than 5 mg/L for freshwater stations. In the box and whisker plots, the box represents the inter-quartile range (bottom of the box = 25th percentile, middle of the box = median, and top of the box = the 75th percentile) while the whiskers represent the minimum and maximum and the red dot represents the mean concentration. Timeseries plots of water quality parameters by sampling station are presented in Appendix E for the complete period of record. In addition to the discussion of the plots described above, trend tests were run on individual station data when sufficient data were available (i.e., at least 5 years of routine sample collection and 40 sampling events). The Kendall Tau trend test (Reckhow, 1990) is a robust and commonly used statistical test for water quality trend detection. Results of the Kendall Tau trend test for water quality constituents are provided in the following subsections along with the discussion of water quality in their respective tributaries.

- **St. Joseph Sound**

In St. Joseph Sound, there are four tributaries with water quality data: Anclote River, Klosterman Bayou, Sutherland Bayou, and Smith Bayou. A timeseries plot of annual average chlorophyll *a* concentrations by tributary is presented in Figure 4-5, while a box and whisker plot of all samples is presented in Figure 4-6 by tributary. As is clear from these plots, chlorophyll *a* concentrations are highest in Klosterman Bayou (median=22.2 μg/L) and lowest in Smith Bayou (median = 1.7 μg/L), while the median concentrations in the other two tributaries are closer to but higher than Smith Bayou (Anclote River = 4.7 μg/L and Sutherland Bayou = 5.9 μg/L). No statistically significant trends were identified in any of these stations for chlorophyll *a* for the period of record that was analyzed.

Analysis of the timeseries plot of annual average fecal coliform counts (Figure 4-7) and the box and whisker plot of fecal coliform counts by tributary (Figure 4-8) reveals that Smith Bayou has the highest fecal coliform counts (median = 2200, mean = 3412), while the other tributaries have fecal coliform counts that are substantially less relative to Smith Bayou. For example, the median fecal coliform counts for Klosterman Bayou, Anclote River and Sutherland Bayou are 120, 58, and 44 colonies/100 ml, respectively. The state water quality standard for fecal coliform is less than 400 colonies/100 ml. Based on this standard, the 25th percentile for Smith Bayou (1400 colonies/100 ml) exceeds the state standard while the 75th percentiles for the other three tributaries are all less than the state standard of 400 colonies/100 ml.

Timeseries plots of annual average TN and TP concentrations by tributary are presented in Figures 4-9 and 4-11, while box and whisker plots of all TN and TP samples are presented in Figures 4-10 and 4-12 by tributary. Based on these plots, it is obvious that the TP concentrations are highest in Klosterman Bayou. In fact, the mean TP concentration in Klosterman Bayou (0.77 mg/L) is more than an order on magnitude greater than that of lowest mean TP concentration which is found in Sutherland Bayou (0.07 mg/L). The mean TP concentrations for the Anclote River and Smith Bayou are 0.09 and 0.11 mg/L, respectively.

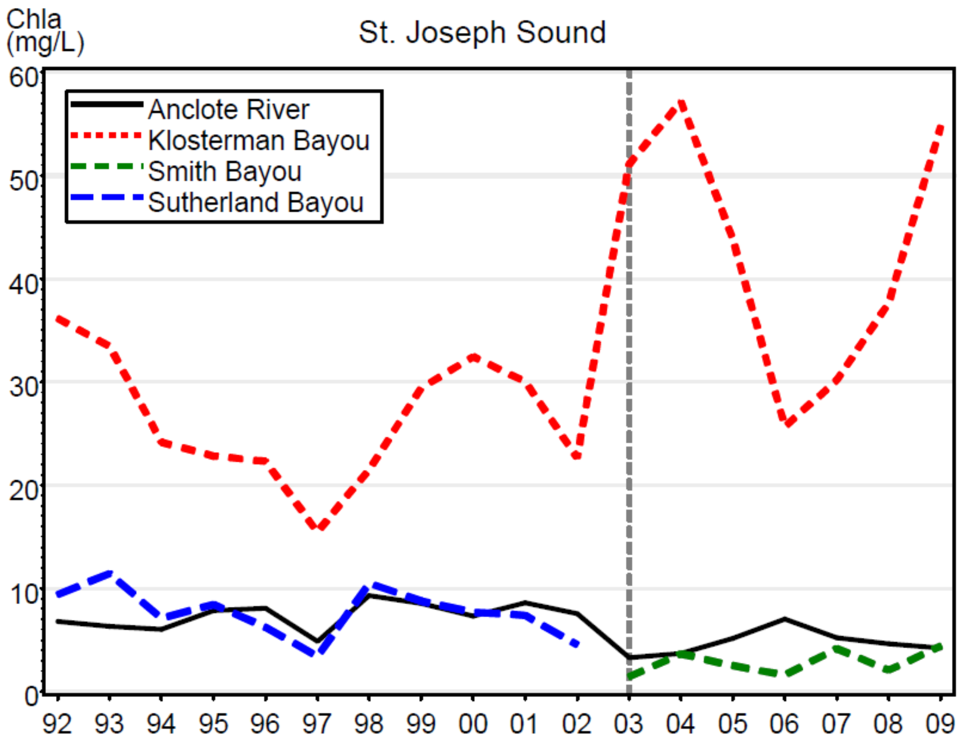


Figure 4-5. **Annual average chlorophyll *a* concentrations by tributary in SJS watershed. Vertical broken line indicates when stations were moved upstream.**

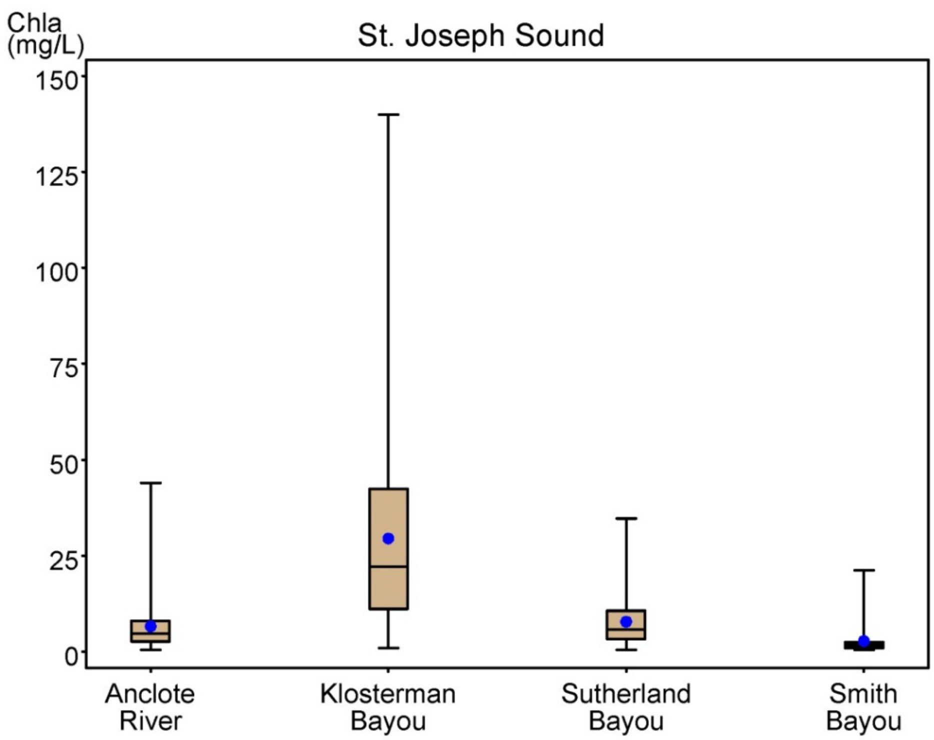


Figure 4-6. **Box and whisker plot of chlorophyll *a* concentrations by tributary in SJS watershed.**

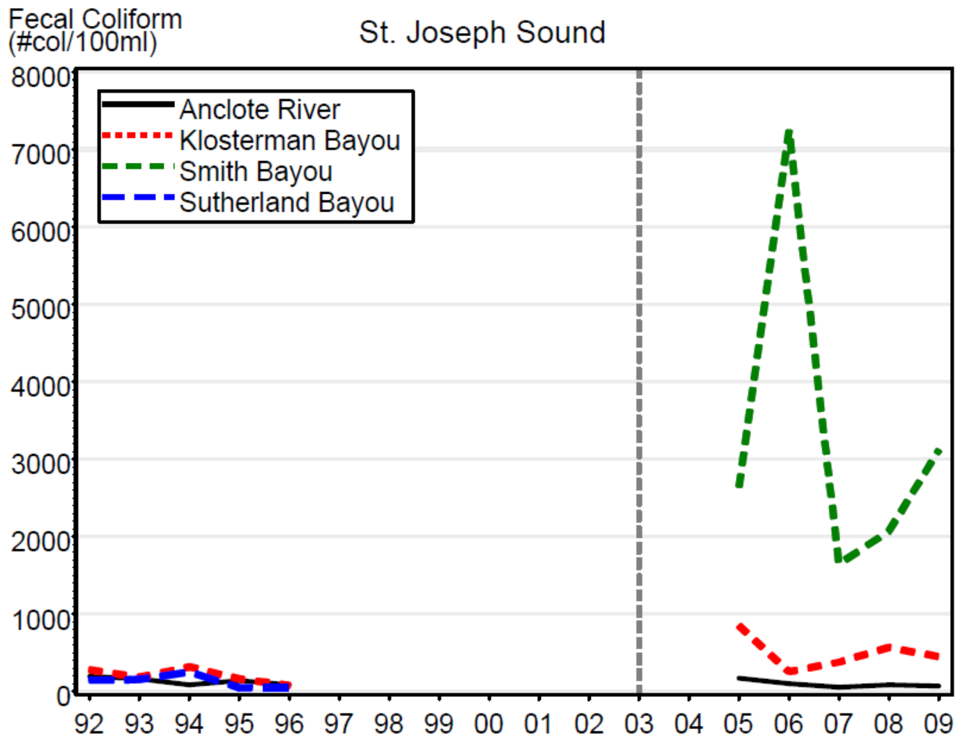


Figure 4-7. **Annual average fecal coliform counts by tributary in SJS watershed. Vertical broken line indicates when stations were moved upstream.**

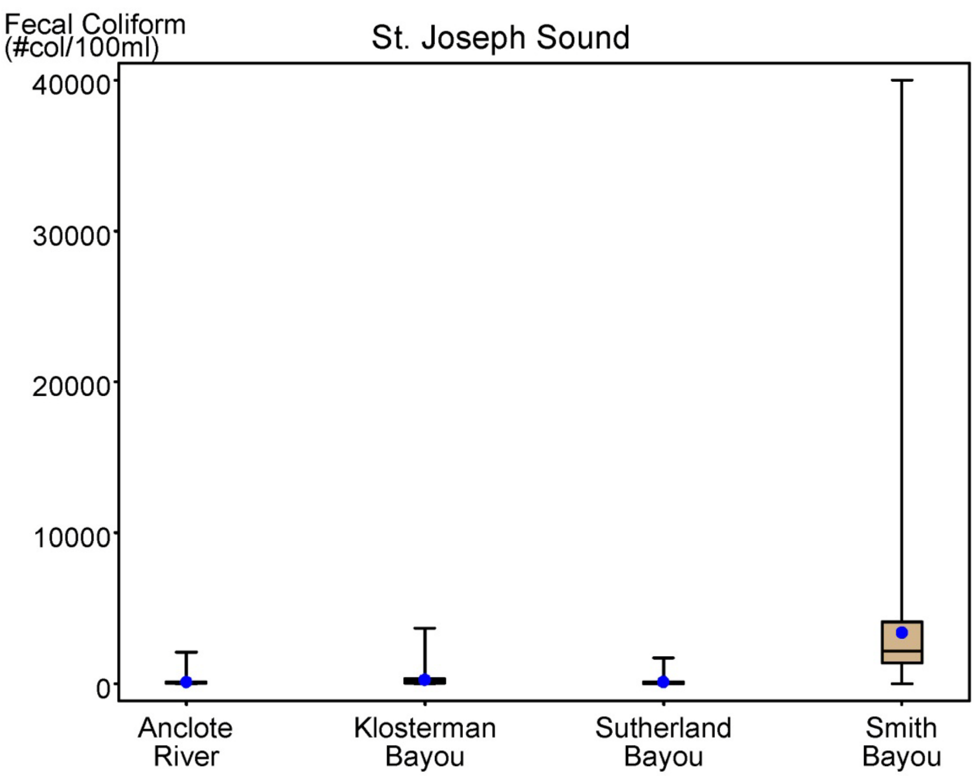


Figure 4-8. **Box and whisker plot of fecal coliform counts by tributary in SJS watershed.**

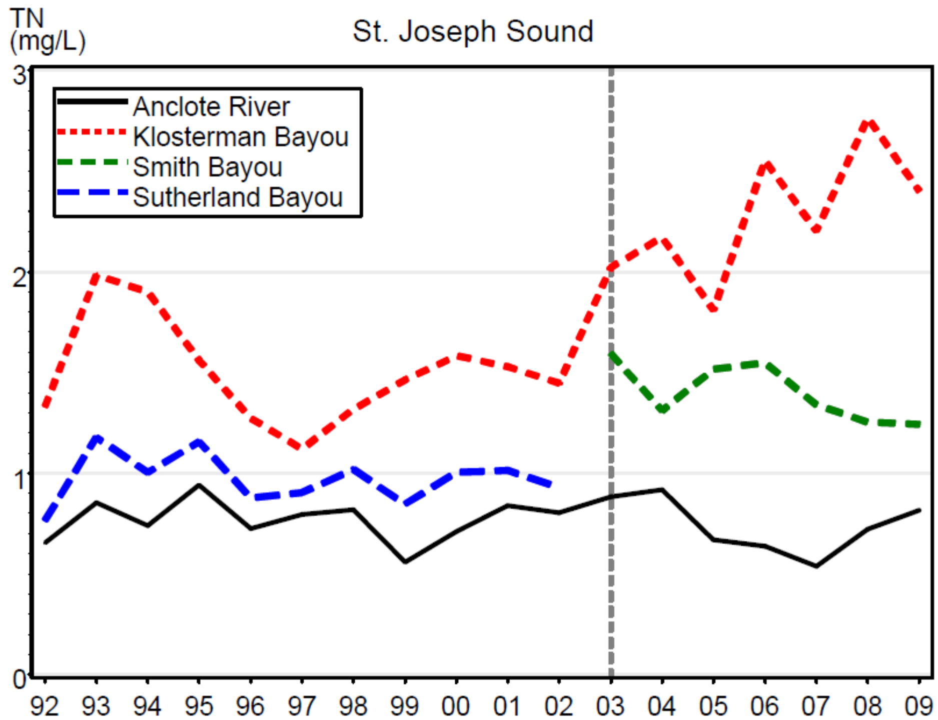


Figure 4-9. **Annual average TN concentrations by tributary in SJS watershed. Vertical broken line indicates when stations were moved upstream.**

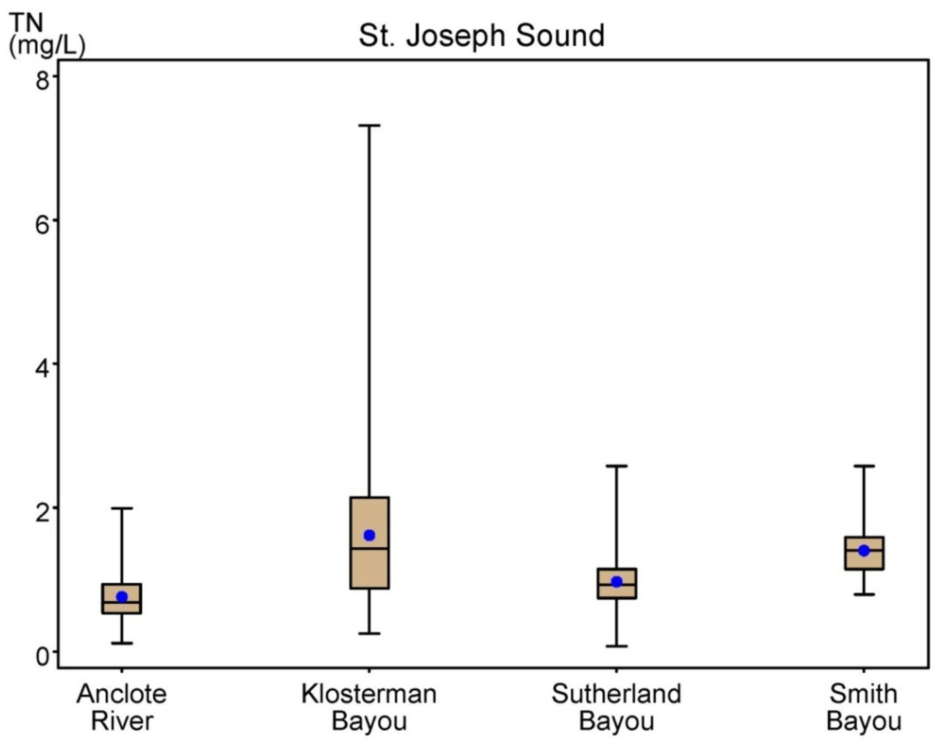


Figure 4-10. **Box and whisker plot of TN concentrations by tributary in SJS watershed.**

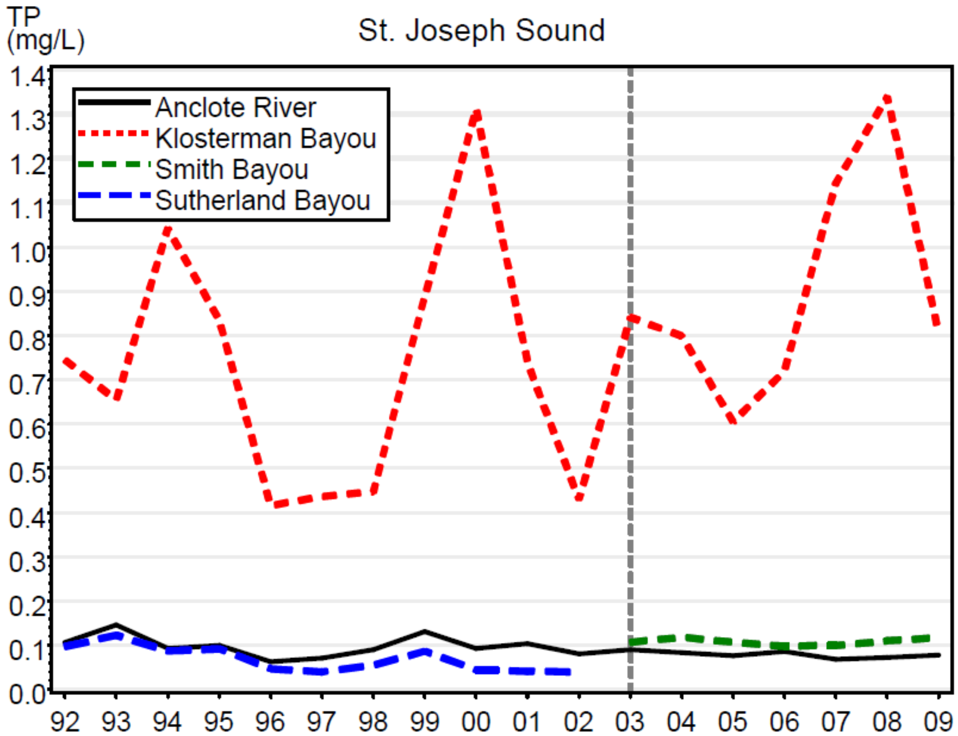


Figure 4-11. **Annual average TP concentrations by tributary in SJS watershed. Vertical broken line indicates when stations were moved upstream.**

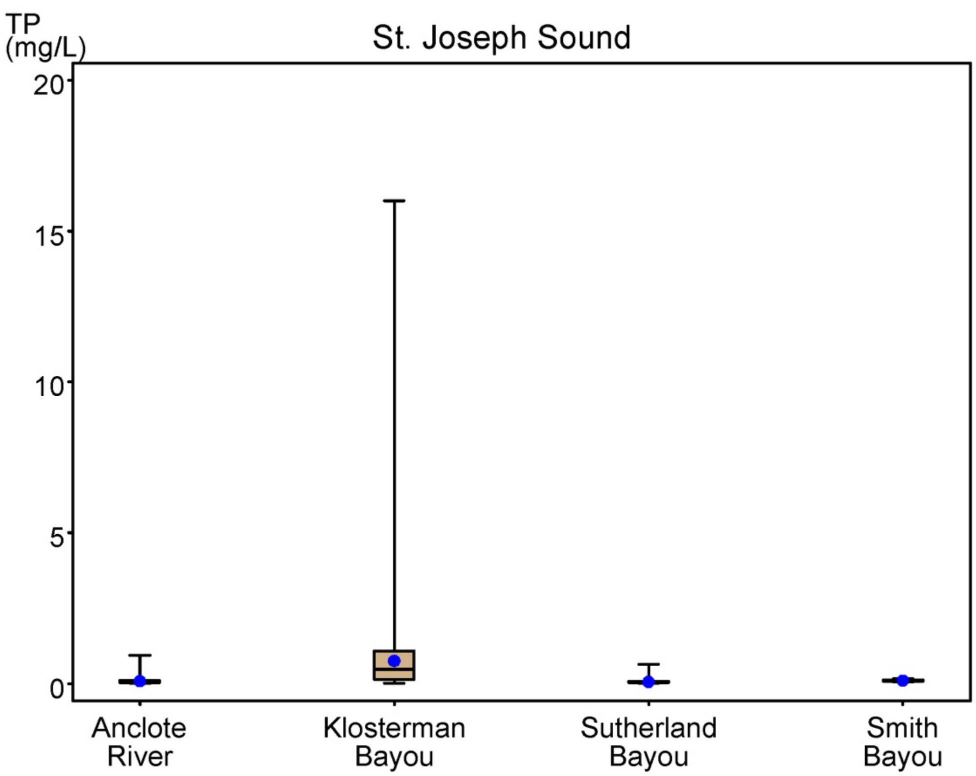


Figure 4-12. **Box and whisker plot of TP concentrations by tributary in SJS watershed.**

As with TP, the average TN concentration in Klosterman Bayou (1.62 mg/L) is greater than the other three tributaries in the St. Joseph Sound segment. However, the difference between the average TN concentration in Klosterman Bayou and the other tributaries is much less than the difference documented in TP concentrations. The average TN concentrations for Smith Bayou, Sutherland Bayou, and Anclote River are 1.41, 0.97, and 0.76 mg/L, respectively. In the recent period (2003-2009), Klosterman Bayou clearly has the highest TN concentrations, followed by Smith Bayou and lastly Anclote River. There were no timeseries trends in the Anclote River TN concentrations, while there were significant decreasing trends in TP at both stations (Table 4-1). In the Smith Bayou station, a significant decrease in TN was documented, while no trend was detected for TP.

Table 4-1. Trend test results for chlorophyll *a* and nutrient concentrations in SJS tributaries. Stations are denoted either marine (M) or freshwater (F) after station name and period of record is given below station name.

Tributary	Station	Parameter	Trend Direction	Median slope
Anclote River	01-01 (M) (1991-2009)	Chla	No Trend	0.023
		DO	No Trend	0.002
		TN	No Trend	0.000
		TP	Decreasing	-0.001
	01-03 (M) (1991-2005)	Chla	No Trend	0.088
		DO	No Trend	0.019
		TN	No Trend	-0.005
		TP	Decreasing	-0.003
Smith Bayou	08-03 (F) (2003-2009)	Chla	No Trend	0.000
		TN	Decreasing	-0.053
		TP	No Trend	0.000

The Anclote River and Sutherland Bayou have only estuarine stations, Smith Bayou has only freshwater stations, and Klosterman Bayou has a mix of estuarine and freshwater stations. This is important to note when investigating DO concentrations given that the DO standards for freshwater and estuarine waters are not the same. For estuarine waters, the annual percentage of samples collected with DO concentrations < 4 mg/L is not allowed to exceed 10% according to the Impaired Water Rule (F.A.C. 62-303; see Chapter 4.1.4 for details). For freshwater, the annual percentage of samples collected with DO concentrations < 5 mg/L is not allowed to exceed 10% according to the Impaired Waters Rule. A box and whisker plot of DO concentrations by tributary is presented in Figure 4-13 using all data combined. The highest DO concentrations are found in Smith Bayou, where the lowest concentration recorded is greater than the state standard of 5 mg/L for estuarine stations. The 25th percentile DO concentrations for the Anclote River, Klosterman Bayou, and Sutherland Bayou are 3.6, 3.3, and 3.8 mg/L, respectively. Therefore, during the period of record (1992-2009), at least 25% of the DO concentrations have been less than the state standards in these tributaries. Further investigation of the percent of annual DO samples less than the appropriate state standard are presented for each tributary in Figures 4-14 through 4-17. Where both fresh and marine stations are present within a tributary separate plots are produced. For example, both estuarine and freshwater stations exist in Klosterman Bayou. The percentage of DO samples less than 4 mg/L for the estuarine stations and less than 5 mg/L for the freshwater stations is presented in Figure 4-14. For both the estuarine and freshwater portions of the system, the annual percent of DO samples less than the standard exceeded 10% for each year. As discussed above, the Anclote River sampling stations are all estuarine, therefore the annual percent of DO samples less than 4 mg/L is presented in Figure 4-15. With the exception of 2003 and 2006, all years exceeded the 10% standard for DO concentrations less than 4 mg/L. There is a definite pattern of improving DO in the Anclote River as the percent of samples less than 4 mg/L has not exceeded 20% between 2006 and 2009, while the percent of samples less than 4 mg/L exceeded 20% in all but two years prior to 2006. However, trend test on the two stations in the Anclote River showed no statistically significant trend for DO. The percent of annual DO concentrations less than 5 mg/L in Sutherland Bayou is presented in Figure 4-16 as only estuarine stations existed in Sutherland Bayou. In every instance, the annual percent of DO samples less than 5 mg/L exceeded the state standard of 10% of samples in a year. Lastly, none of the DO samples from Smith Bayou was less than the state standard of 5 mg/L (Figure 4-17).

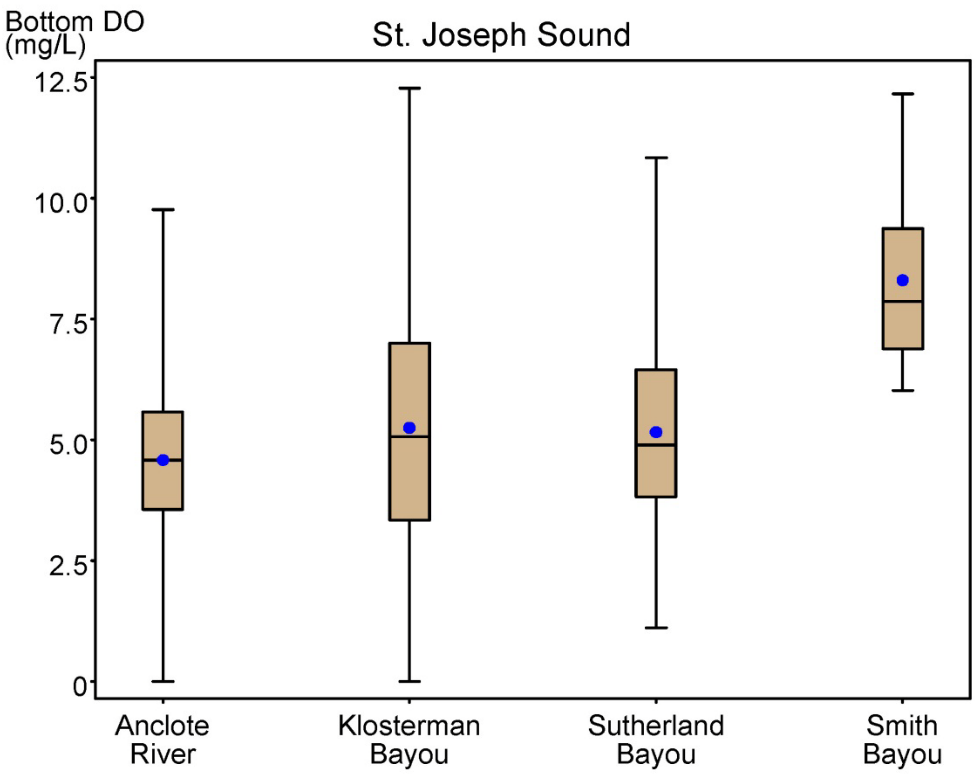


Figure 4-13. Box and whisker plot of bottom DO concentrations by tributary in St. Joseph Sound.

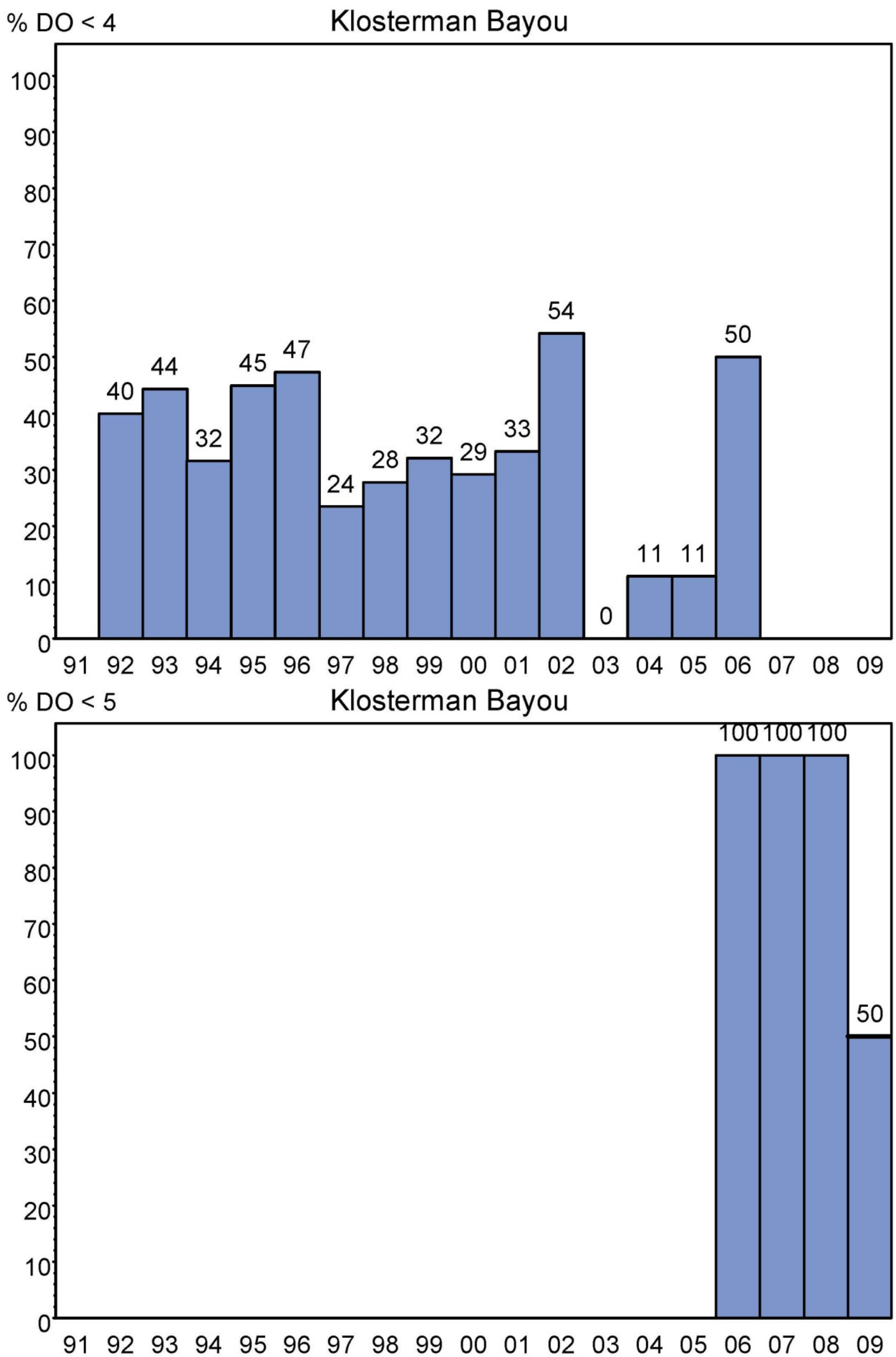


Figure 4-14. **Percent of annual bottom DO concentrations < 4 mg/L (estuarine, top plot) and < 5 mg/L (freshwater, bottom plot) in Klosterman Bayou.**

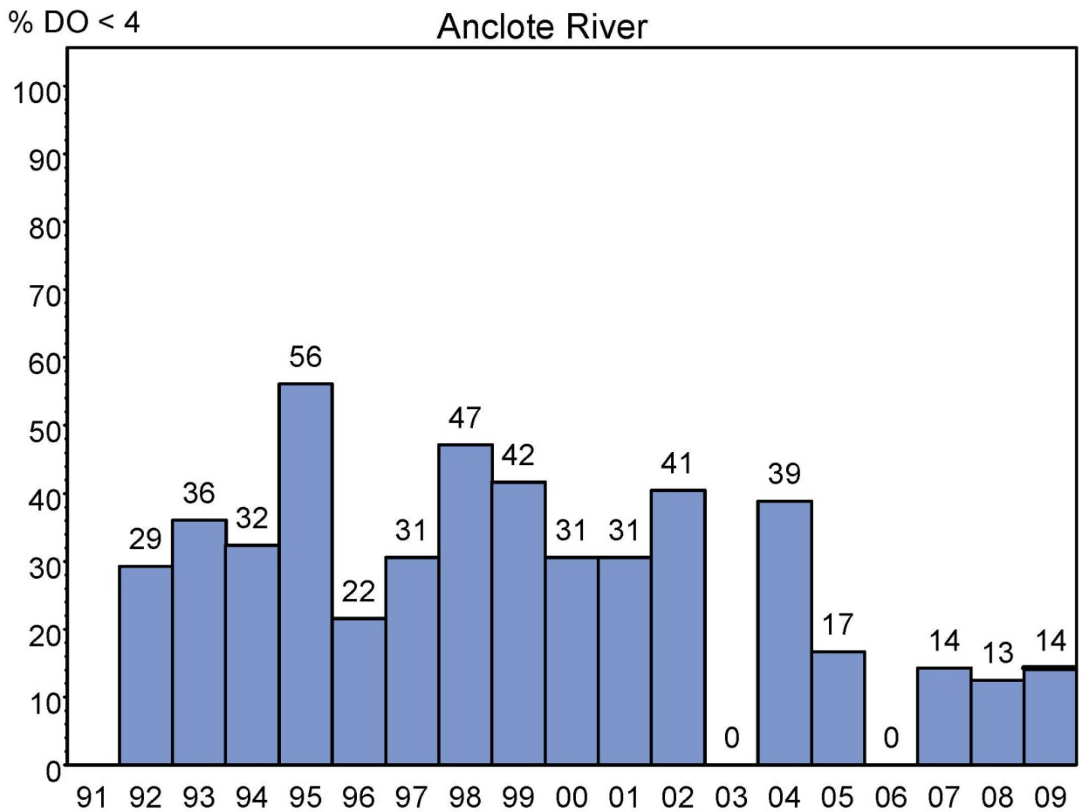


Figure 4-15. Percent of annual bottom DO concentrations < 4 mg/Lin estuarine Anclote River.

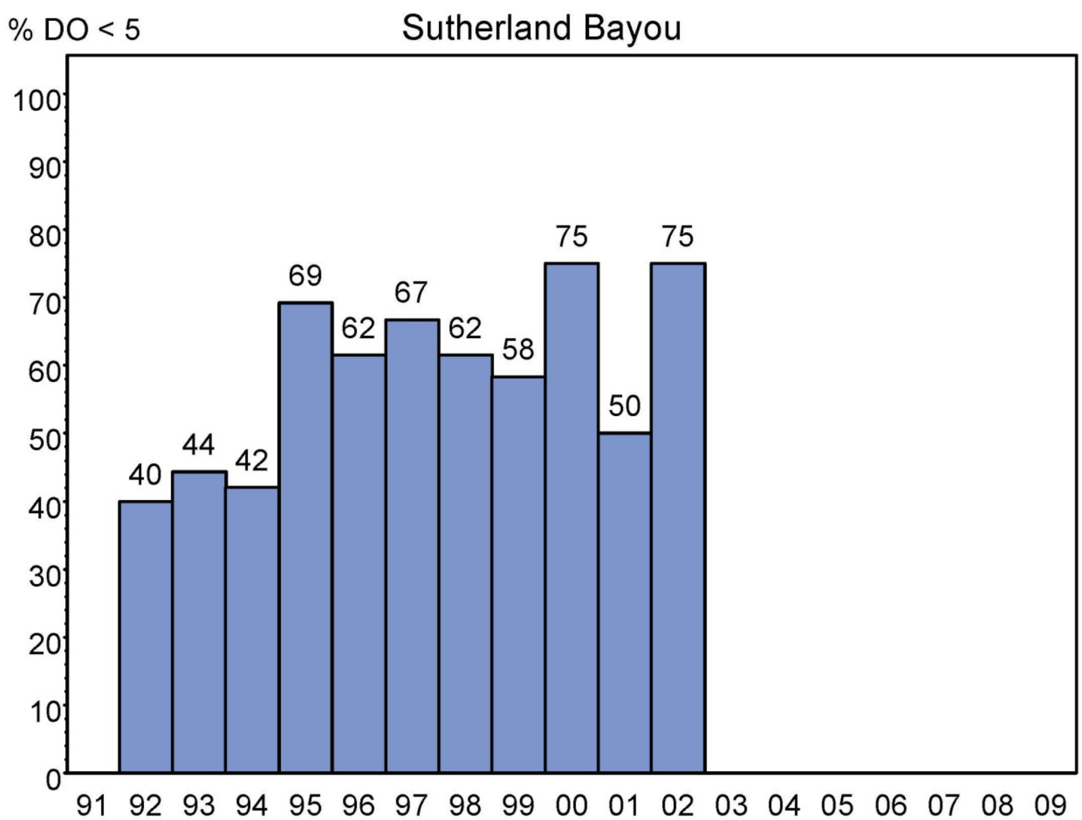


Figure 4-16. Percent of annual bottom DO concentrations < 4 mg/L (estuarine) in Sutherland Bayou.

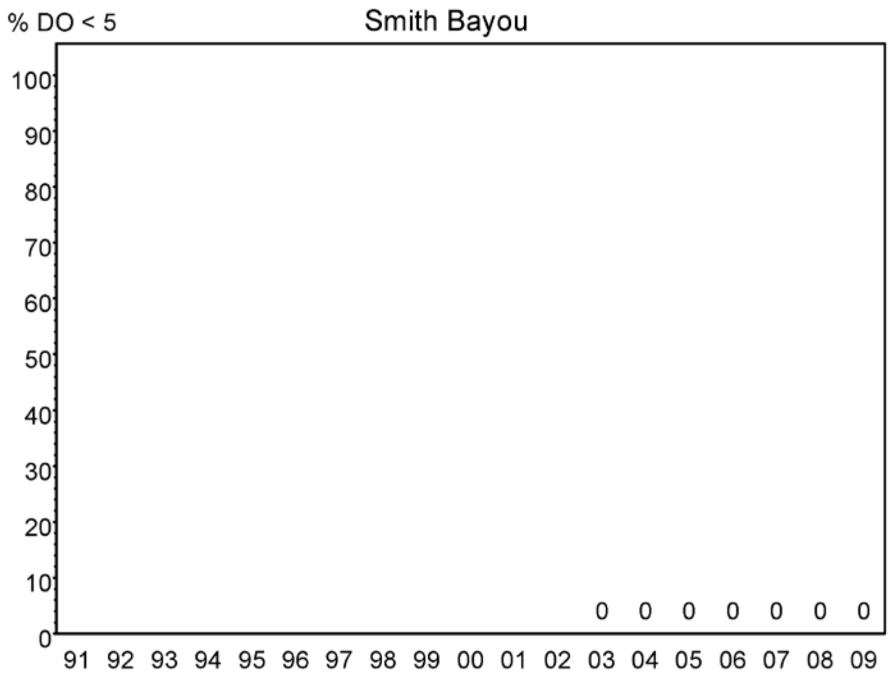


Figure 4-17. Percent of annual bottom DO concentrations < 5 mg/L in freshwater Smith Bayou.

- Clearwater Harbor North

In the Clearwater Harbor North segment, there are four tributaries with water quality data: Curlew Creek, Cedar Creek, Spring Branch, and Stevenson Creek. A timeseries plot of annual average chlorophyll *a* concentrations by tributary is presented in Figure 4-18, while a box and whisker plot of all samples is presented in Figure 4-19 by tributary. As is clear from these plots, chlorophyll *a* concentrations are highest in Stevenson Creek (median = 10.5 μg/L) and lowest in Spring Branch (median = 2.0 μg/L). As was discussed above, in 2003 some sampling stations were relocated to the fresh water portion of the tributaries, above the tidal head. Sampling at four the four estuarine tributary stations in Clearwater Harbor North was discontinued in 2002.

Since 2003, the annual average chlorophyll *a* concentrations are considerably less than the period prior to 2003 when estuarine sampling stations were included. Since 2003 the average annual chlorophyll a concentrations by tributary have been well below the state standard for fresh water (20 μg/L). Chlorophyll *a* concentration data were available for four stations, one in each tributary. A significant decreasing trend was documented in the Curlew Creek station (station 10-02), while no statistically significant trends were identified in the other three tributaries for chlorophyll *a*.

Analysis of the timeseries plot of annual average fecal coliform counts (Figure 4-20) and the box and whisker plot of fecal coliform counts by tributary (Figure 4-21) reveals that Curlew Creek (median = 1800 colonies/100 ml) and Spring Branch (median = 1600 colonies/100 ml) have the highest fecal coliform counts, while the other tributaries have median fecal coliform counts that are less than 800 colonies/100 ml. The state water quality standard for fecal coliform is less than 400 colonies/100 ml. Based on this standard, the 25^{th} percentile for Curlew Creek (960 colonies/100 ml) and Spring Branch (940 colonies/100 ml) exceed the state standard while the 75^{th} percentiles of all tributaries are all greater than the state standard of 400 colonies/100 ml.

Table 4-2. Trend test results for chlorophyll *a* and nutrient concentrations in CHN. Stations are denoted either marine (M) or freshwater (F) after station name and period of record is given below station name.				
Tributary	**Station**	**Parameter**	**Trend Direction**	**Median slope**
Curlew Creek	10-02 (F) (1991-2009)	Chla	Decreasing	-0.075
		TN	No Trend	-0.001
		TP	Decreasing	-0.003
Cedar Creek	09-03 (F) (2004-2009)	Chla	No Trend	0.000
		TN	No Trend	0.000
		TP	No Trend	-0.001
Spring Branch	15-04 (F) (2003-2009)	Chla	No Trend	-0.242
		TN	No Trend	0.008
		TP	Increasing	0.020
Stevenson Creek	18-03 (F) (2003-2009)	Chla	No Trend	-0.300
		TN	No Trend	-0.021
		TP	Decreasing	-0.005

Timeseries plots of annual average TN and TP concentrations by tributary are presented in Figures 4.22 and 4.24, while box and whisker plots of all TN and TP samples are presented in Figure 4-23 and 4.25 by tributary. Based on these plots, TN concentrations are highest in Curlew Creek (median = 1.35 mg/L, mean = 1.55 mg/L) and lowest in Cedar Creek (median = 0.97 mg/L, mean = 1.00 mg/L). Regarding the inter annual variability, TN concentrations are less variable in Cedar Creek relative to the other tributaries in the Clearwater Harbor North segment. Similar to TN concentrations, TP concentrations in Cedar Creek are the lowest relative to the other tributaries in Clearwater Harbor North. However, Spring Branch (median = 0.22 mg/L, mean = 0.26 mg/L) has the highest TP concentrations in the segment. Unlike St. Joseph Sound, where the differences between TP concentrations among tributaries are substantial, the TP concentrations among tributaries in Clearwater Harbor North are more similar (means range from 0.13 to 0.26 mg/L). A summary of the trend tests is presented in Table 4.2. Regarding TN concentrations, no trends were identified. For TP, significant decreasing trends were identified in two tributary stations (Curlew and Stevenson creeks), no trend was identified in Cedar Creek, and a significant increasing trend was identified in the Spring Branch station.

As discussed above, prior to 2003 there were estuarine water quality sampling stations within Curlew Creek, Spring Branch, and Stevenson Creek. However, since 2003, all stations have been moved into the freshwater portions of these tributaries. This is important to note when investigating DO concentrations given that the DO standards for freshwater and estuarine waters are not the same. For estuarine waters, the annual percentage of DO concentrations < 4 mg/L is not allowed to exceed 10% according to state standards. For freshwater, the annual percentage of DO concentrations < 5 mg/L is not allowed to exceed 10% according to state standards. A box and whisker plot of DO concentrations by tributary is presented in Figure 4-28. The highest average DO concentrations are found in Curlew Creek (5.9 mg/L), and the lowest average concentration is in Spring Branch (3.7 mg/L). The 25^{th} percentile DO concentrations for the Cedar Creek, Spring Branch, and Stevenson Creek are 2.8, 2.7, and 2.0 mg/L, respectively. Therefore, during the period of record (1992-2009), at least 25% of the DO concentrations have been less than the state standards in these three tributaries. Further investigation of the percent of annual DO samples less than the appropriate state standard are presented for each tributary in Figures 4.29 through 4.32. Where both fresh and marine stations are present within a tributary, separate plots are produced.

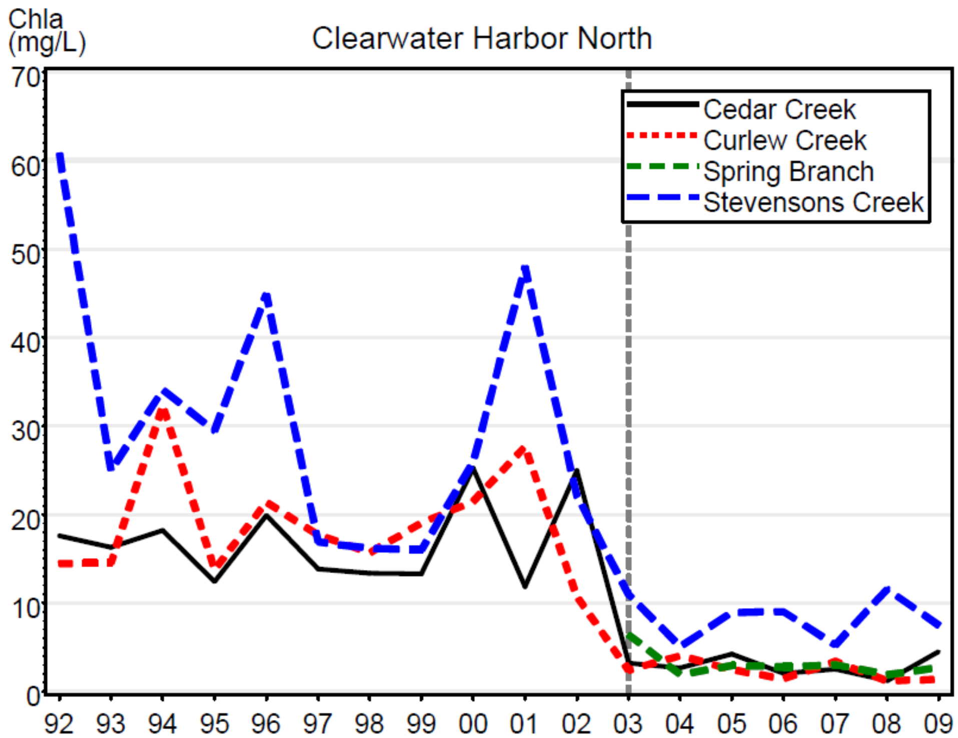


Figure 4-18. **Annual average chlorophyll *a* concentrations by tributary in the CHN watershed. Vertical broken line indicates when stations were moved upstream.**

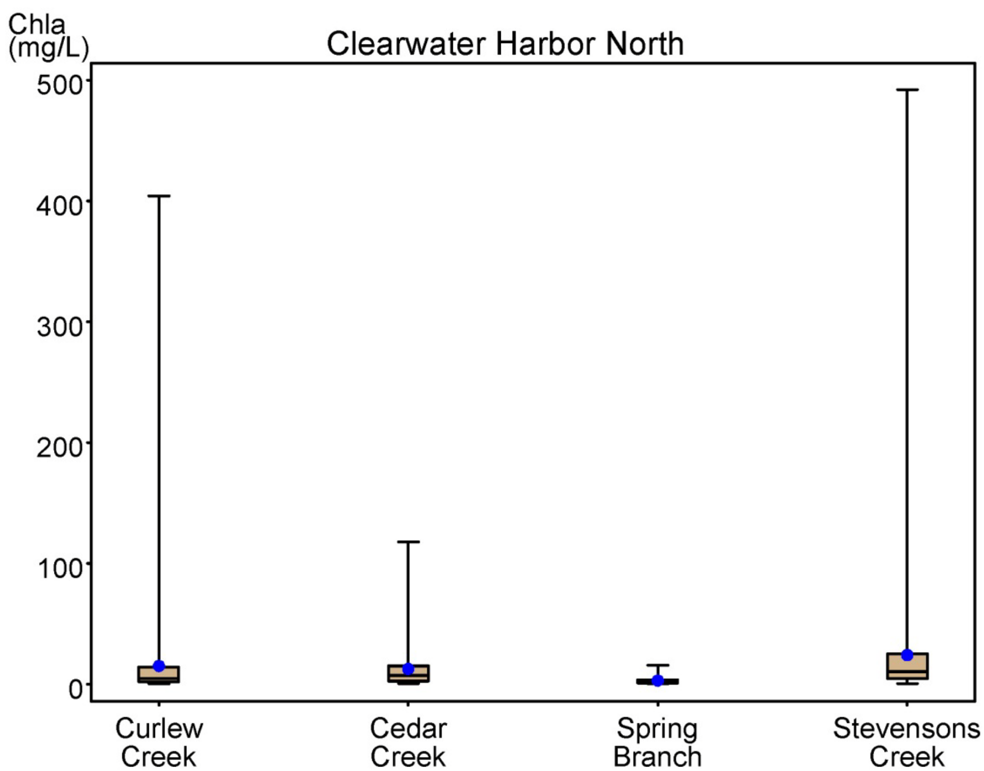


Figure 4-19. **Box and whisker plot of chlorophyll *a* concentrations by tributary in the CHN watershed.**

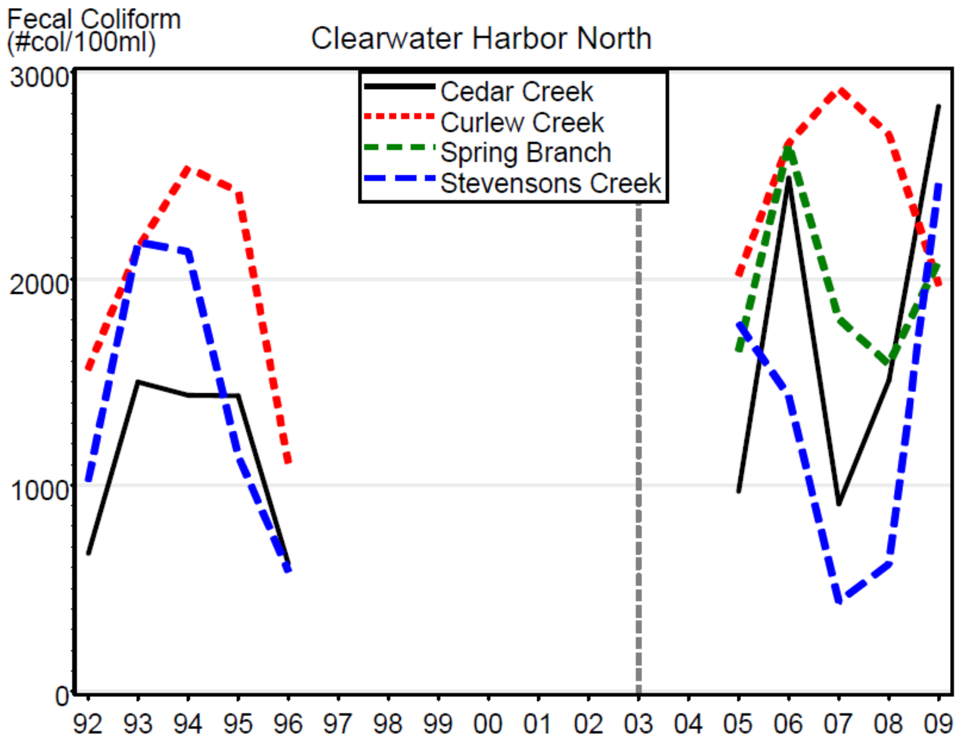


Figure 4-20. **Annual average fecal coliform counts by tributary in the CHN watershed. Vertical broken line indicates when stations were moved upstream.**

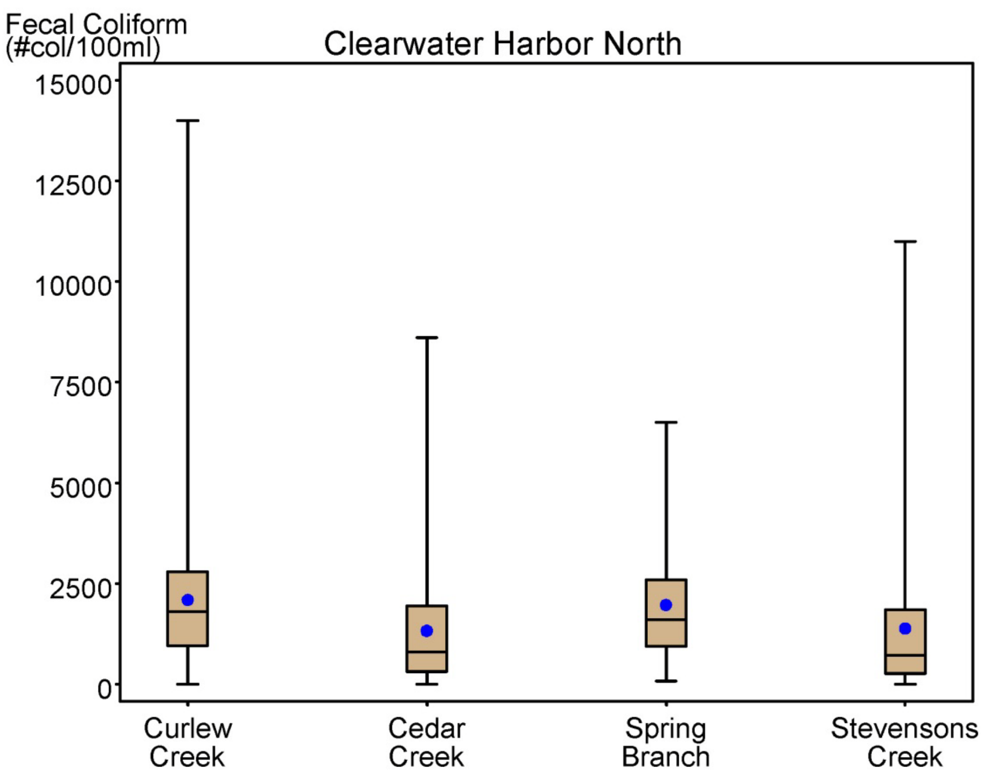


Figure 4-21. **Box and whisker plot of fecal coliform counts by tributary in the CHN watershed.**

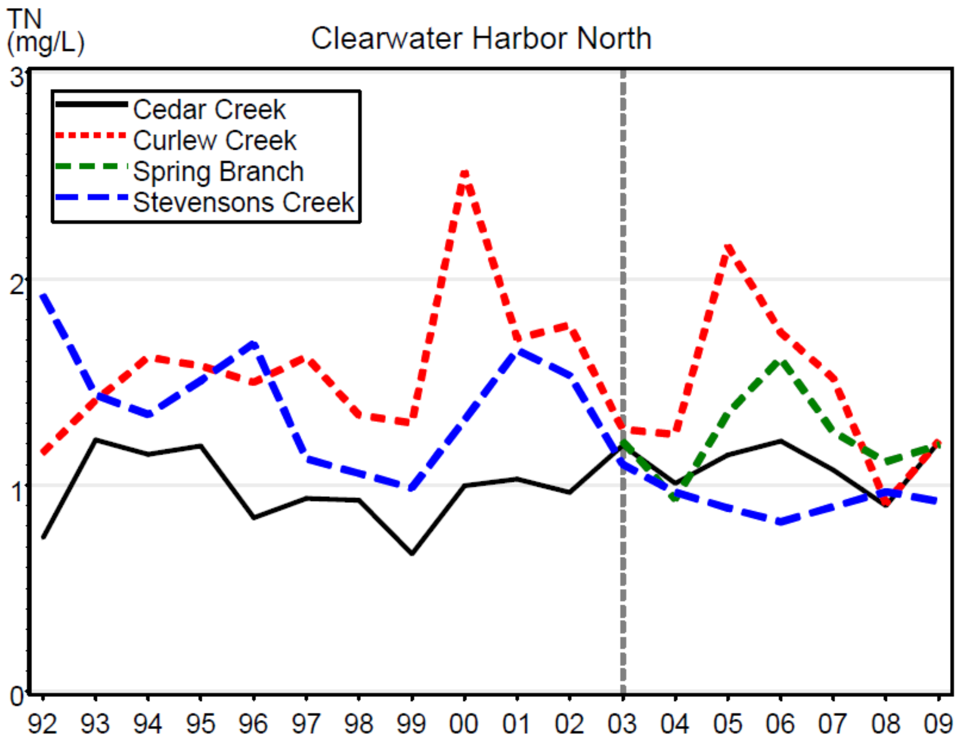


Figure 4-22. **Annual average TN concentrations by tributary in the CHN watershed. Vertical broken line indicates when stations were moved upstream.**

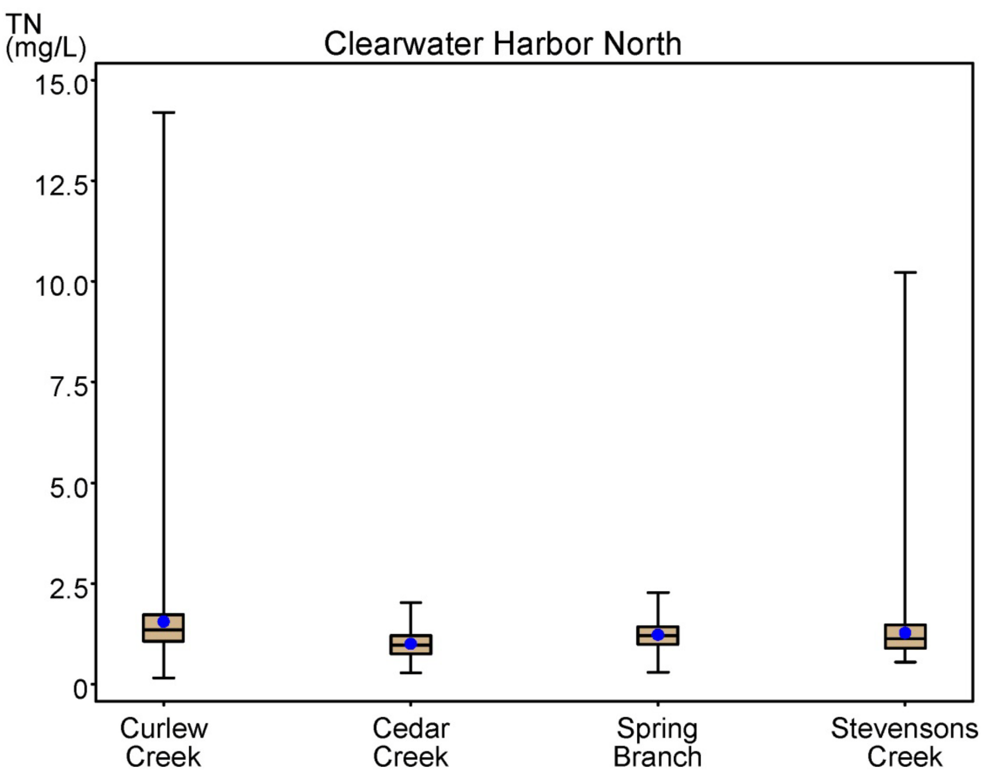


Figure 4-23. **Box and whisker plot of TN concentrations by tributary in the CHN watershed.**

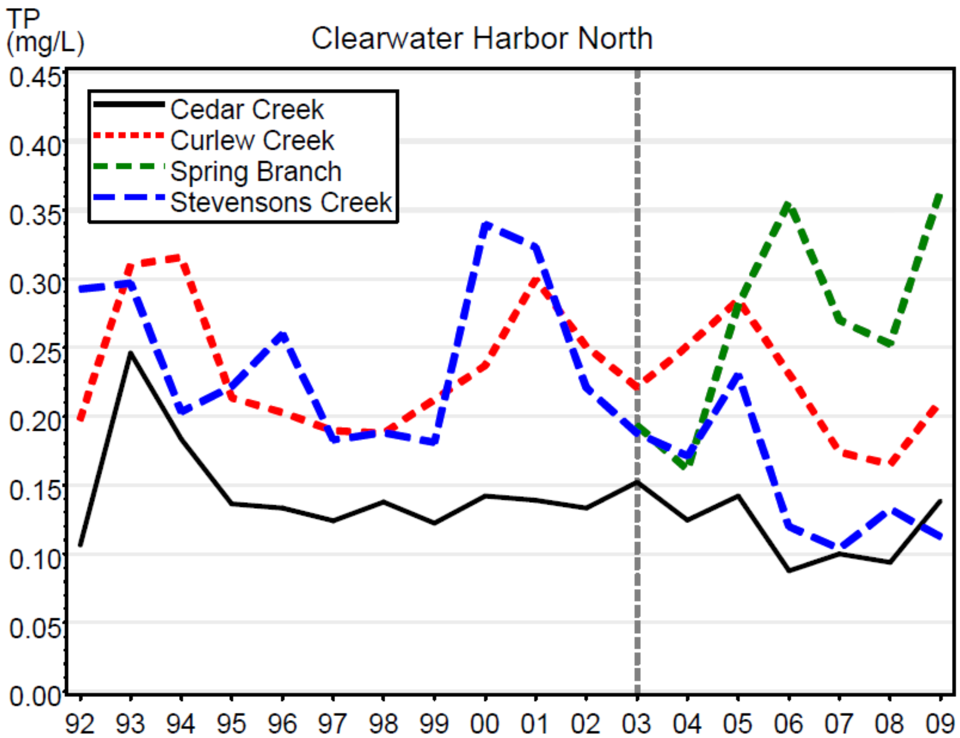


Figure 4-24. **Annual average TP concentrations by tributary in the CHN watershed. Vertical broken line indicates when stations were moved upstream.**

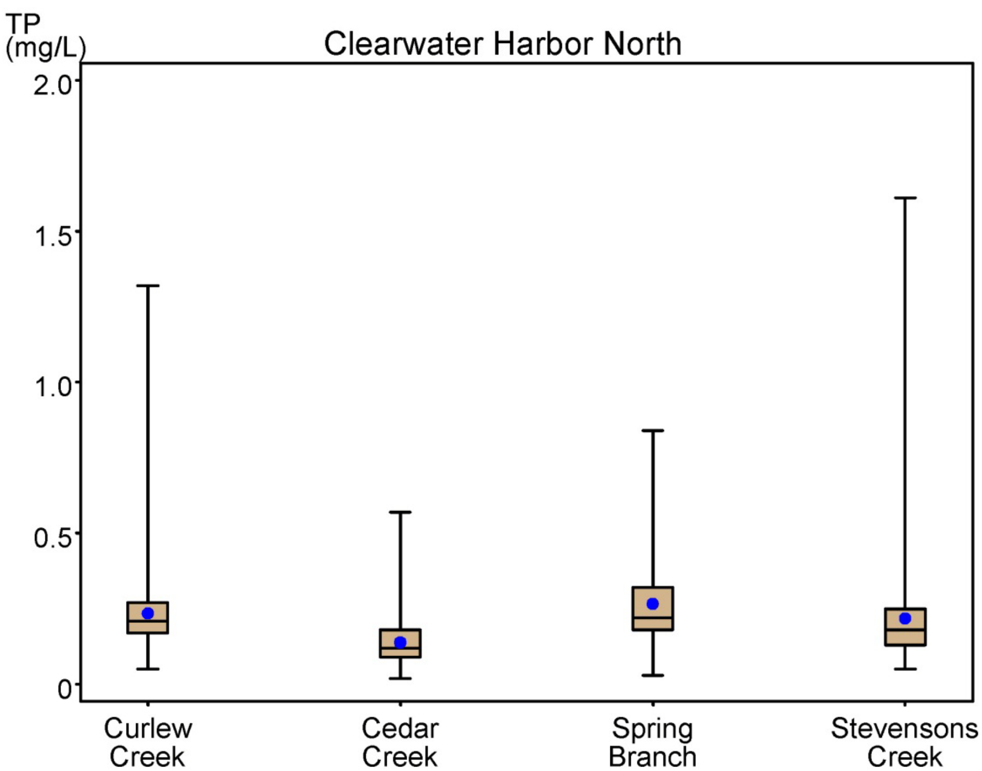


Figure 4-25. **Box and whisker plot of TP concentrations by tributary in the CHN watershed.**

A timeseries plot of annual average salinity is presented in Figure 4-26 and the box and whisker plot of salinity by tributary is presented in Figure 4-27.

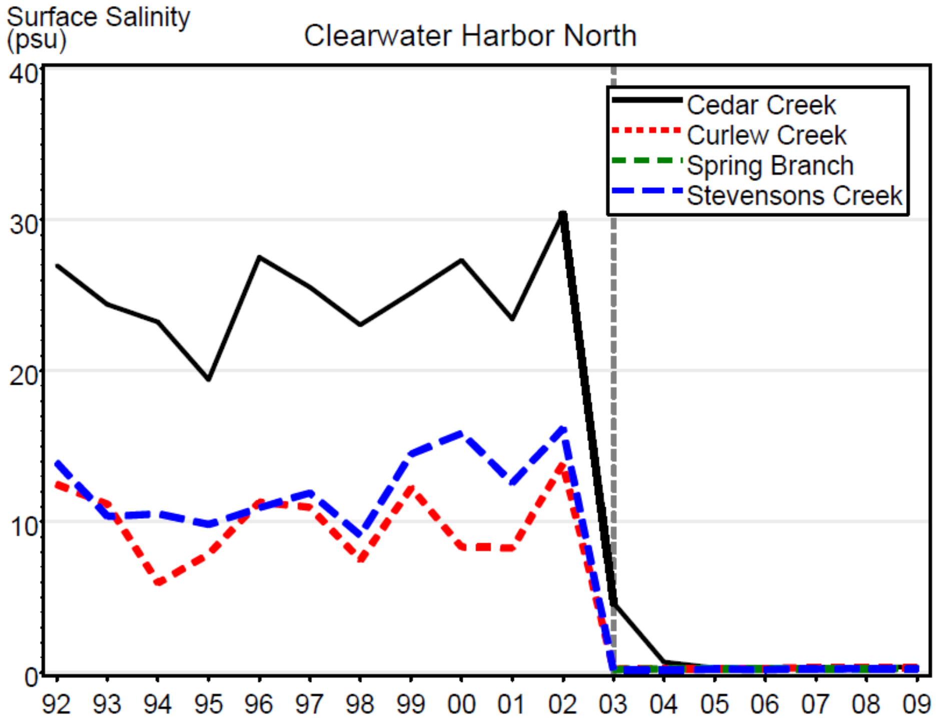


Figure 4-26. Annual surface salinity by tributary in the CHN watershed. Vertical broken line indicates when stations were moved upstream.

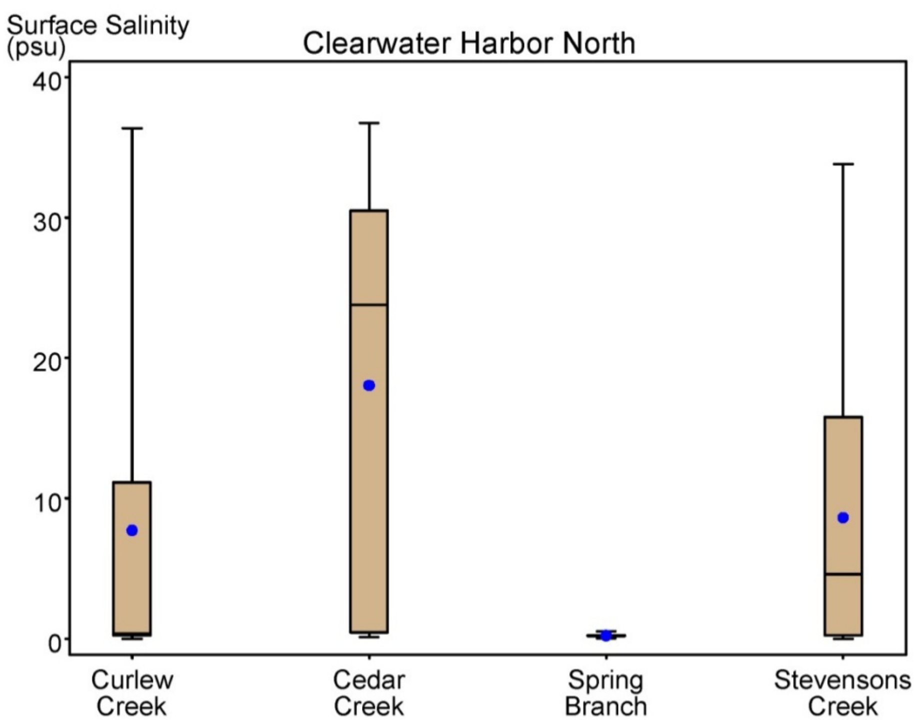


Figure 4-27. Box and whisker plot of surface salinity by tributary in the CHN watershed.

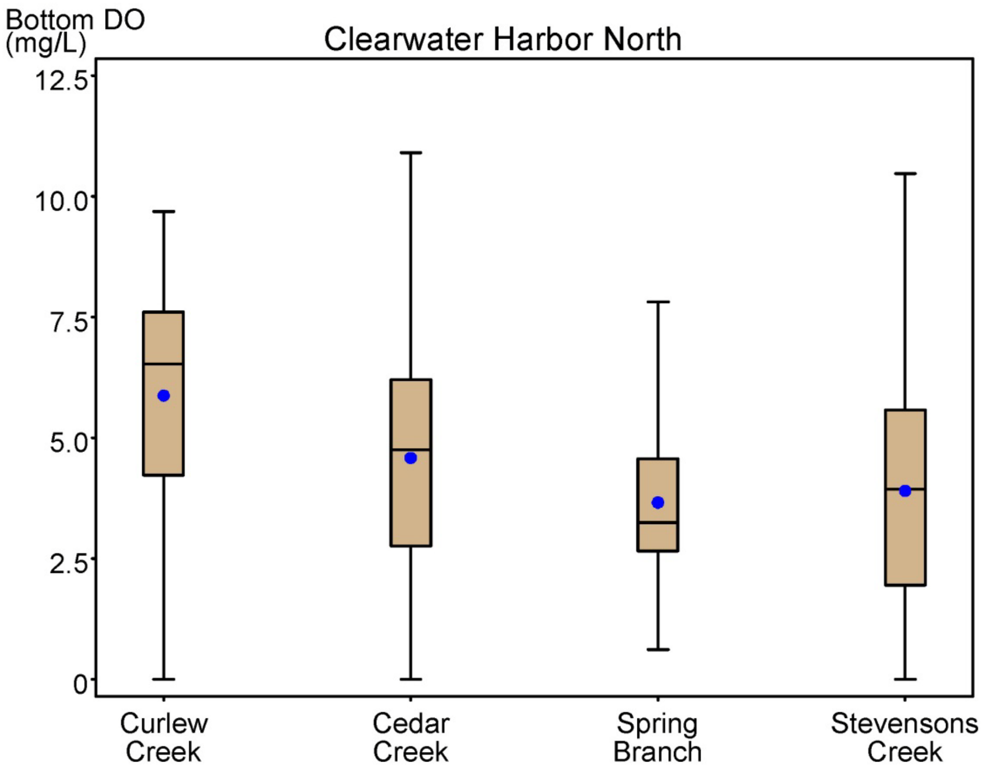


Figure 4-28. Box and whisker plot of bottom DO concentrations by tributary in the CHN watershed.

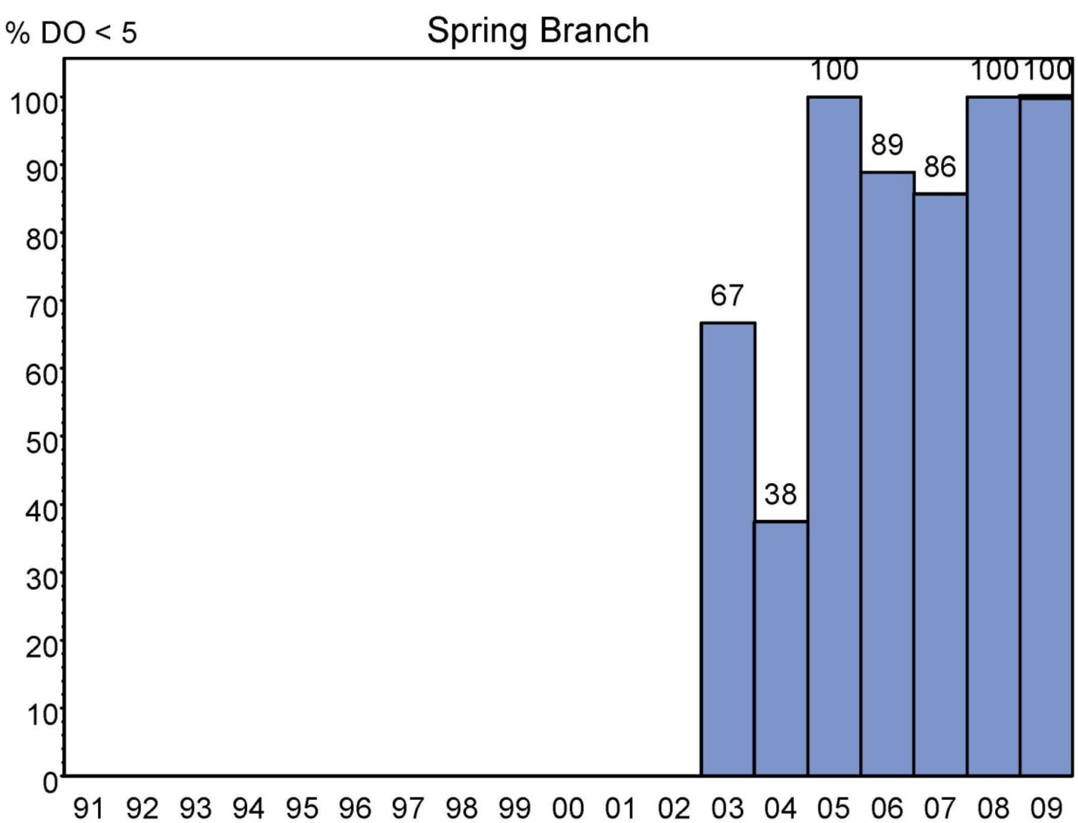


Figure 4-29. Percent of annual bottom DO concentrations < 5 mg/L (freshwater) in Spring Branch.

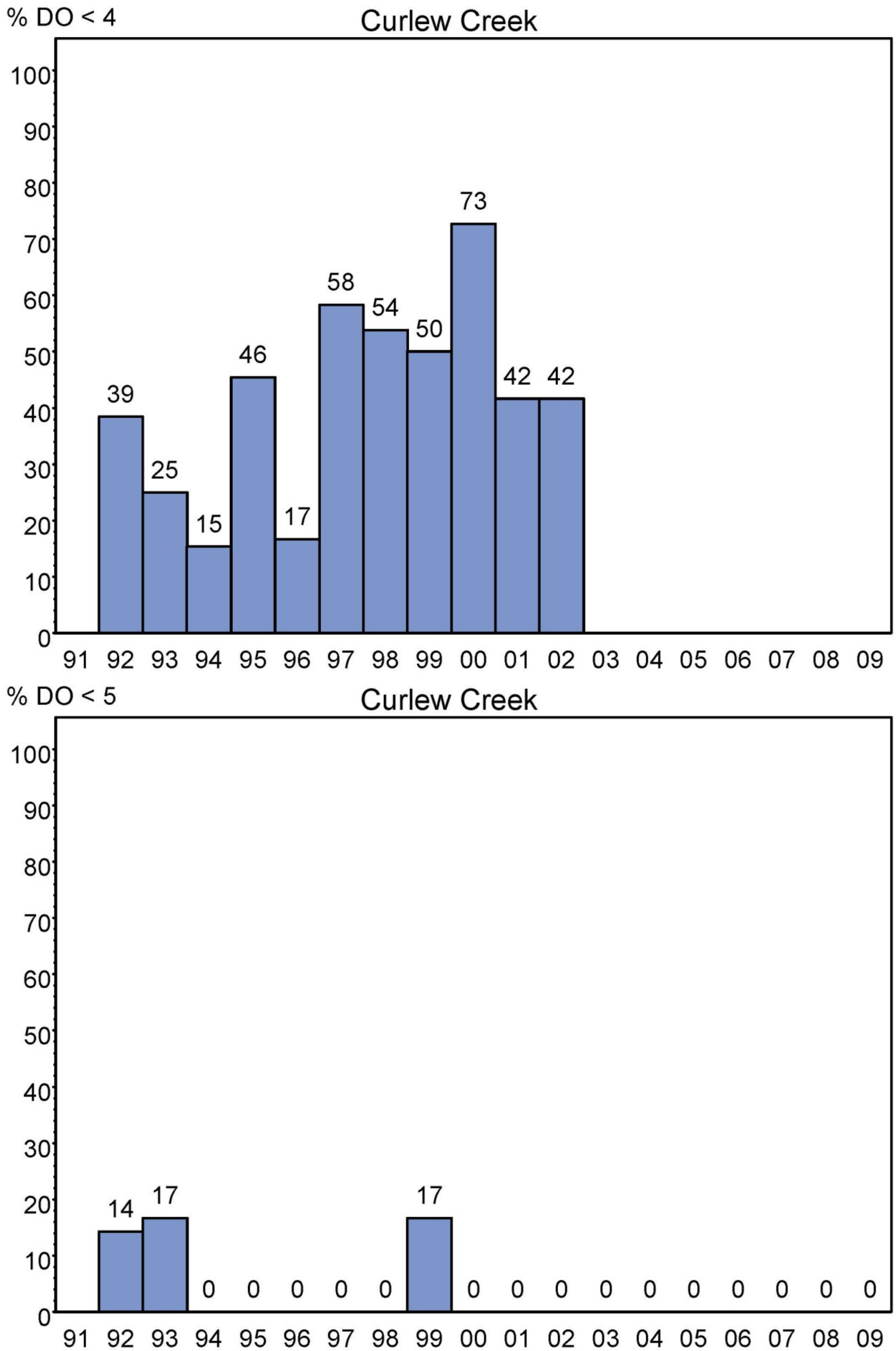


Figure 4-30. **Percent of annual bottom DO concentrations < 4 mg/L (estuarine, top plot) and < 5 mg/L (freshwater, bottom plot) in Curlew Creek.**

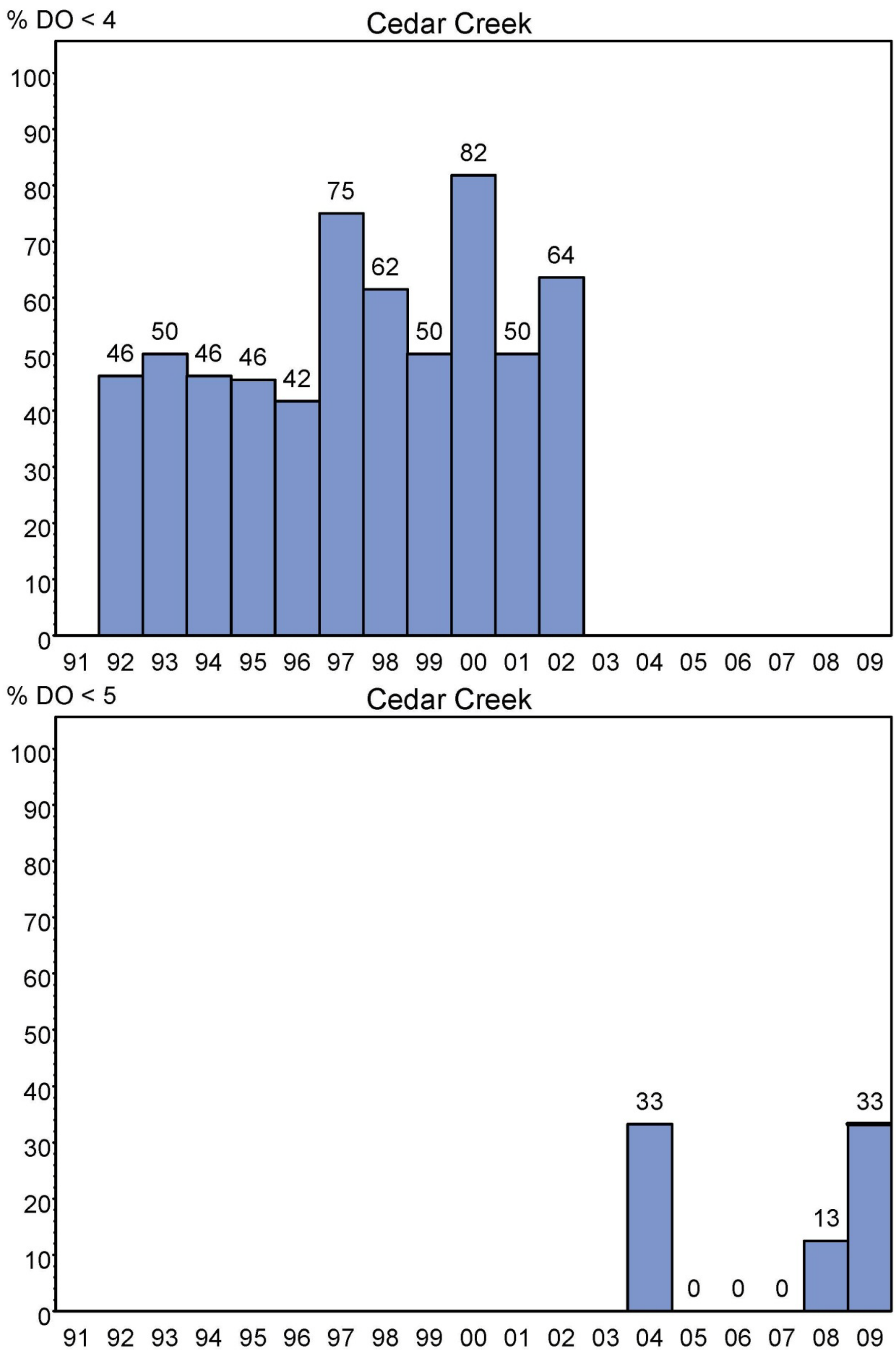


Figure 4-31. **Percent of annual bottom DO concentrations < 4 mg/L (estuarine, top plot) and < 5 mg/L (freshwater, bottom plot) in Cedar Creek.**

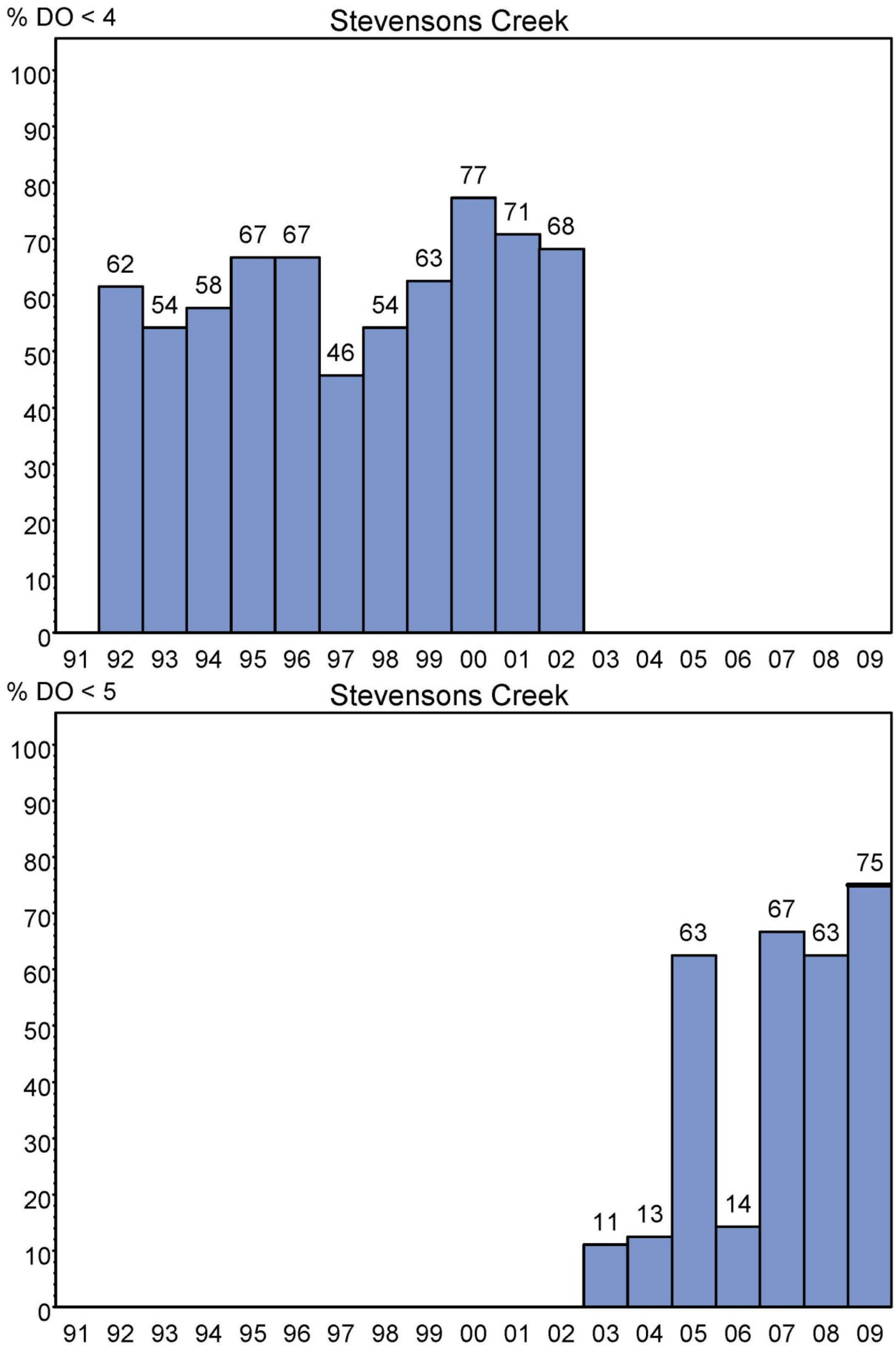


Figure 4-32. **Percent of annual bottom DO concentrations < 4 mg/L (estuarine, top plot) and < 5 mg/L (freshwater, bottom plot) in Stevenson Creek.**

- **Clearwater Harbor South**

In the Clearwater Harbor South segment, there are two tributaries with water quality data: Rattlesnake Creek and McKay Creek. A timeseries plot of annual average chlorophyll *a* concentrations by tributary is presented in Figure 4-33, while a box and whisker plot of all samples is presented in Figure 4-34 by tributary. As is clear from these plots, chlorophyll *a* concentrations are higher in McKay Creek (median=7.6 μg/L and mean = 13.0 μg/L) and lower in Rattlesnake Creek (median = 3.6 μg/L and mean = 6.1 μg/L). As was discussed above, in 2003 some sampling stations were relocated to the freshwater portion of the tributaries, above the tidal head. In the case of the four tributaries in Clearwater Harbor South, sampling in the estuarine stations was discontinued at the end of 2002. Since 2003, the annual average chlorophyll *a* concentrations are considerably less than the period prior to 2003 when estuarine sampling stations were included. Since 2003 the average annual chlorophyll *a* concentrations by tributary have been well below the state standard for freshwater (20 μg/L). A significant decreasing trend was documented in one Rattlesnake Creek station (station 17-01), while no trend was identified in the second Rattlesnake Creek station (17-03). In McKay Creek, two stations (27-08 and 27-09) had no trends and one station (27-03) saw a decreasing trend for chlorophyll *a*.

Analysis of the timeseries plot of annual average fecal coliform counts (Figure 4-35) and the box and whisker plot of fecal coliform counts by tributary (Figure 4-36) reveals that Rattlesnake Creek (median = 2150 colonies/100 ml) had higher fecal coliform counts than McKay Creek (median = 930 colonies/100 ml). The state water quality standard for fecal coliform is less than 400 colonies/100 ml. Based on this standard, the 25th percentile for Rattlesnake Creek (1000 colonies/100 ml) exceeds the state standard.

Timeseries plots of annual average TN and TP concentrations by tributary are presented in Figures 4.37 and 4.39, while box and whisker plots of all TN and TP samples are presented in Figure 4-38 and 4.40 by tributary. Based on these plots, TN concentrations are higher in Rattlesnake Creek (median = 2.08 mg/L, mean = 2.16 mg/L) and lower in McKay Creek (median = 1.09 mg/L, mean = 1.23 mg/L). Regarding inter-annual variability, TN concentrations are less variable in McKay Creek relative to Rattlesnake Creek. As is seen with regard to TN concentrations, TP concentrations in McKay Creek (median = 0.10 mg/L, mean = 0.12 mg/L) are lower than TP concentrations in Rattlesnake Creek (median = 0.18 mg/L, mean = 0.23 mg/L). A summary of the trend tests is presented in Table 4.3. Regarding TN concentrations, one station had an increasing trend and one station had a decreasing trend in Rattlesnake Creek. In McKay Creek, two stations had decreasing trends in TN concentration, while the remaining station had no trend in TN concentration. For TP in Rattlesnake Creek, no trend was identified in one station and a significant increasing trend was identified in the second station. Lastly, a trend test of TP on McKay Creek revealed no trend in two of the stations and a decreasing trend in one station.

Table 4-3. Trend test results for chlorophyll *a* and nutrient concentrations in CHS tributaries. Stations are denoted either marine (M) or freshwater (F) after station name and period of record is given below station name.

Tributary	Station	Parameter	Trend Direction	Median slope
Rattlesnake Creek	17-01 (F) (1991-2009)	Chla	Decreasing	-0.124
		TN	Increasing	0.052
		TP	No Trend	0.000
	17-03 (F) (2003-2009)	Chla	No Trend	0.050
		TN	Decreasing	-0.050
		TP	Increasing	0.010
McKay Creek	27-03 (F) (1991-2009)	Chla	Decreasing	-0.614
		DO	Decreasing	-0.234
		TN	Decreasing	-0.013
		TP	Decreasing	-0.001
	27-08 (F) (1995-2009)	Chla	No Trend	0.020
		TN	No Trend	-0.015
		TP	No Trend	0.001
	27-09 (F) (2003-2009)	Chla	No Trend	-0.188
		TN	Decreasing	-0.037
		TP	No Trend	0.006

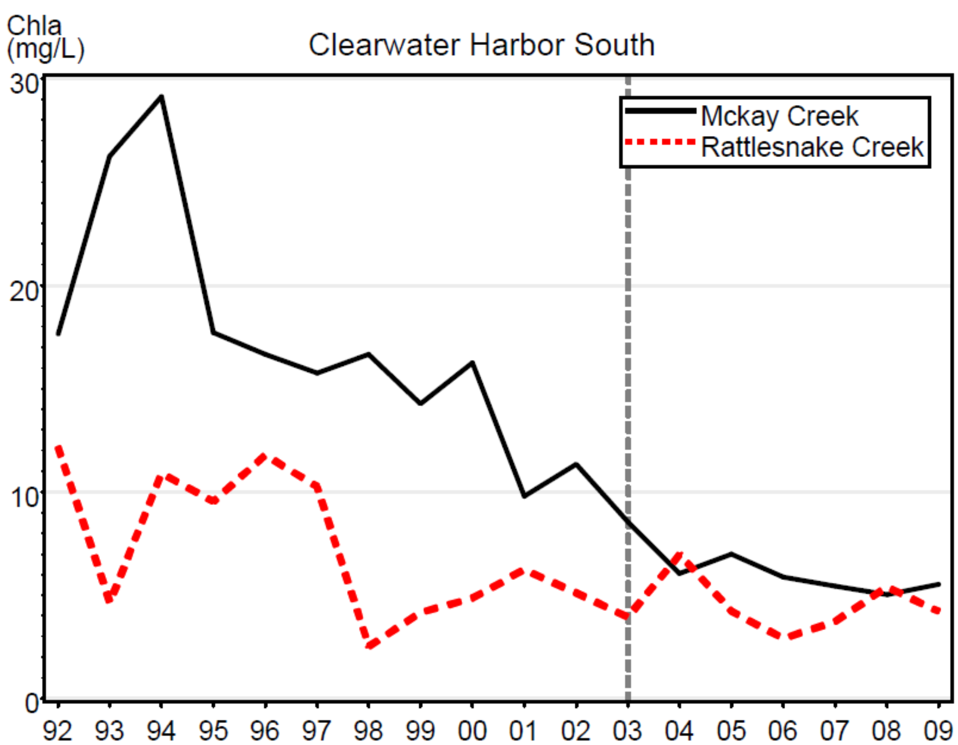


Figure 4-33. Annual average chlorophyll *a* concentrations by tributary in the CHS watershed. Vertical broken line indicates when stations were moved upstream.

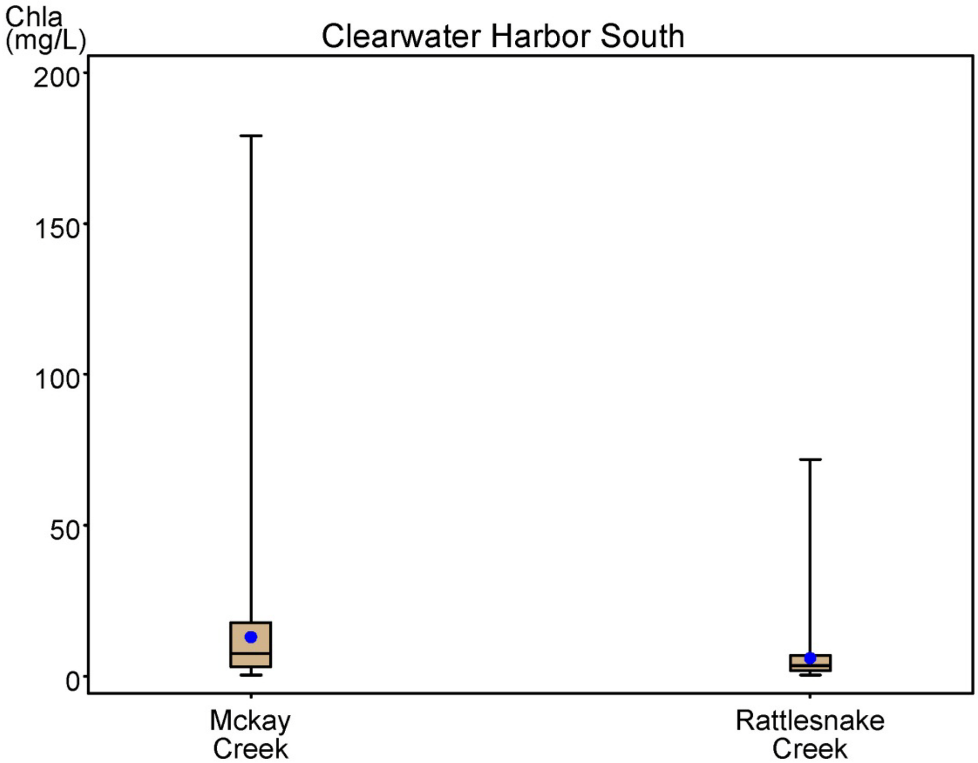


Figure 4-34. **Box and whisker plot of chlorophyll *a* concentrations by tributary in the CHS watershed.**

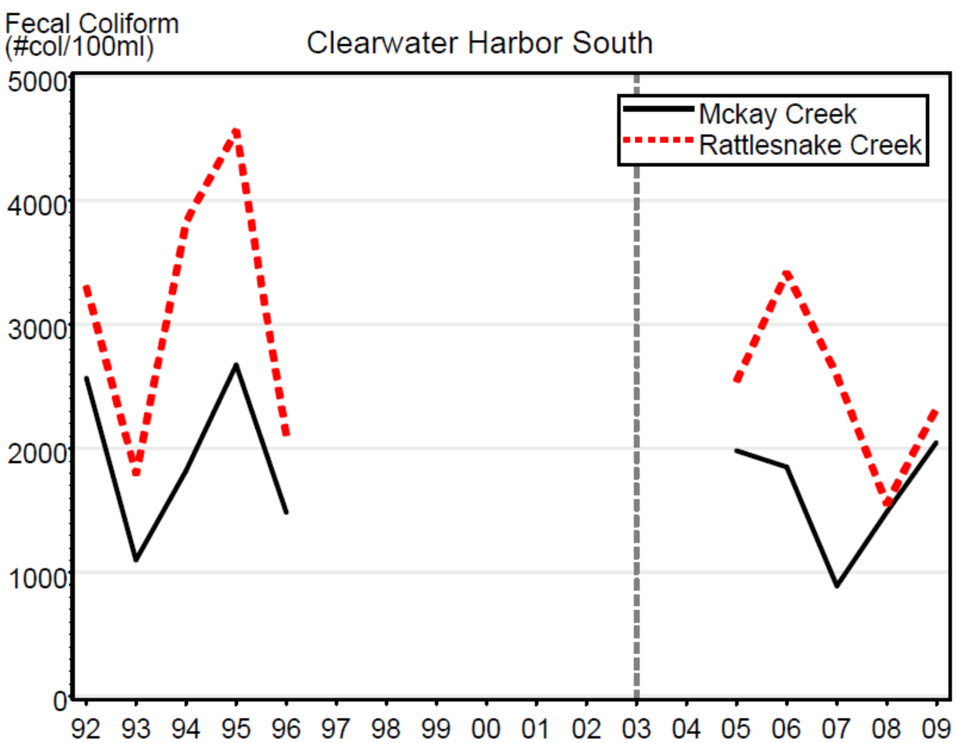


Figure 4-35. **Annual average fecal coliform counts by tributary in the CHS watershed. Vertical broken line indicates when stations were moved upstream.**

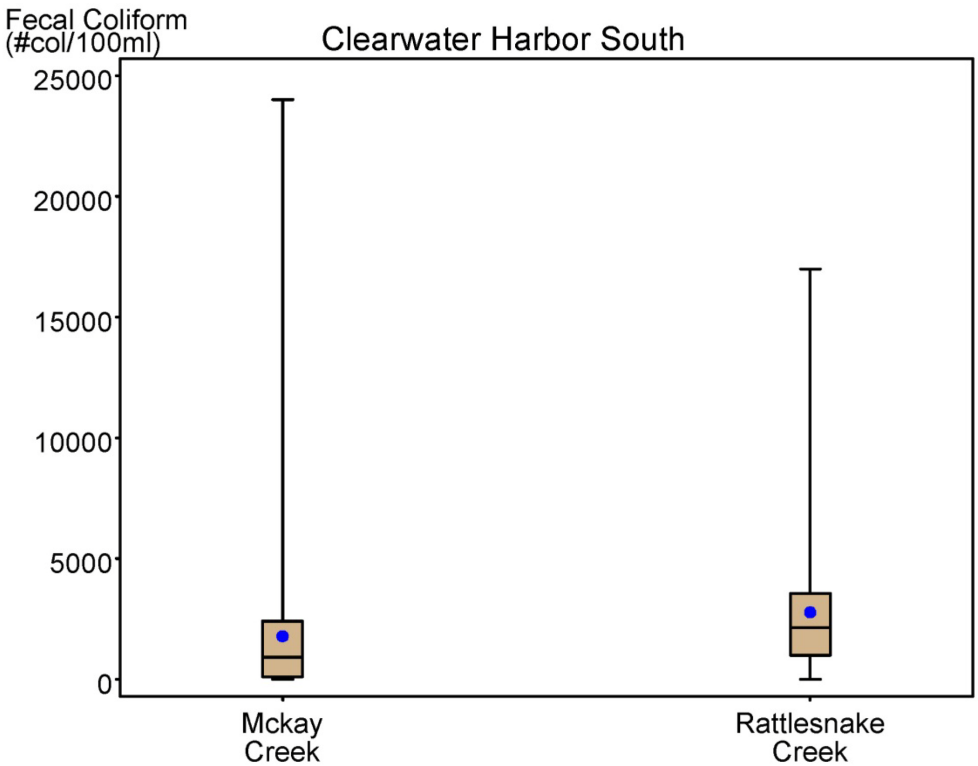


Figure 4-36. Box and whisker plot of fecal coliform counts by tributary in the CHS watershed.

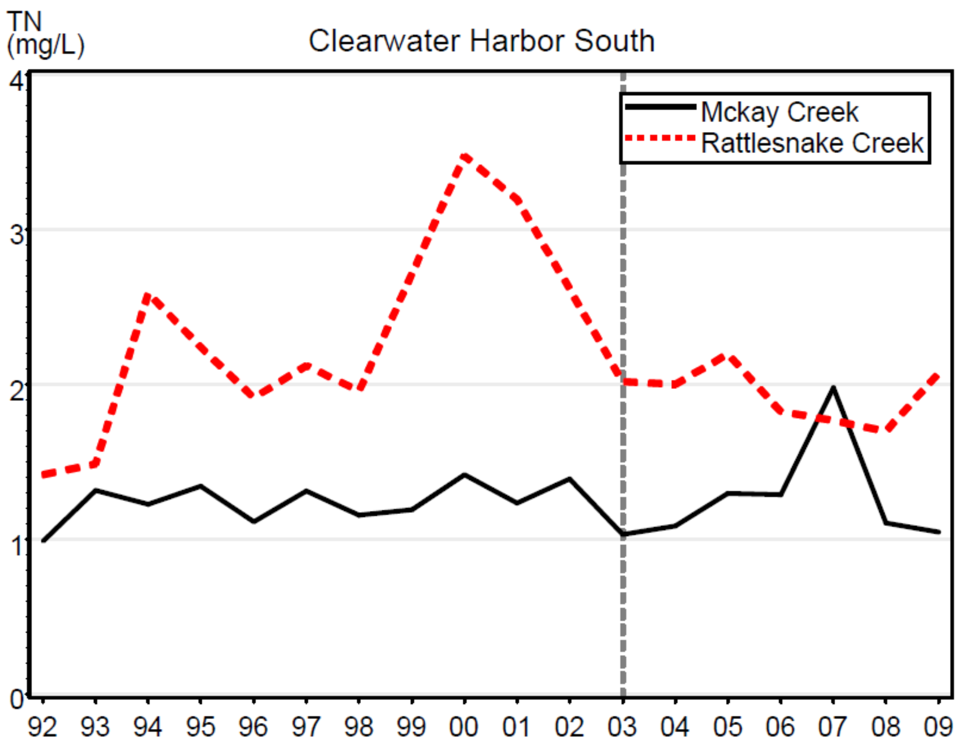


Figure 4-37. Annual average TN concentrations by tributary in the CHS watershed. Vertical broken line indicates when stations were moved upstream.

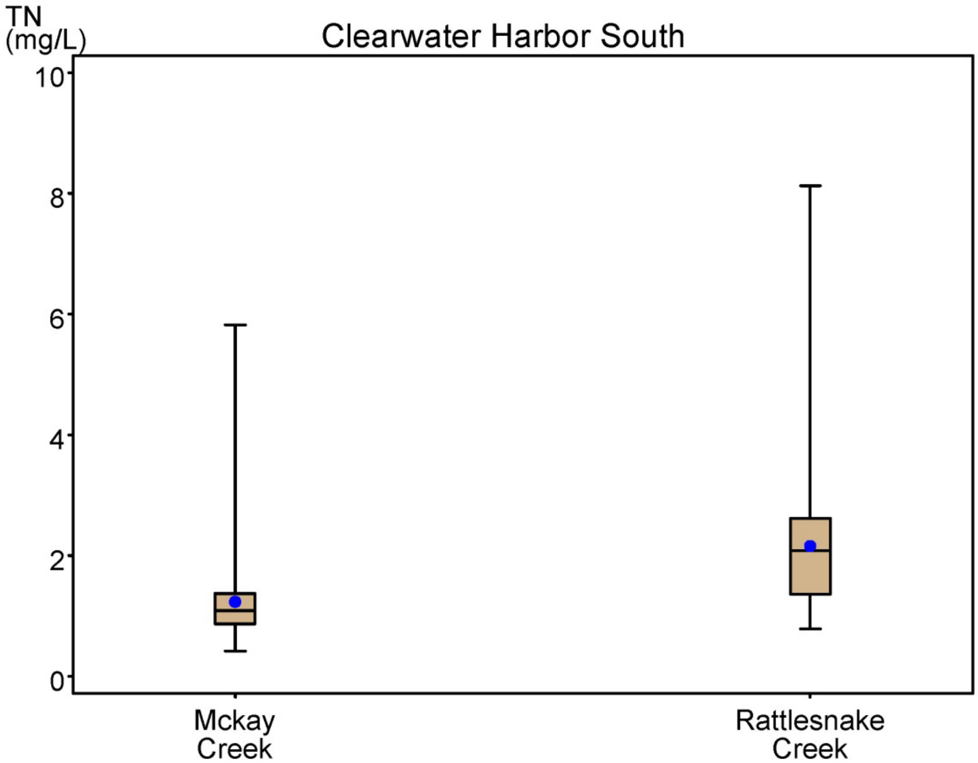


Figure 4-38. Box and whisker plot of TN concentrations by tributary in the CHS watershed.

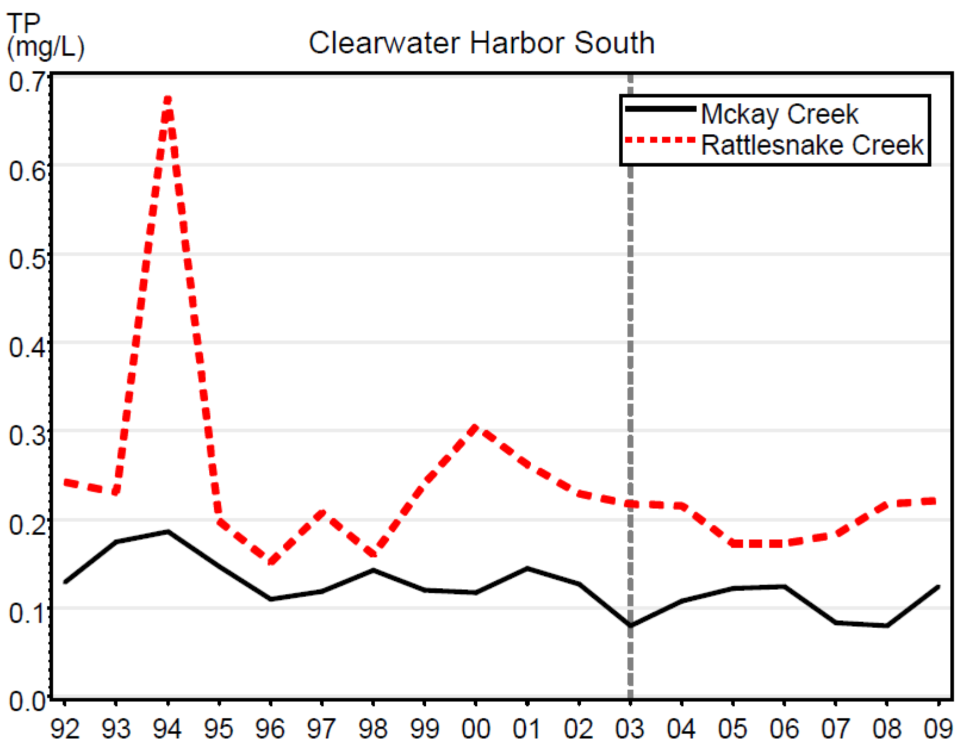


Figure 4-39. Annual average TP concentrations by tributary in the CHS watershed. Vertical broken line indicates when stations were moved upstream.

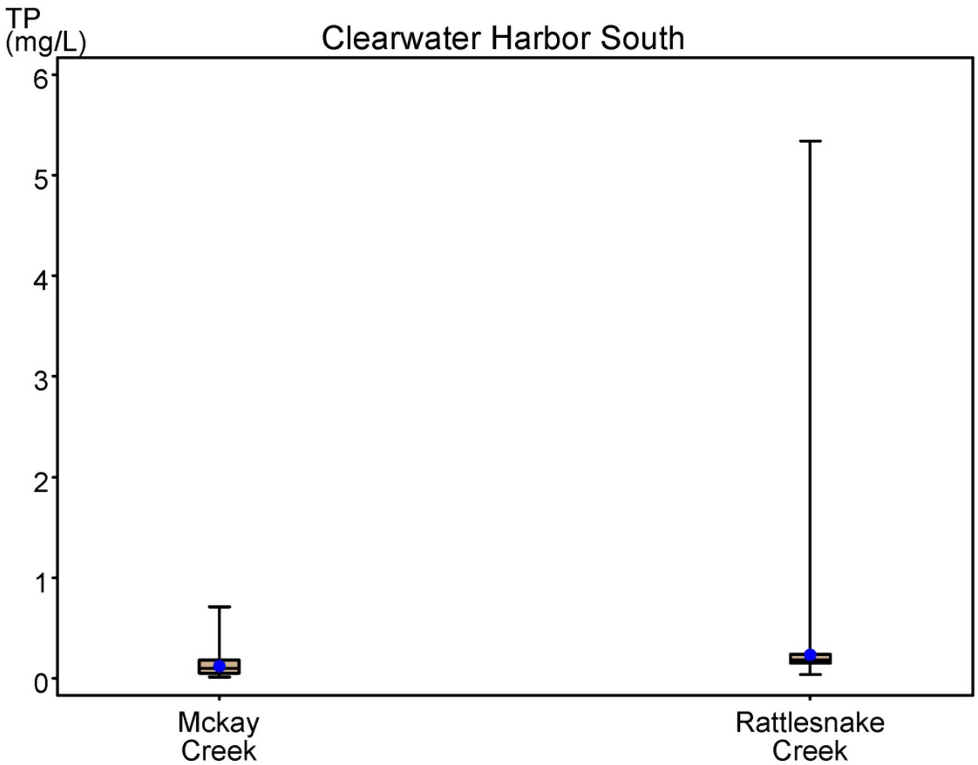


Figure 4-40. Box and whisker plot of TP concentrations by tributary in the CHS watershed.

A timeseries plot of annual average salinity is presented in Figure 4-41 and the box and whisker plot of salinity by tributary is presented in Figure 4-42. As was discussed above, there was an estuarine water quality sampling station in McKay Creek prior to 2003. However, from 2003 onward, all McKay Creek stations have been in the freshwater portion of the tributary. Both Rattlesnake Creek stations are freshwater stations. As discussed above, this is important to note when investigating DO concentrations given different DO standards for freshwater and estuarine waters. A box and whisker plot of DO concentrations by tributary is presented in Figure 4-43. The average DO concentration in Rattlesnake Creek is 6.4 mg/L and the average concentration in McKay Creek is 5.4 mg/L. The 25th percentile DO concentrations for the Rattlesnake and McKay creeks are 5.2 and 3.7 mg/L, respectively. Therefore, during the period of record (1992-2009), at least 25% of the DO concentrations have been less than the state standards in McKay Creek. Further investigation of the percent of annual DO samples less than the appropriate state standard are presented for Rattlesnake Creek (Figure 4-43) and McKay Creek (Figure 4-44). Where both fresh and marine stations are present within a tributary, separate plots are produced.

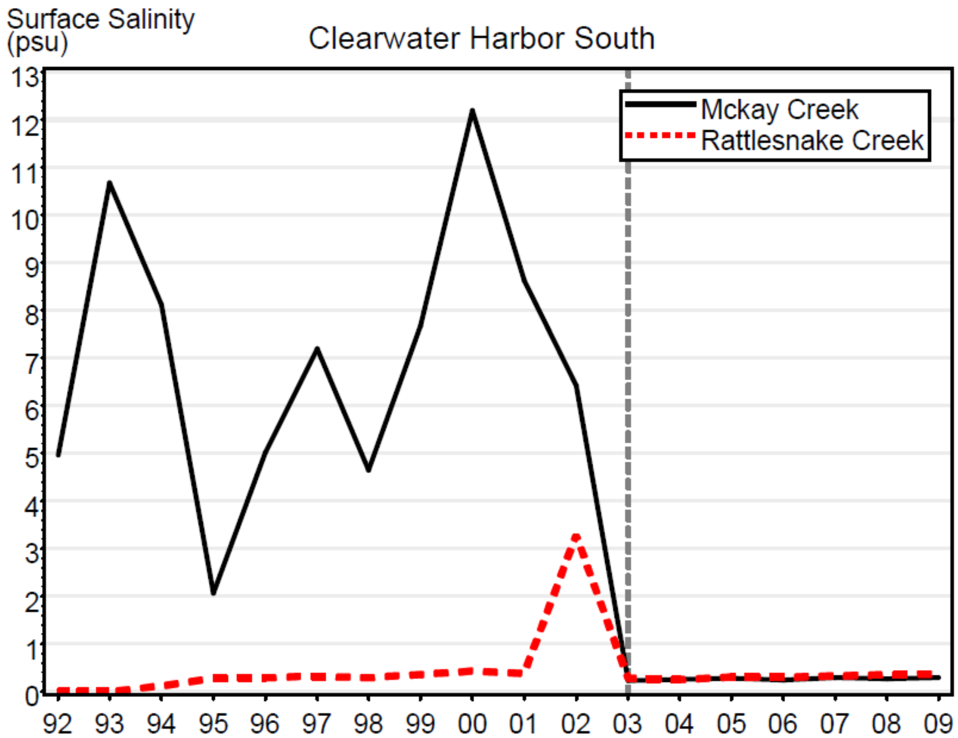


Figure 4-41. **Annual surface salinity by tributary in the CHS watershed. Vertical broken line indicates when stations were moved upstream.**

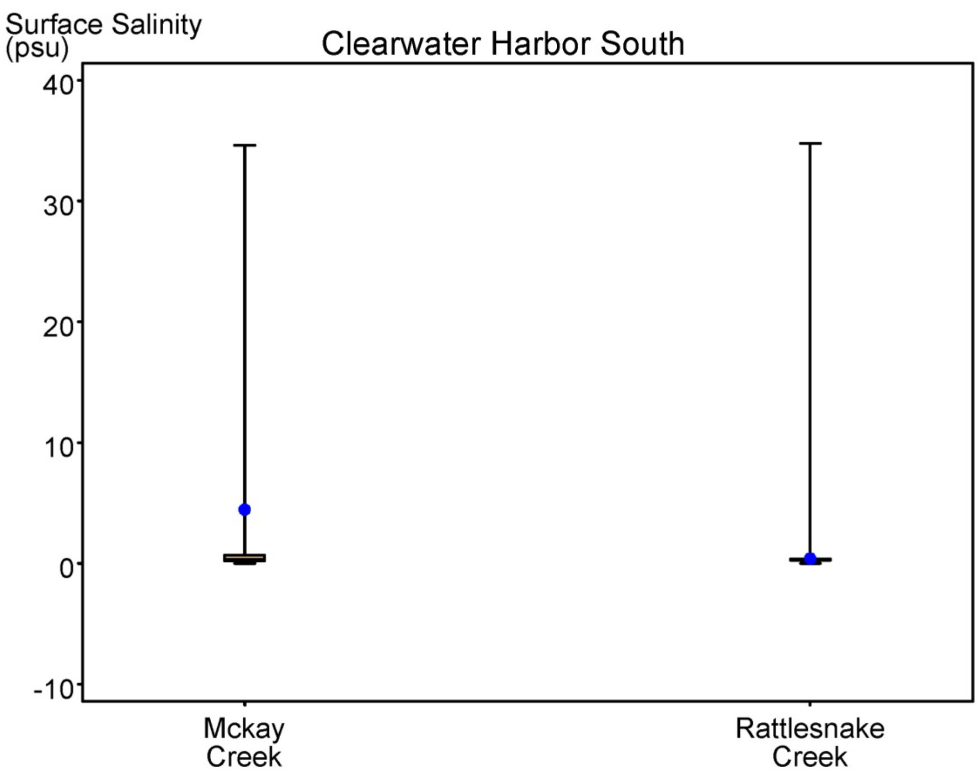


Figure 4-42. **Box and whisker plot of surface salinity by tributary in the CHS watershed.**

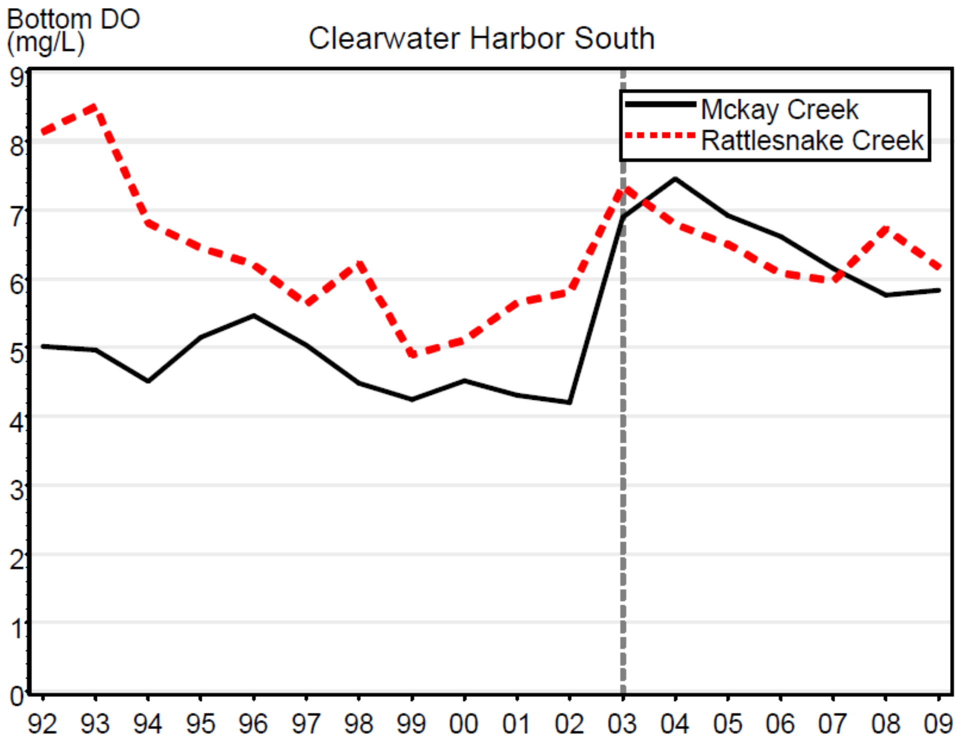


Figure 4-43. **Box and whisker plot of bottom DO concentrations by tributary in the CHS watershed. Vertical broken line indicates when stations were moved upstream.**

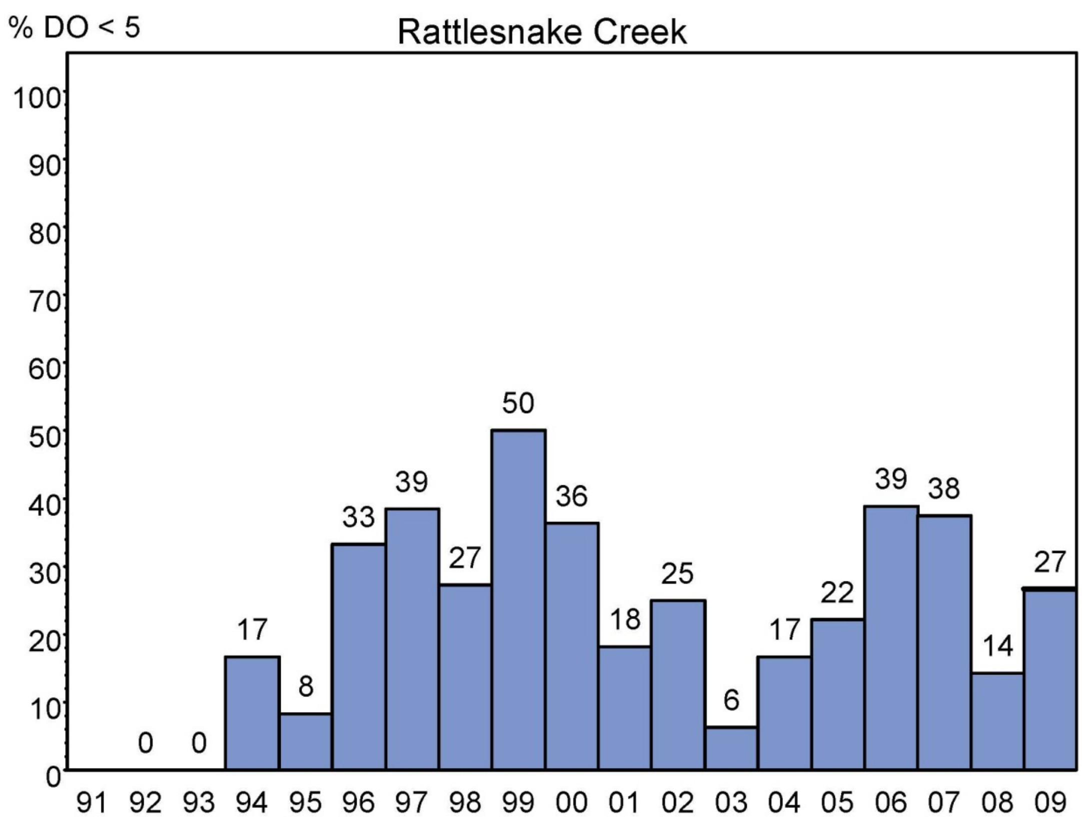


Figure 4-44. **Percent of annual bottom DO concentrations < 5 mg/L (freshwater) in Rattlesnake Creek.**

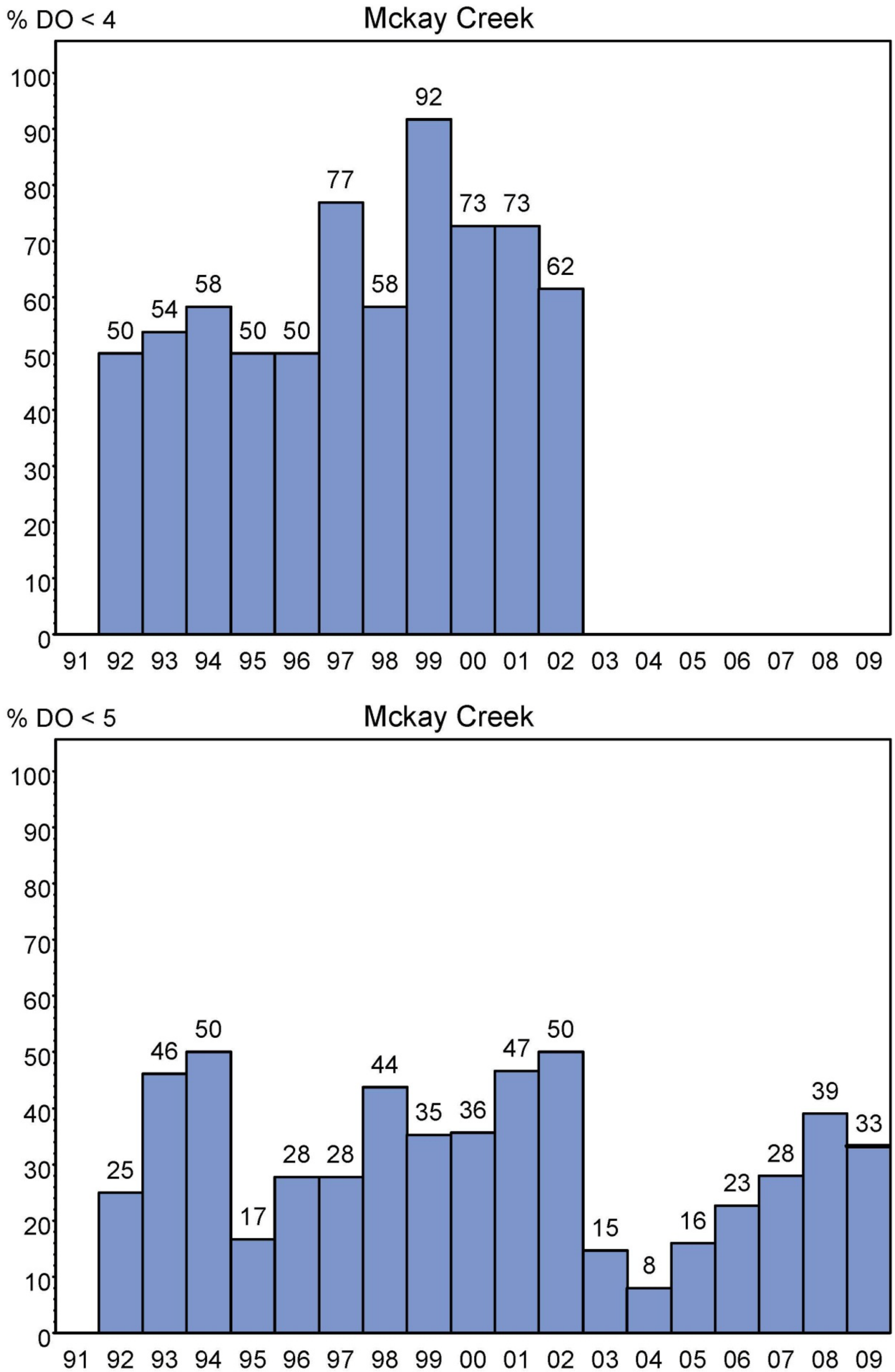


Figure 4-45. **Percent of annual bottom DO concentrations < 4 mg/L (estuarine, top plot) and < 5 mg/L (freshwater, bottom plot) in McKay Creek.**

4.1.3 Watershed Water Quality Management Issues

A major focus of the CHSJS State of the Resource study was to evaluate water quality problems in the estuary and watershed. The Florida Department of Environmental Protection (FDEP) has already designated several waterbodies with the CHSJS as not meeting appropriate water quality standards. The water quality impairments were determined through the application of protocols of the Impaired Waters Rule (IWR). Florida Administrative Code (F.A.C.) Chapter 62-303 contains the criteria for identifying impaired streams, lakes, and marine waters. FDEP has been charged with the responsibility of identifying impaired waterbodies by the US Environmental Protection Agency (USEPA) through the Clean Water Act (CWA). A waterbody is classified as impaired if it fails to meet the criteria for surface waters established in Rule 62-302.500, F.A.C. When a waterbody is designated as impaired, a total maximum daily load (TMDL) must then be determined for the waterbody. A TMDL is the maximum amount of a pollutant that at waterbody can assimilate and not exhibit adverse impacts.

The CHSJS estuary is within FDEP's Anclote River/Coastal Pinellas County planning unit of the Springs Coast Basin for purposes of determining impairment. The Springs Coast Basin is in Group 5, which means that it was investigated in the fifth and final year of the FDEP basin assessment rotation schedule.

The May 19, 2009 Verified list of impaired waters for the Springs Coast lists 17 waterbodies within the planning unit as impaired (Figure 4-46). These impaired waterbodies (WBIDs) are presented in Table 4.4, both freshwater (3F) and estuarine waters (3M) are listed for a variety of impairments including DO (11 WBIDs), nutrients (6 WBIDs), fecal coliform (9 WBIDs), and 2 WBIDs for mercury in fish tissue. Nine of the 17 WBIDs were listed for multiple impairments. A more detailed analysis of the impaired WBIDs is presented in tabular form in Appendix F.

Table 4-4. Impaired WBIDs in the CHSJS area along with cause of impairment.

Segment/Tributary	WBID	Class	Cause of Impairment
St. Joseph Sound	1450B	3F	Mercury in fish
	1512Z	3F	Dissolved Oxygen
Anclote River	1440	3M	Mercury in fish
	1440A	3M	Dissolved Oxygen, Nutrients
Klosterman Bayou	1508	3M	Dissolved Oxygen, Nutrients, Fecal coliform
Sutherland Bayou	1512Z	3F	Dissolved Oxygen
Smith Bayou	1527	3F	Fecal coliform
Curlew Creek	1538A	3F	Fecal coliform
	1538	3M	Dissolved Oxygen, Nutrients
Cedar Creek	1556A	3F	Fecal coliform
	1556	3M	Dissolved Oxygen, Nutrients
Spring Branch	1567B	3F	Dissolved Oxygen, Fecal coliform
Stevenson Creek	1567C	3F	Fecal coliform
	1567	3M	Dissolved Oxygen, Nutrients
Rattlesnake Creek	1614	3F	Dissolved Oxygen, Fecal coliform
McKay Creek	1633B	3F	Dissolved Oxygen, Fecal coliform
	1633	3M	Dissolved Oxygen, Nutrients, Fecal coliform

The DO-impaired WBIDs all had nutrients listed as the causative agent except two. BOD was listed for one WBID (Spring Branch), and no causative agent could be identified for one WBID (McKay Creek freshwater). As mentioned in the previous section, the state Class III DO standard is different for marine water (4.0 mg/L) and freshwater (5.0 mg/L). Since the issuance of the 2009 Verified list, Pinellas County has arbitrated with FDEP regarding several WBIDs listed based on DO and the most recent Verified List (January, 2012) has removed many of the DO related impairments (Addendum to Appendix F).

All of the nutrient-impaired WBIDs were marine waters and each exceeded the standard of 11 micrograms per liter (μg/L) chlorophyll *a* concentration with the required frequency. Nitrogen was identified as the limiting nutrient based on nitrogen to phosphorus (N:P) ratios for all. Both marine and freshwater WBIDs were impaired for fecal coliform. The standard for both marine and freshwaters is repeated exceedance of a concentration of 400 colonies/100 ml.

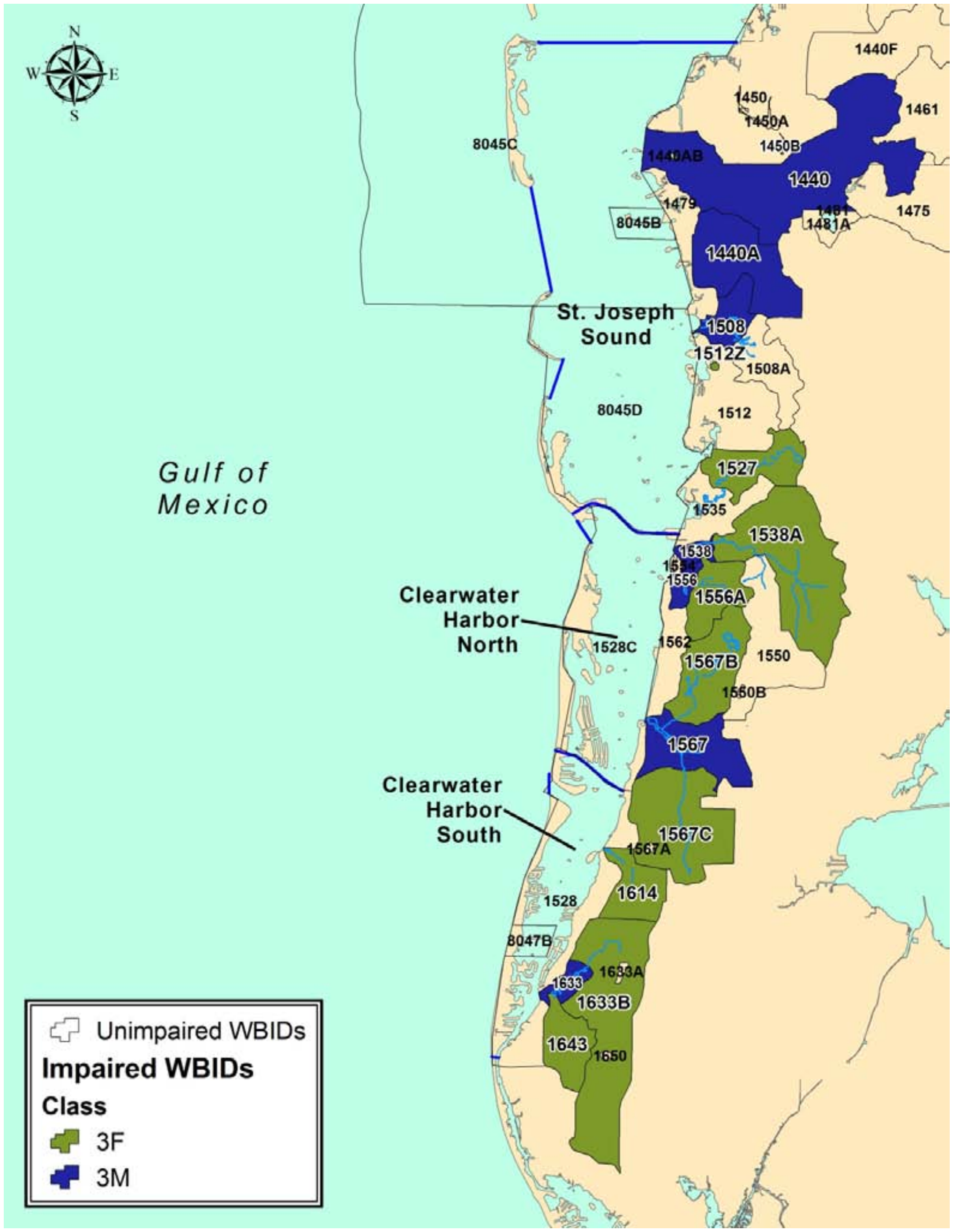


Figure 4-46. **Impaired WBIDs in the CHSJS.**

TMDLs have been developed for nutrients and DO for Klosterman Bayou (WBID 1508) (FDEP, 2008a) and Stevenson Creek (WBID 1567) (FDEP, 2008c). The WBIDs were designated nutrient-impaired based on annual average chlorophyll *a* concentrations greater than the state threshold of 11 (μg/L). If the annual mean chlorophyll a value for any one-year exceeds the threshold, the water is considered verified impaired for nutrients. This is due to the often-demonstrated relationship between excess nutrient inputs and high chlorophyll *a*, which can lead to symptoms of eutrophication (Hazen and Sawyer, 2010). The FDEP rationale was that *"…reductions in nutrients will result in lower algal biomass levels in the water column, and lower algal biomass levels will result in smaller diurnal fluctuations in DO, fewer algal-based total suspended solids, and reduced BOD"* (FDEP, 2008a). The WBIDs were also verified as impaired for DO because more than 10 percent of the sample values were below the Class III marine criterion of 4 (mg/L) over the course of the verified period. BOD loadings were also associated with low DO. The TMDLs were determined by first identifying significant inputs of nutrients in the WBIDs. It should be noted that Pinellas County has challenged the validity of the proposed TMDLs and has formally requested a reassessment before moving forward with the BMAP process (Levy, 2008).

There is one wastewater facility – the County's William Dunn Water Reclamation Facility in the Klosterman Bayou WBID. This facility is highly advanced using biological nutrient removal and meets all advanced wastewater treatment (AWT) requirements. The effluent is used as reuse irrigation water and does not directly discharge to the waterbody. The Suncoast Primate Sanctuary is a small rehabilitation and retirement facility for apes and monkeys that houses 45 primates, primarily common chimpanzees; however, there is no extant evidence of overflow events from this location according to FDEP (2008a).

A portion of Klosterman Bayou is within a Municipal Separate Storm Sewer System (MS4) NPDES area with permitees Pinellas County, the City of Tarpon Springs, and Florida Department of Transportation (FDOT). The remainder of the WBID generates stormwater runoff outside the MS4 boundary. Land use in the WBID consists of high density residential (33%), golf courses (25%) with the rest spread between other urban uses and open lands.

There is one wastewater facility that discharges into the Stevenson Creek WBID – the City of Clearwater's Marshall Street Advanced Wastewater Treatment Facility. Part of the highly-treated effluent is reused as irrigation water and part discharges directly to Stevenson Creek. Stormwater runoff is managed under the same MS4 permit as for Klosterman Bayou. The dominant land use in the WBID is medium density residential (70%) with 10% commercial/industrial use and with only a few percent undeveloped.

Computer models (HSPF for pollutant loadings and EFDC for receiving water response) were used to estimate the reduction in nutrient and BOD loading that would be required to allow Klosterman Bayou and Stevenson Creek to meet DO and chlorophyll *a* targets. Results of the modeling were used to estimate the waterbodies' assimilative capacities. Results indicated that a total nitrogen (TN) and BOD load reduction from nonpoint sources (stormwater runoff) of 80% (Klosterman Bayou) and 85% plus a reduction in wastewater loads (Stevenson Creek) along with reductions in BOD loadings would be required to achieve the WBIDs' designated use.

A TMDL for fecal coliform bacteria was also developed by FDEP for Klosterman Bayou (FDEP, 2008b). The creek was verified as impaired for fecal coliform bacteria because more than 10 percent of the values exceeded the Class III freshwater fecal coliform criterion of 400 counts per 100 milliliters (counts/100mL). Seven out of 37 total samples in the verified period exceeded the criterion of 400 counts/100mL (FDEP, 2008b).

Potential sources of fecal coliform that were investigated included the primate preserve, domestic pets, septic tanks, and reclaimed water. No relationship between fecal coliform counts and season or rainfall was established. It was determined that the water reclamation facility, primate preserve, and the few septic tanks in the area were not significant sources so a TMDL was develop that requires a 52% reduction in fecal bacteria from regulated (MS4) and non-regulated (non-MS4) stormwater runoff (FDEP, 2008b).

The next step in the TMDL process is to develop Basin Management Action Plans (BMAP) for the WBIDs, to develop an implementation plan describing how to meet the TMDL load reductions.

4.1.4 Watershed Loadings

The following sections describe spatial and temporal variation in hydrologic loads and loadings of TN, TP, BOD, and TSS to each of the three segments on annual and intra-annual scales. Loadings are also presented by source type for each segment. Finally, inter-segment comparisons of unit-area loads are presented to identify "hot spots" contributing disproportionate loads to the estuary. Analytical methods used to calculate these loading estimates are presented in Appendix G.

Transport of nutrients and sediments to coastal waters is largely determined by the amount of rainfall over monthly, seasonal, and annual time periods. Rainfall directly impacts surface-water flows, is a significant source of directly deposited nitrogen and phosphorus from the atmosphere and can increase the amount of suspended solids in adjacent waterbodies through sediment erosion and transport to surface waters. Heavy rainfall and high hydrologic loading often cause high nutrient loading which drives primary production and may result in subsequent eutrophication. Increases in sediment loads are another consequence of heavy rainfall and may be associated with increased concentrations of heavy metals and organic contaminants that bind to sediment particles. Suspended solids can also impact light attenuation in the water column and can negatively impact submerged aquatic vegetation as well as benthic invertebrates and fish species.

- **St. Joseph Sound**

The hydrologic load to St. Joseph Sound varied from 123 to 349$10^6$ m^3/yr from 1985 through 2008 (Figure 4-47). The highest hydrologic loads were observed in 1997, 1998 and 2004 and ranged from 274-349 10^6 m^3/yr. The lowest loads were approximately half of the maximum annual loads and were observed in 1989, 1990, and 2006 and ranged from 123-133 10^6 m^3/yr.

Annual TN loads ranged from 89 to 367 tons/yr(Figure 4-48) with highest loads observed in 1998, 2002 and 2003 at 318-367 tons/yr. The smallest TN loads occurred during 1989, 1990, 2006, and 2008 at 89-108 tons/yr.

Annual TP load varied from 6 to 52 tons/yr with the highest TP loads observed during 1998 and 2003 at 48-52 tons/yr. The lowest TP loading occurred during 1993, 1999, 2006, and 2008 at 6-10 tons/yr (Figure 4-49).

Annual loads of total suspended solids (TSS) ranged from 514 to 4,397 tons/yr. The highest TSS loads were observed during 1998 and 2003 at approximately 3,756 - 4,397 tons/yr and the lowest TSS loads during 1989-1990 and 1993 at 514-731 tons/yr (Figure 4-50).

Annual biochemical oxygen demand (BOD) ranged from 128 to 1,131 tons/yr with the highest BOD observed during 1998 and 2003 at approximately 1,000-1,100 tons/yr. The lowest BOD was found during 1989-1990, 1993, and 2008 when levels were less than 200 tons/yr (Appendix H).

Monthly hydrologic loads to St. Joseph Sound ranged from 0.8-110 10^6 m^3/month with TN and TP loads reaching maximum monthly values of 123 and 20 tons/month (tons/mo), respectively. TSS loads ranged from 13-1,726 tons/mo, while BOD loads ranged from 3-436 tons/mo. Box and whisker plots of monthly loads for TN, TP, TSS and BOD for St. Joseph Sound are shown in Figures 4-51 through 4-54. Clearly, there is significant within-year variability in these loads. As expected, the highest loads were found during the wetter summer months.

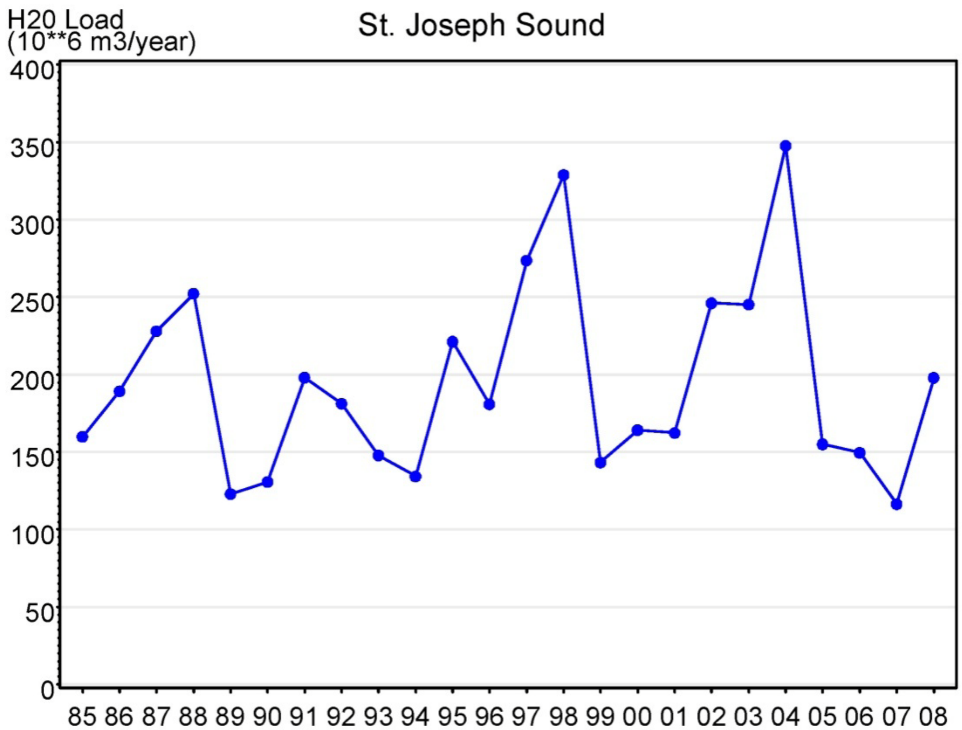


Figure 4-47. Annual hydrologic loads to St. Joseph Sound.

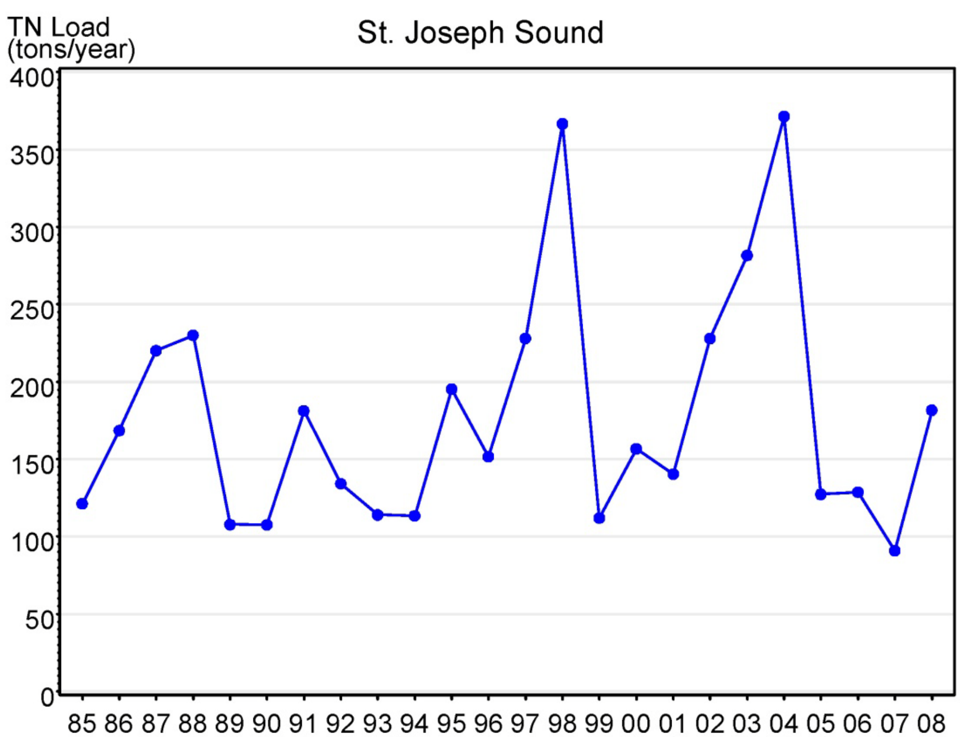


Figure 4-48. **Annual TN loads to St. Joseph Sound.**

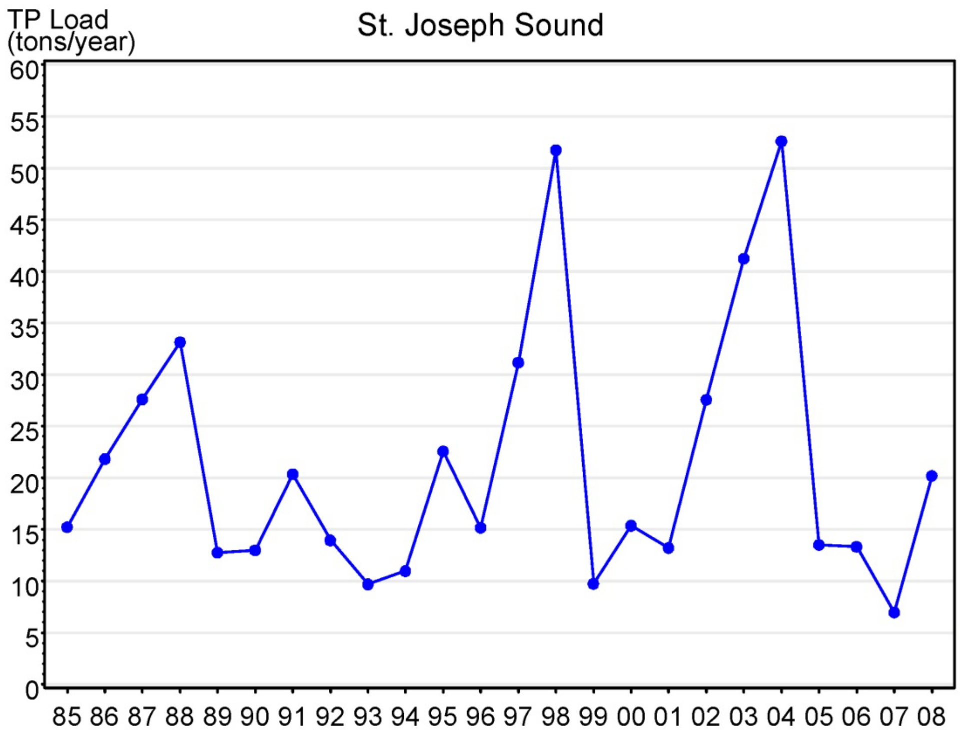


Figure 4-49. **Annual TP loads to St. Joseph Sound.**

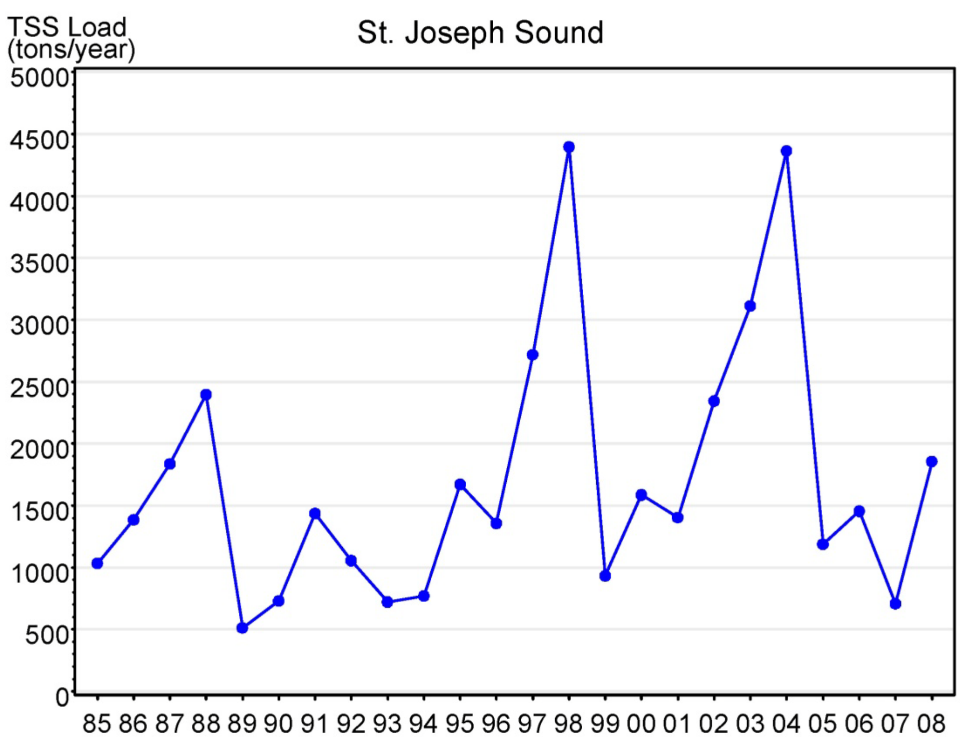


Figure 4-50. **Annual TSS loads to St. Joseph Sound.**

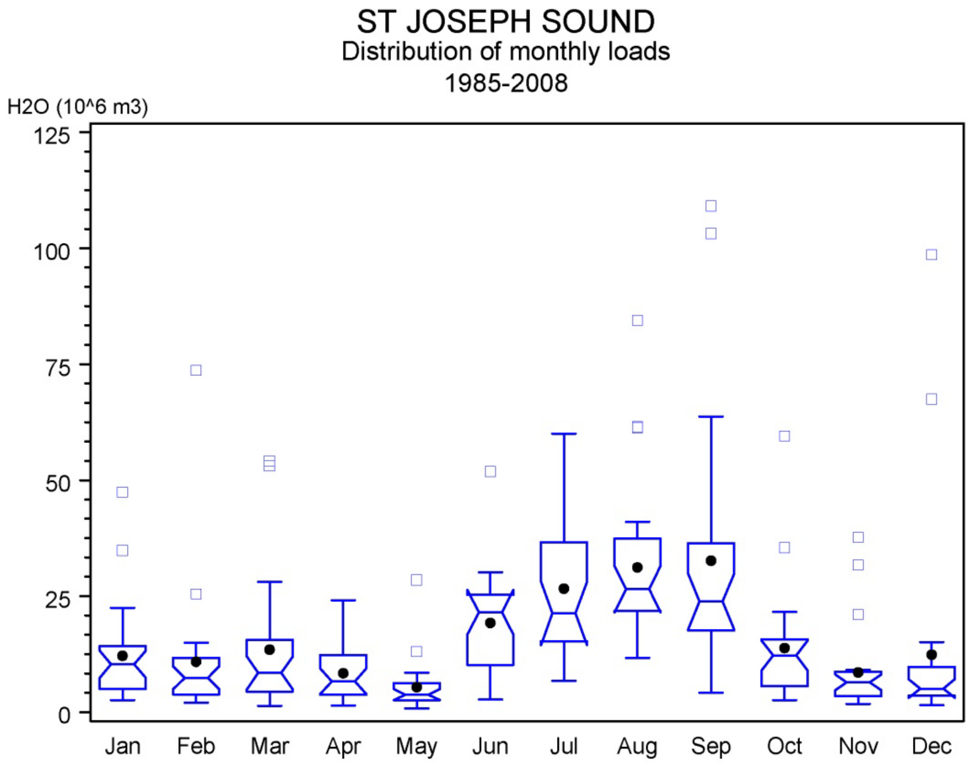


Figure 4-51. **Monthly variability in hydrologic loads to St. Joseph Sound, 1985-2008.**

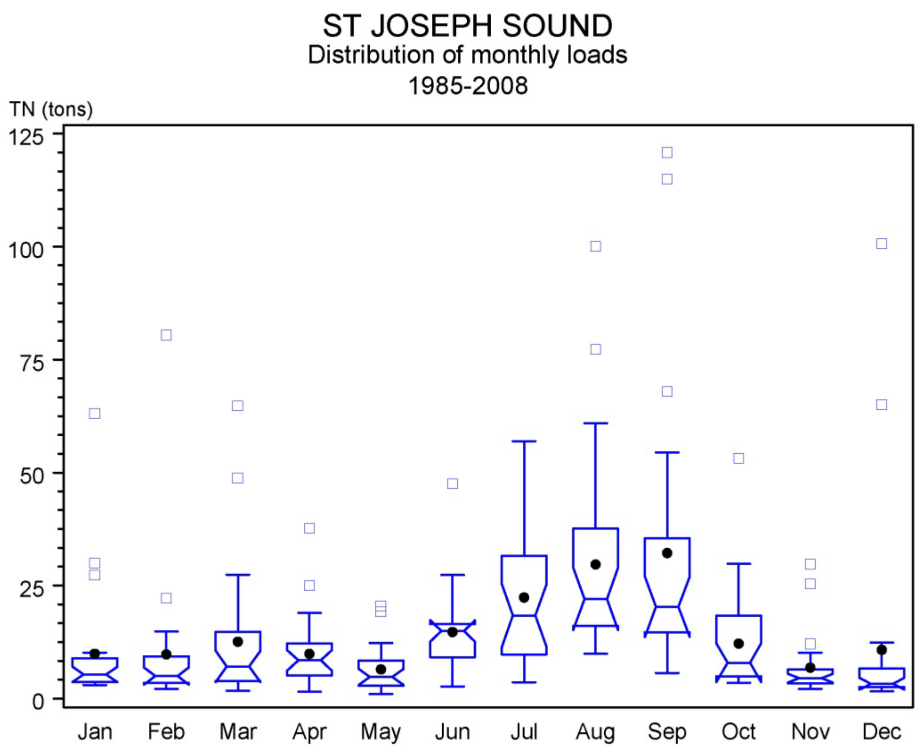


Figure 4-52. **Monthly variability in TN loads to St. Joseph Sound, 1985-2008.**

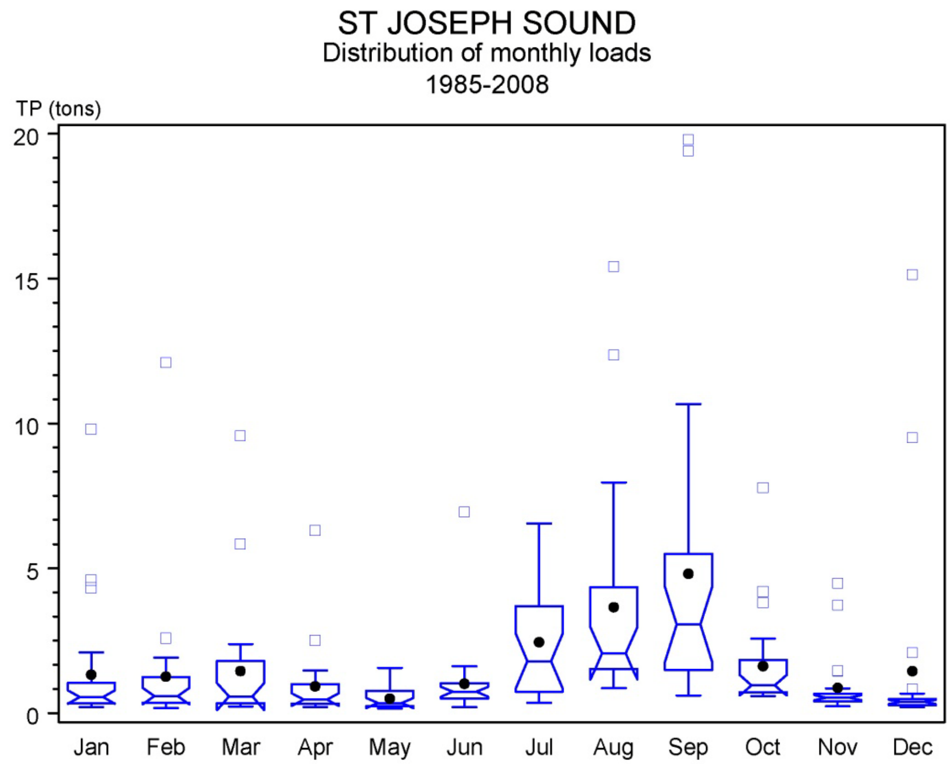


Figure 4-53. **Monthly variability in TP loads to St. Joseph Sound, 1985-2008.**

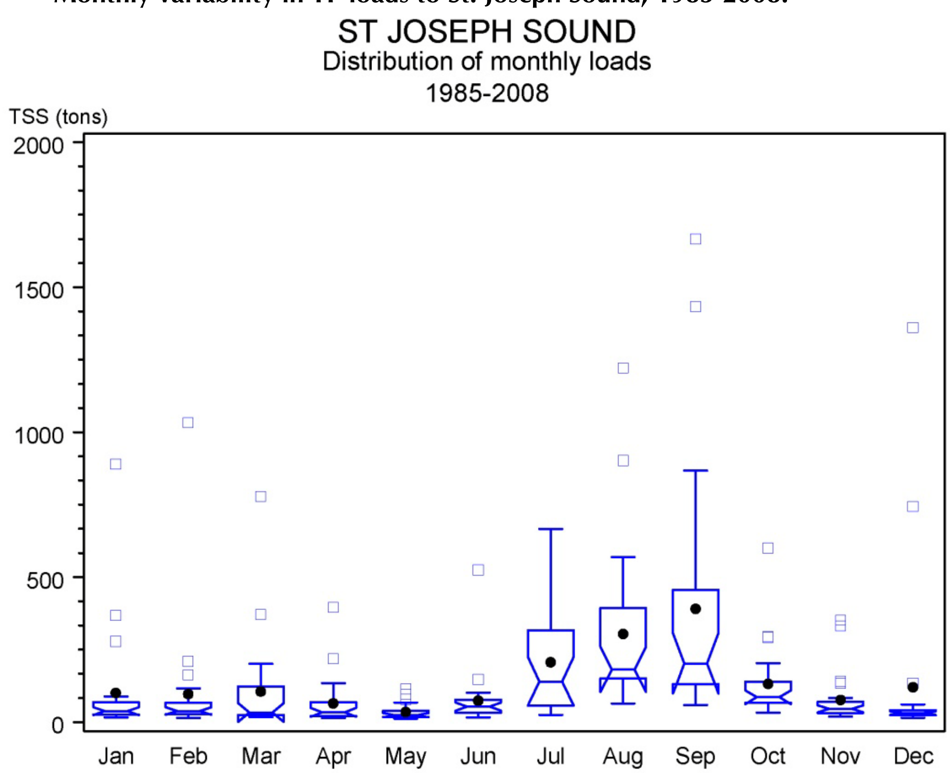


Figure 4-54. **Monthly variability in TSS loads to St. Joseph Sound, 1985-2008.**

Effective management of watershed loads depends upon knowledge of the primary sources, both by type and across sub-basins. Atmospheric deposition (i.e., direct rainfall on the estuary) contributed the largest source of hydrologic loads to St. Joseph Sound (61% of total loading) with nonpoint source (37%) and point-source loads (2%) contributing substantially less (Figure 4-55).

Nonpoint source loads were the primary contributor of TN and TP loads (65% and 89%, respectively). While atmospheric deposition was a major source of TN loads (33%), it was only a very small proportion of the TP load to St. Joseph Sound (5%). Point source loads were a relatively minor source of nutrients to this segment, with only 2% of the TN and 6% of the TP resulting from domestic point sources.

Nearly all (>99%) of the TSS and BOD loads were from nonpoint sources.

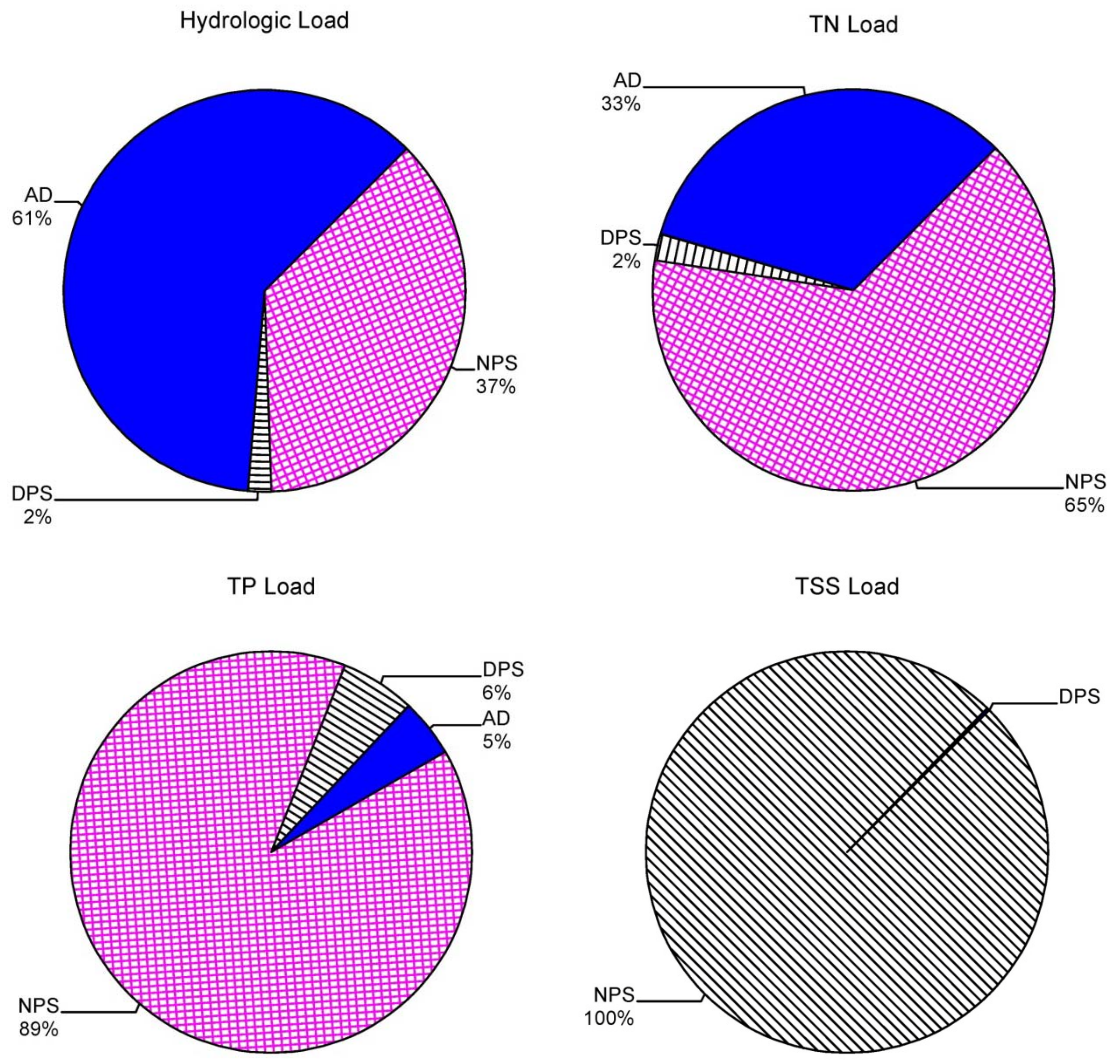


Figure 4-55. Percentage of annual loads contributed to St. Joseph Sound by domestic point sources, nonpoint sources and atmospheric deposition.

The watershed loads also varies significantly among sub-basins. For St. Joseph Sound, the Anclote River sub-basin contributed the largest percentage of all loads to the estuary as a result of its' disproportionately large size relative to the other sub-basins in the watershed. Over 80% of the TN, TP and hydrologic loads to St. Joseph Sound originated in the Anclote River sub-basin (Figure

4-56). Smith Bayou and the sub-basin north of the Anclote River mouth both contributed more than the remaining sub-basins, although the loads from each only equaled approximately 5% of the total loads to the estuary.

Total average annual TSS loads from the Anclote River sub-basin were approximately 70% of the total TSS loads to St. Joseph Sound, with an additional 10-12% contributed by the Smith Bayou and North of Anclote River sub-basins.

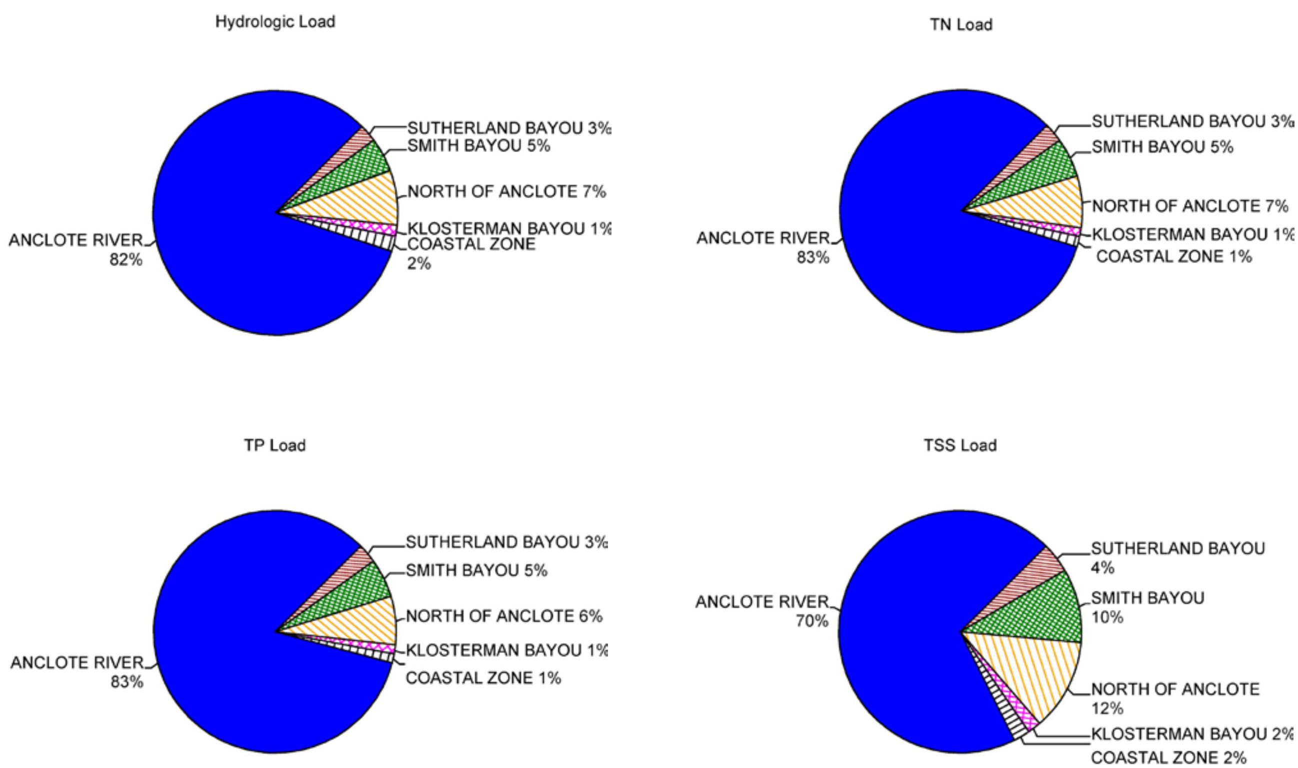


Figure 4-56. Percentage of annual average loads to St. Joseph Sound contributed by sub-basin, 1985-2008.

- Clearwater Harbor North

In Clearwater Harbor North, hydrologic loads varied from 41-89 10^6 m^3/yr between 1985 and 2008 (Figure 4-57). The highest hydrologic loading was observed during 1995, 1997, 1998, and 2004 and ranged from 82-89 10^6 m^3/yr. The lowest loads occurred during 1985, 1986 and 2007 and ranged from 41-48 10^6 m^3/yr.

Annual TN loads to Clearwater Harbor North ranged from 35-189 tons/year and were greatest during 1989, 1990 and 2004 at 118-189 tons/yr (Figure 4-58). Peak TN loads were observed in 1989 due to unusually high TN concentrations from point source loads with monthly averages ranging from 9-18 mg/L. The lowest TN loads occurred between 1985 and 1987 when 35-52 tons/yr were estimated to have entered Clearwater Harbor North. Annual TP loads to Clearwater Harbor North varied from 4-50 tons/yr and peaked during 1989-1990 between 37 and 50 tons/yr. Peak TP loads were observed in 1989 due to unusually high TP concentrations from point source loads with monthly averages ranging from 3-5 mg/L (Figure 4-59). The lowest TP loadings were observed between 1985 and 1987 at 4-6 tons/yr. TSS loads ranged annually from 748 to 2,377 tons/yr in Clearwater Harbor North (Figure 4-60) and were highest during 1988, 1995, 1998 and 2004 with loads from 1,834-2,377 tons/yr. The lowest TSS loads were estimated during 1985, 1993, and 2005 at <800 tons/yr.

Annual BOD loads ranged from 145-468 tons/yr in Clearwater Harbor North (Appendix H). The highest BOD was found during 1988, 1998, and 2004 when loads exceeded 400 tons/yr, while the lowest BOD was observed in 1985, 1986, 1993, and 2005 at <165 tons/yr.

In Clearwater Harbor North, monthly hydrologic loads ranged from 0.6-38 10^6 m^3/month. Monthly nutrient loads ranged from 1-55 tons/mo for TN and <1-9 tons/mo for TP. TSS loads ranged from 12-1,632 tons/mo, while BOD loads from 3-305 tons/mo were observed. Time-series plots of monthly loads for TN, TP, TSS, and BOD for Clearwater Harbor North are shown in Figures 4-61 through 4-64.

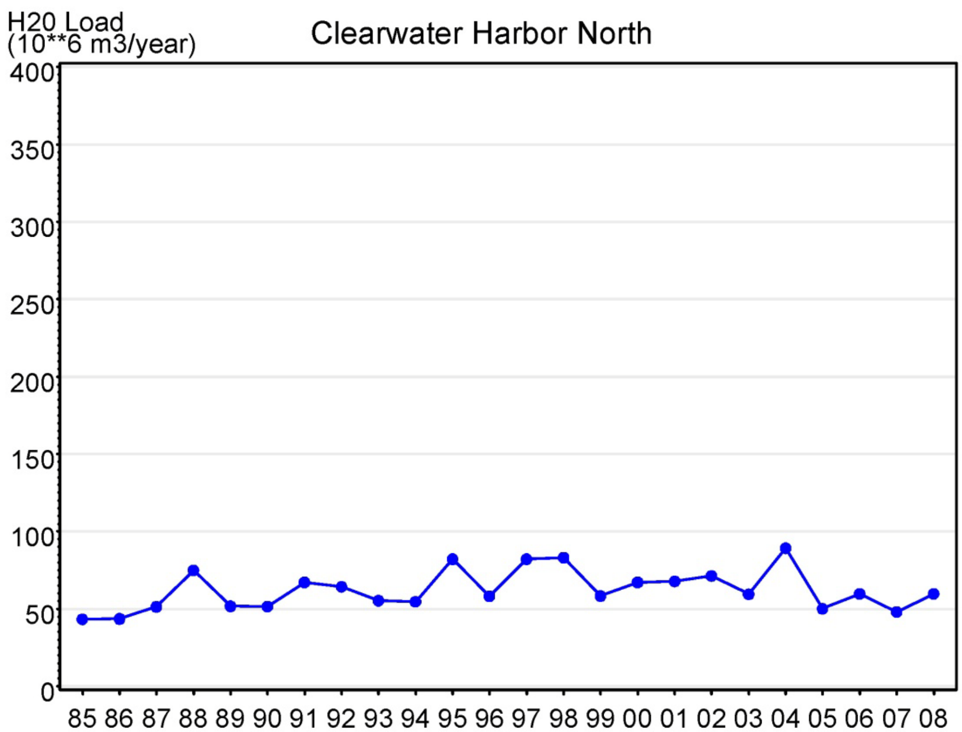


Figure 4-57. Annual hydrologic loads to Clearwater Harbor North.

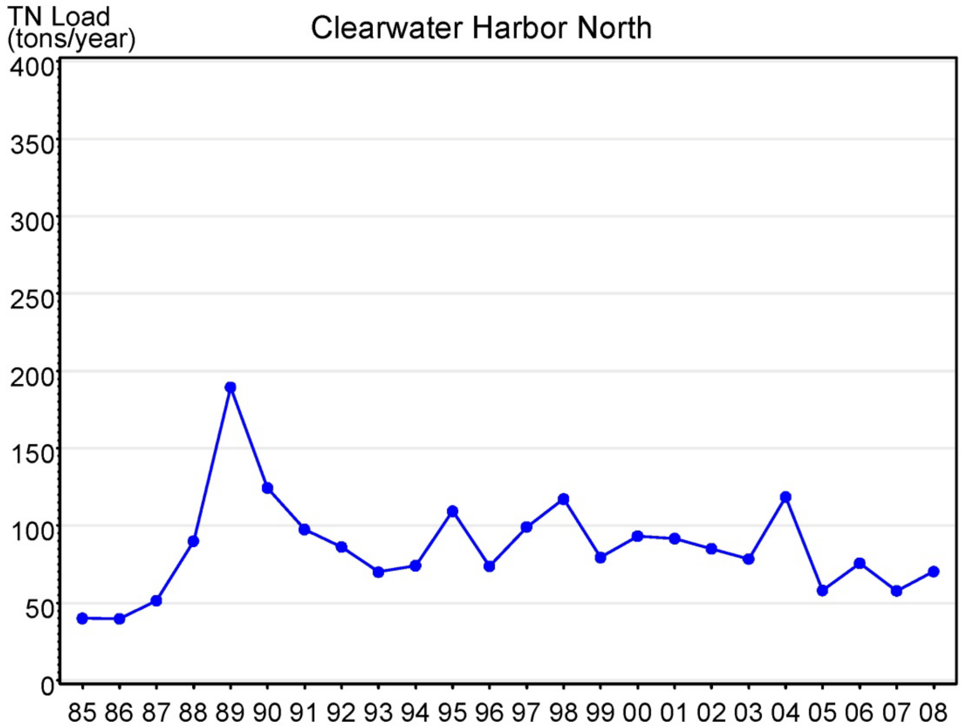


Figure 4-58. Annual TN loads to Clearwater Harbor North.

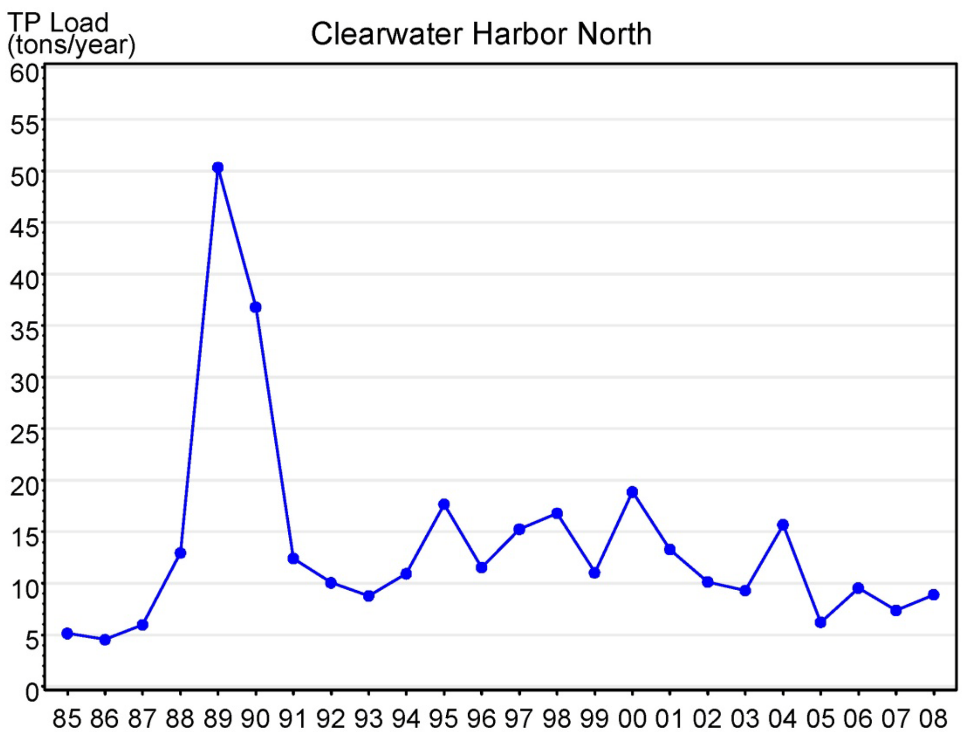


Figure 4-59. Annual TP loads to Clearwater Harbor North.

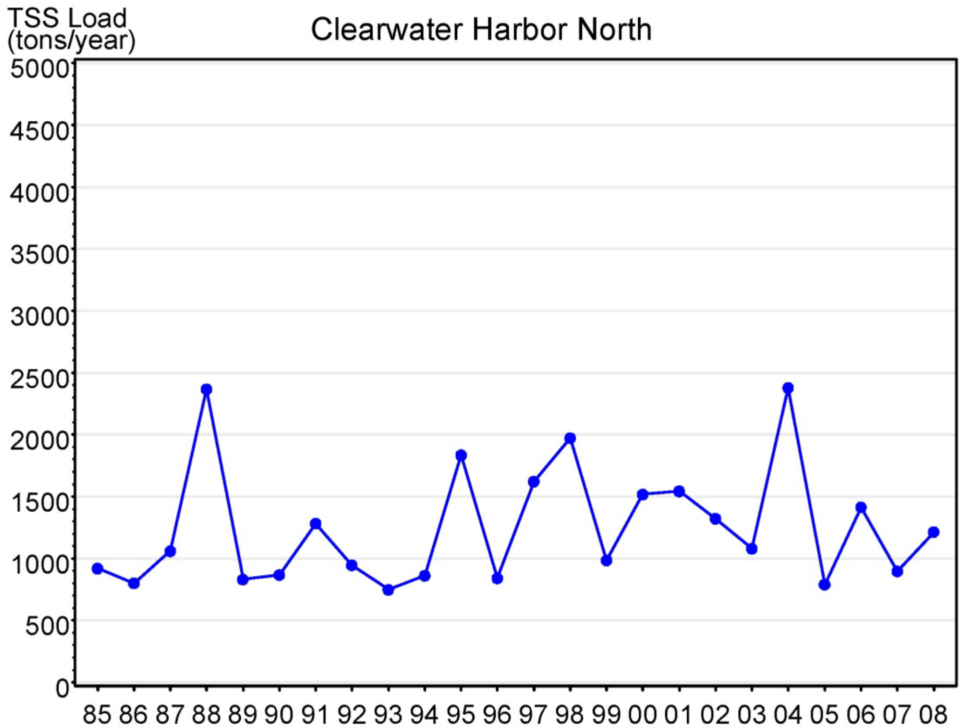


Figure 4-60. **Annual TSS loads to Clearwater Harbor North.**

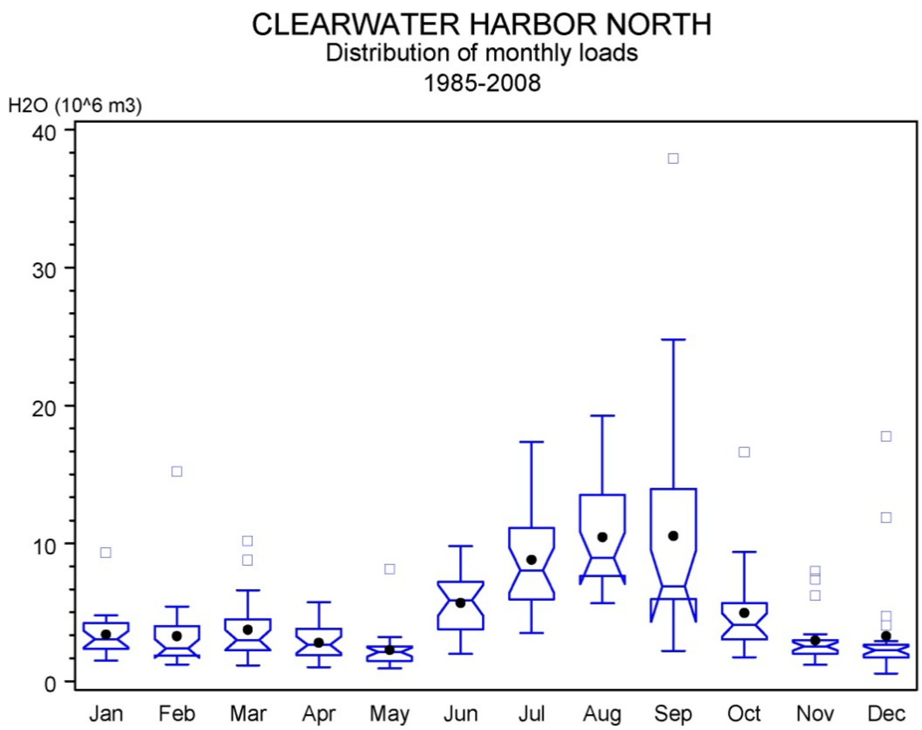


Figure 4-61. **Monthly variability in hydrologic loads to Clearwater Harbor North, 1985-2008.**

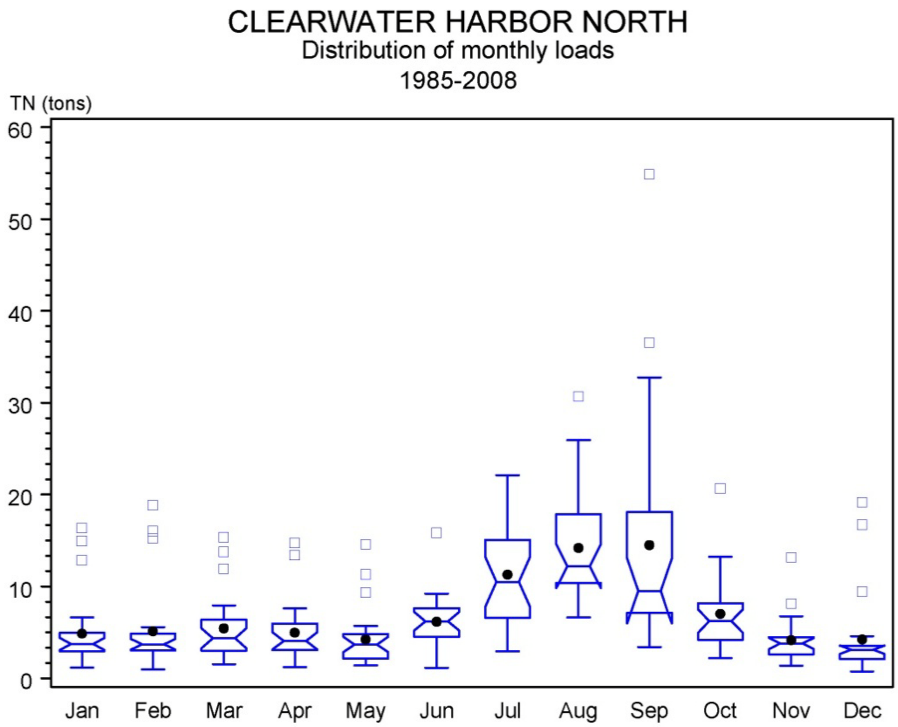


Figure 4-62. **Monthly variability in TN loads to Clearwater Harbor North, 1985-2008.**

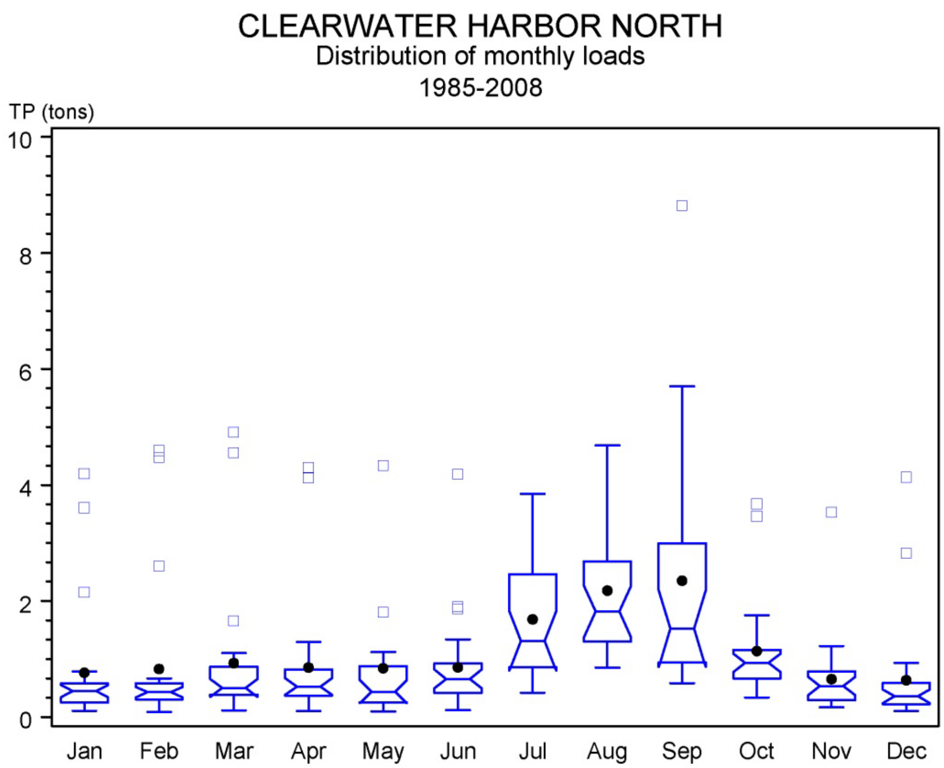


Figure 4-63. **Monthly variability in TP loads to Clearwater Harbor North, 1985-2008.**

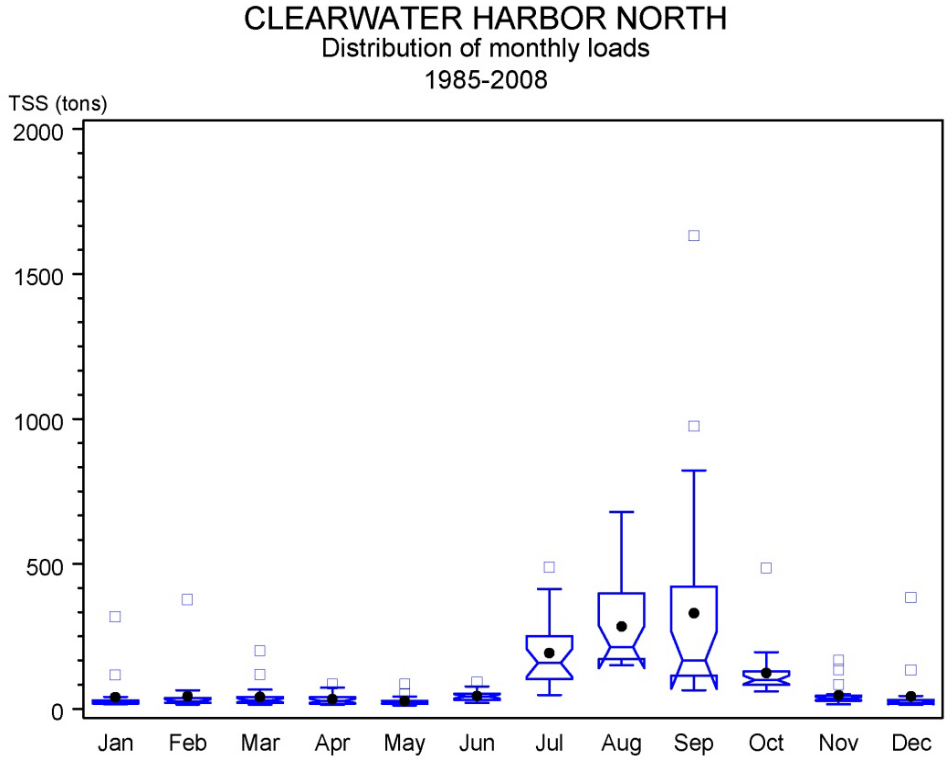


Figure 4-64. Monthly variability in TSS loads to Clearwater Harbor North, 1985-2008.

Effective management of watershed loads depends upon knowledge of the primary sources, both by type and across sub-basins. Atmospheric deposition (i.e., rainfall) contributed 46% of the hydrologic load in Clearwater Harbor North, though loads from nonpoint (32%) and domestic point sources (22%) were substantial as well (Figure 4-65).

Nutrient loads to Clearwater Harbor North were derived largely from nonpoint and domestic point sources with TN loads equally contributed by nonpoint (44%) and domestic point sources (40%) and much less originating from atmospheric deposition (16%). TP loads were also highest from domestic point sources (54%) and from nonpoint sources (44%). Very little of the annual TP load to this segment (2%) were contributed via atmospheric deposition.

Nearly all TSS to Clearwater Harbor North originated from nonpoint sources (97%) with a small percentage (3%) derived from domestic point sources (Figure 4-66). Nonpoint source loads also contributed much of the BOD load (84%) with the remaining 16% produced by domestic point sources.

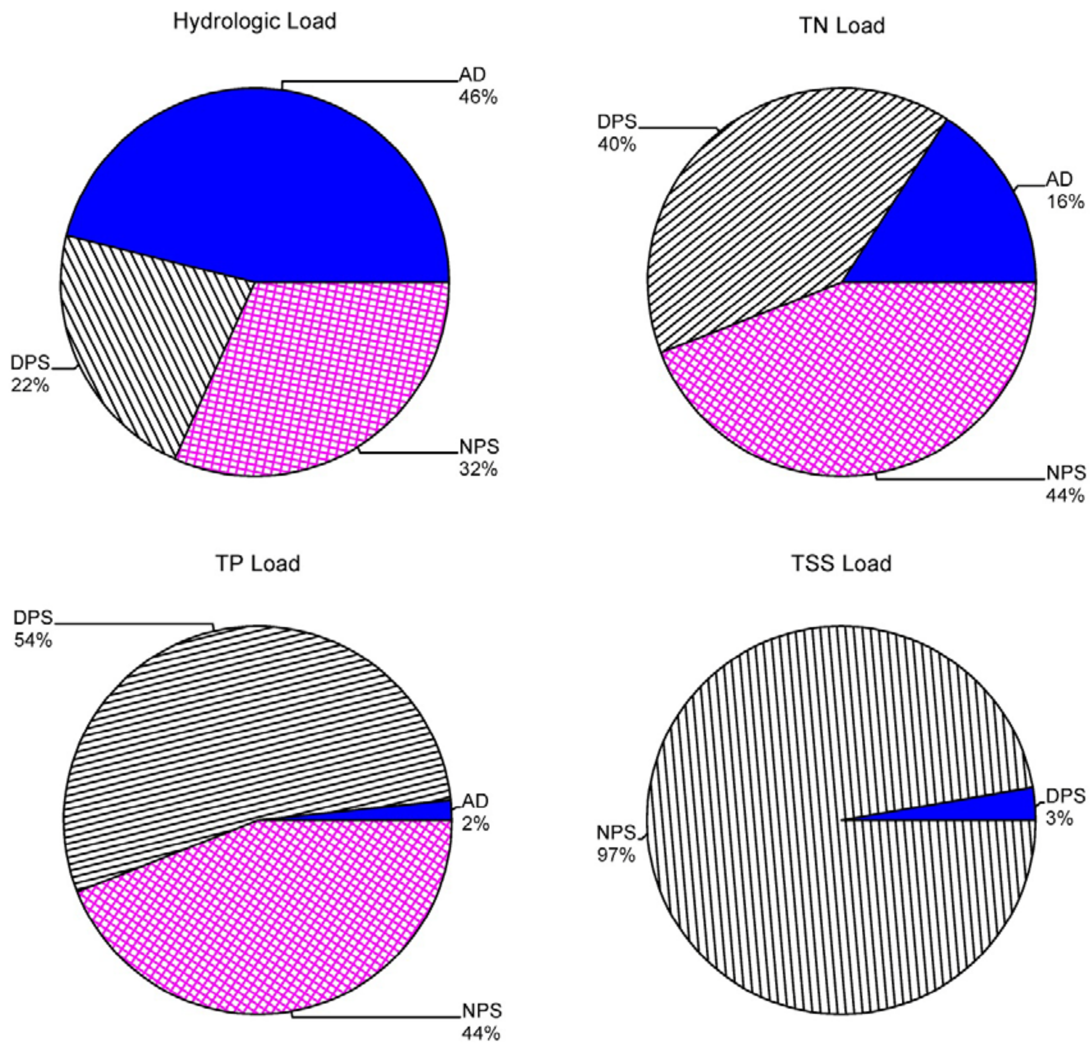


Figure 4-65. Percentage of annual loads contributed to Clearwater Harbor North by domestic point sources, nonpoint sources and atmospheric deposition.

The watershed loads also varies significantly among sub-basins. In Clearwater Harbor North, Stevenson Creek and Curlew Creek each contributed roughly one-third of the hydrologic load to the estuary (Figure 4-66).

Substantial contributions to the total annual average TN load originated in Stevenson Creek, Curlew Creek and the Coastal sub-basin (a small sub-basin with direct runoff to the estuary). Stevenson Creek also contributed nearly half of the total annual average TP load to the estuary, although Curlew Creek contributed close to another 25%.

As with nutrient loads, the majority of the total annual average TSS load (nearly 65%) was contributed by the Stevenson Creek and Curlew Creek sub-basins.

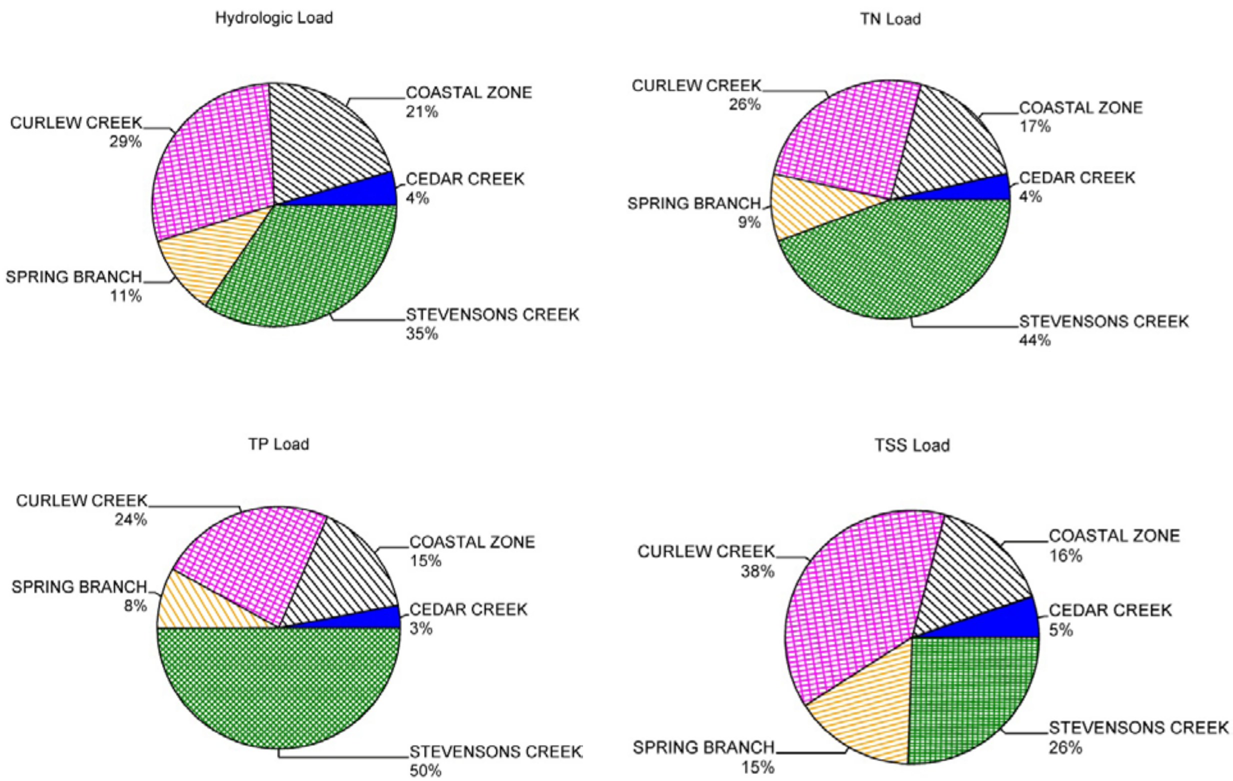


Figure 4-66. Percentage of annual average loads to Clearwater Harbor North contributed by sub-basin, 1985-2008.

- Clearwater Harbor South

In Clearwater Harbor South, the hydrologic load varied from 21-46 10^6 m^3/yr (Figure 4-67). Highest hydrologic loading was found during 1988, 1995, 1997 and 2004 with loads in excess of 39 10^6 m^3/yr. Lowest hydrologic loading occurred during 1989, 1990, and 1993 at <23 10^6 m^3/year.

Annual TN loads in Clearwater Harbor South ranged from 20-56 tons/year (Figure 4-68). TN loading was highest in 1988, 1995 and 2004 and ranged from 47--56 tons/yr during those years. The lowest TN loading occurred during 1985, 1990, 1992, and 1993 but did not exceed 22 tons/yr during that time period.

Clearwater Harbor South received annual TP loads of 2-7 tons/yr with the highest loads estimated during 1988, 1995, 1998, and 2004 at 5-7 tons/yr and the lowest loads (2 tons/yr) during 1990 and 1993 (Figure 4-69).

Annual TSS loads ranged from 273-1,323 tons/yr to Clearwater Harbor South. The highest TSS loads were observed during 1988 and 2004 at 1,107-1,322 tons/yr (Figure 4-70). Lowest TSS loads were estimated during 1989, 1990, and 1993 at <300 tons/yr.

In Clearwater Harbor South, BOD loads ranged from 52-246 tons/yr with loads in excess of 200 tons/yr observed during 1988 and 2004 (Appendix H). Low BOD loads were found during 1989, 1990, and 1993 at <57 tons/yr.

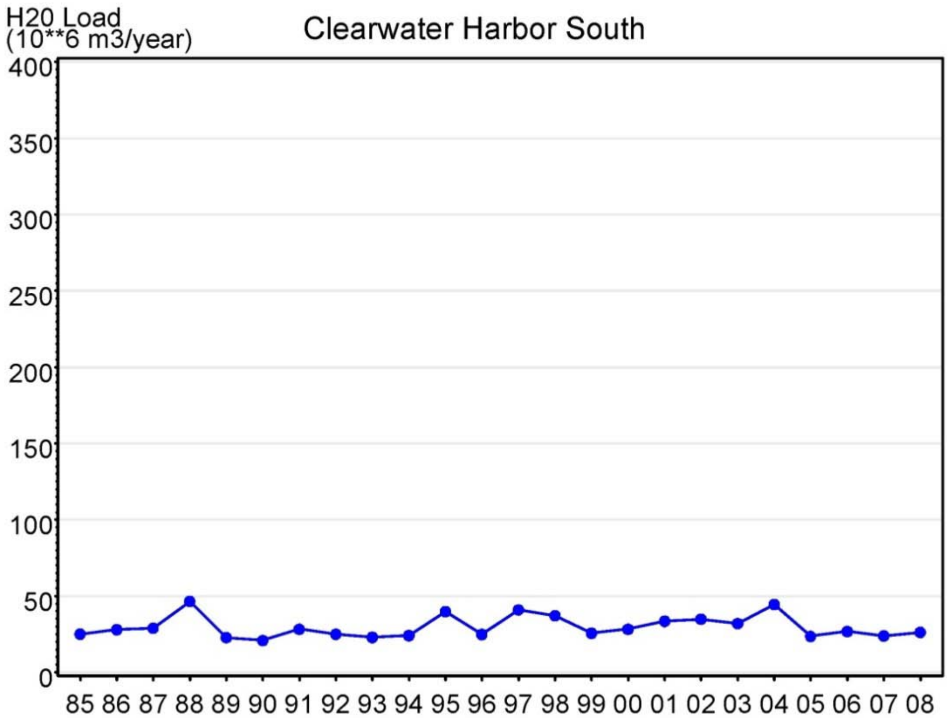


Figure 4-67. Annual hydrologic loads to Clearwater Harbor South.

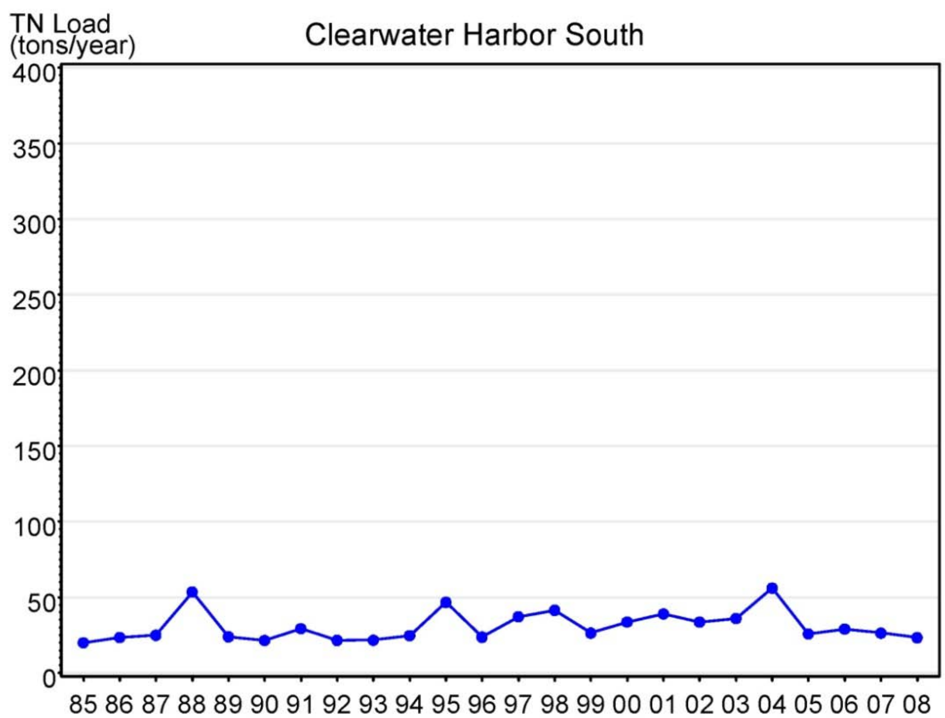


Figure 4-68. Annual TN loads to Clearwater Harbor South.

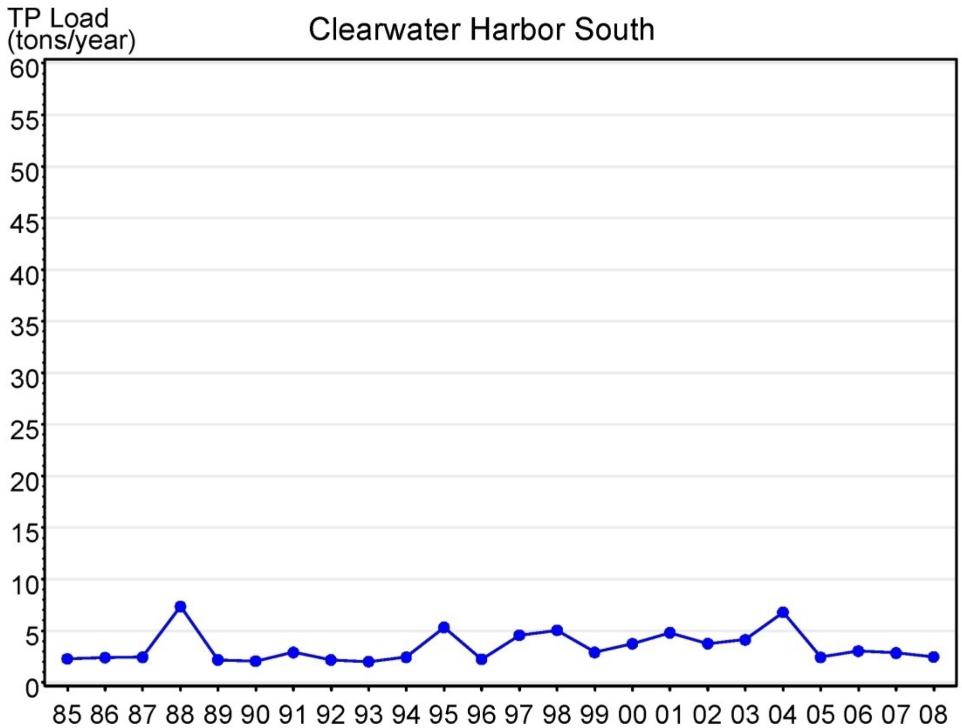


Figure 4-69. Annual TP loads to Clearwater Harbor South.

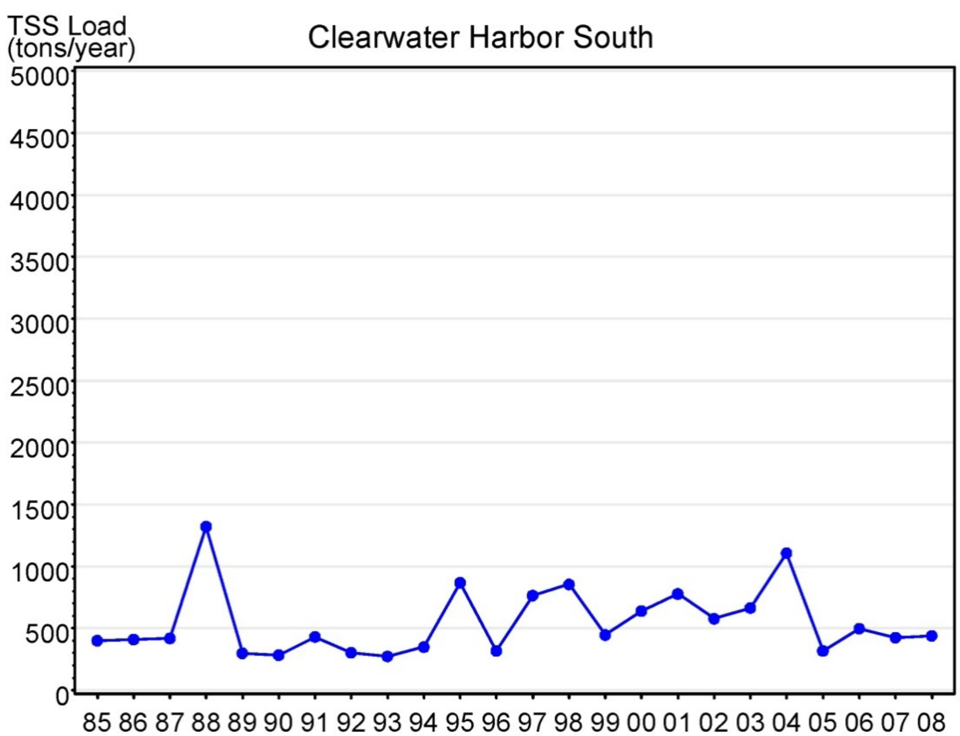


Figure 4-70. Annual TSS loads to Clearwater Harbor South.

In Clearwater Harbor South, monthly hydrologic loads ranged from 0.2-25 10^6 m^3/month. Monthly TN ranged from 0-35 tons while monthly TP loads ranged from 0-5 tons. TSS loads between 5-995 tons/mo were observed. Monthly BOD ranged from 1-185 tons/mo. Box and whisker plots of monthly loads for each constituent are shown in Figures 4-71 through 4-74 and Appendix H.

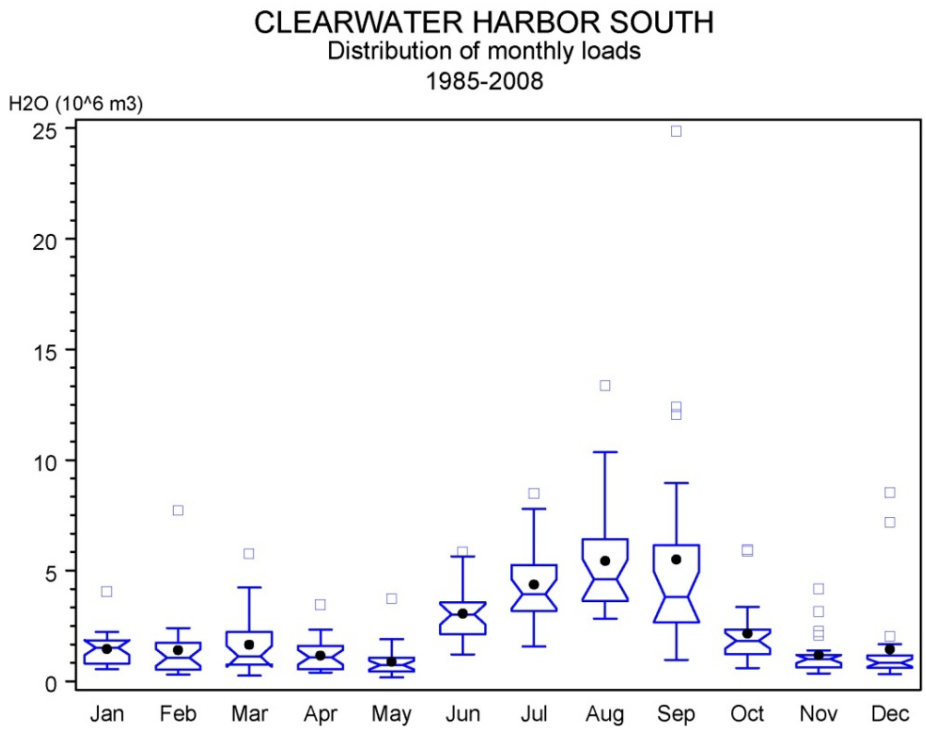


Figure 4-71. Monthly variability in hydrologic loads to Clearwater Harbor South, 1985-2008.

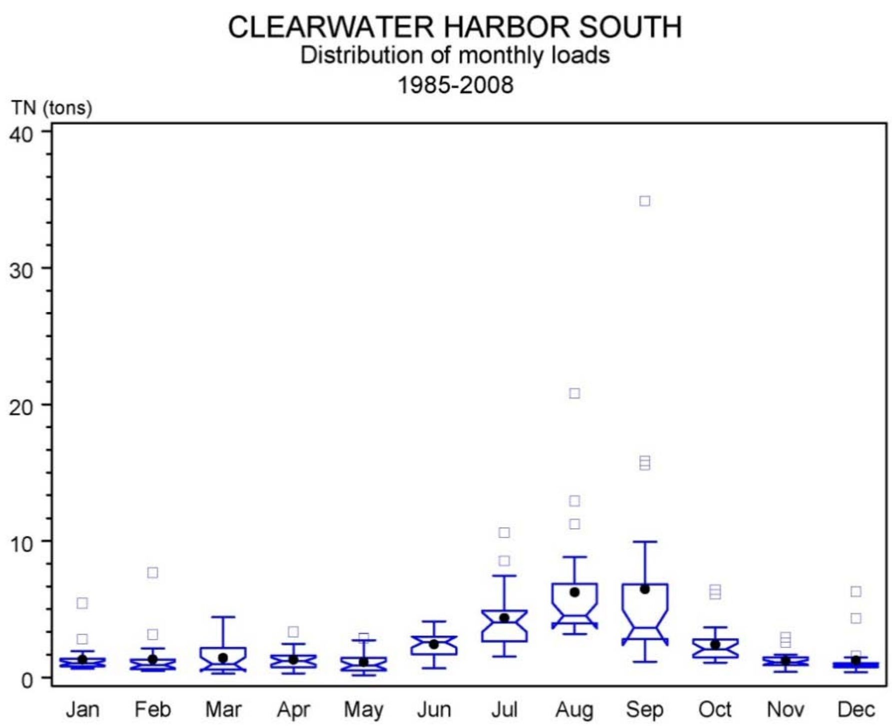


Figure 4-72. Monthly variability in TN loads to Clearwater Harbor South, 1985-2008.

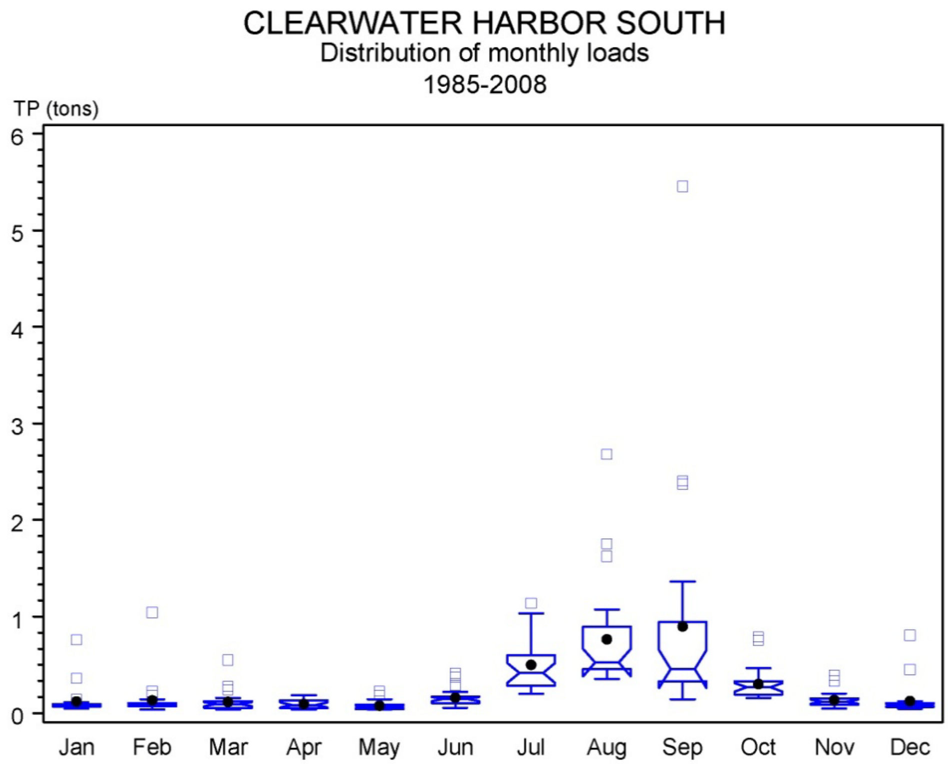


Figure 4-73. **Monthly variability in TP loads to Clearwater Harbor South, 1985-2008.**

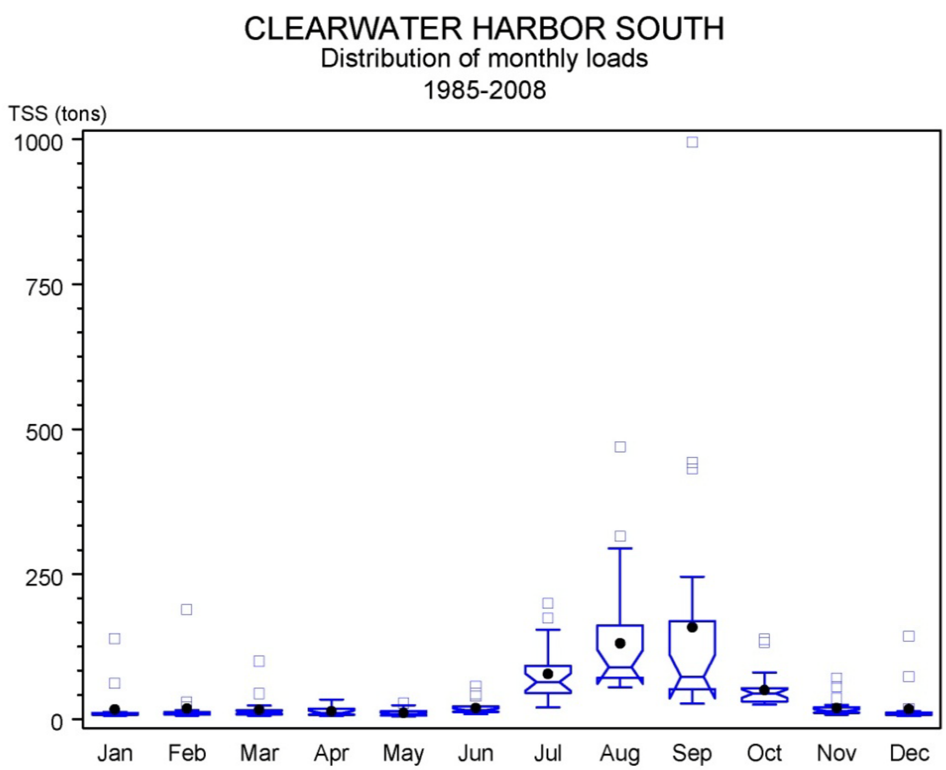


Figure 4-74. **Monthly variability in TSS loads to Clearwater Harbor South, 1985-2008.**

The watershed loads also varies significantly among sub-basins. Atmospheric deposition contributed the majority of the hydrologic load (65%) to Clearwater Harbor South, followed by nonpoint sources (30%) and domestic point sources (5%; Figure 4-75).

TN loads were greatest from nonpoint sources (58%) and atmospheric deposition (31%) and relatively low (12%) from domestic point sources. Nonpoint sources of TP far exceeded (83%) inputs from domestic point sources (12%) and atmospheric deposition (5%) on an annual basis.

Nearly all of the TSS (99.7%) and BOD (98%) were contributed by nonpoint source loads with the remaining <3% from domestic point sources.

The McKay Creek sub-basin contributed the largest percentage of the annual average load for all constituents to Clearwater Harbor South (Figure 4-76 and Appendix H). Between 50-60% of the hydrologic, nutrient, TSS, and BOD loads were derived from this sub-basin.

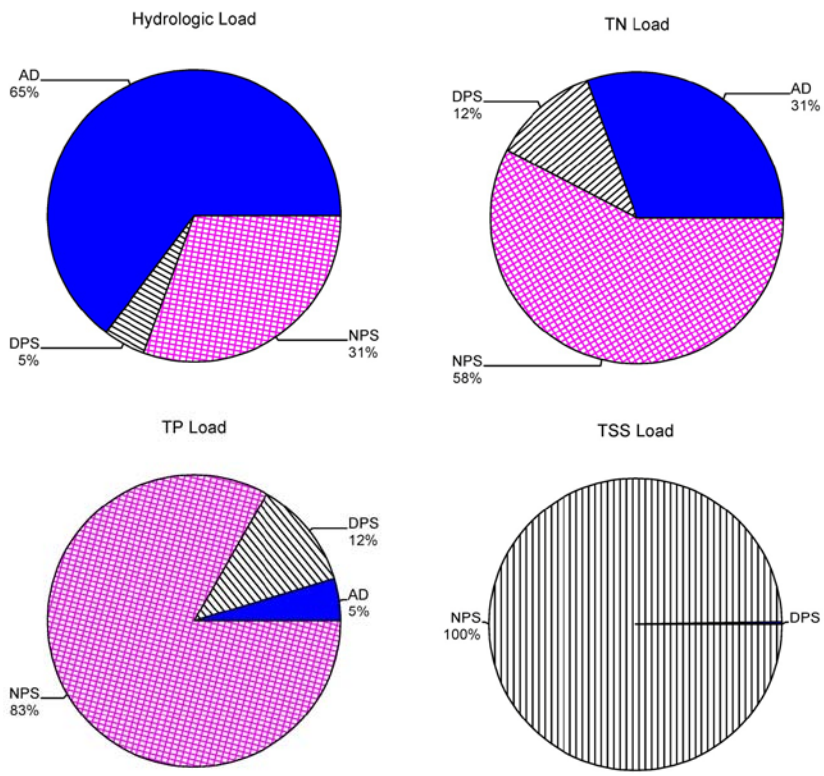


Figure 4-75. Percentage of annual loads contributed to Clearwater Harbor South by domestic point sources, nonpoint sources and atmospheric deposition.

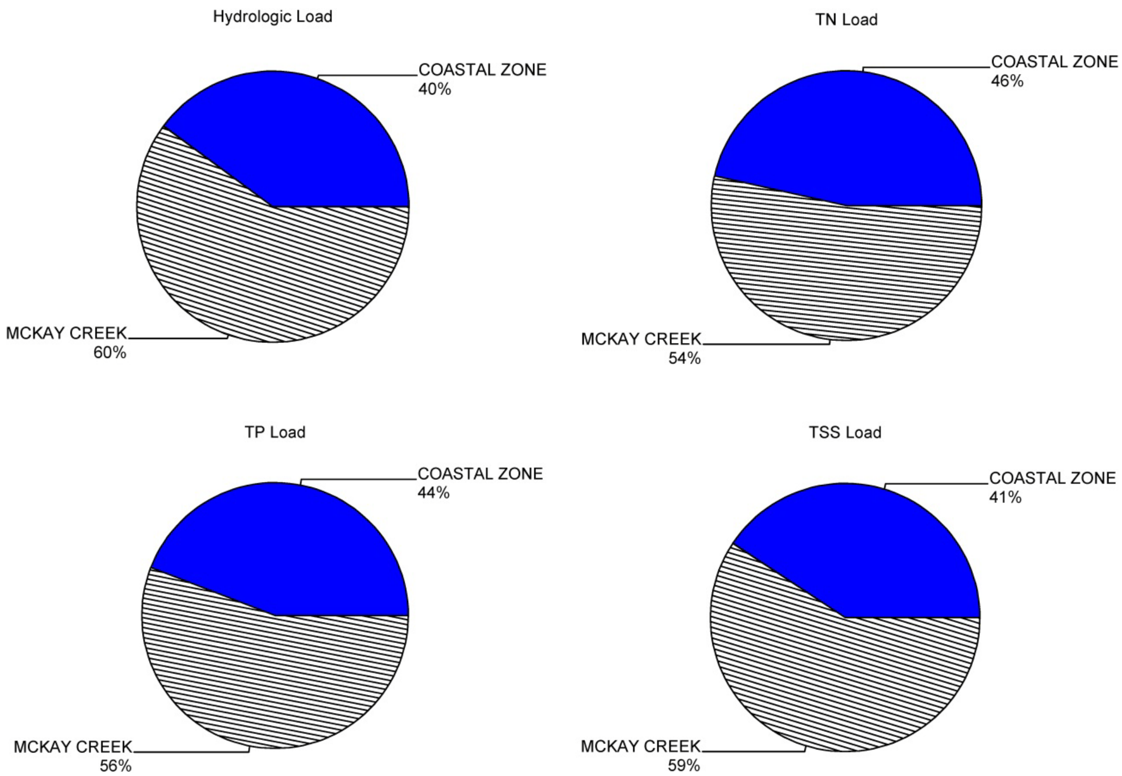


Figure 4-76. Percentage of annual average loads to Clearwater Harbor South contributed by sub-basin, 1985-2008.

- **Inter-annual Loads by Sub-basin**

Annual average hydrologic load per acre for each sub-basin of St. Joseph Sound, Clearwater Harbor North, and Clearwater Harbor South is shown in Table 4-5. Per unit area hydrologic load was highest in the Smith Bayou sub-basin (1,849 m^3/acre) and lowest in the Klosterman Bayou sub-basin (535 m^3/acre), although the Coastal sub-basin contributed a similarly low volume (572 m^3/acre). The highest hydrologic loads per unit area were observed for the Stevenson Creek at 2,902 m^3/acre with the lowest loads for Cedar Creek at 1,182 m^3/acre. The Coastal sub-basin of Clearwater Harbor South and the McKay Creek sub-basin contributed similar hydrologic loads for this segment (897-1,107 m^3/acre).

Average annual TN load per acre was highest for St. Joseph Sound in the Smith Bayou sub-basin at 6.8 pounds per acre (lb/acre) and lowest in the Coastal sub-basin at 1.3 lb/acre. Small TN loads were also observed for the Klosterman Bayou sub-basin (1.3 lb/acre). In Clearwater Harbor North, the highest TN loads were found from the Stevenson Creek sub-basin (16.4 lb/acre) and the lowest loads (4.1-5.5 lb/acre) from Cedar and Curlew Creeks. In Clearwater Harbor South, the Coastal sub-basin and McKay Creek sub-basin each had TN loads of approximately 4.0 lb/acre with a slightly greater contribution of the total annual average load originating in the McKay Creek sub-basin (Table 4-5).

Average annual TP load per acre in St. Joseph Sound was highest in the Smith Bayou sub-basin (1.1 lb/acre) while TP load for each of the other sub-basins was <1 lb/acre and ranged from 0.2-0.7 lb/acre (Table 4-5). In Clearwater Harbor North, Stevenson Creek had TP loads of 3.5 lb/acre TP while all other sub-basins ranged from 0.7-1.4 lb/acre. In Clearwater Harbor South, TP loads were 0.6 lb/acre for both the Coastal sub-basin and the McKay Creek sub-basin.

Average annual TSS load per acre was highest in St. Joseph Sound in the Smith Bayou sub-basin (184 lb/acre) and considerably lower in the Anclote River sub-basin (33 lb/acre). There was a wide range of area-specific loadings from the remaining sub-basins which ranged from 28-90 lb/acre. In Clearwater Harbor North, the highest TSS loading was observed in the Spring Branch sub-basin (181 lb/acre). The lowest per unit area TSS load was estimated for the Cedar Creek sub-basin (107 lb/acre). TSS loads in Clearwater Harbor South were 97 lb/acre in the Coastal sub-basin and only slightly higher for the McKay Creek sub-basin (116 lb/acre).

Average annual BOD loads per acre in St. Joseph Sound was highest in the Smith Bayou sub-basin (35 lb/acre) and lowest in the Coastal sub-basin (5 lb/acre). The highest BOD loading in Clearwater Harbor North was observed in the Stevenson Creek sub-basin (38 lb/acre) and the lowest was observed in the Cedar Creek sub-basin (21 lb/acre). In Clearwater Harbor South, average annual BOD loads ranged from 18 lb/acre in the Coastal sub-basin to 22 lb/acre in the McKay Creek sub-basin.

Table 4-5. Average annual loads per acre to each segment in the CHSJS estuary.

Subbasins	TN Load (lb/ac/yr)	TP Load (lb/ac/yr)	TSS Load (lb/ac/yr)	BOD Load (lb/ac/yr)	Hydrologic Load (m^3/ac/yr)
St Joseph Sound					
Anclote River	2.74	0.47	33.27	9.27	864
Coastal Subbasin	1.27	0.19	27.53	5.10	572
Klosterman Bayou	1.32	0.23	30.06	5.91	535
North of Anclote	3.33	0.54	84.84	17.06	1,106
Smith Bayou	6.75	1.15	183.84	35.05	1,849
Sutherland Bayou	4.03	0.69	90.11	17.91	1,157
Clearwater Harbor North					
Cedar Creek	4.12	0.66	106.61	20.66	1,182
Coastal Subbasin	8.64	1.45	136.24	35.31	2,400
Curlew Creek	5.49	0.95	142.99	28.08	1,410
Spring Branch	6.13	1.02	181.14	33.92	1,617
Stevenson Creek	16.45	3.49	165.83	38.27	2,902
Clearwater Harbor South					
Coastal Subbasin	4.30	0.63	97.25	18.41	897
McKay Creek	4.05	0.65	115.91	21.63	1,107

- **Summary of Watershed Loading Results**

In summary, annual variation in hydrologic loads to each segment reflected annual rainfall totals for Clearwater Harbor and St. Joseph Sound and appeared to be the main determinant of TN, TP, TSS and BOD loads to the estuary. Higher annual rainfall totals resulted in greater hydrologic loading which subsequently increased TN, TP, TSS and BOD loads particularly during 1997-98 and 2003-

04. Years with lower rainfall and less hydrologic loading, 1989-90, 1993-94, 2005, and 2007, also had reduced loadings of all constituents.

Intra-annual patterns of hydrologic loading within the three segments varied seasonally as expected and were driven by higher rainfall during the wet season (June-October) and lower rainfall during the dry season (November-May). Mean monthly loads of TN, TP, TSS and BOD followed a similar pattern for all three segments.

The highest average annual hydrologic loads were observed in the Stevenson Creek and Smith Bayou sub-basins and in the Coastal sub-basin of Clearwater Harbor North. The same trend was true for nutrient loadings, suspended solids and BOD. The Anclote River sub-basin, Klosterman Bayou sub-basin and the St. Joseph Sound Coastal sub-basin contributed among the smallest loads per acre to the greater CHSJS estuary. As a percentage of the total annual average loadings, the Anclote River, Curlew Creek, Stevenson Creek, and McKay Creek sub-basins contributed the largest portion of the total loads to the CHSJS estuary.

4.1.5 Watershed Water Quality Targets and Numeric Nutrient Criteria

The Florida Department of Environmental Protection (FDEP) began development of numeric nutrient criteria (NNC) in December 2001. The FDEP formed a technical advisory committee and an agency work group to assist in identifying appropriate nutrient standards. FDEP conducted a number of workshops and meetings as well as several studies that were conducted since 2002.

In 2008, several environmental groups filed suit against the U. S. Environmental Protection Agency (EPA) in Federal Court alleging that EPA had determined in 1998 that Florida's current narrative nutrient standard did not comply with the Clean Water Act and that EPA had not established numeric nutrient standards pursuant to Section 303(c)(4)(B) of the Clean Water Act. As a consequence of this lawsuit, EPA sent FDEP a letter on January 14, 2009 finding that FDEP's narrative nutrient standard did not comply with the Clean Water Act and directing the State of Florida to develop its own numeric nutrient standards for rivers and lakes by January 2010 and estuarine and coastal waters by January 2011 or EPA would adopt its own nutrient standards. In August 2009, these groups and EPA agreed to a Consent Decree formally establishing these deadlines and EPA will be responsible for establishing these criteria.

In keeping with this Consent Decree, EPA promulgated numeric water quality criteria for nitrogen and phosphorus pollution to

> "...protect aquatic life in lakes, flowing waters, and springs within the State of Florida. These criteria apply to Florida waters that are designated as Class I or Class III waters in order to implement the State's narrative nutrient provision at Subsection 62-302-530(47)(b), Florida Administrative Code (F.A.C.), which provides that [i]n no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations on aquatic flora and fauna." (EPA, 2010a).

These criteria apply to "lakes and springs throughout Florida, and flowing waters (e.g., rivers, streams, canals, etc.) located outside of the South Florida Region" (EPA, 2010a). With regard to numeric criteria for streams and rivers, EPA concluded that a reference system approach was a "strong and scientifically sound approach for deriving numeric criteria" (EPA, 2010a), as total nitrogen and total phosphorus concentrations. In the final rule, lakes and flowing waters have been defined as "inland surface waters that have been classified as Class I (Potable Water Supply) or Class III (Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife) waterbodies pursuant to Section 62-302.400, F.A.C., which are predominantly freshwaters, excluding wetlands" (EPA, 2010a). Based on the reference system approach, EPA promulgated numeric criteria for TN and TP for freshwaters in five distinct watershed regions in Florida. These criteria, described as Instream Protection Values (IPVs), are presented in the table below. The entirety of the CHSJS area is categorized as Peninsula. "For a given waterbody, the annual geometric mean of TN or TP concentrations shall not exceed the applicable criterion concentration more than once in a three-year period."(EPA, 2010a).

Table 4-6. EPA's IPVs for Florida streams (EPA , 2010a).

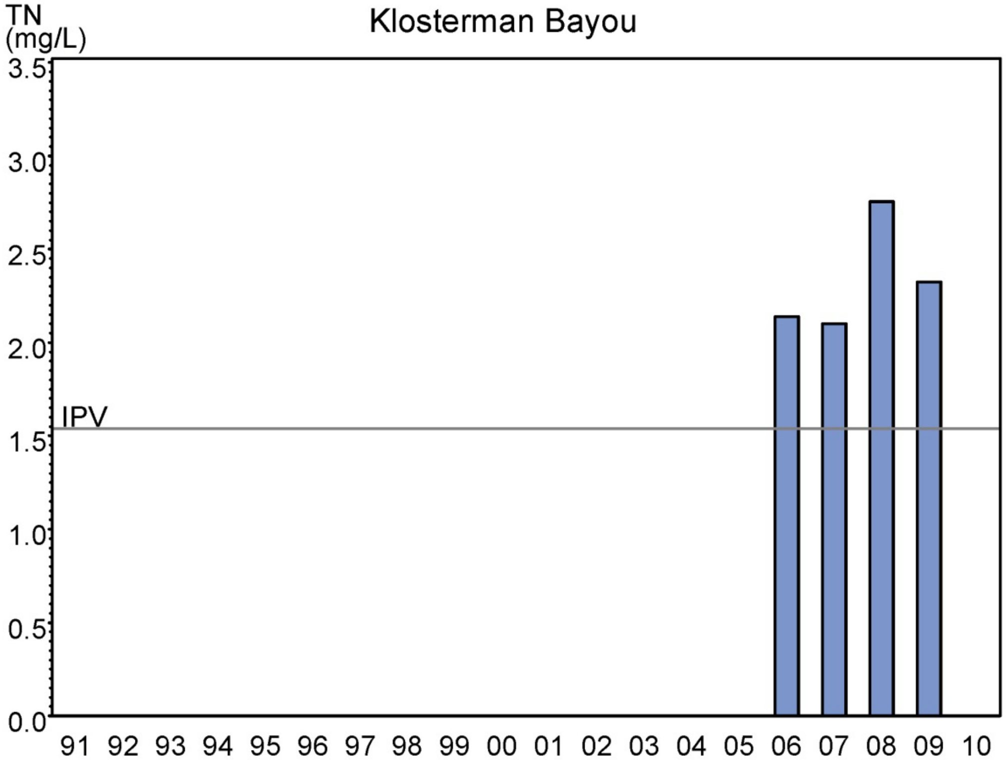
Nutrient Watershed Region	TN IPV (mg/L)	TP IPV (mg/L)
Panhandle West	0.67	0.06
Panhandle East	1.03	0.18
North Central	1.87	0.30
West Central	1.65	0.49
Peninsula	1.54	0.12

In addition to the promulgated criteria for freshwater systems, EPA established a specific procedure in the Federal rule to allow for the development of site-specific alternative criteria (SSAC). This procedure allows any entity to submit a Federal SSAC to EPA for review and a decision as to whether an adjustment to the Federal numeric criteria is "appropriate and warranted".

To better understand how the proposed IPVs compare to the ambient water quality sampling from freshwater stations in tributaries of the CHSJS area, the annual geometric mean TN and TP by tributary has been plotted, along with the appropriate IPV as a reference (Figures 4-77 through 4-85). Table 4-7 summarizes the number of years with data and the number of years with an exceedance based on the IPV.

Table 4-7. Number of years with TN or TP data and number of exceedances relative to the IPV.

	Total Nitrogen		Total Phosphorus	
Tributary	No. of Years	No. of Exceedances	No. of Years	No. of Exceedances
Klosterman Bayou	4	4	4	4
Sutherland Bayou	11	0	11	0
Smith Bayou	7	1	7	0
Curlew Creek	18	4	18	18
Cedar Creek	6	0	6	2
Spring Branch	7	1	7	7
Stevenson Creek	7	0	7	4
Rattlesnake Creek	18	16	18	18
McKay Creek	18	1	18	0



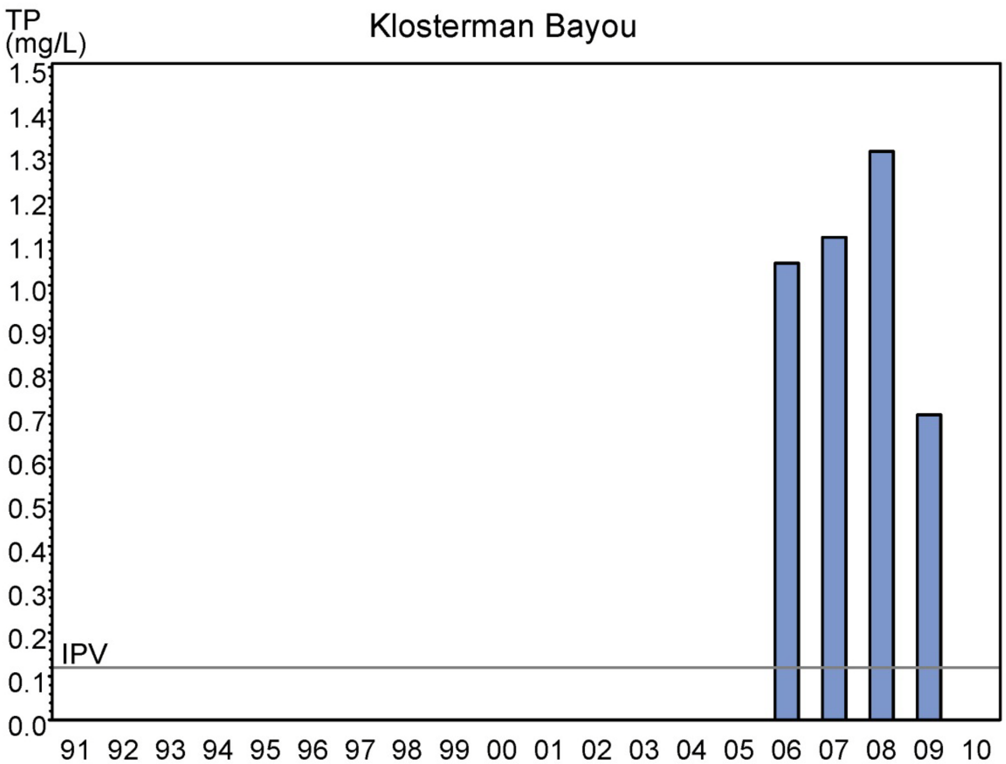


Figure 4-77. **Annual geometric mean TN (top plot) and TP (bottom plot) in Klosterman Bayou.**

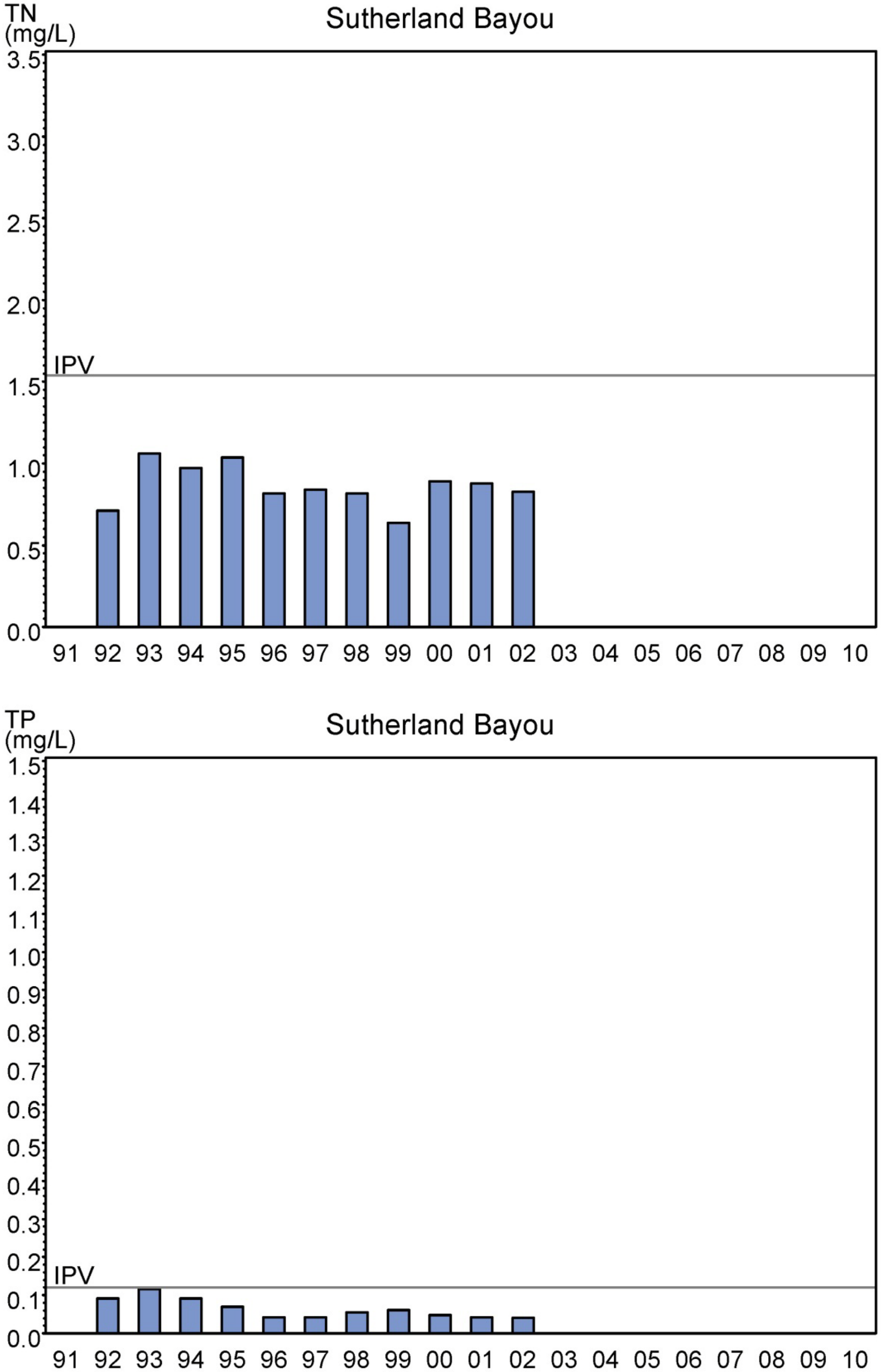
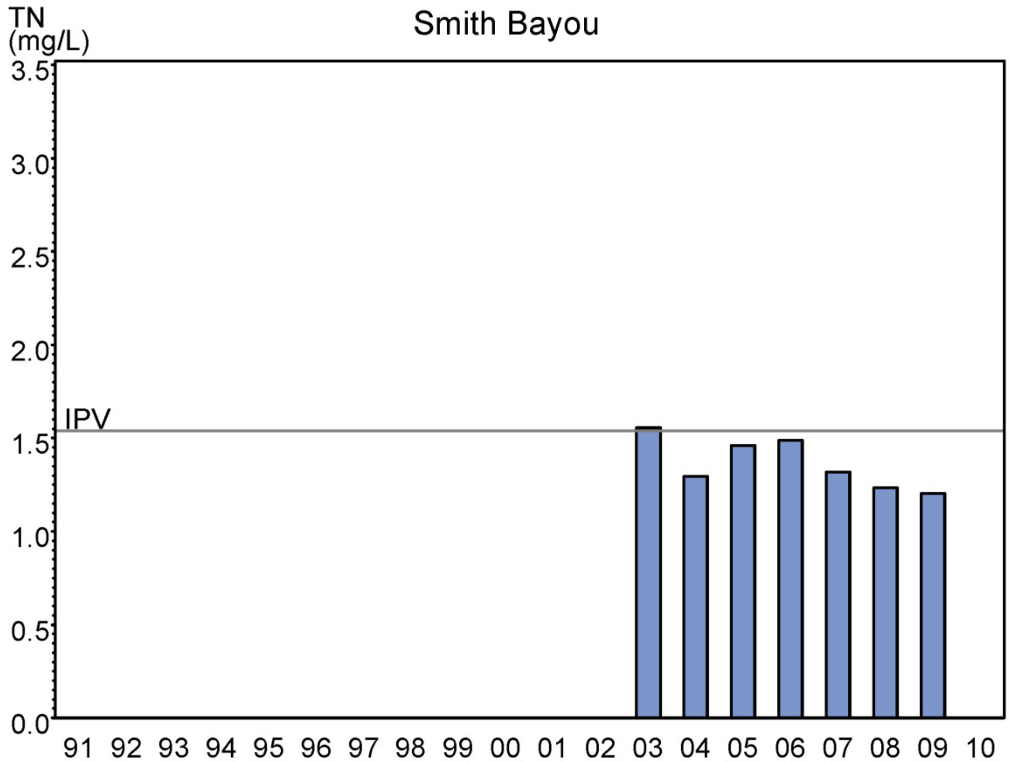


Figure 4-78. Annual geometric mean TN (top plot) and TP (bottom plot) in Sutherland Bayou.



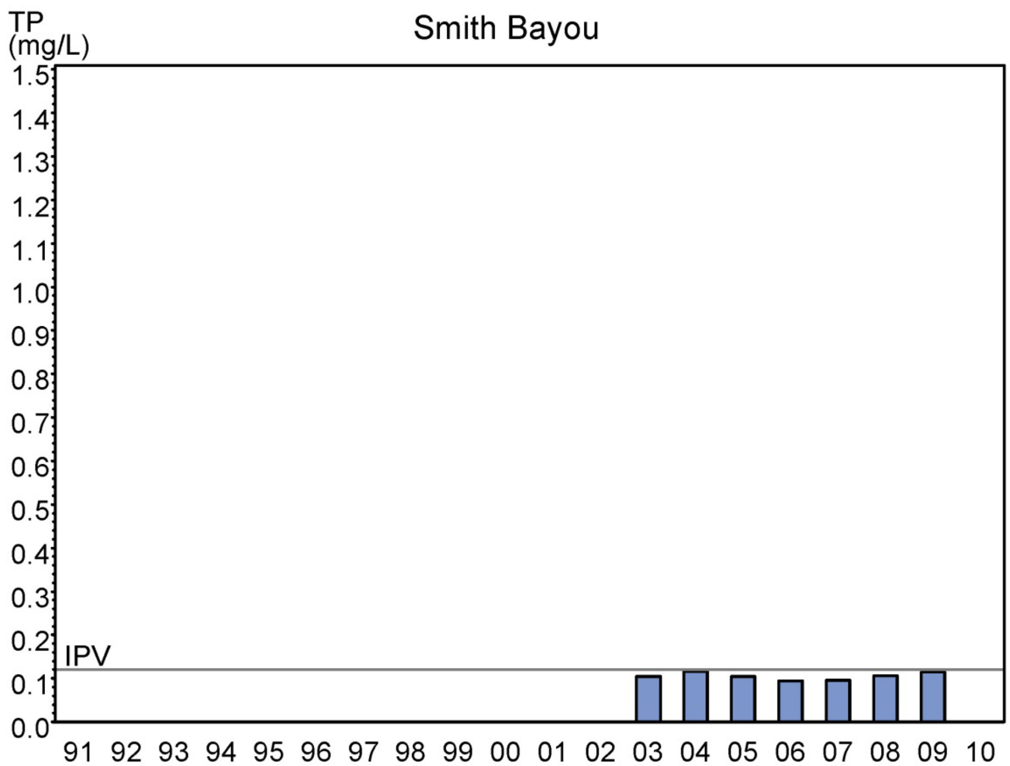


Figure 4-79. Annual geometric mean TN (top plot) and TP (bottom plot) in Smith Bayou.

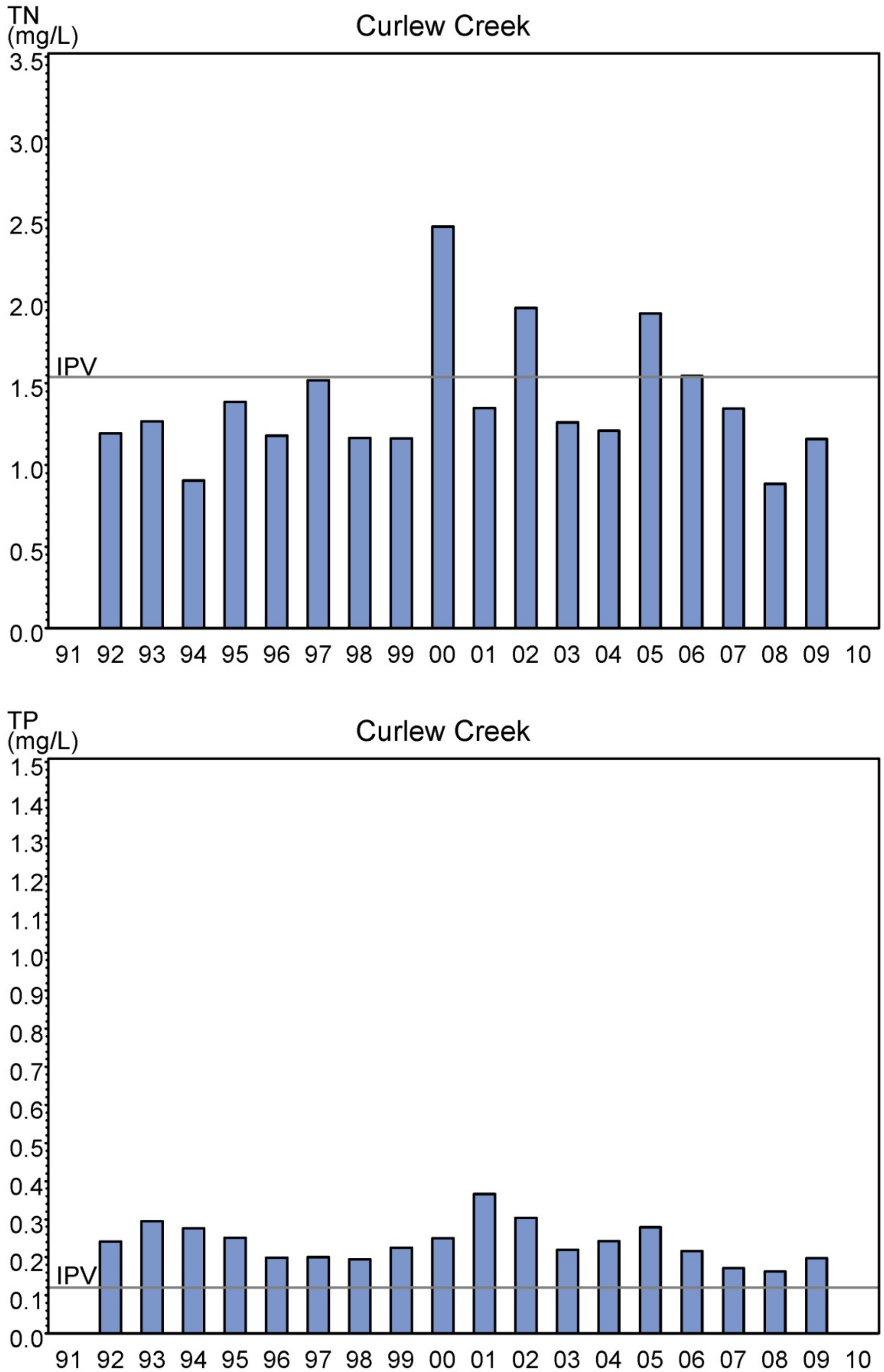


Figure 4-80. **Annual geometric mean TN (top plot) and TP (bottom plot) in Curlew Creek.**

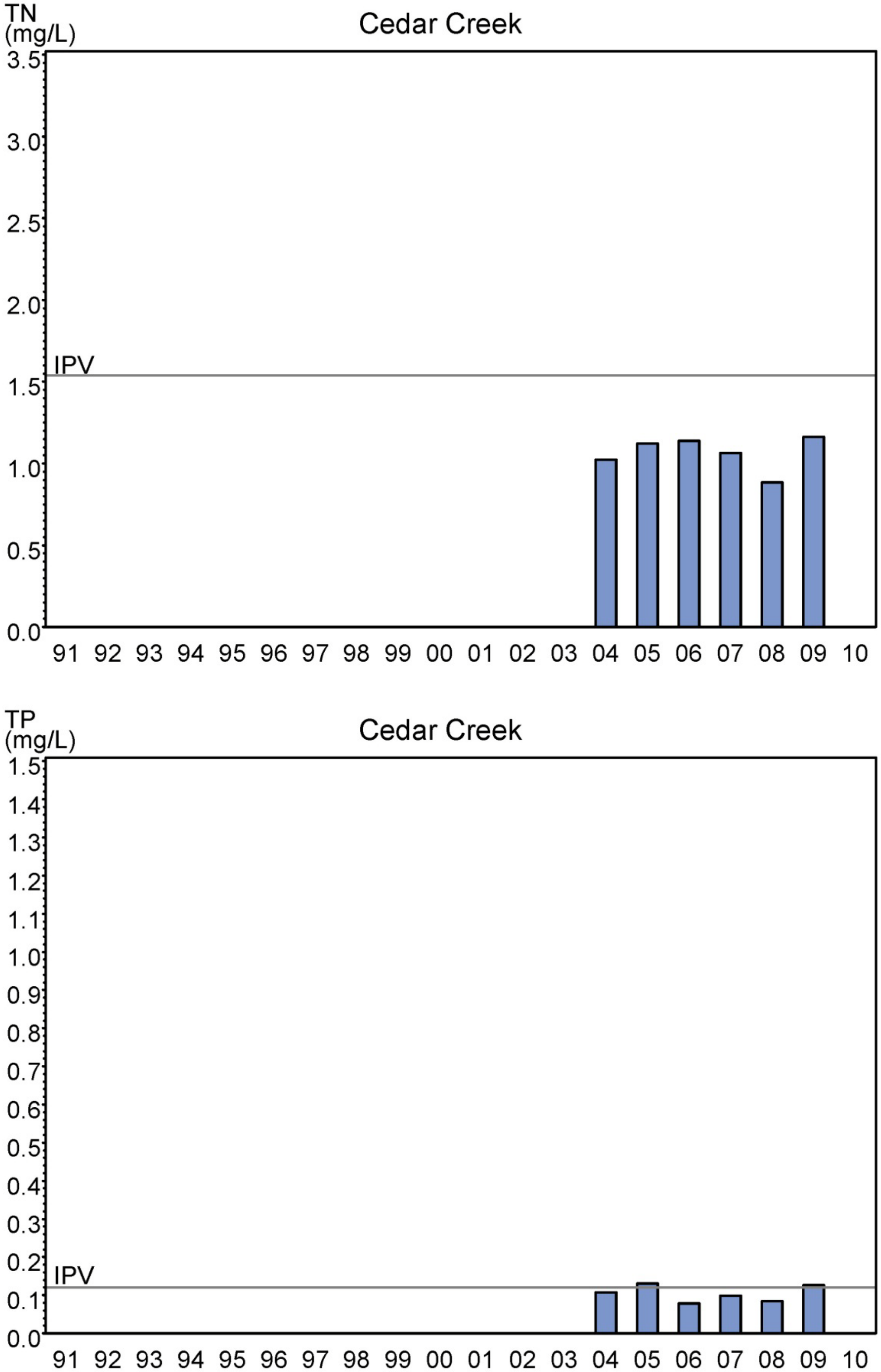


Figure 4-81. Annual geometric mean TN (top plot) and TP (bottom plot) in Cedar Creek.

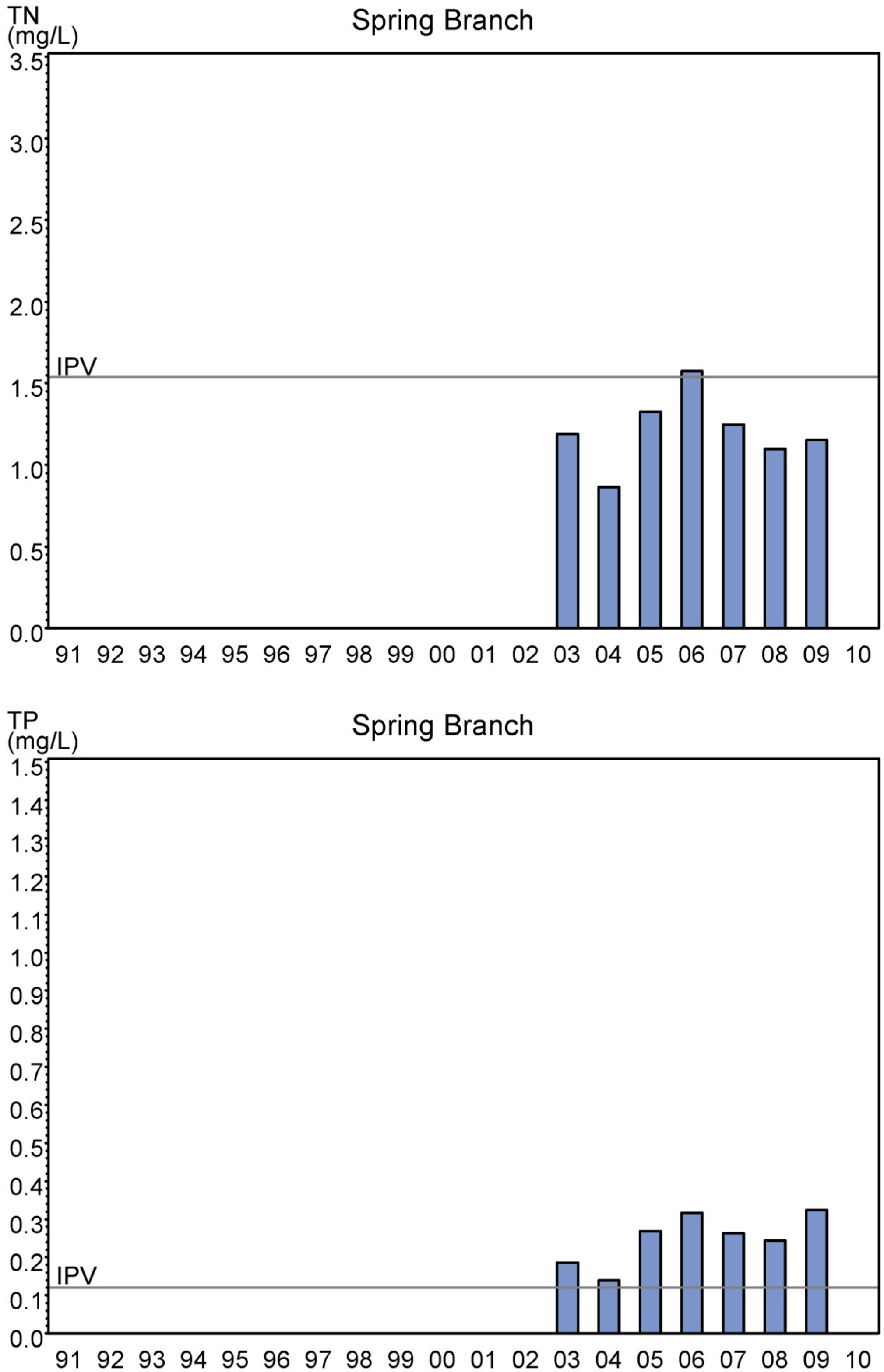


Figure 4-82. Annual geometric mean TN (top plot) and TP (bottom plot) in Spring Branch.

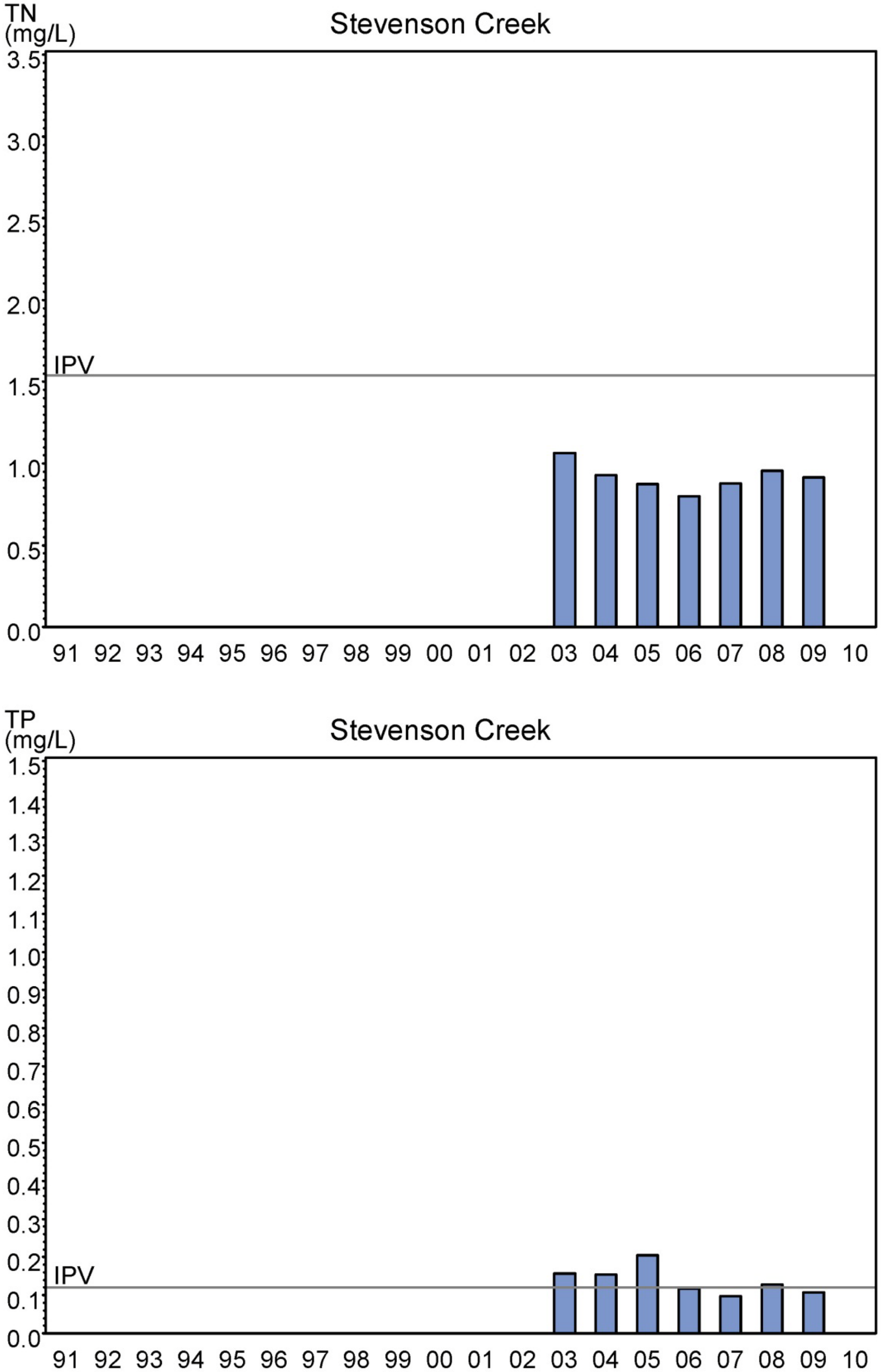


Figure 4-83. Annual geometric mean TN (top plot) and TP (bottom plot) in Stevenson Creek.

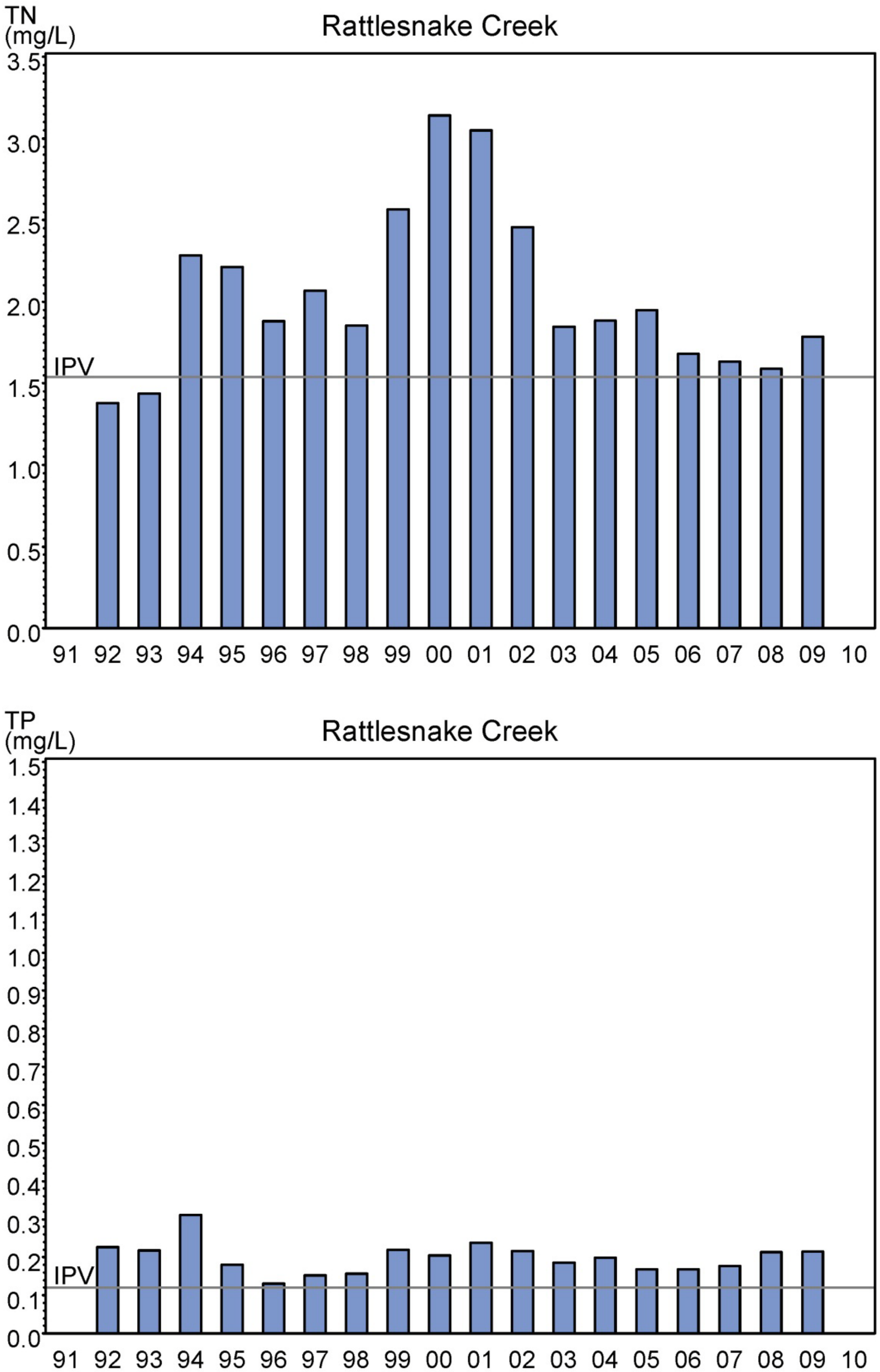
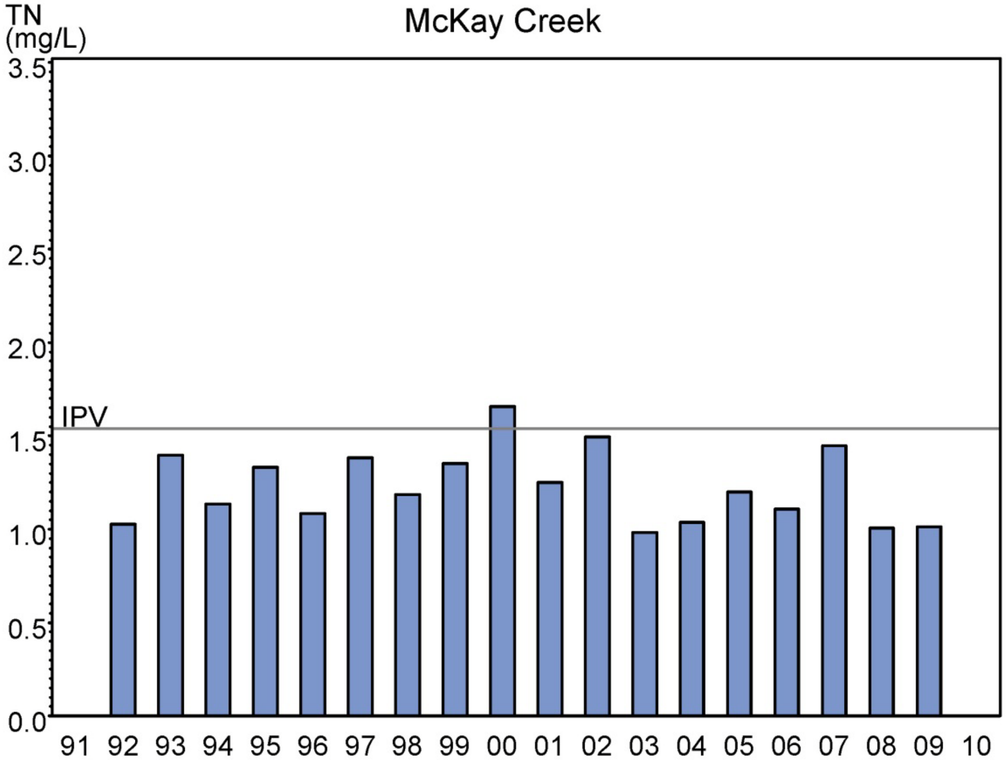


Figure 4-84. **Annual geometric mean TN (top plot) and TP (bottom plot) in Rattlesnake Creek.**



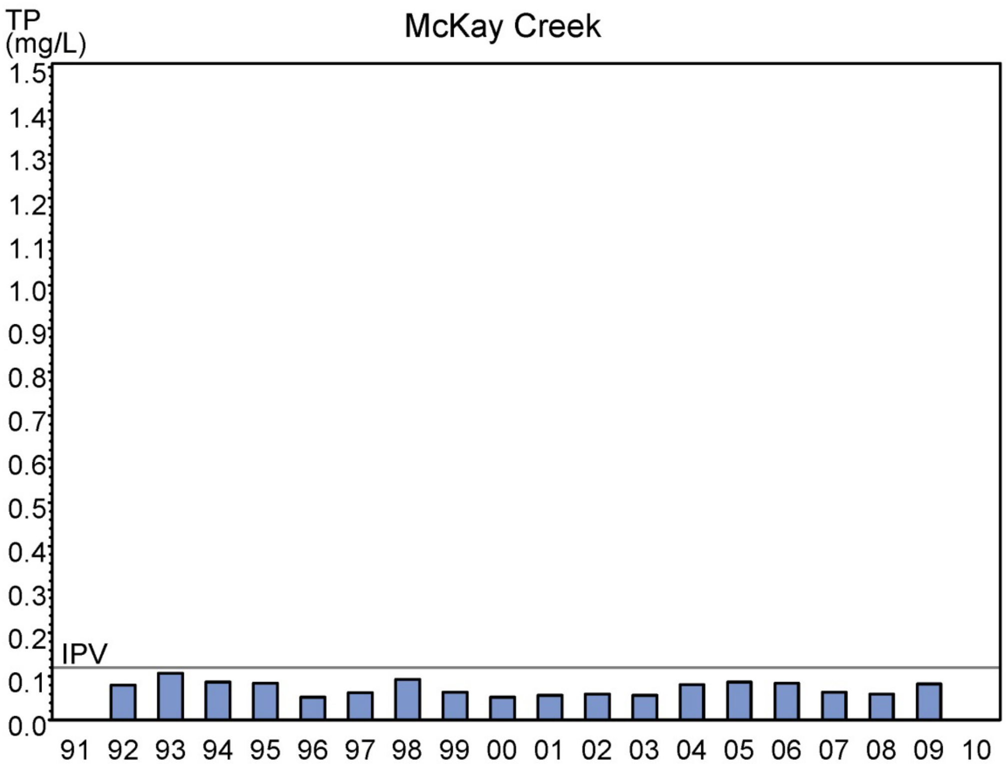


Figure 4-85. **Annual geometric mean TN (top plot) and TP (bottom plot) in McKay Creek.**

In addition to establishing criteria for freshwater systems in Florida, EPA will develop numeric criteria for estuarine and tidally-influenced systems as well. Downstream Protection Values (DPVs) are defined by EPA as those water quality criteria in flowing waters that ensure protection of designated uses in the downstream estuarine waters as required by the Clean Water Act under 40 CFR 131.10(b). EPA previously proposed TN DPVs based on protective estuarine TN loads, with the DPVs being expressed as TN concentrations in the upstream reaches (EPA, 2010b). However, as noted in the March 17, 2010 letter from Peter Silva, EPA Assistant Administrator:

> "…the Agency has decided to delay finalizing promulgation of the "downstream protection values," or DPVs with respect to downstream estuary protection and to address this issue in the 2011 estuary and coastal rulemaking."

For purposes of DPV development, the tributaries have been divided into two sections, the terminal reach and the upstream reach. The terminal reach connects the upstream, freshwater section of the tributary to the downstream estuary. The upstream reach of the tributary is the freshwater portion of the tributary that drains the upstream watershed and connects to the terminal reach. The point where the terminal reach enters the estuary is referred to as the "pour point" (i.e., the point where the terminal reach of the tributary "pours" into the estuary). As discussed by Hagy (2010), "the EPA is considering approaches for developing criteria for all locations in a watershed, including the "pour point" (i.e., where water enters the estuary), and the upstream locations. As part of this approach, EPA is considering approaches that would account for retention and/or loss of TN and TP within the stream network."

As stated in EPA (2010b):

> "The DPV criteria will be computed such that the TN and TP discharged from a stream, after accounting for any expected losses during transport, will not contribute a disproportionate fraction of the maximum TN or TP loading protective of water quality standards in the estuarine receiving water. The proportionate fraction will be based on the fraction of total freshwater flow contributed by the reach."

The protective TN and TP loads are defined as those TN and TP loads from the watershed that are "needed to support balanced natural populations of aquatic flora and fauna in estuarine waters" (EPA, 2010b). For the terminal reach of tributaries in Florida, EPA is proposing to divide these protective loads by the average flow entering the estuary to arrive at terminal reach DPVs expressed as TN and TP concentrations (Figure 4-86). Further, DPVs can be developed for the upstream reaches by taking into account the loss or retention of nutrients in the stream network due to a series of physical, chemical, and biological processes. As discussed in Hagy (2010), EPA is considering a different approach for south Florida due to the highly altered and controlled canal systems in south Florida. For south Florida EPA is considering expressing DPVs as loading limits as opposed to concentrations. Also, in south Florida, EPA may choose to apply DPVs exclusively to terminal reaches, instead of the entire system.

The equation suggested by EPA (2010b) to calculate terminal reach DPVs is the following:

$$\bar{C}_T = \frac{\bar{L}}{\bar{Q}}$$

where: $\bar{C}_T$ = average concentration specified as the terminal reach DPV,
$\bar{L}$ = the average loading rate that is protective of the designated uses in the receiving waterbody (i.e., the estuary or segment), and
$\bar{Q}$ = the average freshwater inflow to the receiving waterbody.

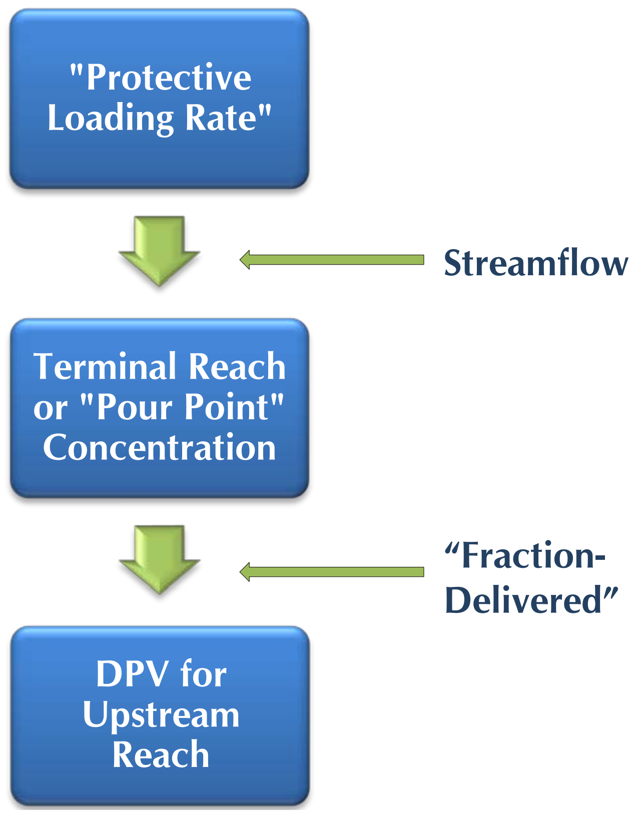


Figure 4-86. Major steps involved in development of numeric nutrient criteria for TN and TP in streams and rivers protective of water quality in downstream estuaries (from Hagy 2010).

These DPVs are expressed as concentrations from the terminal reaches, or "pour point" concentrations, that are protective of the designated uses in the downstream estuarine receiving waters. Because of this fact, the protective load ($\bar{L}$) is the loading from the ***watershed only*** and therefore does not include loads that are discharged or fall directly on the surface of the downstream estuary. Therefore, the loads which are not included in the watershed loads consists of dry and wet atmospheric deposition to the surface of the estuary, point sources that discharge directly to the estuary, and groundwater that discharges directly into the estuary. Similarly, the average freshwater inflows ($\bar{Q}$) consist of the freshwater inflows from the watershed, which excludes rainfall, point source, and groundwater discharges directly to the estuary.

EPA's proposed approach based on the calculation of $\bar{C}_T$ may have some shortcomings. In cases where multiple tributaries deliver loads to the estuarine waterbody, this approach assumes that all terminal reaches would have the same DPV. Clearly, factors other than anthropogenic factors can influence nutrient concentrations in stream channels. The result could be that while the downstream waterbody is meeting its criterion, an exceedance could still be manifest in one or more terminal reaches.

While it is difficult to propose that the quality (i.e., nutrient concentrations) of the water entering an estuary is not an important determinant of the estuarine water quality, it is also difficult to conclude that a stream is impaired when its DPV is exceeded while the downstream estuary is meeting its designated uses. Therefore, either acceptance of, or recommendation for, DPVs should necessarily reference an appropriate implementation strategy that ensures proper inference of any impairment when the downstream estuary is meeting its designated uses.

Specific recommendations for appropriate water quality targets for waterbodies within the CHSJS watershed depend upon the definition of critical environmental response variables and quantitative endpoints that achieve the designated uses in the CHSJS estuary. Seagrasses are being proposed as a key indicator of estuarine health and are examined in detail in Chapter 5, as well as the ambient water quality observed in the CHSJS estuary. Recommendations for water quality within the CHSJS watershed and watershed loading that are protective of seagrasses in the CHSJS are presented in Chapter 5.

4.2 Watershed Land Cover Change Analysis

The conversion of natural lands to development in the CHSJS includes the loss of native uplands and wetland habitats has altered hydrology and natural drainage patterns, increased surface water runoff, reduced surface water infiltration rates, and ultimately reduced the ecological value of the landscape. Agricultural lands appear to be the principal land use development in the watershed prior to 1942. These agricultural practices altered the natural hydrology in the CHSJS. Agricultural lands have since been converted to urban lands, principally residential and commercial development. Increased urbanization has resulted in increased impervious surface (roads, parking lots, buildings etc.) that in turn is associated with adverse impacts to surface water hydrology, including reduced stream stability, habitat, water quality, and biological diversity.

A 135 % increase in the population in Pinellas County between 1950 and 1960 was the largest increase ever recorded in the County and was followed by commensurate increases in residential development (Pinellas County, 2008). By 1970, dredge and fill activities for waterfront development had increased the area of the County by 4,800 acres and environmental impacts due to land development activities led to the establishment of regulatory agencies in the early 1970s. During this same period, portions of northeastern Pinellas County and northwestern Hillsborough County were leased for wellfield development in response to saltwater intrusion into local water supplies. In 1975, the Local Government Comprehensive Planning Act was enacted by the Florida Legislature, and in the late 1970s, Pinellas County began identifying environmentally-significant lands with the intent of "adopting the necessary and appropriate regulatory land use designations to preserve their environmental significance" (Pinellas County, 2008). Development, primarily for residential land uses, has replaced much of the native wetlands and uplands habitat in the St. Joseph Sound, Clearwater Harbor North, and Clearwater Harbor South watersheds and natural areas are now limited primarily to the northeast portion of the St. Joseph Sound watershed and managed environmental lands though the CHSJS .

This section of the report presents an analysis of the changes and trends in wetlands and uplands in the St. Joseph Sound, Clearwater Harbor North, and Clearwater Harbor South watersheds based on historical and present-day aerial photography. Specifically, the following discussion includes:

- Descriptions of the critical natural habitats within the CHSJS watershed,
- Potential impacts of habitat loss on fish and wildlife,
- Identification of stressors to wetland habitats,
- An analysis of land use and habitat changes in the CHSJS watershed, and
- Habitat management goals for the CHSJS watershed.

4.2.1 Critical Habitats within the CHSJS Watershed

Native uplands and wetland habitats are critical habitat within the CHSJS watersheds and are a major focus of the CCMP. The following sections describe the habitats present in the CHSJS, the general ecological function of these habitats, an analysis of changes in these habitats over time, and the proposed goals and targets established to protect and restore the balance of the habitats within the CHSJS. The sections immediately following describe the general ecological function of the various habitat types present in the CHSJS.

Native Uplands

Native uplands provide habitat for larger wildlife such as white-tailed deer and wild turkey. Threatened or endangered species in upland communities in Pinellas County include the gopher tortoise, the eastern indigo snake, and the gopher frog. The southern bald eagle and the osprey may also occasionally nest in the tall trees of this community. Uplands throughout the CHSJS watershed were historically dominated by pine flatwoods ("Pinellas" County is a derivation of the Spanish "Point of Pines"). Pine flatwoods are generally characterized by an open canopy of slash pine (*Pinus elliottii*) and an under story of saw palmetto (*Serenoa repens*), staggerbush (*Lyonia* spp.), wax myrtle (*Myrica cerifera*), gallberry (*Ilex glabra*), and wire grass (*Aristida stricta*). In the absence of a natural fire regime, pine flatwoods are replaced by hardwood species. Common hardwood species in Pinellas County include live oak (*Quercus virginiana*), turkey oak (*Q. laevis*), persimmon (*Diospyros virginiana*) that may occur in the more xeric or dryer locations, while sweetbay (*Magnolia virginiana*), wild olive (*Osmanthus americanus*), pignut hickory (*Carya glabra*), sweetgum (*Liquidambar styraciflua*), and ironwood (*Carpinus caroliniana*) are typical of wetter locations.

Uplands continue to provide opportunities for development in Florida, unlike wetlands that are often purchased for public ownership or protected by regulation since the 1970s. Uplands have been converted to agricultural uses and, more recently, agriculture has transitioned to urban development. Agricultural areas persist in the northeastern portion of the County and may provide opportunities for preservation of open space.

Wetlands

Wetlands may be seasonally, semi-permanently, or permanently flooded and may be forested or characterized by emergent and submersed aquatic vegetation. However, marshes are inundated more frequently and for longer periods of time when compared with forested systems. Wetlands may be isolated or follow the edges of rivers, streams, and other bodies of water that convey water, nutrients, and sediments downstream to the estuary. Large fluxes of energy and material in these systems produce distinct vegetation and soil characteristics as well as a rich diversity of plant and animal species. The productivity of freshwater wetlands is a function of the ecological characteristics of the waterbody, often a river or stream that flows along and/or through it. Wetlands are important as foraging and breeding habitat for many species of mammals, amphibians, reptiles, and resident birds, as well as wintering areas and stopover habitats for migratory birds. Insects of freshwater marshes provide the freshwater source for salt marsh birds and their young. Wetlands, under appropriate conditions, can improve water quality by reducing sediment and nutrient inputs into coastal waters via physical filtration and as a substrate for microbial decomposition and immobilization. Wetlands are also important in stabilizing river and stream banks and providing flood protection.

Classical estuarine ecology (Figure 4-87) generally assigns four salinity habitats from the non-tidal upstream freshwater reaches of a river or stream to the estuary (Odum et al., 1984). During periods of very low flow (droughts) or storm events, brackish (low salinity) conditions often extend well inland (until elevations reach sea level) into what might otherwise be considered "tidal freshwater" habitat. Conversely, during periods of very high flow, plumes of lower salinity water often extend well offshore of the estuary mouth. For example, the venerable Venice System of salinity classification (Venice System, 1959) delineates riverine/estuarine systems into classes based on salinity in parts per thousand (ppt): oligohaline (0.5 to 5 ppt), mesohaline (5 to 18 ppt), polyhaline (18 to 30 ppt) and euhaline (30 to 40 ppt) habitats.

Vegetation distributions along a river are generally limited by salinity at the downstream river reaches and by other factors upstream. Upstream of the influence of salinity, the composition and distribution of species are due primarily to depth and duration of flooding, which are in turn influenced primarily by land surface elevations and river flows. Both natural and anthropogenic changes in river flows alter the types and amount of aquatic habitats, which in turn results in changes to biotic communities (Gorman and Kar, 1978; Baker et al., 1991; Light et al., 2002).

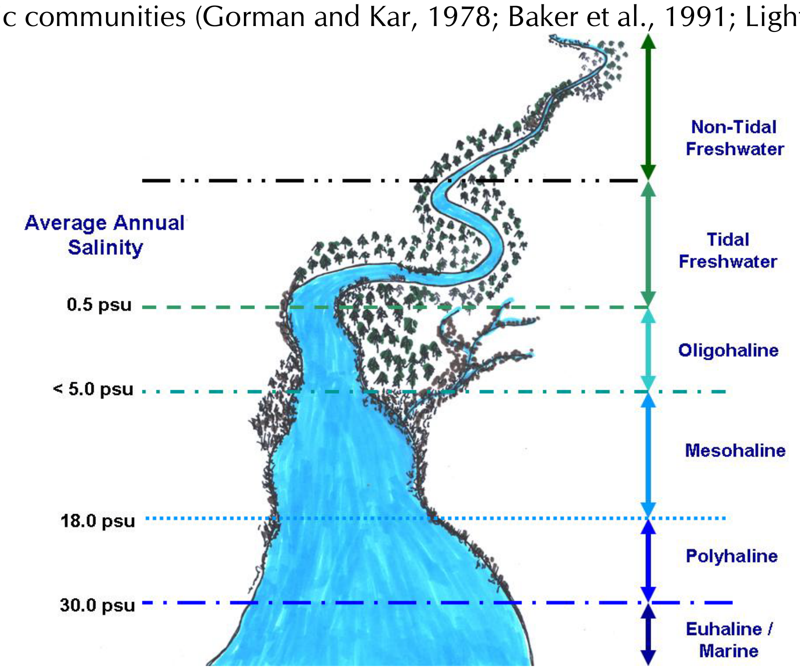


Figure 4-87. Illustration of Venice salinity gradient along an upstream to downstream river gradient (after Odum et al., 1984).

Forested Freshwater Wetlands –Bottomland hardwood forests are the dominant freshwater wetland type in the southeastern U.S. There are few remaining bottomland hardwood forests left within the CHSJS study area though remnant tracts remain along the Anclote River, Curlew Creek, Cedar Creek, Spring Branch, and Stevenson Creek (Figure 4-88).

Forested freshwater wetlands (swamps), unlike mangrove swamps, are not associated with the estuarine portions of the watershed because of the freshwater species' intolerance to salt water for more than short periods of time, such as storm surges or drought. Some tree species, such as cabbage palms (*Sabal palmetto*) and cedars (*Juniperus virginiana*), can tolerate low salinities and often form the downstream-most edge of forested wetlands along rivers.

Cypress swamps and bottomland hardwoods typically correspond with the upstream extent of tidal salt water influence along rivers and creeks or isolated depressions where ground water is relatively close to the land surface. Wetland hardwood species include, for example, red maple (*Acer rubrum*), water hickory (*Carya aquatica*), and water oak (*Quercus nigra*). Cypress sloughs and river corridors with flowing waters may have more bald cypress (*Taxodium distichum*), while isolated cypress domes are typically dominated by pond cypress (*T. ascendens*). Isolated cypress domes are scattered throughout the watershed and, like other wetlands, are limited in their distribution by upland plants that are better able to compete for resources under drier conditions.

Cypress trees are the most tolerant of inundation and cypress swamps are characterized by up to 10 months of inundation at depths of one meter or more (Light et al., 2002; Wharton et al., 1982; Cowardin et al., 1979). Much of the distribution of cypress can be attributed to seedling intolerance of submergence (Souther and Shaffer. 2000; McCarron et al., 1998; Huenneke and Sharitz, 1986; Perry and Williams, 1986). Experiments with cypress trees have shown that a mature tree can survive permanent inundation of up to three meters following adequate establishment (Harms et al. 1980). Wetland mixed forests, as their name implies, typically include a mix of both hardwoods and cypress.

Non-forested Wetlands (Herbaceous Marshes) - Non-forested wetlands may be characterized by either fresh or salt water conditions and typically occur along a salinity gradient (Figure 4-87). Salt marshes just inland of coastal wetlands are limited to saline conditions that preclude colonization by freshwater plant species and in southwest Florida are dominated by black rush (*Juncus roemerianus*) marshes and give way to low salinity and freshwater marshes at the salt/freshwater interface. The lower salinity oligohaline marshes occur upstream of the salt marshes and downstream of the freshwater marshes and include bulrushes (*Schoenoplectus* spp, formerly *Scirpus* spp.), sawgrass (*Cladium jamaicense*), and narrow stem cattails (*Typha angustifolia*).

Black rush has a wide salinity range and may occur from 0 ppt to seawater. Freshwater marshes may be tidal or nontidal, but are restricted to soil water salinities of $<$ 0.5 ppt except for short duration events such as storm surges or short droughts. Marshes are generally semi-permanent to permanently flooded and characterized by herbaceous species such as maidencane (*Panicum hemitomon*), duck potato (*Sagittaria* spp.), pickerel weed (*Pontederia cordata*), and yellow water lilies (*Nymphaea odorata*). Freshwater marshes are replaced by riparian wetland forests upstream of the salt water interface and where inundation does not preclude their germination. Along the Anclote River, forested wetlands are prevalent upstream of the marshes except where interrupted by development.

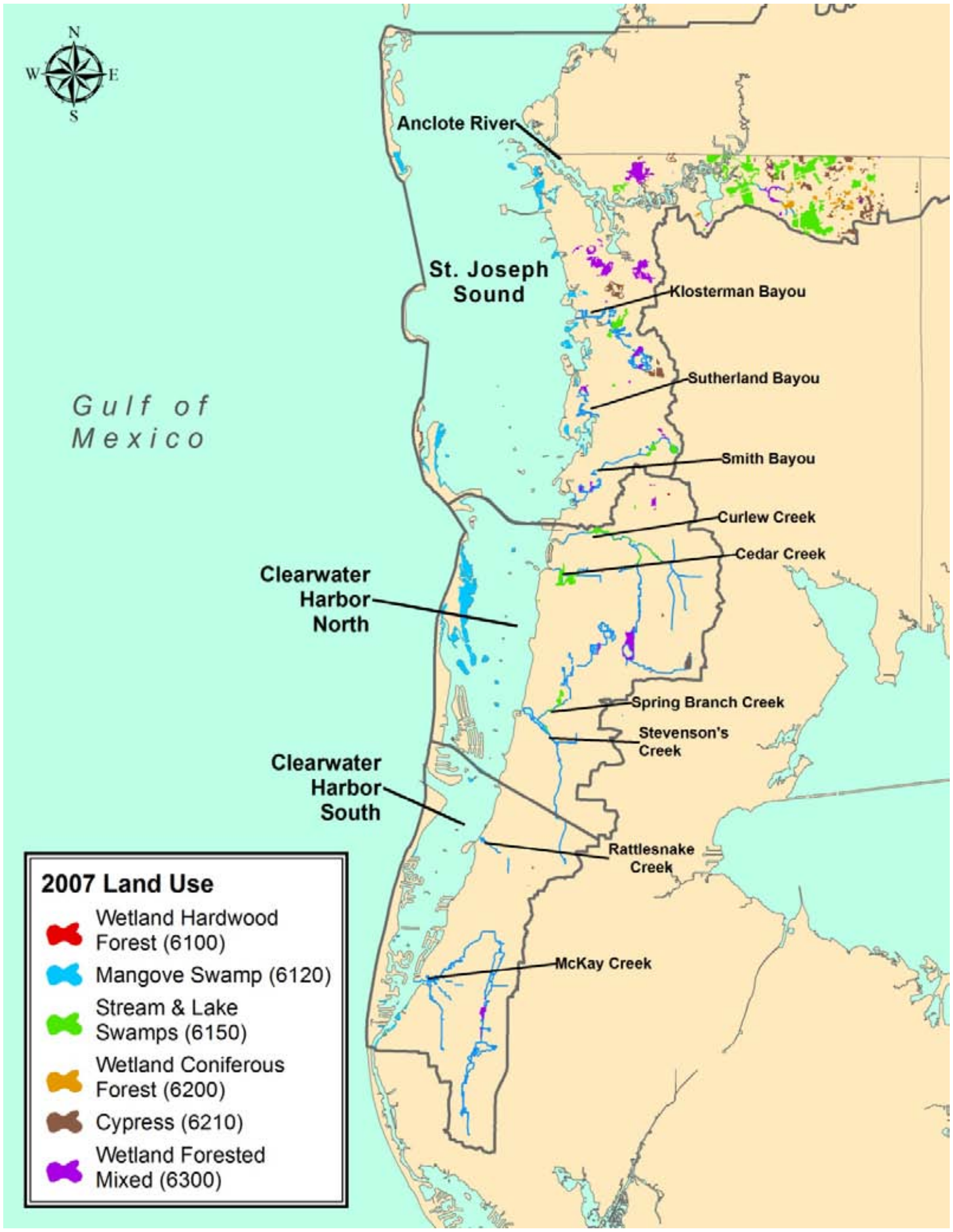


Figure 4-88. Wetland forests remaining in the CHSJS based on 2007 SWFWMD land use.

Freshwater marsh vegetation is intolerant of persistently higher salinities, although vegetation is generally not affected by shorter duration storm surge or drought. Freshwater tidal marshes typically extend downstream along a river or stream until salt water (> 0.5 ppt) is encountered. The plant species assemblage is much more diverse in freshwater tidal marshes when compared with salt marshes and vegetation zonation is not as conspicuous due to the greater number of species and the relatively random distribution of the species. Plant community structure is seasonally and spatially diverse and reflects the dynamics of energy and biomass processing that result from high productivity, rapid decomposition, and seasonal nutrient cycling that occur in the freshwater tidal marshes.

4.2.2 Losses of Freshwater Wetlands

Highly urbanized portions of Pinellas County experienced greater development compared with the interior and the northeastern portion of the watershed. The coastal development resulted in losses of wetlands and associated gains in open water and uplands, typically due to ditching and draining prior to wetlands regulations of the 1970s and 1980s. Wetlands losses were smaller in the northeastern portion of Pinellas County when compared with the southern portion of the County. The loss of freshwater wetlands county-wide was 86%, compared with a 59% loss of forested freshwater wetlands.

Approximately 86% of the freshwater herbaceous wetlands in Pinellas County have been eliminated or converted to open water and 56% of the forested freshwater wetlands were either eliminated, converted to open water or to freshwater herbaceous wetlands (Fetterman 2007). Wetland losses due to ditching and draining were primarily a result of conversions to citrus, row crop and improved pasture in the absence of wetlands regulations. Agricultural development has been one of the primary causes cited for wetland loss, both in the southeast (Heffner at al. 1994) and throughout the United States (Dahl et al. 1990, 2000). The only increases in habitat were for mangroves (23%) and open water (63%), largely attributable to salt water intrusion and mosquito ditching of salt marsh and saltern habitat.

The streams and creeks along the estuarine/watershed interface of the CH/SJS study areas historically discharged freshwater to the estuaries and were characterized by freshwater marshes in their upper reaches. However, coastal development, including water control structures, has altered surface water flows and most of the native vegetation associated with these waterbodies has been replaced by urban development and disturbance-associated plant species. Isolated stands of salt-tolerant mangroves and salt marshes remain scattered along the coast.

The creeks and streams in the Clearwater Harbor watershed are almost completely developed and are characterized by invasive and/or non-native plant species rather than native marsh species. For example, cattails and *Phragmites* are typical species along the waterward sides of seawalls in creeks such as McKay and Church Creeks in Clearwater Harbor South watershed. Brazilian pepper is a significant problem along many of the waterbodies in the Clearwater Harbor and St. Joseph Sound watersheds. Channelization of creeks and the subsequent spoil deposition along the sides has replaced former marshes with berms dominated by upland species such as cabbage palm. Isolated areas of native sawgrass have become established water-ward of some seawalls, along low salinity reaches of Stevenson Creek.

In contrast with the loss of tidal marshes in the Clearwater Harbor and the southern portions of St. Joseph Sound, the Anclote River in northern portion of the St. Joseph Sound watershed is characterized by an extensive tidal marsh system upstream of the town of Tarpon Springs and U.S. Alternate 19 (3.4 miles upstream of the river mouth). At Tarpon Springs, the river shoreline is hardened and developed. However, upstream of U.S. Alternate 19, the river is characterized by large expanses of tidal marshes and the tidal influence of the river extends another 10 miles. Along the river length, salinities range from near-seawater concentrations of 20 to 35 ppt at the river mouth to low salinity ($<$ 5 ppt) at river mile 10 to freshwater ($<$ 0.5 ppt) approximately 12 miles upstream from the mouth.

Vegetation communities range from mangroves at the river mouth, to tidal saltwater and then freshwater marshes upstream. Beyond most tidal and salinity effects, forested wetlands become predominant. To protect the instream and floodplain habitats along the Anclote River, SWFWMD has established minimum flows and levels (MFLs) for the river (Heyl et al., 2010). The MFLs for the Anclote River is based on the hydrologic requirements for the specific biotic assemblages associated with instream and floodplain habitats and addresses other ecological functions of the river system that are more difficult to quantify, such as organic matter transport and the maintenance of river channel geomorphology. The MFL specifically addresses fish passage and fish access to floodplain habitat along the river.

4.2.3 Impacts of Wetlands Loss on Fish and Wildlife

Excessive changes to natural flow regimes can degrade a river ecosystem and compromise its integrity, reducing the high biodiversity characteristic of these systems (Postel and Carpenter, 1997; IUCN, 2000; after Richter et al., 2001). Populations of native species adapted to particular characteristics of natural variability - such as fish that require floods for access to floodplain spawning areas - are lost. Reductions in both the frequency and duration of water levels in riverine wetlands may initiate similar events via associated food webs and biotic community structure and function (Poff et al., 1997; Power et al., 1995).

While fish are probably the most conspicuous group of organisms dependent upon river flows and wetlands, nearly 70% of all vertebrate species rely on riparian wetlands and buffers (Wharton et al., 1982). The floodplain wetlands are important for detrital production and transport, and are the primary sites of aquatic secondary production. The lower portions of the upper floodplain provide larger amounts of forage foods than more inundated zones that lack either nut-bearing hardwoods or berries and seed plants. Finally, the near upland areas of floodplains support the greatest faunal diversity (Wharton et al., 1982).

4.2.4 Stressors to Native Lands

Native lands are stressed by several factors, some natural and many anthropogenic. Different land types have different types of both natural and anthropogenic stressors. For example, water quality and water withdrawal impacts are generally more conspicuous in isolated wetlands and lakes on the mainland when compared with direct coastal runoff. A list of identified stressors to critical land habitats including native uplands and wetlands is provided in the bulleted list below. All of these stressors influenced the critical historical native habitats of the CHSJS watershed.

- Agricultural practices in the CHSJS area have altered hydrology and drained wetlands throughout this area. The conversion of undeveloped lands to agricultural land uses can increase annual flow, base flow, and runoff as a result of irrigation.
- Dredge and fill for development and water supply (e.g., urban development and agriculture). These stressors have resulted in direct loss of historic wetlands and associated habitat. Wetlands and their interaction with ground water play a pivotal role in the protection of water resources of Florida.
- Increased impervious surface as a result of development results in a disproportionate loss of native upland habitats and is associated with adverse stream impacts, including reduced stream stability, habitat, water quality, and biological diversity. Conversion to developed land uses often include loss of native uplands, filled wetlands, and channeled streams.

Additionally, assimilation of anthropogenically-derived nutrients is reduced as wetland acreage is reduced.

- Altered flows and hydrology may alter or eliminate wetlands by draining or diverting flows form wetlands. Reduced flows can increase salinities, reduce the amount of submersed vegetated or woody "snag" habitat, affect fish access to feeding, spawning, or other habitat, and result in direct physical loss of wetlands.
- Fragmentation of a wetland from a contiguous wetland complex. This stressor eliminates travel corridors between habitats (e.g. from one stream to another) and may prevent wildlife that breed, nest, or feed in different areas (e.g. amphibians, reptiles, and birds) from traveling to and from these areas, or eliminate wildlife corridors for larger mammals such as coyotes and bears.
- Point source and nonpoint source pollution. Wastewater treatment facilities have traditionally been a significant source of pollution to waterbodies. Increased control over point source discharges has shifted the focus to non-point source pollution, its effects on the environment, and its control. In Pinellas County, stormwater drains flow directly into streams, lakes, and the Gulf of Mexico. Pollutants degrade water quality and result in commensurate adverse impacts to fish and wildlife and their habitat. Increased nutrients and sediments into lakes may require expensive restoration actions.
- Groundwater withdrawals for public water supply and agriculture continue to be an important component to restoration planning. The expansion of urbanization increases demands on the development of potable supplies, which typically are provided by either ground water and/or surface water withdrawals. Depending on the underlying geology, in areas without distinct confining layers between the surficial and deep aquifers, ground water withdrawals have caused localized reductions in both lake and wetland levels. Surface water withdrawals from lakes, reservoirs and streams have reduced water levels and available aquatic habitat, altered natural hydroperiods, and seasonally altered the salinity gradient of tidal creeks.
- Climate change is a long-term stressor. Changes in sea level, temperature and rainfall patterns will stress native uplands and wetland habitats in the CHSJS watershed. Allowing buffers for these natural systems to adapt to long term changes associated with climate change also continues to be an important component to long-term watershed management planning.

4.2.5 Data Description and Analyses

Land use data were used to quantify trends and changes in land uses wetlands and uplands since 1942 for the St. Joseph Sound, Clearwater Harbor North, and Clearwater Harbor South watersheds. Recent trends were measured using the SWFWMD land use data from 1995, 1999, 2004, 2005, 2006, and 2007 (SWFWMD 1995, 1999, 2004, 2005, 2006, and 2007). Geographic Information Systems (GIS) were used to identify, classify, and quantify historical and existing wetlands and uplands in the three watersheds. Historical aerial photographs were obtained from the National Archives for the years 1942 and 1943 (U.S. National Archives and Records Administration, 2010) and were interpreted and delineated to create a period coverage of wetlands in the watersheds and subsequently compared with the more recent land use data (1995-2007). Soils data (USDA SCS, 1972) were referenced to assist in the identification of historical emergent wetlands. The data include estimated and measured records of the physical and chemical properties of the soil. The names of the components (series, taxonomic unit, or miscellaneous area) and the hydric soil rating were used to identify emergent wetlands.

System-wide assessments were made and trends were separately quantified for the St. Joseph Sound and Clearwater Harbor North and South watersheds. For mapping purposes, wetlands and uplands were classified in the St. Joseph Sound and Clearwater Harbor North and South watersheds landward of the estuarine portions of these watersheds. A detailed description of the mapping procedures for characterizing historical native lands and seagrasses is provided in Appendix I.

4.2.6 Land Use/Land Cover Changes in the CHSJS Watershed

In this section, land use changes that occurred throughout the CHSJS watershed between 1942 and 2007 are described. The section begins with an examination of historical land use types throughout the watershed. Segment-specific land use changes are then described for each of the three watershed segments (i.e. St. Joseph Sound, Clearwater Harbor North, and Clearwater Harbor South); first for the entire segment (including the barrier islands) and then for just the landward portion of the segment. Within of the segments of the watershed, land use changes are further evaluated. Of particular focus is the change from historical native uplands and wetlands to current land uses. A detailed analysis of changes to the coastal emergent wetlands (i.e., mangroves, salt marshes, and salterns) along the barrier islands between 1942 and 2007 is presented in Chapter 5. In 1942, uplands were the dominant land cover within both the estuarine and landward portions of the St. Joseph Sound, Clearwater Harbor North, and Clearwater Harbor South segments of the CHSJS. Uplands included 7,702 acres, 6,088 acres, and 3,322 acres in St. Joseph Sound, Clearwater Harbor North and Clearwater Harbor South, respectively (Table 4-8). Wetlands were the second dominant land cover in two of the three segments and together, wetlands and uplands contributed 65% of the total acreage in the CHSJS. Agriculture represented the majority of the remaining lands in 1942, representing 20% of the watershed acreage. Developed lands including residential and commercial development represented the smallest of the four general (Level 1 land cover classification) land use types. Much has changed since 1942, as described in the following sections,

Table 4-8. Area (acres) of historical (1942) land use/land cover in the three segments of the CHSJS watershed.

1942 Land Cover	St. Joseph Sound	Clearwater Harbor North	Clearwater Harbor South	Total
Urban and Built Up	1,548	2,291	1,905	5,744
Agriculture	2,407	3,574	2,330	8,311
Uplands	7,702	6,088	3,322	17,112
Wetlands	4,646	2,670	2,774	10,090
Total Acres	16,303	14,624	10,331	41,258

The following sections provide segment specific analyses of the land use/land cover changes that have occurred since 1942 within the St. Joseph Sound, Clearwater Harbor North, and Clearwater Harbor South watersheds within the larger CHSJS watershed.

- St. Joseph Sound

The extent of urban lands increased dramatically in the estuarine and landward portions of the St. Joseph Sound segment of the CHSJS watershed from 1942 to 2007 and amounted to a nearly 500% increase in urban and built-up (e.g., residential, commercial, industrial) land uses (Table 4-9, Figure 4-89). Urban land uses increased in extent by more than 9,000 acres between 1942 and 2007.

Declines in agriculture and uplands in the watershed were 64% and 78%, respectively. Wetlands declined by approximately 39%, substantially less than the decline in Clearwater Harbor North and South.

Table 4-9. **Area (acres) of the various land use/land cover types in the estuarine and landward segments of the St. Joseph Sound segment in 1942 and 1995-2007.**

Land Use	1942	1995	1999	2004	2005	2006	2007	Percent Change 1942-2007
Urban and Built-Up	1,548	9,981	10,363	10,636	10,672	10,717	10,797	597%
Agriculture	2,407	1,234	1,130	953	940	929	877	-64%
Uplands	7,702	2,160	1,958	1,785	1,747	1,720	1,701	-78%
Wetlands	4,646	2,833	2,886	2,838	2,837	2,814	2,840	-39%
Total Acres	16,303	16,208	16,337	16,212	16,196	16,180	16,215	NA

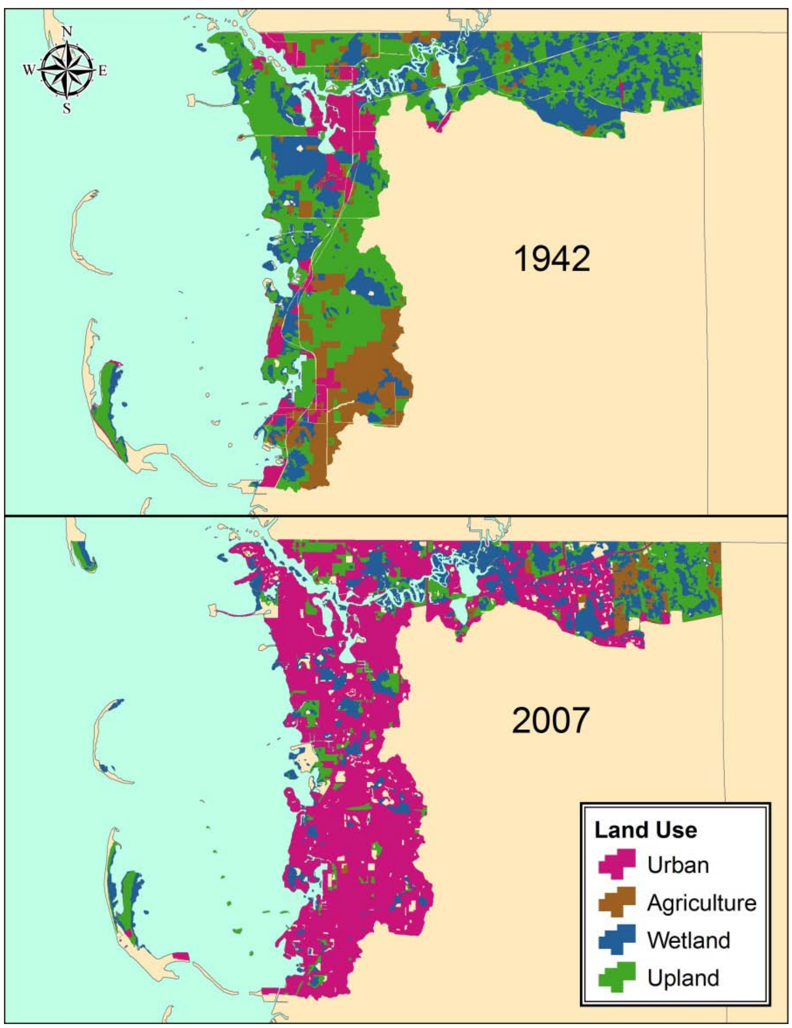


Figure 4-89. **Land use/land cover in the estuarine and landward portions of the St. Joseph Sound segment during 1942 and 2007.**

To characterize and use changes in the landward portion of the St. Joseph Sound watershed segment (i.e. uplands and freshwater wetlands) between 1942 and 2007, the land uses to which historical uplands, agriculture, and wetlands were converted to by 2007 were quantified. The greatest changes in land uses in the St. Joseph Sound watershed occurred prior to 1995 and likely occurred in the 1970s, consistent with the greatest population growth in the County and prior to permitting and environmental regulations. Relatively little change in land use composition was apparent from 1995 to 2007, although the small increases in the urban expansion in the St. Joseph Sound watershed corresponded with similarly steady declines in agriculture and uplands. Approximately 81% (5,873 acres) of historical uplands in the St. Joseph Sound inland watershed were developed by 2007 and 57% of these former uplands were converted to residential land uses and golf courses (Table 4-10).

Table 4-10. 2007 land uses to which historical (1942) uplands in the St. Joseph Sound watershed were converted.

	Land Use	Acres	Percent of Total
Developed	Residential, High Density	1,664	23
	Residential, Medium Density	1,384	19
	Residential, Low Density	575	8
	Golf Course	539	8
	Open Land	202	3
	Tree Plantations	225	3
	Recreational	194	3
	Reservoirs	177	2
	Commercial and Services	176	2
	Other Open Lands – Rural	176	2
	Cropland and Pastureland	150	2
	Industrial	108	1
	Utilities	97	1
	Transportation	74	1
	Institutional	66	1
	Tree Crops	41	1
	Disturbed Land	24	<1
Subtotal		5,873	81
Undeveloped	Hardwood - Conifer Mixed	465	6
	Pine Flatwoods	279	4
	Saltwater Marshes/ Halophytic Herbaceous Prairie	84	1
	Freshwater Marshes/ Graminoid Prairie - Marsh	80	1
	Longleaf Pine - Xeric Oak	78	1
	Upland Shrub and Brushland	69	1
	Stream and Lake Swamps (Bottomland)	65	1
	Mangrove Swamp	53	1
	Wet Prairies	49	1
	Cypress	40	1

Table 4-10. 2007 land uses to which historical (1942) uplands in the St. Joseph Sound watershed were converted.			
Land Use		Acres	Percent of Total
	Wetland Forested Mixed	32	<1
	Wetland Coniferous Forest	25	<1
	Wetlands and Open Water Classes (6)	16	<1
Subtotal		1,371	19
Total = acres of uplands exclusive of the barrier islands.		7,244	100

No other developed land uses individually accounted for more than 3% of the reduction in historical uplands. A total of 6% of the former (historical) were converted to other urban uses (e.g. commercial, industrial, etc.), while 6% were converted to agriculture (including tree plantations). Nineteen percent (1,371 acres) of historic uplands were not converted to developed land uses and 12% (891 acres) of the former uplands include present day undeveloped uplands, e.g., pine flatwoods, long leaf pine-xeric oak, hardwood-conifer forested mix, and shrub, and brushland.

Approximately 93% (2,513 acres) of the historical agricultural lands in the St. Joseph Sound watershed were converted to other developed land uses by 2007 (Table 4-11). High and medium density residential land uses accounted for 63% of the conversion and only 17 acres (less than 0.5%) remained in agricultural use in 2007. A total of 177 acres of former agricultural lands were converted to undeveloped land uses and uplands and wetlands accounted for about 7% of the conversion.

Table 4-11. 2007 land uses to which historical (1942) agricultural lands in the St. Joseph Sound watershed were converted.			
Land Use		Acres	Percent of Total
Developed	Residential, High Density	1,012	38
	Residential, Medium Density	676	25
	Residential, Low Density	193	7
	Commercial and Services	173	6
	Institutional	129	5
	Golf Course	78	3
	Industrial	56	2
	Transportation	51	2
	Recreational	40	1
	Open Land	39	1
	Other Open Lands – Rural	29	1
	Utilities	22	<1
	Cropland and Pastureland	12	<1
	Tree Crops	5	<1
Subtotal		2,513	93
dev elo	Hardwood - Conifer Mixed Forest	74	3

Table 4-11.	**2007 land uses to which historical (1942) agricultural lands in the St. Joseph Sound watershed were converted.**		
Land Use		**Acres**	**Percent of Total**
	Reservoirs	40	2
	Wetland Forested Mixed	22	1
	Intermittent Ponds	11	< 1
	Pine Flatwoods	10	< 1
	Freshwater Marshes/ Graminoid Prairie - Marsh	6	< 1
	Other (5 classes)	12	< 1
Subtotal		177	7
Total		2,689	100

Loss of wetlands in the St. Joseph Sound watershed totaled 40% from 1942 (4,352 acres) to 2007 (2,617 acres, Figure 4-90). There was a net loss of only 24 acres were lost between 1995 and 2007 and account for less than 2% of the change from historical wetland acreages.

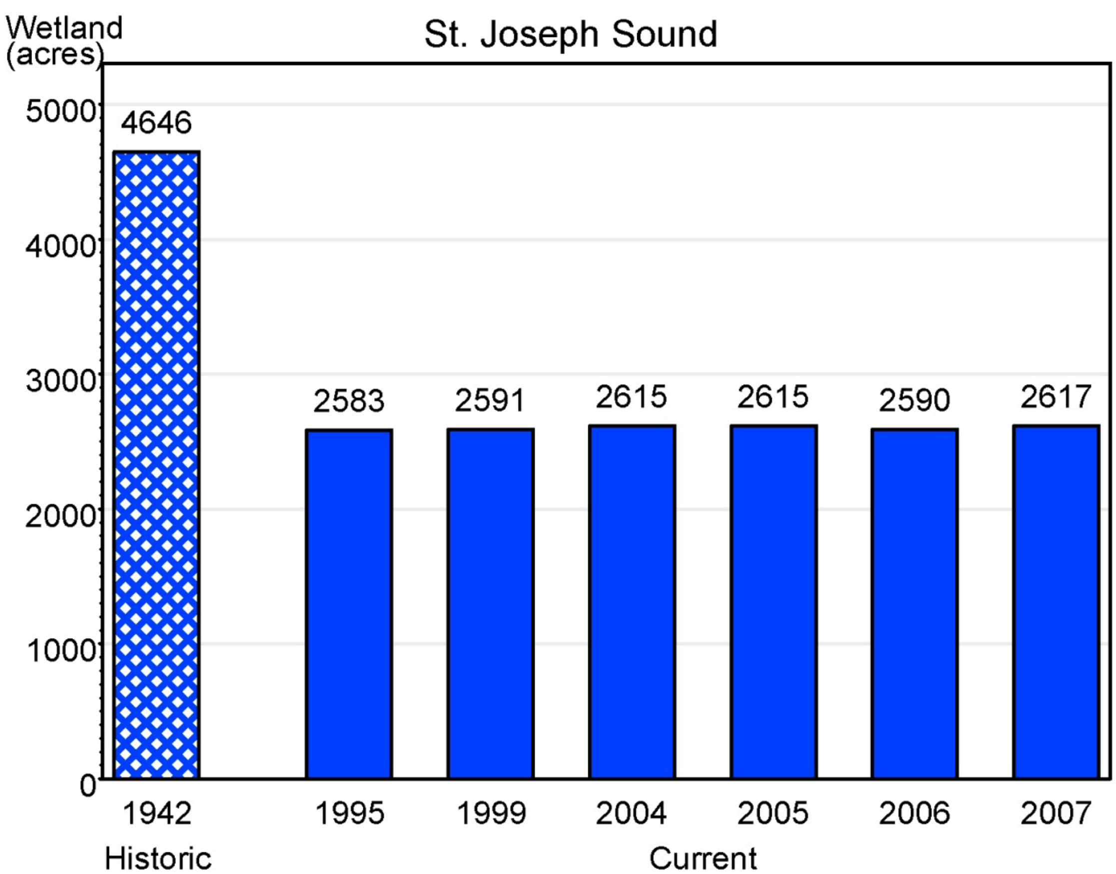


Figure 4-90. Area (acres) of wetlands in landward portion of St. Joseph Sound watershed from 1942 through 2007.

Figure 4-90 illustrates the net change in the extent of wetlands in the St. Joseph Sound watershed, but does not indicate what land uses the historical wetlands changed *to*. For example, the net loss of 2,617 acres of wetlands is not simply a conversion of 2,617 acres of wetlands to development: it represents the conversion of hundreds of acres of uplands to wetlands (Table 4-10), agriculture changes to reservoirs and wetlands (Table 4-11), combined with the conversions of wetlands to reservoirs, lakes, and uplands (Table 4-13). The acres of wetlands developed and not developed are listed in Table 4-12: 47 % of historical wetlands (2,045 acres) still remain in the watershed and represent approximately 700 acres less than the total number of wetlands in the watershed.

Approximately 24% of the historical wetlands in the St. Joseph Sound watershed were converted to residential land uses (Table 4-12). In St. Joseph Sound, 61% of the historical wetlands remained undeveloped in 2007; however, some wetlands were converted to other undeveloped land uses leaving only 47% of historic acreage as remaining wetlands.

Table 4-12. Fate of historical (1942) wetlands the St. Joseph Sound and Clearwater Harbor segment watersheds using 2007 land use classification.

Watershed	Wetlands Loss Relative to Individual Watersheds				
	Total Historical Area (acres)	Developed (percent)	Residential (percent)	Undeveloped (percent)	Remaining Wetlands (percent)
St. Joseph Sound	4,646	38	24	61	47
Clearwater Harbor North	2,670	80	61	19	10
Clearwater Harbor South	2,774	86	72	12	2.5

Residential land uses and golf courses accounted for 27% of the loss of historical wetlands in the St. Joseph Sound watershed, while other developed land uses accounted for approximately 13% of their loss (Table 4-13). Five percent of the historical wetlands were converted to uplands in the watershed by 2007. Remaining wetlands were characterized by predominantly forested wetlands, including bottomlands, mixed forest, cypress, and hardwood-conifer mixed forests. Freshwater marshes made up 13% of the remaining wetlands and mangroves made up the remaining 5%.

Table 4-13. 2007 land uses to which historical (1942) wetlands in the St. Joseph Sound watershed were converted.

2007 Land Use/ Land Cover		Area (acres)	Percent of Total
Developed	Residential, High Density	525	12
	Residential, Medium Density	358	8
	Golf Course	161	4
	Residential, Low Density	144	3
	Open Land	114	3
	Other open Lands - Rurual	72	2
	Recreational	70	2
	Cropland and Pastureland	66	2
	Institutional	61	1
	Commercial and Services	60	1
	Transportation	35	1
	Other	27	<1
Subtotal		1,693	39

Table 4-13. 2007 land uses to which historical (1942) wetlands in the St. Joseph Sound watershed were converted.			
2007 Land Use/ Land Cover		Area (acres)	Percent of Total
Undeveloped	Stream and Lake Swamps (Bottomland)	544	12
	Wetland Forested Mixed	341	8
	Cypress	317	7
	Saltwater Marshes/ Halophytic Herbaceous Prairie	296	7
	Freshwater Marshes/ Graminoid Prairie - Marsh	249	6
	Hardwood - Conifer Mixed Forest	205	5
	Wetland Coniferous Forest	122	3
	Mangrove Swamp	118	3
	Reservoirs	113	3
	Pine Flatwoods	96	2
	Tree Plantations	72	1
	Lakes	57	1
	Wet Prairies	47	1
	Upland Shrub and Brushland	30	1
	Bays and Estuaries	28	1
	Other (< 1%)	24	<1
Subtotal		2,659	61
Total		4,352	100

- Clearwater Harbor North

The increase in urban land uses (493%) and the commensurate decline in agriculture (99%), uplands (90%), and wetlands (72%) in the Clearwater Harbor North watershed was much greater when compared with the St. Joseph Sound watershed changes (Table 4-14, Figure 4-91). Similar to St. Joseph Sound, the greatest changes in land use occurred prior to 1995 and likely occurred in the 1970s, consistent with the greatest population growth in the County and prior to permitting and environmental regulations. Agricultural land uses continued to decline from 1995 to 2007 as the extent of urban land uses increased, while wetlands and uplands changed little over the recent time period. Losses of uplands (103 acres) and agriculture (11 acres), combined with a 46-acre increase in urban land uses (Table 4-14), represent a small change the watershed since 1995.

Table 4-14. Area (acres) of primary land use/land cover classes in the Clearwater Harbor North watershed in 1942 and 1995-2007.							
Land Use	1942	1995	1999	2004	2005	2006	2007	Percent Change 1942-2007
Urban and Built-Up	2,291	13,541	13,560	13,546	13,557	13,556	13,587	493%
Agriculture	3,574	40	40	29	29	29	29	-99%
Uplands	6,088	664	632	613	607	604	604	-90%
Wetlands	2,670	739	727	730	731	729	736	-72%
Total Acres	14,623	14,984	14,959	14,918	14,924	14,918	14,956	NA

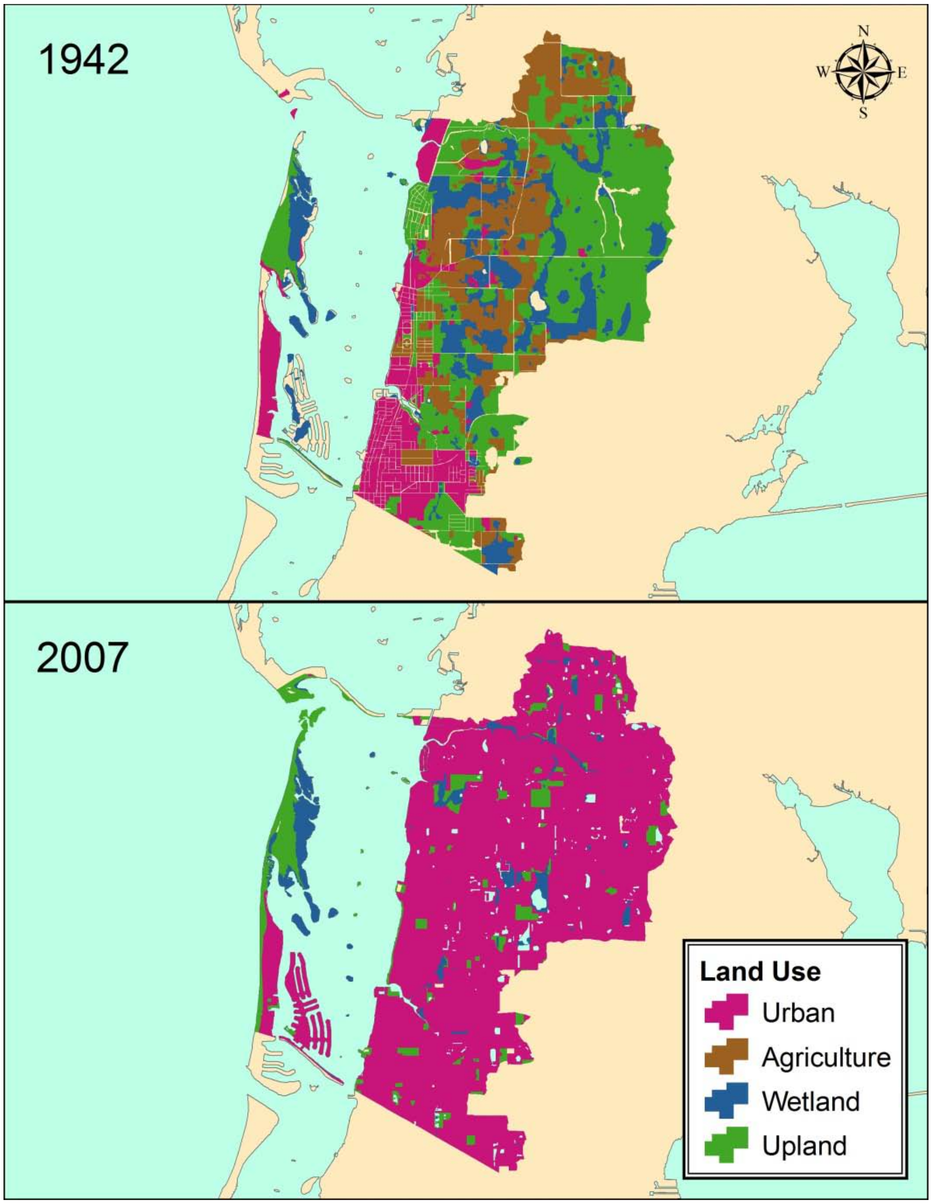


Figure 4-91. Land uses changes 1942-2007 in the Clearwater Harbor North watershed.

Historical aerial extent of uplands, agriculture and wetlands in CHN were described by their current (2007) land use to characterize land use changes in the landward portion of the watershed segment between 1942 and 2007,. Nearly all (97%) of the 6,088 acres of historical uplands in the mainland Clearwater Harbor North watershed have been converted to developed lands uses (Table 4-15). Approximately 72% of the historical uplands were converted to residential land uses and golf courses (although golf courses made up less than 1%). None of the remaining 13 developed land use classes individually accounted for more than 3% of the converted uplands. Transportation, recreation, utilities, reservoirs, and other urban uses accounted for the remainder of the decline in historical uplands in the watershed. Less than 200 acres (3%) of the former uplands remained undeveloped as of 2007 and only 58% (115 acres) of those remained upland forest (upland hardwood and hardwood-conifer mixed forest).

Table 4-15. 2007 land uses to which historical (1942) uplands in the Clearwater Harbor North watershed were converted.			
Land Use		Acres	Percent of Total
Developed	Residential, High Density	3,255	56
	Commercial and Services	655	11
	Residential, Medium Density	494	9
	Golf Course	230	4
	Transportation	187	3
	Institutional	167	3
	Residential, Low Density	153	3
	Recreational	130	2
	Utilities	130	2
	Reservoirs	84	2
	Open Land	59	1
	Other Urban Classes (5)	27	<1
Subtotal		5,571	97
Undeveloped	Hardwood - Conifer Mixed Forest	91	2
	Stream and Lake Swamps (Bottomland)	37	1
	Upland Hardwood Forest	24	<1
	Freshwater Marshes/ Graminoid Prairie - Marsh	14	<1
	Wetland Forested Mixed	12	<1
	Other Wetland and Open Water Classes (10)	20	<1
Subtotal		198	3
Total		5,769	100

Ninety-seven percent (3,456 acres) of the 3,562 acres of historical agricultural lands were converted to developed land uses by 2007 (Table 4-16) and nearly all underwent conversion prior to 1995. Approximately 77% of the former agricultural lands were converted to residential land uses and golf courses. There were 106 acres of former agricultural lands that converted to undeveloped land uses, including 31 acres of upland forest, 27 acres of reservoir(s), and 39 acres of wetlands.

Table 4-16. 2007 land uses to which historical (1942) agricultural lands in the Clearwater Harbor North watershed were converted.			
Land Use		Area	Percent of Total
Developed	Residential, High Density	2,219	62
	Residential, Medium Density	464	13
	Institutional	278	8
	Commercial and Services	183	5
	Recreational	113	3
	Residential, Low Density	65	2
	Transportation	52	1
	Other Open Lands - Rural	21	<1

Table 4-16. 2007 land uses to which historical (1942) agricultural lands in the Clearwater Harbor North watershed were converted.			
Land Use		Area	Percent of Total
	Open Land	20	<1
	Utilities	18	<1
	Other Classes (3)	17	<1
Subtotal		3,456	97
Undeveloped	Hardwood - Conifer Mixed Forest	31	1
	Reservoirs	27	<1
	Freshwater Marshes/ Graminoid Prairie - Marsh	24	<1
	Wetland Forested Mixed	11	<1
	Stream and Lake Swamps (Bottomland)	4	<1
	Other Classes (6)	9	<1
Subtotal		106	3
Total		3,562	100

Historical wetlands in Clearwater Harbor North declined by 83% from 1942 to 2007 (Figure 4-91). Similar to the St. Joseph Sound and Clearwater Harbor South, changes in wetlands between 1995 and 2007 were negligible (less than 1%). Of the 2,231 acres of remaining wetlands in all three segment watersheds (Table 4-12), only 10% (223 acres) occurred in the Clearwater Harbor North watershed in 2007. These small remaining wetlands are primarily bottomland hardwoods or mixed forested wetlands and less than 1% are cypress wetlands or marshes.

Sixty-one percent of the historical wetlands in the Clearwater Harbor North watershed were converted to residential land uses by 2007 (Table 4-17). Another 24% of the former wetlands were converted to other developed land uses, including recreational, institutional, utilities, industrial, and nearly 15 acres (1%) of extractive lands. Six percent (127 acres) of the historical wetlands that were not developed as urban uses were converted to reservoir(s). Approximately 213 acres (9.5%) of historical wetlands remain in the watershed and are characterized by forested and non-forested wetlands. Less than 79 acres (4%) of the former wetlands were converted to uplands.

Table 4-17. 2007 land uses to which historical (1942) wetlands in the Clearwater Harbor North watershed were converted.			
Land Use		Acres	Percent of Total
Developed	Residential, High Density	1,076	48
	Residential, Medium Density	275	12
	Commercial and Services	176	8
	Institutional	73	3
	Transportation	48	2
	Recreational	38	2
	Open Land	31	1
	Residential, Low Density	28	1
	Golf Course	26	1
	Utilities	16	1

Table 4-17.	2007 land uses to which historical (1942) wetlands in the Clearwater Harbor North watershed were converted.		
	Other	1	< 1
Subtotal		1,788	80
Undeveloped	Reservoirs	128	6
	Stream and Lake Swamps (Bottomland)	109	5
	Hardwood - Conifer Mixed Forest	79	4
	Wetland Forested Mixed	64	3
	Cypress	25	1
	Freshwater Marshes/ Graminoid Prairie - Marsh	15	1
	Other	23	< 1
Subtotal		443	20
Total		2,232	100

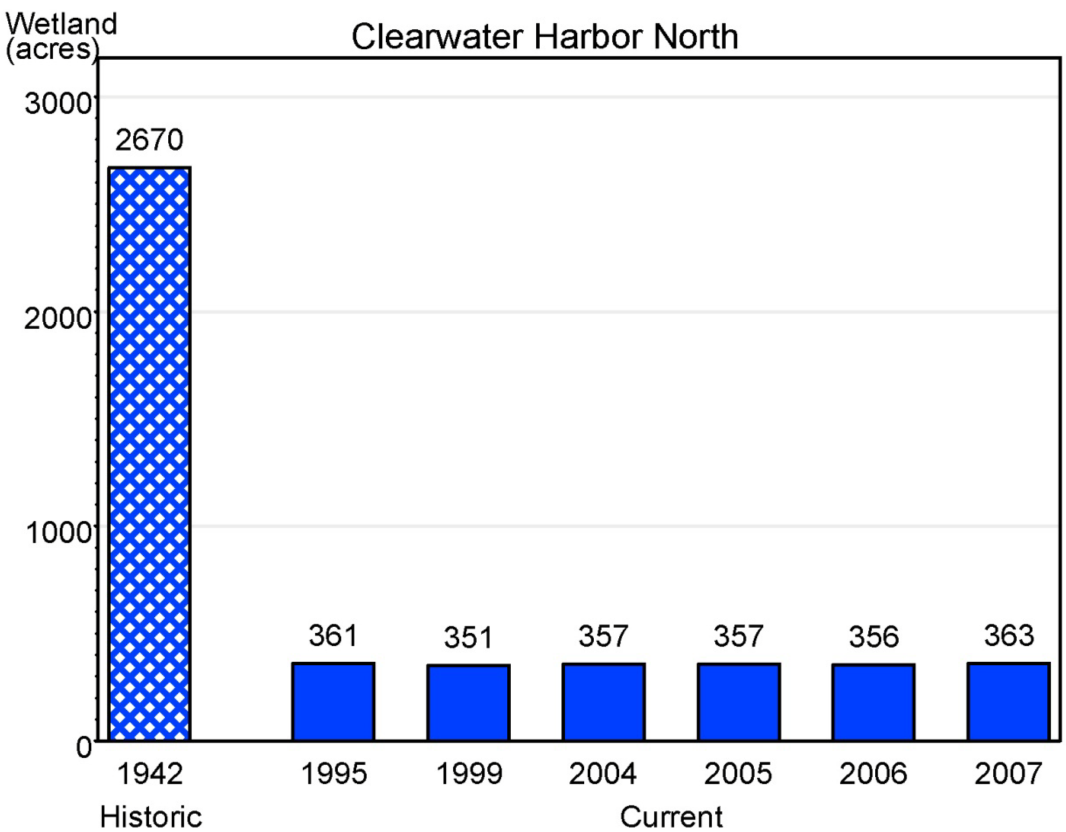


Figure 4-92. Timeseries trend in wetland acreage in Clearwater Harbor South between 1942-2007.

- Clearwater Harbor South

Urban land uses increased by 446% in the watershed since 1942 (Table 4-18). The decline of uplands in the Clearwater Harbor South watershed amounted to a 93% loss between 1942 and 2007 (Figure 4-93). The loss of 106 acres of uplands and a 34 acre increase in urban lands between

1995 and 2007accounted for much of the land use change in the watershed over the recent time period.

Table 4-18. Area (acres) of the various land use/land cover types in the Clearwater Harbor South watershed in 1942 and 1995-2007.

Land Use	1942	1995	1999	2004	2005	2006	2007	Percent Change 1942-2007
Urban and Built-Up	1,905	10,372	10,371	10,412	10,413	10,403	10,406	446%
Agriculture	2,330	35	35	35	35	35	35	-98%
Uplands	3,322	347	346	248	247	241	241	-93%
Wetlands	2,493	123	123	120	120	135	147	-94%
Total Area	10,050	10,877	10,875	10,815	10,815	10,814	10,829	NA

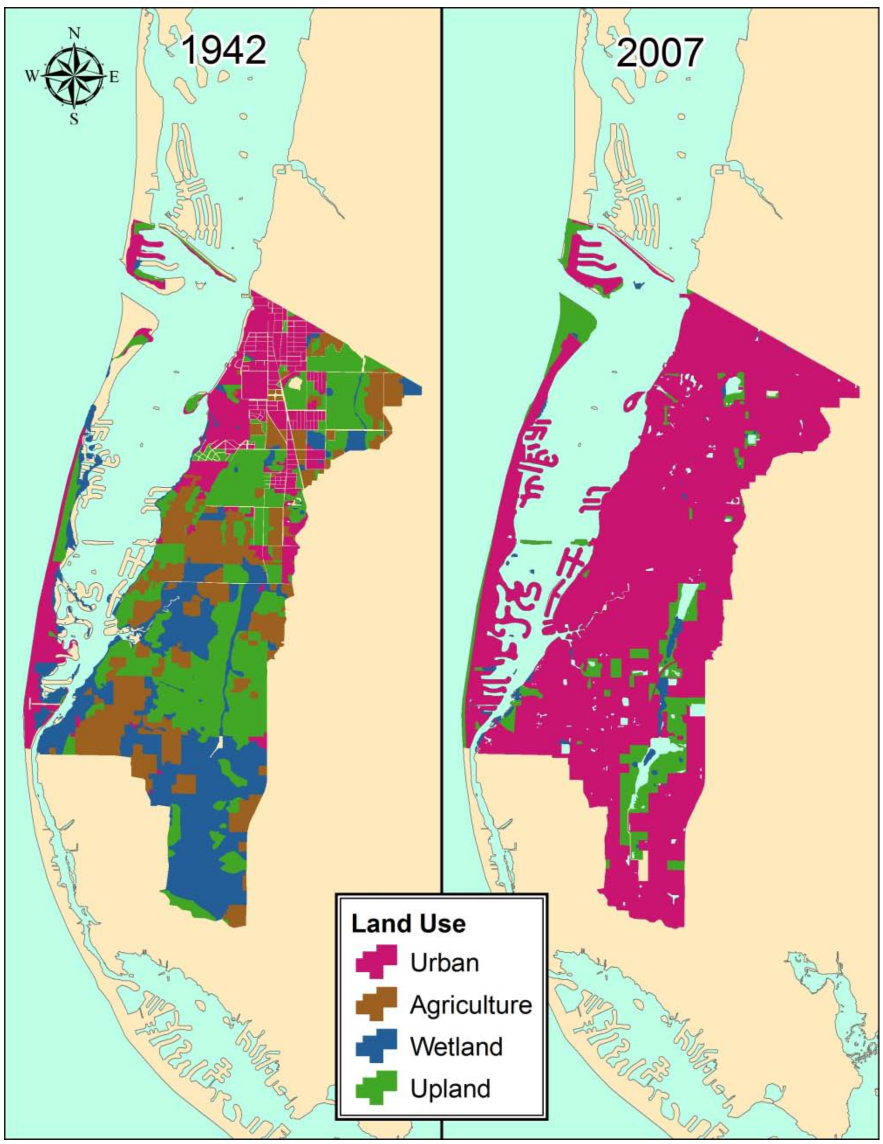


Figure 4-93. Land uses changes 1942-2007 in the Clearwater Harbor South watershed.

Land use changes in the watershed (i.e. landward side) between 1942 and 2007 were compared for the historic aerial extent of uplands, agriculture and wetlands in CHS with their current (2007) land use. Approximately 70% (2,235 acres) of the historic uplands in Clearwater Harbor South watershed were converted to residential land uses and golf courses (Table 4-19). Undeveloped land cover classes accounted for less than 10% of the former uplands in the Clearwater Harbor South watershed. Approximately 5% of the historical upland forested lands were converted to other natural land cover, including pine flatwoods and mixed hardwoods. Forested wetlands and open water accounted for the remainder of the converted uplands.

Table 4-19. 2007 land uses to which historical (1942) uplands in the Clearwater Harbor South watershed were converted.

Land Use		Acres	Percent of Total
Developed	Residential, High Density	1,864	58
	Commercial and Services	255	8
	Golf Course	215	7
	Recreational	173	5
	Institutional	133	4
	Residential, Medium Density	90	3
	Reservoirs	67	2
	Residential, Low Density	66	2
	Open Land	36	1
	Utilities	29	1
	Transportation	29	1
	Industrial	17	1
	Extractive, Communication	10	<1
Subtotal		2,984	93
Undeveloped	Hardwood - Conifer Mixed Forest	77	2
	Pine Flatwoods	64	2
	Lakes	19	1
	Upland Coniferous Forest	18	1
	Wetland Forested Mixed	17	1
	Wetlands and Open Water Classes (6)	21	<1
Subtotal		215	7
Total		3,199	100

Ninety-nine percent of the 2,330 acres of historical agricultural lands were converted to developed land uses by 2007 (Table 4-20) and nearly all underwent conversion prior to 1995. Approximately 80% of the former agricultural lands were converted to residential land uses and golf courses. Only 16 acres became undeveloped land covers, including 13 acres of hardwood mixed forests, upland coniferous forest (pine flatwoods), and other forested and non-forested wetlands.

Table 4-20. 2007 land uses to which historical (1942) agricultural lands in the Clearwater Harbor South watershed were converted.			
Land Use		Acres	Percent of Total
Developed	Residential, High Density	1,765	76
	Commercial and Services	261	11
	Residential, Medium Density	71	3
	Institutional	67	3
	Recreational	49	2
	Transportation	29	1
	Inactive Lands with Street Pattern	22	1
	Utilities, Industrial, other Urban Land Uses	24	<1
	Golf Course	11	<1
	Reservoirs	11	<1
Subtotal		2,314	>99
Undeveloped	Hardwood - Conifer Mixed Forest	13	1
	Upland Coniferous Forest	1	<1
	Forested and Non-forested Wetlands (5 Classes)	2	<1
Subtotal		16	1
Total		2,330	

Historical wetlands in Clearwater Harbor South declined by 94% from 1942 to 2007, accounting for the greatest proportional and absolute (2,355 acres) loss of historical wetlands among the three wetlands (Figure 4-94, Table 4-21). Similar to the St. Joseph Sound and Clearwater Harbor North, changes in wetlands between 1995 and 2007 were negligible (less than 1%). Seventy-two percent of the historical wetlands in the Clearwater Harbor South watershed were converted to residential land uses and golf courses by 2007 (Table 4-21). Another 24% of the former wetlands were converted to other developed land uses, including recreational, institutional, utilities, industrial, and nearly 15 acres (1%) of extractive lands. Seven percent (176 acres) of the historical wetlands that were not developed as urban uses were converted to reservoir(s). Approximately 146 acres (5%) of historical wetlands remain in the watershed and are characterized by forested and non-forested wetlands. Less than 1% of the former wetlands were converted to uplands.

Table 4-21. 2007 land uses to which historical (1942) wetlands in the Clearwater Harbor South watershed were converted.			
Land Use		Acres	Percent of Total
Developed	Residential Low Density	1,362	55
	Recreational	283	11
	Residential, Medium Density	123	5
	Institutional	104	4
	Commercial and Services	73	3
	Golf Course	40	2
	Specialty Farms	31	1
	Open Land	31	1
	Residential, Low Density	28	1

Table 4-21.	**2007 land uses to which historical (1942) wetlands in the Clearwater Harbor South watershed were converted.**		
	Land Use	**Acres**	**Percent of Total**
	Utilities	19	1
	Industrial	18	1
	Extractive	15	1
	Transportation, Communications	16	1
Subtotal		2,143	87
Undeveloped	Reservoirs	178	7
	Hardwood - Conifer Mixed Forest	55	2
	Wetland Forested Mixed	40	2
	Mangrove Swamp	22	1
	Emergent Aquatic Vegetation	12	<1
	Streams and Waterways	9	<1
	Upland Coniferous Forest	9	<1
	Other	10	<1
Subtotal		335	13
Total		2,479	100

4.2.7 Preservation and Restoration Targets for Natural Lands

Prior to 1942, 14% of the watershed was classified as developed lands including agriculture or what is called "urban or built out" lands which includes residential, commercial and municipal development within the watershed. Over 65% of the historic land cover was either forested uplands or agriculture. Today less than 20%, 10% and 5% of historic native lands remain in St. Joseph Sounds, Clearwater Harbor North and Clearwater Harbor South, respectively. The dramatic losses to uplands and wetlands in the three watersheds of the CCMP are due predominantly to conversions to high and medium density residential land uses which have increased impervious surfaces and dramatically reduced available habits for now listed species including the gopher tortoise, Bald Eagle and Red Cockaded Woodpecker (Pinellas County 2008). Effects of wetland loss on aquatic species is less well documented but the effects of wetland loss on bird populations has been well documented (Pinellas County, 2008).

Remaining undeveloped uplands in the St. Joseph Sound are limited to northeast Pinellas County and smaller parks and conservation areas throughout the watershed (Figure 4-95). These areas include: the Anclote River, Hammock Park, Taylor Park, Ridgecrest Park, and Walsingham County Park. Wetlands have suffered a similar fate and now represent a small fraction of their historic extent. Remaining wetlands in the watershed include forested freshwater wetlands, non-forested freshwater wetlands, mangrove areas fringing creeks and bayous, and saltwater marshes (Figure 4-96). Much of these areas is also in public or conservation land. Some agricultural areas persist in the northeastern portion of the County and may provide opportunities for preservation of open space and restoration of wetlands although, as of 2007, less than 1 % of the total land area in Pinellas County supported agricultural uses.

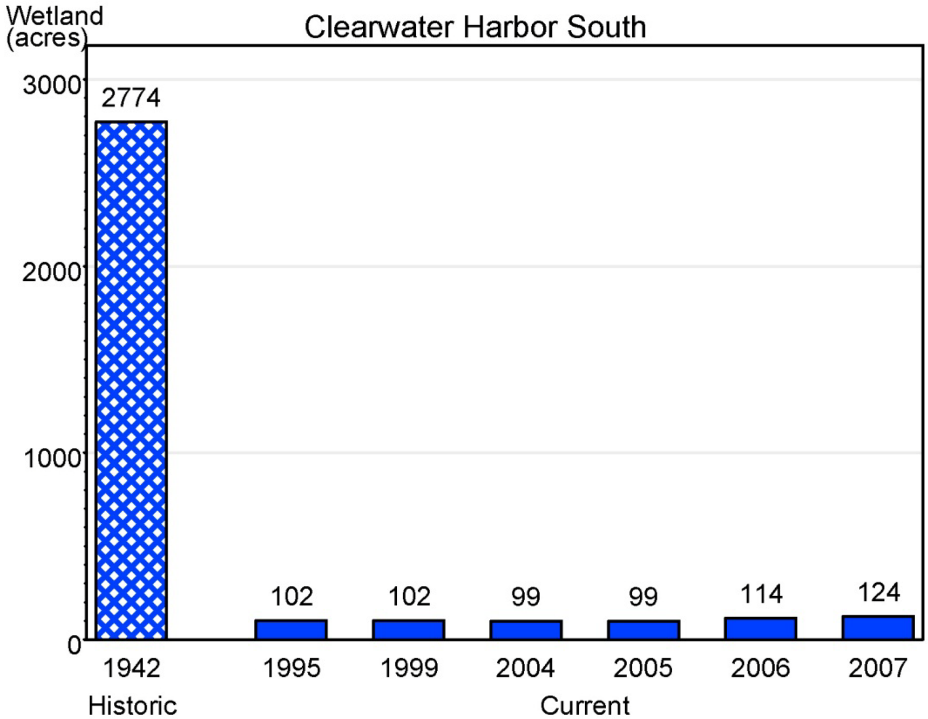


Figure 4-94. Area (acres) of wetlands in Clearwater Harbor South watershed from 1942 through 2007.

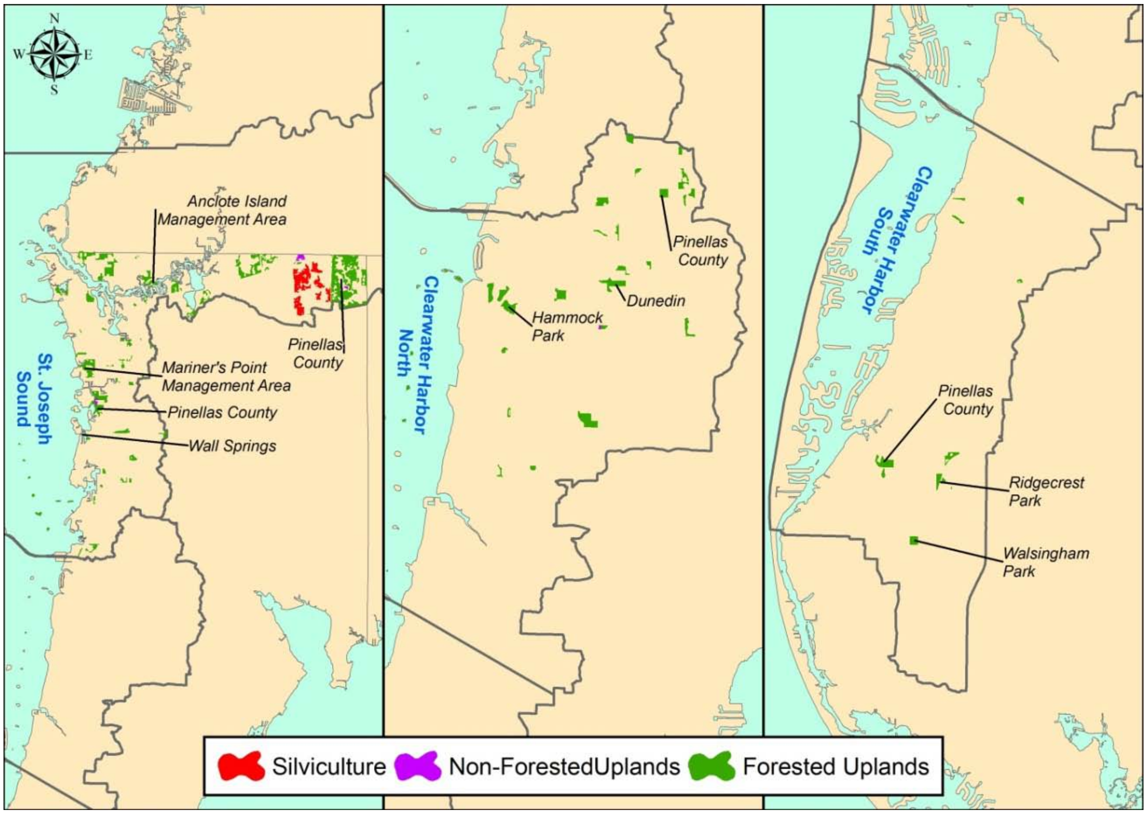


Figure 4-95. **Upland habitats remaining as of 2007 in the CHSJS watershed.**

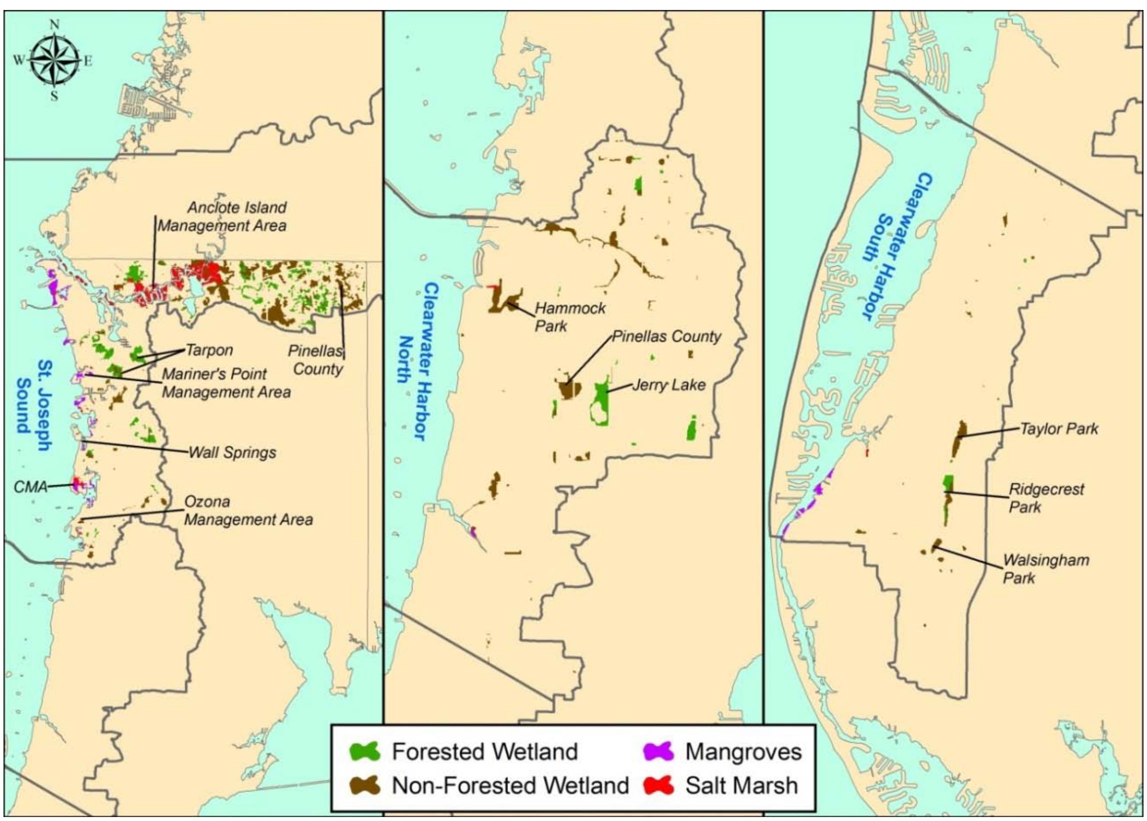


Figure 4-96. **Wetland habitats remaining as of 2007 in the CHSJS watershed.**

While nearly half of the historical native uplands and wetlands remain in the St. Joseph Sound watershed, these habitats have been virtually eliminated by development in the Clearwater Harbor North and South watershed segments. Given the extensive loss of both native uplands and wetlands has occurred in the CHSJS watershed, a "no-loss" strategy is proposed as a *minimum acceptable target* for natural lands. The no-loss strategy using 2007 land use (April, 2010 version) would result in natural lands targets as follows:

	St. Joseph Sound	Clearwater Harbor North	Clearwater Harbor South	Total Acres
Uplands (acres)	1500	517	241	2258
Forested Wetlands (acres)	1567	252	23	1842
Non-Forested Wetlands (acres)	536	137	86	759
Mangroves (acres)	209	3	24	236
Saltwater Marshes (acres)	448	3	2	454

These targets should be regarded as minimum acceptable acreage for the CCMP. A goal of the CCMP should be restoration of wetland habitats to the extent practical. Given that wetland acres cannot reasonably be restored to the historical extent due to the extensive development of the watershed, restoration efforts should focus on restoring a balance of wetland types within the watershed. Several options are available as potential restoration strategies to focus and prioritize restoration activities on increasing the extent and restoring the balance of freshwater wetlands and protecting the diversity of habitat types in the watershed circa 1940. One potential strategy is presented in Appendix J.

5.0 State of the CHSJS Estuary Resources

This chapter summarizes the data on a number of critical resources within the CHSJS estuary. Specifically, the following resources are examined:

- Seagrasses,
- Estuarine water quality status and trends,
- Estuarine water quality targets and numeric nutrient criteria,
- Estuarine emergent wetlands,
- Sediments and associated benthic communities,
- Fish communities,
- Megafauna, and
- Birds.

As an initial step of these analyses, the resource components were identified, attributes that contributed to stress them were identified, and a list of potential management issues was compiled to help guide the development of the final CCMP. These lists were then formulated into a list of critical questions that became the analytical pathway for establishing estuarine natural resource targets. Where the data allow, quantitative targets for resource protection and restoration are presented. When the data do not allow defensible quantitative targets to be proposed qualitative targets are presented. Both the quantitative and qualitative targets will provide critical context and input to the CCMP development process.

5.1 Estuarine Seagrasses

Seagrasses are an important estuarine resource, functioning as keystones in healthy estuaries. Seagrasses are sessile organisms that are effective integrators of water quality and function as sentinel species in estuarine and marine environments (Orth et. al., 2006). The strong link between water quality and seagrass distribution makes seagrass a good indicator of ecosystem health (Moore et al., 2004).

Seagrasses are valuable structural and functional components of coastal ecosystems and are currently experiencing worldwide decline (Bull et al., 2010, Short and Wyllie-Echeverria 1996). Seagrasses support a complex trophic food web and a detritus-based food chain, as well as provide sediment and nutrient filtration, sediment stabilization, and breeding and nursery areas for finfish and shellfish (Bull et al. 2010, references therein). Seagrass meadows are also a direct food source for the West Indian manatee (*Trichechus manatus*), green sea turtle (*Chelonia mydas*), and ecologically important invertebrates such as the variegated sea urchin, *Lytechinus variegates* (Ogden, 1980 and references therein). Seagrass meadows support a complex trophic food web and a detritus based food chain (Bull et al., 2010) and are important to nutrient cycling, water clarity (via settling out of various suspended particles), and shoreline stabilization (Rasmussen, 1977; Hine et al., 1987) as well as other ecosystem functions (Dawes et. al., 2004).

In addition to providing habitat and food for invertebrates, small vertebrate marine organisms, and large grazing herbivores, seagrass beds also support epiphytic and macro algae as substrata for their development. Seagrass communities constitute highly productive and diverse ecosystems, in part due to the presence of these epiphytes, which include diatoms, green algae, and cyanobacteria (Moncreiff and Sullivan, 2001). The epiphytic algal assemblage present on the surface of seagrass leaves functions as a primary food source within these communities, in addition to the seagrasses and their detrital material (Moncreiff and Sullivan, 2001). Macro algae also attach themselves to seagrasses for stability, and thus increase diversity within these systems (Janicki et al., 1995).

Nutrient cycling and assimilation is another of the many ecosystem services that seagrass communities provide. Seagrasses filter nutrients and contaminants, which helps improve water quality and support adjacent habitats and fisheries (Dawes et al., 2004). They are hotspots for organic-matter accumulation and nutrient regeneration and recycling, which support primary production and sustain food webs (Dawes et al., 2004). They can also serve as sinks for nitrogenous loads from watershed sources, which can aid attenuation to nutrient polluting when seagrasses are located in abundance.

Seagrasses are photosynthetic organisms, and the amount of light available is typically, but not always, the primary factor that controls the depth to which seagrass meadows can grow (see review in Duarte et al., 2007). However, light requirements at offshore edges can be influenced by wave energy, as was found in a study of seagrass meadows offshore of Anclote and Egmont Keys (Dawes and Tomasko, 1988).

Anthropogenic nitrogen loads can lead to excessive algae growth, which adversely affects light penetration to submerged seagrasses (Dennison et al., 1993; SBEP, 1995; Chesapeake Bay Program, 2000; Morris and Virnstein, 2004; Greening and Janicki, 2006). Sediment deposition related to development of shorelines and the watershed also negatively impact seagrass growth (Moore et al., 2004). As seagrasses live in the shallow, protected coastal waters that are directly proximal to the shore and watershed, these systems are highly susceptible to nutrient and sediment inputs (Orth, et al., 2006).

In Florida, a vast array of estuarine and marine organisms relies upon seagrass habitats for a portion or all of their life cycles (Dawes et al., 2004). The canopy structure of a seagrass bed provides protection and cover for fish in their fry and juvenile stages, essentially serving as a nursery ground (Dawes et al., 2004; Orth et al., 2006). Primary production within seagrass beds provides food for recreationally and commercially important fish species and serves as a trophic foundation for the ecosystem. Additionally, large herbivores such as sea turtles and manatees graze on seagrasses as an important food source (Orth et al., 2006). The stability for these valuable habitats is provided by the hearty root systems of seagrasses (Janicki et al., 1995). These root systems provide stability not only for the seagrass and lotic communities, but also for sediments and the benthic production that is found at the sea floor (Dawes et al., 2004).

Over the past few decades, catastrophic declines in seagrass cover have been documented in a number of estuaries, most often associated with degrading water quality due to human activities (see reviews in Ralph et al. 2006, and references therein). Anthropogenic stressors that may affect seagrass distributions include direct physical impacts such as the Intracoastal Waterway (ICW), spoil islands, and shoreline modification. Indirect anthropogenic stressors may include water quality degradation due to increased turbidity and increased nutrient availability. Natural stressors may also affect seagrass distributions and include hurricanes, disease, and overgrazing by herbivores (e.g. sea urchins). Climate change also affects seagrass distributions (Short and Neckles 1999).

Seagrass restoration is a major focus in the management of many estuarine resources including the following estuaries: Chesapeake Bay, Long Island Sound, Indian River Lagoon, Sarasota Bay, and Tampa Bay.

A common pattern in seagrass coverage has emerged throughout each region. As the shorelines and watersheds proximal to seagrass beds become more developed, anthropogenic loadings of nitrogen and sediments have increased. These load increases have had detrimental effects on water quality; of particular importance to seagrass health are the resultant algal blooms from nitrogenous loads and increased turbidity from sedimentation. Algal blooms and increased turbidity each negatively impact light attenuation in seagrass communities, which is devastating to green leafy plants. Seagrass populations have declined as such.

As researchers and managers within these systems began to identify the relationships between pollutant loadings and seagrass declines, the notion of seagrass as an ecological bellwether developed. Seagrass communities were soon recognized as *in situ* indicators of estuarine health because their success is governed by adequate water quality and water clarity conditions and because their success can be relatively easily measured. Thus, seagrasses are now being used extensively as indicators for watershed-based management and planning actions. Seagrasses have now been identified as a principal response indicator in efforts to reduce watershed pollutant loads in estuaries as diverse as Chesapeake Bay, the Indian River Lagoon, and Tampa Bay.

Chesapeake Bay was perhaps the first major estuary in the United States to make seagrass restoration and protection a keystone within a greater water pollution control framework. The 1987 Chesapeake Bay Agreement identified the "need to determine the essential elements of habitat quality and environmental quality necessary to support living resources and to see that these conditions are attained and maintained" as instrumental to overall bay health. Researchers in Chesapeake Bay estimate that only about 15% of the bay's historical seagrass distribution presently exists (Moore et al., 2004). Having reviewed aerial photography dating back to 1937, the researchers suggested that these declines in seagrass are linked to deteriorating water quality conditions in Chesapeake Bay (Moore et al., 2004). The Chesapeake Bay Program (2002) established seagrass restoration targets and defined water quality and habitat-based requirements for seagrasses in Chesapeake Bay.

Similar to Chesapeake Bay, the Indian River Lagoon (IRL) on Florida's east coast has witnessed a dramatic decrease in seagrass coverage concurrent with watershed development. Since 1980, some regions within the IRL have lost up to 95% of their coverage (Virnstein et al., 2007; Rey and Rutledge, 2001). This trend has also prompted the Indian River Lagoon National Estuary Program (1996) to initiate a seagrass restoration program within its boundaries, in recognition of the unique and valuable function these communities contribute (Morris and Virnstein, 2004). It is estimated that, within the IRL, seagrasses form the foundation of a fishery industry worth approximately one billion dollars annual (Rey and Rutledge, 2001).

The model for the current project in the Sarasota Bay Estuary Program (SBEP) is from Tampa Bay. After decades of losses, seagrass meadows were identified by the Tampa Bay Estuary Program (TBEP) as critical estuarine habitats for fish and wildlife targeted for protection and restoration (Janicki et al., 1995). In addition to the proximity that Sarasota Bay and Tampa Bay have with one another, similar patterns of development and urbanization also make Tampa Bay a conductive model for restoration target setting in Sarasota Bay. The methodology employed in the present study is based largely on work done by the TBEP in 1995.

Multiple studies have been completed on seagrass communities in Sarasota Bay in recent years, with a focus on water quality studies and spatial and temporal and trends in seagrasses. Tomasko et al. (1996) analyzed the impacts of anthropogenic nutrient loads on distribution patterns within four turtle grass meadows in Sarasota Bay. Turtle grass biomass and productivity were negatively correlated with watershed nitrogen inputs (Tomasko et al., 1996). Additionally, light attenuation has been studied in relation to Sarasota Bay's seagrass communities (Dixon and Kirkpatrick, 1995). The researchers have asserted that light limitation is a major factor in losses of seagrasses at the deep edge of once-extensive meadows (Dixon and Kirkpatrick, 1995). The Sarasota Bay Estuary Program has identified light attenuation as a controlling abiotic factor in the density and distribution of seagrass beds within Sarasota Bay (Dixon and Kirkpatrick, 1995).

Tomasko et al. (2005) observed that there is more extensive seagrass coverage in 2002 than in the 1980s and linked this observation to greater water clarity. Similar trends were observed in Tampa Bay, but seagrass was constant in adjacent Lemon Bay and Charlotte Harbor, which suggests that a system-specific approach is an appropriate resource management strategy (Tomasko et al., 2005).

The following describes the data used in the seagrass assessment, the analytical approaches, and results from those analyses.

5.1.1 Data Sources

Several sources of data were used in this assessment. Historical aerial photography was acquired from the National Archives and Records Administration in Washington D.C. (1942), as well as data from the U.S. Department of Agriculture (USDA) (1957) for the northwest section of St. Joseph Sound. Seagrass maps and mapping data for St. Joseph Sound and Clearwater Harbor were obtained from SWFWMD for the years 1999, 2001, 2004, 2006, and 2008. Data from seagrass monitoring transects for the years 2006 to 2009 were obtained from Pinellas County, and 2007 bathymetry data were obtained from the United States Geological Survey (USGS). A summary of seagrass distribution and trends was published for the Clearwater Harbor and St. Joseph Sound area by Tomasko and Greening (2007). These seagrass distribution estimates were subsequently updated by Meyer and Levy (2008).

In addition to seagrass mapping efforts, seagrass densities, species composition, and relative epiphyte abundance data are available from transect-based monitoring completed for Clearwater Harbor and St. Joseph Sound. Results for the period of 1998 to 2006 were summarized by Meyer and Levy (2008).

5.1.2 Analytical Approach

Historical aerial photography was used to develop a seagrass coverage for the open bay segments of the CHSJS. All of the seagrass visible in Clearwater Harbor in National Archive aerial photographs taken on April 2, 1942, was digitized. Some of the seagrass in St. Joseph Sound was digitized from National Archive aerial photographs taken on April 2, 1942. Seagrass in the western portion of St. Joseph Sound, for which no National Archive photographs were available, was digitized from USDA aerial photographs taken in 1957. Historical aerial photographs were geo-referenced in ArcInfo 9.3. Landmarks and roads from the 2008 SWFWMD aerial photographs were used to acquire a minimum of three reference points for each image. The root mean square error

(RMSE) was calculated after each photograph was geo-referenced. All RMSEs were less than half the image pixel length. Polygons were digitized in ArcMap at a scale of 1:6,000 with flexibility to examine areas at a finer scale. The minimum mapping unit (MMU), or smallest feature delineated and characterized on the map, was two acres for seagrass. For details on mapping historical seagrass acreage see Appendix I.

These data were combined with other GIS layers representing channels, spoil islands, and shoreline modifications to estimate the extent of seagrass loss that should be considered non-restorable due to direct impacts. To assess potential impacts of water quality degradation on seagrass distribution, bathymetric data were used to identify areas of loss or gain based on depth.

5.1.3 Existing Seagrass Conditions

The most recent seagrass mapping efforts, completed in 2010, are displayed in Figures 5-1. It should be noted that the geographic boundaries used in this analysis differs from those of the Southwest Florida Water Management District in that these estimates do not include seagrass acreage west of the barrier islands or in the Anclote River.

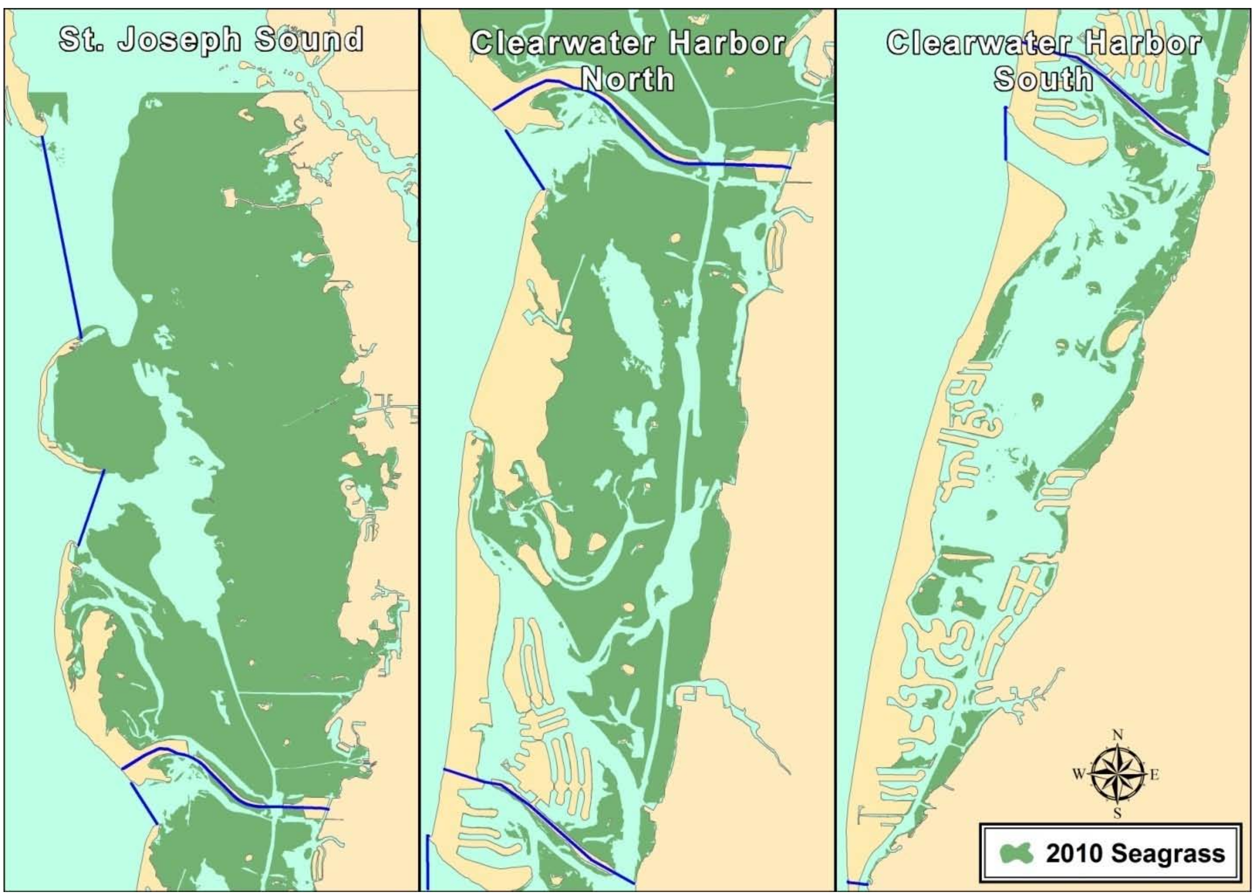


Figure 5-1. Distribtuion of seagrass in the three estuarine segments of the CHSJS based on SWFWMD 2010 aerial mapping.

In St. Joseph Sound, seagrass cover in 2010 was 15% higher than in 1999, an increase of 1,680 acres (Figure 5-2). However, seagrass cover decreased between mapping events twice (1999 to

2001 and 2004 to 2006) and increased between mapping events three times. The temporally variable pattern of gains and/or losses in seagrass cover in St. Joseph Sound led to further evaluations of the potential factor(s) involved. In Clearwater Harbor North, seagrass acreage increased 56%, from 2,416 acres in 1999 to 3,758 acres in 2010. Seagrass cover in Clearwater Harbor South increased 66%, from 545 acres to 902 acres between 1999 and 2010. These substantial increase in seagrass acreage are concurrent with improved water quality between 1999 to 2010 and with a general trend of reduced nutrient and chlorophyll a concentrations since 1992 (see Chapter 5.2).

St. Joseph Sound exhibited more substantial inter-annual variability in seagrass acreage than the other segments. To investigate the basis for the variable seagrass cover in St. Joseph Sound, transect data from Pinellas County were examined. These transect data are recorded for a probabilistic monitoring design that monitors the species composition and abundance of seagrasses throughout the bay segments. Data from these transects show a species distribution pattern (Figure 5-3) wherein shallow areas (i.e., less than 6 feet meters in depth) contain a mixture of turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*) and shoal grass (*Halodule wrightii*). The very shallowest water depths do not contain manatee grass, perhaps due to the inability of its blades to lay horizontal during low tide events. Both shoal grass and turtle grass blades can lie flat on shallow bay bottoms during low tides, thus minimizing physiological stress due to desiccation.
Results in Figure 5-3 also show that turtle grass is the dominant species in depths up to 2 feet, but that turtle grass is less abundant in deeper waters and was not encountered in waters deeper than 5 feet. Manatee grass was most abundant in depths of 3 to 5 feet, but was also encountered in some of the deeper sites. However, for depths greater than 6 feet, shoal grass was the dominant species.

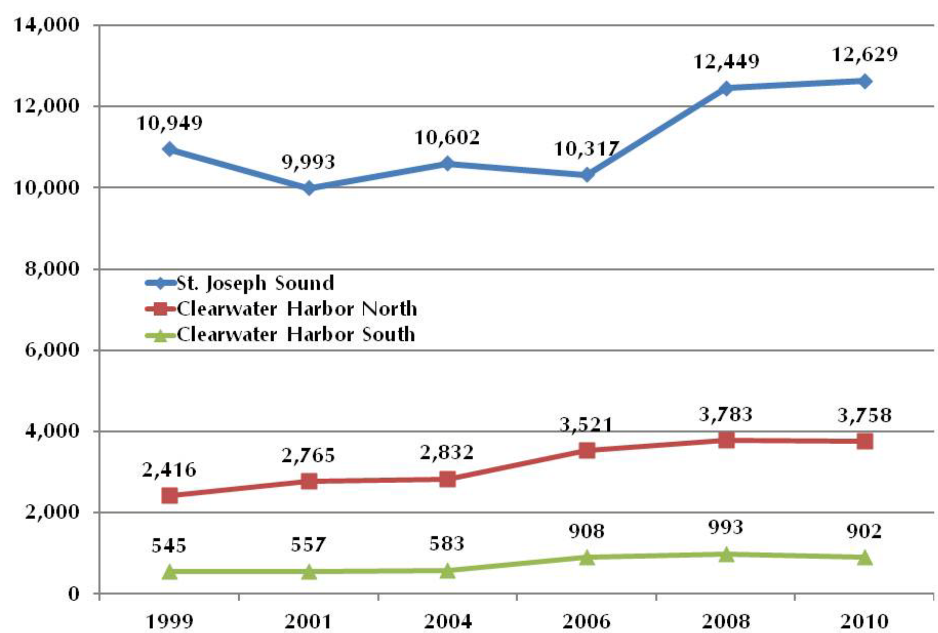


Figure 5-2. Recent seagrass coverage estimates in the CHSJS estuary. *Note: The numbers reported above do not include seagrass acreage west of the barrier islands or in the Anclote River and are therefore different from the seagrass acreages reported by the Southwest Florida Water Management District*

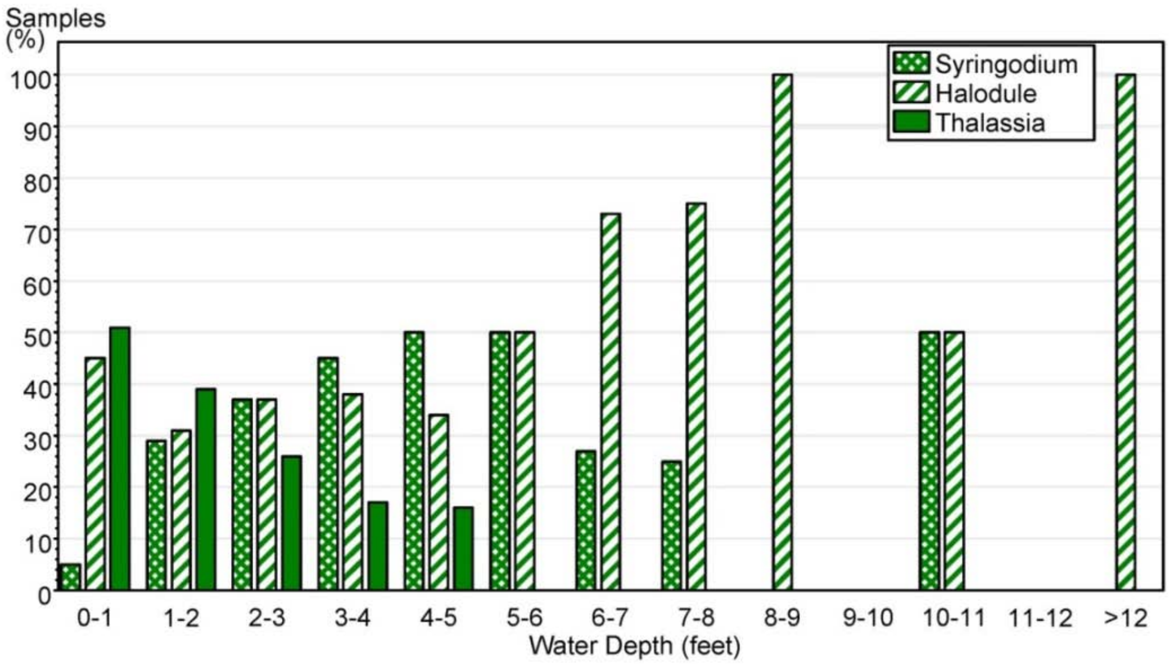


Figure 5-3. Species distributions as a function of depth for seagrass meadows in the CHSJS estuary.

To further investigate the basis for the variable seagrass cover in St. Joseph Sound, composite maps that shows bathymetry data and a map of seagrass persistence on the same scale for each CHSJS segment were developed (Figures 5-4 - 5-6). Most of the seagrass cover in St. Joseph Sound that was only mapped once or twice is farther offshore and in deeper waters. In contrast, areas that were consistently mapped as seagrass cover are mostly in shallower waters closer to either the mainland or the barrier islands. Dominance of shoal grass in deeper areas has particular relevance for mapping purposes because the areas where seagrass cover was most variable (i.e., mapped only once or twice) are also in those deeper areas. Within St. Joseph Sound, Dawes and Tomasko (1988) found that seagrass biomass decreased with increasing water depth. Also, shoal grasses typically have lower above-ground biomass than either turtle or manatee grass (e.g., Zieman and Wetzel, 1980). Therefore, the finding that areas where seagrasses are sometimes mapped (and sometimes not) are probably low-biomass shoal grass meadows suggests that mapping units showing areas of "loss" from any given mapping event should be field-verified and appropriate caveats included in mapping effort results.

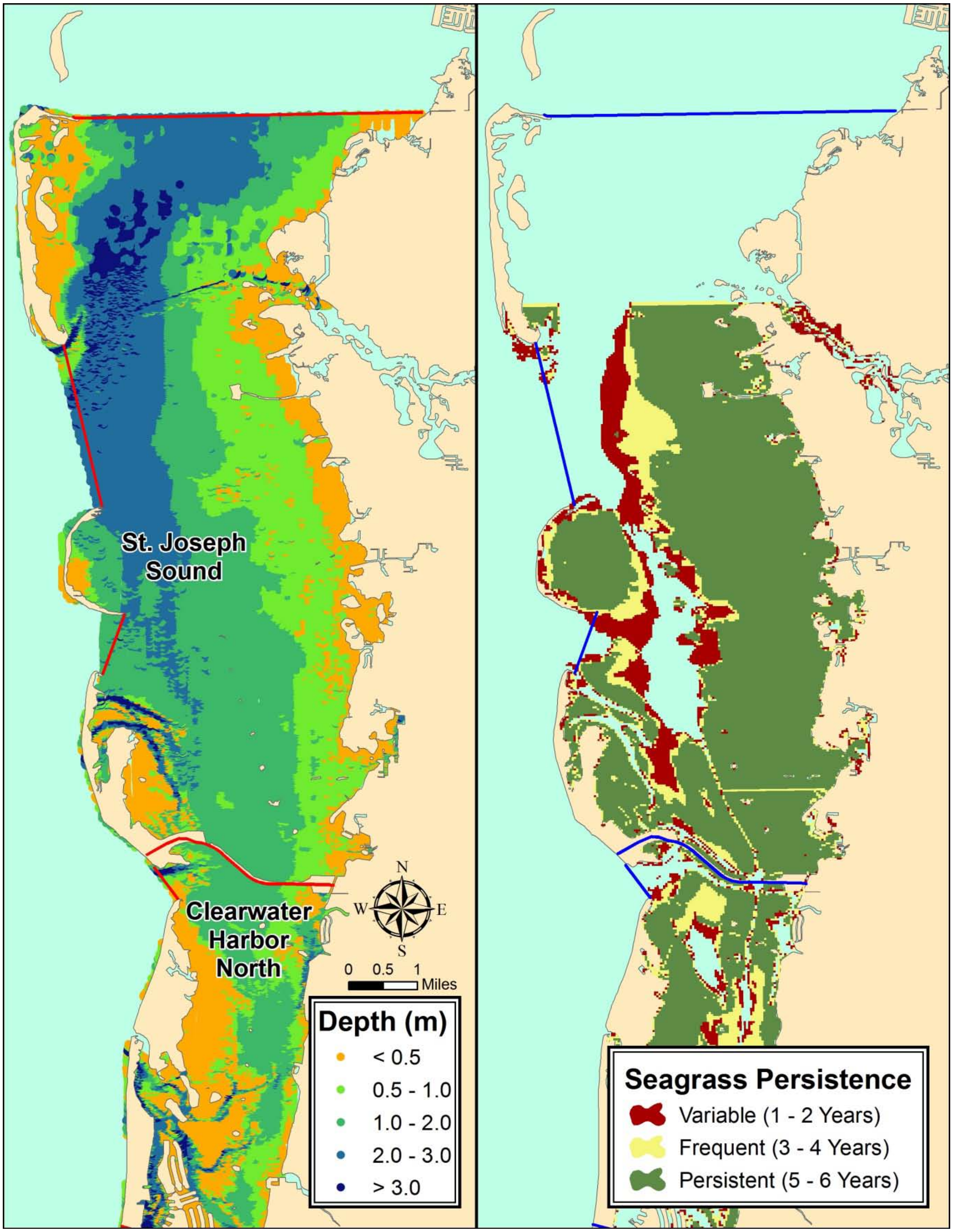


Figure 5-4. **Comparison of bathymetry and mapped seagrass persistence (1 to 2 mapping events, 3 to 4 mapping events, and 5-6 mapping events) for the St. Joseph Sound segment. Mapping events included 1999, 2001, 2004, 2006, 2008, and 2010.**

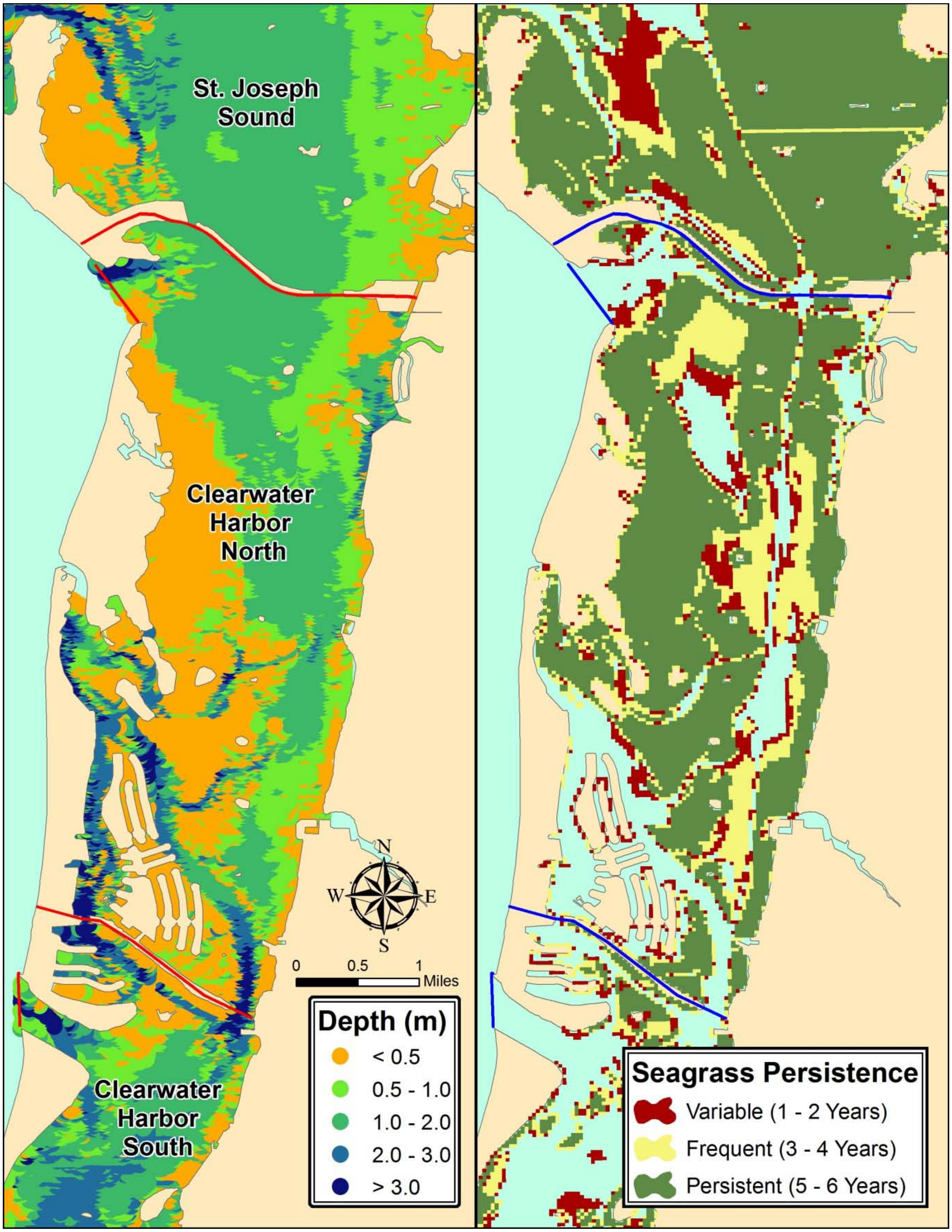


Figure 5-5. **Comparison of bathymetry and mapped seagrass persistence (1 to 2 mapping events, 3 to 4 mapping events, and 5-6 mapping events) for the Clearwater Harbor North segment. Mapping events included 1999, 2001, 2004, 2006, 2008, and 2010.**

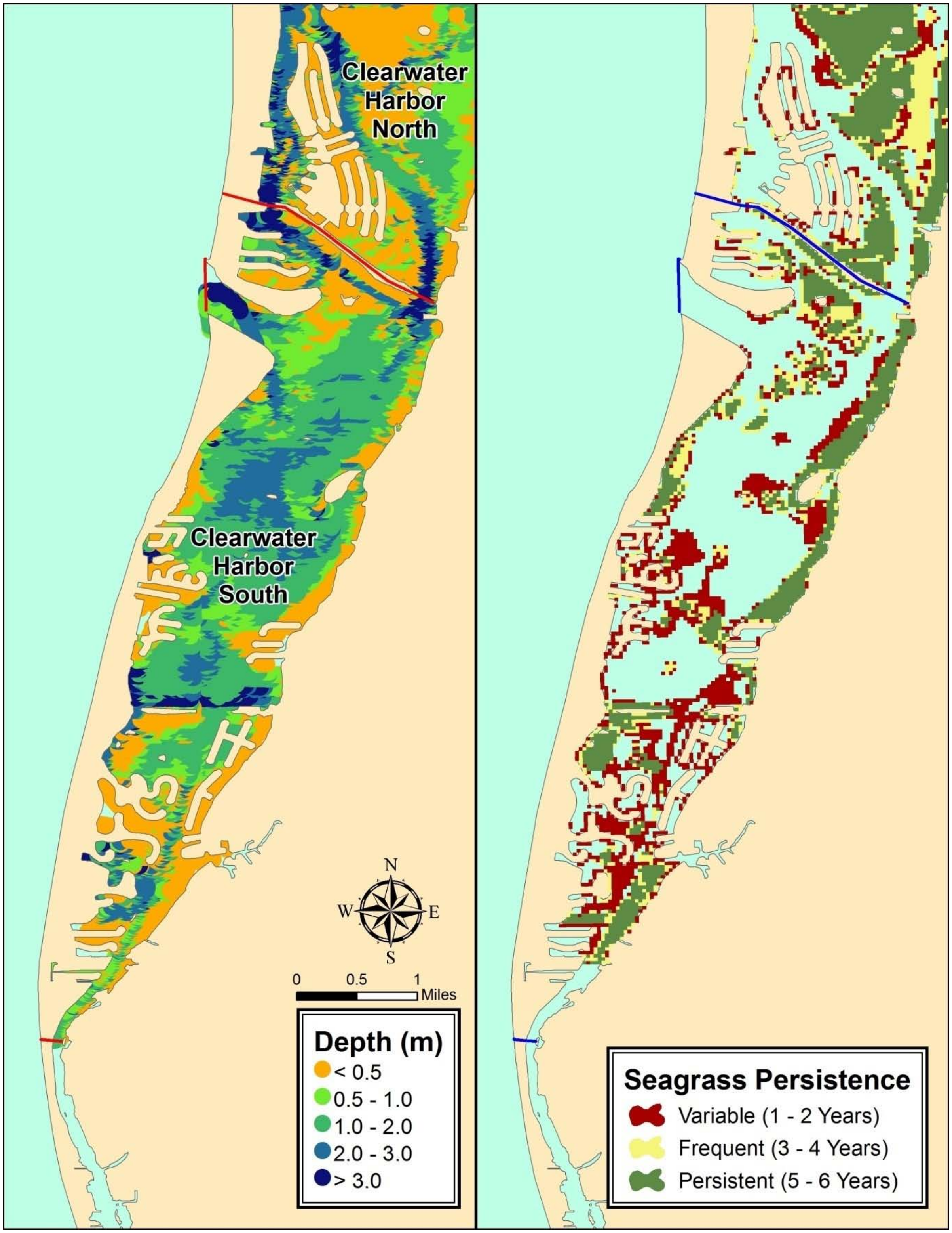


Figure 5-6. Comparison of bathymetry and mapped seagrass persistence (1 to 2 mapping events, 3 to 4 mapping events, and 5-6 mapping events) for the Clearwater Harbor South segment. Mapping events included 1999, 2001, 2004, 2006, 2008, and 2010.

5.1.4 Historic Seagrass Acreage

While all three estuary segments show a generally increasing trend in seagrass extent in recent years (1999 to 2010), it is important to compare the current seagrass extent to what may have occurred historically. Estimates of historic seagrass acreages within the open bay segments were estimated from historical aerial photography as described above and shown in Figures 5-7.

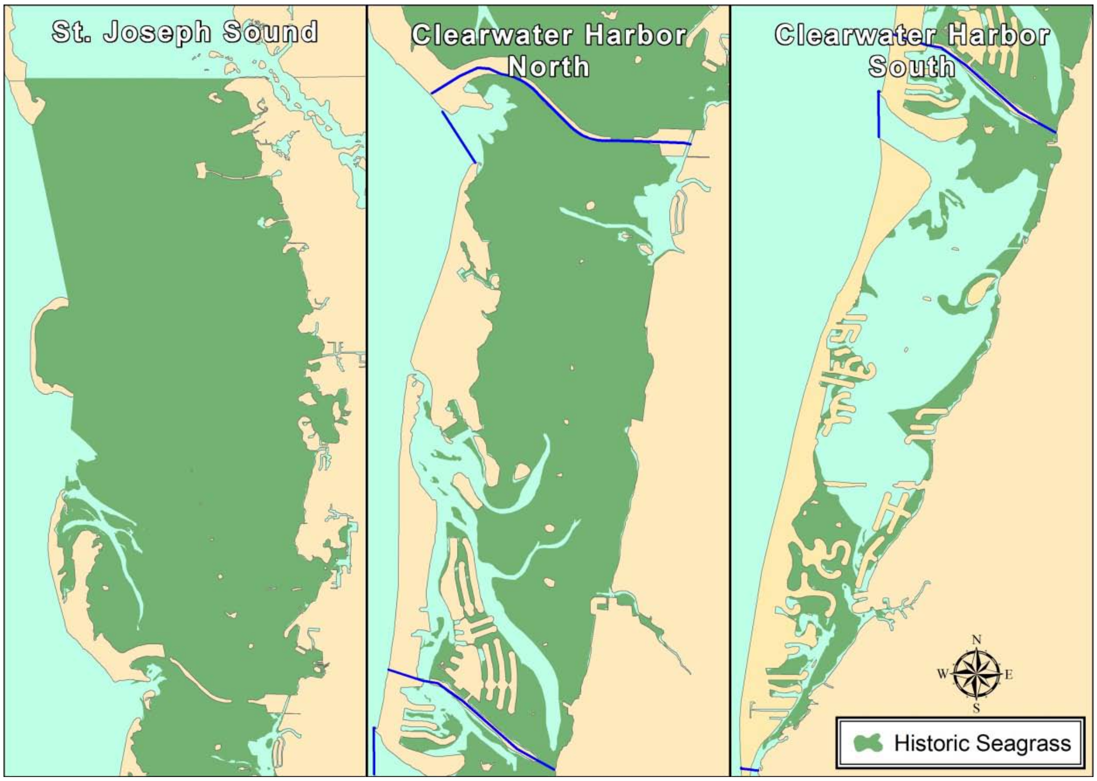


Figure 5-7. Historic distribution of seagrass circa 1942 for each of the three estuarine segments of the CHSJS.

Non-restorable areas, such as dredging of the Intracoastal Waterway and dredge and fill projects have been identified. Accounting for non-restorable areas allowed for the calculation of an "adjusted baseline" estimate, modified from the original 1942 coverage, to compare to recent years. A total of 1,654 acres of historical seagrass were lost to anthropogenic activities in the estuary that cannot be restored (Table 5-1).

Table 5-1. Historical acreage of seagrass and accounting of seagrass lost to anthropogenic activities that cannot be restored.

Watershed	Historical Seagrass (acres)	Non-Restorable Seagrass ICW (acres)	Non-Restorable Seagrass Spoil Islands (acres)	Non-Restorable Seagrass Shoreline (acres)	Non-Restorable Seagrass Total (acres)	Adjusted Baseline (acres)
St. Joseph Sound	15,969	170	23	481	674	15,295
Clearwater Harbor North	5,273	75	24	392	491	4,782
Clearwater Harbor South	1,719	60	13	416	489	1,230
Total	22,961	305	60	1,289	1,654	21,307

The most recent seagrass acreage can be compared to the historical seagrass acreage. The spatial distribution of change in the extent of seagrass in each segment between historical and 2010 are plotted in Figures 5-8. After accounting for non-restorable areas, the difference in acreage between historic estimates and the 2010 estimate for each segment is displayed in Figure 5-9.

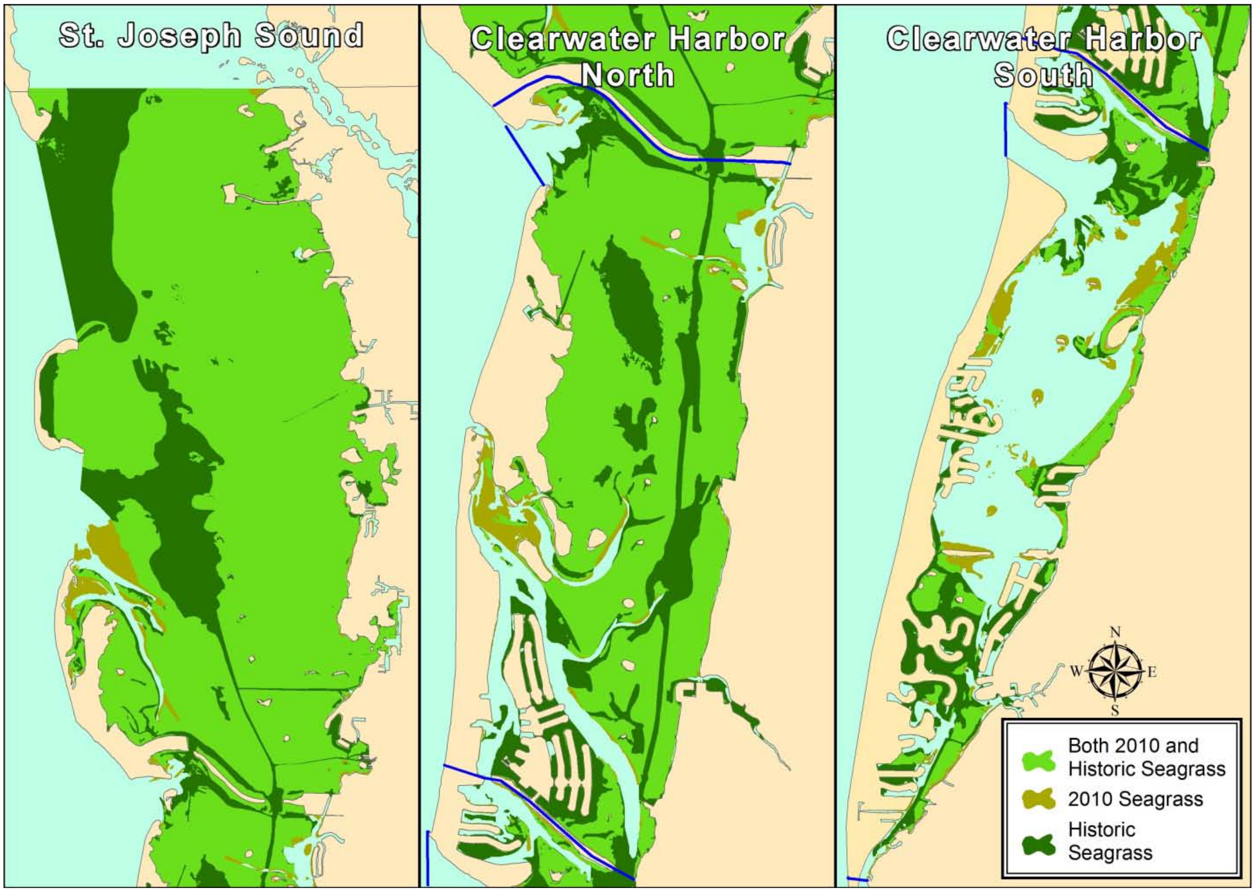


Figure 5-8. Overlay of historical (circa 1942) and 2010 seagrass maps. Areas of light green are common to both coverages while dark green areas represent areas of lost historical seagrass beds. Brown areas indicate areas where seagrass was not present historically but was present in the 2010 survey.

The greatest single continuous area of seagrass loss is in St. Joseph Sound directly north and south of Three Rooker Bar (Figure 5-10). The black outline in the figure delineates the current position of Three Rooker Bar superimposed over a 1957 aerial photography. In this area, water quality is generally quite good, reflecting the distance from land-based pollutant loads (i.e., the area is typically more than two miles offshore of the mainland), and the salinities are high enough to suggest that water quality is dominated by the Gulf of Mexico.

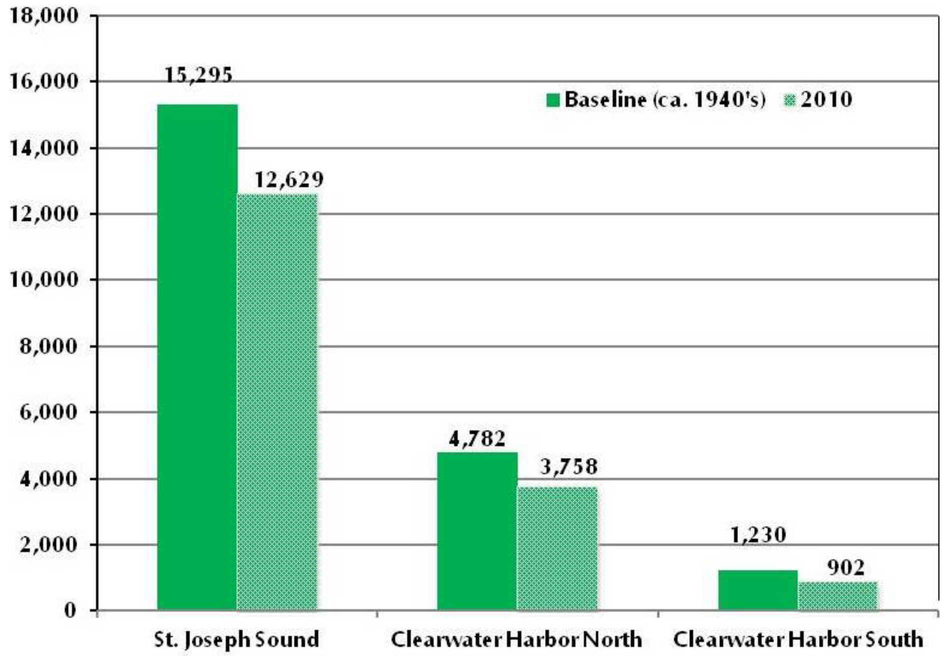


Figure 5-9. Seagrass acreage in St. Joseph Sound, Clearwater Harbor North, and Clearwater Harbor South for the 1940s and 1950s, compared to 2010. *Note: The numbers reported above do not include seagrass acreage west of the barrier islands or in the Anclote River and are therefore different from the seagrass acreages reported by the Southwest Florida Water Management District*

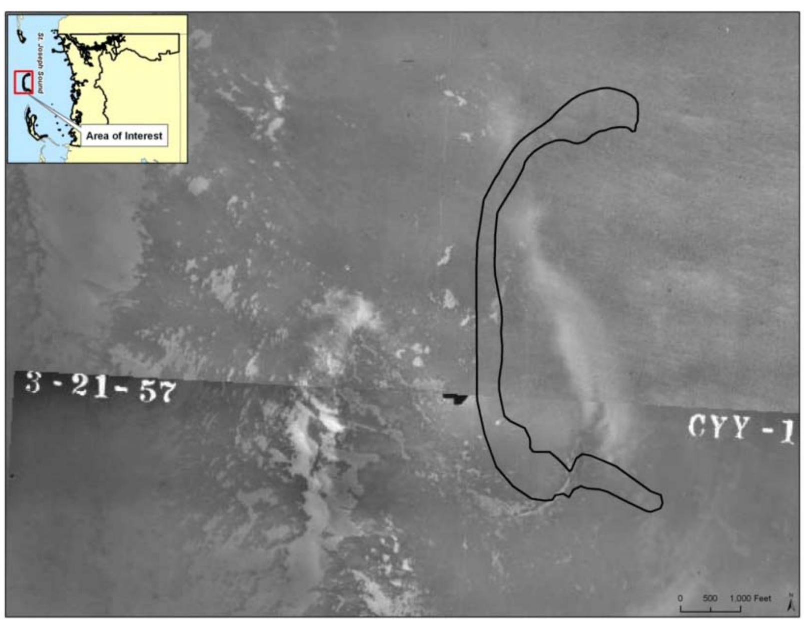


Figure 5-10. 1957 aerial photography with present-day outline of Three Rooker Bar superimposed.

Another example of changes to these offshore coastal features is Anclote Key (Figure 5-11). Again the current position of Anclote Key is denoted with a black outline overlaid on the historic photography. This area has substantially changes since 1957 with significant accretion on the southern and western edges of the island

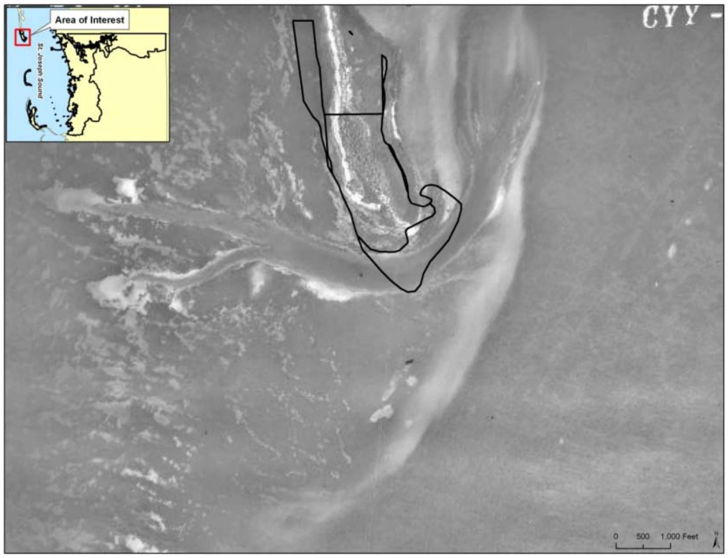


Figure 5-11. 1957 aerial photography with present-day outline of southern Anclote Key superimposed.

Both Figures 5-10 and 5-11 clearly show dense seagrass meadows *west* of the present day locations of these two barrier island features. In fact, the region that later becomes Three Rooker Bar appears to be a sub-tidal unvegetated ridge within a larger seagrass meadow. The widespread change in features, such as Anclote Key, was the focus of prior studies by Hine et al. (1987) who documented a large shoreward migration of sand from areas farther west. Such changes appear to have occurred during the late 1950s to late 1960s and were attributed to a massive mobilization and subsequent onshore movement of sand associated with the loss of extensive offshore seagrass meadows (Hine et al., 1987).

Three potential causes of seagrass loss were assessed by Hine et al. (1987) - hurricanes, water quality degradation, and "overgrazing" events. Hurricanes were not thought to be a likely cause of such a large loss of seagrass cover, as there were no major storms within the Anclote Key region between 1957 and 1973 (Rosen, 1976 as cited by Hine et al., 1987). In addition, there is little evidence of large-scale losses of seagrass cover due to tropical storms and/or hurricanes, as was documented in Biscayne Bay after Hurricane Andrew (Dawes et al., 1995), the Indian River Lagoon after Hurricanes Charley, Frances, and Jeanne (Steward et al., 2006), or the Alabama and Mississippi coasts after Hurricanes Ivan and Katrina (Byron and Heck, 2006).

Likewise, water quality degradation was not thought to be a primary cause of seagrass loss westward of Three Rooker Bar and Anclote Key, as those areas are more than two miles from mainland sources of potential nutrient-enriched stormwater and/or point sources, and areas closer to such potential degradation did not decrease over time. Also, water quality data – limited as it is – did not support the contention that turbidity had become a problem in those areas during the late 1950s to late 1960s (Hine et al., 1987). Instead, Hine et al. (1987) believed that a more likely cause of the massive loss of seagrass meadows offshore of Three Rooker Bar and Anclote Key was a population explosion of the spiny sea urchin, *Lytechinus variegatus*. Population explosions of this urchin have been previously documented in the extensive seagrass meadows between the

Steinhatchee and Suwannee Rivers (Camp et al., 1973). Figure 5-12 (from Camp et al., 1973) shows a "grazing front" moving through a lush meadow in the area near the Pepperfish Keys, Florida.

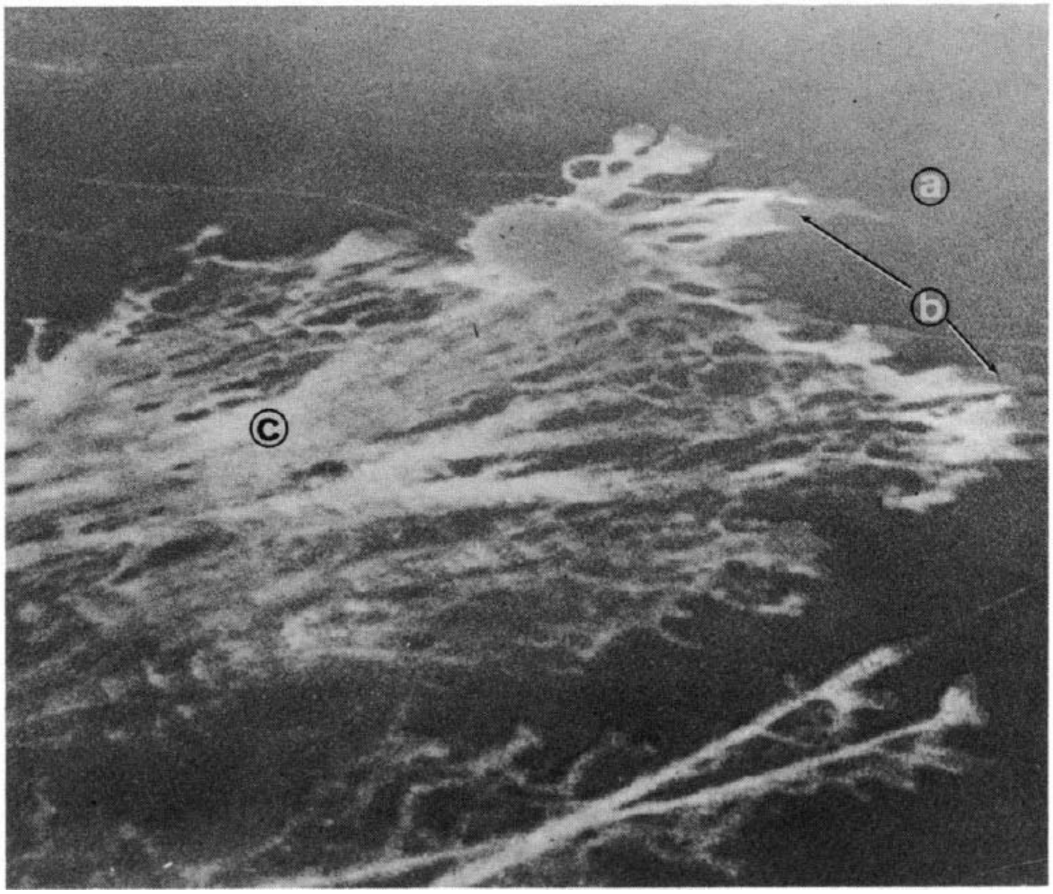


Figure 5-12. Aerial photograph of seagrass meadow offshore of Pepperfish Keys, Florida (from Camp et al. 1973). A = dense seagrass meadow, B = aggregation of sea urchins at grazing front, C – denuded seagrass meadow. Photograph taken at an elevation of approximately 1,000 feet.

As unusual as such a phenomenon may sound, population explosions of sea urchins and subsequent over-grazing events have been previously documented (in addition to Camp et al., 1973) in the waters near Key Largo (Bach, 1979) in Sarasota Bay (Sauers and Patten, 1981) and offshore of the lower Florida Keys (Peterson et al., 2002). Overgrazing of turtle grass by urchins can cause loss of apical meristems, death (not defoliation) of the meadows and subsequent erosion, loss of sediment and seed bank, and potentially permanent losses of acreage (Camp et al., 1973).

Seagrass loss in areas to the north and south of Three Rooker Bar could be indirectly associated with an urchin overgrazing event in another manner. Exposure of remaining seagrass meadows to wave energy from Gulf waters could increase due to the loss of the buffering effect of the former seagrass meadows that were directly lost to overgrazing. Exposure to higher wave energy could cause a loss of seagrass meadows, as offshore edges of seagrass meadows in areas of higher wave energy typically require higher light levels (Dawes and Tomasko, 1988; Duarte et al., 2007). Thus, the distribution of seagrass meadows in areas not directly influenced by grazing events could have declined in deeper water and increased landward into shallower waters in response to higher light level requirements under conditions of increased wave exposure, even without a change in water quality.

5.1.5 Seagrass Target Development

As described above, estimates were made of the amount of seagrass cover in Clearwater Harbor and St. Joseph Sound lost due to direct physical impacts such as the dredging of the ICW, the spoil islands associated with the ICW, and shoreline modification.

For St. Joseph Sound, approximately 297 acres of the decline from the historical seagrass extent is due to non-restorable areas. In addition, much of the seagrass losses since 1942 other than that lost to non-restorable areas can be attributed to factors other than water quality including longshore transport of sediments, accretion of sands along coastal barrier islands, and potential losses due to biological perturbations such as grazing. Therefore, historical seagrass acreages are not an appropriate target for St. Joseph Sound. Given that the recent seagrass surveys (2008 and 2010) have shown relatively greater extent than oberserved from 1999 through 2006, the mean of the recent surveys, 12,539 acres,is proposed as the seagrass target for St. Joseph Sound.

For Clearwater Harbor North, approximately 166 acres of the decline from the historical seagrass extent is due to such impacts. As such, a maximum potential restoration target would be 5,142 acres, which is the 1940s coverage (5,308 acres) minus 166 acres of non-restorable areas.

Similarly, for Clearwater Harbor South, approximately 129 acres of the decline occurs in non-restorable areas. As such, a maximum potential restoration target would be 1,595 acres, which is the 1940s coverage (1,724) minus 129 acres of non-restorable areas.

Table 5-2. Seagrass acreage within each segment for all years.

Segment	Adjusted 1942 Baseline	1999	2001	2004	2006	2008	2010
St. Joseph Sound	15,295	10,949	9,993	10,602	10,317	12,449	12,629
Clearwater Harbor North	4,782	2,416	2,765	2,832	3,521	3,783	3,758
Clearwater Harbor South	1,230	545	557	583	908	993	902

Note: The numbers reported above do not include seagrass acreage west of the barrier islands or in the Anclote River and are therefore different from the seagrass acreages reported by the Southwest Florida Water Management District

In St. Joseph Sound, areas of less persistent seagrass acreage should be further investigated. This effort should be undertaken due to the fact that recent seagrass mapping events have shown approximately equal periods of gains and losses in coverage, with the area of gains and losses mostly being in deeper waters. Investigations should focus on these areas to determine if and to what extent water quality conditions and seagrass biomass are contributing to variability in the mapped presence of seagrasses in these areas

In general, the areal extent of seagrass meadows in Clearwater Harbor North and South have been increasing over the past 10 years, while seagrass meadows in St. Joseph Sound exhibit an increasing trend only in the last two mapping events (i.e. 2008 and 2010). Large areas of historic seagrass loss in St. Joseph Sound appear due to physical disturbances such as barrier island movement, and the dredging of the ICW (and its associated spoil island placement) that account for approximately 20% of the loss of seagrass. Therefore, it seems unrealistic to develop a target for St. Joseph sound that is based on historical conditions and targets are developed based on the two most recent SWFWMD mapping events. However, historical areal seagrass estimates are used to develop seagrass areal extent targets for Clearwater Harbor North and Clearwater Harbor South.

The proposed segment-specific seagrass targets for the CHSJS estuary are:

- St, Joseph Sound 12,539 acres
- Clearwater Harbor North 4,782 acres
- Clearwater Harbor South 1,230 acres

Note: The numbers reported above do not include seagrass acreage west of the barrier islands or in the Anclote River and are therefore different from the seagrass acreages reported by the Southwest Florida Water Management District

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5.2 Estuarine Water Quality

Estuaries are among the most highly productive biological systems on earth. This productivity depends heavily on estuarine water quality dynamics. The combination of nutrient delivery, sediment delivery, circulation, emergent vegetation, submerged aquatic vegetation and the health of benthic and pelagic food webs combine to form a delicate balance that drives estuarine productivity. Circulation prevents stagnation of water, and increases mixing though it can increase turbidity and therefore decrease water clarity (Wolanski, 2007).High residence times allow enough time for organic detritus to contribute nutrients to the food chain but can lead to reduced dissolved oxygen concentrations (Wolanski, 2007). Therefore, estuarine water quality and overall productivity relies on a delicate balance of inputs, nutrient uptake and cycling and mediating influences such as residence times.

In the sub-tropical estuaries of the CCMP, water quality conditions are partially related to the expression of phytoplankton which contribute to overall productivity, but can also contribute to deleterious conditions and harmful algal blooms if allowed to proliferate. Phytoplankton concentrations (as measured by chlorophyll *a* concentrations) are thought to be limited by nutrient concentrations or nutrient loads to the estuary from the watershed. Phytoplankton concentrations can reduce light availability and thus affect the health and success of seagrass in the study area.

Currents, wind speed and sediment type also play a role in the health and success of seagrass in the study area. The health of seagrass contributes to the area being highly prized for recreational fishing. Water quality also impacts the temporal and spatial extent of water column habitat availability for those organisms whose survival and reproductive strategies are dependent on specific water quality conditions (e.g., specific salinity ranges, DO requirements, and water clarity).

This section characterizes past and present water quality conditions in the estuary, presents results of trend tests used to evaluate improving, stable or declining water quality condition over time, and identifies watershed attributes that potentially contribute stress to estuarine health. The process began with the identification of a list of critical questions related to water quality management issues. For estuarine water quality, the critical questions were:

- What is the current and past status of water quality in the estuary?
- How does estuarine water quality compare to regulatory standards?
- Are there trends in estuarine water quality over time?
- Are estuarine water quality conditions related to nutrient concentrations?
- Are estuarine water quality conditions related to nutrient loadings?
- Are there localized differences in estuarine water quality?
- What are appropriate management targets for estuarine water quality?

This section describes in detail outcomes of analysis addressing these critical questions and develops water quality management targets for the CCMP as well as numeric nutrient criteria that should serve as regulatory thresholds for compliance with regulatory obligations of Pinellas County with respect to permitting.

5.2.1 Estuarine Water Quality Data Collection

Pinellas County uses a three-tiered monitoring approach to collect water quality information that includes a probabilistic random design, a fixed-station design, and an event-based sampling design (Levy et al., 2004). The estuarine water quality sampling program was historically based on fixed stations until 2003 when a probabilistic sampling design was initiated (Janicki Environmental, 2003).

The probabilistic routine was designed to generalize water quality information collected at particular locations to the entire study area with statistical confidence specifically to fulfill the needs of the PCDEI while also being applicable to the FDEP for use in their Impaired Waters assessments. The historic fixed stations locations and a the distribution of samples collected under the probabilistic design between 2003 and 2009 in St. Joseph Sound, Clearwater Harbor North and Clearwater Harbor South is provided in Figures 5-13 through 5-15, respectively. The historic fixed stations in the estuary are highlighted with a blue circle.

In the past, a single fixed station within each estuarine segment was sampled monthly as a primary site. The other fixed stations were sampled bi-monthly as secondary sites. The location of these sites was based on professional judgment and sometimes located to monitor known or suspected pollutant sources. When the probabilistic design was implemented in 2003, the sampling frequency was divided into nine equivalently distributed “sampling periods” and the exact

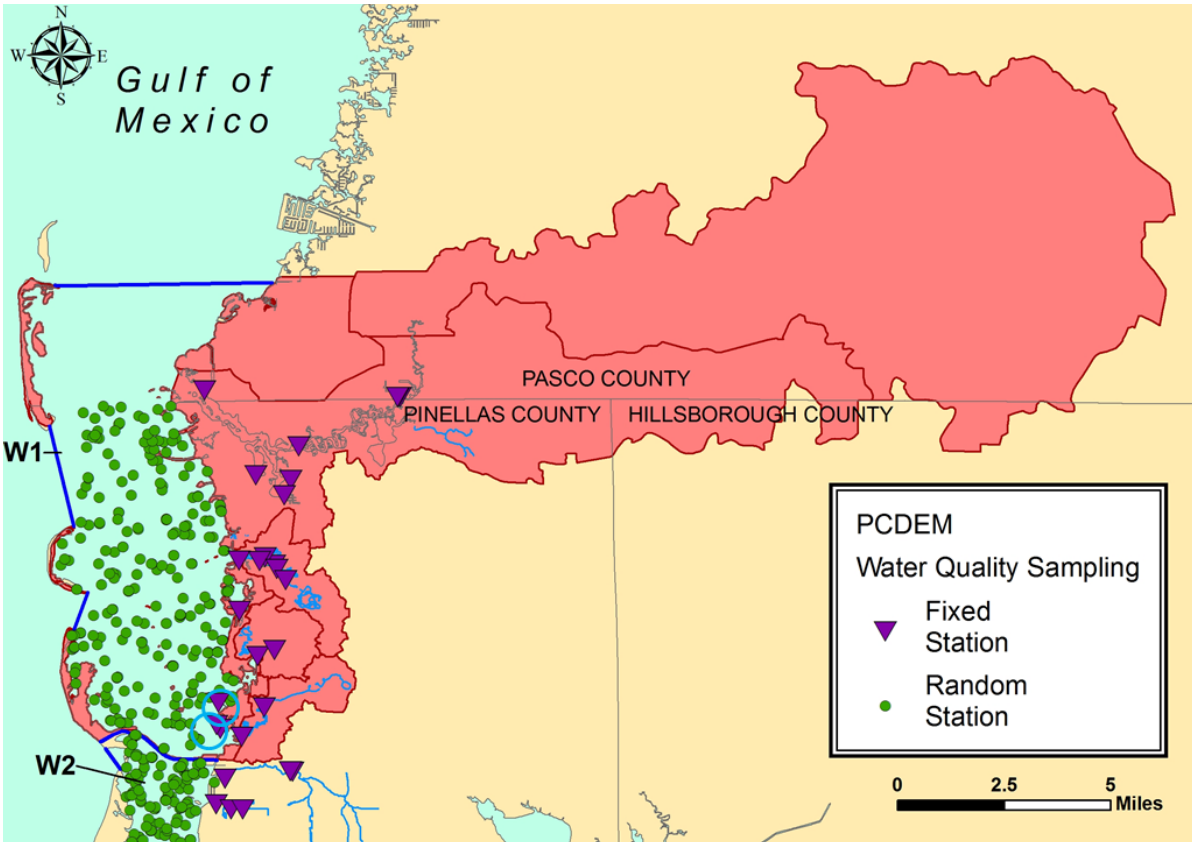

Figure 5-13. **Location of water quality sampling stations in St. Joseph Sound. Historical fixed stations in the estuary highlighted by blue open circles while probabilistic samples collected between 2003 and 2009 are represented by green filled circles.**

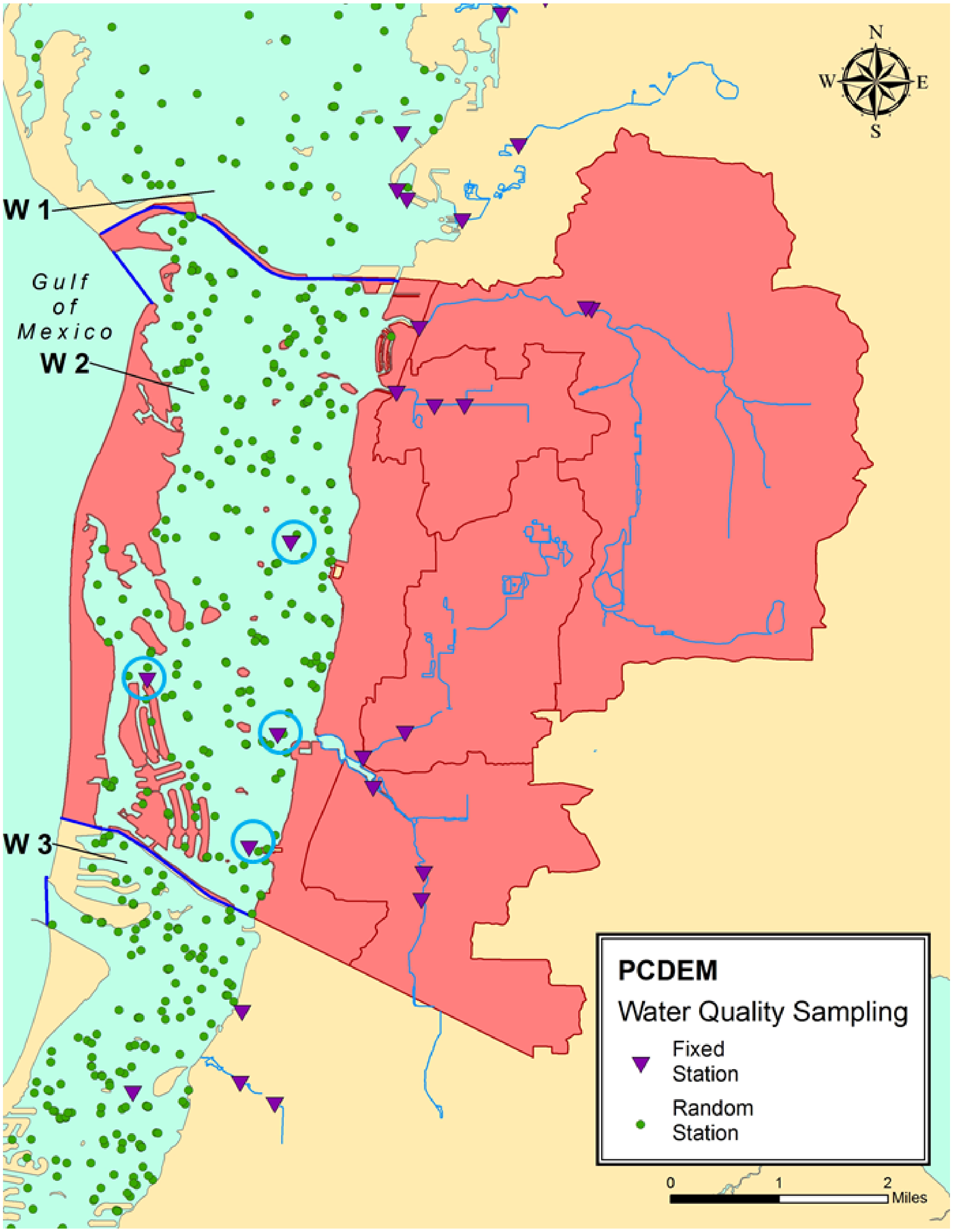

Figure 5-14. **Location of water quality sampling stations in Clearwater Harbor North. Historical fixed stations in the estuary highlighted by blue open circles while probabilistic samples collected between 2003 and 2009 are represented by green filled circles.**

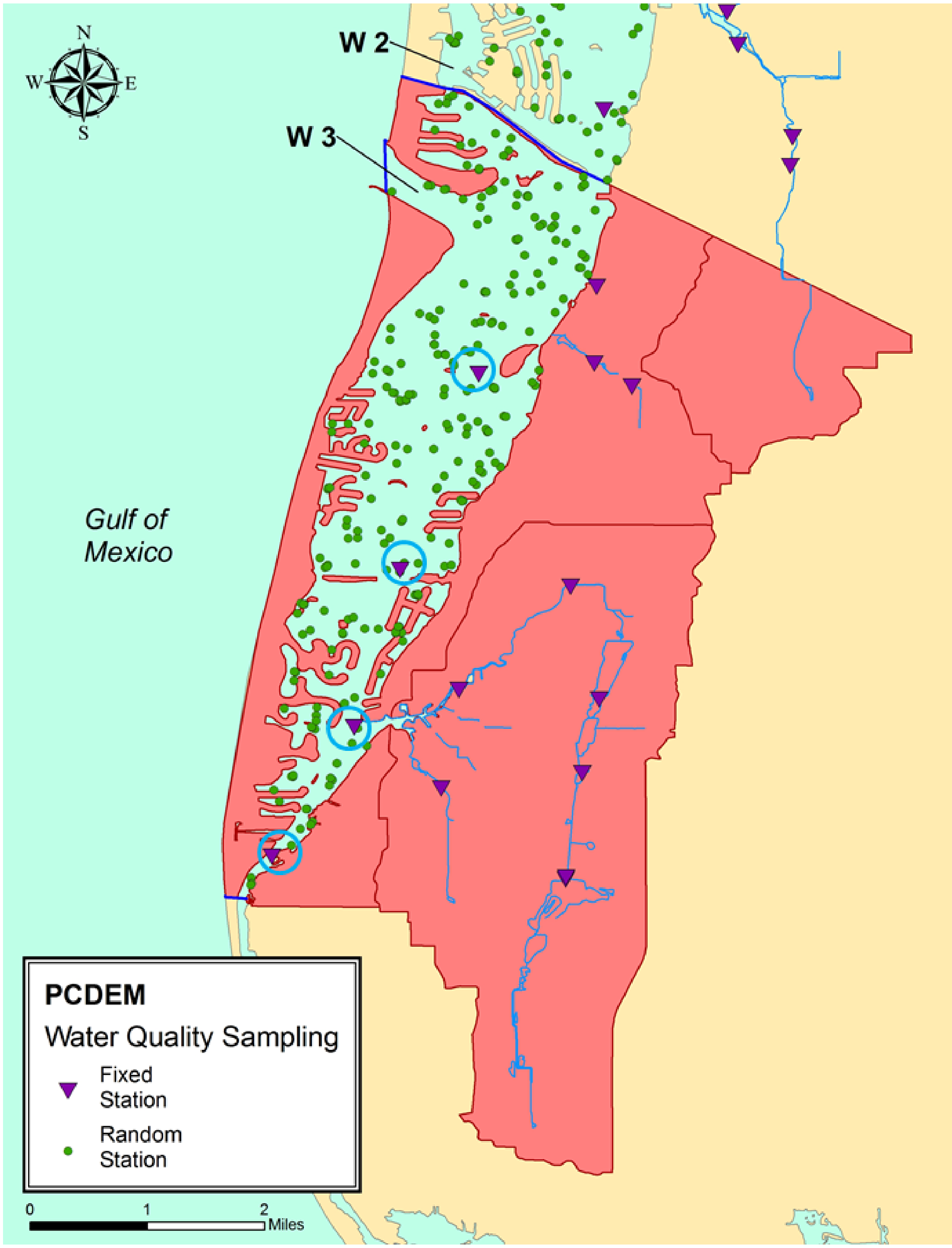

Figure 5-15. Location of water quality sampling stations in Clearwater Harbor South. Historical fixed stations in the estuary highlighted by blue open circles while probabilistic samples collected between 2003 and 2009 are represented by green filled circles.

sampling date within each sampling period was also assigned randomly from a list frame of potential sampling dates (Janicki Environmental, 2003). From 2003-2007, nine sampling periods were used within a year and a total of 36 samples were collected from each of three sampling strata in a year. In 2008, due to budget constraints, the County reduced the number of sampling periods from 9 to 8. Each annual sampling allocation was divided into eight periods and a total of 32 samples were collected in each stratum.

During each sampling event, water quality parameters measured *in situ* included: water temperature (^{O}C), salinity (ppt), conductivity (μS/cm), pH (su), and dissolved oxygen (DO) (mg/L). Grab samples were collected for laboratory analysis of constituents including; total nitrogen(TN) and total phosphorus (TP) (mg/L), chlorophyll *a* (μg/L), turbidity (mg/L), total suspended solids (mg/L), biochemical oxygen demand (mg/L) and 3 measures of light attenuation (Secchi disk depth (m), down-welling irradiance (K_d) (1/m), and transmissivity (%/10cm)). All field collections were performed according to FDEP standard operating procedure and laboratory analysis was performed to NELAC standards.

5.2.2 Estuarine Water Quality Status

As discussed above, one of the critical questions regarding water quality in the CHSJS estuary is "What is the current status of water quality in the estuary?". The following presents an examination of the current status of the CHSJS estuary with regard to chlorophyll *a*, TN, and TP concentrations, as well as examination of the likelihood of low DO conditions.

The average chlorophyll *a* concentration from data collected between 2003 and 2009 was 2.7 μg/L, 4.0μg/L, and 5.7μg/L for St. Joseph Sound, Clearwater Harbor North and Clearwater Harbor South, respectively, well below the FDEP threshold of 11 μg/L. A brief comparison of recent data collected using the probabilistic design (2003-2009) and historical fixed station data collected from 1992-2002 is provided below to give descriptive context to changes in water quality over time. For the purposes of understanding past and present conditions of these segments it was important to understand if and how these disparate datasets may be used in the target setting process. This discussion is followed by a quantitative assessment of trends in water quality.

A descriptive assessment comparing recent and historical water quality suggests that water quality conditions with respect to chlorophyll *a* concentrations have improved over time. Average chlorophyll *a* concentrations based on the historical fixed station data were 6.2μg/L, 7.2μg/L, and 8.3 μg/L for St. Joseph Sound, Clearwater Harbor North, and Clearwater Harbor South, respectively. The distribution of chlorophyll *a* concentrations in historical and recent datasets is provided in Figure 5-16. Note that the distribution of chlorophyll *a* concentrations is higher in the historical fixed station data than in the recent data and that the same latitudinal (north-south) gradient exists in both datasets suggesting a persistent latitudinal gradient in chlorophyll *a* concentrations throughout the study area. All within-segment differences were statistically significant using the Wilcoxon Rank Sum test (Sokal and Rohlf, 1984).

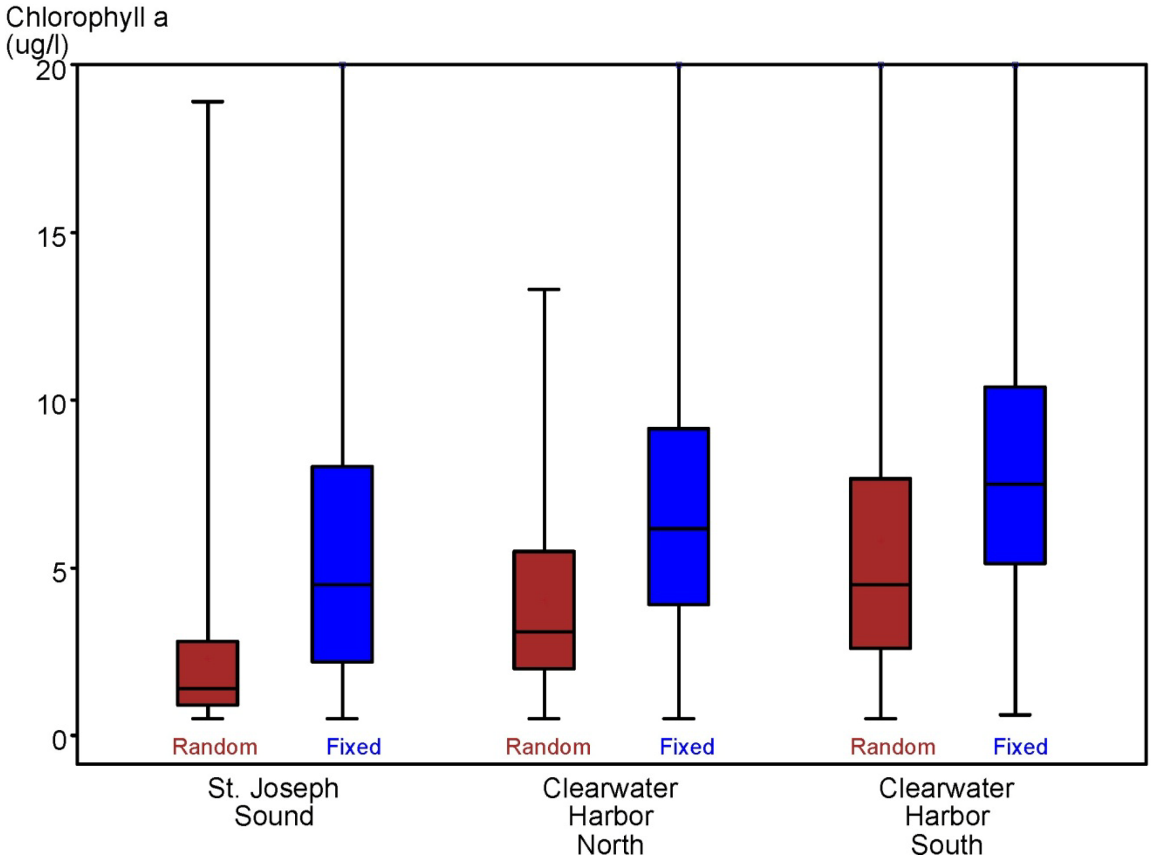

Figure 5-16. Distribution of chlorophyll a concentrations in historical fixed station "Fixed" and recent probabilistic "Random" data in all three CHSJS segments.

Further supporting evidence of improving chlorophyll *a* concentrations comes from an examination of timeseries trends in chlorophyll *a*. Annual averages for chlorophyll *a*, TN and TP were calculated for each historical station within a segment. The probabilistic data were assigned a station name corresponding to the strata name for the segment (i.e. W1 for St. Joseph Sound, W2 for Clearwater Harbor North, and W3 for Clearwater Harbor South) and annual averages were calculated for all of the "random" samples within the segment each year. The annual averages for each timeseries were then plotted with each trend depicted as a single line (Figures 5-17 – 5-19). There are several elements of note in these figures.

- First, there is substantial correlation in the timeseries trend among fixed stations over time in each segment.
- Second, the fixed station trend appears to continue with the timeseries of probabilistic data.
- Lastly, all annual average chlorophyll *a* values were well below the FDEP state threshold of 11 μg/L other than two stations in Clearwater Harbor South in 1997 and 1998 (even in these years the overall segment average was below the threshold value).

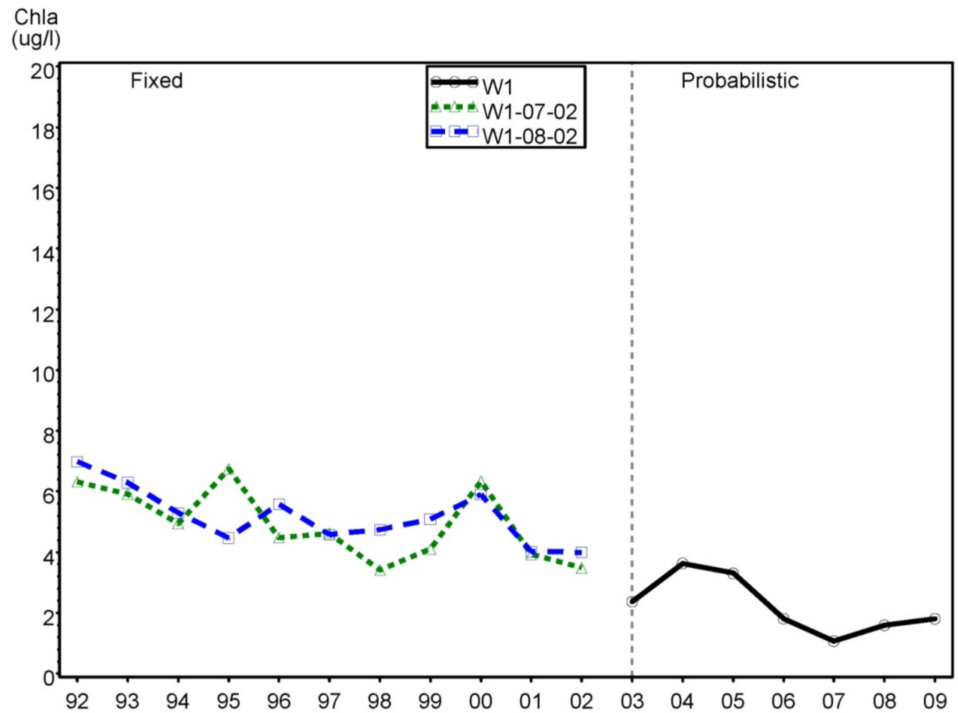

Figure 5-17. **Annual average chlorophyll *a* values in St. Joseph Sound. Individual fixed stations sampled between 1992 and 2002 and the probabilistic data sampled since 2003 (designated as "Station W1"). The broken vertical line indicates the beginning of the probabilistic data collection.**

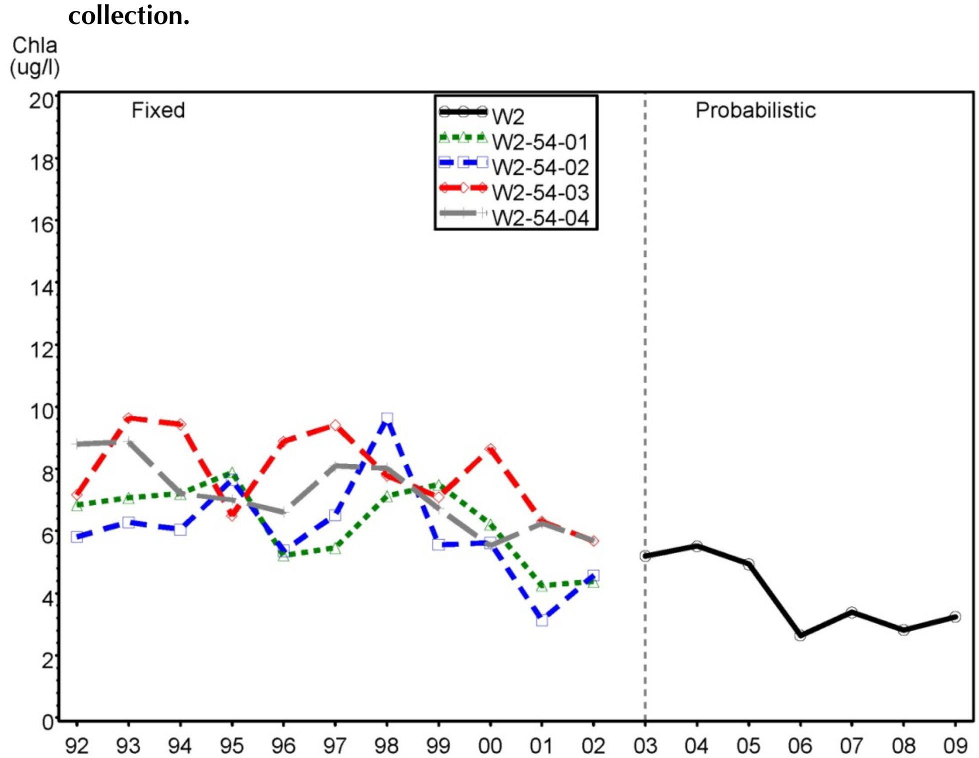

Figure 5-18. **Annual average chlorophyll *a* values in Clearwater Harbor North. Individual fixed stations sampled between 1992 and 2002 and the probabilistic data sampled since 2003 (designated as "Station W2"). The broken vertical line indicates the beginning of the probabilistic data collection.**

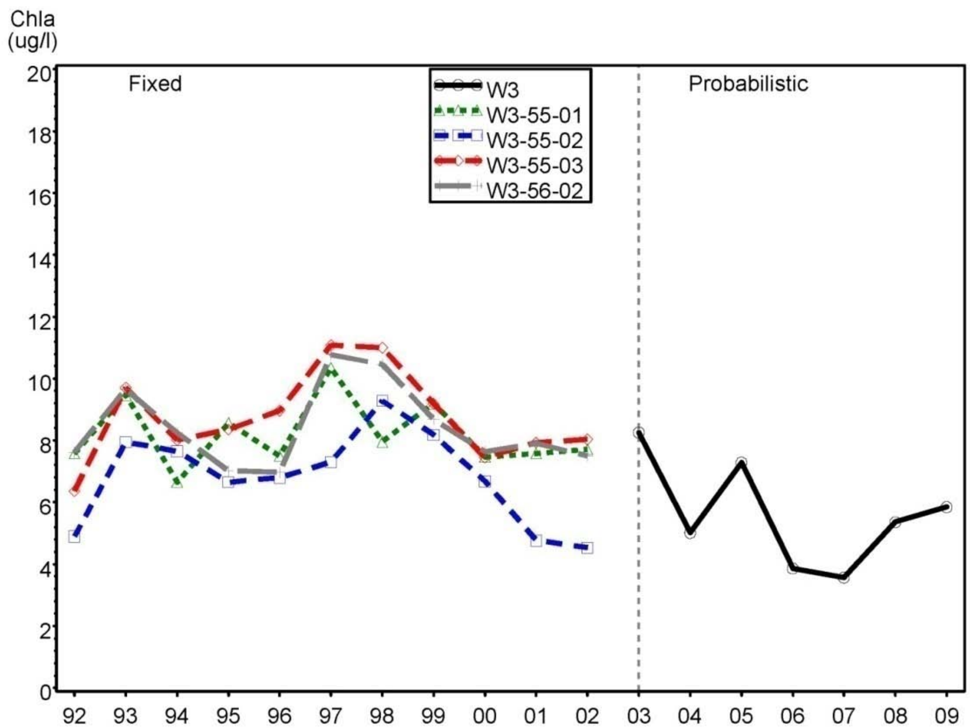

Figure 5-19. **Annual average chlorophyll *a* values in Clearwater Harbor South. Individual fixed stations sampled between 1992 and 2002 and the probabilistic data sampled since 2003 (designated as "Station W3"). The broken vertical line indicates the beginning of the probabilistic data collection.**

This information suggests that while there is an average difference among stations within a segment, water quality at these stations appears to respond similarly to common drivers of water quality within the segment on an annual time scale. Further, individual station averages tended to co-vary over time despite the different sampling frequencies between stations within a segment. This information is supporting evidence that the fixed station information may be generally representative of trends in water quality over time on an annual time scale and that variability within a segment is a significant attribute lending credence to the implementation of the probabilistic design which is more likely to represent the true average condition of the segment. Similar plots for TN and TP are provided in Appendix K.

The evidence provided by these descriptive plots suggests that all segments are currently meeting their designated use with respect to maintaining healthy chlorophyll *a* concentrations. Moreover, chlorophyll *a* concentrations have been declining in both St. Joseph Sound and Clearwater Harbor North over time at the fixed station sites suggesting conditions have improved in these segments since the early to mid-1990s. Clearwater Harbor South appears to respond in a somewhat different manner than the other two segments and may be more susceptible to variability in nutrient loadings and residence times than the other two segments. This will be further discussed in the following section on quantitative targets. The shorter duration of probabilistic data combined with large scale variability in climatic conditions between 2003 and 2009 has resulted in a more hyperbolic pattern in the chlorophyll *a* trends under the probabilistic design with evidence of the drought from 2006 and 2008 expressed in the timeseries.

A comparison of TN concentrations (Figure 5-20) suggests that TN concentrations were more similar between historical and recent data than observed in the chlorophyll *a* concentrations, especially in Clearwater Harbor North and Clearwater Harbor South. A Wilcoxon Rank Sum test suggests that statistically different distributions were only found in St. Joseph Sound. This difference in St. Joseph Sound may be due to the location of the fixed stations towards the southern end of the segment while the probabilistic data were collected throughout the Sound, including waters that may be more characteristic of the Gulf of Mexico.

The distributions of TP concentrations were significantly different between historical and recent data in all segments (Figure 5-21); however, the differences relative to the changes in chlorophyll *a* concentrations were not nearly as dramatic with average differences less than 0.02 mg/L in all segments.

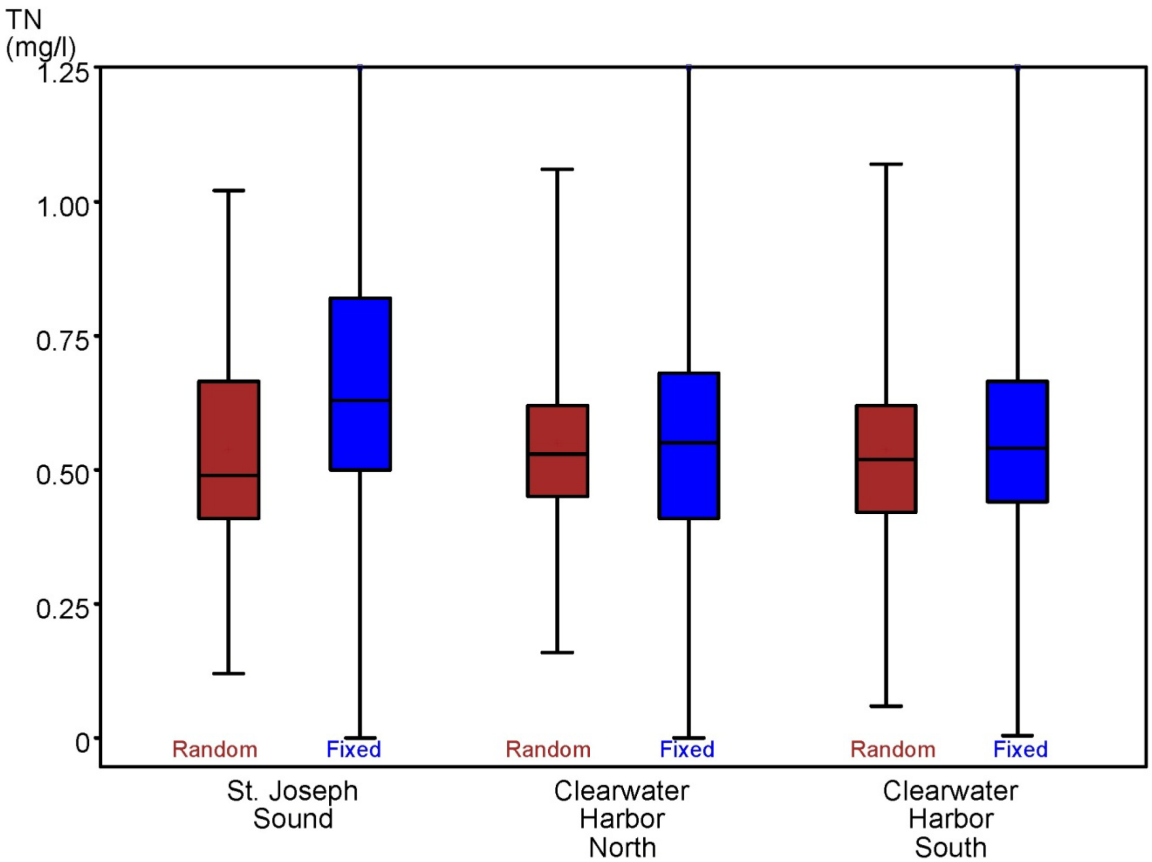

Figure 5-20. Distribution of TN concentrations (mg/L) in historical fixed station "Fixed" and recent probabilistic "Random" data in all three CHSJS segments.

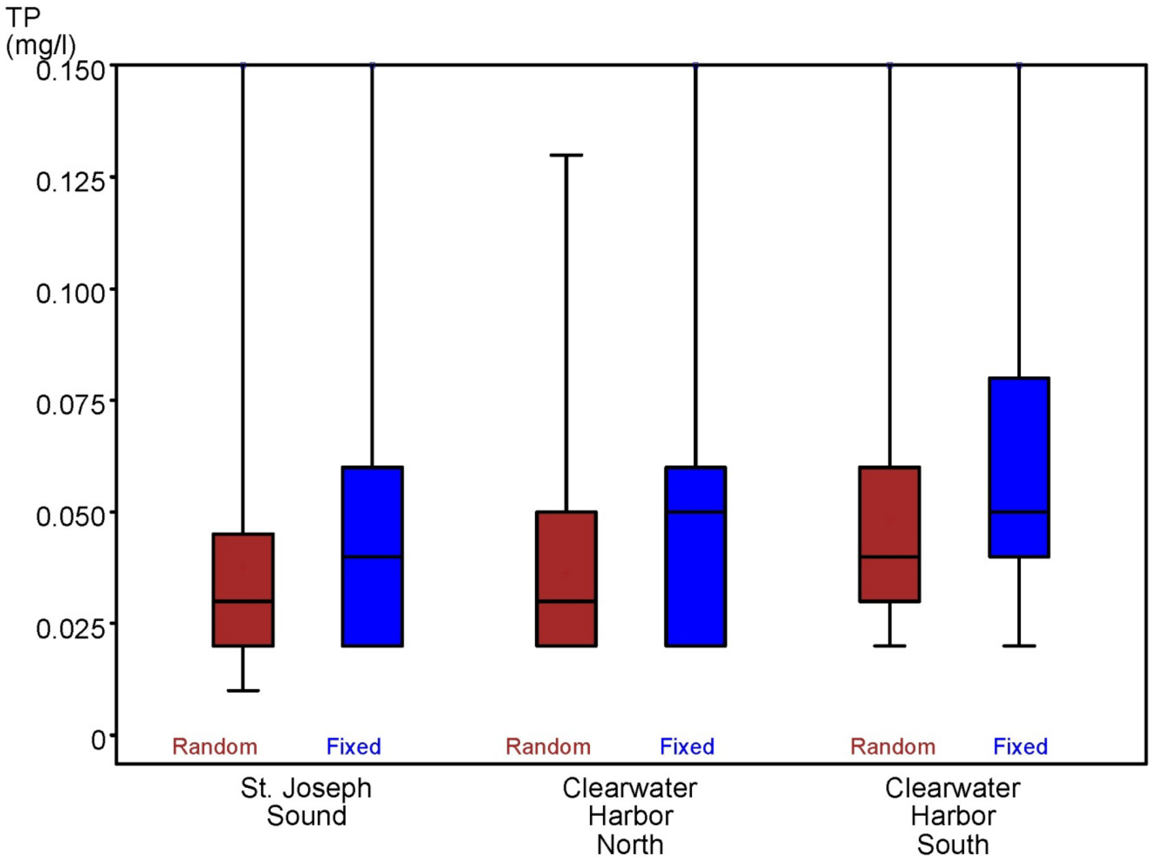

Figure 5-21. Distribution of TP concentrations (mg/L) in historical fixed station "Fixed" and recent probabilistic "Random" data in all three CHSJS segments.

Dissolved oxygen is a measure used to assess a waterbody with respect to meeting its designated uses and providing full aquatic life support. The FDEP uses a 10% exceedance frequency of DO as a measure of impairment in their 303d regulatory assessment. The exceedance frequency (defined as a value below 4 mg/L) for each year for which data exists was calculated in each estuarine segment. The exceedance frequencies for each year within a segment are presented in the bar charts are Figures 5-22 – 5-24. Results of these plots suggest that each of these segments have met their full aquatic life uses with respect to DO in all years. There was only a single year (2001) in a single segment (CHS) when the 4 mg/L exceedance frequency approached 10%.

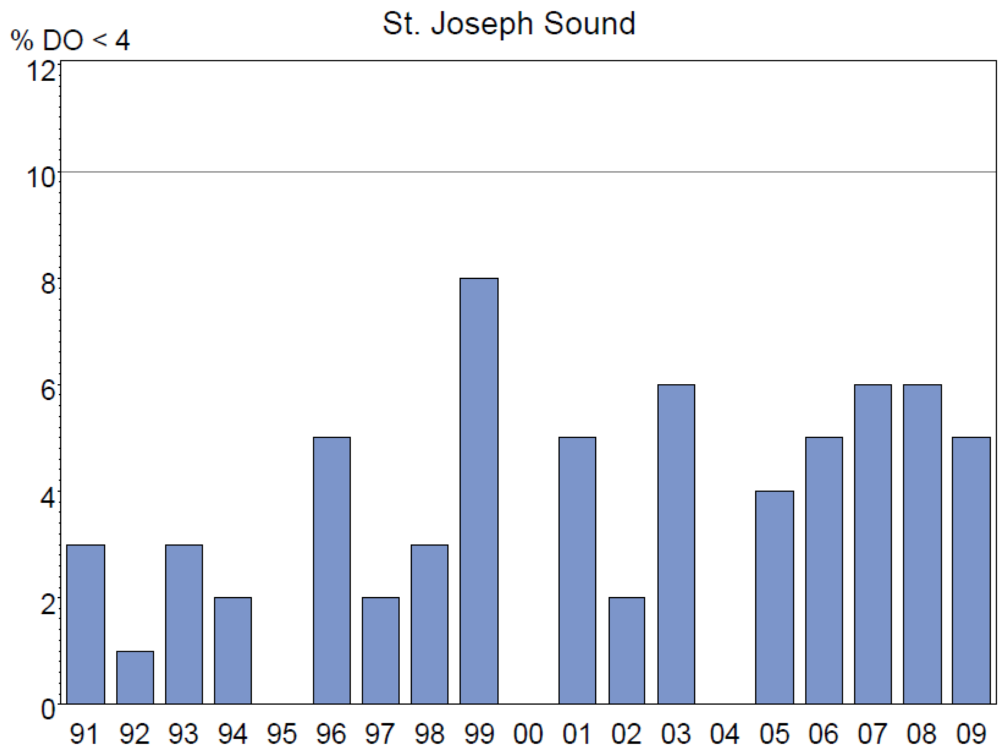

Figure 5-22. Percent of DO samples below 4 mg/L in St. Joseph Sound for each year in the period of record. Years without bars had no values below 4 mg/L.

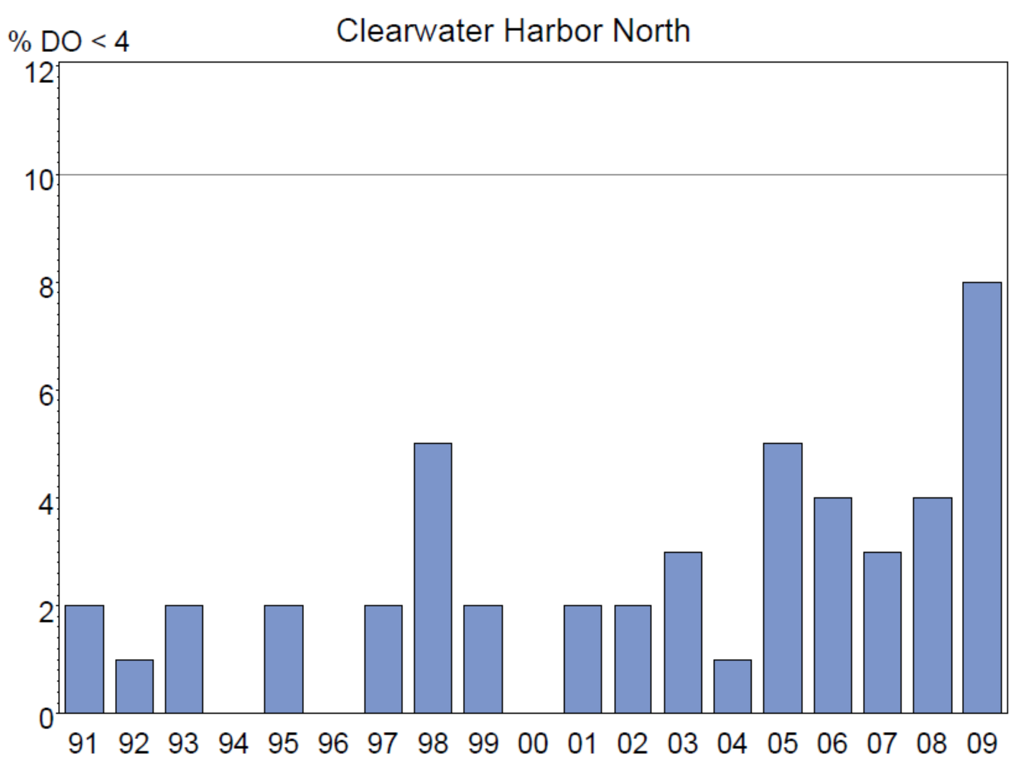

Figure 5-23. Percent of DO samples below 4 mg/L in Clearwater Harbor North for each year in period of record. Years without bars had no values below 4 mg/L.

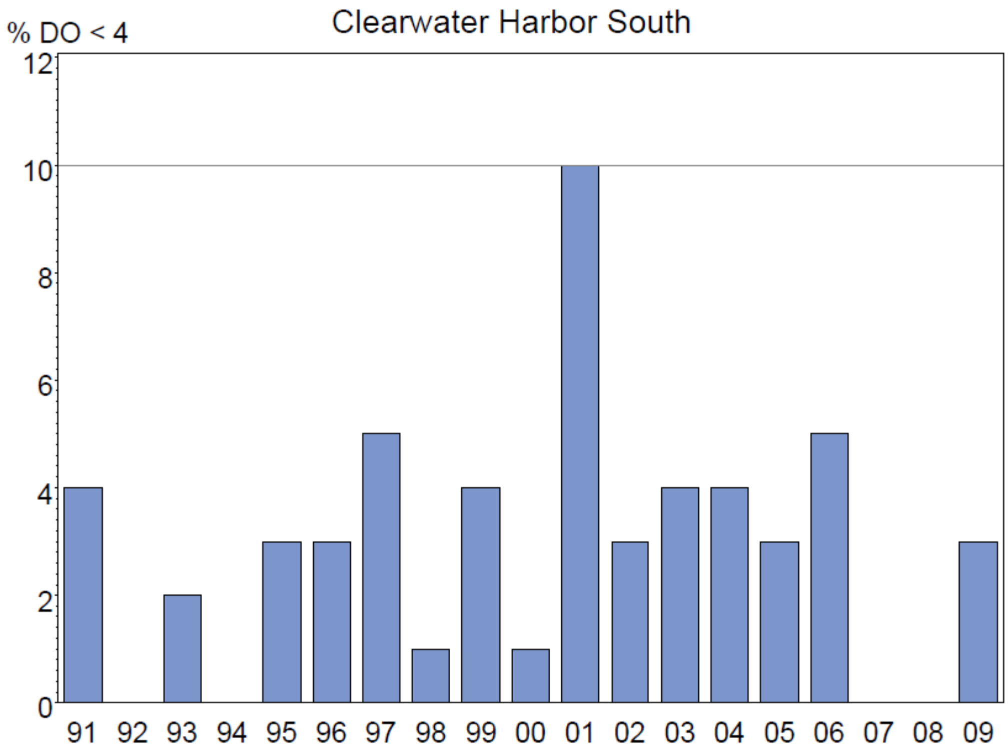

Figure 5-24. Percent of DO samples below 4 mg/L in Clearwater Harbor South for each year in period of record. Years without bars had no values below 4 mg/L.

A comparison of inter-segment similarities in water quality was achieved using a principal components analysis (PCA). This analytical approach provides a multivariate description of sample sites that may be informative for interpretation of ecological processes and useful for resource management of these waterbodies. Water quality variables used to ordinate sites included annual averages for: water temperature, pH, bottom DO, salinity, chlorophyll *a*, TN, TP, TSS, and turbidity. Figure 5-25 graphically presents the PCA results.

The primary water quality differences among the CHSJS segments, observed along PCA axis1, were due to those variables associated with water clarity. St. Joseph Sound differs from Clearwater Harbor North and South due to greater Secchi disc depths and transmittance and lower chlorophyll *a* and turbidity than in harbor segments. Clearwater Harbor North differs, to a lesser degree, from Clearwater Harbor South due to greater Secchi disc depths and transmittance and lower chlorophyll *a* and turbidity than in the latter. Temporal water quality variation in all three segments were captured along the second PCA axis 2. Data from 2007 through 2009 were marked by higher salinity and lower DO and were likely related to the relatively lower freshwater inputs during those years.

5.2.3 Estuarine Water Quality Trends

The second critical question regarding water quality in the CHSJS estuary is "Are there trends in estuarine water quality over time?" Both historical and recent data were used to examine the temporal trends in water quality. As discussed above, the probabilistic data were assigned a station name corresponding to the strata name for the segment (i.e., W1 for St. Joseph Sound, W2 for Clearwater Harbor North, and W3 for Clearwater Harbor South) and averages were calculated for

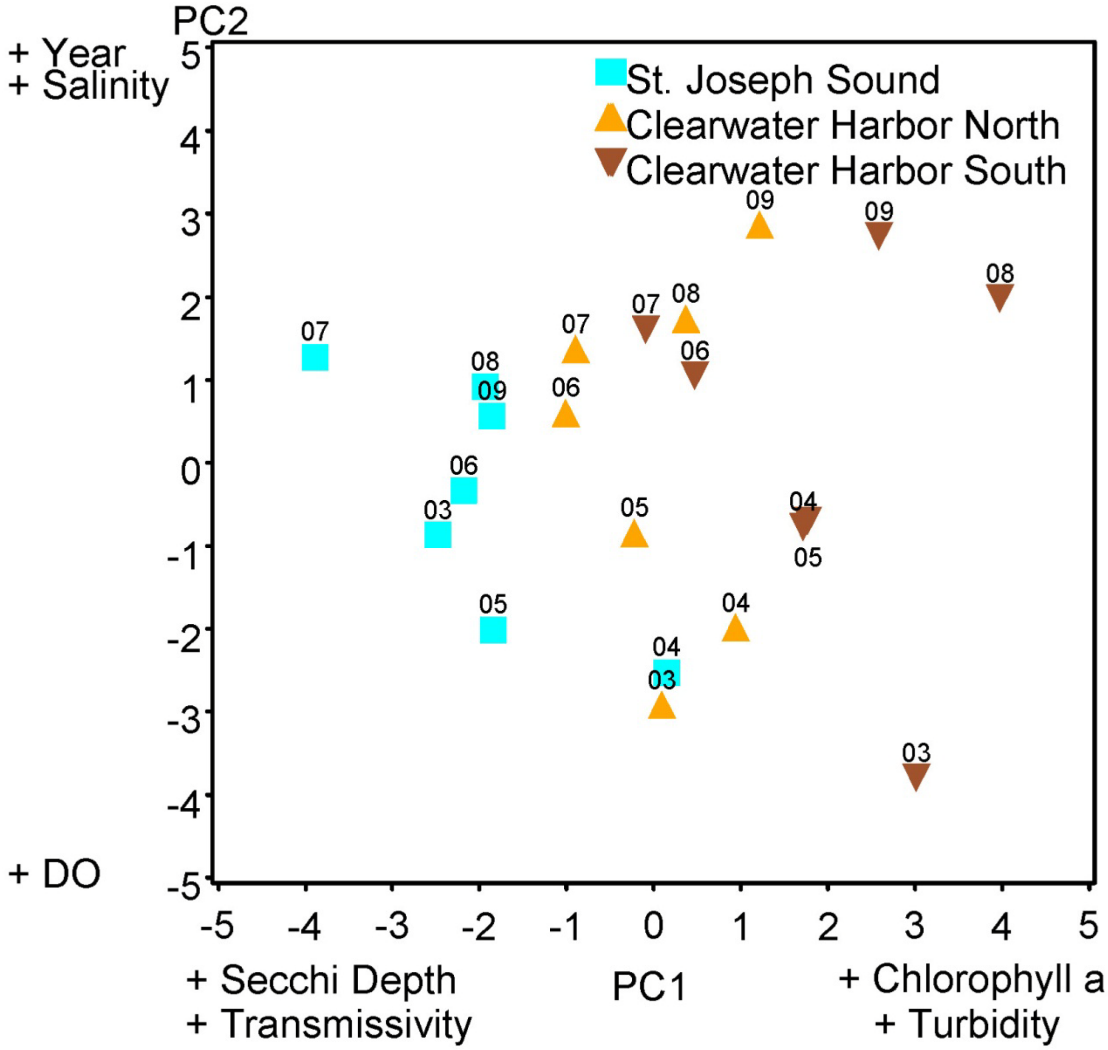

Figure 5-25. **Graphical results of the principal components analysis of estuarine water quality data fro the three CHSJS segments.**

Each sampling period in a year. Historical fixed stations were likewise grouped into sample periods that correspond to the current sampling regime.

The Kendall Tau trend test (Reckhow, 1993) is a robust and commonly used statistical test for water quality trend detection. Results of the Kendall Tau trend test for chlorophyll *a*, TN, and TP concentrations by station are provided in Table 5-3. Statistically significant decreasing trends in chlorophyll *a* were observed in both historical and recent data in St. Joseph Sound and Clearwater Harbor North, but not in Clearwater Harbor South. The majority of TN trend tests resulted in no trend detected except one historical station in Clearwater Harbor North (54-01) and Clearwater Harbor South (55-01) where small decreasing trends were observed (0.1 mg/L or less over 10 years). Decreasing trends in TP were common in the historical fixed station data; however, the more recent data suggests that TP concentrations are stable and have increased slightly in St. Joseph Sound (<0.03 mg/L over 9 years).

Segment	Station	Parameter	Trend Direction	Median slope
St. Joseph Sound	W1	Chla	Decreasing	-0.166
		TN	No Trend	0.000
		TP	Increasing	0.003
	W1-07-02	Chla	Decreasing	-0.200
		TN	No Trend	0.000
		TP	Decreasing	-0.005
	W1-08-02	Chla	No Trend	0.000
		TN	No Trend	0.000
		TP	Decreasing	-0.004
Clearwater Harbor North	W2	Chla	Decreasing	-0.444
		TN	No Trend	0.000
		TP	No Trend	0.000
	W2-54-01	Chla	Decreasing	-0.253
		TN	Decreasing	-0.007
		TP	Decreasing	-0.004
	W2-54-02	Chla	No Trend	0.000
		TN	No Trend	0.000
		TP	Decreasing	-0.005
	W2-54-03	Chla	No Trend	0.000
		TN	No Trend	0.000
		TP	Decreasing	-0.004
	W2-54-04	Chla	Decreasing	-0.258
		TN	No Trend	0.000
		TP	Decreasing	-0.004
Clearwater Harbor South	W3	Chla	No Trend	0.000
		TN	No Trend	0.000
		TP	No Trend	0.000
	W3-55-01	Chla	No Trend	0.000
		TN	Decreasing	-0.011
		TP	Decreasing	-0.004
	W3-55-02	Chla	No Trend	0.000
		TN	No Trend	0.000
		TP	Decreasing	-0.005
	W3-55-03	Chla	No Trend	0.000
		TN	No Trend	0.000
		TP	Decreasing	-0.004
	W3-56-02	Chla	No Trend	0.000
		TN	No Trend	0.000
		TP	No Trend	0.000

Table 5-3. Results of Kendall Tau trend test for chlorophyll *a* and nutrient concentrations. Chla = chlorophyll *a*.

5.2.4 Comparison of CHSJS Estuarine Water Quality to Existing Water Quality Standards

The third critical question regarding water quality in the CHSJS estuary is "How does estuarine water quality compare to regulatory standards?". Currently, none of the FDEP WBIDs within the open bay segments of the estuary are listed as FDEP impaired waterbodies with respect to either nutrients or DO. The WBIDs within the CHSJS estuary, as with all estuarine WBIDs in the state, have been identified as being impaired with respect to mercury. This pervasive problem has been identified as being due to atmospheric deposition.

5.2.5 Estuarine Water Quality Targets and Thresholds

The descriptive assessment above has provided supporting evidence that the CHSJS estuary is currently meeting the regulatory criteria currently established to support a healthy, well-balanced population of fish and wildlife and fully support their designated aquatic uses with respect to chlorophyll *a* and DO. However, identification of scientifically sound quantitative management targets and regulatory thresholds, i.e., numeric nutrient criteria, are desired. To that end, a quantitative analysis leading to the development of quantitative management targets and numeric nutrient criteria is provided below.

Establishment of water quality targets and thresholds initially depends upon identification of critical indicators of estuarine health. Seagrasses have long been accepted as such an indicator (Bortone, 2005; Greening and Janicki, 2006; Janicki Environmental, 2010; EPA, 2010c; FDEP, 2011). Water clarity, to varying degrees, is dependent upon algal abundance, turbidity, and water color. Since chlorophyll *a* (i.e., algal abundance) is dependent upon nutrient conditions, it serves as a second indicator of estuarine health. DO has also been proposed as a critical estuarine health indicator recently by EPA in its work on numeric nutrient criteria for Florida estuaries. Seagrass growth and reproduction depends upon an adequate light environment. Excessive chlorophyll *a* has also been linked to hypoxia in estuarine waters. As a consequence of its relationship to both seagrasses and DO, chlorophyll *a* provides the third indicator of environmental health as it pertains to the establishment of numeric nutrient criteria.

Janicki Environmental (2010c) developed a document that identified a number of empirical approaches for the development of numeric nutrient criteria for southwest Florida estuaries. EPA has also identified three basic approaches for the development of numeric nutrient criteria in Florida waters (EPA, 2010c), including:

1. reference condition approach,
2. stressor-response models, and
3. water quality simulation models.

Each of these approaches has inherent strengths and weaknesses. At a recent meeting of the Science Advisory Board (SAB) convened by EPA, some of the initial input pointed to the support for consideration of the stressor-response model. The following presents the results from examination of a number of stressor-response models that link chlorophyll *a* to a variety of nutrient condition variables including both ambient concentrations and loadings.

- **Stressor-Response Relationships**

The identification of a quantitative relationship between a response in chlorophyll *a* concentrations and known stressors expressed as either nutrient concentrations or nutrient loads would be an important consideration in development of a conservation and management plan for the study area. Quantitative relationships using the stressor-response approach can be used to estimate the value of a response variable that is expected to result from a given value of the causal variable such as TN or TP. Quantitative approaches such as regression are based on the covariance between causal (stressor) and response variables. A simple first step is to assess the univariate correlation among potential stressor and response variables. The nonparametric Spearman's rank correlation procedure was used to obviate the need for transformations and assumptions associated with parametric statistics and to provide insights on which of the water quality constituents co-varied. Positive values indicate that the two constituents increase and decrease in magnitude together while negative values indicate that an increase in one value is correlated with a decrease in the other. For the purpose of this analysis, a meaningful association was operationally defined as a correlation coefficient greater than an absolute value of 0.40 (|0.40|). All correlations with coefficients greater than |0.40| had a p value less than 0.05 indicating statistical significance as well. This simple analysis yielded some insightful results though it is important to understand that inference is restricted to association with this procedure and no causality is inferred. Chlorophyll *a* values were positively associated with turbidity and negatively correlated with 2 of the three measures of light attenuation: Secchi disk depth, and transmittance (Table 5-4).

This correlation pattern was remarkably consistent among segments. The nutrient parameters TN and TP were correlated with chlorophyll *a* values in Clearwater Harbor South according to the 0.40 criterion. The light attenuation parameters transmittance and Secchi disc depths were highly correlated with one another but neither was well correlated with the light attenuation parameter K_d. Associations between chlorophyll *a* and either transmittance or Secchi disc depths were stronger than between chlorophyll *a* and either TN or TP concentrations. Given the extensive seagrass habitat in the CHSJS estuary and the need for protection of these seagrasses, the association between chlorophyll *a*, turbidity, and light attenuation is worthy of further consideration and is described in more detail in the section on light attenuation later in this chapter.

An extension of the correlation analysis was to develop regression models capable of predicting a stressor-response relationship. The use of empirical regression models to quantify stressor-response relationships is a popular and well accepted method of establishing water quality targets, thresholds and criteria used to regulate and manage estuarine waterbodies. When data are sufficient to develop robust regression models, the models can be used to develop expectations for a given response variable given the value of a stressor variable. Sometimes other predictor variables ("covariates") can be used to explain variability in response due to a covariate. In the CCMP study area there were sufficient data to explore stressor-response relationships using chlorophyll *a* concentrations as the response parameter and nutrient values (TN and TP) as stressor variables.

Regression analysis was performed separately for the historical fixed stations and the probabilistic data. Analysis was performed on the raw data, and data averaged monthly by station (or stratum). Initially, exploratory regression analysis was conducted by assessing several potential predictor variables including the parameters listed above (excluding measures of light attenuation) as well as a seasonal term to account for effects of temperature and photoperiod on the expression of chlorophyll *a* via phytoplankton photosynthesis. Those predictor variables identified as statistically significant were then used to develop the final regression models for evaluation. Where multiple predictor variables were identified in the initial regression effort, a variance inflation factor (VIF) was used to assess multi-colinearity among predictors though the correlation analysis suggested few instances where this may be the case. A VIF value greater than 10 indicated the presence of multi-colinearity and the regression was reduced by dropping one of the variables. A criterion used to determine if the final regression models were sufficiently accurate and robust to use in developing estuarine water quality targets and thresholds was operationally defined as a coefficient of determination (R^2) value greater than 0.50. Regression analysis was performed separately using nutrient concentrations as stressor variables and using nutrient loads as stressor variables.

Table 5-4. Table of Spearman rank correlation coefficients for relevant water quality parameters in the CCMP study area by segment. Correlation coefficients > 0.40 are shaded in grey.								
Parameter	Chlorophyll a (μg/L)	TN (mg/L)	TP (mg/L)	TSS (mg/L)	Turbidity (NTU)	Transmittance (%)	K_d (1/m)	Secchi Disc Depth (m)
St. Joseph Sound								
Chla	1.00							
TN	0.36	1.00						
TP	0.26	0.24	1.00					
TSS	0.03	0.12	-0.13	1.00				
Turbidity	0.53	0.18	0.19	0.10	1.00			
Trans	-0.63	0.04	0.09	-0.34	-0.67	1.00		
K_d	0.16	-0.26	-0.17	0.23	0.05	-0.13	1.00	
Secchi	-0.52	-0.37	-0.14	0.03	-0.43	0.74	-0.23	1.00
Clearwater Harbor North								
Chla	1.00							
TN	0.36	1.00						
TP	0.36	0.26	1.00					
TSS	0.18	0.05	-0.01	1.00				
Turbidity	0.40	0.09	0.14	0.37	1.00			
Trans	-0.53	-0.11	0.06	-0.36	-0.59	1.00		
K_d	0.17	0.03	-0.08	0.02	0.24	-0.30	1.00	
Secchi	-0.51	-0.30	-0.19	-0.34	-0.52	0.68	-0.46	1.00
Clearwater Harbor South								
Chla	1.00							
TN	0.40	1.00						
TP	0.48	0.40	1.00					
TSS	0.23	0.07	0.08	1.00				
Turbidity	0.46	0.16	0.26	0.41	1.00			
Trans	-0.56	-0.38	-0.35	-0.48	-0.65	1.00		
K_d	0.43	0.29	0.17	0.23	0.20	-0.48	1.00	
Secchi	-0.52	-0.25	-0.30	-0.42	-0.60	0.76	-0.47	1.00

- **Chlorophyll *a* - Nutrient Concentration Relationships**

None of the stressor-response relationships using the raw data passed the criterion R^2 value of 0.50 established for use in developing water quality targets for the CCMP (Table 5-5). A very few regressions did achieve an R^2 above 0.50 using the monthly averaged data (Table 5-6). Two historical fixed stations in Clearwater Harbor South and one historical station in St. Joseph Sound resulted in significant regression relationships. The coefficients for variables significant in the regression model and the R^2 statistic are listed in these tables. Where significant relationships were established, seasonality and turbidity contributed significantly to the regression and were key determinants of chlorophyll *a* concentrations. Generally, the historical fixed station design regressions were not supported by the probabilistic data. Regressions using the monthly averaged probabilistic data suggested that seasonality was the principal factor in determining chlorophyll *a* concentrations and TN was a contributing factor only in Clearwater Harbor South.

Table 5-5. Regression results using the raw (not temporally average) data values.

Segment	Station	Intercept	Season	TN (mg/L	TP (mg/L)	TSS (mg/L)	Turbidity (NTU)	R^2
St Joseph Sound	W1-08-02	-2.87	2.46	4.5			1.73	0.5
	W1-07-02	0.17	2.52		23.9		1.01	0.35
	W1 -Random	0.79	1.08				0.63	0.15
Clearwater Harbor North	W2-54-03	2.54	4		25.6		0.33	0.43
	W2-54-01	-1.94	2.39	10.2			0.36	0.39
	W2-54-04	0.32	1.95	5.18			0.61	0.31
	W2-54-02	1.67	3.34	5.76				0.28
	W2-Random	0.78	1.5	3.59			0.22	0.15
Clearwater Harbor South	W3-55-03	0.84	3.08	6.82			0.35	0.5
	W3-56-02	0.15	3.63		40.4	0.23		0.47
	W3-55-02	-0.93	2.08		46.9	0.25		0.44
	W3-55-01	0.91	3.16	6.79			0.32	0.38
	W3-Random	-0.16	2.49	6.45	23.7			0.28

Table **5-6. Regression results using the monthly average data values.**

Segment	Station	Intercept	Season	TN (mg/L)	TP (mg/L)	TSS (mg/L)	Turbidity (NTU)	R^2
St Joseph Sound	W1-08-02	-2.15	2.70	4.38			1.51	0.51
	W1-07-02	1.06	3.07	4.51				0.26
	W1-Random	1.87	1.23					0.11
Clearwater Harbor North	W2-54-03	2.74	4.35		28.74		0.31	0.45
	W2-54-01	-1.47	2.03	10.05			0.35	0.33
	W2-54-04	3.56	2.09				0.58	0.25
	W2-54-02	2.01	3.05	5.94				0.24
	W2-Random	3.40	1.82					0.15
Clearwater Harbor South	W3-55-02	-0.34	2.78		39.11	0.15	0.23	0.54
	W3-55-03	2.87	4.58		25.28		0.39	0.53
	W3-56-02	0.80	3.84		38.67	0.24		0.47
	W3-55-01	1.64	3.10	5.89			0.35	0.37
	W3-Random	-0.22	3.08	8.88				0.33

Given that the historical fixed station data and the probabilistic data were temporally discrete, direct comparisons were difficult especially given the historical trend in water quality described above. However, the probabilistic data suggests that the historical fixed station data may not be representative of the entire segment with respect to developing empirical stressor-response relationships to describe potential cause and effect relationships on monthly time scales for regulatory and management purposes. Descriptive statistics and bivariate plots associated with this analysis can be found in Appendix L.

- **Chlorophyll *a* - Nutrient Loading Relationships**

Stressor-response relationships using nutrient loadings to each estuarine segment were assessed using monthly average chlorophyll *a* concentrations and monthly nutrient loadings to each estuarine segment. Cumulative loadings up to 5 months (i.e., sum of the current month and the previous 4 months) were considered as potential stressors along with seasonal factors as described above. Nutrient loadings were natural log transformed for this analysis to conform to assumptions of regression analysis.

Results of loading regressions indicated that nutrient loadings were also poor predictors of chlorophyll *a* concentrations in the CHSJS estuarine segments, using either the historical fixed station data of the probabilistic data of the more 2003-2009 time period (Table 5-7). Highest R^2 statistics were 0.31 and did not meet the *a priori* criterion value of 0.50 to accept the regression for developing water quality targets. In many cases, seasonality was the only significant predictor of chlorophyll *a* concentrations in the estuary. Given that the regression relationships were less than convincing to define a stressor-response relationship, alternative methods were explored.

Table 5-7. Results of regression analysis using nutrient loadings to the estuarine segment of interest. Antecedent loadings are denoted by a number indicating the number of months of cumulative load. For example, L2_TN is the two-month cumulative TN load.

Segment	Station	Intercept	Season	l3_tn	l4_tn	l5_tn	l2_tp	l3_tp	R^2
St. Joseph Sound	W1 -Random	0.50	0.13				1.82		0.31
	W1-08-02	3.93	5.13						0.15
	W1-07-02	3.58	5.50						0.12
Clearwater Harbor North	W2-54-02	1.13	3.04					2.66	0.31
	W2 -Random	-0.18	1.45	1.30					0.26
	W2-54-03	5.92	7.11						0.17
	W2-54-01	4.81	3.83						0.17
	W2-54-04	5.89	3.18						0.08
Clearwater Harbor South	W3-Random	-2.11	3.69			2.42			0.29
	W3-55-03	6.63	4.62						0.28
	W3-56-02	6.34	4.87						0.28
	W3-55-02	3.07	2.22		1.22				0.18
	W3-55-01	6.42	5.12						0.13

- **Localized Effects: Spatial Distributions and Autocorrelation**

Assessment of the spatial distributions of water quality can provide information on potential problem areas within a segment. It is in the interest of the CCMP to understand localized issues within the estuary in order to optimize allocation of resources to mitigate anthropogenic effects on estuarine health. Examining the spatial distribution patterns of water quality data and the extent to which a particular location is surrounded by a cluster of high or low values can provide insights into potential "hotspots" worthy of further investigation. It is also useful to examine the covariance among different water quality constituents by putting the data on a uniform scale. To this end, two statistics were used to examine spatial patterns in estuarine water quality indicators. Moran's I index and the Getis-Ord G* statistic (Ord and Getis, 1995) were calculated with ArcGIS v9.2 (ESRI 2009) and used to identify spatial autocorrelation patterns in chlorophyll *a* and TN concentrations throughout the study area. Moran's I was used to identify a distance band that best described autocorrelation in the data. Results suggested a 3-nautical mile band best described spatial autocorrelation. The 3-mile distance band was then used as the threshold distance to calculate the Getis-Ord G* statistic that identified clustering patterns within the data using a Z score. The Z score is used as a statistical test of clustering with values greater than 2 indicating a statistically significant cluster of data which can be either statistically higher than or lower than the average value.

The CHSJS-wide plots (Figure 5-26) display clear chlorophyll *a* patterns with high value clustering (red dots) in Clearwater Harbor South and low value clustering (blue dots) in St. Joseph Sound. However, a similar gradient for TN concentrations was not observed. In fact, the only statistically significant clustering for TN was low value clustering observed in the vicinity of Clearwater Pass in the northern portion of Clearwater Harbor South and along the western edge of St. Joseph Sound. This result supports the lack of a direct stressor-response relationship between TN and chlorophyll *a* and points to residence times as a factor affecting the expression of phytoplankton biomass in the study area. This analysis generalizes the spatial relationships across seasonal and inter-annual variations but illustrates that the relationship between TN and chlorophyll *a* is more complex than a direct stressor-response relationship. Examination of seasonal TN distributions (across years) reveals no statistically significant clustering pattern with TN in either summer or winter distributions using the same distance band (Figure 5-27). Higher than average values did tend to occur in the northern portion of the study area just below the Anclote River and near Fred Howard Park in Summer. Conversely during winter this area tended to have below average values but in both cases these patterns were not statistically significant.

5.2.6 Establishing Water Quality Targets and Thresholds

Given the results of analysis described above, and the fact that seagrasses are currently stable or improving throughout the CHSJS estuary it is reasonable to conclude the recent water quality conditions are sufficient to maintain full aquatic life uses in the estuary. However, there is little evidence to conclude that:

- increased nutrient concentrations would result in impaired water quality as defined by current regulatory standards,
- increased chlorophyll *a* concentrations would result in impaired water quality with respect to DO, and
- increased chlorophyll *a* concentrations would result in reduced water clarity as measured as downwelling irradiance (K_d).

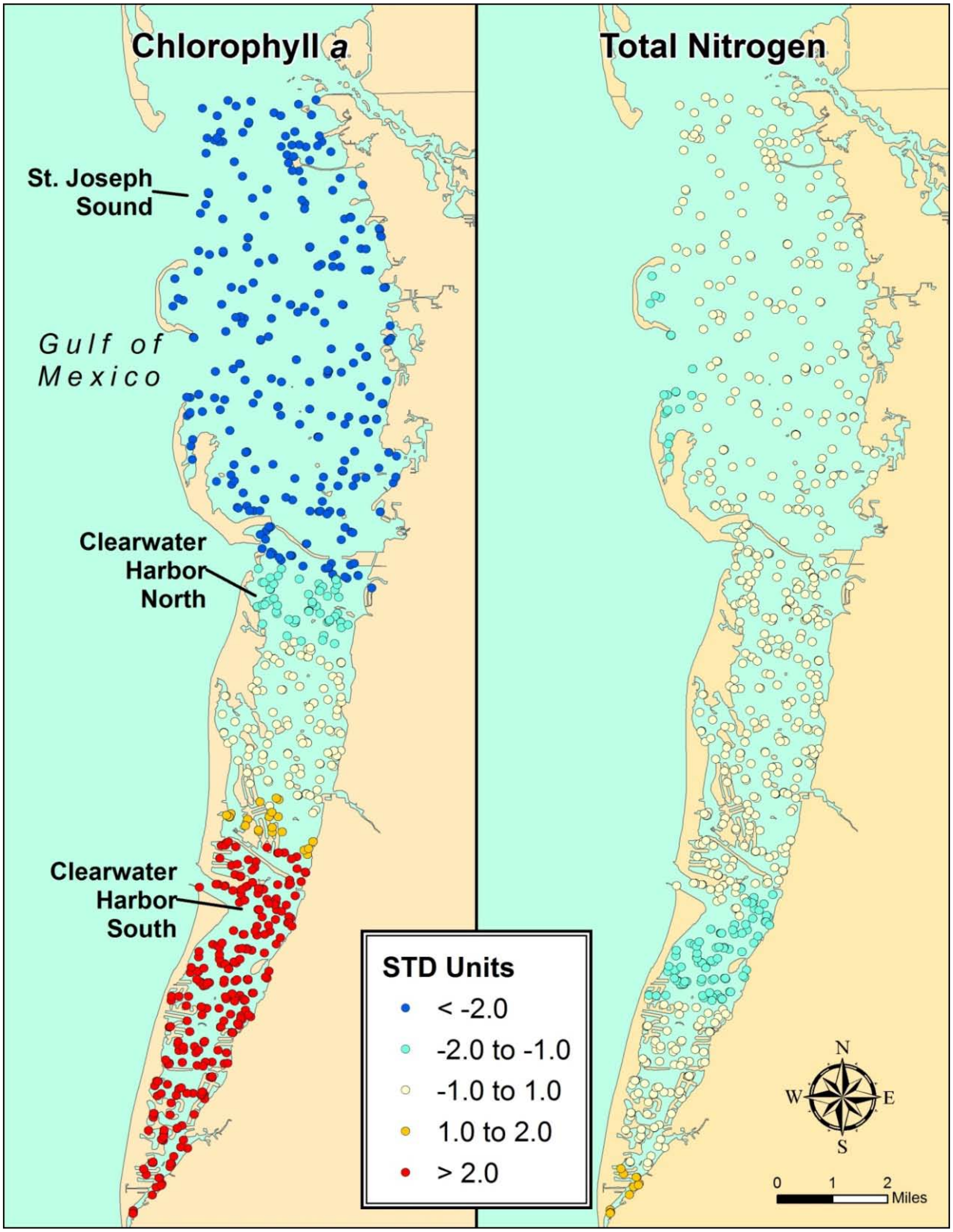

Figure 5-26. **Spatial distribution of chlorophyll *a* (left) and TN (right). Red dots indicate significant clustering of higher than average values and blue dots indicate statistically lower than average values.**

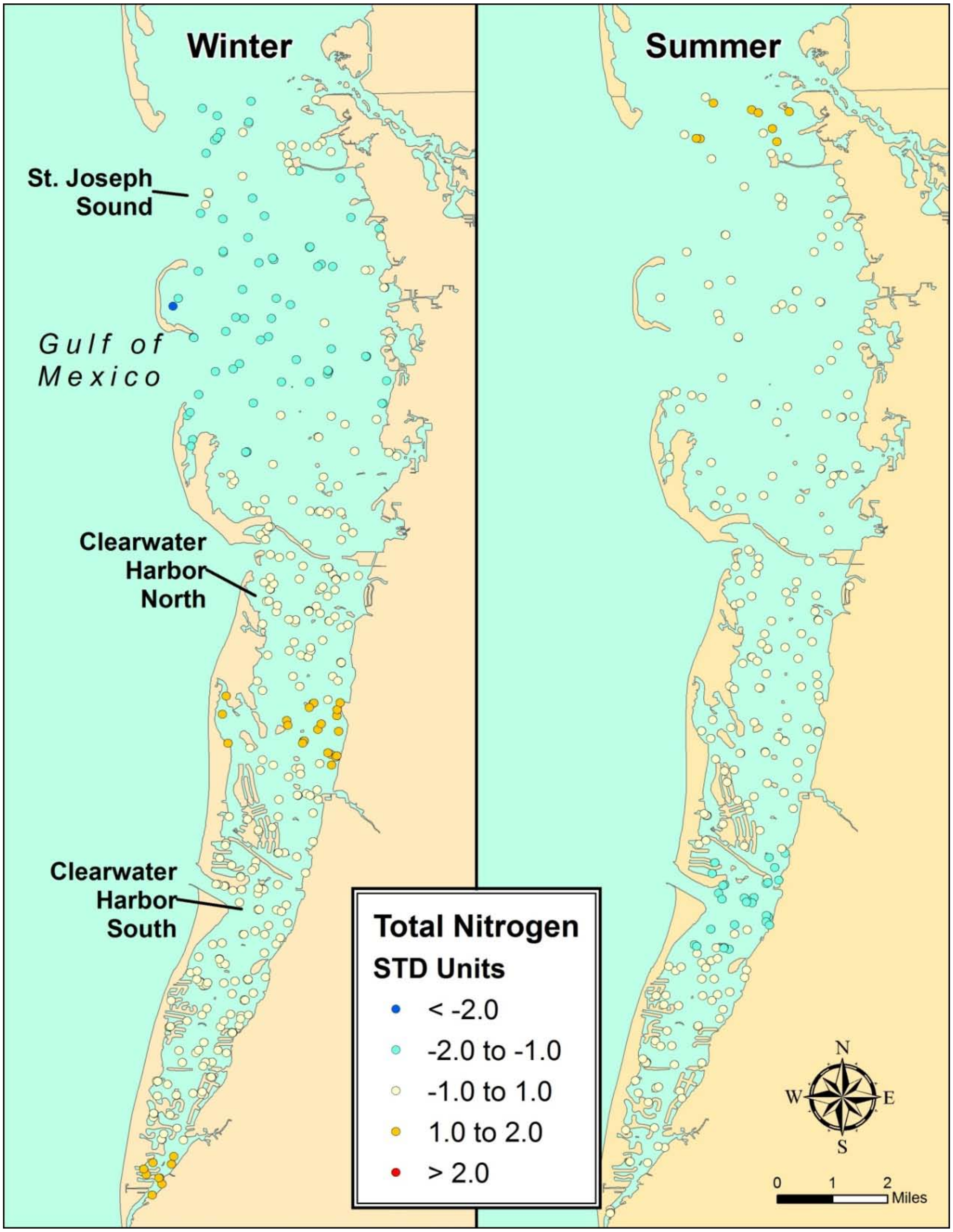

Figure 5-27. **Spatial distribution of TN in winter months (i.e. Oct-May: Left) and summer months (June-September: Right).**

For the purposes of the CCMP and in compliance with recent management practices, a goal of the CCMP should be to ensure that water quality conditions in the estuary are protective of two critical indicators of estuarine health – seagrasses and DO. Therefore, based on the considerations above, the targets and thresholds for water quality were established as follows:

- apply a reference period approach to establish water quality **targets** (e.g., desired chlorophyll *a* and nutrient concentrations) for each CHSJS estuarine segment, and
- establish **threshold** values (i.e., chlorophyll *a* or nutrient concentrations above which undesirable concentrations exist and should not be exceeded) for regulatory inference by characterizing a statistically significant departure from the reference period average.

- **Water Quality Targets**

Following a reference period approach, the proposed estuarine water quality targets are the overall geometric mean of nutrient and chlorophyll *a* concentrations and % transmittance from the probabilistic sampling regime data between 2003 and 2009 (Table 5-9). The standard deviation of the annual averages over the same time period for each constituent is also provided to describe what is considered the population of potential sample means from the reference period.

Table 5-8. Proposed targets expressed as the geometric average and the associated standard deviation (Std) based on the probabilistic data collected between 2003-2009.

Parameter	St. Joseph Sound		Clearwater Harbor North		Clearwater Harbor South	
	Mean	Std	Mean	Std	Mean	Std
Chlorophyll a (μg/L)	1.86	0.63	3.45	0.97	4.75	1.44
TN (mg/L)	0.53	0.07	0.54	0.04	0.53	0.03
TP (mg/L)	0.04	0.01	0.04	0.01	0.05	0.01
Transmittance (%)	89.6	3.5	81.6	3.2	74.3	6.4

To assess compliance with the management targets, the geometric means and standard deviations of Table 5-9 can then be used to define a value from which from which water quality is not expected to exceed. Based on normal distribution theory, at least 95% of all sample means taken would fall below (mean +1.95*Std) if water quality data remained similar to that of the reference period. Therefore, this value (i.e., mean +1.95*Std) is established as the threshold value. A geometric mean higher than the threshold value would then be considered an excursion. This construct can then be used to test the sample geometric means for the three parameters for compliance with the established thresholds. For example, in Clearwater Harbor South an annual geometric mean chlorophyll greater than 7.56 μg/L (i.e., 4.75+1.95*1.44) would result in a water quality excursion for that parameter. A table listing the proposed target exceedance values for evaluating annual geometric means of each constituent in each segment is provided in Table 5-10. If an annual geometric mean is higher than these values then it is to be considered an excursion.

Table 5-9. Proposed thresholds expressed as the sum of the geometric average and 1.95*the associated standard deviations (Std) from Table 5-8.

Parameter	St. Joseph Sound	Clearwater Harbor North	Clearwater Harbor South
Chlorophyll a (μg/L)	3.1	5.4	7.6
TN (mg/L)	0.66	0.61	0.58
TP (mg/L)	0.05	0.05	0.06
Transmittance (%)	82.8	75.4	61.8

- **Proposed Numeric Nutrient Criteria**

The targets and thresholds developed as management criteria are proposed to be used to evaluate water quality with respect to not allowing for degradation of water quality from that observed over recent time period (i.e. 2003-2009) when the open bay estuarine segments were fully meeting their designated uses. Within this context, an excursion is defined as when an annual geometric average for a particular constituent had exceeded the threshold value. This annual geometric mean should be derived from water quality sampling according to Pinellas County's probabilistic water quality sampling design for estuaries (Janicki Environmental 2003) in their designated strata "W1", "W2" , and "W3" corresponding to St. Joseph Sound, Clearwater Harbor North and Clearwater Harbor South, respectively. Further, the use of minimum detection limits other than those used by Pinellas County will affect compliance assessment with respect to these threshold values. These thresholds are not to be considered as end of pipe criteria for regulatory purposes. Further, a single excursion of the threshold value does not necessarily mean that there has been significant degradation of water quality. The analyses described in Chapter 5.2 suggest that there have been times when estuarine water quality values for chlorophyll *a*, TN, TP, and transmittance have historically exceeded the proposed threshold values while the estuarine waters were meeting full aquatic life uses. While it is known that there is a limit for nutrient inputs above which any estuary would become compromised in meeting its full aquatic support, without a defensible quantitative stressor-response relationship, this limit cannot be predicted. The reference period approach was used to provide potential numeric criteria for TN and TP; however, the estuarine responses as measured by seagrass areal extents, and dissolved oxygen concentrations should be used to verify that an excursion of any proposed numeric nutrient criteria such those described above is related to adverse effects relating to full aquatic life uses of these estuarine waterbodies.

With respect to pending numeric nutrient criteria proposed by EPA, The CCMP thresholds may be considered as site specific criteria for these waterbodies under the constraints and assumptions described above. While EPA has stated that the numeric nutrient criteria must be expressed as concentrations others, including DEP, have argued that the estuarine numeric criteria can and should be expressed as loadings. Therefore, both concentration - and loading-based TN and TP criteria are proposed. Pollutant loading-based thresholds have also been derived using the same methods described above for concentrations, using the geometric averages from the reference period and the standard deviations associated with estimate of the population of geometric mean values.

The proposed chlorophyll *a* targets and thresholds are:

	Target	Threshold
• St. Joseph Sound	1.9 μg/L	3.1 μg/L
• Clearwater Harbor North	3.5 μg/L	5.4 μg/L
• Clearwater Harbor South	4.8 μg/L	7.6 μg/L

•

The proposed % transmittance targets and thresholds are:

	Target	Threshold
• St. Joseph Sound	90%	83%
• Clearwater Harbor North	82%	75%
• Clearwater Harbor South	74%	62%

The proposed TN and TP Concentration-based numeric criteria are:

	TN Criterion	TP Criterion
• St. Joseph Sound	0.66 mg/L	0.05 mg/L
• Clearwater Harbor North	0.61mg/L	0.05 mg/L
• Clearwater Harbor South	0.58mg/L	0.06 mg/L

The proposed TN and TP loading-based numeric criteria are:

	TN Criterion	TP Criterion
• St. Joseph Sound	493 tons/yr	85 tons/yr
• Clearwater Harbor North	124 tons/yr	17 tons/yr
• Clearwater Harbor South	58 tons/yr	7 tons/yr

5.3 Estuarine Emergent Wetlands

In Chapter 4, estuarine wetlands occurring on the mainland side of the study area were quantified and management goals and targets were established to protect the extent of estuarine wetland habitat types in the watershed. In this section, the remaining estuarine wetlands occurring along spoil and barrier islands in the estuary are described. Since 1942 there has been a 27% loss in the historical acreage of estuarine wetlands on the coastal islands. The overwhelming majority of this loss has occurred in Clearwater Harbor South where an estimated 89% of historical wetlands were lost. Los mangroves and salt marshes has been replaced by primarily residential development, ship channel dredging, and port construction, resulting in commensurate decreases in fish and wildlife habitat and resources. This section on estuarine wetlands presents the results of a multi-decadal assessment of the changes and trends in estuarine wetlands in Clearwater Harbor and St. Joseph Sound and the factor(s) most likely influencing these changes. The areal extent of changes and targets for conservation and restoration are also presented.

- **Mangroves, Salt Marshes, and Salterns**

Estuarine wetlands in the coastal portions of the Clearwater Harbor and St. Joseph Sound watersheds include primarily mangrove forests (or swamps), salt marshes, and smaller areas of hypersaline salterns (or salt barrens). The ecological value of these communities includes habitat for fish and wildlife, while the value to the public includes recreation, flood attenuation, and water quality benefits. Many species of fish and wildlife depend on wetlands for breeding, nesting, and foraging, making wetlands one of the most productive habitats. Wetlands are also important to maintaining water quality in Clearwater Harbor and St. Joseph Sound and reduce the impact of direct stormwater runoff by filtering sediments and facilitating the microbial activity and chemical sorption processes (Richardson and Marshall, 1986) that account for most of the phosphorus removal (Pietro et al., 2006a; Noeet al., 2003).

- **Mangroves**

Mangrove forests characterize the seaward edges of much of southwest Florida, growing where other land-based plants are intolerant of the high salinities and inundation. The mangrove community in southwest Florida includes three mangrove species, red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*) and white mangrove (*Laguncularia racemosa*), and a species that is variously classified as a mangrove or a mangrove associate, buttonwood (*Conocarpus erectus*). Their landward distribution is limited by competition from other plant species that are better able to compete for resources and, consequently, preclude the mangroves form expanding inland. Geographically, mangrove distribution on Florida's west coast is limited by cold tolerance to areas south of Cedar Key on the west coast, and they typically do not occur much farther north than the Tampa Bay area. Mangroves reduce coastal erosion and hurricane impacts, provide fish and wildlife habitat, sequester carbon, and reduce adverse impacts to water quality from stormwater runoff. Mangroves provide nursery and habitat with large diversity of inhabitants, including zooplankton, benthic infauna and epifauna, nekton, insects, birds, and terrestrial wildlife. During historical periods of rapid sea level rise, mangroves declined worldwide. However, more gradual sea level rise in the more recent past and adequate sedimentation have increased the seaward extent of mangroves (Dawes, 1998).

- **Salt Marshes and Salterns**

Salt marshes and salterns are nonforested estuarine wetlands under tidal and nontidal conditions with salinities greater than 0.5 ppt. (marshes with less than 0.5 ppt salinity are freshwater marshes). Gulf-coast salt marshes occur along low-energy shorelines, at the mouths of rivers, and in bays and bayous. Salt marshes along the southwest coast of Florida are characterized by predominantly needle rush (*Juncus roemerianus*) at higher elevations and smooth cordgrass (*Spartina alterniflora*) in the lower, more frequently inundated marshes. Other species include saltwort (*Batis maritima*) and seashore paspalum (*Paspalum vaginatum*). Giant leather fern (*Acrostichum danaeifolium*) is also locally abundant. Salt marshes function in primary production, food sources, habitat, sediment stabilization, and surface water filtration. In addition to providing nursery areas for fish, shellfish, and crustaceans, salt marshes buffer the effects of storm surges and limit damage to uplands. Tidal creeks that meander through the marshes transport nutrients and pollutants from the watershed to the estuary and like other wetlands, can reduce pollutant loads via filtration and assimilation. Elimination and alteration of Florida salt marshes adversely affects fishery resources. Estuaries provide nursery areas for at least 70% of Florida's important recreational and commercial fishes, shellfish, and crustaceans.

Salterns are hypersaline areas influenced primarily by ground water rather than surface water. While salt marshes typically occur landward of mangroves, salterns are typically located landward of the salt marshes. They are the result of accelerated evaporation (Hoffman and Dawes, 1996) and salinities may range from 40 to 170 ppt. Hypersaline habitats are abundant worldwide and provide important models for studying adaptation of aquatic organisms to extreme environments. These habitats are refuges for migratory birds and home of biota well adapted to the extremely harsh conditions (Torrentera and Dodson, 2004). Salterns are places of storage and release of orthophosphates, transitional sites for plant succession, and habitat for fish and wildlife as an abundance of salt tolerant brine shrimp and other invertebrates that are food for wading birds.

- **Natural and Anthropogenic Stressors**

Anthropogenic stressors generate the greatest impact to estuarine wetlands and are due to increasing population and associated development. Direct loss of wetlands has been extensive in Pinellas County due to replacement of natural areas with homes, businesses, roads, utilities, etc. Indirect impacts of development include point source and nonpoint source pollution that degrades water quality and, consequently, the quality of estuarine wetlands. Ground water withdrawals for water supply may reduce or eliminate ground water flow into estuarine wetlands.

In addition to these direct anthropogenic stressors, sea level rise and greater severity of storm/flood events associated with climate change and seasonal changes and multi-decadal drought events that reduce rainfall and ground water flows to wetlands also affect estuarine wetlands in the watersheds. The rate of sea-level rise along the coast of southwest Florida has increased an order of magnitude, from values around 6 cm / 100 years circa 3,500 years before present to present rates as high as 30 cm / 100 yrs (Cone et al., 2004). The low elevation relief of mangrove forests and marshes along this coast makes them particularly vulnerable to sea level rise. Mangroves forests have historically expanded seaward due to greater sedimentation when compared with sea level rise and changes to this balance could result in landward shifts of coastal wetlands and associated ecotones. Hyper saline salterns, may increase in size as the connection to the ground water expands. However, increased sea level rise that results in greater surface water influence on the salterns could result in a shift to a vegetated community. If current development and river management practices continue, such a rise could eliminate much of coastal marsh along the Florida coast and shifting coastal wetlands farther inland could be limited by existing development (Titus, 2011).

Salt marshes and mangrove swamps in southwest Florida are the most seaward wetlands. Farther inland, freshwater precludes saltwater intrusion and salt tolerant plant communities are replaced by freshwater marshes and forested wetlands (swamps). Although the freshwater marshes may be miles inland, their elevation is often the same as that of the saline wetlands and a rise in sea level would replace freshwater species with salt-tolerant species. However, the substrate underlying freshwaters marshes and swamps is not suitable for salt marshes and a conversion to open water could result, similar to transitions occurring in Louisiana (Wicker et al., 1980).

Some of the stressors and commensurate responses include:

- Dredge and fill for development and water supply (i.e. mining, agriculture, urban development adjacent to a wetland and within watersheds): these stressors result in direct loss of wetlands and associated habitat.

- Altered flows and hydrology (i.e. construction of canals and other water control structures adjacent to a wetland and within watersheds): stressors such as these may alter or eliminate wetlands by draining the wetland, while flooding a wetland will generally kill trees and convert the system to marsh or open water. The consequences of both are reduced fish and wildlife habitat for existing species.
- Fragmentation of a wetland from a contiguous wetland complex: this stressor eliminates travel corridors between habitats (e.g. from one stream to another) and may prevent wildlife that breed, nest, or feed in different areas (e.g. amphibians, reptiles, and birds) from traveling to and from these areas, or eliminate wildlife corridors for larger mammals such as coyotes and bears.
- Point source and nonpoint source pollution: wastewater treatment facilities are historically the largest single point source of pollution into waterbodies. Existing increased control over point source pollution has shifted the focus to nonpoint source pollution, its effects on the environment, and its control. In Pinellas County, stormwater drains flow directly into streams, lakes, and the Gulf of Mexico. Pollutants degrade water quality and result in commensurate adverse impacts.

Climate change (i.e., sea level rise and greater severity of storm/flood events): climate change directly affects rainfall, and consequently the amount of water flowing into streams, lakes, estuaries, and ground water aquifers. Reduced rainfall and associated droughts impact surface and ground water levels, as well as freshwater inputs (and salinity) to estuaries. Impacts to estuarine wetlands include direct and indirect losses of wetlands due to both water and aquifer level declines and flooding

5.3.1 Data Description and Analyses

Land use data were used to quantify changes and trends in the numbers of acres of estuarine wetlands in Clearwater Harbor and St. Joseph Sound over time. Geographic Information Systems (GIS) were used to identify, classify, and quantify historical and existing estuarine wetlands in Clearwater Harbor and St. Joseph Sound. Historical aerial photographs obtained for the years 1942, 1943, and 1957 were photo-interpreted to create a historical coverage of estuarine wetlands. All of the aerial photographs of Clearwater Harbor were from the National Archives (1942). However, National Archives aerial photographs did not extend to the northwest section of St. Joseph Sound. Historical aerial photographs from the U.S. Department of Agriculture (USDA) (1957) were used for photo-interpretation in that section. More recent trends were measured SWFWMD land use data from 1995, 1999, 2004, 2005, 2006, and 2007.

Soils data were referenced to assist in the identification of historical estuarine wetlands. The data contain estimated and measured records on the physical and chemical properties of the soil. The names of the soils components (series, taxonomic unit, or miscellaneous area) and the hydric soil rating classification were used to assist and/or clarify the extent of estuarine wetlands.

While system-wide assessments were made, trends in estuarine wetland acreage on coastal islands were quantified separately for Clearwater Harbor and St. Joseph Sound. Goals and targets for protection and/or restoration of estuarine wetlands on coastal islands are presented in this section. For mapping purposes, estuarine wetlands were classified as mangrove swamps, or saltwater marshes, consistent with SWFWMD's Florida Land Use, Cover and Forms Classification Systems (FLUCFCS) data available for the St. Joseph Sound and Clearwater Harbor.

5.3.2 Comparison of Historical and Present Wetlands Extent

Estuarine wetlands remain largely intact from 1942 estimates throughout the study area with the exception of Clearwater Harbor South which lost 89% of its estuarine wetland habitat (Table 5-10). Net changes in areal extent of estuarine wetlands were 25% between 1942 to 2007. There were slight gains in wetland acreage in all segments between 1995 and 2007.

A closer examination of the location of losses and gains is provided in the comparative maps of figures 5-28 through 5-30. In St. Joseph Sound, the spatial distribution of estuarine wetland habitats remains much as it was circa 1942 (Figure 5-36). Additionally, it appears that mangroves colonized the eastern shoreline of Anclote Key since 1942. In Clearwater Harbor North, estuarine wetlands were dominated by mangroves both historically and currently, and losses in mangrove habitat are principally restricted to the development of what was historically know as Cow Island or Big Mangrove Key and is now called Island Estates (Figure 5-29). In Clearwater Harbor South, loss of mangrove habitat along the eastern shore of Sand Key and Belleair Beach constitutes the majority of the loss of historical mangrove habitat in that CHS (Figure 5-30).

Table 5-10. Change in historical (1942) and current (1995 - 2007) extent (acres) of estuarine wetlands in St. Joseph Sound and Clearwater Harbor North and South.

Watershed	1942	1995	1999	2004	2005	2006	2007	Percent Change (1942-2007)
St. Joseph Sound	238	226	232	248	234	237	230	-3%
Clearwater Harbor North	436	388	366	404	403	403	403	-8%
Clearwater Harbor South	294	20	20	24	24	24	26	-70%
Total	968	635	618	675	661	664	659	-25%

5.3.3 Estuarine Wetland Targets

Ideally, estuarine wetlands in St. Joseph Sound and Clearwater Harbor would be restored to their historical extent. However, as previously described, approximately 6.4% of the historical estuarine wetlands in St. Joseph Sound, 18.8% of historical wetlands in Clearwater Harbor North, and a dramatic 63.7% of the historical wetlands in Clearwater Harbor South, have been converted to urban development. These wetlands cannot be restored to their full historical extent.

Pinellas County, in collaboration with SWFWMD and several municipalities, has developed watershed management plans for 15 areas in the county in an effort to address resource management issues. The goals and objectives for these plans have focused on numerous common elements, including identification of causes and sources of flooding, receiving waters water quality, habitat loss, and public education on the causes and solutions of watershed problems.

Accomplishing these goals depend in part upon the ability to restore wetlands without causing adverse impacts from flooding, as well as the agreeability of land owners, technical feasibility, and funding levels of various environmental restoration programs. Natural wetland functions may be restored in some places by restoring hydrology in the degraded or drained wetland site. The effort necessary to restore wetland sites will vary due to the degree of loss. Nevertheless, these targets should be considered for their ability to enhance wildlife populations via increasing foraging and breeding habitat, reduction of sediment and nutrient inputs to coastal waters, and thus the ability of such efforts to potentially improve water quality of the St. Joseph Sound and Clearwater Harbor watersheds and estuaries.

Habitat restoration and protection targets were developed for mangroves, salt marshes, and salterns in the St. Joseph Sound and Clearwater Harbor watersheds. Historical and current extents of estuarine wetlands in the three CHSJS segment watershed are listed in Table 5-10 and were used to establish restoration/protection targets. For the St. Joseph Sound segment, for example, mangroves are the least impacted habitat with the existing extent of 141 acres representing 70% of the total estuarine wetland area. In comparison, the historical mangrove area was 146 acres representing 69% of the total historical estuarine wetland area. The approximate 1% increase from 1942 to 2007offset an approximately equal loss of saltern habitat.

Historically, the proportion of the estuarine wetlands composed of either salt marshes or salterns was quite low in both Clearwater Harbor North and Clearwater Harbor South (Table 5-10). In 2007, both of these wetland types were essentially eliminated.

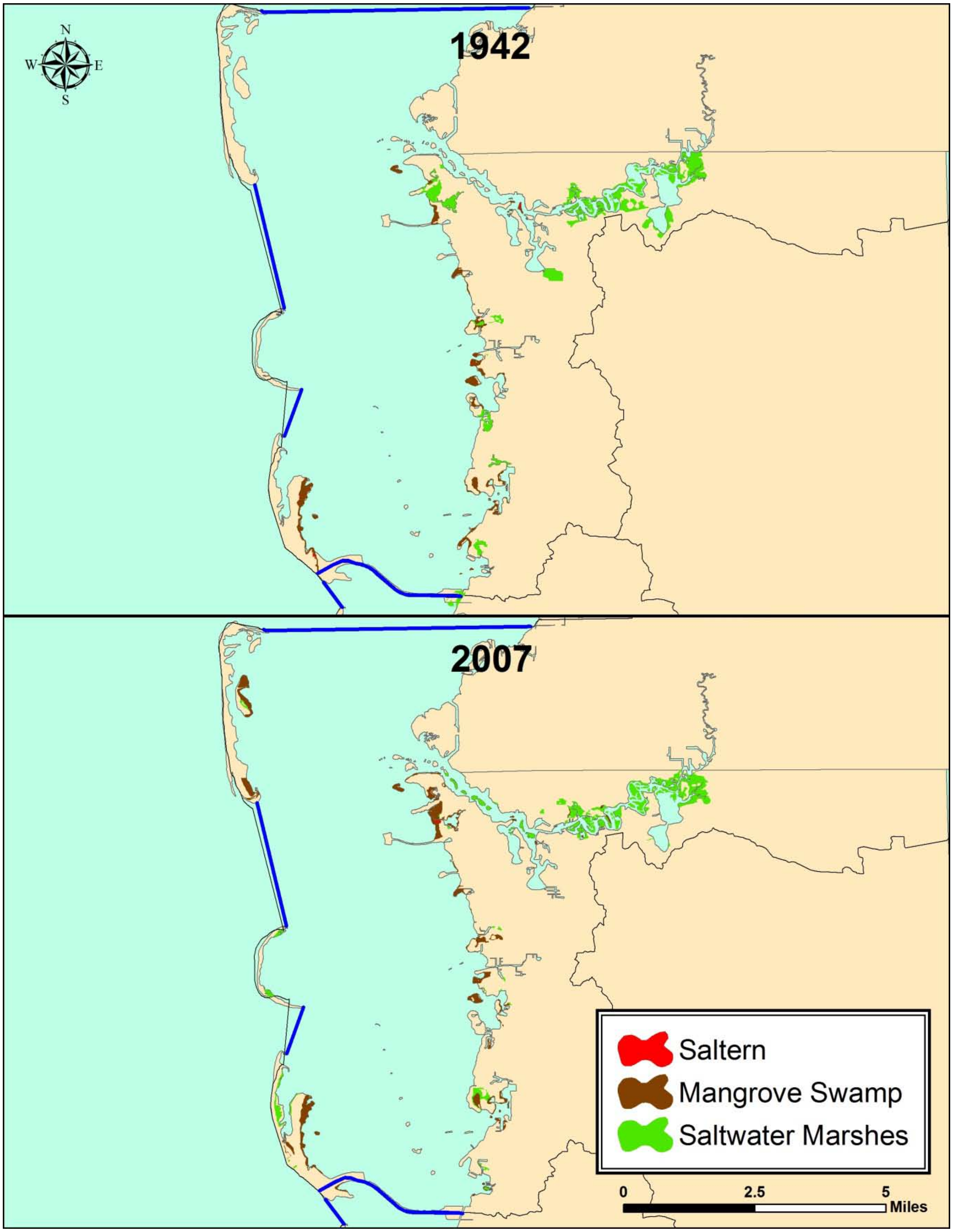

Figure 5-28. Extent of historical (1942) and current (2007) estuarine wetlands in St. Joseph Sound.

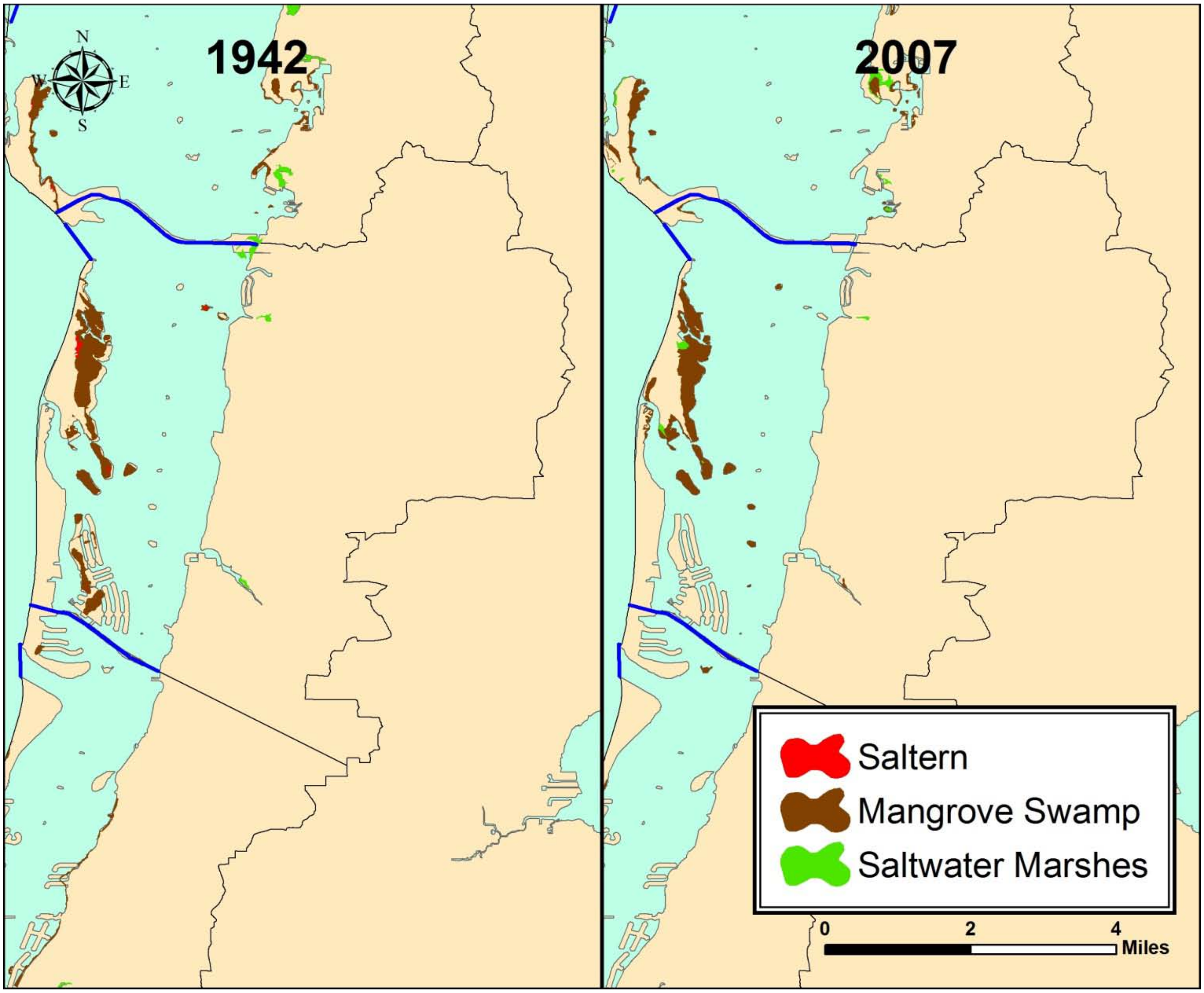

Figure 5-29. Historical (1942) and current (2007) estuarine wetlands in Clearwater Harbor North.

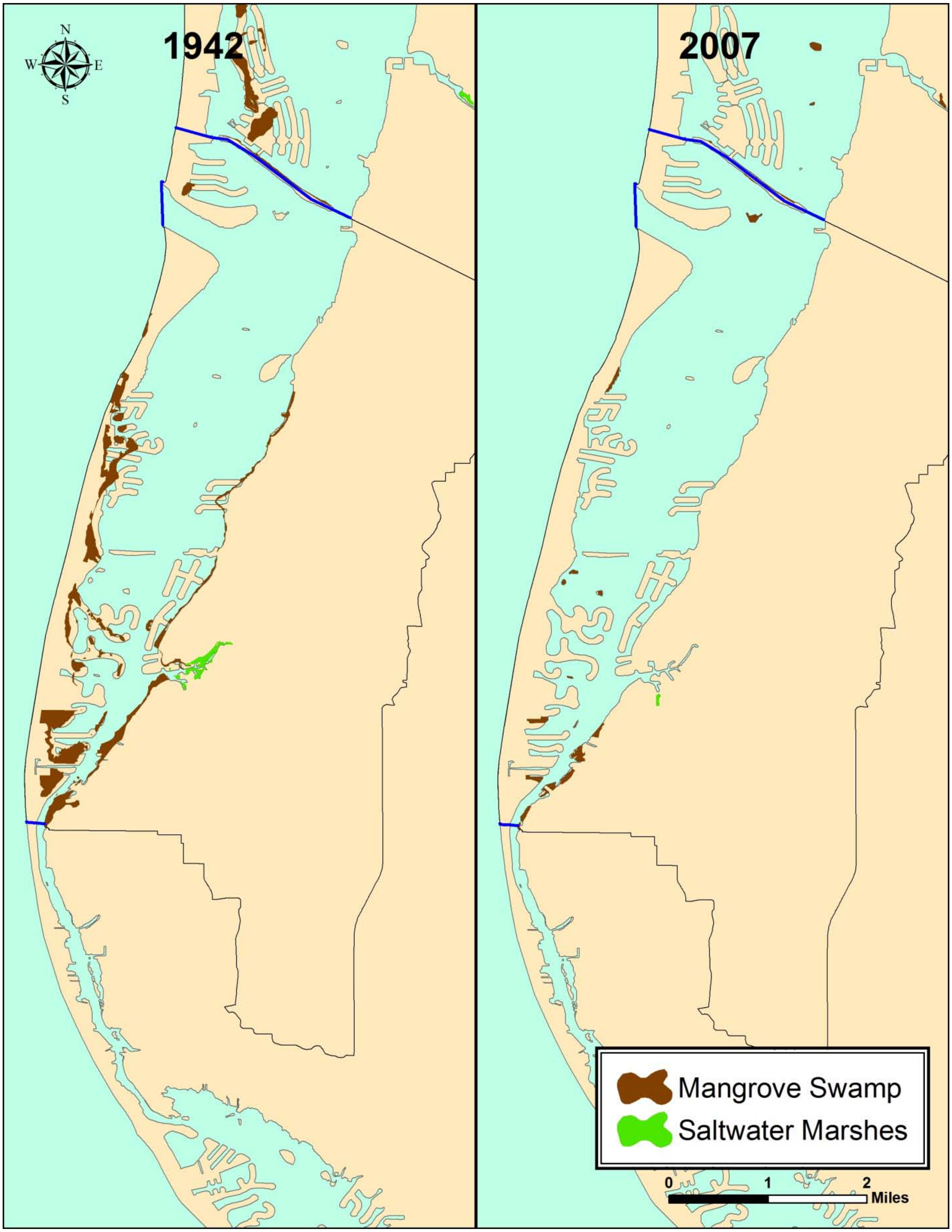

Figure 5-30. Historical (1942) and current (2007) estuarine wetlands in Clearwater Harbor South.

Management goals were defined for estuarine wetlands occurring on the mainland side of the CHSJS in Chapter 4. The recommended management goal for estuarine wetlands along the coastal islands is provided below is:

	Saltwater Marsh	Mangrove
• St. Joseph Sound	77 acres	153 acres
• Clearwater Harbor North	13 acres	390 acres
• Clearwater Harbor South	< 1 acre	24 acres

5.4 Benthic Macroinvertebrates and Sediments in the CHSJS Estuary

Benthic macroinvertebrate communities in subtropical estuaries are characterized by a diverse assemblage of organisms including oligochaete and polychaete worms, amphipod, isopod, copepod and decapod crustaceans, gastropod and bivalve mollusks, and asteroid, holothuroid and echinoid echinoderms (seastars, sea cucumbers, and urchins).

Sediment quality and the associated benthic macroinvertebrate community in Clearwater Harbor and St. Joseph Sound were sampled by the Environmental Protection Commission of Hillsborough County (EPCHC) using standardized sampling procedures detailed in Appendix M. Sampling by EPCHC resulted in 30 core samples collected over three days during September 2009. Sample sites were randomly selected from St. Joseph Sound (15 sites) (Figure 5-31 and Clearwater Harbor North (8 sites) (Figure 5-32), and Clearwater Harbor South (7 sites) (Figure 5-33). From each core sample, the benthic invertebrate community was characterized as were water quality (6 parameters) and sediment chemistry (68 heavy metals and organic compounds).

5.4.1 Sediment and Water Quality

Sediment grain size within Clearwater Harbor and St. Joseph Sound was generally similar among the three segments with medium, fine and very fine grain sediments equally and most frequently observed (Figure 5-34). Mud and coarse-grain substrates were less common. Low DO conditions (<4 mg/L) were found at 4 sites including 2 each in St. Joseph Sound and Clearwater Harbor North (Figure 5-35).

An ecosystem-based framework for assessing and managing sediment quality has been developed by the Tampa Bay Estuary Program (MacDonald et al., 2002). As part of this effort, numerical sediment quality targets (SQTs) were developed for use in assessment of the status of sediment conditions, as not impacted, moderately impacted, or highly impacted. Included in the chemicals of potential concern were nine trace metals, total PCBs, thirteen polycyclic aromatic hydrocarbons (PAHs), six organochlorine pesticides, and a phthalate. For each of these chemicals, an effects level approach was used to derive a threshold effect level (TEL) and a probable effect level (PEL). Below the TEL values, adverse biological effects are unlikely to occur; between the TEL and PEL values, adverse biological effects are possible; and above the PEL values adverse biological effects are likely. These PELs and TELs defined the sediment quality targets for sediment chemistry in Tampa Bay.

Using the established SQTs for Tampa Bay, sediment quality was assessed for sample sites in Clearwater Harbor and St. Joseph Sound. Maps depicting the distribution of sediment contaminants are presented in Appendix N. A listing of sample sites in exceedance of TELs and PELs is provided in Appendix O. In general, contamination of benthic sediments by heavy metals, PCBs, PAHs, and organochlorine pesticides was very low in the CHSJS estuary. Three of the eight sites sampled in Clearwater Harbor North and one site in St. Joseph Sound, however, had levels of several PAHs which exceeded TELs, including benzo(a)anthracene, benzo(a)pyrene, dibenzo(a,h)anthracene, chrysene, fluoranthene, pyrene and several other compounds. Only two sites exceeded PELs for several of the PAHs and organochlorine pesticides (one site in St. Joseph Sound and one site in Clearwater Harbor North), both of which had TEL exceedances.

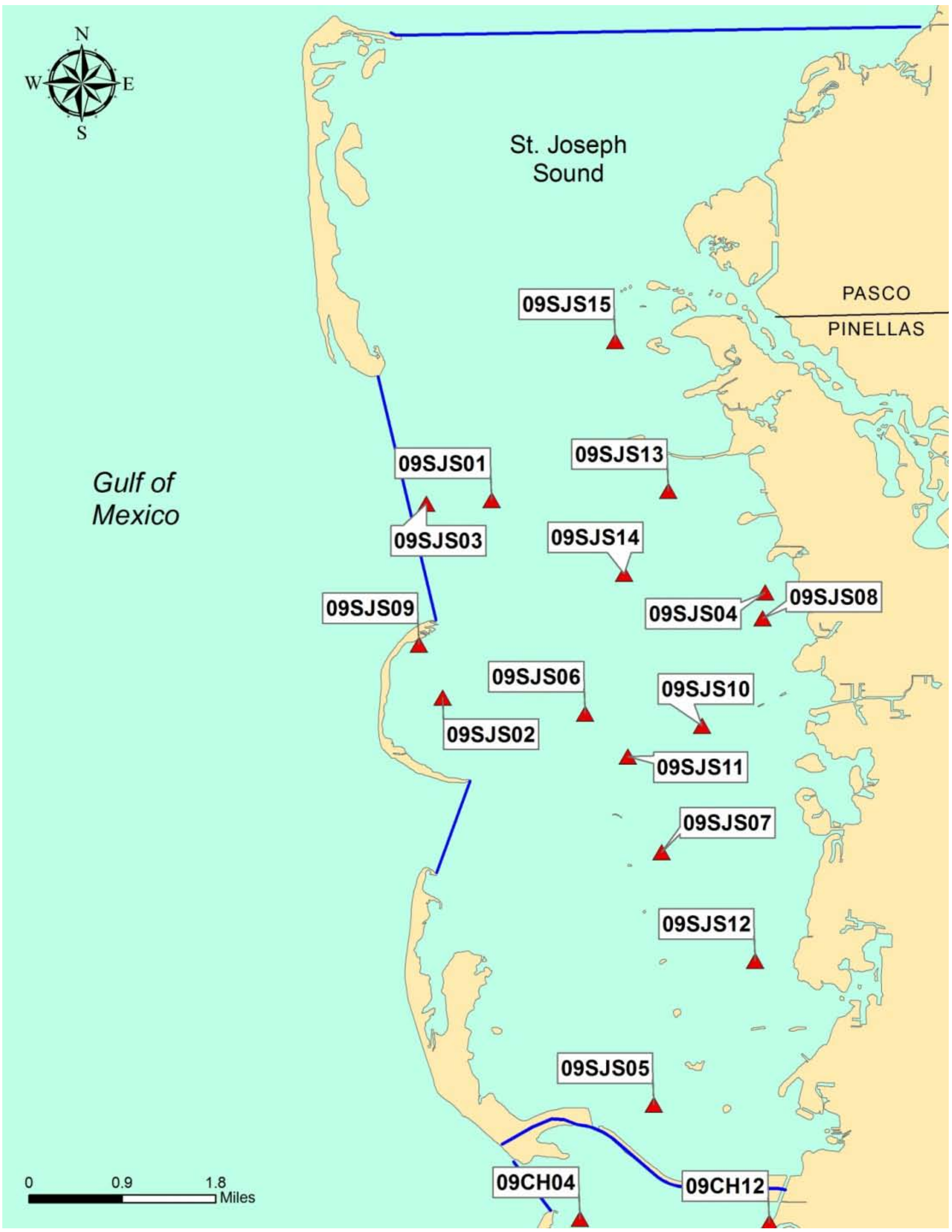

Figure 5-31. Benthic sample sites used to characterize the benthic macroinvertebrate community and sediment quality in St. Joseph Sound (2009).

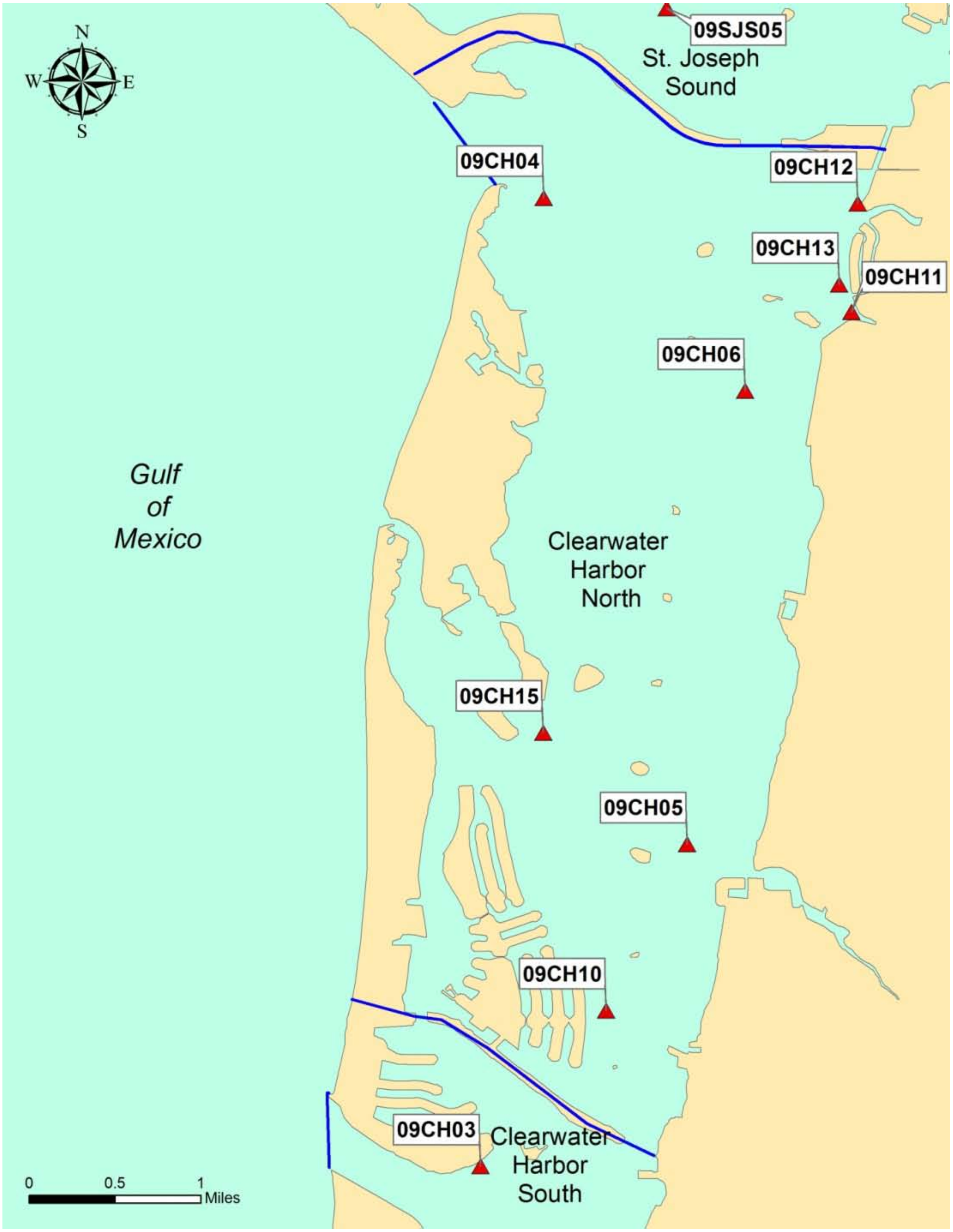

Figure 5-32. Benthic sample sites used to characterize the benthic macroinvertebrate community and sediment quality in Clearwater Harbor North (2009).

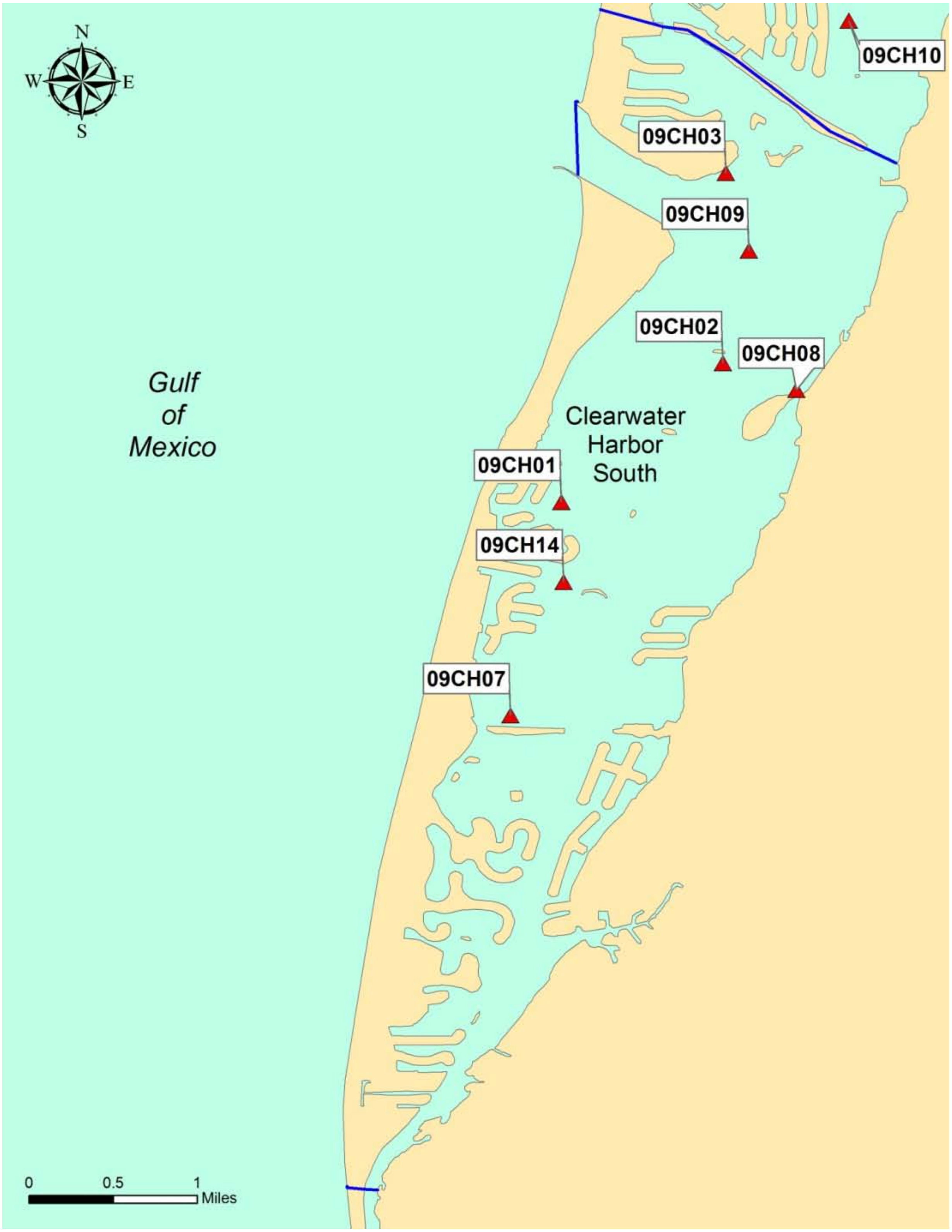

Figure 5-33. Benthic sample sites used to characterize the benthic macroinvertebrate community and sediment quality in Clearwater Harbor South (2009).

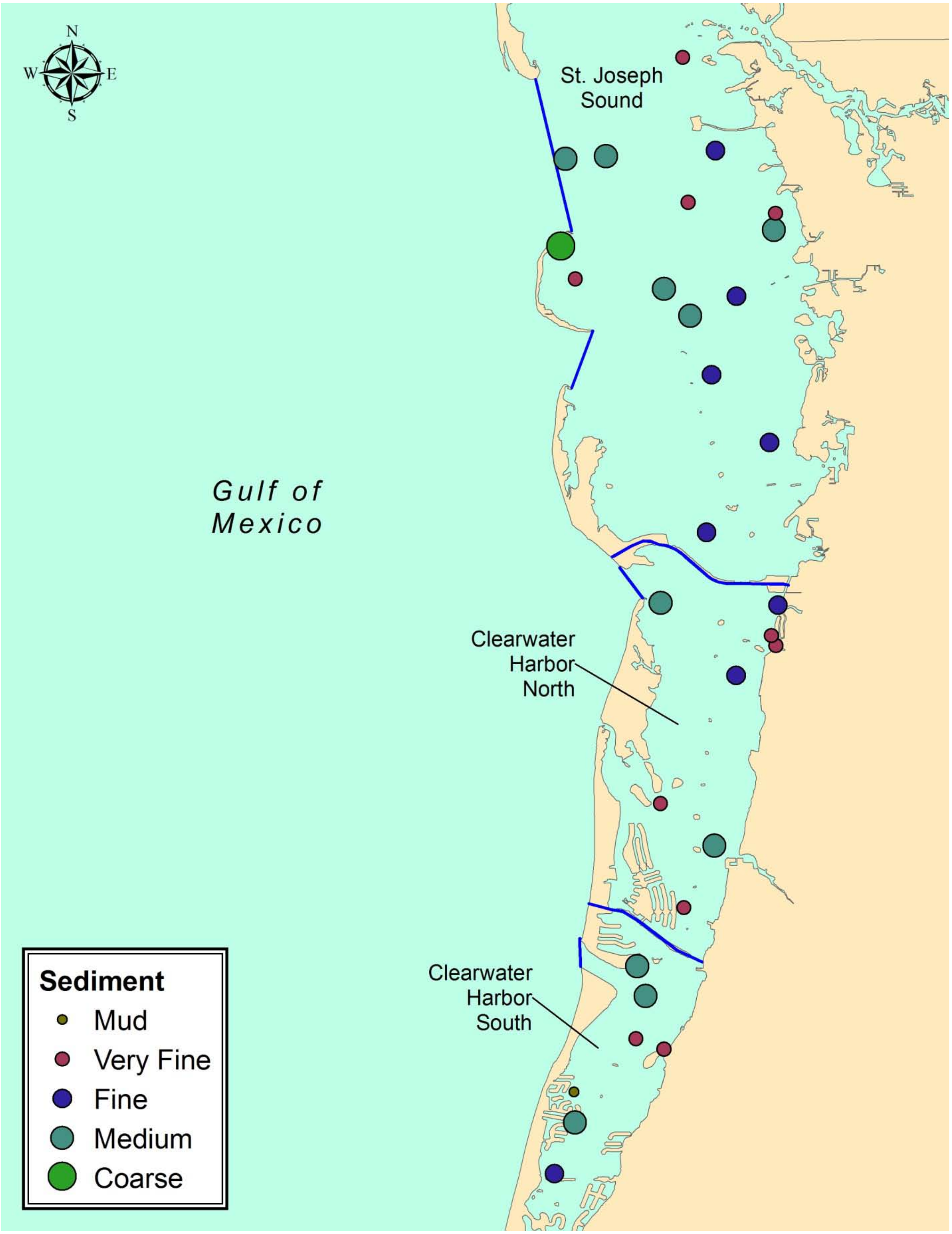

Figure 5-34. Distribution of sediment grain sizes within the CHSJS segments during September 2009.

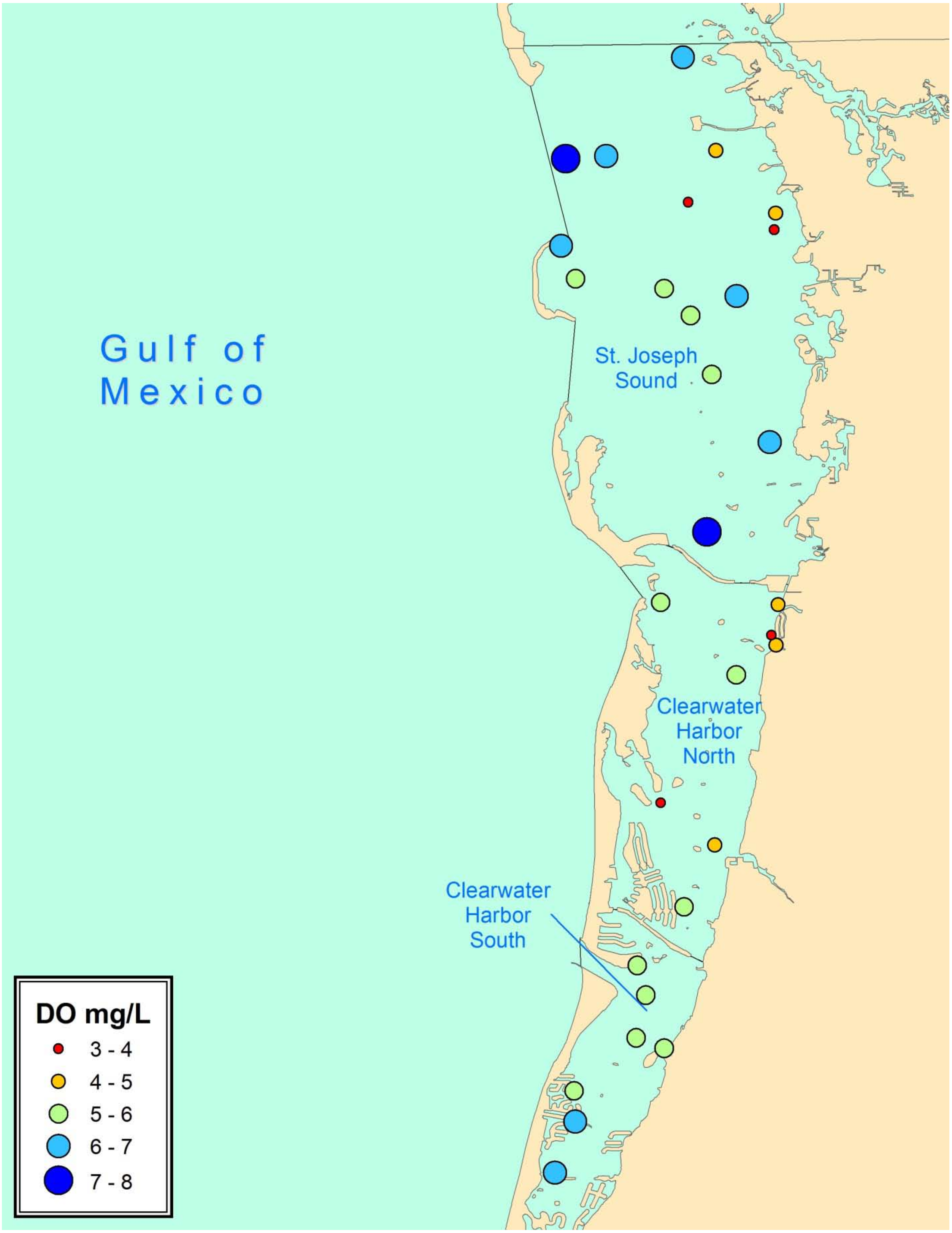

Figure 5-35. **Bottom DO at benthic monitoring sites within the CHSJS segments during September 2009.**

5.4.2 Benthic Macroinvertebrates

A total of 9,237 individuals from 466 taxa were collected in the CHSJS estuary. The majority of these taxa (n = 351) were collected in St. Joseph Sound, while fewer taxa (n = 284) were collected from Clearwater Harbor (North: n = 201, South: n = 175).

The dominant taxa in the estuary were primarily polychaetes worms, but also several families of oligochaetes worms, sipunculid worms, gastropod and bivalve mollusks and amphipod crustaceans (Table 5-11). The numerically dominant taxon in St. Joseph Sound and Clearwater Harbor North was *Caecum pulchellum*, a small gastropod mollusk that represented nearly 20% of the individuals collected in these two segments. Several polychaete worms were also numerically dominant (7-9% each) including *Clymenella mucosa*, *Fabriciola trilobata* and *Paradoneis cf. lyra*. In Clearwater Harbor South, species were more evenly distributed taxonomically and no taxa were clearly most abundant in this segment. Among the more abundant taxa were an oligochaete worm (*Tectidrilus squalidus*), a polychaete worm *(Carazziella hobsonae*) and a bivalve mollusk *(Tagelus divisus*).

Table 5-11. Numerically dominant benthic invertebrates collected from Clearwater Harbor and St. Joseph Sound during September 2009.

St. Joseph Sound	% of all individuals	Clearwater Harbor North	% of all individuals	Clearwater Harbor South	% of all individuals
Caecum pulchellum (Mollusca:Bivalvia)	18.70	Caecum pulchellum (Mollusca:Bivalvia)	16.91	Tectidrilus squalidus (Annelida:Oligochaeta)	5.80
Paradoneis cf. lyra (Annelida:Polychaeta)	7.29	Clymenella mucosa (Annelida:Polychaeta)	8.99	Carazziella hobsonae (Annelida:Polychaeta)	5.08
Tubificidae (Annelida:Oligochaeta)	3.27	Fabriciola trilobata (Annelida:Polychaeta)	8.91	Tagelus divisus (Mollusca:Bivalvia)	3.97
Tubificoides wasselli (Annelida:Oligochaeta)	2.99	Turbonilla sp. (Mollusca:Gastropoda)	5.52	Fabriciola trilobata (Annelida:Polychaeta)	3.65
Syllis alosae (Annelida:Polychaeta)	2.43	Tubificidae (Annelida:Oligochaeta)	4.16	Tubificidae (Annelida:Oligochaeta)	3.49
Fabriciola trilobata (Annelida:Polychaeta)	2.32	Tharyx acutus (Annelida:Polychaeta)	3.20	Grania sp. (Annelida:Oligochaeta)	3.49
Phascolion sp. (Annelida:Sipuncula)	2.10	Exogone dispar (Annelida:Polychaeta)	2.68	Clymenella mucosa (Annelida:Polychaeta)	3.42
Streblosoma hartmanae (Annelida:Polychaeta)	2.01	Neanthes acuminata (Annelida:Polychaeta)	2.28	Mediomastus sp. (Annelida:Polychaeta)	2.94
Inanidrilus bulbosus (Annelida:Clitellata)	1.70	Boguea enigmatica (Annelida:Polychaeta)	2.20	Jaspidella blanesi (Mollusca:Gastropoda)	2.86
Meioceras nitidum (Mollusca:Gastropoda)	1.57	Mediomastus sp. (Annelida:Polychaeta)	1.56	Parapionosyllis uebelackerae (Annelida:Polychaeta)	2.70

Samples contained between 10 and nearly 100 taxa with abundances from 10 to 1,100 individuals per core. Abundances in St. Joseph Sound were frequently higher than those observed in both Clearwater Harbor North and South with the lowest abundances observed in Clearwater Harbor South (Figure 5-36). Species richness was greater in St. Joseph Sound, as well, with 10 of 15 samples containing more than 70 taxa each, compared to only 3 of 15 samples in Clearwater Harbor (Figure 5-37).

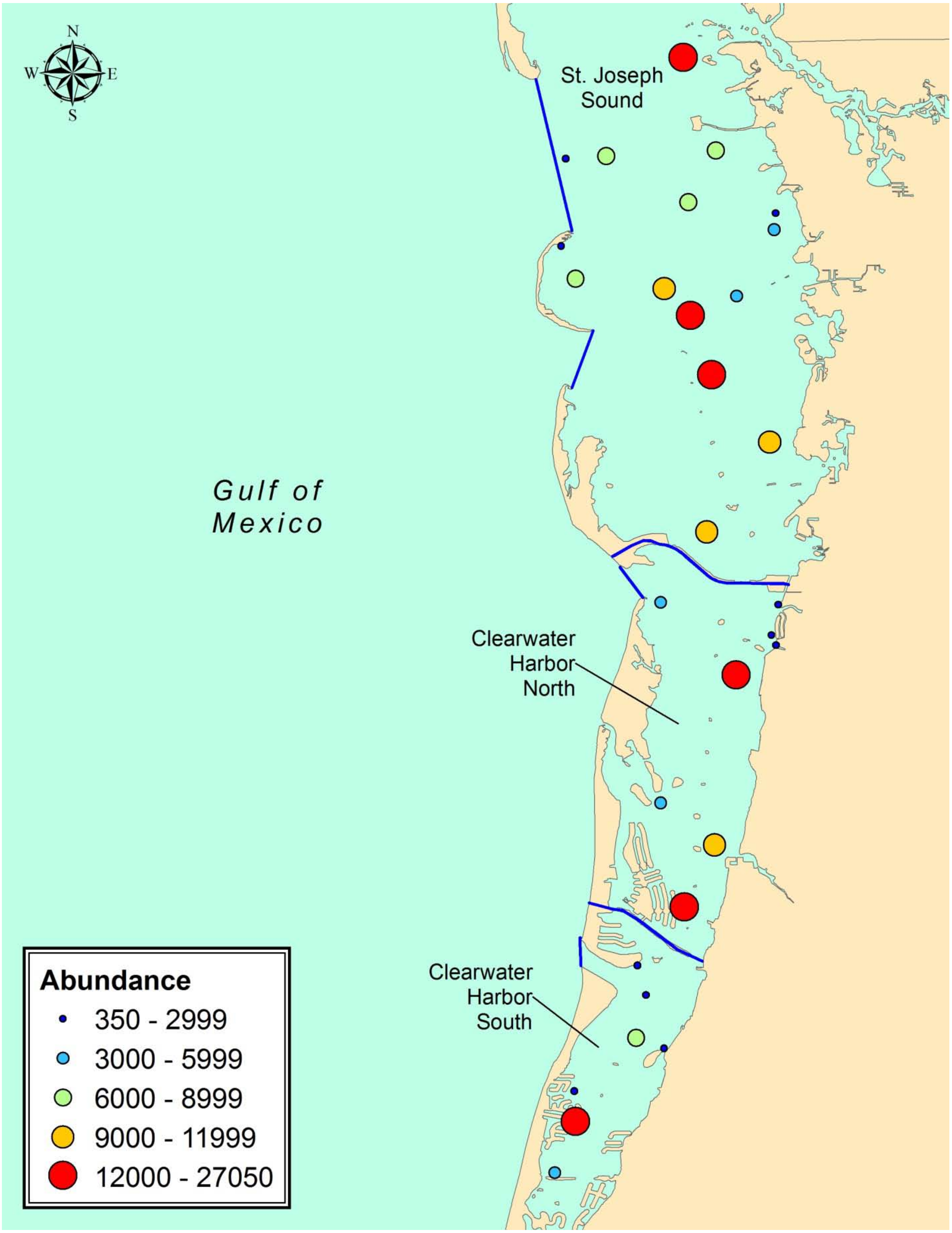

Figure 5-36. Abundance of benthic macroinvertebrates within the CHSJS estuary.

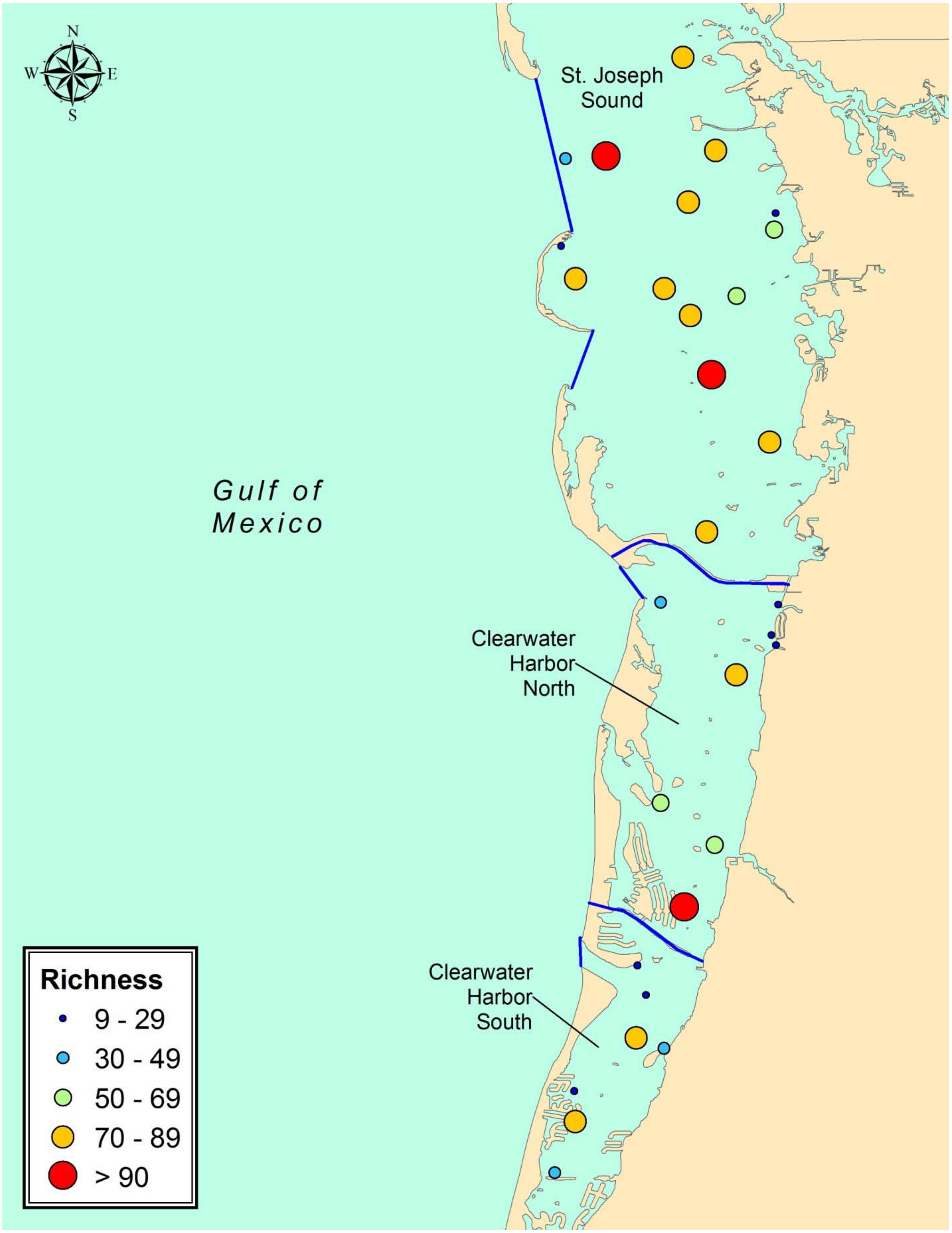

Figure 5-37. Benthic species richness within the CHSJS estuary.

5.4.3 Relationship Between Sediment and Water Quality and Benthic Community Structure

The benthic macroinvertebrate community differed among the CHSJS segments (R=0.28; p=0.002; community dissimilarity increases as r approaches 1.00). This difference is illustrated by Figure 5-38) which shows the similarity and dissimilarity among benthic samples collected throughout the study area. The distance between sample points in Figure 5-38 is directly proportional to the similarity between benthic assemblages collected at those sites. Analysis of Similarity (ANOSIM) comparing the species composition and abundance among bay segments indicates that the greatest difference was between St. Joseph Sound and Clearwater Harbor South (r=0.41; p=0.004), with much less of a difference between St. Joseph Sound and Clearwater Harbor North (R=0.22; p=0.033). Clearwater Harbor North and South had similar benthic communities (R=0.12; p=0.10).

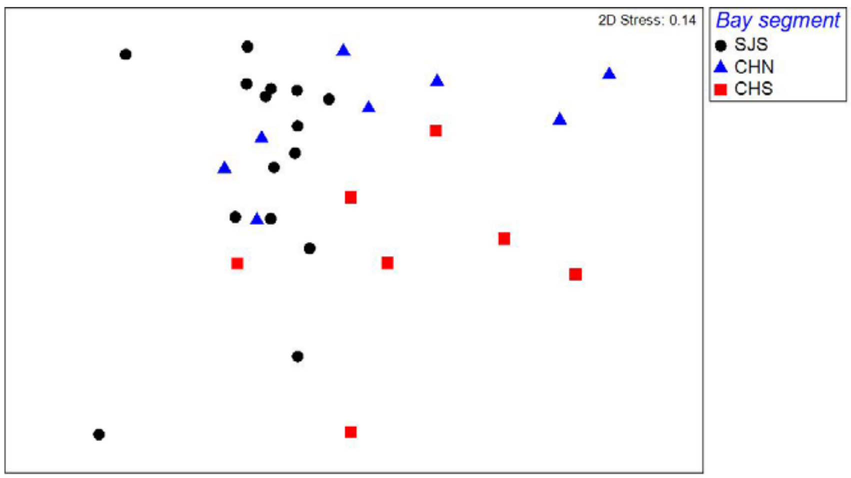

Figure 5-38. Multidimensional scaling plot of benthic community structure within the CHSJS segments.

Percent silt-clay in the sediment explained 31% of the variation in benthic community structure among sample sites based on correlation of sediment quality and biotic data using the BIO-ENV routine in the PRIMER software. The best combination of sediment parameters included percent silt-clay, copper and selenium concentrations and explained 54% of the variation among sites. Similarly, chromium, copper and selenium explained 55% of the differences in the benthic community.

5.4.4 Comparison of Conditions in the CHSJS Estuary and Nearby Boca Ciega Bay

A similar benthic survey was conducted in the Tampa Bay estuary from 1993-2004 (Karlen et al., 2008) during which the majority of samples in Boca Ciega Bay (91%) were normoxic and averaged between 5-6 mg/L. Sediment grain size was primarily medium to fine grain (71%). Several trace metals were found to be in highest concentration in Boca Ciega Bay. Cadmium concentrations across the Tampa Bay estuary, including Boca Ciega Bay often exceeded the TEL and occasionally exceeded the PEL. Copper concentrations were also elevated in Boca Ciega Bay relative to the greater estuary. Exceedances of the TEL were observed in several cases for copper in Boca Ciega Bay. Silver concentrations were highest in Boca Ciega Bay but were not detected in Clearwater Harbor or St. Joseph Sound.

The ten most abundant taxa in Boca Ciega Bay (Table 5-12) represented nearly one-third of all benthos collected there and were primarily annelid worms (seven species of polychaetes and tubificid oligochaetes) as well as an amphipod (*Cymadusa compta*), a tanaid shrimp (*Kalliapseudes macsweenyi*) and a bivalve mollusk (*Tellina* spp.).

Of the ten numerically dominant benthic taxa in Boca Ciega Bay, only three (polychaetes *Clymenella mucosa* and *Monticellina cf. dorsobranchialis* and tubificid oligochaetes) were similarly dominant members of the benthic community in Clearwater Harbor and St. Joseph Sound. Four other taxa including *Tellina* spp. (bivalve gastropods), *Kalliapseudes macsweenyi* (tanaid shrimp), *Exogone dispar* (polychaete worm) and *Cymadusa compta* (amphipod crustacean) were among the more abundant benthic taxa but were not nearly as common as in Boca Ciega Bay. As a whole, these taxa represented 9-17% of the benthic taxa collected from the CHSJS estuary.

Table 5-12. Numerically dominant benthic invertebrates collected from Boca Ciega Bay during 1993-2004 monitoring (Karlen et al., 2008).

Taxon	% of all individuals
Tubificidae(Annelida:Oligochaeta)	7.01
Janua (Dexiospira) steueri(Annelida:Polychaeta)	6.14
Monticellina cf. dorsobranchialis(Annelida:Polychaeta)	3.05
Pileolaria rosepigmentata(Annelida:Polychaeta)	2.78
Cymadusa compta(Crustacea:Amphipoda)	2.48
Kalliapseudes macsweenyi(Crustacea:Tanaidacea)	2.42
Tellina spp.(Mollusca:Bivalvia)	2.09
Pomatoceros americanus(Annelida:Polychaeta)	2.01
Exogone dispar(Annelida:Polychaeta)	1.84
Clymenella mucosa(Annelida:Polychaeta)	1.65

Boca Ciega Bay had among the highest species richness (0-120 taxa per sample, median = 42 taxa) and diversity (Shannon H′ log e = 2.96) observed in Tampa Bay along with Lower and Middle Tampa Bay. Both richness and diversity declined with increasing distance from the Gulf of Mexico.

Karlen et al. (2008) concluded that sediment grain size and dissolved oxygen were the physicochemical factors most strongly correlated with benthic community structure (EPCHC, 2008). Sediment contaminants most closely related to variation in the benthic community included copper, chromium, DDT, and pyrene.

The limited availability of data for the CHSJS estuary precludes establishing quantitative goals or targets for either benthic community integrity or sediment quality. The proposed goals for benthic community integrity or sediment quality include:

- To minimize the extent of contaminated and/or hypoxic benthic sediments.
- To develop a benthic sampling program designed to provide a baseline characterization of sediment quality and the benthic invertebrate community.
- To establish sediment quality targets, similar to those developed for the Tampa Bay estuary, that maintain the sediment quality necessary for a diverse benthic community.

5.5 Fish and Fish Habitats in the CHSJS Estuary

As spawning, nursery, and feeding grounds, estuaries provide important habitats for a number of economically important fish and shellfish species. In Florida, estuaries are also a vital economic engine providing recreational opportunities for millions of people each year. Therefore, the health and productivity of estuarine fish habitats are critical to the long term viability of Florida's natural resources and economic success.

The CHSJS system supports a diverse assemblage of fishes and invertebrates occupying a mosaic of seagrass, mangrove and oyster habitats. The close proximity of the Gulf of Mexico to the west and a significant freshwater source, the Anclote River, to the east contribute to a dynamic and productive estuarine system. Several large barrier islands, Anclote Key, Three Rooker, Honeymoon and Caladesi Islands, and Sand Key provide a buffer from the Gulf and create calm, shallow waters behind them. Strong tidal currents flow through the passes between these islands scouring the bottom and creating deeper areas through which large fishes, sea turtles and marine mammals move between the Gulf and the estuary. These passes also transport planktonic fish and invertebrate larvae that are spawned offshore and along the beaches into the estuary. Since the early 1970s, numerous studies (e.g., Fable, 1973; Rolfes, 1974; Feinstein, 1975;Szedlmayer, 1982) have characterized the fish and invertebrate community of the Anclote River and estuary and examined the relationship between the fish community and the fish habitat provided by the estuary. Fewer studies have been performed on the estuarine segments of Clearwater Harbor North and South. The purpose of this section is to synthesize the various studies that have been conducted in the CHSJS estuary over the past 40 years in order to document the diverse fish and invertebrate community found there and to demonstrate the ecological role of the estuary as fish habitat and as a fisheries resource, so that these resources can be better managed and conserved.

This section summarizes the available information on the fisheries resources of Clearwater Harbor and St. Joseph Sound so that management priorities can be identified. As part of this effort natural and anthropogenic stressors were identified as listed below.

- Natural and Anthropogenic Stressors:
  - Impacts to nursery areas –(e.g., prop scarring of seagrasses, mangrove losses)
  - Fishing pressure – fish mortality – (take and catch and release)
  - Red tide events
  - Cold stress
  - Water quality
  - Fishing pressure – fish mortality – (take and catch and release)
- Management Issues:
  - How to estimate populations in study area
  - How to estimate fishing pressures in study area
  - How to protect critical habitat
  - How to inform public of negative fishing impacts- (e.g., fishing line)

Over170 species of marine, estuarine, and freshwater fishes, decapods crustaceans, and bivalve molluscs have been reported from Clearwater Harbor, St. Joseph Sound, and the Anclote River (Appendix P). Many of these species are typically found offshore in the Gulf of Mexico, but move into the nearshore waters of the estuary to feed or to reproduce. The estuary also provides nursery habitat for many of these "transient" species. The following paragraphs summarize previous studies on fishes in the study area and provide management recommendations on efforts to maintain and conserve fish and fish habitats within the study area.

5.5.1 Fish Surveys in the CHSJS Estuary

A number of fish surveys have been conducted within and near the CHSJS estuary. The following describes them and briefly summarizes their results.

- **Anclote River Estuary Studies**

Several ecological studies were conducted by the University of South Florida to examine fish and fish habitat in the Anclote River area during the 1970s and 1980s including:

- Fable (1973),
- Rolfes (1974),
- Feinstein (1975), and
- Szedlmayer (1982).

These studies appear to be the earliest available descriptions of the fish community from the CHSJS estuary. These studies used various sampling methods to describe spatial and temporal patterns of abundance and habitat use by the fish community and were part of a larger study funded by Florida Power to assess the environmental conditions of the Anclote River prior to construction of the Anclote Power Plant. Their results remain useful as they provide a historical baseline by which to evaluate the current status of fish and fish habitat in the CHSJS system.

The earliest of these studies (Fable, 1973) was limited in that it was conducted in a small bayou (~2.5 hectares) at the mouth of the Anclote River, but provides a useful characterization of the subset of the fish community that uses shallow, intertidal habitat. The majority of the bayou was vegetated by *Spartina alterniflora* and *Juncus roemerianus* and the remainder was relatively shallow (<1.5m depth at high tide) unvegetated habitat. It is interesting to note that the emergent vegetation has since been replaced by mangroves based on personal observation. The fish community was sampled seasonally from 1970-1972 (n=9 samples) with a single fyke net that was set across the entrance of the bayou at high tide and retrieved at low tide. Fifty species were collected over a 21-month period and are representative of the fish community collected from the Tampa Bay estuary (based on data from the State of Florida's Fisheries-Independent Monitoring Program (FIM). Seven species were numerically dominant (87% of all fish collected) and are, in order of decreasing abundance: pinfish (*Lagodon rhomboides*), striped mullet (*Mugil cephalus*), sheepshead minnow (*Cyprinodon variegatus*), spot (*Leiostomus xanthurus*), fantail mullet (*Mugil gyrans*), striped killifish (*Fundulus similis*) and Atlantic stingray (*Dasyatis sabina*).Thirteen species of economic value to recreational or commercial fisheries were collected and comprised 31% of all individuals. These included, in order of decreasing abundance: three species of mullet (*Mugil* spp., primarily *M. cephalus*), spot, silver perch (*Bairdiella chrysoura*), spotted seatrout (*Cynoscion nebulosus*), sheepshead (*Archosargus probatocephalus*), gulf flounder (*Paralichthys albigutta*), common snook (*Centropomus undecimalis*), red drum (*Sciaenops ocellatus*), black drum (*Pogonias cromis*), gray snapper (*Lutjanus griseus*), and cobia (*Rachycentron canadum*). Many of these were juveniles and sub-adults <200-mm SL, though larger individuals (400-800-mm SL) were collected as well. The highest abundances were observed in spring and summer (April-July).

A concurrent study by Rolfes (1974) used trammel nets (n = 340) and otter trawls (n = 171) to sample fish at four fixed-sample stations located at the mouth of the Anclote River. Collections occurred over a 20-month period and characterized seasonal, diel, and habitat-specific patterns of fish abundance in shallow and deep-water seagrass (dominated by *Syringodium filiforme*) and bare sand habitat. One hundred and twenty-five species were collected though species identities were not presented as part of the study. Fish abundances were highest between late spring and mid-fall and were slightly greater in the shallow bare sand habitat versus seagrass habitats. In terms of average number of species per sample, more species were collected from seagrass than from bare sand. The deep-water sand habitat (1.8-m) had particularly low densities and few species were collected there.

Of particular interest to resource management in the CHSJS estuary is a study by Szedlmayer (1982) which describes patterns of fish abundance and distribution along the salinity gradient on the Anclote River and includes a summary of salinity tolerances for many of the fish species collected. This study emphasizes the lower salinity estuarine habitats found in the Anclote River estuary and their role as nursery habitat for fish species considered to be estuarine transients. Bi-monthly fish samples were collected from March-October 1980 with a 6.3-m haul seine at three fixed stations (n = 320 samples). Stations were located along the salinity gradient from the mouth of the Anclote (mean = 30ppt)to an oligohaline tributary approximately 10-km upstream of St. Joseph Sound (mean = 7ppt). An intermediate site (mean = 17ppt) was located between the mouth and the upstream site.Fish habitat at the mouth consisted of seagrass, bare sand, red mangrove (*Rhizophora mangle*) and oyster. The intermediate site was a tidal marsh creek dominated by *Juncus roemerianus*, while the upstream site was characterized by cattails (*Typha* sp.) and cypress (*Taxodium* sp.).

The highest abundances and the greatest number of species were observed at the mouth of the Anclote River, while lower abundances but similar species numbers were observed furthest upstream in the oligohaline tributary. The lowest abundances and fewest species were collected from the tidal marsh. Four species: silverside (*Menidia beryllina*), bay anchovy (*Anchoa mitchilli*), pinfish, and spot were the most abundant taxa collected. Pinfish abundance was much greater at the downstream station and spot abundance was highest in the tidal marsh at the intermediate site. High abundances of silversides accounted for much of the difference in fish abundance among the three sites. Community structure was distinct among the three sample sites, with >60% similarity in species composition and abundance observed within a sample site. The community at the mouth of the Anclote River was characterized by fish species common to high-salinity seagrass habitat and included flatfishes from several families (Cynoglossidae, Paralichthyidae), seahorses and pipefishes (Syngnathidae), halfbeaks (Hemiramphidae), porcupinefishes (Diodontidae), pufferfishes (Tetraodontidae), mojarra (*Eucinostomus gula*), sheepshead minnow, spotted seatrout, pinfish, and permit (*Trachinotus falcatus*).Representative species at the upstream oligohaline site included common freshwater taxa such as gar (*Lepisosteus* sp.), bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), and dace (*Rhinichthys* sp.), as well as euryhaline estuarine taxa common snook and menhaden (*Brevoortia patronus*) and small-bodied residents including sailfin molly (*Poecillia latipinna*), mosquitofish (*Gambusia holbrooki*), and rainwater killifish (*Lucania parva*). The tidal marsh at the intermediate site was considered to be transitional in terms of fish community structure as the species found there were not characteristic of the site and were found commonly at the other sites.

More recently, the FIM program conducted a one-year study (2004-2005) on the Anclote River to evaluate the response of the fish and invertebrate community to variations in freshwater inflow

(Greenwood et al., 2006). The results of this study were used by SWFWMD to assist in the development of scientifically based minimum flows and levels for the river. Samples were collected monthly with plankton nets, seines, and trawls along a salinity gradient from St. Joseph Sound at the mouth of the Anclote River to tidal freshwater habitat at river kilometer 16. The larval fish and invertebrate community along the Anclote River found that the plankton was dominated by larval gobies (*Gobiosoma* spp. and *Microgobius* spp.), anchovies, silversides and skilletfish (*Gobieox strumosus*) as well as gammaridean amphipods, larval decapods crabs and mysid shrimp. River-plume taxa represented by copepods, chaetognaths, ostracods and planktonic shrimp were highly abundant near the river mouth. The nekton in shallow and deeper water samples was dominated by bay anchovy, pinfish and spot as observed by Szedlmayer (1982), but *Eucinotomus* mojarras were also a predominant fish species. Unlike earlier studies, *Menidia* silversides were not observed to be among the most abundant taxa. Several species of palaemonid grass shrimp (*Palaemonetes* spp., *Periclemenes* spp.), arrow shrimp (*Tozeuma carolinense*) and pink shrimp (*Farfantepenaeus duorarum*) were the dominant invertebrates. The nursery value of the Anclote River and adjacent St. Joseph Sound was evident in the high percentage of estuary-dependent species collected as juveniles from this area, including juvenile spot, pinfish, mojarras and pink shrimp. Over half of the ten most abundant species and >80% of all fish and invertebrates collected are spawned offshore but use the inshore estuarine and tidal freshwater habitats as juveniles before moving offshore as adults. The Anclote River also provides spawning habitat for numerous species of fish and invertebrate with eggs from at least a dozen species collected from the plankton. The majority of the eggs collected were from the sciaenid fishes, many of which are economically valuable in Florida as sportfish.

- **Fish Surveys in St. Joseph Sound and Clearwater Harbor**

Since June 2005, staff from the Clearwater Marine Aquarium has collected trawl samples from Clearwater Harbor as part of their Education and Outreach program providing ecological tours of the project area. The study area includes sixty fixed locations throughout Clearwater Harbor from which two samples, on average, are collected every day with the locations rotated among the sixty stations.

The fish and crustacean taxa most commonly collected by the Clearwater Marine Aquarium trawl program are among the dominant members of the seagrass community and include pinfish, silver perch, mojarra, grunts, filefish, penaeid shrimp and blue crabs (Table 5-13). In addition, over 20 economically important fisheries species have been documented by this program (Table 5-14) ranging from inshore recreational species such as red drum, spotted seatrout, common snook, sheepshead and gulf flounder to surf zone and offshore species including gag grouper, gray snapper, white grunts, Florida pompano and hogfish. Commonly collected shellfish and crustaceans included blue crabs, pink shrimp, bay scallops, rock shrimp and stone crabs.

Most recently, the fish and invertebrate community was characterized for the shoreline and nearshore seagrass habitats of St. Joseph Sound in waters ranging from 1.0-3.4 m in depth. During this survey, the Florida Fish & Wildlife Conservation Commission's (FWC's) FIM program collected sixty-three random samples from July to November 2009 (Figure 5-39). Each month, three 183-m haul seine samples and ten trawl samples were collected, with the exception of August (only one seine sample). Over the course of the survey, eighty-two taxa of fishes and invertebrates were collected. Community composition was representative of nearshore seagrass habitat and quite different than that observed in the various habitat provided by the Anclote River.

Table 5-13. Top ten most abundant fish and decapod crustacean taxa collected by the Clearwater Marine Aquarium trawl program (2005 - 2008).		
Common name	**Scientific name**	**Mean number per trawl**
Pinfish	*Lagodon rhomboides*	608.1
Silver perch	*Bairdiella chrysoura*	109.1
Mojarra	*Eucinostomus* spp.	71.7
Planehead filefish	*Stephanolepis hispidus*	59.9
White grunt	*Haemulon plumierii*	54.5
Blue crab	*Callinectes sapidus*	52.5
Pigfish	*Orthopristis chrysoptera*	41.6
Grunt	Haemulidae	37.7
Ghost shrimp	*Callianassa* spp.	34.9
Pink shrimp	*Farfantepenaeus duorarum*	29.9

Table 5-14. Economically important fish and decapod crustacean taxa collected by the Clearwater Marine Aquarium trawl program (2005 - 2008).		
Common name	**Scientific name**	**Mean number per trawl**
White grunt	*Haemulon plumierii*	54.5
Blue crab	*Callinectes sapidus*	52.5
Grunt	Haemulidae	37.7
Pink shrimp	*Farfantepenaeus duorarum*	29.9
Bay scallop	*Argopecten irradians*	16.1
Stone crab	*Menippe mercenaria*	12.8
Seatrout	*Cynoscion* spp.	7.3
Gray snapper	*Lutjanus griseus*	5.5
Gag grouper	*Mycteroperca microlepis*	4.3
Rock shrimp	*Sicyonia* spp.	3.8
Atlantic croaker	*Micropogonias undulatus*	2.2
Black sea bass	*Centropristis striata*	2.1
Spotted seatrout	*Cynoscion nebulosus*	2.1
Red drum	*Sciaenops ocellatus*	1.5
Sheepshead	*Archosargus probatocephalus*	1.4
Grouper	Serranidae	1.3
Gulf flounder	*Paralichthys albigutta*	1.2
Black drum	*Pogonias cromis*	1.1
Hogfish	*Lachnolaimus maximus*	0.5
Snook	*Centropomus undecimalis*	0.4
Sand seatrout	*Cynoscion arenarius*	0.3
Southern kingfish	*Menticirrhus americanus*	0.2
Bluefish	*Pomatomus saltatrix*	<0.1
Florida pompano	*Trachinotus carolinus*	<0.1
Red grouper	*Epinephelus morio*	<0.1

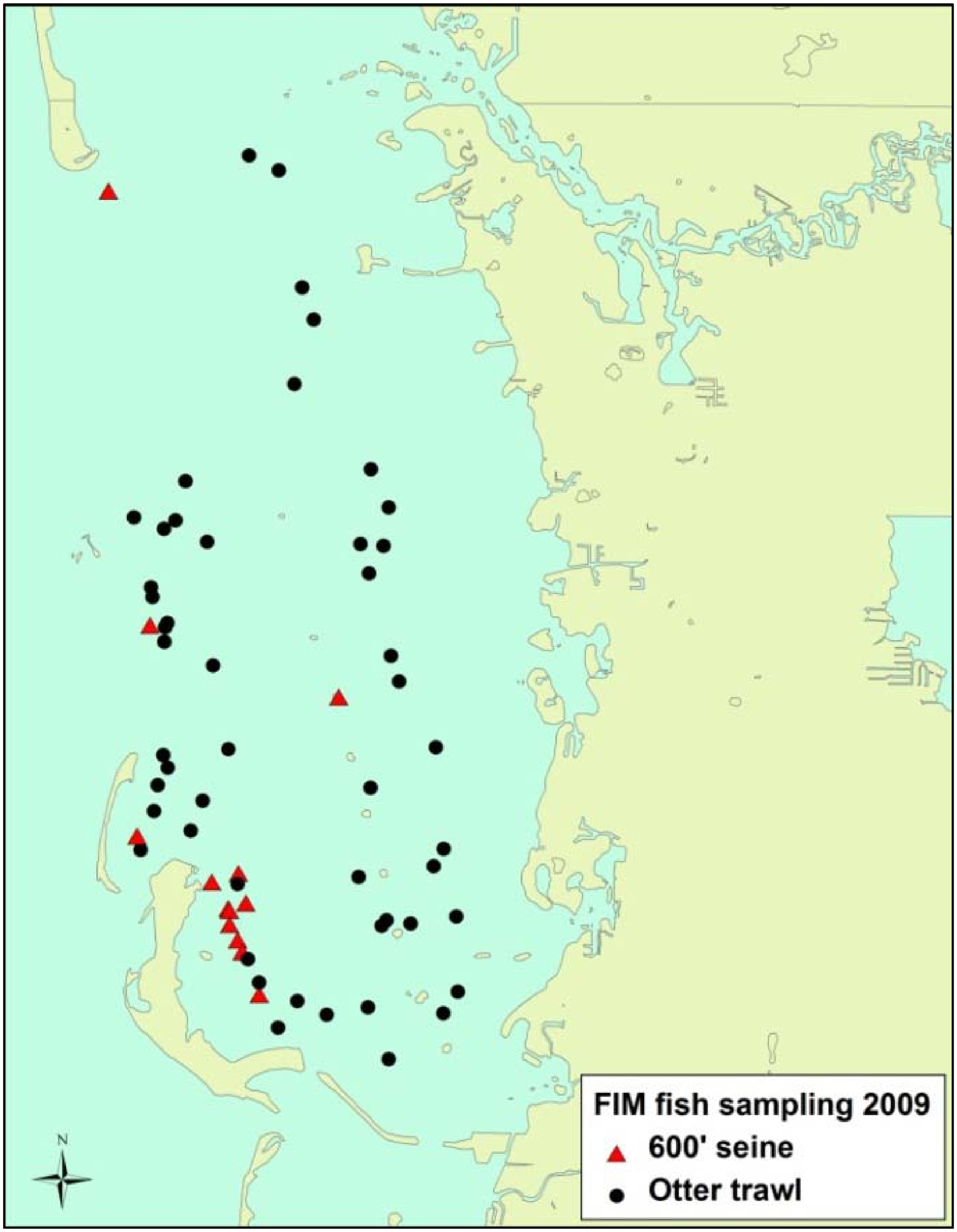

Figure 5-39. Location of fish samples collected by FWC's Fisheries - Independent Monitoring Program during July-November 2009.

Seven of the ten most abundant taxa were the same between shoreline seines and deep water trawls with the ten most abundant taxa from each gear (13 taxa total) representing >90% of the 36,194 individuals collected. As is true throughout the CHSJS estuary, pinfish were the dominant species in both shoreline and offshore seagrass habitats, with silver perch, pigfish (*Orthopristis chyrsoptera*), spottail pinfish (*Diplodus holbrooki*), planehead filefish (*Monacanthus hispidus*) and white grunts (*Haemulon plumieri*) also very abundant in both habitats. Grass porgy (*Calamus arctifrons*), scaled sardine (*Harengula jaguana*), and emerald parrotfish (*Nicholsina usta*) were very abundant in shoreline seines, but were not collected in trawls. Conversely, *Eucinostomus* mojarras and rainwater killifish were highly abundant in trawls but were not collected in shoreline seines (possibly as a result of the larger mesh size of the seine). Interestingly, scallops (*Argopecten* spp.) were among the most abundant species in both gears.

Seventeen species of economic value composed 5% of all individuals collected in both gears with scallops as the most abundant (48% of all economic species).Black seabass (*Centropristis striata*; 15%), lane snapper (*Lutjanus synagris*; 12%), pink shrimp (9%) and spotted seatrout (4%) were among the most abundant economic species. Snappers and groupers, including gray snapper, lane snapper, gag grouper (*Mycteroperca microlepis*) and red grouper (*Epinephalus morio*) represented 20% of all economic species. Many of the species collected from St. Joseph Sound during this survey are commonly associated with nearshore to offshore habitat in the Gulf of Mexico, including snappers, groupers, seabass, grunts, hogfish, barracuda, parrotfish, wrasses, and mackerels. This assemblage of 14 species composed 4% of all individuals collected in St. Joseph Sound.

- **Scallops**

FWC's Molluscan Fisheries Program has monitored the status of the Bay scallop population in St. Joseph Sound since 1994 and has tracked recruitment by scallop spat since 1997 (Figure 5-40). From 1994-2006, adult scallop abundances ranged from 0.2 to 47.4 scallops per 600m^2, but from 2007-2009 abundances more than tripled to138-174 scallops per 600m^2 (Stephenson and Geiger, 2010). Restoration efforts involving the grow-out and release of scallop spat collected between 1999 and 2006 during recruitment monitoring may have contributed to the increased scallop abundance observed in recent years.

Scallop spat are typically observed at peak abundance during the cooler, drier months of December and January though recruitment peaks have been observed as late as April. Although recruitment is observed during the wet season from June through October, spat abundances are typically very low during these months. Since August of 2006, however, recruitment by larval scallops has been continuous with spat observed on settling plates every month during that time. Mean annual abundance of adult scallops and recruitment strength by larval scallops in St. Joseph Sound are among the highest on the Gulf Coast of Florida and emphasize the value of this area's productive bay scallop habitat.

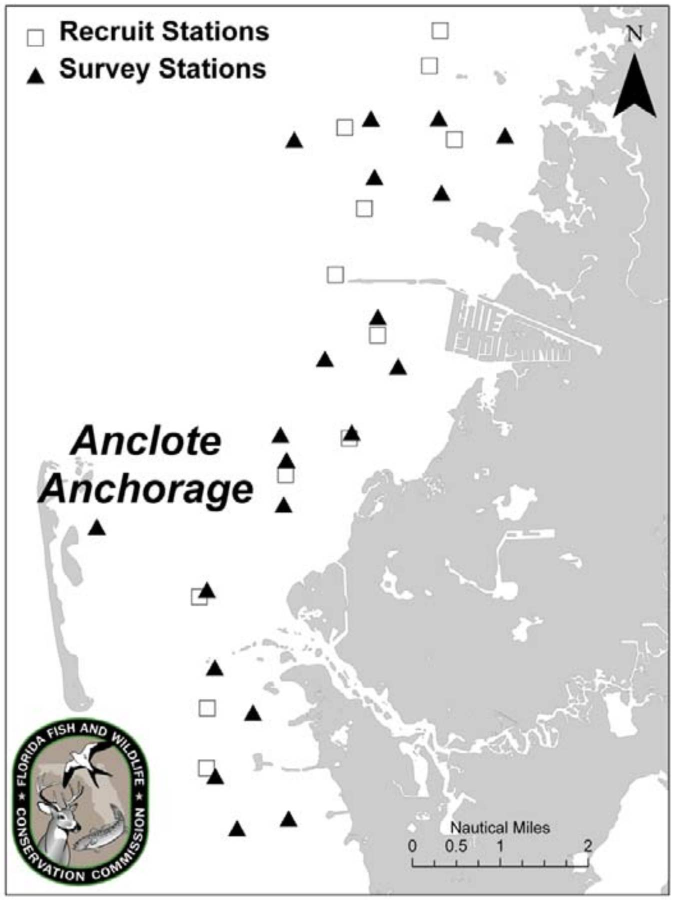

Figure 5-40 Scallop survey and recruitment monitoring stations sampled by FWC's Molluscan Fisheries Program in 2009 (Stephenson and Geiger, 2010).

5.5.2 Angler Pressure on Fisheries Resources in Clearwater Harbor and St. Joseph Sound

The definition of angler pressure is "the average number of anglers that a creel clerk would encounter during an 8-hour time period on an average, good-weather weekend or weekday" (Sauls, B., personal communication). The site locations with the CHSJS estuary are displayed in Figure 5-41 and listed in Table 5-15.The data are ordinal categories indicating the average number of anglers present for either weekdays or weekends (Table 5-16). There were 3 different types of anglers recorded in this data; charter anglers, private boat anglers, and shore anglers. An average of weekends and weekdays by site and type was calculated and displayed spatially for each angler type.

Clearwater Municipal Marina experienced the highest amount of charter boat pressure while other sites showed a much lower number of charter anglers present (Figure 5-41). This is in contrast to private vessel anglers where there was greater pressure at sites within St. Joseph Sound, Clearwater Harbor and the ICW. Areas that experienced a higher than average number of shore anglers were near, or on, passes or channels and also at the Clearwater Pier/Big Pier 60. The data were initially plotted by type, month and site to establish any correlation between the month and the number of anglers present at each site. Some sites showed increases in anglers in the winter months in all categories but there was no interaction between fishing pressure and season suggesting that relative fishing pressure across sites was stable seasonally.

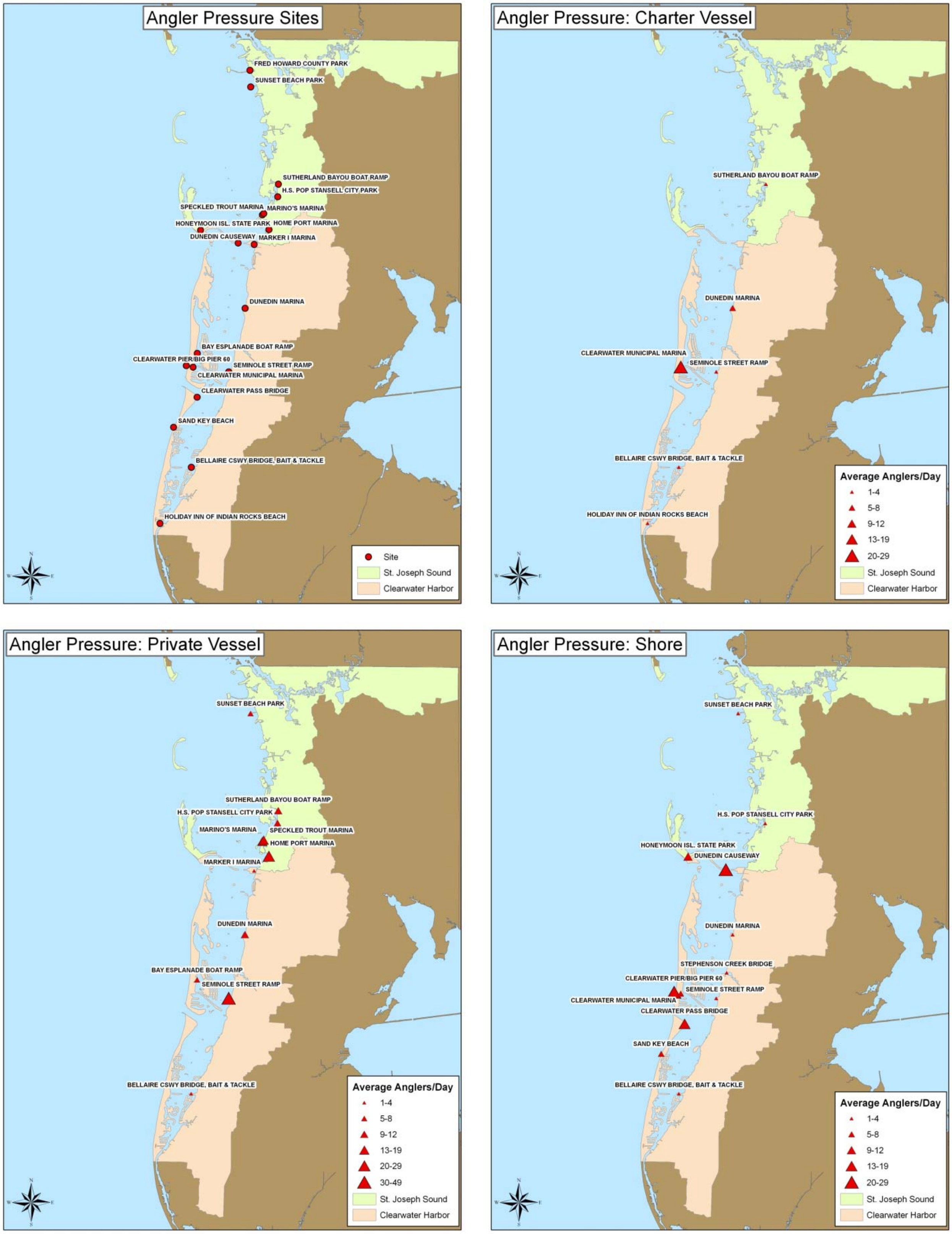

Figure 5-41. **Fisheries-dependent sample sites in St. Joseph Sound and Clearwater Harbor that were used to determine angler pressure classified as the average number of charter vessels, private vessels, or shore anglers per day.**

Table 5-15. Angler pressure sites within the CHSJS estuary.	
Site Name	**City**
Sutherland Bayou Boat Ramp	Palm Harbor
Honeymoon Isl. State Park	Dunedin
H.S. Pop Stansell City Park	Palm Harbor
Stephenson Creek Bridge	Clearwater
Clearwater Municipal Marina	Clearwater Beach
Clearwater Pier/Big Pier 60	Clearwater Beach
Fred Howard County Park	Tarpon Springs
Sunset Beach Park	Tarpon Springs
Marino's Marina	Ozona
Marker I Marina	Dunedin
Dunedin Causeway	Dunedin
Dunedin Marina	Dunedin
Clearwater Pass Bridge	Clearwater Beach
Bellaire Cswy Bridge, Bait & Tackle	Belleair Bluffs
Seminole Street Ramp	Clearwater
Holiday Inn Of Indian Rocks Beach	Indian Rocks Beach
Home Port Marina	Palm Harbor
Sand Key Beach	Sand Key
Speckled Trout Marina	Ozona
Bay Esplanade Boat Ramp	Clearwater Beach

Table 5-16. Categories used by the Florida Fish and Wildlife Conservation Commission to estimate angler pressure.	
Category Number	**# of Anglers Present at Site**
0	1-4
1	8
2	9-12
3	13-19
4	20-29
5	30-49
6	50-79
7	80+
8	Cannot determine
9	Mode not present at site

5.5.3 Management Targets

The limited availability of fisheries data for the CHSJS estuary precludes establishing quantitative targets. However, the proposed goals for the preservation and protection of fish stocks should include:

- Maintaining the current extent of seagrasses and shoreline habitat (i.e., fisheries habitat).
- Leveraging existing fish research efforts to provide a more quantitative estimate of the relative abundance of fishes over various habitat types within the study area.
- Facilitating existing creel surveys to obtain accurate information on angler pressure.
- Facilitating research into the utilization of the estuarine segments by the bay scallop.
- Public education to reduce anthropogenic stressors on fish habitat.

5.6 Charismatic Megafauna - Marine Mammals and Sea Turtles in the CHSJS Estuary

Bottlenose dolphins, Florida manatees, and five species of sea turtles utilize the CHSJS area; all of which are federally protected under the Endangered Species Act. These species are often referred to as “charismatic megafauna” due to their common appeal among humans which tends to invoke a connection with nature and the marine environment. As a result of this connection, these species have successfully been used to promote public awareness and conservation of coastal resources. While there are limited data available for analysis, a characterization of the ecology of these species, natural and anthropogenic stressors and management issues is an important part of the Comprehensive Conservation and Management Plan. Much of the existing information on marine mammals and sea turtles in the CHSJS system comes from research programs at FWC, Mote Marine Laboratory, and the National Marine Fisheries Service (NMFS), though collaborative efforts between these and various other agencies have provided information as well. In Florida, state-wide programs exist to monitor and assess the status of marine mammal and sea turtle populations and to conduct research on the biology and ecology of these species. This information is useful for the management of these natural resources and can be applied to populations that use the estuarine and coastal habitats of Clearwater Harbor and St. Joseph Sound.

Central to the development of an effective resource management plan is the identification of the primary natural and anthropogenic stressors affecting the resource, as well as management issues specific to each species. These stressors and management issues include:

- Natural and Anthropogenic Stressors:
  - Red tide events
  - Cold weather events
  - Food sources
  - Habitat Availability
  - Interaction with humans

- Management Issues:
  - Protection of habitats (e.g., beach habitat for turtle nesting, seagrass habitat forforaging, etc.)
  - Predation of turtle eggs
  - Interactions with humans (e.g., prop scarring, entanglements)

The available information for each of these items, as summarized from technical documents, scientific literature, and raw data, particularly those sources derived from within or near the study area, is summarized below.

5.6.1 Bottlenose Dolphins

The bottlenose dolphin, *Tursiops truncatus*, is probably the most common, and most familiar, marine mammal in the CHSJS estuary. In Florida waters, there are thought to be inshore and offshore populations of bottlenose dolphins which differ in their patterns of habitat use and diet (Barros, 1993). Inshore populations commonly use shallow estuarine waters (<3-m) where they feed primarily on fishes and often over seagrass (Barros and Wells, 1998), though in St. Joseph Sound they have been shown to prefer unvegetated habitats over seagrass for, foraging, despite the greater availability of seagrass habitat there (Allen et al. 2001). Among the most frequently consumed prey items are several of the most abundant species in Clearwater Harbor and St. Joseph Sound, including pinfish (*Lagodon rhomboides*), striped mullet (*Mugil cephalus*), pigfish (*Orthopristis chrysoptera*) and spot (*Leiostomus xanthurus*) (Barros and Wells, 1998). In St. Joseph Sound, foraging dolphins have been shown to prefer dredge channels and spoil islands over seagrass habitat possibly due to the larger size and ease of capture of fishes in these unvegetated habitats (Allen and Read, 2000; Allen et al., 2001).

The population size for bottlenose dolphins has not yet been determined in the CHSJS estuary. The most recent estimates for Tampa Bay indicate a population size of approximately 500 individuals (Wells et al., 1996). These individuals may collectively form 5 distinct "communities" (Urian et al., 2009) within Tampa Bay despite the lack of physical boundaries to maintain these discrete communities. Though they did not attempt to define the home range of each community, Urian et al. (2009) found that the spatial extent occupied by each community covered an area larger than that of Clearwater Harbor and St. Joseph Sound, suggesting that there may be just one community of bottlenose dolphins in this system. Based on the results of this study and the barrier islands that divide Tampa Bay from Clearwater Harbor, it is also likely that the bottlenose dolphins in Clearwater Harbor and St. Joseph Sound are a separate community distinct from those in Tampa Bay. From a monitoring and management perspective, Urian et al. (2009) recommend that the fine-scale distribution of bottlenose dolphin sub-populations be considered when designing sampling programs and when making management decisions for this species, particularly due to the apparent social boundaries that may segregate dolphin sub-populations and affect interactions among them.

One of the most prominent natural stressors to bottlenose dolphins is exposure to red tide. Mass mortality may occur following the consumption of fishes that have bioaccumulated lethal levels of brevetoxin. In fact, the effects of red tides may persist in the food web long after the bloom has subsided (Flewelling et al., 2005).

Among the human-related threats to the bottlenose dolphin, ingestion of, or entanglement in, fishing gear and collisions with watercraft are some of the most prominent (Wells et al., 2008). Recreational and commercial fishing are prevalent human activities in nearshore waters, where ingestion of recreational fishing lures by dolphins have been documented (Wells et al., 2008). Entanglement in monofilament fishing line and crab trap lines may also pose a threat in the coastal waters of Clearwater Harbor and St. Joseph Sound (Wells et al., 2008). Collisions with watercraft have been associated with various water-related activities, including recreational and commercial fishing, but also pleasure boating and eco-tourism (Whitt and Read, 2006). A recent study of the effects of boat traffic on the foraging behavior of bottlenose dolphins in St. Joseph Sound and John's Pass concluded that more boat traffic did not affect the percentage of time spent feeding by dolphins in either location, but the choice of foraging habitat was affected by boat traffic (Allen and Read, 2000). In St. Joseph Sound where boat traffic is relatively light, dolphins spent more time feeding in dredge channels and along spoil islands than in seagrass beds. Similarly, in John's Pass (just south of Clearwater Harbor) where boat traffic is typically heavy, dolphins foraged more often in dredge channels when boat traffic was light but spent more time in seagrass habitat, and along spoil islands, when boat traffic in the channels was heaviest. Boat traffic from dolphin-watching operations in Clearwater Harbor may also pose a threat to dolphins due to violations of approach distance, improper maneuvering around dolphins, and failure to discontinue activities when dolphins exhibited stress behaviors (Whitt and Read, 2006).

5.6.2 Florida Manatees

The Florida manatee, *Trichechus manatus latirostris*, is another common marine mammal species found in the shallow, coastal waters of Clearwater Harbor and St. Joseph Sound. Manatees, which consume seagrasses as a primary part of their diet, are likely closely linked with the extensive seagrass habitat in this system. Despite spending extensive time in estuarine and marine waters, manatees require a fresh source of drinking water and may use natural springs and tributaries, like those in Clearwater Harbor and St. Joseph Sound, but may also take advantage of freshwater hoses along docks and seawalls. During the warmer months, manatees are widely distributed, but during the colder months, manatees aggregate in the warm waters of power plants, including the Anclote River Power Plant which provides a suitable location to survey the manatee population.

During synoptic surveys conducted since 1991 by FWC, 176 manatees have been observed in the coastal waters of St. Joseph Sound. The majority of these observations have been made in the Anclote River, specifically near the power plant and in Spring Bayou (Figure 5-42). Because these surveys are intended to estimate manatee population size, they are designed to take advantage of manatee aggregations during the colder months and are therefore spatially biased. This bias prevents the use of these data for understanding patterns of manatee spatial distribution and habitat use. However, these patterns can be inferred from occurrences of manatee mortality.

As large-bodied marine mammals, manatees face many of the same natural and anthropogenic stressors experienced by bottlenose dolphins. While these stressors can be sub-lethal, such as cold weather events and heavy boat traffic, these stressors can also induce mortality. Estimates of manatee mortality derived from FWC data indicate that, state-wide, approximately 40% of all mortality events are natural, with 20% related to red tide blooms (*Karenia brevis*) or sublethal water temperatures and 20% related to perinatal mortality. Human-related manatee mortality in Florida represents approximately 30% of the total and is primarily the result of watercraft collisions. In comparison, nearly half of all mortality events in Clearwater Harbor and St. Joseph Sound (Figure 5-

43) is due to natural causes (49%), while human-related mortality is about 35% and is similar to the state-wide estimate. Though not observed in the Clearwater Harbor area, numerous mass mortality events have been observed in Sarasota Bay and Charlotte Harbor; three events between 2002-2005 (Landsberg et al., 2009). As with dolphins, mortality appears to be the result of a trophic transfer that occurs following the consumption of a food source that has bioaccumulated the brevetoxin. In the case of manatees, the transfer is thought to occur via seagrasses with attached toxic filter-feeding organisms.

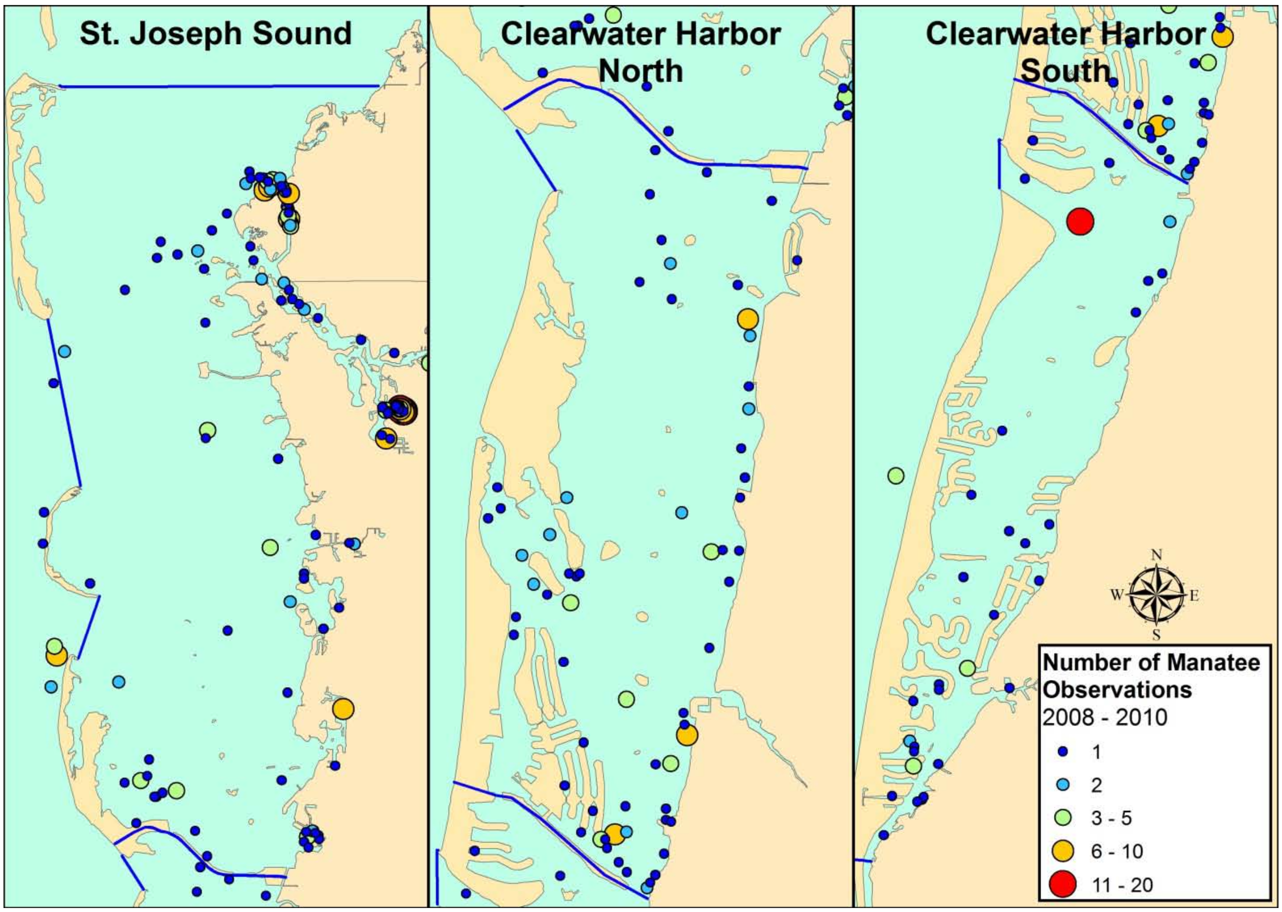

Figure 5-42. **Synoptic survey of Florida manatees from 2008-2010. To improve estimates of population size, surveys are typically conducted during the colder months when manatees aggregate in the warm waters of the power plants and bayous. Data were provided by the Florida Fish and Wildlife Conservation Commission.**

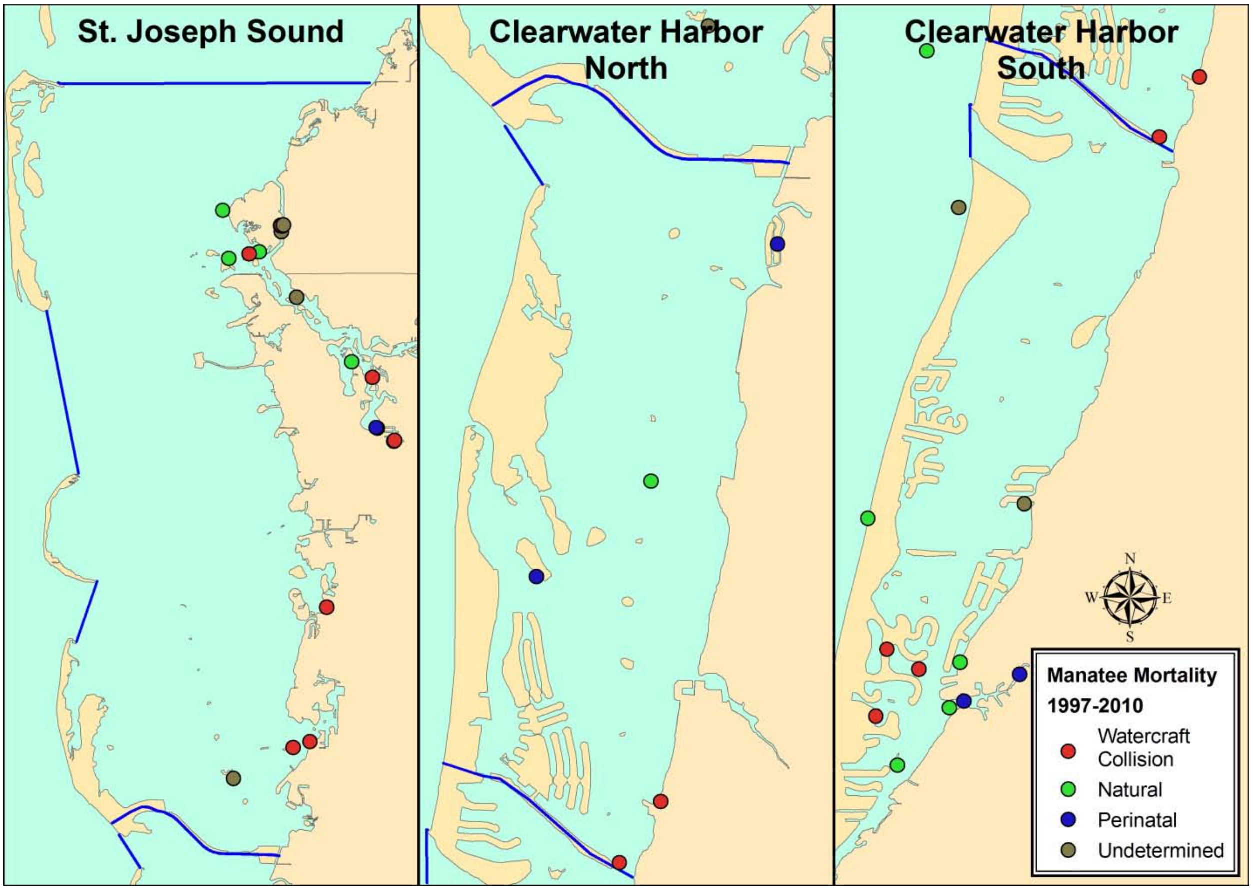

Figure 5-43. Manatee mortality from 1997-2010. Data were provided by the Florida Fish and Wildlife Conservation Commission.

5.6.3 Sea Turtles

Sea turtles utilize the western shorelines of the barrier islands as nesting sites and deposit eggs above the high tide line, westward of the primary dunes. Sea turtles have high site fidelity, returning to the same beaches year after year to nest and the barrier islands associated with the project area have management plans aimed at protecting the nesting sea turtles and their eggs from harm. Three species, the green (*Chelonia mydas*), loggerhead (*Caretta caretta*) and leatherback sea turtle (*Dermochelys coriacea*) routinely use the beaches to nest. During the 2008 nesting season (May-August), there were 196 documented loggerhead nests on Pinellas County beaches from Anclote Key to Fort DeSoto, but none reported for green or leatherback turtles.

Sea turtle strandings are a relatively common event in the study area, primarily along the Gulf beaches, but also in Clearwater Harbor and St. Joseph Sound (Figure 5-44). Based on data maintained by the Florida Sea Turtle Stranding and Salvage Network which is coordinated by FWC, there were 572 sea turtle strandings between 1986-2006 and an average of 27 documented strandings each year. Among these, green sea turtles (46%) and loggerheads (35%) were the most commonly stranded, with fewer Kemp's ridley, *Lepidochelys kempii*(15%), hawksbill, *Eretmochelys imbricata*, (3%) and leatherback sea turtles (1%) reported. Approximately 22% of strandings were still alive and transported to rehabilitation centers, while the rest were remains. Juvenile sea turtles also may use the estuarine portions of the project area for grazing.

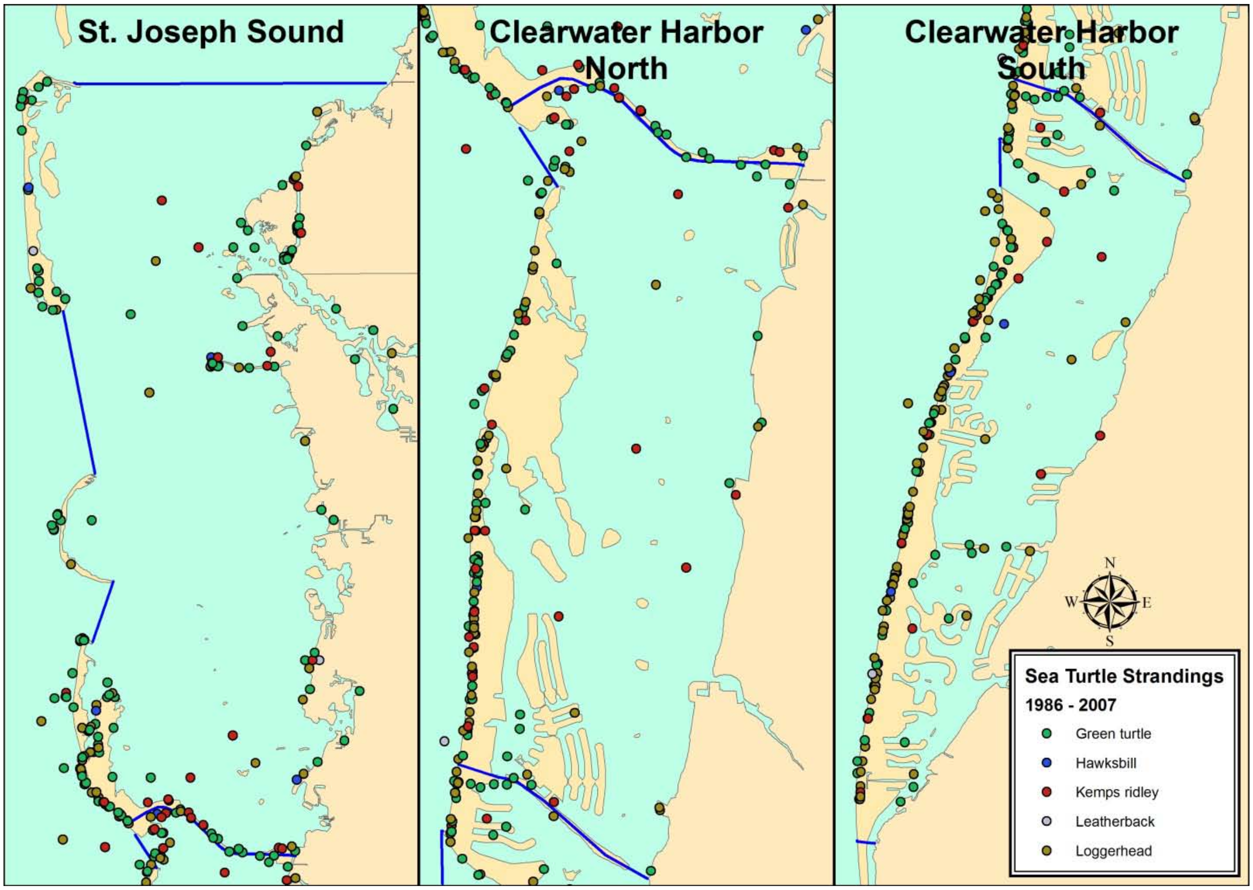

Figure 5-44. **Distribution of sea turtle strandings from 1986-2007. Data were provided by the Florida Fish and Wildlife Conservation Commission.**

5.6.4 Management Targets and Goals

Management goals for these species should focus on the protection of the habitat, including water quality, seagrass, and shorelines, as well as conservation of forage sources such as seagrasses for manatees and turtles, and sustainable fish populations for bottlenose dolphins.

- Public education regarding the human interactions with these animals among the boating and fishing community will continue to be an important part of the management strategy for these species and should be emphasized in the future.
- Facilitating future research into causes of sea turtles and manatee strandings
- Protecting crucial habitats within the estuaries

5.7 Birds of the CHSJS Estuary

A unique assemblage of colonial waterbirds and shorebirds use the Clearwater Harbor and St. Joseph Sound (CHSJS) region of peninsular Florida. At least twenty-five bird species, including several taxonomic groups of colonial waterbirds and territorial birds, breed in CHSJS coastal habitats. Eleven of these species are federally or state-listed as "endangered", "threatened", or as "species of special concern" and many birds that occur in the region are listed on non-regulatory management lists. In 2009, 5,331 pairs (all species combined) nested on islands in the system. This count does not include colonies of Least Terns and Black Skimmers that nested on scattered beaches and rooftops in this region of Pinellas County.

Audubon of Florida has recognized the CHSJS area as highly valuable for its avifauna by inclusion of two of its regions, "Clearwater Harbor-St. Joseph Sound" and the "Gulf Islands GEOPark", in the Important Bird Areas (IBAs) of Florida (Figure 5-45).

The Clearwater Harbor-St. Joseph Sound IBA, which includes the dredged spoil material islands in Clearwater Harbor and St. Joseph Sound, Clearwater Harbor I-25 Bird Sanctuary, the two Belleair Beach Bird Islands, and Indian Rocks Beach Bird Island and Bird Island South, meets the Florida IBA criteria for hosting "significant populations of Threatened, Special Concern, and FCREPA Species (Florida Committee on Rare and Endangered Plants and Animals), and significant populations of larids". The Gulf Islands GEOPark IBA, which includes the Anclote Bars, Anclote Key State Preserve, Three Rooker Island State Preserve, Honeymoon Island State Recreation Area, and Caladesi Island State Park, meets the Florida IBA criteria for hosting "significant populations of Threatened, Special Concern, FCREPA, Watch List, and IBA species, and significant populations of shorebirds, larids, and neotropical migrants; significant overall diversity; and significant natural habitats" (Pranty, 2002). BirdLife International and the National Audubon Society also have recognized the global importance of the Gulf Islands GEOPark IBA because of the wintering population of Piping Plovers that rely on it, a species categorized by BirdLife International as "vulnerable" because their populations are concentrated in one general habitat type or biome (NAS, 2009). In addition to the importance of CHSJS to rare and imperiled bird species, this coastal region's strategic location on the Atlantic Flyway also provides nesting, roosting, wintering, migratory stop-over, and foraging habitats for millions of birds annually.

5.7.1 Species of Birds Using the CHSJS Estuary

The bird species using the study area can be divided into five general categories, which are separated principally by nesting and foraging behavior as described below.

- **Colonial Waterbirds**

Colonial waterbirds include seabirds and wading birds (Table 5-17). These birds consume fish or other wetland animals. Their young are large, take more than two months to fledge once the eggs have hatched, and are raised in often noisy, smelly colonies. Because their nests and young are obvious, these birds must nest where there are no terrestrial predators (generally on small islands). They feed their growing young fish or wetland prey, and can forage widely miles from their nesting site to find these prey, because the fish roam in moving schools, and wetland organisms are not evenly dispersed across the landscape but are concentrated in drying wetlands in spring and early summer. More than 25 species of colonial waterbirds use habitats in CHSJS (Table 5-17).

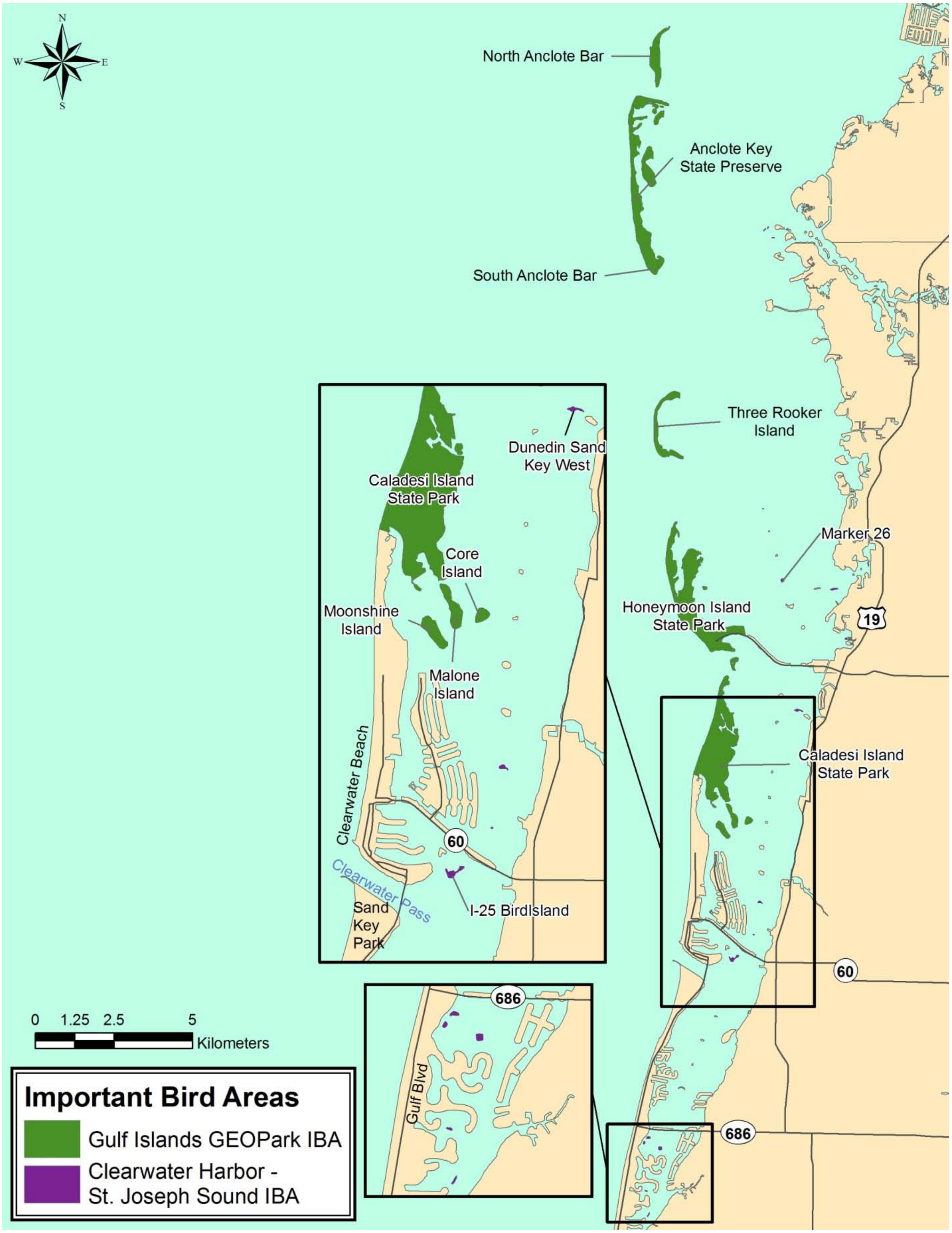

Figure 5-45. Gulf Islands GEOPark and Clearwater Harbor/St. Joseph Sound Important Bird Areas.

- **Migrant Ducks, Loons, Grebes, and Shorebirds**

Over the winter and during migration, thousands of ducks, hundreds of Common Loons and grebes, and thousands of shorebirds use CHSJS waters and shores (Table 5-18). Located on the Atlantic Flyway, these waterways, beaches, and shorelines are extremely important stopover and over-wintering sites for birds that nest further north, some as far as the Arctic tundra, but retreat south in the winter to find their fish, shellfish, insect, and invertebrate prey

Table 5-17. Colonial waterbirds of CHSJS estuary.

Species	Nesting	Wintering	Migrant
American White Pelican		X	X
Brown Pelican	X	X	
Double-crested Cormorant	X	X	X
Anhinga	X	X	
Magnificent Frigatebird			X
Great Blue Heron	X	X	
Great Egret	X	X	
Snowy Egret	X	X	
Little Blue Heron	X	X	
Tricolored Heron	X	X	
Reddish Egret	X	X	
Cattle Egret	X	X	
Green Heron	X	X	
Black-crowned Night-Heron	X	X	
Yellow-crowned Night-Heron	X	X	
White Ibis	X	X	
Roseate Spoonbill	X	X	
Wood Stork		X	
Laughing Gull	X	X	
Ring-billed Gull			X
Herring Gull			X
Gull-billed Tern		X	X
Caspian Tern	X	X	
Royal Tern	X	X	
Sandwich Tern	X	X	
Least Tern	X	X	
Black Tern			X
Black Skimmer	X	X	

Table 5-18. Migratory waterfowl and shorebirds of CHSJS estuary.			
Species	**Nesting**	**Wintering**	**Migrant**
Mottled Duck	X	X	
Blue-winged Teal		X	X
Green-winged Teal		X	X
Lesser Scaup		X	X
Hooded Merganser		X	X
Red-breasted Merganser		X	X
Ruddy Duck		X	X
Common Loon		X	X
Pied-billed Grebe		X	X
Horned Grebe		X	X
Spotted Sandpiper		X	X
Whimbrel		X	X
Long-billed Curlew		X	X
Marbled Godwit		X	X
Ruddy Turnstone		X	X
Red Knot		X	X
Sanderling		X	X
Semipalmated Sandpiper		X	X
Western Sandpiper		X	X
Least Sandpiper		X	X
Dunlin		X	X
Short-billed Dowitcher		X	X

- **Beach-nesting Territorial Shorebirds**

Birds that eat oysters, marine invertebrates, or insects actively defend specific foraging sites that include their nesting and rearing areas (Table 5-19). American Oystercatchers, Snowy and Wilson's plovers, and Willet adults do not allow other members of their species to forage in their territories during the nesting period, to ensure that there will be sufficient food to successfully raise their young. Oystercatchers and plovers nest on the ground, using open substrate. Willets nest in grassy marshes, generally on the sound or harbor side of barrier islands. Birdlife International designated the Gulf Coast GEOPark as an IBA of global significance in part because of the presence of a significant wintering population of Piping Plovers.

Table 5-19. Beach-nesting territorial shorebirds of CHSJS estuary.			
Species	**Nesting**	**Wintering**	**Migrant**
Piping Plover		X	X
Snowy Plover	X	X	
Wilson's Plover	X	X	
Killdeer	X	X	X
American Oystercatcher	X	X	X
Black-necked Stilt		X	
Willet	X	X	X

- Passerines

Passerines (order Passeriformes), also called perching birds or songbirds, tend to be smaller than other bird groups but include highly diverse nesting and foraging behaviors (Table 5-20). Some nesting birds use the CHSJS mangroves, coastal hammocks, and shorelines and others over-winter here or stop during their fall and spring migrations (Table 5-20).

Table 5-20. Passerines of CHSJS estuary.

Species	Nesting	Wintering	Migrant
Yellow-billed Cuckoo	X	X	X
Mangrove Cuckoo	X		X
Belted Kingfisher		X	X
Eastern Phoebe	X	X	X
Great Crested Flycatcher	X	X	X
Eastern Kingbird	X	X	X
Gray Kingbird	X	X	
Loggerhead Shrike	X	X	X
Fish Crow	X	X	X
Northern Rough-winged Swallow	X	X	
Marsh Wren	X		
Prairie Warbler	X		X
Palm Warbler		X	X
Yellow-rumped Warbler		X	X
Red-winged Blackbird	X	X	X
Common Grackle	X	X	X
Boat-tailed Grackle	X	X	X
Brown-headed Cowbird	X	X	X

- Raptors

Raptors are defined by their typical foraging behavior, which is to hunt vertebrate species from the air. These "birds of prey" have strong talons and sharp beaks adapted for piercing and tearing flesh. The species of raptors utilizing the CHSJS study area are presented in Table 5-21.

Table 5-21. Raptors of CHSJS estuary.

Species	Nesting	Wintering	Migrant
Black Vulture		X	X
Turkey Vulture		X	X
Osprey	X	X	
Bald Eagle	X	X	X
Northern Harrier		X	X
Sharp-shinned Hawk	X	X	X
Cooper's Hawk	X	X	X
Red-shouldered Hawk	X	X	X
Red-tailed Hawk	X	X	X
American Kestrel	X	X	X
Merlin		X	X
Peregrine Falcon		X	X

5.7.2 Important Bird Habitats in the CHSJS Estuary

The CHSJS study area includes critical nesting and foraging habitats for birds. These habitats provide nesting substrate, foraging opportunities, and migratory and over-wintering stop-over sites. Bird habitats in CHSJS include forested areas (patches of mangroves, coastal hammocks, or pine flatwoods remaining on barrier islands, some natural mangrove islands, and mangroves and coastal hammock communities on some islands created when the Intracoastal Waterway (ICW) was dredged); beaches on barrier islands and dredged spoil material islands; and coastal marshes.

- **Nesting Habitats**

The dominant types of nesting habitats within the CHSJS study area include arboreal, beach, and coastal marshes. Aboreal (tree) habitats provide nesting and over-wintering opportunities in the CHSJS study area. Many species of colonial waterbirds use arboreal habitats for nesting including: Brown Pelican, Double-crested Cormorant, the herons and egrets, White Ibis, and Roseate Spoonbill. Colonies of birds nesting in trees generally occur only on small islands that have no resident mammalian predators and are off-shore, separated by open water and deep channels with tidal currents that discourage mammals from swimming to them. Colonial waterbirds will not nest on islands if mammalian predators are present.

Three of the larger barrier islands (Honeymoon Island, Caladesi Island, and the northern section of Clearwater Beach) still have relatively undisturbed mangrove forests, coastal hammock communities, salt marshes, beaches, and pine flatwoods. Conversely, most of Clearwater Beach and Sand Key are highly developed and the beach-front communities of condominiums, hotels, and residences on Clearwater Beach, Belleair Shores, Belleair Beach, and Indian Rocks Beach have displaced most native vegetation and shallow water shorelines. In addition, causeways connecting to the mainland provide access to the barrier islands for raccoons and other mammalian predators, which have developed large resident populations locally.

Before the 1940s, neither Clearwater Harbor nor St. Joseph Sound had chains of islands running through them, and nesting birds were concentrated locally on undeveloped barrier beaches and natural islands. Dredged spoil material was piled to form islands on the east side of the ICW in St. Joseph Sound, and on the west side of the ICW in Clearwater Harbor. Those islands that support tree-nesting birds are vegetated now with mangroves, seagrape, privet, Brazilian pepper, cabbage palm, Australian pine, and prickly pear cactus (e.g. Dunedin Sand Key West) (Lewis and Lewis, 1978).

The structure of the forest on each island influences which species may nest there. Of the tree species that occur on the islands, colonial waterbirds generally select mangroves and Brazilian pepper trees as nesting substrate, although some cormorants nest in the Australian pines on SJS Marker 26 and White Ibis nest in seagrapes and cabbage palms on Three Rooker Island. Brown Pelicans, cormorants, and Great Blue Herons typically nest on top of the tree canopy, where they can easily fly to their nests. The other herons, egrets, ibis, and spoonbills generally nest under the canopy, placing their nests at limb junctures, in the shade, often behind inter-lacing leaves that conceal their nests. Reddish Egrets and Roseate Spoonbills nest on tree limbs over-arching small creek channels (e.g., Clearwater Harbor Bird Island I-25, Belleair Beach Bird Islands). Little Blue Herons, Snowy Egrets, and Tricolored Herons nest in dense lower-growing mangroves or Brazilian pepper thickets. White Ibis nest in multiple-nest clusters, using ritualized courtship displays to maximize reproductive synchronicity. Yellow-crowned Night-Herons nest both in mixed species colonies and in small groups high in tall pines or oaks on mainland sites located near estuaries where they can find crabs (the mainstay of their diet), fish, and other food items.

Several songbirds are uniquely dependent on mangroves for nesting habitat, including Mangrove and Yellow-billed Cuckoos, Prairie Warblers, Black-whiskered Vireos, Gray Kingbirds, Great Crested Flycatchers, and Rough-winged Swallows. Mangrove Cuckoos are a tropical, mostly West Indian species that occurs as far south as Brazil, with the most northerly-reported summer (probable nesting) sightings at the Anclote Keys. These birds nest exclusively in mangrove forests. Coastal development and nest parasitism by Brown-headed Cowbirds caused the Florida population decline (Stevenson and Anderson, 1994). It is likely that Mangrove Cuckoos were never plentiful in the CHSJS region, and are extirpated now. Yellow-billed Cuckoos nest in forests along waterbodies in the eastern United States and winter in Central America. Populations are declining across their range (Hughes, 1999). The race of Prairie Warblers that lives in Florida nests exclusively in tall mangrove forests, and locally nest on the eastern side of Anclote Key, Dutchman Key, and the other small islets of the Anclote Key complex, Honeymoon Island, and Caladesi Island. The regional Prairie Warbler population decline is related to loss of mangrove forests and nest parasitism by Brown-headed Cowbirds. Black-whiskered Vireos are another tropical species that formerly bred in low numbers in the CHSJS region, and as far north as Cedar and Seahorse Keys on the west coast of Florida (Stevenson and Anderson, 1994). Loss of mangrove forests and coastal hammock habitats and nest parasitism by Brown-headed Cowbirds caused this species' population decline in Florida and, although a pair was observed feeding young on Honeymoon Island in 1992, it is very rare or absent from Pinellas County today (Pranty, 1993). Gray Kingbirds nest in coastal habitats in large black mangroves at the edge of islands (e.g., Indian Rock Beach South), or just inland from estuaries in oak trees, where they are rare. Other nesting birds of the coastal hammocks and pine flatwoods in the CHSJS region include Great Crested Flycatchers, Northern Rough-winged Swallows, Eastern Towhees, Red-bellied Woodpeckers, Summer Tanagers, Northern Mockingbirds, and Brown Thrashers.

Ospreys, a fish-eating hawk with nearly worldwide distribution, are locally common. They build bulky stick nests lined with grasses, vines, and other materials in tall pines and other high structures along the coast (Ogden, 1996). Bald Eagles also nest along shorelines and inland, generally in tall pines, and recently also in tall man-made structures such as cell towers. On his trip to Florida in 1879, Princeton ornithologist W. E. D. Scott observed that Clearwater Harbor hosted at least 11 pairs of eagles (Scott, 1881, 1888, 1889). For several decades in the 1950s-1990s, the Bald Eagle population was severely depressed by low reproduction rates and hunting, but populations are increasing in Florida and locally, with seven nests presently in Pinellas County (FWC, 2010). Great Horned Owls nest on Anclote Key (Chris Berner, Anclote Key State Park, pers. comm.), and Honeymoon Island (Dan Larremore, Honeymoon Island State Park, pers. comm.).

Beach habitats provide both nesting and foraging opportunities. Birds that nest on the beaches require weather-related disruption of plant succession to provide the sparsely vegetated substrate they prefer. All beach-nesting species nest above the highest high tide line where their nests are not usually inundated. Early storms with associated high tides do flood nest sites or entire colonies in some years, causing the nests to be over-washed and resulting in lost nests if the developing embryos are soaked, suffocated, or chilled, or the eggs float out of flooded nests. Typically, adult birds will re-nest if their initial nesting attempt fails. If nest loss occurs as late as July, they typically will not attempt to nest again that season.

Beach-nesting birds of the CHSJS region that are colonial, i.e., nest in clustered groups, are Laughing Gulls, Caspian, Royal, Sandwich, and Least terns, and Black Skimmers. Solitary-nesting territorial species are Snowy and Wilson's plovers, and American Oystercatchers that defend nest sites located within the foraging habitat needed to raise their young, although they often nest near or among bird colonies. The predominant beach nesting areas within the CHSJS are Anclote Key and its bars, Three Rooker Island, Honeymoon Island, Caladesi Island, and Clearwater Beach. All these areas are Gulf of Mexico barrier islands constructed of bright white quartz sands washed up on shallow coastal shelves. In the past, Black Skimmers, Least Terns, and American Oystercatchers nested on the sandy spoil islands in southern Clearwater Harbor, but these islands have eroded below the high tide line, precluding nesting.

Beach-nesting birds nest in the spring. Snowy and Wilson's plovers, and American Oystercatchers begin nesting in March, Willets in April, and Least Terns, Royal Terns, and Laughing Gulls initiate nesting by mid-May. Black Skimmers typically begin nesting by June and typically choose sparsely-vegetated sites slightly lower on the beach than the terns, which increases their vulnerability to losing their nests from flooding or disturbance.

Birds that require very open substrate include Black Skimmers, Snowy Plovers, and American Oystercatchers. Black Skimmers and Least Terns prefer open sand where they can observe approaching threats, but will accept some widely-interspersed grass clumps. Royal Terns (with some small groups of Caspian Terns or Sandwich Terns nesting near or among them in some years), and Wilson's Plovers place their nests in colony clusters on the bare sand among interspersed clumps of cordgrass, or saltgrass, railroad vine, shoreline purslane, and other halophytic plants pioneering on the lowest dunes developing just above the beach shorelines facing the Gulf of Mexico. The nest sites are closely packed in the case of Royal and Sandwich tern colonies, with each nest just out of reach of the adjacent tern's reach as it is sitting on its nest, resulting in hexagonal packing. Nests are more broadly spaced in Caspian and Least tern and Black Skimmer colonies, although these birds as well choose sites carefully placed beyond "pecking distance" of any adjacent nesting bird sitting on its nest.

Plovers, oystercatchers, skimmers, and terns make shallow "scrapes" in the sand, small circular depressions to hold their eggs. They may place some small shells, stones, or other objects around the crest of the nest scrape to provide subtle shadow, camouflaging the highly cryptic eggs, which are generally colored a light tan with black and brown spots. If nests in a colony are lost due to over-washing by storms or disturbance, gulls, terns, plovers, skimmers, and oystercatchers will nest again, either at the same site or nearby.

Royal and Sandwich terns lay only one egg per pair, but Caspian and Least terns, Laughing Gulls, plovers, Willets, skimmers, and oystercatchers lay clutches averaging three eggs. One of the pair guards and provides thermoregulation for the eggs or the young chicks all the time, while the other typically forages or roosts nearby. The terns and skimmers bring fish one at a time to supply their mate guarding the nest and then the young, once hatched. Once young are large enough that they are not easy prey for gulls, Fish Crows, and other aerial predators, both adults forage for food while the young gather in crèches (groups) near the waterline where the wet sand is cooler. Terns, skimmers, and oystercatchers feed their young until mid-winter, an extended parental care period that is unusual among bird species, likely because of the skill needed by terns and skimmers to forage in open water for small fish and the lengthy time fledged oystercatchers need to develop a fully keratinized bill to pry open oysters and other bivalves. Laughing Gulls nest in high numbers in colonies among grass clumps and construct woven grass nests to hold their three-egg clutch of cryptically-colored eggs (greenish with brown spots or sometimes light blue in color).

Snowy Plovers nest on the brightest, whitest sand portions of the beach, immediately above the high tide line, generally where over-wash supports an algal bloom in the dampened sand. Wilson's Plovers nest slightly higher on the beach among grassy clumps, near open sandflats located on the sound-side. Algal mats growing on the sandflats foster flies and tiger beetles, among other insects, invertebrates, and small crabs, food for the plovers. Hatched chicks' feathers are colored like mottled beach sand, providing camouflage. Chicks are very mobile, and crouch near a shell, flotsam, or other beach material if startled. They forage for some food themselves, and their parents provide protection from predators, thermoregulation, and invertebrate and insect prey.

American Oystercatchers nest on open sites at the tops of dune ridges where they can see to the open water and in all directions. Oystercatchers return to nest near last year's nest, especially if they were successful there the previous year. Oystercatchers are long-lived and mated pairs remain together for many years, although "divorces" will occur occasionally and birds will mate with a replacement if one of the pair perishes. Oystercatcher pairs defend their linear and nesting territory vigorously against other oystercatchers, whistling, flying in circles, and stridently "pointing" at the edge of their territory by extending their beaks downward at that site. Typically they lay three, sandy-colored, spotted eggs. The adult on the nest provides cooling shade and protection from aerial predators, having selected a site free of terrestrial predators. Oystercatchers, if disturbed, walk away from the nest, trusting that the highly camouflaged eggs will conceal the nest. An unattended nest scrape, consisting of sand or pebbles exposed to the sun in May and June, can overheat quickly, killing the vulnerable embryos. Oystercatcher chicks are mobile and will hide from approaching perceived threats by crouching in the shadow of a shell, grass clump, or other object on the beach. The adults typically will stand on either side of their young and protect them from predation by aggressively driving off hawks, egrets and herons, and other aerial predators. Oystercatchers will not challenge intrusion by people, raccoons, dogs, or other large terrestrial threats, but will fly or walk away from the nest or chicks while displaying with whistles, head-bobbing, and other agitated behavior.

Birds use coastal marshes for both nesting and foraging. Low coastal marshes are typically found on along the eastern shoreline of CHSJS and are dominated by halophytic grasses and forbs, and support nesting Willet, Clapper Rail, Mottled Duck, Killdeer, Common Nighthawk, Common Ground-Dove, Marsh Wrens, Boat-tailed and Common grackles, and Red-winged Blackbirds. Willets and plovers perform ardent displays to distract intruders and lure them away from the vulnerable nest with its eggs or young, who hide among the marsh plants in case of danger. The mobile young find some food themselves but are mostly fed by their attending parents. These species are very dependent on large areas of unfragmented marsh, and many, such as Common Nighthawks and Common Ground-Doves are indeed not common, and are recognized as birds in decline, as are Red-winged Blackbird, Killdeer, and Mottled Duck (Butcher, 2004).

- **Foraging Habitats**

Foraging habitats used by shorebirds, seabirds, and colonial waterbirds in the CHSJS region are ecologically and geographically diverse (Gulf of Mexico inshore waters, estuarine waters, seagrass meadows, oyster reefs, inter-tidal sandflats and mudflats, beaches, cordgrass and needlerush marshes, mangrove forests, vegetated beach dunes, coastal hammocks, pine flatwoods, spoil islands, and causeways) and provide an array of prey items that are acquired by guilds of birds with similar foraging strategies and prey (Table 5-22). Seagrass meadows, mangrove and cordgrass marshes, and estuarine creeks provide important habitat for the small fishes (<20 cm; demersal and pelagic coastal species) that are prey for the piscivorous birds.

Table 5-22. Foraging guilds of colonial waterbirds, shorebirds, and seabirds in CHSJS estuary

Bird Species	Primary Prey
Terns, Black Skimmers, Magnificent Frigatebirds	epipelagic, pelagic, estuarine fish
Laughing Gulls	fish, opportunistically omnivorous
Brown Pelican	epipelagic, pelagic, estuarine fish
Reddish Egret	epipelagic fish on intertidal flats
Small herons, Roseate Spoonbill, White Ibis	immature birds require fish, amphibians, and invertebrates of freshwater wetlands, adults also eat small marine fish and invertebrates
Snowy Plover, Wilson's Plover, Willet	estuarine invertebrates, insects of intertidal flats, salterns
American Oystercatcher	oysters, associated marine invertebrates

In the fifty years since the ICW was dredged, the dredged spoil material islands have eroded significantly, showing the typical "crescent-shape" with the "arms" pointing towards the southeast, as described by Lewis and Lewis (1978). Their shorelines provide forage and roosting sites, although some, especially the small sandy islands in Clearwater Harbor, have eroded below the waterline.

The availability of some foraging habitat has decreased as coastal areas have been developed since the 1960s. Most significantly, intertidal sand and mudflat habitats have been severely reduced by dredging and filling for beach and bay-front housing and other development. On Clearwater Beach, Sand Key, Belleair Beach, and Indian Rocks Beach, coastal hammocks, pine flatwoods, mangroves, and other habitats have been eliminated. The intertidal, shoreline, and upland habitats on the Florida state park lands including the Anclote Keys, the Anclote Bars, Three Rooker Island, Honeymoon Island, and Caladesi Island remain relatively intact.

- **Migration and Over-wintering Habitats**

Many species of birds migrating on the Atlantic Flyway use the habitats in the CHSJS estuary. Migrants flying south in the fall and north in the winter stop along the beaches, mudflats, coastal hammocks, pine flatwoods, or mangrove forests to rest and forage to replace lost body fat to continue their migrations. For some species and for individual birds, this stop-over is critical in maintaining populations and lives. Wintering Piping, Snowy, Black-bellied, and Semipalmated plovers arrive on the barrier island beaches by the end of July, having nested on New England and Great Lakes shores and Mississippi River shoals. They survive on the whitest, sandy portions of these beaches, near the ends of the islands where shoals are tidally inundated, creating the algal growth that fosters their insect prey. Gulls, terns, skimmers, plovers, sandpipers, Sanderlings, Whimbrels, dowitchers, and other shorebirds arrive after nesting farther north to rest and forage, some spending the entire winter while others move further south and pass through again the next spring. Black Terns move through the region in August, feeding in the open estuary waters and resting on the open beaches, on their way to wintering in South America. Peregrine Falcons, American Kestrels, Merlins, and hawks of all sorts follow migrating shorebirds and passerines using the Atlantic Flyway through Pinellas County and some stay to eat over-wintering ducks and Fish

Crows. Pelagic birds, including jaegers and gannets, can be seen especially after storms and tropical depressions move them closer to gulf shores. Common Loons regularly spend the winters in the estuaries of the region, arriving with cold fronts in October and leaving with warm winds from the south in March and April. Ducks, loons, grebes, and other waterfowl arrive in October with north winds to spend the winter, leaving for more northern nesting areas in March when winds from the south speed their journeys. Literally thousands of Lesser Scaup spend the winter in the region. Thousands of Black and Turkey vultures spend the winter in the CHSJS region, roosting overnight on bird colony islands (e.g. Clearwater Harbor Bird Island I-25) or tall downtown city buildings and spreading over the adjacent counties to feed during the day. Fish Crows also spend the night by the thousands on Clearwater Harbor Bird Island I-25 and Three Rooker Island, dispersing similarly to forage. Magnificent Frigatebirds are tropical seabirds that nest in the Dry Tortugas and other tropical locations, but once their winter nesting season is over they disperse and some spend the period before the next nesting season in the west-central Florida region. Some frigatebirds roost in the wind-swept Australian pines of SJS Marker 26, and pirate from the terns carrying fish back to their young on Three Rooker Island.

5.7.3 Stressors of Birds Populations

Diverse natural and anthropogenic stressors affect colonial waterbirds, shorebirds, and seabirds nesting and migrating in Clearwater Harbor and St. Joseph Sound (Table 5-23). They include:

- Weather — Strong storm events occurring during the spring and summer nesting season can flood nests, affect foraging, or cause shoreline erosion. Winter and fall storms also erode islands. These effects will be amplified with sea level rise.
- Predator (mammalian, avian, herptilian) population management — Raccoon and other meso-carnivore mammalian predators are a common threat on bird islands during the nesting season, causing the colonies to collapse. Human disturbance can force attending adult birds to fly off their nests, leaving the eggs and young vulnerable to predation by opportunistic Laughing Gulls, Fish Crows, Black-crowned Night-Herons, Black Vultures, and other avian predators. In other regions of Florida, arboreal lizards and snakes have devastated bird populations and caused abandonment of bird colonies. To date, herptiles are not known to be a threat in CHSJS, but the widespread dispersal of unwanted pet snakes and lizards released in natural areas could be a future danger to nesting birds.
- Human disturbance — Beach-nesting and ground-nesting birds are especially vulnerable to human disturbance from recreational and commercial fishermen, boaters, kayakers, campers, swimmers, and dogs, and the presence of dogs brought to islands by boaters is particularly disruptive. Attending adult birds will leave their nests unprotected if a person or dog approaches, and the resulting exposure of the eggs or young to thermal stress or predation commonly causes their death. Tree-nesting birds will respond by flying from nests if approached too closely by beach-walkers or boaters (including canoes and kayaks) visiting islands, and others trespassing on posted nesting islands, resulting in the death of embryos or chicks in the nest. Posting bird nesting colonies, regular patrol and enforcement by wildlife wardens and law enforcement officers can reduce disturbance. In addition, wintering and migrating birds should be protected from human disturbance, as these birds need to accumulate fat to fuel their long-distance journeys and allow them to arrive at distant nesting sites in breeding condition.
- Monofilament litter — Entanglement, whether by monofilament line, other types of fishing line, balloon strings, ropes, and string of various sorts is the leading cause of death for

Brown Pelicans in Florida. Other birds, turtles, manatees, fish, and other wildlife are also killed by entanglement in marine trash. Annual removal from nesting island habitats during the non-nesting season and regular collection of entangling trash from bridges, piers, docks, and other structures and shoreline habitats will help prevent wildlife losses. A crucial initiative is to educate fishermen and the general public about how to properly dispose of fishing line and marine trash while recreating, as an approach to preventing wildlife mortality.

- Habitat availability — Suitable habitat availability is crucial to annual nesting success. Widespread alteration of foraging habitats (especially estuarine intertidal water flats, freshwater wetlands, coastal hammocks, and saltmarshes) and intensive human use of beaches pose significant management challenges to the recovery of regional bird populations. Incremental improvements in habitats through restoration projects and aggressive protection of currently viable productive habitats should be priorities.
- Forage availability of estuarine fish and macroinvertebrates — Protection of the key resources of the CHSJS estuary, particularly seagrass meadows, saltmarsh and mangrove shorelines, and creek and estuary water quality and quantity, will allow those resources to support the complex food chain that nourishes the regional bird populations, including the nesting birds reliant on local resources to raise young, as well as migrating and wintering birds that depend on resources to survive.
- Sea level rise and island erosion — Sea level rise should be considered in the long-term management of the CHSJS estuary. Wavebreaks and shoreline projects that protect island and shoreline habitats for the near and long term, especially those for bird-nesting islands, should be planned and constructed as appropriate. Bird-nesting islands that would benefit from wavebreak construction include Sand Key Dunedin West in Clearwater Harbor and Marker 26 in St. Joseph Sound.
- Epizootics — Not much is known about the presence or consequences of bird diseases and parasites locally. Further research is necessary and appropriate.
- Pollutants and oil spills — The CHSJS estuary is included in the U. S. Coast Guard Sector St. Petersburg emergency planning and agency coordination to control and reduce any influx of pollutants including oil spills into the CHSJS estuary is on-going.

Table 5-23. Natural and anthropogenic stressors affecting colonial waterbirds, shorebirds, and seabirds in the CHSJS estuary.

Stressor	Description	Effect	Management Recommendation
Extreme weather events during the nesting season	Hurricanes, tropical storms, heavy rain, unusual cold weather	All can disrupt and diminish nesting success	Stochastic events
Predators	Mammals (primarily raccoons), birds (e.g. Fish Crows or Laughing Gulls), introduced reptiles (e.g. iguanas)	Birds will abandon islands where raccoons, skunks, opossums, or other terrestrial predators occur	Urban raccoon populations in Pinellas County should be ~60 animals/mi^2 but are estimated at 600 animals/mi^2
Human disturbance	Humans (fishermen, boaters) approaching near nesting colonies or solitary nesting pairs can cause adult birds to leave their nests, eggs, and young	Inadequate colony protection causes nesting, foraging, or roosting disruption; unprotected colonies have reduced reproductive success or fail	Adopt USFWS/FWC buffer recommendations; manage colonies; increase environmental education – distribute boaters guides; post, patrol, and manage colonies to promote reproductive success; coordinate and empower law enforcement officers

Table 5-23. Natural and anthropogenic stressors affecting colonial waterbirds, shorebirds, and seabirds in the CHSJS estuary.			
Stressor	**Description**	**Effect**	**Management Recommendation**
Monofilament litter	Fishing line, lures, plastic, other entangling litter types	Can cause entanglement, debilitation, or death	Removing line and other entangling debris from bird nesting, roosting, and foraging islands and other habitat sites can help protect birds and other wildlife; educate fishermen and public on proper waste disposal
Habitat availability; island erosion and habitat loss; invasive exotic plants	Invasive trees, shrubs, forbs, and grasses can alter habitat	Affects availability of nesting substrate	Some invasive exotics are actually very suitable nesting substrate, while other plants diminish nest site availability; install wavebreaks at selected locations
Forage availability	Fish stock declines, seasonal fish kills throughout coastal Florida	Estuarine fish, macroinvertebrates	Collaborate with FWC fisheries and invertebrate monitoring and management programs
Sea level rise	Global warming	Coastal habitat loss	Assessment and long-term planning; install wavebreaks at selected sites
Epizootics	Infectious wildlife diseases	Wildlife debilitation	Future studies
Pollutants / oil spills	Wildlife health issues	Wildlife debilitation	Future studies

5.7.4 Site-Specific Characterizations

- **St. Joseph Sound**

In the Anclote River system, birds nest and forage within the river west of the Highway 19 bridge. In Tarpon Springs, the tall pines of Chesapeake Point and Kreamer Bayou are nesting sites for a few Great Blue Herons, although some homeowners actively discourage nesting by placing sprinklers in the trees. The oysterbars of Kreamer Bayou have short, sturdy mangroves in which a few Great Blue Herons, Great Egrets, cormorants, and some small herons, including Yellow-crowned Night-Herons and Green Herons nest. The inter-tidal flats around the string of dredged spoil material islands east of Sunset Key provide limited foraging but no nesting. Westward from Brady Island, a small string of mangrove-covered dredged spoil material islands extends from the mouth of the Anclote River. Oystercatchers, Green Herons, and Double-crested Cormorants nest sporadically on Finnell Island, Burney Key, and the small rocky islets beyond it, but some are rapidly eroding and provide only foraging at lower tides. The most westward islet was posted before 1989 as a Florida Fish and Game Commission "Critical Wildlife Area" (Nancy Douglass, Florida Fish and Wildlife Conservation Commission, pers. comm.), although it no longer provides nesting habitat (FCIS, unpublished data). Table 5-24 presents the distribution of nesting birds in the CHSJS estuary.

Bird Key and Rabbit Key are natural mangrove islands located south of the river mouth and about 200 m offshore of the Sunset Hills community of Tarpon Springs. Nesting (Great Blue Herons, cormorants, pelicans, and some small herons in some years) has not occurred on Bird Key in the last three years. Rabbit Key is surrounded by shallow turtlegrass beds that are exposed during low winter tides, and so raccoons are either resident or visit often enough that colonial waterbirds do not nest there, although Prairie Warblers, Red-winged Blackbirds, and Common Grackles are nesting on this island. Bird Key and Rabbit Key are valuable migratory stopovers for neotropical migrants, especially warblers and vireos.

Within St. Joseph Sound, Anclote Key Preserve State Park (the Anclote Keys, North Anclote Key, and South Anclote Bar) offer primary barrier island habitats. A few pairs of oystercatchers, plovers, Willets, and a handful of Least Terns nest where supra-tidal beach habitat exists. These small islands and the shorelines of the other barrier islands, especially Anclote Key, Three Rooker Island, Honeymoon Island, Caladesi Island, and North Clearwater Beach are very important for foraging and roosting by migrating and wintering shorebirds, including Piping, Semipalmated, and Black-bellied plovers, Red Knots, Marbled Godwits, sandpipers, dowitchers, Dunlin, and other shorebirds. The mangroves on the east side of Anclote Key, Dutchman Key, and four small islands on the north end provide foraging sites for wading birds and nesting territories for Prairie Warblers.

Three Rooker Island, an uninhabited, undeveloped barrier island, offers high quality nesting, roosting, and foraging habitats. A small heronry (including rare Reddish Egrets and White Ibis) has developed in cabbage palms and short mangroves clustered on the south end. Least Terns, Snowy Plovers, and American Oystercatchers nest in the mid-section of the island and on the southeastern crescent sand beaches just above the high tide zone, often with little success as these regions are popular with recreational boaters who disturb the nesting birds. Willets nest in the thick saltmarshes on the east side of the island. On the gulf-facing shallow dunes located on the south end, large colonies of Laughing Gulls, Royal Terns, and Black Skimmers nest. Since 1991, Florida Park Service biologists, Clearwater Audubon Society volunteers, and Florida's Coastal Island Sanctuaries (FCIS) staff have posted the colonies to reduce disturbance by recreational boaters and their dogs. As a result, these birds are nesting more successfully. Significant numbers of Piping Plovers and other wintering shorebirds substantiate the designation of Three Rooker Island as a globally-ranked Important Bird Area by BirdLife International and the National Audubon Society.

Dredged spoil material islands located to the east of the Intracoastal Waterway in SJS are rocky and slowly eroding. Spoil islands Markers 30 to 27 are vegetated with Brazilian pepper and some Australian pine trees, which are shallow-rooted trees that uproot during strong storms, destabilizing the shoreline and worsening island erosion. These sites provide roosting sites for Brown Pelicans, cormorants, gulls, and some shorebirds, including Black-bellied Plovers. SJS Marker 26, an important bird colony, is vegetated with pines, pepper trees, and mangroves lining a small cove on its southwestern corner. Cormorants, Great Blue Herons, Great Egrets, Snowy Egrets, Reddish Egrets, Black-crowned Night-Herons, and some of the other small herons nest here.

To the east, the Ozona Spoil Islands are located north of the Ozona channel. The western island is used by recreational boaters and campers and foraging birds. The eastern island has some camping on the east end but the western end is vegetated with dense Brazilian pepper in the higher center

Table 5-24. Distribution of nesting birds in CHSJS (Audubon FCIS 2009 survey data). The total 2009 number of nesting pairs was 5,331. Note: CH Marker 10 submerged after the 2009 nesting season.

Species	2009 nesting pairs	I-25	Marker 10	Belleair Beach	Indian Rocks Beach	Indian Rocks Beach South	SJS Marker 20, 22	SJS Marker 26	Ozona Spoil East	Sand Key Dunedin West	Smith Bayou	North Clearwater Beach	3 Rooker Bar	South Anclote Bar	North Anclote Bar	Caladesi Island	Honeymoon Island
Brown Pelican	155	X		X	X				X	X							
Double-crested Cormorant	180	X		X	X			X	X	X							
Anhinga	4			X													
Great Blue Heron	32	X		X	X	X		X		X	X		X				
Great Egret	265	X		X	X	X		X	X	X	X		X				
Snowy Egret	90	X		X	X	X		X	X	X	X		X				
Little Blue Heron	25	X		X	X	X		X	X	X	X						
Tricolored Heron	24	X			X	X	X	X	X	X	X		X				
Reddish Egret	12	X						X		X	X		X				
Cattle Egret	11	X						X					X				
Green Heron	1	X		X	X						X						
Black-crowned Night-Heron	25	X		X		X		X		X			X				
Yellow-crowned Night-Heron	0				X						X						
White Ibis	1100	X		X				X					X				
Roseate Spoonbill	5	X		X													
Snowy Plover	0											X	X		X	X	
Wilson's Plover	5											X	X		X	X	X
American Oystercatcher	13	X		X	X	X		X	X	X		X	X		X	X	
Willet	10												X		X	X	
Laughing Gull	2500												X				
Caspian Tern	11												X				
Royal Tern	424		X										X				
Sandwich Tern	0												X				
Least Tern	29		X	X								X	X	X		X	X
Black Skimmer	410		X									X	X				

and mangroves on the south shoreline. A small heron colony that includes cormorants (and Brown Pelicans in the 1990s) nests there. Usually 2 pairs of American Oystercatchers nest on the rocky shorelines of the north side and western tip.

The Smith Bayou islands, located just west of Homeport Marina and Mar Marina in Palm Harbor, are privately owned. The north island's mangrove shoreline offers nesting for Yellow-crowned Night-Herons, Great Blue Herons, Great Egrets, and Reddish Egrets. Dredged spoil material from the marina was deposited on the south island where Green Herons Nest. Green Herons nest on the low-growing mangrove branches that stretch out over the water.

In the region south of the Smith Bayou channel, there are some tiny oyster bar islands with single mangroves growing on them. Occasionally, a pair of Great Blue Herons will nest on these, and oystercatchers, shorebirds, and herons forage there.

Honeymoon Island State Park is accessible via the Dunedin Causeway and Caladesi Island State Preserve State Park is accessible by ferry from Honeymoon. The Dunedin Causeway, which separates St. Joseph Sound to the north from Clearwater Harbor to the south, is an area where wading and shorebirds, including migrating dowitchers, Sanderlings, and sandpipers, forage. Most of the island (385 upland acres and 2400 acres of submerged land buffer) is managed by the Division of State Parks as Honeymoon Island State Recreation Area State Park, excluding the high-rise condominiums protected by seawalls on the northwest causeway. This large barrier island and also Caladesi Island (650 upland acres and 1100 acres of mangroves and seagrass meadows) to the south offer considerable habitat diversity, with sandy gulf shorelines, outcrops of rocky shoals, beach dunes, mud and sand flats, coastal hammocks and marshes, mangroves, and pine flatwoods communities, habitat for 260 species of birds recorded to date, mostly migrants. A pair of Bald Eagles moved from Anclote Key to Honeymoon Island in 2009, where one and two eaglets were fledged in 2009 and 2010, respectively (Dan Larremore, Honeymoon Island State Park, pers. comm.). About 30 pairs of Ospreys and one pair of Great Horned Owls nest on Honeymoon Island in the tall pines east of the north trail. Summer Tanagers, Eastern Towhees, and other upland forest birds nest in the pine flatwoods. Prairie Warblers nest in the mangroves on the east side of the islands and Willets in the marshes. Least Terns have set up nesting colonies on the north ends of both islands but these colonies typically fail due to human disturbance, raccoons, or storm-related high tides that inundate nests.

Moonshine, Malone, and Core islands are mangrove-vegetated islands located to the southeast of Caladesi Island, and north of the Pope Channel inlet, a former Gulf of Mexico access to Clearwater Harbor that has shoaled closed. A dredged spoil material island, located east of Pope Channel, east of the Intracoastal Waterway near Marker 1, and west of Stevenson Creek, hosted a White Ibis nesting colony in the south mangroves one year in the early 1990s.

- **Clearwater Harbor North**

The nine rocky and sandy dredged spoil material islands near Markers 1-13 in North Clearwater Harbor situated west of the Intracoastal Waterway are used by recreational boaters and do not support bird nesting, although migrating, foraging, and roosting birds occur occasionally. The Pinellas Aquatic Preserve staff has removed non-native vegetation and replanted some of them with native plants.

Near Cedar Creek, south of the Dunedin Causeway, are two sandy islands, formerly known as the Kings Islands, owned by Pinellas County. The east island, Dunedin Sand Key East, is used by recreational boaters. The west island, Dunedin Sand Key West, is a bird colony island owned by Pinellas County and managed by Audubon's Florida Coastal Islands Sanctuaries (FCIS) where pelicans, cormorants, herons and egrets, oystercatchers, and Willets nest. This island is eroding from weather-driven and boat-wake waves on its west end, and the tall sand bluff, where native slash pines grew into the early 1990s, has eroded, killing the trees and creating a sandbar to the east.

North Clearwater Beach is privately owned and undeveloped, and although there are many beach-walkers, boaters, and other recreational visitors, its shores, beach dunes, mangroves, and marshes provide valuable wildlife habitat. Snowy Plovers and Least Tern colonies have nested there, although disturbance from beach-walkers and their dogs has affected nesting success. With the shoaling-in of the Pope Channel access to the Gulf of Mexico, North Clearwater Beach is connected to the south end of Caladesi Island, allowing beach-walker access to both areas, and recreational boaters can reach all the islands.

- **Clearwater Harbor South**

Clearwater Harbor Bird Island I-25 is south of the Memorial Bridge Causeway, west of the Intracoastal Waterway, east of the Clearwater Beach Marina, and north of Clearwater Pass. This island, owned by the City of Clearwater and managed by Audubon's FCIS, supports the largest wading bird colony in the CHSJS estuary, including Reddish Egrets of both dark and white color morphs and Roseate Spoonbills. A significant population of Great Egrets (140 pairs) and Snowy Egrets (150 pairs) nest there each spring. Brown Pelicans (150 pairs), Double-crested Cormorants, White Ibis, and American Oystercatchers also nest there. Since 1991 and 2000, respectively, Reddish Egrets and Roseate Spoonbills have nested on this island, the first site to which each species returned to nest in the CHSJS region since the 1880s, when they were extirpated regionally by hunting (Scott, 1889). The island is vegetated with mangroves, and has a small shallow lagoon connected to a shallow creek on the north side. On the southeast corner, a slight sand rise is vegetated with Brazilian pepper trees, seagrapes, Florida privets, and buttonwoods, while the small marshes on the north are used by a pair of nesting Willets. Extensive intertidal flats surround the island, providing foraging habitat for shorebirds and wading birds when exposed at low tide. A sandbar on the northeast corner offers a roost for pelicans, cormorants, herons, Royal Terns, Black Skimmers, Black-bellied and Semipalmated plovers, Ruddy Turnstones, and other sandpipers. The riprap rock breakwater located 30 feet south of the island, installed in the 1980s, has effectively protected this island from erosion and formed an isolated lagoon where recently-fledged birds can mature without disturbance.

The sandy dredged spoil islands in south Clearwater Harbor east of Sand Key have eroded significantly, and most are now sub-tidal. Some of these islands offered nesting habitat for Royal and Least terns, Black Skimmers, and American Oystercatchers in the past. Only one, Compass Key (west of Marker 8), used by the Clearwater Marine Aquarium and other tour boats and boaters as a popular recreational destination, remains above mean high water.

Black Skimmers have nested in colonies on some of the Sand Key beaches at Sand Key County Park and on beach zones managed by large hotels and condominiums. Clearwater Audubon Society volunteers and Florida Fish and Wildlife Conservation Commission biologists post these colonies, where young fledge successfully in some years.

South of the Belleair Beach Causeway are three islands, two western islands near the Belleair Shore community and one closer to the Intracoastal Waterway. The two western islands are the Belleair Beach Bird Colony Islands posted as bird sanctuaries by the City of Belleair Beach. These are islands dominated by mangroves, with some Brazilian pepper trees, cabbage palms, and Australian pines on their higher centers, surrounded by oyster bars lining portions of the shorelines and seagrass beds. Nesting birds include Brown Pelicans, Double-crested Cormorants, Great Blue Herons, Great Egrets, the small herons, White Ibis (some years), and American Oystercatchers, plus a pair of Roseate Spoonbills each spring since 2007. The island near the Intracoastal Waterway is used by recreational boaters, but provides foraging habitat for wading birds, Willets, and other shorebirds, and a resting and courtship feeding site for Least Terns, which attempted to nest there in 2008.

The Indian Rocks Beach Bird Colony Island has been abandoned by nesting wading birds since 2007, probably due to a raccoon on the island, but a pair of American Oystercatchers has successfully raised young in most springs. Further south along the Intracoastal Waterway, Indian Rocks Beach South Island hosts a family of Gray Kingbirds, plus nesting Great Blue Herons (over 10 pairs in most years), and a few small herons, a pair of oystercatchers, and a pair of Willets; in 2009, a pair of Roseate Spoonbills nested successfully there. On Indian Rocks Beach South, despite the fact that the island is posted as a bird sanctuary by FCIS, trespassers built a tree house and have caused colony disturbance repeatedly since 2007.

5.7.5 Regional Bird Population Trends

Table 5-25 presents the listing status and declining trends statistics from Butcher (2004). Representative statistics include: -6.8%/yr = 50% loss in 10 years; -3.5%/yr = 30% loss in 10 years; -2.3%/yr = 50% loss in 30 years. Brown Pelicans and Double-crested Cormorants are the two colonial fish-eating pelecaniforms that regularly nest in Clearwater Harbor and St. Joseph Sound. The local Brown Pelican population has declined recently, although the cause is obscure. The major cause of mortality for Brown Pelicans in Florida is entanglement in fishing line (Steve Nesbitt, Florida Fish and Wildlife Conservation Commission, pers. comm.). To minimize these mortalities, Audubon's FCIS and Tampa Bay Watch organize volunteer boat captains and crews to collect fishing line from bird nesting colony islands and other bird habitat sites in the fall when most birds are not nesting.

All three species of the small herons (Snowy Egret, Little Blue Heron, and Tricolored Heron) are state listed as "species of special concern" and are experiencing population declines statewide related to development of freshwater wetlands. The colonies at SJS Bird Island Marker 26 and Clearwater Harbor Bird Island I-25 include all three species, and high numbers of nesting Snowy Egrets in some years.

Reddish Egrets returned to the CHSJS region as a breeding species in the early 1990s and nest in very low numbers at Three Rooker Island, SJS Marker 26, Clearwater Harbor Bird Island I-25, and Smith Bayou North.

White Ibis required freshwater wetland prey, especially when foraging to feed young. In the nesting season after El Niño years, larger populations of White Ibis nest regionally. This is likely because the winter rains associated with El Niño weather patterns discourage the normal winter nesting in the Everglades by raising water levels too high for efficient foraging; meanwhile, the winter rains in west-central Florida fill local wetlands. Under these conditions, ibis from South Florida abandon nesting in south Florida and move to central Florida in March, where the filled wetlands dry through the spring drought, concentrating wetland prey and providing efficient foraging for ibis. However, even in non-El Niño years, White Ibis are a large component of the regional nesting population. White Ibis usually nest in colonies at Three Rooker Island, SJS Bird Island Marker 26, and Clearwater Harbor Bird Island I-25.

Roseate Spoonbills returned as a nesting species to Tampa Bay in 1975, initially at the Alafia Bank Bird Sanctuary in Hillsborough Bay. In spring 1999, 1 pair of spoonbills nested at Clearwater Harbor I-25 Bird Colony Island. In 2010, about 320 spoonbill pairs nested in the combined Clearwater Harbor, Tampa Bay, and Sarasota Bay area. This represents the second largest spoonbill population in Florida, after their traditional stronghold in Florida Bay.

There are no Wood Stork colonies in Pinellas County, but storks use local wetlands as foraging sites during the part of the year when they are not nesting.

Laughing Gulls have few colonies in Florida, and about 75% of this species nest in very large numbers at only three locations in the west-central Florida Gulf coast area, including Three Rooker Island State Preserve. The Tampa Bay population has declined about 50% in the past 25 years.

The first known nesting record for Caspian Terns in Florida occurred in Tampa Bay in 1962. In the 1980s, there was only one known colony in the state, numbering about 80 pairs, located in Hillsborough Bay. Now there are 250 pairs in Florida nesting on three colonies, one of which is the small cluster of Caspian Terns (11 pairs in 2009) nesting at Three Rooker Island. In 2009, 7550 pairs of Royal Terns nested at three local colonies: Egmont Key National Wildlife Refuge in the mouth of Tampa Bay, Tampa Port Authority Spoil Island 2D in Hillsborough Bay, and Three Rooker Island State Preserve in St. Joseph Sound (434 pairs).

In the 1970s, 10 pairs of Sandwich Terns were all that were known in the state, nesting among the Royal Terns in Hillsborough Bay or at Passage Key National Wildlife Refuge in lower Tampa Bay. By 2009, 1350 were found nesting at Egmont Key National Wildlife Refuge. Recently, a few Sandwich Terns have nested among the Royal Tern colony at Three Rooker Island (4 pairs in 2008 but none in 2009, 5 pairs in 2010).

Table 5-25. Listing status of birds in the CHSJS estuary.				
Species	**Listing Status**			
	State	**Federal**	**Audubon Watchlist 2007**	**2004 Declining Trends (%)**
Mottled Duck			Red	-2.8
Brown Pelican	SSC			
Magnificent Frigatebird			Red	
Great Egret				-2.5
Snowy Egret	SSC			
Little Blue Heron	SSC			-2.0
Tricolored Heron	SSC			
Reddish Egret	SSC	BCC	Red	
Black-crowned Night-Heron				-2.2
White Ibis	SSC			
Roseate Spoonbill	SSC			
Wood Stork	E	E		-2.8
Bald Eagle		Bald Eagle Protection Act of 1940		
Southeastern American Kestrel	T			-6.8
Peregrine Falcon	E			
Clapper Rail			Yellow	
King Rail			Yellow	-7.6
Snowy Plover	T	BCC	Yellow	
Wilson's Plover		BCC	Yellow	
Piping Plover	T	BCC/T	Red	
Killdeer				-2.3
American Oystercatcher	SSC			
Black-necked Stilt				-12.1
Long-billed Curlew		BCC	Yellow	
Marbled Godwit		BCC	Yellow	
Red Knot		BCC	Yellow	
Sanderling			Yellow	
SemipalmatedSandpiper			Yellow	
Western Sandpiper			Yellow	
Least Tern	T	BCC	Red	
Gull-billed Tern		BCC		
Black Skimmer	SSC	BCC	Yellow	
Common Ground-Dove				-3.7
Mangrove Cuckoo			Yellow	
Common Nighthawk				-4.3
Red-headed Woodpecker			Yellow	-4.1
Northern Flicker				-5.2
Eastern Kingbird				-5.1
Loggerhead Shrike				-3.8
Red-eyed Vireo				-3.3
Blue-winged Warbler			Yellow	-2.5
Golden-winged Warbler			Red	
Prairie Warbler		BCC	Yellow	-2.9
Prothonotary Warbler		BCC	Yellow	-3.0
Swainson's Warbler		BCC	Yellow	
Kentucky Warbler		BCC	Yellow	
Canada Warbler		BCC	Yellow	
Eastern Towhee				-2.2
Red-winged Blackbird				-3.5
Eastern Meadow				-4.8

The west central Florida population of Least Terns, a state-listed "Threatened" species, numbers about 1200 pairs, with about 80% nesting on gravel-coated, flat roofs in Pinellas County. As new state building codes require that plastic sheeting will replace gravel roofs, the future for locally nesting Least Tern colonies is of concern. Nesting sites of Least Terns on North and South Anclote Bars, Three Rooker Island, Honeymoon Island, Caladesi Island, and North Clearwater Beach are invariably disturbed by people and dogs, despite posting by state parks staff, wildlife officers, and volunteers. The rooftop-nesting population is not included in the estimate in this report.

Sixty percent of Florida's Black Skimmers nest locally, totaling 600-750 pairs in Tampa Bay, Clearwater Harbor, and St. Joseph Sound. Because they select nesting sites on beaches just above the high water line, they are extremely vulnerable to weather and storm impacts and disturbance by humans and their pets. Black Skimmers nest on Three Rooker Island and Sand Key, either in the County Park or in front of the condominiums and hotels fronting the Gulf of Mexico. Many of the dredged spoil material islands where they nested annually in the past in southern Clearwater Harbor have eroded below the waterline. State biologists and volunteers post nesting colonies on Three Rooker Island State Preserve and Sand Key to improve tern and skimmer nesting success.

The FWC state-wide survey of American Oystercatchers found only 400 pairs in Florida (Douglass and Clayton 2004). In the 1980s, the greater Tampa Bay and CHSJS area hosted about 60-75 pairs; today the number has increased to 125 pairs, with the majority now nesting in Hillsborough Bay. Like Black Skimmers, oystercatchers nest on beaches just above the high water line, except that they are defend linear territories. These nests are extremely vulnerable to disturbance by humans and dogs, as well as storm-related surge tides. About 15 pairs nest in the CHSJS region annually, generally successfully raising young on SJS Marker 26, Clearwater Harbor Bird Island I-25, Sand Key Dunedin West, and Indian Rocks Beach Bird Island.

State-wide population surveys of Snowy Plovers estimate only 200 pairs in Florida, with most along the Panhandle and only about 50 pairs on the west coast of peninsular Florida from Citrus County to Marco Island. Obligate white sand beach nesters, one or two pairs have been observed in some years on North Anclote Bar, Three Rooker Island, and North Clearwater Beach. This territorial nester is very vulnerable to human disturbance and is often unsuccessful.

Wilson's Plovers use sandy beaches, too, but also nest on spoil sites and salt barrens. Wilson's Plovers have nested on North Anclote Bar and Three Rooker Island and are likely more successful than Snowy Plovers, due to their use of more habitat types and their preference for slightly grassier habitat providing refuge for hiding small chicks.

5.7.6 Management Recommendations

A summary of the management characteristics of the CHSJS islands is presented in Table 5-26.

Table 5-26.	**Management characteristics of islands in CHSJS estuary.**					
Island	**Management Authority**	**IBA**	**Bird Colony**	**Mixed Use**	**Nesting Habitat Type**	**COMMENTS**
North Anclote Bar State Preserve	FSP	Gulf Coast GEOPark	X	X	B	Yearly posting & enforcement at the nesting area is necessary to reduce human/dog disturbance
Anclote Key State Park	FSP	Gulf Coast GEOPark		X	B	The Florida Park Service staff has removed invasive tree species (Australian pine) and reduced the over-population of raccoons, greatly improving the island as habitat forbirds and turtles
South Anclote Bar State Preserve	FSP	Gulf Coast GEOPark	X	X	B	Because it is so popular with recreational boaters who often bring their dogs, disturbance of the nesting birds is high, despite public education, signage, and enforcement provided by state parks biologists and volunteers. Yearly posting & enforcement at the nesting area is necessary to reduce human/dog disturbance
Dutchman Key	Private	Gulf Coast GEOPark			T	Private landowner management plan
Three Rooker Island State Preserve	FSP	Gulf Coast GEOPark	X	X	B/T	Yearly posting & enforcement at the nesting area is necessary to reduce human/dog disturbance
Honeymoon Island State Park	FSP	Gulf Coast GEOPark	X	X	B/T	Yearly posting & enforcement at the nesting area is necessary to reduce human/dog disturbance; removal of Australian pines, Brazilian pepper and reducing the over-population of raccoons greatly improved habitat use by birds and turtles
Caladesi Island State Park	FSP	Gulf Coast GEOPark	X	X	B/T	Yearly posting & enforcement at the nesting area is necessary to reduce human/dog disturbance
Marker 30	PAqP	CH/SJS		X		Submerged
Marker 29	PAqP	CH/SJS		X		Habitat modification for beach-nesting birds in planning by multi-agency working group
Marker 28	PAqP	CH/SJS		X		Recreation island
Marker 27	PAqP	CH/SJS		X		Recreation island
Marker 26	PAqP / FCIS	CH/SJS	X		T	Human disturbance; no landing; yearly posting & enforcement at the nesting area is necessary to reduce human/dog disturbance
Ozona Spoil West	PAqP	CH/SJS		X		Recreation island
Ozona Spoil East	PAqP / FCIS	CH/SJS	X	X	T	Yearly posting & enforcement at the nesting area is necessary to reduce human/dog disturbance
Marker 22	PAqP	CH/SJS	X	X	T	Recreation island
Marker 21	PAqP	CH/SJS		X		Recreation island; a few nesting records
Smith Bayou Islands	Private / FCIS	CH/SJS	X		T	Posted by FCIS for private landowner
Dunedin Sand Key West	PinCo / FCIS	CH/SJS	X		T/B	Erosion, loss of nesting habitat, human disturbance; no landing; yearly posting & enforcement at the nesting area is necessary to reduce human/dog disturbance

Table 5-26. Management characteristics of islands in CHSJS estuary.						
Island	**Management Authority**	**IBA**	**Bird Colony**	**Mixed Use**	**Nesting Habitat Type**	**COMMENTS**
Dunedin Sand Key East	PinCo	CH/SJS		X		Recreation island
Markers 13	PAqP	CH/SJS		X		Recreation island
Marker 10	PAqP	CH/SJS		X		Recreation island
Marker 9	PAqP	CH/SJS		X		Recreation island
Marker 8	PAqP	CH/SJS		X		Recreation island
Marker 5	PAqP	CH/SJS		X		Recreation island
Marker 3	PAqP	CH/SJS		X		Recreation island
Marker 2	PAqP	CH/SJS		X		Recreation island
Marker 1 / Pope Channel	PAqP / FCIS	CH/SJS	X	X	T	Recreation island
Marker 17, north of Memorial Causeway	PAqP	CH/SJS		X		Recreation island
I-25 Bird Colony Island	City of Clearwater/ FCIS	CH/SJS	X		B/T	No landing; occasional raccoon present, fishing line entanglement
Marker 10	PAqP					Submerged after 2009 nesting season; erosion
Marker 8 / Compass Key	PAqP	CH/SJS		X		Recreation island; Clrwtr Aquarium destination
Marker 6	PAqP					Submerged; erosion
Marker 3	PAqP					Submerged; erosion
Belleair Beach Bird Colony Islands	City of Belleair Beach	CH/SJS	X		T	No landing; fishing line entanglement
Belleair Beach island near Intracoastal waterway	PAqP	CH/SJS		X		Recreation island; high nesting potential for Least Terns, other species.
Indian Rocks Beach Bird Colony Island	City of Indian Rocks Beach/ FCIS	CH/SJS	X		B/T	No landing; occasional raccoon present, fishing line entanglement
Indian Rocks Beach South Bird Colony Island	PAqP / FCIS	CH/SJS	X		T	No landing; human disturbance, building tree houses; erosion, fishing line entanglement; yearly posting & enforcement at the nesting area is necessary to reduce human/dog disturbance

Notes:

1. "Mixed Use" refers to a combination of recreational use, habitat restoration and management, and wildlife habitat.
2. Nesting habitat types: B=beach, T=trees.
3. Agencies: FCIS = Audubon's Florida Coastal Islands Sanctuaries; FDEP = Florida Department of Environmental Protection; FSP = Florida Department of Environmental Protection/Florida State Parks; PAqP = Florida Department of Environmental Protection/Pinellas Aquatic Preserve; PinCo = Pinellas County.

Bird colonies, places where numbers of birds gather to nest together, generally on islands, represent management opportunities. Management and conservation activities conducted by Audubon's FCIS, the Florida Park Service, FDEP's Pinellas County Aquatic Preserves, Pinellas County, and the cities of Clearwater, Belleair Beach, and Indian Rocks Beach, other cooperating agencies, and regional volunteers (Tampa Bay Regional Planning Council's Agency on Bay Management, Clearwater Audubon Society, Suncoast Chapter of the Florida Native Plant Society, Keep Pinellas Beautiful, and boating groups, among others) are addressing some management needs but more work needs to be undertaken (Table 5-27).

Table 5-27. Management recommendations for bird habitats in CHSJS estuary.

Island	Population estimates	Colony protection	Human disturbance & public education	Predator control	Wildlife law enforcement	Monofilament litter	Invasive plants	Erosion abatement
North Anclote Bar State Preserve	X	X	X	X	X	X		
Anclote Key State Park	X	X	X	X	X	X	X	
South Anclote Bar State Preserve	X	X	X	X	X	X		
Three Rooker Island State Preserve	X	X	X	X	X	X		
Honeymoon Island State Park	X	X	X	X	X	X		
Caladesi Island State Park	X	X	X	X	X	X		
Marker 30			X	X	X	X		
Marker 29			X	X	X	X	X	
Marker 28			X	X	X	X		
Marker 27			X	X	X	X		
Marker 26	X	X	X	X	X	X	X	X
Ozona Spoil West			X	X	X	X	X	
Ozona Spoil East	X	X	X	X	X	X		
Marker 22			X	X	X	X	X	
Marker 21			X	X	X	X	X	
Smith Bayou Islands	X	X	X	X	X	X	X	
Dunedin Sand Key West	X	X	X	X	X	X	X	X
Dunedin Sand Key East			X	X	X	X	X	
North Clearwater Harbor Marker 13			X	X	X	X	X	
North Clearwater Harbor Marker 10			X	X	X	X	X	
North Clearwater Harbor Marker 9			X	X	X	X	X	
North Clearwater Harbor Marker 8			X	X	X	X	X	
North Clearwater Harbor Marker 5			X	X	X	X	X	
North Clearwater Harbor Marker 3			X	X	X	X	X	
North Clearwater Harbor Marker 2			X	X	X	X	X	
Marker 1/Pope Channel	X	X	X	X	X	X	X	
Marker 17, north of Memorial Causeway			X	X	X	X	X	
I-25 Bird Colony Island	X	X	X	X	X	X		
Marker 10								
Marker 8/Compass Key			X	X	X	X		
Marker 6								
Marker 3								
Belleair Beach Bird Colony Islands	X	X	X	X	X	X		
Belleair Beach island near Intracoastal waterway			X	X	X	X	X	
Indian Rocks Beach Bird Colony Island	X	X	X	X	X	X		
Indian Rocks Beach South Bird Colony Island	X	X	X	X	X	X		X

The following actions which should be continued or added to ongoing activities for the protection of the birds of the CHSJS estuary include:

- Population estimates: Continue annual surveys to report nesting activity and regional bird populations. Long-term surveys of nesting birds allow regional managers to respond to immediate management needs and implement habitat improvements necessary to promote successful reproduction.
- Colony protection: Post nesting colonies and patrol them to reduce/prevent human disturbance, enlist the boating public, whether they are residents or tourists, to maintain buffer distances and avoid impacting nesting birds.
- Public education: Engage the community in the conservation requirements of locally valuable resources, including the printing and distribution of boater's guides, fishing regulations and wildlife needs, and proper disposal of fishing line. This creates the culture of conservation needed for the long-term commitment of resources to manage regional resources, as well as the short-term compliance with nesting sites posted to protect nesting birds and reduction of fishing line debris in the environment, among other factors. Two key public education strategies in progress are: 1) updating the *Clearwater Harbor/St. Joseph Sound Boaters Guide* and increasing its distribution at marinas, bait shops, boat ramps, and directly to boaters themselves, and 2) giving presentations to the public about habitat values to birds in CHSJS, bird populations, conservation needs, and appropriate recreational use of these habitats.
- Predator control: Reducing the regional meso-carnivore population as recommended by the USDA APHIS Wildlife Services (Parker Hall, USDA APHIS Wildlife Services, pers. comm.), and removing mammalian predators (especially raccoons) immediately from bird nesting islands to allow nesting success are priorities. In addition, raccoon population control programs have improved nesting opportunities for beach-nesting birds on Anclote Key and Honeymoon Island.
- Wildlife law enforcement: Encourage cooperation among law enforcement agencies, landowners, and management authorities to empower officers and improve law enforcement of wildlife and habitat laws regionally. Continued training of law enforcement staff through Marine Unit Interagency Law Enforcement Workshops would improve enforcement of bird and wildlife laws regionally, and increase compliance with trespassing prohibitions in posted bird nesting areas.
- Habitat management: Actions by governments and private landholders to protect and incrementally restore natural communities (including freshwater wetlands) should be planned to provide the key nesting, foraging, and roosting habitats required by these birds. Habitat loss, whether long in the past or presently, continues to reduce the capacity of the region to support large populations of these species. The Florida State Park staff have undertaken large-scale vegetation habitat management projects on Anclote Key, Honeymoon Island, and Caladesi Island, removing Australian pines, Brazilian peppers, and other non-native plant species. In addition, Pinellas Aquatic Preserve staff have removed Australian pines, Brazilian peppers, and non-native vegetation from several of the islands in St. Joseph Sound and Clearwater Harbor North, and replanted these spoil islands with native trees and plants. The Pinellas Aquatic Preserve staff has proposed clearing SJS Spoil Island Marker 29 to promote habitat for nesting Least Terns. Issues regarding this proposal that need to be resolved include posting as a "no trespassing, bird colony" site, patrol and monitoring of recreational boater compliance, erosion management, developing a plan to

manage plant succession, suitability of the location, and other considerations. Pinellas County Environmental Management and Audubon's Florida Coastal Islands Sanctuaries are providing technical assistance for this project.

- Climate change: Global warming affecting sea level rise is an obvious threat to birds that nest, forage, or otherwise rely on coastal habitats. Long-term planning to offset coastal habitat losses and protect similar habitats inland and the coastal uplands that are part of the critical ecosystem will be needed to ensure wildlife population health.
- Fishing line accumulation. Removal of line and other entangling debris from bird nesting, roosting, and foraging islands and other habitat sites can help protect birds and other wildlife. In October, when birds are not nesting, Audubon's FCIS and Tampa Bay Watch organize a community-wide Monofilament CleanUp! as a preemptive action to prevent mortality. Public education of fishermen and others regarding proper disposal of entangling litter material and methods of releasing birds, especially pelicans, from hooks and lines if caught should be expanded.
- Coordination with public agencies and others who own and manage bird nesting colony sites allows a region-wide perspective on the local, national, and international importance of the birds and wildlife of the CHSJS estuary.
- Protecting nesting islands from erosion due to weather-driven or boat-wake waves can be achieved by a site-specific planned and engineered placement of wavebreaks and wave action deflection devices, complemented by oysterbars and marsh vegetation, as potential management toolsto reduce erosion of nesting islands. Addition of a wavebreak to control erosion on Sand Key Dunedin West similar to the rock rip-rap device constructed south of Clearwater Harbor Bird Island I-25 would protect this locally valuable pelican and wading bird colony from continued habitat loss.
- Creating habitat: Adding material to two dredged spoil islands in southern Clearwater Harbor, one for recreation (Compass Key, near Marker 8) and one for beach-nesting birds (Marker 10), with clean material from Clearwater Pass maintenance dredging has been proposed. Issues to resolve would include permitting, avoiding seagrasses, erosion management, management responsibility, and funding.

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