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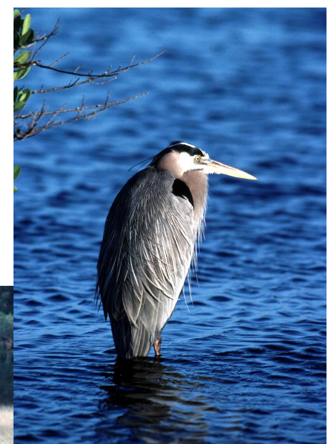
Assessment of Coastal Water Resources and Watershed Conditions at Timucuan Ecological and Historic Preserve (FLORIDA)

Sarah M. Anderson, Christine Katin, and William R. Wise, Ph.D., P.E.



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List of Acronyms

BOD	Biochemical Oxygen Demand
CAMA	Coastal and Aquatic Managed Areas (division of Florida Department of Environmental Protection)
$CBOD_5$	Carbonaceous Biochemical Oxygen Demand (5-day)
COJ	City of Jacksonville
CWA	Clean Water Act
DDT	Dichlorodiphenyltrichloroethane
DIP	Dissolved Inorganic Phosphorus
DO	Dissolved Oxygen
DRP	Dissolved Reactive Phosphorus
EMAP	Environmental Monitoring and Assessment Program
EPD	Environmental Protection Division (of the Georgia Department of Natural Resources)
ER-L	Effects Range - Low
ESRI	Environmental System Research, Inc.
FAC	Florida Administrative Code
FCMP	Florida Coastal Management Program
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FDER	Florida Department of Environmental Regulation
FIM	Fisheries Independent Monitoring
FNAI	Florida Natural Areas Inventory
FOCA	Fort Caroline National Memorial
FWCC	Florida Fish and Wildlife Conservation Commission
GIS	Geographic Information System
HAB	Harmful Algal Blooms
HUC	Hydrologic Unit Code
ICWW	Intracoastal Waterway
JEA	Jacksonville Electric Authority
LSJR	Lower St. Johns River
LSJRB	Lower St. Johns River Basin
MGD	Million Gallons Per Day
MPN	Most Probable Number
MRFSS	Marine Recreational Fisheries Statistics Survey
NADP	National Atmospheric Deposition Program
NCA	National Coastal Assessment
NOAA	National Oceanic and Atmospheric Administration
NOAA-NMFS	National Oceanic and Atmospheric Administration - National Marine Fisheries Service
NOEL	No Observed Effects Level
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPS	National Park Service (of the Department of the Interior)

NSSP	National Shellfish Sanitation Program
NWIS	National Water Information System (maintained by US Geological Survey)
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PEL	Probable Effects Level
PLS	*Pfiesteria*-like Species
SAV	Submerged Aquatic Vegetation
SCECAP	South Carolina Estuarine Coastal Assessment Program
SEAS	Shellfish Environmental Assessment Section (of the Florida Department of Agriculture and Consumer Services, Division of Aquaculture)
SJR	St. Johns River
SRJWMD	St. Johns River Water Management District
STORET	STOrage and RETrieval database (maintained by US Environmental Protection Agency)
TCAA	Tri-County Agricultural Area (located in Putnam, St. Johns, and Flagler Counties)
TDS	Total Dissolved Solids
TIMU	Timucuan Ecological and Historic Preserve
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TOC	Total Organic Carbon
TP	Total Phosphorus
TSS	Total Suspended Solids
USACOE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VOC	Volatile Organic Compounds
WWTP	Wastewater Treatment Plant

Executive Summary

Timucuan Ecological and Historic Preserve (TIMU) encompasses 18,600 hectares (46,000 acres) of salt marsh and coastal hammock habitat in addition to marine and brackish open waters. TIMU contains the seaward confluence of the Nassau and St. Johns Rivers (SJR). It is located along the northeastern coast of Florida (Duval County) entirely within the city limits of Jacksonville. TIMU includes several rare and vulnerable natural communities: coastal strand, maritime hammock, scrub, and shell mound. National Park Service (NPS) facilities within TIMU include Fort Caroline (FOCA) visitor center and maintenance area, the Theodore Roosevelt area with park headquarters, the Kingsley Plantation, the Ribault Column, and the newly-acquired historic Broward house. Other state and city parks in the area are Big and Little Talbot Island State Parks, Fort George Island Cultural State Park, Little Jetties Park, Huguenot Memorial Park, and the Sisters Creek Park and boat ramp.

Water resources are an integral part of TIMU because approximately 75% of the area included within its boundaries is wetlands and open water. These resources include numerous tidal creeks, portions of the Nassau and SJR Rivers, Sisters Creek/Intracoastal Waterway (ICWW), Fort George River, and freshwater resources (Spanish Pond). TIMU's estuarine setting serves as a vital ecological link between freshwater habitats and the ocean. The waters of TIMU are impacted by land use in the surrounding watersheds. Examples of water quality issues applicable to TIMU include nonpoint source pollution from urban and agricultural areas, elevated metal concentrations in the sediments of the SJR, impacts of several Superfund sites and landfills, and water pollution from malfunctioning septic systems within and adjacent to TIMU. Available water quality information was utilized to determine the current condition and possible impairments of TIMU's water resources, and to identify any information gaps that limit determination of whether or not TIMU's waters are degraded or impaired.

Generally, TIMU's water quality is considered good compared to other Florida surface waters. Tidal flushing is considered to be an important contributing factor because upstreams areas of the Nassau and St. Johns River are degraded. However, recent continuous monitoring data collected in the Fort George River indicates that some of the tidal creeks are not well flushed (DiDonato et al., 2005). Residence times were on the order of months, indicating that pollution to these areas could have prolonged effects. In addition, there is a lack of descriptive information detailing the hydrodynamics and currents of the system. Circulation of water within the tidal creeks east of Blount Island are considered especially complex.

The *Baseline Water Quality Data and Inventory Report* (NPS, 2002) retrieved all water quality data entered into the U.S. Environmental Protection Agency (USEPA) STOrage and RETrieval (STORET) database for TIMU and the surrounding area (lands and waters within three miles upstream and one mile downstream) through 1998. The search yielded 493,316 observations for 532 separate parameters collected by various agencies. About 81% (400,249) of the observations were entered by the NPS from data

collected between 1972 and 1998. Of these observations, 97% were recorded at two stations (TIMU 0178 – Cedar Point Creek and TIMU 0213 – Clapboard Creek) within TIMU's boundary. Forty-two stations within the study area did not contain any data and many of the stations represented one-time or intensive single-year sampling efforts.

For this assessment, data were downloaded from the USEPA modernized STORET database, which includes all measurements after 1999, and a limited amount of earlier data that have been transferred from Legacy STORET. These data were contributed by the City of Jacksonville (COJ), the Florida Department of Environmental Protection (FDEP), Division of Environmental Health (Bureau of Water), Florida Fish and Wildlife Conservation Commission (FWCC) Marine Research Institute, NPS, and Florida LAKEWATCH. Additional sources of data were the TIMU Preserve Program (conducted by the City of Jacksonville), the St. Johns River Water Management District (SJRWMD), and the U.S. Geological Survey (USGS) National Water Information System (NWIS) database.

Water quality impairments for the Lower St. Johns River Basin (LSJRB) and the Nassau/St. Mary's Basin provide a starting point for determination of water quality conditions in TIMU. According to the verified list for the LSJRB, there are eight impaired segments in the water basins within the study area established around TIMU. Three of the segments are portions of the SJR including the mouth, the ICWW, and Dames Point. The three segments are all impaired due to iron, copper, and nickel with an additional listing for lead in the ICWW segment. The other segments, with the exception of the Atlantic Coast entry, are urban creeks that are listed as impaired due to dissolved oxygen (DO) levels and fecal coliforms. There are 18 segments on the draft list of impaired waters in the Nassau/St. Mary's Basin within the study area. The impaired parameters are DO, coliforms, iron, chlorophyll, mercury, and biology. Seven of the listings are for coliforms, resulting from downgrades in shellfish harvesting classifications.

Much of the recent water quality information comes from the monitoring efforts of the COJ Ambient Water Quality Section, which samples twelve stations within and adjacent to TIMU. These sites are sampled on a bimonthly basis for numerous parameters including nutrients (various forms of nitrogen and phosphorus) and DO. The nutrient levels at these stations were generally consistent with the typical values for Florida estuarine and stream stations as presented in Friedemann and Hand (1989). However, the total phosphorus (TP) levels at some of the stations exceeded the typical value > 50% of the time. These stations should continue to be monitored as residential development pressure will likely increase in the future.

DO measurements recorded at the COJ's monitoring stations displayed seasonal cycling consisting of summer minima and winter maxima. Continuous monitoring has been conducted at several locations, Clapboard Creek and the Fort George River, to obtain hydrologic and water quality information. At one of these locations (in the Fort George River), measurements were recorded below 4.0 and 5.0 mg/L, which are the respective saltwater and freshwater state criteria. These occasions may not be a cause for alarm, as short hypoxic events often occur during the summer in tidal creeks in this region (DiDonato et al., 2005). Overall, hypoxic events were rare, occurring during 6% of the deployment period, and short, none of the events lasted longer than 12 hours (DiDonato et al., 2005).

Although most of the sediments within TIMU have showed little to no metal or organic contamination, some areas of contamination have been identified. The sediments of Spanish Pond were categorized as "moderately contaminated" with lead and zinc, probably due to stormwater road runoff (Morton and Marchman, as cited in NPS, 1996b). Samples from Chicopit Bay exhibited elevated concentrations of arsenic, chromium, lead, and zinc; organic contaminants were detected in the SJR. Multiple years of high levels of selenium and butyltin compounds have also been documented in Chicopit Bay (O'Connor and Beliaeff, 1996). Additional data regarding contaminants, such as hydrocarbons, organic pollutants, pesticides, and metals, are available from the Environmental Monitoring and Assessment Program (EMAP). Stations in the South Amelia River and Nassau Sound did not demonstrate any evidence of water or sediment quality degradation; however, a station in the SJR displayed elevated levels of total polychlorinated biphenyls (PCBs) and dichlorodiphenyltrichloroethane (DDT). The site was classified as degraded based on the mean infaunal diversity and abundance as well as the mean demersal richness, diversity, and abundance.

It is often difficult to draw direct connections between biological resources and water quality conditions. This report includes information on the species located in each habitat, species of concern, and exotic species. There are four wading bird rookeries located within TIMU that are used by anhinga *(Anhinga anhinga)*, black-crowned night heron (*Nycticorax nycticorax*), cattle egret *(Bubulcus ibis)*, great blue heron (*Ardea herodias*), great egret *(Casmerodius albus)*, little blue heron *(Egretta caerulea)*, snowy egret *(Egretta thula)*, tri-colored heron *(Egretta tricolor)*, white ibis *(Eudocimus albus)*, and wood stork *(Mycteria Americana)*. There are also several upland exotic species, such as Chinese tallow (*Sapium sebiferum*) air potato (*Dioscorea bulbifera*), Chinese wisteria (*Wisteria seninsis*), Boston fern (*Nephrolepis cordifolia*), English ivy (*Hedera helix*), cat's claw vine (*Macfadyena ungis-cati*), kudzu (*Pueraria montana*), and Peruvian primrose willow (*Ludwigia peruviana*). Work has been completed to investigate the effects of urbanization on fish assemblages in four tidal creeks (Dennis et al., 2001). As development pressures increase, indicator species should be used to discern changes in water quality.

In addition to water quality concerns, there are several other coastal management issues that should be mentioned. These matters include the possible closure of the Fort George inlet, which would affect the water quality of TIMU's saltmarshes. A larger portion (or all) of the water supplied to the marshes would originate from Nassau Sound and the SJR, which is most likely of lower quality than that from the Atlantic Ocean. Gosselin et al. (2000) investigated the impacts of three proposed alternatives on the wave climate, tidal circulation, and potential sediment transport near the Fort George inlet to prevent this closure. The U.S. Army Corps of Engineers (USACOE) is investigating options to limit the navigational risks associated with the dangerous cross-currents at

Mile Point. In addition to the dangerous currents, homeowners on the north bank of the SJR at Mile Point have experienced severe erosion of their property. The erosion of South Amelia Island led to the construction of a 460-m (1500-ft) terminal groin and a 90-m (300-ft) detached rock breakwater.

Sea level rise may significantly affect coastal marshes. Predicting shoreline retreat and land loss rates has direct impacts on coastal zone management as well as alterations to biological resources. Altered salinities due to increased tidal inundation time and decreased freshwater inflow have been suggested as the greatest determinants of vegetation changes in TIMU (Steinway-Rodkin and Montague, 2004). A coastal vulnerability index (CVI) was developed to determine the relative vulnerability of various coastal environments to changes due to sea-level rise based on coastal geomorphology, rate of sea-level rise, past shoreline evolution, and other factors (Thieler and Hammar-Klose, 1999). Sections of the Amelia Island shoreline are classified as being at very high, high, and moderate risk based on the calculated CVI. Little Talbot Island and the Atlantic coastline south of the SJR mouth are classified as being at moderate and high risk as a result of future sea-level rise (Thieler and Hammar-Klose, 1999).

The potential for impairment to TIMU's water resources are summarized in **Table i**. The indicators included in the table are contaminants and other indicators of poor water quality, invasive species, sea level rise, habitat disruption, and shoreline change.

Table i. Potential for impairment of Timucuan Ecological and Historic Preserve water resources.

Indicator	St. Johns River (lower section)	Nassau River*	Tidal creeks	Wells	Spanish Pond	Atlantic Coast
Toxic algae	PP	ND	PP	LP	LP	PP
Nutrient loading	HP	MP	HP	ND	HP	LP
Excessive fecal bacteria	MP	HP	MP	ND	ND	HP
Metals contamination	HP	HP (Fe)	PP	PP	HP	HP (Hg)
Toxic compounds	HP	PP	PP	ND	ND	ND
Invasive species	MP	MP	MP	LP	MP	PP
Habitat disruption	HP	MP	HP	LP	HP	PP
Low dissolved oxygen	MP	HP	MP	LP	PP	ND
Impacts of sea level rise	PP	PP	PP	PP	LP	PP
Shoreline change	MP	HP	LP	PP	LP	HP
SAV Decline	MP	LP	LP	LP	LP	LP

Definitions: HP – high concern problem, MP – moderate concern problem, LP – low concern or problem, PP – potential problem, ND – insufficient data to make judgment

*Also includes Nassau Sound

The major water quality issues for the Lower St. Johns River (LSJR) are nutrient loading (based on total maximum daily load (TMDL) development), metals contamination (based on impaired waters listing), toxic compounds (based on EMAP results), and habitat disruption resulting from increased urban growth. For the Nassau River, high concern problems include fecal bacteria levels, dissolved oxygen, and metals contamination (iron) due to 303(d) impaired waters listings. The stabilization efforts at South Amelia Island indicate the importance of shoreline management. For tidal creeks, high priority issues are nutrient loading and habitat disruption based on increased residential development and human alteration in upland watersheds. The indicators for Spanish Pond are similar to the tidal creeks, with the addition of metals contamination due to elevated levels of lead and zinc, most likely from stormwater road runoff. For the Atlantic Coast, high concerns issues are excessive fecal coliform bacteria (based on downgrades in shellfish harvesting classification), metals contamination (due to mercury advisory for fish consumption), and shoreline change (possible closure of Fort George Inlet and South Amelia Island stabilization).

To more accurately evaluate the coastal water resources of TIMU, several recommendations are provided in **Table ii**. Although the NPS will be unable to implement all of these recommendations, they are included to provide a comprehensive picture of the information and data required to completely assess TIMU's water resources.

These recommendations and identification of data gaps range from hydrologic characterization information to expansion of existing monitoring efforts. These suggestions include acquiring additional data and incorporating it into a geographic information system (GIS), expanding monitoring efforts, selecting and monitoring organisms that can act as indicators of degraded water quality. Also of importance is gaining additional information on the hydrologic processes in the area, especially in the tidal creeks, to better couple the relationships between land use and water quality. Determination of residence times and circulation patterns will help quantify exposure and measure the potential vulnerability of various water resources to pollutants.

Table ii. Recommendations for Timucuan Ecological and Historic Preserve.

Data Management	
	Integration of additional areas of interest (dischargers, critical nursery habitats, etc.) into GIS
	Accurate delineation of coastal watershed boundaries
Biological Resources	
	Association of flora and fauna to habitat type
	Identification of species that can be used to detect water quality changes
Lower St. Johns and Nassau Rivers	
	Ongoing review of water quality data at several indicator stations
	Annual review of exotic species and summary of control measures
Tidal Creeks	
	Expansion of sampling effort (monthly vs. bimonthly)
	Dissolved and sediment metals sampling to determine if contamination exists
	Determination of circulation patterns and relative influence of flushing
	Addition of bacteria and chlorophyll monitoring
Wells	
	Regular monitoring to detect head declines and/or saltwater intrusion
Spanish Pond	
	Biological inventory of invertebrates and other fauna
	Establishment of permanent water quality monitoring stations
	Bacteria monitoring during high rainfall to determine prevalence of septic system failure (if present)
Atlantic Coast	
	Addition of nutrient and field parameters to selected beach monitoring sites
	Obtain results of harmful algal species monitoring (possibly from SJRWMD or FWCC)

Park Description

Background

Setting

TIMU encompasses 18,600 hectares (46,000 acres) of salt marsh and coastal hammock habitat in addition to marine and brackish open waters (**Figure 1**). TIMU contains the seaward confluence of the Nassau and St. Johns Rivers. It is located along the northeastern coast of Florida (Duval County) entirely within the city limits of Jacksonville. NPS facilities within TIMU include FOCA visitor center and maintenance area, the Theodore Roosevelt area with park headquarters, the Kingsley Plantation, and the newly-acquired historic Broward house. Other state and city parks in the area are Big and Little Talbot Island State Parks, Fort George Island Cultural State Park, Little Jetties Park, Huguenot Memorial Park, and the Sisters Creek Park and boat ramp.

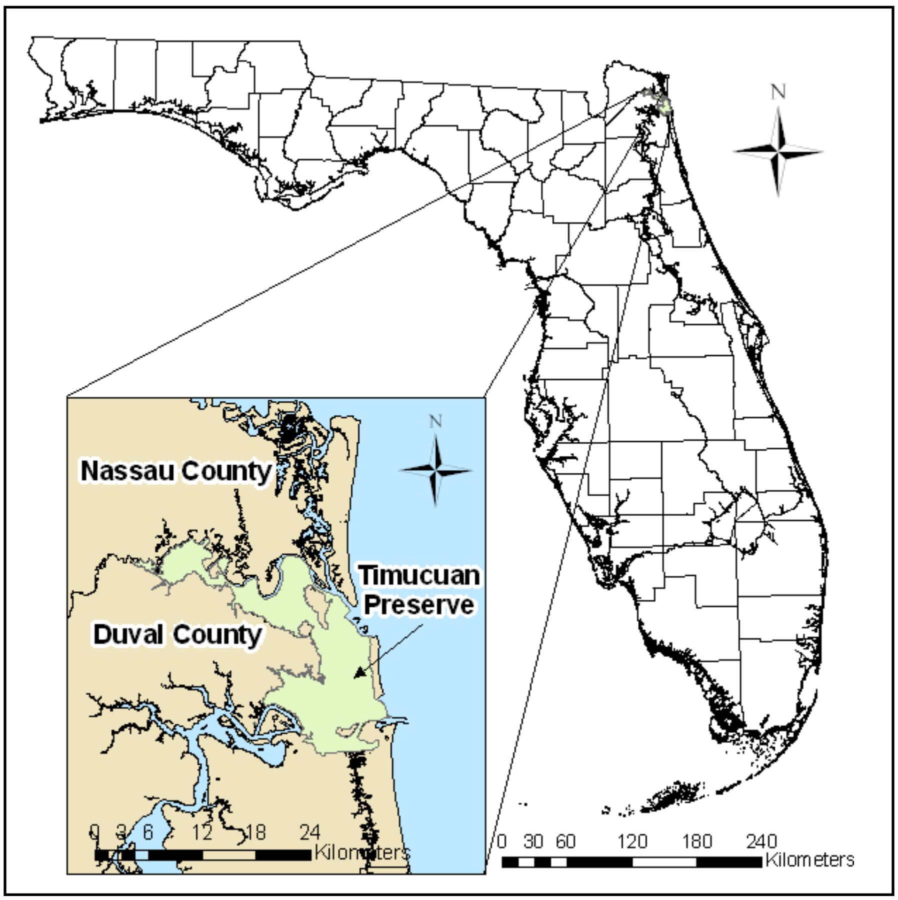


Figure 1. Location of Timucuan Ecological and Historic Preserve in northeast Florida.

(Data Sources: Park Boundary – NPS (1:24,000), 1999; County – FDEP (1:24,000), 1997)

The preservation of this area is important because of the system's unique characteristics. The Nassau and St. Johns Rivers discharge directly into the Atlantic

Ocean whereas most estuaries discharge into an embayment. The SJR is one of the few major north-flowing rivers in North America. Lands and waters within TIMU are owned by the federal government, the State of Florida, the COJ, private conservation organizations, private corporations, the Jacksonville Electric Authority (JEA), and individuals. The boundary used for this assessment delineates the area which the federal government has the authority to purchase land. The NPS does not own all of the land within this boundary. The estuarine wetlands and waters within TIMU are claimed under sovereignty by the State of Florida to the mean high water line (NPS, 1996b). Some salt marsh areas below mean high water are included in legal descriptions of privately-owned uplands. For the purposes of water resources management in TIMU, the state of Florida has jurisdiction over all wetland areas, up to mean high water. Various state agencies within the FDEP manage these submerged lands (NPS, 1996b).

TIMU's surface waters are designated as Outstanding Florida Waters, which provides an extra level of protection by adding measures to the review process for FDEP permits. Also included within TIMU's boundaries is the Nassau-St. Johns River Aquatic Preserve, which also carries the Outstanding Florida Waters designation. It covers an area of approximately 140,850 hectares (57,000 acres) and includes portions of the Amelia, Nassau, and Fort George Rivers. It was designated as a biological preserve to protect crucial habitat for numerous fish and wildlife species as well as to maintain the critical functions performed by these estuarine habitats. Functions such as removal of contaminants through filtering, buffering from storm wind and waves, providing roosting and nesting habitat for wading birds, and generating organic material required to fuel the estuarine food web.

The majority of TIMU lies within the St. Mary's Meander Plain which is part of the Atlantic Coastal Plain; however, the area immediately south of the SJR is part of the Eastern Valley. The St. Mary's Meander Plain is the southern end of the Sea Islands. The Sea Islands consist of a chain of barrier islands that are separated from the mainland by tidal creeks. This chain extends from the Santee River in South Carolina to the north bank of the SJR. Their formation is attributed to a mixture of fluvial and tidal sedimentation in the salt marshes located between beach ridges. These islands serve important functions as they absorb much of the energy from tides and waves and provide areas for sediment deposition (White, 1970).

The marine terraces that make up the topography of northeast Florida were formed during the Pleistocene era when sea level rose and fell several times due to glacial advances and retreats. The terraces that correspond to these Pleistocene shorelines are named Wicomico (30.5 m, 100 ft above sea level), Penholoway (21 m, 70 ft above sea level), Talbot (13 m, 42 ft above sea level), and Pamlico (7.6 m, 25 ft above sea level) (White, 1970). Rivers and streams flow through the swales located between these terraces.

Soils in northeast Florida are partially sedimentary and partially derived from underlying formations (COJ, 1990b). The Piedmont region of the south Appalachian Mountains is considered the primary source of Pleistocene sediments. These sediments were transported southward by streams and long-shore currents (NPS, 1996b). The predominant soil type in the marsh areas of TIMU is Tisonia mucky peat (COJ, 1990b). The soil is flooded daily by tides and permeability is widely variable from less than 1.5 cm to 51 cm (0.6 inches to 20 inches) per hour. Use of these soils for septic tank absorption fields and sewage lagoons is severely limited (NPS, 1996b).

The basin possesses a warm temperate to subtropical climate with an annual average temperature of 21°C (69.8°F) (FDEP, 2004b). The average annual rainfall is approximately 135 cm (53.2 inches); half of this rainfall occurs during the wet season (June through September) (FDEP, 2004b). Tropical storms affect the basin and occur most often during the late summer and early fall (Bergman, 1992). Northeast Florida is also subject to northeasters, which can lead to dune erosion and change the shoreline drastically in a relatively short period of time (Raichle, 1993). The predominant winds in the LSJRB are from the northeast during the months of September through January and from the southeast or southwest during February through August (Bergman, 1992). The average monthly wind speeds typically range from 2.7-4.5 m/s (6-10 mph) (Bergman, 1992).

The ocean currents near Mayport are primarily southerly (Bumpus, 1973) and "prevailing winds are considered to be the determining factor" (Southern Division, 1991, p. 3-6). According to the U.S. Naval Weather Service Command, the dominant wave direction is from the northeast and mean wave heights from this direction have been estimated at 1.5 m (5.0 feet) (cited in Southern Division, 1991). The Weather Service Command also reported mean wave heights from the east and southeast of 1.1 m (3.7 feet) and 0.98 m (3.2 feet), respectively (cited in Southern Division, 1991).

TIMU's estuarine setting serves as a vital ecological link between freshwater habitats and the ocean. Within TIMU boundaries are numerous tidal creeks, portions of the Nassau and SJR Rivers, Sister's Creek/Intracoastal Waterway (ICWW), the Fort George River, and freshwater resources. The Nassau and St. Johns Rivers discharge directly into the Atlantic Ocean whereas most estuaries discharge into embayments. The Nassau River is the only drainage on Florida's east coast that is not channelized or stabilized by engineering structures. The SJR is one of the few major north-flowing rivers in North America. Spanish Pond is the largest freshwater pond (semi-permanent water regime) under NPS ownership within TIMU.

Historically, estuarine systems have not been well-studied and what information has been gathered has not been widely distributed, TIMU is not an exception (NPS, 1996b). Estuarine systems are highly productive, supported by the fact that the southeastern U.S. is responsible for half of the nation's fisheries catch; given this fact, the lack of research seems illogical (NPS, 1996b). Durako et al. (1988) described the economical and social functions of these systems which include spawning and nursery habitat for fish and invertebrate species, an ameliorating zone for storms and floods, sinks for nutrients and contaminants, transportation routes that connect inland commerce to the ocean, and a culturally diverse area attracting people that expand the recreation and tourism industry. An important relationship exists between the estuary and nearby marshes. The energy fixed in the marsh is flushed out of the system in the form of detritus to the waters of the estuary by means of tidal action. In estuaries, this detritus is a food and nutrient source for many organisms (Durako et al., 1988).

Reduced freshwater inflow to estuaries resulting from human activities has been linked to several biological consequences, which were described by Durako et al. (1988). These include the following points (p. 7):

- *Nearshore waters become more saline.*
- *Estuary is starved of essential nutrients of terrestrial origin.*
- *Benthic substrate tends to become anaerobic and heavy metals sequestered in the substrate are liberated; sulfur cycles become dominant.*
- *Certain fisheries are entirely lost for a variety of reasons, such as increased salinity, reduced food supply; loss of a large area of low salinity, etc.*
- *Salt-tolerant mosquito and dipteran populations increase.*
- *Salt marshes and/or mangroves and seagrasses deteriorate under constantly elevated salinity.*
- *Saltwater intrusion appears in coastal groundwater and surface waters.*

Water resources are an integral part of TIMU because approximately 75% of the area is made up of wetlands and open water. In addition, TIMU includes several rare and vulnerable natural communities: coastal strand, maritime hammock, scrub, and shell mound. TIMU's habitats are impacted by land use in the surrounding watersheds. Examples of water quality issues applicable to TIMU include nonpoint source pollution from urban and agricultural areas, elevated metal concentrations in the sediments of the SJR, impacts of several Superfund sites and landfills near TIMU, and water pollution from malfunctioning septic systems within and adjacent to TIMU (NPS, 1996b). Other threats to water quality include two closed landfills located adjacent to TIMU's northern and southern boundaries. One of these landfills operated before lining was mandatory and there is a history of dumping violations (NPS, 1996b).

TIMU is also affected by adjacent industrial and military operations. JEA operates a 142 hectare (350 acre) complex on Pelotes Island and the Naval Station Mayport occupies 491 hectares (1,213 acres) within the southern portion of TIMU (NPS, 1996b).

To analyze the water quality of TIMU and identify possible threats, several levels of geographic analysis were conducted. The USGS divides the nation into 8-digit hydrologic unit codes (HUCs) and TIMU is part of the LSJR (03080103) and the Nassau River (03070205) units (**Figure 2**). TIMU lies entirely within Duval County and Nassau County borders TIMU to the north. Data were obtained using county, HUC, watershed, and preserve boundaries based on sampling frequency and data availability for the water quality assessment.

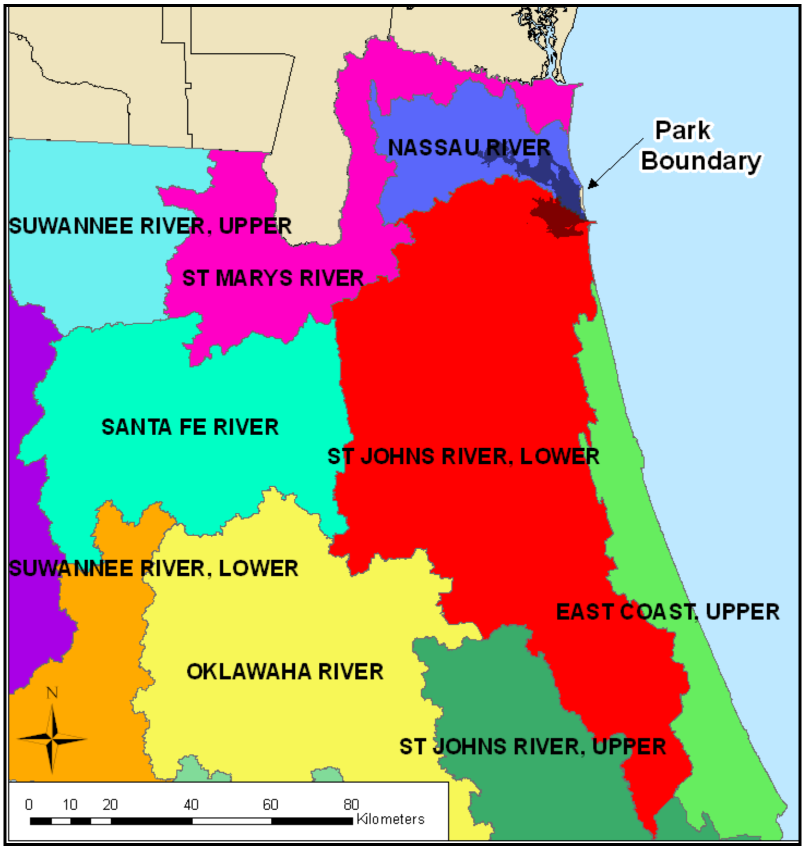


Figure 2. Hydrologic unit codes (HUCs) in northeast Florida.

(Data Sources: GA shoreline – FDEP (1:100,000), 1990; Park Boundary – NPS (1:24,000), 1999; HUCs – FDEP (1:24,000), n.d.)

Land Use

The predominant land uses in Duval County are urban and suburban with heavy industrial use concentrated to the east of downtown Jacksonville and west of TIMU. The COJ occupies approximately 2,165 km^2 (836 $miles^2$) of the 2,201 km^2 (850 $miles^2$) area of Duval County (NPS, 1996b). Several arterial highways connect the central business district to the circumferential areas (NPS, 1996b). Retail, commercial, industrial, and high-density residential development is concentrated along these routes and within the inner business district (NPS, 1996b). Much of the development in the area occurred before formal planning could be completed (NPS, 1996b). As a result, residential growth has diffused into lower density subdivisions and outlying rural tracts. “Leap frog” development has also lead to small pockets of growth (NPS, 1996b). In recent years, the amount of high density subdivisions has increased.

The population of the Jacksonville metropolitan area has increased by an average of 20.5% per decade (Social Science Data Analysis Network, 2005) (**Figure 3**). This area includes Nassau, Duval, Clay, and St. Johns Counties, which make up the Census Bureau’s COJ metropolitan statistical area. The increasing trend is expected to continue with a projected increase of 34.5% from 1990 to 2020 (COJ, 2003). This population growth will present multiple challenges ranging from land use planning to the impacts on environmental resources. Considerations must also be made to accommodate increased traffic and infrastructure needs. Development adjacent to TIMU has increased in recent years and this trend is expected to continue with the projected population growth.

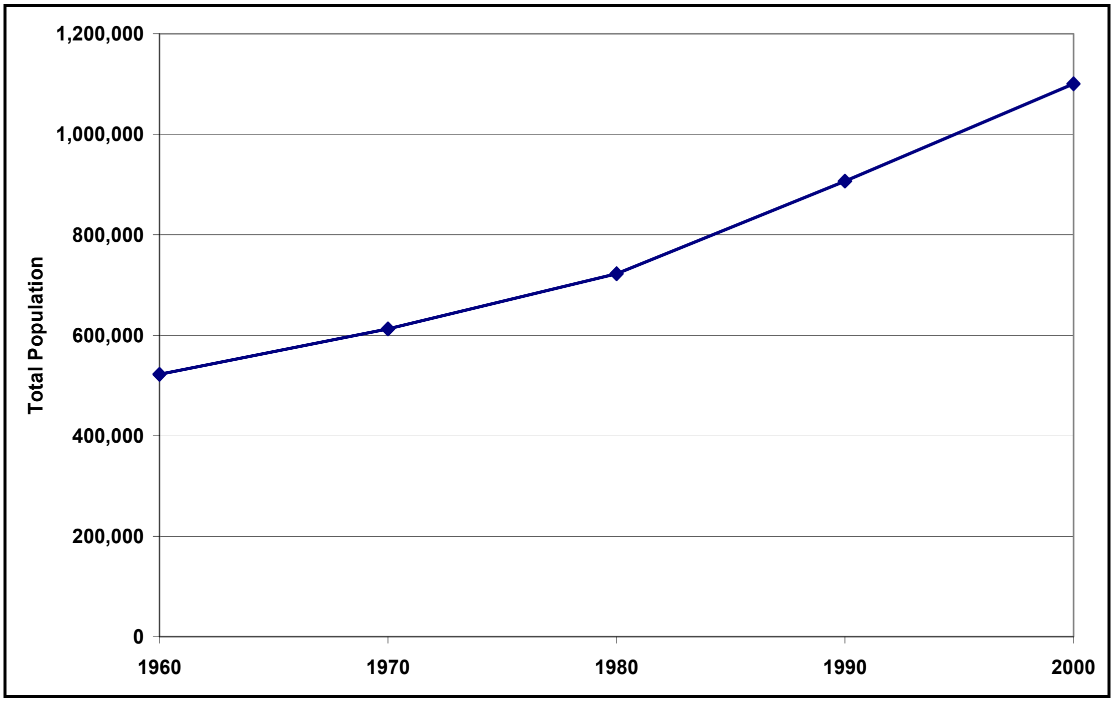


Figure 3. Jacksonville, Florida, area population, 1960-2000.

Includes Nassau, Duval, Clay, and St. Johns Counties.
(Source: Social Science Data Analysis Network, 2005).

Land use within TIMU is limited by the amount of open water and acceptable land for building (**Figure 4**). Due to these restrictions, most of the land is used for conservation or agricultural purposes. The COJ has jurisdiction over zoning and land use planning within TIMU. However, changes in land use and planning must be consistent with the city's current land use plan (COJ, 1990b). The northern portion of TIMU is threatened by current and future residential development. At the time of the current water management plan's publishing (1996), this area was largely undeveloped and zoned for agricultural. The zoning district allows residential units at the rate of up to one unit per 1.0 hectare (2.5 acres), varying with lot size, to be established. Smaller lots of less than 1.0 hectare (2.5 acres) are still eligible for a single family home if certain conditions are met. In recent years, numerous zoning changes have allowed more dense development in and near TIMU. If the northern portion were developed exclusively for residential purposes and added to the units allowed under residential zoning, over 1,000 new houses could result under the new regulations (NPS, 1994). These homes could significantly impact TIMU's water quality because nearly all would rely on septic systems and individual wells (NPS, 1996b).

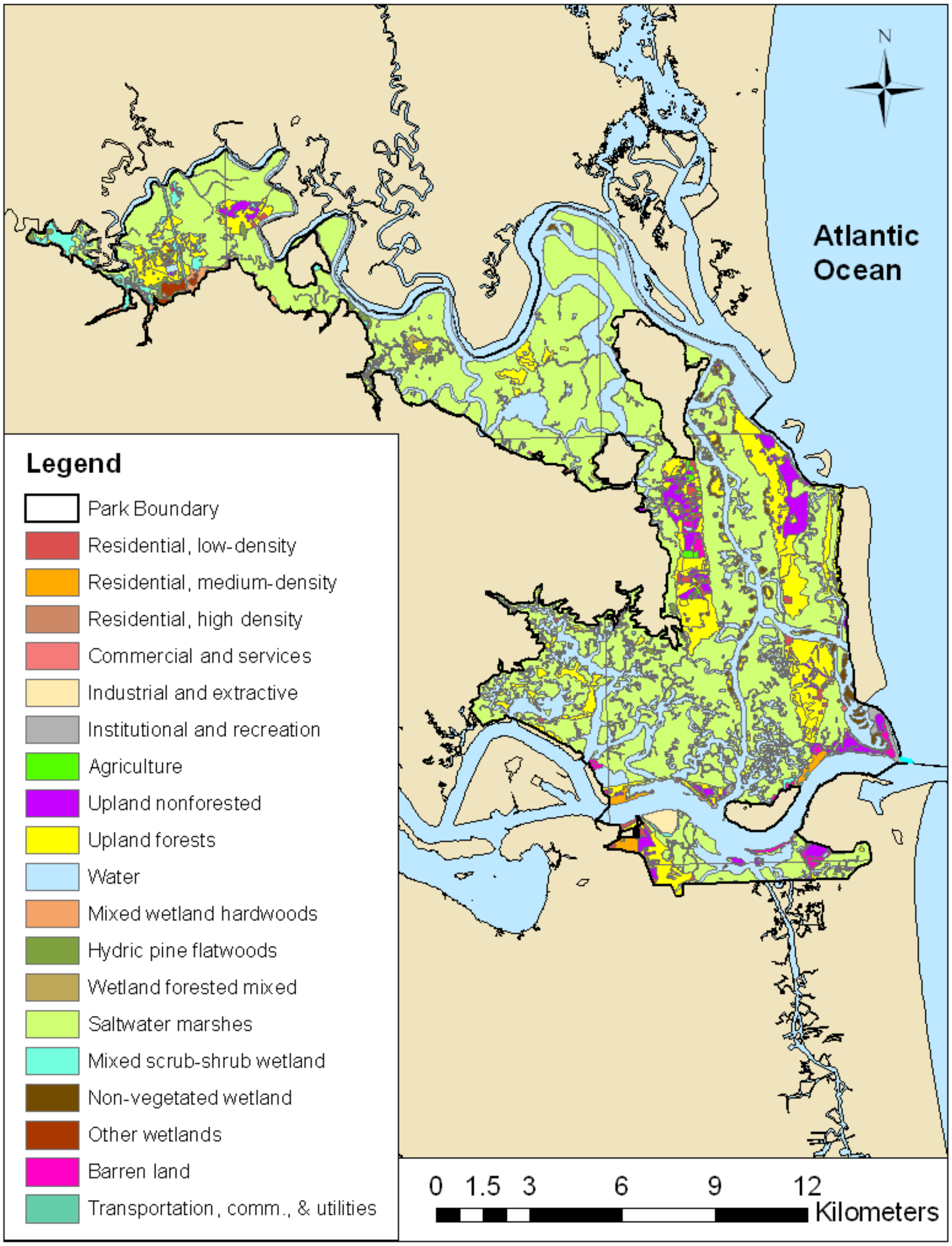


Figure 4. Land use within Timucuan Ecological and Historic Preserve.

(Data Sources: Land Use – SJRWMD (1:40,000); 1999 Digital Orthophoto Quarterquads; Park Boundary – NPS (1:24,000), 1999; County – FDEP (1:24,000), 1997)

The southern portion of TIMU contains 4.90 km^2 (1,213 acres) of Naval Station Mayport (NPS, 1996b). Mayport is the third largest naval facility in the continental U.S.

It was commissioned in December 1942 and includes a harbor capable of accommodating 34 ships and a 2.4-km (8,000-foot) runway. Naval Station Mayport is the operation and training headquarters for the SH-60B Seahawk LAMPS MKIII with a primary mission of anti-submarine warfare (U.S. Navy, 2005).

The land use distribution within TIMU boundaries was determined using ArcGIS 9.0 (Environmental System Research, Inc (ESRI), 2004) and 1999 digital orthophoto quarterquads (1:40,000) interpreted by the SJRWMD. The Florida Land Use, Cover, and Forms Classification System separates land use/cover data into multiple codes. The general divisions, such as urban and built-up, agriculture, wetlands, etc., were used unless a habitat of interest was identified. Land use distribution is presented in **Table 1**.

Table 1. Land use distribution for Timucuan Ecological and Historic Preserve.

Description	Area (hectares)	Percent of Total Park Area
Urban and built-up		
Residential, low-density	136.2	0.7
Residential, medium-density	110.3	0.6
Residential, high-density	0.17	< 0.1
Commercial and services	8.0	< 0.1
Industrial and extractive	59.6	0.3
Institutional and recreation	76.7	0.4
Agriculture	33.1	0.2
Upland nonforested	548.0	3.0
Upland forests	1,985.3	10.7
Water	4,847.2	26.2
Wetlands		
Mixed wetland hardwoods	92.2	0.5
Hydric pine flatwoods	114.6	0.6
Wetland forested mixed	85.6	0.5
Saltwater marshes	9,683.4	52.4
Mixed scrub shrub wetlands	234.2	1.3
Non-vegetated wetland	219.4	1.2
Other wetlands	87.0	0.5
Barren land	123.0	0.7
Transportation, communication and utilities	30.8	0.2
Undefined	0.58	< 0.1
Total	**18,475**	**100**

Source: SJRWMD, 1999 Digital Orthophoto Quarterquads (1:40,000).

The majority of TIMU is classified as saltwater marsh (~ 52%). Water makes up about 26% of the total area. Approximately 11% of TIMU is classified as upland forests, which includes pine flatwoods, upland hardwood forest, upland mixed coniferous/hardwood, coniferous pine, and forest regeneration. Upland nonforested, mixed scrub shrub wetlands, and non-vegetated wetland comprise approximately 3.0%, 1.3%, and 1.2% of TIMU's area, respectively.

The predominant wetland type within TIMU according to the U.S. Fish and Wildlife Service's (USFWS) National Inventory classification system is estuarine (**Figure 5**). Within TIMU boundaries, there are also localized areas of lacustrine, palustrine, and marine wetlands. Descriptions of these wetland types are provided in **Table 2**.

Table 2. Descriptions of U.S. Fish and Wildlife National Inventory major systems and area of each system type located in Timucuan Ecological and Historic Preserve.

System	Description	Area (ha)	Percent of Total Park Area
Estuarine	Salt marshes and brackish tidal water	14633.8	79.1
Lacustrine	Lakes and deep ponds	21.1	0.1
Palustrine	Shallow ponds, marshes, swamps, and sloughs	438.8	2.4
Marine	Open ocean and associated coastline	12.7	0.1

Source: U.S. Fish and Wildlife Service (1:24,000) Metadata.

History and Human Utilization

<u>Fort Caroline</u>

NPS services include the Fort Caroline visitor center, the Theodore Roosevelt area with park headquarters, the Kingsley Plantation, and the historic Broward house. Fort Caroline, located near the mouth of the SJR, marked France's first attempt at staking a permanent claim in North America. Initially, the settlement was established as a commercial venture, but as the French Protestants (Huguenots) experienced greater persecution, the colony became a religious refuge (NPS – Fort Caroline, 2003). Expeditions led by Jean Ribault and René de Goulaine de Laudonnière in the 1560s led to the establishment of a village and fort on the St. Johns south bank called La Caroline after King Charles IX. The French encountered the Timucuans, the native peoples who relied on the resources provided by the surrounding waters for sustenance (NPS – Fort Caroline, 2003). The Timucuans aided the French by sharing food and helping them to build a village and fort (NPS – Fort Caroline, 2003). The Spanish, under the command of Admiral Pedro Menéndez, attacked La Caroline in August 1565. The French waged revenge on the Spanish by attacking and burning the fort in April 1568 under the leadership of Dominique de Gourgues. The Spanish rebuilt the fort in 1569 and the French did not strongly challenge Spanish claims in North America again (NPS – Fort Caroline, 2003). Under the Spanish, the Timucuans were forced into missions and their numbers rapidly diminished (NPS – Fort Caroline, 2003). There are no Native Americans today that call themselves Timucuan.

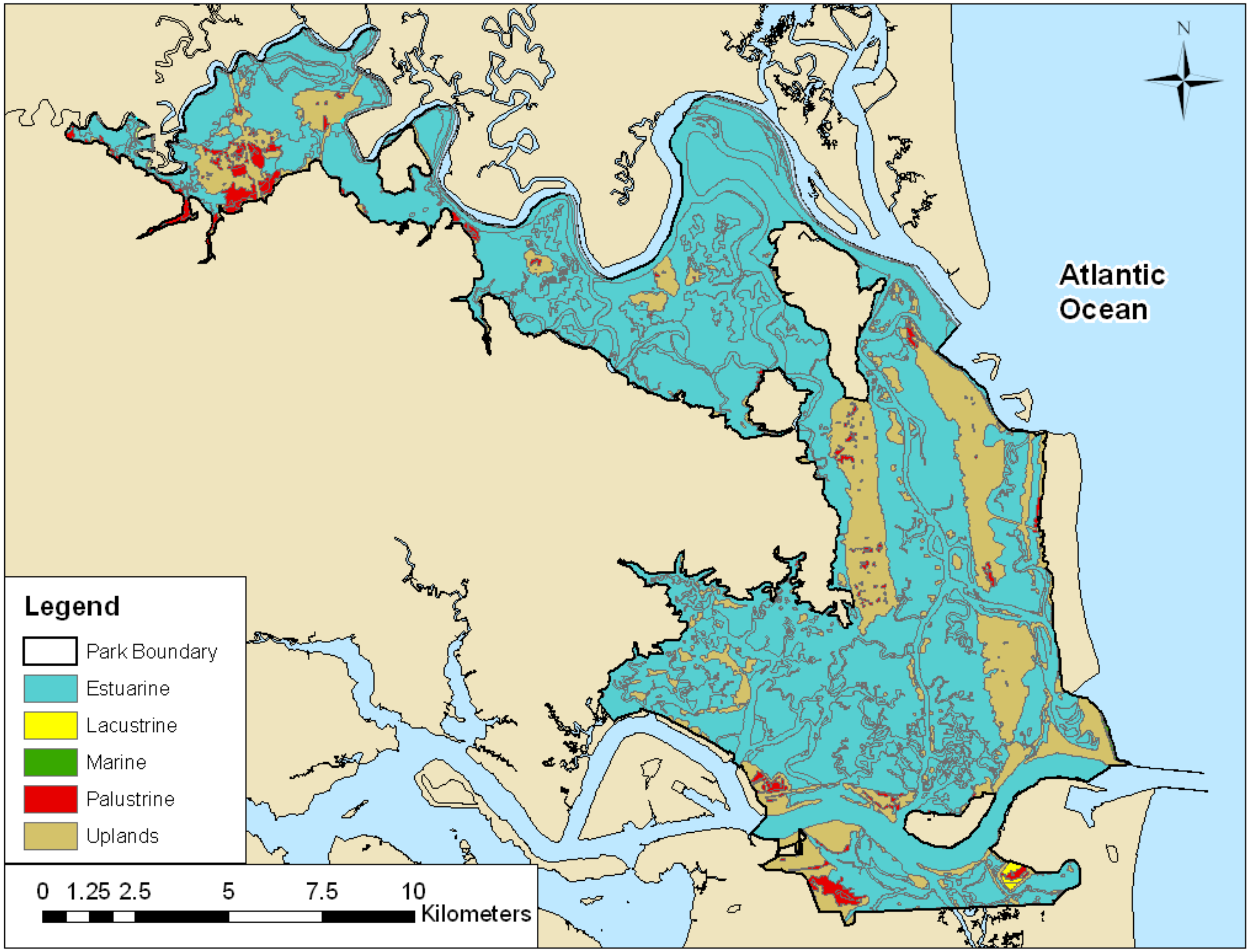


Figure 5. U.S. Fish and Wildlife Service National Wetland Inventory data for Timucuan Ecological and Historic Preserve.

(Data Sources: Wetlands – U.S. Fish and Wildlife Service (1:24,000); 1971-1992, Park Boundary – NPS (1:24,000), 1999; County – FDEP (1:24,000), 1997)

Theodore Roosevelt Area

The Theodore Roosevelt area was established on land donated by William Henry Browne III. Browne grew up on the land, fishing, roaming the nearby shell mounds, and exploring the ruins of Confederate gun batteries (NPS, Theodore Roosevelt Area – The Gift). He received the property on his sixteenth birthday as a gift from his father with instructions to nurture and care for the property, to keep hunters away, and to maintain the land in a natural state (NPS, Theodore Roosevelt Area – The Gift). Willie and his brother, Saxon, made their living on the land by farming, commercial fishing, running a saw mill, and selling oyster shells from the numerous mounds located on the property (NPS, Theodore Roosevelt Area – The Gift). Following Saxon's death in 1953, Willie remained on the land, living a reclusive, isolated existence. The cabin that Willie called home did not have electricity or running water (NPS, Theodore Roosevelt Area – The Gift). Each day, water was hand-pumped from a well and the single light bulb and radio were powered by a Model-T battery (NPS, Theodore Roosevelt Area – The Gift).

Browne donated the land to several organizations that would appreciate and value its natural beauty. In 1960, he donated 2.8 hectares (7 acres) of land along Mt. Pleasant Road to the Campfire Girls organization for construction of a campground and lodge (NPS, Theodore Roosevelt Area – The Gift). TIMU headquarters is currently located on this land. In 1969, Browne donated all of his remaining land to The Nature Conservancy, stipulating that any future owner must keep the land in its natural state (NPS, Theodore Roosevelt Area – The Gift). Twenty-one years later, this land was sold to the NPS and added to TIMU. The land was named after President Theodore Roosevelt at the request of Browne. He admired Roosevelt because he was the first president to make conservation a national policy and goal (NPS, Theodore Roosevelt Area – The Gift). Today, the foundations of Willie's cabin and the Browne's two-story home, which burned in the early 1900s, remain on the shell mound overlooking Round Marsh (NPS, Theodore Roosevelt Area – The Gift).

Kingsley Plantation

Zephaniah Kingsley moved to what is now considered Kingsley Plantation with his wife and three children in 1814 (NPS - Kingsley Plantation). His wife, Anna Madgigine Jai, was from Africa and purchased by Kingsley as a slave. The Kingsley Plantation crops included Sea Island cotton, citrus, sugarcane, and corn (NPS - Kingsley Plantation). Eventually, Kingsley's holdings in north Florida included more than 12,950 hectares (32,000 acres) and over 200 slaves. Slavery laws were changed in 1821 when the U.S. purchased Florida from the Spanish (NPS - Kingsley Plantation). Many slaveholders feared slave rebellions. To prevent uprisings from occurring, oppressive laws were enacted and the conditions for all African Americans deteriorated. Kingsley did not agree with these laws, believing that more humane treatment would ensure peace and the continuation of slavery (NPS - Kingsley Plantation). His opinions on the subject were published in the 1828 work, *A Treatise on The Patriarchal, or Co-operative System of Society As It Exists in Some Governments…Under the Name of Slavery* (NPS - Kingsley Plantation). Kingsley left Florida in 1837 and moved to Haiti with his wife and children (NPS - Kingsley Plantation). In 1839, Fort George Island was sold to his nephew Kingsley Beatty Gibbs (NPS - Kingsley Plantation).

Today, visitors to the Kingsley Plantation can view the Kingsleys' residence, kitchen house, barn/stable, and the ruins of 23 tabby slave houses (NPS - Kingsley Plantation).

Historic Broward House

The historic summer residence of Florida's 19th Governor, Napoleon Bonaparte Broward, was recently added to TIMU through the efforts of the NPS, the State of Florida, the COJ, and the national nonprofit organization Trust for Public Land (NPS, 2004a). This house is an example of the Folk Victorian Style of architecture popular between 1870 and 1910. Broward was born in rural Duval County in 1857 and known as an adventurer and politician. He served as Duval County sheriff for three terms and in 1904 was elected governor of Florida. As governor, he worked for better salaries for teachers, prison reform, child labor laws, and an eight-hour work day; however, he is best known for his desire to drain the Everglades (NPS, 2004a).

The house remained in the Broward family until 1996 when it was sold to attorney Karl Zillgitt, who spent seven years rehabilitating the structure. He was the first non-Broward family member to own the house since Broward purchased it in 1897. The NPS has begun a public process to determine how to best meet TIMU's goals and objectives while protecting the historic structure and allowing public access (NPS, 2004a).

Recreation activities occurring within TIMU include fishing, hiking, bicycling, picnicking, birding, kayaking, boating, sightseeing, and camping at Huguenot Memorial Park and Little Talbot Island State Park (NPS, 2005). An additional park site is the Ribault Club, which is owned and operated by the State Park Service. The club has been placed on the National Register of Historic Places by the USDOI and is listed as a Historic Landmark by the COJ (NPS, 2005).

Coastal Management Issues

Boating Activities

A recent study focused on the frequency and impacts of recreational boating traffic on the Fort George River and several of the creeks (Simpson, Myrtle, and Garden Creeks) near Kingsley Plantation (Kennedy and Thieke, 2004). Summer months and holidays were selected based on the high usage rates and greatest potential impacts. It was estimated that there are between 15,000 and 21,000 unique boating visits to the Fort George River near Kingsley Plantation from April to October. The numbers were much lower for the smaller creek systems with estimates of 4,000 to 6,000 for the Simpsons/Myrtle Creek system and 1,000 for Garden Creek over the same period (Kennedy and Thieke, 2004).

The study also investigated some of the environmental impacts of heavy recreational boat traffic. The erosional effects from boat wakes were determined to be negligible on the sandy shorelines. No conclusive evidence of erosion of muddy banks was observed (Kennedy and Thieke, 2004). Conflicts among boaters were observed during periods of heavy usage and varied watercraft (personal watercraft vs. kayakers) (Kennedy and Thieke, 2004). Speed controls were recommended near the Long Island Outfitters' dock, and at the Simpson Creek/Myrtle Creek/Nassau Sound confluence (Kennedy and Thieke, 2004).

<u>Fort George Inlet</u>

The Fort George Inlet is unstabilized with an inlet throat that is approximately 99 m (325 ft) wide at low tide and 259 m (850 ft) wide at high tide (Olsen Associates, Inc., 1999). The main channel of the inlet is approximately 4.6 to 6.0 m (15 to 20 ft) deep. The measured spring tidal range in the inlet is 21 million m^3 (747 million ft^3), which is approximately 22% of the prism for Nassau Sound (Olsen Associates, Inc., 1999). The 1998 National Ocean Service's tide tables report that the astronomical tides in the region are semi-diurnal, with a mean spring range of 1.71 m (5.6 ft) at the National Oceanic and Atmospheric Administration's (NOAA) Simpson Creek gage (cited in Olsen Associates, Inc., 1999). The north and south sides of the SJR were impacted by the stabilization of the SJR entrance by jetties, which began in the 1880s. To the north, the Fort George Inlet has been forced to migrate northward. South of the jetties, numerous beach nourishment projects have been completed to combat erosion (Foster et al., 2000).

The Fort George Inlet is a highly migratory inlet located between Little Talbot Island and Wards Bank (Foster et al., 2000). From 1853 through 1934, the inlet migrated southward. Since about 1934, when the north jetty of the SJR was made impermeable, the inlet has migrated northward irregularly. The north jetty restricts the littoral drift to the south, resulting in accretion on Wards Bank (Marino et al., 1990). The sediment also contributes to the growth of shoals in the bay and upstream of the bridge in the Fort George River (Marino et al., 1990). Due to the accumulated sediment, the inlet is forced to migrate northward (Kojima and Mehta, 1979). This pattern has threatened the bridge that spans the Fort George River and has significantly eroded the south end of Little Talbot Island. The Department of Transportation has stabilized parts of this shoreline to protect State Highway A1A and slow the erosion; a new bridge was completed in 2004. They have placed rip-rap at strategic locations to slow the erosion, although it has not been stopped completely (Marino et al., 1990). This revetment was constructed in the late 1970s and armored 914 m (3,000 ft) of shoreline (Olsen Associates, Inc., 1999). This action has saved the shoreline at one location, but there have been significant land and infrastructure losses within Little Talbot Island State Park (Olsen Associates, Inc., 1999). The history of the shoreline changes in the area is depicted in **Figure 6** and summarized in **Table 3**.

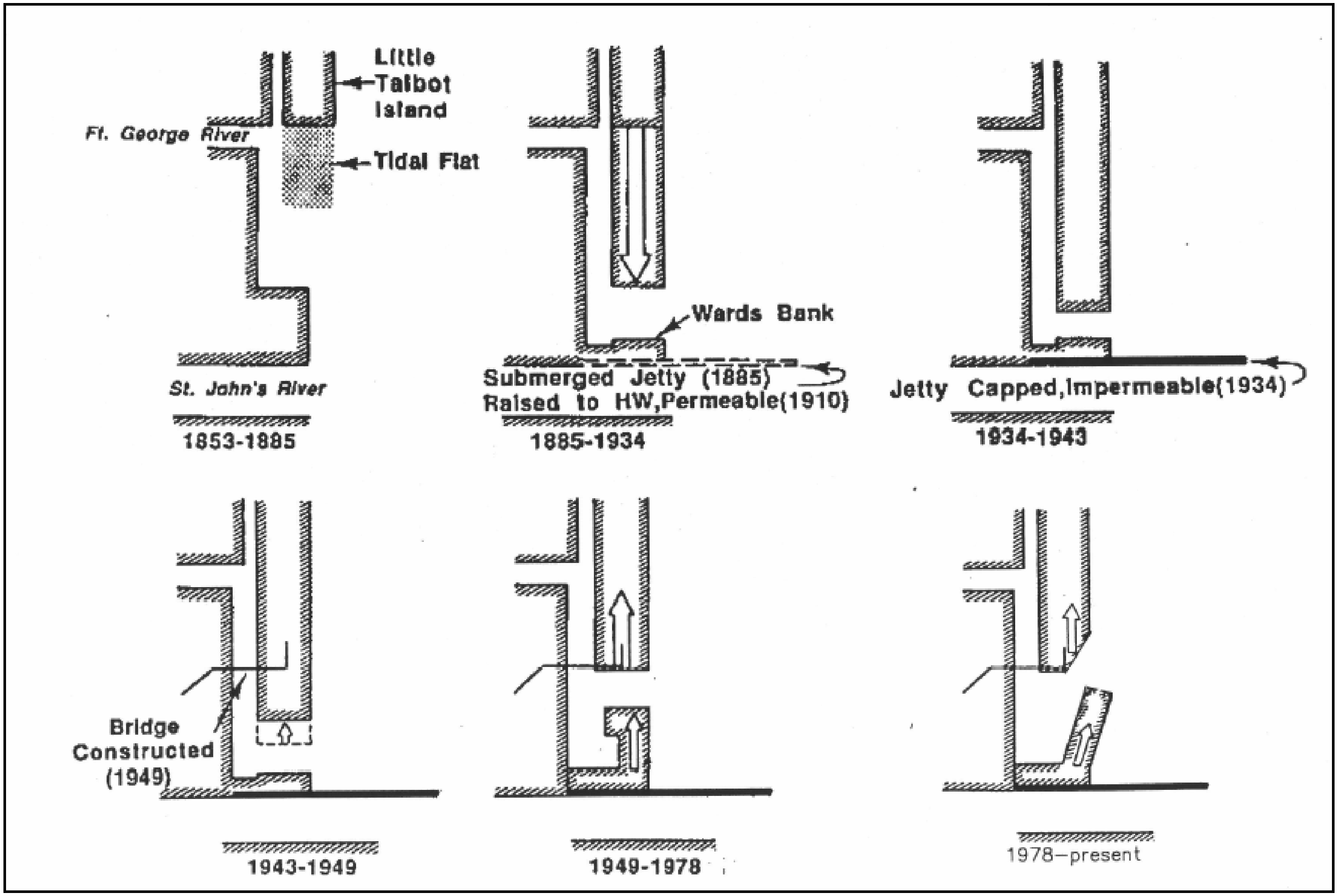


Figure 6. Schematic diagram of movement of Fort George Inlet in response to the construction and modification of the north jetty of the St. Johns River.

(Figure obtained from Olsen Associates, Inc., 1999)

Table 3. Shoreline changes along the northeast Florida coast in the vicinity of the Fort George Inlet.

Time Period	Description	Shoreline Changes
Pre-1881	Time period prior to construction of any coastal engineering works in study area.	Natural inlets at Fort George and St. Johns Rivers with common ebb tidal shoal.
1881-1934	St. Johns River jetties constructed beginning in 1881. Jetties are permeable.	Southerly migration of Fort George Inlet. Substantial accretion of southern end of Little Talbot Island (2.3 miles).
1934-1943	North St. Johns River jetty capped, impermeable in 1934.	The inlet and south shoreline of Little Talbot Island continued to advance south.
1943-1949	SR 105 (A1A) Ft. George Bridge over Ft. George River constructed in 1949.	The inlet and Ward's Bank shoreline began to advance northerly. Subsequently, the south shoreline of Little Talbot Island retreated.
1949-1978	Post SR 105 (A1A) Ft. George Bridge construction.	The inlet and Ward's Bank shoreline continued to advance north and the south shoreline of Little Talbot Island continued to retreat. The bridge channel experience serious scour.
1978-1999	Rubble revetment constructed along 3,600 ft of southern Little Talbot Island to protect S.R. A1A from undermining.	Revetment prohibits erosion of the protected inlet throat shoreline. The shoreline located east of the revetment continues to erode. Fort George Inlet migrates north and Wards Bank accretes northward and eastward.

Source: Olsen Associates, Inc., 1999; Gosselin et al., 2000.

The erosion of the south end of Little Talbot Island is expected to continue if remedial actions are not taken (Olsen Associates, Inc., 1999). This will result in the loss of upland acreage, shoreline, and infrastructure of Little Talbot Island State Park. The study conducted by Olsen Associates, Inc. (1999) investigated alternatives to reduce or eliminate the erosion impacting the state park. Two alternatives were evaluated in detail. The first was the installation of a singular terminal stabilizing structure, such as a groin/jetty, at the south end of Little Talbot Island (Olsen Associates, Inc., 1999). The second alternative involved relocating the inlet channel to its 1950s configuration through the closure of the existing inlet with fill material from the construction of the new channel (Olsen Associates, Inc., 1999). After applying four primary criteria, Olsen Associates, Inc. recommended the inlet relocation alternative to the Division of Parks and Recreation. This alternative was selected based on its consistency with the goals of the Florida Park Service, the NPS, and Duval County (Olsen Associates, Inc., 1999).

The stability of the Fort George inlet must be considered based on its migratory tendency as well as the likelihood of closure. Fort George Inlet is unstable because it has migrated in the past; however, the complex behavior conditioned by the north jetty of the

SJR makes future behavior difficult to predict (Marino et al., 1990). Stabilization efforts on the southern shoreline of Little Talbot Island conflict with the natural migration of the inlet northward (Marino et al., 1990). If these protective measures continue and Wards Bank continues to grow northward, the inlet will become more susceptible to closing (Marino et al., 1990). The shoals and sand bars that have developed in the mouth of the Fort George River are of concern as hydrologists feel that the inlet could close during a storm event. In addition, the amount of sand being deposited has restricted the flow into and out of the river mouth on every tidal cycle. Based on the existing conditions, Olsen Associates, Inc. (1999) considered the inlet to be hydraulically stable, and under existing conditions, "not prone to rapid and predictable closure" (p. 35). However, the authors do caution that the hydraulic conditions of the inlet are subject to change (Olsen Associates, Inc., 1999).

Gosselin et al. (2000) investigated the impacts of three proposed alternatives on the wave climate, tidal circulation, and potential sediment transport near the Fort George inlet. The area to be dredged and the placement of the dredged material for each alternative are displayed in **Table 4 and Figure 7**. Alternative 1 provides shoreline protection to Little Talbot Island, while reducing scour potential at the A1A bridge; however, compared to the other alternatives, the nourishment life will not last very long (Gosselin et al., 2000). Alternative 2 also provides shoreline protection and is not expected to last for a long period. In addition, it may increase scouring at the A1A bridge. It was determined that Alternative 3 caused the least impact to coastal processes (wave climate, tidal circulation, and potential sediment transport) (Gosselin et al., 2000). To render a final decision, additional information, such as cost and volume of available sediment are required (Gosselin et al., 2000).

Table 4. Dredging location and placement of dredged material for three sediment management alternatives considered in Fort George Inlet vicinity.

		Dredging Location	Dredged Sediment Placement
Alternative	1	Flood shoal located in Fort George River north of the A1A bridge	Southern tip of Little Talbot Island
	2	Ward's Bay across Ward's Bank and into the ocean	Southern tip of Little Talbot Island
	3	Shoal located south of the western tip of the St. Johns River Entrance north jetty	Beaches south of the St. Johns River entrance

Adapted from Gosselin et al., 2000.

Figure 7. Locations of proposed borrow sites for three sediment management alternatives in Fort George Inlet vicinity.

(Adapted from Gosselin et al., 2000)

Full or partial closure of this inlet could affect the water quality of TIMU's saltwater marshes. If this occurs, a larger portion (or all) of the water flow into the marshes would originate from Nassau Sound and the SJR (Olsen Associates, Inc., 1999). It is reasonable to assume that the water from these sources would be of lower quality than that currently entering from the Atlantic Ocean (Olsen Associates, Inc., 1999). There are additional concerns that inlet closure would increase the potential for pollutants to enter TIMU via the ICWW (Olsen Associates, Inc., 1999). In June 2005, a draft report entitled *Characterization of the Fort George River Bathymetric, Side Scan, and Sediment Surveys* was completed by Gayes et al. The information from these reports will aid in decision making and provide information required to assess changes in the inlet over time.

<u>Mile Point</u>

Mile Point is located at the intersection of the SJR and the ICWW, in the southern portion of TIMU (**Figure 8**). Sisters Creek, also known as the ICWW, enters the main channel of the SJR at a 45° angle from the north. To the south, the flow from Pablo Creek (ICWW) enters the SJR almost parallel, but with an opposite flow direction. This large confluence angle produces cross-currents at the intersection of the SJR and the

ICWW. This area is the site of the most navigational accidents on the SJR (Cornwell, 2000).

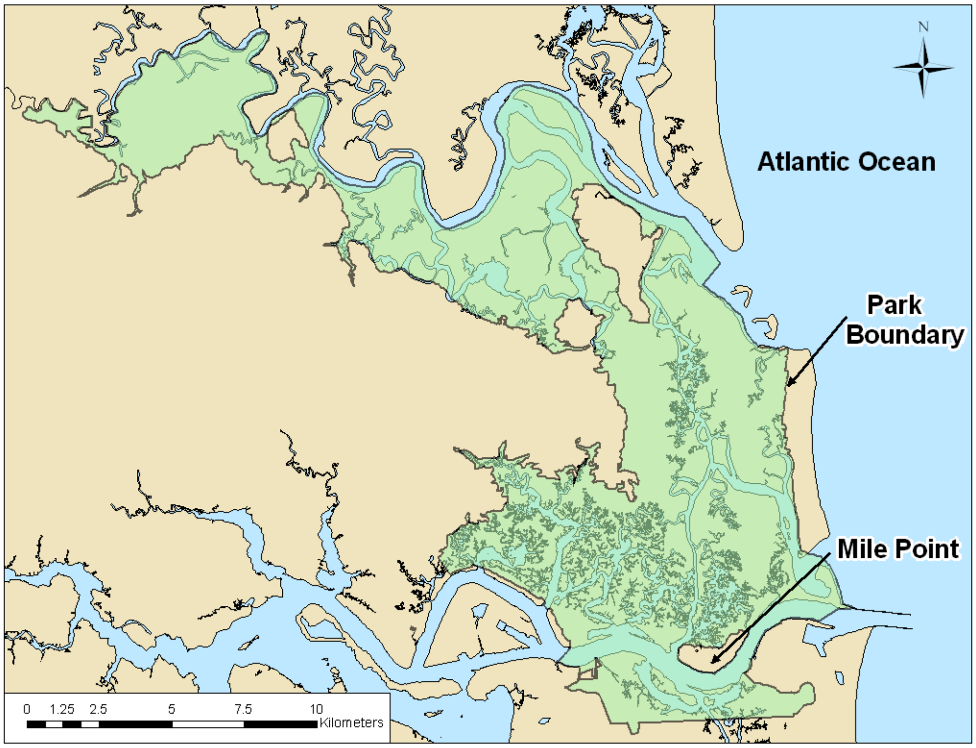


Figure 8. Location of Mile Point in relation to Timucuan Ecological and Historic Preserve.

(Data Sources: Park Boundary – NPS (1:24,000), 1999; County – FDEP (1:24,000), 1997)

A training wall, called "Little Jetties," was constructed prior to 1910 on the southern bank of the SJR at Mile Point (**Figure 9**). In 1931, the deteriorated training wall was rebuilt to the design height of 1.8 m (6 ft) above mean low water. Over the past 70 years, the training wall has deteriorated, causing many of the sections to become submerged, even at low water (Cornwell, 2000). In addition, homeowners on the north bank of the SJR at Mile Point have experienced severe erosion of their property. It has been speculated that the erosion was caused by past dredging conducted by the USACOE, installation of the Atlantic Marine dry dock on the north bank of the river, and/or the deterioration of the Little Jetties training wall. There has also been a breakthrough of Great Marsh Island on the southern bank of the SJR at this location, which allows water to flow directly into Chicopit Bay (Cornwell, 2000). The water depth in the bay is, at times, approximately 15 cm (6 inches), leaving the residents without boat access to the ICWW (Cornwell, 2000).

Figure 9. Points of interest near Mile Point.

(Adapted from Cornwell, 2000; Source: SJRWMD, 8-bit true color DOQQ, 1-m resolution, 2004)

A hydrodynamic analysis completed by Cornwell (2000) investigated the effects of several alternatives on the erosion of the north bank of the SJR at Mile Point. These alternatives included no action (existing conditions), repair of the training wall, removal of the wall, creation of a new opening at Sherman Point on the eastern end of Chicopit Bay (multiple sizes), construction of a groin field on the north bank of the SJR (with few or many groins), and construction of a submerged breakwater running parallel to the north bank (Cornwell, 2000). The report found that erosive velocities (~0.91 m/s or 3 ft/s) existed on the northern bank of the SJR at Mile Point (Cornwell, 2000). The groin field alternatives were the only measures that decreased the shoreline velocities significantly; however, installation of groin fields may not be economically feasible due to the 12.2-m (40-ft) water depth at some locations (Cornwell, 2000). This would require a wide base to support 13.7 m (45 ft) of rock, which would be 4.6 m (15 ft) wide at the top. The report also stated that waves from passing ships, the breakthrough at Great Marsh Island, and flow produced from hurricanes and floods may also contribute to the shoreline erosion (Cornwell, 2000).

The USACOE is currently investigating options to limit the navigational risks associated with the dangerous cross-currents at Mile Point. The existing conditions model is being updated before the various alternatives are modeled. One of the alternatives may affect flows in the eastern portion of Chicopit Bay; however, it is unknown whether this altnerative will meet the project objectives or be selected for implementation (B. Cornwell, USACOE, pers. comm.).

Sea-level Rise

Sea level rise could have significant impacts on coastal marshes because they are located in low-lying areas. It has been estimated that over half of the coastal wetlands in the continental U.S. would be lost as a result of the erosion and inundation accompanying sea level rise (Park et al., 1989). Substantial environmental and economic damages will be incurred, including reduced fish production, saltwater intrusion into freshwater resources, and increase frequency and duration of storm surge on the shoreline (Lee and Park, 1992).

A CVI was developed to determine the relative vulnerability of various coastal environments to changes due to sea-level rise based on coastal geomorphology, rate of sea-level rise, past shoreline evolution, and other factors (Thieler and Hammar-Klose, 1999). Sea-level rise is a critical issue because predicting shoreline retreat and land loss rates impacts the coastal zone management and development as well as quantifying biological impacts due to habitat loss or alteration. Thieler and Hammar-Klose's (1999) preliminary report provides an overview of the regions where physical changes are expected due to sea level rise. For the Atlantic Coast, 27% of the mapped coastline was classified as being at very high risk due to future sea-level rise, 22% as being at high risk, 23% as moderate risk, and 28 % as low risk (Thieler and Hammar-Klose, 1999). One of the regions of high vulnerability is the northern Florida coast. Sections of the Amelia Island shoreline are classified as being at very high, high, and moderate risk based on the calculated CVI. Little Talbot Island and the Atlantic coastline south of the SJR mouth are classified as being at moderate and high risk as a result of future sea-level rise. The highest vulnerability areas are generally high-energy barrier island coastlines with little regional coastal slope (Thieler and Hammar-Klose, 1999).

Fox and Montague (2003) examined salt marsh loss near Hecksher Drive due to sea level rise and anthropogenic influences. The sample areas included the smallest or terminal ends of creeks. Using Arcview Spatial Analyst and aerial photography, it was determined that approximately 12% (500 hectares) of the 4,700-hectare (11,600-acre) study site was converted to open water from 1943 to 1999 (Fox and Montague, 2003). However, the percentage of salt marsh loss was not consistent and varied greatly over the study area (Fox and Montague, 2003). The variation was attributed to extreme weather events, bank slope, and elevation, including subsidence. Salt marsh losses were the greatest in tidal creeks with direct connections to the SJR and the ICWW (Noon et al., 2002). The salt marsh loss in the vicinity of creeks (Hannah Mills and Cedar Point Creeks) blocked during the construction of Hecksher Drive was typically less than those directly connected (Noon et al., 2002). The causeways may protect the marshes from sea level rise by providing sediment from the large amounts deposited at the former creek mouths, thereby preventing excess loss of sediment (Fox and Montague, 2003). In addition, the dredging of the SJR may also impact erosion and sediment loss from Clapboard and Sisters Creeks, which are open to the SJR (Noon et al., 2002).

Stabilization of South Amelia Island

Amelia Island is bordered to the north by St. Mary's Inlet and to the south by Nassau Sound. In 2005, a 460-m (1500-ft) terminal groin and 90-m (300-ft) detached rock breakwater were completed on the South end of Amelia Island. In addition, there is a small rock groin located west of the Highway A1A bridge (Olsen Associates, Inc., 2005). Taylor Engineering (2003) investigated the impacts of these structures on the Nassau Sound inlet. The analysis determined that following adjustment, the structures "should not significantly change the overall hydraulic stability characteristics of the inlet" (p. 49). The groin, if not filled to capacity with sand immediately following construction, could alter the sedimentation and erosion patterns within Nassau Sound (Taylor Engineering, 2003). The ebb shoals are also expected to experience increases in sediment transport, about 100-200% in some areas, which will shift the continuously-changing ebb shoals (Taylor Engineering, 2003). Monitoring in Nassau Sound is ongoing to detect adverse impacts to the environment, particularly the Bird Island Shoal complex, which provides valuable seabird habitat (Olsen Associates, Inc., 2005). Observations of the system will allow natural and man-induced changes to be detected and discussed.

Hydrologic Information

St. Johns River

The SJR, including its tributaries, drains approximately 23,745 km^2 (9,168 mi^2) over its 483-km (300-mile) flow from St. Lucie County to the Atlantic Ocean (Foose, 1981). The LSJRB covers an area of approximately 6,853 km^2 (2,646 mi^2), including the river (Foose, 1981). The river elevation changes an average of about 0.03 m (0.1 ft) per

1.6 km (1 mile) (Campbell et al., 1993). The river width expands from 1.6 km (1 mile) near Palatka to 4.8 km (3 miles) at Jacksonville with an average depth of less than 3 m (9.84 ft) (FDEP, 2004b). The average annual tidal amplitude is 1.38 m (4.51 ft) at the ocean inlet and varies upstream due to channel morphology and other factors (Morris, 1995). Tidal influence extends more than 161 km (100 miles) upstream and salinity is affected by the tide approximately 48 km (30 miles) from the mouth (FDEP, 1998a). The tides along the east coast of Florida are classified as mixed with two highs and lows per day of noticeably different heights (NPS, 1996b). At the river mouth, the maximum flood and ebb currents occur about one hour before the high and low tides (Bourgerie, 1999). At a point approximately 24 to 27 km (15 to 17 miles) from the ocean, the flood and ebb periods occur almost simultaneously with the high and low tides (Bourgerie, 1999). The mean residence time of water is 40 days in October and 95 days in May (Phlips et al., 2000).

The LSJR exhibits characteristics of riverine, lacustrine, and estuarine aquatic environments. The system can be divided into three ecological zones based on salinity: a tidally influenced, freshwater lacustrine zone that extends from the city of Palatka north to the city of Orange Park; a predominately oligohaline lacustrine zone extending from Orange Park northward to the Fuller Warren Bridge (I-95) in Jacksonville; and a meso-polyhaline riverine zone from the Fuller Warren Bridge downstream to the mouth (Hendrickson and Konwinski, 1998). The river is classified as freshwater riverine from south of Palatka to Lake George. The salinity is at a minimum from Palatka north to Green Cove Springs (FDEP, 2004b). The salinity increases south of Palatka due to groundwater inflows containing sodium chlorides and calcium (FDEP, 2004b).

The SJR between Jacksonville and the ocean has been classified as slightly stratified with some vertical mixing and stratification (NPS, 1996b). In water column profiles measured by the COJ, located upstream of TIMU, the stratification exceeded 0.2 parts per thousand (ppt) half of the time (NPS, 1996b). The salinity in this area increases from 3 to 26 parts per thousand (ppt) from downtown Jacksonville to the ocean (NPS, 1996b).

The average discharge of the SJR at the mouth is estimated to be 235 cms (8,300 cfs) (NPS, 1996b). The maximum daily flood flow is approximately 1,730 cms (61,100 cfs) and the maximum ebb flow is about 1,445 cms (51,040 cfs) (NPS, 1996b). Runoff in the SJRB is approximately 38 to 51 cm (15 to 20 inches) or 28% to 38% of the annual rainfall (NPS, 1996b).

Nassau River

The Nassau River has been called one of the "last relatively pristine estuarine systems on the east coast of the U.S." (Coffin et al., 1992). The river originates in Nassau County and flows 88.5 km (55 miles) to discharge into Nassau Sound. The river drains an area of approximately 1,110 km^2 (430 $miles^2$) (NPS, 1996b). The river has not been affected by channelization, bank or inlet stabilization structures. The zone of fresh and salt water mixing is located at the western edge of TIMU. The mean daily net discharge of the river has been estimated as approximately 21 cms (730 cfs), which is slightly greater than 5% of the mean maximum tidal discharge (Coffin et al., 1992). The Nassau River is not maintained as a navigable river by the USACOE, but the St. Johns River and Sisters Creek to the south are maintained by dredging. The average runoff in the Nassau River Basin has been estimated as 25.4 to 38 cm (10 to 15 inches) or 19% to 28% of the annual rainfall (NPS, 1996b).

The Nassau River has been described as "well-mixed vertically with a broad mixing zone" rather than a well-defined salt wedge (Coffin et al., 1992, p. 17). This broad mixing zone is located between Interstate I-95 and a point located about 3.2 km (2 miles) downstream from U.S. 17 (NPS, 1996b). The system becomes stratified during periods of fairly high freshwater inflow, when the freshwater flows on top of the denser saltwater (NPS, 1996b). Measurements have shown that the mean salinity increases from 7 ppt at Interstate 95 to approximately 27.5 ppt near Nassauville (NPS, 1996b). Overall, the mixing zone and estuarine sections are homogenous with respect to specific conductance, salinity, temperature, and DO for most of the year (NPS, 1996b).

Sisters Creek (ICWW)

Sisters Creek (ICWW) connects the Nassau and Lower St. Johns Rivers. The channel is maintained by dredging at the discretion of the USACOE. There are a number of tidal creeks in the area with interconnecting channels (NPS, 1996b) (**Figures 10 and 11**). The strong tidal influence makes it difficult to determine the current directions and net flow, but a slight, net flow from north to south is generally accepted to exist (NPS, 1996b). The flow from the northern part of Sisters Creek empties into Nassau Sound and the Fort George Inlet. The majority of the flow from the southern portion of the creek drains to the SJR.

Nassau Sound

Nassau Sound is located between Amelia Island and Little Talbot Island. Similar to the Fort George Inlet, the Sound is influenced by jetty installations at the entrances to the St. Mary's and St. Johns Rivers (Browder and Hobensack, 2003). Depths in Nassau Sound range from over 11 m (36 ft) to 0 m (0 ft). Raichle (1993) estimated that the tidal prism is approximately 77 million m^3 (2,718 million ft^3) over an average tidal range of 1.6 m (5.2 ft). The shape and position of the Sound have changed over the last century in response to the interruption of littoral supply caused by the jetties. The jetties have not only decreased the sediment supply, but have also "backed up" the tidal entrances as they attempt to migrate north (Browder and Hobensack, 2003). Actions have been taken along the southern end of Amelia Island to protect a state park and privately held lands from the erosional pressure. Most recently, a groin and detached rock breakwater were constructed (2005). Since the mid-1980s, approximately 4.3 million m^3 (5.6 million yd^3) of sand has been placed along a 6-km (3.8-mile) stretch of the southern portion of the island to counteract the effects of erosion (Browder and Hobensack, 2003). The amount of erosion is estimated at over 200,000 m^3 (267,000 yd^3) annually.

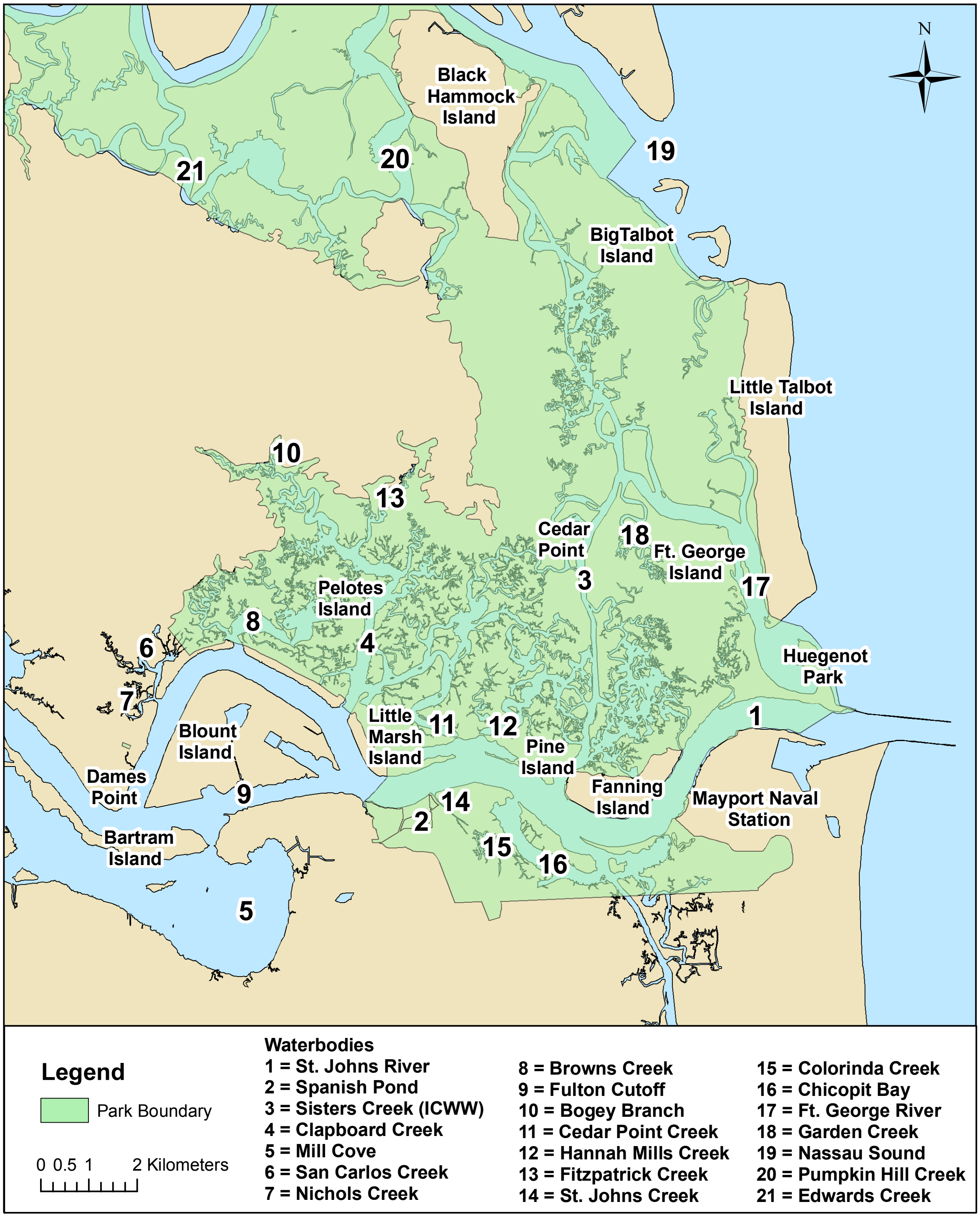


Figure 10. Landforms and hydrologic features of the southern portion of Timucuan Ecological and Historic Preserve.

(Data Sources: Park Boundary – NPS (1:24,000), 1999; County – FDEP (1:24,000), 1997)

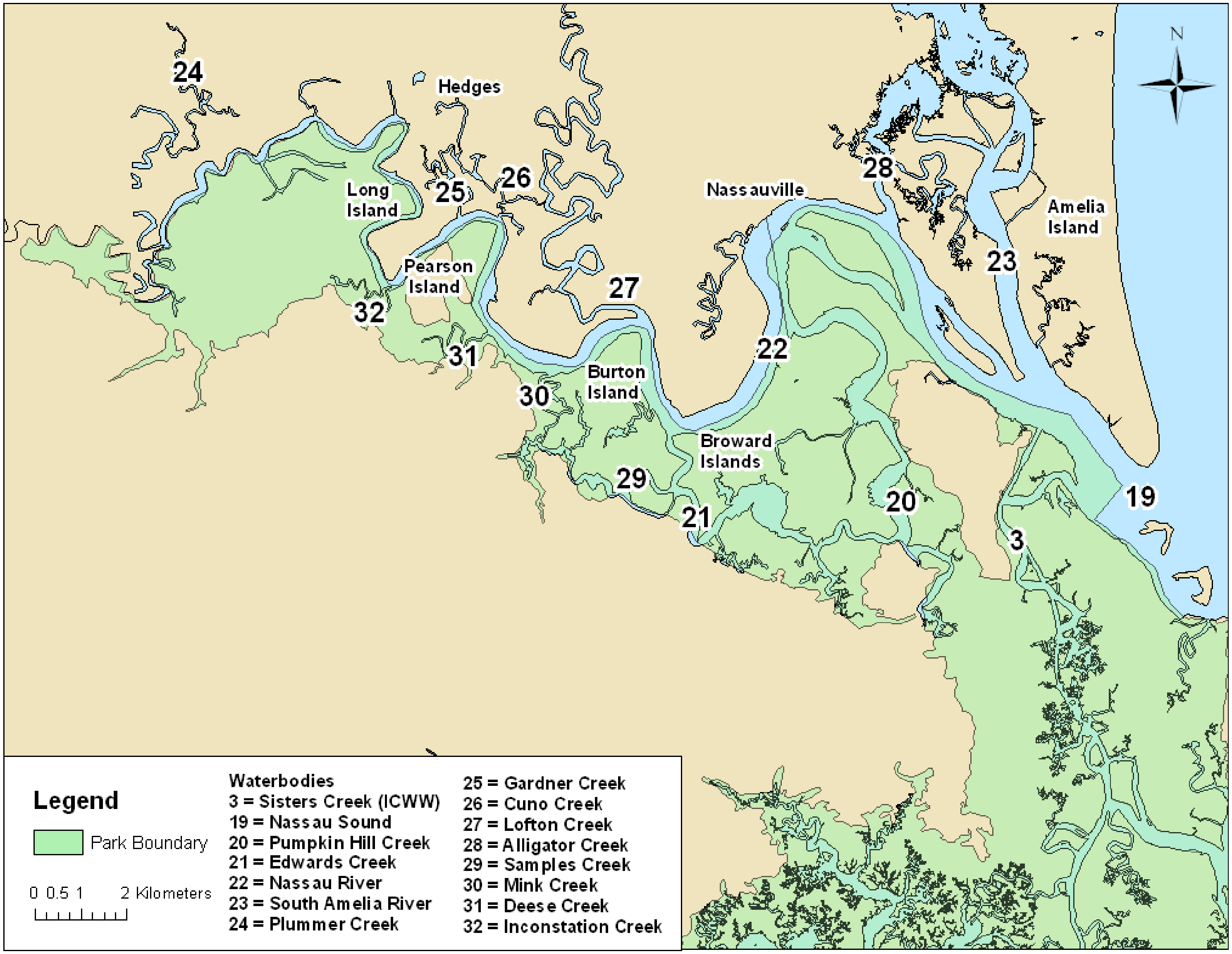


Figure 11. Landforms and hydrologic features of the northern section of Timucuan Ecological and Historic Preserve.

(Data Sources: Park Boundary – NPS (1:24,000), 1999; County – FDEP (1:24,000), 1997)

Freshwater Ponds

Spanish Pond is the largest freshwater pond (semi-permanent water regime) under NPS ownership within TIMU. The pond is included on the National Register of Historic Places, thus making it one of the contributing elements of TIMU (NPS, 1994). Water levels in the pond are controlled by an overflow device installed in 1998 to prevent the flooding of Fort Caroline Road. The effects of regulating water level on the sediment and water quality have not been studied. Residential development near the pond has influenced both the water quantity and quality (NPS, 1996b). The greater impervious area supplies more water to the pond during rainfall events. Oils and metals from the roads as well as nutrients from landscaped lawns may also contribute pollutants to the pond (NPS, 1996b). There are also four small ponds located on Fort George Island, all of which appear to be man-made or altered during recent development.

Water and sediment quality samples were collected and analyzed by the COJ in 1993 to evaluate the impacts of urban stormwater runoff on Spanish Pond (NPS, 1996b). Water quality parameters, with the exception of DO, were classified as good (cited in NPS, 1996b). The low DO levels indicated that the pond does not provide suitable habitat for fish populations (NPS, 1996b). Sediment analysis found elevated levels of zinc and lead, common constituents of stormwater road runoff. Morton and Marchman concluded that the sediments were moderately contaminated and adverse biological impacts cannot be ruled out, although there is low occurrence of instantaneous water column contamination during good weather (cited in NPS, 1996b). In 1995, septic system failure occurred at multiple homes in the area, possibly affecting the pond's water quality (NPS, 1996b). In 2004, the COJ analyzed water samples from three stations to determine the nutrient input from the residential areas surrounding Spanish Pond. Station SP2 is located where a stream flowing into the pond crosses the boardwalk, SP2 is located where the stream from a ditch crosses the fenceline, and SP3 is at the Spanish Pond outfall. The results of this sampling are displayed in **Table 5**. Sampling of these stations should be continued to identify long-term trends and determine the impacts of the residential development on the water quality of Spanish Pond.

Table 5. Nutrient levels in Spanish Pond based on 2004 sampling.

Site	Date	Ammonia (mg/L)	Nitrite + Nitrate (mg/L)	Orthophosphorus (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Phosphorus (mg/L)	Carbonaceous Biochemical Oxygen Demand (mg/L)	Total Suspended Solids (mg/L)	Color (PCU)	Chloride (mg/L)	Turbidity (NTU)	Fecal Coliforms
SP2	1/15/2004	0.337	0.01	0.028	0.77	0.04	3.6	28	100	120	13	20
SP2	3/10/2004	0.01^{U}	0.01^{U}	0.027	0.495	0.055^{I}	$<2^{U}$	$<1^{U}$	80	91	3.8	20
SP2A	1/15/2004	0.082	0.189	0.024	0.536	0.063	2	2	120	108	2.4	160
SP2A	3/10/2004	0.014	0.072	0.014	0.559	0.063^{I}	$<2^{U}$	1	80	92	1.5	20
SP2A	4/6/2004	0.03	0.019^{I}	0.027	0.982	0.112	4.9	15	80	99	7.1	760
SP2A	4/20/2004	0.021	0.05	0.044	0.439	0.077^{I}	$<2^{U}$	1	80	96	1.3	5000
SP 3	1/15/2004	0.014^{I}	0.01	0.01	0.433	0.062	2	1	120	83	1.1	20
SP 3	3/10/2004	0.01	0.01^{U}	0.01^{U}	0.661	0.05^{U}	$<2^{U}$	2	100	66	1.3	20
SP3	4/6/2004	0.01^{U}	0.01^{U}	0.01^{U}	1.16	0.09^{I}	4.1	11	120	72	7	20
SP3	4/20/2004	0.014	0.01^{U}	0.016^{I}	0.989	0.163	3.4	5	120	78	2.3	70

PCU = Platinum color units
NTU = Nephlometric turbidity units
U = Compound was analyzed for, but not detected.
I = Value reported is between Method Detection Limit and Practical Quantiation Limit.
Source: COJ, 2005.

Groundwater

The Floridan aquifer system, the intermediate aquifer system, and the surficial aquifer system comprise the groundwater flow system of the LSJRB (Toth, 1993). The Floridan aquifer, the deepest system, is made up of limestone and dolomite formations from the Paleocene and Eocene epochs. The formations found in this aquifer include the Ocala, Avon Park, Oldsmar, and the upper part of the Cedar Keys limestone (**Table 6**). There is a middle confining unit that separates the aquifer into the Upper Floridan aquifer and the Lower Floridan aquifer (Miller, 1986). For the area near TIMU, the Lower Floridan can be further divided into two water bearing zones separated by a less permeable unit (Martin, 2004). The upper zone is sometimes referred to as the middle aquifer and is about 152 m (500 ft) thick (Martin, 2004). The lower water bearing unit, referred to as the Fernandina permeable zone, can be salty, making it less desirable for consumption. In Duval and Nassau Counties, the upper and middle aquifers of the Floridan are usually of low salinity, but areas exist where breaks in the confining layers coincide with lower hydraulic pressure, drawing salty water from below into the Floridan (NPS, 1996b). In the LSJRB, the maximum thickness of the Floridian aquifer system is approximately 213 m (700 ft) (FDEP, 2002b).

The intermediate aquifer system does not cover an extensive area geographically, occurring in portions of Duval, St. Johns, Clay, Putnam, and Flagler Counties (Toth, 1993). It is located from less than 3 m to about 91 m (10 ft to 300 ft) below land surface. The intermediate system consists of the Hawthorn Group and undifferentiated post-Hawthorn Group sediments (Toth, 1993). The Hawthorn Group consists of early to middle Miocene clay, limestone, and layers of interbedded sand and shell, serving as a confining unit that separates the surficial aquifer and the Floridan aquifer system. The thickness of this layer varies from less than 0.3 m to about 4.6 m (1 to 15 ft) (Bermes et al., 1963). It has also been reported that there are only two aquifer systems underlying TIMU: the Floridan and surficial systems (NPS, 1996b). The interbedded lenses of low permeability material in the surficial aquifer system can form semiconfining beds and the aquifer can be described as having upper and lower zones, with the lower zone also called the “intermediate” aquifer (NPS, 1996b).

The surficial aquifer system consists of late and post-Miocene surficial deposits that have extremely variable lithology (clay, sand, coquina, limestone) (Toth, 1993). These surficial deposits range from less than 15.2 m to greater than 45.7 m (50 to 150 ft). Typically, water in the surficial aquifer system is unconfined (Toth, 1993). The water table is generally at or near the land surface for most of the year in swampy lowland and flatland areas (FDEP, 2004b).

Table 6. Approximate correlation of hydrologic units and geologic formations with associated hydrologic properties.

Hydrologic Unit	Approximate Geologic Equivalent	Lithology	Hydrologic Properties
Surficial Aquifer System	Undifferentiated surficial deposits	Sand, shells, limestone, coquina	Local water supply, water table conditions, some confined limestone
Intermediate Confining Unit	Hawthorn Formation	Interbedded sand clay and limestone	Clay beds are principal confining unit
Floridan Aquifer System			
Upper	Ocala Limestone	Massive marine limestone	Principal source of groundwater, some high salinity
Middle	Avon Park Formation	Alternating beds of massive limestone and dense dolomite	Principal source of groundwater, some high salinity
Lower	Oldsmar Formation	Alternating beds of massive limestone and dense dolomite	High permeability, high salinity in some areas
Sub-Floridan Confining Unit	Cedar Keys Formation	Dense limestone, evaporate deposits	Low permeability, highly saline

Source: Martin, 2004.
Semi-confining layers exist between Upper, Middle, and Lower Floridan aquifers.

The Floridan aquifer is the primary artesian aquifer in north Florida and is frequently used for water supply. It is tapped for public supply, domestic self-supply, irrigation, heating and cooling pump units, commercial and industrial self-supply, and self-supplied power generation (Toth, 1993). The intermediate and surficial aquifer systems are important water sources in Duval, Clay, St. Johns, Flagler, and Putnam Counties. The surficial system is utilized if the Floridan aquifer system contains nonpotable water or is deeper than 61 m (200 ft). In some industrial and urban areas of northeast Florida, cones of depression have developed because the discharge has exceeded the recharge (NPS, 1996b). The effects of these withdrawals can be seen based on the changes in the potentiometric surface of the aquifer over time.

It is estimated that before development, the potentiometric surface of the Floridan aquifer in Duval and Nassau Counties was 18 to 21 m (60 to 70 feet) above sea level (Durden and Motz, 1991). In 1985, the potentiometric surfaces showed several depressions caused by large withdrawals. The areas nearest to TIMU are at Fernandina Beach and near a large spring in northern St. Johns County (Durden and Motz, 1991). The depression in Fernandina Beach was caused by a very large withdrawal for a pulp mill. This depression extends as much as 21.3 m (70 ft) below sea level in Nassau County (Durden and Motz, 1991). It is believed that the depression associated with the spring has moved further north; being impacted by industrial and public-supply wells in the area (Spechler, 1994). It has been estimated that between 1940 and 1962, water levels dropped 3 to 7.6 m (10 to 25 ft) in northeast Florida (NPS, 1996b).

The 2000 SJRWMD District Water Supply Plan designated a portion of the LSJRB in southeastern Duval County and all of St. Johns County as a Priority Water Use Caution Area due to the potential for future water resource problems (FDEP, 2004b). Estimates of future groundwater withdrawals in the area are unsustainable and could damage wetlands and degrade water quality. In addition, overpumping in the basin may adversely affect local groundwater supplies (FDEP, 2002b). These areas are designated based on five constraints: impacts to native vegetation (primarily wetlands), impacts to minimum flows and levels (primarily spring flows), impacts to groundwater quality in terms of increased saltwater intrusion, impacts to existing legal users, and failure to identify a source of supply for future development (FDEP, 2004b). In addition to overpumping, saltwater intrusion is a major concern affecting the quality of coastal groundwater. Saltwater intrusion, specifically the wells on Fort George Island, will be discussed in more detail in the Groundwater Quality Section.

Biological Resources

Numerous reviews have been completed of the flora and fauna of TIMU and the surrounding areas that are within its administrative boundaries; this includes Big and Little Talbot Island State Parks, Fort George Island Cultural State Park, and the surrounding estuarine areas. The *Final General Management Plan / Development Concept Plans / Environmental Impact Statement* (NPS, 1996a), *Water Resources Management Plan* (NPS, 1996b), *Fort George Island Cultural State Park Unit Management Plan* (FDEP, 2003), and *Big Talbot Island State Park and Little Talbot Island State Park Unit Management Plan* (FDEP, 1998b) are comprehensive surveys that were utilized to describe the area's natural communities and associated species, including those species classified federally or within Florida as non-native, endangered, threatened, commercially exploited, or under review. Brody (1994) summarizes the aquatic and biological communities that exist within the LSJRB. TIMU's estuarine habitat and associated species were identified according to the *Assessment of Fisheries Habitat: Northeast Florida* (Durako et al., 1988) and *Nekton Species Inventory for the Timucuan Ecological and Historical Preserve and Surrounding Area* (Dennis et al., 2001). The significant community habitats that occur in TIMU were prioritized consistent with the system established by the Florida National Areas Inventory (FNAI).

Additionally, several studies have been completed of submerged aquatic vegetation (SAV) related to the LSJR; however, there are little to no SAV present within TIMU. The loss of SAV beds in the meso-polyhaline section of the river is due to dredging and increased turbidity (FDEP, 2002b). The reports include *Distribution of Submerged Aquatic Vegetation in the Lower St. Johns River* (Dobberfuhl and Trahan, 2003), *Environmental Factors Affecting the Distribution and Health of Submersed Aquatic Plants in the Lower St. Johns River: Phase V Final Report* (Boustany et al., 2003), and *Lower St. Johns River Basin Submerged Aquatic Vegetation (SAV) Monitoring* (Sagan, 2001). Other studies of the SAV of the LSJR that may be consulted for further information were completed by Burns et al. (1997) and Sagan (2002).

Natural Vegetative Communities

The FNAI classifies natural communities according to their vulnerability to extinction. Important natural communities in TIMU, their global and state ranks, and an explanation of each rank are shown in **Table 7**. Although many publications list dry prairie among the natural communities in TIMU, this is not the case; dry prairie has been more strictly defined of late as a community confined to the area between central and extreme south Florida (approximately Osceola to Charlotte and Glade Counties) (A. Johnson, FNAI, pers. comm.). Selected communities are defined in the following sections in further detail with respect to TIMU.

Table 7. Natural communities within Timucuan Ecological and Historic Preserve.

Community	Global Rank	State Rank
Coastal Strand	G3	S2
Maritime Hammock	G3	S2
Scrub	G2	S2
Shell Mound	G2	S2
Estuarine Tidal Marsh	G5	S4
Estuarine Unconsolidated Substrate	G5	S5
Marine Tidal Marsh	G5	S4

Key:
G2= Rare or vulnerable to extinction due to some biological or man-made factor.
G3= Either found locally in a restricted range; very rare throughout its range; or vulnerable to extinction due to other factors.
G5= Demonstrably secure globally.
S2= Rare in Florida (6-20 occurrences or less than 3,000 individuals) or biological or man-made factors make the community vulnerable to extinction.
S4= Apparently secure in Florida (may be rare in parts of range).
S5= Demonstrably secure in Florida.

Sources: FNAI, 2004; FNAI, 2005; E. Abbey, FNAI, pers. comm.

Upland Communities

Coastal Strand

Coastal strand is a rapidly disappearing community in Florida. Where this community used to exist as a continuous band along the Atlantic coast, it now occurs as broken and isolated stretches. This community serves to protect inland communities from severe storms (FDEP, 1998b).

Vegetation common to the wind-deposited coastal dunes of this community are salt-tolerant, such as the saw palmetto *(Serenoa repens)*. Other common plants are myrtle oak *(Quercus myrtifolia),* cabbage palm (*Sabal palmetto*), sea grape *(Molgula manhattensis),* sea oats (*Uniola paniculata),* yaupon *(Ilex vomitoria*), lantana *(Lantana depressa*), buckthorn (*Rhamnus caroliniana*), and pineweed *(Lechea mucronata)* (FDEP, 1998b). Animals typically found in this community are the gopher tortoise *(Gopherus polyphemus),* six-lined racerunner (*Cnemidophorus sexlineatus*), and southern hognose snake *(Heterodon simus)* (FDEP, 1998b).

Maritime Hammock

Maritime hammock generally lies inland of the coastal strand community and occurs as a narrow band of hardwood forest. Natural fires are inhibited by the "generally mesic conditions and insular locations of well-developed maritime hammock communities" (FDEP, 1998b, p. A4-2). Soils tend to be well-drained.

The maritime hammock communities of Little and Big Talbot Islands were characterized by Johnson and Muller (1993). The maritime hammock community of Little Talbot Island is located on the inner dune ridge, Long Island. The canopy layer consists of Virginia live oak *(Quercus virginiana),* redbay *(Persea borbonia)*, cabbage palm, magnolia *(Magnolia grandiflora)*, and southern red cedar *(Juniperus silicicola)*.

The understory consists mainly of yaupon and wax myrtle *(Myrica cerifera)*. The canopy of Big Talbot Island differs in that it consists of mixed oaks, including Virginia live oak, laurel oak *(Quercus hemisphaerica)*, sand live oak *(Quercus geminata),* magnolia, and/or cabbage palm with an understory that may include myrtle oak, saw palmetto, yaupon, wild olive *(Osmanthus americana)*, and/or redbay.

Scrub

Scrub is a temperate or sub-tropical xeric community that is defined as old dune with deep sand substrate. Fires occur rarely (FNAI, 2005). The oak scrub of Big Talbot Island is dominated by sand live oak or myrtle oak. Wild olive, redbay, saw palmetto, and rosemary are also encountered in this community (Johnson and Muller, 1993).

Shell Mound

Shell mound is a xeric-mesic, subtropical to temperate coastal upland community that consists of shell substrate through which water drains very quickly (FNAI, 2005; FDEP, 1998b). It is also known as midden or Indian mound. Fire is rare or never occurs (FNAI, 2005). This community is unique in that it results from Native American activities rather than natural physical factors. It is an elevated mound of mollusk shells and aboriginal garbage on which a hardwood, closed-canopy forest develops (FDEP, 1998b). These communities are often disturbed by archaeological excavations or people searching for artifacts. Shell mound may be covered by maritime hammock or support species that are located outside of the climactic region in which they are typically encountered (FDEP, 1998b).

The Rollins Bird and Plant Sanctuary on Fort George Island is an example of shell mound. Plants typically found in the sanctuary are the tiny-leafed buckthorn, Godfrey's privet *(Forestiera godfreyi)*, red cedar, cabbage palm, terrestrial peperomia (*Peperomia humilis)*, and wild coffee *(Psychotria nervosa)* (FDEP, 2003). The Grand Site on Big Talbot Island, listed on the National Register of Historic Places, is another example of Shell Mound; species encountered include little buckthorn *(Sageretia minutiflora),* red salvia *(Salvia coccinea)*, and soapberry *(Sapindus saponaria)* (FDEP, 1998b).

Wetland Communities

Estuarine/Marine Tidal Marsh (also Coastal Wetland, Coastal Marsh, or Saltmarsh)

Estuarine/marine tidal marsh is the most prevalent community in TIMU. Tidal marshes tend to be located in abundance north of the freeze line in Florida. The community is generally comprised of expanses of grasses, rushes, and sedges along coastlines of low wave-energy and river mouths (FDEP, 1998b). Tidal marshes are extremely productive; many commercially important species dwell in these areas at some point in their life cycles. These systems are also capable of storm buffering and filtering pollutants. The community is identified by the presence of black needlerush *(Juncus roemerianus)* and smooth cordgrass *(Spartina alterniflora)* (FDEP, 1998b).

Four marsh community associations were identified in a study by the COJ in 1984: *Spartina* marsh, *Spartina/Juncus* marsh, short *Juncus* marsh (*Salicornia virginica*) being dominant in density, but limited in scope), and a transition zone that consisted of sea daisy (*Borrichia frutescens*) and sea blight (*Suaeda linearis*) (NPS, 1996a). **Table 8** summarizes the species that were found in the study to exist in TIMU. In general, smooth cordgrass tends to dominate salt marshes because of its ability to tolerate sea-strength salinity (Durako et al., 1988). Smooth cordgrass is typically located adjacent to creek bank zones. Black needlerush dominates the high marsh and salt-tolerant terrestrial plants lie at the upper edge/transition zone (Durako et al., 1988).

Table 8. Plant species of the estuarine tidal marsh community in Timucuan Ecological and Historic Preserve.

Dominant Species	Associated Species	Transitional Species
Black needlerush *(Juncus roemerianus)*	Big cordgrass *(Spartina cynosuroides)*	Broomsedge *(Andropogon elliottii)*
Marsh hay cordgrass *(Spartina patens)*	Glasswort *(Salicornia virginica)*	Cabbage palm *(Sabal palmetto)*
Saltgrass *(Distichlis spicata)*	Narrow-leaved cattail *(Typha angustifolia)*	Groundsel tree *(Bacaris halimifolia)*
Saltwort *(Batis maritima)*	Sea blight *(Suaeda linearis)*	Marsh elder *(Iva frutescens)*
Sea daisy *(Borrichia frutescens)*	Sea purslane *(Sesuvium portulacastrum)*	Marsh lavender *(Limoniom carolinianum)*
Smooth cordgrass *(Spartina alterniflora)*		Wort *(Batis maritima)*
		Sawgrass *(Cladium jamaicense)*
		Staggerbush *(Lyonia ferruginea)*
		Wax myrtle *(Myrica cerifera)*

Source: NPS, 1996b.

Steinway-Rodkin and Montague (2004) investigated the major biotic resources of TIMU as a cooperative effort between the NPS and the University of Florida. Data specific to TIMU will be included in a GIS database made available to the SJRWMD. Eighty-one sites were randomly-selected in TIMU to complete the study of marsh habitats as they vary with salinity and elevation; 20 low salinity, 20 high elevation, and 21 mono-typic (limited to *Spartina alterniflora* and *Juncus roemerianus)* stands were evaluated. Soil salinity, elevation, vegetation, and conspicuous animals were recorded at or near each site. The vegetation found to be associated with the low salinity and high elevation habitats follows in **Table 9**. The mono-typic stands, as predicted by SJRWMD Wetland Vegetation Maps, were found to be dominated by *Spartina alterniflora* and *Juncus roemerianus*, although there was limited variation in species composition. According to Steinway-Rodkin and Montague (2004), bands of *Spartina alterniflora* near creek banks were especially important because they housed Carolina marsh wren (*Cistothorus palustris*) nests. Whereas vegetation was found to be diverse in low salinity areas, food resources for large birds such as the great blue heron (*Ardea herodias*), green heron (*Butorides virescens*), and black-crowned night heron (*Nycticorax nycticorax*) were found to be diverse in brackish water communities. Additionally, the study found species richness to strongly decrease with increasing soil salinity (Steinway-Rodkin and Montague, 2004). Steinway-Rodkin and Montague (2004) also report that "increased tidal inundation time and decreased freshwater inflow may be the greatest determinants of vegetation changes in the Timucuan" (p. iv).

Table 9. Vegetation associated with low- and high- salinity habitats in Timucuan Ecological and Historic Preserve.

Low Salinity Habitats	
Most frequent vegetation (occurring in 50% or more of the sites)	Other common species (occurring in 20-49% of the sites)
Red maple (*Acer rubrum)*	Alligator weed (*Alternanthera philoxeroides)*
Saltbush (*Baccharis halimifolia)*	Southern water-hemp (*Amaranthus australis)*
Sawgrass (*Cladium jamaicense)*	*Ampelopsis* spp.
Saltmarsh fringe-rush (*Fimbristylis* spp. , most commonly *castanea)*	Climbing aster (*Aster carolinianus)*
	Swamp hibiscus (*Hibiscus grandiflorus)*
Marsh pennywort (*Hydrocotyle* spp., most commonly *verticillata*)	Saltmarsh morning globry (*Ipomoea sagittata)*
	False-lily (*Lilaeopsis* spp.)
Wax myrtle (*Myrica cerifera)*	Saltmarsh loosestrife (*Lythrum lineare)*
Osmunda spp.	Climbing hempvine (*Mikania scandens)*
Persea spp.	Smartweed (*Polygonum* spp.)
Mock bishop's weed (*Ptilimnium capillaceum)*	Southern dewberry (*Rubus trivialis)*
Water pimpernels (*Samolus* spp.)	Lance-leaf arrowhead *(Sagittaria* spp., most commonly *lancifolia*)
Sand cord grass (*Spartina bakeri)*	
Poison ivy (*Toxicodendron radicans)*	Seaside goldenrod (*Solidago sempervirens)*
	Sphagnum spp.
	Cypress (*Taxodium* spp.)
	Cattail (*Typha* spp.*)*
	Cowpea (*Vigna luteola)*
High Elevation Habitats	
Common vegetation by cover (20% or more cover in at least one site)	Associated vegetation (present in more than two sites)
Saltbush (*Baccharis halimifolia)*	Saltmarsh aster (*Aster tenuifolius)*
Sawgrass (*Cladium jamaicense)*	Saltmarsh morning glory (*Ipomoea sagittata)*
Spikerush (*Eleocharis* spp.)	Saltmarsh loosestrife (*Lythrum lineare)*
Saltmarsh fringe-rush (*Fimbristylis castanea)*	Seaside goldenrod (*Solidago sempervirens)*
Soft rush (*Juncus effusus)*	Big cord grass (*Spartina cynosuroides)*
Sea-lavender (*Limonium carolinianum)*	
Saltmarsh bulrush (*Scirpus robustus)*	
Sea-purslane (*Sesuvium* spp.*)*	
Sand cord grass (*Spartina bakeri)*	

Source: Steinway-Rodkin and Montague, 2004.

Typical animal species in the estuarine tidal marsh include the diamondback terrapin (*Malaclemys terrapin Tequesta)*, wading birds, waterfowl, osprey *(Pandion haliaetus)*, marsh wren, seaside sparrow *(Ammodramus maritimus),* muskrat *(Neofiber alleni)*, and raccoon *(Procyon lotor)*. Fishes found in this community include blacktip shark *(Carcharhinus limbatus),* Southern stingray *(Dasyatis Americana)*, ladyfish *(Elops saunas),* bonefish *(Albula vulpes)*, and menhaden *(Brevoortia* spp.) (FDEP, 1998b). The nekton species that are associated with TIMU are addressed further in the Aquatic Species Section. Invertebrate species encountered by Steinway-Rodkin and Montague (2004) are listed in **Table 10**.

Table 10. Invertebrate species encountered in the Timucuan Ecological and Historic Preserve, 1999-2001.

Scientific Name	Common Name
Order Aranae	Orb Weaver Spiders
Alpheus spp.	Snapping Shrimp
Callinectes sapidus	Blue Crab
Eurytium limosum	Mud Crab
Menippe mercenaria	Stone Crab
Sesarma cinereum	Squareback Marsh Crab
Uca minax	Red-Jointed Fiddler Crab
Uca pugilator	Sand Fiddler Crab
Uca pugnax	Saltmarsh Mud Fiddler Crab
Uca thayeri	Caribbean Mud Fiddler Crab
Aedes taeniorhynchus	Black Saltmarsh Mosquito
Crematogaster spp.	Ants
Culicoides furens	Black No-see-ums
Family Cicadellidae	Leafhopper
Family Geometridae	Moth
Family Gryllidae	Cricket
Family Mantidae	Praying Mantis
Leptoconops bequaerti	Sand Fly (No-see-um)
Orchelimum fidicinium	Saltmarsh Grasshopper
Order Odonata	Dragon Fly
Prokelesia marginata	Saltmarsh Planthopper
Tabanus nigrovittatus	Saltmarsh Horse Fly
Class Scyphozoa	Jellyfish
Crassostrea virginica	Eastern Oyster
Geukensia demissa	Ribbed Mussel
Polymesoda caroliniana	Carolina Marsh Clam
Littorina irrorata	Saltmarsh Periwinkle
Melampus bidentatus	Common Saltmarsh Snail
Subclass Pulmonata	Pulmonate Snail

Source: Steinway-Rodkin and Montague, 2004.

Long (2004) reviewed benthic invertebrate data, collected intermittently from 1977 to 2003 at a single site in Sisters Creek, to determine if trends that may be indicative of changes in water quality were present (p. 2). Changes in the invertebrate community occurred as the conductivity increased throughout the 1980s before leveling out in the early 1990s (Long, 2004). In addition to salinity, other possible factors, such as organic pollution, were suggested as reasons for changes in the benthic invertebrate community. Species that are pollution sensitive (Tellinidae) as well as those found most often in moderately polluted waters (*Caulleriella* spp. and *Tharyx* spp.) were identified in 2003 (Long, 2004). Significant differences ($P < 0.5$) in the number of taxa, density, and conductivity were noted between 1983 and 2003. Although annelids were the predominant fauna for both sampling years, a species shift occurred and the significant presence of Tellinidae as part of the benthic community was observed. In 1983, *Mediomastus californiensis* and *Streblospio benedicti* were the predominant annelid species. In 2003, *Mediomastus californiensis* was not collected, *Streblospio benedicti* was at half of its original abundance, and the predominant species were *Tharyx*, *Caulleriella*, and Tellinidae. The presence of both pollution tolerant and pollution sensitive species supports the need for additional research. Due to the lack of comprehensive water quality data, the typical environmental conditions of these benthic invertebrates can not be assessed to determine the water resource conditions.

Estuarine Unconsolidated Substrate (also Beach and Mud Flat)

Marine and estuarine unconsolidated substrates are the most widespread communities in the world and are mineral based natural communities generally characterized as expansive, relatively open areas of subtidal, intertidal and supratidal zones which lack dense populations of sessile plant and animal species (FDEP, 1998b). These zones are often located among seagrass beds and salt marshes or mangroves. In northeast Florida, unvegetated subtidal bottom underlies most open estuarine water that is too deep for seagrasses to exist or that is within the seagrass zone, but does not have seagrass cover (Peterson, 1981). Although no rooted vegetation exists there, microscopic, benthic algae and green algae exist and contribute greatly to the total productivity of an estuary (Durako et al., 1988).

Tourism, increasing populations of people living near beaches, increased vehicular traffic on beaches that are susceptible to compaction, dredging activities, and low DO levels are current threats to this community. Additionally, unconsolidated substrate may accumulate heavy metals, oils, and pesticides originating from industrial activities in the surrounding area, possibly threatening aquatic life (FDEP, 1998b).

Oyster Reefs

TIMU houses the largest oyster reef communities in the Jacksonville area; the largest beds are located in the salt marsh area (NPS, 1996a). Oyster reefs, or mounds, are estuarine communities that serve as habitat for many organisms. Oyster and clam shells contribute hard substrate for attachment by macrofaunal consumers. Oyster reef communities may help to counteract erosion by enhancing sedimentation. Stresses of concern that negatively affect the oyster reef community include sedimentation, increased salinity, eutrophication, toxicants, over-harvesting, and loss of wetlands (Durako et al., 1988).

The American Oyster *(Crassostrea virginica)* and the quahog *(Mercenaria* spp.) dwell in TIMU. Shellfish harvesting areas are classified by the Shellfish Environmental Assessment Section (SEAS) as approved, conditionally approved, restricted, conditionally restricted, prohibited, or unclassified (not permitted pending bacteriological and sanitary surveys) (SEAS, 2004-2005). Please consult **Appendix A** for explanations of these designations. All areas in Duval and Nassau Counties have been classified as prohibited. The basis for these classifications will be discussed in the Bacterial Contamination Section.

Flora and Fauna

Primary Production

DeMort and Bowman (1985) investigated the lower 42 km (26 miles) of the SJR estuary over a two-year period in order to correlate seasonal changes in phytoplankton populations and chlorophyll concentrations with physical and chemical factors. The study found the ten most abundant species of phytoplankton to be, in descending order, *Skeletonema costatum, Chaetoceros decipiens, Rhizosolenia alata, Nitzschia seriata, Melosira italica, Chaetoceros debile, Coscinodiscus lineatus, Thalassionema nitzschiodes, Thalassiothrix fraunfeldii*, and *Gyrosigma* spp. The most abundant diatom species was found to be *Skeletonema costatum*, as in most east coast estuaries. However, unlike east coast estuaries, phosphorous, rather than nitrogen, seemed to be the limiting nutrient (DeMort and Bowman, 1985). The high concentration of nitrogen may be attributed to prolonged retention time in the LSJR or municipal and industrial inputs (NPS, 1996a).

Submerged Aquatic Vegetation

The SAV studies that have been completed do not focus on TIMU or surrounding areas, but on the entire LSJRB. Seagrasses generally occur only as far north as Ponce de Leon Inlet in Florida, which is south of TIMU (Durako et al., 1988). The three species of major importance in Florida are turtle grass *(Thalassia testudinum),* manatee grass *(Syringodium filiforme),* and shoal grass *(Halodule wrightii)*. Turtle grass does not occur along the northeast coast of Florida, manatee grass occurs only as far north as the Indian River west of Cape Canaveral, and shoal grass occurs along the east coast in various outlets (Myers and Ewel, 1990).

Although little or no SAV is present in TIMU, SAV is an important biological component of the LSJR. Increased nutrient loading and changes in salinity, light, and color caused by anthropogenic activities have induced changes that threaten the health of the area's SAV. Increased nutrient loading adversely affects SAV in that it causes increased algal populations, which serve as competitors, and light reduction, which inhibits SAV growth (Boustany et al., 2003). SAV is critically important to the overall health of an estuary; it provides food and habitat for fish, manatees, and invertebrates (Dobberfuhl and Trahan, 2003). SAV performs a number of other valuable functions; it adds oxygen to the water column, reduces sediment suspension and shoreline erosion, and consumes nutrients that may otherwise lead to algal blooms or epiphytic growth (Sagan, 2003).

The distribution of SAV in the LSJR was monitored in 2001 using aerial photography and transect interpolation (groundtruthing transects) (Dobberfuhl and Trahan, 2001). Aerial photography was analyzed from Lake George to the mouth of the SJR; photo data were unable to be groundtruthed north of the Ortega River, which includes TIMU. The photo interpretive method seemed to underestimate the SAV that was actually present, possibly due to high turbidity that obscures the SAV signature in photos. The photo interpretation method predicted 233 hectares (575 acres) of SAV, whereas transect interpolation predicted 1,272 hectares (3,143 acres) of SAV (Dobberfuhl and Trahan, 2001). Map sheets 38-41 from Dobberfuhl and Trahan (2001) are included as **Appendix B** to show the spatial extent of SAV in the LSJR in the vicinity of TIMU. Transect data and GIS coverages (2003) are available from the SJRWMD; however, none of these stations are located downstream of the Fuller Warren Bridge because SAV is generally absent from this region.

Boustany et al. (2003) monitored water quality and algal growth in the LSJR to study the effects of salinity pulsing and nutrient loading on the distribution and abundance of tape grass (*Vallisneria americana* Michx), the dominant SAV species in the river, and its associated algal community. The salinity tolerance of tape grass was reported to range from 8-20 ppt, although this tolerance may vary among populations. Salinity pulsing seemed to affect seagrass growth and distribution more than nutrients.

Sagan (2001) surveyed changes in SAV coverage and water quality over a three-year period in the area from Jacksonville to Palatka, Florida. Tape grass was found to account for 50% of the SAV coverage within a meadow. In the oligohaline reach of the LSJR, all SAV species, with the exception of widgeon grass (*Ruppia maritima*), were found to decline between 1998 and 2000. Widgeon grass, which is able to tolerate extreme salinity but unable to tolerate low light conditions, increased significantly during this period. The decline in the remainder of the species was attributed to high salinity levels resulting from drought conditions in the Basin (Sagan, 2001). Sagan (2001) also adds that water quality conditions, such as high color and organic and inorganic suspensions in the water column, could have intensified the impact of high salinity levels by decreasing light availability to SAV. Light attenuation is considered a major limiting factor for SAV in the LSJR because it is a blackwater system (Sagan, 2002). The resurgence of SAV in Crescent Lake was attributed to reduction in light attenuation due to color reduction (Sagan, 2001). Light attenuation determines the depth at which SAV will grow in the LSJRB (Sagan, 2002). The data collected from these studies provides a baseline to judge which differences in SAV distribution and growth result from changes in water quality and/or natural disturbances and which are due to anthropogenic activities (Sagan, 2002).

Commercial and Recreational Fisheries

Commercial fisheries for a number of fish and shellfish species exist in Duval and Nassau Counties. The FWCC compiles county landing tables that include pounds harvested and fishing trips divided by county landed. The landing tables include finfish, invertebrates, and food and bait shrimp. According to these records (1994-2004), the predominant finfish species in Duval County, by weight, were black mullet (*Mugil cephalus*), kingfish (whiting) (*Menticirrhus americanus*), and shark. In Nassau County, kingfish (whiting) accounted for the greatest percentage, by weight, of the total catch. Overall, the finfish catch is much greater in Duval County than Nassau County (**Figures 12 and 13**).

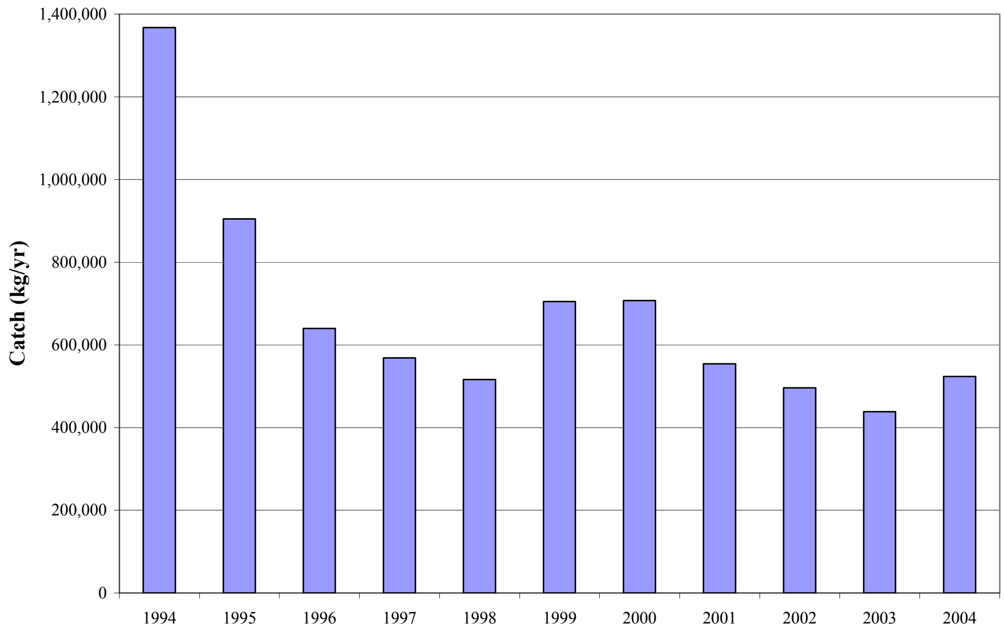


Figure 12. Commercial finfish catch (kg/yr) in Duval County, 1994-2004.

These values have not been converted to whole weight and are subject to change. 2004 data are preliminary and are updated as information is received (Source: FWCC, 2005c).

Figure 13. Commercial finfish catch (kg/yr) in Nassau County, 1994-2004.

These values have not been converted to whole weight and are subject to change. 2004 data are preliminary and are updated as information is received (Source: FWCC, 2005c).

Recreational fisheries information is provided by the Marine Recreational Fisheries Statistics Survey (MRFSS), which was developed by the National Marine Fisheries Service to monitor recreational fisheries. Florida is divided into two regions, the east and west, because the fish in the Atlantic Ocean and the Gulf of Mexico are manged as separate stocks (FWCC, 2005d). Catch and harvest data are collected through interviews with anglers in the field and information regarding the frequency of fishing trips and the number of participants is gained through telephone interviews. In 2004, over 45,000 anglers were interviewed by field samplers and fish were weighed, measured, and identified to species (FWCC, 2005d). Based on annual data provided by the MRFSS from 1995 to 2004, the most common recreational fish in Duval and Nassau Counties are Atlantic croaker (*Micropogonias undulatus*), Atlantic spadefish (*Chaetodipterus faber)*, mullet, menhaden, black drum (*Pogonias cromis)*, black sea bass (*Centropristis striata)*, king mackerel (*Scomberomorus cavalla*), red drum (*Sciaenops ocellatus*), sheepshead *(Archosargus probatocephalus)*, southern flounder (*Paralichthys lethostigma*), southern kingfish (whiting), spotted seatrout (*Cynoscion nebulosus)*, and weakfish (*Cynoscion regalis*).

Species Inventory

Thorough lists of the plant and wildlife species that are known to occur within and surrounding TIMU were completed by the COJ (1998), the FDEP (1998b, 2003), the FNAI (2004), Newman et al. (1988), and the NPS (1996a, 1996b). As Big Talbot, Long Islands, the estuarine areas that surround the Big and Little Talbot Island State Parks, and Fort George Island Cultural State Park are included within the administrative boundary of TIMU, the species found in these areas were accepted as occurring within TIMU (FDEP, 1998b; 2003). In addition, Bezanilla (2002) updated the list of plants that are found within TIMU. Dennis et al. (2001) completed a species inventory of the aquatic life associated with TIMU.

Four wading bird rookeries located within TIMU are used by the following species: anhinga, black-crowned night heron, cattle egret, great blue heron, great egret, little blue heron, snowy egret, tri-colored heron, white ibis, and wood stork. The Theodore Roosevelt Nature Area, Big Talbot Island, Fort George Island, and Cedar Point house the rookeries; rookeries tend to exist in quiet, isolated areas that are free from external disturbances (NPS, 1996a).

The Inventory and Monitoring Program of the Southeast Coast Network is in the process of completing baseline inventories of natural resources for national parks within its designated area. The area, which includes TIMU, extends north along the Atlantic coast from Cape Canaveral to the North Carolina-Virginia border and as far west as Atlanta, Georgia and the Alabama Coastal Plain. The biological inventories to be completed for the parks include amphibians, bats, birds, fish, mammals, reptiles, small mammals, and vascular plants. At the time of this report’s publication, the biological inventories for TIMU were either “in progress” or “completed and awaiting certification” (NPS, 2004b).

Aquatic Species

TIMU provides habitat for numerous aquatic species. Dennis et al. (2001) completed a species inventory of the nekton that were present in and surrounding TIMU. Additionally, the *Assessment of Fisheries Habitat: Northeast Florida* (Durako et al., 1988) reviews aquatic life that is known to inhabit TIMU.

In the USGS study (Dennis et al., 2001), 10 sites were sampled in each of four creeks during four periods of the year (July 1996, December 1996, February 1997, and May 1997). Two sampled creeks (Clapboard Creek and Cedar Point Creek) were located within or near TIMU (Dennis et al., 2001). The oligohaline portions of TIMU's tidal creeks provide critical habitat for freshwater fish populations as well as nursery habitat for juvenile estuarine species (Weaver et al., 1997). Various techniques were used for nekton collection: 3.0-m, 3.2-m, and 5.0-m otter trawls and benthic sled trawls; gill nets varying in size; minnow traps (eel trap and PVC pipe trap); hook and line; electroshock via electroshocker boat or backpack shocker; seine; and other (box trap, dip net, fish trap, hand, hoop net, light trap, and plankton net) (**Table 11**). Dennis et al. (2001) compared the findings of the survey to those of McLane (1955) and Tagatz (1968) who surveyed stations throughout the SJR; to Dahlberg (1972) who surveyed Georgia estuaries; and to Tremain and Adams (1995) who surveyed the northern Indian River Lagoon. The species that were identified in the study are summarized in **Appendix C**.

Table 11. Species collection by gear type for Dennis et al., 2001.

	Total	Trawl	Minnow trap	Gill net	Electroshock	Hook and Line	Seine	Other
No. of stations		833	53	57	25	39	13	34
No. of taxa	136	113	11	32	35	22	43	26
No. of unique taxa		37	1	4	1	3	5	5
No. of individuals	35,224	31,472	95	184	317	87	1,461	1,608

Source: Dennis et al., 2001.

Dennis et al. (2001) investigated the impacts of freshwater flow and anthropogenic activity (based on the level of human development) on tidal fish assemblages in four creeks north of the SJR: Clapboard Creek, Broward River, Cedar Point Creek, and Dunn Creek. Faunal composition and abundance were utilized to evaluate the impacts of development on these assemblages (Dennis et al., 2001). A gradient of anthropogenic impacts was established from west to east with the greatest disturbance in the Broward River drainage, followed by the Dunn River, Clapboard Creek, and Cedar Point Creek. The Cedar Point Creek drainage basin lies entirely within the TIMU boundaries. Fish assemblages varied along the freshwater and urbanization gradients; however, the gradients coincided, making identification of the dominant factor problematical. The creeks were used by the greatest number of species during the wet season, when the salinity was lowest. Broward River and Dunn Creek were similar because they were used by freshwater species, while the presence of polyhaline taxa was recorded in Clapboard and Cedar Point Creeks (Dennis et al., 2001). These marine species were able to diffuse these regions because of the high salinities and proximity to the Atlantic Ocean (Weaver et al., 1997).

The study did not find measurable impacts of urbanization on fish assemblages (Dennis et al., 2001). The most urbanized creeks, Broward River and Dunn Creek, provided nursery habitat for numerous species. These results were attributed to the increased circulation in the creeks due to daily tidal flushing and retention of critical shallow-water habitat near the shoreline (Dennis et al., 2001). Felley (1987) reported that hogchocker (*Trinectes maculatus*), bay whiff (*Citharichthys spilopterus*), naked goby (*Gobiosoma bosc*), southern flounder, and gulf pipefish (*Syngnathus scovelli*) were rare or absent from altered tidal creeks in southwestern Louisiana. All of these taxa were found in the Broward River and Dunn Creek (Dennis et al., 2001). Pelagic species, such as bay anchovy (*Anchoa mitchilli*), have been found to dominate estuarine systems that have been altered (Bechtel and Copeland, 1970; Lindall et al., 1973). Pelagic species, which are found in the oxygenated surface layer, are more tolerant of low oxygen conditions than demersal fish species (Weaver et al., 1997). Bay anchovy were unusually abundant at the mouth of Cedar Point Creek in July (Dennis et al., 2001). The mouth of Cedar Point Creek was altered by impoundment and installation of a culvert during the construction of Hecksher Drive. Although poor circulation may exist at the mouth, lateral connections to Clapboard and Sisters Creeks upstream may limit the impacts of this modification (Dennis et al., 2001). To maintain the valuable nursery function of these creeks, the freshwater inflow to the Broward River and Dunn Creek must be preserved (Dennis et al., 2001). Weaver et al. (1997) found that freshwater/oligohaline creeks seemed "to provide more suitable nursery habitat than higher salinity creeks of similar width and depth" (p. 15). One must also consider the impacts to uplands outside TIMU's boundaries as they influence the quality and quantity of water contributing to the saltmarshes.

Dennis et al. (2001) provided several monitoring recommendations to detect environmental changes and gain additional information on the hydrological and biological resources of TIMU. Routine quarterly or annual trawl sampling was suggested to identify changes in species diversity or abundance, possibly due to urbanization in the tidal creek drainage basins. Certain habitats, such as the marsh fringe and sandy shorelines, are poorly sampled and additional sampling is needed to adequately characterize these areas. Dennis et al. (2001) also mention the need for hydrologic data and identification of freshwater sources. Deployment of continuous monitoring devices was recommended to monitor salinity conditions and to measure the contributions from freshwater sources.

Durako et al. (1988) reviewed the fish and invertebrates that occur in northeast Florida. Several families of finfish are mentioned as important to commercial and recreational fisheries, the Sciaenidae among them. Estuaries serve as nursery grounds for young and juvenile finfish; adults dwell in estuaries or shallow coastal waters. Other fish that are viewed as important as forage or prey for other fish are anchovies (*Anchoa* spp.) and menhaden. American shad *(Alosa sapidissima),* mullet (*Mugil cephalus* and *M. curema),* flounder *(Paralichthys* spp.), sea catfish *(Arius felis)*, and porgies (Sparidae) are important commercially or recreationally.

The Fisheries Independent Monitoring (FIM) Program conducts monthly sampling in northeast Florida to describe and compare population trends for a number of estuarine species. A stratified-random sampling approach is utilized to reduce statistical error and manage habitat variations, which complicate data collection (FWCC, 2005b). Population data are collected from 21-meter river seines, 6.1-meter otter trawls, and 183-meter haul seines. In addition to population data, FIM records habitat features, temperature, pH, salinity, and DO (FWCC, 2005b). The fish samples are also inspected for any external abnormalities or signs of poor health. Tissue samples are taken from selected fish for analysis of mercury content (FWCC, 2005b). The most abundant fish species collected from 2001-2003 in TIMU's geographic zones were bay anchovy, striped anchovy (*Anchoa hepsetus*), silver perch (*Bairdiella chrysoura*), menhaden, spot (*Leiostomus xanthurus*), Atlantic croaker, striped mullet, Atlantic silverside (*Menidia menidia*), and *Menidia* spp.

Commercially exploited aquatic organisms that rely on estuaries during some stage of their development include penaeid shrimp (white, brown, and pink), blue crabs, and American oysters. Estuaries serve as nursery ground for white, brown, and pink shrimp (Durako et al., 1988); the SJR is considered vital nursery ground for these populations (NPS, 1996a). American oysters are commonly found in salt marsh creeks and other estuarine habitats (NPS, 1996a).

The tidal creeks and marshes in TIMU provide ideal habitat for the Carolina diamondback terrapin. To begin studying the extent of this species in northeastern Florida, Butler (2000) identified basking and/or nesting groups, determined the most effective method of capture, collected baseline population data (such as distribution, sex ratios, and size classes), evaluated terrapin habitats (based on water depths, air and water temperatures, and salinity), and provided management and conservation recommendations. Butler (2000) recommended continued monitoring and expansion of the study area, further research on the impacts of shrimp trawling on terrapin populations, protection of nesting beaches, limitation of anthropogenic activities (dredging, channelization, and development) in heavily used areas, and supplementary studies on the relationship between terrapins and their primary predator, the raccoon.

Species of Concern - Protected and exotic species

Exotic Species

Various surveys of the notable and exotic species found within TIMU have been completed in Pelotes Island (Newman et al., 1988), Kingsley Plantation (NPS, 1996a), Big and Little Talbot Islands (FDEP, 1998b), and Fort George Island (2003). Bezanilla (2001) completed surveys of the exotic and invasive plants in the areas of Fort George Island, Kingsley Plantation, Theodore Roosevelt Area and Spanish Pond, Fort Caroline, Thomas Creek, and Cedar Point, while Meyer (1999) examined the non-native plant species in and around Spanish Pond.

Bezanilla (2001) recommended annual surveys for specific exotic species in various areas of TIMU. Surveys for Chinese tallow were suggested for Spanish Pond, Thomas Creek, and Cedar Point; air potato at the Theodore Roosevelt area and Spanish

Pond; and Chinese wisteria at Cedar Point and Kingsley Plantation. Consistent monitoring was also recommended for Boston fern, English ivy, and cat's claw vine at Kingsley Plantation (Bezanilla, 2001). Additional exotic species at Spanish Pond are kudzu and Peruvian primrose willow. In addition, Bezanilla summarized eradication efforts at Kingsley Plantation/Ft. George Island, Theodore Roosevelt and Spanish Pond/Fort Carolina, Thomas Creek, and Cedar Point in 2001. Bezanilla (2001) also summarized exotic plant control, including both manual removal and herbicide treatment for 2001 (**Table 12**).

Table 12. Summary of plant eradication efforts at Kingsley Plantation, Theodore Roosevelt Area/Fort Caroline, Thomas Creek, and Cedar Point, 2001.

Kingsley Plantation/Fort George Island			
Common Name	**Scientific Name**	**Plants Removed**	**Plants Treated**
Kudzu	*Pueraria montana*		25
Coral ardisia	*Ardisia crenata*	5	
Chinese wisteria	*Wisteria senensis*	45	32
Chinaberry	*Melia azederach*		15
English ivy	*Hedera helix*	(cut vines) 122	
Air potato	*Dioscorea bulbifera*	75	

Theodore Roosevelt Area and Spanish Pond/Fort Caroline			
Common Name	**Scientific Name**	**Plants Removed**	**Plants Treated**
Kudzu	*Pueraria montana*	64	195
Air potato	*Dioscorea bulbifera*	68	74
Mimosa	*Albizia julibrissin*	23	20
Chinese tallow	*Sapium sebiferum*	166	2
Creeping fig	*Phicus* spp.	(ongoing) 150	

Thomas Creek			
Common Name	**Scientific Name**	**Plants Removed**	**Plants Treated**
Chinese tallow	*Sapium sebiferum*	42	20

Cedar Point			
Common Name	**Scientific Name**	**Plants Removed**	**Plants Treated**
Mimosa	*Albizia julibrissin*	4	6
Chinese wisteria	*Wisteria sinensis*		15

Source: Bezanilla, 2001.

Table 13 lists encountered exotic plant species and their relative locations within TIMU. Non-native animal species encountered on Fort George Island (FEDP, 2003) are listed in **Table 14**. No non-native animal species were reported as occurring on Big or Little Talbot Islands (1998b). Of the exotic mammal species, feral hogs (*Sus scrofa)* have been known to be destructive at Cedar Point. They compete with native species for food and shelter, can adversely affect sensitive plant species, and/or disturb the ground while foraging for food (COJ, 1998).

Table 13. Exotic plant species encountered within Timucuan Preserve.

Pelotes Island[1]	
coinwort *(Centella asiatica)*	oleander (*Nerium oleander)*
mimosa *(Albizia julibrissin)*	English ivy (*Hedera helix)*
chinaberry *(Melia azedarach)*	common ragweed *(Ambrosia artemisiifolia)*
Chinese tallow tree (*Sapium sebiferum)*	white sweet clover *(Melilotus alba)*
Kingsley Plantation[2]	
air-potato *(Dioscorea bulbifera)*	tree privet *(Lingustrum lucidum)*
bamboo *(Bambusa* spp.)	crepe myrtle *(Langerstroemia indica)*
wild taro *(Colocasia esculenta)*	azalea *(Rhodendron* spp.)
lantana *(Lantana camara)*	Chinese wisteria *(Wisteria sinensis)*
Sprenger's asparagus-fern *(Asparagus densiflorus)*	English ivy *(Hedera helix)*
rose *(Rosa* spp.)	Turk's-cap mallow *(Malvaviscus arboreus)*
Big and Little Talbot Islands[3]	
Bermuda grass *(Cynodon dactylon)*	climbing false buckwheat *(Persicaria convolvulus)*
yellow nut sedge *(Cyperus esculentus)*	broad-leaf pink purslane *(Portulaca amilis)*
crowfootgrass *(Dactyloctenium aegyptium)*	purslane *(Portulaca oleracea)*
goose grass *(Eleusine indica)*	Brazilian pusley *(Richardia brasiliensis)*
English ryegrass *(Lolium perenne)*	Russian thistle *(Salsola kali)*
Bahia grass *(Paspalum notatum)*	black nightshade *(Solanum nigrescens)*
annual blue grass *(Poa annua)*	spiny-leaved sow thistle *(Sonchus asper)*
Mexican tea *(Chenopodium ambrosioides)*	puncture weed *(Tribulus terrestris)*
hairy indigo *(Indigofera hirsuta)*	Brazil vervain *(Verbena brasiliensis)*
creeping indigo *(Indigofera spicata)*	common vetch *(Vicia sativa)*
black medic *(Medicago lupulina)*	Asiatic bellflower (*Wahlenbergia marginata*)
sweet clover *(Melilotus alba)*	
Fort George Island[4]	
Prostrate Jointvetch *(Aeschynomene viscidula)*	black medic *(Medicago lupulina)*
mimosa *(Albizia julibrissin)*	nephrolepis *(Nephrolepis cordifolia)*
giant reed *(Arundo donax)*	Boston fern *(Nephrolepis exaltata)*
mouse-ear chickweed *(Cerastium glomeratum)*	Bahia grass *(Paspalum notatum)*
camphor *(Cinnamomum camphora)*	natalgrass *(Rhynchelytrum repens)*
sour orange *(Citrus aurantium)*	Brazil pusley *(Richardia brasiliensis)*
sweet orange *(Citrus sinensis)*	smutgrass *(Sporobolus indicius)*
showy rattlebox *(Crotalaria spectabilis)*	thelypteris *(Macrothelypteris torresiana)*
sagotia beggarweed *(Desmodium triflorum)*	purplequeen *(Tradescantia pallida)*
goosegrass *(Eleusine indica)*	Asiatic bellflower *(Wahlenbergia marginata)*
centipede grass *(Eremochloa ophiuroides)*	Chinese wisteria *(Wisteria sinensis)*
loquat *(Eribotrya japonica)*	Spanish dagger *(Yucca aloifolia)*
English ivy *(Hedera helix)*	lawn orchid *(Zeuxine strateumatica)*
Japanese honeysuckle *(Lonicera japonica)*	ryegrass (*Lolium perenne*)

Sources: 1 – Newman et al., 1988; 2 - NPS, 1996b; 3 – FDEP, 1998b; 4 – FDEP, 2003.

Table 14. Exotic species known to occur on Fort George Island and Cedar Point.

Common Name	Scientific Name
BIRDS	
European starling	*Sturnus vulgaris*
House sparrow	*Passer domesticus*
MAMMALS	
Nine-banded armadillo	*Dasypus novemcinctus*
Dog	*Canis familiaris*
Cat	*Felis domesticus*
Feral hog[1]	*Sus scrofa*

[1]found on Cedar Point; others occurred on Fort George Island.
Source: FDEP, 2003 (Fort George Island); COJ, 1998 (Cedar Point).

Protected/Rare Species

The General Management Plan for TIMU (NPS, 1996a), the Big Talbot Island State Park and Little Talbot Island State Park Unit Management Plan (1998b), and the Fort George Cultural State Park Unit Management Plan (2003) list protected species of fish, birds, amphibians, reptiles, mammals, and plants that may occur within TIMU's boundaries (**Appendix D**). The national and state species designations were updated according to the most recent information provided by the USFWS (2005), FWCC (2004), the Florida Department of Agriculture and Consumer Services (FDACS) (Coile and Garland, 2003), the Institute for System Biology (Wunderlin and Hansen, 2004), and the National Oceanic and Atmospheric Association – National Marine Fisheries Service (NOAA-NMFS, 2005). A series of reports was completed by The Nature Conservancy for the NPS of rare and protected species (1996b), rare bird species (1996a), and rare plants (Duever, 1996). Additionally, avian, mammal, herpetofaunal, other animal, and vegetation surveys were completed for Cedar Point (COJ, 1998).

Several studies have been completed concerning the Florida manatee *(Trichechus manatus latirostrus),* which resides in Jacksonville waters throughout the year. Duval County was identified in 1989 as among the 13 counties that had the highest manatee mortality rates. Duval County was then mandated to develop an effective manatee protection plan based on research efforts carried out by Jacksonville University (Jacksonville University-MaRCO, n.d). The Duval County Manatee Protection Plan was last updated in September 2004 (at the time of this report's publication) and tracks aerial sightings, manatee mortality (watercraft-related and other), trends, habitats, and cumulative counts (JU, 2004).

Water Resources Assessment

Water Quality

Data Sources

Information about the water quality of TIMU is available from a number of sources including TIMU personnel, NPS reports, and a variety of federal, state, local, and academic organizations. Background information on TIMU and water quality concerns was also provided by Shauna Ray Allen, formerly the Natural Resource Program Manager for TIMU, and Richard Bryant, Chief of Resources Stewardship for TIMU.

Most of the water quality data discussed in this report was retrieved from the USEPA STORET database. STORET is a "user-beware" water quality database system. For data analysis, it was assumed that data quality assurance/quality control procedures were implemented by the agency generating the data. There is some concern that inaccurate data may enter the system due to inappropriate measurement techniques, sample mistreatment, and other reasons. To retrieve STORET data, a 3.2-km (2-mile) buffer around TIMU was used to generate a bounding box based on latitude and longitude. The buffer zone size was based on that used for similar watershed studies, such as the *Baseline Water Quality Data and Inventory Report* (NPS, 2002). In this report, an area extending at least 4.8 km (3 miles) upstream and 1.6 km (1 mile) downstream from TIMU's boundary was utilized for data retrieval. These distances are somewhat arbitrary; however, an easily automated approach that limited the amount of data retrieved to that most relevant to TIMU was needed (NPS, 2002). For this assessment, an intermediate distance of 3.2 km (2 miles) was selected to form the buffer around TIMU. After drawing a bounding box around TIMU, the longitudinal coordinates ranged from 81.73 W to 81.36 W and latitudes from 30.34 N to 30.62 N.

To represent current water quality issues, data were retrieved from January 1, 1993 to January 1, 2004. This is based on the guidelines for the Impaired Waters Rule, Chapter 62-303, Florida Administrative Code (FAC). For this rule, data older than 7.5 years were considered "not representative of current water quality." This assessment uses ten years of data because it is consistent with the time period utilized for developing the planning list of potentially impaired waters by the FDEP. Data were downloaded from modernized STORET which includes all measurements after 1999 and a limited amount of earlier data transferred from Legacy STORET. Legacy data for TIMU was present in the modernized STORET database with measurements dating back to 1993. The majority of these data correspond to sediment and water samples listed under the NPS. Additional data were contributed by COJ, FDEP, Division of Environmental Health (Bureau of Water), FWCC Marine Research Institute, NPS, and Florida LAKEWATCH. Currently, SJRWMD does not upload data into this system; however, data from this agency is present in Legacy STORET. Data were obtained through direct communication with the district because it is one of the primary data collectors in the SJR Basin. In addition, the most recent publications regarding the TMDL development and water quality of the LSJR were reviewed and the results synthesized in this document.

The *Baseline Water Quality Data and Inventory Report* (NPS, 2002) retrieved all data entered into STORET for TIMU and the surrounding area through 1998. The search yielded 493,316 observations for 532 separate parameters collected by the NPS, USGS, USEPA, FDEP, COJ Air and Water Quality Division, Watershed Action Volunteers, JEA, and SJRWMD. About 81% (400,249) of the observations were entered by the NPS from data collected between 1972 and 1998. Of these observations, 97% were recorded at two stations (TIMU 0178 – Cedar Point Creek and TIMU 0213 – Clapboard Creek) within TIMU's boundary (**Figure 14**). Forty-two stations within the study area did not contain any data and many of the stations represented one-time or intensive single-year sampling efforts (NPS, 2002). Of the 445 stations, 179 were located within the TIMU boundary (NPS, 2002).

Figure 14. Locations of Clapboard Creek and Cedar Point Creek stations.

(Data Sources: Stations – USEPA, 2005a; Park Boundary – NPS (1:24,000), 1999; County – FDEP (1:24,000), 1997)

Lower St. Johns River Basin

A recent analysis of water quality status and trends at selected stations in the SJRWMD provides information concerning the water quality of the LSJR and Nassau River Basins (Winkler and Ceric, 2004). None of the stations were located within the study area; however, there was one station located in the Nassau River Basin and six stations in the Duval County portion of the LSJRB. All of the stations had fair water quality based on information reported from 1997 to 2001 (Winkler and Ceric, 2004).

Five of the stations did not have enough data for trend analysis, while the remainder displayed improvement from 1987 to 2001 (Winkler and Ceric, 2004). The improving stations were located in the SJR at the Main Streeet Bridge, which is located approximately 27 km (17 miles) upstream of TIMU, and at Beauclerc Bluff, which is 43 km (27 miles) upstream (Winkler and Ceric, 2004).

Water quality in TIMU and surrounding estuarine areas

Water quality data were compared to Florida and USEPA standards. Standards used for comparison as part of this assessment are included in **Table 15.** The entire list of Florida surface water standards is available at http://www.dep.state.fl.us/legal/rules/shared/62-302t.pdf.

Nutrients

Elevated nutrient concentrations can lead to eutrophication, which is defined as the process of changing the ecological status of a waterbody by increasing its nutrient resources (FDEP, 2002b). With regard to estuaries, eutrophication is generally regarded as "an increase in the rate of supply of organic carbon to an ecosystem" (Nixon, 1995, p. 199).

The initial impact of eutrophication is the increase of macroalgae, phytoplankton, and macrophyte biomass. When nutrients levels continue to increase, the species composition will change, affecting the food web and energy flow of the ecosystem (FDEP, 2002b). Secondary effects of eutrophication include less light penetration, increased occurrences of toxic/noxious phytoplankton blooms, hypoxic events (DO levels less than or equal to 2.0 mg/L), and behavioral effects on organisms (FDEP, 2002b). Algal productivity in riverine estuaries exhibits regular annual peaks as a result of nutrient inputs in late winter and high spring flows (FDEP, 2002b). Increases in phytoplankton biomass are favored by readily available nutrients, increased sunlight and temperatures, and water column stability (FDEP, 2002b).

Lower St. Johns River – Freshwater Reach

Algal growth in the freshwater reach of the LSJR is usually considered to be limited by nitrogen availability[1], growth continues beyond this point because nitrogen-fixing blue green algae are present (Hendrickson et al., 2003). Phosphorus limitation takes place in the freshwater zone only during long, dry periods that produce extended residence times. Several weeks of phosphorus limitation can induce precipitous bloom crashes accompanied by low DO levels. Low DO events in the LSJR tend to be vertically uniform and cover significant longitudinal extents (Hendrickson et al., 2003). In this section of the LSJR, chlorophyll *a* concentration was a reliable indicator of algal biomass, while the marine reaches demonstrated poor correlation (Hendrickson et al., 2003).

[1] Silica is actually the first limiting macronutrient. When there is no bioavailability of this nutrient, the blue-green algae begin to dominate (Schelske and Aldrige, as cited in Hendrickson et al., 2003).

Table 15. Water quality criteria used for assessment of water quality in Timucuan Ecological and Historic Preserve.

Parameter	Freshwater	Saltwater	Source
Nutrients			
Nitrate Nitrogen (mg/L)	10 (drinking supply)	n/a	FAC 62-302.530
Total Phosphorus (µg/L)	40 (rivers and streams)	90 (SC estuaries)[1]	USEPA 822-B-00-021
Total Nitrogen (mg/L)	0.9 (rivers and streams)	0.95 (SC estuaries)[1]	USEPA 822-B-00-021
Chlorophyll *a* (µg/L)	0.4 (rivers and streams)	Annual mean = 11.0[2]	Fresh: USEPA 822-B-00-021 Estuarine: FAC 62-303.353
Other Parameters			
Dissolved Oxygen	5.0 mg/L	4.0 mg/L (average not less than 5.0 in a 24-hr period)[3]	FAC 62-302.530
Fecal Coliform	800 colonies/100 mL (single sample); 200 col/100 mL monthly (geometric mean 10+ samples); 400 col/100 mL (10% of samples)	800 colonies/100 mL (single sample); 200 col/100 mL monthly (geometric mean 10+ samples); 400 col/100 mL (10% of samples)	FAC 62-302.530
Total Coliform	2,400/100 mL (single sample); 1,000/100mL (geometric mean 10+ samples); 1,000/100 mL (20% of samples)	2,400/100 mL (single sample); 1,000/100mL (geometric mean 10+ samples); 1,000/100 mL (20% of samples)	FAC 62-302.530
Metals[4]			
Arsenic (µg/L)	150	36	USEPA 822-R-02-047[5]
Cadmium (µg/L)	0.25	8.8	USEPA 822-R-02-047
Chromium (µg/L)	11	50	FAC 62-302.530[6]
Copper (µg/L)	9	3.1	USEPA 822-R-02-047
Iron (µg/L)	1	0.3	FAC 62-302.530
Lead (µg/L)	2.5	8.1	USEPA 822-R-02-047
Mercury (µg/L)	0.012	0.025	FAC 62-302.530
Nickel (µg/L)	52	8.2	USEPA 822-R-02-047
Selenium (µg/L)	5	71	USEPA 822-R-02-047
Silver (µg/L)	0.07	2.3	FAC 62-302.530
Zinc (µg/L)	120	81	USEPA 822-R-02-047

[1]Based on historical data compiled by South Carolina Department of Health and Environmental Control, values above 75th percentile were considered to be moderately enriched and were used as guidelines for comparison.
[2]Also, if annual mean chlorophyll *a* values increased by more than 50% over historical values for at least two consecutive years.
[3]This criterion also applies to Class II waters.
[4]All values represent continuous chronic criterion.
[5]Measured as total dissolved metals.
[6]Measured as total recoverable metals. Cadmium, chromium, copper, lead, nickel, silver, and zinc can be expressed as dissolved metals based on conversion factors provided in *Guidance for Establishing a Metals Translator*, Florida Department of Environmental Protection, December 17, 2001.

Lower St. Johns River – Predominantly Marine Reach

Diatoms dominant the phytoplankton community in the marine reaches of the LSJR (mouth of Black Creek to the mouth of the SJR), while cyanobacteria dominate the freshwater reach (Hendrickson et al., 2003). In addition, the oligo/mesohaline reach possesses a greater population of dinoflagellates. Low silica levels, which limit diatom growth, allow other algal species (such as dinoflagellates) to take advantage of the available nutrients and reduced competition to increase their abundance (Hendrickson et al., 2003). Certain dinoflagellate species can produce toxins that adversely affect aquatic fauna.

In the mesohaline reach of the river, inorganic nitrogen and phosphorus concentrations are above limiting levels; however, in the near coastal waters of the Atlantic Ocean, levels approach what would be considered limiting (Hendrickson et al., 2003). Nitrogen was determined to be the limiting nutrient in the LSJR from north of Lake George to the ICWW (Banks, 1997). However, phosphorus has been identified as the limiting nutrient in the estuarine portion of the river, although most estuaries along the east coast are typically nitrate-limited (DeMort and Bowman, 1985; Hendrickson, as cited in NPS, 1996b). High nitrate levels in the LSJR have been attributed to blackwater drainage from swamps, municipal and industrial discharges, and prolonged retention times (DeMort and Bowman, 1985; J. Hendrickson, SJRWMD, pers. comm.). Much of the nitrogen is unavailable in blackwater streams because it is in refractory colored dissolved organic matter (J. Hendrickson, SJRWMD, pers.comm.).

Lower St. Johns River – Total Maximum Daily Load Development

Due to historical data and biological responses (algal blooms and impacts on fish populations), a TMDL for nutrients has been developed for the LSJR. This guideline establishes allowable loads of TN and TP to the freshwater and marine sections of the LSJR that will enable it to meet the applicable water quality criteria for nutrients. Although there are no impaired waters listings for DO along the LSJR main stem, monitoring has demonstrated significant periods when DO levels are below the applicable criteria. Therefore, the TMDL addresses the impacts of nutrients on DO due to the possible implications of low DO levels on aquatic fauna (Magley and Joyner, 2004). A number of factors contribute to the severity of low DO events, such as imported algal blooms, upstream detrital load, and the location of the polyhaline transition zone (Hendrickson et al., 2003). DO considerations were incorporated into the TMDL based on achieving the chronic low DO impairment index described in the USEPA guidance document *Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hatteras* rather than the achievement of an algal biomass level (Hendrickson et al., 2003).

The marine DO criterion applies to TIMU because it is located within the area downstream of the Fuller Warren Bridge to the mouth of the SJR. The stations sampled by the COJ as part of the TIMU Preserve Program are all classified as predominantly marine based on the criteria set forth in the FAC[2], although for some of the stations in the Nassau River, the tidal influence is not as pronounced. The DO criterion for Class III (designated use for recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife) predominantly marine waters is a minimum of 4 mg/L with a minimum daily average of 5 mg/L. This is the same criterion that applies to Class II waters. Since this system can naturally vary below these values, a more appropriate DO target was investigated and developed by Hendrickson et al. (2003). The methodology and development of this criterion is discussed further in the Dissolved Oxygen Section.

A nutrient-related target was required to identify levels which would result in a probable imbalance in flora or fauna based on the narrative Florida nutrient criterion. To determine this threshold, the relative contribution of nonpoint and point sources to the river were identified and evaluated. Thirty-six permitted wastewater treatment facilities contributed approximately 27% and 55% of the annual average above-background TN and TP loads to the LSJR (Magley and Joyner, 2004). Based on nonpoint loading data from 1995-1999, upstream sources are the dominant form of TN to the LSJR, while the point and nonpoint sources and the upstream sources contribute approximately equal amounts of TP to the LSJR (Magley and Joyner, 2004). Hendrickson and Konwiniski (1998) estimated that development within the basin has increased the nutrient load (both point and nonpoint sources) 2.4 times greater than the natural background for TN and 6 times greater for TP.

In the oligohaline/mesohaline portion of the river, N inputs must be reduced to meet the designated target. Data from the 1999 fish kill were used to develop the TMDL to prevent adverse effects on biota (Magley and Joyner, 2004). The SJRWMD recommended that the anthropogenic point and nonpoint N loads located within this reach be reduced 22% (Magley and Joyner, 2004). This load reduction is dependent upon on the 30% reduction recommended for the upstream freshwater reach. The TN TMDL for the estuarine portion of the LSJR includes a waste load allocation (point sources) of 1,112,480 kg/year and a load allocation (nonpoint sources) of 360,504 kg/year (Magley and Joyner, 2004). The freshwater portion also includes waste load allocations and load allocations for TP.

This TMDL does not directly address nutrient impacts on SAV. Although the selected model allows for SAV simulation, the required studies regarding the effects of nutrients, light, and salinity were not completed at the time of the TMDL determination. As it becomes available, this information will be assimilated into the model and the rule adopting the TMDL revised accordingly (Magley and Joyner, 2004).

The nutrient threshold for impairment for the freshwater zone based on chlorophyll *a* states that chlorophyll *a* concentrations should not exceed 40 µg/L for continuous durations longer than 40 days to protect the aquatic flora and fauna

[2] Surface waters in which the surface chloride concentration at the surface is greater than or equal to 1,500 milligrams per liter (mg/L) are considered "predominantly marine" (Rule 62-302, F.A.C.).

(Hendrickson et al., 2003). This criterion is based on the maximum algal biomass levels that maintain the diversity of the plankton community, facilitate the upward transfer of primary production to higher trophic levels (and maintain zooplankton diversity), and minimize the potential dominance of detrimental algal species and the production of algal toxins (Hendrickson et al., 2003). When chlorophyll *a* levels exceed this threshold, blue-green algae and toxic algal species predominate and zooplankton abundance decreases (Hendrickson et al., 2003).

Timucuan Ecological and Historic Preserve

It is difficult to assess nutrient concentrations because there are no USEPA standards or guidelines for estuaries and the Florida nutrient criterion is narrative only. Preliminary numeric values for Florida's freshwater rivers, streams, and lakes are expected in summer 2005; however, values for estuaries will require additional analysis due to variability between sites (K. Weaver, FDEP, pers. comm.). The Florida criterion states that the nutrient concentrations of a body of water shall not be altered so as to cause an imbalance in natural populations of aquatic flora or fauna. In order to assess the water quality in the absence of a standard, observations were compared to historical data. The two sources used for comparison were the data collected as part of the South Carolina Estuarine Coastal Assessment Program (SCECAP) and the Typical Water Quality Values for Florida's Lakes, Streams and Estuaries (Friedemann and Hand, 1989).

SCECAP sampled approximately 60 sites located in tidal creeks and open waters annually for a number of parameters from 1999 to 2002. For analysis, the results were grouped into two study periods: 1999-2000 and 2001-2002. These results were compared to observations obtained from 1993 -1997, which comprised a historical database. Values that exceeded the 75th percentile of all observations were considered moderately enriched and any that exceeded the 90th percentile were considered very enriched (Van Dolah et al., 2002a).

Several factors must be considered before comparing the data near TIMU to these studies. The core monitoring for SCECAP was completed during the summer months to represent the time when water quality parameters would be most limiting and to coincide with the period when many fish and crustacean species are utilizing the estuaries for nursery habitat (Van Dolah et al., 2002a). The STORET data are year round and are not focused on one particular season.

Duplicates were averaged to yield one result per station per sampling trip. Averages and standard deviations were calculated for the parameters, regardless of differences in analytical procedure and sampling depth. Treatment of two data qualifiers should be explained; the first indicating that the value was below the method detection limit and the other signifying that it was between the method detection limit and the practical quantiation limit. Values were halved if below the method detection limit and if between the two limits, the reported value was used in the data analysis.

Nutrient levels are regularly monitored as part of the COJ's Timucuan Preserve Program, which commenced in 1997. Currently, twelve sampling stations are monitored bi-monthly for field parameters and laboratory samples are analyzed for nutrients, turbidity, total suspended solids (TSS), chloride, and other parameters. The locations of these stations are shown in **Figure 15**. Whenever possible, samples are obtained at ebb tide to accurately represent the water quality of the basin rather than water supplied by the ocean. The TN and TP for the twelve active stations as of December 2003 are shown in **Table 16**. Four stations were selected for detailed analysis and comparison to the South Carolina data (**Table 17**). These stations are TIM3, TIM8, TIM9A, and TIM11. These stations were selected to represent the varying degrees of tidal influence along the major waterbodies of TIMU.

Figure 15. Locations of Timucuan Preserve Program stations (City of Jacksonville Monitoring Program).

(Data Sources: Stations – USEPA, 2005a; Park Boundary – NPS (1:24,000), 1999; County – FDEP (1:24,000), 1997)

Table 16. Total nitrogen and total phosphorus averages (± standard deviation) at Timucuan Preserve Program sampling stations, February 1997 to April 2004.

Station	Total Nitrogen[1] (mg/L)	Total Phosphorus (mg/L)
TIM1	1.08 ± 0.34 (n=37)	0.17 ± 0.08 (n=37)
TIM2	0.99 ± 0.30 (n=36)	0.17 ± 0.08 (n=37)
TIM3	0.72 ± 0.38 (n=36)	0.15 ± 0.07 (n=37)
TIM4	0.67 ± 0.34 (n=36)	0.15 ± 0.08 (n=37)
TIM5	0.66 ± 0.33 (n=35)	0.13 ± 0.06 (n=36)
TIM6	0.62 ± 0.24 (n=33)	0.12 ± 0.05 (n=34)
TIM7	0.58 ± 0.29 (n=35)	0.10 ± 0.05 (n=36)
TIM8	0.51 ± 0.50 (n=37)	0.09 ± 0.04 (n=38)
TIM9A	0.48 ± 0.25 (n=28)	0.12 ± 0.07 (n=35)
TIM10	0.45 ± 0.26 (n=37)	0.11 ± 0.07 (n=38)
TIM11	0.40 ± 0.25 (n=38)	0.08 ± 0.04 (n=37)
TIM12	0.49 ± 0.28 (n=36)	0.11 ± 0.06 (n=37)

[1]Total nitrogen calculated as the sum of Total Kjeldahl Nitrogen and nitrate + nitrite.

Table 17. Comparison of nutrient levels in selected Timucuan Ecological and Historic Preserve stations to South Carolina Estuarine Coastal Assessment Program.

	Timucuan Preserve Program Stations				1999-2000 Survey[1]		2001-2002 Survey[2]	
Parameter	TIM3	TIM8	TIM9A	TIM11	SC tidal creeks	SC open water	SC tidal creeks	SC open water
Nitrate + Nitrite (mg N/L)	0.03 ± 0.02	0.02 ± 0.02	0.03 ± 0.04	0.02 ± 0.03	0.02	0.04	0.03	0.07
Total Nitrogen[3] (mg N/L)	0.72 ± 0.38	0.51 ± 0.50	0.48 ± 0.25	0.40 ± 0.25	0.65	0.53	0.53	0.47
Orthophosphate (mg P/L)	0.05 ± 0.03	0.01 ± 0.02	0.03 ± 0.02	0.02 ± 0.02	0.043	0.033	NR	NR
Total Phosphorus (mg P/L)	0.15 ± 0.07	0.09 ± 0.04	0.08 ± 0.04	0.10 ± 0.14	0.1	0.07	0.073	0.058

Note: All four stations would be considered open water according to Van Dolah et al. (2004) sampling design: tidal creeks are defined as those estuarine waterbodies less than 100 m wide from marsh bank to marsh bank.

NR = Not reported

[1] Source: Van Dolah et al., 2002a; 2002b.

[2] Source: Van Dolah et al., 2004.

[3]Total nitrogen calculated as the sum of Total Kjeldahl Nitrogen and nitrate + nitrite.

Total nitrogen (TN) as measured by Van Dolah et al. (2002a; 2002b; 2004) is best represented as the sum of nitrate-nitrite and Total Kjeldahl Nitrogen (TKN). TN values > 1.29 mg/L are considered highly enriched and values > 0.95 mg/L and < 1.29 mg/L were classified as moderately enriched. The TN averages of the four selected stations are below the moderately enriched classification of 0.95 mg/L. The averages for Stations TIM8, TIM9A, and TIM11 are comparable to the 1999-2000 and 2001-2002 survey results for the South Carolina open water stations. However, the average for TIM3 is greater than the open water stations. These results may be attributed to the residential development located on Pearson Island, which is northwest of this station. This island was excluded from TIMU boundaries because it was developed prior to establishment of TIMU.

The FDEP has established threshold values for nutrients based on waterbody type. The waterbody types for the TIMU Preserve Program stations were determined based on the waterbody type of the basin they are located in. According to this system, all of the stations, with the exceptions of TIM1, TIM2, and TIM3, are categorized as estuary stations. TIM1, TIM2, and TIM3 are considered streams. The TN threshold for estuaries is 1.0 mg/L and for streams the corresponding value is 1.6 mg/L. None of the averages exceed these thresholds. The averages for the stations along the Nassau River (TIM1, TIM2, TIM3, and TIM4) decrease to the mouth (TIM8), which is expected based on tidal influence. TIM8 and TIM11, which are located closest to the ocean, displayed fairly low values compared to the other stations.

The TN measurements for the selected TIMU Preserve Program stations are displayed in **Figure 16** with the median value of 0.80 mg/L for 1471 Florida estuarine stations and the median value of 1.2 mg/L for 2320 stream stations as reported in Friedemann and Hand (1989). Stations TIM8, TIM9A, and TIM11 were compared to the estuarine median, while TIM3 was compared to the stream median. The corresponding median value was exceeded for 4 out of 36 measurements (11%) at Station TIM3, 5 out of 37 observations (14%) at TIM8, 2 out of 28 measurements (7%) at TIM9A, and 1 of 37 measurements (3%) at TIM11.

The average nitrate + nitrite levels were slightly lower than those reported for the two surveys (1999-2000 and 2001-2002) of South Carolina's open waters. The values for the TIMU stations were more consistent with those of the tidal creek sites. Previous analysis by Hendrickson has indicated that compared to other estuaries in northeast Florida, the LSJR has unusually high levels of nitrate + nitrite (cited in NPS, 1996b). These concentrations were attributed to several factors such as extended retention time, point source inputs, and blackwater drainage (NPS, 1996b). The TN and TP concentrations were low to moderate for the LSJR compared to other northeast Florida estuaries according to Hendrickson's analysis (cited in NPS, 1996b). The Nassau River had similar low to moderate values for TN, but the TP values were high compared to other estuaries based on data from Coffin et al. (1992).

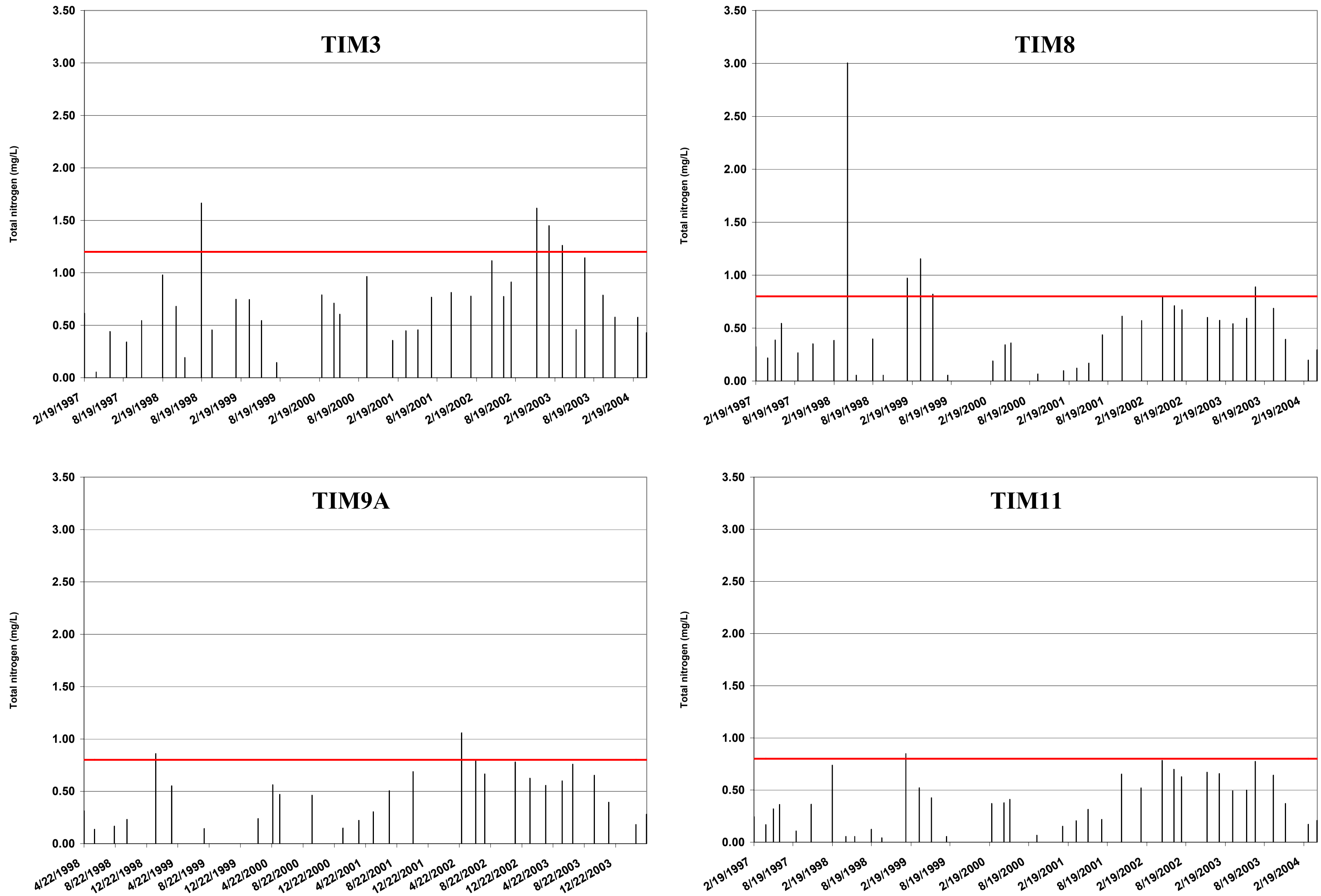


Figure 16. Total nitrogen (mg/L) concentrations at Stations TIM3, TIM8, TIM9A, and TIM11, February 1997- April 2004.

The solid line denotes the median TN value for Florida estuaries (0.80 mg/L) or streams (1.2 mg/L) as presented in Friedemann and Hand, 1989.

According to the historical data used by the SCECAP, average TP levels > 0.17 mg/L are considered to be highly enriched and values between 0.09 mg/L and 0.17 mg/L are considered moderately enriched. The average values for the four TIMU stations were above the values reported for the open water and tidal creek stations in South Carolina (1999-2002). Three of the stations, TIM3, TIM9A, and TIM11, would be characterized as moderately enriched based on comparison with the SCECAP historical data. As expected, the stations with greater tidal influence, TIM8 and TIM11, exhibited lower averages, probably due to tidal action and dilution with ocean water. Similar to TN, the averages for the stations near the Nassau River (TIM1, TIM2, TIM3, and TIM4) decrease along the river to station TIM8, which is expected based on tidal influence. The orthophosphate levels for TIMU's stations were consistent with those reported by Van Dolah et al. (2002a; 2002b) for tidal creeks and open water stations in South Carolina.

The TP measurements for the selected TIMU Preserve Program stations are displayed in **Figure 17** with the median value of 0.10 mg/L for 1479 Florida estuarine stations and the median value of 0.11 mg/L for 2524 stream stations as reported in Friedemann and Hand (1989). Stations TIM8, TIM9A, and TIM11 were compared to the estuarine median, while TIM3 was compared to the stream median. The corresponding median value was exceeded for 26 out of 37 measurements (70%) at Station TIM3, 16 out of 38 observations (42%) at TIM8, 19 out of 29 measurements (66%) at TIM9A, and 16 of 37 measurements (43%) at TIM11.

In addition to the monitoring conducted as part of the TIMU Preserve Program, phosphorus data were collected for two stations (JAXSJR01 and JAXSJR04) in the SJR and one station (19020002) in the Nassau River. These data are displayed in **Figure 18**. At Station JAXSJR01, the median TP value for Florida estuaries (0.10 mg/L) was exceeded 42% of the time (20 out of 48 observations), which was similar to the 52% (70 out of 134 measurements) found for Station JAXSJR04. At Station 19020002 in the Nassau River, the value for streams was exceeded 64% of the time (45 out of 70 observations). These results are consistent with other reports which have stated that the Nassau River has demonstrated high TP levels compared to other estuaries in the SJRWMD (NPS, 1996b).

The FDEP has established threshold values for nutrients based on waterbody type. Stations JAXSJR01 and JAXSJR04 have been classified as estuarine stations, while Station 19020002 is a stream. The TP threshold for estuaries is 0.19 mg/L and for streams the corresponding value is 0.22 mg/L. The median values for JAXSJR01 (0.09 mg/L), JAXSJR04 (0.10 mg/L), and 19020002 (0.14 mg/L) do not exceed their respective thresholds. It should be noted that the median values for the SJR stations are calculated from vertically integrated water samples rather than surface water grab samples, which are the types of samples collected at the TIMU Preserve Program stations and Station 19020002.

The *National Coastal Condition Report II* (USEPA, 2004c) rated dissolved inorganic phosphorus (DIP) as fair in Southeast estuarine areas based on levels greater

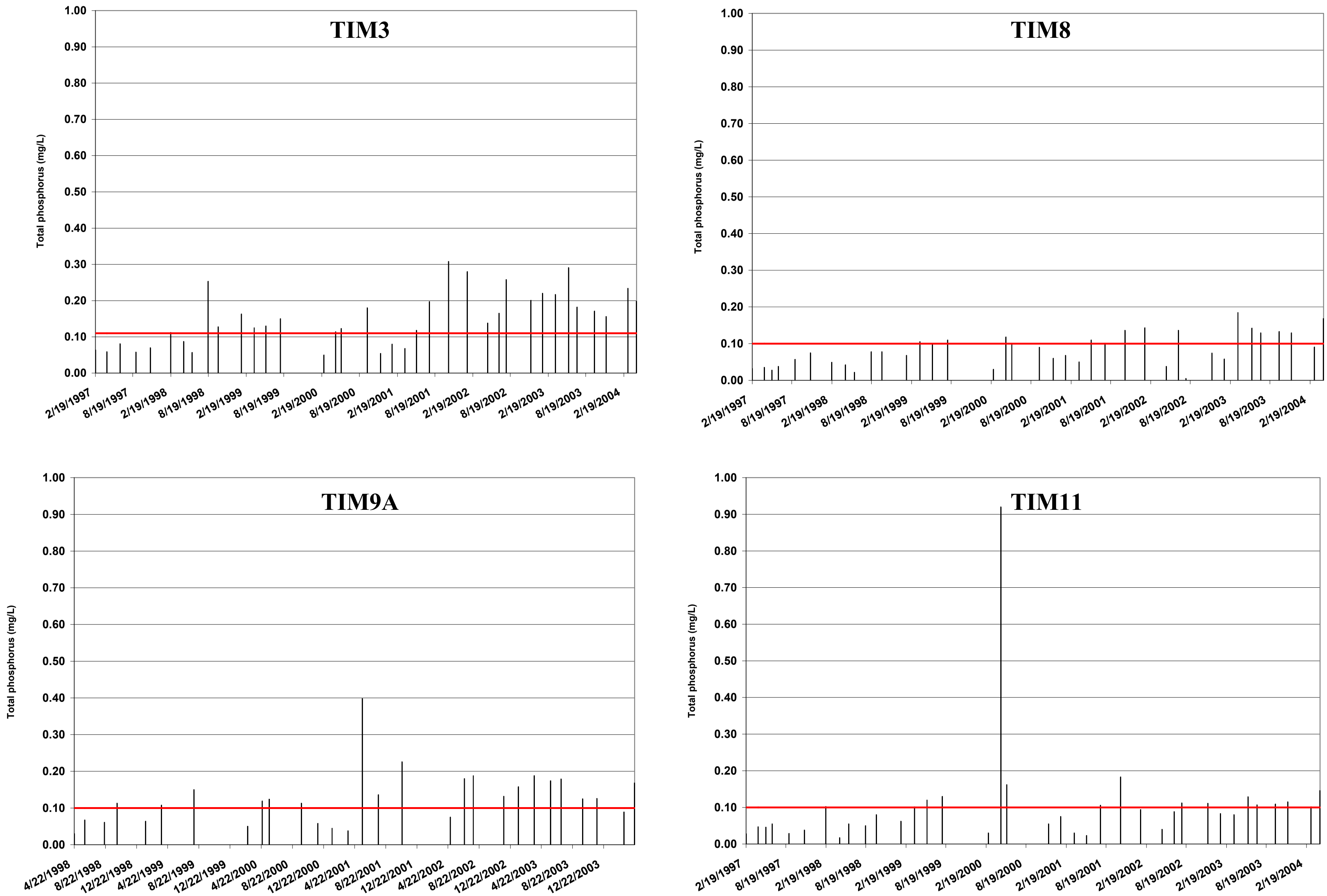
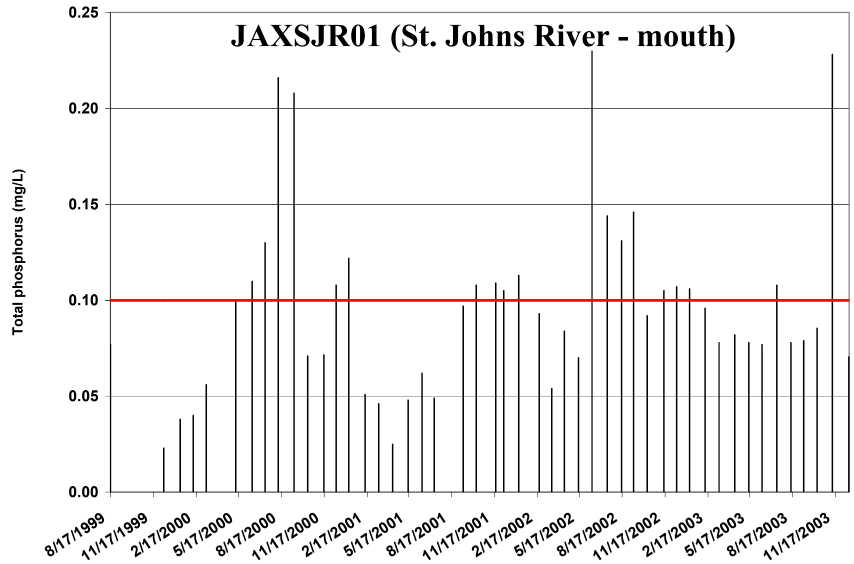
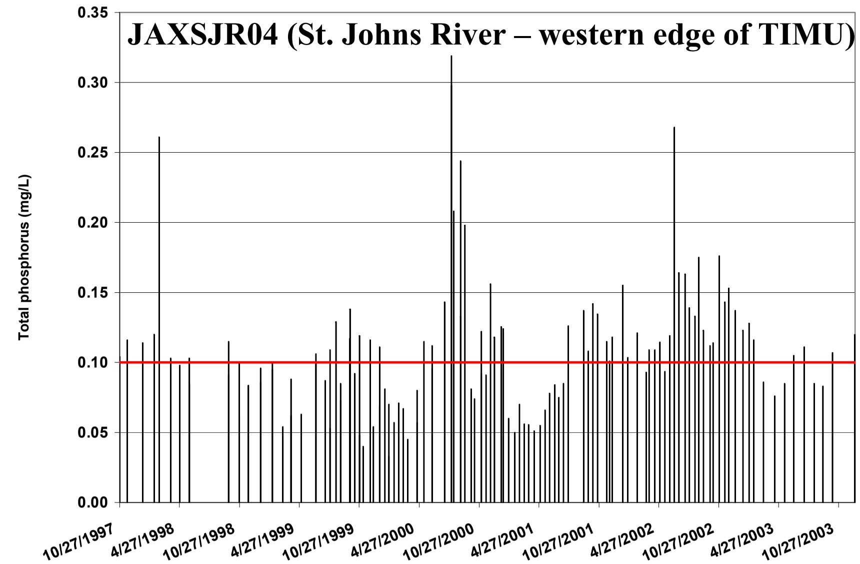


Figure 17. Total phosphorus concentrations (mg/L) at Stations TIM3, TIM8, TIM9A, and TIM11, February 1997- April 2004.

The solid line denotes the median TP value for Florida estuaries (0.10 mg/L) or streams (0.11mg/L) as presented in Friedemann and Hand, 1989.





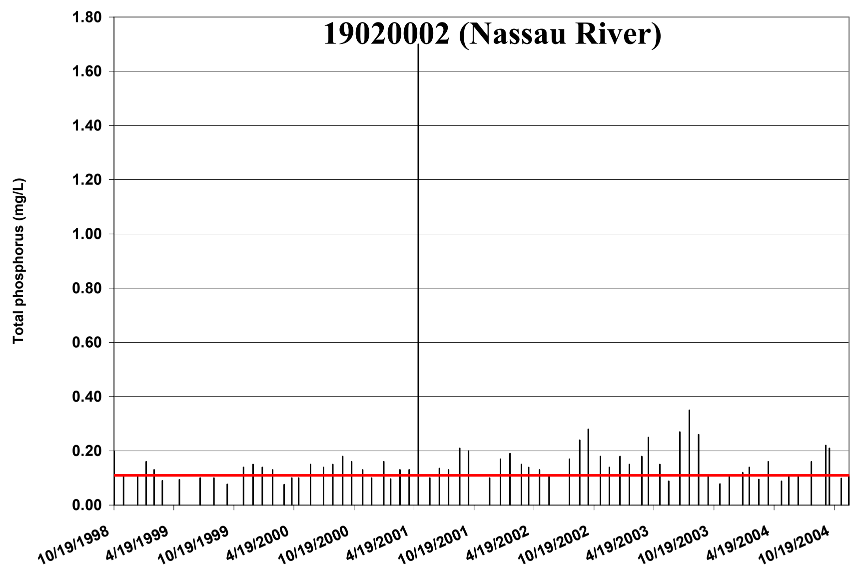


Figure 18. Total phosphorus concentrations (mg/L) at Stations JAXSJR01, JAXSJR04, and 19020002.

The solid line denotes the median TP value for Florida estuaries (0.10 mg/L) or streams (0.11mg/L) as presented in Friedemann and Hand, 1989.

than 0.05 mg/L in 12% of the sampled sites. Chlorophyll *a* also received a fair rating because 83% of the Southeast Coast estuarine area had concentrations greater than 5 µg/L (USEPA, 2004c). Literature suggests that for estuaries in the Southeast Coast region, DIP represents about 97% of the TP (Van Dolah et al., 2002).

Nutrient data were also provided by Florida LAKEWATCH and the FWCC. Modernized STORET includes LAKEWATCH data for 21 stations located within the TIMU study area. Parameters measured include chlorophyll *a*, phosphorus, mixed forms of nitrogen (nitrate, nitrite, organic, ammonia, and ammonium), and Secchi disk depth. All of the measurements represent one-time sampling events, which precludes trend analysis. The FWCC measurements were collected at 13 stations in July 2000, August 2001, and July 2002. The data were obtained from single site visits, with the exception of a couple stations which were sampled twice. A number of field measurements were recorded, such as wind speed, salinity, DO, and pH, as well as water samples. These samples were analyzed for nutrients (various forms of nitrogen and phosphorus and silicate), chlorophyll *a*, true color, and turbidity.

The FDEP also sampled multiple stations within the study area for nutrients, chlorophyll *a*, field parameters, total organic carbon (TOC), and total and fecal coliforms (**Figure 19**). These stations, except for Stations 3537 and 19020002, were only sampled once or the date range is not more than one year. The stations, sampling period, and parameters of interest are included in **Table 18**.

The SJRWMD maintains a database with additional stations that are not included in modernized STORET. The locations of these stations are displayed in **Figure 20**. The stations are sampled for a number of parameters such as nutrients, field parameters, dissolved metals, and chlorophyll *a*. Some of these stations were measured for programs to monitor SAV, ambient water quality, phytoplankton, chlorophyll levels, and light penetration. The stations included within the TIMU study area that have nutrient data are summarized in **Table 19**. Relevant metals data will be discussed in the Contaminants Section.

Chlorophyll *a*

The amount of chlorophyll *a* data (corrected for pheophytin) available from the modernized STORET database was limited; however, additional data were supplied by the SJRWMD. The most extensive data were recorded at Stations JAXSJR01, JAXSJR04, and JAXSJR09; all are located in the SJR. The numeric criteria for chlorophyll *a* in estuaries have not been developed for Florida. In the interim, waters in estuarine areas are considered nutrient enriched if the annual mean chlorophyll *a* values are greater than 11 µg/L or if chlorophyll *a* values increase by more than 50% over historical values for at least two consecutive years. The majority of the measurements for the three stations were below 10 µg/L and the annual means do not show a significant increasing trend for the data plotted in **Figures 21-23.**

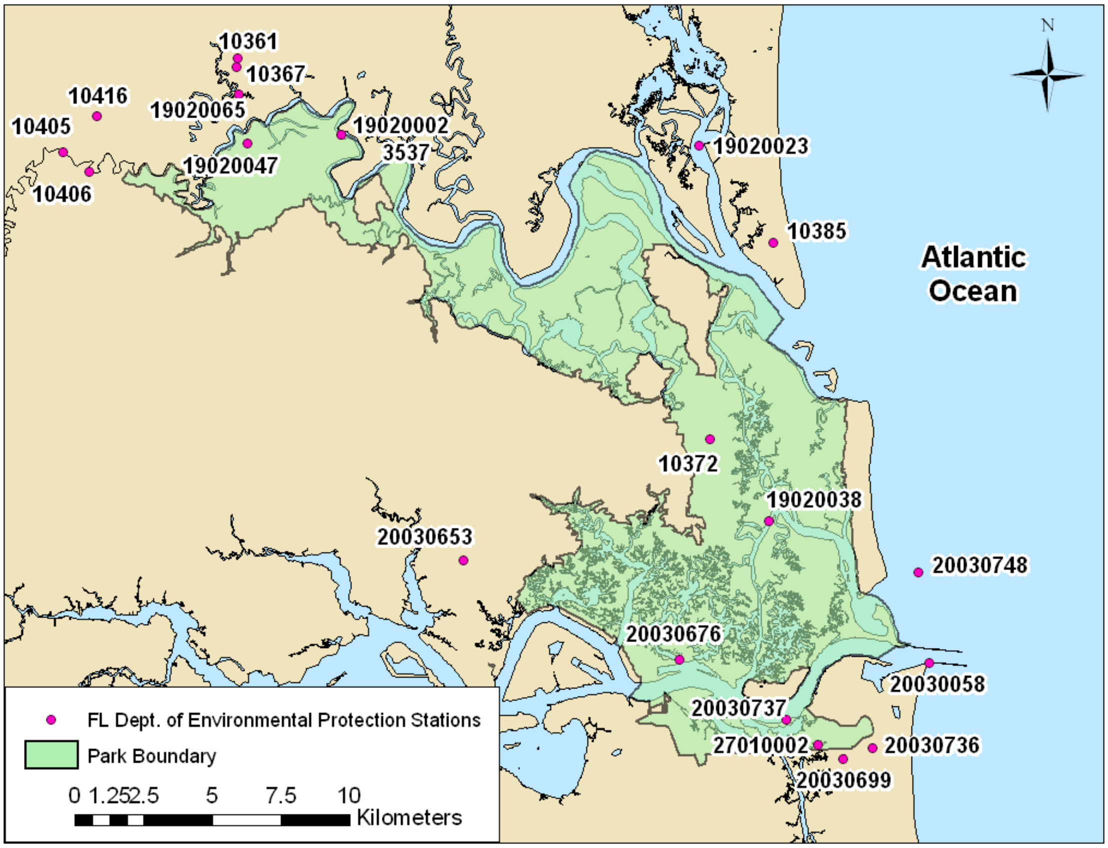


Figure 19. Locations of Florida Department of Environmental Protection stations within Timucuan Preserve study area.

(Data Sources: Stations – USEPA, 2005a; Park Boundary – NPS (1:24,000), 1999; County – FDEP (1:24,000), 1997)

<u>Dissolved Oxygen</u>

<u>Lower St. Johns River Basin</u>

Extended periods of low DO levels (below the criterion of 5.0 mg/L) have been documented in the freshwater and oligo/mesohaline reaches of the LSJR (Magley and Joyner, 2004). Low DO episodes have also been noted in other southeastern U.S. estuarine systems (Schroeder and Wiseman, 1988). The state standard for DO in freshwaters is an instantaneous measurement of 5.0 mg/L and for predominately marine waters, the 24-hour average should not be below 5.0 mg/L and shall never be less than 4.0 mg/L. The dissolved oxygen targets have recently been refined based upon the minimum required levels for the support of native estuarine communities (Magley and Joyner, 2004).

An alternative to the fixed standard of 5 mg/L was recommended by Hendrickson et al. (2003). It is based on the procedure described in the USEPA Guidance, *Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hatteras* (USEPA, 2000). This method was used to define the oxygen criterion utilized

Table 18. Stations, date range, and parameters of interest with more than one record in modernized STORET sampled by the Florida Department of Environmental Protection.

Station ID	Date Range	Field Parameters and Nutrients of Interest	Metals of Interest
3537	October 1998-March 2003	Fecal coliform, chlorophyll *a*, enterococcus group bacteria, phosphorus, nitrogen, DO, turbidity, TOC, E. coli	
10361	July 2001	Fecal coliform, chlorophyll *a*, enterococcus group bacteria, phosphorus, nitrogen, DO, turbidity, TOC	
10367	July 2001	Fecal coliform, chlorophyll *a*, enterococcus group bacteria, phosphorus, nitrogen, DO, turbidity, TOC	
10372	July 2001	Fecal coliform, chlorophyll *a*,enterococcus group bacteria, phosphorus, nitrogen, DO, turbidity, TOC	
10385	August 2001	Fecal coliform, chlorophyll *a*, enterococcus group bacteria, phosphorus, nitrogen, DO, turbidity, TOC	
10405	May 2001	Fecal coliform, chlorophyll *a*, enterococcus group bacteria, E. coli, phosphorus, nitrogen, DO, turbidity, TOC	
10406	May 2001	Fecal coliform, chlorophyll *a*, enterococcus Group bacteria, E. coli, phosphorus, nitrogen, DO, turbidity, TOC	
10416	May 2001	Fecal coliform, chlorophyll *a*, enterococcus group bacteria, E. coli, phosphorus, nitrogen, DO, turbidity, TOC	
19020002	June 2000-June 2003	Fecal coliform, chlorophyll *a*, phosphorus, nitrogen, DO, turbidity, TOC	Mercury
19020023	June 2000	Phosphorus, nitrogen, turbidity, TOC	
19020038	March 2003-October 2003	Fecal coliform, DO, turbidity	
19020047	February 2001 and June 2003	Fecal coliform, chlorophyll *a*, phosphorus, nitrogen, DO, turbidity, TOC	
19020065	March 1999-December 1999	Fecal coliform, chlorophyll *a*, phosphorus, nitrogen, DO, turbidity, TOC	
20030058	December 2002	DO	
20030653	March 2002-December 2002	Fecal coliform, DO	
20030676	March 2002-December 2002	Chlorophyll *a*, phosphorus, nitrogen, DO, turbidity	
20030699	March 2002-November 2002	Fecal coliform, DO	
20030736	March 2002-November 2002	Fecal coliform, DO	
20030737	March 2002-December 2002	Fecal coliform, DO	
20030748	April 2002-November 2002	DO	
27010002	March 2002-October 2002	Fecal coliform	

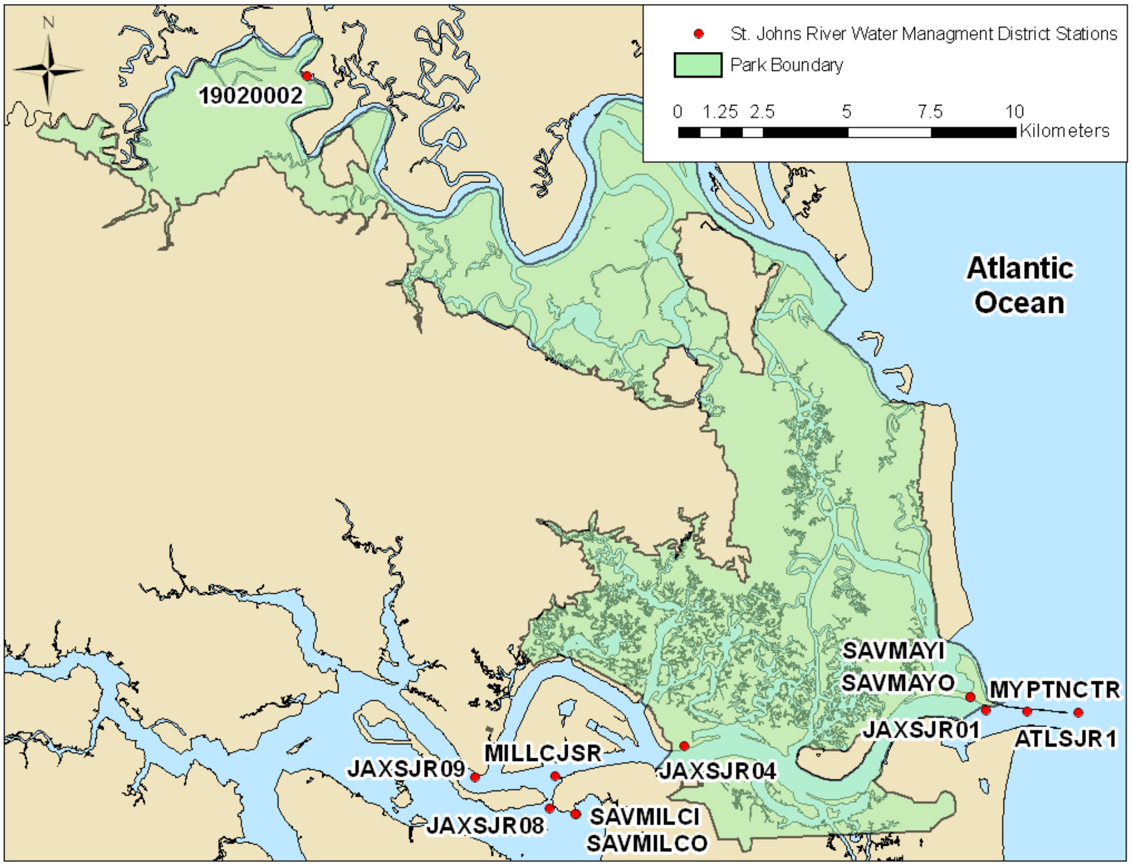


Figure 20. Locations of St. Johns River Water Management District stations within Timucuan Preserve study area.

(Data Sources: Stations – SJRWMD, 2005; Park Boundary – NPS (1:24,000), 1999; County – FDEP (1:24,000), 1997)

to develop the nutrient TMDL for the LSJR. The guidance is based upon the low oxygen tolerance of estuarine fish and invertebrates as opposed to considerations for both freshwater and saltwater species (Magley and Joyner, 2004). In addition, the guidance sets an absolute minimum oxygen level that protects most species from acute low concentrations that would result in organism mortality (Magley and Joyner, 2004). This level is distinguished from a sub-lethal range which reduces growth and recruitment, affecting fish health and survival. The document provides explanatory information regarding how to assess the effects of two types of low DO events common to estuarine systems: "persistent, low DO associated with late season algal bloom decline" (common to LSJR system) and "diurnal patterns of low DO associated with high algal standing stock photosynthesis and respiration cycles or tidal transport of water with low oxygen content" (Hendrickson et al., 2003, p. 76). The procedures used to develop the criterion minimum concentration and determine growth effects and larval recruitment are described in detail in the report, *Characteristics of Accelerated Eutrophication in the Lower St. Johns River Estuary and Recommended Targets to Achieve Water Quality Goals for the Fulfillment of TMDL and PLRG Objectives* (Hendrickson et al., 2003). The main points are highlighted in the following paragraphs.

Table 19. Stations, date range, and parameters of interest within Timucuan Preserve study area from St. Johns River Water Management District database.

Station ID	Date Range	Parameters of Interest (excluding metals)
JAXSJR01	August 1999- December 2003	Chlorophyll, TKN[1], NOx[2], ammonium, phosphorus, DO[3], turbidity, and TOC[4]
JAXSJR04	July 1996 - December 2003	Chlorophyll, TKN, NOx, ammonium, phosphorus, DO, turbidity, and TOC
JAXSJR08	September 1999	Chlorophyll, TKN, NOx, ammonium, phosphorus, DO, and turbidity
JAXSJR09	October 1999 - November 2003	Chlorophyll, TKN, NOx, ammonium, phosphorus, DO, turbidity, and TOC
19020002	October 1998-December 2003	Chlorophyll, TKN, NOx, ammonium, phosphorus, DO, turbidity, fecal coliform, Enterococcus Group bacteria, and E. coli
ATLSJR1	January 1998	Chlorophyll, TKN, NOx, ammonium, phosphorus, DO, and turbidity
MILLCJSR	August 1999- October 2000	Chlorophyll, DO, and turbidity
MYPTNCTR	August 1999- October 2000	Chlorophyll, DO, and turbidity
SAVMAYI	October 1997	Chlorophyll, TKN, NOx, ammonium, phosphorus, DO, and turbidity
SAVMAYO	October 1997	Chlorophyll, TKN, NOx, ammonium, phosphorus, DO, and turbidity
SAVMILCI	October 1997-January 2003	Chlorophyll, TKN, NOx, ammonium, phosphorus, DO, and turbidity
SAVMILCO	October 1997-January 2003	Chlorophyll, TKN, NOx, ammonium, phosphorus, DO, and turbidity

[1]TKN = Total Kjeldahl Nitrogen

[2]NOx = Sum of nitrate and nitrite

[3]DO = Dissolved oxygen

[4]TOC = Total organic carbon

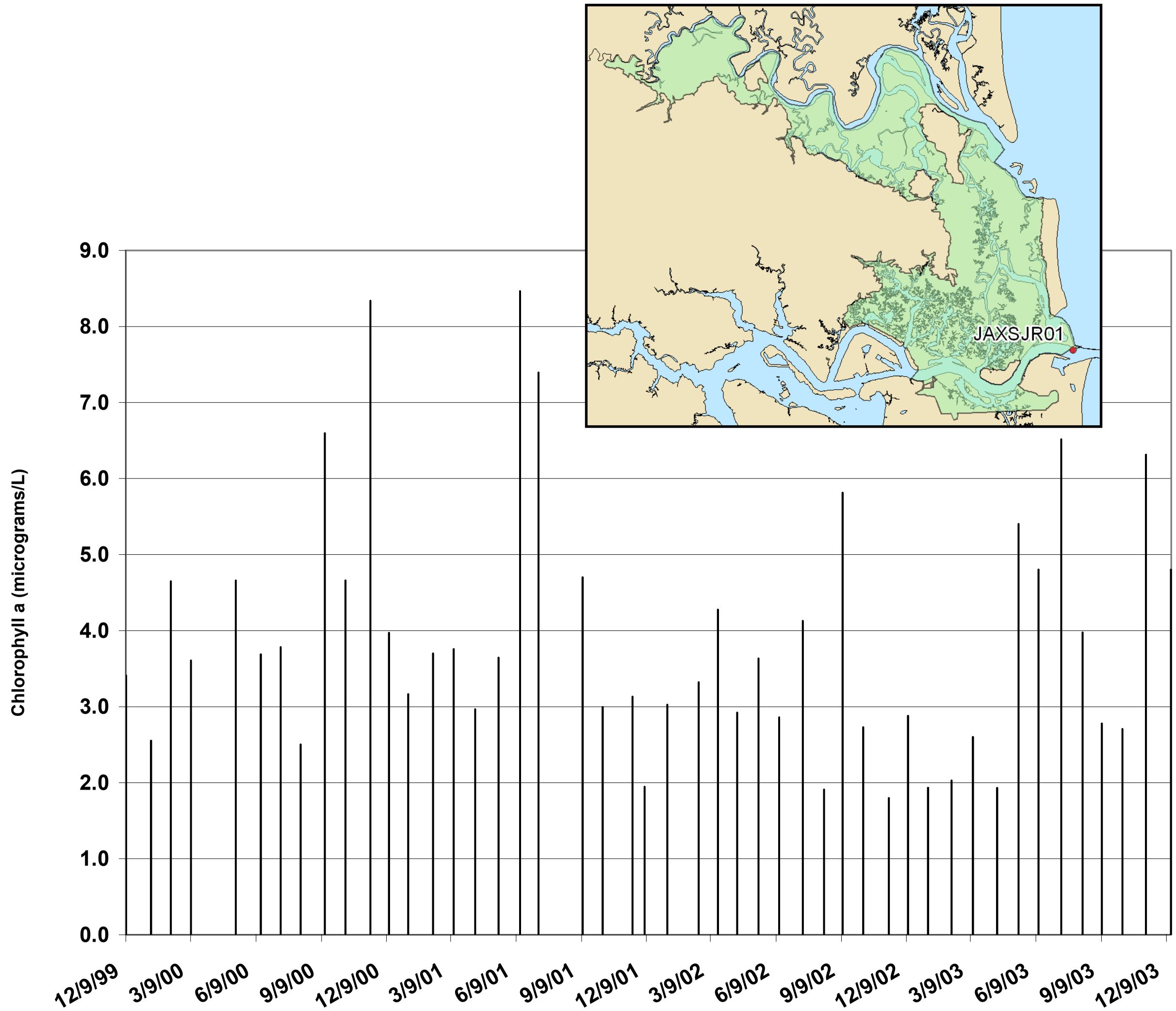


Figure 21. Chlorophyll *a* measurements (µg/L) at Station JAXSJR01, December 1999 – December 2003.

Estuaries are considered nutrient enriched if the mean annual chl *a* value is above 11 µg/L.
(Source SJRWMD, 2005)

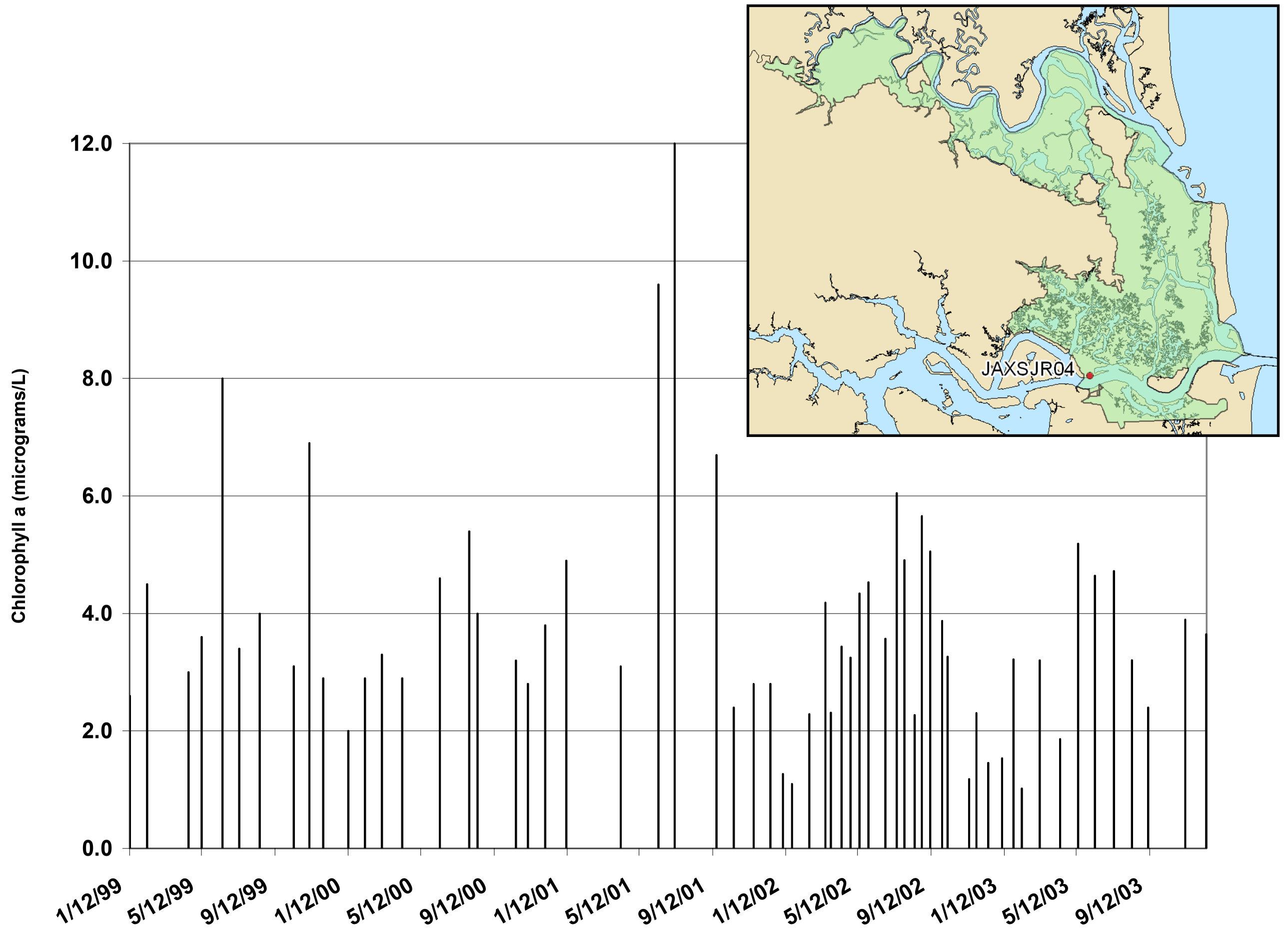


Figure 22. Chlorophyll *a* measurements (µg/L) at Station JAXSJR04, January 1999 – December 2003.

Estuaries are considered nutrient enriched if the mean annual chl *a* value is above 11 µg/L.

(Sources: USEPA, 2005a; SJRWMD, 2005)

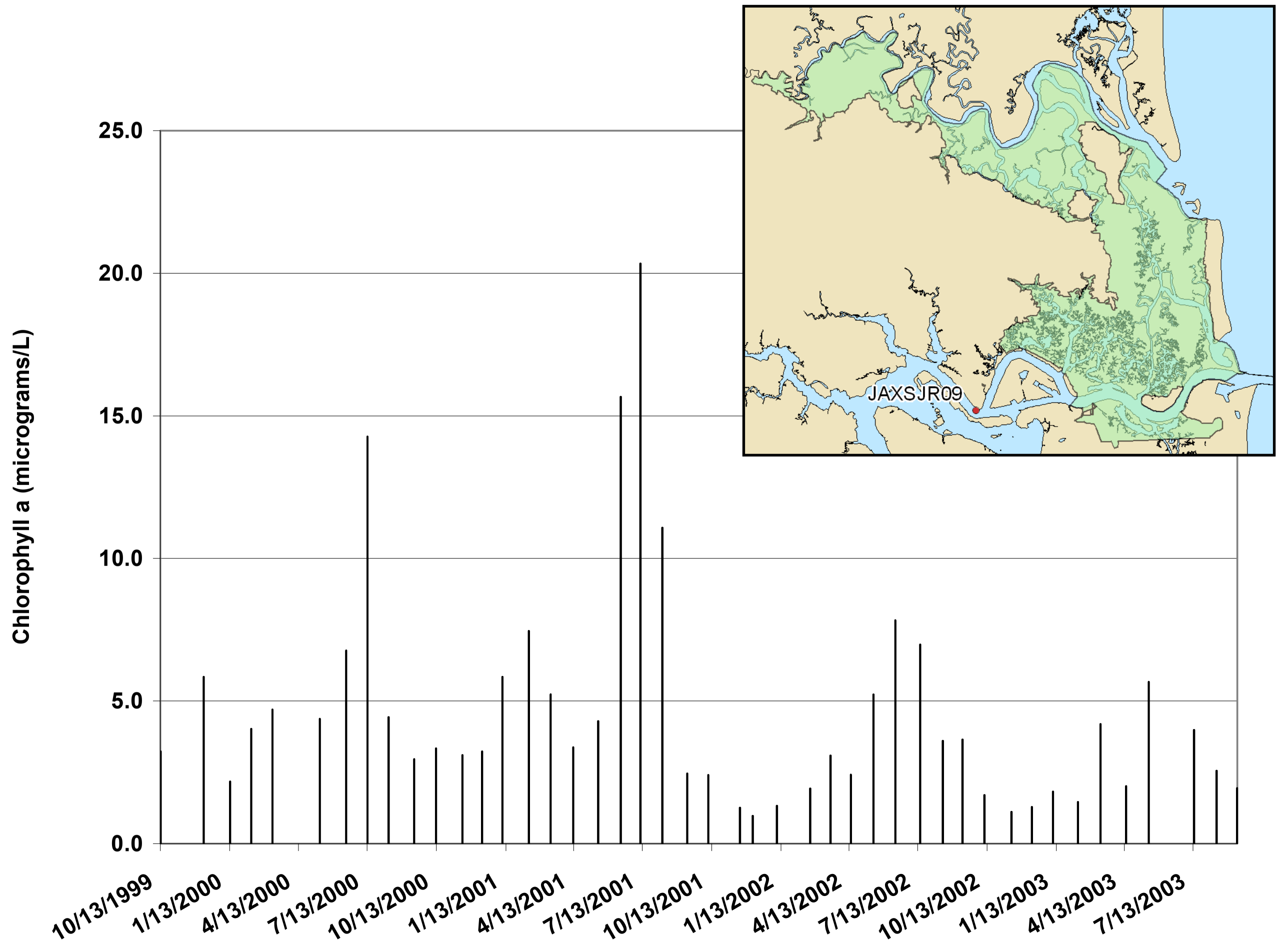


Figure 23. Chlorophyll *a* measurements (µg/L) at Station JAXSJR09, October 1999 – September 2003.

Estuaries are considered nutrient enriched if the mean annual chl *a* value is above 11 µg/L.

(Source SJRWMD, 2005

One relationship relates the intensity and duration of a continuous, low DO event to the effects of the maximum acute value, growth effects threshold, and larval recruitment model (Hendrickson et al., 2003). Estuarine organisms are not expected to suffer chronic effects from hypoxia when the DO concentration is greater than 4.8 mg/L, while levels below 2.3 are assumed to result in acute mortality for at least some organisms (Hendrickson et al., 2003). For the intermediate DO range between 2.3 and 4.8 mg/L, observations from numerous dose-response studies were used to relate the length of exposure to the degree of mortality in the population (Hendrickson et al., 2003). A "dose" or given interval of potentially low DO is expressed as the fraction of the total duration of the interval at a specific concentration required to cause mortality in at least 5% of the most sensitive species of the fish community (Hendrickson et al., 2003). For instance, the "impairment index calculated duration of exposure to DO at 3 mg/L is 5.57 days" (Hendrickson et al., 2003, p. 80). Therefore, one-day of 3 mg/L DO is considered to be 18% (1/5.57) of a lethal dose. Lethal doses are said to occur when the summation of individual doses of continuous exposure are greater than 1 (Hendrickson et al., 2003).

Application of this method to data collected at the Dames Point Station of the LSJR found that for three out of the six years, there was at least one, long excursion of continuous low DO. The durations lasted from 4 to 7 weeks (Hendrickson et al., 2003). The impairment scores calculated for Dames Point were 1.74, 3.57, and 1.07 for 1997, 1999, and 2001. The low DO event in 1999 is connected to a fish kill of thousands of adult shad and menhaden in this reach of the river. In contrast, at the Acosta Bridge station, there were no measured low DO events between 1996 and 2001 that qualify for chronic impairment based on this approach (Hendrickson et al., 2003).

Timucuan Ecological and Historic Preserve

DO measurements were recorded at a number of locations within and near TIMU. The DO measurements considered for this assessment were collected by the COJ Ambient Water Quality Section as part of the TIMU Preserve Program. The DO measurements were taken at specified water depths using an oxygen probe. This analysis only considers measurements classified as "at the surface," with depths ranging from 0.2 to 0.8 m (0.66 to 2.62 ft). The measurements were recorded at different times of the day; however, most of the observations were measured around noon or in the early afternoon.

Monthly averages (± standard deviation) for all of the stations are depicted in **Figure 24** with the exception of December, when no sampling data were recorded. There is a seasonal cycling consisting of summer minima and winter maxima. These results were expected based on the levels of algae and photosynthetic activity in the summer as compared to the winter. None of the monthly averages was below the Florida predominantly marine waters instantaneous criterion of 4 mg/L. Generally, the lowest DO levels occurred in August, September, and October. These trends are also displayed in **Figures 25 and 26** which show the DO measurements for two stations (TIM8 and TIM12) from 1997 to 2004. DO measurements were recorded from October 1998 to March 2003, with the exception of 2000, for Station 3537 located in the Nassau River. The location of this station is depicted in **Figure 27** and the data are plotted in **Figure 28**.

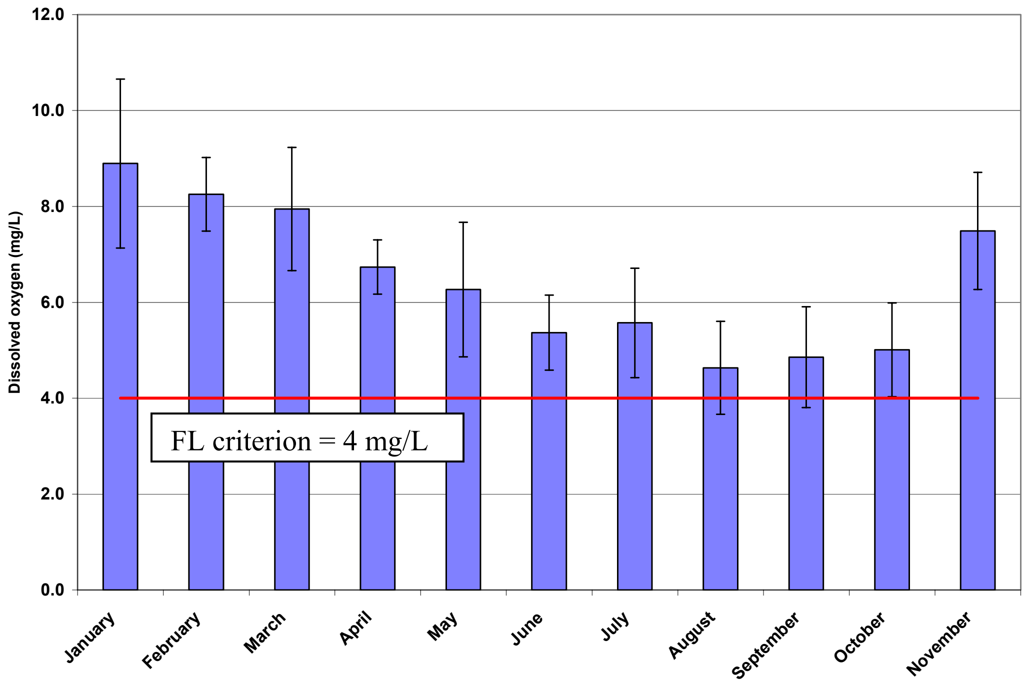


Figure 24. Average monthly dissolved oxygen (±standard deviation) concentrations (mg/L) at Timucuan Preserve Program stations, February 1997-April 2004.

(Source: COJ, 2004)

DO was below the criterion on three occasions (n = 42) or ~7% of the time during this period.

Herzog et al. (2001) assessed the impact of impounded causeways on the biological productivity in the estuary by collecting water quality parameters at two locations: Cedar Point Creek (impounded by a causeway) and Clapboard Creek (bridge, free-flowing). The free-flowing creek was expected to exhibit higher productivity due to the transport of nutrients, carbon, and oxygen into the system through tidal flow (Herzog et al., 2001). The causeways were constructed in the 1920s as part of the installation of Heckscher Drive. The measured water quality parameters included DO, turbidity, specific conductance, salinity, pH, and temperature, which were recorded every 15 minutes from February 1997 to June 1998. The study found that the data collected from the free-flowing creek were dominated by tidal effects; while the impounded creek data were not influenced by the tides (Herzog et al., 2001).

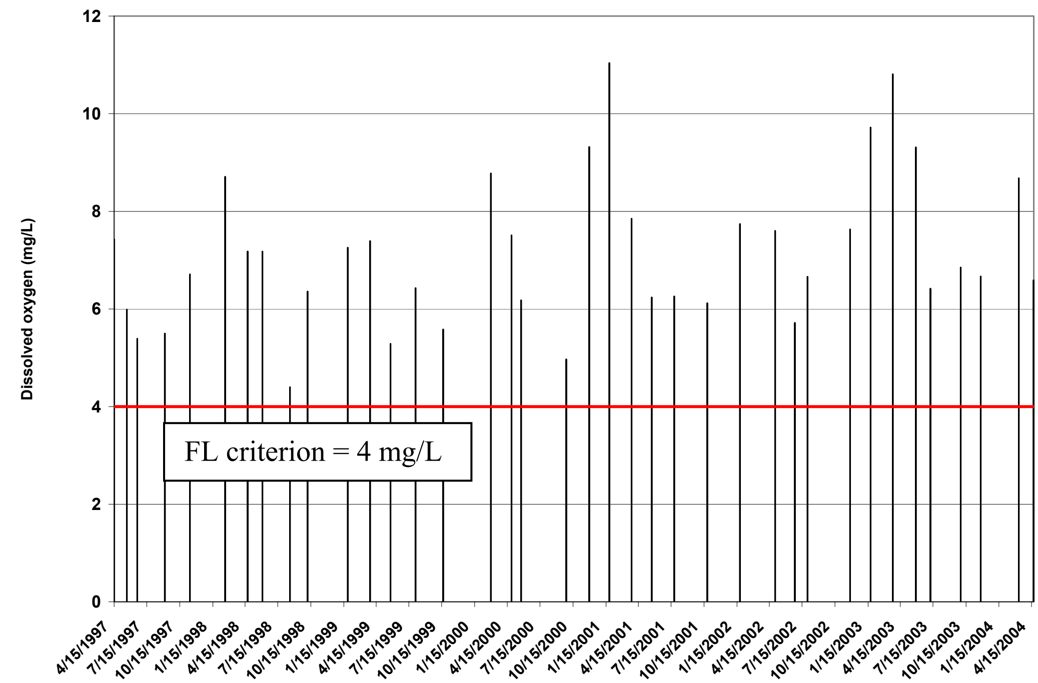


Figure 25. Surface dissolved oxygen (mg/L) measurements at Station TIM8, 1997-2004.

The solid line represents the FL predominately marine waters criterion.

(Source: COJ, 2004)

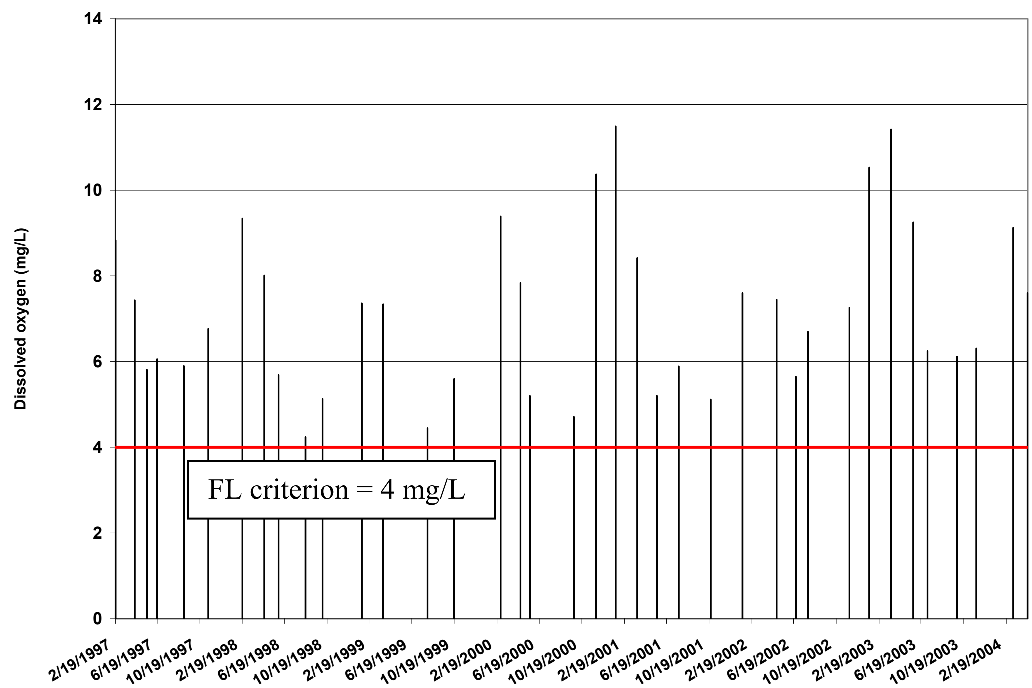


Figure 26. Surface dissolved oxygen (mg/L) measurements at Station TIM12, 1997-2004.

The solid line represents the Florida predominately marine waters criterion.

(Source: COJ, 2004)

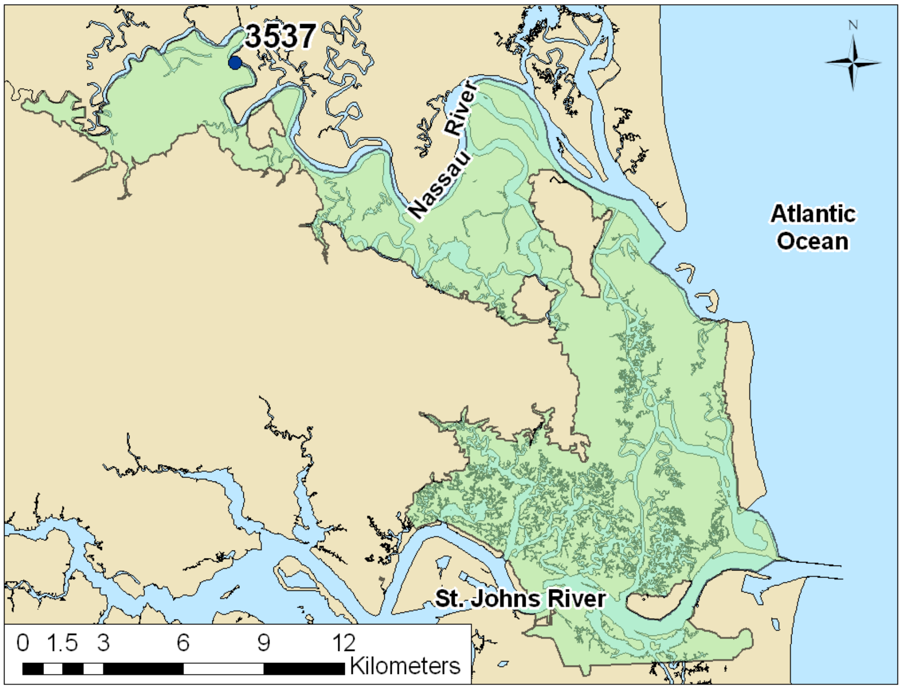


Figure 27. Location of Station 3537 in Timucuan Ecological and Historic Preserve.

(Data Sources: Stations – USEPA, 2005a; Park Boundary – NPS (1:24,000); 1999, County – FDEP (1:24,000),1997)

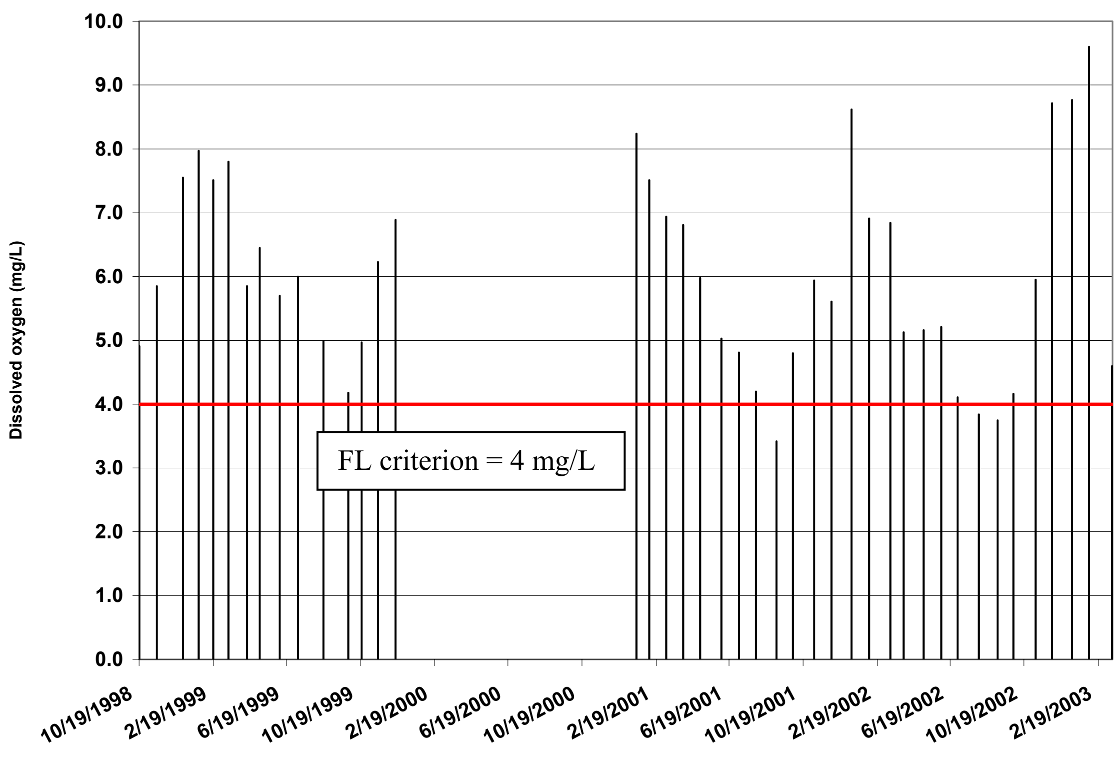


Figure 28. Surface dissolved oxygen (mg/L) measurements at Station 3537, October 1998-March 2003.

The solid line represents the Florida predominantly marine waters criterion.
(Source: USEPA, 2005a)

The DO levels were slightly higher in the free-flowing creek compared to the impounded creek. These differences were attributed to the greater diffusion of oxygen from the air to the water as a result of tidal action and the effects of advection on the rate of diffusion of oxygen across the probe membrane (Herzog et al., 2001). Contributing factors may include the amount of oxygen-demanding substances present in the creek beds and the higher levels of photosynthesis resulting from the plant growth supported by nutrients that are transported with tidal flow (Herzog et al., 2001). The study also indicated that the average percent DO saturation suggests that the rate of respiration exceeds photosynthesis and oxygen and carbon are being imported from another system (Herzog et al., 2001).

Continuous monitoring data were collected by the FDEP from March 2004 to February 2005 for a station located at Kingsley Plantation and from September 2004 to February 2005 for a station located in the headwaters of Clapboard Creek. Measurements were recorded every half hour by a Hydrolab Datasonde YSI 6600 meter. Measured parameters included water temperature, specific conductivity, DO (in mg/L and % saturation), salinity, depth, pH, and turbidity.

Visual inspection of the data collected from Kingsley Plantation show seasonal trends in the DO readings. During summer months, the measurements were often below 4.0 or 5.0 mg/L, which are the respective saltwater and freshwater criteria set by the state of Florida. These occurrences do not necessarily indicate water quality degradation as short hypoxic events often occur during the summer in tidal creeks in this region (DiDonato et al., 2005). Overall, hypoxic events were rare, occurring during 6% of the deployment period, and short, none of the events lasted longer than 12 hours (DiDonato et al., 2005). A report summarizing these data is expected be completed by September 2005 (A. Kalmbacher, FDEP/CAMA, pers. comm.). Another meter was installed in June 2005 at the mouth of Lofton Creek in the Nassau River. This site was selected to obtain baseline data before residential development in the area occurs (A. Kalmbacher, FDEP/CAMA, pers. comm.).

DO levels in the Southeast Coast estuaries were classified as good in the USEPA's *National Coastal Condition Report II* (2004c). This classification applied to summer months, when the lowest levels are expected. Twenty-four percent of the bottom waters had DO levels between 2 and 5 mg/L, and 74% of the bottom waters recorded levels above 5 mg/L (USEPA, 2004c).

Bacterial Contamination

Surface waters in the state are organized into five classes based on the present and potential designated use of the water. The classes and uses are found in FDEP rule 62-302.400, FAC (Class I, II, III, IV, and V) and dictate the water quality standards that apply to the waters. The designated use of Class II waters for water quality standards is "Shellfish Harvesting or Propagation." The DACS, SEAS, classifies waters for the suitability of shellfish harvesting and consumption of shellfish based on public health standards and guidelines of the National Shellfish Sanitation Program (NSSP). A change in classification by one agency does not necessarily translate to the other because their objectives, attainment of designated use vs. human health, are not identical, although, they both involve water quality.

To protect individuals from shellfish-borne illnesses and maximize shellfish harvest, FDACS classifies shellfishing areas. This is accomplished through regular monitoring of fecal coliform and water quality parameters at stations throughout Florida's shellfish harvesting areas. For areas to be classified approved or conditionally approved, the level of fecal coliform in subsurface water samples must meet the NSSP 14/43 standard[3]. For areas to be classified restricted or conditionally restricted, the level of fecal coliform in subsurface water samples must meet the NSSP 88/260 standard[4].

In 1998, the Nassau Soil and Water Conservation District identified sources of pollution, primarily fecal coliforms, which would adversely affect oyster harvesting in Nassau County, specifically in Alligator Creek. The study describes each site, its general water quality, and sources of pollution located nearby (Main, 1998). In September 1984, the Nassau County shellfish harvesting area was reclassified from approved to prohibited based on actual fecal coliform pollution (H. Beadle, FDACS, Division of Aquaculture, pers. comm.).

In 1994, it was recommended that the entire Duval County shellfish harvesting area be classified as prohibited and all pollution assessment and sampling be discontinued. This conclusion was based on a lack of data, inability to meet required standards, and limitations on the department's resources (Browning, 1994). According to SEAS, the area was closed due to unpredictability in water quality. A predictor, such as rainfall, could not be determined that would accurately forecast the water quality conditions, making the area difficult to actively manage (H. Beadle, FDACS, Division of Aquaculture, pers. comm.). The recommendation became effective January 31, 1996 and is officially based on actual fecal coliform pollution. The waters listed as Class II in Duval and Nassau Counties are included in **Table 20**. Currently, none of the waters in these counties are actively managed for shellfish harvesting by the SEAS.

The Florida Healthy Beaches Program began in 1998 with a pilot program that included 11 coastal counties, which conducted beach water sampling every two weeks. In August 2000, the program was expanded to include 34 counties. There are 10 stations located in Duval County and 11 stations in Nassau County. Several of the stations are within the study area established around TIMU. The coastal beach water samples collected by the county health departments are analyzed for enterococci bacteria and fecal coliform. The results are categorized as good, moderate, or poor based on the number of organisms per 100 mL of marine water and the geometric mean of five weeks of results.

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[3] NSSP 14/43 standard: The fecal coliform median or geometric mean must not exceed 14 MPN/100 mL, and not more than 10 percent may exceed 43 MPN/100mL.

[4] NSSP 88/260 standard: The fecal coliform media or geometric mean must not exceed 88 MPN/100 mL, and not more than 10 percent may exceed 260 MPN/100 mL.

Table 20. Shellfish propagation or harvesting waters in Duval and Nassau Counties.

Duval County
Ft. George River and Simpson Creeks
Ft. George Inlet north to Nassau Sound
Intracoastal Waterway and Tributaries
Confluence of Nassau and Amelia Rivers south to Flashing Marker 73 thence eastward along Ft. George River to Ft. George Inlet and includes Garden Creek.
Nassau River and Creek
From the mouth of Nassau Sound, (a line connecting the northeasternmost point of Little Talbot Island to the southeasternmost tip of Amelia Island) westerly to a north-south line through Seymore Point.
Pumpkin Hill Creek
Nassau County
Alligator Creek
Nassau River and Creek
From the mouth of Nassau Sound, (a line connecting the northeasternmost point of Little Talbot Island to the southeasternmost tip of Amelia Island) westerly to Seymore Point.
South Amelia River
Nassau River north to a line from the northern shore of the mouth of Alligator Creek to the northernmost shore of Harrison Creek.
Waters between South Amelia River and Alligator Creek.

Source: FAC 62-302.400.

Advisories/warnings indicate that contact with the water at this site may pose an increased risk of infectious disease, particularly for susceptible individuals. A poor rating may result in a resampling event to confirm poor conditions, otherwise, a health advisory or warning will be issued immediately. The values corresponding with a poor rating are 104 or greater enterococci per 100 mL of marine water, 35 or greater enterococcus geometric mean, and 400 or greater fecal coliform per 100 mL of marine water. Data were assessed based on comparison of single measurements to the Florida Healthy Beaches Program thresholds for poor classification.

Seven of the Healthy Beaches monitoring stations are located within the study area (**Figure 29**). From August 2000 through 2004, there have been no instances when the fecal coliform measurements exceeded 400 colony forming units per 100 mL of marine water for these stations. The enterococcus geometric mean guideline for a poor rating was not exceeded for any of the stations from August 2000 to January 2004. However, in January 2004, the criterion for the enterococcus mean was exceeded on two occasions at the Nassau191 Station (South End). The criterion for enterococcus (104 per 100 mL) was exceeded seven times during this same period. These occurrences took place in April, September, November, and December (**Figure 30**). Bacterial contamination at public beaches does not appear to be of concern because there were relatively few instances of elevated bacteria concentrations, especially during summer months when usage is greatest.

Figure 29. Florida Healthy Beaches Program stations located within Timucuan Ecological and Historic Preserve study area.

(Data Sources: Park Boundary – NPS (1:24,000), 1999; County – FDEP (1:24,000), 1997; Stations –FL Healthy Beaches Program, http://esetappsdoh.doh.state.fl.us/irm00beachwater/default.aspx, 2004)

In addition to the Healthy Beaches program, other agencies (COJ and FDEP) test water samples for total coliforms and fecal coliforms. The Florida fecal coliform bacteria one-day standard for Class III surface waters is 800 most probable number (MPN) per 100 mL of water. The corresponding standard for total coliforms is 2,400 MPN per 100 mL of water on any one day. Three stations (SC1, SC3, and 20030653) exceeded the fecal coliform standard on multiple occasions with values ranging from 1367 to 66,600 (estimated) MPN per 100 mL of water. Two of these stations (SC1 and SC3) are located southeast of TIMU and Station 20030653 is located to the west of TIMU (**Figure 31**). SC1 (Puckett Creek at Wonderwood Drive) and SC3 (Sherman Creek at Wonderwood Dive) are monitored quarterly as part of the Duval County Tributary Monitoring Program.

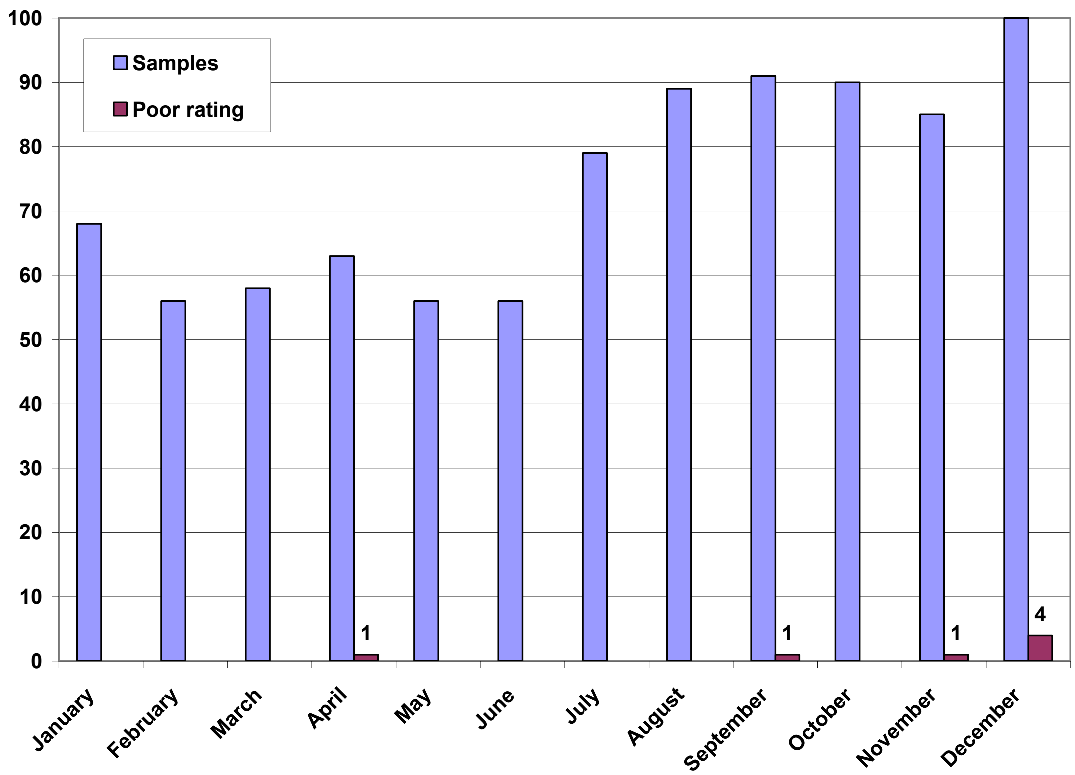

Figure 30. Number of samples and enterococcus poor ratings for Florida Healthy Beaches stations (n =7) located within Timucuan Ecological and Historic Preserve study area, August 2000 to January 2004.

Poor rating is given for a measurement of 104 or greater enterococci per 100 mL of marine water based on Florida Healthy Beaches Program guidelines.

Four stations (20030699, 20030736, 20030748, and 20030653) that exceeded the standard for total coliforms are monitored by the FDEP. Three of these stations also exceeded the standard for fecal coliforms, demonstrating that fecal and total coliforms are related. Stations 20030736 and 20030699 are located close to Stations SC3 and SC1.

Stations located within and adjacent to TIMU are monitored for *E. coli* and enterococcus group bacteria. The values for *E. coli* ranged from 4 to 76 per 100 mL of water. These values are below the USEPA standards for *E. coli* (126 colony forming units or MPN per 100 mL of water). Using the criteria for the Healthy Beaches Program poor rating categorization yields three instances when the enterococcus measurements were greater than 104 per 100 mL of water. All of these events occurred at the same station, Station 3537 (**Figure 25**), located in the northeast section of TIMU in the Nassau River.

Figure 31. Locations of Stations 20030653, SC1, and SC3 near Timucuan Ecological and Historic Preserve.

(Data Sources: Park Boundary – NPS (1:24,000), 1999; County – FDEP (1:24,000), 1997; Stations – USEPA, 2005a)

Lower St. Johns River Basin

Sources of fecal coliforms include improperly functioning septic systems, stormwater runoff, wastewater treatment plants, and agricultural runoff. Birds and wild animals are also sources of fecal coliforms which may impact waterbodies. The predominant species in the fecal coliform group is *E. coli*, which indicates fecal coliform pollution and the possible presence of enteric pathogens. Septic systems, in particular, have been investigated as a possible source of fecal coliforms to the urban tributaries of the SJR near Jacksonville. A recent article in the *Jacksonville Business Journal* reported the groundbreaking of the first project undertaken by the city's Water and Sewer Expansion Authority to replace residential septic tank systems (Verney, 2005). This project is in the Ortega neighborhood of Triangle Estates. There are an estimated 175,000 homeowners in Duval County with septic tanks and many of these systems are old and failing. The Duval County Health Department has identified chronic septic tank failure areas (**Figure 32**). Sewer connections will be provided for six areas; none of these zones are within the assessment study area. These areas are Lake Forest, Murray Hill, Pernecia, Oakwood Villa Estates, Glynlea, and Scott Mill (FDEP, 2004b). Additional areas are classified as being investigated or will be investigated in the future (FDEP, 2004b).

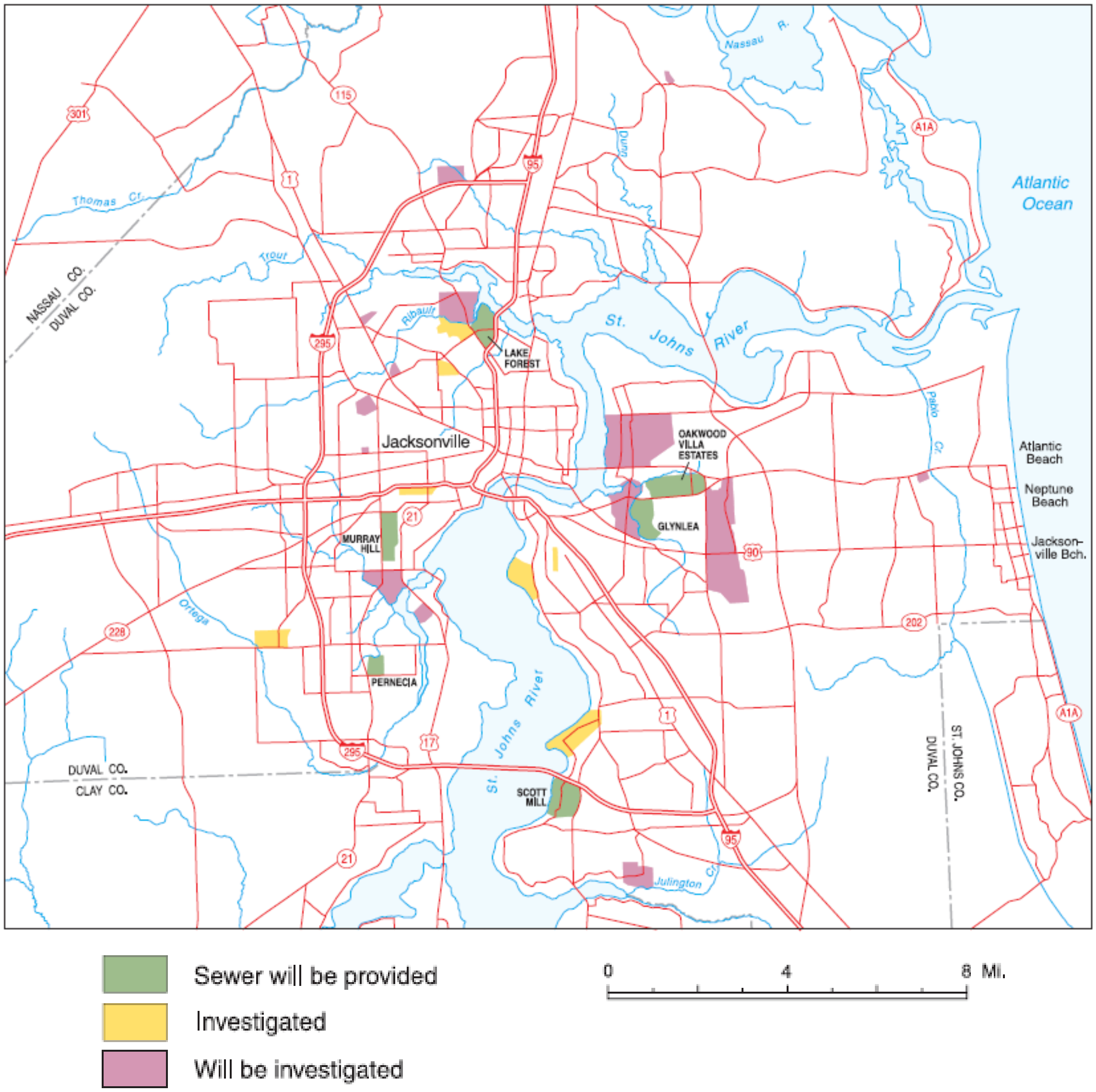

Figure 32. Septic tank failure areas identified in Duval County.

(Figure obtained from FDEP, 2004b)

The impact of septic tank effluent on two urban tributaries in Duval County was described by Wicklein (2004). The goals of the study were to evaluate the effects of future remedial activities in selected tributaries by measuring major ion and nutrient concentrations as well as fecal coliform concentrations, detecting wastewater compounds, and tracking bacterial sources to document septic tank influences on the water quality of selected tributaries (Wicklein, 2004). The Fishing Creek and Big Fishweir Creek tributaries were sampled because they drain neighborhoods selected as priority locations for septic tank phase-out projects (Wicklein, 2004). The corresponding neighborhoods are the Pernecia and Murray Hill B subdivisions, respectively. Originally, the project aimed to address the changes in water quality concentrations following installation of sanitary sewer systems and removal of the septic systems. The installation of the sanitary sewer systems was delayed, which limited the study to a discussion of the baseline conditions prior to the removal of the septic tank systems (Wicklein, 2004).

Samples were collected during low-flow periods to represent surface water quality conditions indicative of groundwater seepage, septic tank effluent, and the upward of movement of groundwater (Wicklein, 2004). They were also collected during storm events to represent the water quality associated with surface runoff and shallow subsurface flow of water to the stream (Wicklein, 2004). The sources of bacteria were distinguished based on a tracking method which uses antibiotic resistance to determine if the source is of human or non-human origin (Wicklein, 2004).

Fecal coliform bacteria concentrations were measured on a monthly basis. Sixty-three percent of the 115 samples exceeded the Florida fecal coliform bacteria standard of 800 colonies per 100 mL of water on any one day (Wicklein, 2004). Fecal coliform bacteria concentrations were significantly higher in the South Branch Big Fishweir Creek basin than in the Fishing Creek basin, probably due to the higher density of septic tanks per acre in the former basin (Wicklein, 2004). Fecal coliform bacteria concentrations were significantly greater at the downstream site on Fishing Creek compared to the upstream site due to the accumulation of septic tank effluent as stream water moved downstream (Wicklein, 2004).

Most of the fecal coliform bacteria were classified as originating from human sources. Fecal coliforms were detected at significant levels for all study sites in both the Fishing Creek and South Branch Big Fishweir Creek basins (Wicklein, 2004). Fecal coliform bacteria from wild animals were detected at significant levels at Fishing Creek during and following installation of the sanitary sewer system (Wicklein, 2004). As humans were found to be the most significant source of fecal coliforms, management of septic systems may substantially improve microbiological water quality in both the Fishing Creek and South Branch Big Fishweir Creek basins (Wicklein, 2004).

Contaminants

Water samples were collected and analyzed for arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, silver, tin, and zinc. The majority of the samples collected within the study area were gathered as part of the COJ's monitoring programs. For several of the parameters, such as nickel, silver, copper, lead, and mercury, the detection limit was above the standard. For some of the measurements, if the observation value was much higher than the Florida standard, these data could be used to determine if the criteria were exceeded. However, it is also possible that some of the measurements recorded as non-detects actually exceeded the Florida surface water classifications for predominantly marine waters (FAC 62-302.530).

Analysis of the data revealed several stations within the study area that exceeded the applicable criteria for a number of metals including cadmium, iron, lead, mercury, nickel, and copper. Three of the stations, TIM8, TIM9A, and TIM10, are located near Sister's Creek (ICWW), which experiences heavy boat traffic. The stations that exceeded the Florida water quality standards for more than one parameter are listed in **Table 21**.

With the exceptions of the JAX stations, the data were collected over a relatively short time period (1999-2000) and generally included one or two measurements for each station.

The JAX station data were collected from 2000 to 2003. For the majority of the parameters, the exceedances occurred during 2000; since that time, the levels were generally below the detection limits. According to the SJRWMD, these samples were analyzed by a different laboratory (L. McCloud, SJRWMD, pers. comm.). Subsequent investigation did not reveal any problems with the analyses, but these results should be interpreted with caution as they are not consistent with data trends (L. McCloud, SJRWMD, pers. comm.) Exceedances occurring after 2000 include copper at Stations JAXSJR04 and JAXSJR09. These data coupled with the impairments of the SJR indicate that metals pose a potential threat to TIMU's water quality.

Table 21. Metals of concern at stations sampled within study area surrounding Timucuan Ecological and Historic Preserve.

Station ID	Metals of Concern
JAXSJR01	Cadmium, chromium, copper, lead, nickel
JAXSJR04	Cadmium, copper, iron, lead, and nickel
JAXSJR09	Cadmium, copper, nickel, and lead
TIM1	Copper and iron
TIM2	Copper, iron, and mercury
TIM5	Iron and lead
TIM7	Iron and lead
TIM8	Iron and lead
TIM9A	Copper and mercury
TIM10	Copper, iron, and lead

A joint health advisory has been issued by Florida, Georgia, North Carolina and South Carolina for high levels of mercury in large king mackerel[5] (FDOH, 2004). This updates a previous advisory in Florida and extends the advisory along the northern Atlantic coastline from the Flagler-Volusia county line to the Georgia-Florida state line. This advisory now affects the entire coastline of the state including both the Gulf of Mexico and the Atlantic Ocean. King mackerel samples from the north Florida region of the Atlantic contained mercury above the standards of the health advisory guidelines (FDOH, 2004). Mercury levels in the SJR have indicated possible health risks to individuals who consume fish from the river (Beason et al., n.d.). Between 1983-1984, prominent species, such as spotted sea trout (*Cynoscion nebulosus*), striped mullet, croaker, spot, and blue crab (*Callinectes sapidus*) were obtained from the LSJR to determine mercury levels (Beason et al., n.d.). The study noted an increase in mercury levels in the fish from 1983 to 1984 and encouraged further water quality monitoring due

[5] King Mackerel less than 33 inches fork-length (from nose to where the tail forks) is safe to eat, but King Mackerel over 39 inches should not be eaten. People should limit their consumption of 33 to 39 inch fish. Women of child bearing age and children age 12 and under should eat no more than one eight-ounce portion a month and other adults should eat no more than four eight-ounce portions a month.

to the industrial activities in the area and natural weathering (Beason et al., n.d.). There is a statewide advisory due to elevated mercury levels in sharks as well as an advisory for Moncrief Creek and the consumption of mullet due to PCBs (FDEP, 2002b).

<u>Algal Blooms</u>

<u>Lower St. Johns River Basin</u>

Historically, many of Florida's coastal systems have experienced harmful algal blooms (HABs). HABs are the rapid growth of a harmful algal species that contains toxins or a species that negatively affects humans or natural resources. Red tides can be carried up the Atlantic Coast in strong flows of warm water from the Gulf Stream. Nutrients and organic matter enrichment stimulate the growth of marine dinoflagellate algal species such as *Karolina breve* (red tide) and *Prorocentrum minimum*. The toxin produced by *Karolina breve* is also transported by wind and can lead to respiratory irritation in humans. These tides can appear red, green, brown, purple, or have no color associated with them. No fish kills were attributed to red tide in Duval and Nassau Counties between 1993 and 2003 (FWCC, 2005a).

A previously unidentified dinoflagellate, *Cryptoperidineopsis brodii*, was identified in the mid-1990s in the mesohaline sediments of the LSJR (FDEP, 2004b). Dinoflagellate infections have been proposed as a factor in the ulcerative disease syndrome that affected the LSJR for much of the early 1990s (Hendrickson et al., 2003). This algal species produce a toxin that may affect the central nervous systems of fish, leading to fish kills.

Recent research has focused on *Pfiesteria piscicida* and other related dinoflagellate species, called PLS, and their associations with fish kills and fish skin lesions. *Pfiesteria piscicida* has not been found in the LSJR; however, PLS species have been reported in the LSJR in low numbers (Burkholder and Glasgow, 1997a; 1997b).

Algal blooms composed primarily of blue-green species have also been noted in the LSJR, especially in the freshwater regions. DeMort and Bowman (1985) conducted monthly phytoplankton sampling from January 1975 through January 1997 at seven stations in the lower reaches of the SJR (FDEP, 2004b). They found that the number of diatom species decreased and the numbers of Chlorophyta and Cyanophyta increased as the salinity decreased (FDEP, 2004b). Dominance changes seasonally with an increase in phytoplankton populations during the summer months. Algal densities and dominance also vary along the length of the LSJR (FDEP, 2004b).

An exotic blue-green alga called *Cylindrospermopsis raciborskii* has also been found in Florida waters. There is uncertainty regarding the true classification of this species. It is of particular concern because it is exotic with a wider distribution than expected (FDEP, 2004b). Little is known about this species, including the long-term effects of its toxin (FDEP, 2004b). Its presence is often overlooked because it does not form the surface scums commonly associated with blue-green algal blooms (FDEP, 2004b). It has been found throughout the main stem of the SJR at relatively high concentrations, though not at levels considered blooms (more than 500 algal cells per 100 mL of water). Often, *C. raciborskii* is found with *Microcystis* spp. and *Anabaena* spp. (FDEP, 2004b).

Sediment Quality

When assessing the overall water quality of waterbodies, one must also consider the sediment quality. Generally, water chemistry can change fairly rapidly, while sediments can accumulate pollution over time and indicate a history of contamination (Durell et al., 1998). Polluted sediments can impact biota by exerting acute and/or chronic toxic effects directly to organisms, degrading the habitat required for biological processes, or increasing the potential for bioaccumulation, which can ultimately affect human health (Keller and Schell, 1993; MacDonald, 1994). The *National Coastal Condition Report II* (USEPA, 2004c) calculated a sediment quality index using three indicators: sediment toxicity, sediment contaminants, and sediment TOC. Estuarine areas near Jacksonville and the LSJR are classified as poor (sediment quality and TOC), undetermined (sediment toxicity), and good (sediment contaminants) (USEPA, 2004c).

The sediments in the SJR are generally classified as fine-textured silts and clays, high in moisture and poorly sorted (Keller and Schell, 1993). To account for differences in the tendency of sediments to accumulate organic matter, sediment data are normalized to TOC and/or grain size (Keller and Schell, 1993; Seal et al., 1994). Tributary sediments have high organic content, making them accumulators for organic contaminants such as PAHs, phthalates, PCBs, and chlorinated pesticides (DDT, benzene hexachloride, and chlordane) (Keller and Schell, 1993). Sediments high in TOC can reduce the bioavailability of contaminants in the water column due to adsorption; however, this can negatively affect benthic organisms (NPS, 1996b).

Metals data must be normalized to background levels of aluminum to determine contamination in sediments (MacDonald, 1994). Aluminum levels are usually highest in unaffected sediments because they are not influenced by anthropogenic activities (Keller and Schell, 1993). Metal enrichment due to human activities can be determined by comparing the ratios of selected metals to aluminum for impacted areas and relatively pristine environments (Keller and Schell, 1993).

Lower St. Johns River

Keller and Schell (1993) and the USACOE with the SJRWMD (1994) reviewed sediment characteristics and quality in the LSJR Basin. At the time of publication, there had been nine studies during the past decade that evaluated the degree of contamination of the LSJR sediments (Dames and Moore, 1983; Boehnke et al., 1983; Pierce et al., 1988; Savannah Laboratories and Environmental Services, 1988; Florida Department of Environmental Regulation (FDER), 1988; COJ, 1990a; Delfino et al., 1991; Hanson and Evans, 1991; and SJRWMD, 1993). Although there are a number of reports, few studies were comprehensive or dealt with the biological significance of the contamination, focusing instead on locating contaminated areas (Keller and Schell, 1993).

Durell et al. (1998) conducted a study to determine the current status of sediment quality in the SJR. Elevated concentrations of PAHs, PCBs, and toxic metals, including mercury, lead, arsenic, and silver, were found in the LSJR near Jacksonville. PAH concentrations at urban sites were not higher than most comparable U.S. locations; there were no obvious or dramatic hot spots (Durell et al., 1998). PCB levels were also comparable to other U.S. urban sites with some minor hot spots scattered throughout the watershed. The pesticides (DDT and chlordane) displayed a pattern indicative of localized sources and uses (Durell et al., 1998).

One of the stations near TIMU, Nassau River at U.S. 17, was unique because it was one of a few samples with PAHs of mostly petrogenic composition. PAHs of petrogenic origin enter the aquatic environment in a more soluble, bulk, or loosely bound form than pyrogenic PAH. This makes it more mobile and available for uptake and bioaccumulation (Durell et al., 1998). The study also identified the portion of the study area closest to TIMU as a possible hot spot for trace metal contaminants (Durell et al., 1998). In addition, the LSJR near Jacksonville displayed elevated concentrations of most contaminants, notably PAHs, PCBs, and toxic metals (Durell et al., 1998).

The LSJR sediments have been impacted by industrial and residential activities in the area. Several comprehensive studies have documented heavy metal and organic contamination of these sediments, particularly in the vicinity of Jacksonville (Keller and Schell, 1993; Seal et al., 1994). Alexander et al. (1993) generated historical profiles of metal accumulation for the LSJR and demonstrated that sediments are enriched in cadmium, lead, and zinc near Jacksonville. Enrichment factors are referenced to the upper 95% confidence interval of the metal vs. aluminum plots in the uncontaminated sediment database developed by Windom et al. (1989) and Schropp et al. (1990). This threshold was used "for greater statistical significance" (p.633) in the enrichment estimates (Alexander et al., 1993). These results are supported by the *Florida Sediment Atlas* (Seal et al., 1994) which stated that enrichment factors are greater than 1 for cadmium, lead, and zinc in almost all urban Florida coastal areas. Sediments were classified as "enriched" if the trace metal concentration was located above the upper 95% confidence limit on a plot of the trace metal of interest vs. aluminum (**Figure 33**) (FDEP, 1994). The enrichment factor is the ratio of the measured metal concentration to its maximum expected concentration in natural sediments (FDEP, 1994). For a given concentration of aluminum, the enrichment factor is calculated based on the following equation:

$$\text{Metal Enrichment Factor} = \frac{\text{Observed Metal Concentration } (\mu g\ g^{-1})}{\text{Maximum Expected Natural Metal Concentration } (\mu g\ g^{-1})}$$

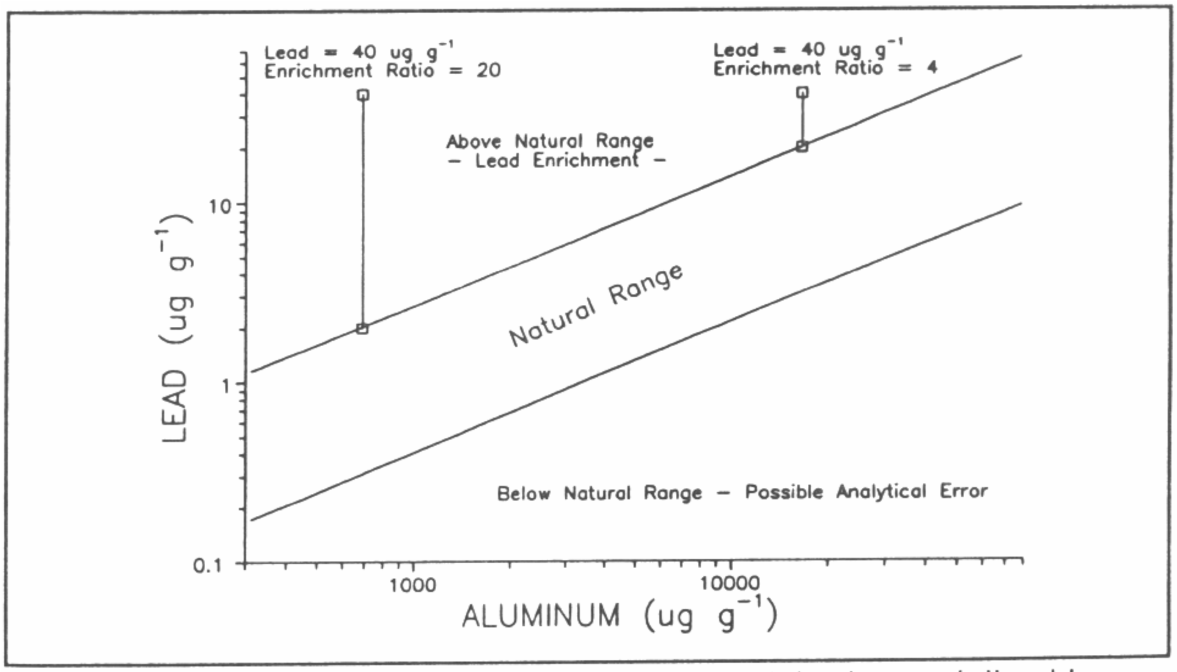

Figure 33. Interpretation of enrichment factor using lead/aluminum relationship.

Figure obtained from FDEP, 1994.

In addition to the industrialized areas, the greatest areas of sediment contamination are located in the freshwater and saltwater mixing zones (NPS, 1996b). Metals are present at levels that have adversely affected biota elsewhere, indicating that the faunal communities of the LSJR basin may also be affected (NPS, 1996b). Keller and Schell (1993) state that "toxicity tests and surveys of biological communities are the only ways to assess actual impacts because significant portions of sediment metals may be bound to sulfides, hydroxides, or oxides and, therefore, may be biologically inert" (p. 45).

A benthic macroinvertebrate survey of the LSJR and its tributaries found morphological deformities in chironomid menta (teeth) (Evans and Higman, 2001). The deformities were observed at 11 of 20 sites, affecting *Chironomus* spp. and *Coelotanypus concinnus* (Evans and Higman, 2001). The highest numbers of affected larvae were collected at Cedar River, at the mouth of Little Fish Weir Creek, Ortega River, and Julington Creek (Evans and Higman, 2001). Elevated metal concentrations, particularly lead and copper, can cause such deformities and some organic compounds are hypothesized to have similar effects (Janssens de Bisthoven et al., 1992; Warwick, 1980). A supplemental report benthic macroinvertebrate survey was conducted from October 2002 through August 2003 (Evans et al., 2004). In this survey, morphological deformities were observed at 10 of the 20 sites. The number of chronomid deformities decreased with increasing salinity, most likely due to the fact that the chronomid larvae (*Coelotanypus* and *Djalmabatista*) prefer freshwater environments (Evans et al., 2004). The site located in Clapboard Creek was 100% dominated by salt-tolerant organisms and displayed low sediment hazard risk based on a composite benthic sediment quality index (Evans et al., 2004).

Timucuan Ecological and Historic Preserve

Sediment quality within the TIMU boundary has generally showed little to no metal or organic contamination (NPS, 1996b). However, samples from Chicopit Bay obtained as part of the National Status and Trends Program (NOAA, 1988) exhibited concentrations of arsenic, chromium, lead, and zinc above the "no observed effects level" established by the FDER (NOEL). The NOEL is the highest concentration at which no detrimental impact on biota is expected. Another critical concentration is the "probable effects level" (PEL), which represents the concentration at which a contaminant is likely to exert a negative impact on biota. Organic contaminants were also detected at both SJR estuary sampling sites that were part of the NOAA study (1988). Based on comparison with 212 coastal sites, Chicopit Bay had the 17th highest level of PCB contamination (384 μg/kg) (NOAA, 1988).

These results are supported by the findings of O'Connor and Beliaeff's (1996) mollusk study. Based on eight years of data, the Chicopit Bay area was one of 21 coastal locations since 1990 that demonstrated increasing trends for pollutants, in this case, arsenic. There may be a natural explanation for these observations. High levels of arsenic in the southeastern U.S. have been observed due to phosphate deposits in the region (Vallette-Silver et al., 1999). The site also showed multiple years of high levels of selenium and butyltin compounds (O'Connor and Beliaeff, 1996).

Sediment quality is also an important issue when mechanisms that will resuspend sediment, such as dredging or construction, may occur. Two creeks within TIMU, Cedar Point and Hannah Mills Creeks, were impounded in the 1920s during the construction of Hecksher Drive. Hannah Mills Creek was completely blocked and Cedar Point Creek had a 91-cm (36-in) culvert placed to connect it with the SJR (Bryant and Fox, 2003). If the creeks are opened, the sediment that has accumulated can move into the SJR as well as any contaminants sorbed to the sediment. This sediment has received stormwater runoff from the roads, which may contain large quantities of heavy metals and PAHs (Bryant and Fox, 2003). These contaminants could negatively affect organisms in the system; however, this may not be significant compared to the high levels of contamination found at several sites in the SJR (Keller and Schell, 1993).

To determine if the sediments and oysters near Hecksher Drive contain greater quantities of contaminants compared to sites further from the roadway, samples were obtained from 12 locations for sediment and 17 for oysters (Bryant and Fox, 2003). The sediment sampling sites were concentrated in the area of Sisters Creek (ICWW), Clapboard Creek, White Shell Bay, and in the creeks at varying distances from Hecksher Drive. The oyster sampling sites were the same with the addition of sites near the Nassau River, Browns Creek, Fitzpatrick Creek, and the Fort George River (Bryant and Fox, 2003).

The results did not show that heavy metal and PAH levels were higher adjacent to Hecksher Drive in the sediment or the oysters (Bryant and Fox, 2003). However, there was some evidence that sediment PAH levels were slightly higher immediately adjacent to the road in Hannah Mills Creek (Bryant and Fox, 2003). Generally, the sites located in the creeks with direct connection to the SJR had higher PAH values than those closed off by the causeways. No trends were evident in the metal contamination data for the sediments (Bryant and Fox, 2003).

The metal levels measured at three sites, Pumpkin Hill Creek, Marker 67 (ICWW), and the confluence of the Nassau River and ICWW, were consistently higher than those found at most of the oyster sites for eight of the 10 metals tested (Bryant and Fox, 2003). The arsenic levels at these sites were an order of magnitude higher when compared to the other fourteen sites (Bryant and Fox, 2003). These results indicate that the impoundment of these creeks did not create a large amount of contaminated sediments that threaten the water quality of TIMU (Bryant and Fox, 2003). Graham (1999) suggested that the source of these sediments was the collapse of marsh banks, rather than the SJR; therefore, reopening these creeks may not contribute a concentrated source of contaminants.

In 1993, three sites located in Spanish Pond were sampled to determine the sediment levels of numerous heavy metals and organic pollutants (**Figure 34**). None of the organic pollutants (PCBs, DDT, chlordane, and dieldrin) were present at detectable levels. Morton and Marchman determined that the sediments were moderately contaminated (lead and zinc) and adverse biological impacts could not be eliminated from consideration (cited in NPS, 1996b). Stormwater runoff is the most likely cause of the high levels of lead and zinc because they are common components of stormwater runoff. However, these samples were obtained over 10 years ago, follow-up sampling should be completed to ascertain whether contamination exists, and if so, the extent of the contamination.

The FDEP developed an interpretive tool in 2002 to provide information on metals enrichment in freshwater sediments. The tool normalizes the sediment metals concentrations to aluminum and iron concentrations to determine the impacts of anthropogenic activities (FDEP, 2004c). It allows users to determine if freshwater sediment metals concentrations are above anticipated natural concentrations (FDEP, 2002a). To accompany the tool, a document entitled *Interpretive Tool for the Assessment of Metal Enrichment In Florida Freshwater Sediment* (FDEP, 2002a) was released.

Additional data on contaminants, such as hydrocarbons, organic pollutants, pesticides, and metals, are available from the EMAP. The National Coastal Assessment (NCA) is the coastal and estuarine sampling conducted as part of EMAP. It includes all of the EMAP stations sampled since 1990 in addition to the Regional EMAP studies completed by the regional EPA offices. Five stations located within the study area were sampled from 1993 to 1995 as part of EMAP and NCA. These stations are located in the Nassau River (CP93NAS), Nassau Sound (CP94018), South Amelia River (CP95170), and two in the SJR (CP94JAC and CP95171) (**Figure 35**). The results from the sampling are discussed in two reports (Hyland et al., 1996; 1998), which provide a summary of the ecological conditions of estuaries of the Carolinian Province (extends from Virginia to Florida). The sampling conducted as part of this program is intended to determine

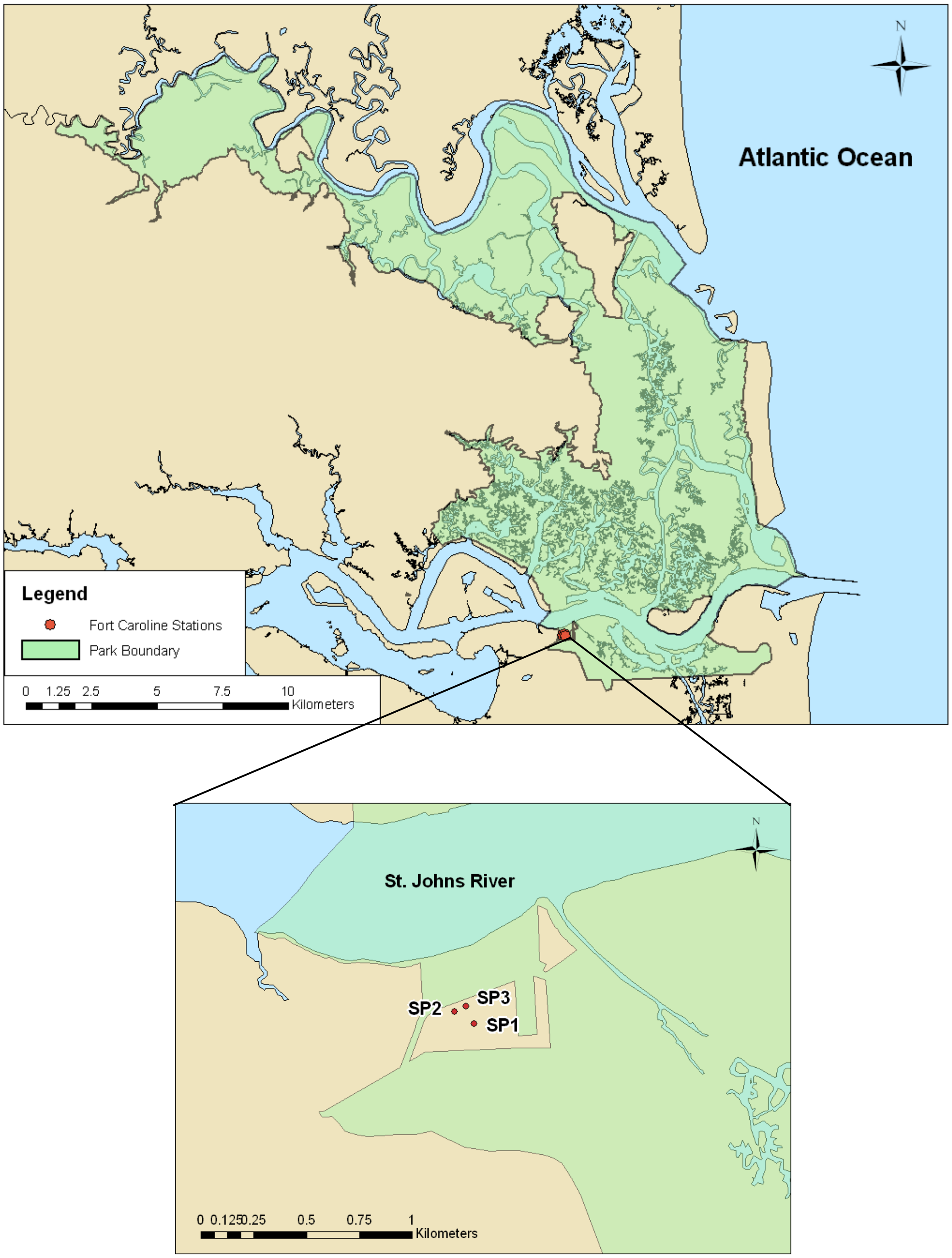

Figure 34. Locations of Stations SP1, SP2, and SP3 (Spanish Pond) in Timucuan Ecological and Historic Preserve.

(Data Sources: Stations – USEPA, 2005a; Park Boundary – NPS (1:24,000), 1999; County – FDEP (1:24,000), 1997) probability-based estimates of the percent area of degraded and nondegraded estuaries across the region (Hyland et al., 1996). Therefore, the data's ability to provide detailed information on the pollutant sources and distribution within individual estuarine systems is limited (Hyland et al., 1996).

The EMAP stations in the South Amelia River (CP95170) and Nassau Sound (CP94018) did not demonstrate any evidence of water or sediment quality degradation. The DO and pH levels were within normal ranges and there were no exceedances of bioeffect guidelines for selected aliphatic and aromatic hydrocarbons, PCBs, pesticides, or metals. Station CP95171 is located off the west side of Blount Island in the SJR. This station showed evidence of elevated levels of total PCBs and DDT. For both parameters, the concentrations were above the Effects Range-Low (ER-L) guidelines. At this site, arsenic also exceeded the ER-L and tributyltin was above the potential sediment toxicity level. The site was classified as degraded based on the mean infaunal diversity and abundance as well as the mean demersal richness, diversity, and abundance. In addition, toxicity effects were observed based on Microtox® toxicity[6] and *Mercenaria mercenaria*[7] tests.

The 1994 site located in the SJR (CP94JAC) was selected as a supplemental station. This station is located within TIMU boundary near Mile Point. Supplemental stations were sites selected non-randomly in areas for which there was "some prior knowledge of the ambient environmental conditions" (Hyland et al., 1996, p. 5). These sites included both pristine sites and those with histories of anthropogenic impacts. They were used to test the "discriminatory power of various ecological indicators" included in the program (Hyland et al., 1998, p. 5). Additional EMAP stations located in the LSJR are found in the Ortega (CP93ORT) and Trout Rivers (CP94017), Julington Creek (CP94016), and Doctors Lake (CP95172 and CP97172). The EMAP results indicate that there are some concerns regarding sediment quality in the LSJR near TIMU. The results also show that the degradation has impacted both benthic and demersal organisms. Additional data are needed to accurately characterize the system and the specific effects on TIMU's biota.

In addition to metals and organic contaminants, nutrients can also bind to sediments and alter the redox potential of the sediment-water interface. This change occurs because nutrients stimulate the growth of benthic algae and bacteria that generate or consume oxygen, changing the redox potential (NPS, 1996b). In addition, the solubility of sediment-bound metals also increases, thereby affecting the overlying water column (NPS, 1996b). Due to the shallow and slow-moving nature of the LSJR, the upward flux of nutrients from the sediments makes up a significant portion of the bioavailable nutrient load at certain times of the year (Magley and Joyner, 2004).

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[6] Significant Microtox® toxicity: $EC_{50} \leq 0.2\%$ if sediment silt-clay content ≥ 20%. EC_{50} – the sediment concentration causing a 50% reduction in light production by photoluminescent bacteria, *Vibrio fischeri*, relative to controls (nontoxic reagent blank).

[7] Significant *Mercenaria mercenia* toxicity: mean growth rate in test sediment significantly different than in control sediment (at $\alpha = 0.05$), and mean growth in test sediment < 80% of mean growth in control sediment.

Figure 35. Environmental Monitoring and Assessment Program (EMAP) and National Coastal Assessment (NCA) sampling stations, 1993-1995.

(Data Sources: EMAP Stations – USEPA, 2002b; Park Boundary – NPS (1:24,000), 1999; County – FDEP (1:24,000), 1997)

Malecki et al. (2004) quantified the flux of dissolved reactive phosphorus (DRP) and ammonium under aerobic and anaerobic conditions to estimate the contributions of the sediments to N and P loading of the LSJR. The study estimated that the mean annual internal DRP load was 330 metric tons (Mg) per year, 21% of the total P load to the river, while the mean annual internal load of ammonium was 2066 Mg, 28% of the total N load to the estuary (Malecki et al., 2004). The fluxes were much greater from the anaerobic cores for both parameters. The study concluded that as the external loads to the LSJR are reduced; the frequency of anaerobic events will decline, reducing the internal loading of DRP and ammonium. However, this internal loading must be considered in restoration efforts because it represents a significant portion of the nutrient load to the LSJR (Malecki et al., 2004).

Water Quality Impairments

The Clean Water Act (CWA) requires states to develop a list of waters not supporting their designated uses or not meeting water quality standards. This list is termed the 303(d) list after the section of the CWA it addresses. These lists are based on the 305(b) water quality assessment reports. These reports use all existing water quality related data, physical, biological, and chemical, to evaluate the state's surface waters, groundwater, and wetlands. For the assessment of Florida's waters, data were obtained from the USEPA STORET database, the Statewide Biological Database, and fish consumption advisory information. TMDLs must be developed for waters on the 303(d) list. A watershed-based management approach was employed to divide the state's 52 major hydrologic units into five basin groups which govern the rotation of TMDL development. The basins for TIMU are the Lower St. Johns River (Group 2) and Nassau/St. Marys (Group 4).

In 2002 and 2004, updates to the 1998 303(d) list were published with a list of water segments to be delisted. The 2002 report is limited to Group 1 Basins which does not include water segments applicable to TIMU. In May 2004, the verified lists of impaired waters for the Group 2 Basins, which includes the LSJR, were adopted. Also adopted was a list of waters proposed for delisting from the 1998 303(d) list. In July 2004, the FDEP published the *Integrated Water Quality Assessment for Florida: 2004 305(b) Report and 303(d) List Update*, which describes the state's surface and groundwater quality and trends. This report fulfills the reporting requirements of Sections 303(d) and 305(b) of the CWA and must be completed every two years. The information for the Nassau/St. Mary's Basin was provided by the draft verified list of impaired waters, which was released in July 2005.

In the following discussion of impairments, nearfield applies to waterbodies within the assessment units in the 3.2-km (2-mile) study area established around TIMU. A 3.2-km (2-mile) buffer was generated around the TIMU boundary and the FDEP assessment units intersecting the study area were considered nearfield impairments. The FDEP assessment units are subdrainages of larger drainage basins developed with the goal of delineating useable, small watersheds (approximately 13 km^2 or 5 $miles^2$) for water quality evaluation. The verified (or proposed for addition to the verified list) impaired waterbodies within the study area are shown in **Figure 36**. Farfield impairments include waterbodies located within the same 8-digit HUCs as TIMU.

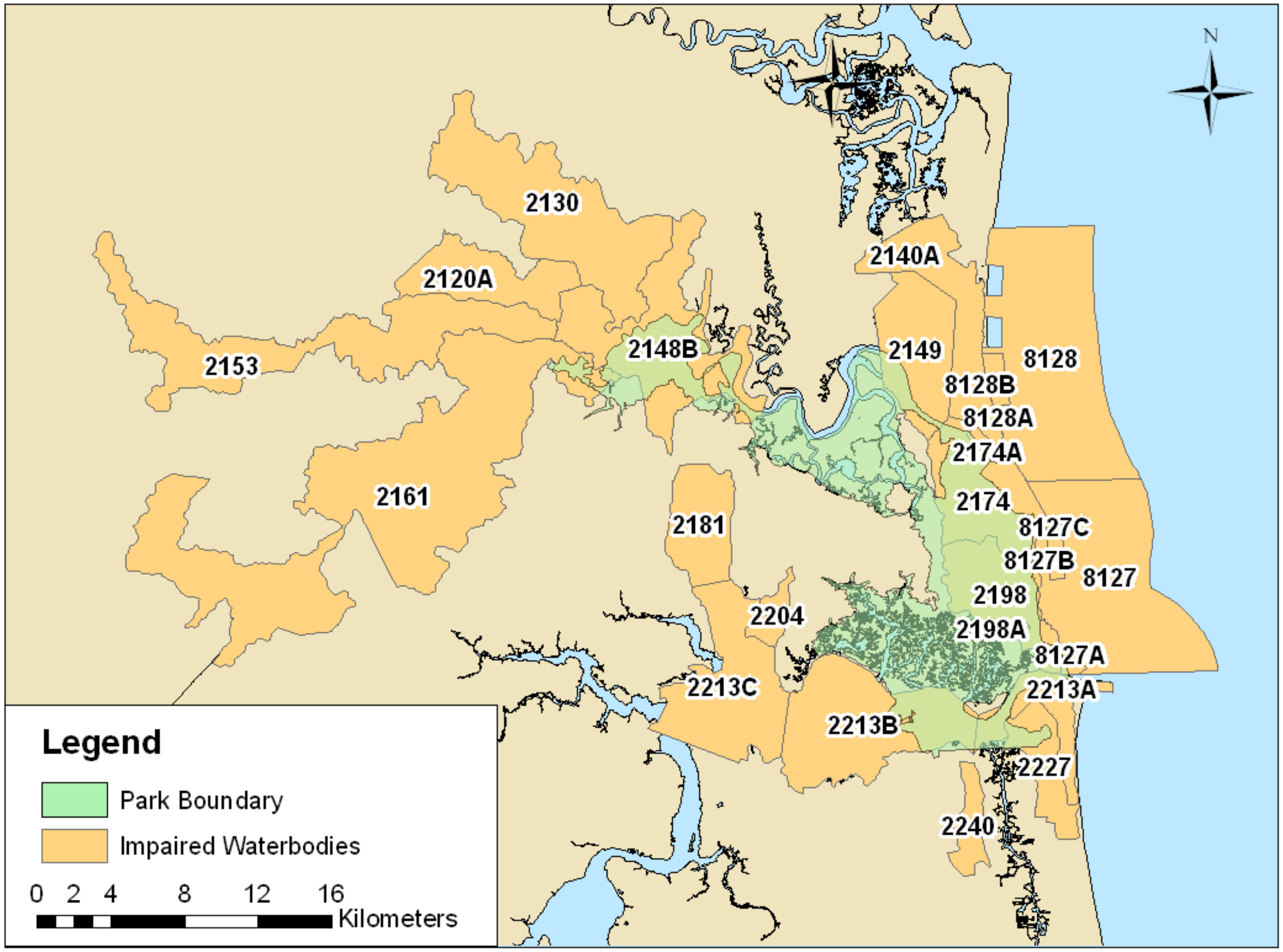
Nearfield Impairments in TIMU and Surrounding Estuarine Areas

TIMU is located in the LSJR (03080103) and Nassau River (03070205) HUCs (**Figure 2**). According to the verified list for the LSJR, there are eight impaired segments in the water basins within the study area established around TIMU (**Table 22**). Three of the segments are portions of the SJR, including the mouth, the ICWW, and Dames Point. The three segments are all impaired due to iron, copper, and nickel with an additional listing for lead in the ICWW segment. The other segments, with the exception of the Atlantic Coast entry, are urban creeks that are listed as impaired due to DO levels and fecal coliforms.

Generally, the water quality within TIMU is considered good, probably due to the high tidal flushing (Coffin et al., 1992; Hand et al., 1994). However, DiDonato et al. (2005) found that the tidal creeks near Kingsley Plantation were not well flushed. This conclusion was based on measurements recorded by a water-quality datalogger in the Fort George River at the Kingsley Plantation dock. The pH values fell in a narrow range over the recording period, 7.2 to 8.2, indicating that the system is well buffered and receives little freshwater input (DiDonato et al., 2005). DiDonato et al. (2005) also concluded that the freshwater flushing of tidal creeks was slow, on the order of months, based on variations in salinity following Hurricane Francis. Lack of flushing in the tidal creeks is an important consideration in water management decisions, as contaminants and nutrients that enter the system may remain for extended time periods. Upstream from the tidal influence, the water quality of the main stem of the SJR is poor and the tributaries feeding into the system has been classified as fair to poor (Hand et al., 1994). These tributaries are impaired for DO, biochemical oxygen demand (BOD), coliforms, and nutrients.

The master list of impaired water segments for the Nassau/St. Mary's Basin shows 18 verified segments that are located within the study area (**Table 23**). The impaired parameters are DO, coliforms, iron, chlorophyll, mercury, and biology. The listed segments include the South Amelia River, Nassau River, Nassau Sound, Nassau Sound (Ocean 1 and 2), Fort George River, Jackson Creek, Plummer Creek, Mills Creek, Marina Bay at Fort George, Alligator Creek, Thomas Creek, South End, Huguenot Park, South and North Little Talbot Island, Piper Dunes, and AIP Beach Club. Seven of the listings are for coliforms because of downgrades in shellfish harvesting classification. Nine of the listings are for mercury (in fish tissue) that requiring verification that data are within 7.5 years. In addition, there are four listings for DO, which include Mills, Plummer, Alligator, and Thomas Creeks. Mills, Alligator, and Thomas Creeks are the major freshwater creeks to the Nassau River. These tributaries drain approximately one half of the total basin (Coffin et al., 1992). The water quality of these creeks provides crucial information regarding the overall health of the Nassau River.

In the past, the Nassau River subdrainages typically have good water quality; however, Mills and Alligator Creeks have been considered moderately impaired from dairy farm runoff, failing septic tanks, and urbanization (NPS, 1996b). Nassau Sound has exhibited good water quality but degradation trends for nitrogen enrichment and overall water quality have been noted (Hand et al., 1994). Despite urbanization in some areas of the Nassau River basin, nonpoint sources (silviculture and agriculture) other than urban runoff are considered the primary sources of pollutants (NPS, 1996b).



WBID	Waterbody Segment Name
2120A	Mills Creek
2130	Plummer Creek
2140A	Jackson Creek
2148B	Nassau River
2149	South Amelia River
2153	Alligator Creek
2161	Thomas Creek
2174	Nassau Sound
2174A	South End
2181	Dunn Creek
2198	Fort George River
2198A	Marina Bay at Fort Geo
2204	Terrapin Creek
2213A	St. Johns River AB Mouth
2213B	St. Johns River AB ICWW
2213C	St. Johns River AB Dames Pt.
2227	Sherman Creek
2240	Greenfield Creek
8127	Nassau Sound Ocean 1
8127A	Huguenot Park
8127B	South Little Talbot Island
8127C	North Little Talbot Island
8128A	Piper Dunes
8128B	AIP Beach Club
8128	Nassau Sound – Ocean 2

Figure 36. Verified (or draft verified list) impaired waterbodies located within Timucuan Preserve study area.

(Data Sources: Impaired waterbodies – FDEP, 2005; Park Boundary – NPS (1:24,000), 1999; County – FDEP (1:24,000), 1997)

Table 22. Impaired waters within Timucuan Ecological and Historic Preserve study area based on Lower St. Johns River Basin verified list.

Basin Group Name	WBID	Waterbody Segment Name	Parameters Assessed Using the Impaired Waters Rule	Concentrations Causing Impairment[1]	Priority for TMDL Development[2]	Projected Year for TMDL Development[2]	Comments[3] (# Exceedances/ # Samples) PP= Planning Period VP= Verified Period
Lower St. Johns River	2181	Dunn Creek	Fecal coliforms	> 400 colonies per 100 ml	Medium	2008	PP - 26/58 Potentially impaired; VP - 14/39 Verified
Lower St. Johns River	2204	Terrapin Creek	Dissolved oxygen	< 5.0 mg/l	Medium	2008	PP - 17/52 Potentially impaired; VP - 20/53 Verified Linked to elevated TN, TP, and BOD during the PP (9.34, 0.33 mg/l, and 5.0 mg/l, respectively).
Lower St. Johns River	2204	Terrapin Creek	Fecal coliforms	> 400 colonies per 100 ml	Medium	2008	PP - 21/29 Potentially impaired; VP - 19/28 Verified
Lower St. Johns River	2213A	STJ River AB Mouth	Iron	> 0.3 mg/l	Medium	2008	PP - 5/13 Potentially impaired; VP - 10/33 Verified
Lower St. Johns River	2213A	STJ River AB Mouth	Copper	>3.7 ug/L	Medium	2008	PP - 9/13 Potentially impaired; VP - 9/33 Verified
Lower St. Johns River	2213A	STJ River AB Mouth	Nickel	> 8.3 ug/l	Medium	2008	PP - 16/18 Potentially impaired; VP - 14/35 Verified
Lower St. Johns River	2213B	STJ River AB ICWW	Copper	> 3.7 ug/l	Medium	2008	PP - 15/25 Potentially impaired; VP - 13/34 Verified
Lower St. Johns River	2213B	STJ River AB ICWW	Iron	> 0.3 mg/l	Medium	2008	PP - 9/27 Not impaired; VP - 24/62 Verified
Lower St. Johns River	2213B	STJ River AB ICWW	Lead	> 5.6 ug/l	Medium	2008	PP - 14/26 Potentially impaired; VP - 10/20 Verified
Lower St. Johns River	2213B	STJ River AB ICWW	Nickel	> 8.3 ug/l	Medium	2008	PP - 27/29 Potentially impaired; VP - 20/22 Verified
Lower St. Johns River	2213C	STJ River AB Dames Point	Copper	> 3.7 ug/l	Medium	2008	PP - 19/22 Potentially impaired; VP - 22/30 Verified
Lower St. Johns River	2213C	STJ River AB Dames Point	Iron	> 0.3 mg/l	Medium	2008	PP - 16/32 Potentially impaired; VP - 29/69 Verified
Lower St. Johns River	2213C	STJ River AB Dames Point	Nickel	> 8.3 ug/l	Medium	2008	PP - 27/31 Potentially impaired; VP - 24/28 Verified
Lower St. Johns River	2227	Sherman Creek	Dissolved oxygen	< 5.0 mg/l	Medium	2008	PP - 73/152 Potentially impaired; VP - 51/119 Verified Believed linked to elevated TP levels in both the PP and VP.

Basin Group Name	WBID	Waterbody Segment Name	Parameter Assessed Using the Impaired Waters Rule	Concentrations Causing Impairment[1]	Priority for TMDL Development[2]	Projected Year for TMDL Development[2]	Comments[3] (# Exceedances/ # Samples) PP= Planning Period VP= Verified Period
Lower St. Johns River	2227	Sherman Creek	Fecal coliforms	> 400 colonies per 100 ml	Medium	2008	PP - 57/85 Potentially impaired; VP - 25/58 Verified
Lower St. Johns River	2240	Greenfield Creek	Fecal coliforms	> 400 colonies per 100 ml	Medium	2008	PP - 28/75 Potentially impaired; VP - 9/40 Verified
Lower St. Johns River	8998	Florida Atlantic Coast	Mercury (fish)	> 0.5 ppm	Low	2011	Statewide coastal mercury advisory issued for king mackerel, spotted seatrout, and shark in 2002. Advisory applies to WBIDs 8126 and 8126A - 8126G.

[1]Concentrations for nutrients represent median values; mercury in fish represent mercury advisory levels in fish tissue; criteria for hardness based metals are based upon total hardness (H) expressed as mg/L of CaCO3.

[2]Where a parameter was 1998 303(d) listed, the priority shown for it in the 1998 303(d) list was retained (high or low). Where a parameter was only identified as impaired under the Impaired Waters Rule (IWR), priorities of high, medium, or low were used. Waterbodies where mercury (in fish tissue) has been identified as impaired under the IWR, have been given a medium priority and a TMDL is scheduled for 2011.

[3] PP - Planning period (1/1991 - 12/2000); VP - Verified period (1/1996 - 6/2003).

Assessment based on IWR Run 14.2.

Table 23. Impaired waters within Timucuan Ecological and Historic Preserve study area based on Nassau/St. Mary's Basin draft verified list.

Planning Unit Name	WBID	Water Segment Name	Parameter Assessed Using Impaired Waters Rule	Priority for TMDL Development	Projected Year for TMDL Development[1]	Comments[2] (# Exccedances/ # Samples) PP = Planning Period VP = Verified Period
Nassau River	2174	Nassau Sound	Shellfish (coliforms)	Medium	2010	Verified due to downgrade in shellfish harvesting classification.
Nassau River	2120A	Mills Creek	Dissolved Oxygen	Medium	2010	One value from PP - 8.5 mg/L. VP - 16/23 exceedances, VP Median = 3.7 mg/L, VP minimum = 0.4 mg/L, VP maximum = 7.1 mg/L, VP Average = 3.68, Data from 2003 - 2004. Need to identify causative pollutant. Nutrients below threshold levels, no BOD data. May be moved to planning list if no causative pollutant can be identified.
Nassau River	2130	Plummer Creek	Dissolved Oxygen	High	2005	PP - 22/24 Exceedances, PP Median = 2.7 mg/L, PP Minimum = 0.5 mg/L, PP Maximum = 6.8 mg/L, PP Average = 2.76 mg/L, Data from 1998-1999. VP - 39/55 Exceedances. VP Median = 2.9 mg/L, VP Minimum = 0.5 mg/L, VP Maximum = 10.1 mg/L, VP Average = 3.61 mg/L, Data from 1998, 1999, 2003, 2004. Causative pollutant expected to be BOD- PP Median = 1.00 mg/L, PP Minimum = 1.00 mg/L, PP Maximum = 4.00 mg/L, PP Average = 1.53 mg/L, PP N = 15, Data from 1993, 1994. No data from VP.
Nassau River	2130	Plummer Creek	Biology	Medium	2010	One biorecon score from 1998 was "impaired;" Two SCI's from 1999 were "poor." Suspect DO to be a causative pollutant.
Nassau River	2140A	Jackson Creek	Shellfish (coliforms)	Medium	2010	Verified due to downgrade in shellfish harvesting classification.
Nassau River	2148B	Nassau River	Chlorophyll (Historical)	High	2005	Chlorophyll increased > 50% over background (2.87 µg/L - years 1992 - 1996) in 1999 (7.51 µg/L), 2000 (6.33 µg/L) and 2001 (6.27 µg/L).
Nassau River	2148B	Nassau River	Iron	Medium	2010	PP - 87/96 Exceedances, PP Average = 809 µg/L, PP Median= 722 µg/L, PP Maximum = 1960 µg/L, PP Minimum = 102 µg/L, Data from 1994 - 1999. VP - 39/43 Exceedances, VP Average = 683 µg/L, VP Median = 550 µg/L, VP Maximum = 1750 µg/L, VP Minimum = 5.4 µg/L, Data from 1998-2003.

Planning Unit Name	WBID	Water Segment Name	Parameter Assessed Using Impaired Waters Rule	Priority for TMDL Development	Projected Year for TMDL Development[1]	Comments[2] (# Exccedances/ # Samples) PP = Planning Period VP = Verified Period
Nassau River	2149	South Amelia River	Shellfish (coliforms)	Medium	2010	Verified due to downgrade in shellfish harvesting classification.
Nassau River	2149	South Amelia River	Mercury (in fish tissue)	Low	2011	Need to verify data are within 7.5 years for verification.
Nassau River	2153	Alligator Creek	Dissolved Oxygen	High	2005	VP - 12/36 Exceedances, VP Median = 6.15 mg/L, VP Average = 5.89 mg/L, VP Minimum = 0.3 mg/L, VP Maximum = 10.7 mg/L, Data from 2001, 2003, 2004. Need to identify causative pollutant. If no causative pollutant can be identified, then may be moved to planning list.
Nassau River	2153	Alligator Creek	Total coliforms	Medium	2010	(#/100 ML) VP - 7/23 Exceedances, VP Median = 720, VP Average = 1,870, VP Minimum = 280, VP Maximum = 7,400, Data from 2001, 2004
Nassau River	2161	Thomas Creek	Dissolved Oxygen	Medium	2010	VP - 29/47 Exceedances, VP Median = 4.87 mg/L, VP Average = 4.86 mg/L, VP Minimum = 0.3 mg/L, VP Maximum = 11.53 mg/L. Data from 1998-2002. Need to identify causative pollutant. If no causative pollutant can be identified, then may be moved to planning list.
Nassau River	2174A	South End	Shellfish (coliforms)	Medium	2010	Verified due to downgrade in shellfish harvesting classification.
Nassau River	2198A	Marina Bay at Fort Geo	Shellfish (coliforms)	Medium	2010	Verified due to downgrade in shellfish harvesting classification.
Nassau Sound	8127A	Huguenot Park	Mercury (in fish tissue)	Low	2011	Need to verify data are within 7.5 years for verification.
Nassau Sound	8127B	South Little Talbot Island	Mercury (in fish tissue)	Low	2011	Need to verify data are within 7.5 years for verification.
Nassau Sound	8127C	North Little Talbot Island	Mercury (in fish tissue)	Low	2011	Need to verify data are within 7.5 years for verification.
Nassau Sound	8128A	Piper Dunes	Mercury (in fish tissue)	Low	2011	Need to verify data are within 7.5 years for verification.
Nassau Sound	8127	Nassau Sound Ocean 1	Shellfish (coliforms)	Medium	2010	Verified due to downgrade in shellfish harvesting classification.

Planning Unit Name	WBID	Water Segment Name	Parameter Assessed Using Impaired Waters Rule	Priority for TMDL Development	Projected Year for TMDL Development[1]	Comments[2] (# Exccedances/ # Samples) PP = Planning Period VP = Verified Period
Nassau Sound	8127	Nassau Sound Ocean 1	Mercury (in fish tissue)	Low	2011	Need to verify data are within 7.5 years for verification.
Nassau Sound	8128	Nassau Sound Ocean 2	Mercury (in fish tissue)	Low	2011	Need to verify data are within 7.5 years for verification.
Nasau River	2198	Fort George River	Shellfish (coliforms)	Medium	2010	Verified due to downgrade in shellfish harvesting classification.
Nassau River	2174	Nassau Sound	Mercury (in fish tissue)			Need to verify data are within 7.5 years for verification.
Nassau Sound	8128B	AIP Beach Club	Mercury (in fish tissue)	Low	2011	Need to verify data are within 7.5 years for verification.

[1]Priorities were retained from the 1998 303(d) list (i.e. high or low), but high, medium, and low are used for newly listed waters identified under the impaired waters rule.
[2] PP = Planning period (January 1, 1993 – December 31, 2002); VP = Verified Period (January 1, 1998 – June 30, 2005).

Farfield Impairments in TIMU and Surrounding Estuarine Areas

Lower St. Johns River Basin

The LSJRB encompasses about 6,853 km^2 (2,646 mi^2) of northeast Florida (Foose, 1981), including the SJR and the land that drains to it from the confluence of the Ocklawaha River near Welaka north to the river's mouth at Jacksonville. The basin includes all or portions of the following counties: Volusia, Flagler, Putnam, St. Johns, Clay, and Duval. The 2004 verified list of impaired water segments lists 154 segments; however, as each row contains one parameter some of the segments are listed multiple times due to impairments for more than one parameter.

Due to the large size of the basin, it was divided into smaller sections to provide a smaller-scale geographic basis for assessment, reporting, and planning activities under the watershed management approach (FDEP, 2002b). The LSJRB contains 11 planning units: Crescent Lake, Etonia Creek, Black Creek, Deep Creek, Sixmile Creek, Julington Creek, Ortega River, Trout River, ICWW, South Main Stem, and North Main Stem (**Figure 37**). The units nearest to TIMU include the North Main Stem, Trout River, and the ICWW. The impairments for these units will be discussed in this section.

The majority of the segments in all three planning units are listed as impaired due to DO, fecal, or total coliforms. Most of the waterbodies in these units are urban tributaries susceptible to bacterial contamination from septic systems. In the North Main Stem unit, two segments of the SJR (AB Trout River and AB Warren Bridge) are impaired for copper, iron, and nickel. In addition, the Arlington River is listed for nutrients. In the Trout River unit, Moncrief Creek is listed for nutrients, copper, iron, lead, and fecal and total coliforms.

The water quality of the LSJR has been described as relatively good in the main stem from the mouth to downtown Jacksonville; however, several heavily polluted tributaries empty into the LSJR just before it turns from the north to the east (NPS, 1996b). This area of the SJR is known as the "bend" area in downtown Jacksonville. The river receives inputs from various industrial dischargers, urban/stormwater runoff, and polluted urban tributaries (Cedar and Trout Rivers, Strawberry, Pottsburg, and Moncrief Creeks) (NPS, 1996b). Cedar River has experienced frequent fish kills and been described as "having the worst water quality in the area" (NPS, 1996b). The river receives discharges from several wastewater facilities and wire and chemical industries (NPS, 1996b). Strawberry and Pottsburg Creeks exhibit poor water quality due to urban/stormwater runoff and wastewater treatment facility discharges (NPS, 1996b). Both creeks are listed as impaired for fecal coliforms; Strawberry Creek is also listed for total coliforms.

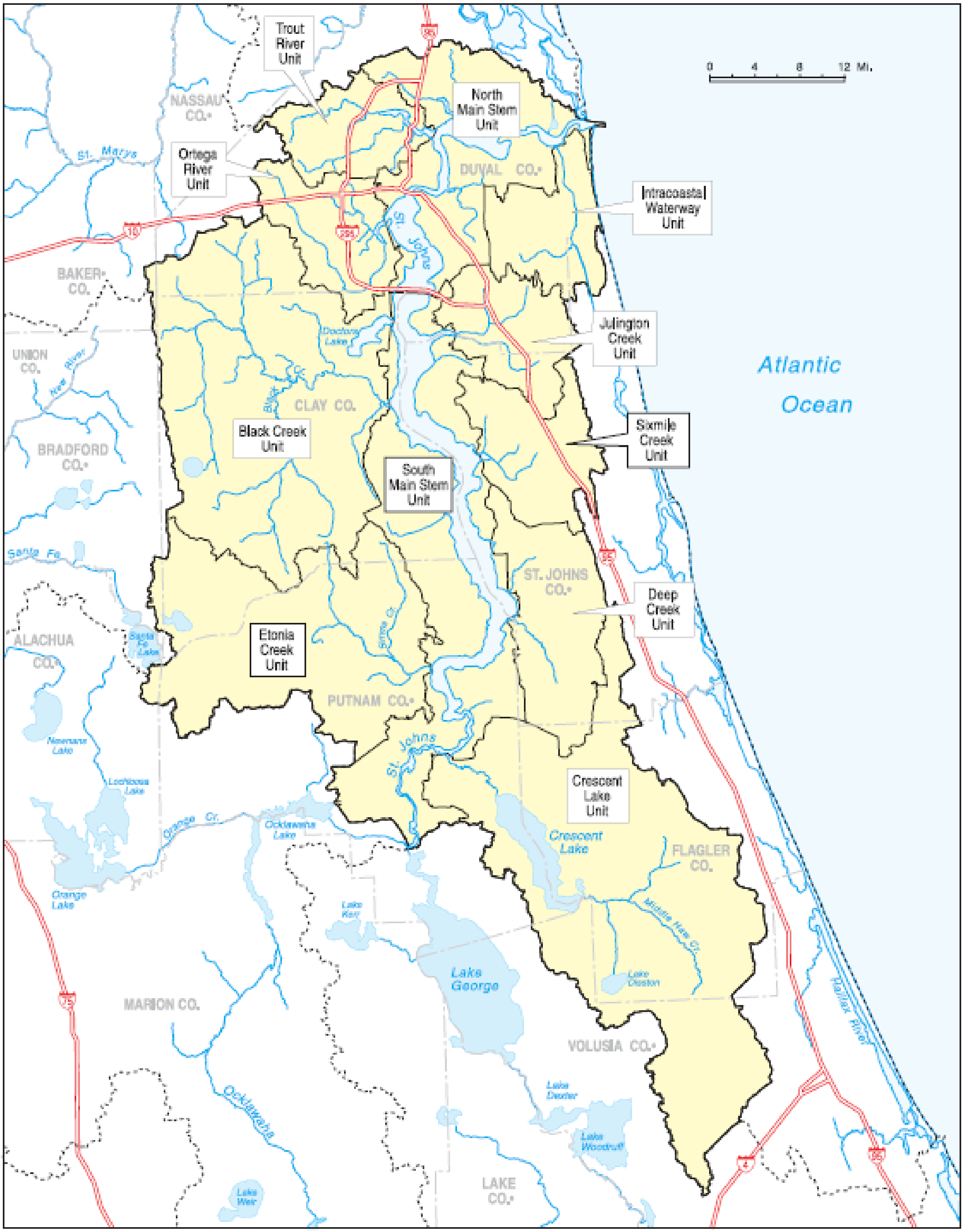


Figure 37. Locations of planning units in the Lower St. Johns River Basin.

(Figure obtained from FDEP, 2004b.)

Nassau/St. Mary's River Basin

Although TIMU is not located in the St. Mary's HUC, it has been included in this assessment because the basins are combined by the state of Florida. The segments placed on the draft verified list of impaired waters are the St. Mary's River (lower, middle, and upper), an Unnamed Branch, St. Mary's River (north and middle Prongs), Little St. Mary's River, Little Mill Creek, Deep Creek, Brandy Branch, Ocean Pond, American Beach, and Peter's Point. The segments are impaired for DO (upper, lower, middle prong, and north prong - St. Mary's River, Little Mill Creek, Deep Creek, Unnamed Branch), biology (Deep Creek and Brandy Branch), BOD (lower St. Mary's River), iron (middle prong - St. Mary's River), mercury (Ocean Pond, upper, lower, and middle prong – St. Mary's River, American Beach, Peter's Point), and coliforms (Unnamed Branch and Little Mill Creek).

Information about the St. Mary's River (03070204) HUC is also provided by the Georgia Environmental Protection Division (EPD). The *Saint Marys River Basin Management Plan 2002* was prepared based on water quality information collected from 1998-1999. The report lists five river/stream segments (164 km, 102 miles) that are partially supporting their designated uses. The listed concerns are DO levels and fish consumption guidelines. Four segments (40 km, 25 miles) were listed for not supporting their designated uses primarily due to DO levels (one segment also had a fecal coliform listing). Nonpoint sources were listed as the reason for all of the impairments and the EPD plans to form a watershed protection strategy. There was also one listing for an estuarine area, 7.8 km^2 (3 mi^2), because of a shellfishing ban due to industrial sources. The updated 2004 303(d) list contains much of the same information with a few changes. A segment of the St. Mary's River was added to the list of river/streams not supporting designated uses for DO. One of the segments impaired for DO was also listed for fecal coliforms on the 2004 list. The estuarine segment did not appear on the 2004 list, possibly due to an improvement in water quality.

Groundwater Quality

According to the USGS NWIS database (updated to September 2003), there are 21 wells located within the 3.2-km (2-mile) study area established around TIMU for data retrieval (**Appendix E**). The wells have water quality data, groundwater data (including levels), or both types of data associated with them. All of these wells with the exception of one (DS-522 Fort Caroline National Memorial) are completed in the Floridan aquifer system. The water quality parameters most frequently measured include hardness, chloride, and specific conductance. Other parameters analyzed less frequently were sulfate, iron, fluoride, sodium, potassium, silica, strontium, and color. The secondary drinking water standards utilized for this assessment are found in **Table 24**. Specific groundwater quality concerns are addressed in the following section.

The primary water quality concerns for the surficial aquifer include iron, hardness, septic tank leachate, and saltwater intrusion. Localized areas have demonstrated high concentrations of iron and high hardness. In a study conducted by Causey and Phelps (1978), seven of 13 test sites had iron concentrations greater than 0.3

Table 24. Secondary drinking water standards utilized for assessment of Timucuan Ecological and Historic Preserve.

Contaminant	Secondary Standard
Chloride	250 mg/L
Color	15 (color units)
Fluoride	2.0 mg/L
Iron	0.3 mg/L
pH	6.5-8.5
Total dissolved solids	500 mg/L
Sulfate	250 mg/L

Source: USEPA, 2005b.

mg/L. The hardness of the water samples ranged from 60 to 180 mg/L (Causey and Phelps, 1978).

Generally, chloride, sulfate, and total dissolved solids (TDS) are used as indicators of saline water in the surficial aquifer. Elevated chloride levels are caused by the intrusion of seawater or the migration of high salinity waters from below the aquifer into the aquifer through breaks in the confining beds (Toth, 1990). High sulfate concentrations are also associated with these conditions as well as the dissolution of minerals high in sulfate in slow moving water (Toth, 1990).

The chloride concentrations in TIMU are generally below 50 mg/L with the exception of the area along the eastern boundary near Fort George Island. In this region, overpumping of the surficial aquifer has led to chloride concentrations that are above 1,000 mg/L (NPS, 1996b). The upper and middle aquifers of the Floridan are generally low in chloride and sulfate; however, there are localized areas of elevated chloride and/or sulfate concentrations (chloride greater than 100 mg/L and sulfate greater than 150 mg/L) (Toth, 1990). The Floridan aquifer underlying Little Talbot Island has high concentrations of chloride and sulfate. Data recorded between 1964 and 1984 showed chloride concentrations greater than 50 mg/L and sulfate concentrations that ranged from 50 to 149 mg/L (Toth, 1990). Sulfate and TDS concentrations vary dramatically throughout the SJR aquifer system. TDS concentrations are generally below 500 mg/L in TIMU (NPS, 1996b).

Instances of saltwater contamination in the middle and upper Floridan aquifers are expected to increase as withdrawals reduce the potentiometric head of the aquifers (NPS, 1996b). This decrease in pressure draws water from below the aquifer through discontinuities (faults, fractures, collapse features, or poorly cased wells) in confining beds. An example of this occurrence is the Fort George Island Ribault club well. When the well was drilled in the 1920s or 1930s, it was placed on top of a fracture or other geologic anomaly. Saltwater migrated through higher permeability zones as a result of decreased pressure head caused by pumping or uncontrolled flow from artesian wells (Martin, 2004). This intruded saltwater then traveled laterally producing a bull's-eye pattern of increased chloride concentrations radiating out from the well site (NPS, 1996b). Chloride concentrations near the clubhouse area have exceeded 300 mg/L (Spechler, 1994). Samples from three wells located on Fort George Island (D-164 replacement well, D-164 J-228 golf course, and D-0913 J-1048) have demonstrated chloride levels above the secondary drinking water standard (250 mg/L) for chloride. The chloride concentrations from these wells were approximately 340-410 mg/L from 2003-2005. Only a few additional anomalies have been mapped in the Duval/Nassau County area. One extends in a north-south direction from the Nassau River and some collapse features are located along the St. Johns River (NPS, 1996b). Excessive groundwater pumping could produce similar results in other regions close to TIMU, such as Little and Big Talbot Islands (FDEP, 1998b).

These results are especially important because TIMU is investigating water supply options for a planned expansion of visitor facilities on Fort George Island. Park personnel consulted Michael Martin, a NPS hydrologist, to help determine if the existing well would be sufficient to meet the increased water demand associated with the development. Currently, there are three NPS-owned artesian wells on Fort George Island. The primary supply well for TIMU facilities is the Kingsley well which is finished in the Upper Floridan aquifer and discharges about 76 liters per minute (20 gpm) (Martin, 2004). There are 17 other wells located on the island that pump water from the Upper Floridan aquifer (Martin, 2004). Multiple wells have shown a distinct increase in salinity, there has been an increase in the area of contamination, although Kingsley plantation is not included in this area (Martin, 2004). This contamination will likely spread through the Upper Floridan aquifer, eventually reaching the NPS wells on the island (Martin, 2004).

Martin (2004) recommended a monitoring program to determine if there are any trends in salinization and/or head declines of the NPS wells. These data could be combined with an existing monitoring program the USGS is currently conducting which measures the chloride concentrations in a limited number of wells on the island. The report determined that the expansion should not contribute to the water quality threats if the discharge is limited to the free-flowing volume and appropriate conservation measures are taken (Martin, 2004). TIMU cannot implement these measures throughout the island due to ownership by other groups; however, to preserve water quality within TIMU, water withdrawals should be minimized and uncontrolled artesian flow from Upper Floridan aquifers restricted (Martin, 2004).

Sources of Pollutants

Point Sources

The majority of the point sources that threaten TIMU are located in the areas surrounding TIMU. The highest concentration of these sources is located southwest of TIMU near the city of Jacksonville. The point sources most relevant to TIMU's water quality are those located in Duval and southern Nassau Counties.

Superfund and National Priorities List (NPL)

The Superfund program was initiated in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act. This act was updated in 1986 by the Superfund Amendments and Reauthorization Act. Sites placed on the NPL are given high priority for remediation and evaluation because of potential health and environmental risks. The NPL is intended to guide the EPA in determining which sites warrant further investigation. There are seven sites associated with the NPL in Duval County and none in Nassau County. Five of the seven sites are currently on the NPL. One site (Cecil Field Naval Air Station) was partially deleted and another (Yellow Water Road Dump) was deleted from the NPL.

No NPL sites were located within the study area established for this report. However, there are NPL sites in Duval County, which may impact the water quality of TIMU, especially facilities where groundwater contamination has occurred. The contamination at these sites includes metals, PCBs, and other organic compounds. Detailed information about each site is included in **Table 25**. Additional information regarding the historic uses and sources of contamination are available at the USEPA's NPL website (http://www.epa.gov/superfund/sites/npl/fl.htm).

Table 25. National Priorities List sites located within Duval County.

Location	Site Name	EPA ID	Contaminants of Concern
Jacksonville	Whitehouse Oil Pits	FLD980602767	Heavy metals, semi-volatile and volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), chlorinated organics, and acids
Jacksonville	Pickettville Road Landfill	FLD980556351	VOCs, metals, and heavy metals (chromium and iron)
Jacksonville	Naval Air Station (NAS) Jacksonville	FL6170024412	PCBs, polyaromatic hydrocarbons, and heavy metals
Jacksonville Heights	Hipps Road Landfill	FLD980709802	Vinyl chloride, benzene, and other VOCs
Whitehouse	Coleman-Evans Wood Preserving Company	FLD991279894	Pentachlorophenol and dioxin
Jacksonville[1]	Cecil Field Naval Air Station	FL517002474	Chlorinated solvents, petroleum waste products, metals, and organics
Baldwin[2]	Yellow Water Road Dump	FLD980844179	PCBs

[1]Partially deleted from National Priorities List (NPL)
[2]Deleted from NPL
Source: USEPA, 2004b.

National Pollutant Discharge Elimination System (NPDES)

The NPDES program was initiated as part of the CWA to monitor point source discharges from industrial and municipal facilities. The USEPA maintains records of NPDES permit-holders and instances of enforcement. The FDEP maintains downloadable records of domestic, industrial, and stormwater NPDES facilities that are updated monthly. These records show that 78 domestic and industrial permits have been issued in Duval County and 13 in Nassau County. Details about each of these facilities are included in **Appendix F**. The facility types for both counties include industrial wastewater, domestic wastewater treatment plants (WWTPs), concrete batch general permits, and petroleum cleanup general permits (long-term).

Wastewater facilities discharging to the SJR are required to monitor for conventional pollutants such as TSS, carbonaceous biochemical oxygen demand ($CBOD_5$), and fecal coliforms (Jenkins, 1997). Although there are no numeric nutrient limits required by permit or law, nutrient levels are often monitored due to the potential negative effects on surface waters, such as eutrophication and algal blooms. Nutrient parameters that are measured include ammonia (NH_3), nitrate (NO_3), nitrite (NO_2), TKN, TP, and orthophosphate (Jenkins, 1997). The largest domestic dischargers to the surface waters of the LSJR are the COJ wastewater treatment plants: Buckman Street (52.5 (million gallons per day (MGD)), Arlington East (15 MGD), JEA District II (10 MGD), and Southwest District (10 MGD). JEA operates 11 large sewer plants in the Jacksonville area in addition to seven small plants which combined have a total capacity of 3.8 MGD (JEA, 2005). JEA also maintains two major grids of water treatment plants: the North and the South Grids. The North Grid is comprised of nine water treatment plants, while the South Grid is made up of 13 plants. There are also five smaller, hydraulically independent plants, which include Julington Creek Plantation, Marshview, Mayport, Ortega-Blanding, and San Jose (JEA, 2005).

The Neptune Beach (1.5 MGD) and Buccaneer WWTP (1.9 MGD) are located within the study area designated for this report. Additional plants located in close proximity to TIMU are the JEA District II, Arlington East, Atlantic Beach (3 MGD), and Buckman Street WWTP. Although the Buckman Street plant is located approximately 19.3 km (12 miles) upstream of TIMU, it discharges the greatest flow to the LSJR and, therefore, the highest nutrient load. It is a complete mix activated sludge wastewater facility consisting of bar screens, an aerated grit chamber, pre-aeration, primary and secondary clarification, chlorination, and dechlorination (Jenkins, 1997). The facility also has a large number of heavy industrial facility users (Jenkins, 1997). Improvement efforts include expanding the pretreatment monitoring program and evaluating reuse opportunities for some of the discharge (Jenkins, 1997).

All of the WWTPs were designed to remove $CBOD_5$, TSS, and fecal coliforms; however, recent concerns are focused on the increased nutrient loading to the LSJR and the effects of eutrophication on the system. The COJ, in a report published by CH2M Hill (*Conceptual Construction Cost Estimate to Upgrade Water Reclamation Facilities to Advanced Wastewater Treatment*), estimated that it would cost $145.6 million with increased annual operating costs of $4.1 million to provide advanced water treatment (AWT) to the city's five wastewater facilities (Jenkins, 1997). The effluent from AWT contains $CBOD_5$ of 5 mg/L, TSS of 5 mg/L, TN of 3 mg/L, and TP of 1 mg/L (Jenkins, 1997). Additional options that will lower nutrient levels and conventional pollutants with lower cost are also being considered.

Industrial facilities, such as power plants, pulp and paper mills, chemical plants, and manufacturing plants, also discharge to the LSJR. The pulp and paper mills and power plants generally discharge to surface water, while the majority of the chemical and manufacturing plants send process water to the publicly owned wastewater treatment facilities (FDEP, 2004b). Industrial NPDES dischargers of significance are the Stone Container Corporation (20 MGD), Anheuser-Busch, and the Jefferson Smurfit Corporation (currently on cold standby). In the 1990s, the Stone Container facility converted from a pulp and paper mill to a recycling mill which reduced the volume of discharge (Magley and Joyner, 2004). Many of the industrial facilities also discharge to percolation ponds and/or participate in reuse programs (FDEP, 2004b).

One site of interest in Nassau County is Rayonier, Inc. Rayonier's Fernandina Beach Mill is a dissolving sulfite pulp mill located on Amelia Island that began operation in 1939. In the early 1990s, while conducting bioassessment sampling of the Amelia River estuary, FDEP scientists noted a biological imbalance near the mill's discharge point. Elevated levels of ammonia were suspected of suppressing the phytoplankton populations in the area (FDEP, 2004a). Livingston et al. (2002) determined that biological responses in the Amelia Estuary, such as significantly lower phytoplankton numbers and species diversity compared to the Nassau Estuary, were most likely due to relatively high ammonia concentrations. Following the installation of new equipment and changes in chemical processes, there was an 85% reduction in the amount of ammonia discharged. The ammonia levels in the discharge were reduced from an average of 48 ppm in the early 1990s to an average of 10 ppm (FDEP, 2004a). Once the levels were reduced, the phytoplankton populations increased and a natural balance was achieved (FDEP, 2004a).

The largest NPDES dischargers are the city's power plants: JEA Northside, JEA Southside, and JEA Kennedy. The capacities of these facilities are 827, 358, and 222 MGD of cooling water, respectively (FDEP, 2004b). Two power plants are located close to TIMU, the SJR Power Park and the Northside Generating Station. The SJR Power Plant, put into service in 1987, uses coal and petroleum coke in two steam units to produce more than 1260 MW of electricity to JEA and Florida Power & Light Company (JEA, 2005). The Northside Generating Station uses natural gas, fuel oil, coal, and petroleum coke in three steam units and four diesel-power peaking units to produce more than 1270 MW of electricity. This plant has been in operation since 1966, but the oldest operating unit (Unit III) was completed in 1977. The facility contains the world's largest circulating fluidized bed combustors (JEA, 2005).

Data are available for the NPDES permittees from the Florida Geographic Data Library (GeoPlan Center, 2003). The original list was competed in 1994 by the NOAA Coastal Services Center with updates made in 1998. Utilizing these data, there were 1933 NPDES sites in Duval and Nassau Counties in 1998. Five of these sites were located within the TIMU park boundaries. However, only two of the permits were current based on a query of the Permit Compliance System database. These two facilities were the Atlantic Dry Dock WWTF (FL0040592) and Buccaneer WWTF – (Atlantic

Beach #2) (FL0023248). The Buccaneer site is classified as a major discharger with a permitted capacity of 1.9 MGD.

The USEPA maintains the Enforcement and Compliance History Online program, which provides information on the number of federally reportable inspections conducted over the past three years, the number of quarters that a facility has been in violation during the last three years, and the number of enforcement actions taken against the facility within the last three years. The domestic and industrial facilities listed as major discharges (26) were entered into this program to determine their compliance in recent years (**Appendix G**). Twenty-three of the facilities yielded results and six of the facilities have faced formal enforcement actions within the past three years. These facilities include JEA – Buckman WWTP, JEA – Monterey WWTF, JEA – Royal Lakes WWTP, JEA – San Jose WWTP, JEA – Southwest WWTP, and JEA – Northside, Units 1, 2, and 3.

The impacts of a specific point source, the Buckman WWTP, were the subject of a dye study conducted in June 1998 (ECT, 1999). The objectives of the study were "to determine the initial mixing of the effluent in the river, determine the vertical and horizontal extent of the plume and maximum upstream extent of the effluent, provide field data for subsequent model calibration and verification, and provide a theoretical estimate of the effluent distribution in the river" (ECT, 1999, p. 2). The study concluded that in general, the initial mixing resulted in 20:1 dilution by the time the effluent appeared from beneath the pier, where the plant's discharge structure was located (ECT, 1999). The dilution ratio was also noted to be 100:1 within 1,500 m (0.93 mile) of the discharge point (ECT, 1999). Following the three-day dye injection period, the "1,000:1 dilution contour extended approximately 5,500 m (3.4 miles) downstream at low tide and more than 10,000 m (6.2 miles) upstream at high tide" (ECT, 1999, p. 52). The results were consistent with those developed from the theoretical, steady-state equation, which based on the effluent discharge and river flow rates predicted that the 1,000:1 contour would extend over 16,000 m (10 miles) upstream (ECT, 1999). The theoretical equation also predicts that if there is measurable salinity in the river upstream of the plant, neglecting the effects of salt springs, a small fraction of that water originated from the Buckman WWTP (ECT, 1999). The animations of the plume's movement show that water from the SJR enters the tidal creeks of TIMU. It remains there and pulses in and out with the tidal action of the estuary. The water quality of the SJR is important to the maintaining the integrity of TIMU's waters.

In addition to NPDES permit holders, there are multiple facilities in the area that produce air emissions, toxic releases, or engage in hazardous waste activities. These facilities are listed in the USEPA's Envirofacts website which compiles information from multiple databases. A search of the counties included in the TIMU study area yielded the results displayed in **Table 26**.

Table 26. Number of facilities with air emissions, toxic releases, and hazardous waste activities listed in USEPA's Envirofacts database.

Pollution Activities	Duval Co.	Nassau Co.
Air emissions	245	9
Toxic releases	108	3
Hazardous waste activities	2,404	135

Source: USEPA, 2004a.

Point sources have contributed greatly to the decline of water quality in the SJR. In the 1970s, raw sewage was periodically discharged into the river and in Duval County, there were over 390 wastewater treatment plants discharging to groundwater and surface water (FDEP, 2002b). The COJ began a regionalization program in the 1970s which created five regional WWTPs (FDEP, 2002b). The number of treatment plants was reduced to less than 100 using improved treatment, collection systems, and pumping stations (FDEP, 2002b). The number of facilities continues to decrease, especially with the merger of the city's Department of Public Utilities Water and Sewer Operations and the JEA. JEA provides more than 80% of the water and sewer service to Duval County residents (FDEP, 2002b).

As part of Phase I of the federal NPDES stormwater program, municipalities with populations greater than 100,000 were required to obtain a Municipal Separate Storm Sewer System (MS4) permit. One requirement of this permit is the development of a Master Stormwater Management Plan. The plan was completed by Camp Dresser and McKee with assistance from SJRWMD. Phase I, finished in 1989, includes portions of Black Creek and Julington Creek, which are outside the COJ (FDEP, 2004b). Phase II of the plan identified basins with water quality and flooding problems. A second list of priority basins was created by the COJ and the SJRWMD based on projected population growth (FDEP, 2004b). The second list was used to put the basins in priority order for implementation of stormwater management activities. The priority order, in descending order, is the SJR upstream of Trout River, the ICWW, Trout River, Ortega River, Broward River, Dunns Creek, SJR downstream of Trout River, and Julington Creek (FDEP, 2004b). Phase II was completed in 1994 when specific watershed plans were developed to address the water quality and flooding problems in each unit (FDEP, 2004b).

Solid Waste Facilities

There are multiple solid waste facilities located in Duval and Nassau Counties (**Table 27**). Landfills are considered point sources of contamination because the point where contaminants enter the environment can be identified with a reasonable amount of certainty. Landfill leachate can contain a variety of chemicals including metals and organic compounds that can contaminate soil or groundwater if not contained properly.

Three of the facilities are located within the study area established around TIMU. These facilities include the JEA Northside Generating Station Byproduct Storage Area, the Mayport Solid Waste Transfer Station, and the North Landfill. The East and Lofton Creek Landfills are located just outside the assessment study area. This list only includes facilities with independent solid waste permits. There may be additional landfills in the area that are permitted differently. For instance, the St. Johns River Power Park Landfill permit is included in the power plant siting; therefore, it is not included in **Table 27**.

Table 27. Facilities with independent solid waste permits in Duval and Nassau Counties, Florida.

Facility Name	Facility Type/Status	Location
Duval County		
American Rubber Technologies, Inc.	Water Treatment Plant/Active	Jacksonville
Gerdau Ameristeel	Class II Landfill/Closed	Baldwin
	N/A	Jacksonville
East Landfill	Class I Landfill/Closed	Jacksonville
Hogan-Newton Landfill	Class I Landfill/Closed	Jacksonville
Jacksonville Zoological Gardens	Composting Facility/Active	Jacksonville
Jaxson Brown	Class I Landfill/Closed	Jacksonville
JEA Northside Generating Station Byproduct Storage Area	Class I Landfill/Active	Jacksonville
Jones Rd Landfill and Recycling	Construction and Demolition Debris/Active	Jacksonville
Kimmons Recycling Corporation	Transfer Station/Inactive	Jacksonville
Mayport Solid Waste Transfer Station	Transfer Station/Active	Mayport
North Landfill	Class I Landfill/Closed	Jacksonville
Old Kings Road Landfill	Construction and Demolition Debris/Active	Jacksonville
Old Kings Road Materials Recovery Facility	Inactive	Jacksonville
Realco Recycling Co., Inc.	Materials Recovery Facility/Active	Jacksonville
Sandler Road Landfill	Class I Landfill/Closed	Jacksonville
Salisbury Road Landfill	Class I Landfill/Closed	Jacksonville
Stetson Road Landfill	Class III Landfill/Closed	Jacksonville
Sunbeam Hill	Class I Landfill/Closed	Jacksonville
Trail Ridge Landfill	Class I Landfill/Active	Baldwin
Trinity Hammond Landfill	Class I Landfill/Closed	Jacksonville
Nassau County		
Bryceville Landfill	Class III Landfill/Closed	Bryceville
Lofton Creek Landfill	Class I Landfill/Closed	Fernandina Beach
Nassau Sanitation C/D Landfill	Construction and Demolition Debris/Active	Callahan
Sandhill Recycling	Construction and Demolition Debris/Active	Hilliard
West Nassau Landfill	Class I Landfill/Active	Callahan
West Nassau Landfill (closed)	Class I Landfill/Closed	Callahan
West Nassau Waste Tire Collection	Waste Tire Collection/Active	Callahan
Agricycle Farm	N/A	N/A

N/A – Information not available
Source: M. Nogas, FDEP, pers. comm.

Transportation

There are two deep water ports in Duval and Nassau Counties: JAXPORT located in Duval County and the Port of Fernandina located in Nassau County. There are three public marine and one passenger cruise terminal owned and operated by JAXPORT in Jacksonville, Florida. These include the Blount Island Marine Terminal, the Talleyrand

Marine Terminal, the Dames Point Marine Terminal, and the temporary JAXPORT Cruise Terminal. Trade at the JAXPORT dates back to 1565 when the first recorded act of international waterborne commerce took place. English traders sailed to the mouth of the SJR and traded guns and ammunition for food and a vessel with the French Huguenots who settled at Fort Caroline (JAXPORT, 2005a). Today, over 16 million tons of cargo are handled each year through JAXPORT, which includes the three public terminals and more than a dozen private terminals (JAXPORT, 2005a)

The Blount Island Marine Terminal is JAXPORT's largest container facility (754 acres) handling 80% of the nearly 700,000 twenty-foot-equivalent units moved annually through JAXPORT facilities. Blount Island is one of the largest vehicle import-export centers on the east coast of the U.S. (JAXPORT, 2005a). The terminal handles recreational boats, tractors, paper, wood pulp, forest products and a variety of general cargoes (JAXPORT, 2005a). The Talleyrand Marine Terminal handles South American and Caribbean containerized cargoes, breakbulk commodities such as steel and paper, imported automobiles, frozen and chilled goods, and liquid bulk commodities. The Dames Point Marine Terminal is the newest terminal and one of the few major greenfield sites on the U.S. East Coast available for port development (JAXPORT, 2005a).

The cruise terminal established at JAXPORT is temporary. The current location is not ideal because ships are required to sail beneath electric power lines and the Dames Point Bridge to reach the terminal (JAXPORT, 2005b). The height of the bridge precludes many cruise ships from entering Jacksonville (JAXPORT, 2005b). Han-Padron and Associates studied the entire length of the SJR from Mayport to the JEA powerlines to identify a location for a permanent cruise terminal with no height restrictions (JAXPORT, 2005b). The firm presented two potential locations: Pine Island and Blount Island (**Figure 38**). The Pine Island site is within TIMU boundaries and activities in the area would likely affect TIMU. It has been stated that there would be nominal environmental impact to TIMU due to the location of parking and other operations and no discharging of wastewater or solid waste into the harbor (JAXPORT, 2005b); a statement that the NPS has publicly disagreed with. Martin Associates completed a report in March 2005 that outlined the various cargo and cruise opportunities for JAXPORT over the next several years. According to Robert Peek, Director of Communications for JAXPORT, the Board of Directors has decided to operate from the temporary cruise terminal indefinitely. This determination was based on the lack of an easily available property for the permanent terminal to be built. If a property becomes available, the Port Authority will consider it for location of a permanent terminal.

Ports can introduce exotic species in the ballast waters of ships. This can disrupt ecosystems and result in habitat loss for native species. The dredging activities associated with maintaining waterways disrupt sediments and may release toxic chemicals into the overlying water column. The placement of dredged materials may also impact existing water chemistry and ecological habitats. The oil and gas emissions from ships and private boats contribute additional contaminants to the atmosphere and waters.

Figure 38. Potential cruise terminal sites near Jacksonville, Florida.

(Figure obtained from R. Peek, JAXPORT, pers. comm.)

One of the primary concerns associated with the Port of Jacksonville is the maintenance dredging required to maintain operation of the port. Originally, the artificial channel was maintained at 11.6 m (38 ft); however, in 2002, 23 km (14 miles) of the main channel from the mouth of the river to Drummond Point were deepened to a maintained depth of 12.2 m (41 ft) (JAXPORT, 2005a). The natural depth of the river is approximately 4.6 m (15 ft). The USACOE is also investigating the impacts of deepening the main channel to 13.7 m (45 ft) (JAXPORT, 2005a). Sites considered for the placement of the dredged material are the Jacksonville Harbor Ocean Dredged Material Disposal Site, an off-shore artificial reef, the beach or nearshore south of the harbor's entrance, or Bartram Island.

Dredging activity in the LSJR began in the early 1950s to maintain safe navigation depths. The majority of the activity is conducted between downtown Jacksonville and Mayport (Florida Coastal Management Program (FCMP), 1995). The type of material ranges from sands near the river mouth to organic peat and muck near downtown Jacksonville (SJRWMD, 1994). The dredged material has been utilized for beach nourishment or disposed of in spoil areas, such as Bartram, Blount, Reed, or Buck Islands, or the ocean (FCMP, 1995). A limited amount has been used for wetland creation and construction material for roads and parks (FCMP, 1995). However, extensive development along the LSJR in recent years has limited disposal sites within an economically feasible pumping distance (FCMP, 1995).

Beneficial uses of the dredged material obtained from the LSJR were examined as an alternative to continued disposal at the existing sites, which will not be sustainable. Alternative uses for this material are wetland/marsh creation, agriculture, aquaculture, beach nourishment, underwater berm construction, parks and recreation, sanitary landfill cover, strip mine reclamation, coastal dune restoration, river bank stabilization, upland creation, construction, and industrial uses (FCMP, 1995). The physical and chemical properties of the material must be considered for these uses. It has been noted that the sediment quality in the lower 32 km (20 miles) of the river is generally of good quality, whereas the sediment in the upper portion of the river and the tributaries is of lesser quality (FCMP, 1995). The sediments closer to the river mouth experience strong tides compared to the weaker circulation patterns further upstream, which allows deposition of fine fractions of sediment (FCMP, 1995). Beach nourishment is one of the best solutions for Duval County because of the large amount of material required for the periodic nourishment of beaches (FCMP, 1995). The environmental impacts can be minimized by application of clean materials and seasonal planning to avoid periods of high recreational use (FCMP, 1995).

In addition to dredge material placement, concerns regarding the impact of waves produced by large vessels that may erode the shoreline and the impacts of blasting on historical monuments were considered (USACOE, 1998). Environmental concerns also result from the disturbance of benthic fauna and flora as well as blasting which may stun fish and other aquatic organisms. The greatest water quality impact of dredging is an increase in turbidity (USACOE, 1998). Monitoring must be conducted during dredging activities to ensure that levels are not above the state standards, otherwise, activities must be suspended until conditions return to normal (USACOE, 1998).

Several islands in the LSJR, such as Blount, Buck, and Bartram Islands, were artificially created from dredge spoil. Bartram Island was originally built from dredged material and has been heavily impacted by use for dredged material placement. Some of the island's original vegetative cover remains, mainly in the form of fringing smooth cordgrass, along with black needle rush, glasswort, saltwort salt grass, salt marsh bulrush (*Scirpus robustus*), sea ox-eye (*Wedelia trilobata*), groundsel, and marsh elder (USACOE, 1998). However, much of the island is characterized by early successional plants as a result of disposal activities. These areas provide habitat for roosting herons and egrets. There is also a shallow open-water impoundment created by disposal activities on the far western section of the island (USACOE, 1998). The impoundment and salt marsh support populations of fish, reptiles, including the diamond-back terrapin, and many species of shore and wading birds. The section east of the Dames Point Bridge also has several wet depressions supporting willow (*Salix* spp.) and wax myrtle (USACOE, 1998). Other vegetation found less frequently includes black cherry (*Prunus serotina*), sumac (*Rhus* spp.), southern red cedar, slash and longleaf pine (*Pinus elliottii* and *P. palustrus)*, oaks, and cabbage palm (USACOE, 1998). Buck Island, which is located next to the Ribault Column, continues to be used for dredged material placement. Currently, the Jacksonville Port Authority removes material, such as sand, for road construction and other projects.

Transportation impacts are not limited to water, but also include air. There are several airports located in Duval and Nassau Counties. The Jacksonville International Airport provides commercial airline service to the region. General aviation airports in Duval County are Cecil Commerce Center, Craig Municipal Airport, Herlong Field, and Whitehouse Nolf Airport. The Fernandina Beach Municipal Airport is a general aviation airport located in Nassau County. In addition, there are two airports associated with the military near Jacksonville: the Mayport Naval Station's Admiral David L. McDonald Field and the Jacksonville Naval Air Station's Towers Field. The environmental impacts of airports are increases in impervious area due to building and runway construction, impacts on air and water quality, noise pollution, and possible risks associated with fuel or other chemical spills.

Nonpoint Sources

Nonpoint source pollution is the type of pollution that is transported to a receiving water body in a dispersive or diffuse manner. Examples of nonpoint source pollution are stormwater runoff containing heavy metals and sediment, leaky septic systems or animal waste applications that can contribute organic matter and fecal coliforms, nutrients from fertilizers applied to lawns or golf courses, atmospheric deposition of compounds such as mercury or lead, and herbicides or pesticides in runoff from golf courses, lawns, or agricultural fields.

Marinas and Boatyards

Marinas contribute nonpoint source pollution during construction and operation. Some of the pollutants associated with marinas and boats include hydrocarbons (fuel and grease) from boat exhaust and fuel spills, solid waste from trash, solvents associated with boat cleaning, heavy metal contamination from paints and other chemicals, and bacteria from boat head facilities (Thorpe et al., 1997). The FDEP, the Marine Industry Association of Florida, and the Florida SeaGrant Program developed the Clean Marina and Clean Boatyard Programs to prevent pollution (FDEP, 2004b). The facilities that participate in the program have agreed to implement simple, innovative solutions, called Marina Environmental Measures, to everyday marina operations that protect the environment. Possessing this designation means that the business owners adhere to, or exceed, the current regulatory requirements and that the facility is concerned about environmental issues (FDEP, 2004b). Currently, there are 20 facilities enrolled in this program in the LSJRB and four are designated as clean marinas. These facilities include Palm Cove Marine, Whitney's Marine, Ortega River Boat Yard, and Lamb's Yacht Center. A similar program encouraging clean boating techniques for recreational boaters also exists (FDEP, 2004b).

Urban Stormwater

The growth of Jacksonville as a major urban center has contributed to water quality degradation through the large amounts of stormwater (FDEP, 2002b). Jacksonville and the surrounding urban area has been designated a priority nonpoint source pollution management area due to this stormwater (FDEP, 2004b). A comparison completed by Stanley Consultants showed that the nitrogen loading to the SJR doubled from 1978 to 1997, while the orthophosphate and BOD have remained relatively constant (FDEP, 2004b). Stormwater from urban areas can have elevated levels of nitrogen, phosphorus, BOD, suspended solids, zinc, and lead. According to Schwenning (2001), untreated stormwater contributes nine times more oxygen demanding substances than most point sources and 80-95% of the heavy metals that reach waterbodies. Traditional approaches to stormwater management have focused on handling the quantity of wastewater without addressing the quality. Measures that can be employed to minimize environmental impacts include implementing buffer zones, limiting impervious areas, utilizing grassed waterways, minimizing pesticide applications, and using best management practices for construction sites.

The Better Jacksonville Plan is a $2.2 billion comprehensive growth management strategy that addresses road and infrastructure improvements, land preservation, economic development, and new and improved public facilities (FDEP, 2004b). One of the goals of the road and infrastructure improvements is to improve drainage for stormwater management. The Preservation Project, Jacksonville, established in 1999, aims to preserve and provide access to environmentally sensitive lands, including TIMU, while managing growth and improving water quality (FDEP, 2004b).

The implementation of the COJ's Master Stormwater Management Plan is critical to the reduction of stormwater impacts (FDEP, 2004b). As part of the MS4 permit application process, a database of stormwater structures, treatment facilities, illegal connections, and potential toxic pollutant generators is being created (FDEP, 2004b). Some actions are already underway as part of the Master Stormwater Management Plan (FDEP, 2004b). Stormwater retention ponds are being built in the Hogans Creek and McCoys Creek watersheds. The Riverside area has been identified for the installation of baffle boxes to reduce sediment loads. In addition, $122 million in stormwater retrofits and other improvements are planned (FDEP, 2004b).

Septic Systems

Septic systems are common in the area surrounding TIMU, especially in the subdivisions close to TIMU's salt marshes, which are not connected to public facilities. The leachate from these systems can contaminate surface and groundwater with nutrients and bacteria when not installed or maintained properly or during storm events. Rainfall and tidal action supply water to the salt marshes and estuaries in TIMU (NPS, 1996b). Durden and Williams (SJRMWD) estimated that approximately 10% of the incoming water to the salt marshes results from surface runoff and percolation from adjacent upland areas (cited in NPS, 1996). Monitoring conducted by the COJ has indicated that there are bacterial contamination problems resulting in exceedance of state water quality standards in the urban tributaries in Duval County (FDEP, 2004b). The affected tributaries include the Cedar and Arlington Rivers, McCoys Creek, Fishweir Creek, and creeks in the Mandarin area. These creeks are not located immediately adjacent to TIMU, but there is concern that as development encroaches upon TIMU, these issues may arise. Twenty-four areas have been identified by the Duval County Health Department as septic tank failure areas (FDEP, 2004b). Six of these areas will be connected to sewers with funds from the legislature, cost-sharing with JEA, and homeowners (FDEP, 2004b).

Agricultural Runoff

Agricultural and silvicultural lands are located in southern Nassau County and the LSJR watershed. These activities contribute runoff that contains sediments, pesticides, herbicides, and nutrients from fertilizer application. Forestry operations can also increase sedimentation in waterbodies and disrupt pH (Thorpe et al., 1997). The removal of trees from the banks increases solar radiation, which raises water temperature, possibly disrupting the ecological balance of aquatic systems (Thorpe et al., 1997).

Lower St. Johns River Basin

Two agricultural areas of concern are the Tri-County Agricultural Area (TCAA) located in Putnam, St. Johns, and Flagler Counties and the historical dairy operations in the Black Creek watershed (located almost entirely in Clay County). The TCAA covers an area of approximately 15,000 hectares (38,000 acres) and was first identified by Hendrickson (1987) as a significant source of nutrients in the early 1980s. Storm events, not irrigation, flush nutrients and suspended solids from the fields into canals discharging to the SJR. Research revealed that manipulation of the water table and fertilizer application reduction were the most effective best management practices for controlling agriculture stormwater runoff (FDEP, 2004b). These actions will not reduce the nutrient loads enough to meet the pollutant load reduction goals and the TMDL. The SJRWMD is considering purchasing land for use as riparian buffers or the construction of treatment wetlands to meet the goals (FDEP, 2004b).

Another area of water quality concern is the Peters Creek watershed within the Black Creek watershed. Historically, dairies were considered the primary cause of pollution in the watersheds; however, a recent survey found only four operational dairies in the area (FDEP, 2004b). None of these facilities had surface discharges to Peters or Black Creeks. The largest dairy has ended all milking operations and is currently a bottling operation; two others have plans to close within the next seven years (FDEP, 2004b). Other nonpoint source activities in the watershed requiring attention are beef cattle and calving operations and land application of manure. There are also flooding and soil erosion problems in the Black Creek watershed (FDEP, 2004b).

Atmospheric Deposition

Another source of nonpoint source pollution is atmospheric deposition. An airshed is defined as the area responsible for emitting 75% of the air pollution that reaches a specific waterbody. Due to variations in chemical reactivities, airsheds vary based on the pollutant. Mathematical models are used to determine the airshed for a particular waterbody. The USEPA has identified five categories of pollutants with the greatest potential to harm water quality. They include nitrogen compounds, mercury, other metals, pesticides, and combustion emissions (USEPA, 2003). Nitrogen, in particular, is of concern because high levels produce eutrophic conditions, or harmful increases in algal growth in surface waters. Modeling efforts found that utility and mobile (automobile exhaust) sources are approximately equal contributors of nitrogen via atmospheric deposition (Appleton, 1995). In addition, Paerl (1993) has shown that atmospheric deposition contributes 10 to 50% of the nitrogen budget of estuaries worldwide. In Tampa Bay, atmospheric deposition has been determined to provide 29% of the TN load (Pribble and Janicki, 1998). Currently, studies are underway to quantify the rates of atmospheric deposition and its relevant importance as contaminant sources to water resources. The atmospheric deposition of phosphorus is usually a minor component of the LSJR budget and is not typically considered in modeling efforts (Magley and Joyner, 2004).

In the initial calculations of the nutrient budgets for the LSJR, Hendrickson and Konwinski (1998) estimated that atmospheric wet deposition contributed 15% of the total inorganic nitrogen to the river on an annual average basis and 21% during the peak algal bloom season, from April through July. However, a reporting unit error was discovered, and the estimated contribution from atmospheric deposition was reduced to about 4% annually. It was also determined that a more detailed atmospheric deposition load assessment was necessary (Magley and Joyner, 2004). To achieve these goals, several factors were considered in the detailed report of atmospheric deposition. A greater number of nutrient forms, dry and wet deposition, an increased number of stations, and an examination of existing data were completed. The authors also considered whether spatial and temporal variations of inputs were needed to adequately describe the nutrient enrichment. Pollman and Roy (n.d.) determined that approximately 2% of the TN load to the SJR is supplied through direct atmospheric deposition.

Information on TIMU's air quality can be obtained from a variety of sources. Historical and current air quality data are available at the FDEP website. In addition, there are multiple specific programs to assess air quality. One of these is the National Atmospheric Deposition Program/National Trends Network. The sites closest to TIMU are GA09 (Okefenokee National Wildlife Refuge) and FL03 (Bradford Forest). These sites are monitored for a number of constituents including calcium, magnesium, potassium, sodium, ammonium, nitrate, inorganic nitrogen, chloride, sulfate, and hydrogen. The closest site measured for the Mercury Deposition Network is GA09. The 2002 and 2003 total wet deposition rates for this station were 11.4 and 14.9 $\mu g\ m^{-2}$, respectively (NADP, 2005).

Conclusions and Recommendations

Current Level of Knowledge

Monitoring recommendations are based on the information included in **Table 28**, which was utilized to identify indicators of current or future water quality degradation. This table represents the authors' best professional judgment regarding the potential for impairment of TIMU's water resources based on specific indicators. The table will be utilized by the NPS to draw conclusions regarding the status of coastal water resources and to prioritize between parks and regions. Additional recommendations are provided based on gaps in the current knowledge base.

Data Management

Data available from several sources, including the USEPA modernized STORET database, the SJRWMD, and the USGS NWIS database, were utilized to assess the overall water quality of TIMU. The most recent lists of impaired waters for the LSJR and Nassau/St. Mary's Rivers Basins were used to identify water segments not meeting their designated uses. Segments within TIMU's boundary are included in the verified lists of impaired waters for the LSJR and in the draft verified list of impaired waters for the Nassau/St. Mary's HUC.

Biological Resources

Natural communities occurring within TIMU include the coastal strand, maritime hammock, scrub, shell mound, estuarine tidal marsh, estuarine unconsolidated substrate, and marine tidal marsh. Tidal marsh is the dominant habitat type within the preserve. Vegetative changes within TIMU have been attributed to increased tidal inundation and decreased freshwater inflow (Steinway-Rodkin and Montague, 2004). Increased salinity was also implicated as a factor in invertebrate population shifts observed between 1983 and 2003 (Long, 2004).

Although little or no SAV is present within TIMU, it is an important component of the LSJRB. Boustany et al. (2003) found that salinity pulsing affected seagrass growth and distribution to a greater extent than nutrients. In the oligohaline reach of the LSJR, all SAV species, with the exception of widgeon grass, declined between 1998 and 2000 (Sagan, 2001). Widgeon grass, which is able to tolerate extreme salinity, increased significantly during the same period. High salinity due to drought conditions was proposed as the predominant factor for the species change (Sagan, 2001). Additional contributing factors were high color and suspensed materials, organic and inorganic, in the water column (Sagan, 2001).

Numerous species inventories have been completed or are currently in progress for TIMU. By correlating these inventories with habitat and water quality conditions, biological impacts of degradation can be investigated. Dennis et al. (2001) did not find measurable impacts of urbanization on fish assemblages in four tidal creeks north of the

Table 28. Potential for impairment of Timucuan Ecological and Historic Preserve water resources.

Indicator	St. Johns River (lower section)	Nassau River[1]	Tidal creeks	Wells[2]	Spanish Pond	Atlantic Coast
Toxic algae	PP	ND	PP	LP	LP	PP
Nutrient loading	HP[3]	MP	HP	ND	HP	LP
Excessive fecal bacteria	MP[4]	HP[5]	MP[6]	ND	ND	HP[7]
Metals contamination	HP[8]	HP (Fe)[9]	PP[10]	PP[11]	HP[12]	HP (Hg)[13]
Toxic compounds	HP[14]	PP	PP[10]	ND	ND	ND
Invasive species	MP[16]	MP[16]	MP[16]	LP	MP[16]	PP[17]
Habitat disruption[18]	HP[19]	MP[19]	HP	LP	HP[19]	PP
Low dissolved oxygen	MP	HP[20]	MP[21]	LP	PP[12]	ND
Impacts of sea level rise	PP[22]	PP[22]	PP[22]	PP[2]	LP	PP[22]
Shoreline change	MP[23]	HP[24]	LP	PP	LP	HP[25]
SAV Decline	MP[26]	LP	LP	LP	LP	LP

Definitions: HP - high concern problem, MP - moderate concern problem, LP - low concern or no problem, PP - potential problem, ND - insufficient data to make judgment

[1]Including Nassau Sound.

[2]Major concern in localized areas (such as Fort George Island) is saltwater intrusion (NPS, 1996b; Spechler, 1994).

[3]Based on TMDL development for nutrients for the LSJR (Hendrickson et al., 2003; Magley and Joyner, 2004).

[4]Based on fecal coliform levels for contributing urban tributaries (FDEP, 2004b).

[5]Based on downgrade in shellfish harvesting classification for Nassau Sound and water quality in contributing tributaries.

[6]Due to 303(d) listings for Dunn, Terrapin, Sherman, and Greenfield Creeks.

[7]Based on downgrades in shellfish harvesting classification (H. Beadle, FDACS, pers. comm.; Browning, 1994).

[8]Due to 303(d) listings for iron, copper, nickel, lead.

[9]Due to 303(d) listing.

[10]Based on work summarized in Bryant and Fox (2003).

[11]Based on levels of iron found by Causey and Phelps (1978).

[12]Based on data collected by Morton and Marchman (as cited in NPS, 1996b).

[13]Based on fish consumption advisory for Atlantic Coast (FDOH, 2004).

[14]Based on heavy industry in downtown Jacksonville, Superfund sites, and results from National Ocean and

Atmospheric Administration study (NOAA, 1988) and Environmental Monitoring and Assessment Program sampling (Hyland et al., 1998; Hyland et al., 1996).

[15]Based on large amounts of water hyacinth (*Eichhornia crassipes*) reported by Meyer (1999) and plant control efforts summarized in Bezanilla (2001).

[16]Based on plant control efforts reported in Bezanilla (2001).

[17]Due to shipping traffic.

[18]Habitat disruption includes development, dredging, etc.

[19]Based on increasing residential development.

[20]Based on 303(d) listings for Plummer, Mills, Alligator, and Thomas Creeks.

[21]Due to 303(d) listings for Sherman and Terrapin Creeks.

[22]Based on results from Thieler and Hammar-Klose, 1999.

[23]Erosion at Mile Point (Cornwell, 2000).

24Due to stabilization of South Amelia Island (Taylor Engineering, 2003).

[25]Based on status of Fort George Inlet (Gosselin et al., 2000; Marino et al., 1990; Olsen Associates, Inc., 1999) and stabilization of South Amelia Island (Taylor Engineering, 2003).

[26]Little to no SAV present in TIMU. Classification based on current monitoring of LSJR downstream of Warren Fuller Bridge (Dobberfuhl and Trahan, 2003; Sagan, 2001; Sagan, 2002; Sagan, 2003).

SJR. Daily tidal flushing and retention of critical shoreline shallow-water habitat were suggested as driving factors behind these results (Dennis et al., 2001).

Exotic plant species in Spanish Pond, Thomas Creek, Cedar Point, and Kingsley Plantation were identified by Bezanilla (2001). Species of concern include kudzu, coral ardisia, Chinese wisteria, chinaberry, English ivy, air potato, mimosa, Chinese tallow, and creeping fig. The numbers of plants removed and treated in 2001 were summarized in addition to suggestions regarding the future monitoring frequency.

St. Johns and Nassau Rivers

The SJR, which flows along the southern portion of TIMU has been influenced by increased urban stormwater runoff, discharges from wastewater treatment plants, and agricultural activities in upstream watersheds. According to the verified list for the LSJR, there are eight impaired segments within the TIMU study area. Three of the segments are portions of the SJR (the mouth, the ICWW, and Dames Point). The three segments are all impaired for iron, copper, and nickel with an additional listing for lead in the ICWW segment. The other segments, with the exception of the Atlantic Coast entry, are urban creeks that are listed as impaired due to DO levels and fecal coliforms.

The Nassau River, which forms the northern border of TIMU, is generally considered pristine (Coffin et al., 1992). However, phosphorus levels were at the upper end of the scale when compared to other northeast Florida estuaries (NPS, 1996b). There are 18 segments on the draft verified list of impaired waters in the Nassau/St. Mary's Basin within the study area. The impaired parameters are DO, coliforms, iron, mercury, chlorophyll, and biology. The listed segments include the South Amelia River, Nassau River, Nassau Sound, Nassau Sound (Ocean 1 and 2), Fort George River, Jackson Creek, Plummer Creek, Mills Creek, Marina Bay at Fort George, Alligator Creek, Thomas Creek, South End, Huguenot Park, South and North Little Talbot Island, Piper Dunes, and AIP Beach Club. Seven of the listings are for coliforms because of downgrades in shellfish harvesting classification.

Tidal Creeks

TIMU's water quality is considered good compared to other Florida surface waters (Hand et al., 1994). Tidal flushing is an important contributing factor because portions of the upstream areas along the Nassau and St. Johns Rivers are degraded (NPS, 1996). However, DiDonato et al. (2005) found that the tidal creeks near Kingsley Plantation were not well flushed. This conclusion was based on measurements recorded by a water-quality datalogger in the Fort George River at the Kingsley Plantation dock. Over the one-year recording period, the pH varied between 7.2 and 8.2, indicating that the system is well buffered and receives little freshwater input (DiDonato et al., 2005). In addition, DiDonato et al. (2005) concluded that the freshwater flushing of tidal creeks was slow, on the order of months, based on variations in salinity following Hurricane Francis. Lack of flushing in the tidal creeks is an important consideration in water management decisions, as contaminants and nutrients that enter the system may remain for extended periods of time.

General information concerning tidal influence and water movement within TIMU is available, but there is a lack of descriptive information detailing the hydrodynamics and currents of the system (NPS, 1996b). The hydrodynamics of the tidal creeks east of Blount Island are considered especially complex. Past human activities, including dredging and road construction have altered the hydrology of the system; detailed information will allow the NPS to minimize the impacts of future activities such as dredging, spoil deposition, and road construction projects.

Wells (Groundwater)

Several depressions in the potentiometric surface have been observed in northeast Florida as a result of large withdrawals. The areas nearest to TIMU are at Fernandina Beach and near a large spring in northern St. Johns County (Durden and Motz, 1991). The depression in Fernandina Beach was caused by a very large withdrawal for a pulp mill. It has been estimated that between 1940 and 1962, water levels dropped 3 to 7.6 m (10 to 25 ft) in northeast Florida (NPS, 1996b).

The 2000 SJRWMD District Water Supply Plan designated a portion of the LSJRB in southeastern Duval County and all of St. Johns County as a Priority Water Use Caution Area in anticipation of future water resource problems (FDEP, 2004b). Estimates of future groundwater withdrawals in the area are unsustainable, which may damage wetlands and degrade water quality (FDEP, 2004b). In addition to overpumping, saltwater intrusion is a major concern groundwater quality concern. Saltwater intrusion has already occurred in wells located on Fort George and Little Talbot Islands.

Spanish Pond (Freshwater resources)

Spanish Pond is the largest freshwater pond (semi-permanent water regime) under NPS ownership within TIMU. Residential development near the pond has influenced water delivery and water quality (NPS, 1996b). There are also four small ponds located on Fort George Island, all of which appear to be man-made or altered during recent development.

In 1993, water quality parameters in Spanish Pond, with the exception of DO, were classified as good (cited in NPS, 1996b). The DO levels were too low to support fish populations (NPS, 1996b). Sediment analysis found elevated levels of zinc and lead, common constituents of stormwater road runoff. In 2004, the COJ analyzed water samples from three stations to determine the nutrient input from the residential areas surrounding Spanish Pond. However, there was not enough data ($n = 2$ or $n = 4$) to perform statistical or trend analysis. Sampling of these stations should be continued to identify long-term trends and determine the impacts of the residential development on the water quality of Spanish Pond.

Atlantic Coast

The full or partial closure of the Fort George Inlet may substantially impact the water quality of TIMU's salt marshes. Upon closure, there would be a greater contribution of water from the Nassau Sound and the SJR as opposed to the Atlantic

Ocean, which currently supplies water to the marshes. It is reasonable to assume that the water from these sources would be of lower quality (Olsen Associates, Inc., 1999). Pollutants may also enter TIMU via the ICWW (Olsen Associates, Inc., 1999). As a result, the NPS has commissioned several projects to obtain baseline data for the Fort George River. In addition, the erosion of South Amelia Island is an important coastal management issue. To prevent further erosion of the island, a 460-m (1500-ft) terminal groin and 90-m (300-ft) detached rock breakwater were completed on the south end of Amelia Island in 2005. Monitoring of Nassau Sound continues to detect any natural and/or structure-induced changes to the system.

The north Florida coast was determined to be highly vulnerable to sea-level rise based on an index of coastal vulnerability (Thieler and Hammar-Klose, 1999). Sections of the Amelia Island shoreline are classified as being at very high, high, and moderate risk based on the calculated CVI. Little Talbot Island and the Atlantic coastline south of the SJR mouth are classified as being at moderate and high risk (Thieler and Hammar-Klose, 1999). Salt marsh loss at the smallest or terminal ends of creeks due to sea level rise and anthropogenic influences were investigated by Montague and Fox (2003). Approximately 12% (500 hectares) of the 4,700-hectare (11,600-acre) study site was converted to open water from 1943 to 1999 (Fox and Montague, 2003).

There are two deep water ports in Duval and Nassau Counties: JAXPORT located in Duval County and the Port of Fernandina located in Nassau County. A temporary cruise terminal will continue to operate from its current location until a permanent site becomes available. The decision to remain at the temporary location was based on the absence of an easily available property for the permanent terminal to be built.

One of the concerns associated with the Port of Jacksonville is the dredging required to maintain operation of the port. Concerns associated with dredging are material placement, erosion of the shoreline by large vessel waves, impacts of blasting on historical monuments, disturbance of benthic flora and fauna, and increases in turbidity (USACOE, 1998). Several islands in the LSJR, such as Blount, Buck, and Bartram Islands, and Sisters Creek (ICWW) were artificially created from dredge spoil. Bartram Island was originally built from dredged material and has been heavily impacted by use for dredged material placement. Buck Island, which is located within TIMU's boundaries and next to the Ribault Column, was also built from dredged material.

Identification of Data Gaps and Monitoring Recommendations

Although the NPS will be unable to implement all of these recommendations, they are included to provide a comprehensive picture of the information and data required to completely assess TIMU's water resources.

Data Management

For this assessment, water quality measurements were compiled and stored in a single GIS for spatial analysis. However, the locations of additional areas of interest, such as NPDES permittees, critical nursery habitats, septic tanks, and dredging activities, were not displayed in the same manner. This information should be collected in the future to distinguish relationships between biological resources and factors that influence water quality. Plotting some of these data may be complicated by current databases which do not include accurate and/or complete spatial information. Additional information regarding the activities of Naval Station Mayport should also be obtained to determine the water quality impacts of the military's facilities.

There is also a need for accurate delineation of coastal watershed boundaries. This becomes more problematic as one approaches the ocean. It is difficult to determine which upland areas contribute flow to some of the water quality stations. This information is needed to make decisions regarding the impacts of land use changes on TIMU's water quality. To accomplish this goal, an understanding of the circulation patterns and residence times of certain waterbodies is required. Information regarding groundwater flow and extent of contamination is also needed to establish if industrial sources in downtown Jacksonville or the Superfund sites in Duval County influence TIMU.

Biological Resources

Some of the habitat surveys link species with habitat type; however, this is not always the case. Work to link the habitat types with the typical flora and fauna would be helpful. Additional investigation of aquatic species, including the presence of exotic species, is also needed. There was not much information relating water quality parameters to biological resources. It is difficult to draw direct cause-effect relationships between biological responses and water quality because of the large number of factors at work. Dennis et al. (2001) revealed that urbanization did not appear to affect fish assemblages. However, changes in the abundance and species diversity at designated stations should be monitored to detect future impacts of human alteration. Although information regarding commercial and recreational fisheries is available, it is not specific to TIMU. Establishing permanent stations and regular monitoring will provide aquatic species information specific to TIMU.

St. Johns and Nassau Rivers

Stations along the main stems of the St. Johns and Nassau Rivers are regularly monitored by a number of agencies and uploaded into modernized STORET or the collecting agencies' databases. There are a number of water quality concerns in the LSJR due to rapid urban development. A nutrient TMDL has been established for the LSJR; there are addition impaired listings for copper, iron, lead, and nickel. In the future, development is also expected to occur along the northern edge of TIMU in Nassau County. It is recommended that a water quality database be constructed to provide information regarding water quality prior to development, especially in the central and northern portions of TIMU.

TIMU personnel should carefully monitor changes in the water quality of these two rivers, as they are hydrologically connected to the tidal creeks which nourish the salt marshes. Data from specific stations, such as JAXSJR04 and 19020002, should routinely be reviewed and analyzed for trends and water quality changes. Information concerning the presence of toxic dinoflagellates or other potentially toxic algae should be obtained either through annual monitoring or contact with other agencies, such as the SJRWMD or the Fish and Wildlife Research Institute.

Increases in habitat disturbance caused by development could allow non-native species to establish and eventually enter TIMU. It is recommended that annual surveys and summaries of actions against non-native species similar to those completed by Bezanilla (2001; 2002) be continued.

Tidal Creeks

The tidal creeks in TIMU are sampled as part of the TIMU Preserve Program (City of Jacksonville), which seems to be working well. The data are placed in the modernized STORET database at regular intervals for public data retrieval. The main limitations of this program are the frequency of the sampling, lack of chlorophyll *a* data, and lack of metals and contaminants data. The NPS is interested in doubling the sampling frequency from bimonthly to monthly, but this has been prevented by the limited availability of city personnel to conduct the sampling. These data provide an insight into the water quality of TIMU before some of the intense development, which has occurred over the past two years. It is recommended that NPS personnel routinely inspect these data to identify any changes in water quality.

Due to the relatively pristine and unfragmented nature of TIMU, one would not expect to find high levels of metals and contaminants. However, dissolved metals data at several stations (1993) exceeded the applicable criteria for a number of metals including cadmium, iron, lead, mercury, nickel, and copper. These sites should be resampled to determine if contamination remains. If no contamination exists, sampling may only need to be conducted every 2-5 years; however, if contamination is present, sampling would likely occur more often. There is also a strong possibility that a governmental agency would investigate the sources and extent of contamination. One possible source of these contaminants is stormwater runoff from roads. Sampling summarized by Bryant and Fox (2003) found that sediments and oysters near Hecksher Drive did not contain greater quantities of contaminants compared to sites further from the roadway. However, there was some evidence that the levels of PAHs within the sediment were slightly higher immediately adjacent to the road in Hannah Mills Creek (Bryant and Fox, 2003). Three oyster sampling sites displayed higher metals concentrations than most of the sites (Bryant and Fox, 2003). Sampling is recommended to determine the possible sources of metals in the vicinity of these three sites.

Numerous reports and interviews with NPS personnel have indicated concern regarding the potential for water quality degradation due to failing septic systems in the upland areas within and adjacent to TIMU. However, this matter has not been quantitatively assessed. It is recommended that fecal coliform and/or enterococci be added to the list of parameters sampled as part of the TIMU Preserve Program, or at a minimum, bacteria monitoring should be conducted following major rainfall events when water levels rise and the possibility of septic tank failure is the greatest.

Continuous monitoring data were collected from March 2004 to February 2005 at Kingsley Plantation and from September 2004 to February 2005 in Clapboard Creek. These data should be analyzed to determine hydrologic characteristics of the tidal creeks, including approximate residence time and the influence of freshwater inputs. DiDonato et al. (2005) have already conducted preliminary analysis on the data acquired from the Kingsley Plantation meter. Another meter has been installed at the mouth of Lofton Creek in the Nassau River, which will provide hydrologic information for the northern portion of TIMU (A. Kalmbacher, FDEP, pers. comm.).

In addition to water quality concerns, the quantity of water delivered to the salt marshes is of concern. Changes in land use, specifically from agricultural or forest land to urban, increases the amount of impervious area. Impervious areas deliver water and pollutants more quickly to waterbodies. Data collected from the continuous monitoring devices coupled with rainfall data will provide preliminary information on the relative contributions of surface runoff and salinity variations, which may later be correlated to changes in biota. Steinway-Rodkin and Montague (2004) reported that increased tidal inundation and decreased freshwater inflow may be the greatest determinants of vegetation change within TIMU. Any change in water delivery will likely affect the marsh vegetation, especially tidal freshwater marshes, which are often the sites of highest diversity (Steinway-Rodkin and Montague, 2004). They recommend the installation of water and salinity recorders to determine the relative influence of water delivery on the marsh vegetation composition (Steinway-Rodkin and Montague, 2004).

Wells (Groundwater)

One of the primary groundwater quality concerns is saltwater intrusion. Elevated chloride concentrations, indicative of saltwater intrusion, are present in the Floridan aquifer underlying Little Talbot Island and on Fort George Island. Measured chloride concentrations from three wells located on Fort George Island were approximately 340-410 mg/L, exceeding the secondary standard for chloride in drinking water (250 mg/L). It is recommended that the NPS wells are monitored to determine if there are any trends in salinization or head declines. To safeguard water quality within TIMU, water withdrawals should be minimized and uncontrolled artesian flow from Upper Floridan aquifers restricted (Martin, 2004). Additional water quality concerns include localized areas of high iron and hardness. The surficial aquifer is also susceptible to pollution from septic fields, stormwater runoff, and toxic materials disposed of at other locations.

Spanish Pond (Freshwater Resources)

There is very little water quality information available concerning the condition of freshwater resources within TIMU. Water quality of Spanish Pond was assessed as "good" in 1993; however, sediment samples demonstrated evidence of contamination, most likely from stormwater road runoff (NPS, 1996b). This sampling also revealed that DO levels were too low to support fish populations (NPS, 1996b). A biological inventory of the invertebrates and other fauna would provide useful information on the species that inhabit the pond.

Permanent stations should routinely (quarterly or semiannually) monitored for field parameters (DO, salinity, conductivity, pH, water temperature), nutrients (TN, nitrate + nitrite, ammonia, TP, and orthophosphate), and chlorophyll *a*. Sediment and water samples should also be collected, especially following storm events, to determine the extent and type of contamination that occurs during high water levels in the pond based on the results discussed in TIMU's *Water Resources Management Plan*. Bacteria and nutrient levels should be measured following storm events when the possibility for septic system failure is high. If high levels are found, dye studies may be conducted to determine if septic leachate is the source.

Atlantic Coast

The majority of the water quality monitoring along the Atlantic Coast is conducted to determine bacteria levels as part of the Florida Healthy Beaches Program. Analysis of the data obtained from August 2000 to 2004 revealed that the fewest number of samples were recorded during the summer months, when usage is greatest. Currently, samples are obtained weekly. Some of these stations could be expanded to provide nearshore water quality data. Monitored parameters would include field parameters (DO, salinity, conductivity, pH, water temperature), nutrients (TN, nitrate + nitrite, ammonia, TP, and orthophosphate), and chlorophyll *a*.

Although red tides or other harmful algal blooms are not common on the Atlantic Coast of Florida (due to transport via the loop and Florida currents), algal abundances should be monitored during summer months to protect public health. Annual surveys should also be conducted to monitor the presence of toxic dinoflagellates or other potentially harmful algal species, which may be introduced through the ballast water discharged near JAXPORT. It may not be necessary for the NPS to conduct these studies, as it may be available from the SJRWMD or other state agencies.

From the perspective of TIMU, water quality along the Atlantic Coast is focused on inlet stability, specifically that of the Fort George Inlet. The closure of this inlet would most likely have detrimental impacts on the water quality of the salt marshes. Studies have focused on the susceptibility of the inlet to closure and the current water quality and biological resources in the Fort George River. Additional shoreline management issues include the erosion of the Little Talbot Island State Park and the effects of the structures recently constructed (2005) on South Amelia Island.

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Appendices

Appendix A – Shellfish Harvesting Waters in Timucuan Ecological and Historic Preserve

Appendix B – Extent of Submerged Aquatic Vegetation in Vicinity of Timucuan

Appendix C – Nekton Species Identified by Dennis et al. (2001)

Appendix D – Protected Species of Fish, Amphibians, Reptiles, Birds, Mammals, and Plants that May Occur Within Timucuan Boundaries

Appendix E – US Geological Survey Documented Wells Located Within Timucuan Ecological and Historic Preserve Study Area

Appendix F – Domestic and Industrial National Pollutant Discharge Elimination System Permittees in Duval and Nassau Counties

Appendix G – Compliance History of Major National Pollutant Discharge Elimination System Dischargers in Duval and Nassau Counties

Appendix A – Explanation of Shellfish Harvesting Classifications

Shellfish may only be harvested from approved or conditionally approved areas, unless under special permit and supervision. Shellfish areas under the conditionally approved category are reopened when the appropriate National Shellfish Sanitation Program (NSSP) standards are met and adequate time has elapsed for purification to occur. No shellfish may be harvested from prohibited and unclassified areas.

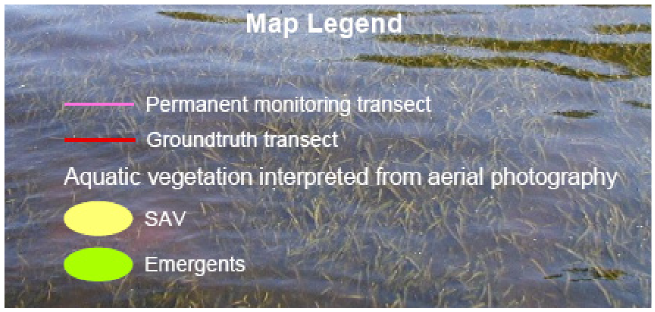
Shellfish Harvesting Classifications

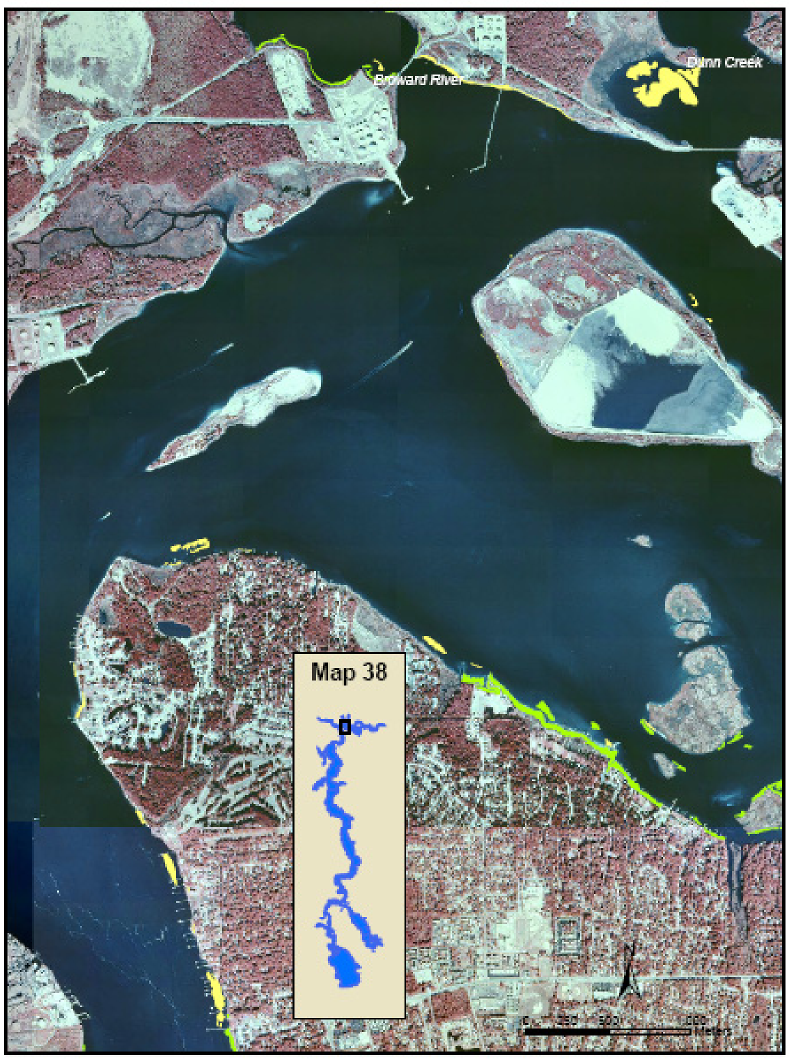
Approved	Normally open to shellfish harvesting, may be temporarily closed under extraordinary circumstances such as red tides, hurricanes, and sewage spills. The 14/43 standard must be met for all combinations of defined adverse pollution conditions (tide, rainfall, river, tide/rainfall, tide/river, and tide/rainfall/river).
Conditionally Approved	Periodically closed to shellfish harvesting based on pollution events such as rainfall or increased river flow
Restricted	Normally open to relaying or controlled purification, allowed only by special permit and supervision; may be temporarily closed under extraordinary circumstances, such as red tides, hurricanes, or sewage spills
Conditionally Restricted	Periodically, relay and controlled purification activity is temporarily suspended based on pollution events, such as rainfall or increased river flow.
Prohibited	Shellfish harvesting is not permitted due to actual or potential pollution
Unclassified (Unapproved)	Shellfish harvesting is not permitted pending bacteriological and sanitary surveys

Based on classifications from Florida Department of Agriculture and Consumer Sciences.

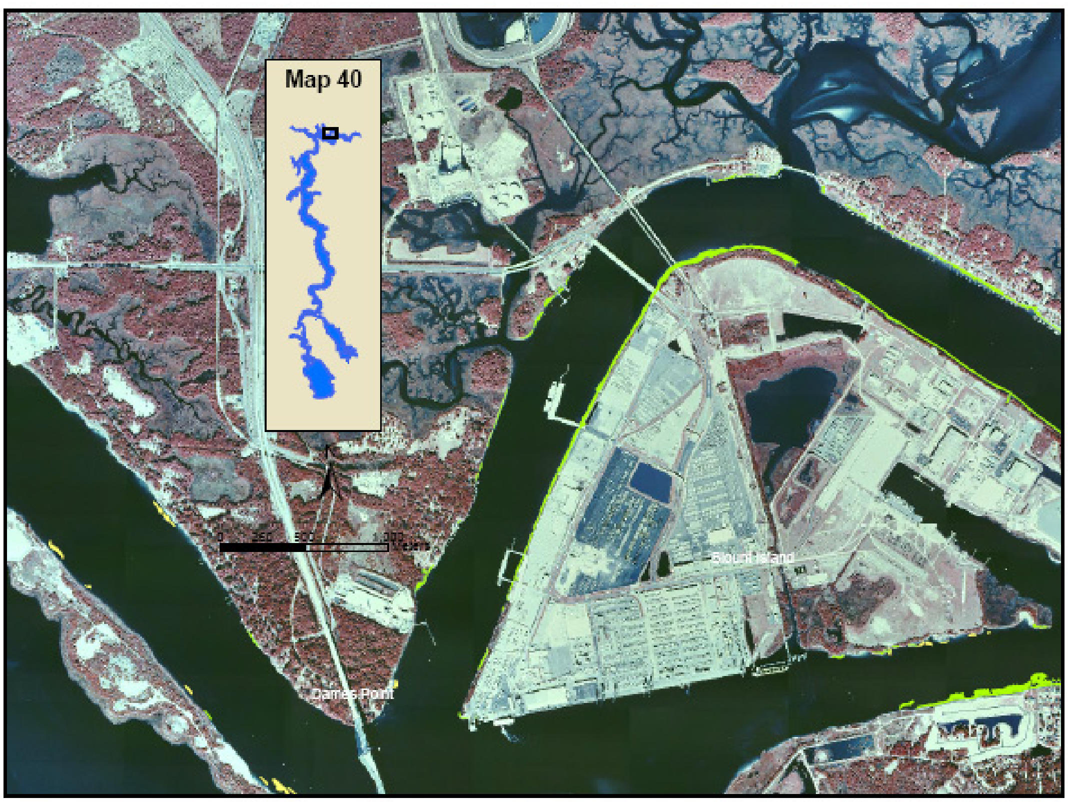
Appendix B – Extent of Submerged Aquatic Vegetation in Vicinity of Timucuan

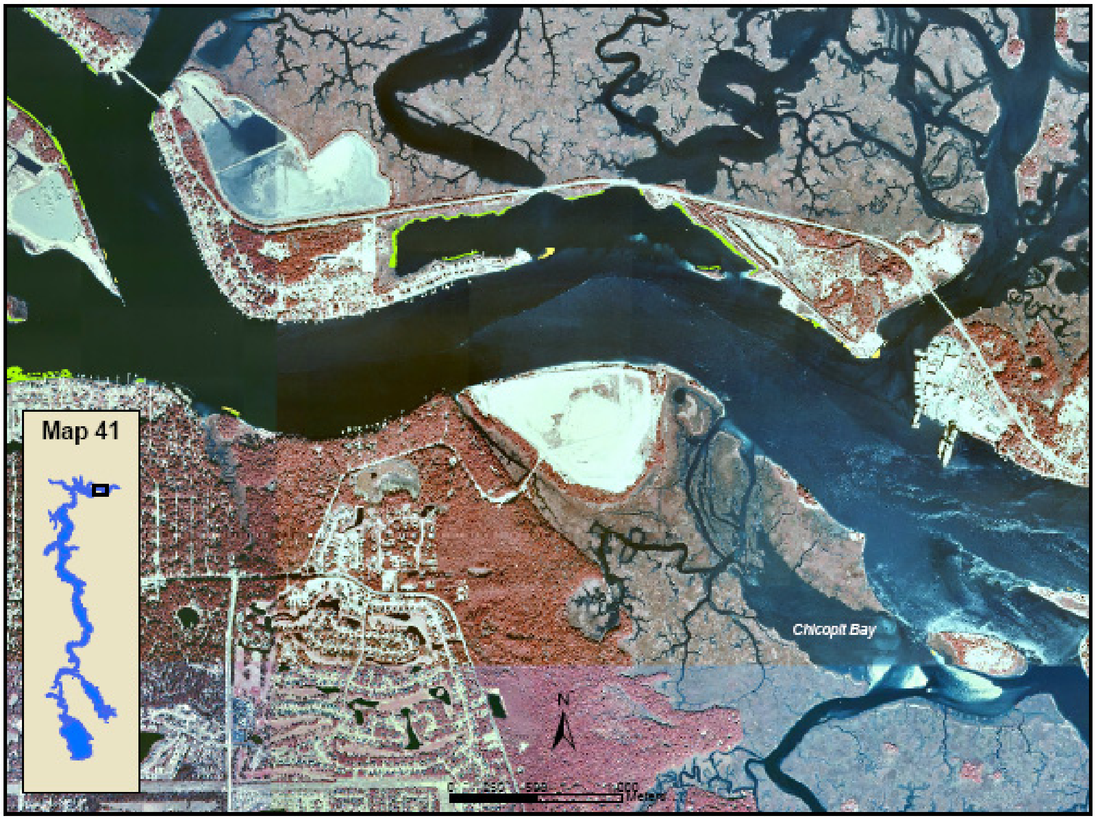
True color aerial photographs were obtained at a scale of 1”=1,000’ in January 2001. Images were scanned and spatially referenced to SAV groundtruthing data (UTM17, NAD83, meters) (Dobberfuhl and Trahan, 2001). The following slides include the area from the bend area of the SJR to the mouth. All slides obtained from Dobberfuhl and Trahan, 2001.

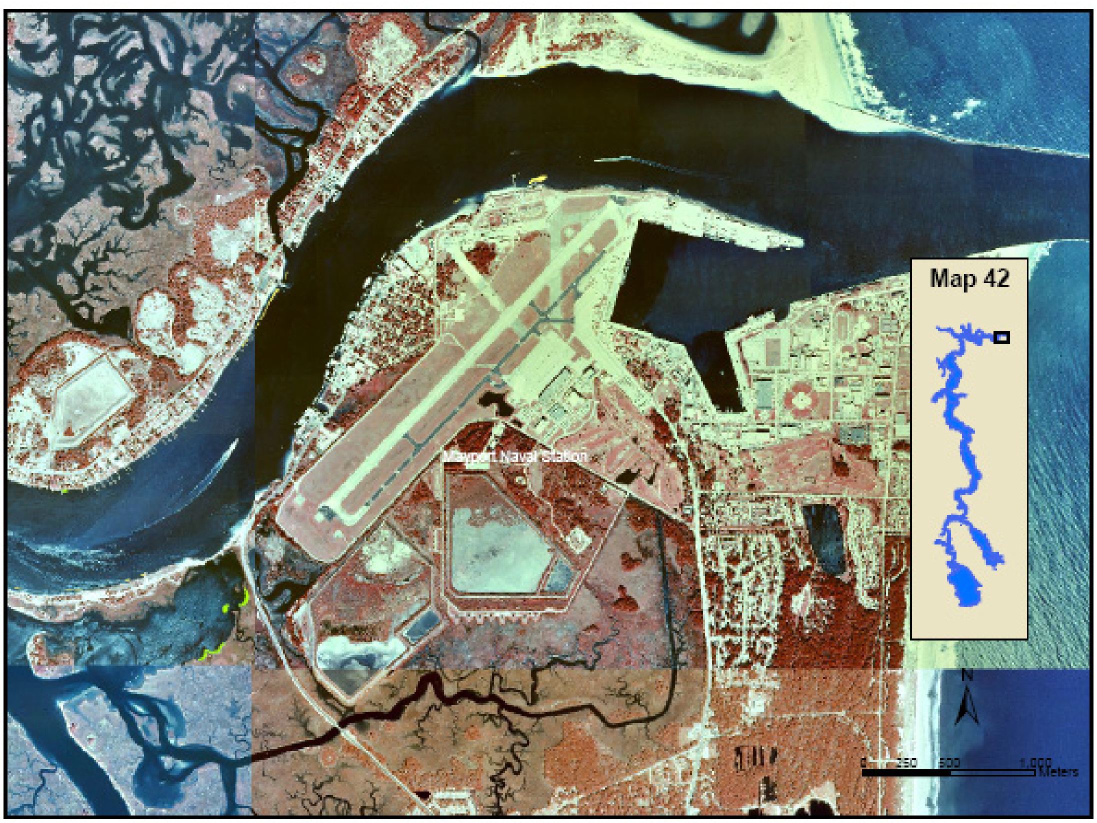





Map 39
Mill Cove


Map 40
Blount Island
Dames Point


Map 41
Chicopit Bay
N
Meters


Map 42
Mayport Naval Station
N
Meters

Appendix C – Nekton Species Identified by Dennis et al. (2001)

Scientific Name (Common Name)

Albulidae
Albula vulpes (bonefish)

Ariidae
Arius felis (hardhead catfish)
Bagre marinus (gafftopsail catfish)

Atherinidae
Labidesthes sicculus (brook silverside)
Membras martinica (rough silverside)
Menidia beryllina (inland silverside)
Menidia menidia (Atlantic silverside)
Menidia peninsulae (tidewater silverside)

Anguillidae
Anguilla rostrata (American eel)
Myrophis punctatus (speckled worm eel)
Ophichthus gomesii (shrimp eel)
Alosa mediocris (hickory shad)
Brevoortia smithi (yellowfin menhaden)
Brevoortia tyrannus (Atlantic menhaden)
Dorosoma cepedianum (gizzard shad)
Dorosoma petenense (threadfin shad)
Harengula jaguana (sealed sardine)
Opisthonema oglinum (Atlantic thread herring)

Batrachoididae
Opsanus tau (oyster toadfish)

Blenniidae
Chasmodes bosquianus (striped blenny)
Hypsoblennius ionthas (freckled blenny)

Belonidae
Strongylura marina (Atlantic needlefish)
Strongylura timucu (timucu)

Carangidae
Caranx crysos (blue runner)
Caranx hippos (crevalle jack)
Chloroscombrus chrysurus (Atlantic bumper)
Oligoplites saurus (leatherjacket)
Selene vomer (lookdown)
Trachinotus carolinus (Florida pompano)
Trachinotus falcatus (permit)

Centrarchidae
Enneacanthus gloriosus (bluespotted sunfish)
Lepomis auritus (redbreast sunfish)
Lepomis gulosus (warmouth)
Lepomis macrochirus (bluegill)
Lepomis microlophus (redear sunfish)
Micropterus salmoides (largemouth bass)
Pomoxis nigromaculatus (black crappie)

Carcharhinidae
Carcharhinus leucas (bull shark)
Carcharhinus limbatus (blacktip shark)
Rhizoprionodon terraenovae (Atlantic sharpnose shark)

Centropomidae
Centropomus undecimalis (common snook)

Cynoglossidae
Symphurus plagiusa (blackcheek tonguefish)

Cyprinidae
Notemigonus crysoleucas (golden shiner)

Cyprinodontidae
Cyprinodon variegatus (sheedshed minnow)
Floridichthys carpio (goldspotted killifish)

Diodontidae
Chilomycterus schoepfii (striped burrfish)

Engraulidae
Anchoa hepsetus (striped anchovy)
Anchoa mitchilli (bay anchovy)

Fundulidae
Fundulus confluentus (marsh killifish)

Elopidae
Elops saurus (ladyfish)

Ephippidae
Chaetodipterus faber (Atlantic spadefish)

Gerreidae
Diapterus auratus (Irish pompano)
Diapterus plumieri (striped mojarra)

Scientific Name (Common Name)

Fundulus heteroclitus (mummichog)
Fundulus majalis (striped killifish)
Lucania parva (rainwater killifish)

Gobiesocidae
Gobiesox strumosus (skilletfish)

Haemulidae
Orthopristis chrysoptera (pigfish)

Ictaluridae
Ameiurus catus (white catfish)
Ameiurus nebulosus (brown bullhead)
Ictalurus punctatus (channel catfish)

Lepisosteidae
Lepisosteus osseus (longnose gar)
Lepisosteus platyrhincus (Florida gar)

Monacanthidae
Stephanolepis hispidus (planehead filefish)

Paralichthyidae
Citharichthys spilopterus (bay whiff)
Etropus crossotus (fringed flounder)
Paralichthys albigutta (gulf flounder)
Paralichthys dentatus (summer flounder)
Paralichthys lethostigma (southern flounder)

Pomatomidae
Pomatomus saltatrix (bluefish)
Scombridae
Scomberomorus maculatus (Spanish mackerel)

Serranidae
Centropristis striata (black sea bass)
Mycteroperca microlepis (gag)

Soleidae
Achirus lineatus (lined sole)
Trinectes maculatus (hogchoker)

Sparidae
Archosargus probatocephalus (sheepshead)
Lagodon rhomboides (pinfish)

Syngnathidae
Hippocampus erectus (lined sea horse)
Hippocampus zosterae (dwarf sea horse)

Eucinostomus argenteus (spotfin mojarra)
Eucinostomus gula (silver jenny)
Eucinostomus harengulus (tidewater mojarra)
Eucinostomus jonesii (slender mojarra)

Gobiidae
Bathygobius soporator (frillfin goby)
Gobioides broussonnetii (violet goby)
Gobionellus boleosoma (darter goby)
Gobionellus hastatus (sharptail goby)
Gobionellus shufeldti (freshwater goby)
Gobiosoma bosc (naked goby)
Gobiosoma ginsburgi (seaboard goby)
Microgobius gulosus (clown goby)
Microgobius thalassinus (green goby)

Lobotidae
Lobotes surinamensis (tripletail)

Lutjanidae
Lutjanus griseus (gray snapper)
Lutjanus synagris (lane snapper)

Mugilidae
Mugil cephalus (striped mullet)
Mugil curema (white mullet)

Percichthyidae
Morone saxatilis (striped bass)

Poeciliidae
Gambusia holbrooki (mosquitofish)
Poecilia latipinna (sailfin molly)

Sciaenidae
Bairdiella chrysoura (silver perch)
Cynoscion nebulosus (spotted seatrout)
Cynoscion nothus (sand seatrout)
Cynoscion regalis (weakfish)
Larimus fasciatus (banded drum)
Leiostomus xanthurus (spot)
Menticirrhus americanus (southern kingfish)
Menticirrhus littoralis (golf kingfish)
Menticirrhus saxatilis (northern kingfish)
Micropogonias undulatus (Atlantic croaker)
Pogonias cromis (black drum)
Sciaenops ocellatus (red drum)
Stellifer lanceolatus (star drum)

Sphyrnidae
Sphyrna tiburo (bonnethead)
Dasyatis Americana (southern stingray)
Dasyatis Sabina (Atlantic stingray)
Dasyatis say (bluntnose stingray)

Scientific Name (Common Name)

Syngnathus floridae (dusky pipefish)
Syngnathus fuscus (northern pipefish)
Syngnathus louisianae (chain pipefish)
Syngnathus scovelli (gulf pipefish)

Tetraodontidae
Sphoeroides maculates (northern puffer)
Sphoeroides nephelus (southern puffer)

Triglidae
Prionotus carolinus (northern sea robin)
Prionotus evolans (striped sea robin)
Prionotus scitulus (leopard sea robin)
Prionotus tribulus (bighead sea robin)

Amia calva (bowfin)

Synodontidae
Synodus foetens (inshore lizardfish)

Trichiuridae
Trichiurus lepturus (Atlantic cutlassfish)

Uranoscopidae
Astroscopus y-graecum (southern stargazer)

Source: Dennis et al., 2001.

Appendix D - Protected Species of Fish, Amphibians, Reptiles, Birds, Mammals, and Plants that May Occur Within Timucuan Boundaries.

Common Name	Scientific Name	Designated Status[1] FWCC	USFWS	NOAA-NMFS
Fish				
Atlantic sturgeon	*Acipenser oxyrhynchus*	SSC (1)	-	C2
Shortnose sturgeon	*Acipenser breviostrum*	E	-	E
Amphibians and Reptiles				
American alligator	*Alligator mississippiensis*	SSC (1,3)	T (S/A)	-
Alligator snapping turtle	*Macroclemys temminicki*	SSC (1)	-	-
Atlantic green turtle	*Chelonia mydas*	E	-	E
Atlantic hawksbill turtle	*Eretmochelys imbricate*	E	-	E
Atlantic leatherback turtle	*Dermochelys coriacea*	E	-	E
Atlantic loggerhead turtle	*Caretta caretta*	T	-	T
Atlantic ridley turtle	*Lepidochelys kempi*	E	-	E
Atlantic salt marsh snake	*Nerodia fasciata teaeniata*	T	T	-
Eastern indigo snake	*Drymarchon corais couperi*	T	T	-
Florida pine snake	*Pituophis melanoleuas mugitus*	SSC (2)	-	-
Gopher frog	*Rana areolata*	SSC (1,2)	-	-
Gopher tortoise	*Gopherus polyphemus*	SSC (1,2,3)	-	-
Birds				
American oystercatcher	*Haematopus palliates*	SSC (1,2)	-	-
Arctic peregrine falcon	*Falco peregrinus tundrius*	E	DM	-
Bald eagle	*Haliaeetus leucocephalus*	T	T	-
Black skimmer	*Rynchops niger*			
Brown pelican	*Pelecanus occidentalis*	SSC (1)	DM	-
Florida scrub jay[2]	*Aphelecona coerulescens coerulescens*	T	T	-
Least tern	*Sterna antillarum*	T	-	-
Little blue heron	*Egretta caerulea*	SSC (1,4)	-	-
Osprey	*Pandion haliaetus*	SSC[2] (1,2)	-	-
Peregrine falcon	*Falco Peregrinus*	E	E	-
Piping plover	*Caradrius melodus*	T	T	-
Red-cockaded woodpecker	*Picoides borealis*	SSC	E	-
Reddish egret	*Egretta rufescens*	SSC (1,4)	-	-
Roseate spoonbill	*Ajaja ajaja*	SSC (1,4)	-	-
Smyrna seaside sparrow[2]	*Ammodramus maritimus pelonotus*	-	C3A	-
Snowy egret	*Egretta thula*	SSC (1)	-	-
Southeastern American kestrel	*Falco sparverius paulus*	T	-	-
Tri-colored (Louisiana) heron	*Egretta tricolor*	SSC (1,4)	-	-
White ibis	*Eudocimus albus*	SSC (2)	-	-
Wood stork	*Mycteria americana*	E	E	-
Worthington's marsh wren	*Cistothorus palustris griseus*	SSC (1)	-	-
Mammals				
Finback whale	*Balaenoptera physalus*	E	-	E
Florida black bear	*Urus americanus floridanus*	T[3]	-	-
Florida panther[2]	*Felis concolor corvi*	E	E	-
Florida mouse	*Peromscus floridanus*	SSC (1)	-	-
Humpback whale	*Megaptera novaengliae*	E	-	E
Right whale	*Eubaleana glacialis*	E	-	E
Sei whale	*Balaenoptera borealis*	E	-	E
Sherman's fox squirrel	*Sciurus niger shermani*	SSC (1,2)	-	-
Sperm whale	*Physeter catodon*	E	-	E
West Indian manatee	*Trichechus manatus latirostris*	E	E	-

		Designated Status FDACS[3]
Plants		
Abrupt-tip maiden fern	*Thelypteris augescens*	T
Atlantic coast Florida lantana	*Lantana depressa* var *floridana*	E
Bartram's ixia	*Sphenostigma caelestina*	E
Butterfly orchid	*Encyclia tampensis*	CE
Catesby lily	*Lilium catesbaei*	T
Cinnamon fern	*Osmunda cinnamomea*	CE
Crested coralroot	*Hexalectris spicata*	E
Dutchman's pipes	*Aristolochia tomentosa*	E
Eastcoast coontie	*Zamia umbrosa*	CE
Florida ladies-tresses	*Spiranthes brevilabris var. floridana*	E
Godfrey's privet	*Forestiera godfreyi*	E
Green ladies-tresses	*Spiranthes polyantha*	E
Greenfly orchid	*Epidendrum conopseum*	CE
Hooded pitcher plant	*Sarracenia minor*	T
Lace-lip ladies-tresses	*Spiranthes laciniata*	T
Little ladies-tresses	*Spiranthes grayi*	T
Long-lip ladies-tresses	*Spiranthes longilabris*	T
Many-flowered grass pink	*Calopogon multiflorus*	E
Nodding club moss	*Lycopodium cernuum*	CE
Oval ladies-tresses	*Spiranthes ovalis*	E
Polypody fern (unnamed)	*Polypodium plumula*	E
Prickly-pear cactus	*Opuntia stricta*	T
Rosebud Orchid	*Cleistes divaricata*	T
Royal fern	*Osmunda regalis*	CE
Shadow-witch orchid	*Ponthieva r. var. racemosa*	E
Slender ladies-tresses	*Spiranthes gracilis*	E
Southern lady fern	*Athyrium asplenioides*	T
Southern lip fern	*Cheilanthes microphylla*	E
Southern twayblade orchid	*Listera australis*	T
Southern tubercled orchid	*Platanthera flava*	T
Terrestrial peperomia	*Peperomia humilis*	E
Texas ladies-tresses	*Spiranthes brevilabris var. brevilabris*	E
Water sundew	*Drosera intermedia*	T
Wild pine	*Tillandsia bartramii*	E
Yellow fringe orchid	*Platanthera ciliaris*	T

[1]In the event that a species has federal status that varies by state, the federal listing as it pertains to the state of Florida was used in this table.
[2]No record of occurrence in TIMU, but listed based on Table 8 in NPS, 1996a.
[3] None of the plant species is federally protected at the time of this report's publication.

Key:

E	=	Endangered
T	=	Threatened
T (S/A)	=	Threatened due to similarity of appearance in the entire range
C2	=	A candidate for listing, with some evidence of vulnerability, but for which not enough data exist to support listing. This designation provides no protection under the Endangered Species Act. However, it is NPS policy to treat such taxa as threatened or endangered until additional data on their population sizes and distribution show otherwise.
C3A	=	Species no longer being considered for listing (probably extinct)
DM	=	De-listed taxon, recovered, being monitored first five years
SSC	=	Species of special concern
CE	=	Commercially exploited

Sources for Species: COJ, 1998; FDEP, 1998b; FDEP, 2003; FNAI, 2004; NPS, 1996a.
Sources for Status: Coile and Garland, 2003; FWCC, 2004; FWS, 2005; NOAA-NMFS; Wunderlin and Hansen, 2004.

Appendix E - US Geological Survey Documented Wells Located Within Timucuan Ecological and Historic Preserve Study Area

Site number	Station Name	Latitude	Longitude	HUC	Aquifer Code	Well Depth (ft)	Water Quality Begin Date	Water Quality End Date	Water Quality Data Count	Groundwater Begin Date	Groundwater Data End Date	Groundwater Data Count
302159081235601	D-2386 HANNA PARK TEST WELL	30.3666	-81.3987	3080103	120FLRD	2026	2/1/1981	10/23/2000	189	11/26/1985	1/25/2005	218
302301081295001	DS-522 FT. CAROLINE NATIONAL MEMORIAL PARK	30.3839	-81.4970	3080103	122HTRN	34	N/A	N/A	N/A	N/A	N/A	N/A
302301081295002	DS-523 FT. CAROLINE NATIONAL MEMORIAL PARK	30.3839	-81.4970	3080103	120FLRD	204	N/A	N/A	N/A	N/A	N/A	N/A
302307081293801	D-424 FT.CAROLINE NATL PARK SPANISH POND	30.3855	-81.4937	3080103	120FLRD	700	12/16/1966	8/11/2000	199	12/19/1966	10/21/2004	226
302339081254702	D-464A J-0531 1459 JULIA ST; MAYPORT, FL.	30.3944	-81.4295	3080103	120FLRD	1000	4/3/1974	9/18/2003	148	5/3/1977	9/23/2004	54
302502081330701	D-0228 J-0295	30.4175	-81.5518	3080103	120FLRD	850	5/8/1974	7/24/2003	99	4/25/1980	7/27/2004	86
302502081321001	D-0270 J-0335 5186 HECKSHER DR, JAX, FL.	30.4175	-81.5359	3080103	120FLRD	N/A	1/21/1960	9/12/2000	59	1/21/1960	5/17/2004	62
302503081332001	D-1149 J-1138	30.4177	-81.5554	3080103	120FLRD	1104	10/13/1976	7/24/2003	94	1/17/1980	7/27/2004	72
302505081331001	D-1150 J-1139	30.4183	-81.5526	3080103	120FLRD	1104	9/13/1976	7/24/2003	91	1/9/1981	7/27/2004	67
302511081331201	D-1151 J-1140	30.4200	-81.5531	3080103	120FLRD	1104	9/13/1976	7/24/2003	90	6/5/1984	7/24/2004	49
302519081331501	D-1152 J-1141	30.4222	-81.5540	3080103	120FLRD	1104	10/25/1979	1/30/2003	90	1/9/1981	7/27/2004	69
302531081253902	D-625R AT FT GEORGE ISLAND, FL	30.4255	-81.4273	3070205	120FLRD	N/A	N/A	N/A	N/A	N/A	N/A	N/A
302538081253201	D-164 REPLACEMENT WELL AT FT GEORGE ISLAND, FL	30.4275	-81.4254	3070205	120FLRD	N/A	0000-00-00	0000-00-00	0	12/15/2003	5/25/2004	5

Site number	Station Name	Latitude	Longitude	HUC	Aquifer Code	Well Depth (ft)	Water Quality Begin Date	Water Quality End Date	Water Quality Data Count	Groundwater Begin Date	Groundwater Data End Date	Groundwater Data Count
302538081253101	D-164 J-228 GOLF COURSE @ FT. GEORGE ISLAND, FL.	30.4275	-81.4251	3080103	120FLRD	619	8/19/1930	7/25/2003	364	8/19/1930	9/20/2004	341
302545081330901	D-3065 (J-3619)	30.4294	-81.5523	3080103	120FLRD	750	7/30/2003	7/30/2003	1	0000-00-00	0000-00-00	0
302550081331501	D-3840 ST.JOHNS RIVER POWER PARK REPLACEMENT WELL	30.4308	-81.5540	3080103	N/A	750	0000-00-00	0000-00-00	0	5/2/1990	5/2/1990	1
302557081253101	D-0913 J-1048	30.4327	-81.4251	3080103	120FLRD	N/A	4/13/1976	7/25/2003	59	10/31/1990	10/28/2004	57
302709081311601	D-1307 CAMDEN RD NR EASTPORT,FL	30.4527	-81.5209	3070204	N/A	978	0000-00-00	0000-00-00	0	5/19/2003	9/20/2004	4
302724081244801	D-0395 J-0462 LITTLE TALBOT IS. ST. PARK; JAX,FL	30.4569	-81.4131	3080103	120FLRD	N/A	5/10/1966	7/25/2003	110	5/10/1966	10/28/2004	117
303209081371801	TISONIA FIRETOWER NR JACKSONVILLE,FL	30.5361	-81.6215	3080103	120FLRD	850	12/8/1989	9/12/2000	10	6/19/1989	9/20/2004	18
303357081295601	N-119 CHARLES ALLEN WELL N-100 SUB	30.5661	-81.4987	3070205	120FLRD	N/A	5/14/1985	9/11/2000	32	5/14/1985	9/20/2004	40

Aquifer Codes
120FLRD = Floridan Aquifer System
122HTRN = Hawthorn Formation

Appendix F - Domestic and Industrial National Pollutant Discharge Elimination System Permittees in Duval and Nassau Counties

County	Facility ID	Name	Major or minor Discharge	Facility Type	City	Treatment Process Summary	Permitted Capacity (MGD)	Domestic Wastewater Class
DUVAL	FL0026441	ARLINGTON EAST WWTF	MA	Domestic WWTP	JACKSONVILLE	ACTIVATED SLUDGE SEWAGE TREATMENT PLANT W/ EFFLUENT TO ST. JOHNS RIVER	15	2A
DUVAL	FL0038776	ATLANTIC BEACH WWTF	MA	Domestic WWTP	ATLANTIC BEACH	Complete mix or conventional WWTP with effluent to St. Johns River (D-001) or Intracoastal Waterway (D-002)	3	2B
DUVAL	FL0026778	BEACON HILLS SUBDIVISION WWTF	MA	Domestic WWTP	JACKSONVILLE	An existing activated sludge domestic wastewater treatment facility which can be operated in either the extended aeration mode or the contact stabilization mode. The design capacity in the extended aeration mode is 0.836 MGD AADF and in the contact stabilization mode, the design capacity is 1.3 MGD AADF. The package plant consists of an influent bar rack, 212,400 gallon contact zone, 424,900 gallon reaeration zone, a 2,827 square foot (253,750 gallon) secondary clarifier, gas chlorine disinfection, a 70,400 gallon chlorine contact chamber, dechlorination with sulfur dioxide, and a 381,500 gallon aerobic digester. Wastewater residuals are hauled for land application at an approved site. To construct and operate a Sodium Hypochlorite facility for disinfection.	1.3	2B
DUVAL	FL0023248	BUCCANEER WWTF (ATLANTIC BEACH WWTF #2)	MA	Domestic WWTP	ATLANTIC BEACH	Advanced secondary activated sludge wastewater treatment facility consisting of an influent screening unit, a master pump station, a grit removal unit , an odor control system, three sequencing batch reactors (0.457 Mgal. each), two chlorine contact chambers (47,870 gallons total), one 16,500 gallon dechlorination basin, and two aerobic digesters (79,300 Gal. and 50,800 Gal.)	1.9	3B
DUVAL	FL0026000	BUCKMAN WWTF	MA	Domestic WWTP	JACKSONVILLE	ACTIVATED SLUDGE SEWAGE TREATMENT PLANT W/ EFFLUENT TO ST JOHNS RIVER	52.5	2A
DUVAL	FL0026450	DISTRICT II WWTF	MA	Domestic WWTP	JACKSONVILLE	ACTIVATED SLUDGE SEWAGE TREATMENT PLANT W/ EFFLUENT TO ST. JOHNS RIVER	10	2A
DUVAL	FL0020231	JACKSONVILLE BEACH WWTF	MA	Domestic WWTP	JACKSONVILLE BEACH	CONVENTIONAL ACTIVATED SLUDGE WITH BASIC DISINFECTION	4.5	2B

County	Facility ID	Name	Major or minor Discharge	Facility Type	City	Treatment Process Summary	Permitted Capacity (MGD)	Domestic Wastewater Class
DUVAL	FL0023671	JACKSONVILLE HEIGHTS WWTF	MA	Domestic WWTP	JACKSONVILLE	ACTIVATED SLUDGE SEWAGE TREATMENT PLANT W/ EFFL TO DITCH TO FISHING CREEK	2.5	2B
DUVAL	FL0037869	JEA - SAINT JOHNS RIVER POWER PARK WWTF	MA	Industrial Wastewater	JACKSONVILLE	ELECTRIC POWER GENERATING STATION STORM WATER; COOLING TOWER BLOWDOWN		UK
DUVAL	FL0001023	JEA KENNEDY GENERATING STATION	MA	Industrial Wastewater	JACKSONVILLE	2 EVAPORATION PERC POND W/ .3 MGD FLOW 222 MGD COOLING WATER W/ MIXING ZONE		UK
DUVAL	FL0001031	JEA NORTHSIDE UNITS 1 2 3	MA	Industrial Wastewater	JACKSONVILLE	827 MGD COOLING WATER TO ST. JOHNS 3.0 MGD CWTS TO EVAP/PERC PONDS		UK
DUVAL	FL0000892	JEFFERSON SMURFIT CORP - JAX	MA	Industrial Wastewater	JACKSONVILLE	flow equalization, grit removal, neutralization, primary clarification, activated sludge treatment with nutirent additin and pure oxygenation, secondary clarification, recycling of effluent , sludge dewatering system		UK
DUVAL	FL0023493	MANDARIN WRF	MA	Domestic WWTP	JACKSONVILLE	A 7.5 MGD AADF NITROGEN REMOVAL ACTIVATED SLUDGE WWTF AND ULTRAVIOLET DISINFECTION PRIOR TO DISCHARGE TO THE ST JOHNS RIVER	7.5	2B
DUVAL	FL0000884	MILLENNIUM SPECIALITY CHEMICALS (FKA SCM GLIDCO)	MA	Industrial Wastewater	JACKSONVILLE	non-process wastewater and storm water treated separately. Non-process wastewater is treated in a lined pond and then Storm Filter-disinfection with partial discharge to D-001 and proposed to golf course for reuse. Storm water is disposed of to D-001 after settling and storm filter treatment.	0.6	UK
DUVAL	FL0023604	MONTEREY WWTF	MA	Domestic WWTP	JACKSONVILLE	Four Sequencing Batch Reactors with discharge to the Saint Johns River.	3.6	3B
DUVAL	FL0020427	NEPTUNE BEACH WWTF	MA	Domestic WWTP	NEPTUNE BEACH	Plant 1- 0.90 MGD contact/stabilization, plant 2- 0.60 MGD contact/stabilization plant discharge to beaches outfall (Sherman Point)	1.5	2C
DUVAL	FL0026751	ROYAL LAKES WWTF	MA	Domestic WWTP	JACKSONVILLE	ACTIVATED SLUDGE SEWAGE TREATMENT PLANT W/ EFFLUENT TO ST. JOHNS RIVER	3.25	2B
DUVAL	FLG110502	S & W BALDWIN CONCRETE BATCH PLANT	MA	Concrete Batch GP	JACKSONVILLE			
DUVAL	FL0023663	SAN JOSE WWTF	MA	Domestic WWTP	JACKSONVILLE	ACTIVATED SLUDGE SEWAGE TREATMENT PLANT W/ EFFLUENT TO ST. JOHNS RIVER	2.25	2B

County	Facility ID	Name	Major or minor Discharge	Facility Type	City	Treatment Process Summary	Permitted Capacity (MGD)	Domestic Wastewater Class
DUVAL	FL0026468	SOUTHWEST DISTRICT WWTF	MA	Domestic WWTP	JACKSONVILLE	Conventional activated sludge WWTP with effluent to the St. Johns River, the chlorination/dechlorination system is currently being converted to UV disinfection. Additional aeration basins are being constructed with modifications to allow biological nutrient reduction (BNR) using integral anoxic zones.	10	2A
DUVAL	FL0000400	STONE CONTAINER CORPORATION	MA	Industrial Wastewater	JACKSONVILLE	PRIMARY CLARIFICATION - AERATION BASIN	20	UK
DUVAL	FL0000922	USN MAYPORT NAVAL STATION WWTF	MA	Domestic WWTP	MAYPORT	ACTIVATED SLUDGE SEWAGE TREATMENT PLANT W/ EFFLUENT TO ST. JOHNS RIVER	2	2B
DUVAL	FL0000957	USN NAS JACKSONVILLE WWTF	MA	Domestic WWTP	JACKSONVILLE	Activated sludge with filtration and high-level disinfection.	2.25	2B
NASSAU	FL0027260	FERNANDINA BEACH WWTF	MA	Domestic WWTP	FERNANDINA BEACH	ACTIVATED SLUDGE SEWAGE TREATMENT PLANT W/ EFFLUENT TO AMELIA RIVER	3.5	2B
NASSAU	FL0001104	JEFFERSON SMURFIT CORP-FERNANDINA BEACH MILL	MA	Industrial Wastewater	FERNANDINA BEACH	37.5 MGD discharge of TRT process wastewater and stormwater. TRT-grit chamber, primary clarifier, WW cooling tower, UNOX activated sludge system, dual secondary clarifiers with discharge to Amelia River (D001).	37.5	UK
NASSAU	FL0000701	RAYONIER, INC	MA	Industrial Wastewater	FERNANDINA BEACH	Primary clarifier & 34 acre aerated stabilization basin with discharge to Amelia River on outgoing tides.	26.31	UK
DUVAL	FLG110033	ALTA ROAD CONCRETE BATCH PLANT	MI	Concrete Batch GP	JACKSONVILLE	retention pond		UK
DUVAL	FL0001295	AMERADA HESS CORPORATION	MI	Industrial Wastewater	JACKSONVILLE	TWO WW streams (tank drawdown & load rack/stormwater/boiler). Two 10000 gal doublewalled fiberglass underground storage tanks. oil/water seperator, fiberglass stripping tower, sand filter to activated carbon trt system, with final discharge of load rack stormwater & boiler blowdown to St. Johns River. Tank drawdowns to onsite evaporation pad. 100% vehicle wash facility		UK

County	Facility ID	Name	Major or minor Discharge	Facility Type	City	Treatment Process Summary	Permitted Capacity (MGD)	Domestic Wastewater Class
DUVAL	FL0041530	ANHEUSER BUSCH-MAIN ST,OLD SOD FARM	MI	Industrial Wastewater	JACKSONVILLE	Adding nanofiltration reject to south borrow bit		UK
DUVAL	FL0041556	ANHEUSER BUSCH-NEW SOD FARM	MI	Industrial Wastewater	JACKSONVILLE	SPRAY APPLICATION OF BREWERY LIQUOR		UK
DUVAL	FL0178845	ARAMARK UNIFORMS SERVICES INC	MI	Industrial Wastewater	JACKSONVILLE	air stripping, filtration	0.096	UK
DUVAL	FL0040592	ATLANTIC DRY DOCK WWTF	MI	Domestic WWTP	JACKSONVILLE	Extended aeration domestic wastewater treatment facility with final effluent discharged to St. Johns River.	0.06	3C
DUVAL	FL0115231	BAILEY'S MOBILE HOME PARK WWTF	MI	Domestic WWTP	JACKSONVILLE	Extended aeration WWTF consisting of surge tank, one aeration tank, one secondary clarifier, one chlorine contact chamber, one dechlorination unit & one digester.	0.003	3D
DUVAL	FL0027812	BALDWIN WWTF	MI	Domestic WWTP	BALDWIN	Extended aeration WWTP with effluent to unnamed ditch to Deep Creek to St. Marys River	0.4	2C
DUVAL	FL0001287	BP PRODUCTS NORTH AMERICA, INC (FKA WILLIAMS)	MI	Industrial Wastewater	JACKSONVILLE	OIL WATER SEPARATOR, WITH 10,000 GAL HOLDING TANK, EXCESS HAULED TO IWS	0.93	UK
DUVAL	FL0061204	CEDAR BAY COGENERATION PLANT	MI	Industrial Wastewater	JACKSONVILLE	LAG, COF, IOX, ROM,		UK
DUVAL	FLG110368	CEMEX INC - MAIN STREET	MI	Concrete Batch GP	JACKSONVILLE			UK
DUVAL	FLG110285	CEMEX INC - MARSHALL STREET PLANT	MI	Concrete Batch GP	JACKSONVILLE	Type I and Type II system along with 100% Recycle Wash Area		UK
DUVAL	FLG110367	CEMEX INC - SHAD ROAD	MI	Concrete Batch GP	JACKSONVILLE			UK
DUVAL	FL0042421	CENTURION TRUCK PLAZA WWTF	MI	Domestic WWTP	JACKSONVILLE	Extended aeration WWTF with effluent discharged to ditch that flows to Ribault River	0.02	3D
DUVAL	FL0032271	CHEROKEE VILLAGE MOBILE HOME PARK WWTF	MI	Domestic WWTP	JACKSONVILLE	Extended aeration with chlorination and dechlorination	0.005	3D

County	Facility ID	Name	Major or minor Discharge	Facility Type	City	Treatment Process Summary	Permitted Capacity (MGD)	Domestic Wastewater Class
DUVAL	FLG110165	COASTAL CONCRETE OF JACKSONVILLE	MI	Concrete Batch GP	JACKSONVILLE	Retention pond for Type I, Wet detention pond for non-contact storm water, containment for Type II		UK
DUVAL	FLG110283	CSR-RINKER-MARIETTA	MI	Concrete Batch GP	JACKSONVILLE	Type I and Type II		UK
DUVAL	FL0176877	CSX TRANSPORTATION, INC MONCRIEF RAIL YARD	MI	Industrial Wastewater	JACKSONVILLE	air strip	0.138	UK
DUVAL	FLG110329	FLORIDA ROCK - NEW BERLIN ROAD	MI	Concrete Batch GP	JACKSONVILLE	Type I and Type II		UK
DUVAL	FLG110267	FLORIDA ROCK - PALMETTO	MI	Concrete Batch GP	JACKSONVILLE	Type I and Type II systems		UK
DUVAL	FLG110539	FLORIDA ROCK INDUSTRIES, INC. - CR 210	MI	Concrete Batch GP	JACKSONVILLE	Type I and Type II		
DUVAL	FLG110323	FLORIDA ROCK PLANT 2 (UNIVERSITY CBP)	MI	Concrete Batch GP	JACKSONVILLE	type 1 system, type 2 system with clarifiers, and surge basin		UK
DUVAL	FLG110164	FLORIDA ROCK PLANT NO 5 (EDGEWOOD)	MI	Concrete Batch GP	JACKSONVILLE	wet detention ponds for Type I, containment for Type II		UK
DUVAL	FLG110251	FLORIDA ROCK ROOSEVELT CBP	MI	Concrete Batch GP	JACKSONVILLE	Type I Wet Detention and Type II pond		UK
DUVAL	FLG910781	FORMER AAA GAS RAYCO	MI	Petroleum Cleanup GP (long term)	JACKSONVILLE	air strip		UK
DUVAL	FLG910892	FORMER CHUNG'S CHEVRON	MI	Petroleum Cleanup GP (long term)	JACKSONVILLE	diffused aeration, carbon adsorption		UK
DUVAL	FL0167061	FORMER EAGLE PICHER INDUSTRIES FACILITY	MI	Industrial Wastewater	JACKSONVILLE	Air stripping & Activated Carbon Treatment	0.018	UK
DUVAL	FLG911622	FORMER KERR-MCGEE TERMINAL PROPERTY	MI	Petroleum Cleanup GP (long term)	JACKSONVILLE			

County	Facility ID	Name	Major or minor Discharge	Facility Type	City	Treatment Process Summary	Permitted Capacity (MGD)	Domestic Wastewater Class
DUVAL	FLG911774	FORMER TYSON FOODS PLANT	MI	Petroleum Cleanup GP (long term)	JACKSONVILLE			
DUVAL	FLG110365	GRISWOLD READY MIX	MI	Concrete Batch GP	JACKSONVILLE			UK
DUVAL	FL0023426	IDEAL MOBILE HOME PARK WWTF	MI	Domestic WWTP	JACKSONVILLE	Extended aeration activated sludge WWTF consisting of an aeration tank with a volume of approximately 11,810 gallons, a secondary clarifier with a volume of approximately 2,200 gallons, a chlorine contact tank with a volume of approximately 300 gallons, and dechlorination facilities. Residuals are transported to the Buckman Residuals Management Facility for processing. Effluent flows to a drainage ditch and to Ribault River, a tributary of the Saint Johns River.	0.011	3D
DUVAL	FL0001040	INTERNATIONAL FLAVORS AND FRANGRANCES (FKA BUSH BOAKE ALLEN)	MI	Industrial Wastewater	JACKSONVILLE	Retention basin with over/under flow weirs for S/W	2.34	UK
DUVAL	FLG110308	JACKSONVILLE BEACH READY MIX BATCH PLANT #7	MI	Concrete Batch GP	JACKSONVILLE	Type I and Type II system		UK
DUVAL	FL0022578	JACKSONVILLE I-10 TRAVEL CENTER (FKA BALDWIN TRAVEL CENTER)	MI	Industrial Wastewater	BALDWIN	Truck wash discharges to POTW, fule island washdown to oil water separator then to ditch		UK
DUVAL	FL0024279	JUSTISS MOBILE HOME PARK WWTF	MI	Domestic WWTP	JACKSONVILLE	Extended aeration WWTF with basic disinfection and effluent to Ortega River thru gravity system owned by U.S. Navy Air Station	0.015	3D
DUVAL	FL0043150	NAPOLI'S TRAILER PARK WWTF	MI	Domestic WWTP	JACKSONVILLE	Extended aeration, chlorination, dechlorination, reaeration discharge to ditch	0.015	3D

County	Facility ID	Name	Major or minor Discharge	Facility Type	City	Treatment Process Summary	Permitted Capacity (MGD)	Domestic Wastewater Class
DUVAL	FL0033405	PRODUCE TERMINAL OF JACKSONVILLE WWTF	MI	Domestic WWTP	JACKSONVILLE	Septic tank followed by intermittent sand filter. Filtrate collected beneath sand filter, chlorinated in chlorine contact tank, dechlorinated in chlorine contact tank discharge pipe and discharged to a ditch on site. Ditch discharges to drainage ditch along North Edgewood Avenue to Little Sixmile Creek.	0.0042	5D
DUVAL	FLG110284	RINKER - EASTPORT ROAD	MI	Concrete Batch GP	JACKSONVILLE			UK
DUVAL	FLG110375	RINKER MATERIALS - BAYMEADOWS PLANT	MI	Concrete Batch GP	JACKSONVILL			UK
DUVAL	FLG110346	RINKER MATERIALS - ORANGE PARK	MI	Concrete Batch GP	JACKSONVILLE			UK
DUVAL	FL0039691	RIVERSIDE PLAZA	MI	Industrial Wastewater	JACKSONVILLE	NON - CONTACT COOLING WATER SYSTEM	2.1	UK
DUVAL	FL0043095	ROYAL COURT MOBILE HOME PARK NORTH WWTF	MI	Domestic WWTP	JACKSONVILLE	EXTENDED AERATION SEWAGE TREATMENT PLANT W/ EFFL TO STORM DRAIN TO FISHING CREEK	0.015	3D
DUVAL	FL0043141	ROYAL COURT MOBILE HOME PARK SOUTH WWTF	MI	Domestic WWTP	JACKSONVILLE	Extended aeration with chlorination and dechlorination	0.015	3D
DUVAL	FL0024767	SAN PABLO WWTF	MI	Domestic WWTP	JACKSONVILLE	Extended aeration domestic wastewater treatment facility consisting of influent screening, aeration, secondary clarification, and ultraviolet disinfection. Domestic wastewater residuals are aerobically digested then transported to the Buckman Wastewater Treatment Facility for further treatment and disposal.	0.499	2C
DUVAL	FL0023001	SILVER DOLPHIN MOBILE HOME PARK WWTF	MI	Domestic WWTP	JACKSONVILLE	Extended Aeration w/ chlorination and dechlorination and a gravity discharge to Trout Creek. The plant has no digestor.	0.0075	3D
DUVAL	FL0000221	SOUTHERN WOOD PIEDMONT COMPANY - BALDWIN	MI	Industrial Wastewater	BALDWIN	Ground water recovery and treatment by carbon adsorption		UK

County	Facility ID	Name	Major or minor Discharge	Facility Type	City	Treatment Process Summary	Permitted Capacity (MGD)	Domestic Wastewater Class
DUVAL	FL0037761	ST SERVICES-MAIN TERMINAL (FKA STEUART PETROLEUM)	MI	Industrial Wastewater	JACKSONVILLE	OIL WATER SEPARATOR, RETENTION OF STORMWATER RUNOFF		UK
DUVAL	FL0043419	STUDY ESTATES WWTF	MI	Domestic WWTP	JACKSONVILLE	Bar Screen, 19,000 gal aeration basin, sec clarifier, chlor, dechlor	0.0175	3D
DUVAL	FL0043915	SUNNY ACRES MOBILE HOME PARK WWTF	MI	Domestic WWTP	JACKSONVILLE	EXTENDED AERATION SEWAGE TREATMENT PLANT W/ EFFLUENT TO DITCH TO DITCH	0.015	3D
DUVAL	FL0043311	SUNTREE MOBILE HOME PARK WWTF	MI	Domestic WWTP	JACKSONVILLE	Extended aeration WWTP with aeration tank, settling tank, sludge holding tank, chlorination & dechlorination prior to discharge to unnamed tributary to Little Pottsburg Creek.	0.024	3C
DUVAL	FLG110255	TARMAC-EASTPORT	MI	Concrete Batch GP	JACKSONVILLE			UK
DUVAL	FLG911664	THE PANTRY NO. 6116	MI	Petroleum Cleanup GP (long term)	JACKSONVILLE			
DUVAL	FL0001350	TRANSMONTAIGNE PRODUCT SERVCES, INC. -(FKA-COASTAL FUELS .)	MI	Industrial Wastewater	JACKSONVILLE	Retention structure acts as an oil/water separation unit with manual removal of floating oil required. Wastewater from tank water bottoms, boiler condensate, and loading rack drains are collected and hauled off site for disposal.		UK
DUVAL	FL0032492	USN SUPPLY CTR - FUEL DEPOT	MI	Industrial Wastewater	JACKSONVILLE	secondary containment		UK
DUVAL	FL0026786	WOODMERE WWTF	MI	Domestic WWTP	JACKSONVILLE	0.5 mgd Conventional WWTF (current), 0.7 mgd extended (after new construction) with effluent pumped to St. Johns River	0.7	3C

County	Facility ID	Name	Major or minor Discharge	Facility Type	City	Treatment Process Summary	Permitted Capacity (MGD)	Domestic Wastewater Class
NASSAU	FL0038407	CALLAHAN WWTF	MI	Domestic WWTP	CALLAHAN	AADF permitted capacity rotating biological contactor (RBC) WWTF consisting of a communitor system, a primary screening and grit removal unit, a flow equalization tank (15,300 gallons), a RBC unit which consists of one row with three conventional shafts, a secondary clarifier (26 ft in diameter, 10 feet side water depth, and 39,700 gallons total volume) , a chlorine contact chamber (1,257 gallons), and an aerobic digester (45,500 gallons). The domestic wastewater residuals are transported to Circle C RMF for further treatment and final disposal.	0.3	3C
NASSAU	FLG110257	EAST COAST CONCRETE - CALLAHAN	MI	Concrete Batch GP	CALLAHAN			UK
NASSAU	FLG110345	FERNANDINA BEACH READY MIX PLANT	MI	Concrete Batch GP	JACKSONVILLE			UK
NASSAU	FLG110163	FLORIDA ROCK - YULEE	MI	Concrete Batch GP	YULEE	wet detention pond		UK
NASSAU	FL0032662	GOODBREAD MOBILE HOME PARK WWTF	MI	Domestic WWTP	YULEE	Extended aeration WWTF - secondary effluent treatment - discharge to Lofton Creek.	0.005	3D
NASSAU	FL0043079	HILLIARD WWTF	MI	Domestic WWTP	HILLIARD	A AWT SBR with basic disinfection and discharge to constructed wetlands	0.32	2C
NASSAU	FLG911307	ISLAND FOOD STORE NO. 120	MI	Petroleum Cleanup GP (long term)	CALLAHAN	air stripper and activated carbon filtration		
NASSAU	FL0032654	MARSH COVE WWTF	MI	Domestic WWTP	FERNANDINA BEACH	Package WWTP featuring equalization, two aeration basins, two clarifiers, a chlorine contact basin, two tertiary filters and effluent discharge to surface water	0.099	2C
NASSAU	FL0116921	NASSAU HOST WWTF	MI	Domestic WWTP	YULEE	Contact stabilization/conventional activated sludge wastewater treatment facility	0.023	2C
NASSAU	FL0167258	YULEE WWTF	MI	Domestic WWTP	YULEE	2 Sequence Batch Reactors W/ EFF DISPOSAL TO YULEE SWAMP	0.5	UK

Domestic Wastewater Class	Description
5D	Subsurface Disposal System: flow >= 0.005 MGD
1A	AWT: flow >= 3 MGD
1B	AWT: 0.5 MGD <= flow < 3 MGD
1C	AWT: no flow < flow < 0.5 MGD
2A	Act Slg/Cont Stab: flow >= 5 MGD
2B	Act Slg/Cont Stab: 1 MGD <= flow <5 MGD
2C	Act Slg/Cont Stab: no flow < flow < 1 MGD
3A	Ext Air: flow >= 8 MGD
3B	Ext Air: 2 MGD <= flow < 8 MGD
3C	Ext Air: 0.025 MGD <= flow < 2 MGD
3D	Ext Air: no flow < flow < 0.025 MGD
4A	Biofilm: flow >= 10 MGD
4B	Biofilm: 3 MGD <= flow < 10 MGD
4C	Biofilm: 0.025 MGD <= flow < 3 MGD
4D	Biofilm: no flow < flow < 0.025 MGD

Appendix G – Compliance History of Major National Pollutant Discharge Elimination System Dischargers in Duval and Nassau Counties

Facility ID	Name	City	Inspections (3 yrs)	Qtrs Alleged Non Compliance (3 yrs)	Alleged Current Significant Violations	Informal Enforcement Actions (3 yrs)	Formal Enforcement Actions (3 yrs)	Federally required to be reported to EPA
FL0023248	ATLANTIC BEACH - BUCCANEER STP	JACKSONVILLE	3	3	no		i[1]	yes
FL0038776	ATLANTIC BEACH WWTP	ATLANTIC BEACH	4	5	yes		i	yes
FL0027260	FERNANDINA BEACH-MUNICIPAL STP	FERNANDINA BEACH	4	2	no	1	i	yes
FL0020231	JAX BEACH STP	JACKSONVILLE	6	1	no	1	i	yes
FL0026441	JEA - ARLINGTON WWTF	JACKSONVILLE	3	3	no		i	yes
FL0026000	JEA - BUCKMAN WWTF	JACKSONVILLE	9	2	no		3	yes
FL0023671	JEA - JACKSONVILLE HEIGHTS WWT	JACKSONVILLE	5		no		i	yes
FL0023493	JEA - MANDARIN WWTF DIV.	JACKSONVILLE	4	2	no		i	yes
FL0023604	JEA - MONTEREY WWTF	JACKSONVILLE	3	5	no		3	yes
FL0026450	JEA - NORTHEAST WWTF (FKA DIST	JACKSONVILLE	4	6	no		i	yes
FL0026751	JEA - ROYAL LAKES WWTF	JACKSONVILLE	8	7	no		1	yes
FL0037869	JEA - SAINT JOHNS RIVER POWER	JACKSONVILLE	8	5	no		i	yes
FL0023663	JEA - SAN JOSE WWTF	JACKSONVILLE	2	9	no		1	yes
FL0026468	JEA - SOUTHWEST WWTF	JACKSONVILLE	4	1	no		1	yes
FL0001023	JEA KENNEDY GENERATING STATION	JACKSONVILLE	2		no		i	yes
FL0001031	JEA NORTHSIDE UNITS 1 2 3	JACKSONVILLE	7	1	no		1	yes
FL0000892	JEFFERSON SMURFIT CORPORATION	JACKSONVILLE	2	3	no		i	yes
FL0001104	JEFFERSON SMURFIT FERNANDINA	FERNANDINA BEACH	6	3	no		i	yes
FL0020427	NEPTUNE BEACH WWTP	NEPTUNE BEACH	3	6	no		i	yes
FL0000701	RAYONIER, INC.	FERNANDINA BEACH	5	2	no		i	yes
FL0000400	STONE CONTAINER CORPORATION	JACKSONVILLE	5	1	no		i	yes

Facility ID	Name	City	Inspections (3 yrs)	Qtrs Alleged Non Compliance (3 yrs)	Alleged Current Significant Violations	Informal Enforcement Actions (3 yrs)	Formal Enforcement Actions (3 yrs)	Federally required to be reported to EPA
FL0000957	USN NAS JACKSONVILLE STP	JACKSONVILLE	2	8	no		i	yes
FL0000922	USN NS MAYPORT	MAYPORT	3	6	yes		i	yes

[1]i= Indicates that the database shows no formal EPA or state enforcement action. Note that enforcement actions that are in process are not publicly available.

As the nation’s principal conservation agency, the nation’s principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

TIMU D-29, August 2005