Water Resources Management Plan

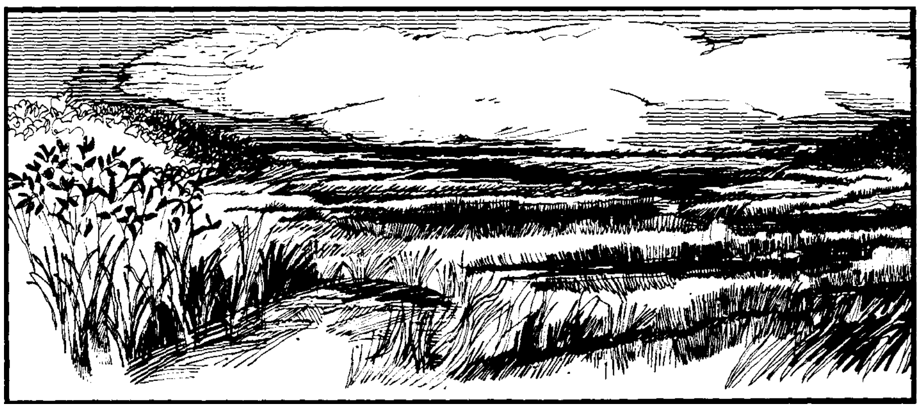
TIMUCUAN

Ecological and Historic Preserve • Florida

WATER RESOURCES MANAGEMENT PLAN

TIMUCUAN ECOLOGICAL AND HISTORIC PRESERVE

FLORIDA



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UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

Approved by: Suzanne Lewis November 1, 1996

Superintendent, Timucuan Ecological and Historic Preserve **Date**

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EXECUTIVE SUMMARY

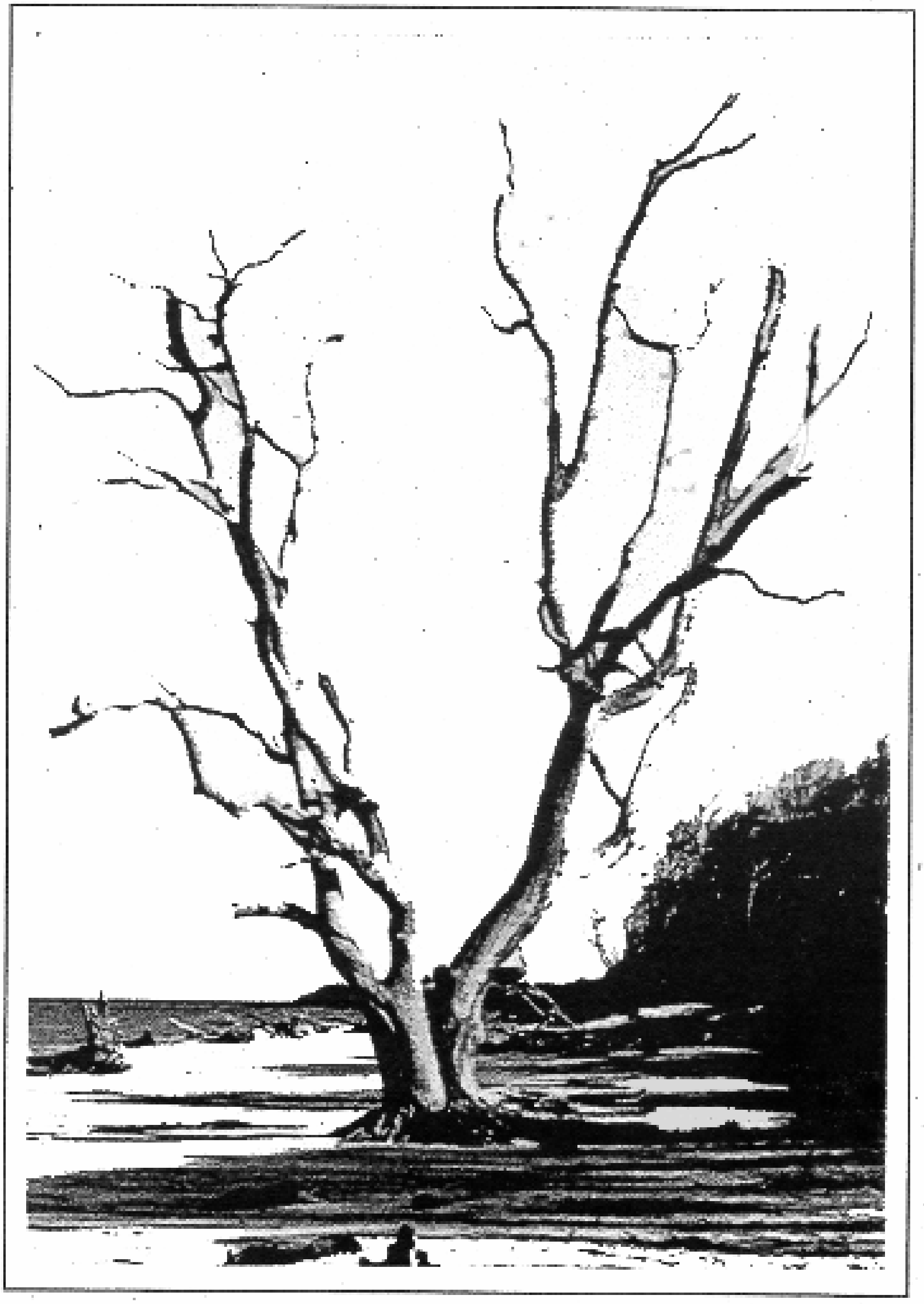
Timucuan Ecological and Historic Preserve encompasses approximately 46,000 acres that include the seaward confluence of the Nassau and St. Johns rivers. These rivers form an extensive estuarine system dominated by salt marsh and coastal hammock habitat, and marine and brackish open waters. These wetlands and waterways are notable for several reasons: both rivers are unusual in that they discharge directly into the Atlantic Ocean rather than into an embayment as is typical of most estuaries; the St. Johns River flows northward (one of the few major north-flowing rivers in North America) through one of the most heavily industrialized areas of Florida; the Nassau River is the only major drainage on the east coast of Florida not channelized or stabilized by engineering structures, especially at the ocean inlet; the estuary is the largest marsh-estuarine system on the east coast of Florida, and is the only example of an Atlantic Sea Island estuarine system in Florida; the estuary is one of the most productive in Florida, based on commercial landings of fmfish; and, the area provides habitat for several state- and federally-listed rare, threatened, or endangered species. Lands and waters within the preserve are owned by the federal government, the State of Florida, the City of Jacksonville, private conservation organizations, private corporations, authorities, and individuals.

Because the preserve is largely a hydrological phenomenon (75% wetlands and open water), water-related issues naturally dominate. For that reason, land use within and adjacent to the preserve as well as land use anywhere in the watersheds, connected by either groundwater or surface water, has the potential to affect the preserve. For example, varied land use results in: (1) severe water pollution in many St. Johns River tributaries upstream of the preserve; (2) elevated metal concentrations in upstream sediments of the St. Johns River; (3) industrial effluent (especially from pulp and paper mills) input upstream of the preserve; (4) presence of several landfills adjacent to the preserve; (5) several sites targeted for cleanup by the U.S. Environmental Protection Agency's Superfund program; and, (6) a propensity for malfunctioning septic systems within and adjacent to the preserve. While information exists concerning the water resources in the preserve, systematically collected information and adequate analysis addressing the preserve's water resources is lacking. The primary purpose of this water resources management plan is co provide information on potential threats to water resources of the preserve and guidance on immediate actions that can prevent or mitigate water resource degradation. Management of preserve water resources must also involve coordination among the numerous and diverse landowners as well as participation from all stakeholders.

Units of the national park system are not required to develop a water resources management plan. However, where water resource issues or management constraints are particularly numerous, complex, or controversial, a water resources management plan is useful in providing an identification and analysis of water-related information and issues, and presenting a coordinated action plan to address them. The water resources management plan is complementary to and consistent with the general management plan for the preserve. The water resources management plan is similar to the preserve's resources management plan, but includes a more thorough review of existing information, an in-depth analysis of water resources issues, and the development of an action plan to address them.

Water resources issues identified as most pressing include the following: (1) coordinating efforts among government agencies and academic institutions with interest in preserve water resources; (2) protecting water resources from degradation through land use planning in and around the preserve; (3) preserving and/or restoring the surface water hydrology within the estuary; (4) preserving and/or restoring good surface water quality within the preserve; (5) preserving and/or restoring good groundwater quality and quantity; (6) preserving Spanish Pond hydrology and water quality; (7) preserving a healthy salt marsh system; (8) preserving healthy freshwater wetlands; and, (9) tracking park development.

Management recommendations, in the form of project statements, have been developed to address these water resources issues. Project statements are standard National Park Service programming documents that describe a problem or issue, discuss actions to deal with it, and identify the additional staff and/or funds needed to carry out the proposed actions. They are planning tools used to identify problems and needed actions, and programming documents used to compete with other projects and park units for funds and staff.



INTRODUCTION

INTRODUCTION

The Timucuan Ecological and Historic Preserve is located on the northeast coast of Florida (Duval County), entirely within the city limits of Jacksonville (Figure 1). The preserve was authorized by Congress in 1988 through Public Law 100-249. Named for the extirpated native American Timucua tribes, the preserve was designated to protect and interpret the ecological and historic resources of the area.

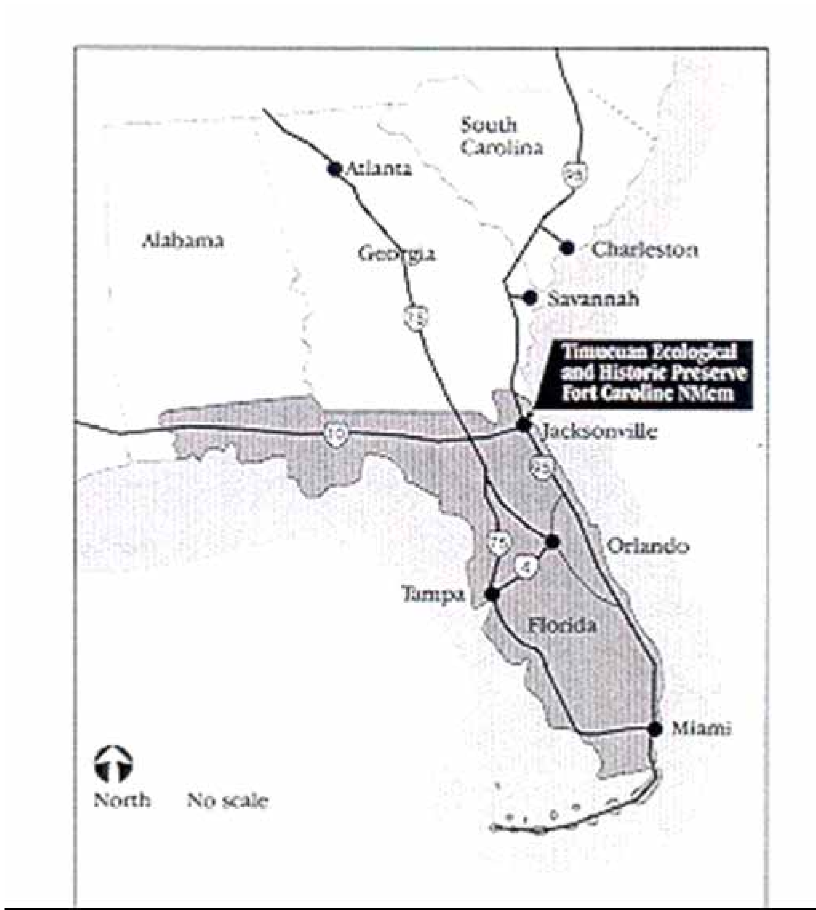
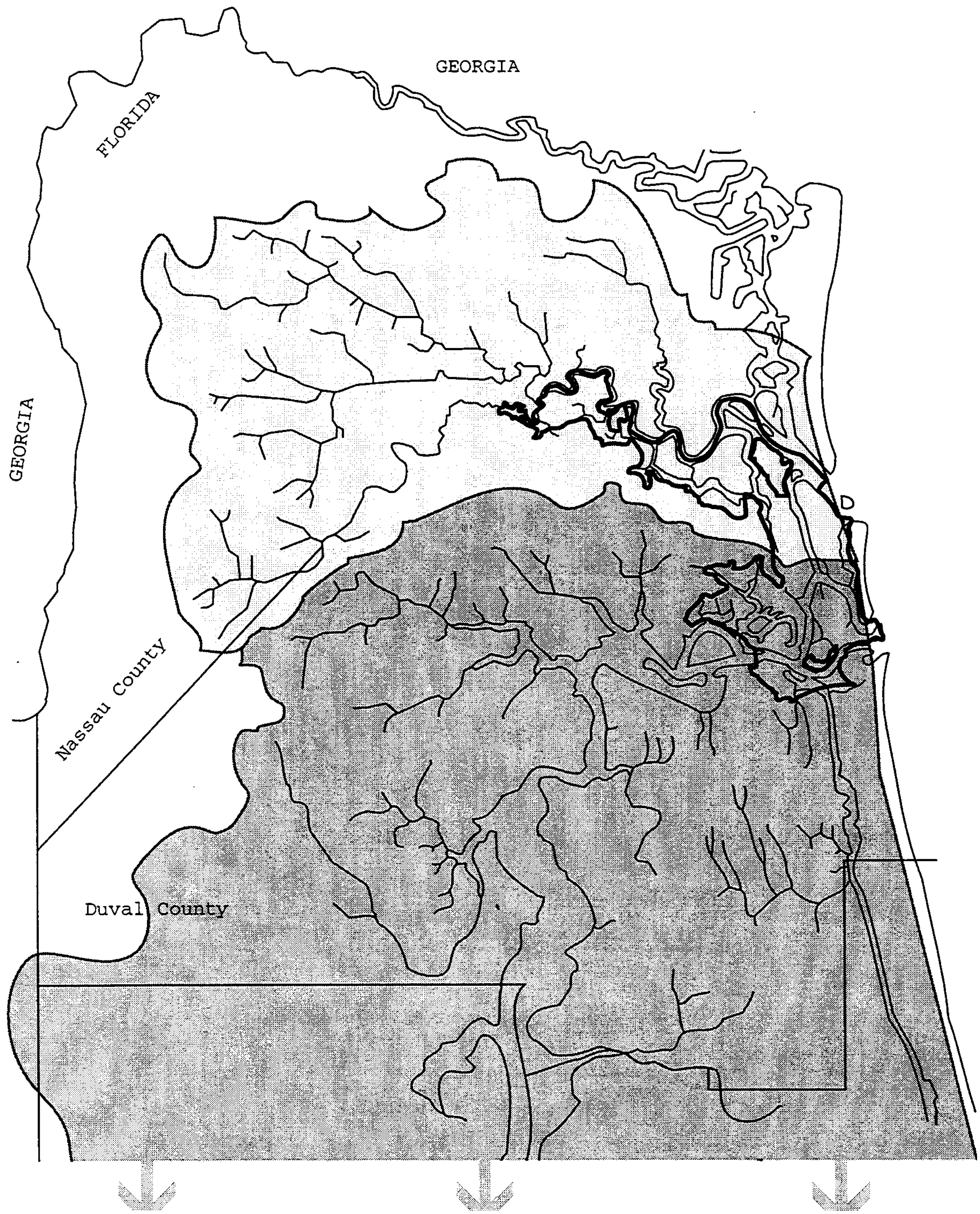


Figure 1. Location of Timucuan Ecological and Historical Preserve in northeast Florida. After National Park Service (1994a).

The preserve encompasses approximately 46,000 acres that include the seaward confluence of the Nassau and St. Johns rivers (Figure 2). These rivers form an extensive estuarine system dominated by salt marsh and coastal hammock habitat, and marine and brackish open waters (Figure 3). These wetlands and waterways are notable for several reasons: both rivers are unusual in that they discharge directly into the Atlantic Ocean rather than into an embayment as is typical of most estuaries; the St. Johns River flows northward (one of the few major north-flowing rivers in North America) through one of the most heavily industrialized areas of Florida; the Nassau River is the only major drainage on the east coast of Florida not channelized or stabilized by engineering structures, especially at the ocean inlet; the estuary is the largest marsh-estuarine system on the east coast of Florida (Florida Department of Environmental Protection 1994), and is the only

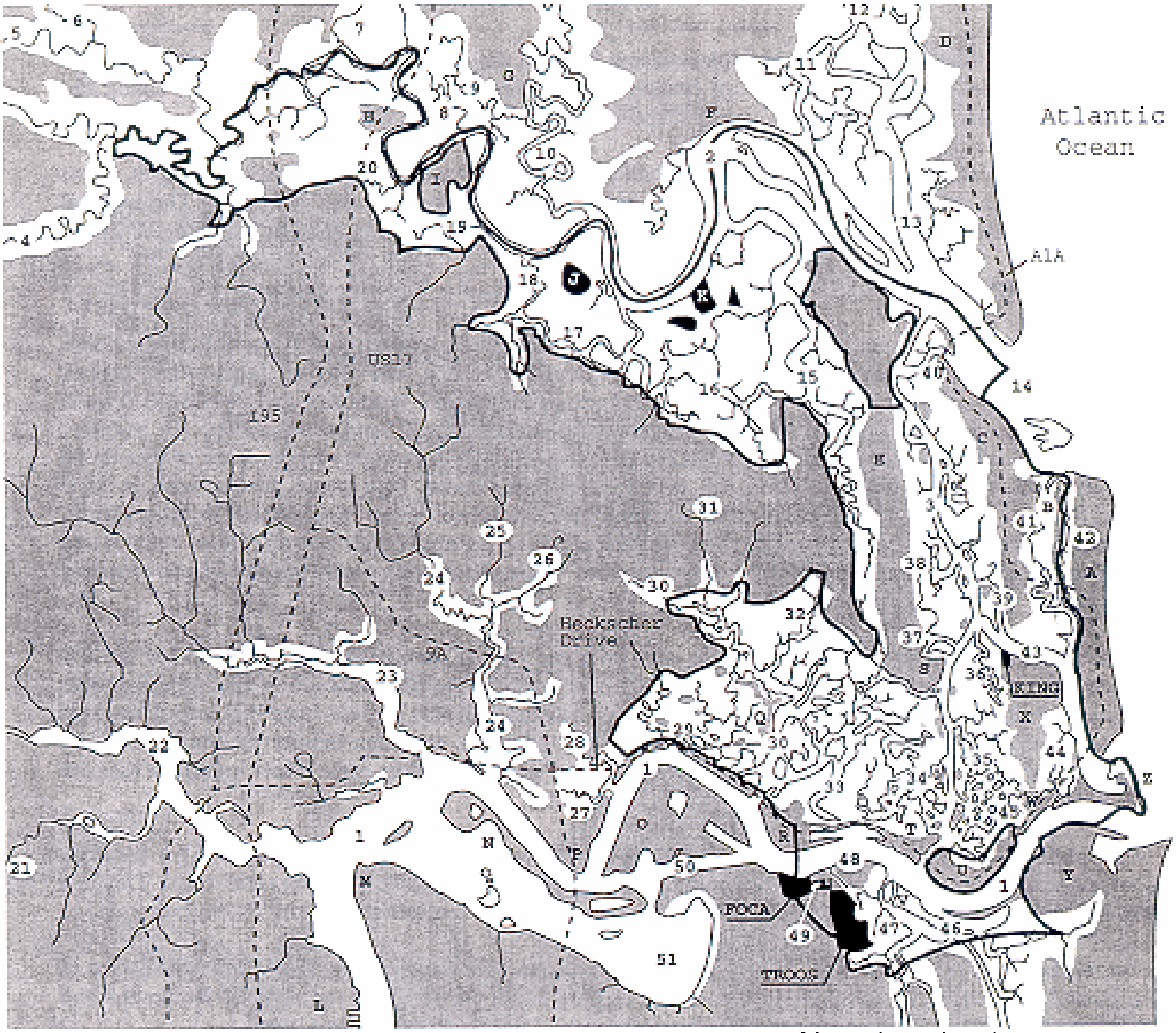


= Nassau River Drainage Basin

= lower St. Johns River Drainage Basin

= Timucuan Ecological and Historic Preserve

Figure 2. Delineation of Nassau and lower St. Johns river drainages.



■ = Uplands owned by National Park Service

▩ = Other uplands

FOCA = Fort Caroline Historic Site
TROOS = Theodore Roosevelt Natural Area
KING = Kingsley Plantation

◡ Timucuan Preserve Boundary (Pearson, north Black Hammock and Fanning Islands excluded)

LANDFORMS
A = Little Talbot Island
B = Long Island
C = Big Talbot Island
D = Amelia Island
E = Black Hammock Island
F = Nassauville
G = Hedges
H = Halfmoon Island
I = Pearson Island
J = Burton Island
K = Broward Islands
L = Downtown Jacksonville
M = Reddie Point
N = Bartram Island *
O = Blount Island *
P = Dames Point
Q = Pelotes Islands
R = Little Marsh Island
S = Cedar Point
T = Pine Island
U = Fanning Island
V = Great Marsh Island
W = Batten Island
X = Fort George Island
Y = Mayport Naval Base
Z = Huegenot Park

WATERBODIES
1 = St. Johns River
2 = Nassau River
3 = Sisters Creek/ICWW
4 = Thomas Creek
5 = Mills Creek
6 = Swamp Creek
7 = Plummer Creek
8 = Gardner Creek
9 = Cuno Creek
10 = Lofton Creek
11 = Alligator Creek
12 = Kingsley Creek
13 = South Amelia River
14 = Nassau Sound
15 = Pumpkin **Hill** Cr
16 = Edwards Creek
17 = Samples Creek
18 = Mink Creek
19 = Deese Creek
20 = Inconstation Cr
21 = Sixmile Creek
22 = Trout River
23 = Broward River
24 = Dunn Creek
25 = Caney Branch
26 = Rushing Branch
27 = Nicholas Creek
28 = San Carlos Cr
29 = Browns Creek
30 = Clapboard Creek
31 = Bogey Branch
32 = Fitzpatrick Cr
33 = Cedar Point Cr
34 = Hannah Mills Cr
35 = Deep Creek
36 = Garden Creek
37 = Horseshoe Creek
38 = Broward Creek
39 = Mud River
40 = Sawpit Creek
41 = Simpson Creek
42 = Myrtle Creek
43 = Fort George River
44 = Haulover Creek
45 = Shad Creek
46 = Chicopit Bay
47 = Clorinda Creek
48 = St. Johns Creek
49 = Spanish Pond
50 = Fulton Cutoff
51 = Mill Cove

* artificially created from dredge spoil

Figure 3. Timucuan Ecological and Historic Preserve, landforms and hydrologic features.

example of an Atlantic Sea Island estuarine system in Florida; the estuary is one of the most productive in Florida, based on commercial landings of fmfish; and, the area provides habitat for several state- and federally-listed rare, threatened, or endangered species (National Park Service 1994a).

Prior to creation of the preserve, Fort Caroline National Memorial was established along the lower St. Johns River in 1950 to commemorate the first French-Protestant settlement in North America. The national memorial was included as part of the Timucuan Ecological and Historic Preserve in Public Law 100-249.

LANDOWNERSHIP AND LAND USE

Lands within the preserve are owned by the federal government (including the U.S. Navy, U.S. Army Corps of Engineers, and U.S. National Park Service), the State of Florida, the City of Jacksonville, private conservation organizations, private corporations, the Jacksonville Electric Authority, and individuals (Figure 4). Presently, only 20 to 30% of the total acreage is in National Park Service ownership. In addition, estuarine wetlands and waters within the preserve are claimed under sovereignty by the State of Florida up to mean high water. However, 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 the preserve, the state of Florida has jurisdiction over all wetland areas, up to mean high water. These state-owned submerged lands are managed by various state agencies within the Florida Department of Environmental Protection.

Duval County has a total area of 850 square miles with the City of Jacksonville occupying 836 of the 850 square miles. Within the City of Jacksonville, 30% of the area is developed in urban and suburban uses (Figure 5; National Park Service 1994a). Several major arterial highways radiate from the central business district connecting circumferential routes. Retail, office, industrial, and high density residential uses are concentrated in strips and centers along these corridors and inside the urban core. Heavy industrial uses are concentrated east of the urban core and west of the preserve.

Many of the outlying development patterns were established prior to formal land use planning for the area. The non-urban residential uses are spread out in lower density subdivisions and outlying rural tracts. The area has also experienced "leap frog" development resulting in scattered pockets of growth.

Primary demands for retail, office, and light industrial businesses for the northern and Arlington subareas of Jacksonville, of which the preserve is a part, are met by development along the Atlantic Boulevard and Monument Road corridors, and by the core city, all south of the St. Johns River.

Land uses within the preserve are greatly influenced by the fact that over 35,000 acres are wetlands and open water, which limits acceptable building areas and restricts access (Figure 5). Current uses are predominately agricultural and conservation. The City of Jacksonville has jurisdiction over zoning and land use decisions within the preserve. Changes in zoning and land use must comply with the city's land use plan in place at the time of the decision (City of Jacksonville 1990b).

The City of Jacksonville will adopt new regulations for the preserve as part of its special management area requirements (City of Jacksonville 1993a). This designation is part of the city's efforts to comply with state land use policies and grants the preserve special status in land use decision making. These regulations are expected to eliminate many uses that would constitute new construction. Allowed uses expected to remain include: marinas; riding academies; dude ranches; essential services; and, all resource-based uses. Uses to be allowed by exception include: radio and television transmission towers; churches; bed and breakfast establishments; bait and tackle shops; and, commercial hunting and fishing camps. However, policies and regulations governing these uses have not been adopted at this writing.

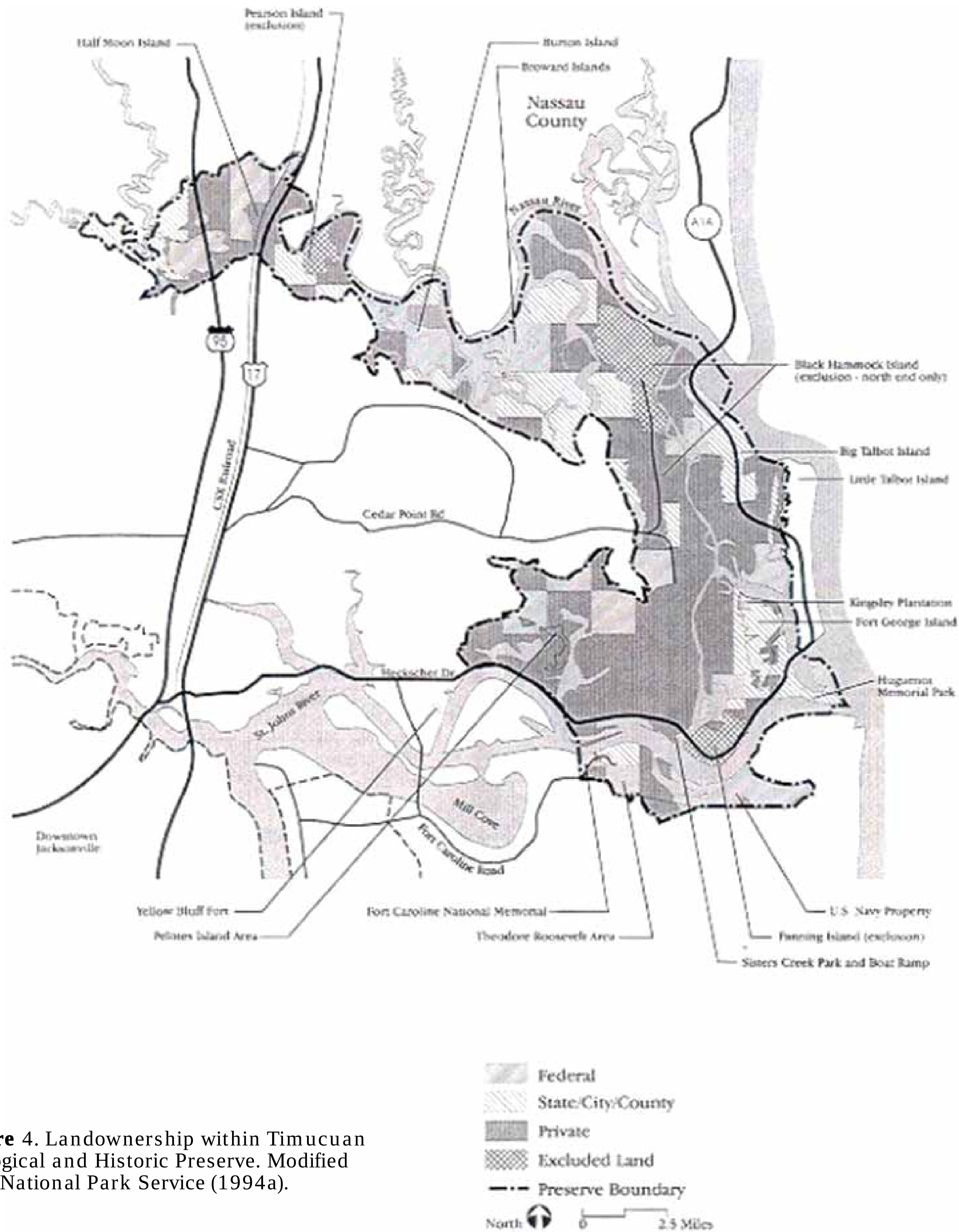


Figure 4. Landownership within Timucuan Ecological and Historic Preserve. Modified from National Park Service (1994a).

Figure 5 is now located at the end of this document.

The agricultural zone district in Jacksonville allows some decidedly nonagricultural uses. Many of these, if developed, could have very dramatic impacts on preserve resources. These include: logging; land application of domestic sludge; and, other resource-dependent uses such as mining, game preserves, marinas, and recreational facilities. Nonresource-based uses that may be allowed if they meet certain criteria include: race tracks; solid waste management facilities; power plants; major utility lines; airports; prisons; slaughter houses; radio and television station antennas; and, railroad switching yards.

This zoning district may also be used for residential units at the rate of up to one unit per 2.5 acres, varying with lot size. Larger lots in single ownership would have more stringent subdivision restrictions. Nonconforming lots of less than 2.5 acres would still be eligible for a single family home if certain conditions are met.

Generally, the northern portion of the preserve (approximately 22,000 acres; however, developable land would be considerably less) is zoned agricultural and is currently undeveloped. If this area is 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 (National Park Service 1994a). All homes would be dependent on individual wells and septic systems.

There is a solid waste landfill outside the boundary in the northern portion of the preserve. The landfill has been closed, but contamination from the facility may be of concern as it pre-dated the requirement for lining dump sites. The facility also had a history of dumping violations. The southern portion of the preserve has experienced some development, including almost 700 acres of rural and low density residential. The 350-acre Jacksonville Electric Authority complex on Pelotes Island (E. Dale Joyner Nature Preserve) and 1,213 acres of the Naval Station Mayport lie within the southern portion. Outside the southern boundary of the preserve is another closed landfill.

National park services within the preserve include the Fort Caroline visitor center and maintenance area, the Theodore Roosevelt area with park headquarters, and Kingsley Plantation. Other state and city parks in the preserve are Big Talbot Island State Park, Little Jetties Park, Huguenot Memorial Park, and the Sisters Creek Park and boat ramp.

PURPOSE OF THE WATER RESOURCES MANAGEMENT PLAN

The enabling legislation of the preserve calls for the National Park Service to protect and interpret the ecological and historic resources. At the same time the National Park Service must facilitate public use, both now and in the future. In order to achieve these goals, National Park Service policies require that each unit of the national park system develop and implement a general management plan. Adopted in 1996, the Timucuan Ecological and Historic Preserve General Management Plan (National Park Service 1996) provides the overall basis for managing the park's resources, uses, and facilities. This general management plan recognizes that management of the preserve's resources must involve coordination among numerous and diverse landowners, as well as participation by all concerned individuals and special interest groups. It calls for the formation of a "Timucuan Alliance," a management entity coordinated by preserve staff, that brings all stakeholders together to further each entity's interest while accomplishing resource protection and interpretation.

The preserve's general management plan identifies several "action" plans that address specific needs and actions. This water resources management plan, the first for Timucuan Ecological and Historic Preserve, is such an action plan. It is designed to guide preserve water-related activities over the next 10 years. It is complementary to, and consistent with, other existing park management documents, including the general management plan (National Park Service 1996) and resource management plan (National Park Service 1994b).

Whether in support of natural systems or providing for visitor use, water is often a significant resource in National Park Service units. Consistent with its fundamental purpose, the National Park Service seeks to perpetuate surface and ground waters as integral components of park aquatic and terrestrial ecosystems by carefully managing the consumptive use of water. It also strives to maintain the natural quality of surface and ground waters in accordance with all applicable federal, state, and local laws and regulations. In addition, water-based recreation such as swimming, fishing, and boating, as well as the health of the estuarine ecosystem, are dependent upon the maintenance of adequate water quality.

Because the preserve is largely a hydrological phenomenon, water-related issues naturally dominate. For that reason, land use within and adjacent to the preserve as well as land use anywhere in the watersheds, connected by either groundwater or surface water, has the potential to affect the preserve. While information exists concerning the water resources in the preserve, systematically collected information and adequate analysis addressing the preserve's water resources is lacking. The primary purpose of this water resources management plan is to provide information on potential threats to water resources of the preserve and guidance on immediate actions that can prevent or mitigate water resource degradation. Management of preserve water resources must also involve coordination among the numerous and diverse landowners as well as participation from all stakeholders.

Water resources planning for a unit of the national park system typically involves several steps. The planning starts with consideration of the reasons for the park's establishment, identification of the exceptional water-related resource values of the preserve, and articulation of management objectives. These have been identified in the preserve's general management plan (National Park Service 1996). In addition, the water resources management plan provides resource-specific information to support the decision-making process related to the protection and management of the preserve's water resources and water-dependent environments. This plan includes a review of available information about the preserve's water resources and water-dependent environments. It also contains descriptions of significant water resources management issues, including constraints on water management brought about by the preserve's enabling legislation. Finally, the plan provides a recommended management program for water resources, including recommended actions for inventory and monitoring, resources management, and research. These recommended actions are identified as water-related project statements, consistent with guidelines of the National Park Service, and designed to be incorporated into the Timucuan Ecological and Historic Preserve Resource Management Plan (National Park Service 1994b). These actions address the water resource issues within the context of the management objectives. The common thread between management actions, issues, and management objectives is the cornerstone of issue-driven planning.

DESCRIPTION OF WATER RESOURCES

DESCRIPTION OF WATER RESOURCES

PHYSIOGRAPHY

The preserve lies mainly within the St. Marys Meander Plain, a subdivision of the Atlantic Coastal Plain, except for the area immediately south of the St. Johns River called the Eastern Valley. At Jacksonville the St. Johns River turns eastward to the sea, and immediately north of the river the terrain changes. To the south the dominant geomorphic factors have been marine, but to the north of this rather sharp boundary, the dominant geomorphic feature appears to have been a system of meandering, sediment-laden streams (White 1970).

Within the confines of the St. Marys Meander Plain are the Nassau and lower St. Johns rivers and their network of abandoned channels and tributaries. In a regional way the St. Marys Meander Plain is the southern end of a large section of the coast known as the Sea Islands, which extend from the north bank of the St. Johns River to the Santee River in South Carolina. The name Sea Islands derives from a barrier island chain separated from the mainland by tidal creeks. These islands apparently resulted from a mixture of fluvial and tidal sedimentation in salt marshes between beach ridges. Fort George and Big and Little Talbot Islands are typical Sea Islands. The meandering tidal creeks that connect the Nassau and St. Johns Rivers in a zone immediately landward of these islands are typical of the sediment-dominated estuaries of the Sea Islands (White 1970). The islands absorb much of the energy from tides and waves and allow sediments from mainland rivers to be deposited in the sheltered areas behind the islands.

Other islands (e.g., Burton Island, Broward Islands, and Pelotes Island) are scattered throughout the estuarine systems. These islands are of various origins. Some of the hammock (forested) islands are remnants of old barrier islands formed in the past during periods of higher sea level. Others may have been separated from larger islands by erosion. Most of the marsh islands are alluvial deposits dissected and shaped by estuarine drainage systems (White 1970).

The preserve is geologically young and has been changed by deposition and erosion. Topographically, northeast Florida is composed of ancient marine terraces, parallel to the coast, which were formed during the Pleistocene era when the sea level rose and fell several times in association with glacial advances and retreats. The marine terraces corresponding to these Pleistocene shorelines are named Wicomico (100 feet above sea level), Penholoway (70 feet above sea level), Talbot (42 feet above sea level), and Pamlico (25 feet above sea level) (White 1970). Between these ridges are poorly drained swales through which present day rivers and streams course.

ESTUARINE SETTING

Estuaries are vital ecological links between inland freshwater habitats and the oceans. However, many of these estuaries and associated habitats (especially salt marshes) have been poorly studied. Timucuan Ecological and Historic Preserve is no exception. Available data have not been widely disseminated nor, in many cases, synthesized into a coherent body of knowledge available to other scientists or decision makers. This seems counter-productive since nearly one-half of the nation's fisheries catch comes from the southeastern region of the Atlantic coast, and given this region's ecologically rapid loss of estuarine wetlands. For example, between 1850 and 1973 the total area of wetlands, including salt marshes, declined from over 20 million acres to nearly 8 million acres (Florida Game and Fresh Water Fish Commission 1989).

An estuary may be defined as a semi-enclosed, coastal water body with a free connection to the open sea, influenced by tidal action, and characterized by seawater measurably diluted by freshwater from land drainage (Pritchard 1967). The freshwater influence differentiates an estuary from a lagoon, which is simply a coastal zone depression connected with the sea but protected by some type of barrier. Estuaries and lagoons occupy 80 to 90% of the Atlantic and Gulf coasts of the United States.

Estuaries serve several economically and socially important functions as summarized by Durako et al. (1988):

- They provide important spawning and nursery habitat for many species of fish and invertebrates. Approximately 72% of commercial and 74% of sport species of fish and shellfish must spend all or part of their lives in or associated with the estuarine system.

  The area of nursery grounds usually represents only a small portion of the total estuarine system. For example, of the approximately 2.3 million acres of estuaries in North Carolina, only 75,000 acres have been designated primary nursery grounds (DeMort and White 1987). These areas usually lie at the downstream end of small tributaries and are vulnerable to changes in land use patterns and water quality degradation;

- They serve as a buffer between the oceans and the land, providing an important ameliorating zone for storms and floods. For example, a fringe of salt marsh only 8 feet wide can reduce wave energy by over 50%;

- They serve as important sinks for materials, both nutrients and contaminants, that flow from the land and human activities, catching these materials before they reach the ocean;

- They serve as important transportation routes that connect inland commerce to ocean shipping; and,

- They are culturally-diverse areas, attracting people who support a growing recreational and tourism industry.

Estuarine communities are often characterized by high productivity, low species richness and diversity, and high dominance. It is this productivity, the ability to capture enough energy to produce a great volume of living tissue and to pass that energy along to organisms humans find useful, that makes an estuary so economically valuable. In fact, estuaries are among the most productive ecosystems on earth. The high primary production of estuaries reflects their nutrient-rich conditions and the presence of several classes of primary producers, including submerged vascular plants, macro- and micro-algae and emergent grasses, shrubs, and trees.

The most well developed salt marshes in the United States are found on the Atlantic coast from Cape Lookout, North Carolina, south to the Jacksonville area, with the most extensive from Myrtle Beach, South Carolina, to Jacksonville. The latter includes some of the most productive salt marshes in the world. These marshes, often called low marshes, form behind Sea Islands in areas influenced by silt deposition from large rivers. There is usually a relatively small amount of open water behind the barrier islands. Timucuan Ecological and Historic Preserve is approximately 75% wetlands and interspersed open waters.

An important feature of the salt marsh is the intimate relationship that exists between the marsh and the adjacent waters of the estuary. Energy fixed in the marsh is flushed out by the tide, irr the form of organic matter called detritus (Durako et al. 1988). Detritus forms the primary food for many animals in the estuary. The importance of salt marshes to fisheries production results, for the most part, from the high rates of primary production and interaction with the estuary. Important nutrients, such as potential limiting factors phosphorus and nitrogen, are exchanged between the marsh and the estuary.

The interaction between tidal and river flows, the dominant physical process in an estuary, results not only in salinity fluctuations, but also water level fluctuations. The latter exposes intertidal areas to alternating periods of inundation and drying, and to relatively wide temperature fluctuations. Estuarine organisms have adopted physiological and behavioral mechanisms to minimize stress induced by alternate flooding and exposure.

SOILS

Soils of northeast Florida are partly sedimentary and partly derived from underlying formations (City of Jacksonville 1990b). The major source of Pleistocene sediments is probably the Piedmont Region of the south Appalachian Mountains, where materials were moved southward by streams and long-shore currents. Little or no silt or clay have accumulated farther south than the St. Johns River inlet because Florida upland rocks do not weather to produce such materials, and no northeast Florida rivers drain true interior areas like the Piedmont Region. The presence of relatively large quantities of clay, coupled with low to moderate wave-energy levels, may account for the salt marshes of the Sea Islands.

Most of the salt marsh area of the preserve is composed of Tisonia mucky peat soil (City of Jacksonville 1990b). The salt marsh is saline in most places but is brackish where small feeder streams enter it. This soil is flooded daily by tides and has a surface of peat and a water table from 0.0 to 2.0 feet above ground surface. Permeability ranges from less than 0.6 to 20 inches per hour. In particular, this soil type has severe limitations for septic tank absorption fields and sewage lagoons.

OVERVIEW OF ANTHROPOGENIC SOURCES AND INPUTS

In 1986, following extensive publicity about water quality problems in the lower St. Johns River, the Florida Department of Environmental Regulation published a review of water quality in the lower St. Johns River of Duval County (Florida Department of Environmental Regulation 1986). This review noted that the river has shown signs of decline since the early 1950s. The last of Jacksonville's 78 raw sewage outfalls and its two paper mills stopped discharging untreated wastewater into the river around 1978, yet critical pollution of the lower river continues. Numerous tributaries of the St. Johns River flow through the developed area of Jacksonville, and rapid urban expansion is increasing their pollutant loadings. Land use has changed from predominately low density housing in rural areas to dense urban development with industrial components. Conclusions of the water quality review are as follows:

- Severe water pollution is present in many tributaries to the St. Johns River in Duval County;
- Elevated concentrations of metals are found in the sediments throughout the Duval County section of the St. Johns River;
- Major sources of pollution include nonpoint stormwater runoff and surface water discharges. Poorly functioning septic tanks and deteriorated sewage collection pipes are other sources of water quality problems;
- Because of the economic importance of the area's seafood industry, more knowledge is needed of pollution impacts on fishery resources; and, -
- Studies to date have not proven a relationship between high levels of certain heavy metals and petroleum hydrocarbons in the tissue of fish, and the presence of disease in the organism.

In 1994 there were approximately 360 domestic and 49 permitted industrial point sources releasing more than 3,100 cubic feet per second (cfs) of secondarily treated wastewater into surface waters of the lower St. Johns River basin (U.S. Army Corps of Engineers and St. Johns River Water Management District 1994). In addition approximately 70 point sources discharged directly into groundwater (approximately 2.17 cfs). However, the City of Jacksonville has been eliminating smaller discharges by connecting them to larger regional treatment plants. Currently, there are 145 regulated surface water discharges. It is believed that point sources account for only 10% of the pollution, with 90% attributed to nonpoint sources, related primarily to urban growth. The only permitted surface water point source present in the preserve discharges into the St. Johns River at Little Jetties Park (National Park Service 1994a). Little Jetties Park is Naval Station Mayport property located on the south bank of the St. Johns River directly opposite Fanning Island (see Figure 3).

Hendrickson (1995) estimates that between Orange Park and the Intracoastal Waterway, wastewater treatment facilities currently discharge a continuous flow of 108 cfs, equivalent in magnitude to the normal runoff of a 100 square mile watershed – roughly the size of the Trout or Ortega river basins. Existing nutrient data for these facilities indicate average total nitrogen and phosphorus concentrations of 15.4 and 3.4 mg/1 respectively, which are roughly 10 to 50 times that typical for tributary runoff. With such high nutrient input, domestic wastewater has been an easy target for speculation regarding the source of high mineral nutrient forms in these river reaches. However, conclusive evidence of eutrophication effects or persistent oxygen depletion in the preserve section of the river is not convincing (Hendrickson 1995).

Pulp and paper mills generate the industrial effluent of greatest water quality concern within the lower St. Johns basin. The sum of the actual discharge of this effluent to the St. Johns River based on limited data is roughly 93 cfs, or approximately 80% of the actual domestic effluent volume. This effluent typically exhibits high oxygen demand, suspended solids, and organic carbon (Hendrickson 1995). Total nitrogen and phosphorus concentrations are typically 5 to 10 times that of the receiving water body. Ammonia concentrations are especially elevated, at roughly 70 times that of backgrounds typical of their receiving waters.

Industrial activities in Duval County have resulted in high accumulations of heavy metals and organic priority pollutants, particularly in sediments (Keller and Schell 1993). Disposal and storage of hazardous industrial and military wastes increase the potential for surface water contamination and have had a significant impact on various sections of the lower St. Johns River basin. Seven sites in Duval County have been targeted for cleanup by the U.S. Environmental Protection Agency's Superfund Program; however, no superfund site is in the preserve area. As of September 1989, seven military installations in Duval County, with a total of 97 contaminated sites, have been identified for remediation by the Defense Cleanup Programs (U.S. Army Corps of Engineers and St. Johns River Water Management District 1994). Of these military sites 16 are located at Naval Station Mayport and adjacent to the preserve. Finally, the State of Florida has identified 12 petroleum-contaminated sites along Hecksher Drive (Florida Department of Environmental Regulation 1991b).

Nonpoint source runoff from urban areas can significantly degrade water quality by increasing turbidity and suspended solids, biological oxygen demand, toxic metals and hydrocarbons, and nutrients. Coupling these impacts with various hydrologic modifications by urban development (e.g., impervious surface enlargement) increases swift transport of pollutants to the lower St. Johns River.

Because urban stormwater runoff is a significant pollutant, several models were used for initial development of a stormwater master plan for the City of Jacksonville (Campbell et al. 1993). During model confirmation, stormwater runoff concentrations were found to be largely in violation of state standards or in excess of what is known to lead to eventual degradation of the downstream aquatic environment. - The city's plans to regionalize the wastewater disposal system have resulted in the phaseout of 59 wastewater facilities since October, 1987. The phaseout of wastewater facilities and development of areawide sewer service are critical to manage and restore water quality in the lower St. Johns River.

The serious degradation of the tributaries has been recognized for several years. However, more recently there has been growing concern over the St. Johns River itself (Hand et al. 1994). Benthic biological data indicate poor diversity and low density. Water quality trends for most of the river reaches indicate degradation problems. However, there is improvement of the river's water quality near its mouth ostensibly due to: 1) the flushing effect of the tides; 2) the flushing effect of net river discharge; 3) the lack of point and nonpoint source pollution in this section of the river; and, 4) the water quality improvement function of the adjacent marshland.

Contamination of groundwater by seepage from failing septic tank systems continues to be a problem and has been identified as one of the three primary causes of surface water quality standards violations within Duval County (Campbell et al. 1993). Past surveys found an areawide (Duval, Clay, and St. Johns counties) average septic tank violation rate of 14%.

Primarily in response to the lack of technical information pertaining to water quality and spatiotemporal variations in physicochemical and biological components of the St. Johns River, the St. Johns River Water Management District recently initiated a comprehensive reconnaissance of the lower St. Johns River basin that incudes basin hydrology, surface hydrology, hydrodynamics of surface water, water quality, river sediment characteristics and quality, biological resources, economic values, and intergovernmental management (see Brody 1994; U.S. Army Corps of Engineers and St. Johns River Water Management District 1994; Keller and Schell 1993; and, Toth 1993 for examples). This reconnaissance, when completed, will identify the need for more research and assimilation of information leading to development of a management strategy for the estuary.

Campbell et al. (1993) provided the following examples of how deteriorating water quality and sediment conditions affect the species composition and overall health of aquatic communities within the basin:

- Discharges from sewage treatment plants, industrial sources, agricultural runoff, and seepage from septic tank drainfields can cause nutrient enrichment of receiving waters. High nutrient levels cause algal blooms, elevated bacterial levels, and increased biological oxygen demand. Increased biological oxygen demand can lower oxygen concentrations to the point where fish kills occur. Species adapted to low oxygen and light levels can increase, resulting in a decrease in species richness;

- Survival/reproduction rates of aquatic organisms can be limited by the carcinogenic, mutagenic, or teratogenic effects of toxic substances originating from industry and agriculture. Many of these toxic substances precipitate out of the water column and reside in the sediments directly affecting benthic organisms. When sediments are disturbed, organisms in the water column can be exposed to resuspended contaminants;

- Abnormally high peak flows of stormwater can be detrimental to the St. Johns River estuary. Major storm events result in the discharge of large volumes of freshwater into the river in a short period of time. Although fish are mobile and can sometimes avoid freshwater inflows, slow moving shellfish and sedimentary invertebrates which are important components of the estuarine food chain can be directly exposed to fresh water or to salinities that are below tolerance limits;

- Excessive low flows, when combined with point and nonpoint source pollution, can be detrimental to aquatic communities. Low flows can occur as a result of drought, excessive groundwater withdrawals, and surface water diversions. Contaminants become concentrated and dissolved oxygen concentrations drop, creating lethal conditions for organisms. The resulting high salinities can be detrimental or lethal to some organisms; and,

- The cumulative and synergistic influences of contaminated discharges from point and nonpoint sources, combined with varying salinity, temperature, and flow regimes, can cause a decline in species diversity, productivity, and overall health of aquatic communities.

SURFACE WATERS

Hydrology

Both the St. Johns and Nassau rivers within the preserve are strongly influenced by tides . Discharge in these tidally affected rivers is influenced by seasonal changes in tide and estuary levels which affect estuarine water storage (Haight 1938). Tidal action appears to be the dominant factor (from among a group of interacting meteorological, hydraulic, and hydrological factors) controlling river discharge of the estuary (Coffm et al. 1992; Hendrickson 1995). Tidal fluctuations penetrate far upstream, e.g., upstream tidal penetration on the St. Johns River is approximately 200 miles). Tides are generally categorized as diurnal, semi-diurnal, and mixed. Along the east coast of Florida including the preserve, tides are typically a mixed typed and have two highs and two lows per day of noticeably different heights. At these rivers' mouths tidal amplitude ranges from approximately 1 5 to 2 meters (4 to 6 feet). The mean tidal period for the preserve is estimated at 12.4 hours (at Mayport). Tidal stages within the estuary inland of the ocean are influenced by interacting meteorological, hydraulic, and hydrologic factors, including wind, bottom friction, inertia, and freshwater inflows. The flowing and ebbing tides serve to flush the lower reaches of these slow-moving rivers. The entire portions of the rivers and their drainages within the preserve are subject to flow reversals due to tidal inundation.

The lower St. Johns River is part of the St. Johns River system. The St. Johns River is often described as a series of interconnected lakes and lagoons with a slow-moving northward flow. The St. Johns River is the largest watershed entirely within the State of Florida, the third largest drainage basin in Florida, Florida's longest river (318 miles), and one of the few north-flowing rivers in North America. Flow is sluggish, with an elevational drop of less than 30 feet over its entire length (0.11 feet/mile), making it one of the "flattest" rivers in the world. The width of the river north of Palakta ranges from 1.5 to 3 miles and narrows to about a quarter of a mile in Jacksonville. The gradient in the lower part of the river is extremely small (0.05 feet per mile). The lower St. Johns is the section between the Atlantic Ocean and Okiawaha River, approximately 100 miles upstream, and drains about 2,200 square miles, including 12 main tributaries and land adjacent to its main course (Bergman 1992). From a 22-year period of data (1954-76), the average flow at river mile 25 (City of Jacksonville) is estimated at 5,687 cfs with a maximum daily downstream discharge of 64,000 cfs and a maximum daily reverse flow of 62,700 cfs (U.S. Army Corps of Engineers and St. Johns River Water Management District 1994). At the mouth of the St. Johns River the maximum daily flood flow is approximately 61,100 cfs and the maximum ebb flow about 51,040 cfs. Total average flow is estimated at 7,000 cfs (Hand et al. 1994). The average discharge of the St. Johns River at its mouth is estimated at 8,300 cfs. Although the lower St. Johns is tidally influenced and subject to flow reversals, there is a net downstream, depth-integrated flow about 75% of the time. The transitional zone, where fresh and salt waters mix, is located in southern Duval County (Hendrickson 1995). From downtown Jacksonville to the Atlantic Ocean (the reach partially included within Timucuan's boundary), the river is dredged and maintained by the U.S. Army Corps of Engineers for deepwater navigation. This navigation channel is 38 feet deep (mean low water) along the portion within and immediately upstream of the preserve. The width of the channel is from 400 to 1,200 feet. The spoil material from maintenance dredging (about 800,000 cubic yards per year in the first 20 miles of lower St. Johns River) is presently disposed of on Bartrum and Buck islands, which were created totally from dredge spoil.

The Nassau River is one of the last relatively pristine estuarine systems on the east coast of the United States. The river originates in Nassau County and extends for 54.8 miles while draining approximately 430 square miles The river and its tributaries exhibit classic dendritic and meander patterns unaffected by channelization, bank or inlet stabilization structures. The fresh/salt water mixing zone is located at the western edge of Timucuan Preserve, from the confluence of Thomas Creek to roughly 2 miles downstream from U.S. Highway 17, and above Lofton and Pumpkin Hill creeks. Coffin et al. (1992) estimated the mean daily maximum flood (upstream) discharge in this area to be about 13,900 cfs and the daily maximum ebb (downstream) discharge at 13,500 cfs. Daily mean net discharge of the Nassau River is estimated to be about 730 cfs (Coffin et al. 1992). This daily mean net discharge is slightly more than five percent of the mean maximum tidal discharge (i.e., 13,900 cfs). Discharge near Tisonia (below Lofton Creek but above Pumpkin Hill Creek) showed a mean daily maximum flood discharge of 21,000 cfs and mean maximum ebb discharge of 18,700 cfs (Coffm et al. 1992). The mouth of the river also receives waters from behind Amelia Island, with a net drainage to the south and out the Nassau River Inlet. The Nassau River is not maintained as a navigable river by the U.S. Army Corps of Engineers; however, Fort George River, part of the Nassau River drainage, is maintained by the Corps with dredged spoil also deposited on Bartrum and Buck islands. Both rivers have been subject to significant shoaling problems and are navigable only by small craft.

Sisters Creek, which is also the Intracoastal Waterway, connects the Nassau and lower St. Johns Rivers in a typical backbay estuarine system associated with Sea Islands of the southeastern U.S. coast. Tidal creeks are abundant and often have interconnecting channels. Current directions and net flows are difficult to describe due to the strong tidal influence, but a slight, net flow from the north to the south is generally accepted. The upper part of Sisters Creek drains out Nassau Sound and through Fort George River to Fort George Inlet. The lower part of Sisters Creek predominantly drains to the St. Johns River. The Intracoastal Waterway channel is maintained through dredging by the U.S. Army Corps of Engineers. Recently, spoil was deposited on two areas of Black Hammock Island (Florida Inland Navigation District 1987a, b).

Rainfall (average annual rainfall of 51.43 inches as measured at Jacksonville Airport) is the main factor affecting the amount of freshwater available in both the lower St. Johns and Nassau rivers (Bergman 1992). Rainfall in the area is intermittent and widely variable with respect to areal distribution, duration, and magnitude. On average, precipitation follows a seasonal cycle with relatively wet conditions prevailing from June through September (rainfall of 26.36 inches) and dry conditions from December through March (rainfall of 12.44 inches) (Bergman 1992).

The amount of water available for runoff is determined by the difference between rainfall and losses due to groundwater infiltration and evapotranspiration, which is defined as evaporation from water and soil surfaces and transpiration by plants. Most of the water entering these basins as rainfall is returned to the atmosphere by evapotranspiration. The average runoff in the Nassau River basin is estimated to be about 10 to 15 inches or 19 to 28% of the estimated average annual rainfall; in the St. Johns River basin runoff is 15 to 20 inches or 28 to 38% of annual rainfall.

Preserve salt marshes receive waters through tidal action and rainfall. Although scientific information on the hydrology of the salt marshes is not currently available, assessments by hydrologists familiar with the area estimate that surface runoff and percolation from nearby upland areas account for about 10 % of the water input into the salt marsh system (D. Durden and S. Williams, pers.comm., St. Johns River Water Management District 1995).

Mean monthly discharges for the period of record at the Nassau River near Hedges and the St. Johns River at the Main Street Bridge sites show a similar pattern to that of the seasonal rainfall data (Coffin et al. 1992; U.S. Army Corps of Engineers and St. Johns River Water Management District 1994). The runoff to rainfall ratio and the total runoff generally are greater during the winter months than during summer months because evaporation is less and groundwater levels are higher. These conditions tend to increase soil moisture in winter, and decrease infiltration. Consequently, a greater portion of rainfall in winter runs off. Discharge in June and July is relatively low, although rainfall amounts are relatively high, until soil moisture, storage, and evapotranspiration demands are met. Discharge at these tidally-affected sites is, in addition, affected by seasonal changes in tide and estuary levels which change the volume of water stored in the estuary.

Within northeast Florida, stream discharge typically peaks in March and September (Bergman 1992; Coffin et al. 1992). The March peak follows the moderate but regular frontal precipitation of winter. Following a dry season from April through mid June, a summer convective storm season ushers in the second phase of high stream discharge. This rainy season ends during September and resultant streamflows recede in late October.

The St. Johns and Nassau rivers and most of their tributaries are blackwater systems. The color results from the high loads of suspended materials and tannins (non-volatile polymeric carboxylic acids) from the breakdown of forest leaf litter (Bergman 1992; Coffin et al. 1992). The dark color and turbidity limit light penetration and probably limit sessile plant growth to the shallows. This blackwater system probably includes high bacterial, organic and inorganic chemical oxygen demand, but these aspects of the ecosystem have not been studied (Brody 1994).

Physicochemical Characteristics and Trends

Mean monthly surface water temperatures reflect the dominant seasonal cycle with minima during January and maxima in July for both the Nassau and St. Johns rivers (Coffm et al. 1992; Hendrickson 1995). Mean monthly minimum temperatures, which reach approximately 13° C are sustained only briefly. Conversely, mean monthly maximum temperatures remain within a degree or two of the maximum temperature (around 29° C) from June through August.

In the lower St. Johns River, longitudinal dissolved oxygen concentrations show a general decrease downstream of Julington Creek in response to the dominance of heterotrophic production and decreased saturation content under saline conditions (Hendrickson 1995). The longitudinal pattern in mean difference between saturation and measured dissolved oxygen further supports the hypothesis of heterotrophic production (Hendrickson 1995). Overall, the lower St. Johns River seems to maintain a dissolved oxygen deficit of about 1 mg/l. Photosynthesis at the chlorophyll a maximum brings mean dissolved oxygen to saturation. Downstream of the Ortega River, where heterotrophic production is high and reaeration through wind mixing is minimal, dissolved oxygen maintains roughly a 2 mg/l deficit on saturation concentration (Hendrickson 1995). In contrast, limited work in the Nassau River by Coffin et al. (1992) shows a general downstream increase in dissolved oxygen concentrations.

Both the Nassau and St. Johns river segments in the preserve reach their annual salinity minimum in March, associated with the winter stream discharge peak and the annual ocean elevation minimum. Following this minima, salinities rise rapidly during the dry season to an annual maximum, occurring between May and August. This is followed by the less pronounced, late summer minima, after which salinities rise slightly but then decline again to the annual March low (Coffin et al. 1992; Hendrickson 1995). In the St. Johns River from the City of Jacksonville downstream to the mouth, mean salinity increases from about 3 to 26 parts per thousand (ppt). In the Nassau River from Interstate 95 downstream to around Nassauville, mean salinity increases from around 7 to 27.5 ppt.

Along the northeast Florida coast, most estuaries are probably well mixed because average tidal flow exerts a greater force than does freshwater inflow, resulting in a fairly homogeneous salinity throughout the water column. This description applies, for the most part, to the Nassau River; however, the St. Johns River between Jacksonville and the ocean may be classified as a slightly stratified estuary with some vertical stratification and vertical mixing.

Data indicate that during most of the year, the Nassau River is well mixed vertically with a broad mixing zone rather than a well-defined salt wedge (Coffin et al. 1992). However, during periods of relatively high freshwater discharge, the freshwater tends to move on top of the denser saltwater, resulting in significant stratification. For example, specific conductance increases during the relatively dry months from March to June, peaks in July, and decreases with increasing flow during the relatively wet months. As discharge increases in July, freshwater begins to flush the saltwater which moved into the estuary in the dry season. During this period, freshwater flows on top of saltwater and results in a significant vertical specific conductance gradient.

The broad mixing or transition zone is generally located in the geographic center of the Nassau River drainage between I-95 and a point about 2 miles downstream from U.S. 17. Salinities collected in this zone ranged from less than 0.1 ppt to 25 ppt (Coffin et al. 1992). Analysis of data indicates that during much of the year both the mixing zone and the estuary are vertically well-mixed and are homogeneous with respect to depth in terms of specific conductance, salinity, temperature, and dissolved oxygen.

In contrast, the St. Johns River between Jacksonville and the ocean may be classified as a slightly stratified estuary with some vertical stratification and vertical mixing. Stratification is greatest in tidally influenced narrow tributaries, moderate in the relatively narrow and deep river channel, and least in the shallow embayments which typically reside at the junction between the river and its tidal tributaries. Limited vertical profile measurements of salinity, conducted by the City of Jacksonville from 1989 to 1993 (upstream of the preserve boundary) demonstrate the limited stratification in the water column of the river. In only half of the profiles did stratification exceed 0.2 ppt, and stratification exceeded 10 ppt in less than 10 % of collections.

For both the lower St. Johns and Nassau rivers, data from Coffm et al. (1992) and Hendrickson (1995) show similar longitudinal trends. Nutrient concentrations generally decreased, upstream to downstream, with increasing salinity, probably as a result of simple dilution with seawater, except for ammonia, nitrogen, and total phosphorus which were variable and at times greater at the downstream sites. Color values decreased in the downstream direction probably reflecting the lower solubility of dissolved organic matter in water of greater ionic strength, and dilution with seawater of lesser dissolved organic content. In the Nassau River, color ranged from 226 Platinum-Cobalt (Pt-Co) units at I-95 to 63 units at Nassauville. In the St. Johns River, color ranged from 60 units at Dames Point to about 5 units at the mouth.

An examination of the frequency distributions of nitrate+nitrite, total nitrogen, and total phosphorus for estuaries of northeast Florida shows the lower St. Johns River to be low to moderate in total nitrogen and phosphorus. The estuary is unique, however, in its unusually high concentration of nitrate+nitrite, surpassing all other estuaries in northeast Florida (Hendrickson 1995; Figures 6, 7, 8). The Nassau River has similar low to moderate values for total nitrogen; for nitrate+nitrite the values are moderate (Figures 6, 7). However, the values for total phosphorus are at the high end compared to other estuarine systems (Figure 8; Coffin et al. 1992).

The much greater concentration of nitrate+nitrite in the St. Johns River estuary is apparently due to a combination of factors involving prolonged retention time in the lower river. Some of this nutrient loading is due to municipal and industrial input. However, much of the nitrogen comes from blackwater drainage. This swamp drainage is high in organic nitrogen but relatively low in phosphorus. Phosphorus appears to be the limiting nutrient in the St. Johns River estuary; most east coast estuaries studied have been limited in nitrate (Hendrickson 1995). However, the concentration of phosphorus at any one time may bear little relation to the productivity of the estuary. It appears that a rapid flux of phosphate is typical of highly productive systems, and that the flux rate is more important than the concentration in maintaining high rates of organic production (Pomeroy 1960). Also of note for both rivers, monthly mean nitrate + nitrite concentrations are inversely correlated with chlorophyll a, suggesting a regular assimilation during the phases of maximum phytoplankton abundance. On the other hand, the phosphorus trend in both rivers is less strongly synchronized with the annual phytoplankton cycle.

Water Quality

A profusion of surface and ground water quality information exists in and around the Timucuan Ecological and Historic Preserve. Many data collectors, including the U.S. Geological Survey, Florida Department of Environmental Protection, St. Johns River Water Management District, the City of Jacksonville, and the U.S. Environmental Protection Agency post their water quality information to the U.S. Environmental Protection Agency's STORET database. The Water Resources Division of the National Park Service queried STORET

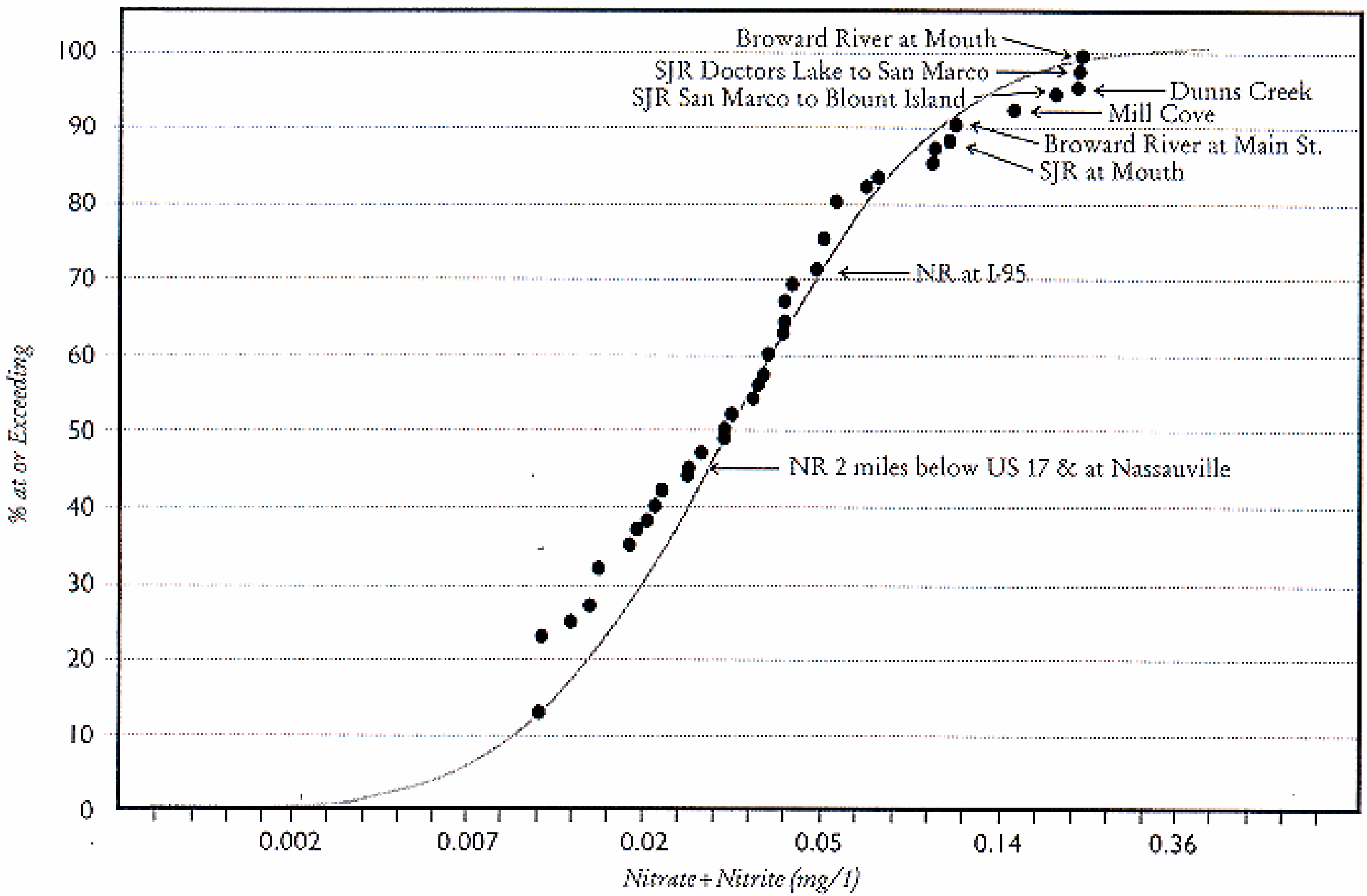


Figure 6. Frequency distribution of annual mean total nitrate+nitrate for estuaries in the St. Johns River Water Management District (modified from Hendrickson 1995). Nassau River data are from Coffin et al. (1992). Abbreviations are as follows: SJR = St. Johns River; NR = Nassau River.

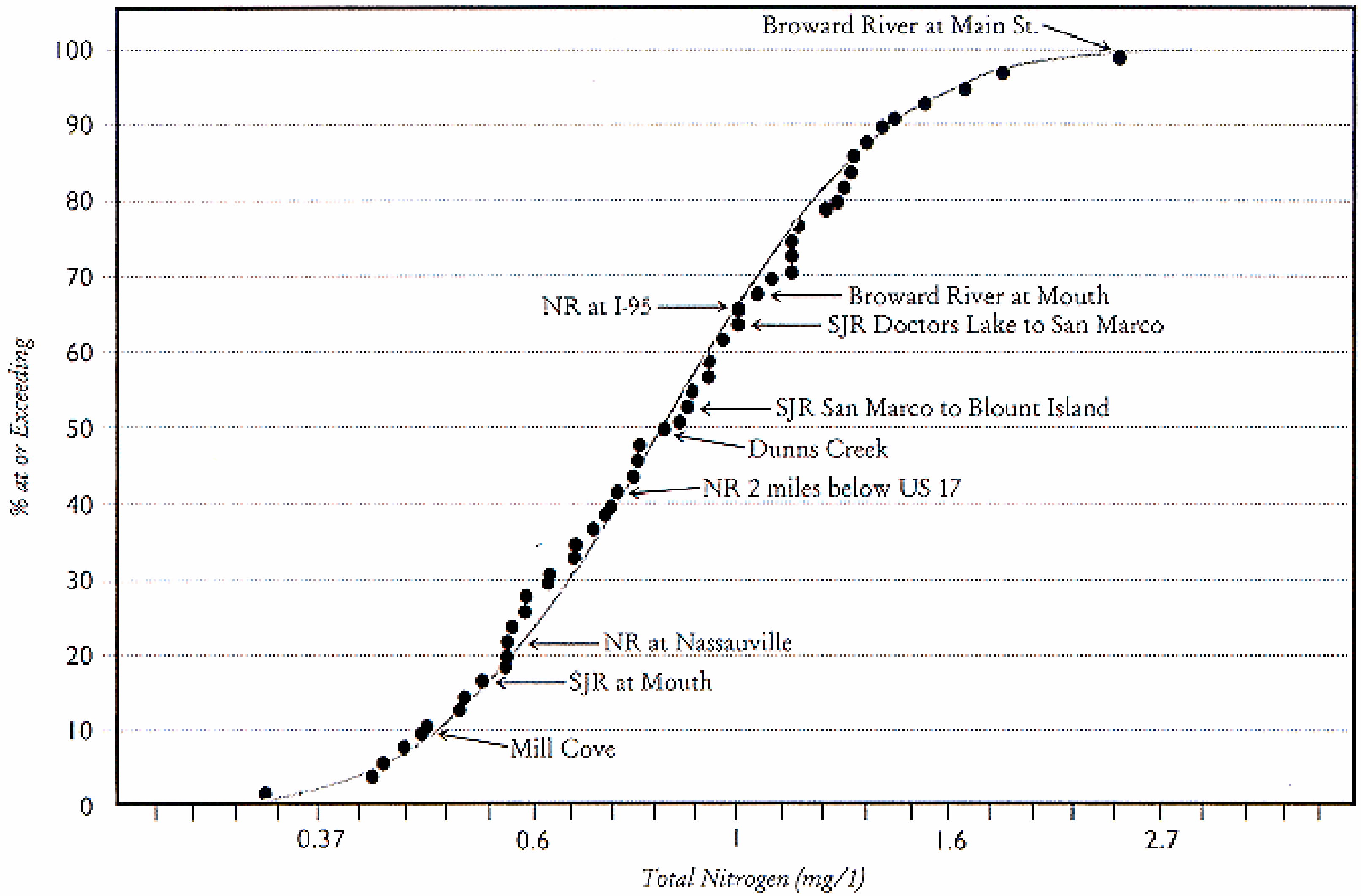


Figure 7. Frequency distribution of annual mean total nitrogen for estuaries in the St. Johns River Water Management District (modified from Hendrickson 1995). Nassau River data are from Coffin et al. (1992). Abbreviations are as follows: SJR = St. Johns River; NR = Nassau River.

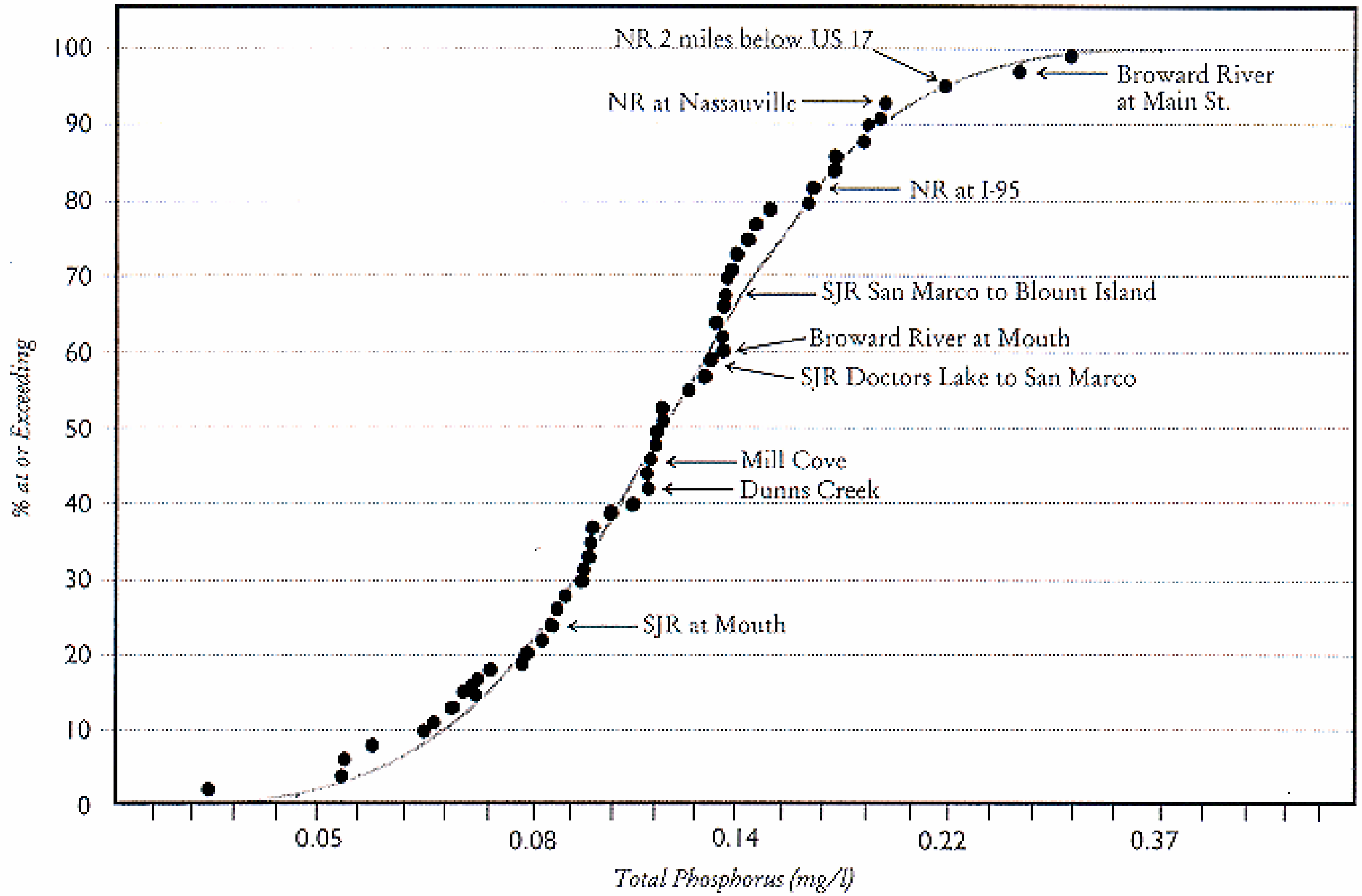


Figure 8. Frequency distribution of annual mean total phosphorus for estuaries in the St. Johns River Water Management District (modified from Hendrickson 1995). Nassau River data are from Coffin et al. (1992). Abbreviations are as follows: SJR = St. Johns River; NR = Nassau River.

for information in and near Timucuan. Six hundred thirteen (613) data collection stations were identified within a 5-mile buffer from the preserve's boundary, with 150 stations identified within the preserve (D. Tucker, pers. comm., Water Resources Division, National Park Service 1995). The data associated with these stations are both surface and groundwater, and include over 108,000 observations. However, the majority of these stations represent past studies; relatively few are currently operating data collection sites.

An in-depth analysis of STORET water quality data is beyond the scope of this water resources management plan; however, the National Park Service's Inventory and Monitoring Program, in conjunction with the Water Resources Division, is currently compiling and interpreting STORET water quality data for 250 units of the National Park Service, including the preserve. The report for the preserve will provide a comprehensive analysis of an array of physical and chemical water quality conditions taken at monitoring stations both within and outside the preserve boundary. This report is scheduled for completion in 1997 (D. Tucker, pers. comm., Water Resources Division, National Park Service 1996).

The State of Florida has classified its surface waters according to instructions in section 303 of the Federal Water Pollution Control Act. The most recent (1995) assignment and description of classifications is given in Chapter 62-302 of the Florida Administrative Code (Florida Department of Environmental Protection 1995a). Classifications are based upon assessment of the most beneficial uses, present and future, of the waters. Water quality criteria (also known as standards) are the limits to values for water quality parameters deemed necessary to assure beneficial use. All Florida surface waters have been assigned to one of five classes, given here in descending order of protection:

- Class I - Potable water supplies;
- Class II - Shellfish propagation or harvesting;
- Class III - Recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife;
- Class IV - Agricultural water supplies; and,
- Class V - Navigation, utility and industrial use.

Both Class II and Class III waters are present within the preserve (Figure 9). The criteria for Class II are slightly more stringent than for Class III waters (Appendix A). The last remaining Class II waters in Duval County where shellfish harvesting can take place are located within the preserve (Florida Department of Environmental Protection 1995a). However, at this time, those Class II waters have been closed to shellfish harvesting by the State of Florida. The effect of this closure on continued designation of those waters as Class II remains problematic.

Surface water classifications and their associated criteria serve as a guide to state regulatory activity and restoration programs. Regulation is achieved through permitting, and evaluation of permit applications must show maintenance of water quality based upon the criteria for that class. The Florida Department of Environmental Protection permits most point source discharges, including stormwater, wastewater treatment facilities, and public works facilities. The St. Johns River Water Management District is responsible for non-point sources and stormwater management programs. Restoration programs are designed to facilitate attainment of water quality standards for those waters that fail to meet their designated-use criteria (Florida Department of Environmental Protection 1995a; Florida Department of Environmental Regulation 1981, 1991a).

Although an abundance of data has been collected in the preserve area, systematic analysis for determination of both current and historic water quality is limited. The Florida Department of Environmental Protection produces a biennial "water quality assessment" in accordance with Section 305(b) of the Federal Clean Water Act. These reports consolidate STORET data and other information to assess the status of surface waters. The most recent assessment (Hand et al. 1994) provides perhaps the best summary of water quality monitoring activities and assessment of water quality, to date, for preserve waters.

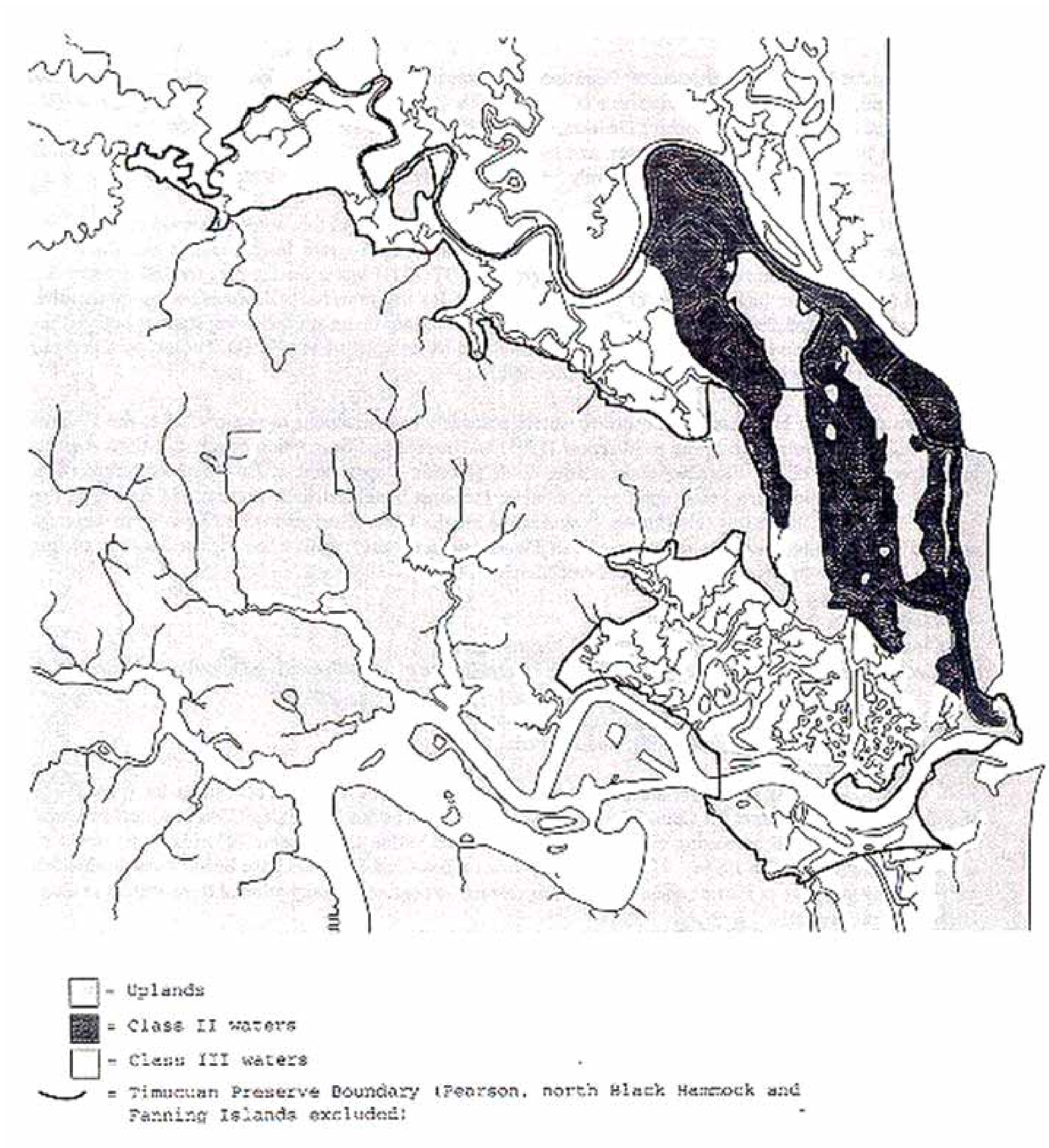


Figure 9. Class II and Class III designated waters within Timucuan Ecological and Historic Preserve.

The 1994 Water Quality Assessment uses several different methods to estimate water quality for each subdrainage unit (Hand et al. 1994). First, the lower St. Johns and Nassau river drainages were divided into subdrainages (Figure 10). Each subdrainage formed an assessment unit and all water quality stations within the subdrainage were aggregated as if they were from the same site. Second, a water quality inventory was performed on the STORET database. Twenty-one different water quality constituents were inventoried using the annual median value for each monitoring station. The inventory included the years 1970 through 1993, and was classified as recent (1989-1993) and historic (1970-1988). Data generated by this inventory provided the basis for the water quality assessment (Table 1). Three assessment procedures were used. A water quality index was calculated to determine the overall quality of the freshwater subdrainages (Table 2). The water quality index summarizes information from six categories including water clarity (turbidity and total suspended solids); dissolved oxygen; oxygen demanding substances (biochemical oxygen demand, chemical oxygen demand, and total organic carbon); nutrients (total nitrogen and total phosphorus); and, bacteria (total substrate samples, artificial substrate samples, and Beck's Biotic Index). The water quality of estuarine subdrainages is described by the Trophic State Index which is a measure of the potential for algal or aquatic weed growth. The components which make up the Trophic State Index include total nitrogen, total phosphorus, chlorophyll, and Secchi depth (Table 2). Index values, based on the annual median values of STORET water quality parameters, were tailored by the percentile distribution of Florida water quality data. In addition to the Water Quality Index and Trophic State Index, the assessment of water quality for the lower St. Johns and Nassau rivers also included (Hand et al. 1994):

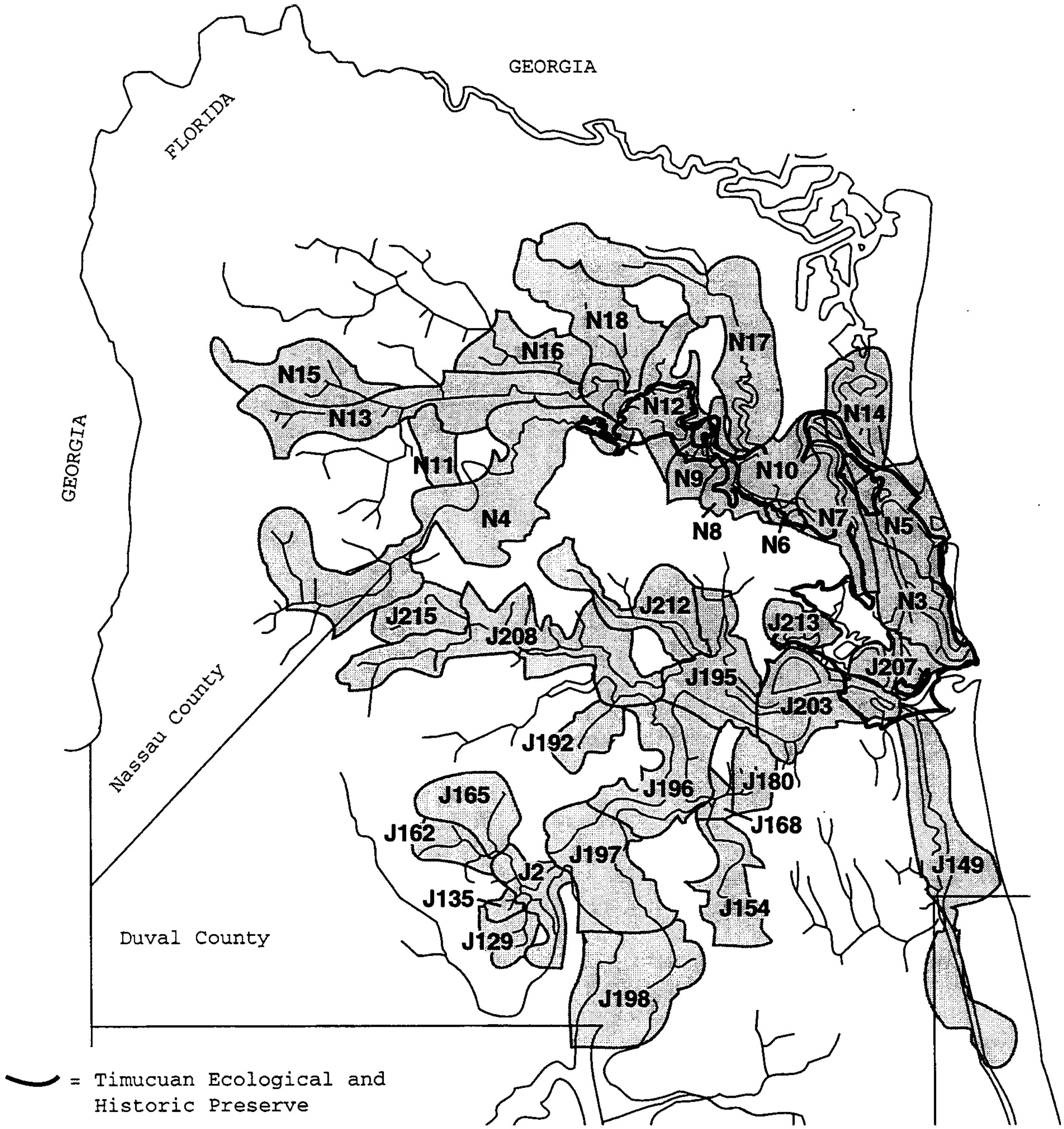
- Screening levels linked to relative position of selected STORET parameter values among values for all Florida's waters (screening levels = eightieth percentile of water quality data for Florida);
- Trends analysis for degradation/no change/improvement over the past 10 years (when enough data were present) (Table 2); and,
- An extensive nonpoint source impacts assessment through a questionnaire survey of regulatory and management agencies, environmental organizations and resource users (Table 3).

All this information was brought together to produce an assessment of water quality on a subdrainage basis: either good, threatened, fair, poor, or unknown. In general, the waters of the preserve are in good condition relative to the other surface waters in the state of Florida (Figure 11). However, nearby upstream areas in both rivers show poor water quality, and the better water quality of the downstream reaches is probably a product of the high tidal flushing (Coffin et al. 1992; Hand et al. 1994; Hendrickson 1995).

Although the Nassau River subdrainages have relatively good water quality, the Mills-Alligator Creek drainages are moderately impaired from dairy farm runoff, failing septic tanks, and urban activities. The town of Callahan wastewater treatment plant discharges to Alligator Creek. Coffin et al. (1992) found the greatest concentrations of nitrogen and phosphorus in the Alligator Creek system. The Thomas Creek drainage is suspected of having similar problems. The Amelia Island subdrainage exhibits minor degradation, probably associated with development on the island and/or pulp mill discharges. Even though the Nassau Sound subdrainage presently shows good water quality, degradation trends were identified for nitrogen enrichment and overall water quality (Hand et al. 1994). The Nassau River downstream of the Mills Creek also shows a degrading trend in nutrients.

All Nassau River subdrainages show screening exceedances to some degree. Nutrient exceedances in the upper portion of the watershed (Mill and Alligator creeks) are of greatest concern.

Eight out of 16 assessed subdrainages are threatened by nonpoint sources (Table 3), primarily nutrients from agricultural and silvicultural activities. Although urban activities are on the increase in the Nassau River drainage with a corresponding increase in point source activities, currently this river drainage is being impacted primarily by nonpoint source activities other than urban runoff.



Nassau **River**
N3 = Fort George **River**
N5 = Nassau Sound
N14 = South **Amelia River**
N7 = Pumpkin **Hill Creek**
N6 = **Edwards Creek**
N10 = Nassau **River**
N8 = **Mill** Branch **Creek**
N9 = **Deese Creek**
N17 = Lofton **Creek**
N12 = Nassau **River**
N18 = Plummer **Creek**
N16 = **Mills Creek**

N13 = Alligator **Creek**
N15 = **Little Mill Creek**
N11 = Cushing **Creek**
N4 = **Mills Creek** Reach

St. Johns **River**
J149 = IntraCoastal **Waterway**
J207 = **Sisters Creek**
J203 = **St.** Johns @ **ICWW**
J213 = Browns Creek
J195 = **St.** Johns @ **Dames Pt.**
J196 = **St.** Johns @ Trout **Cr.**
J180 = Strawberry **Creek**

J168 = Arlington **River**
J154 = Pottsburg **Creek**
J197 = **St.** Johns @ Fuller
J198 = **St.** Johns @ Piney **Pt**
J2 = **Ortega River J129** = Fishing Creek J135 = Butcher **Pen**
J162 = **Willis** Branch
J165 = **Cedar River**
J192 = Moncrief **Creek**
J208 = Trout **River**
J215 = **Little** Trout **River**
J212 = Broward **River**

Figure 10. Subdrainages of the Nassau and lower **St.** Johns **Rivers.** **Adapted** from Hand **et al. (1994).**

ID'	SUBDRAINAGE	MAXIMUM NUMBER OF SAMPLES	TIME PERIOD (YEAR)	TURBIDITY (MG/L)	SECCHI DEPTH (METER)	COLOR (PCU)	TOTAL SUSPENDED SOLIDS	DISSOLVED OXYGEN (MG/L)	DISSOL a OXYGEN' (% SATURATION)	BILOGICAL OXYGEN DEMAND (MG/L)	TOTAL ORGANIC CARBON (MG/L)	PH	ALKALINITY (MG/L)	TOTAL NITROGEN (MG/L)	TOTAL PHOSPHORUS (MG/L)	CHLOROPHYLL A (UG/L)	TOTAL COLIFORM (MPN PER)	FECAL COLIFORM (100 ML)	CONDUCTIVITY (UMHOS)
N3	Fort George River	55	89-90	5.8	1.1	23	32	75	75	1.1		7.8	108	0.5	0.08	5	18	7	43550
N4	Thomas Creek	15	89-92	7.2	0.4	400	23	5.5	68			6.4	31	1.26	0.13	3	298	86	3140
N5	Nassua Sound	91	89-93	5.5	0.9	25	42	7.3	81	1.4		7.7	110	0.44	0.1		49	12	39450
N6	Edwards Creek	14	89-90	7.2			67							0.42	0.1		9	12	
N7	Pumpkin Hill Creek	7	89-90	4.9			60							0.99	0.08		43	19	
N8	Mill Branch Creek	7	89-90	4.5			47							0.46	0.14		60	50	
N9	Deese Creek	7	89-90	6.2			61							0.59	0.15		46	25	
N10	Nassau River	4	79-79	26	0.5	:0	10	5	57	1.6		7.7		1.74	0.11		790	27	27100
N11	Cushing Creek	6	93-93	3.6	0.5	50	9	5.3	60			7	103	50		3		650	381
N12	Nassau River	27	89-92	8.1	1.3	375	18	5.5	65	1.1	25	6.5	31	132	0.24	5	117	48	8145
N13	Alligator Creek	2	90-90	11		150	6	6.5	67	0.9		6.5		1.14	0.87	1	520		100
N14	South Amelia River	108	89-93	6.2	0.8	39	41	6.4	70	1.4	8	7.6	107	0.72	0.1	10	42	10	38938
N15	Little Mill Creek	4	93-93	183	0.1	45	90	5	55			6.6	211	1.64		59		1615	528
N16	Mills Creek	9	90-92	55	5	250	10	4.2	47	6	30	6.8	63	4.5	1.8	4		410	290
N17	Lofton Creek	14	89-90	6.7			50							0.89	0.15		54	35	
N18	Plummer Creek	3	92-92	6.5	0.5	500	6	4.7	55			6.4	28	1.32	0.2	7		190	780
J2	Ortega River	28	89-90	3.1			26	8.7	91			7.6		1.03	0.44		1610	173	531
J129	Fishing Creek	4	92-92	10.8	0.3	50	18	4.9	57		11	6.3	77	2.49	0.48	9		92	170
J135	Butcher Pen Creek	4	92-92	8.9	0.3	55	22	5	57		12	6.6	88	1.14	0.21	66		1650	65
J149	Intracoastal Waterway	242	89-93	3.8	0.8	58	40	6.6	71	1.1		7.5	77	0.75	0.11		303	63	15205
J154	Pottsburg Creek	4	92-92	7.3	0.5	70	6	6	47		12	6.7	81	1.01	0.16	45		170	990
J162	Willis Branch	5	92-92	7	0.7	40	10	3.8	42		11	6.8	94	1.29	0.17	16		720	360
J165	Cedar River	54	92-92	7.8	0.7	50	5	3.6	40		11	7	105	0.87	0.19	14		1364	520
J168	Arlington River	15	•89-92	4.8	0.5	0	25	7.9	83		12	7.8	76	1.09	0.17	32	718	300	19800
J180	Strawberry Creek	4	92-92	3.5	0.7	50	2	4.8	54		8	6.5	81	0.91	0.09	9		927	420
J192	Moncrief Creek	4	92-92	18	0.4	40	32	5	58		10	6.8	97	1.24	0.24	31		664	3130
J195	St. Johns River above Dames Point	64	89-92	6.4	0.6	56	18	6.8		1.1		7.2		0.92	0.1	3			20290
J196	St. Johns River above Trout Creek	300	89-93	6.8	0.7	73	19	7		1		7.6	95	1.03	0.14	3	400	55	16365
J197	St. Johns River above Fuller	447	89-93	4.7	0.7	65	17	7.3	83	1		7.7		1.08	0.13	7	400	40	9474
J198	St. Johns River above Piney Point	333	89.93	3.5	0.8	65	13	7.8	85	1		7.7		1.18	0.1	1	98	20	4800
J203	St. Johns River above Intracoastal Waterway	99	89-92	6	0.7	59	26	6.7	73	1.3		7.4		0.64	0.1	3	46	28	31325
207	Sisters Creek	40	92-93	4.2	1	35	16	7.4	75	1.1		7.7	84	0.65	0.07		75	13	38275
J208	Trout River	41	89-92	6.7	0.6	81	21	6.8	75	1.3		7.3		1.02	0.16	2	285	105	20329
J212	Broward River	29	90-91	10		43	37	6.7	75	1.8		7.6		1.25	0.14		900	200	15089
J213	Browns Creek	4	92-92	6.8	0.9	25	19	65	73		6	6.9	135	0.35	0.09	7		10	43000
J215	Little Trout River	50	91-91								34			2.11	0.33				

TABLE 2. WATER QUALITY INDICES AND TRENDS ANALYSIS FOR SUBDRAINAGES OF THE NASSAU AND LOWER ST. JOHNS RIVER DRAINAGES. Adapted from Hand et al. (1994). Abbreviations are as follows: N=Nassau River drainage, J=St. Johns River drainage.[1]

ID[2]	SUBDRAINAGE	MAXIMUM NUMBER OBSERVED	TIME PERIOD (YEAR)	WATER QUALITY INDEX[3]	TROPHIC STATE INDEX[3]	INDEX RANK	OVERALL TREND[4]	DEGRADING TRENDS[4]	IMPROVING TRENDS[4]
N3	Fort George River	55	89-90		47	Good	Stable	None - Unknown	Turbidity/Coliforms
N4	Thomas Creek	15	89-92	59		Fair	Stable	Turbidity	Total Coliforms
N5	Nassau Sound	91	89-93		44	Good	Degrading	Trophic State Index/Total nitrogen	Total suspended solids
N6	Edwards Creek	14	89-90		38	Good	Stable	None - Unknown	None - Unknkown
N7	Pumpkin Hill	7	89-90		59	Fair			
N8	Mill Branch Creek	7	89-90		41	Good			
N9	Deese Creek	7	89-90		45	Good			
N10	Nassau River	4	79-79		76	Poor			
N11	Cushing Creek	6	93-93	45		Fair			
N12	Nassau River	27	89-92	58		Fair	Stable	Water Quality Index/Total nitrogen/pH/Alkalinity/ Temperature	Fecal Coliforms
N13	Alligator Creek	2	90-90	44		Good	Stable	None - Unknown	Water Quality Index
N14	South Amelia River	108	89-93		57	Fair	Stable	None - Unknown	Total nitrogen/Turbidity/ Total suspended solids Dissolved oxygen saturation
N15	Little Mill Creek	4	93-93	69		Good			
N16	Mills Creek	9	90-92	73		Good	Stable	None — Unknown	None — Unknown
N17	Lofton Creek	14	89-90	44		Good	Stable	None - Unknown	None - Unknown
N18	Plummer Creek	3	92-92	66		Good			
J2	Ortega River	28	89-90	44		Good	Stable	None - Unknown	Turbidity
J129	Fishing Creek	4	92-92	63		Poor			
J135	Butcher Pen Creek	4	92-92	65		Poor			
J149	Intracoastal Waterway	242	89-93		56	Fair	Stable	Trophic State Index/Total nitrogen	Total phosphorus/pH/ Turbidity/Dissolved oxygen/ Temperature
J154	Pottsburg Creek	4	92-92	51		Fair			
J162	Willis Branch	5	92-92	64		Poor			
J165	Cedar River	54	92-92	61		Poor			
J168	Arlington River	15	89-92	47		Fair	Stable	None - Unknown	pH
J180	Strawberry Creek	4	92-92	48		Fair			
J192	Moncrief Creek	4	92-92	66		Poor			

TABLE 2. WATER QUALITY INDICES AND TRENDS ANALYSIS (CONTINUED)

ID[2]	SUBDRAINAGE	MAXIMUM NUMBER OBSERVED	**TIME PERIOD (YEAR)**	**WATER QUALITY INDEX[3]**	**TROPHIC** STATE INDEX[3]	**INDEX RANK**	OVERALL TREND[4]	DEGRADING TRENDS[4]	IMPROVING TRENDS°
J195	St. Johns River above Dames Point	64	89-92	43		Good	Stable	Total nirogen/pH/Dissolved oxygen/Dissolved oxygen saturation	Turbidity/Total suspended solids
J196	St. Johns River above Trout	300	89-93	44		Good	Stable	None — Unknown	Water Quality Index
J197	St. Johns River above Fuller	447	89-93		62	Poor	Degrading	Trophic State Index/Water clarity	Turbidity/Biological oxygen demand
J198	St. Johns River above Piney Point	333	89-93		63	Poor			
J203	St. Johns River above Intracoastal Waterway	99	89-92	42		Good	Stable	Total nitrogen/Dissolved oxygen/dissolved oxygen saturation	Total suspended solids
J207	Sisters Creek	40	92-93		55	Fair			
J208	Trout River	41	89-92	45		Fair	Stable	Dissolved oxygen/Dissolved oxygen saturation	None — Unknown
J212	Broward River	29	90-91	56		Fair	Stable	None — Unknown	pH
J213	Browns Creek	4	92-92		47	Good			
J215	Little Trout River	50	91-91	72		Poor			

1 See text for further explanation.
2 Refer to Figures 10 and 11.
3 For Water Quality Index: 0-44 (good); 45-59 (fair); 60-90 (poor); for Trophic State Index: 0-49 (good); 50-59 (fair); 60-100 (poor).
4 Timeframe is 1983-94. Trends based on Spearman's ranked correlation of annual STORET station medians.

TABLE 3. NONPOINT SOURCE QUALITATIVE SURVEY RESULTS FOR SUBDRAINAGES OF THE NASSAU AND LOWER ST. JOHNS RIVER DRAINAGES. Adopted from Hand et al. (1994). Abbreviations are as follows: N=Nassau River drainage, J=St. Johns River drainage.

113[1]	SUBDRAINAGE	MEETS DESIGNATED USE?	NONPOINT THREAT STATUS	NONPOINT SOURCES	NONPOINT SYMPTOMS
N3	Fort George River	Yes			
N4	Thomas Creek	Partial			
N5	Nassau Sound	Yes			
N6	Edwards Creek	Yes	Threatened	Agriculture/Silvaculture/Other	Nutrients
N7	Pumpkin Hill	Partial			
N8	Mill Branch Creek	Yes			
N9	Deese Creek	Yes			
N10	Nassau River	No	Threatened	Agriculture/Silvaculture	Nutrients
Nil	Cushing Creek	Partial	Threatened	Construction sites/Other	
N12	Nassau River	Partial	Threatened	Agriculture/Silvaculture	Nutrients
N13	Alligator Creek	Yes	Threatened	Silvaculture/Construction sites/Other	Nutrients
N14	South Amelia River	Partial	Threatened	Silvaculture/Urban runoff/Construction site/Other	
N15	Little Mill	No			
N16	Mills Creek	No	_		
N17	Lofton Creek	Yes	Threatened	Silvaculture/Other	
N18	Plummer Creek	No	Threatened	Agriculture/Silvaculture/Hydrologic modifications/Other	
J2	Ortega River	Yes	Fair	Same as J168	Same as J197
J129	Fishing Creek	No	Poor	Land disposal/Urban runoff/ Construction sites/Hydrologic modifications/Other	Nutrients/Bacteria/Sediments/Oil/Pesticides/ Other chemicals/Debris/Oxygen depletion/ Salinity/Metals/Habitat alteration/ Flow alterations/Other pollution/Fishkills/Weeds/ Turbidity/Fish declines
J135	Butcher Pen Creek	No	Poor	Same as J129	Same as J129
J149	Intracoastal Waterway	Partial	Threatened	Agriculture/Resource extraction/Silvaculture/ Land disposal/Urban runoff/Construction sites/Hydrologic modification/Other	
J154	Pottsburg Creek	Partial	Threatened	Same as J168	Same as J168
J162	Willis Branch	No	Poor	Same as J129	Same as J129
J165	Cedar River	No	Poor	Same as J129	Same as J129, plus Algal blooms/Odor
J168	Arlington River	Partial	Threatened	Resource extraction/Land disposal/Urban runoff/Construction sites/ Hydrologic modifications/Other	Nutrients/Bacteria/Oils/Pesticides/ Other chemicals/Debris/Habitat alteration/Fishkills/ Algal blooms/Turbidity/Fish declines

TABLE 3. NONPOINT SOURCE QUALITATIVE SURVEY RESULTS (CONTINUED)

ID'	SUBDRAINAGE	MEETS DESIGNATED USE?	NONPOINT THREAT STATUS	NONPOINT SOURCES	NONPOINT SYMPTOMS
J180	Strawberry Creek	Partial	Fair	Same as J203, except Agriculture	Nutrients/Bacteria/Sediments/Pesticides/ Debris/Habitat alteration
J192	Moncrief Creek	No	Poor	Land disposal/Urban runoff/Hydrologic modifications/Other	Same as J129, plus Odor
J195	St. Johns River above Dames Point	Yes	Fair	Same as J203, except Agriculture	Same as J203
J196	St. Johns River above Trout	Yes	Fair	Same as J203, except Agriculture	Same as J203
J197	St. Johns River above Fuller	No	Fair	Same as J168	Same as J168, plus Sediments/Oxygen depletion/Salinity/Metals/Flow alterations/ Thermal polution/Other pollution/Other symptoms
J198	St. Johns River above Piney Point	No	Fair	Same as J168	Same as J197
J203	St. Johns River above Intracoastal Waterway	Yes	Fair	Agriculture/Resource extraction/ Land disposal/Urban runoff/Construction sites/ Hydrologic modification/Other	Nutrients/Bacteria/Sediments/Oil/Pesticides/ Other chemicals/Debris/Oxygen depletion/ Salinity/Metals/Habitat alteration/Flow alteration/Thermal pollution/Other pollution/ Fishkills/Al al blooms/Turbidity/Fish
J207	Sisters Creek	Partial	Threatened	_Same as J149	Same as J149
J208	Trout River	Partial	Fair	Agriculture/Resource extraction/ Silvaculture/ Land disposal/Urban runoff/Construction sites/Hydrologic modification/Other	Same as J129, except Fishkills
J212	Broward River	Partial	Threatened	Same as J129	Nutrients/Bacteria/Sediments/Oil/Pesticides/ Other chemicals/Debris/Oxygen depletion/ Salinity/Metals/Habitat alteration/Thermal pollution/Fishkills/Fish declines
J213	Browns Creek	Yes	Threatened	Same as J149	Same as J149
J215	Litter Trout	No	Fair	Same as J208	Same as J208

1 Refer to Figures 10 and 11.

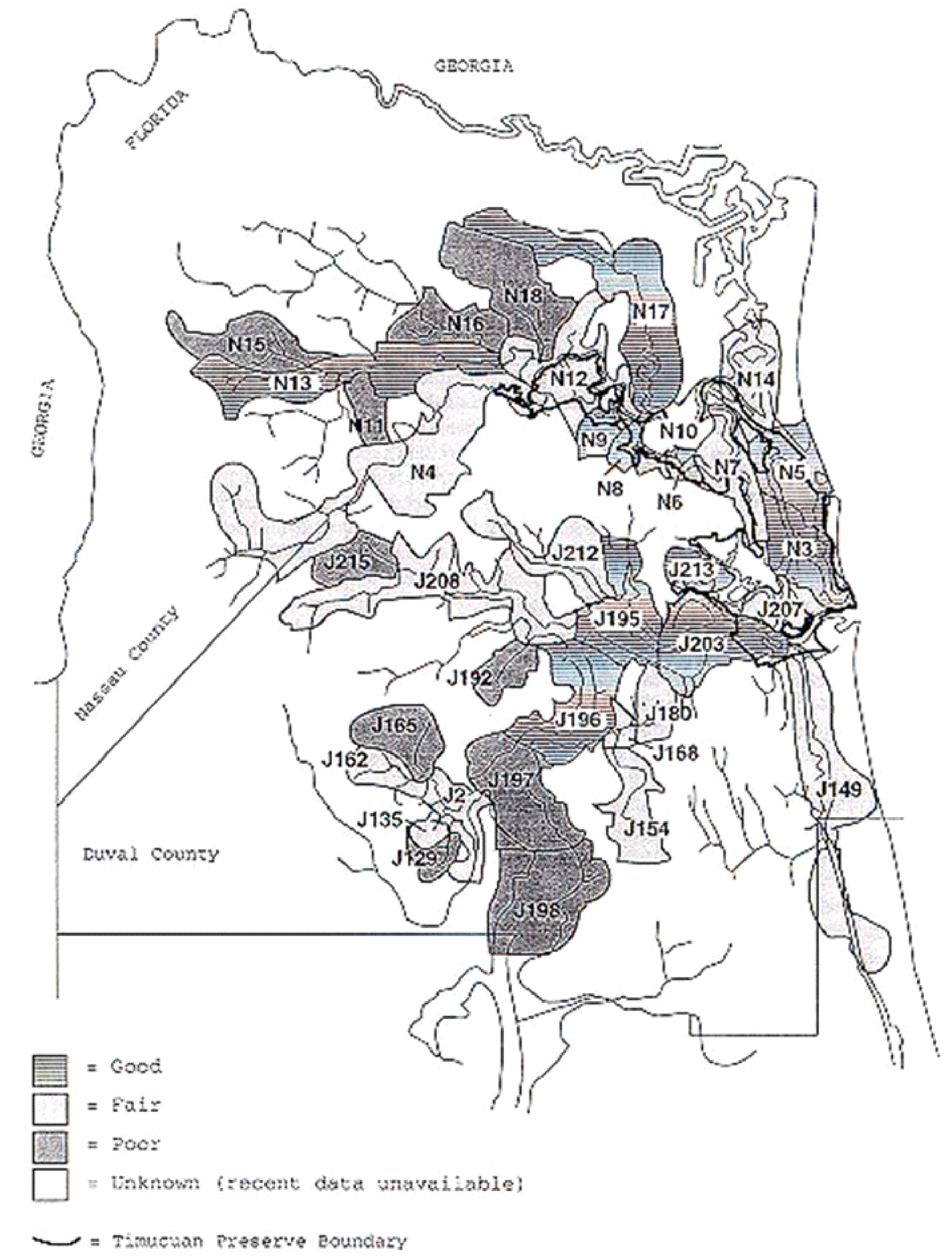


Figure 11. Overall water quality condition for each subdrainage of Nassau and lower St. Johns Rivers. Adapted from Hand et al. (1994).

The general assessment of the water quality status along the lower St. Johns in Duval County is relatively good in the main stem from the mouth to downtown Jacksonville, with fair quality in tributaries adjacent to the main stem. The good main stem quality is linked to tidal flushing. Further upstream from the tidal influence, the main stem quality is poor, with fair to poor tributaries (Hand et al. 1994).

Several heavily polluted tributaries empty into the lower St. Johns just before the river turns from the north to the east (the "bend" area in downtown Jacksonville), particularly the Cedar and Trout Rivers, and Strawberry, Pottsburg and Montcrief Creeks. At the bend, the river receives input from shipyards, industrial discharges, urban/stormwater runoff, and the polluted tributaries, making it the most polluted portion of the river. Near the mouth, water quality improves due to flushing and dilution from tidal effects (Hand et al. 1994).

The most concentrated area of water quality problems in the lower St. Johns River is in the "bend" area in Duval County, where both banks are almost completely sea walled and lined with industries and downtown development. Starting in the southern portion of the county, one of the notable problem areas is the Cedar River/Wills Branch/Ortega River system. Cedar River has the worst water quality in the area with frequent fish kills. The area receives discharges from wire and chemical industries as well as numerous wastewater treatment package plants. This tributary system appears to have a negative impact on the quality of the lower St. Johns itself. However, just north of this segment, the St. Johns also receives drainage from two small polluted urban creeks and the Jacksonville shipyards. Adjacent to this reach are Strawberry and Pottsburg creeks that also exhibit poor water quality caused by pollution loads from wastewater treatment facilities and stormwater runoff.

The Ribault River, lower Trout River and Moncrief Creek, probably the second worst tributary system after the Cedar River, also empty into the St. Johns a few miles north of this area. Downstream from the confluence of the Trout River, the St. Johns River receives treated paper mill wastewater effluent. Discharges from the Broward River and Dunn Creek further affect the river. These tributaries, although not as severely degraded as the previously mentioned systems, exhibit low dissolved oxygen and high concentrations of nutrients and biochemical oxygen demand from domestic and industrial point sources and dairy operations.

Screening exceedances in subdrainages in or adjacent to the preserve involve issues of water clarity (turbidity and total suspended solids). Considering the estuarine environment and the high tidal flushing within the lower St. Johns, these exceedances should not be considered noteworthy, except that resuspension of sediments also resuspends sediment contaminants (see below). Further upstream of the preserve, seven subdrainages show screening exceedances for dissolved oxygen, biochemical oxygen demand, coliforms, and nutrients.

Although the most oceanward reach of the lower St. Johns River (J203; see Figure 11) received a good overall status rating, degrading trends in nitrogen enrichment and dissolved oxygen were identified (Tables 2 and 3). The two subdrainages entering this river segment within Timucuan, Sisters (J207) and Browns creeks (J213), were assessed as fair and good, respectively (Figure 11). Trend data were not available for these sections, but they were both identified as "threatened" by nonpoint pollution sources (Table 3; Hand et al. 1994).

No subdrainage within or near the preserve is experiencing an overall degrading trend, although the St. Johns River above Fuller subdrainage does show an overall degrading trend. However, the St. Johns River above the Intracoastal Waterway subdrainage is showing a degrading trend for nutrients and dissolved oxygen.

Only six out of 19 subdrainages are threatened by nonpoint source pollution. Of those six, three [Intracoastal Waterway (not including Sisters Creek), Sisters Creek, and Browns Creek] are within or adjacent to the preserve (Table 3). While there has been an improvement in point source pollution control, the lower St. Johns is still experiencing significant point source inputs. Perhaps of greater concern at present are the potential nonpoint source impacts from urban stormwater runoff:

Longer term trend analysis for the lower St. Johns River mainstem was performed by Hendrickson (1995) using data from 1955 to 1992 in downtown Jacksonville for biochemical oxygen demand, dissolved oxygen, nitrate, and phosphorus concentrations. The biochemical oxygen demand levels reflect the installation of wastewater treatment plants and implementation of secondary wastewater treatment in the early 1970s and 1980s (Figure 12). After the mid 1980s, biochemical oxygen demand concentrations have consistently increased. Dissolved oxygen and nitrogen show no major changes since the late 1960s, with dissolved oxygen remaining roughly at 80 to 90% and nitrogen holding at approximately 02 mg/I. Phosphorus concentrations show a declining trend since the early 1980s, probably associated with application of secondary wastewater treatment and phosphorus reductions in detergents.

Spanish Pond is the largest freshwater pond (semi-permanent water regime) within the preserve that is under National Park Service ownership (three freshwater ponds, under State of Florida jurisdiction, are present on Fort George Island). The pond is on the National Register of Historic Places and, as such, is a contributing element of Fort Caroline National Memorial (National Park Service 1994a). The accounts of the attack by the Spanish on Fort Caroline state that they made a camp at a freshwater pond a short distance from the fort. Whether Spanish Pond is the same pond mentioned in the Spanish accounts of the attack remains questionable.

The water level of Spanish Pond is determined by rainfall and water table fluctuations, no tributaries or outlets exist. Although the spatial bounds of the pond have oscillated historically, recent residential development and road construction adjacent to the pond may have affected pond hydrology and/or water quality. For example, this development has increased the amount of impermeable surface surrounding the pond and it is often within the flood boundaries of the pond. Scientific information about past and present pond hydrology is not currently available.

Water quality in Spanish Pond has been assessed as "good" in the past, but recent data indicate some potential for contamination from nearby road stormwater runoff. The City of Jacksonville analyzed water and sediment samples taken from Spanish Pond in May, 1993 (Morton and Marchman 1993). Water column parameters were generally good, with the exception of low dissolved oxygen levels. The samples were taken during a period of low rainfall, indicating that baseline water quality in the pond can be classified as "good," but not conducive for support of fish populations due to the low oxygen levels. Sediment analysis for metals, pesticides and other organics revealed elevated levels of lead and zinc, both known to be common constituents of stormwater runoff associated with roads. The sediment concentrations for lead and zinc were above the "no observed effects level," but below the "probable effects level." Morton and Marchman (1993) concluded that although instantaneous water column contamination during good weather is low, sediments are moderately contaminated and adverse biological impacts cannot be ruled out. More recently septic systems from six to eight homes have failed during highest water levels (1995). Water quality may have been affected by these septic system failures.

Water Quality Monitoring

Existing water quality monitoring occurs at over 100 routinely sampled stations by various entities on the lower St. Johns River, including the major tributaries and point source loads. Sampling frequency is typically monthly for the following parameters: ammonium-nitrogen; nitrate + nitrite; total Kjeldahl nitrogen; total phosphorus; orthophosphate; dissolved oxygen; dissolved silica; total suspended solids; total dissolved solids; sulfate; chloride; chlorophyll *a, b, c* and phaeophyton a; total organic carbon; alkalinity; turbidity; and, color (U.S. Army Corps of Engineers and St. Johns River Water Management District 1994).

Recently, the St. Johns River Water Management District produced a water quality atlas that describes the water quality monitoring efforts being conducted by various state and local agencies which have water quality responsibilities within the lower St. Johns River basin (St. Johns River Water Management District 1994b).

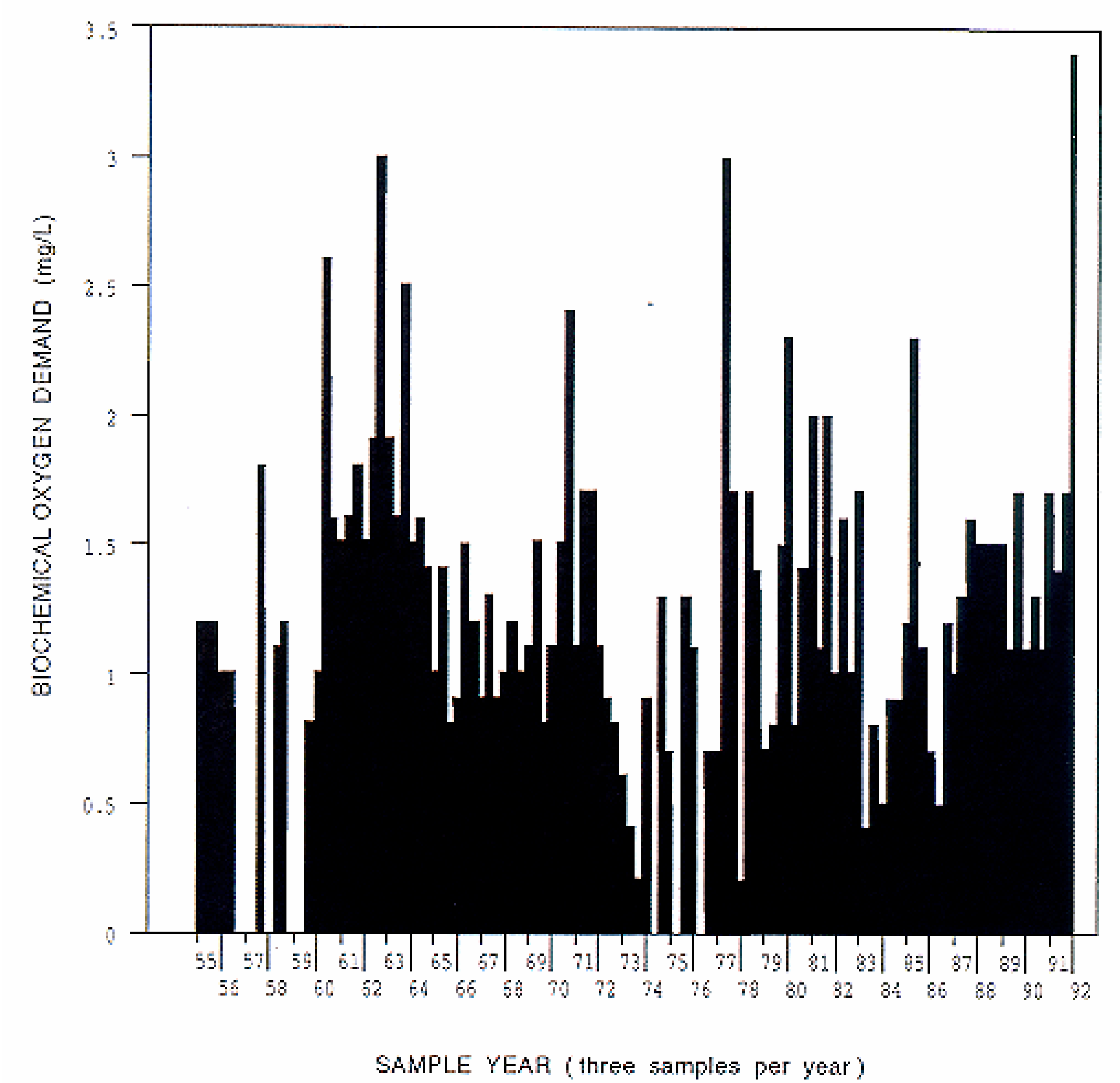


Figure 12. Biochemical oxygen demand from the city of Jacksonville Main Street Bridge, 1955 - 1992. Adapted from Hendrickson (1995).

Duval County, the St. Johns River Water Management District, and the Florida Department of Environmental Protection's Northeast District Office currently conduct ambient water quality monitoring within the lower St. Johns River basin. All ambient monitoring program objectives, locations, and frequencies are coordinated through the Lower St. Johns Technical Advisory Committee, a group of involved public agencies and private individuals. Presently, only two monitoring stations are within preserve boundaries and both are St. Johns River mainstem stations. Another station at the mouth of the Intracoastal Waterway (south bank of St. Johns River) is part of Duval County's tributary monitoring program and measures only three parameters used for screening purposes: total ammonia-nitrogen, and total and fecal coliforms. Recent, long-term water quality monitoring activities (including biomonitoring) within the preserve are summarized in National Park Service (1994a).

No regular and consistent biological monitoring occurs within preserve boundaries, nor for that matter anywhere upstream of the preserve in either the lower St. Johns or Nassau rivers. Some past biological monitoring occurred within and adjacent to preserve waters. National Park Service (1994a) summarized these efforts.

The most recent attempts at long-term monitoring within the Nassau River/St. Johns River estuary covered the years 1980 to 1991, and were maintained by Duval County, Florida Department of Environmental Regulation, and the St. Johns River Water Management District. Duval County sampled six stations in the Nassau River basin of the county from 1985 to 1990 and one station in the lower St. Johns River basin from 1983 to 1991. The Florida Department of Environmental Regulation monitored nine stations in the Nassau River estuary and Fort George River from 1980 to 1989. The St. Johns River Water Management District sampled five stations from 1980 to 1990 in the Nassau, Amelia, and Fort George Rivers. For all of these efforts, the sampling frequency was only irregular, at best. Parameters sampled were similar to those currently being measured in the lower St. Johns River except that metals were sampled at the only lower St. Johns River station.

Sediment Ouality

Sediments not only act as pollutant traps, but resuspended contaminated sediments can significantly contribute to the degradation of an ecosystem. Sediment movement in an estuarine system may reduce navigability by shoaling, undermine the integrity of the foundation of marine structures by scouring, or increase turbidity and contaminant concentrations of the ambient water, especially during resuspension events. Suspended or dissolved pollutants pose a very serious problem to sediment bottoms; small sediment particles have an affinity for dissolved or suspended pollutants. Understanding water-sediment interactions is important in assessing aquatic ecosystem integrity.

Several river sediment characteristics are important in determining the transport potential of sediments and the likelihood of sediments serving as contaminant sinks: knowledge of the geology and land use of a watershed; particle size and distribution; and, total organic carbon. Sediments with high total organic carbon act as a contaminant sink through adsorption. Therefore, total organic carbon, through adsorption of contaminants, may reduce the bioavailability of contaminants in the water column by interfering with organism uptake. However, benthic organisms may be adversely impacted by contaminated sediments.

Sediments bind nutrients (primarily nitrogen and phosphorus) that enter the river from sewage treatment plants, landscape fertilizers, agricultural sources, and decomposition of riparian vegetation. Nutrients stimulate growth of benthic algae and bacteria; this can lead to changes in the redox potential of the sediment-water interface as the algae and bacteria generate and/or use oxygen. When anoxia occurs at the sediment-water interface, nutrients are released to the water column. Also of importance, the solubility of sediment-bound metals increases. This variable benthic environment affects both water quality and biological community development.

Keller and Schell (1993) and the U.S. Army Corps of Engineers and St. Johns River Water Management District (1994) reviewed sediment characteristics and quality in the lower St. Johns River basin. They found that during the past decade, nine studies have evaluated the degree of contamination of lower St. Johns River sediments (Boehnke et al. 1983; Florida Department of Environmental Regulation 1988; Dames and Moore 1983; Mote Marine Laboratory 1988; Savannah Laboratory and Environmental Services, Inc. 1988; City of Jacksonville 1990a; Delfino et al. 1991; Hanson and Evans 1991; St. Johns River Water Management District 1993). Although that number of studies is higher than for most other Florida estuaries, few of the lower St. Johns area studies were comprehensive. As a result, the extent of the contamination of the river basin is not well defined, nor is the biological significance of contamination understood. Rather than determining the extent of the contamination or assess the environmental risk, these investigations were designed to simply locate contaminated areas.

Taken together, data from these studies demonstrate that sediment contamination along the lower St. Johns River follows the same general pattern as the water column pollution described above, but for different reasons. Rather than dilution and removal of pollutants by tidal flushing, the pattern for sediment contamination is linked to the amount of organic matter in the sediments and the freshwater/saltwater mixing zone in the river. The mixing zone changes the ionic equilibrium in the water column and for suspended particles, causing the particles to flocculate and settle. Contamination occurs when metals and organic compounds are attracted to binding sites that open on the particles when salt ions break the water molecule envelope that surrounds the particles in fresh water, or take on configurations that precipitate out of the water column (St. Johns River Water Management District 1993, 1994a; Keller and Schell 1993). While sediments from many locations in the lower St. Johns River are contaminated with heavy metals, impacts on resident biota have not been determined. Several metals are found at concentrations toxic to biota elsewhere, which suggests that faunal communities of the lower St. Johns River are being adversely affected by these contaminants. Toxicity tests and biological surveys of communities are the only methods to assess actual impacts because significant portions of sediment metals may be bound to sulfides, hydroxides, or oxides and therefore may be biologically inert (Keller and Schell 1993).

These studies also determined that the portion of the St. Johns within the preserve boundary, when studied, showed little to no metal/organic contamination. However, sediments from two sites in Chicopit Bay (across the river from Sisters Creek) sampled by the National Status and Trends Program (National Oceanic and Atmospheric Administration 1988), had concentrations of arsenic, chromium, lead, and zinc above the "no observed effects level." The "no observed effects level" is the highest concentration at which no detrimental impact on biota is expected. Also used is the "probable effects level," which represents the concentration at which a contaminant is likely to exert a negative impact on biota. These levels vary from one substance to another (Table 4). Also, the National Oceanic and Atmospheric Administration study detected organic contaminants at both of its St. Johns River estuary sample sites. At the Chicopit Bay site, total PCB [67.9 micrograms per kilogram (ug/kg)] and tDDTs (8.56 ug/kg) exceeded "no observed effects level" established by the Florida Department of Environmental Regulation. The St. Johns River site near its mouth had total PCB concentration of 180 ug/kg, seven times the "no observed effects level." Compared to 212 other coastal sites around the nation, Chicopit Bay had the 17th highest level of PCB contamination (384 ug/kg). Elevated levels of DDT, DDT derivatives, and chlordane were also reported.

O'Connor and Beliaeff (1995), using results from 8 years of collecting and analyzing mollusks, found that the Chicopit Bay area of the St. Johns River was one of 21 estuarine or coastal locations out of a total of approximately 300 since 1990 that showed increasing trends for specific chemicals; in this case the specific chemical was arsenic. Also since 1990 at this location, arsenic showed high levels three years; selenium showed high levels two years; and, butylin compounds showed two years of high values.

Table 4. Sediment quality guidelines for metals in Florida coastal areas. Modified from Keller and Schell (1993).

Contaminant	No Observed Effects Level (mg/kg)	Probable Effects Level(mg/kg)
Arsenic	8	64
Cadmium	1	7.5
Chromium	33	240
Copper	28	170
Lead	21	160
Mercury	0.1	1.4
Silver	05	2.5
Zinc	68	[illegible]

The City of Jacksonville (1989) examined sediments of the Nassau stem as well as tributaries including Sisters, Pumpkin Hill and Edward organic compounds. None of the organics was present in detectible l the "no observed effects level" at Sisters Creek (chromium and arseni Nassau River (chromium), and two upriver sites on Mills and Thor sites showed cadmium concentrations above the "no observed effects referenced to background aluminum concentration, all except cadmiur from normal, background metals concentrations. Although the cadmi control standard readings associated with the cadmium test indicated elevated during the testing process. These results show that as of contaminated.

The National Biological Service is currently assessing sediment and m contaminants in four tidal creeks feeding into the lower St. Johns Biological Service 1996).

<u>Floodplains and Coastal High Hazard Areas</u>

The preserve experiences its most severe flooding when heavy rainf due to a storm surge or wind and wave setup. Hurricanes and prolc causes of such flooding that can be greatly exaggerated when they cc tide.

Extensive floodplain areas exist in the preserve because of the slight relatively flat topographic relief. Information on 100-year floodplai obtained from federal flood insurance rate maps developed by the F (as presented in City of Jacksonville 1990b). These maps identify a event of a magnitude that statistically would be met or exceeded once

Coastal high hazard areas are defined as those areas within the F velocity zones, as delineated on August 15, 1989, and areas s Environmental Protection's coastal construction control line. For the

Figure 13. 100-year floodplain areas of Timucuan Ecological and Historic Preserve. After National Park Service (1994a).

North

depicted in Figure 14. Lands within the coastal high hazard area are subject to storm surge, high winds, waves, and rain in the event of severe storms.

GROUNDWATER

Hydrogeology

The hydrologic framework of Duval and Nassau Counties is generally divided into two aquifer systems: the surficial and the Floridan. Both aquifers underlie the entire area in and around Timucuan Preserve. The geologic formations below Duval and Nassau Counties consist of sediment layers from past episodes of sea level rise and fall. The aquifers occur in layers that are porous and allow water to flow in and through the sediments. Other layers have low permeability and form barriers to groundwater flow called confming beds. The geologic and hydrogeologic characteristics of the area are described in Table 5. Geology in the lower St. Johns River basin, pertinent to the preserve, was discussed by Leve (1966), Snell and Anderson (1970), and Toth (1990).

The surficial aquifer system underlies the entire area and ranges in thickness from about 20 to 120 feet. It consists of deposits of extremely variable lithology (clay, sand, coquina, and limestone). The top of the aquifer is the top of the water table, and the bottom penetrates the upper parts of the Hawthorne Formation -- a large, nonporous confining bed that separates the surficial from the Floridan aquifer. Scattered throughout the surficial aquifer zone are interbedded lenses of lower permeability sediments. These can form semiconfming beds, and the surficial aquifer is sometimes described as having upper and lower zones, with the lower zone sometimes referred to as the "intermediate" aquifer.

The surficial aquifer system is less extensive than the Floridan aquifer system and is tapped when the Floridan contains nonpotable water or when the Floridan System is generally deeper than 200 feet (Toth 1993).

Water enters the surficial aquifer through infiltration of rainfall and seepage from lakes, streams, and marshes. Some recharge can also occur through lateral groundwater movement from adjacent areas, and by upward leakage in areas where the hydraulic head (water pressure) of underlying aquifers is greater than the surficial aquifer's and discontinuities are present in the confining bed (the Hawthorne Formation). Water leaves the surficial aquifer through evaporation, transpiration through plants, seepage into surface water bodies, lateral flow to adjacent areas, and pumping. Some waters also infiltrate to the underlying aquifers where the hydraulic head of the surficial system is greater than the lower aquifer's, and pathways exist for water movement.

Yields from surficial aquifer wells generally range from 10 to 25 gpm (gallons per minute) in the upper aquifer, and 30 to 100 gpm in the lower, or intermediate, aquifer (Spechler 1994). Water in the surficial aquifer is generally unconfined. In wetland and flatland areas, the water table is generally at or near the land surface throughout most of the year (Toth 1993). Most surficial aquifer withdrawals in the Duval/Nassau area are for domestic use, including residential drinking water, lawn irrigation, and heat pumps.

The Floridan aquifer is a huge system that underlies all of Florida and parts of Alabama, Georgia and South Carolina. In the Duval/Nassau county area, it is separated from surficial aquifers by the Hawthorne Formation (also called the upper or intermediate confining unit), a low permeability bed up to 500 feet thick. The thickness of the Floridan aquifer ranges up to 2,000 feet. It is confined from below by a low permeability bed called the Cedar Keys Formation (Table 5).

The primary water-bearing zones of the Floridan aquifer system consist of porous limestone and dolomite. Massive dolomitic limestone and dolomite beds generally yield little or no water, and act as confining units

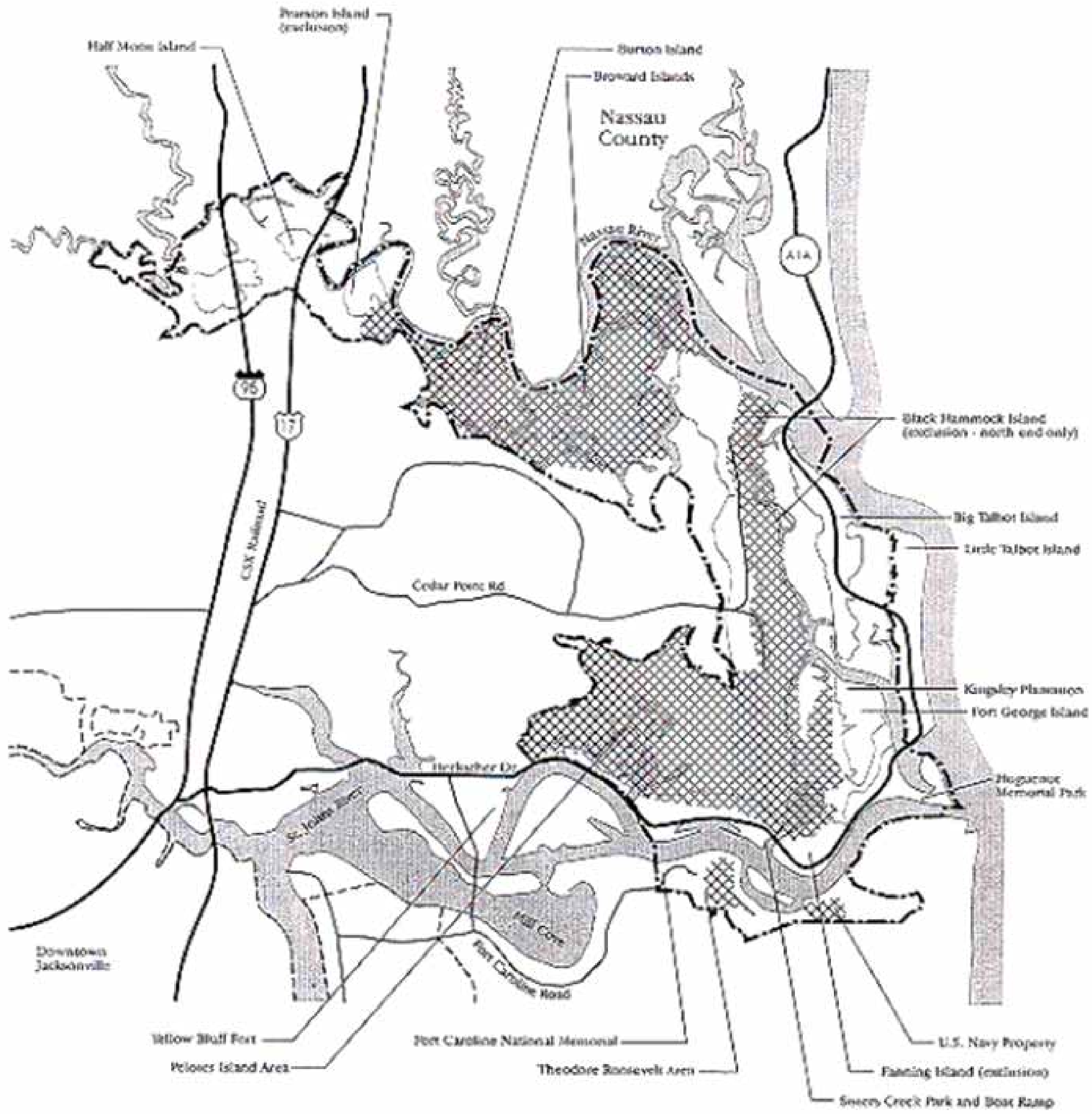


Figure 14. Costal high hazard areas of Timucuan Ecological and Historic Preserve. After National Park Service (1994a).

Coastal High Hazard Areas
Preserve Boundary

North 0 2.5 Miles

TABLE 5. SUMMARY OF GEOLOGIC AND HYDROGEOLOGIC FEATURES IN NASSAU AND DUVAL COUNTIES, FLORIDA. Adapted from Frazee and McCaugherty (1979), Toth (1990), Durden and Motz (1991), and Spechler (1994).

GEOLOGIC AGE (MILLIONS OF YEARS)	GEOLOGIC FORMATION	APPROXIMATE GEOLOGIC THICKNESS	HYDROGEOLOGIC UNIT (ALTERNATE NAME)	APPROXIMATE HYDROLOGIC THICKNESS	HYDROLOGIC DESCRIPTION
Present to late Miocene (—10)	Undifferentiated surface desposits	20 to 120	Surfical Aquifer (shallow aquifer)	20 to 140	Small to moderate quantities of water, local supplies
Miocene (—26)	Hawthorne Formation	100 TO 500	Intermediate Aquifer (lower surficial aquifer) AND Upper Confining Unit (intermediate confining unit)	150 to 500	Intermediate aquifers to 40 feet thick, low permeability clays form semi-confining layers, and the confining bed for Floridan aquifer below. Limited local water supplies
Late Eocene (—40)	Ocala Limestone	100 to 350	Upper Floridan Aquifer	130 to 350	High permeability overall — principal source of groundwater, some wells show increasing salinity
Middle Eocene (—45)	Avon Park Formation	700 to 1,100	Middle Semi-Confining Unit (middle semi-confining zone)	50 to 200	Leaky, low permeability limestone and dolomite
Early Eocene (—54)	Oldsmar Formation	300 to 500	Middle Water Bearing Zone (lower Floridan-semi-confining unit)	-700	Principal source of groundwater, some wells show increasing salinity
			Lower Semi-Confining Unit (lower Floridan-semi-confining unit)		Low permeability limestone and dolomite
			Lower Water Bearing Zone (lower Floridan-Fernandina permeable zone		High permeability, salinity increases with depth
Paleocene (—65)	Cedar Keys Formation	-500	Lower confining Unit (sub-Floridan confining unit)	-500	Low permeability, contains highly saline and mineralized water

(Brown 1984). In northeast Florida, these relatively impermeable beds restrict the vertical movement of water through the aquifer and separate it into three relatively isolated water-bearing zones (Table 5).

The upper and middle units of the Floridan aquifer are the major sources of potable groundwater in northeast Florida. The lower unit, also known as the Fernandina permeable zone, is deep and often salty, making it less desirable for human use. The waters of the upper and middle aquifers are usually low salinity in the Duval/Nassau area, but occasional breaks in the confining layers coincide with lower hydraulic pressure in the upper and middle units, drawing salty water from below up into the Floridan aquifer.

The Floridan aquifer in Duval/Nassau is an immense sheet of water flowing from the northwest to the southeast. Water enters the aquifer through large recharge areas (primarily in western portions of coastal counties) where surface waters have greater hydraulic head than the aquifer and percolate down to it, or through breaks in the confining beds such as sinkholes. Water leaves the aquifer through sheetflow under the ocean to the east, and through springs, pumping and upward leakage where water pressure of the Floridan aquifer is greater than the surficial aquifer and pathways for water movement exist. Very large withdrawals from the aquifer are pumped for municipal and heavy industrial use. In some areas, cones of depression have developed in urban industrial areas of northeast Florida because discharge has exceeded recharge.

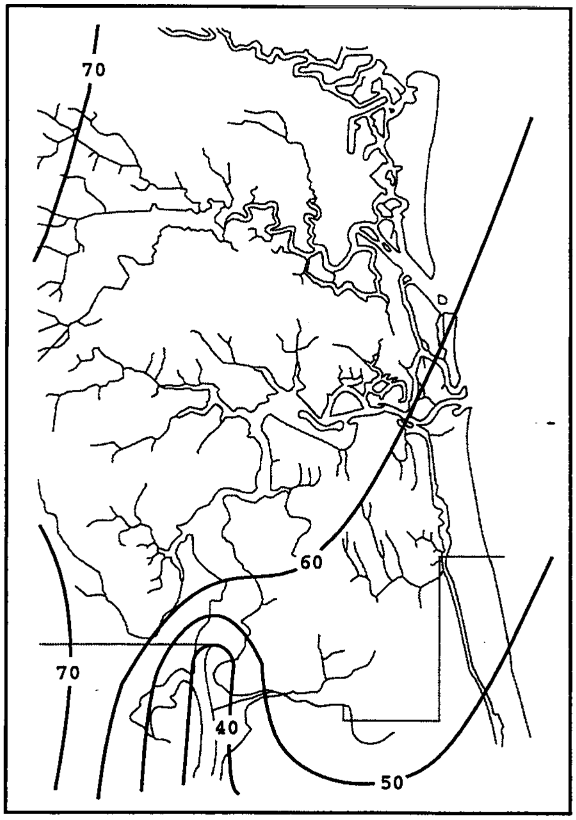
The potentiometric surface of an aquifer is that surface to which water will rise in a tightly cased well that penetrates the aquifer. Groundwater will flow from areas of high potentiometric surface to areas with lower potentiometric surface. The change in the potentiometric surface of the Floridan aquifer over time demonstrates the effect of large human withdrawals upon the aquifer.

The estimated pre-development potentiometric surface of the Floridan aquifer in Duval and Nassau counties was 60 to 70 feet above sea level (Figure 15). The aquifer flowed to the east and was drawn to the south by a large spring releasing water into the St. Johns River in what is now northern St. Johns County. Springs are those areas where a break in the confining beds allow the water, under pressure within the aquifer, to release to the surface. The flow of spring water, like an open faucet, creates areas of lower potentiometric surface, causing aquifer waters to move towards the spring.

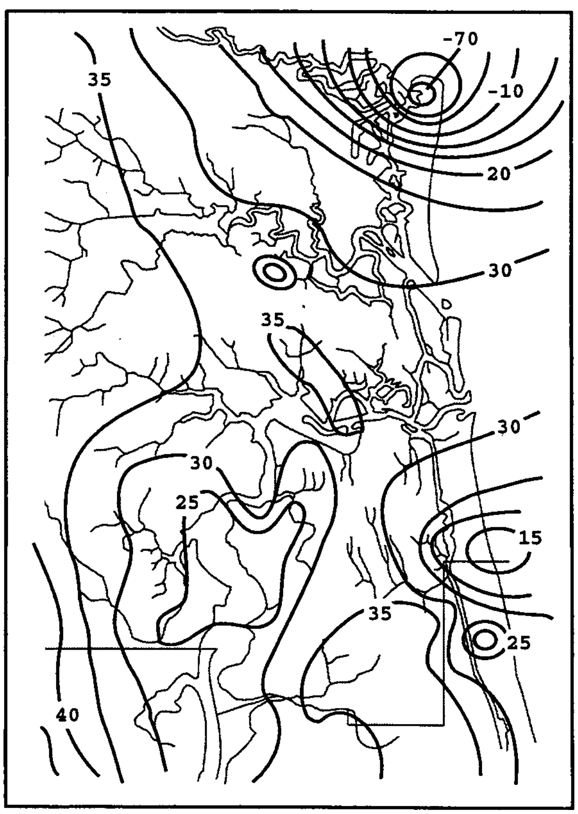
Figure 15 also shows the potentiometric surface of the Floridan aquifer in 1985. A very large withdrawal at Fernandina Beach for industrial use (pulp mill) has caused a massive depression, as much as 70 feet below sea level, in Nassau County (Durden and Motz 1991). The depression associated with the St. Johns River spring has moved to the north, and is believed to be linked to withdrawals for industrial and public-supply wells (Spechier 1994). A small depression is located south of Ponte Vedra Beach, caused by public-supply wells and golf course irrigation. In general, over the entire two-county area, potentiometric surface has dropped from 60 to 70 feet above sea level to 30 to 40 feet above sea level.

The Floridan aquifer system in Duval County has a normal seasonal fluctuation in water level of from 3 to 4 feet from a low in May to a high in September. However, average water levels have been steadily declining due to increasing rates of pump out. Levels dropped 10 to 25 feet in northeast Florida from 1940 to 1962. In Jacksonville, levels dropped more than 20 feet from 1948 to 1972 (Johnson et al. 1982).

Groundwater development has reduced spring flow and discharge to rivers by almost five percent and discharge by seepage in coastal areas by about 30%. Approximately 20% of the groundwater pumped originates from spring flow and river discharge, 20% is from seepage in coastal areas, and the remaining 60% is from additional recharge induced by the lower water levels in the aquifer.



Estimated pre-development potentionmetric surface (prior to 1880)



Potentiometric surface as of 1985.

Figure 15. Pre-development and recent potentiometric surfaces of the Floridan Aquifer. Adapted from Durden and Motz (1991).

Water Quality

The State of Florida assigns groundwaters to one of 4 lasses, given below in descending order of protection:

Class G-I:	Single source, potable with dissolved solids <3,000 mg/1
Class G-II:	Potable with dissolved solids <10,000 mg/1
Class G-III:	Unconfined, non-potable with dissolved solids >10,000 mg/1 or lower dissolved solids but exempted or assessed as having no reasonable potential as a future source of drinking water
Class G-IV:	Confined, non-potable with dissolved solids >_ 10,000 mg/l

The groundwaters in and around Timucuan are class G-II, although some lower Floridan waters arc probably excluded due to high dissolved solids. The surficial aquifer waters may have high iron concentrations, but rarely high enough to remove them from class G-II (J. Mayer, pers.comm., Florida Department of Environmental Protection 1995).

The St. Johns River Water Management District is responsible for permitting of withdrawals, and all permits are evaluated to avoid degradation of groundwater quality. The Florida Department of Environmental Protection permits discharges to groundwaters, which must achieve the groundwater quality class standards within a 100 foot zone of discharge.

The water quality of the surficial aquifer system is generally of acceptable quality for most uses, but in localized areas it may have a high iron concentration and be very hard. The iron concentration from half of 13 test wells in Duval County exceeded 0.3 mg/1 (Causey and Phelps 1978). Water hardness is a measure of total calcium and magnesium concentrations, and well water hardness ranged from soft (less than 60 mg/1) to very hard (more than 180 mg/1), with hard waters being most common. Since the surficial aquifer is unconfined or semi-confined, it is also susceptible to pollution from storm runoff, landfill leachate, toxic materials dumps, and brackish water infiltration (Causey and Phelps 1978). During heavy rain events, the elevation of the water table in the surficial aquifer rises causing septic tank failures. Septic tank leachate could be discharged to the Nassau/St. John rivers estuary.

Chloride, sulfate, and total dissolved solids are common indicators of the presence of saline water in the surficial aquifer. For example, chloride concentrations in the upper 50 feet of the surficial aquifer system are generally below 50 mg/l in the preserve except along the eastern boundary near Fort George Island – chloride concentrations are above 1,000 mg/l within 1 to 4 miles of the coast in Duval County. In the latter case, saltwater intrusion occurs through diffusion gradients set-up by overpumping of the surficial aquifer. This overpumping allows saltwater into close proximity to the surficial aquifer.

More precise information about water quality of the surficial aquifer needs to be collected and documented. There is a paucity of information regarding changes (permanent or seasonal) in water quality at depth (Toth 1993).

The Floridan aquifer is the major source of water for municipal and industrial use, and generally the upper and middle aquifer units exhibit good water quality, with low chloride and sulfate concentrations. Some areas, however, show elevated chloride and/or sulfate concentrations (chloride greater than 100 mg/l and sulfate greater than 150 mg/l being considered significant) (Toth 1990).

High chloride concentrations are strongly influenced by intruded seawater or movement of high salinity waters from below the aquifer up into the aquifer through breaks in the confining beds (Toth 1990). Elevated sulfate concentrations are associated with the above circumstances, and also with slow moving flow through minerals high in sulfates, allowing time for the dissolution of sulfate into the waters. Figure 16 presents the locations of higher chloride/sulfate levels in upper Floridan aquifer of Duval and Nassau Counties.

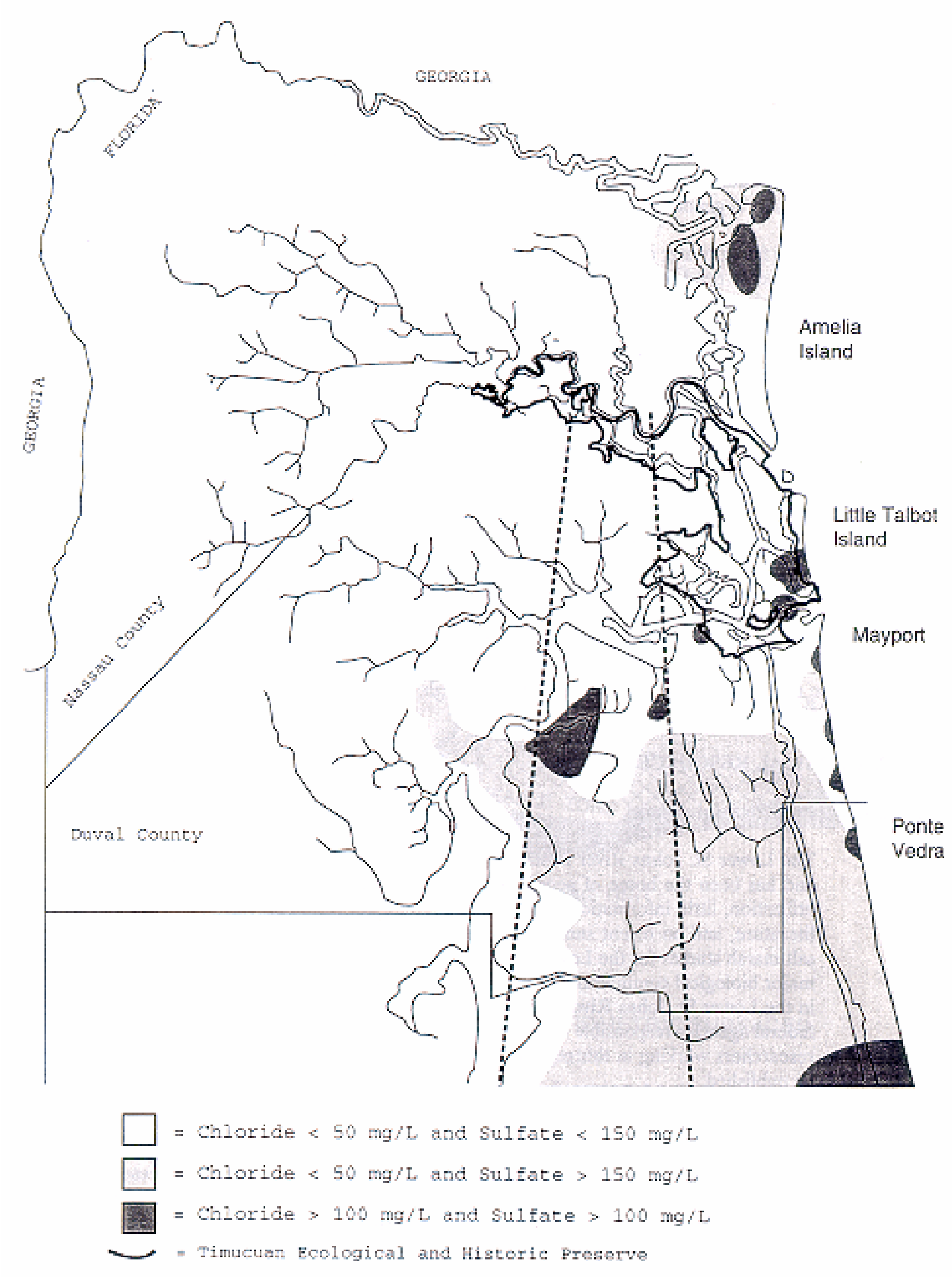


Figure 16. Chloride and sulfate characteristics of the upper Floridan Aquifer in Nassau and Duval counties. Adapted from Toth (1990). Dashed lines are vertical or nearly vertical faults.

The upper Floridan aquifer system contains sulfate concentrations that vary throughout the St. Johns River groundwater flow system. The source of sulfate in the Floridan is the dissolution of gypsum and anhydrate, the oxidation of iron sulfides, or the mixing of relict seawater or connate water with fresher water.

Total dissolved solids concentrations in the upper Floridan also vary dramatically throughout the lower St. Johns River groundwater flow system. Total dissolved solids, which is the sum of all dissolved constituents in groundwater, is generally below 500 mg/l in the preserve.

The potential for saltwater contamination of middle and upper Floridan wells increases as withdrawals reduce the potentiometric head of the aquifers. The reduction in hydraulic pressure draws water from below through discontinuities in the confining beds (Figure 17). Breaks in the confining beds can be due to faults, fractures, collapse features, and poorly cased wells. An illustrative example of this situation is the site of the old golf course clubhouse on Fort George Island (Figure 18).

The Fort George Island clubhouse well was placed on top of a fracture when it was installed in the 1920s or 1930s. Pumping decreased the water pressure around the well and caused movement of higher salinity water from below to be drawn up through the fracture. Once at the upper aquifer level, the saline water spreads laterally. The result is the present condition of upper Floridan aquifer wells on Fort George Island, with a bull's eye pattern of increased chloride concentrations radiating out from the clubhouse area (Figure 16). Chloride concentrations above 250 mg/l are not recommended for public supply. Around the clubhouse area, concentrations can exceed 300 mg/l (Spechler 1994).

Only a few locations of confining bed discontinuities have been mapped in the Duval/Nassau area: two geologic faults traverse roughly north to south from the Nassau River and to the south (Figure 10); the fracture on Fort George Island; and, some collapse features along the St. Johns River. If withdrawals from the upper and middle Floridan aquifer continue to reduce the potentiometric head of the aquifers, accelerated intrusion of less desirable waters from below through known and unknown breaks in the confining beds are expected (Spechler 1994).

BIOLOGICAL RESOURCES

Brody (1994) states:

> The Lower St. Johns River Basin has been inhabited continuously by man for at least 10,000 years and has been the home of people of European descent since 1562. Despite this pattern of cultural utilization, little information on the river's biological resources has been recorded in the scientific literature, and no recent summary exists. For instance, there are only four phytoplankton and two salt marsh studies for the Lower St. Johns River Basin, and few resource studies exist for most of the major biological communities in the basin... Few of the biological resource investigations carried out in the Lower St. Johns River Basin have been reported in peer-reviewed journals. Local, state, and federal agencies responsible for environmental monitoring and regulatory actions and a few academic researchers working in this region have collected a large body of data that has never been analyzed or published.

Flora

Research describing phytoplankton communities and/or primary production in the preserve is limited to one study by DeMort and Bowman (1985). This study described the species composition of the phytoplankton community and water chemistry (including nutrients) during two, complete annual cycles from Jacksonville to the Intracoastal Waterway. DeMort and Bowman found that *Skeletonema costatum* was the most dominant

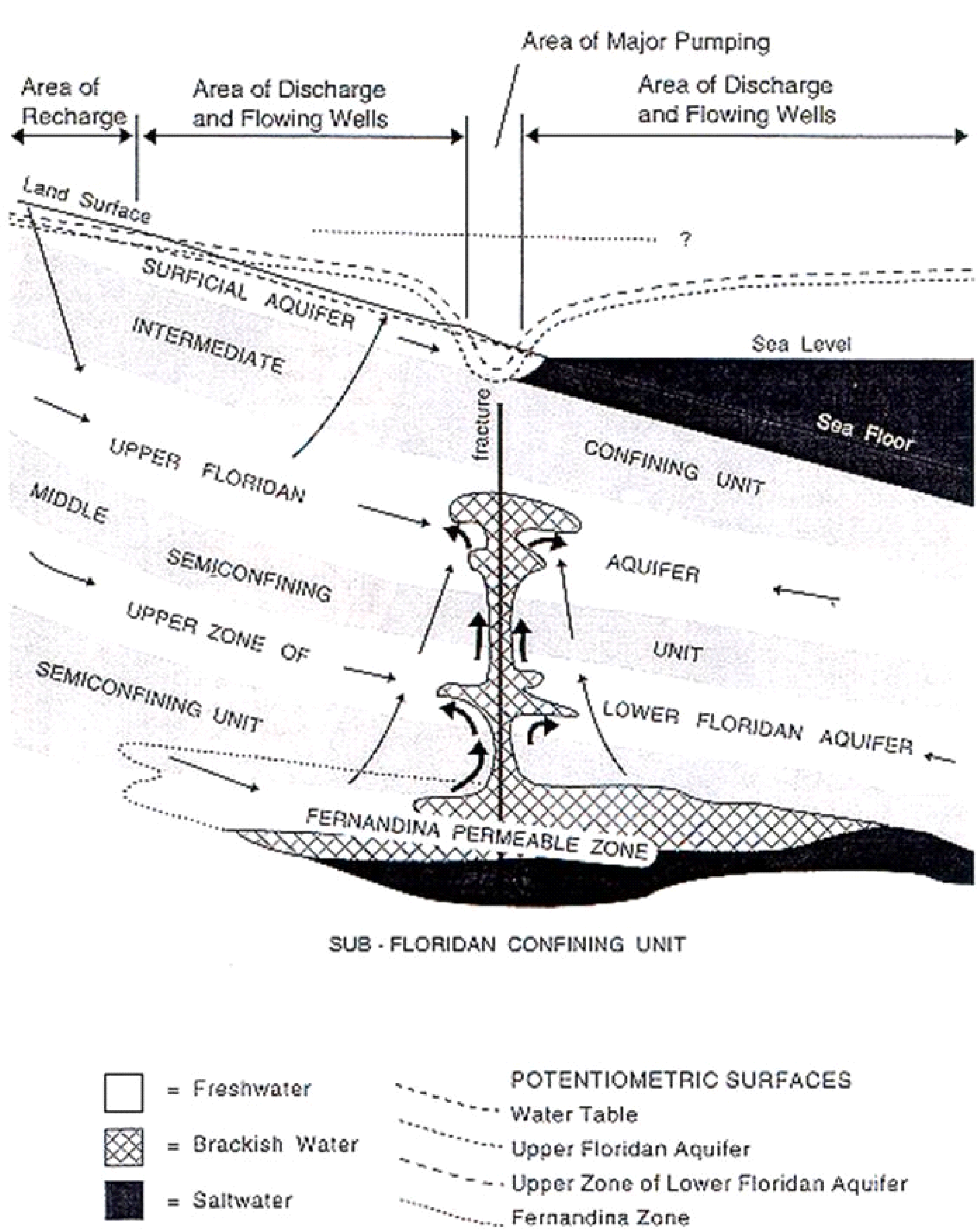


Figure 17. Simplified model of saltwater contamination through a fracture of the upper Floridan Aquifer. Adapted from Spechler (1994).

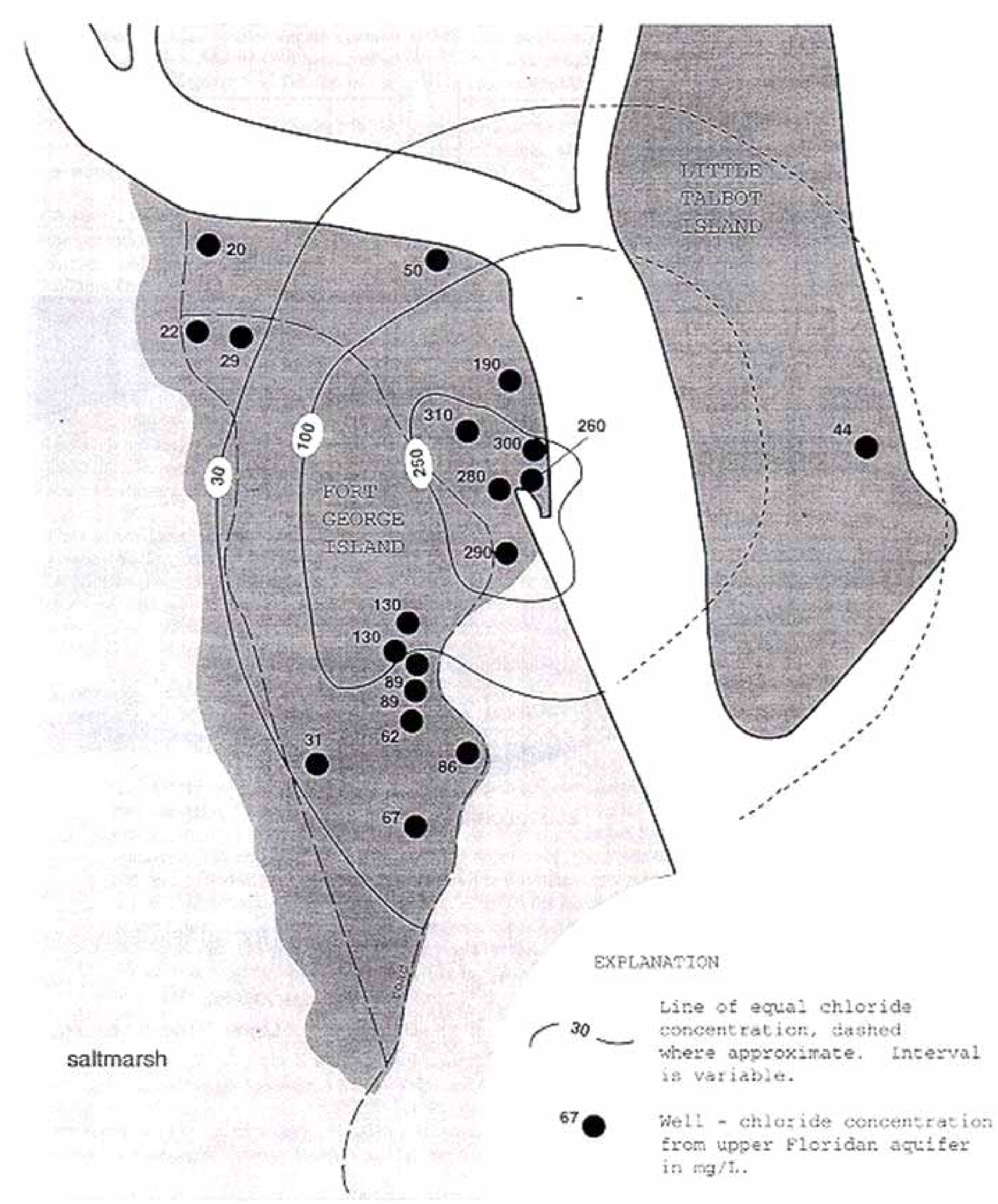


Figure 18. Chloride concentrations from wells on Fort George Island. Adapted from Spechler (1994).

species followed, in decreasing order, by: *Chaetoceros decipiens, Rhizosolenia alata, Nitzschia seriata, Melosira* italica, *Chaetoceros debile, Coscinodiscus lineatus, Thalassionema nitzschoides, Thallassiothrix fraunfeldii,* and *Gyrosigma sp. Skeletonema costatum* was the most abundant diatom species but did not dominate throughout the year at all stations. The number of diatoms decreased with decreasing salinity as numbers of Chlorophyta (green algae) and Cyanophyta (blue green algae) increased and peaked in summer at all stations. DeMort and Bowman observed high nitrogen values and high nitrogen to phosphorus ratios throughout the study area, and suggested that these high nitrogen values resulted from a rapid breakdown of organic nitrogen coupled with the prolonged retention time of water in the lower St. Johns River. The nitrogen to phosphorus atomic ratios (14.2:1 to 27.7:1) were above those reported for other east coast estuaries. They concluded that phosphorous appears to be the limiting nutrient in the St. Johns River estuary. Brody (1994), citing recent review articles (Hecky and Kilham 1988; Cherfas 1990), suggests that because the most abundant phytoplanters were siliceous diatom species, variations in available silica concentrations in the St. Johns River need to be understood before drawing conclusions on nitrogen or phosphorus as the limiting nutrient. Direct evidence of the nutrient limitation can be obtained by comparing the response of primary production to experimental additions of nitrogen, phosphorus, and silica, and complete nutrient media in test bottles or aquaria (C. Montague, pers. comm., University of Florida 1996).

No literature specific to the lower St. Johns and Nassau river basins, including the preserve, records the submerged macrophytes, drift algae, or benthic macroalgae of the open water habitats (Brody 1994).

Although well established in the oligohaline reaches of the lower St. Johns River basin, distribution of the freshwater grass, *Vallisneria americana,* in the more saline reaches of the lower St. Johns River has not been investigated. Twilley and Barko (1990) found that *Vallisneria* tolerates saltwater up to 12 ppt.

The literature on marine sea grasses suggests that true seagrasses are probably not present in abundance in the more marine sections of the lower St. Johns and Nassau rivers but the presence or absence of these submerged macrophytes has not been investigated (Brody 1994). There was an incorrect or at best, unconfirmed report in Dressler et al. (1987) that *Thallassia* was present in the St. Johns River. Also, marine eelgrass, *Zostera marina, is* not found south of northern South Carolina. Shoal grass, *Halodule sp., is* apparently absent from the estuarine portions of the St. Johns and Nassau rivers. The increased tidal range apparently produces a high-energy environment which increase turbidity, sedimentation, and coupled with the dark-colored waters, reduces light penetration. With wintertime temperatures too low for *Thallassia,* summertime too warm for *Zostera,* and conditions improper for *Halodule,* true sea grasses are probably limited in abundance in the preserve (Brody 1994).

No comprehensive list of the salt marsh plants or submerged and emergent aquatic macrophytes specific to the basin has previously been compiled and published (Brody, 1994). A few site-specific plant lists are found in the literature, primarily in environmental impact statements (for a variety of projects) and Florida Game and Fresh Water Fish Commission and Florida Department of Natural Resources reports; Joyce (1965); Rehm et al. (1975); Atlantic Scientific (1976); Dames and Moore (1978); City of Jacksonville (1984); and, Murphy and Johnson (1988). The areal coverage of all the various floral components of the biota has not been accurately estimated. Basic information on the various types and functions of marshes can be found in Montague and Wiegert (1990), Wiegert and Freeman (1989), Montague et al. (1987), and Pomeroy and Wiegert (1981).

Based on a geographic information system map produced by the St. Johns River Water Management District (Figure 19), preserve salt marshes are primarily composed of *Spartina alterniflora* (smooth cordgrass), except in the southwestern portion of the preserve where *ha:cus roen:eria:us* (black needlerush) dominates (but see discussion on page 55). It is not clear whether the black needlerush area (in the vicinity of Browns and

Figure 19 is now located at the end of this document.

Clapboard creeks) has historically exhibited this vegetation pattern, or whether the distribution of black needlerush is linked to restriction of tidal flow due to roadbed build-up and culverting associated with the construction of Heckscher Drive in the 1920s. Also, the alteration of flow characteristics of the main channel of the St. Johns River through deepening and the Fulton Cut could be contributing to reduced tidal flow through the Blount Island Channel and the creeks connecting to it, such as Browns and Clapboard creeks. Black needlerush decomposes more slowly than smooth cordgrass (Kruczynski et al. 1978), therefore displacement of smooth cordgrass by black needlerush could affect the ecological functioning of salt marshes in the area.

The salt marshes of the preserve were described as part of a water quality assessment in the Jacksonville port area (City of Jacksonville 1984). This study was primarily a qualitative survey of the flora and fauna collected at 21 stations in Duval and Nassau counties (Table 6). Several habitat distribution patterns for the dominant plants were discussed. The low marsh (regularly flooded by tides) was dominated by *S. altemiflora,* the high salt marsh by *J. roemerianus. Spartina patens* (marsh hay cordgrass) was most abundant in the Nassau River area, with *S. cynosuroides* (big cordgrass) abundant only at the Inconstantion Creek location. This study is a preliminary investigation which points out the need for more detailed, quantitative work in the salt marshes. Much of the work on similar systems in the St. Marys River and south Georgia (especially quantitative studies that detail energy flow, nursery value, and productivity) might be applied to the preserve salt marsh system if the plant and animal communities were enumerated more completely (Brody 1994).

Montague (1995) visited the preserve on June 7 to 9, 1995, and collected and identified common species of plants and animals. He found that the intertidal marshes of the preserve range from saline to nearly fresh. Brackish tidal marshes are between these extremes. Little is known of the ecological function of the low salinity tidal marshes, but they clearly have much greater plant diversity and biomass, and appear to be more productive than the more saline marshes (Table 7). The preserve has a considerable quantity of this type of marsh, especially along the western upper reaches and tributaries of the Nassau River along the northern border of the preserve.

The saline marshes that are regularly flooded by tides are dominated by *S. altem:flora.* This type of marsh is more prevalent in the eastern half of the preserve in association with the Intracoastal Waterway. Perhaps one-third of the intertidal marshes of the preserve are of this type. Much of the saline to brackish intertidal marshland that is irregularly flooded is dominated by *J. roemerianus.* Irregular flooding occurs where tidal amplitude diminishes and wind can drive water into or out of the marshes. This often occurs in marshes associated with shallow bays that have considerable fetch in prevailing wind directions. The lower half to two thirds of Clapboard Creek is an example of this irregular flooding.

Brackish to fresh tidal marshes occur in the upper reaches of the Nassau River in the northwest portion of the preserve from U.S. 17 westward into various tributary creeks. Brackish to fresh tidal marsh also occurs in the extreme upper reaches of Clapboard Creek.

Montague (1995) roughly estimates that about 35% of the preserve is *S. altemiflora* or regularly flooded saline marshes; 50% is *J. roemerianus* or irregularly flooded saline to brackish marshes; and 15% is brackish to freshwater marshes with variable dominant species and higher plant diversity. Given the difference in scales, these estimates seem to contradict those presented in Figure 19. This contradiction points out the need for more intense wetland community surveys in the preserve. Freshwater wetlands within the preserve are limited, due in large part to the boundary restrictions that include only small portions of non-estuarine areas. Two transitory ponds, some small forested depressions and a shrub bog are found in the Theodore Roosevelt area of the preserve. Several small patches of forested depressions occur on middle and southern Black Hammock Island. Present in the same area are a few small patches of shrub bog and wet prairie (Figure 19). The southern end of Black Hammock Island (approximately 400 acres) was acquired by the National Park Service in 1996.

Habitat loss, especially of wetlands such as salt marshes, is a national problem. Data from the National Marine Fisheries Service indicate that commercial harvests in the southeastern United States have fallen 42% since 1982. The decline is largely attributed to wetland losses, especially in Florida. Wetland destruction is thought to be the most significant factor related to catch declines for this area (Durako et al. 1988).

The extent of habitat losses has not been evaluated for the lower St. Johns River and Nassau river basins. However, the Florida Department of Natural Resources (Durako et al. 1988) has documented a 36% loss

Table 6. Typical saltmarsh plant species found in 1984 in the preserve area. After City of Jacksonville (1984).

Dominant Species	Associated Species	Transitional Species
Black needlerush *(Juncus roemerianus)*	Big cordgrass *(Spartina cynosuroides)*	Broomsedge *(Andropogon elliotti)*
Marsh hay cordgrass *(Spartina patens)*	Glasswort *(Salicomia virginica)*	Groundsel tree *(Baccaris haliinifolia)*
Saltgrass *(Distichlis spicata)*	Narrow-leaved cattail *(Typha angustifolia)*	Marsh elder *(Iva frutescens)*
Saltwort *(Batis maritima)*	Sea Blight *(Suaeda linearis)*	Marsh lavendar *(Limonion carolinianum)*
Sea daisy *(Borrichia frutescens)*	Sea purslane *(Sesuvium portulacastrum)*	Saltwort *(Batis maritima)*
Smooth cordgrass *(Spartina altemiflora)*		Sawgrass *(Cladium jamaicense)*
		Staggerbrush *(Lyonia ferruginea)*
		Wax myrtle *(Myrica cerifera)*
		Cabbage palm *(Sabal palmetto)*

(4,253 acres) of salt marsh habitat at the St. Johns River mouth from 1943 to 1984 because of spoil disposal from channel dredging. Continued dredging for navigational purposes has probably contributed to the filling or siltation of habitats and the alteration of circulation patterns.

Prior to 1943, extensive wetland losses occurred but no records are available (Durako et al. 1988). In the early 1900s major impacts resulted from development of the Intracoastal Waterway and-the St. Johns River navigational channel. Large, once productive wetland areas are now filled and developed or vegetated, and are assumed to be natural by the casual observer.

Rising sea levels will further limit marsh areas. An analysis of the yearly mean sea level values from 1929 to 1992 at Mayport reveals the dominant features are the consistent upward trend and the relatively high degree of year-to-year variability (Figure 20). Regression analysis shows the increase in mean sea level to be 0.007 feet/year (St. Johns River Water Management District 1994c). Mean sea level is predicted to rise

TABLE 7. LIST OF PLANTS FOUND IN BRACKISH TO FRESHWATER TIDAL MARSHES OF TIMUCUAN ECOLOGICAL AND HISTORIC PRESERVE IN JUNE 1995. Adapted from Montague (1995).

LOCATION	FAMILY	COMMON NAME	SPECIES	COMMON NAME
One 10 m^2 plot along Nassau River, upstream of Edward's Road development boat ramp	I yphacea	cattails	*I ypha domingensis*	Southern cattail
	Alismataceae	water plantains	*Sagittaria lancifolia = S. falcata*	Arrowhead, Duck potatoe
	Poaceae	grasses	Spartina *alterniflora*	Saltmarsh or Smooth cordgrass
			Spartina cynosuroides	Big cordgrass, Salt reedgrass
			Zizaniopsis rniliacea	Southern wild rice, Giant cutgrass, Whitemarsh
	Cyperaceae	sedges	Scirpus *robustus*	Saltmarsh bulrush
			Scirpus validus	Moses or Giant bulrush
			Rhynchospora corniculata	Horned or Beak rush
			possible *Cyperus articulatus* (need seeds and rhizomes)	Flat or Sweet sedge
			unidentified sedge #1 (no inflorescence)	
			unidentified sedge #2 (no seeds in inflorescence)	
			unidentified sedge #3 (no seeds in inflorescence)	
	Pontederiaceae	pickerel weeks	*Pontederia cordata*	Pickerel weed
	Iridaceae	irises	*Iris sp.* (need flower)	Blue flag
	Amaranthaceae	amaranths	*Alternanthera philoxeroides*	Alligator weed (an exotic)
	Lythraceae	loosestrifes	*Lythrum lineare*	Saltmarsh loosestrife
Nassau River at Intersection of Plummer Swamp Creek, West of Interstate 95	Alismataceae	water plantains	*Sagittarea lancifolia* = S. falcata	Arrowhead, Duck potato
	Poaceae	grasses	*Spartina alterniflora*	Saltmarsh or Smooth cordgrass
	Cyperaceae	sedges	*Cladium jamaicense*	Sawgrass, Cutgrass
			possible *Cyperus* articulatus (need seeds and rhizomes)	Flat or sweet sedge
	Junaceae	rushes	Juncus *roemerianus*	Black needlerush
	Pontederiaceae	pickerel weeds	Pontederia cordata	Pickerel weed
Nassau River, Dock at Charlie's Fish Camp, at US Highway 17	Cyperaceae	sedges	Scirpus robustus	Saltmarsh bulrush
Branch Creek close to Cedar Point Road, Clapboard Creek drainage	Poaceae	grasses	*Spartina cynosuroides*	Big cordgrass, Salt reedgrass
	Cyperaceae	sedges	*Cladium jamaicense*	Sawgrass, Cutgrass
	Amaryllidaceae	amaryllises	probable *Hymenicallis sp.* (need flower)	Spider lily
	Unknown	unidentified herb (need whole plant with flower)		

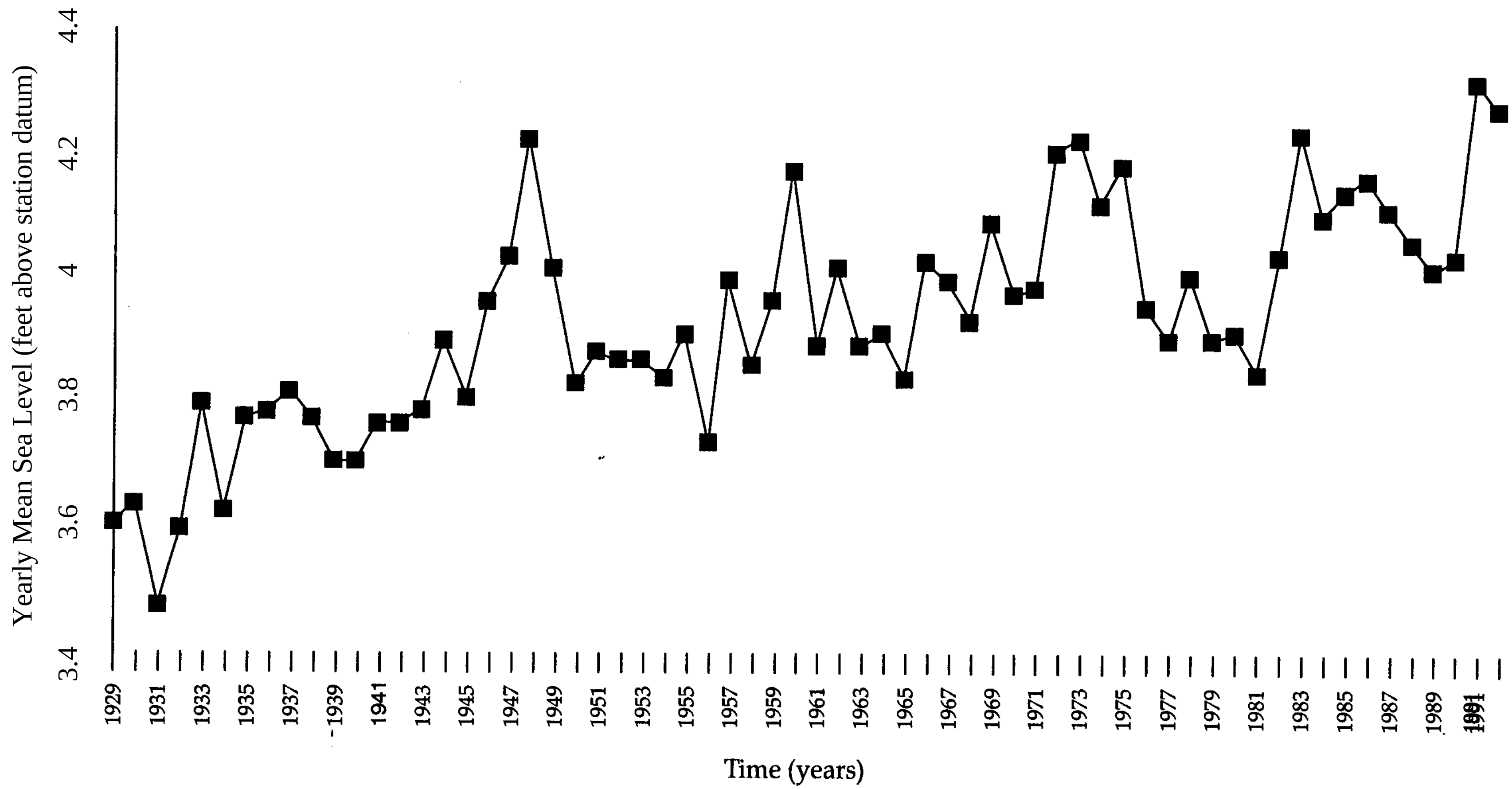


Figure 20. Long-term trend of annual mean sea level at Mayport, Florida. (from St. Johns River Water Management District 1994c)

another foot within the next 30 to 40 years. Coastal wetlands hemmed in by development cannot expand and will diminish in size due to erosion and flooding.

Fauna

As part of the same study by DeMort and Bowman (1985), plankton tows showed copepods to be the dominant zooplankton organisms. The higher salinity zooplankton station is noted to have more species, with a larger number of planktonic forms identified, but no numbers of species are reported for either station.

Three groups of invertebrate animals are important to the fisheries of the lower St. Johns and Nassau rivers: blue crabs; shrimp; and, to a much lesser extent, mollusks (oysters, clams, and mussels). Brody (1994) provides a good overview of these groups.

The largest shellfish beds in the preserve are found throughout the salt marsh area surrounding the Intracoastal Waterway, an area representing Jacksonville's last available Class II waters. At the beginning of 1996, only eight shellfish leases existed in Duval County. These leases range from 5 acres to 58 acres and represent a total of approximately 222 acres. Recently, the Florida Department of Environmental Protection permanently banned shellfish harvesting from these leases. Continued high levels of fecal coliform bacteria and a lack of adequate monitoring equipment were cited in newspaper accounts as reasons for the closure (Jacksonville Times-Union, February 2, 1996). This closure raises a number of questions: since the waters have been closed and the ability to harvest edible shellfish is the definition of Class II waters, does this now mean that the water classification for these waters will change; if the water classification changes, how does that relate to the overall quality of these waters; and when will these waters be monitored to see if the status can be changed and what efforts are planned or underway to initiate monitoring?

The Florida Department of Environmental Protection oversees shellfish harvesting activities in Duval County. Areas specified for shellfish harvesting are monitored regularly to ensure that shellfish are safe for human consumption. Harvesting areas may be downgraded or closed on a permanent or temporary basis when bacterial populations become elevated or when other water quality factors make closure necessary.

Shellfish harvesting areas are classified as approved, conditionally approved, restricted, conditionally restricted, or prohibited on the basis of comprehensive shellfish harvesting area surveys. The last one done for Duval County was 1987 (see National Park Service 1994a). This classification is based on the presence and concentration of fecal material, pathogenic microorganisms, and poisonous or deleterious substances in growing waters. Areas that have not undergone a comprehensive shellfish harvesting area survey are unclassified. Shellfish harvesting for direct market is permitted only from approved or conditionally approved areas. Shellfish harvesting for relaying or controlled purification is permitted in restricted and conditionally restricted areas.

Montague (1995) found four species of fiddler crabs in the preserve. Three are common along the east coast of the U.S: the marsh fiddler crab *(Uca pugnax pugnax);* the sand fiddler crab *(U. pugilator);* and, the red-jointed fiddler crab *(U. nzinax).* The fourth species found *(U. thayeri thayeri) is* of special interest. It is a species of the tropical and subtropical Atlantic, southward to Brazil, and has probably never before been reported north of St. Augustine (Crane 1975). It was found in the Clapboard Creek area -- a search for this crab throughout the preserve and northward would be of interest to extend its known range.

According to the Florida Game and Fresh Water Fish Commission (1983), there are 55 freshwater and 115 marine and estuarine fish species in the St. Johns River Basin. Preliminary work by the National Biological Service in the preserve documents 111 fish species, some of which are new records for northeastern Florida (K. Sulak, pers. comm., National Biological Service 1996). Several families of fish contribute to important recreational and commercial fisheries in the lower St. Johns River and in northeast Florida. The most important of these families is the Sciaenidae, which includes the whitings *(Menticirrhus spp.),* spotted seatrout *(Cynoscion nebulosus),* weakfish (C. *regalis),* croaker *(Micropogonias undulatus),* spot *(Leiostomus xanthurus),* black drum *(Pogonias cromis),* and red drum *(Sciaenops ocellatus).* The young and juveniles of these species require estuaries for nursery grounds, and adults are either permanent residents of estuaries or inhabitants of shallow coastal waters.

Other important fish include those on lower trophic levels such as anchovies *(Anchoa spp.),* herrings (Clupeidae), which include menhaden *(Brevoortia* spp.) and American shad *(Alosa sapidissima),* and mullet *(Mugil* spp.). Flounders *(Paralichthys* spp.) also contribute to catches as do sheepshead *(Archosargus probatocephalus),* pinfish *(Lagodon rhoinboides),* sea catfish *(Arius felis),* and bluefish *(Pomatomus saltatrix).* Table 8 lists species collected in the preserve and adjacent areas by the National Biological Service from 1994-1996.

During 1983 and 1984, reports of large numbers of several species of fish with ulcerated disease syndrome (UDS) in the lower St. Johns River basin caused the Florida Department of Environmental Regulation to request an ichthyofaunal study to provide baseline data on fish populations and to document the level of occurrence of UDS. Continental Shelf Associates (1988), using trawl and gillnet sampled six stations between Clapboard Creek and Palatka. This study found that UDS was of minor importance to the system as a whole (73 lesioned fishes out of approximately 70,000 sampled, or 0.11%). The authors suggested that localized UDS outbreaks may have a pollution-related origin, most likely from heavy metals.

Microbiological studies of the lesions showed that most were the result of bacterial infections *(Aerornonas* and *lrbrio);* only 0.02% of the total fish sampled tested positive for fungi. The bacteria present were fish pathogens commonly found in many estuarine systems, and the UDS outbreak may represent an immune system suppression response from environmental factors more than representing an epidemic bacterial infection. No further sampling or studies of UDS have been published.

The St. Johns River Water Management District, in cooperation with the Florida Game and Fresh Water Fish Commission, has undertaken a pilot study to determine the feasibility of using an index of biological integrity for fish populations in the lower St. Johns and Nassau rivers/estuarine areas (Brody and Schell 1990). The methodology evolves from similar indices developed by Karr (1981) and modified for estuarine systems (Miller et al. 1988; Thompson and Fitzhugh 1985).

Rare, Threatened, and Endangered Species

The preserve's draft general management plan (National Park Service 1994a) contains a discussion of protected species developed through Endangered Species Act Section 7 consultations with the U.S. Fish and Wildlife and National Marine Fisheries Service. The National Park Service also consulted with the State of Florida to determine if state protected species were present in the preserve. These consultations resulted in the general management plan developing a table of protected species that may occur within the preserve. This species listing contains several noteworthy aquatic species.

The shortnose sturgeon *(Acipenser brevirostnan) is* restricted to the east coast. It has been recorded from the St. Johns River, Canada, to the Indian River in Florida. Throughout its range, the majority of sturgeon populations have their greatest abundance in the estuaries of their respective rivers. The Shortnose Sturgeon Recovery Team established by the National Marine Fisheries Service documents only five known occurrences of this species in the St. Johns River of Florida since 1949.

The Atlantic sturgeon *(Acipenser oxyrhynchus)* should also be considered a rare (possibly extirpated) species in northeast Florida. This species may still occur as strays from Georgia populations (K. Sulak, pers. comm., National Biological Service 1996).

Of the federally protected marine turtles, only the threatened loggerhead sea turtle *(Caretta caretta) is* expected to nest in the vicinity of the preserve. Known nesting occurs on the Atlantic beaches of Little Talbot Island, just outside the preserve boundary, and on the critical wildlife area portion of Huguenot Memorial Park, within the preserve. Another possible nesting area within the preserve could be on the northern tip of Big Talbot Island.

Table 8. Preliminary list of fishes and macroinvertebrate species sampled in aquatic habitats in the Timucuan Ecological and Historic Preserve and adjacent areas by the National Biological Service, 19941996 (K. Sulak, pers. comm., National Biological Service, 1996). Scientific and common names of fishes are the official species names recognized by the American Fisheries Society. Some benthic invertebrate species are included in the list.

SCIENTIFIC NAME	COMMON NAME
FISHES	
Achirus lineatus	lined sole
Albula vulpes	bonefish
Amia calva	bowfin
Ameiurus catus	white catfish
Ameiurus nebulosus	brown bullhead
Ameiurus serracanthus	spotted bullhead
Anchoa hepsetus	striped anchovy
Anchoa mitchilli	bay anchovy
Archosargus probatocephalus	sheepshead
Arius fells	hardhead catfish
Bagre marinus	gafftopsail catfish
Bairdiella chrysoura	silver perch
Bathygobius soporator	frillfin goby
Brevoortia smithi	yellowfin menhaden
Brevoortia tyrannus	Atlantic menhaden
Caranx hippos	crevalle jack
Carcharhinus limbatus	blacktip shark
Centropomus undecimalis	common snook
Chaetodiptents faber	Atlantic spadefish
Chas/nodes bosquianus	striped blenny
Chilomycterus schoepfi	striped burrfish
Chloroscombrus chrysouus	Atlantic bumper
Citharichthys macrops	spotted whiff
Cynoscion nebulosus	spotted seatrout
Cynoscion regalis	weakfish
Cynoscion nothus	sand seatrout
Cyprinodon variegatus	sheepshead minnow
Dasyatis americana	southern stingray
Dasyatis sabina	Atlantic stingray

Table 8. Continued.

Diaptenus auratus	Irish pompano
Dorosoma cepidianum	gizzard shad
Elops saunas	ladyfish
Eucinostomus argenteus	spotfin mojarra
Eucinostomus gula	silver jenny
Eucinostomus harengulus	tidewater mojarra
Fundulus confluentus	marsh killifish
***Fundulus** heteroclitus*	mummichog
***Fundulus** majalis*	striped killifish
Gambusia holbrooki	mosquitofish
Gerres cinereus	yellowfin mojarra
Gobiesox strumosus	skilletfish
Gobionellus boleosoma	darter goby
Gobionellus hastatus	sharptail goby
Gobionellus shufeldti	freshwater goby
Gobiosoma bosci	naked goby
Gobiosoma ginsburgi	seaboard goby
Gobiosoma robustum	code goby
Hippocampus erectus	lined sea horse
Hippocampus zosterae	dwarf sea horse
Hypsoblennius hentzi	feather blenny
Ictalunus punctatus	channel catfish
Labidesthes sicculus	brook silverside
Lagodon rhomboides	pinfish
Larimus fasciatus	banded drum
Leiostomus xanthurus	spot
Lepisosteus osseus	longnose gar
Lepisosteus platyrhincus	Florida gar
Lepomis auritus Lepomis	redbreast sunfish
gulosus Lepomis	warmouth
macrochinus Lepomis	
microlophus Lepomis	bluegill
megalotis Lobotes	redear sunfish
surinamensis Lucania	longear sunfish
parva	tripletail
Lutjanus griseus Lutjanus	rainwater killifish
synagris Membras	gray snapper
martinica Menidia menidia	lane snapper rough
Menidia peninsulae	silverside Atlantic
Menticirrhus americanus	silverside tidewater
Menticirrhus saxatilis	silverside southern
Microgobius gulosus	kingfish northern
Micropogonias undulatus	kingfish clown goby
Micropterus sabnoides	Atlantic croaker
Monacanthus hispidus	largemouth bass
Morone saxatilis	planehead filefish
Mugil cephalus	striped bass striped
Mugil curema	mullet white mullet

Table 8. Continued.

Mycteroperca microlepis	gag grouper
Myrophis punctata	speckled worm eel
Notemigonus crysoleucas	golden shiner
Oligoplites saurus	leatherjacket
Ophichthus gomesi	shrimp eel
Opisthonema oglinum	Atlantic thread herring
Opsanus tau	oyster toadfish
Orthopristis chrysoptera	pigfish
Paralichthys albigutta	Gulf flounder
Paralichthys dentatus	summer flounder
Paralichthys lethostigma	southern flounder
Poecilia latipinna Pogonias	sailfm molly
cromis Pomatomus saltatrix	black drum
Pomoxis nigromaculatus	bluefish
Prionotus carolinus Prionotus	black crappie
evolans Prionotus scitulus	northern sea robin striped
Prionotus tribulus	sea robin leopard sea
Rhizoprionodon terraenovae	robin bighead sea robin
Scomberomorus maculatus	Atlantic sharpnose shark
Sciaenops ocellatus Selene	Spanish mackerel red
vomer	drum
	lookdown
Sphoeroides nephelus	southern puffer
Stellifer lanceolatus	stardrum
Strongylura marina	Atlantic needlefish
Strongylura timucu	timucu
Symphurus plagiusa	blackcheek tonguefish
Syngnathus floridae	dusky pipefish
Syngnathus louisianae	chain pipefish
Synodus foetens	inshore lizardfish
Trachinotus falcatus	permit
Trinectes maculatus	hogchoker
CORALS *Leptogorgia*	
virgulata	sea whip
MOLLUSKS	
Nassarius obsoletus	mud dog whelk
Neosimnia implicata	single-tooth simnia
Lolliguncula brevis	brief squid
Rangia cuneata	wedge rangia
CRUSTACEANS	
Tozeuma carolinense	arrow shrimp
Alpheus estuariensis	snapping shrimp

Table 8. Continued.

Callinectes sapidus	blue crab
Callinectes similis	southern blue crab
Clibanarius vittatus	striped hermit crab
Palaeomonetes vulgaris	grass shrimp
Paleomonetes pugio	grass shrimp
Penaeus aztecus Penaeus	brown shrimp
setiferus Petrolisthes	white shrimp
annatus Squilla sp.	porcelain crab
(zoeae)	mantis shrimp
ECHINODERMS	
Luidia clathrata	armored sea star
Mellita quinquesperforata	keyhole sand dollar
UROCHORDATES	
Molgula manhattensis	sea grapes

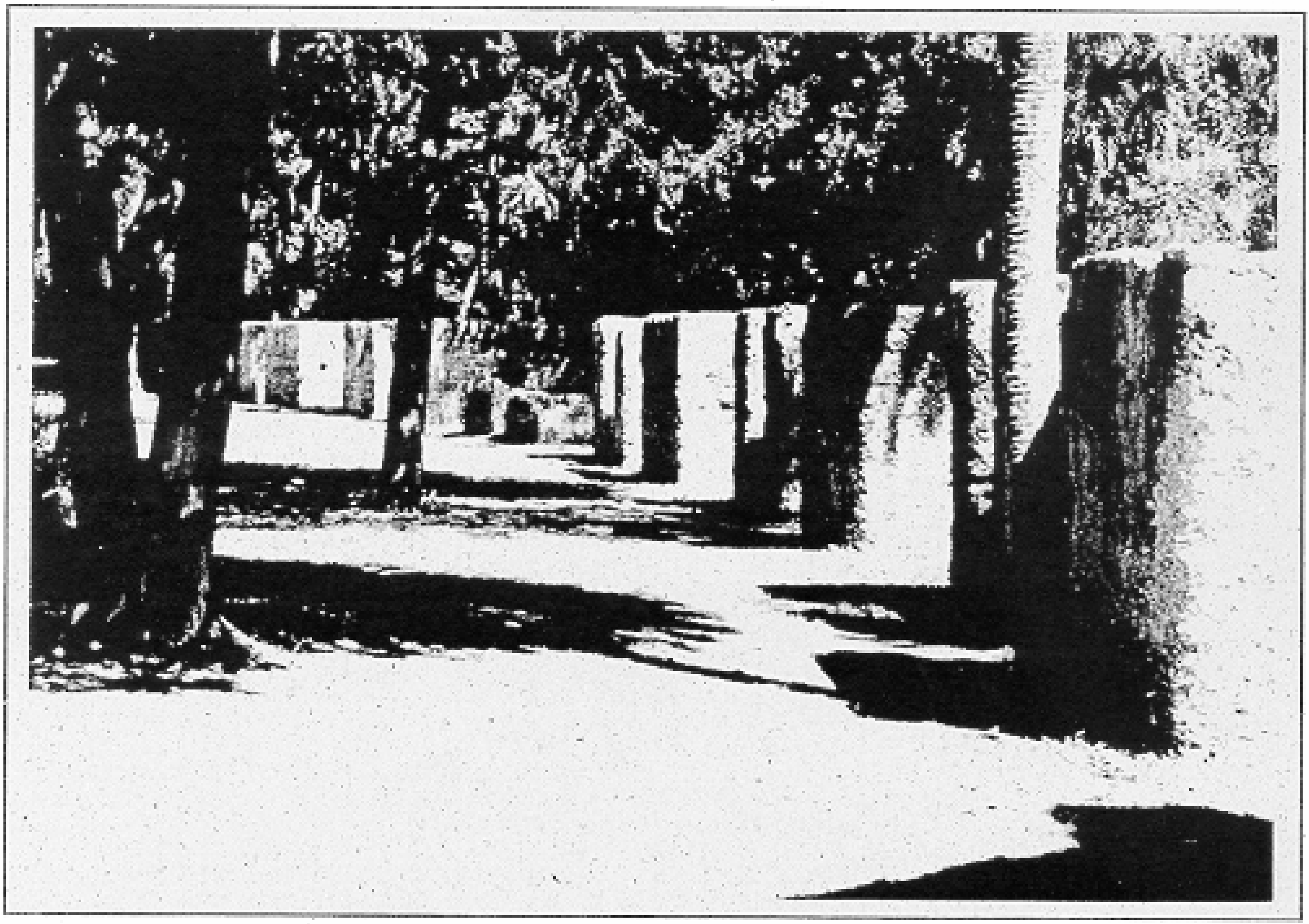
Among the most publicized of the protected species is the manatee *(Trichechus inanatus latirostris).* Manatees are known to occupy large activity ranges in the St. Johns River, but these are upstream of preserve waters. Manatees occupy the Intracoastal Waterway during the warm months, and individuals have been recorded adjacent to Fort George Island. The manatee is the only federally listed species that occurs in the preserve with a critical habitat designation. All preserve waters are within the critical habitat for the manatee. The northeastern stretch of the Intracoastal Waterway is used by manatees primarily as a migratory route along the east coast of Florida and southern Georgia during the late autumn and early spring. Heavy mortality occurs from accidental collisions with boats and barges, and from canal lock operations. Northeastern Florida (and Duval County in particular) is noted for its high incidence of manatee mortalities. In 1994, Duval County ranked third in the state in the number of manatee deaths due to watercraft causes, with most occurring in the St. Johns River vicinity. Another closely related factor in the decline of this species has been the loss of suitable habitat through incompatible coast development, particularly boating facilities. A recovery plan was published in 1989 by the U.S. Fish and Wildlife Service.

No federally or state listed plant species are presently known in the wetlands of the preserve. Several species often associated with freshwater wetlands are listed as possibly present in the preserve by the general management plan (National Park Service 1994a). An ongoing survey of plants in the Theodore Roosevelt area by the Florida Department of Agriculture will document any plants of special concern within that area.

Aquaculture

Aquaculture (farming of freshwater organisms) is a small but growing enterprise in the Nassau and lower St. Johns rivers utilizing the biological resources of the rivers (Brody 1994). Florida Agriculture Statistics Service (1990) reports at least 15 active aquaculture producers in the lower St. Johns River in 1990, a 20% increase over 1988 estimates. Aquaculture ventures include catfish farms, baitfish rearing, and eel and hybrid striped bass growout facilities.

Mariculture (farming of saltwater organisms) in the Nassau and lower St. Johns rivers is limited to the eight shellfish leases in the preserve in the Duval County shellfish harvesting area (National Park Service 1994a; Adamus et al. 1987). Brody (1994) mentioned that a series of legal challenges of Florida Department of Environmental Protection rules to the Marine Resources Commission has recently modified the regulations on oyster lease harvesting, and this form of mariculture may receive revived attention in the lower St. Johns River basin in the future (Florida Aquaculture Association 1990). The Florida Aquaculture Association has recently promoted the "aquaculture is agriculture" concept and takes an active role in attempting to restructure the state bureaucracy to streamline regulation and remove aquaculture products from the jurisdiction of agencies (Brody 1994). Aquaculture industry reaction to classification of fish-farm effluent as industrial waste by the Florida Department of Environmental Protection has prompted interagency research (Brody 1994).



WATER RESOURCES MANAGEMENT PLANNING CONSIDERATIONS

WATER RESOURCES MANAGEMENT PLANNING CONSIDERATIONS

The lands and waters of Timucuan Preserve are subject to myriad regulatory, planning, and management authorities. Many federal, state and local agencies have an interest, mandated or otherwise, in the water resources within the preserve. In addition, the preserve is a patchwork of landownership types and water management classifications. Protection of water resources requires an understanding of the various policy, regulatory, and management designations to facilitate coordination of all agency efforts and other landowners within the preserve. The following section describes federal, state, and local legislation, regulatory designations and management oversight authorities that apply to Timucuan Ecological-and Historic Preserve.

FEDERAL LEGISLATION, POLICIES, AND EXECUTIVE ORDERS

National Park Service Organic Act (1916) In 1916 Congress created the

National Park Service to:

> promote and regulate the use of the federal areas known as national parks, monuments, and reservations ... by such means and measures as to conform to the fundamental purpose of said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations (NPS Organic Act, 16 USC 1).

The dual, and sometimes conflicting, mandates to preserve and protect resources while providing for their enjoyment by the public often complicates park management. Achieving a balance is at the heart of most decisions affecting the management of the preserve.

In recognition of the growing diversity of units and resources in the National Park System, Congress reinforced the primary mandate in 1970 with legislation stating that all park lands are united by a common preservation purpose, regardless of title or designation. Hence, all water resources in the National Park System, including the preserve, are protected equally, and it is the fundamental duty of the National Park Service to protect those resources unless exceptions are specifically provided for by Congress.

Timucuan Ecological and Historic Preserve (1988)

The enabling legislation for the preserve (Public Law 100-249) generally directs the National Park Service to interpret and manage the ecological, historic, and prehistoric resources of the preserve. This legislation provides the following specific directions for management of the preserve:

- The Secretary of the Interior may make minor revisions in the boundary of the preserve in accordance with section 7(c) of the Land and Water Conservation Act of 1965.

- The Secretary of the Interior...is authorized to acquire lands and interests therein within the preserve by donation, purchase with donated or appropriated funds, or exchange, but no lands other than wetlands or interests therein may be acquired without the consent of the owner.

- Lands, interests in lands, and improvements thereon within the boundaries of the preserve which are owned by the State of Florida or any political subdivision thereof may be acquired only by donation or exchange.

- On lands acquired for inclusion within the preserve, the Secretary shall not impair any legal riparian right of access nor shall he preclude the continued used of any legal right of way.

- The Secretary shall administer those lands acquired for inclusion within the preserve in such a manner as to protect the natural ecology of such land and water areas in accordance with this Act and the provisions of law generally applicable to units of the National Park System, including the Act of August 25, 1916 (the National Park Service Organic Act).

- The Secretary shall permit boating, boating-related activities, hunting, and fishing within the preserve in accordance with applicable Federal and State laws. The Secretary may designate zones where, and establish periods when, no hunting or fishing shall be permitted for reasons of public safety.

<u>Federal Water Pollution Control Act (Clean Water Act) (1972)</u>

The Federal Water Pollution Control Act, more commonly known as the Clean Water Act, was first promulgated in 1972 and amended in 1977, 1987, and 1990. This law was designed to restore and maintain the integrity of the nation's waters. Goals set by the act were swimmable and fishable waters by 1983 and no further discharge of pollutants into the nation's waterways by 1985. The two strategies for achieving these goals were a major grant program to assist in the construction of municipal sewage treatment facilities and a program of "effluent limitations" designed to limit the amount of pollutants that could be discharged.

As part of the act, Congress recognized the primary role of the states in managing and regulating the nation's water quality within the general framework developed by Congress. All federal agencies must comply with the requirements of state law for water quality management, regardless of other jurisdictional status or land ownership. States implement the protection of water quality under the authority granted by the Clean Water Act through best management practices and through water quality standards. Best management practices are defined by the U.S. Environmental Protection Agency as methods, measures or practices selected by an agency to meet its nonpoint control needs. These practices include but are not limited to structural and non-structural controls and operations and maintenance procedures. They can be applied before, during and after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters. Water quality standards are composed of the designated use or uses made of a water body or segment, water quality criteria necessary to protect those uses, and an anti-degradation provision which may protect the existing water quality.

Section 402 of the act requires that a National Pollutant Discharge Elimination System (NPDES) permit be obtained for the discharge of pollutants from any point source into the waters of the United States. Point source, waters of the United States, and pollutants are all broadly defined under the Act, but generally all discharges and storm water runoff from major industrial and transportation activities, municipalities, and certain construction activities must be permitted by the NPDES program. The Environmental Protection Agency usually delegates NPDES permitting authority to a state. The state, through the permitting process, establishes the effluent limitations and monitoring requirements for the types and quantities of pollutants that may be discharged into its waters. Under the antidegradation policy, the state must also insure that the approval of any NPDES permit will not eliminate or otherwise impair any designated uses of the receiving waters.

Section 404 of the Clean Water Act requires that a permit be issued for discharge of dredged or fill materials in waters of the United States including wetlands. The Army Corps of Engineers administers the Section 404 permit program with oversight veto powers held by the Environmental Protection Agency. The Environmental Protection Agency, the U.S. Fish and Wildlife Service and the National Marine Fisheries Service provide advice on the environmental impacts of proposed projects. National Park Service activities associated with wetlands are managed under Executive Order 11990, discussed later in this section.

Section 10 of the Rivers and Harbors Appropriations Act of 1899, as amended (33 U.S.C. 403)

This was the first general legislation giving the U.S. Army Corps of Engineers jurisdiction and authority over the protection of navigable waters. Navigable waters of the United States are those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce. U.S. Army Corps of Engineers permits are required under section 10 for structures and/or work in or affecting navigable waters of the United States.

The U.S. Army Corps of Engineers began regulation of wetlands under the Rivers and Harbors Act, and then received a much broader grant of jurisdictional authority under the Clean Water Act. Because of the broader geographic reach of "waters of the United States" jurisdiction under the Clean Water Act, Rivers and Harbors Act jurisdiction will usually not be of significance to wetlands regulation in current cases. There are, however, several situations in which Rivers and Harbors Act jurisdiction alone will be available: when an exemption from Section 404 coverage applies, and when activities, as opposed to waters, are covered by the Rivers and Harbors Act and not the Clean Water Act. For instance, the mooring of houseboats in a bay may require a permit under the Rivers and Harbors Act, but would not under the Clean Water Act.

Floodplain Management (Executive Order 11988)

This executive order requires all federal agencies to "reduce the risk of flood loss, ... minimize the impacts of floods on human safety, health and welfare, and ... restore and preserve the natural and beneficial values weaved by floodplains" (Goldfarb 1988). Federal agencies are therefore required to implement floodplain planning and consider all feasible alternatives which minimize impacts prior to construction of facilities or structures. Construction of such facilities must be consistent with federal flood insurance and floodplain management programs. To the extent possible, park facilities should be located outside these areas. National Park Service guidance pertaining to Executive Order 11988 can be found in Floodplain Management Guidelines (National Park Service 1993).

Protection of Wetlands (Executive Order 11990)

This executive order requires all federal agencies to "minimize the destruction, loss or degradation of wetlands, and preserve and enhance the natural and beneficial values of wetlands" (Goldfarb 1988). Unless no practical alternatives exist, federal agencies must avoid activities in wetlands which have the potential for adversely affecting the integrity of the ecosystem. National Park Service guidance for compliance with Executive Order 11990 can be found in Floodplain Management and Wetland Protection Guidelines, published in the Federal Register (45 FR 35916, Section 9).

Water Quality Improvement Act (1970)

This act requires federally regulated activities to have state certification ensuring that water quality standards are not violated.

Endangered Species Act (1973)

The Endangered Species Act requires the National Park Service to identify and the promote the conservation of all federally listed endangered, threatened or candidate species within park or preserve boundaries. Specifically, Section 7 of the act requires all federal agencies to consult with the U.S. Fish and Wildlife Service to ensure that any action authorized, funded, or carried out by the agency does not jeopardize the continued existence of listed species or critical habitat. While not required by legislation, it is the National Park Service's policy to also identify state and locally listed species of concern, and to cooperate with appropriate state agencies to ensure protection of those species and their habitats within the preserve.

Safe Drinking Water Act (1974) and Amendments (1986)

The Safe Drinking Water Act is implemented by the state in order to ensure that public water supplies are safe. The National Park Service must comply with state regulations regarding the construction, operation, and monitoring of its public water supply systems. Important aspects of this act include the underground injection and well-head protection programs.

National Environmental Policy Act (1969)

The National Environmental Policy Act (NEPA) established a general federal policy for the responsibility of each generation as trustee of the environment for the succeeding generations. Specifically, NEPA requires that an environmental impact statement (EIS) be prepared as part of the review and approval process by federal government agencies of major actions which significantly affect the quality of human life. The primary purpose of an EIS is to ensure evaluation of the impacts of proposed projects and facilitate public review. An environmental assessment (EA) may be prepared prior to initiating an EIS in order to determine if the preparation of an EIS is required.

Regulations implementing NEPA require the cooperation of federal agencies in the NEPA process. The regulations also encourage the reduction of duplication through cooperation with state and local agencies including early efforts of joint planning, joint hearings and joint environmental assessments.

An environmental assessment is not included as part of this water resources management plan because this plan provides a general direction for the water resources program for the preserve. Compliance with NEPA will be undertaken for specific actions resulting from this plan, where appropriate, when it becomes apparent that individual actions, or groups of actions, will be implemented.

National Park Service Management Policies and Guidelines

The National Park Service Management Policies (1988) provide broad policy guidance for the management of units of the National Park System. Topics include park planning, land protection, natural and cultural resource management, wilderness preservation and management, interpretation and education, special uses of the parks, park facilities design, and concessions management. Recommended procedures for implementing service-wide policy are described in the NPS guideline series. The guidelines most directly pertaining to actions affecting water resources include:

- NPS-2 for the planning process;
- NPS-12, for compliance with the National Environmental Policy Act, including preparation of EISs, EAs, and categorical exclusions;
- NPS-75, for natural resources inventory and monitoring;
- NPS-77, for natural resource management; and,
- NPS-83, for public health management.

STATE OF FLORIDA STATUTES AND DESIGNATIONS

The State of Florida follows Riparian Doctrine in allocating its water resources, and has several established programs to help protect resource values within and outside the preserve boundaries.

Florida Air and Water Pollution Control Act (Chapter 403, F.S.)

This 1967 act repealed most of the existing environmental statutes and replaced them with the State of Florida's first real pollution control program. The act contained a declaration from the legislature to prevent the pollution of Florida's air and water. The act was codified in Chapter 403 Florida Statutes, and created the Florida Air and Water Pollution Control Commission, consisting of the Governor and Cabinet. The act was amended in 1971 to require a permit for the construction and operation of every stationary source of water pollution.

Pollutant Discharge Prevention and Control Act (Chapter 376, F.S.

This 1970 act authorizes the Florida Department of Natural Resources to impose rules concerning methods of materials transfer from ships, to contain and clean up any offshore spills of pollutants, and to charge polluters for clean up costs. This act also establishes the Florida Coastal Protection Trust Fund, which uses fees and damage judgements for the administration of the act.

Florida Environmental Land and Water Management Act

This act, established in 1972, created the Development of Regional Impact (DRI) and the Area of Critical State Concern. This program is designed to address state or regional interest in any "...development which because of its character, magnitude, or location would have a substantial effect upon the health, safety, or welfare of citizens of more than one county."

The act also enables the Florida legislature the ability to designate Areas of Critical State Concern (ACSC). An area may be designated a ACSC if it:

- contains or has a significant impact on environmental or natural resources of regional or statewide importance;
- contains or has a significant impact on historical or archaeological resources of regional or statewide importance; or
- has a significant impact upon, or is significantly impacted by, an existing or proposed major public facility.

Land Conservation Act

This 1972 act was the first major land acquisition program for Florida. The program resulted in the issuance of $240 million dollars in state bonds for acquiring environmentally endangered lands. The objective of the act is to protect environmentally unique and irreplaceable lands that are important state ecological resources.

Florida Water Resources Act (Chapter 373, F.S.)

This 1972 act created six water management districts to address the unique water management problems in the various regions of Florida. Each district is governed by a nine member board appointed by the Governor and confirmed by the Senate. The act established regional administration and comprehensive planning for use of state waters.

Environmental Reorganization Act

This 1975 act created the Department of Environmental Regulation to oversee and centralize environmental regulation. Virtually all regulatory functions created in the 1972 Water Resources Act were delegated to the water management districts.

Safe Drinking Water Act

This act, created in 1977, gave Florida's Department of Environmental Regulation authority to regulate public water systems.

Coastal Management Act

This 1978 act provides for Florida's participation in federal/state partnerships to ensure the wise use and protection of coastal resources authorized under the U.S. National Coastal Zone Management Act of 1972. The state receives federal funding assistance to implement approved programs and is granted review authority of federal activities for consistency with the state's coastal resources management program. Under this consistency determination, the state may prevent a federal proposed action if it is found to be inconsistent with the state program.

Conservation and Recreation Lands Trust Fund (CARL Program)

This fund, created in 1979, utilizes money acquired from state severance taxes on oil, gas, and solid minerals to purchase lands. Up to $20 million is collected annually to purchase environmentally endangered lands such as natural floodplains, marshes, estuaries, wilderness areas, and wildlife management areas. These funds may also be used for the restoration of altered ecosystems. High priority is given to lands in or near counties with highly concentrated populations and with Areas of Critical State Concern.

Florida Aquatic Preserve Act

Established in 1975, this act brought all existing aquatic preserves under a standardized set of maintenance criteria. Most of these aquatic preserves (18) were established by the Governor and Cabinet through a 1969 resolution, but others were established by subsequent legislative action.

The Nassau River-St. Johns River Marshes Aquatic Preserve was established in 1969 by the State of Florida to preserve the submerged lands forever. The aquatic preserve includes all state-sovereign estuarine marshes and waters, excluding maintained navigation channels, within Nassau and Duval counties along the Nassau and St. Johns Rivers as shown in Figure 21. The aquatic preserve also includes about 1,600 acres of uplands (predominately tree islands and high marsh) owned by the state. A management plan for the aquatic preserve was approved in 1986 (Florida Department of Natural Resources 1986).

State aquatic preserves are afforded protection against water quality degradation through permit review for dredge and fill, development leases, and dock facilities. Prohibited activities include oil and gas wells, mining, storage of any hazardous materials, habitat modifications for mosquito control, and deep water ports. All proposed uses must be shown to be clearly in the public interest, and cumulative impacts should be considered as well as direct impacts.

Outstanding Florida Waters (Section 403.061, F.S.)

As part of the implementation of the Clean Water Act's antidegradation policy (40 CFR 131.12), this statute grants the Florida Department of Environmental Protection the power to establish rules which provide a special category of water bodies. These rules are intended to prevent any degradation from existing conditions. The two non-degradation categories established under this authority are Outstanding Florida Waters and the more stringent Outstanding National Resource Waters. The waters of Timucuan Ecological and Historic Preserve and the Nassau River St. Johns River Marshes Aquatic Preserve are classified as Outstanding Florida Waters. Designated waters are to be preserved in a non-degraded state and protected in perpetuity for the benefit of the public.

Under the Outstanding Florida Waters designation, industrial, commercial and residential wastewater discharges (treated or untreated), and dredge and fill operations are prohibited except where clearly in the public interest. Stormwater discharge is permitted only if it has been treated according to strict state standards. Permitting under the Outstanding National Resource Waters designation is more restrictive in that

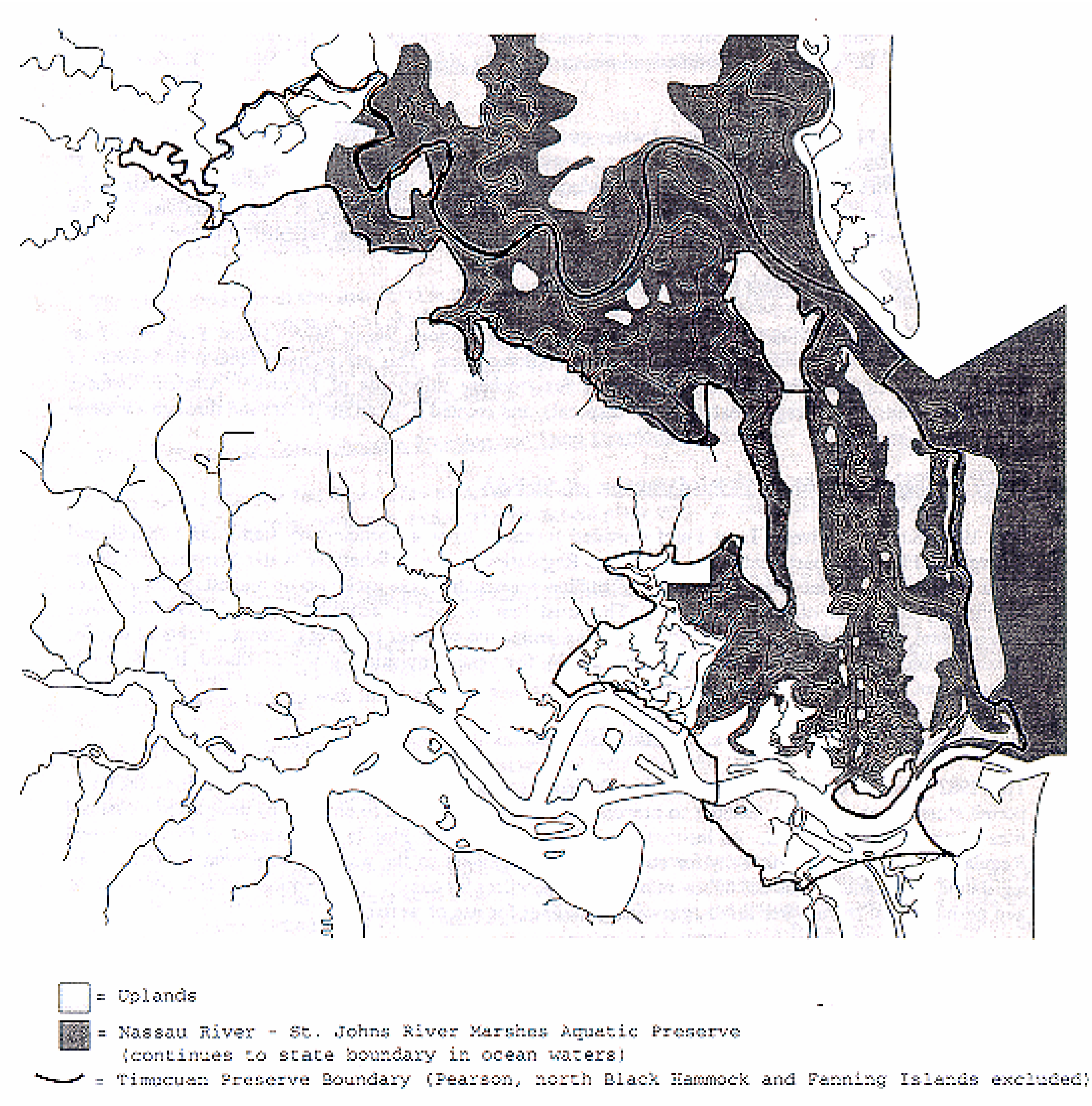


Figure 21. Area in common between the Nassau River - St. Johns River Marshes Aquatic Preserve and Timucuan Ecological and Historic Preserve.

it assumes that the public interest is best served by not permitting any degradation, except in the most extenuating circumstances, and even then, variances, exemptions, and changes in classification can only be granted through legislative action. Because it is so restrictive, an Outstanding National Resource Waters designation can only be granted by the state legislature. In contrast, an Outstanding Florida Waters designation can be granted or modified administratively by the Florida Department of Environmental Protection.

For Outstanding Florida Waters, the usual water quality classification standards or criteria (see Appendix A) are replaced by the ambient water quality characteristics as determined during the "baseline" year (the 1-year time period before the designation date). If inadequate data exists during the baseline year, a reasonable, scientifically-informed estimate of ambient water quality during that time period is used to establish the new criteria. No ambient water quality criteria for any preserve waters have been established to date.

Hazardous Waste Management Act

This act, established in 1980, created the Florida State Hazardous Waste Management Program to set standards for hazardous waste generators and disposal facilities. This act adopted federal definitions of hazardous wastes, established manifest systems for tracking shipments of hazardous wastes (includes generation, transport, storage, treatment and disposal), and created a "clean up" trust fund through an excise tax on waste generators.

Water Management Lands Trust Fund (Section 373.59, F.S.)

This 1981 "Save our Rivers" Trust Fund provided revenues from a documentary stamp tax administered through the Florida Department of Environmental Regulation, and established the Water Management Lands Trust Fund with revenues of approximately $85 million per year from the excise tax on real estate deeds, stock certificates, and other official documents. This trust fund is used to acquire lands "necessary for water management, water supply and the conservation and protection of water resources, except... rights-of-way for canals or pipelines." Lands must be identified in five-year acquisition plans produced by the water management districts and revised annually.

Stormwater Discharge Regulations (Chapter 17-25, F.A.C.)

This 1982 Florida regulation authorizes the Florida Department of Environmental Regulation (DER) to permit stormwater discharge facilities to prevent pollution of waters and to ensure that designated beneficial uses of waters are protected. As instructed by the legislation, the Florida Department of Environmental Regulation has delegated authority for stormwater management to the water management districts. This legislation also mandates the use of best management practices for construction, erosion and sediment control, and permitting of stormwater discharges with guidelines for use of wetlands.

Water Quality Assurance Act

This act, established in 1983, moved authority for water well contractor licensing, regulation of stormwater runoff, and injection well permitting from the Florida Department of Environmental Regulation to water management districts. However, stormwater runoff regulations were moved back to the Florida Department of Environmental Regulation in 1984. The act gave the Florida Department of Environmental Regulation discretion for delegation of all water management authorities, except state water quality certification for federal water pollution permits, to the water management districts. It also instructed the Department to: generate and compile a database; provide a central depository for all scientific information on groundwater; establish a state-wide groundwater monitoring network; create a Pesticide Review Council to comment on restricted-use pesticides; impose a tax on waste handling to accrue to the local government where the waste facility is located; and, change hazardous waste identification and siting procedures.

Warren S. Henderson Wetlands Protection Act

This 1984 act consolidated regulation of dredge and fill operations in the Florida Department of Environmental Regulation, and gave the department jurisdiction over wetlands "up to landward extent of waters" to prevent degradation of water quality below established numerical standards. However, it exempted some activities, such as irrigation and drainage ditches, within an Agricultural Management District.

Florida and Regional Planning Act

This 1984 act requires that the state adopt land use goals and policies, that the state's eleven regions write policy plans that conform to those goals and policies, and that the cities/counties adopt plans whose elements reflect the state and regional goals and policies. The state reviews local plans for conformance and either accepts them or requires modification.

The policy guidance at the state level is provided in Chapter 187, Comprehensive Plan, Florida Statutes for the orderly social, economic, and physical growth of the state, along with policy direction to state and regional agencies. Regional translation of state policy is in the Northeast Florida Comprehensive Regional Policy Plan (Northeast Florida Regional Planning Council 1987). The local government application of state and regional policy is found in Comprehensive Plan - 2010 (City of Jacksonville 1990b).

Local Government Comprehensive Planning and Land Development Act

Contained in Chapter 163, Florida Statutes, this 1985 act requires that regional policy plans must be consistent with the state comprehensive plan, and local government plans must be consistent with the regional and state plans.

Surface Water Improvement and Management Act (SWIM) (Chapter 373, F.S.)

This 1987 act authorizes the water management districts to correct and prevent problems concerning the declining quality of surface waters. This act also created the SWIM Trust Fund, with monies from appropriations, to help with implementation of restoration plans.

The SWIM Act identified the lower St. Johns River basin ,as a high priority for restoration of good water quality. This high priority was justified because of several problems that were identified as contributing to poor water quality in the basin. These problems included:

- point source discharges operating without a permit;
- permitted point source discharges operating in violation of their permit; and,
- non-point sources from such sources as urban/residential lands, rural/agricultural lands, drainage ditches, failing septic fields, erosion, stormwater management systems, disturbance of contaminated sediments (dredging), spills from manufacturing or shipping, peak freshwater discharges to the estuary, and destruction of natural systems.

The SWIM program provides resources through the St. Johns River Water Management District for identification of pollution problems, technical assistance and planning to ameliorate pollution problems, funding for research, enforcement and educational programs, and coordination among regulatory and management agencies. For example, the 1989 Lower St. Johns River SWIM Plan provided funds for inspection of septic sewage systems and determined the average violation rate in the three county region. This information is being used by the City of Jacksonville to prioritize and proceed with enforcement and conversion to utility service connections.

Through the 1993 revision of the Lower St. Johns River SWIM Plan (Campbell et al. 1993), the St. Johns River Water Management District is working closely with the City of Jacksonville to develop a master stormwater management program. Stormwater discharges were identified as the major source of non-point source pollution affecting the lower St. Johns River basin.

Reuse of Reclaimed Water and Land Application Rules (Chapter 17-610. F.A.C.)

These regulations, established in 1989, instruct the Florida Department of Environmental Regulation to set requirements for wastewater treatment and discharge, including land application, absorption fields, overland flow, wetlands application, and injection to protect beneficial uses of affected waters.

Preservation 2000 Act (Section 259.001. F.S.)

This 1990 act provides funding to supplement land acquisition programs designed to protect the integrity of ecological systems and provide multiple benefits (including preservation of fish and wildlife habitat, recreation space, and water recharge areas), if one of five criteria is met:

- Land is in danger of imminent development or subdivision;
- Land value is escalating faster than interest rates;
- Land protects groundwater or provides natural resource based recreation;
- Land can be purchased at 80% of appraised value; or,
- Land has rare, threatened, or endangered species or areas listed in the Florida Natural Areas Inventory (1993) as critically imperiled, imperiled, rare, or excellent natural communities.

The act also requires water management districts to identify lands needed to protect or recharge groundwater supplies and include them in five-year acquisition plans.

Environmental Reorganization Act (1993)

This 1993 act created the Florida Department of Environmental Protection by fusing the Florida Department of Natural Resources and the Florida Department of Environmental Regulation. This act gave the new Department of Environmental Protection responsibility for: management and protection of marine resources including endangered species and their habitats; protection,,restoration and management of environmentally important lands and the ecosystems upon them; parks and recreation; water management; and, pollution control and environmental protection. Six district offices issue permits, provide information, and enforce rules. The Division of Environmental Resource Permitting administers wetlands protection programs through the Bureau of Submerged Lands and Environmental Resources, which reviews applications to use sovereignty submerged lands and is responsible for wetlands dredge and fill permitting. The Division of State Lands, Office of Environmental Services selects lands to be acquired under CARL. The Division of Water Facilities monitors surface water quality, develops standards, and administers stormwater management through its Bureau of Surface Water Management, and issues rules for wastewater treatment and NPDES permitting through its Bureau of Water Facilities Planning and Regulation. The Florida Department of Environmental Protection has general oversight of the water management districts, and delegates authority for permitting to the districts except for: industrial; hazardous; solid or domestic waste facilities; marinas; public works projects; navigational dredging; docks and sea walls not included under other development; and, activities of the water management districts. The Florida Department of Environmental Protection works with the St. Johns Water Management District on a number of programs, including SWIM plans.

Florida Water Ouality Legislation

The Environmental Control statute (Chapter 403, F.S.) declares it is the policy of the state to ensure that the existing and potential drinking water resources of the state remain free from harmful quantities of contaminants, and outlines data management and inter-agency regulatory cooperation. Two relevant subsections of the legislation are:

- Water Resources Restoration and Preservation Act (Chapter 403, F.S.) -- This legislation includes Sections 403.0615 (Pollution Control) and 403.063 (Groundwater Quality Monitoring); and,

- Permitting of Activities in Wetlands (Section 403.91, F.S.) -- This legislation defines requirements regarding dredging, filling, wetland monitoring, and mangrove alteration.

CITY OF JACKSONVILLE DESIGNATIONS

Comprehensive Plan - 2010

Land use planning in the State of Florida is subject to a statewide comprehensive framework. The Florida State and Regional Planning Act of 1984 requires that: the state adopt land use goals and policies; the state's 11 regions write policy plans that conform to those goals and policies; and, the cities/counties adopt plans whose elements reflect the state and regional goals and policies. In 1990 the City of Jacksonville produced "Comprehensive Plan - 2010" (City of Jacksonville 1990b) pursuant to Florida statutes on local government conformity with regional and state planning efforts.

This comprehensive plan addresses a wide range of water quality issues, including the designation of Special Management Areas to protect unique environmentally sensitive areas within the city. The Timucuan Ecological and Historic Preserve has been adopted by the city as a Special Management Area. This designation mandates that the use of lands within the special management area be subject to special criteria to reduce the potential for disruption of the ecological balance in the preserve by inappropriate development. These criteria recognize the preserve's values and strive to protect them, while ensuring the private property owners reasonable use of the land.

Water-related objectives of the city's Special Management Area designation for the preserve are:

- achieve and maintain Class II water quality standards;
- manage upland development to avoid impairment, of natural habitats, water quality or a healthy estuarine system;
- foster no net loss of wetlands;
- preserve natural dynamics of surface water and tidal hydrological regimes;
- manage boating, fishing, hunting, etc. in a manner which will not impair the integrity of the estuarine system; and,
- increase public awareness of the impacts and relationships between human use and natural resources, and dynamics of wetlands and uplands in an estuarine system.

The city produced a management plan for the Special Management Area in September, 1993 (City of Jacksonville 1993a). This plan intends to achieve the above objectives through a suite of management recommendations:

- management of upland development through zoning designation adjustments;
- discourage tree removal and encourage landscaping with native vegetation;
- stormwater treatment systems designed to handle 100 year storms without degrading water quality;
- assure wastewater facilities, including septic systems, do not degrade water quality;
- acquire sensitive and buffer lands to protect wetlands;
- encourage use of community or shared docks; and,
- cooperate with the National Park Service to protect the preserve.

RELATIONSHIP TO OTHER PLANNING EFFORTS

Many preserve management and resource protection issues are a direct result of the complex pattern of multiple landownership within the preserve and the activities that can occur on these lands, as well as activities on lands adjacent to the preserve. These activities could significantly affect the success of the water resources management program.

The following is a brief description of other known planning efforts or plans both within and outside the preserve that could have an effect on preserve water resources management.

Nassau River-St. Johns River Marshes and Fort Clinch State Park Aquatic Preserves Management Plan (1986), by State of Florida, Department of Natural Resources -- A large majority of the Nassau River-St. Johns River marshes, owned and managed by the State of Florida, is within the preserve boundary. This management plan lists major objectives that ensure maintenance of essentially natural conditions and public recreational opportunities. The plan is general and somewhat dated; a new plan for the state aquatic preserve is in progress.

Fort George Unit Management Plan (1990), by Florida Department of Natural Resources (1990), Division of Recreation and Parks -- This plan discusses management of state lands on Fort George Island and identifies objectives, criteria, and standards that guide park administration and sets forth specific measures that would be implemented to meet management objectives. Cooperation between the National Park Service and the Florida Department of Environmental Protection is critical to ensure compatibility of proposed actions involving water-related resources.

P**elotes Island Preserve Interpretation and Land Management Plan (1989),** prepared for Jacksonville Electric Authority by Duever et al. (1989) -- Jacksonville Electric Authority, in joint ownership with Florida Power and Light, owns a chain of maritime hammock islands that serve as a buffer for the St. Johns River Power Park. This area has been developed by these entities into the E. Dale Joyner Nature Preserve. This plan discusses facility design, natural resource management, habitat enhancement, research programs, staffmg, and maintenance. Again, cooperation between these entities and the National Park Service is essential to ensure compatibility of water resource actions.

Management Plan, Huguenot Memorial Park (1993) — This management plan, developed by the City of Jacksonville (1993b) and negotiated with the state of Florida, describes this park's objectives, policies, and procedures. Because this park is within preserve boundaries, cooperation is essential to overcoming any compatibility concerns with regard to water resource actions.

WATER RESOURCES ISSUES AND RECOMMENDED ACTIONS

WATER RESOURCES ISSUES AND RECOMMENDED ACTIONS

The Statement for Management (National Park Service 1994c) and General Management Plan (National Park Service 1996) for Timucuan Preserve presents the following management objectives related to water resources:

- To achieve and maintain Florida Class II (edible shellfish) water quality standards within the preserve in order to promote biodiversity and to protect the estuarine ecosystem;
- To coordinate with agencies responsible for regulating the development of uplands within the preserve to ensure that current and future uses do not impair significant natural habitats, water quality, or a healthy estuarine system;
- To strenuously foster no net loss of wetlands in the preserve;
- To preserve the natural dynamics of the surface water and tidal hydrologic regimes which are critical to the biological systems of the preserve;
- To manage, in cooperation with other agencies, boating, boating-related activities, fishing and hunting to allow the public to experience the various water-based resources and values of the preserve in a manner which will not ... impair the integrity of this relatively undeveloped and undisturbed estuarine system;
- To educate the general population and visitors about the impacts and relationships between human use and natural resources, and the wetlands and upland dynamics of a saltwater estuary complex; and,
- To ensure the provision of land and water-based access to allow visitors to have a visual and sensory understanding of the wetlands ecology.

The General Management Plan (National Park Service 1996) proposes establishment of a 'Timucuan Alliance." This alliance is a cooperative venture where the shared vision, management objectives, and responsibilities for resource management and protection preserve-wide would be pursued through formal agreements, collaboration, cooperation, and/or partnerships among federal, state, and local government agencies, and private landowners. The National Park Service would take the lead in promoting cooperation through the alliance and preparing a comprehensive plan for resource protection that outlines shared objectives and defines responsibilities for implementation. The alliance would be organized and moderated by preserve staff to address water issues using the resources of all of the respective participants.

Similarly, cooperation among federal, state, and local agencies, private organizations, and private landowners would establish guidelines for management and use of water resources and would identify and address potential problems or concerns preserve-wide. To achieve effective, coherent, and cohesive water resource management, these entities must share responsibility for planning, funding, and implementing management actions.

The preserve's General Management Plan (National Park Service 1996) discusses potential avenues that the alliance could pursue with regard to water resources. Cooperative management would maintain and restore, to the extent feasible, natural water flows and water quality in disturbed areas and avoid further hydrological disturbance to the watersheds in the preserve. Management programs would include: 1) enhanced water quality and water level monitoring regimes to identify and quantify existing problems and future threats to preserve water resources; 2) regulatory actions to prevent or mitigate new disturbance-causing activities; and, 3) rehabilitation projects to alleviate existing hydrological problems. Also the alliance could revise the existing

SWIM plan (Campbell et al. 1993) for the lower St. Johns River to include all areas of the preserve for future study and/or monitoring. This revision would, at a minimum meet National Park Service guidelines for a water resource management plan. The water resource management plan would be used for the following purposes: 1) to define the role of the preserve in northeast Florida; 2) to minimize threats to the preserve's ecosystem due to development, pollution, hydrological changes or other disruptive factors caused by human activities inside and outside the preserve; and, 3) to facilitate maximum regional benefit from the preserve within the constraints of ecologically compatible uses.

The current water resources management planning effort is intended as a template that will allow the alliance to build upon and revise as needed when more information becomes available and/or different/modified actions are needed. This water resources management plan is intended to accomplish the above purposes and to provide water resources protection in the short-term until mutually beneficial cooperative ventures are put in place by the alliance.

The following water resources issues are designed to present overviews of water resources problems. Associated project statements are activities needed to begin to address those problems. The project statements (see "RECOMMENDED ACTIONS" section) are not a complete set of activities that will solve water resources problems at the preserve, rather they describe certain activities that should be promoted in the near future to ameliorate impacts or to provide information needed by the preserve and the alliance to protect water resources within the preserve.

WATER RESOURCES ISSUES

Coordinate Efforts Among Government Agencies and Academic Institutions With Interest in Preserve Water Resources

The preserve's draft general management plan identified over 50 different organizational entities with a direct interest in land or water stewardship in or around the preserve (National Park Service 1994a). The authorities under which the organizations operate are often multi-faceted. For example, the U.S. Army Corps of Engineers is not only a land owner within Timucuan, but also performs maintenance dredging of the St. Johns River and the Intracoastal Waterway, as well as being involved in wetlands protection and mitigation projects.

The State of Florida has developed many water resources management and protection programs. However, the functions of particular divisions, bureaus or offices within a single agency can overlap, not only within the agency, but with other federal, state or local agencies as well. As an example, stormwater systems permitting and program planning is managed by the Florida Department of Environmental Protection, Bureau of Surface Water Management, for industrial, domestic-solid, utility and large marina stormwater treatment systems. The St. Johns River Water Management District manages permitting for non-point systems such as roadways and subdivision developments. The U.S. Environmental Protection Agency manages the National Pollution Discharge Elimination System stormwater permits, and the City of Jacksonville conducts stormwater management planning.

In addition, Florida has recently reorganized its two main departments dealing with water resource issues, the Department of Environmental Regulation and the Department of Natural Resources, into a single entity: the Florida Department of Environmental Protection. This fusion was authorized in 1993, and largely accomplished in 1994. Redistribution of duties from the two former agencies into offices of the new agency has only recently been completed.

Although many different organizations deal with some aspect of water resources management in the preserve area, comprehensive information on the different activities of these organizations is not readily available.

Federal, state, local and academic monitoring projects, research projects, permitting activities, and management programs operate as discrete and separate functions.

The Timucuan Alliance proposes to coordinate the efforts of all interested parties to protect the water resources within the preserve. As a first step, identification of functions and authorities of the various government agencies and academic institutions that have an interest in preserve water resources is needed. Project Statement TIMU-N-31 calls for an Alliance-based subcommittee that will act as an 'omsbudman' on water resource activities, such as monitoring, research, management, regulation, protection, enforcement, coordination, planning, and any other water resource related activities within the preserve.

Protect Water Resources From Degradation Through Land Use Planning In and Around the Preserve

Land use patterns of development impact water resources. Point source pollution discharges are associated with industrial and municipal development. Non-point pollution sources come from silviculture, agriculture, dairy farms, septic fields, stormwater runoff, and construction activities. Non-point pollution has been identified as the primary threat to water quality in the preserve area. As suburban development spreads, demands upon water resources increase for provision of drinking water, irrigation water, recreational fishing and boating, etc. Habitat destruction and hydrological modifications, associated with development, also impact water resources.

The State of Florida recognized that land use planning was essential to preservation of natural resources through legislation passed in the mid-1980s. The "State and Regional Planning Act" of 1984 and the "Local Government Comprehensive Planning and Land Development Act" of 1985 require that state, regional and local governments coordinate their comprehensive planning activities. **In** addition, the state acknowledged that some lands should be protected from development in order to preserve water resources. Several land acquisition programs, such as the "Conservation and Recreation Lands (CARL) Trust Fund Act" of 1979 and "Preservation 2000 Act" of 1990, provide public monies for land acquisition. Upon purchase, acquired lands are either transferred to management entities with established preservation goals, or a "conceptual management plan" is developed to guide management for preservation of natural systems.

The City of Jacksonville's Comprehensive Plan 2010 addresses water resources issues at the preserve through the designation of the preserve as a "special management area" (SMA). The management recommendations for the SMA recognize zoning designations as pivotal components of land management in the preserve area to protect water resources. However, the recommendations will not automatically be implemented; the preserve and the Timucuan Alliance must enthusiastically support adoption of the recommendations by the city government. The preserve is subject to encroaching urban/suburban development, as well as impacts from heavy industrial, agricultural and increasing recreational activities (Figure 5). State land acquisition programs are earnestly working to protect water resources through the Pumpkin Hill Creek CARL Project, the Florida Communities Trust Project (Cedar Point area), and the Upper Nassau River - Thomas Creek Project Area (Figure 5). A portion (approximately 400 acres) of the acquired lands making up the southern part of Black Hammock Island was transferred in 1996 to the National Park Service via donations of fee interest. The preserve and the Timucuan Alliance must continue to work with the land acquisition programs to maximize protection to water resources through future potential acquisitions. Creative arrangements, such as linking mitigation banking programs with land acquisition and/or management projects, should be explored.

Much of the Pumpkin Hill CARL acquisition is coastal scrub/rangeland and pine flatlands (Figure 5). These vegetative communities have been identified as having fire as part of their natural ecosystem, therefore the conceptual management plan being developed for these areas would likely include prescribed fire as an element of the management program. Prescribed burning in areas adjacent to the preserve salt marshes creates the potential for fires within salt marshes. Presently, information on whether fire has been a historic component of the salt marsh ecosystem is not available. The response of the preserve to potential prescribed burning in salt marsh areas will depend upon the pre-Columbian fire history of the salt marshes. Information about past fire history might be obtained as part of a salt marsh substrate core investigation described in Project Statement TIMU-N-32.

The Timucuan Alliance must provide input into future land use planning activities by city, district, regional and state agencies to assure that water resource protection in the preserve is included in those efforts. Accurate land use maps, resource maps, zoning maps, projected land and water use maps, etc. are needed to allow the alliance to make informed recommendations for water resources protection. Several GIS operations are ongoing among the land planning agencies, primarily the St. Johns Water Management District, Florida Department of Environmental Protection, and the City of Jacksonville. Project Statement TIMU-I-07 describes establishment of a cooperative agreement between Timucuan Preserve and the St. Johns Water Management District for the production of GIS maps needed to track development and resource status in the Timucuan area.

Preservation and/or Restoration of Surface Water Hydrology Within the Estuary

The surface water hydrology of the preserve estuaries is characterized by two major river drainages, the Nassau and the lower St. Johns Rivers, and the daily inundation of two tidal cycles with amplitudes from 4 to 6 feet. Since the tidal influence complicates efforts to measure stream discharges, most stream gauges have been located in the upper reaches of the Nassau and St. Johns rivers. Descriptive information on the tidal flows and currents within the preserve has not been compiled.

The extent and range of tidal flow from the inlets and sounds through natural and man-made channels into the upper reaches of salt marsh creeks is a determining factor for estuarine ecological functions. The tides bring nutrients to marsh plants, influence plant species distributions, transport aquatic organisms to feeding or nursery refuges, and dilute pollutants. The tides also export nutrients in the form of detritus, transport juvenile aquatic organisms to river channels or the sea, and flush out pollutants. Alteration of the flows and amplitude of tidal hydrology, therefore, could affect the ecological function of the estuarine and salt marsh systems.

The tidal hydrology of preserve waters has undoubtedly been altered by human activities. The lower St. Johns River has been channelized and dredged for deep-water ports access in the Jacksonville area. The Sisters Creek channel has been straightened and dredged to form a section of the Intracoastal Waterway. Artificial dredge spoil islands have been created, on a small scale along the Sisters Creek/Intracoastal Waterway, and on a large scale with Blount and Bartram Islands in the St. Johns River channel. Causeways and culverting for construction of Heckscher Drive have placed barriers to tidal sheet flow and channel flow into the estuary and salt marshes on the north side of the St. Johns River.

Without information on the state and functioning of the estuary prior to these activities, it is difficult to assess the overall impacts to the estuarine and salt marsh ecosystems. However, the present distribution of black needlerush as the dominant plant in the salt marshes on the north side of the St. Johns River could be a result of restricted tidal flow. Project Statement TIMU-32 describes a salt marsh substrate core study that would establish the past vegetative community composition of these salt marshes.

A descriptive study of the present hydrology of the estuarine system is needed not only to help identify impacts of engineering projects, but to provide information needed to minimize impacts of future activities such as dredging, spoil deposition, and road reconstruction projects. Project statement TIMU-N-33 presents a study to describe the existing tidal flows, currents, reaches and magnitudes within the preserve.

Immediate action should be taken to contact and work with the Florida Department of Transportation on any potential plans for modifications to Heckscher Drive. In particular, increased culverting along the entire causeway, and larger culverts at specific channels such as Cedar Point Creek, White Shell, and Training Wall, are recommended to help restore pathways for tidal flows into the estuary.

The extremely high economic and recreational values of the St. Johns River and Sisters Creek dredged channels preclude any consideration of returning these channels to their former state. However, dredging and dredge spoil deposition activities can be conducted so as to minimize impacts upon the natural resources of the preserve. Description of the present tidal hydrology of the preserve will help identify creeks and channels susceptible to any further alteration of their tidal regime (Project Statement TIMU-N-33). An investigation to identify important aquatic organism nursery sites and the conditions associated with those sites (Project Statement TIMU-N-29) would also provide information needed to avoid destroying or disturbing those areas during dredging projects. Creative arrangements for identifying dredge spoil deposition sites, monitoring impacts and evaluating mitigation success could be linked to mitigation banking from construction, dredge, and fill projects from within and nearby the preserve.

Preservation and/or Restoration of Good Surface Water Quality Within the Preserve

The water quality of the preserve estuarine system is generally considered good as compared to the rest of Florida's surface waters (Hand et al. 1994). Tidal flushing is acknowledged to be an important contributing factor to the relatively good water quality within the preserve, since polluted areas with poor water quality are found in nearby upstream areas along the Nassau and lower St. Johns Rivers. In addition, Timucuan Ecological and Historic Preserve contains Duval County's only remaining Class II waters, suitable for shellfish harvesting. The Florida Department of Environmental Protection's 1994 Water Quality Assessment (Hand et al. 1994) synthesized a large amount of water quality information and presented it so that quick, general assessments of water quality status could be made relative to all of Florida's waters. However, different analysis techniques should also be used to assess the water quality status of Timucuan's waters. For example, the Florida Department of Environmental Protection dropped all values listed as "greater than," while many water quality analysts retain such values but ignore the "greater than" qualifier. Removing "greater than" values from the analysis also removes information about pollution events. Also, the Florida Department of Environmental Protection report assessed water quality status on a relative scale by converting values used to generate indices into percentile distribution values based upon the range of values seen in Florida's waters. By using a relative scale, a water body could receive a "good" rating even though water quality was degraded if most of Florida's water bodies were even more degraded.
Analysis of water quality information to produce an "objective" assessment of the status of preserve waters would establish the current condition of water quality within the preserve as compared to Class II water quality standards. This information would be valuable for guiding the preserve and Timucuan Alliance efforts to protect water quality. Project Statement TIMU-N-34 describes an investigation of currently available water quality information to produce an analysis of water quality status within Timucuan Preserve.

In addition to their assignment as Class II or Class III waters, all of the preserve's surface waters have been designated as Outstanding Florida Waters (OFW). This designation provides an extra level of protection by placing additional factors into the review process for Florida Department of Environmental Protection permits (Florida Department of Environmental Protection 1995b). Any proposed action must be clearly in the public interest, and must not cause any degradation of water quality as determined during the year before OFW designation. To take full advantage of OFW protection, the ambient water quality of OFW waters during the year before designation should be established. Project Statement TIMU-N-34 includes determination of the ambient water quality condition of the OFW waters within Timucuan.

Coordination of the many water quality data collectors in or nearby the preserve should be a high priority for the Timucuan Alliance. While there are many water quality monitoring projects in the area, the goals of the various projects can be quite specific, such as documentation of the dissipation plume for a particular point source discharge, or very general, such as description of general water quality in a particular drainage. Water management agencies have recognized the need for consolidation of effort to increase the efficiency and scope of data collection efforts (St. Johns River Water Management District 1994b). The Timucuan Alliance can be a vehicle for the coordination of water quality data collection **in** and nearby the preserve. The identification of water quality monitoring programs through Project Statement TIMU-31 will assist efforts to assure broad coverage of the preserve's waters so that data gaps do not interfere with future analyses.

Biomonitoring has become increasingly recognized as an important component for assessing water quality and long-term degradation trends (Miller et al. 1988). Information about the aquatic organisms within the preserve is spotty and incomplete. The Timucuan Alliance should work with all programs, projects and studies identified through Project Statement TIMU-N-31 to coordinate biomonitoring investigations so that adequate coverage of the preserve's waters using a range of organisms is achieved. An ongoing survey of macro-nekton (primarily fish and crustaceans) within the preserve would provide descriptive information about these organisms, and proposed additional National Biological Service research would produce quantitative biomonitoring information (Sulak 1995). Of particular interest, the proposed research will attempt to identify aquatic organism nursery areas and the conditions associated with them. This information is needed in order to protect such areas from disturbance or degradation. Project Statement TIMU-N-29 describes the expanded NBS research project.

The prospect of degradation of water quality through failing septic systems in the uplands areas in and surrounding the preserve has been identified in numerous reports (Hand et al. 1994; Campbell et al. 1993; City of Jacksonville 1993a), but has not been qualitatively or quantitatively assessed. The estimated input to Timucuan estuarine and salt marsh areas from nearby uplands is about 10%. The potential for contamination should be estimated, and recommendations for attributes of new septic systems to minimize the chance of failure and pollution need to be assembled. The preserve and the Timucuan Alliance could use this information to propose adjustments to septic system design through permitting authorities. Project Statement TIMU-N-35 describes an investigation into the current level of function for septic fields in and around the preserve, and the compilation of recommendations to improve septic system design and function.

Preservation and/or Restoration of Good Groundwater Quality and Quantity

The surficial and Floridan aquifers in the preserve area generally produce good water quality for small-scale uses. Although the water from surficial aquifer wells is often hard, it is within the standards set for drinking water. Since the surficial aquifer is unconfined or semi-confined, it is also susceptible to pollution from failing septic fields, storm runoff, landfill leakage, toxic materials dumps and brackish water infiltration. A 1991 Department of Environmental Regulation listing of known and potential contaminated sites near Timucuan included five petroleum contamination sites along Heckscher Drive east of Dames Point, and five industrial sites, including the U.S. Navy Fuel Depot -- a confirmed petroleum contaminated site (Florida Department of Environmental Regulation 1991b). The possibility of contamination of surficial aquifer waters from nearby sites exists, but no evidence of contamination has yet been described. Timucuan Preserve should encourage and cooperate with all federal, state and local programs to clean up contaminated sites.

The Floridan aquifer has the potential to provide for large-scale use, but new major withdrawals in the eastern portion of Duval County should be evaluated for probable impacts to existing wells. Eastern Duval County is known to contain faults, fractures, and collapse features that can be conduits for saltwater contamination of the aquifer by waters from below when withdrawals create zones of reduced hydraulic head. The preserve and the Timucuan Alliance should promote scientific assessment of the impacts of future withdrawals in the eastern part of Duval County. In addition, Timucuan should encourage programs to cap or fill abandoned wells that can act as pathways for saltwater contamination in the same fashion as natural features (Brown 1984). Finally, by supporting programs that conserve water so that the need for new withdrawals is minimized, Timucuan will help prevent conditions that may cause more saltwater contamination of existing wells.

Preservation of Spanish Pond Hydrology and Water Quality

Spanish Pond is the largest freshwater pond (semi-permanent water regime) within the preserve presently under federal ownership. On the Register of Historic Places, Spanish Pond's historical significance, however, remains problematic. The water level of Spanish Pond is determined by rainfall and water table fluctuations, no tributaries or outlets exist. Although the spatial bounds of the pond have oscillated historically, recent residential development and road construction adjacent to the pond may have affected its hydrology and water quality.

Scientific information about past and present pond hydrology is not currently available. This information is needed to allow the preserve to evaluate the need for, and perhaps plan for, any control projects to limit the extent of pond high water episodes or modifications to the period of recovery after high water events. Project Statement TIMU-N-36 describes a hydrological investigation of Spanish Pond designed to produce the information needed by Timucuan Preserve to address the pond level fluctuations.

Pond water quality was assessed as relatively "good" during a 1993 investigation, but evidence of contamination during stormwater runoff events was present. An ongoing monitoring program is needed to determine the extent and type of contamination during high water events. Project Statement TIMU-N-36 proposes the design and implementation of a water quality monitoring program for Spanish Pond to provide information needed to preserve or restore the water quality of the pond.

Preservation of a Healthy Salt Marsh System

Timucuan Preserve is about 75% wetlands and interspersed open waters. These areas are primarily salt marshes, one of the world's most productive ecosystems. Healthy salt marshes produce large quantities of biomass, which degrades into detritus and provides the basis for aquatic food webs, including many commercial fisheries. Salt marshes and their tidal channels also provide resting, feeding or nursery refuges for myriad aquatic and terrestrial animals, including rare, threatened and endangered species.

There is circumstantial evidence that the preserve's salt marshes may be impacted by changes to the tidal hydrology of the estuary near St. Johns River (see Issue on Preservation and/or Restoration of Surface Hydrology). The dominance of black needlerush in salt marshes of this part of Timucuan could be associated with dredging and channelization of St. Johns River along with barriers to tidal flow from Heckscher Drive causeways and culverts, or it could be the historic configuration of those salt marshes. Project Statement TIMU-N-32 describes a salt marsh substrate core study that should establish the historic composition of the Timucuan salt marshes. Project Statement TIMU-N-30 describes a baseline survey of salt marsh flora and fauna that will establish the present marsh species composition.

Land management activities on some upland areas adjacent to the preserve are likely to include prescribed burning for those vegetative communities identified as having fire as a part of their natural system (see Issue on Water Resource Protection Through Land Use Planning). The potential for fires within salt marshes exists and the management response to salt marsh fires should be described. Presently, information on whether fire has been a historic component of the salt marsh ecosystem is not available. The response of the preserve to possible prescribed fires in salt marsh areas will depend upon the pre-Columbian fire history of the salt marshes. Information about past fire history can be obtained as part of the salt marsh substrate core investigation described in Project Statement TIMU-N-32.

The goals of the general management plan for the Timucuan Ecological and Historic Preserve include: a) defining the role of the preserve in northeastern Florida; b) minimizing threats to its component ecosystems;

and, c) facilitating maximum regional benefit from the preserve. However, no coherent systems study has ever been done of the area at the scale of the preserve. An ecological systems analysis *(sensu* Montague and Odum 1996; Odum 1996) at this scale can help implement these three important management goals by: a) synthesizing information into a quantitative analysis of the current ecological state of the preserve; b) providing a quantitative comparison of the preserve with its surroundings; and, c) forecasting changes in the preserve's ecological state under various scenarios of environmental changes or management actions.

A useful initial analysis need not wait for coherent field studies. Instead it can be based in part on the considerable water resources information contained in this water resources management plan and on estimates taken from well-studied similar areas elsewhere. In fact, the initial analysis can help prioritize needed research. A sensitivity analysis of the resulting ecological model can demonstrate research needs and priorities and the consequences to management of inaccuracies in information.

Although this water resources management plan for the preserve includes references to a considerable amount of relevant water resources information, a general lack of ecological information from within the Timucuan preserve boundary is apparent. Unlike most marsh-dominated estuaries in Florida, however, those of northeastern Florida are geophysically related to the well-studied ones in Georgia and South Carolina (Montague and Wiegert 1990). Published results from these areas should be applicable at least to provide plausible initial estimates for quantifying flows and storages in the preserve ecosystems. Hence a quantified conceptual analysis can now be based on present information from within the preserve supplemented by information from better documented but similar areas. Project Statement TIMU-N-39 proposes an ecological systems analysis of the Timucuan Ecological and Historic Preserve.

Opportunities for imaginative arrangements using wetlands mitigation requirements or banking should be explored to assist in the preservation of Timucuan's salt marshes. As development pressures continue to increase in lower Duval County, impacts to wetlands in those areas will undoubtedly be proposed. Mitigation is required when wetlands areas are destroyed, but some mitigation activities have questionable ecological value, for example, allowing drainage ditches to count as created wetlands. The Timucuan Alliance could coordinate joining the needs of Timucuan for preservation of its relatively pristine salt marsh areas with the outside need for meaningful mitigation options. By doing so, the Timucuan Alliance may be able to promote activities for salt marsh preservation within Timucuan that would otherwise suffer due to lack of funding.

Preservation .of Healthy Freshwater Wetlands

Wetlands arc commonly associated with species of special concern, often due to the dependance of species upon wetlands and the elimination of large areas of wetland habitat. Freshwater wetlands within the preserve are limited, largely due to the boundary restrictions that include only small portions of non-estuarine areas. The Theodore Roosevelt Nature Area has transitory ponds, some small forested depressions and a shrub bog. Some patches of forested depressions, shrub bogs and wet prairie occur on middle and southern Black Hammock Island. The southernmost portion (approximately 400 acres) of Black Hammock Island was transferred to the National Park Service in 1996.

No federally or state listed rare, threatened or endangered plants are presently known in the wetlands within the preserve. However, freshwater wetlands are likely sites for plant species of concern. The Florida Natural Areas Inventory lists plants and animals requiring special protection, but inventory information within the Timucuan Preserve is lacking. An ongoing survey for plants in the Theodore Roosevelt Natural Area by the Florida Department of Agriculture will document any plants of special concern within that area. Information on the Black Hammock wetlands, especially the Cedar Point area, is needed to assure the preservation of the wetlands and any rare flora or fauna associated with them. Project Statement TIMU-N-30 proposes a baseline survey of wetland flora and fauna. The results of the survey will help preserve management prevent degradation to the wetlands and any species of special concern.

Park Development

As the preserve develops or improves its facilities to provide for public access to preserve resources, efforts must be made to minimize impacts to natural resources. Visitor service facilities include visitor centers, historic buildings and sites, nature trails, comfort stations, campgrounds, boat ramps, etc. Presently, the preserve operates three visitor access areas: Fort Caroline, Theodore Roosevelt Area and Kingsley Plantation. In addition, development of the Cedar Point area as a natural recreation and educational site will proceed over the next several years.

During modification or construction of visitor service facilities within the preserve, effort should be made to minimize impacts on water resources. Alteration of hydrology should be avoided, especially near the few freshwater wetlands areas known within the preserve. Impacts to native vegetation can be associated with changes in hydrology, as well as competition from introduced exotic species. All rare, threatened and endangered species should be identified and protected. The design of water producing facilities should take into account the preservation of ground water quality throughout the area by minimizing withdrawals from the Floridan aquifer if saltwater intrusion from below might be aggravated. Wastewater treatment facilities should be designed to preserve surface water quality. In particular, alternatives to septic fields should be explored -- such as raised mound/sand mound systems. At the Cedar Point site, evaluation of possible hazardous materials at the boat launch/boat servicing site should be performed before disturbing the site. Project Statement TIMU-N-30 describes a baseline survey of marsh flora and fauna that will provide important ecological information for future management and/or design and construction concerns.

WATER RESOURCES MANAGEMENT PROGRAM

The current interagency monitoring network within and adjacent to the preserve is not adequate to provide the preserve and the Timucuan Alliance with the level of information needed for responsible management of water resources.

The history of hydrologic monitoring in the preserve over the past decades has left the preserve today with a hydrological database that lacks current and organized information. Prior to establishment of the preserve there was only a modest interest in the salt marsh area of the estuary (City of Jacksonville, 1984; Florida Department of Natural Resources 1986). However, this has changed dramatically with establishment of the preserve, the proposed boundary expansions (National Park Service 1996), and the growing recognition of the preserve's importance as a component of northeast Florida's ecosystem and in general the Sea Islands estuarine ecosystem.

The preserve, with its inadequate staffing and budget support for water resources, has been forced to play a reactive role in regional and interagency activities. Although its philosophy and attitude are proactive, its active participation is limited by a lack of staff and basic information. Even the ability of the preserve to meet its internal needs is limited. The preserve recognizes that it cannot carry out its mandated responsibilities in protecting its water resources in isolation from decisions of its neighbors, both inside and outside the boundary. The development of this comprehensive water resources management plan is evidence of the preserve's recognition of its commitment to fulfilling its role of protecting the relatively pristine waters of the preserve as a part of the St. Johns and Nassau rivers ecosystems.

The preserve requires a dynamic program that will not only meet its internal needs but also enable it to play an active role in the regional context. Enactment of a preserve water resources management program is essential to fulfill both the preserve's legislative commitment, and its responsibility as a significant component of an equally-important objective -- responsible management of the overall water resources of the estuarine systems of northeast Florida.

This program should be developed by the Timucuan Alliance. As a starting point, the National Park Service envisions the following topics as forming the nucleus of the preserve's water resources program:

Inventory and Monitoring
Cooperation and Coordination
Data Management
Specific Water Resource Issues
Staff and Support Needs.

The first three components focus primarily on aspects of the hydrology program. They are critical to understanding the water regime of the preserve and surrounding lands. With this understanding, it will be possible to address the broader range of specific water resource issues in the fourth component. The fifth component defines the staffing needs and expertise necessary to support the four components of the program.

Ten proposed projects have been developed that represent actions needed at this time, some of which address immediate preserve needs within the context of these five components. They are listed by priority needs and discussed as project statements in the next section.

RECOMMENDED ACTIONS

Project statements are standard National Park Service programming documents that describe a problem or issue, discuss actions to deal with it, and identify the additional staff and/or funds needed to carry out the proposed actions. Project statements can be included in the resources management plan for the preserve. They are planning tools used to identify problems and needed actions, and programming documents used to compete with other projects and parks for funds and staff.

The project statements are listed below in order of current priority. Priorities will change as tasks are accomplished, more is learned, and decisions are made internally and externally affecting the relative urgency of various issues.

TIMU-N-31: UNDERSTAND PRESERVE-WIDE WATER RESOURCE ACTIVITIES

TIMU-N-32: INVESTIGATE PALEOECOLOGY OF SALT MARSH

TIMU-I-07: ESTABLISH COOPERATIVE AGREEMENTS FOR GIS PRODUCTS

TIMU-N-33: INVESTIGATE HYDROLOGICAL CONDITION OF ESTUARY

TIMU-N-29: NEKTON INVENTORY AND MONITORING [7]

TIMU-N-28: COMPARATIVE EVALUATION OF PHYSICAL AND BIOLOGICAL WATER QUALITY PARAMETERS

TIMU-N-34: ASSESS WATER QUALITY, STANDARDS, AND MONITORING

TIMU-N-35: ASSESS IMPACTS OF SEPTIC SYSTEMS

TIMU-N-36: HYDROLOGICAL STUDY OF SPANISH POND

TIMU-N-30: BASELINE SURVEY OF WETLAND FLORA AND FAUNA

TIMU-N-39: ECOLOGICAL SYSTEMS ANALYSIS OF THE PRESERVE

Project Statement TIMU-N-031.000

Last Update: 05/30/96 Priority: 006
Initial Proposal: 1996 Page Num: 0001

Title : UNDERSTAND PRESERVE-WIDE WATER RESOURCE ACTIVITIES Funding

Status: Funded: 0.00 Unfunded: 40.00

Servicewide Issues : N24 (OTHER (NATURAL))
Cultural Resource Type
N-RMAP Program codes : Q00 (Water Resources Management) QOl (Water Resources Management)

10-238 Package Number :

Problem Statement

Timucuan is not the typical federally-owned unit of the National Park Service. Only about 20%-30% of the preserve is actually owned by the National Park Service, and these are primarily upland areas. The preserve encompasses about 46,000 acres, basically the salt marshes and open waters between the lower St. Johns and Nassau rivers.

The Timucuan Preserve's General Management Plan (National Park Service 1996) identified over 50 different organizational entities with a direct interest in land or water stewardship in or around the preserve. The authorities under which the organizations operate are often multi-faceted. For example, the U.S. Army Corps of Engineers is not only a land owner within the preserve, but also performs maintenance dredging of the St. Johns River and the Intracoastal Waterway, as well as being involved in wetlands protection and mitigation projects.

The State of Florida has developed many water resources management and protection programs. However, the functions of particular divisions, bureaus or offices within a single agency can overlap, not only within the agency, but with other federal, state or local agencies as well. As an example, stormwater systems permitting and program planning is managed by the Florida Department of Environmental Pfotection, Bureau of Surface Water Management, for industrial, domestic-solid, utility and large marina stormwater treatment systems, by the St. Johns River Water Management District for non-point systems such as roadways and subdivision developments, by the U.S. Environmental Protection Agency for NPDES stormwater permits, and by the City of Jacksonville for stormwater management planning.

In addition, Florida has recently reorganized its two main departments dealing with water resource issues, the Florida

Department of Environmental Regulation and the Department of Natural Resources, into a single entity: the Department of Environmental Protection. This fusion was authorized in 1993, and largely accomplished in 1994. Redistribution of duties from the two former agencies into offices of the new agency has only recently been completed.

Although many different organizations deal with some aspect of water resources management in the Timucuan area, comprehensive information on the different activities of these organizations is not readily available. Federal, state, local and academic monitoring projects, research projects, permitting activities, and management programs operate as discrete and separate functions.

The General Management Plan calls for interagency cooperation through the formation of a "Timucuan Alliance." The Timucuan Alliance would coordinate the efforts of all interested parties to protect the water resources within Timucuan. As a first step, identification of functions and authorities of the various government agencies and academic institutions that have an interest in Timucuan water resources is needed.

Description of Recommended Project or Activity

A "Water Resources Protection and Management Committee" should be established under the Timucuan Alliance. Both the preserve and alliance could use this committee as a tool to identify issues, develop point papers, recommend necessary actions by appropriate entities, understand agency roles and responsibilities, and generally act as an 'omsbudman' to the preserve and alliance on interagency water resources management.

Point papers, to further elucidate, could describe places within programs or project execution wherein the preserve/alliance could interject information or suggestions concerning water resources. For example, at what point during the process of obtaining a zoning variance should the preserve/alliance provide input concerning water resources protection, and what kind of input would be appropriate? Or at what point during the development or routine operation of water quality monitoring projects could the preserve/alliance provide input on the preserve's water quality information needs?

Project Statement TIMU-N-031.000

Last Update: 05/30/96 Priority: 006
Initial Proposal: 1996 Page Num: 0003

Literature Cited

National Park Service. 1996. General management plan. Timucuan Ecological and Historic Preserve. Jacksonville, FL.

BUDGET AND FTEs:

----------------------------FUNDED ----------------------------

Source	Activity	Fund Type	Budget ($1000s)	FTEs
		Total:	0.00	0.00

----------------------------UNFUNDED

	Activity	Fund Type	Budget ($1000s)	FTEs
Year 1:	ADM	One-time	10.00	0.20
Year 2:	ADM	One-time	10.00	0.20
Year 3:	ADM	One-time	10.00	0.20
Year 4:	ADM	One-time	10.00	0.20
		Total:	40.00	0.80

(Optional) Alternative Actions/Solutions and Impacts
(No information provided)

Compliance codes : EXCL (CATEGORICAL EXCLUSION)

Explanation: 516 DM2 APP. 2, L6

Project Statement TIMU-N-032.000

Last Update: 05/29/96 Priority: 028
Initial Proposal: 1996 Page Num: 0001

Title : INVESTIGATE PALEOECOLOGY OF SALT MARSH

Funding Status: Funded: 0.00 Unfunded: 50.00

Servicewide Issues	: N20 (BASELINE DATA)	
	N07 (NAT FIRE REGM)	
Cultural Resource		
N̄-RMAP Program	: V00	(Vegetation Management)
	V02	(Native Aquatic Plant Management and Monitoring)
10-238 Package Number		

Problem Statement

Timucuan Preserve is about 75% wetlands and interspersed open waters. These areas are primarily salt marshes, one of the world's most productive ecosystems. The salt marsh plants
produce tons of organic matter each season, which decomposes into a nutrient soup called "detritus." Tidal flushing moves detritus out of the salt marsh and into estuarine waters where it forms the basis for numerous food webs, including many commercial fisheries. In addition, salt marshes act as protected spawning and nursery areas for aquatic organisms, and nesting or foraging refuges for many migratory waterfowl.

Salt marsh plants grow in low-diversity stands determined primarily by elevation, degree of tidal inundation, and water salinity. Few plants can tolerate daily flooding with salty water. Salt marsh plants have special adaptations which allow them to thrive under conditions that kill other plants. The two predominant salt marsh plants within Timucuan Preserve are smooth cordgrass *(Spartina alternif7ora)* and black needlerush *(Juncos roemerianus).* Smooth cordgrass is usually found in the low salt marsh, where tidal amplitude is most extreme. Black needlerush is often found at slightly higher elevations with reduced tidal inundation. Other plants, such is glasswort *(Salicomia*
virginica) are typically found in areas of high salinity and low tidal influence.

Timucuan salt marshes are primarily composed of smooth cordgrass, except in the southwestern portion of the preserve where black needlerush dominates. It is not clear whether the black
needlerush area (in the vicinity of Browns, Clapboard and Cedar Point creeks) has historically exhibited this vegetation pattern,

or whether the distribution of black needlerush is linked to restriction of tidal flow due to road bed build-up and culverting associated with the construction of Heckscher Drive in the 1920s. Also, the alteration of flow characteristics of the main channel of the St. Johns River through deepening and the Fulton Cut could be contributing to reduced tidal flow through Blount Island Channel and creeks connecting to it, mainly Browns and Clapboard creeks. Black needlerush decomposes slower than smooth cordgrass (Kruczynski et al. 1978), therefore displacement of cordgrass by needlerush could affect the ecological function of a salt marsh.

Vegetative communities in public-management areas adjacent to the preserve's salt marshes have been identified as having fire as part of their natural ecosystem. Prescribed burning in areas adjacent to Timucuan salt marshes creates the potential for fires within salt marshes. Presently, information on whether fire has been a historic component of the salt marsh ecosystem is not available. The response of Timucuan Preserve to potential prescribed burning in salt marsh areas will depend upon the pre-Columbian fire history of the salt marshes.

Description of Recommended Project or Activity

A research project is proposed to determine the species composition of Timucuan's salt marshes prior to engineering projects which altered the tidal hydrology in the early part of this century, and to look for evidence of fire as a natural component of the salt marsh ecosystem prior to European settlement by Europeans.

Methods to determine potential changes to wetland vegetation from engineering structures should include searches of historic literature, including documents likely to contain descriptions or pictures of the salt marshes in the preserve area. However, it is likely that such information is lacking, and that more sophisticated methods should be employed. Such a method would involve the common practice of taking salt marsh cores from relatively stable areas and then identifying the rhizomes (Orson 19%; Orson et al. 1987; Orson and Howes 1992; Niering et al. 1977; Warren and Niering 1993). Rhizomes can remain preserved in marsh peat for several thousand years (or longer). If peat rhizomes analysis is done in conjunction with some dating procedure, such as Carbon 14, Lead 210, or Cesium 137, then the observed vegetation changes can be referenced chronologically. Problematic to the preserve, is the differentiation of tidal freshwater wetlands from salt marsh peat. Chmura and Aharon

(1995) recently used stable carbon isotopic signatures to separate these wetland types. To determine that fire was a natural component of the salt marsh will need deeper cores than above. The effects of fire would be evident through charcoal or scorch layers. Also, vegetative succession in the aftermath of fires would be an ancillary result. Similar dating procedures
could also be employed to determine fire frequency. Cores should be taken from Nassau River drainage areas as well as the lower St. Johns River areas of the preserve for comparative analyses.

Budget estimates should be revised with input from a research proposal by a scientific researcher(s) with expertise in this area, since core analysis and dating procedures can be expensive. This type of research project is ideal for execution by a Master's level graduate student.

Literature Cited

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Project Statement TIMU-N-032.000

Last Update: 05/29/96 Priority: 028
Initial Proposal: 1996 Page Nunm: 0004

BUDGET AND FTEs:

------------------------ FUNDED ----------------------

Source Activity Fund Type Budget ($1000s) FTEs -Total: 0.00 0.00

---------------------- UNFUNDED ----------------------

	Activity	Fund Type	Budget ($1000s)	FTEs
Year 1:	RES	One-time	35.00	0.10
Year 2:	RES	One-time	15.0	0.10
Total:			50.00	0.20

(Optional) Alternative Actions/Solutions and Impacts
(No information provided)

Compliance codes : EXCL (CATEGORICAL EXCLUSION)

Explanation: 516 DM2 APP. 2, 1.6

Project Statement TIMU-I-007.000

Last Update: 05/29/96 Priority: 002
Initial Proposal: 1996 Page Num: 0001

Title : ESTABLISH COOPERATIVE AGREEMENTS FOR GIS PRODUCTS

Funding Status: Funded: 0.00 Unfunded: 60.00

Servicewide Issues : N06 (LAND USE PRAC)
N20 (BASELINE DATA)
Cultural Resource Type
N-RMAP Program codes : Q00 (Water Resources Management) QOl (Water Resources Management)

10-238 Package Number :

Problem Statement

Timucuan Ecological and Historic Preserve encompasses about 46,000 acres, primarily the salt marshes and open waters between the lower St. Johns and Nassau rivers. However, the preserve is not a typical unit of the national park system because the National Park Service is not the principal, if not total, landowner. Only 20 to 30% of the preserve is actually owned by the National Park Service, and these are primarily upland areas.

The preserve's General Management Plan (National Park Service 1996) identifies over 50 different organizational entities with a direct interest, either through landownership or agency mandates and responsibilities, in land or water stewardship in the area of the preserve. The General Management Plan calls for interagency cooperation through the formation of a "Timucuan Alliance." This alliance would attempt to coordinate the efforts of all interested entities in protecting the preserve's natural resources. Because the preserve is primarily water-based, these entities' interests are centered especially around water resources.

Efficient interaction and cooperation with government agencies, landowners, and private organizations responsible for or interested in water resources management in and around the preserve will require accurate spatiotemporal information for analysis and reference. In particular, land use patterns and projections of future land use must be assessed in a spatial format to grasp the effects of myriad, and often disjointed, management practiced by various entities. There is a strong correlation between land use development and the nature of water resource impacts. For example, point source pollution discharges are associated with industrial and municipal development. Land use patterns and development are also intimately linked to the severity of nonpoint pollution impacts such as urban stormwater runoff, septic system drainage fields, and habitat destruction. Nonpoint pollution impacts were recently identified as a primary threat to surface water quality in the preserve and surrounding waters (Hand et al. 1994).

The preserve also has other needs for accurate spatiotemporal information. Wetland surveys and descriptions of wetlands status are important components of long-term monitoring of wetlands. Wetland plant communities are sensitive to changes in surface hydrology and water chemistry. Detection of changes in wetland plant species associations or wetland communities through inspection of satellite imagery and periodic generation of wetlands maps are valuable as early warning indicators for potential water resources problems. Depiction and analysis of spatiotemporal information would also be important in: formulating a water quality monitoring program and analysis of physicochemical and biological parameters; modelling potential effects of past and future hydrological modifications; and assessing the impacts of nonpoint source pollution, especially septic system drainage fields.

The Timucuan Alliance will undoubtedly provide input into future land use planning activities by local, state, and other federal agencies and private individuals to assure that water resources protection within the preserve is included. Accurate land use maps, zoning maps, projected land and water use maps, various resource-based maps, and maps depicted modelling results of spatiotemporal data pertinent to impact assessment are needed to allow the alliance to make informed recommendations for water resources protection and to anticipate potential water resources problems. Several Geographic Information System operations are ongoing among local land planning agencies, primarily the St. Johns River Water Management District, Florida Department of Environmental Protection, and the City of Jacksonville. The St. Johns Water Management District has a Geographic Information System mapping operation with a relatively broad geographic scope, including both the Nassau and the Lower St. Johns rivers drainage basins, and has already embarked upon a detailed wetlands mapping program for the production of maps needed to track development and resource status in the preserve area.

Description of Recommended Project or Activity

Timucuan Preserve should establish cooperative agreements with appropriate local agencies that have active programs in geographic information systems. These cooperative agreements will be used to facilitate or match funds for the production of geographic information system products (i.e. maps or digitized data) useful for management of preserve water resources. It may be helpful to establish an agreement with the St. Johns River Water Management District (SJRWMD) for digitized base maps and essential water resources information. Agreements with other agencies would be for acquisition of appropriate database layers.

Particular GIS products that are scheduled for production by the SJRWMD over the next few years include maps of future land use projections based upon the City of Jacksonville and Northeast Florida Regional Comprehensive Plans, maps of pollutant loadings projected from water use models developed from extrapolations of water use by life-style category, and digital ortho-photo quadrats that will be useful for detection of resource changes. Although these projects are in the planning stages for the preserve, they must compete with many other mapping needs within the SJRWMD. A cooperative agreement with the SJRWMD would demonstrate interest and support of such efforts by the Timucuan Alliance and may facilitate development of mutually beneficial GIS products.

In addition to map production from existing databases, it would also be beneficial for the cooperative agreements to allow for map production based on existing and future preserve-based data. Some examples could include: location of abandoned and in-use wells; location of septic systems; location and results of water quality monitoring program in and around the preserve; results of hydrological studies and ongoing hydrological monitoring; and, baseline data (both field-based and statistically generated) on wetland and nekton surveys, especially important habitats such as nursery areas and rare, threatened, and endangered species breeding/feeding/resting areas.

The wetlands mapping program of SJRWMD has already accomplished much in the Timucuan Area. Timucuan should support the examination of SPOT and LANDSAT satellite imagery at frequent intervals to detect resource changes. Regeneration of the six 7.5 minute topographic quads that make up the Timucuan Preserve can be accomplished on a cost-share basis for about $20,000.

Literature Cited

Hand, J., J. Col, and E. Grimison. 1994. Northeast Florida district water quality assessment, 1994 305(b) technical appendix. Florida Department of Environmental Protection. Tallahassee, Florida.

National Park Service. 1996. General management plan. Timucuan Ecological and Historic Preserve, Jacksonville, Florida.

BUDGET AND FTEs:

----------------------------FUNDED----------------------------

Source	Activity	Fund Type	Budget ($1000s)	FTEs
		Total:	0.00	0.00

---------------------------UNFUNDED

	Activity	Fund Type	Budget ($1000s)	FTEs
Year 1:	ADM	One-time	15.00	0.20
Year 2:	ADM	One-time	15.00	0.20
Year 3:	ADM	One-time	15.00	0.20
Year 4:	ADM	One-time	15.00	0.20
		Total:	60.00	0.80

(Optional) Alternative Actions/Solutions and Impacts

The preserve could attempt to establish its own geographic information system program. This would involve initial investments for hardware, software, data acquisition, and the creation of a full-time Resource Management Specialist to administer the program. This program would cost over $100,000 in infrastructure dedicated costs and would require one full-time FTE over the initial 4-year period.

Also, the preserve could simply wait for GIS products to be provided by the SJRWMD or some other GIS program; however, mandates or goals/objectives from these programs are often at cross-purposes with NPS mandates and goals/objectives. Thus, this effort could result in inconsistent and often inadequate spatiotemporal information for water resources management.

Compliance codes : EXCL (CATEGORICAL EXCLUSION)

Explanation: 516 DM2 APP. 2, 1.6

Project Statement TIMU-N-033.000

Last Update: 05/30/96 Priority: 009
Initial Proposal: 1996 Page Num: 0001

Title : INVESTIGATE HYDROLOGICAL CONDITION OF ESTUARY

Funding Status: Funded: 0.00 Unfunded: 210.00

Servicewide Issues : N20 (BASELINE DATA)
C72 (PROTECTION)
Cultural Resource Type
N-RMAP Program codes : Q00 (Water Resources Management) Q01 (Water Resources Management)

10-238 Package Number :

Problem Statement

Hydrology is probably the single most important determinant for establishment and maintenance of wetlands and wetland processes. Hydrologic pathways such as precipitation, surface runoff, groundwater, tides, and flooding rivers transport energy and nutrients to and from wetlands. Water depth, flow patterns, and duration and frequency of flooding influence the biochemistry of soils and are major factors in the ultimate selection of wetland biota (Mitsch and Gosselink 1986). We need to understand wetland hydrology before we can effectively understand any of the other interactions or processes that occur in wetlands (Roman et al. 1995).

The extent and range of tidal flow from the inlets and sounds through natural and man-made channels into the upper reaches of salt marsh creeks are determining factors for estuarine and wetlands ecological functions. The tides bring nutrients to marsh plants, influence plant species distributions, transport aquatic organisms to feeding or nursery refuges, and dilute pollutants. The tides also export nutrients in the form of detritus, transport juvenile aquatic organisms to river channels or the sea, and flush out pollutants. Alteration of the flows and amplitude of tidal hydrology, therefore, could affect the ecological function of the estuarine and salt marsh systems through changes in species richness and productivity (Mitsch and Gosselink 1986).

The surface water hydrology of the Timucuan estuaries is characterized by two major river drainages, the Nassau and the lower St. Johns rivers, and the daily inundation of two tidal cycles with amplitudes from 4 to 6 feet. Since the tidal influence complicates efforts to measure stream discharges, most stream gauges have been located in the upper reaches of the

Nassau and St. Johns rivers. Descriptive information on the tidal flows and currents within the preserve has not been compiled. The tidal hydrology of preserve waters has undoubtedly been altered by human engineering activities. The lower St. Johns River has been channelized and dredged for deep-water port access in the Jacksonville area. The Sisters Creek channel has been straightened and dredged to form a section of the Intracoastal Waterway. Artificial dredge spoil islands have been created on a small scale along Sisters Creek/Intracoastal Waterway, and on a large scale with Blount and Bartram islands in the St. Johns River channel. Causeways and culverting for construction of Heckscher Drive have placed barriers to tidal sheet and channel flows into the salt marsh on the north side of the St. Johns River.

Without information on the state and functioning of the estuary prior to these engineering projects, it is difficult to assess the overall impacts to the estuarine and salt marsh ecosystems. However, the present distribution of black needlerush *(Juncus roernerianus)* as the dominant plant in the salt marshes on the north side of the St. Johns River could be a result of restricted tidal flow. Black needlerush is usually found in upper marsh areas, where tidal amplitude is slightly less than the lower marsh. Ecological restoration of estuarine salt marsh systems by reintroduction of tidal exchange is a feasible management alternative (Roman et al. 1995).

The extremely high economic and recreational values of the St. Johns River and Sisters Creek dredged channels preclude any consideration of returning these channels to their former state. However, dredging and dredge spoil deposition activities can be conducted so as to minimize impacts upon the natural resources of the preserve. Description of the present tidal hydrology of the preserve will help identify creeks and channels susceptible to any further alteration of their tidal regime.

With this information, creative arrangements for identifying dredge spoil deposition sites, monitoring impacts and evaluating mitigation success could be linked to mitigation banking from construction, dredge, and fill projects from within and near Timucuan Preserve. A hydrological model should be developed to determine watershed dynamics that affect the preserve's wetlands.

Description of Recommended Project or Activity

A three-year descriptive study of the tidal hydrology of Timucuan's estuaries and salt marshes is proposed to identify impacts of engineering projects, and to provide information needed to minimize impacts of future activities such as dredging, spoil deposition, and road reconstruction projects. A hydrological model of the preserve's estuarine system would be the ultimate goal of this project.

The study should:

1) Describe the water level fluctuations associated with tidal cycles, especially into the terminal reaches of tidal creeks, with comparisons as described above. The tide/water level regime is considered to be on par with weather as a driving force in coastal ecosystems, influencing nearly all aspects of physical and biological activity. Tidal amplitude and regularity are known to be major factors influencing *Spartina alternifora* -- the dominant species of the preserve -- which in turn dictate much of the system's functionality. Tidal regime plays an important role in determining circulation patterns, residence times, and ocean exchange in the preserve. As such, understanding local area pollution transport, fate, and effects depends upon an adequate understanding of tide/water level conditions. Even the physical condition and natural dynamics of barrier islands are governed by tide/water conditions -- tidal amplitude and frequency influence inlet dynamics, beach and shoreline configuration, and bar/shoal/mudflat morphology, while storms and flooding/washover events routinely result in dramatic physical changes on a systemwide level. The tide/water level regime is one of the key processes driving the preserve's ecosystem, a process that must be defined in order to effectively understand, and ultimately protect preserve resources.

Tide/water level gauge (automated with continuous readouts) locations or locations for regular staff gauge monitoring would be established. The criteria to be used in siting the gauges include: spatial distribution within preserve estuarine waters, tidal zones, proximity to other monitoring sites, water depth sufficient to ensure readings in all conditions, physical security, and logistical ease of access.

2) Describe the pathways of tidal flow, during flood and ebb cycles, with emphasis on comparing the efficiency of flow into

tidal creeks from major natural channels, such as Nassau River and Pumpkin Hill Creek, to flow into tidal creeks connected to deepened and straightened channels, such as the St. Johns River and Sister's Creek/Intracoastal Waterway. Also describe the extent of tidal reach into the terminal creek channels, with comparison as described above. This may be accomplished through dye studies.

3) Develop a hydrological budget for the estuarine system with the ultimate objective of estimating flushing characteristics and turnover rate. Turnover is a useful measure of how rapidly the water in a system is replaced (Mitsch and Gosselink 1986). Chemical and biotic properties are often determined by the openness of a system, and turnover rate is an index of this. To determine a hydrological budget requires estimates of precipitation, hydroperiod (through 1 above), frequency of flooding, duration of flooding, and bathymetric contours. Evapotranspiration measurements are more difficult to obtain, but one could use the Thornthwaite equation that can use meteorological variables (Chow 1964). A few shallow wells around the estuarine system can determine direction of groundwater flow. However, estimates of permeability are required to quantify flows. Carter et al. (1979) suggest determining input or loss of groundwater flow as a residual of the water budget, but this has limitations.

4) Based on current knowledge, describe and/or predict areas with a combination of appropriate tidal regime and physical configurations that indicate likely nekton nursery areas. Also, data obtained through the nekton monitoring program could be integrated into the hydrological model with the goal of predicting locations of ecologically important habitats and determining a suite of hydrological variables that "define" these habitats.

Potential partners for this major research project, such as the U.S. Geological Survey, the St. Johns River Water Management District, or the City of Jacksonville should be explored. In addition, possible support from Florida Department of Transportation through environmental compliance requirements for Heckscher Drive modifications and/or new alignments should be investigated. Budget estimates should be revised with input from a research proposal by a scientific researcher(s) with expertise in this area.

Literature Cited

Carter, V., M. Bedinger, R. Novitzki, and W. Wilen. 1979. Water resources and wetlands, in Wetlands Functions and Values: The State of Our Understanding, P. Greeson, J. Clark, and J. E. Clark, eds., American Water Resources Assoc. Minneapolis, MN.

Chow, V., ed. 1964. Handbook of applied hydrology. McGraw-Hill, New York.

Mitsch, W., and J. Gosselink. 1986. Wetlands. Van Nostrand Reinhold. New York.

Roman, C., R. Garvine, and J. Portnoy. 1995. Hydrologic modeling as a predictive basis for ecological restoration of salt marshes. Environmental Management 19(4): 559-566.

BUDGET AND FTEs:

----------------------------FUNDED----------------------------

Source	Activity	Fund Type	Budget ($1000s)	FTEs
		Total:	0.00	0.00

UNFUNDED -----

	Activity	Fund Type	Budget ($1000s)	FTEs
Year 1:	RES	One-time	50.00	0.20
	RES	One-time	20.00	0.00
		Subtotal:	70.00	0.20
Year 2:	RES	One-time	50.00	0.20
	RES	One-time	20.00	0.00
		Subtotal:	70.00	0.20
Year 3:	RES	One-time	50.00	0.20
	RES	One-time	20.00	0.00
		Subtotal:	70.00	0.20
		Total:	210.00	0.60

(Optional) Alternative Actions/Solutions and Impacts
(No information provided)

Compliance codes : EXCL (CATEGORICAL EXCLUSION)

Explanation: 516 DM2 APP. 2, 1.6

Project Statement TIMU-N-029.000

Last Update: 05/29/96 Priority: 020
Initial Proposal: 1996 Page Num: 0001

Title : NEKTON INVENTORY AND MONITORING

Funding Status: Funded: 55.80 Unfunded: 50.00

Servicewide Issues : N20 (BASELINE DATA)
N17 (BIODIVERSITY)
Cultural Resource Type
N-RMAP Program codes : W00 (Wildlife Management)
W02 (Native Aquatic Animal Management & Monitoring)

10-238 Package Number :

Problem Statement

Currently, no quantitative baseline or time-series data base exists for the aquatic fauna of Timucuan Ecological and Historical Preserve. Indeed, Timucuan lacks even a comprehensive inventory of the species comprising the aquatic fauna. Such a baseline biodiversity inventory, together with data on faunal organization (e.g., dominance rank, seasonal occurrence, habitat associations, guild structure) is fundamental to monitoring the magnitude and direction of ecosystem change on both a site-specific and between-site basis, as well as over time. Only with a baseline and regular quantitative monitoring can significant and potentially deleterious change be identified at an early stage of ecosystem modification. It is also particularly important that the Timucuan estuarine system is relatively unperturbed considering its proximity to adjacent urban, industrial, and high use recreational areas. This provides a good ecosystem reference.

Concurrently, there is a need to develop and ground-truth sensitive biotic methods of assessing and monitoring estuarine ecosystem health, productivity, and stability in existing high-quality estuaries. Protection of water resources has been guided by a focus on water qualify as a surrogate of biotic integrity in the protection of human health. Lack of integrative consideration of the importance of life-support systems has relegated water-resource systems to continuing degradation, and is likely detrimental to human health as well. The failure to use ecological principles to minimize negative impacts of human activities is arguably an important failure of the twentieth century. In an era when human activities are the dominant force influencing biological communities, proper management requires understanding of pattern and process in biological systems and development of assessment and evaluation procedures that assure protection of biological resources. That assessment must incorporate direct biological monitoring into natural resource decisions.

At the present time there are no standard methods of biological monitoring in estuaries. Historically, biological monitoring efforts of water resources used benthic organisms. However, nekton (fishes and mobile invertebrates) seem more appropriate for monitoring for a variety of reasons, many of which have been elucidated by Karr et al. (1986), Karr (1987), and Fausch et al. (1990). National Biological Service Estuarine Studies in Gainesville, Florida is currently developing a prototype sampling regime for standardized nekton monitoring, and is engaged in ground-truthing and comparative testing of nekton sampling gear aimed at standardized, scientifically-sound, and cost-effective long-term estuarine ecosystem monitoring (K. Sulak, pers. comm., National Biological Service 1994).

Besides providing basic ecological information on nekton species in the preserve, an integration of population, community, and ecosystem level measures should provide inferences regarding the relative health of the preserve's estuarine ecosystem. In particular, this information would be a useful baseline to assess the relative merits of road designs and construction techniques on Hechscher Drive. The current alignment of this roadway restricts water flow (primarily tidal) in estuarine marshes. This baseline information will enable the NPS to anticipate and provide scientific information for any proposed restoration techniques. It seems probable that reopening constricted or closed creek mouths might enhance the integrity of the nekton component through re-establishment of migration routes/patterns of the early life stages of the nekton. This in turn could improve local sport-fishing opportunities.

This project will expand upon initial work that has been completed and provide the level of documentation and baseline information needed to determine species composition, habitat affinities, and community structure of fishes and other nekton in the preserve. In addition, development and integration of ecological measures should allow inferences to be drawn regarding the relative health of the estuarine system.

Description of Recommended Project or Activity

This project will be undertaken in a partnership between the National Park Service and the National Biological Service. Its fundamental objective will be establishment of baseline ecological information on nekton inhabiting the preserve's estuarine system. Secondary objectives include: 1) development of a standardized, quantitative, and cost-effective estuarine nekton sampling program; and, 2) exploration of alternative multi-species based ratios, ranks, and frequencies as quantitative indices of trends in nekton community structure.

Research will center on qualitative, multi-gear field sampling to insure complete faunal and aquatic habitat coverage. This sampling program will provide the baseline data essential to development of quantitative parameters necessary for assessment of ecosystem health and for public information/interpretation regarding the aquatic fauna inhabiting the preserve.

The project will involve field sampling and faunal inventory for approximately two years. Nekton sampling will consist of one three-day period per month coordinated with lunar/tidal cycles for consistency over a period of 24 months. In addition, a database will be created by the National Biological Service to indicate species frequency and abundance throughout the year at selected locations in all portions of the preserve. As a part of the project, the Service will also prepare reports indicating habitat affinities, sampling distribution and relative importance of dominant species. All attempts will be made to dovetail results and/or the development of quantitative indices with the ongoing work at the St. Johns River Water Management District on development of an estuarine index of biotic integrity (Brody and Schell 1990).

Besides providing baseline data and life history information to NPS managers as well as information relating to the relative health of the preserve ecosystem; this project addresses the fundamental mandate of the National Biological Service to inventory and monitor biodiversity of the nation's ecosystems. It implements the Department of Interior's holistic, multi-species, ecosystem-based approach that guides the Service's research, as well as resource stewardship/management undertaken by the National Park Service and sister Interior agencies. The National Biological Service is currently considering the Timucuan Preserve as a candidate site for long-term estuarine nekton monitoring in national ecosystem monitoring programs.

Literature Cited

Brody, R., and J. Schell. 1990. St. Johns River index of biological integrity pilot project: scope of work. Unpublished report, St. Johns River Water Management District. Palatka, Florida.

Fausch, K., J. Lyons, J. Karr, and P. Angermeier. 1990. Fish communities as indicators of environmental degradation. Pages 123-144 in Symposium 8 of the American Fisheries Society. Bethesda, Maryland.

Karr, J. 1987. Biological monitoring and environmental assessment: a conceptual framework. Environmental Management 11:249-256.

Karr, J. K. Fausch, P. Angermeier, P. Yant, and I. Schlosser. 1986. Assessing biological integrity in running waters: a method and its rationale. Illinois Natural History Survey, Special Publication 5. Champaign, Illinois.

BUDGET AND FTEs:

---------------------------- FUNDED --

Source	Activity	Fund Type	Budget ($1000s)	FTEs
1996: PKBASE-NR	RES	One-time	7.60	0
FED-OTHER	RES	One-time	20.30	0
Subtotal:			27.90	0
1997: PKBASE-NR	RES	One-time	7.60	0
FED-OTHER	RES	One-time	20.30	0
Subtotal:			27.90	0
Total:			55.80	0

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	Activity	Fund Type	Budget ($1000s)	FTEs
Year 1:	RES	One-time	25.00	0
Year 2:	RES	One-time	25.00	0
Total:			50.00	0

Last Update: 05/29/96 Priority: 020

Initial Proposal: 1996 Page Num: 0005

(Optional) Alternative Actions/Solutions and Impacts
(No information provided)
Compliance codes : EXCL (CATEGORICAL EXCLUSION)

Explanation: 516 DM2 APP. 2, 1.6

Project Statement TIMU-N-028.000

Last Update: 05/30/96 Priority: 016
Initial Proposal: 1996 Page Num: 0001

Title : COMPARATIVE EVALUATION OF PHYSICAL AND BIOLOGICAL WATER QUALITY PARAMETERS

Funding Status: Funded: 0.00 Unfunded: 90.80

Servicewide Issues : Nll (WATER QUAL-EXT)
N20 (BASELINE DATA)
Cultural Resource Type
N-RMAP Program codes : 000 (Water Resources Management) Q01
(Water Resources Management)

10-238 Package Number :

Problem Statement

The act which established the Timucuan Ecological and Historic Preserve states that the Secretary of the Interior is authorized to preserve certain wetlands and historic and prehistoric sites in the St. Johns River valley, Florida. Purposes of the preserve as stated in the General Management Plan include: to protect and interpret the wetlands of Timucuan as a healthy functioning estuarine system; and to contribute to the protection, preservation, and management of the Nassau River/lower St. Johns river drainages.

Approximately three-fourths of the acreage within the preserve consists of either an extensive salt marsh estuary or open water; the only NPS preserve in the Southeast with a dedicated estuarine focus. The estuarine landscape and nekton fauna (fish, shrimp, and crabs) are fundamental attributes of the preserve. The quality of these resources is intimately tied to water quality and availability.

The complex Timucuan estuary appears healthy and fairly undisturbed, especially considering its proximity to adjacent urban, industrial, and high-use recreational areas. However, the landscape and waterways of the preserve have been altered substantially by past human development. The General Management Plan for the preserve seeks to increase visitor access and availability throughout the preserve and seek locations where restoration of the historic landscape may be possible to improve water quality and overall health of the estuarine system.

It may be possible to reconnect through bridging, or with additional culverting or causeways, major creeks with the St. Johns River. The current severe flow restrictions and water exchange between some of these creeks and the St. Johns River may have created a cul-de-sac effect in the south end of each creek. The result may be substantially degraded water quality (low mixing, low dissolved oxygen, temperature and salinity extremes in summer and winter, and high turbidity) and reduced species richness and diversity in the nekton in closed creek mouths, as compared to adjacent open creek mouths.

The area encompassed by this project includes a major arterial roadway, Heckscher Drive, that is currently under study by the Florida Department of Transportation for realignment, replacement, or reconstruction. The current alignment has contributed to the restricted water flow in the estuary. Data derived from this project may be used by the National Park Service to encourage the Florida Department of Transportation to examine differing designs and construction techniques when construction proposals are presented.

Composition of the nekton fauna, as compared to adjacent open creeks, will provide an excellent indicator of water quality. Prior to any planning for increased water flow via roadway alteration, a physical and biological water quality information base must be developed to substantiate the probable effects of reconnection of tidal creeks to the main river course. This information base will enable the National Park Service to anticipate and provide scientific information for any proposed restorative actions. It seems probable that reopening closed creek mouths may enhance the quality of sport fishing via reestablishment of migration routes and a nekton community indicative of high quality water.

Description of Recommended Project or Activity

This project will be undertaken between the National Park Service and the National Biological Service. The primary objective will be site specific evaluation of physicochemical and biological parameters at mouths of two study creeks (Cedar Point and Hannah Mills creeks) and two adjacent control creeks.

Physicochemical parameters will consist of temperature, salinity, pH, turbidity, and dissolved oxygen. These parameters will be monitored continuously with submersible recording Hydrolab monitors. Quantitative biological parameters will consist of species abundance rank order, rarefaction diversity, population density, species density, and seasonal species progression of top ranking members of the nekton.

The length of the project will be two years to provide a reasonable time series of data. The sampling itinerary will involve continuous physicochemical monitoring at the mouth of one closed and one open creek. Nekton sampling will consist of one, 3-day period per month coordinated with lunar/tidal cycle for consistency over the project length. Nekton will be sampled, quantitatively and consistently, inside and outside the mouths of two closed study creeks and the two adjacent control creeks.

BUDGET AND FTEs:

--------------------------- FUNDED --------------------------

	Source	Activity	Fund Type	Budget ($1000s)	FTEs
Total:				0.00	0.00

--------------------------- UNFUNDED

	Activity	Fund Type	Budget ($1000s)	FTEs
Year 1:	RES	One-time	27.00	0.50
	RES	One-time	6.30	0.20
	RES	One-time	19.10	0.00
		Subtotal:	52.40	0.70
Year 2:	RES	One-time	13.00	0.50
	RES	One-time	6.30	0.20
	RES	One-time	19.10	0.00
		Subtotal:	38.40	0.70
		Total:	90.80	1.40

(Optional) Alternative Actions/Solutions and Impacts

Compliance codes : EXCL (CATEGORICAL EXCLUSION)

Explanation: 516 DM2 APP. 2, 1.6

Project Statement TIMU-N-034.000

Last Update: 05/30/96 Priority: 008
Initial Proposal: 1996 Page Num: 0001

Title : ASSESS WATER QUALITY, STANDARDS, AND MONITORING

Funding Status: Funded: 0.00 Unfunded: 75.00

Servicewide Issues : C72 (PROTECTION)
N11 (WATER QUAL-EXT)
Cultural Resource Type
N-RMAP Program codes : Q00 (Water Resources Management) QOl
(Water Resources Management)

10-238 Package Number :

Problem Statement

The water quality of the Timucuan estuaries is generally considered good as compared to the rest of Florida's surface waters (Hand et al. 1994). Tidal flushing is acknowledged to be an important contributing factor to the relatively good water quality within Timucuan, since polluted areas with poor water quality are found in nearby upstream areas along the Nassau and lower St. Johns rivers. In addition, Timucuan Preserve contains Duval County's only remaining Class II waters, suitable for shellfish harvesting. A management goal of both the Timucuan Preserve and the City of Jacksonville's designated Special Management Area that includes the preserve, is to achieve and maintain Class II water quality standards within the preserve (National Park Service 1994; City of Jacksonville 1993a).

The Florida Department of Environmental Protection's 1994 Water Quality Assessment (Hand et al. 1994) synthesized a large amount of water quality information and presented it so that quick, general assessments of water quality status could be made relative to all of Florida's waters. However, different analysis techniques should also be used to assess the water quality status of Timucuan's waters. For example, the DEP dropped all values listed as "greater than," while many water quality analysts retain such values but ignore the "greater than" qualifier. Removing "greater than" values from the analysis also removes information about pollution events. Also, the DEP report assessed water quality status on a relative scale by converting values used to generate indices into percentile distribution values based upon the range of values seen in Florida's waters. By using a relative scale, a water body could receive a "good" rating even though water quality was degraded, if most of Florida's water bodies were even more degraded.

Analysis of water quality information to produce an objective assessment of the status of Timucuan's waters would establish the current condition of water quality within the preserve as compared to Class II water quality standards. This information will be valuable for guiding Timucuan Preserve and Timucuan Alliance efforts to protect water quality.

In addition to their assignment as Class II or Class III waters, all of Timucuan's surface waters have been designated as Outstanding Florida Waters (OFW). This designation provides an extra level of protection by placing additional factors into the review process for Florida Department of Environmental Protection permits. Any proposed action must be "clearly in the public interest," and must not cause any degradation of water quality as determined during the year before OFW designation. To take full advantage of OFW protection, the ambient water quality of OFW waters during the year before designation should be established. The waters of Timucuan Preserve were designated OFW in six different sections and time frames, but none of the ambient standards for these sections have been researched.

Coordination of the many water quality data collectors in or nearby Timucuan Preserve should be a high priority for the Timucuan Alliance. While there are many water quality monitoring projects in the area, the goals of the various projects can be quite specific, such as documentation of the dissipation plume for a particular point source discharge, or very general, such as description of general water quality in a particular drainage. Coverage of Timucuan Preserve waters is spotty, with the exception of the main stem of the St. Johns River. Water management agencies have recognized the need for consolidation of effort to increase the efficiency and scope of data collection efforts (St. Johns River Water Management District 1994). The Timucuan Alliance can be a vehicle for the coordination of water quality data collection in and nearby the preserve. Recommendations for a water quality monitoring program with good coverage of preserve waters will provide the Timucuan Alliance with a reference tool for coordinating the various water quality monitoring projects in and near Timucuan Preserve.

Description of Recommended Project or Activity

A research project is proposed to: 1) provide information on the current status of Timucuan Preserve surface water quality; 2) establish ambient water quality standards for Outstanding Florida Waters within Timucuan; and, 3) given the information obtained in

1) and 2) convene a workshop of technical experts to lay the foundation for a water quality monitoring program within the preserve.

The assessment of current status of Timucuan surface water quality should include all available data sources. The first place to begin is the National Park Service, Water Resources Division's compilation and interpretation of STORET data in and around the preserve. Because of the magnitude of this effort for 250 park units, the data analysis and interpretation will necessarily be at a basic level. A water quality analysis specialist should take this work several steps further in statistical analysis and interpretation.

While STORET provides an impressive quantity of recent data, other sources, which do not post data to STORET, should be included to augment the analysis. For example, some Federal programs, such as NOAA's E-MAP program, do not post data to STORET. Additionally, local academic researchers could have water quality information on specific studies in the Timucuan area. The water quality assessment should compare Timucuan water quality to the criteria for Class II waters.

Determination of the ambient water quality standards for Outstanding Florida Waters within the preserve should be performed in consultation with the Florida Department of Environmental Protection. OFW standards are usually established using STORET data for the year prior to the OFW designation date. If insufficient data exist to make a determination, the standards are "reasonable expected values" as estimated by water quality experts. If recent data indicate an improvement in water quality from the year before designation, the improved values become the criteria. Within this overall framework for determining OFW water quality standards, the distribution-free statistical approach of Breidt et al. (1991) offers strong quantitative advantages. In this approach, data for water quality parameters are first evaluated for data density, serial correlation, trend, seasonality, and other factors. These analyses are based on observation of data plots and application of distribution-free statistical techniques that are insensitive to outliers and are robust to relatively mild violations of basic assumptions. Distribution-free statistical methods are developed and used to derive intervals within which there is high confidence (usually greater than 95%) that the quantiles with potential use as standards for a particular parameter lie.

The lack of a systematic approach to estuarine monitoring and assessment prevents a full understanding of the threats and implementation of actions that may resolve them. The third aspect of this project requests funds to assist in the design and testing of protocols for a sustainable long-term monitoring program for water resources at Timucuan. A technical workshop is proposed that would include participants representing a range of disciplines including groundwater hydrology; physical and chemical specialists in estuarine systems; estuarine biologists; nutrient and geochemical processes; and estuarine ecology. The broad objective of the workshop will be to design a monitoring program enabling the preserve to characterize estuary status, to detect subtle and dramatic changes in water quality and/or biotic integrity over time, and to determine the causes of any observed changes. During the workshop, participants will: 1) review existing data; 2) identify monitoring objectives; 3) evaluate options for monitoring; 4) select variables to monitor and provide rationale for selection; 5) provide a sampling design enabling detection of meaningful changes and/or trends; 6) identify field and laboratory methods; and, 7) identify significant gaps in the understanding of the preserve's aquatic environment and recommend research needs.

The results from the workshop will be formulated, either by Water Resources Division staff or a contractor, into a written draft monitoring protocol. The draft protocol will be subjected to peer review by workshop participants and other scientists.

Finally, the protocol should be field tested, at least over two field seasons. Field testing of the proposed sampling (and laboratory methods, if necessary) is a critical element to the success of any long-term monitoring program. Details of sample collection, analyses, and data management must be documented and worked out in advance of implementing long-term monitoring to ensure that the program goal will be met.

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BUDGET AND FTEs:

FUNDED

Source	Activity	Fund Type	Budget ($1000s)	FTEs
Total:			0.00	0.00

UNFUNDED

	Activity	Fund Type	Budget ($1000s)	FTEs
Year 1:	RES	One-time	45.00	0.80
Year 2:	RES	One-time	30.00	0.60
Total:			75.00	1.40

(Optional) Alternative Actions/Solutions and Impacts
(No information provided)

Compliance codes : EXCL (CATEGORICAL EXCLUSION)

Explanation: 516 DM2 APP. 2, 1.6 120

Project Statement TIMU-N-035.000

Last Update: 05/29/96 Priority: 005
Initial Proposal: 1996 Page Num: 0001

Title : ASSESS IMPACTS OF SEPTIC SYSTEMS

Funding Status: Funded: 0.00 Unfunded: 80.00

Servicewide Issues : N06 (LAND USE PRAC)
N20 (BASELINE DATA)
Cultural Resource Type
N-RMAP Program codes : Q00 (Water Resources Management) QOl (Water Resources Management)

10-238 Package Number :

Problem Statement

Preserve waters were assessed as having relatively good water quality, but many subdrainages in or near the preserve have been identified as threatened by non-point source pollution (Hand et al. 1994). Non-point sources include failing septic systems.

Local and regional water management agencies have recognized the pollution threat from failed septic systems. For example, the 1989 Lower St. Johns River SWIM Plan provided funds for inspection of septic sewage systems and determined that the Duval, Clay and St. Johns Counties average violation rate was about 15% (Campbell et al. 1993). This information is being used by the City of Jacksonville to prioritize and proceed with enforcement and conversion to utility service connections.

Although much work to remove failing septic systems from operation through regionalization and connection to sewage systems has been accomplished, septic drainage fields remain a common waste treatment choice in and around Timucuan Preserve which is relatively remote from the urban facilities.

The potential for pollution to water resources from septic system failures includes ground as well as surface waters. Since the surficial aquifer is unconfined of semi-confined, it is susceptible to contamination from pollution sources such as failing septic fields, storm runoff, landfill leachate, toxic materials dumps and brackish water infiltration (Causey and Phelps 1978). The Timucuan salt marshes and estuaries receive waters primarily through tidal action and rainfall. Although scientific information on the hydrology of the salt marshes is not currently available, informed assessments by hydrologists familiar with the area estimate that surface runoff and
percolation from nearby upland areas account for about 10% of the

water input into the salt marsh system (Durden and Williams, pers. comm., St. Johns River Water Management District, 1995). Present septic systems in nearby upland areas, and the installation of new septic systems, create an opportunity for pollution through sub-optimal design or actual failure.

Several potential avenues for reducing the possibility of pollution from septic sources exist. The City of Jacksonville's Special Management Areas Plan (Timucuan is one of four special management areas in the city) included a management recommendation to "assure wastewater facilities, including septic systems, do not degrade water quality" (City of Jacksonville 1993a). With reliable information on septic system failures, cumulative impacts, and alternative designs, the City of Jacksonville could possibly adjust land use and development activities to reduce pollution.

Much of preserve is also the Nassau River-St. Johns River Marshes State Aquatic Preserve and is afforded protection against water quality degradation through permit review for dredge and fill, development leases, and dock facilities. All proposed uses must be shown to be clearly in the public interest, and cumulative impacts should be considered as well as direct impacts.
Information on cumulative impacts from the typical septic system design could be incorporated into the consideration of cumulative impacts for those activities reviewed by the state aquatic preserve.

Description of Recommended Project or Activity

A research study is proposed to assess the status and cumulative impacts of septic systems in Timucuan Preserve area, and provide recommendations for modifications of septic system design intended to reduce potential for non-point pollution.

The investigation will include:

1) archival research to locate and eventually map extant septic systems;

2) estimation of the current rate of septic failure among systems in area within and adjacent to Timucuan. Methods used must not infringe upon any private landowner's privacy or property rights. Information could be obtained from City of Jacksonville and other local or regional agencies. Site inspections of willing property owners is another option. Test wells in publically-owned land near septic drainage fields could also produce information;

3) assessment of cumulative impacts based upon the estimated failure rate from above, and projected development as extrapolated from current and proposed zoning designations; and

4) recommendations for improvements to septic system design to reduce failure rates and, in general, reduce cumulative impacts. Alternatives to septic fields should also be explored, such as raised mound/sand mound systems.

Potential partners for collaboration on this research project should be investigated. The City of Jacksonville and the St. Johns River Water Management District are the most likely collaborators with a vested interest and the potential for matching funds.

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Project Statement TIMU-N-035.000

Last Update: 05/29/96 Priority: 005
Initial Proposal: 1996 Page Num: 0004

BUDGET AND FTEs:

--------------------------- FUNDED --------------------------

Source	Activity	Fund Type	Budget ($1000s)	FTEs
		Total:	0.00	0.00

UNFUNDED --

		Activity	Fund Type	Budget ($1000s)	FTEs
Year 1:		RES	One-time	0.00	0.00
	Cooperator	RES	One-time	20.00	0.00 ------
			Subtotal:	40.00	0.00
Year 2:		RES	One-time	10.00	0.00
	Cooperator	RES	One-time	10.00	0.00
			Subtotal:	20.00	0.00
Year 3:		RES	One-time	10.00	0.00
	Cooperator	RES	One-time	10.00	0.00
			Subtotal:	20.00	0.00
			Total:	80.00	0.00

(Optional) Alternative Actions/Solutions and Impacts
(No information provided)

Compliance codes : EXCL (CATEGORICAL EXCLUSION)

Explanation: 516 DM2 APP. 2, 1.6

Project Statement TIMU-N-036.000

Last Update: 05/30/96 Priority: 002
Initial Proposal: 1996 Page Num: 0001

Title : HYDROLOGICAL STUDY OF SPANISH POND

Funding Status: Funded: 0.00 Unfunded: 50.00

Servicewide Issues : N12 (WATER FLOW)
C70 (ENVRM IMPCT)
Cultural Resource Type
N-RMAP Program codes : Q00 (Water Resources Management) Q01
(Water Resources Management)

10-238 Package Number :

Problem Statement

Spanish Pond is the only freshwater pond within Timucuan Ecological and Historic Preserve presently under federal ownership. The pond is an ecologically and historically significant feature of Fort Caroline National Memorial. Historic significance derives from the possibility that Spanish soldiers camped at the pond before attacking the French settlement at Fort Caroline. Ecologically, the pond is the preserve's only freshwater wetland associated with a persistent, open freshwater body.

In the past 30 to 40 years the water level in the pond has fluctuated with times of high water levels and other periods where the pond became dry. Prior to the early 1970s the surrounding area was rural with minimal development except along the bluffs on Fort Caroline Road and fluctuating water levels did not impact private property. Increasing development has transformed the area into a suburban landscape with 135 homes and the potential for 11 additional construction starts surrounding the pond along Fort Caroline Road and in two subdivisions. The development increased the amount of impermeable surface surrounding the pond and has been sited in areas that are impacted when the pond is in a high water cycle. Additionally, permitted stormwater retention ponds were required to retain only the first inch of water in a rain event, allowing the excess to drain towards the pond. In 1995, septic systems in approximately six to eight homes failed during the highest water levels, which also posed a potential damage to road surface and base of Fort Caroline Road.

Water quality may have been impacted by the failure of the septic systems. Previous water quality sampling indicates that water quality in Spanish Pond was generally good, with the exception of dissolved oxygen levels (Morton and Marchman 1993). Sediment

Project Statement TIMU-N-036.000

Last Update: 05/30/96 Priority: 002
Initial Proposal: 1996 Page Num: 0001

Title : HYDROLOGICAL STUDY OF SPANISH POND

Funding Status: Funded: 0.00 Unfunded: 50.00

Servicewide Issues : N12 (WATER FLOW)
C70 (ENVRM IMPCT)
Cultural Resource Type
N-RMAP Program codes : Q00 (Water Resources Management) QOl (Water Resources Management)

10-238 Package Number :

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Water quality may have been impacted by the failure of the septic systems. Previous water quality sampling indicates that water quality in Spanish Pond was generally good, with the exception of dissolved oxygen levels (Morton and Marchman 1993). Sediment analysis for metals, pesticides, and other organics revealed elevated levels of lead and zinc, both known to be common constituents of stormwater runoff associated with roads. Morton and Marchman (1992) concluded that although instantaneous water column contamination during good weather is low, sediments are moderately contaminated and adverse biological impacts cannot be ruled out.

Description of Recommended Project or Activity

A hydrological study of Spanish Pond is necessary to evaluate its present and pre-development (if possible) conditions and to provide information needed to minimize impacts from additional development and provide necessary hydrological information to assist in developing appropriate engineering designs to alleviate the current impacts to public and private lands.

The study will consist of three major aspects, as described below, and the study should also be considered an appropriate monitoring program to determine the effectiveness of any mitigative design/construction:

1) Assess Hydrological Conditions

Develop a hydrological budget for the pond which requires bathymetric contours and estimates of water inputs (e.g. precipitation, groundwater) and outputs (overflow, evaporation). Estimate turnover rate which is a useful measure of how rapidly the water in the system is replaced. An estimate of turnover rate should be useful in determining drainage designs that will negate impacts to residential development and, at the same time, foster appropriate conditions for biological development (e.g., primary and secondary productivity).

2) Assess Spanish Pond Water Quality

On a monthly basis, the following water quality parameters will be monitored to determine levels of nutrients, productivity, and oxygen. Episodic monitoring, that is monitoring after a significant precipitation event, should be done to determine contaminant inputs from surrounding development.

a. Diurnal patterns of dissolved oxygen, especially over the warmest months of the year.

b. Profiles of temperature, pH, and conductivity to evaluate the degree of stratification/mixing.

c. Productivity, as measured by chlorophyll a.

d. Determine nature of pond sediments and sedimentary oxygen demand.

e. Determine levels of nitrates, phosphates total nitrogen, and total phosphorus.

f. Determine total and fecal coliform levels in pond water.

3) Inventory Aquatic Biota

A base inventory of macroinvertebrates, both benthic and planktonic, will be conducted to determine:

a. species occurrence and relative abundance;

b. relationships of species occurrence and relative abundance and species diversity to physicochemical conditions.

Literature Cited

Morton, D., and L. Marchman. 1993. Results of 1993 wqater testing of Spanish Pond. City of Jacksonville, Department of Regulatory and Environmental Services. Jacksonville, Florida. 7 pp.

BUDGET AND FTEs:

--------------------------- FUNDED --------------------------

Source Activity Fund Type Budget ($1000s) FTEs - - - - - - - - -
- - - - - - - - - - - - - -Total:0.00 0.00

--------------------------- UNFUNDED

	Activity	Fund Type	Budget ($1000s)	FTEs
Year 1:	MON	One=time	25.00	0.30
Year 2:	MON	One-time	25.00	0.30
		Total:	50.00	0.60

Last Update: 05/30/96 Priority: 002
Initial Proposal: 1996 Page Num: 0004

(Optional) Alternative Actions/Solutions and Impacts
(No information provided)

Compliance codes : EXCL (CATEGORICAL EXCLUSION)

Explanation: 516 DM2 APP. 2, 1.6

Project Statement TIMU-N-030.000

Last Update: 06/03/96 Priority: 029
Initial Proposal: 1996 Page Num: 0001

Title : BASELINE SURVEY OF WETLAND FLORA AND FAUNA

Funding Status: Funded: 0.00 Unfunded: 25.00

Servicewide Issues : N17 (BIODIVERSITY)
N20 (BASELINE DATA)
Cultural Resource Type
N-RMAP Program codes : V00 (Vegetation Management)
VOl (Native Terrestrial Plant Management and Monitoring)

10-238 Package Number :

Problem Statement

The majority of the Timucuan Preserve is intertidal marsh. Saline marshes characterized by single dominant plant species occur in eastern sections with brackish to freshwater tidal marshes of greater plant diversity in the west. The fresher marshes lie along creeks that drain low lying land to the west of the preserve.

Fiddler crabs are the most conspicuous animal in tidal marshes and are as important as earthworms in garden soils. They continually burrow into marsh sediments, resulting in considerable stimulation of plant production and decomposition. They.are important ecological links to estuarine fish and wildlife and are consumed by redfish, blue crabs, egrets, rails, raccoons, and other animals. Four species of fiddler crab occur in the preserve including one that heretofore has not been reported north of St. Augustine.

The presence of particular species of plants and the ubiquitous fiddler crabs in different areas of the preserve indicates much about the intertidal environment. The distributions of these biota are determined in large part by soil salinity, water level, regularity of tidal flooding, and sediment type. Therefore, a characterization of plants and conspicuous animals can lead to a classification of marsh habitats in the preserve, a habitat map, and quantification of areal coverage of each habitat type.

Tidal marsh is quantitatively the most important ecological component of the preserve, but no ground level assessment of major intertidal biotic components or description of areal coverage by different marsh types is available. Such an assessment is needed to document the biotic resources of the park so that appropriate public areas, scientific study, and protection can be planned and initiated.

Major intertidal biota can be identified by a combination of ground level surveys, aerial reconnaissance, and interpreting of existing aerial photos. The St. Johns River Water Management District (SJRWMD) has a collection of aerial photos from which they have produced vegetation maps for the eastern part of the preserve. These maps include a useful level of detail for distinguishing among two prevalent types of saline tidal marsh: regularly flooded marsh dominated by smooth cordgrass and irregularly flooded marsh dominated by black needlerush. However, in brackish to fresh areas and at higher intertidal elevations, many other plant species occur in mixtures that are not distinguishable without field surveys. Some of these areas are indicated on the SJRWMD vegetation map as "intermediate marsh," or by other similar names in which particular species are not indicated. The SJRWMD vegetation maps and collection of aerial photos can be used as a guide for initiating field surveys yielding greater utility for preserve planning. Since these maps are produced from a computerized database, field data can be added to update them.

Description of Recommended Project or Activity

This project will be undertaken in partnership between the NPS and the University of Florida, with cooperation from the National Biological Service, whose ongoing project on nekton can supply logistical support, and the SJRWMD, whose photo-interpretation and GIS personnel will provide valuable guidance and analytical assistance. The primary objectives are to identify major biotic resources in the tidal marshes of the preserve, classify and map distinctive marsh types, and integrate mapped areas to provide a quantified coverage by type of tidal marsh habitat.

Field surveys will be done to identify vascular plant species composition and to collect information on soil characteristics, water level, and distribution of conspicuous animals (fiddler crabs, snails, bivalves). Soil characterization will include soil salinity and moisture and percent sand, silt, clay, and organic matter. Plants and animals will be identified to the lowest taxonomic level possible, given the limitations of available taxonomic keys and the time of collection. A species list and classification of intertidal marshes within the preserve will be developed from these data.

Support of this project should encourage SJRWMD to complete its vegetation mapping within preserve boundaries ahead of the many unfinished quadrangles within their district. Their photo-interpreters have expressed a desire to interact with the NPS and University for this purpose. The intent is to encourage that process of supplying refined data from field surveys and, if possible, a student intern from the University to assist.

All SJRWMD mapping information is in a large ARCINFO GIS database. Biotic and environmental field information will be added to the database to allow a more refined classification scheme of the preserve.

BUDGET AND FTEs:

----------------------------FUNDED --------------------------

Source	Activity	Fund Type	Budget ($1000s)	FTEs
		Total:	0.00	0.00

--------------------------UNFUNDED

	Activity	Fund Type	Budget ($1000s)	FTEs
Year 1:	RES	One-time	10.00	0.10
	RES	One-time	5.00	0.00
		Subtotal:	15.00	0.10
Year 2:	RES	One-time	7.00	0.10
	RES	One-time	3.00	0.00
		Subtotal:	10.00	0.10
		Total:	25.00	0.20

(Optional) Alternative Actions/Solutions and Impacts
(No information provided)

Compliance codes : EXCL (CATEGORICAL EXCLUSION)

Explanation: 516 DM2 APP. 2, 1.6

Project Statement TIMU-N-039.000

Last Update: 09/26/96 Priority: 030
Initial Proposal: 1996 Page Num: 0001

Title : ECOLOGICAL SYSTEMS ANALYSIS OF THE PRESERVE

Funding Status: Funded: 0.00 Unfunded: 150.00

Servicewide Issues : N20 (BASELINE DATA)
N09 (COASTAL DYNAM)
Cultural Resource Type
N-RMAP Program codes : Q00 (Water Resources Management) Q01 (Water Resources Management)

10-238 Package Number :

Problem Statement

The goals of the general management plan for the Timucuan Ecological and Historic Preserve include: a) defining the role of the preserve in northeastern Florida; b) minimizing threats to its component ecosystems; and, c) facilitating maximum regional benefit from the preserve (National Park Service 1996). However, no coherent systems study has ever been done of the area at the scale of the preserve. An ecological systems analysis at this scale can help implement these three important management goals by: a) synthesizing information into a quantitative analysis of the current ecological state of the preserve; b) providing a quantitative comparison of the preserve with its surroundings; and, c) forecasting changes in the preserve's ecological state under various scenarios of environmental changes or management actions.

A useful initial analysis need not wait for coherent field studies. Instead it can be based in part on the considerable water resources information reviewed in the preserve's water resources management plan and on estimates taken from well-studied similar areas elsewhere. In fact, the initial analysis can help prioritize needed research. Sensitivity analysis demonstrates the consequences to management of inaccuracies in information and pinpoints those that have the most dramatic consequences. These then can be moved nearer the top of the priority list.

Although the management plan for the preserve includes references to a considerable amount of relevant water resources information, a general lack of ecological information from within the preserve boundary is apparent. Unlike most marsh-dominated estuaries in Florida, however, those of northeastern Florida are geophysically related to the well-studied ones in Georgia and South Carolina

(Montague and Wiegert 1990). Published results from these areas should be applicable at least to provide plausible initial estimates for quantifying flows and storages in the preserve ecosystems. Hence a quantified conceptual analysis can now be based on present information from within the preserve supplemented by information from better documented but similar areas. A sensitivity analysis of the resulting model system can point to critical areas of needed research.

Description of Recommended Project or Activity

A modern ecological systems analysis includes both static and dynamic models of key variables in the system. These key variables cannot include everything, but must be identified relative to a particular management objective or problem. Hence, system identification is the first step of a systems study. The chosen key variables are usually represented in the systems diagram that accompanies a study. An example of a diagram for a salt marsh-dominated estuarine system is given in Montague and Odum (1996). This diagram identifies some of the primary flows and storages that must be considered in both static and dynamic analyses. The current state of the preserve will be examined through a static analysis of flows and storages. A dynamic simulation model will be constructed that predicts patterns of change in key variables under different scenarios.

At a minimum, predictions from the dynamic model must be plausible, and be produced by plausible chains of cause and effect using plausible values for coefficients. Hence, both relational and quantitative estimates are included in a model. These are subject to development, examination, and alteration by all those involved for whom the model is being built.
Eventually, the model will represent the highest level of understanding possible given present knowledge about the preserve. This then will be subjected to a sensitivity analysis useful for prioritizing information needs.

The static analysis proposed for assessing the current state of the preserve within the context of a larger regional system is H.T. Odum's "emergy analysis" (Odum 1996). This analysis measures the energy required to produce and maintain every component represented in a system, whether it be made naturally or through manufacturing. Therefore, it measures the energy "embodied" in a product. This has led to the term "emergy." Its main feature is that it allows a fair comparison among varied products by expressing all forms of energy in equivalent energy terms (solar energy).

One characteristic of emergy analysis is the thoroughness that is required to do one. An estimate for every important flow or storage is needed, which leads to a thorough review of all sources of information. By itself, this can be a useful product, but emergy analysis also provides a standardized quantitative synthesis of this knowledge that can be compared to the region within which the preserve sits and to other estuarine and regional analyses that have been completed (e.g., Brown et al. 1993; Engle et al. 1995) Furthermore, emergy analysis is useful for weighing the overall consequences of different management scenarios by computing the emergy contribution of proposed changes (Odum 1996).

In summary, a systems analysis is proposed for the Timucuan Ecological and Historical Preserve that will quantitatively synthesize present information, predict future conditions within the limits of current understanding, help prioritize research needs, and place the preserve into the larger regional context of northeastern Florida. This analysis will facilitate the management goals of defining the role of the preserve in northeastern Florida, minimizing threats to its component ecosystems, and maximizing regional benefit from the preserve.

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BUDGET AND FTEs:

----------------------------FUNDED----------------------------

Source	Activity	Fund Type	Budget ($1000s)	FTEs
		Total:	0.00	0.00

------------------------- UNFUNDED

	Activity	Fund Type	Budget ($1000s)	FTEs
Year 1:	RES	One-time	50.00	0.00
Year 2:	RES	One-time	50.00	0.00
Year 3:	RES	One-time	50.00	0.00
		Total:	150.00	0.00

[The $50,000.00 per year is sufficient to support one doctoral student, one month of summer salary and required academic year support for the principal investigator, and necessary travel funds. fee waivers, student assistance support, computer support, and indirect costs (approximately 45% of direct costs)]

(Optional) Alternative Actions/Solutions and Impacts
(No information provided)

Compliance codes : EXCL (CATEGORICAL EXCLUSION)

Explanation: 516 DM2 APP. 2, 1.6

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APPENDICES

APPENDIX A. CRITERIA FOR FLORIDA SURFACE WATER QUALITY CLASSES II AND III. Does not contain all parameters for which criteria have been established.

PARAMETER	UNITS	CLASS II: SHELLFISH PROPAGATION *OR* HARVESTING	CLASS HI: RECREATION, PROPAGATION *AND* MAINTENANCE *OF A* HEALTHY, WELL-BALANCED POPULATION OF FISH AND WILDLIFE	
			PREDOMINANTLY FRESH WATERS	PREDOMINANTLY MARINE *WATERS*
Alkalinity	Milligrams/1 as $CaCO_3$		Shall not be depressed below 20	
Aluminum	Milligrams/1	[5]51.5		51.5
Ammonia (un-ionized)	Milligrams/1 as NH_3		50.02	
Arsenic (total)	Micrograms/I	[5]_50	550	[5]_50
Bacteriological Quality (Fecal Coliform Bacteria)	Number per 100 ml (Most Probable Number (MPN) or Membrane Filter (MF)	MPN shall not exceed a median value of 14 with not more than 10% of the samples exceeding 43	MPN or MF counts shall not exceed monthly average of 200, nor exceed 400 in 10% of the samples, nor exceed 800 on any one day. Monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over	MPN or MF counts shall not exceed a monthly average of 200, nor exceed 400 in 10% of the samples, nor exceed 800 on any one day. Monthly averages shall be expressed as geometric means based on a minimum of 10 samples
Bacteriological Quality (Total Coliform Bacteria)	Number per 100 ml (MPN or MF)	Median MPN shall not exceed 70, and not more than 10% of the samples shall exceed an MPN of 230	51,000 as a monthly average, nor exceed 1,000 in more than 20% of the samples examined during any month, 52,400 at any time. Monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30-day period, using either the	51,000 as a monthly average, nor exceed 1,000 in more than 20% of the samples examined during any month, 5_2,400 at any time. Monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30-day period, using either the
Biological Integrity	Per cent reduction of Shannon-Weaver Diversity Index	The index for benthic macroinvertebrates shall not be reduced to less than 75% of established background levels as measured using organisms retained by a U.S. Standard No. 30 sieve and collected and composited from a minimum of three natural substrate samples taken with Ponar type samplers with minimum sampling	The index for benthic macroinvertebrates shall not be reduced to less than 75% of established background levels as measured using organisms retained by a U.S. Standard No. 30 sieve and collected and composited from a minimum of three Hester-Dendy type artificial substrate samplers of 0.10 to 0.15 m^2 area each, incubated	The index for benthic macroinvertebrates shall not be reduced to less than 75% of established background levels as measured using organisms retained by a U.S. Standard No. 30 sieve and collected and composited from a minimum of three natural substrate samples taken with Ponar type samplers with minimum
BOD (Biochemical Oxygen Demand)		Shall not be increased to exceed values which would cause dissolved oxygen to be depressed below the limit established for each class and, in no case, shall it be great enough to produce nuisance conditions.		
Cadmium	Micrograms/I	59.3	Cd 5_ $_c$(0.7852[InHI—3.49)	

APPENDIX A. **CRITERIA FOR FLORIDA SURFACE WATER QUALITY CLASSES II AND III (CONTINUED)**

PARAMETER	**UNiTS**	**CLASS** II	CLASS III: **FRESH**	CLASS III: MARINE
Chlorides	Milligrams/l	Not increased more than 10% above normal background. Normal daily and seasonal fluctuations shall be maintained.		Not increased more than 10% above normal background. Normal daily and seasonal fluctuations shall be maintained.
Conductance, Specific	Micromhos/cm		Shall not be increased more than 50% above background or to 1275, whichever is greater.	
Dissolved Oxygen	Milligrams/1	Shall not average less than5.0 in a 24-hour period and shall never be less than 4.0. Normal daily and seasonal fluctuations above these levels shall be maintained.	Shall not be less than 4.0. Normal daily and seasonal fluctuations above these levels shall be maintained.	Shall not average less than 5.0 in a 24-hour period and shall never be less than 4.0. Normal daily and seasonal fluctuations above these levels shall be maintained.
Iron	Milligrams/1	[5]50.3	551.0	[5]50.3
Lead	Micrograms/1	5_5.6	Pb_c(1.273[lnH]—4.705), 50 max	5_5.6
Mercury	Micrograms/I	[5]_0.025	[5]_0.012	[5]_0.025
Nutrients		The discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in this chapter. Man-induced nutrient enrichment (total nitrogen or total phosphorus) shall be considered degradation in relation to the provisions of Sections 17-302.300, 17-302.700, and 17-.242, F.A.C. In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna.		
pH (Class ii Waters)	Standard Units	Shall not vary more than one unit above or below natural background of coastal waters as defined in Section 17-302.520(3)(b), F.A.C., or more than two-tenths unit above or below natural background of open waters as defined in Section 17-302.520(3)(f), F.A.C., provided that the pH is not lowered to less than 6.5 units or raised above 8.5 units. If natural background is less than 6.5 units, the pH shall not vary below natural background or vary more than one unit above natural background for coastal waters or more than two-tenths unit above natural background for open waters. If natural background is higher than 8.5 units, the pH shall not vary above natural background or vary more than one unit below natural background of coastal waters or more than two-tenths unit below natural background of open waters.		
pH (Class III Waters)	Standard Units	Shall not vary more than one unit above or below natural background of predominantly fresh waters and coastal waters as defined in Section 17-302.520(3)(b), F.A.C., or more than two-tenths unit above or below natural background of open waters as defined in Section 17.302.520(3)(f), F.A.C., provided that the pH is not lowered to less than 6 units in predominantly fresh waters, or less than 6.5 units predominantly marine waters, or raised above 8.5 units. If natural background is less than6 units, in predominantly fresh waters or 6.5 units in predominantly marine waters, the pH shall not vary below natural background or vary more than one unit above natural background of predominantly fresh waters and coastal waters, or more than two-tenths unit above natural background of open waters. If natural background is higher than 8.5 units, the pH shall not vary above natural background or vary more than one unit below natural background of predominantly fresh waters and coastal waters, or more than two-tenths unit below natural background of open waters.		
Polychlorinated Biphenyls (PCBs)	Micrograms/1	5_0.000045 annual average; 0.03 maximum	50.000045 annual average; 0.03 maximum	5_0.000045 annual average; 0.03 maximum

PARAMETER	UNITS	CLASS II	CLASS III: FRESH	CLASS **HI:** MARINE
Polycyclic Aromatic Hydrocarbons (PAHs). Total of Acenaphthylene, Benso(a)anthracene; Benso(a)pyrene, Benso(b)fluoranthene, Benzo(ghi)perylene, Benzo(k)fluoranthene; Chrysens, Dibenzo-(a,h)anthracene, Indeno(1,2,3-	Micrograms/1	5_0.031 annual average	5_0.03 annual average	5_0.031 annual average
Transparency	Depth of the compensation point for photosynthetic activity	Shall not be reduced by more than 10% as compared to the natural background value.	Shall not be reduced by more than 10% as compared to the natural background value.	Shall not be reduced by more than 10% as compared to the natural background value.
Turbidity	Nephelometric Turbidity Units (NTU)	5_29 above natural background conditions	5_29 above natural background conditions	5_29 above natural background conditions

APPENDIX B. COPIES OF THE DRAFT WATER RESOURCES MANAGEMENT PLAN DISTRIBUTED FOR REVIEW

National Biological Service
Southeastern Biological Science Center
7920 NW 71st Street
Gainesville, Florida 32653

Florida Department of Environmental Protection
7825 Baymeadows Way, Suite B200 Jacksonville,
Florida 32256

Jacksonville Department of Environmental Sciences
Air and Water Quality Division
421 W. Church Street, Suite 422
Jacksonville, Florida 32202

Jacksonville Planning and Development Department
Florida Theatre Building, Suite 700
128 East Forsyth Street
Jacksonville, Florida 32202

U.S. Fish and Wildlife Service
6620 Southpoint Drive South, Suite 310
Jacksonville, Florida, 32216

U.S. Environmental Protection Agency
Wetland Regulatory Section
345 Courtland Street NE
Atlanta, Georgia 30308

U.S. Army Corps of Engineers
Environmental Branch
P.O. Box 4970
Jacksonville, Florida 32232

U.S. Navy
Mayport Naval Station
Mayport, Florida 32208

U.S. Navy
Naval Facilities Command
P.O. Box 190010
Charleston, South Carolina 29419

U.S. Coast Guard
Marine Safety Office
7820 Arlington Expressway, Suite 400
Jacksonville, Florida 32111

St. Johns River Water
Management District 7775
Baymeadows Way, Suite 102
Jacksonville, Florida 32256

St. Johns River Water
Management District P.O. Box
1429
Palatka, Florida 32178

Talbot Islands State Parks 12157
Heckscher Drive Jacksonville,
Florida 32226

Congaree Swamp National
Monument Resource Management
200 Caroline Sims Road
Hopkins, South Carolina 29061

Gulf Islands National Seashore
Resource Management
1801 Gulf Breeze Parkway Gulf
Breeze, Florida 32561

Big Cypress National Preserve
Resource Management
HCR 61, Box 110
Ochopee, Florida 33942

Southeast Field Area National
Park Service 75 Spring St. SW
Atlanta, Georgia 30303

Southeast Field Area
Atlantic Coast System Support
Office National Park Service
75 Spring St. SW
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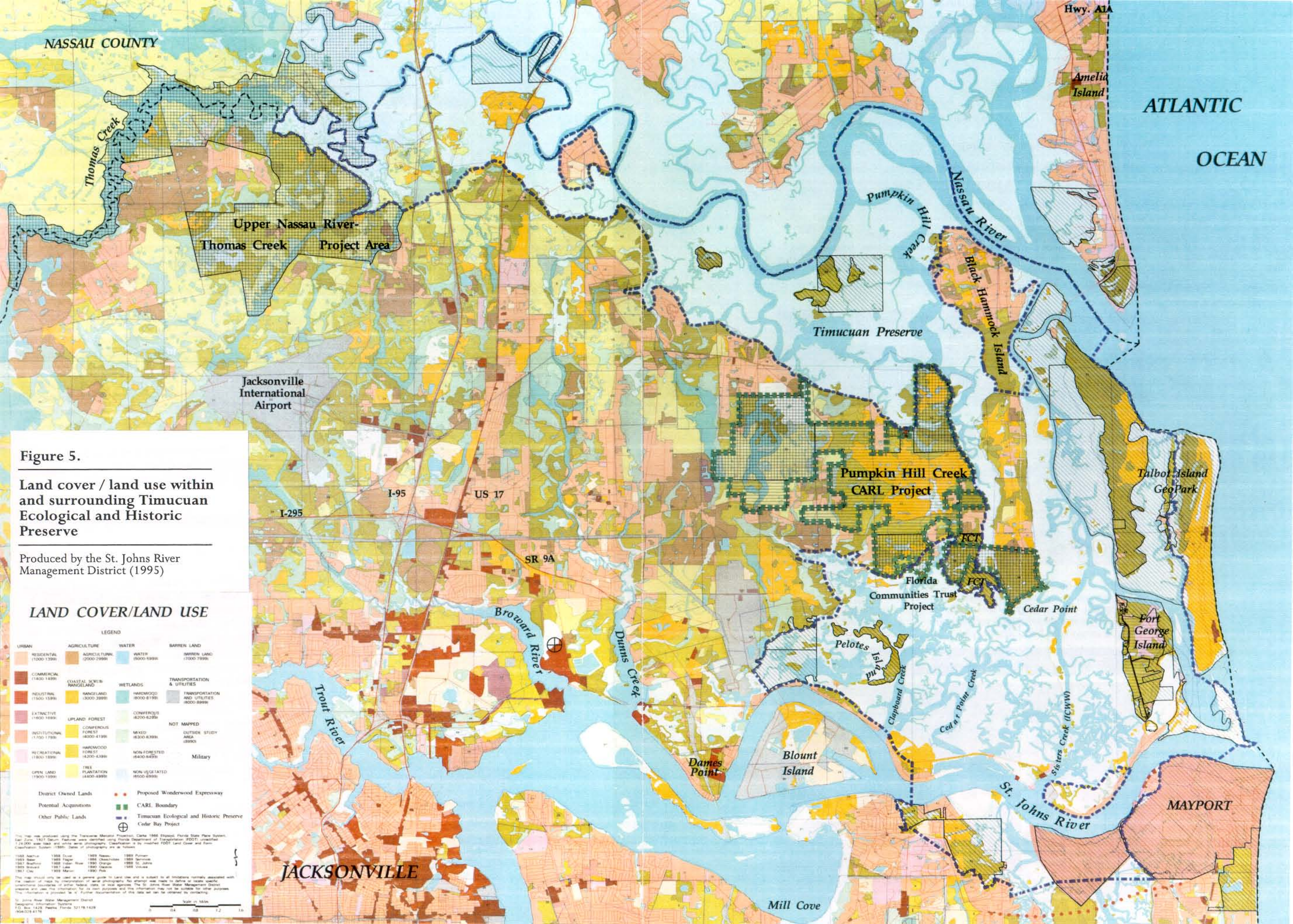

Figure 5.

Land cover / land use within and surrounding Timucuan Ecological and Historic Preserve

Produced by the St. Johns River Management District (1995)

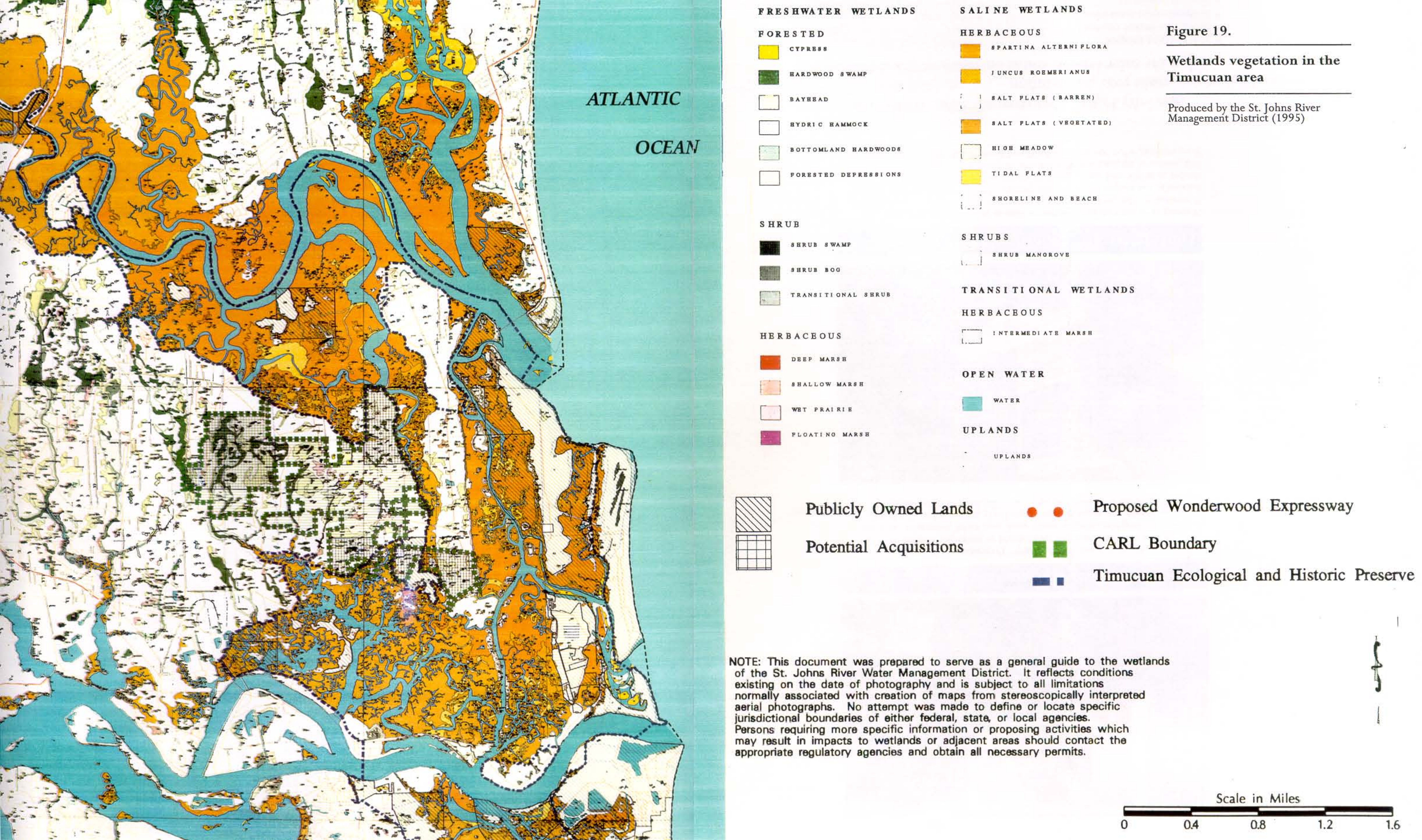

Figure 19.

Wetlands vegetation in the Timucuan area

Produced by the St. Johns River Management District (1995)

NOTE: This document was prepared to serve as a general guide to the wetlands of the St. Johns River Water Management District. It reflects conditions existing on the date of photography and is subject to all limitations normally associated with creation of maps from stereoscopically interpreted aerial photographs. No attempt was made to define or locate specific jurisdictional boundaries of either federal, state, or local agencies. Persons requiring more specific information or proposing activities which may result in impacts to wetlands or adjacent areas should contact the appropriate regulatory agencies and obtain all necessary permits.