TECHNICAL PUBLICATION SJ2007-1

MINIMUM FLOWS AND LEVELS DETERMINATION: ST. JOHNS RIVER AT STATE ROAD 50, ORANGE AND BREVARD COUNTIES, FLORIDA

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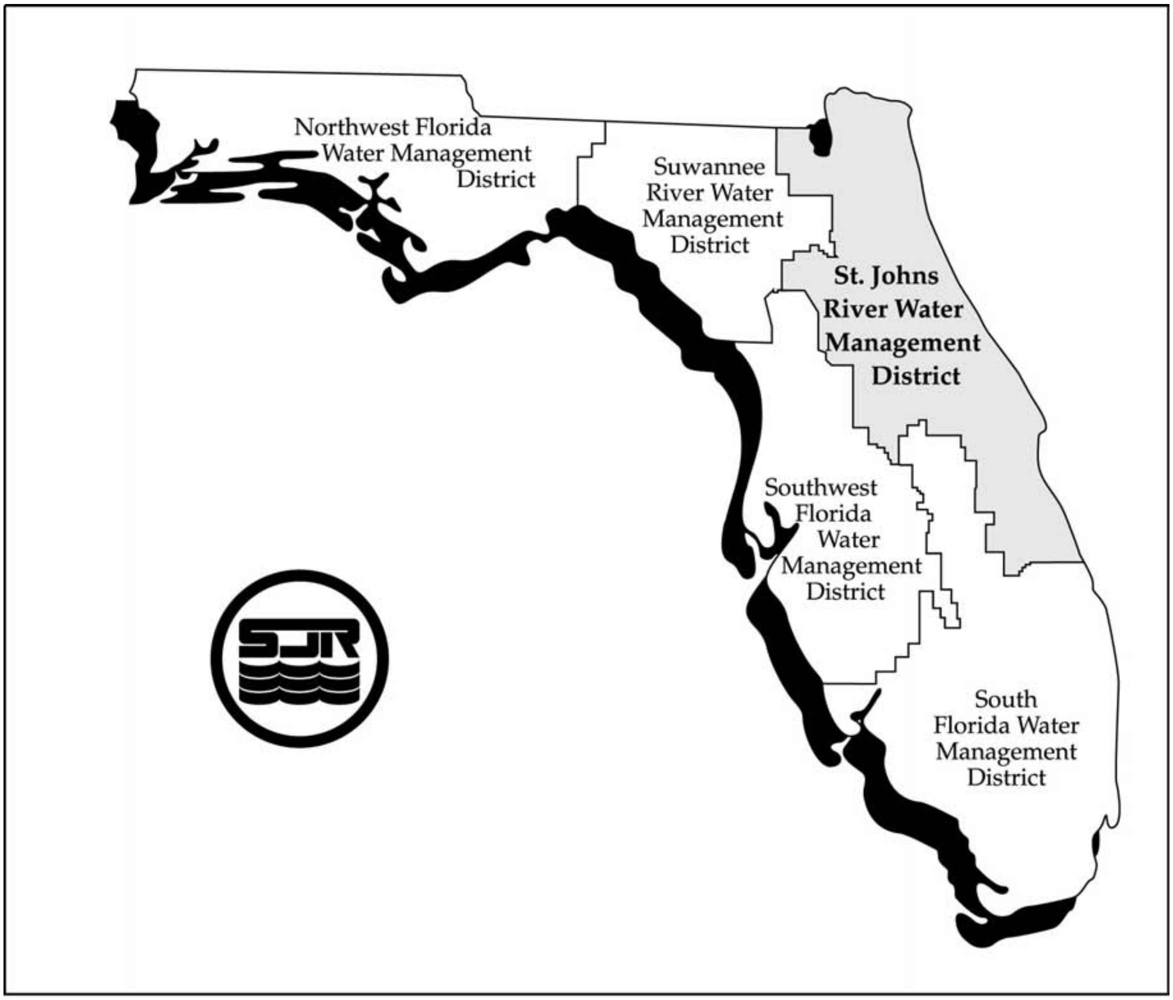

The St. Johns River Water Management District (SJRWMD) was created by the Florida Legislature in 1972 to be one of five water management districts in Florida. It includes all or part of 18 counties in northeast Florida. The mission of SJRWMD is to ensure the sustainable use and protection of water resources for the benefit of the people of the District and the state of Florida. SJRWMD accomplishes its mission through regulation; applied research; assistance to federal, state, and local governments; operation and maintenance of water control works; and land acquisition and management.

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EXECUTIVE SUMMARY

This document presents the St. Johns River Water Management District's (SJRWMD) recommended minimum flows and levels (MFLs) for the St. Johns River at State Road (SR) 50 and describes work performed to support development of the recommendations. The SJRWMD Governing Board is scheduled to adopt these recommendations in 2007. The St. Johns River at SR 50 is on the MFLs Priority Water Body List and Schedule (SJRWMD 2006a) for the establishment of MFLs pursuant to Section 373.042(2) of the *Florida Statues* (F.S.).

SJRWMD's MFLs program, which is implemented based on the requirements of Section 373.042, F.S., establishes MFLs for lakes, streams and rivers, wetlands, and groundwater aquifers. SJRWMD expresses MFLs in multiple flows or levels defining a minimum hydrologic regime to the extent practical and necessary to establish the limit beyond which further withdrawals would be significantly harmful to the water resources or the ecology of the area (Section 373.042(1), F.S.).

The protection of nonconsumptive uses of water, including navigation, recreation, fish and wildlife habitat, and other natural resources, is considered when developing MFLs. MFLs take into account the ability of wetlands and aquatic communities to adjust to changes in the return intervals of high and low water events. Therefore, MFLs allow for an acceptable level of hydrologic change relative to existing hydrologic conditions. When the use of water resources shifts the hydrologic conditions below that defined by the MFLs, significant ecological harm is expected to occur. As it applies to wetland and aquatic communities, significant harm is a function of changes in the frequencies and durations of water level and/or flow events, causing impairment of ecological structures and functions.

SJRWMD used a multiple MFLs methodology (Hall 2006; Neubauer et al. 2005) to develop recommended MFLs for the St. Johns River at SR 50. MFLs determinations incorporated biological and topographical information collected in the field with stage data, wetland, soils, and landownership data from geographic information system (GIS) coverages, aerial photography, the scientific literature, and hydrologic and hydraulic models to generate an MFLs regime.

Field-collected soil, vegetation community, and topographic data are the principle components of each MFL determination. The elevations of the river channels and wetland communities in the St. Johns River floodplain near SR 50 can be associated with the long-term stage record where typical durations and frequencies of flooding and drying are known. Then the river channels and wetland community elevations can be applied toward the MFLs determinations. Recommended MFLs for the St. Johns River at SR 50 are based upon field data collected at nine locations in the St. Johns River floodplain up- and downstream from SR 50. Data collected from five of these locations (Figure ES-1) were analyzed to characterize wetland communities with existing flooding and drying regimes and to define water level elevations, durations, and frequencies that characterized those regimes. On this basis, the minimum frequent-high, minimum average, and minimum frequent-low levels were determined at each of the five locations. The five sets of locally determined levels were then used as the basis of developing recommended minimum frequent-high, minimum average and minimum frequent-low levels for the St. Johns River at SR 50. Data collected from four shallow main channel locations (Figure ES-1) in the St. Johns River up- and downstream from SR 50 were analyzed to calculate minimum infrequent-low levels at the four locations. The four shallow reaches in the main channel of the St. Johns River do not occur at the sites instrumental in determining the five sets of local minimum frequent-high, minimum average, and minimum frequent-low levels. The four locally determined minimum infrequent-low levels were used as the basis of developing the recommended minimum infrequent-low level for the St. Johns River at SR 50. SJRWMD utilized a surface water profile model (HEC–RAS; Robison 2006) for this reach of the St. Johns River and a water budget model, hydrologic simulation program–FORTRAN (HSPF), developed for SJRWMD by Camp, Dresser and McKee Inc. (CDM 2004).

CONCLUSIONS

The following conclusions are drawn from the work performed in association with developing recommended MFLs for the St. Johns River at SR 50.

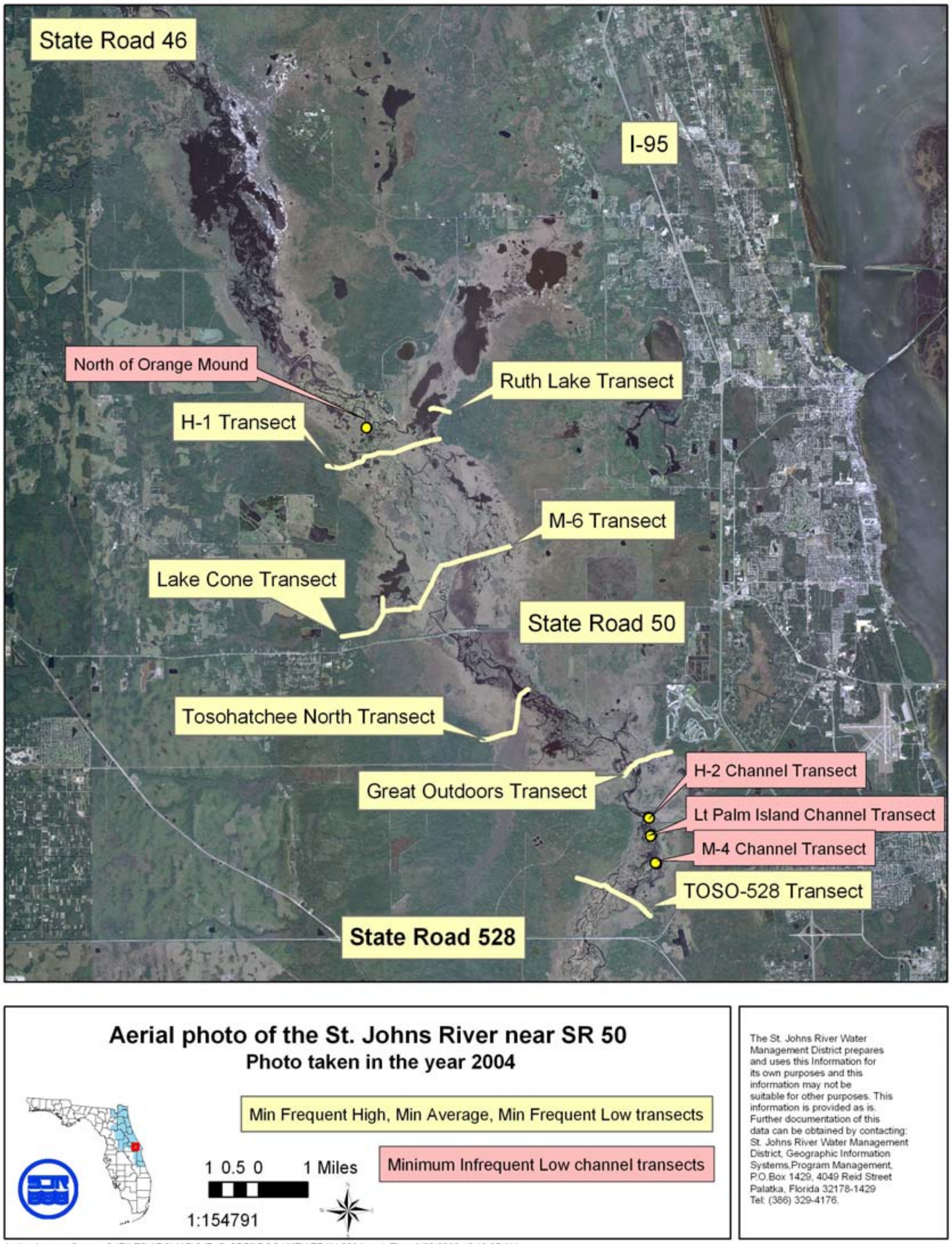

Figure ES-1. Aerial photograph of the St. Johns River near SR 50 with field transect

1. Establishment and enforcement of the recommended MFLs for the St. Johns River at SR 50, as presented in this document, should adequately provide for the protection of the water resources or ecology of the area, which includes the St. Johns River and its associated flood plain from SR 528 on the south to SR 46 on the north, from significant harm as a result of consumptive uses of water (Table ES-1).

Table ES-1. Recommended minimum surface water flows and levels for the St. Johns River at SR 50, Orange and Brevard counties

Minimum Level	Elevation (ft NGVD) 1929 datum	St. Johns River Flows at SR 50 (cfs)	Duration	Return Interval
Minimum frequent-high level	8.1	1950	30 days	2 years
Minimum average level	5.9	580	180 days	1.5 years
Minimum frequent-low level	4.2	140	120 days	5 years
Minimum infrequent-low level	2.7	43	60 days	50 years

ft NGVD = feet National Geodetic Vertical Datum
cfs = cubic feet per second

2. Periodic reassessments of these recommended MFLs, based on monitoring data collected in the future, would better assure that these levels are providing the expected levels of protection of the water resources and ecology of the area.

RECOMMENDATIONS

The following recommendations are offered.

1. The following recommended MFLs for the St. Johns River at SR 50 should be considered for establishment and enforcement by rule (Table ES-1).

2. Existing data collection associated with the development of the recommended MFLs for the St. Johns River at SR 50 should be continued at least until a comprehensive monitoring plan is developed and implemented.

3. A comprehensive monitoring plan should be developed within six months of the date of establishment of MFLs for the St. Johns River at SR 50. This plan should include an implementation schedule that assures that identified data collection and management is in place in advance of any significant withdrawals from the St. Johns River in the area from SR 528 to SR 46.

4. Any proposed changes in hydrologic conditions upstream of SR 50 should be evaluated using modeling as outlined in Appendix D to determine the extent to which the proposed changes are likely to affect MFLs. These hydrologic condition changes could include surface water withdrawals, or changes in the configuration or operation of the Upper St. Johns River Basin project.

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INTRODUCTION

This report defines the method, provides detailed information on the transects selected, and provides results associated with the St. Johns River Water Management District's (SJRWMD) efforts to develop recommended minimum flows and levels (MFLs) for the St. Johns River at State Road (SR) 50 in Orange and Brevard counties. The MFLs are water levels and flows that primarily serve as hydrologic constraints for water supply development, but may also apply in environmental resource permitting.

BACKGROUND

The St. Johns River at SR 50 is on the MFLs Priority Water Body List and Schedule (SJRWMD 2006a). As a priority listed water body, MFLs must be established for this river segment pursuant to Section 373.042(2) of the *Florida Statutes* (F.S.). The Priority Water Body List and Schedule is based upon the importance of the water body to the region and the existence of or potential for significant harm to the water resources or ecology of the region.

In determining the priority list, the following factors are considered:

- Whether the existing or projected demand for water in the area is sufficient to meaningfully affect flows and / or levels of the surface water or groundwater
- Whether any water supply development is planned in the area that may adversely affect regionally significant environmental resources
- Whether the system includes regionally significant environmental resources
- Whether historic hydrologic records (flows and / or levels) are available to allow statistical analysis and calibration of computer models when selecting particular water bodies in areas with many water bodies

The St. Johns River at SR 50 is consistent with these factors due to (1) the projected demand for water in the region; (2) possible water supply development projects near Titusville; (3) the numerous environmental resources in the Puzzle Lake and Tosohatchee Planning Units of the Upper St. Johns River Basin (Adamus et al. 1997); and (4) the extensive, historic hydrologic records for the St. Johns River at SR 50 (Robison 2006).

The following water supply development project options identified in the *District Water Supply Plan 2005* (SJRWMD 2006b) include potential surface water withdrawals for public supply from the St. Johns River to meet projected 2025 demands.

- St. Johns River at SR 50 Project
- St. Johns River / Taylor Creek Reservoir Water Supply Project

In addition to the MFLs proposed for the St. Johns River at SR 50, MFLs are scheduled for establishment for the St. Johns River at Lake Monroe (Mace 2006a). Additionally, MFLs were established for the St. Johns River downstream from Lake Washington at river mile 253.1 in 1998 (Hall and Borah 1998) and for the St. Johns River at river mile 144 near DeLand in 2003 (Mace 2006b). The establishment of MFLs at these different locations on the St. Johns River will allow SJRWMD to monitor and protect the St. Johns River from significant harm caused by consumptive uses of water.

MFLs Program Description

SJRWMD's MFLs program establishes MFLs for lakes, streams and rivers, wetlands, springs, and aquifers, pursuant to the requirements of Section 373.042, F.S.

Purpose

The MFLs program is subject to rule, Chapter 40C-8, *Florida Administrative Code (F.A.C.),* and provides technical support to SJRWMD's regional water supply planning process (Section 373.036, F.S.) and the consumptive use permitting program (Chapter 40C-2, *F.A.C.*). Policy regarding MFLs states "… the Governing Board shall use the best information and methods available to establish limits which prevent significant harm to the water resources or ecology" (Chapter 40C-8.011 (3), *F.A.C.*). Significant harm, or the environmental effects resulting from the reduction of long-term water levels and/or flows below MFLs, is prohibited by Section 373.042(1a)(1b), F.S.

Factors Affected By MFLs

According to Section 62-40.473, *F.A.C.*, the establishment of MFLs should consider natural seasonal fluctuations in water flows or levels, nonconsumptive uses, and environmental values associated with coastal, estuarine, riverine, spring, aquatic and wetlands ecology, including the following:

a. Recreation in and on the water (Section 62.40.473 (1)(a), *F.A.C.*)

b. Fish and wildlife habitats and the passage of fish (Section 62.40.473 (1)(b), *F.A.C.*)

c. Estuarine resources (Section 62.40.473 (1)(c), *F.A.C.*)

d. Transfer of detrital material (Section 62.40.473 (1)(d), *F.A.C.*)

e. Maintenance of freshwater storage and supply (Section 62.40.473 (1)(e), *F.A.C.*)

f. Aesthetic and scenic attributes (Section 62.40.473 (1)(f), *F.A.C.*)

g. Filtration and absorption of nutrients and other pollutants (Section 62.40.473 (1)(g), *F.A.C.*)

h. Sediment loads (Section 62.40.473 (1)(h), *F.A.C.*)

i. Water quality (Section 62.40.473 (1)(i), *F.A.C.*)

j. Navigation (Section 62.40.473 (1)(j), *F.A.C.*)

These 10 natural resources and environmental values are hereafter referred to as water resource values (WRVs).

Hydrology

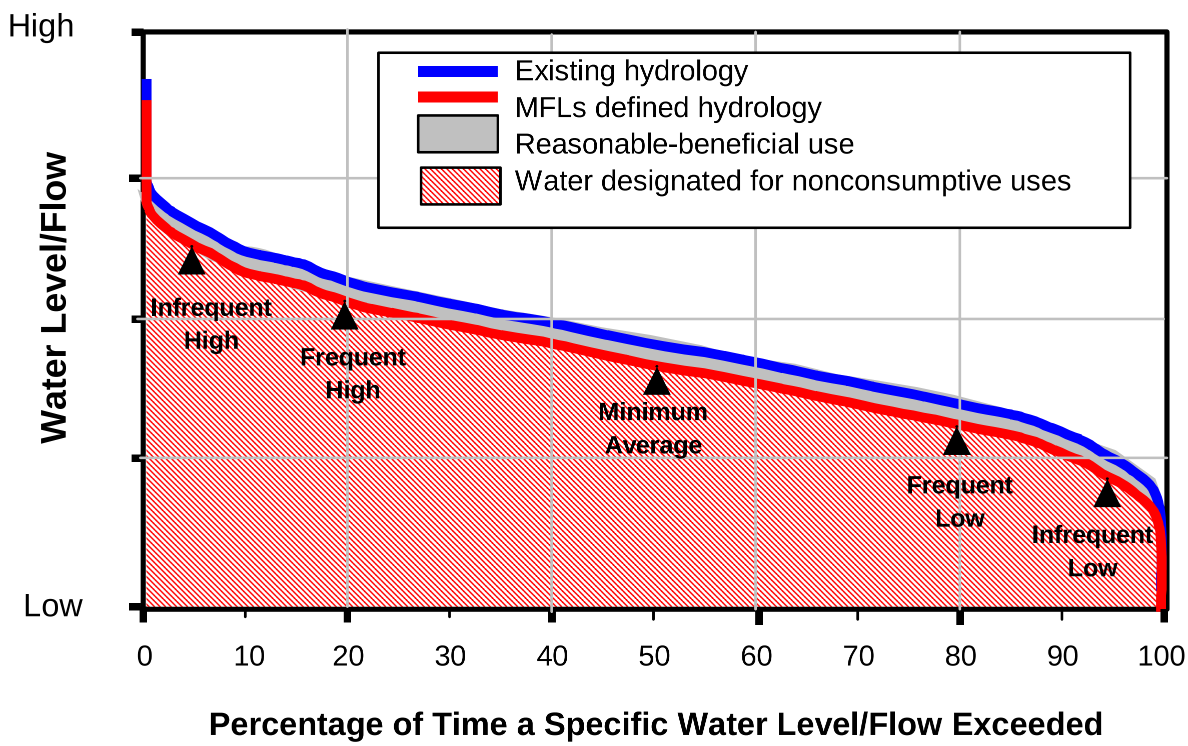
Hydroperiod, hydrologic constraints, and changes in hydrology are factors considered in the MFLs determination process. MFLs designate a hydrologic regime below which significant harm would occur and above which water is available for reasonable–beneficial use. Reasonable–beneficial use is “the use of water in such quantity as is necessary for economic and efficient utilization for a purpose and in a manner which is both reasonable and consistent with the public interest" (Section 373.019 (13), F.S.).

Hydroperiod Categories. MFLs define the return intervals of high and low water events necessary to prevent significant harm to aquatic habitats and wetlands. Three to five MFLs are usually defined for each system—minimum infrequent-high, minimum frequent-high, minimum average, minimum frequent-low and minimum infrequent-low—flows and/or water levels. The MFLs represent hydrologic statistics comprised of three components: water level and/or flow, duration, and frequency. SJRWMD staff have synthesized from Cowardin et al. (1979) the continuous duration and frequency components of the MFLs into seven discrete hydroperiod categories. The hydroperiod categories with related frequencies and durations are defined in Chapter 40C-8.021, *F.A.C.*, and further summarized in Table 1.

Table 1. MFLs hydroperiod categories, approximate frequency, and duration

Hydroperiod Category	Approximate Frequency	Approximate Duration
Intermittently flooded	Once every 10 years high	Weeks to months
Temporarily flooded	Once every 5 years high	Weeks to months
Seasonally flooded	Once every 2 years high	30 days or more
Typically saturated	Once every 2 years low	About six months
Semipermanently flooded	Once every 5 to 10 years low	Several months
Intermittently exposed	Once every 20 years low	Weeks to months
Permanently flooded	More extreme drought	Days to weeks

Changes in Hydrology. MFLs are water levels and/or flows that primarily serve as hydrologic constraints for water supply development, but may also apply in environmental resource permitting (Figure 1). MFLs take into account the ability of wetlands and aquatic communities to adjust to changes in the return intervals of high and low water events. Therefore, MFLs allow for an acceptable level of change to occur relative to the existing hydrologic conditions (gray-shaded area, Figure 1). However, when use of water resources shifts the hydrologic conditions below that defined by the MFLs, significant ecological harm occurs (pink-diagonally lined area, Figure 1). As it applies to wetland and aquatic communities, significant harm is a function of changes in the frequencies and durations of water level and/or flow events, causing unacceptable changes to ecological structures and / or functions. Significant harm can be prevented if water withdrawals do not cumulatively alter the hydrology beyond the minimum hydrologic regime defined by the MFLs.



The existing hydrology curve represents the current river stage or flow regime. The MFLs-defined hydrology curve represents the new river stage or flow regime, which provides for the reasonable–beneficial use of water (gray-shaded area).

Figure 1. Hypothetical percentage exceedence curves for existing and MFLs-defined hydrologic conditions

MFLs apply to decisions affecting consumptive use permit applications, declarations of water shortages, and assessments of water supply sources. Surface water and groundwater computer simulation models are used to evaluate existing and / or proposed consumptive uses and the likelihood they might cause significant harm. Actual or projected conditions where water levels would fall below established MFLs require the SJRWMD Governing Board to develop recovery or prevention strategies (Chapter 373.0421(2), F.S.). MFLs are reviewed periodically and revised as needed (Chapter 373.0421(3), F.S.).

MFLs Methodology

MFLs determinations incorporate biological, soils, and topographical information collected in the field with stage data, hydrologic and hydraulic models, and the scientific literature to generate a MFLs regime. The MFLs methodology provides a process for incorporating these factors. This section describes the MFLs methodology and assumptions used in the MFLs determination process for the St. Johns River at SR 50, including field procedures, such as site selection and field data collection, data analyses, and levels determination criteria. The SJRWMD general MFLs methodology is described more completely in the *MFLs Methods Manual* (Hall 2006).

Field Site Selection

MFLs determinations for the St. Johns River at SR 50 involved an extensive field effort that was concentrated along transects, which are field survey lines that traverse the floodplain. Seven transects were located upstream and downstream from SR 50 at five locations (Ruth Lake and H-1, Lake Cone and M-6, Tosohatchee North, Great Outdoors, and TOSO-528; Figure 2). Data from the five locations were evaluated to develop the minimum frequent-high, minimum average, and minimum frequent-low levels for each of the five local sites. Data from four additional locations were evaluated to develop a minimum infrequent-low level for the four additional sites. The field investigations were initiated in March 2002.

Transects, or fixed sample lines across a river, lake or wetland floodplain, typically extend from open water to uplands, along which, elevation, soils, and vegetation are sampled to characterize the influence of surface water flooding on the distribution of soils and plant communities. Selecting transect sites involved the following steps.

Information Gathering

Field site selection began with the implementation of a site history survey and data search. The team collected existing information and conducted data searches of the SJRWMD library, project record files, the hydrologic database, and Division of Surveying Services files. The types of information collated included the following:

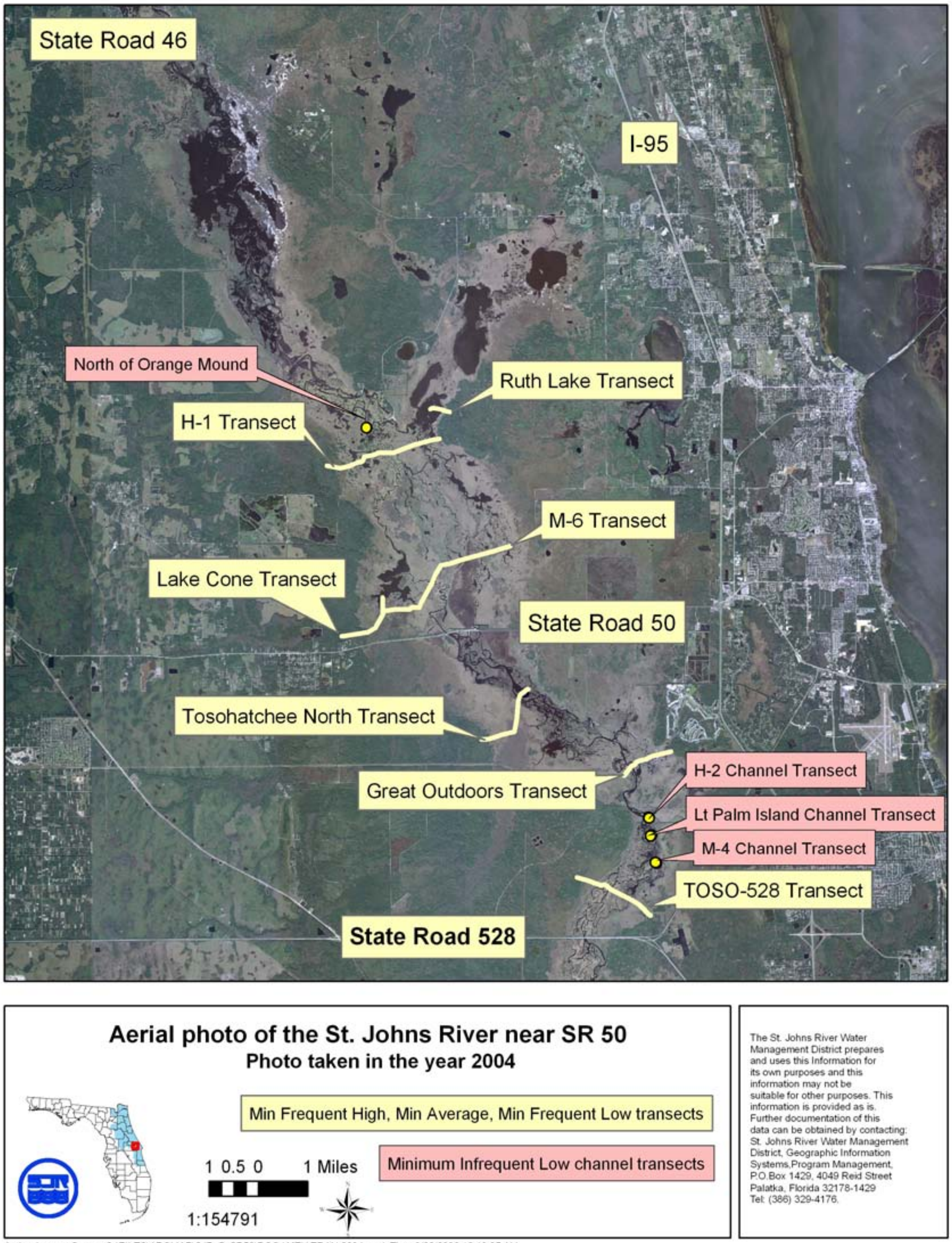


Figure 2. Aerial photograph of the St. Johns River near SR 50 with field transects

- On-site and regional vegetation surveys and maps
- Aerial photography (existing and historical)
- Remote sensing (vegetation, land-use, etc.) and topographic maps
- Soil surveys, maps, and descriptions
- Hydrologic data (hydrographs and stage duration curves)
- Environmental, engineering, or hydrologic reports
- Topographic survey profiles
- Occurrence records of rare and endangered flora and fauna

Transect Site Identification

The data sources were reviewed to familiarize the investigator with site characteristics, locate important basin features that may need to be evaluated, and assess prospective sampling locations. Copies of this information were organized and placed in permanent files for future reference.

Potential transect locations were initially identified from maps of wetlands, soils, topography, and landownership. Specific transect site selection goals included the following:

- Establish transects at sites where multiple wetland communities of the major types occur
- Establish transects at locations where the common wetland types occur at two or more different sites

The second goal had the purpose of ensuring ecosystem protection of similar wetland types at different locations and of different wetland ecosystems between SR 528 and SR 46. The 10 most common wetland communities within a one-mile buffer of the river channel between SR 528 and SR 46 were traversed by at least one transect.

Transect characteristics were subsequently field verified to ensure the particular locations contained representative wetland communities, hydric soils, and reasonable upland access, while also avoiding archaeological sites and alligator nests. Locating transects on public land was preferable to avoid futuredevelopment that would affect transects and to facilitate access for long-term ecological monitoring. Numerous sites were field evaluated. Seven final wetland transect sites, which traversed multiple wetland communities as well as the river channels, were selected at five locations (Table 2). The wetland transects were located at sites which best represented typical wetland communities in the St. Johns River floodplain near SR 50. Additionally, four more transects, which only traversed the main channel of the St. Johns River, were selected to characterize the four shallowest locations (Table 2) The four extremely shallow main river channel locations were

Table 2. Field transect names and locations

Transect Name	Transect Location	Description and Date of Fieldwork
Ruth Lake	SJR near Hatbill Park; river mile 201.5	East shore of Ruth Lake; March and December 2002
H-1		Traversed entire floodplain and multiple river channels, one mile upstream from Hatbill Pk; January, October, and December 2003
Lake Cone	SJR at Lake Cone; river mile 208	SW edge of Lake Cone to uplands; March, April, and June 2003
M-6		Traversed lowest elevation floodplain in vicinity of Lake Cone; January and October, 2003 and January–February 2004
Toso North	SJR at Tosohatchee North; river mile 212	Primarily west floodplain in the Tosohatchee State Reserve; April, June, and December 2003 and March 2004
Great Outdoors	SJR near the Great Outdoors; river mile 215	Primarily the east floodplain, west of the Great Outdoors development; June and November 2002
Toso-528	SJR near SR 528; river mile 220	Traversed majority of floodplain from the Tosohatchee State Reserve to near SR 407; November and December 2003 and January, February, and April 2004
North of Orange Mound	SJR RM 201	Main channel, extremely shallow May 2006
H-2	SJR RM 216.6	Main channel, extremely shallow May 2006
Little Palm Island	SJR RM 217	Main channel, extremely shallow May 2006
M-4	SJR RM 217.7	Main channel, extremely shallow May 2006

identified, in 2006, after the wetland transect work was completed. The four extremely shallow main channel locations did not coincide with the five locations where the wetland community transects were located.

FIELD DATA COLLECTION

The field data collection procedure for determining MFLs typically involved gathering information and sampling elevation, soils, and vegetation data along fixed lines (transects) that cross a hydrologic gradient. Transects were established in areas where there were changes in vegetation and soils, and the hydrologic gradient was marked (Hall 2006). The main purpose in using transects in these situations, where the change in vegetation and soils is clearly directional, was to describe maximum variations over the shortest distance in the minimum time (Martin and Coker 1992).

Site Preparation and Survey

Once established, transect site vegetation was trimmed to allow a line of sight along the length of the transect. A measuring tape was then laid down on the ground along the length of the transect. One elevation measurement was recorded every 5 to 50 feet (ft) on the ground along the length of each of the seven field wetland transects included in the process of developing recommended MFLs for the St. Johns River at SR 50. Elevation measurements were recorded at 1- to 2-foot (ft) intervals along the length of each of the four shallowest main channel transects. Elevations were surveyed with a conventional level by professional land surveyors along each transect. Elevations were brought to the individual transects from established Florida Department of Environmental Protection (FDEP) elevation benchmarks.

In general, the elevation gradient was very low and the vegetation communities were very broad at the seven wetland transects. Consequently, elevations were typically recorded at 20- or 50-ft intervals. Additional elevations were measured at obvious elevation changes, vegetation community changes, soil changes, and within river channels.

Latitude and longitude data were also collected along the length of the transects, using a global positioning system (GPS) receiver with approximately one-meter accuracy. Typically, GPS points were collected at frequent intervals (every 50 to 200 ft) and at directional changes along the transects. The data collection interval varied depending upon the overall length of the transect, the frequency and width of plant community changes, and the number of directional changes along the transect. These GPS data accurately located specific features along the transects, such as vegetation ecotones, and facilitated recovering transect locations in the future. The latitude and longitude data collected with the GPS were subsequently downloaded for map production and stored in both electronic and paper files for future retrievals.

Soil Sampling Procedures

Detailed soil profiles were obtained at selected stations along the seven wetland transects. Soil profiles were described following standard Natural Resources Conservation Service (NRCS) procedures (USDA 1998a). Each soil horizon (unique layer) was described with respect to texture, thickness, Munsell color (Kollmorgen Corp.1992), structure, consistency, boundary, and presence of roots.

The primary soil criteria considered in the MFLs determination were the presence and depth of organic soils, as well as the extent of hydric soils observed along the field transects. The procedure to document hydric soils included the following:

- Removal of all loose leaf-matter, needles, bark, and other easily identified plant parts to expose the soil surface; digging a hole and describing the soil profile to a depth of at least 20 inches (in.); and, using the completed soil description, specifying which hydric soil indicators have been matched
- Examination of the soil to greater depths, where required, for field indicators not easily seen within 20 in. of the soil surface (It is always recommended that soils be excavated and described as deep as necessary to make reliable interpreations and classifications.)
- Paying particular attention to changes in microtopography over short distances, since small elevation changes may result in repetitive sequences of hydric/nonhydric soils and the delineation of individual areas of hydric and nonhydric soils may be difficult (USDA 1998b)

Soil sampling intervals varied considerably along the seven wetland transects. The sampling interval was dependent upon on-site soil changes. Typically, sampling occurred in a broad vegetation community at intervals of 100–300 ft. However, upon recording a soil change from the previously sampled station, more sampling occurred closer to the previously sampled station, in order to identify the location of soil change.

The following soil features, if present, were identified and their locations marked along the transect line so that soil surface elevations could be determined for these features:

- Landward extent of hydric soils
- Landward extent of surface organics
- Landward extent of histic epipedon (surface organic horizon with depths of 8–16 in. thick)
- Landward extent of histosols (organic horizon with thickness > 16 in. within 32 in. of soil surface)
- Thickness of organic surface horizon

Vegetation Sampling Procedures

Vegetation sampling associated with the development of recommended MFLs for the St. Johns River at SR 50 was completed with a specialized line transect called a belt transect. A belt transect is a line transect with width (belt width). It is essentially a widening of the line transect to form a long, thin rectangular plot divided into smaller sampling areas called quadrats that correspond to the spatial extent of plant communities or transitions between plant communities (Figure 3; Hall 2006). The transect belt width varied depending upon the type of plant community sampled (Hall 2006). For example, a belt width equal to 10 ft on both sides of the transect line was used to sample the herbaceous plant communities in the floodplain marsh. However, a belt width of 50 ft was required to adequately represent a forested community (e.g. hardwood swamp).

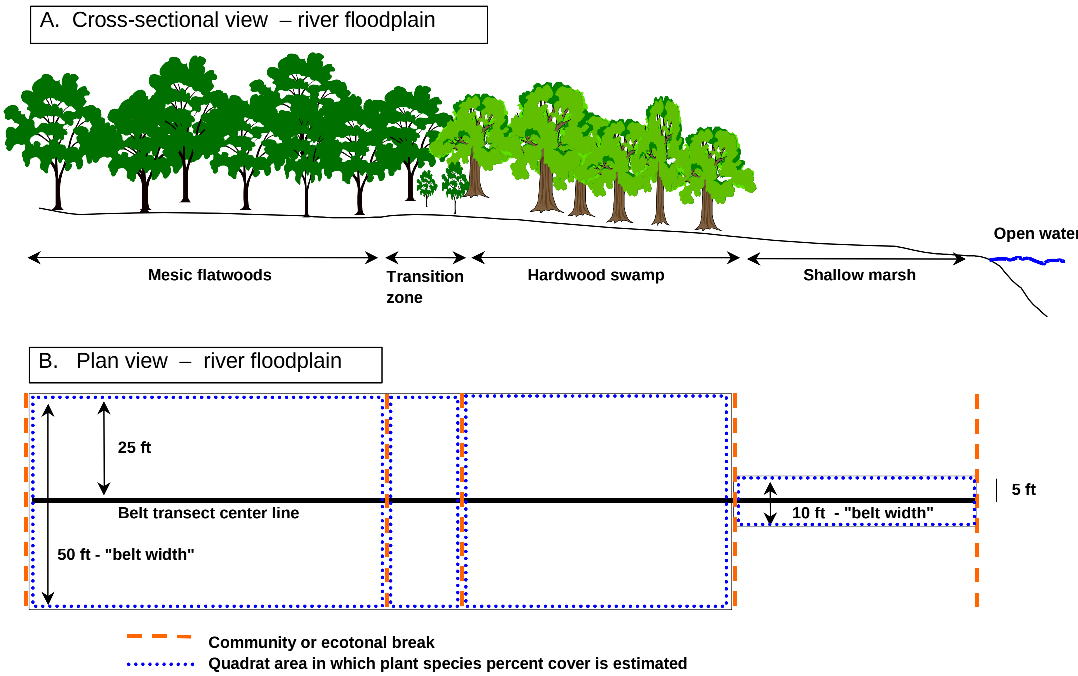


Figure 3. Belt transect through forested and herbaceous plant communities

Plants were identified and the percent cover of plant species was estimated for the plants within the established belt width for the plant community under evaluation (quadrat). Percent cover is defined as the vertical projection of the crown or shoot area of a plant to the ground surface expressed as a percentage of the quadrat area (Hall 2006). Percent cover as a measure of plant distribution is often considered as being of greater ecological significance than density, largely because percent cover gives a better measure of plant biomass than does the number of individuals. The canopies of the plants inside the quadrat will often overlap each other, so the total percent cover of plants in a single quadrat will frequently add up to more than 100% (Hall 2006). Multiple site visits occurred at all field wetland transects near SR 50 to improve the ability to characterize the vegetation communities.

Percent cover was estimated visually using cover classes (ranges of percent cover). The cover class and percent cover ranges are a variant of the Daubenmire method (Mueller-Dombois and Ellenberg 1974) and are summarized in Table 3 (Hall 2006).

Table 3. Summary of cover classes and percent cover ranges

Cover Class	Percentage Cover Range	Descriptor
0	< 1 %	Rare
1	1–10 %	Scattered
2	11–25 %	Numerous
3	26–50 %	Abundant
4	51–75 %	Co-dominant
5	> 75 %	Dominant

Plant species, plant communities, and percent cover data were recorded on field vegetation data sheets (Appendix A). The data sheets are formatted to facilitate data collection in the field and computer transcription (Hall 2006).

The *Wetlands Diagnostic Characteristics* (Kinser 1996) was used as the basis of standardizing wetland plant community names recorded in the field. SJRWMD has districtwide wetland maps developed from aerial photography utilizing this classification system. Terrestrial (upland) plant community names are modified from the Florida Natural Areas Inventory classification (FNAI, FDNR 1990).

DATA ANALYSIS

The primary data analysis consisted of creating statistical summary tables on the surveyed elevation data by using a graph format in a computer spreadsheet. Vegetation and soils information collected along the transect were incorporated with the elevation data. Vegetation community average, median, minimum, and maximum elevations were calculated, along with various soil groupings. For example, the average soil surface elevation of a hardwood swamp was calculated along with the average surface elevation of histosols within the hardwood swamp where the histosols were observed within a portion of the hardwood swamp.

Transect elevation data were also graphed to illustrate the elevation profile between the open water and upland community (Figure 3).

Location of vegetation communities along the transect, with a list of dominant plant species, statistical results, and soil information, were labeled on the graph, space permitting.

Minimum Levels for the St. Johns River at the SR 50 Gauge Site

To develop recommended minimum frequent-high, minimum average, and minimum frequent-low levels for the St. Johns River at SR 50, seven transects were located upstream and downstream from SR 50 at five locations (Ruth Lake and H-1, Lake Cone and M-6, Tosohatchee North, Great Outdoors, and TOSO-528; Figure 2). Data from the five locations were evaluated to determine minimum frequent-high, minimum average, and minimum frequent-low levels for each of the five local sites. The five sets of local levels were used to calculate minimum frequent-high, minimum average, and minimum frequent-low levels for the St. Johns River at the SR 50 gauge site.

In addition, minimum infrequent-low levels were determined at four locations up- and downstream from SR 50 (Figure 2). The four minimum infrequent-low level sites were identified in 2002 and 2006 during low river stages as extremely shallow points within the St. Johns River main channel. Likewise, the four infrequent-low levels were used to calculate an infrequent-low level for the St. Johns River at the SR 50 gauge site. Typical criteria used to determine each local MFL are described in Minimum Levels Concepts and Criteria for the St. Johns River at SR 50, later in the Methodology section of this report.

Water surface slopes change from one field-data collection location to the next. As a result, determining MFLs for the St. Johns River at SR 50 from the five sets of local minimum frequent-high, minimum average, minimum frequent-low levels, and the four infrequent-low levels was accomplished by using a surface water profile model (HEC–RAS) and a water budget model (HSPF), developed for the SJRWMD by Camp Dresser and McKee Inc. (CDM 2004).

The method of determining the minimum frequent-high, minimum average, and minimum frequent-low levels for the St. Johns River at SR 50 from the five field sets of local levels included the following:

- Development of flow duration curves representing the southern, central, and northern extent of the river reach near SR 50

- Simulation of water levels for each MFL category and of the same exceedence probability along the entire river reach

- Summation of the differences between water levels resulting from model output and corresponding recommended levels

- Identification of the exceedence probability resulting in the surface water profile with the smallest sum of the differences for the recommended level.

Flow duration curves were developed at three locations along the St. Johns River (SR 520, SR 50, and Puzzle Lake outlet) from HSPF model output. These three locations represent the southern, central and northern extent of the river reach near SR 50. In order to calculate, for example, the recommended minimum frequent-high level for the St. Johns River at SR 50, flows of the same exceedence probability (e.g. 20%) from the three model output locations were entered into the HEC–RAS surface water profile model to simulate frequent high water levels along the entire river reach.

The resulting model output water levels at the five field locations were then subtracted from the corresponding field-determined recommended minimum frequent-high levels and the differences summed. This process was repeated for flows of different exceedence probabilities (e.g. 19% and 21%). The exceedence probability resulting in the surface water profile with the smallest sum of the differences (i.e., near zero) was selected as the recommended minimum frequent-high level surface water profile.

This procedure was repeated to determine the recommended minimum average and minimum frequent-low levels at SR 50 (Robison 2006). The method used to calculate the minimum infrequent-low level for the St. Johns River at SR 50 was similar to that used to calculate the other levels at SR 50. A minimum level was determined at each of the four cross sections representing the shallowest reaches. The objective of the method was to identify the shallowest or most restrictive channel among these four locations. A water surface profile corresponding to St. Johns River flows of a given exceedence (e.g. 98%), at SR 520, SR 50, and the Puzzle Lake outlet, was calculated using the SJRWMD HEC–RAS model. The stages of the four cross sections corresponding to this water surface profile were compared to the appropriate minimum infrequent-low levels. This step was repeated for incrementally larger exceedences (lower discharges) until one of the minimum infrequent-low levels was equaled. Because the stages at the other three locations were still higher than the corresponding minimum infrequent-low levels, this then, in effect, constituted the shallowest cross section. The St. Johns River stage at SR 50 corresponding to this river profile was recommended as the minimum infrequent-low level at SR 50. One final set of MFLs for the St. Johns River at SR 50 facilitates periodic hydrologic monitoring and eliminates possible confusion regarding multiple sets of levels.

Minimum Flows

Each minimum level can be associated with a minimum flow for a river system. While water resource decisions can be made based on minimum levels alone, pairing each level with a corresponding minimum flow adds context to better understand the effects of proposed changes to a hydrologic system. The pairing of levels and flows of similar statistical characteristics was used to determine a recommended minimum flow for each of the final four levels for the St. Johns River at SR 50 (Robison 2006). For example, based on statistical analysis of stage data for the St. Johns River at SR 50, the recommended minimum frequent-high level calculated for the St. Johns River at SR 50 would be equaled or exceeded for 30 continuous days, on average, approximately 70 out of every 100 years. Analysis of the flows at the SR 50 gauge indicated that the flow that would be equaled or exceeded for 30 continuous days, on average, approximately 70 out of 100 years equals 1950 cubic ft per second (cfs). Thus the recommended minimum frequent-high flow for the St. Johns River at SR 50 equals 1,950 cfs. Similar analyses determined the recommended minimum average flow, the recommended minimum frequent-low flow, and the recommended minimum-infrequent low flow.

St. Johns River Near SR 50—General Information

The St. Johns River originates in floodplain marshes north of Lake Okeechobee and flows north over 300 mi to a point near Jacksonville where it abruptly turns eastward and flows approximately 24 mi farther into the Atlantic Ocean. The St. Johns River is the longest north-flowing river in the United States and the longest river in Florida, with its tributary basins lying entirely within the state boundaries (Morris 1995). The St. Johns River is divided into four major hydrologic basins (Upper, Middle, Lake George, and Lower; Adamus et al. 1997; Figure 4). The St. Johns River is normally tidal to the north end of Lake George, 110 mi upstream from the mouth, although tides have, on occasion, been reported in Lake Monroe (161 mi upstream from the mouth). The St. Johns River at SR 50 is 209 mi upstream from the mouth within the northern portion of the Upper St. Johns River Basin (Figure 4).

The St. Johns River near SR 50 is characterized by a wide expanse of flat, open floodplain primarily within the 10-ft elevation contour. The low gradient and large floodplain allows the St. Johns River near SR 50 to function as a water storage area, serving as a natural regulator during high and low water stages. During low water stages, numerous secondary channels and sloughs are evident, but sheetflow during high water periods results in the loss of channel identity (SJRWMD 2005). Typical river stages at SR 50 are between 4.6 and 8.2 ft. NGVD (Figure 5) with an average stage equal to 6.6 ft NGVD, based upon a daily record between October 3, 1933, and March 23, 2005. Minimum- and maximum-recorded stage values are 1.97 and 12.41 ft NGVD, respectively.

The St. Johns River near SR 50 is a river reach comprised of multiple, extensive public land parcels with high quality, environmentally sensitive, natural ecosystems. The public land parcels bordering the river between SR 528 and SR 46 include the Tosohatchee State Reserve, St. Johns National Wildlife Refuge, Seminole Ranch Conservation Area, Canaveral Marshes Conservation Area, the Yarborough Conservation Easement, the Orlando Wetlands Park, and the Little Big Econ State Forest (Figure 6). A contiguous corridor of publicly owned land, protecting the floodplain of the St. Johns River, including the reach at SR 50, extends approximately 100 river miles from the south starting at Fort Drum Conservation Area at SR 60 north to Lake Harney north of SR 46 (SJRWMD 2005).

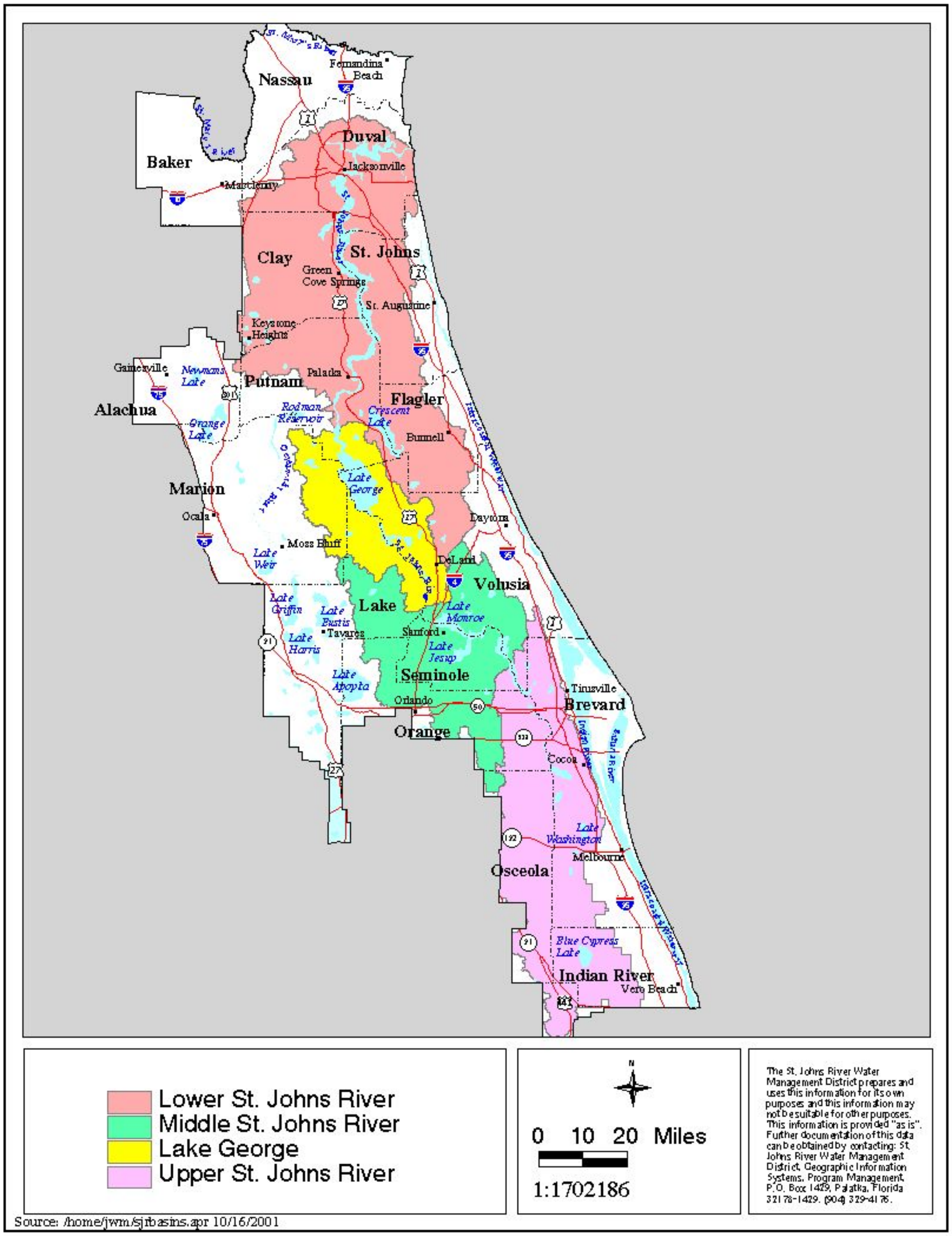
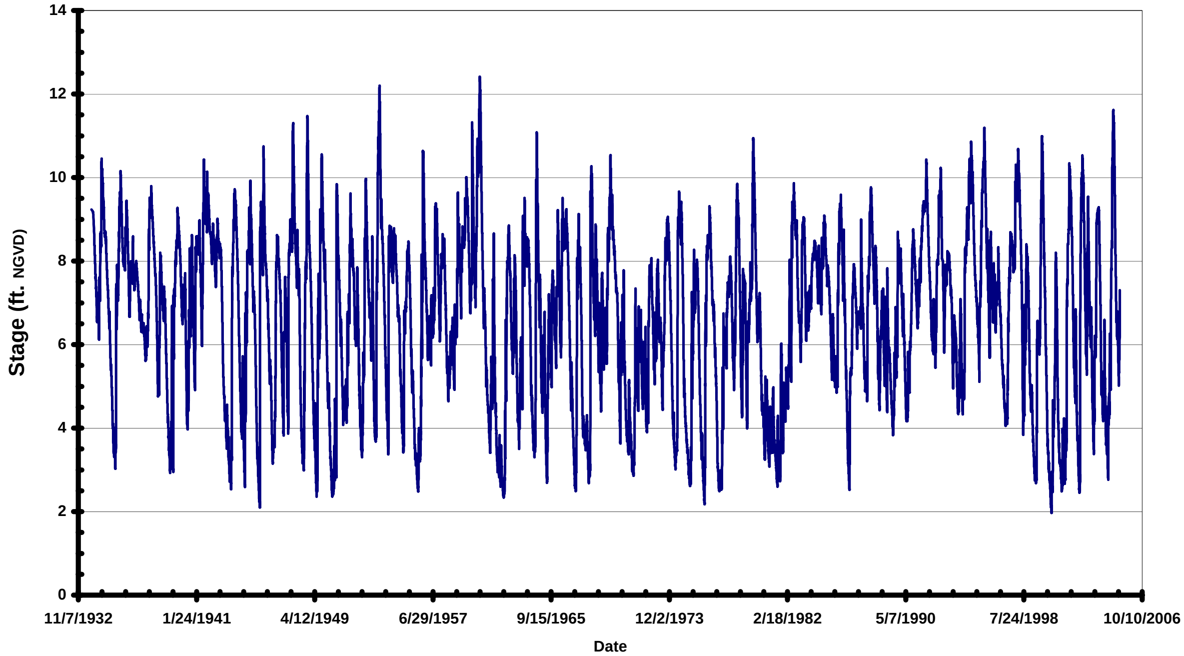


Figure 4. St. Johns River surface water basin map



Source: USGS. Gauge 02232500 1929 datum

http://waterdata.usgs.gov/fl/nwis/current/?type=flowandgroup_key=basin_cd

Figure 5. St. Johns River at SR 50 daily stage data October 3,1933–March 3, 2005

Recreational opportunities located in or adjacent to the St. Johns River floodplain near SR 50 include hiking, biking, horseback riding, primitive camping, fishing, canoeing, boating, hunting, and wildlife viewing. The Florida Trail passes through the Tosohatchee State Reserve and the southwest portion of Seminole Ranch before entering the Orlando Wetlands Park. Detailed recreational information for the specific public land parcels (Figure 6) along the St. Johns River near SR 50 are located at *www.sjrwmd.com* for Seminole Ranch, Canaveral Marshes, and the Yarborough Conservation Easement properties. Information on the Tosohatchee State Reserve is located at *http://www.floridastateparks.org/tosohatchee/ default.cfm*. Information on the St. Johns National Wildlife Refuge is located at *http://www.fws.gov/merrittisland/subrefuges/SJ.html* and information on the Orlando Wetlands Park at *http://myfwc.com/viewing/sites/site–c10.html*. Information on the Little Big Econ State Forest is located at *http://www.fl–dof.com/state_forests/little_big_econ.html*.

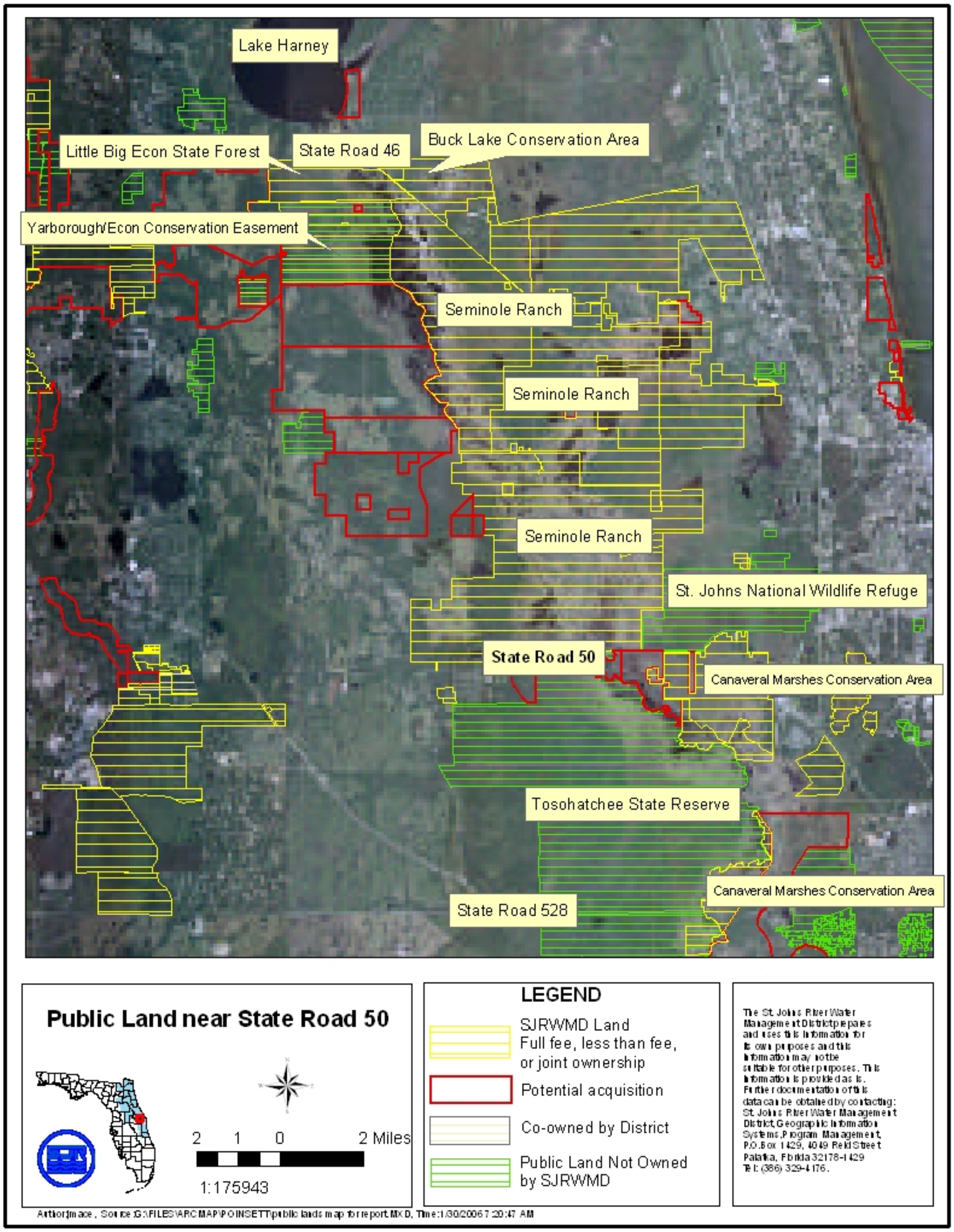


Figure 6. Public land near SR 50

The St. Johns River floodplain also provides habitat for fish and wildlife, including many listed species. The American shad (*Alosa sapidissima*) is a fish species of special interest in the St. Johns River at SR 50. American shad live the majority of their lives in the North Atlantic Ocean, journeying to spawn in the freshwater part of the St. Johns River between Lakes Monroe and Poinsett, upstream and downstream of SR 50. Each river from Florida to Canada draining into the north Atlantic presumably hosts a reproductively isolated population of American shad. American shad research has led to important insights regarding the evolutionary ecology of fishes. Researchers often use specimens from the St. Johns River when examining intraspecific genetic morphological, or life-history variations because the St. Johns River population is at the limit of the southern range of the species (McBride 2000).

Adequate water flow and water quality at American shad spawning grounds are now probably the major factors limiting Florida's American shad abundance and recovery (McBride 2000). Physical characteristics of current, depth, bottom type, and bottom contour apparently determine spawning locations. American shad spawning primarily occurs in February on a clean sand bottom of less than 4 meters' depth where current is 1.0 to 1.5 ft / sec (Williams and Bruger 1972). Spawning locations may shift from year to year between either the Lake Monroe–Lake Harney reach or the Lake Harney–Lake Poinsett reach, depending on currents and water levels. In low flow years, the shad prefer to spawn between Lakes Harney and Poinsett (Williams and Bruger 1972), including the SR 50 reach of the St. Johns River. The relatively large elevation gradient between Lakes Harney and Poinsett is an important characteristic that ensures a current in the upper river and ensures that American shad have a suitable spawning area, even during low water conditions (McBride 2000; Williams and Bruger 1972; Walburg 1960). Williams and Bruger (1972) suggest that the St. Johns River American shad require a minimum current of 1 foot per second (ft / sec) upstream from Lake Harney to ensure an environment conducive to spawning and egg incubation. Currents less than 1 ft / sec would allow for the deposition of silts, which is hazardous to spawning and egg incubation. In addition, currents greater than 1 ft / sec are important for moving newly hatched shad to their nursing grounds downstream.

Listed wading birds utilizing the floodplain include the little blue heron, snowy egret, tricolored heron, and white ibis. Detailed information on wading birds near SR 50 is located in *Survey of Wading Bird Utilization of the Upper St. Johns River Basin 1998–2000* (SJRWMD 2001). Additional listed species utilizing the St. Johns River floodplain near SR 50 include wood stork, Florida sandhill crane, bald eagle, creasted caracara, Florida black bear, Sherman’s fox squirrel, round-tailed muskrat, Florida mink, American alligator, gopher tortoise, and eastern indigo snake (SJRWMD 2005).

There are also a number of rare and listed plants found within the floodplain of the St. Johns River near SR 50, including fall-flowering ixia (*Nemastylis floridana*), butterfly orchid (*Encyslia tampernsis*), greenfly orchid (*Epidendrum canopseum*), cinnamon fern (*Osmunda cinnamomea*), and green leather fern (*Acrostichum danaeifolium*) (SJRWMD 2005). Additional plant information is located in the next section of this document and in the Results and Discussion section.

ST. JOHNS RIVER NEAR SR 50—WETLANDS

The SJRWMD geographic information system (GIS) wetland coverage (Figure 7) illustrates the various wetland communities delineated along the St. Johns River near SR 50. Table 4, generated from the same SJRWMD GIS wetland coverage, lists the 10 most common vegetation community types within a one-mile buffer of the St. Johns River channel between SR 528 and SR 46.

The wet prairie community represents the most extensive vegetation community found within the St. Johns River floodplain near SR 50 (Figure 7). The wet prairie supports large areas of sand cordgrass (*Spartina bakeri*), interrupted by depressions, sloughs, and relic river channels that support shallow marsh species. Prescribed fire occurs in the wet prairies near SR 50 every 3 to 5 years as a means to deter the invasion of woody shrubs (SJRWMD 2005; pers. comm., Scott Spaulding, Park Manager, Tosohatchee State Reserve 2005). The prescribed fires in the floodplain near SR 50 result in a nearly homogenous plant species composition across the wet prairies over a relatively large elevation gradient.

The shallow marsh is the second most prevalent vegetation community in the St. Johns River floodplain near SR 50, commonly located immediately adjacent to the river channels and/or open water areas. Typical shallow marsh plant species include coast cockspur grass (*Echinochloa walteri*), dotted smartweed (*Polygonum punctatum*), Dixie signalgrass (*Urochloa ramosa*), smartweed (*Polygonum densiflorum*), mock bishop's weed (*Ptilmnium capillaceum*), stiff marsh bedstraw (*Galium tinctorium*), and pickerelweed (*Pontedaria cordata*). Slight elevation increases result in a shift from shallow marsh to wet prairie plant species across the floodplain.

The third most prevalent plant community in the St. Johns River floodplain near SR 50 is the hydric hammock. The hydric hammocks are at the edge of the floodplain, immediately adjacent to the upper elevations of the wet prairie communities. Typically, the lower elevations of the hydric hammocks flood infrequently from the St. Johns River. Vince et al., (1989) suggesting that hydric hammocks that are low in species diversity, such as the ones traversed along the St. Johns River near SR 50 and dominated by cabbage palm and live oak, exist where

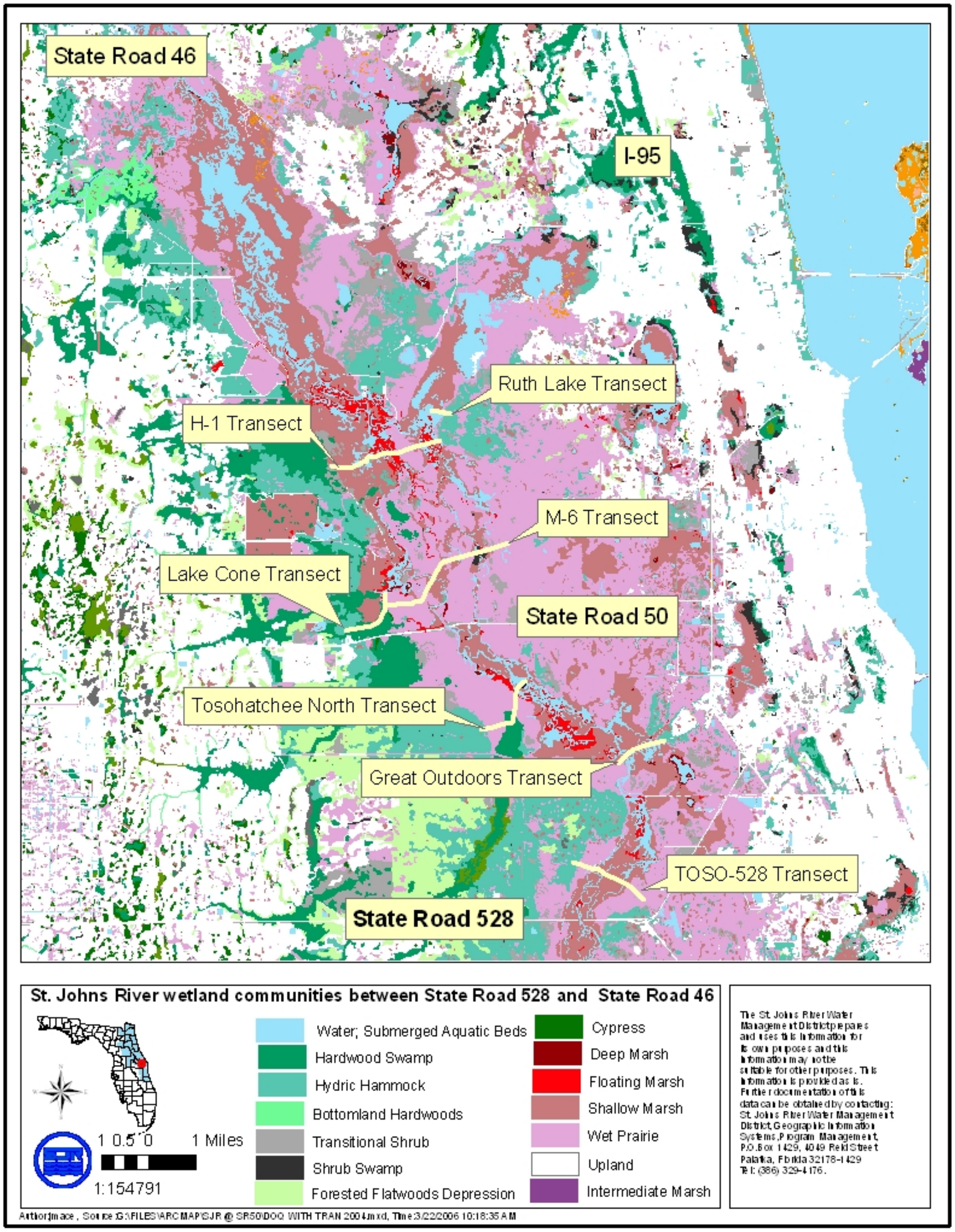


Figure 7. St. Johns River floodplain vegetation between SR 528 and SR 46

Table 4. Ten most abundant vegetation community types within a one-mile buffer of the St. Johns River channel between SR 528 and SR 46

Wetland Community	Acres	Ranking By Acres
Wet prairie	10,564	1
Shallow marsh	9,866	2
Water	4,583	3
Hydric hammock	1,877	4
Transitional shrub	1,187	5
Free floating	1,074	6
Upland	795	7
Hardwood swamp	604	8
Cabbage palm–hydric hammock	218	9
Deep marsh	67	10

long dry periods are interrupted by occasional episodes of flooding. These hammocks are inundated approximately once per decade, due to tropical weather systems that impact the Upper St. Johns River Basin. However, more frequent surface water ponding occurs within these hydric hammocks during periods of high local rainfall due to the soil characteristics, including hardpan layers, which impede drainage.

All 10 of the vegetation community types listed in Table 4 were traversed at least once by field transects as part of the MFL determination for the St. Johns River at SR 50. Detailed vegetation community descriptions are presented in the Results and Discussion section of this document.

ST. JOHNS RIVER NEAR SR 50—HYDRIC SOILS

River hydrology is related to the development of hydric soils in the St. Johns River floodplain. Hydric soils are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part (USDA, SCService 1987). Hydric soils were mapped (Figure 8; Soil Survey Geographic (SSURGO) database) and sampled extensively along the St. Johns River near SR 50. Differences were encountered between the specific soil types sampled along the field transects and the soil types mapped in the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) Soil Surveys. Regardless of the exact soils type sampled along the field transects, the hydric/nonhydric classification of the sampled soils closely matched the designation on the SSURGO map (Figure 8).

The field-soil sampling results, which involved more detailed soil sampling as compared to the NRCS soil surveys, were relied upon to assist in the minimum frequent-high, minimum average, and minimum frequent-low levels determinations. Field soil sampling was performed as part of this MFL determination by Debra Segal and Ben Skulnick, soil scientists with Jones, Edmunds and Associates, contractor to SJRWMD. Soils were identified at numerous stations along each wetland field transect. Transect specific field soil sample descriptions are presented in the Results and Discussion section of this document. Additionally, a brief description of each soil type sampled is provided in Appendix B. Table 5 summarizes pertinent soil water table information for the soil series field sampled near SR 50.

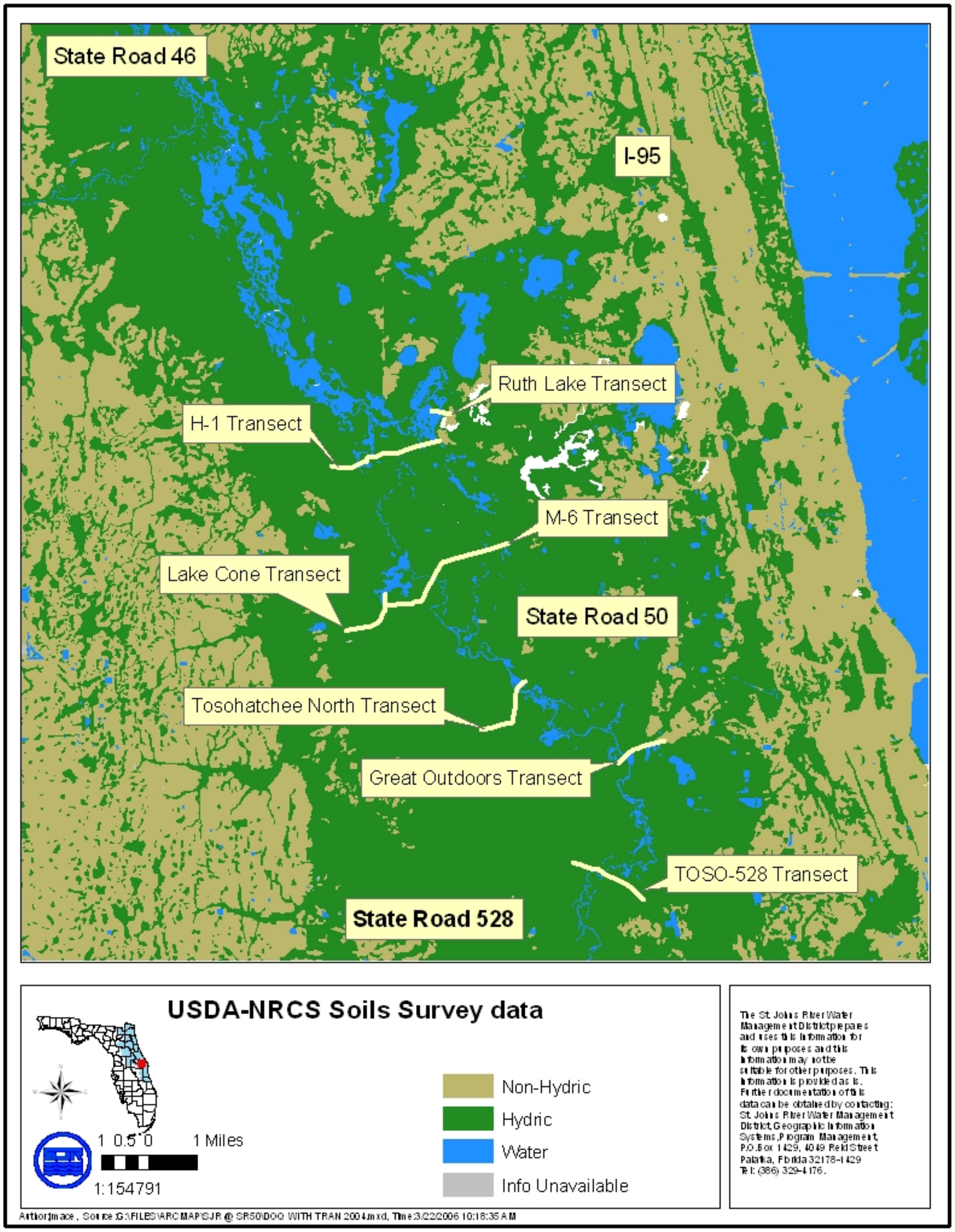


Figure 8. Hydric soils along the St. Johns River near SR 50

Table 5. Soil water table information for soil series sampled near SR 50

Soil Name	Water Table Above Soil Surface	Typical Depth Below Soil Surface to Water Table
Anclote sand	Frequently flooded during the rainy season; depressional areas ponded	<10" for 6+ months; recedes to >20" during the driest season
Bradenton fine sand		<18" for 2–6 months annually
Chobee loamy fine sand	Depressional areas are ponded for long durations	<6" for 1–4 months
Delray fine sand	Deprssional areas are ponded for 6+ months	<12" for 6–9 months
Denaud sand	Ponded for 6–9 months	Saturated to surface rest of the year
Eaton loamy sand	Depressional areas are ponded for long periods	<10" for periods of 1–4 months during most years
Floridana sand	Floodplains flooded for 1–3 months; depressional areas ponded for 6+ months	<10" below surface
Holopaw sand	Depressional areas are ponded for > 6 months	<12" for 2–6 months
Lynne sand		<12" for 1–4 months
Manatee loamy fine sand	Depressional areas ponded for 6–9 months	<10" for >6 months
Pomona sand	Depressional areas ponded 6–9 months or more in most years	6–18" for 1–3 months and 10–40" for 6 months or more during most years.
Pompano fine sand	Depressional areas ponded for more than 3 months each year	<10" for 2–6 months; <30" for more than 9 months
Tuscawilla fine sand		<10" for 2–6 months in most years
Wabasso fine sand	Depressional areas are ponded for 6–9 months in most years.	<12" for <60 days in wet seasons; 12–40" >6 months in most years and >40" during very dry seasons

Source: Official Soil Series Descriptions (NRCS 2003)
http://ortho.ftw.nrcs.usda.gov/cgi–bin/osd/osdname.cgi

MINIMUM LEVELS CONCEPTS AND CRITERIA FOR THE ST. JOHNS RIVER AT SR 50

Recommended minimum flows and levels (MFLs) for the St. Johns River at SR 50 are based upon the concept that if the essential characteristics of the natural flooding and drying regime are maintained, then the basic structure and functions of the environmental system will be maintained. Soil, vegetation community, and channel elevation data collected in the field are the principle components of each recommended minimum level. The elevations of the wetland communities in the St. Johns River floodplain near SR 50 can be associated with the long-term river stage record where typical durations and frequencies of flooding and drying are known. These wetland community elevations can be applied toward the development of recommended MFLs. The standardized procedures for setting each level using the best available information, as described in greater detail in the *MFLs Methods Manual* (Hall 2006), were followed as the basis of developing the recommended MFLs for the St. Johns River at SR 50. MFLs criteria vary depending upon the level being determined (i.e. minimum frequent-high, minimum average, minimum frequent-low or minimim infrequent-low) and the on-site wetland community and river channel characteristics.

For example, the primary high-level criterion may equal the average elevation of a wetland community that experiences flooding approximately 20% of the time, based upon the scientific literature and hydrologic data. Additional high-level criteria may include the maximum elevation of a vegetation community that typically floods frequently, and/or the elevation equal to the landward extent of the hydric soils or the landward extent of a shallow (depth < 8 in) surface organic soil. The minimum frequent-high flow and level should maintain the seasonal flooding regime. Seasonal high water flows or levels occur in natural systems with unaltered hydrology that provide for out-of-bank flooding of the riparian wetlands adjacent to the mainstem of a river at duration and return intervals sufficient to support important ecological processes (Hill et al 1991). Levels and flows equal to the minimum frequent high should occur for at least 30 continuous days in the growing season at least one in 3 years, on average. Stream biota relies upon inundation of the floodplain for habitat and for the exchange of nutrients and organic matter (McArthur 1989). Flooding of wetlands and upland fringes redistributes and concentrates organic particulates across the floodplain (Junk et al. 1989) In streams, flood flows are necessary to deposit the sediment that allows the riparian floodplain forming process to occur (Hill et al. 1991).

The primary minimum frequent-high level criterion for four of the five local level determinations for the St. Johns River at SR 50 equaled the average elevation of the upper wet prairie. In the floodplain of the St. Johns River near SR 50, the upper wet prairies extend to an elevation, which based upon the long-term stage record, floods infrequently. As mentioned previously, prescribed fires in the floodplain near SR 50 result in a nearly homogenous plant species composition across the wet prairies and upper wet prairies over a relatively large elevation gradient. In fact, short hydroperiod wet prairies in the Everglades are maintained by prescribed fire (White 1994). Consequently, the average elevation of the upper wet prairie was used as the primary minimum frequent-high level criterion. At one location (Lake Cone), the transects did not traverse an upper wet prairie, so the minimum frequent-high level primary criterion equaled the average elevation of the hardwood swamp between stations 220–1600 at Lake Cone. This criterion ensures surface water inundation across the entire hardwood swamp at Lake Cone.

Both the hardwood swamp at Lake Cone and the upper wet prairies traversed in the St. Johns River floodplain near SR 50 are extensive wetland communities, which transition abruptly to palm hydric hammocks at significantly higher elevations. As mentioned previously, the palm hydric hammocks and the ecotone elevation between the upper wet prairies and palm hydric hammocks experience surface water flooding infrequently.

The minimum average flow and level represents the surface water level and flow necessary over a long period to maintain the integrity of hydric soils and wetland plant communities. This level and flow is considered the minimum that must be sustained for extended periods to maintain floodplain hydric soils and to impede the encroachment of upland plant species into the wetland plant communities. The minimum average level determination criteria typically focus on soil characteristics, when extensive histosols or a histic epipedon are sampled. An appropriate minimum average water level is necessary to conserve the floodplain organic soils. Low water levels for extended periods cause oxidation of organic soils, ultimately resulting in soil subsidence. However, the St. Johns River floodplain soils near SR 50 are primarily mineral with an occasional histic epipedon (surface organic horizon with thickness of 8–16 in.). Consequently, the primary minimum average level criterion for the St. Johns River at SR 50 equaled the average ground elevation of the shallow marsh communities, to ensure soil saturation within the shallow marshes and to provide shallow inundation of secondary channels and open water areas.

As mentioned previously, soil saturation will impede the invasion of upland plant species into the shallow marshes while shallow inundation will provide aquatic refugia for numerous small fish, amphibians, and small reptiles. The shallow water depths are also ideal for wading bird foraging. Wading birds can only forage in relatively shallow water. Great Egrets need water depths of less than 10 in., and the small herons need depths of less than 6 in. Dropping water levels cause fish to be concentrated in isolated sloughs throughout the shallow marshes. Birds effectively exploit these concentrations (Bancroft, et al. 1990).

The minimum frequent-low level typically results in dewatered wetlands. This dewatering is a natural consequence of drought and has ecological benefits. Drawdown conditions enable seeds of emergent wetland plants to germinate from the seed banks of the floodplain. Seeds of many wetland plant species require exposed soils in order to germinate (Van der Valk 1981). Exposing the floodplain for suitable durations maintains the composition of emergent plant species and increases plant diversity. The minimum frequent low represents a low water level and flow that generally occurs only during periods of reduced rainfall.

Criteria for setting the minimum frequent-low level also typically focus on soil characteristics if extensive histosols or a histic epipedon were sampled. Typically, when a widespread histic epipedon or histosol is observed, the low level is based upon a 20-in. soil water table drawdown. This 20-in. drawdown criterion was based on the best available supporting information from the literature that described seasonally flooded marsh systems average minimum dry season water table depths of 15.6 to 26.2 in., with an average hydroperiod of 255 $\pm$ 11.1 days (Environmental Science and Engineering Inc. 1991).

Due to the lack of widespread organic soils in the St. Johns River floodplain near SR 50, a 20-in. mineral soil water table drawdown from the average ground surface elevation of the shallow marshes was the primary low level criterion at the five locations. The 20-in. mineral soil water table drawdown criterion is based upon the NRCS (2003), the *Soil Survey of Brevard County* (USDA, SCS 1974) and the *Soil Survey of Lake County* (USDA, SCS 1975) descriptions of dry season soil water table depths for Chobee, Manatee, Bradenton, and Floridana series soils. Chobee series soil was the most commonly occurring soil observed in the shallow marshes near SR 50, while Manatee, Bradenton, and Floridana soil were also commonly observed. Chobee soil contains both mollic and argillic horizons indicative of prolonged soil saturation and very poorly drained soil characteristics where high concentrations of organic matter develop and persist in flooded soils. According to the *Soil Survey of Brevard County* (USDA, SCS 1974), Chobee soils are continuously flooded for one to six months in many places. Additionally, in most years the Chobee soil water table occurs within 10 in. of the soil surface for six to nine months and between 10 and 40 in. of the soil surface for three to six months. In very dry seasons, the Chobee soil water table occurs at depths greater than 40 in., below the soil surface for short periods.

The shallow marsh communities in the St. Johns River floodplain near SR 50 are primarily located between the multiple river channels and/or open water areas, typically occurring at the lowest vegetated elevations in depressions. Consequently, an average 20-in. soil water table drawdown within the depressional shallow marshes is considered a reasonable, minimum frequent-low level criterion, based upon the best available information. Additionally, a capillary fringe of varying thickness exists above the soil water table. In the capillary fringe zone, the soil is nearly water-saturated; the water is adsorbed to soil particles to a greater degree than water below the water table. The capillary fringe zone contains various amounts of water depending upon the pore size and the elevation of the water table (Richardson et al 2001). A sandy clay loam, such as Chobee soil, with an average porosity of 0.005 centimeters (cm), should have a saturated zone extending at least 12 in. (30 cm) above the soil water table (Mausbach 1992). Consequently, soil moisture may be available to the marsh vegetation at depths considerably closer to the soil surface than that predicted from the 20-in. soil water table drawdown criterion.

The minimum infrequent-low level is an extreme low water level that usually occurs during severe drought. This dewatering event typically occurs for short durations with very long return intervals. Vegetation, if present near the associated elevation, is composed primarily of submersed, floating-leaved, or emergent obligate wetland plant species. Vegetation in the St. Johns River channel near SR 50 is largely absent at the minimum infrequent-low level.

The primary minimum infrequent-low level criterion for the St. Johns River at SR 50 was to provide adequate water depths ($\geq$0.8 ft depth over 25% of the channel width) for fish passage in the main channel at four sites identified as the most-shallow points between SR 46 and SR 528. If the main river channel had multiple deep zones, the 25% width criterion could be noncontiguous. However, the width of the individual deep zones must equal at least 10% of the overall channel width and combine to at least 25% of the total channel width. Thompson (1972) developed minimum depth criteria of 0.6–0.8 ft over at least 25% of the channel width for the passage of fish in typically high gradient streams, based on the body dimensions of large salmonid. The fish passage criterion providing a 0.8 ft minimum water depth over at least 25% of the channel width has been implemented for other MFL determinations (SWFWMD 2002; Water Resources Associates Inc. 2004) as well as for the St. Johns River downstream from Lake Washington at river mile 253.1 (Hall and Borah 1998).

The following additional concepts further describe the theoretical, practical, and methodological background for the process used to establish biological criteria, and ultimately develop the recommended MFLs for the St. Johns River at SR 50.

- A given wetland community type will have similar hydrologic and soil characteristics and occur in similar relative topographic positions across all transect locations.

- The final MFLs is more robust because it is derived from the multiple sets of local levels, based upon stand-alone work replicated in multiple geographic areas.

- The shallow marsh communities along the St. Johns River near SR 50 are considered depressional areas with regard to the NRCS (2003) soil water table typical dry season drawdown descriptions. The shallow marshes typically occur at the lowest vegetated elevations within the floodplain and are primarily located between the multiple river channels and/or sloughs. Soils within the shallow marshes are dewatered to limited depths for limited durations.

- The application of mineral soil water table drawdown criterion to the minimum frequent-low levels will provide for protection of the structural integrity of the soil horizons and maintenance of hydric soil characteristics.

- The hydric soil characteristics observed at the higher elevations in the wet prairies, upper wet prairies and palm hydric hammocks are not maintained solely by surface water inundation of the St. Johns River. The hydric soil characteristics observed at the higher elevations are largely a function of soil porosity, local rainfall, and shallow groundwater seepage, as well as infrequent surface water inundation.

- Vegetation composition and dominance in the St. Johns River floodplain near SR 50 is heavily influenced by fire. Fire may be the most influential factor maintaining the wet prairie communities. In general, on public lands in the St. Johns River floodplain near SR 50, prescribed fire occurs every 3 to 5 years to eliminate woody shrubs from the wet prairies and shallow marshes. Wax myrtle, buttonbush, and groundsel tree quickly invade and dominate the wet prairie communities in the absence of fire.

- Prescribed fire results in wet prairie communities extending over a wide elevation gradient, with the lower elevations primarily maintained by the river hydrology and the upper elevations maintained primarily by fire and groundwater seepage. Consideration for the role of fire and other disturbances (i.e. hurricane wind impacts, cattle grazing) is necessary in interpreting relationships between vegetation communities and hydrologic conditions.

- Extensive wet prairie communities in the St. Johns River floodplain, which display little vegetation change over a wide elevation gradient and extend to the palm hydric hammocks, are divided into upper wet prairie and wet prairie. The upper wet prairies are distinguished from the wet prairies by the presence of scattered cabbage palms in the upper wet prairies.

- Vegetation composition and dominance in the St. Johns River floodplain near SR 50 changes dramatically throughout the year due to seasonal weather patterns, prescribed fire, fluctuating river levels, and cattle grazing. Consequently, on any given date field transect site, vegetation monitoring may result in subtle to dramatically different vegetation composition and dominance, as compared to a previous site visit. Multiple site visits occurred at all field transects near SR 50 to improve the ability to characterize the vegetative communities. The basic vegetation community classification and distribution of overall community types was stable.

- Infrequent high flows and levels (river flows and levels above the minimum frequent high) are dependent upon seasonal weather events (i.e. tropical storms) when high rainfall occurs within the Upper St. Johns River Basin. These infrequent high river flows and levels should continue to occur and are important in maintaining the existing floodplain wetland communities. MFLs need not be set to protect these infrequent high flows and levels as long as infrastructure is not developed to take advantage of the infrequent high river flows and levels.

- Palm hydric hammocks along the St. Johns River near SR 50 occurred at high elevations, greater than the recommended minimum frequent-high levels, and flood infrequently (i.e., on average once per decade) from the river. Seasonal shallow ponding, which maintains the hydric soil characteristics within the palm hydric hammocks, occurs frequently due to local rainfall, shallow groundwater seepage, and the poorly drained soil characteristics. Therefore, recommended MFLs are not developed for this community.

- Two attributes of natural hydrology that are commonly studied with respect to wetland and aquatic communities are the seasonality or timing of flooding and drying, and the rate at which water levels change. In the St. Johns River system, seasonality and rate of change are currently controlled by natural forces (e.g. climate) and are not expected to change significantly by consumptive use. Consequently, these two aspects of natural hydrology are not considered in the development of recommended MFLs reported in this document (Wilson 2005).

- Rainfall patterns and subsequent river flows and levels in Florida respond to the Atlantic multidecadal oscillation (AMO) cycles. AMO denotes long-term oscillations in the sea surface temperature of the North Atlantic Ocean and how it affects rainfall and, thus, river flow patterns over multidecadal periods. Rivers in central and south Florida were in a multidecadal period of higher flows from 1940 to 1969 and have generally exhibited lower flows from 1970 to 1999 (Kelly 2004). Stage- and flow-data analyses and surface water modeling performed as part of the development of recommended MFLs for the St. Johns River at SR 50 incorporate stage and flow data from both the high- and low-flow periods, thus, ensuring that the model output and stage- and flow-data analyses were not skewed towards either a low- or high-rainfall time period.

- Vegetation community shifts within the St. Johns River floodplain near SR 50 due to the AMO cycles that may occur at elevations below the palm hydric hammocks. During high river flow cycles, the wet prairie acreage may decrease as the shallow marsh shifts upslope, while during low river flow cycles the wet prairie acreage may increase as the shallow marsh moves downslope. The upper elevations of wet prairie and upper wet prairie are predicted to remain stable regardless of the AMO cycle due to the influence of fire in maintaining these vegetation communities at the higher elevations, as well as the relatively stable ecotone at the water ward extent of palm hydric hammocks.

In summary, the foundation of the MFLs determinations is comprised of the field collected elevation, vegetation, and soils data in order to first characterize the floodplain wetland communities and river channels and then relate the wetland communities and river channel morphology to the natural flooding and drying regime of the St. Johns River. The following Results and Discussion section describes the field collected data and the subsequent local levels determinations upstream and downstream from SR 50, as well as the recommended levels for the St. Johns River at SR 50.

RESULTS AND DISCUSSION

To develop recommended minimum levels for the St. Johns River at SR 50, field data were collected at nine locations upstream and downstream from SR 50. Then local levels were determined for the nine locations. Minimum frequent-high, minimum average and minimum frequent-low levels were determined at each of five locations, while a minimum infrequent-low level was determined at four additional locations. The locally determined levels were then transferred to SR 50, using the St. Johns River at SR 50 as a convergent endpoint. One final set of levels for the St. Johns River at SR 50 facilitates periodic hydrologic monitoring and eliminates possible confusion regarding multiple sets of levels.

This section provides results for the following:

1. MFLs determinations for each of the five transect locations where local minimum frequent-high, minimum average, and minimum frequent-low levels were determined, including (1) St. Johns River near Hatbill Park, (2) St. Johns River at Lake Cone, (3) St. Johns River at the Tosohatchee North, (4) St. Johns River near the Great Outdoors, and (5) St. Johns River near SR 528 (TOSO-528)
2. Minimum infrequent-low levels determinations for each of the four shallowest reaches of the St. Johns River between SR 46 and SR 528
3. Recommended MFLs for the St. Johns River at SR 50

FIELD TRANSECTS

Eleven transects were examined in association with the development of recommended MFLs for the St. Johns River at SR 50. The data and analyses for these 11 transects are described by transect location in the following discussion (Table 6).

St. Johns River Near Hatbill Park

The Ruth Lake Transect and the H-1 Transect traversed different vegetation communities in the St. Johns River floodplain less than 1 mi upstream (south) from Hatbill Park (Table 7). Hatbill Park is a Brevard

Table 6. Field transects names, locations, and types of local levels determined

Transect Name	Transect Location	Type of Levels Determined
Ruth Lake	SJR near Hatbill Park	Minimum frequent-high, minimum average, minimum frequent-low
H-1		
Lake Cone	SJR at Lake Cone	Minimum frequent-high, minimum average, minimum frequent-low
M-6		
Tosohatchee North	Tosohatchee North	Minimum frequent-high, minimum average, minimum frequent-low
Great Outdoors	Great Outdoors	Minimum frequent-high, minimum average, minimum frequent-low
TOSO-528	Tosohatchee near SR 528	Minimum frequent-high, minimum average, minimum frequent-low
North of Orange Mound	Near Hatbill Park	Minimum infrequent-low
H-2	RM 216.6	Minimum infrequent-low
Little Palm Island	RM 217.0	Minimum infrequent-low
M-4	RM 217.7	Minimum infrequent-low

Table 7. Hatbill Park transects location information

Transect Name and River Mile	Latitude–Longitude (Beginning Station)	Latitude–Longitude (End Station)	Location and Date of Fieldwork
Ruth Lake RM 201.2	28 36 32.24; 80 56 53.95 (Station -1500) 28 36 30.16; 80 56 40.01 (Station 0)	28 36 28.14; 80 56 32.47 (Station 740)	Open water of Ruth Lake to the uplands on the east shore; March and December 2002.
H-1 RM 201.8	28 35 31.12; 80 59 00.06 (Station -1500) 28 35 29.08; 80 58 42.90 (Station 0; H-1)	28 36 00.60; 80 56 44.53 (Station 11013; H-1)	West floodplain in palm hydric hammock-transitional shrub across entire floodplain and multiple channels to east edge of wet prairie; January. October, December 2003

County boat ramp on the St. Johns River accessed from SR 46, approximately 4 mi west of Interstate 95 (I-95).

Field Data for Ruth Lake Transect

The Ruth Lake Transect was located on the east Shore of Ruth Lake. Ruth Lake is permanently connected to the St. Johns River at approximately river mile 201.2 (Figures 2, 7, and 9). This transect is approximately 7.8 river miles downstream from the SR 50 bridge over the St. Johns River and 11.2 river miles upstream from the SR 46 bridge over the St. Johns River.

Transect Selection Criteria Ruth Lake Transect

The primary criteria for selecting this transect location included the following:

- A unique area due to the relatively unimpacted wet prairie and comparatively short distance from open water to uplands without intercepting an indian midden
- Located on SJRWMD property (Seminole Ranch), minimizing future development and facilitating access for long-term ecological monitoring

Downstream (north) from Ruth Lake to SR 46 the St. Johns River floodplain is more impacted by cattle grazing, agricultural fields, and residential dwellings.

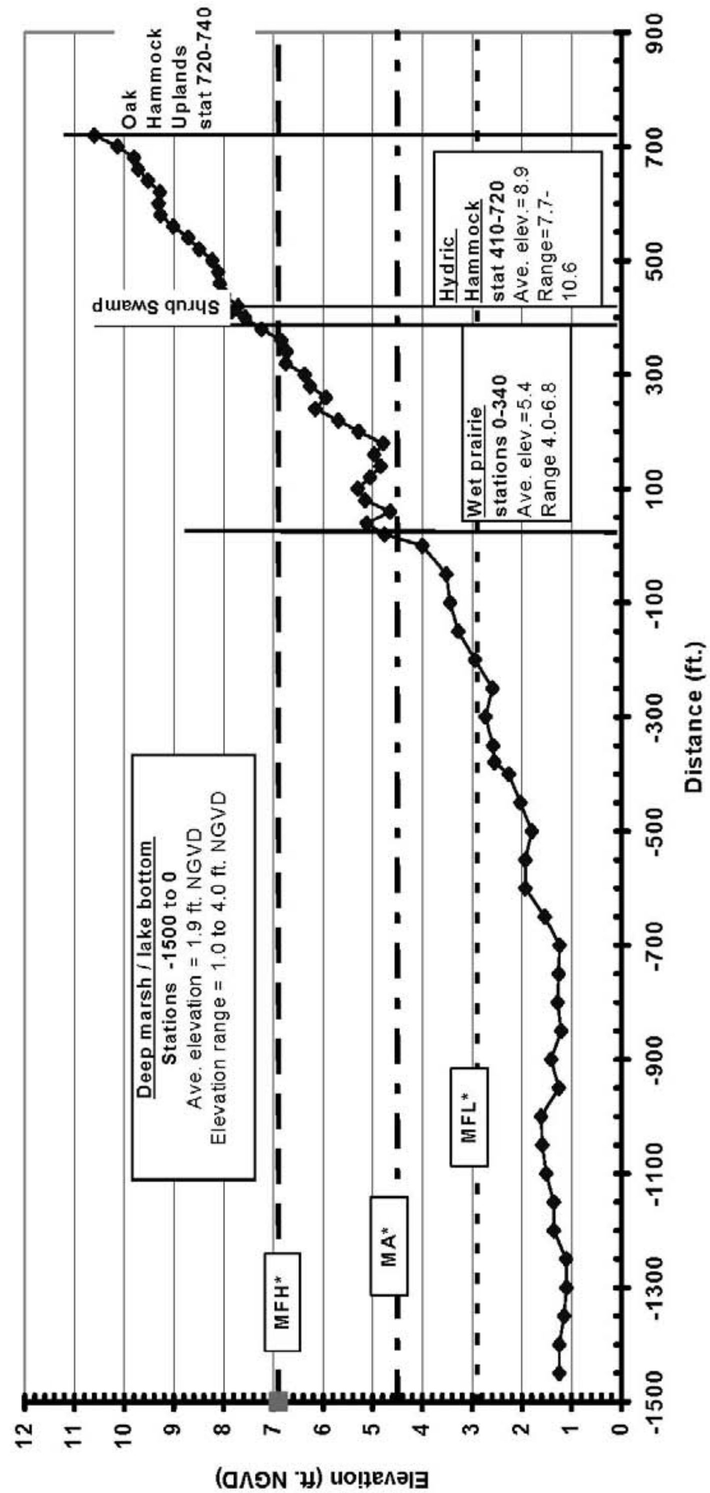
Vegetation at Ruth Lake Transect

The Ruth Lake Transect originated in the open water of Ruth Lake and traversed in an easterly direction across the lake bottom / deep marsh, a wet prairie, a transitional shrub, a palm hydric hammock, and terminated at the edge of an oak upland (Figures 9 and 10; Tables 7–9).

The lake bottom / deep marsh (stations -1500 to 0) was sparsely vegetated with scattered clumps of soft-stem bulrush (*Scirpus validus*). The transect traversed a wet prairie from station 0 to 340. Wet prairie vegetation included dominant sand cordgrass (*Spartina bakeri*); abundant swamp hibiscus (*Hibiscus grandiflorus*); and scattered soft-stem bulrush

Figure 9. Ruth Lake Transect topography with ecological communities

*At Hatbill Park / Ruth Lake the Minimum Frequent High (MFH) equals 6.9 ft. NGVD, the Minimum Average (MA) equals 4.5 ft. NGVD, and the Minimum Frequent Low (MFL) equals 2.9 ft. NGVD



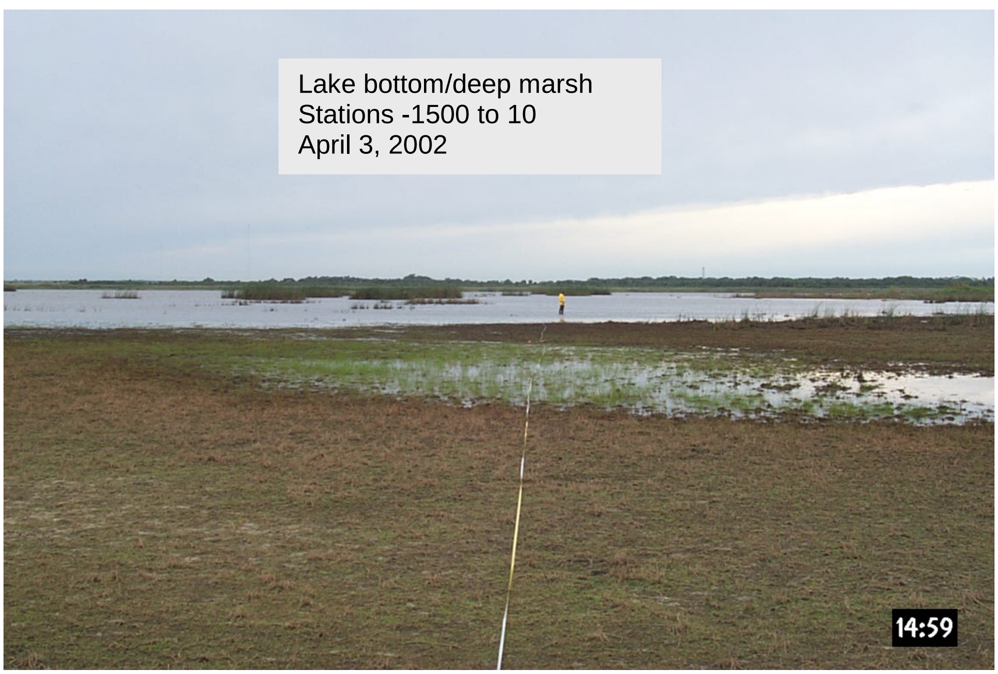


Figure 10. Ruth Lake Transect photos

Figure 10. Ruth Lake Transect photos—*continued*

Figure 10. Ruth Lake Transect photos—*continued*

Table 8. Ruth Lake Transect vegetation community statistics

Vegetation Community	Stations Distance (ft)	Mean (ft NGVD)	Median (ft NGVD)	Min (ft NGVD)	Max (ft NGVD)	N
Deep marsh/lake bottom	-1500 to 0	1.9	1.6	1.0	4.0	33
Wet prairie	0–340	5.4	5.2	4.0	6.8	18
Transitional shrub	340–410	7.2	7.2	6.7	7.8	5
Palm hydric hammock	410–720	8.9	9.0	7.7	10.6	17

ft NGVD = feet National Geodetic Vertical Datum

and saw grass (*Cladium jamaicense*). The transect traversed a transitional shrub community from station 340 to 410. Transitional shrub vegetation included co-dominant groundsel tree (*Baccharis glomerulifolia*); numerous saw grass; and scattered immature cabbage palm (*Sabal palmetto*), wax myrtle (*Myrica cerifera*), sand cordgrass, swamp hibiscus, dahoon holly (*Ilex cassine*), and Brazilian pepper (*Schinus terebinthifolius*).

Adjacent to the transitional shrub, the Ruth Lake transect traversed a palm hydric hammock (stations 410–720). Palm hydric hammock overstory vegetation included co-dominant cabbage palm; abundant sand live oak (*Quercus geminata*); numerous southern red cedar (*Juniperus silicicola*); and scattered American elm (*Ulmus americana*) and water oak (*Quercus nigra*). The palm hydric hammock mid-canopy contained co-dominant immature cabbage palm and abundant guava (*Psidium guajava*). The palm hydric hammock understory was sparsely vegetated with scattered leather fern (*Acrostichum danaeifolium*). The Ruth Lake transect terminated at the palm hydric hammock–oak uplands ecotone. The oak uplands overstory contained co-dominant sand live oak with a sparsely vegetated understory consisting of scattered grape (*Vitis rotundifolia*), cat-briar (*Smilax bona–nox*), and saw palmetto (*Serenoa repens*).

Additional plant species observed along the Ruth Lake Transect are listed in Table 9.

Soils at Ruth Lake Transect

Soil auger holes were dug at 13 selected stations to characterize the soils along the Ruth Lake Transect between stations -100 and 740 (Table 10).

Soil samples were not taken downslope of station -100 within the deep marsh/lake bottom zone due to deep surface water inundation below station -100 on December 18, 2002, when soil sampling occurred. Soils were characterized in the field based upon epipedons, horizons, soil texture, soil color, and horizon depth. These soil features were used to determine the soil series at each soil sampling station. One or more hydric soil indicators (dark surface, histic epipedon, muck, mucky mineral, and/or loamy gleyed matrix) were observed at all sampled stations. Additionally, all soils sampled at the Ruth Lake Transect were mineral soils with a shallow surface organic horizon.

Table 9. Ruth Lake Transect vegetation species list

Common Name	Scientific Name	FWDM Code[1]	Plant Community Species Cover Estimates [2]				
			LB/DM	WP	TS	PHH	OU
American elm	*Ulmus americana*	FACW				1	
Brazilian pepper	*Schinus terebinthifolius*	FAC			1	1	
Cabbage palm–immature	*Sabal palmetto*	FAC			1	4–5	
Cabbage palm–mature	*Sabal palmetto*	FAC				4	
Cat briar	*Smilax bona–nox*	FAC					1
Dahoon holly	*Ilex cassine*	OBL			1		
Guava	*Psidium guajava*	FAC				2	
Groundsel tree	*Baccharis glomeruliflora*	FAC		0	4		
Leather fern	*Acrostichum danaeifolium*	OBL				1	
Muscadine	*Vitis rotundifolia*	FAC					1
Sand cordgrass	*Spartina bakeri*	FACW		5	1		
Sand live oak	*Quercus geminata*	UPL				3	4
Saw grass	*Cladium jamaicense*	OBL		1	2		
Saw palmetto	*Serenoa repens*	UPL					1
Soft-stem bulrush	*Scirpus validus*	OBL	1	1			
Southern red cedar	*Juniperus silicicola*	UPL				2	
Swamp mallow	*Hibiscus grandiflorus*	OBL		3	1		
Water oak	*Quercus nigra*	FACW				1	
Wax myrtle	*Myrica cerifera*	FAC			1		

[1]FWDM Code Indicator categories established in Florida Wetlands Delineation Manual (Gilbert et. al 1995)
Upland (UPL) = Plants that occur rarely in wetlands, but occur almost always in uplands
Facultative (FAC) = Plants with similar likelihood of occurring in both wetlands and uplands
Facultative Wet (FACW) = Plants that typically exhibit their maximum cover in areas subject to surface water flooding and/or soil saturation, but may also occur in uplands
Obligate (OBL) = Plants that are found or achieve their greatest abundance in an area which is subject to surface water flooding and/or soil saturation; rarely uplands

[2]Plant Community Species Cover Estimates: Aerial extent of vegetation species along transect within given community where
0 = <1% (rare); 1 = 1–10% (scattered); 2 = 11–25% (numerous); 3 = 26–50% (abundant); 4 = 51–75% (co-dominant); and 5 = greater than 75% (dominant)
LB/DM = lake bottom /deep marsh (stations -1500 to 0)
WP = wet prairie (stations 0 to 340)
TS = transitional shrub (stations 340 to 410)
PHH = palm hydric hammock (stations 410 to 720)
OU = oak uplands (beginning at station 720)

Table 10. Ruth Lake Transect soil descriptions

Station/Soil Series	Vegetation Community	Soil Horizon	Horizon Description
-100 /Bradenton	Deep marsh/lake bottom	A 0–2"	Dark gray loamy sand
		Cg 2–26+	Very dark gray sandy clay loam
0/Manatee	Deep marsh/lake bottom–wet prairie ecotone	Oa 0–1"	Black muck
		A 1–16"	Black sand
		Cg 16"+	Dark gray sandy loam

Table 10—*Continued*

Station/Soil Series	Vegetation Community	Soil Horizon	Horizon Description
100/Denaud	Wet prairie	Oa 0–13”	Black muck
		A 13–15”	Black sand
		Aeg 15–17”	Black, dark gray, and gray sand; stripping present
		A’ 17–27”	Black sand
		Cg1 27–38”	Very dark gray sand
		Cg2 38–54”+	Dark gray sand
200/Denaud	Wet prairie	Oa 0–13”	Black muck
		Eg 13–18”	Light gray and gray sand; stripping present
		Ab 18–26”	Black loamy sand
		Cg1 26–31”	Dark gray and gray loamy sand
		Cg2 31”+	Dark gray sandy loam
300/Denaud	Wet prairie	Oa 0–8.5”	Black muck
		A 8.5–15”	Black sandy loam
		Eg1 15–23”	Gray, dark gray and very dark gray sand; stripping present
		Eg2 23–35”+	Gray and dark gray sand
360/Anclote	Transitional shrub	Oa 0–7”	Black muck
		A1 7–8”	Black mucky sand
		A2 8–15”	Black loamy sand
		A3 15–20”	Black sand
		E1 20–32”	Dark gray sand
		Eg1 32–39”	Gray sand
		Eg2 39–48”+	Gray and dark gray sand with redoxomorphic concentrations
400/Anclote	Transitional shrub	Oe 0–0.5”	Hemic material
		Oa 0.5–6”	Black muck
		A1 6–7”	Black mucky sand
		A2 7–18”	Black sand
		E 18–40”	Dark gray sand
		Eg 40–48”+	Gray sand
460/Anclote	Palm hydric hammock	Oe 0–1”	Hemic material
		Oa1 1–2”	Very dark-brown muck
		Oa2 2–6”	Black muck
		A1 6–8”	Black mucky sand
		A2 8–24”	Black sand
		E 24–39”	Dark gray sand with redoxomorphic concentrations
		Eg1 39–55”	Yellowish brown and gray sand
		Eg2 55–60”	Gray sand
		Eg3 60”+	Gray sand with redoxomorphic concentrations

Table 10—*Continued*

Station/Soil Series	Vegetation Community	Soil Horizon	Horizon Description
500/Pompano	Palm hydric hammock	Oe 0–0.5"	Hemic material
		Oa 0.5–3.5"	Black muck
		A1 3.5–6"	Black mucky sand
		A2 6–8"	Black sand
		AE 8–18"	Black and gray sand
		E 18–24"+	Yellowish brown with gray sand with iron concretions
540/Anclote	Palm hydric hammock	Oe 0–0.5"	Hemic material
		Oa 0.5–3"	Black muck
		A1 3–5"	Black mucky sand
		A2 5–14"	Black sand
		E1 14–18"	Gray sand
		E2 18–42"	Yellowish brown with gray sand with iron concretions
		E3 42–64"	Gray sand
		Cg 64"+	Dark gray loamy sand
600/Anclote	Palm hydrick hammock	Oi 0–0.1"	Fibric material
		Oe 0.1–1"	Hemic material
		Oa1 1–2"	Very dark brown muck
		Oa2 2–2.5"	Black muck
		A1 2.5–3"	Black mucky sand
		A2 3–13"	Black sand
		E1 13–25"	Light gray and gray sand; stripping present
		E2 25–34"	Brownish yellow and gray sand
		E3 34–60"	Gray sand
		Cg 60"+	Dark gray loamy sand
700/Delray	Palm hydric hammock	Oi 0–0.1"	Fibric material
		Oe 0.1–0.5"	Hemic material
		Oa1 0.5–1"	Very dark-brown muck
		Oa2 1–1.5"	Black muck
		A1 1.5–5"	Black sand
		A2 5–14"	Very dark gray sand
		A3 14–21"	Very dark-brown sand
		E1 21–32"	Grayish brown sand
		E2 32–35"	Grayish brown sand with redoxomorphic concentrations
		Bw 35–43"	Yellow and yellowish brown sand
		Cg 43"+	Dark gray sandy clay loam with redoxomorphic concent.

Table 10—*Continued*

Station/Soil Series	Vegetation Community	Soil Horizon	Horizon Description
740/Pomona	Oak hammock upland	Oi 0–0.1"	Fibric material
		Oe 0.1–0.5"	Hemic material
		Oa 0.5–1.5"	Very dark-brown muck
		A 1.5–8"	Black sand
		E 8–21"	Dark gray sand
		BH-1 21–25"	Very dark-brown sand
		Bh2 25–29"	Very dark grayish brown sand
		Bh3 29–37"	Brown sand
		BwBh 37–39"	Brownish yellow with brown sand
		Cg 39–56”+	Dark gray sandy clay loam with redoxomorphic concent.

Fluvial and other hydrologic processes constantly modify the soils throughout the St. Johns River floodplain. Sediment accretion frequently occurs during flood activities, creating transitory features within the soils, especially those closest to the stream channels (Lindbo and Richardson 2001). When the river rises and inundates the floodplain, erosional and depositional processes combine to deposit coarse sediments at the edge of the floodplain (nearest the channel) and finer-textured material throughout the floodplain. Consequently, sediments found in the St. Johns River floodplain can be comprised of depositional material transported from upstream, depositional material derived locally from channel erosion, and parent material that has been reworked from centuries of flood events. Numerous relatively thin soil horizons can occur from frequent deposition of alluvial sediments and often result in accretion topography. As a result, soil features, such as texture and color, can vary greatly over a short distance (D. Segal, pers. comm. 2004). In the St. Johns River floodplain, fine-textured material may occur near the surface in one place and at a depth of as much as 48 in. at a nearby location (Leighty et al. 1957).

The history of erosional and depositional processes in the St. Johns River floodplain gives rise to a complex distribution of soils across the floodplain. Lateral and horizontal changes in sediment deposition result in soil series with a large degree of variability (Lindbo and Richardson 2001). This combination makes the identification of soil series difficult due to the high variability of soil features found across the Ruth Lake transect. Often soil features found at a given site will not conform to the characteristics of any particular soil series (Segal, pers. comm. 2004). Since the soils resulted in many discrepancies with the official soil series descriptions, Wade Hurt, hydric soil scientist with the USDA, NRCS, in Gainesville, Florida, was consulted to help decipher the correct soil series that most closely represented the described soils.

The soil series and the soil taxonomic classification subgroups are briefly described below for each soil station sampled at the Ruth Lake Transect. The soil taxonomic classification subgroup provides additional information for each soil series and is interpreted starting at the right-hand side of the subgroup name and progressing to the left (JEA 2004; Appendix C).

Beginning with station -100 in the deep marsh/lake bottom the soil series was Bradenton. This Bradenton soil had a shallow surface horizon of dark gray loamy sand. Below this was very dark gray sandy clay loam (Table 10). Bradenton series soil consists of very deep, poorly drained, moderately permeable soils on low ridges and floodplains. The Bradenton soil water table is at depths of less than 18 in. for two to six months annually during most years (NRCS 2003).

The taxonomic classification subgroup for Bradenton soil is a Typic Endoaqualf, meaning it is an Alfisol because it contains an argillic horizon that is high in base saturation. Bradenton is in the aquic moisture regime and is endosaturated, meaning it derives its moisture primarily internally from groundwater. The argillic horizon in Bradenton soil occurs within 20 in. of the ground surface. The Bradenton series is classified as poorly drained, although this particular soil is probably very poorly drained; because it is at the bottom of the topographic gradient, it is within the lake shoreline and contains an extremely shallow argillic horizon (2 in. below the soil surface) that would preclude vertical water percolation (JEA 2004; Appendix C).

At station 0 in the deep marsh/lake bottom and wet prairie ecotone, the soil series was Manatee. This Manatee soil had a 1-in.-thick surface muck horizon, then a 15-in.-thick black sand horizon and a dark gray sandy loam at a depth of 16 in. below the soil surface. Manatee soil consists of very deep, very poorly drained, moderately permeable soils in depressions, broad drainage ways, and on floodplains. The Manatee soil water table is at depths of less than 10 in. for six or more months annually during most years. Depressional areas are ponded for about six to nine months during most years (NRCS 2003). According to the Soil Survey of Lake County, Florida (USDA, SCS 1975), the Manatee soil water table is at or near the surface except during dry periods, when it may reach a depth of 20 in. below the soil surface.

The taxonomic classification subgroup for Manatee soil is a Typic Argiaquoll. Manatee soil is a Mollisol. All Mollisols have a mollic epipedon. The mollic epipedon is comprised of one or more dark surface horizons with sufficiently high concentrations of organic material that has stained or coated the mineral material black. The mollic epipedon has at least a 10-in.-thick depth. This dark surface epipedon is indicative of very poorly drained conditions where the soil environment is largely inundated and reduced. Consequently, organic matter accumulates and persists rather than decomposing in an aerated environment. Manatee soil is classified as very poorly drained and is in the aquic moisture regime. All soils near SR 50 that contain a mollic epipedon are also classified as very poorly drained. Manatee soil contains an argillic horizon and the argillic horizon occurs within 20 in. of the soil surface (JEA 2004; Appendix C).

Soils sampled upslope within the wet prairie at stations 100, 200, and 300 were Denaud series. The Denaud series consists of deep, very poorly drained, moderately permeable soils with a thin organic layer over sandy and loamy material. These soils formed in sandy and loamy marine deposits and are ponded for six to nine months, in most years, and saturated to the soil surface the rest of the time during most years (NRCS 2003). The taxonomic classification subgroup for Denaud soil is a Histic Humaquept. A Histic Humaquept is an Inceptisol meaning it is a somewhat young soil and has minimal horizon development, but somewhat more development than the youngest Entisols. Denaud soil is in the aquic moisture regime, has distinct organic material at the surface, and has a histic epipedon. A histic epipedon contains 8 to 16 in. of organic material (JEA 2004; Appendix C). Denaud is the only soil series sampled along the Ruth Lake Transect containing a histic epipedon. The landward extent of the histic epipedon was located at station 348, slightly above the wet prairie—transitional shrub ecotone (station 340).

Soils were sampled upslope of the wet prairie within the transitional shrub at stations 360 and 400. At station 360, the surface organic horizon depth equaled 7 in., and the soil series was Anclote. At station 400, the surface organic horizon depth equaled 6 in., and the soil series was also Anclote. The Anclote soil is quite similar to the Denaud soil immediately downslope, only differing by 1 to 2 in. of surface muck (JEA 2004; Appendix C). Anclote series soil consists of very deep, very poorly drained, rapidly permeable sandy soils in depressions, poorly defined drainage ways, and floodplains. The Anclote soil water table is within 10 in. of the surface for six or more months during most years and recedes to depths of more than 20 in. during the driest season. Under natural conditions, Anclote soils are saturated and frequently covered with shallow water during the summer rainy season. Depressional areas are ponded (NRCS 2003).

The taxonomic classification subgroup for Anclote soil is a Typic Endoaquoll, meaning it contains a mollic epipedon, is in the aquic moisture regime, and the mollic epipedon is 30 in. or less in thickness. The term endo implies that Anclote soils are endosaturated, where water is frequently derived from groundwater rather than surface water (JEA 2004; Appendix C).

Soil sampling within the palm hydric hammock, upslope from the transitional shrub, occurred at stations 460, 500, 540, 600, and 700. Palm hydric hammock soils sampled at stations 460, 540, and 600 were Anclote sand. At station 500 Pompano sand was identified. Pompano is very similar to Anclote soil in all the subsurface horizons. However, the Pompano soil lacked 2 in. of black sand to be classified as a Mollisol, and thus as an Anclote soil (JEA 2004; Appendix C). Pompano sand consists of very deep, poorly and very poorly drained sand that formed in sandy and loamy marine sediments. Under natural conditions, the Pompano sand water table is within a depth of 10 in., for two to six months in most years, and is within 30 in., for more than six months during most years (NRCS 2003).

The taxonomic classification subgroup for Pompano soil is a Typic Psammaquents, meaning it is a young soil in the Entisol soil order and, consequently, has minimal soil horizon development. Entisols are thought to be geologically young soils that lack a long weathering process that would produce distinct horizons. Pompano soil is in the aquic moisture regime and the soil profile is comprised of sand. Pompano soil is given the Typic adjective because it typifies the great group Psammaquents, rather than having a distinct characteristic that would warrant a more descriptive adjective (JEA 2004; Appendix C).

Near the palm hydric hammock to oak upland ecotone at station 700 the soil series was Delray. Delray series consists of very deep, very poorly drained, moderately permeable soils on broad flats, floodplains, and depressions. The Delray series soil water table is at depths of less than 12 in., for six to nine months in most years. Depressions are ponded for six months or more in most years. Floodplains are flooded for very long durations (NRCS 2003).

The taxonomic classification subgroup for Delray soil is a Grossarenic Argiaquoll. Delray is a Mollisol. All Mollisols have a mollic epipedon. As mentioned previously, the mollic epipedon is a collection of thick dark surface horizons with sufficiently high concentrations of organic material that has stained or coated the mineral material black. Delray is very poorly drained and is in the aquic moisture regime. All soils near SR 50 that contain a mollic epipedon are also classified as very poorly drained. The grossarenic adjective implies that the argillic horizon occurs at depths greater than 40 in. below the soil surface. At the Ruth Lake transect the Delray soil is located at a relatively high topographic position. This Delray soil is likely associated with a seepage slope, which would explain the accumulation of organic material and very poorly drained moisture category (JEA 2004; Appendix C).

Pomona fine sand was observed at station 740 in the oak hammock upland. This Pomona soil also had a shallow organic horizon (Table 10). Pomona series consists of very deep, poorly and very poorly drained, moderate to moderately slowly permeable soils located on low ridges. The Pomona soil water table is within a depth of 6 to 18 in. below the soil surface for one to three months and is at a depth of 10 to 40 in. below the soil surface for six months or more during most years (NRCS 2003).

The taxonomic classification subgroup for Pomona soil is an Ultic Alaquod, meaning it is a spodosol. All spodosols have a spodic horizon. Pomona soil is in the aquic moisture regime, which is a reducing water regime. Pomona soil has light colored albic subsurface layer(s) below the A-horizon. Pomona soil also has an argillic horizon occurring at least 40 in. below the soil surface. Both the spodic and argillic horizons are hardpan layers that impede vertical water movement and can cause surface saturation during high rain events. These hardpan layers, combined with a low landscape position, contribute to the poorly drained moisture classification of Pomona soil (JEA 2004; Appendix C).

In summary, soils at the Ruth Lake Transect formed and persist in very wet and hydrologically dynamic conditions. These soils are very poorly or poorly drained and are strongly affected by river flooding, as well as subsurface drainage from the surrounding uplands. High surface organic matter content is common in these soils and is manifested as a mollic or histic epipedon, or ochric epipedon that lacked only a few inches of black material to be a mollic epipedon. Organic material accumulates in these soils due to the reduced, low oxygen conditions inhibiting decomposition (JEA 2004, Appendix C).

Field Data for H-1 Transect

The H-1 Transect was located approximately 0.6 river miles upstream from the Ruth Lake Transect and approximately 7.2 river miles downstream from the SR 50 bridge over the St. Johns River (Figures 7, 11 and 12).

Transect Selection Criteria H-1 Transect

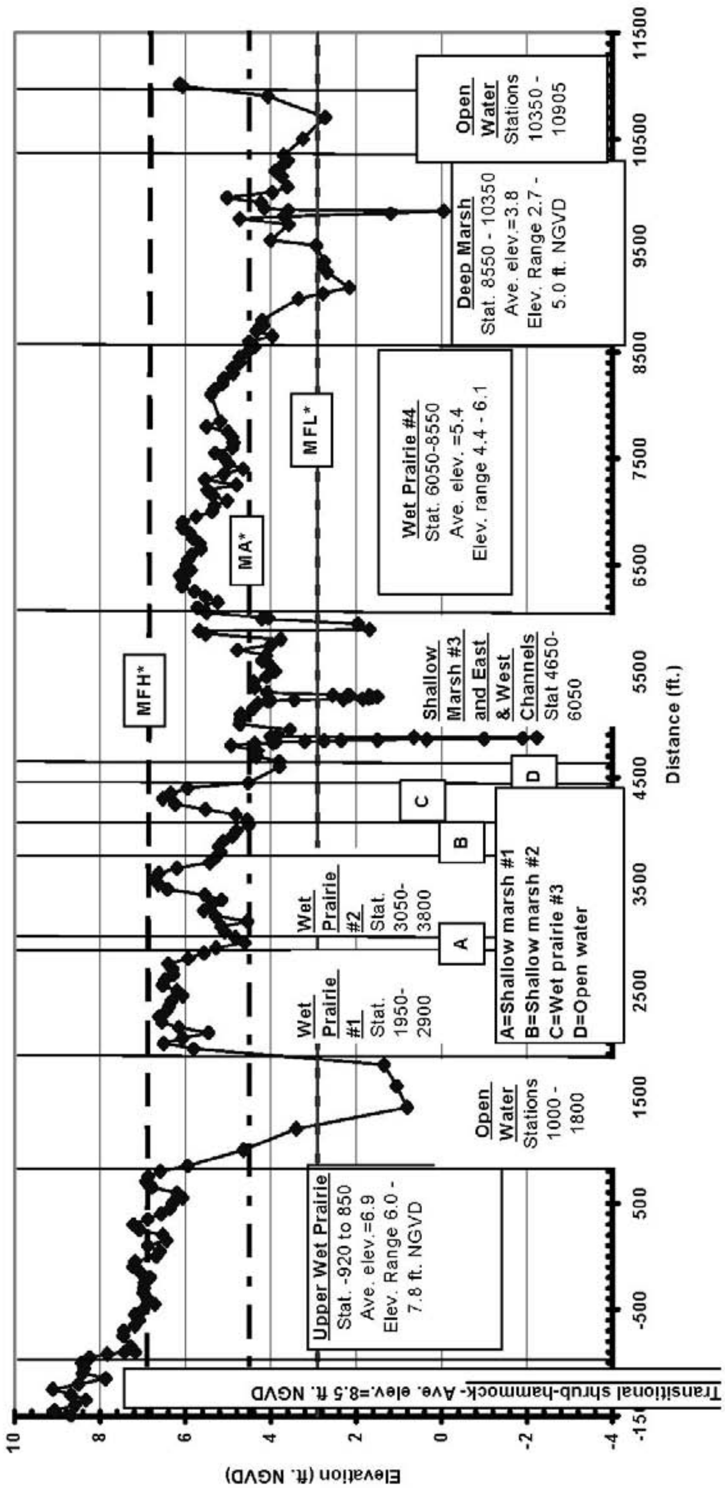
The primary criteria for selecting this transect location include the following:

Includes the lowest floodplain vegetation communities that were not traversed at the nearby Ruth Lake Transect (The St. Johns River floodplain at this locale consists of multiple river channels and drainages dotted with numerous small cabbage palm islands. Subtle changes in elevation result in shifts between wet prairie and shallow marsh communities.)

- Traverses multiple, relatively unimpacted wet prairie and marsh communities (Figure 7)
- Is located on SJRWMD property (Seminole Ranch), preventing future development and facilitating access for long-term ecological monitoring

Figure 11. H-1 Transect topography with ecological communities

*At Hatbill Park / H-1 the Minimum Frequent High (MFH) equals 6.9 ft. NGVD, the Minimum Average (MA) equals 4.5 ft. NGVD, and the Minimum Frequent Low (MFL) equals 2.9 ft. NGVD



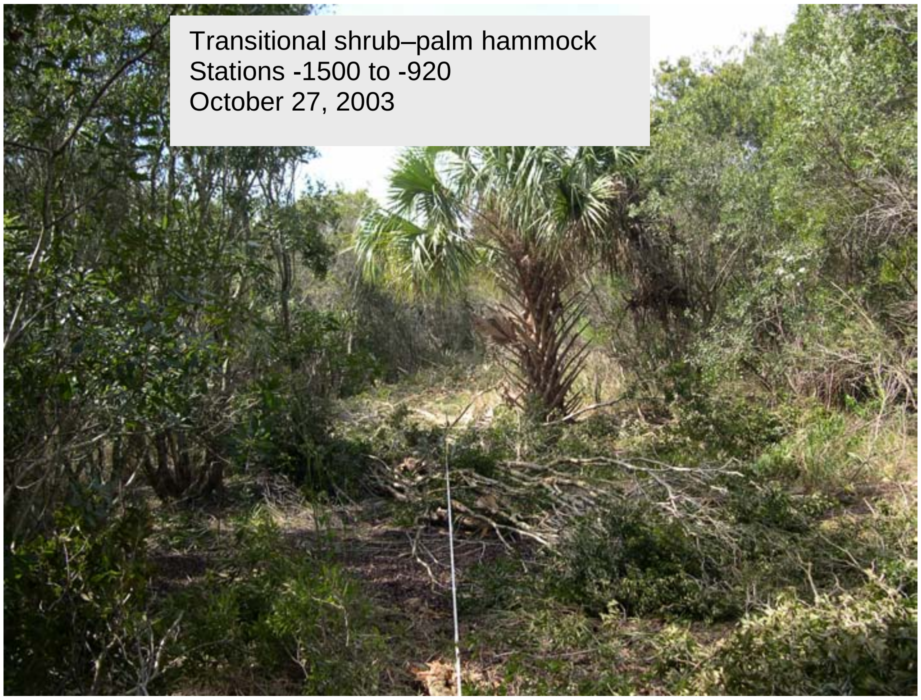


Figure 12. H-1 Transect photos

Figure 12. H-1 Transect photos—*continued*

Figure 12. H-1 Transect photos—*continued*

Figure 12. H-1 Transect photos—*continued*

Figure 12. H-1 Transect photos—*continued*

Figure 12. H-1 Transect photos—*continued*

Extensive elevation surveys of the river channels at H-1 facilitated additional surveys of the floodplain at H-1.

Vegetation at H-1 Transect

The H-1 transect originated on the west floodplain within a palm hammock–transitional shrub and traversed in an easterly direction approximately 12,500 ft across multiple wet prairies, open water areas, river channels, shallow marshes and a deep marsh (Figures 11 and 12; Tables 7, 11 and 12).

Beginning with the palm hammock–transitional shrub (stations -1500 to -920), the vegetation included co-dominant wax myrtle; numerous cabbage palm, sand cordgrass, groundsel tree, and bushy broom grass (*Andropogon glomeratus*); and scattered dog fennel, false willow (*Baccharis angustifolia*), blackberry (*Rubus betulifolius*), and *Juncus sp*.

East and downslope from the palm hammock–transitional shrub, the H-1 transect traversed an upper wet prairie (station -920 to 850). The upper wet prairie vegetation included dominant sand cordgrass (Table 12). Additional vegetation species included numerous southeastern sunflower (*Helianthus agrestis*), swamp hibiscus, and bull arrowhead (*Sagittaria lancifolia*); and scattered saltmarsh mallow (*Kosteletzkya virginica*), sugarcane plumegrass (*Erianthus giganteus*), cabbage palm, and coastal cockspur (*Echinochloa walteri*).

Immediately east of the upper wet prairie, the H-1 transect traversed an open water area (stations 1000–1800). The next vegetation community traversed at H-1 was wet prairie #1 (stations 1950–2900; Figure 11; Tables 11 and 12). The most distinguishing characteristic between the upper wet prairie and the wet prairies (1–4) traversed at H-1 was the absence of mature cabbage palm in the wet prairies (1–4). Wet prairie #1 vegetation included abundant sand cordgrass and fall panic grass (*Panicum dichotomiflorum*); numerous southeastern sunflower; and scattered swamp hibiscus, saltmarsh mallow, and dotted smartweed (*Polygonum punctatum*).

Table 11. H-1 Transect vegetation community statistics

Vegetation Community	Stations Distance (ft)	Mean (ft NGVD)	Median (ft NGVD)	Min (ft NGVD)	Max (ft NGVD)	N
Palm hammock–transitional shrub	-1500 to -920	8.5	8.4	7.8	9.1	13
Upper wet prairie	-920 to 850	6.9	6.9	6.0	7.8	37
Open water	1000–1800	2.2	1.4	0.8	4.6	4
Wet prairie #1	1950–2900	6.2	6.3	5.3	6.6	20
Shallow marsh #1	2900–3050	5.0	5.0	4.6	5.3	4
Wet prairie #2	3050–3800	5.6	5.4	4.6	6.7	16
Shallow marsh #2	3800–4100	4.9	4.9	4.5	5.2	7
Wet prairie #3	4100–4450	5.6	5.7	4.5	6.5	6
Open water	4450–4650	3.8	3.8	3.8	3.8	2
Shallow marsh #3	4650–6050 excluding channels	4.4	4.2	3.6	5.7	28
West channel	4820–4885	1.8	2.6	-2.2	4.4	14
East channel	5890–5995	2.6	2.0	1.7	4.2	3
Wet prairie #4	6050–8550	5.4	5.4	4.4	6.1	47
Deep marsh	8550–10350	3.8	3.8	2.7	5.0	24
Open water	10350–10905	3.4	3.5	2.7	4.1	4
All shallow marshes		4.5	4.4	3.6	4.7	39
Wet prairies 1–4		5.6	5.5	4.4	6.7	91
All wet prairies		6.0	6.0	4.4	7.8	128

ft NGVD = feet National Geodetic Vertical Datum

Adjacent to wet prairie #1 the H-1 transect traversed shallow marsh #1 (stations 2900–3050). Shallow marsh #1 vegetation included abundant common reed (*Phragmites australis*); numerous hemp sesbania (*Sesbania herbacea*); and scattered saltmarsh mallow and sand cordgrass.

East of shallow marsh #1 the H-1 transect traversed wet prairie #2 (stations 3050–3800). Wet prairie #2 vegetation included abundant sand cordgrass and fall panic grass; numerous hemp sesbania; and scattered groundsel tree, dog fennel, southeastern sunflower, swamp hibiscus, saltmarsh mallow, wax myrtle, dotted smartweed, American cupscale (*Sacciolepis striata*) and giant foxtail (*Setaria magna*).

East of wet prairie #2 the H-1 transect traversed shallow marsh #2 (stations 3800–4100). Shallow marsh #2 vegetation included abundant dotted smartweed; numerous southern water hemp (*Amaranthus australis*) and sand cordgrass; and scattered hemp sesbania.

Table 12. H-1 Transect vegetation species list

Scientific Name	Common Name	FWDM[1] Code	Plant Community Species Cover Estimates[2]									
			PH–TS (–1500 to –920)	UWP (–920–850)	WP#1 (1950–2900)	SM #1 (2900–3050)	WP #2 (3050–3800)	SM #2 (3800–4100)	WP #3 (4100–4450)	SM #3 (4650–6050)	WP #4 (6050–8550)	DM (8550–10350)
Juncus sp.			1									
Sacciolepis striata	American cupscale	OBL				1	1			0	0	
Rubus sp.	Blackberry		1									
Sesbania vesicaria	Bladder Pod	FAC								0	1	
Sagittaria lancifolia	Bull arrowhead	OBL		2			0				1	
Andropogon glomeratus	Bushy broom grass	FACW	2	1								
Cephalanthus occidentalis	Buttonbush	OBL			0						2	
Sabal palm	Cabbage palmetto	FACW	2	1								
Salix caroliniana	Carolina willow	OBL		0						1	0	
Typha sp.	Cattail	OBL								0	0	
Echinochloa walteri	Coast cockspur	FACW		1							1	
Phragmites australis	Common reed	OBL				3				1		
Urochloa ramosa	Dixie Signalgrass								1	4	0	2–3
Eupatorium capillifolium	Dog fennel	FAC	1				1		0			
Polygonum punctatum	Dotted smartweed	OBL		1	1		1	3		1	1	1
Panicum dichotomiflorum	Fall panic grass	FACW	0	0	3		3		4	1	2	1–3
Baccharis angustifolia	False willow	OBL	1									
Thalia geniculata	Fire–flag	OBL					0			1		
Erehtites hieracifolia	Fireweed	FAC		1								
Cyperus polystachyos	Flatsedge	FACW		0								
Setaria magna	Giant foxtail	OBL					1	0			0	
Sesbania herbacea	Hemp Sesbania	FAC		0		2	2	1	1	2	0	2–3
Panicum hemitomon	Maidencane	OBL									3	
Baccharis halimifolia	Salt myrtle	FAC	2	1			1					
Kosteletzkya virginica	Saltmarsh mallow	OBL		1	1	1	1		0		0	
Spartina bakeri	Sand cordgrass	FACW	2	5	3	1	3	2	2	1	4	1
Cladium jamaicense	Saw grass	OBL		1							0	
Cyperus haspan	Sheathed flatsedge	OBL		1								
Polygonum densiflorum	Smartweed	OBL					0	0		3		2
Scirpus validus	Softstem bulrush	OBL									1	

Table 12—*Continued*

Scientific Name	Common Name	FWDM[1] Code	Plant Community Species Cover Estimates[2]									
			PH–TS (–1500 to –920)	UWP (–920–850)	WP#1 (1950–2900)	SM #1 (2900–3050)	WP #2 (3050–3800)	SM #2 (3800–4100)	WP #3 (4100–4450)	SM #3 (4650–6050)	WP #4 (6050–8550)	DM (8550–10350)
Helianthus agrestis	Southeastern sunflower	FACW		2	2		1		2		1	
Amaranthus australis	Southern water hemp	OBL			0		0	2	0			
Erianthus giganteus	Sugarcane plumegrass	OBL		1								
Persea palustris	Swamp bay	OBL	0–1									
Hibiscus grandiflorus	Swamp hibiscus	OBL		2	1		1		1		2	
Myrica cerifera	Wax myrtle	FAC	4	1			1					

[1]FWDM Code Indicator categories established in Florida Wetlands Delineation Manual (Gilbert et al.1995).

Upland (UPL) = Plants that occur rarely in wetlands, but occur almost always in uplands.
Facultative (FAC) = Plants with similar likelihood of occurring in both wetlands and uplands.
Facultative Wet (FACW) = Plants that typically exhibit their maximum cover in areas subject to surface water flooding and/or soil saturation, but may also occur in uplands.
Obligate (OBL) = Plants that are found or achieve their greatest abundance in an area which is subject to surface water flooding and/or soil saturation; rarely uplands.

[2]Plant Community Species Cover Estimates: Aerial extent of vegetation species along transect within given community where 0 = <1% (rare); 1 = 1–10% (scattered); 2 = 11–25% (numerous); 3 = 26–50% (abundant); 4 = 51–75% (co-dominant); and 5 = greater than 75% (dominant).

PH–TS = Palm hammock –Transitional shrub (stations -1500 to -920)
UWP = upper wet prairie (stations -920 to 850)
WP#1 = wet prairie #1 (stations 1950 to 2900)
SM#1 = shallow marsh #1 (stations 2900 to 3050)
WP#2 = wet prairie #2 (stations 3050 to 3800)
SM#2 = shallow marsh #2 (stations 3800 to 4100)
WP#3 = wet prairie #3 (stations 4100 to 4450)
SM#3 = shallow marsh #3 (stations 4650 to 6050; excluding channels)
WP#4 = wet prairie #4 (stations 6050 to 8550)
DM = deep marsh (stations 8550 to 10350)

Adjacent to the shallow marsh #2 the H-1 transect traversed wet prairie #3 (stations 4100–4450). Wet prairie #3 vegetation included co-dominant fall panic grass; numerous sand cordgrass and southeastern sunflower; and scattered swamp hibiscus, hemp sesbania, and Dixie signalgrass (*Urochloa ramosa*).

The next vegetation community traversed at H-1 was shallow marsh #3 (stations 4650–6050). Two river channels bisected shallow marsh #3. The river channels elevations were excluded from the shallow marsh #3 elevations when calculating the shallow marsh #3 elevation statistics. Shallow marsh #3 vegetation included co-dominant Dixie signalgrass; abundant smartweed (*Polygonum densiflorum*); numerous hemp sesbania; and scattered fire-flag (*Thalia geniculata*), Carolina willow (*Salix caroliniana*), dotted smartweed, common reed, fall panic grass, and sand cordgrass.

East of shallow marsh #3 the transect traversed wet prairie #4 (stations 6050–8550). Wet prairie #4 vegetation included co-dominant sand cordgrass; abundant maidencane (*Panicum hemitomon*); numerous fall panic grass, swamp hibiscus, and buttonbush (*Cephalanthus occidentalis*); and scattered coastal cockspur, southeastern sunflower, American cupscale, dotted smartweed, softstem bulrush (*Scirpus validus*), and bladder pod (*Sesbania vesicaria*).

East of wet prairie #4, the transect traversed a deep marsh (stations 8550–10350). The deep marsh vegetation included abundant hemp sesbania and Dixie signalgrass; scattered to abundant fall panic grass; numerous smartweed; and scattered dotted smartweed and sand cordgrass.

East of the deep marsh, the transect traversed another open water area (stations 10350–10905) and terminated at station 11013 in a narrow wet prairie community downslope from a palm hammock–Indian midden. This final wet prairie has been heavily impacted by cattle and vehicles and was not characterized.

Additional plant species observed along the H-1 transect are listed in Table 12.

Soils at H-1 Transect

Soil auger holes were dug at 40 selected stations to characterize the soils along the H-1 Transect between stations -1500 and 10,350 on December 16 and 22, 2003, and January 7, 2004 (Table 13). Soils were characterized in the field based upon epipedons, horizons, soil texture, soil color, and horizon thickness. These soil features were used to determine the soil series at each soil sampling station. One or more hydric soil indicators (muck, histic epipedon, stripped matrix, loamy gleyed matrix, mucky mineral) were observed at each soil sampling station. Additionally, all soils sampled at the H-1 transect were mineral soils with a shallow surface organic horizon.

Table 13. H-1 Transect soil descriptions

Station/Soil Series	Vegetation Community	Soil Horizon	Horizon Description
-1500/Eaton	Palm hammmock–transitional shrub	Oa 0–3"	Black muck
		A 3–4.5"	Black mucky sand
		Eg1 4.5–11”	Very dark gray sand; stripping present
		Eg2 11–24”	Gray sand
		EgBw 24–32”	Gray and yellow sand with redoxomorphic concentrations
		Cg 32”+	Dark gray sandy clay loam with redoxomorphic concentrations
-1400/Eaton	Palm hammock–transitional shrub	Oa 0–6"	Black muck
		A 6–7"	Black mucky sand
		Eg1 7–13”	Very dark gray sand; stripping present
		Eg2 13–18”	Gray sand with redoxomorphic concentrations
		EgBw 18–38”	Gray and yellow sand
		Cg 38”+	Dark gray sandy clay loam with redoxomorphic concentrations
-1200/ Holopaw	Palm hammock–transitonal shrub	Oa 0–0.1”	Black muck
		A1 0.1–0.5”	Black mucky sand
		A2 0.5–6”	Black sand
		Eg1 6–11”	Very dark gray sand; stripping present
		Eg2 11–22”	Gray sand
		EgBw 22–27”	Gray and yellow sand
		Bw 27–30”	Yellowish brown sand
		EgBw’ 30–48”	Gray and yellow sand
		Eg 48–53”	Light gray sand
		Cg 53”+	Dark gray sandy clay loam with redoxomorphic concentrations

Table 13—*Continued*

Station/Soil Series	Vegetation Community	Soil Horizon	Horizon Description
-1000/Eaton variant	Palm hammock–transitional shrub	Oa 0–0.1”	Black muck
		A1 0.1–0.5”	Black mucky sand
		A2 0.5–6.5”	Very dark gray sandy loam
		Eg 6.5–14”	Dark gray and gray sand; stripping present
		EgBw 14–20”	Gray and yellow sand
		Eg 20–25”	Light gray sand
		Bw 25–32”	Yellowish brown sand
		BwEg 32–34”	Yellowish brown with gray sand
		Cg 34”+	Dark gray sandy clay loam with redoxomorphic concentrations
-700/Eaton variant	Upper wet prairie	Oa 0–4”	Black muck
		A1 4–5”	Black mucky sand
		A2 5–6”	Black loamy sand
		Eg/A 6–10”	Very dark gray and gray sand with black pockets of loamy sand
		A 10–11”	Black clay loam
		Eg1 11–15”	Very dark gray, dark gray, and gray sand; stripping
		Eg2 15–24”	Gray sand
		Cg 24”+	Dark gray sandy clay loam
-400/Denaud	Upper wet prairie	Oa1 0–4”	Very dark brown muck
		Oa2 4–8”	Black muck
		Cg1 8–9”	Black mucky loam
		Cg2 9–30”	Black clay loam
		Cg3 30–38”	Black loamy sand
		Cg4 38”+	Very dark gray sandy clay loam
-100/Denaud	Upper wet prairie	Oa1 0–4”	Very dark brown muck
		Oa2 4–9”	Black muck
		Cg1 9–10”	Black mucky loam
		Cg2 10–60”+	Black loam; increases in organic matter at 25”
200/Floridana	Upper wet prairie	Oa1 0–3”	Very dark brown muck
		Oa2 3–5”	Black muck
		A 5–7”	Black mucky loamy sand
		ACg 7–12”	Black sand with splotches and strands of black loam
		E 12–22”	Dark gray, gray and light gray sand; stripping present
		Cg 22”+	Dark gray sandy clay loam with redoxomorphic concentrations

Table 13—*Continued*

Station/Soil Series	Vegetation Community	Soil Horizon	Horizon Description
500/Manatee	Upper wet prairie	Oa1 0–5”	Very dark brown muck
		Oa2 5–7”	Black muck
		Cg1 7–13”	Black loam
		Cg2 13–18”	Black loamy sand
		Cg3 18–29”	Dark gray sandy loam
		Cg4 29”+	Dark gray sandy clay loam
700/Bradenton variant	Upper wet prairie	Oa 0–2”	Black muck
		A1 2–5”	Black mucky loam
		A2 5–6”	Black loam
		A3 6–8”	Very dark gray sandy loam
		Eg1 8–10”	Very dark gray, dark gray and gray sand; stripping
		Eg2 10–15”	Gray and light gray sand; stripping present
		Cg1 15–21”	Dark gray sandy loam
		Cg2 21–35”	Dark gray sandy loam with dark gray sandy clay loam with redoxomorphic concentrations
		Cg3 35”+	Dark gray sandy clay loam with dark gray sandy loam with redoxomorphic concentrations.
2150/Chobee	Wet prairie #1	Oa 0–4”	Black muck
		A1 4–5”	Black mucky loamy sand
		A2 5–14”	Black sandy loam
		E 14–20”	Dark gray and gray sand; stripping present
		Cg 20”+	Dark gray sandy clay loam
2400/Eaton variant	Wet prairie #1	Oa 0–4”	Black muck
		A1 4–5”	Black mucky loamy sand
		A2 5–9”	Black sandy clay loam
		E 9–20”	Dark gray and gray sand; stripping present
		Cg1 20–24”	Dark gray sandy loam
		Cg2 24–31”	Dark gray sandy clay loam
		Cg3 31–38”+	Very dark gray clay loam
2700/Chobee	Wet prairie #1	Oa 0–2.5”	Black muck
		A1 2.5–3.5”	Black mucky loamy sand
		A2 3.5–12”	Black sandy clay loam
		E 12–20”	Dark gray and gray sand; stripping present
		Cg1 20–24”	Dark gray sandy loam
		Cg2 24–28”	Dark gray sandy clay loam
		Bw 28–32”	Grayish brown and brown sand
		E 32–50”	Very dark gray and dark gray sand
		Cg3 50”+	Very dark gray sandy clay loam

Table 13—*Continued*

Station/Soil Series	Vegetation Community	Soil Horizon	Horizon Description
2950/Chobee	Shallow marsh #1	Oa 0–6”	Black muck
		A1 6–7”	Black mucky loamy sand
		A2 7–14”	Black sandy clay loam
		AE 14–17”	Black, very dark gray and gray sand
		Cg1 17—28”	Black clay loam
		Cg2 28–30”	Very dark gray sandy clay loam
		Cg3 30”+	Very dark gray loamy sand; increases in sand with depth
3000/Chobee	Shallow marsh #1	Oa 0–4”	Black muck
		A 4–6”	Black mucky loam
		Cg1 6–39”	Black clay loam
		Cg2 39”+	Very dark gray sandy clay loam
3200/Holopaw	Wet prairie #2	Oa 0–3”	Black muck
		A1 3–5”	Black mucky loamy sand
		A2 5–9”	Black loamy sand
		AEg 9–26”	Black, dark gray, and gray sand; stripping present
		Btg 26–46”	Dark grayish brown loamy sand
		Cg 46”+	Very dark gray sandy clay loam
3500/Eaton	Wet prairie #2	Oa1 0–2”	Black muck
		A1 2–5”	Black mucky loamy sand
		A2 5–8”	Black loamy sand
		Eg1 8–16”	Very dark gray, dark gray, and gray sand; stripping
		Eg2 16–20”	Gray sand; stripping present
		Eg3 20–23”	Gray loamy sand with redoxomorphic concentrations
		Eg4 23–31”	Gray sandy clay loam with redoxomorphic concentrations
		Btg 31–35”	Dark gray and dark grayish brown loamy sand
		Cg 35–38”	Very dark gray sandy clay loam
		Ab 38–44”	Very dark gray sand
		Eg 44–50”	Gray sand
		Cg1 50–60”	Very dark gray and dark gray sand
		Cg2 60”+	Very dark gray sand
3700/Pompano	Wet prairie #2	Oa 0–3”	Black muck
		A 3–5”	Black mucky sand
		Aeg 5–19”	Very dark gray and dark gray sand; stripping present
		Eg 19–22”	Dark gray and gray sand; stripping present
		Bw 22–36”	Grayish brown sand
		Cg 36”+	Light gray sand

Table 13—*Continued*

Station/Soil Series	Vegetation Community	Soil Horizon	Horizon Description
3900/Chobee	Shallow marsh #2	Oa 0–3”	Black muck
		A 3–5”	Black mucky loam
		Cg 5–30”	Black loam
		Oab 30–43”	Very dark gray muck
		A 43–45”	Very dark gray mucky loam
		Cg 45”+	Black sandy clay loam
4050/Denaud	Shallow marsh #2	Oa 0–8”	Black muck
		A 8–9”	Black mucky loam
		Cg 9–20”	Black loam
		Ab 20–23”	Very dark gray mucky loam
		Oab 23–43”	Very dark gray muck
		A 43–60”	Black loamy sand with many shell fragments
		Cg 60”+	Black loam
4200/Chobee	Wet prairie #3	Oa 0–7”	Black muck
		A 7–8”	Black mucky loam
		Cg1 8–32”	Black silt loam
		Cg2 32–36”	Black very dark gray loamy sand
		Cg3 36–48”+	Dark gray sandy clay loam
4400/Pompano	Wet prairie #3	A 0–6”	Black sand
		E1 6–9”	Very dark gray and dark gray sand; stripping present
		E2 9–21”	Gray sand; stripping present
		Ab 21–23”	Black sand
		Cg1 23–29”	Dark gray and gray sand; stripping present
		Cg2 29–33”	Dark gray and gray sandy clay loam; stripping present
		Cg3 33–40”	Light brownish gray sand
		Cg4 40–53”+	Dark gray sand
4700/Chobee	Shallow marsh #3	Oa 0–2”	Black muck
		A2–4”	Black mucky loam
		Cg1 4–12”	Black silty clay
		Cg2 12–22”	Black and very dark gray sandy clay loam
		Cg3 22–26”	Very dark gray and dark gray sandy clay loam
		Cg4 26–29”+	Black sandy clay
4800/Eaton variant	Shallow marsh #3	Oa 0–3”	Black muck
		A 3–4”	Black mucky loam
		Cg1 4–9”	Black loam
		Cg2 9–20”	Very dark gray, dark gray, and grayish brown sand; stripping present
		Eg 20–25”	Gray and light gray sand; stripping present
		Ab 25–37”	Black sandy loam
		Eg 37–41”	Light gray sand; stripping present
		Cg1 41–46”	Black sandy loam
		Cg2 46”+	Black sandy clay loam

Table 13—*Continued*

Station/Soil Series	Vegetation Community	Soil Horizon	Horizon Description
4900/ Bradenton	Shallow marsh #3	Oa 0–6”	Black muck
		A 6–7”	Black mucky sand
		Eg 7–12”	Dark gray and gray sand; stripping present
		Cg1 12–20”	Black silt loam
		Cg2 20–22”	Very dark gray sandy clay loam
		Eg 22–27”	Gray sand; stripping present
		Ab 27–30”	Black sandy loam
		Eg 30–42”	Light gray sand; stripping present; pockets of silt loam
		Cg 42”+	Black sandy clay loam
5100/Eaton variant	Shallow marsh #3	Oa 0–1”	Black muck
		A 1–3”	Very dark gray sand
		Oa 3–5”	Very dark gray muck
		A 5–6”	Black mucky loam
		Cg 6–7”	Black silt loam
		Eg 7–20”	Very dark gray, dark gray, and light gray sand; stripping present
		Cg’ 20–28”	Black silt loam
		Cg 28”+	Black silty clay
5200/Manatee	Shallow marsh #3	Oa 0–3”	Black muck
		A 3–5”	Black mucky sand
		Cg1 5–18”	Black sandy loam with light brownish gray sand
		Cg2 18”+	Black silty clay
5600/Chobee	Shallow marsh #3	Oa 0–6”	Black muck
		A 6–7”	Black mucky loam
		Cg1 7–22”	Black silty clay
		Cg2 22–27”	Black sandy loam
		Eg 27–31”	Light gray sand
		Cg 31–32”	Black silt loam
		Eg’ 32–34”	Light gray sand
		Cg 34”+	Black sandy loam
6300/ Bradenton	Wet prairie #4	Oa 0–1.5”	Black muck
		A1 1.5–4”	Black mucky sand
		A2 4–6”	Black sand
		AEg 6–9”	Black, very dark gray and dark gray sand; stripping present
		Eg 9–11”	Very dark gray loamy sand
		Cg1 11–14”	Dark gray and gray sandy loam with redoxomorphic conc.
		Cg2 14–28”	Dark gray and gray sandy clay loam with redoxomorphic Conc.
		Cg3 28”+	Gray sandy clay loam with many redoxomorphic concentrations and depletions

Table 13—*Continued*

Station/Soil Series	Vegetation Community	Soil Horizon	Horizon Description
6600/ Bradenton	Wet prairie #4	Oa 0–3”	Black muck
		A 3–5”	Black mucky sand
		AEg 5–9.5”	Black, very dark gray and dark gray sand; stripping present
		Eg 9.5–14”	Dark gray with very dark gray loamy sand
		Cg1 14–20”	Dark gray sandy clay loam with pockets of gray sand
		Cg2 20–26”	Dark gray silty clay with pockets of gray sand and redoxomorphic concentrations
		Cg3 26–33	Dark gray sandy clay loam with many lg. Iron concretions
		Cg4 33”+	Gray and light-greenish-gray sandy clay loam with redoxomorphic concentrations and depletions
7000/Eaton variant	Wet prairie #4	Oa 0–4”	Black muck
		A 4–5”	Black mucky sand
		Cg1 5–7”	Black sandy clay loam
		Cg2 7–16”	Dark gray with gray sand
		Cg3 16–22”	Gray with dark gray sand; redoxomorphic concentrations
		Cg4 22”+	Gray and light-greenish-gray sandy clay loam with redoxomorphic concentrations and depletions
7500/Manatee	Wet prairie #4	Oa 0–6”	Black muck
		A 6–8”	Black mucky sand
		Cg1 8–19”	Black sandy loam
		Cg2 19–26”	Dark gray and gray sand
		Cg3 26”+	Gray with dark gray sandy clay loam with redoxomorphic concentrations
8200/Chobee	Wet prairie #4	Oa1 0–4”	Very dark-brown muck
		Oa2 4–7”	Black muck
		A 7–8”	Black mucky sand
		Cg 8–20”	Black loam
		Oab 20–32”	Very dark-brown and black muck
		Cg1 32–38”	Very dark gray sandy loam
		Cg2 38”+	Very dark gray sandy clay loam
8400/Chobee	Wet prairie #4	Oa1 0–4”	Very dark-brown muck
		Oa2 4–6”	Black muck
		A 6–7”	Black mucky sand
		Cg 7–20”	Black silt clay
		Oab1 20–26”	Very dark-brown and black muck
		Oab2 26–30”	Black muck with many small shells
		Cg1 30–36”	Very dark gray sand with many small shells
		Cg2 36”+	Very dark gray sandy clay loam with iron concretions

Table 13—*Continued*

Station/Soil Series	Vegetation Community	Soil Horizon	Horizon Description
8800/Chobee	Deep marsh	Oa 0–1”	Black muck
		A 1–2”	Black mucky sand
		Cg 2–21”+	Black silty clay
9300/Chobee	Deep marsh	Oa 0–1”	Black muck
		A 1–2”	Black mucky sand
		Cg 2–10”	Black silty clay loam
		Ab 10–13”	Very dark-brown and black mucky mineral
		Cg1 13–31”	Very dark gray and gray sandy loam
		Cg2 31”+	Black and very dark gray sandy loam with many small shells.
9700/Chobee	Deep marsh	Oa 0–4”	Black muck
		A 4–4.5”	Black mucky sand
		Cg1 4.5–22”	Black silty clay
		Cg2 22”+	Very dark gray silty clay loam
10000/Chobee	Deep marsh	Oa 0–2”	Black muck
		A 2–3”	Black mucky sand
		Cg1 3–5”	Black silty loam
		Cg2 5–22”+	Black silty clay
10200/Chobee	Deep marsh	Oa 0–3”	Black muck
		A 3–4”	Black mucky sand
		Cg1 4–7”	Black silty loam
		Cg2 7–21”+	Black silty clay
10350/Chobee	Deep marsh	Oa 0–3.5”	Black muck
		A 3.5–5”	Black mucky sand
		Cg1 5–10”	Black silty loam
		Cg2 10–16”+	Black silty clay

Fluvial and other hydrologic processes constantly modify the soils throughout the St. Johns River floodplain. Sediment accretion frequently occurs during flood activities, creating transitory features within the soils, especially those closest to the stream channels (Lindbo and Richardson 2001). When the river rises and inundates the floodplain, erosional and depositional processes combine to deposit coarse sediments at the edge of the floodplain (nearest the channel) and finer-textured material throughout the floodplain. Consequently, sediments found in the St. Johns River floodplain can be comprised of depositional material transported from upstream, depositional material derived locally from channel erosion, and parent material that has been reworked from centuries of flood events. Numerous relatively thin soil horizons can occur from frequent deposition of alluvial sediments and often result in accretion topography. As a result, soil features such as texture and color can vary greatly over a short distance (D. Segal, pers. comm., 2004). In the St. Johns River floodplain, fine-textured material may occur near the surface in one place and at a depth of as much as 48 in. at a nearby location (Leighty et al. 1957).

The history of erosional and depositional processes in the St. Johns River floodplain gives rise to a complex distribution of soils across the floodplain. Lateral and horizontal changes in sediment deposition result in soil series with a large degree of variability (Lindbo and Richardson 2001). This combination makes the identification of soil series difficult due to the high variability of soil features found across the H-1 transect. Often soil features found at a given site will not conform to the characteristics of any particular soil series (Segal, pers. comm. 2004). Since the soils resulted in many discrepancies with the official soil series descriptions, Wade Hurt, hydric soil scientist with the USDA, NRCS, in Gainesville, Florida, was consulted to help decipher the correct soil series that most closely represented the described soils.

Soils along the H-1 transect were particularly complex in comparison with soils sampled at the other SR 50 transects. Soils at the H-1 Transect exhibited a high degree of variation, especially within a given soil profile. Soils were frequently encountered that exhibited many thin horizons that are typical of accretion topography. While many soils exhibited the diagnostic epipedon and subsurface horizon for a specified soil series, they often contained many “extra” accreted soil horizons that created variability outside of the official soil description. To avoid listing so many unknown soil series, these soils were classified as a specific soil series provided they contained the correct diagnostic epipedon and subsurface horizon. The soil series and the soil taxonomic classification subgroup are briefly described below for each soil station sampled at the H-1 Transect. The soil taxonomic classification provides additional information for each soil series and is interpreted starting at the right-hand side of the taxonomic name and progressing to the left (JEA 2004; Appendix C).

Eaton, Holopaw, Denaud, Floridana, Manatee, Bradenton, Chobee, and Pompano soil series were observed at the H-1 transect (Table 13). The Eaton and Chobee soil series were most common at H-1 with the Eaton series generally at the higher elevations and the Chobee series located at the lowest elevations.

Specifically, Eaton or Eaton variant soil was observed initially at the highest elevations within the palm hammock–transitional shrub at stations -1500, -1400, and -1000. Eaton soils were also observed at one location in the upper wet prairie, at one location in wet prairie #1, at one location in wet prairie #2, at one location in wet prairie #4 and at one location in shallow marsh #3 (Table 13). The Eaton series consist of poorly and very poorly drained soils formed in clayey marine sediments with a water table at depths of less than 10 in. below the soil surface for periods of one to four months during most years. Depressional areas are ponded for very long periods (NRCS 2003).

The taxonomic classification subgroup for Eaton soil is an Arenic Albaqualf. Eaton is an Alfisol meaning it has an argillic horizon that is high in base saturation. It is poorly drained and in the aquic moisture regime, contains light-colored albic subsurface horizon(s) and the arenic adjective implies that the argillic horizon occurs between 20 and 40 in. below the soil surface (JEA 2004; Appendix C).

Holopaw soil was also sampled at a relatively higher elevation within the palm hammock–transitional shrub vegetative community (Table 13). The Holopaw series consists of deep and very deep, poorly and very poorly drained soils formed in sandy marine sediments. These soils occur on low flats, in poorly drained drainages or depressional areas. The Holopaw soil water table is within 12 in. of the soil surface for two to six months during most years. Depressional areas are ponded for more than six months during most years (NRCS 2003).

The taxonomic classification subgroup for Holopaw is a Grossarenic Endoaqualf, meaning it is an Alfisol, with an argillic horizon, that is high in base saturation and an aquic moisture regime. The term endo implies that Holopaw soils are endosaturated, where water is frequently derived from groundwater rather than surface water. The Grossarenic adjective implies that the argillic horizon is greater than 40 in. below the soil surface (JEA 2004; Appendix C). Eaton soil differs from Holopaw by the depth of the argillic horizon. In Eaton soil, the argillic horizon occurs at a depth between 20 and 40 in. below the soil surface. The argillic horizon in Holopaw soil occurs at a depth greater than 40 in. below the soil surface.

Downslope in the upper wet prairie community the soils were an Eaton variant, Denaud, Floridana, Manatee, and a Bradenton variant. The Eaton variant occurred at station -700 and was named an Eaton variant because while it exhibited the same diagnostic subsurface horizons that typify Eaton, the surface horizon was loamy rather than sandy (JEA 2004; Appendix C).

The Denaud series soil was observed at three scattered locations at the H-1 Transect beginning at stations -400 and -100 within the upper wet prairie. Denaud soils were also observed in shallow marsh #2 at station 4050 (Table 13). According to the NRCS (2003), the Denaud series soils consists of deep, very poorly drained, moderately permeable soils with a thin organic layer over sandy and loamy material. These soils are ponded for six to nine months in most years and are saturated to the surface the rest of the time during most years (NRCS 2003).

The taxonomic classification subgroup for Denaud soil is a Histic Humaquept. A Histic Humaquept is an Inceptisol meaning it is a somewhat young soil and has minimal horizon development, but somewhat more development than the youngest Entisols. Denaud soil is in the aquic moisture regime, has distinct organic material at the surface, and has a histic epipedon. A histic epipedon contains 8 to 16 in. of organic material (JEA 2004; Appendix C). Denaud is the only soil series sampled along the H-1 Transect containing a histic epipedon.

Floridana series soil was observed at one location along the H-1 transect in the upper wet prairie (Table 13). Floridana series soil consists of very deep, very poorly drained, slowly to very slowly permeable sands on low broad flats, floodplains, and in depressional areas. The Floridana soil water table occurs at depths of less than 10 in. below the soil surface and depressional areas are ponded for more than six months during most years. Floodplains are flooded for one to three months during most years (NRCS 2003).

The taxonomic classification subgroup for Floridana soil is an Arenic Argiaquoll, meaning it is a Mollisol. All Mollisols have a mollic epipedon. The mollic epipedon is a collection of dark surface horizons that are cumulatively at least 10 in. thick. The mollic epipedon is high in organic matter and is predominantly black. This dark surface mollic epipedon is indicative of very poorly drained conditions where the soil environment is often inundated and reduced. Consequently, organic matter accumulates and persists rather than decomposing in an aerated environment. Floridana is very poorly drained and in the aquic moisture regime. All soils near SR 50 that contain a mollic epipedon are also classified as very poorly drained. The arenic adjective implies that the argillic horizon is between 20 and 40 in. below the soil surface. Floridana lacks a spodic horizon, presumably because the site is too wet to form a spodic (JEA 2004; Appendix C).

The Manatee soil was also observed at one location within the upper wet prairie, at one location in shallow marsh #3 and at one location in wet prairie #4. Manatee series soil consists of very deep, very poorly drained, moderately permeable loamy fine sands occurring in depressions, broad drainage ways, and on floodplains. The Manatee soil water table occurs within 10 in. below the soil surface for more than six months annually during most years. Depressional areas are ponded for about six to nine months during most years (NRCS 2003).

The taxonomic classification subgroup for Manatee soil is a Typic Argiaquoll. Manatee soil is a Mollisol. As mentioned previously, all Mollisols have a mollic epipedon. The mollic epipedon is comprised of one or more dark surface horizons with sufficiently high concentrations of organic material that has stained or coated the mineral material black. The mollic epipedon is at least 10 in., in thickness. This dark surface mollic epipedon is indicative of very poorly drained conditions where the soil environment is often inundated and reduced. Consequently, organic matter accumulates and persists rather than decomposing in an aerated environment. Manatee soil is classified as very poorly drained and is in the aquic moisture regime. Again, all soils near SR 50 that contain a mollic epipedon are also classified as very poorly drained. Manatee soil also contains an argillic horizon and the argillic horizon is within 20 in. of the soil surface (JEA 2004; Appendix C).

Bradenton variant was the final soil observed within the upper wet prairie at the H-1 Transect; it occurred at station 700. Bradenton or Bradenton variant soils were observed at four scattered locations at the H-1 Transect. Bradenton soil also occurred within shallow marsh #3 and wet prairie #4 (Table 13). Bradenton series soils are typically fine sands consisting of very deep, poorly drained, moderately permeable soils on low ridges and on floodplains with water table depths of less than 18 in. below the soil surface for two to six months annually during most years (NRCS 2003).

The taxonomic classification subgroup for Bradenton soil is a Typic Endoaqualf, meaning it is an Alfisol because it contains an argillic horizon that is high in base saturation. Bradenton is in the aquic moisture regime, and is endosaturated, meaning it derives its moisture primarily internally from groundwater. The argillic horizon in Bradenton soil occurs within 20 in. below the soil surface (JEA 2004; Appendix C).

Progressing downslope from the upper wet prairie at the H-1 Transect, soils identified in wet prairie #1 were Chobee and an Eaton variant. Chobee or Chobee variant soils were the most frequently observed (observed at 16 sample stations) soil series at the H-1 Transect, occurring in wet prairie #1, then in shallow marsh #1, shallow marsh #2, wet prairie #3, shallow marsh #3, wet prairie #4 and the deep marsh (Table 13). Chobee soil is typically a sandy loam consisting of very deep, very poorly drained, slowly to very slowly permeable soils in depressions, flats, and occasionally on river floodplains. The Chobee soil water table is within 6 in. of the soil surface for one to four months during most years. Depressional areas are ponded for long duration (NRCS 2003). According to the *Soil Survey of Brevard County, Florida* (USDA, SCS 1974), the Chobee soil water table is within a depth of 10 in. below the soil surface for six to nine months and 10 to 40 in. below the soil surface for three to six months. In very dry seasons, the Chobee soil water table occurs at a depth of greater than 40 in. below the soil surface for short periods. Chobee soil is continuously flooded for one to six months in many places (USDA, SCS 1974).

The taxonomic classification subgroup for Chobee soil is a Typic Argiaquoll, meaning it is a mollisol in the aquic moisture regime, containing an argillic horizon and the argillic horizon occurs within 20 in. below the soil surface. Again, the presence of a mollic epipedon is indicative of the high concentrations of organic matter that develops and persists in flooded soils (JEA 2004; Appendix C).

East of wet prairie #1, the next four vegetation communities (shallow marsh #1, wet prairie #2, shallow marsh #2, and wet prairie #3) traversed at the H-1 Transect were relatively narrow in extent (Figure 11). Slight changes in elevation, combined with landscape positioning closely associated with the multiple river channels, resulted in vegetation community changes. Shallow marsh #1, located between wet prairies #1 and #2 (Figure 11), soils were identified as Chobee.

Wet prairie #2 (Figure 11) soils were identified as Holopaw, Eaton, and Pompano series. Pompano soil was observed at two locations at the H-1 Transect in wet prairie #2 and wet prairie #3 (Table 13). The Pompano series consists of very deep, very poorly drained sandy soils in depressions, drainage ways, and broad flats. The water table in Pompano soil occurs at depths of less than 10 in. below the soil surface for two to six months each year. Even during the drier months, it is within depths of 30 in. below the soil surface for more than nine months each year. In depressional areas, the water table is above the soil surface for more than three months each year (NRCS 2003).

The taxonomic classification subgroup for Pompano soil is a Typic Psammaquents, meaning it is a young soil in the Entisol soil order, and consequently has minimal soil horizon development. Entisols are thought to be geologically young soils that lack a long weathering process that would produce distinct horizons. Pompano soil is in the aquic moisture regime and the soil profile is comprised of sand. Pompano soil is given the Typic adjective because it typifies the great group Psammaquents, rather than having a distinct characteristic that would warrant a more descriptive adjective (JEA 2004; Appendix C).

Continuing in an easterly direction across the floodplain, soils sampled in shallow marsh #2 (Figure 11) were Chobee and Denaud series (Table 13). Chobee and Denaud soils are very similar with the distinguishing characteristic being the thickness of the surface organic horizon. Denaud soils have a histic epipedon (surface organic horizon 8 to 16 in. thick while Chobee soils have a surface organic horizon 0 to 7 in., in thickness (JEA 2004; Appendix C).

Soils observed in wet prairie #3 were Chobee and Pompano while soils observed in shallow marsh #3 were Chobee, an Eaton variant, Bradenton, and Manatee. Soils observed in wet prairie #4 were Bradenton, an Eaton variant, Manatee, and Chobee. The soil characteristics, which separated these soil types, were often only minor differences in thickness or depth of diagnostic epipedons or argillic horizons, or texture of the argillic horizon. These soils share characteristics that are indicative of frequently flooded and low oxygenated conditions (JEA 2004; Appendix C).

The final vegetation community traversed at the H-1 Transect was the deep marsh. All deep marsh soils were identified as Chobee (Table 13).

In summary, all soils sampled at the H-1 Transect are in the aquic moisture regime. The aquic moisture regime implies a reducing regime that is virtually free of dissolved oxygen because the soil is saturated by water (Soil Conservation Service 1975). While the entire soil profile is often inundated and reduced; during dry periods, only the lower horizons are saturated. The duration of time that the soil must be saturated to have an aquic regime is not known (Soil Conservation Service 1975).

Additionally, soils along the H-1 Transect were classified as either poorly drained or very poorly drained. In general, the poorly drained soils occurred within the palm hammock–transitional shrub and upper wet prairie vegetation communities (stations -1500 to 850), while the very poorly drained soils occurred in the remaining vegetation communities at lower elevations (stations 1950 to 10350), where the vegetation communities are more closely associated with the river channels. Occasionally, soils observed within the lower vegetation communities were classified as poorly drained. These poorly drained soils occurred on slight topographic mounds. Actually, these poorly drained soils are probably very poorly drained because they are subjected to frequent river flooding and subsurface drainage from the surrounding upland. Soil morphological characteristics, specifically high surface organic matter accumulation and accretion topography, suggest that the soils observed at the H-1 Transect that are most closely associated with the river channels exist in a constantly inundated, reduced, and hydrologically dynamic environment (JEA 2004; Appendix C). As mentioned previously, additional soils information is available in the appendices name the appendix.

Minimum Levels Near Hatbill Park, St. Johns River Mile 201.5

Minimum Frequent-High Level Near Hatbill Park (6.9 ft NGVD)

The minimum frequent-high level recommended for the St. Johns River near Hatbill Park equals 6.9 ft NGVD. This level corresponds to a typical seasonally flooded river stage. During extended periods of normal or above normal rainfall, the minimum frequent-high level is expected to occur, on average, for several weeks to several months approximately once every 2 years (Chapter 40C-8.021(15), *F.A.C.)*.

The recommended minimum frequent-high level for the St. Johns River near Hatbill Park equals the average elevation of the upper wet prairie community traversed at the H-1 Transect (Figure 11; stations -920 to 850). This level will ensure that the lower elevations of the upper wet prairie are inundated at least every 1 to 2 years for a period of several weeks to several months (Robison 2006). Additionally, the recommended minimum frequent-high level (6.9 ft NGVD) will ensure inundation of all other wet prairie communities traversed at the H-1 and Ruth Lake transects, as well as the histic epipedon observed in the wet prairie and transitional shrub at Ruth Lake. The histic epipedon is a shallow (8 to <16 in., in thickness) surface organic horizon, a hydric soil indicator, and an indicator of frequent long-term inundation and / or soil saturation. The histic epipedon was observed within an elevation range of 5.3 to 6.8 ft NGVD at the Ruth Lake Transect. A histic epipedon was also observed within the upper wet prairie at the H-1 Transect at stations -400 and -100 where the ground surface elevation equaled 6.9 and 7.2 ft NGVD, respectively.

Of the marsh types in Florida, wet prairies are the least frequently flooded (50–150 days / year; Kushlan 1990). The type of vegetation present in wet prairies varies depending upon hydroperiod, soils, and site history. At the H-1 Transect the average land surface elevation of the upper wet prairie equaled the 18% exceedence on the interpolated stage duration curve (Figure 13) for the St. Johns River at this location. The stage duration curves illustrate the length of time the St. Johns River stage exceeds (percent exceedence) a given elevation or stage at the five field transect locations. In general, the minimum frequent-high level is an elevation or river stage that is exceeded approximately 20% of the time based upon a long-term hydrologic record. Taking into account the stage data and the literature references describing the wide range in variation of hydroperiods for wet prairies in Florida, the average elevation of the upper wet prairie traversed at the H-1 Transect became the primary minimum frequent-high level criterion for the Hatbill Park location. Additionally, the vegetation community immediately upslope from the upper wet prairie traversed at the H-1 Transect was the palm hammock–transitional shrub, which occurred at a much higher elevation (average elevation equaled 8.5 ft NGVD).

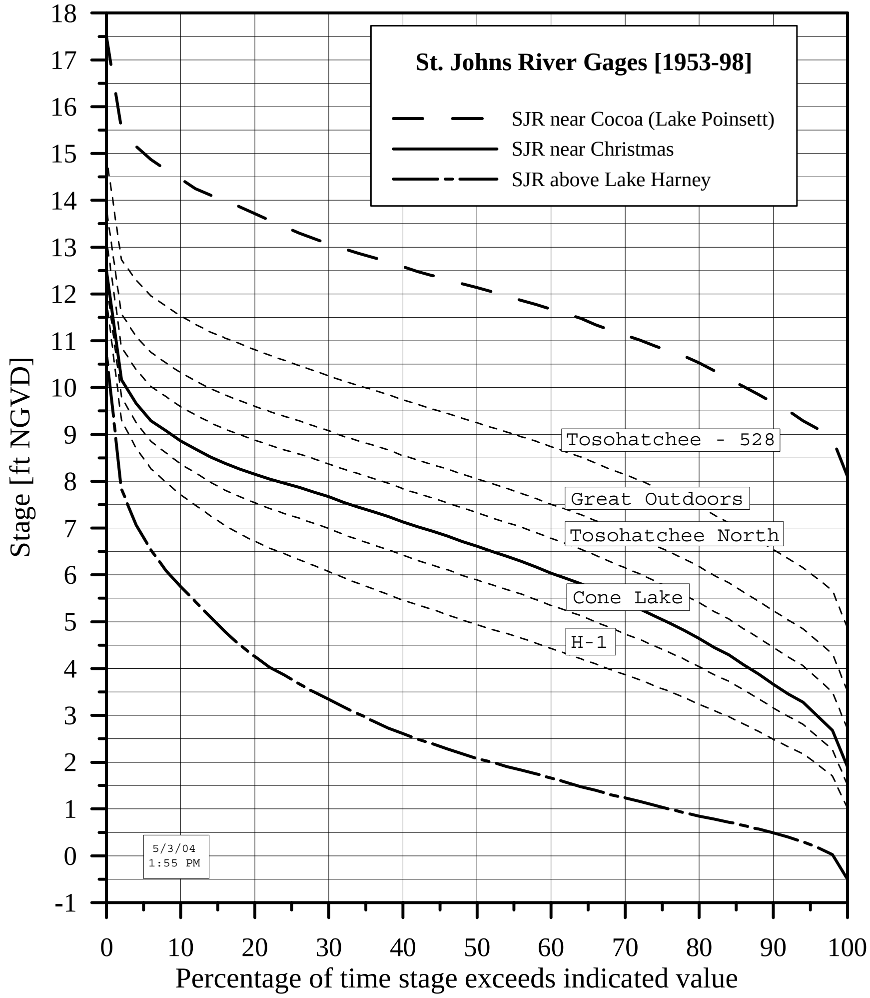


Figure 13. Stage duration curves for the St. Johns River near SR 50. Curves for field transect sites are estimated by interpolation (Robison 2006).

Due to the short hydroperiods experienced by wet prairies, this community type is the most species rich of Florida's marshes, containing a variety of grasses, sedges, and flowering forbs (Kushlan 1990). Wet prairie species have considerable tolerance to both flooding and drying. Many shallowly rooted species typical of the wet prairies associated with coastal flatwoods (like St. John's wort) are killed by drying but reseed readily. As a result, their zone of dominance migrates up- and downslope in response to changing water conditions (Kushlan 1990). Higher wet prairies may, under some conditions, be invaded by saw palmetto. Environmental characteristics of wet prairies include a hydroperiod shorter than six months, a low accumulation of organic matter (e.g. a few inches or nonexistent), and a fire frequency of more than one per decade (Kushlan 1990).

Fire is an influential factor helping maintain the wet prairie communities along the St. Johns River near SR 50. The upper wet prairie traversed at the H-1 Transect was prescribed burned in the spring of 2003. Prescribed fire in this upper wet prairie typically occurs every 3 to 5 years, to deter woody shrubs and upland vegetation encroachment into the upper wet prairie community (SJRWMD 2005). Wax myrtle and groundsel tree quickly invade and dominate the wet prairie communities along the St. Johns River in the absence of fire. As mentioned previously, prescribed fire results in wet prairie and upper wet prairie communities extending over a wide elevation gradient. The lower wet prairie elevations are primarily maintained by the river hydrology while the higher wet prairie and the upper wet prairie elevations are maintained primarily by fire and groundwater seepage. Consideration of the role of fire and other disturbances (i.e. hurricane wind impacts, cattle grazing) is necessary in interpreting relationships between vegetation communities and hydrologic conditions.

The aquatic faunal habitat is greatly expanded when the St. Johns River inundates the extensive shallow marshes, wet prairies, secondary channels, and deep marshes near Hatbill Park at the recommended minimum frequent-high level. Interactions with the adjacent marshes and wet prairies by connecting the channel to the floodplain are extremely important to animal productivity in lower coastal plain rivers (Bain 1990; Poff, et al. 1997). When the floodplains are flooded, many fish migrate from the main channel to the inundated areas for spawning and feeding. These migrations are more lateral, perpendicular to river flow, than upriver or down river (Guillory 1979). As the river stage continues to rise, the amount of vegetative structure available to aquatic organisms increases greatly as large areas of the floodplain are inundated (Light, et al. 1998). Table 14 lists the inundation depths provided by the recommended minimum frequent-high level in the floodplain vegetation communities at the H-1 and Ruth Lake transects.

Table 14. Inundation depths at the minimum frequent-high level near Hatbill Park

Vegetation Community	Transect Name	Range of Inundation (ft)	Average Inundation (ft)
Upper wet prairie	H-1	0–0.9	saturated
Wet prairie #1	H-1	0.3–1.6	0.7
Wet prairie #2	H-1	0.2–2.3	1.3
Wet prairie #3	H-1	0.4–2.4	1.3
Wet prairie #4	H-1	0.8–2.5	1.5
Wet prairie	Ruth Lk.	0.1–2.9	1.5
Shallow marsh #1	H-1	1.6–2.3	1.9
Shallow marsh #2	H-1	1.7–2.4	2.0
Shallow marsh #3	H-1	1.2–3.3	2.5
Deep marsh	H-1	1.9–4.2	3.1

Additionally, river water quality may improve significantly as water flows through the floodplain. The floodplain with its vast marshes, functions as an important filter and sink for dissolved and suspended constituents (Wharton et al. 1982).

An additional consideration in determining the minimum frequent-high level (6.9 ft NGVD) was the fact that this level is similar to the average elevation (7.2 ft NGVD) of the transitional shrub community traversed at the Ruth Lake Transect. The mean elevation of transitional shrub communities has been used to determine the minimum frequent-high level for other aquatic systems. The transitional shrub community traversed at the Ruth Lake Transect is a narrow (70 ft wide) community wedged between the wet prairie and palm hydric hammock. Based upon visual observations made during site visits when the river level was low (<3.5 ft NGVD at Hatbill Park), seepage from higher elevations maintains a saturated surface soil within the transitional shrub and wet prairie traversed by the Ruth Lake Transect. Consequently, due to the seepage and the narrow extent of the transitional shrub community at the Ruth Lake transect, the mean elevation of this community was not considered a primary criterion for determining the minimum frequent-high level for the St. Johns River near Hatbill Park.

Additionally, the palm hydric hammock traversed by the Ruth Lake Transect and the palm hammock–transitional shrub traversed at the H-1 Transect will experience surface water inundation when the St. Johns River rises to an infrequent high level (>7.7 ft NGVD). More frequent surface water ponding will occur within these palm hydric hammocks due to local rainfall and the poorly drained soil characteristics. Vince et al., (1989) suggest that hydric hammocks low in species diversity, such as the ones traversed at the H-1 and Ruth Lake transects, dominated by cabbage palm and live oak, exist where long dry periods are interrupted by occasional episodes of flooding. These hammocks are inundated less often, perhaps only once per decade, due to tropical weather systems impacting the Upper St. Johns River Basin.

Minimum Average Level Near Hatbill Park (4.5 ft NGVD)

The recommended minimum average level for the St. Johns River near Hatbill Park is 4.5 ft NGVD. The minimum average level approximates a typical river stage that is slightly less than the long-term median stage while still protecting the wetland resources. At the minimum average level, substrates may be exposed during nonflooding periods of typical years, but the substrate remains saturated. The minimum average level corresponds to a water level that is expected to occur, on average, every year or two for about six months during the dry season.

The recommended minimum average level equals the average ground surface elevation of all the shallow marshes (#1–3) traversed at the H-1 Transect (Figure 11; Table 11). This level will result in saturated or inundated soil conditions over the majority of the shallow marsh stations surveyed at the H-1 Transect. Saturated soil conditions will prevent long-term encroachment of upland plant species into the shallow marshes. Shallow marshes #1–3 at the H-1 Transect had Chobee, Denaud, Eaton variant, Bradenton and Manatee series soils (Table 13). Of these mineral soils, the majority is classified as very poorly drained, and these soils typically experience flooding in depressional areas for long durations (NRCS 2003). Additionally, the H-1 Transect shallow marsh soils are predominately mollisols or have a histic epipedon, indicative of very poorly drained conditions where the soil environment is often inundated and reduced. Therefore, organic matter accumulates and persists rather than decomposing in an aerated environment. Consequently, soil saturation and shallow ponding at the lower elevations within the shallow marshes traversed at the H-1 Transect at the recommended minimum average level typify annual dry season conditions in these depressional shallow marsh communities.

The mineral soil water table depths, predicted to occur in the wet prairies and upper wet prairie at the H-1 and Ruth Lake transects when the St. Johns River equals the recommended minimum average level, are well within reported dry season levels (NRCS 2003)

Additionally, the recommended minimum average level for the St. Johns River near Hatbill Park will ensure shallow inundation of the secondary channels and open water areas traversed at the H-1 Transect. Table 15 lists average water depths provided by the minimum average level in the open water areas and channels traversed at the H-1 Transect.

Table 15. Water depths at H-1 Transect at the minimum average level

Community Description	Stations	Average Inundation (ft)	Range of Inundation (ft)
Open water	1000–1800	2.3	0–3.7
Open water	4450–4650	0.7	0.7
West channel	4820–4885	2.7	0.1–6.7
Shallow marshes		Saturated	0–0.9
Deep marsh	8550–10350	0.7	0–1.8
East channel	5220–5280	2.1	0.4–3.0
Open water	10350–10905	1.1	0.4–1.8

Shallow ponding within the open water areas of the H-1 Transect will provide aquatic refugia for numerous small fish, amphibians, and small reptiles. Also, the shallow water depths are ideal for wading bird foraging. Wading birds can only forage in relatively shallow water. Great Egrets need water depths of less than 10 in. and the small herons need depths of less than 6 in. water level declines can cause fish to be concentrated in isolated sloughs throughout the shallow marshes. Birds effectively exploit these concentrations (Bancroft, et al. 1990).

Aquatic habitats, such as those open water areas traversed at the H-1 Transect, connected to the main river channel are of crucial importance to fishes and invertebrates of the floodplain. Connected habitats provide shallow, quiet waters in floodplain streams as refugia from the deep, swiftly flowing waters of the main channel (Light, et al.1998).

The recommended minimum average level (4.5 ft NGVD) is 1.3 ft below the average elevation of the histic epipedon observed at the Ruth Lake Transect. Typically, a 0.3 ft water table drawdown from the average soil surface elevation of histosols or a histic epipedon is employed as the primary minimum average level criteria. However, the histic epipedon was only observed in a relatively narrow band (248 ft wide) within the wet prairie at the Ruth Lake Transect in comparison to the entire floodplain width (>12,500 ft) traversed at the H-1 Transect. At the H-1 Transect a histic epipedon was observed at only three noncontiguous locations. As mentioned previously, significant seepage was observed at the Ruth Lake Transect where the histic epipedon occurred. The seepage resulted in saturated and ponded soil conditions across the Ruth Lake wet prairie (elevation range 4.0–6.8 ft NGVD) when the river level was less than 3.5 ft NGVD at Hatbill Park. Consequently, the seepage observed at the Ruth Lake Transect when the river level was considerably less than the recommended minimum average level will protect this soil from oxidation and subsidence and is likely the reason organic soil occurs at this location.

Minimum Frequent-Low Level Near Hatbill Park (2.9 ft NGVD)

The minimum frequent-low level determined for the St. Johns River near Hatbill Park equals 2.9 ft NGVD. This level represents a low river stage that generally occurs only during mild drought. The minimum frequent-low level is predicted to occur, on average, approximately once every 5 years for duration of several months. This level typically results in dewatered wetlands. This dewatering is a natural consequence of drought and has ecological benefits. Drawdown conditions enable seeds of emergent wetland plants to germinate from the seed banks of the floodplain. Seeds of many wetland plant species require exposed soils in order to germinate (Van der Valk 1981). Exposing the floodplain for suitable durations maintains the composition of emergent plant species and increases plant diversity.

The recommended minimum frequent-low level for the St. Johns River near Hatbill Park equals a soil water table level 20 in. below the average soil surface elevation of the shallow marshes traversed at the H-1 Transect. The primary minimum frequent-low level criterion equal to a 20-in. soil water table drawdown below the average soil surface elevation of all the shallow marshes traversed at the H-1 Transect is based upon the NRCS (2003), the *Soil Survey of Brevard County, Florida* (USDA, SCS 1974), the *Soil Survey of Seminole County, Florida* (USDA, NRCS 1990), and the *Soil Survey of Lake County, Florida* (USDA, SCS 1975). These references describe the dry season soil water table depths for Chobee, Manatee, and Denaud series soils. Chobee soil was the most commonly sampled soil series, followed by Manatee and Denaud series at the H-1 Transect shallow marshes. These three soil types are all classified as very poorly drained. They each contain soil morphological characteristics, specifically mollic epipedons, high surface organic matter accumulations and accretion topography, indicative of frequently inundated soils. Based upon the NRCS (2003), Chobee soil would be expected to occur at the lowest elevations, experiencing the longest periods of inundation compared to the Bradenton, Eaton, Holopaw, and Pompano series soils. In general, at the H-1 Transect the Chobee series was most commonly observed at the lowest elevations of the wet prairies and shallow marshes. Additionally, Chobee was the only soil series identified in the deep marsh (Table 13).

According to the NRCS (2003), the Chobee soil water table is typically within 6 in. below the soil surface for one to four months during most years in the rainy season. Depressional areas with Chobee soil are ponded for long durations in most years. According to the *Soil Survey of Brevard County, Florida* (USDA, SCS 1974), in most years, the Chobee water table is within 10 in. below the soil surface for six to nine months and between 10 and 40 in. below the soil surface for three to six months. In very dry seasons, the water table occurs at a depth of greater than 40 in. below the soil surface for short periods. Chobee soil is continuously flooded for one to six months in many places (USDA, SCS 1974). In most years, Manatee soils have a seasonal high water table that occurs within 12 in. of the soil surface for six to nine months and are subject to frequent flooding during rainy periods (USDA, NRCS 1990). Denaud soils under natural conditions are ponded for six to nine months and are saturated to the soil surface the rest of the time during most years (NRCS 2003). A dry season Manatee and Denaud soil water table description was unavailable. Because the shallow marshes traversed at the H-1 Transect are within a large depressional area and are located at the lower-vegetated elevations in the floodplain, closely associated with the multiple river channels, a 20-in. average soil water table drawdown in the shallow marshes is considered reasonable and based upon the best available information for an event which is predicted to reoccur once every 5 years for 60 continuous days (Robison 2006).

Chobee soil observed in the wet prairies at the H-1 Transect, as well as the other soils observed within the wet prairies traversed at the H-1 Transect, will experience average soil water table drawdowns of between 30 and 40 in. (Table 16), within the range described in the *Soil*

Survey of Brevard County, Florida (1974), when the river equals the minimum frequent-low level. Soil series observed farther upslope of the wet prairie communities at the H-1 and Ruth Lake transects might experience soil water table declines of greater than 40 in. However, one of the commonly occurring soil types upslope from the wet prairies was Denaud, which typically occurs on slopes that experience seepage due to slight topographic gradients, resulting in nearly continually saturated conditions. Additionally, a capillary fringe of varying thickness exists above the soil water table. In the capillary fringe zone, the soil is nearly water-saturated; the water in this zone is adsorbed to soil particles to a greater degree than water below the water table. The capillary fringe zone contains various amounts of water depending upon the pore size and the height in the soil above the water table (Richardson et al, 2001). A sandy clay loam such as Chobee soil, with an average porosity of 0.005 cm should have a saturated zone extending at least 12 in. (30 cm) above the soil water table (Mausbach 1992). Consequently, soil moisture may be available to the marsh vegetation at depths considerably closer to the soil surface than that predicted from the 20-in. soil water table drawdown criterion.

Table 16. Average water table drawdowns at the H-1 Transect at the recommended minimum frequent-low level (2.9 ft NGVD)

Vegetation Community	Soil Series Identified in Vegetation Community	Average Soil Water Table Drawdown
Deep marsh	Chobee	11”
Shallow marsh #3	Chobee, Eaton variant, Bradenton, Manatee	18”
Shallow marsh #2	Chobee, Denaud	24”
Shallow marsh #1	Chobee	25”
Wet prairie #4	Bradenton, Eaton variant, Manatee, Chobee	30”
Wet prairie #2	Holopaw, Eaton, Pompano	32”
Wet prairie #3	Chobee, Pompano	32”
Wet prairie #1	Chobee, Eaton variant	40”

Additionally, the recommended minimum frequent-low level (2.9 ft NGVD) results in an 11-in. average drawdown in the soil water table in the deep marsh traversed at the H-1 Transect. Chobee soil was observed exclusively across the deep marsh traversed at the H-1

Transect. Shallow ponding would occur within the open water area between stations 1000–1800 at the H-1 Transect and deeper water would occur in the river channels (Table 11) at the recommended minimum frequent-low level.

According to Kushlan (1990), sand substrates, as observed in the wet prairies, shallow marshes and deep marsh at the H-1 Transect, are found in marshes with short hydroperiods and significant drying of the soil during the dry season. Table 16 lists the soil series identified and the average soil water table drawdowns predicted to occur within the shallow marshes, deep marsh, and wet prairies traversed at the H-1 Transect when the stage of the St. Johns River at Hatbill Park equals the recommended minimum frequent-low level (2.9 ft NGVD).

The marked seasonality of Florida’s rainfall and evaporation plays an important role in the functioning of marsh ecosystems by creating a seasonal fluctuation in surface water. This seasonal fluctuation is most pronounced in southern Florida because it experiences less winter rainfall than occurs farther north. Water levels rise during the summer rainy season, gradually decline during the winter, and annually reach drought conditions as evapotranspiration increases in the spring. In most years, standing water is absent from southern Florida marshes at the height of the dry season, a condition that may last from several weeks to several months. Most marshes flood during each rainy season, but some may flood only in very wet years. Annual variation in rainfall may cause substantial differences in the depth and extent of flooding in various years at a single marsh site (Kushlan 1990).

St. Johns River at Lake Cone

The Lake Cone and M-6 Transects traversed different portions of the St. Johns River floodplain adjacent to Lake Cone. The west-main channel of the St. Johns River flows through Lake Cone at river mile 207, approximately two river mile downstream from SR 50 (Figures 2 and 7; Table 17).

Table 17. Lake Cone Transect location information

Transect Name and River Mile	Latitude–Longitude (Beginning Station	Latitude–Longitude (End Station)	Location and Date of Fieldwork
Lake Cone RM 207	28 33 12.06; 80 57 53.149 (Station -1860)	28 32 29.85; 80 58 42.69 (Station 5635)	Open water of Lake Cone to the uplands on the west shore; March, April, June 2002.
M-6 RM 206–208	28 32 57.714; 80 57 52.375 (Station -4030)	28 33 45.344; 80 56 42.921 (Station 4850)	West edge of upper wet prairie across floodplain and multiple channels to east edge of shallow marsh; January and October 2003, January and February 2004

Field Data for Lake Cone Transect

The Lake Cone Transect originated on the southwest shore of Lake Cone. At high-river stages (>7.0 ft NGVD), river water sheetflows north through the marshes and prairies from SR 50 over a distance of approximately 1 mi downstream to Lake Cone. At river stages below approximately 7.0 ft NGVD, the river flows within a defined west channel from SR 50, following a circuitous route over a distance of approximately 2 mi to Lake Cone.

Transect Selection Criteria Lake Cone Transect

The primary criteria for selecting this transect location included the following:

- A relatively unique area due to the cypress and hardwood swamps (Figure 7)
- Located on SJRWMD property (Seminole Ranch), preventing future development and facilitating access for long-term ecological monitoring
- Close proximity to the SR 50 long-term gauging station
- Extensive pristine palm hammocks
- Terminates in an upland community

Vegetation at Lake Cone Transect

The Lake Cone Transect traversed in a southwesterly and westerly direction beginning in the open water of Lake Cone, across an aquatic bed, a shallow marsh, a wet prairie, a cypress strand, a slough, a lower hardwood swamp, a hardwood swamp, a lower palm hydric hammock, a palm hydric hammock and terminated in an oak-palm upland (Figures 14 and 15; Tables 17–19).

The aquatic bed vegetation (stations -1780 to -1720) was sampled on April 30, 2002, when the water level of Lake Cone equaled 3.0 ft NGVD, resulting in an exposed aquatic bed. The aquatic bed was vegetated with co-dominant crabgrass (*Digitaria serofina*); and rare stiff-marsh bedstraw (*Galium tinctorium*), musky mint (*Hyptis alata*), and mock bishop-weed (*Ptlimnium capillaceum*).

The shallow marsh (stations -1720 to -1690) vegetation included abundant musky mint; numerous stiff-marsh bedstraw and mock bishop-weed; and scattered butterweed (*Senecio glabellus*) and sand cordgrass.

The wet prairie (stations -1690 to -140) landward of the shallow marsh contained co-dominant swamp mallow and sand cordgrass; and numerous buttonbush. Additional wet prairie species included scattered groundsel tree, saw grass, morning glory (*Ipomoea sp*.), wax myrtle, bull arrowhead, and butterweed.

Landward of the wet prairie, the Lake Cone transect traversed a cypress strand (stations -140 to -40). The cypress strand overstory vegetation included abundant bald cypress (*Taxodium distichum*) and pop ash (*Fraxinus caroliniana*). The cypress strand understory vegetation included abundant stiff-marsh bedstraw, musky mint, panicum (*Panicum sp*.), and mock bishop-weed; and scattered bull arrowhead and swamp mallow.

Landward of the wet prairie, the Lake Cone transect traversed a cypress strand (stations -140 to -40). The cypress strand overstory vegetation included abundant bald cypress (*Taxodium distichum*) and pop ash (*Fraxinus caroliniana*). The cypress strand understory vegetation

Figure 14. Lake Cone Transect topography with ecological communities

*At Lake Cone the Minimum Frequent High (MFH) equals 7.6 ft NGVD, the Minimum Average (MA) equals 5.8 ft NGVD and the Minimum Frequent Low (MFL) equals 4.1 ft NGVD

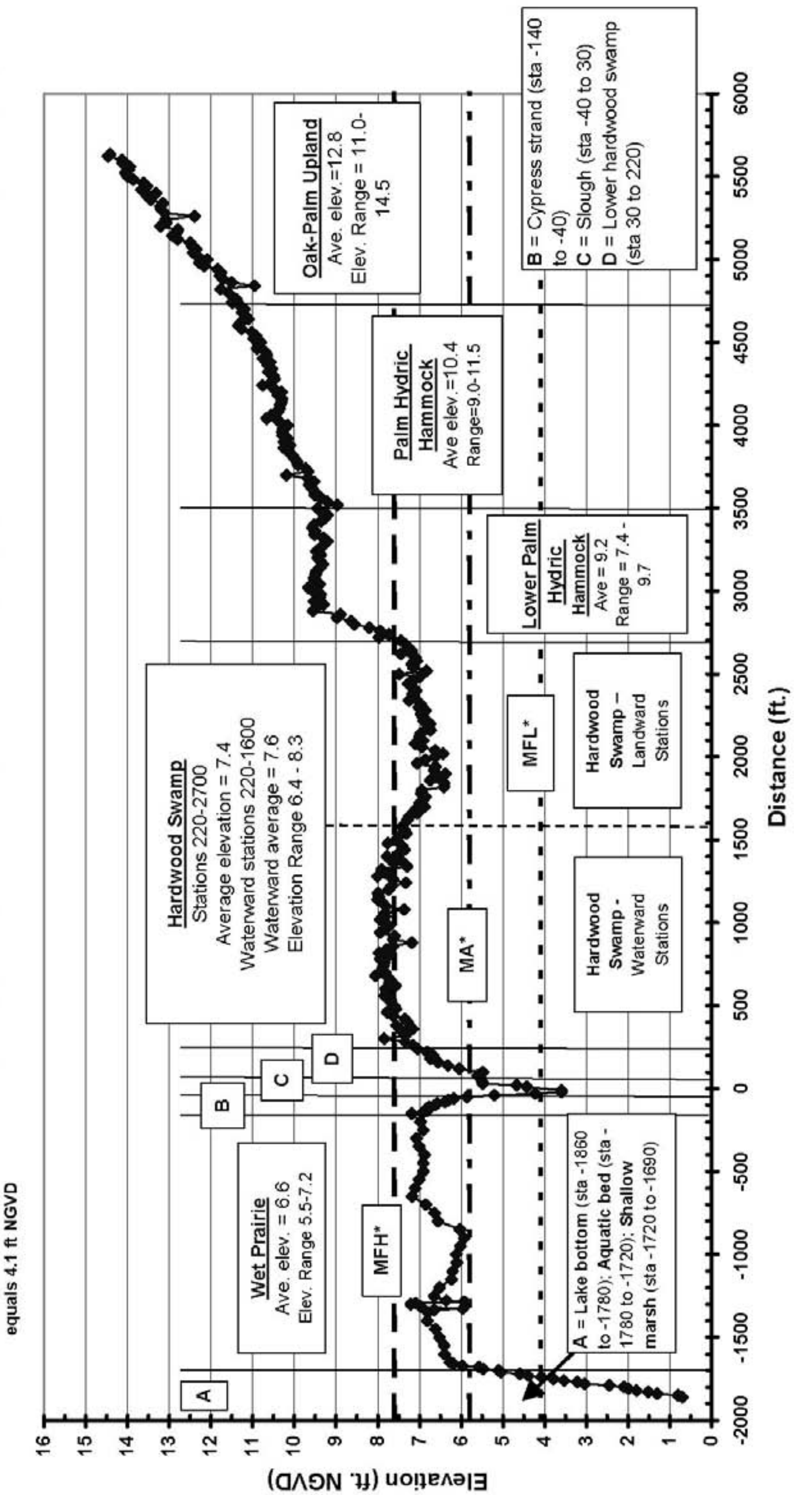


Figure 15. Lake Cone Transect photos

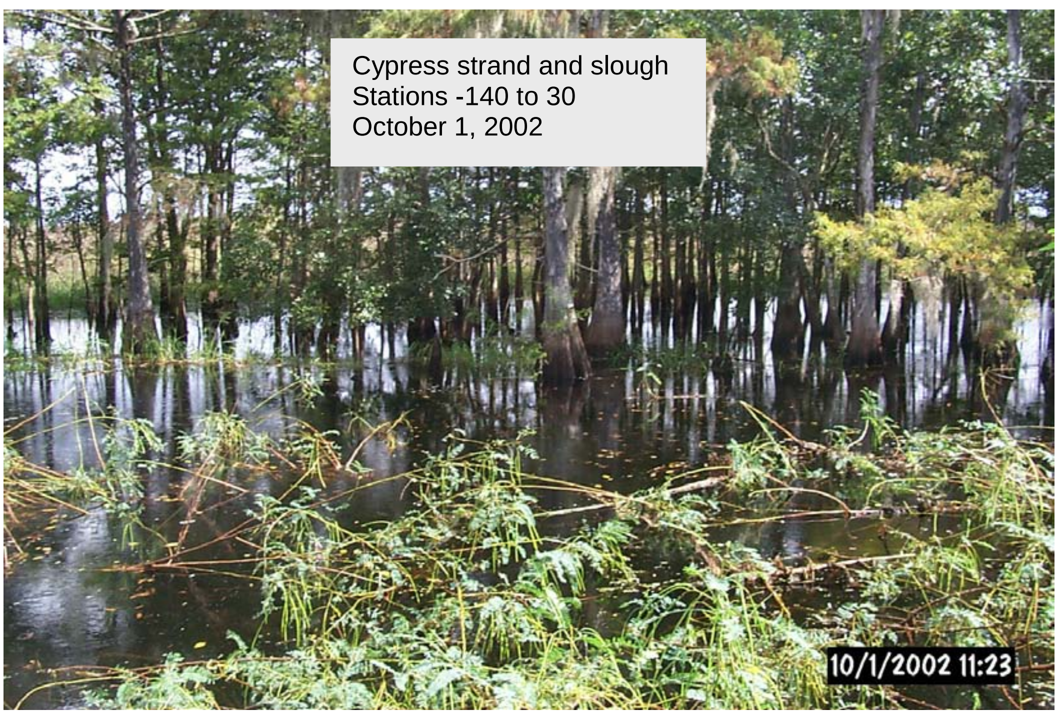


Figure 15. Lake Cone Transect photos—*continued*

Figure 15. Lake Cone Transect photos—*continued*

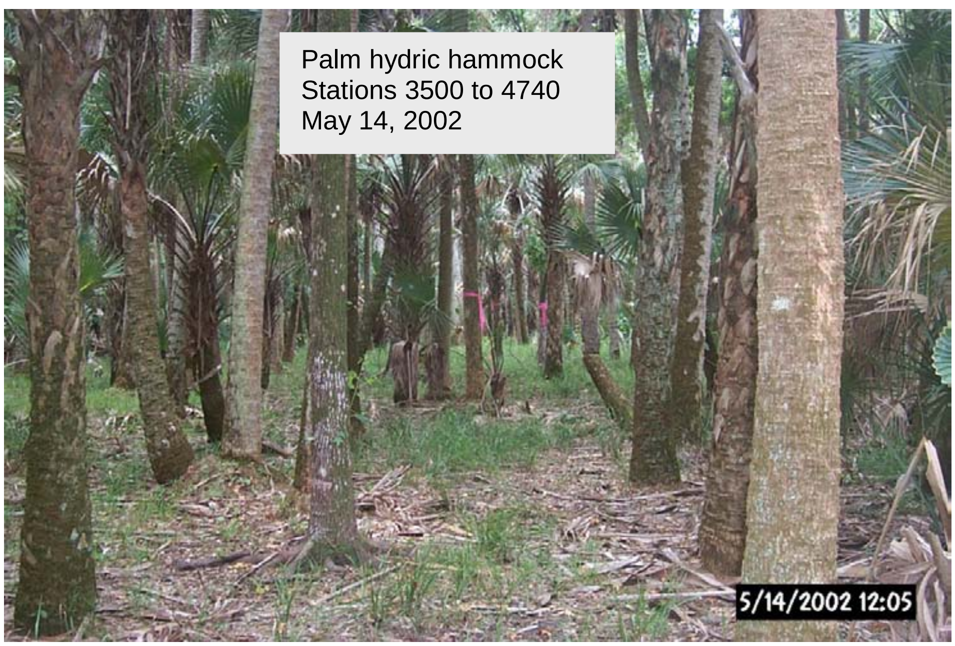


Figure 15. Lake Cone Transect photos—*continued*

Figure 15. Lake Cone Transect photos—*continued*

Table 18. Lake Cone Transect vegetation community statistics

Vegetation Community	Stations Distance (ft)	Mean (ft NGVD)	Median (ft NGVD)	Min (ft NGVD)	Max (ft NGVD)	N
Lake bottom	-1860 to -1780	1.8	1.8	0.7	3.0	9
Aquatic bed	-1780 to -1720	3.8	3.8	3.0	4.6	7
Shallow marsh	-1720 to -1690	5.0	5.1	4.6	5.5	4
Wet prairie	-1690 to -140	6.6	6.6	5.5	7.2	42
Cypress strand	-140 to -40	6.4	6.6	5.2	6.9	11
Slough	-40 to 30	4.5	4.4	3.6	5.5	7
Lower hardwood swamp	30 to 220	6.1	6.0	5.5	6.8	11
Hardwood swamp	220 to 2700	7.4	7.3	6.4	8.3	125
Hardwood swamp–water ward/higher section	220 to1600	7.6	7.7	6.8	8.1	69
Bluff soils	-1500 to 3400	7.4	7.2	3.6	9.7	220
Lower palm hydric hammock	2700 to 3500	9.2	9.4	7.4	9.7	41
Palm hydric hammock	3500 to 4740	10.4	10.4	9.0	11.5	63
Upland oak-palm hammock	4740 to 5635	12.8	12.9	11.0	14.5	45

ft NGVD = feet National Geodetic Vertical Datum

Table 19. Lake Cone Transect vegetation species list

Common Name	Scientific Name	FWDM Code[1]	Plant Community Species Cover Estimates[2]									
			AB	SM	WP	CYP	SLG	LHS	HS	LPHH	PHH	UPL
Alligator-weed	*Alternanthera philoxeroides*			0		0	0					
American elm	Ulmus americana	FACW						1	1		1	1
American germander	*Teucrium canadense*	FACW			0	0		0	1	0	0	0
American hornbean	Carpinus caroliniana	FACW									1	1
Bald cypress	Taxodium distichum	OBL			0	3	1	3–4	2–3	2	1	
Beakrush	Rhynchospora caduca	OBL								0	1	1
Beakrush, short-bristle	Rhynchospora corniculata	OBL							0	0		
Beautyberry	Callicarpa americana	FACU									0	0
Bull arrowhead	*Sagittaria lancifolia*	OBL			1	1						
Butterweed	Senecio glabellus	OBL		1	1	0						1
Buttonbush	Cephalanthus occidentalis	OBL			2			0	1			
Cabbage Palm	Sabal palmetto	FACW			0	0		0	0–2	2–4	3–4	4
Carolina willow	Salix caroliniana	OBL					2					
Coinwort	Centella asiatica	FACW							0	0	0	
Crabgrass	*Digitaria serotina*	FAC	4									
Fall panic grass	Panicum dichotomum	FACW									1	1
False-nettle	Boehmeria cylindrica	OBL					0	1	1			
Fireweed	Erehtites hieracifolia	FAC					0	1	2	1	1	1
Flatsedge	*Cyperus sp.*	FAC		0								
Golden-rod	*Solidago sp.*	FACW			0							
Golden-rod	Solidago stricta	FACW										0
Groundsel tree	*Baccharis glomeruliflora*	FAC			1							
Indigo-bush	Amorpha fruticosa	FACW							1			.
Laurel oak	Quercus laurifolia	FACW								1	1–2	2
Lizard's tail	Saururus cernuus	OBL								1	0–1	
Maidencane	Panicum hemitomon	OBL					3	1	0			
Milkweed	*Asclepias sp.*	OBL		0								
Mock bishop-weed	Ptlimnium capillaceum	FACW	0	2	0	3	1–2	1	1			
Morning–glory	*Ipomoea sp.*	FAC			1							
Musky mint	*Hyptis alata*	OBL	0	3	0	3	2		1		2–3	1
Nuttail's thistle	*Cirsium nuttaillii*	FACW			0			1	1			
Panicum	*Panicum sp.*			0	0	3	1					
Panicum, red-top	Panicum rigidulum	FACW							0			

Table 19—*Continued*

Common Name	Scientific Name	FWDM Code[1]	Plant Community Species Cover Estimates[2]									
			AB	SM	WP	CYP	SLG	LHS	HS	LPHH	PHH	UPL
Pepper-vine	Ampelopsis arborea	FAC						0	1			
Persimmon	Diospryos virginiana	FAC							1	1–2	1	1
Pickerelweed	Pontedaria cordata	OBL							0			
Pig weed	*Amaranthus australis*	OBL			0							
Poison Ivy	Toxicodendron radicans	FAC									1	1
Pop ash	Fraxinus caroliniana	OBL			0	3	3	1	1	1	1	
Rattle-bush	Sesbania sp.	FAC					1					
Red maple	Acer rubrum	FACW						1	2	2–3	1	0
Red maple-saplings	*Acer rubrum*	FACW			0							
Royal fern	Osmunda regalis	OBL										0
Sand cordgrass	*Spartina bakeri*	FACW		1	4	0						
Sand live oak	Quercus geminata	UPL									1–3	3
Saw palmetto	Serenoa repens	UPL										1
Saw grass	*Cladium jamaicense*	OBL			1			0	0			
Seashore mallow	Kosteletzkya virginica	OBL					0					
Sedge	Carex gigantea	OBL							2	1	0	
Smartweed	Polygonum densiflorum	OBL					2					
Smartweed	*Polygonum sp.*	OBL		0	0							
Southern blue-flag	Iris virginica	OBL							0			
Southern red cedar	Juniperus silicicola	FACU								1	1	1
Spikegrass	Chasmanthium nitidium	FACW								1	1	1–2
St. John's wort	Hypericum sp.	OBL								0	0	0
Stiff-marsh bedstraw	*Galium tinctorium*	FACW	0	2	0	3	1–2	1	0			
Swamp bay	Persea palustris	OBL								1	0	
Swamp dogwood	Cornus foemina	FACW							0	0		
Swamp fern	Blechnum serrulatum	FACW									1–3	1–3
Swamp mallow	*Hibiscus grandiflorus*	OBL			4	1						
Sweetgum	Liquidambar styraciflua	FACW									1	1
Virginia chain fern	Woodwardia virginica	FACW						2–3	2–3		1	
Walter Millet	Echinochloa walteri	OBL					2–3		0			
Water hickory	*Carya aquatica*	OBL										1
Water oak	Quercus nigra	FACW										1
Water pennywort	Hydrocotyle umbellata	FACW			0		0		1–2		1	1
Water-locust	Gledisia aquatica	FACW						1–2	1			

Table 19—*Continued*

Common Name	Scientific Name	FWDM Code[1]	Plant Community Species Cover Estimates[2]									
			AB	SM	WP	CYP	SLG	LHS	HS	LPHH	PHH	UPL
Wax myrtle	Myrica cerifera	FAC			1			0	1–2	0		
White stopper	Eugenia sp.	UPL									0	0
White-top sedge, starrush	Dichromena colorata	FACW								0		1
Wild coffee	Psychotria nervosa	FAC									0	1

[1]FWDM Code Indicator categories established in Florida Wetlands Delineation Manual (Gilbert et al.1995).
Upland (UPL) = Plants that occur rarely in wetlands, but occur almost always in uplands.
Facultative (FAC) = Plants with similar likelihood of occurring in both wetlands and uplands.
Facultative Wet (FACW) = Plants that typically exhibit their maximum cover in areas subject to surface water flooding and/or soil saturation, but may also occur in uplands.
Obligate (OBL) = Plants that are found or achieve their greatest abundance in an area which is subject to surface water flooding and/or soil saturation; rarely uplands.

[2] Plant Community Species Cover Estimates: Aerial extent of vegetation species along transect within given community where 0 = <1% (rare); 1 = 1–10% (scattered); 2 = 11–25% (numerous); 3 = 26–50% (abundant); 4 = 51–75% (co–dominant); and 5 = greater than 75% (dominant).
AB = Aquatic bed (stations -1780 to -1720)
SM = Shallow marsh (stations -1720 to -1690)
WP = Wet prairie (stations -1690 to -140)
CYP = Cypress strand (stations -140 to -40)
SLG = Slough (stations -40 to 30)
LPHH = Lower palm hydric hammock (stations 2700–3500)
LHS = Lower hardwood swamp (stations 30–220)
PHH = Palm hydric hammock (stations 3500–4740)
HS = Hardwood swamp (stations 220–2700)
UPL = Upland (stations 4740–5635

included abundant stiff-marsh bedstraw, musky mint, panicum (*Panicum sp*.), and mock bishop-weed; and scattered bull arrowhead and swamp mallow.

Landward of the cypress strand, the Lake Cone transect traversed a slough (stations -40 to 30). Slough vegetation included abundant short (<20 ft tall) pop ash and maidencane (*Panicum hemitomon*); numerous to abundant Walter millet (*Echinochloa walteri*); numerous Carolina willow (*Salix caroliniana*), musky mint, and smartweed (*Polygonum densiflorium*); scattered to numerous stiff-marsh bedstraw and mock bishop-weed; and scattered rattle-bush (*Sesbania sp*.), bald cypress, and panicum (*Panicum sp*.).

Landward of the slough, the Lake Cone transect traversed a lower hardwood swamp (stations 30 to 220). Bald cypress was abundant to co-dominant in the lower hardwood swamp overstory. Additional lower hardwood swamp overstory species included scattered American elm (*Ulmus americana*), pop ash, and red maple (*Acer rubrum*); and scattered to numerous water locust (*Gledisia aquatica*). The lower hardwood swamp understory vegetation included numerous to abundant Virginia chain fern (*Woodwardia virginica*); and scattered mock bishop-weed, fireweed (*Erechtites hieracifolia*), stiff-marsh bedstraw, maidencane, false nettle (*Boehmeria cylindrica*), and Nuttail's thistle (*Cirsium nuttaillii*).

Landward of the lower hardwood swamp the Lake Cone Transect traversed an extensive hardwood swamp (stations 220–2700). The hardwood swamp overstory vegetation included numerous to abundant bald cypress; numerous red maple; rare to numerous cabbage palm; and scattered persimmon (*Diospryos virginiana*), pop ash, water locust, and American elm. The hardwood swamp understory vegetation included numerous to abundant Virginia chain fern; numerous sedge (*Carex gigantea*) and fireweed; scattered to numerous water pennywort (*Hydrocotyle umbellata*) and wax myrtle; and scattered indigo-bush (*Amorpha fruticosa*), pepper-vine (*Ampelopsis arborea*), false nettle, buttonbush, nuttail's thistle, musky mint, mock bishop-weed, and American germander (*Teucrium canadense*).

Within the hardwood swamp subtle vegetation changes were noted. For example, wax myrtle and cabbage palm were numerous between stations 220 and 1600 but nonexistent between stations 1600 and 2700. This may be due to the lower ground elevation between stations 1600–

2700 or sunlight competition. Also, Virginia chain fern was co-dominant in patches between stations 1900 and 2100. Buttonbush was numerous only in the deeper slough areas (between stations 1600–2700) within the hardwood swamp.

Landward of the hardwood swamp the Lake Cone transect traversed a lower palm hydric hammock (stations 2700–3500). The lower palm hydric hammock overstory vegetation included numerous to co-dominant cabbage palm; numerous to abundant red maple; numerous bald cypress; scattered to numerous persimmon; and scattered American elm, swamp bay (*Persea palustris*), pop ash, southern red cedar (*Juniperus silicicola*), and laurel oak (*Quercus laurifolia*). The lower palm hydric hammock understory vegetation included scattered lizard's tail (*Saururus cernuus*), fireweed, sedge and spikegrass (*Chasmanthium nitidium*).

A subcommunity in the lower palm hydric hammock occurred between station 2700–2900 where cabbage palms were very dense, with scattered bald cypress and red maples, and no understory vegetation.

Landward of the lower palm hydric hammock, the Lake Cone transect traversed a palm hydric hammock (stations 3500–4740). The ground elevation gradually increased throughout the palm hydric hammock (Figure 14). This elevation change resulted in subtle vegetation changes within the palm hydric hammock. In general the dominant palm hydric hammock overstory vegetation included numerous to co-dominant cabbage palm; scattered to abundant sand live oak; scattered to numerous laurel oak; and scattered bald cypress, red maple, American hornbean (*Carpinus caroliniana*), pop ash, southern red cedar, sweetgum (*Liquidambar styraciflua*), and American elm. The palm hydric hammock understory vegetation included abundant to scattered swamp fern (*Blechum serrulatum*); numerous to abundant musky mint; scattered spikegrass, fireweed, water pennywort, fall panic grass (*Panicum dichotomum*), beakrush (*Rhynchospora caduca*), poison ivy (*Toxicodendron radicans*), and Virginia chain fern; and rare to scattered lizard's tail.

The Lake Cone transect terminated within an upland oak-palm hammock (stations 4740–5635). The upland oak-palm hammock overstory vegetation included co-dominant cabbage palm; abundant sand live oak; numerous live oak; and scattered American elm, American hornbean, water hickory (*Carya aquatica*), sweetgum, water oak (*Quercus nigra*) southern red cedar, and persimmon. The upland oak-palm understory vegetation included abundant to scattered swamp fern; scattered to numerous nuttail's thistle; and scattered white-top sedge (*Dichromena colorata*), fireweed, water pennywort, musky mint, fall panic grass, wild coffee (*Psychotria nervosa*), beakrush, butterweed, saw palmetto (*Serenoa repens*), and poison ivy.

Additional plant species observed along the Lake Cone Transect are listed in Table 19.

Soils at Lake Cone Transect

Soil auger holes were dug at 28 selected stations to characterize the soils along the Lake Cone Transect between stations 1750 and 5600 on June 4 and 5, 2002 (Table 20). Soils were characterized in the field based upon

Table 20. Lake Cone Transect soils descriptions

Station/Series	Vegetation Community	Soil Horizon	Horizon description
-1750/Tuscawilla	Aquatic bed	Oa 0–0.5"	Black muck
		E1 0.5–4.0"	Gray, grayish brown, and brown sand; stripping present
		E2 4–9"	Gray, light brownish gray, and pale brown sand; stripping present with very dark gray splotches
		C 9"+	very dark gray loam
-1500/Chobee	Wet prairie	Oa 0–2"	Black muck
		C1 2–8"	Very dark gray loam
		C2 8"+	Very dark gray clay loam
-1250/Chobee	Wet prairie	Oa 0–5"	Black muck
		C1 5–12"	Very dark gray clay loam
		C2 12"+	Very dark gray sandy clay loam
-850/Chobee	Wet prairie	Oa 0–5"	Black muck
		C1 5–13"	Very dark gray loam
		C2 13"+	Very dark gray sandy clay loam
-400/Chobee	Wet prairie	Oa 0–3"	Black muck
		C1 3–9"	Very dark gray loam
		C2 9"+	Very dark gray sandy loam
-120/Chobee	Cypress strand	Oa 0–3"	Black muck
		C1 3–7"	Very dark gray loam
		C2 7"+	Very dark gray sandy clay loam

Table 20—*Continued*

Station/Series	Vegetation Community	Soil Horizon	Horizon description
0/Tuscawilla	Slough	Oa 0–7”	Black muck
		A 7–8”	Black mucky sand
		C1 8–11”	Gray and grayish brown sand; stripping present
		C2 11”+	Very dark gray clay loam
100/Chobee	Lower hardwood swamp	Oa 0–4”	Black muck
		A 4–6”	Black mucky loam
		C1 6–9”	Black loam
		C2 9”+	Very dark gray clay loam
200/Chobee	Lower hardwood swamp	Oa 0–3”	Very dark gray muck, many fine roots
		C1 3–13”	Black sandy clay loam
		C2 13”+	Very dark gray clay loam
400/Chobee	Hardwood swamp	Oa 0–3”	Black muck
		A 3–4”	Black mucky loam
		C1 4–14”	Black sandy clay loam
		C2 14–20”	Black sandy loam
		C3 20–23”	Very dark gray sandy loam very dark gray (3/), clay loam
		C4 23”+	Very dark gray sandy clay loam
700/Chobee	Hardwood swamp	Oa 0–3”	Very dark gray muck
		C1 3–8”	Black clay loam
		C2 8–14”	Black sandy clay loam
		C3 14”+	Very dark gray sandy loam
1000/Chobee	Hardwood swamp	Oa 0–4”	Black muck
		C1 4–9”	Black sandy clay loam
		C2 9”+	Very dark gray (clay loam
1400/Chobee	Hardwood swamp	Oa 0–4”	Black muck
		C1 4–9”	Black clay loam
		C2 9”+	Black sandy clay loam
1580/Chobee	Hardwood swamp	Oa 0–4”	Very dark gray muck
		A 4–8”	Very dark gray mucky loam
		C1 8–14”	Very dark gray sandy clay loam
		C2 14”+	Dark gray sandy loam
1900 /Denaud	Hardwood swamp	Oa 0–9”	Very dark gray muck
		A 9–12”	Black mucky sand
		Bw 12–15”	Yellowish brown sandy loam; unusual yellowish brown horizon
		C 15”+	Black clay loam
2100/Chobee	Hardwood swamp	Oa 0–6”	Black muck
		Bw 6–8”	Yellowish brown sandy loam
		C 8”+	Very dark gray clay loam

Table 20—*Continued*

Station/Series	Vegetation Community	Soil Horizon	Horizon description
2300/Bradenton	Hardwood swamp	Oa 0–4”	Black muck
		A 4–6”	Black mucky sand
		Bw 6–14”	Yellowish brown sandy loam
		C 14”+	Very dark gray sandy clay loam
2600/Bradenton	Hardwood swamp	Oa 0–5”	Very dark gray muck, many fine and medium roots.
		A 5–8”	Black mucky sand
		C1 8–14”	Dark gray sandy loam
		C2 14–17”	Very dark gray clay loam
		C3 17”+	Very dark gray sandy loam
3000/Manatee	Lower palm hydric hammock	A1 0–3”	Black mucky sand
		A2 3–9”	Black loamy sand
		A3 9–19”	Very dark gray loamy sand
		C 19”+	Gray loamy sand
3400/Manatee	Lower palm hydric hammock	Oa 0–2”	Very dark gray muck, many fine roots.
		A1 2–4”	Black mucky sand, many fine roots.
		A2 4–6”	Black mucky sand, few fine roots.
		C1 6–12”	Very dark gray loamy sand
		C2 12”+	Dark gray sandy loam. Few, fine, faint redoximorphic features at 24"
3600/Eaton	Palm hydric hammock	A1 0–4”	Black mucky sand, common medium roots.
		A2 4–6”	Black mucky sand, few fine roots.
		A / E 6–10”	Dark gray and grayish brown sand. Stripped matrix
		E 10–20”	Grayish brown sand
		Bt 20”+	Gray sandy loam
4000/Eaton	Palm hydric hammock	A1 0–3”	Black mucky sand
		A2 3–5”	Black sand
		A / E 5–15”	Very dark gray, dark gray, and gray sand. Stripped matrix
		E1 15–20”	Dark gray sand
		E2 20–26”	Gray sand with few, fine, faint pale brown redoximorphic features
		Bt 26”+	Gray sandy loam, with many, coarse, prominent brownish yellow mottles.
4200/Eaton	Palm hydric hammock	A1 0–4”	Black mucky sand. Less than 2% organic bodies present
		A2 4–8”	Very dark gray sand; less than 70% coated with organic material
		E1 8–14”	Very dark gray, dark gray, and gray sand. Stripped matrix
		E2 14–20”	Gray sand
		Bt 20”+	Gray loamy sand

Table 20—*Continued*

Station/Series	Vegetation Community	Soil Horizon	Horizon description
4400/Eaton	Palm hydric hammock	A 0–4”	Black mucky sand; more than 2% organic bodies present
		A / E 4–17”	Dark gray and gray sand; weak stripping
		E1 17–23”	Gray sand; stripping present
		E2 23–36”	Gray sand; common, medium, faint, light yellowish brown redoximorphic features.
		Bt 36”+	Gray sandy clay loam; common, medium, faint, light yellowish brown redoxomorphic features.
4600/Eaton	Palm hydric hammock	A1 0–3”	Black mucky sand; more than 2% organic bodies present
		A2 3–5”	Black sand
		E1 5–12”	Gray and grayish brown sand; stripping present
		E2 12–22”	Light brownish gray and light gray sand; stripping present
		E3 22–38”	Gray sand; common, fine, faint, light yellowish brown redoxomorphic features at 29"
		Bt 38”+	Gray sandy loam; many, medium, prominent, brownish yellow and strong brown redoximorphic features
4800/Eaton	Oak palm upland	A1 0–2”	Black mucky sand; more than 2% organic bodies present
		A2 2–7”	Black sand
		A / E 7–23”	Dark gray and grayish brown sand; stripping present
		E 23–36”	Gray sand; stripping present; few, fine, faint redoximorphic features at 24"
		Bt 36”+	Gray loamy sand; many, coarse, prominent, light yellowish brown mottles

Table 20—*Continued*

Station/Series	Vegetation Community	Soil Horizon	Horizon description
5000/Eaton	Oak palm upland	A1 0–3”	Black mucky sand; more than 2% organic bodies present
		A2 3–7”	Black sand
		A / E 7–10”	Dark gray and gray sand; stripping present
		E 10–35”	Gray and grayish brown sand; stripping present; redoximorphic features at 24"
		Bt 35”+	Gray loamy sand; many, coarse, prominent, light yellowish brown mottles
5600/Holopaw	Oak palm upland	A 0–5”	Gray sand
		E1 5–10”	Gray sand; weak stripping present
		E2 10–40”	Gray and light brownish gray sand; stripping present; redoximorphic features begin at 22" and end at 37"
		E3 40–48”	Gray sand;
		Bt 48”+	Dark gray loamy sand

epipedons, horizons, soil texture, soil color, and horizon depth. These soil features were used to determine the soil series at each soil station. At least one hydric soil indicator (histic epipedon, muck, mucky mineral, organic bodies, loamy gleyed matrix, and/or stripped matrix) was observed at all sampled stations.

As mentioned previously, fluvial and other hydrologic processes constantly modify the soils throughout the St. Johns River floodplain. Sediment accretion frequently occurs during flood activities, creating transitory features within the soils, especially those closest to the stream channels (Lindbo and Richardson 2001). When the river rises and inundates the floodplain, erosional and depositional processes combine to deposit coarse sediments at the edge of the floodplain (nearest the channel) and finer-textured material throughout the floodplain. Consequently, sediments found in the St. Johns River floodplain can be comprised of depositional material transported from upstream, depositional material derived locally from channel erosion, and parent material that has been reworked from centuries of flood events. Numerous relatively thin soil horizons can occur from frequent deposition of alluvial sediments and often result in accretion topography. As a result, soil features such as texture and color can vary greatly over a short distance (D. Segal, pers. comm. 2004). In the St. Johns River floodplain, fine-textured material may occur near the surface in one place and at a depth of as much as 48 in. below the soil surface at a nearby location (Leighty et al. 1957).

The history of erosional and depositional processes in the St. Johns River floodplain gives rise to a complex distribution of soils across the floodplain. Lateral and horizontal changes in sediment deposition result in soil series with a large degree of variability (Lindbo and Richardson 2001). This combination makes the identification of soil series difficult due to the high variability of soil features found across the Lake Cone transect. Often soil features found at a given site will not conform to the characteristics of any particular soil series (Segal, pers. comm., 2004). Because the soils description process resulted in many discrepancies with the official soil series descriptions, Wade Hurt, hydric soil scientist with the USDA, NRCS, in Gainesville, Florida, was consulted to help identify the correct soil series; the one that most closely represents the described soils.

The soil series and the soil taxonomic classification subgroup are briefly described below for each soil station sampled at the Lake Cone Transect. The soil taxonomic classification subgroup provides additional information for each soil series (JEA 2004; Appendix C).

Soil series identified at the Lake Cone transect included Chobee, Eaton, Tuscawilla, Bradenton, Denaud, Manatee, and Holopaw. Chobee soil was the most frequently observed (observed at 13 soil sampling stations) soil series at the Lake Cone Transect, occurring across the wet prairie, the cypress strand, the lower hardwood swamp, and most of the hardwood swamp (Table 20). These Chobee soils had a shallow surface organic horizon, ranging from 2 to 6 in., in thickness, underlain by a loam, clay loam, and / or sandy clay loam. As mentioned previously, according to the NRCS (2003), the Chobee series consists of very deep, very poorly drained, slowly to very slowly permeable soils occurring in depressions, flats, and occasionally on river floodplains. The Chobee water table is within 6 in. of the soil surface for one to four months during most years. Depressional areas are ponded for long durations (NRCS 2003). According to the *Soil Survey of Brevard County, Florida* (USDA, SCS 1974), the Chobee soil water table is within a depth of 10 in. of the soil surface for six to nine months and 10 to 40 in. of the soil surface for three to six months. In very dry seasons, the water table occurs at a depth greater than 40 in. below the soil surface for short periods. Chobee soil is continuously flooded for one to six months in many places (USDA, SCS 1974).

The taxonomic classification subgroup for the described Chobee soil is a Typic Argiaquoll, meaning it is a mollisol in the aquic moisture regime, containing an argillic horizon and the argillic horizon occurs within 20 in. of the soil surface. The presence of a mollic epipedon is indicative of the high concentrations of organic matter that develop and persist in flooded soils (JEA 2004; Appendix C).

Additional soil series observed at the Lake Cone transect included Tuscawilla, Denaud, Bradenton, Manatee, Eaton and Holopaw. Tuscawilla series was identified in the aquatic bed at Lake Cone and in the slough (Table 20). The Tuscawilla series consists of very deep, very poorly drained, moderately permeable soils in hammocks on the lower Coastal Plain. They formed in sandy and loamy marine sediments containing shells and shell fragments. The water table occurs within 10 in. of the soil surface for two to six months in most years (NRCS 2003). At Lake Cone, the Tuscawilla soil is frequently flooded for long durations.

The taxonomic classification subgroup for the described Tuscawilla soil is a Typic Endoaqualf, meaning it is an Alfisol because it contains an argillic horizon that is high in base saturation. Tuscawilla is not a mollisol because it lacks a high accumulation of organic matter. Tuscawilla is in the aquic moisture regime, and is endosaturated, meaning it derives its moisture primarily internally from groundwater. The argillic horizon occurs within 20 in. of the soil surface. Tuscawilla was noted in the two lowest areas of the Lake Cone Transect where sand quickly settles out and water scouring is greatest. Therefore, surface organic material cannot accumulate at these locations (JEA 2004; Appendix C).

Denaud soil was identified at one location on the Lake Cone transect (station 1900; hardwood swamp). Chobee soil was observed at both the water ward and landward adjacent soil sampling stations nearest the Denaud station (Table 20). Denaud and Chobee series soils are very similar, with the distinguishing characteristic being the depth of the surface organic horizon. Denaud soils have a histic epipedon (surface organic horizon 8 to 16 in., in thickness) while Chobee soils have a surface organic horizon 0 to 7 in., in thickness. This Denaud soil at station 1900 was the only soil sampled at Lake Cone containing a histic epipedon.

According to the NRCS (2003), the Denaud series consists of deep, very poorly drained, moderately permeable soils with a thin organic layer over sandy and loamy material. These soils are ponded for six to nine months in most years and are saturated to the surface the rest of the time during most years. The taxonomic classification subgroup for Denaud soil is a Histic Humaquept. A Histic Humaquept is an Inceptisol, meaning it is a somewhat young soil and has minimal horizon development, but somewhat more development than the youngest Entisols. Denaud soil is in the aquic moisture regime, has distinct organic material at the surface, and has a histic epipedon. A histic epipedon contains 8 to 16 in. of organic material (JEA 2004; Appendix C).

Bradenton series occurred in the landward section of the hardwood swamp at stations 2300 and 2600 (Table 20). Bradenton series is typically fine sands consisting of very deep, poorly drained, moderately permeable soils on low ridges and on floodplains with a water table that occurs at depths of less than 18 in. below the soil surface for two to six months annually during most years (NRCS 2003). The taxonomic classification subgroup for Bradenton soil is a Typic Endoaqualf, meaning it is an Alfisol because it contains an argillic horizon that is high in base saturation. Bradenton is in the aquic moisture regime, and is endosaturated, meaning it derives its moisture primarily internally from groundwater. The argillic horizon in Bradenton soil occurs within 20 in. of the soil surface. Bradenton soil is poorly drained, rather than very poorly drained (JEA 2004; Appendix C).

Upslope from the hardwood swamp, Manatee soil occurred in the lower palm hydric hammock at stations 3000 and 3400. Manatee series typically consists of very deep, very poorly drained, moderately permeable loamy fine sands occurring in depressions, broad drainage ways, and on floodplains. The Manatee soil water table occurs within 10 in. below land surface for more than six months annually during most years. Depressional areas are ponded for about six to nine months during most years (NRCS 2003). The taxonomic classification subgroup for Manatee soil is a Typic Argiaquoll, meaning it is a mollisol in the aquic moisture regime, containing an argillic horizon and the argillic horizon occurs within 20 in. below land surface. As mentioned previously, the presence of a mollic epipedon is indicative of the high concentrations of organic matter that develops and persists in flooded soils (JEA 2004; Appendix C).

Eaton soil was the second most commonly occurring (observed at 7 soil sampling stations) soil series at the Lake Cone transect. Eaton soil was observed extending across the palm hydric hammock and into the oak palm upland (Table 20). The Eaton series consist of poorly and very poorly drained soils formed in clayey marine sediments with a water table that occurs at depths of less than 10 in. below the soil surface for periods of one to four months during most years. Depressional areas are ponded for very long periods (NRCS 2003). The taxonomic classification subgroup for Eaton soil is an Arenic Albaqualf. Eaton is an Alfisol, meaning it has an argillic horizon that is high in base saturation. It is poorly drained and in the aquic moisture regime, contains light-colored albic subsurface horizon(s) and the arenic adjective implies that the argillic horizon occurs between 20 and 40 in. below the soil surface (JEA 2004; Appendix C).

The Lake Cone transect terminated within an oak-palm upland where Eaton and Holopaw soils were sampled (Table 20). Eaton soil differs from Holopaw by the depth of the argillic horizon. In Eaton soil, the argillic horizon occurs at a depth of 20 to 40 in. below the soil surface. The argillic horizon in Holopaw soil occurs at a depth of greater than 40 in. below the soil surface.

Holopaw soil was identified at the upland end of the Lake Cone transect at station 5600 (Table 20). The Holopaw series consists of deep and very deep, poorly and very poorly drained soils formed in sandy marine sediments. These soils occur on low flats, in poorly drained depressional areas. The Holopaw soil water table occurs within 12 in. of the soil surface for two to six months during most years. Depressional areas are ponded for more than six months during most years (NRCS 2003). The taxonomic classification subgroup for Holopaw is a Grossarenic Endoqualf, meaning it is an Alfisol with an argillic horizon that is high in base saturation and with an aquic moisture regime. The term endo implies that Holopaw soils are endosaturated, where water is frequently derived from groundwater rather than surface water. The Grossarenic adjective implies that the argillic horizon occurs at depths greater than 40 in. below the soil surface (JEA 2004; Appendix C).

In summary, soils along the Lake Cone Transect formed and persist in very wet conditions. The drainage classification changed from primarily very poorly drained at the lower elevations to poorly drained in the palm hydric hammock and oak-palm uplands. Additionally, the majority of the soils between the open water of Lake Cone and the palm hydric hammock contained a mollic or histic epipedon. These two epipedons result from high organic matter accumulation that occurred in constantly reduced conditions (JEA 2004; Appendix C).

Field Data for M-6 Transect

The M-6 Transect originated at station -320 on the Lake Cone Transect and traversed in an easterly direction across the floodplain for 8,880 ft (Figures 2 and 7; Table 17).

Transect Selection Criteria M-6 Transect

The primary reasons for selecting this transect location included the following:

To characterize the lowest floodplain vegetation communities that were not adequately traversed at the adjacent Lake Cone Transect (The St. Johns River floodplain at this locale consists of multiple river channels. Subtle changes in elevation result in shifts between wet prairie and shallow marsh communities.)

- To traverse multiple relatively unimpacted wet prairie and marsh communities (Figure 7)
- Located on SJRWMD property (Seminole Ranch), preventing future development and facilitating access for long-term ecological monitoring

Extensive elevation surveys of the river channels at M-6 facilitated additional surveys of the floodplain at M-6.

Vegetation at M-6 Transect

The M-6 Transect originated on the west floodplain within a wet prairie community and traversed in an east and northeast direction across multiple wet prairies, open water areas, the west river channel, and shallow marshes (Figures 16 and 17, Tables 21 and 22).

The wet prairie #1 (stations -4030 to -2150) at the origin of the M-6 Transect contained numerous to co-dominant sand cordgrass; co-dominant swamp hibiscus; numerous buttonbush, dead (burned) wax myrtle, and bull arrowhead; and scattered saltmarsh mallow and saw grass. A prescribed fire occurred in wet prairie #1 in the late spring of 2003.

Adjacent and east of wet prairie #1, the M-6 Transect traversed shallow marsh #1 (stations -2150 to -900). Shallow marsh #1 vegetation included dominant swamp hibiscus; abundant saw grass; numerous maidencane and bull arrowhead; scattered to numerous buttonbush; and scattered water paspalum, American cupscale, Carolina willow, softstem bulrush, bald cypress, and giant foxtail.

Adjacent to shallow marsh #1 the M-6 Transect traversed wet prairie #2 (stations -900 to 800). Wet prairie #2 vegetation included dominant sand cordgrass; numerous bull arrowhead, American cupscale, fall panic grass, and coastal cockspur grass; scattered to numerous buttonbush and swamp hibiscus; and scattered dotted smartweed.

Adjacent to and east of wet prairie #2 the M-6 Transect traversed shallow marsh #2 (stations 800 to 1100). Shallow marsh #2 vegetation included abundant dotted smartweed and sand cordgrass; numerous buttonbush and swamp hibiscus; and scattered fire-flag.

Adjacent and east of shallow marsh #2, the M-6 Transect traversed wet prairie #3 (stations 1100 to 1400). Wet prairie #3 vegetation included co-dominant sand cordgrass; numerous dotted smartweed and buttonbush; and scattered American cupscale and fire-flag.

Adjacent and east of wet prairie #3 the M-6 Transect terminated within shallow marsh #3 (stations 1400 to 4900). Shallow marsh #3 vegetation included numerous to abundant dotted smartweed; abundant to co-dominant dixie signalgrass; and scattered hemp sesbania, sand

Figure 16. M-6 Transect topography with ecological communities

*At Lake Cone and M-6 the Minimum Frequent High (MFH) equals 7.6 ft. NGVD, the Minimum Average (MA) equals 5.8 ft. NGVD and the Minimum Frequent Low (MFL) equals 4.1 ft. NGVD

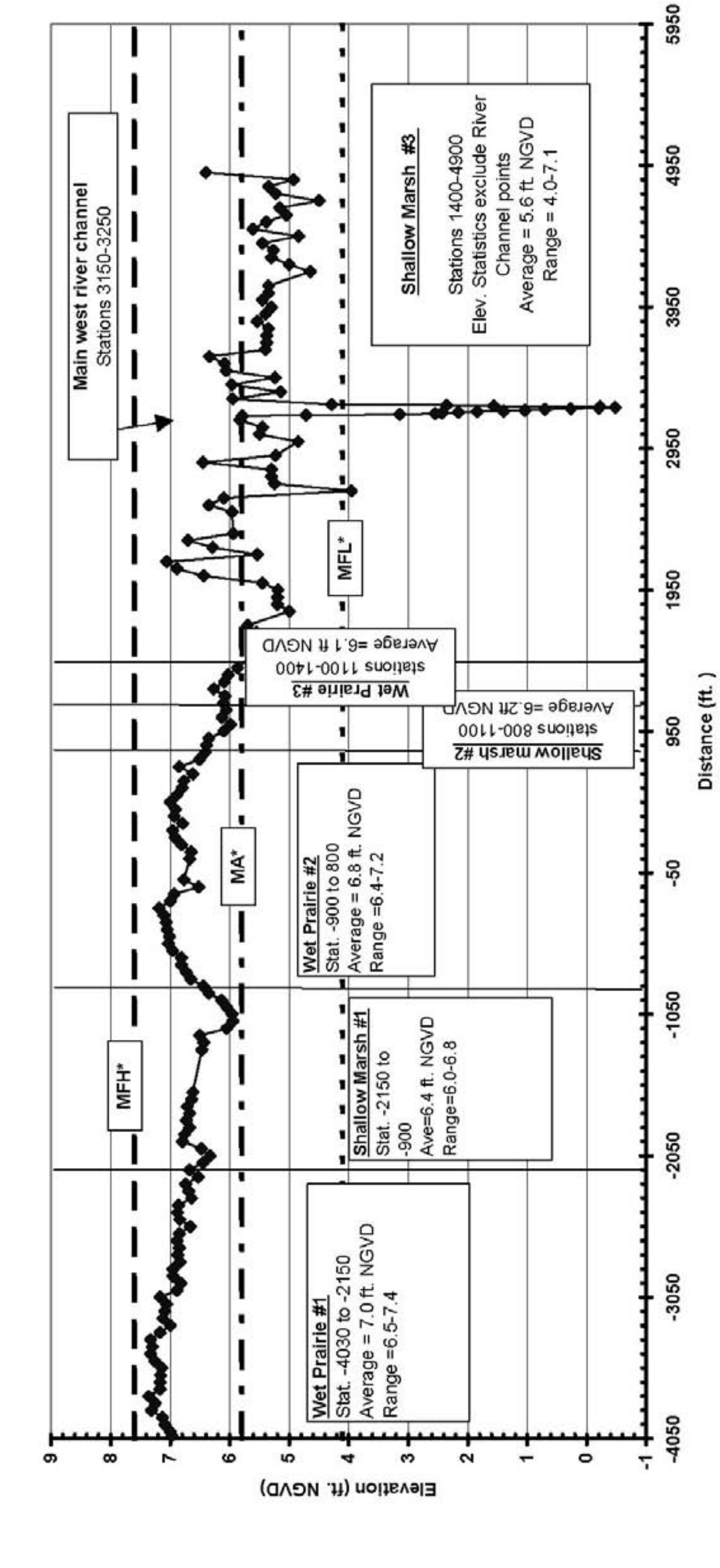


Figure 17. M-6 Transect photos

Figure 17. M-6 Transect photos—*continued*

Figure 17. M-6 Transect photos—*continued*

Table 21. M-6 Transect vegetation community statistics

Vegetation Community	Stations Distance (ft)	Mean (ft NGVD)	Median (ft NGVD)	Min (ft NGVD)	Max (ft NGVD)	N
Wet prairie #1	-4030 to -2150	7.0	7.0	6.5	7.4	39
Shallow marsh #1	-2150 to -900	6.4	6.5	6.0	6.8	21
Wet prairie #2	-900 to 800	6.8	6.8	6.4	7.2	33
Shallow marsh #2	800 to 1100	6.2	6.1	6.0	6.4	7
Wet prairie #3	1100 to 1400	6.1	6.1	5.9	6.3	7
Shallow marsh #3	1400 to 4900	5.6	5.4	4.0	7.1	62
Wet prairies 1–2	-4030 to -2150 -900 to 800	6.9	6.9	6.4	7.4	72
Shallow marshes 1–3	-2150 to -900 800 to 1100 1400 to 4900	5.8	5.9	4.0	7.1	90

ft NGVD = feet National Geodetic Vertical Datum

cordgrass, and Carolina willow. Between stations 2600 to 2800 in shallow marsh #3 the vegetation included abundant to co-dominant smartweed; numerous buttonbush; scattered to numerous fire-flag; and scattered softstem bulrush.

Additionally, from stations 3250 to 3300 in shallow marsh #3 common reed was co-dominant. Common reed was not observed at other points in shallow marsh #3 immediately adjacent to the M-6 Transect, but was visible in the distance. Higher elevations were surveyed within shallow marsh #3 immediately adjacent to the west river channel, as well as at other locations with small aerial extent. Sand cordgrass was co-dominant at the higher elevations near stations 2800 and 4800 but otherwise was scattered within the shallow marsh #3. Additional plant species observed along the M-6 Transect are listed in Table 22.

Soils at M-6 Transect

Soil auger holes were dug at 36 selected stations to characterize the soils along the M-6 Transect between stations -4030 and 4800 on January 20, and February 3 and 4, 2004 (Table 23). Soils along the M-6 Transect were characterized based upon epipedons, horizons, soil texture, soil color, and horizon depth. These soil features were used to determine the soil

Table 22. M-6 Transect vegetation species list

Scientific Name	Common Name	FUWDM Code[1]	Plant Community Species Cover Estimates[2]					
			WP #1	SM #1	WP #2	SM #2	WP #3	SM #3
Sacciolepis striata	American cupscale	OBL		1	2		1	
Taxodium distichum	Bald cypress	OBL		1				
Sesbania vesicaria	Bladder Pod	FAC						
Sagittaria lancifolia	Bull arrowhead	OBL	2	2	1–2			
Cephalanthus occidentalis	Buttonbush	OBL	2	1–2	1–2	2	2	2
Sabal palmetto	Cabbage palm	FAC	0					
Salix caroliniana	Carolina willow	OBL		1			0	1
Typha sp.	Cattail	OBL			0			
Echinochloa walteri	Coastal cockspur	FACW			2*			
Phragmites australis	Common reed	OBL						4**
Urochloa ramosa	Dixie Signalgrass							3–4**
Polygonum punctatum	Dotted smartweed	OBL			1	3	2	2–3
Panicum dichotomiflorum	Fall panic grass	FACW			2*			
Thalia geniculata	Fire-flag	OBL			0	1	1	1
Setaria magna	Giant foxtail	OBL		1		0		
Sesbania herbacea	Hemp Sesbania	FAC					1	1
Panicum hemitomon	Maidencane	OBL		2				
Kosteletzkya virginica	Saltmarsh mallow	OBL	1					
Spartina bakeri	Sand cordgrass	FACW	2–4		5	3	4	2
Cladium jamaicense	Saw grass	OBL	1	3				
Polygonum densiflorum	Smartweed	OBL						2
Scirpus validus	Softstem bulrush	OBL		1				1
Hibiscus grandiflorus	Swamp hibiscus	OBL	4	5	1–2	2		

Table 22—*Continued*

Scientific Name	Common Name	FUWDM Code[1]	Plant Community Species Cover Estimates[2]					
			WP #1	SM #1	WP #2	SM #2	WP #3	SM #3
Paspalum repens	Water paspalum	OBL		1				
Myrica cerifera	Wax myrtle-dead	FAC	2					

[1]FWDM Code Indicator categories established in Florida Wetlands Delineation Manual (Gilbert et al.1995)
Upland (UPL) = Plants that occur rarely in wetlands, but occur almost always in uplands
Facultative (FAC) = Plants with similar likelihood of occurring in both wetlands and uplands
Facultative Wet (FACW) = Plants that typically exhibit their maximum cover in areas subject to surface water flooding and/or soil saturation, but may also occur in uplands
Obligate (OBL) = Plants that are found or achieve their greatest abundance in an area which is subject to surface water flooding and/or soil saturation; rarely uplands

[2] Plant Community Species Cover Estimates: Aerial extent of vegetation species along transect within given community where 0 = <1% (rare); 1 = 1–10% (scattered); 2 = 11–25% (numerous); 3 = 26–50% (abundant); 4 = 51–75% (co–dominant); and 5 = greater than 75% (dominant)

* Coastal cockspur and fall panic grass were a (2) only at stations -150 to -100

** Phragmites (4) and Urochloa ramosa (3) only between stations 3250 to 3300

WP #1 = wet prairie #1 (stations -4030 to -2150)
SM #1 = shallow marsh #1 (stations -2150 to -900)
WP #2 = wet prairie #2 (stations -900 to 800)
SM #2 = shallow marsh #2 (stations 800 to 1100)
WP #3 = wet prairie #3 (stations 1100 to 1400)
SM #3 = shallow marsh #3 (stations 1400 to 4850)

Table 23. M-6 Transect soil descriptions

Station/Series	Vegetation Community	Soil Horizon	Horizon Description
-4030/Chobee	Wet prairie #1	Oa 0–2.5”	Black muck
		A 2.5–5”	Black mucky loamy sand
		Cg1 5–15”	Black fine sandy clay
		Cg2 15–29”+	Dark gray silty clay
-3850/Chobee	Wet prairie #1	Oa 0–2”	Black muck
		A 2–3”	Black mucky loamy sand
		Cg1 3–17”	Black fine sandy clay
		Cg2 17–29”+	Dark gray silty clay
-3550/Unknown cumulic argiaquoll	Wet prairie #1	Oa 0–5”	Black muck
		A 5–6”	Black mucky loam
		Cg1 6–39”	Black sandy clay loam
		Cg2 39–45”+	Dark gray with gray fine sandy clay
-3150/Unknown cumulic argiaquoll	Wet prairie #1	Oa 0–4.5”	Black muck
		A 4.5–5.5”	Black mucky loam
		Cg1 5.5–13”	Black loam
		Cg2 13–25”	Black silty clay
		Cg3 25–45”	Black sandy clay loam
		Cg4 45”+	Black clay
-2850/Chobee	Wet prairie #1	Oa 0–4”	Black muck
		A 4–5”	Black mucky loam
		Cg1 5–9”	Black loam
		Cg2 9–20”	Black silty clay
		Cg3 20–24”+	Dark gray silty clay
-2550/Chobee	Wet prairie #1	Oa 0–4”	Black muck
		A 4–4.5”	Black mucky loam
		Cg1 4.5–8”	Black clay loam
		Cg2 8–21”	Black silty clay
		Cg3 21–25”+	Dark gray silty clay
-2000/Chobee	Shallow marsh #1	Oa 0–3”	Black muck
		A 3–4”	Black mucky sand
		Cg1 4–8”	Black sandy loam
		Cg2 8–15”+	Black silty clay
-1800/Chobee	Shallow marsh #1	Oa 0–3”	Black muck
		A 3–4”	Black mucky sand
		Cg1 4–7”	Black sandy loam
		Cg2 7–15”+	Black silty clay

Table 23—*Continued*

Station/Series	Vegetation Community	Soil Horizon	Horizon Description
-1600/Chobee	Shallow marsh #1	Oa 0–3.5”	Black muck
		A 3.5–4”	Black mucky sand
		Cg1 4–7”	Black sandy loam
		Cg2 7–15”+	Black silty clay
-1250/Chobee	Shallow marsh #1	Oa 0–3.5”	Black muck
		A 3.5–4.5”	Black mucky sand
		Cg1 4.5–9”	Black sandy loam
		Cg2 9–15”+	Black silty clay
-1100/Chobee	Shallow marsh #1	Oa 0–6”	Black muck
		A 6–7”	Black mucky sand
		Cg1 7–14”	Black sandy loam
		Cg2 14–17”+	Black silty clay
-950/Chobee	Shallow marsh #1	Oa 0–5.5”	Black muck
		A 5.5–6.5”	Black mucky sand
		Cg1 6.5–12”	Black sandy loam
		Cg2 12–17”+	Black silty clay
-850/Chobee	Wet prairie #2	Oa 0–2”	Black muck
		A1 2–3”	Black mucky sandy loam
		A2 3–5”	Black sandy loam
		Cg1 5–21”	Black silty clay
		Cg2 21–25”+	Dark gray silty clay
-500/Chobee	Wet prairie #2	Oa 0–0.5”	Black muck
		A1 0.5–1”	Black mucky loam
		A2 1–3.5”	Black sandy loam
		Cg1 3.5–13”	Black fine sandy clay
		Cg2 13–16”+	Dark gray silty clay
-300/Chobee	Wet prairie #2	Oa 0–0.1”	Black muck
		A 0.1–4”	Black sandy loam
		Cg1 4–19”	Black sandy clay
		Cg2 19–23”+	Dark gray silty clay
50/Chobee	Wet prairie #2	Oa 0–0.5”	Black muck
		A 0.5–1”	Black mucky sand
		Cg1 1–6”	Black loam
		Cg2 6–16”+	Black silty clay
200/Chobee	Wet prairie #2	Oa 0–2”	Black muck
		A 2–3”	Black mucky sand
		Cg1 3–5.5”	Black sandy loam
		Cg2 5.5–16”+	Black silty clay

Table 23—*Continued*

Station/Series	Vegetation Community	Soil Horizon	Horizon Description
400/Chobee	Wet prairie #2	Oa 0–1”	Black muck
		A 1–2”	Black mucky sand
		Cg1 2–5.5”	Black sandy loam
		Cg2 5.5–25”	Black silty clay
		Cg3 25–30”+	Dark gray silty clay
600/Chobee	Wet prairie #2	Oa 0–2”	Black muck
		A 2–2.5”	Black mucky sand
		Cg1 2.5–6”	Black sandy loam
		Cg2 6–16”+	Black silty clay
900/Chobee	Shallow marsh #2	Oa 0–2”	Black muck
		A 2–3”	Black mucky sand
		Cg1 3–7”	Black sandy loam.
		Cg2 7–16”+	Black silty clay.
1100/Chobee	Shallow marsh #2	Oa 0–2”	Black muck
		A 2–2.5”	Black mucky sand
		Cg1 2.5–7”	Black sandy loam
		Cg2 7–15”+	Black silty clay
1300/Unknown cumulic argiaquoll	Wet prairie #3	Oa 0–2”	Black muck
		A 2–2.5”	Black mucky sand
		Cg1 2.5–8”	Black sandy loam
		Cg2 8–30”+	Black silty clay
1700/Chobee	Shallow marsh #3	Oa 0–0.5”	Black muck
		A 0.5–1”	Black mucky sand
		Cg1 1–7”	Black sandy loam
		Cg2 7–20”+	Black silty clay
1900/Chobee	Shallow marsh #3	Oa 0–3.5”	Black muck
		A 3.5–4.5”	Black mucky sand
		Cg1 4.5–12”	Black loam
		Cg2 12–18”+	Black silty clay
2200/Chobee	Shallow marsh #3	Oa 0–2”	Black muck
		A 2–3”	Black mucky sand
		Cg1 3–7”	Black loam
		Cg2 7–12”+	Black silty clay
2400/Unknown cumulic argiaquoll	Shallow marsh #3	Oa 0–2”	Black muck
		A 2–6.5”	Black mucky sand
		Cg1 6.5–18”	Black loam
		Cg2 18–33”	Black silty clay
		Cg3 33–44”	Black sandy loam
		Cg4 44–48”+	Dark gray and gray sand

Table 23—*Continued*

Station/Series	Vegetation Community	Soil Horizon	Horizon Description
2550/Chobee	Shallow marsh #3	Oa 0–1”	Black muck
		A 1–1.5”	Black mucky sand
		Cg1 1.5–5”	Black loam
		Cg2 5”+	Black silty clay
2750/Unknown cumulic argiaquoll	Shallow marsh #3	Oa 0–4”	Black muck
		A 4–5.5”	Black mucky sand
		Cg1 5.5–10”	Black loam
		Cg2 10–24”	Black clay loam
		Oab 24–34”	Black muck
		OabCg 34–41”	Black muck and dark gray sand
		Cg 41”+	Dark gray and gray sand
3000/Chobee	Shallow marsh #3	Oa 0–2”	Black muck
		A 2–3”	Black mucky sand
		Cg1 3–8.5”	Black loam
		Cg2 8.5–14”+	Black clay loam
3450/Chobee	Shallow marsh #3	Oa 0–4.5”	Black muck
		A 4.5–5.5”	Black mucky sand
		Cg1 5.5–7”	Black loam
		Cg2 7–11”	Black clay loam
		Cg3 11–18”+	Black silty clay
3700/Chobee	Shallow marsh #3	Oa 0–2.5”	Black muck
		A 2.5–3”	Black mucky sand
		Cg1 3–5”	Black loam
		Cg2 5–10”	Black clay loam
		Cg3 10–15”	Black loam
		Cg4 15–23”+	Black silty clay
3900/Chobee	Shallow marsh #3	Oa 0–2”	Black muck
		A 2–2.5”	Black mucky sand
		Cg1 2.5–23”	Black loam
		Cg2 23–27”+	Black silty clay
4100/Unknown cumulic argiaquoll	Shallow marsh #3	Oa 0–5”	Black muck
		A 5–6”	Black mucky sand
		Cg1 6–28”	Black loam
		Cg2 28–46”	Black clay loam
		Cg3 46–70”	Black loam
		Cg4 70–76”+	Black silty clay

Table 23—*Continued*

Station/Series	Vegetation Community	Soil Horizon	Horizon Description
4450/Unknown cumulic argiaquoll	Shallow marsh #3	Oa 0–4.5”	Black muck
		A 4.5–5.5”	Black mucky sand
		Cg 5.5–24”	Black loam
		Oab 24–44”	Black muck
		Cg 44–48”+	Black sandy loam
4650/Unknown cumulic argiaquoll	Shallow marsh #3	Oa 0–3”	Black muck
		A 3–3.5”	Black mucky sand
		Cg 3.5–20”	Black loam
		Ab 20–31”	Black mucky sand
		Eg 31–34”	Light brownish gray and gray sand
		Cg1 34–39”	Black sandy clay loam
		Cg2 39–41”+	Black sandy loam
4800/Chobee	Shallow marsh #3	Oa 0–2.5”	Black muck
		A 2.5–3.5”	Black mucky sand
		Cg1 3.5–6”	Black sandy loam
		Cg2 6–9”	Black clay loam
		Cg3 9–16”+	Black silty clay

series at each soil station. Additionally, one or more hydric soil indicators (muck, mucky mineral, and/or umbric surface) were observed at all sampled stations.

As mentioned previously, fluvial and other hydrologic processes constantly modify the soils throughout the St. Johns River floodplain. Sediment accretion frequently occurs during flood activities, creating transitory features within the soils, especially those closest to the stream channels (Lindbo and Richardson 2001). When the river rises and inundates the floodplain, erosional and depositional processes combine to deposit coarse sediments at the edge of the floodplain (nearest the channel) and finer-textured material throughout the floodplain. Consequently, sediments found in the St. Johns River floodplain can be comprised of depositional material transported from upstream, depositional material derived locally from channel erosion, and parent material that has been reworked from centuries of flood events. Numerous relatively thin soil horizons can occur from frequent deposition of alluvial sediments and often result in accretion topography. As a result, soil features such as texture and color can vary greatly over a short distance (D. Segal, pers. comm., 2004). In the St. Johns River floodplain, fine-textured material may occur near the soil surface in one place and at a depth of as much as 48 in. below the soil surface at a nearby location (Leighty et al. 1957).

The history of erosional and depositional processes in the St. Johns River floodplain gives rise to a complex distribution of soils across the floodplain. Lateral and horizontal changes in sediment deposition result in soil series with a large degree of variability (Lindbo and Richardson 2001). This combination makes the identification of soil series difficult due to the high variability of soil features found across the M-6 Transect. Often soil features found at a given site will not conform to the characteristics of any particular soil series (Segal, pers. comm. 2004). Because the soils descriptions resulted in many discrepancies with the official soil series descriptions, Wade Hurt, hydric soil scientist with the USDA, NRCS, in Gainesville, Florida, was consulted to help identify the correct soil series that most closely represented the described soils.

The soil series and the soil taxonomic classification subgroup are briefly described below for each soil station sampled at the M-6 Transect. The soil taxonomic classification subgroup provides additional information for each soil series (JEA 2004; Appendix C).

Chobee soil was the predominant soil, identified at 28 of the 36 soil sampling locations along the M-6 Transect (Table 23). The only other soil type identified at the M-6 Transect was an unknown soil in the Cumulic Argiaquoll subgroup, observed at eight locations. The two soil types were separated according to the thickness of the mollic epipedon. Chobee soils contained a mollic epipedon with a thickness of less than 30 in., whereas the unknown Cumulic Argiaquoll soil contained a mollic epipedon with a thickness of at least 30 in. Otherwise, the soils were similar with respect to horizon designation, horizon colors, horizon thicknesses and horizon textures (JEA 2004; Appendix C).

As mentioned previously, the Chobee series typically consists of very deep, very poorly drained, slowly to very slowly permeable sandy loam soils in depressions, flats, and occasionally on river floodplains in the lower coastal plain (NRCS 2003). The Chobee soil water table is within 6 in. of the soil surface for one to four months during most years. Depressional areas are ponded for long durations in most years (NRCS 2003). According to the *Soil Survey of Brevard County, Florida* (USDA, SCS

1974), the Chobee soil water table occurs within a depth of 10 in. of the soil surface for six to nine months and within 10 to 40 in. below the soil surface for three to six months in most years. In very dry seasons, the Chobee soil water table occurs at a depth of greater than 40 in. below the soil surface for short periods. Chobee soil is continuously flooded for one to six months in many places (USDA, SCS 1974).

The taxonomic classification subgroup for Chobee soil is a Typic Argiaquoll, meaning it is a mollisol in the aquic moisture regime, containing an argillic horizon and the argillic horizon occurs within 20 in. of the soil surface. The presence of a mollic epipedon is indicative of the high concentrations of organic matter that develops and persists in flooded soils (JEA 2004; Appendix C).

The unknown series Cumulic Argiaquoll taxonomic classification subgroup indicates the soil is also a Mollisol, in the aquic moisture regime with an argillic horizon. The thick argillic horizon signifies a cumulic adjective. There are no soil series classified as cumulic argiaquoll located in the hyperthermic temperature regime, therefore no series name was determined. The St. Johns River floodplain near SR 50 occurs within the hyperthermic temperature regime (JEA 2004; Appendix C).

The soils sampled along the M-6 Transect were surprisingly consistent in regard to horizon designations, texture, color, and thickness compared to the soil samples along the other field transects near SR 50. The soil characteristic that separated the two soil types was thickness of the mollic epipedon. The surface muck horizon remained thin throughout the transect; the A-horizon was typically mucky sand, but also included mucky loamy sand or mucky loam at the beginning of the transect, and the argillic horizon was shallow throughout the transect and generally began within the upper 6 in. of the soil.

As noted with the other field transects near SR 50, the soils sampled along the M-6 Transect are strongly affected by river flooding as well as subsurface drainage from the surrounding uplands. These soils formed and persist in very wet conditions. All soils sampled along the M-6 Transect are very poorly drained as suggested by their low floodplain position and high accumulation of organic material. Again, the mollic epipedon exhibited by all soils sampled at the M-6 Transect is indicative of the high concentration of organic matter that has developed and persists in these very poorly drained conditions (JEA 2004; Appendix C).

Minimum Levels at Lake Cone, St. Johns River Mile 206

Minimum Frequent-High Level for the St. Johns River at Lake Cone (7.6 ft NGVD)

The minimum frequent-high level determined for the St. Johns River at Lake Cone equals 7.6 ft NGVD. This level corresponds to a typical seasonally flooded river stage. During extended periods of normal or above normal rainfall, the minimum frequent-high level is expected to occur on average for several weeks to several months approximately once every 2 years (Chapter 40C-8.021(15), *F.A.C.)*.

This recommended minimum frequent-high level equals the average elevation of the hardwood swamp between stations 220 and 1600, traversed at the Lake Cone Transect (Figure 14). This level will ensure that the majority of the hardwood swamp is inundated at least every 1 to 2 years for a period of several weeks to several months. Monk (1968) described mixed hardwood swamps as being dominated primarily by broad-leaved deciduous species and as occurring along creeks, rivers, sloughs, and basins that are flooded seasonally.

Figure 14 illustrates the topography at the Lake Cone Transect. Note that between stations 220 and 1600 (the water ward portion of the hardwood swamp) the topography resembles a natural river berm. To ensure inundation of the landward, lower section of the hardwood swamp between stations 1600 and 2700, the recommended minimum frequent-high level must provide surface water across the average land surface elevation of the water ward portion of the hardwood swamp. Within the water ward portion of the hardwood swamp, the transect traversed lower elevation sloughs (historic logging skidder trails), which would allow surface water inundation of the landward portion of the hardwood swamp (stations 1600–2700), when the river stage equals or exceeds the average land surface elevation of the water ward hardwood swamp. Additionally, a vegetation change was noted within the hardwood swamp where cabbage palm and wax myrtle were numerous within the higher water ward section (stations 220–1600) and nonexistent between stations 1600–2700 where the elevation decreased. This lower landward portion of hardwood swamp is likely ponded for longer durations than the water ward hardwood swamp due to water becoming trapped within the landward hardwood swamp after the river recedes, along with more upland seepage occurring downslope from the palm hydric hammocks.

Additionally, the recommended minimum frequent-high level will ensure inundation of the lower hardwood swamp (stations 30–220), all wet prairies, and shallow marshes traversed at the Lake Cone and M-6 transects. As mentioned previously, wet prairies in Florida are the least frequently flooded (50–150 days / year; Kushlan, 1990) marsh type. The type of vegetation present in wet prairies varies depending upon hydroperiod, soils and site history. Table 24 lists the inundation depth provided by the recommended minimum frequent-high level in the floodplain vegetation communities at the M-6 and Lake Cone transects.

Further validation of the mean elevation of the hardwood swamp from stations 220 to 1600 as the primary minimum frequent-high level criterion at Lake Cone is provided by a comparison of the wet prairies average inundation depths at the recommended minimum frequent-high level at the Lake Cone and M-6 transects (equal to 0.6, 0.8, and 1.0 ft; Table 24). These average inundation depths are similar to the wet prairies average inundation depths at Hatbill Park (0.7, 1.1, 1.3, 1.5, and 1.5 ft), Tosohatchee North (2.1 ft), the Great Outdoors (1.3 and 1.4 ft) and TOSO-528 (0.8 ft) when the river equals the minimum frequent-high level at these locations.

The aquatic faunal habitat is greatly expanded when the St. Johns River inundates the extensive shallow marshes, wet prairies, and secondary channels at the Lake Cone and M-6 transects at the recommended minimum frequent-high level. As mentioned previously, interactions with the adjacent marshes, wet prairies, and forested swamps by connecting the channel to the floodplain are extremely important to animal productivity in lower coastal plain rivers (Bain, 1990; Poff, et al. 1997). When the floodplains are flooded, many fish migrate from the main channel to the inundated areas for spawning and feeding. These migrations are more lateral, perpendicular to river flow, than upriver or down river (Guillory 1979). As the river continues to rise, the amount of vegetative structure available to aquatic organisms increases greatly as large areas of the floodplain are inundated (Light, et al. 1998).

Table 24. Inundation depths at the minimum frequent-high level at Lake Cone

Vegetation Community	Transect Name	Range of Inundation (ft)	Average Inundation (ft)
Hardwood swamp (stations 220–1600)	Cone	0–0.8	saturated
Entire Hardwood swamp (220–2700)	Cone	0–1.2	0.2
Lower hardwood swamp	Cone	0.8–2.1	1.5
Slough	Cone	2.1–4.0	3.1
Cypress strand	Cone	0.7–2.4	1.2
Aquatic bed	Cone	3.0–4.6	3.8
Lake bottom	Cone	4.6–6.9	5.8
Wet prairie	Cone	0.4–2.1	1.0
Wet prairie #1	M-6	0.2–1.1	0.6
Wet prairie #2	M-6	0.4–1.2	0.8
Shallow marsh	Cone	2.1–3.0	2.5
Shallow marsh #1	M-6	0.8–1.6	1.2
Shallow marsh #2	M-6	1.2–1.6	1.4
Shallow marsh #3	M-6	0.5–3.6	2.0

Additionally, river water quality may improve significantly as water flows through the floodplain. The floodplains with vast marshes and wet prairies function as an important filter and sink for dissolved and suspended constituents (Wharton et al. 1982).

Minimum Average Level for the St. Johns River at Lake Cone (5.8 ft NGVD)

The recommended minimum average level for the St. Johns River at Lake Cone is 5.8 ft NGVD. The minimum average level approximates a typical river stage that is slightly less than the long-term median stage while still protecting the wetland resources. At the minimum average level substrates may be exposed during nonflooding periods of typical years, but the substrate remains saturated. The minimum average level corresponds to a water level that is expected to occur on average every year or two for about six months during the dry season.

The recommended minimum average level equals the average ground surface elevation of all the shallow marshes traversed at the Lake Cone and M-6 transects (Figures 14 and 16; Tables 18 and 21). This level will result in saturated or inundated soil conditions over the majority of the shallow marsh stations surveyed at the Lake Cone and M-6 transects. Saturated soil conditions will prevent long-term encroachment of upland plant species into the shallow marshes.

Soils in shallow marshes 1 through 3 at the M-6 Transect were predominately Chobee series. An unknown cumulic argiaquoll was also observed at five locations in shallow marsh #3. The shallow marsh at Lake Cone was such a narrow community (30 ft along the transect) that a soil sample was not taken. However, immediately upslope and adjacent to the Lake Cone shallow marsh in the wet prairie the soil type was also Chobee. Both Chobee and the unknown cumulic argiaquoll soil series are very poorly drained mollisols. The soil characteristic that separated the two soil types was thickness of the mollic epipedon (JEA 2004; Appendix C). As mentioned previously, the presence of a mollic epipedon is indicative of the high concentrations of organic matter that develops and persists in flooded soils. According to the *Soil Survey of Brevard County, Florida* (USDA, SCS 1974), Chobee soil in most years has a water table that occurs within a depth of 10 in. below the soil surface for six to nine months and is continuously flooded for one to six months in many places. Consequently, soil saturation and shallow ponding at the lower elevations within the shallow marshes traversed at the M-6 and Lake Cone transects at the recommended minimum average level typify annual dry season conditions in these depressional shallow marsh communities.

Also, the mineral soil water table depths, predicted to occur in the wet prairies and hardwood swamps at the Lake Cone and M-6 transects when the St. Johns River equals the recommended minimum average level, are within reported dry season levels (NRCS 2003).

Additionally, the recommended minimum average level for the St. Johns River at Lake Cone will ensure shallow inundation of the secondary channels and open water areas traversed at the M-6 and Lake Cone transects. Table 25 lists average water depths provided by the minimum average level in the open water areas, channels, and marshes traversed at M-6 and Lake Cone transects.

Shallow ponding within the marshes and open water areas traversed at the M-6 and Lake Cone transects will provide aquatic refugia for numerous small fish, amphibians, and small reptiles. Aquatic habitats, such as the open water areas traversed at the M-6 and Lake Cone transects, connected to the main river channels are of crucial importance

Table 25. Water depths at the M-6 and Lake Cone transects at the minimum average level equal to 5.8 ft NGVD

Open water descriptions	Average Inundation (ft)	Range of Inundation (ft)
Open water at 10 locations—M-6	2.5	0–4.2
Aquatic bed—Lake Cone	2.0	1.2–2.8
West channel—M-6	4.6	1.6–6.8
East channel—M-6	4.9	1.8–6.7
Shallow marsh #1—M-6	saturated	–
Shallow marsh #2—M-6	saturated	–
Shallow marsh #3—M-6	0.2	0–1.8
Shallow marsh—Lake Cone	0.8	0.3–1.2
Slough—Lake Cone	1.3	0.3–2.2

ft NGVD = feet National Geodetic Vertical Datum

to fishes and invertebrates of the floodplain. Connected habitats provide shallow, quiet waters in floodplain streams as refugia from the deep, swiftly flowing waters of the main channel (Light, et al. 1998).

At the recommended minimum average level shallow ponding in the shallow marshes also provides ideal foraging habitat for wading birds at the M-6 and Lake Cone transects. Wading birds can only forage in relatively shallow water. Great Egrets need water depths of less than 10 in. and the small herons need depths of less than 6 in. Dropping water levels cause fish to be concentrated in isolated sloughs throughout the shallow marshes. Birds effectively exploit these concentrations (Bancroft, et al. 1990).

Minimum Frequent-Low Level for the St. Johns River at Lake Cone (4.1 ft NGVD)

The minimum frequent-low level determined for the St. Johns River at Lake Cone equals 4.1 ft NGVD. This level represents a low river stage that generally occurs only during mild drought. The minimum frequent-low level is predicted to occur on average, approximately once every 5 years for the duration of several months. This level typically results in dewatered wetlands. This dewatering is a natural consequence of drought and has ecological benefits. Drawdown conditions enable seeds of emergent wetland plants to germinate from the seed banks of the floodplain. Seeds of many wetland plant species require exposed soils in order to germinate (Van der Valk 1981). Exposing the floodplain for suitable durations maintains the composition of emergent plant species and increases plant diversity.

The recommended minimum frequent-low level for the St. Johns River at Lake Cone equals a soil water table drawdown of 20 in. below the combined average soil surface elevations of the shallow marshes traversed at the M-6 Transect. As mentioned previously, the shallow marsh soils were predominately Chobee series. An unknown cumulic argiaquoll was also observed at five locations in shallow marsh #3 at the M-6 Transect. Both Chobee and the unknown cumulic argiaquoll soil are mollisols. The soil characteristic that separates the two soil types is the thickness of the mollic epipedon (JEA 2004; Appendix C).

The primary minimum frequent-low level criterion, a 20-in. soil water table drawdown from the average soil surface elevation of the shallow marshes, is based upon the NRCS (2003) and the *Soil Survey of Brevard County, Florida* (USDA, SCS 1974) descriptions of typical Chobee soil water table levels during moderate droughts. As mentioned previously, Chobee soil is classified as very poorly drained and contains a mollic epipedon indicative of high accumulations of organic matter, which persists in inundated soils. According to the NRCS (2003), the Chobee soil water table typically occurs within 6 in. below the soil surface for one to four months during most years in the rainy season. Depressional areas with Chobee soil are ponded for long duration in most years. According to the *Soil Survey of Brevard County, Florida* (USDA, SCS 1974), in most years the Chobee water table occurs within a depth of 10 in. below the soil surface for six to nine months and within a depth of 10 to 40 in. below the soil surface for three to six months. In very dry seasons, the water table occurs at a depth of greater than 40 in. below the soil surface for short periods. Chobee soil is continuously flooded for one to six months in many places (USDA, SCS 1974). Consequently, because the shallow marshes traversed at the M-6 Transect are geographically located within a large depressional area at the lower-vegetated elevations in the floodplain and are closely associated with the multiple river channels, a 20-in. average soil water table drawdown in the shallow marshes is considered reasonable, based upon the best available information, for an event which is predicted to reoccur once every 5 years for 60 continuous days (Robison 2006).

Chobee soil observed upslope in the wet prairies at the M-6 and Lake Cone transects will experience average soil water table drawdowns of between 30 and 35 in. when the river stage equals the minimum frequent-low level. These predicted average soil water table declines are also within the soil water table drawdown range described in the *Soil Survey of Brevard County, Florida* (1974). Soil series observed farther upslope in the hardwood swamp at the Lake Cone Transect would experience an average soil water table drawdown equal to 40 in. Chobee series was the predominate soil observed within the hardwood swamp at the Lake Cone Transect. Denaud and Bradenton series soils, classified as very poorly drained and poorly drained, respectively, were also observed in the hardwood swamp. Denaud soil typically occurs where slight topographic gradients result in seepage, and therefore nearly continually saturated conditions. Bradenton series soil was sampled near the landward extent of the hardwood swamp at stations 2300 and 2600. Bradenton soil contains an argillic horizon that occurs within 20 in. of the soil surface. The argillic horizon is a hardpan layer that impedes vertical water movement and can cause surface saturation during high rainfall events. Bradenton soil is also classified as endosaturated, meaning it derives its moisture primarily internally from groundwater (JEA 2004; Appendix C). Thus groundwater seepage and local rainfall likely maintains the hydric soil characteristics of the Chobee, Denaud, and Bradenton soils observed at the higher elevations in the hardwood swamp traversed at the Lake Cone Transect.

Additional considerations regarding the 20-in. soil water table drawdown and ultimately soil moisture include the soil's capillary fringe. A capillary fringe of varying thickness exists above the soil water table. In the capillary fringe zone the soil is nearly water-saturated; the water is adsorbed to soil particles to a greater degree in the capillary fringe zone than below the water table. The capillary fringe zone contains various amounts of water depending upon the pore size and the height in the soil above the water table (Richardson et al, 2001). A sandy clay loam such as Chobee soil, with an average porosity of 0.005 cm should have a saturated zone extending at least 12 in. (30 cm) above the soil water table (Mausbach 1992). Consequently, soil moisture may be available to the marsh vegetation at depths considerably closer to the soil surface than that predicted from the 20-in. soil water table drawdown criterion.

Also, according to Kushlan (1990), sand substrates, as observed in the wet prairies and shallow marshes at the Lake Cone and M-6 transects, occur in marshes with short hydroperiods and significant drying of the soil during the dry season. The marked seasonality of Florida's rainfall and evaporation plays an important role in the functioning of marsh ecosystems by creating a seasonal fluctuation in surface water. This seasonal fluctuation is most pronounced in southern Florida because it experiences less winter rainfall than occurs farther north. Water levels rise during the summer rainy season, gradually decline during the winter, and annually reach drought conditions as evapotranspiration increases in the spring. In most years, standing water is absent from southern Florida marshes at the height of the dry season, a condition that may last from several weeks to several months. Most marshes flood during each rainy season, but some may flood only in very wet years. Annual variation in rainfall may cause substantial differences in the depth and extent of flooding in various years at a single marsh site (Kushlan 1990).

Last, at the recommended minimum frequent-low level of 4.1 ft NGVD, shallow ponding would occur at the lower elevations in shallow marsh #3, as well as within the open water areas traversed at the M-6 Transect. Deeper water would occur in the river channel traversed at the M-6 Transect (Table 26).

Table 26. Water depths at the M-6 Transect at the minimum frequent-low level

Open Water Descriptions	Average Inundation (ft)	Range of Inundation (ft)
Open water at 10 locations	0.9	0–2.6
West channel	3.0	0–5.2
East channel	3.3	0.2–5.1
Shallow marsh #3	–	0–0.2

St. Johns River at Tosohatchee North Transect

The Tosohatchee North Transect was located approximately three river miles upstream (south) from SR 50, at river mile 212, primarily on the west floodplain of the St. Johns River (Table 27).

Table 27. Tosohatchee North Transect location information

Transect Name and River Mile	Latitude–Longitude (Beginning Station	Latitude–Longitude (End Station)	Location and Date of Fieldwork
Toso North RM 212	28 31 30.16; 80 55 01.74 (Station -1480)	28 30 40.34; 80 55 54.67 (Station 7050)	West and southwest from the east side of the east most river channel to the palm hydric hammock on the Tosohatchee State Reserve; April–June and December 2003

Field Data for Tosohatchee North Transect

This transect was located primarily on the Tosohatchee State Reserve on the west floodplain of the St. Johns River approximately three river mile upstream from SR 50 and approximately three river miles downstream from the Great Outdoors Transect.

Transect Selection Criteria Tosohatchee North Transect

The primary criteria for selecting this transect location included the following:

- Relatively unique area due to the hardwood swamp (Figure 7)
- Located on public land (Tosohatchee State Reserve), preventing future development and facilitating access for long-term ecological monitoring
- Close proximity to the SR 50 long-term gauging station
- Extensive shallow marsh, hardwood swamp, wet prairie and palm hydric hammock

Vegetation at Tosohatchee North Transect

The transect traversed in a south and southwesterly direction for 8540 ft beginning at station -1480, which is approximately 1080 ft east of the east edge of the main river channel. From station -1480 to -400 the Tosohatchee Transect traversed a shallow marsh and two secondary river channels. The main river channel was traversed between stations -400 and 0. From stations 0 to 50, the ground was not vegetated. Next, the transect traversed a wet prairie (stations 50 to 2000), a transitional lower hardwood swamp (stations 2000 to 2800), a hardwood swamp (stations 2800 to 4250), an upper wet prairie (stations 4250 to 6310), and terminated in a palm hydric hammock (stations 6310 to 7060) (Figures 18 and 19; Tables 28 and 29).

The shallow marsh vegetation (stations 1480 to 400) included abundant fire-flag; numerous dotted smartweed, water paspalum, American cupscale, and water hyacinth; and scattered pickerelweed, horsetail (*Equisetum hyemale*) and red ludwigia (*Ludwigia repens*).

The wet prairie (stations 50 to 2000) vegetation included abundant to co-dominant sand cordgrass; abundant mock bishop’s weed and swamp hibiscus; numerous stiff-marsh bedstraw, buttonbush, dotted smartweed, bull arrowhead, and butterweed; and scattered to numerous red ludwigia.

Landward of the wet prairie, the transect traversed a transitional lower hardwood swamp community (stations 2000–2800). The transitional lower hardwood swamp vegetation included: abundant buttonbush, maidencane, immature bald cypress, stiff marsh bedstraw, and mock bishop’s weed; numerous red maple, beakrush (*Rhynchospora corniculata*), pickerelweed, and butterweed; and scattered bull arrowhead, dotted smartweed, fireweed, false nettle (*Boehmeria cylindrical*), ladies sorrel (*Oxalis corniculata*), beaked panicum, shield fern (*Thelypteris interrupta*), coinwort, marsh pennywort, red ludwigia, wood sage (*Teucrium canadense*), swamp hibiscus, St. John’s wort (*Hypericum mutilum*), and water pimpernel (*Samolus parviflorus*).

Figure 18. Tosohatchee North Transect topography with ecological communities

*At the Tosohatchee North Transect the Minimum Frequent High (MFH) equals 8.8 ft. NGVD, the Minimum Average (MA) equals 6.2 ft. NGVD, and the Minimum Frequent Low (MFL) equals 4.5 ft. NGVD

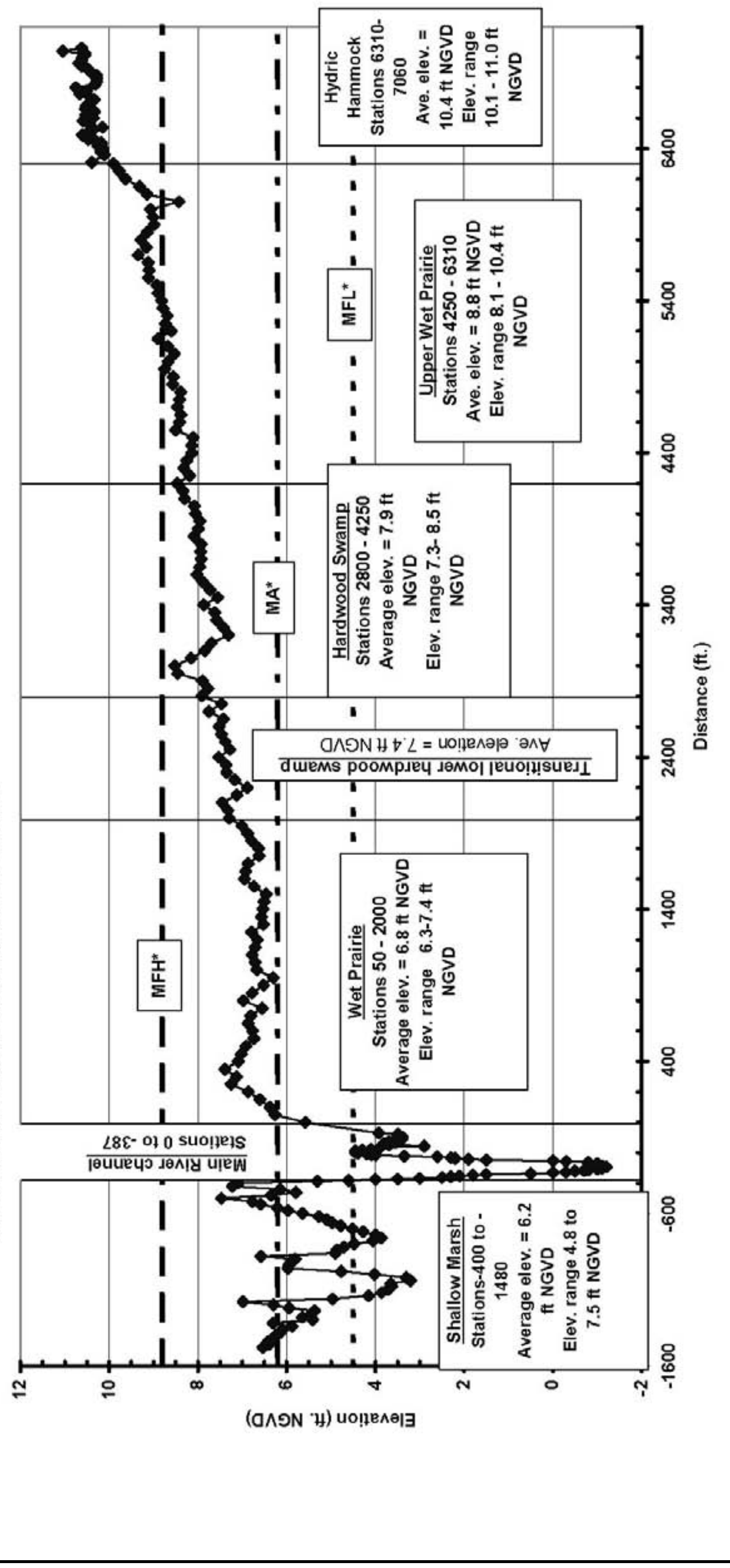


Figure 19. Tosohatchee North Transect photos

Figure 19. Tosohatchee North Transect photos—*continued*

Figure 19. Tosohatchee North Transect photos—*continued*

Figure 19. Tosohatchee North Transect photos—*continued*

Table 28. Tosohatchee North Transect vegetation community statistics

Vegetation Community	Stations Distance (ft)	Mean (ft NGVD)	Median (ft NGVD)	Min (ft NGVD)	Max (ft NGVD)	N
Shallow marsh; excluding open water areas	-1480 to -1200 -960 to -880 -580 to -400	6.2	6.2	4.8	7.5	31
Open water/sub-channels	-600 to -860 -980 to -1180	4.7 4.2	4.8 3.9	3.9 3.2	5.6 7.0	14 11
River channel	-400 to 0	2.2	2.8	-1.2	7.1	56
Wet prairie	50–2000	6.8	6.8	6.3	7.4	40
Transitional lower hardwood swamp	2000–2800	7.4	7.4	6.9	7.9	17
Hardwood swamp	2800–4250	7.9	7.9	7.3	8.5	30
Hardwood swamp and upper wet prairie	2800–6310	8.5	8.4	7.3	10.4	72
Upper wet prairie	4250–6310	8.8	8.8	8.1	10.4	43
Palm hydric hammock	6310–7060	10.4	10.4	10.1	11.0	42

ft NGVD = feet National Geodetic Vertical Datum

Table 29. Tosohatchee North Transect vegetation species list

Common Name	Scientific Name	FWDM Code[1]	Plant Community Species Cover Estimates[2]					
			SM	WP	TLHS	HS	UWP	PHH
Alligator weed	*Alternanthera philoxeroides*	OBL	3	1		0	1	
American cupscale	Sacciolepis striata	OBL	2					0
American Elm	Ulmus americana	FACW				0		
Bald Cypress	Taxodium distichum	OBL			3	3		
Barnyard grass	Echinochloa crusgalli	FACW				0		
Beaked panicum	Panicum anceps	FAC				1	0	1
Beakrush	Rhynchospora corniculata	OBL			2	1	1	
Beakrush	Rhynchospora microcarpa	FACW						1
Beggar-ticks	*Bidens mitis*	FAC				0		
Blackberry	Rubus betulifolius	FAC						0
Blue hyssop	Bacopa caroliniana	OBL					0	
Broomsedge	Andropogon virginicus	FACW						0
Bugleweed	Lycopos rubellus	OBL						0
Bull arrowhead	Saggitaria lancifolia	OBL		1–2	1	1	1	
Butterweed	Senecio glabellus	OBL		2	2	1	0	
Buttonbush	Cephalanthus occidentalis	OBL		1–3	3	3	0	
Buttonweed	*Diodia virginiana*	FACW						0
Cabbage Palm	Sabal palmetto	FAC				1		2–3
Coast cockspur grass	Echinochloa walteri	FACW		0		0–1	0	
Coinwort	*Centella asiatica*	FACW		1	1	0		1
Columbia waxweed	Cuphea carthagenensis	FAC		0–1			0	1
Cypress witchgrass	*Dicanthelium dichotomum*	FACW						1
Dog fennel	Eupatorium capillifolium	FAC			0		0	0
Dotted smartweed	Polygonum punctatum	OBL	2	2–3	1	1	1	0
Dwarf St. John's wort	Hypericum mutilum	FACW			1	1	0	1
Fall panic grass	Panicum dichotomiflorum	FACW				0	0	1
False nettle	Boehmeria cylindrica	OBL			1	0		
Fireweed	Erechtites hieracifolia	FAC		0	1	1		0
Flat sedge	*Cyperus virens*	FACW					1	
Fringe–rush	Fimbristylis castanea	OBL						0
Frog's bit	Limnobium spongia	OBL			1			
Frog–fruit	Phyla nodiflora	FAC		0		0	0	0–1
Giant bulrush	Scirpus validus	OBL		0				
Grassy arrowhead	Sagittaria graminea	OBL			1	0		

Table 29—*Continued*

Common Name	Scientific Name	FWDM Code[1]	Plant Community Species Cover Estimates[2]					
			SM	WP	TLHS	HS	UWP	PHH
Greenbrier	Smilax bona–nox	UPL						0
Groundsel tree	Baccharis glomerulifolia	FACW					0	1
Harsh verbena	Verbena scabra	FACW						0
Hemp sesbania	Sesbania herbacea	FAC	0–1					
Herb-of-grace	Bacopa monnieri	OBL						0
Hop sedge	Carex lupulina	OBL				1		
Horned beakrush	Rhynchospora inundata	OBL						2
Horsetail	Equisetum hyemale	FACW	1					
Knotroot foxtail	Setaria geniculata	FAC						1
Ladies' sorrel	Oxalis corniculata	FAC			1	0		
Lizard's tail	Saururus cernuus	OBL				1		1
Maidencane	Panicum hemitomon	OBL		1	3	2	1	1
Marsh fern	Thelypteris palustris	FACW				1		
Marsh fleabane	Pluchea rosea	FACW		0–2			0	0
Marsh pennywort	Hydrocotyle umbellata	FACW		0–1	1	0		0
Marsh pink	Sabattia grandiflora	FACW					0	0
Mermaid weed	Proserpinaca palustris	OBL				0		
Mistflower	Eupatorium coelestrinum	FAC						3
Mock bishop's weed	Ptilimnium capillaceum	FACW		2–3	3	0	0	
Muscadine grape	Vitis rotundifolia	FAC						0
Paspalum grass	Paspalum sp.	FAC						0
Pepper vine	Ampelopsis arborea	UPL			1	1		0
Persimmon saplings	Diospyros virgiana	FAC						1
Pickerelweed	Pontedaria cordata	OBL	1	0–1	2	1	1	
Poison ivy	*Toxicodendron radicans*	FAC				1		1
Pop ash	*Fraxinus caroliniana*	OBL				0–1		
Rabbit-foot grass	Polypogon monspeliensis	FAC		1				
Ragweed	Ambrosia artemisifolia	FAC				0		
Red ludwigia	Ludwigia repens	OBL	1	1–2	1	0	1	0
Red maple	Acer rubrum	FACW		0	2	2–3		0
Royal fern	Osmunda regalis	OBL				0		
Rush	*Juncus validus*	OBL					0	
Rush	*Juncus sp.*	OBL	0–1					
Saltmarsh finger-grass	Eustachys glauca	UPL						1

Table 29—*Continued*

Common Name	Scientific Name	FWDM Code[1]	Plant Community Species Cover Estimates[2]					
			SM	WP	TLHS	HS	UWP	PHH
Saltmarsh mallow	*Kosteletzkya virginica*	OBL					1	1
Sand cordgrass	Spartina bakeri	FACW		3–4			5	1
Sand live oak	*Quercus geminata*	UPL						1
Sand vetch	Vicia acutifolia	FACW					1	
Saw grass	Cladium jamaicense	OBL			0	0		
Sheathed flatsedge	Cyperus haspan	OBL		0		1	1	
Shield fern	Thelypteris interrupta	FACW			1	1		
Shoestring fern	Vittaria lineata	FAC						0
Shore rush	*Juncus marginatus var. marginatus*	FACW					1	
Southern blue flag	Iris virginica	OBL				0		1
Southern red cedar	Juniperus silicicola	FAC						1
Southern tickseed	Coreopsis gladiata	FACW						0
Spikerush	Eliocharis sp.	OBL		0–1	0	1	1	
Stiff–haired bedstraw	*Galium tinctorium*	FACW		2	3	0	0	
Swamp bay	Persea palustrus	OBL						0
Swamp dock	Rumex verticiallatus	FACW		0–1				
Swamp hibiscus	*Hibiscus grandiflorus*	OBL		1–3	1	2	3	
Sword-leaf panic grass	*Panicum ensifolium*	OBL					1	
Taper-tip rush	Juncus acuminatus	OBL		0			0	
Variable panic grass	Panicum commutatum	FAC				1		
Water hyacinth	Eichhornia crassipes	OBL	2					
Water-hyssop	Bacopa sp.	OBL		0–1				
Water locust	Gleditsia aquatica	OBL				0–1		
Water paspalum	Paspalum repens	OBL	2					
Water pimpernel	Samolus parviflorus	OBL		1	1	0	0	
Wax myrtle	Myrica cerifera	FAC			0	0	2	2
White-topped sedge	Dichromena colorata	FACW					1	0

Table 29—*Continued*

Common Name	Scientific Name	FWDM Code[1]	Plant Community Species Cover Estimates[2]					
			SM	WP	TLHS	HS	UWP	PHH
Winged loosestrife	Lythrum alatum	OBL					0	
Wood sage	*Teucrium canadense*	FACW			1	2	0	3

[1]FWDM Code Indicator categories established in Florida Wetlands Delineation Manual (Gilbert et al.1995)

Upland (UPL) = Plants that occur rarely in wetlands, but occur almost always in uplands
Facultative (FAC) = Plants with similar likelihood of occurring in both wetlands and uplands
Facultative Wet (FACW) = Plants that typically exhibit their maximum cover in areas subject to surface water flooding and/or soil saturation, but may also occur in uplands
Obligate (OBL) = Plants that are found or achieve their greatest abundance in an area which is subject to surface water flooding and/or soil saturation; rarely uplands

[2] Plant Community Species Cover Estimates: Aerial extent of vegetation species along transect within given community where 0 = <1% (rare); 1 = 1–10% (scattered); 2 = 11–25% (numerous); 3 = 26–50% (abundant); 4 = 51–75% (co–dominant); and 5 = greater than 75% (dominant)

Vegetation community abbreviations:
SM = Shallow marsh (station -1480 to -400)
WP = Wet prairie (station 50 to 2000)
TLHS = Transitional lower hardwood swamp (2000 to 2800)
HS = Hardwood swamp (station 2800 to 4250)
UWP = Upper Wet prairie (station 4250 to 6310)
PHH = Palm hydric hammock (station 6310 to 7060)

Landward of the transitional lower hardwood swamp, the transect traversed a hardwood swamp (stations 2800–4250). The hardwood swamp overstory vegetation included abundant bald cypress; numerous to abundant red maple; scattered cabbage palm; rare to scattered water locust and pop ash. The hardwood swamp mid-canopy vegetation included abundant buttonbush. The hardwood swamp understory vegetation included abundant maidencane; numerous swamp hibiscus and wood sage; and scattered spikerush, shield fern, pickerelweed, lizard’s tail, and dotted smartweed.

Upslope and west of the hardwood swamp, the transect traversed an upper wet prairie (stations 4250–6310). The upper wet prairie vegetation included dominant sand cordgrass; abundant swamp hibiscus; numerous wax myrtle; and scattered alligator weed, beakrush, bull arrowhead, dotted smartweed, flat sedge, maidencane, pickerelweed, red ludwigia, and saltmarsh mallow.

The Tosohatchee North Transect terminated within a palm hydric hammock (stations 6310–7060) adjacent to the upper wet prairie. The palm hydric hammock overstory vegetation included abundant cabbage palm with scattered sand live oak and scattered southern red cedar. The palm hydric hammock mid-canopy vegetation included numerous wax myrtle and scattered groundsel tree. The palm hydric hammock understory vegetation included abundant wood sage and mistflower; numerous horned beakrush; and scattered southern blue flag, lizard’s tail, maidencane, knotroot foxtail, saltmarsh mallow, sand cordgrass, coinwort, Columbia waxweed, and fall panic grass.

Additional plant species observed along the Tosohatchee North Transect are listed in Table 29.

Soils at Tosohatchee North Transect

Soil auger holes were dug at 36 selected stations to characterize the soils along the Tosohatchee North Transect between stations 1360 and 7000 on June 9, 2003, and January 12, 2004 (Table 30). Soils were characterized in the field based upon epipedons, horizons, soil texture, soil color and horizon depth. These soil features were used to determine the soil series at each soil station. One or more hydric soil indicators (histic epipedon, muck, mucky mineral, umbric surface, dark surface, and/or stripped matrix) were observed at all sampled stations.

Table 30. Tosohatchee North Transect soil descriptions

Station/ Series	Vegetation Community	Soil Horizon	Horizon Description
-1360/Chobee variant	Shallow marsh	Oa 0–0.1”	Black muck
		A 0.1–0.5”	Black mucky sandy loam
		C 0.5–3”	Black sandy loam
		Cg1 3–9”	Black silty clay
		Cg2 9–17”	Black sandy clay loam
		Cg3 17–22”	Very dark gray, gray and light gray sand; stripping present
		Cg4 22–28”	Very dark gray sandy clay
		Cg5 28–42”	Dark grayish brown sand
		Cg6 42–58”+	White sand
-1280/Chobee	Shallow marsh	Oa 0–3”	Black muck
		A 3–3.5”	Black mucky loam
		Cg1 3.5–10”	Black silty clay
		Cg2 10–21”+	Black sandy clay loam
-940/Chobee	Shallow marsh	Oa 0–2.5”	Black muck
		A 2.5–3”	Black mucky loam
		Cg 3–13”+	Black silty clay
-900/Chobee	Shallow marsh	Oa 0–1.5”	Black muck
		A 1.5–2.5”	Black mucky loam
		Cg1 2.5–7”	Black loam
		Cg2 7–13”+	Black sandy clay loam
-540/Chobee	Shallow marsh	Oa 0–2”	Black muck
		A 2–2.5”	Black mucky loam
		Cg1 2.5–6”	Black loam
		Cg2 6–13”+	Black silty clay
-460/Chobee	Shallow marsh	Oa 0–3”	Black muck
		A 3–3.5”	Black mucky loam
		Cg1 3.5–8”	Black loam
		Cg2 8–23”+	Black silty clay
100/Chobee	Wet prairie	Oa 0–6”	Black muck
		A 6–18”	Black sandy loam
		Cg_1 18–35”	Very dark gray sandy clay loam with few, fine, faint dark brownish yellow redoxomorphic concentrations
		Cg_2 35–48”+	Very dark gray sandy clay loam with many, moderate, distinct yellow and yellowish brown redoxomorphic concentrations and many, large, faint gray redoxomorphic depletions; presence of shell fragments at 48”
300/Chobee	Wet prairie	Oa 0–6.5”	Black muck
		A 6.5–9”	Black loamy sand
		C 9–28”+	Black sandy clay loam; increase of sand and presence of shell fragments at 28”

Table 30—*Continued*

Station/ Series	Vegetation Community	Soil Horizon	Horizon Description
600/Denaud	Wet prairie	Oa 0–8”	Black muck
		C_1 8–17”	Black sandy loam
		C_2 17–26”+	Black sandy clay loam
900/Denaud	Wet prairie	Oe 0–6”	Hemic
		Oa 6–15”	Black muck
		C_1 15–29”	Black loamy sand
		C_2 29–43”	Black sandy loam
		C_3 43–47”+	Black sandy clay loam
1200/Denaud	Wet prairie	Oa_1 0–7”	Very dark brown muck
		Oa_2 7–12”	Black muck
		C_1 12–35”	Black sandy loam
		C_2 35–42”+	Very dark gray sandy clay loam
1500/Denaud	Wet prairie	Oa_1 0–3”	Very dark brown muck
		Oa_2 3–12”	Black muck
		C_1 12–17”	Black sandy loam
		C_2 17–41”	Black sandy loam
		C_3 41–45”+	Black sandy clay loam
1800/Denaud	Wet prairie	Oa_1 0–5”	Very dark brown muck
		Oa_2 5–12”	Black muck
		C_1 12–28”	Black sandy loam
		C_2 28–45”	Black loamy sand
		C_3 45–48”+	Black sandy clay loam
1960/Denaud	Wet prairie	Oa_1 0–8”	Black muck
		C_1 8–34”	Black sandy loam
		C_2 34–42”+	Black sandy clay loam
2200/Chobee	Transitional lower hardwood swamp	Oa_1 0–2”	Black muck
		C_1 2–16”+	Black sandy clay loam
2500/Denaud	Transitional lower hardwood swamp	Oa_1 0–8”	Black muck
		C_1 8–34”	Black sandy loam
		C_2 34–42”+	Black sandy clay loam
2700/Manatee	Transitional lower hardwood swamp	Oa_1 0–6”	Black muck
		C_1 6–19”	Black sandy loam
		C_2 19–22”+	Black sandy clay loam
2900/Denaud	Hardwood swamp	Oa_1 0–2”	Very dark brown muck
		Oa_2 2–9”	Black muck
		C 9–16”+	Black sandy clay loam
3100/Chobee	Hardwood swamp	Oa_1 0–2”	Very dark brown muck
		Oa_2 2–7”	Black muck
		C 7–16”+	Black sandy clay loam
3400/Denaud	Hardwood swamp	Oa_1 0–5”	Very dark brown muck
		Oa_2 5–9”	Black muck
		C 9–16”+	Black sandy clay loam

Table 30—*Continued*

Station/ Series	Vegetation Community	Soil Horizon	Horizon Description
3500/Denaud	Hardwood swamp	Oa_1 0–6”	Very dark brown muck
		Oa_2 6–9”	Black muck
		C 9–16”+	Black sandy clay loam
3800/Chobee	Hardwood swamp	Oa_1 0–5”	Very dark brown muck
		Oa_2 5–6.5”	Black muck
		C 6.5–16”+	Black sandy clay loam
4100/Denaud	Hardwood swamp	Oa_1 0–5”	Very dark brown muck
		Oa_2 5–8”	Black muck
		C 8–16”+	Black sandy clay loam
4300/Chobee	Upper wet prairie	Oa 0–6”	Black muck
		C 6–16”+	Black sandy clay loam
4500/Chobee	Upper wet prairie	Oa 0–7”	Black muck
		C_1 7–9”	Black sandy loam
		C_2 9–16”+	Black sandy clay loam
4600/Chobee	Upper wet prairie	Oa 0–5”	Black muck
		C_1 5–7”	Black sandy loam
		C_2 7–30”	Black sandy clay loam
		C_3 30–48”+	Black sandy clay loam with many fine, distinct dark brownish yellow redoxomorphic concentrations
4900/Manatee	Upper wet prairie	Oa 0–6”	Black muck
		A 6–8.5”	Black mucky mineral
		C 8.5–15”+	Black sandy loam
5300/Manatee	Upper wet prairie	Oa 0–6”	Black muck
		C 6–16”+	Black sandy loam
5600/Manatee	Upper wet prairie	Oa 0–5”	Black muck
		A 5–7”	Black mucky mineral
		C 7–16”+	Black sandy loam
6000/Chobee	Upper wet prairie	Oa 0–7”	Black muck
		C 7–16”+	Black sandy clay loam
6200/Unknown cumulic argiaquoll	Upper wet prairie	Oa_1 0–1”	Very dark brown muck
		Oa_2 1–3.5”	Black muck
		A 3.5–4.5”	Black mucky mineral
		C_1 4.5–18”	Black sandy loam
		C_2 18–24”	Black loamy sand loam
		C_3 24–32”	Black sandy loam with many, moderate, distinct dark brownish yellow redoxomorphic concentrations
		Cg 32–38”+	Black sandy clay loam with many moderate, distinct dark brownish yellow redoxomorphic concentrations

Table 30—*Continued*

Station/ Series	Vegetation Community	Soil Horizon	Horizon Description
6240/Eaton	Upper wet prairie	Oa 0–5”	Black muck
		A_1 5–7”	Black mucky mineral
		Aeg 7–17”	Very dark gray, dark gray, and light brownish gray sand; stripping present
		Eg_1 17–23”	Dark gray and gray sand
		Eg_2 23–27”	Dark gray and gray sand with many, fine, distinct brownish yellow redoxomorphic conc.
		Cg 27–34”+	Very dark gray and dark gray sandy clay loam with many, moderate, distinct brownish yellow redoxomorphic concentrations
6360/Eaton	Palm hydric hammock	Oa 0–0.1”	Black muck
		A_1 0.1–0.5”	Black mucky mineral
		A_2 0.5–9”	Black sand
		Aeg 9–18”	Very dark gray, dark gray, and light brownish gray sand; stripping present
		Eg_1 18–22”	Dark gray and gray sand
		Eg_2 22–28”	Grayish brown and gray sand with few, fine, faint yellow redoxomorphic concentrations
		Cg 28–41”+	Very dark gray and dark gray sandy clay loam with many, moderate, distinct brownish yellow redoxomorphic concentrations
6440/Eaton	Palm hydric hammock	A_1 0–1”	Black mucky mineral
		A_2 1–9”	Black sand
		Aeg 9–18”	Very dark gray, dark gray, and light brownish gray sand; stripping present
		Eg 18–32”	Grayish brown and gray sand with few, fine, faint yellow redoxomorphic concentrations
		Cg 32–35”+	Very dark gray and dark gray sandy clay loam with many moderate, distinct brownish yellow redoxomorphic concentrations
6700/Holopaw	Palm hydric hammock	Oa 0–2”	Black muck
		A_1 2–6”	Black mucky mineral
		A_2 6–8”	Black sand
		Aeg 8–32”	Very dark gray, dark gray, and light brownish gray sand; stripping present
		Eg 32–48”	Dark gray and gray sand
		Cg 48”+	Dark gray sandy clay loam

Table 30—*Continued*

Station/ Series	Vegetation Community	Soil Horizon	Horizon Description
7000/Holopaw	Palm hyrdric hammock	Oa 0–0.1”	Very dark brown muck
		A_1 0.1–4”	Very dark gray sand faint stripping at 5.5”
		A_2 4–8”	Black with yellowish brown sand
		A_3 8–12”	Black and yellowish brown sand
		Eg_1 12–27”	Dark gray and gray sand
		Eg_2 27–42”	Gray sand with few, fine, distinct brownish yellow redoxomorphic concentrations
		Cg 42–60”+	Dark gray sandy clay loam

As mentioned previously, fluvial and other hydrologic processes constantly modify the soils throughout the St. Johns River floodplain. Sediment accretion frequently occurs during flood activities, creating transitory features within the soils, especially those closest to the stream channels (Lindbo and Richardson 2001). When the river rises and inundates the floodplain, erosional and depositional processes combine to deposit coarse sediments at the edge of the floodplain (nearest the channel) and finer-textured material throughout the floodplain. Consequently, sediments found in the St. Johns River floodplain can be comprised of depositional material transported from upstream, depositional material derived locally from channel erosion, and parent material that has been reworked from centuries of flood events. Numerous relatively thin soil horizons can occur from frequent deposition of alluvial sediments and often result in accretion topography. As a result, soil features such as texture and color can vary greatly over a short distance (D. Segal, pers. comm. 2004). In the St. Johns River floodplain, fine-textured material may occur near the soil surface in one place and at a depth of as much as 48 in. below the soil surface at a nearby location (Leighty et al. 1957).

The history of erosional and depositional processes in the St. Johns River floodplain gives rise to a complex distribution of soils across the floodplain. Lateral and horizontal changes in sediment deposition result in soil series with a large degree of variability (Lindbo and Richardson 2001). This combination makes the identification of soil series difficult due to the high variability of soil features found across the Tosohatchee North Transect. Often soil features found at a given site will not conform to the characteristics of any particular soil series (Segal, pers. comm. 2004). Since the soils description process resulted in many discrepancies with the official soil series descriptions, Wade Hurt, hydric soil scientist with the USDA, NRCS, in Gainesville, Florida, was consulted to help identify the soil series that most closely represented the described soils.

The soil series and the soil taxonomic classification subgroup are briefly described below for each soil station sampled at the Tosohatchee North Transect. The soil taxonomic classification subgroup provides additional information for each soil series (JEA 2004; Appendix C).

Soils at the Tosohatchee North Transect were divided into two general categories, the lower floodplain soils and the upper floodplain soils. The lower floodplain soils extended across the shallow marsh, the wet prairie, the transitional lower hardwood swamp, the hardwood swamp, and the upper wet prairie (stations -1500 to 6200). The upper floodplain soils occurred at the higher elevations from stations 6240 to 7060, which included the highest elevations of the upper wet prairie and the entire palm hydric hammock. The lower and upper floodplain soils were categorized based upon soil drainage classification and surface accumulation of organic material (JEA 2004; Appendix C). Following is a description of soils in these two categories.

Chobee, Denaud, Manatee, and an unknown cumulic argiaquoll soil series were observed in the lower floodplain at the Tosohatchee North transect. Chobee soil was observed at the lowest elevations beginning in the shallow marsh and into the wet prairie (Table 30). Chobee was the only soil series sampled within the shallow marsh at the Tosohatchee North Transect. As mentioned previously, Chobee soil typically consists of very deep, very poorly drained, slowly to very slowly permeable loamy fine sands in depressions, flats, and occasionally on river floodplains (NRCS 2003). According to the NRCS (2003), the Chobee soil water table occurs within a depth of 6 in. below the soil surface for one to four months during most years. Depressional areas are ponded for long durations in most areas. According to the *Soil Survey of Brevard County, Florida* (USDA, SCS 1974), the Chobee soil water table in most years occurs within a depth of 10 in. below the soil surface for six to nine months and within a depth of 10 to 40 in. below the soil surface for three to six months. In very dry seasons, the water table occurs at a depth greater than 40 in. below the soil surface for short periods.

Chobee soil is continuously flooded for one to six months in many places (USDA, SCS 1974).

The taxonomic classification subgroup for Chobee soil is a Typic Argiaquoll, meaning it is a mollisol in the aquic moisture regime, containing an argillic horizon and the argillic horizon occurs within 20 in. of the soil surface. The presence of a mollic epipedon is indicative of the high concentrations of organic matter that develops and persists in flooded soils (JEA 2004; Appendix C).

While Chobee soils occurred at the lowest elevations in the wet prairie, the wet prairie soils were primarily Denaud series (Table 30). Denaud soils consist of deep, very poorly drained, moderately permeable soils with a thin organic layer over sandy and loamy material. Denaud soils formed in sandy and loamy marine deposits and are ponded for six to nine months in most years. These soils are saturated to the surface the rest of the time during most years (NRCS 2003). The taxonomic classification subgroup for Denaud soil is a Histic Humaquept. A Histic Humaquept is an Inceptisol meaning it is a somewhat young soil and has minimal horizon development, but somewhat more development than the youngest Entisols. Denaud soil is in the aquic moisture regime, has distinct organic material at the surface, and has a histic epipedon. A histic epipedon contains 8 to 16 in. of organic material. Denaud is the only soil sampled at the Tosohatchee North Transect with a histic epipedon (JEA 2004; Appendix C).

Chobee, Denaud, and Manatee soils were each observed within the transitional lower hardwood swamp (Table 30). In the hardwood swamp, Denaud and Chobee soils were observed. Denaud and Chobee soils are very similar, with the distinguishing characteristic being the depth of the surface organic horizon. Denaud soils have a histic epipedon (surface organic horizon 8–16 in., in thickness) while Chobee soils have a surface organic horizon between 0–7 in., in thickness. Additionally, Chobee and Manatee soils are very similar, differing in soil texture within the upper 20 in. of the argillic horizon. Manatee soils have a greater sand content in the argillic horizon. The origin of the sand could be from original parent material rather than alluvial deposition, and/or erosional sand (JEA 2004; Appendix C).

Manatee soil consists of very deep, very poorly drained, moderately permeable loamy fine sands, which are located in depressions, broad drainage ways, and on floodplains. The Manatee soil water table occurs within 10 in. of the soil surface for more than six months annually during most years. Depressional areas are ponded for about six to nine months during most years (NRCS 2003). The taxonomic classification subgroup for Manatee soil is a Typic Argiaquoll, meaning it is a mollisol in the aquic moisture regime, containing an argillic horizon and the argillic horizon occurs within 20 in. of the soil surface. Again, the presence of a mollic epipedon is indicative of the high concentrations of organic matter that develops and persists in flooded soils (JEA 2004; Appendix C).

Adjacent and upslope from the hardwood swamp within the upper wet prairie the soils were identified at four sampling stations as Chobee. Manatee soil was also identified at four sampling stations within the upper wet prairie while an unknown Cumulic Argiaquool and an Eaton soil were each identified at one sampling station in the upper wet prairie (Table 30). The unknown soil series with a taxonomic classification subgroup of Cumulic Argiaquoll is a Mollisol, in the aquic moisture regime with an argillic horizon. The thick argillic horizon signifies a cumulic adjective. There are no soil series classified as cumulic argiaquoll located in the hyperthermic temperature regime, therefore no series name was determined. The St. Johns River floodplain near SR 50 occurs within the hyperthermic temperature regime (JEA 2004; Appendix C).

The soil characteristics that separated the soil types in the lower floodplain (shallow marsh, wet prairie, transitional lower hardwood swamp, hardwood swamp, and upper wet prairie to station 6200) were thickness of organic horizon, thickness of the mollic epipedon, and texture of the argillic horizon. All soils described in the lower floodplain share characteristics that are indicative of frequently flooded and reduced soil conditions. The similarities include very poorly drained classification, aquic moisture regime, and high accumulation of organic matter (JEA 2004; Appendix C).

The upper floodplain soils designation beginning at station 6240 was based upon the presence of Eaton soil at this location. The Eaton soil first occurred at station 6240 in the upper wet prairie, near the upper wet prairie–palm hydric hammock ecotone. Eaton soil was also identified at two stations in the palm hydric hammock (Figure 18 and Table 30). Eaton soil consists of poorly and very poorly drained loamy sands. Eaton soils formed in clayey marine sediments. The Eaton soil water table occurs at depths of less than 10 in. below the soil surface for periods of one to four months during most years. Depressional areas are ponded for very long periods (NRCS 2003). The taxonomic classification subgroup for Eaton soil is an Arenic Albaqualf. Eaton is an Alfisol, meaning it has an argillic horizon that is high in base saturation. It is poorly drained and in the aquic moisture regime, contains light-colored albic subsurface horizon(s) and the arenic adjective implies that the argillic horizon occurs between 20 and 40 in. below the soil surface (JEA 2004; Appendix C).

The Tosohatchee North Transect terminated within the palm hydric hammock (stations 6310–7060) where Eaton and Holopaw soils were sampled (Table 30). This short segment of the Tosohatchee North Transect was also categorized as the upper floodplain with regard to the soils (JEA 2004; Appendix C). The upper floodplain soils lack a sufficient accumulation of surface organic matter to meet the mollic epipedon requirement and, therefore, were not classified as Mollisols. Sand is more prevalent throughout the profile in the upper floodplain soils. The absence of surface organic matter content and the increase in sand content is reflected in a slightly improved drainage classification where the upper floodplain soils are poorly drained rather than very poorly drained (JEA 2004; Appendix C).

Again, Eaton and Holopaw soils were identified in the palm hydric hammock traversed at the Tosohatchee North Transect (Table 30). Eaton soil differs from Holopaw soil by the depth of the argillic horizon. In Eaton soil, the argillic horizon occurs at a depth of between 20 and 40 in. below the soil surface. The argillic horizon in Holopaw soil occurs at a depth greater than 40 in. below the soil surface. The Holopaw series consists of deep and very deep, poorly and very poorly drained soils, which are formed in sandy marine sediments. The Holopaw soil water table occurs within 12 in. of the soil surface for two to six months during most years. Depressional areas are ponded for more than six months during most years (NRCS 2003).

The taxonomic classification subgroup for Eaton soil (Arenic Albaqualf) is previously described in this section. Holopaw is classified as a Grossarenic Endoaqualf, meaning it is an Alfisol with an argillic horizon that is high in base saturation and with an aquic moisture regime. The term endo implies that Holopaw soils are endosaturated, such that water is frequently derived from groundwater rather than surface water. The Grossarenic adjective implies that the argillic horizon occurs greater than 40 in. below the soil surface (JEA 2004; Appendix C).

Similar to the other field transects along the St. Johns River near SR 50, the floodplain soils at the Tosohatchee North Transect are closely associated with the river channels and thus river hydrology. These soils were formed and persist in very wet conditions. The reduced soil conditions result in the accumulation of organic matter, which is manifested as a mollic or histic epipedon. Soils in the lower floodplain are very poorly drained and strongly influenced by river flooding as well as groundwater seepage. Drainage conditions improved with increased elevation in the upper floodplain / palm hydric hammock. Consequently, soils in the upper floodplain are considered more stable, under less influence of alluvial forces, and contain greater horizon development (JEA 2004; Appendix C).

Minimum Levels at Tosohatchee North Transect, St. Johns River Mile 212

Minimum Frequent-High Level at Tosohatchee North (8.8 ft NGVD)

The recommended minimum frequent-high level for the St. Johns River at the Tosohatchee North Transect is 8.8 ft NGVD. This level corresponds to a typical seasonally flooded river stage. During extended periods of normal or above normal rainfall, the minimum frequent-high level is expected to occur, on average, for several weeks to several months approximately once every 2 years (Chapter 40C-8.021(15), *F.A.C.*).

This recommended minimum frequent-high level equals the average elevation of the upper wet prairie community (stations 4250–6310; Table 28 and Figure 18) traversed at the Tosohatchee North Transect. This level will ensure inundation of the shallow marsh, wet prairie, the transitional lower hardwood swamp, the hardwood swamp, and the lower elevations of the upper wet prairie. The topography at the Tosohatchee North Transect, gradually increases in elevation from the west edge of the main river channel to the transect termination in the palm hydric hammock (Figure 18). The hardwood swamp traversed at the Tosohatchee North Transect divides the wet prairie from the upper wet prairie (Figures 2 and 7). Additionally, at the Tosohatchee North

Transect the hardwood swamp hydrology is influenced by Jim Creek, providing wetter conditions within the hardwood swamp. Sheetflow flowing north from Jim Creek inundates the hardwood swamp at the Tosohatchee North Transect as noted on July 30, 2003, when the summer rains had begun but the St. Johns River stage was considerably below the land surface elevations surveyed within the hardwood swamp (mean hardwood swamp land surface elevation equal to 7.9 ft NGVD).

As mentioned previously, of Florida marsh types, wet prairies are the least frequently flooded (50–150 days / year; Kushlan 1990). The type of vegetation present in wet prairies varies depending upon hydroperiod, soils, and site history. At the Tosohatchee North Transect, the average land surface elevation of the upper wet prairie equaled the 20% exceedence on the interpolated stage duration curve (Figure 13) for the St. Johns River at the Tosohatchee North Transect. Consequently, taking into account the stage data and the literature references describing the wide range in variation of hydroperiods for wet prairies in Florida, the average land surface elevation of the upper wet prairie traversed at the Tosohatchee North Transect became the primary minimum frequent-high level criterion. Additionally, the vegetation community immediately upslope from the upper wet prairie was the hydric palm hammock which occurred at a much higher elevation.

Due to the short hydroperiods experienced by wet prairies, this community type is the most species rich of Florida's marshes, containing a variety of grasses, sedges, and flowering forbs. Wet prairie species have considerable tolerance to both flooding and drying. Higher wet prairies may, under some conditions, be invaded by saw palmetto. Environmental characteristics of wet prairies include a hydroperiod shorter than six months, a low accumulation of organic matter, and a fire frequency of more than one per decade (Kushlan 1990).

The upper wet prairie and wet prairie traversed at the Tosohatchee North Transect were prescribe-burned in February 2001 and, again, in 2005. These wet prairie communities are typically burned every 5 years (Charlie Mathews, Tosohatchee State Reserve Park Manager, pers. comm. 2003). The vegetation composition of the upper wet prairie (stations 4250–6310) and wet prairie (stations 50–2000) at the Tosohatchee North Transect is nearly identical, primarily because fire management within the upper wet prairie eliminated the woody shrubs. Concurrently, longer periods of surface water inundation from the St.

Johns River and Jim Creek within the water ward wet prairie (stations 50–2000) reduce the encroachment of woody shrubs. Consideration of the role of fire and other disturbances (i.e. hurricane wind impacts, cattle grazing) is necessary in interpreting relationships between vegetation communities and hydrologic conditions. Cattle grazing does occur along the Tosohatchee North Transect because cattle on the east floodplain venture onto the Tosohatchee State Reserve property.

Table 31 lists the inundation depths provided by the recommended minimum frequent-high level in the floodplain vegetation communities traversed at the Tosohatchee North Transect.

The recommended minimum frequent-high level will also result in inundation of the Denaud soils observed scattered between stations 600 and 4100 within the wet prairie, the transitional lower hardwood swamp, and the hardwood swamp. The Denaud soils were the only soils identified at the Tosohatchee North Transect containing a histic epipedon. As mentioned previously, the histic epipedon is a shallow (8 to <16 in. thick) surface organic horizon, a hydric soil indicator, and an indicator of frequent long-term inundation and/or soil saturation.

Table 31. Inundation depths at the minimum frequent-high level at the Tosohatchee North Transect

Vegetation Community	Range of Inundation (ft)	Average Inundation (ft)
Shallow marsh	1.3–4.0	2.6
Sub-channel (-1180 to -980)	1.8–5.6	4.6
Sub-channel (-860 to -600)	4.0–4.7	4.1
River channel	1.7–10.0	6.6
Wet Prairie	1.4–2.5	2.0
Transitional lower hardwood swamp	0.9–1.9	1.4
Hardwood swamp	0.3–1.5	0.9
Upper wet prairie	0–0.7	saturated

The aquatic faunal habitat is greatly expanded when the St. Johns River inundates the extensive shallow marsh, wet prairies, secondary channels, and the hardwood swamp at the Tosohatchee North Transect at the recommended minimum frequent-high level. As mentioned previously, interactions with the adjacent marshes, wet prairies, and hardwood swamp by connecting the channel to the floodplain are extremely important to animal productivity in lower coastal plain rivers (Bain 1990; Poff, et al. 1997). When the floodplains are flooded, many fish migrate from the main channel to the inundated areas for spawning and feeding. These migrations occur more laterally, perpendicular to river flow, than upriver or down river (Guillory 1979). As the river continues to rise, the amount of vegetative structure available to aquatic organisms increases greatly as large areas of the floodplain are inundated (Light, et al. 1998).

River water quality may improve significantly as water flows through the floodplain. The floodplains with vast marshes function as an important filter and sink for dissolved and suspended constituents (Wharton et al. 1982).

Additionally, the palm hydric hammock traversed at the Tosohatchee North Transect may have surface water inundation when the St. Johns River reaches an infrequent high level (>10.1 ft NGVD). More frequent surface water ponding will likely occur within this palm hydric hammock due to local rainfall and the poorly drained soil characteristics. Vince et al. (1989) suggest that hydric hammocks low in species diversity, such as the one traversed at the Tosohatchee North Transect and dominated by cabbage palm and live oak, exist where long dry periods are interrupted by occasional episodes of flooding. These hammocks are inundated less often, perhaps only once per decade, due to tropical systems impacting the Upper St. Johns River Basin.

Minimum Average Level for the St. Johns River at the Tosohatchee North Transect (6.2 ft NGVD)

The recommended minimum average level for the St. Johns River at the Tosohatchee North Transect is 6.2 ft NGVD. The minimum average level approximates a typical river stage that is slightly less than the long-term median stage while still protecting the wetland resources. At the minimum average level substrates may be exposed during nonflooding periods of typical years, but the substrate remains saturated. The minimum average level corresponds to a water level that is expected to occur, on average, every year or two for about six months during the dry season.

The recommended minimum average level equals the average ground surface elevation of the shallow marsh traversed at the Tosohatchee North Transect (Figure 18; Table 28). This level will result in saturated or inundated soil conditions over the majority of the shallow marsh stations surveyed at the Tosohatchee North Transect. Saturated soil conditions will inhibit long-term encroachment of upland plant species into the shallow marsh. Chobee soil, as observed across this shallow marsh (Table 30), is classified as a very poorly drained mollisol. As mentioned previously, the presence of a mollic epipedon is indicative of the high concentrations of organic matter that develops and persists in flooded soils. Also, according to the *Soil Survey of Brevard County, Florida* (USDA, SCS 1974), Chobee soil, in most years, has a water table that occurs within a depth of 10 in. below the soil surface for six to nine months and is continuously flooded for one to six months in many places. Consequently, soil saturation and shallow ponding at the lower elevations within the shallow marsh at the recommended minimum average level typify dry season conditions in this depressional shallow marsh community containing Chobee soil. Additionally, the mineral soil water table depths, predicted to occur in the wet prairie, upper wet prairie, and hardwood swamps at the Tosohatchee North Transect when the St. Johns River equals the recommended minimum average level, are well within the reported dry season levels (NRCS 2003).

The recommended minimum average level (6.2 ft NGVD) is very similar to the elevation (6.4 ft NGVD) determined when the 0.3 ft histosol / histic epipedon soil water table drawdown criterion is employed. At the Tosohatchee North Transect a histic epipedon (surface organic soil horizon occurring at depths of between 8 and 16 in. below the soil surface) in the Denaud soils was observed continuously between stations 600 and 1960 within the wet prairie community where the average land surface elevation equaled 6.7 ft NGVD. A histic epipedon was also observed at one location within the transitional lower hardwood swamp and within the hardwood swamp at four of the six soil-sampling locations (Table 30). However, due to the noncontinuous nature of the histic epipedon in the transitional lower hardwood swamp and the hardwood swamp, these swamp elevation points were not used in the soil water table drawdown criterion calculations.

This criterion (0.3 ft below mean surface elevation of histosols or soils with a histic epipedon) has been used to protect organic soils in other MFLs determinations and was developed for Everglade’s peat soils

(Stephens 1974). Studies of marshes in the Upper St. Johns River Basin (Brooks and Lowe 1984; Hall 1987) indicate that this 0.3 ft depth corresponds to a water level exceeded approximately 60% of the time. Studies of the Wekiva River system found this hydrologic condition can also be expressed as the low stage occurring on the average every 1 to 2 years with a duration of less than or equal to 180 days (Hupalo et al. 1994).

The application of the 0.3 ft average water table drawdown in histosols or soils with a histic epipedon in central and north Florida is considered to be reasonable, protective toward the environment, and meets the legislative requirement to use best available information. Long–term monitoring will improve SJRWMD’s knowledge of soil water table drawdowns in relation to fluctuating river levels. For comparison, Stephens (1974) reported that a 0.8 ft average long-term water table drawdown prevented oxidation/subsidence for peat systems in northern Indiana. Indiana wetland systems, which remain frozen during winter months, have much lower oxidation and subsidence rates than similar Florida wetlands.

The 0.3 ft drawdown criterion for histosols or soils with a histic epipedon was not the primary minimum average level criterion for the Tosohatchee North Transect location. The minimum average criterion, equal to the average soil surface elevation of the shallow marsh was applied in order to maintain consistency with the minimum average level determinations for the St. Johns River near Hatbill Park, and at Lake Cone, the Great Outdoors, and the TOSO-528 transects. The Tosohatchee North Transect was the only transect site sampled near SR 50 with soils containing an extensive histic epipedon where the organic soil drawdown criterion could be applied. Additionally, field observation indicated that the hardwood swamps, wet prairie, and shallow marsh traversed at the Tosohatchee North Transect were considerably wetter due to sheetflow from Jim Creek, which parallels a portion of the Tosohatchee North Transect. The additional source of moisture from Jim Creek may account for the presence of a histic epipedon in the wet prairie at the Tosohatchee North Transect.

The recommended minimum average level for the St. Johns River at the Tosohatchee North Transect will also ensure shallow inundation of the open water areas and secondary channels traversed within the shallow marsh. Open water areas within the shallow marsh would have water depths ranging from 0 to 3.0 ft. Shallow ponding within the marsh and open water areas of the Tosohatchee North Transect will provide aquatic refugia for numerous small fish, amphibians, and small reptiles. Aquatic habitats, such as those open water areas traversed at the Tosohatchee North Transect, which are connected to the main river channel, are of crucial importance to fishes and invertebrates of the floodplain. Connected habitats provide shallow, quiet waters in floodplain streams as refugia from the deep, swiftly flowing waters of the main channel (Light, et al. 1998).

Also, at the recommended minimum average level, the shallow water depths in the shallow marsh are ideal for wading bird foraging. Wading birds can only forage in relatively shallow water. Great Egrets need water depths of less than 10 in. and the small herons need depths of less than 6 in. Declining water levels can cause fish to be concentrated in isolated sloughs throughout the shallow marshes. Birds effectively exploit these concentrations (Bancroft, et al. 1990).

Minimum Frequent-Low Level at Tosohatchee North (4.5 ft NGVD)

The minimum frequent-low level determined for the St. Johns River at the Tosohatchee North Transect equals 4.5 ft NGVD. This level represents a low river stage that generally occurs only during mild drought. The minimum frequent-low level is predicted to occur, on average, approximately once every 5 years, for the duration of several months. This level typically results in dewatered wetlands. This dewatering is a natural consequence of drought and has ecological benefits. Drawdown conditions enable seeds of emergent wetland plants to germinate from the seed banks of the floodplain. Seeds of many wetland plant species require exposed soils in order to germinate (Van der Valk 1981). Exposing the floodplain for suitable durations maintains the composition of emergent plant species and increases plant diversity.

The recommended minimum frequent-low level for the St. Johns River at the Tosohatchee North Transect equals a soil water table level of 20 in. below the average soil surface elevation of the shallow marsh traversed at the Tosohatchee North Transect (Table 28). Chobee series soil was identified at all soil sampling stations within the shallow marsh (Table 30). The primary minimum frequent-low level criterion equal to a 20-in. soil water table drawdown below the average soil surface elevation of the shallow marsh is based upon the NRCS (2003) and the

Soil Survey of Brevard County, Florida (USDA, SCS 1974), descriptions of typical Chobee soil water table levels during moderate droughts.

As mentioned previously, Chobee soil is classified as very poorly drained and contains a mollic epipedon indicative of high accumulations of organic matter, which persists in inundated soils. According to the NRCS (2003), the Chobee soil water table typically occurs within 6 in. of the soil surface for one to four months during most years in the rainy season. Depressional areas with Chobee soil are ponded for long durations in most years. According to the *Soil Survey of Brevard County, Florida* (USDA, SCS 1974), in most years the Chobee water table occurs within 10 in. of the soil surface for six to nine months and within 10 to 40 in. of the soil surface for three to six months. In very dry seasons, the water table occurs at depths greater than 40 in. below the soil surface for short periods. Chobee soil is continuously flooded for one to six months in many places (USDA, SCS 1974). Consequently, because the shallow marsh traversing at the Tosohatchee North Transect was geographically located within a large depressional area at the lower vegetated elevations in the floodplain and was closely associated with the multiple river channels, an average soil water table drawdown of 20 in., in the shallow marsh, is considered reasonable and based upon the best available information for an event which is predicted to reoccur once every 5 years for 60 continuous days (Robison 2006).

Upslope within the wet prairie where the Denaud soil was observed (stations 600–1960) at the Tosohatchee North Transect, the average soil water table drawdown would equal 26 in. at the recommended minimum frequent-low level. Denaud is a mineral soil with a histic epipedon (surface organic horizon of 8 to 16 in., in thickness). The 26-in. Denaud soil average water table drawdown is similar to the minimum frequent-low level criterion of a 20-in. average organic soil water table drawdown, which is typically used where extensive histosols (surface organic horizons $\geq$ 16 in., in thickness) or soils with a histic epipedon occur (Hall 2006). The 20-in. average organic soil water table drawdown criterion was based upon the following quotations:
"In Gator muck the water table is at or above the soil surface in spring, summer, and fall and is within 10 in. of the soil surface in winter. In Terra Ceia muck the water table is as much as 2 ft above the soil surface during the rainy season. It is at or above the surface for six to nine months in most years and is seldom below a depth of 10 in. except

during extended dry periods." *(Soil Survey of Volusia County, Florida*, SCS 1980)

"In Tomoka muck, the soil water table is within a depth of 10 in. for nine to 12 months in most years, and water is frequently above the surface. In dry periods, it is between 10 and 30 in. In Monteverde peat, the water table is within a depth of 10 in. for nine to 12 months in most years, and water stands on the surface each year for more than six months. In dry seasons, the water table is lower, but seldom falls below a depth of 30 in." (*Soil Survey of Brevard County, Florida*, USDA, SCS. 1974)

The 26-in. Denaud soil average water table decline is within the organic soils drawdown ranges cited in the Soil Survey of Brevard County and in the South Florida Water Management District Wetland Hydroperiods Study Task 2 Report (Literature Review and Analysis). The Denaud soil is a mineral soil with a histic epipedon. Therefore, it likely exists in slightly drier conditions and experiences more frequent dewatering events as compared to histosols.

As mentioned previously, the Denaud soil occurred continuously at the Tosohatchee North Transect within the wet prairie between stations 600 and 1960. However, at no other transect investigated near SR 50 were histosols or soils with a histic epipedon widespread. In fact, no histosols were observed at any of the transects near SR 50 and Denaud was the only soil series identified with a histic epipedon. Typically, where Denaud soils were identified at the other transects they were scattered at a few discontinuous locations. Consequently, in order to maintain consistency between the other transects sites, the primary minimum frequent-low level criterion at the Tosohatchee North Transect equaled a 20-in. average Chobee soil water table drawdown in the shallow marsh.

Soil series identified farther upslope in the transitional lower hardwood swamp were Chobee, Denaud, and Manatee. Soils upslope in the hardwood swamp were Chobee and Denaud. Average soil water table drawdown in the transitional lower hardwood swamp and hardwood swamp would equal 34 and 40 in., respectively. As mentioned previously, the soil moisture and surface water hydrology within the wet prairie, the transitional lower hardwood swamp, and the hardwood swamp at the Tosohatchee North Transect are definitely influenced by sheetflow from Jim Creek and shallow groundwater seepage.

Additional considerations regarding the 20-in. soil water table drawdown and ultimately soil moisture include the soils capillary fringe. A capillary fringe of varying thickness exists above the soil water table. In the capillary fringe zone, the soil is nearly water-saturated; the water is adsorbed to soil particles to a greater degree in the capillary fringe zone than is water below the water table. The capillary fringe zone contains various amounts of water depending upon the pore size and the height in the soil above the water table (Richardson et al, 2001). A sandy clay loam such as Chobee soil, with an average porosity of 0.005 cm, should have a saturated zone extending at least 12 in. (30 cm) above the soil water table (Mausbach 1992). Consequently, soil moisture may be available to the marsh vegetation at depths considerably closer to the soil surface than that predicted from the 20-in. soil water table drawdown criterion.

According to Kushlan (1990), sand substrates, as observed in the wet prairie and shallow marsh at the Tosohatchee North Transect, occur in marshes with short hydroperiods and significant drying of the soil during the dry season. The marked seasonality of Florida’s rainfall and evaporation plays an important role in the functioning of marsh ecosystems by creating a seasonal fluctuation in surface water. This seasonal fluctuation is most pronounced in southern Florida because it experiences less winter rainfall than occurs farther north. Water levels rise during the summer rainy season, gradually decline during the winter, and annually reach drought conditions as evapotranspiration increases in the spring. In most years, standing water is absent from southern Florida marshes at the height of the dry season, a condition that may last from several of weeks to several months. Most marshes flood during each rainy season, but some may flood only in very wet years. Annual variation in rainfall may cause substantial differences in the depth and extent of flooding in various years at a single marsh site (Kushlan 1990).

Last, at the recommended minimum frequent low-level shallow ponding would occur in the open water areas (stations -600 to -860 and -980 to -1180) traversed at the Tosohatchee North Transect. Table 32 lists water depths in the main river channel and the open water areas traversed at the Tosohatchee North Transect when the river stage equals the recommended minimum frequent-low level.

Table 32. Inundation depths at the minimum frequent-low level at the Tosohatchee North Transect

Description	Range of Inundation (ft)	Average Inundation (ft)
Open water -600 to -860	0–0.6	saturated
Open water -980 to -1180	0–1.3	0.3
River channel	0–5.7	2.3

St. Johns River Near the Great Outdoors

The Great Outdoors Transect is located primarily on the east floodplain, immediately west of the Great Outdoors residential community (Table 33). The Great Outdoors residential community is located 2 mi west of I-95 on the south side of SR 50.

Table 33. Great Outdoors Transect location information

Transect Name and River Mile	Latitude–Longitude (Beginning Station)	Latitude–Longitude (End Station)	Location and Date of Fieldwork
Great Outdoors RM 215	28 30 27.536; 80 52 06.757 (Station 0)	28 30 02.434; 80 53 02.877 (Station 5850)	Begins in uplands on east side of floodplain, immediately adjacent to the Great Outdoors development; June and November 2002.

Field Data for the Great Outdoors Transect

The transect was located on a tract of the Canaveral Marshes Conservation Area (SJRWMD 2004) at approximately river mile 215 (Figures 2 and 7). This transect is approximately 6 river miles upstream from the SR 50 bridge over the St. Johns River.

Transect Selection Criteria the Great Outdoors Transect

The primary criteria for selecting this transect location included the following:

- Relatively pristine extensive wet prairie and palm hydric hammock (Figure 7)
- Located on public land (SJRWMD), preventing future development and facilitating access for long-term ecological monitoring
- Begins at the edge of a natural upland community

Vegetation at Great Outdoors Transect

The Great Outdoors Transect originated in a palm hydric hammock on the east floodplain of the St. Johns River. The transect traversed in a westerly direction through the palm hydric hammock and an extensive wet prairie, across the St. Johns River and a shallow marsh, and terminated within another wet prairie community (Figures 20 and 21, Tables 34 and 35).

Station 0 was located at the upland edge of the palm hydric hammock. The palm hydric hammock (stations 0–247) overstory vegetation included dominant cabbage palm; scattered sand live oak, southern red cedar, and longleaf pine. The palm hydric hammock understory vegetation included numerous panic grass (*Dichanthelium laxiflorum*), sour paspalum (*Paspalum conjugatum*), white crownbeard (*Verbesina virginica*), and false pimpernel (*Lindernia crustacea*); with scattered yellow top (*Flaveria linearis*) and wood grass (*Oplismenus setarius*).

West of the palm hydric hammock, the transect traversed an upper wet prairie (stations 247–900). The upper wet prairie vegetation included co–dominant sand cordgrass with abundant groundsel tree, scattered swamp mallow, frog fruit (*Phyla nodiflora*), and marsh fleabane.

Downslope from the upper wet prairie the transect traversed wet prairie #1 (stations 900–3750). The wet prairie #1 vegetation included dominant sand cordgrass; numerous crabgrass (*Digitaria serotina*) and dotted smartweed; and scattered groundsel tree, water hyssop (*Bacopa monnieri*), flat sedge (*Cyperus haspan* and *Cyperus odoratus*), seaside

Figure 20. Great Outdoors Transect topography with ecological communities
*At the Great Outdoors the Minimum Frequent High (MFH) equals 9.4 ft. NGVD, the Minimum Average (MA) equals 7.5 ft. NGVD and the Minimum Frequent Low (MFL) equals 5.8 ft. NGVD

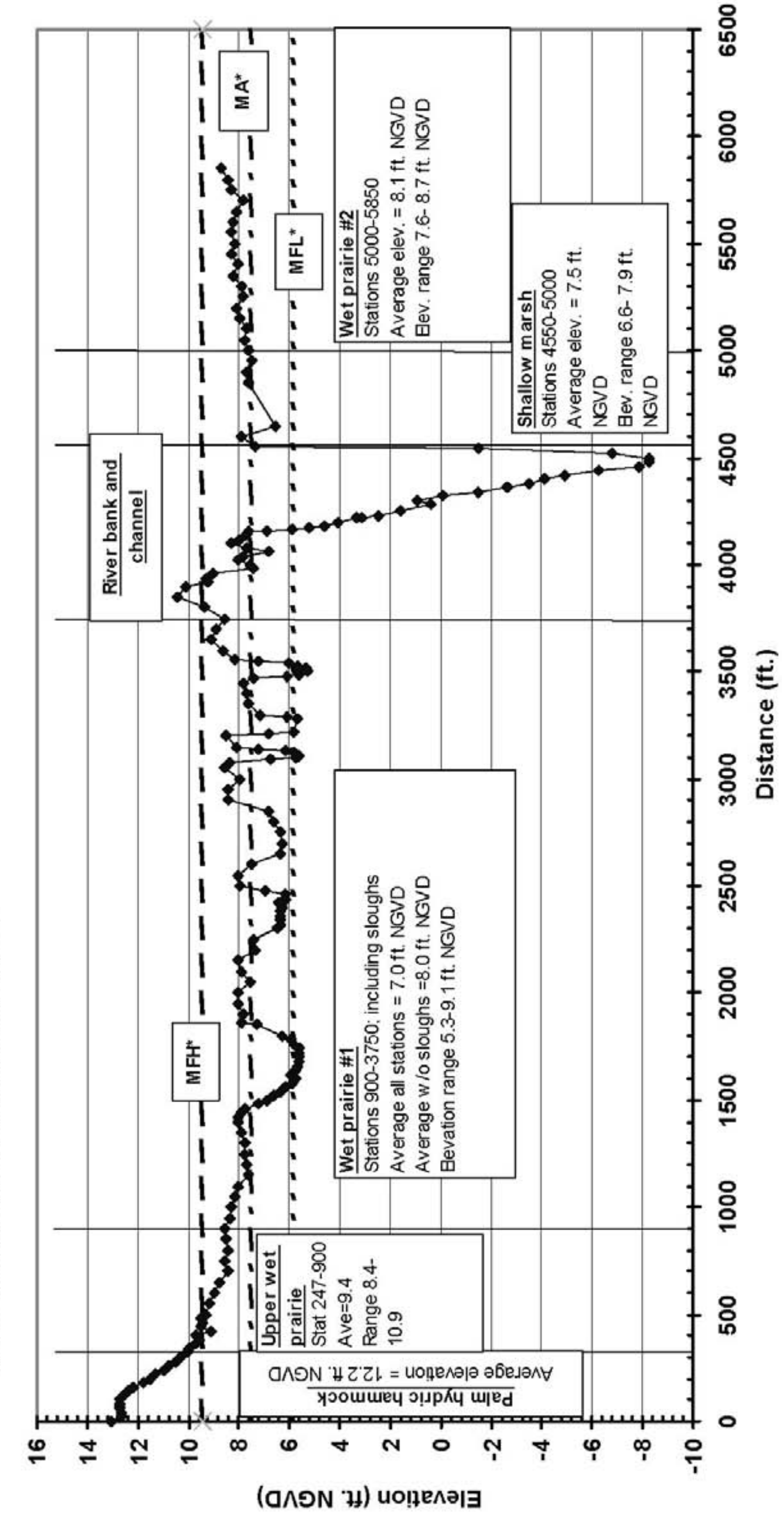


Figure 21. Great Outdoors Transect photos

Figure 21. Great Outdoors Transect photos—*continued*

Figure 21. Great Outdoors Transect photos—*continued*

Table 34. Great Outdoors Transect vegetation community statistics

Vegetation Community	Stations Distance (ft)	Mean (ft NGVD)	Median (ft NGVD)	Min (ft NGVD)	Max (ft NGVD)	N
Palm hydric hammock	0–247	12.2	12.5	10.9	13.0	14
Upper wet prairie	247–900	9.4	9.5	8.4	10.9	22
Wet prairie #1; including slough points	900–3750	7.0	7.1	5.3	9.1	94
Wet prairie #1; excluding slough points	900–3750	8.0	8.0	7.4	9.1	41
River channel	4120–4550	0.5	0.9	-8.3	7.9	27
Shallow marsh	4550–5000	7.5	7.6	6.6	7.9	7
Wet prairie #2	5000–5850	8.1	8.1	7.6	8.7	18

ft NGVD = feet National Geodetic Vertical Datum

heliotrope (*Heliotropium curassavicum*), swamp mallow, frog fruit, marsh fleabane, soft-stem bulrush, sea purslane (*Sesuvium sp.*), and fire-flag.

Within wet prairie #1, the transect traversed three different drainage ways six times. These drainage ways were either sparsely vegetated with crabgrass, dotted smartweed, flat sedges, and soft-stem bulrush;or were not vegetated. Presumably these drainage ways are sparsely vegetated because of long-term inundation and because cattle walk primarily in them rather than in the dense sand cordgrass.

The Great Outdoors Transect crossed the main channel of the St. Johns River between stations 4120 and 4550. From stations 4550 to 5000 the Great Outdoors Transect traversed a shallow marsh. Shallow marsh vegetation included abundant fire-flag, water hyacinth, and dotted smartweed; numerous bull arrowhead; and scattered sand cordgrass, fall panic grass, and pickerelweed. West of the shallow marsh, the Great Outdoors Transect terminated within wet prairie #2 (stations 5000–5850). Wet prairie #2 vegetation included co-dominant sand cordgrass; abundant bull arrowhead and swamp mallow; numerous dotted smartweed and buttonbush; and scattered groundsel tree, Carolina willow, fire-flag, water hyacinth, and fall panic grass.

Additional plant species observed along the Great Outdoors transect are listed in Table 35.

Table 35. Great Outdoors Transect vegetation species list

Common Name	Scientific Name	FWDM Code[1]	Plant Community Species Cover Estimates[2]				
			PHH	UWP	WP#1	SM	WP#2
Bull arrowhead	Saggitaria lancifolia	OBL				2	3
Buttonbush	Cephalanthus occidentalis	OBL					2
Cabbage Palm	Sabal palmetto	FACW	5		0		
Carolina willow	Salix caroliniana	OBL			0		1
Crabgrass	*Digitaria serotina*	FAC			2		
Dog fennel	*Eupatorium capillifolium*	FAC				0	0
Dotted smartweed	*Polygonum punctatum.*	OBL			2	3	2
Fall panic grass	Panicum dichotomiflorum	FACW				1	1
False pimpernel	Lindernia crustacea	FAC	2				
Flat sedge	*Cyperus haspan*	FAC			1		
Flat sedge	*Cyperus odoratus*	FACW			1		
Fire–flag	*Thalia geniculata*	OBL			1	3	1
Frog fruit	Phyla nodiflora	FAC		1	1		
Groundsel tree	*Baccharis glomeruliflora*	FAC		3	1		1
Longleaf pine	Pinus palustris	UPL	1				
Marsh fleabane	Pluchea rosea	FACW		1	1		
Panic grass	*Dichanthelium laxiflorum*	FAC	2				
Pickerelweed	*Pontederia cordata*	OBL				1	
Sand cordgrass	*Spartina bakeri*	FACW		4	5	1	4
Sand live oak	Quercus geminata	UPL	1				
Sea purslane	Sesuvium sp.	FACW			1		
Seaside heliotrope	Heliotropium curassavicum	OBL			1		
Soft-stem bulrush	Scirpus validus	OBL			1		
Sour paspalum	*Paspalum conjugatum*	FAC	2				
Southern red cedar	Juniperus silicicola	FACU	1				
Swamp mallow	*Hibiscus grandiflorus*	OBL		1	1		3
Water hyacinth	*Eichhornia crassipes*	OBL				3	1
Water hyssop	*Bacopa monnieri*	OBL			1		
White crownbeard	Verbesina virginica	FAC	2				

Table 35—*Continued*

Common Name	Scientific Name	FWDM Code[1]	Plant Community Species Cover Estimates[2]				
			PHH	UWP	WP#1	SM	WP#2
Wood grass	Oplismenus setarius	UPL	1				
Yellow top	Flaveria linearis	FACW	1				

[1]FWDM Code Indicator categories established in Florida Wetlands Delineation Manual (Gilbert et al.1995)

Upland (UPL) = Plants that occur rarely in wetlands, but occur almost always in uplands
Facultative (FAC) = Plants with similar likelihood of occurring in both wetlands and uplands
Facultative Wet (FACW) = Plants that typically exhibit their maximum cover in areas subject to surface water flooding and/or soil saturation, but may also occur in uplands
Obligate (OBL) = Plants that are found or achieve their greatest abundance in an area which is subject to surface water flooding and/or soil saturation; rarely uplands

[2] Plant Community Species Cover Estimates: Aerial extent of vegetation species along transect within given community where 0 = <1% (rare); 1 = 1–10% (scattered); 2 = 11–25% (numerous); 3 = 26–50% (abundant); 4 = 51–75% (co–dominant); and 5 = greater than 75% (dominant)

PHH = Palm hydric hammock (stations 0–247)
UWP = Upper wet prairie (stations 247–900)
WP#1 = Shallow marsh / Wet Prairie (stations 900–3750)
SM = Shallow Marsh (stations 4550–5000)
WP#2 = Wet Prairie (stations 5000–5850)

Soils at the Great Outdoors Transect

Soil auger holes were dug at 20 selected stations to characterize the soils along the Great Outdoors Transect between stations 100 and 5750 on November 13, 2002, and April 6, 2004 (Table 36). Soils were characterized in the field based upon epipedons, horizons, soil texture, soil color, and horizon depth. These soil features were used to determine the soil series at each soil station. Hydric soil indicators (histic epipedon, muck, mucky mineral, loamy gleyed matrix, and/or stripped matrix) were observed at all sampled stations.

Table 36. Great Outdoors Transect soil descriptions

Station/Soil Series	Vegetation Community	Soil Horizon	Horizon Description
100/Pomona	Palm hydric hammock	Oa 0–0.5"	Black muck
		A 0.5–4"	Black sand
		E 4–10"	Gray sand
		Bh 10–18"	Brown sand
		Bw1 18–27"	Brown sand with redoxomorphic conc.
		Bw2 27–31"	Brown and gray sand with redoxomorphic conc.
		Bw3 31–40"	Yellow and brown sand; stripping present
		Btg1 40–48"	Gray sandy loam with redoxomorphic conc.
		Btg2 48”+	Gray sandy clay loam with redoxomorphic conc.
250/Delray	Upper wet prairie	Oa 0–1"	Black muck
		A1 1–6"	Black mucky sand
		A2 6–19"	Black sand
		Eg1 19–31"	Gray sand with redoxomorphic conc
		Eg2 31–70"	Gray sand; stripping present
		Btg 70”+	Gray sandy loam with redoxomorphic conc.
400/Eaton	Upper wet prairie	Oa 0–0.5"	Black muck
		A 0.5–6"	Black sand with gray stratified layer
		AE 6–13"	Black and gray sand
		EA 13–25"	Dark gray sand with redoxomorphic conc.
		Btg 25–35”+	Gray sandy clay loam with redoxomorphic conc.

Table 36—*Continued*

Station/Soil Series	Vegetation Community	Soil Horizon	Horizon Description
600/Eaton	Upper wet prairie	Oa 0–2"	Black muck
600/Eaton	Upper wet prairie	A 2–9"	Black sand
600/Eaton	Upper wet prairie	EA 9–29"	Gray sand with redoxomorphic conc.
600/Eaton	Upper wet prairie	Btg1 29–40"	Gray sandy clay loam with redoxomorphic conc.
600/Eaton	Upper wet prairie	Btg2 40–52"+	Gray loamy sand with redoxomorphic conc.
800/Eaton	Upper wet prairie	Oa 0–3"	Black muck
800/Eaton	Upper wet prairie	A 3–6"	Black sand
800/Eaton	Upper wet prairie	Eg 6–24"	Gray sand with redoxomorphic concentrations; stripping present
800/Eaton	Upper wet prairie	Btg1 24–41"	Dark gray sandy clay loam
800/Eaton	Upper wet prairie	Btg2 41–48"+	Gray loamy sand
1400/Lynne	Wet prairie #1	Oa 0–5"	Black muck
1400/Lynne	Wet prairie #1	A 5–11"	Black sand
1400/Lynne	Wet prairie #1	Eg1 11–18"	Gray sand; stripping present
1400/Lynne	Wet prairie #1	Eg2 18–26"	Brown sand with redoxomorphic concentrations
1400/Lynne	Wet prairie #1	Btg1 26–32"	Sandy clay loam
1400/Lynne	Wet prairie #1	Btg2 32–44"	Dark gray sandy clay loam
1400/Lynne	Wet prairie #1	Ab 44"+	Very dark gray sand
1834/Anclote	Wet prairie #1	Oa 0–2"	Black muck
1834/Anclote	Wet prairie #1	A 2–8"	Black sand
1834/Anclote	Wet prairie #1	Eg 8"+	Gray sand with redoxomorphic concentrations
1850/Anclote	Wet prairie #1	Oa 0–4"	Black muck
1850/Anclote	Wet prairie #1	A1 4–8"	Black mucky sand
1850/Anclote	Wet prairie #1	A2 8–17"	Black sand
1850/Anclote	Wet prairie #1	Eg 17–36"	Gray and brown sand; stripping present
1850/Anclote	Wet prairie #1	Bh 36–42"+	Very dark gray sand
2100/Anclote	Wet prairie #1	Oa 0–6"	Black muck
2100/Anclote	Wet prairie #1	A 6–12"	Black mucky sand
2100/Anclote	Wet prairie #1	Eg 12–48+	Gray and very dark gray sand; stripping present
2500/Anclote	Wet prairie #1	Oa 0–7"	Black muck
2500/Anclote	Wet prairie #1	A 7–9"	Black sand
2500/Anclote	Wet prairie #1	AE 9–13"	Black and gray sand
2500/Anclote	Wet prairie #1	E 13–42"	Gray and dark gray sand; stripping present; sporadic pockets of muck
2500/Anclote	Wet prairie #1	AE' 42"+	Black with gray sand

Table 36—*Continued*

Station/Soil Series	Vegetation Community	Soil Horizon	Horizon Description
2950/Anclote variant	Wet prairie #1	Oa 0–7"	Black muck
		A1 7–15"	Black sandy clay loam
		A2 15–30"	Black clay loam
		A3 30–36"	Black and dark gray sand
		Eg1 36–43"	Light gray sand
		Eg2 43"+	Gray sand with 1.0" thick black muck stratified layer at 43"
3000/Denaud	Wet prairie #1	Oa 0–12"	Black muck
		A 12–30"	Black sandy clay loam
		Eg 30–39"	Light gray and gray sand
		Ab/Eg 39"+	Black, very dark gray and gray sand; stripping present
3400/Anclote variant	Wet prairie #1	Oe 0–1"	Hemic material
		Oa 1–7"	Black muck
		A1 7–37"	Black clay loam
		A2 37–46"	Black and very dark gray sandy clay loam
		Bh 46"+	Very dark grayish brown sand
3800/Pompano	Wet prairie #1	Oa 0–0.5"	Black muck
		A 0.5–2"	Black sand
		Bh/E 2–15"	Black, dark gray, and light brownish gray sand with redoxomorphic concentrations
		C1 15–22"	Dark gray loamy sand
		C2 22–34"	Gray and dark gray sand; stripping present
		C3 34–79"	White sand
		C4 79"+	Grayish brown sand
4600/Chobee variant	Shallow marsh	Oa 0–4"	Very dark brown muck
		A 4–7"	Black mucky loam
		C' 7–15"	Black loam
		Cg 15–32"+	Black clay loam
4850/Chobee variant	Shallow marsh	A1 0–3"	Very dark grayish brown mucky loam
		A2 3–6"	Very dark gray sandy loam
		Cg1 6–10"	Very dark gray loam
		Cg2 10–15"	Very dark gray clay loam
		Cg3 15–25"	Black clay
		Cg4 25–30"	Black clay loam
		Cg5 30–33"	Dark gray fine sandy loam
		Cg6 33–42"+	Black sandy clay loam

Table 36—*Continued*

Station/Soil Series	Vegetation Community	Soil Horizon	Horizon Description
4950/Chobee variant	Shallow marsh	Oa 0–3”	Very dark gray muck
		A 3–4”	Black mucky loam
		C1 4–13”	Black clay loam
		C2 13–22”	Black clay
		Cg 22–40”+	Very dark gray sandy clay loam
5200/Anclote	Wet prairie #2	Oa 0–1”	Very dark gray muck
		A 1–3”	Black mucky loam
		C1 3–12”	Loamy sand
		C2 12–17”	Sandy loam
		Cg1 17–28”	Very dark gray loamy sand
		Cg2 28–32”	Gray and grayish brown coarse sand
		Cg3 32–43”	Dark gray and gray loamy sand
		Cg4 43–48”+	Sandy clay
5500/Chobee	Wet prairie #2	Oa 0–3”	Very dark gray muck
		A 3–4”	Black mucky loam
		Cg1 4–10”	Very dark gray sandy clay loam
		Cg210–16”	Very dark gray sandy loam
		Cg3 16–22”	Very dark gray sandy clay loam
		Cg4 22–26”	Very dark gray sandy loam
		Cg5 26–30”	Gray loamy sand
		Cg6 30–38”	Gray sandy clay loam
		Cg7 38–42”+	Gray and grayish brown sand
5750/Chobee	Wet prairie #2	Oe 0–3”	Very dark grayish brown hemic material with many fine roots
		Oa 3–4”	Very dark gray muck
		A 4–6”	Black mucky loam
		Cg 6–48”+	Very dark gray silty clay

As mentioned previously, fluvial and other hydrologic processes constantly modify the soils throughout the St. Johns River floodplain. Sediment accretion frequently occurs during flood activities, creating transitory features within the soils, especially those closest to the stream channels (Lindbo and Richardson 2001). When the river rises and inundates the floodplain, erosional and depositional processes combine to deposit coarse sediments at the edge of the floodplain (nearest the channel) and finer-textured material throughout the floodplain. Consequently, sediments found in the St. Johns River floodplain can be comprised of depositional material transported from upstream, depositional material derived locally from channel erosion, and parent material that has been reworked from centuries of flood events.

Numerous relatively thin soil horizons can occur from frequent deposition of alluvial sediments and often result in accretion topography. As a result, soil features such as texture and color can vary greatly over a short distance (D. Segal, pers. comm. 2004). In the St. Johns River floodplain, fine-textured material may occur near the surface in one place and at a depth of as much as 48 in. below the soil surface at a nearby location (Leighty et al. 1957).

The history of erosional and depositional processes in the St. Johns River floodplain gives rise to a complex distribution of soils across the floodplain. Lateral and horizontal changes in sediment deposition result in soil series with a large degree of variability (Lindbo and Richardson 2001). This combination makes the identification of soil series difficult due to the high variability of soil features found across the transect. Often soil features found at a given site will not conform to the characteristics of any particular soil series (Segal, pers. comm. 2004). Since the soils resulted in many discrepancies with the official soil series descriptions, Wade Hurt, hydric soil scientist with the USDA, NRCS, in Gainesville, Florida, was consulted to help decipher the correct soil series that most closely represented the described soils.

The soil series and the soil taxonomic classification subgroup are briefly described below for each soil station sampled at the Great Outdoors Transect. The soil taxonomic classification subgroup provides additional information for each soil series (JEA 2004; Appendix C).

At the Great Outdoors Transect, beginning with station 100 in the palm hydric hammock (stations 0–247) the soil had a 0.5-in.-thick black muck surface horizon, below that was black sand (Table 36). The soil series at station 100 was determined to be Pomona. Pomona sand consists of very deep, poorly and very poorly drained soils that formed in sandy and loamy marine sediments. Pomona soils are on low, broad, nearly level ridges within the flatwoods areas of the Lower Coastal Plain. Under natural conditions, the water table occurs within a depth of 6 to 18 in. below the soil surface for one to three months and occurs at a depth of 10 to 40 in. below the soil surface for six months or more during most years. Depressional areas are ponded for six to nine months or more in most years (NRCS 2003).

The taxonomic classification subgroup for Pomona soil is an Ultic Alaquod, meaning it is a spodosol. All spodosols have a spodic horizon. Pomona soil is in the aquic moisture regime, which is a reducing water regime. Pomona soil has light-colored albic subsurface layer(s) below the A-horizon. Pomona soil also has an argillic horizon occurring at least 40 in. below soil surface. Both the spodic and argillic horizons are hardpan layers that impede vertical water movement and can cause surface saturation during high rainfall events. These hardpan layers, combined with a low landscape position, contribute to the poorly drained moisture classification of Pomona soil (JEA 2004; Appendix C).

Downslope from the palm hydric hammock in the upper wet prairie (stations 247–900) Delray and Eaton soils were observed (Table 36). Beginning with station 250 near the palm hydric hammock–upper wet prairie ecotone the soil was Delray series with a shallow (1 in thick) surface black muck horizon below which was black mucky sand and black sand (Table 36). Delray series consists of very deep, very poorly drained, moderately permeable sandy soils on broad flats, floodplains, and depressions. The Delray series water table occurs at depths of less than 12 in. below the soil surface for six to nine months in most years. Depressions are ponded for six months or more in most years. Floodplains are flooded for long duration (NRCS 2003).

The taxonomic classification subgroup for Delray soil is a Grossarenic Argiaquoll. Delray is a Mollisol. All Mollisols have a mollic epipedon. The mollic epipedon is a collection of thick dark surface horizons with sufficiently high concentrations of organic material that has stained or coated the mineral material black. Delray is very poorly drained and is in the aquic moisture regime. All soils near SR 50 that contain a mollic epipedon are also classified as very poorly drained. The grossarenic adjective implies that the argillic horizon occurs at a depth greater than 40 in. below the soil surface. At the Great Outdoors Transect the Delray soil is located at a relatively high topographic position. This Delray soil is likely associated with a seepage slope, which would explain the thicker accumulation of organic material and very poorly drained moisture category (JEA 2004; Appendix C).

Eaton soil was identified at stations 400, 600, and 800 in the upper wet prairie (Table 36). Eaton soils consist of poorly and very poorly drained loamy sands. Eaton soils formed in clayey marine sediments. The Eaton soil water table occurs at depths of less than 10 in. below the soil surface for periods of one to four months during most years. Depressional areas are ponded for very long periods (NRCS 2003). Eaton soils contain a moderately deep argillic horizon (occurs between 20 and 40 in. below the soil surface) that formed under and persists in very wet conditions. The water table in Eaton soil is likely maintained by the thick argillic horizon below, allowing the formation of aquic conditions (Segal, pers. comm., 2004).

The taxonomic classification subgroup for Eaton soil is an Arenic Albaqualf. Eaton is an Alfisol meaning it has an argillic horizon that is high in base saturation. It is poorly drained and in the aquic moisture regime, contains light-colored albic subsurface horizon(s). The arenic adjective implies that the argillic horizon occurs between 20 and 40 in. below soil surface (JEA 2004; Appendix C).

In wet prairie #1, downslope from the upper wet prairie, the soils were Lynne (station 1400), Anclote or an Anclote variant (stations 1834, 1850, 2100, 2500, 2950, and 3400), Denaud (station 3000), and Pompano (station 3800) series (Table 36). Soil sampling between stations 1834 and 3400 occurred at lower elevations in the section of wet prairie #1, which was bisected with drainage channels (Figure 20).

According to the NRCS (2003), Lynne series soil consists of poorly drained, deep sandy soils that are at least 72 in., in thickness, with a seasonal high water table within one ft of the soil surface for one to four months in most years. Like Pomona soil identified at station 100, Lynne soil is classified as an Ultic Alaquod, meaning it is a spodosol in the aquic moisture regime and contains an argillic horizon. The argillic layer is closer to the soil surface in Lynne soils and contributes to a somewhat wetter hydrology compared to Pomona soils. This is confirmed in the soil profile description where Pomona contained 0.5 in. of muck and Lynne contained 5.0 in. of muck. A lower landscape position on the Great Outdoors Transect also contributes to the more poorly drained conditions of the Lynne soil (JEA 2004; Appendix C).

Anclote soil, which was the most frequently observed soil type in wet prairie #1, is typically a very deep, very poorly drained, rapidly permeable sandy soil occurring in depressions, poorly defined drainage ways, and floodplains. The Anclote soil water table occurs within 10 in. of the soil surface for six or more months during most years and recedes to depths of greater than 20 in. below the soil surface during the driest season. Depressional areas with Anclote soil are ponded (NRCS 2003).

The taxonomic classification subgroup for Anclote soil is a Typic Endoaquoll, meaning it contains a mollic epipedon, is in the aquic moisture regime, and the mollic epipedon occurs within 30 in. of the soil surface. The term endo implies that Anclote soils are endosaturated, such that water is frequently derived from groundwater rather than surface water (JEA 2004; Appendix C).

Denaud soil, sampled at station 3000 in wet prairie #1, consists of deep, very poorly drained, moderately permeable soils with a thin organic layer over sandy and loamy material. Under natural conditions, Denaud soils are ponded for six to nine months and are saturated to the soil surface the rest of the time during most years (NRCS 2003).

The taxonomic classification subgroup for Denaud soil is a Histic Humaquept. A Histic Humaquept is an Inceptisol meaning it is a somewhat young soil and has minimal horizon development, but somewhat more development than the youngest Entisols. Denaud soil is in the aquic moisture regime, has distinct organic material at the surface, and has a histic epipedon. A histic epipedon contains 8 to 16 in. of organic material. Denaud is the only soil sampled at the Great Outdoors Transect with a histic epipedon. The Denaud soil is quite similar to the Anclote soil, which surrounds it, only differing by an additional one to two in. of surface muck in the Denaud soil (JEA 2004; Appendix C).

The final soil sampled in wet prairie #1 was at station 3800. Station 3800 is located approximately 200 ft east of the main river channel on a slightly higher riverbank. The soil series at station 3800 was Pompano (Table 36). Pompano series consists of very deep, very poorly drained, rapidly permeable soils in depressions, drainage ways, and broad flats. The Pompano soil water table occurs at depths of less than 10 in. below the soil surface for two to six months each year. Even during the drier months, it occurs at depths of less than 30 in. below the soil surface for more than nine months each year. In depressional areas, the Pompano soil water table is above the soil surface for more than three months each year (NRCS 2003).

The taxonomic classification subgroup for Pompano soil is a Typic Psammaquents, meaning it is a young soil in the Entisol soil order, and consequently has minimal soil horizon development. Entisols are thought to be geologically young soils that lack a long weathering process that would produce distinct horizons. Pompano soil is in the aquic moisture regime and the soil profile is comprised of sand. Pompano soil is given the Typic adjective because it typifies the great group Psammaquents, rather than having a distinct characteristic that would warrant a more descriptive adjective. This Pompano soil, occurring at station 3800 on a slight rise (riverbank) is likely constantly dewatered from the adjacent deep river channel (Figure 20). The dewatering effect would result in slightly better drained conditions (poorly drained rather than very poorly drained) with less organic matter accumulation (JEA 2004; Appendix C).

Soil sampling in the shallow marsh (stations 4550–5000), west of the main river channel indicated an unknown fluvaquent similar to Chobee soil (Table 36). This soil did not conform to the official Chobee soil profile description, but was more similar to Chobee than any other soil series. Chobee series consist of very deep, very poorly drained, slowly to very slowly permeable soils in depressions, flats, and occasionally on river floodplains. According to the *Soil Survey of Brevard County, Florida* (USDA, SCS 1974), the water table in Chobee soil, in most years, occurs within a depth of 10 in. below the soil surface for six to nine months and occurs at depths of 10 to 40 in. below the soil surface for three to six months. In very dry seasons, the water table occurs at depths greater than 40 in. below the soil surface for short periods. Chobee soil is continuously flooded for one to six months in many places.

The taxonomic classification subgroup for Chobee soil is a Typic Argiaquoll, meaning it is a mollisol in the aquic moisture regime, containing an argillic horizon, which occurs within 20 in. of the soil surface. Again, the presence of a mollic epipedon is indicative of the high concentrations of organic matter that develops and persists in flooded soils (JEA 2004; Appendix C).

Last, soil samples within wet prairie #2, the final vegetation community traversed at the Great Outdoors Transect, were identified as Anclote (station 5200) and Chobee series (stations 5500 and 5750) (Table 36). Anclote soil was the most commonly observed soil in wet prairie #1;

a Chobee-like soil was also observed across the adjacent shallow marsh (Table 36).

Similar to the other field transects along the St. Johns River near SR 50, the floodplain soils at the Great Outdoors Transect are closely associated with the river channels. Overland flow during high river stages dominates the hydrologic conditions in the floodplain soils, whereas groundwater flow dominates the hydrologic conditions in the floodplain soils during low river stages. This results in floodplain soils that are frequently inundated or saturated. Consequently, the majority of the soils observed along the Great Outdoors Transect are classified as very poorly drained. Additionally, the soils at the Great Outdoors Transect are similar to each other in that they exhibit a dark surface in the form of muck, mucky texture, umbric surface, and/or dark surface, which are all indicators of a wet moisture regime (JEA 2004; Appendix C). As mentioned previously, additional soils information is available in the appendices.

Minimum Levels at the Great Outdoors Transect, St. Johns River Mile 215

Minimum Frequent-High Level at the Great Outdoors (9.4 ft NGVD)

The recommended minimum frequent-high level for the St. Johns River at the Great Outdoors Transect is 9.4 ft NGVD. This level corresponds to a typical seasonally flooded river stage. During extended periods of normal or above normal rainfall, the minimum frequent-high level is expected to occur, on average, for several weeks to several months approximately once every 2 years (Chapter 40C-8.021(15), *F.A.C.*).

This recommended minimum frequent-high level equals the average elevation of the upper wet prairie community (stations 247–900; Table 34). This level will ensure that the lower elevations of the upper wet prairie will be inundated at least every 1 to 2 years for a period of several weeks to several months. At the recommended minimum frequent high-level wet prairies #1 and #2 traversed at the Great Outdoors Transect will be inundated with average water depths equal to 1.4 and 1.3 ft, respectively. Similar average water depths will occur in the wet prairies at Hatbill Park (0.7, 1.1, 1.3, 1.5, and 1.5 ft), Lake Cone (0.6, 0.8, and 1.0 ft) Tosohatchee North (2.1 ft) and TOSO-528 (0.8 ft) when the river stage equals the recommended minimum frequent-high level at each location.

As mentioned previously, of the marsh types in Florida, wet prairies are the least frequently flooded (50 to 150 days/year; Kushlan 1990). The type of vegetation present in wet prairies varies depending upon hydroperiod, soils, and site history. At the Great Outdoors Transect, the average elevation of the upper wet prairie equaled the 22% exceedence on the interpolated stage duration curve for the St. Johns River at the Great Outdoors. Consequently, taking into account the stage data and the literature references describing the wide range in variation of hydroperiods for wet prairies in Florida, the average elevation of the upper wet prairie traversed at the Great Outdoors Transect became the primary minimum frequent-high level criterion. Additionally, the vegetation community immediately upslope from the upper wet prairie was the palm hydric hammock, which occurred at a much higher elevation (>10.8 ft NGVD; Table 34).

As mentioned previously, due to the short hydroperiod wet prairies experience, this community type is the most species rich of Florida's marshes, containing a variety of grasses, sedges, and flowering forbs. Wet prairie species have considerable tolerance to both flooding and drying. Many shallowly rooted species typical of the wet prairies associated with coastal flatwoods (like St. John's wort) are killed by drying but reseed rapidly. As a result, their zone of dominance migrates up- and downslope in response to changing water conditions (Kushlan 1990). Higher wet prairies may, under some conditions, be invaded by saw palmetto. Environmental characteristics of wet prairies include a hydroperiod shorter than six months, a low accumulation of organic matter (e.g. a few inches or nonexistent), and a fire frequency of more than once per decade (Kushlan 1990).

Fire is an influential factor helping maintain the upper wet prairie and wet prairies traversed at the Great Outdoors Transect. The majority of this transect is located on a tract of the Canaveral Marshes Conservation Area where prescribed fire is planned every 3–5 years in order to deter woody shrubs and upland vegetation encroachment (SJRWMD 2004). As mentioned previously, prescribed fire results in wet prairie and upper wet prairie communities extending over a wide elevation gradient. The lower elevations of the wet prairie are primarily maintained by the river hydrology while the higher elevations in the wet prairie and the upper wet prairie elevations are maintained primarily by fire and groundwater seepage. Consideration of the role of fire and other disturbances (i.e. hurricane wind impacts, cattle grazing) is necessary in interpreting relationships between vegetation communities and hydrologic conditions. Additionally, a cattle lease exists for portions of the Canaveral Marshes Conservation Area (SJRWMD 2004), resulting in cattle grazing along the Great Outdoors Transect.

The aquatic faunal habitat is greatly expanded when the St. Johns River inundates the extensive wet prairies, shallow marshes, secondary channels, and drainage ways near the Great Outdoors Transect at the recommended minimum frequent-high level. Interactions with the adjacent marshes and wet prairies by connecting the channel to the floodplain are extremely important to animal productivity in lower coastal plain rivers (Bain 1990; Poff, et al. 1997). When the floodplains are flooded, many fish migrate from the main channel to the inundated areas for feeding and spawning. These migrations are more lateral, perpendicular to river flow, than upriver or down river (Guillory 1979). As the river continues to rise, the amount of vegetative structure available to aquatic organisms increases greatly as large areas of the floodplain are inundated (Light, et al. 1998).

Additionally, river water quality may improve significantly as water flows through the floodplain. The floodplains with vast marshes function as an important filter and sink for dissolved and suspended constituents (Wharton, et al. 1982).

The palm hydric hammock immediately upslope from the upper wet prairie at the Great Outdoors Transect will experience surface water inundation when the St. Johns River rises to an infrequent high level. More frequent surface water ponding will likely occur within this palm hydric hammock due to local rainfall and the poorly drained soil characteristics. Vince et al., (1989) suggest that hydric hammocks low in species diversity, such as the one traversed at the Great Outdoors Transect, and dominated by cabbage palm and live oak exist where long dry periods are interrupted by occasional episodes of flooding. These hammocks are inundated less often, perhaps only once per decade, due to tropical systems impacting the Upper St. Johns River Basin.

Minimum Average Level for the St. Johns River at the Great Outdoors Transect (7.5 ft NGVD)

The recommended minimum average level for the St. Johns River at the Great Outdoors Transect is 7.5 ft NGVD. The minimum average level approximates a typical river stage that is slightly less than the long-term median stage while still protecting the wetland resources. At the minimum average level substrates may be exposed during nonflooding periods of typical years, but the substrate remains saturated. The minimum average level corresponds to a water level that is expected to occur, on average, every year or two for about six months during the dry season.

The recommended minimum average level equals the average land surface elevation of the shallow marsh traversed at the Great Outdoors Transect (Figure 20; Table 34). This level will result in saturated or inundated soil conditions in the shallow marsh. Saturated soil conditions will prevent long-term encroachment of upland plant species into the shallow marsh at the Great Outdoors Transect. The unknown fluvaquent similar to Chobee soil (Table 36) observed in the shallow marsh at the Great Outdoors Transect experiences depressional floodplain hydrology with a soil water table typical of depressional Chobee soils. Additionally, the unknown fluvaquent soil contains a mollic epipedon that is indicative of very poorly drained conditions where frequent flooding promotes the accumulation rather than oxidation of organic matter (JEA 2004; Appendix C).

According to the *Soil Survey of Brevard County, Florida* (USDA, SCS 1974), the Chobee soil water table, in most years occurs within a depth of 10 in. below the soil surface for six to nine months and is continuously flooded for one to six months in many places. Consequently, soil saturation and shallow ponding at the lower elevations within the shallow marsh traversed at the Great Outdoors Transect at the recommended minimum average level typify annual dry season conditions in this depressional marsh community containing soils similar to the Chobee series.

Additionally, the mineral soil water table depths predicted to occur in the wet prairies, upper wet prairie, and palm hydric hammock at the Great Outdoors Transect when the stage of the St. Johns River equals the recommended minimum average level, are well within reported dry season levels (NRCS 2003). Table 37 lists the average soil water table drawdowns calculated for each soil series observed along the Great Outdoors Transect when the stage of the St. Johns River equals the recommended minimum average level (7.5 ft NGVD).

Table 37. Soil water table drawdowns at the Great Outdoors Transect at the minimum average level

Soil Series	Stations and Vegetation Community	Average Soil Water Table Drawdown (in.)
Pomona	100—Palm hydric hammock	62
Delray	250—Upper wet prairie	40
Eaton	400 to 800—Upper wet prairie	19
Lynne	1400—Wet prairie #1	6
Anclote or Anclote variant	1834,1850, 2100, 2500, 2950, 3400; Wet prairie #1	5
Denaud	3000; Wet prairie #1	6
Pompano	3800; Wet prairie #1/river bank	22
Chobee variant	4600, 4850, 4950; Shallow marsh	saturated
Anclote	5200; Wet prairie #2	7
Chobee	5500, 5750; Wet prairie #2	8

The Anclote soil was most widespread along the Great Outdoors Transect, occurring in wet prairies #1 and #2. Anclote soil would experience a 5 and 7-in. average soil water table drawdowns in wet prairies #1 and #2, respectively at the recommended minimum average level. According to the NRCS (2003), the Anclote soil water table occurs within 10 in. of the soil surface for six or more months during most years, and recedes to depths of greater than 20 in. below the soil surface during the driest season. Depressional areas with Anclote soil are frequently ponded. Consequently, a 5- and 7-in. average Anclote soil water table drawdown is reasonable for the dry season in a depressional setting such as the St. Johns River floodplain at the Great Outdoors Transect.

The recommended minimum average level (7.5 ft NGVD) is 0.5 ft below the surface elevation of the histic epipedon observed at station 3000 at the Great Outdoors Transect. This is similar to a 0.3 ft drawdown from the average surface elevation of histosols or a histic epipedon, typically employed as the primary minimum average level criterion. However, since a histic epipedon was only observed at station 3000 at the Great Outdoors Transect this criterion was not used as a basis for the recommended minimum average level.

Additionally, the recommended minimum average level for the St. Johns River at the Great Outdoors Transect will ensure shallow inundation of the secondary channels and open water areas traversed at this location. Table 38 lists water depths provided by the minimum average level in the open water areas, secondary channels, and main channel traversed at the Great Outdoors Transect.

Table 38. Inundation depths at the Great Outdoors Transect at the minimum average level equal to 7.5 ft NGVD

Community Description	Stations	Average Inundation (ft)	Range of Inundation (ft)
Open water	1480–1850	1.4	0.2–1.9
Sec. Channel	2200–2480	0.9	0.1–1.3
Sec. Channel	2650–2850	1.0	0.7–1.2
Sec. Channel	3090–3140	1.3	0.3–1.9
Sec. Channel	3210–3300	1.2	0.3–1.8
Sec. Channel	3480–3550	1.7	0.3–2.2
Main channel	4120–4550	7.0	0–15.8

ft NGVD = feet National Geodetic Vertical Datum

Shallow ponding within the open water areas of the Great Outdoors Transect will provide aquatic refugia for numerous small fish, amphibians, and small reptiles. Also, the shallow water depths are ideal for wading bird foraging. Wading birds can only forage in relatively shallow water. Great Egrets need water depths of less than 10 in. and the small herons need depths of less than 6 in. Declining water levels can cause fish to be concentrated in isolated sloughs throughout the shallow marshes. Birds effectively exploit these concentrations (Bancroft, et al. 1990).

Minimum Frequent-Low Level for the St. Johns River at the Great Outdoors Transect (5.8 ft NGVD)

The recommended minimum frequent-low level for the St. Johns River at the Great Outdoors Transect equals 5.8 ft NGVD. This level represents a low river stage that generally occurs only during mild drought. The minimum frequent-low level is predicted to occur, on average, approximately once every 5 years for the duration of several months. This level typically results in dewatered wetlands. This dewatering is a natural consequence of drought and has ecological benefits. Drawdown conditions enable seeds of emergent wetland plants to germinate from the seed banks of the floodplain. Seeds of many wetland plant species require exposed soils in order to germinate (Van der Valk 1981). Exposing the floodplain for suitable durations maintains the composition of emergent plant species and increases plant diversity.

The recommended minimum frequent-low level at the Great Outdoors Transect equals a soil water table level 20 in. below the average soil surface elevation of the shallow marsh (stations 4550–5000) traversed at the Great Outdoors Transect. All soils sampled within the shallow marsh were identified as a Chobee-like unknown fluvaquent (Table 36). The primary minimum frequent-low level criterion equal to a 20-in. soil water table drawdown from the average soil surface elevation of the shallow marsh is based upon the NRCS (2003) and the *Soil Survey of Brevard County, Florida* (USDA, SCS 1974), descriptions of typical Chobee soil water table levels during moderate droughts.

As mentioned previously, Chobee soil is classified as very poorly drained and contains a mollic epipedon indicative of high accumulations of organic matter, which persists in inundated soils. According to the NRCS (2003), the Chobee soil water table typically occurs within 6 in. of the soil surface for one to four months during most years in the rainy season. Depressional areas with Chobee soil are ponded for long durations in most years. According to the *Soil Survey of Brevard County, Florida* (USDA, SCS 1974), in most years, the Chobee soil water table occurs within a depth of 10 in. below the soil surface for six to nine months and 10 to 40 in. below the soil surface for three to six months. In very dry seasons, the soil water table occurs at depths greater than 40 in. below the soil surface for short periods. Chobee soil is continuously flooded for one to six months in many places (USDA, SCS 1974). Consequently, because the shallow marsh traversed at the Great Outdoors Transect was geographically located within a large depressional area at the lower vegetated elevations in the floodplain, which is closely associated with the river channel, a 20-in. average soil water table drawdown in the shallow marsh is considered reasonable. This criterion is based upon the best available information for an event which is predicted to reoccur once every 5 years for 60 continuous days (Robison 2006).

The average soil water table drawdown would equal 27 in. within wet prairie #2, adjacent and upslope from the shallow marsh at the Great Outdoors Transect at the recommended minimum frequent-low level. The soil series in wet prairie #2 (stations 5000–5850) was Anclote and Chobee. According to the NRCS (2003), the Anclote soil water table occurs within 10 in. of the soil surface for six or more months during most years and recedes to a depth of more than 20 in. below the soil surface during the driest season. Also, in wet prairie #1, across the main river channel from the shallow marsh and wet prairie #2, Anclote soil was the most extensive soil series identified (Table 36). Upslope in the upper wet prairie the soil was predominately Eaton series and the average Eaton soil water table drawdown would equal 40 in. below the soil surface at the recommended minimum frequent-low level. Eaton is classified as poorly drained with an argillic horizon. As mentioned previously, the argillic horizon is a hardpan layer that impedes vertical water movement and can cause surface saturation during high rain events. Consequently, the soil water table in the upper wet prairie is likely maintained at an elevation greater than the minimum frequent-low level due to the poorly drained soil characteristics and groundwater seepage.

Additional considerations regarding the 20-in. soil water table drawdown criterion and ultimately soil moisture include the extent of the soils capillary fringe. A capillary fringe of varying thickness exists above the soil water table. In the capillary fringe zone, the soil is nearly water-saturated; the water is adsorbed to soil particles to a greater degree than water below the water table. The capillary fringe zone contains various amounts of water depending upon the pore size and the height in the soil above the water table (Richardson et al 2001). A sandy clay loam such as Chobee soil, with an average porosity of 0.005 cm should have a saturated zone extending at least 12 in. (30 cm) above the soil water table (Mausbach 1992). Consequently, soil moisture may be available to the marsh vegetation at depths considerably closer to the soil surface than that predicted from the 20-in.soil water table drawdown criterion.

As mentioned previously, according to Kushlan (1990), sand substrates, as observed in the wet prairies and shallow marsh at the Great Outdoors Transect, occur in marshes with short hydroperiods and significant drying of the soil during the dry season. The marked seasonality of Florida's rainfall and evaporation plays an important role in the functioning of marsh ecosystems by creating a seasonal fluctuation in surface water. This seasonal fluctuation is most pronounced in southern Florida because it experiences less winter rainfall than occurs farther north. Water levels rise during the summer rainy season, gradually decline during the winter, and annually reach drought conditions as evapotranspiration increases in the spring. In most years, standing water is absent from southern Florida marshes at the height of the dry season, a condition that may last from several weeks to several months. Most marshes flood during each rainy season, but some may flood only in very wet years. Annual variation in rainfall may cause substantial differences in the depth and extent of flooding in various years at a single marsh site (Kushlan 1990).

Last, at the recommended minimum frequent-low level shallow ponding would occur in the open water areas and drainage way traversed at the Great Outdoors Transect, with deep water in the main river channel (Table 39).

Table 39. Inundation depths at the minimum frequent-low level at the Great Outdoors Transect

Community Description	Stations	Range of Inundation (ft)
Open water	1480–1850	0–0.2
Sec. channel	2200–2480	0
Sec. channel	2650–2850	0
Sec. channel	3090–3140	0–0.2
Sec. channel	3210–3300	0–0.1
Sec. channel	3480–3550	0–0.5
Main channel	4120–4550	0–14.1

St. Johns River Near SR 528

The SR 528 Transect, herein after referred to as the TOSO-528 Transect, traversed the St. Johns River floodplain approximately one river mile downstream (north) of SR 528 at river mile 220 (Table 40).

Table 40. TOSO-528 Transect location information

Transect Name and River Mile	Latitude–Longitude (Beginning Station)	Latitude–Longitude (End Station)	Location and Date of Fieldwork
TOSO-528 RM 220	28 28 13.288; 80 53 59.886 (Station 0)	28 27 33.682; 80 52 30.540 (Station 8900)	Began in uplands on west side of floodplain within the Tosohatchee State Reserve; November–December 2003, January–March and April 2004

Field Data for the TOSO-528 Transect

This Transect was located on the Tosohatchee State Reserve (west floodplain) and SJRWMD property known as Canaveral Marshes Conservation Area (east floodplain) at approximately river mile 220 (Figures 2 and 7). This transect is approximately 11 river miles upstream from the SR 50 bridge over the St. Johns River. It is the south most transect described in this document.

Transect Selection Criteria for the TOSO-528 Transect

The primary criteria for selecting this transect location included the following:

- Traversed relatively pristine extensive palm hydric hammock, wet prairies, shallow marshes, secondary and main river channels (Figure 7)
- Located on public lands, preventing future development and facilitating access for long-term ecological monitoring

Impacted less by cattle grazing than other areas between the Great Outdoors Transect and SR 528. Begins at the edge of a natural upland community

Vegetation TOSO-528 Transect

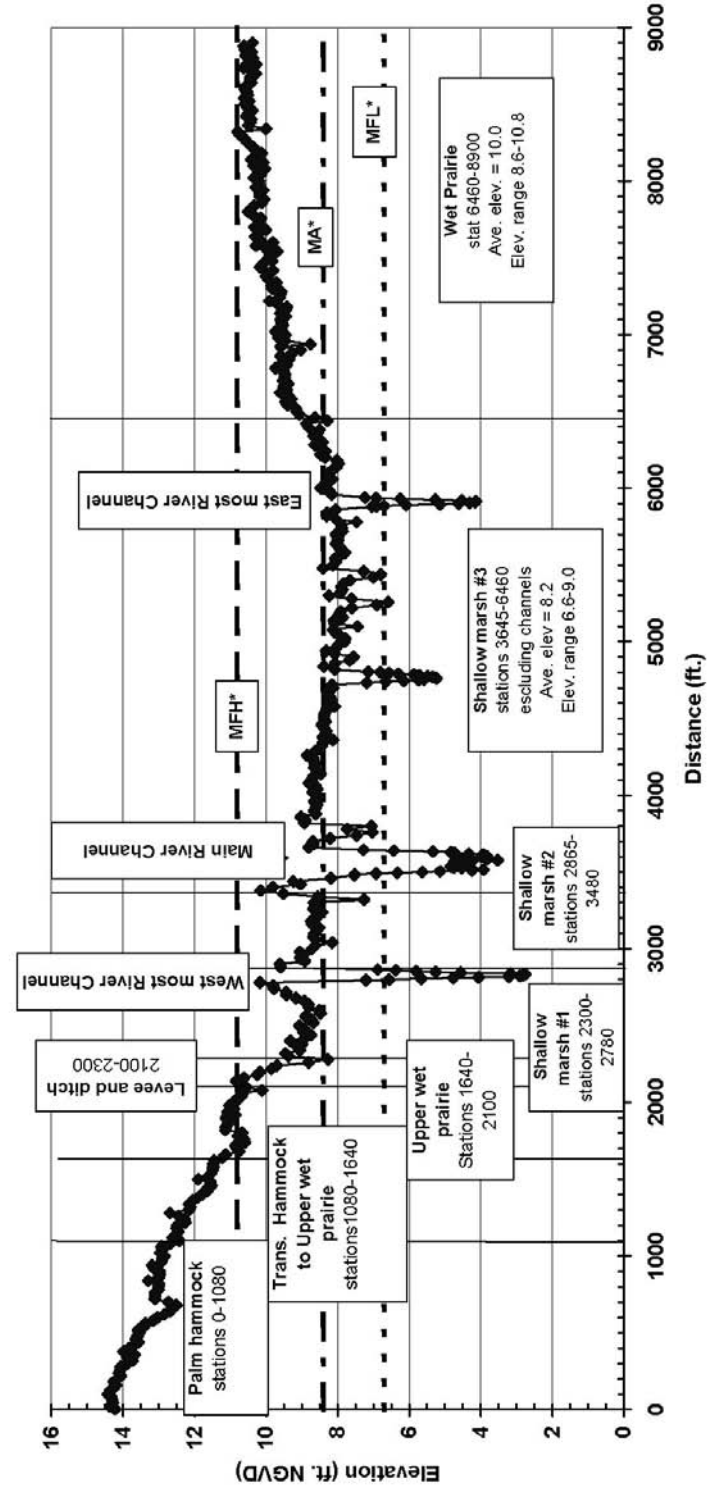
The TOSO-528 Transect originated on the Tosohatchee State Reserve within a palm hydric hammock and traversed in an east and southeast direction for 8,900 ft across various vegetation communities and river channels. Specifically, the TOSO-528 Transect traversed a palm hydric hammock, a transitional hammock–upper wet prairie, an upper wet prairie, a remnant levee, a shallow marsh, the west most river channel, another shallow marsh, the main river channel, another shallow marsh, multiple minor river channels, the main east channel, and terminated within a wet prairie near SR 407 (Figures 22 and 23; Tables 41 and 42).

The palm hydric hammock (stations 0–1080) within the Tosohatchee State Reserve burned severely in 1998. At the time of vegetation sampling preformed in support of the development of recommended MFLs at SR 50 the overstory vegetation included numerous dead southern red cedars, numerous live and dead cabbage palms; and scattered dead (burned) sand live oak and dead slash pine. Many of the dead trees have fallen over resulting in a sparsely vegetated overstory. The palm hydric hammock mid-canopy vegetation included abundant groundsel tree and wax myrtle; and scattered Brazilian pepper and false willow. The palm hydric hammock understory vegetation included numerous sand cordgrass, southern red cedar saplings, saltmarsh finger grass (*Eustachys glauca*), bushy broom grass; and scattered swamp fern, saw grass, yellow top, marsh pennywort, St. Andrew’s cross (*Hypericum hypericoides*), soft rush (*Juncus effuses*), variable panic grass (*Panicum commutatum*), fall panic grass, panic grass (*Panicum ensifolium*), southern beakrush (*Rhynchospora microcarpa*), blackberry, bull arrowhead, horned beakrush, marsh fleabane, mistflower, musky mint, pickerelweed, St. John’s wort, and water pimpernel.

The transitional hammock–upper wet prairie community (stations 1080–1640) was also severely burned in 1998. Due to the fire, it is difficult to determine exactly where the vegetation community shifts from the palm hydric hammock into the upper wet prairie. The transitional hammock–upper wet prairie vegetation included co-dominant sand cordgrass; numerous cabbage palm, wax myrtle, and giant foxtail; and scattered

Figure 22. TOSO-528 Transect topography with ecological communities

*At the TOSO-528 Transect the Minimum Frequent High (MFH) is 10.8 ft. NGVD, the Minimum Average (MA) is 8.4 ft. NGVD, and the Minimum Frequent Low (MFL) is 6.7 ft. NGVD



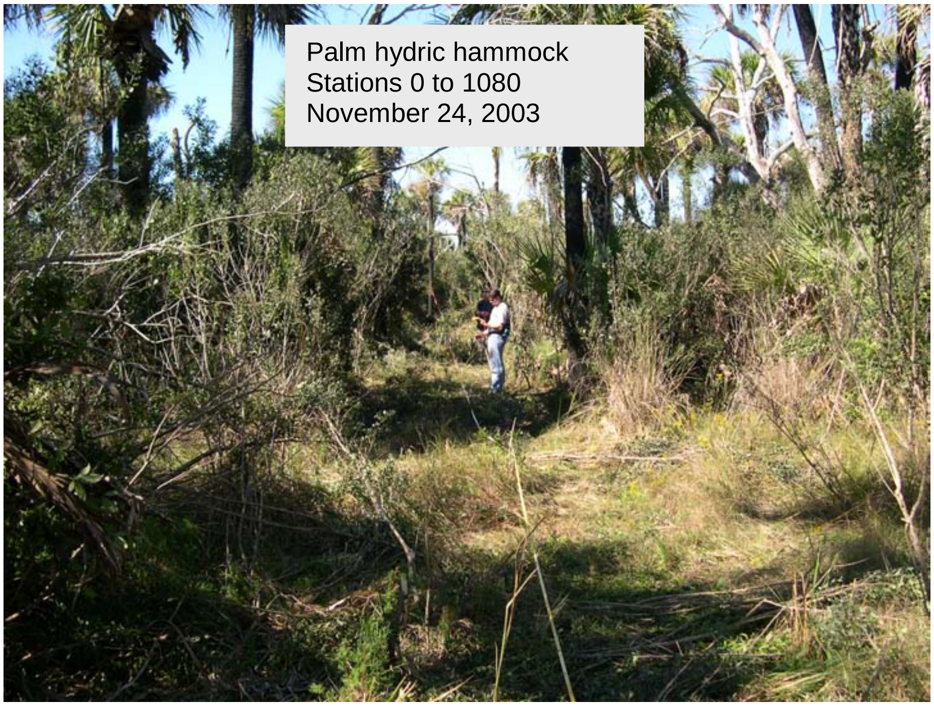


Figure 23. TOSO-528 Transect photos

Figure 23. TOSO-528 Transect photos—*continued*

Figure 23. TOSO-528 Transect photos—*continued*

Figure 23. TOSO-528 Transect photos—*continued*

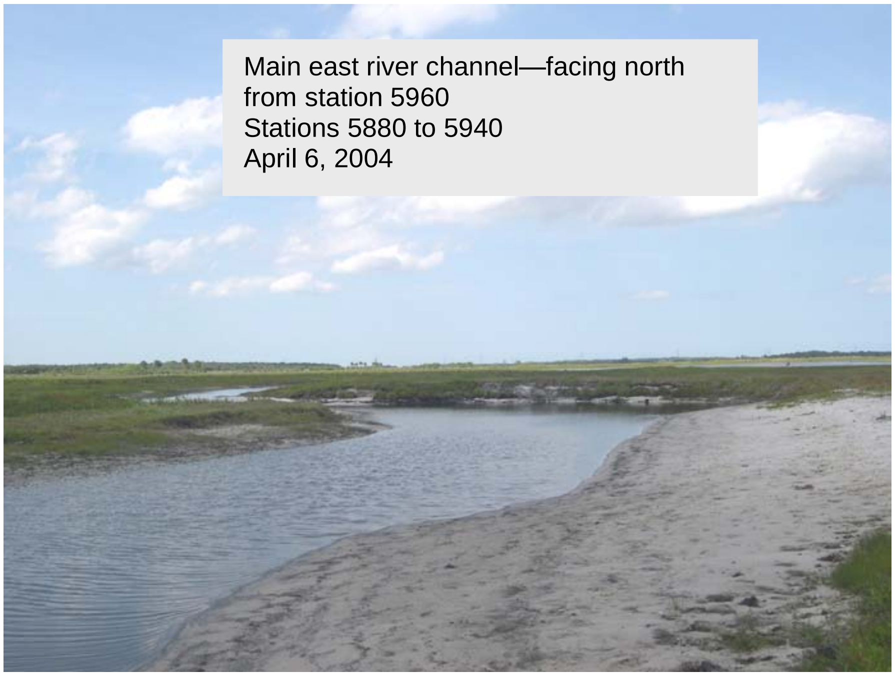


Figure 23. TOSO-528 Transect photos—*continued*

Figure 23. TOSO-528 Transect photos—*continued*

Table 41. TOSO-528 Transect vegetation community statistics

Vegetation Community	Stations Distance (ft)	Mean (ft NGVD)	Median (ft NGVD)	Min (ft NGVD)	Max (ft NGVD)	N
Palm hydric hammock	0–1080	13.5	13.4	12.5	14.4	55
Transitional hammock–upper wet prairie	1080–1640	12.0	12.1	11.2	12.7	29
Upper wet prairie	1640–2100	10.8	10.9	10.1	11.2	24
Remnant levee and ditch	2100–2300	9.9	10.2	8.3	10.8	11
Shallow marsh #1	2300–2780	9.1	9.0	8.5	9.8	24
West river channel	2795–2865	4.8	4.8	2.8	7.2	15
Shallow marsh #2	2865–3480	8.6	8.7	6.9	9.6	29
Main river channel	3485–3645	4.8	4.7	3.5	7.5	32
Shallow marsh #3	3645–6460	8.2	8.2	7.0	9.0	131
Secondary river channel	4733–4802	6.1	5.9	5.2	7.2	15
East river channel	5880–5940	5.7	5.7	4.1	7.2	14
Wet prairie	6460–8900	10.0	10.1	8.6	10.8	123
Wet prairie and Upper wet prairie	6460–8900 1640–2100	10.1	10.2	8.6	11.2	147
Shallow marshes #1 and #2	2300–2780 2865–3480	8.8	8.8	6.9	9.8	53
Shallow marshes #1–3	2300–2780 2865–3480 3645–6460	8.4	8.4	6.9	9.8	184

ft NGVD = feet National Geodetic Vertical Datum

fall panic grass, southern beakrush, horned beakrush, marsh fleabane, panic grass, saltmarsh mallow, winged loosestrife (*Lythrum alatum*), bull arrowhead, knotroot bristlegrass (*Setaria geniculata*), spider lily

(*Hymenocallis sp*.), yellowtop, lake rush (*Fuirena squarrosa)*, flat–topped goldenrod (*Euthamia minor*), star rush (*Dichromena colorata*), saw grass, water horn fern (*Ceratopteris thalictroides*), coinwort, swamp fern, bushy broom grass, and groundsel tree. The transitional hammock–upper wet prairie community vegetation is similar to the upper wet prairie vegetation except for the presence of more cabbage palms and less sand cordgrass in the transitional hammock–upper wet prairie community.

Table 42. TOSO-528 Transect vegetation species list

Scientific Name	Common Name	FWDM[1] Code	Plant Community Species Cover Estimates[2] PHH (0–1080)	TH–UWP (1080–1640)	UWP (1640–2100)	Remnant Levee (2100–2300)	SM #1 (2300–2780)	SM #2 (2865–3480)	SM #3 (3645–6460)	WP (6460–8900)
Alternanthera philoxeroides	Alligator weed	OBL			0					
Sacciolepis striata	American cupscale	OBL					1	2		
Teucrium canadense	American germander	FACW		0						
Rubus sp.	Blackberry	FAC	1	0						
Sesbania vesicaria	Bladder Pod	FAC							0	
Schinus lerebinthifolius	Brazilian pepper	FAC	1							
Sagittaria lancifolia	Bull arrowhead	OBL	1	1	2–3					1
Andropogon glomeratus	Bushy broom grass	FACW	2	1	0					
Senecio glabellus	Butterweed	OBL							1	
Cephalanthus occidentalis	Buttonbush	OBL					2	1		
Sabal palmetto	Cabbage palmetto	FACW	2	2	0			0		
Salix caroliniana	Carolina willow	OBL	0							
Echinochloa walteri	Coast cockspur–grass	FACW			3				3	
Centella asiatica	Coinwort	FACW		1	1					
Eupatorium capillifolium	Dog fennel	FAC	1				1	1	2	
Polygonum punctatum	Dotted smartweed	OBL	0				2	2	2–3	
Panicum dichotomiflorum	Fall panic grass	FACW	1	1	0		1	2	2	
Baccharis angustifolia	False willow	OBL	1							
Asclepias lanceolata	Fen-flower milkweed	OBL		0						
Thalia geniculata	Fire-flag	OBL			0		3	2–3	2	
Erechtites hieracifolia	Fireweed	FAC							1	
Euthamia minor	Flat-topped goldenrod	FAC		1						
Fimbristylis puberula	Fringe rush	FACW	0		0					
Cyperus polystachyos	Flat sedge	FACW			0					
Phyla nodiflora	Frog-fruit	FAC			0					
Setaria magna	Giant foxtail	OBL	0	2	1		0	2	1	
Baccharis glomeruliflora	Groundsel tree	FACW	3	1	1				0	1
Rhynchospora inundata	Horned beakrush	OBL	1	1	0					
Equisetum hyemale	Horsetail	FACW							1	
Paspalum distichum	Knot grass	OBL			1				1	

Table 42—*Continued*

Scientific Name	Common Name	FWDM[1] Code	Plant Community Species Cover Estimates[2]							
			PHH (0–1080)	TH–UWP (1080–1640)	UWP (1640–2100)	Remnant Levee (2100–2300)	SM #1 (2300–2780)	SM #2 (2865–3480)	SM #3 (3645–6460)	WP (6460–8900)
Setaria geniculata	Knotroot bristlegrass	OBL	0	1	0					
Fuirena squarrosa	Lake rush	OBL	0	1	0					
Panicum hemitomon	Maidencane	OBL			0		0			
Pluchea rosea	Marsh fleabane	FACW	1	1	0		1		2	
Hydrocotyle umbellata	Marsh pennywort	OBL	1		0					
Conoclinium coelestinum	Mistflower	FAC	1		1					
Ptilimnium capillaceum	Mock bishop's weed	FACW							2–3	
Hyptis alata	Musky mint	FACW	1	0	0					
Cirsium nuttallii	Nuttail's thistle	FACW		0				0		
Panicum ensifolium	Panic grass	OBL	1	1						
Pontederia cordata	Pickerelweed	OBL	1	0	2		1		2–3	
Ambrosia artemisiifolia	Ragweed	UPL				2				
Ludwigia repens	Red ludwigia	OBL			1			1	2	
Acer rubrum	Red maple	FACW								0
Eustachys glauca	Saltmarsh finger grass	FACW	2							
Kosteletzkya virginica	Saltmarsh mallow	OBL		1	0					
Spartina bakeri	Sand cordgrass	FACW	2	4	5	2	2–4	3	1	5
Quercus geminate	Sand live oak (dead/burned)	UPL	1							
Cladium jamaicense	Saw grass	OBL	1	1						1
Eupatorium milanioides	Semaphore thoroughwort	FACW		0						
Cyperus haspan	Sheathed flatsedge	OBL	0		0					
Pinus elliottii	Slash pine (burned/dead)	FACW	1							
Polygonum densiflorum	Smartweed	OBL						1	1	
Juncus effuses	Soft rush	FACW	1		1			1		
Scirpus validus	Softstem bulrush	OBL					1		1	
Rhynchospora microcarpa	Southern beakrush	OBL	1	1	0					
Juniperus silicicola	Southern red cedar (burned/dead)	FAC	2							
Juniperus silicicola	Southern red cedar saplings	FAC	2							

Table 42—*Continued*

Scientific Name	Common Name	FWDM[1] Code	Plant Community Species Cover Estimates[2]							
			PHH (0–1080)	TH–UWP (1080–1640)	UWP (1640–2100)	Remnant Levee (2100–2300)	SM #1 (2300–2780)	SM #2 (2865–3480)	SM #3 (3645–6460)	WP (6460–8900)
Amaranthus australis	Southern water hemp	OBL		0				0		
Hymenocallis sp.	Spider lily	OBL		1	1					
Eleocharis sp.	Spikerush	OBL	0	0	0				0	
Hypericum hypericoides	St. Andrew's cross	FAC	1							
Hypericum cistifolium	St. John's wort	FACW	1							
Dichromena colorata	Star rush	FACW		1	0					
Galium tinctorium	Stiff marsh bedstraw	FACW							2	
Erianthus giganteus	Sugarcane plumegrass	OBL			1					
Blechnum serrulatum	Swamp fern	FACW	1	1						
Hibiscus grandiflorus	Swamp hibiscus	OBL					2	1	1	2
Panicum commutatum	Variable panic grass	FAC	1							
Ceratopteris thalictroides	Water horn fern	OBL		1						
Eichhornia crassipes	Water hyacinth	OBL						1	1	
Bacopa monnieri	Water hyssops	OBL			0					
Samolus parviflorus	Water pimpernel	OBL	1	0						
Habenaria repens	Water spider orchid	FACW		0						
Myrica cerifera	Wax myrtle	FAC	3	2	1			0		2
Lythrum alatum	Winged loosestrife	FACW		1				1		

Table 42—*Continued*

Scientific Name	Common Name	FWDM[1] Code	Plant Community Species Cover Estimates[2]							
			PHH (0–1080)	TH–UWP (1080–1640)	UWP (1640–2100)	Remnant Levee (2100–2300)	SM #1 (2300–2780)	SM #2 (2865–3480)	SM #3 (3645–6460)	WP (6460–8900)
Manisuris rugosa	Wrinkled joint–tail grass	FACW	0							
Flaveria linearis	Yellowtop	FACW	1	1						

[1]FWDM Code Indicator categories established in Florida Wetlands Delineation Manual (Gilbert et al.1995)

Upland (UPL) = Plants that occur rarely in wetlands, but occur almost always in uplands

Facultative (FAC) = Plants with similar likelihood of occurring in both wetlands and uplands

Facultative Wet (FACW) = Plants that typically exhibit their maximum cover in areas subject to surface water flooding and/or soil saturation, but may also occur in uplands

Obligate (OBL) = Plants that are found or achieve their greatest abundance in an area which is subject to surface water flooding and/or soil saturation; rarely uplands

[2] Plant Community Species Cover Estimates: Aerial extent of vegetation species along transect within given community where 0 = <1% (rare); 1 = 1–10% (scattered); 2 = 11–25% (numerous); 3 = 26–50% (abundant); 4 = 51–75% (co–dominant); and 5 = greater than 75% (dominant)

PHH = Palm hydric hammock (stations 0–1080)
TH–UWP = Transitional hammock–upper wet prairie (stations 1080–1640)
UWP = Upper wet prairie (stations 1640–2100)
Levee = Remnant levee (stations 2100–2300)
SM#1 = Shallow marsh #1 (stations 2300–2780)
SM#2 = Shallow marsh #2 (stations 2865–3480)
SM#3 = Shallow marsh #3 (stations 3645–6460)
WP= Wet Prairie (stations 6460–8900)

The upper wet prairie (stations 1640–2100) vegetation included dominant sand cordgrass; abundant coastal cockspur-grass; numerous pickerelweed; numerous to abundant bull arrowhead; and scattered giant foxtail, groundsel tree, knot grass, mistflower, wax myrtle, spider lily (*Hymenocallis sp.*), coinwort, soft rush, red ludwigia, sugarcane plumegrass, and cabbage palm. The upper wet prairie ended at station 2100 where the TOSO-528 Transect traversed a remnant levee (stations 2100–2300). The remnant levee was sparsely vegetated with numerous ragweed (*Ambrosia artemisiifolia*) and numerous sand cordgrass. The most distinguishing characteristic between the upper wet prairie and the wet prairie (stations 6460–8900) traversed at the TOSO-528 Transect was the absence of cabbage palm in the wet prairie.

Downslope from the remnant levee, the transect traversed shallow marsh #1 (stations 2300–2780). Shallow marsh #1 vegetation included abundant fire-flag; numerous to co-dominant sand cordgrass; numerous buttonbush, dotted smartweed, and swamp hibiscus; and scattered softstem bulrush, dog fennel, marsh fleabane, pickerelweed, American cupscale, and fall panic grass.

Adjacent to shallow marsh #1, the transect traversed the west most river channel (stations 2795–2865). Then the TOSO-528 Transect traversed shallow marsh #2 (stations 2865–3480). Shallow marsh #2 vegetation included abundant sand cordgrass; numerous to abundant fire-flag; numerous dotted smartweed, giant foxtail, American cupscale, and fall panic grass; and scattered water hyacinth, buttonbush, dog fennel, swamp hibiscus, soft rush, red ludwigia, winged loosestrife, and smartweed.

East of shallow marsh #2 the TOSO-528 Transect traversed the main river channel (stations 3485–3645). Next, the transect traversed shallow marsh #3 (stations 3645–6460). Shallow marsh #3 vegetation included abundant coastal cockspur-grass; numerous to abundant dotted smartweed, pickerelweed, and mock bishop’s weed; numerous red ludwigia, marsh fleabane, fall panic grass, stiff marsh bedstraw, fire-flag, dog fennel; and scattered smartweed, butterweed, sand cordgrass, giant foxtail, southern beakrush, swamp hibiscus, water hyacinth, fireweed, horsetail, and knot grass (*Paspalum distichum*). Several secondary channels, shallow pools, and the east most river channel (stations 5880–5940) were traversed within shallow marsh #3.

Adjacent to shallow marsh #3 the TOSO-528 Transect terminated within a wet prairie community (stations 6460–8900). Wet prairie vegetation included dominant sand cordgrass; numerous wax myrtle and swamp hibiscus; and scattered saw grass, bull arrowhead, and groundsel tree. Additional plant species observed along the TOSO-528 Transect are listed in Table 42.

Soils at the TOSO-528 Transect

Soil auger holes were dug at 36 selected stations to characterize the soils along the TOSO-528 Transect between stations 0 and 8900 on December 10, 2003, January 12, 2004, and April 6, 2004 (Table 43). Soils were characterized based upon epipedons, horizons, soil texture, soil color, and horizon depth. These soil features were used to determine the soil series at each station. One or more hydric soil indicators (muck, mucky mineral, dark surface, loamy gleyed matrix and / or stripped matrix) were observed at all sampled stations.

Table 43. TOSO-528 Transect soil descriptions

Station/Series	Vegetation Community	Soil Horizon	Horizon Description
0/Wabasso	Palm hydric hammock	A1 0–0.5”	Black mucky sand
		A2 0.5–2”	Very dark gray sand
		E 2–7”	Dark gray and gray sand; stripping present
		Bh 7–14”	Very dark gray and dark grayish brown sand with few, fine, distinct yellowish red redoxomorphic concentrations
		BhBw 14–19”	Dark grayish brown with yellowish brown sand
300/Wabasso	Palm hydric hammock	Oa 0–0.5”	Black muck
		A1 0.5–1.5”	Black mucky sand
		A2 1.5–4.5”	Black sand
		AE 4.5–11”	Very dark gray and dark gray sand; stripping present
		EA 11–20”	Very dark gray, dark gray, and gray sand with few, fine, distinct yellowish red redoxomorphic concentrations
		Bh 20–25”	Very dark gray and dark grayish brown sand with few, fine, faint yellowish brown redoxomorphic concentrations
		Bw 25–32”	Yellowish brown and gray sand
		Cg 32”+	Dark gray with greenish gray sandy clay loam with many, medium, distinct yellowish brown redoxomorphic concentrations

Table 43—*Continued*

Station/Series	Vegetation Community	Soil Horizon	Horizon Description
500/Wabasso	Palm hydric hammock	Oa 0–1”	Black muck
		A 1–4”	Black sand; stripping present
		EBh 4–20”	Very dark gray, dark grayish brown, and gray sand; stripping present
		Bw 20–36”	Grayish brown and pale brown sand with many, medium, distinct yellowish brown redoxomorphic concentrations
		Cg 36”+	Dark gray with greenish gray sandy clay loam with many, medium, distinct yellowish brown redoxomorphic concentrations
640/Manatee variant	Palm hydric hammock	Oa 0–2”	Black muck
		A1 2–3”	Black mucky sand
		A2 3–8”	Black sand
		Cg1 8–24”	Black sandy loam
		Cg2 24–36”	Black loamy sand
		Cg3 36–42”	Dark gray with greenish gray sandy clay loam with few, fine, distinct yellowish brown redoxomorphic concentrations
		Cg4 42”+	Greenish gray sandy clay loam
840/Wabasso	Palm hydric hammock	Oa 0–4”	Black muck
		A1 4–6”	Black mucky sand
		A2 6–11”	Black loamy sand
		EgBh 11–26”	Very dark gray and dark grayish brown loamy sand.
		Cg 26”+	Dark gray and gray sandy clay loam with few, medium, distinct yellowish brown redoxomorphic concentrations
940/Wabasso	Palm hydric hammock	Oa 0–2”	Black muck
		A 2–3”	Black mucky sand
		EgBh 3–7’	Very dark gray, dark grayish brown, and gray sand; stripping present
		Bw 7–34”	Dark grayish brown, grayish brown, and light brownish gray sand; stripping present
		Cg 34”+	Dark gray with greenish gray sandy clay loam with few, fine, distinct yellowish brown redoxomorphic concentrations
1140/Wabasso	Transitional hammock–upper wet prairie	Oa 0–1”	Black muck
		AE 1–17”	Very dark gray and dark gray sand; stripping present
		Bh 17–30”	Dark grayish brown sand with few, medium, distinct yellowish brown redoxomorphic concentrations
		Cg 30”+	Dark gray with greenish gray (N 4/, 5G 5/) sandy clay loam with many, medium, distinct yellowish brown redoxomorphic concentrations

Table 43—*Continued*

Station/Series	Vegetation Community	Soil Horizon	Horizon Description
1300/Wabasso	Transitional hammock–upper wet prairie	Oa 0–1”	Black muck
		A 1–6”	Black sand
		EgBh 6–17”	Very dark gray and dark grayish brown sand; stripping present
		BwEg 17–28”	Dark gray and grayish brown sand with many, medium, distinct brownish yellow redoxomorphic concentrations
		Cg 28”+	Dark gray with greenish gray sandy clay loam with many, medium, distinct yellowish brown redoxomorphic concentrations
1400/Floridana	Transitional hammock–upper wet prairie	Oa 0–1.5”	Black muck
		A1 1.5–2”	Black mucky sand
		A2 2–5”	Very dark gray sand; stripping present
		A3 5–19”	Black loamy sand
		EgBw 19–27”	Dark gray and gray brown sand with few, fine, faint yellow redoxomorphic concentrations
		Cg 27”+	Dark gray with greenish gray sandy clay loam with many, medium, distinct yellowish brown redoxomorphic concentrations
1540/Floridana variant	Transitional hammock–upper wet prairie	Oa 0–4”	Black muck
		A1 4–9”	Black loamy sand
		A2 9–16”	Very dark gray sandy loam
		Eg 16–24”	Dark gray and gray sand with few, fine, faint yellow redoxomorphic concentrations
		Cg 24”+	Dark gray with greenish gray sandy clay loam with many, medium, distinct yellowish brown redoxomorphic concentrations
1700/Chobee	Upper wet prairie	Oa 0–6”	Black muck
		A 6–8”	Black mucky sand
		Cg 8–20”+	Black clay loam
1800/Chobee	Upper wet prairie	Oa 0–5.5”	Black muck
		A 5.5–9”	Black mucky sand; within this layer is a band of black and light gray sand 0.5 in.es thick
		Cg1 9–22”	Black clay loam
		Cg2 22”+	Dark gray with greenish gray sandy clay loam with many, medium, distinct yellowish brown redoxomorphic concentrations

Table 43—*Continued*

Station/Series	Vegetation Community	Soil Horizon	Horizon Description
2000/Eaton	Upper wet prairie	Oa 0–2”	Black muck
		A 2–2.5”	Black mucky sand
		AE 2.5–7.5”	Very dark gray and dark gray sand; stripping present
		Eg1 7.5–16”	Gray and light brownish gray sand with few, fine, faint yellow redoxomorphic concentrations
		Eg2 16–27”	Gray and light brownish gray sand with few, fine, faint yellowish brown redoxomorphic concentrations
		Cg 27”+	Dark gray with greenish gray sandy clay loam with many, medium, distinct yellowish brown redoxomorphic concentrations
2200/Floridana	Levee	C 0–7”	Sandy clay loam dredged material from construction of levee
		Ab1 7–11”	Black sand
		Ab2 11–15”	Black loamy sand
		Ebg 15–29”	Dark gray and gray sand with few, fine, distinct brownish yellow redoxomorphic concentrations
		Cbg 29”+	Dark gray with greenish gray sandy clay loam with many, medium, distinct yellowish brown redoxomorphic concentrations
2400/Chobee	Shallow marsh #1	Oa 0–5”	Black muck
		A 5–6”	Black mucky sand
		Cg1 6–14”	Black loamy sand
		Cg2 14”+	Black silty clay
2500/Chobee	Shallow marsh #1	Oa 0–5.5”	Black muck
		A 5.5–6”	Black mucky sand
		Cg1 6–10”	Black loamy sand
		Cg2 10”+	Black silty clay
2600/Chobee	Shallow marsh #1	Oa 0–3.5”	Black muck
		A 3.5–5”	Black mucky loam
		Cg1 5–13”	Black clay loam
		Cg2 13–23”+	Black silty clay
2700/Manatee	Shallow marsh #1	Oa 0–2”	Black muck
		A 2–4”	Black mucky sandy loam
		Cg1 4–12”	Black sandy loam
		Cg2 12–18”+	Black silty clay

Table 43—*Continued*

Station/Series	Vegetation Community	Soil Horizon	Horizon Description
3000/Manatee	Shallow marsh #2	Oa 0–2”	Black muck
		A 2–3”	Black mucky loamy sand
		Cg1 3–21”	Black sandy loam
		Cg2 21–22”	Gray sand
		Cg3 22”+	Black silty clay
3280/Chobee	Shallow marsh #2	Oa 0–1”	Black muck
		A 1–2”	Black mucky loamy sand
		Cg1 2–8.5”	Black sandy loam
		Cg2 8.5–15”+	Black silty clay
3420/Unknown fluvaquent	Shallow marsh #2	Oa 0–1”	Black muck
		A 1–2”	Black mucky loamy sand
		Cg1 2–5”	Black clay loam
		Cg2 5–8”	Black silty clay
		Cg3 8–29”	Light brownish gray with black sand
		Cg4 29–31”	Black muck
		Cg5 31–51”	White sand
		Cg6 51–52”	Black muck
		Cg7 52”+	White sand
3900/Chobee	Shallow marsh #3	Oa 0–2”	Black muck
		A 2–2.5”	Black mucky loamy sand
		Cg1 2.5–9”	Black sandy loam
		Cg2 9–17”	Black sandy clay
		Cg3 17–22”	Black sandy clay loam
		Cg4 22–25”	Black sandy loam
		Cg5 25”+	Black sandy clay
4100/Manatee	Shallow marsh #3	Oa 0–4”	Black muck
		A 4–4.5”	Black mucky loamy sand
		Cg1 4.5–13”	Black sandy loam
		Cg2 13–16”	Black sandy clay loam
		Cg3 16–20”	Black sandy loam
		Cg4 20–42”	Very dark gray, dark gray, and gray sand with pockets of very dark gray sandy clay
		Cg5 42”+	Light gray sand

Table 43—*Continued*

Station/Series	Vegetation Community	Soil Horizon	Horizon Description
4300/Chobee	Shallow marsh #3	Oa 0–3”	Black muck
		A 3–4”	Black mucky sandy loam
		Cg1 4–9”	Black sandy loam
		Cg2 9–18”	Black sandy clay loam
		Cg3 18”+	Black and gray sandy loam
4500/Manatee	Shallow marsh #3	Oa 0–5”	Black muck with black sandy loam
		Cg1 5–13”	Black sandy loam
		Cg2 13–18”+	Black sandy clay
4700/Manatee	Shallow marsh #3	Oa 0–3”	Black muck
		A 3–4”	Black mucky loamy sand
		Cg1 4–11”	Black sandy loam
		Cg2 11–18”+	Black sandy clay
5000/Floridana variant	Shallow marsh #3	Oa 0–6”	Very dark gray muck
		A 6–11”	Very dark brown mucky loam
		Cg1 11–17”	Very dark gray sandy clay loam w /pockets of gray sand
		Cg2 17–28”	Light gray and dark gray sand
		Cg3 28–32”	Dark gray loamy sand
		Cg4 32–43”	Very dark gray clay loam
		Cg5 43–46”	Very dark gray sandy loam
		Cg6 46–50”+	Very dark gray clay loam
5500/Chobee	Shallow marsh #3	Oa 0–4”	Very dark grayish brown muck
		Cg1 4–7”	Very dark gray loam
		Cg2 7–15”	Very dark gray clay loam
		Cg3 15–18”	Dark gray sandy clay loam
		Cg4 18–46”+	Dark gray sandy clay loam
5700/Chobee	Shallow marsh #3	Oa 0–6”	Very dark grayish brown muck
		A 6–11”	Very dark brown mucky sandy loam
		Cg1 11–16”	Very dark gray clay loam
		Cg2 16–19”	Gray loamy sand
		Cg3 19–22”	Dark gray sandy loam
		Cg4 22–45”	Dark gray sandy clay loam
		Cg5 45–48”+	Gray loamy sand withyellowish brown redoxomorphic concentrations

Table 43—*Continued*

Station/Series	Vegetation Community	Soil Horizon	Horizon Description
6300/Unknown cumulic argiaquoll	Shallow marsh #3	Oa 0–7”	Very dark gray muck
		A 7–10”	Very dark brown mucky loam
		Cg1 10–15”	Black loam
		Cg2 15–20”	Black clay loam
		Cg3 20–23”	Black sandy loam
		Cg4 23–39”+	Very dark gray sandy clay loam
6600/Floridana	Wet prairie	Oa 0–2”	Very dark brown muck
		A 2–9”	Very dark grayish brown mucky loam
		Cg1 9–11”	Black sandy loam
		Cg2 11–13”	Black loamy sand
		Cg3 13–18”	Gray loamy sand
		Cg4 18–21”	Gray sandy loam
		Cg5 21–35”	Dark gray sandy clay loam
		Cg6 35–46”+	Dark gray and gray sandy clay loam withredoxomorphic features along root channels; horizon increases in coarse sand with depth
7300/Floridana	Wet prairie	Oa 0–3”	Very dark brown muck
		A1 3–8”	Black mucky loam
		A2 8–12”	Black mucky sandy loam
		Cg1 12–21”	Gray sand with redoxomorphic features
		Cg2 21–28”	Gray loamy sand
		Cg3 28–33”	Gray sandy loam
		Cg4 33–40”+	Gray sandy clay loam with redoxomorphic features
7700/Eaton variant	Wet prairie	Oa 0–7”	Very dark brown muck
		Cg1 7–15”	Dark gray and gray sandy loam
		Cg2 15–35”	Gray loamy sand
		Cg3 35–42”+	Gray sandy clay loam with many dead roots
8000/Denaud	Wet prairie	Oa 0–9”	Very dark gray muck
		A 9–12”	Very dark brown mucky loam
		Cg1 12–14”	Black loam
		Cg2 14–15”	Very dark brown loamy sand
		Cg3 15–40”+	Gray coarse sand with yellowish brown redoxomorphic Concentrations; redoxomorphic concentrations darken to grayish brown with depth

Table 43—*Continued*

Station/Series	Vegetation Community	Soil Horizon	Horizon Description
8500/Denaud	Wet prairie	Oa 0–8”	Very dark grayish brown muck
		A 8–10”	Very dark brown mucky loam
		Cg1 10–13”	Black sandy loam
		Cg2 13–15”	Black coarse sand
		Cg3 15–35”	Gray coarse sand
		Cg4 35”+	Gray sandy clay loam
8800/Eaton variant	Wet prairie	Oa 0–4”	Very dark grayish brown muck
		A1 4–6”	Black sandy loam
		A2 6–10”	Black loamy sand
		Cg1 10–28”	Gray coarse sand with yellowish brown redoxomorphic concentrations starting at 24”
		Cg2 28–36”+	Dark gray sandy clay loam with gray redoxomorphic depletions

As mentioned previously, fluvial and other hydrologic processes constantly modify the soils throughout the St. Johns River floodplain. Sediment accretion frequently occurs during flood activities, creating transitory features within the soils, especially those closest to the stream channels (Lindbo and Richardson 2001). When the river rises and inundates the floodplain, erosional and depositional processes combine to deposit coarse sediments at the edge of the floodplain (nearest the channel) and finer-textured material throughout the floodplain. Consequently, sediments found in the St. Johns River floodplain can be comprised of depositional material transported from upstream, depositional material derived locally from channel erosion, and parent material that has been reworked from centuries of flood events. Numerous relatively thin soil horizons can occur from frequent deposition of alluvial sediments and often result in accretion topography. As a result, soil features such as texture and color can vary greatly over a short distance (D. Segal, pers. comm., 2004). In the St. Johns River floodplain, fine-textured material may occur near the surface in one place and at a depth of as much as 48 in. below the soil surface at a nearby location (Leighty et al. 1957).

The history of erosional and depositional processes in the St. Johns River floodplain gives rise to a complex distribution of soils across the floodplain. Lateral and horizontal changes in sediment deposition result in soil series with a large degree of variability (Lindbo and Richardson 2001). This combination makes the identification of soil series difficult due to the high variability of soil features found across the TOSO-528 Transect. Often soil features found at a given site will not conform to the characteristics of any particular soil series (Segal, pers. comm., 2004). Because the soils descriptions resulted in many discrepancies with the official soil series descriptions, Wade Hurt, hydric soil scientist with the USDA, NRCS, in Gainesville, Florida, was consulted to help identify the correct soil series that most closely represented the described soils. Wabasso, Manatee, Floridana, Chobee, Eaton, and Denaud soil series were observed at the TOSO-528 Transect. Additionally, Manatee variant, Floridana variant, Eaton variant, and an unknown fluvaquent soils were observed (Table 43).

The soil series and the soil taxonomic classification subgroup are briefly described below for each soil station sampled at the TOSO-528 Transect. The soil taxonomic classification subgroup provides additional information for each soil series and is interpreted starting at the right–hand side of the subgroup name and progressing to the left (JEA 2004; Appendix C).

Wabasso soil was observed beginning at station 0 of the palm hydric hammock and extended into the transitional hammock–upper wet prairie at the TOSO-528 Transect, (Table 43). Wabasso soils were formed in sandy and loamy marine sediments. Wabasso soils are poorly and very poorly drained, typically occurring in flatwoods, floodplains, and depressions. The Wabasso soil water table occurs at depths of 12 to 40 in. below the soil surface for more than six months in most years. It occurs at depths of less than 12 in. below the soil surface for less than 60 days during the wet season and occurs at depths of greater than 40 in. below the soil surface during very dry seasons. In depressions, Wabasso soils are ponded for periods of six to nine months in most years (NRCS 2003).

Wabasso soil is classified as an Alfic Alaquod, meaning it is a Spodosol. The spodic horizon in Wabasso soil is shallow, within 20 in. of the soil surface. Development of the spodic horizon indicates a more stable landscape where drainage is slightly improved. A spodic horizon cannot develop in very poorly drained areas where fluvial processes, such as erosion and accretion continue to occur. Wabasso soil is poorly drained and in the aquic moisture regime. Wabasso soils contain an argillic horizon that is high in base saturation and this argillic horizon occurs within 40 in. of the soil surface. While all Spodosols contain a spodic horizon, not all Spodosols have an argillic horizon. Both the spodic and argillic horizons are hardpan layers that impede vertical water movement and can cause surface saturation during high rain events. These hardpan layers, along with a low landscape position, contribute to the poorly drained moisture classification of Wabasso soil (JEA 2004; Appendix C).

A Manatee variant soil was also observed in the palm hydric hammock at one location (station 640) in a depression. Manatee and/or Manatee variant soil also occurred at one location within shallow marsh #1, one location within shallow marsh #2, and at three locations within shallow marsh #3 (Table 43). Manatee soil differs considerably from Wabasso. Manatee soil is very poorly drained rather than poorly drained. In addition, Manatee soil contains a thick accumulation of surface organic material, indicative of a mollic epipedon, lacks a spodic horizon, and contains less sand and more fine-textured soils. The Manatee series consists of very deep, very poorly drained, moderately permeable soils in depressions, broad drainage ways, and on floodplains. The Manatee soil water table occurs within 10 in. of the soil surface for more than six months annually during most years. Depressional areas with Manatee soil are ponded for about six to nine months during most years (NRCS 2003).

The taxonomic classification subgroup for Manatee soil is a Typic Argiaquoll, meaning it is a mollisol in the aquic moisture regime, containing an argillic horizon and the argillic horizon occurs within 20 in. of the soil surface. Again, the presence of a mollic epipedon is indicative of the high concentrations of organic matter that develops and persists in flooded soils (JEA 2004; Appendix C).

Downslope from the palm hydric hammock in the transitional hammock–upper wet prairie, the Floridana and Floridana variant soil series was observed at one location each and the Wabasso soil was observed at two locations (Table 43). Floridana series consists of very deep, very poorly drained, slowly to very slowly permeable soils on low broad flats, floodplains, and in depressional areas. The Floridana water table occurs at depths of less than 10 in. below soil surface and depressional areas are ponded for more than six months during most years. Floodplains are flooded for one to three months during most years (NRCS 2003).

The taxonomic classification subgroup for Floridana soil is an Arenic Argiaquoll, meaning it is a Mollisol. All Mollisols have a mollic epipedon. The mollic epipedon is a collection of thick dark surface horizons that are high in organic matter and are predominantly black. Floridana is very poorly drained and in the aquic moisture regime. The arenic adjective implies that the argillic horizon occurs at depths of 20 to 40 in. below the soil surface. Floridana lacks a spodic horizon, presumably because the site is too wet to form a spodic (JEA 2004; Appendix C).

Downslope, in the upper wet prairie (stations 1640–2100), Chobee and Eaton series soils were observed (Table 43). As mentioned previously, according to the NRCS (2003), the Chobee series consists of very deep, very poorly drained, slowly to very slowly permeable soils occurring in depressions, flats, and occasionally on river floodplains. The Chobee water table occurs within 6 in. of the soil surface for one to four months during most years. Depressional areas are ponded for long durations (NRCS 2003). According to the *Soil Survey of Brevard County, Florida* (USDA, SCS 1974), the Chobee soil water table occurs within a depth of 10 in. of the soil surface for six to nine months and within a depth of 10 to 40 in. of the soil surface for three to six months. In very dry seasons, the water table occurs at depths greater than 40 in. below the soil surface for short periods. Chobee soil is continuously flooded for one to six months in many places (USDA, SCS 1974).

The taxonomic classification subgroup for Chobee soil is a Typic Argiaquoll, meaning it is a mollisol in the aquic moisture regime, containing an argillic horizon and the argillic horizon is within 20 in. of the soil surface. Again, the presence of a mollic epipedon is indicative of the high concentrations of organic matter that develops and persists in flooded soils (JEA 2004; Appendix C).

The Eaton series consist of poorly and very poorly drained soils formed in clayey marine sediments with a water table that occurs at depths of less than 10 in. below the soil surface for periods of one to four months during most years. Depressional areas are ponded for very long periods (NRCS 2003). The taxonomic classification subgroup for Eaton soil is an Arenic Albaqualf. Eaton is an Alfisol meaning it has an argillic horizon that is high in base saturation. It is poorly drained and in the aquic moisture regime, and contains light-colored albic subsurface horizon(s). The arenic adjective implies that the argillic horizon occurs at depths of 20 to 40 in. below the soil surface (JEA 2004; Appendix C).

Between stations 2100 to 2300 the TOSO-528 Transect traversed a remnant levee where, at station 2200, the soil was Floridana. Downslope from the remnant levee, the transect traversed shallow marsh #1 where the soils were Chobee (stations 2400, 2500, and 2600) and Manatee (station 2700) (Table 43).

Soils in the center of the TOSO-528 Transect between approximately stations 2300 to 6460 were more closely associated with the multiple river channels and were located in the shallow marsh communities. Likewise, these shallow marsh soils exhibited noticeably different soil characteristics than soils at the higher elevations farther from the river channels. Finer-textured soils, such as sandy loam, clay loam, sandy clay loam, and silty clay, replaced the sandy subsurface horizons noted at the higher elevations (Table 43). A complex distribution of soils occurred in the shallow marshes that are under the greatest influence of the multiple river channels. Consequently, the soil series changed from one station to the next. These soils in the shallow marshes are considered geologically young and constantly changing, whereas soils at the higher elevations, especially in the palm hydric hammock are more stable, geologically older, and exhibit greater horizon development (Segal, pers. comm. 2004).

The western most river channel separates shallow marsh #1 from shallow marsh #2 (Figure 22). As mentioned previously, soil series observed within shallow marsh #1 were Chobee and Manatee. Soil series observed within shallow marsh #2 were Manatee, Chobee, and an unknown fluvaquent at one location each (Table 43). The main river channel separates shallow marsh #2 from shallow marsh #3 (Figure 22).

Soil series observed within shallow marsh #3 included Chobee, Manatee, Floridana variant, and an unknown cumulic argiaquoll (Table 43). Changes between soil stations were most prevalent in shallow marsh #3. Shallow marsh #3 is closely associated with the main river channel, as well as two minor channels, and the eastern most river channel (Figure 22). Numerous soil horizons were described at each soil sampling station in shallow marsh #3. The shallow marsh #3 soils are under the greatest influence of alluvial forces, both erosional and depositional, and are representative of accretion topography (Segal, pers. comm. 2004). The soil series observed within shallow marsh #3 (Chobee, Manatee, Floridana variant, and an unknown cumulic argiaquoll) were seemingly randomly scattered with no soil type occurring extensively (Table 43). Chobee, Manatee, and Floridana soil series are very similar soils but differ in that Floridana contains an argillic horizon that occurs at depths of 20 to 40 in. below the soil surface, whereas Chobee and Manatee soils contain an argillic horizon that occurs within 20 in. of the soil surface. At one time Chobee and Manatee were combined into one series, but now are separated based on soil texture within the upper 20 in. of the argillic horizon. Manatee has higher sand content and Chobee has higher clay content in the upper 20 in. of the argillic horizon (JEA 2004; Appendix C).

The primary soil characteristics that separated the four soil types identified in all the shallow marshes at the TOSO-528 Transect were the depth and texture of the argillic horizon. All soils identified in the shallow marshes are very poorly drained and share characteristics that are indicative of frequent flooding and/or saturation, which is typical for the aquic moisture regime (JEA 2004; Appendix C).

The TOSO-528 Transect terminated within a wet prairie (stations 6460–8900) located on the eastern floodplain. Similar to shallow marsh #3, none of the soil series observed within the wet prairie occurred extensively. Soils observed within the wet prairie included Floridana, an Eaton variant, and the Denaud series (Table 43). Denaud soils are very poorly drained and moderately permeable with a histic epipedon over sandy and loamy material. Under natural conditions, Denaud soils are ponded for six to nine months and are saturated to the surface the rest of the time during most years (NRCS 2003). The greatest accumulation of organic matter along the TOSO-528 Transect is represented by Denaud soils.

The taxonomic classification subgroup for Denaud soil is a Histic Humaquept. A Histic Humaquept is an Inceptisol meaning it is a young soil and has minimal horizon development, but more development than the youngest Entisols. Denaud soil is in the aquic moisture regime, has distinct organic material at the surface, and has a histic epipedon. A histic epipedon contains 8 to 16 in. of organic material. Denaud is the only soil sampled at the TOSO-528 Transect with a histic epipedon (JEA

2004; Appendix C). The histic epipedon present in Denaud soil could have resulted from groundwater seepage from the adjacent upland. Lindbo and Richardson (2001) described groundwater discharge from the upland to the edge of the floodplain often occurring along seepage slopes, resulting in organicrich soils at the upper edge of the floodplain. Consistent with Denaud soil stations along the Tosohatchee North transect, shallow ponding and/or saturation, indicating groundwater seepage, was noted on April 6, 2004, at the Denaud soil stations at the TOSO-528 Transect, when the St. Johns River stage occurred at a considerably lower elevation.

The soil characteristics that separated the three soil types identified in the wet prairie were the thickness of the surface organic horizon, the thickness of the mollic epipedon, and the texture and depth of the argillic horizon. All wet prairie soils share characteristics that are indicative of frequently flooded and oxygen depleted conditions, which is defined as the aquic moisture regime. Of the three wet prairie soil types, Eaton is classified as poorly drained while Denaud and Floridana are classified as very poorly drained (JEA 2004; Appendix C).

In summary, soils along the TOSO-528 Transect formed and persist in very wet conditions. The driest, although still poorly drained, soils occurred in the palm hydric hammock and the transitional hammock–upper wet prairie communities, while the wettest soils occurred in the shallow marshes and the wet prairie, more closely associated with the multiple river channels. Soils along the TOSO-528 Transect developed from frequent episodes of erosion and alluvial deposition. Soils in the shallow marshes nearest the river channels contain many thin, fine-textured soil horizons of sandy loam, clay loam, and sandy clay loam. These multiple fine-textured layers represent accretion topography from centuries of river flooding. Additionally, the majority of the soils along the entire TOSO-528 Transect had a mollic or histic epipedon. These two epipedons are representative of a high organic matter accumulation that occurs in reduced conditions (JEA 2004; Appendix C).

As mentioned previously, additional soils information is available in the appendices.

Minimum Levels at the TOSO-528 Transect, St. Johns River Mile 220

Minimum Frequent-High Level at the TOSO-528 (10.8 ft NGVD)

The recommended minimum frequent-high level for the St. Johns River at the TOSO-528 Transect is 10.8 ft NGVD. This level corresponds to a typical seasonally flooded river stage. During extended periods of normal or above normal rainfall, the minimum frequent-high level is expected to occur, on average, for several weeks to several months approximately once every 2 years (Chapter 40C-8.021(15), *F.A.C.*).

This recommended minimum frequent-high level equals the average elevation of the upper wet prairie community (stations 1640–2100; Table 41). Figure 22 illustrates the topography at the TOSO-528 Transect, indicating an increase in elevation across the upper wet prairie except for a lower depressional area at the ecotone between the upper wet prairie and the transitional hammock–upper wet prairie. Due to seepage and the depressional area located in the landward portion of the upper wet prairie, nearly the entire upper wet prairie community is expected to experience surface water inundation at the recommended minimum frequent-high level of 10.8 ft NGVD. This level will ensure that the lower elevations of the upper wet prairie will be inundated at least every 1 to 2 years for a period of several weeks to several months. Additionally, the wet prairie station 6460–8900) will be inundated with an average water depth equal to 0.8 ft. Similar average water depths will occur in the wet prairies, at Hatbill Park (0.7, 1.1, 1.3, 1.5, 1.5 ft), Lake Cone (0.6, 0.8, 1.0 ft), Tosohatchee North (2.1 ft), and the Great Outdoors (1.3 and 1.4 ft), at the minimum frequent-high level for each respective location.

As mentioned previously, of the marsh types in Florida, wet prairies are the least frequently flooded (50–150 days / year; Kushlan, 1990). The type of vegetation present in wet prairies varies depending upon hydroperiod, soils, and site history. At the TOSO-528 Transect the average elevation of the upper wet prairie equaled the 20% exceedence on the interpolated stage duration curve (Figure 13) for the St. Johns River at this location. Consequently, taking into account the stage data and the literature references describing the wide range in variation of hydroperiods for wet prairies in Florida, the average elevation of the upper wet prairie traversed at the TOSO-528 Transect became the primary minimum frequent-high level criterion. Additionally, the vegetation community immediately upslope from the upper wet prairie was the transitional hammock–upper wet prairie, occurred at a much higher elevation (average elevation equaled 12.0 ft NGVD; Table 41).

Due to the short hydroperiods experienced by wet prairies, this community type is the most species rich of Florida's marshes, containing a variety of grasses, sedges and flowering forbs. Wet prairie species have considerable tolerance to both flooding and drying (Kushlan 1990). Many shallowly rooted species typical of the wet prairies associated with coastal flatwoods are killed by drying but reseed readily. As a result, their zone of dominance migrates up- and downslope in response to changing water conditions (Kushlan 1990). Higher wet prairies may, under some conditions, be invaded by saw palmetto. Environmental characteristics of wet prairies include a hydroperiod shorter than six months, a low accumulation of organic matter (e.g. a few inches or nonexistent), and a fire frequency of more than one per decade (Kushlan 1990).

Fire is an influential factor helping maintain the wet prairie communities along the St. Johns River. The upper wet prairie traversed at the TOSO-528 Transect was burned by a wildfire in 1998 and by a prescribed fire in 2003. Prescribed fire in this upper wet prairie community typically occurs every 3–5 years to deter the encroachment of woody shrubs and upland vegetation into the upper wet prairie community (pers. comm., Charlie Mathews, Tosohatchee State Reserve Manager 2003). Wax myrtle and groundsel tree quickly invade and dominate the wet prairie communities along the St. Johns River in the absence of fire. As mentioned previously, prescribed fire results in wet prairie and upper wet prairie communities extending over a wide elevation gradient. The lower elevations of the wet prairie are primarily maintained by the river hydrology while the higher elevations of the wet prairie and the upper wet prairie elevations are maintained primarily by fire and groundwater seepage. Consideration of the role of fire and other disturbances (i.e. hurricane impacts, cattle grazing) is necessary in interpreting relationships between vegetation communities and hydrologic conditions. Cattle grazing does occur along the TOSO-528 Transect because of cattle on the east floodplain whom venture onto the Tosohatchee State Reserve property.

The aquatic faunal habitat is greatly expanded when the St. Johns River inundates the extensive shallow marshes, wet prairies, and secondary channels traversed at the TOSO-528 Transect at the recommended minimum frequent-high level. Interactions between multiple river channels and adjacent marshes and wet prairies are extremely important to animal productivity in lower coastal plain rivers (Bain 1990; Poff, et al. 1997). When the floodplains are flooded, many fish migrate from the main channels to the inundated areas for spawning and feeding. These migrations are more lateral, perpendicular to river flow, than upriver or down river (Guillory 1979). As the river level continues to rise, the amount of vegetative structure available to aquatic organisms increases greatly as large areas of the floodplain are inundated (Light, et al. 1998).

Additionally, river water quality may improve significantly as water flows through the floodplain. The floodplains with vast marshes function as an important filter and sink for dissolved and suspended constituents (Wharton, et al. 1982).

The palm hydric hammock and the transitional hammock–upper wet prairie communities traversed at the TOSO-528 Transect will experience surface water inundation when the St. Johns River rises to an infrequent high level (Table 41). However, more frequent surface water ponding will occur during the rainy season within these palm hydric hammocks due to local rainfall and the poorly drained soil characteristics. Vince et al., (1989) suggest that hydric hammocks dominated by cabbage palm and live oak exist where long dry periods are interrupted by occasional episodes of flooding. These hammocks are inundated less often, perhaps only once per decade due to tropical systems impacting the Upper St. Johns River Basin.

Minimum Average Level for the St. Johns River at the TOSO-528 Transect (8.4 ft NGVD)

The recommended minimum average level for the St. Johns River at the TOSO-528 Transect is 8.4 ft NGVD. The minimum average level approximates a typical river stage that is slightly less than the long-term median stage while still protecting the wetland resources. At the minimum average level substrates may be exposed during nonflooding periods of typical years, but the substrate remains saturated. The minimum average level corresponds to a water level that is expected to occur, on average, every year or two for about six months during the dry season.

The recommended minimum average level equals the average soil surface elevation of all the shallow marshes traversed at the TOSO-528 transect (Figure 22; Table 41). This level will result in saturated or inundated soil conditions over the shallow marsh stations surveyed at the TOSO-528 Transect. Saturated and inundated soil conditions will prevent long-term encroachment of upland plant species into the shallow marshes.

Chobee and Manatee were the commonly reoccurring soil types observed in the shallow marshes (Table 43). Chobee and Manatee soils are very similar but are separated based on soil texture within the upper 20 in. of the argillic horizon. Both Chobee and Manatee are mollisols. Mollisols have a mollic epipedon, which is a collection of thick dark surface horizons that are high in organic matter. The mollic epipedon develops and persists in flooded soils. These soils are classified as very poorly drained and typically experience flooding in depressional areas for long durations (NRCS 2003). According to the *Soil Survey of Brevard County, Florida* (USDA, SCS 1974), the water table in Chobee soil, in most years, occurs at depths within 10 in. of the soil surface for six to nine months. Chobee soil is continuously flooded for one to six months in many places. Consequently, soil saturation and shallow ponding at the lower elevations within the shallow marshes traversed at the TOSO-528 Transect at the recommended minimum average level typify annual dry season conditions in these depressional shallow marsh communities. Also, the mineral soil water table depths predicted to occur in the wet prairies and upper wet prairie at the TOSO-528 Transect when the St. Johns River equals the recommended minimum average level, are within reported dry season levels (NRCS 2003).

Additionally, the recommended minimum average level will ensure shallow inundation of the secondary channels and open water areas traversed at the TOSO-528 Transect (Table 44).

Table 44. Inundation depths at the TOSO-528 Transect at the minimum average level

Location Along Transect	Average Inundation (ft)	Range of Inundation (ft)
West most channel	3.6	1.2–5.6
Main channel	3.6	0.9–4.9
Secondary east channel	2.3	1.2–3.2
Main east channel	2.7	1.2–4.3
Shallow marsh #1	saturated	saturated
Shallow marsh #2	saturated	0–1.5
Shallow marsh #3	0.2	0–1.4

Shallow ponding within the marshes and open water areas at the TOSO-528 Transect will provide aquatic refugia for numerous small fish, amphibians, and small reptiles. Aquatic habitats connected to the main river channels, such as the open water areas traversed at the TOSO-528 Transect, are of crucial importance to fishes and invertebrates of the floodplain. Connected habitats provide shallow, quiet waters in floodplain streams as refugia from the deep, swiftly flowing waters of the main channel (Light, et al. 1998).

At the recommended minimum average level the water depths in shallow marshes #2 and #3 at the TOSO-528 Transect are ideal for wading bird foraging. Wading birds can only forage in relatively shallow water. Great Egrets need water depths of less than 10 in. and the small herons need depths of less than 6 in. Declining water levels can cause fish to be concentrated in isolated sloughs throughout the shallow marshes. Birds effectively exploit these concentrations (Bancroft, et al. 1990).

Minimum Frequent-Low Level for the St. Johns River at the TOSO-528 Transect (6.7 ft NGVD)

The recommended minimum frequent-low level determined for the St. Johns River at the TOSO-528 Transect equals 6.7 ft NGVD. This level represents a low river stage that generally occurs only during mild drought. The minimum frequent-low level is predicted to occur, on average, approximately once every 5 years for the duration of several months. This level typically results in dewatered wetlands. This dewatering is a natural consequence of drought and has ecological benefits, which enable seeds of emergent wetland plants to germinate from the seed banks of the floodplain. Seeds of many wetland plant species require exposed soils in order to germinate (Van der Valk 1981). Exposing the floodplain for suitable durations maintains the composition of emergent plant species and increases plant diversity.

The recommended minimum frequent-low level for the St. Johns River at the TOSO-528 Transect equals a soil water table level 20 in. below the average soil surface elevation of the three shallow marshes traversed at the TOSO-528 Transect. Chobee and Manatee soils were the most commonly observed soil types occurring in the shallow marshes traversed at the TOSO-528 transect (Table 45). Chobee and Manatee series soils are very similar but are separated based on soil texture within the upper 20 in. of the argillic horizon. Both Chobee and Manatee are mollisols with argillic horizons. Mollisols have a mollic epipedon, which is a collection of thick, dark surface horizons that are high in organic matter. The mollic epipedon develops and persists in flooded soils. The argillic horizon is a hardpan layer that impedes vertical water movement and can cause surface saturation during high rain events. These soils are classified as very poorly drained and typically experience flooding in depressional areas for long durations (NRCS 2003).

The primary minimum frequent-low level criterion of a 20-in. soil water table drawdown from the average soil surface elevation of all the shallow marshes traversed at the TOSO-528 Transect, is based upon the NRCS (2003), the *Soil Survey of Brevard County, Florida* (USDA, SCS 1974), and the *Soil Survey of Lake County, Florida* (USDA, SCS 1975), descriptions of dry season soil water table depths for Chobee and Manatee series soil. According to the *Soil Survey of Brevard County, Florida* (USDA, SCS 1974), the Chobee soil water table occurs within 10 in. of the soil surface for six to nine months and 10 to 40 in. below the soil surface for three to six months. In very dry seasons, the Chobee soil water table occurs at depths of greater than 40 in. below the soil surface for short periods. According to the NRCS (2003), the Chobee soil water table is typically within 6 in. of the soil surface for one to four months during most years in the rainy season. Depressional areas with Chobee soil are ponded for long durations in most years. The Manatee series soil water table is described in the *Soil Survey of Lake County, Florida* (USDA, SCS 1975), as occurring at depths up to 20 in. below the soil

Table 45. Soil types in the shallow marshes at the TOSO-528 Transect

Soil Series	Vegetation Community	Station
Chobee	Shallow marsh #1	2400
Chobee	Shallow marsh #1	2500
Chobee	Shallow marsh #1	2600
Manatee	Shallow marsh #1	2700
Manatee	Shallow marsh #2	3000
Chobee	Shallow marsh #2	3280
Unknown fluvaquent	Shallow marsh #2	3420
Chobee	Shallow marsh #3	3900
Manatee	Shallow marsh #3	4100
Chobee	Shallow marsh #3	4300
Manatee	Shallow marsh #3	4500
Manatee	Shallow marsh #3	4700
Floridana variant	Shallow marsh #3	5000
Chobee	Shallow marsh #3	5500
Chobee	Shallow marsh #3	5700
Unknown cumulic argiaquoll	Shallow marsh #3	6300

surface during dry periods. According to the NRCS (2003), the Manatee soil water table occurs within 10 in. of soil surface for more than six months annually during most years. Depressional areas with Manatee soil are ponded for about six to nine months during most years. Consequently, because the shallow marshes traversed at the TOSO-528 Transect were geographically located within a large depressional area at the lower vegetated elevations in the floodplain, which were closely associated with the river channels, a 20-in. average drawdown in the soil water table in the shallow marshes is considered reasonable and based upon the best available information for an event that is predicted to reoccur once every 5 years for 60 continuous days (Robison 2006).

In the wet prairie adjacent and upslope from shallow marsh #3 where the soils were identified as Floridana, Eaton variant, and Denaud (Table 43) the average soil water table drawdown would equal 40 in. below the soil surface at the recommended minimum frequent-low level. However, field observations during soil sampling on April 6, 2004, indicated that seepage occurred providing saturation to the soil surface, across much of the wet prairie, when the river stage was at a considerably lower elevation. Thus groundwater seepage maintains the hydric soil characteristics in the wet prairie traversed at the TOSO-528 Transect when the St. Johns River stage occurs at an elevation lower than the wet prairie soil surface elevations. Lindbo and Richardson (2001) described groundwater discharge from the upland to the edge of the floodplain often occurring along seepage slopes, resulting in organic rich soils, like Denaud, at the upper edge of the floodplain.

Additional considerations regarding the 20-in. soil water table drawdown and ultimately soil moisture include the soils capillary fringe. A capillary fringe of varying thickness exists above the soil water table. In the capillary fringe zone, the soil is nearly water-saturated; the water is adsorbed to soil particles to a greater degree than water below the water table. The capillary fringe zone contains various amounts of water depending upon the pore size and the height in the soil above the water table (Richardson et al, 2001). A sandy clay loam such as Chobee and Manatee soil, with an average porosity of 0.005 cm should have a saturated zone extending at least 12 in. (30 cm) above the soil water table (Mausbach 1992). Consequently, soil moisture may be available to the marsh vegetation at depths considerably closer to the soil surface than that predicted from the 20-in. soil water table drawdown criterion.

Also, as mentioned previously, according to Kushlan (1990), sand substrates, as observed in the wet prairie and shallow marshes traversed at the TOSO-528 Transect, occur in marshes with short hydroperiods and significant drying of the soil during the dry season. The marked seasonality of Florida’s rainfall and evaporation plays an important role in the functioning of marsh ecosystems by creating a seasonal fluctuation in surface water. This seasonal fluctuation is most pronounced in southern Florida because it experiences less winter rainfall than occurs farther north. Water levels rise during the summer rainy season, gradually decline during the winter, and annually reach drought conditions as evapotranspiration increases in the spring. In most years, standing water is absent from southern Florida marshes at the height of the dry season, a condition that may last from a couple of weeks to several months. Most marshes flood during each rainy season, but some may flood only in very wet years. Annual variation in rainfall may cause substantial differences in the depth and extent of flooding in various years at a single marsh site (Kushlan 1990).

At the recommended minimum frequent-low level, shallow ponding would occur in the secondary and primary channels traversed at the

TOSO-528 Transect (Table 46). As mentioned previously, shallow ponding within the multiple channels will provide aquatic refugia for numerous small fish, amphibians, and small reptiles. Aquatic habitats, such as the multiple secondary river channels traversed at the TOSO-528 Transect, connected to the main river channel are of crucial importance to fishes and invertebrates of the floodplain. Connected habitats provide shallow, quiet waters as refugia from the deep, swiftly flowing waters of the main channel (Light, et al. 1998).

Table 46. Inundation depths at the minimum frequent-low level at the TOSO-528 Transect

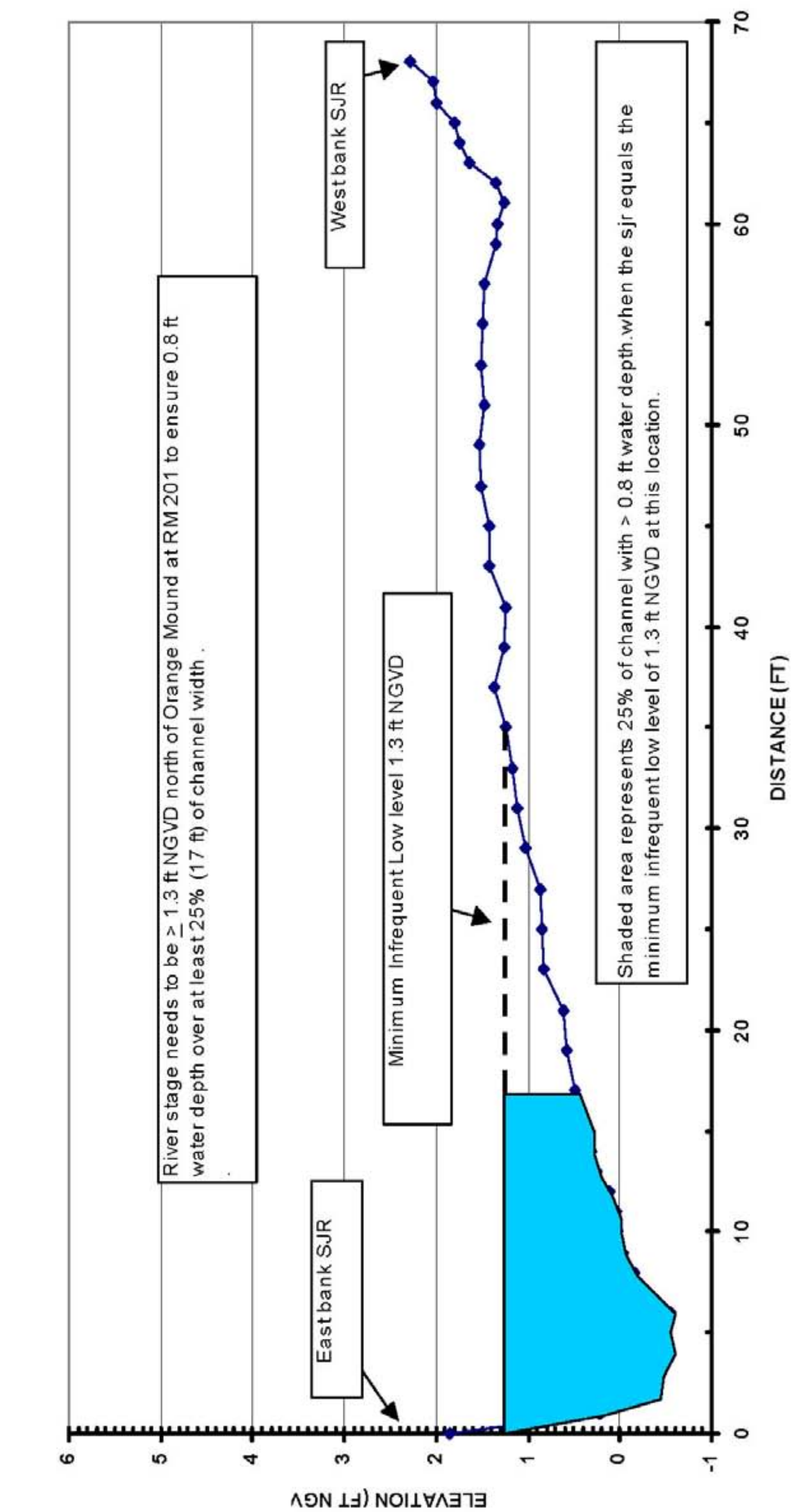
Community Description	Stations	Average Inundation (ft)	Range of Inundation (ft)
West channel	2795–2865	2.8	0.4–4.8
Main channel	3485–3645	2.8	0.1–4.1
Secondary channel	4733–4802	1.5	0.4–2.4
East channel	5880–5940	1.9	0.4–3.5

St. Johns River Shallow Reaches

Bathymetry data collected in 2006 within the main river channel between SR 46 and SR 528 identified four particularly shallow reaches (Figures 2, 24–27; and Table 47). The four shallow reaches in the main channel of the St. Johns River do not occur at the seven transect sites instrumental in determining the five sets of local minimum frequent-high, minimum average, and minimum frequent-low levels.

Under existing conditions at very low river stages ($\leq$ 2.8 ft NGVD at SR 50) the four shallow reaches surveyed in the St. Johns River main channel have water depths of less than 0.5 ft across the majority of the width of the main river channel. Consequently, in order to ensure these shallow reaches remain inundated with connectivity and adequate fish passage depths, a minimum infrequent-low level was determined for each of these four reaches.

Figure 24. St. Johns River main channel north of Orange Mound - RM 201.0



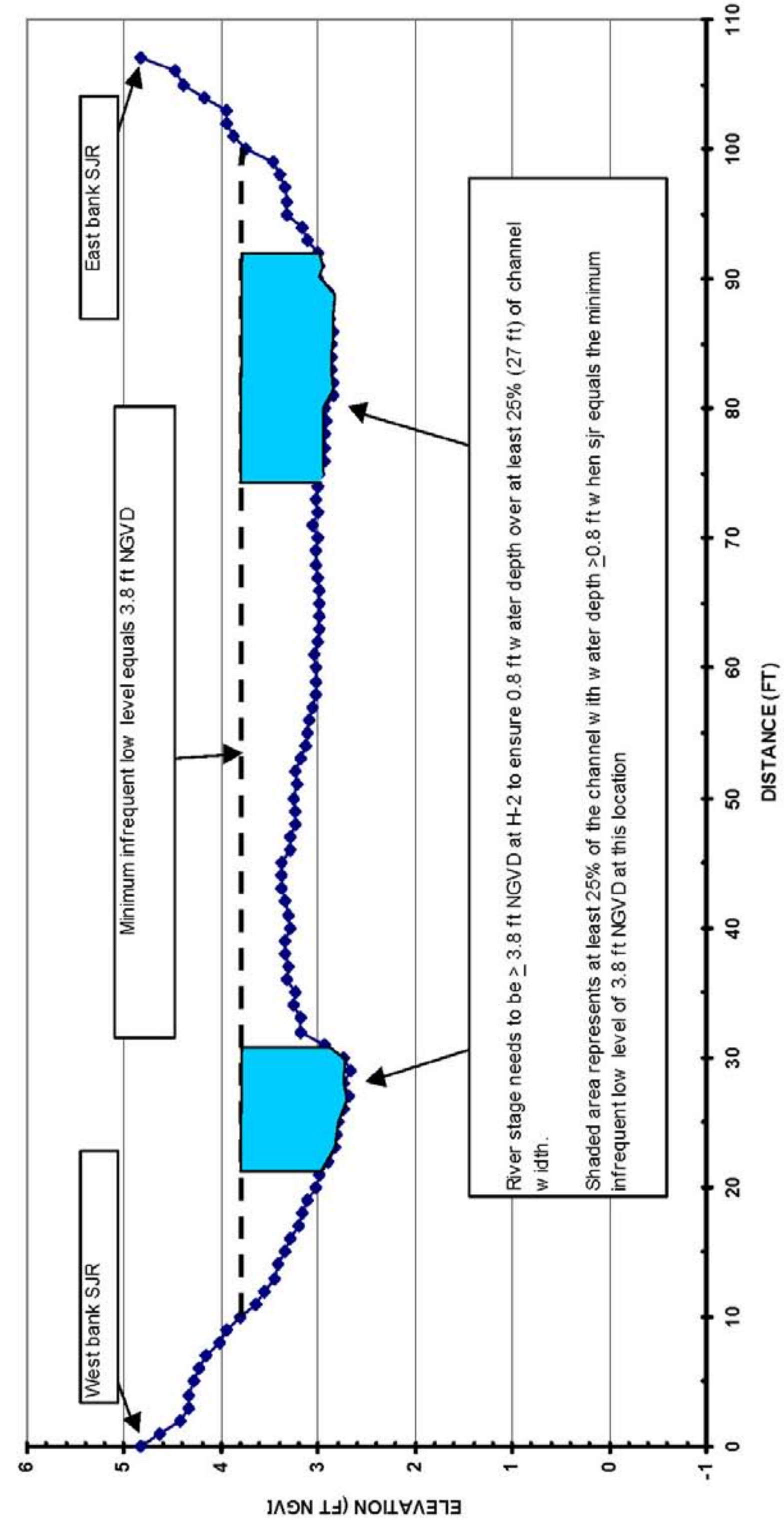


Figure 25. St. Johns River main channel at H-2 - RM 216.6

Figure 26. St. Johns River main channel at Little Palm Island - RM 217

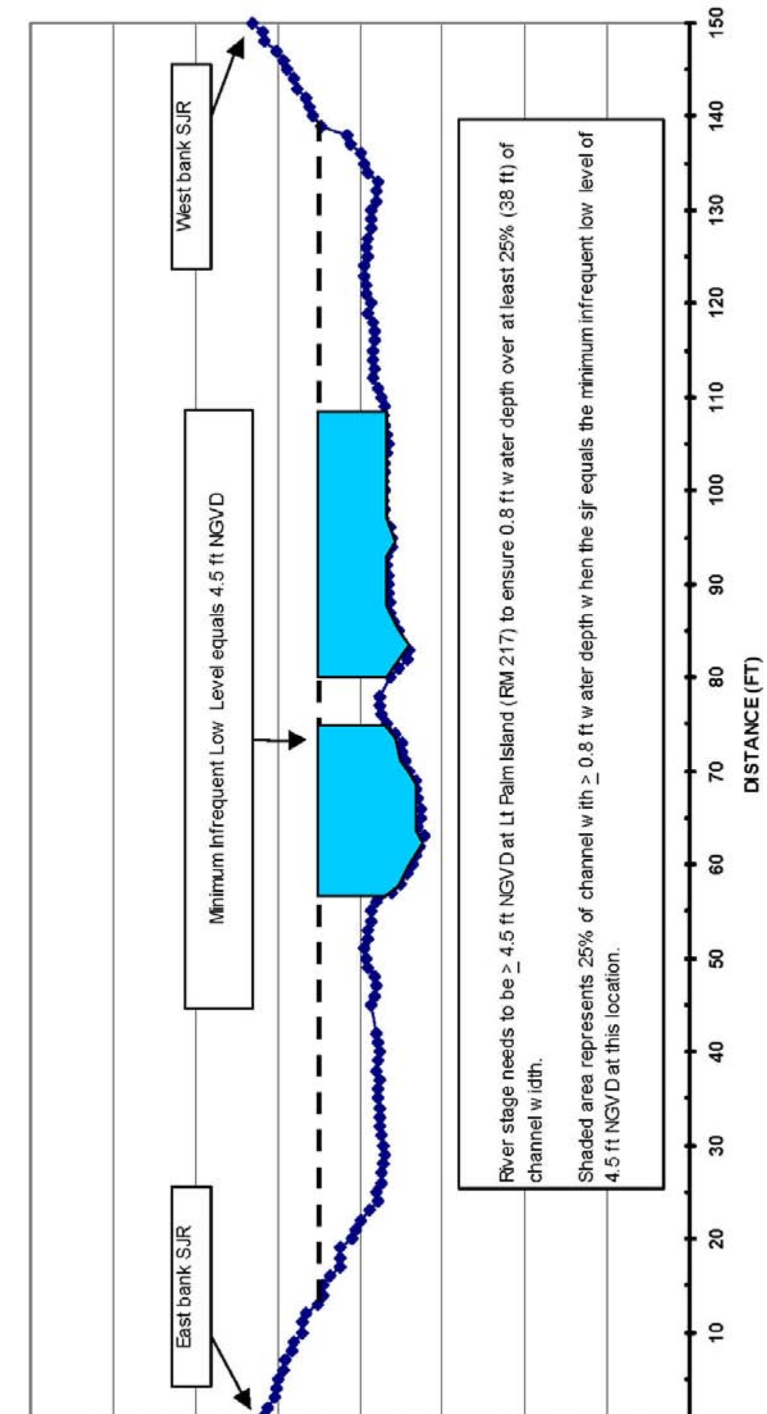


Figure 27. St. Johns River main channel at M-4 - RM 217.7

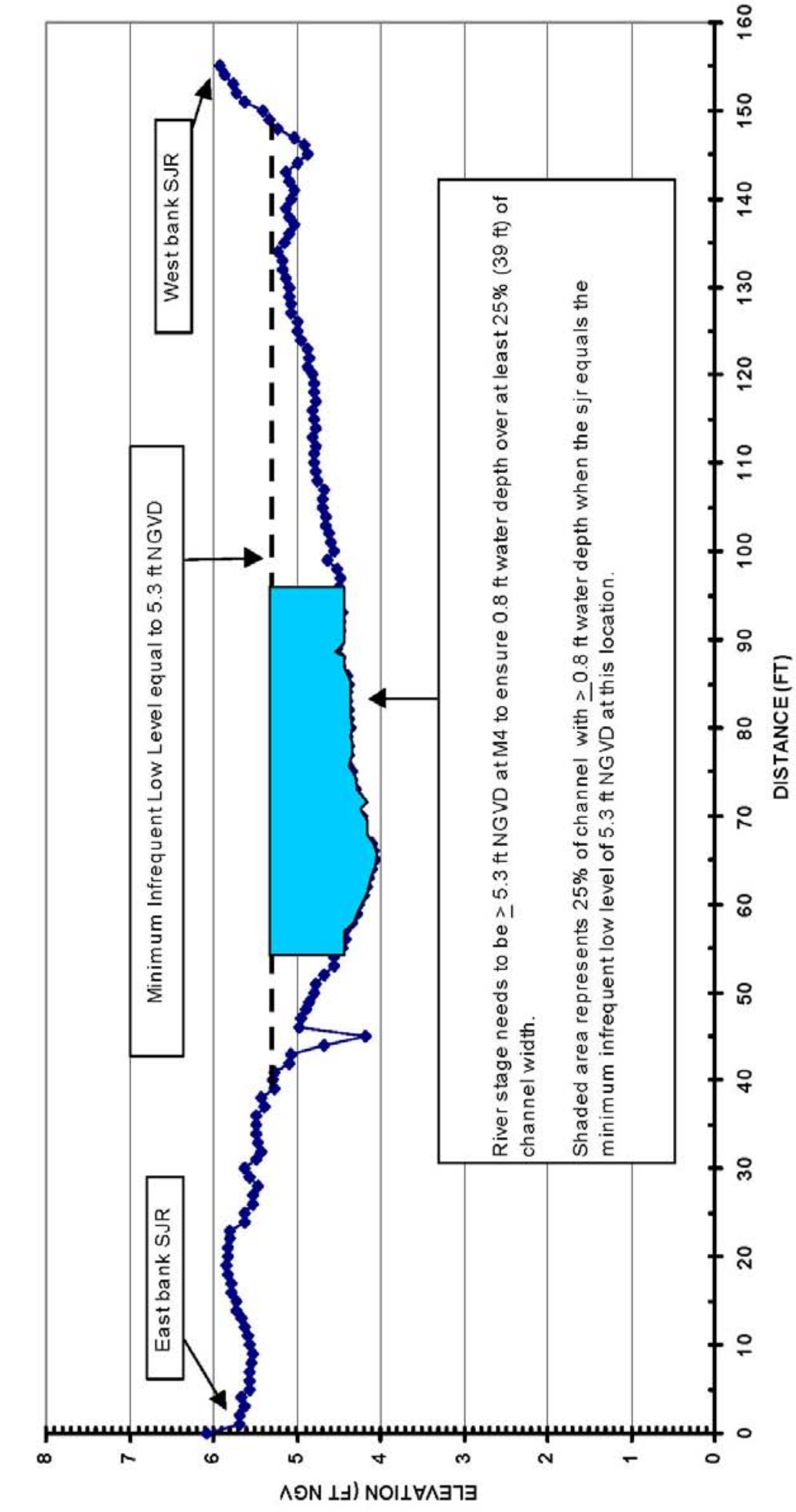


Table 47. St. Johns River shallow reach name and location information

Transcect Name and River Mile	Latitude–Longitude (Beginning Station)	Latitud –Longitude (Center of Channel)	Latitude–Longitude (Ending Station)
North of Orange Mound RM 201.0	28 36 12.35; 80 58 11.55 (Station 0)	28 36 12.34; 80 56 11.91 (Station 34)	28 36 12.33; 80 58 12.30 (Station 68)
H-2 RM 216.6	28 29 18.61; 80 52 33.12 (Station 0)	28 29 18.21; 80 52 32.73 (Station 53)	28 29 17.83; 80 52 32.36 (Station 106)
Little Palm Island RM 217	28 28 59.90; 80 52 29.25 (Station 0)	28 28 59.47; 80 52 29.94 (Station 75)	28 28 59.07; 80 52 30.61 (Station 150)
M-4 RM 217.7	28 28 29.26; 80 52 23.23 (Station 0)	28 28 29.59; 80 52 23.94 (Station 87.5)	28 28 29.99; 80 52 24.77 (Station 171)

ft NGVD = feet National Geodetic Vertical Datum

Minimum Infrequent-Low Levels at Shallow Reaches

The minimum infrequent-low level is an extreme low water level that usually occurs during severe drought. This dewatering event typically occurs for short durations with very long return intervals. Vegetation, if present near the associated elevation, is composed primarily of submersed, floating-leaved, or emergent obligate wetland plant species. Vegetation in the St. Johns River channel near SR 50 is typically absent at the minimum infrequent-low level. As mentioned previously, the primary minimum infrequent-low level criterion for the St. Johns River near SR 50 is to provide adequate water depths ($\geq$ 0.8 ft depth over $\geq$ 25% of the channel width) for fish passage in the main channel. If the main river channel had multiple deep zones (Figures 25 and 26), the 25% width criterion could be noncontiguous. However, the width of the individual deep zones must equal at least 10% of the overall channel width and combine to at least 25% of the total channel width.

Survey data including the main channel width and detailed channel cross section elevations obtained at the shallow reaches were used to calculate each minimum infrequent-low level. Figures 24–27 illustrate the shallow reach cross sections along with the river level necessary to provide 0.8-ft water depth across 25% of the channel width for fish passage. Table 48 lists the four minimum infrequent-low levels.

Table 48. St. Johns River shallow reaches and minimum infrequent-low levels

Transect Name and River Mile	Minimum Infrequent-Low Level (ft NGVD)
North of Orange Mound—RM 201.0	1.3
H-2—RM 216.6	3.8
Little Palm Island—RM 217	4.5
M-4—RM 217.7	5.3

ft NGVD = feet National Geodetic Vertical Datum

These minimum infrequent-low levels are less than ideal for navigation and recreation. However, airboat tours, the primary navigation and recreation activity, currently operate when the river stage falls below the minimum infrequent-low levels. Cautious boat handling is required at numerous locations up- and downstream from SR 50 when the St. Johns River is within its banks and considerably higher than the recommended minimum infrequent low-level due to sharp river bends, vegetation creating blind corners, and narrow channels.

MFLs for the St. Johns River at SR 50

Ecological data were not collected immediately adjacent to SR 50 due to undesirable site features at this location, including canals, spoil/fill, two boat ramps, and cattle grazing. However, it is preferable to adopt one set of MFLs located at the long-term gauge at SR 50 in order to facilitate long-term hydrologic monitoring while eliminating possible confusion regarding multiple sets of levels. Therefore, levels for transect sites upstream and downstream from SR 50 were used as the basis for calculating recommended minimum levels for the SR 50 gauge site.

Minimum Levels

Water surface slopes change between each of the MFLs transect sites upstream and downstream from SR 50 (Robison 2006). As a result, calculating the MFLs for the St. Johns River at SR 50 from the five sets of local levels, as well as for the four shallowest sites surveyed to determine the minimum infrequent-low level, was accomplished with a surface water profile model (using HEC–RAS; Robison 2006), for this reach of the St. Johns River, and a water budget model (using HSPF) developed for SJRWMD by Camp Dresser and McKee Inc (CDM 2004).

The method of determining the MFLs for the St. Johns River at SR 50 from the local levels was described previously in the Methodology section.

Table 49 lists the original field local minimum levels as well as the resulting minimum levels at SR 50. Additional information regarding the surface water modeling, water budget model and the subsequent transfer of levels to SR 50 are located in the St. Johns River at SR 50 minimum flows and levels hydrologic methods report (Robison 2006 and Robison 2004).

Table 49. Local minimum levels and levels transferred to the St. Johns River at SR 50

Location	Minimum Levels (ft NGVD) 1929 datum			
	Frequent High	Minimum Average	Frequent Low	Infrequent Low
North of Orange Mound	NA	NA	NA	1.3
Hatbill Park	6.9	4.5	2.9	NA
Lake Cone	7.6	5.8	4.1	NA
SR 50	8.1	5.9	4.2	2.7
Tosohatchee North	8.8	6.2	4.5	NA
Great Outdoors	9.4	7.5	5.8	NA
H-2	NA	NA	NA	3.8
Little Palm Island	NA	NA	NA	4.5
M-4	NA	NA	NA	5.3
TOSO-528	10.8	8.4	6.7	NA

ft NGVD = feet National Geodetic Vertical Datum

Minimum Flows

Each minimum level can be associated with a minimum flow for a river system. While water resource decisions can be made based on minimum levels alone, pairing each level with a corresponding minimum flow adds context to better understand the effects of proposed changes to a hydrologic system. The pairing of levels and flows of similar statistical characteristics was used to determine a recommended minimum flow for each of the final four levels for the St. Johns River at SR 50 (Robison 2006). For example, based on statistical analysis of stage data for the St. Johns River at SR 50, the recommended minimum frequent-high level of 8.1 ft NGVD would be equaled or exceeded for 30 days, on average, approximately 70 out of every 100 years. Analysis of the flows at the SR 50 gauge indicated that the flow that would be equaled or exceeded for 30 continuous days, on average, approximately 70 out of 100 years equals 1950 cubic ft per second (cfs). Thus the recommended minimum frequent-high flow for the St. Johns River at SR 50 equals 1,950 cfs. Similar analyses determined that the recommended minimum average flow equals 580 cfs and the recommended minimum frequent-low flow equals 140 cfs and the recommended minimum infrequent-low flow equals 43 cfs. Table 50 lists the recommended minimum levels for the St. Johns River at SR 50 along with the associated flow, duration, and, return interval.

Durations and Return Intervals at SR 50

Each of the recommended minimum flows and levels is associated with duration and a return interval (Table 50). The recommended minimum frequent-high flow and level for the St. Johns River at SR 50 currently occurs under existing conditions for a duration of 30 continuous days approximately 7 out of every 10 years (return interval of 1.4 years), based upon gauge data analyses for the time period 1953 through 1998 (Robison 2006). During extended periods of normal or above normal rainfall, the minimum frequent-high level is expected to occur from several weeks to several months every 1 to 2 years (Chapter 40C-8.021(15), *F.A.C.*). The recommended minimum frequent-high flow and level for the St. Johns River at SR 50 results in a change in the return interval of this flooding event from an event which historically occurred, on average, every 1.4 years to a flooding event which would occur, on average, every 2.0 years, while maintaining a 30-continuous-day duration at a stage of 8.1 ft NGVD and a flow of 1,950 cfs (Table 50).

Table 50. Minimum surface water flows and levels for the St. Johns River at SR 50, Orange and Brevard counties

Minimum Level	Elevation (ft NGVD) 1929 datum	St. Johns River Flows at SR 50 (cfs)	Duration	Return Interval
Minimum frequent-high level	8.1	1950	30 days	2 years
Minimum average Level	5.9	580	180 days	1.5 years
Minimum frequent-low level	4.2	140	120 days	5 years
Minimum infrequent-low level	2.7	43	60 days	50 years

The recommended minimum average flow and level for the St. Johns River at SR 50 currently occurs under existing conditions for a duration of 180 days approximately 55 out of 100 years (return interval of 1.8 years), based upon gauge data analyses for the time period from 1953 through 1998 (Robison 2006). The minimum average level corresponds to a water level that is expected to occur approximately every year or two for about six months during the dry season. The minimum average level approximates a typical level that is slightly less than the long-term median water level while still protecting the wetland resources. At the minimum average level substrates may be exposed during nonflooding periods of typical years, but the substrate remains saturated. The recommended minimum average level results in a change in the return interval of this dry season event from an event which historically occurred, on average, every 1.8 years to an event which would occur, on average, every 1.5 years (66 out of 100 years), while maintaining a 180-day duration at a stage of 5.9 ft NGVD and a flow equal to 580 cfs (Table 50).

The recommended minimum frequent low flow and level for the St. Johns River at SR 50 currently occurs under existing conditions for a duration of 120 continuous days, on average, 10 out of every 100 years (return interval 10 years), based upon gauge data analyses for the time period of 1953 through 1998 (Robison 2006). The minimum frequent-low level corresponds to a dewatering event, which occurs during periods of mild drought. Minimum frequent low water levels and flows are expected to occur, on average, approximately once every 5 years (20 out of 100 years) for the duration of several months or more (Chapter 40C-8.021(15), *F.A.C.* The recommended minimum frequent-low level and flow would result in a change in the return interval of this mild drought event from an event which historically occurred, on average, every 10 years to an event, which would occur, on average, every 5 years, while maintaining a 120-day duration at a stage of 4.2 ft NGVD and a flow equal to 140 cfs (Table 50).

The recommended minimum infrequent-low flow and level for the St. Johns River at SR 50 currently occurs under existing conditions for a duration of 60 continuous days on average once every 100 years based upon gauge data analyses for the time period of 1953 through 1998 (Robison 2006). The minimum infrequent-low level corresponds to an extreme low water level that usually occurs during severe droughts. This dewatering event typically occurs for short durations with very long return intervals. Minimum infrequent-low water levels and flows are expected to occur, on average approximately once every 50 to 100 years for a duration of 1 to 3 months (Chapter 40C-8.021(15) F.A.C. The recommended minimum infrequent-low level and flow would result in a change in the return interval of this severe drought from an event which historically occurred on average once every 100 years to an event which would occur on average once every 50 years while maintaining a 60 day duration at a stage of 2.7 ft NGVD and a flow equal to 43 cfs (Table 50).

Validity of Recommended MFLs at SR 50

The process of developing recommended MFLs for the St. Johns River at SR 50 included a multitude of information gathering tasks and subsequent analyses. The foundation of this effort was comprised of the field collected elevation, vegetation, and soils data. The field data were used to characterize the floodplain wetland communities. Multiple site visits occurred at all field transects near SR 50 to improve the ability to characterize the wetland communities. The basic wetland community classifications and distribution of overall community types were stable between 2002 and 2006. The wetland communities were then related to the natural flooding and drying regime of the St. Johns River near SR 50. Use of the best available information from the scientific literature, ecological maps, personal communications with on-site public land managers, analyses of many years of river stage data, and intensive surface water modeling (Robison 2006) combined with the extensive field data collection effort, resulted in the recommended MFLs.

The establishment of MFLs should consider natural seasonal fluctuations in water flows or levels, nonconsumptive uses, and the 10 water resource values (WRVs) associated with coastal, estuarine, riverine, spring, aquatic and wetlands ecology (Section 62-40.473, *F.A.C.*). HSW Engineering Inc. (HSW) was contracted by SJRWMD to conduct an environmental assessment to determine whether the minimum frequent-high, minimum average, and minimum frequent-low flows and levels recommended within this report for the St. Johns River at SR 50 protect the 10 WRVs. HSW's assessment did not include the minimum infrequent-low flow and level because the minimum infrequent-low recommendation was not available at the time of the HSW contract. HSW performed its assessment based on the assumption that the existing hydrologic regime is adequate to protect the identified WRVs (Table 51, HSW 2004).

In a separate analysis, SJRWMD determined that the proposed MFLs would no longer be met if an additional constant surface water withdrawal of greater than 50 million gallons per day (mgd) occurred upstream from SR 50. HSW also determined that all WRVs except for recreation, fish and wildlife habitats, and navigation would be protected under the additional 50 mgd constant withdrawal scenario. To protect the three WRVs, which were not protected under the 50 mgd surface water withdrawal, HSW recommended a surface water withdrawal schedule that results in no surface water withdrawals from the St. Johns River when the river discharge at SR 50 is below 300 cubic ft per second (the 80–85% exceedence value).

One example illustrating the strength of the MFLs field data collected near SR 50 included a comparison of the stage exceedence values expected to occur within similar vegetation communities at different transect localities (Table 52). For example, the St. Johns River stage under existing conditions is predicted to exceed the average elevation of the upper wet prairie communities at the TOSO-528 Transect, at the Great Outdoors Transect, at the Tosohatchee North Transect and at the Hatbill Park H-1 Transect approximately 20, 22, 20, and 18 percent of the time, respectively. River levels under existing conditions are predicted to exceed the average elevation of the wet prairie communities at the

Table 51. Water resource values and assessment of protection under a proposed MFLs regime

Water Resource Value (WRV)	Flow Condition Evaluated to Determine if WRV Protected	MFLs Regime Protective/Not Protective
1. Recreation in and on the water	Low flow	Not protective
2. Fish and wildlife habitats and the passage of fish	High flow (elevated habitats) Low flow (fish passage; all other fish and wildlife habitats)	Protective (elevated habitats) Not protective (fish passage and all other habitats)
3. Estuarine resources	(None required)	Protective
4. Transfer of detrital material	High flow	Protective
5. Maintenance of freshwater storage and supply	(None required)	Protective
6. Aesthetic and scenic attributes	Low flow	Protective
7. Filtration and absorption of nutrients and other pollutants	High flow	Protective
8. Sediment loads	High flow	Protective
9. Water quality	Low flow	Protective
10. Navigation	Low flow	Not protective

Note: 50 million gallons per day (mgd) withdrawal scenario
Source: HSW 2004

Table 52. Stage exceedence at vegetation communities at average elevation

Vegetation Community—Location	Stage Exceedence at Community Average Elevation (% of Time)
Upper wet prairie–TOSO-528	20
Upper wet prairie–Great Outdoors	22
Upper wet prairie–Tosohatchee North	20
Upper wet prairie–Hatbill Park	18
Lower hardwood swamp–Tosohatchee North	48
Lower hardwood swamp–Lake Cone	46
Wet prairie–TOSO-528	35
Wet prairie–Great Outdoors	52
Wet prairie–Tosohatchee North	58
Wet prairie–Lake Cone	38
Wet prairie–Hatbill Park	38
Shallow marsh–TOSO-528	64
Shallow marsh–Great Outdoors	60
Shallow marsh–Tosohatchee North	65
Shallow marsh–Lake Cone	52
Shallow marsh–Hatbill Park	58

TOSO-528, Lake Cone and Hatbill Park H-1 transects approximately 35, 38, and 38 percent of the time, respectively. Wet prairie communities surveyed at the Great Outdoors and the Tosohatchee North transects were identified at relatively lower elevations, which experienced inundation for longer periods (52 and 58% stage exceedence, respectively). These two sites were more impacted by cattle grazing. Field observation of cattle behavior indicated that the cows preferred to eat the shallow marsh vegetation, which allowed the dominant wet prairie vegetation (*Spartina bakeri)* to extend downslope and resulted in lower average elevation wet prairies at the Tosohatchee North and Great Outdoors transects. In fact, *Spartina bakeri* is classified as an increaser in areas where cattle forage (USDA 1965). Cattle select palatable vegetation other than *Spartina bakeri* and under continuous grazing pressure the more palatable vegetation decreases with *Spartina bakeri* increasing (USDA 1965). The typically strong similarities of the stage exceedence values for a given vegetation community at different locations illustrates the accuracy of field sampling at different locations and lends credence to the surface water modeling results (Table 52).

Additional analyses performed to illustrate the strength of the methodology and particularly the field data used in the process of developing recommended MFLs for the St. Johns River at SR 50 included the development of normalized land surface elevation duration curves. Normalized land surface elevation duration curves were created for the shallow marsh (Figure 28) and upper wet prairie (Figure 29) vegetation communities to facilitate visually comparing the vegetation communities surveyed upstream and downstream from SR 50 at different land surface elevations. In particular, this comparison focuses on whether or not the field methodology resulted in identical types of vegetation communities being delineated similarly. Similarly delineated vegetation communities should experience similar surface water hydrology at the different locations. The upper wet prairie and shallow marsh communities were chosen for this analysis because the average elevations of these communities were the primary criteria used in determining minimum levels.

Figure 28. Shallow marsh normalized elevation durations near State Road 50

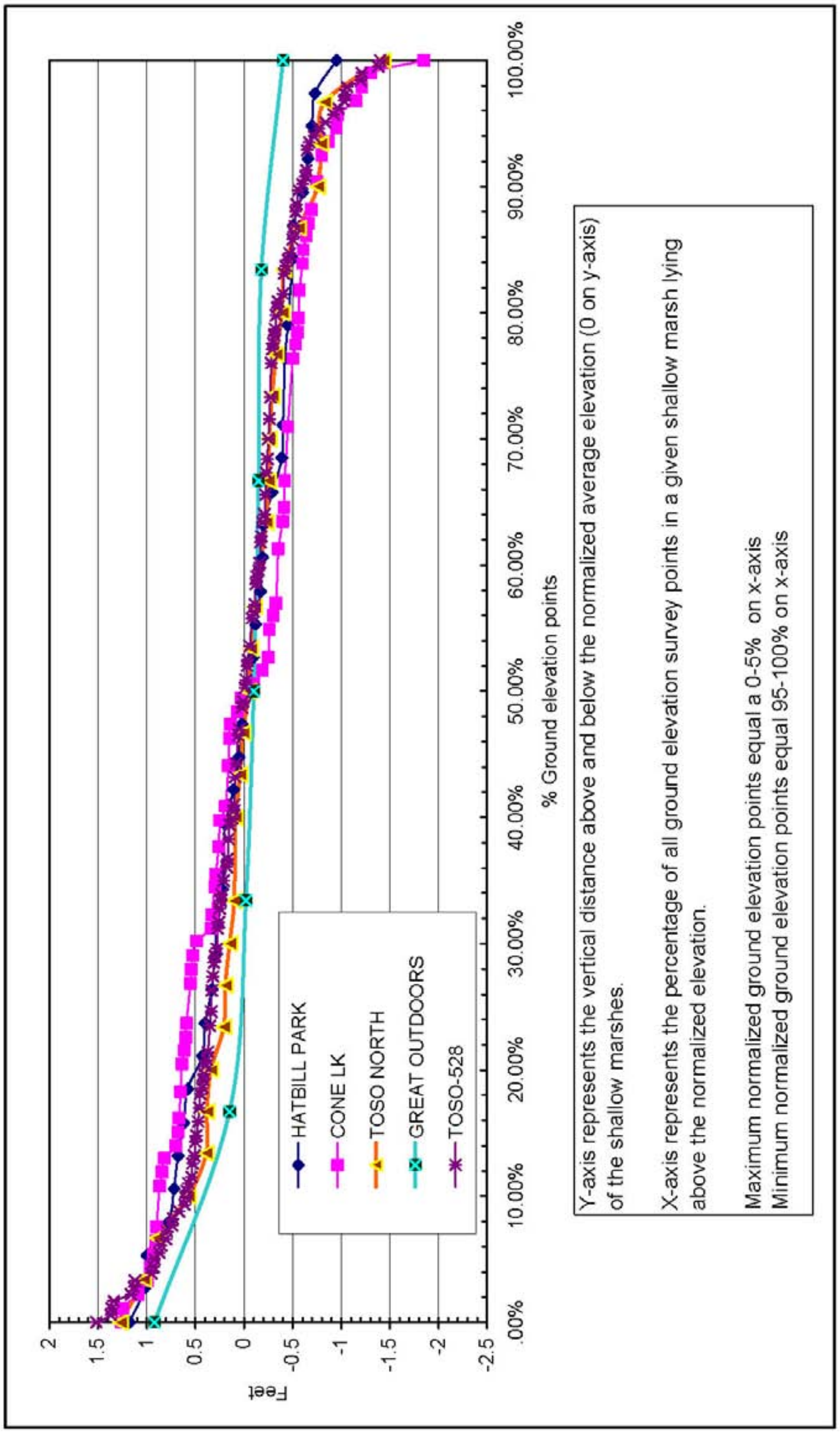
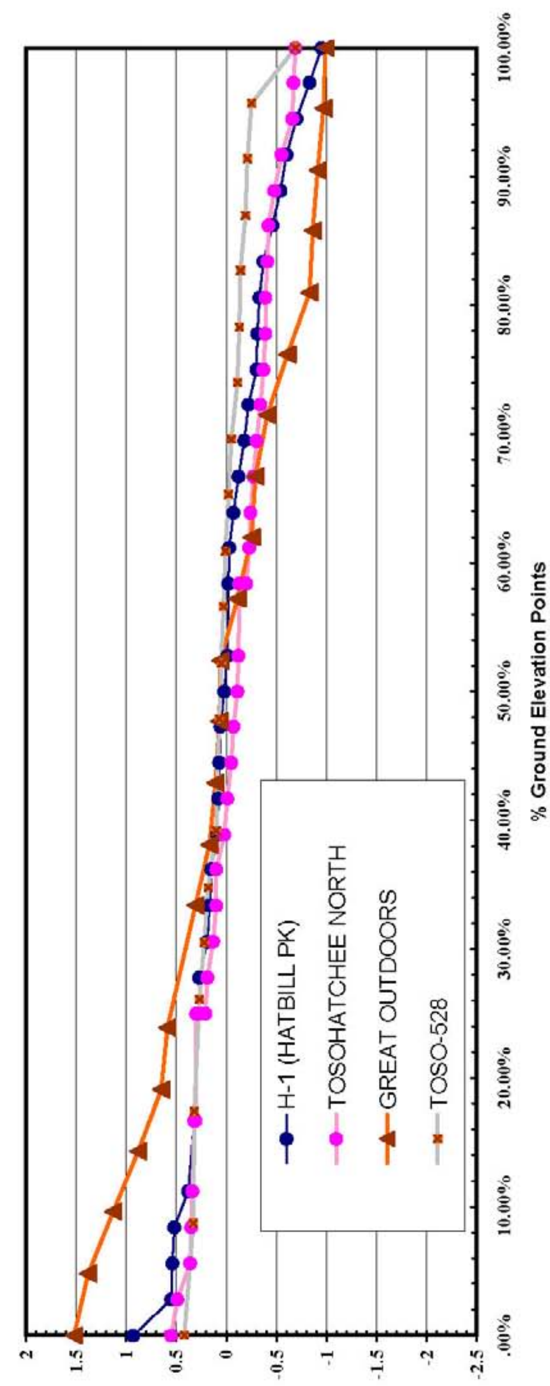


Figure 29. Upper wet prairie normalized elevation durations near State Road 50



Y-axis represents the vertical distance above and below the normalized average elevation (0 on y-axis) of the upper wet prairies.

X-axis represents the percentage of all ground elevation survey points in a given upper wet prairie lying above the normalized elevation.

Maximum normalized ground elevation points equal a 0-5% on x-axis
Minimum normalized ground elevation points equal 95-100% on x-axis

An analysis of shallow marsh normalized elevation duration data (Figure 28) indicates the close and parallel shape of the five shallow marsh lines. This confirms that the vegetation communities at the different locations were delineated similarly in the field and will experience similar river hydrology. Additionally, the maximum normalized shallow marsh elevation points were within 0.5 ft of each other. These maximum shallow marsh elevation points are also only 1 to 1.5 ft greater than their individual average shallow marsh elevations. Field identity of the shallow marsh ecotone where the shallow marsh community subtly graded into the wet prairie community was difficult. The closeness of the normalized maximum shallow marsh elevation points indicates strong consistency in the field data collection of the shallow marsh vegetation community information upstream and downstream from SR 50 (Figure 28).

Typically, the shallow marsh community low elevation ecotone occurred at an open water slough or river channel. However, alligator holes and other relatively low-vegetated shallow marsh elevation points were noted embedded within the shallow marshes and may account for the lowest shallow marsh elevation points (Figure 28).

The shallow marsh at the Great Outdoors Transect had the least topographic relief. This may be due to the relatively narrow extent of this shallow marsh, as well as the geographic setting of this shallow marsh compared to the shallow marshes at the other locations. The Great Outdoors Transect shallow marsh was a 450-ft-wide depressional area bordered by the main river channel to the east and an extensive wet prairie to the west with no river channels bisecting it. The shallow marsh traversed at the Tosohatchee North Transect was also relatively narrow in extent (combined distance of 560 ft) but it had more topographic relief attributed to the local setting where the shallow marsh was bisected by three minor river channels, as well as bordering the main river channel. The shallow marshes traversed at the remaining sites (TOSO-528, Lake Cone, and Hatbill Park transects) were extensive in size and had topographic relief similar to the shallow marsh at the Tosohatchee North Transect. Like the shallow marsh at the Tosohatchee North Transect, the shallow marshes at the TOSO-528, Lake Cone, and Hatbill Park transects were located between multiple river channels with major and minor river channels bisecting them.

The normalized ground elevation duration curves for the minimum frequent-low levels were identical to the normalized ground elevations curves for the minimum average levels because each minimum frequent-low level primary criterion equaled a 20-in. soil water table drawdown from the average shallow marsh elevations. Consequently, a chart of the normalized ground elevation duration curves for the minimum frequent-low levels was not included in this report.

The average ground surface elevation of the upper wet prairie community was the primary minimum frequent-high level criterion at four of the five locations. Normalized ground elevation duration curves for the upper wet prairie vegetation community facilitate comparing this vegetation community type, delineated at the field transect locations, upstream and downstream from SR 50 (Figure 29). As mentioned previously, no upper wet prairie was traversed at the Lake Cone Transect and thus the site is not considered in this analysis. The analysis confirms this community type was delineated similarly and will experience similar river hydrology at the different locations (Figure 29).

Based on an analysis of upper wet prairie normalized elevation duration data (Figure 29), the parallel shape of the four upper wet prairie lines confirms that this community type was delineated similarly and will experience similar river hydrology at the different locations.

Based on this analysis, the maximum normalized upper wet prairie elevation points were within 1.1 ft of each other. These maximum elevation points were only 0.4 to 1.5 ft greater than their individual average upper wet prairie elevations. Identifying the upper wet prairie upper ecotone was relatively straightforward at the H-1, Tosohatchee North and Great Outdoors transects due to an abrupt transition to either a palm hydric hammock or in the case of the H-1 and TOSO-528 transects, a palm hammock–transitional shrub community. However, the TOSO-528 transect upper wet prairie upper ecotone was difficult to delineate due to a 1998 wildfire which severely impacted the adjacent palm hydric hammock and palm hammock–transitional shrub communities, killing many of the cabbage palms and, thus, eliminating an abrupt transition into the typically dominant cabbage palm overstory of the palm hydric hammock. Even so, the TOSO-528 upper wet prairie was delineated similarly to the upper wet prairies traversed at the Tosohatchee North, H-1, and Great Outdoors Transects (Figure 29).

Also noteworthy are the relatively higher normalized maximum upper wet prairie ground surface elevation points surveyed at the Great Outdoors Transect. These maximum normalized upper wet prairie elevation points collected at the Great Outdoors are only 1–1.5 ft greater than the average upper wet prairie elevation at this location and yet these points are noticeable because they are less similar to the other upper wet prairie normalized maximum elevations (Figure 29). Possible explanations for the Great Outdoors maximum normalized upper wet prairie elevations difference includes the fact that the adjacent and upslope palm hydric hammock occurred on a relatively steep slope, likely providing greater shallow groundwater and a higher soil water table downslope in the upper wet prairie. Thus the adjacent upper wet prairie soils are too wet for the palm hydric hammock to occur downslope at a relative elevation similar to the other transects. Additionally, cattle were prevalent at the Great Outdoors Transect and a man-made water reservoir was located approximately 500 ft south of the Great Outdoors upper wet prairie. The construction of this reservoir occurred many years ago and likely resulted in soil deposition in the nearby Great Outdoors upper wet prairie which resulted in a slightly higher normalized maximum ground surface elevation points at this location.

The analysis indicates a relatively small range in normalized minimum upper wet prairie normalized elevation points. Typically, the upper wet prairie community low elevation was a very subtle ecotone transition to the adjacent wet prairie. Thus this small range (<0.4 ft) in minimum normalized upper wet prairie elevations indicates strong consistency in the upper wet prairie field data collection methodology upstream and downstream from SR 50 (Figure 29).

In summary, normalized ground elevation duration curves (Figures 28 and 29) along with stage duration analyses (Table 52) indicate that like vegetation community types were delineated similarly, thus adding credibility to the field data collection and ultimately the recommended MFLs for the St. Johns River at SR 50.

Implementation of MFLs

As changes in hydrologic conditions upstream of SR 50 are considered, SJRWMD plans to perform modeling evaluations as outlined in

Appendix D to determine the extent to which the proposed changes are likely to affect MFLs. These hydrologic condition changes could include surface water withdrawals, changes in the configuration or operation of the Upper St. Johns River Basin Project, or similar changes.

CONCLUSION

The following conclusions are drawn from the information presented in this document.

1. Establishment and enforcement of the recommended MFLs for the St. Johns River at SR 50, as presented in this document, should adequately provide for the protection of the water resources or ecology of the area, which includes the St. Johns River and its associated flood plain from SR 528 on the south to SR 46 on the north, from significant harm as a result of consumptive uses of water (Table 50).

2. Periodic reassessments of these recommended MFLs, based on monitoring data collected in the future, would better assure that these levels are providing the expected levels of protection of the water resources and ecology of the area.

RECOMMENDATION

The following recommendations are offered concerning the information presented in this document.

1. The recommended MFLs for the St. Johns River at SR 50 should be considered for establishment and enforcement by rule (Table 50).

2. Existing data collection associated with the development of the recommended MFLs for the St. Johns River at SR 50 should be continued at least until a comprehensive monitoring plan is developed and implemented.

3. A comprehensive monitoring plan should be developed within six months of the date of establishment of MFLs for the St. Johns River at SR 50. This plan should include an implementation schedule that assures that identified data collection and management is in place in advance of any significant withdrawals from the St. Johns River in the area from SR 528 to SR 46.

4. Any proposed changes in hydrologic conditions upstream of SR 50 should be evaluated using modeling as outlined in Appendix D to determine the extent to which the proposed changes are likely to affect MFLs. These hydrologic condition changes could include surface water withdrawals, changes in the configuration or operation of the Upper St. Johns River Basin project, or similar changes.

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APPENDIX A—VEGETATION DATA SHEET

Vegetation Record Data Sheet

Date ______________________ **Transect No.** ______________________

Locality ______________________ **Transect Length (ft)** ______________

Observers ____

Notes ____

____

____

Cover Estimates		
Class	Percent	Description
1	< 1%	Rare
2	1-10%	Sparse
3	11-25%	Uncommon
4	26-50%	Common
5	51-75%	Abundant
6	76 -95%	Dominant
7	> 95%	Monocluture

V	Plant Species Name:	Plant Community Name									
		Distance on Transect (ft)									

Note: Estimates of percent cover are made only for plants rooted within a particular habitat Page ____ of _____

APPENDIX B—SOIL DESCRIPTIONS

Soil types sampled along transects near State Road (SR) 50

Soil Name/Typical Pedon	Transect Names were Soil observed
Anclote sand	Ruth Lake, Great Outdoors
Bradenton fine sand	Ruth Lake, H-1, Lake Cone
Chobee loamy fine sand	H-1, Lake Cone, M-6, Toso North, Great Outdoors, TOSO-528
Delray fine sand	Ruth Lake, Great Outdoors
Denaud sand	Ruth Lake, H-1, Lake Cone, Toso North, Great Outdoors, TOSO-528
Eaton loamy sand	H-1, Lake Cone, Toso North, Great Outdoors, TOSO-528
Floridana sand	H-1, TOSO-528
Holopaw	H-1, Lake Cone, Toso North
Lynne sand	Great Outdoors
Manatee loamy fine sand	Ruth Lake, H-1, Lake Cone, Toso North, TOSO-528
Pomona sand	Ruth Lake, Great Outdoors
Pompano fine sand	Ruth Lake, H-1, Great Outdoors
Tuscawilla fine sand	Lake Cone
Unknown cumulic argiaquoll	M-6, Toso North, TOSO-528
Wabasso fine sand	TOSO-528

Source: *Official Soil Series Descriptions* (Prepared by Soil Survey staff, U.S. Dept. of Agriculture, NRCS, Soil Survey Division, Lincoln, Nebr.: accessed on the NRCS Soils Web site at *http://ortho.ftw.nrcs.usda.gov/cgi–bin/osd/osdname.cgi)*

Anclote Sand. Anclote sand consists of very deep, very poorly drained, rapidly permeable soils occurring in depressions, poorly defined drainage ways, and floodplains. They formed in thick beds of sandy marine sediments. Under natural conditions, Anclote sands are saturated and frequently covered with shallow water during the rainy season. The water table is within 10 inches (in.) of the surface for 6 or more months during most years, and recedes to depths of more than 20 in. during the driest season. Depressional areas are ponded.

Bradenton Fine Sand. The Bradenton series consists of very deep, poorly drained, moderately permeable soils on low ridges and on flood plains. They formed in loamy marine sediments influenced by calcareous material. Bradenton series soil water table is at depths of less than 18 in. for 2–6 months annually during most years.

Chobee Fine Sandy Loam. Chobee fine sandy loam is a very poorly drained soil found in low places in coastal hammocks, in drainage ways, and on flood plains. This soil is covered with standing water for extended periods during the rainy season from June–November and after prolonged heavy rain in winter. The water table is within 6 in. of the soil surface for 1–4 months during most years and is seldom below 10 in., even during prolonged dry spells.

Delray Fine Sand. The Delray series consists of soils that are very poorly drained. These soils form in sandy and loamy marine sediment. They are in sloughs and on broad, low plains on the flatwoods. In most years, Delray soils have a seasonal high water table within 12 in. of the surface for 6 months or more. The surface layer of Delray soil remains wet for long periods after heavy rains.

Denaud Sand. The Denaud series consists of deep, very poorly drained, moderately permeable soils with a thin organic layer over sandy and loamy material. These soils formed in sandy and loamy marine deposits and are ponded for 6–9 months, in most years, and are saturated to the surface the rest of the time.

Eaton Loamy Sand. The Eaton series consists of poorly and very poorly drained soils more than 80-in. thick. Eaton soils formed in clayey marine sediments. They occur in uplands and depressions of peninsular Florida. Eaton series soil water table is at depths of less than 10 in. for periods of 1–4 months during most years. Depressional areas are ponded for very long periods.

Floridana Sand. The Floridana series consists of very deep, very poorly drained, slowly to very slowly permeable soils on low broad flats, floodplains, and in depressional areas. They formed in thick beds of sandy and loamy marine sediments. The water table within Floridana soil is typically at depths of less than 10 in. below the surface and depressional areas are ponded for more than 6 months during most years. Floodplains are flooded for 1–3 months during most years.

Holopaw Sand. The Holopaw series consists of deep and very deep, poorly and very poorly drained soils formed in sandy marine sediments. The Holopaw soil water table is within 12 in. of the soil surface for 2–6 months during most years. Depressional areas are ponded for more than 6 months during most years.

Lynne Sand. The Lynne series consists of poorly drained soils that are 72 in. or more deep. Lynne soils formed in sandy and loamy marine sediments. A seasonal high water table is within 1 foot of the surface for 1–4 months in most years.

Manatee Loamy Fine Sand. The Manatee series consists of very deep, very poorly drained, moderately permeable soils in depressions, broad drainage ways, and on floodplains. They formed in sandy and loamy marine sediments. The water table is within 10 in. of the surface for more than 6 months annually during most years. Depressional areas are ponded for about 6–9 months during most years.

Pomona Sand. Pomona sand consists of very deep, poorly and very poorly drained soils that formed in sandy and loamy marine sediments. Pomona soils are on low, broad, nearly level ridges within the flatwoods areas of the Lower Coastal Plain Under natural conditions the water table is within a depth of 6 to 18 in. for 1–3 months and is at a depth of 10 to 40 in. for 6 months or more during most years. Depressional areas are ponded for 6–9 months or more in most years.

Pompano Fine Sand. Pompano fine sand is a poorly drained sandy soil that formed in thick beds of marine sands. This soil occurs in depressions and drainage ways, and broad low flat areas in the flatwoods. Typically, the surface layer is dark gray fine sand about 7-in. thick. The underlying material is fine sand to a depth of 80 in. or more. The water table is at depths of less than 10 in. from the soil surface for 2–6 months each year. Even during the drier months, the water table is within 30 in. from the soil surface for more than 9 months each year.

Tuscawilla Fine Sand. The Tuscawilla series consists of very deep, very poorly drained, moderately permeable soils in hammocks on the lower coastal plain They formed in sandy and loamy marine sediments containing shells and shell fragments. The water table is within depths of 10 in. for 2–6 months in most years.

Wabasso Fine Sand. The Wabasso series consists of deep, very poorly and poorly drained, very slowly and slowly permeable soils on flatwoods, floodplains, and depressions in peninsular Florida. They formed in sandy and loamy marine sediments. The water table is at depths of 12 to 40 in. for more than 6 months in most years. The water table is at depths of less than 12 in. for less than 60 days in wet seasons and is at depths of more than 40 in. during very dry seasons. Depressions are ponded for periods of 6–9 months in most years.

APPENDIX C—SJRWMD MFL FIELD TRANSECTS NEAR SR 50 SOIL SAMPLING REPORTS FROM SOIL CONTRACTOR

Under Separate Cover

APPENDIX D—IMPLEMENTATION OF MFLS ON THE ST. JOHNS RIVER AT STATE ROAD 50

Prepared by
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The objective of minimum flows and levels (MFLs) is to establish limits to allowable hydrologic change in a water body or watercourse, to prevent significant harm to the water resources or ecology of an area. Hydrologic changes within a water body or watercourse may result from an increase in the consumptive use of water or the alteration of basin characteristics, such as down-cutting outlet channels or constructing outflow structures.

MFLs define a series of minimum high and low water levels and / or flows of differing frequencies and durations required to protect and maintain aquatic and wetland resources. MFLs take into account the ability of wetlands and aquatic communities to adjust to changes in hydrologic conditions. MFLs allow for an acceptable level of change to occur relative to existing hydrologic conditions, without incurring significant ecological harm to the aquatic system.

Before MFLs can be applied, the minimum hydrologic regime must be defined or characterized statistically. Resource management decisions can then be made predicated on maintaining at least these minimum hydrologic conditions as defined by the appropriate statistics.

One way to understand how changes within a watershed alter a hydrologic regime and, therefore, how the aquatic and wetland resources might be affected, is by simulating the system with a hydrologic model. Significant harm can be avoided by regulating hydrologic changes based on the comparison of statistics of the system with and without changes.

MFLs determinations are based on a philosophy of maintaining the duration and return periods of selected stages and / or flows. Thus a water body can fall below a minimum level, but if it does so too often and / or for too long, then that minimum level would no longer be met.

Statistical analysis of model output provides a framework to summarize the hydrologic characteristics of a water body. The St. Johns River Water

Management District (SJRWMD) MFLs program relies on a type of statistical analysis referred to as frequency analysis.

Frequency Analysis

As discussed previously, aquatic resources are sustained by a certain hydrologic regime. Depending on the resource in question, a selected ground elevation might need to

- Remain wet for a certain period of time with a certain frequency
- Remain dry for a certain period of time with a certain frequency
- Be under a given minimum depth of water for a certain period of time with a certain frequency

Frequency analysis estimates how often, on average, a given event will occur. If annual series data are used to generate the statistics, frequency analysis estimates the probability of a given hydrologic event happening in any given year.

A simple example illustrates some of the concepts basic to frequency analysis. A frequently used statistics with respect to water level is the yearly peak stage of a water body. If a gauge has been monitored for 10 years, then there will be 10 yearly peaks $S_1, S_2, \cdots, S_{10}$. Once sorted and ranked, these events can be written as $\hat{S}_1, \hat{S}_2, \cdots, \hat{S}_{10}$, with $\hat{S}_1$ being the highest peak. Based on this limited sample, the estimated probability of the yearly peak being greater than or equal to $\hat{S}_1$ would be

$$P(S \geq \hat{S}_1) = \frac{1}{n} = \frac{1}{10} = 0.1; \qquad \textbf{(A1)}$$

the probability of the 1-day peak stage in any year being greater than $\hat{S}_2$

$$P(S \geq \hat{S}_2) = \frac{2}{10} = 0.2; \qquad \textbf{(A2)}$$

and so on. The probability of the stage equaling or exceeding $\hat{S}_{10}$ would be

$$P(S \geq \hat{S}_{10}) = \frac{10}{10} = 1.0. \qquad \textbf{(A3)}$$

Since this system of analysis precludes any peak stage from being lower than $\hat{S}_{10}$, the usual convention is to divide the stage continuum into 11 parts: nine between each of the 10 peaks, one above the highest peak, and one below the lowest peak ($n - 1 + 2 = n + 1 = 11$). This suggests what is known as the Weibull plotting position formula:

$$P(S \geq \hat{S}_m) = \frac{m}{n+1} \tag{A4}$$

where,

$P(S \geq \hat{S}_m) =$ probability of S equaling or exceeding $\hat{S}_m$
$m =$ rank of the event

Thus, in the example, the probability of the peak in any year equaling or exceeding $\hat{S}_1$ would be

$$P(S \geq \hat{S}_1) = \frac{1}{n+1} = \frac{1}{11} = 0.0909; \tag{A5}$$

the probability of the 1-day peak stage in any year being greater than $\hat{S}_{10}$

$$P(S \geq \hat{S}_{10}) = \frac{10}{11} = 0.9091; \tag{A6}$$

and so on. The probability of the stage in any year is smaller than $\hat{S}_{10}$ would be

$$P(S < \hat{S}_{10}) = 1 - P(S \geq \hat{S}_{10}) = 1 - \frac{10}{11} = 1 - 0.9091 = 0.0909 \tag{A7}$$

The return period (in years) of an event, T, is defined as

$$T = \frac{1}{P} \tag{A8}$$

so the return period for $\hat{S}_1$ would be

$$T(\hat{S}_1) = \frac{1}{P(S \geq \hat{S}_1)} = \frac{1}{\frac{1}{11}} = 11 \tag{A9}$$

Said another way, $\hat{S}_1$ would be expected to be equaled or exceeded, on average, once every 11 years.

As the size of the sample increases, the probability of $\hat{S}_1$ being exceeded decreases. Thus, with n = 20,

$$P(S \geq \hat{S}_1) = \frac{1}{n+1} = \frac{1}{21} = 0.048 \tag{A10}$$

and

$$T(\hat{S}_1) = \frac{1}{P(S \geq \hat{S}_1)} = 21 \tag{A11}$$

The stage or flow characteristics of a water body can be summarized using the Weibull plotting position formula and a frequency plot. For example, Figure D1 shows a flood frequency plot generated from annual peak flow data collected at the U.S. Geological Survey (USGS) gauge on the Wekiva River.

Minimum events are treated in much the same way as maximum events, except with minimums the events are ranked from smallest to largest. Thus $\hat{S}_1$ is the smallest or lowest event in a sampling. The minimum stage or flow characteristics of a gauge or water body can be summarized using the Weibull plotting position formula and a frequency plot. For example, Figure D2 shows a drought frequency plot generated from a hydrologic simulation of the middle St. Johns River.

One of the purposes of performing this process of sorting, ranking, and plotting events is to estimate probabilities and return periods for events larger than $\hat{S}_1$, smaller than $\hat{S}_n$, or any event between sample points. There are two methods of obtaining these probabilities and return periods. The first method is to use standard statistical methods to mathematically calculate these probabilities and return periods (Figure D3). This method is beyond the scope of this appendix; the reader is referred to a standard hydrology text (Ponce 1989, Linsley et al. 1982) or the standard flood frequency analysis text, Bulletin 17B (USGS 1982).

With the second method, interpolated or extrapolated frequencies and return periods can also be obtained by the graphical method. Once the period-of-record or period-of-simulation events have been sorted and ranked, they are plotted on probability paper. Probabilities and return periods for events outside of the sampled events can be estimated by drawing a line through the points on the graph to obtain an estimated best fit (Figure D4).

Frequency analysis is also used to characterize hydrologic events of durations longer than 1 day. Frequency analysis encompasses four types of events: (1) maximum average stages or flows, (2) minimum average stages or flows, (3) maximum stages or flows continuously exceeded, and (4) minimum stages or flows continuously not exceeded.

Maximum Average Stages or Flows. In this case, an event is defined as the maximum value for a mean stage or flow over a given number of days. For example, if the maximum yearly values for a 30-day average are of interest, the daily-value hydrograph is analyzed by using a moving 30-day average. Therefore, a 365-day hydrograph would have 336 (365 – 30 + 1 = 336) different values for a 30-day average. These 336 values are searched and the highest is saved. After performing this analysis for each year of the period of record or period of simulation, the events are sorted and ranked. The analytical process is then the same as for the 1-day peaks.

Minimum Average Stages or Flows. In this case, an event is defined as the minimum value for a mean stage or flow over a given number of days. For example, if the minimum yearly values for a 30-day average are of interest, the daily-value hydrograph is analyzed by using a moving 30-day average. Therefore, a 365-day hydrograph would have 336 (365 – 30 + 1 = 336) different values for a 30-day average. These 336 values are searched and the lowest is saved. After performing this analysis for each year of the period of record or period of simulation, the events are sorted and ranked. The process is then the same as for the 1-day low stages.

Maximum Stage or Flow Continuously Exceeded. In this case, an event is defined as the stage or flow that is exceeded continuously for a set number of days. For example, if the maximum yearly ground elevation that continuously remains under water for 60 days is of interest, the stage hydrograph of each year is analyzed by taking successive 60-day periods and determining the stage that is continuously exceeded for that period. This is repeated for 306 (365 – 60 + 1 = 306) periods of 60 days. The maximum stage in those 306 values is saved. Once that operation is performed for all years of record or of simulation, the results are sorted and ranked as for the 1-day peaks.

Minimum Stage or Flow Continuously Not Exceeded. In this case, an event is defined as the stage or flow that is not exceeded continuously for a set number of days. For example, if the minimum yearly ground elevation that continuously remains dry for 60 days is of interest, the stage hydrograph of each year is analyzed by taking successive 60-day periods and determining the stage that is continuously not exceeded for that period. This is repeated for 306 (365 – 60 + 1 = 306) periods of 60 days. The minimum stage in those 306 values is saved. Once that operation is performed for all years of record or of simulation, the results are sorted and ranked as for the 1-day low stages.

In frequency analysis, it is important to identify the most extreme events occurring in any given series of years. Because high surface water levels (stages) in Florida generally occur in summer and early fall, maximum value analysis is based on a year that runs from June 1 to May 31. Conversely, because low stages tend to occur in late spring, the year for minimum events runs from October 1 to September 30.

Hydrologic Statistics and Their Relationships to the St. Johns River at SR 50 MFLs

This section will illustrate the process used to relate long-term hydrologic statistics to the establishment of MFLs. As discussed in the main body of this report, SJRWMD has determined four MFLs on the St. Johns River at SR 50: (1) the minimum frequent high (MFH); (2) the minimum average (MA); (3) the minimum frequent low (MFL); and (4) the minimum infrequent low (MIL). The MFH for this location will be used to illustrate how long-term hydrologic statistics of a river system relate to MFLs.

Each of the four MFLs is tied to characteristic stage durations and return frequencies. For example, the ground elevation represented by the MFH is expected to remain wet continuously for a period of at least 30 days. This event is expected to occur, on average, at least once every 2 years.

The standard stage frequency analysis described previously in this appendix was performed on stage data at the St. Johns River near Christmas USGS gauge (02232500). In particular, stages continuously exceeded (ground elevations remaining wet) for 30 days were determined, sorted, ranked, and plotted (Figure D5). The ground elevation of the MFH can be superimposed on the plot (Figure D6) to demonstrate how the level is related to the pertinent hydrologic statistics. Finally, a box bounded by (1) the MFH on the bottom, (2) a vertical line corresponding to a frequency of occurrence of once in every 2 years on the right, and (3) a vertical line corresponding to a frequency of occurrence of once in every 1.5 years on the left, is superimposed on the plot (Figure D7).

As, for example, surface water withdrawals are imposed on the St. Johns River system, the pertinent 30-day events will tend to occur less often. Therefore, the plotted events of Figure D7 will tend to shift to the right as conditions become drier. Given large enough withdrawals, eventually all 30-day values will shift outside of the box. In this case, based on modeling results, the MFH will no longer be met. Similar analyses are done for the MA (Figure D8), the MFL (Figure D9), and the MIL (Figure D10).

Determination of Minimum Flows Corresponding to Each Minimum Level for the St. Johns River at SR 50

MFLs generally are based on stages or water levels. However, in the case of a river system, each of these minimum levels can be associated with a minimum flow. The hydrologic model developed for the St. Johns River at SR 50 simulates only flows for this particular location, so conversion of minimum levels to minimum flows is required.

The same statistical analyses performed on stages at the gauge were performed on flows (Figures D10 through D12). Each of the minimum levels is associated with duration and return period. If flows of similar statistical characteristics can be assumed associated with each of the minimum levels, then minimum flows can be determined. For example, the 30-day, continuously exceeded stage just above the MFH level of 8.1 ft NGVD corresponds to an annual exceedence probability of approximately 70 % (Figure D7). The corresponding flow is approximately 1,950 cfs (Figure D11). The MA flow (Figure D12), MFL flow (Figure D13), and MIL flow (Figure D14) were estimated using the same procedure.

Summary of MFLs for the St. Johns River at SR 50

A summary of the MFLs for the St. Johns River at SR 50 is shown in Table D1. Values in this table will be used as benchmarks for modeling outputs to determine if water withdrawals upstream of this location will meet MFLs.

Table D1. Summary of MFLs for the St. Johns River at SR 50

MFLs	Level/Flow	Duration	Series	Water Year	Statistical Type	Minimum Return period	Maximum Return period
Minimum frequent-high	1,950 cfs	30 days	Annual	June 1–May 31	Maximum, continuously exceeded	NA	2 yrs
Minimum average	580 cfs	180 days	Annual	Oct. 1–Sept. 30	Minimum, mean not exceeded	1.5 yrs	NA
Minimum frequent-low	140 cfs	120 days	Annual	Oct. 1–Sept. 30	Minimum, continuously not exceeded	5 yrs	NA
Minimum infrequent-low	43 cfs	60 days	Annual	Oct. 1–Sept. 30	Minimum, continuously not exceeded	50 yrs	NA

References

Linsley, R.K., M.A. Kohler, and J.L.H. Paulhus. 1982. *Hydrology for Engineers*. 3d ed. New York: McGraw–Hill.

Ponce, V.M. 1989. *Engineering Hydrology: Principles and Practices*. Englewood Cliffs, N.J.: Prentice Hall.

[USGS] U.S. Geological Survey. 1982. *Guidelines for Determining Flood Flow Frequency*. Bulletin 17B. Reston, Va.: Interagency Advisory Committee on Water Data.

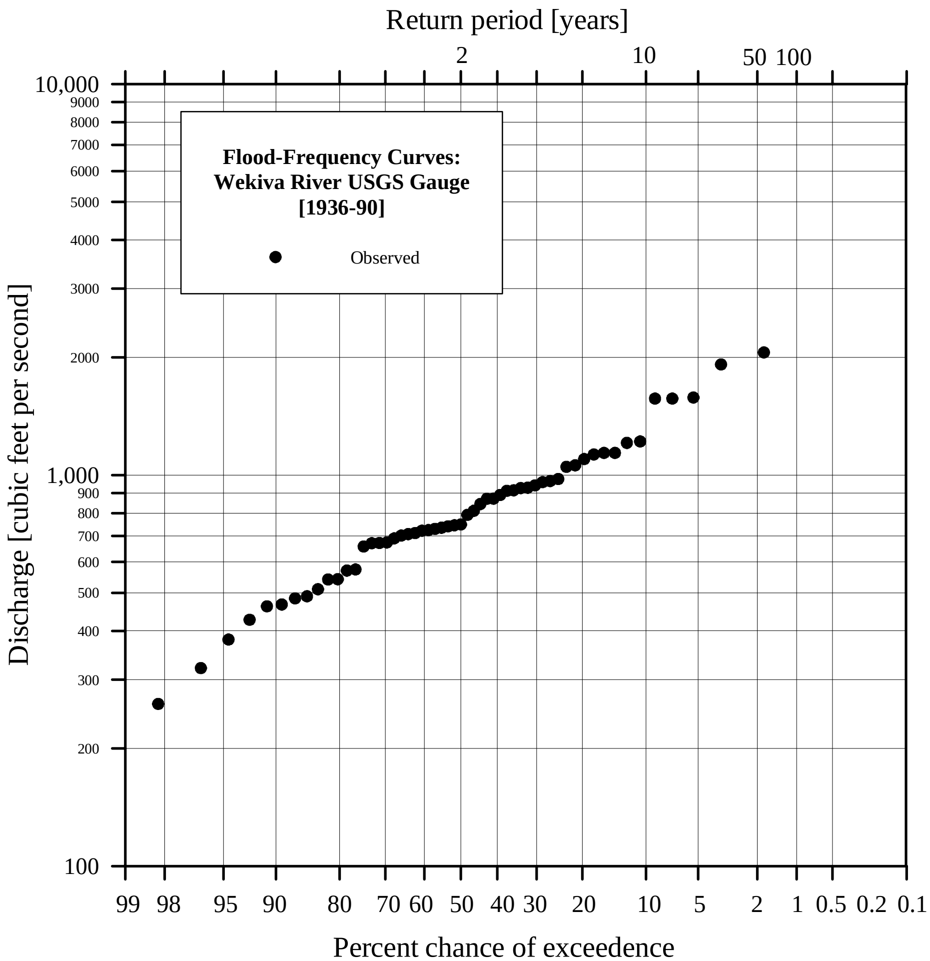

Figure D1. Flood frequencies for the Wekiva River at the USGS gauge near Sanford, Florida. The 1-day peak flows have been sorted, ranked, and plotted according to the Weibull plotting position formula.

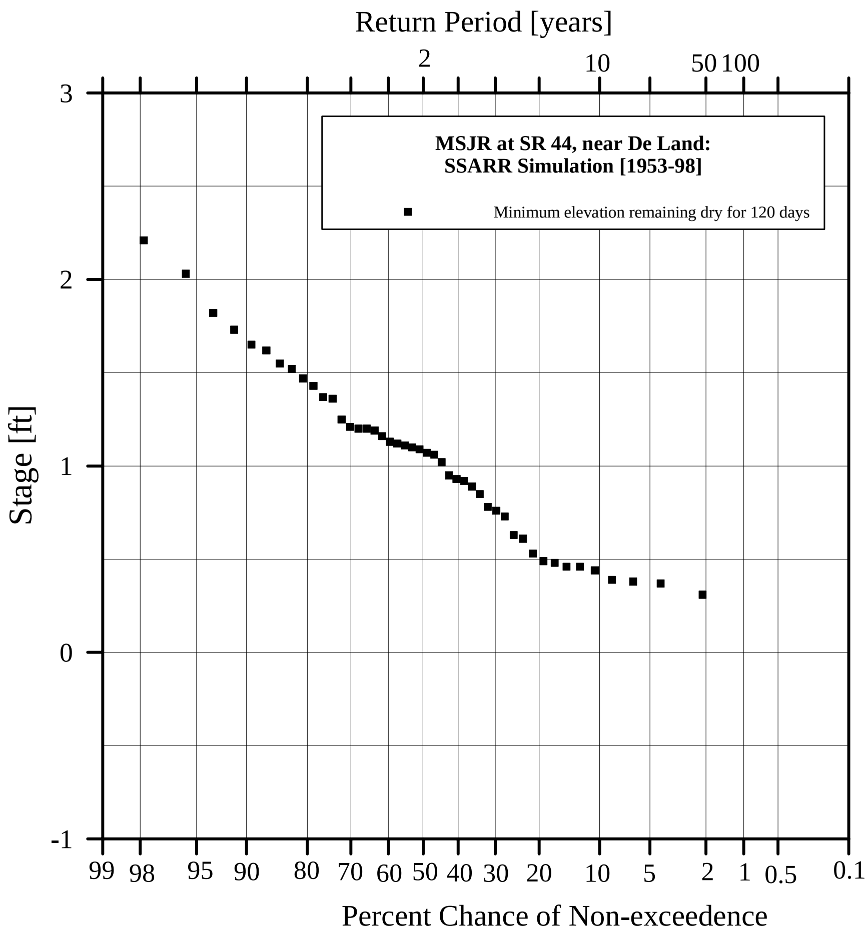

Figure D2. Drought frequencies computed using daily stages simulated by the MSJR SSARR model at SR 44, near DeLand. The minimum stages continuously not exceeded for 120 days have been sorted, ranked, and plotted according to the Weibull plotting position formula.

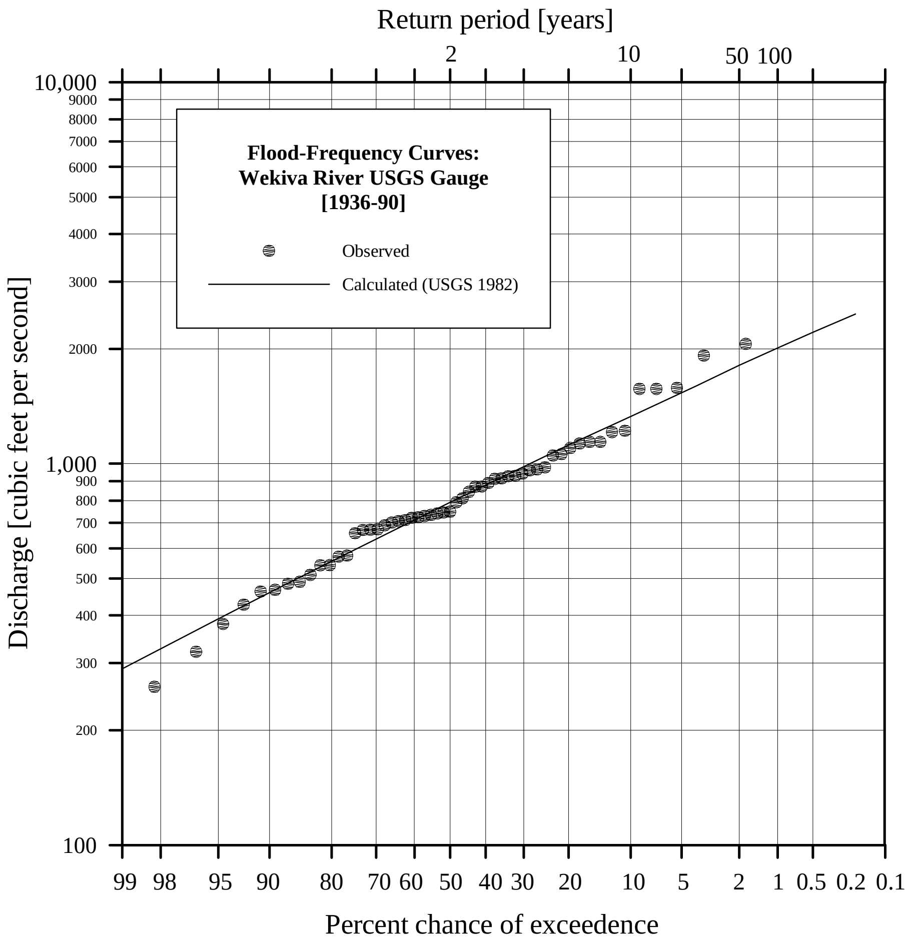

Figure D3. Flood frequencies for the Wekiva River at the USGS gauge near Sanford, Florida, fitted by standard mathematical procedure

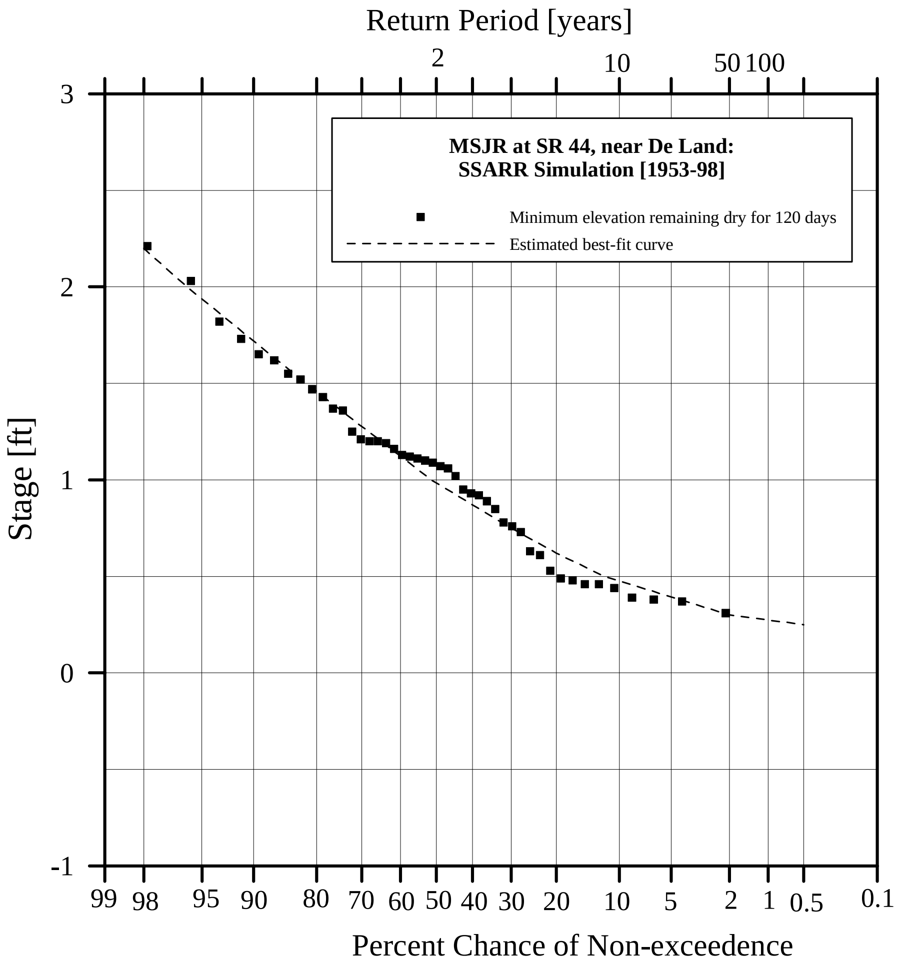

Figure D4. Drought frequencies computed using daily stages simulated by the MSJR SSARR model at SR 44, near DeLand, fitted by the graphical method

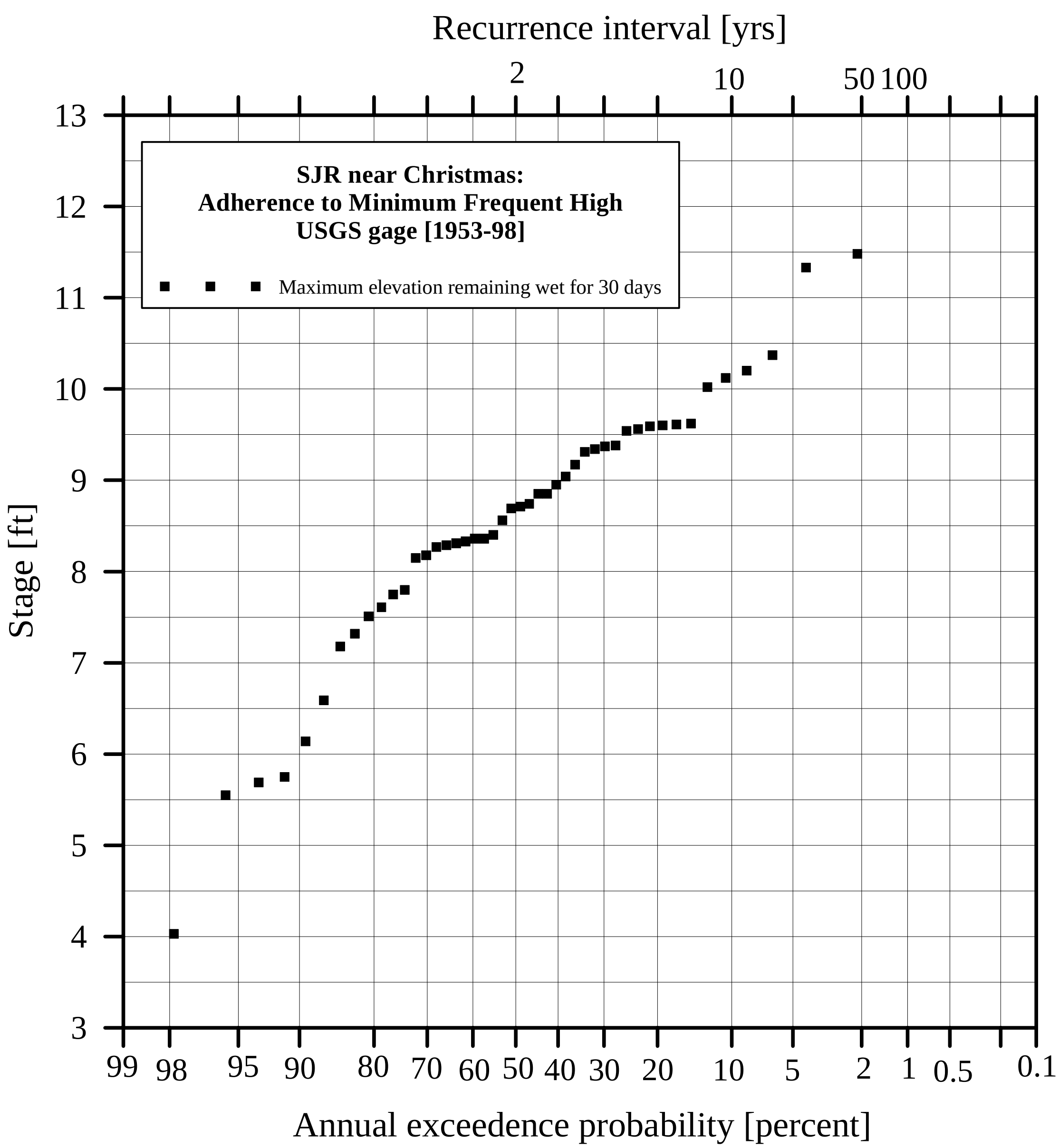

Figure D5. Flood frequencies computed using daily stages at the St. Johns River near Christmas USGS gauge, for elevations continuously wet for 30 days

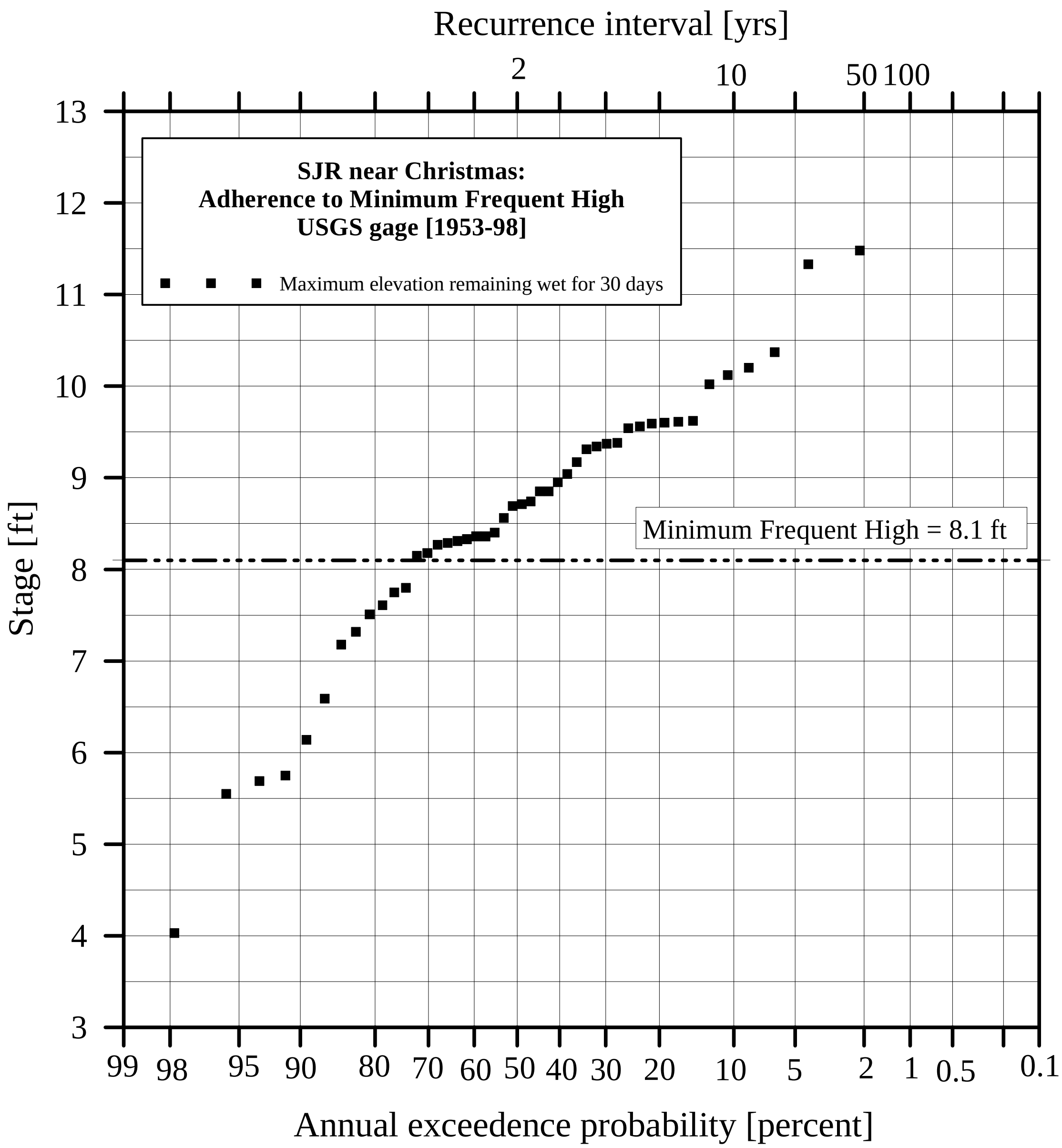

Figure D6. Flood frequencies computed using daily stages at the St. Johns River near Christmas USGS gauge, for elevations continuously wet for 30 days with the MFH of 8.1 ft NGVD superimposed

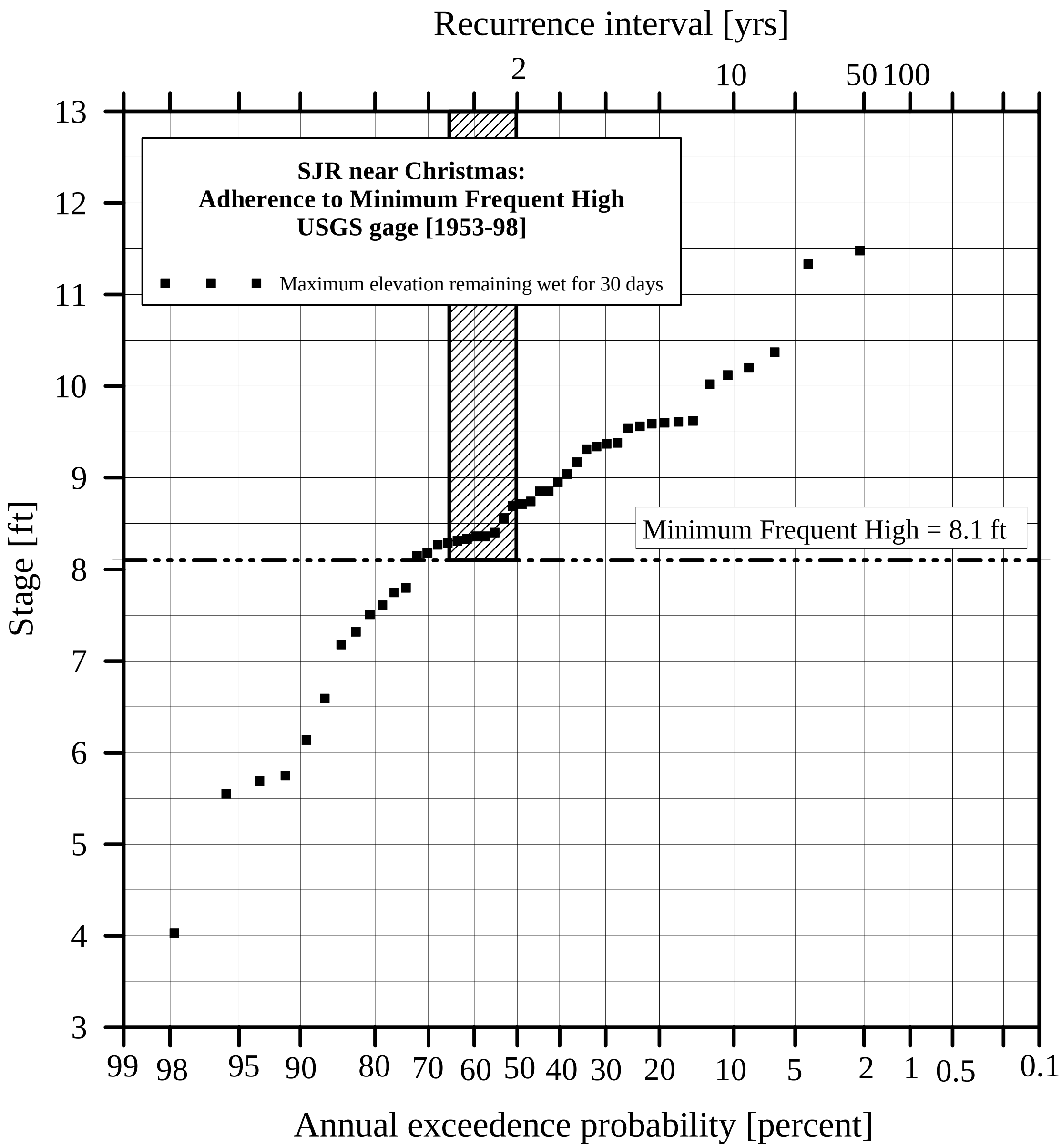

Figure D7. Flood frequencies computed using daily stages at the St. Johns River near Christmas USGS gauge, for elevations continuously wet for 30 days with a superimposed box bounded by (1) the MFH, (2) a vertical line corresponding to a return period of 1.5 years, and (3) a vertical line corresponding to a return period of 2 years

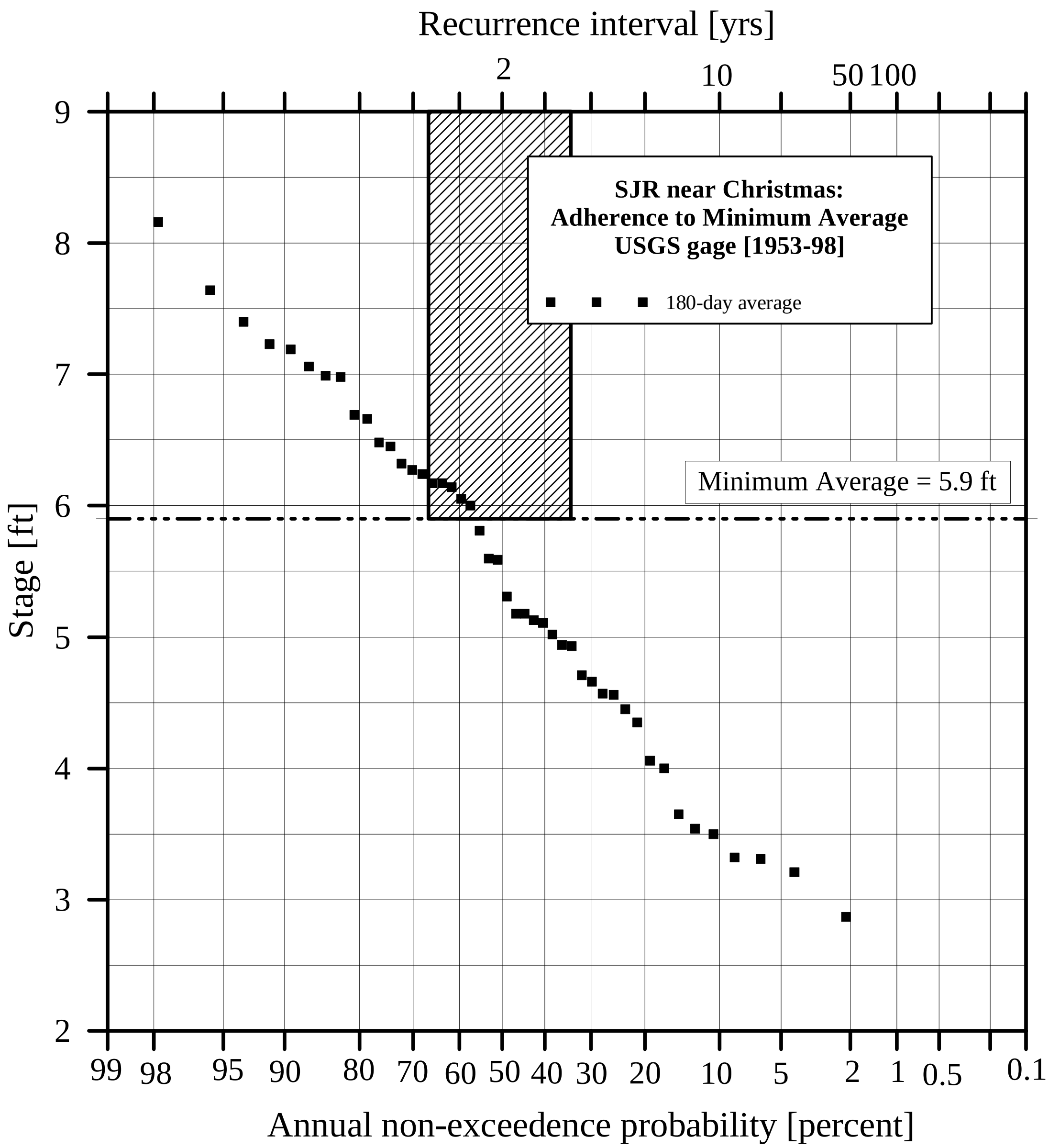

Figure D8. Drought frequencies computed using daily stages at the St. Johns River near Christmas USGS gauge, for the MA level

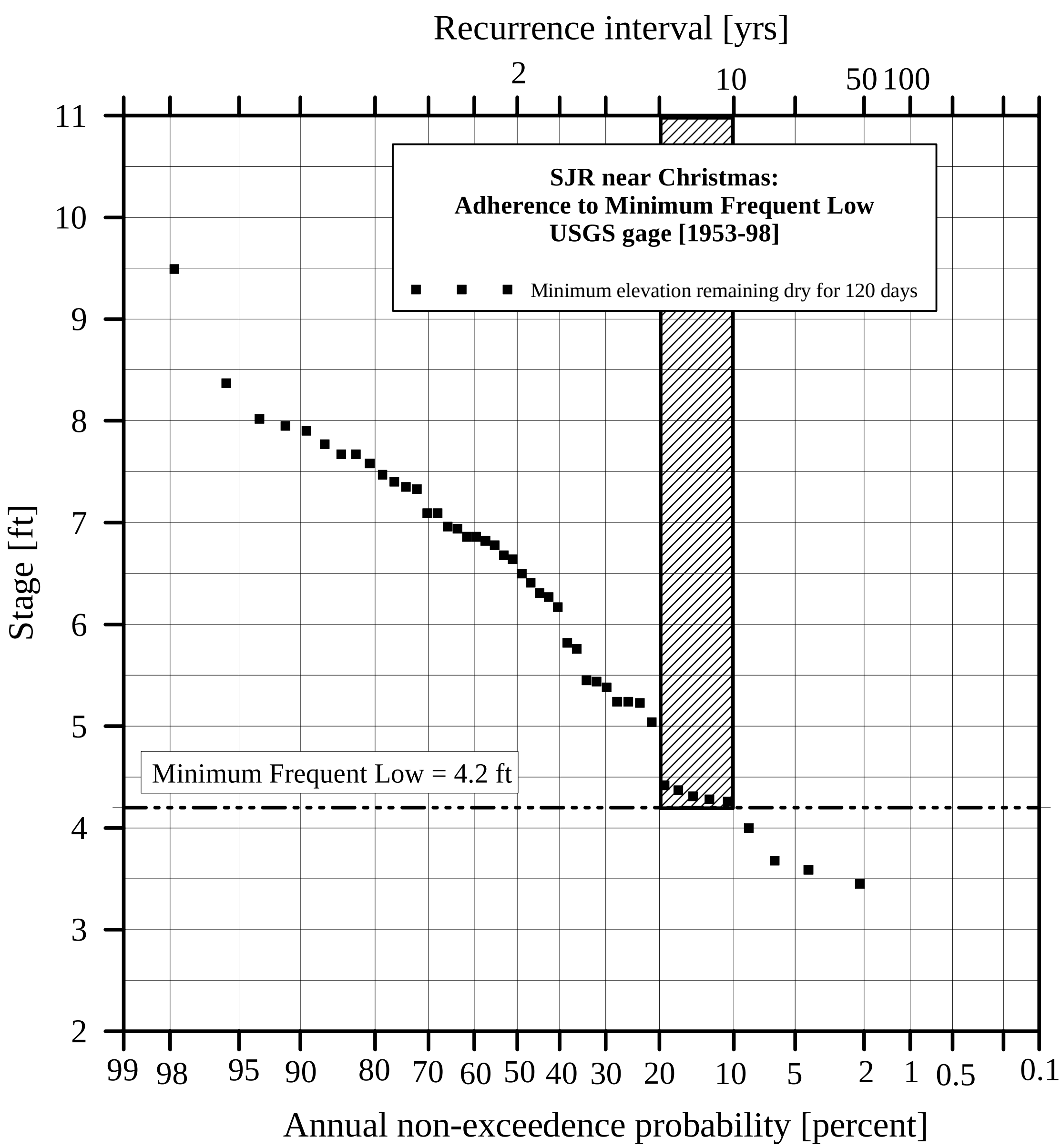

Figure D9. Drought frequencies computed using daily stages at the St. Johns River near Christmas USGS gauge, for the MFL level

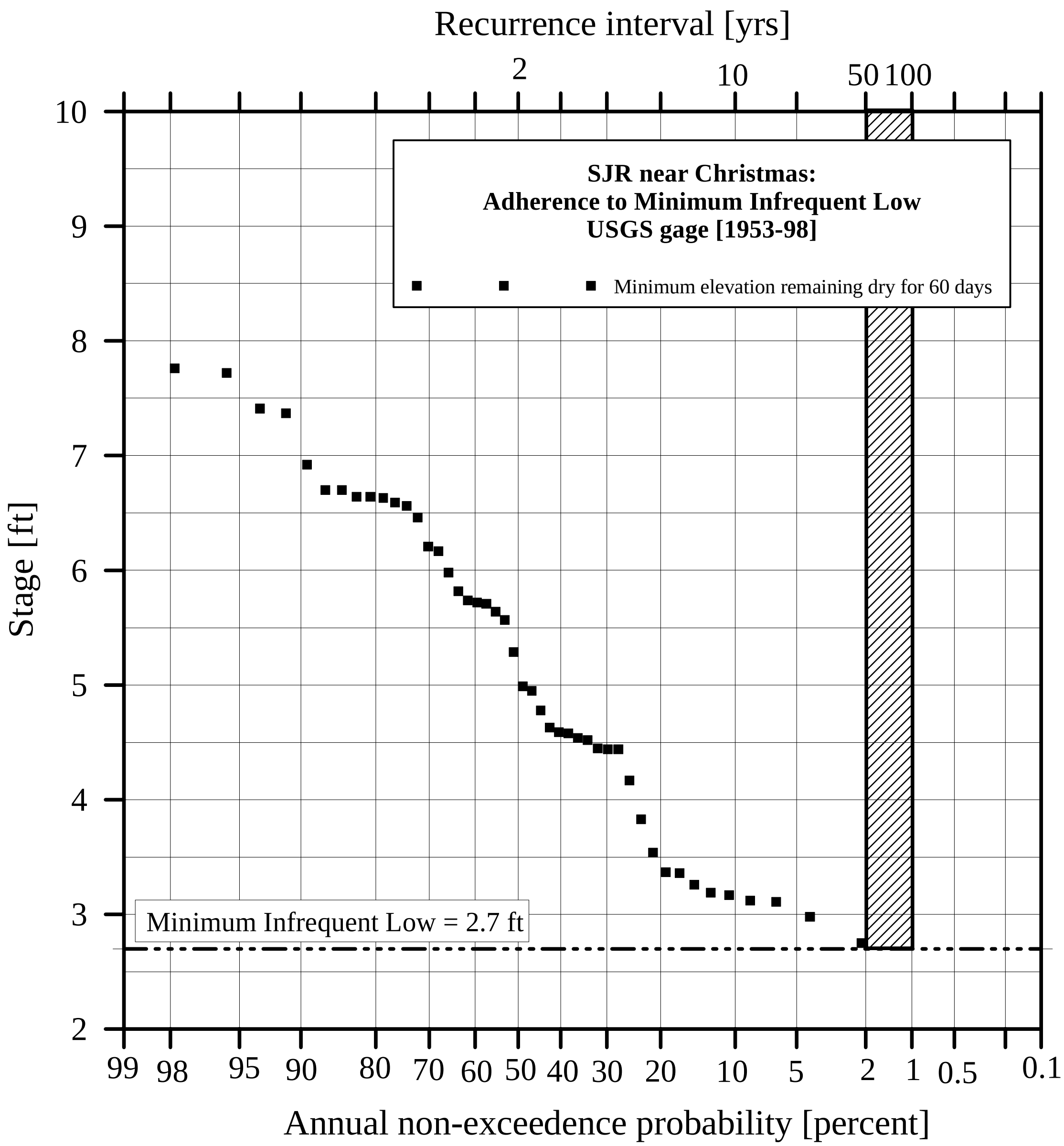

Figure D10. Drought frequencies computed using daily stages at the St. Johns River near Christmas USGS gauge, for the MIL level

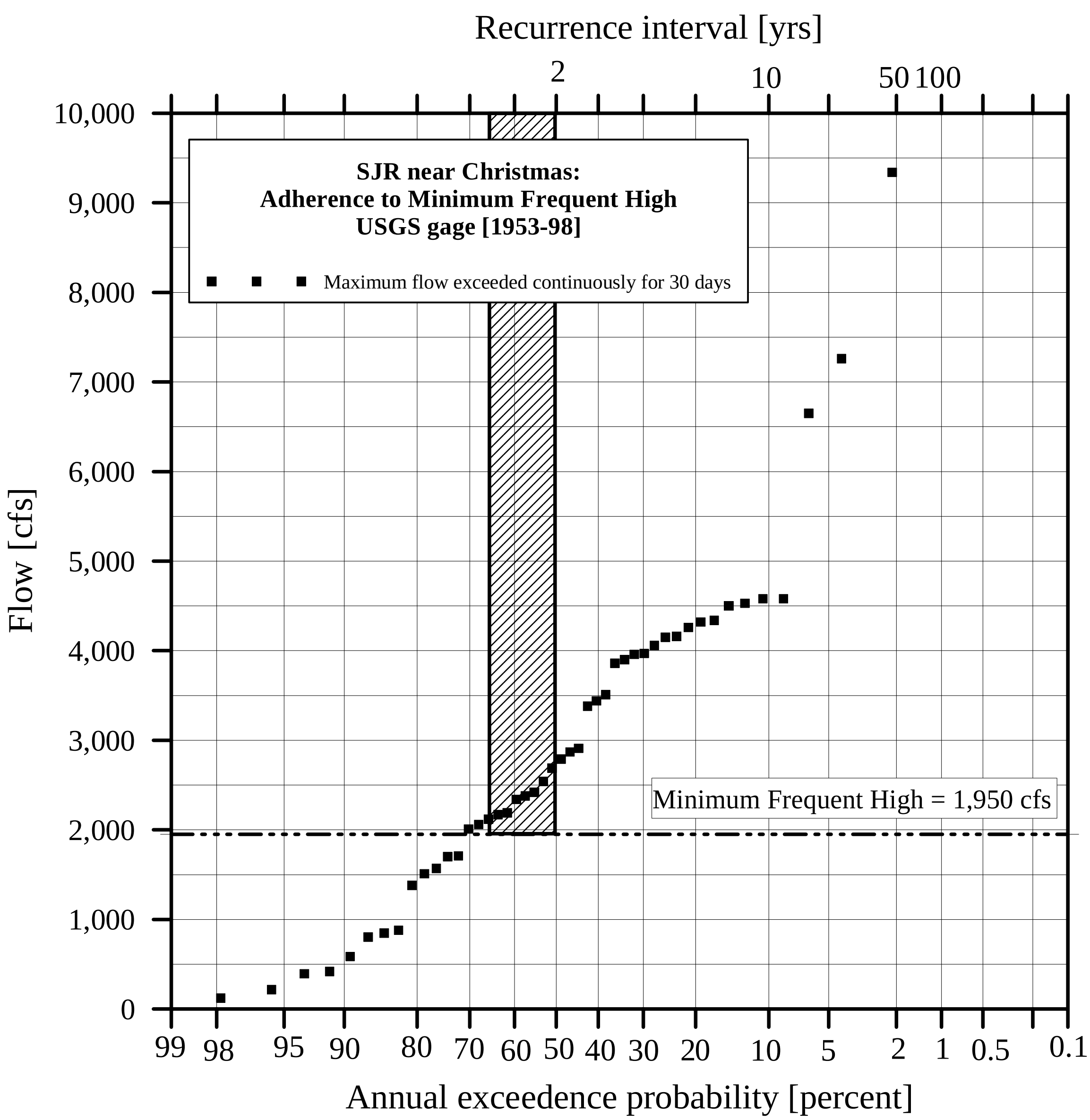

Figure D11. Flood frequencies computed using daily flows at the St. Johns River near Christmas USGS gauge, for the MFH flow

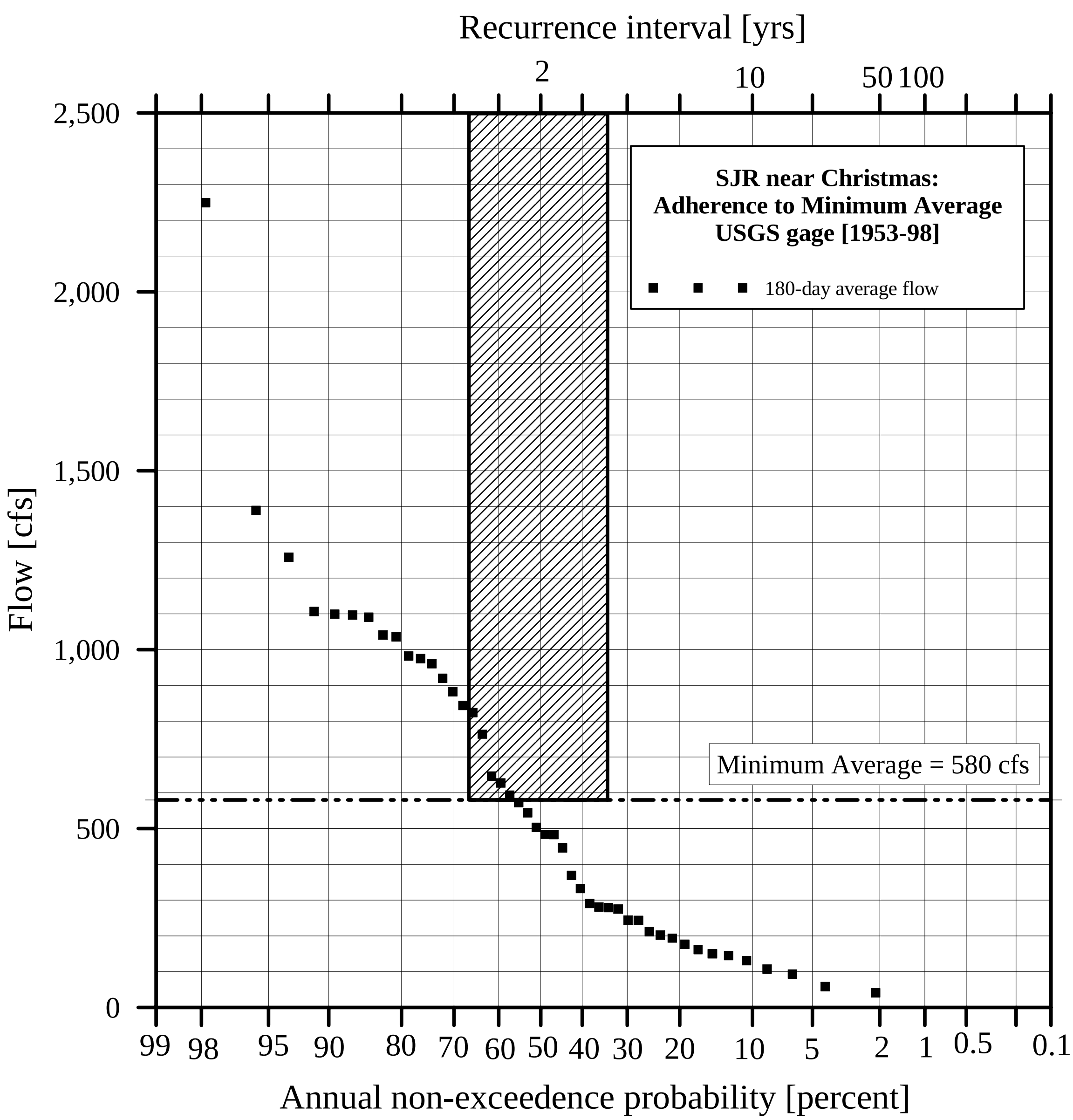

Figure D12. Drought frequencies computed using daily flows at the St. Johns River near Christmas USGS gauge, for the MA flow

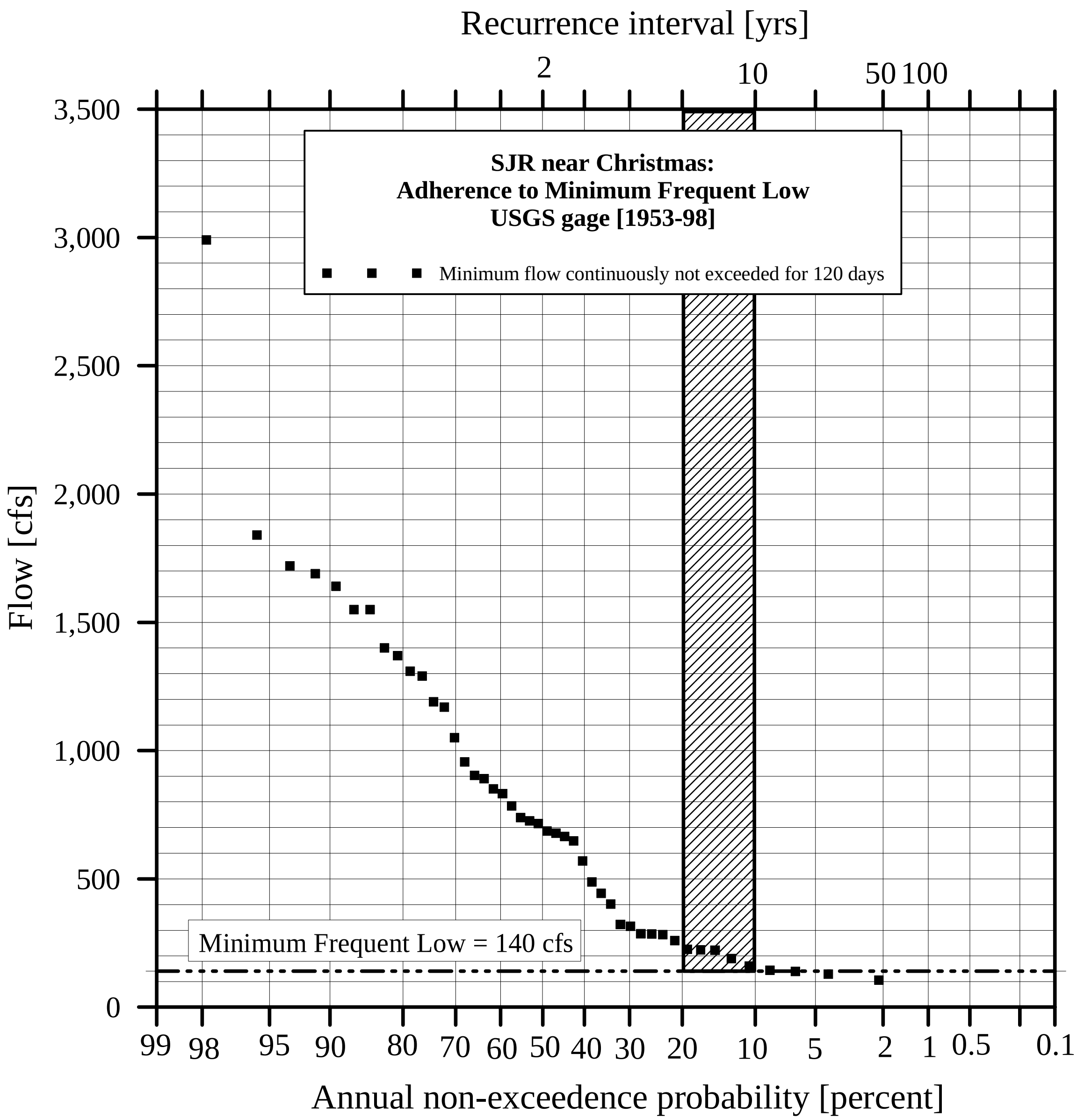

Figure D13. Drought frequencies computed using daily flows at the St. Johns River near Christmas USGS gauge, for the MFL flow

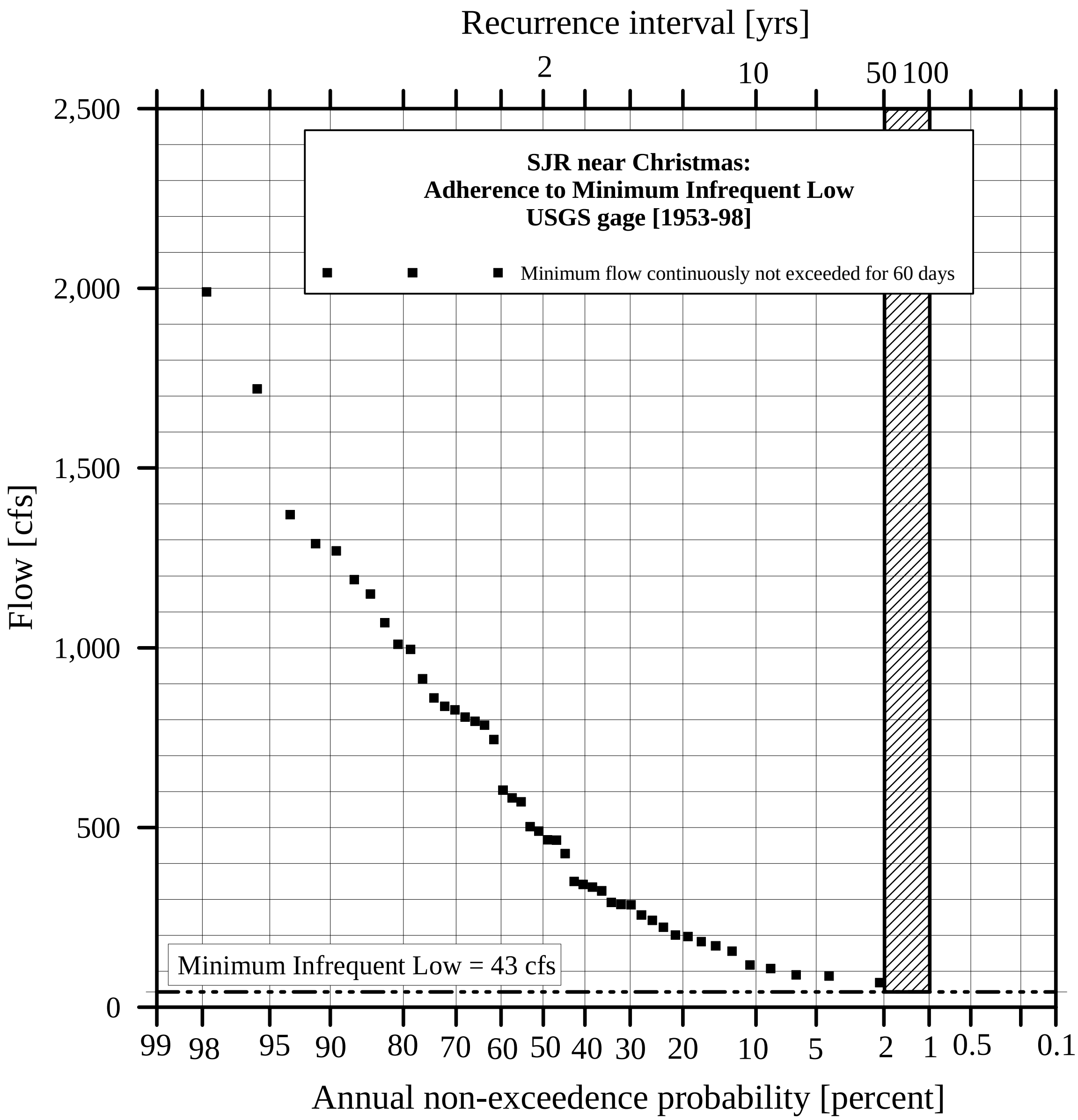

Figure D14. Drought frequencies computed using daily flows at the St. Johns River near Christmas USGS gauge, for the MIL flow