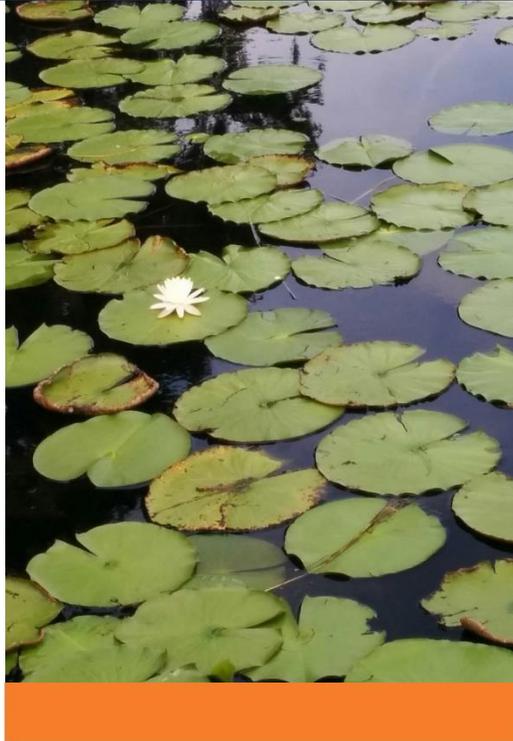**ECT**

1408 N. Westshore Boulevard, Suite 115, Tampa, Florida 33607

MINIMUM RECOMMENDED LAKE LEVELS:
LAKE HAMPTON, FLORIDA

October 2021

Prepared for:

SUWANNEE RIVER
WATER MANAGEMENT DISTRICT

Suwannee River Water Management District
9225 County Road 49
Live Oak, FL 32060

The Suwannee River Water Management District (SRWMD) was created by the Florida Legislature in 1972 to be one of five water management districts in Florida. It includes all or part of 15 counties in north central Florida. The mission of SRWMD 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. SRWMD accomplishes its mission through regulation; applied research; assistance to federal, state, and local governments; and land acquisition and management.

This document is published to disseminate information collected by SRWMD in pursuit of its mission. Copies of this document can be obtained from:

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Executive Summary

Under task work assignment (TWA): 19/20-061.003A, Environmental Consulting and Technology, Inc. (ECT) was authorized by the Suwannee River Water Management District (SRWMD or District) to prepare a report titled Minimum Recommended Lake Levels: Lake Hampton, Florida.

This report presents the SRWMD's recommended minimum flows and levels (MFLs) for Lake Hampton in Bradford County, Florida (Summary Table). These MFLs are based on work performed by Greenman-Pederson, Inc. (GPI), ECT, and SRWMD staff using methodology developed by the Southwest Florida Water Management District (SWFWMD) and supported by methods developed by the St Johns River Water Management District (SJRWMD).

Summary Table. Minimum and guidance levels for Lake Hampton, Bradford County.

Level	Recommended Elevation (ft NAVD88)	Level Description
High Guidance Level (HGL)	129.66	Advisory guideline for construction of lake shore development, water dependent structures, and operation of water management structures. The HGL is the elevation that lake stage is <u>expected</u> to equal or exceed 10% of the time on a long-term basis.
High Minimum Lake Level (HMLL)	128.86	Elevation that lake stage is <u>required</u> to equal or exceed 10% of the time on a long-term basis.
Minimum Lake Level (MLL)	128.15	Elevation that lake stage is <u>required</u> to equal or exceed 50% of the time on a long-term basis.
Low Guidance Level (LGL)	127.27	Advisory guideline for water dependent structures, information for lakeshore residents, and operation of water management structures. The LGL is the elevation that lake stage is <u>expected</u> to equal or exceed 90% of the time on a long-term basis.

ft NAVD88 = feet above North American Vertical Datum of 1988

The SWFWMD methodology (SWFWMD 1999a, b; Leeper *et al.* 2001; Hancock 2007) was utilized to determine the MFLs for Lake Hampton. Guidance and minimum levels determination is based on the evaluation of observed and model simulated stage data, vegetation sampling, hydrologic indicators of sustained inundation, control point elevation, bathymetry, water quality, and elevations of anthropogenic features such as docks. SJRWMD methods used in this study focus upon vegetation sampling (SJRWMD 2006, Neubauer *et al.* 2008). Results presented in this report are considered recommended until the MFLs are adopted by the water management district's Governing Board as rule, as part of Chapter 40B-8, Florida Administrative Code (F.A.C.).

The recommended High Minimum Lake Level (HMLL) for Lake Hampton is 128.86 feet (ft) above the North American Vertical Datum of 1988 (NAVD88), and the recommended Minimum Lake Level (MLL) is 128.15 ft NAVD88 (Summary Table). The MLL was established at the Wetland Offset Standard, or 0.8 ft below the Historic P50 elevation. The HMLL was established at the elevation corresponding to the MLL plus the difference between the Historic P10 and the Historic P50. For the purpose of allowing the lake to continue to periodically achieve historic high water levels, the HMLL is required to be reached or exceeded 10% of the time over a long-term record. The MLL elevation should be reached or exceeded at least 50% of the time for the purpose of preserving the non-cypress fringe wetlands and meeting other environmental values outlined in Rule 62-40.473, F.A.C.,

including: fish and wildlife habitats and the passage of fish, transfer of detrital material, aesthetic and scenic attributes, filtration and absorption of nutrients and other pollutants, and water quality.

Additional elevations presented in the Summary Table represent guidance levels (Leeper *et al.* 2001, Rule 40D-8.021, F.A.C.). Specifically, the High Guidance Level (HGL) represents a high water elevation only exceeded 10% of the time based on historic data, and the Low Guidance Level (LGL) is a low water level achieved 90% of the time over the historic period of record. These guidance levels do not represent regulatory elevations, but they may be useful for planning purposes such as dock construction.

Assessment of the current MFLs status for Lake Hampton will be presented in a separate document.

SRWMD upholds Section 373.042, Florida Statutes (F.S.) and Chapter 40B-8, F.A.C., regarding the development of minimum flows or levels using the best available information. Future re-evaluation efforts will be accomplished using an adaptive management process in both MFLs development and status assessment.

1.0 Introduction

Under task work assignment (TWA): 19/20-061.003A, Environmental Consulting and Technology, Inc. (ECT) was authorized by the Suwannee River Water Management District (SRWMD or District), to determine and document recommended regulatory lake levels for Lake Hampton, Bradford County, Florida.

The MFLs are based on prior work performed by SRWMD staff and Greenman-Pederson, Inc. (GPI), and utilized by ECT following methods developed by the Southwest Florida Water Management District (SWFWMD). The work effort included separate analyses of both the collected field information and creation of a digital lake water budget model. The model is documented in a separate report titled *"Lake Hampton Water Budget Modeling – Updated to Include Reference Timeframe Analysis"* (ECT 2021).

2.0 MFLs Program Overview

2.1 Statutory Framework

The SRWMD MFLs program is based on the requirements of Sections 373.042 and 373.0421, F.S., and is subject to the provisions of Chapter 40B-8, F.A.C., The MFLs program provides technical support to the SRWMD regional water supply planning process (Section 373.0361, F.S.), consumptive use permitting (Chapter 40B-2, F.A.C.), and environmental resource permitting (Chapter 40B-4, F.A.C.) programs.

Based on the provisions of Rule 40B-8.011(3), F.A.C., "… the Governing Board shall use the best information and methods available to establish limits which prevent significant harm to the water resources or ecology." Significant harm is prohibited by Section 373.042(1), F.S. Additionally, "minimum flows and levels should be expressed as 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.…" (Rule 62-40.473(2), F.A.C.).

2.2 Water Resource Values

According to Rule 62-40.473(1), F.A.C., in establishing MFLs pursuant to Sections 373.042 and 373.0421, F.S., consideration shall be given to natural seasonal fluctuations in water flows or levels, non-consumptive uses, and environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands ecology. These environmental values, also referred to as water resource values (WRVs) are listed below with their respective working definitions. All of these items were qualitatively reviewed, but fish and wildlife habitat and the passage of fish (Value #2) was quantitatively evaluated, because it was considered most appropriate for this lake and would maintain other relevant values. All relevant items were considered through determination of the Cypress Standard, explained in Section 2.3, and other significant change standards. WRVs are listed as follows:

- Recreation in and on the water;
- Fish and wildlife habitats and the passage of fish;
- Estuarine resources;
- Transfer of detrital material;
- Maintenance of freshwater storage and supply;
- Aesthetic and scenic attributes;
- Filtration and absorption of nutrients and other pollutants;
- Sediment loads;
- Water quality; and
- Navigation.

In addition to these factors, based on Section 373.0421(1), F.S., the following considerations are also required:

"When establishing minimum flows and levels pursuant to Section 373.042, the department or Governing Board shall consider changes and structural alterations to watersheds, surface waters, and aquifers and the effects such changes or alterations have had, and the constraints such changes or alterations have placed, on the hydrology of an affected watershed, surface water, or aquifer, provided that nothing in this paragraph shall allow significant harm as provided by Section 373.042(1) caused by withdrawals."

2.3 Hydrologic Regime

MFLs designate an environmentally protective hydrologic regime (i.e., hydrologic conditions that prevent significant harm) and identify levels and/or flows above which water may be available for reasonable–beneficial use.

MFLs developed using the SWFWMD methodology define the high and average levels and their frequency necessary to protect relevant water resource values and prevent significant harm to aquatic and wetland habitats. The SWFWMD has developed specific methodologies for establishing MFLs for lakes, wetlands, rivers, estuaries, and aquifers, subjected the methodologies to independent, scientific peer-review, and has incorporated minimum levels for specific waterbodies determined by rules thereof into its Water Level and Rates of Flow Rule (Chapter 40D-8, F.A.C.). The rule also provides for the establishment of Guidance Levels for lakes, which serve as advisory information for the SWFWMD, lakeshore residents and local governments, or to aid in the management or control of adjustable water level structures.

Information regarding the development of adopted methods for establishing minimum and guidance lake levels is included in SWFWMD (1999a, b), Leeper *et al*. (2001), and Hancock (2007). For lakes, methods have been developed for establishing minimum levels for systems with fringing cypress-dominated wetlands greater than 0.5 acre in size, and for those without fringing cypress wetlands. Lakes with fringing cypress wetlands where water levels currently rise to an elevation expected to fully maintain the integrity of the wetlands are classified as Category 1 Lakes. Lakes with fringing cypress wetlands that have been structurally altered such that lake water levels do not rise to levels expected to fully maintain the integrity of the wetlands are classified as Category 2 Lakes. Lakes with less than 0.5 acres of fringing cypress wetlands are classified as Category 3 Lakes.

Categorical significant change standards and other available information are developed to identify criteria that are sensitive to long-term changes in hydrology and can be used for establishing minimum levels. For all lake categories, the most sensitive, appropriate criterion or criteria is/are used to develop recommend minimum levels. For Category 1 or 2 Lakes, a significant change standard, referred to as the Cypress Standard, is developed. For Category 3 Lakes, six significant change standards, including a Basin Connectivity Standard, a Recreation/Ski Standard, an Aesthetics Standard, a Species Richness Standard, a Lake Mixing Standard, and a Dock-Use Standard are typically developed. Other available information, including potential changes in the coverage of herbaceous wetland vegetation and submersed aquatic plants, is also considered when establishing minimum levels for Category 3 Lakes. To provide protection for non-cypress fringing wetlands, a Wetland Offset Standard is developed for Category 3 Lakes, based on the Cypress Wetland Standard for Category 1 and 2 Lakes (Hancock 2007). Although the Cypress Standard is the only standard considered in setting the minimum lake levels for Category 1 and 2 Lakes, calculation of the Category 3 significant change standards is useful for comparative purposes.

Under the SWFWMD approach, two Minimum Levels (High Minimum Lake and Minimum Lake Levels) and two Guidance Levels (High and Low Guidance Levels) are typically established for lakes. The levels, which are expressed as elevations in feet above the North American Vertical Datum of 1988 (ft NAVD88), may include the following (SWFWMD 1999a, b; Leeper *et al.* 2001; Hancock 2007; Rule 40D-8.021, F.A.C.).

- A High Guidance Level (HGL) that is provided as an advisory guideline for construction of lake shore development, water dependent structures, and operation of water management structures. The High Guidance Level is the elevation that a lake's water levels are expected to equal or exceed ten percent of the time on a long-term basis.
- High Minimum Lake Level (HMLL) that is the elevation that a lake's water levels are required to equal or exceed ten percent of the time on a long-term basis.
- Minimum Lake Level (MLL) that is the elevation that the lake's water levels are required to equal or exceed fifty percent of the time on a long-term basis.
- Low Guidance Level (LGL) that is provided as an advisory guideline for water dependent structures, information for lakeshore residents and operation of water management structures. The Low Guidance Level is the elevation that a lake's water levels are expected to equal or exceed ninety percent of the time on a long-term basis.

Event-based MFLs methods used by the SJRWMD define the frequency and duration of high, average, and low water events necessary to protect relevant water resource values and prevent significant harm to aquatic and wetland habitats. Three types of events that are routinely used by the SJRWMD are referred to as minimum frequent high, minimum average, and minimum frequent low flows and/or water levels (SJRWMD 2006, Neubauer *et al.* 2008). The MFLs represent hydrologic statistics composed of three components: a magnitude (a water level and/or flow), duration (days), and a frequency or return interval (years). Discrete hydroperiod categories to facilitate MFL determinations are listed according to specific duration and return interval values in Table 2-1 (SJRWMD 2009). "High" approximate frequencies refer to high stage/flow events that occur for a minimum approximate duration. "Low" approximate frequencies refer to low stage/flow events occurring for a maximum approximate duration (i.e., a low stage event occurring every two years and not exceeding six months).

Table 2-1. MFLs hydroperiod categories with approximate frequencies and durations (SJRWMD 2009).

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	Weeks to months
Typically saturated	Once every 2 years low	Months
Semi-permanently flooded	Once every 5 to 10 years low	Months
Intermittently exposed	Once every 20 years low	Weeks to months
Permanently flooded	More extreme drought	Days to weeks

MFLs apply to decisions affecting 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 their likelihood to cause significant harm. Actual or projected instances where water levels fall below established MFLs may require the SRWMD Governing Board to develop recovery or prevention strategies (Section 373.0421(2), F.S.). MFLs are to be reviewed periodically and revised as needed (Section 373.0421(5), F.S.).

2.4   Management Stakeholders

Lake Hampton is located within the North Florida Regional Water Supply Partnership planning area (North Florida Regional Water Supply Partnership 2021). The Partnership is a collaborative effort between SRWMD, SJRWMD, the Florida Department of Environmental Protection (FDEP), local governments, concerned citizens, and other stakeholders throughout the region. The Partnership's mission is to protect the shared resources of the Floridan aquifer system through collaborative planning, scientific-tool development, and other efforts.

2.5   Consideration of Environmental Values

As described in SWFWMD (2020), specific categorical significant change standards are developed to identify criteria that are sensitive to long-term changes in hydrology and therefore useful for establishing minimum levels. For all lake categories, the most sensitive, appropriate criterion is used to develop and recommend minimum levels. For Category 1 or 2 Lakes, a significant change standard, referred to as the Cypress Standard, is developed. The MLL and HMLL are determined with the Cypress Standard by subtracting 1.8 feet and 0.4 feet from the Historic Normal Pool elevation, respectively. For Category 3 Lakes, seven significant change standards, including a Basin Connectivity Standard, a Recreation/Ski Standard, an Aesthetics Standard, a Species Richness Standard, a Lake Mixing Standard, a Dock-Use Standard, and a Wetland Offset Standard are typically developed. Other available information, including potential changes in the coverage of herbaceous wetland vegetation and submersed aquatic plants is also considered when establishing minimum levels for Category 3 Lakes.

The standards and other available information are associated with the environmental values identified for consideration in Rule 62-40.473, F.A.C., when establishing MFLs (Table 2-2). Descriptions of the specific standards and other information evaluated to support development of minimum levels for Lake Hampton are provided in subsequent sections of this report.

Table 2-2. Environmental values from the Water Resource Implementation Rule (62-40.473, F.A.C.), and the significant change standards (and other information) associated with each that are considered when establishing minimum flows and levels (SWFWMD 2021).

Environmental Value	Associated Significant Change Standards and Other Information for Consideration
Recreation in and on the water	Basin Connectivity Standard, Recreation/Ski Standard, Aesthetics Standard, Species Richness Standard, Dock-Use Standard, Herbaceous Wetland Information, Submersed Aquatic Macrophyte Information
Fish and wildlife habitats and the passage of fish	Cypress Standard, Wetland Offset, Basin Connectivity Standard, Species Richness Standard, Herbaceous Wetland Information, Submersed Aquatic Macrophyte Information
Estuarine resources	*This value is not applicable for consideration for most priority lakes.*
Transfer of detrital material	Cypress Standard, Wetland Offset, Basin Connectivity Standard, Lake Mixing Standard, Herbaceous Wetland Information, Submersed Aquatic Macrophyte Information
Maintenance of freshwater storage and supply	*This value is addressed by development of minimum levels based on appropriate significant change standards and other information and use of minimum levels in permitting programs.*
Aesthetic and scenic attributes	Cypress Standard, Dock-Use Standard, Wetland Offset, Aesthetics Standard, Species Richness Standard, Herbaceous Wetland Information, Submersed Aquatic Macrophyte Information
Filtration and absorption of nutrients and other pollutants	Cypress Standard, Wetland Offset, Lake Mixing Standard, Herbaceous Wetland Information, Submersed Aquatic Macrophyte Information
Sediment loads	*This value is not applicable for consideration for most priority lakes.*
Water quality	Cypress Standard, Wetland Offset, Lake Mixing Standard, Dock-Use Standard, Herbaceous Wetland Information, Submersed Aquatic Macrophyte Information
Navigation	Basin Connectivity Standard, Submersed Aquatic Macrophyte Information

2.6 Consideration of Structural Alterations and Other Changes

Based on the provisions of Section 373.0421(1)(a), F.S., when establishing MFLs, SRWMD considers changes and structural alterations to watersheds, surface waters, and aquifers and the effects such changes or alterations have had, and the constraints such changes and alterations have placed, on the hydrology of an affected watershed, surface water, or aquifer. However, when considering such changes and alterations, SRWMD cannot allow significant harm caused by withdrawals. To accomplish this, SRWMD reviews and evaluates available information, and makes site visits to ascertain the following information concerning the subject watershed, surface water body, or aquifer:

• The nature of changes and structural alterations that have occurred.

- The effects the identified changes and alterations have had.
- The constraints the changes and alterations have placed on the hydrology.

SRWMD has developed hydrologic models (ECT 2021), which addressed existing structural features, and has used these models to consider the effects these changes have had on the long-term hydrology of water bodies for which recommended MFLs are being developed.

SRWMD considered that the existing hydrologic conditions, which were used to calibrate and verify the models, reflected the hydrologic changes due to structural alterations that have occurred in addition to changes that are the result of groundwater withdrawals existing at the time of model development.

This consideration may also apply to vegetation and soils conditions if the hydrologic changes, structural alterations, and water withdrawals have been sufficiently large to affect vegetation and soils and have been in place for a sufficiently long period to allow vegetation and soils to respond to the altered hydrology. However, the condition of vegetation and soils may not reflect the long-term existing hydrologic condition if the hydrologic changes, structural alterations, and water withdrawals are relatively recent. This is because vegetation and soil conditions do not respond to all hydrologic changes nor respond rapidly to changes in hydrology that are sufficiently large to cause such change.

SRWMD typically develops recommended MFLs based on vegetation and soils conditions that exist at the time fieldwork is being performed to support the development of these recommended MFLs. Unfortunately, the condition of vegetation and soils surrounding Lake Hampton did not reflect the long-term existing hydrology due to structural alterations created with excavation of the drainage ditch connecting the lake to the Santa Fe River. The ditch also predates the lake stage data records, which were initiated in 1988.

3.0   Lake Setting and Description

3.1   Lake Basin Morphometry

Lake Hampton is located in southern Bradford County near the intersection of State Roads 200 and 221 (US 301 and CR 18, respectively) (Figure 3-1). The lake occupies approximately 823 acres (Mattson 1999), with a median water surface elevation of 128.51 feet (ft) above the North American Vertical Datum of 1988 (NAVD88) from the period of record of November 9, 1988, through December 31, 2020. Lake Hampton is designated by the FDEP as a Class III water. The lake is not designated as impaired under the Impaired Waters Rule (Chapter 62-303, F.A.C.).

The bathymetric data depicted in Figure 3-2 and 3-3 was surveyed by SRWMD on June 30 and July 1, 1976. The lake elevation was surveyed as 130.88 ft above the National Geodetic Vertical Datum of 1929 (NGVD29) or 130.03 ft NAVD88 during this event. The lake has a mean depth of approximately 12 ft (Figure 3-2 and Figure D6).

The lake is mesotrophic, with an average total phosphorus concentration of 10 ug L^{-1}, total nitrogen concentration of 464 ug L^{-1}, chlorophyll-a concentration of 5 ug L^{-1}, and a Secchi depth of 7.2 ft (Terrell *et al.* 2000).

The lake watershed covers approximately 4,456.6 acres (Figure 3-4). As summarized in Table 3-1 and illustrated in Figure 3-4, the majority of the land use in the watershed is upland forests (40.1%), followed by wetlands (17.9%) and waters (17.6%). Agricultural and range land comprise 10.8% of the watershed; while developed areas, including transportation and urban land use, comprise a total of 12.6%.

Table 3-1. Statistical summary of 2006 land use in Lake Hampton watershed

FLUCCS	Description	Area (acre)	Percentage
1000	Urban & Built-up	433.2	9.7%
2000	Agriculture	285.1	6.4%
3000	Rangeland	196.0	4.4%
4000	Upland Forests	1,785.5	40.1%
5000	Waters	785.8	17.6%
6000	Wetlands	796.1	17.9%
7000	Barren Land	44.4	1.0%
8000	Transportation, Communication & Utilization	130.6	2.9%
	Total	4,456.6	100.0%

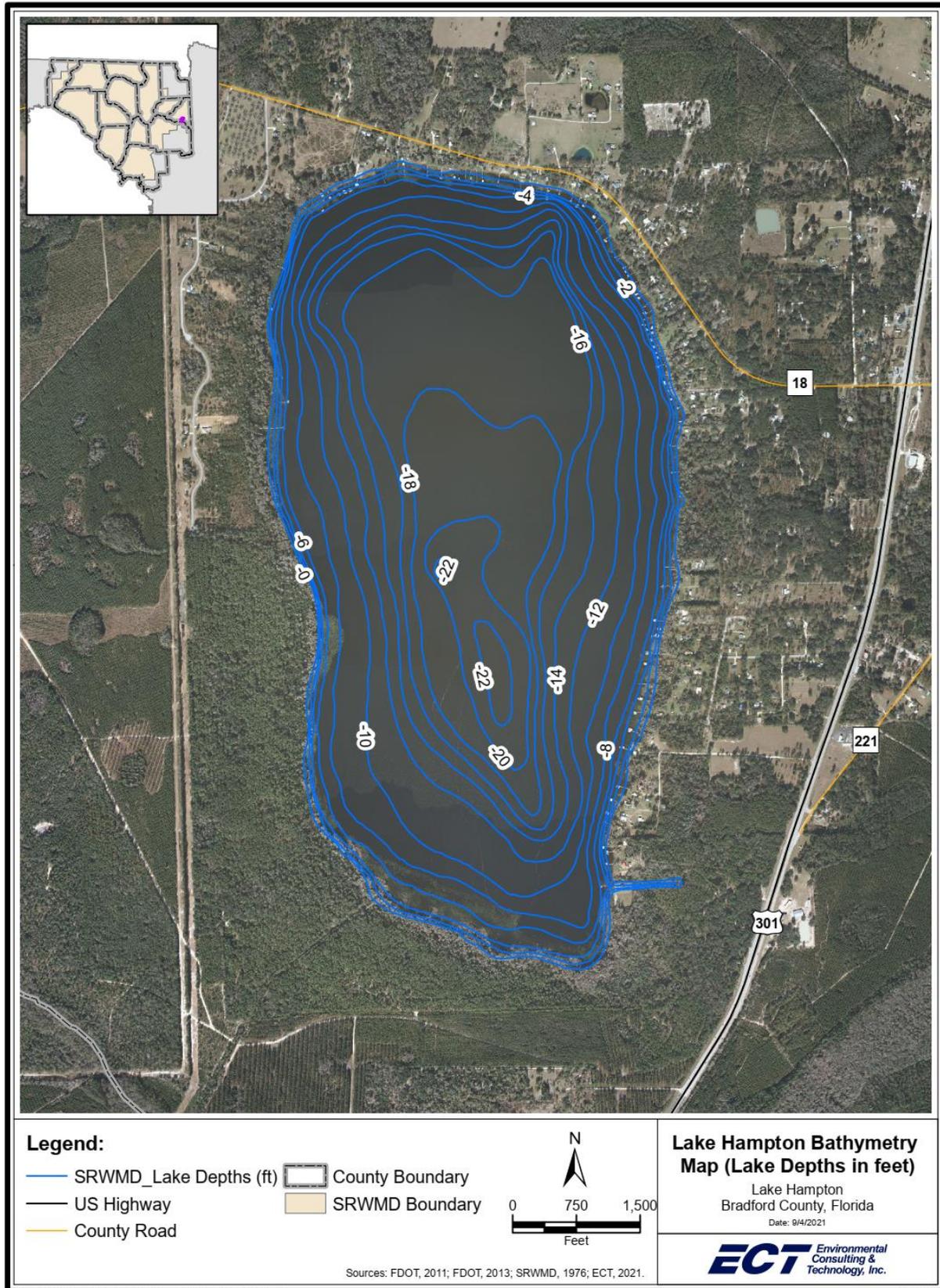*Figure 3-1. Lake Hampton location map.*

Figure 3-2. Lake Hampton bathymetry map (lake depth in feet).
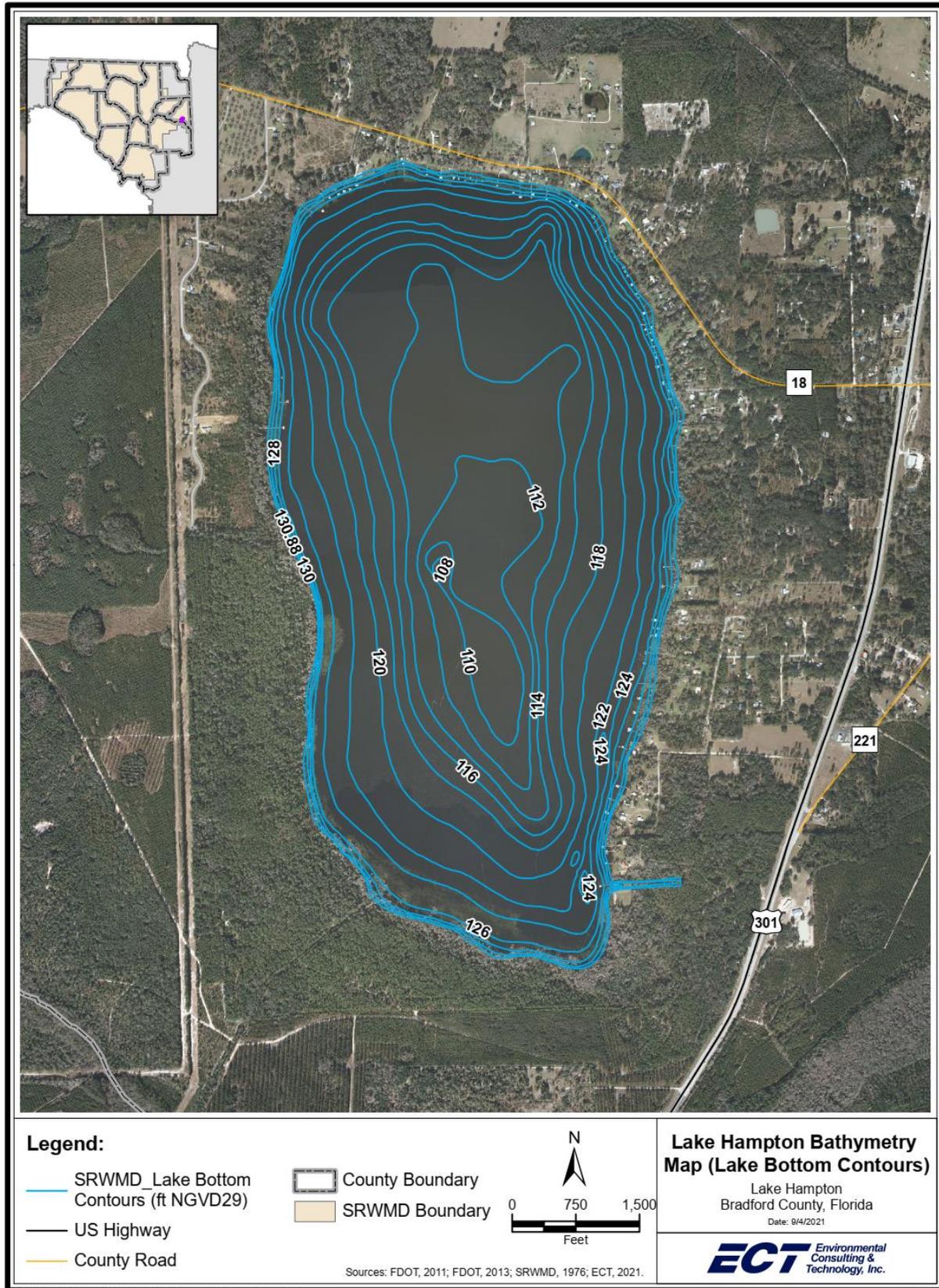
Figure 3-3. Lake Hampton bathymetry map (lake bottom contours in ft NGVD29).
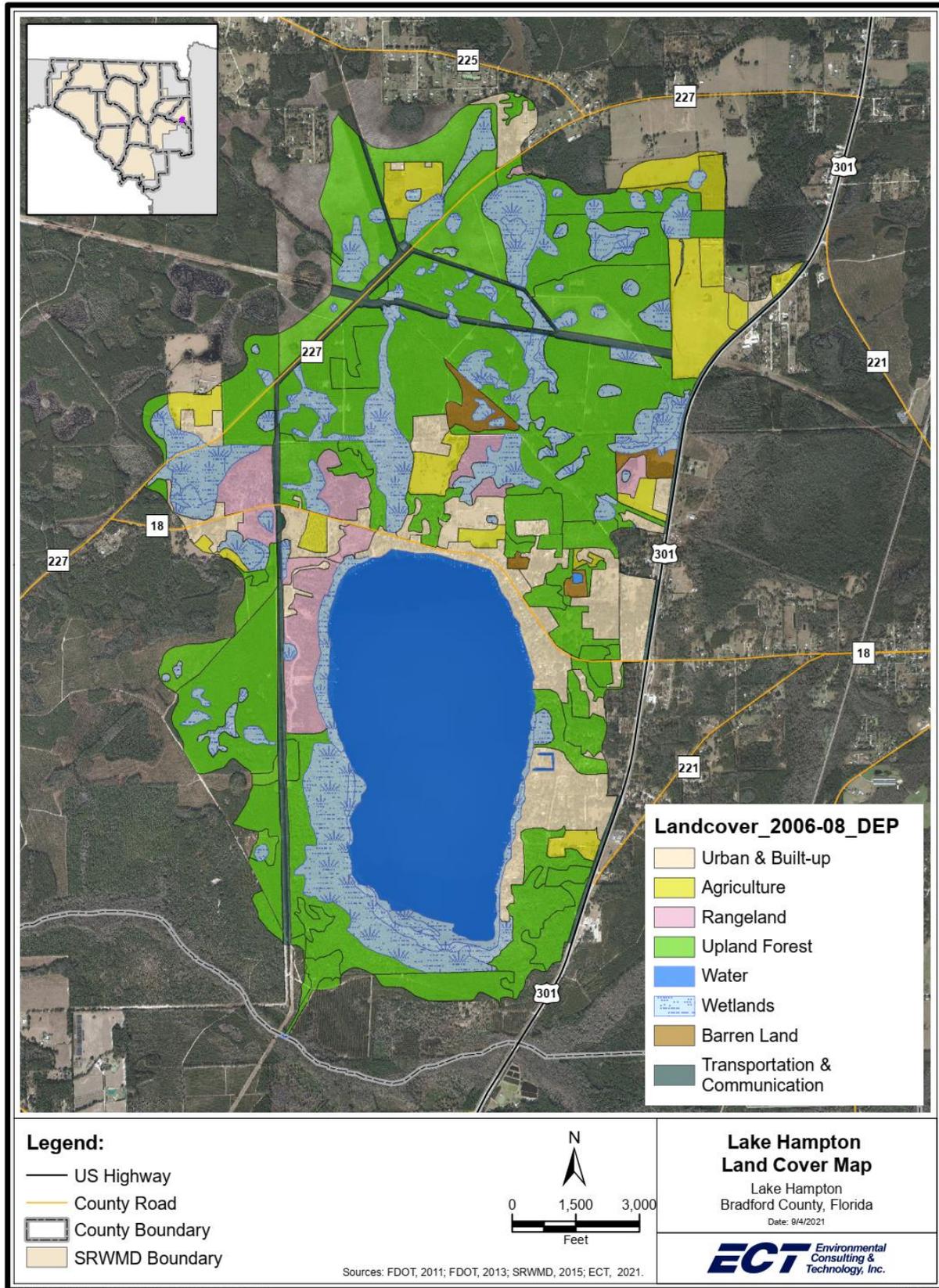
Figure 3-4. Land cover within the Lake Hampton watershed (colored areas).

3.2   Wetlands

Natural wetlands that are either contiguous or hydrologically connected to Lake Hampton were mapped using data produced by the US Fish and Wildlife Service, National Wetlands Inventory (NWI) and are shown in Figure 3-5. This geospatial data was developed for the purpose of mapping and tracking the status of wetlands and deep water habitats in the United States and its territories. The NWI classifies wetlands by a hierarchical structure (Federal Geographic Data Committee 2013). In the case of Lake Hampton, wetland classification is based mainly upon dominant vegetation type and hydrologic regime.

Wetlands contiguous to the lake are shown in Figure 3-5 and classified accordingly:

- Deciduously vegetated, semi-permanently flooded (PFO6F);
- Evergreen or deciduous forests, semi-permanently-flooded (PFO7/FO6F);
- Broad-leaved evergreen or broad-leaved deciduous, seasonally flooded (PFO3/FO1C);
- Deciduous, seasonally flooded wetlands (PFO6C), which are hydrologically connected from the north of CR 18 and located in the relict drain to the southeast nearest US 301;
- One scrub-shrub, seasonally flooded wetland (PSS3C), which is located landward of contiguous forested wetlands on the west side of the lake. This community was located between station numbers 8+60.0 and 10+00.0 (Figure B2 in Appendix B);
- Broad-leaved evergreen or needle-leaved evergreen, temporarily flooded (PFO3/FO4A); and
- Needle-leaved evergreen or broad-leaved evergreen, temporarily flooded (PFO4/FO3A).

The diverse combinations of forested wetlands listed above characterize vegetation communities with deciduous trees represented by swamp tupelo (*Nyssa sylvatica var. biflora*), pond cypress (*Taxodium ascendens*), or red maple (*Acer rubrum*). Evergreens include loblolly bay (*Gordonia lasianthus*), and sweetbay magnolia (*Magnolia virginiana*). The water regimes in the preceding list are sorted from wettest to driest in the following order: semi-permanently flooded is flooded more often than seasonally flooded, which is flooded more often than temporarily flooded. The wettest system adjacent to the lake (cypress) is classified the same as the forested floodplain of the Santa Fe River, located south of the lake, which is semi-permanently flooded.

Marshes located within the lake are not shown by the NWI polygons in Figure 3-5 but are presented and described in Appendix B of this report.
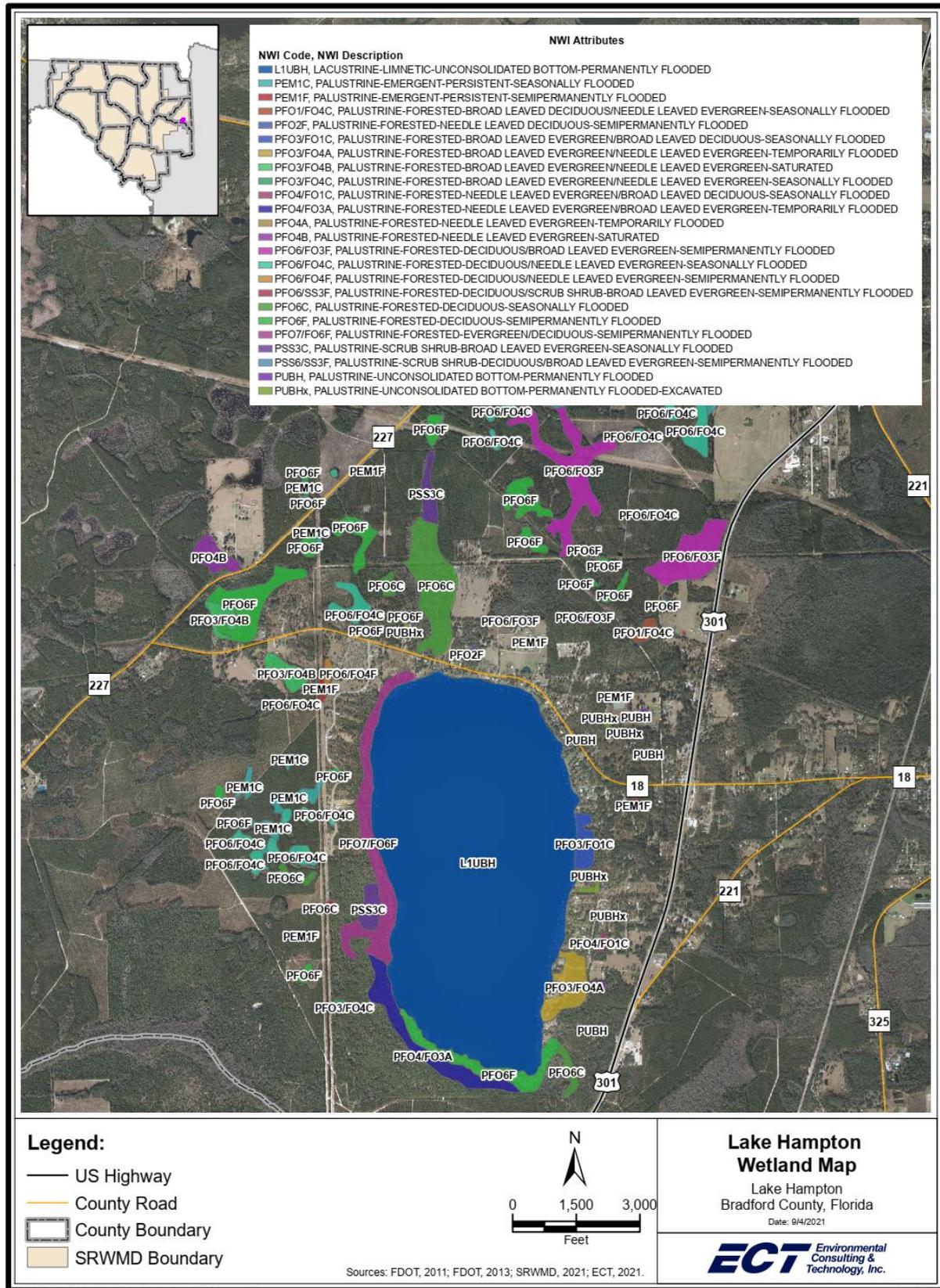
Figure 3-5. Lake Hampton wetlands map.

3.3　　Lake Stage Record

The U.S. Geological Survey (USGS) has a long-term stage gage, USGS 02320696 near Hampton, Florida located near a boat ramp on the east lakeshore (ECT 2021). This gage provides a long-term lake stage record at various reporting frequencies from November 9, 1988, to current (Figure 3-6), and has been operated by the District since inception. The highest lake stage elevation on record is 132.54 ft NAVD88 and occurred on March 1, 1998. The lowest lake stage elevation on record is 123.61 ft NAVD88 and occurred on May 27, 2002.
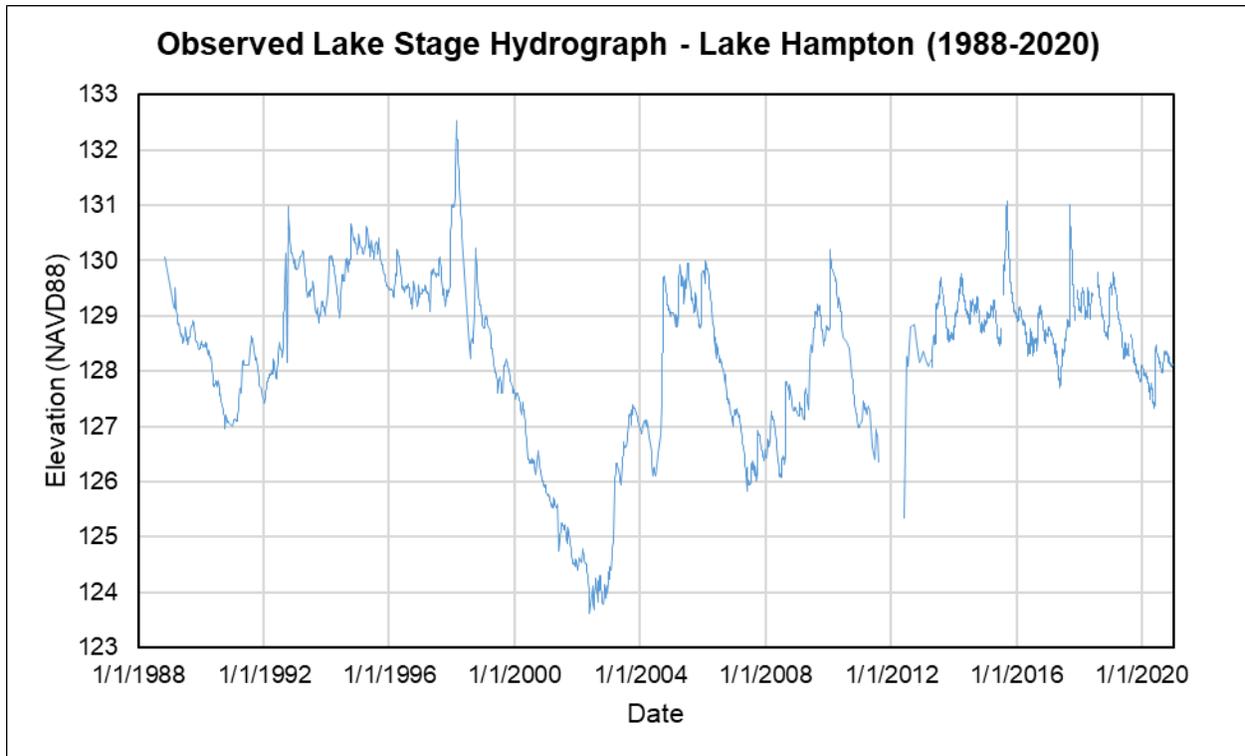
Figure 3-6. Hydrograph for Lake Hampton observed stage data for the period of record of 11/9/1988 - 12/31/2020.

3.4　　Outfall Canal History

The lake drains directly to the Santa Fe River through a man-made canal in the lake's southwest corner. The Santa Fe River is coincident with the County line located south of the lake and west of US 301 (Figure 3-1). Available aerial imagery indicates that the outfall canal was constructed prior to photographic history (before 1938). Topographic surveys, Light Detection and Ranging (LiDAR) and associated digital elevation models (DEMs) suggest that the lake drained to the east through what is currently the US 301 corridor. This eastern route has been eliminated by highway construction; and its function has been replaced by the canal, which may have increased flows from the lake to the Santa Fe River compared to pre-canal conditions (ECT 2021).

4.0   MFLs Methodology for Lake Hampton

This section provides an overview of the methods and assumptions used in the minimum water levels evaluation process for Lake Hampton, including procedures such as site selection, field data collection, and data analyses. Detailed methods are provided in respective appendices of this report. The SWFWMD Lake MFLs methods are detailed in SWFWMD (1999a, b), Leeper *et al*. (2001), and Hancock (2007). The SJRWMD MFLs methods are described more completely in their Minimum Flows and Levels Methods Manual (SJRWMD 2006, Neubauer *et al.* 2008).

The field data collection procedures included gathering detailed elevations, vegetation, and hydrologic indicator data along fixed transects. In addition to sampling procedures presented for field data collection, aerial imagery, maps, and other information types were obtained and reviewed for evidence of alterations that may have occurred within the lake and its watershed.

All ground survey field operations took place from August 7 through December 2, 2014 and from January 27 through January 28, 2015. All field surveys for vegetation and hydrologic indicators were conducted on September 30 through October 3, 2014, and January 27 through 28, 2015, by GPI. A return visit was conducted with SJRWMD staff to provide guidance in the interpretation of preliminary results, and SRWMD staff followed up with deep marsh depth soundings on March 24, 2016.

4.1   Site Selection

Using aerial imagery, the NWI, and soil maps as guides, two transects were chosen as representative for further investigation. As part of the evaluation process, the suitability of each potential transect was based on four major criteria:

- Representative of plant communities and soil types surrounding the lake;
- Accessibility in terms of ease of access and land ownership; and
- Total transect length.

The selected Lake Hampton transects extend from open water to uplands. Elevation, soils, vegetation, and hydrologic indicator data were sampled along the transects to characterize the influence of surface water flooding on the distribution of plant communities and soils. Figure 4-1 illustrates transect locations, each oriented perpendicular to the lake shoreline and extending from the uplands to open water. Supplementary elevation data were collected along four shoreline segments at the landward boundary of the lake's deep marsh community. These locations are also shown in Figure 4-1.
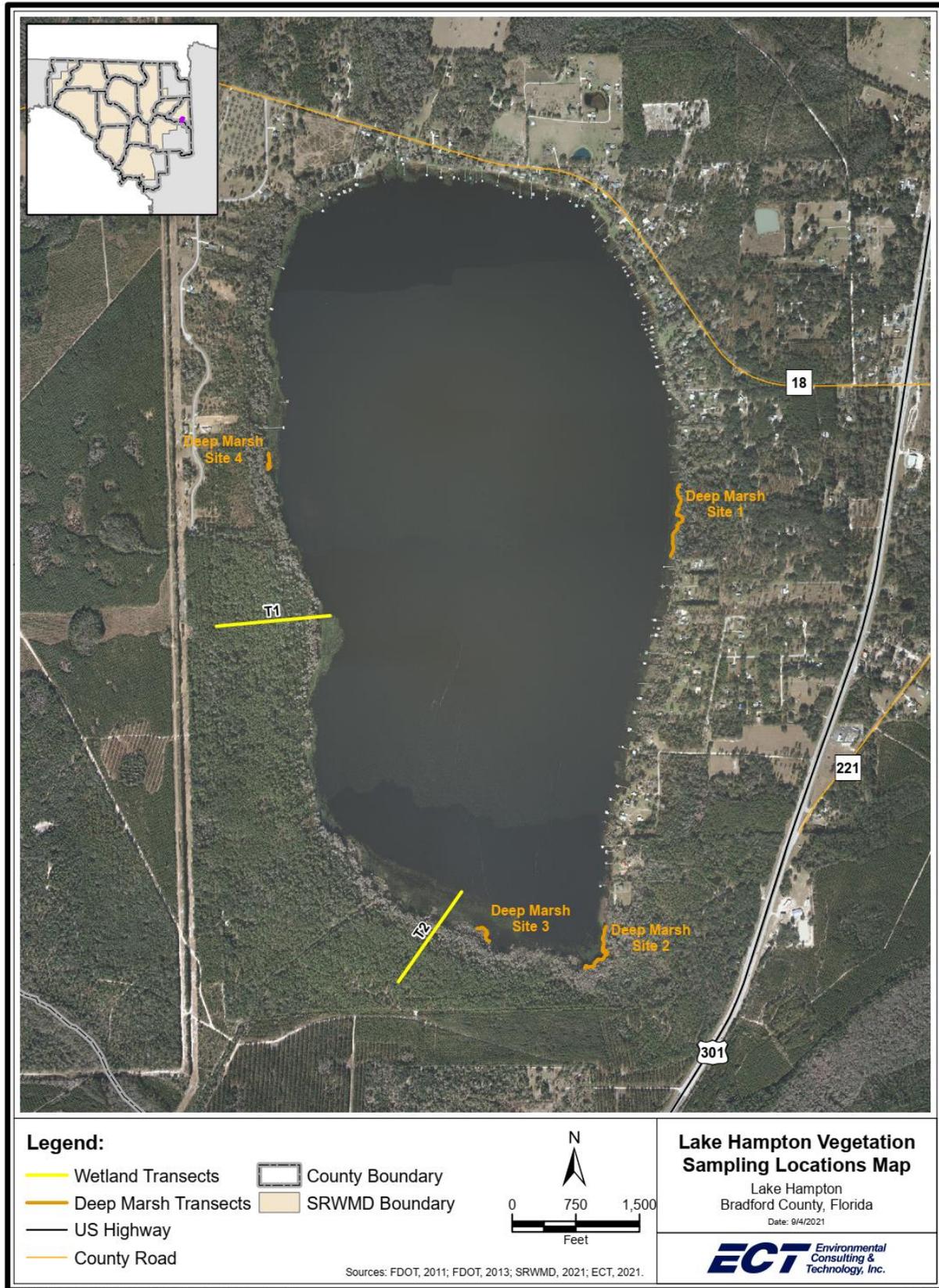
Figure 4-1. Lake Hampton vegetation sampling locations

4.2   Site Survey

To relate relevant benchmarks to existing hydrologic data, a detailed elevation survey was conducted by a Florida-licensed Professional Surveyor and Mapper (PSM). Detailed procedures are presented in Appendix A. Surveying tasks included:

- Establishment of a standard elevation datum;
- Preparation of sampling transects;
- Gathering elevation data for vegetation communities and hydrologic indicators along the transects;
- Gathering elevation data of natural and man-made drainage features near the lake; and
- Gathering elevation data of residential and recreational infrastructure around the lake perimeter.

4.3   Vegetation Sampling Procedures

The main objective of this sampling was to qualitatively describe vegetative communities and collect data to determine an average elevation of specific vegetation communities in anticipation of applying SJRWMD MFLs methods (SJRWMD 2006, Neubauer *et al*. 2008). Detailed vegetation sampling procedures, analyses, and results (for terrestrial, emergent, and submerged vegetation) are presented in Appendix B of this report. Vegetation sampling along transects focused upon the following tasks:

- Field identification of plant communities along sampling transects using descriptions provided by Kinser (1996) and the Florida Natural Areas Inventory, Guide to the Natural Communities of Florida (FNAI 2010);
- Field determination of the boundaries of all plant communities identified along sampling transects; and
- Field collection of plant community data using the point-centered quarter method (Mitchell 2010) in order to describe species composition of the plant communities.

Deep marsh field-sampling focused upon the following tasks:

- Field determination of the deep marsh community by plant species composition (Kinser 1996); and
- Collecting depth soundings at the landward extents of cow-lilies (*Nuphar advena*).

4.4   Hydrologic Indicator Sampling Procedures

Hydrologic indicators selected for this determination included cypress (*Taxodium* spp.) buttress inflection points, which may represent the Historic Normal Pool of a lake (SWFWMD 1999a, b; Leeper *et al.* 2001; Hancock 2007). Other indicators of normal pool are illustrated in Figure 4-2 (Carr *et al.* 2006). These indicators identify boundaries where morphological plant adaptations occur in response to ponding or flooding. Such adaptations may occur above or below the waterline. Buttressing of tree bases, adventitious rooting, and moss collars are also morphological plant adaptations used in the delineating the landward extent of wetlands and other surface waters (Rule 62-340.500(9), F.A.C.). Detailed sampling procedures are presented in Appendix C of this report.
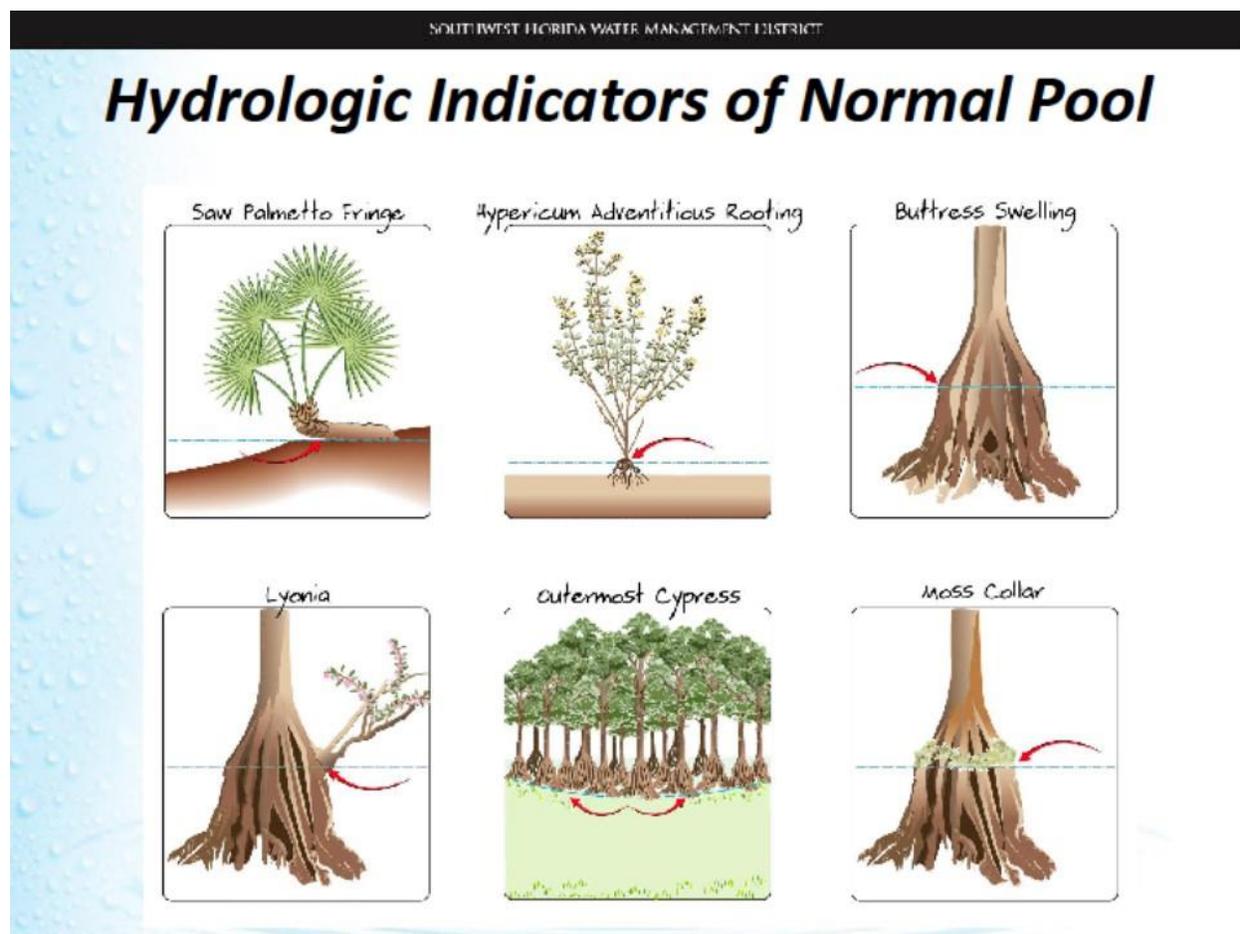
Figure 4-2. Hydrologic indicators of normal pool (Courtesy of Doug Leeper, SWFWMD). Adventitious roots occur on stems or trunks of certain plants when inundated; and Lyonia is a wetland shrub shown rooted above normal pool.

4.5 Data Analyses

The primary data analysis consisted of using Microsoft Excel, Statistical Analysis System (SAS) Version 9.4, and the R Project for Statistical Computing (R Core Team 2014) to construct figures and perform statistical analyses on surveyed elevation data. The ArcGIS Spatial Analyst Extension was used to calculate the 2D and 3D areas of the lake associated with various levels.

Detailed procedures are provided in Appendices B through D for vegetation, hydrologic indicators, and additional supporting information for development of minimum and guidance levels, respectively.

5.0 Development of Minimum and Guidance Levels for Lake Hampton

Minimum and Guidance Levels for Lake Hampton were developed using the SWFWMD methodology for Category 3 Lakes (SWFWMD 1999a, b; Leeper *et al.* 2001; Hancock 2007). Levels, standards, and additional information are provided in Table 5-1, along with lake surface areas for each level. Detailed descriptions of the development and use of these data are provided in subsequent sections of this report.

Table 5-1. Minimum levels, guidance levels, and significant change standards for Lake Hampton.

Levels	Elevation (ft NAVD88)	Lake Area (Acres)
Lake Stage Percentiles		
Historic P10	129.66	823.96
Historic P50	128.95	810.35
Historic P90	127.27	790.90
Current P10	129.58	822.27
Current P50	128.84	808.89
Current P90	126.92	785.78
Other Levels		
Historic Normal Pool	133.01	1,149.28
Control Point	128.75	807.70
Guidance Levels		
High Guidance Level	129.66	823.96
Low Guidance Level	127.27	790.90
Significant Change Standards		
Cypress Standard*	131.21	965.01
Wetland Offset Standard	128.15	800.89
Dock-Use Standard	127.94	798.59
Aesthetics Standard	127.27	790.90
Species Richness Standard	123.15	688.80
Lake Mixing Standard	123.15	688.68
Recreation/Ski Standard	117.14	387.44
Basin Connectivity Standard	NA	NA
Minimum Levels		
High Minimum Lake Level	128.86	809.16
Minimum Lake Level	128.15	800.89

NA – not available/not appropriate

* Used for comparison purposes only.

For the purpose of minimum levels and guidance levels determination, lake stage data are classified as "Historic" for periods when there are no measurable impacts due to water withdrawals, and the impacts due to structural alterations are similar to existing conditions. "Structural alterations", in this context, means anthropogenic modification of the control point, or highest stable point along the outlet conveyance system of a lake, to the degree that water level fluctuations are affected. The classification "Current" is applied to stage data where the hydrologic stresses due to water withdrawals and structural alterations are stable and representative of the current situation.

5.1   Bathymetry

Relationships between lake stage, inundated area, and volume can be used to evaluate expected fluctuations in lake size that may occur in response to climate, other natural factors, and anthropogenic impacts such as structural alterations or water withdrawals. Long term reductions in lake stage and size can be detrimental to many of the environmental values identified in the Water Resource Implementation Rule for consideration when establishing MFLs. Stage-area-volume relationships are therefore useful for developing significant change standards and other information identified in the methods for developing minimum lake levels.

Stage-area-volume relationships were determined for Lake Hampton by building and processing digital elevation models (DEMs) of the lake bathymetry and land surface elevations of the surrounding watershed. The 1976 SRWMD bathymetric contours (elevation in ft NGVD29, Figure 3-3) were used to build the DEM through a series of analyses using ArcGIS 3D and Spatial Analyst Extensions. The topographic DEM for water and land surface was developed based on the 2011 LiDAR topographic survey and the National Elevation Dataset (NED), both provided by USGS (NGC 2011). The bathymetric and topographic DEMs are illustrated on Figures D1 and D2 in Appendix D, respectively.

The bathymetric DEM was used to calculate the stage areas and volumes at 0.5-foot elevation change increments using the Surface Volume tool in the Functional Surface toolset of the ArcGIS 3D Analyst toolbox. The resultant stage-area-volume relationships are listed in Appendix D, Table D1, from the deepest pool of 105.15 ft NAVD88 to the lake surface elevation of 130.03 ft NAVD88, which was surveyed on June 30 and July 1, 1976.

Table D2 in Appendix D summarizes the stage-area relationships, at varied elevation change increments, for the land surface of surrounding watershed based on the USGS topographic DEM, using the ArcGIS Spatial Analyst. The stage-area relationship in this table was used to estimate the surface lake areas relative to the levels that exceed the highest elevation listed in Table D1 of Appendix D, e.g., Historic Normal Pool and Cypress Standard (Table 5-1 and Figure 5-1).

The hybrid stage-area (2D area) relationship created from Appendix D, Tables D1 and D2 is plotted on Figure 5-1. The hybrid stage-area data was also utilized for the development of lake water budget models that estimate the lake's response to rainfall and runoff, outfall or discharge, evaporation, leakance, and groundwater withdrawals.

The relationships of stage versus surface area (2D area), bottom area (3D area), volume, mean depth, and maximum depth, are illustrated on Figures D3 through D7 in Appendix D, respectively.
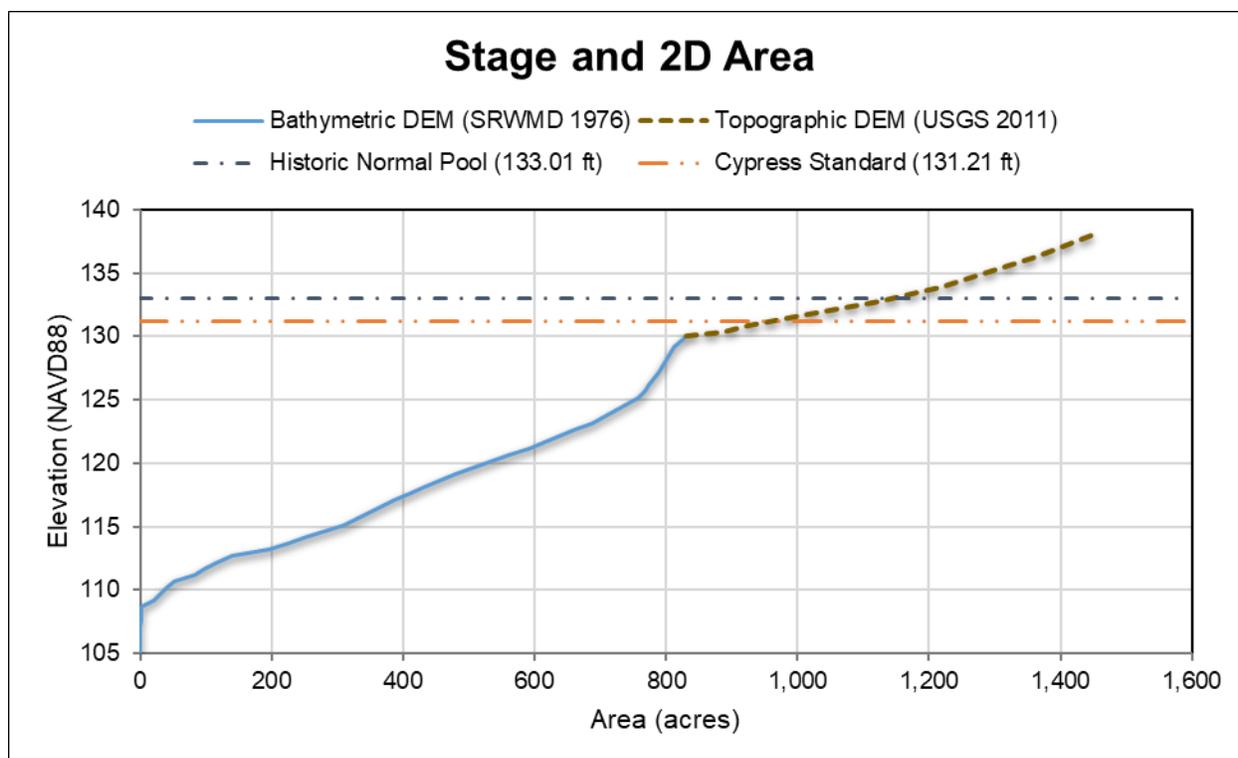
Figure 5-1. Lake stage to surface area for Lake Hampton with Historic Normal Pool and Cypress Standard elevations.

5.2 Lake Stage Data and Exceedance Percentiles

A key part of establishing Minimum and Guidance Levels is the development of exceedance percentiles based on historic lake stage data. For the purpose of minimum level determinations, lake stage data are categorized as "Historic" for periods when there were no measurable impacts due to water withdrawals and impacts due to structural alterations were similar to existing conditions. In the context of minimum levels development, "structural alterations" means anthropogenic physical alteration of the control point, or highest stable point along the outlet conveyance system of a lake, to the degree that water level fluctuations are affected.

A long-term historic lake stage record is critical for development of exceedance percentiles. As described in Section 3.3 above, there is a stage gage (USGS 02320696) near Hampton, Florida located near the public boat ramp on the east lakeshore. This gage provides a long-term lake stage record at various reporting frequencies from November 9, 1988, to December 31, 2020 (Figure 3-6). The 32-year period of record (POR) at this USGS gage includes the four lowest lake stage periods based on a comparison to the lake stage data collected at Lake Santa Fe, which is located approximately 7 miles southeast of Lake Hampton. The lake stage data collected during the 32-year POR does not adequately represent the longer-term Historic conditions at Lake Hampton (ECT 2021).

To better represent the Historic conditions, the calibrated Lake Hampton water budget model was used to run long-term simulations for a total of 55.7 years from April 25, 1960, to December 31, 2015. Based on the reference timeframe (RTF) analysis results provided by the District, the groundwater level data set for the no-pumping and current pumping scenarios were created using

the "measured" groundwater data set estimated at Lake Hampton. This "measured" groundwater dataset was estimated using data collected at the USGS Graham station (USGS ID: 295055082130801) and the SJRWMD Lake Brooklyn Wells near Keystone Heights (SJRWMD ID: 70078104). The term RTF data set is referred to as the "no-pumping" groundwater levels, which was created by adding the time-varying RTF adjustment factors to the "measured" groundwater level data set. "Current" refers to the end of the hydrologic record utilized to develop the MFLs, in this case, 2015. The "current pumping" groundwater level data set represents a 2015 average water use for the District and a 2011-2015 average water use for the SJRWMD portions in the model domain of a groundwater model used for the RTF analysis by the District (ECT 2021).

A technical memorandum *"Development of a Reference Timeframe Flow (RTF) Regime for the Minimum Flows and Minimum Water Levels (MFLs) Re-Evaluation of the Lower Santa Fe and Ichetucknee Rivers and Priority Springs"* was developed by the District in 2019 and published as Appendix D of a recent MFL report *"Minimum Flows and Minimum Water Levels Re-Evaluation for the Lower Santa Fe and Ichetucknee Rivers and Priority Springs"* (HSW 2021). This memo outlines the process used to develop reference timeframe flow and/or groundwater-head (head) time-series (e.g., "no-pumping" condition) at groundwater monitoring locations, springs and/or stream gage locations using observed and modeled data and an estimated time series of historic groundwater withdrawals. The model used in this analysis is the North Florida Southeast Georgia Groundwater Model, (NFSEG 1.1) (Durden *et al.* 2019).

The groundwater level data sets developed for the no-pumping and current pumping scenarios were implemented in the long-term model simulations to estimate the groundwater loss from the lake for these two scenarios. It was assumed that the 55.7-year simulated lake stage data sets for the Historic (no-pumping) and Current (current pumping) scenarios are a statistically realistic representation of the hydrology, absent significant anthropogenic or climatological changes, over the next 55.7 years (ECT 2021). This approach was considered appropriate for extending the POR for lake stage values in developing Historic and Current lake stage exceedance percentiles.

Based on the daily model simulated lake stage data sets for the no-pumping and current pumping scenarios (Figure 5-2), the Historic and Current P10, P50, and P90 elevations were developed for Lake Hampton (Table 5-2, Figures 5-3 and 5-4).

Table 5-2. Daily stage frequency percentiles for Lake Hampton. These levels were determined using daily model simulated lake stage data set for the POR of 4/25/1960 - 12/31/2015.

Percentile	Daily readings for the POR (ft NAVD88)
Historic P10 (HP10)	129.66
Historic P50 (HP50)	128.95
Historic P90 (HP90)	127.27
Current P10 (CP10)	129.58
Current P50 (CP50)	128.84
Current P90 (CP90)	126.92

Note: See definitions below

Definitions:

- "P10" means the elevation of the water surface of a lake or wetland that is equaled or exceeded 10% of the time as determined from a long-term stage frequency analysis.
- "P50" means the elevation of the water surface of a lake or wetland that is equaled or exceeded 50% of the time as determined from a long-term stage frequency analysis.
- "P90" means the elevation of the water surface of a lake or wetland that is equaled or exceeded 90% of the time as determined from a long-term stage frequency analysis.
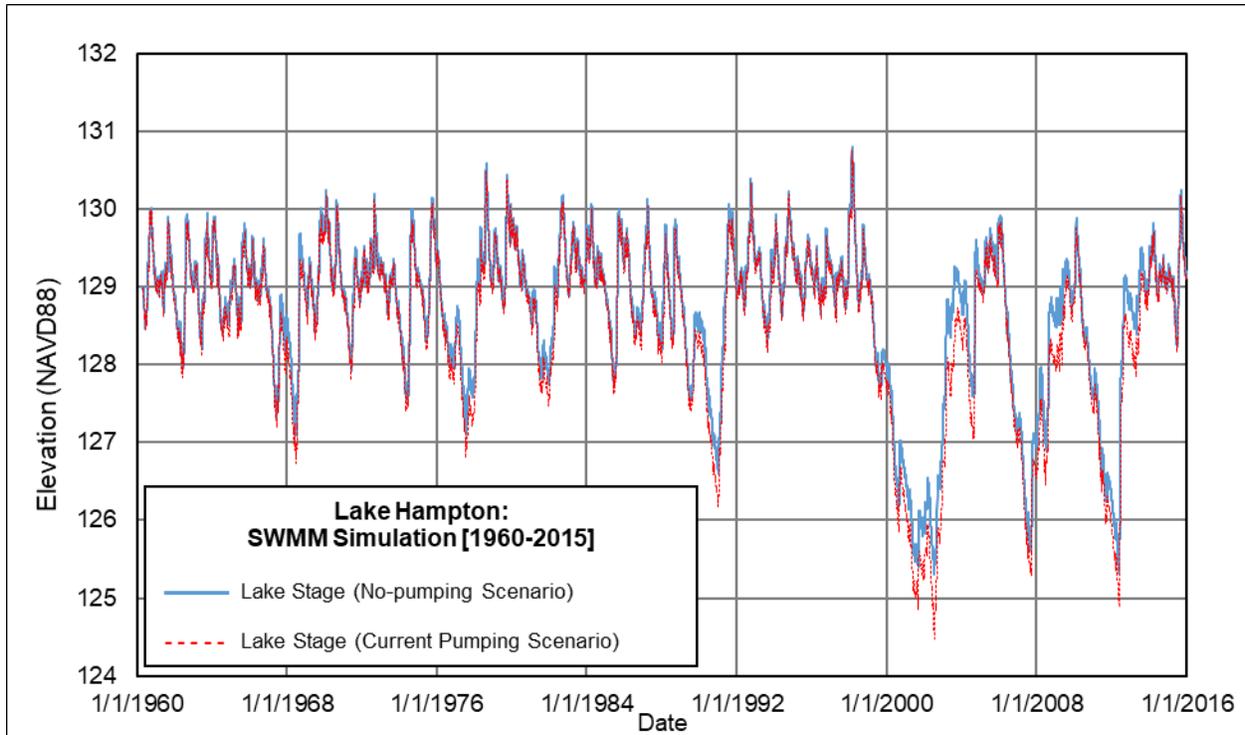
Figure 5-2. Hydrographs for Lake Hampton model simulated stage data (no-pumping vs. current pumping scenario) for the POR of 4/25/1960 - 12/31/2015.
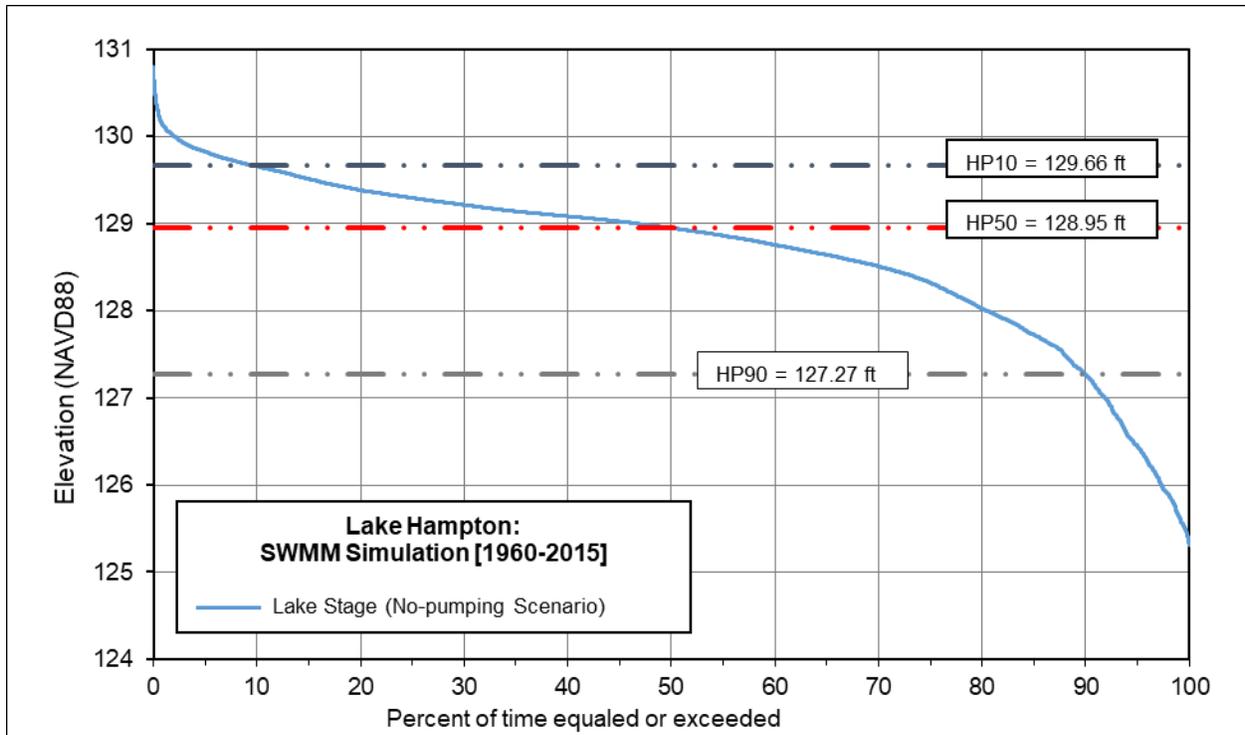
Figure 5-3. Exceedance probability chart for Lake Hampton model simulated stage data for no-pumping scenario, HP10, HP50, and HP90 for the POR of 4/25/1960 - 12/31/2015.
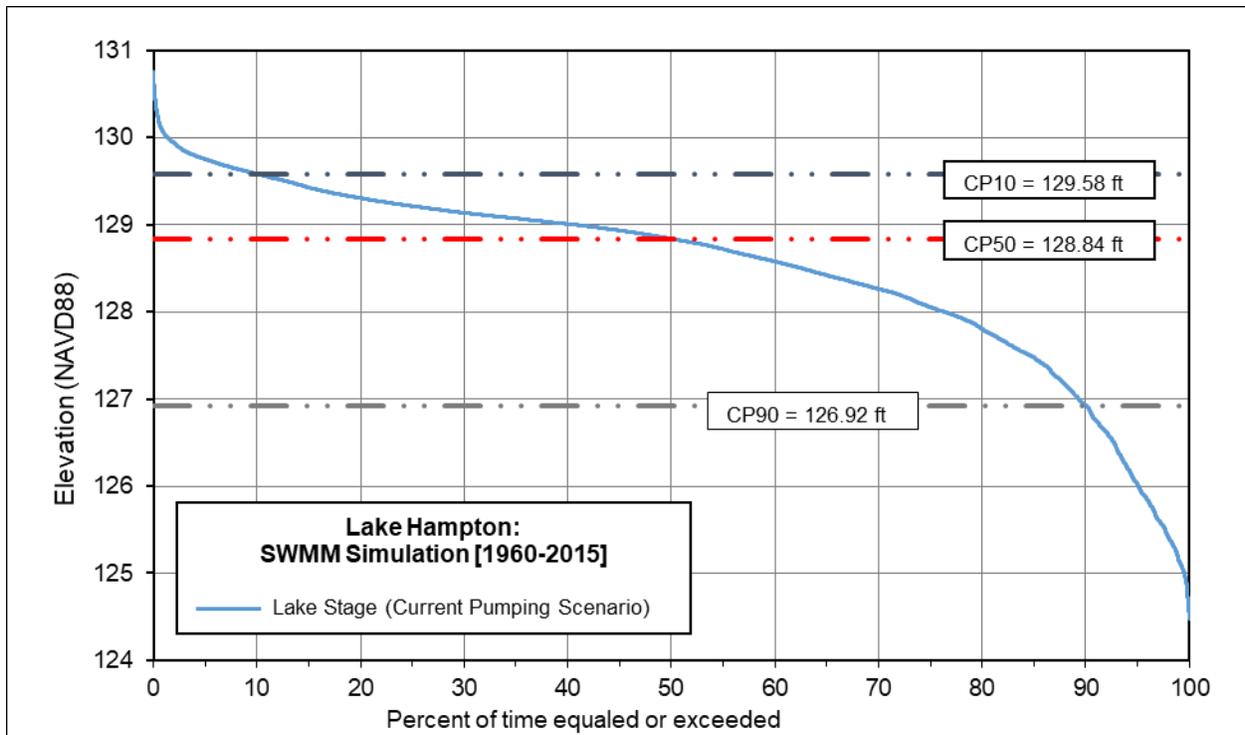
Figure 5-4. Exceedance probability chart for Lake Hampton model simulated stage data for current pumping scenario, CP10, CP50, and CP90 for the POR of 4/25/1960 - 12/31/2015.

5.3 Historic Normal Pool Elevation, Control Point Elevation, and Structural Alteration Status

The Historic Normal Pool (HNP) elevation, a reference elevation used for development of minimum lake levels, is established based on the elevations of hydrologic indicators of sustained inundation. The indicators selected change slowly with changing hydrology, so they are considered useful for defining the Historic water level regime. The buttress inflection points on the trunks of *Taxodium* spp. (Figure 5-5) are known to be reliable biologic indicators of historical hydrology (Carr *et al.* 2006). A total of 20 cypress buttress inflection points were surveyed, distributed along Transects 1 and 2 (Figure 4-1). The average elevation of 133.01 ft NAVD88 (Table C1 in Appendix C) represents the HNP elevation on Lake Hampton (Table 5-1).

Figure 5-5. Example of marked buttress inflection point on cypress tree.

The Control Point elevation is the elevation of the highest stable point along the outlet profile of a surface water conveyance system (e.g., weir, ditch, culvert, etc.) representing the principal control of water level fluctuations in the lake. In the case of Lake Hampton, the outlet conveyance is a man-made canal located in the lake's southwest corner. Available aerial imagery indicates that the outfall canal was constructed prior to photographic history (1938). Based on the ground survey data collected by GPI between 8/7/2014 through 1/28/2015 and LiDAR-based DEM data, the highest point of the outfall canal appears to be located at its upstream segment near the lake, which was modeled as Channel RB0100C in the model. During modeling calibration, the upstream invert of Channel RB0100C was adjusted based on the observed lake stage values when the lake levels

exceeded the Control Point elevation at the outfall canal (ECT 2021). The final upstream invert of Channel RB0100C or Control Point elevation was set at 128.75 ft NAVD88 (Table 5-1).

Structural alteration status is determined to support development of minimum and guidance levels and for the modeling of historic lake stage records. In addition to identification of outlet conveyance characteristics, comparison of the Control Point elevation and HNP elevation is typically used to determine if a lake has been structurally altered. If the Control Point elevation is below the HNP, the lake is classified as a structurally altered system. If the Control Point elevation is above the HNP and the lake has no outlet, the lake is not considered to be structurally altered. Based on the existence of the outfall canal and given that the HNP of 133.01 ft NAVD88 is considerably higher than the Control Point elevation of 128.75 ft NAVD88 (Table 5-1), Lake Hampton was classified as structurally altered.

5.4   Guidance Levels

5.4.1 High Guidance Level

The High Guidance Level (HGL) is provided as an advisory guideline for construction of lakeshore development, water dependent structures, and operation of water management structures. The High Guidance Level is the expected Historic P10 of the lake and is established using historic data if it is available, or is estimated using the Current P10, the Control Point elevation and the Historic Normal Pool elevation. Based on the availability of historic lake stage data developed for Lake Hampton, the High Guidance Level was established at the Historic P10 elevation, 129.66 ft NAVD88. The recorded data at USGS 02320696 indicates that the highest levels reached were in February and March 1998, with a peak of 132.54 ft NAVD88 (Figure 3-6).

5.4.2 Low Guidance Level

The Low Guidance Level (LGL) is provided as an advisory guideline for water dependent structures, and as information for lakeshore residents and operation of water management structures. The Low Guidance Level is the elevation that a lake's water levels are expected to equal or exceed ninety percent of the time on a long-term basis. The level is established using Historic or Current lake stage data and, in some cases, Reference Lake Water Regime (RLWR) statistics. Based on the availability of Historic data for Lake Hampton, the Low Guidance Level was established at the Historic P90 elevation, 127.27 ft NAVD88. The recorded data at USGS 02320696 indicates the lowest lake level elevation was 123.61 ft NAVD88, in May 2002. The most recent record of the water level dropping below the Low Guidance Level was in June 2012, with a recorded level of 125.35 ft NAVD88 (Figure 3-6).

5.5   Lake Classification

Lakes are classified as Category 1, 2 or 3 for the purpose of minimum lake levels development. Those with fringing cypress wetlands greater than 0.5 acres in size where water levels currently rise to an elevation expected to fully maintain the integrity of the wetlands (i.e., the Historic P50 is equal to or higher than the elevation 1.8 ft below the HNP elevation) are classified as Category 1 lakes. Lakes with fringing cypress wetlands greater than 0.5 acres in size that have been structurally altered such that the Historic P50 elevation is more than 1.8 ft below the HNP elevation are classified as Category 2 Lakes. Lakes without fringing cypress wetlands or with cypress wetlands less than 0.5 acres in size are classified as Category 3 Lakes. Lake Hampton meets the classification as

a Category 2 lake, based on the presence of the lake-fringing cypress wetlands of 0.5 acre or more in size, and because the Historic P50 elevation of 128.95 ft NAVD88 is lower than 1.8 ft below the HNP elevation of 133.01 ft NAVD88.

5.6 Significant Change Standards and Other Information for Consideration

Lake-specific significant change standards and other available information are considered for establishing minimum lake levels. The standards are used to identify thresholds for preventing significant harm to environmental values associated with lakes in accordance with guidance provided in the Florida Water Resources Implementation Rule (62-40.473, F.A.C.). Other information taken into consideration includes potential changes in the coverage of herbaceous wetland vegetation and aquatic plants (Table 2-2).

For Category 1 or 2 Lakes, a significant change standard is established at 1.8 ft below the HNP elevation. This standard identifies a desired median lake stage that if achieved, is expected to preserve the ecological integrity of lake-fringing wetlands. This elevation 1.8 ft below HNP is typically referred to as the Cypress Standard in SWFWMD documents pertaining to minimum levels development. For Lake Hampton, the Cypress Standard was established at 131.21 ft NAVD88 (Table 5-1). Based on the 55.7-year model simulated lake stage data set for the no-pumping scenario, the Cypress Standard was not exceeded for the entire POR of April 25, 1960, to December 31, 2015 (Figure 5-2). The observed stage data at USGS 02320696 indicates that the lake levels exceeded the Cypress Standard elevation only in February and March 1998, with a peak of 132.54 ft NAVD88, during the 32-year POR (Figure 3-6).

However, based on evaluation of the vegetation and hydrologic indicator sampling data (Appendices B and C), the vegetative communities surrounding the lake have been historically dewatered due to the excavation of the outfall canal prior to photographic history (1938). The District decided that it would be prudent to not use the Cypress Standard for Lake Hampton since the elevations of the cypress community likely represent relic soil surfaces and hydrologic conditions prior to excavation of the outfall canal. Although Lake Hampton is a Category 2 Lake, relevant Category 3 Lake standards were developed and utilized in the development of the minimum lake levels, in lieu of the Cypress Standard for Category 1 or 2 Lakes.

Seven significant change standards for Category 3 Lakes, including a Wetland Offset Standard, a Dock-Use Standard, a Basin Connectivity Standard, an Aesthetics Standard, a Recreation/Ski Standard, a Species Richness Standard, and a Lake Mixing Standard are developed. Potential changes in the coverage of herbaceous wetland vegetation and submersed aquatic plants are also considered when establishing minimum levels for Category 3 Lakes. These standards identify desired median lake stages that if achieved, are intended to preserve various environmental values (Table 2-2).

5.6.1 Wetland Offset Standard

The Wetland Offset Standard is developed to protect non-cypress fringing wetlands. Based on the rationale used to develop the Cypress Wetland Standard for Category 1 and 2 Lakes (1.8 ft below the HNP elevation), a Wetland Offset Standard for Category 3 Lakes was developed. Because hydrologic indicators of sustained inundation used to determine the HNP elevation likely represent relic soil surfaces and hydrologic conditions prior to excavation of the outfall canal (see Appendix B), another

datum, in this case the Historic P50 elevation, was used in the development of the Wetland Offset Standard. Based on an evaluation of the relationship of the Cypress Wetland Standard with the Historic P50 for hydrologically unimpacted cypress wetlands, the Wetland Offset Standard for Category 3 Lakes is established at an elevation 0.8 ft below the Historic P50 elevation (Hancock 2007). For Lake Hampton, the Wetland Offset Standard was established at 128.15 ft NAVD88. Based on the 55.7-year model simulated lake stage data set for the no-pumping scenario, the standard was equaled or exceeded 77.95 percent of the time, i.e., the standard elevation corresponds to the Historic P78 (Figure 5-3).

5.6.2   Dock-Use Standard

The Dock-Use Standard is developed to provide for sufficient water depth at the end of existing docks to allow mooring of boats and prevent adverse impacts to bottom-dwelling plants and animals caused by boat operation. The standard is based on the elevation of lake sediments at the end of existing docks, a clearance water depth value for boat mooring, and use of Historic lake stage data. The Dock-Use Standard for Lake Hampton was established at 127.94 ft NAVD88, based on the elevation of sediments at the minimum of the eight docks surveyed at the lake (124.26 ft NAVD88, Appendix D: Figure D8), plus a two-foot water depth based on use of powerboats in the lake, and an additional 1.68 feet which represents the difference between the Historic P50 and Historic P90. Based on the 55.7-year model simulated lake stage data set for the no-pumping scenario, the standard was equaled or exceeded 81.47 percent of the time, i.e., the standard elevation corresponds to the Historic P81 (Figure 5-3).

5.6.3   Aesthetics Standard

The Aesthetics Standard is intended to protect aesthetic values associated with the median lake stage from becoming degraded below the values associated with the lake when it is staged at the Low Guidance Level. The Aesthetic Standard is established at the Low Guidance Level, which is 127.27 ft NAVD88 for Lake Hampton. Because the Low Guidance Level was established at the Historic P90 elevation, the Aesthetic Standard elevation corresponds to the Historic P90.

5.6.4   Species Richness Standard

The Species Richness Standard is developed to prevent a decline in the number of bird species that may be expected to utilize a lake ecosystem. Based on an empirical relationship between lake surface area and the number of birds expected to occur at Florida lakes (Bachmann and Hoyer 1999, Emery *et al.* 2009), the standard is established at the lowest elevation associated with less than a 15 percent reduction in lake surface area relative to the lake area at the Historic P50 elevation. The Species Richness Standard for Lake Hampton was established at 123.15 ft NAVD88 (Figure 5-1, for a plot of lake stage versus lake surface area [2D Area]). Based on the 55.7-year model simulated lake stage data set for the no-pumping scenario, the standard was equaled or exceeded 100 percent of the time. The lowest simulated lake stage for Lake Hampton in the same period was 125.31 ft NAVD88.

5.6.5   Lake Mixing Standard

The Lake Mixing Standard is developed to prevent substantial changes in patterns of wind-driven mixing of the lake water column and sediment re-suspension. The standard is established at the highest elevation at or below the Historic P50 elevation where the dynamic ratio (Bachmann *et al.* 2000) shifts from a value of <0.8 to a value >0.8, or from a value >0.8 to a value of <0.8. The

dynamic ratio shift across the 0.8 threshold occurred at 123.15 ft NAVD88 (Appendix D, Table D3 and Figure D9). Based on the 55.7-year model simulated lake stage data set for the no-pumping scenario, the standard was equaled or exceeded 100 percent of the time (Figure 5-3).

The implication of ratio values being below 0.8 for the entire POR of Lake Hampton is that not all areas of the lake bottom have been subject to periodic wind-driven wave disturbance given the depth of the lake relative to its surface area (Bachmann *et al.* 2000).

5.6.6   Recreation/Ski Standard

The Recreation/Ski Standard is developed to identify the lowest elevation within the lake basin that will contain an area suitable for safe water skiing. The standard is based on the lowest elevation (i.e., the Ski Elevation) within the basin that can contain a five-foot deep ski corridor delineated as a circular area with a radius of 418 ft, or as used in this case, a rectangular ski corridor 200 feet in width and 2,000 feet in length (Appendix D, Figure D1), and use of historic lake stage data. The Recreation/Ski Standard was established at 117.14 ft NAVD88, based on the sum of the elevation at which the lake could provide an area suitable for safe skiing (115.46 ft NAVD88) and the difference between the Historic P50 and Historic P90 (1.68 feet). Based on the 55.7-year model simulated lake stage data set for the no-pumping scenario, the standard was equaled or exceeded 100 percent of the time (Figure 5-3).

5.6.7   Basin Connectivity Standard

The Basin Connectivity Standard is developed to protect surface water connections between lake basins or among sub-basins within lake basins to allow for movement of aquatic biota, such as fish, and support recreational lake-use. The standard is based on the elevation of lake sediments at a critical high-spot between lake sub-basins, clearance water depths for movement of aquatic biota or powerboats and other watercraft, and use of historic lake stage data or region-specific reference lake water regime statistics. A review of the morphology of the Lake Hampton basin (Figures 3-1 through 3-3) indicates that Lake Hampton is composed of one main basin with no navigable surface water connections to other waters, so no Basic Connectivity Standard was developed.

5.6.8   Herbaceous Wetlands Information for Consideration

Information on herbaceous wetlands is taken into consideration when determining the elevation at which changes in lake stage would result in substantial changes in potential emergent wetland area within the lake basin (i.e., basin area with a water depth of four or less feet). Based on the deep marsh community depth sounding results, the maximum depth from all four sites was estimated at 3.1 ft (Appendix B, Table B10). Given the lake stage was 128.82 ft NAVD88 during time of the soundings on March 24, 2016, and the natural fluctuation of lake levels, the herbaceous wetlands appear to have a maximum depth of approximately 4 ft during the wet seasons at Lake Hampton (Figure 3-6).

A review of a graph of lake stage versus area of Lake Hampton less than 4 ft deep (Appendix D, Figure D10) indicates there would be an increase of approximately 19 acres of potential herbaceous coverage with a lowering of the median water level from the Historic P50 (128.95 ft NAV88) to a lower level proposed here as the MLL (128.15 ft NAVD88). 19 acres is a relatively small value compared to the total lake area at its Historic P50 of 810.35 acres. Further lowering of the median water level below the MLL would be expected to allow much larger increases in herbaceous coverage based on the shape of the function plotted in Figure D10 in Appendix D. For example, a drop from

the Historic P50 to the Recreation/Ski Standard of 117.14 ft NAVD88, would potentially boost the coverage of herbaceous wetlands by 133 acres, likely greatly impacting recreational use of the lake.

5.6.9 Submersed Aquatic Macrophyte Information for Consideration

Changes in lake stage associated with changes in area available for colonization by rooted submersed macrophytes are also evaluated, using water transparency values (Appendix D, Figure D11). Based on available Secchi disk data and using the equation of Caffery (2006), we concluded that the maximum depth of colonization of submersed aquatic vegetation (SAV) is approximately 10 ft. Since the deepest part of the lake is slightly above 105 ft NAVD88, the depth at the Historic P50 is approximately 24 ft, so light penetration is expected to be a limiting factor on SAV growth at the lake bottom at median stage. As a result of SAV having the potential to grow within a water depth of 10 or less feet, the change in area that is available for SAV colonization is a function of lake stage versus lake bottom area (i.e., 3D area) less than 10 ft deep (Appendix D, Figure D12). A change from the Historic P50 (128.95 ft NAV88) to a lower level proposed here as the MLL (128.15 ft NAVD88) would increase the submerged lake bottom area by approximately 27 acres or 3% of the total submerged area at the Historic P50 of 810.35 acres.

5.7 Minimum Levels

Although Lake Hampton is classified as a Category 2 Lake, relevant Category 3 Lake standards described above were utilized in developing the minimum lake levels for this lake.

5.7.1 Minimum Lake Level

The Minimum Lake Level is the elevation that a lake's water levels are required to equal or exceed fifty percent of the time on a long-term basis. For Category 3 Lakes, the Minimum Lake Level is established at the elevation corresponding to the most conservative significant change standard, i.e., the standard with the highest elevation, except where that elevation is above the Historic P50 elevation, in which case, the MLL is established at the Historic P50 elevation (SWFWMD 2006). The MLL was established at the Wetland Offset Standard of 128.15 ft NAVD88, which is lower than the Historic P50, but higher than other significant change standards for Category 3 Lakes (Table 5-1).

5.7.2 High Minimum Lake Level

The High Minimum Lake Level (HMLL) is the elevation that a lake's water levels are required to equal or exceed ten percent of the time on a long-term basis. For a Category 3 lake, the HMLL may be established using one of two methods. The High Minimum Lake Level is established at the elevation corresponding to the Minimum Lake Level plus the difference between the Historic P10 and the Historic P50, or alternatively, the HMLL is established at the elevation corresponding to the MLL plus the RLWR value. Due to the availability of Historic percentiles (Tables 5-1 and 5-2), the HMLL was established using the first method, resulting in a HMLL of 128.86 ft NAVD88. This elevation accounts for a natural fluctuation of lake levels.

Minimum and Guidance levels for Lake Hampton are plotted on the observed lake stage hydrograph (Figure 5-6).
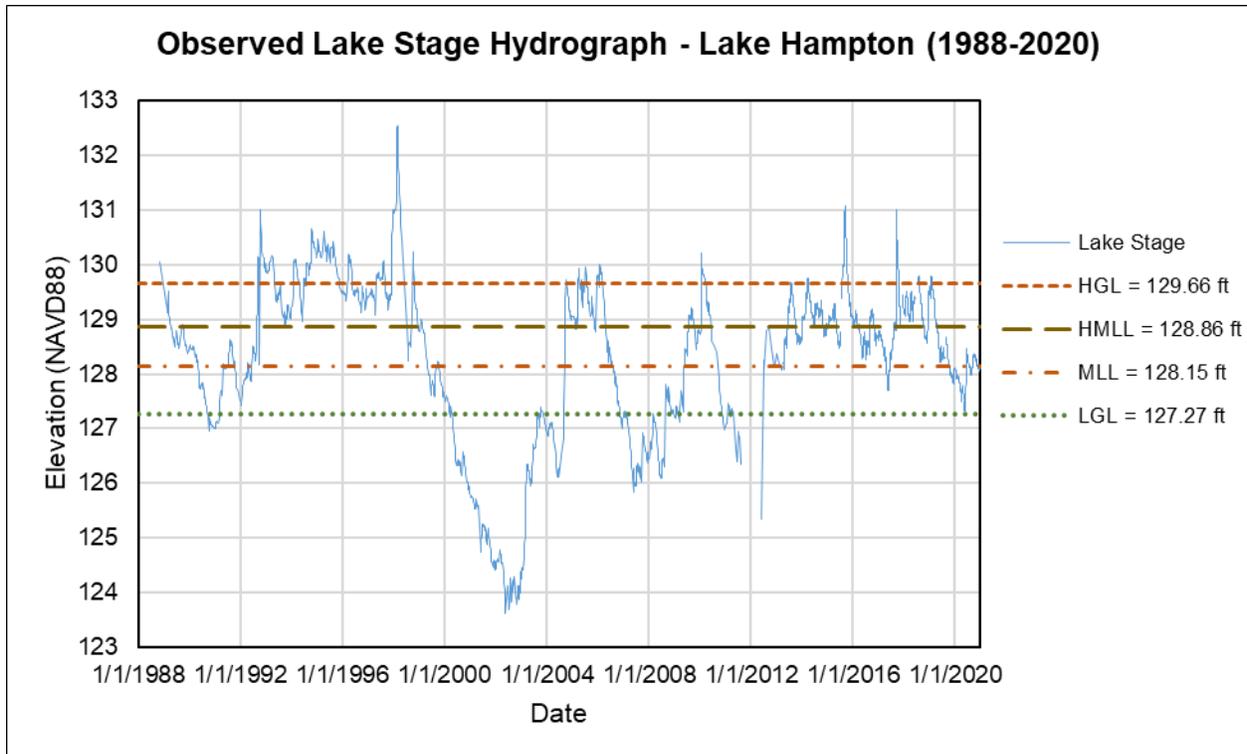
Figure 5-6. Hydrograph for observed stage data for the POR of 11/9/1988 - 12/31/2020 with guidance and minimum lake levels for Lake Hampton.

6.0   Consideration of Environmental Values

The minimum levels for Lake Hampton are protective of all relevant environmental values identified for consideration in the Water Resource Implementation Rule when establishing MFLs (Rule 62-40.473, F.A.C.). When developing MFLs, the SRWMD evaluates the categorical significant change standards and other available information as presented above to identify criteria that are sensitive to long-term changes in hydrology and represent significant harm thresholds.

The Wetland Offset Standard was used for developing minimum levels for Lake Hampton. This elevation is associated with protection of several environmental values identified in Rule 62-40.473, F.A.C., including: fish and wildlife habitats and the passage of fish, transfer of detrital material, aesthetic and scenic attributes, filtration and absorption of nutrients and other pollutants, and water quality (Table 2-2). The Wetland Offset Standard is also protective of the Species Richness Standard and assures the maintenance of herbaceous wetlands and the potential for establishment of submersed aquatic vegetation would not be greatly affected.

The environmental value, maintenance of freshwater storage and supply is protected by the minimum levels based on the relatively small potential changes in storage associated with the minimum flows hydrologic regime as compared to the non-withdrawal impacted Historic conditions. The reduction in volume held by the lake at the MLL relative to the Historic P50 is estimated to be a reduction from 2.99 to 2.78 billion gallons, or 7%. Maintenance of freshwater supply is also expected to be protected by the minimum levels based on inclusion of conditions in water use permits that stipulate that permitted withdrawals will not lead to violation of adopted minimum flows and levels.

The environmental values, recreation in and on the water and navigation are met because under the proposed Minimum Lake Level, the Recreation/Ski Standard is met.

Two environmental values identified in Rule 62-40.473, F.A.C., were not considered relevant to development of revised minimum levels for Lake Hampton. Estuarine resources were not considered relevant because the lake is not connected to an estuarine resource. Sediment loads were similarly not considered relevant for the lake, because the transport of sediments as bedload or suspended load is a phenomenon associated with flowing water systems.

7.0   Conclusions and Recommendations

The SWFWMD methodology (SWFWMD 1999a, b; Leeper *et al.* 2001; Hancock 2007) was utilized to determine the minimum lake levels for Lake Hampton. Guidance and minimum levels determination is based on the evaluation of observed and model simulated stage data, vegetation sampling, hydrologic indicators of sustained inundation, control point elevation, bathymetry, water quality, and elevations of anthropogenic features such as docks.

The recommended Minimum and Guidance Levels for Lake Hampton are summarized in Table 7-1. Results presented in this report are considered recommendations until the minimum flows and levels are adopted by the SRWMD Governing Board as rule. SRWMD MFLs are listed in Chapter 40B-8, F.A.C.

Table 7-1. Minimum and guidance levels for Lake Hampton.

Level	Recommended Elevation (ft NAVD88)	Level Description
High Guidance Level (HGL)	129.66	Advisory guideline for construction of lake shore development, water dependent structures, and operation of water management structures. The HGL is the elevation that lake stage is <u>expected</u> to equal or exceed 10% of the time on a long-term basis.
High Minimum Lake Level (HMLL)	128.86	Elevation that lake stage is <u>required</u> to equal or exceed 10% of the time on a long-term basis.
Minimum Lake Level (MLL)	128.15	Elevation that lake stage is <u>required</u> to equal or exceed 50% of the time on a long-term basis.
Low Guidance Level (LGL)	127.27	Advisory guideline for water dependent structures, information for lakeshore residents, and operation of water management structures. The LGL is the elevation that lake stage is <u>expected</u> to equal or exceed 90% of the time on a long-term basis.

Based on the provisions of Section 373.0421(1)(a), F.S., as part of establishing MFLs, SRWMD considers changes and structural alterations to surface waters and the effects such changes or alterations have had, and the constraints such changes and alterations have placed, on the hydrology of an affected surface water. The history of hydrologic alteration at the lake by the excavation of an outfall canal makes the development of the Minimum Lake Level (MLL) based on the significant change standard for Category 1 or 2 Lakes, or the Cypress Standard, very challenging. Higher elevations of certain hydrologic indicators in the cypress community and soil subsidence may represent artifacts of lake-fringing wetlands prior to artificial drainage created by the outfall canal rather than those currently influenced by seasonal flooding. Given this consideration, the significant change standards for Category 3 Lakes were developed and used to establish the MLL for this lake.

The recommended High Minimum Lake Level (HMLL) for Lake Hampton is 128.86 ft NAVD88, and the recommended MLL is 128.15 ft NAVD88 (Table 7-1). The MLL was established at the Wetland Offset Standard, or 0.8 ft below the Historic P50 elevation. The HMLL was established at the elevation corresponding to the MLL plus the difference between the Historic P10 and the Historic P50. For the purpose of allowing the lake to continue to periodically achieve historic high water levels, the HMLL is required to be reached or exceeded 10% of the time over a long-term record. The MLL elevation should be reached or exceeded at least 50% of the time for the purpose of preserving

the non-cypress fringe wetlands and meeting other environmental values outlined in Rule 62-40.473, F.A.C., including: fish and wildlife habitats and the passage of fish, transfer of detrital material, aesthetic and scenic attributes, filtration and absorption of nutrients and other pollutants, and water quality.

Additional elevations presented in Table 7-1 represent guidance levels (Leeper *et al.* 2001, Rule 40D-8.021, F.A.C.). Specifically, the High Guidance Level (HGL) represents a high water elevation only exceeded 10% of the time based on historic data, and the Low Guidance Level (LGL) is a low water level achieved 90% of the time over the historic period of record. These guidance levels do not represent regulatory elevations, but they may be useful for planning purposes such as dock construction.

Assessment of the current MFLs status for Lake Hampton will be presented in a separate document.

The SRWMD upholds Section 373.042, F.S. and Chapter 40B-8, F.A.C., regarding the development of MFLs using the best available information. In the re-evaluation process, adjustments to established MFLs may be appropriate when new data and methods of analysis become available. For example, SJRWMD has revised minimum lake levels upon the basis of improved soils evaluations and the availability of more current hydrologic models (Epting 2009, Neubauer 2009). Planning the re-evaluation of an existing MFL may begin at the time of establishment by adopting an adaptive management process for the assessment and management of uncertainty (Williams *et al.* 2009).

In the case of Lake Hampton, perhaps the greatest uncertainties encountered in development of MFLs were related to determining Historic lake stages, which account for impacts due to groundwater withdrawals and/or structural alterations, with the models (both the lake water budget model and the NFSEG groundwater model) that were calibrated to the current conditions. Investigations in the surrounding floodplains and wetlands indicated that hydrologic indicators of sustained inundation represent hydrologic conditions prior to excavation of the lake's outfall canal (Sections 5.3 and 5.6, and Appendix B). The Control Point elevation at the outfall canal was estimated during modeling process and assumed to be constant through the entire POR of the lake water budget model, and this assumption presents its own level of uncertainty with consideration of the dynamics of sediment transport and erosion at the canal. There are also uncertainties related to the extension of hydrologic data records to represent Historic conditions from regression analyses of various combinations of hydrologic data from contemporary data sources. Extended Historic lake stage data and estimated groundwater withdrawals impacts are further subject to the precision of the respective methods and models used in their creation. These uncertainties will be further evaluated in future MFL re-evaluation efforts through additional data collection and improved modeling and analysis techniques.

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Appendix A: Site Survey

Introduction

This report contains an outline of the Survey and Mapping Services that supported the Lake Hampton Minimum Flows and Levels Project in Bradford County, Florida; SRWMD Work Order 10/11-068.06; Greenman-Pedersen, Inc. (GPI) Project Number FTP-2013104.06.

Project Area

The project area encompasses Lake Hampton and bordering shores in Bradford County, Florida.

Purpose

The purpose of this survey was to:

- Establish Horizontal and Vertical Control - set three benchmarks;
- Establish elevation at "0" mark on existing manual read staff gauge near boat ramp;
- Stake and Station two transect lines;
- Locate hydrologic indicators, habitat zone breaks, and soil borings as marked by GPI environmental staff (and sub-consultants) along the two transect lines;
- Locate select docks, houses, and boat ramp;
- Provide three Cross-Sections along Santa Fe River outlet channel;
- Provide three Cross-Sections along and adjacent to the bridge crossing the Santa Fe River outlet channel; and
- Provide two Cross-Sections along and adjacent upstream edge of dirt road crossing Santa Fe River at east edge of power line right-of-way.

Date of Survey

All ground survey field operations took place between August 7 through December 2, 2014, and between January 27 through January 28, 2015.

Datum Reference and Final Coordinates

GPS coordinates shown herein are based on the North American Datum of 1983 (2011), Florida State Plane Coordinate (SPC) system, North Zone, U.S. Survey Feet.

Control elevations are based on feet (ft) above the North American Vertical Datum of 1988 (NAVD88), U.S. Survey Feet, utilizing differential leveling techniques and National Geodetic Survey benchmarks J368 (elevation 140.19 ft NAVD88) and G368 (elevation 136.71 ft NAVD88).

GPS-derived elevations were used for some of the non-control locations. These GPS elevations were computed from the GPS-derived ellipsoid heights and geoid heights obtained from the GEOID12A geoid model published by the National Geodetic Survey and were verified through redundant ties to the project control benchmarks.

Methodology

Horizontal Control

The horizontal control points established consist of 5/8" rebar 18" in length with plastic caps marked "LB 7560" and were observed with Leica survey grade dual frequency GPS receivers. Redundant observations at various GPS epochs were taken at each horizontal control point, operating in Real Time Kinematic (RTK) mode on Florida Department of Transportation's (FDOT) Florida Permanent Reference Network (FPRN). To find out more about the FDOT FPRN go to: https://www.fdot.gov/geospatial/fprn.shtm

Vertical Control

The benchmarks established consist of 5/8" rebar 18" in length with plastic caps marked "LB 7560" and were established utilizing differential leveling techniques and ties to the two National Geodetic Survey benchmarks (listed above).

Transects

Transect end points (waterward) were staked with 1/2" PVC pipe and located with Leica survey grade dual frequency GPS receivers, operating in Real Time Kinematic (RTK) mode on Florida Department of Transportation's (FDOT) Florida Permanent Reference Network (FPRN). The transect lines were manually cut using machetes. Stationing and indicator locations were performed using both RTK GPS and a survey tape starting from the beginning point (upland) and extending to the waterward end. The beginning points were monumented with a rebar & cap marked "LB 7560" and located with RTK GPS observations. Transect elevations were established using a combination of RTK GPS observations, trigonometric total station observations, and water soundings and/or differential leveling with station/offset locations, depending on the transect location and visibility conditions.

Locations

Dock, house, and boat ramp locations were performed with RTK GPS observations. Elevations were variously obtained through a combination of RTK GPS observations, water soundings, and/or differential leveling, depending on the location and visibility conditions.

Appendix B: Vegetation Sampling Methods, Analyses, Results, and Discussions

Vegetation Sampling Methods

Vegetation sampling closely followed the methods described in SJRWMD (2006). Two belt transects were used to characterize lake plant communities and soils. Each transect extended from the edge of lake, through the forested wetland, and ended in uplands (Figure B1). Along each transect, the beginning and ending locations of recognized vegetation community types were marked, using the key provided in "The Wetlands Diagnostic Characteristics" (Kinser 1996). Habitat types not supported by Kinser (1996), including terrestrial (upland) plant community names, were modified from the Florida Natural Areas Inventory classification method (FNAI 2010). A minimum of five natural ground elevation samples were surveyed per habitat type, and ground-shots were surveyed at 10 ft intervals by convention. Hydrologic indicators were also marked for subsequent location and elevation surveys by Florida Licensed Professional surveyors (Appendices A and C).

Vegetation data were collected between September 30 and October 3, 2014; and January 27 and 28, 2015, along belt transects that were 10 ft wide. Belt transects are designed as long rectangular plots where organisms may be counted and measured, allowing the use of computational procedures of plot sampling (Brower *et al.* 1998). The belt may be divided into zones of different vegetation communities, each representing a unique plot.

Plants were identified along the length of both transects. For the purpose of describing the species composition of each community, plants were placed into one of three main categories on the basis of stature: canopy, sub-canopy (mid-story), and groundcover, following the convention of Cowardin *et al.* (1979). Woody vegetation that was 6 m (20 ft) or taller was considered canopy vegetation. Mid-story species included true shrubs, young trees, and trees or shrubs that may be small or stunted because of environmental conditions. Shrubs are woody plants which generally exhibit several erect, spreading, or prostrate stems and have a bushy appearance. Groundcover included erect, rooted, herbaceous hydrophytes, excluding mosses and lichens; annual herbs and forbs; and low-growing, spreading plants other than climbing vines.

Sampling sites were located randomly in each plant community within individual transects; and the point-centered quarter (PCQ) sampling method was used to characterize species composition (Mueller-Dombois and Ellenberg 1974, Kent and Coker 1992). With the exceptions of the deep marsh communities, a minimum of two sites from each community were sampled. Density, frequency, basal area, and importance value (IV) were calculated for each tree species, by transect and community. Only densities and frequencies were calculated for shrubs in each community. In order to facilitate the determination of PCQ metrics for trees, diameter at breast height (dbh) was measured at 1.4 meters for all tree species. For dbh measurements, conventions were necessary for defining "stems." Multiple stems arising from a common root system were recorded separately if they branched below 50 cm. Branches arising above 50 cm were not counted separately, only the main (largest) stem's diameter were tallied. Canopy species were designated as measuring greater than 2.54 cm dbh.

A follow-up visit was conducted with SJRWMD staff to adjust the landward boundaries of the cypress communities along vegetation sampling transects (Robert Freese, PhD, Andrew Sutherland, PhD,

and Casey Harris, personal communication, March 10, 2016). SRWMD staff conducted lake-wide depth-soundings on March 24, 2016, to determine the landward elevation of the deep marsh community. Multiple soundings (n=117) were conducted along four separate segments of shoreline where an abrupt boundary occurred between emergent sawgrass (*Cladium jamaicense*) and floating-leaved cow lily (*Nuphar advena*).
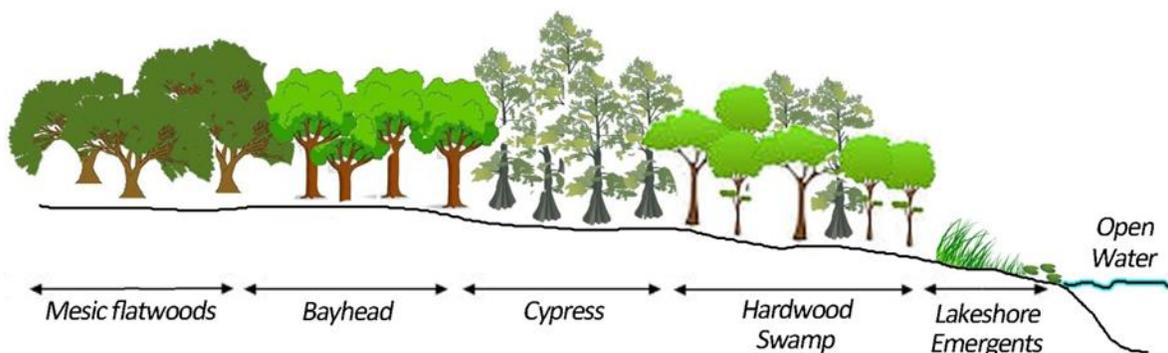

Figure B1. Cross-section of a typical belt transect through forested and herbaceous plant communities described by Kinser (1996).

Vegetation Data Analyses

Transect elevation data were graphed using Microsoft Excel to illustrate the gradient from open water to uplands, and descriptive statistics were calculated for the elevations of individual vegetation communities. Statistics were calculated on all surveyed elevation data using Version 9.4 of the Statistical Analysis System (SAS) Proc Univariate statement, specifying the Normal option for each community. The NPAR1WAY procedure was used to perform nonparametric tests for differences in location and scale between communities; and a comparison of elevations between individual communities was conducted using the Analysis of Variance (ANOVA) procedure with a post-hoc Tukey's Studentized Range (HSD) Test.

Descriptive statistics were determined for depth soundings collected on March 24, 2016, using R version 3.0.1. An ANOVA was performed for depth soundings between the four sites, as were tests for normality (Shapiro-Wilk), homoscedasticity (Bartlett's), and a post-hoc multiple comparison (Tukey's). Depths representing the definitive boundary separating emergent sawgrass and floating-leaved cow lily stands were combined between sites, averaged, subtracted from ambient lake stage (129.70 ft NGVD29) and converted to ft NAVD88.

Vegetation Results

Vegetation at Transect 1

Transect 1 is located on the western shore of Lake Hampton south of the Edith Ellen Estates Subdivision (Figure 4-1). Transect 1 was the longest transect sampled, traversing approximately 1,453 ft (Table B1).

Table B1. Transect 1 location and fieldwork dates.

Northing – Easting (Station 0; upland)	Northing – Easting (Station 14+10.0; DM-LS endpoint)	Dates of Fieldwork
319064.39 – 2704161.94	319208.23 – 2705564.58	10/2/2014; 3/10/2016

Transect 1 was surveyed from the interior of the deep marsh, through cypress and baygall, and into the interior of the wet flatwoods (Table B2). Natural ground elevations were surveyed at a total of 163 points along the transect, ranging from 124.56 to 132.41 ft NAVD88 (Table B2 and Figure B2). The steepest slope occurs between the cypress and deep marsh communities (Figure B2).

Table B2. Lake Hampton Transect 1 vegetation community elevation statistics (ft NAVD88).

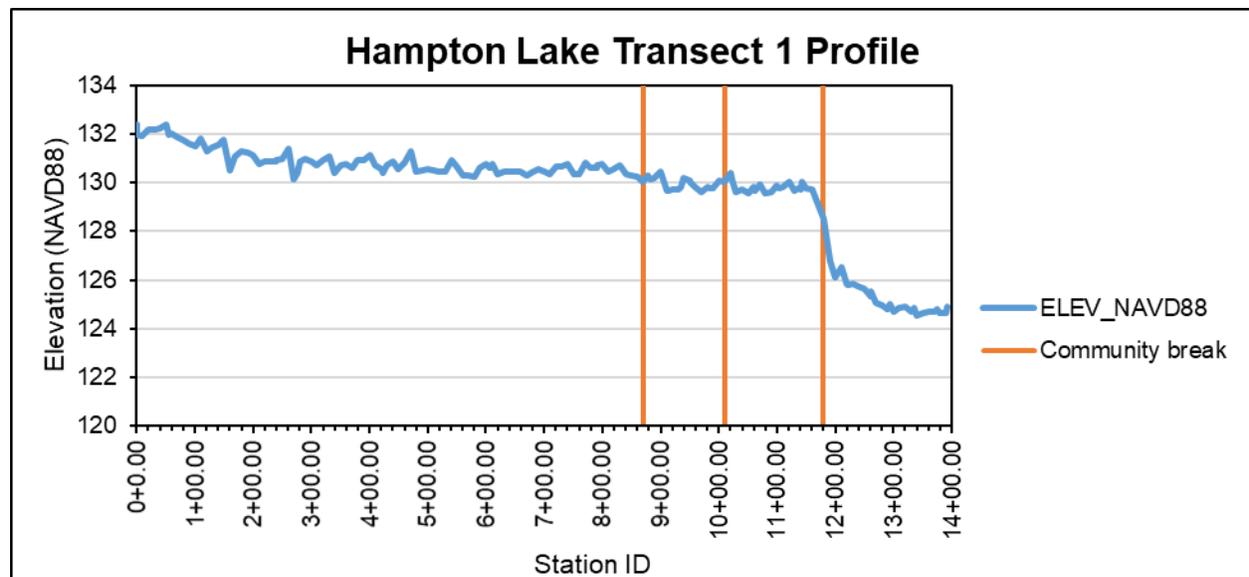| Vegetation Community	Stations	Mean	Standard Deviation	Median	Minimum	Maximum	N
Deep marsh	13+93.3 – 11+69	125.32	0.87	124.93	124.56	128.50	28
Cypress	11+69 – 10+08	129.83	0.21	129.77	129.58	130.40	21
Baygall	10+08 – 8+63	129.96	0.25	129.92	129.62	130.45	20
Wet flatwoods	8+63 – 0+60	130.91	0.56	130.75	130.17	132.41	94

Figure B2. Elevations along Transect 1, from the highest point surveyed in the wet flatwoods to the lowest point surveyed in the deep marsh.

Kinser (1996) described the deep marsh community as deep water wetlands dominated by a mixture of water lilies and deep water emergent species. It is a community that experiences a semi-permanent to permanent flooding regime. Typical genera include: *Scirpus* (*Schoenoplectus*), *Nymphaea*, *Nuphar*, *Nelumbo*, *Brasenia* and *Nymphoides*.

The deep marsh community in Lake Hampton was composed mainly of native vegetation, with the minor exception of the invasive exotic alligatorweed (*Alternanthera philoxeroides*). Deep-rooted, floating-leaved species of this community included banana lily (*Nymphoides aquatica*), fragrant water

lily (*Nymphaea odorata*), and cow lily (*Nuphar advena*) (Figure B3). Floating vegetation included water fern (*Salvinia minima*). Submersed aquatic vegetation included red ludwigia (*Ludwigia repens*), southern naiad (*Najas guadalupensis*), and bladderwort (*Utricularia* sp.). Emergent vegetation that extended into deep water, greater than depths of 3 ft, included giant bulrush (*Schoenoplectus californicus*), maidencane (*Panicum hemitomon*), and jointed spikerush (ether *Eleocharus equisitoides* or *E. interstincta*). Shallow emergents were represented by pickerelweed (*Pontederia cordata*), American cupscale (*Sacciolepis striata*), and sawgrass (*Cladium jamaicense*).

Figure B3. View of the southeast corner of Lake Hampton where fragrant water lilies are shown adjacent the emergent sawgrass that fringe the cypress communities in the background.

The cypress community is a forested wetland dominated by bald cypress or pond cypress (*Taxodium distichum* or *T. ascendens*), flooded annually for periods of long duration - typically 4 to 8 months in any given year. It includes cypress dome, strand, and lakeshore variants. The Transect 1 cypress community was represented by a canopy of pond cypress (*Taxodium ascendens*), loblolly bay (*Gordonia lasianthus*), and swamp tupelo (*Nyssa sylvatica var. biflora*). Mid-story and groundcover plants included fetterbush (*Lyonia lucida*), wax myrtle (*Morella cerifera*), Virginia willow (*Itea virginica*), and Virginia chain fern (*Woodwardia virginica*). Several plants fringing the shoreline included buttonbush (*Cephalanthus occidentalis*), sawgrass (*Cladium jamaicense*), Virginia marsh St. John's wort (*Triadenum virginicum*), titi (*Cyrilla racemiflora*), dahoon holly (*Ilex cassine*), and highbush blueberry (*Vaccinium corymbosum*).

The baygall community is a forested wetland typically dominated by one or more species of evergreen bay trees or less commonly by dahoon holly, deciduous hardwoods, or pine. It is often

located at the bases of sandy slopes and maintained by downslope seepage. Soils are organic and nearly constantly saturated but infrequently flooded. The canopy of the Transect 1 baygall community included a mixture of loblolly bay, swamp tupelo, dahoon holly, and sweet bay magnolia (*Magnolia virginiana*). Mid-story and groundcover included swamp bay (*Persea palustris*) wax myrtle, Virginia willow, fetterbush, and Virginia chain fern.

Wet flatwoods are typically pine forests with a sparse or absent mid-story and a dense groundcover of hydrophytic grasses, herbs, and low shrubs. The Transect 1 wet flatwoods canopy consisted mainly of tall slash pine (*Pinus elliottii*). The midstory was sparse and represented by red maple (*Acer rubrum*), pond cypress, dahoon holly, loblolly bay, water oak (*Quercus nigra*), red bay, and swamp tupelo. The mid-story and groundcover included galberry (*Ilex glabra*), fetterbush, highbush blueberry (*Vaccinium corymbosum*), Virginia chain fern, and cinnamon fern (*Osmunda cinnamomea*).

An analysis of Point-Centered Quarter (PCQ) data rendered canopy species Importance Values (IVs) for each community (Table B3): deep marsh (DM), cypress (CY), baygall (BG), and wet flatwoods (WF). The number of sites sampled by community are as follows: DM (n=1), CY (n=4), BG (n=4), and WF (n=5). The IV is a metric combining relative basal area, relative density, and relative frequency of occurrence of individual woody plant species within each community. The sum of the IVs for each community should equal 300. These IVs indicate that pond cypress, loblolly bay, and slash pine provide large relative contributions of area, density, and frequency in their respective communities. Although PCQ data are not utilized in delineating the landward extent of wetlands, the importance of slash pine in canopy of the wet flatwoods supports exclusion of this vegetative community as a wetland, per Rules 62-340.300 (2), (a) and (b), F.A.C.

Since stem diameters were not measured for shrubs, IVs were not computed; but data were sufficient to estimate relative densities and frequencies of shrub species in each community (Table B4). The shrubs represented in PCQ survey results indicate low species diversity in each community.

Table B3. Canopy species Importance Values (IV) by community for Transect 1.

Species	IV Deep Marsh	IV Cypress	IV Baygall	IV Wet Flatwoods
Quercus laurifolia	-	-	-	42.07
Gordonia lasianthus	-	150.21	223.87	30.59
Vaccinium sp.	-	-	-	11.73
Ilex cassine	-	-	-	25.79
Morella cerifera	-	-	18.44	28.98
Lyonia lucida	-	-	14.18	11.70
Pinus elliottii	-	-	-	120.30
Taxodium ascendens	300.00	149.79	-	12.83
Acer rubrum	-	-	-	16.00
Nyssa sylvatica (var. biflora)	-	-	43.52	-

Table B4. Shrub species Relative Density (RD) and Relative Frequency (RF) by community for Transect 1.

Species	RD Deep Marsh	RF Deep Marsh	RD Cypress	RF Cypress	RD Baygall	RF Baygall	RD Wet Flatwoods	RF Wet Flatwoods
Morella cerifera	50.00	50.00	-	-	-	-	-	-
Cephalanthus occidentalis	50.00	50.00	-	-	-	-	-	-
Gordonia lasianthus	-	-	93.75	80.00	33.33	40.00	70.00	60.00
Itea virginica	-	-	6.25	20.00	-	-	-	-
Lyonia lucida	-	-	-	-	66.67	60.00	-	-
Ilex glabra	-	-	-	-	-	-	30.00	40.00

Vegetation at Transect 2

Transect 2 was located approximately 775 ft east of the outlet canal on the southern shoreline of Lake Hampton (Figure 4-1, Table B5). Transect 2 was surveyed from the interior of the deep marsh, through the cypress community, and into the interior of the wet flatwoods. Natural ground elevations were surveyed at a total of 146 locations, ranging from 124.30 to 137.03 ft NAVD88 (Table B6 and Figure B4).

The plants found in the lake's deep marsh community are universal in terms of species composition, particularly the deep-rooted, floating-leaved, submersed aquatic, and deep-water emergent vegetation species listed in the preceding section. Shallow emergent plants unique to Transect 2 were represented by rush fuirena (*Fuirena scirpoidea*), swamp loosestrife (*Decodon verticillatus*), and sawgrass.

The cypress community included a canopy of pond cypress, loblolly bay, red maple, dahoon holly, and sweetbay magnolia. Mid-story species included wax myrtle, fetterbush, and red bay. Groundcover plants included Virginia chain fern, witchgrass (*Dichanthelium* sp.), and sawgrass.

Table B5. Transect 2 location and fieldwork dates.

Northing – Easting (Station 0; upland)	Northing – Easting (Station 14+10.0; DM-LS endpoint)	Location and Dates of Fieldwork
314884.61 – 2706309.12	315947.18 – 2707057.73	Southern shore of Lake Hampton October 1, 2014

Table B6. Lake Hampton Transect 2 vegetation community elevation statistics (ft NAVD88).

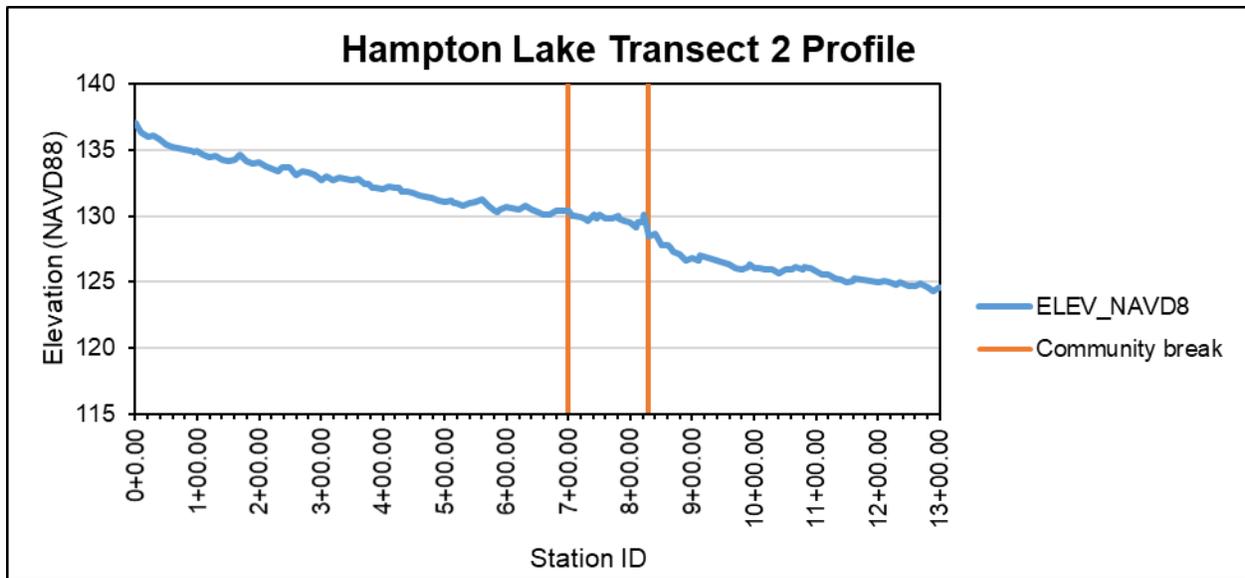| Vegetation Community	Stations Distance (ft)	Mean	Standard Deviation	Median	Minimum	Maximum	N
Deep marsh	12+68.2 – 8+24	125.95	1.03	125.98	124.30	128.62	48
Cypress	6+95 – 8+24	129.82	0.29	129.79	129.09	130.37	20
Wet flatwoods	8+24 – 0+5	132.84	1.88	132.73	130.11	137.03	78

Figure B4. Elevations along Transect 2, from the highest point surveyed in the wet flatwoods to the lowest point surveyed in the deep marsh.

The wet flatwoods canopy consisted of loblolly pine (*Pinus taeda*), slash pine, red maple, laurel oak (*Quercus laurifolia*), water oak, and dahoon holly. The mid-story was represented by red bay, loblolly bay; and perennial shrubs and groundcover such as galberry, saw palmetto (*Serenoa repens*), fetterbush, and a species of *Vaccinium* with considerable basil area that was likely sparkleberry (*V. arboretum*). Virginia chain fern represented the groundcover.

PCQ data analyses rendered canopy species Importance Values (IVs) for cypress (CY) and wet flatwoods (WF) communities (Table B7). The number of sites sampled by community are as follows: DM (n=1), CY (n=3), and WF (n=5). These IVs indicate that pond cypress, slash pine, and loblolly pine each make large relative contributions of area, density, and frequency in their respective communities.

Estimates of relative densities and frequencies of shrub species demonstrate a relatively greater diversity of species in each community of Transect 2 (Table B8) in comparison to those of Transect 1.

Table B7. Canopy species Importance Values (IV) by community for Transect 2.

Species	IV Deep Marsh	IV Cypress	IV Wet Flatwoods
Quercus laurifolia	-	-	34.76
Quercus nigra	-	-	49.05
Gordonia lasianthus	-	28.97	14.18
Vaccinium sp.	-	-	-
Ilex cassine	-	29.95	27.72
Morella cerifera	-	39.98	-
Lyonia lucida	-	-	-
Pinus elliottii	-	-	82.16
Pinus taeda	176.75	-	61.47
Taxodium ascendens	123.35	152.30	-
Acer rubrum	-	19.55	17.95
Nyssa sylvatica (var. biflora)	-	-	-
Magnolia virginiana	-	30.95	-
Vaccinium sp.	-	-	12.71

Table B8. Shrub species Relative Density (RD) and Relative Frequency (RF) by community for Transect 2.

Species	RD_{DM}	RF_{DM}	RD_{CY}	RF_{CY}	RD_{WF}	RF_{WF}
Morella cerifera	-	50.00	8.33	16.67	-	-
Cephalanthus occidentalis	50.00	50.00	-	-	-	-
Gordonia lasianthus	-	-	-	-	15.00	11.11
Itea virginica	-	-	-	-	-	-
Lyonia lucida	-	-	25.00	33.33	15.00	22.22
Ilex glabra	-	-	-	-	40.00	33.33
Salix Carolineana	50.00	-	-	-	-	-
Persea palustris	-	-	66.67	50.00	25.00	22.22
Vaccinium sp.	-	-	-	-	5.00	11.11

Boxplots representing natural ground elevations surveyed for individual communities are shown in Figure B5. The inter-quartile ranges (IQRs) of cypress and wet flatwoods communities are completely separated between respective maximum and minimum elevations. A similar relationship exists between the cypress and deep marsh communities. It is apparent that most variability in the cypress survey data occurs near the boundary of the deep marsh communities (Figures B2 and B4). Overlap in the IQRs occur between the baygall and two cypress communities with respective medians differing by 0.13 ft (Table B9). Deep marsh maximum elevations have a high level of agreement between transects, as this represents the lake shoreline. The highest and lowest elevations surveyed from wet flatwoods communities differed by nearly 6 ft; but this does not indicate skewness, as these transect endpoints did not represent community ecotones.

Results of both Shapiro-Wilk and Bartlett tests found the residuals of the data were not normally and independently distributed with mean zero and constant variance, so an ANOVA was not used to test for differences in mean elevation between communities (Montgomery 2001). However, results of a one-way nonparametric analysis of variance indicate that community type accounts for a significant portion of the variability in elevation (p<0.0001), and the accompanying Kruskal-Wallis test leads to rejection of the null hypothesis that there is no difference in location for elevation among communities (p<0.0001).
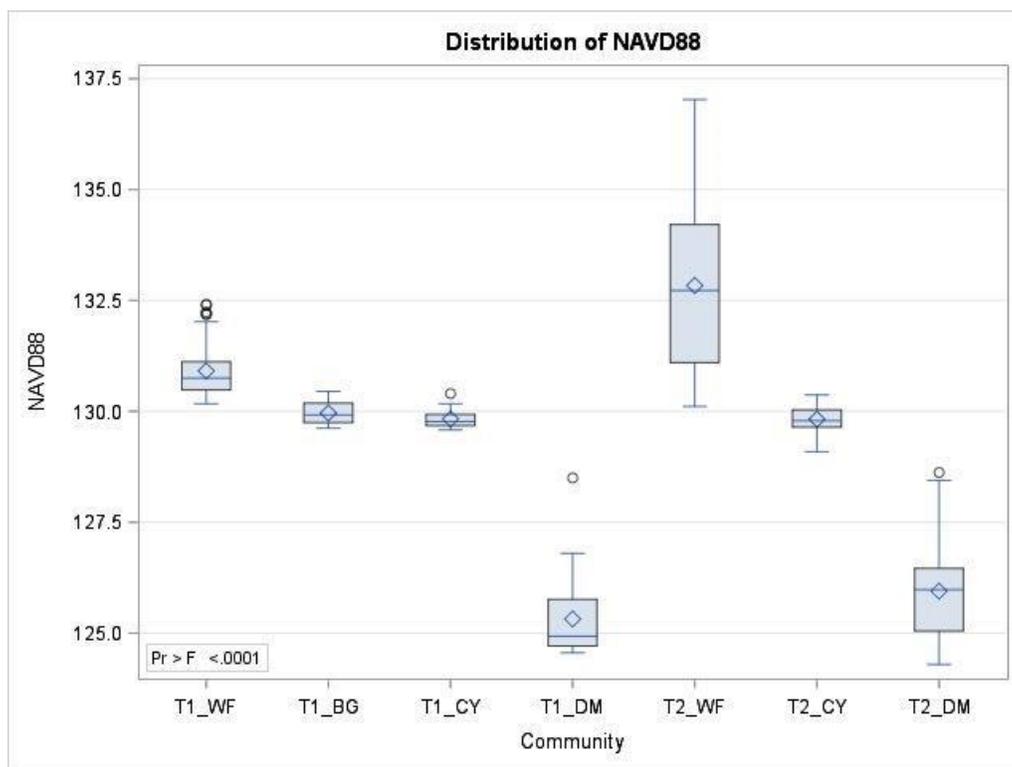
Figure B5. Boxplots representing natural ground elevations surveyed for individual communities from Transects 1 and 2.

Since minimum lake levels are established to protect specific types of communities, such as seasonally flooded cypress, it is appropriate to combine survey data from the two transects by community (Table B9 and Figure B6). Similar to results taken separately according to transect, data combined by community did not conform to normality or homoscedasticity, and community type accounts for a significant portion of the variability in elevation (p<0.0001).

Table B9. Community elevations combined from Transect 1 and 2, survey data (ft NAVD88).

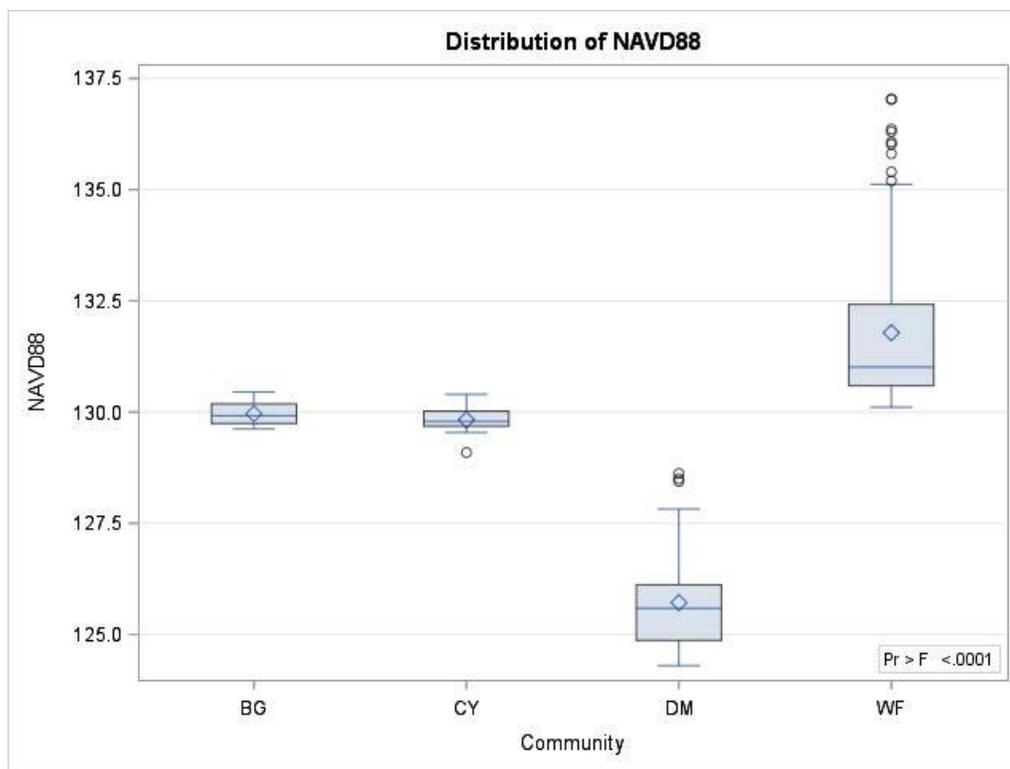| Community	N Observations	N	Mean Elevation	Standard Deviation	Minimum Elevation	Maximum Elevation
BG	20	20	129.96	0.25	129.62	130.45
CY	41	41	129.83	0.24	129.09	130.40
DM	76	76	125.72	1.01	124.30	128.62
WF	172	172	131.78	1.64	130.11	137.03

Figure B6. Boxplots representing natural ground elevations surveyed by community.

Deep Marsh Community Depth Soundings

Mean depth soundings of the boundary separating emergent sawgrass and floating-leaved cow lily stands are listed for individual sites in Table B10 and illustrated in Figure B7. This boundary represents the landward extent of the deep marsh community. Results of both Shapiro-Wilk and Bartlett tests found the residuals of the data normally and independently distributed with mean zero and constant variance, so an ANOVA was performed with a post-hoc Tukey test. Results indicated that significant differences existed in means from individual sites with the exceptions of Sites 1 and 2 ($p<0.05$).

Collectively, the mean depth from all sites is equal to 2.58 ft. The lake stage was 129.70 ft NGVD29 during time of the soundings. After subtracting the sounding depths and a datum correction factor of 0.88 ft, the mean elevation of the landward extent of the deep marsh community is estimated as 126.24 ft NAVD88.

Table B10. Descriptive statistics of the depth soundings (ft) at the boundary of the cow-lilies and sawgrass on Lake Hampton, 03/24/2016.

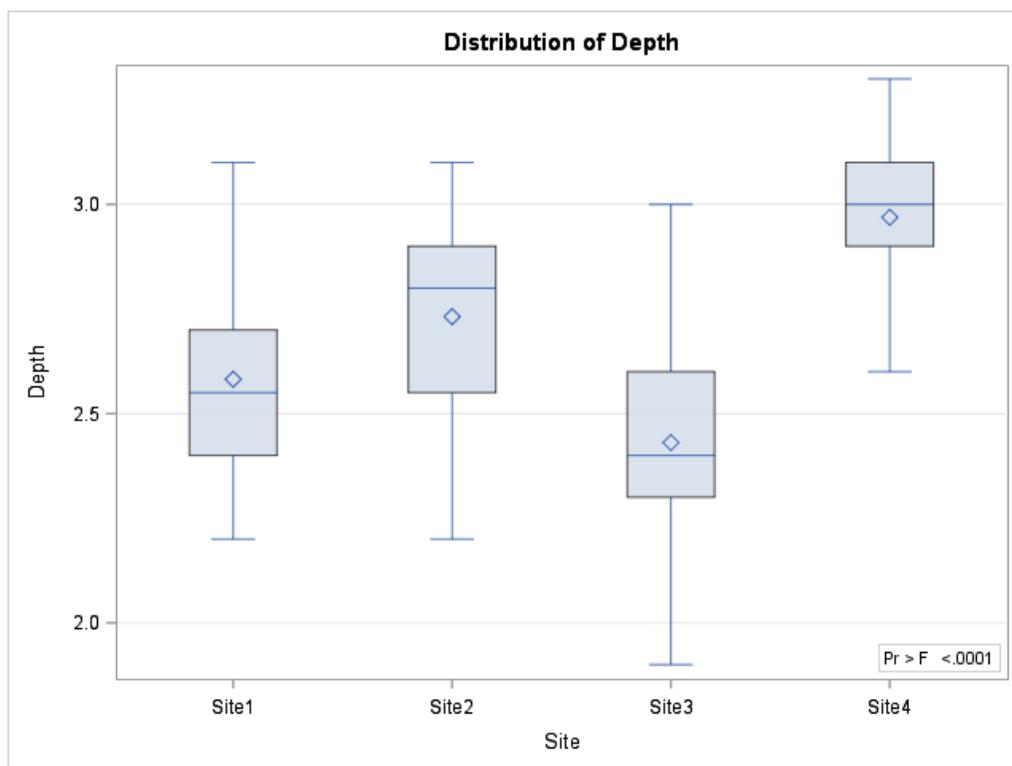| Site	N	Mean Depth	Standard Deviation	Minimum Depth	Maximum Depth
Site1	25	2.58	0.23	2.20	3.10
Site2	22	2.73	0.24	2.20	3.10
Site3	57	2.43	0.22	1.90	3.00
Site4	13	2.97	0.22	2.60	3.30

Figure B7. Boxplots constructed from depth soundings at the boundary of the cow-lilies and sawgrass on Lake Hampton, 03/24/2016.

Vegetation Discussions

The SJRWMD event-based MFLs methods define the frequency and duration of high, average, and low water events necessary to protect relevant water resource values and prevent significant harm to aquatic and wetland habitats. Three types of events that are routinely used by the SJRWMD are referred to as minimum frequent high, minimum average, and minimum frequent low flows and/or water levels (SJRWMD 2006, Neubauer *et al.* 2008).

Natural communities occurring in the Lake Hampton study site were classified in accordance with descriptions developed by the Florida Natural Areas Inventory (FNAI 2010) and Kinser (1996). These included wet flatwoods, baygall, cypress, and deep marsh. Maintenance of the hydrologic regime for the cypress and deep marsh communities were most important in developing minimum levels for Lake Hampton. Community elevation benchmarks are shown in Table B9.

The average elevation of the cypress community could be used to set a minimum frequent high (FH) level on Lake Hampton, ensuring the maintenance of flooding events with a minimum 30-day duration at a minimum frequency of 2 years for seasonally flooded communities adjacent the lake.

The cypress and wet flatwood communities are separated in elevation, albeit by a very narrow spread. The maximum elevation surveyed from the cypress community was 130.40 ft NAVD88, while the wet flatwoods minimum elevation was 130.11 ft NAVD88. Since the frequency of fire is more

important in maintenance of the wet flatwoods community (FNAI 2010), these two communities should be separated on the landscape, as demonstrated by the results of this study.

A similar separation in surveyed elevations cannot be shown between the cypress and baygall communities (Table B9). The baygall community is typically located at the bases of sandy slopes and maintained by downslope seepage; soils in this community are organic and nearly constantly saturated but infrequently flooded (Kinser 1996).

The cypress and deep marsh communities are also narrowly separated, with the minimum elevation of the seasonally flooded (cypress) approximately 0.5 ft above the maximum elevation of the semi-permanently to permanently flooded (deep marsh) (Kinser 1996).

The elevation data collected for vegetative communities supports their use in setting minimum levels for Lake Hampton, according to the SJRWMD event-based MFLs methods.

The results of the vegetation sampling may be improved through the collection of additional and refined elevation data, particularly within the cypress community where potential impacts from artificial drainage created by the outfall canal are experienced. Exaggerated hummocks and exposed roots surrounding cypress trees provide evidence of soil subsidence (Figure B8). It is likely the elevations may represent relict soil surfaces and not those currently influenced by seasonal flooding. By the same reasoning, dewatering may have resulted in baygall encroachment on the landward extent of the cypress community (SWFWMD 1998).

The longitudinal extent of the wet flatwoods was not established, due to their extensive range into the surrounding landscape. This community does not have a specific hydrologic regime that minimum lake levels were designed to protect.

The deep marsh elevation soundings were represented by four well-balanced sampling sites (Figure 4-1). Collectively, the mean depth from all sites is equal to 2.58 ft and the maximum difference in their average depth was approximately 0.54 ft (Table B10). The average elevation of the landward extent of the deep marsh community (126.24 ft NAVD88) could be used to set the minimum frequent low level, ensuring the maintenance of a hydrologic regime where dewatering occurs for a maximum duration of 120 days at a minimum frequency of 5 years (SJRWMD 2006).

Figure B8. Exposed roots surrounding a cypress tree on Transect 1.

Appendix C: Hydrologic Indicator Sampling, Analyses, Results, and Discussions

Hydrologic Indicator Sampling Methods

Important physical indicators of historical inundation were identified along Transects 1 and 2 (Figure C1). These indicators included cypress buttress inflection elevations, historic soil lines, occurrence of saw palmetto (*Serenoa repens*) closest the lake, well-developed adventitious roots, lichen lines, and moss lines. With the exception of the saw palmetto edge, all of these indicators are listed in Rule 62-340.500 F.A.C. All indicators have known hydrologic associations. Locations of these hydrologic indicators were marked for subsequent elevation survey.

Hydrologic Indicator Data Analyses

Descriptive statistics (i.e., mean, median, min, max, and n [sample size]) were calculated for the elevations of specific hydrologic indicators using the Version 9.4 SAS Means procedure (SAS).

Hydrologic Indicator Results

The highest mean elevation recorded with these hydrologic indicator results was the saw palmetto edge in the vicinity of both transects (Table C1 and Figure C1). This elevation represents a definitive break between wetland and upland communities along the elevation gradient. The average elevation of all cypress buttress inflection points surveyed was 133.01 ft NAVD88, abbreviated HNP ("High Normal Pool"). The average elevation of the historic soil line (HSL) is similar to the HNP, occurring relatively higher in elevation than the remaining indicators surveyed. Lichen lines (Lichen_M) and adventitious roots (AdvRoot) represent indicators of seasonal high water and associated morphological plant adaptations, respectively. Tight inter-quartile ranges of the lichen line and adventitious root elevation data demonstrate the consistency of each.

Table C1. Elevations of hydrologic indicators along Lake Hampton transects (ft NAVD88).

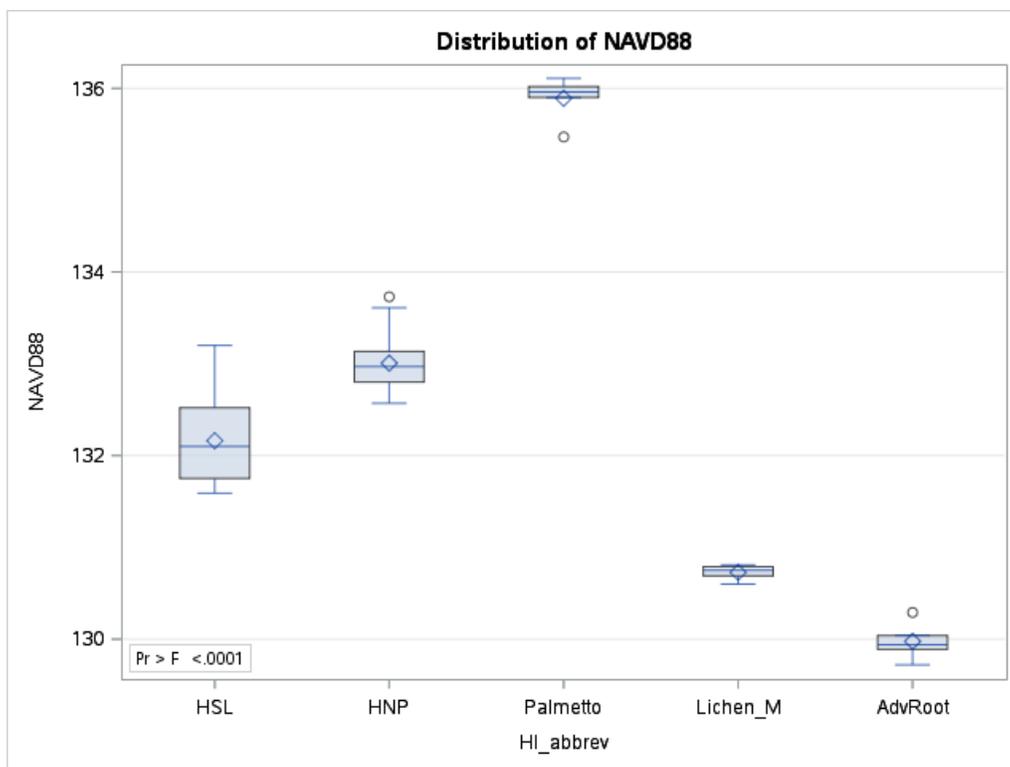| Hydrologic Indicator	N	Mean Elevation	Standard Deviation	Minimum Elevation	Maximum Elevation
Adventitious roots	5	129.98	0.21	129.72	130.29
High normal pool	20	133.01	0.30	132.57	133.73
Historic soil line	9	132.16	0.52	131.59	133.20
Lichen lines	5	130.73	0.08	130.60	130.81
Palmetto edge	5	135.89	0.25	135.47	136.11

Figure C1. Distribution of elevations across Lake Hampton hydrologic indicators.

Hydrologic Indicator Discussions

Elevations of hydrologic indicators were surveyed in anticipation of applying SWFWMD MFLs referenced in Rules 40D-8.021 and 40D-8.624, F.A.C., Definitions and Guidance and Minimum Levels for Lakes. Methods are detailed in SWFWMD (1999a, b), Leeper *et al.* (2001), and Hancock (2007).

Two MFLs typically proposed by the SWFWMD methodology are the High Minimum Lake Level (HMLL) and the Minimum Lake Level (MLL). The HMLL is a stage that represents the elevation of the water surface equaled or exceeded 10 percent of the time as determined from a long-term stage frequency analysis. The MLL is a stage that represents the elevation of the water surface equaled or exceeded 50 percent of the time as determined from a long-term stage frequency analysis. These levels are also referred to as the Historic P10 (HP10) and Historic P50 (HP50), respectively.

According to the model simulated lake stage data set for the no-pumping scenario (Section 5.2), the Lake Hampton HP10 and HP50 determined for the period of record (POR) of April 25, 1960, to December 31, 2015, were 129.66and 128.95 ft NAVD88, respectively (Table 5-2).

Hydrologic indicators are often utilized by SWFWMD methods to approximate both the HP10 and HP50. An inflection in the buttresses, located at the base of cypress trunks, may be utilized to approximate the HP50 when sufficient hydrologic records do not exist: The average elevation of this inflection on Lake Hampton was 133.01 ft NAVD88, which represents the HNP elevation. According to the methodology, 1.8 ft may be subtracted from the HNP elevation to approximate a HP50 of 131.21 ft NAVD88 for Lake Hampton (SWFWMD 1999a, b; Leeper *et al.* 2001; Hancock 2007). Depending upon classification by the same methods, the HP10 may be estimated by either

subtracting 0.4 ft from the HNP (132.61 ft NAVD88) or using a set (i.e., structurally-regulated) guidance level. The estimated HP10 and HP50 for Lake Hampton are considerably higher than those determined from the long-term model simulated lake stage data set, beginning in 1960 (Figure C2). The potential reason for this discrepancy is that the cypress buttress inflections were shaped by hydrologic conditions prior to excavation of the outfall canal that has facilitated drainage of the lake.

The average cypress buttress inflection elevation, and the apparent average elevation of the HSL, support the theory that the vegetative communities surrounding the lake have been historically dewatered. The latter elevation was determined to be 132.16 ft NAVD88 (Table C1).

Duration of inundation periods have been estimated for other indicators: Carr *et al.* (2006) determined moss collars and cypress buttress swellings were inundated 2 to 3% of the time; and other indicators including lowest roots of palmetto (*Serenoa repens*), landward-most cypress, and the uppermost woody adventitious root of St John's wort (*Hypericum fasciculatum*) were inundated 13 to 29% of the time while hydric soils were inundated 38% of the time. For Lake Hampton, the mean elevations of cypress buttress swellings (HNP), the minimum elevation of the palmetto roots, and the minimum HSL were inundated less than 1% of the time; and the mean elevations of the St John's wort adventitious roots were inundated approximately 2% of the 55.7-year model simulation period of April 25, 1960, to December 31, 2015, for the no-pumping scenario. Mean elevations of the lichen lines were exceeded less than 1% of the time for the same period, at an elevation near the ordinary high water line (OHWL) of the lake (see following paragraph).

Current regulatory benchmarks for Lake Hampton also indicate Historic water levels may have been staged higher than present. Sovereign submerged lands (SSL) occur below the OHWL of approximately 130.54 ft NAVD88. The SSL are therefore located at an elevation that is higher than the HP10 of 129.66 ft NAVD88 for the same POR (Figure C2).
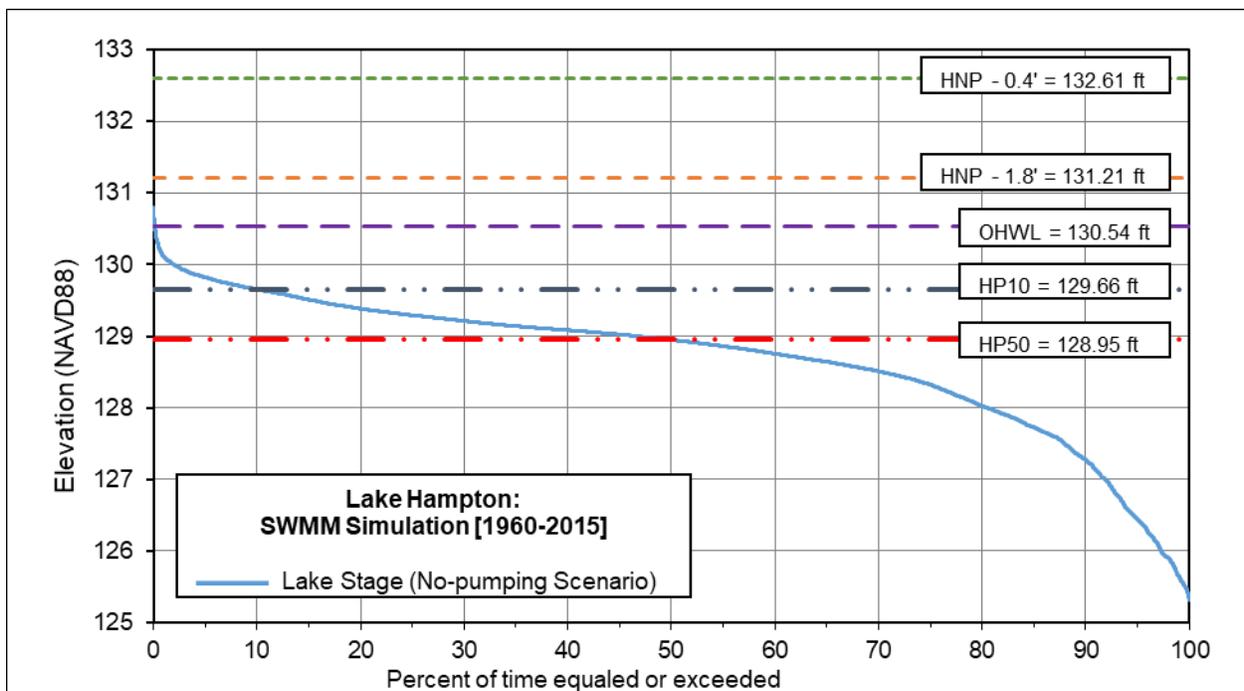

Figure C2. Exceedance probability chart, HP10, HP50, estimated HP50 (HNP - 1.8 ft), estimated HP10 (HNP - 0.4 ft), and OHWL for the period of record of 4/25/1960 – 12/31/2015.

Appendix D: Supporting Information for Development of Minimum and Guidance Levels

Bathymetry

The stage-area-volume relationships were developed for Lake Hampton by building and processing digital elevation models (DEMs) of the lake bathymetry and land surface elevations of surrounding watershed (Figures D1 and D2).

The resultant stage-area-volume relationships created from the 1976 SRWMD bathymetric survey are listed in Table D1. Since the 1976 bathymetric contour elevations were provided in the vertical datum of NGVD29, the bathymetric contour elevations were converted to ft NAVD88 with a datum correction factor of 0.85 ft. The stage-area data derived from the 2011 USGS topographic DEM (elevation in ft NAVD88) is provided in Table D2.

The relationships of lake stage versus surface area (2D area), bottom area (3D area), volume, mean depth, and maximum depth, are graphically presented on Figures D3 through D7, respectively.

Table D1. Stage-area-volume table for Lake Hampton (from the 1976 SRWMD bathymetric survey).

Elevation (ft NAVD88)	Area_2D (ft²)	Area_3D (ft²)	Volume (ft³)	Area_2D (acres)	Area_3D (acres)
105.15	3,625.00	3,625.00	0.00	0.08	0.08
105.65	7,206.74	7,209.74	2,732.44	0.17	0.17
106.15	11,491.56	11,498.34	7,350.53	0.26	0.26
106.65	17,168.70	17,179.87	14,447.50	0.39	0.39
107.15	25,311.29	25,327.25	24,831.48	0.58	0.58
107.65	39,197.02	39,218.52	40,904.77	0.90	0.90
108.15	57,404.48	57,432.26	64,803.46	1.32	1.32
108.65	82,385.29	82,419.96	99,412.26	1.89	1.89
109.15	924,315.04	924,356.92	149,045.00	21.22	21.22
109.65	1,328,668.64	1,328,724.31	715,959.84	30.50	30.50
110.15	1,750,252.53	1,750,322.60	1,483,068.87	40.18	40.18
110.65	2,283,626.15	2,283,711.16	2,484,155.78	52.42	52.43
111.15	3,599,246.53	3,599,346.98	3,830,046.37	82.63	82.63
111.65	4,317,419.10	4,317,545.30	5,811,029.14	99.11	99.12
112.15	5,122,662.68	5,122,815.48	8,165,127.43	117.60	117.60
112.65	6,110,754.60	6,110,934.58	10,963,808.73	140.28	140.29
113.15	8,554,066.08	8,554,273.60	14,337,297.80	196.37	196.38
113.65	9,902,028.85	9,902,276.69	18,985,420.37	227.32	227.32
114.15	11,021,689.93	11,021,979.07	24,217,755.97	253.02	253.03
114.65	12,141,561.66	12,141,892.87	30,007,259.11	278.73	278.74
115.15	13,519,905.21	13,520,278.90	36,373,447.14	310.37	310.38
115.65	14,357,033.48	14,357,461.27	43,348,480.27	329.59	329.60

Table D1. Stage-area-volume table for Lake Hampton (from the 1976 SRWMD bathymetric survey).

Elevation (ft NAVD88)	Area_2D (ft²)	Area_3D (ft²)	Volume (ft³)	Area_2D (acres)	Area_3D (acres)
116.15	15,176,480.12	15,176,963.74	50,731,403.23	348.40	348.42
116.65	16,009,687.90	16,010,227.93	58,527,248.48	367.53	367.54
117.15	16,894,731.14	16,895,327.13	66,745,061.96	387.85	387.86
117.65	17,865,204.18	17,865,858.83	75,440,560.30	410.13	410.14
118.15	18,824,333.38	18,825,048.51	84,612,230.30	432.15	432.16
118.65	19,803,266.40	19,804,042.61	94,268,200.01	454.62	454.64
119.15	20,836,679.31	20,837,515.92	104,420,192.03	478.34	478.36
119.65	22,013,871.35	22,014,758.71	115,138,808.65	505.37	505.39
120.15	23,187,612.24	23,188,551.62	126,437,948.20	532.31	532.34
120.65	24,395,686.91	24,396,678.87	138,332,119.40	560.05	560.07
121.15	25,729,537.11	25,730,581.37	150,842,460.29	590.67	590.69
121.65	26,753,897.36	26,755,008.52	163,969,959.21	614.18	614.21
122.15	27,766,186.80	27,767,366.64	177,599,003.95	637.42	637.45
122.65	28,806,302.75	28,807,551.75	191,740,751.07	661.30	661.33
123.15	29,999,040.10	30,000,357.39	206,413,030.59	688.68	688.71
123.65	30,766,711.05	30,768,142.36	221,611,227.36	706.31	706.34
124.15	31,508,246.88	31,509,795.43	237,179,642.46	723.33	723.37
124.65	32,259,954.68	32,261,620.57	253,121,167.83	740.59	740.62
125.15	33,058,307.10	33,060,087.68	269,442,440.27	758.91	758.96
125.65	33,401,538.64	33,403,573.40	286,062,079.09	766.79	766.84
126.15	33,719,412.10	33,721,712.94	302,842,019.78	774.09	774.14
126.65	34,040,062.30	34,042,629.83	319,781,477.68	781.45	781.51
127.15	34,389,475.68	34,392,300.77	336,883,222.34	789.47	789.54
127.65	34,648,946.27	34,652,118.58	354,147,124.19	795.43	795.50
128.15	34,886,565.38	34,890,101.84	371,530,826.84	800.89	800.97
128.65	35,125,538.47	35,129,439.59	389,033,743.81	806.37	806.46
129.15	35,414,657.46	35,418,907.60	406,657,306.01	813.01	813.11
129.65	35,883,778.37	35,888,259.27	424,487,410.17	823.78	823.88
130.03	36,184,175.00	36,188,793.70	438,186,471.96	830.67	830.78

Table D2. Stage-area table for Lake Hampton (from the USGS Topographic DEM).

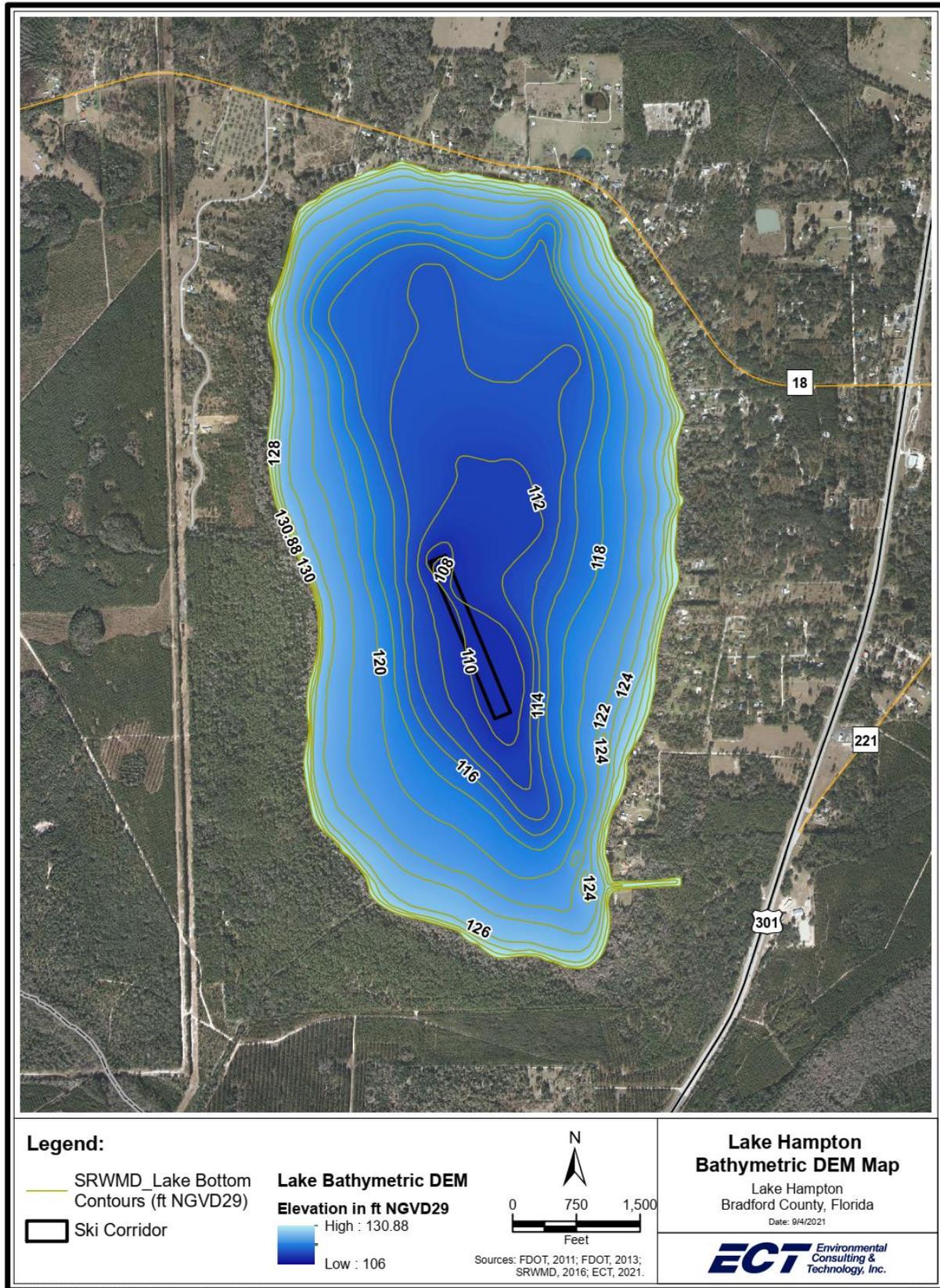| Elevation (ft NAVD88)	Area_2D (ft²)	Area_2D (acres)	Elevation (ft NAVD88)	Area_2D (ft²)	Area_2D (acres)
130.3	38,647,900	887.23	133.9	53,038,720	1217.60
130.8	40,228,000	923.51	134.8	55,328,420	1270.17
131.6	43,755,820	1004.50	136.2	59,110,620	1356.99
132.7	48,927,020	1123.21	136.6	60,052,350	1378.61
133.5	51,857,350	1190.48	138.0	63,065,080	1447.78

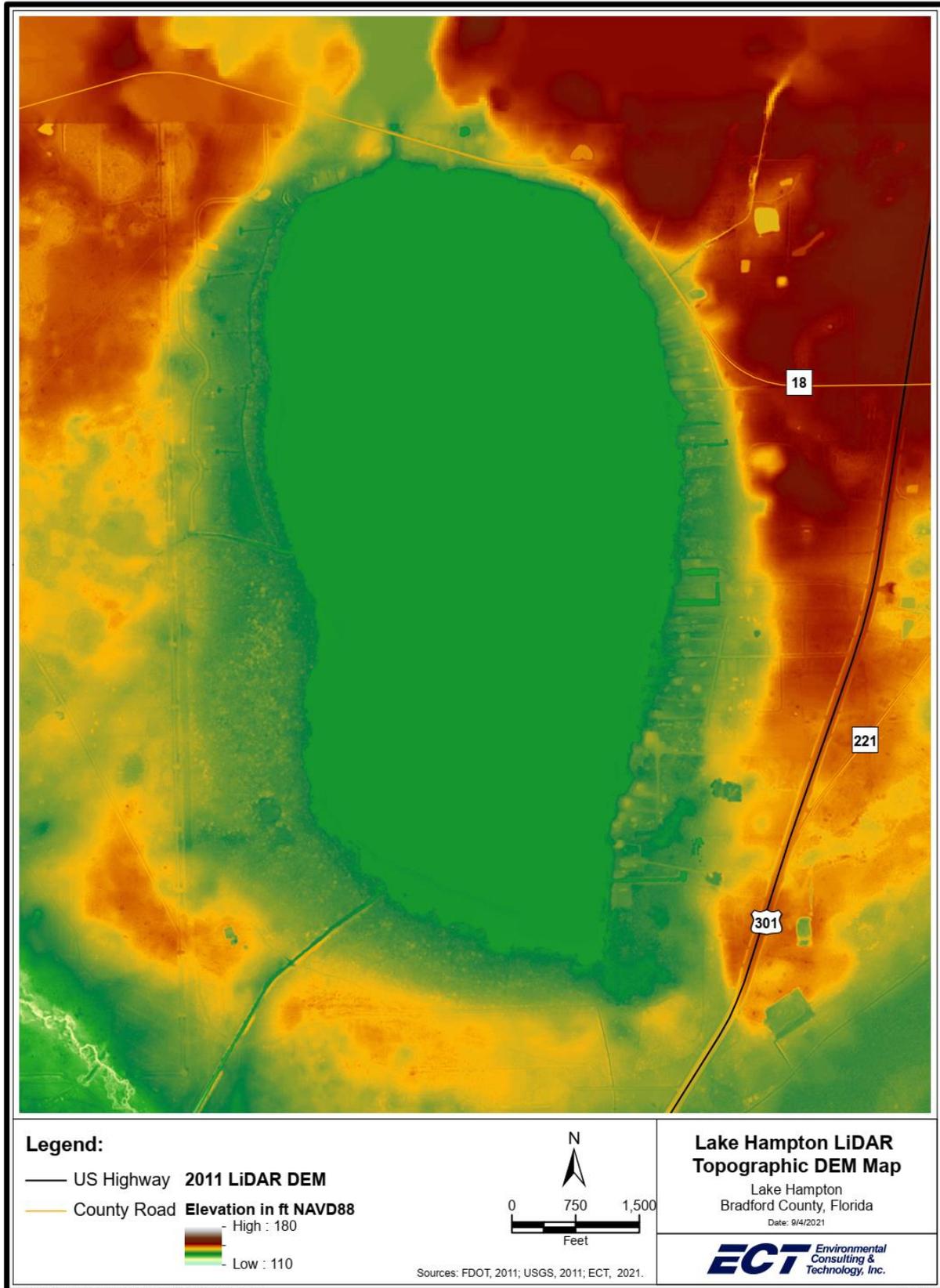*Figure D1. Lake Hampton bathymetric DEM map (elevation in ft NGVD29).*

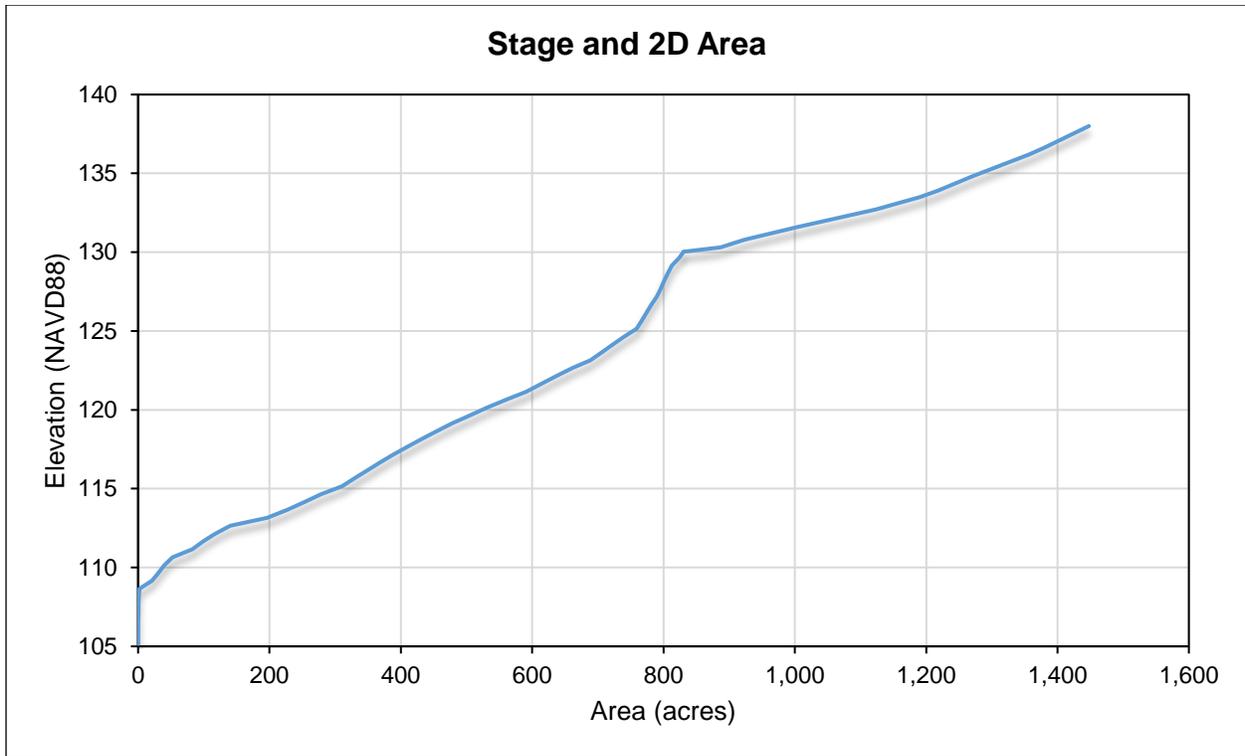*Figure D2. Lake Hampton LiDAR topographic DEM map (elevation in ft NAVD88).*

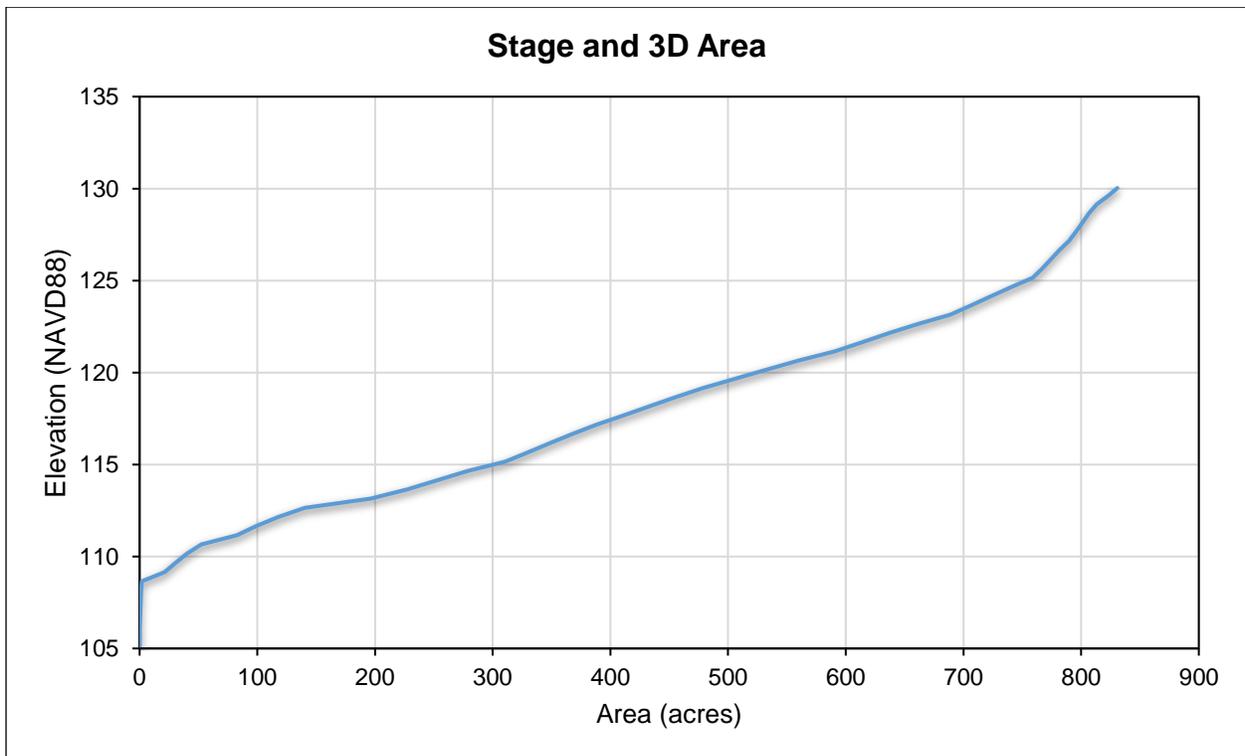*Figure D3. Lake stage to surface area (2D area) for Lake Hampton.*

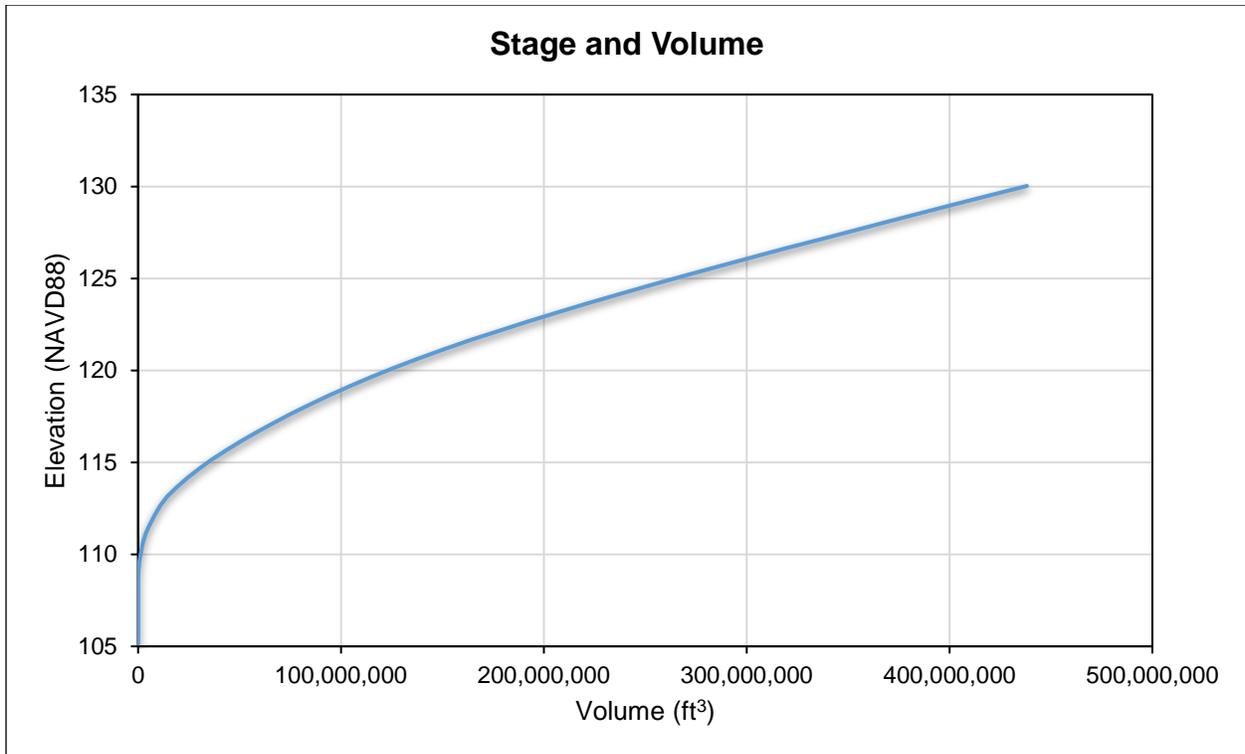*Figure D4. Lake stage to bottom area (3D area) for Lake Hampton.*
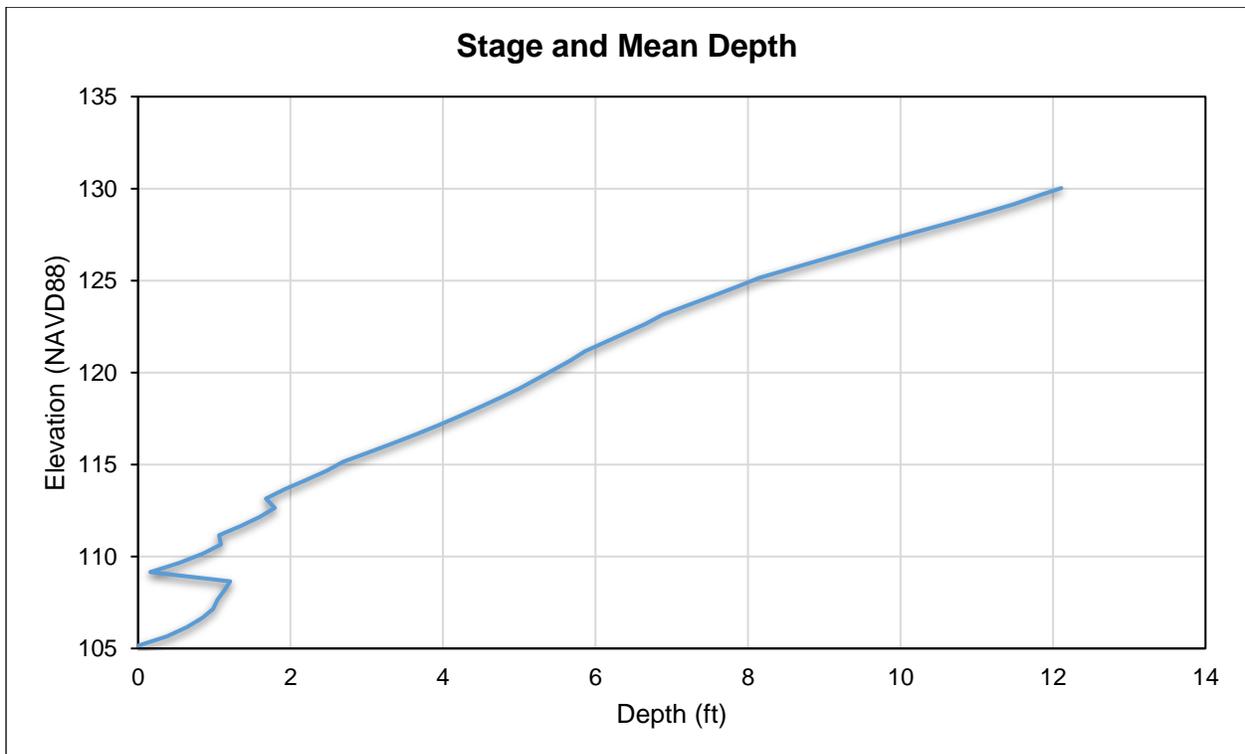
Figure D5. Lake stage to volume for Lake Hampton.

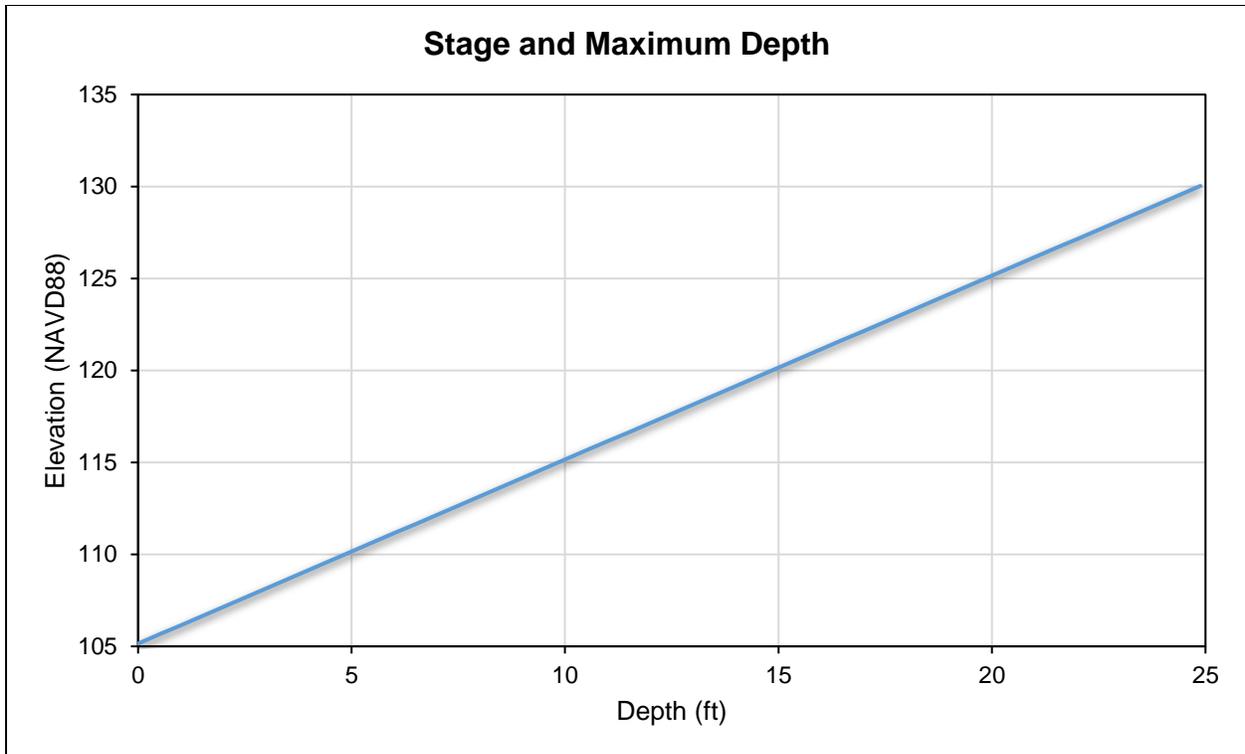*Figure D6. Lake stage to mean depth for Lake Hampton.*

Figure D7. Lake stage to maximum depth for Lake Hampton.

Significant Change Standards

The following sections summarize the supporting data and methodology utilized in the development of the seven significant change standards for Category 3 Lakes, including a Wetland Offset Standard, a Dock-Use Standard, an Aesthetics Standard, a Species Richness Standard, a Lake Mixing Standard, a Recreation/Ski Standard, and a Basin Connectivity Standard. Potential changes in the coverage of herbaceous wetland vegetation and submersed aquatic plants are also discussed below.

Wetland Offset Standard

Based on an evaluation of the relationship of the Cypress Wetland Standard with the Historic P50 (HP50) for hydrologically unimpacted cypress wetlands, the Wetland Offset Standard for Category 3 Lakes is established at an elevation 0.8 ft below the HP50 elevation (Hancock 2007).

The HP50 elevation was 128.95 ft NAVD88 for lake Hampton. So, the Wetland Offset Standard was established at 128.15 ft NAVD88,

Dock-Use Standard

The Dock-Use Standard was estimated by calculating the P10 of dock sediment elevations, then adding 2 feet to that and adding the absolute difference between the Historic P90 (HP90) and HP50 (i.e., 128.95 - 127.27 = 1.68 ft) to get the final standard.

As there were only eight docks surveyed on the lake (Figure D8), the minimum elevation of 124.26 ft NAVD88 was used to approximate the P10 of dock sediment elevations. Using the Dock-Use Standard formula, that gives a final Dock-Use Standard of 127.94 ft NAVD88.
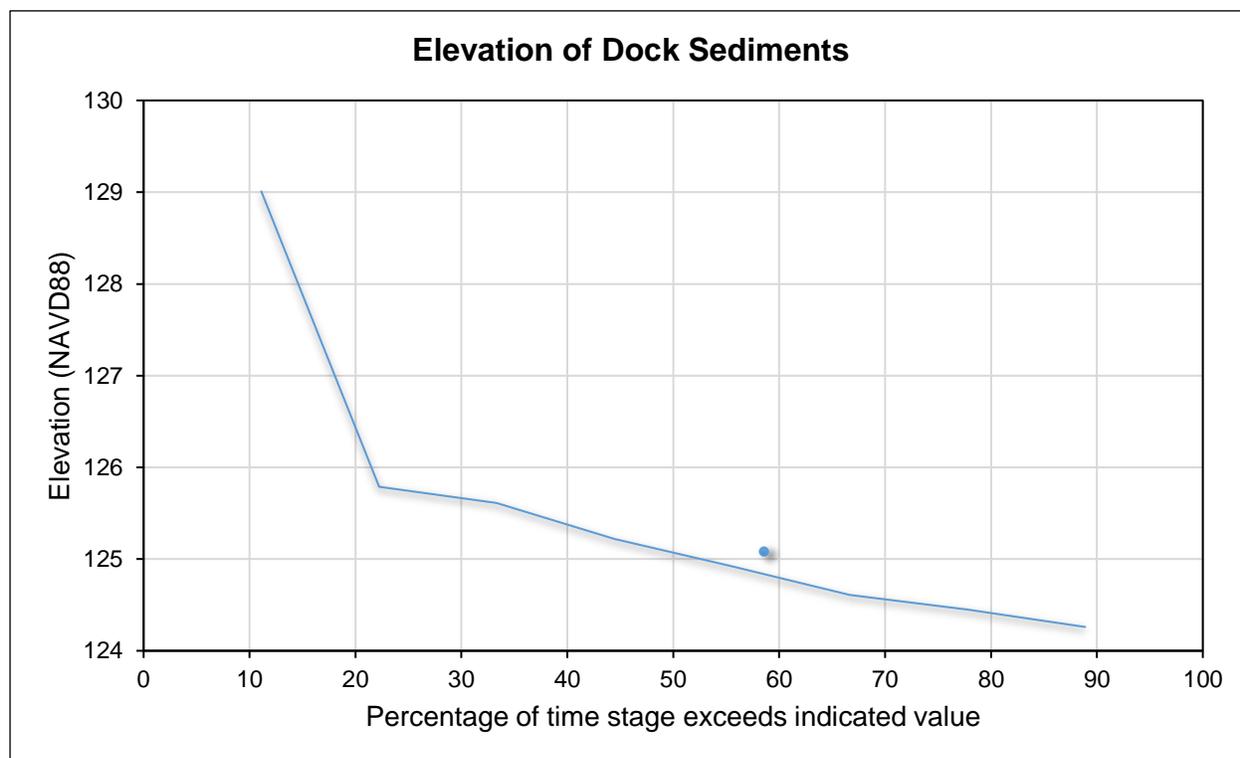

Figure D8. Elevation of dock sediments surveyed for Lake Hampton.

Aesthetics Standard

The Aesthetic Standard was established at the Low Guidance Level, which was 127.27 ft NAVD88 for Lake Hampton.

Species Richness Standard

The Species Richness Standard was estimated by identifying what drop in elevation from the HP50 water elevation will result in a 15% change in lake area. Preventing a loss of 15% of the area is expected to preserve the species richness (i.e., number) of birds utilizing the lake based on previous empirical research (Bachmann and Hoyer 1999, Emery *et al.* 2009). Based on the stage-area relationship (Table D1 and Figure D3), the lake area at the HP50 elevation of 128.95 ft NAVD88 was estimated at 810.35 acres; and a 15% reduction in this area results in an area of 688.80 acres. By using linear interpolation method, the Species Richness Standard was established at an elevation of 123.15 ft NAVD88.

Lake Mixing Standard

We calculated the Lake Mixing Standard by calculating the dynamic ratio (Bachmann *et al.* 2000) at the HP50, then gradually lowering it to see when the ratio changes from either above 0.8 to below 0.8, or from below 0.8 to above 0.8. More detailed methods included the following:

1. Converted lake surface area (2D area in Table D1) from ft² to km².
2. Mean depth in feet calculated as volume in ft³/2D area in ft².
3. Converted mean depth in feet to meters.
4. Dynamic Ratio calculated as (sqrt(lake 2D area in km²))/(mean depth in meters).
5. Repeated steps 1 through 4 for each elevation listed in Table D1 and any new elevations to have a Dynamic Ratio of 0.8, if needed.

The dynamic ratio calculation results for selected lake stages are listed in Table D3. Figure D9 illustrates the relationship of lake stage versus dynamic ratio for Lake Hampton. Based on the data listed in Table D3, the Lake Mixing Standard was established at an elevation of 123.15 ft NAVD88.

Table D3. Lake Stage and Dynamic Ratio

| Elevation (ft NAVD88)	2D Area (ft²)	Volume (ft³)	Mean Depth (meter)	2D Area (km²)	Dynamic Ratio
121.15	25,729,537.11	150,842,460.29	1.79	2.39	0.87
121.65	26,753,897.36	163,969,959.21	1.87	2.49	0.84
122.15	27,766,186.80	177,599,003.95	1.95	2.58	0.82
122.65	28,806,302.75	191,740,751.07	2.03	2.68	0.81
123.15	29,999,040.10	206,413,030.59	2.10	2.79	0.80
123.65	30,766,711.05	221,611,227.36	2.20	2.86	0.77
124.15	31,508,246.88	237,179,642.46	2.29	2.93	0.75
124.65	32,259,954.68	253,121,167.83	2.39	3.00	0.72
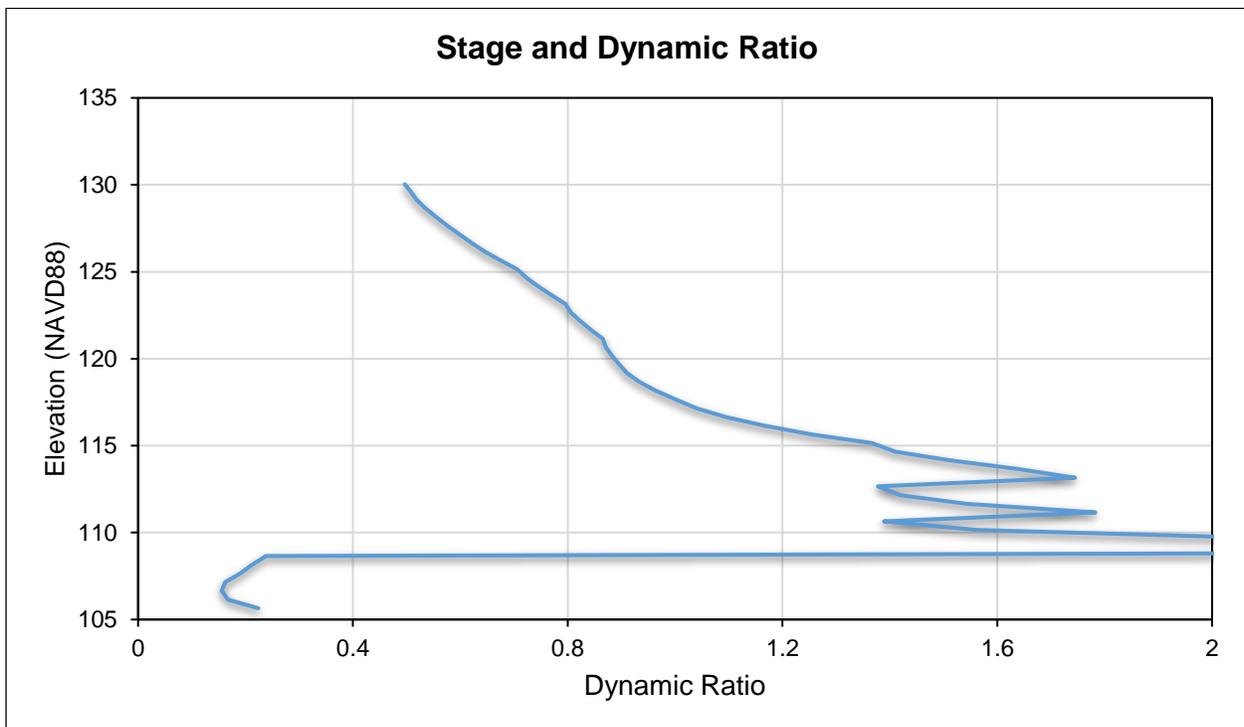
Figure D9. Lake stage to dynamic ratio for Lake Hampton.

Recreation/Ski Standard

The Recreation/Ski Standard was estimated using a rectangular corridor that was 2000 feet x 200 feet in size aligned with the deepest part of lake (Figure D1). Using the Zonal Statistics tool in the Zonal toolset of the ArcGIS Spatial Analyst toolbox, the maximum elevation within the corridor was estimated at 110.46 ft NAVD88. Then, 5 feet and the difference of the HP90 and HP50 (1.68 feet) were added to establish the Recreation/Ski Standard at 117.14 ft NAVD88.

Basin Connectivity Standard

A review of the morphology of the Lake Hampton basin (Figures 3-1 through 3-3) indicates that Lake Hampton is composed of one main basin with no navigable surface water connections to other waters, so no Basin Connectivity Standard was developed.

Herbaceous Wetlands Information for Consideration

The herbaceous wetland information was evaluated by identifying the lake bottom area (3D area) less than 4 feet deep at the median water level (HP50), then plotting how that area changes with lowered depth.

As shown in Figure D10, a change in the median water level from the HP50 (128.95 ft NAVD88) to a lower level proposed here as the Minimum Lake Level (128.15 ft NAVD88) would be expected to result an 18.8-acre increase in the potential herbaceous coverage, from 58.8 to 77.6 acres. Based on the gradual slope of the function on the graph, even lower water levels would result in relatively large increases potential herbaceous coverage relative to changing lake stage.
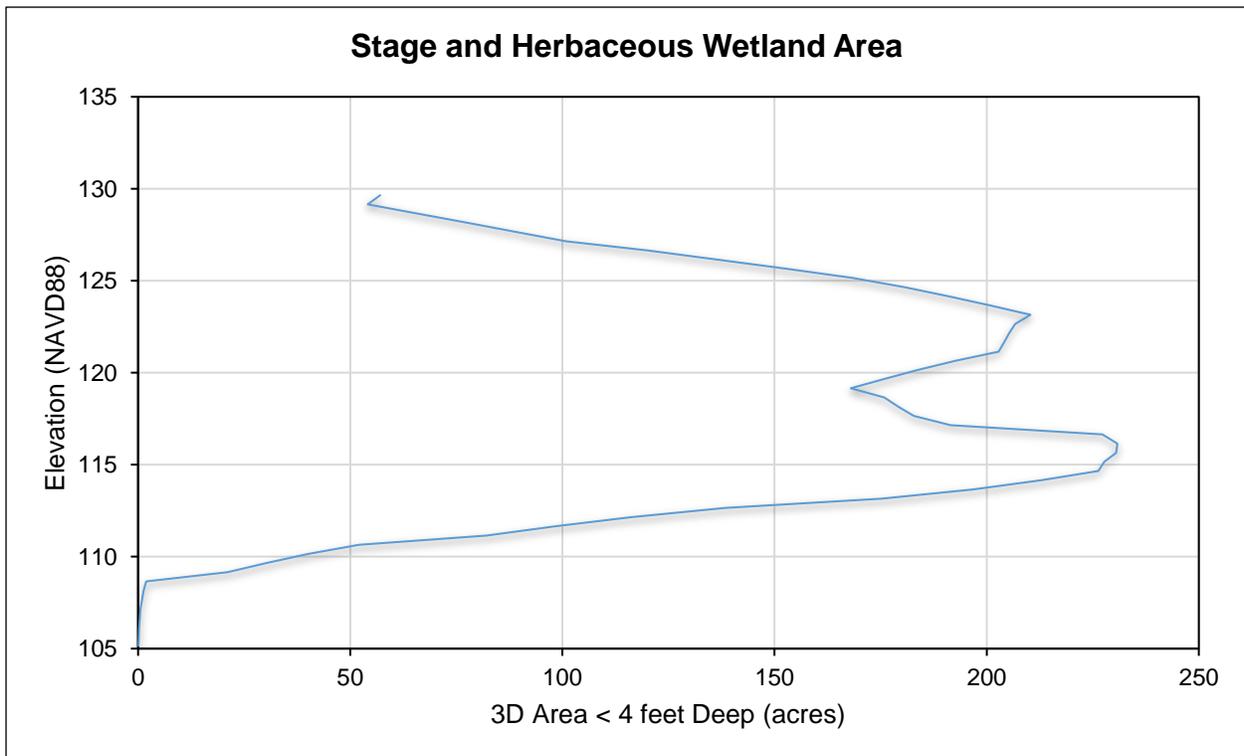

Figure D10. Lake stage to herbaceous wetland area for Lake Hampton.

Submersed Aquatic Macrophyte Information for Consideration

Changes in lake stage associated with changes in area available for colonization by rooted submersed macrophytes are evaluated, based on water transparency values.

Secchi disk data for Lake Hampton was assembled by the District and provided to ECT, including the water quality data monitored by SRWMD, the data from the FDEP Watershed Information Network as well as Florida LAKEWATCH. The daily mean for each unique date (n=183) was calculated and used to estimate an overall mean for Secchi disk depth of 1.87 meters (Figure D11). This value was used as a variable in the maximum depth of colonization (MDC) equation provided below (Caffery 2006).

Log10(MDC) = 0.66 * log10(1.87) + 0.30 = 0.478795 -> 10^x = 3.01 meters or 9.88 feet

For the lake bathymetry (Table D1 and Figure D7), we concluded that the estimated MDC value of 9.88 ft, say 10 ft, was not deep enough to support submersed aquatic vegetation (SAV) colonization for the entire lake bottom. As a result of SAV having the potential to grow within an MDC of 10 ft, the change in area that is available for SAV colonization is a function of lake stage versus lake bottom area (i.e., 3D area) less than 10 ft deep (Figure D12). A change from the HP50 elevation (128.95 ft NAV88) to a lower level proposed here as the Minimum Lake Level (128.15 ft NAVD88) would increase the submerged lake bottom area by approximately 27.2 acres, from 341.6 to 368.8 acres, or 3% of the total SAV area at the HP50 of 810.35 acres.
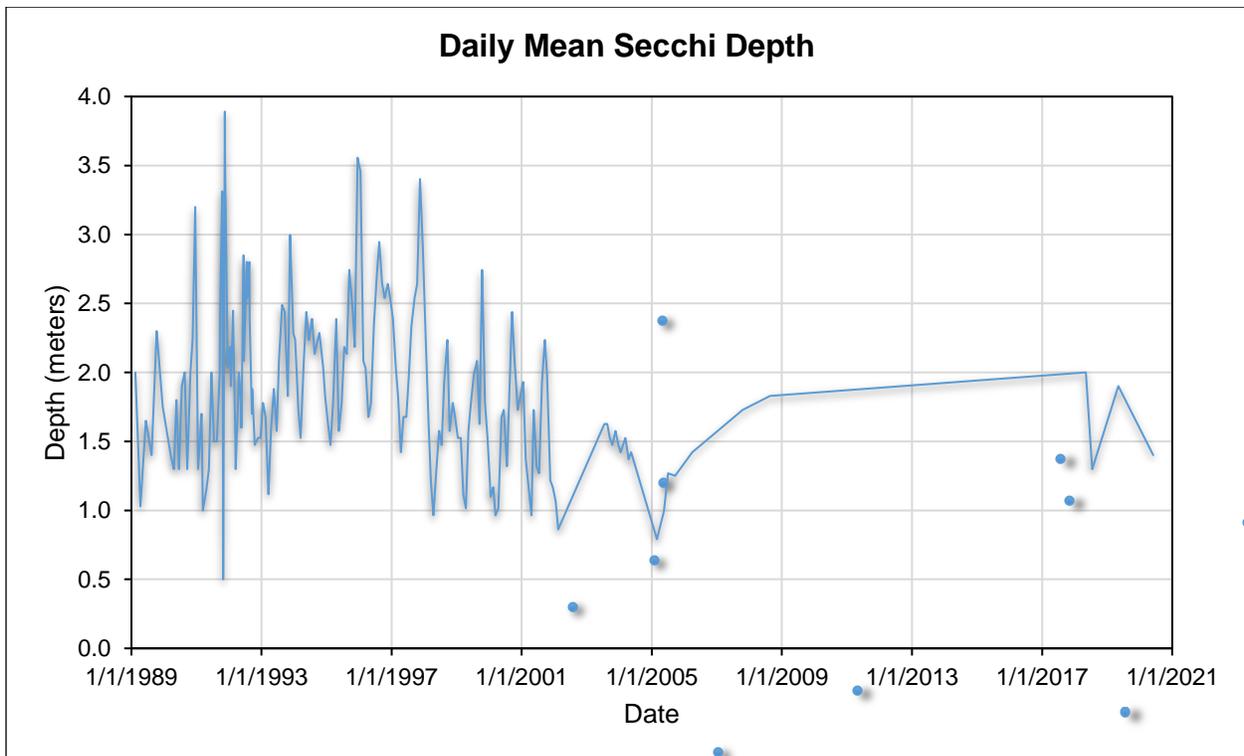

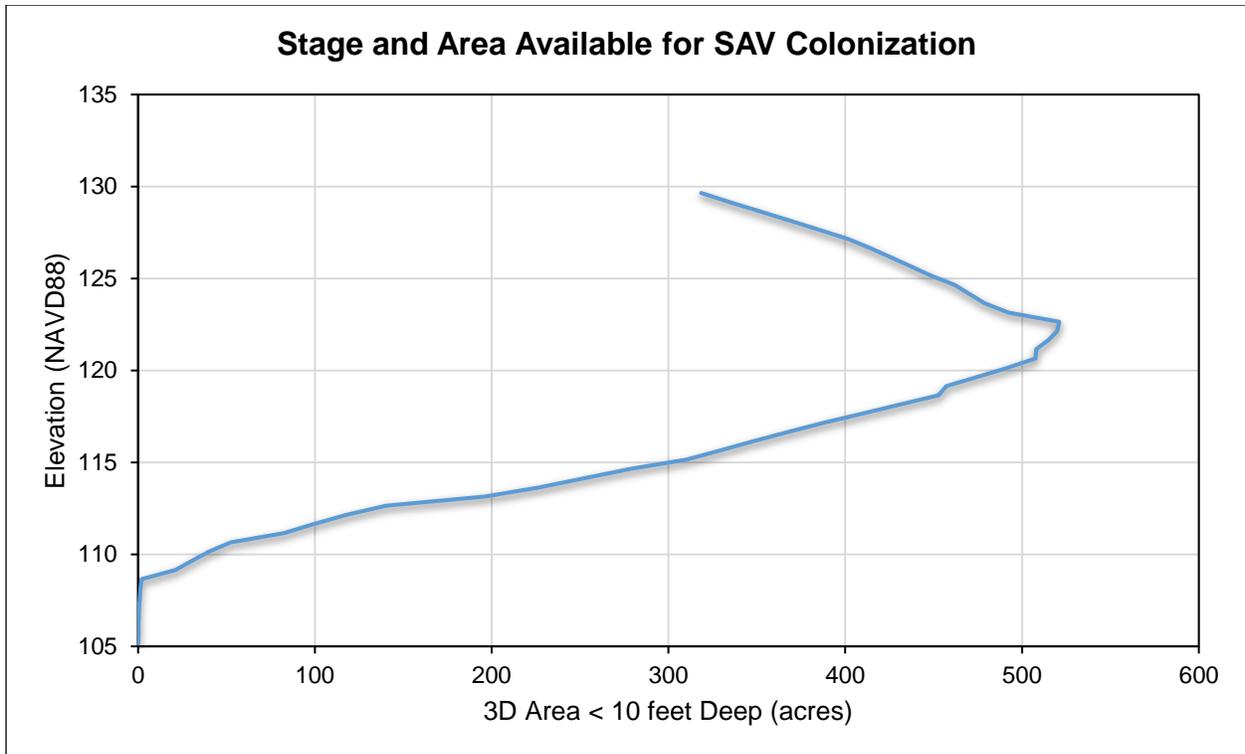*Figure D11. Mean daily Secchi disk depths for Lake Hampton.*

Figure D12. Lake stage to area available for SAV colonization for Lake Hampton.