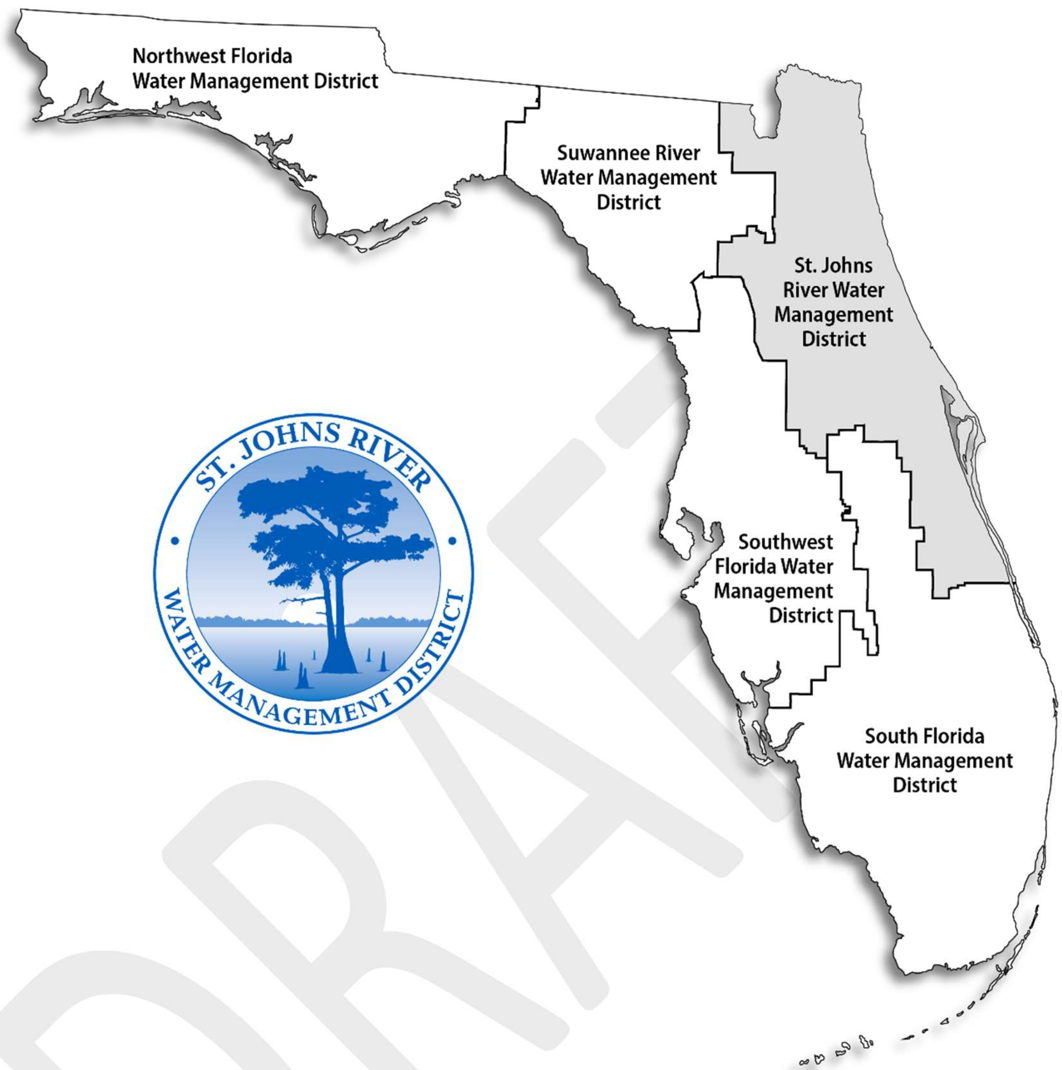
Technical Publication SJ2025-

MINIMUM LEVELS DETERMINATION FOR JOHNS LAKE, ORANGE AND LAKE COUNTIES, FLORIDA

by
Connor Blais
Olkeba Leta, PhD
Courtney R. Shadik, PhD
Andrew B. Sutherland, PhD Sandra L. Fox, MS, GISP
and
Fatih Gordu, PhD, PE

Bureau of Water Supply Planning
St. Johns River Water Management District
Palatka, Florida

2025



The St. Johns River Water Management District was created in 1972 by passage of the Florida Water Resources Act, which created five regional water management districts. The St. Johns District includes all or part of 18 counties in northeast and east-central Florida. Its mission is to preserve and manage the region's water resources, focusing on core missions of water supply, flood protection, water quality and natural systems protection and improvement. In its daily operations, the district conducts research, collects data, manages land, restores and protects water above and below the ground, and preserves natural areas.

This document is published to disseminate information collected by the district in pursuit of its mission. Electronic copies are available at *www.sjrwmd.com/documents/technical-reports* or by calling the district at the number below.

Scientific Reference Center
St. Johns River Water Management District
4049 Reid Street/P.O. Box 1429
Palatka, FL 32178-1429 (32177 for street deliveries)
386-329-4500

EXECUTIVE SUMMARY

As a part of fulfilling its mission and statutory responsibilities, the St. Johns River Water Management District (SJRWMD) establishes minimum flows and levels (MFLs) for priority waterbodies within its boundaries. MFLs establish a minimum hydrologic regime and define the limits at which further consumptive use withdrawals would be significantly harmful to priority water bodies. MFLs are one of many tools used by SJRWMD to assist in making sound water management decisions and preventing significant adverse impacts due to water withdrawals.

Johns Lake is important both locally and regionally for bass fishing and other recreational activities. This system also provides essential habitat for a diverse array of fish and wildlife. Due to its significant resources and connection to the Upper Floridan aquifer (UFA), Johns Lake serves as a key indicator of potential impacts resulting from groundwater pumping within the Central Florida Water Initiative (CFWI). The minimum levels recommended herein were developed to protect biological, scenic, and recreational resources from significant harm due to water withdrawal.

The recommended minimum levels for Johns Lake are based on current SJRWMD MFLs determination and assessment methodologies including analysis of 73 years of hydrologic data and development of hydrologic regimes under current and no-pumping conditions using the most recent surface and groundwater models. Recommended minimum levels for Johns Lake are based on a variety of metrics developed to protect important ecological structures and functions, including vegetation communities and key environmental habitat attributes, as well as human beneficial uses (e.g., recreation and aesthetic values).

The SJRWMD MFLs approach involves two separate but interrelated processes: 1) the MFLs Determination; and 2) the MFLs Assessment. The first process involves establishing the MFLs condition by determining a minimum hydrologic regime necessary to protect environmental metrics that represent a suite of relevant water resource values. The second process involves comparing the MFLs condition to a current-pumping condition to determine the current status of each environmental metric. Once all metrics are evaluated, the most limiting metric(s) in terms of available water form the basis of the overall MFL.

Numerous criteria were investigated to ensure that proposed minimum levels would protect important environmental values and beneficial uses. For each environmental criterion, the MFLs condition (recommended minimum condition) and current-pumping condition were compared to determine the current status. The current-pumping condition is defined as the average pumping condition between 2016 and 2020 and represents withdrawals influenced by the range of climatic conditions (e.g., rainfall) present during that period. The East Central Florida Transient Expanded version 2.0 (ECFTX v2.0) groundwater model was used for the groundwater pumping impact analysis. This impact analysis was used to develop the current-pumping condition timeseries data used in the MFLs assessment.

The status assessment indicates that all environmental criteria evaluated are met under the 2016 – 2020 average current-pumping condition. The most constraining criterion (open water area metric) has a UFA freeboard of 1.3 feet (ft) under this impacted condition. For a lake level MFL, such as Johns Lake, freeboard represents the allowable reduction in Upper Floridan aquifer levels, calculated to the nearest tenth of a foot. UFA drawdown of 0.8 ft is projected within the 20-year planning horizon, resulting in a remaining freeboard of 0.5 ft at 2045. Therefore, Johns Lake is neither in prevention nor in recovery.

Three minimum levels, a minimum P25, P50, and P75, are recommended for Johns Lake (Table ES-1). These three percentiles were calculated from the MFLs condition lake level timeseries data (1948 – 2020). The MFLs condition is a long-term lake level timeseries, associated with the minimum hydrological regime. Adopting these three minimum levels will ensure the protection of the minimum hydrologic regime at low, average and high levels for Johns Lake.

Table ES-1: Recommended Minimum Levels for Johns Lake.

Exceedance Percentiles (P)	Recommended Minimum Lake Level (feet NAVD88)
25	94.8
50	93.7
75	92.2

A suite of ten environmental values (also called water resource values [WRVs]), listed in the Water Resource Implementation Rule (Rule 62-40.473, *Florida Administrative Code* [*F.A.C.*]), were considered to ensure that the MFLs condition protects all relevant WRVs. SJRWMD concludes that the recommended minimum levels for Johns Lake will protect relevant environmental values from significant harm due to water withdrawals. The recommended minimum levels presented in this report are preliminary and will not become effective until approved by the SJRWMD Governing Board and adopted in Rule 40C-8.031, *F.A.C.*

CONTENTS

Contents v

List of Figures vii

List of Tables viii

GLOSSARY ix

ACRONYMS AND ABBREVIATIONS xi

Introduction 1
LEGISLATIVE OVERVIEW 1
SJRWMD MFLS PROGRAM OVERVIEW 2

Setting and Description 4
Location and Physiographic Setting 4
Bathymetry 4
Hydrology 9
Water Level Data 9
Rainfall and Evapotranspiration 13
Long-term UFA Groundwater Levels 13
Surface Water Basin Characteristics 15
Land Use/Land Cover (LULC) 15
Mapped Vegetation 15
Mapped Hydric Soils 19
Water Quality 22

MFLs Determination 25
HYDROLOGICAL ANALYSES 25
ENVIRONMENTAL ANALYSES 31
Overview 31
Environmental Criteria 31
Hydroperiod Tool Approach 39
MFLs Determination Summary 44

MFLs Assessment 47
Current Status Assessment 47

Future / Projected Status 49
Water Resource Values (WRVs)..... 50

Conclusions and Recommendations 54
Recommended Minimum Levels 54
Ongoing Status / Adaptive Management 56

Literature Cited 57

List of Figures

Figure 1: Location of Johns Lake in relation to major roadways and other large lakes nearby 5
Figure 2: Recharge capacity of the Johns Lake watershed and surrounding areas......................... 6
Figure 3: Bathymetry of Johns Lake when the water level is 96.0 ft NAVD88............................ 7
Figure 4: Digital Elevation Model (DEM) of Johns Lake displayed in feet NAVD88 8
Figure 5: Johns Lake's observed water levels from 9/7/1959 – 4/25/2024. Water Level Gage 03840562.. 10
Figure 6: Surface water and groundwater levels gages relevant to Johns Lake. 12
Figure 7: Annual rainfall near Johns Lake from Isle Win composite station (blue bars) and RET from relevant NEXRAD pixels (orange line) 14
Figure 8: Groundwater and surface water data from gages near Johns Lake. Observed data are depicted in circles, while the lines represent data hindcast using the line of organic correlation method. 17
Figure 9: 2014 Land Use and Land Cover data for the Johns Lake watershed. 18
Figure 10: Wetland types surrounding Johns Lake (SJRWMD 2014) 20
Figure 11: Hydric soil classification for the area surrounding Johns Lake. Data from SSURGO. 21
Figure 12: Johns Lake TSI measurements from 1979-2022... 24
Figure 13: Estimated historical groundwater pumping within 15 miles of Johns Lake from 1948 to 2020. 26
Figure 14: Daily estimated historical impact from pumping on UFA levels near Johns Lake using the 15-mile buffer area.. 27
Figure 15: No-pumping condition lake levels compared to the Current-pumping condition lake levels. 29
Figure 16: No-pumping condition exceedance curve compared to the Current-pumping condition exceedance curve.: 30
Figure 17: Conceptual drawing showing the five most common minimum flows and/or levels developed using SJRWMD's event-based approach.. 33
Figure 18: Johns Lake transects overview (T1-T5). 34
Figure 19: Johns Lake Transects 1 and 2.. 35
Figure 20: Johns Lake Transects 3, 4, and 5.. 36
Figure 21: Nearshore habitats and water depth ranges used in fish and wildlife habitat analyses. 41
Figure 22: Hydroperiod tool output data showing lake stage versus habitat area for seven habitats and recreational/aesthetic metrics for Johns Lake. 44

List of Tables

Table 1: Summary statistics for Johns Lake's observed water level from 9/7/1959 – 4/25/2024. Water Level Gage 03840562. 9
Table 2: Johns Lake MFLs surface and groundwater level data monitoring station locations and periods of record. 11
Table 3: Summary of Isle Win and NEXRAD composite rainfall data and NEXRAD RET data. .... **Error! Bookmark not defined.**
Table 4: Land use/land cover types present in the Johns Lake watershed and their percent coverages.......... 17
Table 5: Acreages and percent coverages of wetland types around Johns Lake. 19
Table 6: Florida's Numeric Nutrient Standards (Rule 62-302.531, *F.A.C.*). 22
Table 7: Long term averages and most recent measurements for Chl *a*, total phosphorous and total nitrogen concentrations of Johns Lake. 23
Table 8: Classifications of TSI values. 24
Table 9: Habitat and Lake characteristics calculated by the Hydroperiod Tool. 40
Table 10: Percent change and acre change from the No-Pumping Condition to the potential MFLs Condition. 43
Table 11: The two event-based metrics evaluated for Johns Lake, with their corresponding magnitude, duration, and return interval; minimum metric condition equals a 15% reduction in average acres (over the POR) from the no-pumping condition 45
Table 12: Event-based metrics for Johns Lake, the environmental values they protect, and their UFA freeboards. 48
Table 13: No-pumping and Current-pumping acreages and percent change based on hydroperiod results for the seven different depth ranges. 49
Table 14: The WRVs represent environmental values/functions and percent reduction under the MFLs condition relative to the no-pumping condition. 52
Table 15: Recommended Minimum Levels for Johns Lake. 54

GLOSSARY

Atlantic Multidecadal Oscillation (AMO): Long-term variability of the sea surface temperature occurring in the North Atlantic Ocean, including cool and warm phases with an estimated quasi-cycle period of 60-80 years. These changes are natural and have been occurring for at least the last 1,000 years.

Consumptive Use Permit (CUP): A permit which allows water to be withdrawn from groundwater or surface water for reasonable-beneficial uses — such as public supply (drinking water), agricultural and landscape irrigation, commercial use and power generation — in a manner that does not interfere with other existing legal water uses and protects water resources from harm.

Current-pumping Condition Flow or Level: Long-term simulated flow or water level time series that represents what flows or water levels would be if “current” groundwater pumping was present throughout the entire period of record. The estimated “current” groundwater pumping condition is based on the average amount of groundwater pumping over the latest five-year period, based on the best available data.

Deficit: The amount of water needed to recover MFLs, that is not currently being achieved. For a lake level MFL, deficit is expressed as the amount of recovery needed in Upper Floridan aquifer levels in feet.

El Nino Southern Oscillations (ENSO): periodic departures from expected sea surface temperatures (SSTs) in the equatorial Pacific Ocean, ranging from about three to seven years. These warmer or cooler than normal ocean temperatures can affect weather patterns around the world by influencing high- and low-pressure systems, winds, and precipitation.

Environmental criteria: Specific ecological or human use functions or values in Rule 62-40.473(1), *F.A.C.*, that are evaluated when setting or assessing an MFL.

Event: A component of an MFL composed of a magnitude and duration.

Freeboard: The amount of water available for withdrawal before an MFL is not achieved. For a lake level MFL, freeboard is expressed as the allowable reduction in Upper Floridan aquifer levels in feet.

Frequency Analysis: a statistical method used to estimate the annual probability of a given hydrological (exceedance or non-exceedance) event; used to assess the current status of an event-based MFL by comparing the frequency of critical hydrological events under current-pumping conditions to recommended minimum frequency of these events.

Hydrologic Regime: A timeseries of flows (or water levels) within a specified period of record for a specific water body. Flows (or water levels) typically vary over time, and this variation is an important component of the regime, maintaining critical environmental functions and values.

Minimum Hydrologic Regime: A hydrologic regime with an average flow (or level) that is lower than the no-pumping condition, that protects relevant environmental values from significant harm.

MFLs Condition: The MFLs Condition is a specific "minimum hydrologic regime" (see definition above) that is based on the most constraining MFLs metric and is necessary to protect a water body from significant harm. The MFLs condition represents an allowable change from the no-pumping condition for the entire period of record. It represents a lowering of the no-pumping condition, but only to the degree that still protects a water body from significant harm. The MFLs Condition is based upon the minimum flow or level that is most constraining to water withdrawal, for a given water body.

Minimum Flows and Levels (MFL): Environmental flows or levels expressed as hydrological statistics, based on the most constraining environmental value, that defines the point at which additional water withdrawals will result in significant harm to the water resources or the ecology of the area (Sections 373.042 and 373.0421, F.S.).

No-pumping Condition Levels: A long-term simulated time series that represents what flows or water levels would be if there were no impact due to water withdrawal.

Pacific Decadal Oscillation (PDO): a long-lived El Niño-like pattern of Pacific climate variability with an estimated quasi-cycle period of 20-30 years.

ACRONYMS AND ABBREVIATIONS

AMO	Atlantic Multidecadal Oscillation
BMAP	Basin Management Action Plan
BOD	Biological Oxygen Demand
CFWI	Central Florida Water Initiative
CP	Current-pumping [condition]
CUP	Consumptive Use Permit
DEM	Digital Elevation Model
ECFTX	East-Central Florida Transient Expanded [groundwater model]
ENSO	El Nino Southern Oscillation
F.A.C.	*Florida Administrative Code*
FDEP	Florida Department of Environmental Protection
FH	Frequent High [MFL level]
FLUCCS	Florida Land Use Classification Code System
F.S.	*Florida Statutes*
GIS	Geographic Information System
HAT	[CFWI] Hydrologic Analysis Team
H/HE	Histosol and Histic Epipedon
LiDAR	Light Detection and Ranging
MA	Minimum Average [MFL level]
MFLs	Minimum Flows and Levels
NAVD 88	1988 North American Vertical Datum
NEXRAD	Next Generation Weather Radar
NOAA	National Oceanic and Atmospheric Administration
NP	No-pumping [condition]
NRCS	Natural Resources Conservation Service
PDO	Pacific Decadal Oscillation

POR	Period of Record
SJRWMD	St. Johns River Water Management District
SPI	Standardized Precipitation Index
SR 50	[Florida] State Road 50
SWFWMD	Southwest Florida Water Management District
SSURGO	Soil Survey Geographic database
SWIDS	Surface Water Inundation and Dewatering Signatures
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSI	Trophic State Index
UFA	Upper Floridan aquifer
USGS	U.S. Geological Survey
USDA	U.S. Department of Agriculture
WRV	Water Resource Value

INTRODUCTION

The St. Johns River Water Management District's (SJRWMD) completed a minimum flows and levels (MFLs) determination for Johns Lake, located in Orange and Lake counties, Florida. Johns Lake is on the *MFLs Priority Water Body List and Schedule* and scheduled for adoption in 2025. As a priority water body, minimum levels must be established for this lake pursuant to Section 373.042, *Florida Statutes* (F.S.). This lake is a locally and regionally important water resource within the Central Florida Water Initiative (CFWI) area. As part of the CFWI's regional network of MFLs, Johns Lake is a critical indicator of potential impacts due to groundwater pumping.

The minimum levels recommended for Johns Lake are intended to support the protection of aquatic and wetland ecosystems, as well as human beneficial uses, from significant harm caused by the consumptive use of water.

LEGISLATIVE OVERVIEW

SJRWMD establishes minimum flows and levels for priority water bodies within its boundaries (section 373.042, F.S.) MFLs for a given water body are limits "at which further withdrawals would be significantly harmful to the water resources or ecology of the area" (section 373.042, F.S.). MFLs are established using the best information available (section 373.042, F.S.), with consideration also given to "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 the affected watershed, surface water, or aquifer...," provided that none of those changes or alterations shall allow significant harm caused by water withdrawals (section 373.0421, F.S.).

Additionally, the MFLs section of the State Water Resources Implementation Rule (rule 62-40.473, Florida Administrative Code [*F.A.C.*]) also requires that "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." The environmental values described in thisby the rule include:

1. Recreation in and on the water;
2. Fish and wildlife habitats and the passage of fish;
3. Estuarine resources;
4. Transfer of detrital material;
5. Maintenance of freshwater storage and supply;
6. Aesthetic and scenic attributes;
7. Filtration and absorption of nutrients and other pollutants;
8. Sediment loads;
9. Water quality; and
10. Navigation.

As part of the MFLs Assessment process (see below), each of the 10 environmental values are evaluated to determine their relevance to a given priority water body. Specific criteria are developed and assessed for environmental values that are relevant for a given system.

MFLs are used in SJRWMD's regional water supply planning process (Section 373.709, F.S.), the consumptive use permitting program (Chapter 40C-2, *F.A.C.*), and the environmental resource permitting program (Chapter 62-330, *F.A.C.*).

SJRWMD MFLs Program Overview

SJRWMD continues its districtwide effort to develop MFLs to protect priority surface water bodies, watercourses, associated wetlands, and springs from significant harm caused by water withdrawals. MFLs provide an effective tool for decision-making regarding the planning and permitting of surface water and groundwater withdrawals. The purpose of setting MFLs is to answer an overarching question:

> *"What minimum hydrologic regime is necessary to protect the critical environmentalvalues of a priority water body from significant harm due to withdrawals?"*

These environmental values typically include ecological structure and function as well as human beneficial uses. Conversely, MFLs are *not* meant to represent *optimal* conditions. Rather, they are mandated by statute to set the limit to water withdrawals beyond which significant harm will occur. A fundamental assumption of SJRWMD's approach is that alternative hydrologic conditions exist for a specific water body that are lower than pre-withdrawal conditions but still protect the environmental functions and values of priority water bodies from significant harm caused by water withdrawals.

Significant harm is defined differently depending on the environmental metric being evaluated. There are "event-based" metrics for which significant harm is associated with a change in hydrologic event frequency. MFLs events are composed of a magnitude and duration; events are typically assessed by evaluating the effect of water withdrawal on their return interval (Neubauer et al. 2008). MFLs are developed to ensure that withdrawal-related changes in return interval of critical events are not substantial enough to cause significant harm, defined as impairment or loss of ecological structure or function. In addition to event-based metrics, there are other metrics (e.g., hydroperiod tool ecological and recreational criteria; see Hydroperiod Tool Approach sectionbelow) for which significant harm is defined as a 15% reduction relative to a pre-withdrawal condition.

The SJRWMD MFLs approach involves two separate but interrelated processes: 1) the MFLs Determination and 2) the MFLs Assessment. The first process involves establishing the MFLs condition by determining a minimum hydrologic regime necessary to protect each specific water resource value (i.e., environmental metric). The second process involves comparing this "MFLs condition" to a current-pumping condition to determine the current status of each metric. Once all metrics are evaluated, the most limiting metric(s), in terms of available water, form(s) the basis of the overall MFLs. Finally, the MFL current status is compared to future water use withdrawal projections to determine future status. The overall process involves environmental assessments, hydrologic modeling, independent scientific peer review, and rulemaking.

Many SJRWMD MFLs define a minimum hydrologic regime by establishing a protective frequency of high, intermediate, and low hydrologic events (e.g., setting multiple event-based metrics). For some priority water bodies, a protective regime is established based on a percentage of change allowable from a pre-withdrawal condition. No matter how environmental thresholds are set or how many MFLs are adopted for a given water body, the most constraining MFL (i.e., most sensitive to pumping) is always used for water supply planning and permitting. Setting a minimum allowable hydrologic condition for a given metric does not imply that this impact threshold will occur, but that the metric will be assessed to ensure that the minimum condition is always exceeded.

If the status assessment indicates that an MFL is currently not being met or is projected to not be met during the 20-year planning horizon, a water management district or the Florida Department of Environmental Protection (FDEP) must adopt a recovery or prevention strategy concurrently with the adoption of the MFL. A recovery strategy is required when an MFL is not currently being met. A prevention strategy is required when an MFL is projected to not be met over the 20-year planning horizon.

SETTING AND DESCRIPTION

LOCATION AND PHYSIOGRAPHIC SETTING

Johns Lake is located south of Lake Apopka, approximately two miles southwest of the City of Winter Garden on the border of Lake and Orange counties, Florida (Figure 1). It is primarily located in Section 36, Township 22 South, and Range 26 East. Johns Lake is situated in the physiographic province known as The Gap is an area in an advanced stage of erosion within the Lake Wales Ridge of the Central Lake District. The Central Lakes District is characterized by the uplifted carbonate deposits of the Upper Floridan aquifer (UFA), which lie unconformably beneath a veneer of mostly quartz surficial sands with sand hills in this area around 40 to 60 feet high (Brooks 1981). This is a sand hill karst terrane with numerous solution basins. The Central Lake District has active collapsed sink holes. Johns Lake is considered a sandhill lake because it exhibits sinkhole features, is in a sandy landscape, and lacks significant accumulations of organic matter (JEA Inc. 2006). The xeric hills and closed drainage basins around Johns Lake are characterized by areas of high and medium recharge to the UFA (Figure 2). Areas of high recharge can contribute greater than 10 in/yr to the UFA, medium (or moderate) recharge areas can contribute 5 to 10 in/yr, and low recharge areas can contribute 1 to 5 in/yr (Boniol and Mouyard 2016).

Johns Lake connects to and receives inflows from Black Lake at the southeast (Figure 1). The Johns Lake then drains northward into Lake Apopka through a water control structure regulating its outflow through ditches and culverts. Like many other places in central Florida, there has been considerable development within the Johns Lake watershed. This basin has transitioned from primarily agricultural and natural to largely residential in recent years.

BATHYMETRY

Johns Lake has a surface area of 2,239 acres when the lake level is at its average observed stage of 92.2 ft NAVD88. The average land elevation of Johns Lake is 87.0 ft. However, because the lake basin has a complex morphology comprised of deeper holes, shallow solution basins, and submerged ridges, water depths vary significantly across the lake. Depths range from 0.1 to 17.0 ft when the lake level is 92.2 ft NAVD88. At this elevation the lake has approximately 956 acres of open water, defined for the purpose of this MFLs determination as portions of the lake greater than or equal to seven feet deep. At Johns Lake's maximum stage of 99.0 ft NAVD88, the surface area is 3,106 acres, the open water extent is 2,214 acres, and the maximum depth is 23.8 ft. At 96.0 NAVD88, Johns Lake is split into two similarly sized main lobes (Figure 3). The relationship between water level and lake area was determined based on a digital elevation model (DEM) created to develop and assess fish and wildlife metrics (Figure 4; see *MFLs Determination* for details). The surface expression of the solution basins is readily apparent throughout the mosaic of smaller lobes comprising the lake.

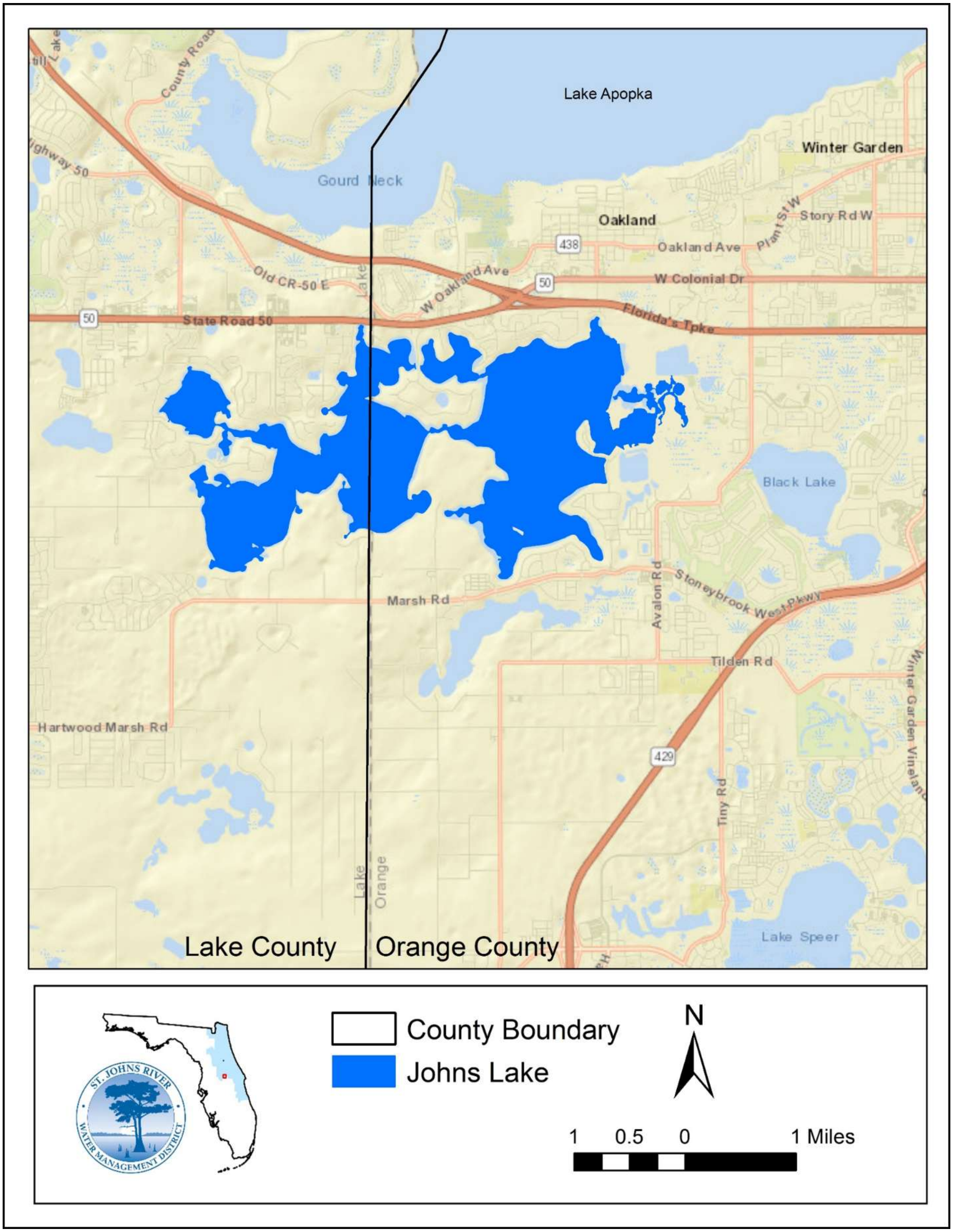


Figure 1: Location of Johns Lake in relation to major roadways and other large lakes nearby

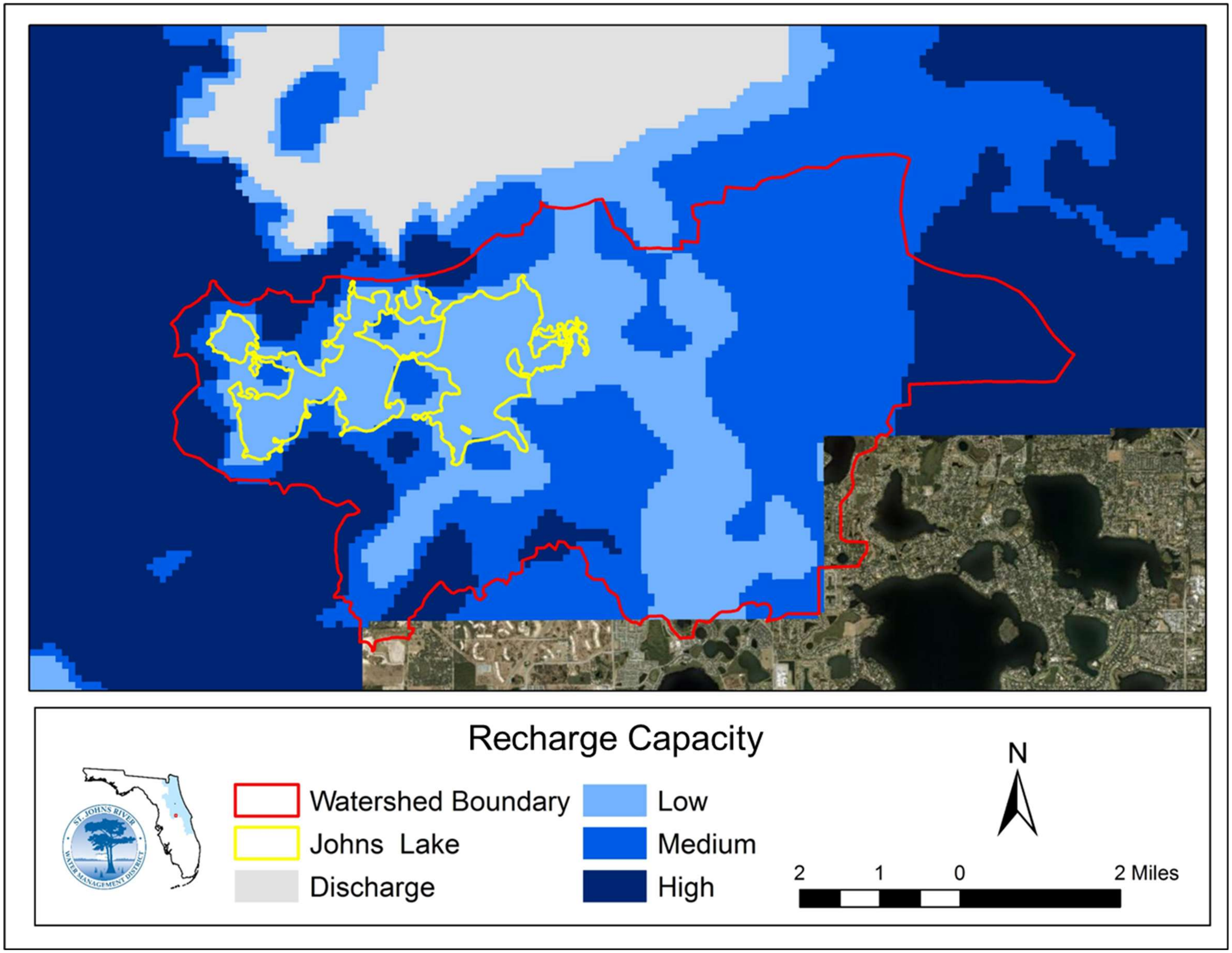


Figure 2: Recharge capacity of the Johns Lake watershed and surrounding areas

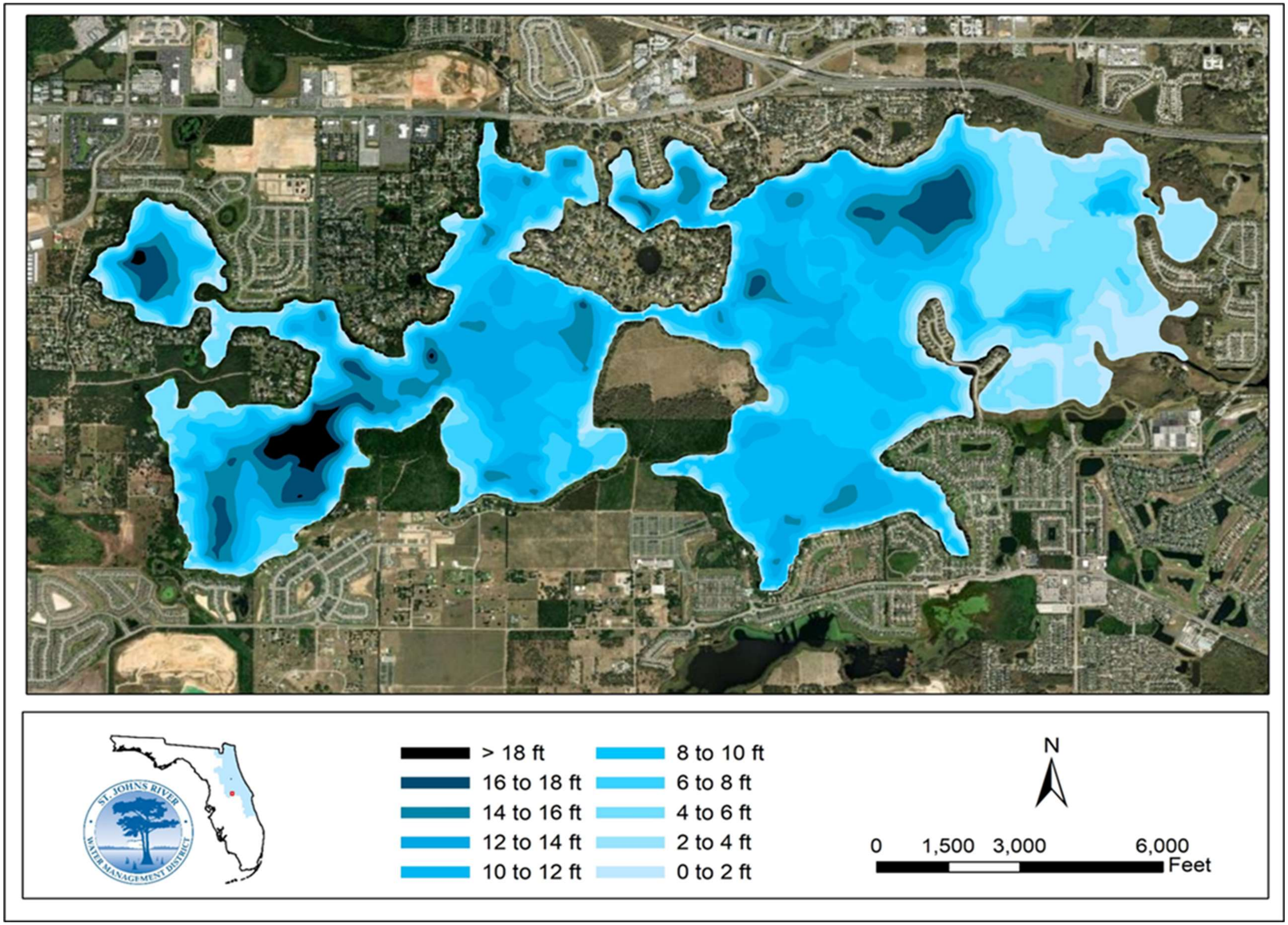


Figure 3: Bathymetry of Johns Lake when the water level is 96.0 ft NAVD88

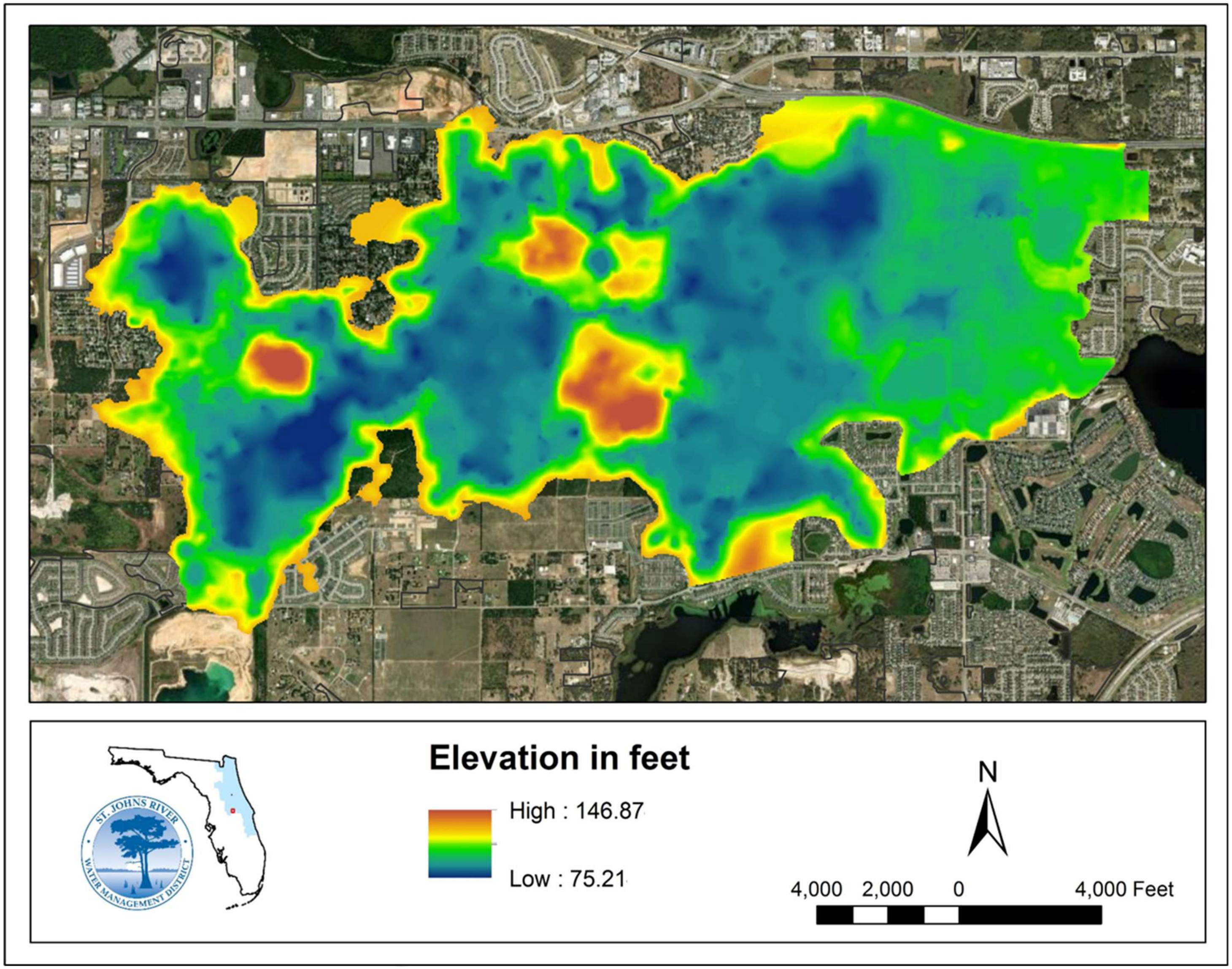


Figure 4: Digital Elevation Model (DEM) of Johns Lake displayed in feet NAVD88

HYDROLOGY

The Johns Lake watershed is roughly 26.9 square miles. Johns Lake is classified as having a high water level fluctuation range and average water level symmetry (Epting et al. 2008). This classification includes isolated to intermittent ridge lakes with moderate leakage to the UFA and low surface water outflow (Epting et al. 2008).

Water primarily enters Johns Lake from Black Lake through a channel on the southeast side. Johns Lake drains to the north under SR 50 through the Motamassek Canal to Lake Apopka, ultimately discharging to the lower Ocklawaha River, a St. Johns River tributary. This flow way is man-made and portions of it are maintained by Orange County, while other portions are on private property. The canal has an operable water control structure north of SR 50. The control structure for Johns Lake is a concrete weir within Motamassek Canal, and the controlling elevation of the weir is approximately 94.5 feet NAVD88 (CWR 2019). The average observed water levels for Johns Lake and Lake Apopka are 92.15 ft and 65.4 ft NAVD88, respectively.

Water Level Data

SJRWMD collected water level data at gage 03840562 (Table 1; Figure 5) to develop and assess the Johns Lake MFLs. The period of record (POR) for water level data collection is from September 7, 1959, to April 25, 2024. Data from groundwater gages were also used to develop the Johns Lake surface water model used in the MFLs determination and assessment (see Appendix B for details regarding the surface water model) (Tables 1 and 2; Figures 5 and 6).

Table 1: Summary statistics for Johns Lake's observed water level from 9/7/1959 – 4/25/2024. Water Level Gage 03840562.

WL Parameter	Johns Lake WL (ft NAVD88)
Minimum	84.42
Median	92.09
Average	92.15
Maximum	99.00
Range	14.58
Standard Deviation	2.77

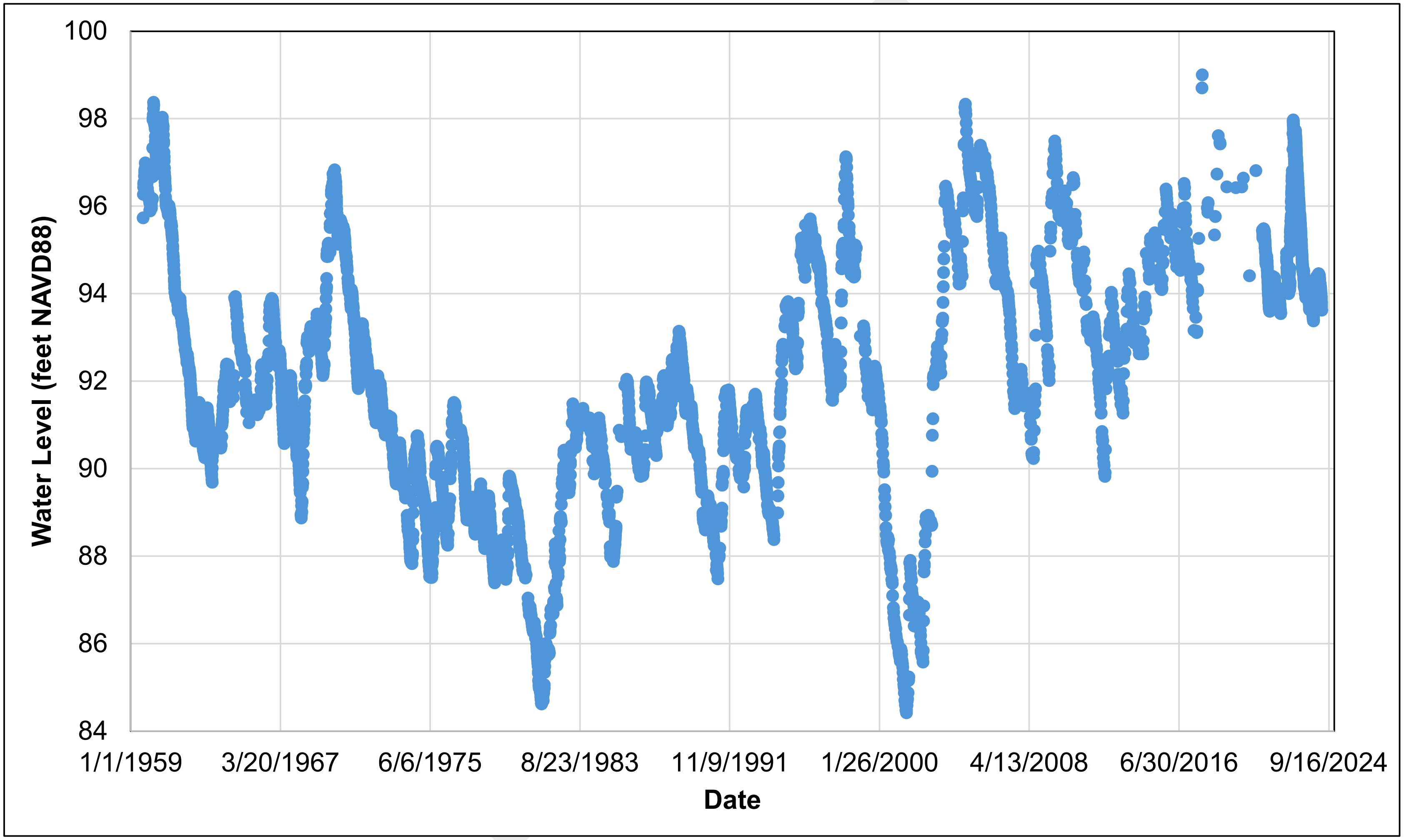


Figure 5: Johns Lake's observed water levels from 9/7/1959 – 4/25/2024. Water Level Gage 03840562.

Table 2: Johns Lake MFLs surface and groundwater level data monitoring station locations and periods of record.

Gage Type	Station Code	Station Name	Station Number	Period of Record	Latitude	Longitude
Groundwater	OR1123	Johns Lake E Well	31792877	10/21/2010 – ongoing	28.529135	-81.6103336
Groundwater	L-0052	Johns Lk Well	05310981	6/29/1993 – ongoing	28.525014	-81.679929
Groundwater	OR0047	Orlo Vista	09272094	9/30/1930 – ongoing	28.548385	-81.475985
Surface water	03840562	Johns Lake at Oakland	03840562	9/7/1959 – ongoing	28.545033	-81.659222

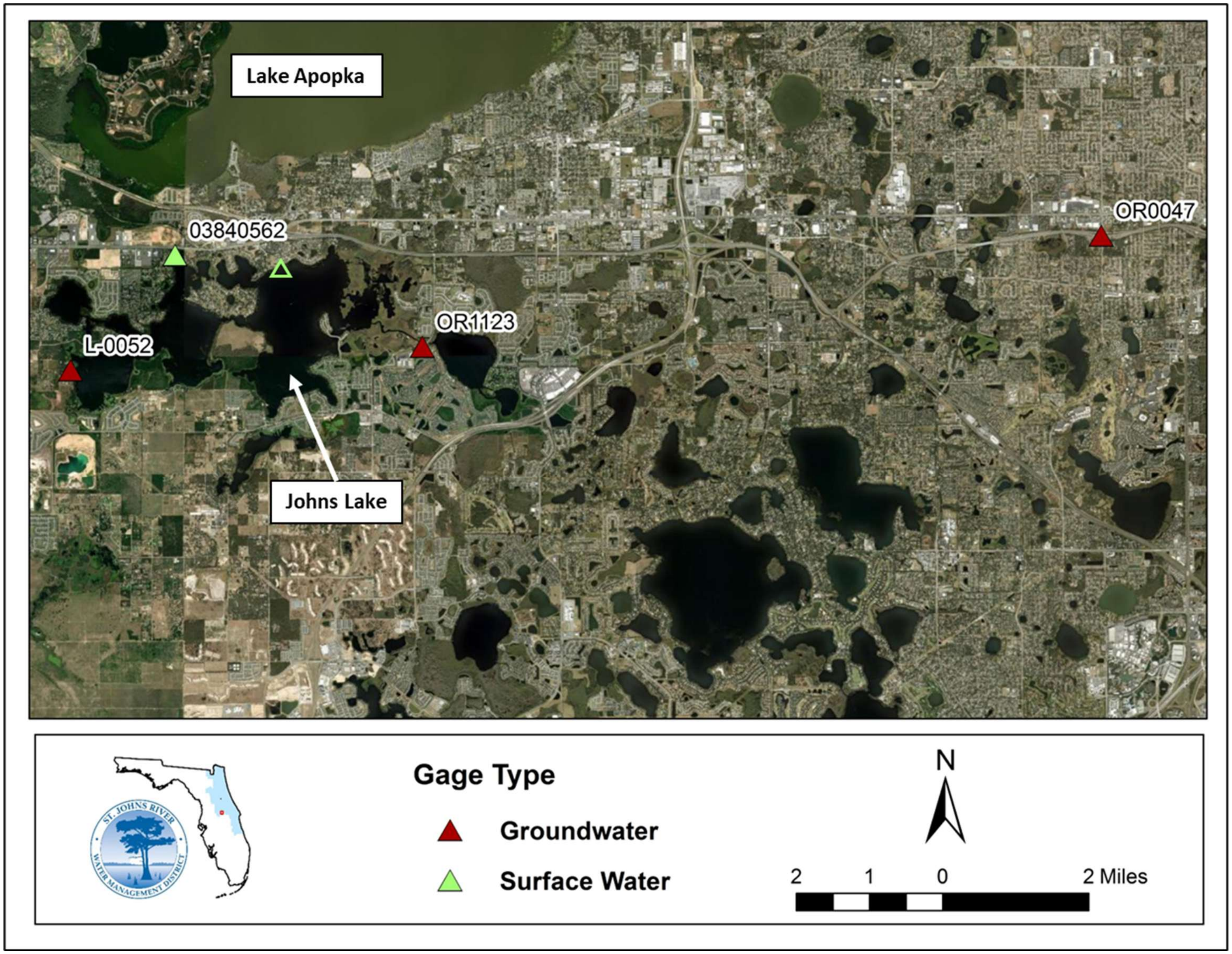


Figure 6: Surface water and groundwater levels gages relevant to Johns Lake. The hollow green triangle represents the old location of surface water gage 03840562 and the solid green triangle represents its current location (POR: 10/1/2024 – ongoing).

Rainfall and Evapotranspiration

Hourly rainfall data were obtained from Next Generation Weather Radar (NEXRAD) pixels for the period from 1995-2020, and from the SJRWMD's Isle Win station for the period from 1948-2020. Data from both sources were combined to create a composite rainfall data set for the period from 1948 to 2020 (Table 3), which was used in the Johns Lake interconnected channel and pond routing (ICPR4) surface water model (see Appendix B for details regarding the surface water model)

Daily reference evapotranspiration (RET) data for the period 1/1/1985 to 12/31/2018 were also obtained for each NEXRAD pixel. USGS RET data were used to supplement missing SJRWMD data. Values missing from both data sets were filled with the daily average values within a month. Completed annual RET values were hindcasted to 1948 and forecasted through 12/31/2020 (Table 3; Figure 7), with the lowest RET values recorded in 2001 (Figure 7).

Table 3: Summary of Isle Win and NEXRAD composite rainfall data and NEXRAD RET data.

	Composite Rainfall (inches)	Reference ET (RET) (inches)
POR	1948-2020	1948-2020
Mean	50.36	54.61
Standard Deviation	9.88	2.14
Minimum	25.2	48.6
Median	49.5	54.5
Maximum	78.8	59.3
Range	53.6	10.7

Long-term UFA Groundwater Levels

UFA groundwater monitoring wells near Johns Lake include OR0047, L0052, and OR1123 (Figure 6; Table 2). Wells L0052 and OR1123 are close to Johns Lake and well OR0047 is approximately 8 miles to the east. The OR0047 well has the longest POR of the three wells, with a POR from 1930 to the present. Extended UFA groundwater levels (from 1/1/1948 to 12/31/2020) used in the Johns Lake surface water model are presented in Figure 8. The figure includes observed (obs) data as well as well data that were hindcasted using the line of organic correlation (LOC) method. A 31.3 ft fluctuation in UFA levels was observed over this POR in well OR0047.

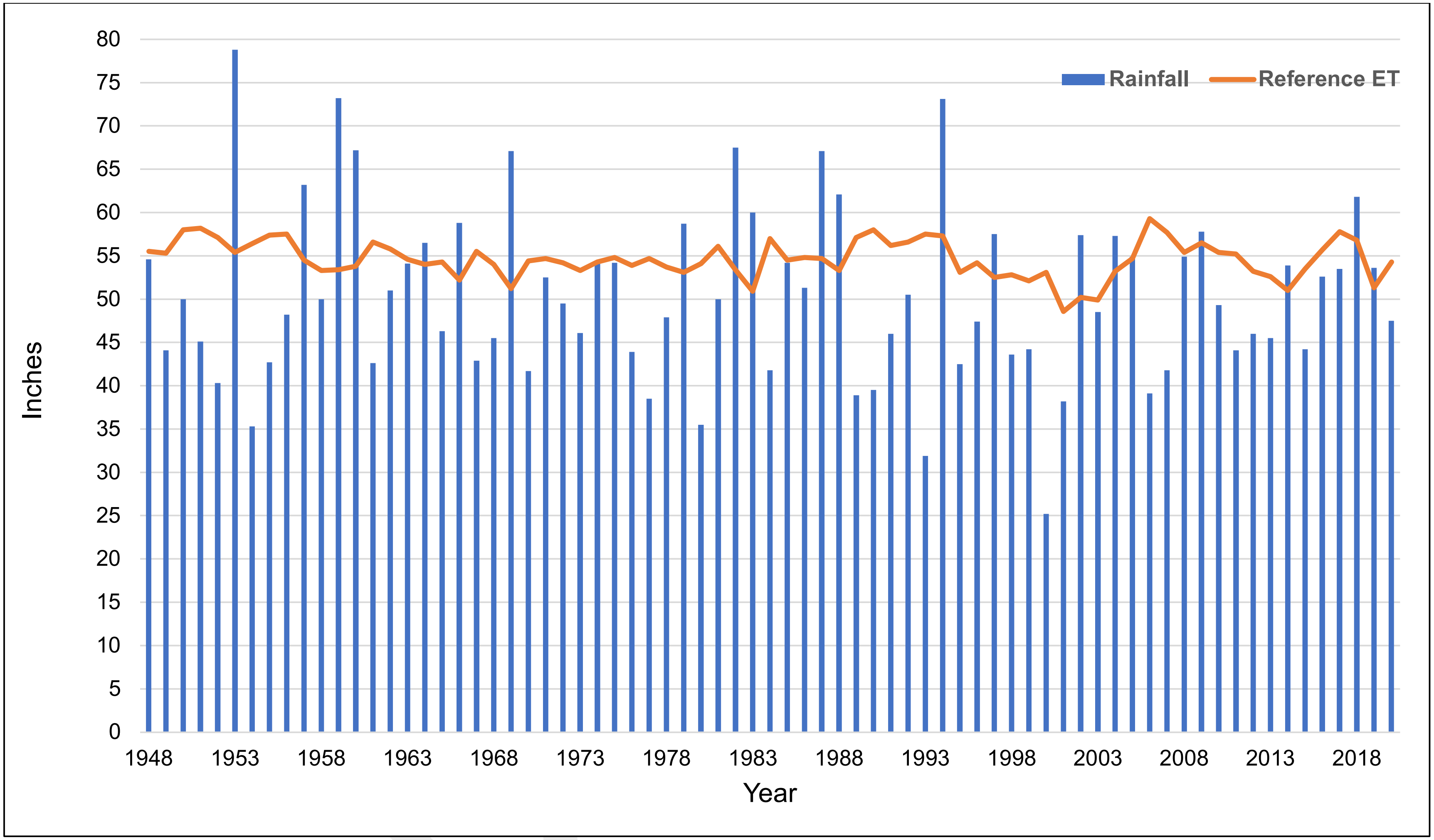


Figure 7: Annual rainfall near Johns Lake from Isle Win composite station (blue bars) and RET from relevant NEXRAD pixels (orange line)

SURFACE WATER BASIN CHARACTERISTICS

Land Use / Land Cover

The land use/land cover (LULC) data used in the Johns Lake surface water model are from 2014 and codes are derived from the Florida Land Use Classification Code System (FLUCCS). These data indicate that approximately 52% of the Johns Lake watershed is urban development, which includes residential, industrial, and commercial uses (Table 4; Figure 9). The second largest land use category is upland non-forested which comprises 13.4% of the watershed and the third largest is Forest which comprises 11.5% of the watershed. All other land cover types combined (water, agriculture, wetland, barren land, transportation, communication, utilities) occupy roughly 25% of the watershed.

Table 4: Land use/land cover types present in the Johns Lake watershed and their percent coverages.

Land Use / Land Cover Type	Percent Coverage of Watershed
Urban	51.5
Upland non-forested	13.4
Forest	11.5
Water	9.4
Agriculture	6.8
Wetland	6.0
Transportation, Communication, Utilities	0.9
Barren land	0.6

Mapped Vegetation

Wetland communities around Johns Lake are limited due to its sandhill physiography and the urban development around the lake (Figure 10). Based on SJRWMD remotely sensed data (i.e., mapped wetlands) and field site visits, wetland communities at and in the vicinity of Johns Lake are dominated by shallow marsh (839.9 acres; ~51%), wet prairie (360.7 acres; ~22%) and shrub swamp (235.6 acres; ~14%) (SJRWMD 2014; **Error! Reference source not found.** 10). Acreage and percentages of all wetland communities are presented in Table 5.

While remotely sensed wetland data are a useful preliminary planning tool, their coarse resolution means that there are inevitable differences between them and the vegetation found at the lake. As such, wetland community descriptions and boundaries used for this MFLs determination were developed based on field data collected along field transects at Johns Lake (see Appendix C for details).

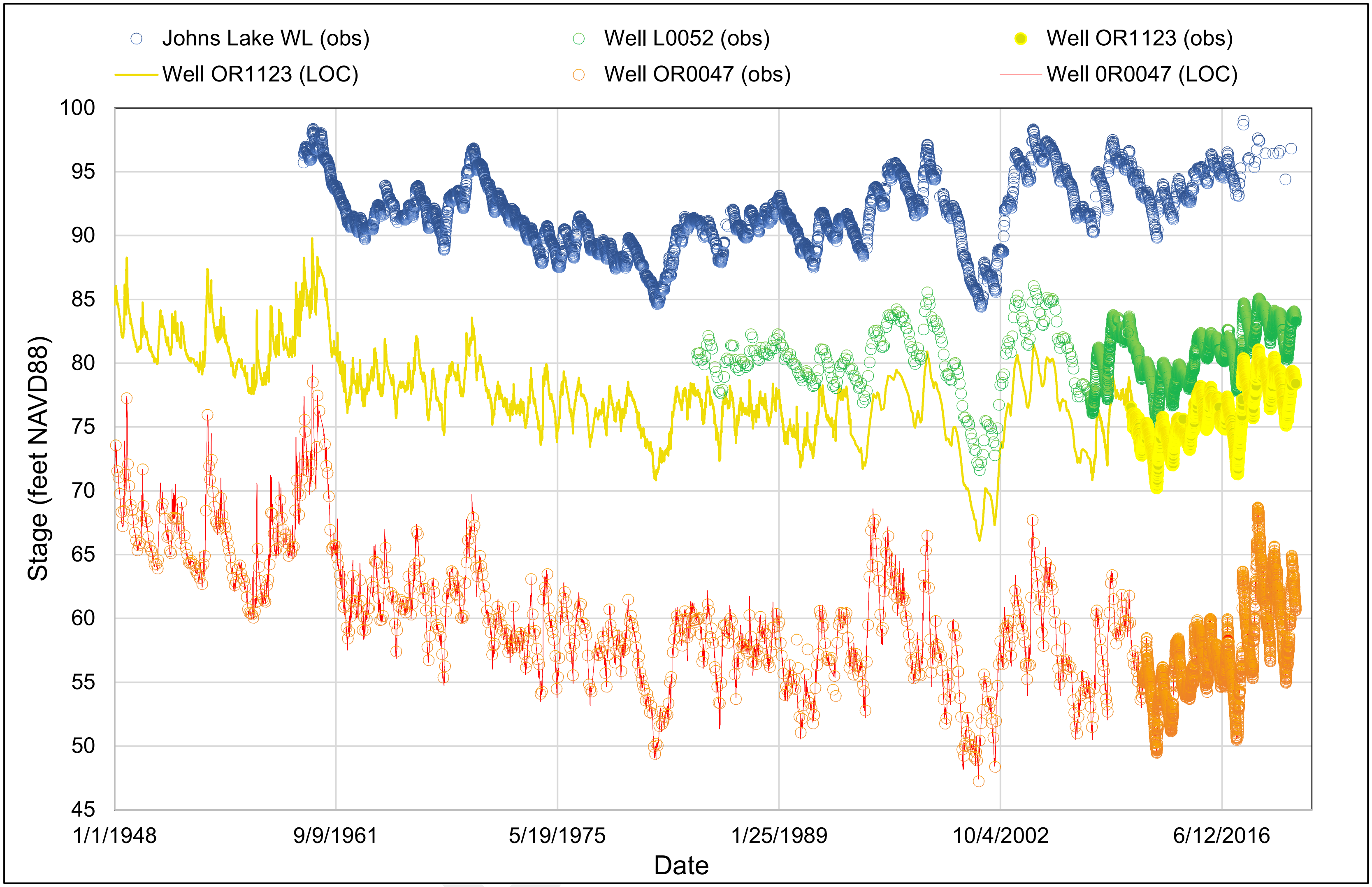


Figure 8: Groundwater and surface water data from gages near Johns Lake. Observed data are depicted in circles while the lines represent data hindcasted with the line of organic correlation method.

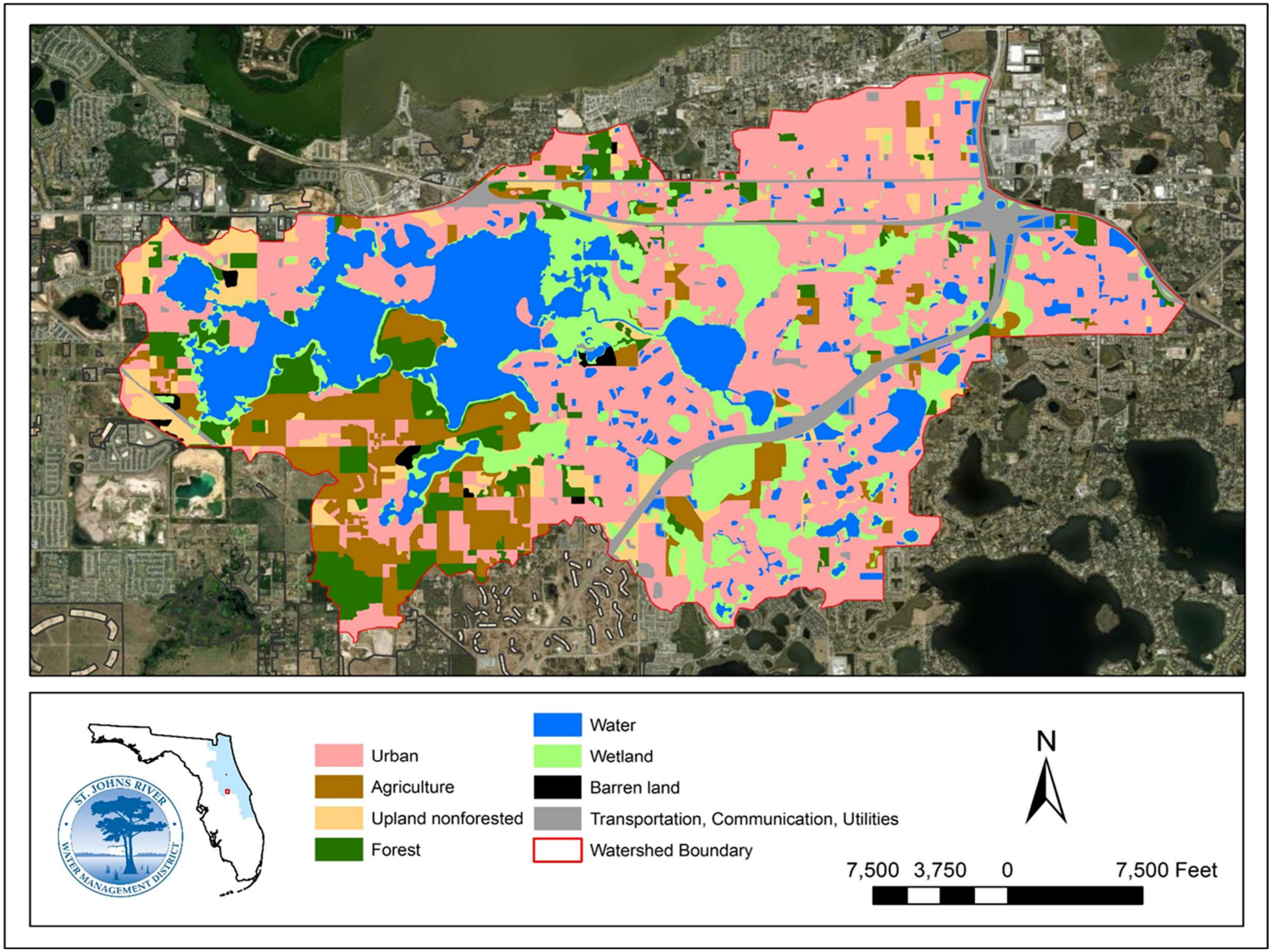


Figure 9: 2014 Land Use and Land Cover data for the Johns Lake watershed.

Table 5: Acreages and percent coverages of wetland types around Johns Lake.

Wetland Type	Acres	Percent Coverage
Shallow Marsh	839.9	51.0
Wet Prairie	360.7	21.9
Shrub Swamp	235.6	14.3
Deep Marsh	129.0	7.8
Baygall	25.0	1.5
Transitional Shrub	24.7	1.5
Hydric Hammock	16.8	1.0
Hardwood Swamp	9.3	0.6
Bottomland Hardwood	4.9	0.3
Floating Marsh	0.5	> 0.1
Cypress	0.3	> 0.1

Mapped Hydric Soils

Hydric soils are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part (USDA, NRCS 2018). Under natural conditions, these soils are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation (USDA, NRCS 2018).

Hydric and non-hydric soils were mapped at Johns Lake using USDA Soil Survey Geographic (SSURGO) data (Figure 11). In the Johns Lake watershed, approximately 47% of the area is classified as non-hydric, 37% is predominantly non-hydric, 11% is predominantly hydric and 6% is hydric. Hydric soils are uncommon around Johns Lake since it is a sandhill system.

As with wetland maps, SSURGO soils maps are useful as a planning tool, but the coarse data resolution results in differences between mapped and actual soils found on site. Detailed soils descriptions developed from data collected along field transects are presented in the environmental appendix (Appendix C).

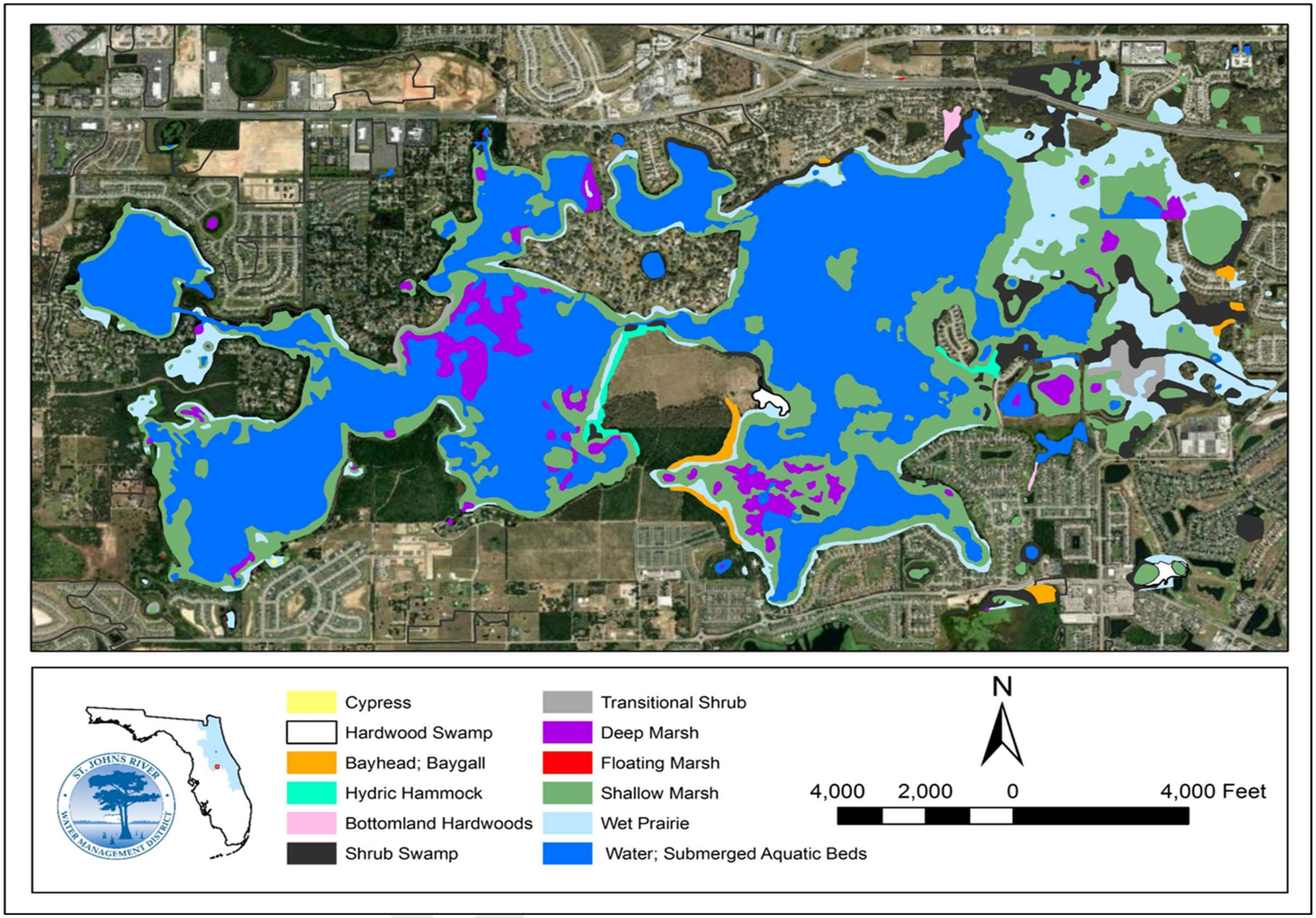


Figure 10: Wetland types surrounding Johns Lake (SJRWMD 2014)

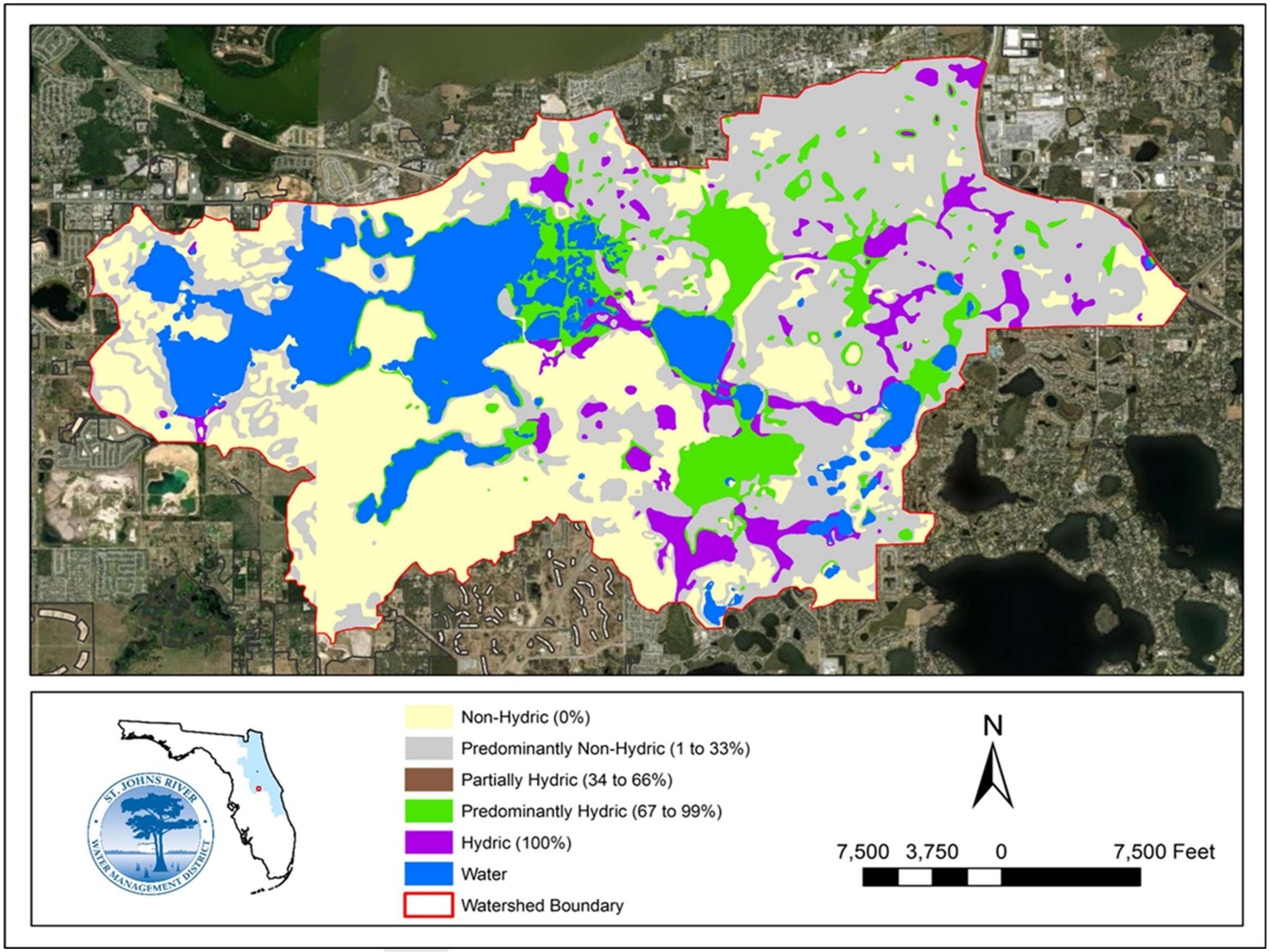


Figure 11: Hydric soil classification for the area surrounding Johns Lake. Data from SSURGO.

Water Quality

Johns Lake is designated as a Class III waterbody by the State of Florida. Designated beneficial uses for Class III waters include recreation and supporting the propagation and maintenance of a healthy, well-balanced fish and wildlife population. Lakewatch, FDEP, SJRWMD, and Orange County have intermittently collected water quality data for Johns Lake since 1966. These data are available on the Orange County Water Atlas (Orange.WaterAtlas.org), which is maintained by the University of South Florida, Water Institute, School of Geosciences.

The FDEP established a numeric nutrient standard for colored lakes (i.e., with long-term mean color > 40 platinum cobalt units [PCU]) with a chlorophyll-*a* threshold of 20 µg/L (annual geometric mean), a total phosphorous (TP) maximum annual geometric mean of 0.16 mg/L and a total nitrogen (TN) maximum annual geometric mean of 2.23 mg/L (Table 6; Rule 62-302.531 *F.A.C.*). Calculating the annual geometric mean for the FDEP numeric nutrient criteria requires at least four temporally independent samples per year with at least one sample taken between May 1 and September 30th and at least one sample taken during the other months of the calendar year. These standards are considered in violation if exceeded more than once in a three-year period. Johns Lake is a colored lake and meets all numerical nutrient criteria FDEP set for lakes with mean lake color greater than 40 PCU (Table 7). For more information on water quality data analyses, see Appendix E.

Table 6: Florida's Numeric Nutrient Standards (Rule 62-302.531, *F.A.C.*).

Long Term Geometric Mean Lake Color and Alkalinity	Annual Geometric Mean Chlorophyll *A*	Maximum calculated numeric interpretation	
		Annual Geometric Mean Total Phosphorous	Annual Geometric Mean Total Nitrogen
> 40 Platinum Cobalt Units	**20 µg/L**	**0.16 mg/L**	**2.23 mg/L**
< 40 Platinum Cobalt Units and > 20 mg/L CaCO3	20 µg/L	0.09 mg/L	1.91 mg/L
< 40 Platinum Cobalt Units and < 20 mg/L CaCO3	6 µg/L	0.03 mg/L	0.93 mg/L

Table 7: Long term averages and most recent measurements for Chl *a*, total phosphorous and total nitrogen concentrations of Johns Lake.

Long Term Average Measured Values for Johns Lake (c. 1980 - 2023)			
Color	**Chl *A***	**Total Phosphorous**	**Total Nitrogen**
62 PCU	8.51 µg/L	0.03 mg/L	0.95 mg/L
Most Recent Measured Values for Johns Lake (2023)			
Color	**Chl *A***	**Total Phosphorous**	**Total Nitrogen**
21 PCU	7.60 µg/L	0.03 mg/L	0.78 mg/L

Trophic state index (TSI) values have been calculated at Johns Lake since 1979 by the Lake County Water Resource Management's Environmental Services Division (Figure 12). TSI is based on water quality data and is an indirect measurement of the biological productivity of a given lake. TSI is calculated by averaging two other indices, an index for chlorophyll *a* and an index for nutrients (TN and TP).

Chlorophyll and nutrient indices were developed for Florida lakes and are based on regression analyses of 313 Florida lakes (Paulic et al. 1996). The nutrient index requires TN data, TP data and determining the waterbody's limiting nutrient. The chlorophyll index was developed based on an upper limit of chlorophyll *a* concentration of 20 µg/L for Florida waterbodies, which relates to a TSI of 60 (Paulic et al. 1996). At 40 µg/L of chlorophyll *a,* TSI increases to 70. A TSI value of 70-100 is considered undesirable or "poor", a value of 60-69 is "fair", and a value of 0-59 is considered "good" (Table 8). This is based on the relationship between TSI and the potential for algal and aquatic weed growth affecting whether a lake's "designated use" is supported (Paulic et al. 1996).

Based on available data, the majority of Johns Lake TSI values are within the range considered "good" suggesting that it meets all use criteria for Class III water bodies (swimmable, fishable, supports healthy habitat; Figure 12).

Note that water quality is an environmental value evaluated as part of the MFLs assessment process (see *MFLs Assessment* below) pursuant to Rule 62-40.473, *F.A.C.* However, for most lakes in Florida excessive nutrient enrichment is monitored and remediated, if necessary, by FDEP by establishing Total Maximum Daily Loads and Basin Management Action Plans for affected systems.

Table 8: Classifications of TSI values.

Trophic State Index value	Trophic State Classification	Water Quality
0-59	Oligotrophic through Mid-Eutrophic	Good
60-69	Mid-Eutrophic through Eutrophic	Fair
70-100	Hypereutrophic	Poor

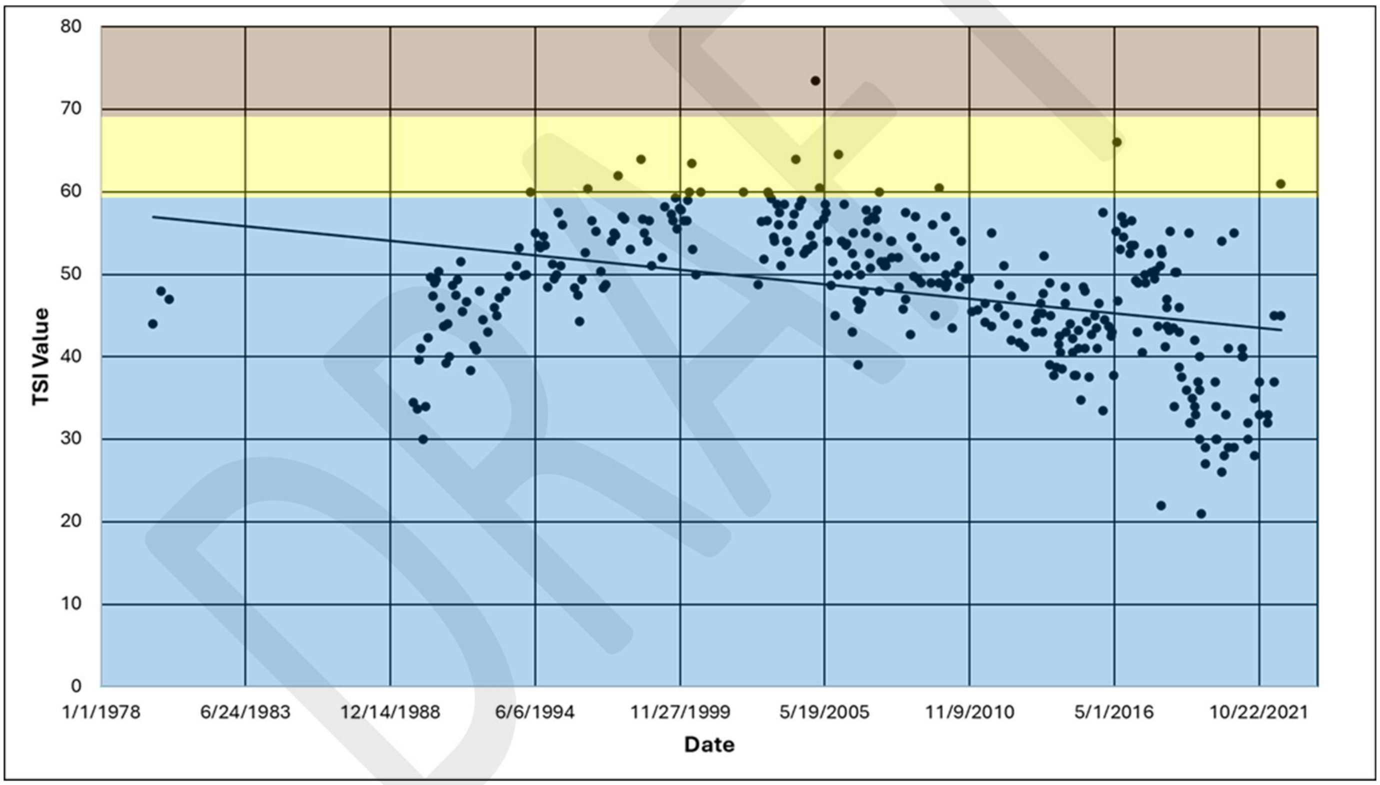


Figure 12: Johns Lake TSI measurements from 1979-2022.

MFLs Determination

The MFLs determinations for Johns Lake involved both hydrological and environmental analyses. The *Hydrological Analyses* section below briefly describes modeling and data analyses used to develop long-term lake level time series, which were used to develop and assess environmental criteria and minimum lake levels for the system. More details on hydrological analyses are provided in Appendix B.

The *Environmental Analyses* section briefly describes the environmental criteria evaluated as part of the MFLs determination for Johns Lake. In addition to methods descriptions, results are also presented, including the calculation of a recommended minimum metric condition (i.e., threshold condition) for each criterion (see Appendix C for more details). Criteria were chosen to ensure the consideration and protection of both ecological structure and function as well as human beneficial uses.

The current status of the system, based on the most constraining criterion, is summarized in the MFLs Assessment section (see Appendix D). In addition to the development and assessment of primary criteria, on which the system's minimum levels are based, consideration was also given to the protection of a suite of 10 environmental values, listed in Rule 62-40.473, *F.A.C.* The evaluation of these Water Resource Values (WRVs) is summarized in the *MFLs Assessment* section below and details are provided in Appendix E. The general approach for determining minimum levels for Johns Lake is presented below and details regarding data and analyses are provided in Appendix B and Appendix C.

Hydrological Analyses

Significant hydrological analyses are required to establish and assess MFLs. The primary purpose of these analyses is to better understand the impact of groundwater pumping on water levels. This information is then used to develop no-pumping and current-pumping condition long-term water level time series which are then used for MFLs determination and assessment. Several steps were involved in performing these hydrological analyses, including:

1. Review of available data;
2. Historical groundwater pumping impact assessment;
3. Development of lake level datasets representing no-pumping and current-pumping conditions; and
4. Estimating available water (freeboard or deficit).

Water level data are discussed in the *Hydrology* section above. Groundwater impact analysis and development of no-pumping and current-pumping timeseries are briefly summarized below. Additional details are available in Appendix B. Appendix D includes a description of the estimation of UFA freeboard (i.e., available water).

Historical Groundwater Pumping Impact Assessment

Groundwater levels near Johns Lake are susceptible to changes due to climate and/or water withdrawal. As described below, the contribution of climate versus pumping was estimated by developing a pre-withdrawal condition, termed the no-pumping condition, for Johns Lake.

Groundwater Use

MFLs are established to set the limit at which further water withdrawals would be significantly harmful to water resources. Monthly groundwater use data from 1948 to 2020 were compiled or estimated at all stations within a 15-mile radius or buffer zone of the Johns Lake centroid to estimate the impact on groundwater levels from historical pumping. It should be noted that the groundwater pumping within the 15-mile buffer zone was only used as a proxy to understand the variation of regional groundwater pumping from 1948 to 2020. The impact of groundwater pumping on lake levels was assessed based on all groundwater pumping within the groundwater model domain. As shown in Figure 13, the total groundwater use reached its highest level within the 15-mile buffer zone in approximately 2000 (~ 278 mgd) and has declined since then. Average groundwater use over the five-year period of 2016–2020 is approximately 156 mgd. As explained below, this five-year period was used to develop current impacted lake levels for Johns Lake, termed the current-pumping condition.

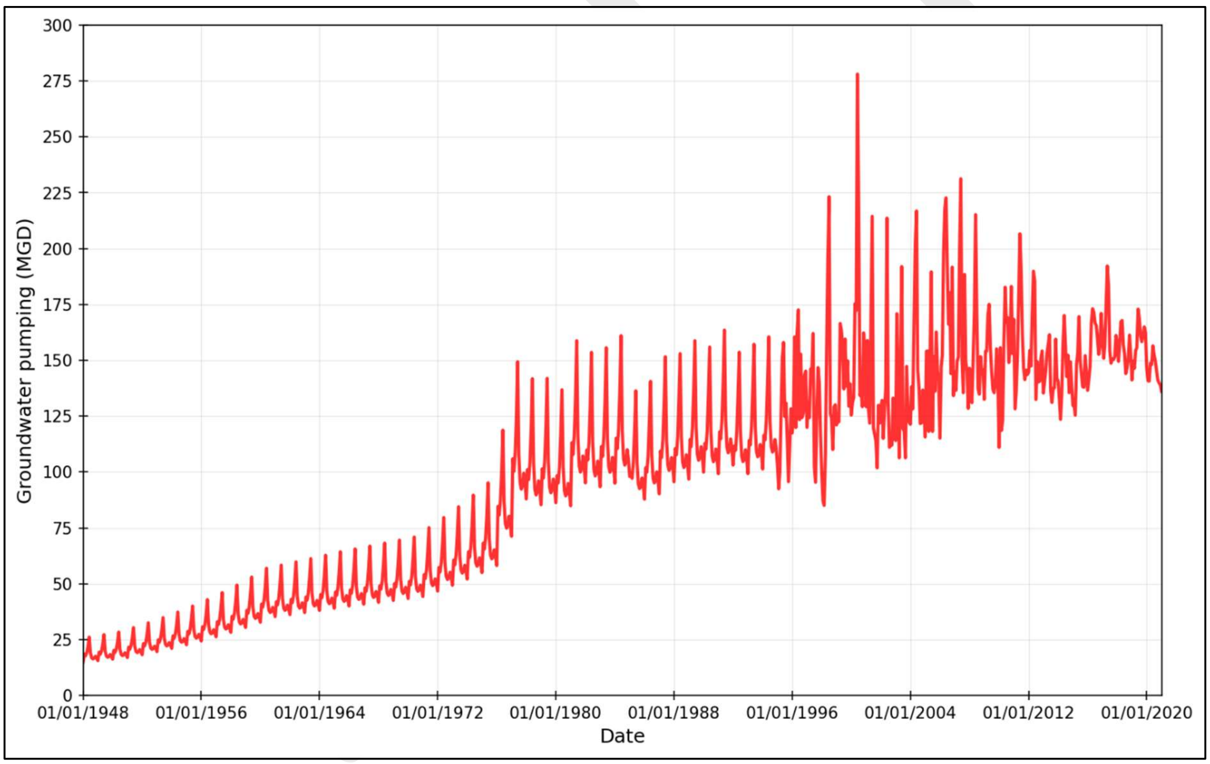


Figure 13: Estimated historical groundwater pumping within 15 miles of Johns Lake from 1948 to 2020.

Groundwater Modeling

The CFWI developed the ECFTX groundwater flow model to support regional water supply planning and understand groundwater resource limitations for sustainable water supplies while protecting natural systems (CFWI HAT 2020). The ECFTX model was recalibrated in 2022, referred to as ECFTX v2.0, to improve the simulation of groundwater levels and flows within the Wekiva River basin (Gordu et al. 2022). ECFTX v2.0 was used for the Johns Lake pumping impact analysis.

Estimated Historical Impact on Water Levels

An estimate of monthly UFA reductions from 1948 to 2020 at Johns Lake resulting from regional groundwater pumping was used to establish the no-pumping condition lake levels. The monthly estimated historical impact due to pumping was disaggregated to a daily time series extending from 1948 to 2020 using linear interpolation. The daily estimated historical impact on UFA levels for the period of 1948 to 2020 from pumping near Johns Lake using thea 15-mile buffer zone is shown in Figure 14.

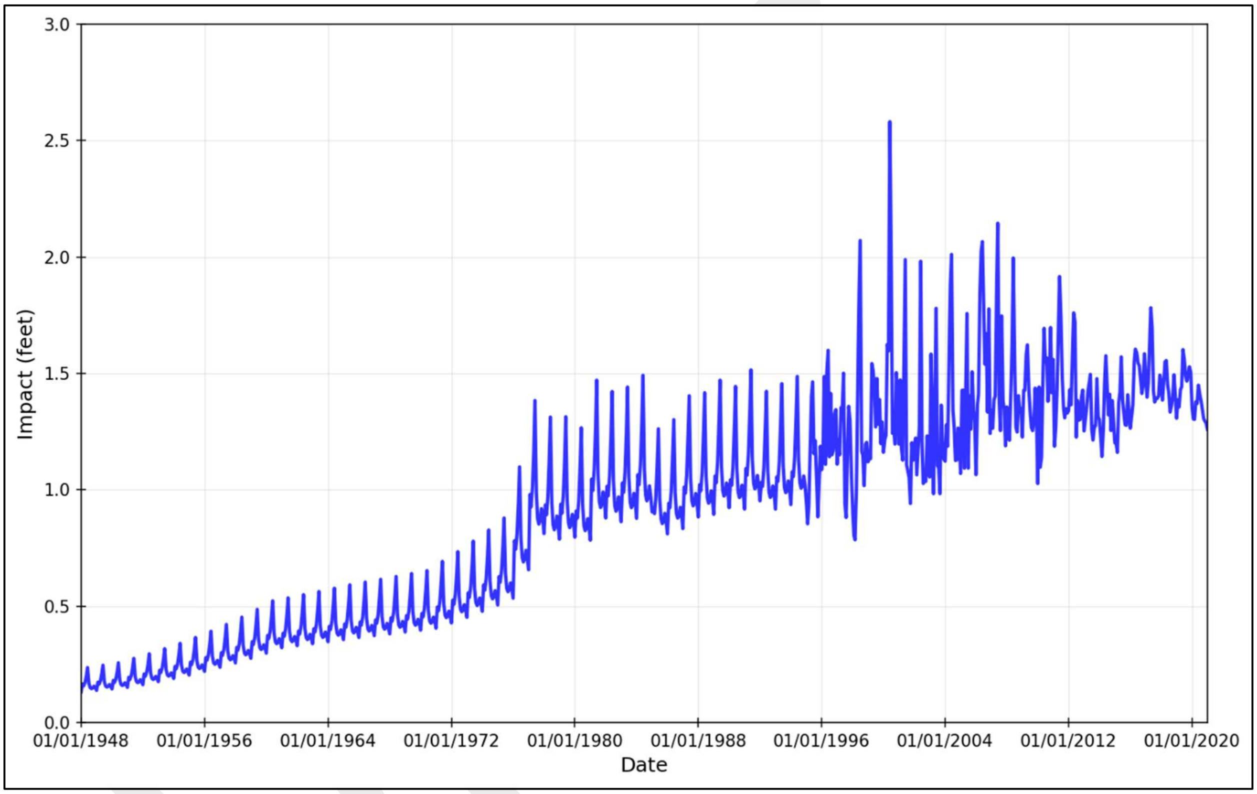


Figure 14: Daily estimated historical impact from pumping on UFA levels near Johns Lake using the 15-mile buffer area.

No-pumping and Current-pumping Condition Lake Levels

Long-term lake level time series, representative of a no-pumping condition and a current-pumping) condition are needed for both MFLs determinations and assessments. The estimated historical water level decline caused by groundwater pumping (described above) is added to the observed dataset to create the no-pumping condition UFA level dataset. The no-pumping condition time series represents hydrologic conditions of Johns Lake in which impacts from groundwater pumping are assumed to be minimal (Figure 15; Figure 16).

The current-pumping condition lake level dataset was developed by subtracting an estimate of impact due to current groundwater pumping (average 2016–2020) from the no-pumping lake level time series. The current-pumping condition lake level dataset represents a reference hydrologic condition for Johns Lake in which the total regional groundwater pumping impacting the lake is assumed to be constant from 2016 to 2020 (Figure 15; Figure 16). See Appendix B for more details about the creation of the no-pumping and current-pumping groundwater levels and lake levels.

Assuming climatic, rainfall, and other conditions from 1948 to 2020 are repeated over the next 73 years , the current-pumping conditionreflects the future condition of lake levels if the average regional groundwater pumping does not change from the 2016-2020 condition. The current-pumping time series can then be used to determine current available water (i.e., freeboard or deficit) by assuming that future climatic variability is similar to the past and that future pumping impact is held constant at the current condition.

Our understanding of possible future climatic conditions is limited and there are significant uncertainties in global climate model predictions. According to the Florida Climate Institute, the climatic cycles such as El Niño Southern Oscillations (ENSO), Atlantic Multidecadal Oscillation (AMO) and the Pacific Decadal Oscillation (PDO) have the strongest influence on Florida's climate variability (Kirtman et al. 2017). ENSO cycles typically range from two to seven years, PDO cycles typically range from 20 to 30 years and AMO cycles typically range 60 to 80 years (Schlesinger and Ramankutty 1994; Obeysekera et al. 2011; Kuss and Gurdak 2014).

There are strong relationships of short- and long-term climatic cycles such as ENSO and AMO to rainfall, river flows and groundwater levels in Florida (Enfield et al. 2001; Kelly 2004; Kuss and Gurdak 2014). These strong relationships are not expected to disappear in the foreseeable future. Because of this, MFLs development requires the use of long-term lake levels to capture the effects of short- and long-term climatic variations such as ENSO and AMO on lake levels.

SJRWMD acknowledges that the MFLs analyses assume that hydrological history will repeat itself. Given the uncertainties in future rainfall and temperature predictions by global climate models, this assumption is considered appropriate but will need to be regularly tested by implementing an adaptive management strategy. The SJRWMD implements an adaptive management strategy described later in this report to address continuing challenges and uncertainties in ecohydrological data and tools. Moreover, . MFLs are established to prevent water bodies from being significantly harmed by water withdrawals, not changes in rainfall conditions. Therefore, using historical conditions to generate current-pumping condition time series is considered reasonable.

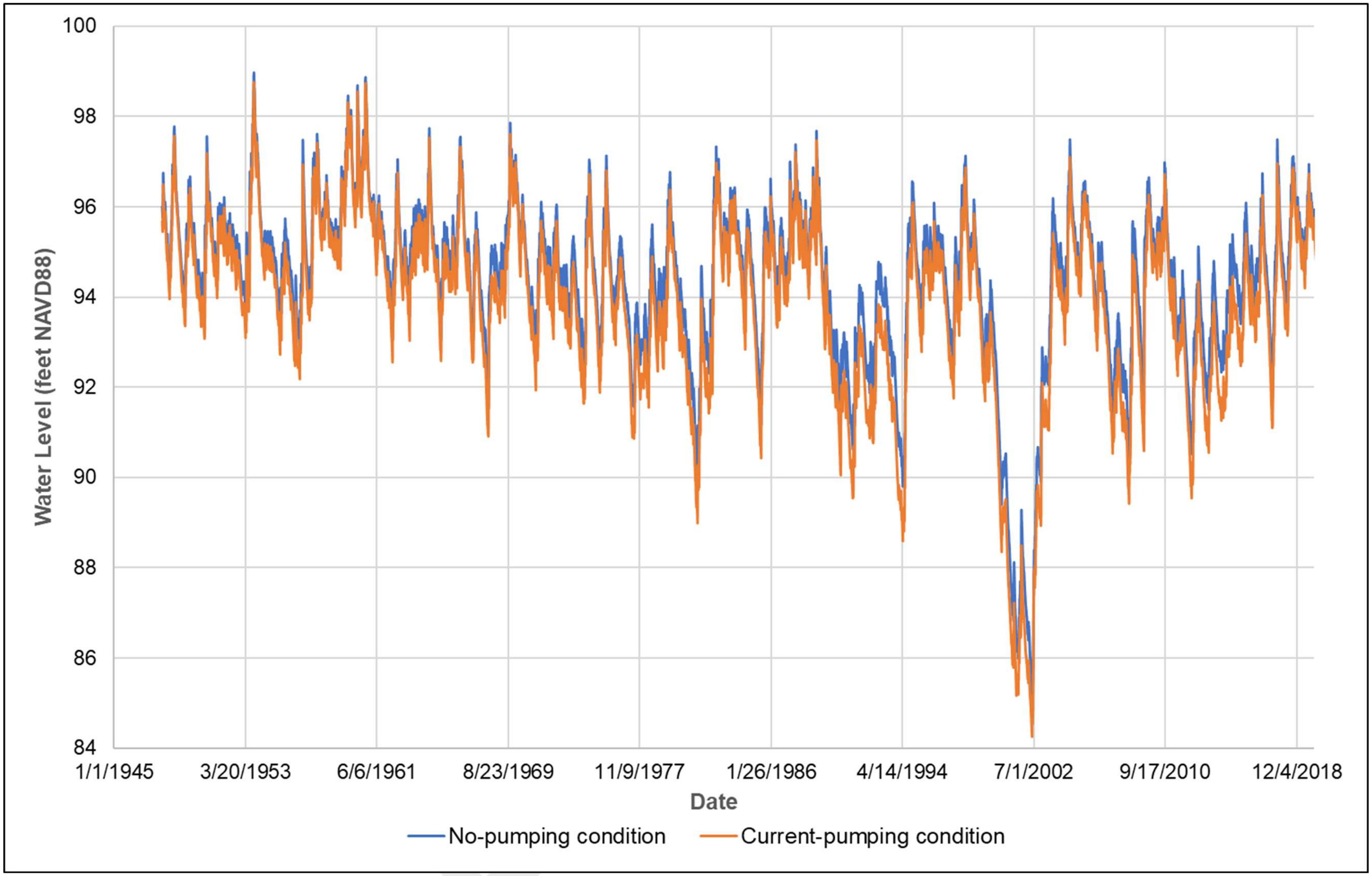


Figure 15: No-pumping condition lake levels compared to the Current-pumping condition lake levels.

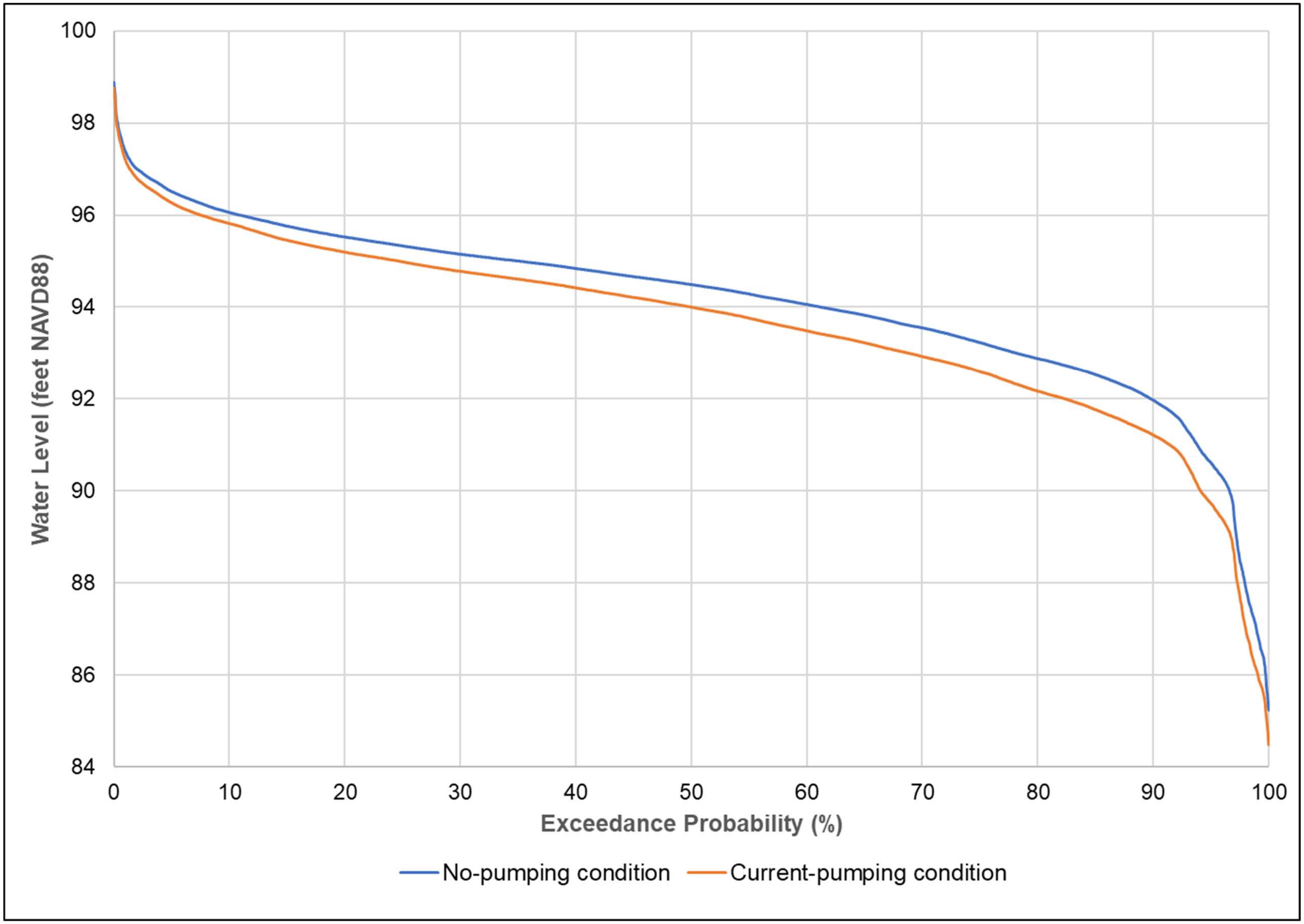


Figure 16: No-pumping condition exceedance curve compared to the Current-pumping condition exceedance curve.:

ENVIRONMENTAL ANALYSES

Overview

MFLs environmental analyses focus on determining relevant environmental attributes (e.g., fish and wildlife habitat) and beneficial uses (e.g., recreational value) for a given water body, as well as determining criteria and thresholds to protect these functions and values. This process typically includes consideration of:

- site-specific field-based ecological and soils data;
- non-ecological environmental data (e.g., data used to assess recreational values);
- topographical information;
- historical, remotely sensed and mapped data, aerial photographs; and
- scientific literature and agency reports.

This information determines the most important environmental values for a given water body. Next, appropriate criteria are chosen to represent these environmental values, and a minimum hydrologic regime (MFLs condition) is determined, which ensures their protection.

Environmental Criteria

A variety of environmental criteria were evaluated to ensure protective minimum levels were developed for Johns Lake. SJRWMD's standard event-based criteria were first evaluated to determine whether this approach was appropriate for Johns Lake. In recent years, it has been demonstrated that this conventional approach may not be appropriate for all systems (e.g., see Jennewein et al. 2020; Sutherland et al. 2021; Sutherland et al. 2025). Where appropriate, event-based metrics are typically developed to protect ecological and soils-based functions and values in floodplain and near-shore environments (e.g., see Sutherland et al. 2017).

Vegetation, soils, and elevation data for Johns Lake were collected along five transects. A literature and data search was conducted prior to establishing field transects. Vegetation and soil sampling followed standard field procedures. Detailed information on field transect selection and data collection methods is provided in Appendix C.

The preliminary environmental criteria assessed were chosen based on their potential to protect non-consumptive environmental values and beneficial uses (also called WRVs; see below for details), as mandated by Rule 62-40.473, *F.A.C.* The final recommended environmental metrics, used to establish minimum levels for Johns Lake, are described below.

Event-Based Approach

A water body's hydroperiod is the primary driver of wetland plant distribution and diversity, hydric soils type and location, and to a varying degree freshwater fauna (Foti et al. 2012; Murray-Hudson et al. 2014). A system's natural hydrologic regime, represented by variable flooding and/or drying events, is necessary to maintain the extent, composition, and function of wetland and aquatic communities (Poff et al. 1997; Thorp et al. 2008; Arthington 2012). Wetland and aquatic species, as well as hydric soils, require a minimum frequency of critical hydrologic events for long-term persistence (Richter et al. 1997; Winemiller 2005; Arthington 2012).

Event-based MFLs metrics are developed to protect a minimum hydroperiod necessary for maintaining specific environmental values. They are described with a magnitude component (i.e., water level or flow), a duration, and a return interval; the latter is also expressed as frequency of exceedance or non-exceedance. SJRWMD's conventional event-based approach defines ecologically relevant events as the combination of their magnitude and duration components. The return interval/frequency of these events is often described as the manageable component (i.e., minimum thresholds are associated with an allowable change in the frequency of events; Neubauer et al. 2008); however, it is recognized that a minimum hydroperiod could be developed that holds magnitude and frequency constant and associates a change in duration with significant harm; both methods would still (theoretically) arrive at the same minimum hydroperiod.

The aim of SJRWMD's event-based metrics is to prevent significant harm due to an excessive change in event frequency caused by water withdrawal. Significant harm is associated with impairment or loss of ecological structure (e.g., reduction in wetland acreage) or function (e.g., insufficient fish reproduction or nursery habitat).

Protective event frequencies (i.e., recommended return intervals) are determined using hydrologic event probabilities called Surface Water Inundation and Dewatering Signatures (SWIDS). SWIDS of vegetation species or communities provide a hydrologic range for a population of water bodies, that exhibit a transition from drier conditions on one side of the range to wetter conditions on the other side. A primary assumption is that these hydrologic signatures are for a group of hydrologically similar water bodies and thus provide an estimate of the shift in return interval of flooding or drying events that can occur before causing significant harm to the species or community in question. See Appendix C for details regarding SWIDS analysis and event frequency calculations.

Because hydroperiods vary spatially and temporally (Mitsch and Gosselink 2015), and because species and communities are adapted to different parts of a system's hydrologic regime, multiple event-based (or other) criteria are typically used to protect different portions of a system's ecological structure and function (Neubauer et al. 2008). For many systems, SJRWMD sets three MFLs; minimum frequent high (FH), minimum average (MA), and minimum frequent low (FL) water levels. In some cases, a minimum infrequent high (IH) and/or minimum infrequent low (IL) water level may also be set (Figure 17).

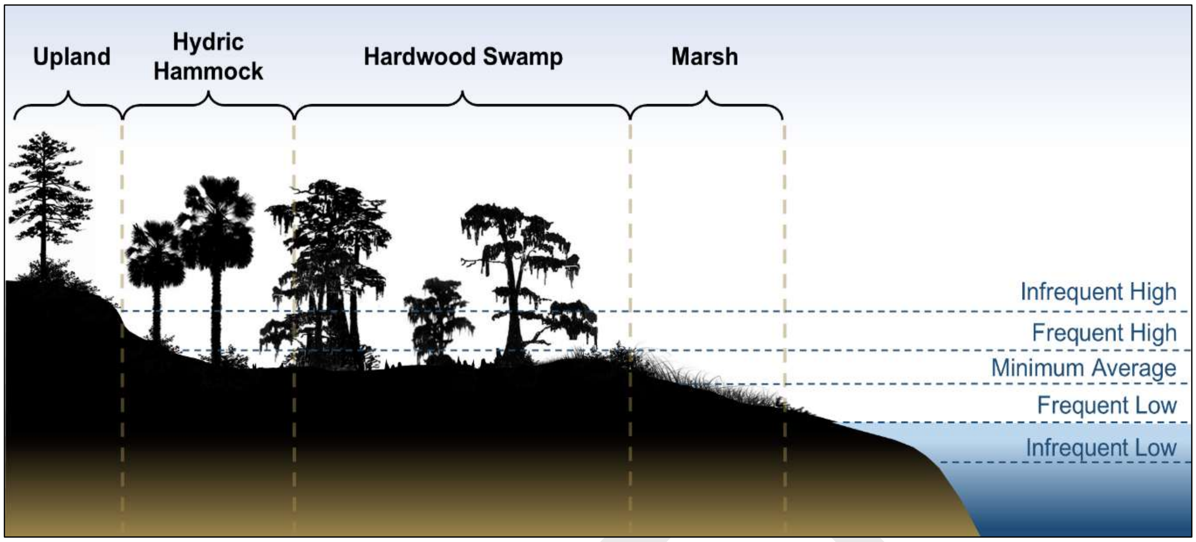


Figure 17: Conceptual drawing showing the five most common minimum flows and/or levels developed using SJRWMD's event-based approach.

Site Selection and Data Collection

Vegetation, soils, and elevation data were collected along five transects for the Johns Lake MFLs (Figure 18; Figure 19; Figure 20). Transects typically extended from uplands, across multiple wetland communities, to open water. A search of aerial photographs, and remotely sensed data (e.g., mapped vegetation, soils, and other data) was conducted prior to establishing field transects. Proposed transects were inspected prior to intensive data collection to confirm the presence of desired features, including:

- representative examples of common wetland communities;
- unique or high-quality wetlands;
- edge of uplands or open water; and
- deep organic and other hydric soils.

Vegetation and soil sampling followed standard field procedures. More information on field transect selection and data collection methods is provided in Appendix C.

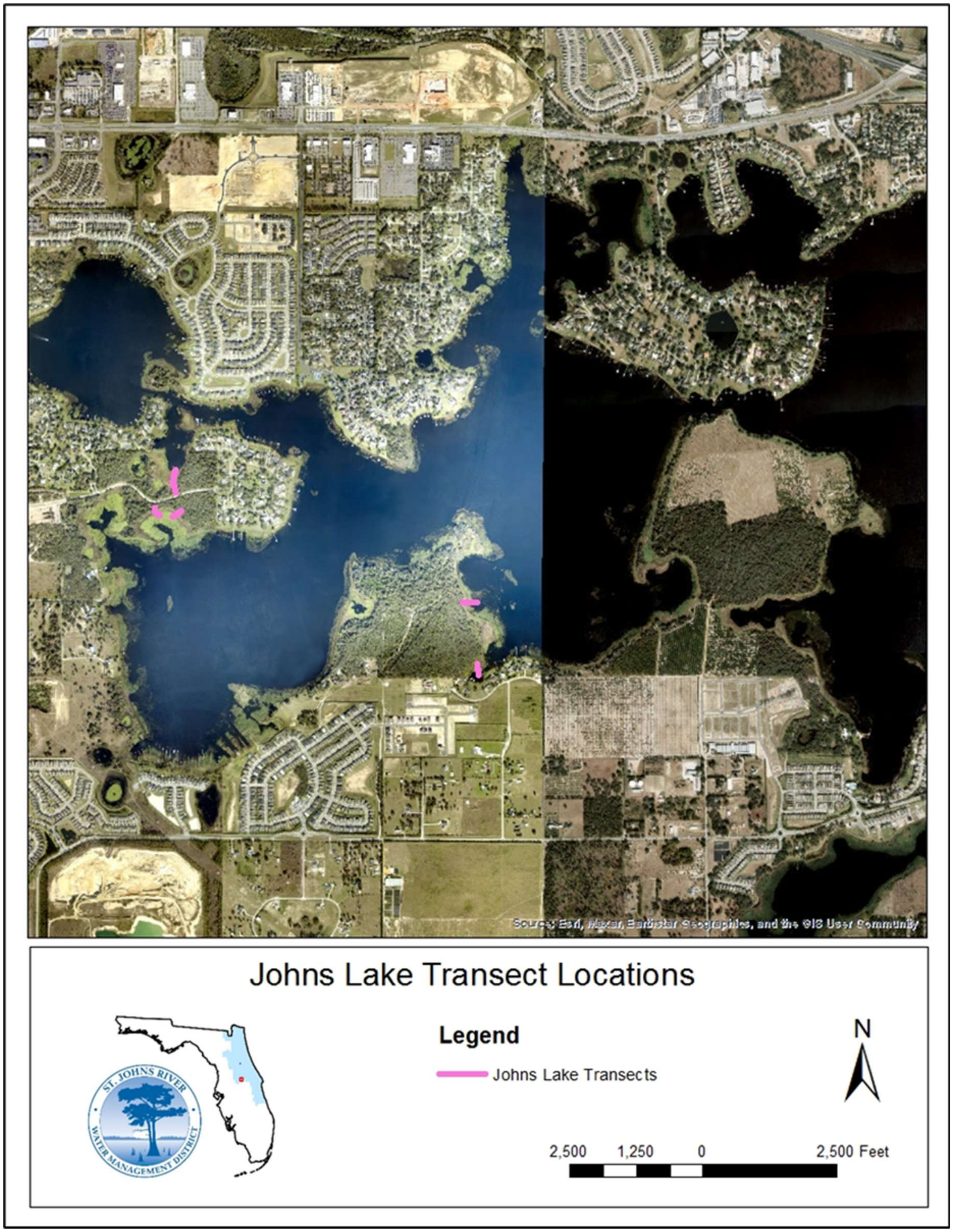


Figure 18: Johns Lake transects overview (T1-T5).

Figure 19: Johns Lake Transects 1 and 2.

Figure 20: Johns Lake Transects 3, 4, and 5.

Minimum Frequent High (FH) #1

A FH is typically associated with a seasonally flooded hydroperiod "…where surface water is typically present for extended periods (30 days or more) during the growing season, resulting in a predominance of submerged and transitional wetland species. During extended periods of normal or above normal rainfall, lake levels causing inundation are expected to occur several weeks to several months every one to two years" (Rule 40C-8.021, *F.A.C.*).

This FH aims to ensure frequent inundation in seasonally flooded wetlands, sufficient to maintain species composition, vegetative structure, and associated ecological functions. The FH is meant to maintain a sufficient occurrence of high surface water levels during typical periods of normal or above normal rainfall.

For Johns Lake, the buttonbush (*Cephalanthus occidentalis*) community is the highest elevated (i.e., most upslope), seasonally flooded community. In more stable systems with less hydrologic fluctuation, hardwood swamps generally establish in this zone,. However, in the case of Johns Lake and other sandhill-type systems, the buttonbush community (or other dominant shrub species) is common and ecologically important. The FH determined for Johns Lake ensures that an elevation of 94.1 ft NAVD88 has a minimum flood duration of 30 continuous days, at a return interval of 1.6 years (~63 years out of 100 years, on average).

<u>FH #1 Magnitude</u>

The FH level of 94.1 ft NAVD88 equals the average elevation of the seasonally flooded buttonbush wetlands from representative field transects where buttonbush was at a cover class of 3 or above. The goal of the recommended FH level is to maintain the spatial extent and functions of the seasonally flooded buttonbush wetlands and the contiguous wetlands at Johns Lake. Maintaining water levels at this average elevation will promote inundation and/or saturation conditions sufficient to support hydrophytic (i.e., obligate, facultative wet, and facultative) plant species (Ahlgren and Hansen 1957; Menges and Mark 2008; Mace 2015), thus preventing a permanent downward shift of these seasonally flooded wetland communities and lower elevated wetland communities. See Appendix C for more details and magnitude calculations for FH#1.

<u>FH #1 Duration</u>

The duration component of the FH is a minimum of 30 days continuously flooded at or above 94.1 ft NAVD88. A 30-day continuous flooding event represents a sufficient period of soil saturation or inundation needed to protect the structure and functions of these seasonally flooded buttonbush wetland communities (Ahlgren and Hansen 1957; Menges and Mark 2008; Mace 2015).

The 30-day flooding duration roughly corresponds to the duration of saturation that defines the upper boundaries of many wetlands. From a regulatory standpoint, the U.S. Army Corps of Engineers (USACE) uses durations of saturation between 5% and 12.5% of the growing season in most years as the standard in their wetland delineation manual (Environmental Laboratory 1987). Given the year-round growing season in Florida, this corresponds to durations of 18 to 46 days. However, the National Research Council (NRC 1995) has recommended a shorter duration hydroperiod to define wetland hydrology: saturation within 1 ft of the soil surface for a duration of 2 weeks (14 days) or more during the growing season in most years. In addition, the 30-day flooding duration is sufficient to cause the mortality of young upland plant species that have become established in the seasonally flooded buttonbush wetlands during low water events, maintaining the hydrophytic structure and diversity (Ahlgren and Hansen 1957; Menges and Mark 2008; Mace 2015).

FH #1 Return Interval

The FH is typically associated with a "seasonally flooded" hydroperiod as previously defined. For many MFLs systems, a FH return interval of 2 to 3 years is typical. For Johns Lake, the return interval of 1.6 years for the FH was based on a SWIDS analysis of wetland vegetation communities (see Appendix C). The SWIDS analysis used hydrologic signatures for communities most similar to Johns Lake's buttonbush dominated communities. This analysis resulted in the FH return interval with a mean + SE of 1.6 years. See Appendix C for more details on calculating the FH#1 return interval using SWIDS.

Minimum Frequent High (FH) #2

The goal of the second FH level is to protect the largemouth bass (*Micropterus salmoides*) spawning habitat and the regionally significant bass fishery at Johns Lake. Fishing for largemouth bass (and other game species) is a very important recreational value at Johns Lake.

By maintaining sufficient water depths within floating deep marsh vegetation communities during the spawning season, this minimum level will help ensure successful recruitment of largemouth bass year classes. Declines in natality or increases in juvenile mortality over extended periods, due to loss of spawning and refugia habitat, could substantially reduce Johns Lake's largemouth bass population. The purpose of the FH is to ensure that water withdrawals do not reduce the frequency of flooding events in floating deep marsh habitats to the point where this would cause significant harm to largemouth bass spawning activity. The FH is an inundation threshold that is meant to protect and maintain the following ecological structure and functions:

- maintenance of hydrophytic vegetation, mainly *Nymphaea odorata* and *Nuphar advena*;
- protection of spawning habitat for largemouth bass and other fish species; and
- protection of forage habitat and refugia for bass and other aquatic species.

This FH is composed of an elevation of 90.4 ft. NAVD88, with a corresponding minimum flood duration of 60 continuous days between January 1st and May 31st, and a return interval of 3 years (i.e., 33 out of 100 years, on average). This FH was developed in consultation with largemouth bass biologists from the Florida Fish and Wildlife Conservation Commission (FWC).

FH #2 Magnitude

The FH level of 90.4 ft. NAVD88 was calculated by averaging the ground elevations of transect locations where the vegetated community is dominated by deep marsh floating plants (e.g., *Nymphaea odorata* and *Nuphar advena*). After averaging the average elevation of floating deep marsh at transects 1, 2 and 5, one foot was added to ensure adequate spawning depth for largemouth bass and other game fish. This depth also allows juvenile fish to use most of the floating deep marsh as forage habitat and refugia from predation (See Appendix C for more details on FH #2 magnitude).

<u>FH #2 Duration</u>

This FH includes a duration of 60 continuous days between January 1st and May 31st. This duration and time of year areis based on studies suggesting that most largemouth bass in central Florida spawn during this time (Nagid 2022) (see Appendix C for more details on FH2 duration).

<u>FH #2 Return Interval</u>

Research suggests that largemouth bass require a strong year class approximately once every three to four years to maintain stable populations (Nagid et al. 2015; E.J. Nagid, FWC, pers. comm., 2023). A return interval of 3 years was selected for Johns Lake, based on scientific literature andconsultation with largemouth bass biologists at FWC (See Appendix C for more details on FH2 return interval).

Hydroperiod Tool Approach

To ensure that MFLs developed for Johns Lake will adequately protect all relevant ecological and human-use values, it was deemed prudent to develop other metrics to augment the event-based criteria described above. Seven ecological and recreational criteria were developed and assessed using the recently developed “hydroperiod tool (HT)” approach (Table 9). Before using the HT for MFLs, the tool played a significant role in the Water Supply Impact Study (WSIS) wetlands evaluation (Fox et al, 2012; Kinser et al, 2012). The District contracted with the National Research Council (NRC) of the National Academy of Sciences to provide independent review and advice. The NRC concluded that although the application of the HT was computationally challenging, the result is a robust picture of the spatial extent of dewatering and shifting boundaries between wetland types (National Research Council, 2012).

This approach has been used to set MFLs for other lakes in SJRWMD (Jennewein et al. 2020; Sutherland et al. 2021; Sutherland et al. 2025). The MFLs HT approach has been used with the following lakes: Lakes Geneva and Brooklyn (Sutherland et al., 2021), Lake Butler (Jennewein, et al 2020) Lake Apshawa (Sutherland et al, 2025) and Lake Prevatt (Shadik et al, in prep).

The hydroperiod tool functions primarily with raster (grid-based) representations of the environment, in which elevation values from a DEM are subtracted from an interpolated water surface elevation on a grid cell by grid cell basis, producing a new raster surface containing elevation or depth of water for each grid cell (i.e., ponded depth raster). Because the hydroperiod tool uses a Geographic Information System (GIS), it is possible to evaluate the effects of water level decline on the average area of various fish and wildlife habitats or areas with specific depths important for recreation (see Appendix C).

The hydroperiod tool is an extension for Environmental Systems Research Institute's (ESRI) ArcMap and ArcPRO and was developed for the South Florida Water Management District to define depth and duration of flood inundation as a function of location in a portion of the restored Kissimmee River floodplain (Sorenson et al. 2004; Sorenson and Maidment 2004; Carlson et al. 2005.) Geospatial data requirements for the HT include a detailed topobathymetric digital elevation model (DEM) and input tables for stage analyses. Appendix A describes the development of the DEM for Johns Lake. The HT automates a series of complex and computationally intensive GIS functions including: (1) interpolation of water surface from stage data, either for specific conditions (e.g., exceedences) or in time series; (2) intersection of the interpolated water surface with ground elevation (DEM) to produce rasters (grids) representing ponded depth at that water surface elevation, either for specific conditions or in time series; (3) reclassification of the ponded depth rasters, as needed for some analyses such as habitat; (4) change analyses to identify areas potentially affected (i.e., before and after surface or ground water withdrawals); (5) summarization and statistical analysis for specific wetland types (using zonal statistics) or by grid cell (using cell statistics). (Fox et al, 2012; Kinser et al, 2012).

Since the HT's development, it has been used to set MFLs for other lakes within SJRWMD's boundaries, including: Lakes Geneva and Brooklyn (Sutherland et al., 2021), Lake Butler (Jennewein, et al 2020) Lake Apshawa (Sutherland et al, 2025) and Lake Prevatt (Shadik et al, in prep). For Johns Lake, the HT was used to estimate the area of different fish and wildlife habitats and how they change with lake level change (Figure 21; See Appendix C for details about the hydroperiod tool development). The significant harm threshold used for this metric is a 15% or greater reduction in the areal extent (acreage) of different habitats due to groundwater pumping. Other water management districts have used a 15% reduction of habitat availability as a significant harm threshold for MFLs (Munson and Delfino 2007). This threshold has been peer reviewed and has been the basis for numerous adopted MFLs (see SJRWMD MFLs developed for Lakes Brooklyn and Geneva or SWFWMD MFLs developed for Crystal River, Gum Slough, Chassahowitzka River, and Homosassa River, among others). While many MFLs using this threshold are for flowing systems, A 15% reduction in habitat has also been used as a critical threshold for lakes and is based on bird species richness studies (Hoyer and Canfield 1994; Leeper et al. 2001; Emery et al. 2009).

Table 9: Habitat and Lake characteristics calculated by the Hydroperiod Tool.

Habitat and Lake Characteristics	Depth Range (feet)
Small wading bird forage habitat	0.1-0.5
Lake area	≥ 0.1
Large wading bird forage habitat	0.1-1
Sandhill Crane Nesting	0.5 - 1
Canoe Depth	≥ 1.7

Emergent marsh habitat	0.1 - 7
Open Water Area	≥ 7

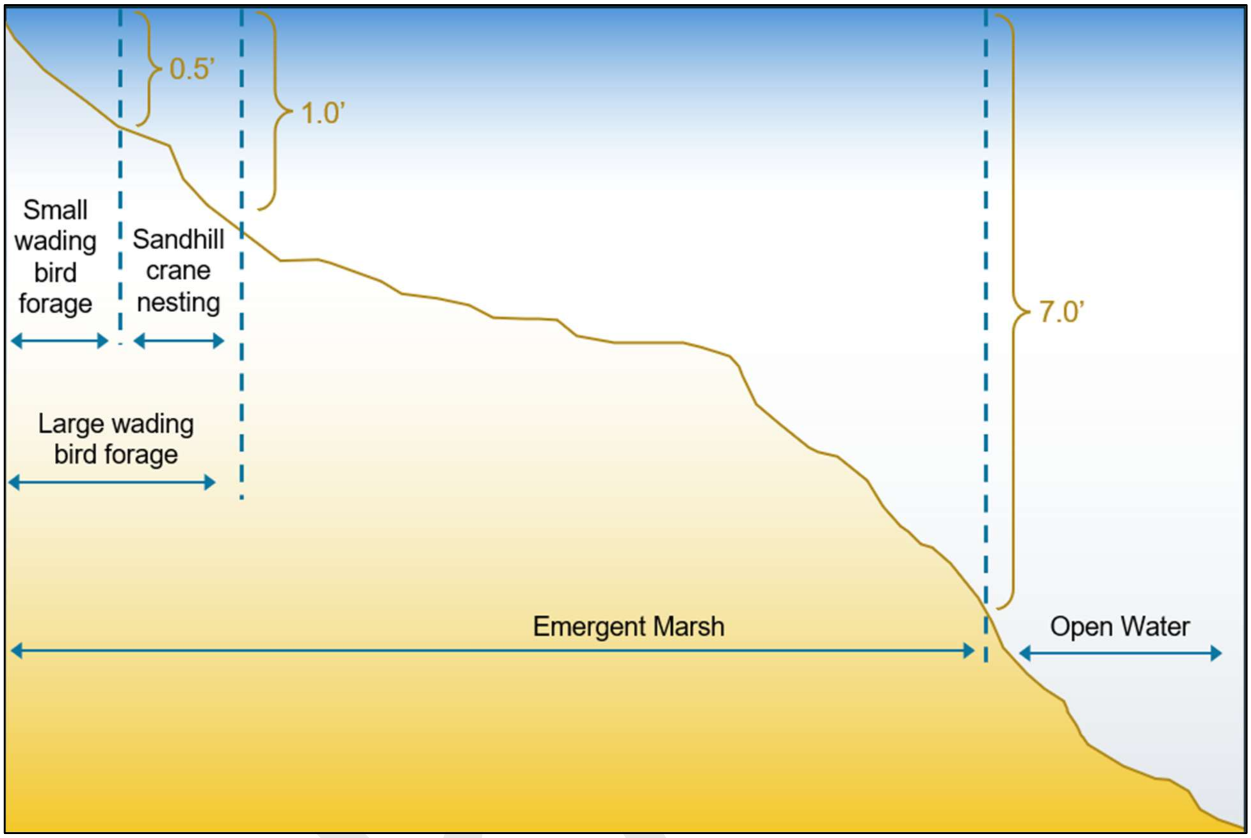


Figure 21: Nearshore habitats and water depth ranges used in fish and wildlife habitat analyses.

Nearshore Habitats and Recreational Values

Nearshore Habitats

The nearshore environment (littoral zone) within Johns Lake provides habitat for numerous wildlife species. The shallow littoral zone fringing the lake provides valuable habitat for various life stages, including refugia and forage habitat for aquatic invertebrates and small-bodied fishes. These areas also provide important reproductive habitat for fish, amphibians, and reptiles and forage habitat for wading birds.

Four nearshore habitats were defined for this analysis. For this analysis, habitats are areas within the nearshore environment with specific depth ranges and are based on water level requirements of plant and animal species known to inhabit these areas (See Appendix C for more details on habitat depth ranges).

- *Emergent Marsh Habitat*
- *Large Wading Bird Forage Habitat*
- *Small Wading Bird Forage Habitat*

- *Sandhill Crane Nesting Habitat*

These habitats were chosen to ensure that multiple portions of the nearshore environment were evaluated, in case one or more wereparticularly sensitive to water level change. Each habitat listed above was evaluated using the hydroperiod tool to determine the amount of water level decline that is associated with a 15% reduction in habitat extent (acres), relative to the long-term average no-pumping condition (see Appendix C for more details):

Recreational and Aesthetic Values

In addition to fish and wildlife habitat WRV, Rule 62-40.473, *F.A.C.*, also mandates consideration of other environmental values and beneficial uses. One of these WRVs is "recreation, in and on the water," the purpose of which is to protect water depths necessary to allow for various recreational activities (e.g., fishing, swimming, etc.). Recreation in and on Johns Lake is an important beneficial use, both historically and currently. The recreational values that were analyzed are: (See Appendix C for more details).

- *Canoe Depth*
- *Open Water*
- *Lake Area*

Hydroperiod Tool Metric Results

Average Habitat or Recreational Area

Average area was calculated for the seven hydroperiod tool metrics, for each day in the POR, using the stage/habitat area relationship derived from the hydroperiod tool and the simulated water surface elevations for the no-pumping condition. The MFLs condition for the hydroperiod tool metrics equals a 15% reduction in average habitat or recreational area under the no-pumping condition (i.e., habitat area averaged across the entire no-pumping condition lake level timeseries). Assessment of HT metrics is then simply the comparison of the average area under the no-pumping condition to the average area under the current-pumping condition (see Appendix D for more details).

Nearshore Fish and Wildlife Habitat Results

The four Johns Lake nearshore fish and wildlife habitats have varying trends relating to water levels (Figure 22). Shallow water metrics including Small wading bird forage habitats (0.1 – 0.5 ft), lLarge wading bird forage habitats (0.1 – 1.0 ft), and Sandhill crane nesting habitat (0.5 – 1.0 ft), all peak in maximum area around 87 feet NAVD88. Emergent marsh habitat (0.1– 7.0 ft) peaks at 89 feet NAVD88. After the peaks in water elevation at 87 and 89 feet, these metrics generally decrease in available area. The minimum metric conditions for hydroperiod tool metrics are provided below and represent a 15% reduction in average area relative to the no-pumping condition (Table 10).

The occasional exposure of these lower elevations is especially important in this system as Johns Lake is within a wood stork (*Mycteria americana*) Core Foraging Area (CFA) and is used by numerous other wading bird species as a foraging habitat. Low water habitats concentrate forage fish into shallow pools, facilitating foraging for wading bird species.

Recreation and Lake Area Metrics

Recreation and lake area metrics (Lake Area, Open Water, and Canoe Depth) have similar trends; average area for all three metrics is positively related to water level (Figure 22). The minimum metric conditions for recreation metrics are provided below (Table 10).

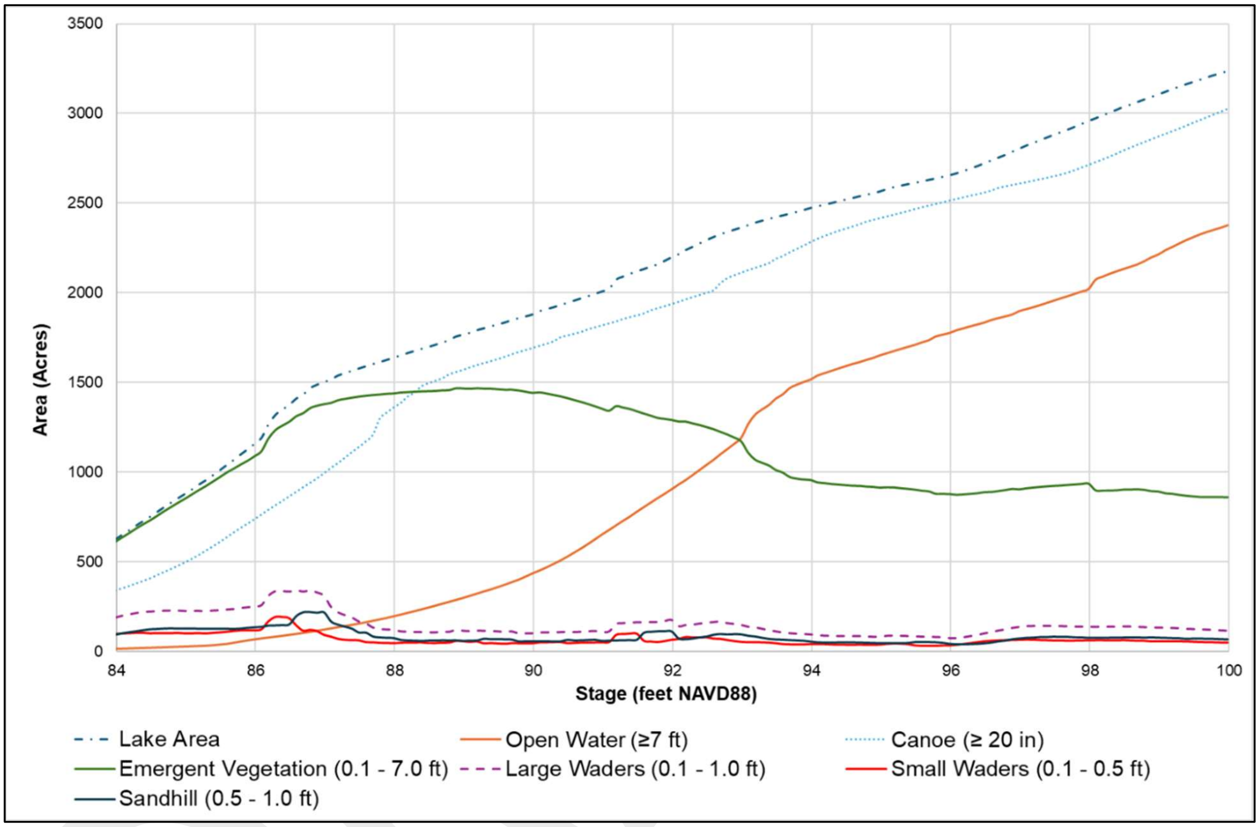


Figure 22: Hydroperiod tool output data showing lake stage versus habitat area for seven habitats and recreational / aesthetic metrics for Johns Lake.

Table 10: Hydroperiod tool metric area calculations under the no-pumping (NP) condition and the minimum metric condition.

Environmental Criterion	NP Condition Average Area (acres)	Minimum Metric Condition (15% reduction from NP condition)
Small wading bird forage habitat (0.1-0.5 ft)	46.0	39.1
Large wading bird forage habitat (0.1-1.0 ft)	105.5	89.7
Sandhill crane nesting habitat (0.5-1.0 ft)	59.5	50.6
Emergent marsh habitat (0.1-7 ft)	993.3	844.3
Canoe Depth (≥ 20 in)	2,299.1	1,954.2

Open-water (≥7 ft)	1,495.2	1,270.9
Lake Area (> 0.1 ft)	2,488.5	2,115.2

MFLs Determination Summary

The MFLs determination for Johns Lake involved the evaluation of critical environmental features applying two different methods: an event-based approach and a hydroperiod tool approach. Using the event-based approach two frequent high (FH) metrics were established and involved determining a minimum hydroperiod to maintain key environmental features; the two FH metrics are as follows:

- FH #1: a minimum frequent high flooding event based on SWIDS data for buttonbush (*Cephalanthus occidentalis*, developed to protect seasonally flooded wetland communities; and
- FH #2: An event-based metric developed to ensure largemouth bass spawning success based on an FWC-recommended hydroperiod (duration and return interval) required for sufficient access to suitable habitat.

The hydroperiod tool method utilized a stage-area analysis of the lake in relation to key lake habitat or recreational features (e.g. emergent marsh, open water, etc.). The minimum metric condition (i.e., recommended threshold or habitat reduction) for the Johns Lake environmental criteria is summarized below (Table 11). The assessment of environmental criteria (i.e., whether they are being met currently) is discussed below in the *MFLs Assessment* section and in Appendix D.

Table 11: The two event-based metrics evaluated for Johns Lake, with their corresponding magnitude, duration, and return interval; minimum metric condition equals a 15% reduction in average acres (over the POR) from the no-pumping condition

Environmental Criterion	**Environmental Value(s) Protected**	**MFLs Condition**		
Event-based Metrics		**Level (ft)**	**Duration (days)**	**Return Interval (years)**
FH#1	Seasonally Flooded Wetland Habitat	94.1	30	1.6
FH#2	Largemouth bass spawning habitat	90.4	60*	3
Hydroperiod Tool Metrics		**No-pumping (average acres)**		**Minimum Metric Condition (average acres)**
Small wading bird forage habitat	Fish and wildlife habitat	46.0		39.1
Large wading bird forage habitat	Fish and wildlife habitat	105.5		89.7
Sandhill crane nesting habitat	Fish and wildlife habitat	59.5		50.6
Emergent marsh habitat	Fish and wildlife habitat	993.3		844.3
Lake Area	Aesthetics	2,488.5		2,115.2
Canoe Depth	Recreation	2,299.1		1,954.2
Open-water area (7ft or deeper)	Recreation and Fish and wildlife habitat	1,495.2		1,270.9

* 60 continuous days between January 1st and May 31st

MFLs Assessment

MFLs are not meant to represent optimal conditions, but rather set a limit to water withdrawals, beyond which significant harm would occur. A fundamental assumption of SJRWMD's approach is that alternative hydrologic regimes exist that are lower than a priority water body's historical (i.e., pre-withdrawal) regime but that still protect important environmental functions and values from significant harm caused by water withdrawals. The MFLs determination described above defined a minimum metric condition necessary to protect each relevant environmental criterion (Table 11).

The MFLs assessment involves comparing the minimum metric condition for each metric with the hydrologic regime subject to impacts from current groundwater withdrawals (termed the current-pumping condition). This comparison determines whether each criterion, at each system, is being achieved under the current-pumping condition and if there is water available for additional withdrawal (freeboard), or whether water is necessary for recovery (deficit). If any of the MFLs environmental criteria are not being achieved under the current-pumping condition, indicating a deficit of water, a recovery strategy is necessary. If the MFLs are currently being achieved, but a deficit is projected within the 20-year planning horizon, a prevention strategy is needed. No-pumping and current-pumping condition water level datasets developed for Johns Lake were used to calculate freeboard or deficit and determine whether the system is in recovery, prevention, or neither (see *Hydrological Analyses* section above and Appendix B for more details).

Current Status Assessment

Current MFLs status for Johns Lake was based on the 2016–2020 current-pumping condition (see Appendix B for details) and was assessed for each environmental criterion used in the MFLs determination. The minimum metric condition required to protect each final criterion was compared to the current-pumping condition to determine a UFA freeboard for each criterion. UFA freeboards were compared to determine the most constraining environmental criterion for the system. The most constraining criterion is the basis for recommended minimum levels for Johns Lake.

Event-based metrics

Current status for event-based metrics (FH #1 and FH #2) was assessed using frequency analysis. The current-pumping condition frequency of each event was compared to the recommended minimum frequency to determine if the level was met under current conditions. The difference between the current-pumping condition water level and the MFLs magnitude represents the freeboard or deficit in the lake (see Appendix D for details). UFA freeboards represent the amount of allowable change in the aquifer and are calculated after determining the lake freeboard. UFA freeboard calculations are provided below and details are provided in Appendix D.

Under the current pumping condition, both event-based metrics are being maintained.

- FH #1, which provides protection for seasonally flooded and downslope wetlands (94.1 ft, 30-day duration, 1.6-year return interval), has a UFA freeboard of 1.5 feet (Table 12).
- FH #2, which provides protection for largemouth bass spawning habitat (90.4 ft, 60-day duration between January 1st and May 31st, 3-year return interval), has a UFA freeboard greater than three feet (Table 12).

Table 12: Event-based metrics for Johns Lake, the environmental values they protect, and their UFA freeboards.

Environmental Criterion	Environmental Value(s) Protected	UFA Freeboard (ft)
FH #1	Seasonally inundated wetland communities	1.5
FH #2	Largemouth Bass spawning habitat	> 3.0

Hydroperiod Tool metrics

Current status was assessed for seven hydroperiod tool metrics at Johns Lake. Hydroperiod tool metrics were assessed by estimating the reduction in area (acreage) over the simulated POR under the current-pumping condition, relative to the no-pumping condition. The impact threshold for these metrics is an allowable 15% reduction in average area under the no-pumping condition, over the entire POR (see Hydroperiod Tool Approach section for more details).

All hydroperiod tool metrics at Johns Lake had freeboard available under the current-pumping condition. Small wading bird forage habitaters, large wading bird forage habitaters, sandhill crane nesting habitat, emergent marsh habitat, lake area, and canoe depth all had >3.0 ft of UFA freeboard (Table 13). The largest percent area reduction from the no-pumping to current-pumping condition was for the open-water area metric, with a reduction of 7.1%. This is the most sensitive metric and the basis of the MFLs condition. For the open-water area metric, a UFA drawdown of 1.3 feet results in a 14.7% reduction in average area, relative to the no-pumping condition. However, a drawdown of 1.4 feet results in a 15.4% reduction. Since the latter results in open-water area reduction greater than the 15% threshold, 1.3 feet is considered the UFA freeboard for this metric (Table 13).

Table 13: No-pumping and Current-pumping acreages and percent change based on hydroperiod results for the seven different environmental criteria.

Environmental Criterion	NP Condition area (acres)	CP Condition area (acres)	Percent reduction (-) or gain (+) from NP to CP (%)	MFLs Condition (15% reduction) area (acres)	UFA Freeboard
Small wading bird forage habitat	46.02	48.75	+5.92	39.12	> 3.0
Large wading bird forage habitat	105.47	111.68	+5.88	89.65	> 3.0
Sandhill crane nesting habitat	59.45	62.93	+5.85	50.53	> 3.0
Emergent marsh habitat (7ft and less)	993.34	1034.08	+4.10	844.34	> 3.0
Lake Area	2,488.51	2,422.68	-2.65	2,115.24	> 3.0
Canoe Depth	2,299.08	2,222.87	-3.31	1,954.22	> 3.0
Open-water area (7ft or deeper)	1,495.18	1,388.60	-7.13	1,270.90	1.3

Summary of Lake and UFA Freeboard/ Deficit

The status assessment for Johns Lake indicates that all evaluated environmental criteria are met under the 2016-2020 current-pumping condition. All metrics have freeboard in the UFA (i.e., do not have a deficit); therefore, the waterbody is not in recovery (Table 13). The most constraining of the hydroperiod tool metrics, and all metrics overall, was the open water 7 ft metric with 1.3 ft UFA freeboard. This minimum hydrologic regime will ensure protection of the open water metric and all other less constraining metrics.

FUTURE / PROJECTED STATUS

MFLs water bodies that are currently being achieved but are projected not tobe achieved within the 20-year planning horizon, are in "prevention" and require a prevention strategy to be developed concurrently with the MFLs. Whether MFLs are being achieved within the planning horizon is determined by comparing the current-pumping condition UFA freeboard of the most constraining environmental criterion to the amount of projected UFA drawdown at the planning horizon.

Water withdrawal information used to assess future status was based on water supply planning projections at the 20-year planning horizon (i.e., not current CUP allocations). The projected UFA drawdown at 2045 was estimated for Johns Lake using the ECFTXv2.0 groundwater model. Assuming all future pumping equals the projected 2045 water demand, the predicted UFA drawdown at the planning horizon is 0.8 feet for Johns Lake.

Under current-pumping conditions, all Johns Lake MFLs are met, and the most constraining metric (open water area metric) for Johns Lake has a UFA freeboard of 1.3 feet. The additional 0.8 feet of drawdown at the planning horizon results in a remaining UFA freeboard of 0.5 feet at 2045. Therefore, the MFLs are met at the planning horizon and Johns Lake is not in prevention or recovery.

WATER RESOURCE VALUES (WRVS)

The following section summarizes the WRVs) assessment conducted for Johns Lake (Table 14). See Appendix E for details regarding WRV metrics and how they were evaluated.

Rule 62-40.473, *F.A.C.* requires that "consideration shall be given to…environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands ecology." The environmental values described in Rule include:

1. Recreation in and on the water;
2. Fish and wildlife habitats and the passage of fish;
3. Estuarine resources;
4. Transfer of detrital material;
5. Maintenance of freshwater storage and supply;
6. Aesthetic and scenic attributes;
7. Filtration and absorption of nutrients and other pollutants;
8. Sediment loads;
9. Water quality; and
10. Navigation.

Consideration of these WRVs) is meant to ensure that the recommended MFLs condition for Johns Lake protects the full range of water-related functions and values that provide beneficial use to humans and ecological communities. However, all 10 WRVs are typically not applicable to a specific priority water body because of varying hydrologic characteristics (e.g., riverine vs. lake systems or the presence/absence of tidal influence). The suite of 10 WRVs listed above were divided into the following three groups based on relevance to Johns Lake and based on whether they protect ecological versus non-ecological structure and function of this system:

- Group 1: WRVs 3, 8 and 10
- Group 2: WRVs 2, 4, 5 and 7
- Group 3: WRVs 1, 6 and 9

Group 1: WRVs 3, 8 and 10

The three WRVs in Group 1 were determined to be inapplicable and thus were not considered as part of this assessment. WRV 3 (Estuarine resources) was not assessedis because the lake has no surface water connection to any Estuarine resources. WRV 8 (Sediment loads) is inapplicable because lakes typically serve as sinks instead of sources of sediment loads. Since transporting inorganic materials as bed load is typically relevant for flowing systems, this WRV was not considered for this evaluation of Johns Lake. WRV 10 (Navigation) is not considered for this lake because this WRV is for the navigation of large watercraft. The use of small watercraft is considered under WRV 1 (Recreation in and on the water).

Group 2: WRVs 2, 4, 5, and 7

The four WRVs in group 2 (fish and wildlife habitat and the passage of fish, the Transfer of detrital material, the maintenance of freshwater storage and supply, and the Filtration and absorption of nutrients and other pollutants) are associated with and depend on the ecological functions and biochemical processes provided by the wetland communities surrounding Johns Lake. The two event-based metrics (FHs) and the seven hydroperiod tool metrics (i.e., fish and wildlife habitats) evaluated for this lake are designed to protect these important ecological functions and biochemical processes by protecting resident habitats from significant harm. The FHs and hydroperiod tool metrics were developed to ensure the protection of a minimum hydrologic regime necessary to protect these functions and values. The Johns Lake MFLs condition was determined based on the most constraining metrics out of all those evaluated (see *MFLs Assessment* for details), assuming that protecting the most constraining metric would be protective of the other less constraining metrics.

The MFLs condition for Johns Lake results in all hydroperiod tool habitat areas being reduced by less than 15% relative to the no-pumping condition (i.e., less than the significant harm threshold for these metrics). The MFLs condition also ensures protection of a hydrologic regime thatwhich will ensure sufficient flooding events (i.e., protects the two FHs) to maintain the ecological structure and functions at Johns Lake (Table 14).

Group 3: WRVs 1, 6, and 9

The three WRVs in Group 3 (recreation in and on the water, aesthetic and scenic attributes, and water quality) are closely related to lake area and depth, and the latter two are also related to conditions of the wetland vegetation communities in and around the lake. The determination of whether these WRVs are protected was based on whether there was significant harm (i.e., a 15% reduction) from the no-pumping condition to the MFLs condition, for specific criteria evaluated for each WRV. The MFLs condition represents the minimum hydrologic regime necessary to protect all the minimum levels (i.e., it is based on the most constraining levels for Johns Lake). The WRVs assessment results indicate that all three WRVs in this group do not exceed the 15% reduction threshold and are therefore protected by the MFLs condition (see Appendix E for details).

Table 14: The WRVs represent environmental values/functions and percent reduction under the MFLs condition relative to the no-pumping condition.

WRV	Representative values or functions	Allowable change from no-pumping	Change Under MFLs Condition	Protected by the MFLs (Yes/No)
Recreation in and on the water	Hydroperiod Tool (HT) Open Water and Canoe depth metrics	15% reduction from the no-pumping condition	≤ 15%	Yes
Fish and wildlife habitats and the passage of fish	The FHs were primarily based on the protection of fish and wildlife habitats with sufficient frequency and duration of flooding events to prevent a down-slope shift in the location of the floodplain wetlands. Several hydroperiod metrics are also based on protecting specific areal depths and coverages for fish and wildlife habitats.			Yes
Estuarine resources	This environmental value is inapplicable because the lake is landlocked and has no surface water connection to estuarine resources.			NA
Transfer of detrital material	Compliance with the recommended open water HT metric provides for the protection of flooding events necessary for the transfer of detrital material in Johns Lake.			Yes
Maintenance of freshwater storage and supply	Because the overall purpose of the event-based MFLs, hydroperiod tool metrics and other WRVs is to protect environmental resources, and other non-consumptive beneficial uses while also proving for consumptive uses, this environmental value is considered protected.			Yes
Aesthetic and scenic attributes	Visual setting around the lake	15% reduction in open water viewing (lake surface area) at median lake level	≤ 15%	Yes
Filtration and absorption of nutrients and other pollutants	Compliance with the recommended MFLs condition provides for the protection of wetland communities which will maintain filtration and absorption of nutrients and other pollutants in Johns Lake.			Yes

WRV	Representative values or functions	Allowable change from no-pumping	Change Under MFLs Condition	Protected by the MFLs (Yes/No)
Sediment loads	This environmental value is not relevant because transport of inorganic materials such as suspended or bed load is important primarily in flowing systems.			NA
Water quality	Water Quality Standards for TN, TP, and CHL-a	15% increase in TN, TP, chl-a concentrations	Water quality would exhibit insignificant change.	Yes
Navigation	This environmental value is not relevant because the primary navigation on Johns Lake is by recreational boaters which is addressed under WRV 1.			NA

CONCLUSIONS AND RECOMMENDATIONS

Minimum levels were developed for Johns Lake using a minimum hydrological event-based approach and a hydroperiod tool approach. The premise of this MFLs determination is that by maintaining the lake's natural flooding and drying characteristics, the basic structure and functions of the ecosystem will also be maintained. SJRWMD investigated numerous ecological and human-use criteria, including two event-based metrics, seven hydroperiod tool metrics and several WRV metrics, to ensure all relevant environmental values and beneficial uses are protected.

RECOMMENDED MINIMUM LEVELS

Minimum levels were developed for Johns Lake using a variety of metrics that were developed to protect important ecological structures and functions, as well as human beneficial uses. The assessment of the recommended minimum levels included evaluating primary ecological metrics as well as assessing a comprehensive suite of both ecological and human-use criteria (see Water Resource Values (WRVs) section and Appendix E). These criteria were developed to ensure that both the main lake body and surrounding wetland attributes and functions are protected by the recommended MFLs condition.

Three minimum levels, a P25, P50 and P75, are recommended for Johns Lake (Table 15; Figure 23). These three percentiles were calculated from the MFLs condition lake-level time series data. This is the lake-level time series that just meets the most constraining environmental metric (i.e., the open water area metric). Adopting these three minimum levels will ensure the protection of the minimum hydrologic regime at low, average and high levels.

Table 15: Recommended Minimum Levels for Johns Lake.

Exceedance Percentiles (P)	Recommended Minimum Lake Level (feet NAVD88)
25	94.8
50	93.7
75	92.2

A suite of 10 environmental values listed in 62-40.473, F.A.C., was considered to ensure the MFLs condition protects all relevant WRVs for Johns Lake. Based on this evaluation, the SJRWMD concludes that the recommended minimum levels for Johns Lake will also protect all relevant WRVs.

The ECFTX v2.0 steady state groundwater model was used for the groundwater pumping impact analysis (see Appendix B for details of the groundwater pumping impact analysis). Assuming climatic, rainfall, and other conditions present from 1948 to 2020 are repeated over the next 73 years, the current-pumping condition reflects the future condition of water levels if the average regional groundwater pumping does not change from the 2016-2020 condition

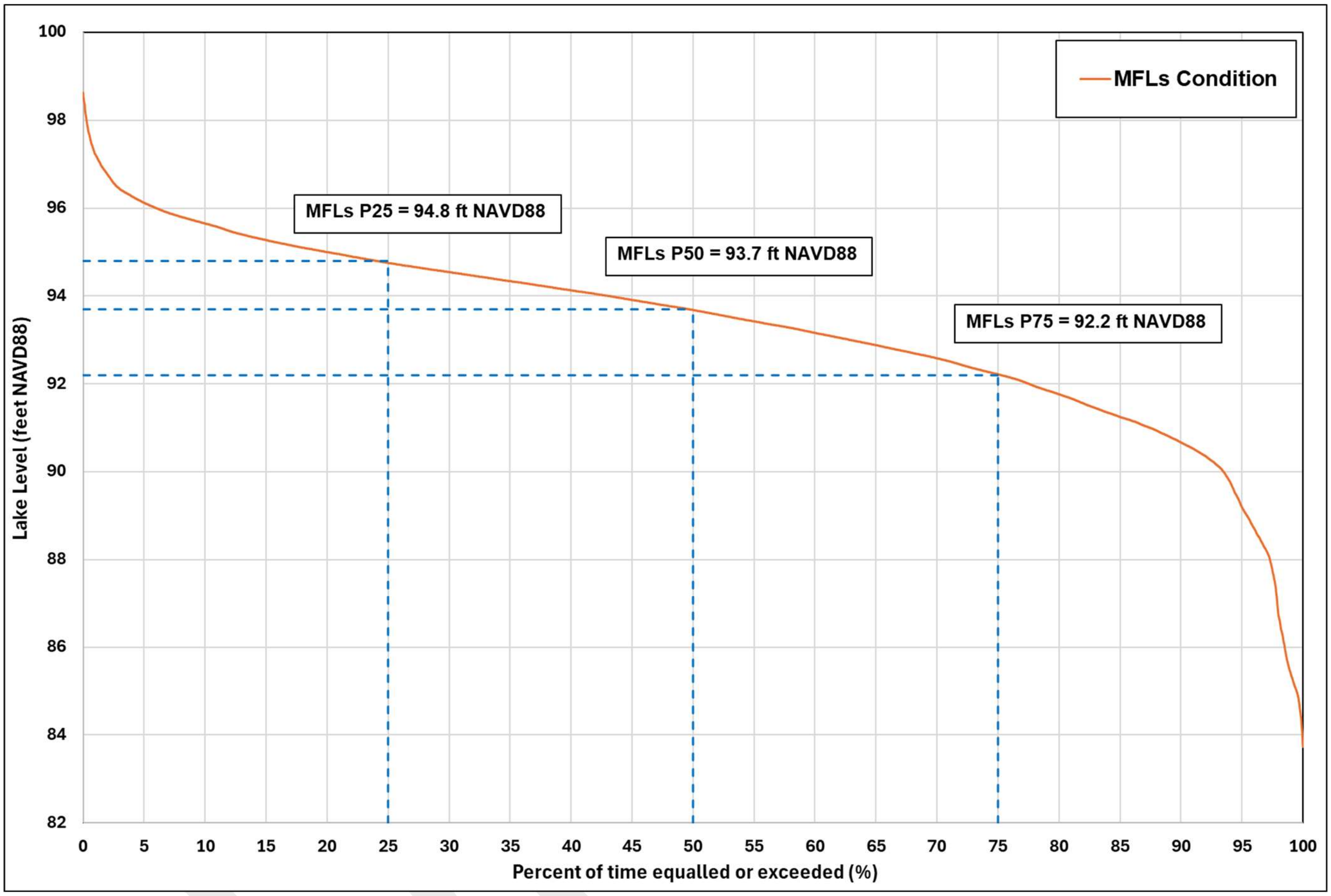


Figure 23: Johns Lake MFLs condition exceedance curve based on the most constraining minimum level (open water ≥ 7 ft). Dashed blue lines indicate the recommended minimum P25, P50, and P75 lake levels.

The MFLs assessment indicates that the two event-based metrics and the seven hydroperiod tool metrics that were assessed are met under the current-pumping condition. The most constraining metric for Johns Lake is the open water area metric, with a UFA freeboard of 1.3 feet; therefore, Johns Lake is not in recovery. Assuming all future pumping is equal to projected 2045 water demand, the predicted UFA drawdown at the planning horizon is 0.8 feet for Johns Lake. Because the planning horizon drawdown is less than the current freeboard, Johns Lake is not in prevention. The information presented in this report is preliminary and will not become effective until adopted by the SJRWMD Governing Board and incorporated in Rule 40C-8.031, *F.A.C.*

ONGOING STATUS / ADAPTIVE MANAGEMENT

Given data, modeling, and other ecohydrological analysis uncertainties, it is important to test implicit assumptions made as part of setting and assessing MFLs. The SJRWMD acknowledges that the MFLs determination and assessment methods, described herein, assume that Johns Lake's hydrological history will repeat itself.

Given the lack of information about the future, and substantial uncertainties in future rainfall and temperature predictions by global climate models, this assumption is considered appropriate but needs to be regularly tested by implementing an adaptive management strategy.

The SJRWMD will implement an adaptive management strategy to address continuing challenges and uncertainties in ecohydrological data and tools. This screening level analysis, considering changes in rainfall and temperature trends and uncertainty, will be performed to monitor the status of the adopted P25, P50, and P75 lake levels for Johns Lake. The constraining metric (open water area) will also be analyzed to ensure it is protected, in addition to the minimum water level percentiles.

This analysis will be performed approximately every five years as part of regional water supply planning efforts or as needed. MFLs status will also be monitored periodically by reviewing the status of system-specific constraining metrics. If the average long-term observed levels fall below the adopted minimum level, a more detailed analysis will be triggered. This analysis will determine whether reductions in lake levels are caused by groundwater pumping or rainfall and whether a further evaluation of the MFLs is necessary. If the screening level analysis shows that MFLs are still being met, no further actions are required beyond continued monitoring.

LITERATURE CITED

Ahlgren, C. E. and H. L. Hansen. 1957, Some effects of temporary flooding on coniferous trees. Journal of Forestry 59: 647-650.

Arthington A.H. 2012. Environmental Flows: Saving rivers in the third millennium. University of California Press: Berkeley.

Boniol, D., and K. Mouyard. 2016. Recharge Areas to the Floridan aquifer in the St. Johns River Water Management District. GIS Layer. Supplemental information to Boniol, D., and K. Mouyard, 2016a: Recharge to the Upper Floridan quifer in the St. Johns River Water Management District, Florida. Technical Fact Sheet SJ2016-FS1, St. Johns River Water Management District.

Brooks, H.K. 1981. Guide to the Physiographic Divisions of Florida. Compendium to the map Physiographic Divisions of Florida, 8-5M-82. Univ. of Florida, Institute of Food and Agricultural Sciences, Cooperative Extension Service, Gainesville, FL.

Carlson, C., D. Maidment and J. Hampson. (2005). Hydroperiod Analysis Tools and Enhanced Time Series for Arc Hydro. Environmental Systems Research Institute International User Conference, San Diego, CA.

[CFWI HAT] Central Florida Water Initiative Hydrologic Analysis Team. 2020. Model Documentation Report. East-Central Florida Transient Expanded (ECFTX) Model Report. Retrieved from https://cfwiwater.com/pdfs/ECFTX_Model_Final_Report_Feb_2020.pdf

Collective Water Resources (CWR), 2019. Hydrologic Modeling Services for Lakes Johns and Avalon.

Enfield, D. B., Mestas-Nunez, A. M., Trimble, P. J., 2001. The Atlantic Multidecadal Oscillation and its relationship to rainfall and river flows in the continental U.S. Geophysical Research Letters. Vol 28. Pg. 2077–2080.

Epting, R. J., Robison, C. P., & Reddi, R. C. 2008. Gauge record hydrologic statistics: Indicators for lake classification. Environmental Bioindicators, *3*(3-4), 193-204.

Foti, R., M. del Jesus, A. Rinaldo, and I. Rodriguez-Iturbe. 2012. Hydroperiod regime controls the organization of plant species in wetlands. Proceedings of the National Academy of Sciences, November 27, 2012. 109(48) 19596-19600

Fox, S, P Kinser, L Keenan, C Montague and D Hydorn. (2012) Appendix D. Hydroperiod Tool Analysis of St Johns River Segment 7. Chapter 10. Wetland Vegetation, St Johns River Water Supply Impact Study, Edgar. F; Lowe, editor. Palatka, FL. Available at https://www.sjrwmd.com/documents/water-supply/#wsis-final-report.

Gordu, F., Sisco, L., Basso, R., Zhang, H., Patterson, J., Kwiatkowski, P., & Obeysekera, A. 2022. East-Central Florida Transient Expanded (ECFTX) V2.0 Model Report. Retrieved from https://cfwiwater.com/pdfs/ECFTX_2.0_Report_040522_final.pdf

JEA Inc. 2006. Sandhill lakes minimum flows and levels values, functions, criteria, and thresholds for establishing and supporting minimum levels. *Prepared for:* St. Johns River Water Management District P.O. Box 1429 Palatka, Florida 32178-1429 *Prepared by:* Jones Edmunds & Associates, Inc.

Jennewein, S., J. Di, F. Gordu, O. Leta, R. Deschler, and A. Sutherland. 2020. Minimum levels determination for Lake Butler, Volusia County, Florida. St. Johns River Water Management District Technical Publication SJ2022-03.

Kelly, M.H. 2004. Florida River Flow Patterns and the Atlantic Multidecadal Oscillation. Draft report. Ecologic Evaluation Section. Southwest Florida Water Management District. Brooksville, FL. 80 pp. + appendix

Kinser, P, S Fox, L Keenan, A Ceric, F Baird, P Sucsy, W Wise and C Montage (2012). Chapter 10. Wetland Vegetation, St Johns River Water Supply Impact Study, Edgar F. Lowe, editor. Palatka, FL. Available at https://www.sjrwmd.com/documents/water-supply/#wsis-final-report

Kirtman, B. P., V. Misra, R.J. Burgman, J. Infanti, and J. Obeysekera. 2017. Florida climate variability and prediction. In E. P. Chassignet, J. W. Jones, V. Misra, & J. Obeysekera (Eds.), Florida's climate: Changes, variations, & impacts (pp. 511–532). Gainesville, FL: Florida Climate Institute. https://doi.org/10.17125/fci2017.ch17

Kuss, A. J. M. and Gurdak, J. J., 2014. Groundwater level response in U.S. principal aquifers to ENSO, NAO, PDO, and AMO. J. Hydrol., 519, pp. 1939-1952.

Leeper, D., M. Kelly, A. Munson, and R. Gant. 2001. A Multiple-Parameter Approach for Establishing Minimum Levels for Category 3 Lakes. Southwest Florida Water Management District. June 14, 2001. Draft Technical Report.

Mace, J.W. 2015. Minimum levels reevaluation: Lake Melrose, Putnam County, Florida. Technical Publication SJ2015-1. St. Johns River Water Management District, Palatka, FL.

Menges, E.S., and P.L. Marks. 2008. Fire and Flood: Why are South-central Florida Seasonal Ponds Treeless? American Midland Naturalist 159(1): 8-20.

Mitsch, W.J. and J.G. Gosselink. 2015. Wetlands. 5th ed. John Wiley & Sons, NY.

Munson, A.B. and J.J. Delfino. 2007. Minimum wet-season flows and levels in southwest Florida rivers. Journal of American Water Resources Association 43(2):522-532.

Murray-Hudson, M., P. Wolski, F. Murray-Huson, M.T. Brown, and K. Kashe. 2014. Disaggregating hydroperiod: components of the seasonal flood pulse as drivers of plant species distribution in floodplains of a tropical wetland. Wetlands 34(5):927-942.

Nagid, E., Tuten, T., and Johnson, K. 2015. Effects of Reservoir Drawdowns and the Expansion of Hydrilla Coverage on Year-Class Strength of Largemouth Bass. North American Journal of Fisheries Management. 35. 10.1080/02755947.2014.963750.

Nagid, E. J. 2022. Florida Handbook of Habitat Suitability Indices. Florida Fish and Wildlife Conservation Commission. Final Report to the Southwest Florida Water Management District, Project 19PO0000689, Gainesville,Florida. https://doi.org/10.6095/YQWK-P357.

National Research Council. 2012. *Review of the St. Johns River Water Supply Impact Study: Final Report*. Washington, DC: The National Academies Press. https://doi.org/10.17226/13314.

Neubauer, C.P., G.B. Hall, E.F. Lowe, C.P. Robison, R.B. Hupalo, and L.W. Keenan. 2008. Minimum Flows and Levels Method of the St. Johns River Water Management District, Florida. Environmental Management 42:1101-1114.

Obeysekera, J, J. Park, M. Irizarry-Ortiz, P. Trimble, J. Barnes, J. VanArman, W. Said, E. Gadzinski 2011. Past and Projected Trends in Climate and Sea Level for South Florida. Interdepartmental Climate Change Group. South Florida Water Management District, West Palm Beach, Florida, Hydrologic and Environmental Systems Modeling Technical Report.

Paulic, M., Hand, J., and Lord, L. 1996. Water-quality Assessment for the State of Florida. Florida Department of Environmental Protection, Tallahassee, FL, Main Report Section 305(b).

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg. 1997. The Natural Flow Regime—A Paradigm for River Conservation and Restoration. Bioscience 47(11):769–784.

Richter, B. D., J. V. Baumgartner, R. Wigington, and D. P. Braun. 1997. How much water does a river need? Freshwater Biology 37:231-249.

Schlesinger, M.E., and Ramankutty N., 1994. An oscillation in the global climate system of period 65-70 years. Nature 367:723–726

Shadik, C., E. Revuelta, A. B. Sutherland, A. Karama, H. N. Capps Herron, and S. Fox (in prep). Minimum Levels Reevaluation for Lake Prevatt, Orange County.

[SJRWMD] St. Johns River Water Management District. 2014. Land cover Land use 2014. GIS Layer. Available online at https://data-floridaswater.opendata.arcgis.com/datasets. Accessed 2023.

Sorenson, J. K. and D. R. Maidment (2004). Temporal Geoprocessing for Hydroperiod Analysis of the Kissimmee River. Center for Research in Water Resources, University of Texas, Austin, TX.

Sorenson, J., J. Goodall, and D. Maidment (2004). Arc Hydro Time Series Framework for Defining Hydroperiod Inundation. Proceedings of the American Water Resources Association GIS and Water Resources Specialty Conference, Nashville, TN.

Sutherland, A.B., R. Freese, J.B. Slater, F. Gordu, J. Di, and G.B. Hall, 2017. Minimum flows determination for Silver Springs Marion County, Florida. Technical Publication SJ-2017-2. St. Johns River Water Management District, Palatka, FL.

Sutherland, A.B., F. Gordu and S. Jennewein. 2021. Minimum levels reevaluation for Lakes Brooklyn and Geneva, Clay and Bradford counties, Florida. St. Johns River Water Management District Technical Publication SJ2021-04. p. 82.

Sutherland, A.B., F. Gordu and A. Karama. 2025. Minimum levels reevaluation for Apshawa Lake South, Lake County, Florida. St. Johns River Water Management District Technical Publication SJ2025-01. p. 86.

Thorp J.H., M.C. Thoms and M.D. Delong. 2008. In Thorp J.H., M.C. Thoms and M.D. Delong. (Eds.), The riverine ecosystem synthesis: Toward conceptual cohesiveness in river science (1st ed.). London, UK: Academic Press/Elsevier.

[USDA, NRCS] United States Department of Agriculture, Natural Resources Conservation Service. 2018. Official Soil Series Descriptions. Available online at http://soils.usda.gov/technical/classification/osd/index.html.

[USDA NRCS] United States Department of Agriculture, Natural Resource Conservation Service. 2023. Official Soil Series Descriptions, USDA – NRCS Soil Survey Division. Available online at url: http://soils.usda.gov/technical/classification/osd/index.html

USF Water Institute, School of Geosciences, University of South Florida. (n.d.). *Johns Lake – Orange County Water Atlas*. https://orange.wateratlas.usf.edu/waterbodies/lakes/14038

Winemiller, K.O. 2005. Life history strategies, population regulation, and implications for 1033 fisheries management. Canadian Journal of Fisheries and Aquatic Sciences 62:872–885.