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MINIMUM LEVELS REEVALUATION

FOR APSHAWA LAKE SOUTH,

LAKE COUNTY, FLORIDA

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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.

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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 water bodies within its boundaries. MFLs establish a minimum hydrologic regime and define the limits at which further consumptive use withdrawals would be significantly harmful to the water resources or ecology of an area. MFLs are one of many effective tools used by SJRWMD to assist in making sound water management decisions and preventing significant adverse impacts due to water withdrawals.

SJRWMD has completed a reevaluation of minimum levels for Apshawa Lake South in Lake County, Florida. Apshawa Lake South is a sandhill lake in the Central Lakes District and is located approximately three miles north of Clermont, in Lake County, Florida. Minimum levels were originally adopted for Apshawa Lake South in 2002. Reevaluated minimum levels are based on implementation of updated methods and more appropriate environmental criteria. The updated methods include results from an updated regional groundwater model and updated surface water model used to quantify the effects of local and regional groundwater withdrawals, and the analysis of an additional ~ 20 years of hydrological data.

Numerous criteria were investigated to ensure that proposed minimum levels would protect important environmental values and beneficial uses. The criteria chosen for this reevaluation include an event-based metric (i.e., the Minimum Average) and six fish and wildlife habitat metrics evaluated using SJRWMD’s hydroperiod tool.

For each environmental criterion, the MFLs condition (recommended minimum condition) and current-pumping condition were compared to determine current status. The current-pumping condition is defined as the average pumping condition between 2014 and 2018, and represents withdrawals influenced by the range of climatic conditions (e.g., rainfall) present over that period. The East Central Florida Transient Expanded version 2.0 (ECFTX v2.0) steady state 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 2014–2018 average current-pumping condition. The most constraining criterion (open-water area metric) has an Upper Floridan aquifer (UFA) freeboard of 0.8 ft under this impacted condition. A UFA drawdown of 0.7 ft is projected at 2045, relative to the current-pumping condition, leaving a freeboard of 0.1 ft at 2045. Therefore, Apshawa Lake South MFLs are met at the planning horizon and this water body is not in prevention or recovery.

Three minimum levels, a minimum P25, P50 and P75, are recommended for Apshawa Lake South (Table ES-1). These three percentiles were calculated from the MFLs condition lake level time series data, based on the most constraining environmental criterion.

Table ES-1. Recommended Minimum Levels for Apshawa Lake South, Lake County, Florida

Percentile	Recommended minimum lake level (ft; NAVD88)
25	83.6
50	82.3
75	80.8

A suite of 10 environmental values (also called water resource values [WRVs]), listed in Florida's Water Resource Implementation Rule, were considered to ensure that the MFLs condition protects all relevant WRVs. SJRWMD concludes that the recommended minimum levels for Apshawa Lake South will also protect all relevant WRVs. The information presented in this report is preliminary and will not become effective until adopted by the SJRWMD Governing Board and incorporated into Rule 40C-8.031, Florida Administrative Code.

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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.

Current-pumping Condition Levels: A long-term simulated water level (lake or aquifer) time series that represents what water levels would be if “current” groundwater pumping was present throughout the entire period of record. The average groundwater pumping available over the latest five-year period is used to estimate “current” groundwater pumping.

Deficit: The amount of water needed to recover an MFL that is not being achieved. Aquifer deficit, for a lake MFL, is expressed as the amount of recovery (in feet) needed in the Upper Floridan aquifer (UFA).

Digital Elevation Model (DEM): Arrays of regularly spaced elevation values referenced horizontally either to a Universal Transverse Mercator (UTM) projection or to a geographic coordinate system. The grid cells are spaced at regular intervals along south to north profiles that are ordered from west to east.

Environmental Criteria: Specific ecological or human use functions evaluated when setting or assessing an MFL.

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.

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. Aquifer freeboard, for a lake MFL, is expressed as the allowable drawdown (in feet) in the UFA.

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 MFL by comparing the frequency of critical hydrological events under current-pumping conditions to the recommended (i.e., MFLs) frequency of these events.

Hydrologic Regime: A timeseries of water levels (or flows) within a specified period of record for a specific water body. Water levels (or flows) 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 level (or flow) that is lower than the no-pumping condition, that protects relevant environmental values from significant harm.

MFLs Condition: The MFLs Condition for a given priority water body is a specific "minimum hydrologic regime" (see definition above) and is based on the most constraining MFLs metric for that system. 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.

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 withdrawals will result in significant harm to the water resources or the ecology of the area (Sections 373.042 and 373.0421, F.S.).

Minimum Level: A hydrological statistic (e.g., minimum median lake level) that is developed and adopted to protect a priority water body. Some minimum levels (e.g., Minimum Infrequent High, Minimum Average, or other MFL) are hydrological events, composed of a magnitude and duration, and a return interval. Some are hydrological exceedance percentiles (e.g., P25, P50, P75).

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

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.

Return Interval: a component of an event-based minimum level or flow representing the recommended frequency of a minimum hydrological event.

Threshold: The allowable change to an environmental criterion, from the no-pumping condition.

INTRODUCTION

The St. Johns River Water Management District (SJRWMD) completed a reevaluation of minimum levels for Apshawa Lake South in Lake County, Florida. SJRWMD's Governing Board adopted Minimum Flows and Levels (MFLs) for Apshawa Lake South and Apshawa Lake North in 2002 (Curtis and Robison 2001; Appendix A; Table 1).

Table 1. Adopted (2002) minimum levels for Apshawa Lake South and Apshawa Lake North, Lake County, Florida

System	Minimum Level	Level (ft; NAVD88)	Hydroperiod Category
Apshawa Lake South	Frequent high	84.9	Seasonally flooded
	Average	83.6	Typically saturated
	Frequent low	82.1	Semipermanently Flooded
Apshawa Lake North	Frequent high	83.9	Seasonally Flooded
	Average	82.2	Typically saturated
	Frequent low	80.2	Semipermanently Flooded

Apshawa Lake South is on SJRWMD's MFLs Priority List and is scheduled for reevaluation in 2024. Although original set at the same time as Apshawa Lake South, the adjacent Apshawa Lake North is not being reevaluated. This is because preliminary analyses show that it will be protected by setting MFLs that provide protection for environmental resources at Apshawa Lake South. This protection is afforded due primarily to differences between lake morphometry and landscape position. Apshawa Lake North is surrounded by relatively steep slopes while Apshawa Lake South has a more extensive floodplain, particularly on the north and west sides of the lake. Therefore, changes in water levels cause larger changes in lake area at Apshawa Lake South as compared to Apshawa Lake North. The latter is at a lower elevation and receives surficial inflow from the former.

Because Apshawa Lake South is higher in the landscape, the protection of water levels at this lake will provide protection for Apshawa Lake North (i.e., because the latter is downstream). Previous analyses provide support for this conclusion, showing that critical elevations at Apshawa Lake North are less sensitive to groundwater withdrawal than those at Apshawa Lake South. Wetland and soils boundaries were found to be approximately 1 to 2 ft lower in elevation at the northern lake, and analyses showed that protection of the higher lake provided protection of the lower lake. For this reason, and to simplify future status assessment efforts, it was deemed appropriate to move forward with the MFLs reevaluation for only Apshawa Lake South.

Further, Apshawa Lake South was selected for reevaluation because it is an important water sentinel for assessing the effects of groundwater withdrawal within the Central Florida Water Initiative (CFWI) area. This lake is highly connected to the Upper Floridan aquifer (UFA) and is therefore an important part of a regional network of sentinel sites needed to indicate potential impacts due to groundwater pumping. The current reevaluation was also conducted to ensure that the MFLs for Apshawa Lake South are based on the most up to date methods. The reevaluation described herein resulted in the recommendation to modify the adopted MFLs for Apshawa Lake South based on current SJRWMD MFLs determination and assessment methodologies. This report summarizes environmental analyses used to develop protective criteria and updated minimum levels for Apshawa Lake South. Hydrological analyses and current and future status assessment of recommended minimum levels are also provided.

LEGISLATIVE OVERVIEW

SJRWMD establishes minimum flows and levels for priority water bodies within its boundaries pursuant to section 373.042, Florida Statutes (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(1)(a), F.S.). MFLs are established using the best information available (section 373.042(1), 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 withdrawals (section 373.0421(1)(a), F.S.).

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 by 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.

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.).

MFLs Program Overview

SJRWMD is engaged in a districtwide effort to develop MFLs for protecting 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 planning and permitting of surface water or groundwater withdrawals.

The purpose of setting MFLs is to answer an overarching question: What hydrologic regime is needed to protect critical environmental functions and values of a priority water body from significant harm due to withdrawals?

MFLs are not meant to represent optimal conditions. Rather, they are mandated by statute to set the limit to withdrawals, beyond which significant harm will occur. A fundamental assumption of SJRWMD's approach is that alternative hydrologic regimes exist for a specific water body that are lower than the pre-withdrawal historical regime but will protect the environmental functions and values of priority water bodies from significant harm caused by water withdrawals.

The Apshawa Lake South MFLs reevaluation involved two separate but interrelated components: 1) the MFLs Determination; and 2) the MFLs Assessment. The first involves determining a minimum hydrologic regime (e.g., MFLs condition) necessary to protect relevant water resource values. The second involves comparing this MFLs condition to the current-pumping condition (see below for details) to determine the current status of the MFLs. The overall approach involves environmental assessments, hydrologic modeling, independent scientific peer review, and rulemaking.

Many SJRWMD MFLs define a protective frequency of high, intermediate, and low hydrologic events (Neubauer et al. 2008). However, for some priority water bodies, for which an event-based approach is not appropriate, a protective minimum hydrologic regime is established based on a percentage of change allowable from a pre-withdrawal (no-pumping) condition. The goal of both approaches is to identify relevant environmental metrics that are sensitive to water withdrawal and, through their assessment, determine the amount of water available for consumptive and non-consumptive uses.

No matter how environmental thresholds are set, or how many MFLs are adopted for a water body, the most constraining MFL is always used for water supply planning and permitting. If water levels are below an MFL, or are projected to fall below within 20 years, SJRWMD must adopt a recovery or prevention strategy concurrent with the MFL to ensure that MFLs are achieved now or in the future. By ensuring that the most sensitive environmental metric is protected, assurance is also provided that all other relevant environmental metrics will be protected.

SETTING AND DESCRIPTION

LOCATION AND PHYSIOGRAPHIC SETTING

Apshawa Lake South is located in Lake County, Florida, approximately three miles north of Clermont, and one mile west of US highway 27 (Figure 1). It is located within Section 2, Township 22 South, Range 25 East, in the U.S. Geological Survey (USGS) Clermont West 7.5-minute topographic quadrangle map. Apshawa Lake South is located in the physiographic region known as the Groveland Karst subdistrict of the Central Lakes District (Figure 2). According to Brooks (1982), it is "…an area of linearly oriented, low, sand hills and solution lakes in an advanced stage of planation. The area of prairie, swamps, and lakes exceeds that of xeric [droughty] sand hills." Apshawa Lake South is immediately west of the Sugarloaf Mountains section of the Lake Wales Ridge, an area of very high sand hills underlain by sand, gravel, and clayey sand. The Central Lakes District as a whole is an important recharge area for the Floridan aquifer (Brooks 1982). While the surrounding sand hills have high recharge rates (Figure 3), the areas immediately adjacent to the lake have recharge estimated at 0-4 inches (in.) per year. The surrounding high sand hills have very high recharge rates of > 20 in. per year (Boniol and Fortich 2005).

BATHYMETRY

Apshawa Lake South is a bowl-shaped lake consisting of a rim of high elevation surrounding a deeper center with a maximum depth of roughly 20 ft at a stage of 85.8 ft NAVD88 (Figure 4). Based on observed water levels period of record (POR), which spans from 1953 to 2022, Apshawa Lake South ranges from 78.6 acres at the 10th exceedance percentile (P10 = 86.0 ft; NAVD88) to 53.6 acres at the P90 (80.2 ft; NAVD88), with a median (P50) acreage of 65.4 acres at 83.3 ft NAVD88. 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 5; see *MFLs Determination* for details).

The northern edge of the lake has a more gradual decrease in elevation, leading to some wet prairie and shallow marsh communities. There are two lobes present that consist of lower elevations and contain organic soils. A hydroperiod tool analysis utilizing the bathymetric data shows that the acreage of the lake varies from 43.8 acres at 77.9 ft NAVD88 to 100.8 acres at 91.4 ft NAVD88. Acoustic doppler profiling, soundings, and LIDAR data were all used to develop the DEM and bathymetric map for Apshawa Lake South.

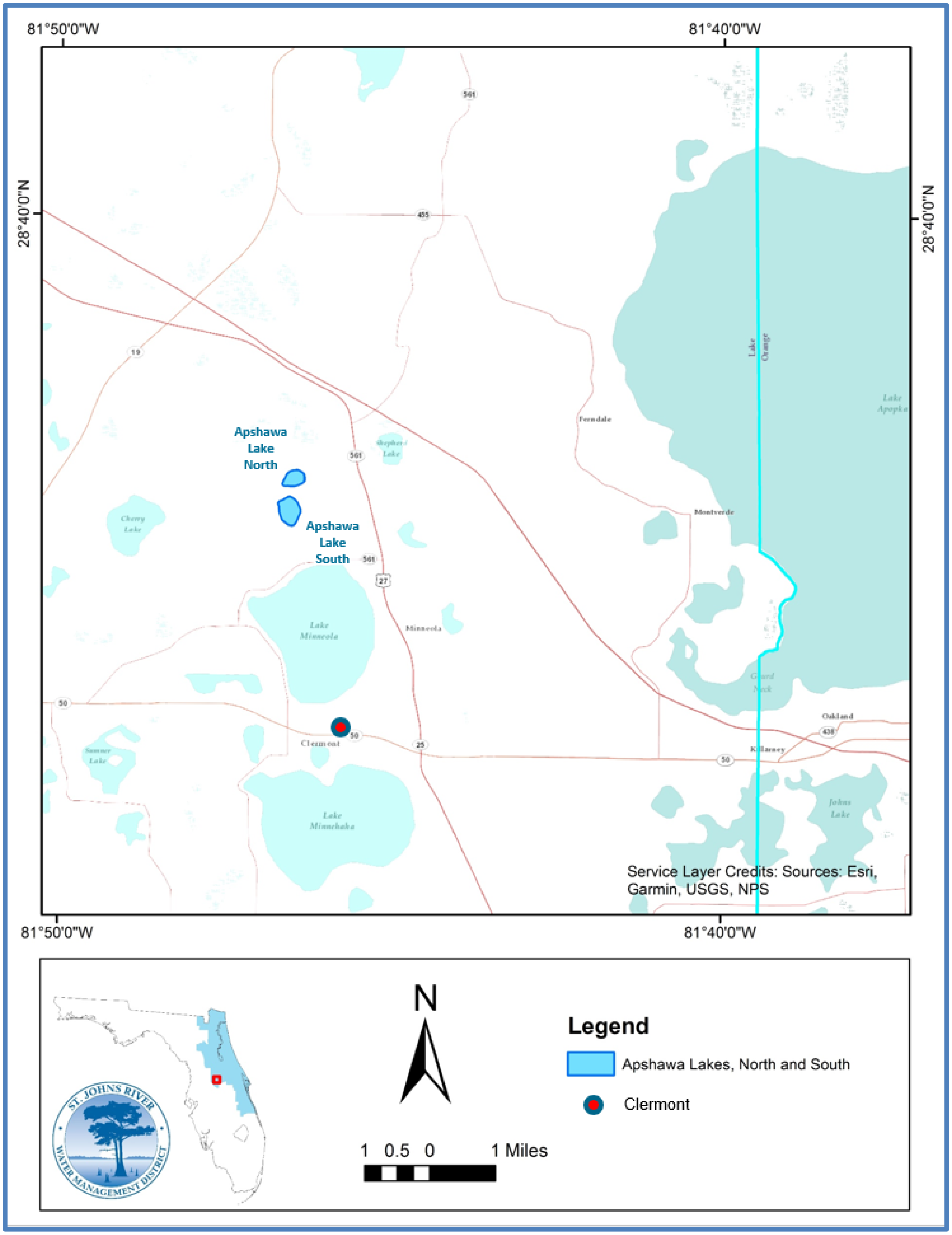

Figure 1. Location of Apshawa Lakes North and South, near the city of Clermont in Lake County, Florida

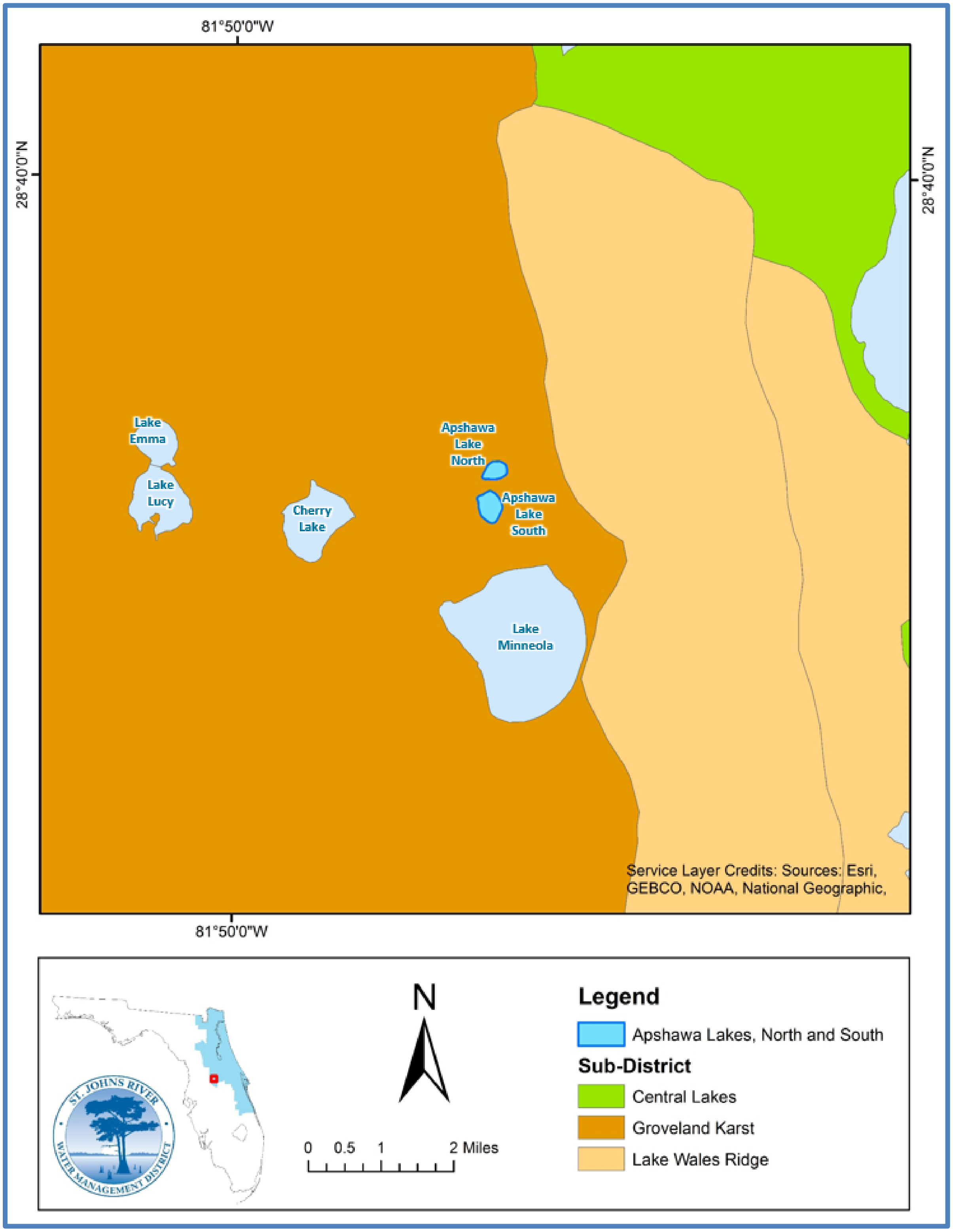

Figure 2. Physiographic sub-districts surrounding Apshawa Lakes North and South, Lake County, Florida

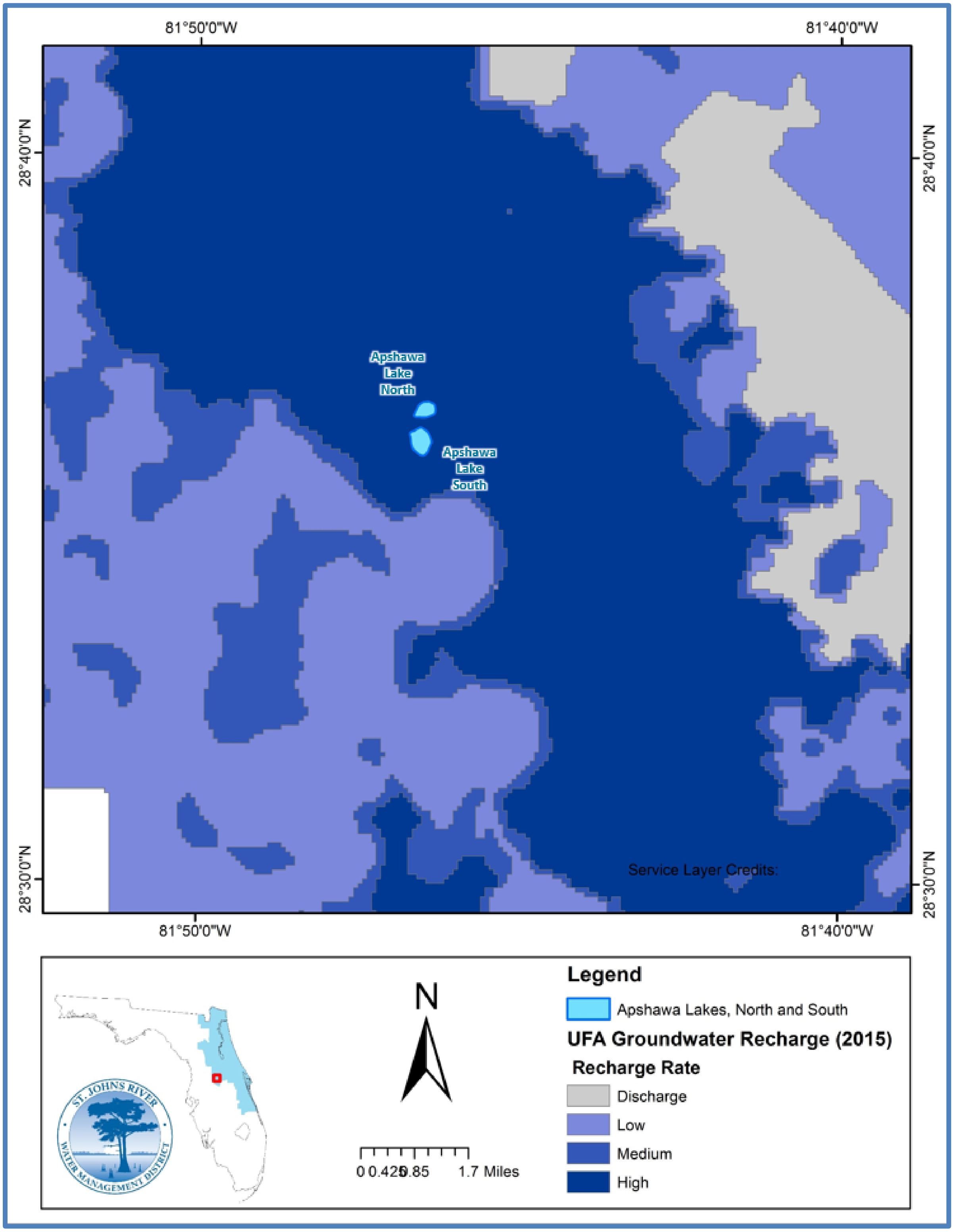

Figure 3. Recharge rates near Apshawa Lakes North and South, Lake County, Florida (Source: SJRWMD 2015)

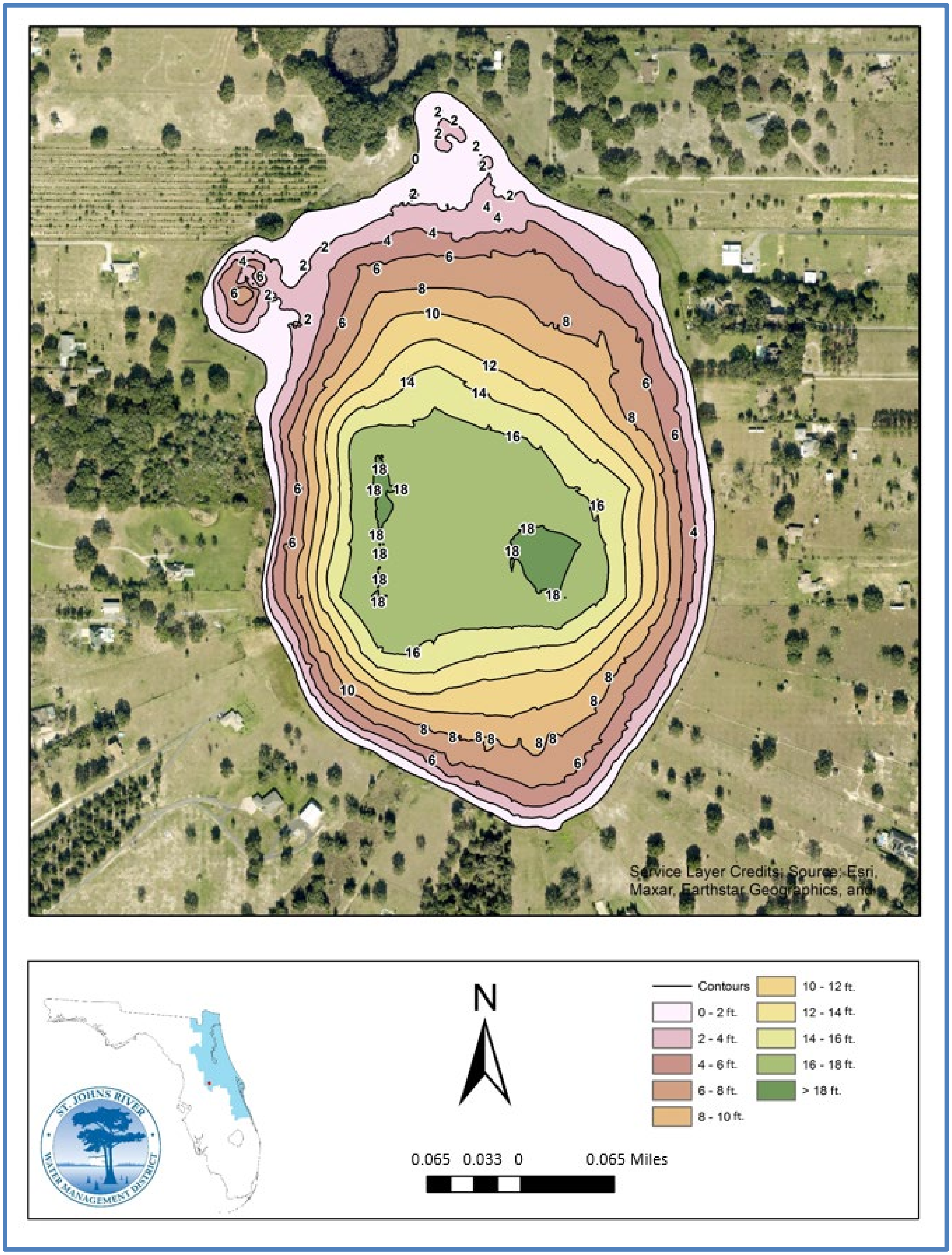

Figure 4. Apshawa Lake South bathymetric contour map, based on digital depth model (Source: SJRWMD 2015)

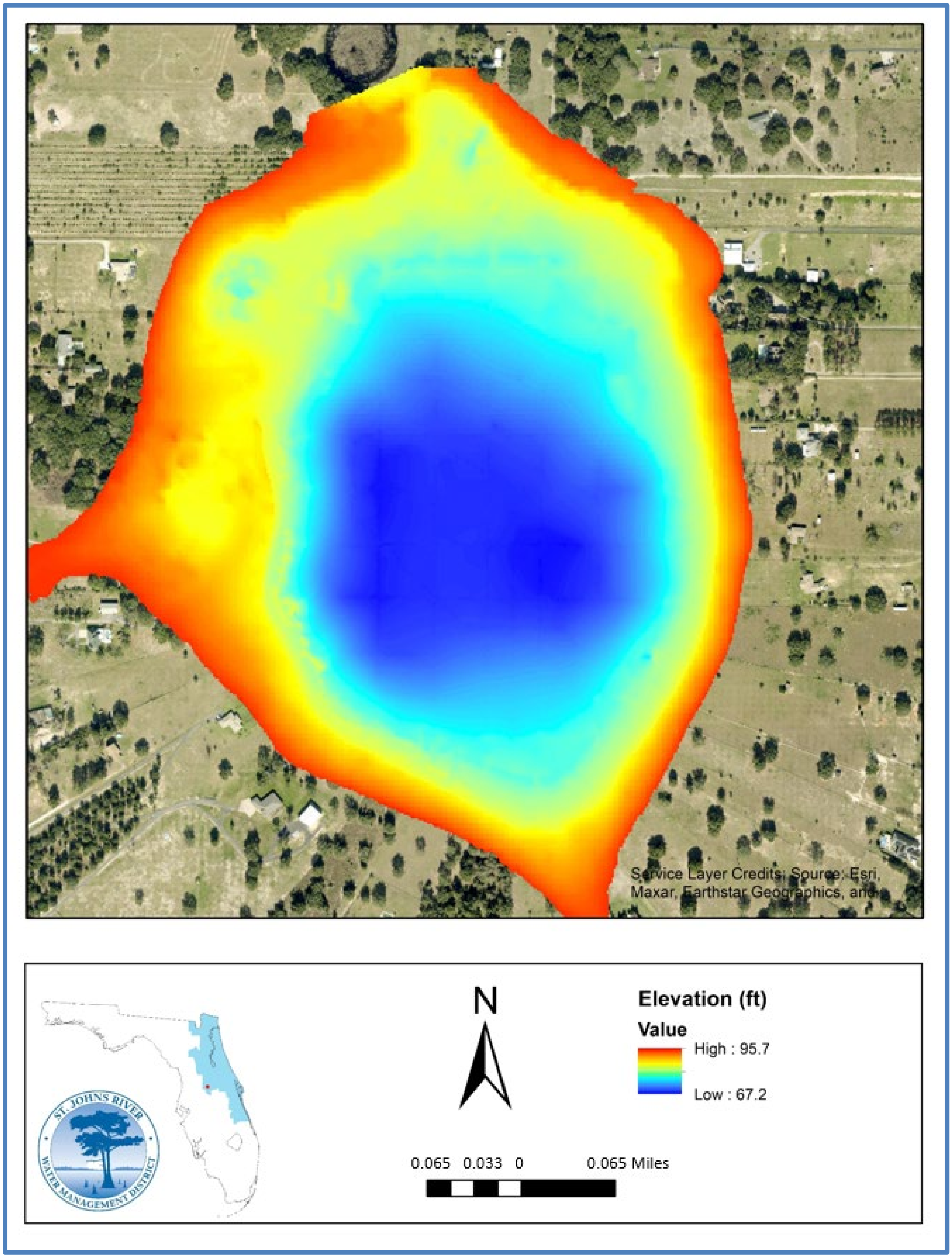

Figure 5. Apshawa Lake South digital elevation model (DEM) data (Source: SJRWMD 2022)

Hydrology

Apshawa Lake South is classified as a high range, average symmetry lake (Epting et al. 2008). This classification includes isolated to intermittent ridge lakes with moderate leakage to the Floridan aquifer and low surface water outflow. The dominant water budget components of these lakes are runoff from a pervious basin and seepage to the Floridan aquifer. Over the long term, direct rainfall and direct evaporation approximately offset each other for these lakes.

Water Level Data

Water level data are available for Apshawa Lake South (SJRWMD station 02930258) from 1953 to the present. Based on 11,801 daily observations from 1953–2022, Apshawa Lake South fluctuated 13.5 ft, with an average stage of 83.0 ft NAVD88 and a median stage of 83.2 ft NAVD88 (Figure 6). The maximum and minimum water level elevations during this period are 91.4 and 77.9 ft NAVD88, respectively (Table 2).

Table 2. Summary statistics for Apshawa Lake South water level data (SJRWMD station 02930258; 1953-2022).

Hydrologic Statistic	Value based on POR: 1/27/1953 to 12/9/2022
Mean	83.0
Median	83.2
Standard Deviation	2.0
Range	13.5
Minimum	77.9
Maximum	91.4

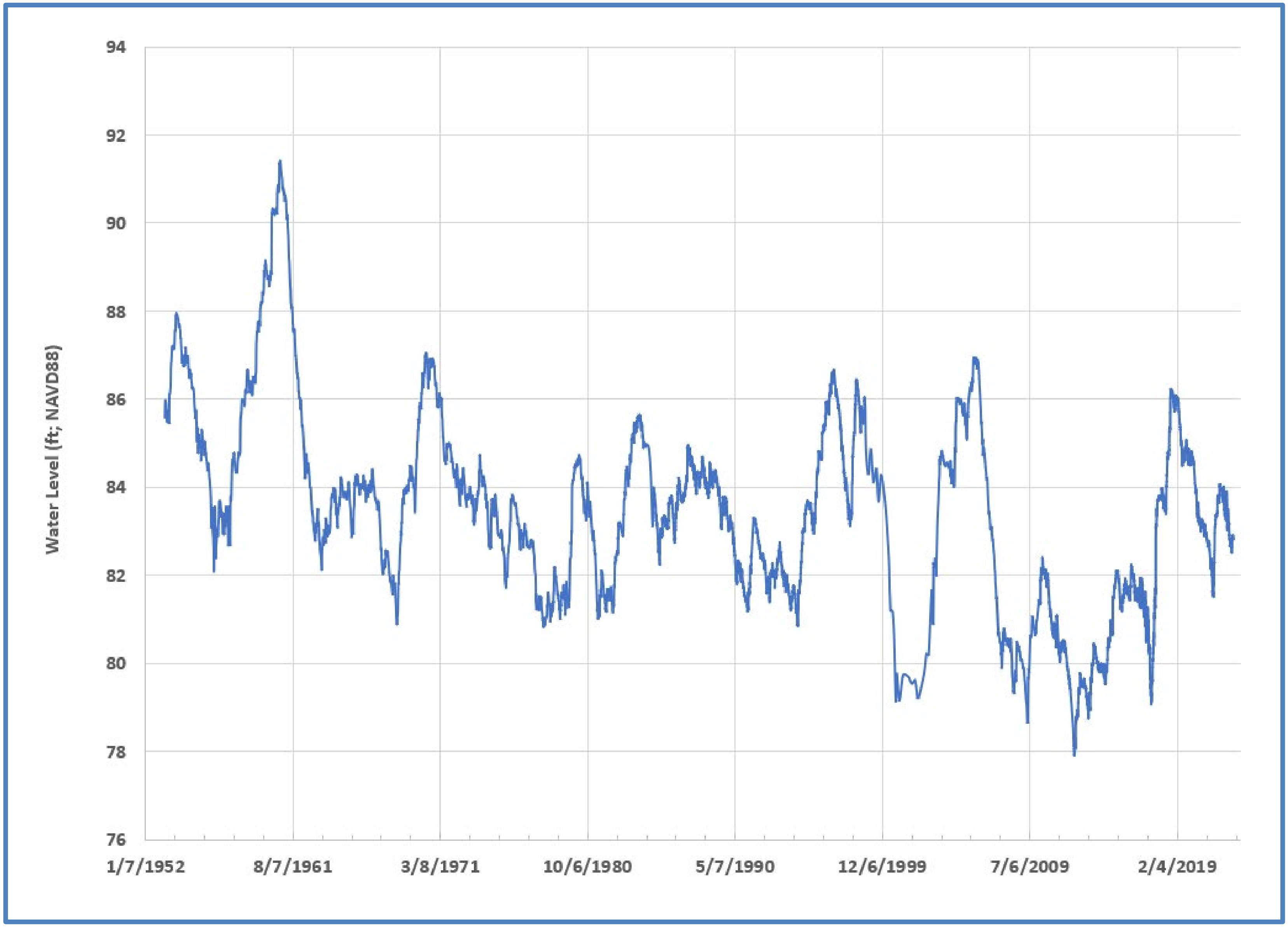

Figure 6. Apshawa Lake South water level hydrograph (1953–2022)

Rainfall and Evapotranspiration

Long-term rainfall data used in the Apshawa Lake South hydrologic analysis are from different rainfall stations recorded at Isle Win (see Appendix B for details). The rainfall data at Isle Win are available from January 1, 1916, to December 31, 2018. Annual rainfall ranges from 22.3 inches in year 2000 to 78.8 inches in year 1953, with an average annual precipitation of 50.4 inches (Table 3).

Potential evapotranspiration (PET) was computed from temperature data obtained from the NOAA station in Clermont. Clermont PET is available from January 1, 1948, to December 31, 2018. The annual PET at Clermont ranges from 55.2 inches in year 1983 to 65.5 inches in year 2000, with an average annual PET of 59.5 inches (Table 3).

Table 3. Rainfall and PET summary statistics for Apshawa Lake South

Descriptive Statistics	Annual Precipitation (in) at the Isle Win	Annual PET (in)
Average	50.4	59.5
Median	50.0	59.3
Standard Deviation	9.6	1.9
Minimum	22.3	55.2
Maximum	78.8	65.5

Long-term UFA groundwater levels

UFA groundwater monitoring wells near Apshawa Lake South include L-0001, L-0062 and L-0054 (Table 4). L-0001 well is the closest one and was used in the surface water model. L-0062 and L-0054 wells were used to extend or fill in the missing values of L-0001. The extended long-term L-0001 UFA groundwater levels are from January 27, 1959, to present (Figure 7).

Table 4. UFA Groundwater Stations near Apshawa Lake South

Station Number	Station Name	Latitude	Longitude	POR Start date	POR End date
11111435	L-0001 Clermont Deep Replacement (WL) FA	28.554	-81.765	5/17/1982	present
09252090	L-0062 Mascotte Deep (WL) FA	28.535	-81.913	1/27/1959	present
09680944	L-0054 College St at Leesburg (WL) FA	28.812	-81.892	9/12/1973	present

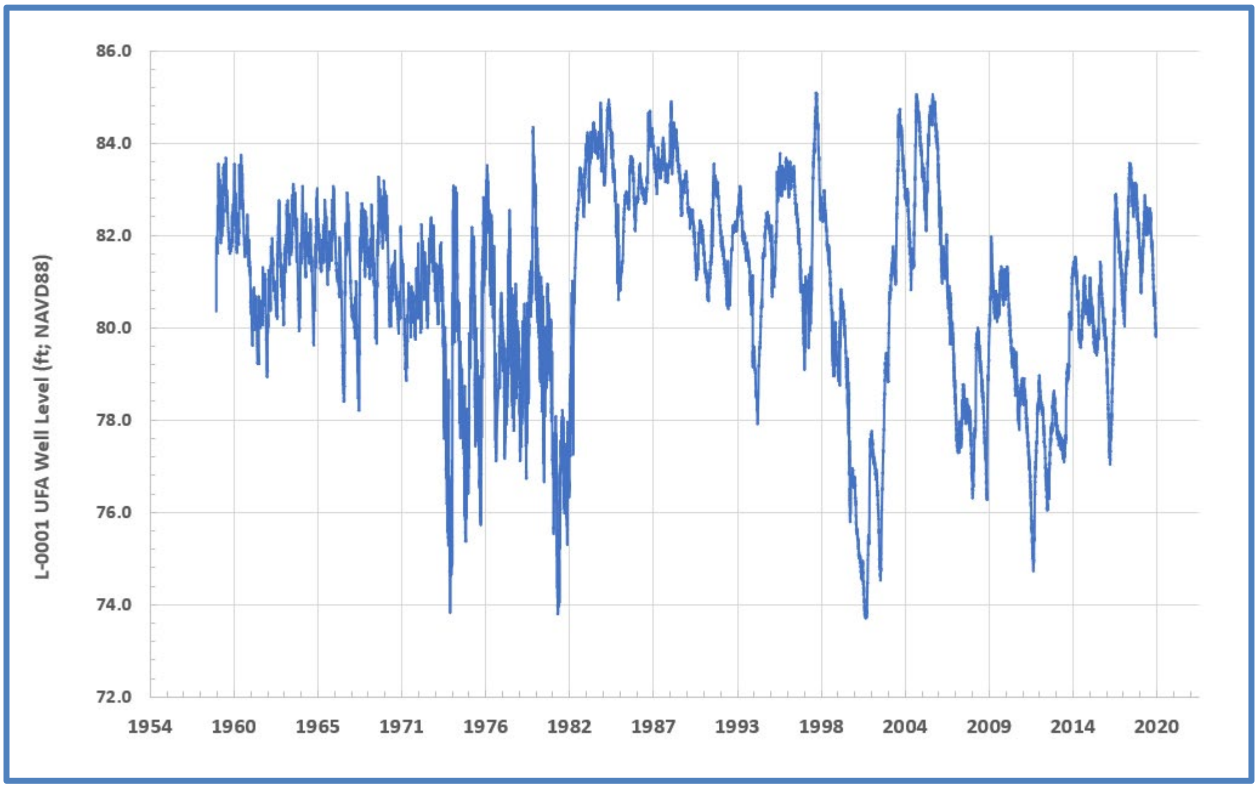

Figure 7. Extended Long-term UFA Groundwater Levels at Well L-0001

Historical Groundwater Use

Groundwater pumping within a 30-mile radius buffer zone around Apshawa Lake South was used as part of the MFLs impact assessment to build a pumping-drawdown relationship. This relationship was used as a proxy to understand the variation of regional groundwater pumping during the simulated POR (1930 to 2018). Ultimately the impact of groundwater pumping on lake levels was assessed based on all groundwater pumping within the groundwater model domain (see Appendix B for more details).

Groundwater pumping was estimated from 1930 to 2018 using the data available from multiple sources. Data from 1995 to 2014 was from the Central Florida Water Initiative (CFWI) regional water supply plan which was a collective effort between water management districts and stakeholders. Data for 2015 to 2018 was from SJRWMD's historical water use database with actual monthly use and station-level details. The data from 1965 to 1995 were based on the United States Geological Service (USGS) published county-level water use (available every five years starting in 1965) and SJRWMD county-level Annual Water Use Survey (AWUS), starting in 1978. Using these two sources, the water use data was aggregated to the county for every five years and some years in between from 1965. Any missing years for each county were estimated using an exponential growth assumption to create a complete aggregate table. If the USGS and AWUS estimates do not match, the published AWUS data were used. To estimate annual groundwater use by county for the period before 1965, per capita groundwater use was estimated for each county. Multiplying the 1965 per capita water use by the historic county-level population from U.S. Census, the annual groundwater uses by county were estimated for the period before 1965. The U.S. Census data was reported in 10-year intervals. An exponential growth was assumed to estimate the annual population between 10-year intervals. The 1995 proportion of county water use captured in the buffer zone was multiplied to the county aggregate from 1930 to 1994 to estimate the water use within the Apshawa Lake South buffer zone. Total average annual groundwater use in the 30-mile buffer reached its highest in 2006 (450 mgd) and declined afterwards to an average total groundwater use from 2014–2018 of approximately 370 mgd (Figure 8).

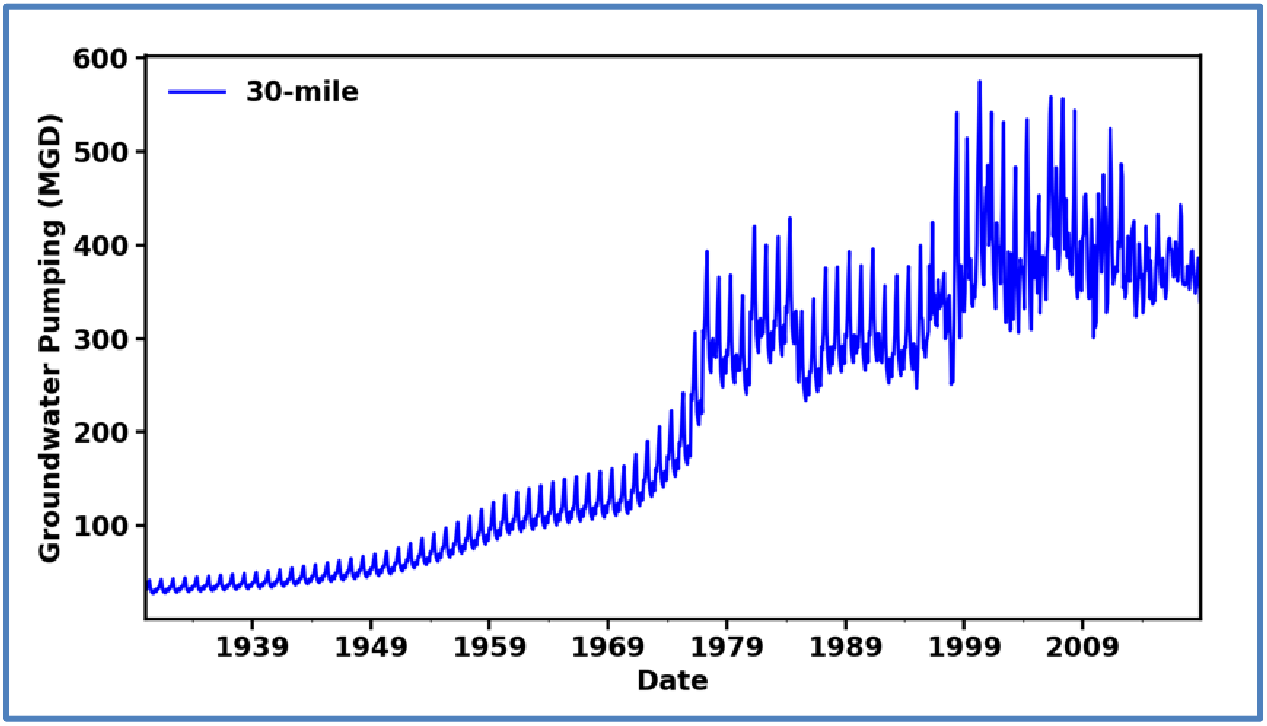

Figure 8. Extended historical groundwater use near Apshawa Lake South within a 30-mile radius

SURFACE WATER BASIN CHARACTERISTICS

Land Use

The land use surrounding Apshawa Lake South is a mix of low-density residential development and agriculture, with the latter comprised primarily of horse pastures and orange groves to the north (Figure 9). The contributing basin surrounding Apshawa Lake South is just under 1,500 acres in size and is based on the boundary used for the Apshawa Lake South surface water model. Low-density residential, agricultural (pasture) and non-forested upland comprise the majority of the basin, at 63.6% (953.0 acres), 19.4% (290.9 acres) and 11.5% (172.9 acres), respectively (Table 5). Other land uses include approximately 2.8 acres (0.2 %) of forest; 29.2 acres (2.0 %) of wetlands and 48.9 acres (3.3 %) of open water (Table 5). There is no public access to Apshawa Lake South, but fishing and boating are common recreational activities for residents (SJRWMD staff observations).

Mapped Wetlands

Based on SJRWMD remotely sensed data (i.e., mapped wetlands) and field site visits, wetland communities at and in the vicinity of Apshawa Lake South are dominated by shallow marsh (11.3 acres; ~40%) and emergent vegetation/deep marsh (8 acres; ~28%) (Kinser 1996, Kinser et al., 2012; Figure 10). Acreage and percentages of all wetland communities are presented in Table 6.

Shallow marshes are herbaceous or graminoid communities dominated by species such as sawgrass, maidencane, cattails, pickerel weed, arrowhead or other grasses and broad-leaved herbs. It occurs most often on organic soils subject to lengthy seasonal inundation and occasional fire. Emergent vegetation, including deep marsh communities are dominated by a mixture of water lilies and deep-water emergent species. Deep marshes are distinguished from submerged aquatic beds, which are permanently flooded and consist of aquatic plants rooted in the sediments of shallow water bodies with most of photosynthetic tissue below the water surface (Kinser 1996). Wet prairies are communities of grasses, sedges, rushes, and herbs typically dominated by sand cord grass, maidencane, or a mixture of species. It usually occurs on mineral soils that are inundated for a relatively short duration each year, but with prolonged soil saturation. Mixed shrub wetland refers to vegetation communities dominated by willows, buttonbush, and similar shrubby species.

The wetland community maps are a useful preliminary planning tool, but the coarse scale of resolution means that there are inevitable differences between mapped and actual vegetation found at the lake. Wetland community descriptions were developed based on field data collected along field transects at Apshawa Lake South (Appendix C).

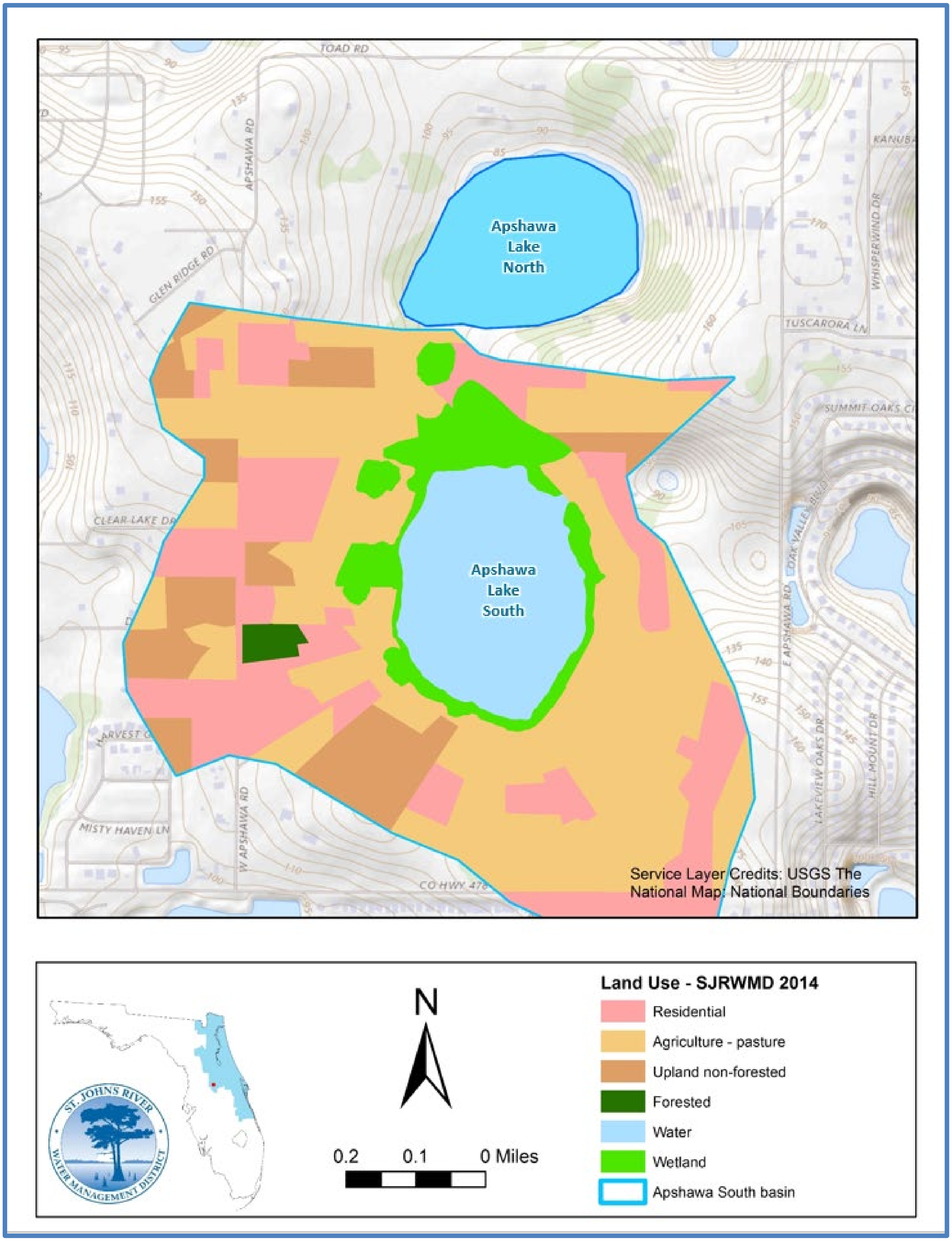

Figure 9. Land uses surrounding Apshawa Lake South, Lake County, Florida (Source: SJRWMD 2014)

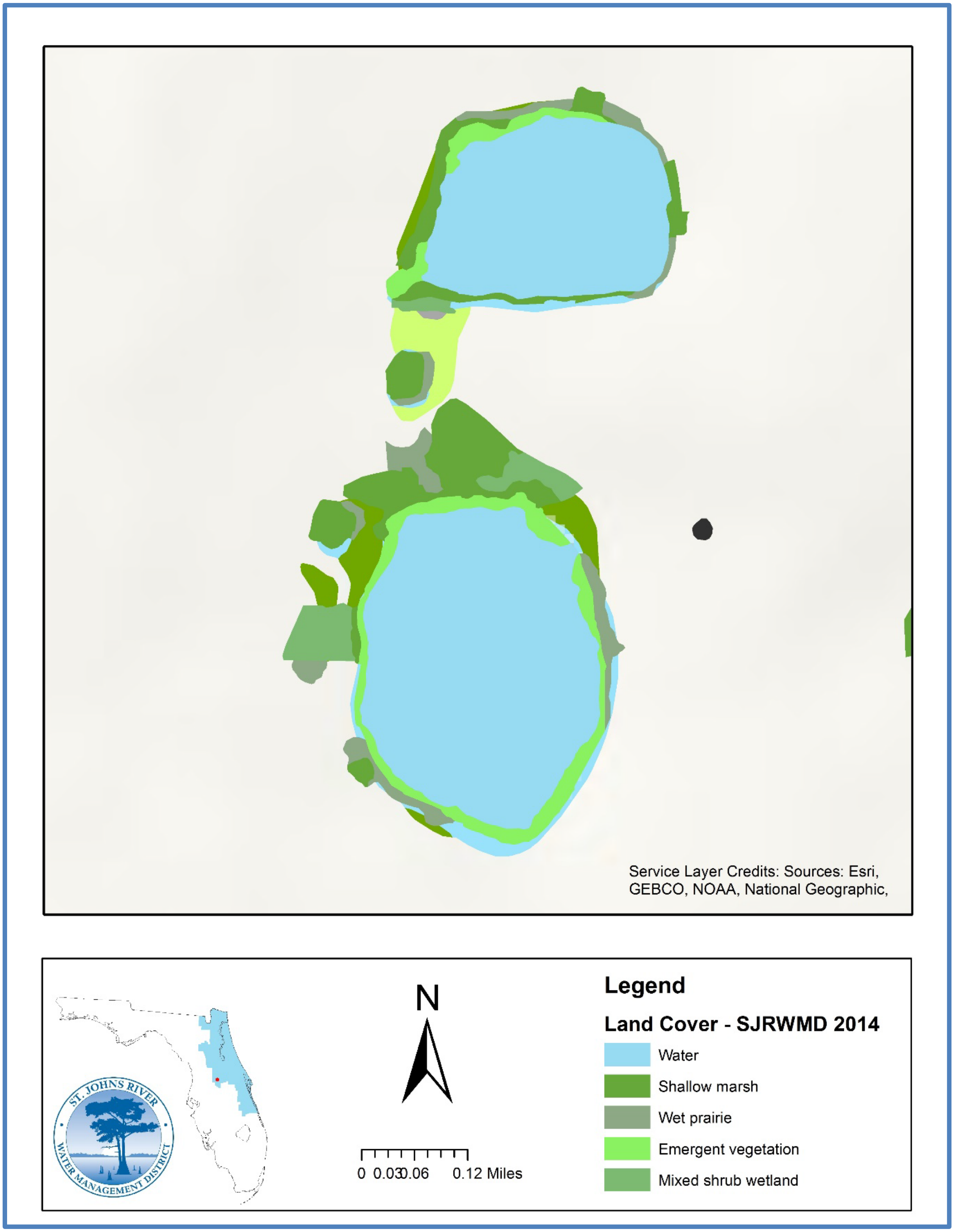

Figure 10. Mapped wetland communities surrounding Apshawa Lakes North and South, Lake County, Florida (Source: SJRWMD 2014)

Table 5. Land Use within the contributing basin of Apshawa Lake South

Land Use	Acres	Percent of Basin
Residential	953.0	63.6
Agricultural / Pasture	290.9	19.4
Non-forested upland	172.9	11.5
Forest	2.8	0.2
Wetland	29.2	2.0
Water	48.9	3.3
Total	1,497.7	100.0

Table 6. Area (acres) of wetlands adjacent to Apshawa Lake South, Lake County, Florida

Community	Acres	Percent of Basin
Shallow marsh	11.3	39.8
Wet prairie	4.6	16.2
Emergent vegetation	7.9	27.8
Mixed shrub wetland	4.6	16.2
Total	28.4	100.0

Mapped Hydric Soils

The development of hydric soils and hydric soil indicators are related to biogeochemical processes that occur in inundated soils. Hydric soils are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part (USDA Soil Conservation Service 1987). Hydric soil indicators are often confounding on sandhill lakes due to the presence of ephemeral wetland plant communities (Nkedi-Kizza and Richardson, 2007). Hydric soils are currently mapped on the northern and western perimeter of Apshawa Lake South (Figure 11; USDA 2019). They are located where subsurface water flows from Apshawa Lake South to Apshawa Lake North, generally coinciding with

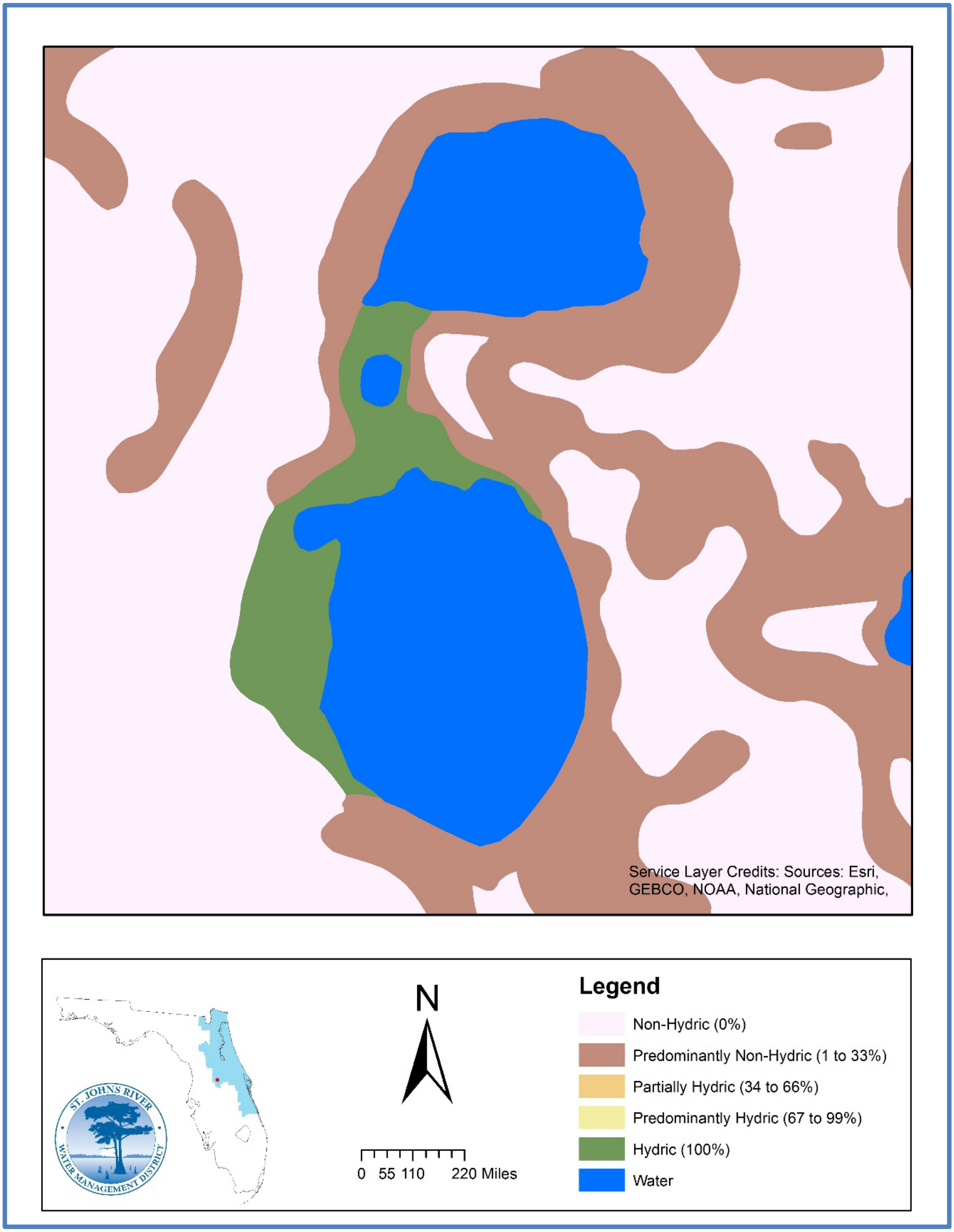

Figure 11. Hydric soils distribution surrounding Apshawa Lakes North and South, Lake County, Florida (Source: USDA 2019)

the location of shallow marsh and wet prairie.

Three soil classes are mapped adjacent to Apshawa Lake South: Entisols, Spodosols, and Inceptisols. (USDA NRCS 2007, FAESS 2000; Figure 12). As with wetland maps, remotely sensed hydric 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 Appendix C. Soils data were also used in the MFLs reevaluation (see below for more details).

Water Quality

Water quality data collected at Apshawa Lake South are limited. Parameters related to trophic state were sampled at Apshawa Lake South 12 times by the University of Florida's Lakewatch program between February 2006 and January 2007 (Table 7). A brief summary of the data, including Secchi depth (Figure 13), Trophic State Index (TSI: Figure 14), Total Phosphorus (TP: Figure 15), Total Nitrogen (TN: Figure 16), and Chlorophyll (chl a: Figure 17), are presented below. Based on the sparse data collected in 2006 and 2007, secchi depth (a measure of water clarity) is generally positively related to water level; a relationship between water level and TSI, TP, TN and chl *a* is not apparent based on these data. A summary of typical water quality for the Clermont Uplands region is described by Griffith et al. (1997) and presented in Table 8. Based on the sparse data available, Apshawa Lake South has TP and chl *a* concentrations typical of the region, and TN concentrations lower than typical.

Table 7. Summary of available Lakewatch water quality data for Apshawa Lake South (n=12; Source: Lakewatch 2007)

Parameter	Minimum	Average	Maximum
Total Phosphorus (μg/l)	7	9	20
Total Nitrogen (μg/l)	300	426	540
Chlorophyll *a* (μg/l)	1	2	3
Secchi depth (ft)	8	11	16

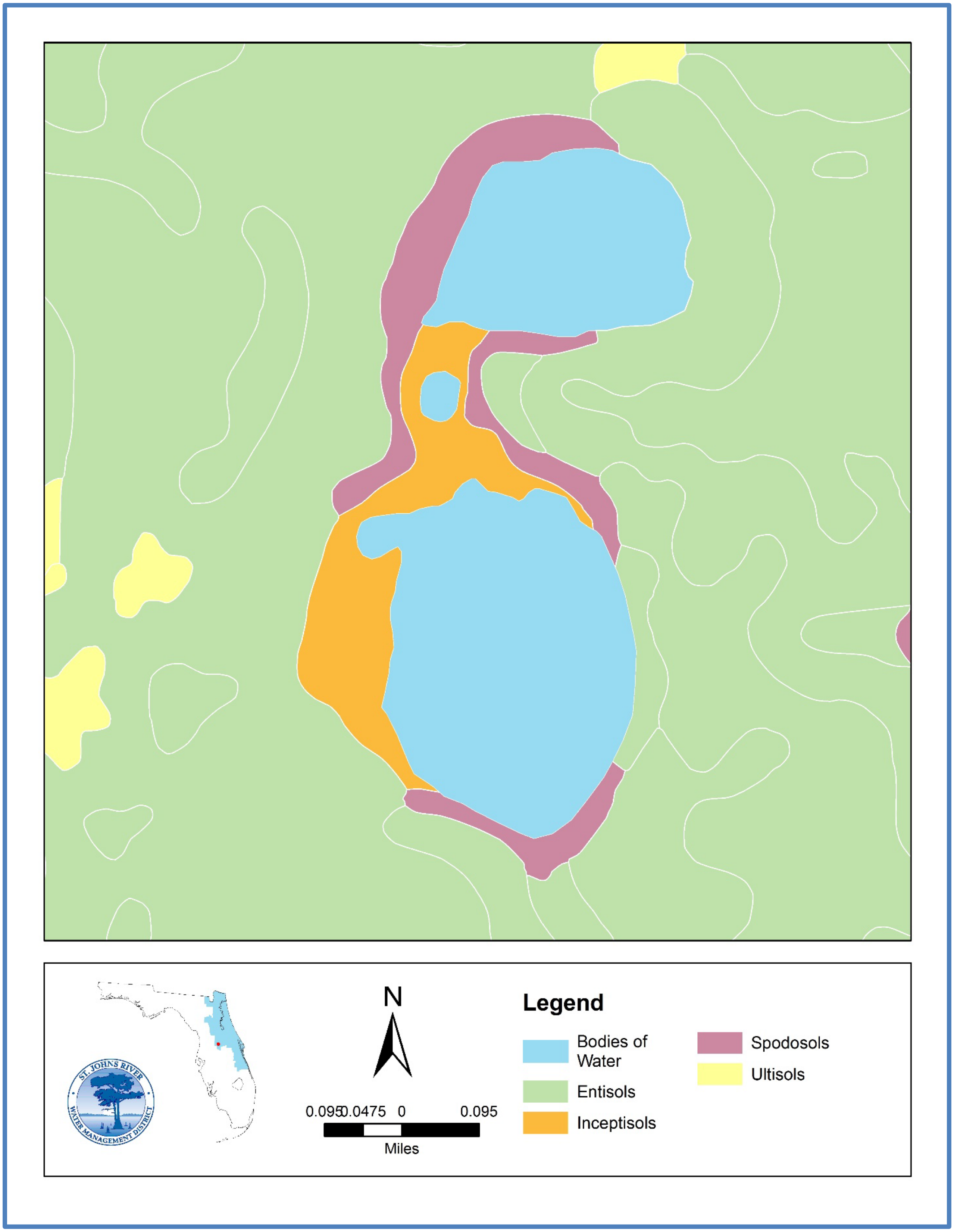

Figure 12. Soil series around Apshawa Lake South based on Soil Survey Geographic Database (Source: NRCS Soil Survey 2017)

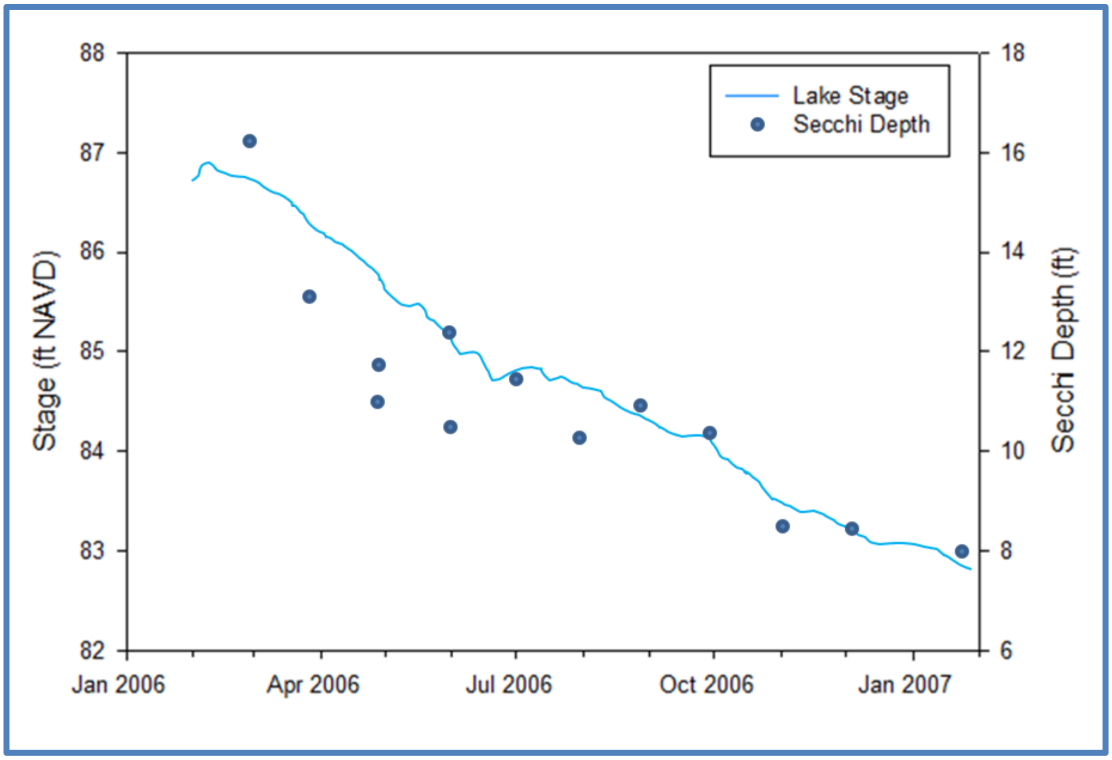

Figure 13. Relationship between Lake Stage and Secchi depth in Apshawa Lake South

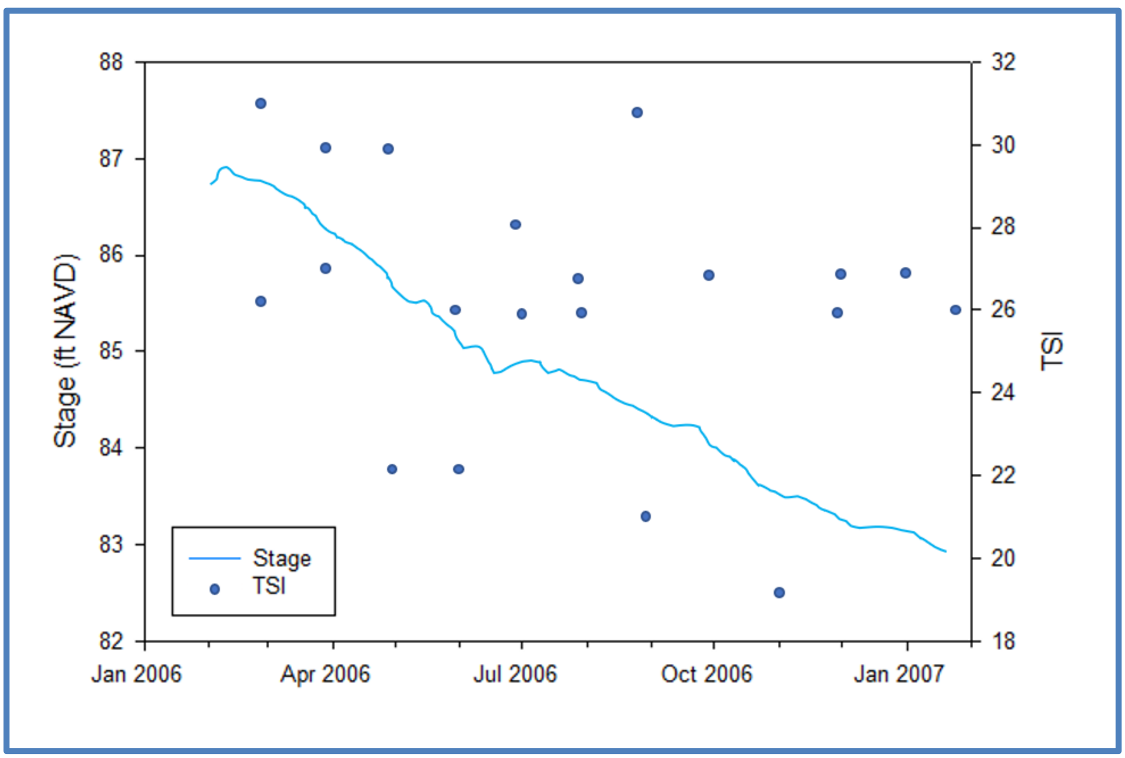

Figure 14. Relationship between Lake Stage in Apshawa Lake South and trophic state index

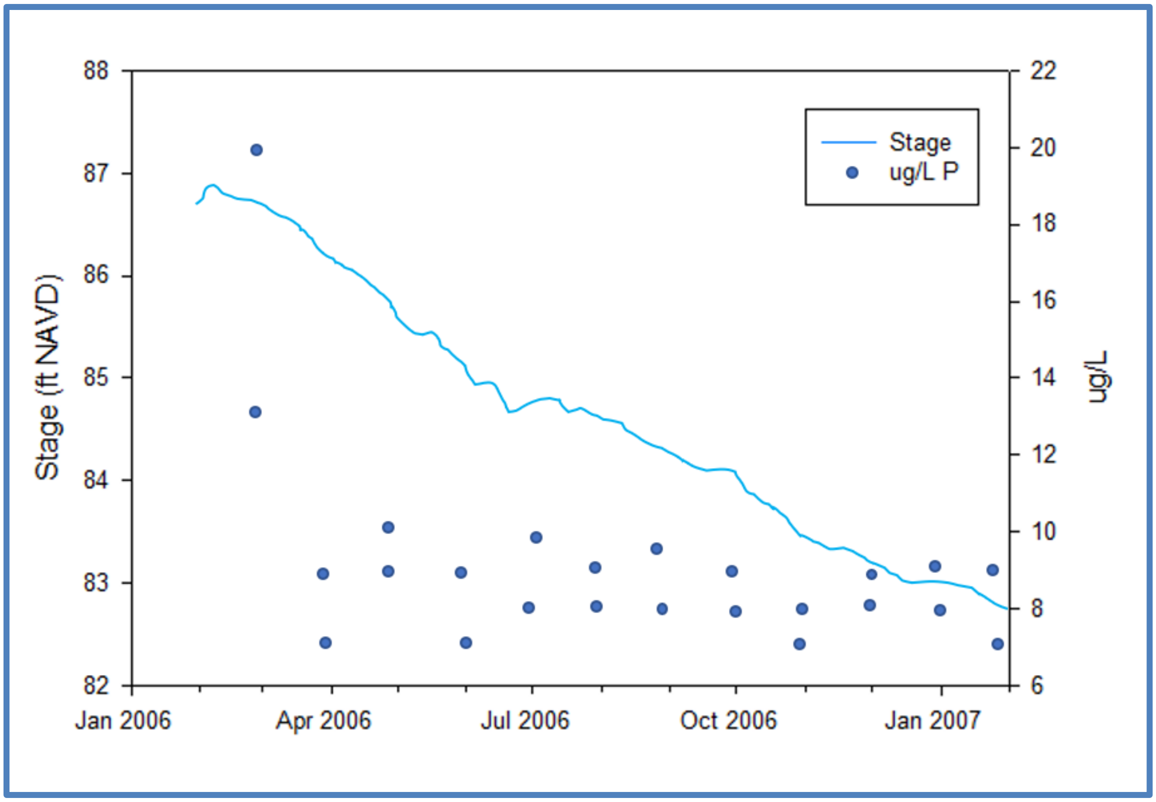

Figure 15. Relationship between Lake Stage in Apshawa Lake South and total phosphorus concentration

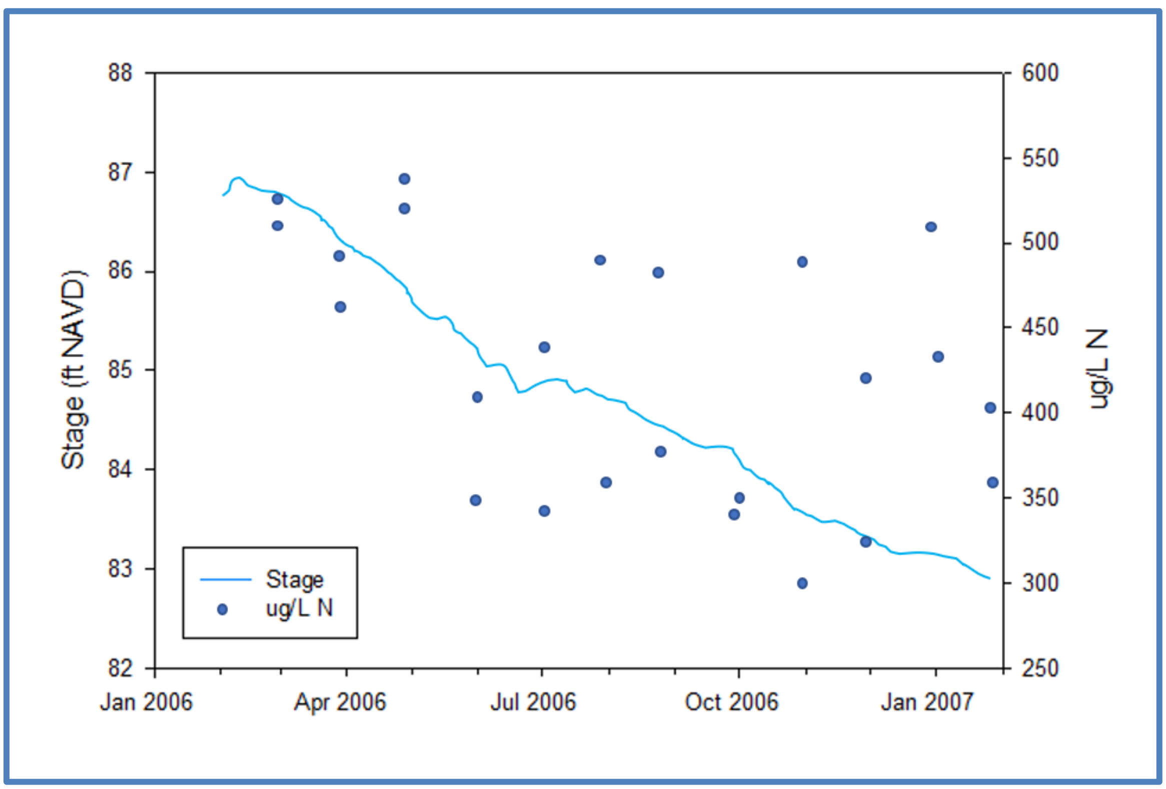

Figure 16. Relationship between Lake Stage in Apshawa Lake South and total N concentration

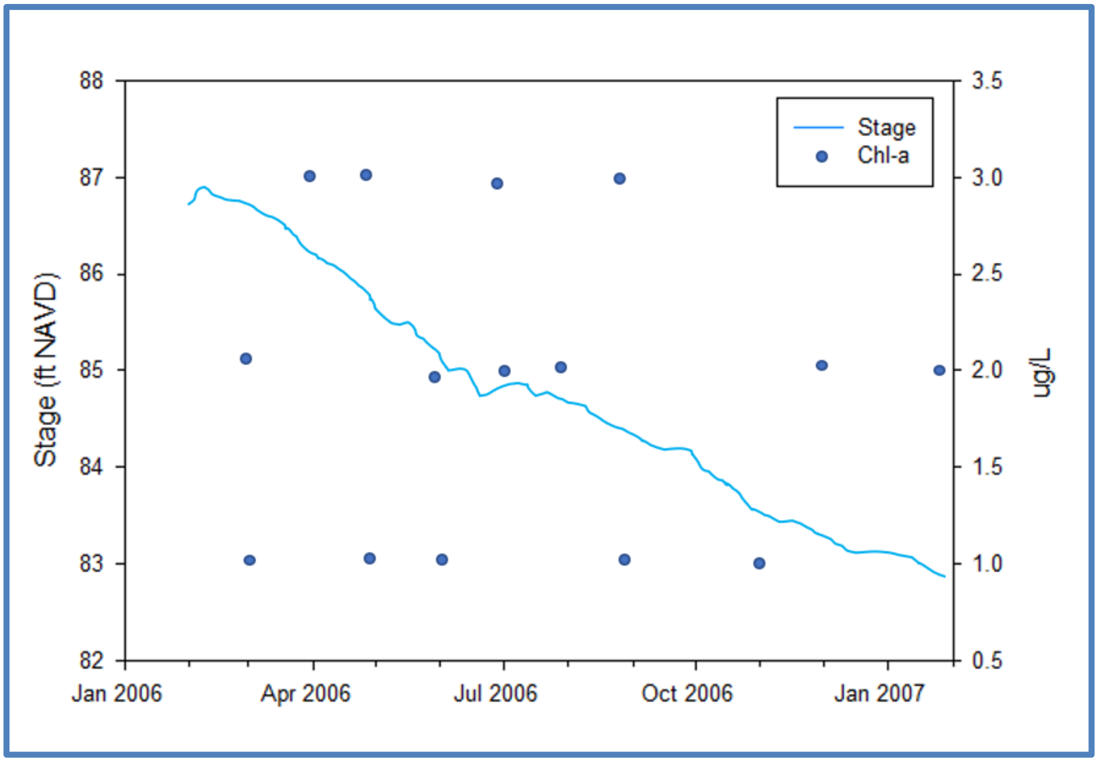

Figure 17. Relationship between Lake Stage in Apshawa Lake South and chl-*a* concentration

Table 8. Typical water quality data of lakes within the Clermont Uplands subdivision (Griffith et al., 1997)

Mean Value	pH (lab) n=29	Total Alkalinity (mg/l) n=29	Conductivity (µS/cm @ 25° C) n = 29	Total Phosphorus (µg/l) n = 51	Total Nitrogen (µg/l) n = 50	Chlorophyll_a (µg/l) n = 50	Color (pcu) n=28	Secchi (ft) n=46
minimum	4.7	0.0	49	5	347	1	5	0.7
25th %	6.3	2.0	101	10	608	2	17	3.3
median	6.6	4.4	122	12	885	3	50	5.2
75th %	7.0	14.0	168	16	1084	5	90	7.9
maximum	8.5	77.0	268	28	1557	21	471	15.1

MFLs DETERMINATION

The MFLs determination for the Apshawa Lake South reevaluation involved both hydrological and environmental analyses. The *Hydrological Analyses* section provides a brief description of modeling and data analyses used to develop long-term lake level time series, which were used to develop some of the minimum lake levels for the system (see Appendix B for more details on hydrological analyses).

The *Environmental Analyses* section provides a brief description of environmental criteria evaluated for Apshawa Lake South. Criteria descriptions, methods and results are presented, including the calculation of minimum lake levels based on each criterion. Environmental criteria were chosen based on their potential to protect non-consumptive environmental values and beneficial uses, as mandated by Rule 62-40.473, F.A.C.

The protection of other environmental values, also called Water Resource Values (WRVs), is discussed further in the *MFLs Assessment* section.

HYDROLOGICAL ANALYSES

Determining MFLs and assessing the status of water bodies requires substantial hydrological analysis. The main purpose of the hydrological analyses for Apshawa Lake South is to better understand the impact from groundwater pumping on lake levels and to develop no-pumping and current-pumping condition long-term lake levels for use in both the MFLs determination and assessment (see MFLs Assessment for details regarding the latter). Several steps were involved in performing these hydrological analyses, including:

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

Available water level data, long-term rainfall and historical groundwater use are briefly discussed in the *Hydrology* section (see Appendix B for more details). The following provides a summary of the development of the no-pumping and current-pumping datasets (see Appendix B for more details), which were used for the Apshawa Lake South MFLs determination and assessment.

Long-term lake level time series, representative of a no-pumping condition and a current impacted (current-pumping) condition, are needed to develop specific criteria and to assess all criteria. In order to develop the no-pumping condition lake level dataset for Apshawa Lake South, an estimate of lake level decline due to historical groundwater pumping (Figure 8) is needed. The estimated lake level decline caused by groundwater pumping is added to the observed dataset to create the no pumping condition dataset. The no-pumping condition time series represents hydrologic conditions of Apshawa Lake South in which impacts from groundwater pumping are assumed to be minimal (Figures 18 and 19).

The current-pumping condition lake level dataset was developed by subtracting an estimate of impact due to current groundwater pumping (average 2014–2018) from the no-pumping lake level time series. The current-pumping condition lake level dataset represents a reference hydrologic condition for Apshawa Lake South in which the total regional groundwater pumping impacting the lake is assumed to be constant from 2014 to 2018 (Figures 18 and 19; 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 present during the current-pumping period are repeated over the next 59 years (i.e., same as long-term modeling period from 1959 to 2018), the current-pumping condition lake levels reflect the future condition of lake levels if the average regional groundwater pumping does not change from the current-pumping condition. SJRWMD's 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 Nino 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 15 to 25 years and AMO cycles typically range 60 to 70 years (Schlesinger and Ramankutty, 1994; Obeysekera et al., 2011; and 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 and Kuss and Gurdak, 2014). These strong relationships are not expected to disappear in the foreseeable future. Florida sandhill lakes usually exhibit different behaviors in terms of frequency of certain water levels during wet and dry periods over long-term climatic cycles. 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 thought to be appropriate but will be regularly tested by implementing an adaptive management strategy, which is described later in this report. MFLs are established to prevent water bodies from being significantly harmed by groundwater pumping. Therefore, using historical conditions to generate current-pumping condition lake levels is reasonable.

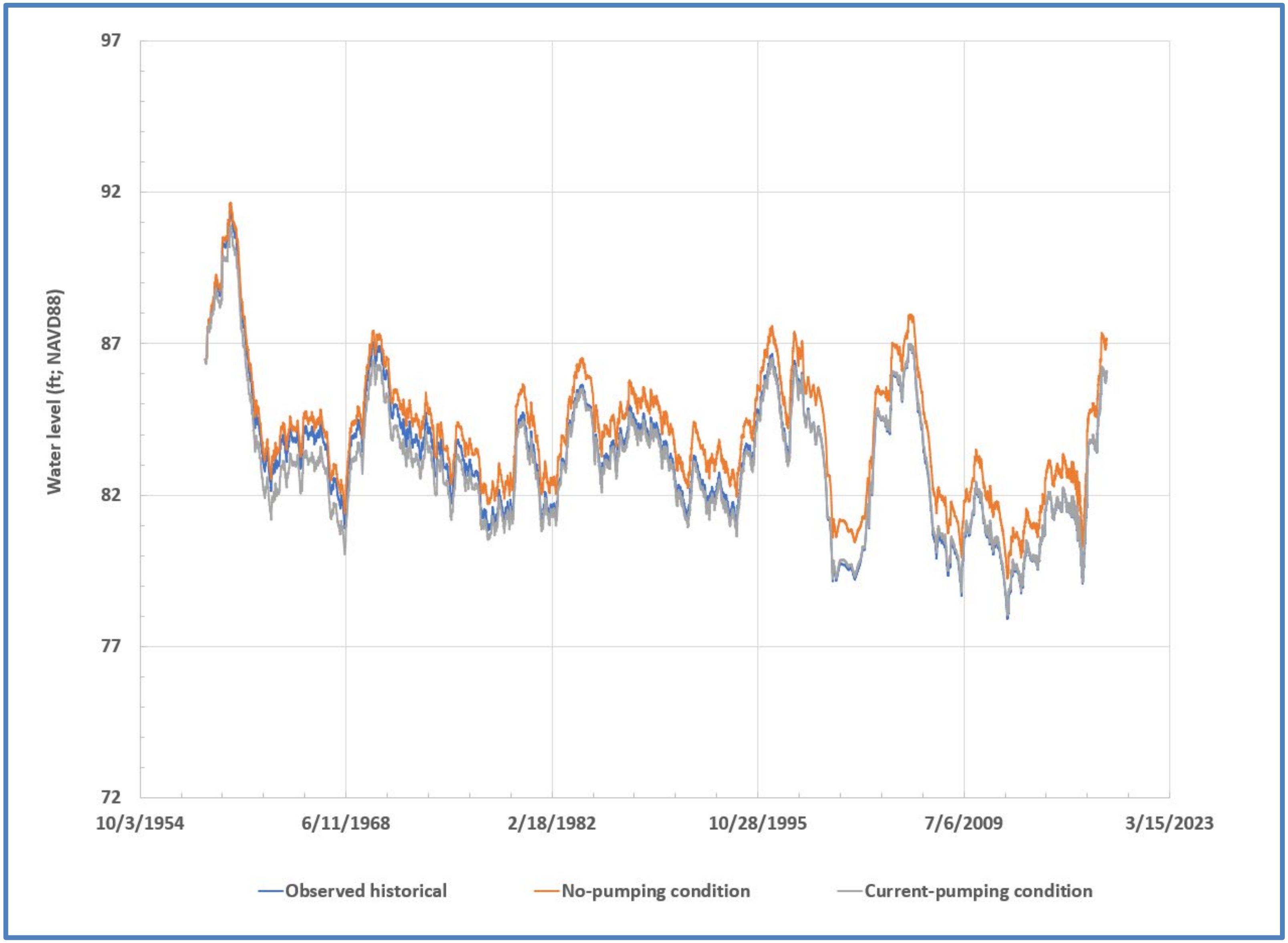

Figure 18. No-pumping condition and current-pumping condition lake levels for Apshawa Lake South

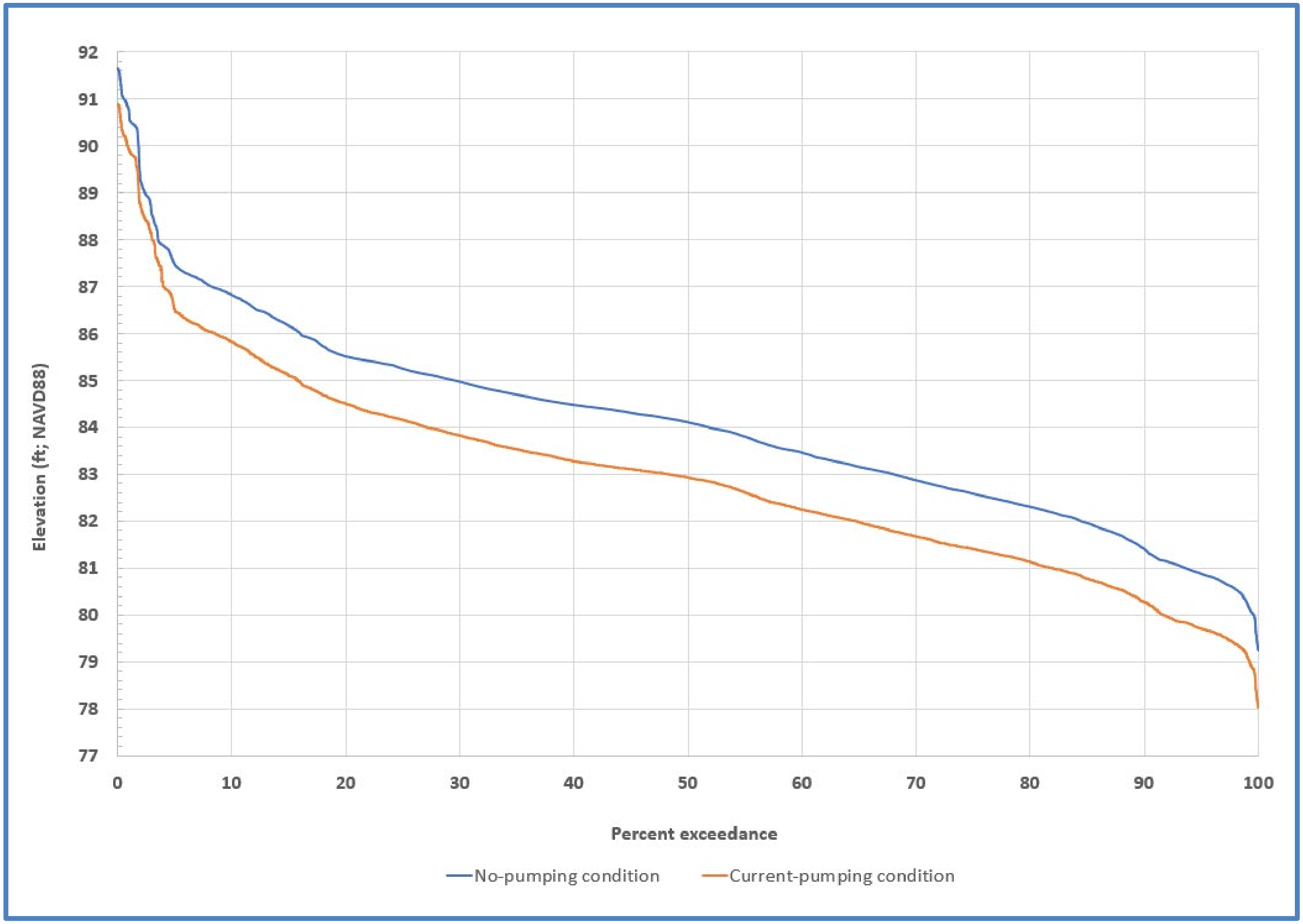

Figure 19. No-pumping condition and current-pumping condition lake level percent exceedance curves for Apshawa Lake South

Environmental Analyses

A critical part of the MFLs determination process is to identify relevant environmental attributes (e.g., fish and wildlife habitat) and beneficial uses (e.g., recreational value) for each water body, and then to determine appropriate criteria and thresholds to protect these environmental values. This process typically includes consideration of:

- Site-specific field-based ecological data;
- Environmental data;
- Recreational data;
- Topographical information;
- Data collected at other MFLs sites; and
- Supportive information from scientific literature.

Using this information, a determination is made of the most important environmental values for a given water body. Next, appropriate criteria are determined to represent these environmental values, and a minimum hydrologic regime (MFLs condition) is determined, that ensures their protection.

As part of the background information search for Apshawa Lake South, the Florida Natural Areas Inventory (FNAI) biodiversity matrix tool (http://www.fnai.org/) was checked for the presence of threatened or endangered species in a four-square mile area surrounding the lake. This search resulted in 46 potential, three likely, and no documented species. The three likely species were Florida sandhill crane (*Grus canadensis*), wood stork (*Mycteria americana*), and needleleaf waternymph (*Najas filifolia*). During multiple site visits, SJRWMD environmental scientists have observed sandhill cranes foraging and nesting at Apshawa Lake South but have not observed any of the other imperiled species listed by FNAI.

Environmental Criteria

Few studies have been published on environmentally protective lake levels, relative to the large body of literature available on protective flows for rivers and streams (Tharme 2003, Arthington 2012, Gleeson and Richter 2017). This is especially true regarding the acceptable reduction in hydrologic regime for a lake, relative to an undisturbed "reference" state. The majority of published studies on lake level thresholds are associated with determining the effects of reservoir regulation alternatives on recreational uses (Cordell and Bergstrom 1993, Hanson et al., 2002) and economic valuations (e.g., home and property values; Allen et al., 2010, Dickies and Crouch 2015). Some of these studies allow very large water level reductions from full pool (e.g., reducing reservoir storage by 69%; Shang 2013), while other lake studies suggest a less dramatic reduction (Hoyer and Canfield 1994, Emery et al., 2009). Studies based on reservoir regulation are not helpful for determining minimum hydrologic regimes for more natural lakes, especially sandhill-type lakes with moderate to large natural fluctuation ranges. Guidance (from the state or hydroecology literature) on protective criteria and thresholds for sandhill lakes is largely absent. However, recent work by the Southwest

Florida Water Management District (SWFWMD) does provide information regarding acceptable change from a pre-withdrawal condition for xeric (i.e., sandhill) lakes (GPI and SWFWMD 2022); this is explored further in the *MFLs Assessment* section.

Multiple environmental criteria were evaluated to ensure that protective minimum levels are set at Apshawa Lake South. Criteria were chosen based on their potential to protect non-consumptive environmental values and beneficial uses (also called WRVs), whose consideration is mandated by Rule 62-40.473, F.A.C. These criteria include:

1. Minimum Average: One event-based metric, a Minimum Average, was developed based on SJRWMD's conventional approach; and

2. Hydroperiod Tool Metrics: Multiple fish and wildlife habitat and recreational metrics were developed using SJRWMD's GIS-based hydroperiod tool.

Field Data Collection

Wetland vegetation and soils were characterized in 1998 using data collected in the field, as part of the original Apshawa Lake South MFLs determination (Appendix C). Precise transect coordinates used for the original determination were not available, but approximate locations were estimated based on maps in the original report. Two transects were established in 1998 and one was resampled in April 2010. In 2010 one of the original (1998) transects was dropped and a new one was added. These two transects were evaluated by staff in 2018 and 2021, to verify conclusions from fieldwork conducted in 2010 (Figure 20).

Wetland data

Based on field work conducted as part of the original MFLs, it was determined that seasonally flooded wetlands at Apshawa Lake South were too disturbed to use as a basis for conventional event-based criteria (i.e., event criteria based on maintaining the location of mean or maximum wetland elevations). This was verified in 2010 when detailed wetland vegetation data were collected and on subsequent field visits by SJRWMD staff from 2018 through 2021. Wetland species are present along the northern boundary of Apshawa Lake South. However, wetland communities that could be used for setting event-based MFLs are subject to periodic human disturbance (e.g., mowing). Therefore, only hydric soils data were used as the basis for an event-based metric (Minimum Average), and thus only soils data are described below (see Appendix C for more information on wetland community data).

Soils data

Transect 1

Transect 1 is located at the northern end of Apshawa Lake South (Figure 20). The transect begins in an upland area and extends approximately 600 ft to the south, ending in open water (Figures 21 and 22). The elevation drops sharply over the transect length from 40 to 70

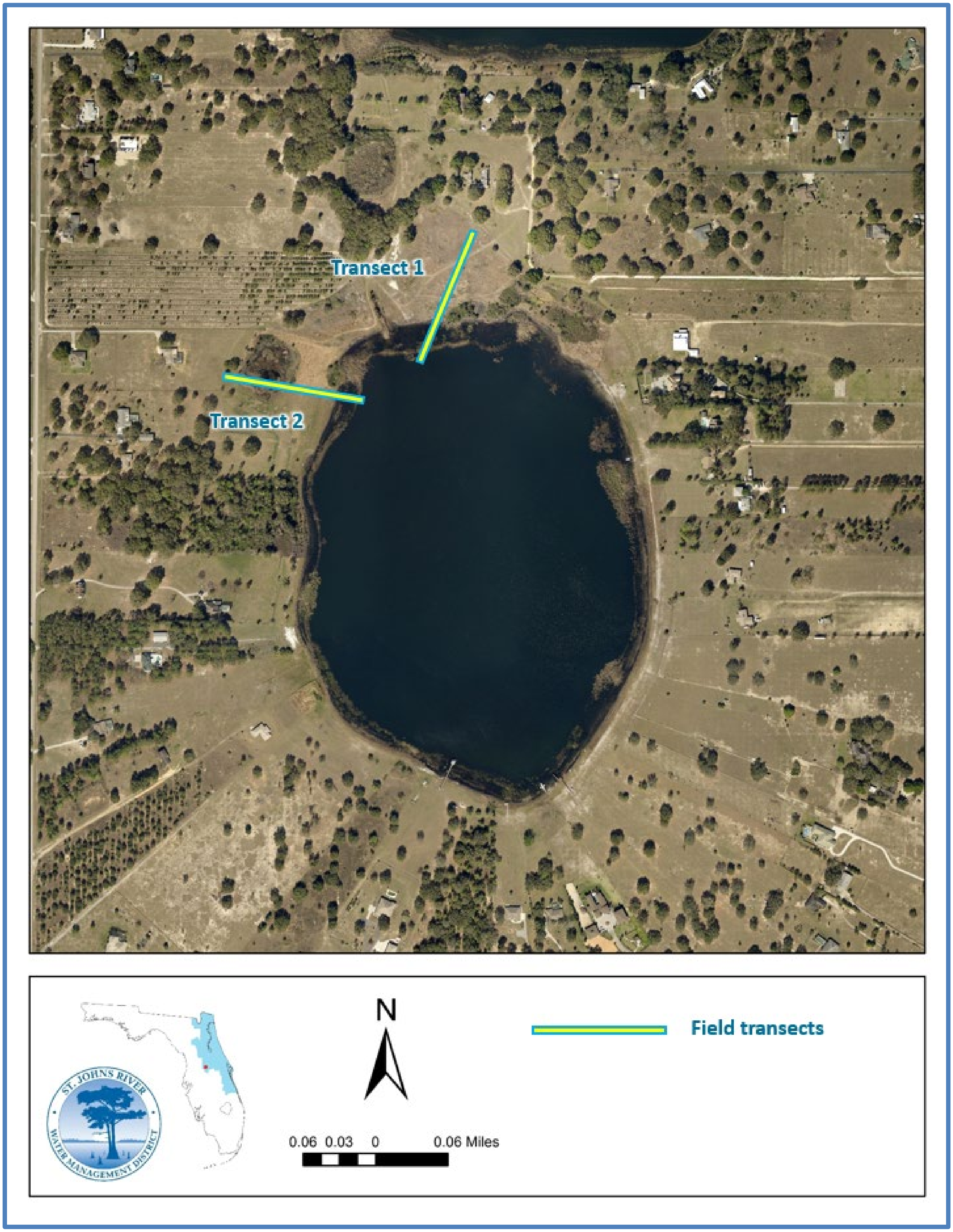

Figure 20. Transect locations of field work performed in 2010 and verified in 2018 and 2021

Figure 21. Transect 1 at station 100 depicting shallow marsh and wet prairie

Figure 22. Transect 1 at station 400 depicting shallow marsh, deep marsh and open water

ft marking a transition to the lake floodplain. The transect crosses a rise in the floodplain from 260 to 360 ft and then slopes gradually to the lake.

Mapped Soils: The Lake County Soil Survey Report (SCS-USDA, 1975) shows two soil map units present at Transect 1. Astatula sand, 0 to 5 percent slopes (Hyperthermic, uncoated Typic Quartzipsamments) was mapped in the uplands. This excessively drained, rapidly permeable soil forms in eolian and marine sands. Astatula sand is non-hydric and depth to the seasonal high-water table is greater than 120 inches. Placid and Myakka sands, 0 to 2 percent slopes (Sandy, siliceous, hyperthermic Typic Humaquepts and Aeric Alaquods) is a complex of poorly and very poorly drained soils that occurs in low, marshy depressions. This complex was mapped at lower elevations of the transect bordering the lake. This soil is considered hydric and is characterized by a water table that is at the surface for 4 to 6 months in most years.

On-site Soil Descriptions: Soil profiles were described at 18 stations along Transect 1. Detailed soil descriptions are provided in Appendix C. The soil at stations 0 (91.55 ft. NAVD88) and 80 (87.70 ft. NAVD88) was Astatula sand (see above for description). The soil at station 420 (83.06 ft. NAVD88) was described as Sanibel muck (Sandy, siliceous, hyperthermic Histic Humaquept) but would be a variant on this series due to the presence of tight clay loam/clay substrate at a depth of 46 to 55 inches. Estimates of the extent of hydric soil indicators, soil summary statistics, and a cross-section of the transect are shown in Figure 23.

Transect 2

Transect 2 is located within the western lobe of Apshawa Lake South (Figure 20). It starts in an upland pasture and extends approximately 600 ft to the east terminating at the waterward edge of a deep marsh. The first 100 ft of the transect slope at an approximate eight percent grade into a depression which at low water levels is an isolated pond and at high water levels is connected to the lake. This depression extends an additional 200 feet and then merges with the lake floodplain, which extends an additional 180 ft. The land surface then decreases gradually to the open water of the lake (Figures 24 and 25).

Mapped Soils: The Lake County Soil Survey Report (SCS-USDA 1975) shows the same two soil map units described for Transect 1. Astatula sand occurs in the uplands and Placid - Myakka complex occurs in the low areas bordering the lake.

On-site Soil Descriptions: Soil profiles were described at 26 stations. Detailed soil descriptions are provided in Appendix C. Two holes were bored to a depth sufficient to determine soil series. The soil at station 20 (87.7 ft. NAVD88) were Astatula sand and the soil at station 312 (83.5 ft. NAVD88) was Placid sand. No hydric soil indicators were observed in the upland community. The first hydric soil indicator was dark surface (S7)

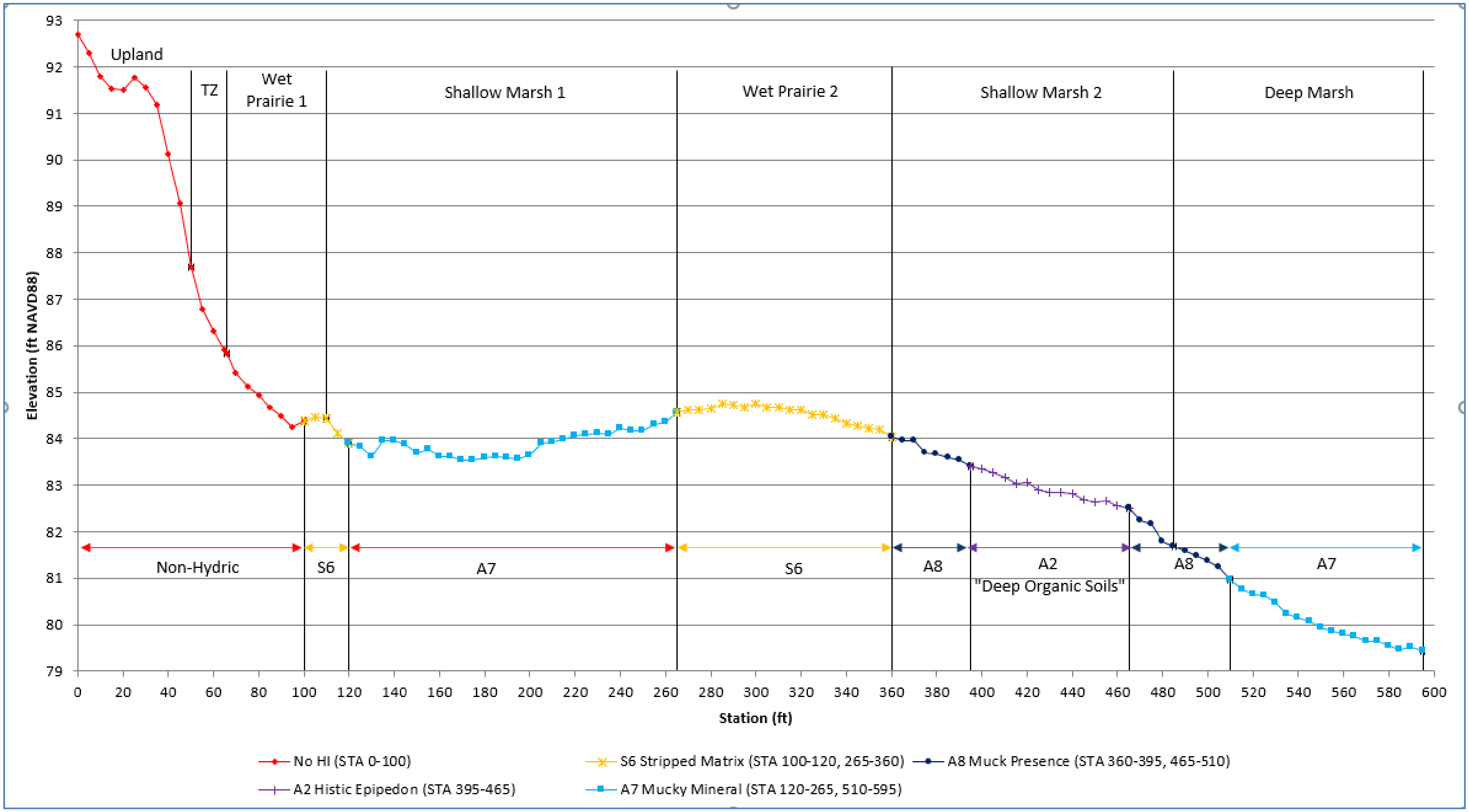

Figure 23. Profile of Transect 1 showing vegetation communities, hydric soil indicators, and elevation

Figure 24. Transect 2 at station 300 facing west depicting shallow marsh, deep marsh, transitional shrub, open water and upland communities (in background)

Figure 25. Transect 2 at station 300 facing east depicting shallow marsh, deep marsh and open water

which occurred at station 60 in the transitional shrub community. Mucky mineral (A7) occurred at stations 65 and 75 and muck presence (A8) occurred at station 80, all of which were in the transitional shrub community. A8 also occurs in the shallow marsh at station 90. Histosol (A1) occurred at stations 100, 140, 240 in deep marshes #1 and 2. No borings were taken in the open water zone (station 150 to 237 ft) but it also appeared to be underlain by thick beds of muck. Histic epipedon (A2) occurred intermittently at station 120 in the first deep marsh and at station 250 in the second shallow marsh. A7 occurred at station 260 in the second shallow marsh. S7 occurred at station 280 in the third shallow marsh. Organic matter levels and depth increase progressively across the third shallow marsh with A8 occurring at stations 312 and 417. A2 occurs at stations 420 and 447 and A1 occurs at station 477. Organic matter levels diminish in the deep marsh bordering the lake and A7 at stations 492 and 500 was the only hydric indicator observed. Estimates of the extent of hydric soil indicators, soil summary statistics, and a cross-section of the transect are shown in Figure 26.

Stripped matrix (S6) occurred at station 100 in wet prairie #1 and was the first hydric soil indicator observed. Mucky mineral (A7) occurred at stations 120 and 180 in the shallow marsh. S6 occurred again at station 295 in wet prairie #2 and was the highest elevation hydric soil indicator encountered on the transect. Muck presence (A8) occurred at station 390 in shallow marsh #2. Histic epipedon (A2) occurred at stations 395, 420 and 455, also in shallow marsh #2 at lower elevations than A8. A8 occurred again in the deep marsh at stations 490 and 510.

Soils data were collected in 2018 and 2021 to determine whether the location of deep organic soils had changed significantly since 2010. Soil core descriptions and loss on ignition (LOI) samples were analyzed and confirmed that the location and elevations of organic soils, determined in 2010, are still appropriate for use in the Apshawa Lake South MFLs reevaluation (see Appendix C for additional details on LOI analyses).

Importance of organic soils in wetlands

Organic soils are important to wetland biogeochemical cycles, particularly as sinks for carbon (Reddy and DeLaune, 2008). Frequent anaerobic conditions impede microbial activity and primary production exceeds decomposition. Organic soils gradually accrue as a result. Minimum flows and levels seek to maintain organic soil structure and function by ensuring that dewatering events do not occur often enough to cause organic soils to oxidize and subside. Wetland soils are a medium for denitrification, a process important in maintaining aquatic/wetland water quality. The periodic, short duration alternating aerobic/anaerobic conditions will ensure effective nitrification (the conversion of ammonium to nitrate), which is then subject to denitrification, while the combination of inundation and dewatering will maintain the composition and productivity of wetlands and associated biota adapted to long-term saturation (Payne, 1981; Reddy and DeLaune, 2008). Soil organic matter in wetlands provides long-term nutrient storage and is a source of mineralizable nutrients for plant growth. Slow release of nutrients occurs at a level sufficient to sustain plant growth within native plant communities. Organic soils also sustain productivity within the larger system by releasing dissolved organic material, which supports downstream (or within lake) aquatic life (Mitsch and Gosselink, 2015).

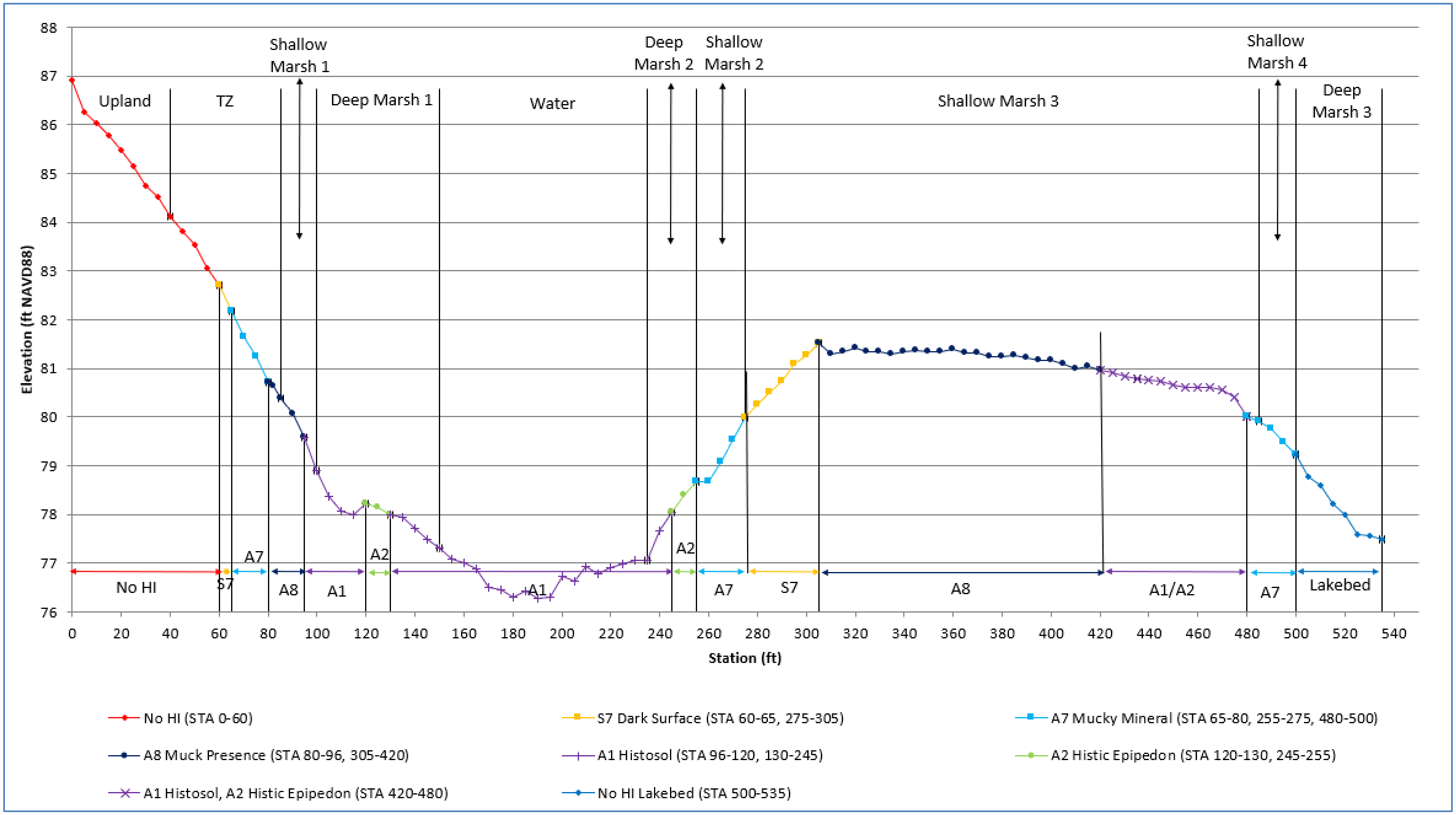

Figure 26. Profile of Transect 2 showing vegetation communities, hydric soil indicators, and elevation

Minimum Average

MFLs criteria development typically starts with data exploration to determine if SJRWMD's standard "event-based approach" is appropriate for a given system. As previously described, Apshawa Lake South is a sandhill lake, and is characterized by moderate water level fluctuations. Some evidence suggests that existing wetland vegetation locations have shifted over time. Further, and more significant, is the fact that resident wetland communities have been subject to periodic disturbance (e.g., mowing) over the years and are therefore not ideal for use in developing event-based criteria that rely on specific wetland elevations (e.g., mean or boundary elevations).

Therefore, conventional event-based metrics *based on wetland communities* (e.g., Minimum Frequent High and Minimum Frequent Low; Neubauer et al., 2008) were not pursued. The only conventional metric developed was a Minimum Average (MA), which is based on protecting the location of deep organic soils. Field data collected since 1998 demonstrate that the location of deep wetland soils has not changed significantly during this period (see Appendix C for details on soils location verification).

The MA is defined in Rule 40C-8.021(9), F.A.C., as "…the surface water level…necessary over a long period to maintain the integrity of hydric soils and wetland plant communities". The MA was developed to prevent an excessive number of drying events to provide protection for deep organic soils (i.e., ≥8 in. thick organic layer within the top 32 in. of soil) from oxidation and subsidence, preventing adverse impacts to wetland habitat and water quality. The general indicator of protection for the MA water level is to ensure that organic soils are saturated or inundated frequently enough to maintain anaerobic conditions that preserve soil structure and associated ecological functions. The specific indicator of protection is a water level that equals a 0.3 ft water table drawdown from the average ground surface elevation of deep organic soils surveyed at Apshawa Lake South.

Magnitude

The magnitude of the MA was determined based on the average elevation of deep organic soils surveyed at Apshawa Lake South. The average elevation of deep organics was calculated as a weighted mean of three different locations with histosols (A1 hydric indicator) and/or histic epipedon (A2 hydric indicator) soils. This elevation corresponds to the average elevation of deep organic soils (80.9 ft. NAVD88) minus a water table drawdown of 0.3 ft. (80.6 ft NAVD88). The average elevation of these three locations was weighted based on their percentage of the total length of deep organics. At Transect 1, the mean elevation of A1/A2 equaled 82.9 ft and composed 24.1% of the total length of deep organics (i.e., 70 of 290 ft). At Transect 2, location 1, the mean elevation of A1/A2 equaled 82.9 ft and composed 20.6% of the total length of deep organics. At Transect 2, location 2, the mean elevation of A1/A2 equaled 79.6 ft and composed 55.1% of the total length of deep organics. Based on the length and mean elevation of deep organics, the weighted average was calculated as:

82.9*0.241 + 82.9*0.206 + 79.6*0.551 = 80.9 ft

When the water table offset of 0.3 ft is applied, the MA magnitude equals 80.6 ft, NAVD88.

Duration

The duration for the average non-exceedance water level for the MA is 180 days. This duration is meant to prevent drying events from occurring too often, so that adequate saturation of deep organic soils are maintained. As previously described, wetland soils are important for denitrification, a process important in maintaining aquatic/wetland water quality. As noted, the MA is a dewatering event that usually occurs for a long duration with short return intervals, corresponding to a water level that typically occurs during normal dry seasons.

A drawdown of no more than 0.3 ft below mean surface elevation of deep organic soils has been used for numerous adopted MFLs as a criterion to protect muck soils and was developed based on the minimum hydrology needed to protect peat soils in the Everglades (Stephens, 1974). Studies of the Wekiva River system found this hydrologic condition can also be expressed as the low stage, occurring, on average, every 1 to 2 years, with a duration of less than or equal to 180 days (Hupalo et al., 1994).

Return Interval

Protective event frequencies (i.e., recommended return intervals) are determined using hydrologic event probabilities called Surface Water Inundation and Dewatering Signatures (SWIDS; see Appendix C for general description of SWIDS). A primary assumption is that these hydrologic probabilities (i.e., signatures) are for a group of *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. If water bodies used for this analysis (i.e., to determine an average return interval for a given event) are not similar it may result in a wide range of hydroperiods and inappropriate return interval for the test system. When all central Florida lakes with MA data (i.e., mean elevation of deep organics minus 0.3 ft offset) are used, the resulting range in return intervals for a 180-day non-exceedance event (i.e., the MA) is high (Figure 27).

To address this concern, two analyses were performed to identify lake groups with similar hydrological and landscape characteristics, in an effort to reduce uncertainty and base the Apshawa Lake South return interval on similar sites. The first was an ordination analysis aimed at determining whether hydrological and landscape factors could help explain variability among SWIDS sites. Principal components analysis (PCA) was conducted for twenty-nine central Florida lakes and based on fourteen hydrological and landscape variables (Table 12 in Appendix C). A single parameter, water level range (P10 minus P90), explained the most variability among sites. Other parameters identified by the PCA were:

- Water level symmetry: kurtosis of four-week stage elevation change;
- Connection to the UFA: maximum cumulative fluctuation index value;

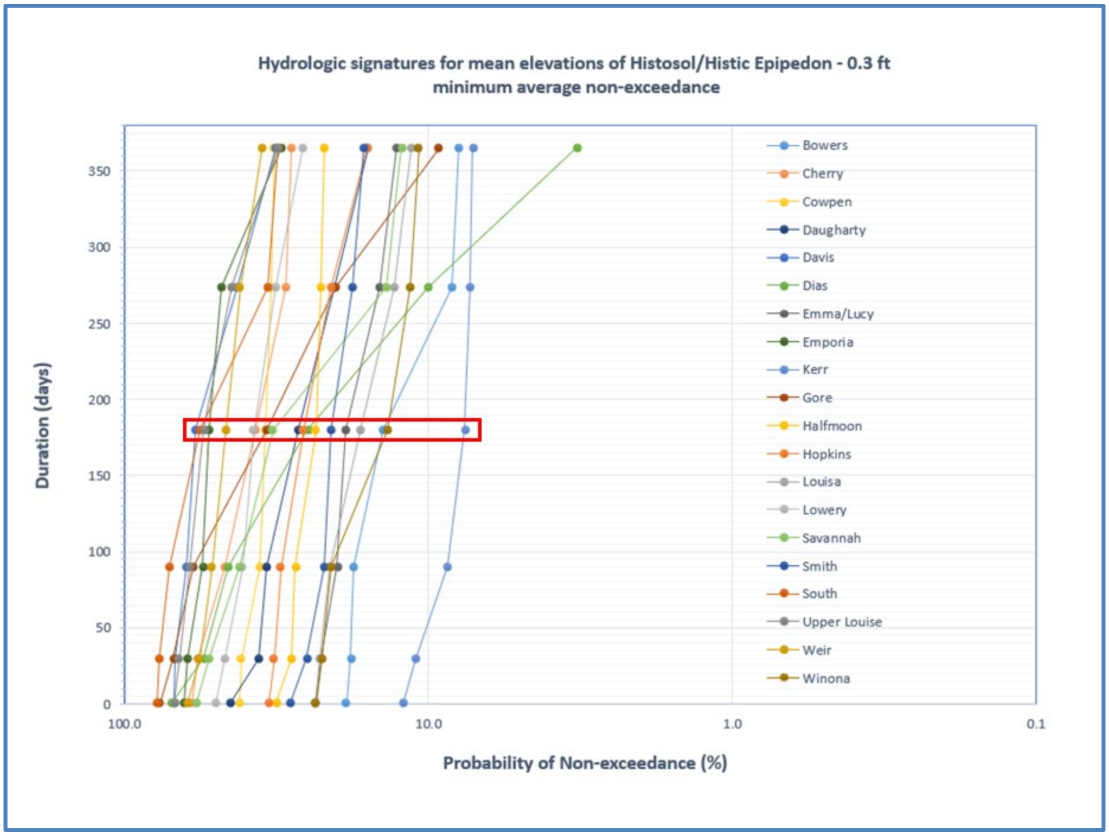

Figure 27. SWIDS plot showing distribution of hydrologic signatures for average non-exceedance elevations (of various durations) for mean elevations of deep organic soil elevations for 29 lakes in central Florida

- Depth to water table (NRCS data; annual minima);
- Landscape drainage: percent of surrounding landscape with high drainage class ranking (NRCS data); and
- Soil permeability: percentage of surrounding landscape with high soil permeability ranking (NRCS data).

Next, a cluster analysis was performed, using the parameters listed above, to identify lake groups with similar hydrological and landscape characteristics. Ward's Method of hierarchical clustering was used, which minimizes variance between sites within a group while maximizing variance between groups. The resulting cluster of sites that included Apshawa Lake South was used for the preliminary SWIDS analysis. This analysis was conducted for the eight lakes in the Apshawa Lake South cluster for which there also exists corresponding MA (i.e., deep organic soils) data (Figure 28).

The PCA and cluster analysis resulted in only a moderate reduction in the range of the MA return intervals (i.e., using eight lakes versus the original twenty lakes; Figures 27 versus 28). Further, the range of return intervals for lakes in the Apshawa Lake South cluster exhibited a six-fold difference (from 2.2 years to 13.2 years). The central tendency (mean minus standard error) of these return intervals equaled 4.4 years, making this far more constraining than any

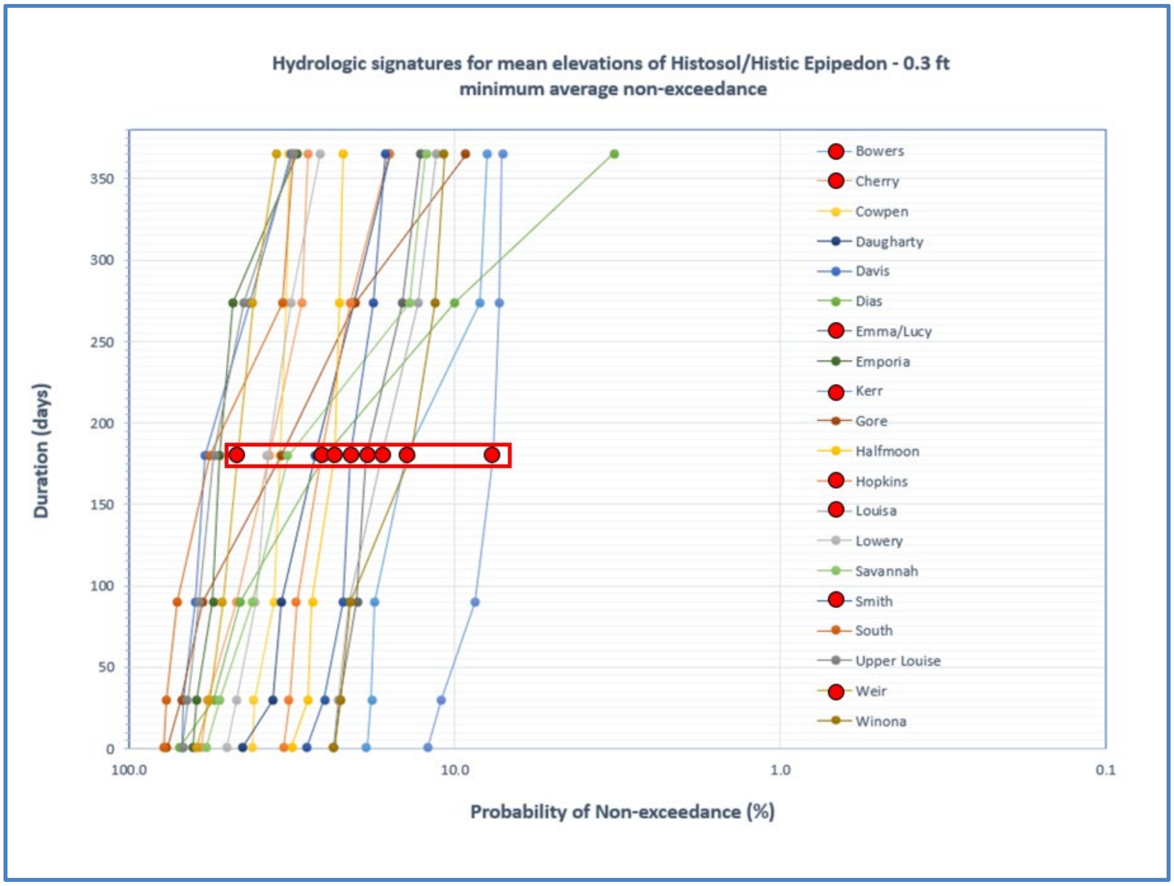

Figure 28. SWIDS plot showing distribution of hydrologic signatures for average non-exceedance elevations (of various durations) for mean elevations of deep organic soil elevations for 8 lakes in central Florida, based on cluster analysis; red dots are lakes in the same cluster as Apshawa Lake South

MA adopted in the past. For these reasons, instead of using the cluster analysis results, which yielded almost as high a range in values as using all sites, a different approach was pursued.

Because the most significant parameter identified in the PCA (and in earlier work by Epting et al., 2008) was water level range (P10–P90), the next step was to investigate those sites (for which deep organic hydroperiods exist) with similar water level range. The result was five (of the original twenty) lakes, with deep organics data, that also have water level range (P10–P90) similar to Apshawa Lake South. These lakes (Cowpen Lake, Lake Daugharty, Lake Davis, Lake Emporia and Smith Lake) have a mean (± SD) water level range of 6.0 ft (± 0.4 ft), whereas all sites have a mean (± SD) of 4.3 ft (± 1.8 ft). The former is much more similar to the water level range at Apshawa Lake South, which equals 6.4 ft.

The return interval central tendency (mean minus standard error) of these five lakes (i.e., those with similar range) was used for the Apshawa Lake South recommended MA return interval. Using these five lakes yielded a tighter return interval range (1.7 years to 4.8 years) than either all sites, or those based on the cluster analysis. It was deemed prudent to base the recommendation on sites that are similar in water level range, and that yield less uncertainty in the return interval range. Based on this analysis, the recommended return interval for the Apshawa Lake South MA is 2.4 years.

The resulting recommended MA for Apshawa Lake South is composed of an elevation of 80.6 ft NAVD88, with a corresponding mean non-exceedance duration of 180 days, and a maximum return interval of 2.4 years (i.e., the drying event should occur no more often than once in 2.4 years, on average; no more than 42 out of 100 years, on average; Table 9).

Table 9. Recommended Minimum Average for Apshawa Lake South, Lake County, Florida

Minimum Level	Level (ft NAVD88)	Duration (days)	Return Interval (years)
Minimum Average	80.6	180	2.4

Hydroperiod Tool Metrics

In an effort to ensure that the Apshawa Lake South MFL will adequately protect *all* relevant ecological and human-use values, it was deemed prudent to develop other metrics to augment the single event-based criterion (i.e., MA). Six fish and wildlife criteria were developed and assessed using a Geographic Information System (GIS)-based “hydroperiod tool” (Fox et al., 2012). This approach involves a customized tool developed with the South Florida Water Management District (SFWMD) and the University of Texas (Austin) to work with ESRI’s ArcMap© (see Appendix D for details regarding hydroperiod tool design and operation). This approach has been used to set MFLs for other lakes in SJRWMD (Jennewein et al., 2020; Sutherland et al., 2021). Using this tool, 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.

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; Figure 29). A DEM for Apshawa Lake South was developed using 2006–2007 LIDAR data, acoustic doppler profiler data, aerial photography and elevation data surveyed along transects (see Appendix E for more details). The hydroperiod tool was used to estimate habitat area for different fish and wildlife taxa as well as for important recreational values, represented by specific depth ranges. With the hydroperiod tool, the effect of bathymetry and water level reduction on habitat area is quantifiable. Habitat and recreational areas were compared under different pumping conditions (e.g., no-pumping versus current-pumping condition; Figures 18 and 19).

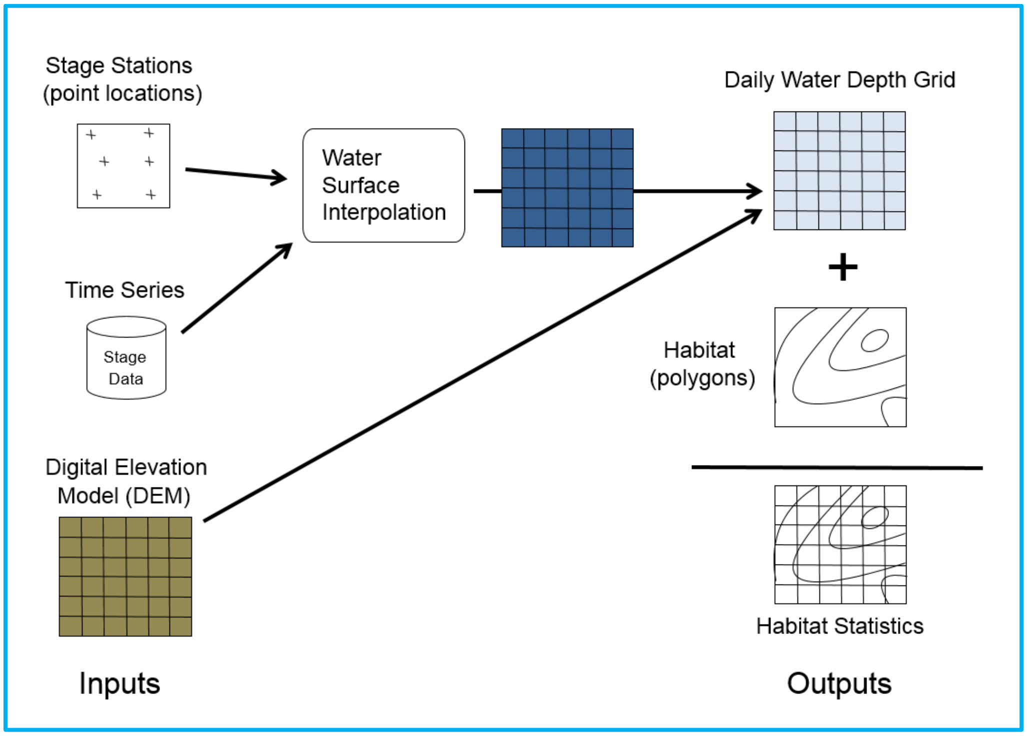

Figure 29. Conceptual diagram of the hydroperiod tool used to estimate the relationship between lake stage and habitat area

Impact threshold

The significant harm threshold used for hydroperiod tool metrics is a 15% change in areal extent (acreage) of habitat, relative to the no-pumping condition over the simulated model period of 1959–2018. A 15% reduction of habitat availability has been used by other water management districts as a significant harm threshold for MFLs (Munson and Delfino 2007). This threshold has been peer reviewed numerous times and has been the basis for numerous adopted MFLs (see SWFWMD MFLs 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 (Hoyer and Canfield 1994, Leeper et al., 2001, Emery et al., 2009, Jennewein et al., 2020; Sutherland et al., 2021). This threshold is also within the range (10 to 33%) of percent allowable change documented in other studies (Munson and Delfino 2007).

Average habitat area

Average habitat area was calculated for each metric, for each day in the simulated POR, using the stage/habitat area relationship derived from the hydroperiod tool and the simulated water surface elevations for a given pumping scenario (e.g., the no-pumping condition). For example, the stage/habitat area curve (i.e., hydroperiod tool output data) for the open-water area metric (defined as area of lake with depths greater than 5 ft) is depicted in Figure 30.

The MFLs condition for hydroperiod tool habitat metrics equals a 15% reduction in average habitat area under the no-pumping condition (i.e., habitat area averaged across the entire no-pumping condition lake level timeseries). Assessment of habitat metrics is performed by comparing the average habitat area under no-pumping condition to the average habitat area under the current-pumping condition (see MFLs Assessment for more details).

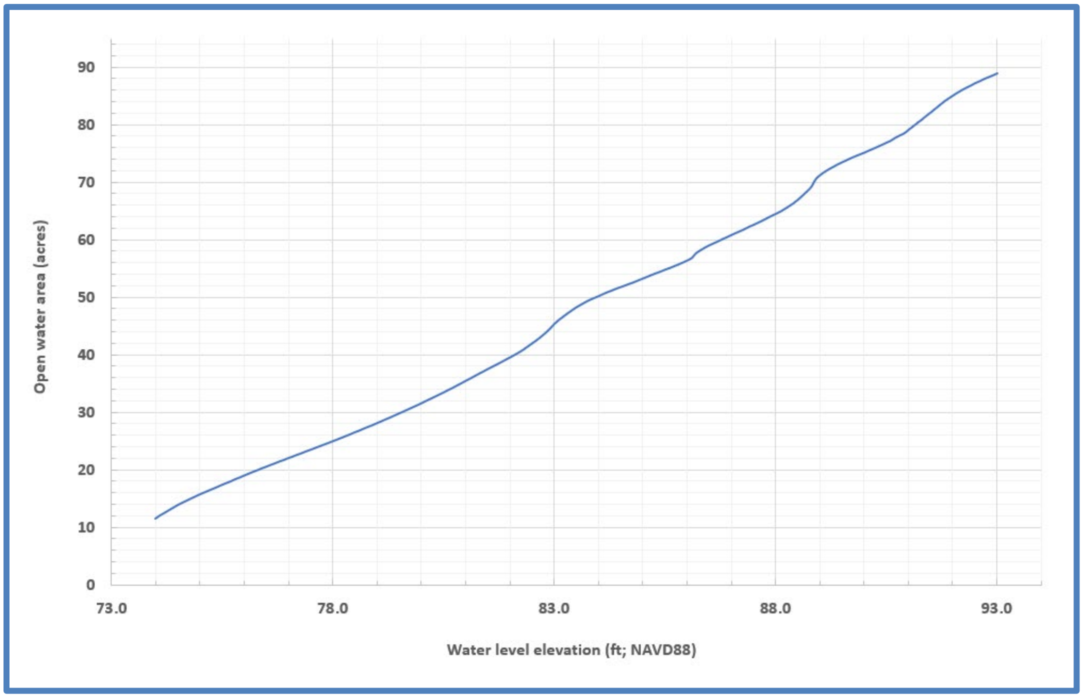

Figure 30. Example of hydroperiod tool output; stage/habitat area (acres) for open-water (> 5 ft depth) area for Apshawa Lake South, Lake County, Florida.

Fish and Wildlife Habitats

Per Rule 62-40.473, *F.A.C.*, water management districts are directed to consider a suite of environmental values when setting MFLs. One of these environmental values is "*fish and wildlife habitats and the passage of fish*". For many MFLs, SJRWMD provides protection for fish and wildlife habitats with event-based metrics that are developed to maintain the long-term persistence and integrity of wetland communities. As discussed above, the wetland communities at Apshawa Lake South continue to be periodically disturbed by human activities. Despite this, there are important wetland habitats and other ecological features at Apshawa Lake South that need to be protected from significant harm due to withdrawals.

Six habitats were evaluated for this MFLs reevaluation, including five nearshore habitats and one deep water (open-water area) habitat. These habitats are defined by specific depth ranges important to the long-term persistence of the particular taxa group or function (SJRWMD staff observations). These habitats were chosen to ensure that multiple portions of the nearshore and pelagic environments were evaluated, in case one or more was particularly sensitive to water level change. Each habitat described below was evaluated using the hydroperiod tool to determine the amount of water level decline associated with a 15% reduction in habitat extent (acres), relative to the long-term average no-pumping condition. Habitat areas were estimated based on a stage/area curve developed using the hydroperiod tool (previously described .

Nearshore habitats

The shallow nearshore (littoral) zone fringing Apshawa Lake South provides valuable habitat for various life stages of numerous species (Figure 31). This includes refugia and forage for aquatic invertebrates, small-bodied fishes (in nearshore environment) and juveniles of large-bodied species (e.g., game fish). These areas also provide important reproductive habitat for fish, amphibians and reptiles, forage habitat for wading birds, and nesting habitat for the Florida sandhill crane (*Grus canadensis pratensis*).

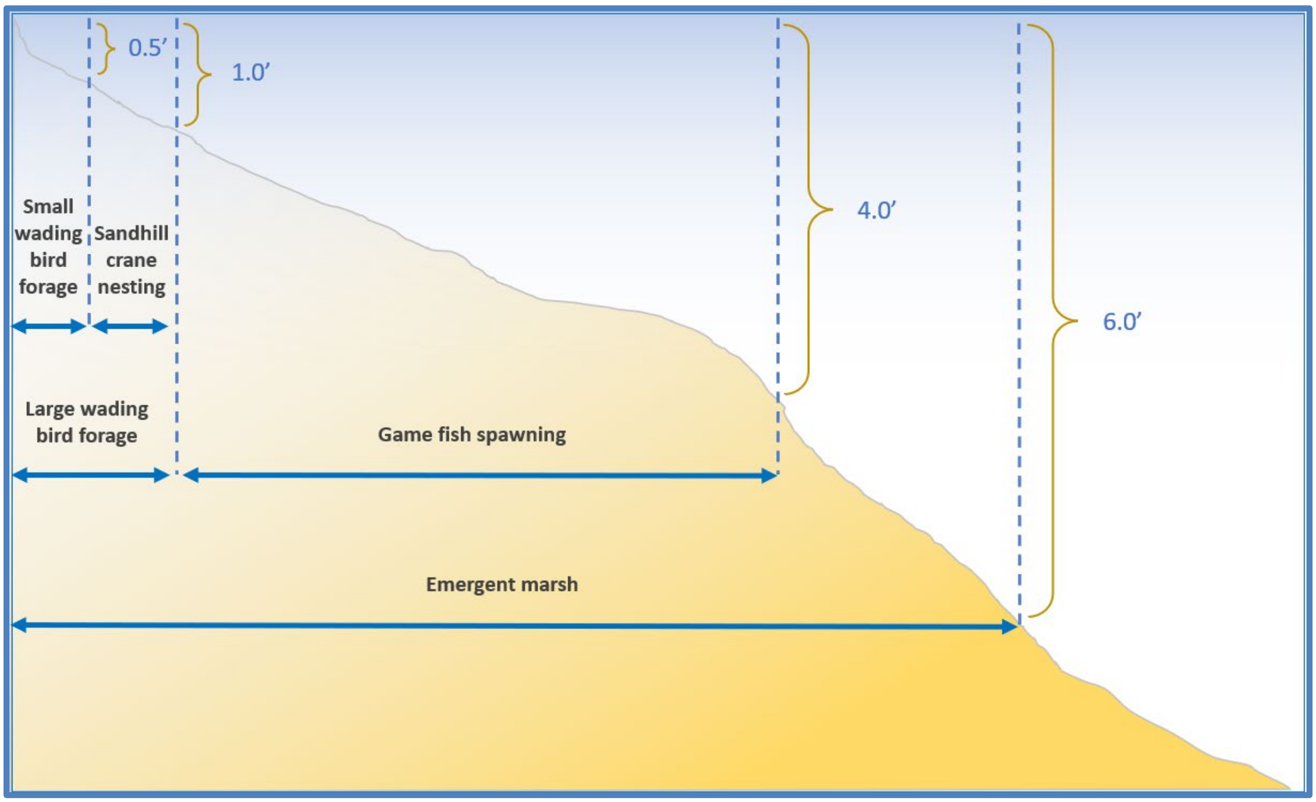

Figure 31. Depth ranges used for hydroperiod tool-based nearshore fish and wildlife habitats

Emergent Marsh Habitat

The littoral zone at Apshawa Lake South consists of wet prairie, shallow marsh and deep marsh. The wet prairie vegetation communities are dominated by broomsedge (*Andropogon virginicus*) and blue maidencane (*Amphicarpum muhlenbergianum*). The deep marsh vegetation community is dominated by fringe rush (*Fuirena scirpoidea*) and torpedo grass (*Panicum repens*). Emergent marsh generally extends from the edge of the shore to approximately 6 ft deep. A maximum depth of 6 ft was used based on the known depth ranges for species inhabiting these communities (e.g., maidencane, and fringe rush). Based on this, the emergent marsh habitat depth range used for this analysis is 0 to 6 ft.

Game Fish Spawning Habitat

The purpose of this habitat metric is to prevent significant harm to game fish spawning habitat, due to withdrawal. Largemouth bass and other lake game fish (e.g., *Lepomis spp.*) typically construct their nests in shallow water in close proximity to emergent vegetation. While the range of nest depths for largemouth bass can vary from less than one foot to over 10 ft, the average depth is typically 1 to 4 ft (Stuber et al., 1982, Bruno et al., 1990, Hill and Cichra 2005, Strong et al. 2010). Therefore, the depth range used for this habitat metric – game fish spawning habitat – equals 1 to 4 ft.

This depth range will also provide important refuge habitat for small forage fish that form the base of production for game fish, birds, and other wildlife in the lake chain. Forage fish found in the system may include mosquito fish (*Gambusia spp*.), shiners (*Notropis spp*.), golden topminnow (*Fundulus chrysotus*), killifish (*Fundulus spp*.) and other small bodied species. Shallow marshes provide important refugia and forage habitat for these small fish, as well as for game fish (largemouth bass, bluegill, etc.) young-of-the-year.

These small-bodied fish seek refuge from larger fish, birds and other predators, among the shallow marsh vegetation. Habitat depths of 1 to 4 ft will provide protection for this important component of the aquatic community in Apshawa Lake South.

Large Wading Bird Habitat

Water depth is a critical component of wading bird habitat (Bancroft et al., 2002, Pierce and Gawlik, 2010, Lantz et al., 2011). Forage success of long-legged wading bird species (e.g., great egret (*Ardea alba*), great blue heron (*Ardea herodias*) can be constrained by their leg length (Powell 1987), and typically forage in vegetation in water less than or equal to ~10–12” (Kushlan 1979, Kushlan et al., 1985, Bancroft et al., 1990). Therefore, the depth range used, to prevent a significant shift in forage habitat for large wading birds, is 0 to 1 foot.

Small Wading Bird Habitat

Short-legged wading birds (little blue heron (*Egretta caerulea*), snowy egret (*Egretta thula*), ibis (*Eudocimus albus*), etc.) require shallower habitat (~0.5 ft) for suitable foraging (Kushlan 1979, Kushlan et al., 1985). The depth range used, to prevent significant change to forage habitat for small wading birds, is 0 to 0.5 ft.

Sandhill Crane Nesting Habitat

The Florida sandhill crane typically nests in shallow herbaceous wetlands, dominated by maidencane, pickerelweed, rush and/or smartweed (*Polygonum spp*.; Stys 1997). The shallow maidencane marshes at Apshawa Lake South provide potential nesting and forage habitat for sandhill cranes and other birds. Average water depths for suitable sandhill crane nesting ranges from approximately 0.5 to 1 ft (Stys 1997). This is the depth range used for evaluation of this habitat metric.

Open-Water Area

<u>Fish refugia</u>

An open-water metric has been developed to protect deep water habitats that provide important refuge habitat for fish and other organisms, especially during periods of low water. Open water is defined, for this metric, as those areas of the lake greater than or equal to 5 ft deep. The *majority* of emergent and floating-leaved plants at Apshawa Lake South grow in water ranging in depths from 0 to 5 ft.

In many water bodies, aquatic organisms require refuge from drought. Although droughts are natural phenomena, water withdrawal can mimic and exacerbate drought and drying of aquatic ecosystems (Magoulick and Kobza 2003). Drought refugia is especially important for fish. During periods of low water (whether from drought and/or pumping) decreasing volumes of water can result in increases in extremes of abiotic conditions (e.g., high temperature and low dissolved oxygen) and increases in concentrations of organisms (Magoulick and Kobza 2003). In drought refugia, fish are concentrated into increasingly small areas, competing for space and resources, increasing their exposure to competition, predation (e.g., from birds and other fish) and disease (Lowe-McConnell 1975, Magoulick and Kobza 2003, Mathews and Marsh-Mathews 2003, Lennox et al., 2019). As lakes recede, fish and other organisms move from shallow nearshore habitats to deeper areas (Gaeta et al. 2014). These open-water deep areas within lakes are more resistant than shallow areas to water level decline, and thus provide critical refugia for fish and other species (White et al. 2016). Deep areas in lakes provide protection for fish from both predation (e.g., avian predators) and protection from high temperatures. Deeper, cool water refugia are important habitats for game fish species throughout Florida (Florida Fish and Wildlife Conservation Commission, personal communication).

The recommended open-water area metric provides protection of thermal refugia for game fish and other species. Deep areas of relatively cool water reduce physiological stress caused by high temperatures and low dissolved oxygen, especially during summer months and prolonged drought periods (Lennox et al. 2019). The open-water area metric will help prevent significant harm from occurring by the reduction of important thermal-refuge habitats at these lakes, relative to the no-pumping condition. Largemouth bass, bluegill, black crappie and other game fish species rely on open-water habitats most of the year. Black crappie resides in open-water areas most of the time, moving to nearshore habitats in the spring to spawn (Mesing and Wicker 1986, Bull et al. 1995, Matthias et al. 2014). Protection of open-water habitats is positively correlated with the diversity of fish and other aquatic species. Fish are known to prefer an intermediate mixture of open water and littoral habitat (Wiley et al. 1984, Aho et al. 1986, Trebitz and Nibbelink 1996, Miranda and Pugh 2011). A lack of open water can reduce both the abundance and diversity of game fish species (Colle and Shireman 1980, Allen and Tugend 2002, SFWMD 2011).

Recreation

In addition to providing protection for deep water (pelagic) habitats of Apshawa Lake South, the open-water area metric will also help protect recreational uses and water quality. Regarding the former, the open-water area metric will provide a safety depth for boating and other open-water recreational activities, ensuring the protection of areas that are free from vegetation and other obstacles within the littoral zone. A 5-ft boating depth is recommended based on the US Coast Guard's (USCG) safety guidelines (http://www.uscgboating.org/index.aspx). The USCG suggests a 5 to 6 ft minimum depth, and the minimum of this range (i.e., 5 ft) is being used.

While the USCG guideline is focused on waterskiing, the primary purpose of the recommended safety depth is to ensure that boating and other water-related recreation are in areas free from obstacles. Emergent marsh, as defined above, grows predominantly in water ranging in depths from 0 to 6 ft. Therefore, the open-water area metric will provide for recreation in deep areas that are beyond the majority of littoral zone (i.e., these two metrics overlap).

This metric has been the constraint at other MFLs with peer reviewers noting that open-water areas are "…required for [not just] water skiing but also the amount of depth needed for safe operation of power boats." (Cardno 2018). Further, Leeper et al. (2001) note that "…lake areas exceeding three to six feet in depth may be considered suitable for most recreational activities."

Water quality

Water level decline due to drought and/or withdrawal can also negatively affect lake water quality, indirectly affecting fish and other organisms. As lake levels decline, remaining refuge areas become warmer, have higher solar irradiation, and increased concentrations of nutrients (Lennox et al. 2019). These factors can lead to the increased potential for excessive algal growth and decreased water quality. The open-water metric will benefit Apshawa Lake South water quality by reducing the potential for an increase in these negative effects.

The open-water metric also serves to protect Apshawa Lake South from increased eutrophication due to wind-driven mixing. Water depth, relative to surface water area, mediates wind-driven mixing of sediments and nutrients in surface waters (Magoulick and Kozba 2003). By ensuring areas of deeper water are not reduced significantly, relative to a no-pumping condition, the open-water area metric will help maintain summer stratification and reduce the likelihood of wind-driven mixing of sediments and nutrients.

Drought-related reductions in habitat area/volume, increased physical and chemical extremes, and increased negative biotic interactions (i.e., predation and competition) naturally occur in aquatic ecosystems (Magoulick and Kozba 2003, Humphries and Baldwin 2003). However, these stressors can be exacerbated by human-induced alterations (Lennox et al. 2019), including water level declines due to withdrawal (Magoulick and Kozba 2003). In addition to protecting ecological functions and values, the open-water metric will also help minimize these negative effects of water level decline on recreational uses and water quality at Apshawa Lake South.

Hydroperiod Tool Metrics Results

Nearshore fish and wildlife habitat

Using output data from the hydroperiod tool, the relationship between no-pumping condition water level and habitat area was evaluated for the five nearshore fish and wildlife metrics (Table 10). While habitat area for all five nearshore metrics fluctuated with water level, the overall magnitude of habitat area did not change significantly from high to low water level (Figure 32). This is presumably due to the bowl-shaped bathymetry of Apshawa Lake South, and the fact that the overall slope of the nearshore environment doesn't change significantly with water level decline. The average habitat area under the MFLs condition (i.e., 15% reduction from average area under the no-pumping condition) for each metric is provided in Table 10. The MFLs-condition area for each metric is compared to the current-pumping condition in the *MFLs Assessment* section.

Open-Water Area

In sharp contrast to the relationship between water level change and nearshore habitat areas, open-water area exhibited a marked positive linear relationship with water level (Figure 32). The lack of a threshold response is one of the reasons that a 15% reduction in average no-pumping area is being used as an impact threshold. This equates to an allowable change of 7.4 acres of open water area from the no-pumping condition area (49.4 acres) to the MFLs condition (42.0 acres).

Table 10. Average acreage for nearshore fish and wildlife habitats and open-water area, under no-pumping (NP) condition and MFLs condition based on hydroperiod tool output

Fish and wildlife habitat metric	Habitat acreage (acres; averaged over entire POR)	
	NP	MFLs
Small wading bird forage habitat	1.8	1.5
Large wading bird forage habitat	4.1	3.5
Sandhill crane nesting habitat	2.3	2.0
Emergent marsh habitat	25.1	21.3
Game fish spawning habitat	12.6	10.7
Open-water area	49.4	42.0

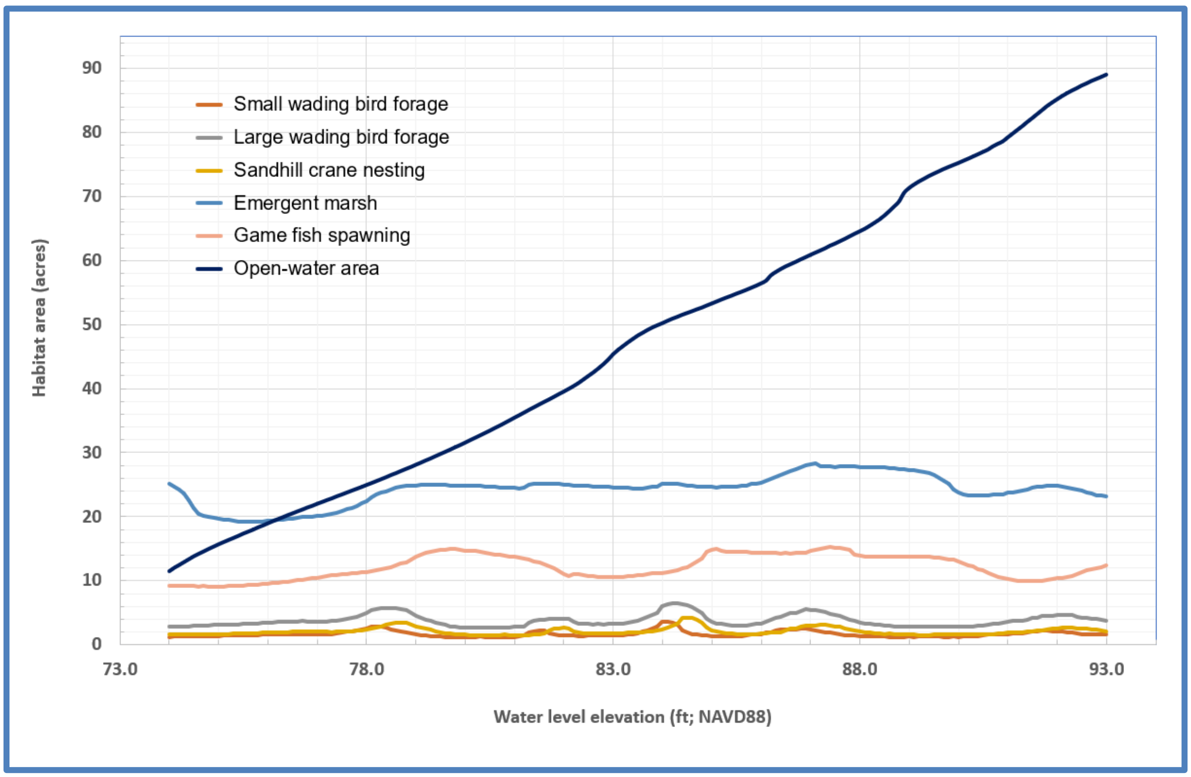

Figure 32. Hydroperiod tool output data showing water level versus habitat area for five nearshore fish and wildlife metrics and open-water area for Apshawa Lake South, Lake County, Florida

MFLs Determination Summary

The MFLs condition (i.e., recommended threshold or habitat reduction) Apshawa Lake South environmental criteria are summarized below (Table 11). The assessment of environmental criteria (i.e., whether they are being met currently and based on future withdrawal projects) is discussed in the *MFLs Assessment* section.

Table 11. MFLs condition for Apshawa Lake South environmental criteria; NP = no-pumping condition

Environmental Criterion	**Environmental values protected**	**MFLs Condition**		
Minimum Average	Average Organic Soils Elevation	Level (ft, NAVD88)	Duration (days)	Return Interval (years)
		80.6	180	2.4
Small wading bird forage habitat	Fish and wildlife habitat	NP = 1.8 acres	MFLs condition = 1.5 acres	
Large wading bird forage habitat	Fish and wildlife habitat	NP = 4.1 acres	MFLs condition = 3.5 acres	
Sandhill crane nesting habitat	Fish and wildlife habitat	NP = 2.3 acres	MFLs condition = 2.0 acres	
Emergent marsh habitat	Fish and wildlife habitat	NP = 25.1 acres	MFLs condition = 21.3 acres	
Game fish spawning habitat	Fish and wildlife habitat	NP = 12.6 acres	MFLs condition = 10.7 acres	
Open-water area	Fish habitat, recreation, water quality	NP = 49.4 acres	MFLs condition = 42.0 acres	

MFLs Assessment

As previously described, MFLs are not meant to represent optimal conditions, but rather set the limit to 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 regime but that still protect important environmental functions and values from significant harm caused by water withdrawals. The MFLs determination component (described above) involves defining a minimum hydrologic regime (which defines the MFLs condition) necessary to protect relevant water resource values.

The no-pumping condition and current-pumping condition lake level datasets developed for Apshawa Lake South were used to calculate freeboard or deficit and determine whether the lake is in recovery, prevention or neither (see *Hydrological Analyses* and Appendix B for more details regarding development of the no-pumping and current-pumping conditions). The MFLs assessment compares the MFLs condition for each metric with the current pumping condition (defined as the impact condition based on the 2014–2018 average). This comparison determines whether the MFLs criteria are being achieved under the current-pumping condition, and whether there is water available for withdrawal (freeboard), or if water is needed for recovery (deficit). If any of the MFLs criteria are not being protected under the current-pumping condition, indicating a deficit of water, a recovery plan is required. If the most constraining MFLs criterion is currently being met, but a deficit is projected within the 20-year planning horizon, a prevention plan is required.

Current Status

Current status was assessed for the final suite of environmental criteria selected as part of the MFLs determination process (Table 11). The MFLs-condition and current-pumping condition were compared for each environmental metric, resulting in a freeboard or deficit. The most constraining environmental metric was used as the basis for the Apshawa Lake South MFLs. The following briefly summarizes the assessment of each environmental metric.

Event Based Metric

Only one event-based metric was determined for Apshawa Lake South, a minimum average (MA; see *MFLs Determination* section for more details). The MA was assessed by using frequency analysis to compare the recommended return interval of the event to the return interval under the current-pumping condition (See Appendix F for frequency analysis details and UFA freeboard assessment details).

Under current-pumping (2014–2018 average impact) conditions the MA is met and has a UFA freeboard of 1.4 ft (see Figure 2 in Appendix F).

Fish and Wildlife Metrics – Hydroperiod Tool

SJRWMD's GIS-based hydroperiod tool was used to evaluate the effect of water level decline on the six fish and wildlife criteria described above. For each metric, habitat area was calculated at 0.1 ft intervals for the no-pumping lake level timeseries, using stage/habitat area output from the hydroperiod tool. Current status was assessed by comparing the percent reduction of average habitat area (i.e., averaged across the entire POR) under the current-pumping condition (See Appendix F for details).

UFA freeboard was calculated for the three fish and wildlife metrics with the highest habitat acreage under the no-pumping condition (i.e., UFA freeboard was not calculated for the three metrics with less than 5 acres of habitat; Table 12). The freeboards for both the emergent marsh habitat and game fish spawning habitat metrics equal > 1.4 ft. Both exhibited minimal reduction in habitat area under this withdrawal scenario, and so further modeling and assessment was not done for these metrics. Based on this analysis, the open-water area metric had the smallest amount of freeboard (i.e., is most constraining); UFA freeboard for this metric equals 0.8 ft (See Appendix F for details).

Table 12. UFA freeboard for Apshawa Lake South environmental criteria

Environmental Criterion	UFA freeboard (ft)
Minimum average	1.4
Emergent marsh habitat	> 1.4 ft
Game fish spawning habitat	> 1.4 ft
Open-water area	0.8

This status assessment indicates that all environmental criteria evaluated are met under the 2014–2018 average current-pumping condition. The most constraining criterion (open-water area metric) has a UFA freeboard of 0.8 ft under this impacted condition.

A UFA drawdown of 0.7 ft is projected at 2045, relative to the current-pumping condition, leaving a freeboard of 0.1 ft at 2045. Therefore, Apshawa Lake South MFLs are met at the planning horizon and this water body is not in prevention or recovery.

WATER RESOURCE VALUES

Consideration of Environmental Values Under 62-40.473, F.A.C.

Pursuant to Sections 373.042 and 373.0421, F.S., 10 environmental values (also called water resource values [WRVs]) identified in rule 62-40.473, F.A.C., were considered as part of the Apshawa Lake South MFLs reevaluation. As described below, only relevant WRVs were evaluated. SJRWMD uses the following working definitions when considering these WRVs:

1. Recreation in and on the water—The active use of water resources and associated natural systems for personal activity and enjoyment. These legal water sports and activities may include, but are not limited to swimming, scuba diving, water skiing, boating, fishing, and hunting.
2. Fish and wildlife habitat and the passage of fish—Aquatic and wetland environments required by fish and wildlife, including endangered, endemic, listed, regionally rare, recreationally or commercially important, or keystone species; to live, grow, and migrate. These environments include hydrologic magnitudes, frequencies, and durations sufficient to support the life cycles of wetland and wetland-dependent species.
3. Estuarine resources—Coastal systems and their associated natural resources that depend on the habitat where oceanic saltwater meets freshwater. These highly productive aquatic systems have properties that usually fluctuate between those of marine and freshwater habitats.
4. Transfer of detrital material—The movement by surface water of loose organic material and associated biota.
5. Maintenance of freshwater storage and supply—The purpose of this environmental value is to protect, from significant harm due to water withdrawal, an adequate amount of freshwater for non-consumptive uses and environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands ecology. This value encompasses all other environmental values identified in Rule 62-40.473 F.A.C. Because the overall purpose of the MFL is protect environmental resources, and other non-consumptive beneficial uses while also providing for consumptive uses, this environmental value is considered protected if the remaining relevant values are protected.
6. Aesthetic and scenic attributes—Those features of a natural or modified waterscape usually associated with passive uses, such as birdwatching, sightseeing, hiking, photography, contemplation, painting and other forms of relaxation, that usually result in well-being and contentment.

7. Filtration and absorption of nutrients and other pollutants—The reduction in concentration of nutrients and other pollutants through the process of filtration and absorption (i.e., removal of suspended and dissolved materials) as these substances move through the water column, soil or substrate, and associated organisms.
8. Sediment loads—The transport of inorganic material, suspended in water, which may settle or rise. These processes are often dependent upon the volume and velocity of surface water moving through the system.
9. Water quality—The chemical and physical properties of the aqueous phase (i.e., water) of a water body (lentic) or a watercourse (lotic) not included in definition number 7 (i.e., nutrients and other pollutants).
10. Navigation—The safe passage of watercraft (e.g., boats and ships), which is dependent upon adequate water depth and channel width.

The determination of whether each WRV is protected was based on whether there was a significant change, from the no-pumping to MFL condition, for specific criteria evaluated for each WRV. For each WRV, a significant harm threshold of 15% was used as the allowable reduction from the no-pumping condition (see above for discussion of 15% impact threshold). No-pumping and MFLs conditions exceedance curves were created to help assess whether relevant environmental values are protected by the recommended MFLs (Figure 33).

The exceedance curves were created using no-pumping condition and MFLs condition daily lake level time series, respectively (see above for discussion of creation of no-pumping condition time series). The MFL condition lake level time series was simulated by lowering groundwater levels incrementally in the Apshawa Lake South surface water model until it produced a lake level time series that just meets (but does not trip) the most constraining environmental metric (i.e., the open-water area metric).

Consideration of these values is meant to ensure that recommended MFLs protect the full range of water-related functions 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 the 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 Apshawa Lake South and also based on whether they protect ecological versus non-ecological structure and function.

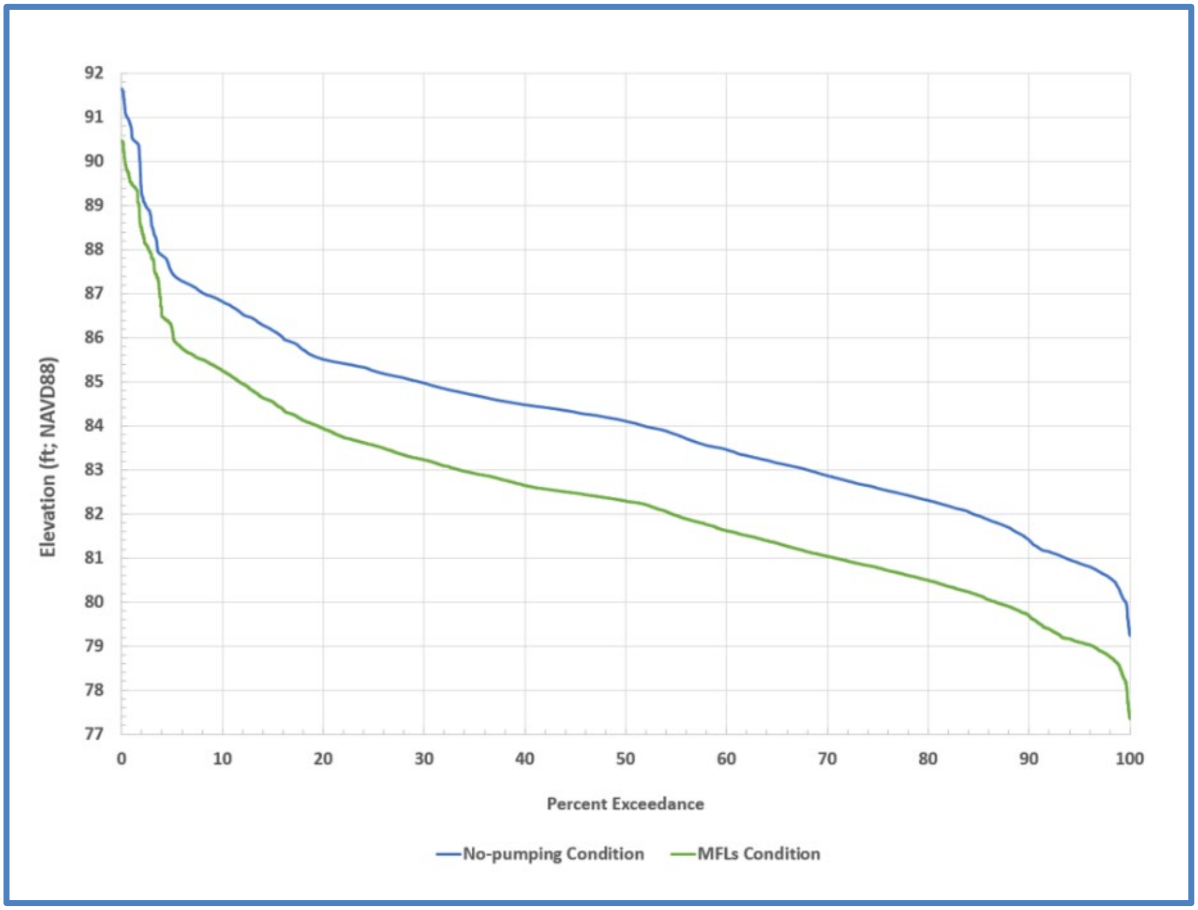

Figure 33. No-pumping condition (blue) and MFLs condition (green) exceedance curves for Apshawa Lake South

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

Group 1: WRV3, WRV8, WRV9, and WRV10

The four WRVs in this group are not applicable to this lake and thus were not considered as part of this assessment.

- Estuarine resources (WRV3): This environmental value is not relevant because the lake is land-locked and has no surface water connection to any estuarine resources. Therefore, WRV-3 was not considered for this evaluation.

- Sediment loads (WRV8): Transport of inorganic materials as bed load is considered relevant only in flowing systems, where riverine fluvial dynamics are critical to maintenance of geomorphic features (i.e. bed forms and the floodplain) and their associated ecological communities. Lakes typically serve as sinks instead of sources of sediment load, and therefore WRV-8 was not considered for this evaluation.
- Water quality (WRV9): Sufficient data were not available for evaluating the relationship between lake stage and water quality. Due to the lack of water quality data, WRV-9 was not considered for this evaluation.
- Navigation (WRV10): The navigation of large watercraft (e.g., boats and ships) is not relevant to this lake. Therefore, WRV-10 was not considered for this evaluation.

Group 2: WRV2, WRV4, WRV5, and WRV7

The four WRVs in this group are closely associated with and depend on the ecological functions and biochemical processes provided by the wetland communities at Apshawa Lake South. Protection of wetland communities is afforded by the MA (wetland soils protection) and the fish and wildlife hydroperiod tool metrics (emergent marsh, and various wildlife habitats).

The MFLs condition (based on 15% reduction in open-water area) results in less than a 15% change in area for all other hydroperiod tool metrics (i.e., the five nearshore metrics; Table 13). The MFLs condition also ensures that the MA is met, because the available water for the former (0.8 ft) is less than that of the latter (1.4 ft).

WRV 2 – Fish and wildlife habitat and the passage of fish

WRV 2 is meant to ensure the consideration and protection of aquatic and wetland environments required by fish and wildlife, including endangered, endemic, listed, regionally rare, recreationally or commercially important, or keystone species. The MA and fish and wildlife metrics for Apshawa Lake South are based on the protection of fish and wildlife habitats in nearshore and deep-water habitats, as well as fringing wetlands (i.e., MA). These wetlands include shallow and deep marsh habitats that provide important refuge habitat for small forage fish and juveniles of game fish that form the base of production for larger fish, birds and other wildlife. Littoral habitats provide important refugia and forage for invertebrates, fish, mammals, birds, and other wildlife. Therefore, compliance with the primary environmental metrics evaluated will provide protection of “fish and wildlife habitats and the passage of fish” for Apshawa Lake South.

Table 13. Percent change in habitat area relative NP condition, for each habitat type based on the most constraining environmental metric (15% reduction in open-water area)

Environmental Criterion	NP-Condition area (acres)	Percent change in NP-Condition area, based on most constraining metric
Small wading bird forage habitat	1.8	10.4
Large wading bird forage habitat	4.1	12.0
Sandhill crane nesting habitat	2.3	13.3
Emergent marsh habitat	25.1	1.0
Game fish spawning habitat	12.6	-0.4*
Open-water area	49.4	15.0

**increase in habitat area*

WRV 4 – The transfer of detrital material

WRV4 is meant to ensure consideration of the movement by water of loose organic material and debris and associated decomposing biota. Detrital material is an important component of aquatic food webs (Mitsch and Gosselink 2015). Wetland communities, such as wet prairie, shallow marsh and deep marsh, are important sources of detrital material for Apshawa Lake South. The transport of detritus is defined as the movement by water of loose organic material and debris and associated decomposing biota. The organic particles consist of decomposing vegetation, including leaves and wood, processed by microbes (e.g., bacteria and fungus). A significant portion of detrital transfer occurs during high-water events, when accumulated detrital materials in adjacent wetlands are moved to the aquatic system. Compliance with the recommended MA will ensure adjacent habitats are not subject to excessive drying, and the nearshore wetland metrics will provide protection for organic sources within the littoral zone. Therefore, the "transfer of detrital material" is considered to be protected by the MFLs condition.

WRV 5 – The maintenance of freshwater storage and supply

The maintenance of freshwater storage and supply (WRV5) is also included in this group. The purpose of this environmental value is to protect, from significant harm due to water withdrawal, an adequate amount of freshwater for non-consumptive uses and environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands ecology. This environmental value encompasses all other environmental values identified in Rule 62-40.473 F.A.C. Because the overall purpose of the MFL is to protect environmental resources, and other non-consumptive beneficial uses, while also providing for consumptive uses, this environmental value is considered protected if the remaining relevant values are protected.

WRV 7 – The filtration and absorption of nutrients and other pollutants

WRV7 is meant to ensure consideration of nutrient and pollution filtration and absorption (i.e., the removal of suspended and dissolved materials as these substances move through the water column, soil, or substrate and associated organisms). Water quality data are not sufficient to understand the relationship between water-level fluctuation and nutrient dynamics for this lake. However, maintaining the wetlands around Apshawa Lake South will provide for some filtration and absorption of excess nutrients and other pollutants. Compliance with the recommended MA will ensure adjacent habitats are not subject to excessive drying, and the hydroperiod tool nearshore wetland metrics will provide protection for the littoral zone. Therefore, the WRV 7 is considered to be protected by the MFLs condition.

Group 3: WRV1 and WRV6

The two WRVs in this group are closely related to lake area and depth, although WRV 6 is also related to the condition of wetland vegetation communities in and around the lake.

WRV 1 – Recreation in and on the water

The MFLs condition is based on the open-water area metric. Compliance with the MFLs will ensure that there is no more than a 15% reduction from the no-pumping condition in water and that it is safe for boating and other recreational activities (see open-water area metric description above). Protection of depths greater than or equal to five feet will also protect other forms of water-based recreation such as canoeing and kayaking. A protective paddling water depth of 20 inches was defined in 1990 by the Florida Department of Natural Resources (FDNR 1990). Protection of the MFLs condition will provide protection for paddling depths both in shallow (based on nearshore metrics) and deep (open-water area metric) portions of Apshawa Lake South.

WRV 6 – Aesthetics and scenic attributes

The purpose of this environmental value is to protect, from significant harm due to water withdrawal, those features of a water body typically associated with passive uses, such as birdwatching, sightseeing, hiking, photography, contemplation, painting and other forms of relaxation. This WRV was evaluated based on the change to total lake area (nearshore and open-water area) from the no-pumping to MFLs condition. The hydroperiod tool output was used to determine the relationship between water level and total lake area for these two conditions. Average (over the POR) total lake area for Apshawa Lake South under the no-pumping condition is 70.3 acres. Average total lake area under the MFLs condition, based on protecting deep water habitat, is 62.6 acres, which equates to an 11% reduction. The MFLs condition also represents a 14% reduction in total area at the median (P50) lake level, relative to the no-pumping condition (Figure 34). The reduction in average total lake acreage and median total lake acreage are both less than the 15% threshold used for the hydroperiod tool metrics. Therefore, this WRV is considered protected by the recommended MFLs condition.

Summary

As discussed above, the Apshawa Lake South MFLs condition, based on protection of open-water area (area ≥ 5 feet deep), will provide protection for all relevant environmental values identified in rule 62-40.473, F.A.C (Table 14).

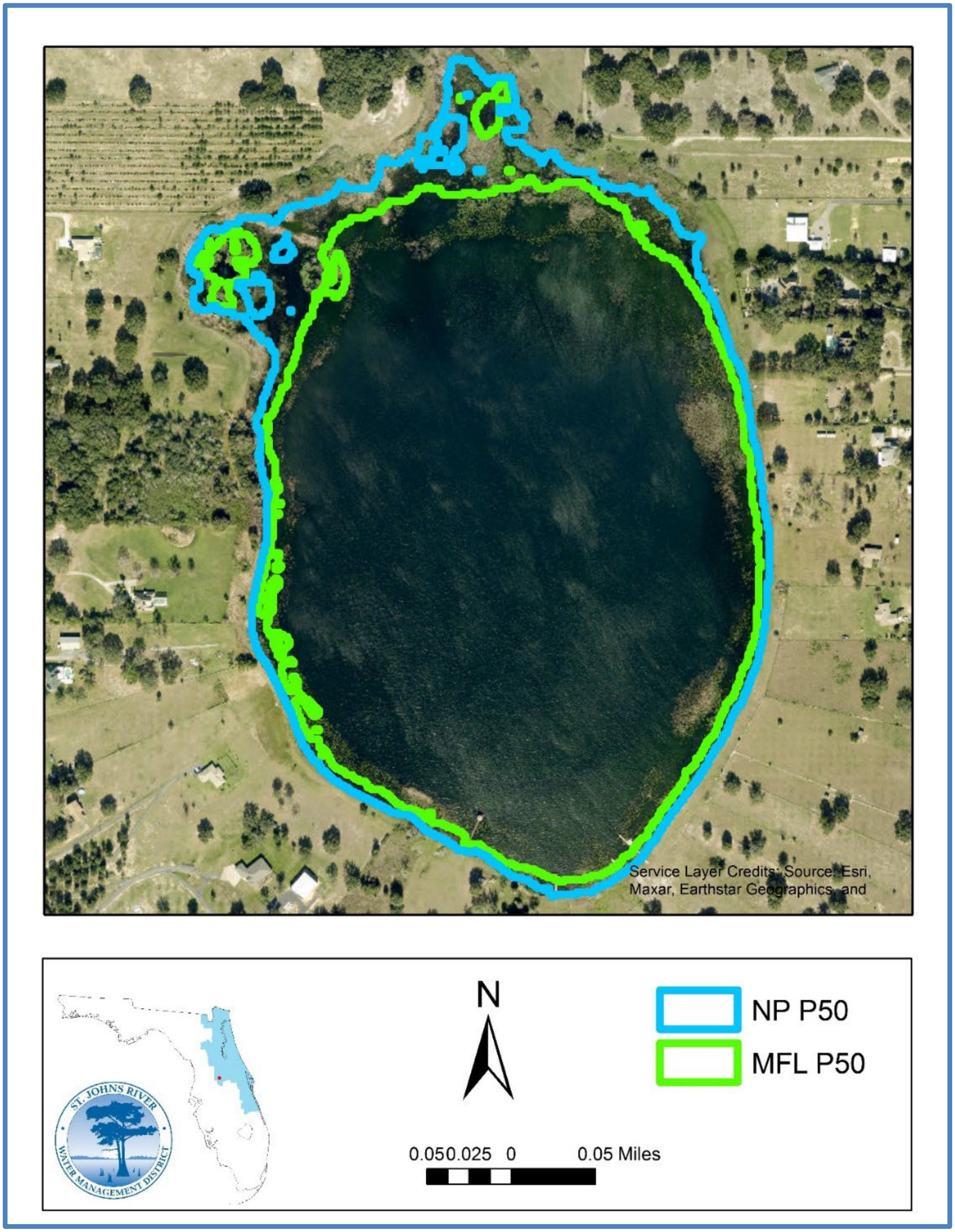

Figure 34. Comparison of total lake area for no-pumping P50 versus MFLs P50

Table 14. Relevant WRVs protected by Apshawa Lake South MFLs condition

WRV	Representative values or functions	Change under MFLs condition	Protected by the MFLs condition?
Recreation in and on the water	Open-water area	15.0% reduction in area open deep water	Yes
Fish and wildlife habitats and the passage of fish	Open-water area	15.0% reduction in area open deep water	Yes
	Emergent marsh habitat	1.0% reduction in habitat area	Yes
	Gamefish habitat	0.4% increase in habitat area	Yes
	Small wading bird habitat	10.4% reduction in habitat area	Yes
	Large wading bird habitat	12.0% reduction in habitat area	Yes
	Sandhill crane habitat	13.3% reduction in habitat area	Yes
	Minimum Average	drying event occurs less often than recommended under MFLs condition	Yes
Transfer of detrital material	The movement of loose organic material and debris and associated decomposing biota	1.0% reduction in average marsh area	Yes
Aesthetic and scenic attributes	Visual setting around the lake	11% reduction in reduction of average lake area	Yes
Filtration and absorption of nutrients and other pollutants	The process of absorption and filtration	1.0% reduction in mean marsh area	Yes
Maintenance of freshwater storage and supply	Protection of water for non-consumptive uses and environmental values is ensured by protecting all other WRVs		Yes

SWFWMD Xeric Offset

An additional evaluation was conducted to put the recommended MFLs condition for Apshawa Lake South in context and help determine whether it is reasonable and protective. The SWFWMD has recently developed a protective offset (i.e., median lake level offset) for those lakes determined to be “xeric” based on soils and physiography (sandhill lakes located in ridge physiographic provinces; GPI and SWFWMD 2022). This xeric offset is based on a study of over 150 stressed and unstressed central Florida lakes. It allows a reduction in P50 water level of 2.2 ft, relative to a pre-withdrawal “historic” condition, which is conceptually similar to SJRWMD's no-pumping condition. This offset is based on an empirical crossing point method that was used to identify a threshold that minimizes classification error (i.e., classification of lake as stressed or non-stressed).

A comparison of the Apshawa Lake South MFLs condition to the xeric offset was deemed appropriate because of the sandhill characteristics of this lake. It is very similar to the lakes used to develop the xeric offset. The Apshawa Lake South MFLs condition, based on the open-water area metric, results in a 1.8-foot reduction from the no-pumping condition P50 (no-pumping condition P50 = 84.1 ft; MFLs condition P50 = 82.3 ft). This result is similar to the 2.2-foot reduction from historic P50 allowed by the SWFWMD xeric offset, and within the distribution of allowable reduction from historic P50, based on the bootstrap analysis described above (Figure 35). This comparison shows that the Apshawa Lake South recommended MFLs condition is of a similar magnitude to a threshold developed for the same purpose but using a totally unique methodology. This comparison provides support for the Apshawa Lake South MFLs condition, suggesting that it is not overly constraining or under protective.

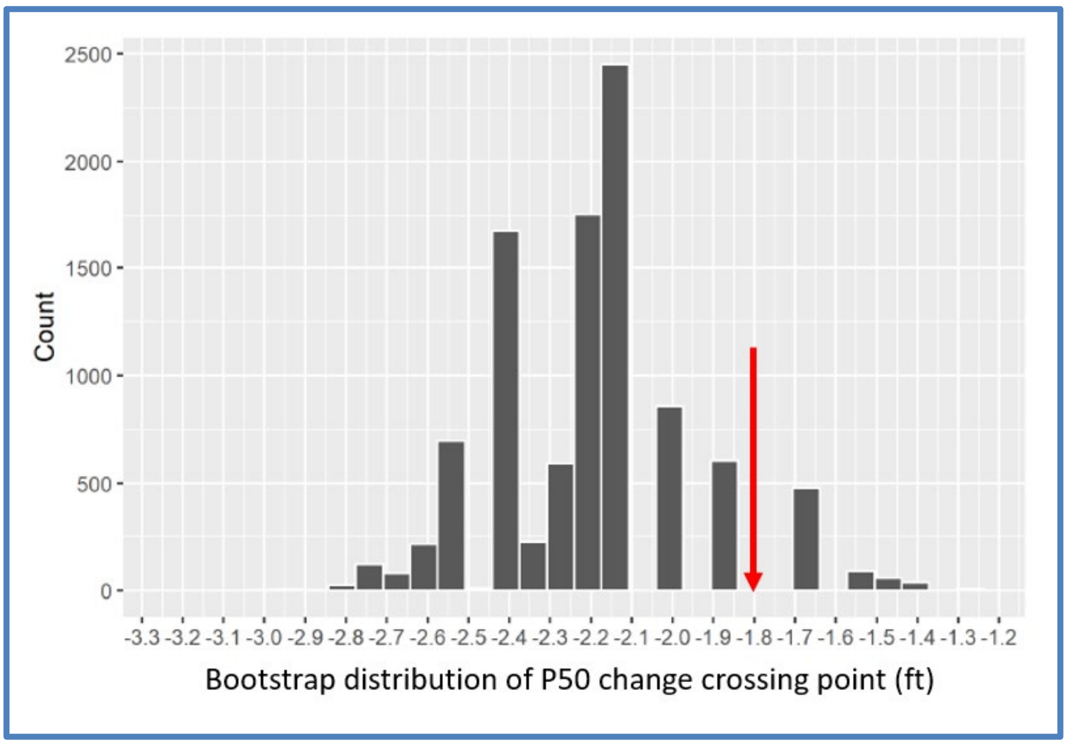

Figure 35. SWFWMD xeric offset method: bootstrap distribution of P50 reduction; data depicts P50 offset results that were best at discriminating between stressed and unstressed sites, with a median value of 2.2 ft (the offset used by SWFWMD for this metric) based on 10,000 resamples; Red arrow shows how allowable reduction in no-pumping P50 for Apshawa Lake South fits in the distribution

CONCLUSIONS AND RECOMMENDATIONS

Minimum levels for Apshawa Lake South were originally adopted in 2002. The reevaluated minimum levels described herein are based on implementation of updated methods and more appropriate environmental criteria. The updated methods include results from an updated regional groundwater model and updated surface water model used to quantify the effects of local and regional groundwater withdrawals, and the analysis of an additional ~ 20 years of hydrologic data. The proposed minimum levels for Apshawa Lake South are based on the most up-to-date and appropriate methods, criteria and data.

Numerous criteria were investigated to ensure that proposed minimum levels would protect important environmental values and beneficial uses. Some preliminary criteria were determined to be inappropriate (e.g., event-based wetland criteria were not appropriate given the on-going disturbance and land management around the lake). The criteria used for this reevaluation include an event-based metric (i.e., the Minimum Average) and six fish and wildlife habitat metrics evaluated using SJRWMD's hydroperiod tool.

The MFLs condition (recommended minimum hydroperiod) and current-pumping condition were compared for each metric to determine current status. The current-pumping condition is defined as the average pumping condition between 2014 and 2018, and represents withdrawals influenced by the range of climatic conditions (e.g., rainfall) present over that period. If these conditions are repeated over the next 59 years (i.e., the length of the POR), and average pumping remains the same, the current-pumping condition lake levels are expected to reflect future lake levels. The ECFTX v2.0 steady state 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 (See Appendix B for details of the groundwater pumping impact analysis).

The MFLs assessment indicates that all environmental criteria evaluated are met under current-pumping conditions. The most constraining criterion (open-water area metric) has a UFA freeboard of 0.8 ft. A UFA drawdown of 0.7 ft is projected at 2045, relative to the current-pumping condition, leaving a freeboard of 0.1 ft at 2045. Therefore, Apshawa Lake South MFLs are met at the planning horizon and this water body is not in prevention or recovery.

RECOMMENDED MINIMUM LEVELS

Three minimum levels, a minimum P25, P50 and P75, are recommended for Apshawa Lake South (Figure 36; Table 15). 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, is based on the protection of open-water habitat and is associated with an UFA freeboard of 0.8 ft. Adopting these three minimum levels will ensure the protection of the minimum hydrologic regime at low, average and high levels for Apshawa Lake South.

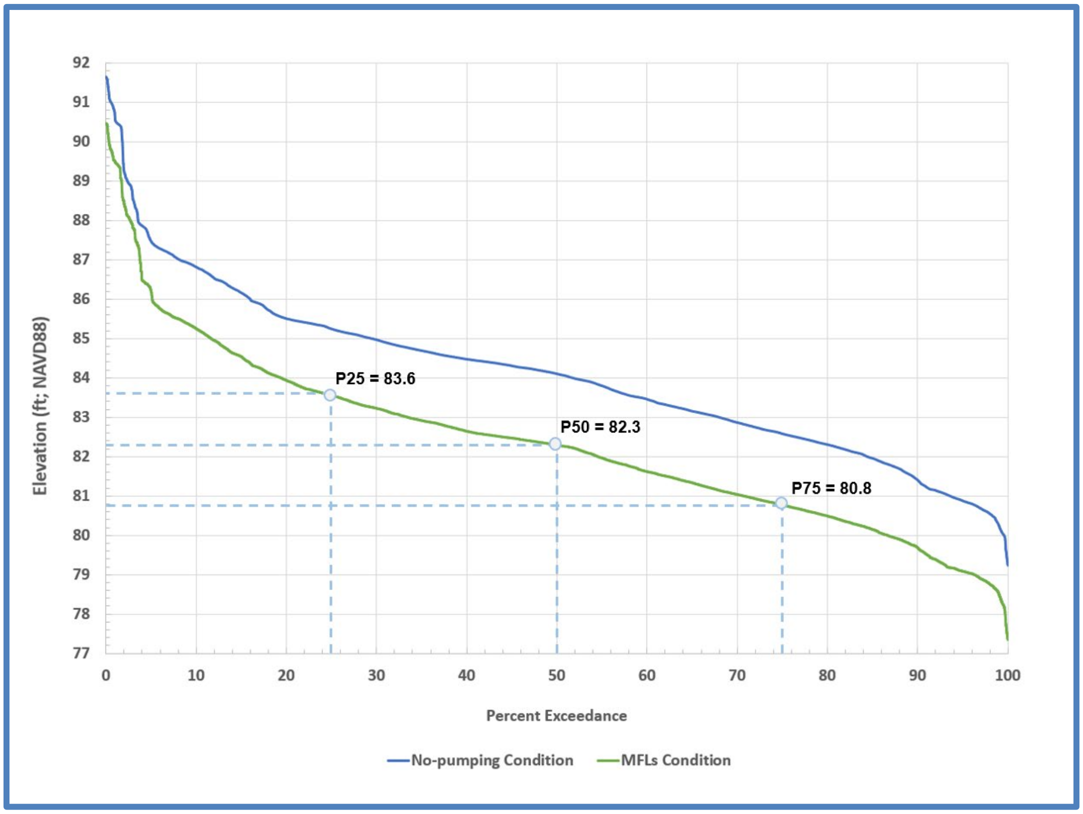

Figure 36. MFLs condition exceedance curve based on most constraining environmental metric. Dashed blue lines indicate the recommended minimum P25, P50 and P75 elevations for Apshawa Lake South, Lake County, Florida

Table 15. Recommended Minimum Levels for Apshawa Lake South, Lake County, Florida

Percentile	Recommended minimum lake level (ft; NAVD88)
25	83.6
50	82.3
75	80.8

A suite of 10 environmental values, listed in Rule 62-40.473, F.A.C., were considered to ensure that the MFLs condition protects all relevant water resource values (WRVs) for Apshawa Lake South.

Based on this evaluation, SJRWMD concludes that the recommended minimum levels for Apshawa Lake South will also protect all relevant WRVs. 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 prudent to test implicit assumptions made as part of setting and assessing MFLs. SJRWMD acknowledges that the MFLs determination and assessment methods, described herein, assume that Apshawa Lake South's hydrological history (i.e., water level period of record) will repeat itself in the future. Given the lack of information about the future, and substantial uncertainties in future rainfall and temperature predictions by global climate models, this assumption is thought to be appropriate, but will be regularly tested by implementing an adaptive management strategy.

SJRWMD implements this 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 minimum P25, P50 and P75 for Apshawa Lake South. The constraining metric (open water area) will also be analyzed to ensure it is protected, in addition to the three water level percentiles.

These analyses will be performed approximately every five years, as well as when permit applications are considered that may impact the MFL. MFL status will also be monitored periodically by reviewing multiple exceedance curve percentiles, updated with post current-pumping condition (i.e., observed) water levels. If these fall below the corresponding MFLs condition percentiles (minus standard error), this may trigger a more detailed analysis to determine whether the change in lake levels is 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, then no further actions are required beyond continued monitoring. If the analysis shows that MFLs are not being met or are trending toward not being met, SJRWMD will conduct a cause-and-effect analysis to independently evaluate the potential impacts of various stressors on the MFLs water body.

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