Technical Publication SJXX

MINIMUM LEVELS REEVALUATION FOR SYLVAN LAKE SEMINOLE COUNTY, FLORIDA

by

Raymond J. Deschler

Andrew B. Sutherland, PhD

Jian Di

Anne-Elise Wester, PhD

Fatih Gordu, PhD, PE

and

Greenville B. Hall

Division of Water Supply Planning and Assessment

St. Johns River Water Management District

Palatka, Florida

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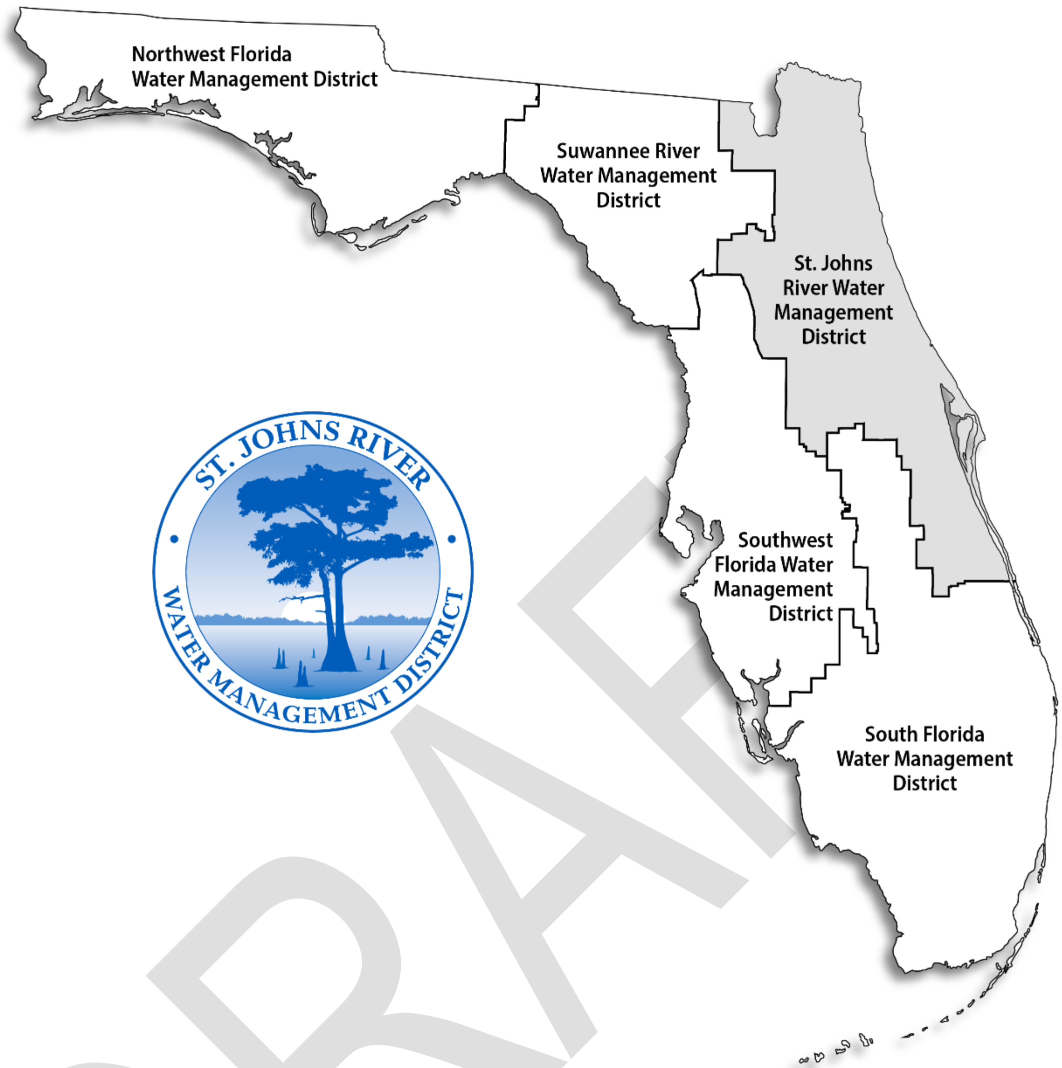

The St. Johns River Water Management District was created in 1972 by passage of the Florida Water Resources Act, which created five regional water management districts. The St. Johns District includes all or part of 18 counties in northeast and east-central Florida. Its mission is to preserve and manage 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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Scientific Reference Center
St. Johns River Water Management District
4049 Reid Street/P.O. Box 1429
Palatka, FL 32178-1429 (32177 for street deliveries)
386-329-4500

EXECUTIVE SUMMARY

As a part of fulfilling its mission and statutory responsibilities, the St. Johns River Water Management District (SJRWMD) establishes minimum flows and levels (MFLs) for priority waterbodies within its boundaries. MFLs establish a minimum hydrologic regime and define the limits at which further consumptive use withdrawals would be significantly harmful to 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 completed a minimum levels reevaluation for Sylvan Lake in Seminole County, Florida. Sylvan Lake MFLs were originally adopted in 1998 and was selected for reevaluation because it is an important water resource within the Central Florida Water Initiative area. Sylvan 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 Sylvan MFL is based on the most up to date methods. The reevaluation resulted in the recommendation to modify the adopted MFLs for Sylvan Lake based on current SJRWMD MFLs determination and assessment methodologies.

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 an alternative hydrologic regime exists that is lower than the pre-withdrawal regime but still protects the environmental functions and values of MFLs waterbodies from significant harm caused by water withdrawals.

A minimum hydrologic regime for Sylvan Lake encompasses a range of water levels within which the waterbody must fluctuate to protect the inherent ecological structure and function of the system. Three minimum levels were developed to ensure appropriate protection of Sylvan Lake's ecological structure and function, as well as human beneficial uses, from significant harm. The minimum levels are based on the protection of 1) transitional shrub communities and associated wetland and wildlife habitat values; 2) organic soils and seasonally flooded wetland habitat; and 3) shallow and deep marsh habitats.

MFLs status was assessed using frequency analysis for each of the three minimum levels developed for Sylvan Lake. This involved comparing the frequency of each MFL hydrologic event (defined with specific lake level and duration components) to the frequency of the same hydrologic event under the current-pumping condition. 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 ~70 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 groundwater model was used for the groundwater pumping impact analysis, which was used to develop the current-pumping condition lake level timeseries used in the MFLs assessment.

Assuming the current-pumping condition (2014-2018) does not change in the future, the MFLs assessment indicates that all three minimum levels are met under current-pumping conditions. The most constraining level (Frequent Low [FL]) has a UFA freeboard of 0.5 feet, and the Minimum Average (MA) and Frequent High (FH) have UFA freeboards of 0.6 feet and 1.5 feet, respectively. UFA drawdown of 0.65 feet is projected within 20 years, resulting in a deficit of 0.15 feet. Therefore, Sylvan Lake is in prevention and a prevention strategy must be developed concurrently with the MFLs.

Three minimum levels, a minimum P25, P50 and P75, are recommended for Sylvan Lake (Table ES-1). These three percentiles were calculated from the MFLs condition lake level time series data (1948–2018). The MFLs condition is a long-term lake level time series, associated with the minimum hydrological regime. This is the lake level timeseries that just meets the most constraining level (FL), is based on the protection of wetland habitat, and is associated with an UFA freeboard of 0.5 ft. Adopting these three minimum levels will ensure the protection of the minimum hydrologic regime at low, average and high levels for Sylvan Lake.

Table ES-1. Recommended Minimum Levels for Sylvan Lake, Seminole County, Florida

Percentile	Recommended minimum lake level (ft; NAVD88)
25	39.4
50	38.2
75	36.9

After developing the three event-based criteria, a suite of 10 environmental values, listed in Rule 62-40.473, F.A.C., were considered to ensure that the recommended minimum levels protect all relevant environmental and human-use water resource values (WRVs) for Sylvan Lake. Based on this analysis, SJRWMD concludes that the most constraining minimum level (FL) for Sylvan Lake also protects all other relevant WRVs, including recreation and other beneficial uses.

The appropriateness of the MFLs condition is also supported by a recent UF study on the relationship between organic soil stability and hydrology. The minimum mean water level supported by this UF study, determined based on maximum reduction below organic soils, yields a long-term mean water of 38.2 ft (NAVD88), which is equal to the long-term mean (and median) water level provided by the MFLs condition.

The MFLs presented in this report are preliminary and will not become effective until adopted by the SJRWMD Governing Board, as directed in Rule 40C-8.031, F.A.C.

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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.

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

Current-pumping Condition 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).

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

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

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

Freeboard: The amount of water available for withdrawal before an MFL is not achieved. 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 recommended minimum 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 is a specific “minimum hydrologic regime” (see definition above) that is based on the most constraining MFLs metric and is necessary to protect a water body from significant harm. The MFLs condition represents an allowable change from the no-pumping condition for the entire period of record. It represents a lowering of the no-pumping condition, but only to the degree that still protects a water body from significant harm. The MFLs Condition is based upon the minimum flow or level that is most constraining to water withdrawal, for a given water body.

Minimum Flows and Levels (MFL): Environmental flows or levels expressed as hydrological statistics, based on the most constraining environmental value, that defines the point at which additional 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: Each minimum level (e.g., Minimum Infrequent High, Minimum Average, or other MFL) is a hydrological event, composed of a magnitude and duration, and a return interval.

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.

INTRODUCTION

The St. Johns River Water Management District (SJRWMD) completed a minimum levels reevaluation for Sylvan Lake in Seminole County, Florida. Pursuant to Florida Statutes (F.S.), SJRWMD is charged with protecting priority waterbodies by developing minimum flows and levels (MFLs). The SJRWMD Governing Board adopted minimum levels for Sylvan Lake in 1998 (Hupalo 1997; Appendix A). Sylvan Lake was selected for reevaluation because it is an important water resource within the Central Florida Water Initiative (CFWI) area. Sylvan 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 Sylvan MFL is based on the most up to date methods. The reevaluation resulted in the recommendation to modify the adopted MFLs for Sylvan Lake based on current SJRWMD MFLs determination and assessment methodologies. The Sylvan Lake MFLs are scheduled for reevaluation by 2020. This report describes environmental analyses used to develop protective criteria and updated minimum levels for Sylvan Lake. Hydrological analyses and current and future status assessment of recommended minimum levels are also provided.

The recommended minimum levels for Sylvan Lake are intended to support the protection of aquatic and wetland ecosystems from significant ecological harm caused by the consumptive use of water. In addition, MFLs provide technical support to SJRWMD's regional water supply planning process (Section 373.0361, F.S.), the consumptive use permitting program (Chapter 40C-2, *Florida Administrative Code* [*F.A.C.*]), and the environmental resource permitting program (Chapter 62-330, *F.A.C.)*.

LEGISLATIVE OVERVIEW

SJRWMD establishes MFLs for priority water bodies within its boundaries (section 373.042, F.S.). MFLs for a given water body are the limits "at which further withdrawals would be significantly harmful to the water resources or ecology of the area" (section 373.042, F.S.). MFLs are established using the best information available (section 373.042(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 minimum flows and levels section of the State Water Resources Implementation Rule (rule 62-40.473, *F.A.C.*) 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 373.0361, F.S.), the consumptive use permitting program (Chapter 40C-2, *F.A.C.*), and the environmental resource permitting program (Chapter 62-330, *F.A.C.*).

SJRWMD MFLs Program Overview

SJRWMD is engaged in a districtwide effort to develop MFLs to protect priority surface water bodies, watercourses, associated wetlands, and springs from significant harm caused by water withdrawals. MFLs provide an effective tool for decision-making regarding planning and permitting of surface water or groundwater withdrawals.

The purpose of setting MFLs is to answer an overarching question: What minimum hydrologic regime is necessary 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 conditions exist that are lower than pre-withdrawal conditions, but that still protect the environmental functions and values of MFLs water bodies from significant harm caused by water withdrawals.

For the Sylvan Lake MFLs, significant harm is a function of changes in hydrologic event frequencies. MFL events are composed of a magnitude and duration, and the return interval (frequency) of events is considered the manageable component (Neubauer et al. 2008). MFLs are developed to ensure that changes in return interval of critical events, due to water withdrawals, are not sufficient to cause significant harm, defined as impairment or loss of ecological structure (e.g., permanent downhill shift in plant communities) or function (e.g., insufficient fish reproduction or nursery habitat).

The SJRWMD MFLs approach involves two separate but interrelated, processes: 1) MFLs Determination; and 2) 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 a current-pumping condition to determine the current status of the MFLs. The overall process 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). Three or more minimum levels are often developed for lakes, but no matter how many are developed, the most constraining (i.e., most sensitive to pumping) minimum level is always the basis of the adopted MFL. If water levels are below an MFL, or are projected to fall below within 20 years, the district must adopt a recovery or prevention strategy, to ensure that MFLs are achieved now or in the future. By ensuring that the most sensitive MFL is achieved, assurance is also provided that all other MFLs will be achieved.

SETTING AND DESCRIPTION

LOCATION AND PHYSIOGRAPHIC SETTING

Sylvan Lake is in Seminole County, Florida, approximately 5 miles west of the city of Sanford (Figure 1). The lake is located within the Casselberry-Oviedo-Chulota Hills physiographic division of the Central Lakes District. This region is characterized by sandhill karst with solution basins; the hills are less than 95 ft in elevation and have a parent material of Plio-Pliestocene sand and shell (Brooks, 1982). Recharge to the Floridan aquifer directly around the lake is moderate (5 to 10 inches per year), while recharge just east of the lake is high (10 to 15 inches per year) (CDM 2017; model report is an attachment to Appendix B). Recharge varies greatly nearby, ranging from discharge areas at the Wekiva River to high recharge (>12 inches per year) around the city of Lake Mary (Boniol and Fortich, 2005).

The lake's drainage basin area covers approximately 823 acres and consists primarily of residential development, wetlands, and forest (Figures 2 and 3). Sylvan Lake's drainage basin is contained within the larger Yankee Lake watershed, which flows north during high water events to the Wekiva River and eventually into the St. Johns River (Figure 2).

BATHYMETRY

Sylvan Lake has a surface area of 180.4 acres when the lake stage is 38.6 ft NAVD88 (Appendix B). The lake basin has a complex morphology comprised of shallow solution basins and submerged ridges. Consequently, water depths vary across the lake, ranging from 0-14 ft when the lake level is 38.6 ft NAVD88. Inundated ridges or plateaus between the solution basins are typically 6-8 ft deep, whereas, basins are 10-14 ft deep (Figure 4). The surface expression of the solution basins is readily apparent throughout the mosaic of wetlands encompassing the lake (Figure 3).

The Sanford SW USGS topographic quadrangle map delimits an intermittent flow-way from the lake that drains to the northwest under SR 46 to Yankee Lake, ultimately discharging to the lower Wekiva River, a St. Johns River tributary (Figure 2). The outlet of the lake consists of a concrete ditch that connects to a transverse weir. Roughly 100 ft downstream of the weir is a ditch that flows through a 2 ft by 8 ft box culvert (elevation 40.5 ft NAVD88) under a residential access road. The box culvert is the hydrologic control for Sylvan Lake (Appendix B).

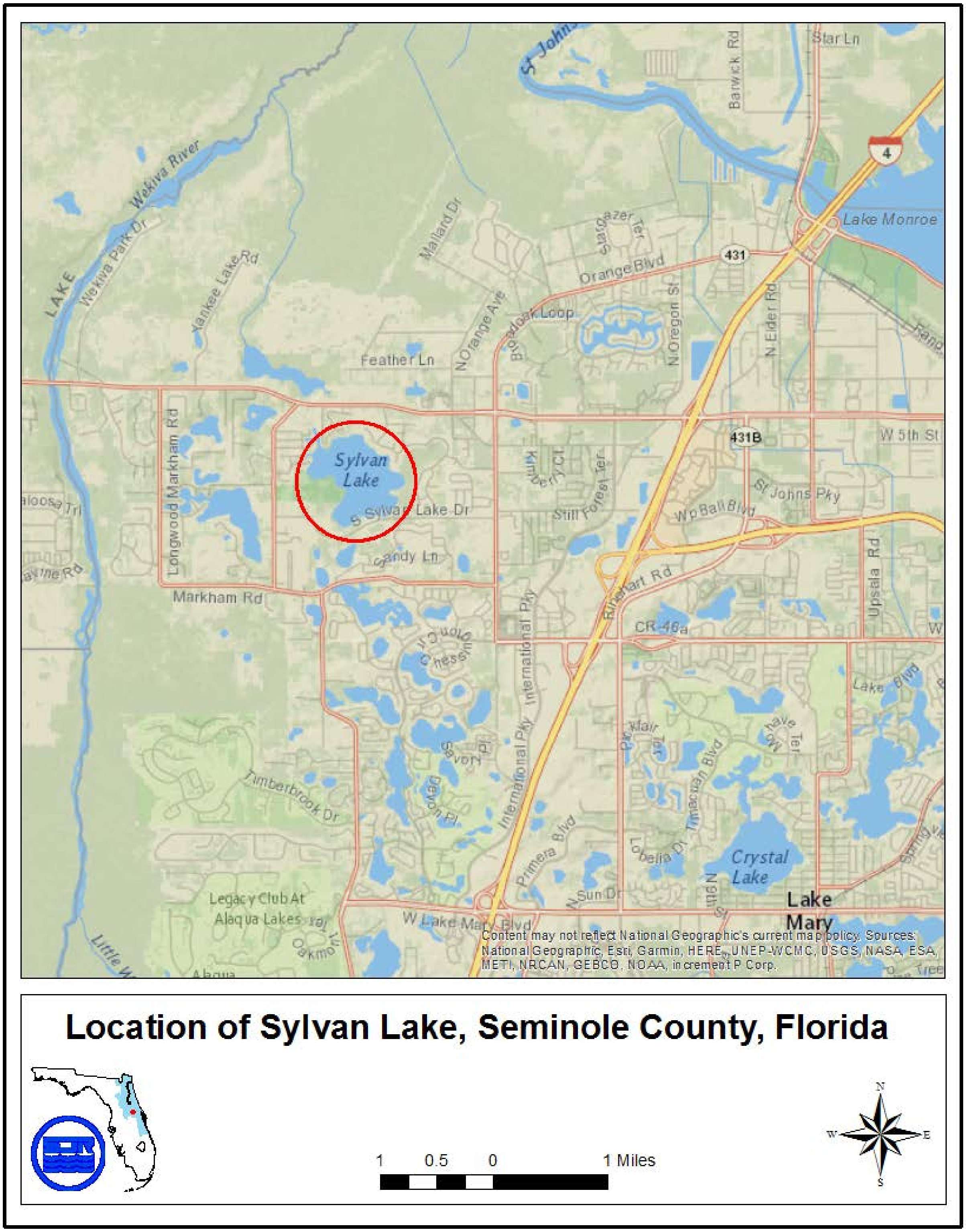

Figure 1. Regional location map of Sylvan Lake, Seminole County, Florida

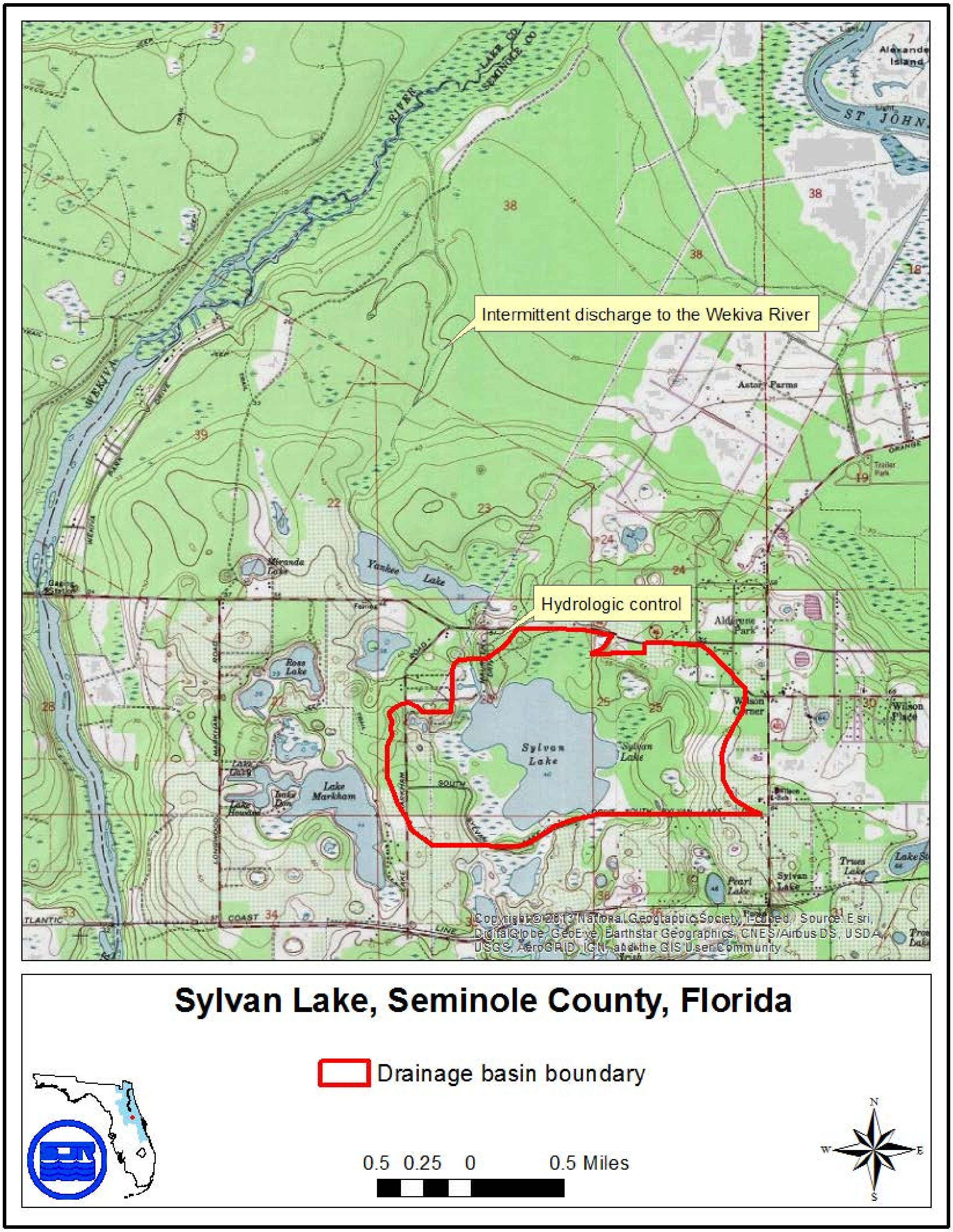

Figure 2. Sanford SW quadrangle map of Sylvan Lake drainage basin

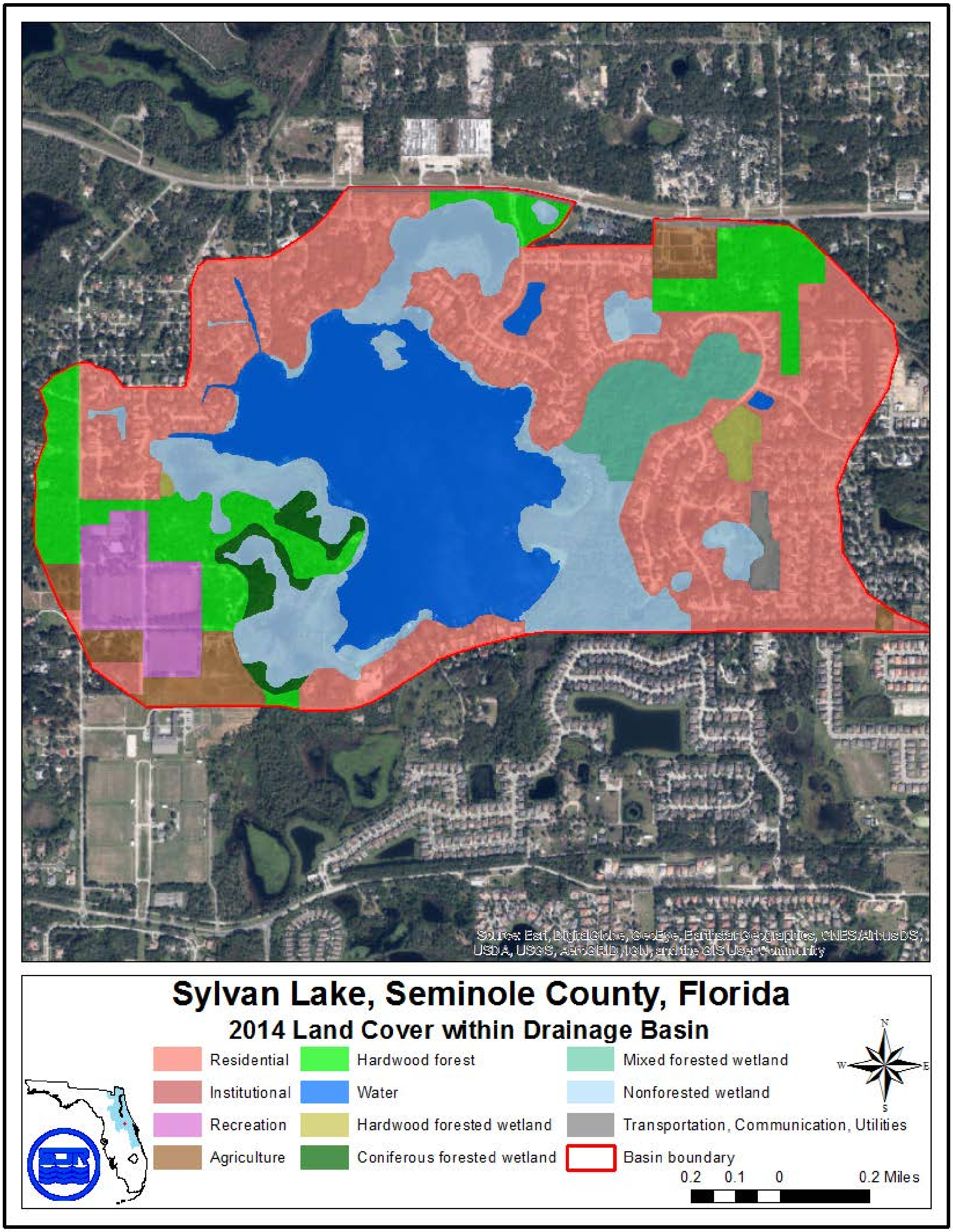

Figure 3. Land cover in the Sylvan Lake drainage basin (SJRWMD, 2014)

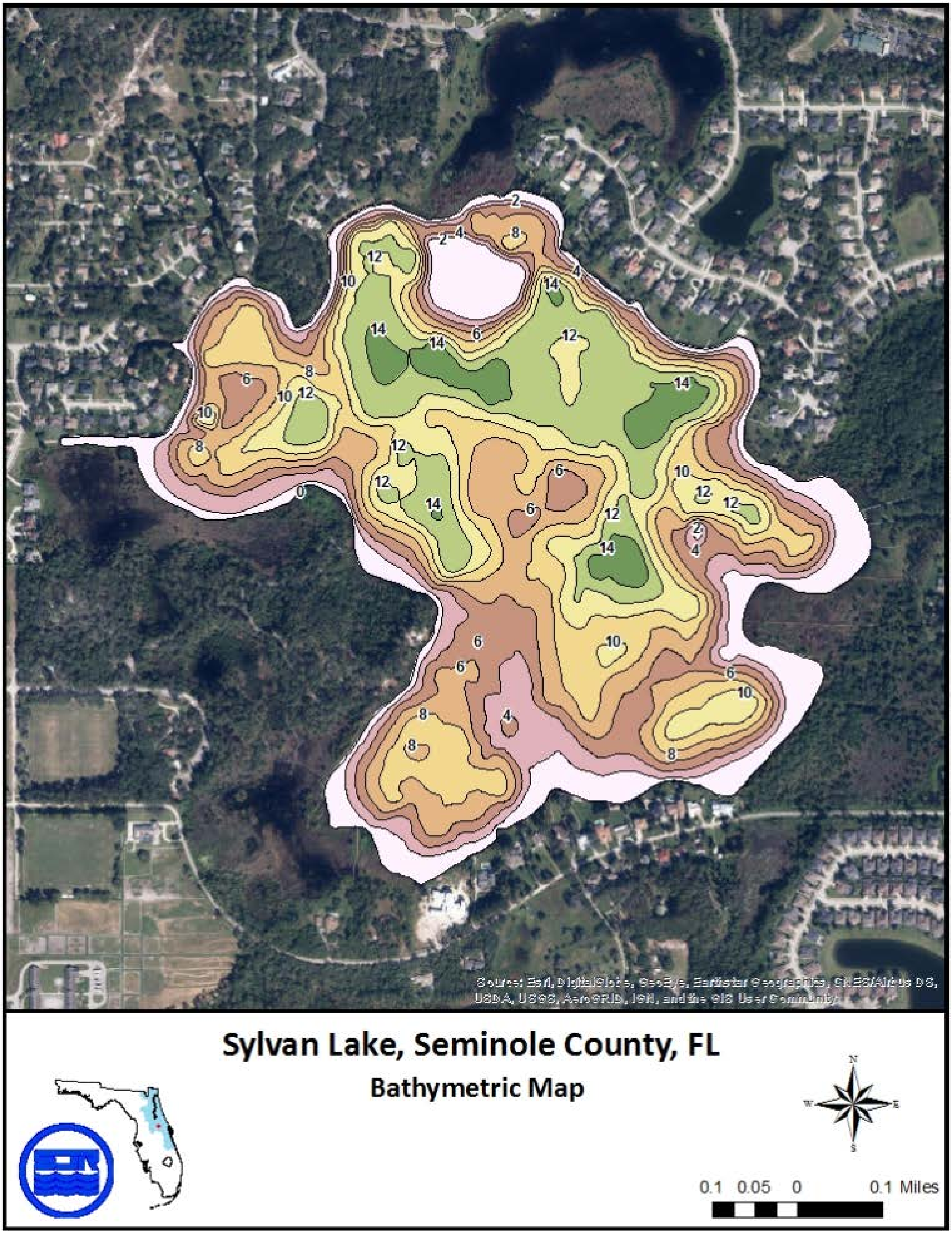

Figure 4. Sylvan Lake bathymetry (Seminole County, 2002)

HYDROLOGY

Water Level Data

Sylvan Lake water level data is collected by Seminole County, on an approximately monthly basis. The period of record (POR) for Sylvan Lake water level data is from October 1978 to present (Figure 5). The gauge is located on the west lakeshore at Sylvan Lake Park (845 Lake Markham Road). During the period of record (POR), Sylvan Lake water levels have ranged between 32.9 ft and 42.0 ft NAVD88 (range 9 ft), with an average level of 38.3 ft NAVD88 (Appendix B). A summary of water level statistics for Sylvan Lake is provided in Table 1.

Table 1. Water level (WL) summary statistics for Sylvan Lake

Descriptive Statistics	Sylvan Lake WL
Average	38.3
Median	38.2
Standard Deviation	1.8
Range	9.0
Minimum	32.9
Maximum	42.0

Rainfall and Evapotranspiration

Rainfall data were compiled using data from the Sanford and Sylvan Lake stations. Potential evapotranspiration (PET) was computed from temperature data obtained from the Sanford station. Figure 6 shows the annual average PET and rainfall data. The long-term annual average rainfall and PET are approximately 51.65 and 51.59 inches, respectively (Table 2) for the period of 1948 to 2018. Appendix B includes detailed information about rainfall and PET.

Table 2. Rainfall and PET statistics

Descriptive Statistics	Annual Precipitation (in)	Annual PET (in)
Average	51.7	51.6
Median	51.1	51.5
Standard Deviation	9.0	1.6
Minimum	32.8	48.3
Maximum	74.1	54.7

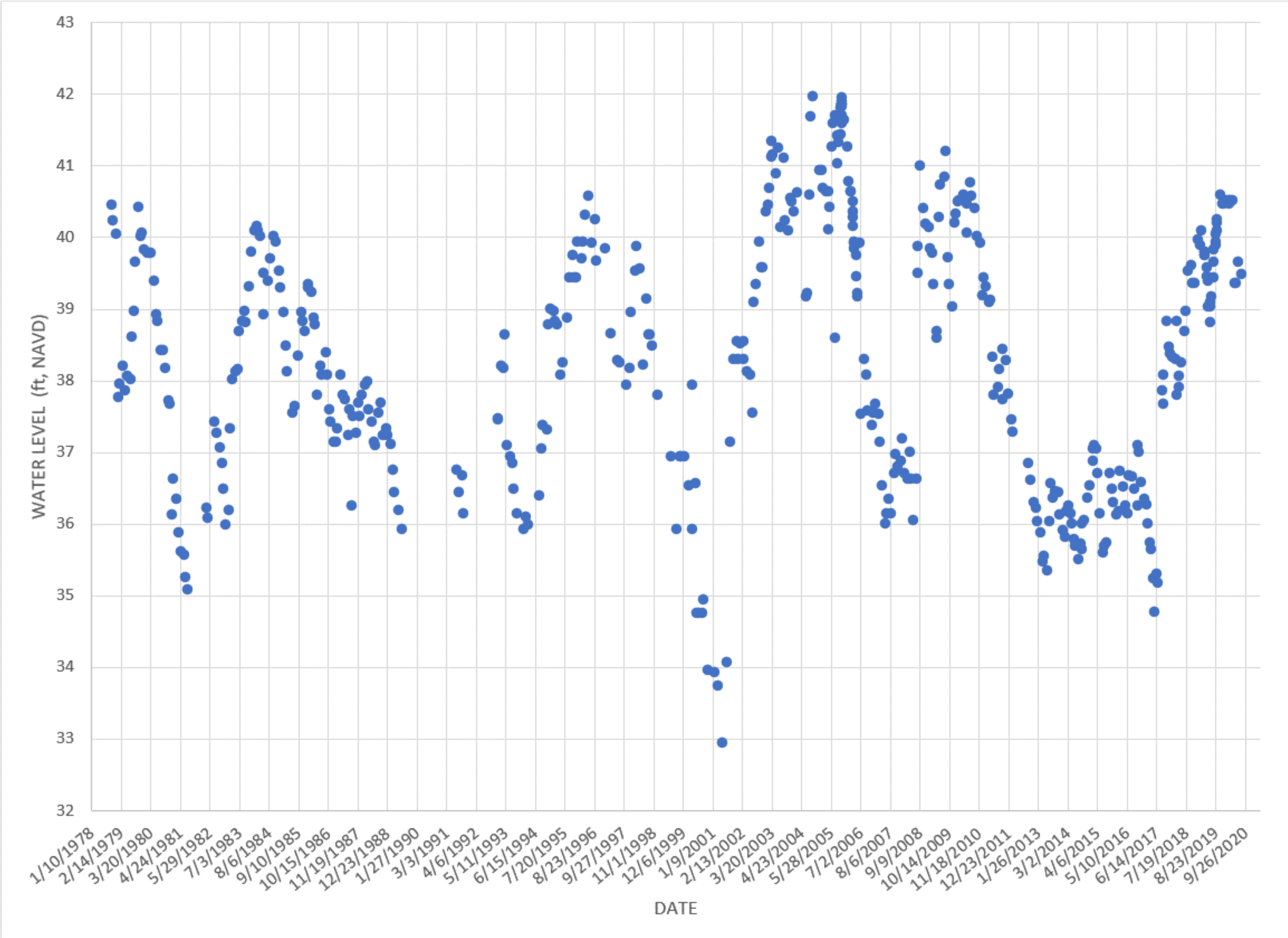

Figure 5. Observed Sylvan Lake water levels (1978-2020)

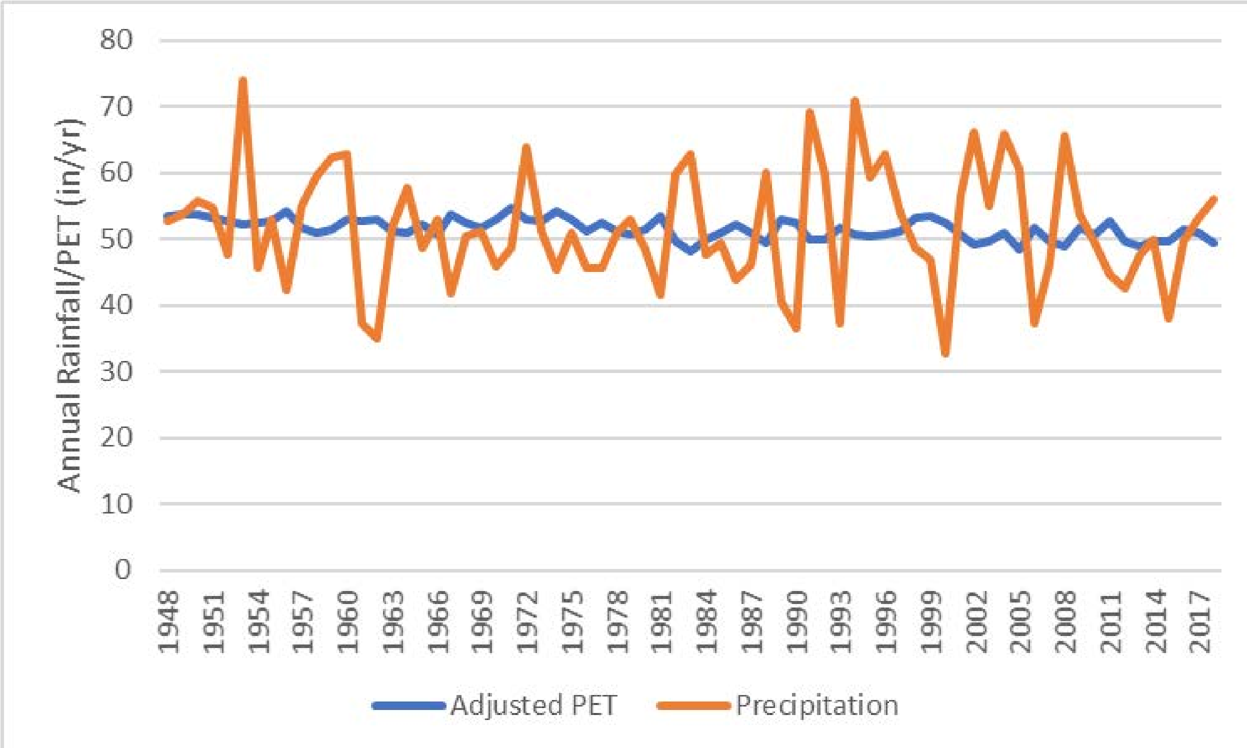

Figure 6. Annual average rainfall and PET, 1948 - 2018

SURFACE WATER BASIN CHARACTERISTICS

Land Use

Urbanization in the Sylvan Lake watershed has increased since MFLs were first adopted in 1998. The dominant land use is now residential, accounting for 37.8% of total land coverage within the lake's 823-acre drainage basin (Table 3). Current SJRWMD land cover data (Figure 3 and Table 3) indicates the watershed is comprised of ~311 acres (37.8%) residential; ~30.1 acres (3.7%) agriculture; ~ 34.6 acres (4.2%) recreation; ~ 9.3 acres (1.1%) transportation, communications, utilities; ~84.3 acres (10.2%) hardwood forest; ~6.6 acres (0.8%) hardwood forested wetland; ~13.3 acres (1.6%) coniferous forested wetland; 31.8 acres (3.9%) mixed forested wetland; ~138.9 acres (16.9%) non-forested wetland; and ~162.4 acres (19.7%) of open water.

Wetlands

Based on current SJRWMD wetland coverage data (Table 4 and Figure 7), the dominant wetland plant community around Sylvan Lake is shallow marsh, accounting for 81.1 acres of the total wetland acreage. Other wetland communities adjacent to Sylvan Lake include bayhead; baygall (49.0 ac), shrub bog (18.0 ac), deep marsh (16.8 ac), hardwood swamp (11.9 ac), wet prairie (11.4 ac), transitional shrub (2.9 ac), cypress (0.5 ac), and shrub swamp (0.4 ac). Detailed wetland community descriptions are presented in Appendix C for each sampling transect located at Sylvan Lake.

The hydroperiod is the dominant factor controlling the composition and distribution of wetland communities, and is composed of different components, including frequency, duration, magnitude, rate of change and seasonality (Murray-Hudson et al. 2014). Hydroperiod descriptions for the wetland communities found around Sylvan Lake are presented in Appendix C.

Table 3. 2014 Land cover distribution in the Sylvan Lake drainage basin

Land Cover	2014 Land Cover (acres)	
Residential	311.4	37.8%
Institutional	0.4	0.0%
Recreation	34.6	4.2%
Agriculture	30.1	3.7%
Hardwood forest	84.3	10.2%
Water	162.4	19.7%
Hardwood forested wetland	6.6	0.8%
Coniferous forested wetland	13.3	1.6%
Mixed forested wetland	31.8	3.9%
Non-forested wetland	138.9	16.9%
Transportation, Communications, Utilities	9.3	1.1%
Total	**823.1**	**100.0%**

Table 4. Wetland plant communities adjacent to Sylvan Lake by size and ranking

Wetland Community	Acres	Ranking by Acres
Shallow marsh	81.1	1
Bayhead; Baygall	49.0	2
Shrub bog	18.0	3
Deep marsh	16.8	4
Hardwood swamp	11.9	5
Wet prairie	11.4	6
Transitional shrub	2.9	7
Cypress	0.5	8
Shrub swamp	0.4	9

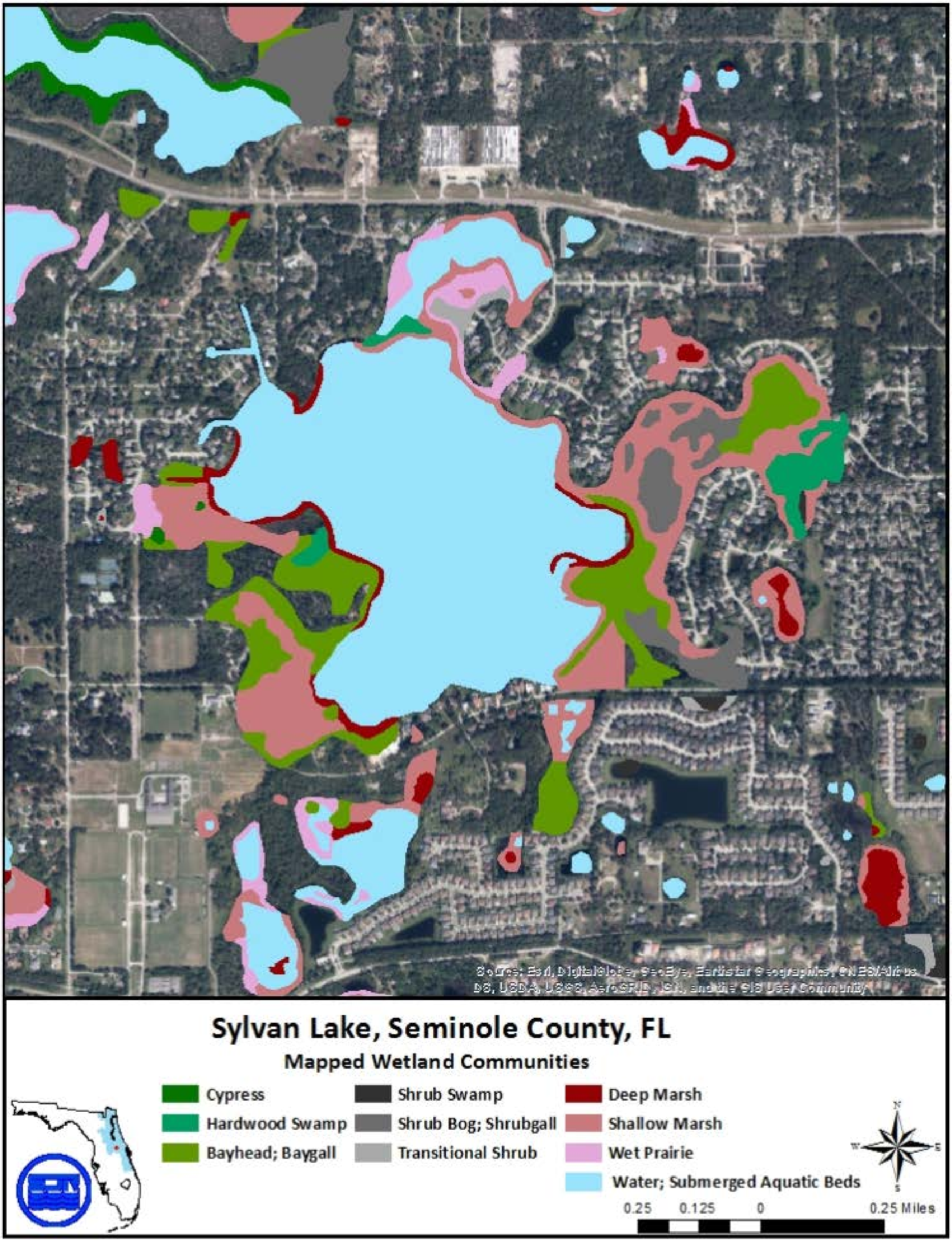

Figure 7. Sylvan Lake mapped wetlands (SJRWMD 2014)

Soils

The development of hydric soils is related to long-term hydrology. Hydric soils are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part (USDA, SCS 1987). The hydric soils Brighton, Samsula, Sanibel, Bassinger, and Hontoon (Hurt, 2007) were mapped at Sylvan Lake (Figures 8 and 9; Soil Survey Geographic SSURGO Database). The Brighton and Hontoon series consist of deep and poorly drained organic soils found in freshwater marshes, swamps, and depressions. The Basinger and Sanibel series are poorly drained sandy soils found primarily in freshwater swamps, marshes, and depressions. The Samsula series is a poorly drained muck soil underlain with sandy marine sediment and is found in swamps and depressions. Undrained areas of these soils are typically ponded for 6 to 9 months or more except during extended dry periods (USDA, SCS 1990).

While Sylvan Lake is located within a region characterized by sandhill solution basins, it is not typical of this lake class in that it has extensive contiguous regularly flooded wetlands, with deep organic soils. The presence of organic soils is not surprising, however, given the relatively modest fluctuation range of Sylvan Lake, of approximately 9 feet over the POR. The extent of hydric soils indicators was identified at each transect. Transect-specific field soil sample descriptions are presented in Appendix C.

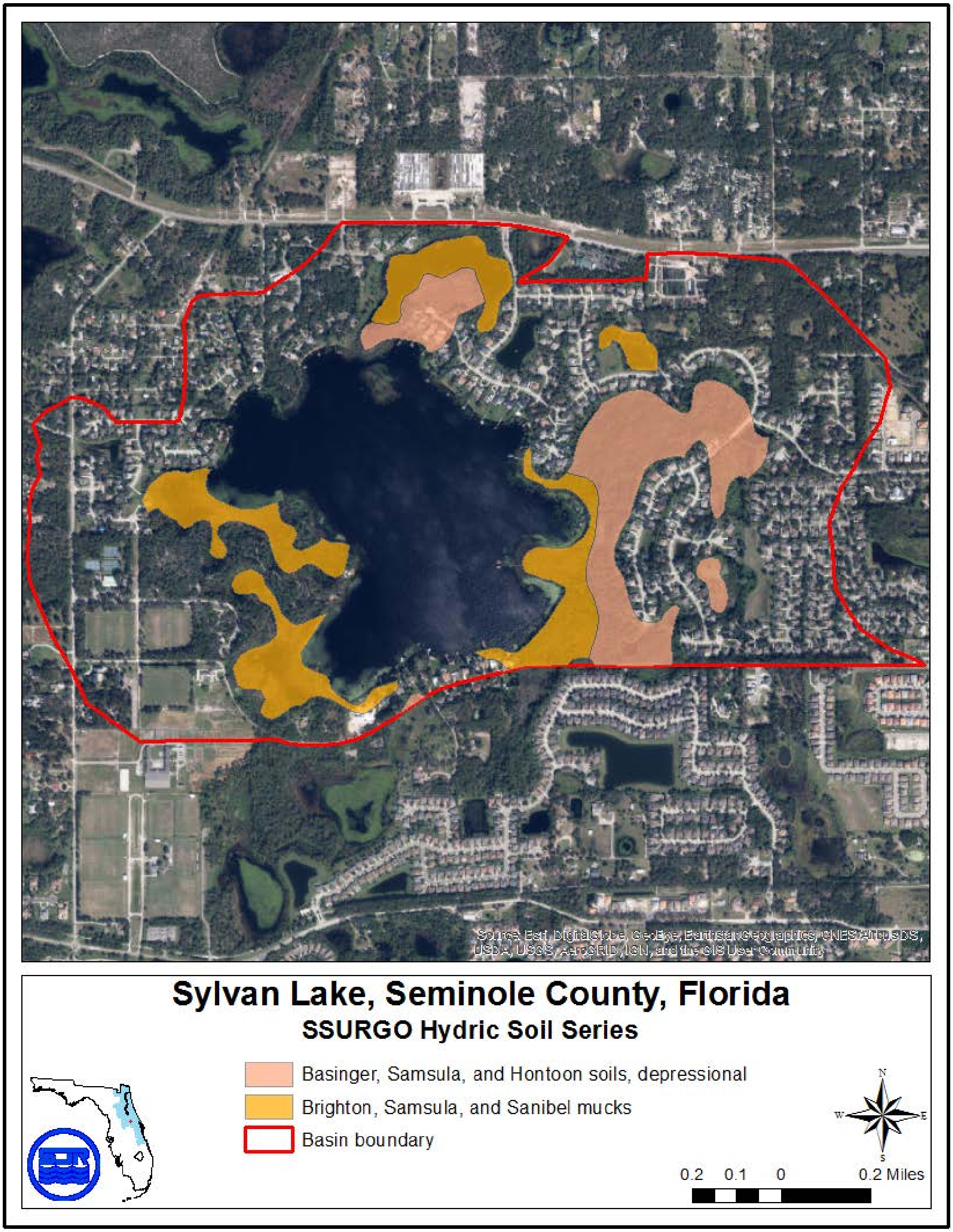

Figure 8. Sylvan Lake hydric soils series (SSURGO, 2017)

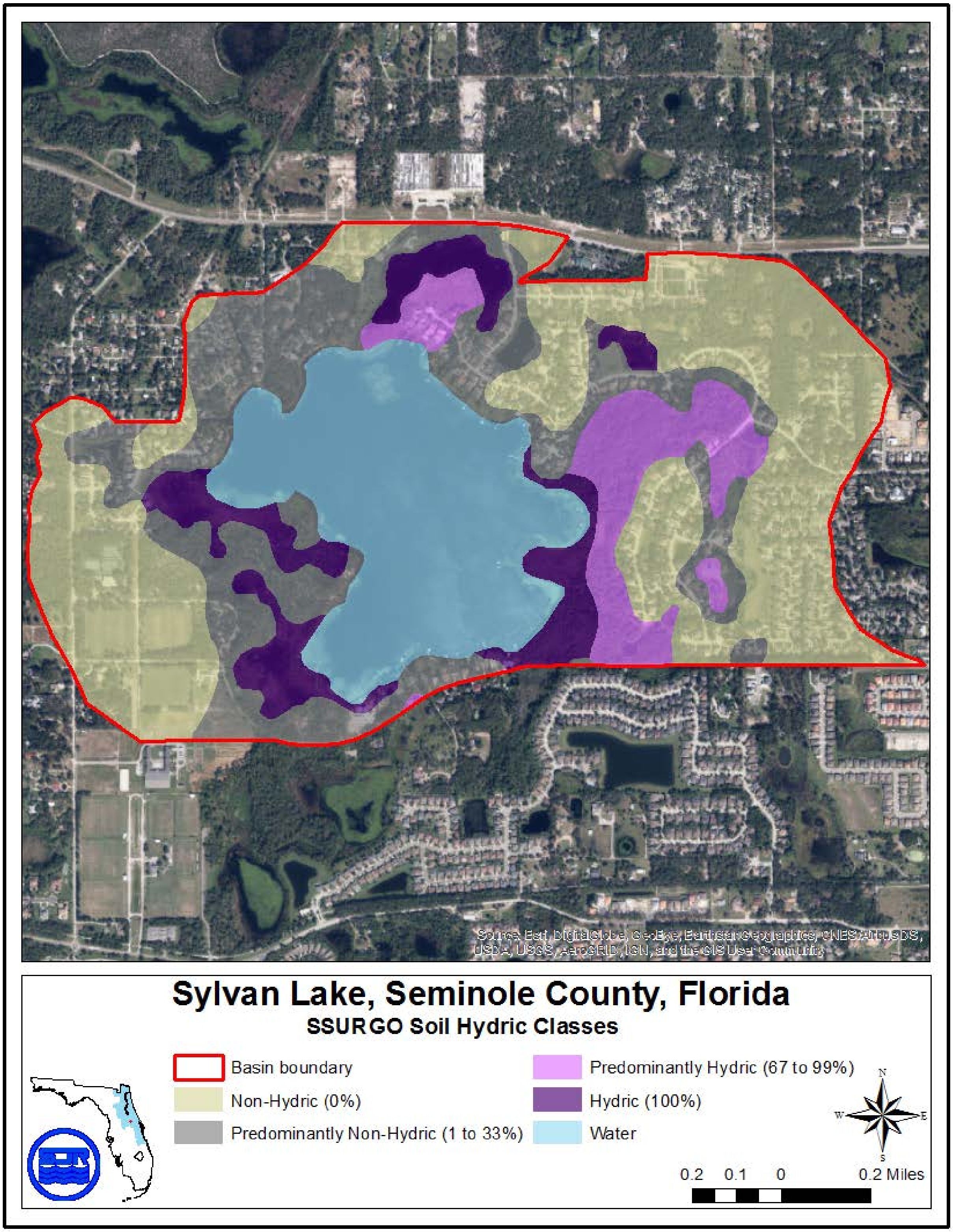

Figure 9. Soil hydric classes surrounding Sylvan Lake (SSURGO, 2017)

Water Quality

Water quality data has been collected at Sylvan Lake since 1998 by Seminole County and the University of Florida's Lakewatch program. Sylvan Lake is a colored lake (i.e., > 40 Platinum Cobalt Units [PCU]) and, according to the water quality standards defined by FDEP, has good water quality (FDEP, 2013). The average annual geometric mean color for Sylvan lake is 56 PCU (Figure 10). Long term average annual geometric mean concentrations of three primary water quality parameters (TN = 0.807 mg/L, TP = 0.016 mg/L, and Chl-a = 7.0 µg/L) meet the numerical nutrient criteria FDEP sets for lakes with color greater than 40 PCU (Tables 5 and 6).

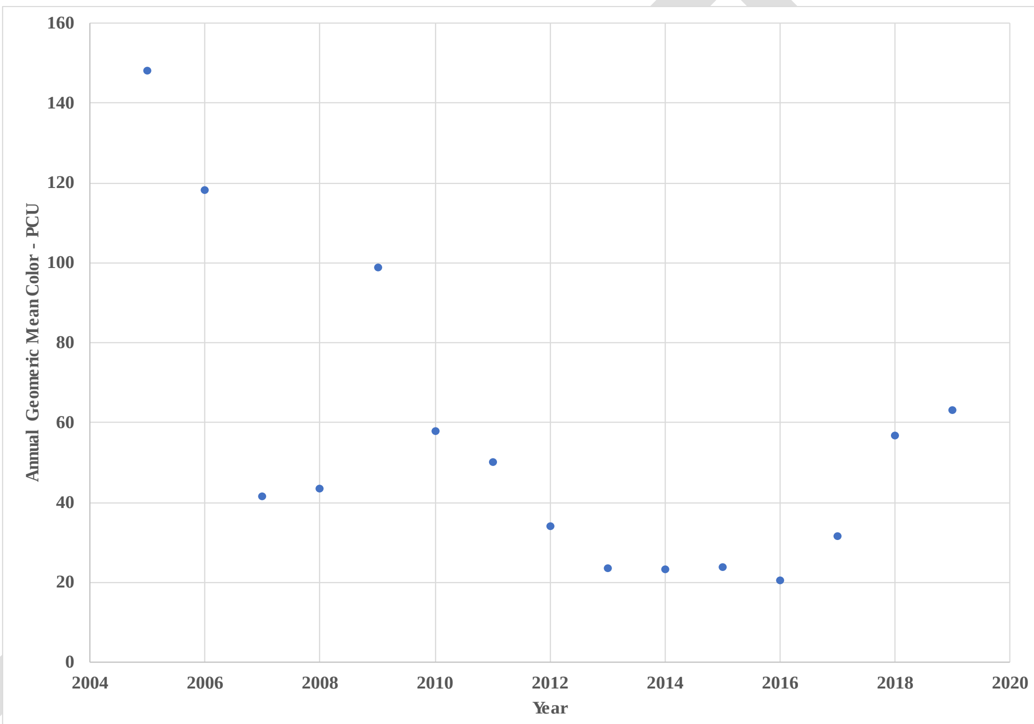

Figure 10. Annual geometric mean color (PCU) of Sylvan Lake from 2005 to 2019

Table 5. Chlorophyll a, TN, and TP criteria (from Implementation of Florida's Numeric Nutrient Standards, FDEP 2003)

Long Term Geometric Mean Lake Color	Annual Geometric Mean Chlorophyll a	Minimum calculated numeric interpretation		Maximum calculated numeric interpretation	
		Annual Geometric Mean Total Phosphorus	Annual Geometric Mean Total Nitrogen	Annual Geometric Mean Total Phosphorous	Annual Geometric Mean Total Nitrogen
> 40 Platinum Cobalt Units	20.0 µg/L	0.05 mg/L	1.27mg/L	0.16 mg/L	2.23 mg/L

Table 6. Geometric mean of total phosphorus (TP), total nitrogen (TN), and chlorophyll-a (Chl-a) from 1998 to 2018 in Sylvan Lake

Year	TP (ug/L)	TN (ug/L)	Chl-a (ug/L)
1998	12	599	9
1999	10	545	6
2000	NA	NA	5
2001	NA	NA	4
2002	12	805	5
2003	16	909	7
2004	28	1077	8
2005	20	947	10
2006	19	944	10
2007	18	779	10
2008	16	817	9
2009	15	964	7
2010	14	818	7
2011	12	778	8
2012	14	725	7
2013	18	812	7
2014	17	761	7
2015	16	742	6
2016	13	756	4
2017	12	725	3
2018	16	832	5
Average	**16**	**807**	**7**

Trophic State Index (TSI) provides an indicator of system health/integrity based on water quality and biological productivity. It is calculated using total phosphorus (TP), total nitrogen (TN) and chlorophyll-a (Chl-a) data, with values above 70 considered poor water quality, and values 60 or below considered good water quality (Friedemann and Hand, 1989). The average TSI for Sylvan Lake is 42 during the period of 1998 – 2019, which indicates good water quality (Figure 11). Further, the declining trend in TSI indicates that water quality had improved in recent years. This improvement may be as the result of the implementation of the Fertilizer Ordinance approved by Seminole County Board of County Commissioners, effective February 28, 2017. The Fertilizer Ordinance regulates fertilizers containing nitrogen and/or phosphorous and provides specific management guidelines for fertilizer application (http://www.seminolecountyfl.gov/departments-services/public-works/watershed-management/fertilizer-ordinance/).

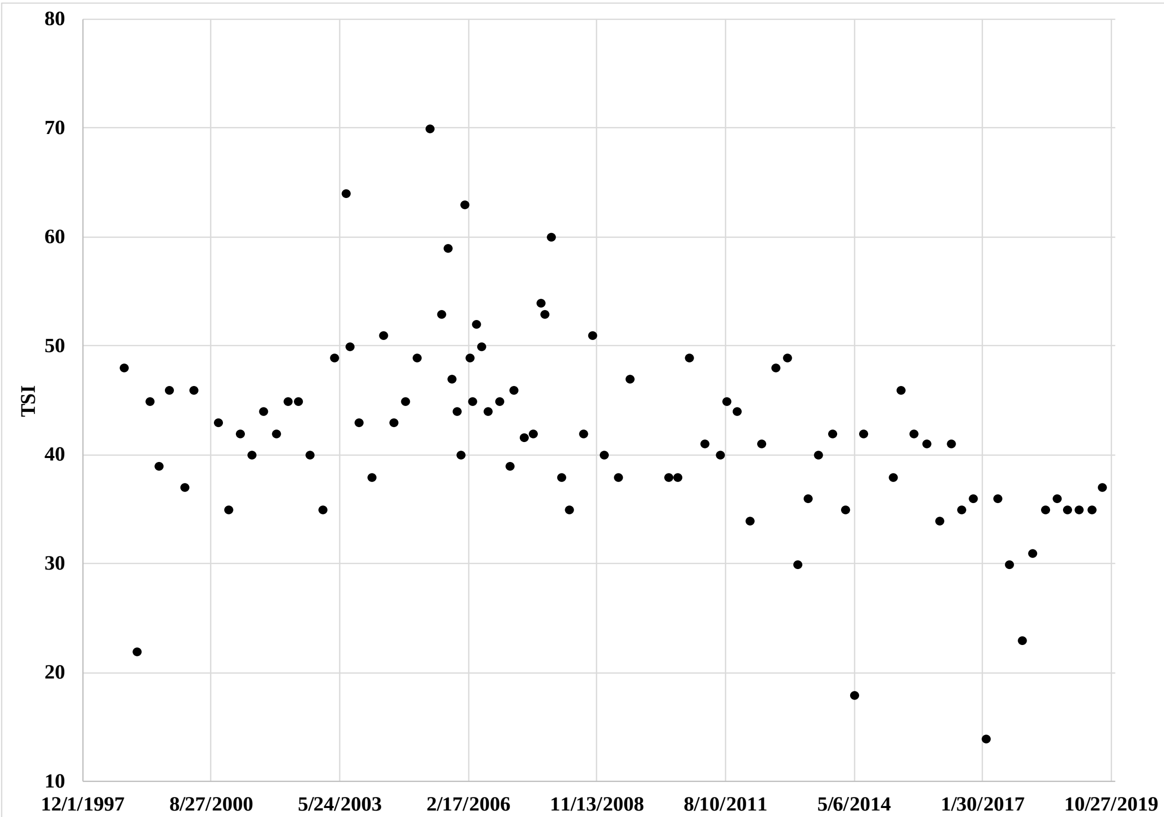

Figure 11. Trophic State Index of Sylvan Lake from 1998 to 2019

MFLs Determination

A key component of the MFLs determination is an analysis to determine relevant environmental attributes and/or beneficial uses for each water body. This analysis also involves determining appropriate criteria and thresholds to protect these environmental values. This process includes consideration of site-specific field-based ecological data, topographical information, recreational or other environmental data, as well as data collected at other MFLs sites, and supportive information from scientific literature. Using this information, a determination is made of the most important environmental features for a waterbody. Next, appropriate criteria are determined to represent these environmental values and a minimum hydrologic regime (MFLs condition), that ensures their protection, is established.

Further, a suite of 10 environmental values, listed in Rule 62-40.473, F.A.C., are typically considered to ensure that the MFLs condition protects all relevant water resource values (WRVs) for a priority water body. This evaluation is discussed in the *MFLs Assessment* section. The current and future status of the lake, based on the most constraining criterion, is also presented in the *MFLs Assessment* section. The general approach for determining minimum levels for Sylvan Lake is presented below, and specific details are provided in Appendix C.

Environmental Analyses

The environmental analysis for Sylvan Lake involved characterizing existing ecological attributes. This included collecting site-specific field-based ecological and topographical information. It also involved the use of empirical data collected at other MFLs sites, and supportive information from the scientific literature. Non-ecological beneficial uses of the water body (e.g., recreation) were evaluated as part of the WRVs assessment, discussed in the *MFLs Assessment* section and Appendix E.

Site Selection and Data Collection

Vegetation, soils and elevation data for Sylvan Lake were collected along transects that extended from uplands to open water. A literature and data search were conducted prior to establishing field transects. Proposed transects were inspected prior to data collection to confirm the presence of desired features, including representative examples of common wetland communities; unique or high-quality wetlands; edge of uplands or open water; and organic and other hydric soils. Vegetation and soil sampling followed standard field procedures. Detailed information on field transect selection and data collection methods are provided in Appendix C.

Event-Based Approach

A water body’s hydroperiod is the primary driver of wetland plant distribution and diversity, hydric soils type and location, and to a lesser degree freshwater fauna (Foti et al., 2012; Murray-Hudson et al., 2014). Variable flooding and/or drying events are necessary to maintain the extent, composition, and function of wetland and aquatic communities. Wetland and aquatic species, and hydric soils require a minimum frequency of critical hydrologic events for long-term persistence.

Event-based MFLs are described with a magnitude component (i.e., water level elevation), a duration, and a return interval. The magnitude and duration components define biologically relevant events. The return interval (frequency) of hydrological events is typically described as the manageable component (Neubauer et al., 2008). MFLs are developed to ensure that changes in return interval due to water withdrawals do not cause significant harm. Significant harm is associated with impairment or loss of ecological structure (e.g., permanent downhill shift in plant communities) or function (e.g., insufficient fish reproduction or nursery habitat).

Hydrologic event probabilities, called Surface Water Inundation and Dewatering Signatures (SWIDS), are used to determine protective return intervals (i.e., recommended event frequencies). SWIDS of vegetation species or communities provide a hydrologic range, with a transition from a drier condition on one side of the range to a wetter condition on the other side. These hydrologic signatures 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. More details regarding SWIDS calculations are provided in Appendix C.

Because hydroperiods vary spatially and temporally (Mitsch and Gosselink, 2015), and because species and communities are adapted to different parts of a system's hydrologic regime, multiple events are typically used to protect different portions of a system ecological structure and function (Neubauer et al. 2008). For many systems, SJRWMD sets three MFLs; minimum frequent high (FH), minimum average (MA), and minimum frequent low (FL) water levels. In some cases, a minimum infrequent high (IH) and/or minimum infrequent low (IL) water level may also be set (Figure 12). The FH, MA and FL are typically used for lakes with stable wetland communities and/or organic soils. Because of Sylvan Lake's modest (~ 9 ft) inter-annual water level fluctuation range, and the presence of stable wetlands and organic soils, SJRWMD established FH, MA and FL water levels for this lake.

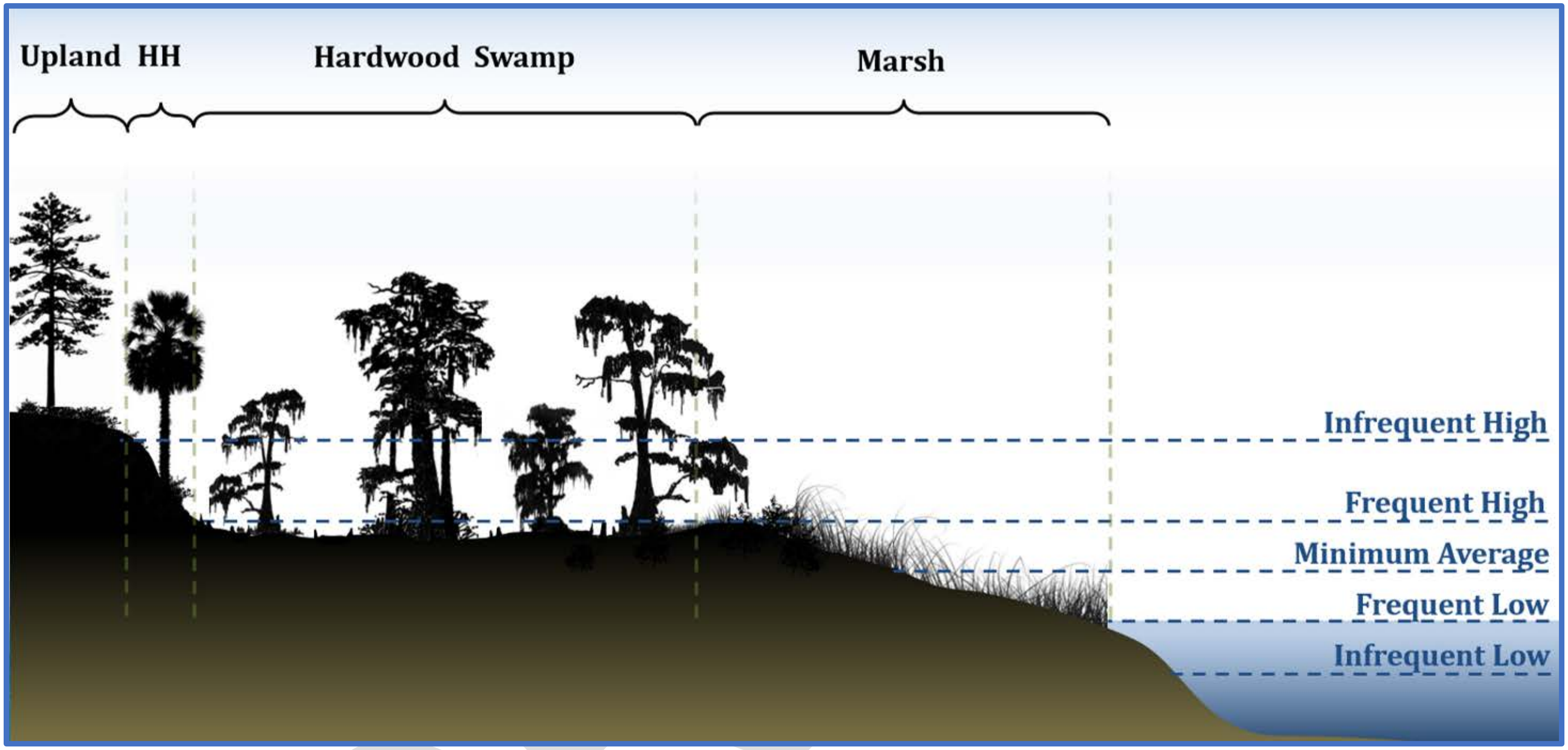

Figure 12. Conceptual drawing showing the five most common minimum levels developed using SJRWMD's event-based approach.

SYLVAN LAKE MINIMUM LEVELS

Sylvan Lake is located within a region characterized by sandhill solution basins. However, it has extensive contiguous regularly flooded wetlands, with deep organic soils. The three minimum levels developed for Sylvan Lake are based on maintaining the minimum hydrologic regime necessary to protect the ecological structure and function of existing wetlands and organic soils. The FH is based on providing a sufficient number of flood events to protect seasonally flooded shrub wetlands and associated wildlife habitat values. The MA is designed to prevent an excessive number of drying events, to protect organic soils from oxidation and subsidence and avoid adverse impacts to habitat and water quality. The FL prevents an excessive number of frequent drying events to protect marsh habitats, organic soils, and associated wildlife values. Vegetation data were collected in 2005 and verified in 2017 and 2020. Soils data were collected in 2005 and verified in 2018 and 2020 (see Appendix C for details regarding field data collection and results). These data represent current conditions are a function of historical changes in land use, structural alterations (e.g., lake outlet structure). Therefore, MFLs developed using these data are meant to protect current extant wetland community composition and extent, and that the current use of SWIDS and scientific literature (used to inform duration and return interval for these minimum levels) is meant to prevent further change in location or composition of extant wetlands.

Minimum Frequent High

The minimum frequent high (FH) determined for Sylvan Lake is composed of an elevation of 40.2 ft. NAVD88, with a corresponding flooding duration of 30 continuous days, and a return interval of 5.2 years (i.e., ~19 out of 100 years, on average; Table 7). The purpose of the FH is to ensure frequent inundation in seasonally flooded wetlands, sufficient to maintain species composition, vegetative structure, and associated ecological functions.

The FH magnitude component was calculated by averaging the ground elevations of transitional shrub communities located along three representative field transects at Sylvan Lake. See Appendix C for details of original reevaluation fieldwork conducted in 2005, and verification conducted in 2020. The resulting average ground elevation equals 40.2 ft. NAVD88. The mean elevation of these seasonally flooded wetlands is used as the FH magnitude because it provides sufficient water depths to maintain the transitional shrub communities while also providing sufficient depths for fish and other aquatic organisms to feed and spawn in these communities (Guillory, 1979; Ross and Baker, 1983; Bain, 1990; Poff et al., 1997).

The duration component of the FH will ensure a minimum of 30 days continuously flooded at or above 40.2 ft. NAVD88. Maintaining water levels for this duration at the average elevation of transitional shrub communities will promote inundation and/or saturation conditions sufficient to support hydrophytic (i.e., obligate, facultative wet, and facultative) plant species (Ahlgren and Hansen 1957, Menges and Mark 2008 and Mace 2015), thus preventing a permanent downward shift of the transitional shrub and other wetland communities.

The FH is typically associated with a seasonally flooded hydroperiod (Rule 40C-8.021(17), *F.A.C.*) "…where surface water is typically present for extended periods (30 days or more) during the growing season, resulting in a predominance of submerged or submerged and transitional wetland species. During extended periods of normal or above normal rainfall, lake levels causing inundation are expected to occur several weeks to several months every one to two years.” For many MFLs lakes, a FH return interval of 2 to 3 years is typical. For Sylvan Lake, the return interval for the FH was informed by hydroperiod data collected for other transitional shrub communities located within SJRWMD. Based on a SWIDS analysis of 12 SJRWMD lakes with transitional shrub communities a FH return interval of 5.2 years was selected for Sylvan Lake (see Appendix C for more details). The FH is meant to maintain a sufficient occurrence of high surface water levels, during typical periods of normal or above normal rainfall.

Table 7. Environmental criteria and minimum levels for Sylvan Lake, Seminole County, Florida

Minimum Levels	Environmental criteria	Minimum Level Components		
		Level (ft NAVD88)	Duration (days)	Return Interval (years)
FH	Transitional shrub communities; Fish and wildlife habitat	40.2	30	5.2
MA	Organic soils; Seasonally flooded wetland habitat	37.9	180	1.7
FL	Shallow and deep marsh habitat; Organic soils	35.7	120	11.8

Importance of FH for Wetland Structure and Functions

A frequently occurring high water level is necessary to maintain the structure and function of wetlands contiguous with lakes (CH2M HILL 2005). Frequent short-duration flooding events redistribute plant seeds within aquatic habitats (Schneider and Sharitz, 1986) and influence species composition and structural development of plant communities (Huffman, 1980). Frequent flooding events support anaerobic soil conditions within wetlands, favoring hydrophytic vegetation and eliminating upland vegetation that invades during low water events (CH2M HILL, 2005). The recommended FH level should allow sufficient water depths for fish and other aquatic organisms to feed, spawn, and seek refuge in the flooded habitats of the lake (Guillory, 1979; Ross and Baker, 1983) and should occur for a duration sufficient to complete critical portions of their life cycles. Inundation is also necessary for wetland processes involving exchange of particulate organic matter and nutrients within the floodplain (McArthur, 1989). Dissolved and particulate organic matter and nutrients are assimilated by bacteria and fungi, which serve as food for invertebrate populations (Cuffney, 1988) and ultimately for larger fauna. The frequency of recurrence of such flood events varies widely, generally ranging from 1-5 years.

Habitat and food resources available to aquatic fauna (e.g., fishes, amphibians, reptiles, invertebrates) expand when lakes inundate higher elevation areas. Surface water connections between aquatic and wetland habitats are restored and previously isolated areas become available for feeding and spawning (Guillory, 1979; Ross and Baker, 1983). The amount of vegetative structure available to aquatic organisms increases; fish productivity increases correspondingly (Light et al., 1998; Kushlan, 1990). The life cycles of many fishes are related to seasonal water level fluctuations, particularly the annual flood pattern (Hill and Cichra, 2005; Guillory, 1979). Floodplains and wetlands provide critical refugia for juvenile fishes of many species (Hill and Cichra, 2005; Ross and Baker, 1983; Finger and Stewart, 1987).

A frequent flooding regime maintains important biogeochemical processes. Water quality improves as water filters through wetland vegetation and soils. Wetlands can transform or retain dissolved and suspended constituents (Wharton et al., 1982). The FH provides for flooding events that promote organic soil accrual, which balance losses of organic matter that may occur during droughts. Long durations of saturation create anaerobic and/or anoxic conditions that slow microbial activity and allow plant productivity to exceed decomposition (Sahrawat, 2004; Reddy and DeLaune, 2008). Frequent, short-term flooding creates alternating anaerobic and aerobic conditions, which maintains hydric soil functions such as denitrification (Reddy and DeLaune, 2008). See Appendix C for more details regarding the FH.

Minimum Average

The minimum average (MA) determined for Sylvan Lake is composed of an elevation of 37.9 ft. NAVD88, with a corresponding mean non-exceedance duration of 180 days, and a maximum return interval of 1.7 years (i.e., no more often than once in 1.7 years, on average; 59 out of 100 years, on average; Table 7). The MA for Sylvan Lake was developed to protect the long-term location of organic soils while preventing oxidation and subsidence in the floodplain. The MA, defined as "…the surface water level…necessary over a long period to maintain the integrity of hydric soils and wetland plant communities" (Rule 40C-8.021(9), F.A.C.), was developed to prevent an excessive number of drying events to protect 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 soil structure and associated ecological functions. The specific indicator of protection is a water level that equals a 0.3ft water table drawdown from the average ground surface elevation of deep organic soils surveyed at Sylvan Lake (for more details *see* Appendix C).

The MA magnitude component is based on the average elevation of deep organic soils surveyed at Sylvan Lake. A 0.3 ft offset is applied to the average organic soil elevation, resulting in a MA elevation of 37.9 ft. NAVD88. The 0.3 ft offset is based on the maximum allowable soil water table drawdown from the average ground surface elevation of the histic epipedon and histosols in the shallow marshes/shrub swamps and/or deep marshes observed at Transects 1 through 3 in 2005 (38.2 ft. NAVD88) and verified in 2020 (See Appendix C for details).

The duration for the average non-exceedance water level for the MA is 180 days. This will ensure that the average duration of drying events is not too long, and thus will maintain adequate saturation of deep organic soils on Sylvan Lake. 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. It is most often associated with the "typically saturated" hydroperiod defined below:

> …where for extended periods of the year the water level should saturate or inundate. This results in saturated substrates for periods of one-half year or more during non-flooding periods of typical years. Water levels causing inundation are expected to occur fifty to sixty per cent of the time over a long-term period of record. This water level is expected to have a recurrence interval, on the average, of one or two years over a long-term period of record (Rule 40C-8.021(20), F.A.C.).

Based on this description of drying events that typically occur within this part of central Florida, the return interval for the Sylvan Lake MA is 1.7 years. This return interval is also supported by SWIDS data of the average elevation of deep organic soils minus 0.3 ft., which is based on hydroperiods analyzed for 20 SJRWMD lakes (Appendix C). Further, studies show that the minimum hydrology required to maintain organic soils (Appendix E; Osborne et al. 2014) is close to 50% exceedance. The recommended 1.7-yr return interval results in mean elevation of deep organic soils being inundated for 50% of the time. Therefore, a 1.7-year return interval is recommended for the MA.

Importance of MA for Soils and Wetland Plant Communities

Organic soils are important to wetland biogeochemical cycles, particularly as sinks for carbon (Mitsch et al., 2015; Reddy and DeLaune, 2008). Frequent anaerobic conditions impede microbial activity and primary production exceeds decomposition. Organic soils gradually accrue as a result. The recommended MA maintains organic soil structure and function by ensuring that dewatering events do not occur often enough to cause organic soils to oxidize and subside. By preventing permanent loss of deep organic soils, the MA provides conditions that support retention of soil carbon and nutrients and provides for the filtration of metals and toxins.

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).

Minimum Frequent Low

The minimum frequent low (FL) determined for Sylvan Lake is composed of an elevation of 35.7 ft NAVD88 with a corresponding continuous non-exceedance duration of 120 days, and a maximum return interval of 11.8 years (i.e., no more often than once in 11.8 years, on average; Table 7). The FL for Sylvan Lake was developed to prevent an excessive number of frequent drying events, with the primary goal of protecting shallow and deep marsh habitats along with their associated ecological functions and values. As a secondary supporting criterion, the FL also provides a suitable water table depth to support floodplain soils during periodic droughts to prevent loss of deep organic soils (≥8 in. thick, histic epipedon and histosols; See Appendix C for details).

The FL level is defined in Rule 40C-8.021(10), *F.A.C.*, which states, "…a chronically low surface water level…that generally occurs only during periods of reduced rainfall. This level is intended to prevent deleterious effects to the composition and structure of floodplain soils, the species composition and structure of floodplain and instream biotic communities, and the linkage of aquatic and floodplain food webs."

The goal of the FL is to prevent excessive floodplain drawdown while simultaneously allowing seed germination and growth of wetland plants, maintaining the extent of deep marsh habitat, and ensuring adequate open water area. The general indicator of protection is to prohibit excessive floodplain drawdown in order to maintain species composition, vegetative structure, and ecological functions of flooded wetland plant communities and deep marsh habitats.

The FL magnitude component is based on the average minimum elevation of shallow marsh habitat surveyed at Transects 1 and 2. This elevation is supported by the elevation that corresponds to a 30-inch offset from mean organic soils elevation, which is a metric used for FL elevations in sandhill lakes. The resulting elevation is 35.7 ft NAVD (See Appendix C for more information).

The duration component of the FL is a minimum of 120 days for this continuously non-exceeded drying event. This corresponds to the length of a normal dry season in central Florida between the end of winter rains and the start of the summer rainy season. This duration will maintain the ecological integrity of deep marsh habitats, while also allowing for seed germination and providing adequate time for regeneration and growth of shallow marsh wetland plants to a height able to survive the next flood event (Ware, 2003).

The FL return interval for Sylvan Lake is once every 11.8 years, on average. This return interval is supported by SWIDS data for the mean minimum elevation of shallow marsh communities, which is based on hydroperiods analyzed at 14 lakes (Appendix C). This return interval ensures a hydrologic signature adequate to maintain the shallow marsh plant communities and the associated deep organic soils. The FL return interval is expected to prevent a permanent downhill shift of shallow marsh plant communities or a permanent net loss of deep marsh and open water habitats.

Importance of FL for Wetland Functions

The FL allows for periodic dewatering of the floodplain facilitating seed germination and maintenance of emergent and shallow marsh vegetation communities while protecting deep marsh habitats from extended periods of drying. As long as dewatering events are not too frequent, flora such as water lilies and the related spatterdock species (family: Nymphaceae), can persist, out competing other species due to their ability to germinate under water (Gerritsen and Greening, 1989). Protection of deep marsh vegetation is important refugia for fish and invertebrates, providing dense structure and extended inundation. The recommended FL also maintains the long-term ecotone between deep marsh and shallow marsh, thereby preventing downhill shift in species and loss of open water.

The recommended duration for the FL will allow for seed germination of wetland plants, which generally require saturated but not inundated substrates (Kushlan, 1990). This duration also allows time for seedlings to grow sufficiently tall to survive subsequent flooding (Ware 2003). Additionally, dewatering events enable wading birds to feed within formerly deep habitats and allow access to the resources by wildlife species that usually inhabit upland plant communities (Harris and Gosselink, 1990).

MFLS ASSESSMENT

MFLs are not meant to represent optimal conditions, but rather set the limit to water withdrawals, beyond which significant harm would occur. A fundamental assumption of SJRWMD's MFL approach is that alternative hydrologic regimes exist that are lower than pre-withdrawal conditions but still protect the environmental functions and values of water bodies from significant harm caused by withdrawals. The MFLs determination (described above) involves defining a minimum hydrologic regime (MFLs condition) necessary to protect relevant water resource values. For Sylvan Lake, the MFLs condition is defined by the recommended frequency for each of the event-based metrics (i.e., FH, MA and FL).

The MFLs assessment compares the MFLs condition with the current hydrologic regime (current-pumping condition) to assess whether the MFLs are being achieved under the current-pumping condition, and to determine if there is water available for withdrawal (freeboard), or whether water is necessary for recovery (deficit). If any of the MFLs are not being achieved under the current-pumping condition, indicating a deficit of water, a recovery plan is necessary. If the MFLs are currently being achieved, but a deficit is projected within the 20-year planning horizon, a prevention plan is needed.

HYDROLOGICAL ANALYSES

Assessing the MFL status of waterbodies requires substantial hydrological analysis. Several steps were involved in performing the hydrological analysis for the Sylvan Lake MFLs assessment, 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.

These analyses are briefly described below. For more information on these analyses, see Appendix B.

Long-term Lake Levels

Available water level data were discussed previously in the *Hydrology* subsection under the *Setting and Description* section. Because minimum levels established for Sylvan Lake are based on an event-based approach associated with return periods, MFL assessment requires frequency analysis of lake levels. Due to the presence of short and long-term climatic cycles (e.g. El Nino Southern and Atlantic Multidecadal Oscillations), the frequencies of lake levels could be significantly different in wet periods versus dry periods. Thus, it is important to perform frequency analysis using long-term lake levels so that short- and long-term variations in lake levels can be captured.

Although observed long-term lake levels data are available, the data only consists of monthly water level readings that extend back to October of 1978 (Figure 5). To build a continuous daily long-term lake levels data set and simulate the influence of the Upper Floridan aquifer on lake levels, the surface water model developed in 2017 (CDM, 2017) was updated to simulate lake levels from 1948 to 2018 (Appendix B).

Development of No-pumping and Current-pumping Lake Levels

The MFL assessment of Sylvan Lake includes an assessment of MFLs under current groundwater pumping conditions. The current status assessment of Sylvan Lake MFLs is based on long-term lake level dataset representative of the current-pumping condition. The current-pumping condition lake levels represent a reference hydrologic condition of the lakes in which the impact from regional groundwater pumping on the lakes is constant from 1948 to 2018 at a rate of current-pumping impact. Current-pumping impact is defined as the impact due to the averaged groundwater pumping from 2014 to 2018. Groundwater pumping, used to calculate the current-pumping condition, was averaged over five years so that it is more representative of the most recent average groundwater demand.

Assuming climatic conditions such as rainfall and other conditions present from 1948 to 2018 are repeated over the next ~70 years (i.e., the length of the POR), the current-pumping condition lake levels would reflect the future condition of the lake levels if the current-pumping condition does not change.

The influence of long-term climatic cycles on water bodies should be considered when setting MFLs. Our understanding of possible future climatic conditions is limited and there are significant uncertainties in global climate model predictions. According to the Florida Climate Institute, the climatic cycles such as El 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 2 to 7 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 sinkhole lakes, such as Sylvan Lake, usually exhibit different behaviors in terms of frequency of certain water levels during wet and dry periods of long-term climatic cycles. The exceedance probability of a given lake level could easily be different in 1960s than 2000s. 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.

The district acknowledges that the MFLs analyses assumes history will repeat itself. Given the lack of information about the future and substantial uncertainties in future rainfall and temperature predictions by global climate models, this assumption is thought to be appropriate, but needs to be regularly tested by implementing an adaptive management strategy. The strategy, performed approximately every five years, involves a screening level analysis, considering changes in rainfall and temperature trends and uncertainty, to monitor the status of the adopted MFLs. If the analysis shows that MFLs are not being met or are trending toward not being met, SJRWMD conducts a cause-and-effect investigation to independently evaluate the potential impacts of various stressors on the MFLs water body.

MFLs are established to prevent the lake from being significantly harmed by only groundwater pumping. Therefore, using historical conditions to generate current-pumping condition lake levels is reasonable.

A surface water model was utilized to simulate current-pumping condition lake levels. The interaction between the lake and the UFA was simulated by setting the UFA levels as a boundary condition in the surface water model. Thus, the impact of groundwater pumping on the UFA levels near the lake was estimated first. The East Central Florida Transient Expanded (ECFTX) groundwater model was used for the groundwater pumping impact assessment. The details of this analysis are described in Appendix B.

The observed UFA levels used in the surface water model were adjusted by removing the effect of estimated impact from historical pumping, resulting in the no-pumping condition UFA levels. To generate current-pumping condition UFA levels, the impacts from current-pumping (average 2014-2018 pumping) were subtracted from the no-pumping condition UFA levels from 1948 to 2018. The no-pumping and current-pumping Sylvan lake levels were simulated by using the no-pumping and current-pumping UFA levels as inputs into the surface water model. Figure 13 shows the simulated historical, no-pumping and current-pumping conditions lake levels for Sylvan Lake.

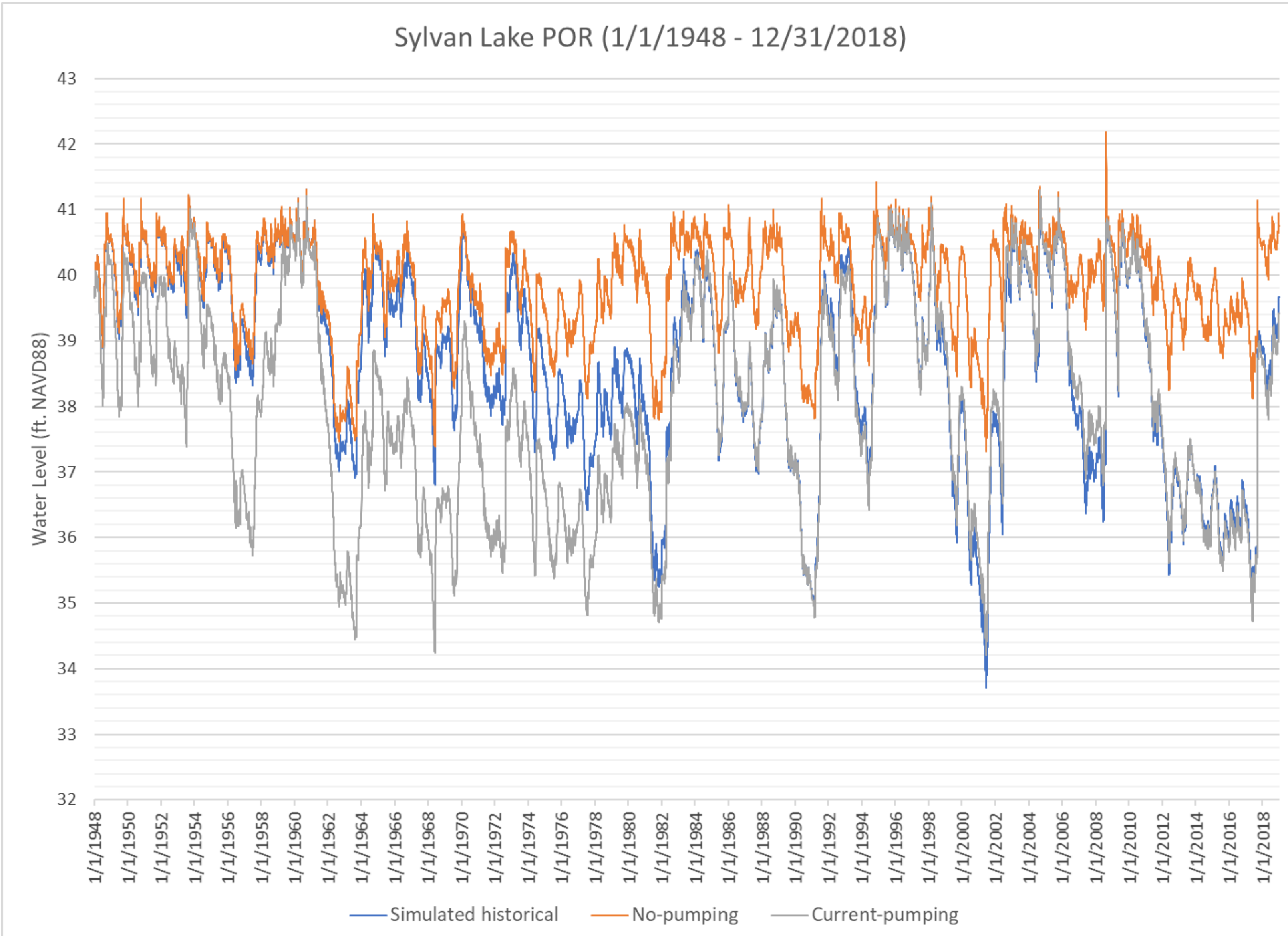

Figure 13. The simulated historical, no-pumping and current-pumping condition levels for Sylvan Lake, Seminole County, Florida

CURRENT STATUS

The assessment of current status determines whether or not each minimum level is met under current withdrawal conditions. The water withdrawals used to assess current status are based on the 2014-2018 current-pumping condition (not current CUP allocations; see above for description of current-pumping condition). Current status was assessed for each of the minimum levels described above (Table 7 in *Determination* section). MFLs status was assessed by comparing the frequency of an MFLs defined hydrologic event (defined with specific lake level and duration components) to the frequency of the same hydrologic event under the current-pumping condition. The frequency of an MFLs hydrologic event under the current-pumping condition was calculated based on annual series data. See Appendix D for details regarding frequency analyses used to assess the status of minimum levels.

Minimum Frequent High

Under the current-pumping condition, the FH flooding event (40.2 feet, duration of 30 days) has a probability of 27% (3.7-year return interval) compared to a probability of 19% (5.2-year return interval) under the MFLs condition. Therefore, the FH is achieved under current-pumping conditions (see Appendix D for details).

Minimum Average

Under the current-pumping condition, the MA drying event (37.9 feet, duration of 180 days) has a probability of 52.6% (1.9-year return interval) compared to a probability of 58.6% (1.7-year return interval) under the MFLs condition. Therefore, the MA is achieved under current-pumping conditions (see Appendix D for details).

Minimum Frequent Low

Under the current-pumping condition, the FL drying event (35.7 feet, duration of 120 days) has a probability of 4.3% (23.5-year return interval) compared to a probability of 8.5% (11.8-year return interval) under the MFLs condition. Therefore, the FL is achieved under current-pumping conditions (see Appendix D for details).

UFA freeboard/deficit analysis

Each of the three Sylvan Lake MFLs have lake freeboards greater than zero, and therefore UFA freeboard analyses were performed for each level. The FH, MA and FL have lake freeboards of 0.4 ft, 0.6 ft and 0.3 ft, respectively (See Appendix D for details). For each of the three MFLs, the current-pumping UFA and lake level timeseries were iteratively decreased using the surface water model until the event frequency just met the recommended minimum frequency. This iterative modeling and frequency analysis process resulted in UFA freeboards for the FH, MA and FL of 1.8 ft, 0.6 ft and 0.5 ft, respectively (Table 8; Appendix D).

No matter how many MFLs are adopted, the most constraining (i.e., most sensitive to water withdrawal) MFL is used for water supply planning and permitting. By ensuring that the most sensitive MFL is achieved, assurance is also provided that all other MFLs will be achieved. The MA and FL are both the most constraining for Sylvan Lake, each with a UFA freeboard of 0.5 ft.

Table 8. MFLs criteria and aquifer freeboard for Sylvan Lake, Seminole County, Florida

MFLs	Environmental Criteria	Minimum Level Components				Lake Freeboard (ft)	UFA Freeboard (ft)
		Level (ft NAVD88)	Duration (days)	MFL Condition Return Interval (years)	Current-pumping Condition Return Interval (years)		
Frequent High (FH)	Transitional shrub communities; Fish and wildlife habitat	40.2	30	5.2	3.7	0.4	1.8
Minimum Average (MA)	Organic soils	37.9	180	1.7	1.9	0.6	0.6
Frequent Low (FL)	Shallow and deep marsh communities / associated wildlife values	35.7	120	11.8	23.5	0.3	0.5

FUTURE / PROJECTED STATUS

Water withdrawal information used to assess future status was based on water supply planning projections for the planning horizon (i.e., not current CUP allocations). The projected UFA drawdown at the 20-year planning horizon (2040) was estimated for Sylvan Lake using the ECFTX groundwater model. Assuming all future pumping is equal to projected 2040 water demand, the predicted UFA drawdown is 0.65 feet.

Under current-pumping conditions, all three Sylvan Lake MFLs are met, and the most constraining (FL) has a UFA freeboard of 0.50 ft. However, the additional 0.65 ft of drawdown at the planning horizon creates a projected UFA deficit of 0.15 ft. Therefore, Sylvan Lake is in prevention, and a prevention strategy must be developed concurrently with the MFLs to ensure that the projected UFA deficit does not occur.

CONSIDERATION OF ENVIRONMENTAL VALUES UNDER 62-40.473, F.A.C.

Pursuant to Sections 373.042 and 373.0421, F.S., SJRWMD considered the following 10 environmental values (also called water resource values [WRVs]) identified in rule 62-40.473, F.A.C.

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
10. Navigation

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 Sylvan Lake and also based on whether they protect ecological versus non-ecological structure and function.

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

Group 1: WRV3, WRV8 and WRV10

The three WRVs in Group 1 were determined not applicable and thus were not considered as part of this assessment:

WRV 3 – Estuarine resources:

This environmental value is not relevant because the lake is land-locked (except during extremely high flooding events) and generally has no surface water connection to any estuarine resources. Therefore, WRV-3 was not considered in this evaluation;

WRV8 – Sediment loads:

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 serve as sinks instead of sources of sediment load, and therefore WRV-8 was not considered in this evaluation;

WRV10 – Navigation:

The primary navigation on Sylvan Lake is by recreational boaters. As such, this WRV is addressed under WRV1 (Recreation in and on the water).

Group 2: WRV2, WRV4, WRV5, and WRV7

The four WRVs in Group 2 are closely associated with and depend on the ecological functions and biochemical processes provided by the wetland communities surrounding Sylvan Lake. The event-based MFLs criteria are designed to protect these important ecological functions and biochemical processes by protecting the resident wetland communities from significant harm. The three Sylvan Lake minimum levels (FH, MA and FL) were developed to ensure protection of the hydrologic regime and are based on the protection of 1) transitional shrub communities and associated wildlife habitat values; 2) organic soils and seasonally flooded wetland habitat; and 3) shallow and deep marsh habitats. The most constraining minimum levels are based on the protection of shrub wetlands, shallow marsh and deep marsh communities. These constraining event-based MFLs provide protection for each of the four WRVs in this group.

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 recommended MFLs for Sylvan Lake are based on the protection of fish and wildlife habitats, providing a sufficient frequency of high water (flooding) events and preventing too many low water (drying) events thus ensuring existing wetland communities are maintained.

These wetlands include extensive 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. Shallow marshes provide important refugia and forage habitat for invertebrates, fish, mammals, birds, and other wildlife. Therefore, compliance with all three recommended MFLs (FH, MA and FL) provides for the protection of “fish and wildlife habitats and the passage of fish” for Sylvan Lake.

<u>MFLs Condition and Organic Soils Protection</u>

As described above, the recommended MFLs provide protection for wetlands and organic soils. The MFLs Condition, based on the FL, yields a minimum median and a minimum mean lake level that both equal 38.2 ft (NAVD88; Appendix E). This long-term minimum mean water level provides saturation sufficient to prevent organic soils oxidation and subsidence and is supported by a recent University of Florida (UF) study on the relationship between organic soil stability and hydrology in the Upper St. Johns River Basin (Osborne et al., 2014). Using the maximum drawdown recommended by Osborne et al. (2014; 7 cm from mean soil elevation) yields a long-term mean water level of 38.2ft (NAVD88) at Sylvan Lake. This is identical to the long-term mean (and median) water level provided by the MFLs condition. This study suggests that the MFLs condition is sufficient to protect the long-term maintenance of organic soils (see Appendix E for more details).

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. A significant portion of detrital transfer occurs during high-water events, when accumulated detrital materials in floodplain wetlands are moved to the aquatic system. The FH is based on providing a sufficient number of high-water (flooding) events to protect floodplain wetlands and associated wildlife habitat values. Maintaining sufficient high-water events will also ensure that detrital material, that has accumulated during drier periods, is transported to aquatic habitats downslope. Compliance with the recommended FH provides for the protection of flooding events necessary for the transfer of detrital material in Sylvan Lake. Therefore, the "transfer of detrital material" is considered to be protected by the MFLs condition.

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). Existing wetlands around Sylvan Lake include transitional shrub, and marsh communities, which provide for filtration and absorption of excess nutrients and other pollutants. The purpose of the FH and FL is to ensure the long-term maintenance of these wetland communities. Therefore, by protecting existing wetlands, the most constraining MFL also provides protection for WRV7.

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 change 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 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.

Group 3: WRV1, WRV6, and WRV9

The three WRVs in Group 3 are closely related to lake area and depth, rather than conditions of the wetland vegetation communities in and around the lake. The determination of whether these WRVs are protected was based on whether there was a significant harm, from the no-pumping condition to the MFL condition, for specific criteria evaluated for each WRV. The MFLs condition represents the minimum hydrologic regime necessary to protect all the minimum levels (i.e., it is based on the most constraining levels for Sylvan Lake).

An exceedance curve based on the MFLs condition timeseries was created and compared to the no-pumping condition exceedance curve to help assess whether WRVs in this group are protected (see Appendix E). The MFLs condition and no-pumping exceedance curves were created using the respective daily lake level timeseries. The no-pumping condition time series was simulated using the Sylvan Lake HSPF model, with the no-pumping groundwater level time series as an input (Appendix B). The MFL condition lake level time series was simulated by adjusting groundwater levels incrementally in the surface water model until the model produced a lake level time series that just meets the most constraining MFLs (MA and FL).

A significant harm threshold of 15% was used as the maximum allowable change, for a specific WRV, between the MFLs condition and the no-pumping condition. A threshold of 15% reduction in exceedance of critical elevations has been peer reviewed numerous times and has been the basis for numerous adopted MFLs within Florida (Munson and Delfino, 2007; Mouzon et al., 2018). The WRVs assessment results indicate that all three WRVs in this group are protected by the MFLs (Table 9). See Appendix E for specific details regarding the assessment of each of these WRVs.

Table 9. WRVs representative environmental values/functions and percent reduction under the MFLs condition relative to the no-pumping condition. (See Appendix E for more details on WRVs assessment).

WRV	Representative values or functions	Allowable change from no-pumping	Change under MFLs condition	Protected by the MFLs (Yes/No)
Recreation in and on the water	Dock access	15% reduction in exceedance of critical elevation	0% reduction in dock access	Yes
Fish and wildlife habitats and the passage of fish	The event-based MFLs were primarily based on the protection of fish and wildlife habitats with a sufficient frequency and duration of high water (flooding) and low water (dewatering) events to prevent a down-slope shift in the location of floodplain wetlands (i.e., no net loss of wetlands). Compliance with all three recommended MFLs provides for the protection this WRV.			Yes
Estuarine resources	This environmental value is not relevant because the lake is land-locked (except during rare extreme events) and has no surface water connection to any estuarine resources.			NA
Transfer of detrital material	Compliance with the recommended FH provides for the protection of flooding events necessary for the transfer of detrital material in Sylvan Lake.			Yes
Maintenance of freshwater storage and supply	Because the overall purpose of the event-based MFLs and other WRVs 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.			Yes
Aesthetic and scenic attributes	Visual setting around the lake	15% reduction in open water viewing (lake surface area) at median lake level	10% reduction in open water viewing (lake surface area) at median lake level	Yes
Filtration and absorption of nutrients and other pollutants	Compliance with the recommended FH and FL levels provides for the protection of wetland communities which will maintain filtration and absorption of nutrients and other pollutants in Sylvan Lake.			Yes
Sediment loads	Transport of inorganic materials as suspended or bed load is considered relevant only in flowing systems. Therefore it was not considered in this evaluation.			NA
Water quality	Water quality standards for TN,TP and chl-*a*	15% increase in TN, TP, chl-*a* concentrations	Water quality would improve or exhibit no change with lake stage decline.	Yes
Navigation	The primary navigation on Sylvan Lake is by recreational boaters. As such, this WRV is addressed under WRV 1.			NA

Conclusions and Recommendations

Minimum levels were developed for Sylvan Lake using a minimum hydrological event-based approach. A premise of this MFLs determination is that by maintaining the lake's natural flooding and drying characteristics, the basic structure and functions of the ecosystem will also be maintained. SJRWMD investigated ecological and human-use criteria using a multiple event-based level method and a WRVs assessment, to ensure that all relevant environmental values and beneficial uses are protected.

Three minimum lake levels were developed for Sylvan Lake. Multiple levels are typically developed because different ecological and human-use values require the protection of different portions of a system's hydrologic regime. For Sylvan Lake, a frequent high (FH), minimum average (MA) and frequent low (FL) were developed (Table 8).

The FH is based on providing a sufficient number of flood events to protect seasonally flooded transitional shrub communities and associated wildlife habitat values. These flood events also promote filtration and absorption of nutrients and other pollutants. The MA is designed to prevent an excessive number of drying events to protect organic soils from oxidation and subsidence, and to avoid adverse impacts to wetland habitat. The FL is designed to prevent an excessive number of drying events to protect shallow and deep marsh habitats, and associated wildlife values. The FL also maintains an appropriate water-table level under organic soils during periodic droughts.

Recommended Minimum Level

MFLs status was assessed using frequency analysis for each of the three minimum levels developed for Sylvan Lake (Table 8). This involved comparing the frequency of each MFL hydrologic event (defined with specific lake level and duration components) to the frequency of the same hydrologic event under the current-pumping condition (See Appendix D for details). 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 ~70 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 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).

Assuming the current-pumping condition (2014-2018) does not change in the future, the MFLs assessment indicates that all three minimum levels are met under current-pumping conditions. The most constraining level (FL) has a UFA freeboard of 0.5 feet. UFA drawdown of 0.65 feet is projected within 20 years, resulting in a deficit of 0.15 feet. Therefore, Sylvan Lake is in prevention and a prevention strategy must be developed concurrently with the MFLs.

Three minimum levels, a minimum P25, P50 and P75, are recommended for Sylvan Lake (Table 10; Figure 14). These three percentiles were calculated from the MFLs condition lake

Table 10. Recommended Minimum Levels for Sylvan Lake, Seminole County, Florida

Percentile	Recommended minimum lake level (ft; NAVD88)
25	39.4
50	38.2
75	36.9

level time series data (1948–2018). The MFLs condition is a long-term lake level time series, associated with the minimum hydrological regime. This is the lake level timeseries that just meets the most constraining level (FL), is based on the protection of wetland habitat, and is associated with an UFA freeboard of 0.5 ft. Adopting these three minimum levels will ensure the protection of the minimum hydrologic regime at low, average and high levels for Sylvan Lake.

An adaptive management approach will be used to ensure the protection of Sylvan Lake's hydrologic regime (i.e., the shape of the MFLs condition exceedance curve); this analysis is described in the following section.

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 Sylvan Lake (Appendix E). Based on this analysis, SJRWMD concludes that the recommended minimum level for Sylvan Lake, which has been developed primarily for the protection from significant harm to wetland habitat, will also protect all relevant WRVs. The recommended minimum lake levels are also supported by a recent UF study on the relationship between organic soil stability and hydrology (described above). The minimum mean water level recommended by this UF study (based on maximum drawdown below organic soils) equals 38.2 ft (NAVD88) at Sylvan Lake. This is identical to the long-term mean (and median) water level provided by the MFLs condition.

The information presented in this report is preliminary and will not become effective until adopted by the SJRWMD Governing Board, as directed in Rule 40C-8.031, F.A.C.

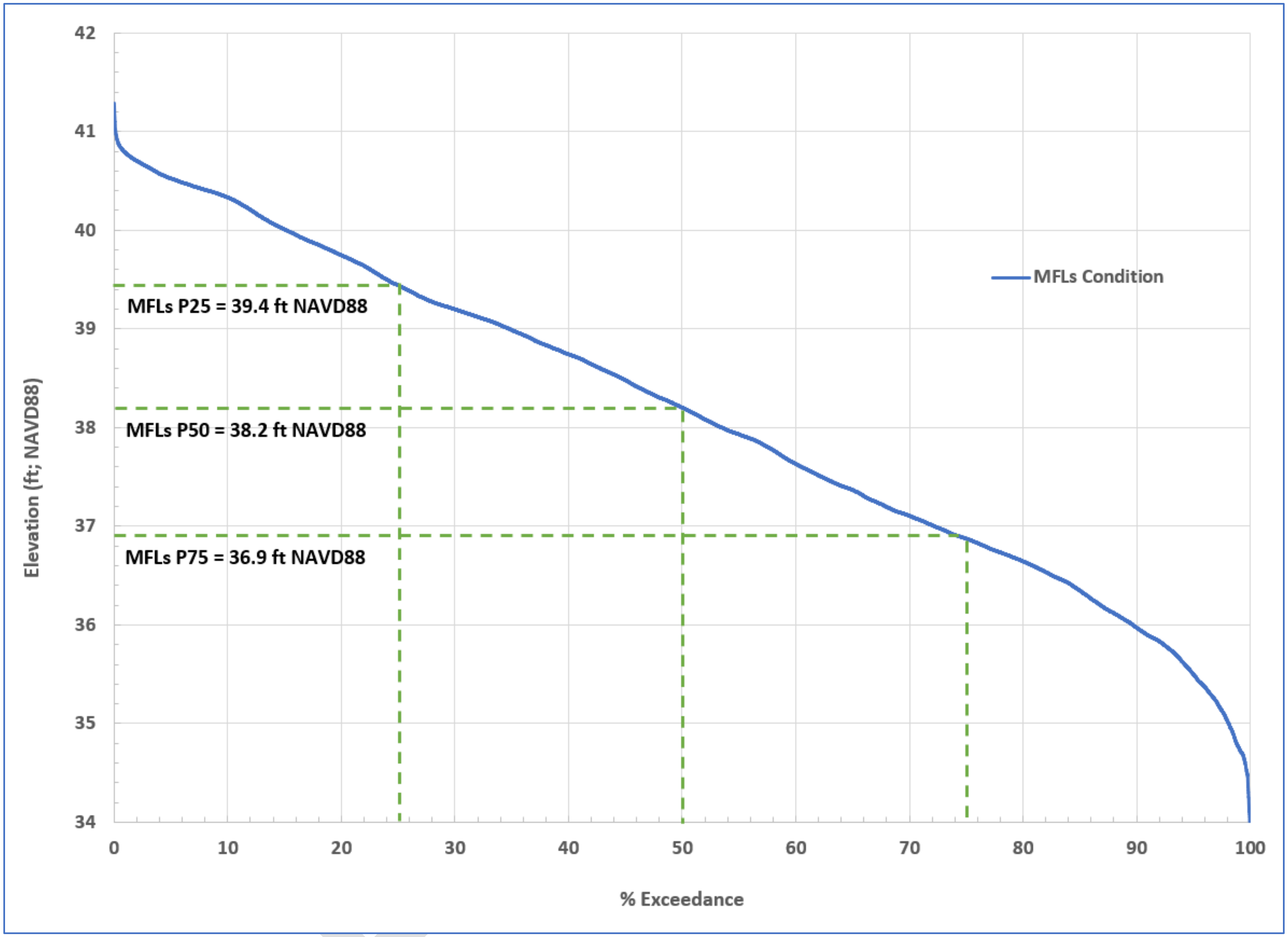

Figure 14. MFLs condition exceedance curve based on most constraining minimum level. Dashed green lines indicate the recommended minimum P25, P50 and P75 elevations for Sylvan Lake, Seminole County, Florida

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. The district acknowledges that the MFLs determination and assessment methods, described herein, assume that Sylvan Lake'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 needs to be regularly tested by implementing an adaptive management strategy.

The district 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 Sylvan Lake. This analysis 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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