Documentation in Support of Category 4e

Waterbody/Watershed Identification

Organization	City of Casselberry
Point of Contact	Kelly Brock, PhD, PE, CFM, LEED AP, ENV SP 95 Triplet Lake Drive Casselberry, FL 32707 kbrock@casselberry.org 407-262-7725 ext. 1235 Edward Northey Florida Department of Transportation – District Five 719 S. Woodland Boulevard Deland, FL 32720 Edward.northey@dot.state.fl.us (386)943-5601
Waterbody(s)	WBID ID # 2994K, Lake Concord
No. Waterbody / Pollutant Combinations	1 waterbody segment; Lake Concord is impaired for nutrients (Group 2, Cycle 4) including total phosphorus (TP) and chlorophyll-a (Chl-a)
EPA Completed TMDL	EPA/FDEP have not developed a TMDL for Lake Concord.

Description of Baseline Conditions

Watershed(s)	Middle St. Johns, Seminole County
Baseline Data	The annual geometric means (AGM) for chlorophyll-a, total nitrogen (TN), and total phosphorus (TP) were assessed during the group 2 cycle 4 verified period, with AGMs exceeding the criteria for chl-a and TP in 2017, 2018 and 2019 respectively. Please see the below table for AGM values. Data were obtained from the Impaired Waters Rule (IWR) Database Run 60 (IWR Run 60). Lake Concord is a Class III fresh waterbody, and also falls into the NNC lake assessment type Category II with a color AGM less than 40 PCU and an alkalinity AGM higher than 20 mg/L $CaCO_3$ (source: see Table 2-8 in **Attachment A**, 2020). The long term geometric mean values of the lake alkalinity and color are presented in the first table, which determines the Category II NNC criteria for Lake Concord. The Category II NNC criteria are compared to the recent Lake Concord AMG for the relevant water quality parameters in the second table below.

WBID	Waterbody Name	Parameter	Year of Coverage	Geomean
2994K	Lake Concord	Alkalinity	3 years	72 mg/L
2994k	Lake Concord	Color	3 years	14 PCU

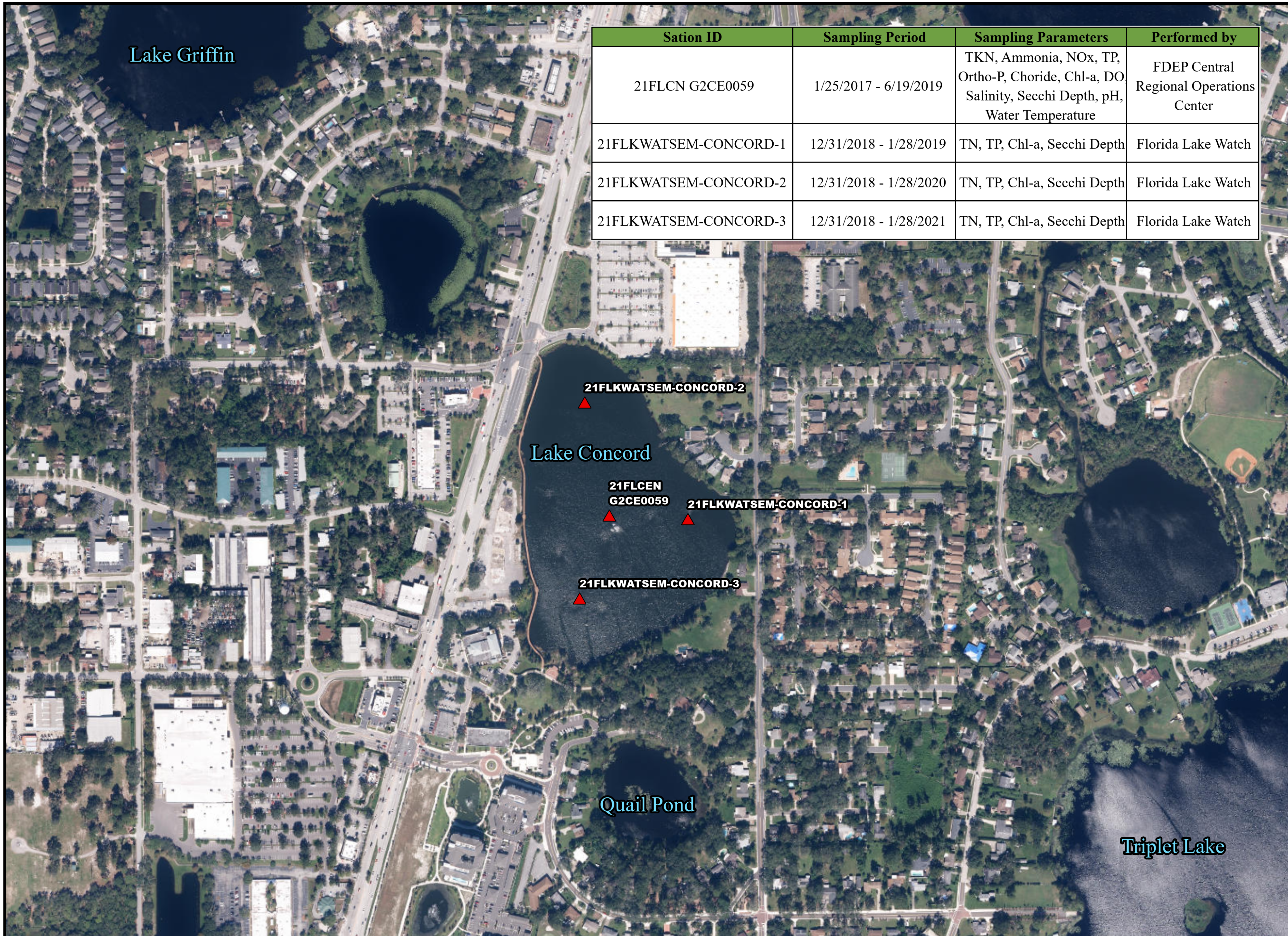
WBID	Waterbody Name	Parameter	Criterion Concentration or Threshold	Verified Period AGMs	Meets NNC Criteria
2994K	Lake Concord	Nutrients (Chl-a)	**Chl-a AGM ≤ 20 µg/L**	2017 (24 µg/L) 2018 (27 µg/L) 2019 (27 µg/L)	No
2994K	Lake Concord	Nutrients (Total Phosphorus)	If Chl-a AGM ≤` 20 µg/L, TP AGM ≤ 0.09 mg/L; If Chl-a has insufficient or No Data to calculate AGM or if Chl-a AGM > 20 µg/L, then **TP AGM ≤ 0.03 mg/L**	2017 (0.04 mg/L) 2018 (0.04 mg/L) 2019 (0.04 mg/L)	No
2994K	Lake Concord	Nutrients (Total Nitrogen)	If Alkalinity AGM > 20, and color ≤ 40 PCU. Then Chl-a AGM < 20 µg/L, TP AGM < 0.03 mg/L, **TN AGM < 1.05 mg/L**.	2017 (0.59 mg/L)* 2018 (0.70 mg/L)* 2019 (0.71 mg/L)	Yes

Note:

1. The bold text indicates the NNC criteria relevant to Lake Concord water quality

Map	Figure 1 illustrates the locations of water quality sample collection stations used during the IWR Run 60.

Sation ID	Sampling Period	Sampling Parameters	Performed by
21FLCN G2CE0059	1/25/2017 - 6/19/2019	TKN, Ammonia, NOx, TP, Ortho-P, Choride, Chl-a, DO Salinity, Secchi Depth, pH, Water Temperature	FDEP Central Regional Operations Center
21FLKWATSEM-CONCORD-1	12/31/2018 - 1/28/2019	TN, TP, Chl-a, Secchi Depth	Florida Lake Watch
21FLKWATSEM-CONCORD-2	12/31/2018 - 1/28/2020	TN, TP, Chl-a, Secchi Depth	Florida Lake Watch
21FLKWATSEM-CONCORD-3	12/31/2018 - 1/28/2021	TN, TP, Chl-a, Secchi Depth	Florida Lake Watch



N
0 200 400
Feet

Legend

IWR Sampling Station

Sources:
Aerial: ESRI. 2021
IWR Station: FDEP, 2019

Figure

1

Lake Concord Water Quality Sampling Stations (IWR Run 60)

Lake Concord 4e Plan

Geosyntec consultants

Area of Effort	Lake Concord is a 19.7 acre lake in west Seminole County in the City of Casselberry, located on the east side of US 17-92 approximately 3.8 miles southwest of Lake Jesup (Section 08, Township 21 South, Range 30 East). The Lake Concord watershed is located entirely within Seminole County. Discharges from Lake Concord travel through a narrow excavated channel which is located on the east side of the lake, passing beneath Sunset Drive N and Secret Way. This channel ultimately discharges into the west side of Secret Lake which discharges to the N. Triplet-Kathryn Canal, Gee Creek, and ultimately to Lake Jesup. Lake Concord is located in the Gee Creek Watershed which discharges to Lake Jesup, Lake Monroe, and the Middle St. Johns River. The area of effort includes the Lake Concord watershed within WBID #2994K. The Lake Concord watershed is shown in Figure #3-1 of **Attachment A** (2020). Watershed characteristics, including land use and soil characteristics, present within the watershed are presented in the tables below.

FLUCCS: Landuse Description	Area (Acres)	% of Watershed Area
1480: Cemetery	0.58	0.3
1400: Commercial	54.26	29.8
1820: Golf Course	5.07	2.8
1300: High Density Residential	10.85	5.9
8140: Highway	11.91	6.5
1500: Industrial	12.33	5.6
1700: Institutional	10.30	6.8
1190: Low Density Residential	7.04	3.9
1200: Medium Density Residential	30.43	16.7
1900: Open Space	14.09	7.7
1800: Recreational	6.35	3.5
6460: Scrub	1.36	0.7
4000: Upland Forest	8.59	4.7
8300: Utilities	0.36	0.2
6000: Wetlands	0.97	0.5
5000: Water	7.99	4.4
Total:	182.48	100

Soil Hydrologic Groups	Area (acres)	% of Watershed Area
A	35.57	19.5
D	138.93	76.1
W	7.98	4.4
Total	182.48	100

Land use and soil type maps for the Lake Concord watershed are presented in Figures #3-3 and #3-4 in the Attachment A (2020).

Key Stakeholders Involved and Their Roles	The City of Casselberry is the key stakeholder that has assessments and existing best management practices in the watershed intended to restore water quality. FDOT is expected to take a role since they also drain to Lake Concord.
Watershed Plan & Other Supporting Documentation	The watershed plan is to reduce the nutrient concentrations in Lake Concord by performing a series of in-lake alum treatments and implementing other stormwater BMPs within the watershed as further described below. The City of Casselberry has taken a proactive approach to address Lake Concord's water quality issues and has recently completed the Lake Concord Hydrologic / Nutrient Budget Evaluation (2020) to identify potential pollutant loading sources contributing to the water quality impairments and to evaluate the potential benefit of in-lake alum treatments to correct the impairment. A copy of the report is included in **Attachment A**. Hydrologic inputs to Lake Concord total approximately 324 ac-ft annually. The City of Casselberry's study found that stormwater runoff contributes about 66% of the hydrologic inputs, while seepage contributes about 7%, with the remaining hydrologic inputs contributed by direct rainfall. The total annual loads of TN and TP to Lake Concord are approximately 157.9 lbs and 2,149 lbs for TP and TN, respectively. This is due to both external and internal sources. Stormwater runoff was estimated to generate approximately 34% of the total phosphorus loading, and 27% of the total nitrogen loading. Groundwater seepage was estimated to contribute about 5% of the total phosphorus loading and 16% of the total nitrogen loading. Sediment flux was estimated to contribute 47% of the total phosphorus loading and 46% of the total nitrogen loading. Effluent from nearby Quail Pond was estimated to contribute 1% of the total phosphorus loading and 3% of the total nitrogen loading. Overland flow was estimated to contribute 4% of the total phosphorus loading and 2% of the total nitrogen loading. The remaining 9% of total phosphorus and 8% of total nitrogen were estimated to be contributed by atmospheric deposition. The City of Casselberry has developed several projects with some ongoing projects to reduce the external and internal nutrient loads to Lake Concord. Completed projects include a fertilizer ordinance and Lake Management Guide. Ongoing projects include the City of Casselberry quarterly newsletter and educational workshops on water quality related topics, eelgrass planting pilot project, and an illicit discharge ordinance, which are discussed in more detail in the Restoration Work Section below. Lake Concord was determined to be phosphorus limited, which means that elevated phosphorus concentrations will stimulate the growth of algae. Thus, the water quality improvements are more focused on phosphorus removal. As the City has been proactive in implementing stormwater treatment BMPs within the watershed, control of the internal loading is believed to provide significant long-term water quality benefits. These include a number of stormwater BMPs within the Lake Concord Stormwater Park, such as baffle box, bioswales, and pervious pavement parking areas, to name a few. Therefore, reduction of internal loading within the lake is the most cost-effective means of achieving significant phosphorus load reduction. This is to be done through sediment phosphorus inactivation using in-lake alum treatments which is expected to provide rapid water quality improvement within Lake Concord. It is noted that the deeper portions of the lake appeared to be contributing

	the majority of phosphorus flux, thus will be specifically targeted for nutrient inactivation.
Point Sources and Indirect Source Monitoring (Sites)	No point sources are contributing to Lake Concord. The City of Casselberry is a co-permittee (FLS 000038) associated with Seminole County's MS4 Permit, which also falls under the Florida Phase 1 MS4 permits with FDOT districts and jurisdictional boundaries Note: Generic Permits for stormwater discharge from large and small construction activities are considered temporary; therefore, are not included in this listing.
Nonpoint Sources	The nutrient loadings to Lake Concord are primarily generated from nonpoint sources, including internal recycling associated with sediments in the lake, surface runoff, groundwater seepage, and precipitation directly on the lake surface.
Water Quality Criteria	Lake Concord is a clear lake with slightly high alkalinity (NNC Category II). Based on the procedure for determining numeric nutrient criteria (NNC), outlined in F.A.C 62-302, the NNC for Lake Concord are chlorophyll-a < 20 ug/L, TP < 0.03 mg/L, and TN < 1.05 mg/L, respectively, which is anticipated to be achieved upon successful completion of all water quality restoration projects identified below.
Restoration Work	The following projects are recently completed or planned projects that could provide a water quality benefit for Lake Concord. These projects are part of the proposed water quality improvement plan. Funding for these projects is approved and included in the City of Casselberry budget for implementation over the next 2 to 3 years. See below for additional details. **In-Lake Alum treatments**: Includes 4 separate in-lake alum treatments for a total alum addition of 36,120 gallons. The alum treatment will be performed by Environmental Research & Design, Inc. (ERD) in the anticipated time frame of April 2021 to April 2022. The alum (aluminum sulfate) forms floc called aluminum hydroxide that binds phosphorus and settles to the lake bottom. This forms a barrier that prevents phosphorus from being released into the water column, thus making it unavailable to algae. The alum treatment is expected to be effective at reducing phosphorus concentrations in Lake Concord for several years. This project is considered the major effort to improve the lake water quality. **Lake Management Guide**: This project was completed in 2019 and is still providing the lake front residents information on water quality concerns, aquatic plant management and shoreline restoration, fish stocking, etc. This is a great educational resource to improve residents' awareness of protecting local lake water quality. It is assumed that this project would result in marginal but long term water quality benefits for Lake Concord. See **Attachment B** for an example of the Lake Management Guide. **Construction and Monitoring of Engineered Phytotechnology for Nitrate Removal in Groundwater**: Construction for this project was completed in 2018 and monitoring was completed in 2020. This project provides tree well and sorption media based phytotechnology to

reduce the nitrate concentration in groundwater on the City of Casselberry golf course. Even though the golf course is not included within the Lake Concord basin boundary, the groundwater in this area appears to discharge to Quail Pond which eventually discharges to Lake Concord. It is assumed that this project would provide long term water quality benefits to Quail Pond, which in turn could benefit Lake Concord. See **Attachment E** for the Site Suitability Assessment Report.

Fertilizer Ordinance:
The fertilizer ordinance was adopted in November 2017 which is intended to inform residents on how to appropriately apply fertilizers to their grass and the importance of keeping their grass clippings and yard debris off sidewalks and other impervious areas to help reduce nutrient loads in stormwater runoff. The primary goal of this project is to educate residents regarding fertilizer restrictions per the City's ordinance. This project could provide marginal but long term water quality benefits to Lake Concord. See **Attachment D** for an example of the Fertilizer Ordinance.

Quarterly Newsletter and Educational Workshops:
This ongoing project provides a platform for residents to learn the latest information about the City's improvement projects, entertainment activities, and resources for water saving and ecological protection. This project is expected to provide marginal water quality benefits to Lake Concord. This project also annually educates residents regarding fertilizer restrictions per the City's ordinance. See **Attachment C** for an example of the City's Quarterly Newsletter.

Quail Pond Circle Complete Street/Pedestrian Connectivity Project:
This upcoming project is anticipated to be completed in 2022. It includes the construction of a swale to improve the runoff water quality to Quail Pond, which eventually discharges to Lake Concord. The project also improves pedestrian/bicycle safety and connectivity, providing improved access to nearby parks, events, public facilities, transit, and businesses. This project is expected to slightly improve water quality in Lake Concord.

Lake Concord Park – Art House Expansion Project:
This project involves expanding the existing Lake Concord Park/Art House to the east to incorporate an additional art gallery and event space and is anticipated to be completed in the year 2022. Other than the aesthetic improvement, the water quality improvements are achieved with additional permeable parking lots and bioswale water management areas. This project is expected to provide marginal water quality benefits to Lake Concord.

Eelgrass Planting Pilot Project:
This upcoming project, planned to begin in 2023, intends to install eelgrass along the perimeter of Lake Concord using volunteers. This project is expected to be completed by 2024 and provide marginal ecological and water quality benefits to Lake Concord.

Illicit Discharge Ordinance:
This project will develop specific regulations regarding illicit discharges into lakes, streams, rivers, canals, ditches, stormwater ponds, and the entirety of the City's MS4 (municipal separate storm sewer system). Residents will be educated regarding the City's ordinance and are encouraged to report any illicit discharges mentioned above to reduce nutrient loads to Lake Concord. This project is expected to begin in 2021 and should have marginal water quality benefits for Lake Concord.

Critical Milestones/Monitoring

Anticipated Critical Milestone(s) and Completion Dates:	The Fertilizer Ordinance and Lake Management Guide have already been completed, see above for details. The Lake Management Guide is an ongoing project. The Illicit Discharge Ordinance is anticipated to begin in 2021. The in-lake alum treatments are already funded and slated to begin this year (2021). The remainder of the projects discussed above are currently in the planning phase and anticipated to begin within the next 1-3 years.
Monitoring Component	The City of Casselberry performs water quality monitoring within Lake Concord on a quarterly basis. Grab surface water samples are taken from the approximate geometric center of the lake. Additionally, several field parameters are collected in approximate 1 foot intervals as described in the Lake Monitoring Field Parameters table below. Samples are analyzed for both nutrients and metals, with nutrient analysis occurring on a quarterly basis and metals analysis occurring on an annual basis. A list of sampled parameters is provided in the tables below.

Lake Monitoring Laboratory Parameters

Laboratory Parameter	Method
Alkalinity	SM2320B
Color	SM2120B
Turbidity	180.1
Chlorophyll-a	SM10200H
Fecal Coliform	SM9230C
E. Coli	SM9222D
Ammonia	350.1
TKN	351.2
Nitrate + Nitrite (NOx)	352.3
Organic Nitrogen	TKN – AMMONIA
Total Nitrogen	TKN + NOx
Ortho-Phosphorus	365.1
Total Phosphorus	365.3
Cadmium	SM3111B
Chromium	
Copper	
Lead	
Zinc	
Secchi Depth	Secchi Disk
Air Temperature	Local Weather Stations
Wind Speed / Direction	
pH	YSI Multiparameter Meter
Specific Conductivity	
Dissolved Oxygen	
ORP	

Lake Monitoring Laboratory Metal Parameters

Laboratory Parameters	Method
Zinc	200.7
Lead	200.7
Copper	200.7
Chromium	200.7
Cadmium	200.7

Other Key Dates

Estimated Date for Delisting from Verified List or Removal from Study List

WBID 2994K (Lake Concord) is in the state's Group 2, Middle St. Johns basin. The current review and assessment cycle (the initial biennial assessment) is scheduled for completion in 2022. This waterbody is currently impaired for nutrients (chlorophyll-a and total phosphorus). The earliest opportunity for delisting these parameters would happen during the upcoming biennial assessment. However, if this WBID doesn't meet delisting requirements, it will remain in assessment category 4e for an additional biennial assessment cycle, which will postpone TMDL development.

Financial Commitments

Estimated Implementation Cost

Alum treatment:
The total estimated cost for alum treatment is $115,075.21.

No maintenance cost is expected.

Quail Pond Circle Complete Street/Pedestrian Connectivity Project:
The design cost is $59,233.

The total construction cost for Quail Pond project is estimated as $351,799.

The estimated 20 year operation and maintenance cost is $170,956 ($7,036 initial year with 2% inflation thereafter). .

Lake Concord Park – Art House Expansion Project:
The design/post-design cost is estimated as $323,511.

The total construction cost for Art House Expansion project is estimated as $2,172,591.

The estimated 20 years maintenance cost for this park is $1,468,630 (including $60,444 on initial year then 2% inflation thereafter).

Fertilizer Ordinance:
The total cost is $100, based on the historical cost of annual flyer printing exclusive of staff time.

Quarterly Newsletter and Educational Workshops:
The total cost is mainly staff time, and an annual $5,000 is provided for the share of Water Atlas and participation in the FY&N (Florida Yard and Neighborhood) program. Note that the educational workshops are held both by Seminole County within City's jurisdiction and also hosted by the City as part of the City's annual Earth Fest event.

Eelgrass Planting Pilot Project:
The total cost is estimated to be $1,500 for materials exclusive of staff time and volunteers.

	Illicit Discharge Ordinance: The total cost is estimated to be $500 for printing flyers exclusive of staff time. **Lake Management Guide**: The total cost for Lake Management Guide project was $1,621.25, which was the actual cost for printing and distribution. **Construction and Monitoring of Engineered Phytotechnology for Nitrate Removal in Groundwater:** The total cost for this project is $89,626.6.
Land Acquisition (if applicable)	**Funding Source:** N/A Total………………………………………………………………...$_______
Design and Construction (if applicable)	**Funding Source:** **In Lake Alum Treatments** Funded by the City of Casselberry Stormwater Utility Fund Total………………………………………………………………...$115,075 **Quail Pond Circle Complete Street/Pedestrian Connectivity Project** Funded by 3rd Generation Sales Tax and Federal Transpiration Funding Total………………………………………………………………...$581,988 **Lake Concord Park – Art House Expansion Project** Funded by Casselberry Parks Bond Total………………………………………………………………...$3,964,732 **Fertilizer Ordinance Project** Funded by the City of Casselberry Stormwater Utility Total (excluding staff time)………………………………………………..$100 **Quarterly Newsletter and Educational Workshops Project** Funded by the City of Casselberry Stormwater Utility Total (excluding staff time)…………………………………………………...$5,000 **Eelgrass Planting Pilot Project** Funded by the City of Casselberry Stormwater Utility Total (excluding staff time)……………………………………………...$1,500 **Illicit Discharge Ordinance Project** Funded by the City of Casselberry Stormwater Utility Total (excluding staff time)………………………………………………..$500 **Lake Management Guide Project** Funded by the City of Casselberry Stormwater Utility Total (excluding staff time)……………………………………...$1,621.25 **Construction and Monitoring of Engineered Phytotechnology for Nitrate Removal in Groundwater** Funded by Geosyntec, Inc. Research and Development Program

City of Casselberry Stormwater Utility
Total……………………………………………………………………...$89,676.6

References:

Harper (2020). Lake Concord Hydrologic / Nutrient Budget Evaluation – Final Report. Environmental Research & Design, Inc. (ERD) (attached)

Attachment A:

ERD Report: Lake Concord Hydrologic/Nutrient Budget Evaluation

LAKE CONCORD HYDROLOGIC / NUTRIENT BUDGET EVALUATION

Final Report – December 2020

Prepared For:

City of Casselberry

Prepared By:

Harvey H. Harper, III, Ph.D., P.E.
Environmental Research & Design, Inc.
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Belle Isle (Orlando), FL 32812-4864
407-855-9465

TABLE OF CONTENTS

TABLE OF CONTENTS -- CONTINUED

Section / Title **Page**

TABLE OF CONTENTS -- CONTINUED

Section / Title **Page**

TABLE OF CONTENTS -- CONTINUED

Appendices

LIST OF FIGURES

Figure Number / Title **Page**

LIST OF FIGURES -- CONTINUED

LIST OF FIGURES -- CONTINUED

LIST OF FIGURES -- CONTINUED

LIST OF TABLES

LIST OF TABLES -- CONTINUED

LIST OF TABLES -- CONTINUED

Table Number / Title **Page**

LIST OF TABLES -- CONTINUED

Table Number / Title **Page**

SECTION 1

INTRODUCTION

1.1 General Description

This report provides a summary of work efforts performed by Environmental Research & Design, Inc. (ERD) for Geosyntec Consultants (Geosyntec) and the City of Casselberry (City) to develop hydrologic and nutrient budgets for Lake Concord. Lake Concord is a 19.7-acre lake in west Seminole County in the City of Casselberry, located on the east side of US 17-92 approximately 3.8 miles southwest of Lake Jesup. Watershed areas for Lake Concord are located entirely within Seminole County. A general location map for Lake Concord is given on Figure 1-1, with a local vicinity map given on Figure 1-2.

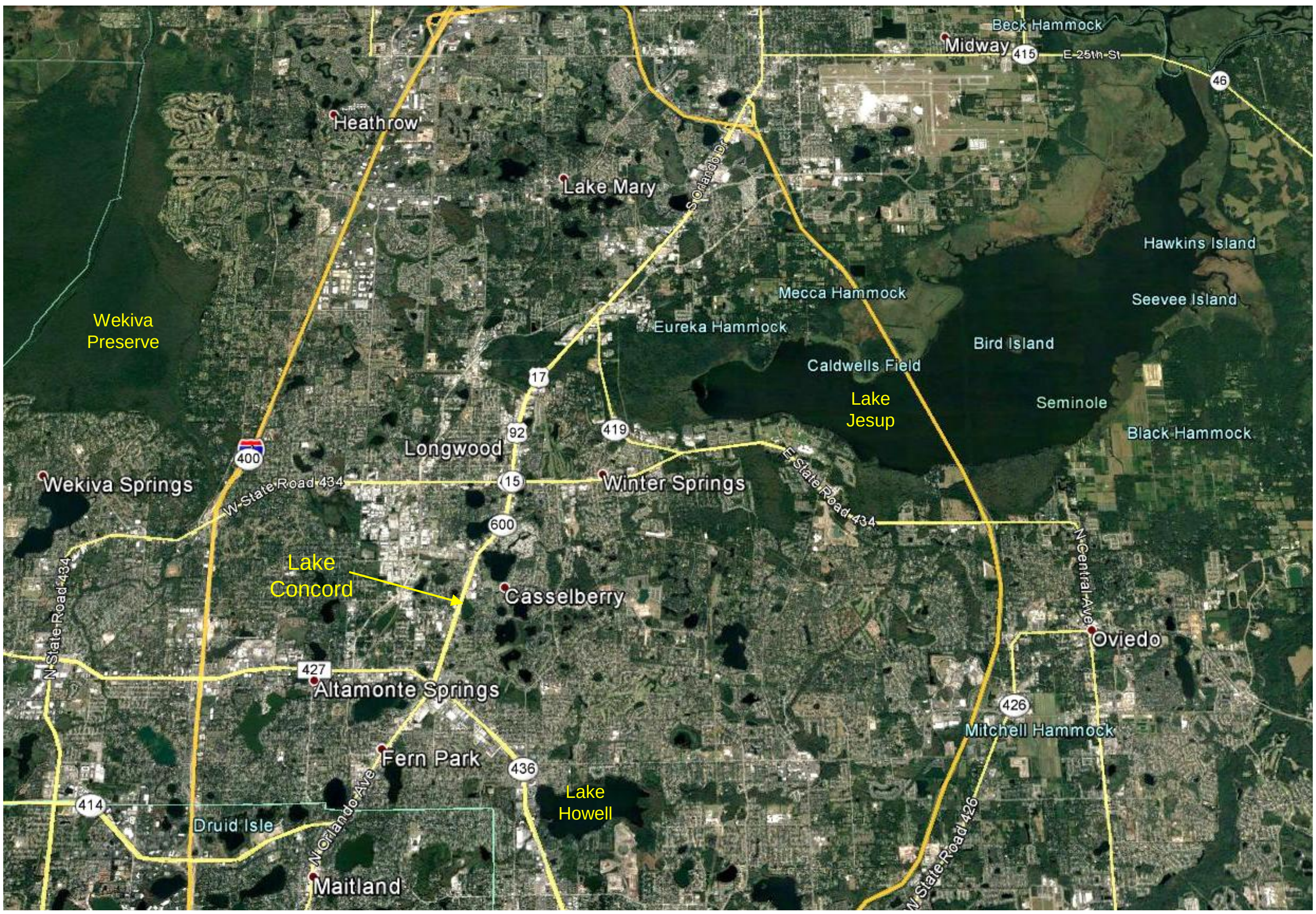


Figure 1-1. Location Map for Lake Concord.

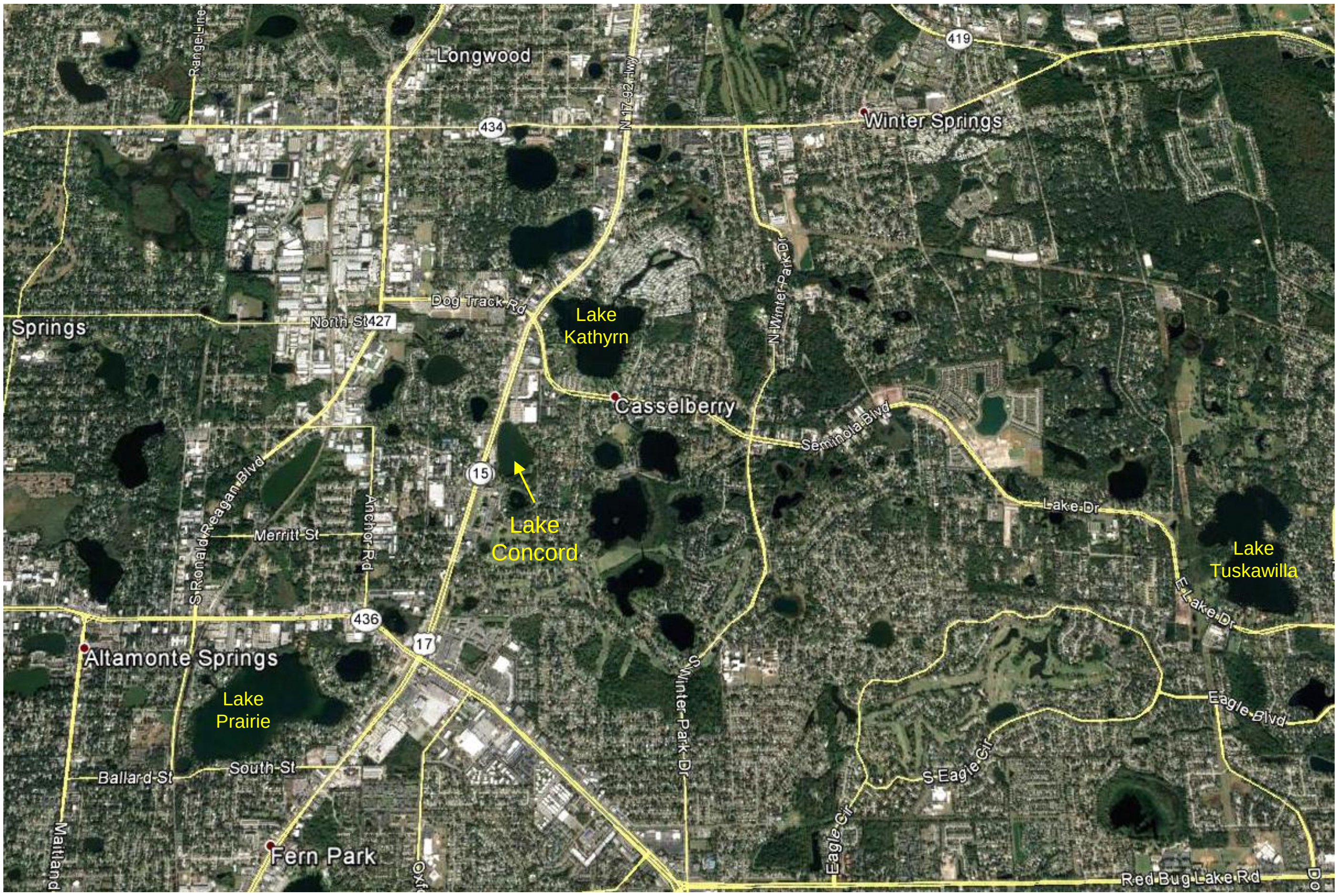


Figure 1-2. Local Vicinity Map for Lake Concord.

An overview of Lake Concord is given on Figure 1-3. Lake Concord has an approximate kidney bean shape. The lake is bounded on the west by US 17-92, on the north by Plumosa Ave., and on the east by Sunset Drive N. Discharges from Lake Concord travel through a narrow excavated channel, located on the east side of the lake, which passes beneath Sunset Drive N and Secret Way, ultimately discharging into the west side of Secret Lake which discharges to the N. Triplet-Kathryn Canal, Gee Creek, and ultimately to Lake Jesup. Lake Concord is located in the Gee Creek Watershed which discharges to Lake Jesup, Lake Monroe, and the Middle St. Johns River.

As indicated on Figure 1-3, watershed areas surrounding Lake Concord consist of a mixture of commercial, highway, wetland, and residential land use activities. Much of the existing development was constructed prior to implementation of regulations requiring stormwater treatment and many older watershed areas have no existing stormwater management systems. Historical water quality within Lake Concord has been variable, ranging from oligotrophic to hypereutrophic conditions. The long-term Trophic State Index (TSI) value (2004-2019) for Lake Concord is 56 which indicates mesotrophic conditions.

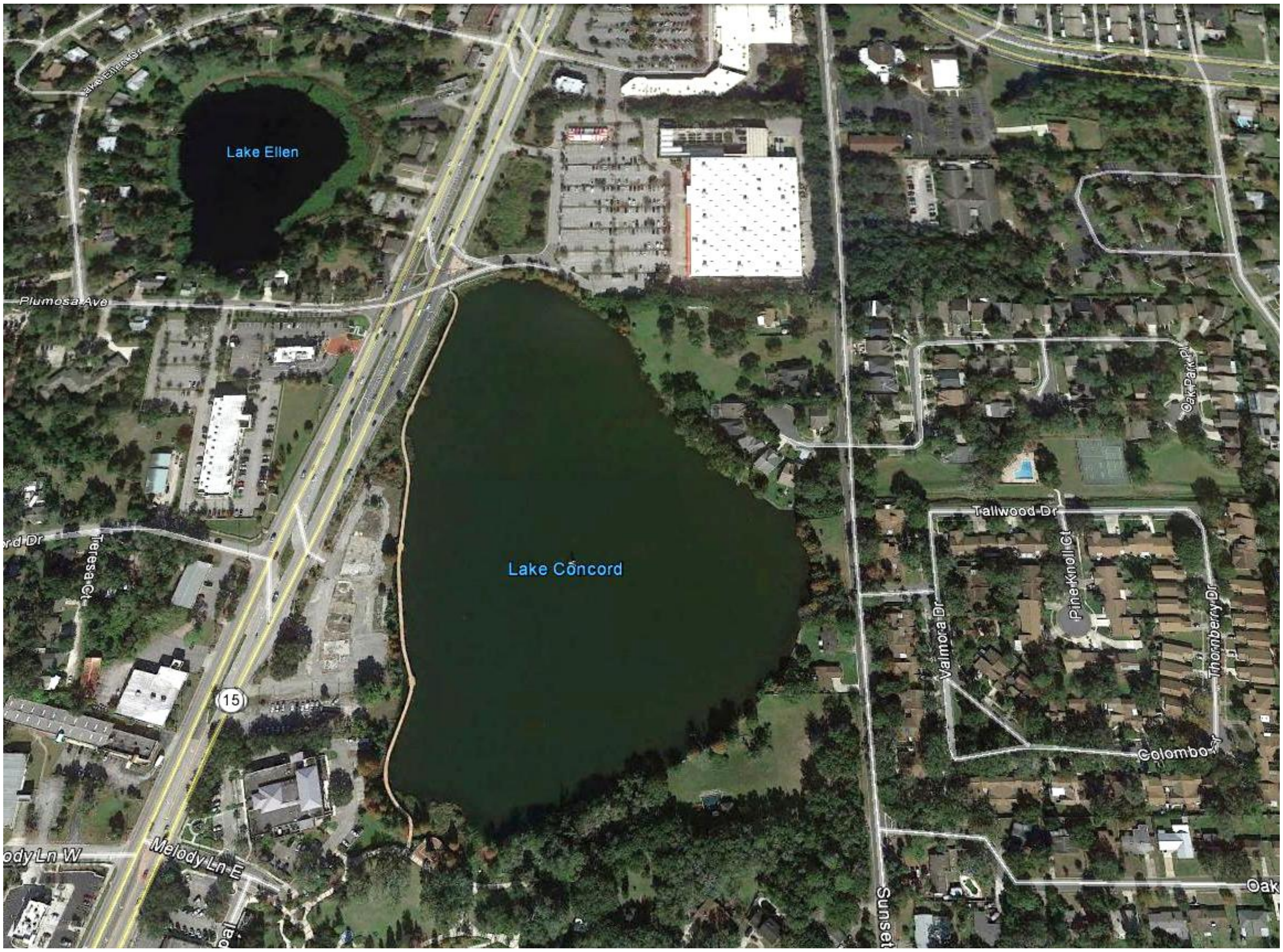


Figure 1-3. Overview of Lake Concord.

1.2 Impaired Waters Designation

Section 303(d) of the Clean Water Act (CWA) requires states to submit lists of surface waterbodies that do not meet applicable water quality standards. These waterbodies are defined as "impaired waters" and Total Maximum Daily Loads (TMDLs) must be established for these waters on a prioritized schedule. The Florida Department of Environmental Protection (FDEP) and the US EPA have established a series of guidelines to identify impaired waters which may require the establishment of TMDLs. Waterbodies within the State of Florida have been divided into five separate groups for planning purposes, with Lake Concord (WBID 2994K) located in the Lake Jesup Planning Unit of the Middle St. Johns River Basin in Group 2. Lake Concord is included on the current (August 18, 2020) Verified List as impaired for chlorophyll-a, based on annual geometric mean (AGM) chlorophyll-a concentrations exceeding 20 μg/l during 2017, 2018, and 2019, with nutrients listed as the causative agent.

1.3 Work Efforts Performed by ERD

Work efforts were initiated on this project by ERD during March 2019. The primary objectives of this project are to define current and historical water quality characteristics of Lake Concord and quantify and rank hydrologic and pollutant loadings. A field monitoring program was conducted by ERD from March-October 2019 to collect data for use in characterizing Lake Concord and developing hydrologic and nutrient budgets for the lake. The hydrologic budget includes estimated inputs from precipitation, stormwater runoff, direct overland flow, and groundwater seepage. The nutrient budget includes inputs from bulk precipitation, stormwater runoff, direct overland flow, groundwater seepage, and internal recycling. Direct measurements of the characteristics of runoff and seepage inputs were conducted as part of this project, as well as quantification of internal nutrient recycling. A detailed evaluation of sediment characteristics in Lake Concord was also conducted which included physical and chemical characterization of surficial sediments and evaluation of internal phosphorus recycling.

This report has been divided into 6 separate sections for presentation of the work efforts performed by ERD. Section 1 contains an introduction to the report and provides a general overview of the work efforts performed by ERD. Current characteristics of Lake Concord are discussed in Section 2, including lake bathymetry, sediment accumulation and characteristics, historical and current water quality, and lake hydrology. A discussion of the drainage basin area is given in Section 3, and the hydrologic budget is presented in Section 4. A nutrient budget, which includes inputs from total nitrogen, and total phosphorus, is given in Section 5. An evaluation of sediment inactivation options is given in Section 6, and cited references are listed in Section 7. Appendices are also attached which contain technical data and analyses used to support the information contained within the report.

SECTION 2

PHYSICAL AND CHEMICAL CHARACTERISTICS OF LAKE CONCORD

2.1 Physical Characteristics

A hydrographic survey of Lake Concord was conducted by the Seminole County Stormwater Division on August 7, 2000 using GPS/Sonar techniques to evaluate water depths within the lake. Contour lines were expressed in 2-ft intervals. The water level elevation in Lake Concord on August 7, 2000 was 57.03 ft (NAVD 88) which is approximately 0.15 ft lower than the mean water elevation of 57.18 (NAVD 88) in Lake Concord from 1993-2019.

A water depth contour map for Lake Concord, digitized by ERD from the original hydrographic survey map, is given in Figure 2-1. The aerial background reflects 2018 high-resolution aerial photography conducted by FDOT. Lake Concord has an approximate kidney bean shape, with the southern portion larger than the northern area. Western portions of the lake are characterized by relatively steep side slopes in most areas which extend to a central area with water depths ranging from 10-12 ft, although the bottom contours are somewhat irregular. Eastern, northern, and southern portions of the lake exhibit relatively mild slopes which also extend to water depths ranging from 10-12 ft. The bathymetric signatures indicated on Figure 2-1 suggest that Lake Concord originated as a result of a sinkhole feature.

The water level in Lake Concord is regulated by an outfall canal on the east side of the lake which discharges to Secret Lake, which outfalls to the N. Triplet-Kathryn Canal, Lake Kathryn, Gee Creek, and ultimately Lake Jesup. Water level control and fluctuations in Lake Concord are discussed in more detail in a subsequent section.

Depth-area-volume relationships for Lake Concord are summarized in Table 2-1 based on the bathymetric survey provided in Figure 2-1. At the water surface elevation of 57.03 ft present on August 7, 2000 the lake surface area is approximately 19.72 acres. The lake volume at this surface area is 168 ac-ft, corresponding to a mean water depth of approximately 8.5 ft. The calculated mean depth is on the lower end of values observed by ERD in Central Florida lakes which typically range from 8-14 ft. A summary of bathymetric characteristics of Lake Concord is given in Table 2-2.

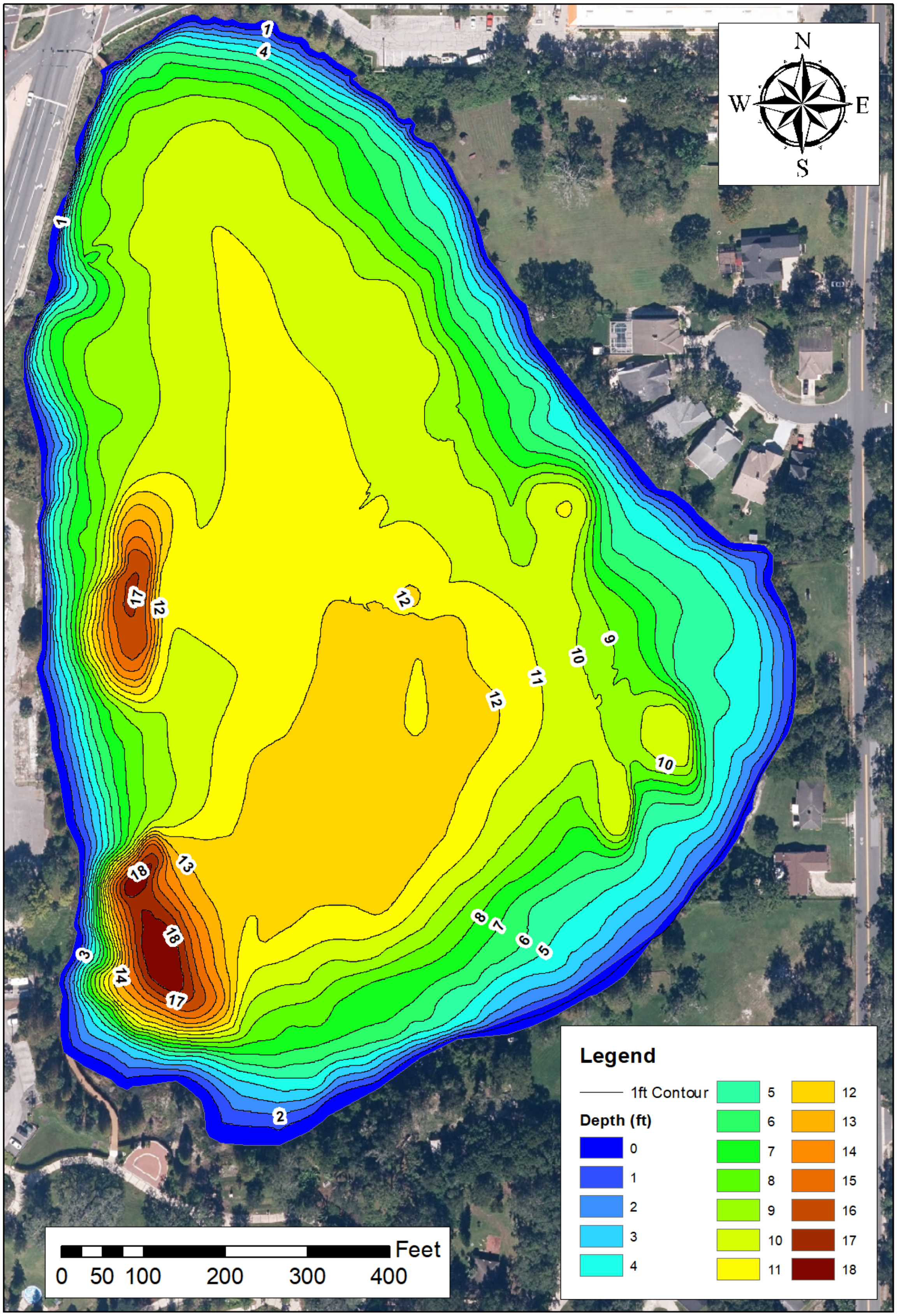


Figure 2-1. Water Depth Contours (ft below water surface) for Lake Concord on August 7, 2000. (Water Elevation = 57.03 ft, NAVD 88; Photo Source/Date: FDOT, 2019)

TABLE 2-1

DEPTH-AREA-VOLUME RELATIONSHIPS FOR LAKE CONCORD (Elev. 57.03 ft, NAVD 88)

WATER DEPTH (ft)	AREA (acres)	CUMULATIVE VOLUME (ac-ft)	WATER DEPTH (ft)	AREA (acres)	CUMULATIVE VOLUME (ac-ft)
0	19.7	168	10	8.22	13.0
1	19.1	148	11	4.69	6.6
2	18.5	130	12	1.97	3.3
3	17.9	111	13	0.77	1.9
4	17.0	94.0	14	0.59	1.2
5	16.0	77.5	15	0.44	0.69
6	14.9	62.1	16	0.29	0.32
7	13.8	47.7	17	0.15	0.10
8	12.6	34.5	18	0.05	0
9	11.1	22.7	Mean Depth = 8.5 ft		

TABLE 2-2

BATHYMETRIC CHARACTERISTICS OF LAKE CONCORD

BATHYMETRIC PARAMETER[1]	VALUE
Surface Area	19.7 acres
Total Volume	168 ac-ft
Mean Depth	8.5 ft
Maximum Depth	18 ft
Shoreline Length	3,855 ft

1. Based upon a water surface elevation of 57.03 ft (NAVD 88) on August 7, 2000

2.2 Sediment Characteristics

Sediment core samples were collected in Lake Concord by ERD to evaluate the characteristics of existing sediments and potential impacts on water quality within the lake. Sediment core samples were collected at 15 locations within the lake on March 11, 2019 by ERD personnel. Locations of sediment sampling sites in Lake Concord are illustrated on Figure 2-2. Based on the lake surface area of 19.7 acres, sediment samples were collected at a rate of one sample for every 1.3 acres of lake area.

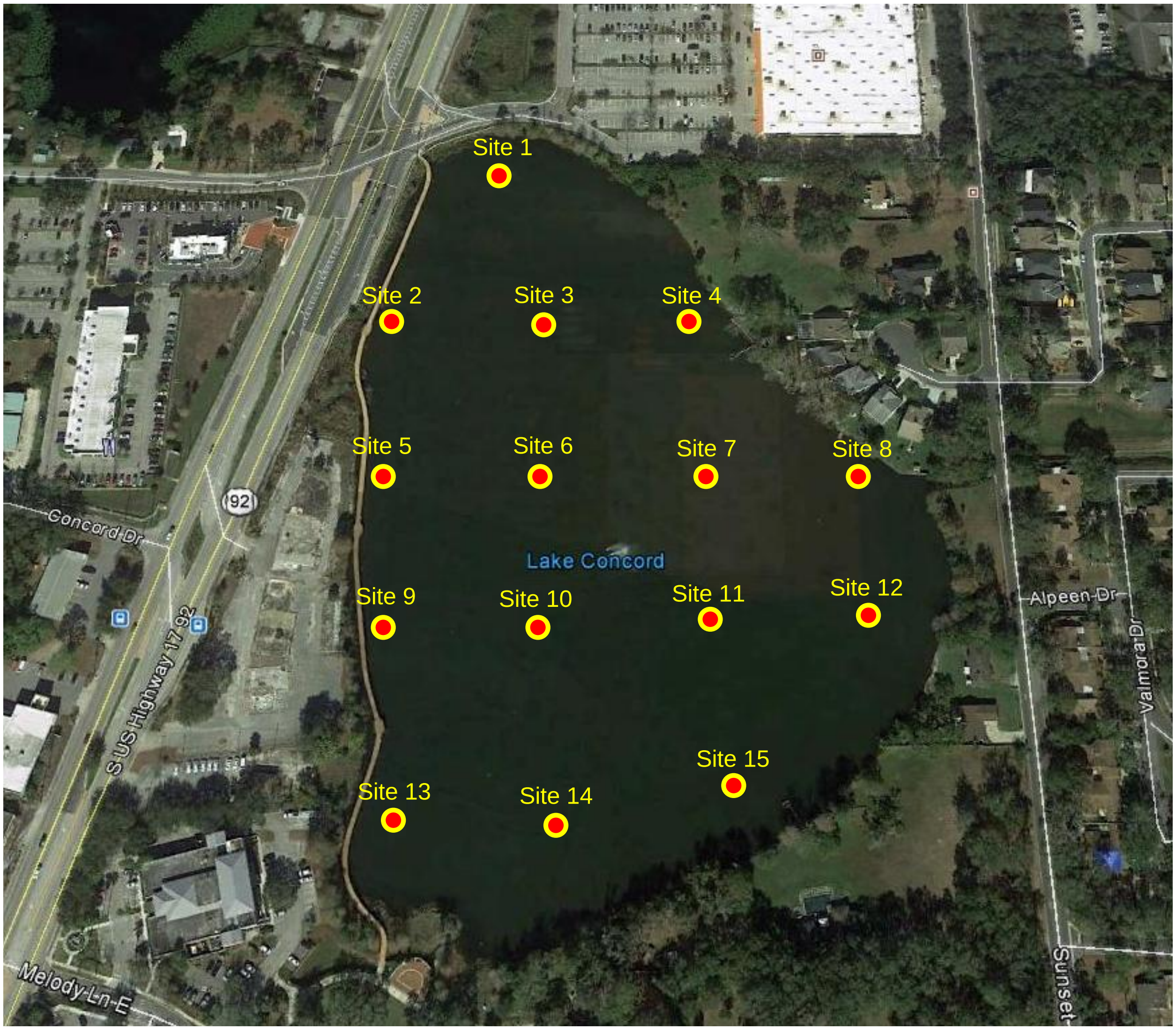


Figure 2-2. Sediment Core Sample Collection Sites in Lake Concord on March 11, 2019. (Photo Source/Date: FDOT, 2019)

2.2.1 Sampling Techniques

Sediment samples were collected at each of the 15 monitoring sites using a stainless steel split-spoon core device, which was penetrated into the sediments at each location to a minimum distance of approximately 0.5 m. After retrieval of the sediment sample, any overlying water was carefully decanted before the split-spoon device was opened to expose the collected sample. Visual characteristics of each sediment core sample were recorded, and the 0-10 cm layer was carefully sectioned off and placed into a 120-ml wide-mouth polyethylene container for transport to the ERD laboratory. Duplicate core samples were collected at each site, and the 0-10 cm layers were combined together to form a single composite sample for each of the 15 monitoring sites. The polyethylene containers utilized for storage of the collected samples were filled completely to minimize air space in the storage container above the composite sediment sample. Each of the collected samples was stored in ice and returned to the ERD laboratory for physical and chemical characterization.

2.2.2 Sediment Characterization and Speciation Techniques

Each of the 15 collected sediment core samples was analyzed for a variety of general parameters, including moisture content, organic content, sediment density, total nitrogen, and total phosphorus. Methodologies utilized for preparation and analysis of the sediment samples for these parameters are outlined in Table 2-3.

TABLE 2-3

ANALYTICAL METHODS FOR SEDIMENT ANALYSES

MEASUREMENT PARAMETER	SAMPLE PREPARATION	ANALYSIS REFERENCE	REFERENCE PREP./ANAL.*	METHOD DETECTION LIMITS (MDLs)
pH	EPA 9045	EPA 9045	3 / 3	0.01 pH units
Moisture Content	p. 3-54	p. 3-58	1 / 1	0.1%
Organic Content (Volatile Solids)	p. 3-52	pp. 3-52 to 3-53	1 / 1	0.1%
Total Phosphorus	pp. 3-227 to 3-228 (Method C)	EPA 365.4	1 / 2	0.005 mg/kg
Total Nitrogen	p. 3-201	pp. 3-201 to 3-204	1 / 1	0.010 mg/kg
Specific Gravity (Density)	p. 3-61	pp. 3-61 to 3-62	1 / 1	NA

*REFERENCES:

1. Procedures for Handling and Chemical Analysis of Sediments and Water Samples, EPA/Corps of Engineers, EPA/CE-81-1, 1981.

2. Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, Revised March 1983.

3. Test Methods for Evaluating Solid Wastes, Physical-Chemical Methods, Third Edition, EPA-SW-846, Updated November 1990.

In addition to general sediment characterization, a fractionation procedure for inorganic soil phosphorus was conducted on each of the 15 collected sediment samples. A modified version of the Chang and Jackson Procedure, as proposed by Peterson and Corey (1966), was used for phosphorus fractionation. The modified Chang and Jackson Procedure allows the speciation of sediment phosphorus into saloid-bound phosphorus (defined as the sum of soluble plus easily exchangeable sediment phosphorus), iron-bound phosphorus, and aluminum-bound phosphorus. Although not used in this project, subsequent extractions of the Chang and Jackson procedure also provide calcium-bound and residual fractions.

The Chang and Jackson procedure was originally developed at the University of Wisconsin to evaluate phosphorus bonding in dried agricultural soils. However, drying of wet sediments will significantly impact phosphorus speciation, particularly the soluble and iron-bound associations. Therefore, the basic Chang and Jackson method was adapted and modified by ERD in 1992 for wet sediments by adjusting solution concentrations and extraction timing to account for the liquid volume in the wet sediments and the reduced solids mass. This modified method has been used as the basis for all sediment inactivation projects which have been conducted in the State of Florida.

Saloid-bound phosphorus is considered to be available under all conditions at all times. Iron-bound phosphorus is relatively stable under aerobic environments, generally characterized by redox potentials greater than 200 mv (E_h), while unstable under anoxic conditions, characterized by redox potential less than 200 mv. Aluminum-bound phosphorus is considered to be stable under all conditions of redox potential and natural pH conditions. A schematic of the Chang and Jackson Speciation Procedure for evaluating soil phosphorus bounding is given in Figure 2-3.

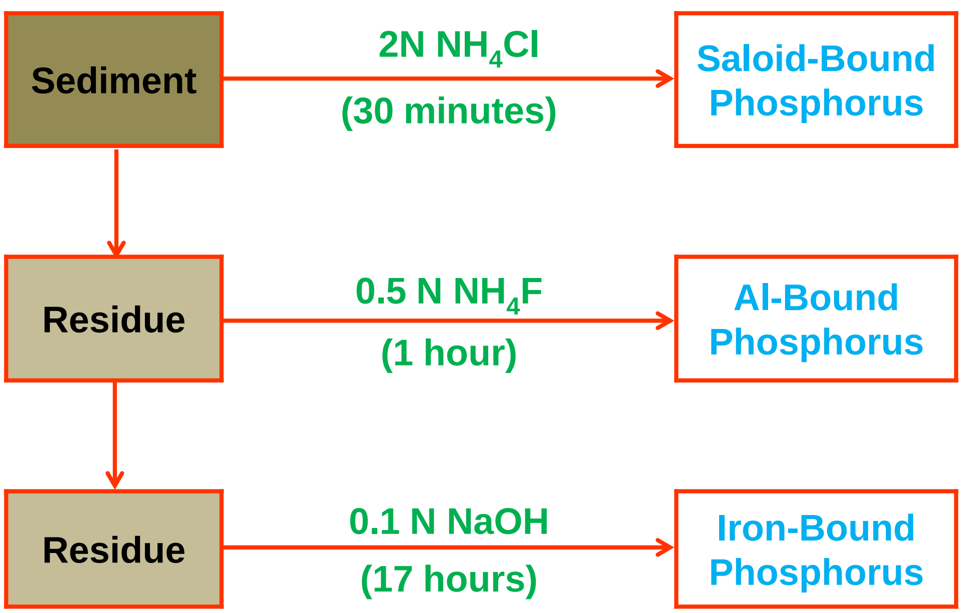


Figure 2-3. Schematic of Chang and Jackson Speciation Procedure for Evaluating Soil Phosphorus Bonding.

For purposes of evaluating release potential, ERD typically assumes that potentially available inorganic phosphorus in soils/sediments, particularly those which exhibit a significant potential to develop reduced conditions below the sediment-water interface, is represented by the sum of the soluble inorganic phosphorus and easily exchangeable phosphorus fractions (collectively termed saloid-bound phosphorus), plus iron-bound phosphorus which can become solubilized under reduced conditions. Aluminum-bound phosphorus is generally considered to be unavailable in the typical sediment pH range of approximately 5.5-7.5 under a wide range of redox conditions.

2.2.3 Sediment Characteristics

2.2.3.1 Visual Characteristics

Visual characteristics of sediment core samples were recorded for each of the 15 sediment samples collected in Lake Concord during March 2019. Photographs of sediment core samples collected at each of the 15 sites in Lake Concord are given in Appendix A. A summary of visual characteristics of sediment core samples is given in Table 2-4. In general, a thin surficial layer of unconsolidated organic muck was observed in Lake Concord at 7 of the 15 monitoring sites, with measured depths ranging from 2-15 cm. This unconsolidated surficial layer is comprised primarily of fresh organic material (such as dead algal cells) and detritus which has recently accumulated onto the bottom of the lake and is easily disturbed by wind action or boating activities.

At many sites with thick muck deposits, the organic muck becomes more consolidated beneath the surficial layer, with a consistency similar to pudding. These layers reflect older organic deposits which are resistant to further degradation and typically do not resuspend into the water column except during vigorous wind activity on the lake or disturbance by boat propellers. Measured depths of the consolidated organic muck layer ranged from 2 cm to >41 cm. Shallow and shoreline areas of the lake are characterized by a mixture of brown fine sand and muck.

2.2.3.2 General Sediment Characteristics

After return to the ERD Laboratory, the collected sediment core samples were evaluated for general sediment characteristics, including pH, moisture content, organic content, sediment density, total nitrogen, and total phosphorus. A summary of general characteristics measured in each of the 15 collected sediment core samples is given in Table 2-5. In general, sediments in Lake Concord were found to be slightly acidic to neutral in pH, with measured pH values ranging from 6.03-7.00 and an overall geometric mean of 6.57. These values are similar to sediment pH measurements commonly observed by ERD in urban lakes which generally range from 5.5-7.5.

TABLE 2-4

VISUAL CHARACTERISTICS OF SEDIMENT CORE SAMPLES COLLECTED IN LAKE CONCORD ON MARCH 11, 2019

SITE NO.	LAYER (cm)	VISUAL APPEARANCE
1	0 - 6 6 - 8 8 - >26	Black unconsolidated organic muck Black consolidated organic muck Fine brown sand with organics
2	0 – 2 2 – 4 4 – 12 12 - >38	Black unconsolidated organic muck Black consolidated organic muck Fine brown sand with organics Black consolidated organic muck
3	0 – 3 3 - > 55	Black unconsolidated organic muck Black consolidated organic muck
4	0 – 3 3 – 4 4 - >14	Fine brown sand with organics and benthic algae Fine dark brown sand with organics Fine brown sand with organics
5	0 – 9 9 - >46	Black unconsolidated organic muck Black consolidated organic muck
6	0 – 3 3 - >33	Black unconsolidated organic muck Black consolidated organic muck
7	0 – 15	Fine brown sand with organics
8	0 – 3 3 – 4 4 - >14	Fine brown sand with organics and benthic algae Fine brown sand with organics Fine dark brown sand with organics
9	0 – 2 2 – 5 5 - >22	Fine brown sand with organics Fine light brown sand Fine brown sand with organics
10	0 – 15 15 – 35 35 - >55	Black unconsolidated organic muck Black consolidated organic muck Fine brown sand with organics
11	0 – 11 11 - >28	Black unconsolidated organic muck Fine brown sand with organics
12	0 – 2 2 – 4 4 – 10 10 - >14	Fine light brown sand and benthic algae Fine brown sand with organics Fine light brown sand and benthic algae Fine brown sand with organics
13	0 – 3 3 – 6 6 – 11 11 – 14 14 - >25	Fine brown sand with organics Fine light brown sand Fine brown sand with organics Fine black sand with organics Fine brown sand with organics
14	0 - >21	Fine brown sand with organics
15	0 – 10 10 – 15 15 – 39 39 - >50	Fine brown sand with organics Black unconsolidated organic muck Black consolidated organic muck Fine brown sand with organics

TABLE 2-5

GENERAL CHARACTERISTICS OF SEDIMENT CORE SAMPLES COLLECTED IN LAKE CONCORD ON MARCH 11, 2019

SITE	pH (s.u.)	MOISTURE CONTENT (%)	ORGANIC CONTENT (%)	WET DENSITY (g/cm^3)	TOTAL NITROGEN ($\mu g/cm^3$)	TOTAL PHOSPHORUS ($\mu g/cm^3$)
1	6.63	90.1	45.9	1.08	1,477	162
2	6.45	51.5	8.4	1.67	2,378	702
3	6.59	86.5	28.7	1.14	1,416	412
4	7.00	25.6	0.5	2.11	722	84
5	6.37	81.8	20.7	1.22	1,879	408
6	6.43	87.7	32.6	1.12	1,862	384
7	6.03	25.5	1.1	2.11	634	154
8	6.74	25.3	0.5	2.12	451	152
9	6.35	25.3	0.9	2.11	1,074	207
10	6.29	60.2	5.5	1.56	1,848	539
11	6.37	83.6	21.5	1.19	1,883	398
12	6.79	23.7	0.3	2.14	529	133
13	6.71	44.8	3.1	1.80	1,371	280
14	6.97	24.0	0.6	2.13	791	545
15	6.85	28.4	0.9	2.06	1,647	181
Minimum Value:	**6.03**	**23.7**	**0.3**	**1.08**	**451**	**56**
Maximum Value:	**7.00**	**90.1**	**45.9**	**2.14**	**2,378**	**702**
Geometric Mean:	**6.57**	**43.9**	**3.4**	**1.65**	**1,185**	**228**

Isopleths of pH in the top 10 cm of sediments in Lake Concord are illustrated on Figure 2-4, based upon the information provided in Table 2-5. The majority of areas within Lake Concord are characterized by pH values ranging from approximately 6.3-6.9. In general, pH values of 6.1-6.3 were observed in east central portions of the lake, with higher pH values in perimeter areas, particularly along the eastern shoreline.

Measurements of sediment moisture content and organic content in Lake Concord were found to be highly variable throughout the lake. Some of the collected sediment samples are characterized by a relatively low moisture content and low organic content, suggesting that these surficial sediments are comprised primarily of fine sand. In contrast, other sediment core samples are characterized by elevated values for both moisture content and organic content, suggesting areas of accumulated organic muck. Measured sediment moisture contents ranged from 23.7-90.1% with an overall geometric mean of 43.9%. The measured sediment moisture contents in Lake Concord are similar to values commonly observed by ERD in urban lakes and reflect a combination of sandy and highly organic sediment.

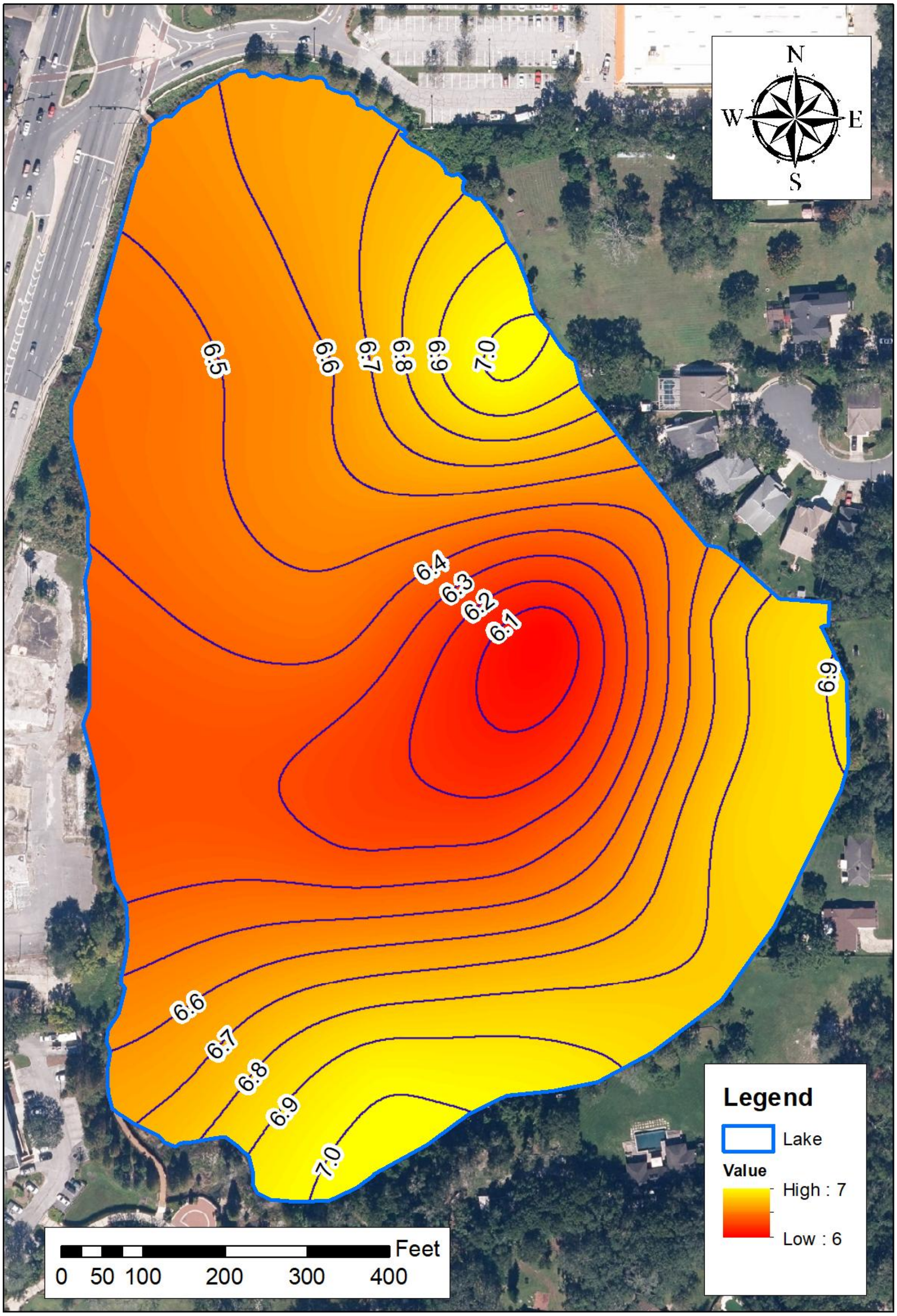


Figure 2-4. Isopleths of pH in the Top 10 cm of Sediments in Lake Concord During March 2019.
(Photo Source/Date: FDOT, 2019)

Isopleths of sediment moisture content in Lake Concord are summarized in Figure 2-5 based upon the information provided in Table 2-5. Areas of elevated moisture content are present in central and northern portions of the lake, with lower moisture content in eastern and southern shoreline areas. Sediment moisture contents in excess of 50% are often indicative of highly organic sediments, while moisture contents less than 50% reflect mixtures of sand and muck. Areas in Lake Concord with sediment moisture contents in excess of 50% include most of the central and northern portions of the lake.

Isopleths of sediment organic content in Lake Concord are illustrated on Figure 2-6 based upon the information provided in Table 2-5. In general, sediment organic content values in excess of 20-30% are often indicative of organic muck type sediments, with values less than 20-30% representing either sand or mixtures of muck and sand. Based upon these criteria, areas of concentrated organic muck are apparent in central and northern portions of Lake Concord, with organic contents less than 20% in eastern, southern, and western perimeter areas. Organic sediments can sometimes be resuspended by waves or boating and often accumulate in deeper areas of a lake. Measured sediment organic content within Lake Concord ranged from 0.3-45.9%, with an overall mean of 3.4%. This value is similar to sediment organic content commonly observed by ERD in urban areas.

Measured sediment density values are also useful in evaluating the general physical characteristics of sediments within a lake. Sediments with calculated wet densities between 1.0 g/cm^3 and 1.25 g/cm^3 are indicative of highly organic muck type sediments, while sediment densities of approximately 2.0 or greater are indicative of sandy sediment conditions. Values between 1.25 g/cm^3 and 2.0 g/cm^3 indicate mixtures of sand and muck. Measured sediment density values in Lake Concord range from 1.08-2.14 g/cm^3, with an overall mean of 1.65 g/cm^3.

Isopleths of wet density in Lake Concord sediments are given in Figure 2-7. Areas of low density sediments are apparent in central and northern portions of Lake Concord, indicating organic muck in these areas. Sediments characterized by densities indicative of sandy sediments are located primarily around the east, south, and west shoreline areas.

Measured concentrations of total phosphorus in Lake Concord sediments were found to be moderate to elevated in value with a moderate degree of variability throughout the lake, ranging from 56-702 $\mu g/cm^3$, with an overall mean of 228 $\mu g/cm^3$. In general, sandy sediments are often characterized by low total phosphorus concentrations, while highly organic muck type sediments are characterized by elevated total phosphorus concentrations. The mean sediment phosphorus concentration of 228 $\mu g/cm^3$ in Lake Concord is similar to sediment phosphorus concentrations observed by ERD in eutrophic urban lakes.

Isopleths of sediment phosphorus concentrations in Lake Concord are presented on Figure 2-8, based on information contained in Table 2-5. The most elevated sediment total phosphorus concentrations are present in the central and northwest portions of the lake and appear to be located in the general vicinity of the primary stormsewer outfall along US 17-92 and the canal inflow from Quail Pond.

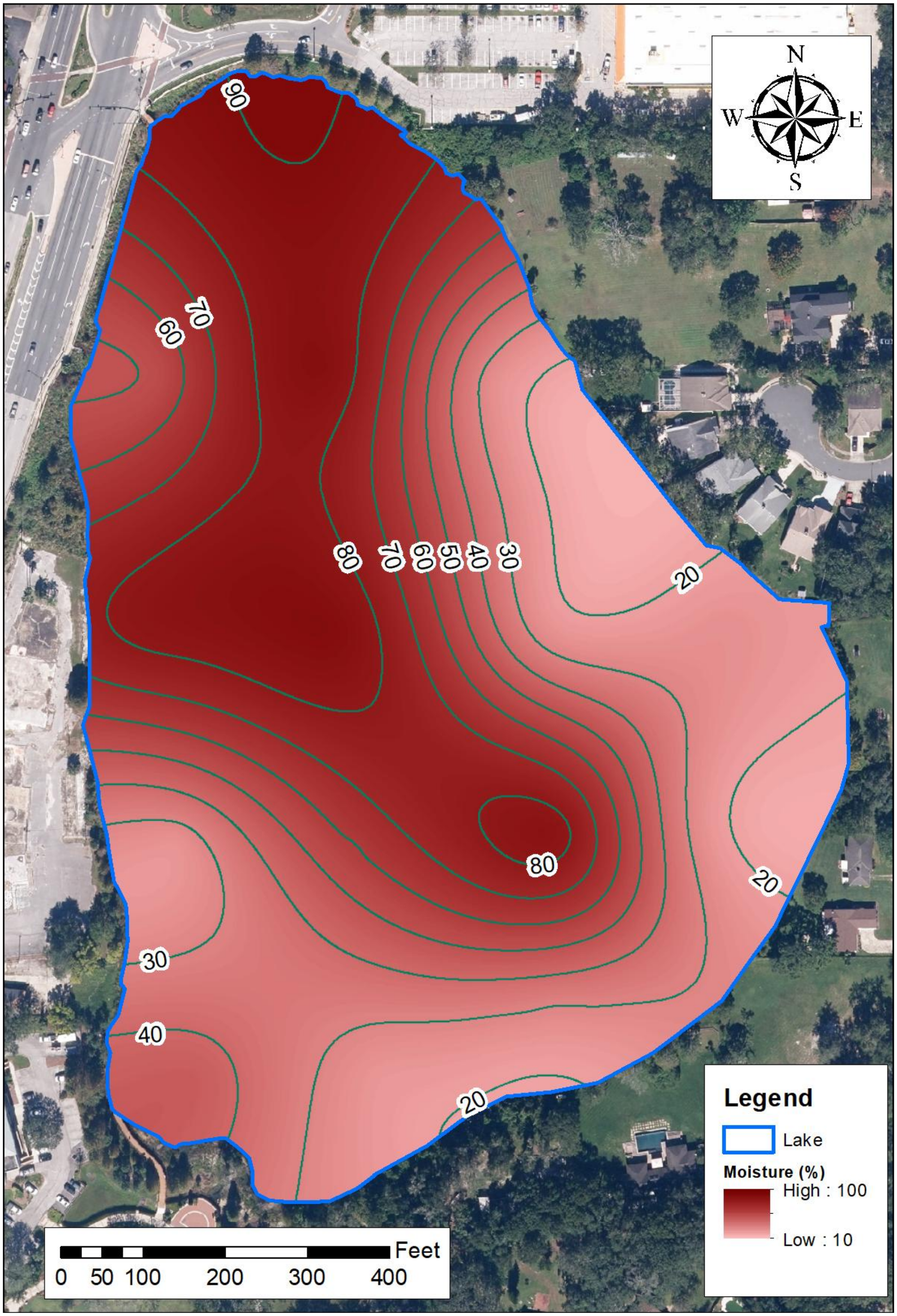


Figure 2-5. Isopleths of Moisture Content (%) in the Top 10 cm of Sediments in Lake Concord During March 2019. (Photo Source/Date: FDOT, 2019)

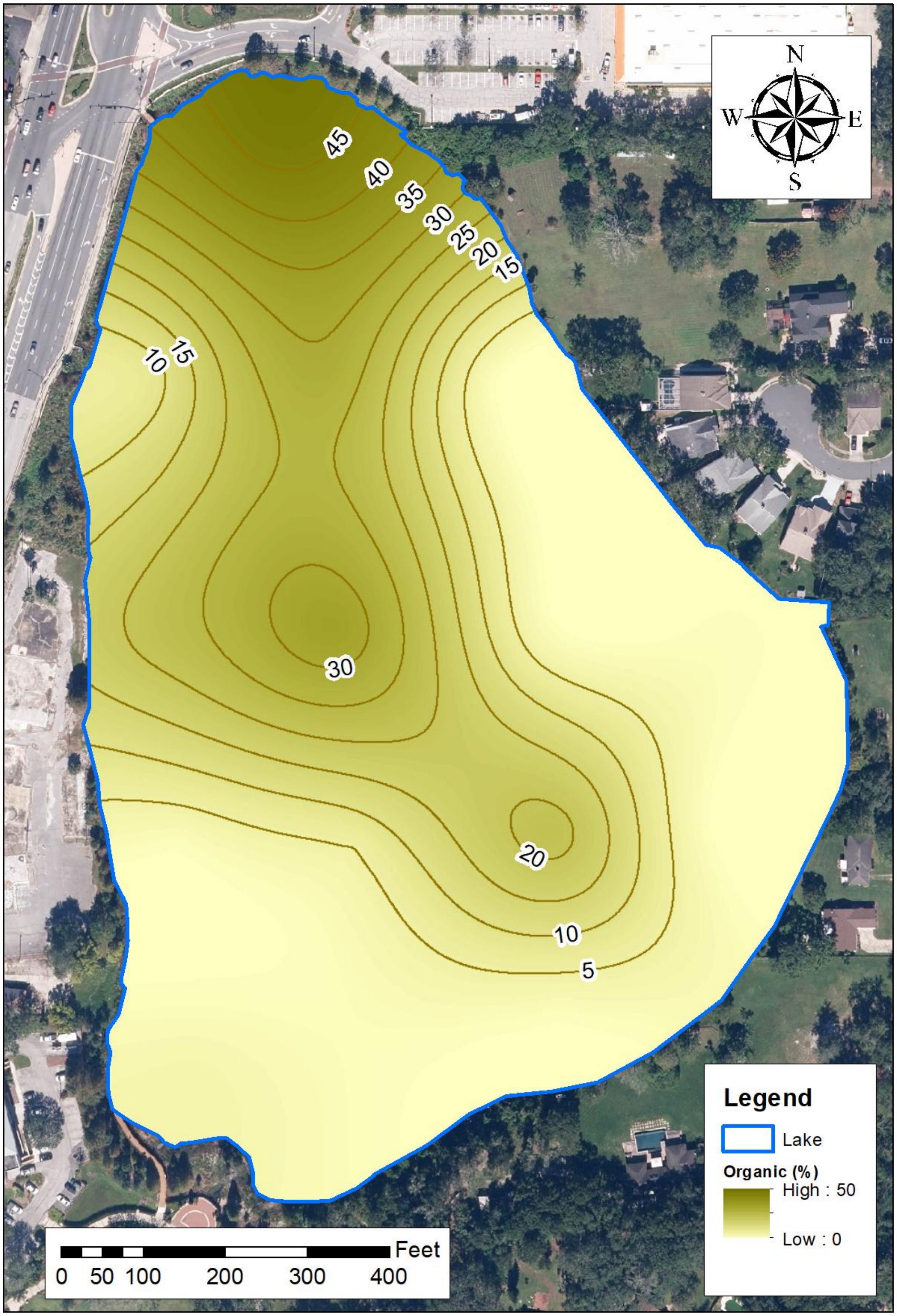


Figure 2-6. Isopleths of Organic Content (%) in the Top 10 cm of Sediments in Lake Concord During March 2019. (Photo Source/Date: FDOT, 2019)

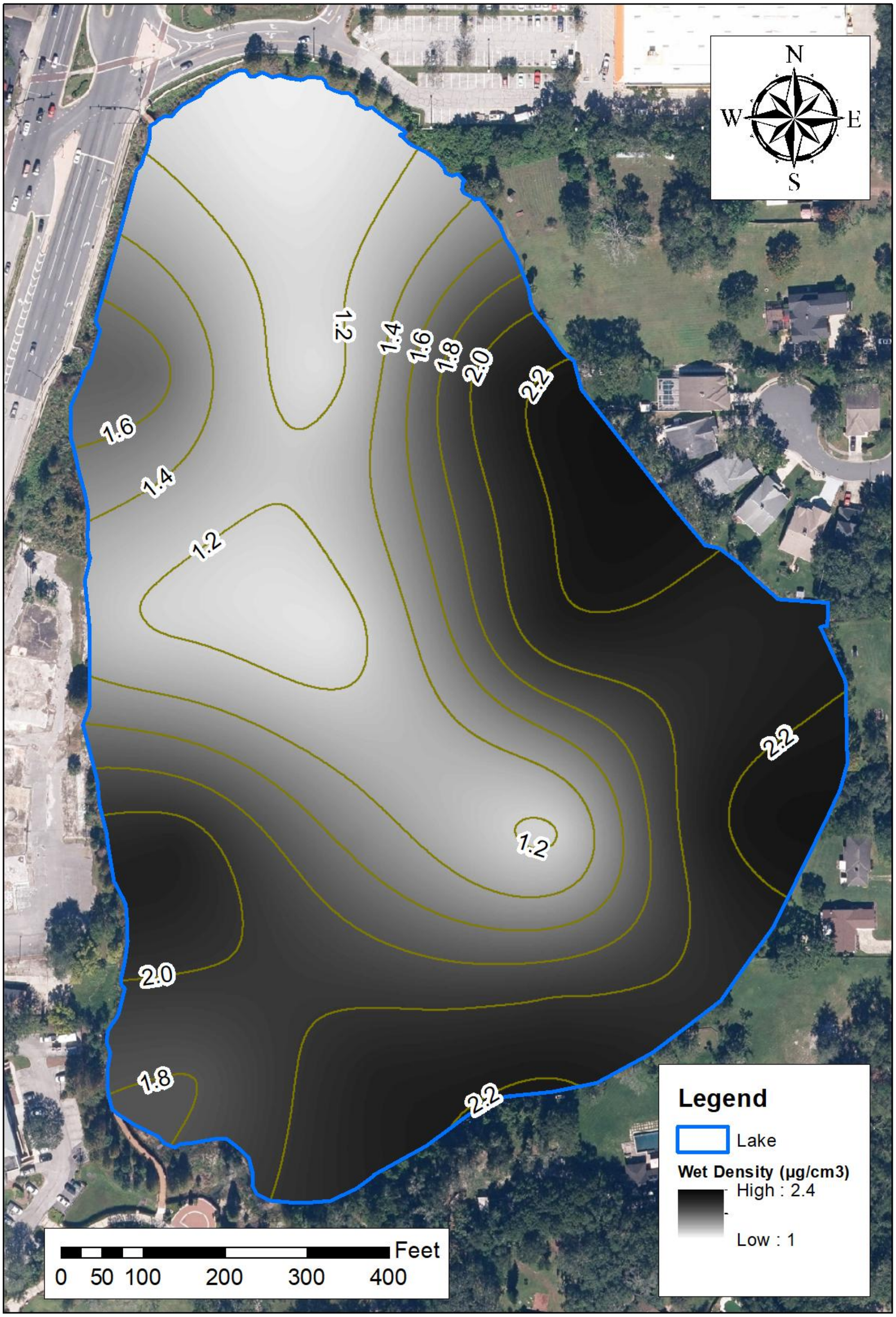


Figure 2-7. Isopleths of Wet Density (g/cm^3) in the Top 10 cm of Sediments in Lake Concord During March 2019. (Photo Source/Date: FDOT, 2019)

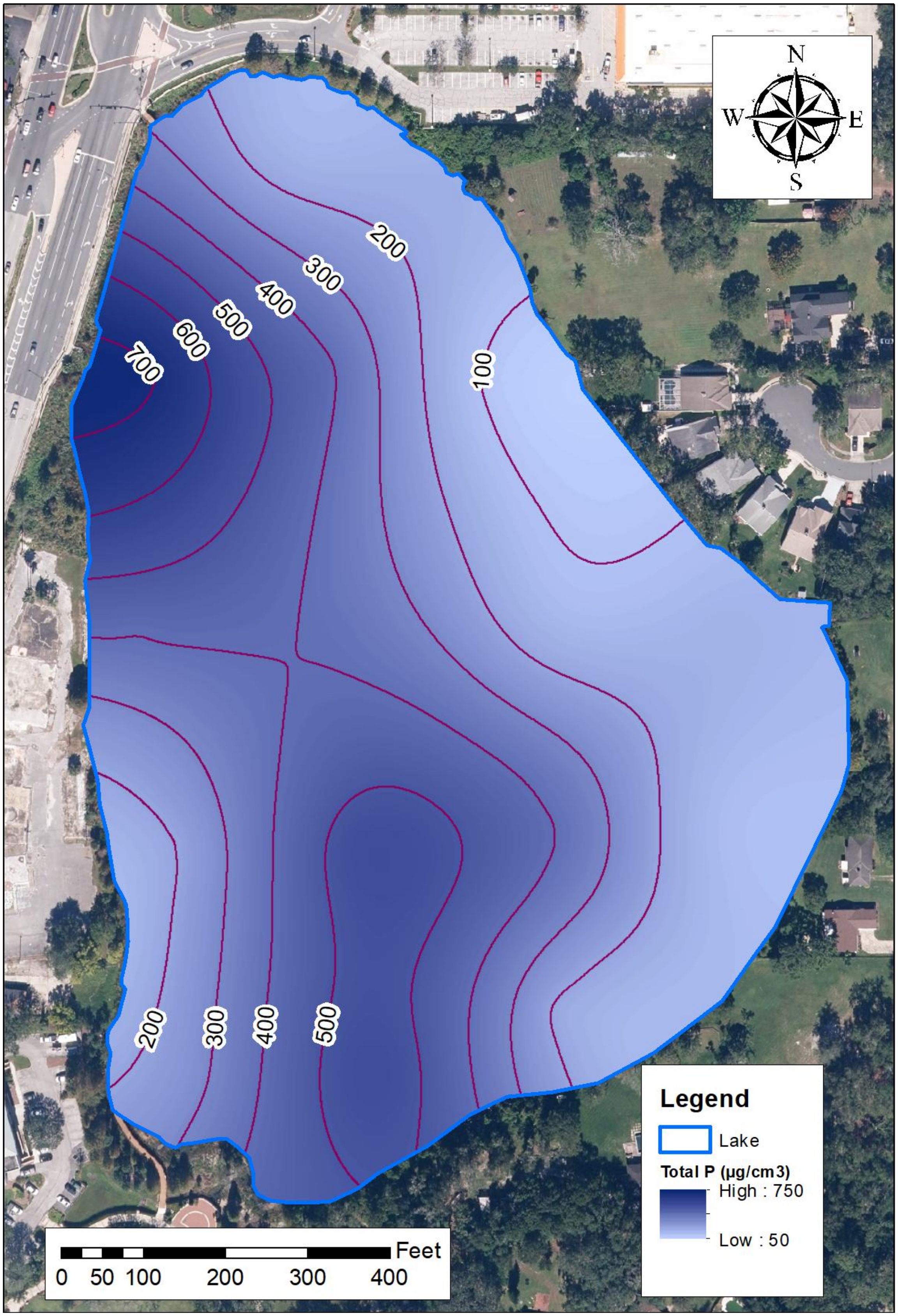


Figure 2-8. Isopleths of Total Phosphorus (µg/cm^3) in the Top 10 cm of Sediments in Lake Concord During March 2019. (Photo Source/Date: FDOT, 2019)

Similar to the trends observed for sediment phosphorus concentrations, sediment total nitrogen concentrations are moderate in value, with a high degree of variability throughout Lake Concord. Measured sediment nitrogen concentrations in the lake range from 451-2,378 $\mu g/cm^3$, with an overall mean of 1,185 $\mu g/cm^3$. Measured sediment nitrogen concentrations in Lake Concord appear to be similar to values normally observed by ERD in urban lakes. Isopleths of sediment nitrogen concentrations in Lake Concord are illustrated on Figure 2-9. In general, areas of elevated nitrogen concentrations are present in the same general areas as elevated concentrations of total phosphorus, moisture content, and organic content.

2.2.3.3 <u>Phosphorus Speciation</u>

As discussed in Section 2.2.2, each of the collected sediment core samples was evaluated for phosphorus speciation based upon the Chang and Jackson speciation procedure. This procedure allows phosphorus within the sediments to be speciated with respect to bonding mechanisms within the sediments. This information is useful in evaluating the stability of phosphorus in the sediments and the potential for release of phosphorus from the sediments under anoxic or other conditions.

A summary of phosphorus speciation in sediment core samples collected from Lake Concord during March 2019 is given in Table 2-6. Saloid-bound phosphorus represents sediment phosphorus which is either soluble or easily exchangeable and is typically considered to be readily available for release from the sediments into the overlying water column. As seen in Table 2-6, saloid-bound phosphorus concentrations appear to be low to elevated in value in Lake Concord. Measured values for saloid-bound phosphorus range from 0.2-28.0 $\mu g/cm^3$, with an overall geometric mean of 4.2 $\mu g/cm^3$. This value is greater than the mean saloid phosphorus concentration measured by ERD in other urban lakes.

Isopleths of saloid-bound phosphorus in the top 10 cm of sediments in Lake Concord are illustrated on Figure 2-10. The most elevated concentrations of saloid-bound phosphorus are located in central portions of the north and south portions of the lake.

In general, iron-bound phosphorus associations in the sediments of Lake Concord appear to be low to elevated in value. Iron-bound phosphorus is relatively stable under oxidized conditions, but becomes unstable under a reduced environment, causing the iron-phosphorus bonds to separate, releasing the bound phosphorus directly into the water column. Iron-bound phosphorus concentrations in the sediments of Lake Concord range from 14-179 $\mu g/cm^3$, with an overall mean of 45 $\mu g/cm^3$. As discussed in Section 2.3.2.1, areas in Lake Concord deeper than 3-3.5 m exhibit anoxic conditions throughout most of the year. Since iron-bound phosphorus can be released under anoxic conditions, portions of Lake Concord sediments may have conditions favorable for release of iron-bound sediment phosphorus into the water column throughout much of the year.

Isopleths of iron-bound phosphorus in the top 10 cm of sediments in Lake Concord are illustrated on Figure 2-11. Areas of elevated iron-bound phosphorus are located in central portions of the lake, primarily in areas with high moisture and organic content.

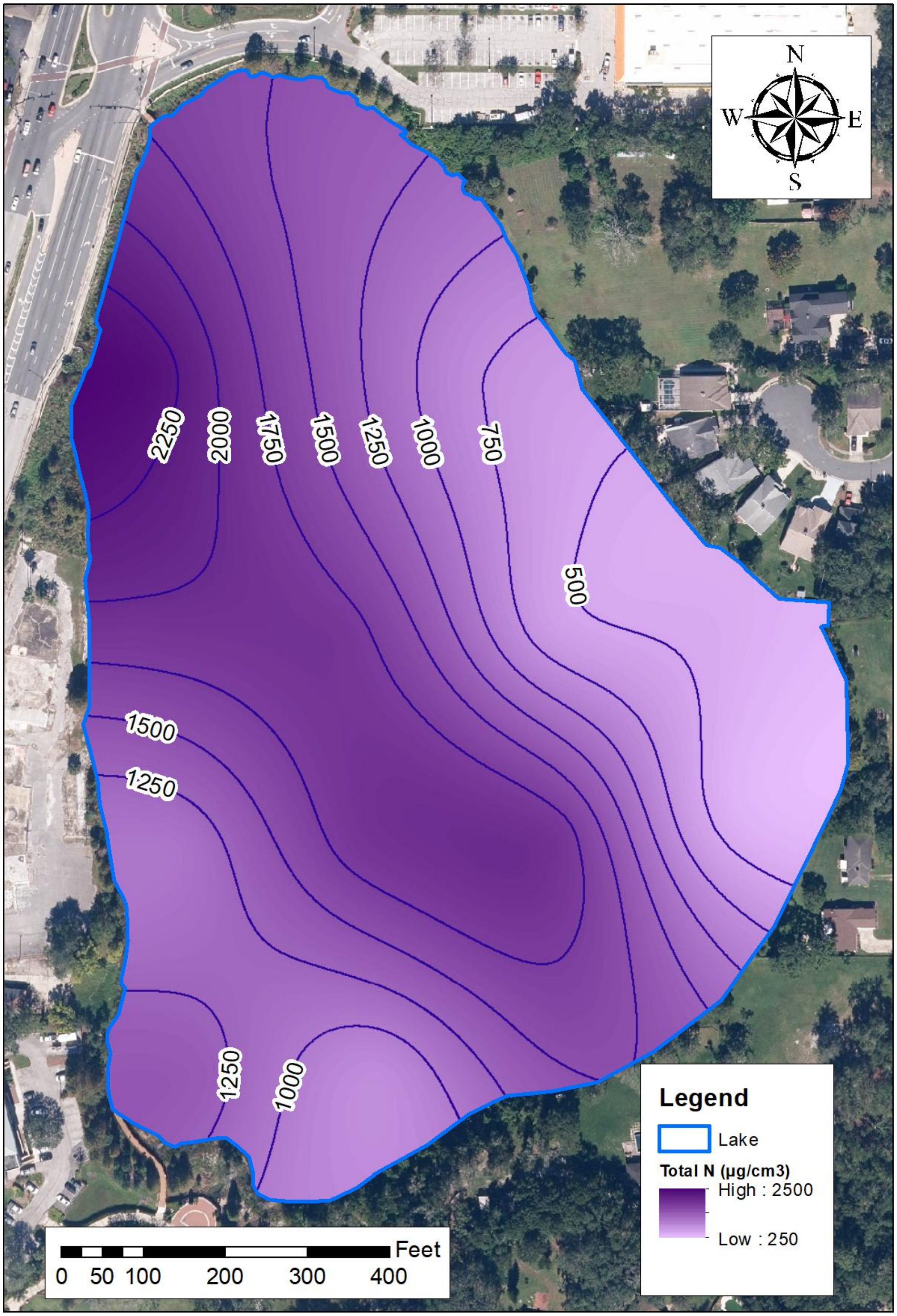


Figure 2-9. Isopleths of Total Nitrogen (µg/cm^3) in the Top 10 cm of Sediments in Lake Concord During March 2019. (Photo Source/Date: FDOT, 2019)

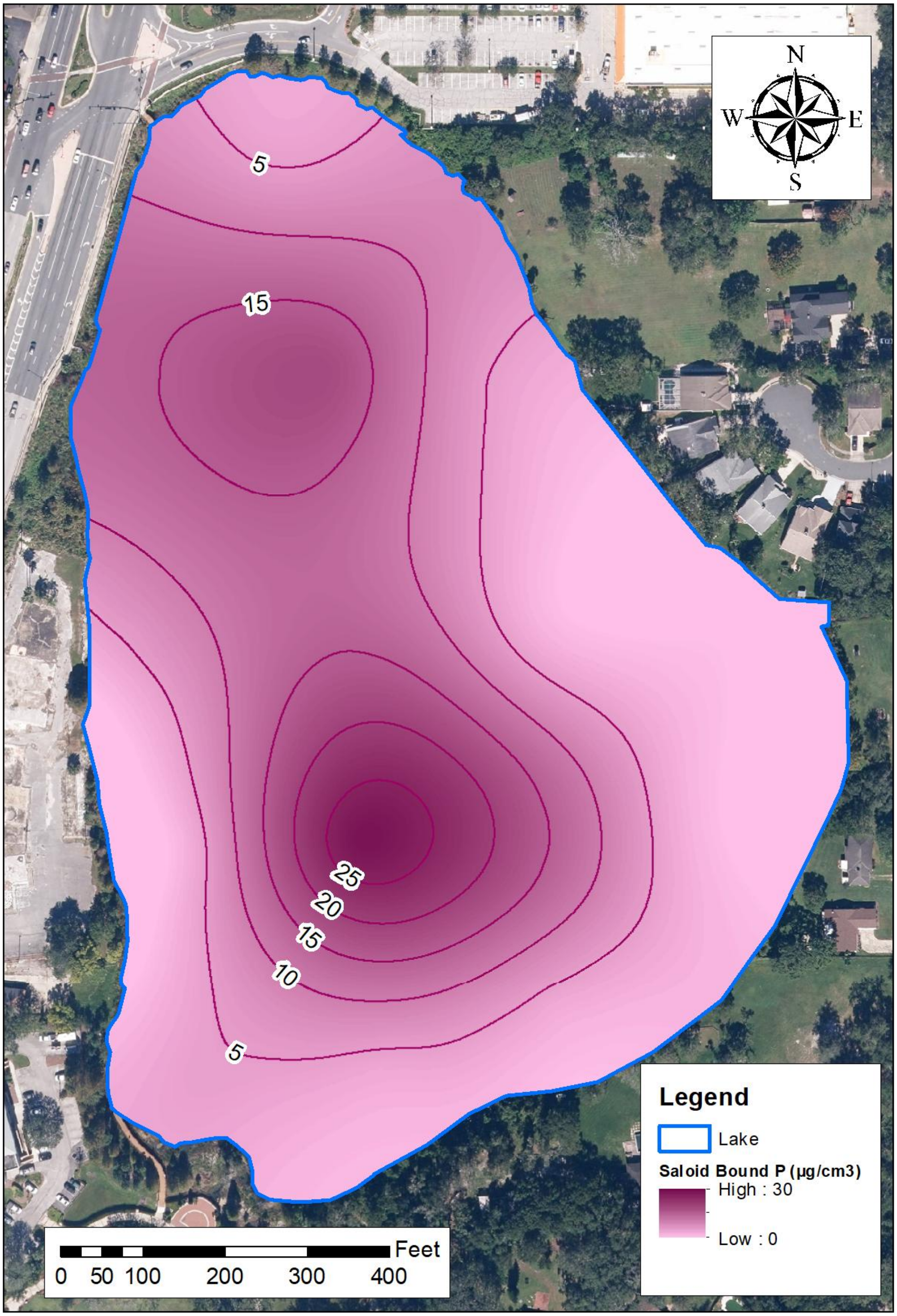


Figure 2-10. Isopleths of Saloid-Bound Phosphorus (µg/cm^3) in the Top 10 cm of Sediments in Lake Concord During March 2019. (Photo Source/Date: FDOT, 2019)

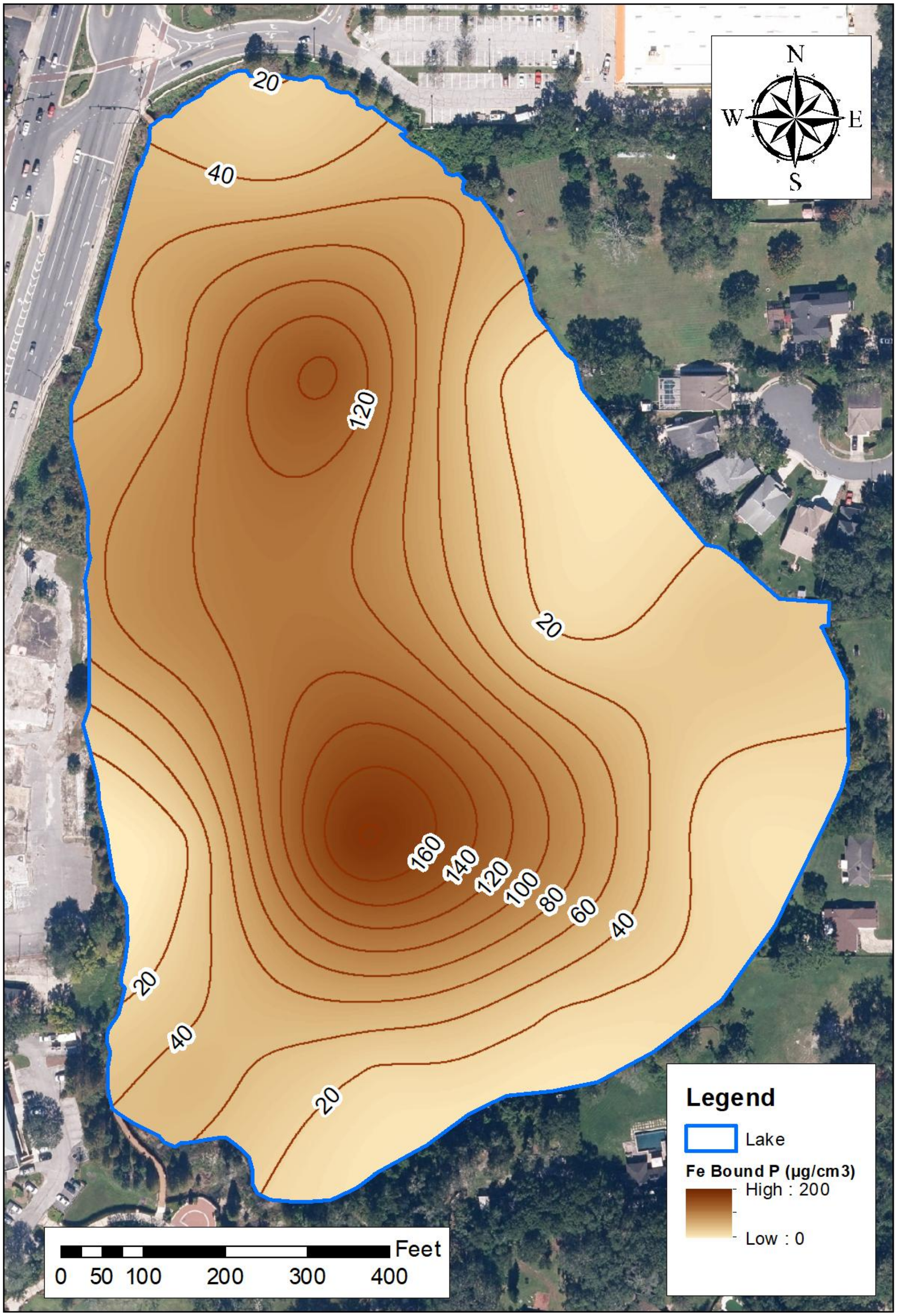


Figure 2-11. Isopleths of Iron-Bound Phosphorus (µg/cm^3) in the Top 10 cm of Sediments in Lake Concord During March 2019. (Photo Source/Date: FDOT, 2019)

TABLE 2-6

PHOSPHORUS SPECIATION IN SEDIMENT CORE SAMPLES COLLECTED IN LAKE CONCORD ON MARCH 11, 2019

SITE	SALOID-BOUND P (µg/cm^3 wet wt.)	IRON-BOUND P (µg/cm^3 wet wt.)	TOTAL AVAILABLE P (µg/cm^3 wet wt.)	ALUMINUM-BOUND P (µg/cm^3 wet wt.)	PERCENT OF SEDIMENT P WHICH IS AVAILABLE (%)
1	4.5	32	36	63	22
2	14.8	64	38	218	11
3	18.4	143	161	188	39
4	4.6	22	27	24	32
5	6.0	83	89	189	22
6	14.2	110	125	173	32
7	1.5	22	23	37	30
8	0.2	35	35	10	62
9	1.3	36	37	131	18
10	28.0	179	207	264	38
11	14.0	96	111	180	28
12	0.8	14	14	14	21
13	4.6	46	51	142	18
14	3.3	17	20	23	4
15	2.6	18	21	27	12
Minimum Value:	**0.2**	**14**	**14**	**10**	**4**
Maximum Value:	**28.0**	**179**	**207**	**264**	**62**
Geometric Mean:	**4.2**	**45**	**50**	**71**	**22**

Total available phosphorus represents the sum of the saloid-bound phosphorus and iron-bound phosphorus associations in each sediment core sample. Since the saloid-bound phosphorus is immediately available, and the iron-bound phosphorus is available under reduced conditions, the sum of these speciations represents the total phosphorus which is potentially available within the sediments. This information can be utilized as a guide for future sediment inactivation procedures. A summary of total available phosphorus in each of the 15 collected sediment core samples is given in Table 2-6. Total available phosphorus concentrations within the lake range from 14-207 µg/cm^3, with an overall geometric mean of 50 µg/cm^3. The mean sediment total available phosphorus in Lake Concord is greater than the mean sediment available phosphorus concentration measured by ERD in Lake Holden, Lake Pineloch, or Lake Pearl, and indicates a relatively large pool of available sediment phosphorus in Lake Concord.

Isopleths of total available phosphorus in the top 10 cm of sediments in Lake Concord are illustrated on Figure 2-12. Areas of elevated total available phosphorus are located in central portions of Lake Concord similar to the trends observed for moisture and organic content. The isopleths presented on Figure 2-12 can be utilized directly as a guide for future sediment inactivation activities, if desired.

Available sediment phosphorus can also be expressed as a percentage of total phosphorus concentrations within the sediments to indicate the percentage of existing sediment phosphorus which is available for release. This value is calculated as the ratio of the total available phosphorus values listed for each site in Table 2-6 divided by the total sediment phosphorus concentrations listed in Table 2-5. The percentage of available phosphorus within the sediments of Lake Concord ranges from approximately 4-62%, with an overall geometric mean of 22%. This suggests that approximately 22% of the existing accumulation of phosphorus within the lake is potentially available for release into the overlying water column as a result of sediment agitation or anoxic conditions. Since the existing sediment phosphorus concentrations are low in value, only a moderate amount of sediment phosphorus is potentially available for release.

Isopleths of the percentage of available sediment phosphorus in the top 10 cm of sediments in Lake Concord are illustrated on Figure 2-13. The highest percentages of available sediment phosphorus generally occur in areas elevated concentrations of moisture and organic content and total phosphorus concentrations.

Aluminum-bound phosphorus represents an unavailable species of phosphorus within the sediments. Phosphorus bound with aluminum is typically considered to be inert under a wide range of pH and redox conditions within the sediments. Aluminum-bound sediment phosphorus concentrations in Lake Concord range from 10-264 $\mu g/cm^3$, with an overall mean of 71 $\mu g/cm^3$. These values appear to be similar to aluminum-bound phosphorus concentrations commonly observed in urban lake systems. These values suggest that approximately 71% of the existing phosphorus within the sediments is bound in sediment associations with aluminum which are considered to be unavailable.

2.3 Water Quality Characteristics of Lake Concord

2.3.1 Historical Water Quality Data Availability

A relatively large amount of historical water quality monitoring has been conducted in Lake Concord, with virtually all data collected by the City of Casselberry or as part of the LakeWatch program. A summary of available historical water quality data for Lake Concord is given in Table 2-7 and locations of the historical water quality monitoring sites are indicated on Figure 2-14.

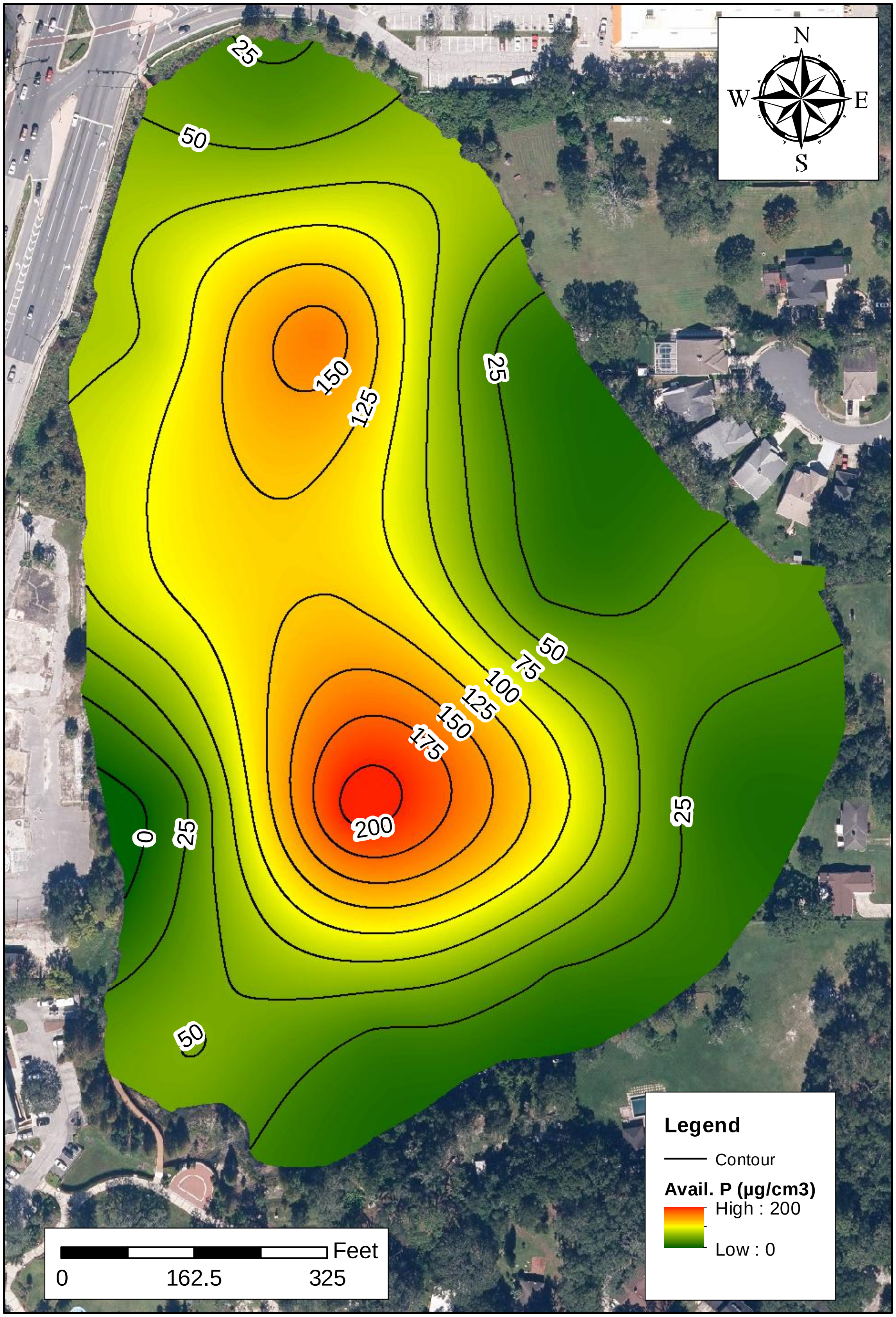


Figure 2-12. Isopleths of Total Available Phosphorus (µg/cm[3]) in the Top 10 cm of Sediments in Lake Concord During March 2019. (Photo Source/Date: FDOT, 2019)

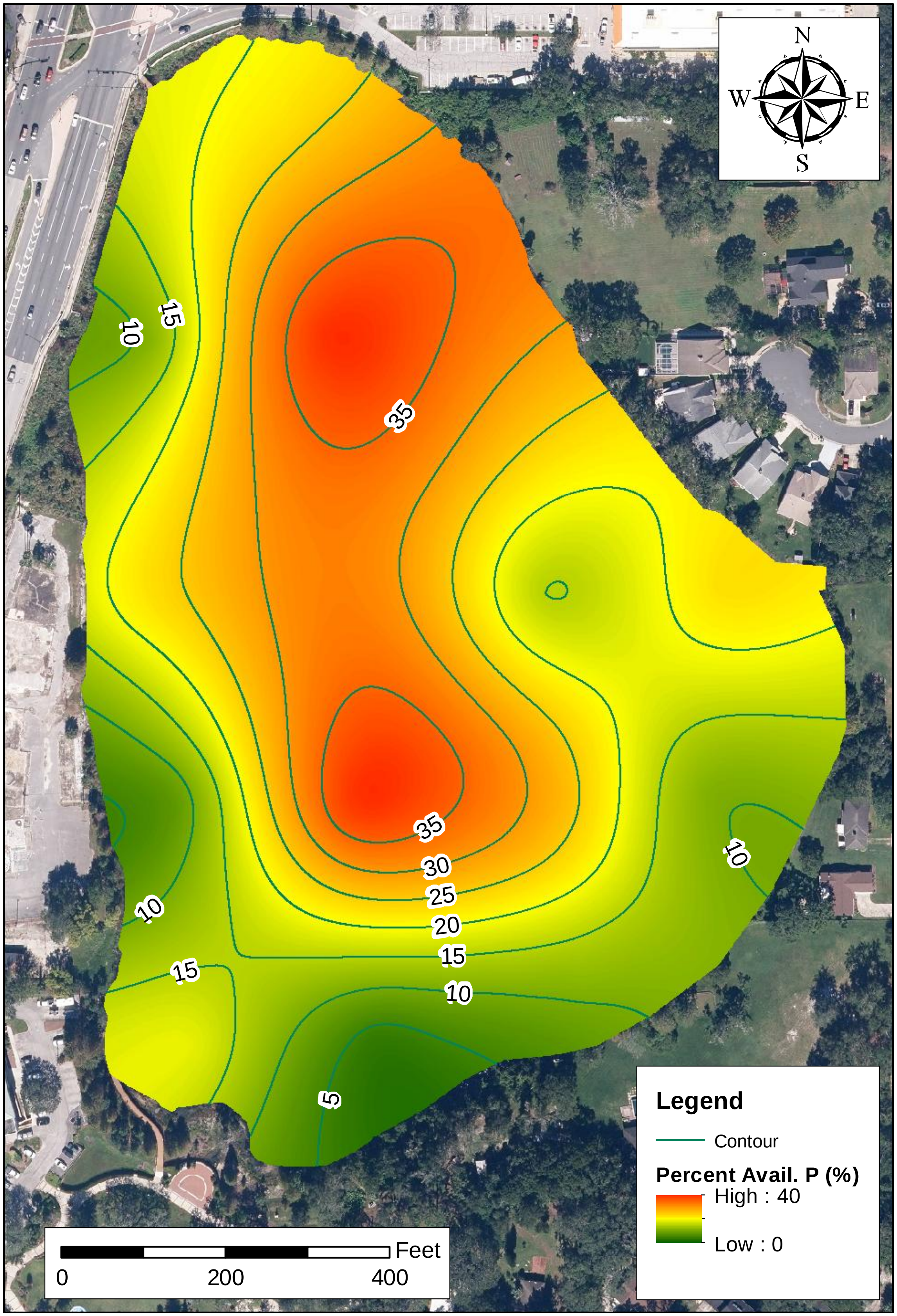


Figure 2-13. Isopleths of Percentage of Available Phosphorus in the Top 10 cm of Sediments in Lake Concord During March 2019. (Photo Source/Date: FDOT, 2019)

TABLE 2-7

SUMMARY OF AVAILABLE HISTORICAL WATER QUALITY DATA FOR LAKE CONCORD

AGENCY	STATION I.D.	COLLECTION DATES	MONITORING FREQUENCY		TOTAL NUMBER OF EVENTS	TYPE OF DATA
			Year and # of events	Year and # of events		
LakeWatch	Concord 1	May 1996- November 2018	1996: 4 1997: 7 1998: 6 1999: 10 2000: 4 2001: 4 2002: 8 2003: 10 2004: 11 2005: 12 2006: 1 2007: 6	2008: 12 2009: 9 2010: 6 2011: 9 2012: 12 2013: 12 2014: 12 2015: 12 2016: 12 2017: 12 2018: 11	202	Total Nitrogen Total Phosphorus Chlorophyll-a Secchi Disk Depth
	Concord 2	May 1996- November 2018	1996: 4 1997: 7 1998: 6 1999: 10 2000: 4 2001: 4 2002: 8 2003: 10 2004: 11 2005: 12 2006: 1 2007: 6	2008: 12 2009: 12 2010: 12 2011: 12 2012: 12 2013: 12 2014: 12 2015: 12 2016: 12 2017: 12 2018: 11	214	Total Nitrogen Total Phosphorus Chlorophyll-a Secchi Disk Depth
	Concord 3	May 1996- November 2018	1996: 4 1997: 7 1998: 6 1999: 10 2000: 4 2001: 4 2002: 8 2003: 10 2004: 11 2005: 12 2006: 1 2007: 6	2008: 12 2009: 9 2010: 6 2011: 9 2012: 12 2013: 12 2014: 12 2015: 12 2016: 12 2017: 12 2018: 11	202	Total Nitrogen Total Phosphorus Chlorophyll-a Secchi Disk Depth
City of Casselberry	Concord	December 2003- December 2019	2003: 1 2004: 4 2005: 4 2006: 4 2007: 4 2008: 4 2009: 4 2010: 4 2011: 4	2012: 4 2013: 4 2014: 4 2015: 4 2016: 4 2017: 4 2018: 4 2019: 3	64	Field Parameters General Parameters Nutrients Chlorophyll-a Microbiological Secchi Disk Depth
FDEP	G2CE0059	February 2017- June 2019	2017: 4	2019: 8	12	Field Parameters General Parameters Nutrients Chlorophyll-a Secchi Disk Depth

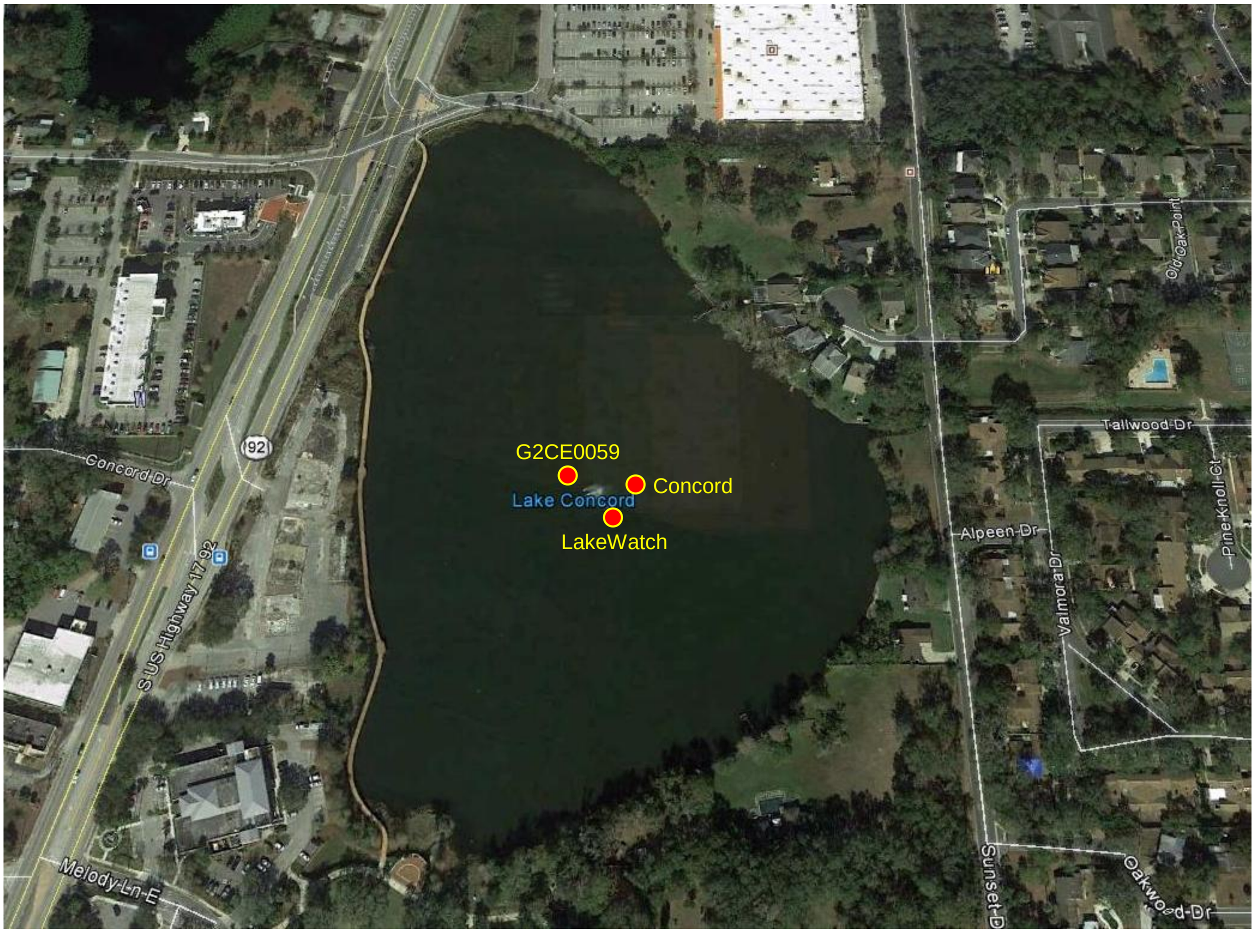


Figure 2-14. Historical Water Quality Monitoring Sites in Lake Concord.

The most complete water quality data for Lake Concord, in terms of the number of events conducted, have been collected by the LakeWatch program through the University of Florida. LakeWatch monitoring was initiated during 1996 with samples collected at 3 separate locations, although the coordinates for the 3 sites are identical in the water quality database. Each of the sites was monitored on a bi-monthly to monthly basis, with more than 200 events conducted at each site. Monitoring conducted by LakeWatch includes measurement of total nitrogen, total phosphorus, chlorophyll-a, and Secchi disk depth. A total of 618 water quality samples were collected as part of the LakeWatch monitoring program.

Water quality monitoring by the City of Casselberry was initiated in December 2003 and has continued on a quarterly basis to the present. Monitoring conducted by the City during this period is more extensive than the LakeWatch program and includes measurements of field parameters, general parameters, nutrients, microbiological parameters, Secchi disk depth and chlorophyll-a. A total of 64 separate samples has been collected as part of the City's monitoring program.

Field monitoring has also been conducted in Lake Concord by FDEP as part of the monitoring efforts to identify Impaired Waters. FDEP conducted water quality monitoring in Lake Concord on 4 occasions during 2017 and approximately monthly during 2019, with a total of 12 samples collected overall. Monitoring conducted by FDEP during this period includes measurements of field parameters, general parameters, nutrients, microbiological parameters, Secchi disk depth and chlorophyll-a. A complete listing of historical water quality data collected in Lake Concord by the City, LakeWatch, and FDEP is given in Appendix B.

2.3.1.1 Data Analysis Techniques

A historical data set for Lake Concord was developed by ERD to evaluate general water quality characteristics and to conduct trend analyses for significant parameters over time. Due to the large amount of data available from LakeWatch, the historical water quality evaluation was conducted using both the LakeWatch and Casselberry data. The historical data set provides a data period of almost 25 years from 1996-2019.

A review of the historical water quality data was conducted by ERD to identify apparent data anomalies and inconsistent or impossible values. No significant data anomalies or impossible values were observed. Secchi disk data provided in feet were converted to meters, and nutrient data were converted from mg/l to μg/l to be consistent with the units used in this report. Orthophosphorus values which exceeded total phosphorus concentrations were made equal to the total phosphorus values.

Historical water quality characteristics in Lake Concord were evaluated by ERD based upon an examination of the results of individual monitoring events as well as mean annual concentrations for total phosphorus, total nitrogen, chlorophyll-a, Secchi disk depth, TN/TP ratio, and TSI. Line plots of concentration over time were developed for each evaluated historical parameter, and mean annual geometric mean values are superimposed over the historical data to provide a less cluttered view of potential water quality trends within the lake.

A linear regression line is also provided to assist in identifying significant water quality trends which is obtained using linear regression techniques on the annual geometric mean values. The calculated probability value (p value) is also provided which indicates the level of significance associated with each regression model. A model which is significant at a 95% confidence level would be associated with a p value of 0.05. However, lakes exhibit normal seasonal cyclic variations in water quality which can reduce the statistical significance of the regression model. Therefore, when evaluating water quality trends in lakes, a p value of 0.1 or less is generally considered to indicate a significant statistical trend, while p values greater than 0.1 suggest an insignificant trend.

2.3.1.2 <u>Total Nitrogen</u>

A graphical summary of historical trends in total nitrogen concentrations in Lake Concord from 1996-2019 is given in Figure 2-15 based on data collected by the City and LakeWatch. Multiple LakeWatch sites for the same date were averaged to obtain a single value for each date. Annual rainfall during the period of record is also included on Figure 2-15, based on rainfall records at the Sanford-Orlando International Airport, to evaluate potential impacts of rainfall patterns on total nitrogen concentrations.

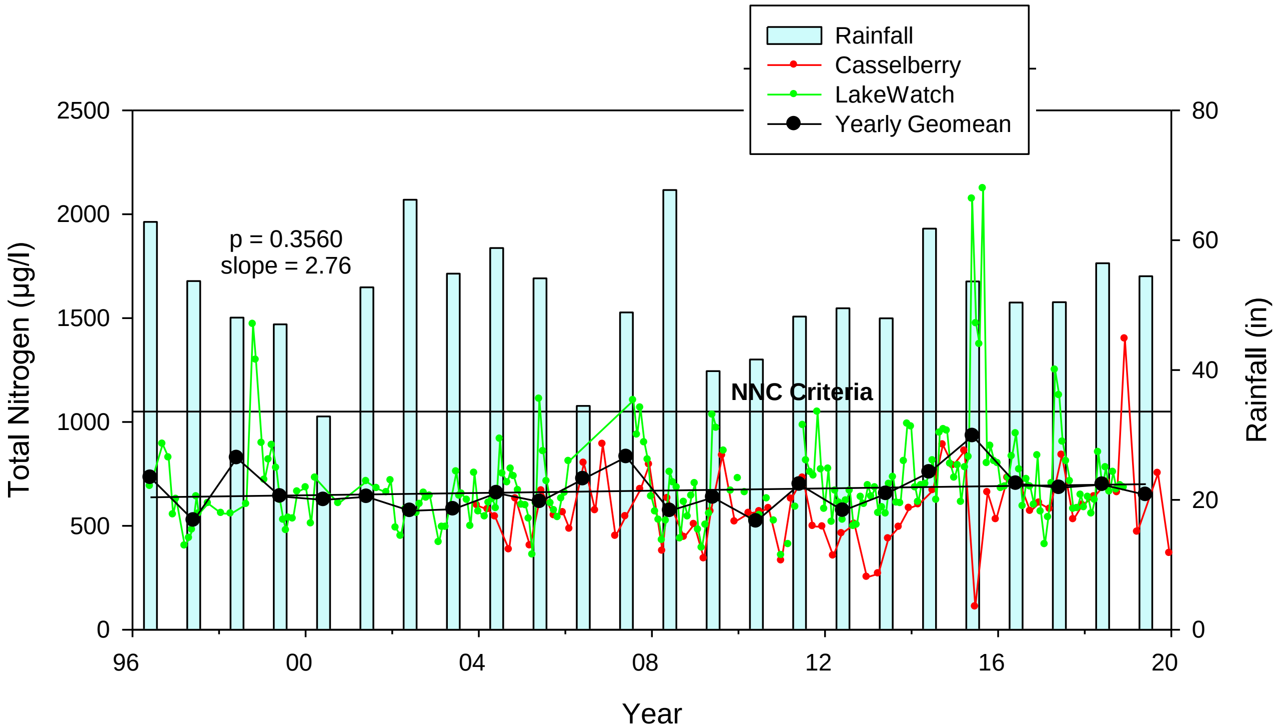


Figure 2-15. Summary of Trends in Total Nitrogen in Lake Concord from 1996-2019.

Measured total nitrogen concentrations in Lake Concord have been low to moderate in value over the historical record from 1996-2019, although more elevated values have been observed at times. Total nitrogen concentrations in the lake have ranged from approximately 110-2,320 µg/l, although the vast majority of measured values have been between 400-800 µg/l. Total nitrogen concentrations in Lake Concord have been variable over time, although the degree of variability in values is less than typically observed by ERD in urban lakes. Overall, total nitrogen concentrations in the City data appear to be slightly lower than values reported by LakeWatch. Extremely large differences in total nitrogen concentrations were observed between Casselberry and LakeWatch measurements during 2015 and 2018.

The trend lines shown on Figure 2-15 suggest a trend of slightly increasing total nitrogen concentrations in Lake Concord over time due to the positive slope on the regression line. However, the calculated p-value of 0.3560 indicates that the trend is not statistically significant. Overall, the data suggest that total nitrogen concentrations in Lake Concord have remained relatively consistent from 1996-2019.

Based on the Florida Numeric Nutrient Criteria (NNC), Lake Concord is a Category II lake since long-term color is less than 40 Pt-Co units and alkalinity exceeds 20 mg/l, and the NNC for total nitrogen is 1,050 µg/l which is indicated on Figure 2-15. None of the annual geometric mean total nitrogen concentrations have exceeded the applicable minimum Numeric Nutrient Criteria (NNC) of 1,050 µg/l throughout the period of available historical data from 1996-2019. There does not appear to be a distinct correlation between annual rainfall and total nitrogen concentrations in Lake Concord which suggests that runoff inputs may not be the primary source of total nitrogen loadings to Lake Concord.

2.3.1.3 Total Phosphorus

A graphical summary of historical trends in total phosphorus concentrations in Lake Concord from 1996-2019 is given on Figure 2-16. Annual rainfall during the period of record is also included on Figure 2-16 to evaluate impacts of rainfall on total phosphorus concentrations. Measured total phosphorus in Lake Concord has been highly variable over time, with low to elevated concentrations. Individual phosphorus measurements in the historical record have ranged from 5-98 µg/l, although the vast majority of measured values have occurred in the range of 20-50 µg/l.

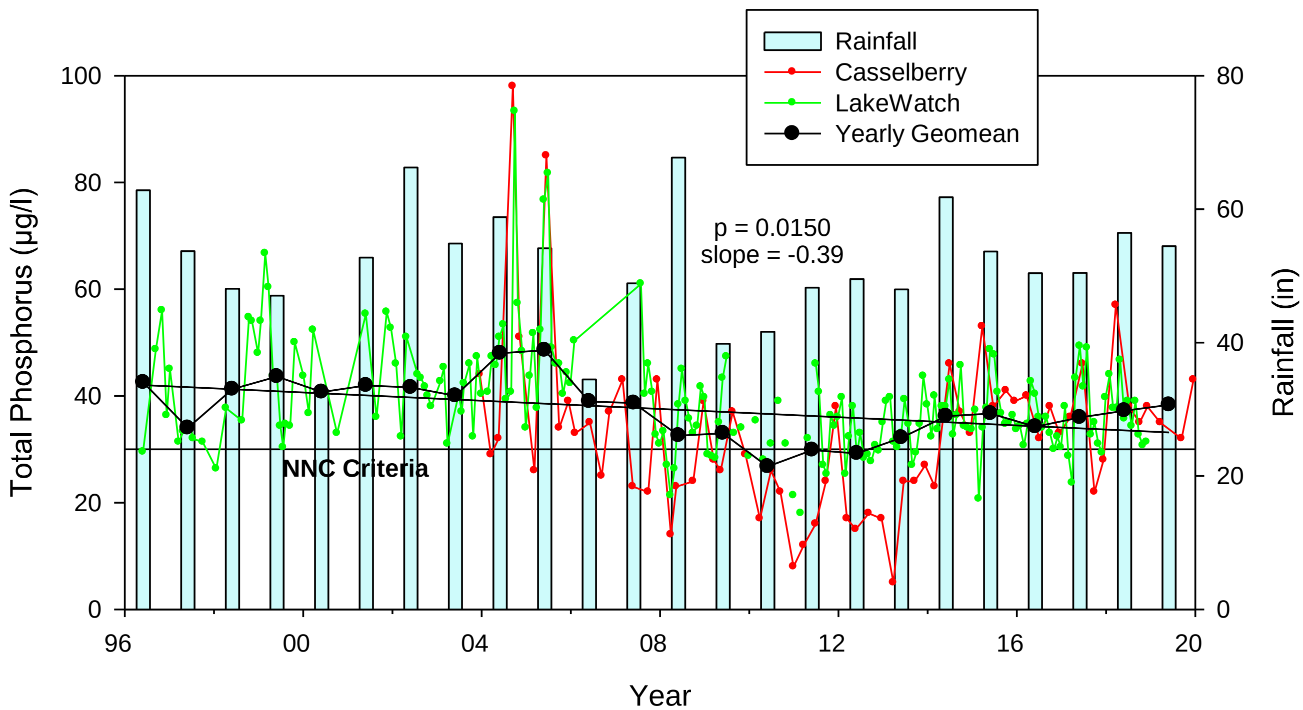


Figure 2-16. Summary of Trends in Total Phosphorus in Lake Concord from 1996-2019.

Measured total phosphorus concentrations in Lake Concord exhibited a high degree of variability from 1996 to approximately 2012, with more consistent values from 2012-2019. Similar to the trend observed for total nitrogen, total phosphorus concentrations reported in the City data appear to be lower than LakeWatch values for many of the monitoring dates from 2003-2013, with more comparable values from 2013-2019. Annual geometric mean total phosphorus values in Lake Concord have exhibited a cyclic pattern, with the most elevated values during 2004-2005 and lowest values during 2010-2013.

The trend line for geometric mean annual total phosphorus concentrations in Lake Concord from 1996-2019 (24 years) exhibits a negative slope which suggests a trend of decreasing total phosphorus concentrations over time, and the p-value of 0.0150 indicates that the trend is highly significant. Unlike the trend observed for total nitrogen, total phosphorus concentrations in Lake Concord appear to be decreasing over time at a rate of 0.39 μg/l per year. However, the phosphorus data suggest there may be short-term trends within the long-term trend. Assuming that a minimum period of 10 years is necessary to detect a potential trend, total phosphorus concentrations in Lake Concord increased from 33 μg/l in 2009 to 38 μg/l in 2019, an increase of 15%. The increase in total phosphorus concentrations from 2009-2019 is statistically significant, with a p-value of 0.0021 and a slope of 0.92 μg TP/liter-yr. However, from 1999-2019, total phosphorus concentrations decreased from 44 μg/l to 33 μg/l, a decrease of 25%. This decrease in total phosphorus concentrations from 1999-2009 is also statistically significant, with a p-value of 0.08 and a slope of -0.31 μg TP/liter-yr. However, from 1996-2019, concentrations have decreased more than increased which results in the long-term significant decrease. It is entirely likely that these short-term trends are related to changes in macrophyte biomass within the lake.

As indicated on Figure 2-16, annual geometric mean total phosphorus concentrations have been above the applicable NNC value of 30 μg/l throughout most of the entire historical water quality monitoring program, with exceedances of the total phosphorus minimum NNC criterion observed during 21 of the 24 years of historical record. The most elevated total phosphorus concentrations occurred during a period of above-normal rainfall, with the lowest total phosphorus values during below-normal rainfall conditions.

The steady trend of decreasing total phosphorus concentrations in Lake Concord suggests that the uptake mechanisms for total phosphorus in the lake have exceeded loading sources during this period. Since the total phosphorus uptake mechanisms in Lake Concord are biologically driven through uptake by algae and aquatic plants, the variability in concentrations are related to either changes in plant biomass over time or reductions in total phosphorus loadings from implemented BMP projects. Total phosphorus concentrations in Lake Concord have been relatively steady over the past 4-5 years which suggest a stable equilibrium between input sources and plant biomass which may be related to more consistent hydrilla management.

2.3.1.4 Chlorophyll-a

A graphical summary of measured concentrations of chlorophyll-a in Lake Concord from 1996-2019 is given in Figure 2-17. Annual rainfall during the period of record is also included on Figure 2-17 to evaluate impacts of rainfall on chlorophyll-a concentrations. In general, measured concentrations of chlorophyll-a in Lake Concord have been low to highly elevated in value over the available period of data. Chlorophyll-a concentrations <10 mg/m^3 are generally considered to reflect low values, with concentrations from 10-30 mg/m^3 reflecting moderate values, and concentrations >30 mg/m^3 representing elevated values.

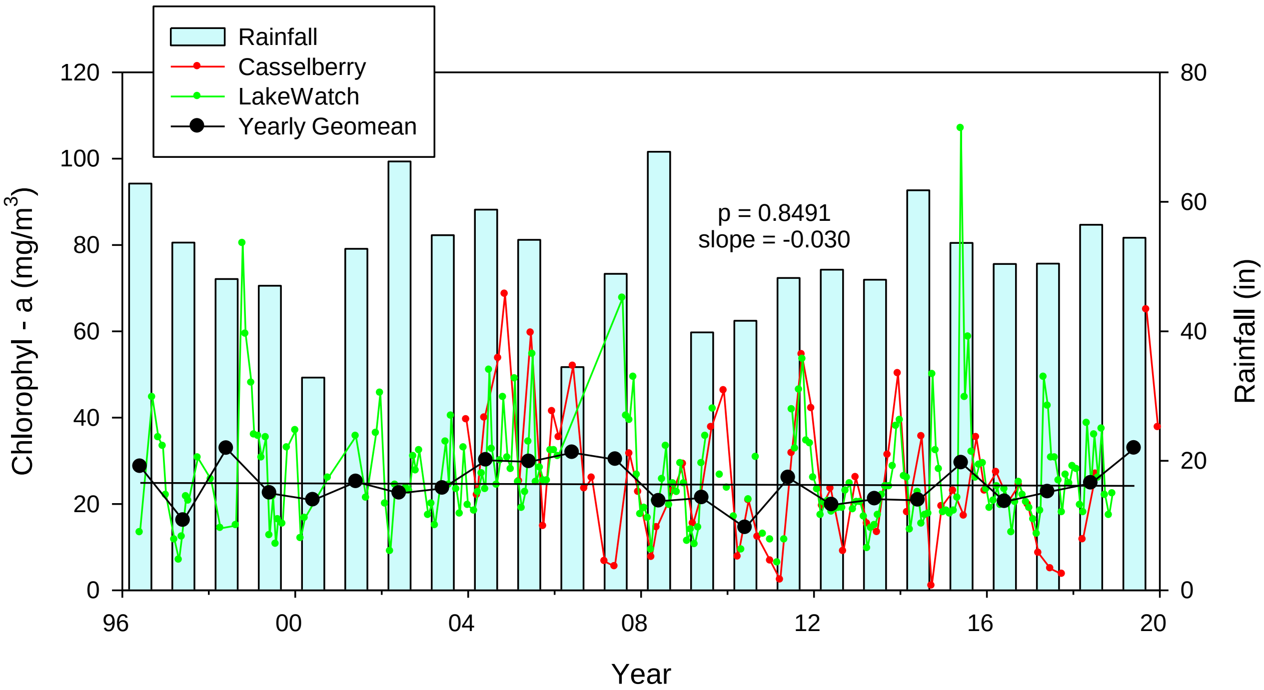


Figure 2-17. Summary of Trends in Chlorophyll-a in Lake Concord from 1996-2019.

Concentrations of chlorophyll-a have ranged from 1.0-112 mg/m^3, although the vast majority of measured values have been approximately 40 mg/m^3 or less. The shape of the plot of annual geometric mean values for chlorophyll-a is somewhat similar to the plot for total phosphorus, with increases and decreases in chlorophyll-a corresponding to increases and decreases in phosphorus. The most elevated chlorophyll-a values in Lake Concord occurred during 2004-2007, with the lowest values observed during 2010. There does not appear to be a strong correlation between chlorophyll-a and annual rainfall.

The regression trend line for chlorophyll-a has a negative slope, suggesting a trend of decreasing chlorophyll-a concentrations over time, but the calculated p-value of 0.8491 indicates that this trend is not statistically significant. Overall, the measured chlorophyll-a concentrations in Lake Concord are indicative of oligotrophic to hypereutrophic conditions. Over the available period of record from 1996-2019, the annual geometric mean chlorophyll-a concentration exceeded the NNC criterion of 20 mg/m^3 during each of the 24 years of historical record except 1997 (16.2 mg/m^3), 2010 (14.5 mg/m^3), and 2012 (19.8 mg/m^3).

The pattern of annual geometric mean values for chlorophyll-a is somewhat similar to the pattern exhibited by total phosphorus. Several short-term patterns are apparent with a decreasing trend from 2004-2010, relatively consistent values from 2011-2014, and increasing values from 2016-2019.

2.3.1.5 <u>Secchi Disk Depth</u>

A graphical summary of measured Secchi disk depths in Lake Concord from 1996-2019 is given on Figure 2-18. Annual rainfall during the period of record is also included on Figure 2-18 to evaluate impacts of rainfall on Secchi disk depths. Recorded Secchi disk depths in Lake Concord have ranged from 0.3-4.57 m, although the majority of Secchi disk depths have ranged from 0.5-1.5 m. Secchi disk depths have been highly variable over the available period of record, with a lower degree of variability in recent years. The variability in Secchi disk depths illustrated on Figure 2-18 appears to be caused by changes in algal productivity since the chlorophyll-a and Secchi disk depth plots appear to exhibit inverse relationships. Due to the low color in Lake Concord, color does not appear to be a significant factor in determining Secchi disk depths.

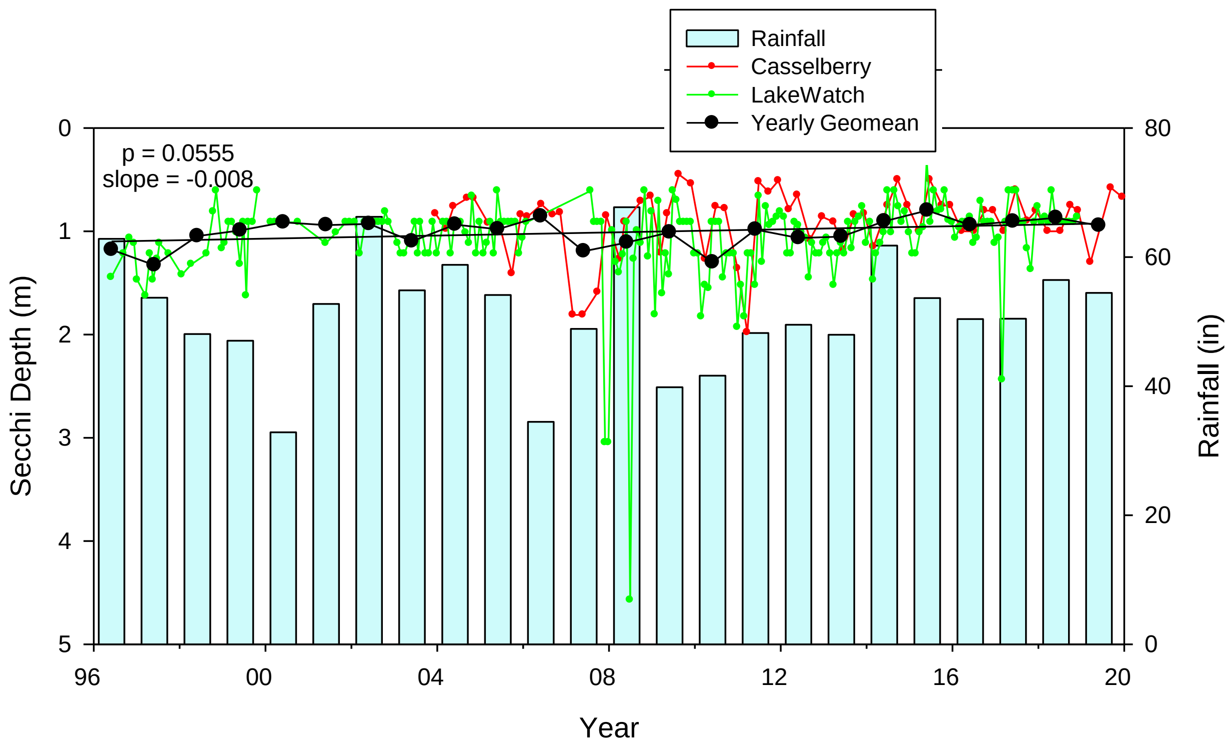


Figure 2-18. Summary of Trends in Secchi Disk Depth in Lake Concord from 1996-2019.

The slope of the trend line for Secchi disk depth in Lake Concord is negative, suggesting a decrease in Secchi disk depth over time of 0.008 m per year, and the calculated p-value of 0.0555 indicates that the trend is close to being statistically significant. The Secchi disk depth data suggest that water clarity has been highly variable over time. Similar to trends observed with previous parameters, annual rainfall does not appear to have a significant impact on Secchi disk depth in Lake Concord.

2.3.1.6 Nutrient Limitation

Nutrient limitation in a waterbody is often evaluated using the total nitrogen/total phosphorus (TN/TP) ratio. The calculated TN/TP ratio is a numerical ratio of the measured water column concentrations of total nitrogen and total phosphorus. This ratio can be useful in evaluating the relative significance of nitrogen and phosphorus in regulating primary productivity (algal growth) in a waterbody resulting from supplemental nutrient loadings. Measured TN/TP ratios less than 10 are considered to indicate nitrogen-limited conditions, suggesting that phosphorus is relatively abundant and nitrogen is the element which regulates primary productivity and the growth of algae within the lake system. Calculated TN/TP ratios between 10-30 indicate nutrient-balanced conditions, with both nitrogen and phosphorus considered important for limiting aquatic growth. Calculated TN/TP ratios in excess of 30 indicate phosphorus-limited conditions, which suggests that nitrogen is abundant within the system and algal growth is limited by the availability of phosphorus. This is the typical situation observed in many lakes in the Central Florida area. However, the concept of nutrient limitation is designed to address impacts from additional nutrient loadings to a waterbody and should not be confused with the process of reducing algal productivity by nutrient load reductions.

A graphical summary of calculated TN/TP ratios in Lake Concord from 1996-2019 is given on Figure 2-19. In general, nutrient ratios in Lake Concord have been highly variable over time, with nutrient-balanced conditions observed from 1996-2019. The historical data clearly indicate that Lake Concord is nutrient-balanced which suggests that the lake is very susceptible to changes in algal productivity resulting from additional inputs of both nitrogen and phosphorus. The trend line suggests increasing TN/TP ratios over time, and the calculated p-value of 0.0046 indicates that the trend is highly significant, indicating that Lake Concord is becoming more sensitive to phosphorus inputs over time.

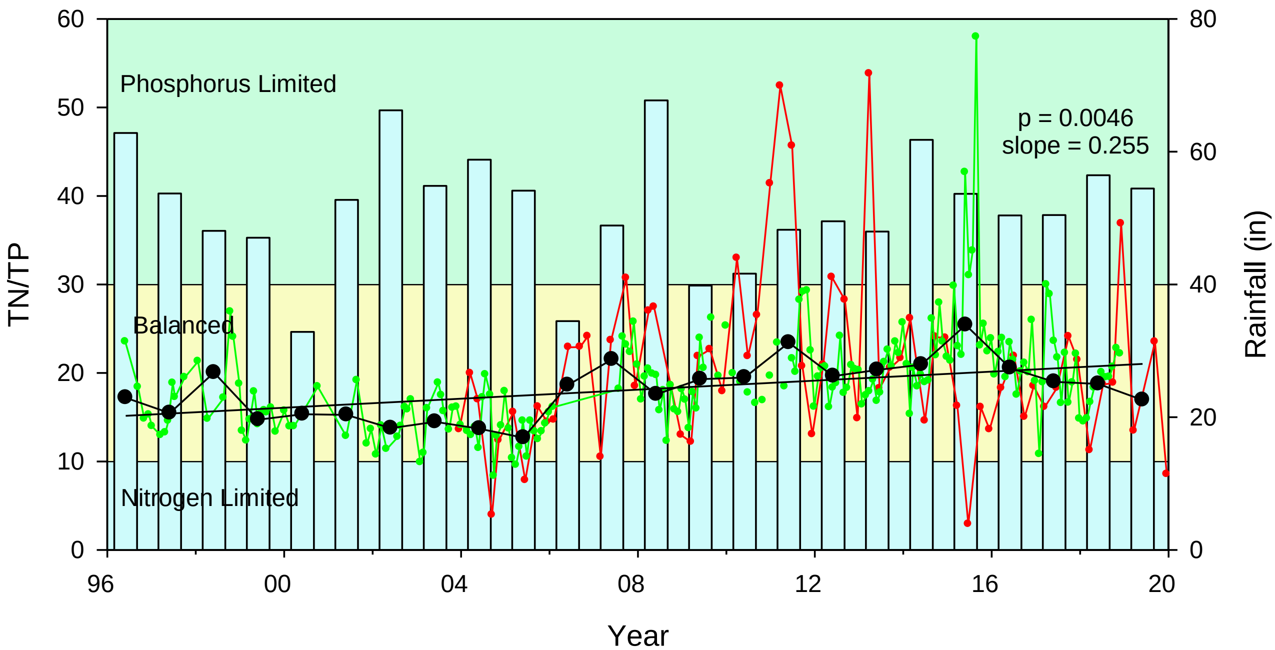


Figure 2-19. Summary of Trends in TN/TP Ratio in Lake Concord from 1996-2019.

2.3.1.7 Trophic State Index (TSI)

Trophic State Index (TSI) values were also calculated by ERD for each monitoring event in Lake Concord over the available period of historical data. TSI is a summary statistic which incorporates measured concentrations of significant parameters in lake systems and is often considered the best overall indicator of the health of a lake system. Calculated TSI values less than 50 indicate oligotrophic conditions, representing lakes with low nutrient loadings and good to excellent water quality characteristics. Calculated TSI values from 50-60 indicate mesotrophic or fair water quality characteristics. Calculated TSI values between 60-70 indicate eutrophic or poor water quality characteristics, with hypereutrophic conditions, reflecting very poor water quality, indicated by TSI values in excess of 70.

The trophic state index was developed by Carlson (1977) as a relative measure of the degree of biological productivity in lakes and incorporates forcing functions such as nutrient supplies, light availability, seasonality, and other factors. Since the TSI value is intended to reflect the level of biological productivity, the best estimator for productivity is chlorophyll-a. Some calculations also include, perhaps incorrectly, concentrations of nutrients and Secchi disk depth in addition to chlorophyll-a. However, including nutrients and Secchi disk depth with chlorophyll-a data in TSI calculations can lead to incorrect conclusions regarding trophic status, and these parameters should only be included as surrogates for biological productivity when chlorophyll data are not available, and TSI values calculated using nutrients and Secchi disk depth as surrogates should be flagged and used with caution. Since chlorophyll-a data for Lake Concord are available for the entire period of record, TSI calculations were conducted for Lake Concord using only measured concentrations of chlorophyll-a according to the following relationship:

$$\textit{TSI (chl-a)} = 16.8 + 14.4 \ln \textit{chl-a } (mg/m^3)$$

A graphical summary of calculated TSI values for Lake Concord is given on Figure 2-20. Annual rainfall during the period of record is also included on Figure 2-20 to evaluate impacts of rainfall on TSI values. Lake Concord has exhibited oligotrophic to hypereutrophic characteristics over the available period of record, although a majority of the historical TSI values have indicated mesotrophic to eutrophic conditions. In general, measured TSI values for individual monitoring events in Lake Concord have ranged from approximately 17-85. Of the 24 annual geometric mean values shown on Figure 2-20, none have indicated oligotrophic conditions, 4 indicated mesotrophic conditions, and 20 reflect eutrophic conditions. The calculated trend line for TSI values in Lake Concord indicates a negative slope with decreasing TSI values over time, but the calculated p-value of 0.9735 indicates that the trend is not statistically significant. Changes in annual rainfall do not appear to have a significant impact on TSI values in Lake Concord.

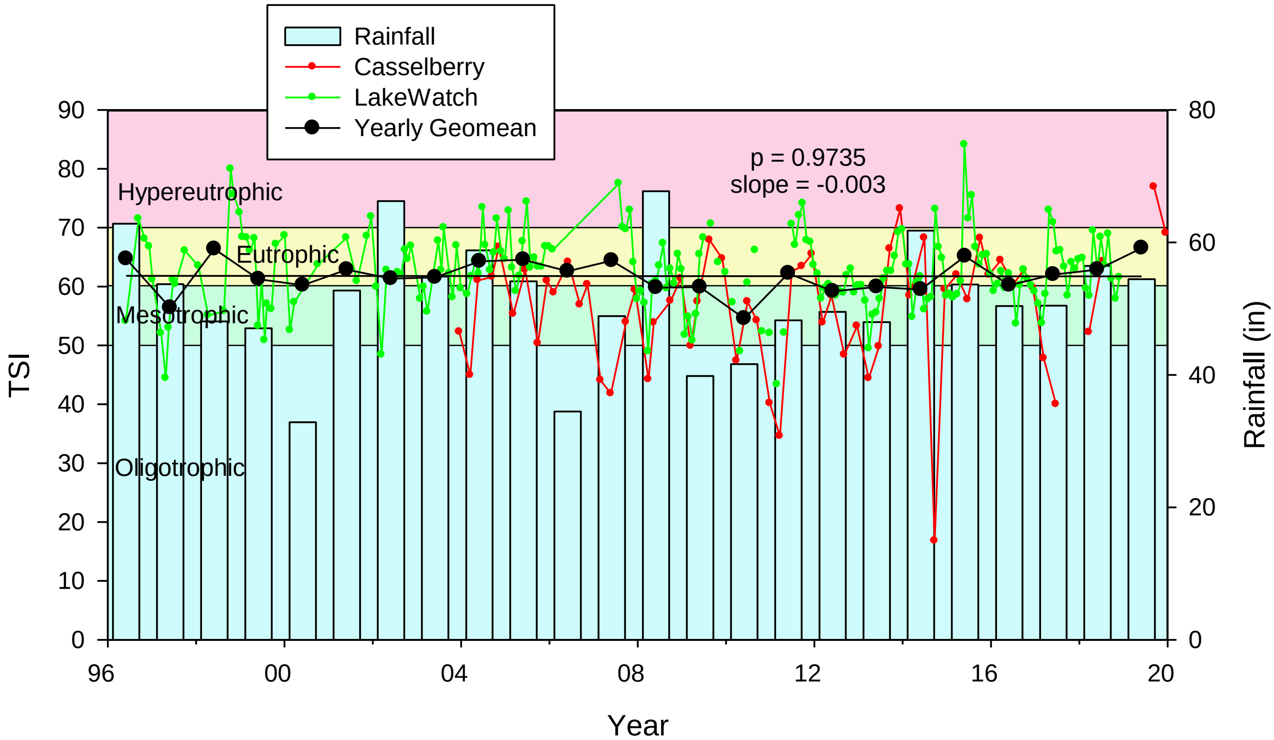


Figure 2-20. Summary of Trends in Trophic State Index (TSI) in Lake Concord from 1996-2019.

2.3.1.8 Seasonal Variability

Additional evaluations were performed to examine seasonal variations in water quality in Lake Concord. For purposes of this analysis, winter is defined as December-February, spring as March-May, summer as June-August, and fall as September-November. Seasonal concentrations were summarized for significant water quality variables such as total phosphorus, total nitrogen, chlorophyll-a, and Secchi disk depth over the available period of data for each variable. A comparison of mean seasonal concentrations of total nitrogen, total phosphorus, chlorophyll-a, and Secchi disk depth in Lake Concord from 1996-2019 is given in Figure 2-21 in the form of box and whisker plots. The vertical scales for each parameter have been reduced to emphasize typical values for these parameters, although multiple values have occurred for each parameter which exceed the vertical scales used.

Seasonal concentrations of total nitrogen in Lake Concord appear to be variable throughout the year, with slightly lower median nitrogen concentrations observed during spring and winter season conditions. Variability in seasonal total nitrogen concentrations also appears to be lowest during winter conditions compared with spring, summer, and fall. The most elevated concentrations of total nitrogen appear to occur during summer.

A similar pattern is apparent on Figure 2-21 for monthly concentrations of total phosphorus in Lake Concord. Phosphorus in the lake is generally moderate to elevated in concentration. The highest median phosphorus concentrations occur during summer conditions with the lowest values during spring.

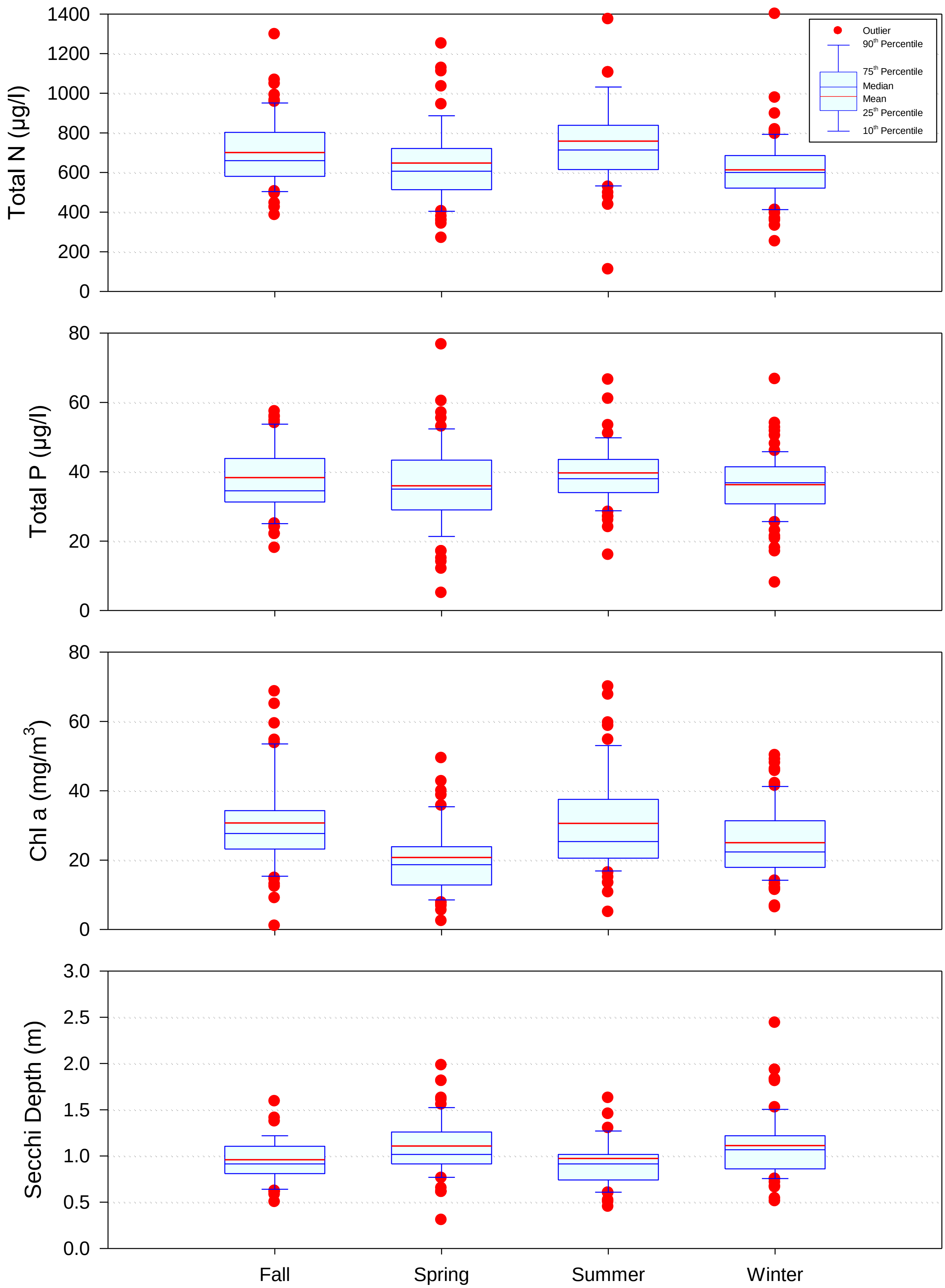


Figure 2-21. Seasonal Concentrations of Total Nitrogen and Total Phosphorus in Lake Concord from 1996-2019.

Seasonal chlorophyll-a concentrations are generally lowest in value during spring, with the highest concentrations during fall, although a high degree of variability has been observed in concentrations over an annual cycle. The seasonal patterns for chlorophyll-a illustrated on Figure 2-21 indicate that the highest degree of variability in chlorophyll-a concentrations occurs during winter and summer conditions.

Measured Secchi disk depths appear to be follow a pattern similar to chlorophyll-a, with the lowest Secchi disk depths during summer and fall and highest values during winter. The variability in Secchi disk depths is similar throughout the year.

2.3.1.9 Historical Water Quality Summary

A tabular summary of historical water quality characteristics in Lake Concord from 1996-2019 is given in Table 2-8. The historical data, provided in Appendix B, are summarized on an annual basis to provide a comparison of changes in water quality characteristics over time.

In general, measured pH values in Lake Concord have been slightly alkaline, with mean annual pH values ranging from approximately 7.4-8.4. Dissolved oxygen concentrations have been adequate to support aquatic organisms, with mean annual concentrations (0.5 m depth) ranging from 6.4-9.1 mg/l in all years.

Surface water in Lake Concord has been characterized by low conductivity, with mean annual conductivity values ranging from 124-205 μmho/cm. Conductivity values appear to have remained relatively consistent in Lake Concord since 2016.

The water column in Lake Concord is moderately buffered, with mean annual alkalinity values ranging from 49.1-78.6 mg/l. Mean annual alkalinity values in Lake Concord have been relatively consistent since 2016.

Measured concentrations of inorganic nitrogen species in Lake Concord have generally been low in value, with the vast majority of mean annual values for ammonia less than approximately 40 μg/l, and mean annual NO_x concentrations of approximately 15 μg/l or less. The majority of total nitrogen measured in Lake Concord consists of organic nitrogen which comprises approximately 90% or more of the total nitrogen measured during each event. Mean annual concentrations of total nitrogen in Lake Concord have ranged from 525-932 μg/l, with the most elevated values occurring from 2014-2015.

Lake Concord is also characterized by extremely low levels of SRP and moderate to elevated concentrations of total phosphorus, with mean annual total phosphorus concentrations ranging from 27-49 μg/l. As indicated in the annual values provided in Table 2-8, concentrations of total phosphorus in Lake Concord have been variable over time, although a general trend of increasing total phosphorus concentrations has been observed since 2008.

TABLE 2-8

SUMMARY OF ANNUAL GEOMETRIC MEAN WATER QUALITY CHARACTERISTICS IN LAKE CONCORD FROM 1996-2019

DATE	PARAMETER																	
	pH (s.u.)	Cond. (µmho/cm)	Diss. O_2 (mg/l)	Alk. (mg/l)	NH_3-N (µg/l)	NO_x-N (µg/l)	Org. N (µg/l)	Total N (µg/l)	SRP (µg/l)	Org. P (µg/l)	Total P (µg/l)	Color (Pt-Co)	Chyl-a (mg/m^3)	Turb. (NTU)	Fecal Coliform (cfu/100 ml)	E. coli (cfu/100 ml)	Secchi Disk Depth (m)	TN/TP Ratio	TSI Chyl-a)
1996	-	-	-	-	-	-	-	731	-	-	43	-	28.6	-	-	-	1.18	17	65
1997	-	-	-	-	-	-	-	525	-	-	34	-	16.2	-	-	-	1.33	15	56
1998	-	-	-	-	-	-	-	827	-	-	41	-	32.8	-	-	-	1.05	20	66
1999	-	-	-	-	-	-	-	641	-	-	44	-	22.5	-	-	-	0.99	15	61
2000	-	-	-	-	-	-	-	624	-	-	41	-	20.9	-	-	-	0.91	15	60
2001	-	-	-	-	-	-	-	640	-	-	42	-	25.1	-	-	-	0.94	15	63
2002	-	-	-	-	-	-	-	572	-	-	42	16	22.5	-	-	-	0.93	14	61
2003	8.01	124	8.6	49.1	3	3	573	579	1	39	40	15	23.6	-	31	-	1.10	14	62
2004	8.36	204	7.7	56.2	12	4	641	657	1	47	48	17	30.1	-	15	-	0.94	14	64
2005	7.88	175	8.6	56.0	62	5	548	615	1	48	49	16	29.7	-	19	-	0.98	13	65
2006	7.97	187	8.4	55.6	24	5	695	725	1	38	39	15	31.9	-	9	-	0.86	19	63
2007	7.78	177	7.8	69.7	46	4	782	831	1	38	39	13	30.2	-	7	-	1.19	22	64
2008	8.31	173	8.0	72.6	33	6	533	572	1	32	33	14	20.6	-	52	-	1.11	18	60
2009	8.28	199	8.3	78.2	17	7	612	636	1	32	33	14	21.4	4.6	12	-	1.01	19	60
2010	7.85	155	8.1	69.7	12	33	476	521	1	26	27	13	14.5	3.1	10	-	1.30	19	55
2011	8.00	153	7.9	63.0	25	5	669	699	1	29	30	12	26.0	2.5	25	-	0.98	23	62
2012	8.15	153	7.9	64.2	14	4	556	573	3	26	29	14	19.8	3.8	32	-	1.07	20	59
2013	7.83	136	7.6	59.2	4	3	646	654	1	31	32	16	21.1	4.2	10	-	1.05	20	60
2014	7.44	134	7.8	55.6	10	13	734	757	2	34	36	15	20.8	3.1	11	-	0.90	21	59
2015	8.05	175	8.2	59.5	10	13	910	932	2	35	37	22	29.5	5.2	9	-	0.80	25	65
2016	8.05	191	6.4	71.7	12	10	681	703	3	31	34	21	20.5	4.2	10	-	0.94	21	60
2017	7.50	190	9.1	69.1	6	10	666	683	3	33	36	19	22.8	3.8	12	-	0.91	19	61
2018	8.04	192	8.9	78.6	18	13	668	698	3	34	37	22	24.8	3.9	75	-	0.87	19	63
2019	7.99	205	8.8	73.2	7	6	637	649	4	34	38	14	32.8	4.5	26	16	0.95	17	67

Lake Concord has exhibited moderate levels of color, with mean annual color values ranging from 12-22 Pt-Co units, and a long-term average of 16 Pt-Co units from 1996-2019. The current Class III Numeric Nutrient Criteria (NNC) divides lakes into high color and low color systems, with a color concentration of 40 Pt-Co units used as the separation criterion. Color values collected in Lake Concord during all annual periods have been lower than 40 Pt-Co units.

Measured chlorophyll-a concentrations in Lake Concord have been moderate to elevated in value, with mean annual concentrations ranging from 14.5 mg/m^3 (2010) to 32.8 mg/m^3 (1998 and 2019), and an overall mean of 24.5 mg/m^3. Chlorophyll-a values in this range typically indicate mesotrophic to eutrophic lake systems.

Measured Secchi disk depths in Lake Concord have exhibited a high degree of variability over time, with mean annual values ranging from 0.80 m (2015) to 1.33 m (1997), reflecting poor to fair water clarity. Measured Secchi disk depths in Lake Concord have been highly variable over time, with an overall average of 1.01 m. Due to the low level of color in Lake Concord, Secchi disk depths are likely regulated primarily by algal productivity.

Calculated TN/TP ratios in Lake Concord have exhibited a moderate degree of variability over time, with a trend of increasing ratios in recent years, indicating that Lake Concord may be becoming more susceptible to additional inputs of phosphorus. Annual mean TSI values (calculated using chlorophyll-a) have been relatively consistent in Lake Concord, ranging from 55-67, with an overall average of 62, reflecting eutrophic conditions.

2.3.1.10 Comparison with Other Florida Lakes

During 2012, ERD downloaded all available LakeWatch data for Florida lakes and developed frequency distribution diagrams for concentrations of significant water quality variables in Florida lakes. This evaluation included the available period of record for 1,198 Florida lakes, with a single overall geometric mean value calculated for total nitrogen, total phosphorus, and chlorophyll-a for each lake. TSI values were calculated by ERD using the equation provided on page 2-33. A summary of this analysis is given on Figure 2-22, with mean concentrations for total nitrogen, total phosphorus, chlorophyll-a, and TSI in Lake Concord superimposed over the frequency distribution curves to provide a comparison of water quality characteristics in Lake Concord with other Florida lakes. Mean water quality concentrations in Lake Concord were determined using the historical water quality data from 2015-2019 to reflect relatively current lake water quality conditions. Mean concentrations of total nitrogen, total phosphorus, chlorophyll-a, and TSI in Lake Concord from 2015-2019 are indicated by **blue lines** on Figure 2-22 and used to estimate the frequency of Florida lakes with concentrations above and below historical values in Lake Concord.

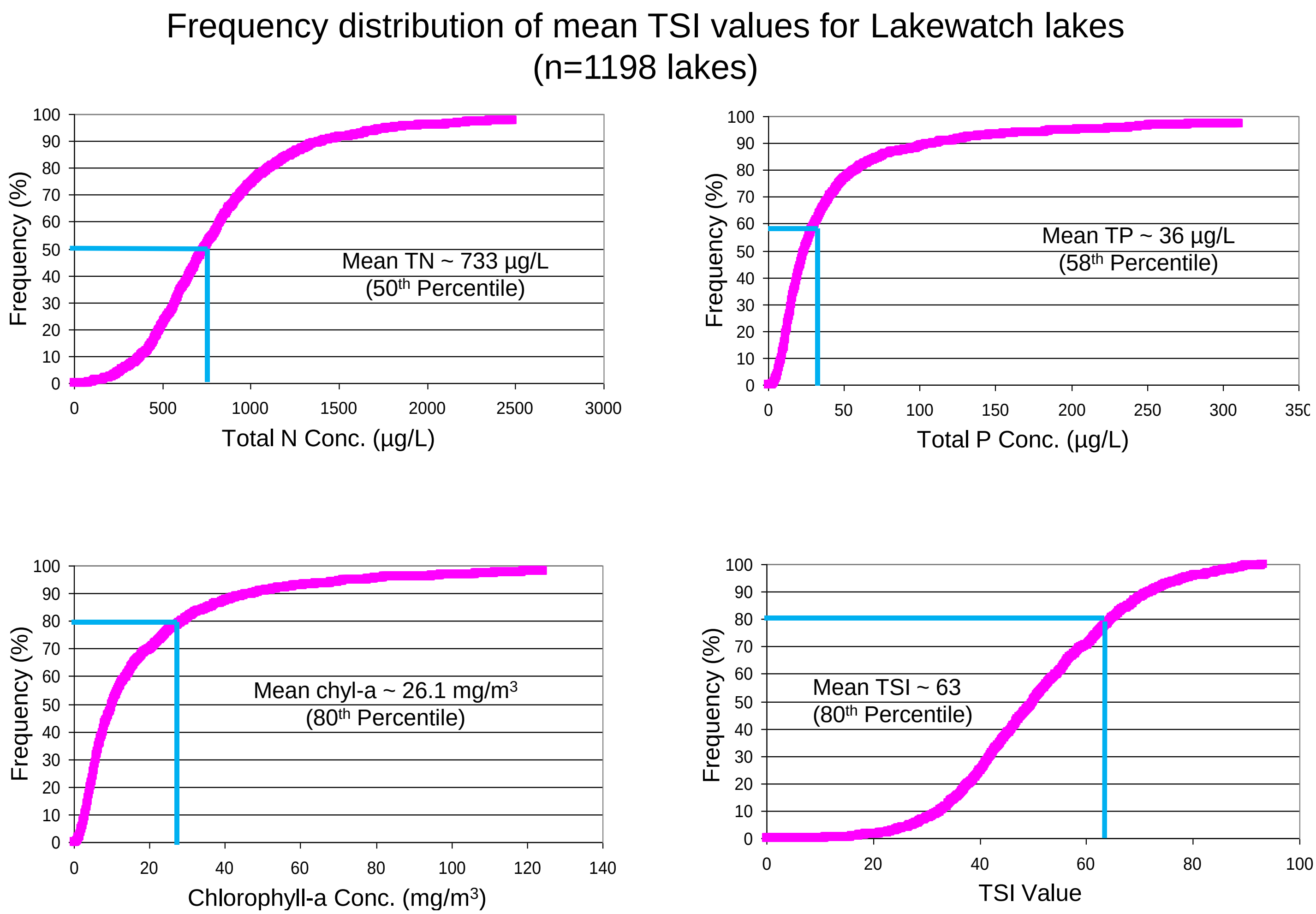


Figure 2-22. Comparison of Significant Water Quality Variables in Lake Concord with Florida LakeWatch Data.

During the period from 2015-2019, the average mean total nitrogen concentration in Lake Concord was approximately 733 µg/l which corresponds to the 50th percentile of waterbodies monitored by the LakeWatch program. The mean total phosphorus concentration of approximately 36 µg/l measured in Lake Concord from 2015-2019 corresponds to approximately the 58th percentile for Florida lakes, while the mean chlorophyll-a concentration of approximately 26.1 mg/m^3 in Lake Concord corresponds to the 80th percentile in comparison with other Florida lakes. The mean TSI value of approximately 63 in Lake Concord from 2015-2019 also corresponds to approximately the 80th percentile in comparison with other Florida lakes. The data suggest that current water quality characteristics in Lake Concord, with the exception of total nitrogen and possibly phosphorus, are much greater than median values in comparison with other Florida lakes.

2.3.2 Current Water Quality Characteristics

A quarterly surface water quality monitoring program has been conducted in Lake Concord by the City since 2003 at a fixed location near the geographic center of the lake. Locations of the current surface water monitoring sites in Lake Concord were indicated on Figure 2-14. Surface water monitoring in Lake Concord was not conducted as part of this specific project, but water quality monitoring is conducted by the City on a quarterly basis, and water quality data were collected in Lake Concord as part of this program.

Data collected as part of this program, including both historical and current water quality characteristics, have been discussed in previous sections. However, vertical field profiles collected in Lake Concord as part of the quarterly monitoring program have not been addressed. Vertical field measurements can provide valuable information concerning biological and chemical processes in lakes. Conditions such as thermal stratification, decreases in pH and increases in conductivity near the water-sediment interface, and oxygen regimes can provide clues concerning issues such as internal recycling. Therefore, a discussion of vertical field profiles collected in Lake Concord as part of the ambient monitoring during 2019 will be used to assess field conditions in Lake Concord.

2.3.2.1 Field Profiles

A compilation of vertical depth profiles collected in Lake Concord during the 3 quarterly monitoring events conducted during 2019 is given on Figure 2-23. Monitoring events were conducted during the months of March, September, and December, and water depths ranged from 3.5-3.9 m. In general, relatively isograde temperature profiles were observed during each of the monitoring events, with only a slight decrease in temperature with increasing depth. The lack of thermal stratification in Lake Concord, common in eutrophic urban lakes, may be related to relatively shallow water depth and the aeration system near the center of the lake installed by the City. Evidence of thermal stratification was not observed during any of the monitoring events. Temperature differences between top and bottom measurements ranged from 0-0.8 ^{o}C. The temperature profiles illustrated on Figure 2-23 suggest a well mixed water column during all events.

Field measured surface pH values in Lake Concord (1 m depth) ranged from approximately 7.3-8.1 during the field monitoring program. Relatively isograde pH conditions were observed to a depth of approximately 3 m during most events, with a trend of decreasing pH with increasing water depth observed below 3 m. Measurements of pH near the water-sediment interface ranged from approximately 6.3-7.5, values which are common in eutrophic urban lakes. Rapid decreases in pH near the water-sediment interface suggest a high rate of decomposition in the surficial sediment layer.

Field measured conductivity values exhibited virtually isograde conditions to a water depth of 3-3.5 m during each of the monitoring events. Measured surface conductivity values were all within a relatively narrow range of approximately 200-215 μmho/cm in the top 3-3.5 m. Increases in conductivity were observed below 3.5 m during each of the field monitoring events, suggesting that internal recycling may be a continuous process in Lake Concord.

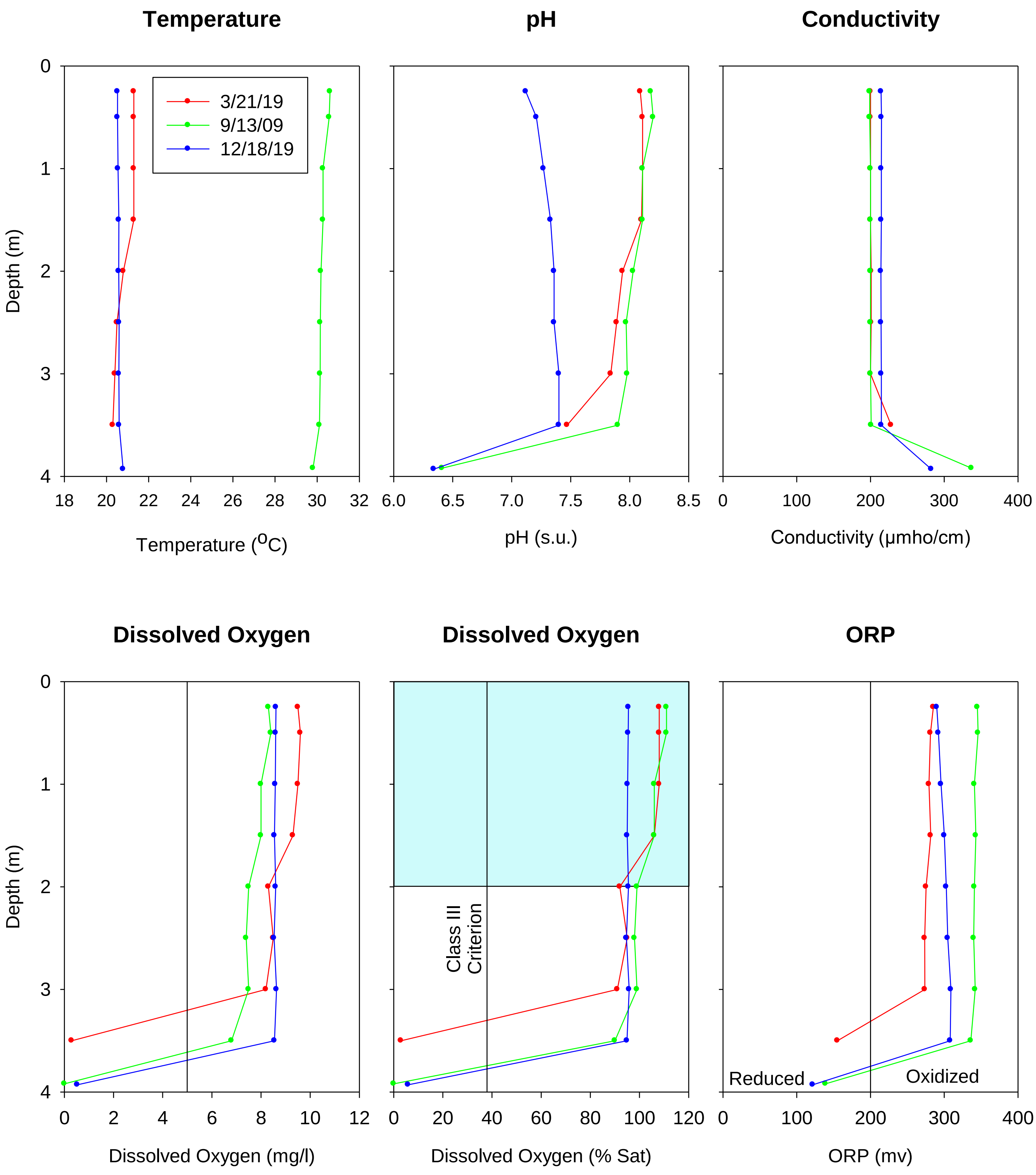


Figure 2-23. Vertical Field Profiles Collected in Lake Concord During 2019.

Relatively isograde dissolved oxygen profiles were observed to a water depth of approximately 3 m during each of the quarterly monitoring events. Dissolved oxygen concentrations above a depth of 3 m were greater than 5 mg/l during each of the events which is the long-term historical dissolved oxygen criterion used within the State of Florida. At depths below 3 m, dissolved oxygen concentrations decreased rapidly to values near zero at the water-sediment interface. Both the dissolved oxygen and temperature profiles indicate a relatively well mixed water column within the top 3 m throughout much of the year, with well oxygenated conditions extending to near the water-sediment interface only during November. An aeration system was installed near the center of Lake Concord during 1996 in response to a fish kill caused by low dissolved oxygen. However, it appears that the aeration system is not capable of maintaining aerobic conditions below a depth of 3-3.5 m during portions of the year. Generally, the dissolved oxygen profiles observed in Lake Concord are indicative of a eutrophic lake with a moderate to large degree of algal productivity.

The standard for dissolved oxygen in Class III freshwater systems (defined as waterbodies used for recreation and wildlife) has historically been 5 mg/l, and this concentration is indicated on Figure 2-23 for reference purposes. However, during 2013, FDEP adopted a revised dissolved oxygen criterion which is based upon oxygen saturation rather than a specific concentration. The revised Class III criterion for dissolved oxygen saturation requires that "the daily average percent dissolved oxygen saturation shall not be below 38% in the top 2 m of the waterbody in the Peninsula region in more than 10% of the locations monitored." Saturation level criteria are also provided in the revised standard for 7-day and 30-day average dissolved oxygen saturation measurements.

For purposes of evaluating compliance with dissolved oxygen in Lake Concord, the 38% saturation value is assumed to apply and is illustrated on Figure 2-23. Based upon the collected field profiles, the 38% saturation criterion was met in the top 2 m of the water column during each of the monitoring events, with saturation concentrations less than 38% at water depths in excess of 3 m during most events. Overall, dissolved oxygen concentrations in the top 2 m of Lake Concord clearly met the FDEP oxygen criterion during the field monitoring program and are suitable for recreation and for wildlife.

In general, measurements of oxygen-reduction potential (ORP) were virtually isograde in the upper 3 m of the water column during each of the monitored events. Highly oxidized conditions were observed to a depth of 3 m during most events, followed by reduced conditions below 3 m during each of the 3 events.

2.3.2.2 <u>Summary</u>

In general, Lake Concord exhibits water quality characteristics which are typical of a eutrophic lake. Continuous historical water quality data, available since 1996, indicate that Lake Concord has exhibited highly variable concentrations of total nitrogen and total phosphorus over time, a characteristic which is consistent with eutrophic Florida lakes. Cyclic patterns of increasing and decreasing chlorophyll-a concentrations have been observed, a pattern which is likely related to changes in plant biomass over time. Stability in total phosphorus concentrations has been observed over the past 4-5 years which may be related to more consistent hydrilla management. Water clarity, as indicated by measurements of Secchi disk depth, has also been highly variable over time and inversely correlated with chlorophyll-a. The historical data show that calculated TN/TP ratios in Lake Concord have indicated nutrient-balanced conditions with a trend toward phosphorus limitation, suggesting that the lake is susceptible to additional phosphorus loadings.

Based upon water quality data collected by the University of Florida LakeWatch Program, Lake Concord is in the 50^{th} percentile of Florida lakes for mean concentrations of total nitrogen, 58^{th} percentile for total phosphorus, 80^{th} percentile for chlorophyll-a, and 80^{th} percentile for trophic state index.

Quarterly water quality monitoring conducted in Lake Concord during 2019 indicates that the water column within the lake is well mixed in the top 3 m throughout virtually all months of the year, with decreases in pH with increasing water depth below 3 m. Virtually isograde conductivity profiles were observed throughout the field monitoring program in upper portions of the water column, with large increases in conductivity near the water-sediment interface which would suggest internal recycling within the lake. Well oxygenated conditions are maintained within the water column to a depth of approximately 3 m which is more than adequate to support recreation and propagation of wildlife, although dissolved oxygen decreased rapidly with depth below 3 m with near-anoxic conditions observed near the water-sediment interface during most events. Oxidized conditions were observed within the lake to a depth of 3 m during most events, with reduced conditions at deeper depths.

Sediment monitoring conducted by ERD indicated deep pockets of organic muck in central portions of the lake. Lake bottom areas outside of the areas of organic muck are comprised mostly of sand.

Overall, Lake Concord appears to be a nutrient-impacted eutrophic waterbody with highly variable water quality. Calculated TN/TP ratios indicate that Lake Concord is sensitive to additional phosphorus loadings, and future development (if any) should maximize phosphorus removal within the stormwater management systems to prevent further degradation of the lake. Since Lake Concord is designated as an Impaired Water, future development will be required to provide stormwater treatment systems which provide sufficient nutrient removal so that the post-development loading does not exceed the pre-development loading from the developed parcel.

2.4 Compliance with Water Quality Criteria

Water quality criteria for Florida lakes are outlined in Chapter 62-302 of the Florida Administrative Code (FAC) titled "Surface Water Quality Standards". Surface water criteria for waterbodies in Florida are based upon the designated uses. Waterbodies such as Lake Concord are considered to be a Class III surface water which is defined as waters used for "fish consumption; recreation; propagation of a healthy, well-balanced population of fish and wildlife" as defined in Section 62-302.400 (FAC).

2.4.1 General Water Quality Criteria

General water quality criteria for Class III freshwater systems are summarized in Section 62-302.530-Surface Water Quality Criteria which contains both numeric and narrative surface water quality that apply to Class III freshwater systems. Surface water quality criteria are provided for more than 100 parameters which include a variety of metals and organic compounds, but only 8 of the standards identified in Section 63-302.530 are common lake parameters which are generally measured as part of ambient lake water quality monitoring programs. A summary of important Class III water quality criteria and observed violations for Lake Concord from 2010-2019 is given in Table 2-9 and includes alkalinity, un-ionized ammonia, fecal coliform, E. coli, BOD, specific conductance, dissolved oxygen, pH, and turbidity.

TABLE 2-9

APPLICABLE CLASS III WATER QUALITY CRITERIA AND OBSERVED VIOLATIONS IN LAKE CONCORD FROM 2010-2019

PARAMETER	WATER QUALITY CRITERIA	VIOLATIONS
Alkalinity	> 20 mg/l unless naturally occurring	None
Un-ionized Ammonia	≤ 0.02 mg/l	None
BOD	Shall not be increased to exceed values which would cause dissolved oxygen to be depressed below limit for established class	None
Specific Conductance	Shall not be increased more than 50% above background or 1,275 μmho/cm, whichever is greater	None
Dissolved Oxygen	> 38% oxygen saturation average within top 2 m of water column	None
pH	6-8.5 s.u.	None
Turbidity	≤ 29 NTU	None
Fecal Coliform	MPN or MF counts shall not exceed a monthly average of 200, nor exceed 400 in 10% of the samples, nor exceed 800 on any one day. Monthly averages shall be expressed as a geometric mean of a minimum of 10 samples taken over a 30-day period.	6-11: 368 cfu/100 ml 10/18: 270 cfu/100 ml
E. Coli	MPN or MF counts shall not exceed a monthly geometric mean of 126 nor exceed the Ten Percent Threshold Value (TPTV) of 410 in 10% or more of the samples during any 30-day period. Monthly geometric means shall be based on a minimum of 10 samples taken over a 30-day period.	None

As discussed in Section 2.3, Lake Concord is a moderate alkalinity system with typical alkalinity values near 60 mg/l. Concentrations of un-ionized ammonia only become significant at pH values in excess of 8.5, and as a result, the low ammonia concentrations combined with the observed historical low pH levels indicate that violations of the un-ionized ammonia criterion are virtually impossible under current conditions.

The water quality criterion for BOD is a narrative standard which states that BOD levels cannot cause conditions where dissolved oxygen would be depressed below the Class III limit for this parameter. BOD measurements were conducted in Lake Concord by the City from 2003-2019, with most values less than 2-3 mg/l. In general, the available BOD measurements in Lake Concord have been low in value, and significant long-term depressions of dissolved oxygen have not been observed. Therefore, no violations of the narrative BOD standard have occurred.

Lake Concord also easily met the maximum criterion of 1,275 μmho/cm for specific conductivity in all lakes at all times which is intended as a point of separation between freshwater and brackish systems Lake Concord also meets the Class III criterion for pH of 6.0-8.5 units on a long-term average. No violations of the turbidity criterion of 29 NTU have been observed during any historical or ambient monitoring event.

The dissolved oxygen criterion for Class III freshwater systems has historically been 5 mg/l. However, during 2012 FDEP adopted a criterion based on oxygen saturation rather than oxygen concentration. The revised dissolved oxygen standard for freshwater systems in the Peninsula Region is a minimum of 38% oxygen saturation as an average value of measurements conducted in the top 2 m of the water column. Oxygen saturation is a function of both the dissolved oxygen concentration as well as the water temperature at the time of the measurement since oxygen solubility increases at lower water temperatures and decreases at higher water temperatures. Oxygen saturation percentages have been included as part of the Lake Concord surface water monitoring program conducted from 2003-2019, and all calculated percentages in the top 2 m easily met the 38% saturation criterion, with the exception of measurements conducted during September 2016 when violations of the 38% criterion were observed in all Casselberry lakes. This highly unlikely event is probably due to a failure of the field monitoring equipment.

Prior to 2016, the Class III microbiological quality indicator was fecal coliform which had a maximum limit of 200 cfu/100 ml. Exceedances of the fecal coliform criterion were observed in Lake Concord during June 2011 (368 cfu/100 ml) and October 2018 (270 cfu/100 ml). These sporadic exceedances do not indicate a chronic microbiological contamination issue in Lake Concord.

Beginning in 2016, the indicator organism was changed to Escherichia coli (E. coli), and the City began including E. coli as a parameter during September 2019. The Class III standard for E. coli bacteria is a variable standard depending upon the availability of data. If a minimum of 10 samples are collected over a 30-day period, then the monthly geometric mean of the samples cannot exceed 126 cfu/100 ml, and no more than 10% of the samples during the monthly period can exceed 410 cfu/100 ml. For purposes of this evaluation, the most conservative criterion (126 cfu/100 ml) is used to indicate E. coli impairment. No exceedances have been observed in subsequent monitoring events in Lake Concord.

2.4.2 Numeric Nutrient Criteria

Surface water within Lake Concord is also subject to the narrative nutrient criteria outlined in Chapter 62-302.531 FAC. This section provides numeric interpretations of the narrative nutrient criteria in Section 62-302.530 (FAC) which states that "In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna". The applicable nutrient criteria vary on an annual basis depending upon geometric mean concentrations for color, alkalinity, and chlorophyll-a within the waterbody. The nutrient criteria also vary depending upon the availability of chlorophyll-a data and concentrations of nutrients and chlorophyll-a in the lake.

A tabular summary of Numeric Nutrient Criteria (NNC) for Florida lakes is given in Table 2-10. Florida lakes are divided into three general categories based upon lake color and alkalinity. The lake color and alkalinity values must be long-term geometric means based on a minimum of 10 data points over a 3-year period with at least one data point in each year. The historical data set for Lake Concord easily meets the data requirements. Based on the selection criteria, Lake Concord is a low color, high alkalinity lake which falls in Category II.

TABLE 2-10

NUMERIC NUTRIENT CRITERIA FOR FLORIDA LAKES
(Source: Chapter 62-302.531 FAC)

CATEGORY	LONG-TERM GEOMETRIC MEAN LAKE COLOR AND ALKALINITY	ANNUAL GEOMETRIC MEAN CHLOROPHYLL-a (mg/m^3)	MINIMUM CALCULATED NUMERIC INTERPRETATION		MAXIMUM CALCULATED NUMERIC INTERPRETATION	
			Annual Geometric Mean Total Phosphorus	Annual Geometric Mean Total Nitrogen	Annual Geometric Mean Total Phosphorus	Annual Geometric Mean Total Nitrogen
I	> 40 Pt-Co units	20	0.05 mg/l	1.27 mg/l	0.16 mg/l	2.23 mg/l
II	≤ 40 Pt-Co units and > 20 mg/l $CaCO_3$	20	0.03 mg/l	1.05 mg/l	0.09 mg/l	1.91 mg/l
III	≤ 40 Pt-Co units and ≤ 20 mg/l $CaCO_3$	6	0.01 mg/l	0.51 mg/l	0.03 mg/l	0.93 mg/l

NOTES: If there are sufficient data to calculate the annual geometric mean chlorophyll-a and the mean does not exceed the chlorophyll-a value for the lake type in the above table, then the TN and TP numeric interpretations for that calendar year shall be the annual geometric means of lake TN and TP samples, subject to the minimum and maximum limits in the above table.

If there are insufficient data to calculate the annual geometric mean chlorophyll-a for a given year or the annual geometric mean chlorophyll-a exceeds the values in the table above for the lake type, then the applicable numeric interpretations for TN and TP shall be the minimum values in the table above.

The applicable nutrient criteria for total nitrogen and total phosphorus in lakes will vary on an annual basis, depending on the availability of chlorophyll-a data and geometric mean concentrations of nutrients and chlorophyll-a in the lake. The applicable nutrient criteria must not be exceeded more than once in any consecutive 3-year period.

A summary of NNC compliance in Lake Concord from 1996-2019 is given in Table 2-11. Although NNC did not become effective until 2015, the criteria are used to evaluate compliance for the entire historical record based on the annual geometric mean values summarized in Table 2-8. No exceedances of the Category II criterion for total nitrogen (1,050 µg/l) have been observed in Lake Concord from 1996-2019. However, exceedances of the chlorophyll-a criterion (20 mg/m^3) have been observed during 21 of the 24 years of available data. Exceedances of the total phosphorus criterion (30 µg/l) have been observed during 22 of the 24 years of data.

TABLE 2-11

SUMMARY OF NNC COMPLIANCE IN LAKE CONCORD FROM 1996-2019

YEAR	CHLOROPHYLL-A	TOTAL NITROGEN	TOTAL PHOSPHORUS	YEAR	CHLOROPHYLL-A	TOTAL NITROGEN	TOTAL PHOSPHORUS
1996	(red)	(green)	(red)	2008	(red)	(green)	(red)
1997	(green)	(green)	(red)	2009	(red)	(green)	(red)
1998	(red)	(green)	(red)	2010	(green)	(green)	(green)
1999	(red)	(green)	(red)	2011	(red)	(green)	(red)
2000	(red)	(green)	(red)	2012	(green)	(green)	(green)
2001	(red)	(green)	(red)	2013	(red)	(green)	(red)
2002	(red)	(green)	(red)	2014	(red)	(green)	(red)
2003	(red)	(green)	(red)	2015	(red)	(green)	(red)
2004	(red)	(green)	(red)	2016	(red)	(green)	(red)
2005	(red)	(green)	(red)	2017	(red)	(green)	(red)
2006	(red)	(green)	(red)	2018	(red)	(green)	(red)
2007	(red)	(green)	(red)	2019	(red)	(green)	(red)

(green) Met NNC for parameter

(red) Exceeded NNC for parameter

2.5 <u>Water Level Control</u>

An overview of outfall drainage patterns for Lake Concord is given on Figure 2-24. Discharges from Lake Concord occur from the east side of the lake into an earthen channel, approximately 10-15 ft in width, which passes beneath Sunset Drive N and Secret Way, ultimately reaching Secret Lake. Discharges from Secret Lake occur through a wide earthen channel on the northwest side of the lake which ultimately discharges to the N. Triplet-Kathryn Canal, entering the southeast side of Lake Kathryn. Lake Kathryn discharges on the north side to Gee Creek and ultimately to Lake Jesup. Lake Concord does not have a water control weir, and water elevations are regulated by the various channels, road crossings, and downstream water elevations.

The City of Casselberry has conducted periodic measurements, generally on a monthly basis, of water surface evaluations in Lake Concord since 1993, although bi-monthly data were collected during some years. A graphical summary of monitored water level elevations in Lake Concord from 1993-2019, based upon information collected by the City, is given on Figure 2-25, with annual rainfall provided for reference purposes. The measured elevations are referenced to the NAVD 88 datum. Reference lines are provided to illustrate the FEMA 10-year flood elevation of 59.5 ft, and the FEMA 100-year flood elevation of 61.50 ft. Lake Concord does not have a stated "control" water level.

Figure 2-24. Outfall Drainage Patterns for Lake Concord.

Over the available period of record, water level elevations in Lake Concord have been highly variable. Water levels in Lake Concord do not appear to be closely correlated with annual rainfall. The peak measured elevation in Lake Concord of approximately 59.1 ft was reached on September 11, 2017 from rainfall generated by Hurricane Irma, which was nearly a 100-year storm in some locations. Over the period from 1993-2019, water levels in Lake Concord ranged from 55.0-59.1 ft, a difference of 4.1 ft.

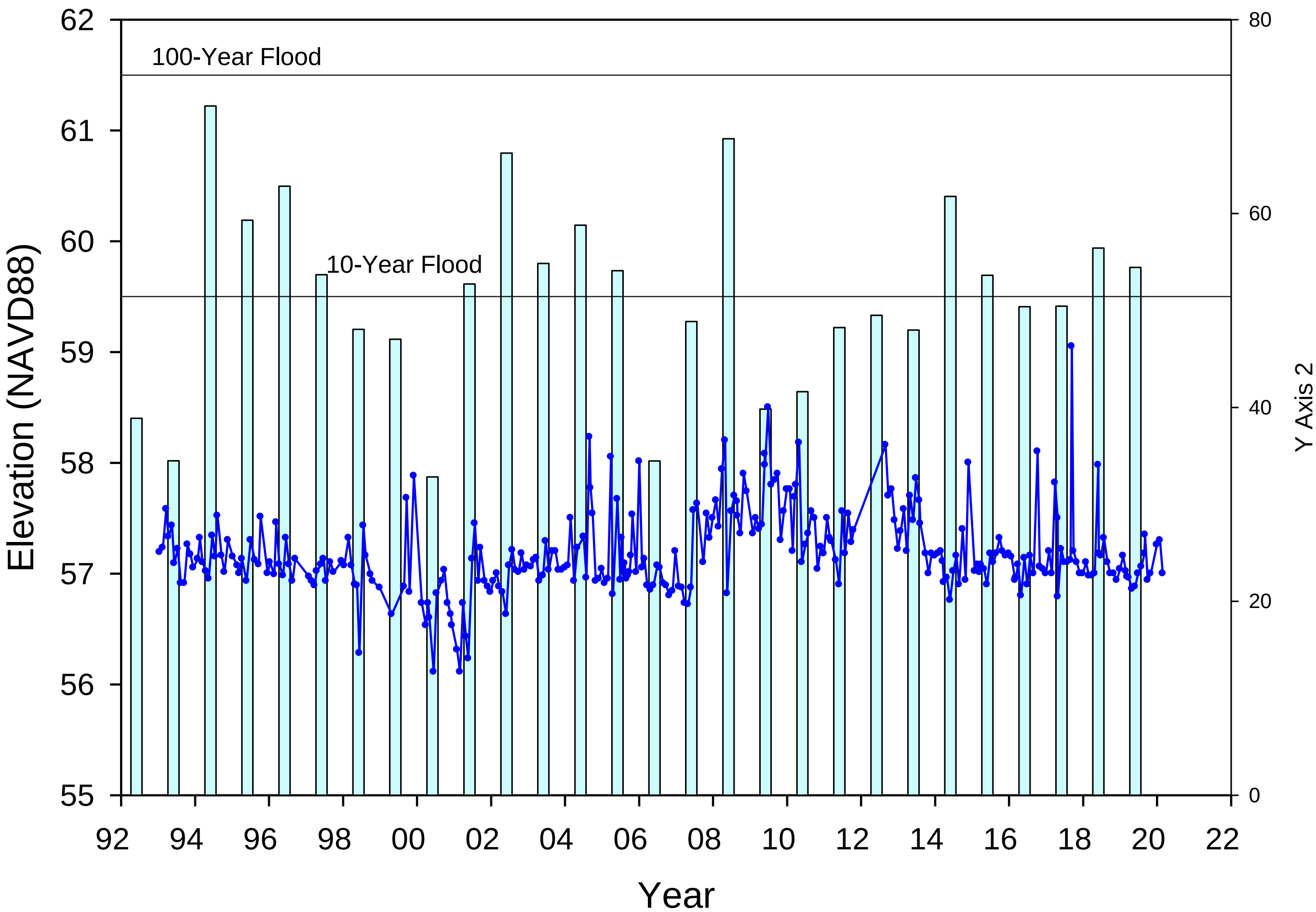


Figure 2-25. Monitored Water Level Elevations in Lake Concord from 1993-2019. (Source: Seminole County)

2.6 Aquatic Vegetation

2.6.1 Shoreline Vegetation

Under existing conditions, shoreline vegetation has been thinned out or removed entirely in most of the developed shoreline areas, while undeveloped areas appear to exist in semi-natural conditions. The original native vegetation has been removed on some of the developed parcels adjacent to the lake, and stands of torpedo grass, water lilies, and other species have colonized in these areas. Shoreline vegetation in undeveloped areas generally reflect natural unaltered conditions, while developed areas have a combination of natural and managed shorelines. No Lake Vegetation Index (LVI) evaluations, a rapid bioassessment tool created by FDEP to assess the biological condition of emergent plant communities, have been conducted in Lake Concord.

2.6.2 Submerged Vegetation

Submerged aquatic vegetation is present in many areas of Lake Concord located within the photic zone. Under existing conditions, the dominant submerged species appears to be hydrilla which is a non-native nuisance submerged aquatic plant. Although ERD observed mostly moderate amounts of hydrilla in Lake Concord during the field monitoring program, hydrilla has created nuisance conditions in Lake Concord since the early-2000s, with reports of hydrilla topped out at the water surface in areas where water depths are less than 6 ft.

2.6.3 Biological Vegetation Control

Concerns over excessive growth of exotic vegetation in Lake Concord date back to the early-2000s. At that time, hydrilla was the primary species of concern with growth that topped out at the surface and was aesthetically unpleasing. In response to these concerns, the City initiated a vegetation control program during 2007 using grass carp. Grass carp are a non-native fish species which eat aquatic vegetation. The addition of biological controls allows for less reliance on chemical methods which reduces the potential for development of chemical tolerance.

Grass carp (*Ctenopharyngodon idella*), also known as white amur, are native to Asia and feed only on aquatic plants. They were first introduced to Florida in 1970 to control nuisance aquatic plant growth. In 1984, a method to sterilize grass carp was developed, which enabled the production of the triploid grass carp used today that have been genetically altered at hatcheries to prevent them from reproducing. Triploid grass carp are a biological and economical alternative for controlling particular aquatic weeds in waterbodies.

Grass carp live for at least 10 years and sometimes much longer in cooler waters. They grow rapidly in Florida conditions, reaching at least 10 pounds, with some fish exceeding 40 pounds. Grass carp are opportunistic herbivores that will consume a variety of aquatic plants. Their preference is based on vegetation taste and texture and not necessarily on plant availability. Grass carp generally only consume submerged vegetation that has soft/tender, non-fibrous stems and leaves. Some common plants they will readily consume are hydrilla, elodea, bladderwort, coontail, najas, milfoil, potamogeton spp. (pondweeds), chara, and nitella. They dislike and rarely eat woody or hardy-stemmed plants such as cattails, lillypads, sedges, primrose, and many more. When desirable plant species have been eliminated, grass carp have been known to eat lawn grasses, particularly St. Augustine, along the water edge. A summary of grass carp feeding preferences for common aquatic plants is given in Table 2-12.

Grass carp feed from the top of the plant down which minimizes broken floating vegetation and disturbance of bottom muds. They often avoid areas of heavy human activity and forage in deeper areas. Photographs of grass carp are given on Figure 2-26.

Grass carp are an inexpensive method of aquatic plant control, with costs ranging from $20-250/acre compared with $200-600/acre for chemical control, and provide a long-term control alternative to chemical applications. Grass carp are commonly used as part of an integrated plant management plan in combination with periodic, but limited, chemical applications.

TABLE 2-12

GRASS CARP FEEDING PREFERENCE FOR COMMON AQUATIC PLANTS

PREFERENCE	SCIENTIFIC NAME	COMMON NAME
Highly Preferred	*Cabomba caroliniana*	Fanwort
	Chara spp.	Muskgrass
	Egeria densa	Brazilian elodea
	Elodea canadensis	Common elodea
	Hydrilla verticillata	Hydrilla
	Lemna spp. and *Spirodela* spp.	Duckweed
	Najas quadalupensis	Southern naiad
Moderately Preferred	*Azolla caroliniana*	Azolla or water-fern
	Bacopa spp.	Water hyssop
	Eleocharis spp.	Slender spikerush
	Potamogeton spp.	Pondweeds
	Utricularia spp.	Bladderworts
Non-Preferred	*Ceratophyllum demersum*	Coontail
	Myriophyllum spp.	Milfoils
	Brasenia schreberi	Water shield
	Nuphar spp.	Spatterdock
	Nymphaea spp.	Waterlillies
	Vallisneria Americana	Tapegrass or eelgrass
	Nelumbo luteum	Lotus

SOURCE: Sutton and Vandiver (1986), Miller and Decell (1984), Wiley et al. (1984)

a. Juvenile grass carp at time of stocking

b. Adult grass carp

Figure 2-26. Photographs of Grass Carp Used for Vegetation Control.

Reported mortality rates for grass carp are highly variable, with values ranging from 2.5-40%/year, with the highest rates often associated with juveniles and the lowest rates for adults, although the most common range appears to be 25-40%/year. Most of the current mortality data are based on studies in temperate reservoirs and may not be applicable to Florida conditions. However, even with fish mortality, vegetation control often remains steady for multi-year periods due to increased consumption as the remaining fish increase in size.

Stocking rates for grass carp have also varied widely depending on the degree of aquatic infestation, type of vegetation, and climate. Literature stocking rates have varied from 1 to >50 fish/acre, with the higher stocking rates in colder climates where the fish metabolism decreases. Faculty in the Department of Fisheries at the University of Florida currently recommend a stocking rate of 2 fish/acre for hydrilla control in most lakes. A stocking rate in this range is intended to provide a slow steady decline in vegetation biomass over a period of years.

In some instances, stakeholders have become frustrated with the slow initial response and stocked additional grass carp which has led to complete vegetation removal and transformation of the lake into a plankton-dominated system with frequent algal blooms and poor water quality. A minimum SAV coverage of 30-50% native vegetation is generally recommended to maintain a healthy lake. Once a lake becomes a plankton-dominated system, it is quite difficult to return the lake to a clear water, macrophytes-dominated system. It is much better to be conservative when estimating required stocking rates. More carp can always be added in a few years if desired control is not achieved. As the grass carp mature, it is hoped that vegetation control will be achieved primarily by the grass carp, and chemical control will be substantially reduced.

A summary of grass carp stocking events in Lake Concord is given in Table 2-13. On August 16, 2007, the City stocked 170 triploid grass carp in Lake Concord to control the growth of aquatic vegetation. Based upon a lake area of 19.7 acres, the stocking corresponds to a rate of approximately 8.6 fish/acre which is much greater than the current recommended grass carp addition rate of 2 fish/acre. On April 4, 2009, an additional 100 grass carp were introduced into Lake Concord, with 15 grass carp added on March 13, 2014. Overall, 285 grass carp have been added to Lake Concord although the current residual population number is not known.

TABLE 2-13

STOCKING EVENTS FOR GRASS CARP IN LAKE CONCORD BY THE CITY OF CASSELBERRY

STOCKING DATE	NUMBER OF FISH ADDED	EVENT STOCKING RATE (fish/acre)
8/16/07	170	8.6
4/4/09	100	5.1
3/13/14	15	0.8
TOTAL:	**285**	**--**

2.6.4 <u>Chemical Vegetation Control</u>

Although a large number of grass carp had been added to Lake Concord during 2007 and 2009, the growth of hydrilla became excessive during 2014, and an initial herbicide application was conducted to the lake on February 23, 2015 using Aquathol K. Additional applications of Aquathol K were conducted during 2016, 2017, 2018, and 2019 for hydrilla control in perimeter areas of the lake. A summary of herbicide applications to Lake Concord is given in Table 2-14.

TABLE 2-14

HERBICIDE APPLICATIONS TO LAKE CONCORD FOR HYDRILLA CONTROL

DATE	AREA TREATED (acres)	HERBICIDE USED	APPLIED WATER COLUMN DOSE
2/23/15	4.0	Aquathol K	4 ppm in perimeter areas
5/13/16	3.5	Aquathol K	4 ppm in perimeter areas
4/5/17	3.0	Aquathol K	3 ppm in perimeter areas
7/13/18	5.4	Aquathol K	3 ppm in perimeter areas
4/8/19	6.5	Aquathol K and Diquat	3 ppm Aquathol and 0.37 ppm Diquat in perimeter areas

SECTION 3

CHARACTERISTICS OF THE LAKE CONCORD DRAINAGE BASIN

This section provides a discussion of characteristics of the drainage basin area for Lake Concord, including information on drainage basin delineations, land use characteristics, soil types, basin topography, hydrologic characteristics, governmental jurisdictions, stormwater treatment facilities and techniques, and methods of sewage disposal. A discussion of current watershed characteristics is given in the following sections. For purposes of this analysis, "current" conditions are defined as January 2019.

3.1 Watershed Characteristics

A delineation of contributing drainage basin areas to Lake Concord was provided to ERD by Geosyntec, along with a GIS file containing available stormsewer inventory. In addition to the information obtained from Geosyntec, ERD also used high-resolution aerial photography (January 2018) for the drainage basin area and conducted extensive field reconnaissance. This information was used by ERD to verify and modify, as appropriate, the watershed delineation provided by Geosyntec to reflect existing conditions at the time of this analysis during 2019, and to ensure that each sub-basin reflected a single point of discharge to Lake Concord. An overview of the final delineated drainage basin for Lake Concord is given on Figure 3-1. In addition to the watershed areas which directly contribute to Lake Concord, the lake also receives overflow discharges from Quail Pond, a small 2.92-acre lake located south of Lake Concord.

An overview of drainage sub-basin delineations and stormsewer infrastructure for Lake Concord is given on Figure 3-2, based on information provided by Geosyntec. Sub-basin areas discharging to Lake Concord were delineated by Geosyntec to assist in modeling runoff and treatment areas. The watershed sub-basin delineations developed by Geosyntec were modified slightly by ERD to separate waterbodies from sub-basin areas. Watershed areas extend approximately 1,400 ft north, 800 ft east, 200 ft south, and 2,200 ft west of Lake Concord. The drainage basin area consists primarily of commercial, industrial, and highway land uses, some of which have stormwater treatment systems, and residential areas without treatment systems.

The sub-basins summarized on Figure 3-2 represent areas which discharge to Lake Concord through a unique point of inflow such as a canal, creek, or stormsewer pipe. Six separate sub-basin areas were identified which discharge to Lake Concord through a unique point of inflow which are designated as Sub-basins 1 through 6 on Figure 3-2.

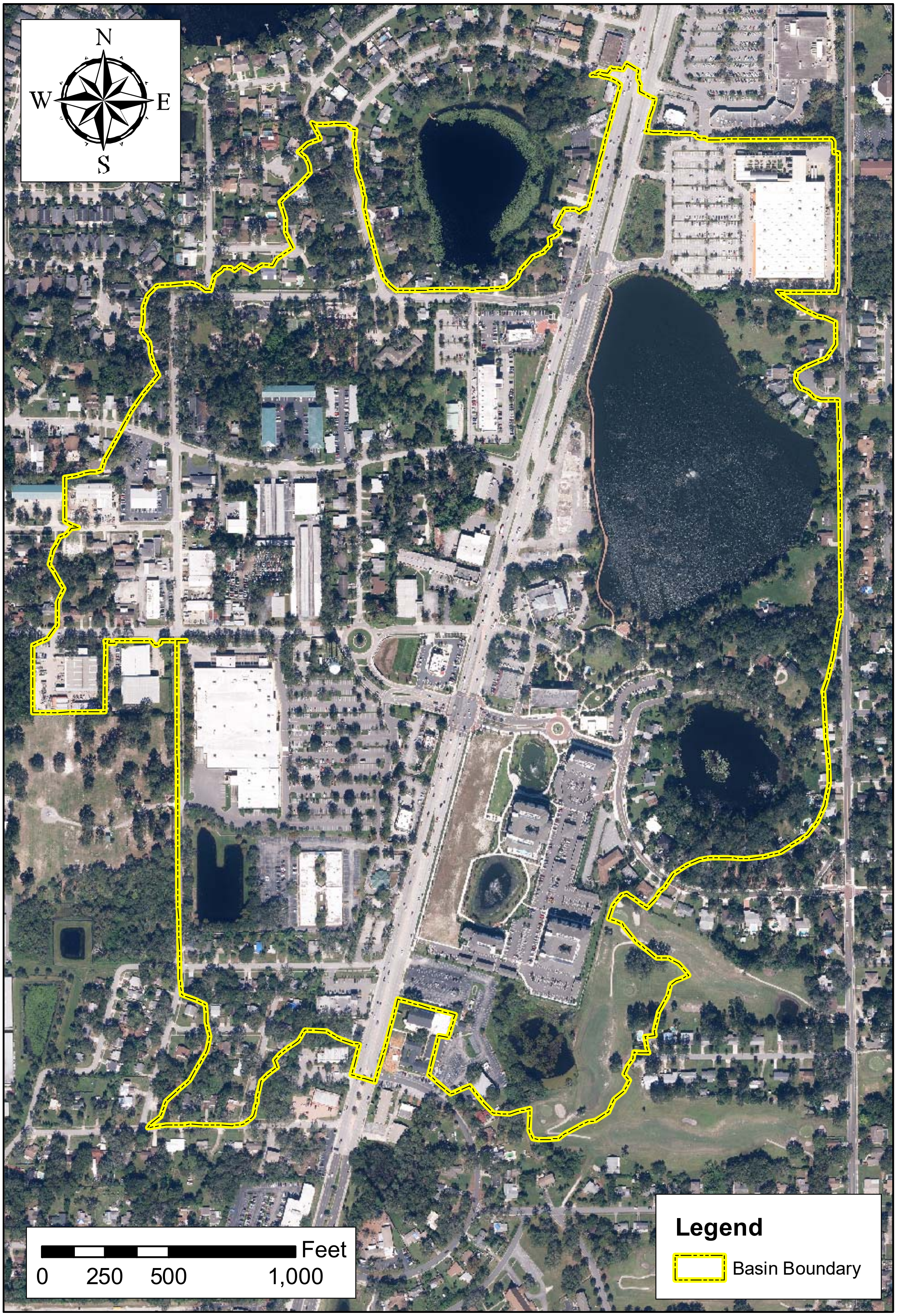


Figure 3-1. Overview of the Lake Concord Drainage Basin Area.
(Photo Date: January 2019)

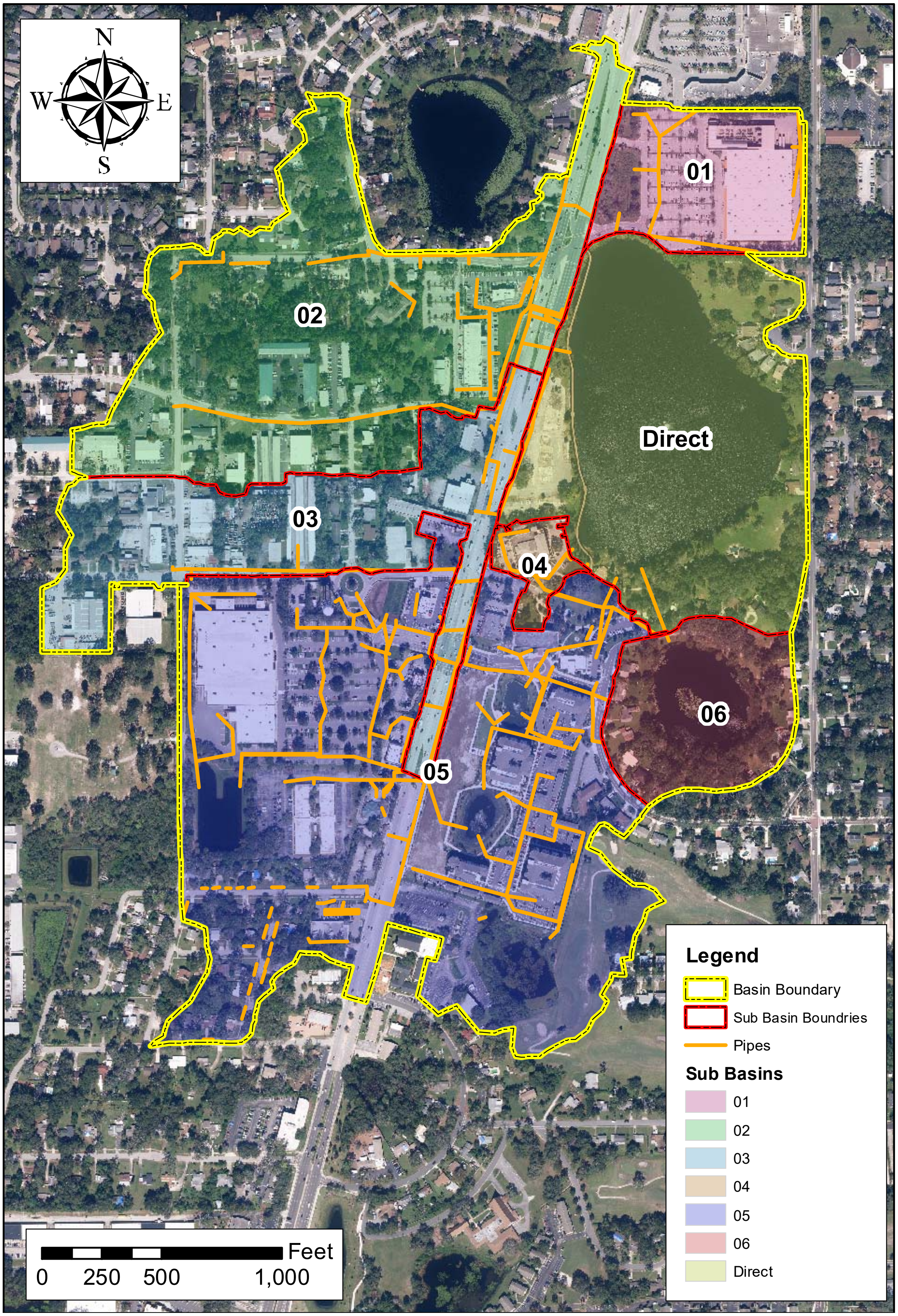


Figure 3-2. Drainage Sub-basin Areas Discharging to Lake Concord, Including Stormsewer Infrastructure. (Photo Date: January 2019)

In addition to the sub-basin areas which discharge through a unique point of inflow, a portion of the drainage basin immediately adjacent to Lake Concord discharges to the lake by diffuse overland flow rather than a defined point of inflow. These areas are referred to as Direct sub-basins and typically consist primarily of rear yards of lake side residential lots and shoulder areas along US 17-92, along with a currently vacant former commercial site.

A tabular summary of sub-basin areas discharging to Lake Concord is given in Table 3-1. The identified sub-basin areas for Lake Concord range in size from 2.40 acres (Sub-basin 4) to 73.17 acres (Sub-basin 5), with a total of 182.48 acres, excluding the lake surface (19.72 acres). The largest sub-basin areas are Sub-basins 2, 3, 5, and the Direct overland flow sub-basin which contain 24.1%, 12.9%, 40.1%, and 9.2%, respectively, of the overall drainage basin area. Each of the remaining sub-basin areas contributes approximately 6% or less of the total basin area.

TABLE 3-1

SUB-BASIN AREAS DISCHARGING TO LAKE CONCORD

BASIN NAME	AREA (acres)	PERCENT OF TOTAL (%)	METHOD OF DISCHARGE TO LAKE
1	11.25	6.2	Outfall from Home Depot pond into north side of lake
2	43.80	24.1	Stormsewer into west side of lake
3	23.60	12.9	Stormsewer outfall into west side of lake
4	2.40	1.3	Stormsewer outfall on southwest side of lake
5	73.17	40.1	Stormsewer on south side of lake; monitored for this project
6	11.39	6.2	Outfall from Quail Pond into south end of lake
Direct	16.87	9.2	Overland flow to lake
TOTAL:	**182.48**	**100**	

Drainage basin/lake area ratios are sometimes useful in evaluating the potential for runoff inputs to have a significant impact on water quality within a waterbody. Some researchers have suggested that drainage basin/lake area ratios substantially less than 7 indicate lakes where nonpoint source pollution should have minimal impacts on lake water quality, while drainage basin/lake area ratios substantially in excess of 7 indicate waterbodies where nonpoint source impacts may be significant. Based on the drainage basin area of 182.48 acres and a lake surface area of 19.72 acres for Lake Concord, the calculated watershed/lake area ratio for Lake Concord is 9.3. Based on this ratio, nonpoint source impacts from adjacent watershed areas may be a significant input to Lake Concord.

3.2 Land Use in the Lake Concord Drainage Basin

Preliminary land use information for Lake Concord was obtained from the 2014 Land Use Inventory conducted by SJRWMD. The Land Use Inventory is the standard resource used by FDEP and engineers throughout Florida for calculating runoff loadings and for developing TMDL documents and analyses. These data provide a uniform methodology for defining land use throughout Florida which is independent of local land use definitions.

The information for the Lake Concord watershed land use was initially obtained in a GIS format in the form of Level III FLUCCS (Florida Land Use Cover and Classification System) codes. The Level III FLUCCS codes were condensed by ERD to a series of general land use categories to simplify presentation of the information and to assist in assigning runoff characteristics for land use types. The SJRWMD inventory was used as a preliminary base map, and modifications to the land use characterization data were made, as necessary, using a combination of recent high resolution aerial photography and field reconnaissance to reflect land use in the Lake Concord drainage basin under current conditions, defined as January 2019 for purposes of this analysis.

An overview of current land use (January 2019) in the Lake Concord drainage basin is given on Figure 3-3. Under current conditions, the drainage basin is dominated primarily by commercial, medium-density residential, open space, institutional, highway, high-density residential, and industrial land uses. In addition to the developed land use categories listed previously, the Lake Concord drainage basin also includes cemetery, golf courses, low-density residential, scrub, upland forest, utilities, wetlands, and water.

A tabular summary of current land use in the Lake Concord drainage basin is given in Table 3-2. A land use summary is provided for each of the sub-basin areas identified on Figure 3-2. Overall, the single largest land use category in the Lake Concord drainage basin is commercial which covers approximately 29.8% of the total drainage basin area. The second most significant land use category is medium-density residential which occupies 16.7% of the overall drainage basin area, followed by open space (7.7%), institutional (6.8%), highway (6.5%), high-density residential (5.9%), and industrial (5.6%). Each of the remaining land use categories contributes approximately 5% or less of the overall drainage basin area.

3.3 Soil Characteristics

Information on soil types within the Lake Concord drainage basin was obtained from the SJRWMD GIS database. Soil information was extracted in the form of Hydrologic Soil Groups (HSG) which classify soil types with respect to runoff-producing characteristics. The chief consideration in each of the soil group types is the inherent capacity of bare soil to permit infiltration. A summary of the characteristics of hydrologic soil groups present in the Lake Concord drainage basin is given in Table 3-3.

A graphical summary of hydrologic soil groups (HSG) in the Lake Concord drainage basin under existing conditions is given on Figure 3-4. Soils in the Lake Concord drainage basin are dominated by HSG A and D, with the HSG A soils exhibiting a low runoff potential under developed conditions, and D soils indicating soils which exhibit a high runoff potential.

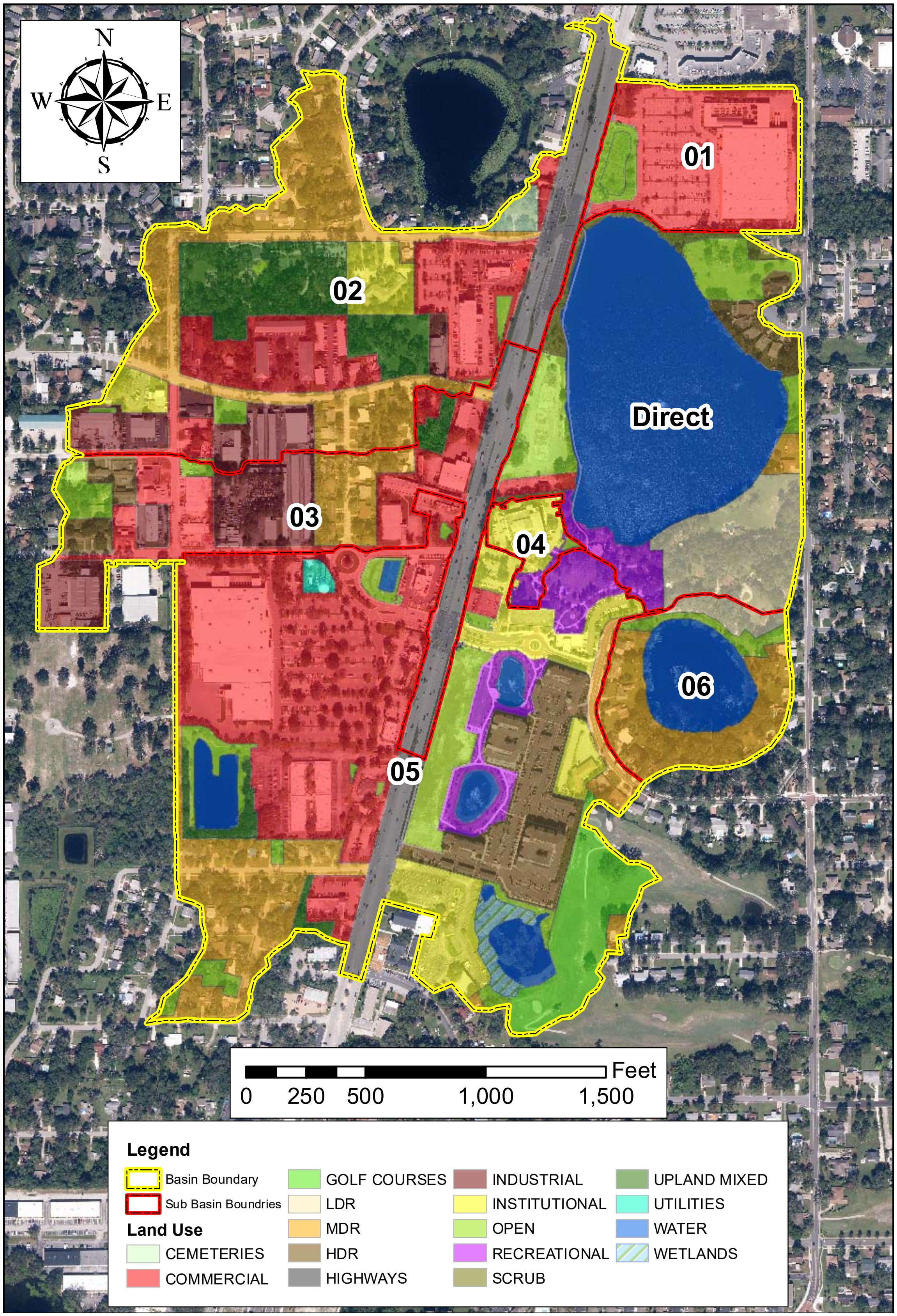


Figure 3-3. Current (2019) Land Use in the Lake Concord Drainage Basin.

TABLE 3-2

CURRENT (2019) LAND USE CHARACTERISTICS IN THE LAKE CONCORD DRAINAGE BASIN

LAND USE CATEGORY	LAND USE AREA BY SUB-BASINS (acres)							TOTAL	PERCENT OF TOTAL (%)
	1	2	3	4	5	6	Direct		
Cemetery	--	0.58	--	--	--	--	--	0.58	0.3
Commercial	9.97	11.17	7.06	--	25.51	--	0.55	54.26	29.8
Golf Course	--	--	--	--	5.07	--	--	5.07	2.8
High-Density Residential	--	--	1.52	--	7.48	--	1.85	10.85	5.9
Highway	0.07	4.84	4.59	--	2.35	--	0.06	11.91	6.5
Industrial	--	4.39	5.91	--	--	--	--	10.30	5.6
Institutional	--	2.76	0.07	1.79	7.71	--	--	12.33	6.8
Low-Density Residential	--	--	--	--	--	1.02	6.02	7.04	3.9
Medium-Density Residential	--	12.41	2.76	--	9.20	5.52	0.54	30.43	16.7
Open Space	1.21	0.72	1.18	0.05	5.38	0.80	4.75	14.09	7.7
Recreational	--	--	--	0.56	4.05	--	1.74	6.35	3.5
Scrub	--	--	--	--	--	--	1.36	1.36	0.7
Upland Forest	--	6.93	0.51	--	1.15	--	--	8.59	4.7
Utilities	--	--	--	--	0.36	--	--	0.36	0.2
Wetlands	--	--	--	--	0.97	--	--	0.97	0.5
Water	--	--	--	--	3.94	4.05	--	7.99	4.4
TOTAL:	**11.25**	**43.80**	**23.60**	**2.40**	**73.17**	**11.39**	**16.87**	**182.48**	**100**

TABLE 3-3

CHARACTERISTICS OF SCS HYDROLOGIC SOIL GROUP CLASSIFICATIONS

SOIL GROUP	DESCRIPTION	RUNOFF POTENTIAL	INFILTRATION RATE
A	Deep sandy soils	Very low	High
D	Sandy soils with high clay or organic content	Very high	Very low
W	Wetland or hydric soils	Very high	Low to none

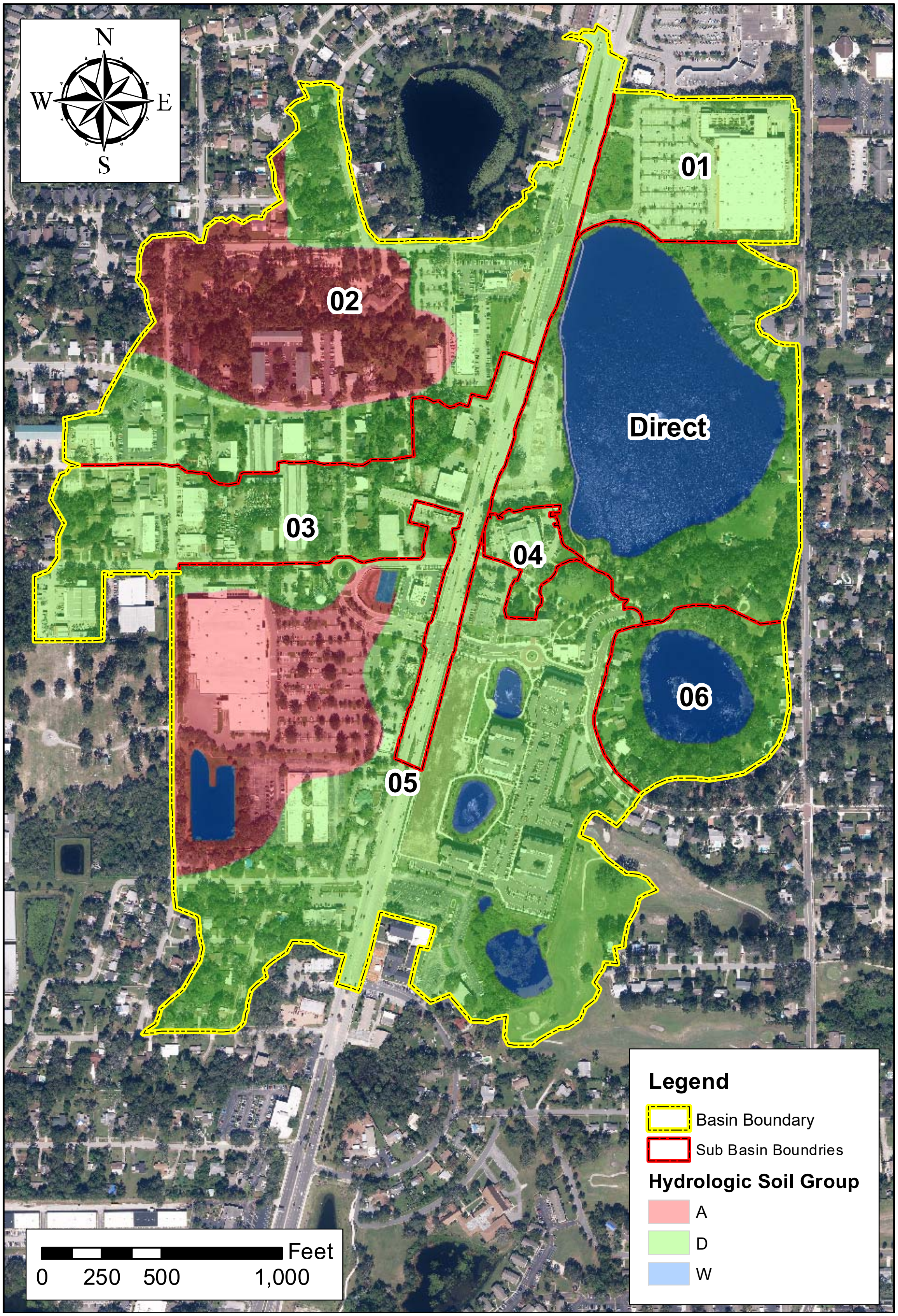


Figure 3-4. Hydrologic Soil Groups (HSG) in the Lake Concord Drainage Basin.

A tabular summary of hydrologic soils in the Lake Concord drainage basin under existing conditions is given in Table 3-4. Approximately 19.5% of the soils within the drainage basin are classified in HSG A which reflects deep sandy soils with a low runoff potential and a high infiltration rate, while 76.1% of the soils within the basin have a classification of HSG D which consists of soils with a high water table and high runoff potential. Approximately 4.4% of the drainage basin area is covered by HSG W soils which consist of wetland, ponds, and hydric soils.

TABLE 3-4

HYDROLOGIC SOIL GROUPS IN THE LAKE CONCORD DRAINAGE BASIN

BASIN NAME	AREA BY HYDROLOGIC SOIL GROUP (acres)			TOTAL (acres)
	A	D	W	
1	--	11.25	--	11.25
2	18.37	25.43	--	43.80
3	--	23.60	--	23.60
4	--	2.40	--	2.40
5	17.20	52.04	3.93	73.17
6	--	7.34	4.05	11.39
Direct	--	16.87	--	16.87
TOTAL:	**35.57**	**138.93**	**7.98**	**182.48**
PERCENT OF TOTAL:	**19.5**	**76.1**	**4.4**	**100**

3.4 Topography

Topographic information for the Lake Concord drainage basin was obtained from the St. Johns River Water Management District (SJRWMD) in the form of a digital elevation map (DEM) dated 2008. The delineated drainage basin boundary was superimposed over the aerial contour maps to develop the drainage basin topographic map which is given on Figure 3-5. Elevation contours for the Lake Concord drainage basin range from approximately 100 ft (NAVD 88) in western perimeter portions of the drainage basin to approximately 50-51 ft in the vicinity of the lake.

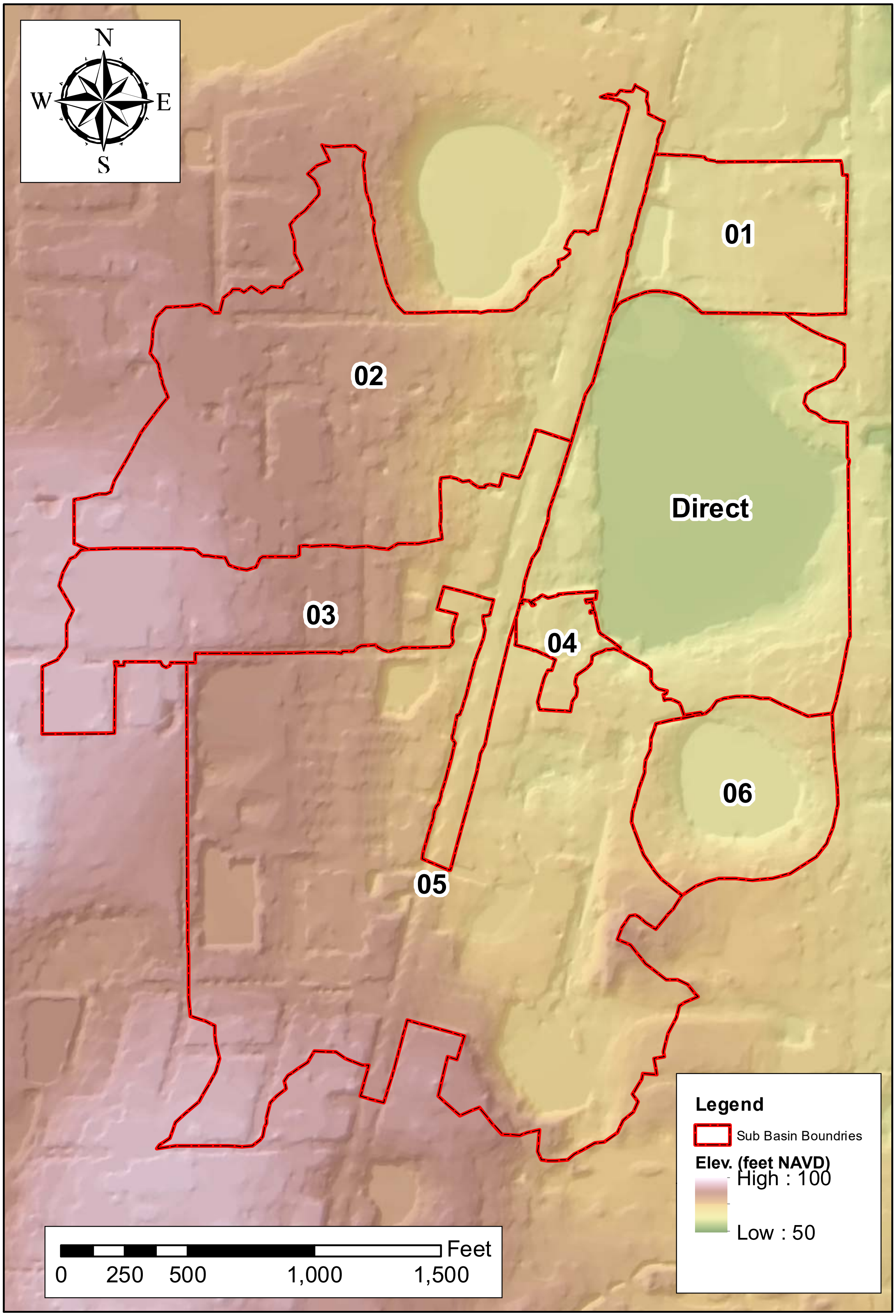


Figure 3-5. Topographic Contour Elevations in the Lake Concord Drainage Basin.

3.5 Governmental Jurisdiction

The Lake Concord drainage basin is located entirely within the City of Casselberry. No portions of the lake or drainage basin are located in any unincorporated area, although FDOT has jurisdiction over the US 17-92 right-of-way (ROW).

3.6 Sewage Disposal

Information on current methods for sanitary sewage disposal within the Lake Concord drainage basin was obtained by ERD as a GIS data layer from the Seminole County GIS System. Wastewater disposal is categorized as "septic" which reflects parcels which use on-site septic tanks for wastewater disposal. Areas categorized as "sewer" reflect areas where central sewer is currently available.

An overview of current sewage disposal methods in the Lake Concord drainage basin is given in Figure 3-6. Under current conditions, virtually all of the developed parcels in the Lake Concord drainage basin use a central sewer system for sewage disposal. The only areas in the Lake Concord basin which do not have central sewer systems are a few scattered parcels in Sub-basin 2, a few residential homes on Quail Pond, and a few parcels in the Direct overland flow sub-basin.

3.7 Stormwater Treatment

Watershed areas which currently receive stormwater treatment within the Lake Concord drainage basin were identified by ERD using a combination of aerial photography, field reconnaissance, and a review of historical permitting records in possession of SJRWMD. A summary of the results of this evaluation are given on Figure 3-7 which illustrates parcels with currently permitted stormwater management systems within the Lake Concord drainage basin during January 2019.

Permitted stormwater management systems within the basin area consist primarily of dry retention ponds and exfiltration trenches (which rely upon infiltration of runoff into the soil), wet detention ponds (which provide stormwater treatment by a combination of physical settling of particles and biological uptake of nutrients), and dry detention systems (which detain the runoff to allow settling of particulates). Runoff also discharges to natural ponds and wetlands in some areas which can also provide some limited treatment. Although not permitted as stormwater treatment systems, roadside swales are also present in Sub-basin 5 which retain portions of the generated runoff volume.

As indicated on Figure 3-7, many of the currently developed parcels within the Lake Concord drainage basin have existing stormwater management facilities, consisting primarily of dry and wet detention ponds. Historical construction drawings for US 17-92 indicate buried underground exfiltration systems beneath the roadway, but the extent of the exfiltration systems, areas served, level of treatment, and current condition are not known and are considered to be negligible for this analysis. The only parcels which do not currently have stormwater treatment systems are the industrial properties located in Sub-basin 3, multiple open areas, and the Direct overland flow area. All future development or redevelopment in the Lake Concord basin will be required to provide stormwater treatment according to design criteria at the time of application for the development.

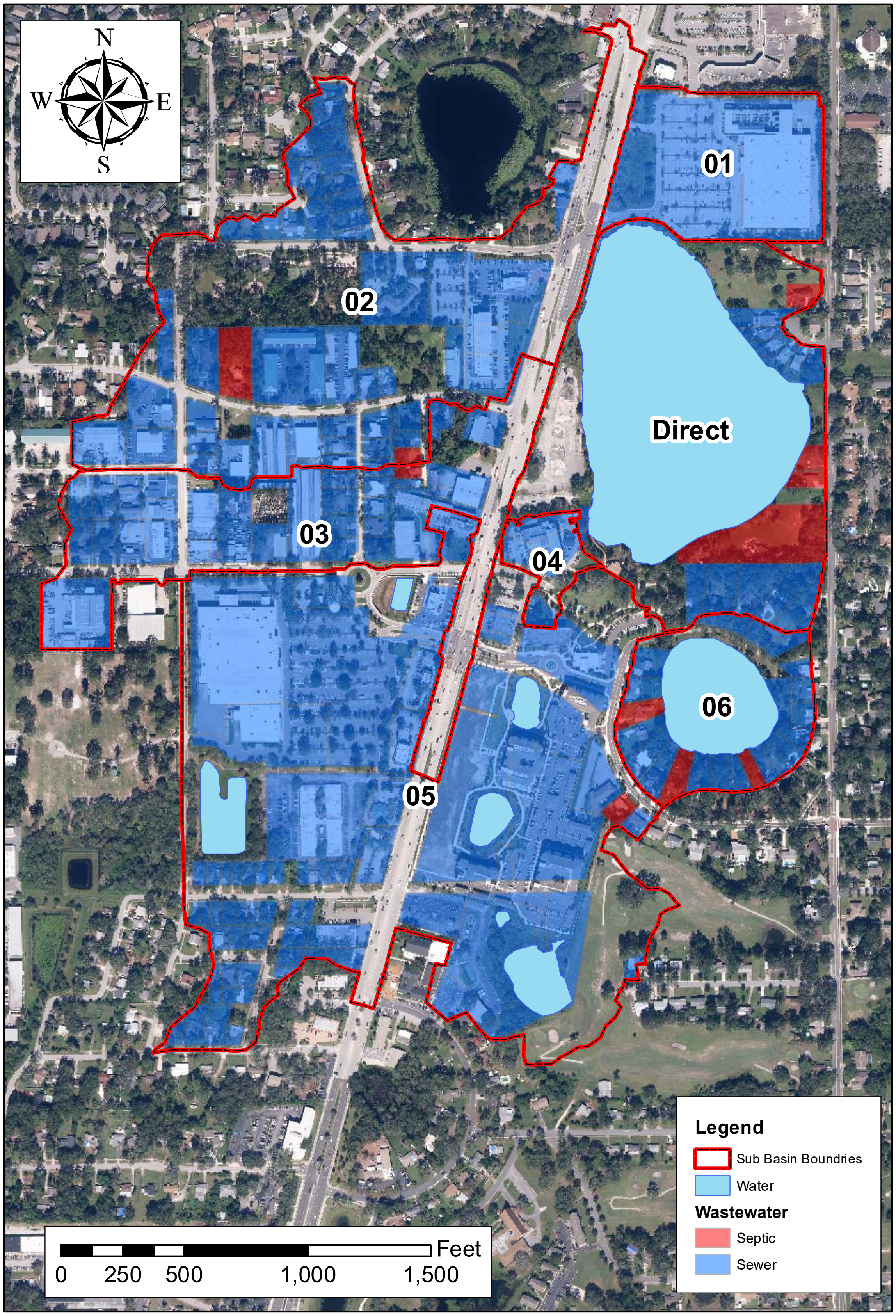


Figure 3-6. Current Sewage Disposal Methods in the Lake Concord Drainage Basin. (January 2019)

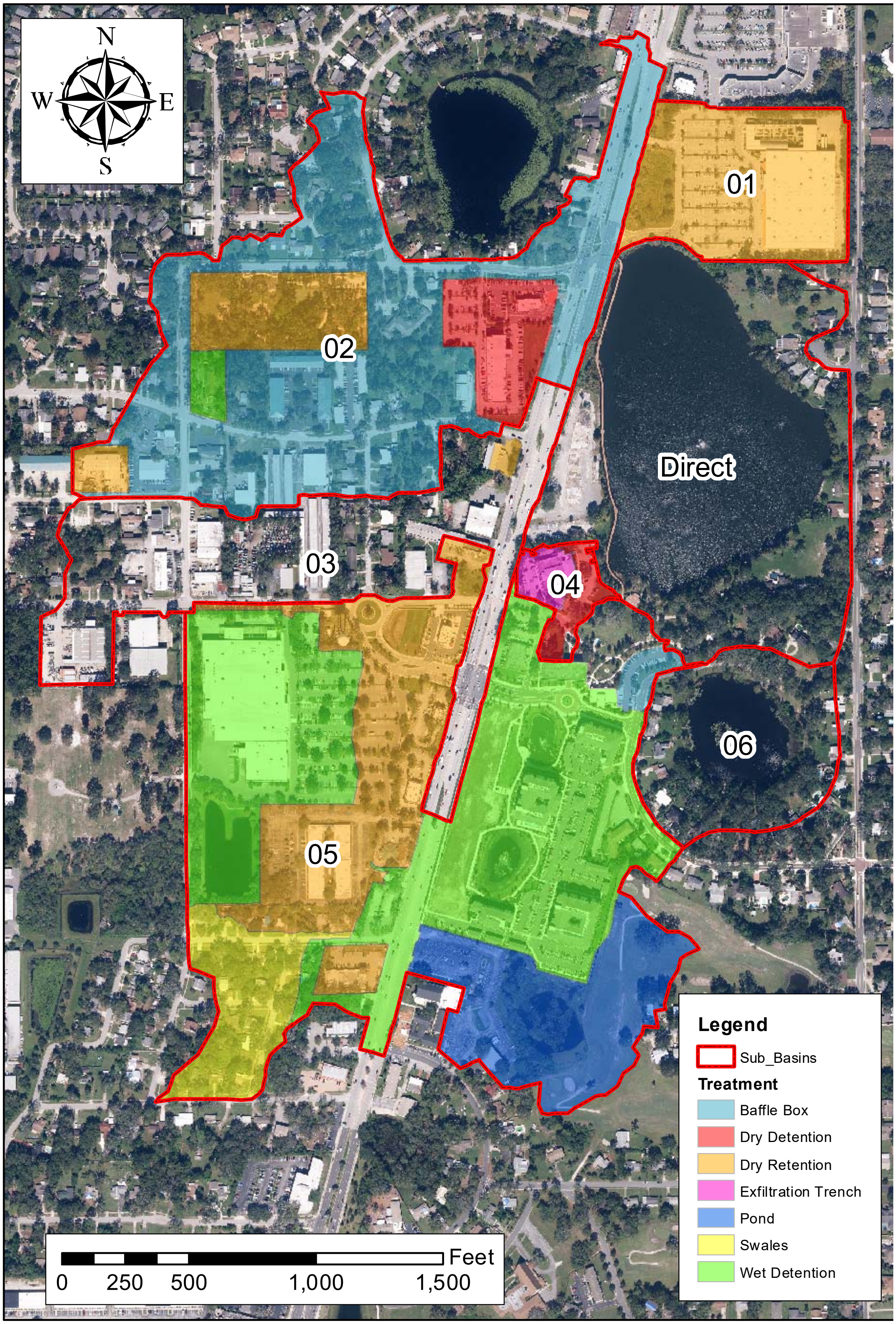


Figure 3-7. Permitted Stormwater Management Systems in the Lake Concord Drainage Basin. (January 2019)

Sub-basin 2 consists of an area of commercial, highway, industrial, residential, and natural land areas which discharge into the west side of Lake Concord through a 30-inch RCP with a baffle box constructed at the outfall. The performance efficiency of this baffle box was evaluated by ERD during 2013, with the results presented in a December 2014 Final Report. The watershed delineation for the baffle box was obtained by ERD from permit documents developed by another consultant which identified this area as Sub-basin G-3 with an area of 5.64 acres, and this information was used by ERD in the 2014 report. However, the sub-basin delineation conducted by Geosyntec for this current project indicates a much larger sub-basin of 43.80 acres, and after reviewing available plans and permits, ERD concurs with this value which is used for purposes of this report. Therefore, the baffle box is assumed to treat all runoff generated in Sub-basin 2 even though upstream portions of the sub-basin also receive treatment in dry detention or dry retention systems.

The stormsewer system beneath US 17-92 is extremely complex, and the available drainage plans do not adequately depict the extent of the drainage system. Multiple pipes discharging into Lake Concord in the area of the baffle box seem to be interconnected and may serve as alternate outfall in the event that the baffle box becomes clogged.

A tabular summary of watershed areas with existing stormwater management systems in the Lake Concord drainage basin is given on Table 3-5. Developed parcels within each sub-basin are divided into areas treated by dry ponds, wet ponds, depressions, or wetlands. Areas with no current stormwater management systems are not colored. Areas with no stormwater treatment system consist primarily of residential parcels located in Direct sub-basin areas for Lake Concord and Quail Pond, along with undeveloped or wetland areas.

TABLE 3-5

WATERSHED AREAS WITH EXISTING STORMWATER MANAGEMENT SYSTEMS IN THE LAKE CONCORD DRAINAGE BASIN

STORMWATER SYSTEM TYPE	TREATED AREAS BY SUB-BASIN (acres)							TOTAL	PERCENT OF TOTAL (%)
	1	2	3	4	5	6	Direct		
Dry Detention	--	4.27	--	1.25	--	--	--	5.52	3.1
Dry Retention	11.25	5.80	0.31	--	15.85	--	--	33.21	19.0
Exfiltration Trench	--	--	--	1.04	--	--	--	1.04	0.6
Ponds	--	--	--	--	10.09	7.34	--	17.43	10.0
Swales	--	--	--	--	5.89	--	--	5.89	3.4
Wet Detention	--	0.85	--	--	34.78	--	--	35.63	20.4
Baffle Box	--	32.88[1]	--	--	0.92	--	--	33.80	19.4
None	--	--	23.29	0.11	1.70	--	16.87	41.97	24.1
TOTAL:	**11.25**	**43.80**	**23.60**	**2.40**	**69.23**	**7.34**	**16.87**	**174.49**	**100**

1. Baffle box provides treatment for entire watershed; value used to make areas add correctly

Approximately 75.9% of the Lake Concord watershed provides stormwater treatment in either wet or dry ponds, swales, or wetlands, while 24.1% of the basin has no treatment. The most common stormwater treatment systems are wet detention (20.4%) and dry retention (19.0%). Theoretically, 100% of the drainage basin area is treated in the baffle box associated with Sub-basin 2, although some of the inflows are treated in either wet or dry ponds before reaching the baffle box. The information summarized in this table is used in a subsequent section to estimate volumetric and nutrient loadings to Lake Concord and Quail Pond from stormwater runoff.

3.8 Hydrologic Characteristics

Hydrologic characteristics were evaluated for each of the identified sub-basin areas discharging to Lake Concord under existing conditions (January 2019) for use in hydrologic modeling to calculate annual runoff inputs to each lake. The hydrologic modeling, discussed in Section 4, is based upon the methodology developed by Harper and Baker (2007) which is the required methodology by FDEP and Florida Water Management Districts when calculating pre- and post-development loadings to Impaired Waters or Outstanding Florida Waters (OFWs). Runoff volumes are calculated using a modified SCS curve number methodology based upon the hydrologic characteristics of the drainage basin, including impervious area, directly connected impervious area (DCIA), and soil curve number values (CN values) to estimate runoff volumes for modeled storm events. Hydrologic characteristics of the sub-basin areas were determined for each of the identified land use types in each sub-basin area in the Lake Concord drainage basin.

3.8.1 Impervious Areas

Impervious areas in the Lake Concord watershed were delineated by ERD using aerial photography to calculate the impervious area within each sub-basin area and developed land use type. Impervious areas include all areas which prevent infiltration of runoff into the ground, such as homes, driveways, roadways, sidewalks, patios, pools, buildings, etc. The impervious area was then expressed as a percentage of the total area for each identified land use type and sub-basin.

3.8.2 Directly Connected Impervious Percentages

One of the parameters used in the modified SCS curve number methodology developed by Harper and Baker for estimating runoff volumes is the directly connected impervious areas (DCIA). DCIA reflects impervious surfaces which are hydraulically connected to the stormsewer or drainage system such that runoff generated on these impervious surfaces flows directly into the drainage system without first flowing over pervious surfaces. Runoff generated in these areas is assumed to discharge directly into the drainage system with losses occurring only as a result of initial abstraction on impervious surfaces which evaporates following the rain event. DCIA for the Lake Concord drainage basin were delineated as a sub-set of the impervious area layer.

3.8.3 Curve Numbers

One of the most important parameters used by the SCS curve number methodology is the curve number (CN) value which is a variable parameter used to estimate runoff depths for modeled rain events based upon soil characteristics and land cover. A discussion of soil characteristics within the Lake Concord drainage basin was provided in Section 3.3. The SCS curve number methodology assigns curve number values to each of the hydrologic soil groups discussed in Section 3.3 as a function of land cover for each soil type. Curve number values range from approximately 30-98 and reflect the runoff generating potential for a particular combination of soil type and land cover. The curve number concept and typical CN values are presented in SCS (now NRCS) Technical Release 55 (TR55) titled "Urban Hydrology for Small Watersheds".

The hydrologic model used in this report modifies the standard SCS Method to estimate generated runoff volumes separately for DCIA and non-DCIA areas. Runoff from DCIA areas is calculated as the rainfall minus initial abstraction, while runoff from non-DCIA areas is calculated using a curve number value. A non-DCIA curve number reflects the area-weighted composite curve number for the land use and soil type combined with impervious areas that are not considered to be DCIA. Non-DCIA curve numbers were calculated for each land use category and sub-basin area in the Lake Concord watershed under existing conditions, and appear to be on the upper end of the range of potential CN values for many of the drainage basin areas due to the highly impermeable soils within many of the sub-basin areas.

3.8.4 Summary

A tabular summary of hydrologic characteristics for land use categories in the Lake Concord drainage basin under current conditions is given in Table 3-6. This information is used to develop estimates of runoff generated hydrologic inputs to the lakes. The values summarized in this table do not include waterbodies or stormwater management systems since the BMP efficiency calculations used by ERD include the volumetric and mass loadings which fall directly on the stormwater management system. Therefore, the sum of the land use areas provided in Table 3-6 exclude the identified stormwater management systems and the sum of the treated and non-treated areas do not equal the total watershed area of 182.48 acres for Lake Concord.

TABLE 3-6

HYDROLOGIC CHARACTERISTICS OF THE LAKE CONCORD WATERSHED

SUB-BASIN	LAND USE	AREA (acres)	PERCENT IMPERVIOUS (%)	PERCENT DCIA (%)	PERVIOUS CN	NON-DCIA CN
1	Commercial	9.96	89.8	89.7	80.0	80.0
	Highways	0.07	95.0	80.7	80.0	93.4
	Open	1.20	0.5	0.4	80.0	80.0
2	Cemeteries	0.58	4.6	0.0	80.0	80.8
	Commercial	11.16	66.2	54.2	58.1	68.5
	Highways	4.84	86.9	85.6	80.0	81.6
	Industrial	4.39	69.6	42.5	73.4	85.0
	Institutional	2.76	44.8	32.1	46.1	55.8
	Medium-Density Residential	12.41	43.8	21.6	68.5	76.8
	Open	0.72	4.6	0.0	75.5	76.6
	Upland Mixed	6.93	15.0	6.4	30.4	36.6
3	Commercial	7.10	66.7	45.8	80.0	86.9
	High-Density Residential	1.52	38.1	6.3	80.0	86.1
	Highways	4.59	89.1	85.9	80.0	84.0
	Industrial	5.91	63.9	50.0	80.0	85.0
	Institutional	0.07	64.5	64.2	80.0	80.1
	Medium-Density Residential	2.76	40.3	3.7	80.0	86.9
	Open	1.18	4.8	1.3	80.0	80.6
	Upland Mixed	0.51	0.3	0.1	79.0	79.1
4	Institutional	1.78	84.9	83.7	80.0	81.3
	Open	0.05	0.0	0.0	80.0	80.0
	Recreational	0.56	21.4	3.5	80.0	83.3
5	Commercial	25.48	80.5	79.7	62.1	63.6
	Golf Courses	5.07	1.6	0.0	80.0	80.3
	High-Density Residential	7.48	79.9	78.9	80.0	80.8
	Highways	2.35	94.2	90.8	80.0	86.7
	Institutional	7.72	77.1	75.0	80.0	81.5
	Medium-Density Residential	9.20	41.2	10.3	76.5	83.9
	Open	5.38	0.9	0.5	71.2	71.3
	Recreational	4.05	23.3	1.2	80.0	84.0
	Upland Mixed	1.15	8.8	8.8	45.8	45.8
	Utilities	0.36	8.9	0.2	80.0	81.6
	Wetlands	0.97	0.0	0.0	87.0	87.0
6	Low-Density Residential	1.02	15.2	0.0	80.0	82.7
	Medium-Density Residential	5.52	17.3	1.7	80.0	82.9
	Open	0.80	2.4	0.9	80.0	80.3
Direct	Commercial	0.54	76.4	2.0	80.0	93.7
	High-Density Residential	1.79	34.8	0.0	80.0	86.3
	Highways	0.06	75.2	0.0	80.0	93.5
	Low-Density Residential	5.83	6.9	0.0	80.0	81.2
	Medium-Density Residential	0.52	17.6	0.1	80.0	83.2
	Open	4.59	40.3	0.0	80.0	87.3
	Recreational	1.68	13.6	0.0	80.0	82.4
	Scrub	1.32	3.2	0.0	73.0	73.8
	TOTAL:	**173.93**	**52.9**	**41.6**	**71.3**	**76.5**

SECTION 4

HYDROLOGIC INPUTS AND LOSSES

An average annual hydrologic budget was developed for Lake Concord which includes inputs from direct precipitation, stormwater runoff, baseflow, inflow from Quail Pond, and groundwater seepage. Hydrologic losses are estimated for evaporation, deep recharge, and outflow to Secret Lake. The hydrologic budget is used as input for development of nutrient budgets as well as estimation of hydraulic residence time. A conceptual schematic of evaluated hydrologic inputs and losses in Lake Concord is given on Figure 4-1. A discussion of identified hydrologic inputs and losses for Lake Concord is given in the following sections.

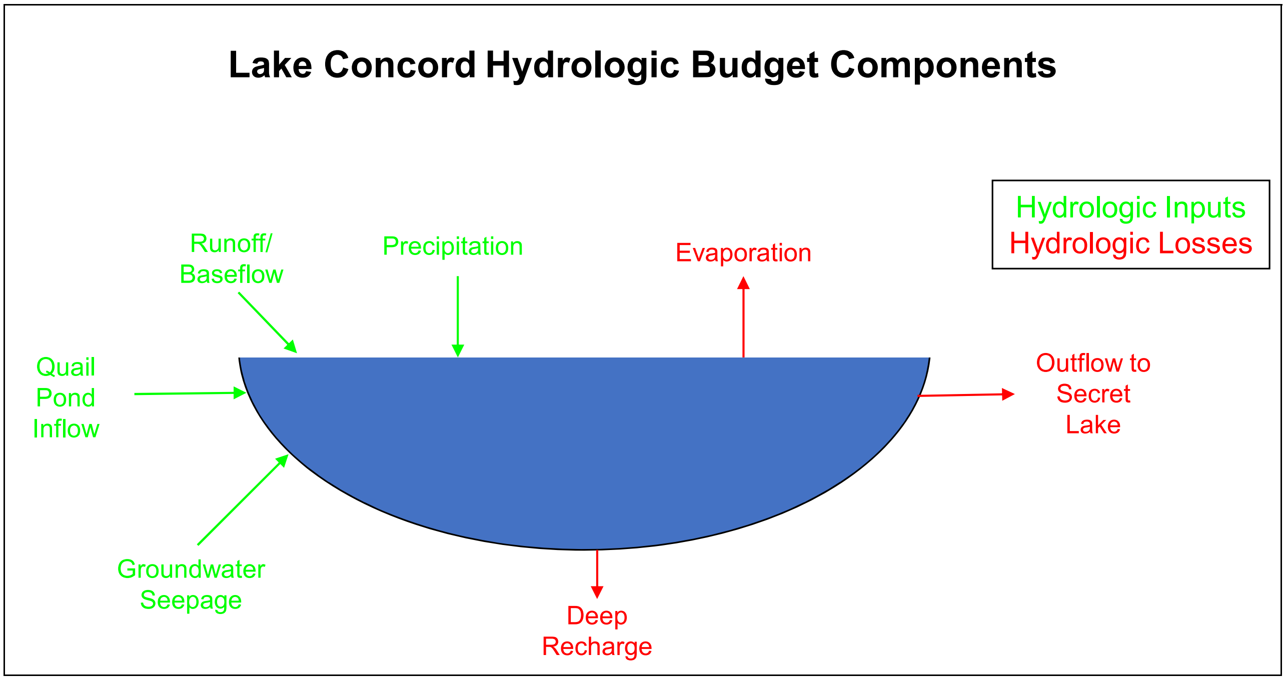


Figure 4-1. Conceptual Schematic of Evaluated Hydrologic Inputs and Losses to Lake Concord.

4.1 Hydrologic Inputs

4.1.1 Direct Precipitation

4.1.1.1 Rainfall Characteristics

Hydrologic inputs from direct precipitation to Lake Concord are calculated based upon historical mean monthly precipitation for the Central Florida area. Estimates of mean monthly precipitation were generated based upon historical monthly rainfall at the Sanford Airport meteorological station (Site ID: USC00087982), the closest long-term rainfall recording site to Lake Concord, over the period from 1981-2010.

A summary of mean monthly rainfall at the Sanford Airport meteorological station from 1981-2010 is given in Table 4-1. Mean monthly rainfall depths range from a low of 2.38 inches during November to a high of 8.32 inches in August, with an annual total of approximately 53.04 inches. The monthly rainfall amounts summarized in Table 4-1 are assumed to be similar to rainfall at Lake Concord.

TABLE 4-1

SUMMARY OF MEAN MONTHLY RAINFALL AT THE SANFORD AIRPORT FROM 1981-2010

MONTH	RAINFALL DEPTH (inches)	MONTH	RAINFALL DEPTH (inches)
January	2.86	July	7.73
February	2.86	August	8.32
March	3.90	September	5.64
April	2.48	October	3.93
May	3.08	November	2.38
June	7.28	December	2.58
		TOTAL:	**53.04**

4.1.1.2 Hydrologic Inputs

Estimated monthly hydrologic inputs to Lake Concord from direct precipitation were calculated by multiplying the mean monthly rainfall measured at the Sanford Airport monitoring site (as summarized in Table 4-1) times the assumed surface area of 19.72 acres for Lake Concord (Table 2-2). A summary of estimated mean monthly hydrologic inputs to Lake Concord from direct precipitation is given in Table 4-2. During an average annual rainfall year, direct precipitation contributes approximately 87.2 ac-ft of water to Lake Concord.

TABLE 4-2

ESTIMATED MEAN MONTHLY HYDROLOGIC INPUTS TO LAKE CONCORD FROM DIRECT PRECIPITATION

MONTH	MONTHLY RAINFALL (inches)	HYDROLOGIC INPUTS[1] (ac-ft/month)
January	2.86	4.7
February	2.86	4.7
March	3.90	6.4
April	2.48	4.1
May	3.08	5.1
June	7.28	12.0
July	7.73	12.6
August	8.32	13.7
September	5.64	9.3
October	3.93	6.5
November	2.38	3.9
December	2.58	4.2
TOTALS:	**53.04**	**87.2**

1. Based on a lake area of 19.72 acres

4.1.2 Stormwater Runoff

Estimates of hydrologic inputs to Lake Concord from stormwater runoff were calculated for each of the identified sub-basin areas discharging to Lake Concord using an average annual rainfall of 53.04 inches. Individual estimates of runoff inputs were generated for each of the sub-basin areas discharging to Lake Concord and are utilized for development of both hydrologic and nutrient budgets. Details of evaluation methods and results of the runoff modeling efforts are given in the following sections.

4.1.2.1 Computational Methods

Estimates of volumetric inputs from direct stormwater runoff were generated for each of the identified sub-basin areas discharging to Lake Concord using the methodology developed by Harper and Baker (2007) for FDEP as part of the Statewide Stormwater Rule. The estimated runoff volumes were calculated for average annual rainfall conditions based upon hydrologic modeling of individual rain events measured in the Central Florida area over the period from 1942-2010. A continuous runoff simulation model was developed by Harper and Baker using a modification of the SCS Curve Number Methodology, and the 69-year period of historical Central Florida rainfall data was used as the precipitation input data. This model is used to provide an estimate of mean annual runoff volumes generated in each sub-basin based on actual rainfall events over the period from 1942-2010.

A modified version of the SCS curve number methodology was used to provide estimates of the runoff volumes generated within each delineated drainage sub-basin area for each historical rain event from 1942-2010. The SCS methodology utilizes the hydrologic characteristics of the drainage basin, including impervious area, directly connected impervious area (DCIA), and soil curve numbers (CN value) to estimate runoff volumes for modeled storm events. Hydrologic characteristics of the sub-basin areas were determined by ERD based upon aerial photography and a field reconnaissance of the watershed areas. This information was discussed previously in Section 3.8. Detailed hydrologic characteristics of the sub-basin areas by land use are provided in Table 3-8 and in the hydrologic models included in Appendix C.

The SCS model calculates runoff volumes using a weighted CN value for each land use type present in the sub-basin area. However, the relationship between CN values and runoff volumes is an exponential function, and large errors in runoff estimation can occur by averaging CN values, especially if the values are widely different in magnitude. To reduce this error, ERD developed a modification to the standard SCS CN model which reduces the need to average CN values by calculating separate runoff volumes for DCIA and non-DCIA portions of each sub-basin. Under this modified approach, the runoff volume for each rainfall event is calculated by adding the rainfall excess from the non-directly connected impervious area (non-DCIA) portion to the rainfall excess created from the DCIA portion for the basin. Rainfall excess from the non-DCIA areas is calculated using the following set of equations:

$$\text{Soil Storage } (S) = \frac{1000}{\text{nDCIA CN}} - 10$$

$$\text{nDCIA CN} = \frac{[CN * (100 - IMP)] + [98\,(IMP - DCIA)]}{(100 - DCIA)}$$

$$Q_{nDCIAi} = \frac{(P_i - 0.2S)^2}{(P_i + 0.8S)}$$

where:

CN	=	curve number for pervious area
IMP	=	percent impervious area
DCIA	=	percent directly connected impervious area
nDCIA CN	=	curve number for non-DCIA area
P_i	=	rainfall event depth (inches)
Q_{nDCIAi}	=	rainfall excess for non-DCIA for rainfall event (inches)

For the DCIA portion, rainfall excess is calculated using the following equation:

$$Q_{DCIAi} = (P_i - 0.1)$$

When P_i is less than 0.1, Q_{DCIAi} is equal to zero. This methodology is used to estimate the generated runoff volume within each of the delineated sub-basin areas for each rainfall event which occurred over the simulation period.

The methodology outlined above provides an estimate of the runoff volume "generated" from each of the individual rain events in each sub-basin over the 69-year period from 1942-2010 based upon a mean annual rainfall of 53.04 inches. The sum of the total generated runoff was then divided by 69 years to obtain an estimate of the mean annual runoff volume. The SCS model calculates generated runoff, but significant portions of the generated runoff volume may be attenuated by depressional areas, wetlands, swales, and in stormwater management systems within each sub-basin area. If the stormwater management system provides dry retention treatment, a large portion of the runoff volume may be infiltrating into the ground and not reach the receiving water as a surface flow. If the stormwater system provides wet detention treatment, a portion of the generated runoff volume may be lost due to evaporation within the pond or infiltration through the pond bottom. Wetlands and depressional areas can also retain portions of the generated runoff volume.

The watershed model includes information on the types of stormwater management systems used within each sub-basin area and the amount of developed area treated by each stormwater management type. The generated runoff volume discharging to stormwater treatment systems is reduced or attenuated for likely volumetric removal processes in the treatment system. Estimates of the amount of generated runoff volume attenuated by each type of stormwater management system and natural features, such as wetlands, are included in the model, and the attenuated volume is subtracted from the generated volume within each sub-basin. The result is an estimate of the runoff volume which actually discharges into the receiving waterbody from each sub-basin area.

A summary of estimated volumetric removal efficiencies for stormwater management systems and natural features in the Lake Concord sub-basin is given in Table 4-3. These volumetric removals are based on previous hydrologic modeling of natural areas performed by ERD and extensive research on the performance efficiencies of stormwater management systems used in the State of Florida. Developed areas treated by dry retention are assumed to have a volumetric loss of approximately 80% for runoff inputs due to infiltration and evaporation within the pond, with a 20% volumetric reduction assumed for wet ponds. Runoff discharging to wetlands can be retained within the wetland area due to storage, infiltration, and evapotranspiration, with an assumed volumetric runoff reduction of 20%. Storage in depressional areas varies depending on the volume of depressional storage compared with generated annual runoff volumes, but for purposes of this analysis, a volume retention of 75% is assumed. The information summarized in Table 4-3 is combined with information on stormwater management systems and wetland areas (Figure 3-7) to assist in calculation of estimated runoff inflow from each sub-basin area.

The runoff models do not include runoff generation for any natural or man-made open waterbodies since the model is designed to estimate runoff on an average annual basis, and precipitation inputs and evaporation losses are approximately equal on an average annual basis. Wet stormwater ponds are also excluded from the modeled area for the same reason, although a volumetric reduction of 20% is assumed for runoff inputs entering wet detention ponds due to groundwater losses.

TABLE 4-3

ESTIMATED VOLUMETRIC REMOVAL EFFICIENCIES FOR STORMWATER MANAGEMENT SYSTEMS IN THE LAKE CONCORD DRAINAGE BASIN

SYSTEM TYPE	VOLUME REDUCTION (% of Annual Runoff)
Exfiltration Trench	80
Dry Retention Pond	80
Wet Pond	20
Dry Detention Pond	50
Swales	20
Baffle Box	0
Natural Ponds	90

4.1.2.2 Modeled Runoff Volumes

Hydrologic modeling was conducted to estimate annual runoff inputs to Lake Concord using the methodology and assumptions discussed in previous sections. A discussion of runoff inputs to the lake is given in the following sections.

A summary of estimated runoff volumes which discharge from each drainage sub-basin area into Lake Concord on an average annual basis is given in Table 4-4. The generated runoff volume represents the modeled runoff volume within each sub-basin prior to volume reduction in stormwater management systems, depressional areas, and ponds. Estimates of the runoff volume removed in dry and wet ponds, exfiltration trenches, and natural ponds are calculated for each sub-basin based upon the volumetric removal efficiencies summarized in Table 4-3, and subtracted from the generated runoff volume. The resulting value represents the observed mean annual runoff volume which is actually discharged to Lake Concord from each sub-basin. Estimates of the model generated and observed runoff coefficients (C value) are also provided for each drainage sub-basin.

The generated and observed runoff coefficients are calculated as follows:

$$\text{Generated C Value} = \frac{\text{Generated Runoff Volume (ac-ft)}}{\text{Total Basin Area (ac)} \times \text{Rainfall Depth (ft)}}$$

$$\text{Observed C Value} = \frac{\text{Observed Runoff Volume (ac-ft)}}{\text{Total Basin Area (ac)} \times \text{Rainfall Depth (ft)}}$$

TABLE 4-4

MODELED ANNUAL RUNOFF VOLUMES DISCHARGING TO LAKE CONCORD

SUB-BASIN	AREA (acres)	GENERATED RUNOFF VOLUME (ac-ft/yr)	GENERATED RUNOFF C VALUE	VOLUME RETAINED IN RETENTION SYSTEMS (ac-ft/yr)	VOLUME RETAINED IN WET PONDS (ac-ft/yr)	VOLUME RETAINED IN DRY DETENTION AND SWALES (ac-ft/yr)	RUNOFF VOLUME TO LAKE (ac-ft/yr)	OBSERVED RUNOFF C VALUE	PERCENT OF TOTAL (%)
1	11.25	33.31	0.670	26.65	0.00	0.00	6.66	0.134	3.1
2	43.80	68.17	0.352	2.11	0.30	5.82	59.94	0.310	28.0
3	23.60	47.22	0.453	0.76	0.00	0.00	46.46	0.445	21.7
4	2.40	5.93	0.559	4.67	0.00	0.00	1.26	0.119	0.6
5	73.17	144.3	0.446	31.34	28.55	0.90	83.50	0.258	39.0
6	11.39	4.70	0.093	0.00	0.00	0.00	4.70	0.093	2.2
Direct	16.87	11.32	0.152	0.00	0.00	0.00	11.32	0.152	5.3
TOTAL:	**182.48**	**314.9**	**0.390**	**65.53**	**28.85**	**6.72**	**213.8**	**0.265**	**100.0**

As indicated on Table 4-4, approximately 314.9 ac-ft/yr of runoff is generated in the Lake Concord watershed, resulting in a generated runoff C Value of 0.390 for the watershed area. Approximately 101.1 ac-ft/yr of the generated runoff volume is lost in stormwater management systems, natural ponds, and swales. The runoff volume which actually reaches Lake Concord each year is approximately 213.8 ac-ft/yr which corresponds to a delivered runoff coefficient of 0.265, indicating that approximately 26.5% of the annual rainfall which occurs in the Lake Concord watershed actually reaches Lake Concord as stormwater runoff on an average annual basis. A runoff delivery coefficient in this range is common for developed watersheds containing large areas of low permeability soils. Generated runoff coefficients (C Values) for individual sub-basins range from 0.093-0.670, with delivered runoff coefficients ranging from 0.093-0.445.

As indicated on Table 4-4, the single largest contribution of runoff to Lake Concord originates within Sub-basin 5 which consists of a 73.17-acre area of commercial, medium- and high-density residential, highway, and institutional areas located southwest of Lake Concord. This sub-basin contributes approximately 39.0% of the annual runoff inputs into Lake Concord, with most developed areas treated in the stormwater management systems. An additional 28.0% of the annual runoff inputs originate from Sub-basin 2 which consists of approximately 43.80 acres of commercial, medium-density residential homes, and natural areas located east of Lake Concord. Sub-basin 3, located west of Lake Concord, contributes 21.7% of the annual runoff inputs.

Approximately 5.3% of the annual runoff inputs originate from areas immediately adjacent to and east of Lake Concord that discharge into the lake by direct overland flow. Each of the remaining sub-basin areas contributes approximately 3.1% or less of the total annual inputs to Lake Concord from stormwater runoff. The annual runoff volume discharging from Sub-basin 6 to Lake Concord reflects annual discharges from Quail Pond to Lake Concord.

4.1.3 Shallow Groundwater Seepage

Field investigations were performed by ERD to evaluate the quantity and quality of shallow groundwater seepage entering Lake Concord during the monitoring program. Groundwater seepage was quantified using a series of underwater seepage meters installed at selected locations throughout the lake. Seepage meters provide a mechanism for direct measurement of groundwater inflow into a lake by isolating a portion of the lake bottom so that groundwater seeping up through the bottom sediments into the lake can be collected and characterized. Use of the direct seepage meter measurement technique avoids errors, assumptions, and extensive input data required when indirect techniques are used, such as the Gross Water Budget or Subtraction Method, as well as computer modeling and flow net analyses.

The seepage meter technique has been recommended by the U.S. Environmental Protection Agency (EPA) and has been established as an accurate and reliable technique in field and tank test studies (Lee, 1977; Erickson, 1981; Cherkauer and McBride, 1988; Belanger and Montgomery, 1992). With installation of adequate numbers of seepage meters and proper placement, seepage meters are a very effective tool to estimate groundwater-surface water interactions. One distinct advantage of seepage meters is that seepage meters can provide estimates of both water quantity and quality entering a lake system, whereas estimated methods can only provide information on water quantity.

4.1.3.1 Seepage Meter Construction and Locations

A schematic of a typical seepage meter installation used in Lake Concord is given in Figure 4-2, and a generic photograph of seepage meters being prepared for deployment in a lake is given in Figure 4-3. Seepage meters were constructed from a 2-ft diameter aluminum cylinder with a closed top and open bottom. The seepage meters were inserted into the lake sediments to a depth of approximately 8-12 inches, isolating a sediment area of 3.14 ft^2. After installation, approximately 3-6 inches of water was trapped inside the seepage meter above the lake bottom.

A 0.75-inch PVC fitting was threaded into the top of each meter. The 0.75-inch PVC fitting was attached to a female quick-disconnect PVC Camlock fitting. A flexible polyethylene bag, with an approximate volume of 40 gallons, was attached to the seepage meter using a quick-disconnect PVC male Camlock fitting with a terminal ball valve. Each of the collection bags was constructed of black polyethylene to prevent light penetration into the bag which could potentially stimulate photosynthetic activity within the sample prior to collection and result in an alteration of the chemical characteristics of the seepage sample.

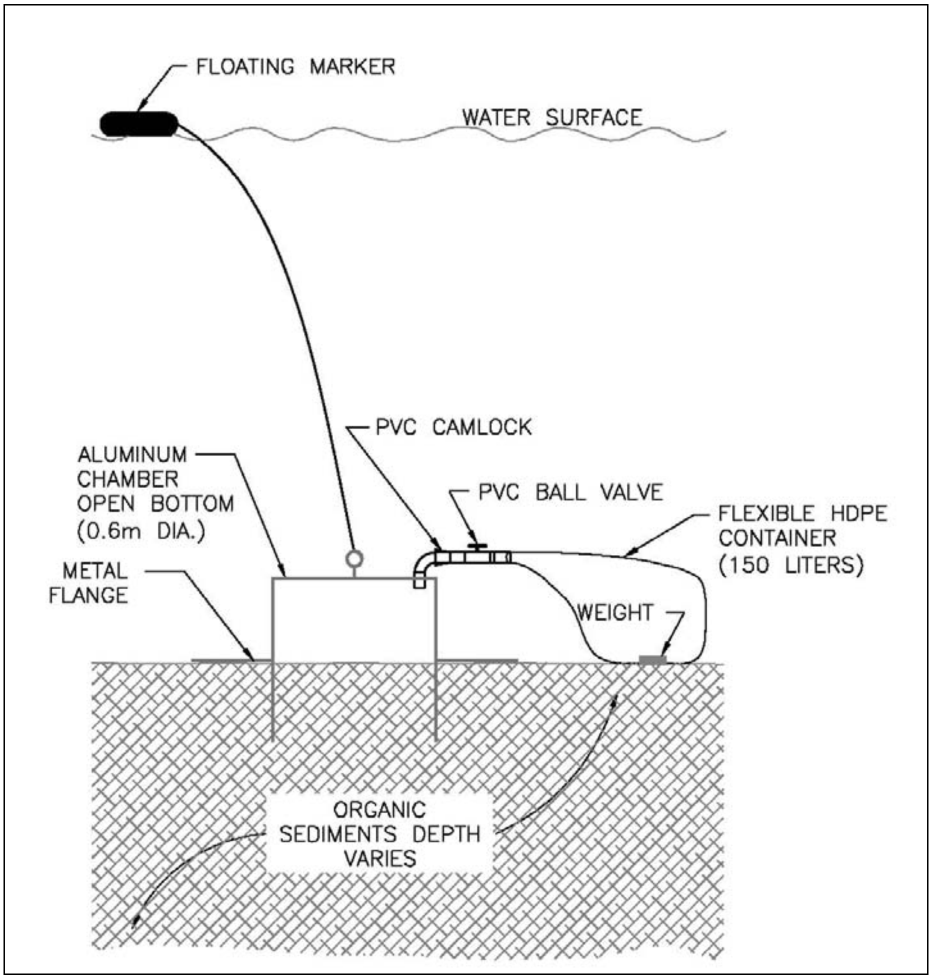


Figure 4-2.

Schematic of a Typical Seepage Meter Installation.

Figure 4-3.

Seepage Meters Being Prepared for Installation.

Prior to attachment to the seepage meter, all air was removed from inside the polyethylene collection bag, and the PVC ball valve was closed so that lake water would not enter the collection container prior to attachment to the seepage meter. A diver then connected the collection bag to the seepage meter using the PVC camlock fitting. After attaching the collection bag to the seepage meter, the PVC ball valve was then opened, and groundwater influx into the open bottom of the seepage meter is collected inside the flexible polyethylene bag.

Each seepage meter was installed with a slight tilt toward the outlet point so that any gases which may be generated inside the seepage meter would exit into the collection container. Two 10-ounce plastic-coated fishing weights were placed inside each of the collection bags to prevent the bags from floating up towards the water surface as a result of trapped gases. The location of each seepage meter was indicated by a floating marker in the lake which was attached to the seepage meter using a coated wire cable.

Seepage meters were installed at 8 locations in Lake Concord on March 11, 2019. Locations for the seepage meters in Lake Concord are indicated on Figure 4-4. Since seepage inflow is often most variable around the perimeter of a lake, the majority of the seepage meters were installed around the perimeter of the lakes at a uniform water depth of approximately 4-5 ft.

Figure 4-4. Seepage Monitoring Sites in Lake Concord.

Seepage meters installed in shoreline areas were inserted through the unconsolidated and consolidated sediment layers and into the parent bottom material by repeatedly pounding around the perimeter of the meter using a 20-pound hammer weight until the seepage meter met significant resistance from the sediment material, and no additional movement of the meter was observed. Seepage meters installed in these areas were extremely stable, and additional settling of the seepage meters during the monitoring program was very unlikely.

In central portions of the lake where the muck accumulations were deeper, the seepage meters were inserted through the surficial unconsolidated sediments into the layer of consolidated sediments, but the depth of consolidated sediments at some locations prevented the seepage meter from reaching the parent bottom material. If possible, the seepage meter was inserted until the top flange was even with the top of the consolidated sediment layer to achieve maximum stability for the seepage meter. The seepage meters installed on muck sediments in central portions of the lakes were less stable than the shoreline meters since the parent bottom material could not be reached. However, each of the meters penetrated through the unconsolidated upper layer and into the consolidated sediment layer, which provided a relatively stable platform since the outer flange was resting on top of the consolidated layer. However, further limited settling of these meters over time cannot be ruled out.

4.1.3.2 Seepage Meter Monitoring

Installation of shoreline seepage meters in Lake Concord was conducted on March 11, 2019. Polyethylene collection bags (200 liter) were attached at the time of installation to each of the seepage meters. The initial seepage monitoring event was conducted on April 16, 2019, approximately 36 days following installation. During this event, the volume of seepage collected at each site was measured and recorded, but the collected sample was discarded since the initial collected seepage sample represents a combination of seepage inflow and lake water trapped inside the seepage meter at the time of installation.

Beginning with the second monitoring event, samples were collected and retained for laboratory analyses. Each of the 8 seepage meters was monitored on approximately a monthly to bi-monthly basis from March-September 2019, with monthly event intervals during wet season conditions and bi-monthly event intervals during dry season conditions. Five separate seepage monitoring events were conducted for evaluation of quantity at each of the monitoring sites. The seepage meters were removed at the end of the monitoring program in September 2019.

4.1.3.3 Seepage Inflow

4.1.3.3.1 Current Conditions

A summary of field measurements of seepage inflow to Lake Concord from March-September 2019 is given in Appendix D-1. During collection of the seepage samples, information was recorded on the date and time of sample collection, the volume of seepage collected at each site, general observations regarding the condition of the seepage collection bags, and replacement/repair details. The seepage inflow rate at each location is calculated by dividing the total collected seepage volume (liters) by the area of the seepage meter (0.27 m^2) and the time (days) over which the seepage sample was collected.

A total of 5 seepage field monitoring events was conducted at the 8 seepage meter sites, with a potential of 40 field measurements in Lake Concord at the 8 seepage monitoring sites. During the field monitoring program, a total of 40 seepage samples was collected out of a possible 40 samples, for a 100% sample success rate which is much better than typical seepage sample collection success rates of 70-75% in studies conducted by ERD when samples are lost due to damaged collection bags or missing seepage meters.

A summary of mean seepage inflow measurements collected in Lake Concord at each of the 8 seepage meter monitoring sites is given in Table 4-5. Mean seepage values measured at the Lake Concord monitoring sites ranged from 0.64-1.75 liters/m^2-day, with a majority of measured values ranging from approximately 0.7-1.3 liters/m^2-day. A similar degree of variability was observed in the measured minimum and maximum seepage influx rates during the field monitoring program.

TABLE 4-5

SUMMARY OF FIELD MEASURED HYDROLOGIC INPUTS TO LAKE CONCORD FROM GROUNDWATER SEEPAGE FROM MARCH - SEPTEMBER 2019

SITE	NUMBER OF SAMPLES	SEEPAGE (liters/m^2-day)		
		Minimum	Maximum	Mean
1	5	0.67	2.94	1.75
2	5	0.64	1.45	0.90
3	5	0.43	0.76	0.64
4	5	0.51	1.68	1.18
5	5	0.64	1.56	0.92
6	5	0.55	3.30	1.28
7	5	0.31	1.30	0.75
8	5	0.38	1.60	0.80
Total:	**40**			

The mean seepage values summarized on Table 4-5 were combined with the geographic coordinates for each site to generate an isopleth contour map for mean seepage inflow into Lake Concord using the AutoDesk Land Desktop 2007 Module for AutoCad. Isopleths of mean seepage inflow to Lake Concord are given on Figure 4-5. The range of seepage values indicated on this figure is from 0.7-1.7 liters/m^2-day.

The most elevated levels of seepage influx were observed along the western shoreline and a portion of the northeast shoreline. More elevated seepage inflows are often observed in areas with greater horizontal groundwater gradients or more permeable soils. Other factors may include ponds or wetlands in close proximity to the lake. The lowest seepage influx was observed in northern central portions of the lake and along the southeastern shoreline.

The seepage isopleths indicated on Figure 4-5 were graphically integrated to obtain estimates of mean daily seepage influx into Lake Concord. A summary of the results of this analysis is given in Table 4-6. The area-weighted mean seepage influx to Lake Concord during the field monitoring program was 0.97 liters/m^2-day, which is equivalent to approximately 23.0 ac-ft/yr.

TABLE 4-6

ESTIMATED MEAN SEEPAGE INFLOW TO LAKE CONCORD UNDER CURRENT CONDITIONS

PARAMETER	UNITS	VALUE
Lake Area	acres	19.72
Mean Seepage Inflow	liters/m^2-day ac-ft/year	0.97 23.0
Seepage/Surface Area Ratio	ft/yr	1.16

The calculated seepage/surface area ratio is provided in the final row of Table 4-6. This value provides an estimate of seepage inflow in terms of a depth over the entire lake surface and provides a method for comparing relative seepage inflow between lakes without consideration of lake area. During the field monitoring program, seepage inflow into Lake Concord contributed a water volume equivalent to 1.16 ft/yr over the entire surface area of the lake, somewhat lower than the long-term mean seepage loading rate of 2.0 ft/yr measured by ERD in other Central Florida lakes. The seepage inflow listed on Table 4-6 is used in subsequent sections for development of a hydrologic budget for Lake Concord.

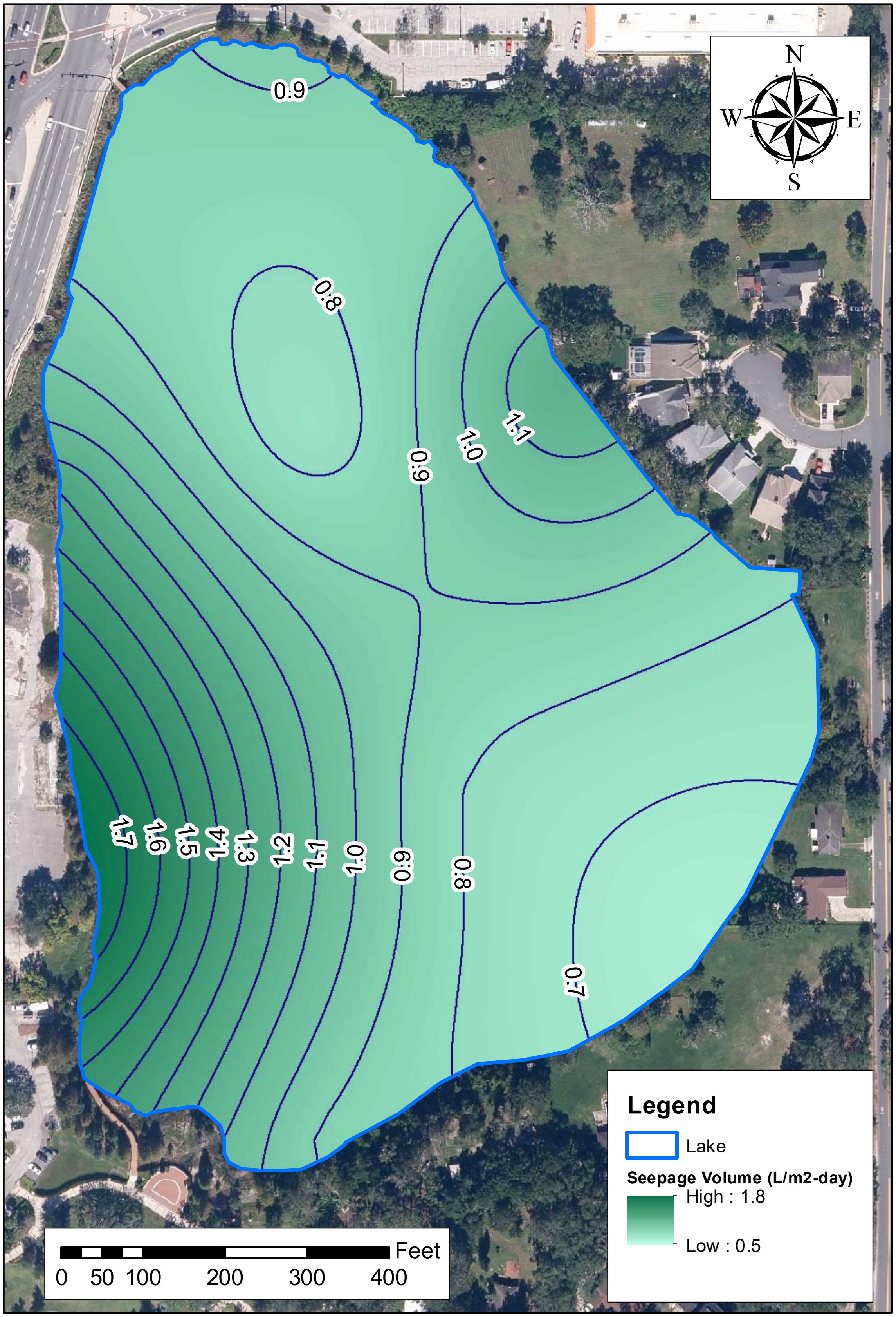


Figure 4-5. Mean Seepage Inflow Isopleths for Lake Concord from March-September 2019.

4.2 Hydrologic Losses

Hydrologic losses from Lake Concord occur as a result of evaporation from the lake surface, discharge through the outfall channel, and outflow from deeper portions of the lake bottom to underground aquifers. Estimated losses from each of these sources are discussed in the following sections.

4.2.1 Evaporation Losses

Long-term reliable evaporation data are relatively rare in Florida, with only a limited number of sites available. Estimates of monthly evaporation from Lake Concord were generated based upon mean monthly evaporation data collected at the Lake Alfred Experimental Station over the 30-year period from 1965-1994. The Lake Alfred Station is located approximately 33 miles southwest of Orlando and appears to be the closest long-term evaporation monitoring site to the Central Florida area. A summary of mean monthly evaporation for this site is given in Table 4-7. For purposes of this project, the mean evaporation measured at the Lake Alfred site is assumed to be similar to evaporation at Lake Concord. The recorded data at the Lake Alfred site reflects pan evaporation, and a pan coefficient, defined as the ratio of "free water surface" (FWS) evaporation to observed pan evaporation, is used to correct the pan evaporation to FWS evaporation. Pan evaporation exceeds FWS evaporation due to energy exchange through the sides and bottom of the pan. The U.S. National Weather Service (NWS) has recommended a pan coefficient of 0.7, and lake evaporation is assumed to be equal to 70% of the pan evaporation values.

TABLE 4-7

MEAN MONTHLY LAKE EVAPORATION AT THE LAKE ALFRED EXPERIMENTAL STATION SITE

MONTH	MEAN PAN EVAPORATION (inches)	LAKE EVAPORATION[1] (inches)	MONTH	MEAN PAN EVAPORATION (inches)	LAKE EVAPORATION[1] (inches)
January	3.47	2.43	July	7.57	5.30
February	4.21	2.95	August	7.16	5.01
March	6.26	4.38	September	6.28	4.40
April	7.60	5.32	October	5.51	3.86
May	8.47	5.93	November	3.98	2.79
June	7.65	5.36	December	3.22	2.25
			TOTAL:	**71.38**	**49.98**

1. Assumed to be 70% of pan evaporation (Farnsworth, et al., 1982).

A summary of estimated monthly evaporation losses from Lake Concord is given in Table 4-8. The values summarized in this table were obtained by multiplying the lake surface area of 19.72 acres for Lake Concord times the estimated monthly lake evaporation values. Mean annual volumetric losses from lake evaporation remove approximately 82.1 ac-ft/yr from Lake Concord.

TABLE 4-8

SUMMARY OF MONTHLY HYDROLOGIC LOSSES FROM LAKE CONCORD AS A RESULT OF SURFACE EVAPORATION

MONTH	EVAPORATION (inches)	LOSSES (ac-ft)
January	2.43	4.0
February	2.95	4.8
March	4.38	7.2
April	5.32	8.7
May	5.93	9.7
June	5.36	8.8
July	5.30	8.7
August	5.01	8.2
September	4.40	7.2
October	3.86	6.3
November	2.79	4.6
December	2.25	3.7
TOTAL:	**49.98**	**82.1**

4.2.2 Deep Aquifer Recharge

In addition to losses from evaporation and discharges through the outfall canal, a portion of the annual hydrologic inputs to Lake Concord are lost as a result of downward migration of water in deeper areas of the lakes into intermediate aquifer layers. This phenomenon occurs simultaneously with groundwater seepage which is a result of groundwater movement into the lake above the initial confining layer, while deep recharge occurs as a result of permeable connections to underlying aquifers in deeper portions of the lake. Aquifer recharge is determined by the difference in piezometric elevation between the lake and the deep aquifer as well as the characteristics and transmissivity of any confining layers.

Information on aquifer recharge rates for Lake Concord was obtained from the SJRWMD GIS recharge map (2005) for the Middle St. Johns River Basin. A summary of the recharge map for areas in the vicinity of Lake Concord is given on Figure 4-6. According to the SJRWMD GIS recharge map, aquifer recharge in the Lake Concord drainage basin ranges from moderate to high, but the lake is located in an area of moderate recharge of 5-10 inches/year. This implies that a volume equivalent to 5-10 inches or more over the lake surface would be lost each year as a result of recharge into deeper aquifers. For purposes of this analysis, an average recharge of 7.5 inches/year is assumed.

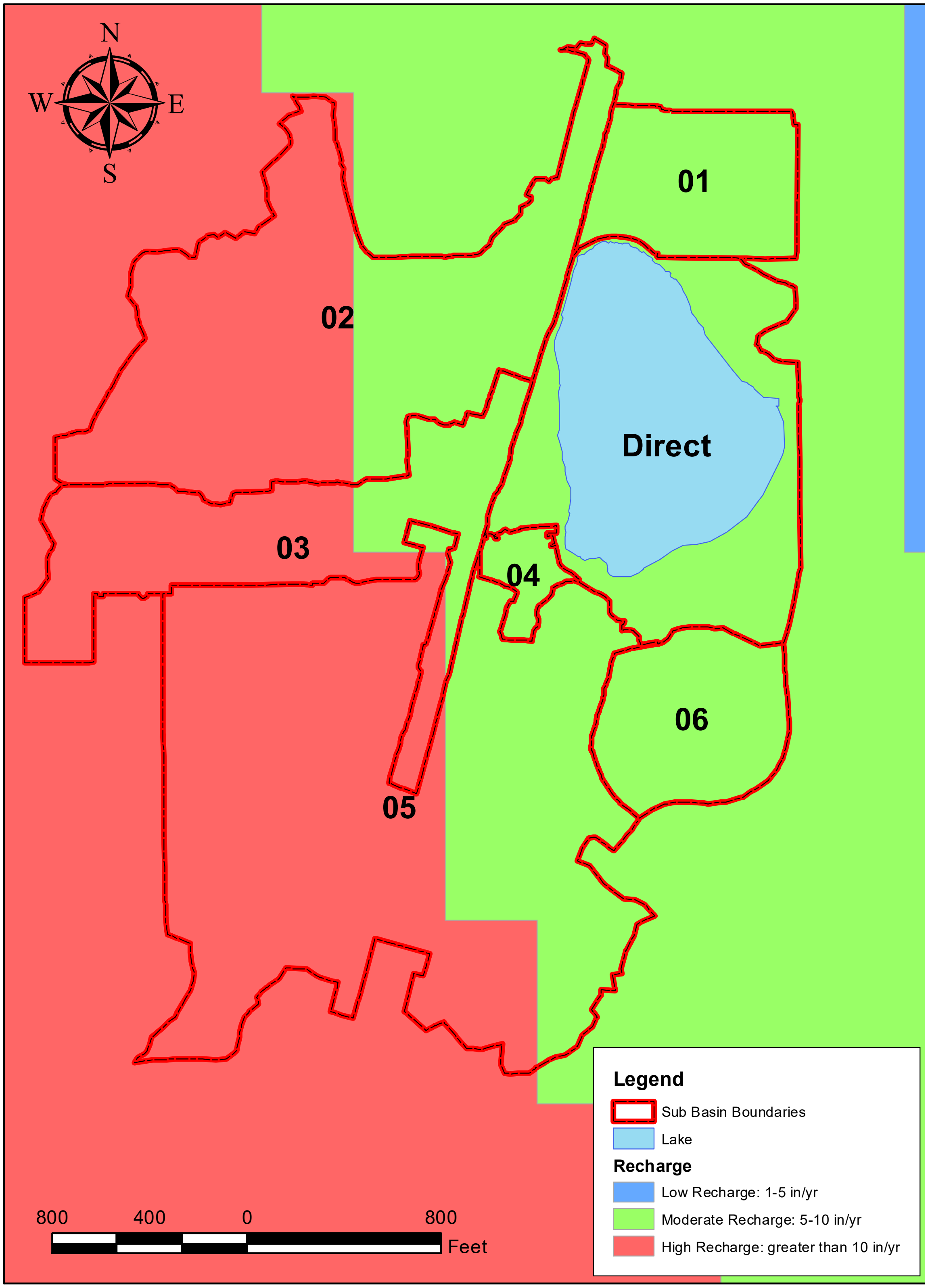


Figure 4-6. Aquifer Recharge Rates in the Vicinity of Lake Concord. (Source: SJRWMD, 2005)

Estimates of annual aquifer recharge for Lake Concord were generated using an average recharge rate of 7.5 inches/year and the assumed lake surface area of 19.72 acres. A summary of estimated annual volumetric losses from deep recharge in Lake Concord is given in Table 4-9. On an average annual basis, deep recharge removes approximately 12.3 ac-ft/yr from Lake Concord.

TABLE 4-9

ESTIMATED ANNUAL DEEP RECHARGE LOSSES FROM LAKE CONCORD

AREA (acres)	ESTIMATED DEEP RECHARGE LOSS	
	inches/year	ac-ft/yr
19.72	7.5	12.3

4.2.3 Outfall Discharges

Discharges from Lake Concord occur through the outfall canal, ultimately reaching Secret Lake. For purposes of this analysis, mean annual discharges from Lake Concord are calculated as the difference between quantified inputs and outputs for the lake on an annual basis according to the following relationship:

Outfall Discharge =

(Precipitation + Runoff Inputs + Seepage) - (Evaporation + Recharge)

This information is calculated as part of the hydrologic budget summarized in Section 4.3 and reflects discharges from the lake over a long-term annual average basis, and does not necessarily reflect or predict lake discharges during any particular year.

4.3 Hydrologic Budget

A mean annual hydrologic budget was developed for Lake Concord based on the analyses provided in previous sections. A discussion of the annual hydrologic budget is given in the following sections.

4.3.1 Hydrologic Inputs

A summary of identified mean annual hydrologic inputs to Lake Concord on an average annual basis under current conditions is given in Table 4-10. Estimates of hydrologic inputs are provided for direct precipitation, stormwater runoff, direct overland flow, Quail Pond inflow, and groundwater seepage.

TABLE 4-10

CALCULATED MEAN ANNUAL HYDROLOGIC INPUTS TO LAKE CONCORD

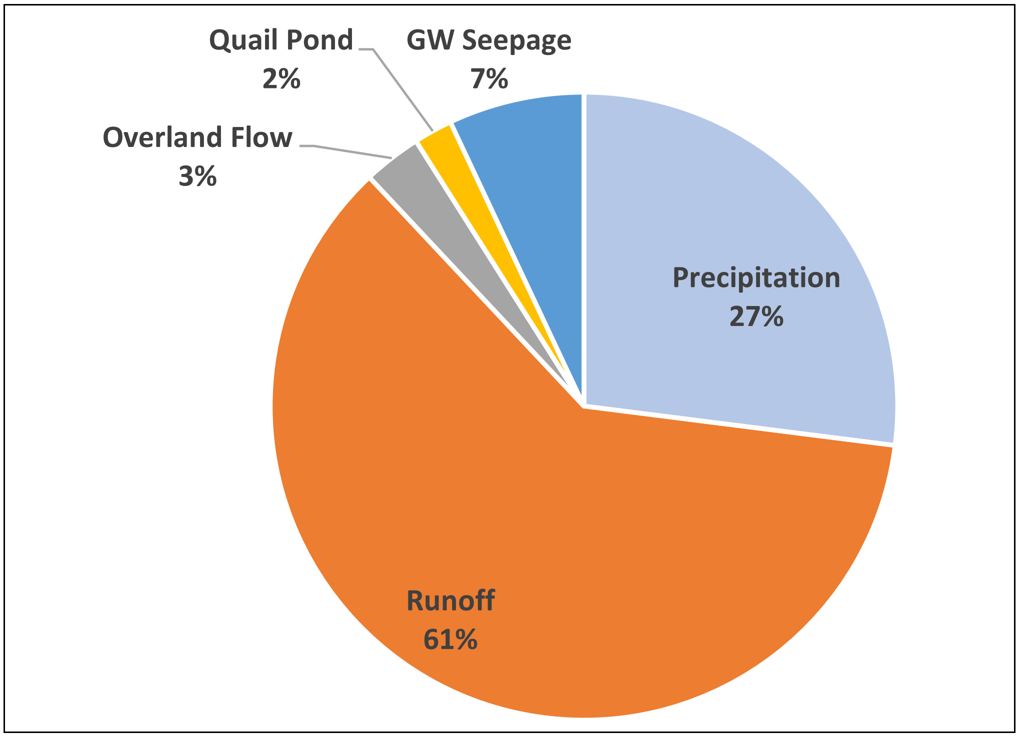
SOURCE	ANNUAL INFLOW (ac-ft/yr)	PERCENT OF TOTAL (%)
Precipitation	87.2	27
Runoff[1]	198	61
Overland Flow[2]	11.3	3
Quail Pond[3]	4.7	2
Groundwater Seepage	23.0	7
TOTAL:	**324**	**100**

1. Includes Sub-basins 1-5
2. Includes Direct sub-basin
3. Includes Sub-basin 6

The largest annual hydrologic input to Lake Concord is stormwater runoff which contributes 61% of the total annual hydrologic inputs to the lake. Approximately 27% of the average annual hydrologic inputs are contributed by direct precipitation. Groundwater seepage contributes an additional 7% of the annual hydrologic inputs, with 2% contributed by inflows from Quail Pond, and 3% contributed by direct overland flow. On an average annual basis, approximately 324 ac-ft of water is discharged to Lake Concord each year.

4.3.2 Hydrologic Losses

A summary of mean annual hydrologic losses from Lake Concord is given in Table 4-11. Approximately 71% of the annual hydrologic inputs to Lake Concord are lost from discharges to Secret Lake, with 25% of the annual hydrologic inputs lost through evaporation, and 4% lost to deep recharge. On an annual average basis, approximately 221 ac-ft discharge from Lake Concord through the outfall, equivalent to 11.2 ft over the lake surface. A graphical comparison of mean annual hydrologic inputs and losses for Lake Concord is given on Figure 4-7.



Hydrologic Inputs

Hydrologic Losses

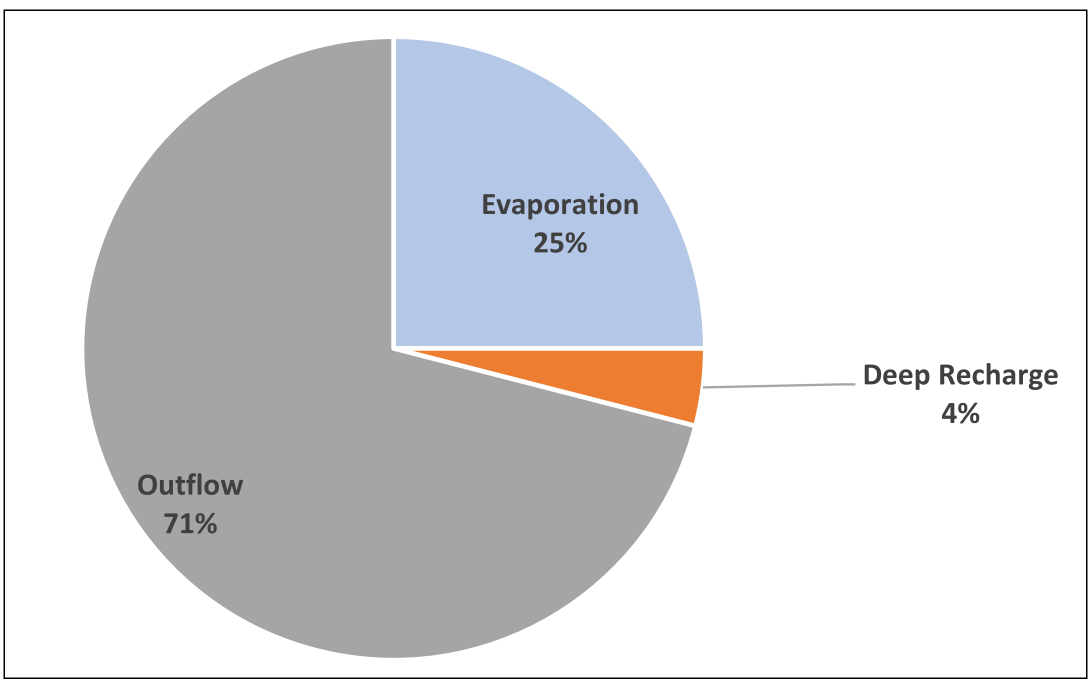


Figure 4-7. Comparison of Mean Annual Hydrologic Inputs and Losses for Lake Concord.

TABLE 4-11

CALCULATED MEAN ANNUAL HYDROLOGIC LOSSES FROM LAKE CONCORD

SOURCE	ANNUAL INFLOW (ac-ft/yr)	PERCENT OF TOTAL (%)
Evaporation	82.1	25
Deep Recharge	12.3	4
Outflow	230	71
TOTAL:	**324**	**100**

4.4 Water Residence Time

For purposes of this analysis, water residence time or hydraulic residence time in a lake is defined as the lake volume divided by the annual hydrologic inputs. Mean annual water residence time was calculated for Lake Concord by dividing the estimated lake water volume (summarized in Table 2-2) by the calculated mean annual hydrologic inputs.

A summary of calculated mean annual residence time in Lake Concord is given in Table 4-12. The calculated mean residence time in Lake Concord is approximately 189 days (0.52 years) which is similar to typical residence times observed by ERD in Central Florida lakes of approximately 0.5-1.0 years.

TABLE 4-12

CALCULATED MEAN ANNUAL RESIDENCE TIME IN LAKE CONCORD

LAKE VOLUME (ac-ft)	ANNUAL INFLOW (ac-ft/yr)	MEAN RESIDENCE TIME (days)
168	324	189

SECTION 5

NUTRIENT INPUTS AND LOSSES

Lake Concord receives nutrient inputs from a variety of sources which include bulk precipitation, stormwater runoff, shallow groundwater seepage, and internal recycling. Chemical characteristics of stormwater runoff and groundwater seepage along with inputs from internal recycling were measured directly by ERD during the period from March-September 2019. A discussion of these inputs, along with calculated mass loadings, is given in the following sections. Information from each of these sources is used to generate annual average nutrient budgets for total nitrogen and total phosphorus for the lake. A conceptual schematic of evaluated nutrient sources and sinks in Lake Concord is given in Figure 5-1.

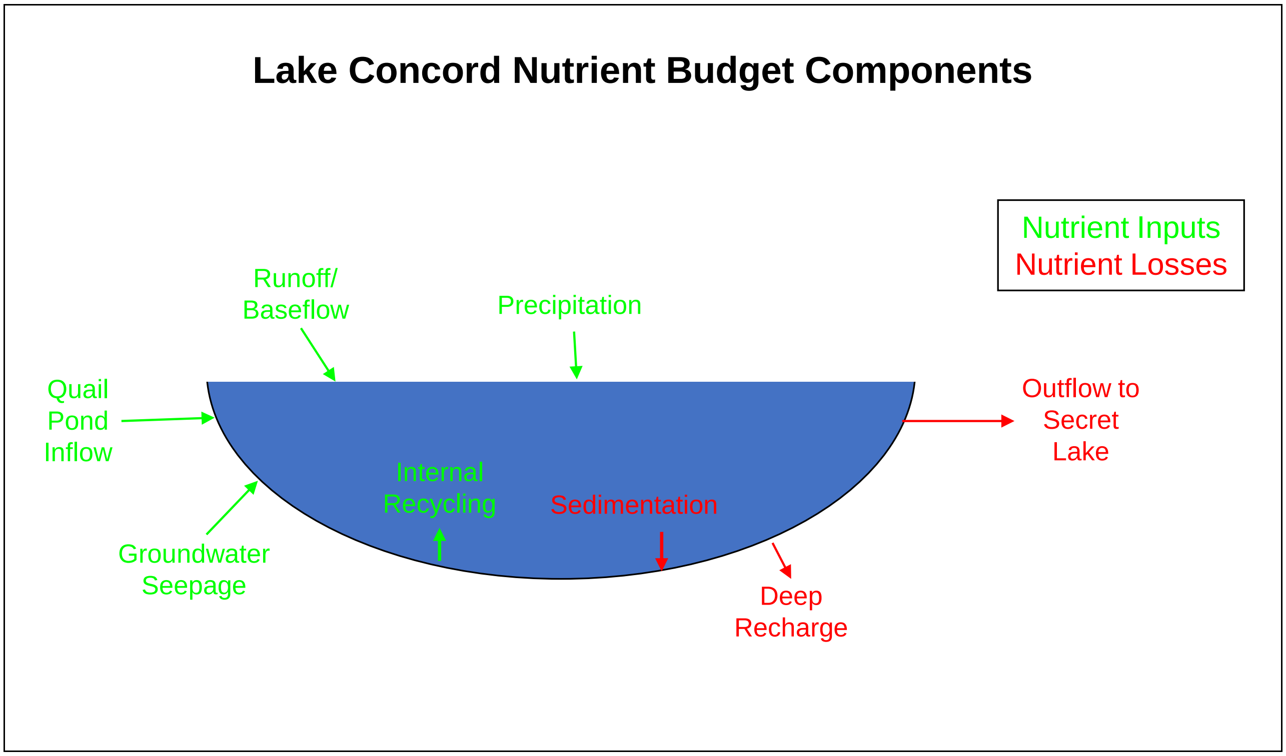


Figure 5-1. Conceptual Schematic of Evaluated Nutrient Inputs and Losses for Lake Concord.

5.1 Characteristics of Nutrient Inputs

5.1.1 Bulk Precipitation

5.1.1.1 Chemical Characteristics

ERD has performed several evaluations of the characteristics of bulk precipitation in the Central Florida area. One of the most comprehensive evaluations was conducted as part of the Butler Chain-of-Lakes hydrologic and nutrient budget project. Bulk precipitation samples were collected by ERD on a continuous basis from December 2004-November 2005 at a monitoring site located adjacent to the Keene's Point boat ramp on Lake Isleworth. Twenty-nine bulk precipitation samples were collected at the monitoring site and analyzed for general parameters, nutrients, and TSS. A summary of the mean measured concentrations of nitrogen and phosphorus in bulk precipitation at the Butler Chain-of-Lakes monitoring site is given in Table 5-1.

TABLE 5-1

MEAN CHARACTERISTICS OF BULK PRECIPITATION IN THE CENTRAL FLORIDA AREA

PARAMETER	UNITS	CONCENTRATION
Nitrogen	µg/l	770
Phosphorus	µg/l	61

Bulk precipitation represents the combined inputs from direct rainfall during rain events and dry weather fallout between rainfall events. The characteristics of bulk precipitation are regulated to a large extent by land cover characteristics and proximity to potential sources of airborne contaminants such as urbanized and industrial areas. For purposes of this evaluation, it is assumed that the bulk precipitation characteristics summarized in Table 5-1 are similar to bulk precipitation which falls on Lake Concord under current conditions.

5.1.1.2 Mass Loadings

Estimates of annual mass loadings from bulk precipitation to Lake Concord were calculated for total nitrogen and total phosphorus based upon the assumed chemical characteristics listed in Table 5-1, and the estimated annual volumetric inputs from direct precipitation listed on Table 4-2. A summary of estimated loadings to Lake Concord from bulk precipitation is given in Table 5-2.

TABLE 5-2

ESTIMATED ANNUAL NUTRIENT LOADINGS FROM BULK PRECIPITATION TO LAKE CONCORD

TOTAL NITROGEN (kg/yr)	TOTAL PHOSPHORUS (kg/yr)
82.8	9.8

5.1.2 Stormwater Loadings

Estimates of runoff generated mass loadings of total nitrogen and total phosphorus entering Lake Concord were calculated using the hydrologic analyses discussed in Section 4, the results of the field runoff monitoring program, and common literature-based runoff values. The results of these analyses are discussed in the following sections.

5.1.2.1 Monitoring Sites

Field monitoring of runoff entering Lake Concord was conducted at the outfall for Sub-basin 5 which enters on the south end of the lake. Sub-basin 5 is the largest sub-basin area discharging to Lake Concord (73.17 acres) and contributes 39% of the annual runoff inflows and 23% of the total annual inflows. Although not monitored for this project, ERD conducted field monitoring of the outfall for Sub-basin 2 during 2013 as part of a project to measure the effectiveness of a baffle box installed at the outfall. A discussion of this monitoring is provided in "Evaluation of Performance Efficiencies of Casselberry Gross Pollutant Separators – Final Report" prepared for the City of Casselberry dated December 2014. Runoff characteristics measured during the 2013 study are used to estimate characteristics for Sub-basin 2.

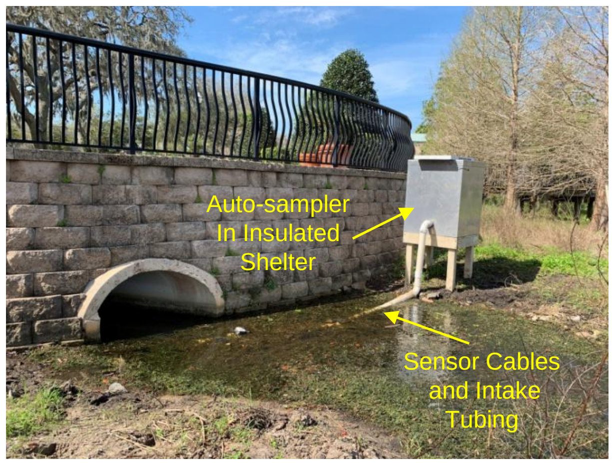
An overview of the monitoring site for Sub-basin 5 monitored for this project, along with the previous monitoring sites for Sub-basin 2, is given on Figure 5-2. Each of the monitoring locations was placed at the final access point, manhole, or outfall structure for the stormsewer system prior to discharge into Lake Concord and on the downstream side of any stormwater treatment systems so that the measured runoff characteristics reflect concentrations reaching Lake Concord.

5.1.2.1.1 Sub-basin 5

An overview of monitoring equipment installed at the Sub-basin 5 monitoring site is given on Figure 5-3. Stormwater monitoring at this site was conducted using an ISCO Model 6712 sequential autosampler which was housed inside an insulated aluminum equipment shelter. The ISCO autosampler was operated using a deep-cycle battery which was recharged with a solar panel attached to the roof of the equipment shelter. The sample tubing and flow meter cables were extended into the 42-inch RCP which discharges to Lake Concord.

Figure 5-2.
Runoff Monitoring Sites for Lake Concord.

a. Overview of Stormsewer Discharge



b. Runoff Collection Equipment

c. Overview of Discharge Channel

d. Point of Discharge to Lake Concord

Figure 5-3. Lake Concord Sub-basin 5 Stormwater Monitoring Site.

Discharge monitoring at this location was conducted using an ISCO Model 750 area velocity flow module which provided continuous measurements of water depth within the pipe and flow velocities which are then used to calculate discharge rates. The integral flowmeter unit was programmed to provide a continuous record of discharges through the 42-inch RCP, with measurements stored into internal memory at 15-minute intervals.

Flow measurements were conducted using an area-velocity sensor which transforms measurements of water depth and velocity into a discharge rate using the Continuity Equation and pipe geometry. The Continuity Equation is expressed as:

$$Q = V \times A$$

where:

where:	Q	=	discharge rate (cfs)
	V	=	flow velocity (fps)
	A	=	cross-sectional area of flow (ft^2)

The internal flow meter for the autosampler provided continuous measurements of discharge through the 42-inch stormsewer, with discharge values stored in internal memory at 15-minute intervals, as well as providing input for collection of flow-weighted samples of the inflow over a wide range of flow conditions. Discharge at this site was continuous and varied between a low volume baseflow, generated by groundwater infiltration or bleed-down of interconnected stormwater systems, to higher discharges during storm events. The autosampler used at this site contained a single 20-liter polyethylene bottle with 250 ml aliquots of inflow pumped into the bottle at pre-set intervals of discharge, producing a composite flow-weighted sample of the inflow, including both baseflow and runoff, over a weekly period. ERD field personnel visited the site on a weekly basis following significant rain events to retrieve collected samples and stored hydrologic data. A total of 12 flow-weighted samples was collected at this site during the field monitoring program.

5.1.2.1.2 Sub-basin 2

The location of the Sub-basin 2 monitoring site is also shown on Figure 5-2. This site reflects the final point of collection for runoff generated in Sub-basin 2 following treatment in the baffle box. A photograph of the former monitoring site for Sub-basin 2 is given on Figure 5-4. Additional details regarding monitoring and collected data are given in the ERD report titled "Evaluation of Performance Efficiencies of Casselberry Gross Pollutant Separators" dated December 2014.

5.1.2.2 Field and Laboratory Methods

Automated monitoring was conducted at the Sub-basin 5 site from February-June 2019. ERD field personnel visited the site on a weekly basis or following significant rain events (> 1 inch). Collected samples were transported to the ERD Laboratory for analysis of general parameters and nutrients. The ERD Laboratory is NELAC accredited (#E1031026) for environmental parameters, microbiological parameters, and metals. A summary of analysis methods and minimum detection limits (MDLs) for analyses conducted in the ERD Laboratory is given in Table 5-3.

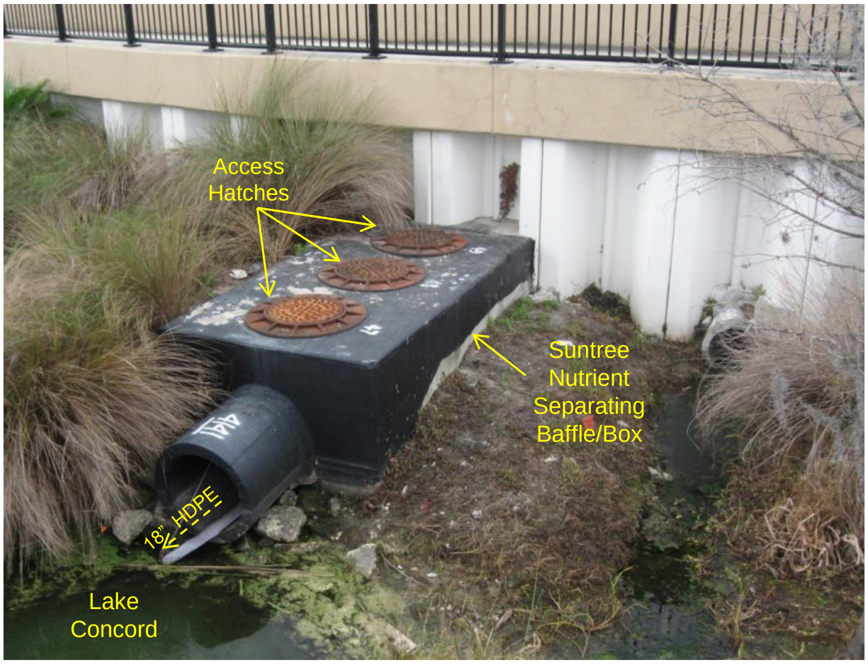


Figure 5-4.

Former Monitoring Site for Sub-basin 2.

TABLE 5-3

ANALYTICAL METHODS/DETECTION LIMITS FOR SURFACE WATER ANALYSES

PARAMETER	METHOD OF ANALYSIS[1]	METHOD DETECTION LIMITS (MDL)[2]
Hydrogen Ion (pH)	SM-22, Sec. 4500-H^+ B	Field
Specific Conductivity	SM-22, Sec. 2510 B	0.2 µmho/cm
Alkalinity	SM-22, Sec. 2320 B	0.6 mg/l
Ammonia-N	SM-22, Sec. 4500-NH_3 G	0.003 mg/l
NO_x-N	SM-22, Sec. 4500-NO_3 F	0.002 mg/l
Total Nitrogen	SM-22, Sec. 4500-N C	0.014 mg/l
Dissolved Total Nitrogen	SM-22, Sec. 4500-N C	0.014 mg/l
Ortho-P (SRP)	SM-22, Sec. 4500-P F	0.001 mg/l
Total Phosphorus	SM-22, Sec. 4500-P F (analysis) and Sec. 4500-P B.5	0.002 mg/l
Dissolved Total Phosphorus	SM-22, Sec. 4500-P F (analysis) and Sec. 4500-P B.5	0.002 mg/l
Turbidity	SM-22, Sec. 2130 B	0.4 NTU
TSS	SM-22, Sec. 2540 D	0.3 mg/l
Color	SM-22, Sec. 2120 C	1 Pt-Co Unit

1. Standard Methods for the Examination of Water and Wastewater, 22nd Ed., 2012
2. MDLs are calculated based on the EPA method of determining detection limits

5.1.2.3 Characteristics of Monitored Inflow Samples

A complete listing of the chemical characteristics of individual runoff samples collected at the Lake Concord monitoring site during the field monitoring program from February-June 2019 is given in Appendix E.

A tabular summary of general descriptive statistics for runoff samples collected at the Sub-basin 5 monitoring site is given on Table 5-4. The collected runoff samples were approximately neutral in pH, with values ranging from 6.78-7.86 and a geometric mean of 7.44. The collected runoff samples were also moderately to well buffered, with measured alkalinity values ranging from 64.0-153 mg/l. Measured conductivity values were low to moderate in value, with collected samples ranging from 210-387 μmho/cm.

TABLE 5-4

GENERAL DESCRIPTIVE STATISTICS FOR RUNOFF SAMPLES COLLECTED AT SUB-BASIN 5 FROM FEBRUARY-JUNE 2019

PARAMETER	UNITS	MINIMUM VALUE	MAXIMUM VALUE	GEOMETRIC MEAN
pH	s.u.	6.78	7.86	7.44
Alkalinity	mg/l	64.0	153	119
Conductivity	μmho/cm	210	387	320
NH_3	μg/l	2	486	20
NO_x	μg/l	73	1,057	489
Dissolved Organic Nitrogen	μg/l	91	470	451
Particulate Nitrogen	μg/l	46	491	163
Total Nitrogen	μg/l	482	1,939	1,124
SRP	μg/l	4	22	8
Dissolved Organic Phosphorus	μg/l	2	17	7
Particulate Phosphorus	μg/l	4	202	31
Total Phosphorus	μg/l	14	230	45
Turbidity	NTU	2.7	31.1	5.1
TSS	mg/l	3.3	57.0	8.4
Color	Pt-Co	24	41	33

(Highlighted) Listed value is MDL for parameter

In general, measured concentrations of total nitrogen at the Sub-basin 5 site were low to elevated in value, with measured values ranging from 482-1,939 μg N/l, and an overall geometric mean of 1,124 μg N/l. Measured concentrations of ammonia were low to elevated in value, with concentrations ranging from <2-486 μg/l. Measured concentrations of NO_x were highly variable, ranging from 73-1,057 μg/l, reflecting low to elevated values. Overall, the most significant nitrogen species present in the runoff samples was NO_x, followed by dissolved organic nitrogen and particulate nitrogen. The geometric mean concentration of total nitrogen (1,124 μg/l) was lower than values commonly observed in urban runoff, likely due to the multiple treatment systems within the sub-basin.

Measured concentrations of total phosphorus were highly variable between the individual monitoring events, ranging from 14-230 μg/l, with an overall geometric mean of 45 μg/l, reflecting an extremely low value which is likely related to the multiple upstream treatment systems. In general, measured concentrations of dissolved organic phosphorus and particulate phosphorus were also low in value compared to concentrations commonly observed in urban runoff. The largest component of the measured total phosphorus was particulate phosphorus followed by SRP and dissolved organic phosphorus.

Turbidity values were generally low in value at the Sub-basin 5 inflow monitoring site, with measured values ranging from 2.7-31.1 NTU. Measured color concentrations were moderate in value, ranging from 24-41 Pt-Co units. Mean TSS concentrations ranged from 3.3-57.0 mg/l, values lower than commonly observed by ERD and reported in urban runoff.

5.1.2.4 Selection of Runoff Characterization Data

Estimates of mean annual runoff concentrations of total nitrogen and total phosphorus discharging to Lake Concord from each of the identified inflows were developed to assist in calculating mass loadings to Lake Concord from stormwater runoff. Direct field monitoring of the characteristics of runoff inflows was conducted at Sub-basin 5, and geometric mean characteristics of samples collected at this site are assumed to reflect annual average concentrations of runoff inputs under current conditions.

Direct monitoring of runoff was not conducted in Sub-basin 6 which enters Lake Concord as discharge from Quail Pond. However, water characteristics of Quail Pond were monitored by ERD for the City during September and December 2019 and March 2020. A summary of geometric mean concentrations of total nitrogen and total phosphorus in Quail Pond for these events is given in Table 5-5, and these values are assumed to reflect inflows to Lake Concord from Sub-basin 6.

TABLE 5-5

CHARACTERISTICS OF SURFACE WATER SAMPLES COLLECTED IN QUAIL POND DURING 2019-2020

DATE	TOTAL NITROGEN (µg/l)	TOTAL PHOSPHORUS (µg/l)
9/11/2019	532	17
12/18/2019	471	25
3/27/2020	539	16
Geometric Mean	**513**	**19**

Direct measurements of runoff characteristics are not available for Sub-basins 1, 3, 4, and the Direct overland flow area. Sub-basin 1 consists of a large box store with a dry retention pond for treatment. Volumetric losses in the dry retention pond were included in the runoff calculations discussed in Section 4, but reductions in runoff concentrations are also likely. During 2014-2015, ERD conducted a study for FDEP of the effectiveness of dry detention systems serving big box store sites. The vast majority of runoff inputs was retained within the pond, similar to the Sub-basin 1 site. Chemical characteristics of the pond discharges were monitored at 4 sites and the mean outfall characteristics are summarized in Table 5-6. For purposes of this analysis, the values listed in Table 5-6 are assumed to reflect the characteristics of runoff discharges from Sub-basin 1.

TABLE 5-6

MEAN CHARACTERISTICS OF POND DISCHARGES FROM COMMERCIAL SITES IN FLORIDA[1]

PARAMETER	MEAN OUTFALL CONCENTRATION (µg/l)
Total Nitrogen	462
Total Phosphorus	76

1. Based on ERD Report titled "Performance Efficiency Evaluation of Underdrain Filtration and Dry Detention Best Management Practices". Final Report prepared for FDEP, June 2015.

Sub-basin 3 consists of 23.60 acres of commercial, highway, industrial, and residential (medium-density and high-density) land uses, with minimal stormwater treatment facilities. Runoff characteristics for this sub-basin are estimated as the volume weighted concentration for the individual land use categories using values from the Florida emc database maintained by ERD for FDEP. A summary of this analysis is given in Table 5-7. Values for annual runoff volumes for each land use category were obtained from the hydrologic model in Appendix C.

TABLE 5-7

CALCULATIONS TO ESTIMATE WEIGHTED emc VALUES FOR SUB-BASIN 3

LAND USE	AREA (acres)	RUNOFF VOLUME (ac-ft/yr)	UNTREATED emc CONCENTRATION (μg/l)	
			Total Nitrogen	Total Phosphorus
Commercial	7.06	14.14	1,070	179
High-Density Residential	1.52	1.47	2,100	497
Highway	4.59	14.54	1,370	167
Industrial	5.91	12.65	1,190	213
Institutional	0.07	0.17	1,510	178
Medium-Density Residential	2.76	2.59	1,870	301
Open Space	1.18	0.66	1,150	55
Upland Forest	0.51	0.24	900	271
TOTAL:	**23.60**	**46.46**	**1,276**[1]	**200**[1]

1. Volume of weighted values

Sub-basin 4 is a small (2.40 acre) area of primarily institutional land use located southwest of Lake Concord. Virtually all of the sub-basin area has treatment systems such as dry retention and exfiltration trenches. This sub-basin is very similar to Sub-basin 1 except that the dominant land use category is institutional rather than low-intensity commercial. However, the runoff characteristics for these land use categories are similar, so the runoff discharges from Sub-basin 4 are assumed to be similar to the values summarized in Table 5-6.

The Direct overland flow sub-basin consists of 16.87 acres of a variety of land use categories dominated by low-density residential, open space, high-density residential, recreational, and natural areas. Estimation of runoff characteristics for this area was conducted in the same manner as Sub-basin 3 using a volume weighted emc value based on untreated runoff characteristics for the listed land use categories. A summary of this analysis is given in Table 5-8. The calculated volume-weighted runoff concentration for the Direct overland flow sub-basin are 1,289 μg/l for total nitrogen and 183 μg/l for total phosphorus.

A tabular summary of assumed runoff characteristics for Lake Concord sub-basin areas is given in Table 5-9 based upon the discussion presented previously. The concentrations listed in this table reflect the assumed characteristics of runoff discharges into Lake Concord following treatment in stormwater ponds, depressions, and wetlands, if applicable, within the individual sub-basin areas.

TABLE 5-8

CALCULATIONS TO ESTIMATE WEIGHTED emc VALUES FOR DIRECT OVERLAND FLOW SUB-BASIN

LAND USE	AREA (acres)	RUNOFF VOLUME (ac-ft/yr)	UNTREATED emc CONCENTRATION (µg/l)	
			Total Nitrogen	Total Phosphorus
Commercial	0.55	0.88	1,070	179
High-Density Residential	1.85	1.43	2,100	497
Highway	0.06	0.09	1,370	167
Low-Density Residential	6.02	3.17	1,190	213
Medium-Density Residential	0.54	0.33	1,870	301
Open Space	4.75	3.99	1,150	55
Recreational	1.74	1.00	1,070	179
Scrub	1.36	0.43	1,109	23
TOTAL:	**16.87**	**11.32**	**1,289**[1]	**183**[1]

1. Volume-weighted emc values

TABLE 5-9

ASSUMED RUNOFF CHARACTERISTICS FOR LAKE CONCORD SUB-BASIN AREAS

SUB-BASIN	GENERATED RUNOFF VOLUME (ac-ft/yr)	RUNOFF CONCENTRATION (mg/l)		RUNOFF CONCENTRATION REFERENCE
		Total Nitrogen	Total Phosphorus	
1	6.7	0.462	0.076	FDEP Dry Pond Study (2012-2013)
2	59.9	1.000	0.100	Direct measurement (2013)
3	46.5	1.276	0.200	Weighted average of land use emc
4	1.3	0.462	0.076	FDEP Dry Pond Study (2012-2013)
5	83.5	1.124	0.045	Direct measurement
6	4.7	0.513	0.019	Direct measurement-Quail Pond
Direct	11.3	1.289	0.183	Weighted average of land use emc
TOTAL:	**213.8**			

5.1.2.5 Runoff Loadings

Estimates of runoff generated annual mass loadings of total nitrogen and total phosphorus to Lake Concord were developed for each of the identified sub-basin areas discussed previously using the annual hydrologic inputs discussed in Section 4.1.2 and assumed runoff emc values listed in Table 5-9. A tabular summary of calculated runoff loadings to Lake Concord is given in Table 5-10. Estimated mass loadings are provided for total nitrogen and total phosphorus by multiplying the assumed sub-basin runoff characteristics (summarized in Table 5-9) times the delivered sub-basin runoff volume reaching Lake Concord on an annual basis (Table 4-4). Overall, runoff loadings contribute approximately 288 kg/yr of total nitrogen and 26.9 kg/yr of total phosphorus to Lake Concord.

TABLE 5-10

CALCULATED ANNUAL RUNOFF LOADINGS TO LAKE CONCORD

SUB-BASIN	GENERATED RUNOFF VOLUME (ac-ft/yr)	MASS LOADING (kg/yr)		FRACTION OF TOTAL LOADING (%)		AREAL MASS LOADING (kg/ac-yr)	
		Total N	Total P	Total N	Total P	Total N	Total P
1	6.7	3.8	0.6	1.3	2.3	0.34	0.06
2	59.9	73.9	7.4	25.6	27.4	1.69	0.17
3	46.5	73.1	11.5	25.4	42.5	3.10	0.49
4	1.3	0.7	0.1	0.2	0.4	0.30	0.05
5	83.5	116	4.7	40.1	17.4	1.58	0.06
6	4.7	3.0	0.1	1.0	0.4	0.26	0.01
Direct	11.3	18.0	2.6	6.2	9.5	1.07	0.15
TOTAL:	**214**	**288**	**26.9**	**100**	**100**	**1.58**	**0.15**

Sub-basins with areal mass loading rates > 50% above the area-weighted mean value

Information is also provided in Table 5-10 on the percentage of the overall annual runoff loading for each parameter contributed by each of the identified sub-basin areas. The single largest source of runoff generated loadings of phosphorus to Lake Concord is Sub-basin 3, an area with minimal stormwater treatment, which comprises 12.9% of the overall drainage basin area and contributes 42.5% of the runoff generated loadings of total phosphorus to Lake Concord. The largest runoff generated loadings of total nitrogen originate from Sub-basin 5, an area with extensive treatment systems, which comprises 40.1% of the watershed area.

The second largest contribution of runoff generated phosphorus loadings occurs from Sub-basin 2, a 43.08-acre area of mixed land use, which contributes approximately 27.4% of the annual loading of total phosphorus from runoff to Lake Concord. The next most significant phosphorus loading originates from Sub-basin 5, 73.17-acre area of mixed land use which contributes approximately 17.4% of the annual runoff generated loadings of total phosphorus to the lake.

Calculated areal loading rates for each sub-basin are provided in the final columns of Table 5-10. The values were obtained by dividing the total mass loadings for nitrogen and phosphorus for each sub-basin by the total sub-basin area which allows an evaluation of pollutant loadings which is independent of the size of an individual sub-basin area. Mean areal mass loadings for the Lake Concord watershed are provided on the bottom-right of Table 5-10 and were calculated by dividing the total mass of total nitrogen and total phosphorus generated in all sub-basins by the total sub-basin area of 182.48 acres. Sub-basin areas which exceed the mean areal loading rates by more than 50% are highlighted in yellow and reflect loading “hot spots” within the Lake Concord drainage basin. Areal mass loading rates for total nitrogen vary widely, with the loading rate in Sub-basin 3 exceeding 50% above the mean value. Areas with areal mass loading rates greater than 50% above the mean value for total phosphorus also include Sub-basin 3, which also exhibits the highest areal mass phosphorus loading rate. Excessive total and areal loadings of both total nitrogen and total phosphorus appear to be generated in Sub-basin 3 compared with the other sub-basin areas.

5.1.3 Groundwater Seepage

5.1.3.1 Chemical Characteristics of Seepage Inflows

Nutrient influx to Lake Concord from groundwater seepage was quantified using a series of underwater seepage meters installed throughout the lake. A discussion of the hydrologic inputs to Lake Concord resulting from groundwater seepage is given in Section 4.1.3. Seepage meters provide a method of measuring combined impacts from all groundwater impacts, including septic tanks, fertilizer use, and rainfall. Each of the collected groundwater seepage samples was analyzed in the ERD Laboratory for pH, alkalinity, conductivity, ammonia, NO_x, total nitrogen, SRP, and total phosphorus using the analytical methods outlined in Table 5-3 for runoff water analyses. A summary of geometric mean characteristics of seepage inflows to Lake Concord from March-September 2019 is given in Table 5-11, and a complete listing of laboratory measurements conducted on seepage samples collected in Lake Concord is given in Appendix D-2.

In general, groundwater seepage collected from Lake Concord was found to be slightly alkaline in pH, with geometric mean pH values at the seepage monitoring sites ranging from 7.24-8.06, reflecting a moderate degree of variability in values throughout the lake.

TABLE 5-11

GEOMETRIC MEAN CHARACTERISTICS OF SEEPAGE INFLOWS TO LAKE CONCORD FROM MARCH-SEPTEMBER 2019

SITE	NUMBER OF SAMPLES	PARAMETER									
		pH (s.u.)	Alkalinity (mg/l)	Conductivity (μmho/cm)	NH_3 (μg/l)	NO_x (μg/l)	Org N (μg/l)	Total N (μg/l)	SRP (μg/l)	Org P (μg/l)	Total P (μg/l)
SP-1	4	8.06	192	460	1,013	2,511	1,622	5,146	227	32	259
SP-2	4	7.36	76.7	225	73	463	585	1,120	25	14	39
SP-3	4	7.35	118	303	321	623	532	1,477	19	17	36
SP-4	4	7.86	182	464	706	3,416	3,510	7,632	100	35	135
SP-5	4	7.44	150	379	267	2,200	869	3,336	19	13	32
SP-6	4	7.92	255	694	2,693	14,838	3,301	20,831	251	39	290
SP-7	4	7.36	99.7	264	223	403	846	1,472	15	15	30
SP-8	4	7.24	102	272	328	160	1,274	1,763	25	27	52
TOTAL:	**32**										

A high degree of variability was observed in measured alkalinity values in the seepage samples, with overall geometric mean alkalinity values ranging from 76.7-255 mg/l, reflecting moderate to well buffered conditions at each site. The observed variability in alkalinity values is likely related to the groundwater characteristics in the vicinity of each individual monitoring site. Sites with low measured alkalinity values are likely impacted by seepage inflows from wetlands or shallow seepage which has migrated through a significant layer of hydric soil or organic muck. Seepage samples with alkalinity values in excess of 100 mg/l suggest influence from deeper limestone formations. The overall seepage alkalinity values in Lake Concord are some of the highest values measured by ERD.

A moderate degree of variability was observed in measured conductivity values in seepage samples collected in Lake Concord, with geometric mean values ranging from 225-694 μmho/cm. The most elevated conductivity value was observed at Site SP-6 which also had the highest seepage values for alkalinity, ammonia, NO_x, total nitrogen, SRP, and total phosphorus. Seepage site SP-6 is located on the west shoreline of Lake Concord near the baffle box site.

Geometric mean concentrations of ammonia in Lake Concord ranged from 73-2,693 μg/l, reflecting extremely low to extremely elevated values. The most elevated values were observed at Sites SP-1 and SP-6, both of which are located along the western shoreline.

Geometric mean concentrations of NO_x in Lake Concord seepage also ranged from extremely low to extremely elevated, with mean concentrations ranging from 160-14,838 μg/l. The most elevated value was observed at Site SP-6, located on the western shoreline of Lake Concord, reflecting one of the highest seepage NO_x concentrations ever measured by ERD.

Geometric mean concentrations of total nitrogen in groundwater seepage entering Lake Concord were highly variable between the monitoring sites. Measured mean total nitrogen concentrations in seepage ranged from 1,120-20,831 μg/l, reflecting moderate to extremely elevated nitrogen concentrations for seepage. The most elevated total nitrogen concentrations were observed at Sites SP-1 and SP-6, each of which is along the western shoreline of the lake, and at Site SP-4 on the northeast shoreline. Seepage total nitrogen concentrations at these sites exceed values in lakes heavily impacted by reuse irrigation.

A high degree of variability was observed in geometric mean concentrations of both SRP and total phosphorus which ranged from 30-290 μg/l, with the most elevated concentrations at the same sites with elevated total nitrogen concentrations, suggesting that similar processes are impacting both total nitrogen and total phosphorus. Seepage concentrations of total phosphorus entering Lake Concord are comprised primarily of SRP and are not as elevated as the measured total nitrogen concentrations.

Isopleths of geometric mean pH values in groundwater seepage entering Lake Concord from March-September 2019 are illustrated on Figure 5-5. The most elevated seepage pH values were observed in central portions of the western shoreline, with the lowest pH values measured in southeastern portions of the lake. Overall, seepage pH values in Lake Concord exhibited a moderate degree of variability compared with pH values in seepage measurements conducted in other urban lakes.

Isopleths of mean alkalinity values in groundwater seepage entering Lake Concord from March-September 2019 are illustrated on Figure 5-6. The most elevated seepage alkalinity values were observed in central portions of the western shoreline, with the lowest alkalinity values measured along the southern shoreline.

Isopleths of geometric mean conductivity values in groundwater seepage entering Lake Concord from March-September 2019 are illustrated on Figure 5-7. Measured conductivity values in the seepage samples exhibited a moderate degree of variability, with seepage isopleth contours ranging from 400-700 μmho/cm. The most elevated seepage conductivity values were observed in central portions of the western shoreline, with the lowest overall values observed in southern portions of the lake.

Isopleths of geometric mean ammonia concentrations in groundwater seepage entering Lake Concord from March-September 2019 are illustrated on Figure 5-8. Seepage ammonia concentrations are highest in central portions of the western shoreline, with the lowest values in eastern portions of the lake. Elevated concentrations of ammonia are often associated with reduced environments created in areas with deep deposits of organic muck.

Isopleths of geometric mean NO_x concentrations in groundwater seepage entering Lake Concord from March-September 2019 are illustrated on Figure 5-9. Seepage NO_x concentrations are highest in central portions of the western shoreline. This area also exhibited the highest concentrations of ammonia which is highly unusual since ammonia and NO_x commonly exhibit inverse relationships in seepage.

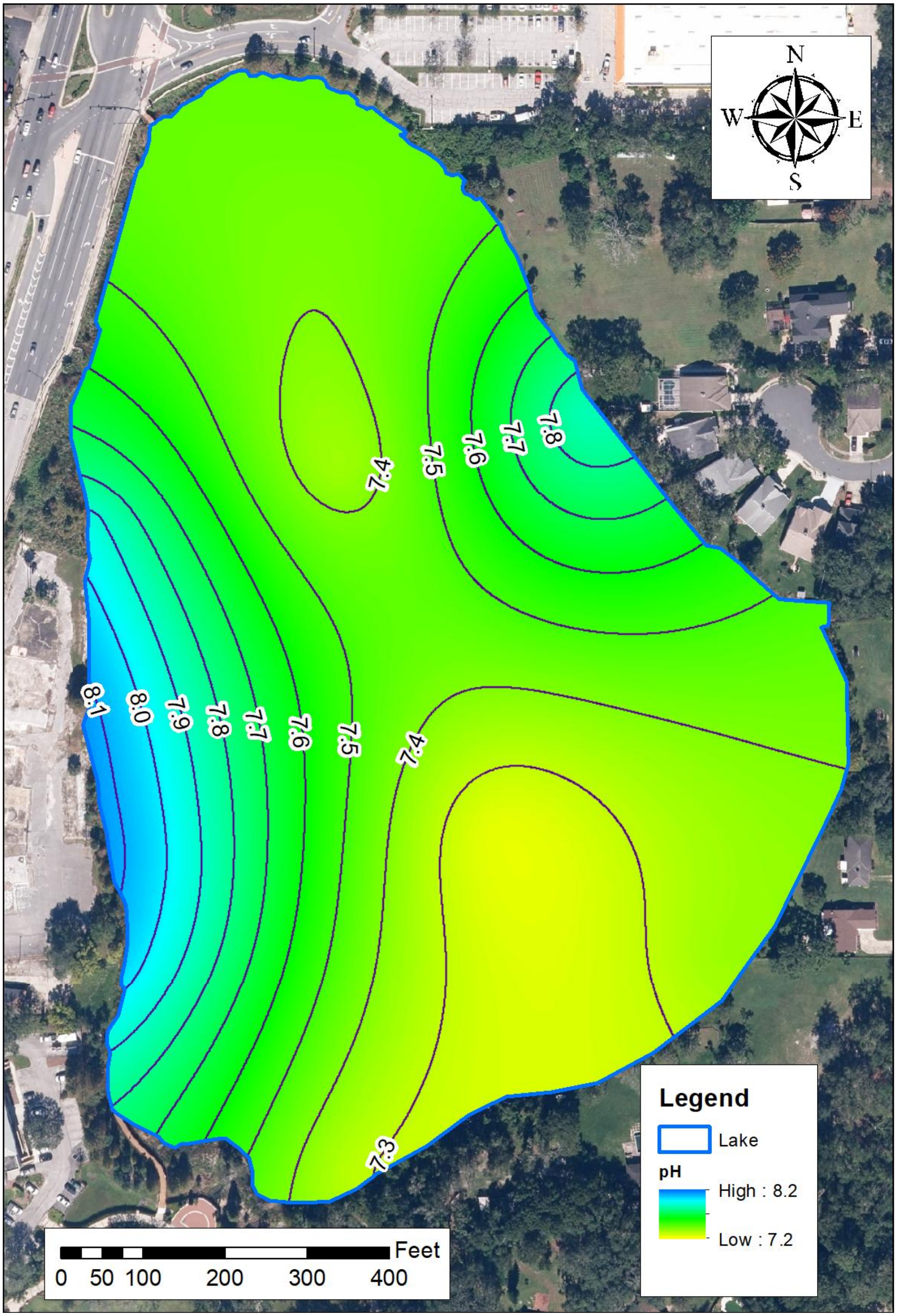


Figure 5-5. Isopleths of Seepage pH Values in Lake Concord from March-September 2019.

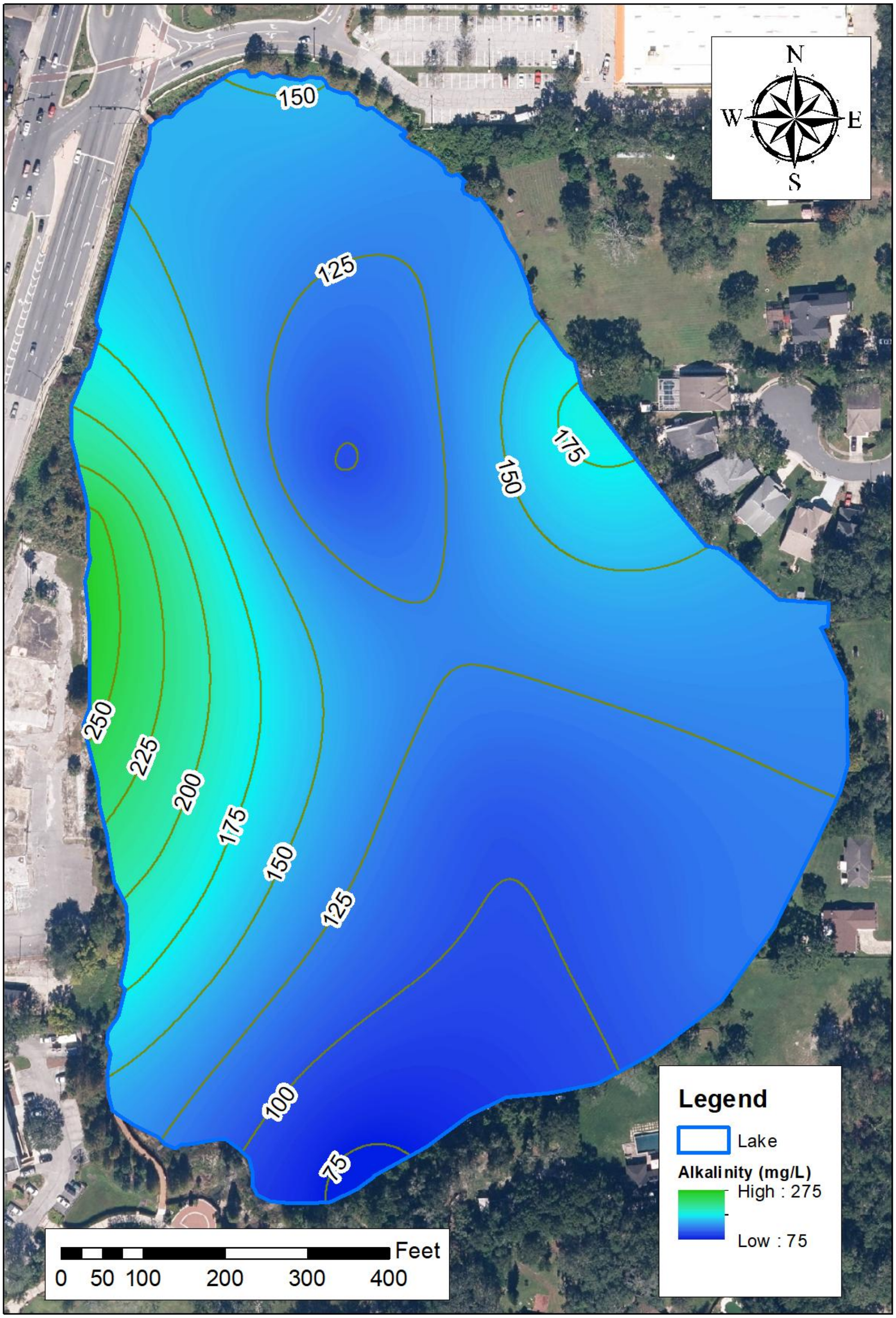


Figure 5-6. Isopleths of Seepage Alkalinity Values in Lake Concord from March-September 2019.

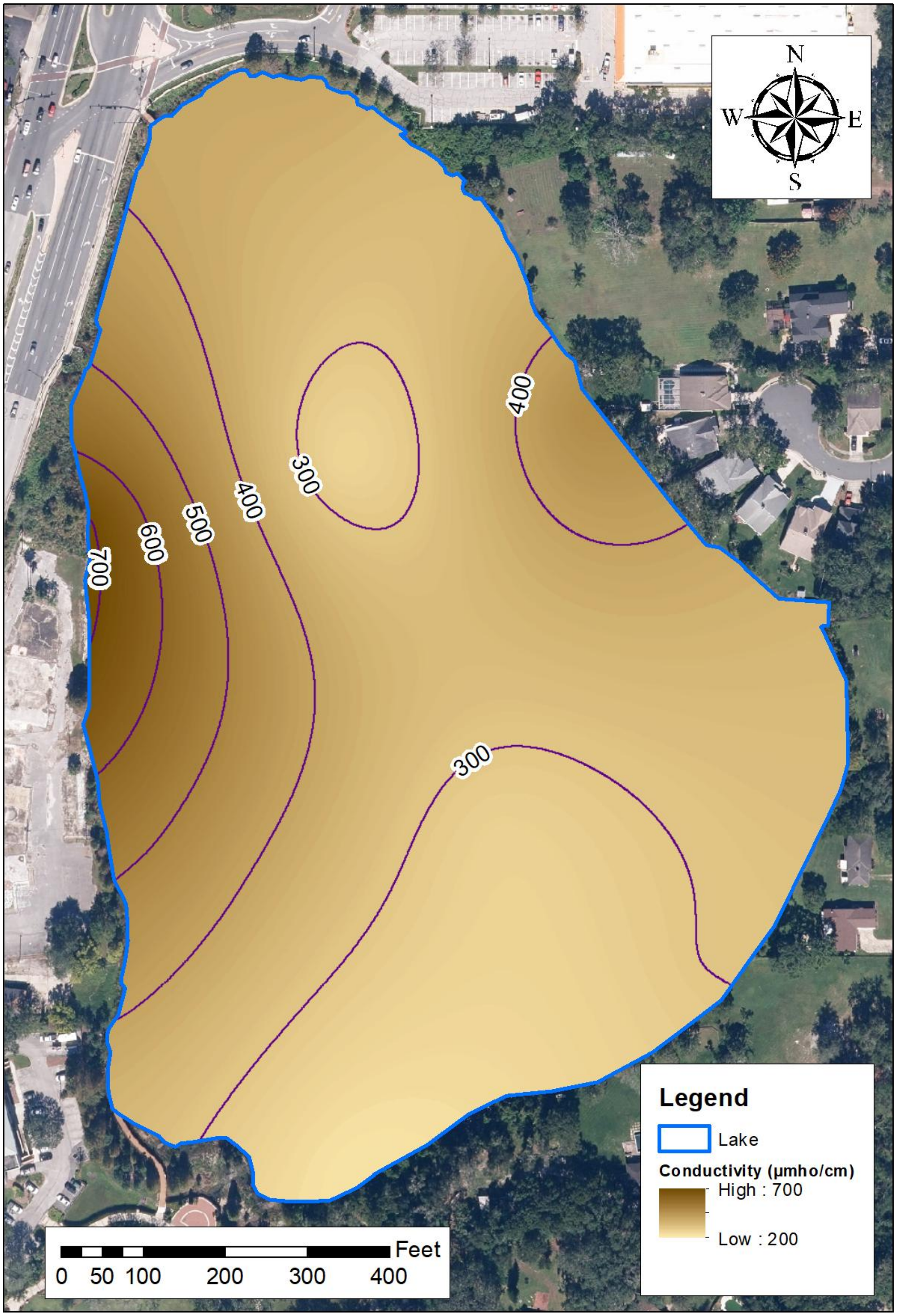


Figure 5-7. Isopleths of Seepage Conductivity Values in Lake Concord from March-September 2019.

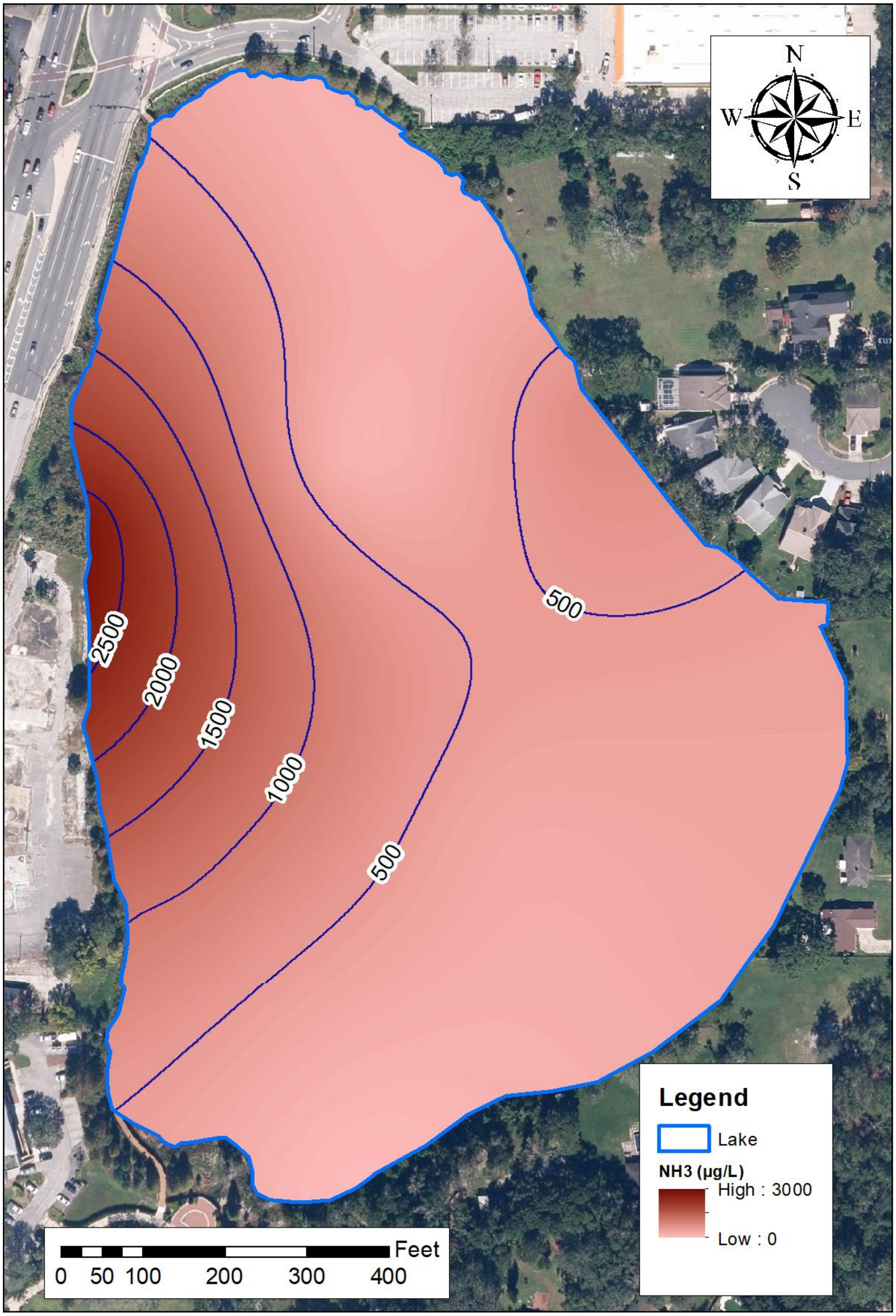


Figure 5-8. Isopleths of Seepage Ammonia Values in Lake Concord from March-September 2019.

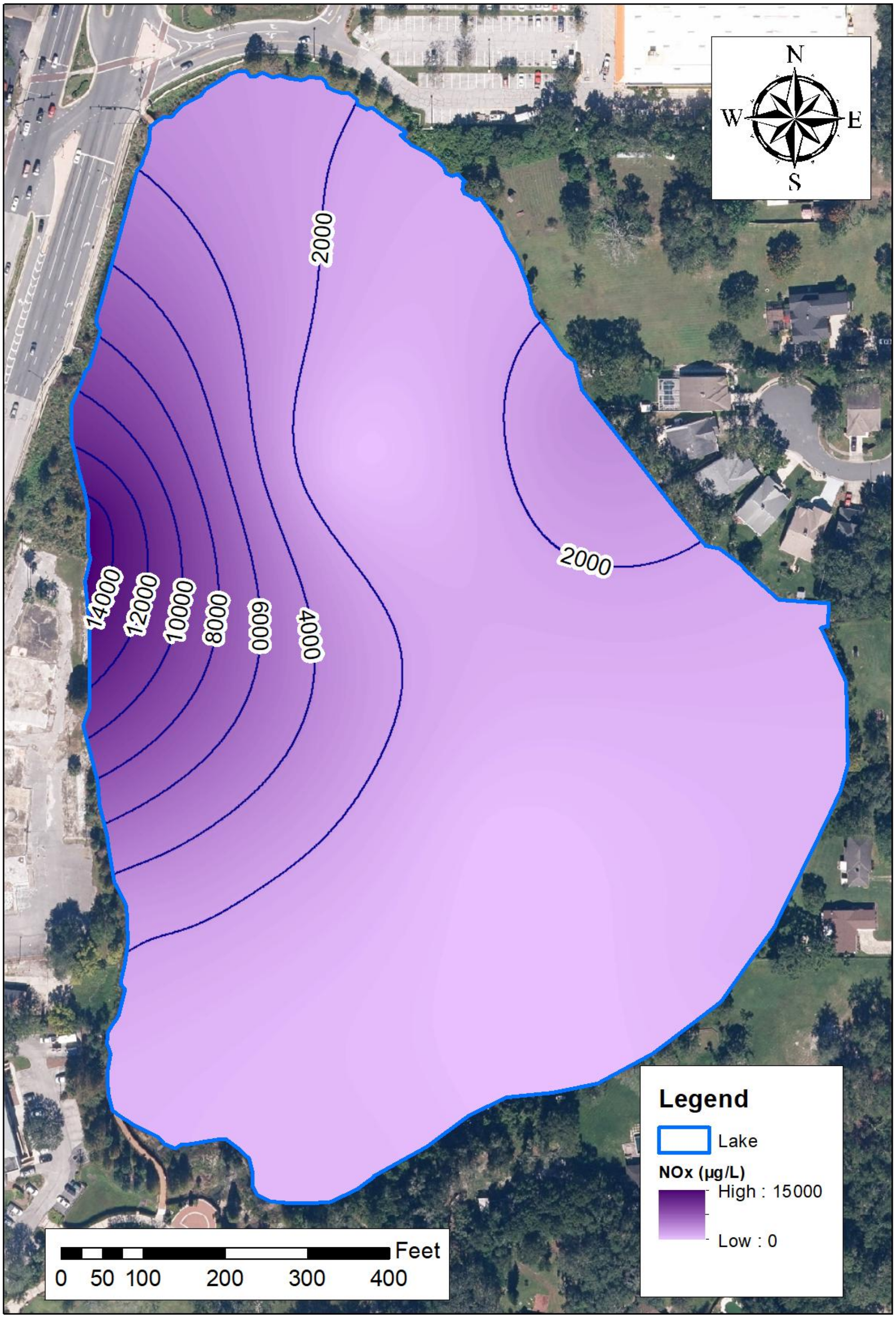


Figure 5-9. Isopleths of Seepage NO_x Values in Lake Concord from March-September 2019.

Isopleths of geometric mean total nitrogen concentrations in groundwater seepage entering Lake Concord from March-September 2019 are illustrated on Figure 5-10. The most elevated levels of total nitrogen were observed in central portions of the western shoreline, with the lowest measured total nitrogen concentrations observed in central and southern portions of the lake. Sources of the extremely elevated total nitrogen concentrations along the western shoreline should be further evaluated using stable isotope analyses or sewage tracer studies.

Isopleths of mean total phosphorus concentrations in groundwater seepage entering Lake Concord from March-September 2019 are illustrated on Figure 5-11. The most elevated concentrations of phosphorus occurred in central portions of the western shoreline, with lower concentrations observed in central and southern portions of the lake. Overall, isopleth values on Figure 5-11 range from 50-300 μg/l, reflecting moderate phosphorus values for groundwater seepage. Areas of highest total phosphorus concentrations in seepage are similar to the areas of elevated total nitrogen concentrations.

5.1.3.2 Mass Loadings

Mean seepage isopleths for influx of total nitrogen and total phosphorus were generated by combining the concentration isopleths for total nitrogen and total phosphorus (provided on Figures 5-10 and 5-11, respectively) with the hydrologic isopleths for groundwater seepage entering Lake Concord (summarized on Figure 4-5). This procedure results in estimates of nutrient flux in terms of mass of nitrogen or phosphorus per square meter of lake surface area per day ($\mu g/m^2$-day).

Isopleths of mean seepage influx of total nitrogen into Lake Concord during the field monitoring program are illustrated on Figure 5-12. In general, nitrogen influx from groundwater seepage ranged from approximately 5,000-25,000 $\mu g/m^2$-day, reflecting extremely elevated values. The most elevated levels of nitrogen influx were observed along central portions of the western shoreline. Substantially lower nitrogen influx rates were observed in central and eastern portions of the lake.

Isopleths of mean seepage influx of total phosphorus into Lake Concord during the field monitoring program are illustrated on Figure 5-13. The most elevated levels of phosphorus influx occurred along the western shoreline, with the lowest concentrations observed in central and eastern portions of the lake. Phosphorus influx values ranged from approximately 50-500 $\mu g/m^2$-day, reflecting moderate to elevated values.

The mass flux isopleths for total nitrogen and total phosphorus (presented on Figures 5-12 and 5-13) were integrated to develop estimates of the total influx of nitrogen and phosphorus from groundwater seepage into Lake Concord on an annual basis. A summary of estimated annual mass loadings of total nitrogen and total phosphorus to Lake Concord from groundwater seepage under current conditions is given in Table 5-12. The area-weighted average total nitrogen influx to Lake Concord from groundwater seepage, based upon the nitrogen influx isopleths summarized on Figure 5-12, is 5,318 $\mu g/m^2$-day, approximately twice the flux rate commonly observed by ERD in urban lakes. The measured phosphorus influx rate to Lake Concord from groundwater seepage, based upon the influx isopleths provided on Figure 5-13, is 123 $\mu g/m^2$-day, which is similar to values observed by ERD in other urban lakes. Overall, on an average annual basis, groundwater seepage contributes approximately 155 kg/yr of total nitrogen and 3.6 kg/yr of total phosphorus to Lake Concord under current conditions. This loading includes all current inputs to groundwater including infiltration of rainfall and septic tank contributions, if any, and potential sanitary sewage leakage.

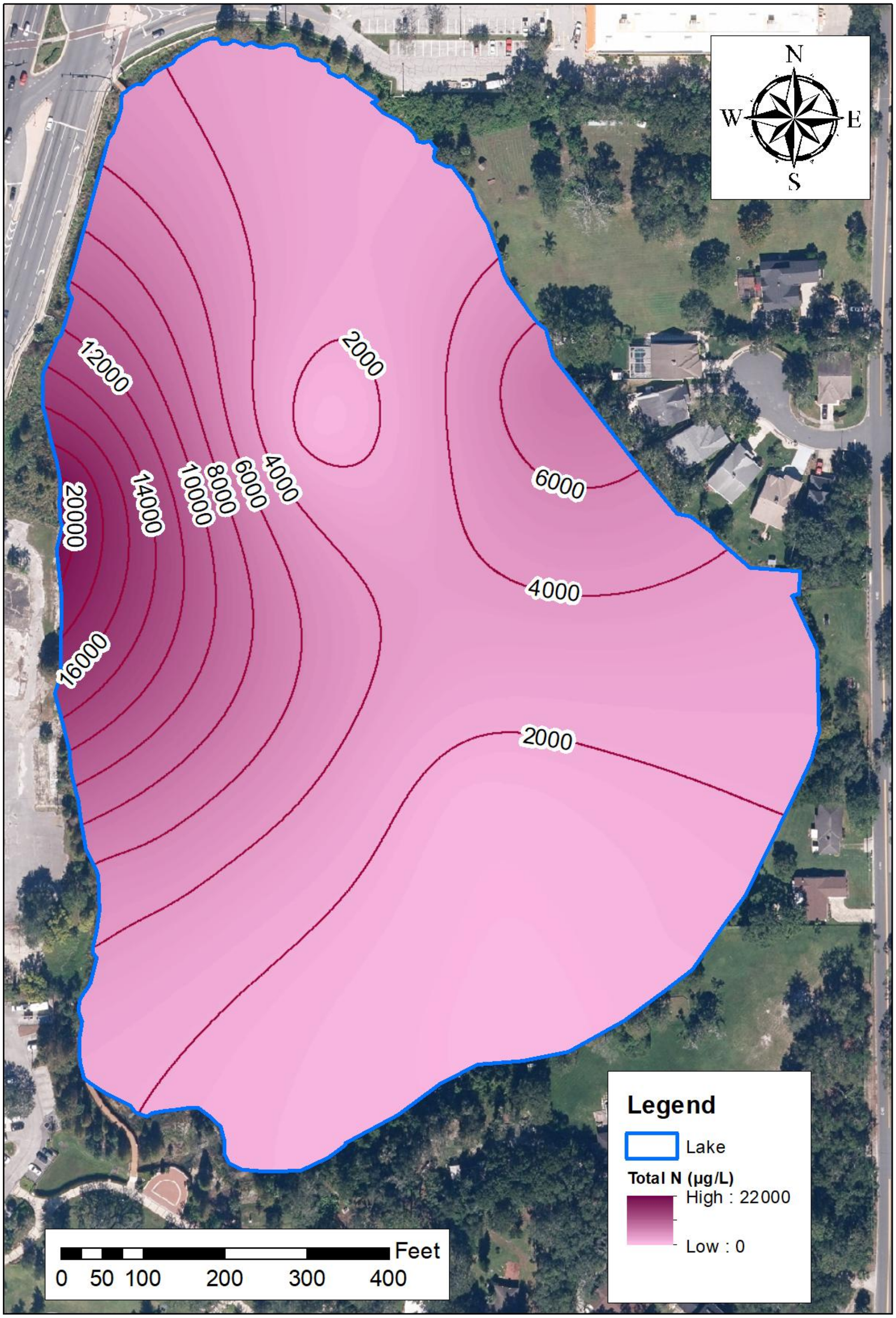


Figure 5-10. Isopleths of Seepage Total Nitrogen Values in Lake Concord from March-September 2019.

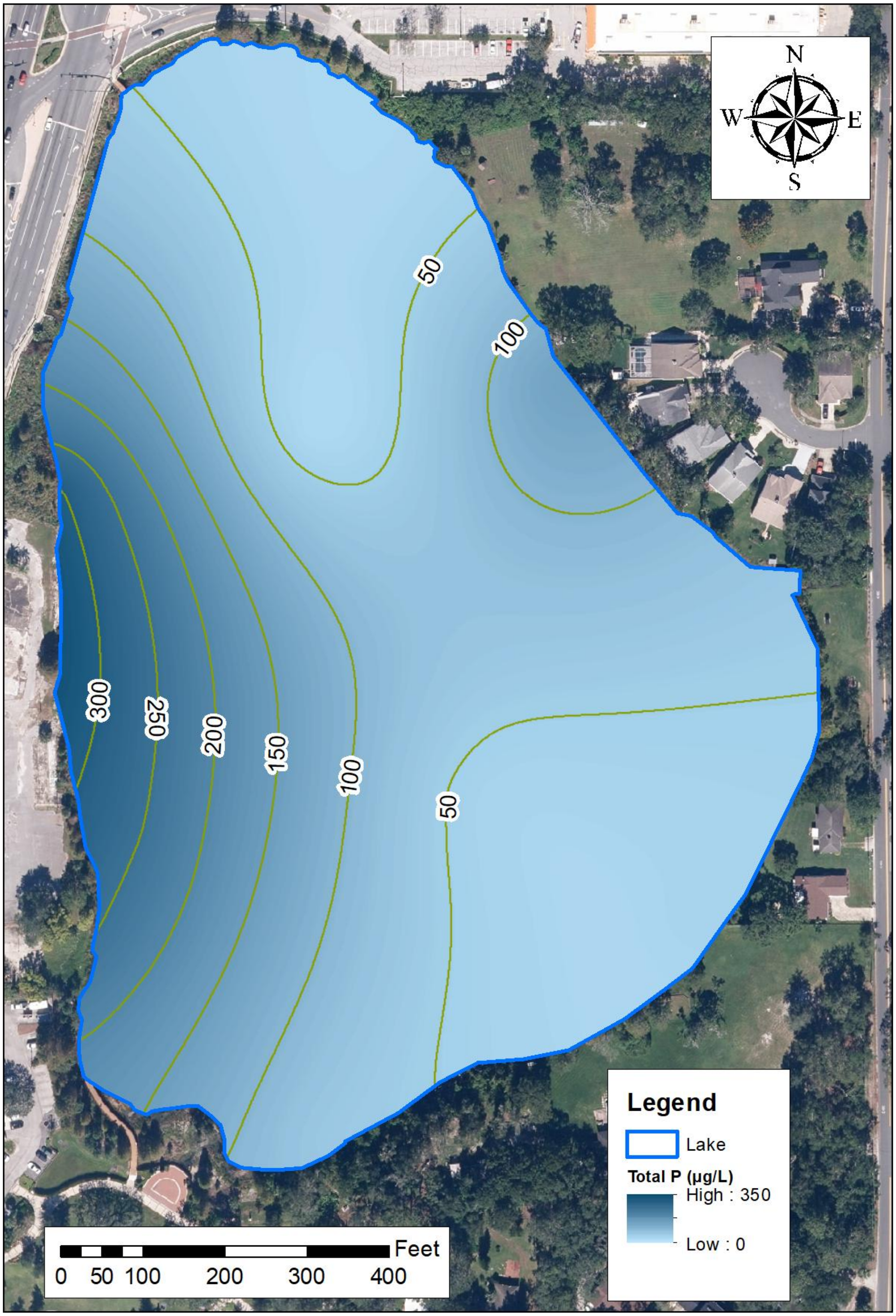


Figure 5-11. Isopleths of Seepage Total Phosphorus Values in Lake Concord from March-September 2019.

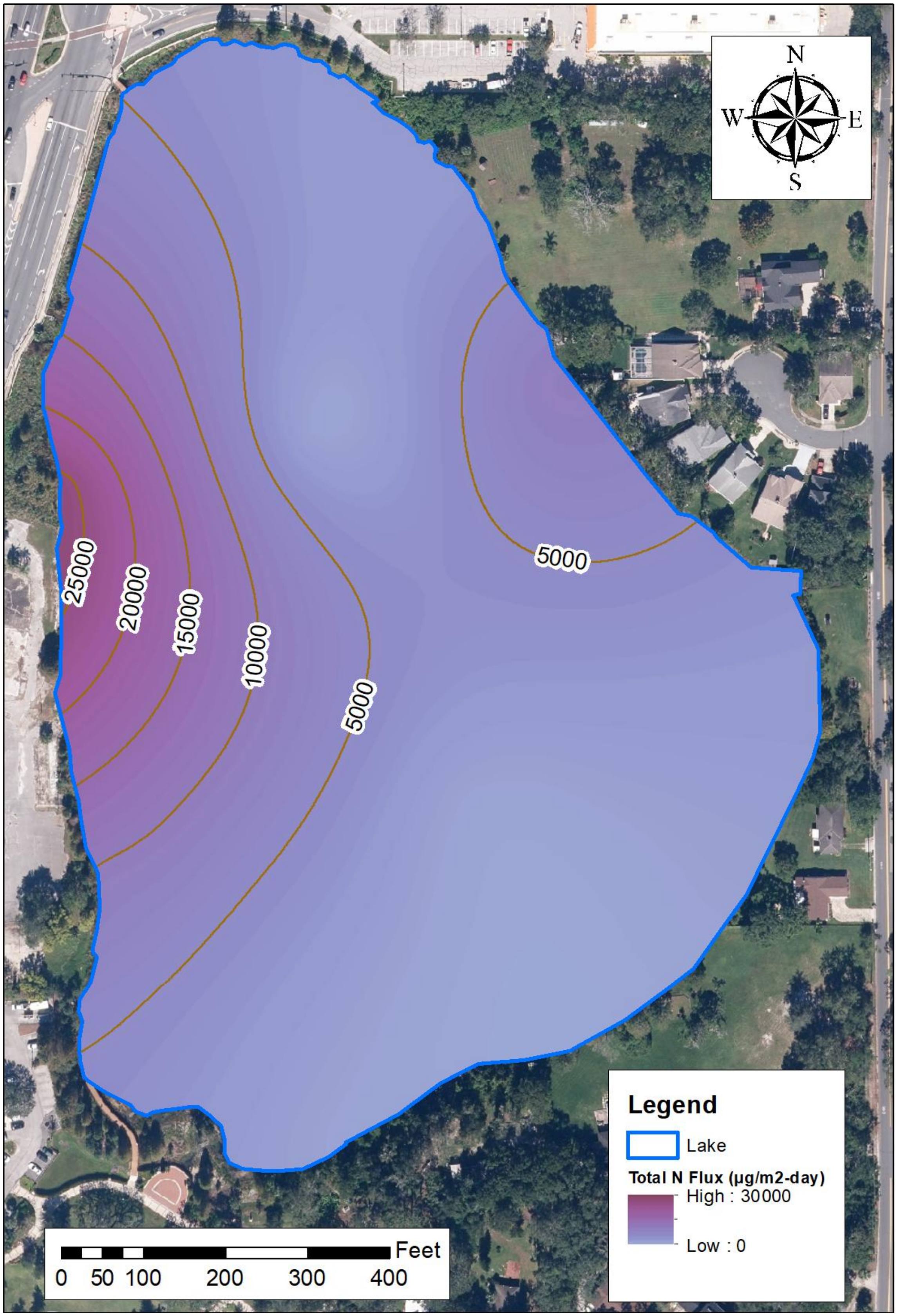


Figure 5-12. Isopleths of Nitrogen Influx (µg/m^2-day) for Groundwater Seepage Entering Lake Concord from March-September 2019.

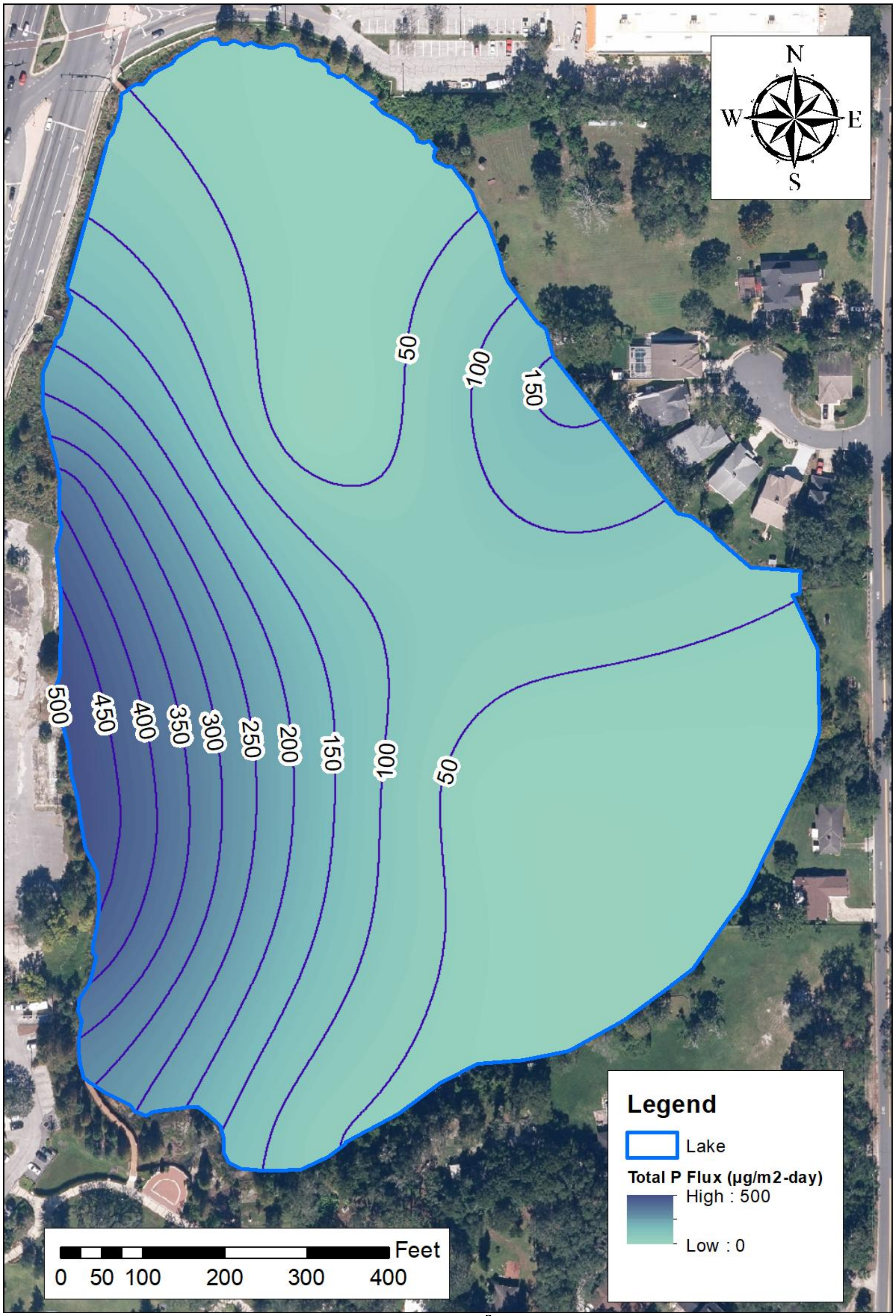


Figure 5-13. Isopleths of Phosphorus Influx (µg/m^2-day) for Groundwater Seepage Entering Lake Concord from March-September 2019.

TABLE 5-12

ESTIMATED ANNUAL MASS LOADINGS TO LAKE CONCORD FROM GROUNDWATER SEEPAGE UNDER CURRENT CONDITIONS

TOTAL NITROGEN			TOTAL PHOSPHORUS			AREAL LOADING (kg/ac-yr)	
$\mu g/m^2$-day	g/day	kg/yr	$\mu g/m^2$-day	g/day	kg/yr	Total N	Total P
5,318	425	155	123	9.8	3.6	7.9	0.18

Calculated areal loadings of groundwater seepage are provided in the final columns of Table 5-12 which reflect the mass influx divided by the lake surface area. These values provide a way of comparing seepage loading between lakes without consideration of lake size. The mean areal seepage loadings of 7.9 kg/ac-yr for total nitrogen and 0.18 kg/ac-yr for total phosphorus are similar to areal mass loading rates for groundwater seepage commonly observed by ERD in Central Florida lakes. The estimated annual mass loadings summarized in Table 5-12 are used in a subsequent section to develop a nutrient budget for Lake Concord.

5.1.4 Internal Recycling

Quantification of sediment phosphorus release as a result of internal recycling in lakes is difficult, and a variety of methods have been used by researchers to estimate this loading. One method which has been used in reservoirs is called the Mass Balance Method. This method is best suited to a waterbody with well defined inputs and outputs. A mass balance is then conducted on the waterbody over a one- to two-week period. An increase of phosphorus mass within the lake, after accounting for inputs and losses, would suggest that a net internal loading has occurred. However, this method appears inappropriate for use in Lake Concord since the lake is impacted by a wide variety of hydrologic and pollutant sources.

A method which has been used extensively in deep northern lakes is to measure changes in phosphorus content in the hypolimnion of a stratified lake over an extended period of anoxia. The increase in phosphorus mass within the stratified hypolimnion can then be directly correlated with sediment release rates. However, this method also appears inappropriate for use in Lake Concord since the lake is relatively shallow compared with northern lakes, and development of a well-defined hypolimnion does not occur.

A third method of quantifying the internal loadings is through trophic state modeling. Using this approach, hydrologic and nutrient inputs are estimated from all quantifiable sources. A trophic state model is then developed to predict water column concentrations of total phosphorus. If the model underestimates phosphorus concentrations, then a missing phosphorus load may be present which can be attributed to internal recycling. However, this methodology can be highly inaccurate and is dependent upon the accuracy of the estimated loadings for other variables and the accuracy of the predictive model.

The final method used for quantification of internal loadings is to perform sediment release experiments. In this method, large diameter sediment cores are collected from various locations within the lake and incubated in the laboratory under a variety of conditions to simulate variability in the lake throughout the year. Changes in phosphorus concentrations are measured in the overlying sediments, and this information is extrapolated to an areal release rate within the lake. This is the only method of estimating internal loadings which provides a direct measurement of phosphorus release. This method has been used by ERD in more than 60 Florida lakes in previous work efforts and was selected as the quantification method for Lake Concord.

Field and laboratory investigations were performed by ERD to quantify the mass of phosphorus released as a result of internal recycling from the sediments to the overlying water column in Lake Concord under both aerobic and anoxic conditions. Large diameter lake sediment core samples were collected at multiple locations in the lake and incubated under anoxic and aerobic conditions. Periodic measurements of orthophosphorus, total phosphorus, ammonia, NO_x, and total nitrogen were used to estimate sediment phosphorus release under the evaluated conditions. This information is used to provide an estimate of the significance of mass loadings of phosphorus from lake sediments as part of the overall nutrient budget for the lake.

5.1.4.1 Field and Laboratory Procedures

Sediment core samples were collected at 2 locations in Lake Concord using 4-inch diameter clear acrylic core tubes. Locations used for collection of the sediment core tubes in Lake Concord are indicated on Figure 5-14. Water depths at each site are also provided for reference purposes based on water depths indicated on the bathymetric map provided in Figure 2-2. In general, the sample locations reflect the major areas of each lobe and a variety of water depths. Each of the acrylic tubes was driven into the sediments to the maximum possible depth using a 20-pound hammer weight. A 4-inch x 4-inch wooden beam was placed on top of the acrylic core tubes to evenly distribute the force of each hammer blow and to prevent direct contact between the hammer weight and the acrylic tube.

The acrylic tubes were penetrated into the sediments to depths ranging from approximately 2-4 ft, depending upon the physical characteristics of the sediments at each of the selected monitoring sites or until a firm bottom material was encountered. Each of the core tubes was retrieved intact, along with the overlying water column present at each of the collection sites. Upon retrieval, a rubber cap was attached to the bottom of each core tube using a stainless steel band to prevent loss of sediments and water. A 4-inch PVC cap was then placed on the top of each collected core tube, and the core tubes were transported to the ERD laboratory in a vertical position to avoid mixing of the sediment layers. Photographs of large sediment core samples collected from Lake Concord are given in Figure 5-15.

Figure 5-14.

Large Core Sample Sites for Measurement of Internal Recycling in Lake Concord.

Site 1 Site 2

Figure 5-15. Large Core Sample Collection Sites in Lake Concord.

After return to the laboratory, the sediment depth in each of the 2 core samples was adjusted to a uniform 24-30 inches by releasing sediment as necessary from the bottom of each core tube. The collected water volume above the sediments was carefully siphoned off and replaced with a 24-inch layer of lake water collected from Lake Concord. Each of the acrylic core tubes was then cut to a uniform height of 54 inches, leaving a 6-inch air space between the water level and the top of the column. Three separate 0.25-inch diameter holes were then drilled into the PVC cap attached to the top of each core sample. A 0.25-inch diameter semi-rigid polyethylene tube was inserted through one of the holes to a depth of approximately 2-3 inches above the sediment surface, and an air stone diffuser was attached to the end of the tubing inside each core tube. This system was used to introduce selected gases into the core tubes to encourage aerobic or anoxic conditions.

A separate piece of polyethylene tubing was inserted into the second hole in the top of each core tube, approximately 1 inch below the level of the cap, but above the water level contained in each tube. The other end of the tubing was connected to a water trap to minimize loss of water from each column as a result of evaporation. This tubing also provided a point of exit for gases which were bubbled into each core tube and provided a visual verification that the purging gases were being added to each tube. The rate of gas addition was monitored by observing the rate of bubbles introduced into the water trap. A third 0.25-inch polyethylene tube was inserted through the top cap of the 4-inch cap and extended to approximately mid-way into the overlying water column for sample collection. The 4-inch core tubes were placed inside a 6-inch Sch. 40 PVC pipe to provide a dark controlled environment for creating either aerobic or anoxic conditions. The 6-inch PVC chambers were attached to a laboratory work bench for support. Schematics of the sediment incubation apparatus are given in Figures 5-16 and 5-17.

After initial set-up of the incubation apparatus, a compressed stream of air was introduced into each of the core tubes through a manifold system with attachments to each of the individual air stone diffusers. Compressed air was gently bubbled through each of the columns to increase dissolved oxygen and create aerobic conditions within each tube. In general, creation of aerobic conditions, as indicated by measurements of redox potential (> 200 mv) within each of the columns, occurred within approximately 24-36 hours. At the onset of aerobic conditions, sample collection was conducted at a 1-2 day interval from each of the columns. The gas addition ensured that water within each of the core tubes was well mixed without disturbing the sediments, so that the nutrient mass released from the sediments could be quantified as a function of changes in concentrations within the water column of each core tube.

On approximately a 1-2 day interval, 20 ml of water was withdrawn from each of the columns through the 0.25-inch polyethylene tube using a plastic laboratory syringe. Each of the collected samples was immediately filtered using a 0.45 micron syringe type membrane filter and analyzed for ammonia, NO_x, total nitrogen, orthophosphorus, and total phosphorus using the analytical methods outlined in Table 5-3.

At the conclusion of the experimentation under anoxic conditions, the compressed air source was replaced with compressed argon. After anoxic conditions were established, as verified by an H_2S smell in the outflow from the water trap, the argon gas addition was reduced to 1-2 hours per day, generally in association with a sampling event, to ensure completely mixed conditions within each tube prior to sample collection. This process was continued in each of the core tubes for a period of approximately 30 days.

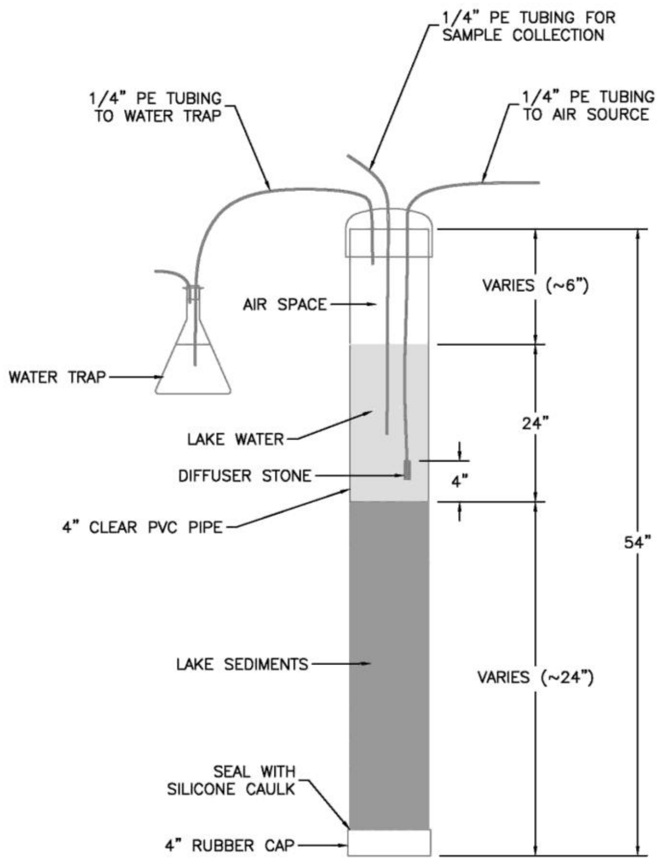


Figure 5-16.

Schematic of Sediment Core Tube Incubation Apparatus.

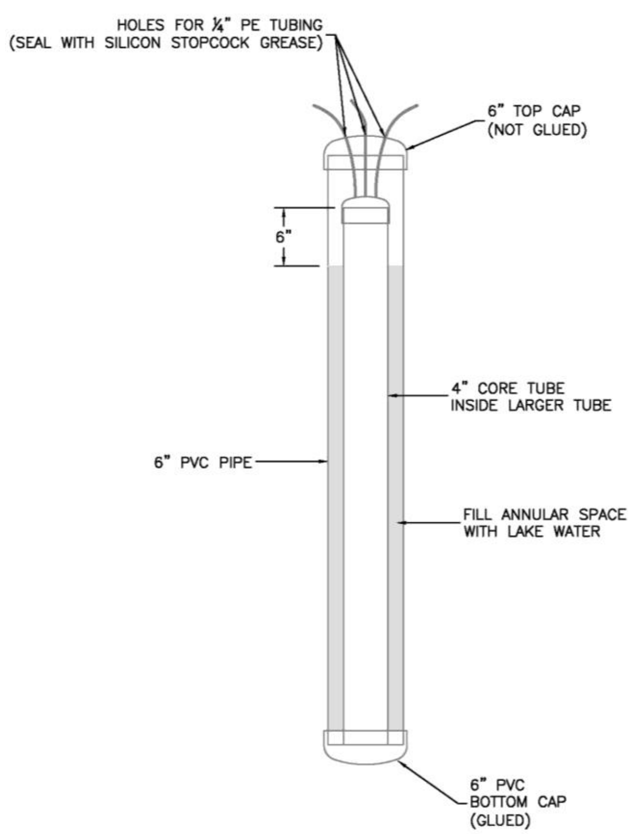


Figure 5-17.

Schematic of Sediment Core Incubation System.

Collection of the large diameter (4-inch) sediment core samples was performed in Lake Concord during April 2019. Experimentation under aerobic conditions was conducted in each core tube for a period of 37 days. Anoxic experimentation was initiated at the end of the aerobic experiments and was continued for a period of 31 days.

5.1.4.2 Calculation of Mass Release

A summary of the laboratory results of samples collected during the sediment release experiments is given in Appendix F-1. Changes in concentrations of phosphorus and nitrogen over time are provided for each of the isolation chamber experiments under both aerobic and anoxic conditions. The measured concentrations of total nitrogen, SRP, and total phosphorus from each sampling date (in μg/l) are multiplied by the volume of water in each large core cylinder (liter), corrected for volume losses due to sample collection, to obtain the mass of each measured parameter in the overlying water column at the time of each monitoring event (mass in μg). The measured values reflect **net** sediment release since some of the released nutrients are likely taken up by biological processes in each tube.

The mass release rate in the incubation experiments is defined as the slope of the rising limb of the total nitrogen, SRP, and total phosphorus release plots presented in Appendix F-2. The mass of nitrogen and phosphorus is plotted as a function of time to evaluate the rate of change in mass over time, and the best-fit regression line through the points is used to calculate the release rate in terms of μg/day. In some chambers, an initial delay in phosphorus release occurred as anoxic or aerobic conditions were established within each chamber. In these cases, the release rate is calculated using the data obtained between the start of the upward release trend and the maximum phosphorus concentrations measured within a sample. In some experiments, phosphorus concentrations began to decrease after reaching the maximum concentration, presumably due to biological uptake within the chamber. These data are also excluded from estimation of the release rate. Regression relationships developed for estimation of sediment phosphorus release rates in the incubation experiments under aerobic and anoxic conditions are included in Appendix F-2.

A summary of calculated sediment phosphorus release rates in Lake Concord during the isolation chamber experiments using the sediment core samples is given in Table 5-13. Release rates are provided for total nitrogen, SRP, and total phosphorus at each of the 2 isolation chamber core samples under both aerobic and anoxic conditions. The release rates reflect the slope of the total nitrogen, SRP, and total phosphorus release rate plots provided in Appendix F-2. The calculated release rates are converted into a mass release per day by dividing by the surface area of the 4-inch diameter incubation chambers resulting in an areal mass release in terms of mg/m^2-day.

Under aerobic conditions, the measured mass release rate for SRP ranged from 0.39-0.52 mg/m^2-day in the 2 sediment isolation chambers, with total phosphorus release rates ranging from 0.66-0.96 mg/m^2-day, and total nitrogen release rates ranging from 24.6-8.3 mg/m^2-day. Overall, SRP contributed approximately 56% of the measured total phosphorus release under aerobic conditions. The aerobic sediment release of nitrogen and phosphorus in Lake Concord is slightly higher than rates recently measured by ERD in other urban lakes.

TABLE 5-13

MEASURED SEDIMENT NUTRIENT RELEASE RATES IN LAKE CONCORD

CONDITION	SITE	MASS RELEASE (μg/day)			MASS RELEASE (mg/m^2-day)		
		SRP	Total P	Total N	SRP	Total P	Total N
Aerobic	1	3.11	5.31	197	0.39	0.66	24.6
	2	4.16	7.64	66.3	0.52	0.96	8.3
	Mean	**3.64**	**6.48**	**132**	**0.45**	**0.81**	**16.5**
Anoxic	1	7.30	7.68	72.4	0.91	0.96	9.1
	2	13.9	14.7	20.0	1.74	1.84	2.5
	Mean	**10.6**	**11.2**	**46**	**1.33**	**1.40**	**5.8**

Under anoxic conditions, release rates for SRP and total phosphorus increased substantially, with SRP release rates ranging from 0.91-1.74 mg/m^2-day and total phosphorus release rates ranging from 0.96-1.84 mg/m^2-day. Under anoxic conditions, SRP release comprised approximately 95% of the total phosphorus release. Release rates for total nitrogen under anoxic conditions were lower than values measured under aerobic conditions, with individual release rates ranging from 9.1-2.5 mg/m^2-day. The anoxic phosphorus release rates in Lake Concord are on the upper end of release rates commonly observed by ERD in eutrophic urban lakes.

As discussed previously, vertical field profiles were collected in Lake Concord during 2019 as part of the routine quarterly surface water monitoring program, and these profiles were used to estimate the annual frequency of aerobic and anoxic conditions at each of the 2 large core monitoring sites. A compilation of vertical field profiles collected in Lake Concord during 2019 was given on Figure 2-23. If dissolved oxygen concentrations were less than 1 mg/l near the water-sediment interface, then anoxic conditions were assumed to occur within the sediments at the time of the monitoring event. If dissolved oxygen concentrations near the water-sediment interface were greater than 1 mg/l, then aerobic conditions were assumed to occur. The vertical field profiles included any impacts from the existing aeration system in Lake Concord.

During 2019, aerobic conditions were maintained to a depth of 3 m (9.8 ft) during all monitoring events, with anoxic conditions below this depth during all events. As indicated in Table 2-1, the lake area below 10 ft is approximately 8.22 acres, with 11.5 acres of lake area with a depth above 10 ft. Therefore, for purposes of this analysis, it is assumed that 8.22 acres of Lake Concord have anoxic sediment conditions throughout the year, and 11.5 acres of the lake have aerobic conditions throughout the year.

The measured aerobic and anoxic release rates (summarized in Table 5-13) were weighted by the estimated frequency of occurrence of aerobic and anoxic conditions at each of the 2 sites to obtain estimates of mean annual nutrient release for SRP, total phosphorus, and total nitrogen within each core tube. A summary of this analysis is given on Table 5-14. Weighted release rates are provided for SRP, total phosphorus, and total nitrogen based upon the areal release rates (summarized in Table 5-13) and the frequency of aerobic and anoxic conditions (summarized in Table 5-14).

TABLE 5-14

CALCULATED ANNUAL SEDIMENT RELEASE OF TOTAL NITROGEN AND TOTAL PHOSPHORUS IN LAKE CONCORD

SITE	FREQUENCY OF CONDITION (%)		WEIGHTED PHOSPHORUS RELEASE (mg/m^2-day)			ASSUMED AREA (acres)	MASS PHOSPHORUS RELEASE (kg/yr)		
	Aerobic	Anoxic	SRP	Total P	Total N		SRP	Total P	Total N
1	100	0	0.39	0.66	24.6	11.5	6.6	11.3	419
2	0	100	1.74	1.84	2.5	8.2	21.1	22.3	30
Geometric Mean:			**0.82**	**1.10**	**7.8**	**19.7**	**27.7**	**33.6**	**449**

The weighted areal nutrient release rates are then multiplied by the assumed lake area over which the release rates apply to obtain estimates of overall nutrient release from the sediments into Lake Concord on an annual basis. Nutrient release rates measured at Site 1 (6 ft) are assumed to represent release rates for areas less than 10 ft deep. As indicated on Table 2-1, areas less than 10 ft cover 11.5 acres of Lake Concord. Nutrient release rates at Site 2 (16 ft) are assumed to reflect release rates for areas with depths greater than 10 ft which covers 8.2 acres of Lake Concord.

Estimates of annual mass nutrient release from sediments in Lake Concord are provided in the final columns of Table 5-14. On an annual average basis, sediment nutrient release contributes approximately 27.7 kg/yr of SRP, 33.6 kg/yr of total phosphorus, and 449 kg/yr of total nitrogen to Lake Concord.

5.2 Nutrient Losses

Nutrient losses from Lake Concord occur as a result of discharges through the lake outfall to Secret Lake and losses due to aquifer recharge. Pollutant mass which is not discharged through the outfall structure or lost to deep recharge is assumed to accumulate into the sediments of the lake. Estimates of the magnitude of nutrient losses by these mechanisms are given in the following sections.

5.2.1 Outfall Discharges

5.2.1.1 Chemical Characteristics of Outfall Discharges

Chemical characteristics of discharges from Lake Concord through the outfall to Secret Lake are assumed to be similar to recent historical water quality characteristics in Lake Concord. A summary of water quality characteristics for Lake Concord was provided in Section 2, with the raw historical water quality data included in Appendix B. For purposes of estimating mass loadings discharging through the outfall, the ambient water quality in Lake Concord is assumed to be similar to the water quality characteristics in discharges from the lake. Ambient water quality characteristics under current conditions are assumed to be similar to the overall mean values for monitoring conducted in Lake Concord from 2016-2019. A summary of mean water quality characteristics in Lake Concord from 2016-2019 is given in Table 5-15 based on information contained in Table 2-8.

TABLE 5-15

MEAN WATER QUALITY CHARACTERISTICS IN LAKE CONCORD

TOTAL N (µg/l)	TOTAL P (µg/l)	DATA SOURCE
683	36	Mean of annual geometric mean values for 2016-2019

5.2.1.2 Mass Loadings

Estimates of mass loadings discharged through the Lake Concord outfall were calculated using the estimated outfall discharge volumes (summarized in Table 4-11) and the assumed in-lake water quality characteristics (summarized on Table 5-15). A summary of the results of this analysis is given in Table 5-16. The information summarized in this table is used in a subsequent section to develop annual nutrient budgets for Lake Concord.

TABLE 5-16

CALCULATED MEAN ANNUAL MASS LOSSES FROM LAKE CONCORD THROUGH THE OUTFALL TO SECRET LAKE

OUTFALL DISCHARGE VOLUME (ac-ft)	MASS LOSS (kg/yr)	
	Total Nitrogen	Total Phosphorus
230	194	10.2

5.2.2 Deep Aquifer Losses

5.2.2.1 Chemical Characteristics of Deep Aquifer Discharges

Chemical characteristics of losses from Lake Concord as a result of recharge to deeper aquifers are also assumed to be similar to the water quality characteristics summarized in Table 5-15. These water quality characteristics are assumed to represent the characteristics of surface water within the lake which is applicable to outflow discharges as well as deep aquifer discharges through the lake bottom.

5.2.2.2 Mass Loadings

Calculated mass losses from deep aquifer recharge in Lake Concord are summarized in Table 5-17. These values were obtained by multiplying the mean water column characteristics (summarized in Table 5-15) times the mean annual volumetric losses from the lake resulting from deep aquifer recharge (provided in Table 4-9). Annual nutrient losses from Lake Concord from deep recharge is approximately 10.4 kg/yr for total nitrogen and 0.55 kg/yr for total phosphorus.

TABLE 5-17

CALCULATED MEAN ANNUAL LOSSES FROM LAKE CONCORD AS A RESULT OF AQUIFER RECHARGE

DEEP RECHARGE VOLUME (ac-ft/yr)	MASS LOSS (kg/yr)	
	Total N	Total P
12.3	10.4	0.55

5.3 Mean Annual Mass Budgets

Estimated mean annual mass budgets were developed for total nitrogen and total phosphorus based upon the analyses presented in previous sections. A discussion of estimated mass inputs and losses for Lake Concord is given in the following sections.

5.3.1 Annual Inputs and Losses

A tabular summary of estimated mean annual mass loadings and losses of total nitrogen and total phosphorus to Lake Concord is given in Table 5-18. Estimated annual mass loadings are provided for precipitation, runoff, overland flow, groundwater seepage, and internal recycling, with losses occurring as a result of discharges through the outfall, deep recharge, and sediment retention.

TABLE 5-18

CALCULATED MEAN ANNUAL INPUTS AND LOSSES OF TOTAL NITROGEN AND TOTAL PHOSPHORUS TO LAKE CONCORD

TYPE	SOURCE	TOTAL NITROGEN LOADING		TOTAL PHOSPHORUS LOADING	
		kg/yr	% of Total	kg/yr	% of Total
Inputs	Precipitation	82.8	8	6.6	9
	Runoff	267	27	24.3	34
	Overland Flow	18.0	2	2.6	4
	Quail Pond Inflow	3.0	1	1.0	1
	Groundwater Seepage	155	16	3.6	5
	Internal Recycling	449	46	33.6	47
	Totals:	975	100	71.6	100
Losses	Lake Outflow	137	14	8.6	12
	Deep Recharge	47.9	5	3.0	4
	Retained in Sediments	790	81	60.0	84
	Totals:	975	100	71.6	100

The most significant loadings of both total nitrogen and total phosphorus to Lake Concord is internal recycling which contributes 46% of the annual total nitrogen loading and 47% of the annual total phosphorus loading to the lake. The significance of internal recycling as a source of total nitrogen and total phosphorus in Lake Concord is similar to measurements conducted by ERD in other eutrophic/mesotrophic lake systems which typically range from 40-65%. Lake Concord has a moderate hydraulic residence time (t_d = 0.52 years) and has accumulated a substantial volume of organic sediments, which is due to the age of the lake and anthropogenic inputs, and this organic material is releasing large amounts of both nitrogen and phosphorus into the overlying water column. The areal release rates for total nitrogen and total phosphorus in the Lake Concord sediments are typical in value and become a significant part of an overall annual budget due to the relatively low loadings associated with inputs from the remaining sources.

The second most significant contributions of total nitrogen and total phosphorus occur from runoff which contributes 27% of the total nitrogen load and 34% of the total phosphorus load. Groundwater seepage inputs contribute 16% of the annual nitrogen loadings and 5% of the annual phosphorus loadings. Loadings of total nitrogen and total phosphorus from overland flow contribute 2% of the annual nitrogen loading and 4% of the annual phosphorus loading.

The vast majority of annual inputs of total nitrogen and total phosphorus are retained within the sediments of the lake, with an annual mass retention of approximately 81% for total nitrogen inputs and 84% for total phosphorus. Losses through the lake outfall constitute the second most significant source of mass loss from Lake Concord on an annual basis, comprising 14% of the annual loss of total nitrogen and 12% for total phosphorus. Mass losses as a result of deep recharge are relatively minimal. A graphical comparison of inputs and losses for total nitrogen and total phosphorus in Lake Concord is given in Figures 5-18 and 5-19, respectively.

5.3.2 Areal Nutrient Loading Rates

A comparison of annual total and areal loadings of nitrogen and phosphorus to Lake Concord is given in Table 5-19. Based upon the identified phosphorus inputs, areal loading rates of total phosphorus to Lake Concord are 0.90 g/m^2-yr. A summary of permissible nutrient loading rates for lakes up to 15 m deep (developed by Vollenweider, 1968) is provided at the bottom of Table 5-19. According to Vollenweider, lakes with areal loading rates less than 0.1 g/m^2-yr typically maintain oligotrophic characteristics, while lakes with more than 0.2 g/m^2-yr will exhibit a trend of accelerated algal growth and potential seasonal algal blooms. Based upon these criteria, the calculated phosphorus loadings to Lake Concord appear to be sufficient to stimulate a large amount of algal growth within the lake, create eutrophic conditions, and the possibility of frequent algal blooms.

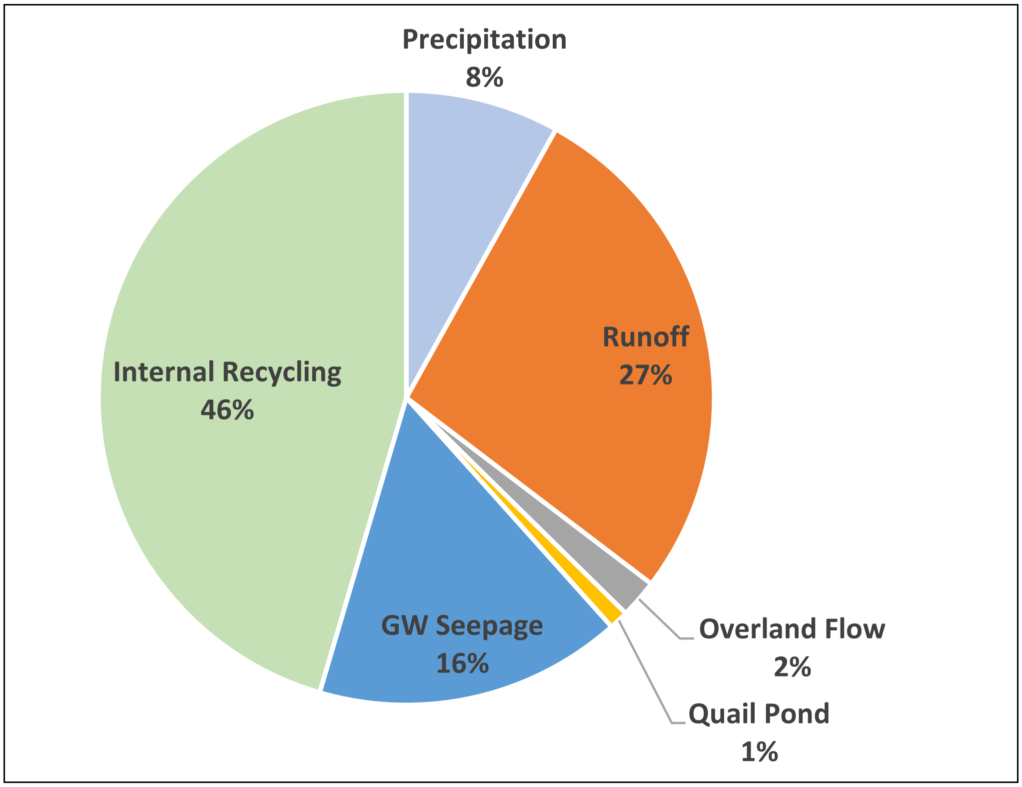
TABLE 5-19

COMPARISON OF ANNUAL AREAL LOADINGS OF NITROGEN AND PHOSPHORUS TO LAKE CONCORD

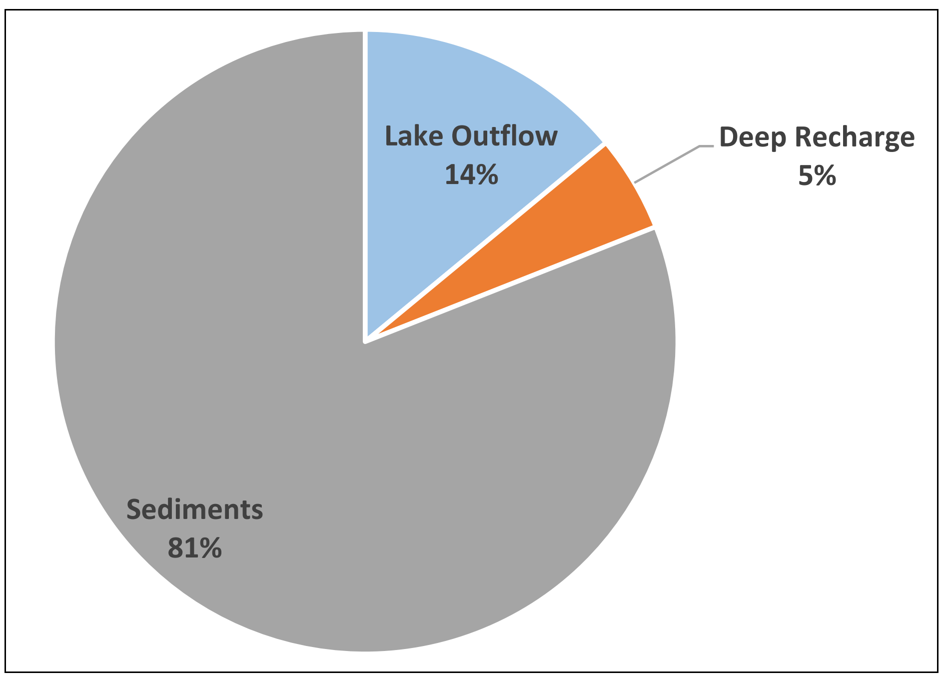
AREA (acres)	PHOSPHORUS LOADING		NITROGEN LOADING	
	kg/yr	g/m^2-yr	kg/yr	g/m^2-yr
19.72	71.6	0.90	975	12.2

Permissible Loading Levels (Vollenweider, 1968) for Lakes up to 15 m Deep:

1. Phosphorus:
   a. Permissible: < 0.1 g/m^2-yr
   b. Dangerous: > 0.2 g/m^2-yr
2. Nitrogen:
   a. Permissible: < 1.5 g/m^2-yr
   b. Dangerous: > 3 g/m^2-yr

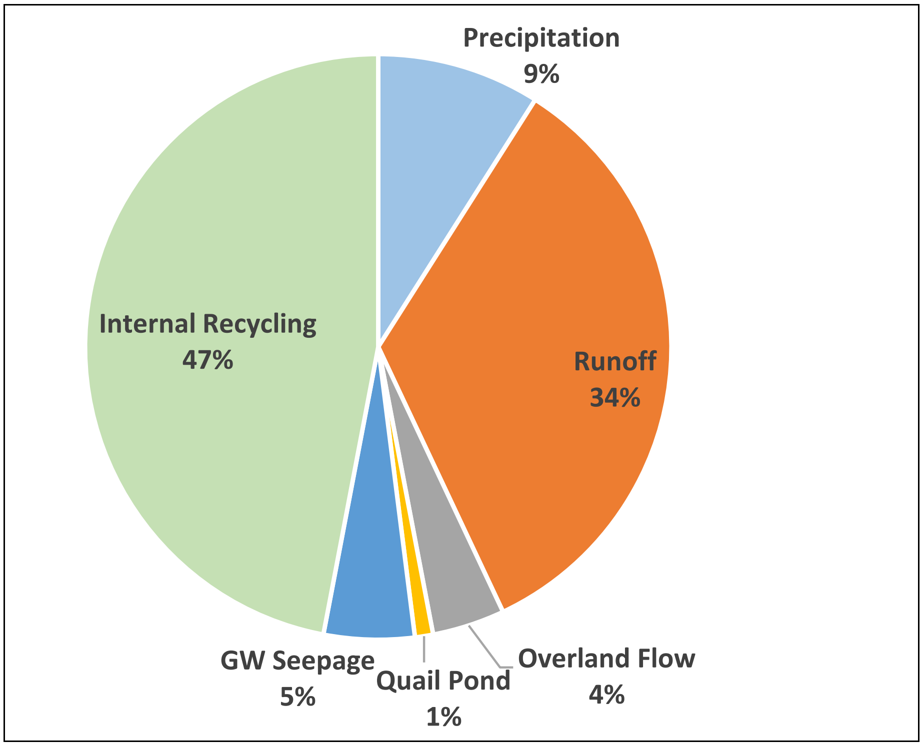


Total Nitrogen Inputs

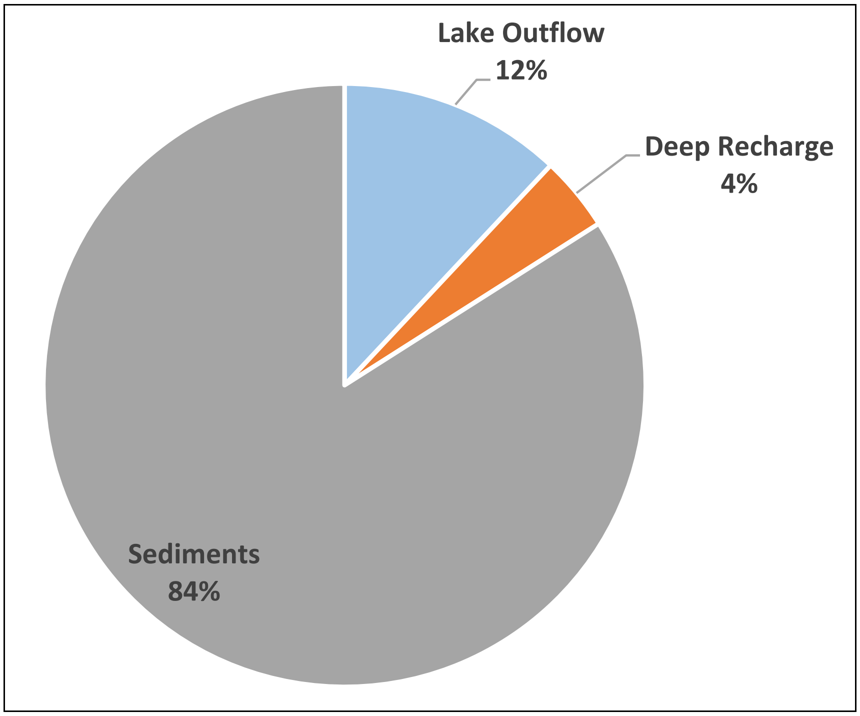


Total Nitrogen Losses

Figure 5-18. Graphical Comparison of Inputs and Losses for Total Nitrogen in Lake Concord.



Total Phosphorus Inputs



Total Phosphorus Losses

Figure 5-19. Graphical Comparison of Inputs and Losses for Total Phosphorus in Lake Concord.

Areal loading rates for total nitrogen in Lake Concord are also summarized in Table 5-19. Based upon this analysis, nitrogen loadings to Lake Concord substantially exceed the dangerous level of 3.0 g/m^2-yr recommended by Vollenweider. However, since algal growth in Lake Concord is regulated primarily by phosphorus, inputs of total nitrogen have minimal impact on water quality within the lake.

SECTION 6

EVALUATION OF SEDIMENT INACTIVATION AS A WATER QUALITY IMPROVEMENT OPTION

The nutrient budget developed for Lake Concord as part of this project indicates that approximately 47% of the annual average phosphorus loading to the lake originates from internal recycling, with 34% contributed by runoff. Bulk precipitation contributes approximately 9% of the annual phosphorus loadings, with 5% contributed by groundwater seepage and 4% by direct overland flow. Internal recycling is the largest single source of phosphorus loading to Lake Concord. Since sediment inactivation also intercepts phosphorus from seepage inflows, a carefully planned sediment inactivation project has the potential to impact 52% of the total annual phosphorus loading to the lake. Phosphorus inputs from runoff contribute 34% of the current phosphorus loadings. Currently, about 75% of the basin area has existing stormwater treatment in both permitted and non-permitted systems, and providing stormwater treatment for the remaining 25% of the watershed would be prohibitively expensive in an urban environment and only impact a small portion of the annual phosphorus loading.

Based upon the field monitoring and sediment incubation experiments conducted by ERD, it is apparent that the existing sediment accumulations contribute a significant phosphorus loading to Lake Concord each year, and water quality within the lake could be improved by reducing the observed internal phosphorus loadings. Aeration is sometimes mentioned as a possible method of reducing internal recycling in eutrophic lakes. Although aeration can improve oxygen conditions in the water column of a lake, there is little evidence that water column aeration can significantly change sediment redox conditions. Even if aeration was successful in creating oxidized sediment conditions, the phosphorus release rate in Lake Concord under aerobic conditions is still sufficient to maintain eutrophic conditions in the lake. Therefore, the most feasible method of substantially reducing sediment nutrient release is to remove the phosphorus from the system by precipitation with aluminum. A discussion of the costs and feasibility of alum sediment inactivation in Lake Concord is given in the following sections.

6.1 Sediment Inactivation

6.1.1 Introduction

Sediment inactivation is a lake restoration technique which is designed to reduce sediment phosphorus release by combining available phosphorus in the sediments with a metal salt to form an insoluble inert precipitate, rendering the sediment phosphorus unavailable for release into the overlying water column. Although salts of aluminum, calcium, and iron have been used for sediment inactivation in previous projects, aluminum salts are the clear compounds of choice for this application due to the low solubility of Al:P compounds, immunity to changes in redox potential, and an effective sediment pH range of 5.5-7.5. Inactivation of sediment phosphorus using aluminum is often a substantially less expensive option for reducing sediment phosphorus release since removal of the existing sediments is not required.

Sediment phosphorus inactivation is most often performed using aluminum sulfate, commonly called alum, which is applied at the surface in a liquid form using a boat or barge. Upon entering the water column, the alum forms an insoluble precipitate of aluminum hydroxide (referred to as floc) which incorporates water column phosphorus, bacteria, algae, and suspended solids within the floc, settling these constituents into the bottom sediments. After reaching the bottom sediments, the residual aluminum binds tightly with phosphorus within the sediments (primarily saloid-bound and iron-bound associations), forming an inert precipitate which will not be re-released under any conceivable condition of pH or redox potential which could occur in a natural lake system.

It is generally recognized that the top 10 cm layer of the sediments is the most active in terms of release of phosphorus under anoxic conditions, although the active layer may extend to 15 cm in highly fluid sediments and in shallow lakes where sediments are impacted by sustained wind and boating activities. Therefore, the objective of a sediment inactivation project is to provide sufficient alum to bind the saloid- and iron-bound phosphorus associations in the top 10 cm of the sediments. More than 50 whole-lake sediment inactivation projects have been conducted by ERD within the State of Florida, with the first large-scale application conducted during 1992 on Lake Conine in Polk County. Previous sediment inactivation projects have been effective from 7 to 25 years, with no evidence of water quality degradation in Lake Conine after 25 years.

Due to differences in electronegativities, phosphorus preferentially attaches to iron in sediments before aluminum. The concept behind inactivating sediment phosphorus using aluminum is based upon increasing aluminum concentrations within the sediments to the point where phosphorus would preferentially bind with aluminum rather than in a redox sensitive form with iron. The addition of aluminum to the sediments uses Le Chatelier's Principle which states that an increase in reactants (in this case aluminum) will drive the chemical reaction to increase the concentration of the products (aluminum-bound phosphorus). Previous sediment inactivation work conducted by ERD as well as other researchers has indicated that a molar Al:P ratio of 10:1 is typically sufficient to provide a driving force to allow aluminum to preferentially absorb phosphorus in sediments over iron. However, if the average available sediment phosphorus concentration is $\leq 50\ \mu g/cm^3$, the molar Al:P ratio is increased to 15:1, or 20:1 for available sediment phosphorus concentrations substantially less than 50 $\mu g/m^3$, to provide a sufficient driving force.

Estimates of chemical requirements for sediment inactivation projects are typically based upon the mass of total available phosphorus within the top 0-10 cm layer of the sediments. For sediment inactivation purposes, available phosphorus is defined as the sum of the saloid-bound phosphorus, defined as soluble + easily exchangeable, and iron-bound phosphorus associations. Phosphorus bound to iron in the sediments is stable under aerobic conditions, but solubilizes under anoxic conditions and is subject to re-release from the sediments into the overlying water column.

Additional aluminum can be added to the sediments to create an active absorption mechanism for other phosphorus inputs into the water column as a result of groundwater seepage. Inputs of phosphorus from groundwater seepage into a lake can easily exceed inputs from internal recycling in only a few annual cycles. Carefully planned applications of alum can provide an abundance of aluminum which can intercept groundwater inputs of phosphorus, regardless of source, over a period of many years. As a result, alum applications can be used to eliminate phosphorus from the combined inputs from internal recycling as well as groundwater seepage.

6.1.2 Chemical Requirements

Estimates of the mass of total available phosphorus within the top 0-10 cm layer of the sediments in Lake Concord were generated by graphically integrating the isopleth map of total available phosphorus in the lake sediments (provided in Figure 2-12). A modified version of Figure 2-12 which illustrates contour intervals is given in Figure 6-1. The top 0-10 cm layer of the sediments is considered to be the most active layer with respect to exchange of phosphorus between the sediments and the overlying water column, and inactivation of phosphorus within the 0-10 cm layer is typically sufficient to inactivate sediment release of phosphorus within a lake. The geometric mean concentration for total available phosphorus in Lake Concord is 50 $\mu g/cm^3$ (Table 2-6), so an Al:P ratio of 15:1 is used for estimating alum requirements.

A summary of estimated total available phosphorus in the sediments of Lake Concord and alum requirements for sediment inactivation is given in Table 6-1. On a mass basis, the sediments of Lake Concord contain approximately 563 kg of available phosphorus in the top 10 cm which equates to approximately 18,150 moles of phosphorus to be inactivated as part of the sediment inactivation process. Since the overall mean sediment available phosphorus concentration in Lake Concord of 50 $\mu g/cm^3$ is in the concentration range where a higher Al:P ratio may be required, the assumed Al:P ratio for Lake Concord is 15:1. Using an Al:P ratio of 15:1, sediment inactivation in Lake Concord would require approximately 33,091 gallons of alum, equivalent to 7.7 tanker loads containing 4,300 gallons each. The equivalent aerial aluminum dose for this application would be 92.2 g Al/m^2.

TABLE 6-1

LAKE CONCORD SEDIMENT INACTIVATION REQUIREMENTS

AVAILABLE P CONTOUR INTERVAL ($\mu g/cm^3$)	CONTOUR INTERVAL MID-POINT ($\mu g/cm^3$)	CONTOUR AREA (acres)	AVAILABLE PHOSPHORUS		ALUM REQUIREMENTS (Al:P Ratio = 15:1)	
			kg	moles	moles Al	gallons alum
0-20	10	3.32	13.4	434	6,504	791
20-40	30	3.60	43.7	1,411	21,159	2,572
40-60	50	2.58	52.2	1,685	25,273	3,072
60-80	70	2.37	67.2	2,167	32,502	3,951
80-100	90	2.15	78.3	2,527	37,910	4,608
100-120	110	2.08	92.6	2,988	44,826	5,448
120-140	130	1.81	95.3	3,073	46,099	5,603
140-160	150	0.93	56.5	1,822	27,330	3,322
160-180	170	0.45	31.0	999	14,988	1,822
180-200	190	0.31	23.8	769	11,539	1,403
200-220	210	0.10	8.5	274	4,114	500
Overall Totals:		19.70	563	18,150	272,245	33,091

Areal Aluminum Dose: 92.2 Al/m^2
Number of Tankers: 7.7
Water Column Dose: 35.4 mg Al/liter

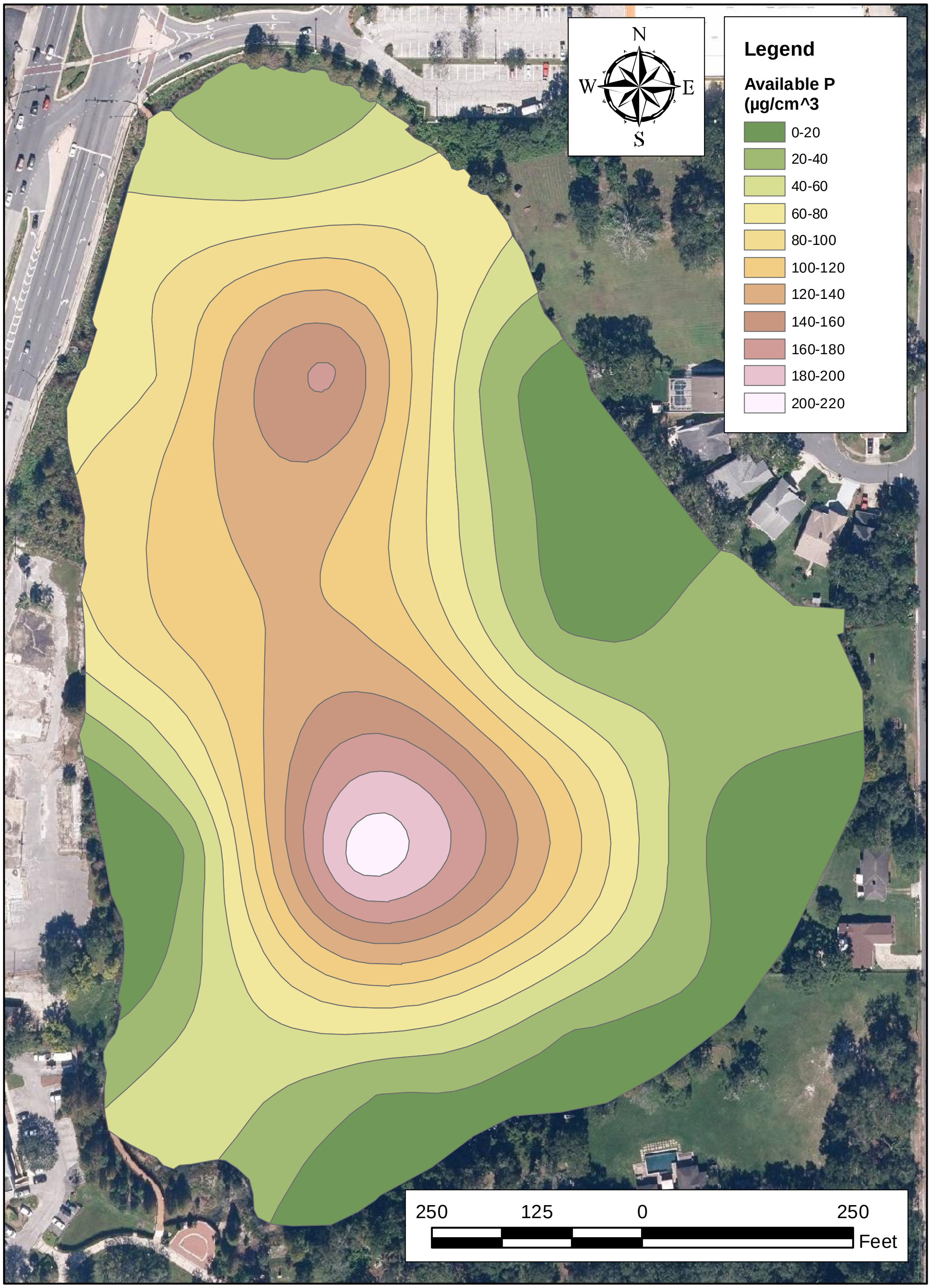


Figure 6-1. Contour Intervals for Available Phosphorus in the Top 0-10 cm of Sediments in Lake Concord.

A summary of alum requirements for control of phosphorus loading from groundwater seepage entering Lake Concord is given in Table 6-2. Based on the field seepage monitoring program, phosphorus inflow to Lake Concord from groundwater seepage is estimated to be approximately 3.6 kg/yr. This analysis assumes that control of groundwater seepage is desired for a period of approximately 15 years. Therefore, the total mass of phosphorus from groundwater seepage which must be inactivated over the 15-year period is approximately 54.0 kg which equates to approximately 1,733 moles of total phosphorus. Assuming an Al:P ratio of 15:1 for adequate phosphorus adsorption of groundwater inflows, control of 1,733 moles of total phosphorus will require approximately 25,991 moles of aluminum which equates to an alum volume of 3,165 gallons.

TABLE 6-2

ALUM REQUIREMENTS FOR CONTROL OF PHOSPHORUS LOADING FROM GROUNDWATER SEEPAGE TO LAKE CONCORD

PARAMETER		UNITS	VALUE
Estimated Phosphorus Mass to be Controlled	Seepage Phosphorus Loading	$\mu g/m^2$-day g/m^2-yr	123 0.045
	Annual Phosphorus Loading from Seepage	kg/yr	3.6
	Desired Length of Control	years	15
	Total Phosphorus Mass to be Inactivated	kg	54
	Moles of Phosphorus to be Inactivated	moles	1,733
Alum Requirements	Inactivation Al:P Ratio	--	15
	Moles of Aluminum Required	moles	25,991
	Alum Required	gallons	3,165
	Number of Tankers @4300 gallons/tanker	--	0.7
	Mean Water Column Dose	mg Al/liter	3.4

The proposed alum treatment to Lake Concord would add sufficient alum to control both internal recycling and intercept phosphorus loadings from groundwater seepage. Assuming that approximately 33,091 gallons of alum are needed for sediment inactivation and 3,165 gallons of alum are needed for interception of groundwater seepage, the total amount of alum to be added to Lake Concord would be 36,256 gallons. This equates to a whole-lake alum dose of approximately 38.9 mg Al/liter which far exceeds the available buffering capacity in the lake to withstand reductions in water column pH at the current alkalinity levels in the lake. Lake Concord is a moderately buffered waterbody with somewhat variable alkalinity values ranging from 50-75 mg/l, with an overall mean near 65 mg/l. As a result, the proposed treatment would need to be divided into a series of multiple applications to reduce the pH impacts from the application, and an alkaline buffering agent (such as lime) may also be required for some of the lake applications.

Previous alum surface applications performed for inactivation of sediment phosphorus release by ERD have indicated that the greatest degree of improvement in surface water characteristics and the highest degree of inactivation of sediment phosphorus release are achieved when the required alum dose is divided into multiple applications of aluminum to the waterbody spaced at intervals of approximately 4-12 months. Each subsequent application results in additional improvements in water column quality and additional aluminum floc added to the sediments for long-term inactivation of sediment phosphorus release. Conducting multiple treatments also allows water column alkalinity to be restored naturally between treatments, reducing the need for supplemental buffering compounds.

If the proposed alum application to Lake Concord were to be divided into 4 treatments, the alum dose per treatment would be 9.7 mg Al/liter (38.9 mg Al/liter divided by 4 treatments) which is still a high dose per application for a moderate alkalinity lake such as Lake Concord. As a result, supplemental lime additions will be required for some of the later treatments.

A summary of proposed alum requirements to control internal recycling and groundwater seepage in Lake Concord is given in Table 6-3. It is recommended that the required alum volume be divided into 4 separate applications, with approximately one-fourth of the required alum volume applied during each application. Supplemental lime additions will also be required, particularly during the later applications, although the quantity is only estimated at this time. Each treatment would be applied using a boat or barge to spread the chemicals over the lake surface based on the available phosphorus isopleth map given in Figure 6-1.

TABLE 6-3

SUMMARY OF ALUM REQUIREMENTS FOR CONTROL OF SEDIMENT PHOSPHORUS RELEASE AND GROUNDWATER SEEPAGE ENTERING LAKE CONCORD

PARAMETER		UNITS	VALUE
Chemical Requirements	Alum Required	gallons tankers	36,256 8.4
	Applied Water Column Dose	mg Al/liter	38.9
	Applied Areal Dose	g Al/m^2	101.0
Alum Requirements (4 Applications)	Number of Treatments	--	4
	Alum Required per Treatment	gallons tankers	9,064 2.1
	Dose per Treatment	mg Al/liter	9.7

The total recommended alum volume for treatment of internal recycling and seepage inflows is 36,256 gallons, equivalent to 8.4 tankers containing 4,300 gallons each. Since a partial tanker is required to achieve the target alum volume, the partial tanker will be included as part of the initial application when natural alkalinity is greatest. Since 4 applications are proposed, the initial application will use 2.4 tankers and the final 3 applications will use 2 tankers each to achieve the goal of 8.4 tankers.

6.1.3 Inactivation Costs

A summary of estimated application costs for sediment inactivation and control of groundwater seepage in Lake Concord is given in Table 6-4. This estimate assumes an alum volume of 10,320 gallons (2.4 tankers) will be applied during the initial application, with 8,600 gallons (2 tankers) applied during each of the 3 final applications. It is assumed that the alum is purchased directly by the City as a piggyback onto either the Orange County or SJRWMD contracts at the current contract price of $0.60/gallon. Planning and mobilization costs are estimated to be approximately $5,000 per application, which includes planning, jar testing, mobilization of equipment to the site, demobilization at the completion of the application process, and clean-up. A unit application rate of $1,500/tanker (full or partial) is assumed which includes labor costs, daily water quality monitoring during the application, expenses, equipment rental, insurance, mileage, and application equipment fees.

TABLE 6-4

ESTIMATED APPLICATION COSTS FOR SEDIMENT INACTIVATION AND CONTROL OF GROUNDWATER SEEPAGE IN LAKE CONCORD
(Based on 4 separate treatments)

PARAMETER			QUANTITY/ TREATMENT	UNITS	UNIT COST ($)	COST PER TREATMENT ($)	TOTAL COST ($)
Initial Application	Chemical Costs	Alum	10,320	gallons	0.60	6,192	6,192
		Lime	0	gallons	5.00	0	0
	Labor Costs	Planning/Mobilization	1	each	5,000	5,000	5,000
		Chemical Application	3	each	1,500	4,500	4,500
	Monitoring/ Lab Testing	Field Monitoring	1	each	1,000	1,000	1,000
		Lab Analyses (pre/post)	8	samples	200	1,600	1,600
	TOTAL – INITIAL APPLICATION:					**$ 18,292**	**$ 18,292**
Applications 2, 3, and 4	Chemical Costs	Alum	8,600	gallons	0.60	5,160	15,480
		Lime	1,500	gallons	5.00	7,500	22,500
	Labor Costs	Planning/Mobilization	1	each	5,000	5,000	15,000
		Chemical Application	2	each	1,500	3,000	9,000
	Monitoring/ Lab Testing	Field Monitoring	1	each	1,000	1,000	3,000
		Lab Analyses (pre/post)	8	samples	200	1,600	4,800
	TOTAL – APPLICATIONS 2, 3, AND 4:					**$ 23,260**	**$ 69,780**
PROJECT TOTAL:							**$ 88,072**

Fees are also included for addition of a lime buffer, although the specific amount will need to be determined through a series of jar tests (included in planning/mobilization costs) at the time of the application. The existing lake alkalinity is likely sufficient to be able to conduct the initial application of 2.4 tankers without need for a supplemental buffering compound. However, supplemental lime will likely be needed during the other applications, and based on previous ERD experience, a total of 1,500 gallons of lime is assumed for each of the 3 final applications. The estimated cost for sediment inactivation and control of groundwater seepage in Lake Concord is $88,072 or approximately $18,292 for the initial application and $23,260 for each of the 3 final applications. Based on historical alkalinity levels, an interval of 4-6 months is recommended. Since the treatment will be spread out over several calendar years, the treatment costs can be distributed over multiple fiscal cycles.

6.1.4 Phosphorus Removal Costs

Estimates of phosphorus mass removal costs were also calculated for the proposed Lake Concord alum treatment. A summary of this analysis is given in Table 6-5. This analysis assumes that the sediment inactivation will be effective in reducing internal recycling and seepage phosphorous loadings for a minimum period of 15 years. Therefore, over the 15-year period of effectiveness, internal recycling will contribute approximately 504 kg (33.6 kg/yr x 15 years) of total phosphorus to Lake Concord.

TABLE 6-5

PHOSPHORUS REMOVAL COSTS FOR SEDIMENT INACTIVATION IN LAKE CONCORD

PARAMETER		UNITS	VALUE
Existing Total Phosphorus Loadings	Internal Recycling – 15 years	kg	504
	Seepage Inflow – 15 years	kg	54.0
	Total:	**kg**	**558**
Removal by Alum Addition	Internal Recycling	% kg	80 403
	Seepage Inflow	% kg	80 43
	Total:	**kg**	**446**
Alum Treatment Cost	Internal Recycling + Seepage	$	$ 88,072
Total Phosphorus Removal Cost	--	**$/kg** **$/lb**	**197** **89**

1. Assumes a 15-year period of effective control
2. Assumes that 80% of the internal recycling and seepage load is removed

As presented in Table 6-2, inputs of total phosphorus from groundwater seepage have the potential to contribute 54.0 kg (3.6 kg/yr x 15 years) over the same 15-year period of control. Therefore, over the anticipated 15-year period of control, the combined inputs of internal recycling and groundwater seepage have the potential to contribute approximately 558 kg of total phosphorus to Lake Concord.

Based on previous research performed by ERD, phosphorus inactivation is approximately 80% effective in retaining available phosphorus within sediments. Therefore, it is assumed that approximately 80% of the potential 558 kg of total phosphorus contributed by internal recycling and groundwater seepage is attenuated by the proposed alum treatment. As a result, the proposed alum treatment has the potential to remove approximately 446 kg of total phosphorus from Lake Concord over the 15-year anticipated life or approximately 29.7 kg/yr. Based upon the estimated treatment cost of $88,072, the cost per kg of phosphorus removed for the proposed alum treatment is $197/kg or $89/lb. This is an extremely attractive phosphorus removal cost, particularly when compared with traditional stormwater retrofit options which frequently exceed $1,000-10,000/kg of total phosphorus. However, this value is somewhat higher than phosphorus removal costs for most sediment inactivation projects, which are generally in the range of $100/kg. The additional cost for the lime application, not generally required in many urban lakes, results in an increase in phosphorus removal costs.

6.1.5 <u>Benthic Impacts</u>

Monitoring of benthic macroinvertebrates was conducted on an annual basis in many of the early lake systems which have received alum additions for sediment inactivation or stormwater treatment. Based upon these available data, long-term trends in benthic macroinvertebrate populations are now becoming apparent. Lake Mizell has received periodic addition of alum floc from multiple alum stormwater treatment systems since the mid-1990s. In addition, during 1998, Lake Mizell received a whole-lake alum treatment for sediment inactivation. A comparison of pre-treatment and post-treatment macroinvertebrate assemblages at monitoring Site 1 in Lake Mizell is given on Table 6-6. Site 1 is located in the northern portion of Lake Mizell which receives substantial alum inputs from an on-going alum stormwater treatment process in addition to the alum floc added as part of the whole-lake alum treatment.

Prior to the use of alum for stormwater treatment and sediment inactivation, the macroinvertebrate assemblage in Lake Mizell was dominated primarily by *Chaoborus punctipennis* and *Chironomus* sp., both of which are indicators of polluted systems. However, after completion of the whole-lake alum treatment, additional macroinvertebrate communities began to become established in Lake Mizell, although the overall organism density was reduced compared with the pre-treatment assemblage. Beginning approximately two years following the alum treatment, population densities began to increase along with introduction of more clean water indicator-type organisms. Approximately three years after the whole-lake alum treatment, the number of benthic species in Lake Mizell had more than doubled and organism densities were substantially greater than existed prior to the use of alum within the lake. This trend has been observed in all monitored lakes following alum addition for sediment inactivation.

TABLE 6-6

COMPARISON OF DOMINANT PRE-TREATMENT AND POST-TREATMENT MACROINVERTEBRATE ASSEMBLAGE AT SITE 1 IN LAKE MIZELL

TAXA	Pre-Treatment (1/28/97)		Post-Treatment Year 1 (1/29/98)		Post-Treatment Year 2 (1/27/99)		Post-Treatment Year 3 (1/31/00)	
	Mean (#/m^2)	%	Mean (#/m^2)	%	Mean (#/m^2)	%	Mean (#/m^2)	%
Chaborus punctipennis	4664	77.9	253	41.7	30	2.0	4502	66.3
Chironomus sp.	647	10.8	74	12.2	1095	73.2	119	1.7
Limnodrilus hoffmeisteri	396	6.6	--	--	74	4.9	592	8.7
Procladius bellus	15	0.2	148	24.4	--	--	252	3.7
Tanytarsus sp.	30	0.5	58	9.6	--	--	--	--
Ablabesmyia rhamphe group	--	--	44	7.2	--	--	--	--
Cladopelma sp.	--	--	15	2.2	--	--	30	0.4
Hyalella azteca	57	0.9	15	2.2	--	--	296	4.4
Dero Nivea	--	--	--	--	237	15.8	74	1.1
Dero Trifida	--	--	--	--	15	1.0	30	0.4
Unid. *Ceratopogonidae*	--	--	--	--	30	2.0	15	0.2
Thienemanniella sp.	--	--	--	--	15	1.0	--	--
Clyptotendipes paripes	--	--	--	--	--	--	726	10.7
Pristina sp.	--	--	--	--	--	--	59	0.9
Cryptochironomus sp.	--	--	--	--	--	--	59	0.2
Ablabesmyia peleensis	--	--	--	--	--	--	15	0.2
Chaetogastor diaphanus	--	--	--	--	--	--	15	0.2

A graphical comparison of pre- and post-treatment macroinvertebrate assemblages in Lake Mizell is given on Figure 6-2. Macroinvertebrate density, mean taxa, species diversity, and evenness increased after approximately three years in the north lobe which receives alum floc from both stormwater treatment as well as a whole-lake sediment inactivation process. Introduction of the alum floc into the sediments appears to improve conditions for the microorganisms, resulting in enhancements in the macroinvertebrate assemblages.

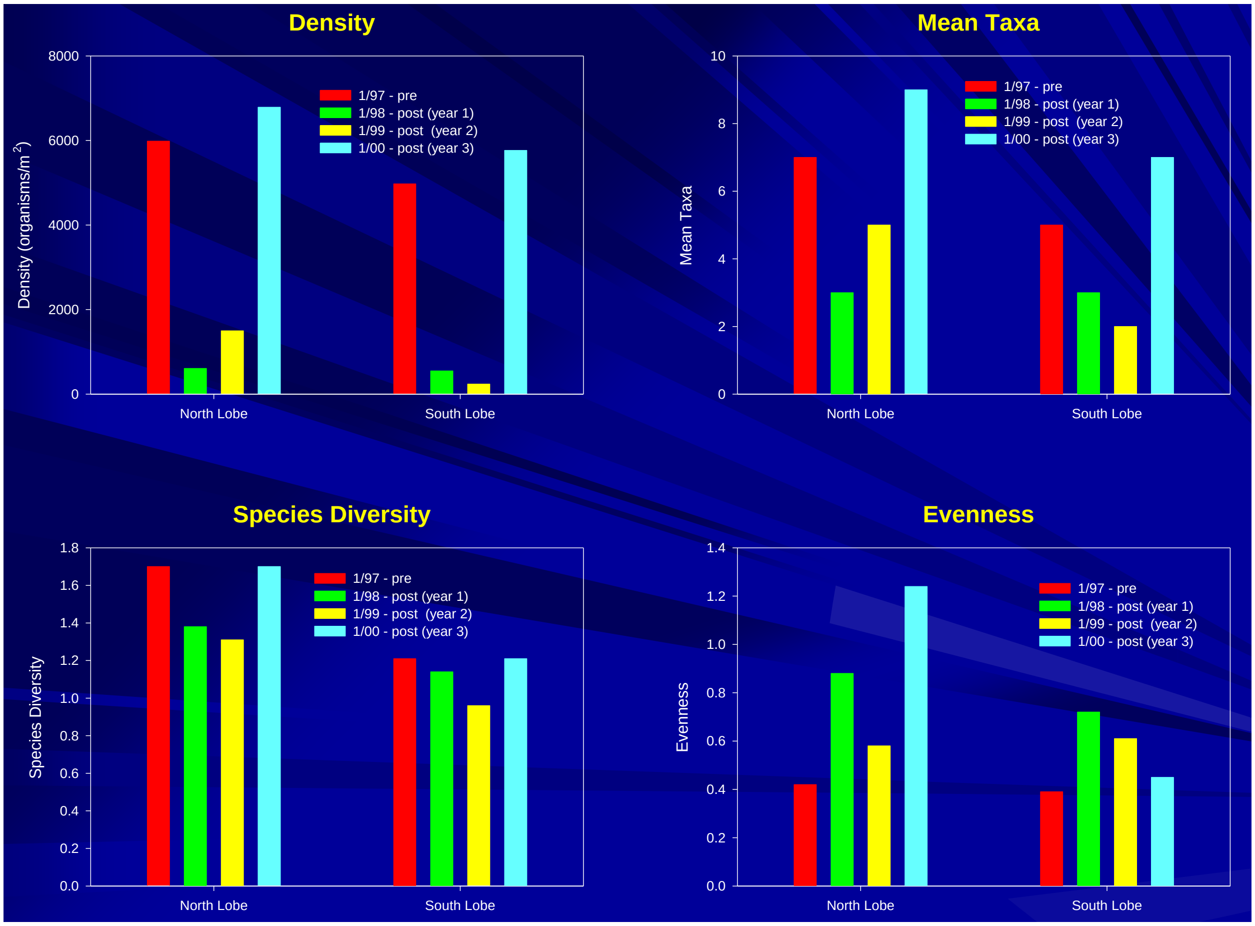


Figure 6-2. Comparison of Pre- and Post-Treatment Macroinvertebrate Assemblages in Lake Mizell.

6.1.6 Longevity of Treatment

After initial application, the alum precipitate will form a visible floc layer on the surface of the sediments within the lake. This floc layer will continue to consolidate for approximately 30-90 days, reaching maximum consolidation during that time. Due to the unconsolidated nature of the sediments in much of the lake, it is anticipated that a large portion of the floc will migrate into the existing sediments rather than accumulate on the surface as a distinct layer. This process is beneficial since it allows the floc to sorb soluble phosphorus during migration through the surficial sediments. Any floc remaining on the surface will provide a chemical barrier for adsorption of phosphorus which may be released from the sediments.

At least 50 previous sediment inactivation projects have been conducted by ERD in the State of Florida since 1992. Approximately half of these waterbodies have sufficient pre- and post-water quality data to evaluate the effectiveness of the alum sediment inactivation process. Based on these data, it appears that a properly planned and executed alum treatment project for Lake Concord would maintain a continuous level of effectiveness for a minimum of approximately 10 years or more.

6.2 Recommendations

Phosphorus loadings from internal recycling and groundwater seepage constitute the largest nutrient source in Lake Concord under current conditions. Sediment inactivation is a relatively inexpensive method of removing a large amount of phosphorus from the phosphorus budget within the lake, and inactivation activities should be undertaken as funding allows.

SECTION 7

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APPENDICES

APPENDIX A

PHOTOGRAPHS OF SEDIMENT CORE SAMPLES COLLECTED IN LAKE CONCORD ON MARCH 11, 2020

Lake Concord Sediment Photos

Sites 1 - 4

Site 1

Site 2

Site 3

Site 4

Lake Concord Sediment Photos

Sites 5 - 8

Site 5

Site 6

Site 7

Site 8

Lake Concord Sediment Photos

Sites 9 - 12

Site 9

Site 10

Site 11

Site 12

Lake Concord Sediment Photos

Sites 13 - 15

Site 13

Site 14

Site 15

APPENDIX B

HISTORICAL WATER QUALITY DATA FOR LAKE CONCORD FROM 1996-2019

Historical Water Quality Data for Lake Concord from 2003 -2019

Monitoring Agency	Site	Date	pH (s.u.)	Conductivity (umho/cm)	Diss. O_2 (mg/l)	Alkalinity (mg/l)	NH3-N (ug/l)	NOx-N (ug/l)	Organic N (ug/l)	Total N (ug/l)	SRP (ug/l)	Organic P (ug/l)	Total P (ug/l)	Color (units)	Chyl-a (mg/m^3)	Turbiditdy (NTU)	Fecal Coliform (CFU/100ml)	E. Coli (CFU/100 mL)	Secchi Disk Depth (m)	TN/TP Ratio	TSI (chyl-a)	Trophic State
City of Casselberry	Concord	12/18/03	8.01	124	8.6	49.1	3	3	592	598	1	43	44	11	39.5	-	31	-	0.83	14	52	Mesotrophic
	Concord	3/17/04	7.74	169	7.2	56.4	81	4	493	578	1	29	29	9	22.0	-	23	-	0.98	20	45	Oligotrophic
	Concord	5/20/04	8.63	236	8.5	61.0	3	3	537	543	1	32	32	20	39.9	-	3	-	0.76	17	61	Eutrophic
	Concord	9/14/04	8.52	195	6.0	53.1	5	3	377	385	16	82	98	20	53.7	-	108	-	0.68	4	62	Eutrophic
	Concord	11/8/04	8.58	222	9.8	54.8	18	6	606	630	1	51	51	17	68.6	-	6	-	0.68	12	67	Eutrophic
	Concord	3/9/05	7.54	184	9.5	52.0	109	3	292	404	1	25	26	14	25.2	-	2	-	0.92	16	55	Mesotrophic
	Concord	6/15/05	8.41	166	8.6	55.6	104	3	561	668	1	85	85	15	59.6	-	15	-	0.94	8	63	Eutrophic
	Concord	9/28/05	8.03	187	7.6	59.2	10	3	536	549	1	33	34	18	14.8	-	368	-	1.41	16	50	Mesotrophic
	Concord	12/13/05	7.57	166	8.9	57.6	128	29	406	563	1	39	39	16	41.4	-	13	-	0.84	14	61	Eutrophic
	Concord	2/7/06	7.76	175	8.6	54.8	3	7	474	484	1	32	33	12	35.4	-	8	-	0.86	15	59	Mesotrophic
	Concord	6/7/06	8.76	177	9.0	54.0	22	3	776	801	1	34	35	19	51.9	-	1	-	0.74	23	64	Eutrophic
	Concord	9/11/06	7.46	212	7.6	54.4	137	11	425	573	1	25	25	14	23.5	-	160	-	0.84	23	57	Mesotrophic
	Concord	11/13/06	7.95	185	8.4	59.4	39	3	850	892	1	36	37	12	26.0	-	9	-	0.82	24	60	Eutrophic
	Concord	3/1/07	7.94	170	8.8	55.6	11	6	433	450	3	40	43	14	6.7	-	2	-	1.81	10	44	Oligotrophic
	Concord	5/24/07	7.29	193	6.4	62.0	53	3	488	544	1	23	23	12	5.5	-	6	-	1.81	24	42	Oligotrophic
	Concord	9/27/07	8.16	185	8.5	78.0	153	3	519	675	1	22	22	14	31.6	-	24	-	1.59	31	54	Mesotrophic
	Concord	12/11/07	7.76	222	7.8	88.0	49	3	742	794	2	41	43	11	22.7	-	8	-	0.85	18	59	Mesotrophic
	Concord	3/31/08	8.20	230	8.9	84.4	46	3	329	378	1	14	14	11	7.6	-	11	-	1.27	27	44	Oligotrophic
	Concord	5/14/08	8.22	236	6.9	89.2	28	5	598	631	1	23	23	9	14.5	-	115	-	0.91	27	54	Mesotrophic
	Concord	9/30/08	8.31	165	7.6	59.4	31	3	411	445	1	24	24	10	23.0	-	152	-	0.71	19	58	Mesotrophic
	Concord	12/23/08	8.53	207	8.6	62.0	29	22	455	506	2	37	39	37	29.2	-	37	-	0.66	13	61	Eutrophic
	Concord	3/17/09	8.42	230	8.6	80.2	39	3	299	341	4	24	28	24	15.4	2.4	2	-	1.21	12	50	Oligotrophic
	Concord	5/12/09	8.73	228	9.5	65.6	39	16	513	568	1	26	26	19	20.8	4.3	12	-	0.83	22	57	Mesotrophic
	Concord	8/18/09	8.11	205	6.5	81.6	15	3	819	837	1	36	37	14	37.7	8.0	50	-	0.45	23	68	Eutrophic
	Concord	12/2/09	7.87	225	9.1	87.2	4	14	501	519	1	29	29	10	46.2	5.6	15	-	0.54	18	65	Eutrophic
	Concord	3/30/10	7.92	204	8.6	71.4	20	130	410	560	1	16	17	12	7.7	2.5	15	-	1.27	33	47	Oligotrophic
	Concord	6/29/10	7.99	187	6.7	65.6	39	16	513	568	1	26	26	19	20.8	4.3	12	-	0.76	22	57	Mesotrophic
	Concord	9/14/10	7.84	199	7.8	65.8	3	19	561	583	1	21	22	16	12.3	3.9	10	-	0.78	27	54	Mesotrophic
	Concord	12/29/10	7.64	180	9.7	76.4	9	29	293	331	1	8	8	11	6.8	2.2	5	-	1.36	41	40	Oligotrophic
	Concord	3/23/11	7.61	182	9.1	61.2	58	6	565	629	2	10	12	12	2.4	1.7	1	-	1.98	52	35	Oligotrophic
	Concord	6/29/11	8.04	179	6.8	64.0	13	16	701	730	3	13	16	19	31.7	0.6	368	-	0.52	46	63	Eutrophic
	Concord	9/22/11	8.18	181	7.2	63.4	100	3	394	497	1	23	24	13	54.6	6.7	22	-	0.62	21	63	Eutrophic
	Concord	12/12/11	8.17	178	8.7	63.4	5	3	487	495	1	38	38	13	42.1	5.3	50	-	0.51	13	66	Eutrophic
	Concord	3/12/12	8.83	173	9.2	65.8	3	5	347	355	1	16	17	13	19.5	4.2	33	-	0.79	21	54	Mesotrophic
	Concord	5/22/12	8.45	208	7.8	72.4	74	5	383	462	7	8	15	12	23.5	3.9	6	-	0.65	31	58	Mesotrophic
	Concord	9/6/12	7.63	136	7.0	50.6	9	3	496	508	2	16	18	21	9.0	2.9	88	-	1.08	28	48	Oligotrophic
	Concord	12/20/12	7.76	152	7.6	70.4	17	3	232	252	4	13	17	14	26.1	4.4	59	-	0.86	15	53	Mesotrophic
	Concord	3/26/13	7.88	192	8.9	64.0	3	3	263	269	1	4	5	15	15.4	3.4	13	-	0.91	54	44	Oligotrophic
	Concord	6/20/13	7.78	139	6.9	52.4	11	3	423	437	1	23	24	15	13.4	2.4	7	-	1.18	18	50	Oligotrophic
	Concord	9/17/13	7.81	151	6.4	57.2	3	3	487	493	5	19	24	16	31.3	4.8	15	-	0.84	21	66	Eutrophic
	Concord	12/12/13	7.86	167	8.3	64.0	3	3	578	584	1	26	27	14	50.2	7.9	7	-	0.83	22	73	Hyper-eutrophic
	Concord	2/28/14	7.45	171	8.2	62.0	3	16	582	601	2	21	23	18	18.0	5.1	9	-	1.15	26	58	Mesotrophic
	Concord	6/30/14	8.29	169	7.8	49.9	10	13	648	670	2	44	46	30	35.6	4.9	8	-	0.75	15	68	Eutrophic
	Concord	9/23/14	7.65	128	6.3	55.8	10	13	868	890	2	35	37	10	1.0	0.7	36	-	0.50	24	17	Oligotrophic
	Concord	12/16/14	6.47	158	9.2	55.3	31	13	747	790	4	29	33	15	19.4	5.1	6	-	0.75	24	59	Mesotrophic
	Concord	3/24/15	7.73	183	7.9	47.6	10	13	838	860	2	51	53	30	23.0	4.5	4	-	1.00	16	62	Hypereutrophic
	Concord	6/23/15	8.13	207	7.5	61.0	10	13	88	110	2	36	38	40	17.2	8.7	2	-	0.50	3	58	Mesotrophic
	Concord	10/5/15	8.26	168	8.6	-	10	13	638	660	2	39	41	25	35.4	4.4	22	-	0.75	16	68	Eutrophic
	Concord	12/15/15	8.10	199	9.1	72.6	10	13	508	530	4	35	39	25	23.0	4.3	34	-	0.75	14	62	Eutrophic
	Concord	3/22/16	8.01	197	8.9	64.7	10	13	708	730	2	38	40	25	27.3	5.0	10	-	1.00	18	64	Eutrophic
	Concord	7/6/16	8.28	199	9.4	66.2	10	13	678	700	2	30	32	25	20.7	4.5	4	-	1.00	22	60	Eutrophic
	Concord	9/30/16	7.98	212	2.1	82.5	20	13	538	570	6	32	38	30	24.4	4.0	60	-	0.80	15	63	Eutrophic
	Concord	12/15/16	7.92	215	10.0	74.6	10	5	595	610	5	28	33	30	19.8	3.6	4	-	0.80	18	60	Mesotrophic
	Concord	3/14/17	8.01	210	9.7	73.4	10	13	558	580	2	34	36	20	8.6	3.0	4	-	1.00	16	48	Oligotrophic
	Concord	6/22/17	7.67	193	10.1	65.0	10	13	818	840	2	44	46	50	5.0	4.6	7	-	0.60	18	40	Oligotrophic
	Concord	9/28/17	7.12	166	8.8	62.5	10	13	508	530	2	20	22	30	3.7	2.9	26	-	0.90	24	36	Oligotrophic
	Concord	12/12/17	7.55	205	9.9	73.2	18	13	570	600	5	23	28	30	-	3.4	28	-	0.80	21	-	-
	Concord	3/22/18	7.97	218	9.2	74.2	18	13	610	640	2	55	57	30	11.7	3.9	74	-	1.00	11	52	Mesotrophic
	Concord	7/10/18	7.77	187	7.0	64.4	18	13	680	710	2	36	38	35	26.9	4.4	97	-	1.00	19	64	Eutrophic
	Concord	10/3/18	7.90	201	9.4	114.0	18	13	630	660	20	16	35	35	-	3.9	270	-	0.75	19	-	-
	Concord	12/6/18	8.54	206	10.2	70.2	18	13	1,370	1,400	2	36	38	30	-	3.3	16	-	0.80	37	-	-

Historical Water Quality Data for Lake Concord from 2003 -2019

Monitoring Agency	Site	Date	pH (s.u.)	Conductivity (umho/cm)	Diss. O_2 (mg/l)	Alkalinity (mg/l)	NH3-N (ug/l)	NOx-N (ug/l)	Organic N (ug/l)	Total N (ug/l)	SRP (ug/l)	Organic P (ug/l)	Total P (ug/l)	Color (units)	Chyl-a (mg/m^3)	Turbididty (NTU)	Fecal Coliform (CFU/100ml)	E. Coli (CFU/100 mL)	Secchi Disk Depth (m)	TN/TP Ratio	TSI (chyl-a)	Trophic State
City of Casselberry	Concord	3/21/19	8.11	200	9.6	80.9	18	32	421	470	2	33	35	15	-	1.9	7	-	1.30	13	-	-
	Concord	9/11/19	8.20	199	8.4	72.9	5	1	746	752	3	29	32	16	65.0	5.2	14	2	0.58	24	77	Hyper-eutrophic
	Concord	12/18/19	7.21	215	8.6	65.8	26	9	332	367	8	35	43	14	37.7	6.0	180	125	0.67	9	69	Eutrophic
FDEP	G2CE0059	2/22/17	6.4	210	9.9	79.0	3			504			36	11	16.0	3.2			1.10	14	57	Mesotrophic
	G2CE0059	6/20/17	8.0	192	8.9	70.0				844			51	15	44.0	6.5			0.70	17	71	Hyper-Eutrophic
	G2CE0059	9/27/17	7.7	172	8.2	63.0	3			424			39	17	26.0	3.9			0.90	11	64	Eutrophic
	G2CE0059	10/23/17	7.7	188	7.9	68.0	2	4	598	604	4	38	42	16	32.0	3.9			0.90	14	67	Eutrophic
	G2CE0059	1/10/19	8.0	201	9.5	72.0	3	4	687	694	4	31	35	13	36.0	5.4			1.00	20	68	Eutrophic
	G2CE0059	1/28/19	7.5	192	8.8	69.0	60	46	565	671	4	33	37	14	17.0	3.9			1.40	18	58	Mesotrophic
	G2CE0059	2/25/19	7.9	202	8.7	72.0	4	4	596	604	4	32	36	15	20.0	4.9			1.30	17	60	Eutrophic
	G2CE0059	4/3/19	8.0	202	8.4	71.0	3	4	447	454	4	29	33	12	17.0	3.2			1.50	14	58	Mesotrophic
	G2CE0059	4/24/19	7.9	219	8.5	77.0	4	4	636	644	4	34	38	12	18.0	3.2			1.10	17	58	Mesotrophic
	G2CE0059	5/9/19	8.1	226	8.6	80.0	3	4	657	664	4	36	40	12	25.0	3.8			1.00	17	63	Eutrophic
	G2CE0059	6/11/19	8.5	205	8.2	73.0	4	4	1,096	1,104	4	63	67	15	70.0	8.6			0.60	17	78	Hyper-Eutrophic
	G2CE0059	6/19/19	8.8	200	9.8	73.0	5	4	1,095	1,104	4	31	35	15	91.0	8.3			0.60	32	82	Hyper-Eutrophic
Lake Watch	Seminole-Concord	2/1/02												18								
	Seminole-Concord	4/26/02												13								
	Seminole-Concord	7/27/02												14								
	Seminole-Concord	1/31/03												18								
	Seminole-Concord	6/27/03												17								
	Seminole-Concord	7/24/03												18								
	Seminole-Concord	2/23/04												19								
	Seminole-Concord	4/28/04												15								
	Seminole-Concord	7/22/04												21								
	Seminole-Concord	1/31/05												17								
	Seminole-Concord	4/29/05												16								
	Seminole-Concord	7/29/05												16								
	Seminole-Concord	1/31/06												17								
	Seminole-Concord	7/30/07		147										15								
	Seminole-Concord	4/30/08		140										11								
	Seminole-Concord	7/31/08												12								
	Seminole-Concord	1/28/09		132										11								
	Seminole-Concord	4/30/10		127										14								
	Seminole-Concord	8/30/10		86										11								
	Seminole-Concord	2/28/11		153										10								
	Seminole-Concord	4/28/11		100										16								
	Seminole-Concord	6/30/11		131										12								
	Seminole-Concord	7/28/11		128										13								
	Seminole-Concord	8/30/11		172										11								
	Seminole-Concord	9/29/11		148										9								
	Seminole-Concord	1/31/12		181										10								
	Seminole-Concord	2/29/12		126										8								
	Seminole-Concord	3/29/12		180										11								
	Seminole-Concord	5/31/12		202										18								
	Seminole-Concord	6/28/12		164										14								
	Seminole-Concord	7/30/12		157										17								
	Seminole-Concord	8/30/12		133										19								
	Seminole-Concord	9/27/12		136										27								
	Seminole-Concord	1/28/13		140										16								
	Seminole-Concord	2/28/13		149										16								
	Seminole-Concord	3/28/13		172										22								
	Seminole-Concord	4/30/13		120										13								
	Seminole-Concord	5/30/13		77										14								
	Seminole-Concord	6/27/13		101										18								
	Seminole-Concord	7/30/13		143										19								
	Seminole-Concord	8/29/13		120										13								
	Seminole-Concord	9/30/13		124										16								

Historical Water Quality Data for Lake Concord from 2003 -2019

Monitoring Agency	Site	Date	pH (s.u.)	Conductivity (umho/cm)	Diss. O_2 (mg/l)	Alkalinity (mg/l)	NH3-N (ug/l)	NOx-N (ug/l)	Organic N (ug/l)	Total N (ug/l)	SRP (ug/l)	Organic P (ug/l)	Total P (ug/l)	Color (units)	Chyl-a (mg/m^3)	Turbididty (NTU)	Fecal Coliform (CFU/100ml)	E. Coli (CFU/100 mL)	Secchi Disk Depth (m)	TN/TP Ratio	TSI (chyl-a)	Trophic State
Lake Watch	Seminole-Concord	2/3/14		107										14								
	Seminole-Concord	2/27/14		88										13								
	Seminole-Concord	3/24/14		121										12								
	Seminole-Concord	4/29/14		123										16								
	Seminole-Concord	5/29/14												10								
	Seminole-Concord	6/30/14		149										13								
	Seminole-Concord	7/31/14		141										14								
	Seminole-Concord	8/27/14		129										16								
	Seminole-Concord	9/30/14		122										12								
	Seminole-Concord	1/28/15		158										15								
	Seminole-Concord	4/30/15		147										13								
	Seminole-Concord	1/26/16		168										16								
	Seminole-Concord	4/28/16		188										17								
	Seminole-Concord	7/28/16		182										17								
	Seminole-Concord	1/30/17		197										15								
	Seminole-Concord	4/26/17		190										18								
	Seminole-Concord	7/31/17		180										17								
	Seminole-Concord	1/31/18		211										14								
	Seminole-Concord	4/26/18		175										17								
	Seminole-Concord	7/31/18		170										14								
LakeWatch	Seminole-Concord-1	5/30/96													13.0				1.52		54	Mesotrophic
	Seminole-Concord-1	9/12/96								980			52		41.0				1.22	19	70	Hyper-eutrophic
	Seminole-Concord-1	11/2/96								790			58		35.0				1.22	14	68	Eutophic
	Seminole-Concord-1	12/10/96								560			36		24.0				1.22	16	63	Eutophic
	Seminole-Concord-1	1/6/97								630			48		18.0				1.52	13	58	Mesotrophic
	Seminole-Concord-1	3/18/97								430			31		11.0				1.52	14	51	Mesotrophic
	Seminole-Concord-1	4/25/97								380			28		9.0				1.22	14	48	Oligotrophic
	Seminole-Concord-1	5/20/97								530			35		13.0				1.37	15	54	Mesotrophic
	Seminole-Concord-1	6/26/97								670			35		23.0				1.22	19	62	Eutophic
	Seminole-Concord-1	7/14/97								520			33		22.0				1.22	16	61	Eutophic
	Seminole-Concord-1	10/1/97								630			29		32.0				1.22	22	67	Eutophic
	Seminole-Concord-1	1/20/98								590			28		24.0				1.37	21	63	Eutophic
	Seminole-Concord-1	4/10/98								630			38		15.0				1.22	17	56	Mesotrophic
	Seminole-Concord-1	8/20/98								600			34		14.0				1.22	18	55	Mesotrophic
	Seminole-Concord-1	10/14/98								1,540			55		78.0				0.76	28	80	Hyper-eutrophic
	Seminole-Concord-1	11/9/98								1,200			51		61.0				0.61	24	76	Hyper-eutrophic
	Seminole-Concord-1	12/28/98								930			46		48.0				1.07	20	73	Hyper-eutrophic
	Seminole-Concord-1	1/21/99								740			53		38.0				1.22	14	69	Eutophic
	Seminole-Concord-1	2/25/99								830			67		35.0				0.91	12	68	Eutophic
	Seminole-Concord-1	3/25/99								920			63		32.0				0.91	15	67	Eutophic
	Seminole-Concord-1	4/30/99								800			48		34.0				1.22	17	68	Eutophic
	Seminole-Concord-1	5/31/99								700			45		15.0				1.37	16	56	Mesotrophic
	Seminole-Concord-1	6/29/99								550			38		25.0				0.91	14	63	Eutophic
	Seminole-Concord-1	7/22/99								490			32		12.0				1.52	15	53	Mesotrophic
	Seminole-Concord-1	8/10/99								530			34		16.0				0.91	16	57	Mesotrophic
	Seminole-Concord-1	9/17/99								600			28		15.0				0.91	21	56	Mesotrophic
	Seminole-Concord-1	10/25/99								700			51		34.0				0.61	14	68	Eutophic
	Seminole-Concord-1	1/4/00								680			45		32.0					15	67	Eutophic
	Seminole-Concord-1	2/17/00								550			35		11.0				0.91	16	51	Mesotrophic
	Seminole-Concord-1	3/24/00								690			52		16.0				0.91	13	57	Mesotrophic
	Seminole-Concord-1	10/5/00								590			35		26.0				0.91	17	64	Eutophic
	Seminole-Concord-1	5/29/01								650			49		37.0				1.22	13	69	Eutophic
	Seminole-Concord-1	8/24/01								660			31		21.0				0.91	21	61	Eutophic
	Seminole-Concord-1	11/16/01								670			53		37.0				0.91	13	69	Eutophic
	Seminole-Concord-1	12/20/01								710			51		47.0				0.91	14	72	Hyper-eutrophic

Historical Water Quality Data for Lake Concord from 2003 -2019

Monitoring Agency	Site	Date	pH (s.u.)	Conductivity (umho/cm)	Diss. O_2 (mg/l)	Alkalinity (mg/l)	NH3-N (ug/l)	NOx-N (ug/l)	Organic N (ug/l)	Total N (ug/l)	SRP (ug/l)	Organic P (ug/l)	Total P (ug/l)	Color (units)	Chyl-a (mg/m^3)	Turbididty (NTU)	Fecal Coliform (CFU/100ml)	E. Coli (CFU/100 mL)	Secchi Disk Depth (m)	TN/TP Ratio	TSI (chyl-a)	Trophic State
Lake Watch	Seminole-Concord-1	2/1/02								490			42		18.0				0.91	12	58	Mesotrophic
	Seminole-Concord-1	3/15/02								480			36		10.0				1.22	13	50	Mesotrophic
	Seminole-Concord-1	4/26/02								580			51		24.0				0.91	11	63	Eutophic
	Seminole-Concord-1	7/27/02								550			42		22.0				0.91	13	61	Eutophic
	Seminole-Concord-1	8/23/02								610			42		22.0				0.91	15	61	Eutophic
	Seminole-Concord-1	9/27/02								670			34		27.0				0.91	20	64	Eutophic
	Seminole-Concord-1	10/18/02								590			41	19	27.0				0.91	14	64	Eutophic
	Seminole-Concord-1	11/15/02								610			36		33.0				0.91	17	67	Eutophic
	Seminole-Concord-1	1/31/03								380			37		19.0				0.91	10	59	Mesotrophic
	Seminole-Concord-1	2/28/03								540			47		18.0				1.22	11	58	Mesotrophic
	Seminole-Concord-1	3/28/03								470			29		14.0				1.22	16	55	Mesotrophic
	Seminole-Concord-1	6/27/03								840			40		33.0				0.91	21	67	Eutophic
	Seminole-Concord-1	7/24/03								720			38		24.0				1.22	19	63	Eutophic
	Seminole-Concord-1	8/12/03								690			48		35.0				0.91	14	68	Eutophic
	Seminole-Concord-1	9/26/03								670			46		23.0				1.22	15	62	Eutophic
	Seminole-Concord-1	10/25/03								440			40	13	17.0				1.22	11	58	Mesotrophic
	Seminole-Concord-1	11/26/03								690			43		27.0				0.91	16	64	Eutophic
	Seminole-Concord-1	12/31/03								560			39		18.0				1.22	14	58	Mesotrophic
	Seminole-Concord-1	2/23/04								510			37		18.0				0.91	14	58	Mesotrophic
	Seminole-Concord-1	3/26/04								620			44		20.0				0.91	14	60	Eutophic
	Seminole-Concord-1	4/28/04								640			42		29.0				1.22	15	65	Eutophic
	Seminole-Concord-1	5/27/04								570			49		23.0				0.91	12	62	Eutophic
	Seminole-Concord-1	6/30/04								950			53		49.0				0.91	18	73	Hyper-eutrophic
	Seminole-Concord-1	7/22/04								910			33		30.0				0.91	28	66	Eutophic
	Seminole-Concord-1	8/31/04								790			38		23.0				0.91	21	62	Eutophic
	Seminole-Concord-1	9/30/04								740			96		28.0				1.22	8	65	Eutophic
	Seminole-Concord-1	10/24/04								740			58		48.0				0.61	13	73	Hyper-eutrophic
	Seminole-Concord-1	11/30/04								680			43		30.0				1.22	16	66	Eutophic
	Seminole-Concord-1	12/29/04								590			37		34.0				0.91	16	68	Eutophic
	Seminole-Concord-1	1/31/05								640			44		47.0				1.22	15	72	Hyper-eutrophic
	Seminole-Concord-1	2/28/05								490			53		24.0				0.91	9	63	Eutophic
	Seminole-Concord-1	3/31/05								350			35		20.0				0.91	10	60	Eutophic
	Seminole-Concord-1	4/29/05								670			58		23.0				1.22	12	62	Eutophic
	Seminole-Concord-1	5/27/05								1,040			67		31.0				0.61	16	66	Eutophic
	Seminole-Concord-1	6/30/05								840			81		50.0				0.91	10	73	Hyper-eutrophic
	Seminole-Concord-1	7/29/05								730			47		26.0				0.91	16	64	Eutophic
	Seminole-Concord-1	8/31/05								640			53		32.0				0.91	12	67	Eutophic
	Seminole-Concord-1	9/30/05								630			50		27.0				0.91	13	64	Eutophic
	Seminole-Concord-1	10/31/05								580			42	20	25.0				0.91	14	63	Eutophic
	Seminole-Concord-1	11/30/05								590			41		31.0				1.22	14	66	Eutophic
	Seminole-Concord-1	12/29/05								590			38		27.0				1.07	16	64	Eutophic
	Seminole-Concord-1	1/31/06								820			49		32.0				0.91	17	67	Eutophic
	Seminole-Concord-1	7/30/07								1,080			55		67.0				0.61	20	77	Hyper-eutrophic
	Seminole-Concord-1	8/31/07								1,010			32		39.0				0.91	32	70	Hyper-eutrophic
	Seminole-Concord-1	9/28/07								1,200			50		41.0				0.91	24	70	Hyper-eutrophic
	Seminole-Concord-1	10/31/07		155						960			46	14	49.0				0.61	21	73	Hyper-eutrophic
	Seminole-Concord-1	11/29/07								710			39		27.0				3.05	18	64	Eutophic
	Seminole-Concord-1	12/28/07								560			25		13.4				3.05	22	54	Mesotrophic
	Seminole-Concord-1	1/31/08								540			33		18.0				1.07	16	58	Mesotrophic
	Seminole-Concord-1	2/29/08								490			26		14.0				1.31	19	55	Mesotrophic
	Seminole-Concord-1	3/28/08								340			23		10.0				1.31	15	50	Mesotrophic
	Seminole-Concord-1	4/30/08								500			26		20.0				1.22	19	60	Eutophic
	Seminole-Concord-1	6/2/08								800			39		22.0				0.91	21	61	Eutophic
	Seminole-Concord-1	6/30/08								760			47		28.0					16	65	Eutophic
	Seminole-Concord-1	7/31/08								740			32		34.0				1.52	23	68	Eutophic
	Seminole-Concord-1	8/29/08								480			35		21.0				0.91	14	61	Eutophic
	Seminole-Concord-1	9/29/08								670			36		26.0				0.91	19	64	Eutophic
	Seminole-Concord-1	10/31/08		102						520			35	19	28.0				0.61	15	65	Eutophic
	Seminole-Concord-1	12/1/08								580			45		29.0				1.37	13	65	Eutophic
	Seminole-Concord-1	12/31/08								750			43		28.0				0.91	17	65	Eutophic

Historical Water Quality Data for Lake Concord from 2003 -2019

Monitoring Agency	Site	Date	pH (s.u.)	Conductivity (umho/cm)	Diss. O_2 (mg/l)	Alkalinity (mg/l)	NH3-N (ug/l)	NOx-N (ug/l)	Organic N (ug/l)	Total N (ug/l)	SRP (ug/l)	Organic P (ug/l)	Total P (ug/l)	Color (units)	Chyl-a (mg/m^3)	Turbididty (NTU)	Fecal Coliform (CFU/100ml)	E. Coli (CFU/100 mL)	Secchi Disk Depth (m)	TN/TP Ratio	TSI (chyl-a)	Trophic State
Lake Watch	Seminole-Concord-1	1/28/09								500			24		11.0				1.83	21	51	Mesotrophic
	Seminole-Concord-1	2/27/09								360			27		14.0				0.61	13	55	Mesotrophic
	Seminole-Concord-1	3/31/09								480			27		10.0				1.62	18	50	Mesotrophic
	Seminole-Concord-1	5/1/09								550			33		15.4				1.22	17	56	Mesotrophic
	Seminole-Concord-1	5/29/09								1,080			41		31.0				1.37	26	66	Eutophic
	Seminole-Concord-1	6/30/09								990			47		35.0				0.61	21	68	Eutophic
	Seminole-Concord-1	8/31/09								710			26		40.0				0.91	27	70	Hyper-eutrophic
	Seminole-Concord-1	10/30/09		195						700			34	13	26.0				0.91	21	64	Eutophic
	Seminole-Concord-1	12/30/09								800			29		25.0				1.22	28	63	Eutophic
	Seminole-Concord-1	2/26/10								600			26		20.0				1.52	23	60	Eutophic
	Seminole-Concord-1	4/30/10								600			28		10.0				1.37	21	50	Mesotrophic
	Seminole-Concord-1	6/30/10								550			30		21.5				0.91	18	61	Eutophic
	Seminole-Concord-1	8/30/10								610			47		32.1				1.68	13	67	Eutophic
	Seminole-Concord-1	10/29/10		146						570			32	12	17.0				1.22	18	58	Mesotrophic
	Seminole-Concord-1	12/30/10								250			32		11.0				1.98	8	51	Mesotrophic
	Seminole-Concord-1	2/28/11								430			15		7.0				1.83	29	45	Oligotrophic
	Seminole-Concord-1	4/28/11								570			32		12.0				1.22	18	53	Mesotrophic
	Seminole-Concord-1	6/30/11								970			41		40.2				0.76	24	70	Hyper-eutrophic
	Seminole-Concord-1	7/28/11								730			35		31.2				1.22	21	66	Eutophic
	Seminole-Concord-1	8/30/11								900			26		46.1				0.76	35	72	Hyper-eutrophic
	Seminole-Concord-1	9/29/11								600			23		54.6				0.91	26	74	Hyper-eutrophic
	Seminole-Concord-1	10/31/11								1,240			39		36.0				0.91	32	68	Eutophic
	Seminole-Concord-1	11/30/11		179						790			33	11	33.5				0.91	24	67	Eutophic
	Seminole-Concord-1	12/29/11		131						580			35	10	30.3				0.91	17	66	Eutophic
	Seminole-Concord-1	1/31/12								1,060			39		24.7				0.76	27	63	Eutophic
	Seminole-Concord-1	2/29/12								500			27		18.0				0.91	19	58	Mesotrophic
	Seminole-Concord-1	3/29/12								680			35		27.0				1.37	19	64	Eutophic
	Seminole-Concord-1	4/30/12								560			34		21.5				0.91	16	61	Eutophic
	Seminole-Concord-1	5/31/12								540			30		17.5				1.01	18	58	Mesotrophic
	Seminole-Concord-1	6/28/12								620			33		21.0				0.91	19	61	Eutophic
	Seminole-Concord-1	7/30/12								710			24		20.0				1.37	30	60	Eutophic
	Seminole-Concord-1	8/30/12								500			26		14.0				1.31	19	55	Mesotrophic
	Seminole-Concord-1	9/27/12								470			27		19.0				1.22	17	59	Mesotrophic
	Seminole-Concord-1	10/31/12		142						620			31	16	24.0				1.22	20	63	Eutophic
	Seminole-Concord-1	11/29/12		149						540			29	14	18.0				1.22	19	58	Mesotrophic
	Seminole-Concord-1	12/31/12		97						820			44	13	22.0				0.91	19	61	Eutophic
	Seminole-Concord-1	1/28/13								700			42		21.0				1.07	17	61	Eutophic
	Seminole-Concord-1	2/28/13								710			43		19.0				1.22	17	59	Mesotrophic
	Seminole-Concord-1	3/28/13								530			30		10.0				1.22	18	50	Mesotrophic
	Seminole-Concord-1	4/30/13								570			31		15.0				1.22	18	56	Mesotrophic
	Seminole-Concord-1	5/30/13								430			31		17.0				1.52	14	58	Mesotrophic
	Seminole-Concord-1	6/27/13								690			39		18.0				1.22	18	58	Mesotrophic
	Seminole-Concord-1	7/30/13								780			34		22.0				0.91	23	61	Eutophic
	Seminole-Concord-1	8/29/13								550			25		25.0				1.22	22	63	Eutophic
	Seminole-Concord-1	9/30/13								640			29		24.0				0.91	22	63	Eutophic
	Seminole-Concord-1	10/30/13		152						800			31	13	30.0				0.91	26	66	Eutophic
	Seminole-Concord-1	11/27/13		124						850			39	15	39.0				0.76	22	70	Hyper-eutrophic
	Seminole-Concord-1	12/30/13		150						920			35	16	36.0				0.91	26	68	Eutophic
	Seminole-Concord-1	2/3/14								520			28		29.0				0.91	19	65	Eutophic
	Seminole-Concord-1	2/27/14								590			38		25.0				1.52	16	63	Eutophic
	Seminole-Concord-1	3/24/14								620			33		13.0				1.22	19	54	Mesotrophic
	Seminole-Concord-1	4/29/14								720			38		22.0				1.07	19	61	Eutophic
	Seminole-Concord-1	5/29/14								730			36		20.0				0.91	20	60	Eutophic
	Seminole-Concord-1	6/30/14								930			43		17.0				0.61	22	58	Mesotrophic
	Seminole-Concord-1	7/31/14								660			33		17.0				1.22	20	58	Mesotrophic
	Seminole-Concord-1	8/27/14								910			33		18.0				0.61	28	58	Mesotrophic
	Seminole-Concord-1	9/30/14								940			35		55.0				0.61	27	75	Hyper-eutrophic
	Seminole-Concord-1	10/28/14		124						1,040			35	16	30.0				0.91	30	66	Eutophic
	Seminole-Concord-1	11/24/14		146						820			31	15	28.0				0.61	26	65	Eutophic
	Seminole-Concord-1	12/30/14		159						810			32	17	19.0				1.22	25	59	Mesotrophic

Historical Water Quality Data for Lake Concord from 2003 -2019

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Lake Watch	Seminole-Concord-1	1/28/15								720			33		19.0				1.22	22	59	Mesotrophic
	Seminole-Concord-1	2/25/15								590			19		19.0				1.22	31	59	Mesotrophic
	Seminole-Concord-1	3/30/15								770			33		21.0				0.91	23	61	Eutophic
	Seminole-Concord-1	4/30/15								930			40		23.0				1.07	23	62	Eutophic
	Seminole-Concord-1	5/28/15								2,190			47		103.0				0.30	47	84	Hyper-eutrophic
	Seminole-Concord-1	6/30/15								1,540			46		44.0				0.91	33	71	Hyper-eutrophic
	Seminole-Concord-1	7/30/15								1,390			40		59.0				0.61	35	76	Hyper-eutrophic
	Seminole-Concord-1	8/27/15								2,320			36		30.0				0.76	64	66	Eutophic
	Seminole-Concord-1	9/30/15								990			36		28.0				0.91	28	65	Eutophic
	Seminole-Concord-1	10/29/15		172						840			37	19	31.0				0.61	23	66	Eutophic
	Seminole-Concord-1	11/30/15								750			38		31.0				0.91	20	66	Eutophic
	Seminole-Concord-1	12/30/15								750			35		25.0				0.91	21	63	Eutophic
	Seminole-Concord-1	1/26/16								610			32		19.0				1.07	19	59	Mesotrophic
	Seminole-Concord-1	2/29/16								640			31		19.0				0.91	21	59	Mesotrophic
	Seminole-Concord-1	3/30/16								750			41		26.0				0.91	18	64	Eutophic
	Seminole-Concord-1	4/28/16								900			44		20.0				0.91	20	60	Eutophic
	Seminole-Concord-1	5/31/16								880			41		25.0				0.76	21	63	Eutophic
	Seminole-Concord-1	6/30/16								740			37		20.0				0.91	20	60	Eutophic
	Seminole-Concord-1	7/28/16								620			35		18.0				1.07	18	58	Mesotrophic
	Seminole-Concord-1	8/30/16								750			35		21.0				0.91	21	61	Eutophic
	Seminole-Concord-1	9/29/16								680			28		28.0				0.91	24	65	Eutophic
	Seminole-Concord-1	10/31/16		174						600			32	14	21.0				0.91	19	61	Eutophic
	Seminole-Concord-1	11/30/16								880			30		20.0				0.91	29	60	Eutophic
	Seminole-Concord-1	12/28/16								580			32		20.0				1.22	18	60	Eutophic
	Seminole-Concord-1	1/30/17								460			38		17.0				1.07	12	58	Mesotrophic
	Seminole-Concord-1	2/28/17								550			28		13.0				2.44	20	54	Mesotrophic
	Seminole-Concord-1	3/30/17								810			22		17.0				0.91	37	58	Mesotrophic
	Seminole-Concord-1	4/26/17								1,190			43		51.0				0.61	28	73	Hyper-eutrophic
	Seminole-Concord-1	5/31/17								1,100			52		43.0				0.61	21	71	Hyper-eutrophic
	Seminole-Concord-1	6/29/17								980			41		37.0				0.61	24	69	Eutophic
	Seminole-Concord-1	7/31/17								850			52		31.0				0.91	16	66	Eutophic
	Seminole-Concord-1	8/31/17								750			37		25.0				0.91	20	63	Eutophic
	Seminole-Concord-1	9/28/17								540			32		18.0				1.22	17	58	Mesotrophic
	Seminole-Concord-1	10/31/17		185						590			32	13	27.0				1.37	18	64	Eutophic
	Seminole-Concord-1	11/30/17								640			30		25.0				0.91	21	63	Eutophic
	Seminole-Concord-1	12/28/17								590			39		29.0				0.76	15	65	Eutophic
	Seminole-Concord-1	1/31/18								680			45		28.0				0.91	15	65	Eutophic
	Seminole-Concord-1	2/28/18								570			40		19.0				0.61	14	59	Mesotrophic
	Seminole-Concord-1	3/29/18								630			42		20.0				0.91	15	60	Eutophic
	Seminole-Concord-1	4/26/18								870			46		37.0				0.61	19	69	Eutophic
	Seminole-Concord-1	5/31/18								650			35		23.0				0.91	19	62	Eutophic
	Seminole-Concord-1	6/28/18								770			39		38.0				0.91	20	69	Eutophic
	Seminole-Concord-1	7/31/18								680			31		31.0				0.91	22	66	Eutophic
	Seminole-Concord-1	8/30/18								740			36		34.0				0.91	21	68	Eutophic
	Seminole-Concord-1	9/27/18								700			32		24.0				0.91	22	63	Eutophic
	Seminole-Concord-1	10/31/18		178						680			27	16	17.0				0.91	25	58	Mesotrophic
	Seminole-Concord-1	11/29/18								690			34		23.0				0.76	20	62	Eutophic

Historical Water Quality Data for Lake Concord from 2003 -2019

Monitoring Agency	Site	Date	pH (s.u.)	Conductivity (umho/cm)	Diss. O_2 (mg/l)	Alkalinity (mg/l)	NH3-N (ug/l)	NOx-N (ug/l)	Organic N (ug/l)	Total N (ug/l)	SRP (ug/l)	Organic P (ug/l)	Total P (ug/l)	Color (units)	Chyl-a (mg/m^3)	Turbididty (NTU)	Fecal Coliform (CFU/100ml)	E. Coli (CFU/100 mL)	Secchi Disk Depth (m)	TN/TP Ratio	TSI (chyl-a)	Trophic State
LakeWatch	Seminole-Concord-2	5/30/96								740			33		14.0					22	55	Mesotrophic
	Seminole-Concord-2	9/12/96								820			44		46.0				1.22	19	72	Hyper-eutrophic
	Seminole-Concord-2	11/2/96								840			53		40.0				1.07	16	70	Hyper-eutrophic
	Seminole-Concord-2	12/10/96								540			35		30.0				0.91	15	66	Eutophic
	Seminole-Concord-2	1/6/97								580			42		22.0				1.37	14	61	Eutophic
	Seminole-Concord-2	3/18/97								430			30		10.0				1.52	14	50	Mesotrophic
	Seminole-Concord-2	4/25/97								480			35		7.0				1.22	14	45	Oligotrophic
	Seminole-Concord-2	5/20/97								480			29		12.0				1.37	17	53	Mesotrophic
	Seminole-Concord-2	6/26/97								570			34		20.0				1.37	17	60	Eutophic
	Seminole-Concord-2	7/14/97								720			35		21.0				1.07	21	61	Eutophic
	Seminole-Concord-2	10/1/97								650			32		27.0				1.22	20	64	Eutophic
	Seminole-Concord-2	1/20/98								530			26		28.0				1.52	20	65	Eutophic
	Seminole-Concord-2	4/10/98								530			38		13.0				1.37	14	54	Mesotrophic
	Seminole-Concord-2	8/20/98								600			33		15.0				1.22	18	56	Mesotrophic
	Seminole-Concord-2	10/14/98								1,430			55		88.0				0.76	26	81	Hyper-eutrophic
	Seminole-Concord-2	11/9/98								1,390			59		62.0				0.61	24	76	Hyper-eutrophic
	Seminole-Concord-2	12/28/98								900			51		50.0				1.22	18	73	Hyper-eutrophic
	Seminole-Concord-2	1/21/99								620			45		32.0				1.07	14	67	Eutophic
	Seminole-Concord-2	2/25/99								840			72		37.0				0.91	12	69	Eutophic
	Seminole-Concord-2	3/25/99								840			57		31.0				0.91	15	66	Eutophic
	Seminole-Concord-2	4/30/99								780			43		35.0				0.91	18	68	Eutophic
	Seminole-Concord-2	5/31/99								590			43		11.0				1.37	14	51	Mesotrophic
	Seminole-Concord-2	6/29/99								530			34		22.0				0.91	16	61	Eutophic
	Seminole-Concord-2	7/22/99								460			30		10.0				1.52	15	50	Mesotrophic
	Seminole-Concord-2	8/10/99								550			34		17.0				0.91	16	58	Mesotrophic
	Seminole-Concord-2	9/17/99								550			38		15.0				0.91	14	56	Mesotrophic
	Seminole-Concord-2	10/25/99								610			44		32.0				0.61	14	67	Eutophic
	Seminole-Concord-2	1/4/00								750			48		45.0					16	72	Hyper-eutrophic
	Seminole-Concord-2	2/17/00								410			36		13.0				0.91	11	54	Mesotrophic
	Seminole-Concord-2	3/24/00								810			55		16.0				0.91	15	57	Mesotrophic
	Seminole-Concord-2	10/5/00								620			32		26.0				0.91	19	64	Eutophic
	Seminole-Concord-2	5/29/01								930			61		35.0				0.91	15	68	Eutophic
	Seminole-Concord-2	8/24/01								730			43		22.0				0.91	17	61	Eutophic
	Seminole-Concord-2	11/16/01								690			52		36.0				0.91	13	68	Eutophic
	Seminole-Concord-2	12/20/01								700			53		45.0				0.91	13	72	Hyper-eutrophic
	Seminole-Concord-2	2/1/02								530			54		20.0				0.91	10	60	Eutophic
	Seminole-Concord-2	3/15/02								460			29		9.0				0.91	16	48	Oligotrophic
	Seminole-Concord-2	4/26/02								560			50		23.0				0.91	11	62	Eutophic
	Seminole-Concord-2	7/27/02								610			46		25.0				0.91	13	63	Eutophic
	Seminole-Concord-2	8/23/02								630			47		25.0				0.91	13	63	Eutophic
	Seminole-Concord-2	9/27/02								640			46		33.0				0.91	14	67	Eutophic
	Seminole-Concord-2	10/18/02								720			41		28.0				0.61	18	65	Eutophic
	Seminole-Concord-2	11/15/02								670			38		33.0				0.91	18	67	Eutophic
	Seminole-Concord-2	1/31/03								430			46		17.0				1.22	9	58	Mesotrophic
	Seminole-Concord-2	2/28/03								490			49		21.0				1.22	10	61	Eutophic
	Seminole-Concord-2	3/28/03								490			33		13.0				1.22	15	54	Mesotrophic
	Seminole-Concord-2	6/27/03								700			41		35.0				0.91	17	68	Eutophic
	Seminole-Concord-2	7/24/03								610			40		26.0				1.22	15	64	Eutophic
	Seminole-Concord-2	8/12/03								650			44		43.0				0.91	15	71	Hyper-eutrophic
	Seminole-Concord-2	9/26/03								620			47		23.0				1.22	13	62	Eutophic
	Seminole-Concord-2	10/25/03								500			30		19.0				1.22	17	59	Mesotrophic
	Seminole-Concord-2	11/26/03								740			41		31.0				0.91	18	66	Eutophic
	Seminole-Concord-2	12/31/03								600			40		19.0				1.22	15	59	Mesotrophic

Historical Water Quality Data for Lake Concord from 2003 -2019

Monitoring Agency	Site	Date	pH (s.u.)	Conductivity (umho/cm)	Diss. O_2 (mg/l)	Alkalinity (mg/l)	NH3-N (ug/l)	NOx-N (ug/l)	Organic N (ug/l)	Total N (ug/l)	SRP (ug/l)	Organic P (ug/l)	Total P (ug/l)	Color (units)	Chyl-a (mg/m^3)	Turbididty (NTU)	Fecal Coliform (CFU/100ml)	E. Coli (CFU/100 mL)	Secchi Disk Depth (m)	TN/TP Ratio	TSI (chyl-a)	Trophic State
Lake Watch	Seminole-Concord-2	2/23/04								570			44		20.0				0.91	13	60	Eutophic
	Seminole-Concord-2	3/26/04								610			50		26.0				0.91	12	64	Eutophic
	Seminole-Concord-2	4/28/04								620			52		27.0				1.22	12	64	Eutophic
	Seminole-Concord-2	5/27/04								540			54		24.0				0.91	10	63	Eutophic
	Seminole-Concord-2	6/30/04								940			53		50.0				0.91	18	73	Hyper-eutrophic
	Seminole-Concord-2	7/22/04								690			47		36.0				0.91	15	68	Eutophic
	Seminole-Concord-2	8/31/04								670			43		23.0				0.91	16	62	Eutophic
	Seminole-Concord-2	9/30/04								740			96		35.0				1.22	8	68	Eutophic
	Seminole-Concord-2	10/24/04								760			56		45.0				0.76	14	72	Hyper-eutrophic
	Seminole-Concord-2	11/30/04								680			48		25.0				1.22	14	63	Eutophic
	Seminole-Concord-2	12/29/04								600			36		27.0				0.91	17	64	Eutophic
	Seminole-Concord-2	1/31/05								580			42		47.0				1.22	14	72	Hyper-eutrophic
	Seminole-Concord-2	2/28/05								560			51		24.0				1.22	11	63	Eutophic
	Seminole-Concord-2	3/31/05								400			42		19.0				0.91	10	59	Mesotrophic
	Seminole-Concord-2	4/29/05								600			52		23.0				1.22	12	62	Eutophic
	Seminole-Concord-2	5/27/05								1,200			80		31.0				0.61	15	66	Eutophic
	Seminole-Concord-2	6/30/05								800			80		53.0				0.91	10	74	Hyper-eutrophic
	Seminole-Concord-2	7/29/05								620			46		24.0				0.91	13	63	Eutophic
	Seminole-Concord-2	8/31/05								630			40		24.0				0.91	16	63	Eutophic
	Seminole-Concord-2	9/30/05								550			43		24.0				0.91	13	63	Eutophic
	Seminole-Concord-2	10/31/05								580			41		24.0				0.91	14	63	Eutophic
	Seminole-Concord-2	11/30/05								600			42		29.0				1.22	14	65	Eutophic
	Seminole-Concord-2	12/29/05								690			45		34.0				1.07	15	68	Eutophic
	Seminole-Concord-2	1/31/06								830			51		29.0				0.91	16	65	Eutophic
	Seminole-Concord-2	7/30/07								1,050			63		71.0				0.61	17	78	Hyper-eutrophic
	Seminole-Concord-2	8/31/07								980			43		42.0				0.91	23	71	Hyper-eutrophic
	Seminole-Concord-2	9/28/07								1,020			45		38.0				0.91	23	69	Eutophic
	Seminole-Concord-2	10/31/07								920			36		50.0				1.07	26	73	Hyper-eutrophic
	Seminole-Concord-2	11/29/07								880			29		27.0					30	64	Eutophic
	Seminole-Concord-2	12/28/07								670			31		21.4					22	61	Eutophic
	Seminole-Concord-2	1/31/08								500			31		21.0				1.01	16	61	Eutophic
	Seminole-Concord-2	2/29/08								540			26		20.0				1.22	21	60	Eutophic
	Seminole-Concord-2	3/28/08								460			19		9.0				1.52	24	48	Oligotrophic
	Seminole-Concord-2	4/30/08								510			26		23.0				1.16	20	62	Eutophic
	Seminole-Concord-2	6/2/08								820			39		21.0				0.91	21	61	Eutophic
	Seminole-Concord-2	6/30/08								660			41		23.0				4.57	16	62	Eutophic
	Seminole-Concord-2	7/31/08								690			42		33.0				1.07	16	67	Eutophic
	Seminole-Concord-2	8/29/08								420			35		20.0				1.07	12	60	Eutophic
	Seminole-Concord-2	9/29/08								630			32		24.0				1.22	20	63	Eutophic
	Seminole-Concord-2	10/31/08								530			34		29.0				0.61	16	65	Eutophic
	Seminole-Concord-2	12/1/08								600			39		28.0				1.16	15	65	Eutophic
	Seminole-Concord-2	12/31/08								730			46		25.0				0.61	16	63	Eutophic
	Seminole-Concord-2	1/28/09								450			33		12.0				1.68	14	53	Mesotrophic
	Seminole-Concord-2	2/27/09								390			29		14.0				0.61	13	55	Mesotrophic
	Seminole-Concord-2	3/31/09								500			28		10.8				1.68	18	51	Mesotrophic
	Seminole-Concord-2	5/1/09								560			35		14.5				1.22	16	55	Mesotrophic
	Seminole-Concord-2	5/29/09								980			43		27.0				1.37	23	64	Eutophic
	Seminole-Concord-2	6/30/09								960			46		37.0				0.61	21	69	Eutophic
	Seminole-Concord-2	7/31/09																	0.70	-	-	
	Seminole-Concord-2	8/31/09								930			36		43.0				0.91	26	71	Hyper-eutrophic
	Seminole-Concord-2	9/30/09																	0.91	-	-	
	Seminole-Concord-2	10/30/09								650			33		28.0				0.91	20	65	Eutophic
	Seminole-Concord-2	11/30/09																	0.91	-	-	
	Seminole-Concord-2	12/30/09								830			29		24.0				1.22	29	63	Eutophic

Historical Water Quality Data for Lake Concord from 2003 -2019

Monitoring Agency	Site	Date	pH (s.u.)	Conductivity (umho/cm)	Diss. O_2 (mg/l)	Alkalinity (mg/l)	NH3-N (ug/l)	NOx-N (ug/l)	Organic N (ug/l)	Total N (ug/l)	SRP (ug/l)	Organic P (ug/l)	Total P (ug/l)	Color (units)	Chyl-a (mg/m^3)	Turbididty (NTU)	Fecal Coliform (CFU/100ml)	E. Coli (CFU/100 mL)	Secchi Disk Depth (m)	TN/TP Ratio	TSI (chyl-a)	Trophic State
Lake Watch	Seminole-Concord-2	1/29/10																	1.22	-	-	
	Seminole-Concord-2	2/26/10								530			25		19.0				1.83	21	59	Mesotrophic
	Seminole-Concord-2	3/30/10																	1.52	-	-	
	Seminole-Concord-2	4/30/10								480			28		9.0				1.62	17	48	Oligotrophic
	Seminole-Concord-2	5/28/10																	0.91	-	-	
	Seminole-Concord-2	6/30/10								500			31		21.1				0.91	16	61	Eutophic
	Seminole-Concord-2	7/29/10																	0.91	-	-	
	Seminole-Concord-2	8/30/10								650			37		29.7				1.22	18	66	Eutophic
	Seminole-Concord-2	9/30/10																	1.22	-	-	
	Seminole-Concord-2	10/29/10								480			31		16.0				1.22	15	57	Mesotrophic
	Seminole-Concord-2	11/30/10																	1.22	-	-	
	Seminole-Concord-2	12/30/10								360			15		10.0				1.83	24	50	Mesotrophic
	Seminole-Concord-2	1/31/11																	1.52	-	-	
	Seminole-Concord-2	2/28/11								380			17		6.0				1.83	22	43	Oligotrophic
	Seminole-Concord-2	3/30/11																	1.22	-	-	
	Seminole-Concord-2	4/28/11								610			32		13.0				1.22	19	54	Mesotrophic
	Seminole-Concord-2	5/31/11																	1.52	-	-	
	Seminole-Concord-2	6/30/11								920			51		44.2				0.61	18	71	Hyper-eutrophic
	Seminole-Concord-2	7/28/11								830			44		32.0				1.22	19	67	Eutophic
	Seminole-Concord-2	8/30/11								720			30		45.4				0.76	24	72	Hyper-eutrophic
	Seminole-Concord-2	9/29/11								690			27		54.3				0.91	26	74	Hyper-eutrophic
	Seminole-Concord-2	10/31/11		160						1,100			31	13	33.5				0.91	35	67	Eutophic
	Seminole-Concord-2	11/30/11								750			33		37.2				0.91	23	69	Eutophic
	Seminole-Concord-2	12/29/11								580			38		22.4				0.61	15	62	Eutophic
	Seminole-Concord-2	1/31/12								700			42		23.2				0.91	17	62	Eutophic
	Seminole-Concord-2	2/29/12								520			23		16.8				1.52	23	57	Mesotrophic
	Seminole-Concord-2	3/29/12								630			31		15.7				1.22	20	56	Mesotrophic
	Seminole-Concord-2	4/30/12								620			38		19.7				0.91	16	60	Eutophic
	Seminole-Concord-2	5/31/12								540			26		18.7				0.91	21	59	Mesotrophic
	Seminole-Concord-2	6/28/12								620			34		12.0				0.91	18	53	Mesotrophic
	Seminole-Concord-2	7/30/12								600			33		20.0				0.91	18	60	Eutophic
	Seminole-Concord-2	8/30/12								560			26		22.0				1.52	22	61	Eutophic
	Seminole-Concord-2	9/27/12								570			27		25.0				1.22	21	63	Eutophic
	Seminole-Concord-2	10/31/12								680			29		25.0				1.22	23	63	Eutophic
	Seminole-Concord-2	11/29/12								720			29		19.0				1.22	25	59	Mesotrophic
	Seminole-Concord-2	12/31/12								740			28		18.0				1.22	26	58	Mesotrophic
	Seminole-Concord-2	1/28/13								650			39		21.0				1.07	17	61	Eutophic
	Seminole-Concord-2	2/28/13								610			41		17.0				1.22	15	58	Mesotrophic
	Seminole-Concord-2	3/28/13								600			33		10.0				1.22	18	50	Mesotrophic
	Seminole-Concord-2	4/30/13								740			32		14.0				1.22	23	55	Mesotrophic
	Seminole-Concord-2	5/30/13								570			34		11.0				0.91	17	51	Mesotrophic
	Seminole-Concord-2	6/27/13								830			45		18.0				1.22	18	58	Mesotrophic
	Seminole-Concord-2	7/30/13								670			34		21.0				0.91	20	61	Eutophic
	Seminole-Concord-2	8/29/13								610			28		23.0				1.07	22	62	Eutophic
	Seminole-Concord-2	9/30/13								630			32		24.0				0.91	20	63	Eutophic
	Seminole-Concord-2	10/30/13								790			35		29.0				0.76	23	65	Eutophic
	Seminole-Concord-2	11/27/13								1,420			56		37.0				0.76	25	69	Eutophic
	Seminole-Concord-2	12/30/13								970			43		42.0				1.22	23	71	Hyper-eutrophic
	Seminole-Concord-2	2/3/14								690			33		30.0				0.91	21	66	Eutophic
	Seminole-Concord-2	2/27/14								680			43		24.0				1.37	16	63	Eutophic
	Seminole-Concord-2	3/24/14								650			32		15.0				1.22	20	56	Mesotrophic
	Seminole-Concord-2	4/29/14								700			39		20.0				1.07	18	60	Eutophic
	Seminole-Concord-2	5/29/14								770			38		22.0				0.91	20	61	Eutophic
	Seminole-Concord-2	6/30/14								710			42		15.0				0.61	17	56	Mesotrophic
	Seminole-Concord-2	7/31/14								550			29		15.0				0.91	19	56	Mesotrophic
	Seminole-Concord-2	8/27/14								890			37		16.0				0.61	24	57	Mesotrophic
	Seminole-Concord-2	9/30/14								1,010			59		50.0				0.76	17	73	Hyper-eutrophic
	Seminole-Concord-2	10/28/14								950			33		27.0				0.91	29	64	Eutophic
	Seminole-Concord-2	11/24/14								680			33		27.0				0.91	21	64	Eutophic
	Seminole-Concord-2	12/30/14								670			35		17.0				0.91	19	58	Mesotrophic

Historical Water Quality Data for Lake Concord from 2003 -2019

Monitoring Agency	Site	Date	pH (s.u.)	Conductivity (umho/cm)	Diss. O_2 (mg/l)	Alkalinity (mg/l)	NH3-N (ug/l)	NOx-N (ug/l)	Organic N (ug/l)	Total N (ug/l)	SRP (ug/l)	Organic P (ug/l)	Total P (ug/l)	Color (units)	Chyl-a (mg/m^3)	Turbididty (NTU)	Fecal Coliform (CFU/100ml)	E. Coli (CFU/100 mL)	Secchi Disk Depth (m)	TN/TP Ratio	TSI (chyl-a)	Trophic State
Lake Watch	Seminole-Concord-2	1/28/15								970			48		19.0				1.22	20	59	Mesotrophic
	Seminole-Concord-2	2/25/15								560			22		15.0				1.22	25	56	Mesotrophic
	Seminole-Concord-2	3/30/15								790			36		17.0				1.22	22	58	Mesotrophic
	Seminole-Concord-2	4/30/15								830			37		21.0				0.91	22	61	Eutophic
	Seminole-Concord-2	5/28/15								1,880			49		112.0				0.30	38	85	Hyper-eutrophic
	Seminole-Concord-2	6/30/15								1,500			47		44.0				0.91	32	71	Hyper-eutrophic
	Seminole-Concord-2	7/30/15								1,390			41		57.0				0.61	34	75	Hyper-eutrophic
	Seminole-Concord-2	8/27/15								2,100			38		36.0				0.76	55	68	Eutophic
	Seminole-Concord-2	9/30/15								700			36		27.0				0.70	19	64	Eutophic
	Seminole-Concord-2	10/29/15								880			37		27.0				0.61	24	64	Eutophic
	Seminole-Concord-2	11/30/15								840			34		27.0				0.91	25	64	Eutophic
	Seminole-Concord-2	12/30/15								880			36		25.0				0.91	24	63	Eutophic
	Seminole-Concord-2	1/26/16								680			34		20.0				1.07	20	60	Eutophic
	Seminole-Concord-2	2/29/16								590			29		20.0				0.91	20	60	Eutophic
	Seminole-Concord-2	3/30/16								690			19		22.0				0.91	36	61	Eutophic
	Seminole-Concord-2	4/28/16								890			45		20.0				0.91	20	60	Eutophic
	Seminole-Concord-2	5/31/16								1,000			40		23.0				0.91	25	62	Eutophic
	Seminole-Concord-2	6/30/16								690			36		19.0				1.22	19	59	Mesotrophic
	Seminole-Concord-2	7/28/16								570			31		10.0				1.07	18	50	Mesotrophic
	Seminole-Concord-2	8/30/16								700			37		19.0				0.61	19	59	Mesotrophic
	Seminole-Concord-2	9/29/16								670			33		18.0				0.91	20	58	Mesotrophic
	Seminole-Concord-2	10/31/16								570			28		25.0				0.91	20	63	Eutophic
	Seminole-Concord-2	11/30/16								570			33		21.0				0.91	17	61	Eutophic
	Seminole-Concord-2	12/28/16								530			24		17.0				0.91	22	58	Mesotrophic
	Seminole-Concord-2	1/30/17								410			39		16.0				1.07	11	57	Mesotrophic
	Seminole-Concord-2	2/28/17								530			27		12.0					20	53	Mesotrophic
	Seminole-Concord-2	3/30/17								620			24		19.0				0.91	26	59	Mesotrophic
	Seminole-Concord-2	4/26/17								1,290			43		48.0				0.61	30	73	Hyper-eutrophic
	Seminole-Concord-2	5/31/17								1,100			57		44.0				0.61	19	71	Hyper-eutrophic
	Seminole-Concord-2	6/29/17								920			44		25.0				0.61	21	63	Eutophic
	Seminole-Concord-2	7/31/17								790			49		31.0				0.91	16	66	Eutophic
	Seminole-Concord-2	8/31/17								670			34		27.0				0.91	20	64	Eutophic
	Seminole-Concord-2	9/28/17								650			36		19.0				1.22	18	59	Mesotrophic
	Seminole-Concord-2	10/31/17								590			29		26.0				1.37	20	64	Eutophic
	Seminole-Concord-2	11/30/17								640			27		24.0				0.91	24	63	Eutophic
	Seminole-Concord-2	12/28/17								600			40		19.0				0.76	15	59	Mesotrophic
	Seminole-Concord-2	1/31/18								610			45		29.0				0.91	14	65	Eutophic
	Seminole-Concord-2	2/28/18								540			37		17.0				1.07	15	58	Mesotrophic
	Seminole-Concord-2	3/29/18								620			36		16.0				0.91	17	57	Mesotrophic
	Seminole-Concord-2	4/26/18								880			48		40.0				0.61	18	70	Hyper-eutrophic
	Seminole-Concord-2	5/31/18								740			38		25.0				0.91	19	63	Eutophic
	Seminole-Concord-2	6/28/18								820			38		32.0				0.91	22	67	Eutophic
	Seminole-Concord-2	7/31/18								670			36		24.0				0.91	19	63	Eutophic
	Seminole-Concord-2	8/30/18								780			44		41.0				0.91	18	70	Hyper-eutrophic
	Seminole-Concord-2	9/27/18								700			33		21.0				0.91	21	61	Eutophic
	Seminole-Concord-2	10/31/18								700			33		17.0				0.91	21	58	Mesotrophic
	Seminole-Concord-2	11/29/18								680			26		22.0				0.91	26	61	Eutophic

Historical Water Quality Data for Lake Concord from 2003 -2019

Monitoring Agency	Site	Date	pH (s.u.)	Conductivity (umho/cm)	Diss. O_2 (mg/l)	Alkalinity (mg/l)	NH3-N (ug/l)	NOx-N (ug/l)	Organic N (ug/l)	Total N (ug/l)	SRP (ug/l)	Organic P (ug/l)	Total P (ug/l)	Color (units)	Chyl-a (mg/m^3)	Turbididty (NTU)	Fecal Coliform (CFU/100ml)	E. Coli (CFU/100 mL)	Secchi Disk Depth (m)	TN/TP Ratio	TSI (chyl-a)	Trophic State
	Seminole-Concord-3	5/30/96								640			26		13.0				1.37	25	54	Mesotrophic
	Seminole-Concord-3	9/12/96								880			50		47.0				1.22	18	72	Hyper-eutrophic
	Seminole-Concord-3	11/2/96								850			57		31.0				0.91	15	66	Eutophic
	Seminole-Concord-3	12/10/96								560			38		46.0				1.22	15	72	Hyper-eutrophic
	Seminole-Concord-3	1/6/97								670			45		26.0				1.52	15	64	Eutophic
	Seminole-Concord-3	3/18/97								350			33		14.0				1.83	11	55	Mesotrophic
	Seminole-Concord-3	4/25/97								460			37		5.0				1.22	12	40	Oligotrophic
	Seminole-Concord-3	5/20/97								430			36		12.0				1.68	12	53	Mesotrophic
	Seminole-Concord-3	6/26/97								680			33		22.0				1.22	21	61	Eutophic
	Seminole-Concord-3	7/14/97								430			28		19.0				1.07	15	59	Mesotrophic
	Seminole-Concord-3	10/1/97								540			33		33.0				1.22	16	67	Eutophic
	Seminole-Concord-3	1/20/98								560			25		25.0				1.37	22	63	Eutophic
	Seminole-Concord-3	4/10/98								510			37		15.0				1.37	14	56	Mesotrophic
	Seminole-Concord-3	8/20/98								610			39		16.0				1.22	16	57	Mesotrophic
	Seminole-Concord-3	10/14/98								1,440			54		75.0				0.91	27	79	Hyper-eutrophic
	Seminole-Concord-3	11/9/98								1,300			52		55.0				0.61	25	75	Hyper-eutrophic
	Seminole-Concord-3	12/28/98								860			47		46.0				1.22	18	72	Hyper-eutrophic
	Seminole-Concord-3	1/21/99								800			64		38.0				1.07	13	69	Eutophic
	Seminole-Concord-3	2/25/99								780			61		35.0				0.91	13	68	Eutophic
	Seminole-Concord-3	3/25/99								900			61		29.0				0.91	15	65	Eutophic
	Seminole-Concord-3	4/30/99								750			40		37.0				0.91	19	69	Eutophic
	Seminole-Concord-3	5/31/99								580			44		12.0				1.22	13	53	Mesotrophic
	Seminole-Concord-3	6/29/99								500			31		18.0				0.91	16	58	Mesotrophic
	Seminole-Concord-3	7/22/99								480			29		10.0				1.83	17	50	Mesotrophic
	Seminole-Concord-3	8/10/99								530			36		16.0				0.91	15	57	Mesotrophic
	Seminole-Concord-3	9/17/99								450			37		16.0				0.91	12	57	Mesotrophic
LakeWatch	Seminole-Concord-3	10/25/99								680			55		33.0				0.61	12	67	Eutophic
	Seminole-Concord-3	1/4/00								620			38		34.0					16	68	Eutophic
	Seminole-Concord-3	2/17/00								570			39		12.0				0.91	15	53	Mesotrophic
	Seminole-Concord-3	3/24/00								690			50		18.0				0.91	14	58	Mesotrophic
	Seminole-Concord-3	10/5/00								610			32		26.0				0.91	19	64	Eutophic
	Seminole-Concord-3	5/29/01								560			56		35.0				1.22	10	68	Eutophic
	Seminole-Concord-3	8/24/01								650			34		21.0				1.22	19	61	Eutophic
	Seminole-Concord-3	11/16/01								620			62		36.0				0.91	10	68	Eutophic
	Seminole-Concord-3	12/20/01								740			54		45.0				0.91	14	72	Hyper-eutrophic
	Seminole-Concord-3	2/1/02								450			42		22.0				0.91	11	61	Eutophic
	Seminole-Concord-3	3/15/02								410			32		8.0				1.52	13	47	Oligotrophic
	Seminole-Concord-3	4/26/02								600			52		26.0				0.91	12	64	Eutophic
	Seminole-Concord-3	7/27/02								520			44		24.0				0.91	12	63	Eutophic
	Seminole-Concord-3	8/23/02								570			41		22.0				0.91	14	61	Eutophic
	Seminole-Concord-3	9/27/02								660			45		33.0				0.91	15	67	Eutophic
	Seminole-Concord-3	10/18/02								590			38		28.0				0.91	16	65	Eutophic
	Seminole-Concord-3	11/15/02								650			40		31.0				0.91	16	66	Eutophic
	Seminole-Concord-3	1/31/03								450			45		16.0				1.22	10	57	Mesotrophic
	Seminole-Concord-3	2/28/03								450			40		21.0				1.22	11	61	Eutophic
	Seminole-Concord-3	3/28/03								520			31		18.0				1.22	17	58	Mesotrophic
	Seminole-Concord-3	6/27/03								740			40		35.0				0.91	19	68	Eutophic
	Seminole-Concord-3	7/24/03								600			33		23.0				1.22	18	62	Eutophic
	Seminole-Concord-3	8/12/03								620			35		43.0				0.91	18	71	Hyper-eutrophic
	Seminole-Concord-3	9/26/03								580			45		24.0				1.22	13	63	Eutophic
	Seminole-Concord-3	10/25/03								550			27		17.0				1.22	20	58	Mesotrophic
	Seminole-Concord-3	11/26/03								830			58		41.0				0.91	14	70	Hyper-eutrophic
	Seminole-Concord-3	12/31/03								540			42		22.0				1.22	13	61	Eutophic

Historical Water Quality Data for Lake Concord from 2003 -2019

Monitoring Agency	Site	Date	pH (s.u.)	Conductivity (umho/cm)	Diss. O_2 (mg/l)	Alkalinity (mg/l)	NH3-N (ug/l)	NOx-N (ug/l)	Organic N (ug/l)	Total N (ug/l)	SRP (ug/l)	Organic P (ug/l)	Total P (ug/l)	Color (units)	Chyl-a (mg/m^3)	Turbididty (NTU)	Fecal Coliform (CFU/100ml)	E. Coli (CFU/100 mL)	Secchi Disk Depth (m)	TN/TP Ratio	TSI (chyl-a)	Trophic State
	Seminole-Concord-3	2/23/04								550			41		17.0				0.91	13	58	Mesotrophic
	Seminole-Concord-3	3/26/04								600			48		22.0				0.91	13	61	Eutophic
	Seminole-Concord-3	4/28/04								620			43		25.0				1.22	14	63	Eutophic
	Seminole-Concord-3	5/27/04								640			50		23.0				0.91	13	62	Eutophic
	Seminole-Concord-3	6/30/04								860			54		54.0				0.91	16	74	Hyper-eutrophic
	Seminole-Concord-3	7/22/04								650			38		32.0				0.91	17	67	Eutophic
	Seminole-Concord-3	8/31/04								660			41		27.0				1.22	16	64	Eutophic
	Seminole-Concord-3	9/30/04								840			88		27.0				0.91	10	64	Eutophic
	Seminole-Concord-3	10/24/04								710			58		41.0				0.61	12	70	Hyper-eutrophic
	Seminole-Concord-3	11/30/04								650			54		37.0				1.22	12	69	Eutophic
	Seminole-Concord-3	12/29/04								610			29		23.0				0.91	21	62	Eutophic
	Seminole-Concord-3	1/31/05								570			45		53.0				1.22	13	74	Hyper-eutrophic
	Seminole-Concord-3	2/28/05								550			51		27.0				1.22	11	64	Eutophic
	Seminole-Concord-3	3/31/05								330			36		18.0				0.91	9	58	Mesotrophic
	Seminole-Concord-3	4/29/05								550			47		22.0				1.22	12	61	Eutophic
	Seminole-Concord-3	5/27/05								1,090			83		41.0				0.61	13	70	Hyper-eutrophic
	Seminole-Concord-3	6/30/05								930			84		61.0				0.91	11	76	Hyper-eutrophic
	Seminole-Concord-3	7/29/05								790			54		25.0				0.91	15	63	Eutophic
	Seminole-Concord-3	8/31/05								550			45		29.0				0.91	12	65	Eutophic
	Seminole-Concord-3	9/30/05								540			45		25.0				0.91	12	63	Eutophic
	Seminole-Concord-3	10/31/05								460			38		27.0				0.91	12	64	Eutophic
	Seminole-Concord-3	11/30/05								700			50		37.0				1.22	14	69	Eutophic
	Seminole-Concord-3	12/29/05								690			44		36.0				1.07	16	68	Eutophic
	Seminole-Concord-3	1/31/06								780			51		32.0				0.91	15	67	Eutophic
	Seminole-Concord-3	7/30/07								1,180			65		65.0				0.61	18	77	Hyper-eutrophic
	Seminole-Concord-3	8/31/07								820			46		40.0				0.91	18	70	Hyper-eutrophic
	Seminole-Concord-3	9/28/07								980			43		39.0				0.91	23	70	Hyper-eutrophic
	Seminole-Concord-3	10/31/07								820			40		49.0				1.07	21	73	Hyper-eutrophic
Lake Watch	Seminole-Concord-3	11/29/07								860			30		26.0				3.05	29	64	Eutophic
	Seminole-Concord-3	12/28/07								690			37		17.8				3.05	19	58	Mesotrophic
	Seminole-Concord-3	1/31/08								660			36		18.0				0.91	18	58	Mesotrophic
	Seminole-Concord-3	2/29/08								550			29		16.0				1.37	19	57	Mesotrophic
	Seminole-Concord-3	3/28/08								490			22		9.0				1.37	22	48	Oligotrophic
	Seminole-Concord-3	4/30/08								560			27		19.0				1.31	21	59	Mesotrophic
	Seminole-Concord-3	6/2/08								650			37		21.0				0.91	18	61	Eutophic
	Seminole-Concord-3	6/30/08								700			47		26.0				4.57	15	64	Eutophic
	Seminole-Concord-3	7/31/08								620			43		33.0				1.22	14	67	Eutophic
	Seminole-Concord-3	8/29/08								410			37		18.0				1.01	11	58	Mesotrophic
	Seminole-Concord-3	9/29/08								540			31		24.0				1.22	17	63	Eutophic
	Seminole-Concord-3	10/31/08								580			34		11.0				0.61	17	51	Mesotrophic
	Seminole-Concord-3	12/1/08								750			41		31.0				1.22	18	66	Eutophic
	Seminole-Concord-3	12/31/08								630			30		21.0				0.91	21	61	Eutophic
	Seminole-Concord-3	1/28/09								490			30		11.0				1.92	16	51	Mesotrophic
	Seminole-Concord-3	2/27/09								430			30		14.0				0.91	14	55	Mesotrophic
	Seminole-Concord-3	3/31/09								530			30		11.0				1.52	18	51	Mesotrophic
	Seminole-Concord-3	5/1/09								560			37		13.5				1.22	15	54	Mesotrophic
	Seminole-Concord-3	5/29/09								1,040			46		30.0				1.52	23	66	Eutophic
	Seminole-Concord-3	6/30/09								960			49		35.0				0.61	20	68	Eutophic
	Seminole-Concord-3	8/31/09								940			37		43.0				0.91	25	71	Hyper-eutrophic
	Seminole-Concord-3	10/30/09								650			35		26.0				0.91	19	64	Eutophic
	Seminole-Concord-3	12/30/09								550			28		22.0				1.22	20	61	Eutophic
	Seminole-Concord-3	2/26/10								850			55		12.0				2.13	15	53	Mesotrophic
	Seminole-Concord-3	4/30/10								510			28		9.0				1.68	18	48	Oligotrophic
	Seminole-Concord-3	6/30/10								600			32		20.2				0.91	19	60	Eutophic
	Seminole-Concord-3	8/30/10								630			33		30.6				1.46	19	66	Eutophic
	Seminole-Concord-3	10/29/10								520			30		6.0				1.22	17	43	Oligotrophic
	Seminole-Concord-3	12/30/10								460			17		14.0				1.98	27	55	Mesotrophic

Historical Water Quality Data for Lake Concord from 2003 -2019

Monitoring Agency	Site	Date	pH (s.u.)	Conductivity (umho/cm)	Diss. O_2 (mg/l)	Alkalinity (mg/l)	NH3-N (ug/l)	NOx-N (ug/l)	Organic N (ug/l)	Total N (ug/l)	SRP (ug/l)	Organic P (ug/l)	Total P (ug/l)	Color (units)	Chyl-a (mg/m^3)	Turbididty (NTU)	Fecal Coliform (CFU/100ml)	E. Coli (CFU/100 mL)	Secchi Disk Depth (m)	TN/TP Ratio	TSI (chyl-a)	Trophic State
Lake Watch	Seminole-Concord-3	2/28/11								420			22		6.0				1.83	19	43	Oligotrophic
	Seminole-Concord-3	4/28/11													10.0				1.22		50	Mesotrophic
	Seminole-Concord-3	6/30/11								1,060			46		41.1				0.61	23	70	Hyper-eutrophic
	Seminole-Concord-3	7/28/11								880			43		35.0				1.46	20	68	Eutophic
	Seminole-Concord-3	8/30/11								650			25		47.6				0.76	26	72	Hyper-eutrophic
	Seminole-Concord-3	9/29/11								930			26		51.6				1.01	36	74	Hyper-eutrophic
	Seminole-Concord-3	10/31/11								800			39		34.2				0.91	21	68	Eutophic
	Seminole-Concord-3	11/30/11								770			37		31.1				0.76	21	66	Eutophic
	Seminole-Concord-3	12/29/11								580			35		25.4				0.91	17	63	Eutophic
	Seminole-Concord-3	1/31/12								560			38		22.0				0.91	15	61	Eutophic
	Seminole-Concord-3	2/29/12								530			26		17.2				1.22	20	58	Mesotrophic
	Seminole-Concord-3	3/29/12								690			31		17.8				1.07	22	58	Mesotrophic
	Seminole-Concord-3	4/30/12								650			42		20.6				0.91	15	60	Eutophic
	Seminole-Concord-3	5/31/12								500			31		18.1				0.91	16	59	Mesotrophic
	Seminole-Concord-3	6/28/12								620			32		23.0				1.22	19	62	Eutophic
	Seminole-Concord-3	7/30/12								690			28		17.0				0.91	25	58	Mesotrophic
	Seminole-Concord-3	8/30/12								430			35		21.0				1.52	12	61	Eutophic
	Seminole-Concord-3	9/27/12								470			29		25.0				0.91	16	63	Eutophic
	Seminole-Concord-3	10/31/12								610			32		25.0				1.22	19	63	Eutophic
	Seminole-Concord-3	11/29/12								550			31		19.0				1.22	18	59	Mesotrophic
	Seminole-Concord-3	12/31/12								520			33		21.0				1.22	16	61	Eutophic
	Seminole-Concord-3	1/28/13								570			36		19.0				1.07	16	59	Mesotrophic
	Seminole-Concord-3	2/28/13								730			35		15.0				1.22	21	56	Mesotrophic
	Seminole-Concord-3	3/28/13								550			31		9.0				2.13	18	48	Oligotrophic
	Seminole-Concord-3	4/30/13								450			28		14.0				1.22	16	55	Mesotrophic
	Seminole-Concord-3	5/30/13								670			34		17.0				0.91	20	58	Mesotrophic
	Seminole-Concord-3	6/27/13								580			34		16.0				1.22	17	57	Mesotrophic
	Seminole-Concord-3	7/30/13								750			36		23.0				0.91	21	62	Eutophic
	Seminole-Concord-3	8/29/13								670			28		24.0				1.22	24	63	Eutophic
	Seminole-Concord-3	9/30/13								550			27		24.0				0.91	20	63	Eutophic
	Seminole-Concord-3	10/30/13								840			38		27.0				0.91	22	64	Eutophic
	Seminole-Concord-3	11/27/13								700			36		38.0				0.76	19	69	Eutophic
	Seminole-Concord-3	12/30/13								1,040			37		40.0				1.22	28	70	Hyper-eutrophic
	Seminole-Concord-3	2/3/14								840			36		20.0				0.91	23	60	Eutophic
	Seminole-Concord-3	2/27/14								570			39		29.0				1.52	15	65	Eutophic
	Seminole-Concord-3	3/24/14								810			36		14.0				1.22	23	55	Mesotrophic
	Seminole-Concord-3	4/29/14								680			37		21.0				1.22	18	61	Eutophic
	Seminole-Concord-3	5/29/14								750			40		26.0				1.22	19	64	Eutophic
	Seminole-Concord-3	6/30/14								800			44		14.0				0.61	18	55	Mesotrophic
	Seminole-Concord-3	7/31/14								660			36		20.0				0.91	18	60	Eutophic
	Seminole-Concord-3	8/27/14								1,040			39		19.0				0.61	27	59	Mesotrophic
	Seminole-Concord-3	9/30/14								940			43		45.0				0.91	22	72	Hyper-eutrophic
	Seminole-Concord-3	10/28/14								880			35		40.0				0.91	25	70	Hyper-eutrophic
	Seminole-Concord-3	11/24/14								890			38		29.0				0.91	23	65	Eutophic
	Seminole-Concord-3	12/30/14								710			34		18.0				0.91	21	58	Mesotrophic
	Seminole-Concord-3	1/28/15								680			31		17.0				1.22	22	58	Mesotrophic
	Seminole-Concord-3	2/25/15								690			21		19.0				1.22	33	59	Mesotrophic
	Seminole-Concord-3	3/30/15								780			33		17.0				0.91	24	58	Mesotrophic
	Seminole-Concord-3	4/30/15								730			36		20.0				0.91	20	60	Eutophic
	Seminole-Concord-3	5/28/15								2,150			50		106.0				0.30	43	84	Hyper-eutrophic
	Seminole-Concord-3	6/30/15								1,380			50		46.0				0.91	28	72	Hyper-eutrophic
	Seminole-Concord-3	7/30/15								1,340			41		60.0				0.61	33	76	Hyper-eutrophic
	Seminole-Concord-3	8/27/15								1,950			36		30.0				0.91	54	66	Eutophic
	Seminole-Concord-3	9/30/15								710			32		23.0				0.76	22	62	Eutophic
	Seminole-Concord-3	10/29/15								930			31		29.0				0.61	30	65	Eutophic
	Seminole-Concord-3	11/30/15								840			37		30.0				0.85	23	66	Eutophic
	Seminole-Concord-3	12/30/15								770			30		20.0				0.91	26	60	Eutophic

Historical Water Quality Data for Lake Concord from 2003 -2019

Monitoring Agency	Site	Date	pH (s.u.)	Conductivity (umho/cm)	Diss. O_2 (mg/l)	Alkalinity (mg/l)	NH3-N (ug/l)	NOx-N (ug/l)	Organic N (ug/l)	Total N (ug/l)	SRP (ug/l)	Organic P (ug/l)	Total P (ug/l)	Color (units)	Chyl-a (mg/m^3)	Turbididty (NTU)	Fecal Coliform (CFU/100ml)	E. Coli (CFU/100 mL)	Secchi Disk Depth (m)	TN/TP Ratio	TSI (chyl-a)	Trophic State
Lake Watch	Seminole-Concord-3	1/26/16								750			37		18.0				1.07	20	58	Mesotrophic
	Seminole-Concord-3	2/29/16								830			32		23.0				1.07	26	62	Eutophic
	Seminole-Concord-3	3/30/16								750			44		24.0				0.91	17	63	Eutophic
	Seminole-Concord-3	4/28/16								710			39		19.0				0.91	18	59	Mesotrophic
	Seminole-Concord-3	5/31/16								950			40		22.0				0.91	24	61	Eutophic
	Seminole-Concord-3	6/30/16								880			35		23.0				1.22	25	62	Eutophic
	Seminole-Concord-3	7/28/16								590			36		12.0				1.07	16	53	Mesotrophic
	Seminole-Concord-3	8/30/16								720			36		21.0				0.61	20	61	Eutophic
	Seminole-Concord-3	9/29/16								710			38		29.0				0.91	19	65	Eutophic
	Seminole-Concord-3	10/31/16								630			30		20.0				0.91	21	60	Eutophic
	Seminole-Concord-3	11/30/16								1,060			34		20.0				0.91	31	60	Eutophic
	Seminole-Concord-3	12/28/16								590			35		20.0				1.22	17	60	Eutophic
	Seminole-Concord-3	1/30/17								360			37		16.0				1.07	10	57	Mesotrophic
	Seminole-Concord-3	2/28/17								540			31		14.0				2.44	17	55	Mesotrophic
	Seminole-Concord-3	3/30/17								680			25		19.0				0.91	27	59	Mesotrophic
	Seminole-Concord-3	4/26/17								1,270			44		49.0				0.61	29	73	Hyper-eutrophic
	Seminole-Concord-3	5/31/17								1,180			39		41.0				0.61	30	70	Hyper-eutrophic
	Seminole-Concord-3	6/29/17								810			40		30.0				0.61	20	66	Eutophic
	Seminole-Concord-3	7/31/17								790			46		30.0				0.91	17	66	Eutophic
	Seminole-Concord-3	8/31/17								720			27		24.0				0.91	27	63	Eutophic
	Seminole-Concord-3	9/28/17								550			37		17.0				1.07	15	58	Mesotrophic
	Seminole-Concord-3	10/31/17								570			32		27.0				1.37	18	64	Eutophic
	Seminole-Concord-3	11/30/17								660			31		25.0				0.91	21	63	Eutophic
	Seminole-Concord-3	12/28/17								570			40		38.0				0.76	14	69	Eutophic
	Seminole-Concord-3	1/31/18								620			42		27.0				0.91	15	64	Eutophic
	Seminole-Concord-3	2/28/18								560			36		23.0				0.91	16	62	Eutophic
	Seminole-Concord-3	3/29/18								620			35		18.0				0.91	18	58	Mesotrophic
	Seminole-Concord-3	4/26/18								810			46		39.0				0.61	18	70	Hyper-eutrophic
	Seminole-Concord-3	5/31/18								650			34		25.0				0.91	19	63	Eutophic
	Seminole-Concord-3	6/28/18								750			40		38.0				0.91	19	69	Eutophic
	Seminole-Concord-3	7/31/18								640			36		23.0				0.91	18	62	Eutophic
	Seminole-Concord-3	8/30/18								750			37		37.0				0.91	20	69	Eutophic
	Seminole-Concord-3	9/27/18								620			33		21.0				0.91	19	61	Eutophic
	Seminole-Concord-3	10/31/18								700			32		18.0				0.91	22	58	Mesotrophic
	Seminole-Concord-3	11/29/18								680			34		22.0				0.91	20	61	Eutophic
	Annual Geometric Means	1996	-	-	-	-	-	-	-	731	-	-	43	-	28.6	-	-	-	1.18	17	65	Eutophic
		1997	-	-	-	-	-	-	-	525	-	-	34	-	16.2	-	-	-	1.33	15	56	Mesotrophic
		1998	-	-	-	-	-	-	-	827	-	-	41	-	32.8	-	-	-	1.05	20	66	Eutophic
		1999	-	-	-	-	-	-	-	641	-	-	44	-	22.5	-	-	-	0.99	15	61	Eutophic
		2000	-	-	-	-	-	-	-	624	-	-	41	-	20.9	-	-	-	0.91	15	60	Eutophic
		2001	-	-	-	-	-	-	-	640	-	-	42	-	25.1	-	-	-	0.94	15	63	Eutophic
		2002	-	-	-	-	-	-	-	572	-	-	42	16	22.5	-	-	-	0.93	14	61	Eutophic
		2003	8.01	124	8.6	49.1	3	3	592	579	1	43	40	15	23.6	-	31	-	1.10	14	62	Eutophic
		2004	8.36	204	7.7	56.2	12	4	496	657	1	44	48	17	30.1	-	15	-	0.94	14	64	Eutophic
		2005	7.88	175	8.6	56.0	62	5	435	615	1	40	49	16	29.7	-	19	-	0.98	13	65	Eutophic
		2006	7.97	187	8.4	55.6	24	5	604	725	1	31	39	15	31.9	-	9	-	0.86	19	63	Eutophic
		2007	7.78	177	7.8	69.7	46	4	534	831	1	30	39	13	30.2	-	7	-	1.19	22	64	Eutophic
		2008	8.31	173	8.0	72.6	33	6	438	572	1	23	33	14	20.6	-	52	-	1.11	18	60	Eutophic
		2009	8.28	199	8.3	78.2	17	7	501	636	1	28	33	14	21.4	4.6	12	-	1.01	19	60	Eutophic
		2010	7.85	155	8.1	69.7	12	33	431	521	1	16	27	13	14.5	3.1	10	-	1.30	19	55	Mesotrophic
		2011	8.00	153	7.9	63.0	25	5	525	699	1	18	30	12	26.0	2.5	25	-	0.98	23	62	Eutophic
		2012	8.15	153	7.9	64.2	14	4	352	573	3	13	29	14	19.8	3.8	32	-	1.07	20	59	Mesotrophic
		2013	7.83	136	7.6	59.2	4	3	421	654	1	15	32	16	21.1	4.2	10	-	1.05	20	60	Eutophic
		2014	7.44	134	7.8	55.6	10	13	703	757	2	31	36	15	20.8	3.1	11	-	0.90	21	59	Mesotrophic
		2015	8.05	175	8.2	59.5	10	13	392	932	2	40	37	22	29.5	5.2	9	-	0.80	25	65	Eutophic
		2016	8.05	191	6.4	71.7	12	10	626	703	3	32	34	21	20.5	4.2	10	-	0.94	21	60	Eutophic
		2017	7.50	190	9.1	69.1	6	10	602	683	3	31	36	19	22.8	3.8	12	-	0.91	19	61	Eutophic
		2018	8.04	192	8.9	78.6	18	13	774	698	3	32	37	22	24.8	3.9	75	-	0.87	19	63	Eutophic
		2019	7.99	205	8.8	73.2	7	6	622	649	4	34	38	14	32.8	4.5	26	16	0.95	17	67	Eutophic

APPENDIX C

HYDROLOGIC MODEL TO ESTIMATE ANNUAL RUNOFF INFLOWS FROM LAKE CONCORD SUB-BASIN AREAS

Florida Statewide Stormwater Rule

Retention System Efficiency Calculator

Project Name: **Lake Concord**

Basin Name: **Lake Concord**

User Inputs

Calc. Values

Meteorological Zone: 2

Annual Rainfall (inches): 53.04

Sub Basin	Treatment 1	Hydrologic Soil Group	Land Use	Area (ac.)	DCIA1 (%)	Non - DCIA CN Value2	Runoff C Value[4]	Generated Runoff Volume (ac-ft)	Runoff Volume Reduction Factor	Runoff Volume Reduction Factor 2	Stormwater Reduction Volume (ac-ft)	Runoff Volume (ac-ft)
01	Dry Retention	D	COMMERCIAL	9.956	89.7	80.0	0.738	32.47	0.80	0.00	25.97	6.49
01	Dry Retention	D	HIGHWAYS	0.074	80.7	93.4	0.721	0.24	0.80	0.00	0.19	0.05
01	Dry Retention	D	OPEN	1.202	0.4	80.0	0.114	0.61	0.80	0.00	0.48	0.12
02	Baffle Box	D	CEMETERIES	0.579	0.0	80.8	0.119	0.30	0.00	0.00	0.00	0.30
02	Baffle Box	A	COMMERCIAL	4.127	41.6	57.5	0.352	6.42	0.00	0.00	0.00	6.42
02	Baffle Box	D	COMMERCIAL	2.205	38.7	86.5	0.426	4.15	0.00	0.00	0.00	4.15
02	Baffle Box	D	HDR	0.004	0.0	98.0	0.595	0.01	0.00	0.00	0.00	0.01
02	Baffle Box	D	HIGHWAYS	4.781	86.6	81.6	0.718	15.16	0.00	0.00	0.00	15.16
02	Baffle Box	A	INDUSTRIAL	0.416	35.3	50.7	0.296	0.54	0.00	0.00	0.00	0.54
02	Baffle Box	D	INDUSTRIAL	3.112	55.2	88.8	0.546	7.51	0.00	0.00	0.00	7.51
02	Baffle Box	A	INSTITUTIONAL	1.829	15.1	50.2	0.136	1.10	0.00	0.00	0.00	1.10
02	Baffle Box	D	INSTITUTIONAL	0.928	65.6	83.2	0.579	2.38	0.00	0.00	0.00	2.38
02	Baffle Box	A	MDR	4.065	25.5	59.8	0.229	4.11	0.00	0.00	0.00	4.11
02	Baffle Box	D	MDR	8.349	19.6	84.5	0.284	10.47	0.00	0.00	0.00	10.47
02	Baffle Box	D	OPEN	0.373	0.0	81.6	0.127	0.21	0.00	0.00	0.00	0.21
02	Baffle Box	A	UPLAND MIXED	2.079	0.0	30.1	0.002	0.02	0.00	0.00	0.00	0.02
02	Baffle Box	D	UPLAND MIXED	0.044	0.0	79.0	0.105	0.02	0.00	0.00	0.00	0.02
02	Dry Detention	A	COMMERCIAL	0.296	85.7	39.0	0.695	0.91	0.50	0.00	0.45	0.45
02	Dry Detention	D	COMMERCIAL	3.690	76.8	80.7	0.649	10.59	0.50	0.00	5.30	5.30
02	Dry Detention	D	HIGHWAYS	0.055	0.0	82.2	0.133	0.03	0.50	0.00	0.02	0.02
02	Dry Detention	D	OPEN	0.224	0.0	80.0	0.111	0.11	0.50	0.00	0.05	0.05
02	Dry Retention	D	INDUSTRIAL	0.864	0.0	89.6	0.235	0.90	0.80	0.00	0.72	0.18
02	Dry Retention	A	OPEN	0.075	0.0	39.0	0.006	0.00	0.80	0.00	0.00	0.00
02	Dry Retention	D	OPEN	0.049	0.0	80.0	0.111	0.02	0.80	0.00	0.02	0.00
02	Dry Retention	A	UPLAND MIXED	4.812	9.2	39.3	0.081	1.71	0.80	0.00	1.37	0.34
02	Wet Detention	A	COMMERCIAL	0.674	43.9	48.0	0.363	1.08	0.20	0.00	0.22	0.86
02	Wet Detention	D	COMMERCIAL	0.172	58.9	80.5	0.524	0.40	0.20	0.00	0.08	0.32

Florida Statewide Stormwater Rule
Retention System Efficiency Calculator

Project Name: **Lake Concord**

Basin Name: **Lake Concord**

User Inputs

Calc. Values

Meteorological Zone: 2

Annual Rainfall (inches): 53.04

03	Dry Retention	D	COMMERCIAL	0.302	83.0	80.0	0.691	0.92	0.80	0.00	0.74	0.18
03	Dry Retention	D	HIGHWAYS	0.024	6.2	80.0	0.154	0.02	0.80	0.00	0.01	0.00
03	Dry Retention	D	MDR	0.008	18.4	80.0	0.240	0.01	0.80	0.00	0.01	0.00
03	None	D	COMMERCIAL	6.793	44.1	87.0	0.465	13.97	0.00	0.00	0.00	13.97
03	None	D	HDR	1.521	6.3	86.1	0.218	1.47	0.00	0.00	0.00	1.47
03	None	D	HIGHWAYS	4.570	86.4	84.2	0.720	14.54	0.00	0.00	0.00	14.54
03	None	D	INDUSTRIAL	5.907	50.0	85.0	0.484	12.65	0.00	0.00	0.00	12.65
03	None	D	INSTITUTIONAL	0.070	64.2	80.1	0.560	0.17	0.00	0.00	0.00	0.17
03	None	D	MDR	2.751	3.6	86.9	0.213	2.59	0.00	0.00	0.00	2.59
03	None	D	OPEN	1.176	1.3	80.6	0.126	0.66	0.00	0.00	0.00	0.66
03	None	D	UPLAND MIXED	0.508	0.1	79.1	0.105	0.24	0.00	0.00	0.00	0.24
03	Wet Detention	D	OPEN	0.000	0.0	80.0	0.111	0.00	0.20	0.00	0.00	0.00
04	Dry Retention	D	INSTITUTIONAL	0.741	85.0	81.0	0.706	2.31	0.80	0.00	1.85	0.46
04	Dry Retention	D	OPEN	0.053	0.0	80.0	0.111	0.03	0.80	0.00	0.02	0.01
04	Dry Retention	D	RECREATIONAL	0.448	3.0	82.8	0.158	0.31	0.80	0.00	0.25	0.06
04	Exfiltration Trench	D	INSTITUTIONAL	1.042	82.8	81.5	0.691	3.18	0.80	0.00	2.55	0.64
04	None	D	RECREATIONAL	0.109	5.3	85.7	0.206	0.10	0.00	0.00	0.00	0.10

Florida Statewide Stormwater Rule

Retention System Efficiency Calculator

Project Name:	**Lake Concord**	**User Inputs**	
Basin Name:	**Lake Concord**	**Calc. Values**	

Meteorological Zone: 2

Annual Rainfall (inches): 53.04

05	Baffle Box	D	INSTITUTIONAL	0.666	79.7	80.0	0.667	1.96	0.00	0.00	0.00	1.96
05	Baffle Box	D	MDR	0.251	69.2	80.0	0.594	0.66	0.00	0.00	0.00	0.66
05	Baffle Box	D	OPEN	0.003	0.0	80.0	0.111	0.00	0.00	0.00	0.00	0.00
05	Dry Retention	A	COMMERCIAL	4.668	80.2	40.3	0.651	13.42	0.80	0.00	10.74	2.68
05	Dry Retention	D	COMMERCIAL	8.650	75.1	80.5	0.637	24.34	0.80	0.00	19.47	4.87
05	Dry Retention	A	MDR	0.224	0.0	48.8	0.014	0.01	0.80	0.00	0.01	0.00
05	Dry Retention	D	MDR	0.794	0.0	84.6	0.156	0.55	0.80	0.00	0.44	0.11
05	Dry Retention	A	OPEN	0.400	3.4	39.8	0.034	0.06	0.80	0.00	0.05	0.01
05	Dry Retention	D	OPEN	0.300	0.0	80.7	0.118	0.16	0.80	0.00	0.13	0.03
05	Dry Retention	A	UPLAND MIXED	0.302	33.5	30.0	0.272	0.36	0.80	0.00	0.29	0.07
05	Dry Retention	D	UPLAND MIXED	0.130	0.0	79.0	0.105	0.06	0.80	0.00	0.05	0.01
05	Dry Retention	D	UTILITIES	0.362	0.2	81.6	0.127	0.20	0.80	0.00	0.16	0.04
05	Dry Retention	W	WATER	0.204	0.0	98.0	0.595	0.54	0.80	0.00	0.43	0.11
05	None	D	RECREATIONAL	1.704	2.7	83.3	0.162	1.22	0.00	0.00	0.00	1.22
05	Pond	D	GOLF COURSES	4.866	0.0	80.3	0.114	2.45	0.90	0.00	2.20	0.24
05	Pond	D	HDR	0.079	0.0	80.0	0.111	0.04	0.90	0.00	0.03	0.00
05	Pond	D	HIGHWAYS	0.001	0.0	80.0	0.111	0.00	0.90	0.00	0.00	0.00
05	Pond	D	INSTITUTIONAL	3.349	73.9	82.0	0.632	9.36	0.90	0.00	8.43	0.94
05	Pond	D	MDR	0.350	0.0	84.2	0.152	0.23	0.90	0.00	0.21	0.02
05	Pond	D	OPEN	0.478	0.0	80.0	0.111	0.23	0.90	0.00	0.21	0.02
05	Pond	W	WATER	1.321	0.0	98.0	0.595	3.47	0.90	0.00	3.12	0.35
05	Pond	D	WETLANDS	0.966	0.0	87.0	0.193	0.82	0.90	0.00	0.74	0.00
05	Swales	A	MDR	0.346	0.0	69.5	0.056	0.09	0.20	0.00	0.02	0.07
05	Swales	D	MDR	4.969	0.0	86.7	0.188	4.12	0.20	0.00	0.82	3.30
05	Swales	D	OPEN	0.552	0.0	80.0	0.111	0.27	0.20	0.00	0.05	0.22
05	Swales	A	UPLAND MIXED	0.021	0.0	30.0	0.002	0.00	0.20	0.00	0.00	0.00
05	Wet Detention	A	COMMERCIAL	9.694	86.3	42.1	0.699	29.97	0.20	0.00	5.99	23.97
05	Wet Detention	D	COMMERCIAL	2.471	69.0	81.5	0.597	6.52	0.20	0.00	1.30	5.22
05	Wet Detention	D	GOLF COURSES	0.202	0.0	80.0	0.111	0.10	0.20	0.00	0.02	0.08
05	Wet Detention	D	HDR	7.398	79.8	80.9	0.670	21.90	0.20	0.00	4.38	17.52
05	Wet Detention	D	HIGHWAYS	2.348	90.9	86.7	0.753	7.81	0.20	0.00	1.56	6.25

Florida Statewide Stormwater Rule
Retention System Efficiency Calculator

Project Name: **Lake Concord**

Basin Name: **Lake Concord**

User Inputs

Calc. Values

Meteorological Zone: 2

Annual Rainfall (inches): 53.04

05	Wet Detention	D	INSTITUTIONAL	3.701	75.1	81.3	0.639	10.45	0.20	0.00	2.09	8.36
05	Wet Detention	A	MDR	0.285	0.8	76.1	0.093	0.12	0.20	0.00	0.02	0.09
05	Wet Detention	D	MDR	1.983	39.1	84.7	0.412	3.61	0.20	0.00	0.72	2.89
05	Wet Detention	A	OPEN	0.767	0.0	39.0	0.006	0.02	0.20	0.00	0.00	0.02
05	Wet Detention	D	OPEN	2.883	0.4	80.0	0.114	1.45	0.20	0.00	0.29	1.16
05	Wet Detention	D	RECREATIONAL	2.345	0.0	84.5	0.155	1.61	0.20	0.00	0.32	1.29
05	Wet Detention	A	UPLAND MIXED	0.490	0.0	30.0	0.002	0.01	0.20	0.00	0.00	0.00
05	Wet Detention	D	UPLAND MIXED	0.210	0.0	79.0	0.105	0.10	0.20	0.00	0.02	0.08
05	Wet Detention	W	WATER	2.414	0.0	98.0	0.595	6.34	0.20	0.00	1.27	5.07
06	None	D	LDR	1.021	0.0	82.7	0.138	0.62	0.00	0.00	0.00	0.62
06	None	D	MDR	5.520	1.7	82.9	0.150	3.66	0.00	0.00	0.00	3.66
06	None	D	OPEN	0.799	0.9	80.3	0.120	0.42	0.00	0.00	0.00	0.42
06	None	W	WATER	4.052	0.0	98.0	0.595	10.65	0.00	0.00	0.00	10.65
Direct	None	D	COMMERCIAL	0.539	2.0	93.7	0.369	0.88	0.00	0.00	0.00	0.88
Direct	None	D	HDR	1.792	0.0	86.3	0.180	1.43	0.00	0.00	0.00	1.43
Direct	None	D	HIGHWAYS	0.060	0.0	93.5	0.356	0.09	0.00	0.00	0.00	0.09
Direct	None	D	LDR	5.829	0.0	81.2	0.123	3.17	0.00	0.00	0.00	3.17
Direct	None	D	MDR	0.515	0.1	83.2	0.142	0.32	0.00	0.00	0.00	0.32
Direct	None	D	OPEN	4.592	0.0	87.3	0.197	3.99	0.00	0.00	0.00	3.99
Direct	None	D	RECREATIONAL	1.678	0.0	82.4	0.135	1.00	0.00	0.00	0.00	1.00
Direct	None	D	SCRUB	1.318	0.0	73.8	0.074	0.43	0.00	0.00	0.00	0.43
Direct	None	W	WATER	20.280	0.0	98.0	0.595	53.29	0.00	0.00	0.00	53.29

APPENDIX D

CHARACTERISTICS OF SEEPAGE INFLOWS TO LAKE CONCORD

D-1. Field Seepage Measurements
D-2. Lab Analyses on Seepage Samples

D-1. Field Seepage Measurements

Seepage Meter Field Measurements

Location: Lk Concord **Site: 1**

Date Installed: 3/11/19 **Chamber Diameter: 0.58 m** **Sediment Area Covered: 0.27 m^2**

Date	Time Collected	Volume Collected (liters)	Previous Collection Event		Seepage Time (days)	Seepage (liters/m^2-day)	Comments / Observations
			Date	Time			
3/11/19	10:25	-----	-----	-----	-----	-----	Bags Installed
4/16/19	8:12	6.5	3/11/19	10:25	35.9	0.67	Sample collected, bag in good condition
6/17/19	6:50	25.25	4/16/19	8:12	61.9	1.51	Sample collected, bag in good condition
7/9/19	7:30	17.5	6/17/19	6:50	22.0	2.94	Sample collected, bag in good condition
8/19/19	7:26	25.25	7/9/19	7:30	41.0	2.28	Sample collected, bag in good condition
9/20/19	7:04	16.75	8/19/19	7:26	32.0	1.94	Sample collected, bag in good condition
					Mean:	**1.75**	

Seepage Meter Field Measurements

Location: Lk Concord **Site: 2**

Date Installed: 3/11/19 **Chamber Diameter: 0.58 m** **Sediment Area Covered: 0.27 m^2**

Date	Time Collected	Volume Collected (liters)	Previous Collection Event		Seepage Time (days)	Seepage (liters/m^2-day)	Comments / Observations
			Date	Time			
3/11/19	10:31	-----	-----	-----	-----	-----	Bags Installed
4/16/19	8:16	6.5	3/11/19	10:31	35.9	0.67	Sample collected, bag in good condition
6/17/19	6:58	10.75	4/16/19	8:16	61.9	0.64	Sample collected, bag in good condition
7/9/19	7:38	7.25	6/17/19	6:58	22.0	1.22	Sample collected, bag in good condition
8/19/19	7:35	9.75	7/9/19	7:38	41.0	0.88	Sample collected, bag in good condition
9/20/19	7:11	12.5	8/19/19	7:35	32.0	1.45	Sample collected, bag in good condition
					Mean:	**0.90**	

Seepage Meter Field Measurements

Location: Lk Concord **Site: 3**

Date Installed: 3/11/19 **Chamber Diameter: 0.58 m** **Sediment Area Covered: 0.27 m^2**

Date	Time Collected	Volume Collected (liters)	Previous Collection Event		Seepage Time (days)	Seepage (liters/m^2-day)	Comments / Observations
			Date	Time			
3/11/19	10:37	-----	-----	-----	-----	-----	Bags Installed
4/16/19	8:20	6.5	3/11/19	10:37	35.9	0.67	Sample collected, bag in good condition
6/17/19	7:04	11.5	4/16/19	8:20	61.9	0.69	Sample collected, bag in good condition
7/9/19	7:44	4.5	6/17/19	7:04	22.0	0.76	Sample collected, bag in good condition
8/19/19	7:40	7.25	7/9/19	7:44	41.0	0.65	Sample collected, bag in good condition
9/20/19	7:21	3.75	8/19/19	7:40	32.0	0.43	Sample collected, bag in good condition
					Mean:	**0.64**	

Seepage Meter Field Measurements

Location: Lk Concord **Site: 4**

Date Installed: 3/11/19 **Chamber Diameter: 0.58 m** **Sediment Area Covered: 0.27 m^2**

Date	Time Collected	Volume Collected (liters)	Previous Collection Event		Seepage Time (days)	Seepage (liters/m^2-day)	Comments / Observations
			Date	Time			
3/11/19	10:41	-----	-----	-----	-----	-----	Bags Installed
4/16/19	8:25	16.25	3/11/19	10:41	35.9	1.68	Sample collected, bag in good condition
6/17/19	7:13	8.5	4/16/19	8:25	61.9	0.51	Sample collected, bag in good condition
7/9/19	7:52	7.25	6/17/19	7:13	22.0	1.22	Sample collected, bag in good condition
8/19/19	7:47	16.5	7/9/19	7:52	41.0	1.49	Sample collected, bag in good condition
9/20/19	7:28	13.0	8/19/19	7:47	32.0	1.51	Sample collected, bag in good condition
					Mean:	**1.18**	

Seepage Meter Field Measurements

Location: Lk Concord **Site:** 5

Date Installed: 3/11/19 **Chamber Diameter:** 0.58 m **Sediment Area Covered:** 0.27 m^2

Date	Time Collected	Volume Collected (liters)	Previous Collection Event		Seepage Time (days)	Seepage (liters/m^2-day)	Comments / Observations
			Date	Time			
3/11/19	10:46	-----	-----	-----	-----	-----	Bags Installed
4/16/19	8:30	10.5	3/11/19	10:46	35.9	1.08	Sample collected, bag in good condition
6/17/19	7:18	12.75	4/16/19	8:30	62.0	0.76	Sample collected, bag in good condition
7/9/19	7:58	9.25	6/17/19	7:18	22.0	1.56	Sample collected, bag in good condition
8/19/19	7:56	9.75	7/9/19	7:58	41.0	0.88	Sample collected, bag in good condition
9/20/19	7:42	5.5	8/19/19	7:56	32.0	0.64	Sample collected, bag in good condition
					Mean:	**0.92**	

Seepage Meter Field Measurements

Location: Lk Concord **Site:** 6

Date Installed: 3/11/19 **Chamber Diameter:** 0.58 m **Sediment Area Covered:** 0.27 m^2

Date	Time Collected	Volume Collected (liters)	Previous Collection Event		Seepage Time (days)	Seepage (liters/m^2-day)	Comments / Observations
			Date	Time			
3/11/19	10:52	-----	-----	-----	-----	-----	Bags Installed
4/16/19	8:34	5.75	3/11/19	10:52	35.9	0.59	Sample collected, bag in good condition
6/17/19	7:26	9.25	4/16/19	8:34	62.0	0.55	Sample collected, bag in good condition
7/9/19	8:05	7.25	6/17/19	7:26	22.0	1.22	Sample collected, bag in good condition
8/19/19	8:09	36.5	7/9/19	8:05	41.0	3.30	Sample collected, bag in good condition
9/20/19	7:47	7.75	8/19/19	8:09	32.0	0.90	Sample collected, bag in good condition
					Mean:	**1.28**	

Seepage Meter Field Measurements

Location: Lk Concord **Site:** 7

Date Installed: 3/11/19 **Chamber Diameter:** 0.58 m **Sediment Area Covered:** 0.27 m^2

Date	Time Collected	Volume Collected (liters)	Previous Collection Event		Seepage Time (days)	Seepage (liters/m^2-day)	Comments / Observations
			Date	Time			
3/11/19	11:00	-----	-----	-----	-----	-----	Bags Installed
4/16/19	8:40	7.5	3/11/19	11:00	35.9	0.77	Sample collected, bag in good condition
6/17/19	7:37	5.25	4/16/19	8:40	62.0	0.31	Sample collected, bag in good condition
7/9/19	8:17	3.75	6/17/19	7:37	22.0	0.63	Sample collected, bag in good condition
8/19/19	8:20	11.25	7/9/19	8:17	41.0	1.02	Sample collected, bag in good condition
9/20/19	7:53	11.25	8/19/19	8:20	32.0	1.30	Sample collected, bag in good condition
					Mean:	**0.75**	

Seepage Meter Field Measurements

Location: Lk Concord **Site:** 8

Date Installed: 3/11/19 **Chamber Diameter:** 0.58 m **Sediment Area Covered:** 0.27 m^2

Date	Time Collected	Volume Collected (liters)	Previous Collection Event		Seepage Time (days)	Seepage (liters/m^2-day)	Comments / Observations
			Date	Time			
3/11/19	11:07	-----	-----	-----	-----	-----	Bags Installed
4/16/19	8:45	15.5	3/11/19	11:07	35.9	1.60	Sample collected, bag in good condition
6/17/19	7:49	11.25	4/16/19	8:45	62.0	0.67	Sample collected, bag in good condition
7/9/19	8:33	2.25	6/17/19	7:49	22.0	0.38	Sample collected, bag in good condition
8/19/19	8:35	5.25	7/9/19	8:33	41.0	0.47	Sample collected, bag in good condition
9/20/19	7:59	7.25	8/19/19	8:35	32.0	0.84	Sample collected, bag in good condition
					Mean:	**0.80**	

D-2. Lab Analyses on Seepage Samples

Characteristics of Shallow Groundwater Seepage Samples Collected in Lake Concord from March-September 2019

Lab ID	Site	Date Collected	pH (s.u.)	Alkalinity (mg/L)	Cond (µmho/cm)	Ammonia (µg/L)	NOx (µg/L)	Organic N (µg/L)	Total N (µg/L)	SRP (µg/L)	Organic P (µg/L)	Total P (µg/L)
1435	SP 1	6/17/19	8.10	140	412	136	3,892	1,087	5,115	157	46	203
2026	SP 1	8/19/19	8.14	223	476	2,873	1,681	926	5,480	280	33	313
1659	SP1	7/9/19	8.11	225	526	2,420	3,247	1,235	6,902	264	27	291
2350	SP1	9/20/19	7.89	195	433	1,115	1,872	639	3,626	229	14	243
Geometric Mean Value:			8.06	192	460	1,013	2,511	1,622	5,146	227	32	259
1437	SP 2	6/17/19	7.47	70.0	238	47	631	1,195	1,873	32	45	77
1661	SP2	7/9/19	7.35	75.9	230	183	832	577	1,592	60	11	71
2028	SP 2	8/19/19	7.49	91.0	226	82	320	445	847	23	6	29
2352	SP2	9/20/19	7.14	71.7	208	40	273	311	624	9	6	15
Geometric Mean Value:			7.36	76.7	225	73	463	585	1,120	25	14	39
1438	SP 3	6/17/19	7.56	104	290	568	471	493	1,532	39	11	50
2029	SP 3	8/19/19	7.92	167	382	278	2,232	648	3,158	26	24	50
1662	SP3	7/9/19	7.46	124	322	225	652	482	1,359	14	11	25
2353	SP3	9/20/19	6.54	89.0	235	300	220	203	723	10	17	27
Geometric Mean Value:			7.35	118	303	321	623	532	1,477	19	17	36
1440	SP 4	6/17/19	8.14	176	475	134	2,655	1,478	4,267	28	26	54
2030	SP 4	8/19/19	7.81	170	401	4,409	1,709	1,236	7,354	117	37	154
1664	SP4	7/9/19	7.81	247	613	4,727	3,916	3,197	11,840	164	35	199
2354	SP4	9/20/19	7.68	148	398	89	7,662	1,381	9,132	188	15	203
Geometric Mean Value:			7.86	182	464	706	3,416	3,510	7,632	100	35	135
1441	SP 5	6/17/19	7.29	90.0	275	249	869	591	1,709	19	9	28
2032	SP 5	8/19/19	7.86	221	480	281	3,970	464	4,715	18	24	42
1665	SP5	7/9/19	7.79	202	505	283	4,149	998	5,430	43	3	46
2356	SP5	9/20/19	6.88	125	311	258	1,636	938	2,832	8	11	19
Geometric Mean Value:			7.44	150	379	267	2,200	869	3,336	19	13	32
1442	SP 6	6/17/19	7.81	220	627	1,905	8,195	3,905	14,005	193	58	251
2033	SP 6	8/19/19	7.93	301	790	3,134	20,287	2,203	25,624	330	44	374
1666	SP6	7/9/19	8.32	231	669	2,115	20,368	2,873	25,356	235	40	275
2357	SP6	9/20/19	7.62	276	702	4,166	14,313	2,216	20,695	266	7	273
Geometric Mean Value:			7.92	255	694	2,693	14,838	3,301	20,831	251	39	290
1443	SP 7	6/17/19	7.11	96.0	267	390	151	554	1,095	9	4	13
2034	SP 7	8/19/19	7.47	88.7	226	200	400	862	1,462	16	29	45
1667	SP7	7/9/19	7.59	145	360	576	525	603	1,704	63	8	71
2358	SP7	9/20/19	7.26	80.0	223	55	833	835	1,723	6	13	19
Geometric Mean Value:			7.36	100	264	223	403	846	1,472	15	15	30
1444	SP 8	6/17/19	7.14	82.0	247	66	35	893	994	12	13	25
2035	SP 8	8/19/19	7.23	120	293	376	28	973	1,377	12	23	35
1668	SP8	7/9/19	7.82	127	327	1,504	635	992	3,131	121	30	151
2359	SP8	9/20/19	6.82	87.4	231	312	1,052	889	2,253	24	33	57
Geometric Mean Value:			7.24	102	272	328	160	1,274	1,763	25	27	52

APPENDIX E

CHEMICAL CHARACTERISTICS OF STORMWATER SAMPLES COLLECTED FROM LAKE CONCORD SUB-BASIN 5 FROM FEBRUARY-JUNE 2019

Characteristics of Runoff Samples Collected at Lake Concord from March - June 2020

Lab ID (19-xx)	Date Collected	pH (s.u.)	Alkalinity (mg/l)	Conductivity (umho/cm)	NH3-N (ug/l)	NOx-N (ug/l)	Diss Org. N (ug/l)	Part. N (ug/l)	Total N (ug/l)	Diss. TN (ug/l)	SRP (ug/l)	Diss Org. P (ug/l)	Part. P (ug/l)	Total P (ug/l)	Diss. TP (ug/l)	Turbididty (NTU)	TSS (mg/l)	Color (units)
480	3/1/19	7.46	143	341	486	218	91	282	1077	795	6	4	20	30	10	4.5	4.7	39
488	3/8/19	7.85	135	360	45	668	417	55	1185	1130	9	6	27	42	15	2.8	5.6	36
678	3/19/19-3/20/19	7.59	153	387	2	1022	356	143	1523	1380	6	4	4	14	10	2.7	4.9	41
720	3/27/19	7.38	127	210	119	459	430	46	1054	1008	4	12	17	33	16	3.2	3.3	33
794	4/5/19	7.19	98.6	302	15	293	466	132	906	774	6	5	33	44	11	3.8	6.3	24
862	4/11/19	7.62	114	327	116	381	207	178	882	704	14	13	14	41	27	3.3	5.1	30
955	4/19/19	7.37	127	371	46	1004	398	491	1939	1448	22	6	202	230	28	31.1	57.0	36
970	4/22/19	7.45	132	366	62	704	462	75	1303	1228	8	2	35	45	10	3.2	7.8	36
1156	5/10/19	7.86	137	333	48	675	205	124	1052	928	5	9	36	50	14	9.5	18.4	33
1164	5/15/19	7.56	123	310	2	665	324	128	1119	991	8	3	20	31	11	4.8	6.6	33
1367	6/5/19-6/6/19	7.22	108	349	2	1057	470	199	1728	1529	11	17	53	81	28	5.7	9.6	35
1404	6/12/19	6.78	64.0	240	2	73	287	120	482	362	4	3	49	56	7	9.1	16.9	24
Minimum Value:		6.78	64.0	210	2	73	91	46	482	362	4	2	4	14	7	2.7	3.3	24
Maximum Value		7.86	153	387	486	1,057	470	491	1,939	1,529	22	17	202	230	28	31.1	57.0	41
Geometric Mean Value:		7.44	119	320	20	489	451	163	1,124	960	8	7	31	45	14	5.1	8.4	33

APPENDIX F

RESULTS OF BENTHIC NUTRIENT RELEASE EXPERIMENTS

F-1. Laboratory Data
F-2. Nutrient Release Plots

F-1. Laboratory Data

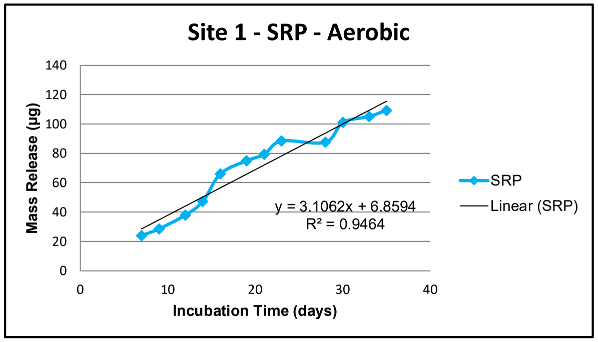
Results of Sediment Benthic Nutrient Release Rate Studies in Lake Concord

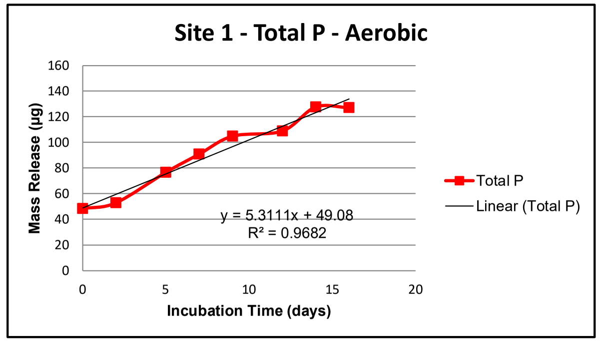
Site	Redox Condition	Date Collected	Time (days)	NH3 (µg/L)	NO_X (µg/L)	Organic N (µg/L)	Total N (µg/L)	SRP (µg/L)	Organic P (µg/L)	Total P (µg/L)	Volume (L)	Total N (µg)	SRP (µg)	Total P (µg)
Starting water level (inches):			24.00	Ending water level (inches):						22.50				
Lake Concord Site # 1	Aerobic	4/17/19	0	36	26	328	390	8	2	10	4.84	1,888	39	48
		4/19/19	2	38	20	338	396	6	5	11	4.82	1,910	29	53
		4/22/19	5	122	21	360	503	5	11	16	4.80	2,414	24	77
		4/24/19	7	162	38	415	615	5	14	19	4.78	2,942	24	91
		4/26/19	9	169	61	471	701	6	16	22	4.77	3,342	29	105
		4/29/19	12	187	182	530	899	8	15	23	4.74	4,263	38	109
		5/1/19	14	109	316	487	912	10	17	27	4.73	4,310	47	128
		5/3/19	16	65	438	519	1022	14	13	27	4.71	4,813	66	127
		5/6/19	19	15	494	506	1015	16	11	27	4.69	4,755	75	127
		5/8/19	21	12	514	458	984	17	9	26	4.67	4,594	79	121
		5/10/19	23	2	525	465	992	19	6	25	4.65	4,615	88	116
		5/15/19	28	2	572	390	964	19	7	26	4.61	4,446	88	120
		5/17/19	30	2	630	357	989	22	3	25	4.60	4,545	101	115
		5/20/19	33	2	596	435	1033	23	3	26	4.57	4,722	105	119
		5/22/19	35	2	726	368	1096	24	2	26	4.55	4,992	109	118
		5/24/19	37	2	818	313	1133	21	3	24	4.54	5,142	95	109
Starting water level (inches):			24.00	Ending water level (inches):						22.75				
Lake Concord Site #1	Anoxic	5/28/19	0	55	25	398	478	6	13	19	4.84	2,314	29	92
		5/29/19	1	99	15	427	541	7	13	20	4.83	2,614	34	97
		5/31/19	3	155	5	426	586	9	18	27	4.82	2,822	43	130
		6/3/19	6	248	1	455	704	16	17	33	4.79	3,373	77	158
		6/5/19	8	322	1	434	757	19	17	36	4.78	3,615	91	172
		6/7/19	10	341	1	453	795	23	15	38	4.76	3,784	109	181
		6/12/19	15	372	1	448	821	32	15	47	4.72	3,874	151	222
		6/17/19	20	380	1	536	917	37	13	50	4.68	4,290	173	234
		6/19/19	22	393	1	527	921	39	16	55	4.66	4,293	182	256
		6/21/19	24	503	1	455	959	42	19	61	4.65	4,455	195	283
		6/24/19	27	651	1	332	984	47	18	65	4.62	4,547	217	300
		6/26/19	29	600	1	386	987	53	19	72	4.60	4,545	244	332
		6/28/19	31	508	1	584	1093	58	18	76	4.59	5,015	266	349

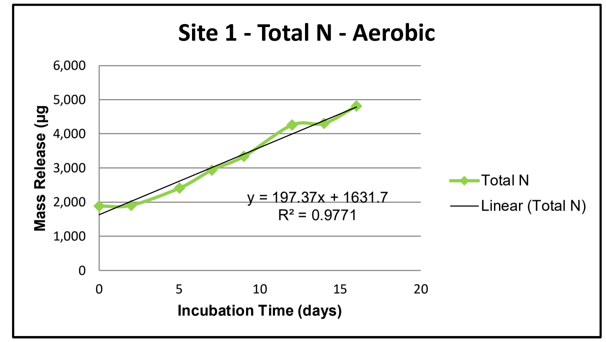
Results of Sediment Benthic Nutrient Release Rate Studies in Lake Concord

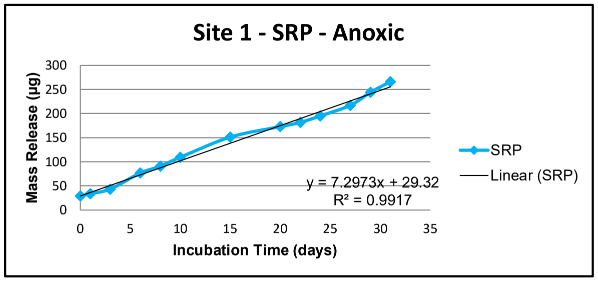
Site	Redox Condition	Date Collected	Time (days)	NH_3 (µg/L)	NO_x (µg/L)	Organic N (µg/L)	Total N (µg/L)	SRP (µg/L)	Organic P (µg/L)	Total P (µg/L)	Volume (L)	Total N (µg)	SRP (µg)	Total P (µg)
Starting water level (inches):			20.00	Ending water level (inches):						18.75				
Lake Concord Site # 2	Aerobic	4/17/19	0	39	18	328	385	5	10	15	4.03	1,553	20	61
		4/19/19	2	221	25	451	697	7	8	15	4.02	2,802	28	60
		4/22/19	5	257	168	552	977	9	7	16	4.00	3,908	36	64
		4/24/19	7	79	444	525	1048	12	13	25	3.99	4,177	48	100
		4/26/19	9	34	629	404	1067	14	16	30	3.97	4,239	56	119
		4/29/19	12	11	650	445	1106	16	21	37	3.95	4,371	63	146
		5/1/19	14	2	770	455	1227	21	18	39	3.94	4,832	83	154
		5/3/19	16	2	813	517	1332	23	11	34	3.92	5,228	90	133
		5/6/19	19	2	866	452	1320	25	10	35	3.90	5,154	98	137
		5/8/19	21	2	999	369	1370	27	5	32	3.89	5,330	105	125
		5/10/19	23	2	987	363	1352	29	3	32	3.88	5,242	112	124
		5/15/19	28	2	1111	363	1476	27	3	30	3.84	5,672	104	115
		5/17/19	30	2	1098	348	1448	25	3	28	3.83	5,545	96	107
		5/20/19	33	2	1143	378	1523	22	8	30	3.81	5,801	84	114
		5/22/19	35	2	1097	374	1473	22	6	28	3.80	5,590	83	106
		5/24/19	37	2	1055	249	1306	21	4	25	3.78	4,939	79	95
Starting water level (inches):			20.00	Ending water level (inches):						18.25				
Lake Concord Site #2	Anoxic	5/28/19	0	119	34	345	498	6	16	22	4.03	2,009	24	89
		5/29/19	1	144	15	368	527	7	15	22	4.02	2,120	28	88
		5/31/19	3	794	12	483	1289	61	22	83	4.00	5,156	244	332
		6/5/19	8	1119	1	311	1431	79	23	102	3.94	5,642	311	402
		6/7/19	10	1084	1	406	1491	112	24	136	3.92	5,845	439	533
		6/12/19	15	1011	1	503	1515	122	29	151	3.86	5,852	471	583
		6/17/19	20	738	1	786	1525	139	26	165	3.81	5,804	529	628
		6/19/19	22	879	1	664	1544	155	28	183	3.78	5,841	586	692
		6/21/19	24	653	1	783	1437	158	31	189	3.76	5,404	594	711
		6/24/19	27	937	1	662	1600	160	27	187	3.73	5,962	596	697
		6/26/19	29	988	1	766	1755	171	30	201	3.70	6,500	633	744
		6/28/19	31	748	1	792	1541	173	31	204	3.68	5,672	637	751

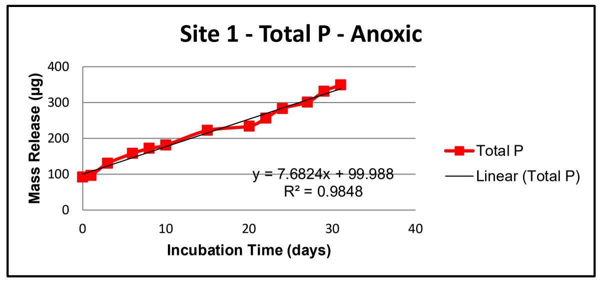
F-2. Nutrient Release Plots

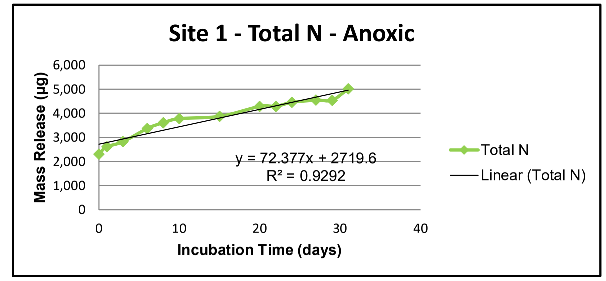

Site 1 - SRP - Aerobic
y = 3.1062x + 6.8594
R² = 0.9464
SRP
Linear (SRP)
Mass Release (µg)
Incubation Time (days)

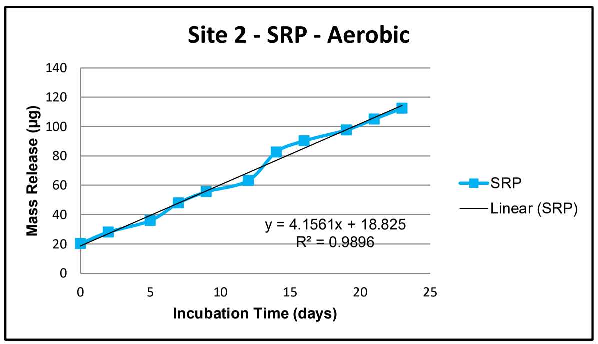

Site 1 - Total P - Aerobic
y = 5.3111x + 49.08
R² = 0.9682
Total P
Linear (Total P)
Mass Release (µg)
Incubation Time (days)

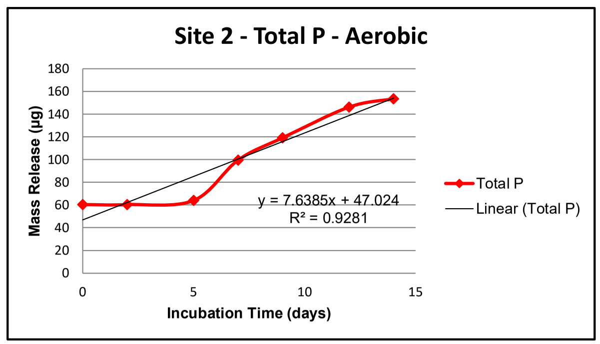

Site 1 - Total N - Aerobic
y = 197.37x + 1631.7
R² = 0.9771
Total N
Linear (Total N)
Mass Release (µg)
Incubation Time (days)

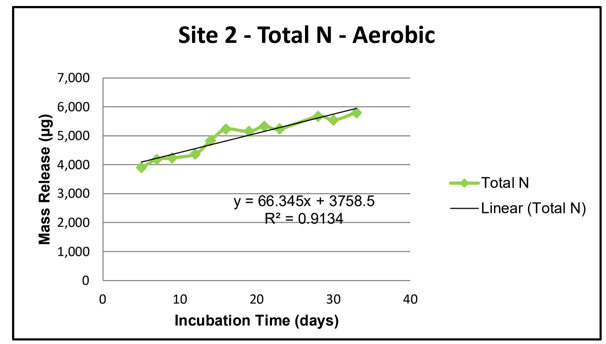

Site 1 - SRP - Anoxic
y = 7.2973x + 29.32
R² = 0.9917
SRP
Linear (SRP)
Mass Release (µg)
Incubation Time (days)

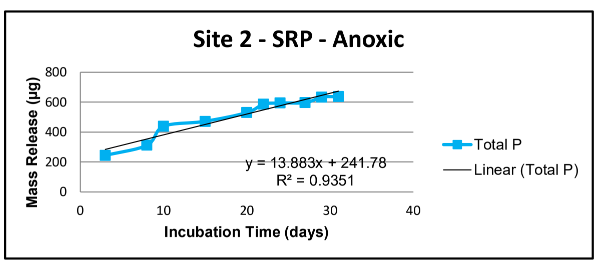

Site 1 - Total P - Anoxic
y = 7.6824x + 99.988
R² = 0.9848
Total P
Linear (Total P)
Mass Release (µg)
Incubation Time (days)

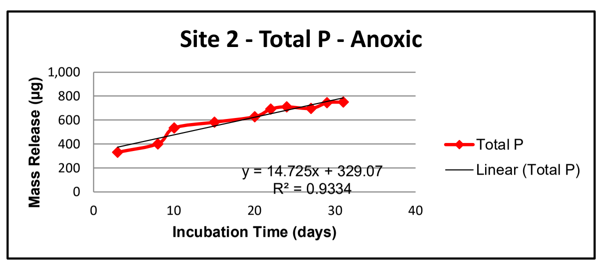

Site 1 - Total N - Anoxic
y = 72.377x + 2719.6
R² = 0.9292
Total N
Linear (Total N)
Mass Release (µg)
Incubation Time (days)

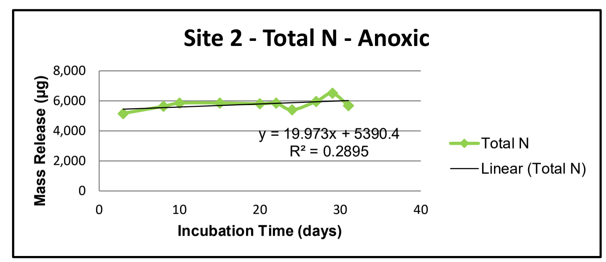

Site 2 - SRP - Aerobic
y = 4.1561x + 18.825
R² = 0.9896
SRP
Linear (SRP)
Mass Release (µg)
Incubation Time (days)


Site 2 - Total P - Aerobic
y = 7.6385x + 47.024
R² = 0.9281
Total P
Linear (Total P)
Mass Release (µg)
Incubation Time (days)


Site 2 - Total N - Aerobic
y = 66.345x + 3758.5
R² = 0.9134
Total N
Linear (Total N)
Mass Release (µg)
Incubation Time (days)


Site 2 - SRP - Anoxic
y = 13.883x + 241.78
R² = 0.9351
Total P
Linear (Total P)
Mass Release (µg)
Incubation Time (days)


Site 2 - Total P - Anoxic
y = 14.725x + 329.07
R² = 0.9334
Total P
Linear (Total P)
Mass Release (µg)
Incubation Time (days)


Site 2 - Total N - Anoxic
y = 19.973x + 5390.4
R² = 0.2895
Total N
Linear (Total N)
Mass Release (µg)
Incubation Time (days)

Attachment B:

Lake Management Guide

Lake Management Guide

2019 Edition

City of Casselberry • 95 Triplet Lake Drive • Casselberry, FL 32707

www.casselberry.org/lakes

A Note from the Lakes Management Advisory Board…….

Dear Lakefront Property Owner,

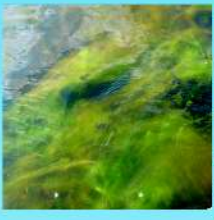
As part of its Stormwater, Lakes Management, and Water Quality Program, the City of Casselberry has been stepping up efforts to let citizens and businesses know how they can help protect our lakes and water quality. These outreach efforts are being conducted in cooperation with the Florida Fish and Wildlife Conservation Commission, the Florida Yards and Neighborhoods Program, and the City's own Lakes Management Advisory Board, which is composed of volunteer citizens.

The City realizes that lakefront property owners and residents are usually not given an "instruction manual" on how to best manage and protect their lakefront at the time of purchase. This updated Guide is part of this program. New for 2018 is a revised, more convenient format, as well as updated and more comprehensive information. This guide, as well as a wealth of other lake-related information, is available electronically at casselberry.org/lakes.

GREEN UP
CASSELBERRY
GROWING COMMUNITY

This guide and related educational efforts are part of a sustainable projects and practices program called Green Up Casselberry. Find out more about the program at casselberry.org/greenup.

*For a **quick reference** overview of topics, refer to* ***page 15****. For **simple steps** you can take to **help protect our lakes**, see* ***pages 8 & 9****. For more detailed information about lake concerns, just start below!*



Water Quality Concerns

In general, Casselberry's lakes exhibit average to good water quality compared to State standards. However, like most urban lakes in Central Florida, there is always a concern that excess nutrients will reach the lakes, resulting in poorer water quality and leading to undesirable effects such as algae blooms and possible fish kills. Excess nutrients can reach the lakes from multiple sources, including nutrients that are carried in stormwater runoff (from yards, storm pipes, streams, etc.) that discharges into the lakes. There are federal regulations that require local governments to clean up the pollution caused by these excess nutrients. This can be a very expensive process. Taking simple steps to **prevent pollution** in the first place, such as being mindful of landscaping and following fertilizer regulations, is a great **moneysaving** method for everyone.

In addition to excess nutrients, illegal dumping into lakes, streams, storm inlets, etc. can have a detrimental effect upon our environment. If you suspect or witness any **illegal dumping**, **PLEASE REPORT IT** online through the **Seminole County Watershed Atlas** at **seminole.wateratlas.org**, or contact Public Works at **(407) 262-7725**.

The City regularly conducts quarterly water quality sampling of twelve lakes to monitor for various pollutants and water quality indicators. In addition, residents may participate in the **Florida Lakewatch** Volunteer Water Quality Monitoring Program, which provides free training and equipment to committed volunteers. Find out more at **lakewatch.ifas.ufl.edu**.

Go"Green" With Florida Friendly Landscaping

Fertilizer used for turf grasses and landscaping can be a major source of excess nutrients that reaches our lakes. As of November 2017, there is an annual nitrogen and phosphorous blackout period from June 1–September 30. A minimum of 50% slow release nitrogen must be used at all other times, unless the activity is exempt. **Save money while saving our lakes:** if you currently irrigate using the City's reclaimed water or water from your lake, you may be able to reduce or eliminate phosphorus in your fertilizer - both reclaimed water and lake water already contain significant nutrients that help plants grow, including phosphorus. Testing your soil can help determine true fertilizer needs. Some plants also require much more irrigation than others, so plant selection is key.

"Florida Friendly Landscaping" includes a focus on selecting the right plant for the right place and watering and fertilizing only when needed. **Recycling grass clippings and composting** can also create a more environmentally friendly yard. Also, storm inlets often discharge directly to lakes, so it's a good practice to avoid placing grass clippings and leaf litter where they may be washed into nearby inlets. Such litter pollutes the lakes with excess nutrients and also reduces the flood control effectiveness of storm drains. Visit **seminolecountyfl.gov/fyn** for more information on the **Florida Yards and Neighborhoods** program, including detailed information on key principles that can help protect your waterfront.

"Beaches", Seawalls, and Docks

In Florida, it is unfortunately a common site to see manmade, sandy beaches on lakes. This is not, however, good for the lake or the environment, and there are several local and state regulations that prohibit this activity. Beaches are usually constructed by importing sand and clearing a part of the shoreline. Importing sand may constitute a fill violation due to its impact to the floodplain, and it is subject to erosion, increasing the sediment load to the lakes while eating away at shorelines.

Seawalls are also quite common along lakes, often constructed in an attempt to abate erosion and/or increase usable yard space. While there are times when seawalls are necessary, in many circumstances they are not the best solution to erosion concerns, and excess fill brought in as part of seawall construction is often a violation of floodplain regulations. Beaches and seawalls can also disrupt native vegetation and natural habitat. Land disturbance due to clearing can increase the chances of non-native, invasive species taking hold. These species are often difficult to control, and they crowd out native plants, disrupting the lake's ecosystem. A better alternative is to develop a plan for maintaining and/or **restoring native plantings** to the lakefront. **Docks** can often be incorporated well into properly maintained shorelines. However, it is important to consider balancing the recreational needs associated with the dock while taking efforts to minimize shoreline and lake habitat impacts. Docks cannot extend farther than 20 feet from the shoreline without sufficient lighting. Both docks and seawalls require proper permits prior to construction. **Contact Public Works at (407) 262-7725 before engaging in any construction, filling, or clearing activity near a lake.** A permit through Florida Department of Environmental Protection (FDEP) may also be required for certain docks and seawalls. Find out more at **dep.state.fl.us/water/wetlands**.

Aquatic Plant Management and Shoreline Restoration

In addition to being beautiful, **native vegetation**, such as bald cypress trees and cordgrass, can provide **erosion protection**, **water quality improvement** through nutrient uptake, and **improved habitat** for natural wildlife. Many shorelines in Casselberry are either overrun with invasive species, or they have been cleared entirely and replaced with sod or sand. There are City and state restrictions on clearing of shorelines, so it is always best to **ask before engaging in any clearing activity.** City and Florida Fish and Wildlife staff can provide assistance in properly planning and permitting shoreline restoration and plant management for lakefront property owners.

In addition to shoreline plants, Casselberry's lakes feature several native, beneficial submerged plants, such as eelgrass, coontail, and muskgrass. However, there are some invasive species, such as **hydrilla**, within the City's lakes. Residents who use the lakes, especially for boating, can help by **closely inspecting** their equipment for any remnants of invasive species before placing it in or near the lakes. This will help prevent **"cross contamination"** from other lakes outside the City. Find out more about aquatic plant management at **casselberry.org/lakes** or **myfwc.com/license/aquatic-plants**, or contact Kris Campbell with FWC at **(407) 204-3306** or **Kristine.Campbell@MyFWC.com**

See pages 10 and 11 in this Guide for example invasive and native species.

Boating, Blueway Trail System, and No Wake Zones

The City does not allow motorized vessel launching from any of its public properties (except for City coordinated lake management activities.) This does not, however, prevent lakefront residents from launching motorized vessels from their own property. Launching of passive vessels, such as kayaks or canoes, from designated public areas is permitted as well. The City has introduced a public **Blueway Trail System** on its Triplet Chain of Lakes, which can be accessed at Secret Lake Park. Kayak and canoe rentals are also available at this location.

The City has several regulations within its City Code (available at **municode.com**) that apply to boating and personal watercraft (Chapter 94, Code of Ordinances). This includes **wake restrictions within 100 feet of the shoreline**, as well as speed restrictions within 40 feet of a shoreline (10 mph) and through canals (5 mph). Passive (non-motorized) vessels have the right of way under City Code, limiting the speed at which motorized vessels can be operated in proximity to passive vessels. There are also restrictions on water skiers and associated boats coming within 100 feet of a dock or shoreline.

For any water body within the City, City Code sets **limits on operating hours for personal watercraft** to: 9AM to 7:30PM from April to September, and 9AM to 5:30PM from October to March. Both **City Code and state law prohibit dangerous weaving or wake jumping** using personal watercraft (Florida Statutes 327.39(4)). By State law, persons operating personal watercraft must be at least the age of 14. There are also **boating safety education requirements** for persons age 21 or under, administered by the Florida Fish and Wildlife Conservation Commission (FWC). For more information on required education and how to get a Boating Safety Education Identification Card, as well as the importance of **life jackets**/personal flotation devices, please visit **myfwc.com/boating.** You can report suspected State boating and wildlife law violations by calling **(888) 404-3922**.

Septic Tanks and Sanitary Sewer Availability

Several homes on lakes within the City use septic systems. Septic systems can have harmful impacts to lake systems, especially if they are failing. If your home uses a septic system, making sure it is well maintained and **operating properly** can help protect the lakes.

Where available, sanitary sewer is a better choice than septic systems. Not only does the City's sanitary sewer system centralize and treat wastewater, but that highly treated wastewater is also then reused for irrigation (**recycling!**), providing positive environmental benefits. Sanitary sewer is not readily available at all locations within Casselberry. While the City is constantly working to expand its system, this is a gradual and often expensive process. Keep this in mind, however, should sanitary sewer become available at your address: switching to sanitary can help better protect our lake systems.

Not sure if sewer is available? Contact Public Works at **(407) 262-7725** to find out!

Fish Stocking: Game Fish and Grass Carp

For **game fish**, most lakes in the City of Casselberry are not eligible for public fish stocking through Florida Fish and Wildlife (FWC). If you are interested in stocking your lake, you may wish to use a private hatchery to provide the fish. Generally no permit is required if the fish are native and not being used for fish farm purposes. A note of caution: often fish stocking does not work well. For more information, contact Eric (Bubba) Thomas with FWC at **(352) 732-1225** or **eric.thomas@myfwc.com**.

Triploid **grass carp** are a special type of fish often used to combat invasive **hydrilla**, as they eat it preferentially over many native plant species. The City, in cooperation with FWC, stocks many of its lakes with carp. These carp do not reproduce, and stocking them requires an FWC permit and careful consideration of stocking rates. For more information, contact Kris Campbell with FWC at **(407) 204-3306** or **Kristine.Campbell@MyFWC.com**, or visit **myfwc.com/license/aquatic-plants**.

Floodplain and Flood Insurance

At least a portion of most properties on or near a lake is likely within the 100 year floodplain, also called the **Special Flood Hazard Area** (SFHA). This means that in any given year, that portion of property has a one percent chance of being inundated. Those chances may sound slim, but over the life of a mortgage, the **chances of flood are significant**. As a result, for homes located within the SFHA, flood insurance is often required by mortgage lenders. Flooding is a serious concern and should always be considered with any construction near a lake. Consider that, for most lakes in the City, Tropical Storm Fay (2008) did not result in 100 year flood levels. In many cases, the projected 100 year flood level would be much higher. Because of these concerns, the City has several regulations that apply to most construction within the floodplain. **Even if your lender does not require it**, flood insurance is often a good idea for lakefront properties. Consider that almost 25% of flood insurance claims come from areas with low to moderate flood risk.

PANEL 0165F

FIRM

FLOOD INSURANCE RATE MAP

SEMINOLE COUNTY, FLORIDA

AND INCORPORATED AREAS

PANEL 165 OF 330

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
ALTAMONTE SPRINGS, CITY OF	120290	0165	F
CASSELBERRY, CITY OF	120291	0165	F
LONGWOOD, CITY OF	120292	0165	F
SEMINOLE COUNTY	120289	0165	F
WINTER SPRINGS, CITY OF	120295	0165	F

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
12117C0165F

MAP REVISED
SEPTEMBER 28, 2007

Federal Emergency Management Agency

FEMA flood maps are available online at **msc.fema.gov**. Also, the City will provide a flood propensity letter for your property free of charge upon request; this letter will typically provide you with a precise 100 year flood elevation for your property. The City does not, however, provide surveying services for properties. Surveys are usually necessary to complete a FEMA Elevation Certificate and/or a Letter of Map Amendment (LOMA) for flood insurance purposes. There are several local surveyors available who can help you with this task if needed. For more information, call Public Works at **(407) 262-7725** or visit **floodsmart.gov**

Permitting Requirements

Many activities in or near a lake, including clearing, fill, and construction of almost any type, require a permit, often from multiple agencies. When in doubt, it is always best to err on the side of caution and request whether a permit is required. Call Public Works at (407) 262-7725 for more information.

Compliance with City Code and State Law is an important consideration for any project. Such regulations are designed to protect the property, property owner, the lake, and users of the lake. Some examples of permits required are below:

- Dock and seawall construction typically requires permits from **both** the City and the Florida Department of Environmental Protection. The City requires site plans and building permits for docks, as they are considered a conditional use.
- **Construction, regrading, clearing, or fill of any kind** along the lakeshore and within the floodplain typically requires permits from the City
- The use of **any herbicide** on the shoreline and/or the removal of exotic plants outside of the access corridor (equivalent to 50 feet or 50% of the linear feet of shoreline, **whichever is less**) requires an **Aquatic Plant Management Permit** through the Florida Fish and Wildlife Conservation Commission (FWC). Physical removal of vegetation (hand removal, mechanical harvesting) within the access corridor is exempt and doesn't require a permit, but it is best to check with FWC first prior to conducting any aquatic plant removal/alterations on the shoreline (contact Kris Campbell with FWC at (407) 858-6170 Kristine.Campbell@MyFWC.com, or visit myfwc.com/license/aquatic-plants.)

Regulations and Enforcement Consequences

The City of Casselberry Code of Ordinances contains multiple regulations related to our lakes. Regulations cover, but are not limited to, floodplain, lakeshore protection, wetland protection, building permits, site plan requirements, and engineering permits. While the most important reasons to comply with the Code should be safety and protection of the environment, there are also potential financial consequences. Below are some possible civil infraction citations and fines contained in Chapter 2 of the City Code related to lakes. It is important to know these **fines can be assessed per day** of continued violation:

- Filling or excavating in a floodplain without a permit - $50 **per day**
- Removal of trees without permit - $50 **per day**
- Construction without a permit - $200 **per day**
- Land clearing, excavation or fill without site plan approval - $200 **per day**

Beyond the City, State agencies such as Florida Department of Environmental Protection (FDEP) and the Florida Fish and Wildlife Conservation Commission (FWC) have their **own regulations** and enforcement procedures.

Everything is connected

No matter where you live, you can help protect our lakes with these 8 simple choices at home...

Best Management Practices

There are many Best Management Practices (or BMPs) that you can apply at home to help protect our watersheds. ***Even if you don't live on a lake, your daily choices can make a real difference****. Following are just a few examples of good BMPs.*

1. Keep Grass Clippings, Leaves, and Other Yard Waste Out of the Streets and Storm Drains

Grass clippings, leaf litter, and other yard waste are major yet often overlooked sources of pollution. If allowed to enter the storm drains, these can lead to clogging and street flooding, and as they decay, the excess nutrients pass into our streams and lakes, contributing to poor water quality. Rather than letting it get into streets and storm drains, keep yard waste at home and put it to work for you instead through recycling or composting, or dispose of it properly by having it picked up on your yard waste day.

2. Water Efficiently and Only When Needed

A yard that thrives mainly on rainfall once plants are established conserves Florida's precious water resources and saves money on your water bill. A few tips to conserve water are 1) Group plants with similar water needs together, 2) Water your lawn and plants only when they show signs of stress. Let your plants tell you when they need water, 3) Put a rain gauge in your yard to track rainfall and avoid unnecessary watering, 4) Use rain sensors and have a soil moisture sensor or other smart irrigation technology connected to your irrigation system, and 5) Mow lawns high to encourage a deeper, more drought- and pest-tolerant root system.

3. Use Fertilizer, Pesticides, & Herbicides Appropriately & Only When Needed

Using fertilizer appropriately reduces potential pest problems and maintenance requirements. Unnecessary fertilizer can burn root systems, make plants more susceptible to pests, and severely pollute our water supply. Managing insects, diseases, weeds, and other pests using Integrated Pest Management (IPM) methods allows you to reach optimum health in your landscape and minimizes the risk of pesticide contamination in your yard and in our water supply. Find out more about fertilizer and IPM at ***casselberry.org/lakes****.or* ***seminolecountyfl.gov/fertilizer***

To find out more about these and other Best Management Practices to help protect our lakes and water resources, visit casselberry.org/lakes

4. Dispose of Household Hazardous Waste Appropriately

Household Hazardous Waste (HHW) includes many common products such as paints, solvents, insecticides, batteries, fluorescent lights, and much more. Improper disposal of these items can lead to health hazards and damage to our water resources. Disposal of HHW is free of charge for the residential households of Seminole County. HHW items are not picked up at curbside and require special handling and disposal. HHW is accepted FREE OF CHARGE at all times during regular business hours at the Seminole County Central Transfer Station. In addition, free Tire Collection Events are held several times a year at the Central Transfer Station and Seminole County Landfill—proper disposal of tires helps reduce pollution and mosquito breeding.

5. Choose the Right Plant for the Right Place

Choosing low maintenance plants and planting them in areas that already have the light, soil, and water conditions they require conserves water, reduces the amount of chemicals near your home and in our threatened waterways, and saves time and money by having healthier plants that need less fertilizer, pesticides, water, and pruning.

6. Reduce Runoff—Plant a Rain Garden or Use Rain Barrels

Stormwater runoff can contribute to flooding and water quality problems as it carries excess nutrients and other pollutants to our lake systems. However, stormwater runoff can also be a useful resource if managed well. Rain gardens and rain barrels are two ways to intercept runoff at your home and use it for your landscape needs. With careful planning and plant selection, you can conserve water and save money while also helping protect our lakes and streams. Be sure to visit the City's Lake Concord Park's demonstration rain barrel and rain garden installations, which can help inspire your own project at home.

7. Clean Up After Pets & Avoid Feeding Wildlife

Please ***pick up after pets, even in yards at home****, and dispose of the waste. Otherwise, as it rains, this concentrated source of nutrients can leach into the lakes and* ***cause harm****. Even for properties not near a lake, runoff from pet waste can reach streets and storm sewers, which ultimately flow to our lakes. Also, water fowl can be a great example of natural wildlife, but feeding them can result in high concentrations of birds that our urban environment cannot support. Not only can this be harmful to our lakes, it can be harmful to the birds themselves by disrupting their natural, healthy diet and migratory patterns.*

8. Report Suspected Illegal Dumping, Improper Disposal, Illicit Discharges, and Water Pollution

You can use the Seminole County Watershed Atlas website to ***report discharges or dumping*** *into lakes, streams, rivers, canals, ditches, stormwater ponds, or even into a manhole, storm drain or curb inlet in the street. You can also use it to report apparent* ***water pollution*** *events and other environmental issues such as algal blooms and fish kills. The Atlas also provides useful information about many of the lakes throughout Seminole County. Access the Watershed Atlas online at* ***seminole.wateratlas.org***

Natural, Beautiful, Vital—

Natively Vegetated Shorelines Protect Our Lakes

*There are a variety of native aquatic plants that benefit Florida's lakes and can be used in re-vegetation projects—below are just a few. Visit **casselberry.org/lakes** to see more plant lists, pictures, descriptions, and benefits.*

Bald Cypress
(Taxodium distichum)
Bald Cypress is a Florida native and Florida-friendly tree often found in wetlands and lake shorelines. It prefers full sun and is highly drought tolerant, and so it is well suited to wet-dry cycles. Bald Cypress is a deciduous tree; its leaves turn brown and are shed during the fall and winter months, giving it a bare or "bald" appearance.

Cord Grass
(Spartina bakeri)
Cord Grass is a Florida native and Florida-friendly grass that prefers full sun. It is highly drought tolerant but can also withstand extended periods of flooding, making it an excellent choice for revegetating shoreline and upland areas near lakes. Cord Grass also provides good erosion control.

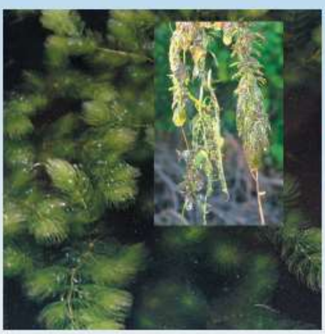
Golden Canna
(Canna flaccida)
Golden Canna, also called the Yellow Florida Canna Lily, is a Florida native and Florida-friendly flower that produces showy yellow flowers, its most identifiable feature. Golden Canna attracts butterflies and prefers full sun and moist soils. It is often found along shorelines of lakes and ponds and is an excellent plant for transitional areas where moisture levels fluctuate.

Pickerelweed
(Pontederia cordata)
Pickerelweed is most easily recognized by its bright lavender flowers, which attract bees and butterflies. It blooms from late spring to early fall. Pickerelweed is a Florida native plant commonly found near water's edge of lakes and ponds. It is very hardy and prefers full sun.

More native, beneficial species...

Lance-leafed Arrowhead
(Sagittaria lancifolia)
Lance-leafed Arrowhead is most easily distinguished from other wetland plants by its showy white flowers on tall bloom spikes. It blooms from late spring to early fall. It is also known as duck potato, in reference to underground, potato-like "corms" that sometimes form. Arrowhead is a Florida native plant commonly found near water's edge of lakes, swamps, and streams. It prefers full sun.

Spatterdock
(Nuphar advena)
Spatterdock has heart shaped leaves and distinctive yellow flowers. Much of the plant is underwater, including large, rootlike "rhizomes" that spread and sprout the floating portions of the plant. Spatterdock provides good shade and habitat for fish and competes against invasive plant species such as hydrilla for space, light, and nutrients. Other similar natives such as fragrant water lily provide similar benefits.



Coontail
(Ceratophyllum demersum)
Coontail (a common name due to its feathery leaves arranged in whorls on its stem, resembling a raccoon's tail) is a submersed (below the water surface), free floating plant. Coontail is a beneficial native that provides valuable fish habitat and improved water clarity. It is ***often mistaken for invasive hydrilla****, as are many other native submersed species such as chara (muskgrass) and southern naiad.*

Eelgrass
(Vallisneria americana)
Eelgrass, also known as tape grass, is a submersed beneficial native plant. It provides fish habitat, improved water quality, as well as competition for invasive hydrilla.

Non-native, invasive plant species—below are just a few to watch out for!

Hydrilla
(Hydrilla verticillata)

Hydrilla is an aggressive submersed (underwater) plant. It can grow and expand very quickly. If broken into pieces, each piece can grow into a separate plant. Thus it spreads easily, and so it is important to ***inspect boat equipment for remnants*** *of the plant. It outcompetes many beneficial, native submersed species. Millions of dollars are spent each year in Florida attempting to control hydrilla by chemical (herbicide), mechanical (harvesting), and biological (grass carp) means.*

Parrot feather
(Myriophyllum aquaticum)

Parrot feather is an emersed (rising above the water surface) aquatic plant. It gets its name from its feathery, bright green leaves. It's frequently found in lakes and canals.

Torpedograss
(Panicum repens)

Torpedograss is an aggressive invasive weed commonly found in Florida near canal banks and lake shorelines. It can grow on land and in the water, quickly displacing native, beneficial vegetation.

Water hyacinth
(Eichhornia crassipes)

Water hyacinth is an aggressive invasive that is a problem in much of the world, including Florida. It is a floating plant that links to form large mats that can clog waterways and impede navigation.

More non-native, invasive plant species...

Alligator weed
(Alternanthera philoxeroides)

Alligator weed is a common invasive species found in Florida. It can grow in the water or on land, and it can form sprawling mats. Alligator weed is one of a handful of success stories for "biological control": in the 1960s and 70s, three South American insects were released in Florida that together have largely kept the weed in check. However, it is still present to some degree in over 80% of Florida's public waters.

Wild Taro
(Colocasia esculenta)

Wild taro is a very common non-native, emersed plant that can grow in the water or on land. Its sap can irritate the skin, and if ingested raw, all parts of the plant can cause irritation. It often outcompetes native species, forming dense growths near lake shorelines and in wetland areas. Wild taro is similar in appearance to another non-native species Xanthosoma sagittifolium (called elephant ear) that can grow even larger but is less widespread.

Brazilian pepper
(Schinus terebinthifolia)

Brazilian pepper is a very aggressive invasive tree, commonly found in both aquatic and upland habitats. Brazilian pepper may exhibit allelopathic abilities, meaning it inhibits growth of other plant species, thereby reducing native habitat. Cutting and removing brazilian pepper alone does not typically control it—herbicides are typically needed to prevent remnant stumps from sprouting new growth.

Chinese tallow
(Triadica sebifera)

Chinese tallow, also called the popcorn tree due to the appearance of its seeds, is an aggressive invasive tree commonly found in Florida in a variety of habitats. Chinese tallow historically was used as a popular landscape ornamental in Florida, in part due to its attractive fall foliage. Unfortunately, its seeds are easily dispersed by birds and streams, so it has become a serious invader and disruptor of native Florida habitat. Attractive native alternatives to Chinese tallow include red maple (Acer rubrum) and river birch (Betula nigra).

Additional Online Resources

casselberry.org/lakes

A comprehensive one-stop resource for lake-related information for the City of Casselberry. There you will find information on upcoming projects, educational events, water quality reports, plant lists, and many additional resources. A PDF version of this Lake Guide is also there!

seminole.wateratlas.org

This link will take you to the Seminole County Watershed Atlas, a valuable resource for lake-related information for all of Seminole County. There you will find information on lakes in the County, upcoming events, and you can even ***report water pollution****.*

myfwc.com

This is the website for the Florida Fish and Wildlife Conservation Commission (FWC). There you can find out information about boating requirements, aquatic plant management permitting, grass carp, wildlife, and more. You can also use this website to ***report wildlife law violations****.*

seminolecountyfl.gov/fyn

Use this website to find out more about the nine principles of Florida Friendly Landscaping, upcoming free Florida Yards and Neighborhoods classes, and a wealth of other Extension Services offered through Seminole County and the University of Florida Institute of Food and Agricultural Sciences (IFAS).

floridayards.org

This is a good companion site for Florida Friendly Landscaping information. It includes a Florida Friendly Plant Database—a great reference when choosing plants!

plants.ifas.ufl.edu/guide

This is the website for Plant Management in Florida Waters. Use it to find out more about native, beneficial and non-native invasive aquatic plants.

Seminolecountyfl.gov/serv

Find out more about the Seminole Education, Restoration & Volunteer Program (SERV) at this website. Volunteer lake restoration and invasive plant removal projects are coordinated through this program. It's a great way to get involved hands-on!

lakewatch.ifas.ufl.edu

Find out more about Florida Lakewatch: Florida's volunteer water quality monitoring program and how to get involved.

dep.state.fl.us/water/wetlands

Find out more about the Florida Department of Environmental Protection (FDEP) Environmental Resource Permitting (ERP) program and whether your project (e.g., docks and seawalls) may need a separate FDEP permit.

casselberry.org/greenup

A "sister" site to the City's lakes website, this website provides information on Green Up Casselberry projects and related educational programs and other events.

Lake Management Quick References

General Inquiries (When In Doubt!) call Casselberry Public Works (407) 262-7725 or visit casselberry.org/lakes for more information

Water Quality Concerns

- Check water quality of individual lakes and report illegal dumping , pollution, or illicit discharge at **seminole.wateratlas.org**

Go "Green" With Florida Friendly Landscaping

- Follow the City's adopted fertilizer regulations. There is a Nitrogen and Phosphorous blackout period from June 1– September 30 and a minimum of 50% slow release nitrogen at all other times, excluding exemptions
- Follow the nine principals of Florida Friendly Landscaping/ Florida Yards & Neighborhoods: **seminolecountyfl.gov/fyn**
- Avoid letting grass clippings, leaf litter, or other yard waste enter storm inlets

"Beaches", Seawalls, and Docks

- Do not install "beaches"
- Carefully plan and permit docks and seawalls to minimize impact; both require City permits and FDEP review: **dep.state.fl.us/water/wetlands**

Aquatic Plant Management and Shoreline Restoration

- Native vegetation can provide a beautiful shoreline, erosion protection, and native habitat
- Ask the City and FWC for guidance before engaging in any clearing or herbicide application: **myfwc.com/license/aquatic-plants** or contact Kristine Campbell at **(407) 204-3306**
- Inspect boating equipment for invasive plant remnants to avoid cross contamination

Fish Stocking

- Check with FWC for more info: for grass carp **(407) 204-3306**; for game fish **(352) 732-1225**

Floodplain and Flood Insurance

- Find out if you are in the 100 year floodplain: **msc.fema.gov**
- Find out more about flood insurance: **floodsmart.gov**
- The City can provide you the flood elevation for your property– call **(407) 262-7725**

Pet Waste and Feeding Water Fowl

- Pick up after pets using biodegradable pet waste bags
- Avoid feeding waterfowl to avoid overpopulation and disease

Boating, Blueway Trail System, and No Wake Zones

- Be aware of boating rules, wake restrictions, and operating hours in Chapter 94 of City Code: **municode.com**
- Report state boating or wildlife law violations to FWC at **(888) 404-3922**
- Wear personal flotation devices, and get mandatory education if under 21: **myfwc.com/boating**

Septic Tanks and Sanitary Sewer Availability

- Make sure septic systems are operating properly and well maintained
- Switch to sanitary sewer when available (call **(407) 262-7725** to check availability)

Permitting Requirements

- **For any construction, filling, or clearing activity near lakes, always ask first: Public Works (407) 262-7725**

Attachment C:

Casselberry Quarterly Newsletter

The Casselberry Quarterly

The City of Casselberry Newsletter

Vol. 1 April/May/June 2018

IN THIS ISSUE:

More information on page 12.

CONNECT WITH US

T: 407-262-7700 F: 407-262-7745

95 Triplet Lake Drive

Casselberry, FL 32707

www.casselberry.org

JOIN A GOLF LEAGUE AT THE CASSELBERRY GOLF COURSE.

SEE PAGE 22

Dear Casselberry Residents and Interested Readers,

We hope you enjoy this first edition of *The Casselberry Quarterly.* This City of Casselberry newsletter will be published on the City's website every three months to bring you news of recent legislative actions taken by the City Commission that may affect City residents and/or business owners, information on upcoming special events and activities, and items of special interest that are intended to inform and prove beneficial to the reader. You can also sign up at www.casselberry.org/notifyme to receive an email notification when a new newsletter has been published.*

Please take a few moments to peruse the newsletter and let us know of additional information you would like to see included in the next edition which is scheduled for publication in July. You can email your comments directly to cityhall@casselberry.org . Thank you and happy reading.

- Under Florida law, e-mail addresses are public records. If you do not want your e-mail address released in response to a public-records request, do not send electronic mail to this entity. Instead, contact this office by phone or in writing.

Casselberry City Commission

Charlene Glancy
Mayor/Commissioner
Seat No. 5
Phone: (407) 929-8947
Email: cglancy@casselberry.org
Re-Elected: 2016

Andrew Meadows
Vice Mayor/Commissioner
Seat No. 2
Phone: (407) 262-7700 Ext. 3101
Email: ameadows@casselberry.org
Elected: 2014
Term Expires: 2018

Bill Hufford
Commissioner
Seat No. 4
Phone: (407) 699-9194
Email: bufford@casselberry.org
Elected: 2016

Sandra Solomon
Commissioner
Seat No. 3
Telephone: (407) 575-9899
Email: ssolomon@casselberry.org
Re-Elected: 2014

Anthony Aramendia
Commissioner
Seat No. 1
Telephone: (407) 695-6069
Email: aaramendia@casselberry.org
Re-Elected: 2014

Casselberry has the City Commission-City Manager form of government. The Casselberry City Commission consists of five members who are elected to serve four year terms and are limited to serving three consecutive terms in office. All members of the City Commission, including the Mayor/Commissioner, serve at large, meaning they represent the entire City and not specific districts or neighborhoods.

You can email all five members of the City Commission at once by sending your email to:

commission@casselberry.org

**Under Florida law, email addresses are public records. If you do not want your email address released in response to a public records request, do not send electronic mail to this entity. Instead, contact this office by phone or in writing.*

COMMISSION REPORT

Highlights of approved items by the City of Casselberry City Commission January—March 2018.

ORDINANCES

- Ordinance 18-1475 expanded the membership on the Parks & Recreation Advisory Board to include an alternate member.
- Ordinance 18-1476 updated the City's flood regulations.
- Ordinance 18-1478 voluntarily annexed ten parcels on Red Bug Lake Road near the intersection of Eagle Circle into the City limits.

RESOLUTIONS

- Resolution 18-3003 terminated the Declaration of a State of Public Emergency related to Hurricane Irma.
- Resolution 18-3005 provided for a piggyback agreement with Waste Pro for residential solid waste collection services.
- Resolution 18-3006 requested the Florida Fish & Wildlife Conservation Commission to declare the City a bird sanctuary.
- Resolution 18-3007 provided for an amendment to the Police Department inter-agency agreement with the Seminole County Sheriff's Office for criminal justice computer services.
- Resolution 18-3011 amended the Fiscal Year 2018-2022 Capital Improvement Program to add $200,000 for Secret Lake Park Improvements in Fiscal Year 2019.
- Resolution 18–3013 established a procedure for developers to vest from the new Seminole County Educational System Impact Fees for a limited time.

CONTRACT AND AGREEMENTS

- Approval of Contingency Change Order No. 6 with Wharton-Smith, Inc. for final construction issues for the Lake Concord Park and the Triplet Lake Drive Signature Street Projects.
- Approval to piggyback the Florida Sheriff's Association and the City of Tallahassee contracts for purchase of nine marked and three unmarked Police vehicles and associated equipment.
- Approval to piggyback the Florida Sheriff's Association for purchase of two service trucks for the Public Works Department.
- Approval of contract renewal with Universal Engineering Sciences for building official, inspection and permitting services.

OTHER ITEMS

- Recognition of a COPS grant for three new entry level police officers.
- Approval to consider acquisition of additional park land when it becomes available.
- Approval to preserve the "Northeast Industrial Park" properties for future park space.
- Approval to complete master site plans for improvements to six identified parks.
- Approval to pursue a bond referendum to fund park service enhancements.
- Considered the design scope for the Sunset Drive Livable Street Improvement project.
- Approved a grant application for Secret Lake Park Redevelopment Project.
- Awarded funding of the 2017-18 Neighborhood Improvement Grants.

2018 Events in Casselberry

January
Jan. 12: Art & Music in the Park & The Food Truck Bazaar
Florida Artists Group at Casselberry Art House

February
Feb 9: Art & Music in the Park & The Food Truck Bazaar
Feb. 17: Mardi Gras Music Festival
SCPS AP Art Student Exhibit at Casselberry Art House

March
March 9: Art & Music in the Park & The Food Truck Bazaar
March 31: Spring Jazz & Art Festival
Artists League of Orange County at Casselberry Art House

April
April 13: Casselberry Folk Festival
April 14: Spring Egg Hunt
April 28: EarthFest 2017
Recycled Art Exhibit at Casselberry Art House

May
May 5: Wine on Nine at Casselberry Golf Club
May 9: Celebrate Casselberry History!
May 11: Art & Music in the Park & The Food Truck Bazaar
May 19: Central Florida Top Brewer
May 26: Hot Rods & Rock 'N Roll Car Show & Concert
Seniors & Students Exhibit at Casselberry Art House

June
June 8: Art & Music in the Park & The Food Truck Bazaar
June 16: Get Outdoors Casselberry!
Nature's Embrace Exhibit at Casselberry Art House

July
July 13: Art & Music in the Park & The Food Truck Bazaar
P.O.W. Artists Exhibit at Casselberry Art House

August
Aug 10: Art & Music in the Park & The Food Truck Bazaar
Aug 18: Runyak
The Artist's Way Exhibit at Casselberry Art House

September
Sept 14: Art & Music in the Park & The Food Truck Bazaar
Sept 15: Battle of the Bands 5K
Sept 28: Swing "Fore" The Arts Golf Tournament
Sept 29: Latin Jazz & Art Festival
Sanford Seminole Art Association Exhibit at Casselberry Art House

October
Oct 12: Country Music Festival
Oct 20: iLLuminArt & Sculpture Walk Event
Oct 27: Franklin's Friends Howl-O-Ween
Oct 27: Community Fall Festival
Florida Sculptor's Guild Exhibit at Casselberry Art House

November
Nov 3: Hook Kids on Fishing
Nov 5: Casselberry Chamber of Commerce Food & Wine Fest
Nov 9: Craft Beers & Blues Festival & The Food Truck Bazaar
Rotary Calendar Art Exhibit at Casselberry Art House

December
Dec 8: Holiday Tree Lighting Ceremony
Dec 11-13: Santa Claus Comes to Town
Dec 14: Art & Music in the Park & The Food Truck Bazaar
Dec 15: New Hope for Kids Holiday Bike Ride
Florida Painters Exhibit at Casselberry Art House

Event dates and times may change. Please visit us online for full event calendar.

For more information, visit our website at
www.casselberry.org or call 407-262-7700 ext. 1507

CASSELBERRY

Earth Fest 2018

Central Florida's 2nd Largest Earth Day Event !

Saturday
April 28, 2018
10am to 3pm

Lake Concord Park
95 Triplet Lake Drive
Casselberry, FL 32707

FREE! FREE! FREE!

Fun activities include:

Live Music - **Beth McKee & The Swamp Sistas**
Human-Powered Snow Cone Machine
Great Butterfly Release
Eco-friendly Vendors
Recycled Art Exhibit
Kid-friendly Art Workshops
Planting Seminars
Great Food • Door Prizes • FREE Trees !
Lady Bug Booth • Butterfly Tent
Bee Keeping Tent • Central Florida Petting Zoo
...and much more...
Fun for the whole Family ...even Fido !

Friends of the Park
wekiva ISLAND
Rotary Club of Casselberry
Keep Seminole Beautiful
Swamp Sistas Songwriters Circle
Central Florida Zoo & Botanical Gardens
Green Up Casselberry Growing Community
TravelCountry.com Gear for Your Outdoor Adventure
Waste Pro Caring For Our Communities
Walmart Save money. Live better.

GREEN UP CASSELBERRY
GROWING COMMUNITY

City of Casselberry

Arbor Day Celebration

Saturday, April 28th, 10am-2pm

During EarthFest 2018
at Lake Concord Park

Free Trees!

One Tree Per Adult

Participants must attend one educational EarthFest workshop for a free tree ticket.

For more information, call 407-262-7700 Ext. 1229
or email mwilliams@casselberry.org | www.casselberry.org

Arbor Day Foundation

TREE CITY USA

WAL★MART

Casselberry Celebrates

OLDER AMERICANS MONTH

ENGAGE AT EVERY AGE: MAY 2018

"You are never too old (or young) to take part in activities that enrich your physical, mental and emotional well being... "

Older Americans Month Casselberry Schedule of Events

May 7 –May 31 Casselberry Art House Senior Exhibit
Hours are 10 am until 5 pm, Monday-Friday.

May 4 Senior Spring Dance Live music, dinner and dance at the Recreation Center from 5-8 pm. Cost is $7 per person.

May 9 Celebrate Casselberry History! Share your stories, Casselberry photos and memorabilia. Light refreshments will be served at this very special occasion at the Recreation Center from 10 am until 1 pm.

May 18 Community Health Fair Vendors, booths and door prizes, from 9 am – noon at the Recreation Center.

May 19 SSAA/ALOC Art Show Free art event at the Recreation Center from 1-3 pm.

May 26 FREE Rock N' Blues Concert & Car Show at Lake Concord Park Casselberry Veteran's Club recognizes all veterans on the big stage at 6 pm. Event hours are 5-9 pm.

CASSELBERRY

Seniors for a Better Community

ART & MUSIC IN THE PARK
AND THE FOOD TRUCK BAZAAR

Every 2nd Friday - Free Entertainment - Free Parking - Great Food!
Lake Concord Park | 95 Triplet Lake Drive | Casselberry, FL 32707

Live Music * More than 15 Gourmet Food & Dessert Trucks * Art Exhibits
About 30 Local Businesses & Artisan Booths * Kids Climbing Wall

Forlorn Strangers

Friday | April 13 | 5-9 pm

Part of the 1st Annual Casselberry Folk Fest!

GT Jam Campaign

Friday | May 11 | 6-9 pm

Dave Capp Project with Frances Neil

Friday | June 8 | 6-9 pm

CASSELBERRY

THE DAILY CITY FOOD TRUCK BAZAAR
THE NATION'S FIRST TRAVELLING FOOD TRUCK EVENT!

For more information visit www.casselberry.org or call: 407-262-7700 Ext. 1507

Wine on Nine Golf Tournament

Casselberry Golf Club
300 South Triplet Lake Drive

Sat., May 5, 2018 4 -7 PM

Nine holes of Golf and Wine Tasting

4:00 PM check in

4:30 PM Shotgun Start

Cost is $35 per player
$60 per Twosome
$100 per foursome

Single players will be paired with other golfers.

Prizes for 1st, 2nd and 3rd place teams

Casselberry Golf Club

Wine tasting at 3 of the 9 holes.
Event ends under the oak trees next to the clubhouse, with live entertainment, hors d'oeuvres, and a silent auction.

****New this year– Prize for best Dressed Team! ****

For more information, call:
Joanne at 407-262-7700 x1127

Tee up and wine down - show your support for parks and the arts!

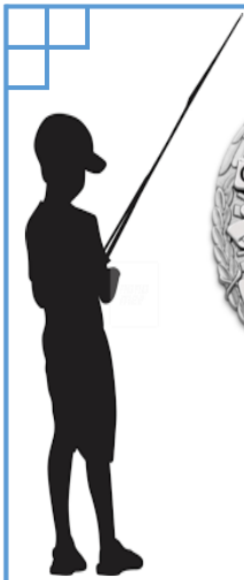
All proceeds will support park beautification projects and arts and culture in Casselberry and throughout Seminole County.

Casselberry Golf Club · Casselberry · Friends of the Park · Integra Lakes · Keep Seminole Beautiful

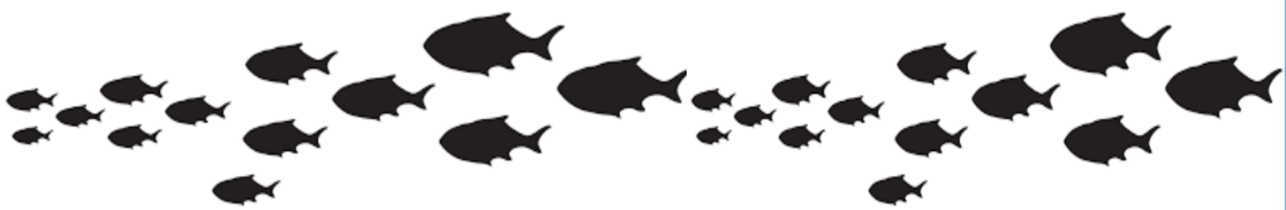
2nd Annual Bike Casselberry

MAY 5, 2018

The Cities of Casselberry, Maitland, Orlando, and Winter Park; the Town of Eatonville; Winter Park Health Foundation; FDOT; Bike/Walk Central Florida; and other partners jointly present the 2nd Annual Bike 5 Cities; a 28+ mile bike ride through these Five Central Florida Cities. As part of the event, Casselberry will host **"Bike Casselberry"** again **at Wirz Park.** This event will include family-friendly bike activities at the park as well as a shorter family-friendly fun ride featuring portions of the Casselberry Greenway Trail. For more details on this event, please visit www.casselberry.org/go.



KIDS-N-COPS FISHIN' DERBY 2018



A day where deserving children will spend hours fishing with Local Police Officers, Deputies and Troopers.

On Saturday, May 12th, 2018 from 8am—2pm at Secret Lake Park in Casselberry, local Law Enforcement will reward elementary school students for their scholastic achievements by spending the day teaching them how to fish and assisting them in a Fishin' Derby!

All proceeds will benefit the Kids House of Seminole.

To sign up to volunteer or for more info contact: Ofc. Sullivan at 407-840-4087 or hsullivan@casselberry.org

ROCK N' BLUES CONCERT & CAR SHOW

Saturday * 5-9:00pm * May 26, 2018

Lake Concord Park * 95 Triplet Lake Dr. * Casselberry

105.9 Sunny FM

CASSELBERRY

Cruisin Orlando

Casselberry City Hall Art Exhibits

Quarterly Art Exhibits Featuring the Area's Top Artists

Splash Into Summer at Wirz Park Pool!

Wirz Park Pool Opens on Saturday, May 26 at Noon!

Open Swim from 12pm – 6pm

Sunday – Saturday

(Weather Permitting)

Fees:

- $2 – Daily Resident Swim
- $3 – Daily Non-Resident Swim
- $50 – Resident Season Pass Individual
- $70 – Resident Season Pass Family
- $70 – Non-Resident Season Pass Individual
- $90 – Non-Resident Season Pass Family

Wirz Park Pool is open from Memorial Day Saturday until Labor Day Monday. The pool is open daily until Seminole County Public Schools return to session when weekend-only hours begin.

CASSELBERRY

American Red Cross

Learn-to-Swim

Swim Lessons Available!

Register for Swim Lessons at Wirz Park Pool

For Ages 3 and up beginning June 4.

4 – 45 minute lessons for $35.00

9AM and 10AM Sessions

Monday, Wednesday, Friday, & Saturday Mornings

American Red Cross Certified Instructors

Wirz Park Pool: 407-236-7177

Contact Rob Bickerstaff for more info: rbickerstaff@casselberry.org


2018 City of Casselberry
SUMMER CAMP
Monday-Friday
7am Early Drop-off
8:30am-4pm Daily Activities
4-6pm Movie Time
June
4-8 - Welcome Week - Roller Skating
11-15 - Animal Adventures - Central FL Zoo
18-22 - Sports - Field Day & BBQ
25-29 - Mad Science - Orlando Science Center
July
2-6 - Wacky Water - Canoeing/Water Slides
9-13 - Olympic Week - WonderWorks
16-20 - Game On! Week - Monkey joes
23-27 - Art & Talent Week - Crayola Experience
Schedule
Casselberry Residents
$95 per week
Non Residents
$120 per week
Payment plans available
2nd child discount $5
Fees includes daily breakfast and lunch, and weekly field trips
Fees
Weekly Swimming
Arts & Crafts
Sports & Games
Weekly Themes
Field Trips
Educational Guests
and much more!
Activities
JUNE 4 TO JULY 27
Open to children entering 1st-7th Grade
Registration Begins April 4th!
CASSELBERRY
www.casselberry.org
Location: Casselberry Elementary, 1075 Crystal Bowl Cir. (Mon.-Thurs.)
Secret lake Park, 200 N. Triplet Lk. Dr. (Fridays) & Weeks 5 & 8
For more info: 407-262-7700 Ext. 1508
amonnett@casselberry.org

Casselberry Art House

127 Quail Pond Circle | Casselberry

education | exhibitions | enrichment

Since 2002, the Casselberry Art House offers community space for art classes, art exhibitions, educational programs, workshops, artist lectures and musical performances for all ages.

Adult Art Classes

Alcohol Inks
Mon. 6:30 - 8:30 pm
Supplies are not included; a supply list is provided online for the class.

Ceramics
Mon. Classes 6:30 - 8:30 pm
25 lbs. of clay and basic tools are provided per each six-week session.

Advanced/Intermediate Watercolors
Tues. 6 - 8 pm
Master watercolor artist Ken Austin guides students through the world of watercolors!

Oil Painting
Tues. 6:00 - 8:00 pm
Supplies are not included; a supply list is provided online for the class.

Acrylic Painting
Wed. 6:00 - 8:00 pm
Supplies are not included; a supply list is provided online for class.

Photography
Thurs. 7:00 - 8:30 pm & Sat. TBA
Must have DSLR with interchangeable lens. Thursday class instruction and Saturday field expedition!

Youth Art Classes

Design! Create! Repeat!
Weds. 4:00 - 6:00 pm
Students will have fun and make are with repetitive patterns. Supplies included. Ages: 5 to 11.

Preschool Clay Class
Weds. 10:00 - 11:45 am
Supplies included! Great class for parents and little ones! Ages: 3-5

Pottery Club for Kids
Weds. 11:00 am - 12:00 pm
Supplies included! Parents welcome! Ages: 5-10

Teen Urban Art
Thurs. 5:30 - 7:00 pm
Learn techniques and think outside the box! Ages 12 - 18.

Workshops

Zentangle Workshop
Sat. 10:30 am (monthly)
Supplies are included!

CASSELBERRY ART HOUSE

Seniors

Senior Painting Group
Fri. 12 pm - 4pm
FREE! Art supplies not included. Come paint with friends.

CASSELBERRY

For more details or class fees contact the Casselberry Art House: 407-262-7700, Ext. 1122 or jcosta@casselberry.org
Online registration available for youth art classes at: www.casselberry.org

SUMMER ART ACADEMY

AT THE

CASSELBERRY ART HOUSE

June 4 - July 27, 2018

Monday - Friday, 9:00 AM - 12 PM

(8 individual 1-week Sessions/No classes July 4)

Painting, Drawing, Ceramics, Mixed Media and More!
Different Medium Every Week!

$65 / Week - Casselberry Residents
$85 / Week - Non-residents
Register online: www.casselberry.org

CASSELBERRY

CASSELBERRY RECREATION

Adult Programming

BINGO – Monday & Wednesday 9:00am – 11:00am. Secret Lake Park Recreation Center. Come enjoy a great morning of Bingo twice a week! $4 gets you in for 21 games of Bingo!

CHAIR YOGA – Monday at 10:00 am – $2 per class. Come enjoy a calming morning of seated yoga. Chair Yoga is great for those who may have limited mobility and offers an excellent way to help center the mind body and spirit.

CHAIROBICS – Monday and Wednesday - 11:05 am – 12:05 pm - $2 per class; Free for Silver Sneakers – Chairobics is a seated exercise class that is perfect for those who may have limited mobility but still want to burn calories. Show up early for your first class to meet the instructor and sign up.

TAI CHI – Beginners Monday at 1:00 pm, Intermediate Tuesday at 1:00 pm and Advanced on Thursday at 1:00 pm – Tai Chi is an exercise program based in Classic Chi Gung (Ch'ih /Qi Gong), mime, dance, yoga, and pilates. As such it emphasizes flexibility, strength, balance, posture, coordination, kinesthetic awareness, mental focus, and relaxation. Show up early to meet the instructor and discuss fees.

TAP DANCE – Beginners Tuesday 11:00 am – 12:00 pm – Put on your tappin' shoes and get back on the dance floor with the Tap Dance class. Students will learn all types of tap steps, dances, and routines in this course. Please arrive early to speak with the instructor and register.

LINE DANCING – Wednesday at 1:00 pm - $2 per class. Join this adult line dancing group every Wednesday afternoon for a fun time learning great line dancing routines and steps.

LINE DANCING With STYLE – Sundays 6:30 – 8:30pm, Secret Lake Park Recreation Center. A high-energy Line Dancing class with Ivan Mao

HOEDOWNERS – Sunday 1:00 pm – 5:00 pm – Join the Hoedowners every Sunday for "Pairs and Spares" Line dancing and circle dancing. 1:30 - 2:30 Mainstream Workshop, 2:30 - 4:30 Club Dance. http://www.squaredancesites.com/casselberry_hoedowners/

DANCE CLUB OF CENTRAL FLORIDA – Sunday 3:30 pm – 6:30 pm. Between the open dancing sessions, a professional instructor gives two 30-minute lessons in two different dance styles. The lessons always start at the absolute-beginner level and always end with something to challenge the more accomplished dancers. Admission: $5 http://www.danceclubofcentralflorida.com/

CASSELBERRY RECREATION

Adult Programming

DO YOU PLAY BRIDGE?

Come join these great groups for weekly games and enjoyment. Arrive early to meet the organizers and sign up at Secret Lake Park Recreation Center.

DUPLICATE BRIDGE – Monday at 12:30 pm

CASUAL BRIDGE – Tuesday at 12:00 pm

PROGRESSIVE BRIDGE – Thursday 12:30 pm.

ZUMBA & STRONG ZUMBA W/VANESSA (Rec Center & Wirz Park) – Monday and Wednesday (Rec Center) 7:30 pm – 8:30 pm; Tuesday 7 pm – 8 pm and Friday 6:00 pm – 8:30 pm (Wirz Park). Come burn some calories and get your dance on with Vanessa in her weekly Zumba classes. Zumba is a high-energy dance fitness class. Arrive early to meet the instructor and register.

ZUMBA with LIZ: Tuesdays and Thursdays 5pm – 6pm Secret Lake Park Ballroom. First Class is Free!

SCRABBLE CLUB (Wirz Park) – Monday 7:30 pm – 10:30 pm – Everyone enjoys a good game of scrabble. Come play this word-creating board game on Monday nights with the Scrabble Club. Score big with this awesome group! Always welcoming new scrabblers!

CHESS CLUB (Wirz Park) – Thursday 6:00 pm – 10:00 pm – Love to play Chess? Well then this is the group for you. Gather weekly for rousing games on the black and white boards. Always welcoming new players!

YOGA WITH AURORA – Tuesday & Thursday 2:30 pm Secret Lake Park and Wednesdays at 6pm Wirz Park – Come Enjoy a relaxing hour of Yoga with Aurora. Join the serenity as you use your mind and senses to allow a feeling of peace, calmness and knowing wash over you.

CASSELBERRY RECREATION

YOUTH AND FAMILY PROGRAMMING

CASSELBERRY LITTLE LEAGUE – Youth Baseball, Softball, and T-Ball. Seasons in Spring and Fall. www.casselberrylittleleague.org

GREATER ORLANDO SOCCER ACADEMY – From your first kick of a soccer ball to premier developmental coaching and training. GOSA provides all your soccer needs. www.GreaterOrlandoSocceraAademy.com

IRISH DANCE – Monday and Wednesday 3:30 – 8:00 pm – The Tir Na Greine school of Irish Dance teaches traditional Irish Dance steps and techniques. Join the accredited instructors for this fun and unique class. Visit www.tirnagreine.com for additional information.

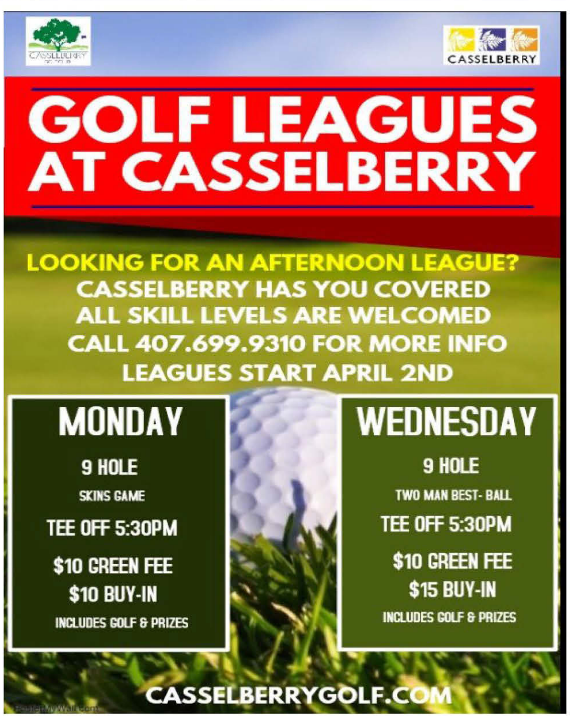
PRE-BALLET (CHILDREN Ages 3-6) – Monday 5:00 pm – Children will learn basic ballet movements, balance and rhythm while exploring dance through imaginative exercises. $40/month. Contact the instructor, Alicia, at akardell@scttech.com

TAE KWON DO – Tuesday and Thursday 6:00 pm – 7:30 pm
Alan's School of Tae Kwon Do and Self Defense focuses on hand techniques, ground techniques and practical applications to help you become well rounded.
Contact Alan Trueba at (407) 718-3672 for more information.

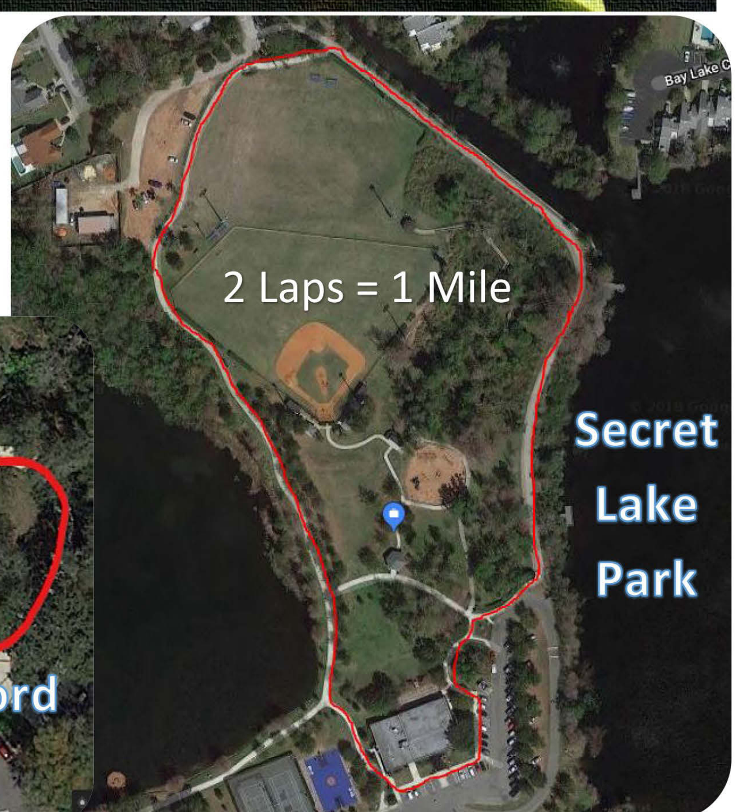
CHEERLEADING – Thursday 6:00 pm – 8:00 pm
DANCE - Saturday 10:00 am – 12:00 pm
Florida Youth Programs hosts its Cheerleading and Dance classes at the Casselberry Recreation Center. For more information, please visit www.floridayouthprograms.org

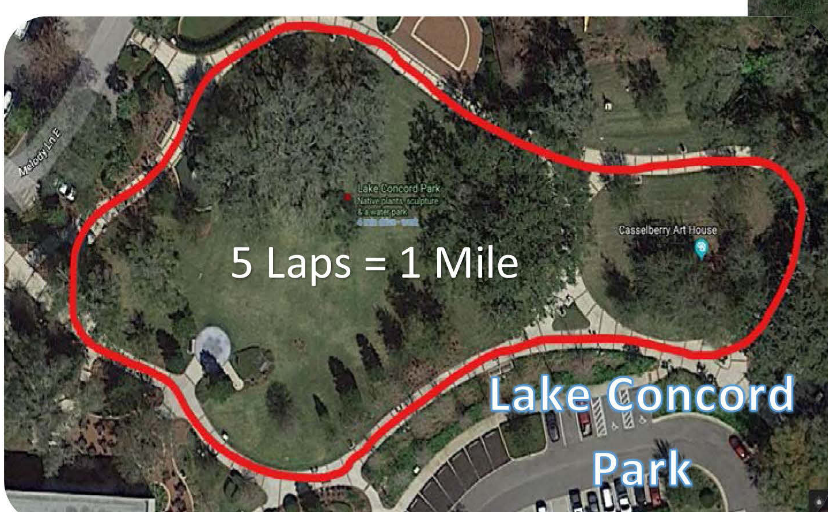
Come Hit the Links At

Casselberry Golf Club



Measured Walking Paths at Secret Lake and Lake Concord Parks





THE TOP FIVE RESIDENTIAL CODE VIOLATIONS

City Code Compliance Officers are hard at work trying to keep our City looking beautiful so be aware of the top five code violations for residential areas. You can also report a code violation via the City website through its Code Compliance portal. Click here for access.

1. **Yard Maintenance Standards** - Yard maintenance standards are the responsibility of every property owner and include the maintenance of plant material in any right-of-way abutting the property. Dead trees and limbs must be removed. Overgrown vegetation must be trimmed so as not to impair vision or obstruct the travel of motorists.

2. **Junk, Trash and Debris** - Junk, trash and debris cannot be left in the yard and must be disposed of properly. This includes auto parts, appliances, furniture, building materials, tires and trash and debris such as cardboard, plastics, tree trimmings, etc.

3. **Commercial Equipment** - Generally, commercial equipment and commercial vehicles may not be parked or stored in a residential area unless they are within a fully enclosed structure that was constructed with a permit. Certain business related vehicles are allowed on a residential property if they are parked within the side yard and screened from view. A maximum of one business related vehicle is allowed on a residential site.

4. **Inoperative Motor Vehicles** - Disabled and/or unlicensed vehicles cannot be stored on premises unless located in a carport or garage. A disabled and/or unlicensed vehicle is a vehicle that does not display a current license tag and/or is not equipped with all parts that are required to legally and safely operate on public streets and/or cannot be driven under its own power (whether or not designed for use on the public streets).

5. Outside Storage - Outdoor storage is prohibited. Generally, any equipment, materials, or furnishings that would ordinarily not be used outdoors may not be stored outdoors. For example, you may not keep indoor furniture, household appliances, auto parts, or building materials outside. You may store items such as barbecue grill, lawn furniture, garden hoses, garden tools, outdoor children's play equipment, or a lawnmower outside in an orderly fashion.

IF YOU RECEIVE A CODE VIOLATION NOTICE:

- **Find out how to correct the problem and do so promptly. Code Compliance Officers want to work with you.**
- **You can ask for additional time, provided you are making progress.**
- **If you do not take prompt action, legal action may become necessary and you may be given notice to appear before the City's Code Enforcement Special Magistrate. Fines of up to $250 per day may be imposed until compliance.**

Remember, Casselberry Code Compliance is here to help. Working together will prevent blight in our neighborhoods and throughout our community, which will result in an improved quality of life.

CONSERVING WATER CAN SAVE YOU DOLLARS.

What does your usage mean?

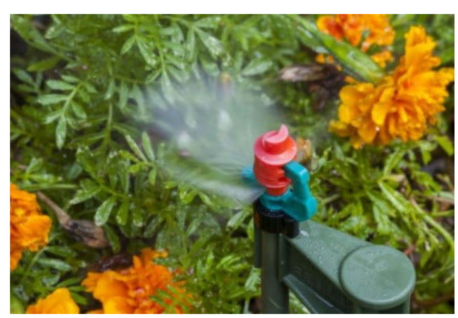
The average American uses around 88 gallons per day per person in the household. That means a family of four would use around 10,500 gallons in a 30-day period. But usage varies a great deal across the country, mostly because of differences in weather patterns. For example, water use tends to be higher in drier areas of the country that rely more on irrigation for outdoor watering than in wetter parts of the country that can rely on more rainfall.

Based on information from *Water Research Foundation*, "Residential End Uses of Water, Version 2." 2016; and *The US Geological Survey*, "Estimated Water Use in the United States." 2010.

https://www.epa.gov/watersense/understanding-your-water-bill

Simple steps can save water indoors and outdoors

Taking a few simple steps inside and outside can save water and money. Most of us turn off the water when brushing our teeth, and wait until the dishwasher is full before we run it. But there are lots of other ways to save water at home and in your business. Finding and fixing leaks is a good place to start. A leaky toilet or faucet can waste thousands of gallons of water each month, putting a hefty dent in your wallet. Your water fixtures may use more water than you think. Installing low-flow toilets and showerheads can dramatically reduce your indoor water consumption without reduced performance.



Outdoors, lawn and landscape irrigation accounts for about half of all residential water use. Watering wisely outside the home saves water and promotes healthier lawns and landscapes. Overwatering a lawn can promote weeds and insect pests, as well as weakened grass roots. Broken or misdirected sprinkler heads spray water onto sidewalks and pavement where it evaporates or trickles into storm drains. You can save water by irrigating lawns and landscapes only when they need it, by properly maintaining your irrigation system and by landscaping with plants and grasses that require minimal water. A well-designed and properly maintained Florida landscape will stay beautiful with minimal care.

Ready to get started saving water? Explore the tips and other information in this section of our website for saving water and money inside and outside. https://www.sjrwmd.com/water-conservation/savingwater/

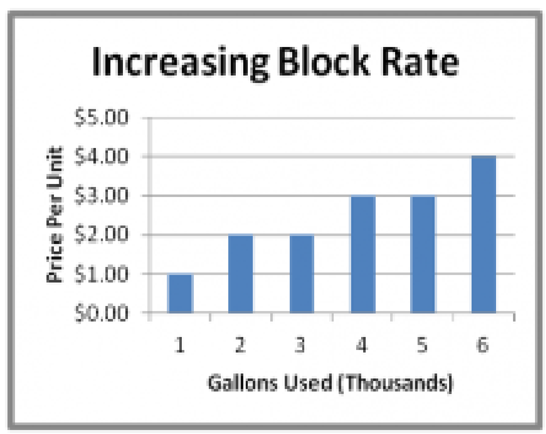
Irrigation Systems

The greatest waste of water is watering too much, too often. The type of sprinkler system you select, the time and frequency you dedicate to watering, and the attention paid to your soil and lawn's needs will help you water more efficiently and will result in a healthier lawn. Overwatering your lawn can lead to a variety of problems including shallow-rooted lawns, increased leaching of fertilizers and nutrients, and an increased potential for disease problems. Supplying too much water also causes grass to grow faster, which means more maintenance for you!

As a rule of thumb, an established lawn requires about 1 inch of water per week – more during the peak of summer and less during spring and fall. To find the gallons per minute (GPM) flow rate of the sprinkler being used from the package of the manufacturer. Multiply the square footage to be watered by .62 gallons or 1 inch of water per square foot. Example: 1,000 square feet x .62 gallons = 620 gallons. This tells you how many gallons of water you need to apply to the lawn. Divide that number by the GPM of your sprinkler, and you can figure how many minutes to water. https://www.conserveh2o.org/measure-your-sprinklers-water-use-watering-gauges

In addition, a broken sprinkler head can lose about 225 gallons per 15 minute watering cycle. If the cycle runs 3 times per week, at least 3,000 gallons of water can be lost per month. Customers are encouraged to inspect their lawn on a regular basis and look for signs of a broken sprinkler head. The signs include looking for broken sprinkler heads, declining plants and looking for soil runoff. Unusual water consumption can also be attributed to broken irrigation pipes underground. A leak the width of a dime can waste 6,300 gallons of water per month. Broken sprinkler heads and irrigation leaks can cause a "normal" water to increase substantially!

How Are You Being Charged?



Water utilities need to charge customers to build and maintain infrastructure—the water storage tanks, treatment plants, and underground pipes that deliver water to homes and businesses. The revenue is also used to pay the workers who provide you with water service day or night. There are a wide variety of rate structures that are used to bill customers. The City of Casselberry uses an Increasing Block Rate Structure.

Increasing Block Rates is a rate structure in which the unit price of each succeeding block of usage is charged at a higher unit rate than the previous block(s). Increasing block rates are designed to promote conservation and are most often found in urban areas and areas with limited water supplies. The graphic to the right is an example of an increasing block rate structure. https://www.epa.gov/watersense/understanding-your-water-bill

The City of Casselberry adopts a Utility Rate Study every five years that determines where to set the City's utility rates to be able to build any new infrastructure and maintain the existing utility infrastructure. The most recent study was adopted in August, 2017. In this study, the City Commission adopted the utility rates for the next 5 years beginning January 1, 2018. Utility customers were notified of this change on their City Utility bill, in addition to public notice being provided through the City Commission agendas. The average residential customer in the City's utility system uses about 4,000 gallons per month. Through adoption of adjusted utility rates, the average residential customer will see a change in their combined monthly water and wastewater bill from $54.57 to $61.60 per month over the 5 year period. Due to the Increasing Block Structure, the more water the customer uses, the more expensive their utility bill becomes. A residential customer that uses 8,000 gallons/month rather than 4,000 gallons/month will pay $46.13 more than the 4,000 gallon/month user for the combined water and wastewater bill. A utility customer's bill will rise even more as more water is used. In addition to paying for water and wastewater on the City's utility bill, customers are also billed for stormwater fees and solid waste pickup, so the total City utility bill is higher than the above-mentioned combined water and wastewater only bill.

City of Casselberry
Solid Waste Management

- **Garbage Collection Schedule**
  The City provides 2 garbage collection days, 1 recycling, and 1 yard waste col-lection per week. Specific collection days can be obtained by contacting Casselberry Public Works Administration at (407) 262-7725 x 1225.

- **Holiday Schedule**
  Garbage collection will not take place on the following holidays: 4th of July, Thanksgiving Day, Christmas Day, and New Year's Day. Any resident affected by this schedule are asked to place garbage and/or recycling out on the next regularly scheduled collection day.

- **Community Clean-up Events**
  Community Clean-up events for the City are held once a quarter in January, April, July, and October. During the Community Clean-up Event, only construction & demolition debris will be accepted (i.e., steel, glass, brick, concrete, asphalt, roofing material, pipe, wallboard, lumber and large tree stumps). The event will take place at the Casselberry Public Works complex located on N. Winter Park Dr./7th St. **The next up-coming Community Clean-up Event will be on April 14, 2018 (8am—noon). No household garbage will be accepted at this facility.** Please refer to the City's website (www.casselberry.org) for further details.

- **Recycling Bins**
  New and replacement recycling bins can be ordered by contacting Casselberry Public Works Administration at (407) 262-7725 x 1225. Please allow 3-5 busi-ness days for free, curbside delivery.

WHEN IN DOUBT, DON'T JUST THROW IT OUT

Please visit www.casselberry.org to find out the next Community Clean-up Event for your construction, demolition, and other hazardous waste.


GREEN UP CASSELBERRY GROWING COMMUNITY
SAVE OUR WATERBODIES
Algae
Will grow and keep growing as long as there is Nitrogen and Phosphorus available.
Too much Algae
• Reduces clarity.
➔ Other plants can't get the light they need
• Uses oxygen.
➔ Leads to fish kills
Our waterways start at your front yard.
Fertilizers • Grass Clippings • Leaves • Sediment
These carry Nitrogen, Phosphorus & other pollutants.
Shoreline plants absorb nutrients.
WHAT WE CAN DO
FERTILIZE APPROPRIATELY
• Fertilizer containing nitrogen or phosphorus cannot be applied between June 1 –Sept 30. Use iron and other micronutrients or "summer blends."
• Never fertilize 24 hours before a rain event.
• If needed, apply fertilizer in April or October.
• You must use 50% or more slow-release nitrogen and phosphorus free fertilizers.
MANAGE GRASS CLIPPINGS
• Keep grass clippings and yard debris off sidewalks, roadways and drains.
• Leave grass clippings on yard or in compost.
• Do not mow or apply fertilizers within 15 feet of a waterbody.
REDUCE RUNOFF
• Clean up fertilizer spills and store safely.
• Do not overwater.
• Use a rain barrel.
Need to know more or learn how? Visit www.casselberry.org/lakes
Call 407-262-7725 X1229.

Telephone Directory

CITY HALL—MAIN NUMBER 407-262-7700

Public Works Main Number	407-262-7725
Police Administration Main Number	407-262-7616

ADMINISTRATION

City Manager	407-262-7700, Ext. 1130
City Clerk	407-262-7700, Ext. 1133
Lien Searches	407-262-7700, Ext. 1140
Human Resources	407-262-7700, Ext. 1113

COMMUNITY DEVELOPMENT

Building Permits	407-262-7700, Ext. 1103
Business Tax Receipts	407-262-7700, Ext. 1109
Code Compliance	407-262-7700, Ext. 1105
Garage Sale Permits	407-262-7700, Ext. 1103
Planning & Zoning	407-262-7700, Ext. 1106

FINANCE

Finance General Inquiry	407-262-7700, Ext. 1148
Procurement	407-262-7700, Ext. 1142

UTILITY PAYMENTS (WATER & SEWER)

To Pay Bill Over the Phone	407-262-7700, Option 4
Utility Billing Customer Service	407-262-7700, Ext. 2110
After Hours Water/Sewer Emergency Calls	407-262-7613

PARKS & RECREATION

Recreation Manager	407-262-7700, Ext 1301
Recreation Programs & Events	407-262-7700, Ext 1507
Recreation Center	407-262-7700, Ext 1575
Art House	407-262-7700, Ext 1122

POLICE

EMERGENCY – Dial 9-1-1

Non-Emergency Dispatch Number	407-262-7606
Administrative Offices Main Number	407-262-7616
Police Records	407-262-7700, Ext 1009

PUBLIC WORKS

After Hours EMERGENCY CALLS	407-262-7613
Public Works Main Number	407-262–7725
Residential Garbage Inquiry	407-262-7725, Ext. 1225
To Reorder Recycle Bins	407-262-7725, Ext. 1225

SEMINOLE COUNTY FIRE DEPARTMENT

EMERGENCY—Dial 9-1-1

Administrative Offices	(407) 830-1411
After Hours	(407) 655-5175

SEMINOLE COUNTY

Animal Services	(407) 665-5201
Property Appraiser's Office	(407) 665-7506
Supervisor of Elections Office	(407) 585-8683
Tax Collector's Office	(407) 665-1000
Request Mosquito Control Spraying	(407) 665-5542

Attachment D:

Fertilizer Ordinance

ORDINANCE 17-1472

AN ORDINANCE OF THE CITY OF CASSELBERRY, FLORIDA, AMENDING CHAPTER 86, "UTILITIES" OF THE CITY CODE OF ORDINANCES BY ESTABLISHING ARTICLE VII, "FERTILIZER MANAGEMENT"; REGULATING THE PROPER USE OF FERTILIZERS BY ANY APPLICATOR; PROVIDING LEGISLATIVE FINDINGS; PROVIDING DEFINITIONS; PROVIDING FOR APPLICABILITY WITHIN THE CITY OF CASSELBERRY; ESTABLISHING A PROHIBITED APPLICATION PERIOD; SPECIFYING ALLOWABLE FERTILIZER APPLICATION RATES AND METHODS, FERTILIZER-FREE ZONES, LOW MAINTENANCE ZONES, AND EXEMPTIONS; REQUIRING THE USE OF BEST MANAGEMENT PRACTICES WHICH PROVIDE SPECIFIC MANAGEMENT GUIDELINES TO MINIMIZE NEGATIVE SECONDARY AND CUMULATIVE ENVIRONMENTAL EFFECTS ASSOCIATED WITH THE MISUSE OF FERTILIZERS WHICH HAVE BEEN OBSERVED IN AND ON THE CITY OF CASSELBERRY'S NATURAL AND CONSTRUCTED STORMWATER CONVEYANCES, RIVERS, CREEKS, CANALS, LAKES AND OTHER WATERBODIES; REQUIRING PROPER TRAINING OF COMMERCIAL AND INSTITUTIONAL FERTILIZER APPLICATORS; ESTABLISHING TRAINING AND LICENSING REQUIREMENTS; PROVIDING FOR ENFORCEMENT AND PENALTIES; AMENDING SECTION 2-210 "SCHEDULE OF VIOLATIONS" OF ARTICLE V "CODE ENFORCEMENT CITATIONS" OF CHAPTER 2, "ADMINISTRATION", TO PROVIDE FOR PENALTIES; PROVIDING FOR CODIFICATION, CONFLICTS, SEVERABILITY AND AN EFFECTIVE DATE.

WHEREAS, pursuant to 33 U.S.C. § 1313(d) (2016) of the Federal Clean Water Act and the resulting Florida Impaired Waters Rule, Chapter 62-303, Florida Administrative Code (2016), the Florida Department of Environmental Protection has classified specific waterbodies in Seminole County as "impaired" as a result of the presence of excess nutrients; and

WHEREAS, the Seminole County National Pollutant Discharge (NPDES) Municipal Separate Storm Sewer System (MS4) Permit No. FLS000038, issued by the Florida Department of Environmental Protection under authority delegated to it by the United States Environmental

Protection Agency, mandates the adoption of a fertilizer ordinance that includes all of the requirements set forth in the Florida Department of Environmental Protection's Model Ordinance for Florida-Friendly Fertilizer Use on Urban Landscapes pursuant to Section 403.9337, Florida Statutes (2016), by December 31, 2013 (the "Model Ordinance"); and

WHEREAS, the Florida Department of Environmental Protection has informally extended the time for the City of Casselberry to adopt the subject ordinance with the understanding that the City of Casselberry will adopt the ordinance as soon as practical; and

WHEREAS, it is the intent of the City Commission to adopt the instant Ordinance consistent with the terms of the Model Ordinance, and the principal purposes of the instant Ordinance are to receive credits and otherwise comply with all applicable Total Maximum Daily Loads (TMDLs) and Basin Management Action Plans (BMAPs); and

WHEREAS, the City Commission of the City of Casselberry, Florida, hereby finds this Ordinance to be in the best interest of the public health, safety, and welfare of the citizens of Casselberry and the general public; and

WHEREAS, words with double underlined type shall constitute additions to the original text and ~~strike through~~ type shall constitute deletions to the original text, and asterisks (* * *) indicate that text shall remain unchanged from the language existing prior to adoption of this Ordinance.

NOW, THEREFORE, BE IT ENACTED BY THE CITY COMMISSION OF THE CITY OF CASSELBERRY, FLORIDA, AS FOLLOWS:

Section I. **Recitals.** The foregoing recitals are hereby fully incorporated herein by this reference as legislative findings and the intent and purpose of the City Commission of the City of Casselberry.

Section II. Establishment of Article VII, "Fertilizer Management" of the City Code. That Article VII, "Fertilizer Management" of Chapter 86 "Utilities" of the Code of Ordinances of the City of Casselberry is hereby established to read as follows:

Article VII – Fertilizer Management

Sec. 86-342. Findings. As a result of impairment to surface waters caused by excessive nutrients, and as a result of increasing levels of nitrogen in the surface and ground water within the aquifers and springs, the City Commission of the City of Casselberry hereby determines that the use of Fertilizers creates a risk to contributing to adverse effects on surface and ground water. Accordingly, the City Commission hereby finds that management measures contained in the most recent edition of the *Florida-Friendly Best Management Practices for Protection of Water Resources by the Green Industries* are required.

Sec. 86-343. Purpose and Intent. This Article: (a) regulates the proper use of Fertilizers by any Applicator; (b) requires proper training of commercial and Institutional Fertilizer Applicators; (c) establishes training and licensing requirements; (d) establishes a Prohibited Application Period; and (e) specifies allowable Fertilizer Application rates and methods, Fertilizer free zones, Low Maintenance Zones, and exemptions. This Article requires the use of Best Management Practices, which provide specific management guidelines to minimize negative secondary and cumulative environmental effects associated with the misuse of Fertilizers. These secondary and cumulative effects have been observed in and on natural and constructed stormwater conveyances, rivers, creeks, canals, springs, lakes, and other water bodies. Collectively, these water bodies are an asset critical to the environmental, recreational, cultural, and economic well-being of City residents and the health of the public in general. Overgrowth of algae and vegetation hinder the effectiveness of flood attenuation provided by natural and constructed stormwater conveyances. Regulation of nutrients, including both nitrogen and phosphorus contained in Fertilizer, will help improve and maintain water and habitat quality.

Sec. 86-344. Definitions. For the purposes of this Article, the following terms have the meanings set forth in this Section. Words not defined in this Article have the meaning as provided in other Sections of this Code, and otherwise have the meaning provided by common and ordinary use:

Application or *Apply.* The actual physical deposit of Fertilizer to Turf, Landscape Plants, or both.

Applicator. Any Person who Applies Fertilizer on Turf, Landscape Plants, or both.

Approved Best Management Practices Training Program. A training program approved pursuant to Section 403.9338, *Florida Statutes* (2016), as this statute may be amended from time to time, or any more stringent requirements set forth in this article that includes the most current version of the Florida Department of Environmental Protection's *Florida-Friendly Best Management Practices for Protection of Water Resources by the Green Industries,* as this document may be amended from time to time.

Best Management Practices. Turf and landscape practices or a combination of practices based on research, field-testing, and expert review, determined to be the most effective and practicable on-location means, including economic and technological considerations, for improving water quality, conserving water supplies and protecting natural resources.

Code Enforcement Officer, Official or *Inspector.* Any designated employee or agent who has the duty to enforce codes and ordinances enacted by the City.

Commercial Fertilizer Applicator. Any Person who Applies Fertilizer for payment or other consideration to property not owned by the Person or firm Applying the Fertilizer or the employer of the Applicator, except as provided in Section 482.1562(9), *Florida Statutes* (2016), as this statute may be amended from time to time.

Fertilize, Fertilizing, or Fertilization. The act of Applying Fertilizer to Turf, specialized Turf, or Landscape Plants.

Fertilizer. Any substance or mixture of substances that contains one or more recognized plant nutrients and promotes plant growth, or controls soil acidity or alkalinity, or provides other soil enrichment, or provides other corrective measures to the soil. *Fertilizer* does not include unmanipulated peat or compost that make no claims as described in the preceding sentence.

Guaranteed Analysis. The percentage of plant nutrients or measures of neutralizing capability claimed to be present in a Fertilizer.

Institutional Fertilizer Applicator. Any Person, other than a private, non-commercial or a Commercial Fertilizer Applicator (unless such definitions also apply under the circumstances), that Applies Fertilizer for the purpose of maintaining Turf, Landscape Plants, or both. *Institutional Fertilizer Applicators* include, but are not limited to, owners, managers or employees of public lands, schools, parks, religious institutions, utilities, industrial, or business sites and any residential properties maintained in condominium or other form of common ownership.

Landscape Plant. Any native or exotic tree, shrub, or groundcover (excluding Turf).

Low Maintenance Zone. An area a minimum of ten (10) feet wide adjacent to water courses that is planted and managed in order to minimize the need for Fertilization, watering, mowing, and related activities.

Person. Any natural Person, business, corporation, limited liability company, partnership, limited partnership, association, club, organization, or any other group of people acting as an organized entity.

Prohibited Application Period. The time period during which a Flood Watch or Warning, or a Tropical Storm Watch or Warning, or a Hurricane Watch or Warning is in effect for any portion of the City, issued by the National Weather Service, or if heavy rain, as defined by the World Meteorological Organization as rainfall greater than or equal to two (2) inches in a twenty-four (24) hour period, is likely.

Reclaimed Water. A high quality alternative water source that has received at least secondary treatment and is reused after being discharged from a domestic wastewater treatment facility. Moreover, there are some constituents, such as nitrogen and phosphorus found in recycled water. These constituents are beneficial for plant growth, and will serve as an additional "Fertilizing" source.

Saturated Soil. A soil in which the voids are filled with water. Saturation does not require flow. For the purposes of this Article, soils are considered saturated if standing water is present or the pressure of a Person standing on the soil causes the release of free water.

Slow Release, Controlled Release, Timed Release, Slowly Available, or *Water Insoluble Nitrogen.* Nitrogen in a form that delays its availability for plant uptake and use after Application or that extends its availability to the plant longer than a reference rapid or quick release product.

Turf, Sod, or *Lawn.* A piece of grass-covered soil held together by the roots of the grass.

Sec. 86-345. Applicability. This Article applies to and regulates any and all Applicators of Fertilizer and areas of Application of Fertilizer within the jurisdictional boundaries of the City, unless such Applicator is specifically exempted by the terms of this Article. This Article operates prospectively only, and does not impair any existing contracts.

Sec. 86-346. Timing of Fertilizer Application.

(a) No Applicator may Apply Fertilizers containing nitrogen, phosphorus, or both to Turf, Landscape Plants, or both during the Prohibited Application Period, or to Saturated Soils.

(b) Fertilizer containing nitrogen or phosphorus may not be Applied before seeding or sodding a site, and may not be Applied for the first thirty (30) days after seeding or sodding, except when hydro-seeding for temporary or permanent erosion control in an emergency situation, or in accordance with an adopted stormwater pollution prevention plan for that site.

(c) Fertilizer containing nitrogen or phosphorus may not be Applied to Turf or Landscape Plants from June 1 through September 30 of each year.

Sec. 86-347. Fertilizer Free Zones. Fertilizer may not be Applied within fifteen (15) feet of any pond, stream, watercourse, lake, canal, or wetland as defined by the Florida Department of Environmental Protection Rule 62-340, *Florida Administrative Code* (2016), as this regulation may be amended from time to time, or from the top of a seawall. Newly planted Turf, Landscape Plants, or both may be Fertilized in this zone only for a sixty (60) day period beginning thirty (30) days after planting if needed to allow the plants to become well established. Caution must be used to prevent direct deposition of nutrients into the water.

Sec. 86-348. Low Maintenance Zones. A voluntary ten (10) foot Low Maintenance Zone is strongly recommended, but not mandated, from any pond, stream, water course, lake, wetland, or from the top of a seawall. A swale/berm system is recommended for installation at the landward edge of this Low Maintenance Zone to capture and filter runoff. No mowed or cut vegetative material may be deposited or left remaining in this zone or deposited in the water. Care must be taken to prevent the over-spray of aquatic weed products in this zone.

Sec. 86-349. Fertilizer Content and Application Rates.

(a) Fertilizers Applied to Turf must be Applied in accordance with requirements and directions provided by Rule 5E-1.003, *Florida Administrative Code*, "Fertilizer Label Requirements for Urban Turf, Sports Turf or Lawns" (2016), as this regulation may be amended from time to time.

(b) Nitrogen or phosphorus Fertilizer may not be Applied to Turf or Landscape Plants except as provided in subsection (a) for Turf, or in the University of Florida/IFAS recommendations for Landscape Plants, vegetable gardens, and fruit trees and shrubs, unless a soil or tissue deficiency has been verified by an approved test. Soil and tissue tests for phosphorus are normally done by UF/IFAS or another accredited laboratory. IFAS recommendations are available from the County Extension Service or http://solutionsforyourlife.ufl.edu/lawn_and_garden/.

(c) No Fertilizer containing phosphorus may be Applied to Turf, Sod, Lawns, or Landscape Plants unless a soil or plant tissue deficiency is verified by a testing methodology approved by the University of Florida, Institute of Food and Agricultural Sciences. If a deficiency is verified, the Application of Fertilizer containing phosphorus must adhere to the rates and directions for the appropriate Region of Florida, as adopted by Florida Administrative Code Rule. This subsection (c) controls over any inconsistent provisions in subsections (a) and (b) above regarding phosphorus.

(d) Fertilizers containing nitrogen Applied to Turf or landscaping plants within the City of Casselberry must contain no less than fifty percent (50%) Slow Release Nitrogen per Guaranteed Analysis Label. If the necessary product is available on the local commercial market on March 1, 2020, then this requirement will increase to no less than sixty-five percent (65%) Slow Release Nitrogen effective on this date. This subsection (d) controls over any inconsistent provisions in subsections (a) and (b) above regarding nitrogen.

(e) The above referenced Application rates must be reduced appropriately on properties where reclaimed wastewater is used for irrigation based on available nutrients in the Reclaimed Water as reported by the provider of the Reclaimed Water.

Sec. 86-350. Application Practices.

(a) Spreader deflector shields are required when Fertilizing by rotary or broadcast spreaders. Deflectors must be positioned such that Fertilizer granules are deflected away from all impervious surfaces, Fertilizer free zones, and water bodies, including wetlands.

(b) Fertilizer must not be Applied, spilled, or otherwise deposited on any impervious surfaces.

(c) Any Fertilizer Applied, spilled, or deposited, either intentionally or accidentally, on any impervious surface must be immediately and completely removed to the greatest extent practicable.

(d) Fertilizer released on an impervious surface must be immediately contained and either legally Applied to Turf or any other legal site, or returned to the original or other appropriate container.

(e) In no case may Fertilizer be washed, swept, or blown off impervious surfaces into stormwater drains, ditches, conveyances, or water bodies.

Sec. 86-351. Management of Grass Clippings and Vegetative Matter. In no case may grass clippings, vegetative material, vegetative debris, or any combination of them be washed, swept, or blown off into stormwater drains, ditches, conveyances, water bodies, wetlands, or sidewalks, or roadways. Any material that is accidentally so deposited must be immediately removed to the maximum extent practicable.

Sec. 86-352. Exemptions. This Article does not apply to:

(a) Bona fide farm operations as defined in Section 823.14, *Florida Statutes* (2016), "Florida Right to Farm Act", as this statute may be amended from time to time.

(b) Other properties not subject to or covered under subsection (a) above that have pastures used for grazing livestock.

(c) Any lands used for bona fide scientific research, including, but not limited to, research on the effects of Fertilizer use on stormwater, water quality, agronomics, or horticulture.

(d) Golf courses, athletic fields and Turf managed for active recreation, whose owners implement Best Management Practices as described in Rule 5E-1.003(2)(d), *Florida Administrative Code*, "Fertilizers Labeled for Sports Turf at Golf Courses, Parks and Athletic Fields" (2016), as this regulation may be amended from time to time.

(e) Any fruit or vegetable gardens, provided they are not within fifteen (15) feet of any waterbody or wetland.

Sec. 86-353. Training.

(a) All commercial and Institutional Fertilizer Applicators shall abide by and successfully complete the six-hour training program in the *Florida-Friendly Best Management Practices for Protection of Water Resources by the Green Industries* offered by the Florida Department of Environmental Protection through the University of Florida/IFAS *Florida-Friendly Landscapes* program, or an approved equivalent.

(b) Private, non-commercial Applicators are encouraged to follow the recommendations of the University of Florida/IFAS *Florida Friendly Landscapes* program when Applying Fertilizers.

Sec. 86-354. Licensing of Commercial Fertilizer Applicators.

(a) By September 30, 2014, all Commercial Fertilizer Applicators were required by state law to abide by and successfully complete training and continuing education requirements in the *Florida-Friendly Best Management Practices for Protection of Water Resources by the Green Industries*, offered by the Florida Department of Environmental Protection through the University of Florida/IFAS *Florida-Friendly Landscapes* program, or an approved equivalent program. Commercial Fertilizer Applicators shall provide proof of completion of the program prior to obtaining a new Local Business Tax Receipt for any category of occupation which may Apply any Fertilizer to Turf, Landscape Plants, or both. Commercial Fertilizer Applicators with an existing Local Business Tax receipt for any category of occupation which may Apply any Fertilizer to Turf, Landscape Plants, or both shall provide proof of completion of the program within thirty (30) days after completing the program as required by state law prior to September 30, 2014.

(b) After September 30, 2014, all Commercial Fertilizer Applicators were required by state law to have and carry in their possession at all times when

Applying Fertilizer, evidence of certification by the Florida Department of Agriculture and Consumer Services as a Commercial Fertilizer Applicator pursuant to Rule 5E-14.117(18), *Florida Administrative Code* (2016), as this regulation may be amended from time to time.

(c) By September 30, 2014, all businesses Applying Fertilizer to Turf, Landscape Plants, or both (including but not limited to residential Lawns, commercial properties, and multi-family and condominium properties) were required by state law to ensure that at least one employee has a *Florida-Friendly Best Management Practices for Protection of Water Resources by the Green Industries* training certificate. Business owners for any category of occupation which may Apply any Fertilizer to Turf, Landscape Plants, or both shall provide proof of completion of the program by at least one employee prior to the business owner obtaining a new Local Business Tax Receipt. Business owners for any category of occupation which may Apply any Fertilizer to Turf, Landscape Plants, or both with an existing Local Business Tax Receipt shall provide proof of completion of the program by at least one employee within thirty (30) days after completing the program and prior to September 30, 2014.

Sec. 86-355. Enforcement, Penalties and Legal Proceedings.

(a) Any Person found to be in violation of the provisions of this Article may be subject to any applicable civil enforcement mechanisms available to the City, including, but not limited to: injunctive relief; referral to the City of Casselberry Special Magistrate; or issuance of a citation pursuant to Section 2-210, of the Casselberry Code of Ordinances.

(b) Violations of this Article can present a serious threat to public welfare and are potentially irreparable or irreversible. Therefore, pursuant to Section 2-151(d) of this Code and Section 162.21(3)(b), Florida Statutes (2016), as these provisions may be amended from time to time, if the Code Enforcement Officer has reason to believe that the violation presents a serious threat to the public health, safety, or welfare, or if the violation is irreparable or irreversible, the Code Enforcement Officer may (1) immediately issue a citation to any Person in violation of this Article; or (2) make reasonable effort to notify the violator and immediately notify the City Special Magistrate and request a hearing.

(c) Each incidence of violation under this Article constitutes a separate violation and offence and a separate offence will be deemed committed on each day during or on which a violation occurs or continues.

(d) In addition to the other remedies provided in this Section, the City is authorized to make application in a court of appropriate jurisdiction for an injunction restraining any person from violating, or continuing to violate any provisions of this Article. Further, the City may avail itself of any other legal or equitable remedy available to it in the enforcement of any provision of this Article or any provision of any resolution enacted pursuant to this Article.

(e) The City may elect to take any or all of the above remedies concurrently, and the pursuit of one does not preclude the pursuit of another.

Section III. Amendment of Section 2-210 "Schedule of Violations". That Section 2-210, "Schedule of Violations" of Article V, "Code Enforcement Citations" of Chapter 2, "Administration" of the City Code of Ordinances, is hereby amended to read as shown on Exhibit "A" attached hereto.

Section IV. Codification. It is the intention of the City Commission of the City of Casselberry, Florida, and it is hereby ordained that the provisions of this Ordinance shall become and be made a part of the Code of Ordinance of the City of Casselberry, Florida; that the Sections of this Ordinance may be renumbered or re-lettered to accomplish such intention; that the word, "Ordinance" may be changed to "Section," "Article," or other appropriate word.

Section V. Conflicts. All Ordinances or Resolutions, or parts of Ordinances or Resolutions in conflict with any provisions of this Ordinance are hereby repealed to the extent of the conflict.

Section VI. **Severability.** If any Section or portion of a Section of this Ordinance proves to be invalid, unlawful, or unconstitutional, it shall not be held to invalidate or impair the validity, force, or effect of any other Section or part of this Ordinance.

Section VII. **Effective Date.** This Ordinance shall become effective ten (10) days after its passage and adoption.

FIRST READING this 30th day of October, A.D. 2017.

SECOND READING and **ADOPTION** this 20th day of November, A.D. 2017.

ATTEST:

Donna G. Gardner, CMC
City Clerk

Charlene Glancy
Mayor/Commissioner

EXHIBIT "A"

Sec. 2-210. - Schedule of violations.

(a) Violation of the following City codes or ordinances is a civil infraction for which a citation shall be issued:

General City Code		
Code Section	Description of Violation	Classification
6-2 et seq.	Distribution of handbills	Class II
26-1	Rummage sales, yard sales, garage sales and similar private sales without a permit	Class I
26-33	Operating a business without a local business tax receipt	Class IV
26-166 thru 26-171	Buying and selling of secondary metals	Class II
46-37	Filling or excavating in a floodplain without a permit	Class I
58-202	Nuisance through temporary display of commercial signs on public property	Class II
~~60-12~~	~~Alcoholic beverages violation (in City Parks)~~	~~Class I~~
~~60-3, 5, 7, 8, 9, 10, 11, 13, 15—20~~ 60-3, 60-4 (C, D, F, G, H, J, K, L, N), 60-5	Conduct at City Parks	Class I
~~60-4~~ 60-6	Failure to obtain permit (in City Parks)	Class II
~~60-6~~ 60-4(E)	Traffic violations (in City Parks)	Class II
~~60-14~~ 60-4(I)	Fires (in City Parks)	Class IV
70-2(C)	Overgrown lots	Class I
70-2(C)	Rubbish and debris in yard	Class I

EXHIBIT "A"

82-13	Abandonment or storage of junked [derelict] vehicles	Class I
86-111	Discharging prohibited substances into public sewers	Class II
86-346 thru 86-354	Improper use of Fertilizers	Class II

***

Attachment E:

Report: Construction and Monitoring of Engineered Phytotechnology for Nitrate Removal in Groundwater

ENGINEERED PHYTOTECHNOLOGY SITE SUITABILITYASSESSMENT: CASSELBERRY GOLF COURSE

TECHNICAL MEMORANDUM

October 2017

Prepared For:

Public Works Division

95 Triplet Lake Drive

Casselberry, Florida 32707

Prepared By:

Geosyntec consultants

1511 East State Road 434, Suite 1005

Winter Springs, FL 32708

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION AND BACKGROUND

1.1 Introduction

This memorandum presents our site suitability assessment of the City of Casselberry's Golf Course as a phytotechnology demonstration site for the removal of nitrate in groundwater. Phytotechnology is the strategic use of plants to solve environmental problems in soil, water, and air resources.

The usefulness and success of phytotechnology for nitrate removal in groundwater is currently unknown as this application of phytotechnology has not been tested within the State of Florida. Geosyntec Consultants, in coordination with Applied Natural Sciences and Environmental Conservation Solutions, LLC, will provide partial funding to design, install, and monitor a phytotechnology system of TreeWell® units with specialized Bio-Active Media (BAM) to promote removal of nitrate in groundwater through the process of denitrification. This phytotechnology system will target nitrate-rich shallow groundwater flow zones before discharge to surface water bodies. A water quality monitoring period of approximately two years is anticipated for the analysis of parameters that include total nitrogen, nitrate, nitrate isotopes, and tracer compound(s).

As part of Geosyntec Consultant's Research and Development program, partial funding has been provided to construct and monitor a phytotechnology system for purposes of demonstrating nitrate removal in groundwater. The initial phase of the demonstration project includes the identification of a suitable site to construct the phytotechnology system. The City of Casselberry is located within the Lake Jesup watershed, which is regulated by a nutrient Total Maximum Daily Load (TMDL). As such, the City is taking a proactive approach to minimizing the amount of nutrients discharged to waterbodies. The City of Casselberry is collaborating with Geosyntec Consultants on identifying a potential site on their golf course that is suitable for installation of the phytotechnology system demonstration project.

Geosyntec Consultants performed a self-funded site suitability assessment of the golf course area between holes #12 and #13 as the initial phase of Geosyntec's Research and Development project. This memorandum serves the purpose of identifying and confirming a suitable location on the golf course for the phytotechnology system.

1.2 Background and Location

The City of Casselberry golf course area of study is near holes #12 and #13 and is bounded to the east by South Sunset Drive, south by Northmoor Road, west by a recently developed Integra Lakes apartment complex, and north by Triplet Lake Drive. The golf course is located within the jurisdiction of the St. John's River Water Management District and within the City of Casselberry's jurisdiction limits. Refer to the Site Map on **Figure 1** for a location of the golf course area of study.

From the Western Seminole County LiDAR topographical data, surface elevations in the study area range from approximately 85 feet to 68 feet NAVD88. In general, this golf course area initially drains to the drainage feature adjacent to the western boundary before draining north via pipe to Quail Pond. Surface elevations of the study area are shown on **Figure 1**.

The current NRCS soils data GIS polygons were downloaded and reviewed. The area of study is classified as Urban and is surrounded by either hydrologic class 'A' (low runoff potential) or 'A/D' (dual classification, low to high runoff potential). Soils classified as Urban are not characterized for drainage by NRCS. It is likely, however, that soil drainage within Urban areas is similar to surrounding areas. The hydrologic classes of the soils near the area of study are shown in **Figure 2**.

The golf course is currently irrigated with reclaimed water per Florida Department of Environmental Protection Permit FLA011066. The recent (August 2017) annual average discharge of reclaimed water land applied to areas including the golf course was reported to contain 6.6 milligrams per liter (mg/L) of nitrate. The golf course is permitted to receive reclaimed irrigation at a rate of 0.359 million gallons per day (MGD) under the condition the monitoring wells within the surficial aquifer contain 10 mg/L or less of nitrate.

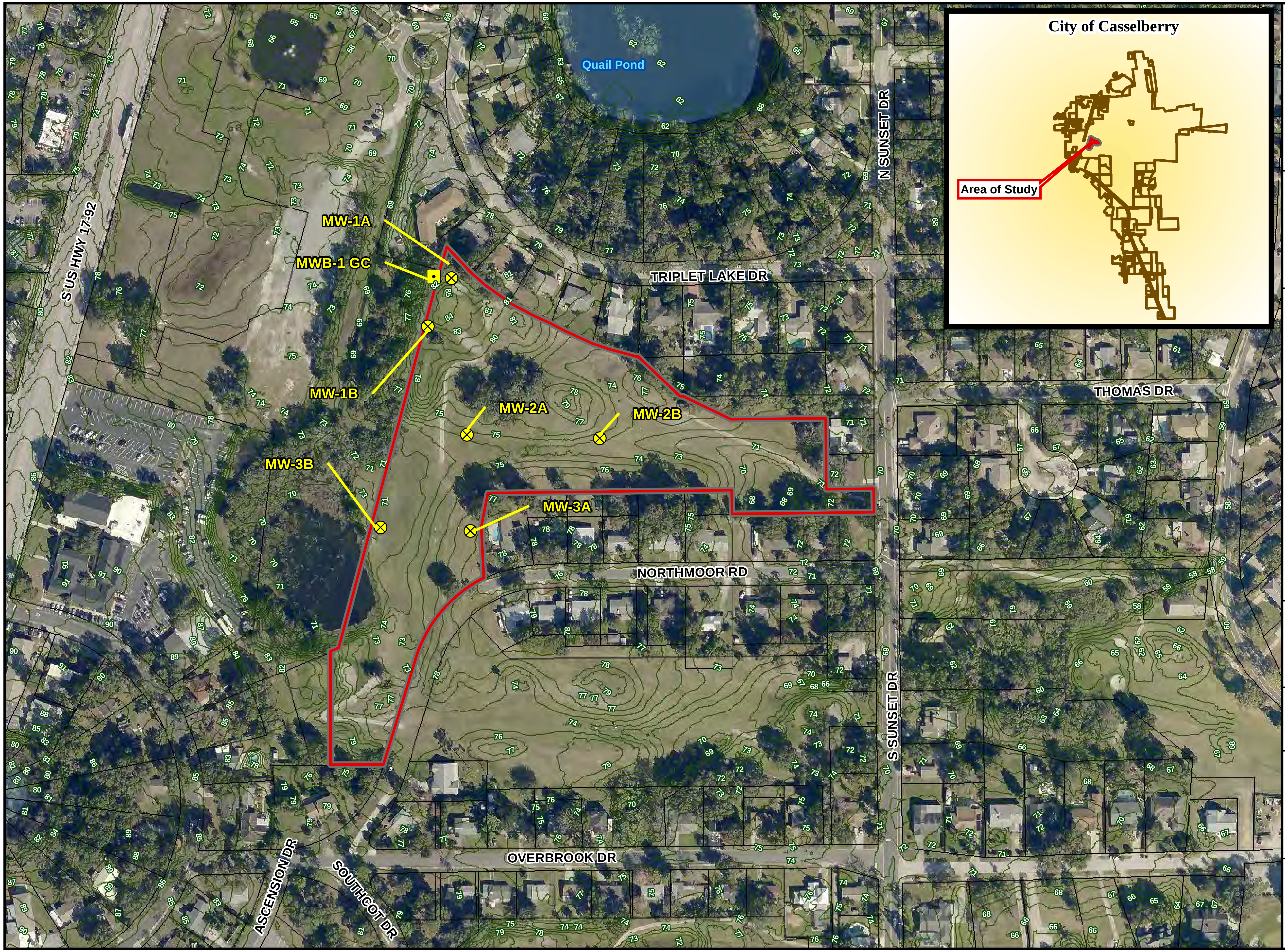
A review of historical golf course monitoring well data as part of Permit FLA011066 showed that MWB-1 GC contained, on average, the highest concentration of nitrate in the surficial aquifer. Between July 2016 and August 2017, MWB-1 GC contained an average quarterly nitrate concentration of approximately 1.1 mg/L. Since July 2016, the highest nitrate concentration recorded in MWB-1 GC was 2.9 mg/L on October 11, 2016. The location of MWB-1 GC is depicted on **Figure 1**.

1.3 Goals of This Study

Nutrient pollution of water is a major environmental problem. Common sources of nutrient loading in watersheds include wastewater discharges, fertilizer applications, and stormwater runoff that infiltrate to groundwater. Nutrient reduction has traditionally focused predominantly on surface water and not groundwater, while in many cases nutrient concentrations in groundwater have been shown to significantly contribute to the degradation of downstream waterbodies. As an increased number of watersheds are becoming regulated by nutrient TMDLs and National Pollutant Discharge Elimination System Permits, municipalities have been faced with the growing challenge of complying with these new requirements. The overall goal of this project is to introduce a practical, low maintenance strategy of nitrate removal from groundwater to address the high nitrate loading associated with common nutrient sources such as fertilizer and reclaimed water usage. It is anticipated that this will be accomplished through a new type of phytotechnology system that is supported by water quality analysis.

The specific purpose of this site suitability assessment is to identify a suitable location for a phytotechnology system on the City's available golf course area. Suitability of the site depends on sufficient nitrate concentrations in groundwater, appropriate hydraulic conductivity values, groundwater flow direction, and ample space to construct the system.

Geosyntec Consultants performed a self-funded site suitability assessment of the golf course area between holes #12 and #13 as the initial phase of Geosyntec's Research and Development project. Should Geosyntec Consultants and the City agree to move forward with installation and monitoring of the phytotechnology system, Geosyntec Consultants, Applied Natural Sciences, Environmental Conservation Solutions, LLC, and the City of Casselberry will share the associated costs.



N

0 100 200 Feet

Legend

- Area of Study
- Parcels
- 1' Ground Elevation Contour
- Monitoring Well
- City Monitoring Well

Sources:
Roads: Seminole County, 2017
Parcels: Seminole County, 2017
Aerial: FDOT, 2015
Contour: Seminole County, 2005 (NAVD88)

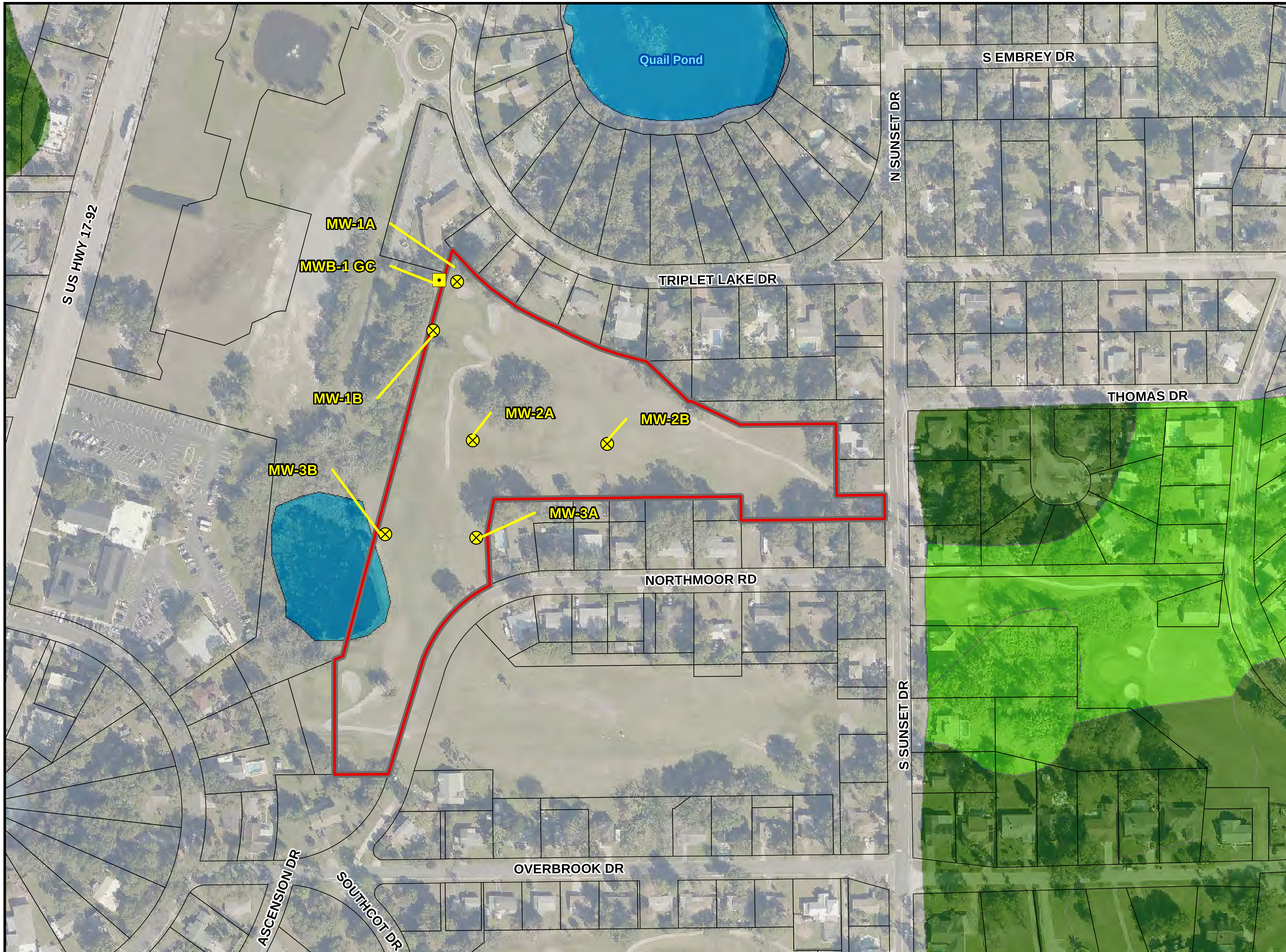
Figure

1

Site Map

Engineered Phytotechnology
Site Suitability Assessment:
Casselberry Golf Course

Geosyntec consultants



N

0 100 200 Feet

Legend

- Area of Study
- Parcels
- 1' Surface Elevation Contour
- Monitoring Well
- City Monitoring Well

NRCS Hydrogroup

- A
- A/D
- Urban
- Water

Sources:
Roads: Seminole County, 2017
Parcels: Seminole County, 2017
Aerial: FDOT, 2015
Soils: NRCS, 2017

Figure

2

Soils Map

Engineered Phytotechnology
Site Suitability Assessment:
Casselberry Golf Course

Geosyntec
consultants

2. SITE SUITABILITY ASSESSMENT

2.1 Methodology

The specific purpose of this site suitability assessment is to identify a suitable location for a phytotechnology system on the City's available golf course area. Suitability of the site depends on sufficient nitrate concentrations in groundwater, appropriate hydraulic conductivity values, groundwater flow direction, and ample space to construct the system.

2.1.1 Soil Profile, Water Quality Analysis, and Well Installation

Well installation was dependent on first identifying the depth at which soils were adequately permeable and nitrate concentrations were sufficiently high. As such, soil profiles and groundwater samples were analyzed at each monitoring location at the time the boreholes were drilled and before the wells were installed.

Soil profiles were collected from a total of six shallow aquifer wells on August 29 and 30, 2017. The soil profile of each well was collected from approximately 1-foot below surface to boring depths ranging from 15 to 25 feet below land surface. Soil was visually examined for color, consistency, and saturation.

To determine the target depth of each monitoring well, water quality was analyzed at varied depths throughout each borehole column. Shallow aquifer groundwater screening samples were collected from each borehole at depths ranging from 5 to 25 feet below ground surface prior to well installation. Groundwater was analyzed for standard parameters including pH, conductivity, temperature, oxygen reaction potential, and dissolved oxygen using a YSI Pro Plus portable multi-parameter meter. Turbidity was analyzed using a Hanna HI98703 portable turbidity meter. Once standard parameters stabilized, field measurements of nitrate and total iron in groundwater samples taken from various depths were determined by Hach Methods 8171 and 8147, respectively, using a Hach DR900 portable colorimeter.

Each monitoring well was installed to the depth corresponding to the highest concentration of field observed nitrate in each borehole. At each monitoring well location, a ten-foot well screen was installed. After well installation and development, groundwater samples were collected and analyzed for standard parameters using a YSI Pro Plus portable multi-parameter meter and Hanna HI98703 portable turbidity meter. Once standard parameters stabilized, groundwater samples were collected for laboratory analysis of nitrate, in addition to parameters including total boron, sodium, and chloride that are required for determination of tree type.

Nitrate, total boron, sodium, and chloride concentrations were analyzed at the Pace Analytical Laboratories in Ormond Beach, Florida. Nitrate concentrations were determined by automated colorimetry (EPA 353.2). Sodium and total boron were determined by inductively coupled plasma mass spectrometry (EPA 200.7). Chloride concentrations were determined by ion chromatography (EPA300.0).

2.1.2 Survey

The phytotechnology system will require monitoring up and downstream of the system. To determine the direction of groundwater flow, a survey of top of grade and water table elevation at each monitoring well was performed. The elevations reported from this survey are relative to an assumed reference point of a nearby fire hydrant valve with an estimated elevation of 79.9 feet NAVD88 based on published construction plans of Lake Concord Park (October 2015). The approximate elevation of groundwater at each monitoring well location, the estimated groundwater flow direction, and the location of the fire hydrant that was used a reference point are each depicted on **Figure 3**.

2.1.3 Hydrogeologic Condition Survey

Variable head permeability tests (slug tests) provide an estimate of hydraulic conductivity and are useful in determining if the groundwater velocity and resulting groundwater flux is within the acceptable range for supplying the TreeWell® system. Ideal groundwater flux values for this phytotechnology system are as low as possible but not to exceed 100 gallons per day.

Slug tests were performed at each of the six wells located within the study area. At each well, three trials of slug tests were performed using readings from a Level TROLL 700 probe as input to the Win-Situ 5 laptop software program. A 3-foot piece of rebar was utilized as the slug that was fully submerged in the well and quickly removed after return of initial water level. Time and displacement values for slug submergence and removal were recorded as output and were processed using AQTESOLV Pro 4.0.

2.1.4 Evaluation of Available Space

The proposed phytotechnology system consists of fifteen individual TreeWell® units that will be contained in a root sleeve approximately 15 feet in depth. To allow sufficient room for the tree canopies, each TreeWell® unit will be separated by a distance of 15-feet on center from each other. Excluding soil and groundwater conditions, sunny areas near holes #12 and #13, at least 15-feet in width, and outside the limits of the fairway and greens are identified as suitable areas for the proposed phytotechnology system.

2.2 Results

As the primary goal of the phytotechnology system is to remove nitrate from groundwater, the ideal location for the phytotechnology system is in an area with high nitrate concentrations along with suitable soil, groundwater, and space conditions. The presence of nitrate varied in the shallow aquifer wells sampled and was observed at greatest concentrations in MW-1A and MW-1B. Refer to **Table 1** for a water quality summary and **Figure 3** for the nitrate concentrations at each monitoring well location.

Table 1: Summary of water quality in groundwater wells

Well ID	Date	Depth (ft)	Boron (µg/L)	Nitrate (mg/L)	Sodium (µg/L)	Chloride (mg/L)	pH	Turbidity (NTU)	Dissolved O_2 (mg/L)	Specific conductance (µS/cm)
MW-1A	8/29/2017	14-24	127	5.1	32300	38.7	5.5	21.2	6.21	328.7
MW-1B	8/29/2017	14-24	115	5.9	36100	39.4	4.72	162	0.77	316.5
MW-2A	8/30/2017	14-24	135	3.0	41200	62.5	4.84	31.5	0.6	298.9
MW-2B	8/30/2017	14-24	66.5	0.8	24000	27.9	5.11	7.78	5.26	183.3
MW-3A	8/29/2017	12-22	127	0.6	26000	33.1	4.53	4.91	2.41	224.2
MW-3B	8/30/2017	5-15	99.9	0.04	25800	33.7	4.9	35.7	5.1	210

Encountered soils were mostly light to dark brown fine sands with some silts. Soil profile results are presented in the **Table 2**.

Groundwater flow and direction was determined from the survey in which depth of water was measured. In general, it appears groundwater flows from MW-3A north and northwest toward Quail Pond. Groundwater elevation contours are presented on **Figure 2**.

Aquifer performance testing of MW-1A and MW-1B resulted in mean conductivity values ranging from 1.8 to 1.9 feet/day, corresponding to typical values of fine sand to silty sand. A summary of input parameters and aquifer performance test results are presented in **Table 3**. Using Darcy's Law, it is estimated that the groundwater flow in the vicinity of MW-1A and MW-1B is equal to approximately 90 gallons per day, which is within the acceptable limit for this phytotechnology system.

CITY OF CASSELBERRY INC. 1940

N

0 100 200 Feet

Legend

- Area of Study
- Groundwater Elevation Contour
- Parcels
- 1' Contour
- Monitoring Well | mg/L Nitrate | Appx Groundwater Elevation
- City Monitoring Well

Sources:
Roads: Seminole County, 2017
Parcels: Seminole County, 2017
Aerial: Seminole County, 2015

Figure

3

Groundwater Map

Engineered Phytotechnology
Site Suitability Assessment:
Casselberry Golf Course

Geosyntec consultants

Table 2: Soil Profile Results

MW-1A
8/29/2017

Depth	
1	
2	
3	
4	
5	fine sand /light brown
6	
7	
8	
9	
10	
11	
12	fine sand with some organics (little fines)
13	
14	
15	
16	sandy silt/light brown/SATURATED
17	fine sand/light brown/SATURATED
18	
19	silty fine sand/light brown/SATURATED
20	
21	
22	
23	
24	
25	fine sand with some silt/light brown/SATURATED

MW-1B
8/29/2017

Depth	
1	
2	
3	fine sand/light to medium brown
4	
5	
6	
7	fine sand/light brown
8	
9	
10	silty fine sand/light brown
11	fine sand/light brown
12	fine sand with some organics (little fines)
13	
14	
15	silty fine sand/light brown
16	
17	fine sand/light brown/saturated
18	
19	
20	fine sand/light brown/saturated
21	fine sand/medium brown
22	
23	
24	
25	fine sand/light brown/SATURATED

MW-2A
8/30/2017

Depth	
1	
2	
3	
4	
5	fine sand/light to medium dark brown
6	fine sand with some silt and iron/light brown
7	fine sand/light brown
8	
9	
10	silty fine sand with iron/light brown
11	
12	
13	
14	
15	fine sand/light brown
16	
17	
18	
19	
20	fine sand/light brown/SATURATED
21	
22	
23	
24	
25	fine sand/light brown/SATURATED

MW-2B
8/30/2017

Depth	
1	
2	
3	
4	
5	fine sand with silt/light to medium dark brown
6	fine sand with iron/medium brown
7	
8	
9	
10	
11	
12	silty fine sand with iron/light brown
13	
14	
15	silty fine sand/light brown
16	fine sand with phosphate and iron/medium brown
17	
18	silty fine sand/medium brown/wet
19	
20	fine sand/light to medium brown/SATURATED
21	
22	
23	
24	
25	fine sand/medium brown/SATURATED

MW-3A
8/29/2017

Depth	
1	
2	
3	
4	fine sand with some silt/dark to light brown with roots
5	
6	
7	fine to medium sand/brown to light brown/little silt and occasional roots
8	
9	
10	
11	clayey-sandy silt/large brown to brown/iron coatings on occasional grain
12	fine-medium sand, some silt, dark, light brown
13	
14	
15	fine sand with some silt/occasional fine grain phosphate/iron
16	staining/SATURATED
17	
18	
19	loose fine sand with some silt/occasional phosphate/occasional limestone
20	fragment/SATURATED

MW-3B
8/30/2017

Depth	
1	
2	
3	
4	
5	silty fine sand/light brown
6	
7	fine sand/light brown/saturated
8	
9	
10	silty fine sand/light brown with iron/saturated
11	
12	
13	
14	
15	silty fine sand/light brown with iron/saturated

Note: The groundwater table was not measured on August 29-30, 2017. The reported saturated soils are soils that were observed to contain water, but do not represent exact depths of the groundwater table.

Table 3: Summary of Input Parameters and Aquifer Performance Test Results

		MW-1A			MW-1B		
Well Information	Borehole Diameter (in)	4			4		
	Well Diameter (in)	1			1		
	Screen interval (ft bls)	12 to 22			14 to 24		
	Well Depth (ft bls)	22.0			24.0		
	Screen Length (ft) [AQTESOLV "L"]	10			10		
	Confined or Unconfined Aquifer	Unconfined			Unconfined		
	Ground Surface Elevation (ft)	81.20			81.90		
	TOC Elevation (ft NAVD 88)	80.95			81.65		
	Slug Test Trial #	1	2	3	1	2	3
	Pre-test Depth-to-groundwater (ft)	11.5	11.5	11.5	11.7	11.7	11.7
	Water level above top of well screen (ft) [AQTESOLV d]	0.50	0.50	0.50	2.30	2.30	2.30
	Initial Displacement (ft) [AQTESOLV Ho]	0.758	0.385	0.740	0.393	0.369	0.462
	Static Water Column Height (ft) [AQTESOLV H]	10.50	10.50	10.50	12.30	12.30	12.30
	Inside Radius of Well Casing (ft) [AQTESOLV r(c)]	0.042			0.042		
	Radius of Well (ft) [AQTESOLV r(w)]	0.167			0.167		
	Well Skin Radius (ft) [AQTESOLV r(sk)]	0.167			0.167		
	Formation Saturated Thickness (ft) [AQTESOLV b]	50	50	50	50	50	50
	Vertical-to-Horizontal hydraulic conductivity anisotropy ratio [AQTESOLV Kv/Kh]	0.2			0.2		
	Bouwer-Rice **k (ft/day)**	1.4	1.4	1.8	1.5	1.4	2.0
	Hvorslev **k (ft/day)**	2.1	2.0	2.6	2.1	2.0	2.9

	MW-1A	MW-1B
K Geometric Mean (ft/day)	1.8	1.9

Assumptions:

1. Calculation based on Slug Out time and displacement values.
2. Borehole diameter of 4" was assumed for the 6620DT Geoprobe that was used.
3. Ground surface elevation is relative to valve on nearby fire hydrant. Approximate elevation of hydrant valve is 79.9 feet NAVD.
4. TOC Elevation was assumed to be 0.25' below ground surface elevation.
5. Aquifer thickness (b) was assumed from estimated depths shown on Figure 20 of USGS report (2016).
6. Vertical-to-Horizontal hydraulic conductivity anisotropy ratio value was estimated from Table 2-1 (USACE, 1999).

3. RECOMMENDATIONS

The purpose of this memorandum was to present the results of the site suitability assessment to determine if the City of Casselberry's available golf course site is appropriate for placement of a phytotechnology system for removal of nitrate in groundwater. Suitability of the site depends on sufficient nitrate concentrations in groundwater, appropriate hydraulic conductivity values, groundwater direction, and ample space to construct the phytotechnology system.

Using the results of soil profiles, water quality of groundwater, survey, and aquifer performance testing, a phytotechnology system concept has been developed to reduce mass loading of nitrate concentrations from the City's golf course to downstream waterbodies. Since nitrate was highest in MW-1A and MW-1B and the hydraulic conductivity in these wells appears to be sufficient, the phytotechnology system will comprise fifteen TreeWell® units placed approximately 15-feet apart (on center) near MW-1A and MW-1B as shown on **Figure 4**. To maximize the amount of sunlight to the phytotechnology system, it is recommended that the branches of nearby trees on City property be trimmed where appropriate.

Both MW-1A and MW-1B were screened to depths of 14 and 24 feet and at these depths, nitrate was detected at concentrations ranging between 5.1 and 5.9 mg/L which will provide the opportunity for proof of concept for nitrate removal. To intercept groundwater where high nitrate concentrations were detected, each TreeWell® unit of the system will be installed by first cutting a 24-foot deep borehole and backfilling with a loam planting mix to create a preferential flow path. A root sleeve will then be set to a depth of approximately 15 feet. The tree will then be planted with a closed top to prevent water entry, which will force the system to draw water from the target zone. The cuttings from the borehole will be used to build a protective mound around the top of the well, which will be covered with gravel to prevent erosion.

The proposed phytotechnology system will be utilized to serve as a demonstration project to gain an awareness of cost, performance, and maintenance of the phytotechnology system intended for nitrate removal in groundwater from the golf course. As such, a two-year monitoring period is expected in which hydraulic and water quality will be monitored within each TreeWell® unit and upstream and downstream of the system. Water quality analysis will include total nitrogen, nitrate, nitrate isotopes, and tracer compound(s).

Based on the demonstration of suitability contained in this report, we recommend moving forward with the construction and monitoring of the proposed phytotechnology system on the City of Casselberry golf course for purposes of nitrate removal in groundwater. Should the City agree to move forward with installation and monitoring of the phytotechnology system, Geosyntec Consultants, Applied Natural Sciences, Environmental Conservation Solutions, LLC, and the City of Casselberry will share the associated costs.

N

0 20 40 Feet

- Area of Study
- Parcels
- Monitoring
- Proposed TreeWell(R)
- Groundwater Elevation Contour

Sources:
Parcels: Seminole County, 2017
Aerial: Seminole County, 2015
World Street Map: ESRI, 2017

Figure

4

Proposed Phytotechnology System Layout

City of Casselberry Golf Course
Phytoremediation for Removal of Nitrate

Geosyntec consultants

4. REFERENCES

Ardaman & Associates (2015) Phase II Environmental Assessment Report Relative to Casselberry Golf Course, Orlando, Florida.

USACE (1999) Engineering and Design Groundwater Hydrology, USACE, Washington DC.

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