Lake Darby

LAKE HABITAT ASSESSMENT, LAKE VEGETATION IDEX, SUBMERGED VEGETATION SURVEY AND WATER QUALITY

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Methods

STUDY AREA ANALYISIS

The watershed containing the Lake Darby was analyzed using ESRI ArcGIS 10.6. Using this software with 2017 Hillsborough County aerial, 2014 Land Use/ Land Cover (LULC), Landscape Development Intensity (LDI) Index values were calculated for the 100 meter buffer surrounding the lake following the procedures of Reiss & Brown 2012(Reiss & Brown. 2012. Landscape Development Intensity (LDI) Index User's Manual. H.T. Odum Center for Wetlands, University of Florida. March 2012). According to Reiss and Brown "The LDI represents a human disturbance gradient for wetland systems. The LDI is an integrated measure of human activity, combining the effects from air and water pollutants, physical damage, changes in the suite of environmental conditions … on the structure and processes of landscapes and ecosystems… Natural, undeveloped LU/LC classes have a LDI index value of one. In the Florida framework, the maximum LDI index score is approximately 42."

The LDI is calculated by multiplying each land use coefficient by the percentage of the area of interest occupied by that land use, and then summing the results. The Florida Department of Environmental Protection (DEP) uses the LDI as a tool to estimate potential land use impacts on streams, lakes, and wetlands. LDI values less than two (≤ 2) can be considered minimally disturbed."

LAKE BATHYMETRY AND MORPHOLOGICAL CHARACTERISTICS ASSESSMENT

The Bathymetric Map[1] provides the lake's morphologic parameters in various units. The bottom of the lake was mapped using a Lowrance Elite 7 Ti Wide Area Augmentation System (WAAS)[2] enabled Global Positioning System (GPS) with Totalscan transducer (bottom sounder) to determine the boat's position, and bottom depth in a single measurement. The result is an estimate of the lake's area, mean and maximum depths, and volume and the creation of a bottom contour map. Besides pointing out the deeper fishing holes in the lake, the morphologic data derived from this part of the assessment can be valuable to overall management of the lake vegetation as well as providing flood storage data for flood models.

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[1] A bathymetric map is a map that accurately depicts all of the various depths of a water body. An accurate bathymetric map is important for effective herbicide application and can be an important tool when deciding which form of management is most appropriate for a water body. Lake volumes, hydraulic retention time and carrying capacity are important parts of lake management that require the use of a bathymetric map.

[2] WAAS is a form of differential GPS (DGPS) where data from 25 ground reference stations located in the United States receive GPS signals form GPS satellites in view and retransmit these data to a master control site and then to geostationary satellites. For more information, see end note 2.

LAKE VEGETATION INDEX ASSESSMENT

Hillsborough County requested the implementation of the Florida Department of Environmental Protection methods for Lake Vegetation Index (LVI 1000) (http://www.dep.state.fl.us/water/sas/sop/sops.htm) using forms FD 9000-03 (Physical/Chemical Characterization), FD 9000-06 (Lake Habitat Assessment) FD 9000-27 (LVI Field Sheet) and FD 9000-31 (Lake Observation Field Sheet).

The Lake Vegetation Index (LVI) is a rapid assessment protocol in which selected sections of a lake are assessed for the presence or absence of vegetation through visual observation and through the use of a submerged vegetation sampling tool called a Frodus. The assessment results provide a list of species presents and the dominant and where appropriate co-dominant species that are found in each segment. These results are then entered into a scoring table and a final LVI score is determined. LVI scores provide an estimate of the vegetative health of a lake. Our assessment team was trained and qualified by FDEP to conduct these assessment as an independent team and must prequalify each year prior to conducting additional assessments. The LVI method consists of dividing the lake into twelve pie-shaped segments (see diagram below) and selecting a set of four segments from the twelve to include in the LVI. The assessment team then travels across the segment and identifies all unique species of aquatic plant present in the segment. Additionally, a Frodus is thrown at several points on a single five-meter belt transect that is established in the center of the segment from a point along the shore to a point beyond the submerged vegetation zone. For scoring, the threshold score for impairment is 37.

Four metrics are utilized in the Lake Vegetation Index Survey; Dominant Coefficient of Conservatism (CoC), Percent Florida Exotic Pest Plant Council Type 1 (% FLEPPC), Percent Native Taxa, Percent Sensitive Taxa.

The Dominant Coefficient of Conservatism (CoC) metric for the dominant or co-dominate species in each section. The CoC applies a score of 0-10 to each species based on its ecological tolerances and fidelity to pre-settlement conditions. Species with higher scores show a high fidelity to native, undisturbed habitats and are typically sensitive to alterations. Available CoC scores can be obtained from LT 7000 from the Florida Department of Environmental Protection at: http://www.dep.state.fl.us/water/sas/sop/sops.htm.

The percent FLEPPC (Florida Exotic Pest Plant Council) Category 1 invasive exotic taxa in a single sampling unit (pie slice) by dividing the number of FLEPPC Category I taxa by the total number of taxa in that sampling unit. Multiply result times 100. Refer to Appendix LVI 1000-1 to determine which plants are on the FLEPPC Category 1 list. Note that not all exotic taxa should be included in this metric, only those listed in Appendix LVI 1000-1 as Category 1 FLEPPC. If the FLEPPC updates their list of Category 1 exotics, those updates shall not be reflected in this calculation until they are included in Appendix LVI 1000-1.

The percent native taxa in a single sampling unit (pie slice) is calculated by dividing the number of native taxa by the total number of taxa in that sampling unit. Multiply result times 100. Nativity status is determined by the Plant Atlas from the Institute for Systematic Botany, and is listed in Appendix LVI 1000-1. For informational purposes, visit the website

http://www.florida.plantatlas.usf.edu/. Taxa that are native according to the Plant Atlas from the Institute for Systematic Botany but are not on the list in Appendix LVI 1000-1 may be included in this metric calculation, but inclusion of these additional taxa is not required.

The percent sensitive taxa in a single sampling unit by summing the number of taxa with a C of C (Coefficient of Conservatism) score >= 7 and then dividing by the total number of taxa in that sampling unit. Multiply result times 100. Refer to Appendix LVI 1000-1 for a list of C of C scores.

The collected bathymetric data is analyzed for submerged aquatic vegetation (SAV) calculations including the percentage of the surface area of the lake inhabited by SAV as well as an estimate of the percent volume of the lake inhabited by SAV. SAV is an important component to a lakes nutrient cycling as well as chlorophyll concentrations due to the SAV and phytoplankton competing for available nutrients in the water column. In addition SAV serves a vital role as habitat for many species of macroinvertebrates and fish as well as substrate for epiphytic algae.

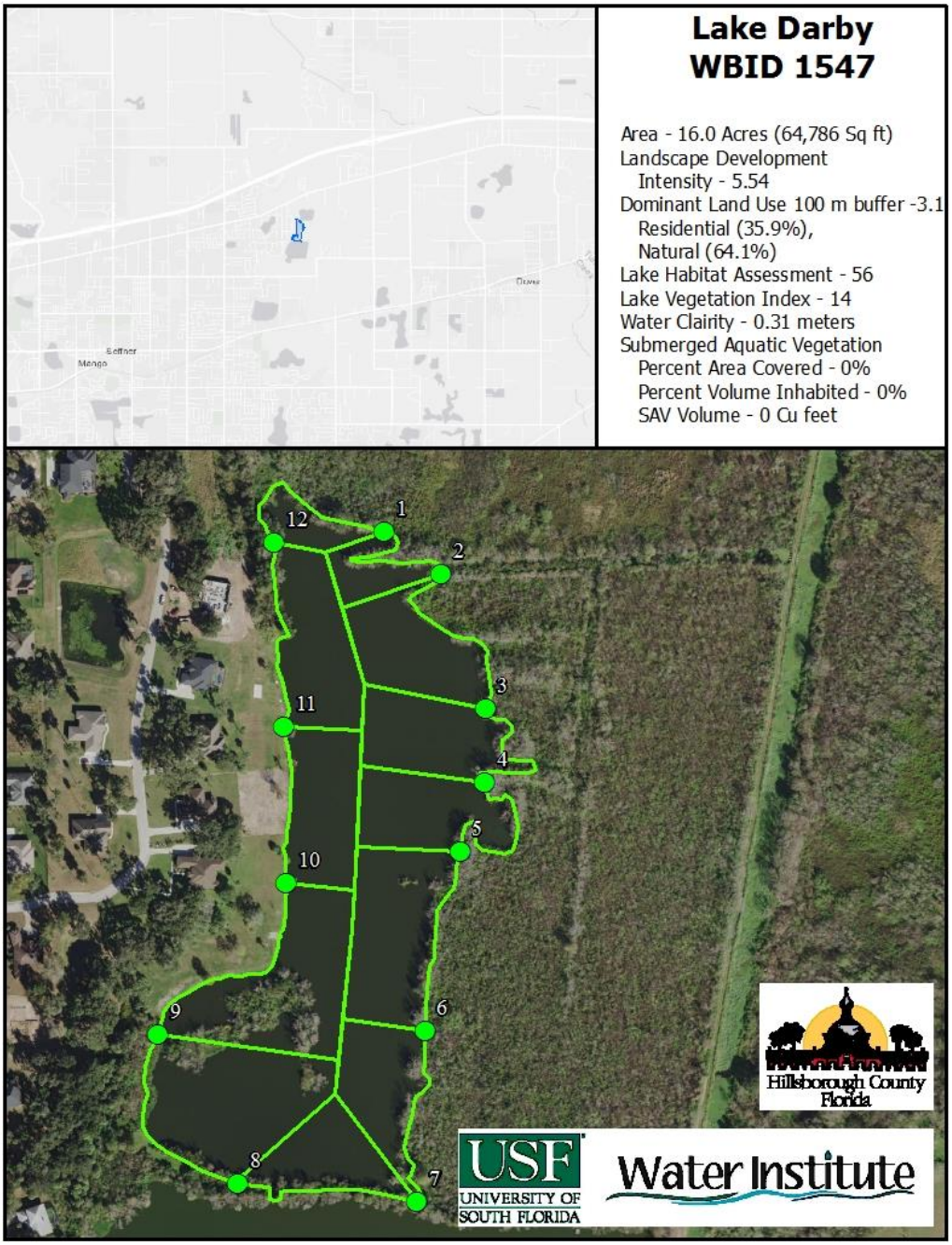
WATER QUALITY ASSESSMENT

Physical water quality samples were taken using a Eureka Manta Sub-2 multiprobe pre and post calibrated on the day of the assessment. Measurements taken with this device include: depth, conductivity, pH, Dissolved Oxygen (mg/l and % Saturation) and salinity. Chemical water parameters were collected and preserved on ice by USF Water Institute staff and analyzed at the Environmental Protection Commission of Hillsborough County Laboratory. Analysis include; Chlorophyll (a, b, c, t and corrected), Alkalinity, Color, EColi, Enterococci, Ammonia, Nitrates/Nitrites, Total Phosphorous, Kjeldahl Nitrogen and Total Nitrogen. The results of the water quality sampling effort will be discussed in the framework of the FDEP Numeric Nutrient Criteria

Study Area

Lake Darby is located in east-central Hillsborough County, Florida. The Landscape Development Intensity Index of the 100 meter buffer around Lake Darby is dominated by Natural (64.1%) and Residential (35.9%) land uses. The resulting LDI value for the 100 meter buffer around Lake Darby is 5.54.

FIGURE 1: 2019 LAKE DARBY ASSESSMENT STUDY AREA MAP



Lake Bathymetry and Morphological Characterization

At the time of the assessment, Lake Darby was experiencing elevated water levels (staff elevation gauge was not available) resulting in a 16.0 acre water body. Lake Darby at the time of the assessment had a mean water depth of 3.46 feet and a maximum observed depth of 7.6 feet. The volume at this time was approximately 18,052,190 gallons. Figure 2 shows the resulting bathymetric contour map for Lake Darby from data collected on May 16, 2019. The collected data has been overlain the 2017 Hillsborough County aerials.

Table 1: Morphological Calculations for Lake Darby

Parameter	Feet	Meters	Acres	Acre-Ft	Gallons
Surface Area (sq)	697,351	64,786	16.0		
Mean Depth	3.46	1.05			
Maximum Depth	7.60	2.32			
Volume (cubic)	2,413,210	68,334		55.4	18,052,190
Gauge (NAVD 88)	Not Available				

Figure 2: 2019 1-Foot Bathymetric Contour Map for Lake Darby

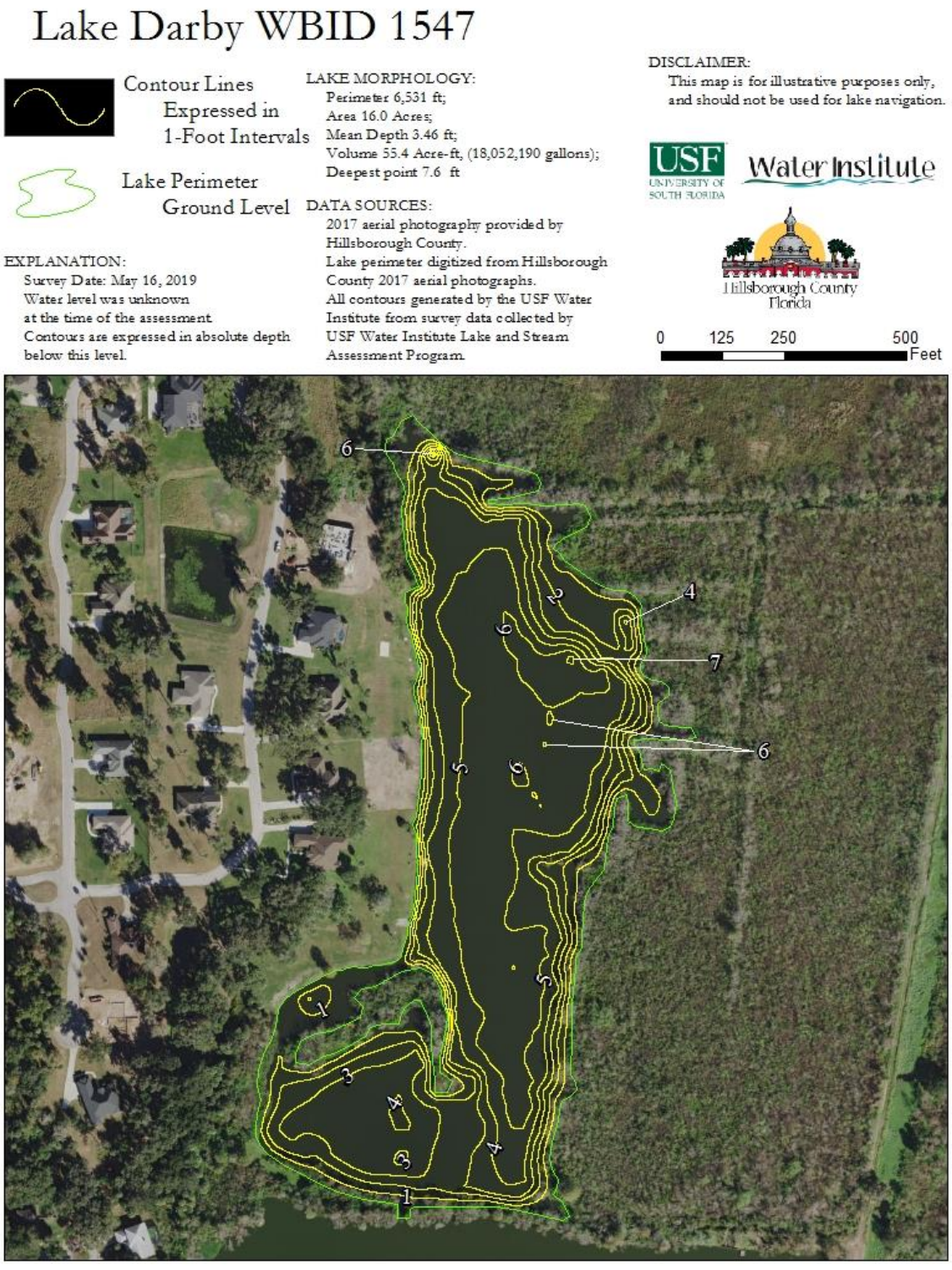


Figure 3 Overview photograph of Lake Darby showing typical shoreline vegetation in an undeveloped area.

Lake Habitat and Lake Vegetation Index Assessment

The lake assessment for Lake Darby was conducted on May 16, 2019. Lake Darby received a lake habitat assessment (FEDP form FD 9000-6) score of 56 due to suboptimal scores for Stormwater Inputs and Adverse Watershed Land Use. Marginal scores were achieved for Vegetation Quality, Upland Buffer Zone and Lakeside Adverse Human Alterations. Secchi and Bottom Substrate Quality received poor scores.

The water in Lake Darby was characterized as a clear water system with high phytoplankton biomass with a color value of 15.0 PCU and a chloropyll-a corrected value of 169.0 µg/l. The secchi disk depth was 0.31 meters in part due to the high biomass of phytoplankton. The vegetation quality of the plants in and buffering Lake Darby are predominantly native species with moderate growths of non-native nuisance species such as *Schinus terebinthifolius, Sapium sebiferum, Panicum repens, Ludwigia peruviana, Alternanthera philoxeroides, Pistia stratiotes,*

Urochloa mutica and *Eichhornia crassipes*. Some direct inputs of stormwater were noted through pipes and ditches to the lake, but most stormwater reaches the lake via sheet flow. The bottom substrate quality was dominated by coarse particulate organic matter near shore and some accumulation of muck. Approximately 35.9% of the surrounding land has been developed for residential housing. Homeowners have not maintained a vegetated buffer zone along the shoreline.

Figure 4 Ludwigia peruviana, Peruvian Primrose, along a vegetated section of Lake Darby shoreline.

The Lake Vegetation Index identified 44 species of wetland vegetation growing in the four selected sections along Lake Darby. The majority of these species (36) are native species. The remaining 11 species (*Schinus terebinthifolius, Sapium sebiferum, Panicum repens, Ludwigia peruviana, Alternanthera philoxeroides, Pistia stratiotes, Urochloa mutica* and *Eichhornia crassipes*) are non-native and invasive to this region. The vegetation community along Lake Darby is dominated by a variety of emergent species including *Salix caroliniana, Sapium sebiferum, Ludwigia peruviana and Panicum repens*. The water's surface in Lake Darby was dominated by *Eichhornia crasipes and Pistia stratiodes*. No species of submerged aquatic vegetation were observed in the lake due to the low water visibility and phytoplankton blocking available light. By analyzing the collected sonar chart, submerged aquatic vegetation was not observed. Figure 5 shows the results of the SAV analysis indicating the location and percent of the water column inhabited by SAV.

The calculated LVI score for Lake Darby was 14, below the impairment threshold of 37 indicating that the vegetation community is "Impaired" based on the vegetation community. Figure 6 shows the map of Lake Darby detailing the LVI regions used for the assessment (Regions 3, 6, 9, 12). Table 2 details the species list results of the Lake Vegetation Index. Table 3 details the scoring result for the Lake Vegetation Index.

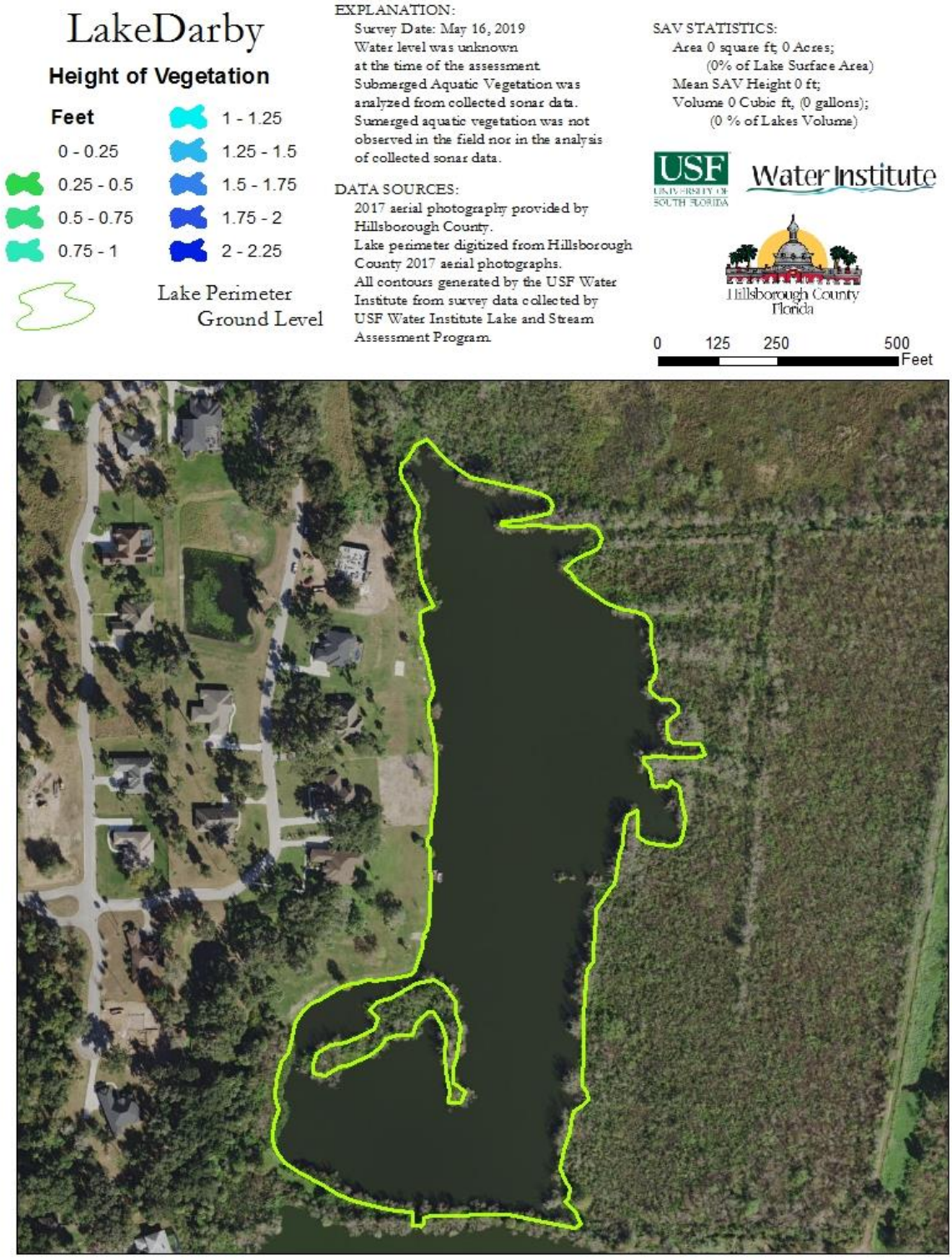


Figure 5 Lake Darby Submerged Aquatic Vegetation Assessment Results

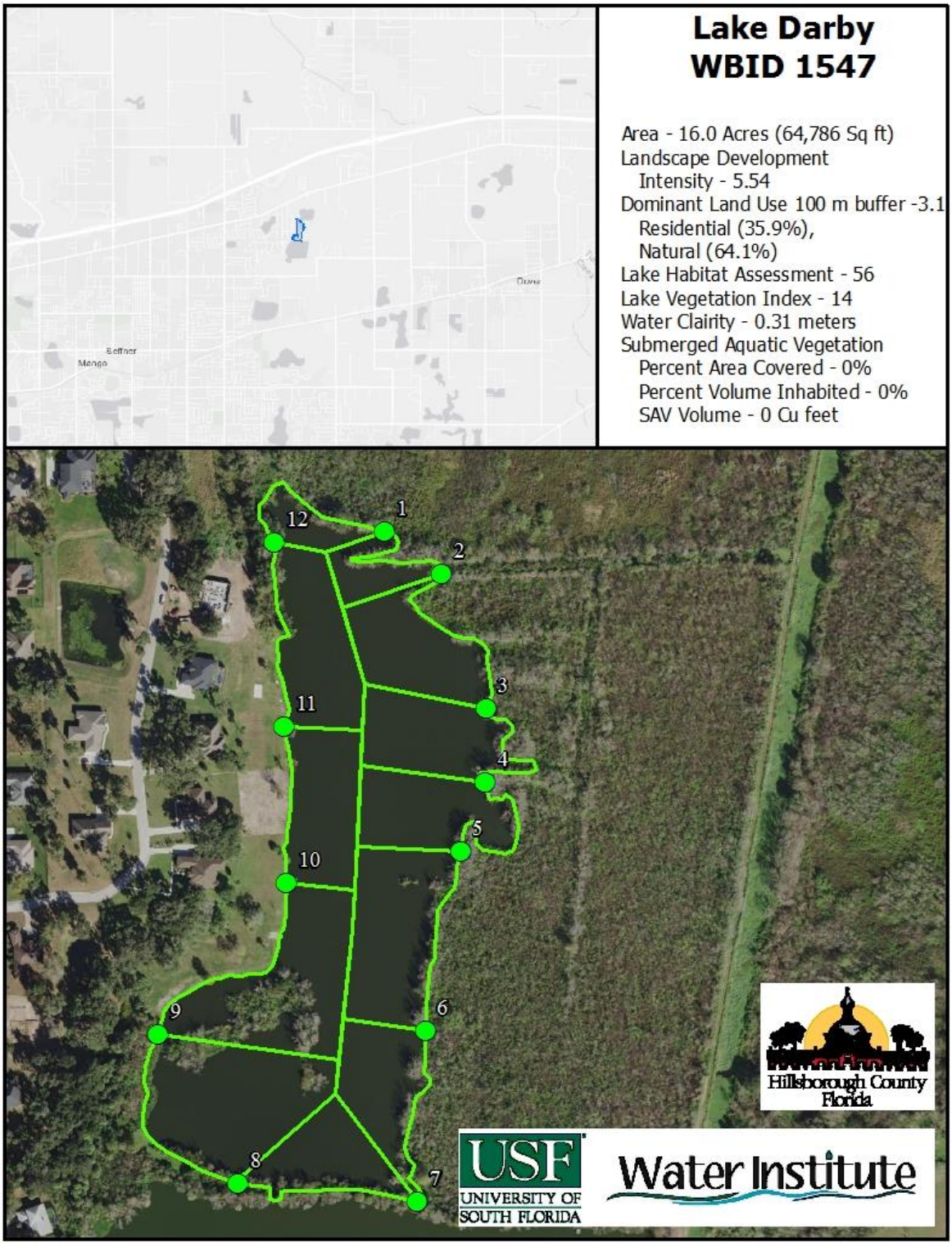


Figure 6: Lake Vegetation Index region map for Lake Darby

Table 2: Lake Vegetation Index results for Lake Darby May 16, 2019

SPECIES	Region				
	CofC	3	6	9	12
Alternanthera philoxeroides	0.00	**1**	**1**	**1**	**1**
Eichhornia crassipes	0.00	**1**	**1**	**1**	**1**
Hydrocotyle	2.00	**1**	**1**	**1**	**1**
Lemna	1.00	**1**	**1**	**1**	**1**
Ludwigia leptocarpa	3.00	**1**	**1**	**1**	**1**
Ludwigia octovalvis	2.00	**1**	**1**	**1**	**1**
Ludwigia peruviana	0.00	**1**	**1**	**1**	**1**
Pistia stratiotes	0.00	**1**	**1**	**1**	**1**
Pluchea baccharis	5.45	**1**	**1**	**1**	**1**
Polygonum hydropiperoides	2.50	**1**	**1**	**1**	**1**
Salix caroliniana	2.95	**C**	**D**	**1**	**C**
Sapium sebiferum	0.00	**C**	**1**	**1**	**C**
Ampelopsis arborea	3.25	**1**	**1**	**1**	
Mikania scandens	1.95	**1**	**1**	**1**	
Myrica cerifera	2.00		**1**	**1**	**1**
Phyla nodiflora	1.92		**1**	**1**	**1**
Rumex	2.23	**1**		**1**	**1**
Amaranthus australis	1.00	**1**	**1**		
Echinochloa walteri	2.50		**1**	**1**	
Myriophyllum aquaticum	0.98		**1**	**1**	
Osmunda cinnamomea	6.44	**1**	**1**		
Panicum repens	0.00	**1**		**D**	
Polygonum glabrum	4.50	**1**	**1**		
Schinus terebinthifolius	0.00	**1**	**1**		
Thelypteris interrupta	6.74			**1**	**1**
Urochloa mutica	0.00			**1**	**1**
Andropogon					**1**
Bacopa monnieri	3.50			**1**	
Boehmeria cylindrica	5.00		**1**		
Cephalanthus occidentalis	5.00				**1**
Diodia virginiana	3.00			**1**	
Eclipta prostrata	2.00			**1**	
Eleocharis baldwinii	2.82		**1**		
Eupatorium capillifolium	0.83		**1**		
Galium tinctorium	5.08	**1**			
Juncus effusus	2.00			**1**	
Nuphar	3.50	**1**			
Quercus laurifolia	4.00				**1**
Sacciolepis striata	5.35			**1**	
Sambucus nigra	1.48	**1**			
Schoenoplectus californicus	5.00			**1**	
Sesbania herbacea	1.00			**1**	
Setaria parviflora	2.50			**1**	
Woodwardia virginica	3.50	**1**			

Table 3: Scoring Summary for the Lake Vegetation Index

LVI Score Summary	Region			
	3	6	9	12
Total # of taxa in sampling unit	24	25	30	20
% Native taxa in sampling unit	66.66667	72	70	65
% FLEPPC CAT 1 taxa in sampling unit	25	20	20	25
% Sensitive taxa in sample unit	0	0	0	0
Dominant CoC in sample unit	1.475	2.95	0	1.475
Native Score ((x-62.5)/37.5) or ((x-66.67)/25.89)=	0	0.205871	0.128621	0
Invasive FLEPPC 1 Score (1 - (x/30))=	0.166667	0.333333	0.333333	0.166667
Sensitive Score (x/(27.78 or 20)) =	0	0	0	0
Dominant CoC Score (x/(7.91 or 7)) =	0.210714	0.421429	0	0.210714
Raw Score Total = N+I+S+D =	0.377381	0.960633	0.461954	0.377381
Division Factor = (3 D=0 or 4) =	4	4	4	4
Average LVI dividend = Raw /DF	0.094345	0.240158	0.115489	0.094345
South				
LVI Score for sampling unit =	9.434524	24.01582	11.54886	9.434524

Total LVI SCORE = 14

Water Quality Assessment

Limited long-term water quality data is available for Lake Darby. The available data was collected by Hillsborough County in late 2018 and 2019 and consists of four samples with two samples during the dry season (11/28/18, 2/21/19) and two samples during the wet season (5/20/19, 6/18/19. Table 4 provides a summary of the Physical/Chemical conditions recorded at the middle of the Lake Darby.

Table 4: Lake Darby Water Quality (Field)

Depth (m)	Temp °C	pH	DO (mg/L)	DO (%sat)	Cond (unho/cm)	Salinity (ppt)	Secchi Depth (m)
0.14	29.49	11.07	13.15	170.4	163.1	0.08	0.31
0.62	28.35	8.72	6.49	82.5	158.6	0.07	
1.35	28.05	8.89	5.22	65.9	158.5	0.07	
POR	27.23	7.14	8.14	98.66	157.4	0.15	

The chemical water quality analysis for Lake Darby is shown in Table 5 for the sample taken on May 23, 2019. Table 6 includes this data in the numeric nutrient criteria framework using the data from this assessment as well as the available geometric mean values for the period of record since complete data for the past three years for available parameters is not available. Total Phosphorous values were above the nutrient threshold for clear alkaline lakes (Alkalinity > 20 mg/l $CaCO_3$ and color < 40 PCU) in the west central region with insufficient data developed by FDEP of 0.03 mg/l with a value of 0.212 mg/l for the POR (0.197 mg/l for 2019) and above the threshold for the most recent single sample with a value of 0.245 mg/l. If sampling were to be sufficient (previous three years of quarterly sampling) the threshold could be as high as 0.09 mg/L.

Total Nitrogen values were above the nutrient threshold for clear - alkaline lakes with insufficient data developed by FDEP of 1.05 mg/l with a value of 1.110 mg/l for the POR data. The Total Nitrogen value associated with the sample for this assessment was 2.801 mg/l (1.175 mg/l for 2019). If sampling were to be sufficient (previous three years of quarterly sampling) the threshold could be as high as 1.91 mg/L. Chlorophyll-a corrected values are above the nutrient threshold for clear - alkaline lakes developed by FDEP of 20.0 µg/l with a value of 47.9 µg/l for 2019 data (54.1 µg/l for the POR).

Bacteria testing showed low levels of E. Coli (18.4 colonies/100ml) and Enterococci (49.3 colonies/100ml) for the POR, below the rules set forth in FDEP 62-302.530 (https://www.flrules.org/gateway/RuleNo.asp?title=SURFACE%20WATER%20QUALITY%20STANDARDS&ID=62-302.500) "Most Probable Number (MPN) or Membrane Filter (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 geometric means based on a minimum of 10 samples taken over a 30 day period."

Table 5: Lake Darby Water Quality Results from 5/23/19 (Laboratory)

Parameter	Lake Darby (Center)	POR Mean Value	Units
Alkalinity	38.0		mg/LCaCO3
Ammonia	0.005	0.006	mg/L
Chlorophyll a	189.4	64.3	ug/L
Chlorophyll b	7.9	3.8	ug/L
Chlorophyll c	7.2	2.7	ug/L
Chlorophyll t	204.5	70.4	ug/L
Chlorophylla Corr	169.0	54.112	ug/L
Chlorophyll-pheo	24.0	16.354	ug/L
Color(345)F.45	15.0	15	Pt/Co
E Coli	4	18.4	#/100ml
Enterococci	8	49.3	#/100 ml
Kjeldahl Nitrogen	2.801	1.107	mg/L
Nitrates/Nitrites	0.018	0.014	mg/L
Total Nitrogen	2.801	1.107	mg/L
Total Phosphorus	0.245	0.212	mg/L

Table 6: Numeric Nutrient Criteria Framework

Parameter	Value
Geometric Mean (Geomean) Color (pcu)	15
Number of Samples	1
Geometric Mean Alkalinity (mg/L $CACO_3$)	38.0
Number of Samples	1
Lake Type	Clear - Alkaline
Chlorophyll a Criteria (ug/L)	20
Insufficient for Geomean Criteria then P mg/L	0.03
Insuffcient for Geomean Criteria then N mg/L	1.05
2019 Geomean Chla Corrected ug/L	47.9
2019 Geomean TP mg/L	0.197
2019 Geomean TN mg/L	1.175
Number of Samples	3
Potential Impaired Chlorophyll a	Impaired
Potential Impaired TP	Impaired
Potential Impaired TN	Impaired

Table 7: FDEP Numeric Nutrient Criteria Values

Long Term Geometric Mean Lake Color and Alkalinity	Annual Geometric Mean Chlorophyll *a*	Minimum calculated numeric interpretation		Maximum calculated numeric interpretation	
		Annual Geometric Mean Total Phosphorus	Annual Geometric Mean Total Nitrogen	Annual Geometric Mean Total Phosphorus	Annual Geometric Mean Total Nitrogen
> 40 Platinum Cobalt Units	**20 µg/L**	**0.05 mg/L**	**1.27 mg/L**	**0.16 mg/L[1]**	**2.23 mg/L**
≤ 40 Platinum Cobalt Units and > 20 mg/L $CaCO_3$	**20 µg/L**	**0.03 mg/L**	**1.05 mg/L**	**0.09 mg/L**	**1.91 mg/L**
≤ 40 Platinum Cobalt Units and ≤ 20 mg/L $CaCO_3$	**6 µg/L**	**0.01 mg/L**	**0.51 mg/L**	**0.03 mg/L**	**0.93 mg/L**

[1] For lakes with color > 40 PCU in the West Central Nutrient Watershed Region, the maximum TP limit is 0.49 mg/L, which is the TP streams threshold for the region.

Conclusion

The results of the assessment of Lake Darby shows an impaired lake based on Chlorophyll-a, Total Nitrogen and Total Phosphorous concentrations according to the FDEP numeric nutrient criteria using the limited long term water quality record. The sampling data was insufficient to calculate proper FDEP Numeric Nutrient Criteria values with only 2019 having suitable data. Consistent Long term sampling would be necessary to determine actual NNC values with a minimum of three samples per year (quarterly preferred) for the previous three years. The 2019 values for Chlorophyll-a, Total Nitrogen and Total Phosphorous are above the nutrient threshold. The system also shows impairment in the vegetation communities according to the Lake Vegetation Index with moderate overall species (44), moderate occurrences of non-native, invasive species and few sensitive plant species with an overall LVI score of 14. The assessment did not observe any submerged aquatic vegetation at the time of the assessment.