

Lake Assessment Report for Rainbow Lake in Hillsborough County, Florida

Date Assessed: May 28, 2010

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Reviewed by: Jim Griffin

INTRODUCTION

This assessment was conducted to update existing physical and ecological data for Rainbow Lake on the [Hillsborough County & City of Tampa Water Atlas](#). The project is a collaborative effort between the University of South Florida's Center for Community Design and Research and Hillsborough County Stormwater Management Section. The project is funded by Hillsborough County and the Southwest Florida Water Management District's Northwest Hillsborough, Hillsborough River and Alafia River Basin Boards. The project has, as its primary goal, the rapid assessing of up to 150 lakes in Hillsborough County during a five-year period. The product of these investigations will provide the County, lake property owners and the general public a better understanding of the general health of Hillsborough County lakes, in terms of shoreline development, water quality, lake morphology (bottom contour, volume, area, etc.) and the plant biomass and species diversity. These data are intended to assist the County and its citizens to better manage lakes and lake-centered watersheds.



Figure 1. General Photograph of Rainbow Lake

The first section of the report provides the results of the overall morphological assessment of the lake. Primary data products include: a contour (bathymetric) map of the lake, area, volume and depth statistics, and the water level at the time of assessment. These data are useful for evaluating trends and for developing management actions such as plant management where depth and lake volume are needed.

The second section provides the results of the vegetation assessment conducted on the lake. These results can be used to better understand and manage vegetation in the lake. A list is provided with the different plant species found at various sites around the lake. Potentially invasive, exotic (non-native) species are identified in a plant list and the percent of exotics is presented in a summary table. Watershed values provide a means of reference.

The third section provides the results of the water quality sampling of the lake. Both field data and laboratory data are presented. The trophic state index (TSI)ⁱ is used to develop a general lake health statement, which is calculated for both the water column with vegetation and the water column if vegetation were removed. These data are derived from the water chemistry and vegetative submerged biomass assessments and are useful in understanding the results of certain lake vegetation management practices.

The intent of this assessment is to provide a starting point from which to track changes in the lake, and where previous comprehensive assessment data is available, to track changes in the lake's general health. These data can provide the information needed to determine changes and to monitor trends in physical condition and ecological health of the lake.

Section 1: Lake Morphology

Bathymetric Mapⁱⁱ. Table 1 provides the lake's morphologic parameters in various units. The bottom of the lake was mapped using a Lowrance LCX 28C HD Wide Area Augmentation System (WAAS)ⁱⁱⁱ enabled Global Positioning System (GPS) with fathometer (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 (Figure 2). 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.

Table 1. Lake Morphologic Data (Area, Depth and Volume)

Parameter	Feet	Meters	Acres	Acre-Ft	Gallons
Surface Area (sq)	2,103,077	195,382	48.28		
Mean Depth	9	2.70			
Maximum Depth	22	6.70			
Volume (cubic)	1,924,481	54,495		44.20	14,396,121
Gauge (relative)	36.51	11.13			

ⁱ The trophic state index is used by the Water Atlas to provide the public with an estimate of their lake resource quality. For more information, see end note 1.

ⁱⁱ 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.

ⁱⁱⁱ WAAS is a form of differential GPS (DGPS) where data from 25 ground reference stations located in the United States receive GPS signals from 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.

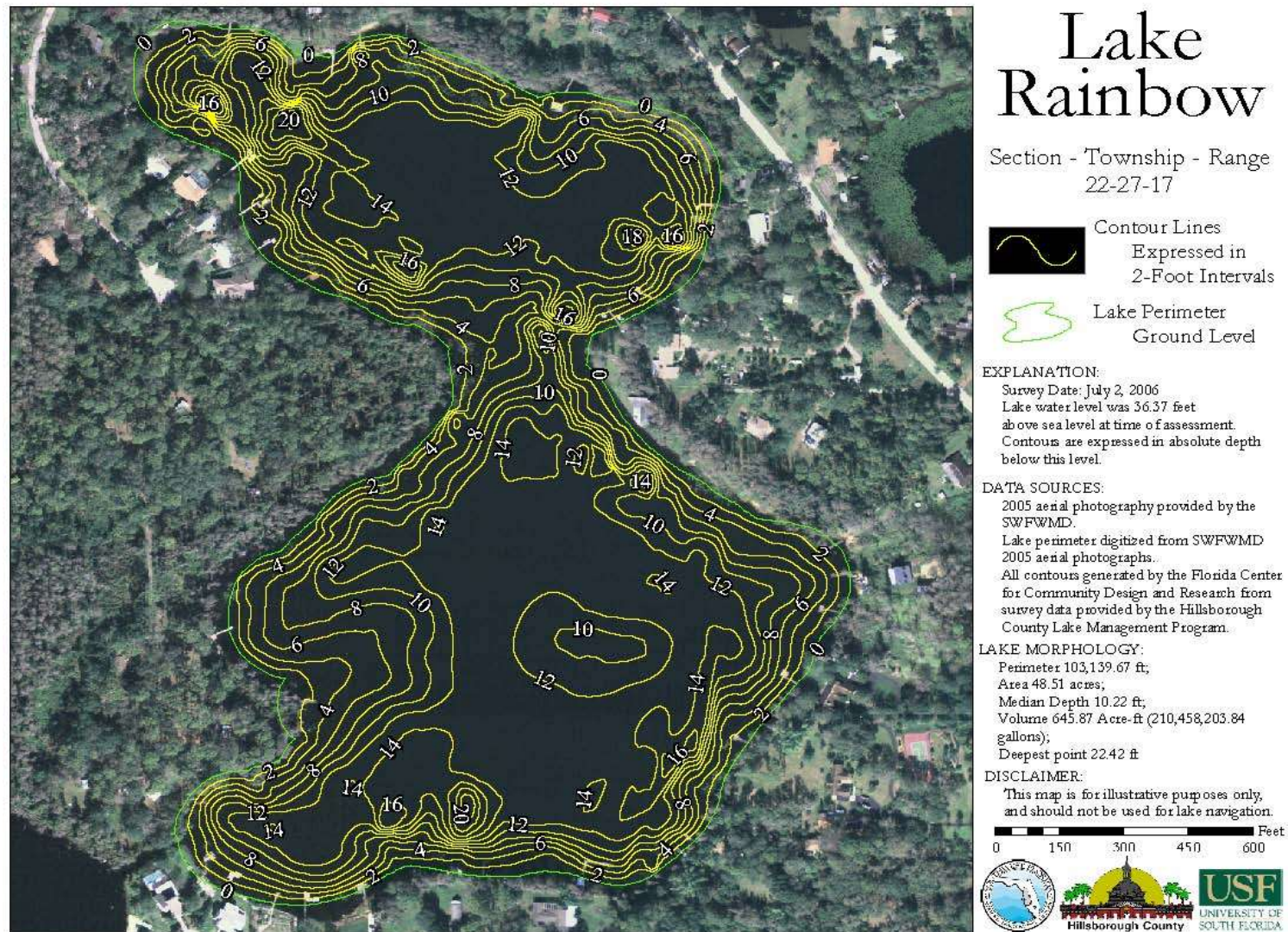


Figure 2. Rainbow Lake Bathymetric Contour Map

Section 2: Lake Ecology (Vegetation)

The lake's apparent vegetative cover and shoreline detail are evaluated using the latest lake aerial photograph as shown in and by use of WAAS-enabled GPS. Submerged vegetation is determined from the analysis of bottom returns from the Lowrance 28c HD combined GPS/fathometer described earlier. As depicted in Figure 3, 10 vegetation assessment sites were chosen for intensive sampling based on the *Lake Assessment Protocol* (copy available on request) for a lake of this size. The site positions are set using GPS and then loaded into a GIS mapping program (ArcGIS) for display. Each site is sampled in the three primary vegetative zones (emergent, submerged and floating)^{iv}. The latest high resolution aerial photos are used to provide shore details (docks, structures, vegetation zones) and to calculate the extent of surface vegetation coverage. The primary indices of submerged vegetation cover and biomass for the lake, percent area coverage (PAC) and percent volume infestation (PVI), are determined by transiting the lake by boat and employing a fathometer to collect "hard and soft return" data. These data are later analyzed for presence and absence of vegetation and to determine the height of vegetation if present. The PAC is determined from the presence and absence analysis of 100 sites in the lake and the PVI is determined by measuring the difference between hard returns (lake bottom) and soft returns (top of vegetation) for sites (within the 100 analyzed sites) where plants are determined present.

Beginning with the 2010 Lake Assessments, the Water Atlas Lake Assessment Team has added the Florida Department of Environmental Protection (FDEP) Lake Vegetation Index (LVI)^v method to the methods used to evaluate a lake. The LVI method was designed by DEP to be a rapid assessment of ecological condition, by determining how closely a lake's flora resembles that expected from a minimally disturbed condition.

The data collected during the site vegetation sampling include vegetation type, exotic vegetation, predominant plant species and submerged vegetation biomass. The total number of species from all sites is used to approximate the total diversity of aquatic plants and the percent of invasive-exotic plants on the lake (Table 2). The Watershed value in Table 2 only includes lakes sampled during the lake assessment project begun in May of 2006. These data will change as additional lakes are sampled. Table 3 through Table 5 detail the results from the 2010 aquatic plant assessment for the lake. These data are determined from the 10 sites used for intensive vegetation surveys. The tables are divided into Floating Leaf, Emergent and Submerged plants and contain the plant code, species, common name and presence (indicated by a 1) or absence (indicated by a blank space) of species and the calculated percent occurrence (number sites species is found/number of sites) and type of plant (Native, Non-Native, Invasive, Pest). In the "Type" category, the codes N and E0 denote species native to Florida. The code E1 denotes Category I invasive species, as defined by the [Florida Exotic Pest Plant Council](#) (FLEPPC); these are species "that are altering native plant communities by displacing native species, changing community structures or ecological functions, or hybridizing with natives." The code E2 denotes Category II invasive species, as defined by FLEPPC; these species "have increased in abundance or frequency but have not yet altered Florida plant communities to the extent shown by Category I species." Use of the term invasive indicates the plant is commonly considered invasive in this region of Florida. The term "pest" indicates a plant (native or non-native) that has a greater than 55% occurrence in the lake and is also considered a problem plant for this region of Florida, or is a non-native invasive that is or has the potential to be a problem plant in the lake and has at least 40% occurrence. These two terms are somewhat subjective; however, they are provided to give lake property owners some guidance in the management of plants on their property. Please remember that to remove or control plants in a wetland (lake shoreline) in Hillsborough County the property owner must secure an [Application To Perform Miscellaneous Activities In Wetlands](#) permit from the [Environmental Protection Commission of Hillsborough County](#) and for management of in-lake vegetation outside the wetland fringe (for lakes with an

^{iv} See end note 3.

^v See end note 4.

area greater than ten acres), the property owner must secure a [Florida Department of Environmental Protection Aquatic Plant Removal Permit](#).

Table 2. Total Diversity, Percent Exotics, and Number of Pest Plant Species

Parameter	Lake	Watershed
Number of Vegetation Assessment Sites	10	216
Total Plant Diversity (# of Taxa)	60	177
% Non-Native Plants	22	17
Total Pest Plant Species	5	18

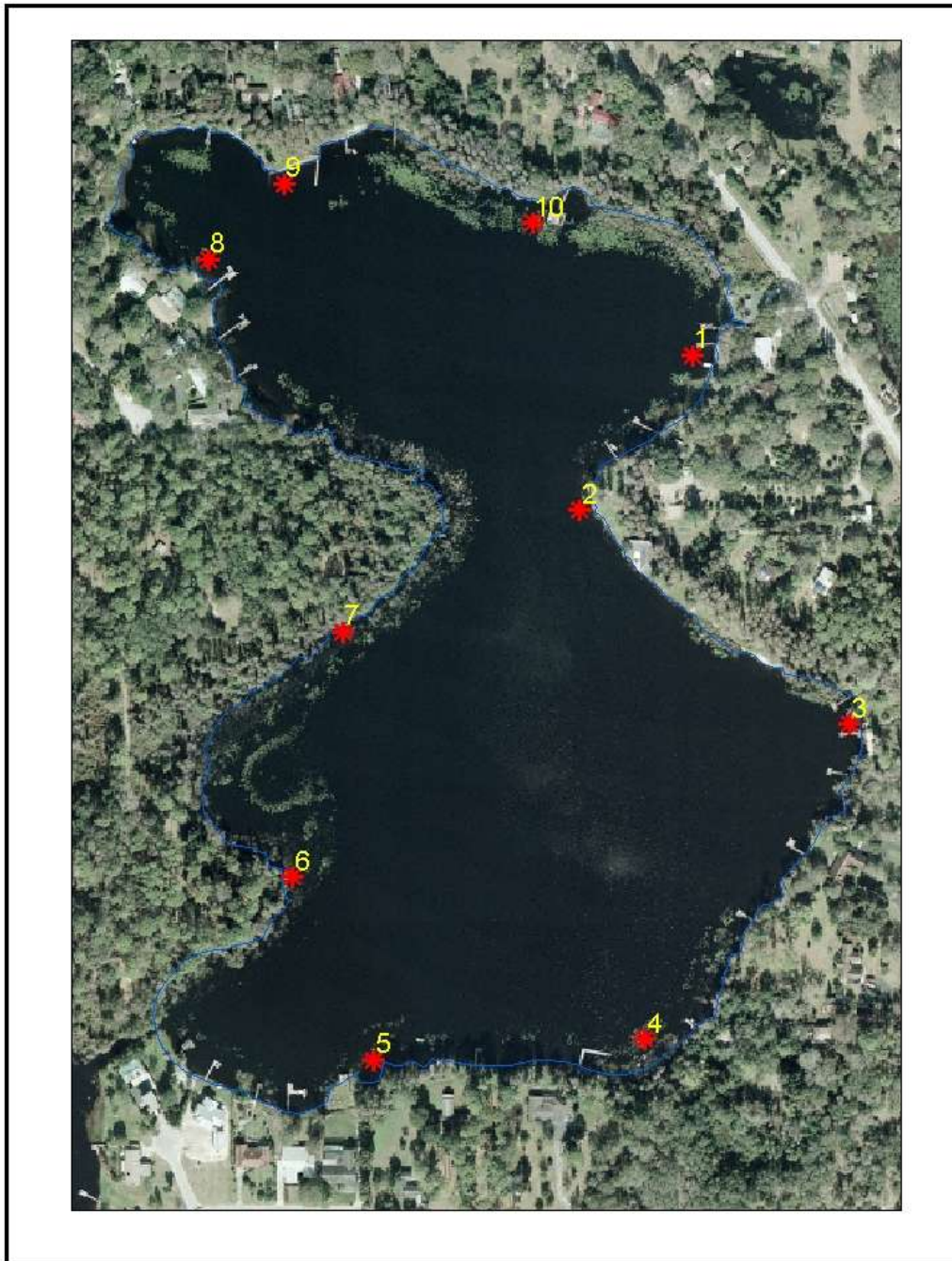


Figure 3. Rainbow Lake Vegetation Assessment Site Map

Table 3. List of Floating Leaf Zone Aquatic Plants Found

Plant Species Code	Scientific Name	Common Name	Percent Occurrence	Type
NLM	<i>Nuphar lutea</i>	Spatterdock, Yellow Pondlily	80%	N, E0
NOA	<i>Nymphaea odorata</i>	American White Water Lily, Fragrant Water Lily	80%	N, E0
NNA	<i>Nymphoides aquatica</i>	Banana Lily, Big Floatingheart	70%	N, E0
IVA	<i>Iris virginica</i>	Southern Blue Flag	20%	E0



Figure 4. *Nymphaea odorata* on Rainbow Lake

Table 4. List of Emergent Zone Aquatic Plants Found

Plant Species Code	Scientific Name	Common Name	Percent Occurrence	Type
HYE	<i>Hydrocotyl umbellata</i>	Manyflower Marshpennywort, Water Pennywort	100%	N, E0
PRS	<i>Panicum repens</i>	Torpedo Grass	90%	E1, P
TDM	<i>Taxodium distichum</i>	Bald Cypress	80%	N, E0
PCA	<i>Pontederia cordata</i>	Pickerel Weed	70%	N, E0
QLA	<i>Quercus laurifolia</i>	Laurel Oak; Diamond Oak	60%	N, E0
TYP	<i>Typha spp.</i>	Cattails	60%	N, E0
SPO	<i>Sabal palmetto</i>	Sabal Palm, Cabbage Palm	50%	N, E0
LPA	<i>Ludwigia peruviana</i>	Peruvian Primrosewillow	50%	E0, P
MEL	<i>Melaleuca quinquenervia</i>	Punk Tree, Melaleuca	50%	E1, P
JUM	<i>Juncus marginatus</i>	Shore Rush, Grassleaf Rush	50%	N, E0
LOP	<i>Ludwigia spp.</i>	Water Primroses, Primrosewillow	50%	E0
CSS	<i>Cyperus surinamensis</i>	Sedge	50%	N, E0
BHA	<i>Baccharis halimifolia</i>	Sea Myrtle	40%	N, E0
JES	<i>Juncus effusus var solutus</i>	Soft Rush	40%	N, E0
POL	<i>Polygonum spp.</i>	Smartweed, Knotweed	40%	N, E0
WTA	<i>Wedelia trilobata</i>	Creeping Oxeye	40%	E2, P
APS	<i>Alternanthera philoxeroides</i>	Alligator Weed	40%	E2, P
MSS	<i>Mikania scandens</i>	Climbing Hempvine	40%	N, E0
VRA	<i>Vitis rotundifolia</i>	Muscandine Grape	40%	N, E0
SLA	<i>Sagittaria lancifolia</i>	Duck Potato	30%	N, E0
PGA	<i>Psidium guajava</i>	Guava	30%	E1
PIN	<i>Pinus spp.</i>	Pine Tree	30%	N, E0
PNA	<i>Phyla nodiflorea</i>	Frog-fruit, Carpetweed, Turkey Tangle Fogfruit	30%	N, E0
BID	<i>Bidens spp.</i>	Bur Marigold	30%	N, E0
BLS	<i>Blechnum serrulatum</i>	Swamp fern, Toothed Midsorus Fern	30%	N
CCA	<i>Cinnamomum camphora</i>	Camphor-tree	20%	N, E1
CEA	<i>Colocasia esculenta</i>	Wild Taro	20%	E1
CHN	<i>Cyperus haspan</i>	Haspan Flatsedge	20%	N, E0
COM	<i>Commelina spp.</i>	Dayflower	20%	N, E0
CPS	<i>Cyperus papyrus</i>	Papyrus Sedge	20%	E2
CRX	<i>Carex spp.</i>	Sedge	20%	
CYO	<i>Cyperus odoratus</i>	Fragrant Flatsedge	20%	N, E0
EAA	<i>Eclipta alba</i>	Yerba De Tajo	20%	N, E0
FSR	<i>Fuirena scirpoidea</i>	Southern Umbrellasedge	20%	N, E0
GLS	<i>Gordonia lasianthus</i>	Loblolly Bay	20%	N, E0

Plant Species Code	Scientific Name	Common Name	Percent Occurrence	Type
SAL	<i>Salix spp.</i>	Willow	20%	N, E0
STS	<i>Schinus terebinthifolius</i>	Brazilian Pepper	20%	E1
WAX	<i>Myrica cerifera</i>	Wax Myrtle	20%	N, E0
XYR	<i>Xyris spp.</i>	Yellow-eyed Grass	10%	N, E0
ULA	<i>Urena lobata</i>	Caesar's-weed	10%	N, E2
SAM	<i>Sambucus canadensis</i>	Elderberry	10%	N, E0
PQA	<i>Parthenocissus quinquefolia</i>	Virginia Creeper, Woodbine	10%	N, E0
PHN	<i>Panicum hemitomom</i>	Maidencane	10%	N, E0
ACE	<i>Acer rubrum</i>	Southern Red Maple	10%	N, E0
PEP	<i>Persea palustris</i>	Swampbay	10%	N, E0
LOS	<i>Ludwigia octovalvis</i>	Mexican Primrosewillow, Long-stalked Ludwigia	10%	N, E0
LRS	<i>Ludwigia repens</i>	Creeping Primrosewillow, Red Ludwigia	10%	N, E0
IAA	<i>Ipomoea aquatica</i>	Water Spinach	10%	E1
CYP	<i>Cyperus spp.</i>	Sedge	10%	E0
DBA	<i>Dioscorea bulbifera</i>	Air Potato	10%	E1
CAA	<i>Centella asiatica</i>	Asian Pennywort, Coinwort	10%	N, E0



Figure 5. Emergent Vegetation Zone in Rainbow Lake

Table 5. List of Submerged Zone Aquatic Plants Found.

Plant Species Code	Scientific Name	Common Name	Percent Occurrence	Type
BCA	<i>Bacopa caroliniana</i>	Lemon Bacopa	100%	N, E0
CHA	<i>Chara spp.</i>	Muskgrass	90%	N, E0
EBI	<i>Eleocharis baldwinii</i>	Baldwin's Spikerush, Roadgrass	80%	N, E0
POT	<i>Potamogeton spp.</i>	Pond Weed	40%	N, E0
VAA	<i>Valisneria americana</i>	Tapegrass	10%	N, E0

Table 6. List of All Plants and Sample Sites

Plant Common Name	Found at Sample Sites	Percent Occurrence	Growth Type
Lemon Bacopa	1,2,3,4,5,6,7,8,9,10	100	Submersed
Manyflower Marshpennywort, Water Pennywort	1,2,3,4,5,6,7,8,9,10	100	Emergent
Muskgrass	1,2,3,4,5,6,7,8,9	90	Submersed
Torpedo Grass	1,2,3,4,5,6,7,8,10	90	Emergent
American White Water Lily, Fragrant Water Lily	1,2,3,4,5,6,8,9	80	Floating
Bald Cypress	1,2,3,4,5,6,7,8	80	Emergent
Baldwin's Spikerush, Roadgrass	1,2,3,5,7,8,9,10	80	Submersed
Spatterdock, Yellow Pondlily	1,2,3,4,5,6,7,10	80	Floating
Banana Lily, Big Floatingheart	1,2,3,7,8,9,10	70	Floating
Pickrel Weed	1,2,4,5,6,7,10	70	Emergent
Cattails	2,3,4,7,9,10	60	Emergent
Laurel Oak; Diamond Oak	4,5,6,7,8,10	60	Emergent
Peruvian Primrosewillow	3,4,5,7,10	50	Emergent
Punk Tree, Melaleuca	3,4,5,7,10	50	Emergent
Sabal Palm, Cabbage Palm	1,2,3,4,5	50	Terrestrial
Sedge	1,2,5,8,9	50	Emergent
Shore Rush, Grassleaf Rush	1,2,6,7,8	50	Emergent
Water Primroses, Primrosewillow	1,2,6,8,9	50	Emergent
Alligator Weed	2,3,4,9	40	Emergent
Climbing Hempvine	3,4,6,7	40	Emergent
Creeping Oxeye	3,4,5,10	40	Emergent
Muscandine Grape	4,5,6,10	40	Emergent
Pond Weed	1,2,3,9	40	Submersed
Sea Myrtle	3,5,7,10	40	Emergent
Smartweed, Knotweed	3,4,7,9	40	Emergent
Soft Rush	2,3,4,6	40	Emergent
Bur Marigold	1,3,4	30	Emergent
Duck Potato	3,6,7	30	Emergent
Frog-fruit, Carpetweed, Turkey Tangle Fogfruit	1,3,5	30	Emergent
Guava	4,6,7	30	Emergent
Pine Tree	4,5,7	30	Emergent
Swamp fern, Toothed Midsorus Fern	4,5,10	30	Emergent

Plant Common Name	Found at Sample Sites	Percent Occurrence	Growth Type
Brazilian Pepper	5,10	20	Emergent
Camphor-tree	1,10	20	Emergent
Dayflower	9,10	20	Emergent
Fragrant Flatsedge	1,2	20	Emergent
Haspan Flatsedge	5,6	20	Emergent
Loblolly Bay	7,10	20	Emergent
Papyrus Sedge	1,2	20	Emergent
Sedge	2,4	20	Emergent
Southern Blue Flag	4,5	20	Floating
Southern Umbrellasedge	2,4	20	Emergent
Wax Myrtle	4,6	20	Emergent
Wild Taro	3,4	20	Emergent
Willow	6,7	20	Emergent
Yerba De Tajo	2,9	20	Emergent
Air Potato	7	10	Emergent
Asian Pennywort, Coinwort	2	10	Emergent
Caesar's-weed	3	10	Emergent
Creeping Primrosewillow, Red Ludwigia	9	10	Emergent
Elderberry	3	10	Emergent
Maidencane	2	10	Emergent
Mexican Primrosewillow, Long-stalked Ludwigia	5	10	Emergent
Sedge	2	10	Emergent
Southern Red Maple	7	10	Emergent
Swampbay	9	10	Emergent
Tapegrass	6	10	Submersed
Virginia Creeper, Woodbine	4	10	Emergent
Water Spinach	4	10	Emergent
Yellow-eyed Grass	1	10	Emergent

Section 3: Long-term Ambient Water Chemistry

A critical element in any lake assessment is the long-term water chemistry data set. These data are obtained from several data sources that are available to the Water Atlas and are managed in the Water Atlas Data Download and graphically presented on the water quality page for lakes in Hillsborough County. The Rainbow Lake Water Quality Page can be viewed at <http://www.hillsborough.wateratlas.usf.edu/lake/waterquality.asp?wbodyid=5107&wbodyatlas=lake>.

A primary source of lake water chemistry in Hillsborough County is the [Florida LAKEWATCH](#) volunteer lake monitor and the Florida LAKEWATCH laboratory at the University of Florida. Rainbow Lake does not have an active LAKEWATCH volunteer presently. The last LAKEWATCH volunteer water chemistry data was collected on August 12, 2001, so only limited trend analysis is possible. Other source data are used as available; however these data can only indicate conditions at time of sampling.

These data are displayed and analyzed on the Water Atlas as shown in Figure 6, Figure 7, and Figure 8 for Rainbow Lake. The figures are graphs of: (1) the overall trophic state index (TSI)¹, which is a method commonly used to characterize the productivity of a lake, and may be thought of as a lake's ability to support plant growth and a healthy food source for aquatic life; (2) the chlorophyll a concentration, which indicates the lake's algal concentration, and (3) the lake's Secchi Disk depth which is a measure of water visibility and depth of light penetration. These data are used to evaluate a lake's ecological health and to provide a method of ranking lakes and are indicators used by the US Environmental Protection Agency (USEPA) and the Florida Department of Environmental Protection (FDEP) to determine a lake's level of impairment. The chlorophyll a and Secchi Disk depth graphs include benchmarks which indicate the median values for the various parameters for a large number of Lakes in Florida expressed as percentiles.

Based on best available data, Rainbow Lake has a color value determined as a platinum cobalt unit (pcu) value of 25 and is considered a Clear lake (has a mean color in pcu greater than 40). The FDEP and USEPA may classify a lake as impaired if the lake is a dark lake and has a TSI greater than 60, or is a clear lake (has a mean color in pcu less than or equal to 40) and has a TSI greater than 40. Rainbow Lake has a TSI of 49 (based on chlorophyll TSI) and does meet the FDEP Impaired Waters Rule (IWR) criteria for impaired lakes. See also Table 7.



Figure 6. Recent Trophic State Index (TSI) graph for Rainbow Lake^{vi}

^{vi} Graph source: Hillsborough County Water Atlas. For an explanation of the Good, Fair and Poor benchmarks, please see the notes at the end of this report. For the latest data go to: http://www.hillsborough.wateratlas.usf.edu/graphs20/graph_it.aspx?wbodyid=5107&data=TSI&data_type=WQ&waterbodyatlas=lake&ny=10&bench=1

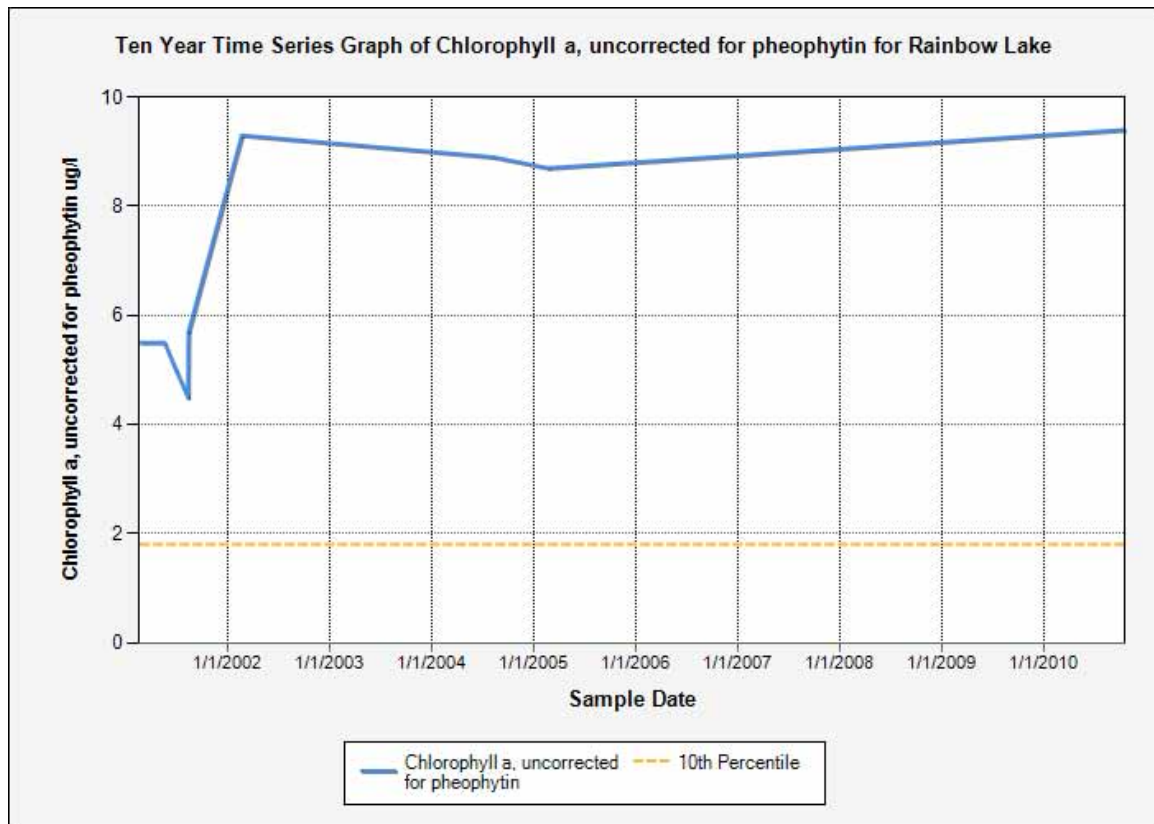


Figure 7. Recent Chlorophyll a graph for Rainbow Lake^{vii}

^{vii} Graph Source: Hillsborough County Water Atlas. For the latest data go to http://www.hillsborough.wateratlas.usf.edu/graphs20/graph_it.aspx?wbodyid=5107&data=Chla_ugl&datatype=WQ&waterbodyatlas=lake&ny=10&bench=1

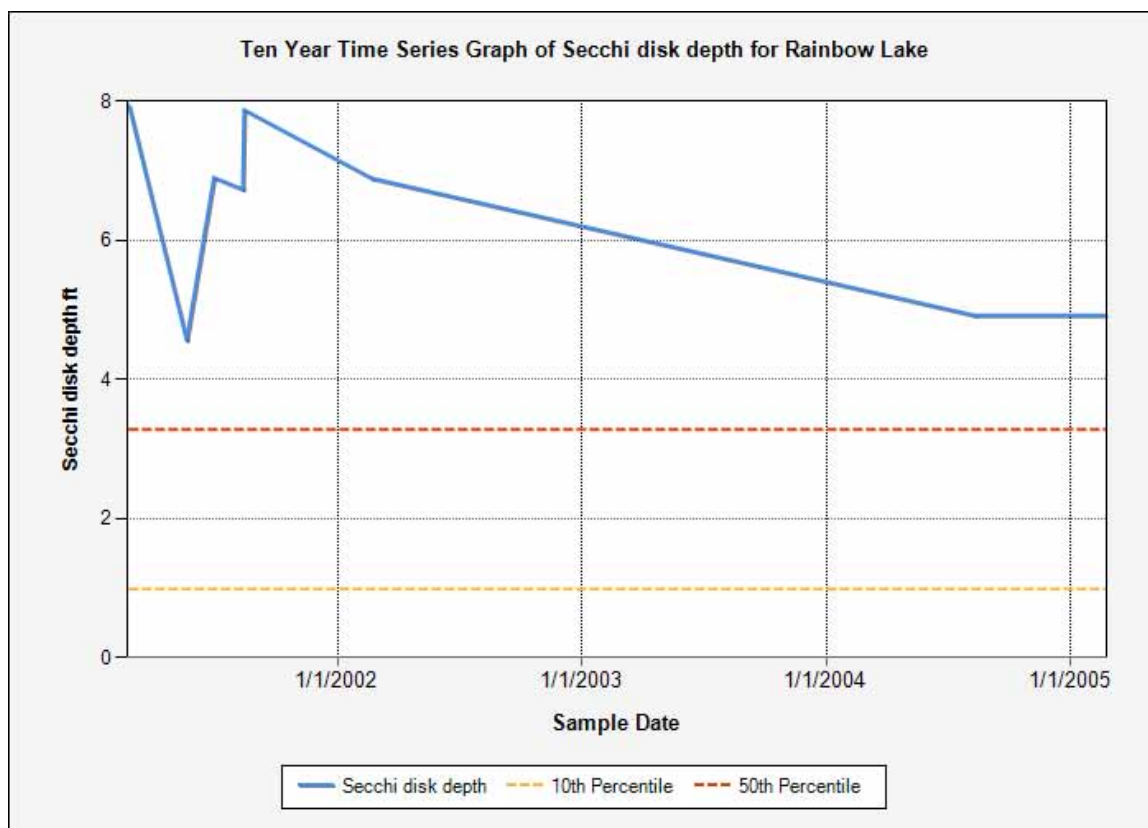


Figure 8. Recent Secchi Disk graph for Rainbow Lake^{viii}

As part of the lake assessment the physical water quality and chemical water chemistry of a lake are measured. These data only indicate a snapshot of the lake's water quality; however they are useful when compared to the trend data available from LAKEWATCH or other sources. Table 7 contains the summary water quality data and index values and adjusted values calculated from these data. The total phosphorus (TP), total nitrogen (TN) and chlorophyll a water chemistry sample data are the results of chemical analysis of samples taken during the assessment and analyzed by the Hillsborough County Environmental Protection Commission laboratory.

The growth of plants (planktonic algae, macrophytic algae and rooted plants) is directly dependent on the available nutrients within the water column of a lake and to some extent the nutrients which are held in the sediment and the vegetation biomass of a lake. Additionally, algae and other plant growth are limited by the nutrient in lowest concentration relative to that needed by a plant. Plant biomass contains less phosphorus by weight than nitrogen so phosphorus is many times the limiting nutrient. When both nutrients are present at a concentration in the lake so that either or both may restrict plant growth, the limiting factor is called "balanced". The ratio of total nitrogen to total phosphorous, the "N to P" ratio (N/P), is used to determine the limiting factor. If N/P is greater than or equal to 30, the lake is considered phosphorus limited, when this ratio is less than or equal to 10, the lake is considered nitrogen limited and if between 10 and 30 it is considered balanced.

^{viii} Graph Source: Hillsborough County Water Atlas. For the latest data go to http://www.hillsborough.wateratlas.usf.edu/graphs20/graph_it.aspx?wbodyid=5107&data=secchi_ft&datatype=WQ&waterbodyatlas=lake&ny=10&bench=1

Table 7. Water Quality Parameters (Laboratory) for Rainbow Lake

Parameter	Value
Lake Area (Acres)	48.28
Lake Area (m2)	195,382.00
Lake Volume (m3)	54,495.00
Number of Vegetation Sites	10
Average Station SAV Weight	0.53
Wet Weight of Vegetation (g)	26,669,674.12
Dry Weight of Vegetation (g)	2,133,573.93
Total Phosphorus (ug/L)	49.00 (mean is 20.43 - see discussion)
Total Nitrogen (ug/L)	460.00
Chlorophyll a (ug/L)	9.40
TN/TP	9.4 (TN/TP mean 33 – see discussion)
Limiting Nutrient	Not Determined (mean values indicate Balanced)
Chlorophyll TSI	49
Phosphorus TSI	Not Determined
Nitrogen TSI	42
TSI	49 (based on Chlorophyll TSI)
Color (PCU)	25
Secchi disk depth (ft)	5.43
Impaired TSI for Lake	40
Lake Status (Water Column)	Impaired

The color of a lake is also important to the growth of algae. Dark, tannic lakes tend to suppress algal growth and can tolerate a higher amount of nutrient in their water column; while clear lakes tend to support higher algal growth with the same amount of nutrients. The color of a lake, which is measured in a unit called the “cobalt platinum unit (PCU)” because of the standard used to determine color, is important because it is used by the State of Florida to determine lake impairment as explained earlier. A new rule which is being developed by USEPA and FDEP, will use alkalinity in addition to color to determine a second set of “clear-alkaline lakes” which will be allowed a higher TSI than a “clear-acid” lake. This is because alkaline lakes have been found to exhibit higher nutrient and algal concentrations than acid lakes. Additionally, lakes connected to a river or other “flow through” system tend to support lower algal growth for the same amount of nutrient concentration. All these factors are important to the understanding of your lake’s overall condition. Table 7 includes many of the factors that are typically used to determine the actual state of plant growth in your lake. These data should be understood and reviewed when establishing a management plan for a lake; however, as stated above other factors must be considered when developing such a plan. Please contact the [Water Atlas Program](#) if you have questions about this part or any other part of this report.

We have concern that an error exists in the phosphorus sample data from our 2010 lake assessment of Lake Rainbow. This may be a sampling error or a laboratory error. This conclusion is based on a comparison of these data with sample data from previous years and from other sampling agencies (Florida LAKEWATCH, SWFWMD and FDEP). We will issue corrections to these data at a later date after lakes have been re-sampled; however until that time we are using the TSI based only on Chlorophyll a. This value from Table 7 is 49. Additionally, nutrient limitation cannot be determined from the sample data alone; however, from previous data, the lake is balanced. Lake Rainbow is in the “Clear” category of lakes based on its mean color value of 25 pcu. This means that to not be considered impaired, the TSI must be equal to or less than 40. The TSI for Lake Rainbow is 49 so the lake would be considered impaired by the FDEP criteria based on this single data set. Figure 7 also indicates that enough single occurrences of TSI greater than 40 exist for the lake to be considered impaired.

Table 8 provides data derived from the vegetation assessment which is used to determine an adjusted TSI. This is accomplished by calculating the amount of phosphorus and nitrogen that could be released by existing submerged vegetation (Adjusted Nutrient) if this vegetation were treated with an herbicide or managed by the addition of Triploid Grass Carp (*Ctenopharyngodon idella*). The table also shows the result of a model that calculates the potential algae, as chlorophyll a (Adjusted Chlorophyll), which could develop due to the additional nutrients held within the plant biomass. While it would not be expected that all the vegetation would be turned into available phosphorus by these management methods, the data is useful when planning various management activities. Approximately 26.00 % of the lake has submerged vegetation present (PAC) and this vegetation represents about 5.13 % of the available lake volume (PVI). Please see additional parameters for adjusted values where appropriate in Table 8. The vegetation holds enough nutrients to add about 55.2 µg/L of phosphorus and 743.9 µg/L of nitrogen to the water column and increase the algal growth potential within the lake potentially adding 25.06 µg/L or chlorophyll to the water column.

Rainbow Lake is a balanced lake in terms of nutrient i.e., an increase in phosphorus and/or nitrogen could change the TSI and increase the potential for algal growth.

Table 8. Field parameters and calculations used to determine nutrients held in Submerged Aquatic Vegetation (SAV) biomass.

Parameter	Value
% Area Covered (PAC)	26.0 %
PVI	5.1 %
Total Phosphorus - Adjusted (ug/L)	55.20
Total Phosphorus - Combined (ug/L)	104.2
Total Nitrogen - Adjusted (ug/L)	743.88
Total Nitrogen - Combined (ug/L)	1203.88
Chlorophyll - Adjusted from Total Nutrients (ug/L)	13.18
Chlorophyll - Combined (ug/L)	22.58
Adjusted Chlorophyll TSI	53.9
Adjusted Phosphorus TSI	Not determined
Adjusted Nitrogen TSI	59
Adjusted TSI (for N, P, and CHLA)	53.9 (Based on Chlorophyll TSI)
Impaired TSI for Lake	40

Lake Rainbow has a medium coverage of submerged vegetation (PAC = 26%) and vegetation represents 5.1%% of the volume of the lake. Vegetation, especially, submerged vegetation is a reservoir for nutrients and for Lake Rainbow this reservoir represents a potential available nutrient concentration of 55.2 µg/L total phosphorus, 743.9 µg/L total nitrogen with the potential chlorophyll (produced from released nutrients) concentration of 13.18 µg/L. These data indicate that the removal of submerged vegetation from Lake Rainbow would result in a TSI increase from 49 to 54 and the lake would become more impaired.

Table 9 contains the field data taken in the center of the lake using a multi-probe (we use either a YSI 6000 or a Eureka Manta) which has the ability to directly measure the temperature, pH, dissolved oxygen (DO), percent DO (calculated from DO, temperature and conductivity). These data are listed for three levels in the lake and twice for the surface measurement. The duplicate surface measurement is taken as a quality assurance check on measured data.

Table 9. Water Chemistry Data Based on Manta Water Chemistry Probe for Rainbow Lake

Sample Location	Sample Depth (m)	Time	Temp (deg C)	Conductivity (mS/cm3)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	pH
Surface	0.83	10/13/2010 2:34:58 PM	26.59	0.168	93.43	7.65	6.13
Middle	2.36	10/13/2010 2:35:30 PM	26.51	0.168	94.21	7.73	6.09
Bottom	3.88	10/13/2010 2:36:10 PM	26.50	0.168	93.20	7.64	6.06
Mean Value	2.36	10/13/2010 2:37:00 PM	26.54	0.168	93.61	7.67	6.09

The lake is generally well mixed (parameters do not change significantly with depth) and the dissolved oxygen at a healthy level throughout the water column.

To better understand many of the terms used in this report, we recommend that the reader visit the [Hillsborough County & City of Tampa Water Atlas](#) and explore the “Learn More” areas which are found on the resource pages. Additional information can also be found using the [Digital Library](#) on the Water Atlas website.

Section 4: Conclusion

Rainbow Lake is a medium area (48.28-acre) lake that would be considered in the [Eutrophic](#) category of lakes based on water chemistry. It has a plant diversity of 60 species relative to the total watershed plant diversity of 177 species with about 26.00 % percent of the open water areas containing submerged aquatic vegetation. Vegetation helps to maintain the nutrient balance in the lake as well as provide good fish habitat. The lake has many open water areas to support various types of recreation and has a good diversity of plant species. The primary pest plants in the lake include *Panicum repens*, *Ludwigia peruviana*, *Melaleuca quinquenervia*.

The lake vegetative assessment also may be used to calculate a Lake Vegetative Index (LVI) for the lake ([See Note 4](#)). An LVI assessment was not conducted this year on your lake; however, it will be scheduled for the next cycle.

This assessment was accomplished to assist lake property owners to better understand and manage their lakes. Hillsborough County supports this effort as part of their [Lake Management Program \(LaMP\)](#) and has developed guidelines for lake property owner groups to join the LaMP and receive specific assistance from the County in the management of their lake. For additional information and recent updates please visit the [Hillsborough County & City of Tampa Water Atlas](#) website. Rainbow Lake does not have an active LAKEWATCH volunteer and the lack of consistent water quality data for the lake will make it difficult for the County to assist property owners in the management of the lake. It is highly recommended that a volunteer be recruited for the lake.

Lake Assessment Notes

1. The trophic state index is used by the Water Atlas to provide the public with an estimate of their lake resource quality. A "Good" quality lake is one that meets all lake use criteria (swimmable, fishable and supports healthy habitat). Based on the discussion above, lakes that are in the oligotrophic through low eutrophic range, for the most part, meet these criteria. A trophic state below 60 indicates lakes in this range and these lakes are given the "Good" descriptor. A trophic state above 60 but below 70 can be considered highly productive and a reasonable lake for fishing and most water sports. This lake is considered "Fair", while a lake in the Hypereutrophic range with a TSI greater than 70 will probably not meet the lake use criteria and these lakes are considered to be poor. Please see Table 10 below.

Table 10. Comparison of Classification Schemes

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

Also see the [Florida LAKEWATCH](#) publication, "[Trophic State: A Waterbody's Ability to Support Plants Fish and Wildlife](#)" and the [Trophic State Index Learn More page](#) on the [Hillsborough County & City of Tampa Water Atlas](#).

In recent years FDEP staff have encountered problems interpreting Secchi depth data in many tannic (tea or coffee-colored) waterbodies where transparency is often reduced due to naturally-occurring dissolved organic matter in the water. As a result, Secchi depth has been dropped as an indicator in FDEP's recent TSI calculations ([1996 Water-Quality Assessment for The State of Florida Section 305\(b\) Main Report](#)). This modification for black water TSI calculation has also been adopted by the Water Atlas.

Also, according to Florida LAKEWATCH use of the TSI is often misinterpreted and/or misused from its original purpose, which is simply to describe biological productivity. It is not meant to rate a lake's water quality. For example, higher TSI values represent lakes that support an abundance of algae, plants and wildlife. If you love to fish, this type of lake would not be considered to have "poor" water quality. However, if you are a swimmer or water skier, you might prefer a lake with lower TSI values.

The trophic state index is one of several methods used to describe the biological productivity of a waterbody. Two scientists, Forsberg and Ryding, 1980, developed another method that is widely used. It's known as the Trophic State Classification System. Using this method, waterbodies can be grouped into one of four categories, called trophic states:

Oligotrophic (oh-lig-oh-TROH-fik) where waterbodies have the lowest level of productivity;

Mesotrophic (mees-oh-TROH-fik) where waterbodies have a moderate level of biological productivity;

Eutrophic (you-TROH-fik) where waterbodies have a high level of biological productivity;

Hypereutrophic (HI-per-you-TROH-fik) where waterbodies have the highest level of biological productivity. The trophic state of a waterbody can also affect its use or perceived utility. Figure 9 illustrates this concept.

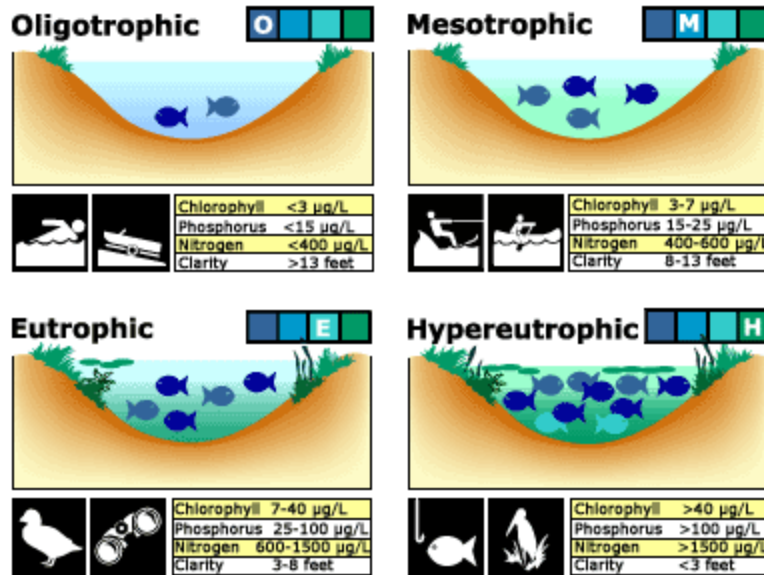
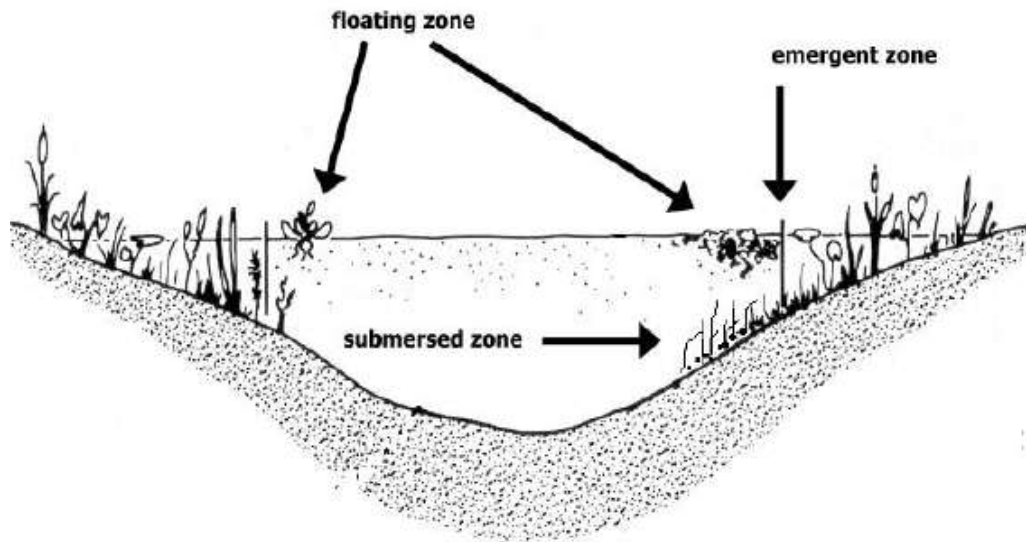


Figure 9. Tropic States

2. **Wide Area Augmentation System (WAAS)** is a form of differential GPS (DGPS) where data from 25 ground reference stations located in the United States receive GPS signals from GPS satellites in view and retransmit these data to a master control site and then to geostationary satellites. The geostationary satellites broadcast the information to all WAAS-capable GPS receivers. The receiver decodes the signal to provide real time correction of raw GPS satellite signals also received by the unit. WAAS-enabled GPS is not as accurate as standard DGPS which employs close by ground stations for correction, however; it was shown to be a good substitute when used for this type of mapping application. Data comparisons were conducted with both types of DGPS employed simultaneously and the positional difference was determined to be well within the tolerance established for the project.
3. The three primary aquatic vegetation zones are shown below:



4. 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. Below is a table of LVI scores recorded in Hillsborough County for comparison:

Lake Name	Sample Date	LVI Score
Lake Magdalene	5/26/2005	64
Lake Magdalene	10/20/2005	38
Burrell Lake, off Nebraska in Lutz area. Ambient Monitoring Program	8/4/2005	16
Silver lake just south of Waters between Habana and Himes Avenues, Tampa. Ambient Monitoring Program	7/29/2005	36
Unnamed lake on Forest Hills Drive south of Fletcher Avenue. Ambient Monitoring Program	8/3/2005	34
Hanna Pond, off Hanna Rd in Lutz. Ambient Monitoring Program	7/25/2005	38
Small lake, Lutz, just east pf Livingston. Ambient Monitoring Program	7/22/2005	39
Small lake, Lutz, adj to Lake Keene. Ambient Monitoring Program	8/5/2005	28
Unnamed small lake, Tampa, off Fowler behind University Square Mall. Ambient Monitoring Program	7/19/2005	16
Tiffany Lake, Lutz, north of Whittaker. Ambient Monitoring Program	7/25/2005	40
Cedar Lake, south of Fletcher, Forest Hills. Ambient Monitoring Program	7/22/2005	37
Unnamed small lake behind Natives Nursery, Lutz. Ambient Monitoring Program	8/5/2005	20
Unnamed lake on Curry Road off Livingston, Lutz. Ambient Monitoring Program	7/19/2005	46
Unnamed lake in Lutz. Ambient Monitoring Program	7/20/2005	45
Lake Josephine - HIL538UL	10/12/2006	40
Lake Magdalene - HIL546UL	10/18/2006	40
Starvation Lake - HIL540NL	9/28/2006	48
Egypt Lake - HIL556UL	10/31/2006	34
Unnamed Lake - HIL544UL	9/25/2008	58
Lake Rogers - L63P	7/22/2009	65
Lake Alice/Odessa, profundal zone	8/6/2009	71
Lake Carroll (Center)	7/15/2009	64
Unnamed Small Lake - Z4-SL-3011	7/21/2009	24
Unnamed Small Lake - Z4-SL-3020	7/21/2009	40
Lake Ruth - Z4-SL-3031	7/16/2009	71
Lake Juanita - Z4-SL-3036	7/20/2009	72
Chapman Lake	6/8/2009	42
Island Ford Lake	8/10/2010	50
Lake Magdalene	7/29/2010	56
Lake Ranibow	7/13/2010	38
Lake Carroll	7/20/2010	57

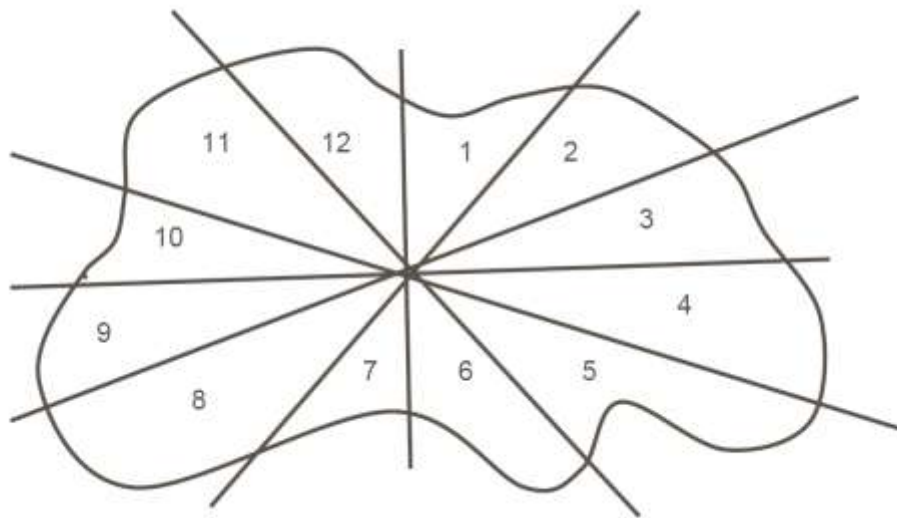
5.

Reference: "[Assessing the Biological Condition of Florida Lakes: Development of the Lake Vegetation Index \(LVI\) Final Report](#)", December, 2007, page 7. Prepared for: Florida Department of Environmental Protection, Twin Towers Office Building, 2600 Blair Stone Road, Tallahassee, FL 32399-2400, Authors: Leska S. Fore*, Russel Frydenborg**, Nijole Wellendorf**, Julie Espy**, Tom Frick**, David Whiting**, Joy Jackson**, and Jessica Patronis**

* Statistical Design

** Florida Department of Environmental Protection

Diagram showing the method used to divide a typical lake into 12 sections for replicate sampling:



6. A lake is **impaired** if: "For the purposes of evaluating nutrient enrichment in lakes, TSIs shall be calculated based on the procedures outlined on pages 86 and 87 of the State's 1996 305(b) report, which are incorporated by reference. Lakes or lake segments shall be included on the planning list for nutrients if: (1) For lakes with a mean color greater than 40 platinum cobalt units, the annual mean TSI for the lake exceeds 60, unless paleolimnological information indicates the lake was naturally greater than 60, or (2) For lakes with a mean color less than or equal to 40 platinum cobalt units, the annual mean TSI for the lake exceeds 40, unless paleolimnological information indicates the lake was naturally greater than 40, or (3) For any lake, data indicate that annual mean TSIs have increased over the assessment period, as indicated by a positive slope in the means plotted versus time, or the annual mean TSI has increased by more than 10 units over historical values. When evaluating the slope of mean TSIs over time, the Department shall require at least a 5 unit increase in TSI over the assessment period and use a Mann's one-sided, upper-tail test for trend, as described in Nonparametric Statistical Methods by M. Hollander and D. Wolfe (1999 ed.), pages 376 and 724 (which are incorporated by reference), with a 95% confidence level."

References: 62-303.352—Nutrients in Lakes. Specific Authority 403.061, 403.067 FS. Law Implemented 403.062, 403.067 FS. History - New 6- 10-02, Amended 12-11-06. Please see page 12 of the [Impaired Waters Rule](#). Updated activity regarding impaired waters may be tracked at: <http://www.dep.state.fl.us/water/tmdl/>

7. An **adjusted chlorophyll a value** ($\mu\text{g/L}$) was calculated by modifying the methods of Canfield et al (1983). The total wet weight of plants in the lake (kg) was calculated by multiplying lake surface area (m^2) by PAC (percent area coverage of macrophytes) and multiplying the product by the biomass of submersed plants (kg wet weight m^2) and then by 0.25, the conversion for the 1/4 meter sample cube. The dry weight (kg) of plant material was calculated by multiplying the wet weight of plant material (kg) by 0.08, a factor that represents the average percent dry weight of submersed plants (Canfield and Hoyer, 1992) and then converting to grams. The potential phosphorus concentration (mg/m^3) was calculated by multiplying dry weight (g) by 1.41 mg TP g⁻¹ dry weight, a number that represents the mean phosphorus (mg) content of dried plant material measured in 750 samples from 60 Florida lakes (University of Florida, unpublished data), and then dividing by lake volume (m^3) and then converting to $\mu\text{g/L}$ (1000/1000). From the potential phosphorus concentration, a predicted chlorophyll a concentration was determined from the total phosphorus and chlorophyll a relationship reported by Brown (1997) for 209 Florida lakes. Adjusted chlorophyll a concentrations were then calculated by adding each lake's measured chlorophyll a concentration to the predicted chlorophyll a concentration.