Total Maximum Daily Load for Total Phosphorus For Lake Harris and Little Lake Harris Lake County, Florida

Wayne Magley, Ph.D, P.E.

Florida Department of Environmental Protection
Watershed Assessment Section
September 19, 2003

Table of Contents

Section Page

List of Figures ii

List of Tables ii

1.0 Introduction 1

1.1 Purpose of Report 1

1.2 Identification of Waterbody 1

2.0 Statement of Problem 1

3.0 Description of the Applicable Water Quality Standards and Numeric Water Quality Target 3

4.0 Assessment of Sources 4

4.1 Types of Sources 4

4.2 Source loads 5

5.0 Loading Capacity – Linking Water Quality and Pollutant Sources 6

6.0 Critical Conditions 6

7.0 Determination of TMDL 7

7.1 Load Allocations (LAs) 8

7.2 Wasteload Allocations (WLAs) 8

7.3 Relationship between Lake Apopka, Lake Carlton, Lake Beauclair, and Lake Dora TMDLs 9

7.4 Margin of Safety (MOS) 9

8.0 Seasonal Variation 9

9.0 Next Steps: Implementation plan development and beyond 10

10. References 11

Appendix A 37

List of Figures

Figure		Page
1.	Upper Ocklawaha River Chain of Lakes	12
2.	Boxplots of Lake Harris (WBID 2838A), Little Lake Harris (WBID 2838B), and Helena Run (WBID 2832) water quality data over the 1989 – 2002 period	13
3.	Time series of Lake Harris (WBID 2838A) and Little Lake Harris (WBID 2838B) water quality data over the 1989 – 2002 period	19
4.	Cyanobacteria levels (biovolumes) in Lake Harris from Lake County Water Authority	20
5.	Microcystin levels in Lake Harris from Lake County Water Authority	22
6.	Plot of TN/TP ratio calculated for measurements in Lake Harris (WBID 2838A) and Little Lake Harris (WBID 2838B) over the 1989 – 2002 period	23
7.	Lake Harris and Little Lake Harris landuse	25

List of Tables

Table		Page
1.	Lake Harris, Little Lake Harris, Helena Run, and Dead River dissolved oxygen, un-ionized ammonia, and Chlorophyll a and/or TSI assessments under the IWR	26
2.	Summary statistics of key water quality parameters for Lake Harris, Little Lake Harris, Helena Run, and Dead River over the 1989 – 2001 period	27
3.	Ammonia concentration (in mg/l as N) that results in un-ionized ammonia of 0.02 mg/l as NH_3	31
4.	Pearson correlation matrix for Lake Harris (WBID 2838A) and Little Lake Harris (WBID 2828B)	32
5.	Estimated average annual total phosphorus and total nitrogen loading to Lake Harris, 1991-2000.	36
6.	TMDL components	8

Phosphorus TMDL for Lake Harris and Little Lake Harris

1.0 Introduction

1.1 Purpose of Report

This report presents a Total Maximum Daily Load (TMDL) for Total Phosphorus (TP) for Lake Harris and Little Lake Harris and describes the projected impact of proposed TP reductions on the concentration of unionized ammonia in the lakes. Using the methodology to identify and verify water quality impairments described in Chapter 62-303, Florida Administrative Code, (Identification of Impaired Surface Waters, which is commonly referred to as the Impaired Waters Rule, or IWR), both lakes were verified as impaired by nutrients, and were included on the verified list of impaired waters for the Ocklawaha Basin that was adopted by Secretarial Order on August 26, 2002. The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions.

Lake Harris discharges to Lake Eustis through the Dead River. The Dead River and Helena Run, a tributary to Lake Harris were also verified as impaired under the IWR for nutrients,and included in the August 26 Secretarial Order. The TMDL for Lake Harris is expected to address the impairments in these waterbodies..

1.2 Identification of Waterbody

Lakes Harris and Little Lake Harris, located in central Florida approximately 30 miles northwest of Orlando, are part of the Upper Ocklawaha River Basin (UORB) (Figure 1). They have a combined drainage basin of approximately 53,073 acres (Fulton et al., 2003). At a lake surface elevation of 63 ft National Geodetic Vertical Datum (NGVD), the lakes have a combined surface area of approximately 7,563 ha (18,689 acres) and an average depth of 3.66 m (12 ft). Surface outflow from the lakes is through the Dead River and into Lake Eustis. Surface elevations in Lakes Eustis, Harris, Dora, and Beauclair are controlled by the Burrel Lock and Dam located on Haines Creek and is operated by the SJRWMD.

For assessment purposes, the watersheds within the Ocklawaha River Basin have been broken out into smaller watersheds, with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed. Lake Harris has been assigned WBID 2838A, Little Lake WBID 2838B, Dead River WBID 2817C, and Helena Run WBID 2832.

2.0 Statement of Problem

The UORB is located primarily in a large lowland area between the Mount Dora Ridge to the east and the Ocala Uplift District to the west. In many areas, the valley floor intersects the potentiometric surface resulting in numerous springs and spring-fed lakes. Karst terrains are present throughout the area due to the soluble calrbonate rock and the nutrient rich soils have combined to produce naturally productive hardwater lakes.

During the 1800s resources were developed for tourism, agricultural, and commercial industry. According to the SWIM Plan (Fulton, 1995), impacts of urban development within the basin were first documented in the late 1940s. Eutrophication of surface waters was accelerated by the direct discharge of domestic, industrial, and agricultural wastes. In addition, construction of control structures and channelization of the system along with destruction of aquatic habits contributed to declines in water quality.

In 1987, the Florida Legislature adopted the Surface Water Improvement and Management (SWIM) Act, which directed Water Management Districts to adopt methodologies to identify waters in need of restoration and/or preservation. In 1989, the St. Johns River Water Management District (SJRWMD) adopted a SWIM plan for the restoration of the UORB.

In 1995, the SJRWMD developed an interim Pollutant Load Reduction Goal (PLRG) for phosphorus (Fulton, 1995) based upon trophic state modeling. PLRGs represent estimated reductions in pollutant loadings from stormwater needed to preserve or restore beneficial uses of receiving waters. Fulton (1995) reported that the largest single source of total phosphorus loading other than muck farms was runoff from agriculture. Lake Harris and Little Lake Harris were combined in the PLRG assessment based upon the interaction between the lakes.

Plots of key water quality parameters over the 1989 – 2002 period indicate that water quality has declined over this period, but that the ranges for some parameters have decreased over time (Figures 2[1] and 3[2]).). Table 1 summarizes DO, un-ionized ammonia, and chlorophyll a or Trophic State Index (TSI) annual averages used to assess Lake Harris, Little Lake Harris, Dead River, and Helena Run under the IWR. Statistical summaries of key water quality parameters are presented for the four WBIDs in Table 2.

In recent years, additional attention has been focused on blue-green algal (cyanobacteria) blooms in Florida lakes. Burns, et al. (2001) reported the presence of *Cylindrospermopsis sp.* and *Microcystis sp.* in samples collected in Lake Harris during the summer of 1999. Measurable levels of microcystins (a cyanotoxin) were also reported in some samples. The *Cylindrospermopsis* genera represents a filamentous bloom-forming cyanobacteria that can fix nitrogen from the atmosphere. The *Microcystis* genera is a non-filamentous bloom-forming cyanobacteria that has not been demonstrated to have the ability to fix nitrogen. In response to the blue-green algal blooms, the Lake County Water Authority (LCWA) funded a monitoring program that measures cyanobacteria abundance and microcystin levels in lakes in the UORB, including Lake Harris. Results of the monitoring to date are shown in Figures 4 and 5 (provided by Mr. Mike Perry, personal communication of the LCWA). Figure 5 indicates that microcystin levels were temporarily above the World Health Institute threshold for drinking water in December 2001, but that microcystin levels have declined from the peak levels in December 2001.

---

[1] . Figure 2 presents water quality information on an annual basis and suggests some reduction in ranges for some parameters over time.

[2] Figure 3 presents the individual observations over time and includes trendlines. Although the r^2 values were low, slopes (with the exception of un-ionized ammonia and total nitrogen in Lake Harris) were positive, suggesting declining water quality with time.

3.0 Description of the Applicable Water Quality Standards and Numeric Water Quality Target

Lake Harris and Little Lake Harris are Class III waterbodies with designated uses of recreation, propagation and maintenance of a healthy, well balanced population of fish and wildlife. The Class III water quality criteria applicable to the observed impairment is the narrative nutrient criterion (nutrient concentrations of a body of water shall not be altered so as to cause an imbalance in natural populations of aquatic flora or fauna). Because the nutrient criterion is narrative only, a nutrient related target was needed to represent levels at which imbalance in flora or fauna are expected to occur.

As part of the ongoing SWIM Program assessments of the lake, the SJRWMD developed a new interim PLRG for phosphorus in Lake Harris (and Little Lake Harris) that considered two approaches to determine an appropriate phosphorus target. The first approach involved modeling both the external loading and resultant lake water quality under historic (natural background) conditions. In the second approach, an appropriate TP target was determined using reference conditions from lakes in the region based upon three estimates (state lake ecoregion data, SJRWMD ecoregion dataset, and a selection of lakes with similar morphology and hydrology). All of these methods relied upon information and/or relationships developed from long-term datasets or steady state conditions. In this case, the TP target developed for the lakes by the SJRWMD (26 ppb) as part of the PLRG development for the lakes was used as the TP target for the lake.

It should be noted that the IWR provides a threshold of impairment for nutrients in lakes based on a Trophic State Index (TSI). While the IWR thresholds were not used as the water quality target for this TMDL (they are not water quality criteria), resultant changes in the TSI for the lake are included in the document to demonstrate that reductions in TP would be expected to result in decreases in lake chlorophyll a levels that would be consistent with a nonimpaired lake.

Reductions in TP loading are also expected to result in additional benefits with respect to other parameters of concern, including dissolved oxygen, un-ionized ammonia, turbidity, and total suspended solids. Reductions in phosphorus will result in lower algal biomass levels in the lake, and lower algal biomass levels will mean smaller diurnal fluctuations in dissolved oxygen, less algal based total suspended solids and turbidity, and lower pH levels in the lake. Since the fraction of ammonia that is un-ionized is directly related to pH, lower pH levels will also result in fewer exceedances of the un-ionized criterion (Table 3).

The expectation that reductions in phosphorus loading will provide improvements in other parameters is supported by statistical evaluation of the Lake Harris and Little Lake Harris data. Based on Pearson correlation coefficients (Table 4) for the Lake Harris data set, total phosphorus is positively correlated with turbidity, DO, corrected chlorophyll a, uncorrected chlorophyll a, ammonia, un-ionized ammonia, organic nitrogen, and TN. In the Little Lake Harris data set, total phosphorus was positively correlated with uncorrected chlorophyll, organic nitrogen, TKN, and TN. The correlation was negative between dissolved oxygen and total phosphorus in the Little Lake Harris data set and positive in the Lake Harris data set.. The simple linear regressions of total phosphorus versus un-ionized ammonia (Little Lake Harris), and uncorrected Chla (both), were significant at an alpha level of 0.05.

This positive correlation between pH and chlorophyll a (Little Lake Harris) reflects changes to the carbonate balance in the water column as CO_2 is used in algal photosynthesis. Reductions in pH in response to lower algal biomass and lower overall photosynthesis will reduce the occurrence of un-ionized ammonia exceedances even without a reduction in ammonia. For example, at a temperature of 20 ^{o}C, a pH reduction from 8.5 to 8 s.u. changes the total ammonia that would result in an un-ionized exceedance from 0.15 to 0.5 mg/l, respectively.

Proposed reductions in phosphorus will also result in a smaller input of nitrogen from nitrogen fixation by cyanobacteria that gets recycled in the lake through processes such as grazing and settling. In addition, additional treatment in the watershed to achieve the proposed phosphorus reduction will also result in additional nitrogen removal. Fulton et al.'s (2003) summary of 13 storm water treatment systems in Florida suggested a mean treatment efficiency of 42% for nitrogen. Those same treatment systems had a mean treatment efficiency of 63% for phosphorus.

Both the PLRG and this TMDL establish the allowable load for phosphorus only, and not nitrogen. Fulton et al. (2003) reported that ratios of nitrogen to phosphorus in the UORB suggest that algal production is potentially limited by phosphorus availability, except in lakes where excessive phosphorus loading has led to potential nitrogen or co-limitation of nitrogen and phosphorus. Total nitrogen to total phosphorus values less than 10 indicate nitrogen limitation, while ratios greater than 30 indicate phosphorus limitation. Figure 6 illustrates the distribution of this ratio for measurements in Lake Harris and Little Lake Harris over the 1989 – 2002 period. The ratio is typically above 30, indicating phosphorus limitation.

Loehr et al. (1980) point out that due to the ability of various cyanobacterial species to fix gaseous nitrogen, it is very difficult to control eutrophication problems in freshwater systems through limitations on nitrogen input. They indicate that phosphorus inputs must be lowered to the point where phosphorus replaces nitrogen as the limiting factor, and then further reduced so that the growth and yield of algal forms is reduced.

Whitton and Potts (2000) cite a study by Sas (1989) where phytoplankton and cyanobacterial components responded to phosphorus reduction in four stages:

Stage 1: no biomass reduction because phosphorus is in excess of algal requirements
Stage 2: declining amount of unused phosphorus results in a small reduction in Algal biomass
Stage 3: phytoplankton biomass falls, with minimal unused phosphorus remaining
Stage 4: further decline in biomass and changes in composition of the phytoplankton.

4.0 Assessment of Sources

4.1 Types of Sources

An important part of the TMDL analysis is the identification of source categories, source subcategories, or individual sources of phosphorus in the watershed and the amount of pollutant loading contributed by each of these sources. Sources are broadly classified as either “point sources” or “nonpoint sources.” Historically, the term point sources has meant discharges to surface waters that typically have a continuous flow via a discernable, confined, and discrete conveyance, such as a pipe. Domestic and industrial wastewater treatment facilities (WWTFs) are examples of traditional point sources. In contrast, the term “nonpoint sources” was used to describe intermittent, rainfall driven, diffuse sources of pollution associated with everyday human activities, including runoff from urban land uses, runoff from agriculture, runoff from silviculture, runoff from mining, discharges from failing septic systems, and atmospheric deposition.

However, the 1987 amendments to the Clean Water Act redefined certain nonpoint sources of pollution as point sources subject to regulation under EPA’s National Pollutant Discharge Elimination Program (NPDES). These nonpoint sources included certain urban stormwater discharges, including those from local government master drainage systems, construction sites over five acres, and from a wide variety of industries (see Appendix A for background information about the State and Federal Stormwater Programs).

To be consistent with Clean Water Act definitions, the term “point source” will be used to describe traditional point sources (such as domestic and industrial wastewater discharges) AND stormwater systems requiring an NPDES stormwater permit when allocating pollutant load reductions required by a TMDL (see Section 6). However, the methodologies used to estimate nonpoint source loads do not distinguish between NPDES stormwater discharges and non-NPDES stormwater discharges, and as such, this source assessment section does not make any distinction between the two types of stormwater.

4.2 Source Loads

As part of the development of a phosphorus PLRG for Lake Harris, Fulton et al. (2003) estimated average annual nitrogen and phosphorus loads to Lake Harris from a variety of sources over the 1991 – 2000 period (Table 5). Loads are presented to the nearest 0.1 kg to illustrate the magnitude of some of the smaller sources that were evaluated. Sources included runoff from land uses such as residential, commercial, industrial, mining, openland/recreational, muck farms, pastures, croplands, silviculture, wetlands, and other agriculture (Figure 7). Atmospheric contributions from wet and dry deposition directly on the lake surface were accounted for based upon measurements in the basin. Inputs from tributaries to the lake such as from the Palatlakaha River and various springs were also incorporated into the nitrogen and phosphorus loading estimates. Permit files from the DEP Central District were also reviewed to develop loading estimates from domestic and wastewater spill at facilities within the watershed.

The mean annual TP load over this period was estimated at 26,901 kg. The three major sources for phosphorus were the Lake Harris Conservation Area (5.71%), the Palatlakaha River (14.48%), and dry atmospheric deposition (11.77%). Total nitrogen was estimated at 177,581.3 kg/year with spring discharges accounting for nearly 25% of the total load. Runoff or spill from permitted industrial or domestic wastewater sources represented less than 0.34% of either the phosphorus or nitrogen load to the lake.

5.0 Loading Capacity – Linking Water Quality and Pollutant Sources

Fulton et al. (2003) calculated a mean lake TP concentration of 38 ug/l over the 1991 – 2000 period. Based upon results from the two approaches used to determine a target TP, the proposed TP target for Lake Harris was 26 ug/l. Fulton estimated that a 32 percent reduction in annual phosphorus loading to the lake was needed to meet this TP target. This was based upon the ratio of the target phosphorus concentration (26 ug/l) to the existing phosphorus concentration (38 ug/l). Fulton et al. (2003) made the simplifying assumption that the phosphorus concentration in the lakes is directly proportional to external loading. Consequently, the ratio was then applied to the long-term annual phosphorus load to determine an allowable load and percent reduction necessary to achieve the TP target.

As discussed earlier, the IWR uses a TSI to assess possible nutrient impairments in lakes. The TSI represents the average of a Chla_{TSI} and $\text{Nutrient}_{\text{TSI}}$. Assuming an average TP of 38 ug/l, the $\text{Nutrient}_{\text{TSI}}$ would be 62, and using a long-term average Chla of 62 ug/l, the Chla_{TSI} would be 76.2. Thus, the long-term average TSI under current conditions is approximately 69. Reducing the in-lake phosphorus concentration to 26 ug/l would result in a $\text{Nutrient}_{\text{TSI}}$ of 53. Fulton (2003a) provided a preliminary evaluation of the effects of the interim PLRG and predicted a mean Chla of 22 ug/l. At this concentration, the Chla_{TSI} would drop to 61, and the TSI would be 57.

Processes that consume oxygen from the water column such as microbial breakdown of organic material and sediment oxygen demand are fairly constant over the short term. Algal populations, however, can increase rapidly and the production of oxygen as a result of photosynthesis during daylight hours and respiration or consumption of water from the water column at night can result in large diurnal fluctuations of DO in the water column. A fraction of increased biomass will also become part of the organic material that will be broken down by microbes or settle to the bottom. The proposed phosphorus reduction is predicted to decrease algal biomass from the current Chla average of 68 ug/l to approximately 20 ug/l. This will have a positive affect on reducing the diurnal fluctuations in DO and improve the DO levels of water leaving Lake Eustis through Haines Creek. Reduced algal biomass also means that BOD levels in the lake and discharges from the lake will also be lower.

6.0 Critical Conditions

Phosphorus reductions proposed by the SJRWMD were based upon a 10-year average phosphorus load to Lake Harris. Nitrogen loads to the lake were also based upon a 10-year average. Fulton et al. (2003) note that the phosphorus load reduction goals should be treated as long-term average annual loads and that there is substantial year to year variation in the phosphorus load to the UORB lakes. They also pointed out that the estimated external phosphorus load was lower than the reduction goal in at least one of the years 1991-2001 in all of the lakes, except for Lake Griffin.

The TMDL was based on long-term average conditions rather than critical/seasonal conditions because a) the methodology used to determine the assimilative capacity does not lend itself very well to short-term assessments, b) we are generally more concerned with the net change in overall primary productivity, which is better addressed on an annual basis, and c) the methodology used to determine impairment is based upon an annual average and requires data from all four quarters of a calendar year.

7.0 Determination of TMDL

The objective of a TMDL is to provide a basis for allocating acceptable loads among all of the known pollutant sources in a watershed so that appropriate control measures can be implemented and water quality standards achieved. A TMDL is expressed as the sum of all point source loads (Waste Load Allocations), nonpoint source loads (Load Allocations), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$\mathbf{TMDL = \sum WLAs + \sum LAs + MOS}$$

As mentioned in Section 4.1, the WLA is broken out into separate subcategories for wastewater discharges and stormwater discharges regulated under the NPDES Program:

$$\mathbf{TMDL \cong \sum WLAs_{wastewater} + \sum WLAs_{NPDES\ Stormwater} + \sum LAs + MOS}$$

It should be noted that the various components of the TMDL equation may not sum up to the value of the TMDL because a) the WLA for NPDES stormwater is typically based on the percent reduction needed for nonpoint sources and is accounted for within the LA, and b) TMDL components can be expressed in different terms [for example, the WLA for stormwater is typically expressed as a percent reduction and the WLA for wastewater is typically expressed as a mass per day].

WLAs for stormwater discharges are typically expressed as “percent reduction” because it is very difficult to quantify the loads from MS4s (given the numerous discharge points) and to distinguish loads from MS4s from other nonpoint sources (given the nature of stormwater transport). The permitting of stormwater discharges is also different than the permitting of most wastewater point sources. Because stormwater discharges cannot be centrally collected, monitored and treated, they are not subject to the same types of effluent limitations as wastewater facilities, and instead are required to meet a performance standard of providing treatment to the “maximum extent practical” through the implementation of Best Management Practices.

This approach is consistent with federal regulations [40 CFR § 130.2(I)], which state that TMDLs can be expressed in terms of mass per time (e.g. pounds per day), toxicity, or **other appropriate measure**. The TMDLs for Lake Harris and Little Lake Harris are combined (Table 6) and are expressed in terms of pounds per year, and represent the maximum annual load the lakes can assimilate and maintain the narrative nutrient criterion. The LA includes the atmospheric contribution (5,421 lbs/year).

Table 6. TMDL Components

WBID	Parameter	WLA		LA (lbs/year)	MOS	TMDL (lbs/year)	Percent Reduction
		Wastewater (lbs/year)	NPDES Stormwater				
2838A and 2838B	TP	N/A	32	18,302	Implicit	18,302	32[1]

[1] Note that this percent reduction was based upon the total annual average load which included atmospheric contributions

7.1 Load Allocations (LAs)

The allowable LA is 18,302 lbs/year for TP. This corresponds to reductions from the existing loadings of 32 percent for TP. It should be noted that the LA includes loading from stormwater discharges regulated by the Department and the Water Management Districts that are not part of the NPDES Stormwater Program (see Appendix A). As noted earlier, the three largest existing sources are the Lake Harris Conservation Area (25.71%), the Palatlakaha River discharge (14.48%), and dry atmospheric deposition (11.77%). Since a TMDL is being developed for the Palatlakaha River, there should be some reduction in phosphorus load from this tributary to Lake Harris.

7.2 Wasteload Allocations (WLAs)

NPDES Stormwater Discharges

As noted in Sections 4 and 7.1, load from stormwater discharges permitted under the NPDES Stormwater Program are placed in the WLA, rather than the LA. This includes loads from municipal separate storm sewer systems (MS4). Based on the 2000 census, the Lake Harris watershed includes areas that will be covered by the MS4 Program, and the WLA for stormwater discharges is a 32 percent reduction of current loading from the MS4. It should be noted that any MS4 permittees will only be responsible for reducing the loads associated with stormwater outfalls for which it owns or otherwise has responsible control, and is not responsible for reducing other nonpoint source loads within its jurisdiction. In addition, implementation of TMDLs for upstream waterbodies that flow into Lake Harris will also influence the percent reduction that MS4 areas will need to meet inorder for the TMDL for the lake to be achieved.

NPDES Wastewater Discharges

There are no wastewater facilities authorized to discharge wastewater to Lake Harris or Little Lake Harris. Fulton et al. (2003) estimated that runoff and spill from existing wastewater facilities contributed less than 0.34% to the annual average load of TN and TP to the lake.

7.3 Relationship between Lake Harris, Palatlakaha River, and Lake Eustis TMDLs

It should also be noted with respect to possible reductions in either the WLA or LA to achieve the TMDL, discharge from the Palatlakaha River currently represents approximately 14.5 percent of the annual load of phosphorus to Lake Harris. A draft TMDL has been proposed for the Palatlakaha River that should result in phosphorus load reductions.

The proposed TMDL for Lake Eustis estimated that discharge from Lake Harris via the Dead River currently contributes nearly 18 percent of the total annual phosphorus load for Lake Eustis. Reductions in phosphorus loading to and from Lake Harris as a result of this TMDL will also become a factor in how the TMDL for Lake Eustis is met.

7.4 Margin of Safety (MOS)

An implicit margin of safety is assumed based upon a long-term (10-year) annual load budget. Calculations of storm water runoff also assumed that there was no storm water treatment for lands already developed in 1987, while lands developed after 1987 were assumed to provide storm water treatment at levels equal to the average of 13 studies in Florida. Finally, in the determination of the target phosphorus concentration, the SJRWMD used the 25th percentile value from each estimate, which is considered a conservative level.

8.0 Seasonal Variation

As discussed earlier, potential nutrient impairments in lakes are based upon calculated annual TSI values. The IWR requires that water quality data from all four quarters of the calendar year in order to calculate a TSI.

With respect to un-ionized ammonia, the fraction of total ammonia that is un-ionized is a function of water temperature and pH. While both water temperature and pH vary seasonally, summer is the most likely period where both increased water temperature and pH are most likely occur together and result in a low allowable total ammonia concentration.

Since DO is a gas, its saturation level is a function of water temperature and salinity. Increased water temperatures and/or salinities reduce the amount of oxygen that can remain in solution. Salinity is not a factor in Lake Harris. Consequently, summer and early fall would represent periods of highest water temperature where DO saturation and DO would be expected to be lower. Algal production during these periods can increase oxygen levels during the day, however, the increased respiration will result in lower levels at night and the possibility of large diurnal fluctuations. Reductions in the algal biomass will reduce these fluctuations.

9.0 Next Steps: Implementation Plan Development and Beyond

Following adoption of this TMDL by rule, the next step in the TMDL process is to develop an implementation plan for the TMDL, which will be a component of the Basin Management Action Plan for the Ocklawaha Basin. This document will be developed in cooperation with local stakeholders and will attempt to reach consensus on more detailed allocations and on how load reductions will be accomplished.

The Basin Management Action Plan (B-MAP) will include:

- Appropriate allocations among the affected parties.
- A description of the load reduction activities to be undertaken.
- Timetables for project implementation and completion.
- Funding mechanisms that may be utilized.
- Any applicable signed agreements.
- Local ordinances defining actions to be taken or prohibited.
- Local water quality standards, permits, or load limitation agreements.
- Monitoring and follow-up measures.

It should be noted that TMDL development and implementation is an iterative process, and this TMDL will be re-evaluated during the BMAP development process and subsequent Watershed Management cycles. The Department acknowledges the uncertainty associated with TMDL development and allocation, particularly in estimates of nonpoint source loads and allocations for NPDES stormwater discharges, and fully expects that it may be further refined or revised over time. If any changes in the estimate of the assimilative capacity AND/OR allocation between point and nonpoint sources are required, the rule adopting this TMDL will be revised, thereby providing a point of entry for interested parties.

10.0 References

Fulton, R.S. III, C. Schluter, T.A. Keller, S. Nagrid, W. Godwin, D. Smith, D. Clapp, A. Karama, J.Richmond. 2003. Interim Pollutant Load Reduction Goals for Seven Major Lakes in the Upper Ocklawaha River Basin. St. Johns River Water Management District. Draft.

Fulton, R.S. III. 2003a. Preliminary Evaluation of the Effects and Feasibility of the Proposed Interim Pollutant Load Reduction Goals for the Seven Major Lakes in the Upper Ocklawaha River Basin. St. Johns River Management District. Draft.

Fulton, R.S. III. 1995. External Nutrient Budget and Trophic State Modeling for Lakes in the Upper Ocklawaha River Basin. St. Johns River Management District. Tech Pub SJ95-6.

Fulton, R.S. III. 1995. SWIM Plan for the Upper Ocklawaha River Basin. St. Johns River Water Management District.

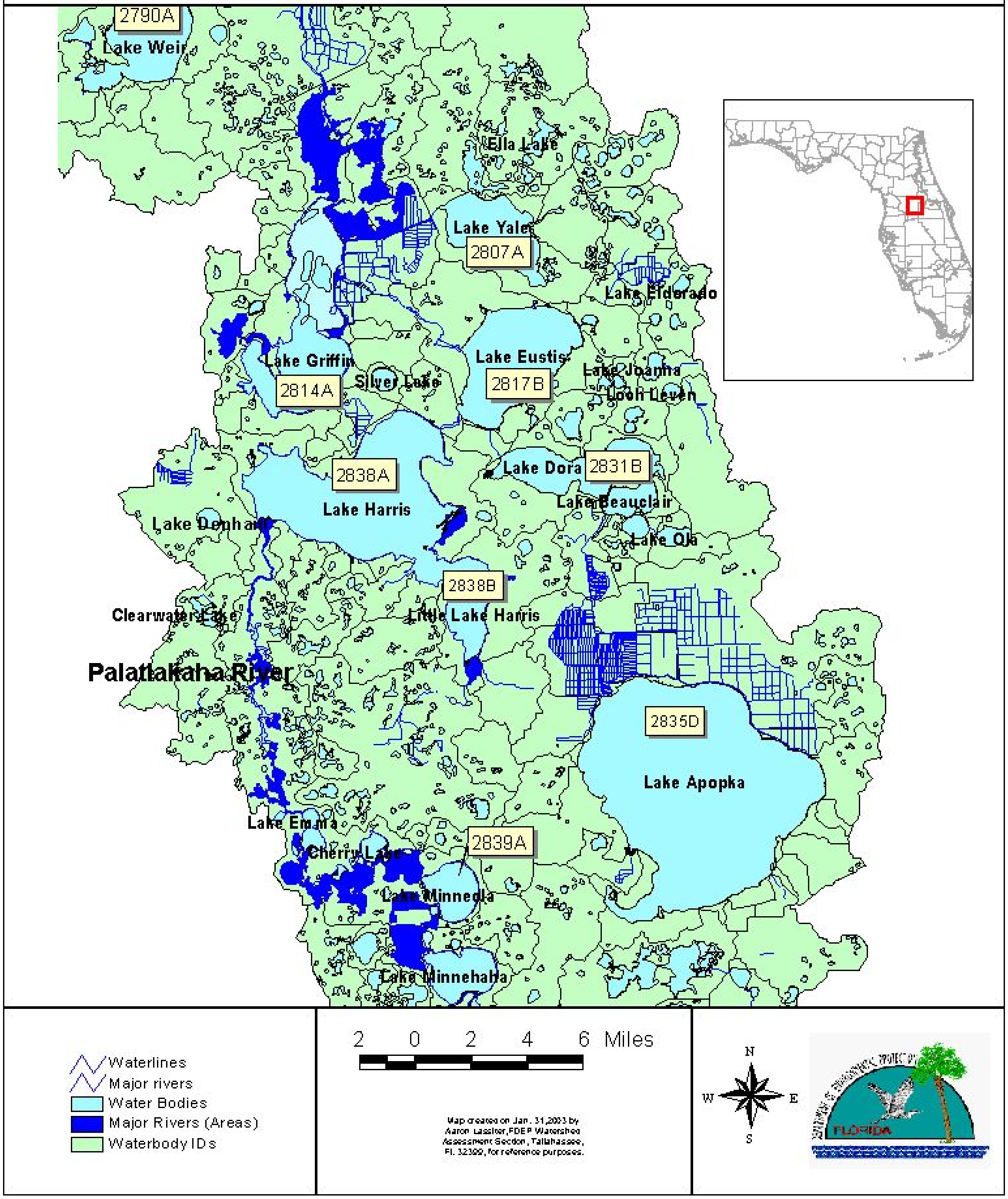
Loehr, R.C., C.S. Marlin, W. Rast, editors. 1980. Phosphorus Management Strategies for Lakes. Proceedings of the 1979 Conference. Ann Arbor Science Publishers, Inc.

Sas, H. 1989. Lake restoration by reduction of nutrient loading; expectations, experiences, extrapolations. Academia Verlag Richarz, St. Augustin p 497.

Williams, C.D., J. Burns, A. Chapman, L. Flewelling, M. Pawlowicz, W. Carmichael. 2001. Assessment of Cyanotoxins in Florida's Lakes, Reservoirs, and Rivers. St. Johns River Water Management District.

Whitton, Brian and Malcolm Potts, editors. 2000. The Ecology of Cyanobacteria. Kluwer Academic Publishers.

Figure 1. Upper Ocklawaha River Chain of Lakes



Map created on Jan. 31, 2003 by Aaron Lassiter, FDEP Watershed Assessment Section, Tallahassee, Fl. 32399, for reference purposes.

Figure 2a. Boxplots of water quality by year in Lake Harris (WBID 2838A) for the 1989 - 2002 period.

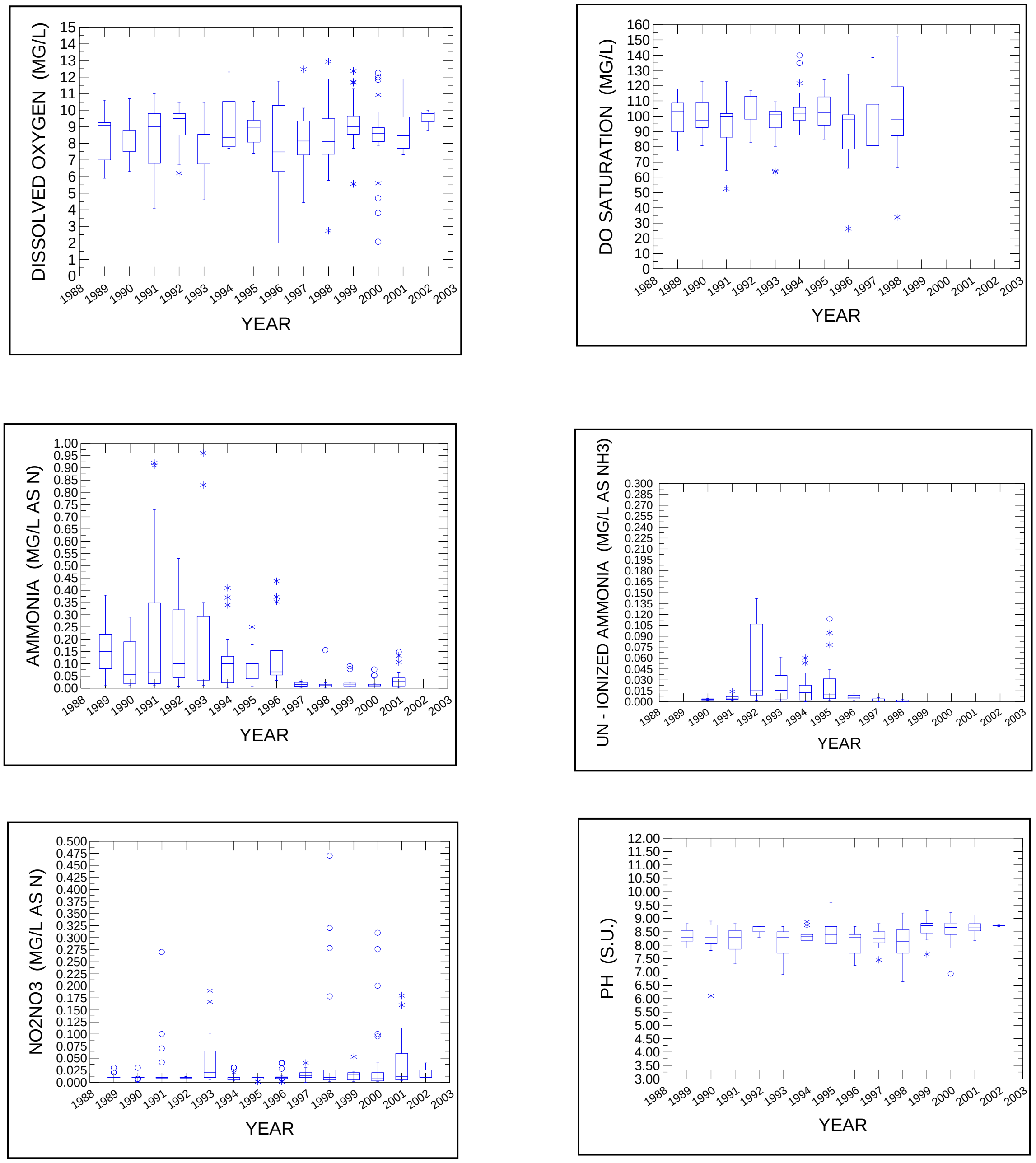


Figure 2a. Continued.

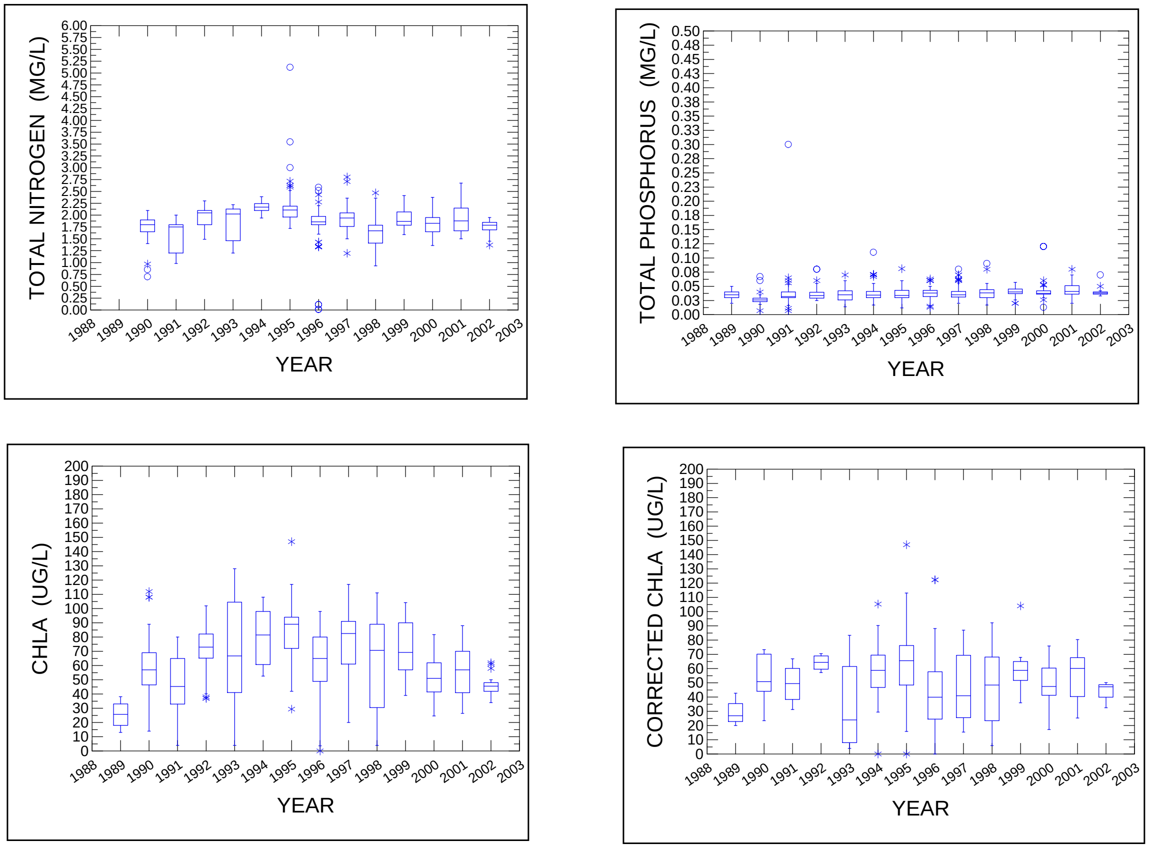


Figure 2b. Boxplots of water quality by year in Little Lake Harris (WBID 2838B) for the 1989 - 2002 period.

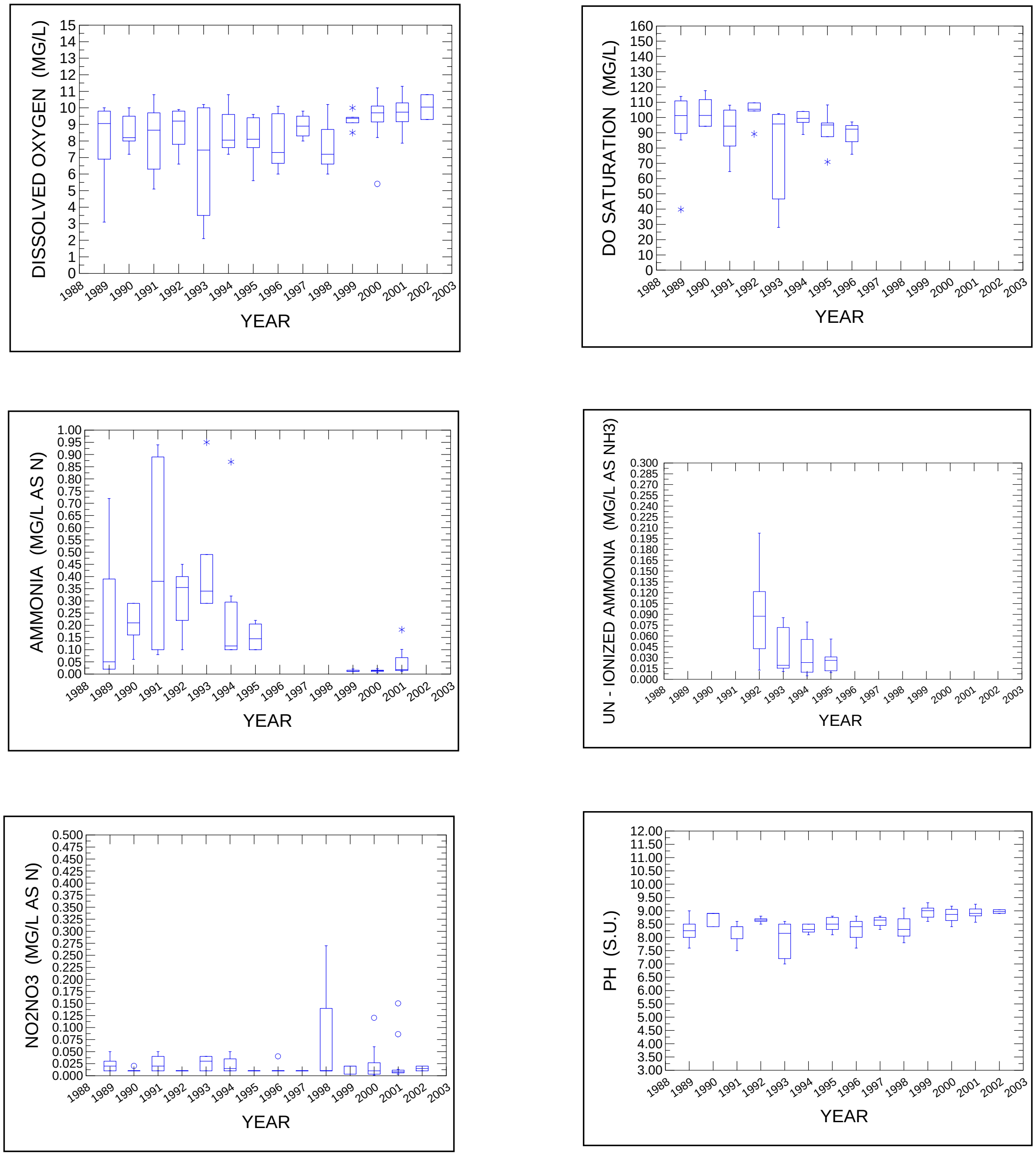


Figure 2b. Continued.

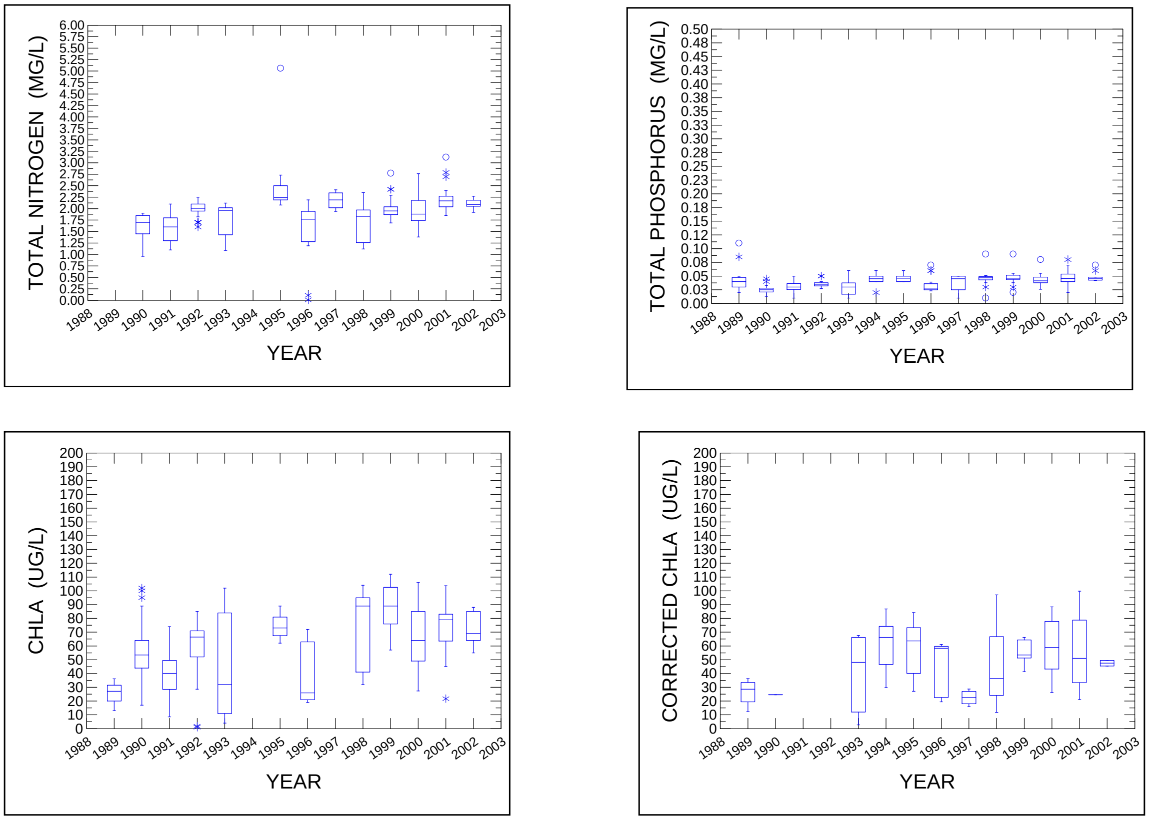


FIGURE 3. PLOTS OF WATER QUALITY FOR LAKE HARRIS FOR THE 1989-2002 PERIOD WITH TRENDLINES.

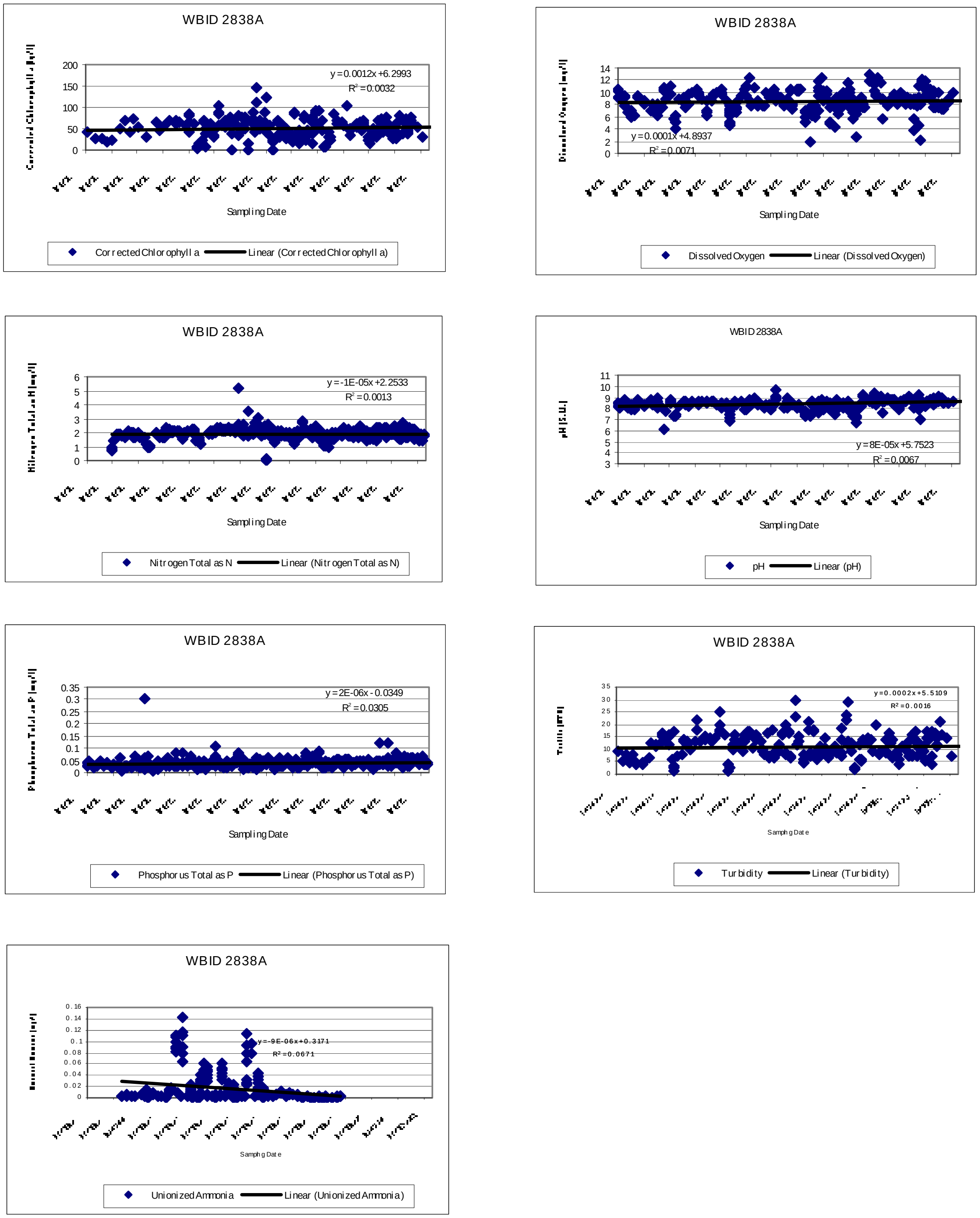


FIGURE 3. PLOTS OF WATER QUALITY FOR LITTLE LAKE HARRIS FOR THE 1989-2002 PERIOD WITH TRENDLINES.

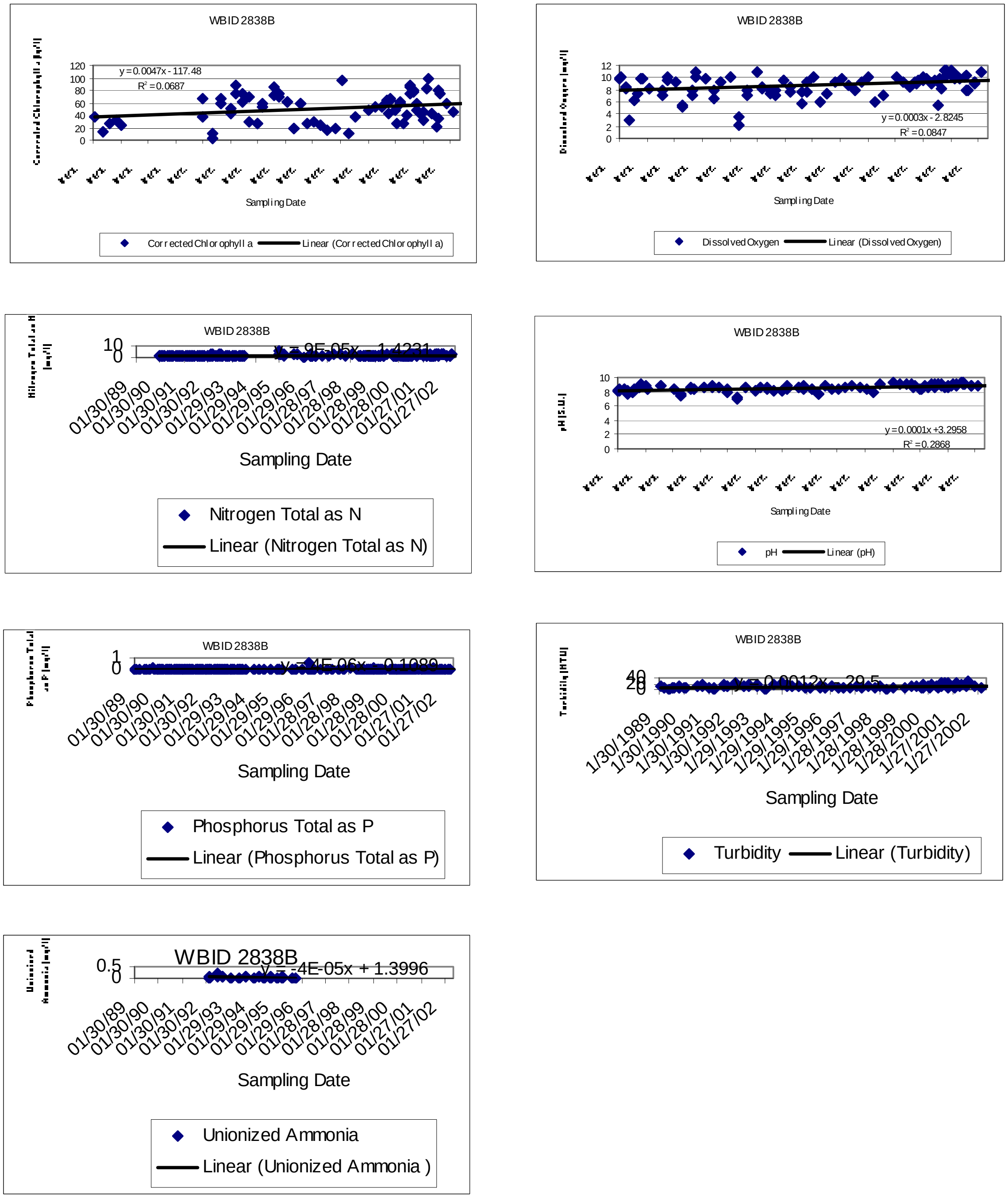


Figure 4. Cyanobacteria levels (biovolumes) in Lake Harris from Lake County Water Authority

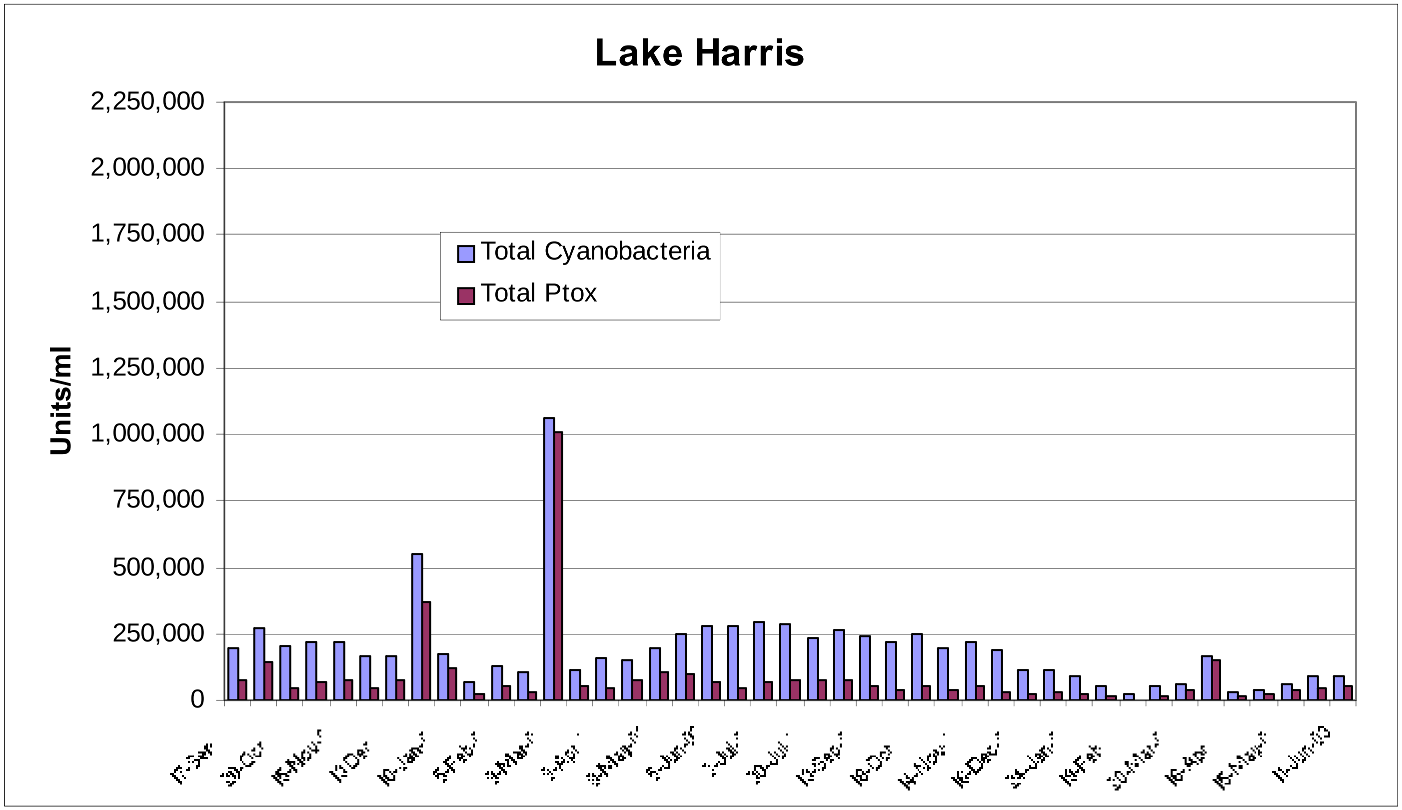


Figure 5. Microcystin levels in Lake Harris from Lake County Water Authority.

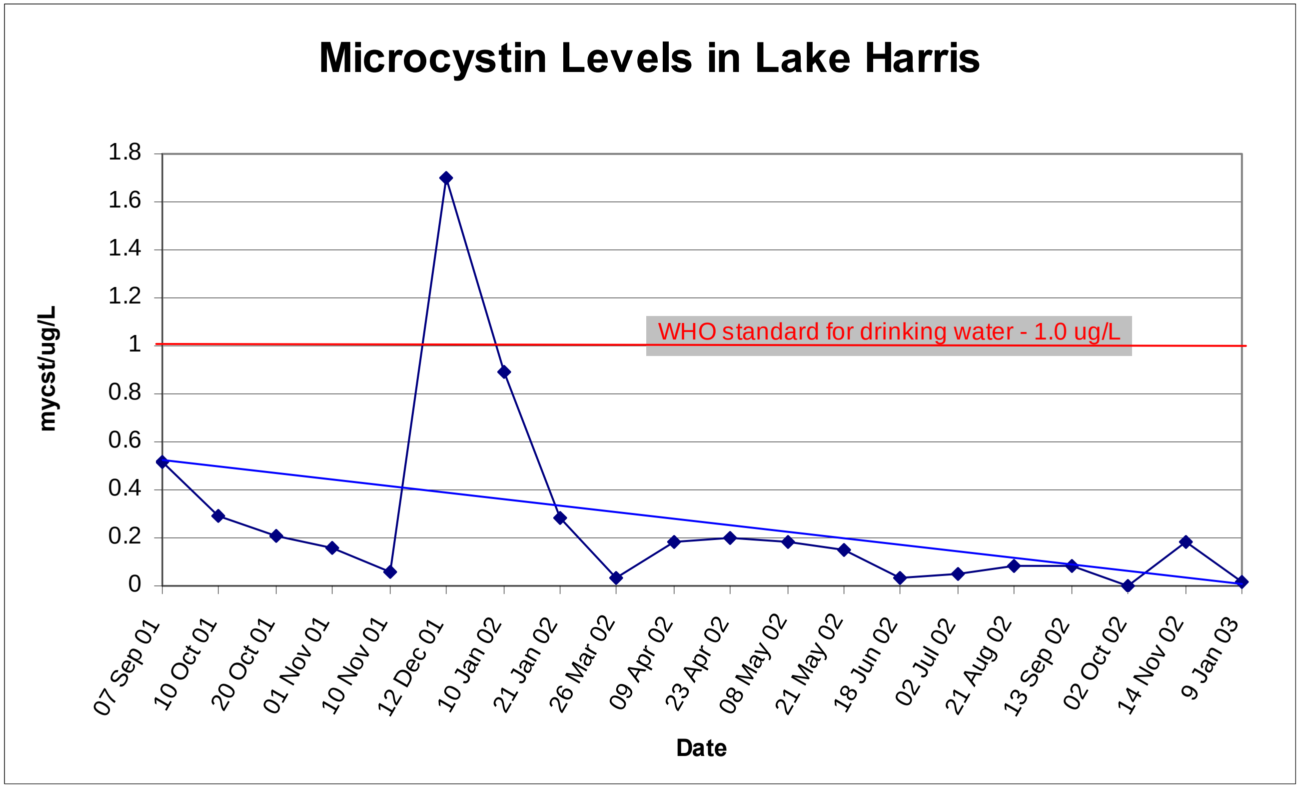


Figure 6a. TN/TP cumulative frequency distribution for measurements in Lake Harris over the 1989 – 2002 period.

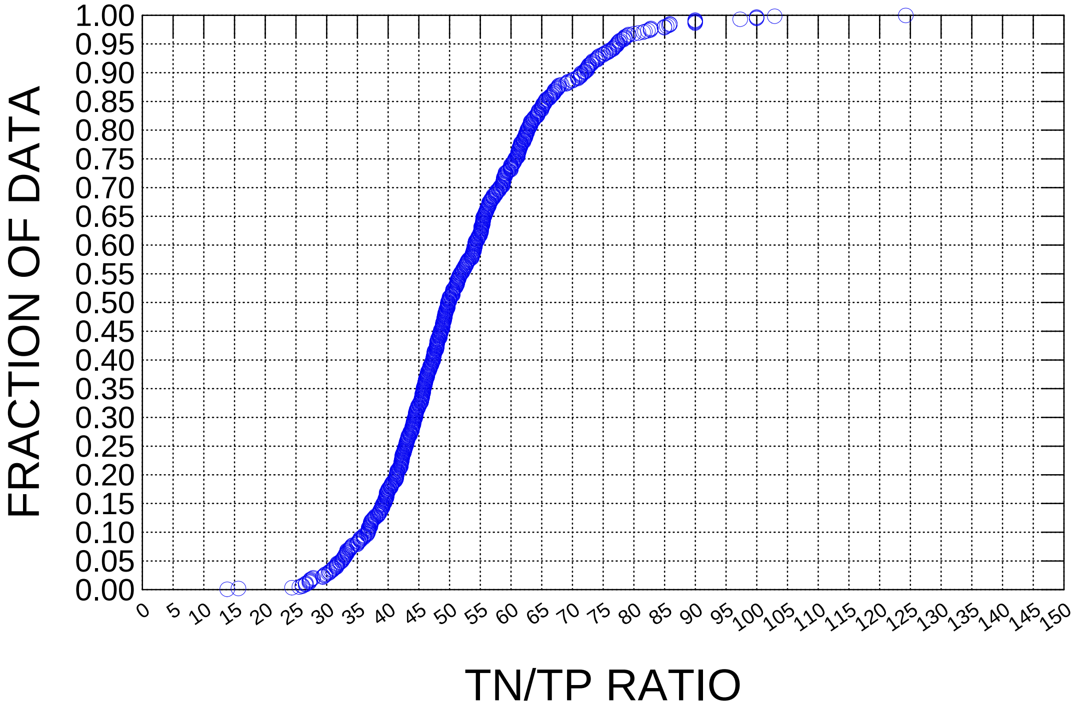


Figure 6b. TN/TP cumulative frequency distribution for measurements in Little
Lake Harris over the 1989 – 2002 period.

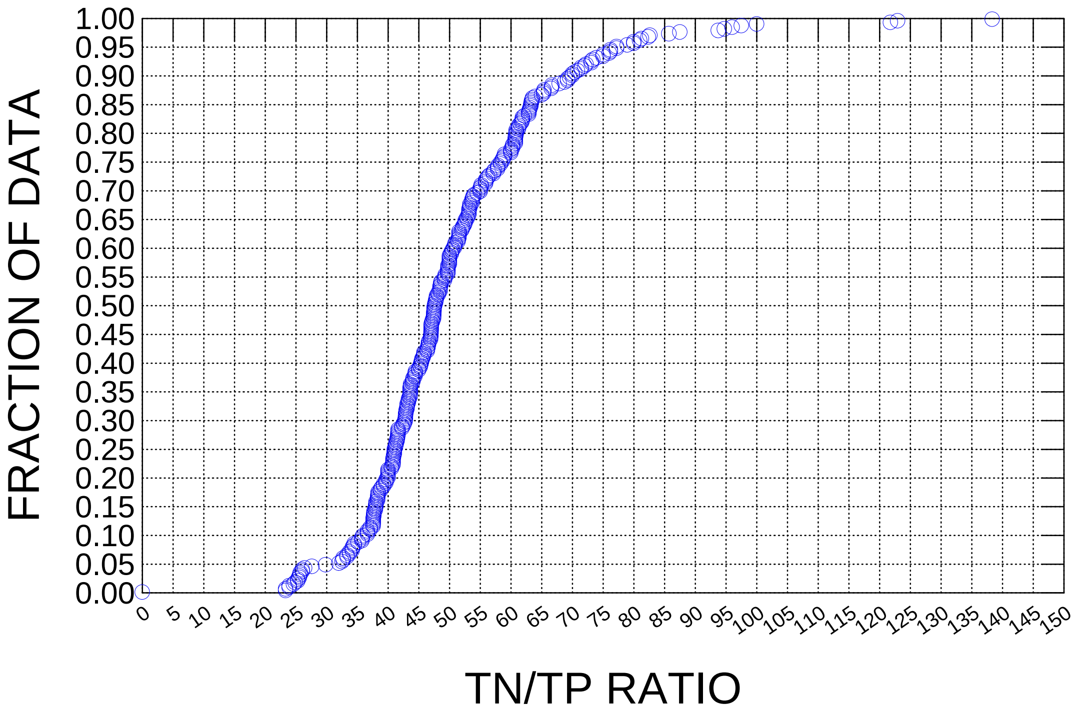
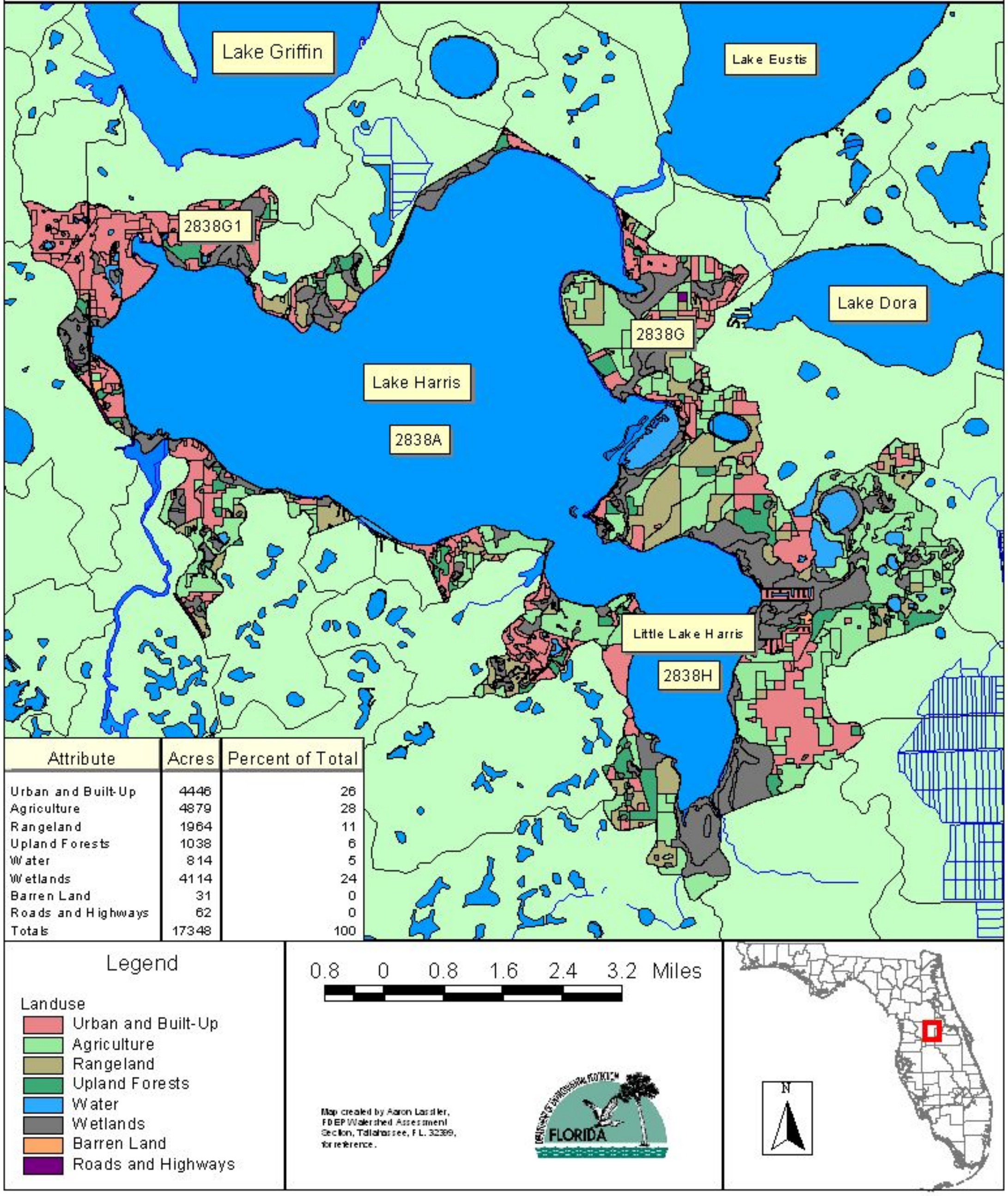


Figure 7: Lake Harris/Little Lake Harris Landuse



Attribute	Acres	Percent of Total
Urban and Built-Up	4446	26
Agriculture	4879	28
Rangeland	1964	11
Upland Forests	1038	6
Water	814	5
Wetlands	4114	24
Barren Land	31	0
Roads and Highways	62	0
Totals	17348	100

Map created by Aaron Lassiter,
FDEP Watershed Assessment
Section, Tallahassee, FL. 32399,
for reference.

Table 1. Lake Harris, Little Lake Harris, Helena Run, and Dead River dissolved oxygen, un-ionized ammonia, Chlorophyll a and/or TSI assessments under the IWR.

Parameter of concern	Lake Harris	Little Lake Harris	Helena Run	Dead River
Annual Chlorophyll a or TSI	TSI	TSI	Chla	Chla
1989				
1990	65.0	65.4		
1991	65.9	62.6		
1992	69.6	67.7		
1993	67.1	59.2	22.1	
1994	70.9	59.5		
1995	70.7	70.8		
1996	67.7	59.2		
1997	69.9	59.5		
1998	68.3	70.8		
1999	70.7	70.5	46.8	
2000	68.6	70.2	48.1	41.4
2001	70.1	70.2	51.0	56.1
Dissolved Oxygen	PP – 5/183 Not impaired VP – 3/156 Not impaired	PP – 3/68 Not impaired VP – 0/53 Not impaired	PP – 5/26 Potentially impaired VP – 12/58 Verified	PP – 1/5 Insufficient data VP – 1/26 Not impaired
Un-ionized Ammonia	PP – 29/119 Potentially impaired VP – 6/56 Not impaired	PP – 18/28 Potentially impaired VP – 5/8 Insufficient data	PP – 2/27 Not impaired VP – No data	PP – 0/4 Insufficient data VP – No data
PP – Planning Period which was the January 1989 thru December 1998 period VP – Verified Period which was the January 1995 thru June 2002 period				

Table 2a. Summary statistics of key water quality parameters for Lake Harris (WBID 2838A) over the 1989 – 2001 period.

	CHLA	CHLAC	DO	DOSAT	NH4
N of cases	628	216	331	175	205
Minimum	0.010	0.000	2.000	26.316	0.001
Maximum	147.000	147.000	12.930	152.141	1.010
Median	65.791	49.819	8.550	100.019	0.042
Mean	64.118	50.202	8.530	98.421	0.113
Standard Dev	25.467	24.778	1.674	17.759	0.174

	NO2	NO3	NO2O3	ORGN	PH
N of cases	0	6	258	81	329
Minimum	.	0.010	-0.005	0.940	6.100
Maximum	.	0.220	21.100	4.950	30.500
Median	.	0.075	0.010	1.890	8.500
Mean	.	0.095	0.108	1.869	8.471
Standard Dev	.	0.094	1.313	0.567	1.301

	PO4	TKN	TN	TP	TURBIDITY
N of cases	6	178	901	1004	244
Minimum	0.010	0.000	0.010	0.007	1.000
Maximum	0.020	3.540	5.120	0.300	30.000
Median	0.010	2.046	1.870	0.037	11.000
Mean	0.013	1.989	1.860	0.038	11.107
Standard Dev	0.005	0.488	0.333	0.014	5.120

	UNNH4	TNTPRATIO
N of cases	121	756
Minimum	0.000	13.833
Maximum	0.142	124.286
Median	0.005	49.756
Mean	0.018	52.282
Standard Dev	0.028	13.843

Table 2b. Summary statistics of key water quality parameters for Little Lake Harris (WBID 2838B) over the 1989 – 2001 period.

	CHLA	CHLAC	DO	DOSAT	NH4
N of cases	295	74	101	57	68
Minimum	1.000	2.700	2.100	28.000	0.006
Maximum	112.000	99.678	11.300	117.647	1.010
Median	62.000	52.100	9.200	97.132	0.100
Mean	60.047	50.578	8.632	94.704	0.216
Standard Dev	26.255	23.043	1.751	17.268	0.259

	NO2	NO3	NO2O3	ORGN	PH
N of cases	0	0	103	48	100
Minimum	.	.	-0.003	0.840	7.000
Maximum	.	.	0.270	4.830	9.300
Median	.	.	0.010	1.975	8.600
Mean	.	.	0.021	1.948	8.537
Standard Dev	.	.	0.033	0.641	0.446

	PO4	TKN	TN	TP	TURBIDITY
N of cases	0	52	404	453	98
Minimum	.	0.000	0.010	0.010	1.000
Maximum	.	3.120	5.060	0.540	26.900
Median	.	2.075	1.940	0.040	10.900
Mean	.	1.995	1.897	0.042	11.175
Standard Dev	.	0.606	0.391	0.036	5.736

	UNNH4	TNTPRATIO
N of cases	28	358
Minimum	0.005	0.000
Maximum	0.203	161.667
Median	0.026	47.600
Mean	0.044	50.932
Standard Dev	0.044	16.583

Table 2c. Summary statistics of key water quality parameters for Helena Run (WBID 2832) over the 1989 – 2001 period.

	TEMP	TRANSM	COLOR	DO	DOSAT
N of cases	81	76	70	86	26
Minimum	12.400	0.200	10.000	0.880	22.222
Maximum	34.840	1.180	500.000	11.600	123.404
Median	23.054	0.485	25.000	6.680	75.113
Mean	22.718	0.523	39.500	6.503	73.865
Standard Dev	5.095	0.234	62.049	2.108	23.638

	PH	TSS	TN	AMMONIA	UUNH3
N of cases	87	85	58	13	27
Minimum	6.190	0.000	0.265	0.041	0.000
Maximum	9.240	69.000	4.577	0.327	0.046
Median	7.810	16.000	1.861	0.194	0.001
Mean	7.890	19.189	2.157	0.160	0.005
Standard Dev	0.644	16.851	1.317	0.089	0.011

	TKN	NO2NO3	TP	ORTHOP	CHLA
N of cases	99	59	106	88	95
Minimum	0.037	-0.001	0.010	0.000	-0.400
Maximum	4.570	0.640	0.392	0.120	127.479
Median	1.440	0.054	0.090	0.010	23.481
Mean	1.713	0.130	0.098	0.024	36.121
Standard Dev	1.350	0.152	0.045	0.026	33.537

	CHLAC	TURBIDITY	TNTPRATIO
N of cases	84	69	6
Minimum	-0.134	0.000	3.786
Maximum	119.959	49.600	32.724
Median	26.821	4.700	8.169
Mean	37.404	9.360	10.993
Standard Dev	33.949	11.450	10.856

Table 2d. Summary statistics of key water quality parameters for Dead River (WBID 2817C)
for the 1980 – 2001 period.

	YEAR	DEPTH	VBOD	VCHLA	VCHLAC
N of cases	34	29	1	32	31
Minimum	1990.000	0.500	6.200	5.721	4.811
Maximum	2001.000	5.740	6.200	105.200	72.602
Median	2000.000	0.500	6.200	51.701	48.908
Mean	1998.647	0.697	6.200	47.181	43.032
Standard Dev	3.472	0.974	.	23.354	20.174

	VCOLOR	VCOND	VDO	VDOSAT	VNH4
N of cases	16	32	32	5	30
Minimum	10.000	242.600	4.400	57.895	0.000
Maximum	30.000	400.000	137.000	103.947	0.440
Median	20.000	268.250	7.475	77.012	0.020
Mean	17.500	284.337	11.563	78.235	0.082
Standard Dev	5.477	41.190	22.934	18.807	0.120

	VNO3O2	VORGN	VPH	VPORD	VSD
N of cases	33	1	32	27	31
Minimum	0.000	3.140	6.700	-0.004	0.210
Maximum	0.175	3.140	8.980	0.017	1.750
Median	0.015	3.140	8.390	0.003	0.450
Mean	0.044	3.140	8.222	0.006	0.544
Standard Dev	0.054	.	0.510	0.005	0.296

	VTEMP	VTKN	TN	VTOC	VTP
N of cases	32	31	31	16	27
Minimum	15.080	1.210	1.238	11.100	0.026
Maximum	32.030	3.060	3.070	20.000	0.095
Median	24.250	2.074	2.139	15.800	0.045
Mean	24.678	2.040	2.087	15.487	0.048
Standard Dev	4.790	0.382	0.369	2.879	0.015

	VTSS	VTURB	VUNNH4	TNTPRATIO
N of cases	32	17	4	26
Minimum	2.000	1.700	0.000	28.145
Maximum	43.000	16.300	0.002	77.185
Median	14.500	9.200	0.000	47.534
Mean	16.131	9.522	0.001	48.923
Standard Dev	9.880	4.993	0.001	10.251

Table 3. Ammonia Concentration (in mg/l as N) that results in un-ionized ammonia of 0.02 mg/ as NH_3

PH (s.u.)	Water Temperature (^{0} C)				
	10	15	20	25	30
6.0	88.71	60.22	41.56	29.00	20.50
6.5	28.20	19.08	13.20	9.17	6.50
7.0	8.87	6.04	4.17	2.91	2.06
7.5	2.24	1.92	1.33	0.93	0.66
8.0	0.90	0.64	0.50	0.31	0.22
8.5	0.30	0.21	0.15	0.11	0.08
9.0	0.10	0.08	0.06	0.04	0.04

Note: At a given pH, as water temperature increases, the un-ionized ammonia fraction increases.
At a fixed water temperature, as pH increases, the un-ionized ammonia fraction increases.

Table 4a. Pearson correlation matrix for Lake Harris (WBID 2838A).

	YEAR	MONTH	CHLA	CHLAC	DO
YEAR	1.000				
MONTH	-0.017	1.000			
CHLA	0.002	0.100	1.000		
CHLAC	0.055	0.011	0.932	1.000	
DO	0.100	-0.215	0.209	0.297	1.000
DOSAT	-0.046	0.081	0.217	0.265	0.872
NH4	-0.345	-0.093	-0.222	-0.410	-0.315
NO2	.	.	.	.	.
NO3	.	-0.952	.	-0.911	-0.712
NO2O3	-0.022	-0.033	-0.027	-0.003	0.077
ORGN	0.355	-0.175	-0.165	-0.711	0.239
PH	0.079	0.009	-0.057	-0.038	0.180
PO4	.	0.000	.	-0.070	0.307
TKN	-0.127	0.158	0.432	0.344	0.047
TN	-0.044	0.065	0.651	0.151	-0.080
TP	0.175	0.041	0.242	0.071	0.054
TURBIDITY	0.042	-0.042	0.699	0.671	0.342
UNNH4	-0.270	0.105	-0.092	-0.269	-0.134
TNTPRATIO	-0.442	-0.073	-0.075	-0.100	0.043

	DOSAT	NH4	NO2	NO3	NO2O3
DOSAT	1.000				
NH4	-0.367	1.000			
NO2	.	.	.		
NO3	-0.803	-0.800	.	1.000	
NO2O3	0.191	-0.033	.	.	1.000
ORGN	-0.031	-0.140	.	0.750	-0.362
PH	0.251	-0.093	.	-0.978	0.011
PO4	0.279	-0.164	.	0.041	.
TKN	0.178	-0.049	.	.	0.041
TN	.	.	.	.	-0.012
TP	-0.058	0.119	.	-0.615	-0.069
TURBIDITY	0.304	-0.306	.	-0.944	-0.023
UNNH4	0.000	0.493	.	-0.888	-0.051
TNTPRATIO	.	.	.	.	-0.048

	ORGN	PH	PO4	TKN	TN
ORGN	1.000				
PH	0.068	1.000			
PO4	-0.101	0.067	1.000		
TKN	.	0.243	.	1.000	
TN	.	-0.177	.	0.902	1.000
TP	0.406	-0.043	0.422	-0.085	0.219
TURBIDITY	0.409	0.041	-0.126	0.435	0.022
UNNH4	0.064	0.319	0.215	0.403	.
TNTPRATIO	.	-0.063	.	-0.019	0.314

	TP	TURBIDITY	UNNH4	TNTPRATIO
TP	1.000			
TURBIDITY	0.123	1.000		
UNNH4	0.080	-0.036	1.000	
TNTPRATIO	-0.758	-0.191	.	1.000

Table 4a. Continued. Pairwise frequency table

	YEAR	MONTH	CHLA	CHLAC	DO
YEAR	1320				
MONTH	1320	1320			
CHLA	628	628	628		
CHLAC	216	216	120	216	
DO	331	331	145	162	331
DOSAT	175	175	102	75	175
NH4	205	205	133	126	165
NO2	0	0	0	0	0
NO3	6	6	0	6	6
NO2O3	258	258	136	165	218
ORGN	81	81	10	6	50
PH	329	329	143	162	326
PO4	6	6	0	6	6
TKN	178	178	121	164	169
TN	901	901	458	15	17
TP	1004	1004	594	171	224
TURBIDITY	244	244	120	155	207
UNNH4	121	121	81	75	121
TNTPRATIO	756	756	458	15	17

	DOSAT	NH4	NO2	NO3	NO2O3
DOSAT	175				
NH4	121	205			
NO2	0	0	0		
NO3	6	6	0	6	
NO2O3	127	199	0	0	258
ORGN	50	81	0	6	75
PH	173	165	0	6	218
PO4	6	6	0	6	0
TKN	78	122	0	0	178
TN	0	0	0	0	17
TP	133	205	0	6	258
TURBIDITY	132	185	0	6	238
UNNH4	121	121	0	6	115
TNTPRATIO	0	0	0	0	17

	ORGN	PH	PO4	TKN	TN
ORGN	81				
PH	50	329			
PO4	6	6	6		
TKN	0	169	0	178	
TN	0	17	0	17	901
TP	81	224	6	178	756
TURBIDITY	78	207	6	161	17
UNNH4	50	121	6	69	0
TNTPRATIO	0	17	0	17	756

	TP	TURBIDITY	UNNH4	TNTPRATIO
TP	1004			
TURBIDITY	244	244		
UNNH4	121	120	121	
TNTPRATIO	756	17	0	756

Table 4b. Pearson correlation matrix for Little Lake Harris (WBID 2838B).

	YEAR	MONTH	CHLA	CHLAC	DO
YEAR	1.000				
MONTH	0.017	1.000			
CHLA	0.460	0.098	1.000		
CHLAC	0.254	0.144	0.999	1.000	
DO	0.301	-0.140	0.144	0.239	1.000
DOSAT	-0.133	0.109	-0.127	.	0.876
NH4	-0.426	-0.169	-0.674	-0.536	-0.660
NO2	.	.	.	.	.
NO3	.	.	.	.	.
NO2O3	0.063	-0.242	-0.197	-0.398	-0.053
ORGN	0.535	0.001	-0.706	.	0.154
PH	0.512	0.256	0.389	0.421	0.558
PO4	.	.	.	.	.
TKN	0.497	0.238	0.740	0.452	0.178
TN	0.344	0.089	0.646	0.377	-0.098
TP	0.183	0.012	0.553	-0.116	-0.159
TURBIDITY	0.302	0.039	0.542	0.669	0.460
UNNH4	-0.510	0.357	-0.758	.	-0.076
TNTPRATIO	-0.492	-0.015	-0.336	-0.119	-0.066

	DOSAT	NH4	NO2	NO3	NO2O3
DOSAT	1.000				
NH4	-0.658	1.000			
NO2	.	.	.		
NO3	.	.	.	.	
NO2O3	-0.342	0.438	.	.	1.000
ORGN	0.105	-0.084	.	.	-0.286
PH	0.760	-0.747	.	.	-0.245
PO4	.	.	.	.	.
TKN	-0.041	-0.026	.	.	-0.289
TN	.	.	.	.	-0.419
TP	-0.080	-0.473	.	.	-0.086
TURBIDITY	0.677	-0.377	.	.	-0.276
UNNH4	0.249	0.204	.	.	-0.410
TNTPRATIO	.	.	.	.	-0.078

	ORGN	PH	PO4	TKN	TN
ORGN	1.000				
PH	0.103	1.000			
PO4	.	.	.		
TKN	.	0.315	.	1.000	
TN	.	-0.007	.	0.979	1.000
TP	0.094	-0.280	.	0.081	0.428
TURBIDITY	0.243	0.431	.	0.480	0.323
UNNH4	0.087	0.451	.	.	.
TNTPRATIO	.	-0.398	.	0.059	0.062

	TP	TURBIDITY	UNNH4	TNTPRATIO
TP	1.000			
TURBIDITY	-0.149	1.000		
UNNH4	-0.189	0.134	1.000	
TNTPRATIO	-0.778	0.173	.	1.000

Table 4b. Continued. Pairwise frequency table

	YEAR	MONTH	CHLA	CHLAC	DO
YEAR	565				
MONTH	565	565			
CHLA	295	295	295		
CHLAC	74	74	21	74	
DO	101	101	33	42	101
DOSAT	57	57	15	1	57
NH4	68	68	26	21	45
NO2	0	0	0	0	0
NO3	0	0	0	0	0
NO2O3	103	103	29	45	79
ORGN	48	48	6	1	28
PH	100	100	32	42	99
PO4	0	0	0	0	0
TKN	52	52	20	43	48
TN	404	404	243	8	9
TP	453	453	274	44	78
TURBIDITY	98	98	26	42	76
UNNH4	28	28	6	1	28
TNTPRATIO	358	358	244	8	9

	DOSAT	NH4	NO2	NO3	NO2O3
DOSAT	57				
NH4	28	68			
NO2	0	0	0		
NO3	0	0	0	0	
NO2O3	37	68	0	0	103
ORGN	28	48	0	0	48
PH	55	45	0	0	80
PO4	0	0	0	0	0
TKN	7	20	0	0	52
TN	0	0	0	0	9
TP	37	68	0	0	102
TURBIDITY	37	64	0	0	98
UNNH4	28	28	0	0	28
TNTPRATIO	0	0	0	0	9

	ORGN	PH	PO4	TKN	TN
ORGN	48				
PH	28	100			
PO4	0	0	0		
TKN	0	49	0	52	
TN	0	9	0	9	404
TP	48	79	0	52	357
TURBIDITY	46	77	0	50	9
UNNH4	28	28	0	0	0
TNTPRATIO	0	9	0	9	357

	TP	TURBIDITY	UNNH4	TNTPRATIO
TP	453			
TURBIDITY	98	98		
UNNH4	28	28	28	
TNTPRATIO	358	9	0	358

TABLE 5. ESTIMATED AVERAGE ANNUAL TOTAL PHOSPHORUS AND TOTAL NITROGEN LOADING TO LAKE HARRIS, 1991-2000

	Lake Harris		**Lake Harris**	
	Mean TP load 1991-2000		**Mean TN load 1991-2000**	
Nutrient Source	**kg/year**	**%**	**kg/year**	**%**
Low density residential	57.5	0.47%	653.6	0.37%
Medium density residential	228.5	1.87%	1,755.2	0.99%
High density residential	224.4	1.84%	1,207.0	0.68%
Low density commercial	41.7	0.34%	394.8	0.22%
High density commercial	510.3	4.19%	3,568.0	2.01%
Industrial	90.3	0.74%	584.2	0.33%
Mining	5.0	0.04%	42.3	0.02%
Openland/recreational	1.8	0.02%	48.9	0.03%
Ja-Mar muck farm	828.4	6.80%	5,297.2	2.98%
Knight-Leesburg muck farm	78.9	0.65%	607.6	0.34%
Pasture	62.3	0.51%	426.7	0.24%
Cropland	53.0	0.43%	405.7	0.23%
Tree crops	22.6	0.19%	337.1	0.19%
Feeding Operations	7.5	0.06%	142.0	0.08%
Other agriculture	10.9	0.09%	72.3	0.04%
Forest/rangeland	23.0	0.19%	539.6	0.30%
Water	34.5	0.28%	1,057.0	0.60%
Wetlands	941.3	7.72%	20,966.0	11.81%
Lake Harris Conservation Area	3,132.6	25.71%	8,276.4	4.66%
Septic tanks	558.6	4.58%	9,859.7	5.55%
Precipitation	1,024.7	8.41%	36,674.5	20.65%
Dry deposition	1,434.4	11.77%	10,692.4	6.02%
Spring dischargs	928.3	7.62%	43,417.2	24.45%
Palatlakaha River discharge	1,765.0	14.48%	25,016.1	14.09%
Lake Eustis discharge	83.0	0.68%	4,941.0	2.78%
Silver Springs Citrus sprayfield runoff	2.8	0.02%	20.0	0.01%
Domestic WWTP spills	2.7	0.02%	13.5	0.01%
Leesburg WWTP sprayfield runoff	15.0	0.12%	258.9	0.15%
Tavares-Woodlea Rd WWTP runoff	17.5	0.14%	306.3	0.17%
Total	**12,186.5**	**100.00%**	**177,581.3**	**100.00%**

Appendix A

In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as authorized in Chapter 403, Florida Statutes (F.S.), was established as a technology-based program that relies upon the implementation of BMPs that are designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Chapter 62-40, Florida Administrative Code (F.A.C.).

The rule requires Water Management Districts (WMDs) to establish stormwater pollutant load reduction goals (PLRGs) and adopt them as part of a SWIM plan, other watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation part of a TMDL. To date, stormwater PLRGs have been established for Tampa Bay, Lake Thonotosassa, Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka. No PLRG has been developed for Newnans Lake at the time this study was conducted.

In 1987, the U.S. Congress established section 402(p) as part of the Federal Clean Water Act Reauthorization. This section of the law amended the scope of the federal NPDES to designate certain stormwater discharges as “point sources” of pollution. These stormwater discharges include certain discharges that are associated with industrial activities designated by specific Standard Industrial Classification (SIC) codes, construction sites disturbing five or more acres of land, and master drainage systems of local governments with a population above 100,000 [which are better known as “municipal separate storm sewer systems” (MS4s)]. However, because the master drainage systems of most local governments in Florida are interconnected, EPA has implemented Phase 1 of the MS4 permitting program on a county-wide basis, which brings in all cities (incorporated areas), Chapter 298 urban water control districts, and the DOT (Department of Transportation) throughout the 15 counties meeting the population criteria.

An important difference between the federal and the state stormwater permitting programs is that the federal program covers both new and existing discharges while the state program focuses on new discharges. Additionally, Phase 2 of the NPDES stormwater permitting program will expand the need for these permits to construction sites between one and five acres, and to local governments with as few as 10,000 people. These revised rules require that these additional activities obtain permits by 2003. While these urban stormwater discharges are now technically referred to as “point sources” for the purpose of regulation, they are still diffuse sources of pollution that can not be easily collected and treated by a central treatment facility similar to other point sources of pollution, such as domestic and industrial wastewater discharges. The DEP recently accepted delegation from EPA for the stormwater part of the NPDES program. It should be noted that most MS4 permits issued in Florida include a re-opener clause that allows permit revisions to implement TMDLs once they are formally adopted by rule.