

# **Total Maximum Daily Load for Total Phosphorus For Lake Dora and Dora Canal Lake County, Florida**

**Wayne Magley, Ph.D, P.E.**



**Florida Department of Environmental Protection  
Watershed Assessment Section  
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# Phosphorus TMDL for Lake Dora

## 1.0 Introduction

### 1.1 Purpose of Report

This report presents a Total Maximum Daily Load (TMDL) for Total Phosphorus (TP) for Lake Dora and describes the projected impact of proposed TP reductions on the concentration of unionized ammonia in the lake. Using the methodology to identify and verify water quality impairments described in Chapter 62-303, Florida Administrative Code, (Identification of Impaired Surface Waters or IWR), the lake was verified as impaired by un-ionized ammonia and nutrients, and was included on the verified list of impaired waters for the Ocklawaha Basin that was adopted by Secretarial Order on August 28, 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 Dora discharges to Lake Eustis through the Dora Canal, which was verified as impaired under the IWR for dissolved oxygen (DO) and included in the Secretarial Order. The reductions in TP needed to meet the TMDL for Lake Dora are expected to address the DO impairment in Dora Canal.

### 1.2 Identification of Waterbody

Lake Dora, located in central Florida approximately 30 miles northwest of Orlando, is part of the Upper Ocklawaha River Basin (UORB) (Figure 1). It has a drainage basin of approximately 11,418 acres (Fulton et al., 2003). At a lake surface elevation of 63 ft National Geodetic Vertical Datum (NGVD), the lake has a surface area of approximately 1,774 ha (4,384 acres) and an average depth of 3.0 m (9.8 ft). Surface outflow from the lake is through the Doral Canal into Lake Eustis. Surface elevations in Lakes Eustis, Harris, Dora, and Beauclair are controlled by the Burrell Lock and Dam located on Haines Creek that is operated by the St. Johns River Water Management District (SJRWMD).

For assessment purposes, the watersheds within the Ocklawaha River Basin have been broken out into smaller watersheds, with a unique **waterbody identification (WBID)** number for each watershed. Lake Dora has been assigned WBID 2831B and the Dora Canal has been assigned WBID 2831A.

## 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 carbonate 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 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) estimated that discharges from Lake Beauclair contributed approximately 76.5% of the phosphorus and 85.9% of the nitrogen loadings to Lake Dora.

Plots of key water quality parameters over the 1989 – 2002 period are shown in Figures 2<sup>1</sup> and 3<sup>2</sup>. While there is significant variability over time, the plots indicate that some water quality parameters have declined over this period. Table 1 summarizes DO, un-ionized ammonia, and Chlorophyll *a* and/or the Trophic State Index (TSI) annual averages used to assess Lake Dora and Dora Canal under the IWR. Statistical summaries of key water quality parameters are presented for the two 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 Dora 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 Dora. 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 above the World Health Institute threshold for drinking water in November 2001 and January 2002, but that microcystin levels have declined and remained below 1.0 ug/l since the peak level in January 2002.

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<sup>1</sup>). Figure 2 presents water quality information on an annual basis and suggests some fluctuations or cycles in some parameters over time.

<sup>2</sup> Figure 3 presents the individual observations over time and includes trendlines. Although the  $r^2$  values were low, slopes (with the exception of dissolved oxygen, total phosphorus, and un-ionized ammonia) were positive, suggesting declining water quality with time.

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

Lake Dora and Doral Canal are Class III waterbodies with designated uses of recreation, propagation and maintenance of a healthy, well balanced population of fish and wildlife. Class III water quality criteria applicable to the observed impairment include the un-ionized ammonia criterion (0.02 mg/l), minimum DO of 5.0 mg/l, and 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 Dora 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. These approaches yielded a TP target of 31 ppb for Lake Dora.

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 statistical evaluation of the Lake Dora and Dora Canal datasets indicated some differences that were not apparent during the evaluation of the other UORB lakes. Based on Pearson correlation coefficients for the Dora Canal data set (Table 4), total phosphorus is positively correlated with turbidity, pH, corrected chlorophyll a, uncorrected chlorophyll a, ammonia, DO, and TKN. This is similar to a number of other lakes in the UORB. In contrast, the correlations of phosphorus with other parameters in the Lake Dora dataset were almost all negative. Further investigation will verify whether an error was made in preparing the dataset for analysis.

This positive correlation between pH and chlorophyll a reflects changes to the carbonate balance in the water column as CO<sub>2</sub> 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 °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 Dora 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 7). 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 Dora, Fulton et al. (2003) estimated average annual nitrogen and phosphorus loads to the lake 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 Apopka-Beauclair Canal and Lake Carlton 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 17,984.4 kg. Total nitrogen was estimated at 302,805.1 kg/year. The Lake Beauclair discharge represented more than 90% of both the phosphorus and nitrogen annual load to Lake Dora. Runoff and spills from permitted industrial or domestic wastewater sources in the watershed represented less than 0.25% 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 92 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 Dora was 31 ug/l. Fulton estimated that a 67 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 (31 ug/l) to the existing phosphorus concentration (92 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  $Nutrient_{TSI}$ . Assuming an average TP of 92 ug/l, the  $Nutrient_{TSI}$  would be 82.9, and using a long-term average  $Chla$  of 170 ug/l, the  $Chla_{TSI}$  would be 90.8. Thus, the long-term average TSI under current conditions is approximately 87. Reducing the in-lake phosphorus concentration to 31 ug/l would result in a  $Nutrient_{TSI}$  of 57. Fulton (2003a) provided a preliminary evaluation of the effects of the interim PLRG and predicted a mean  $Chla$  of 28 ug/l. At this concentration, the  $Chla_{TSI}$  would drop to less than 65.

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 170 ug/l to approximately 28 ug/l. This will have a positive affect on reducing the diurnal fluctuations in DO and improve the DO levels of water leaving Lake Dora through Doral Canal.

## **6.0 Critical Conditions**

Phosphorus reductions proposed by the SJRWMD were based upon a 10-year average phosphorus load to Lake Dora. 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:

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

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:

$$\text{TMDL} \cong \sum \text{WLAs}_{\text{wastewater}} + \sum \text{WLAs}_{\text{NPDES Stormwater}} + \sum \text{LAs} + \text{MOS}$$

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(l)], which state that TMDLs can be expressed in terms of mass per time (e.g. pounds per day), toxicity, or **other appropriate measure**. The TMDL for Lake Dora (Table 6) is expressed in terms of pounds per year, and represents the annual load the lake can assimilate and maintain the narrative nutrient criterion. The LA includes the atmospheric contribution (1,266 lbs/year).

**Table 6. TMDL Components**

WBID	Parameter	WLA		LA (lbs/year)	MOS	TMDL (lbs/year)	Percent Reduction
		Wastewater (lbs/year)	NPDES Stormwater (% Reduction)				
2831B	TP	N/A	67%	13,230	Implicit	13,230	67 <sup>1</sup>

<sup>1</sup> 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 13,230 lbs/year for phosphorus. This corresponds to reductions from the existing loadings of 67 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 Lake Beauclair discharge contributes more than 90% of the annual average phosphorus and nitrogen load to Lake Dora. Since TMDLs are being developed for the upstream lakes, there should be a significant reduction in the Lake Dora discharge to Lake Eustis.

### 7.2 Wasteload Allocations (WLAs)

#### NPDES Stormwater Discharges

As noted previously, 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 Dora watershed includes areas that will be covered by the MS4 Program, and the WLA for stormwater discharges is an 67 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 Dora will also influence the percent reduction that MS4 areas will need to meet for the TMDL for the lake to be achieved.

#### NPDES Wastewater Discharges

There are no wastewater facilities authorized to discharge wastewater to Lake Dora. Fulton et al. (2003) estimated that runoff and spills from existing wastewater facilities in the watershed contribute less than 0.25% of the annual TN and TP load to the lake.

### **7.3 Relationship between Lake Beauclair, Lake Eustis, and Lake Dora TMDLs**

It should also be noted with respect to possible reductions in either the WLA or LA to achieve the TMDL, discharge from Lake Beauclair currently represents approximately 91 percent of the annual load of phosphorus to Lake Dora. A TMDL has been proposed for Lake Beauclair that specifies a significant phosphorus load reduction. Implementation of this TMDL will reduce the contribution to Lake Dora and assist in achieving the TMDL for the lake.

The proposed TMDL for Lake Eustis estimated that discharge from Lake Dora currently contributes nearly 54 percent of the total annual phosphorus load for Lake Eustis. Reductions in phosphorus loading to and from Lake Dora 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 Dora or Dora Canal. 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.

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Figure 1. Upper Ocklawaha River Chain of Lakes

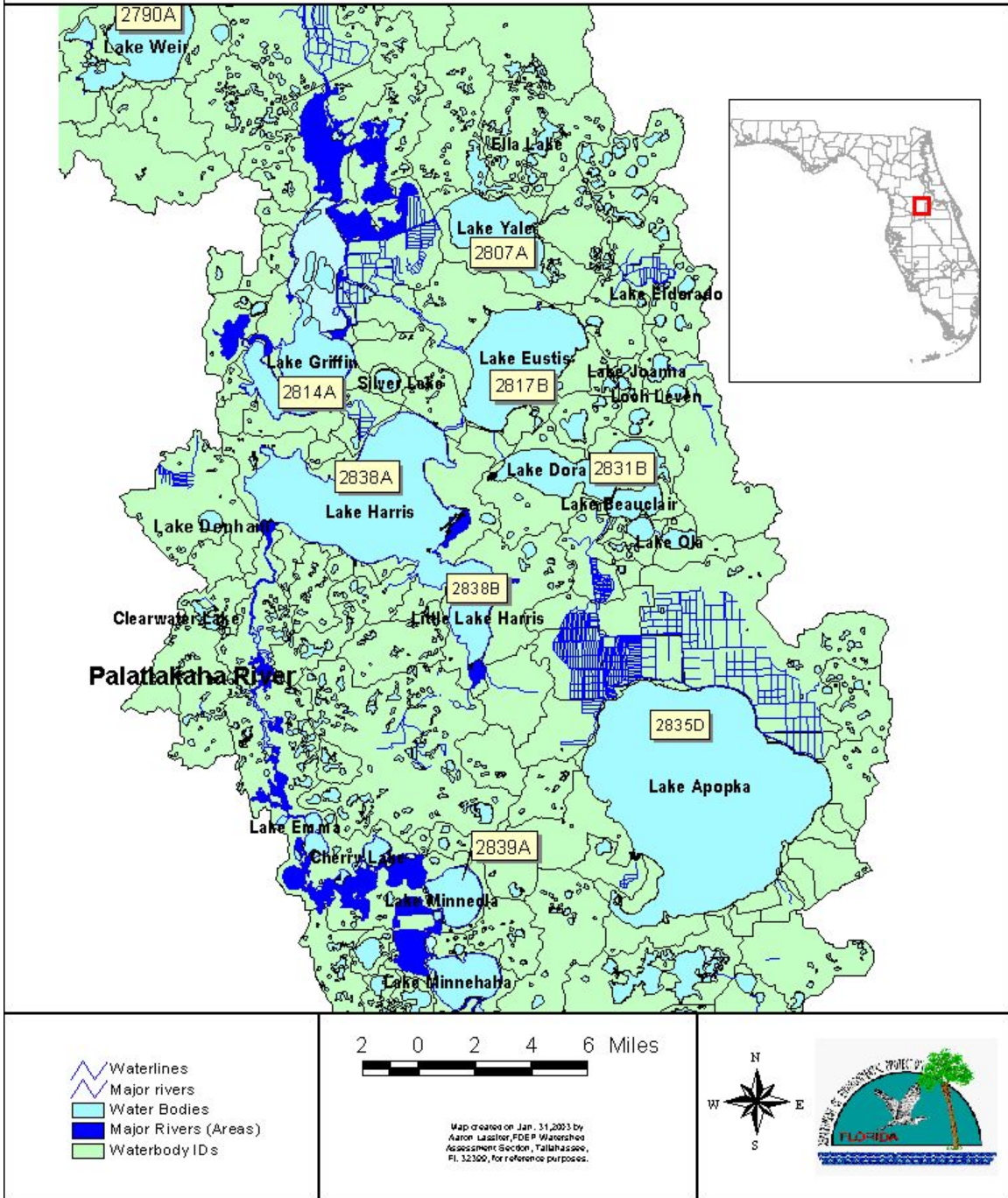


Figure 2a. Boxplots of water quality by year in Lake Dora (WBID 2831B) for the 1989 - 2002 period.

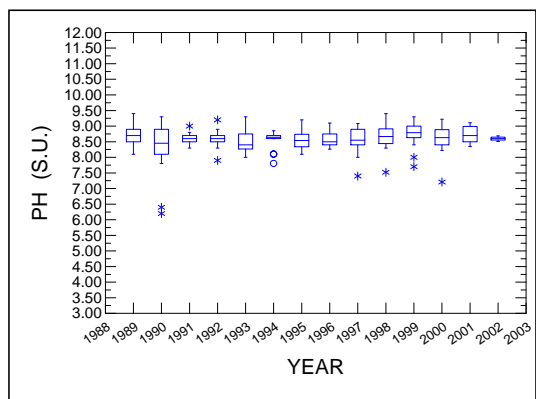
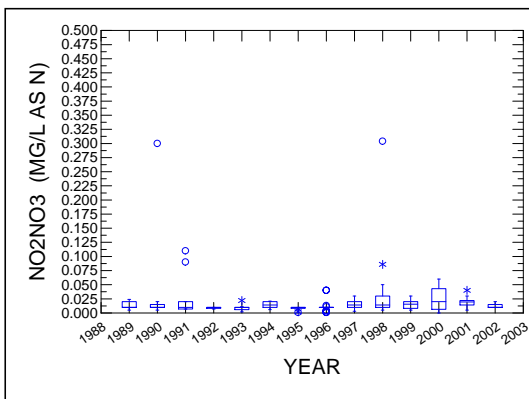
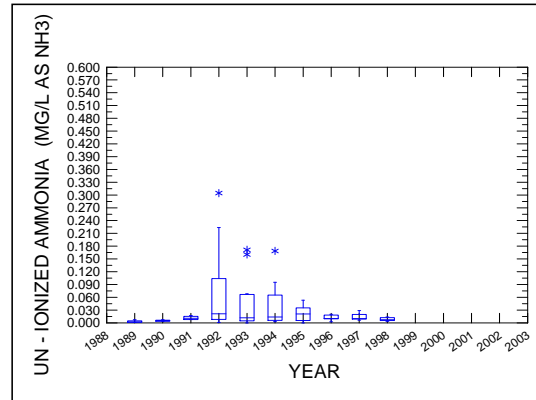
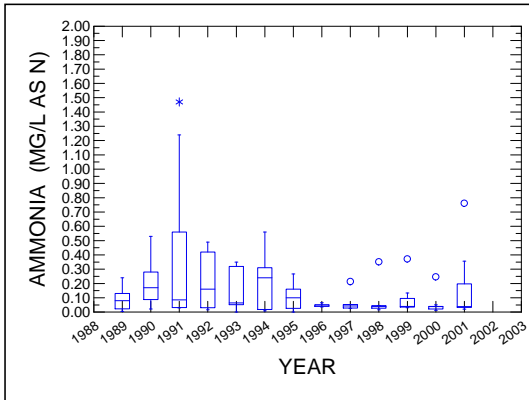
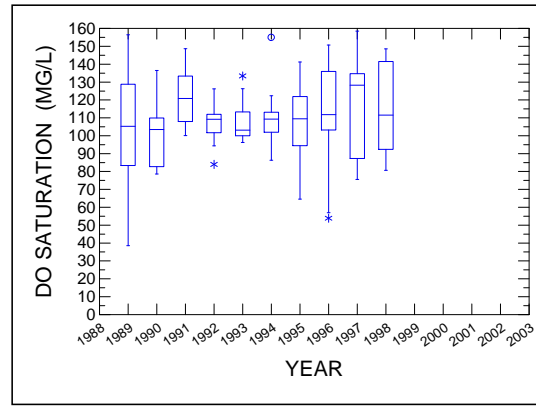
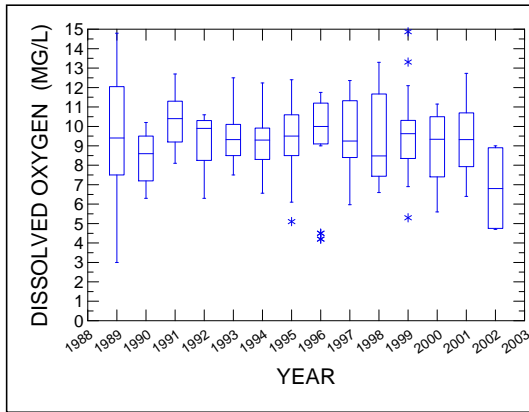




Figure 2a. Continued.

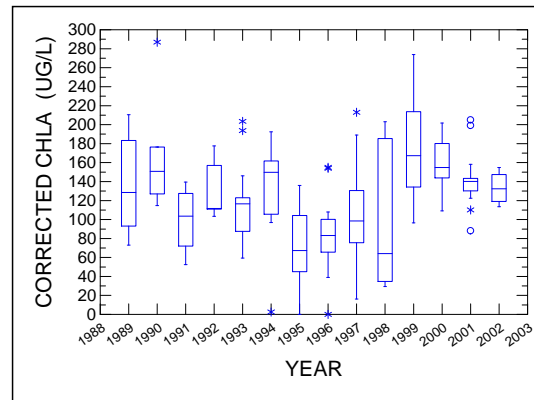
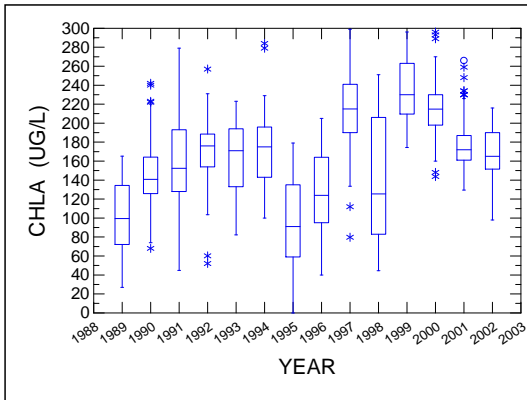
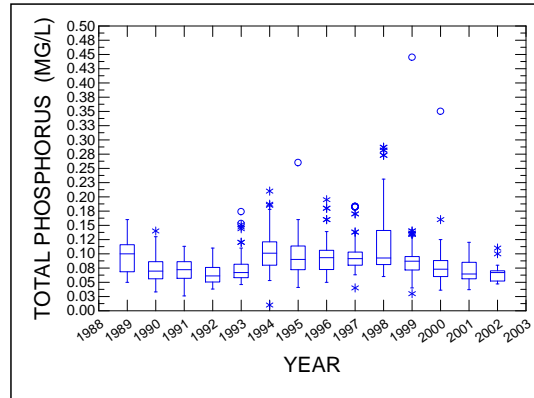
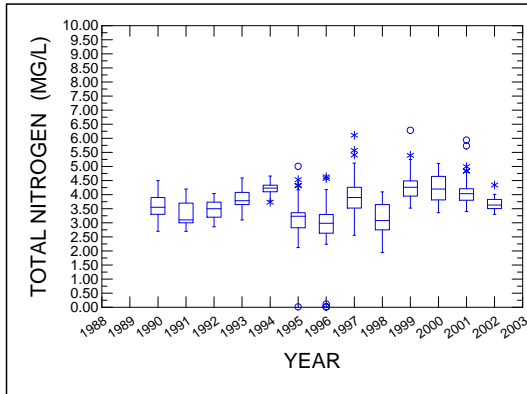


Figure 2b. Boxplots of water quality by year in Dora Canal (WBID 2831A) for the 1989 - 2002 period.

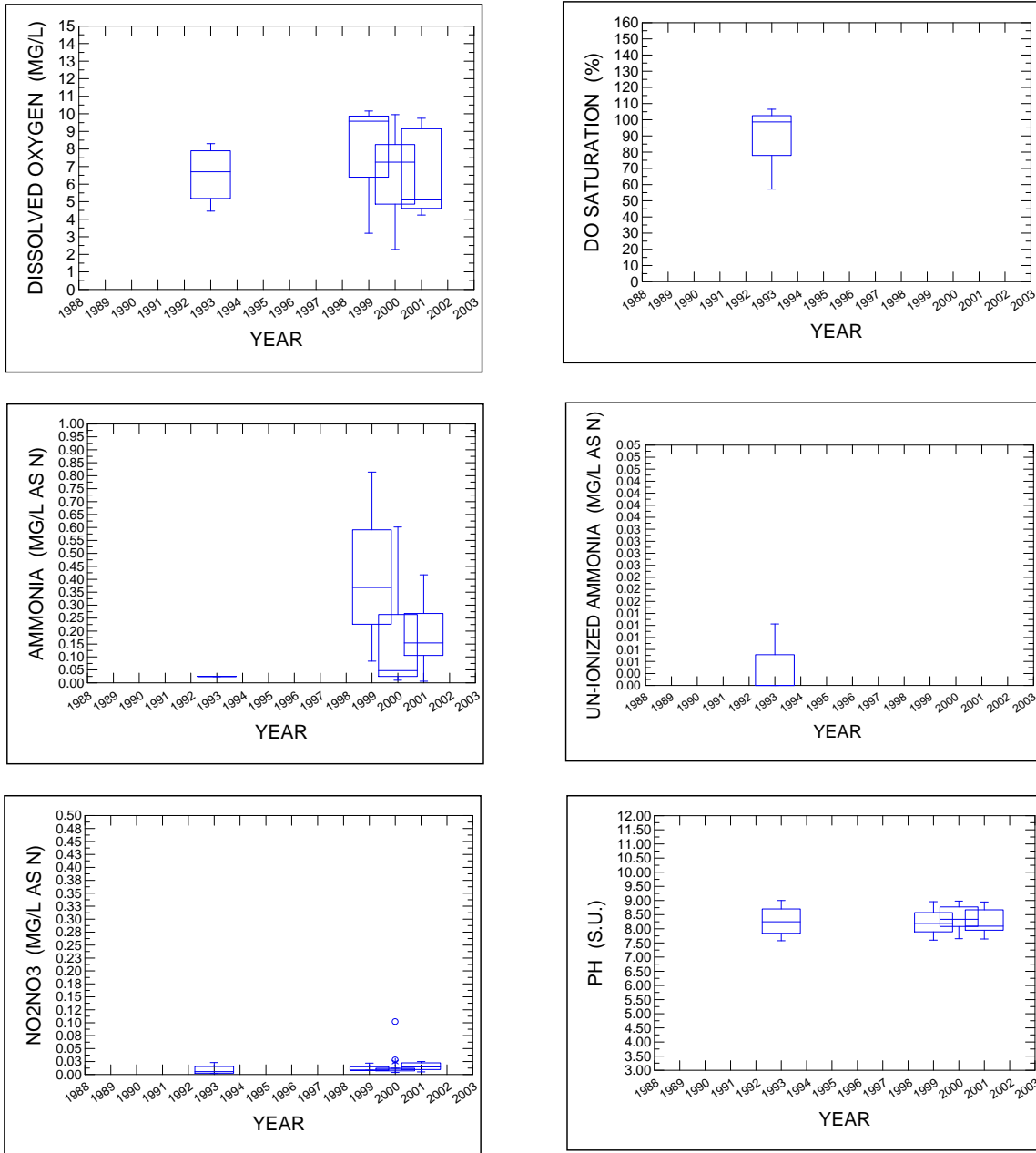


Figure 2b. Continued.

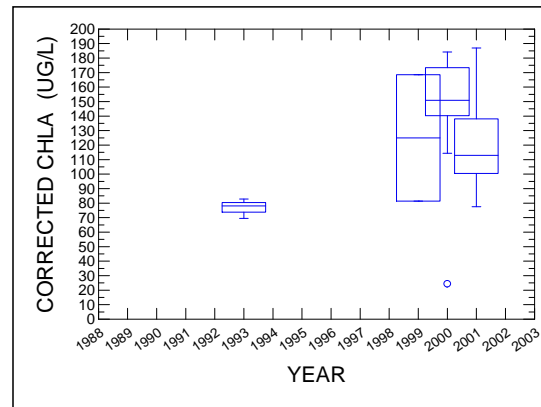
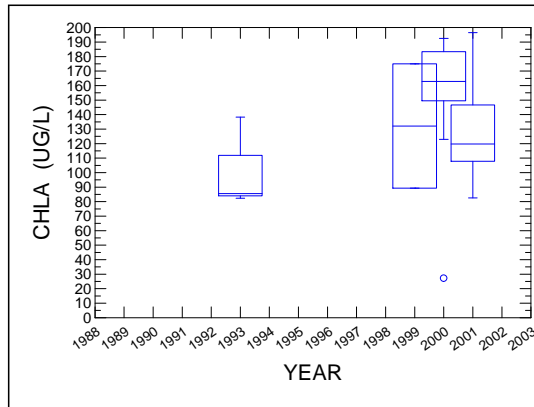
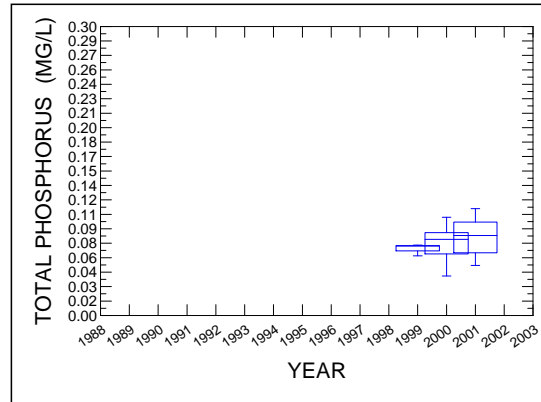
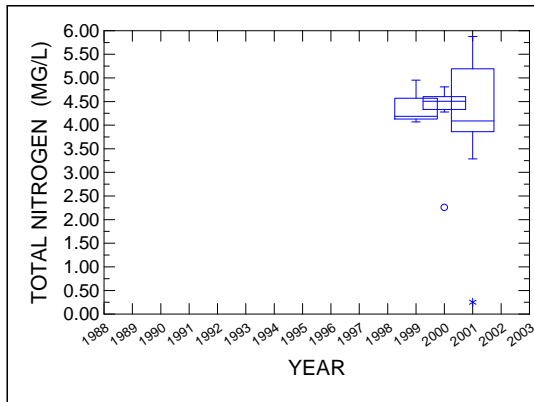


FIGURE 3. PLOTS OF WATER QUALITY FOR LAKE DORA FOR THE 1989-2002 PERIOD WITH TRENDLINES.

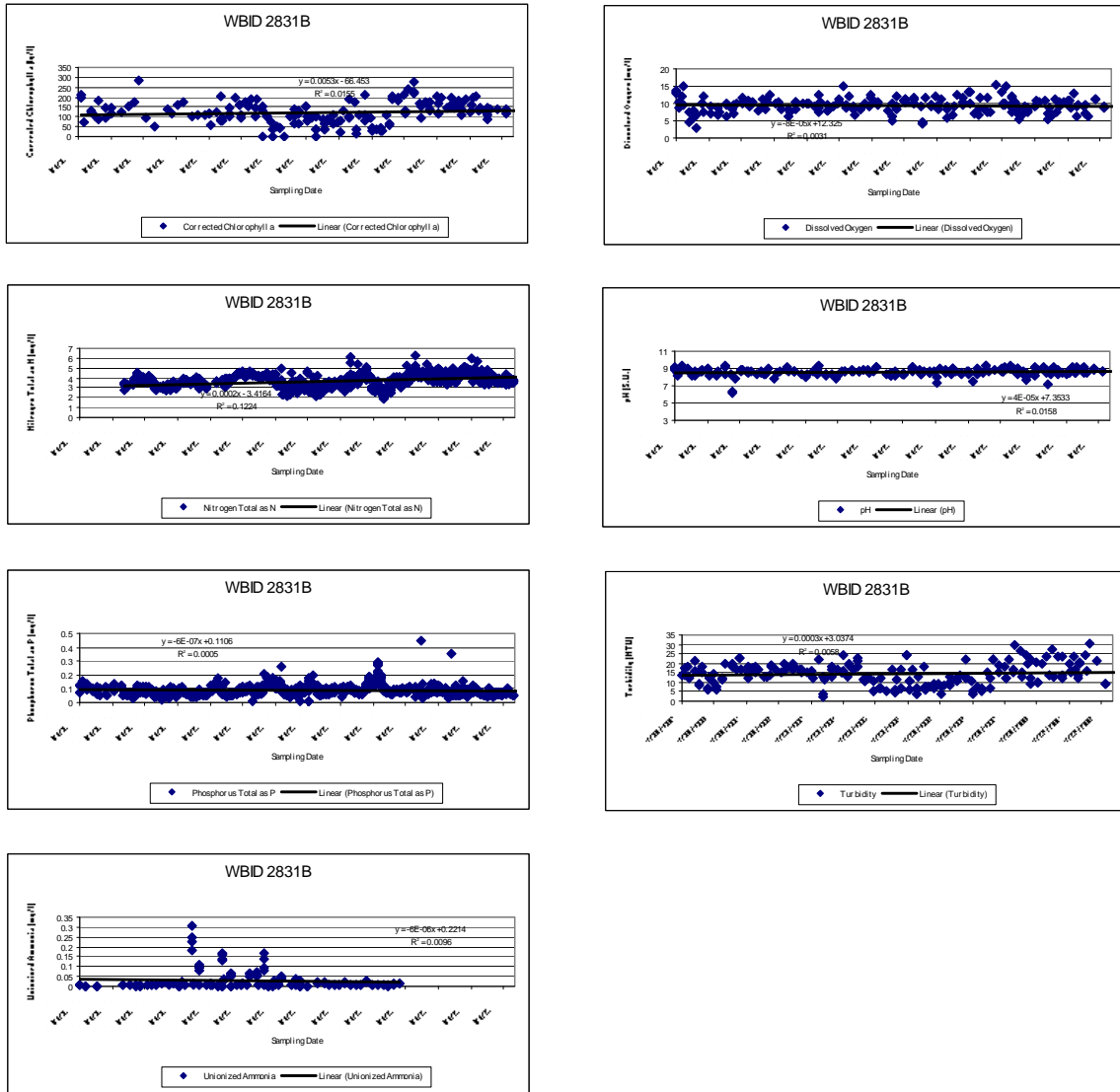


Figure 4. Cyanobacteria levels (biovolumes) in Lake Dora from Lake County Water Authority.

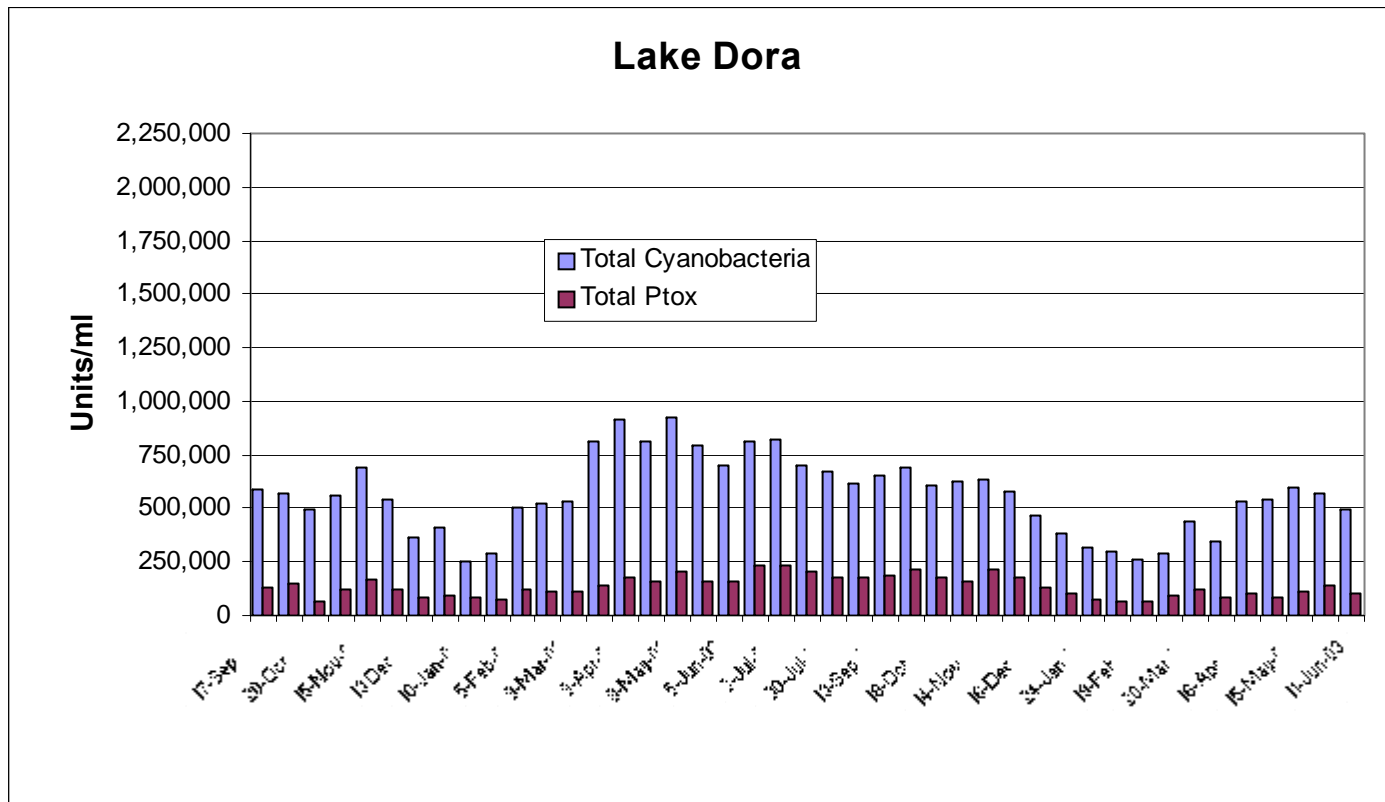


Figure 5. Microcystin levels in Lake Dora from Lake County Water Authority.

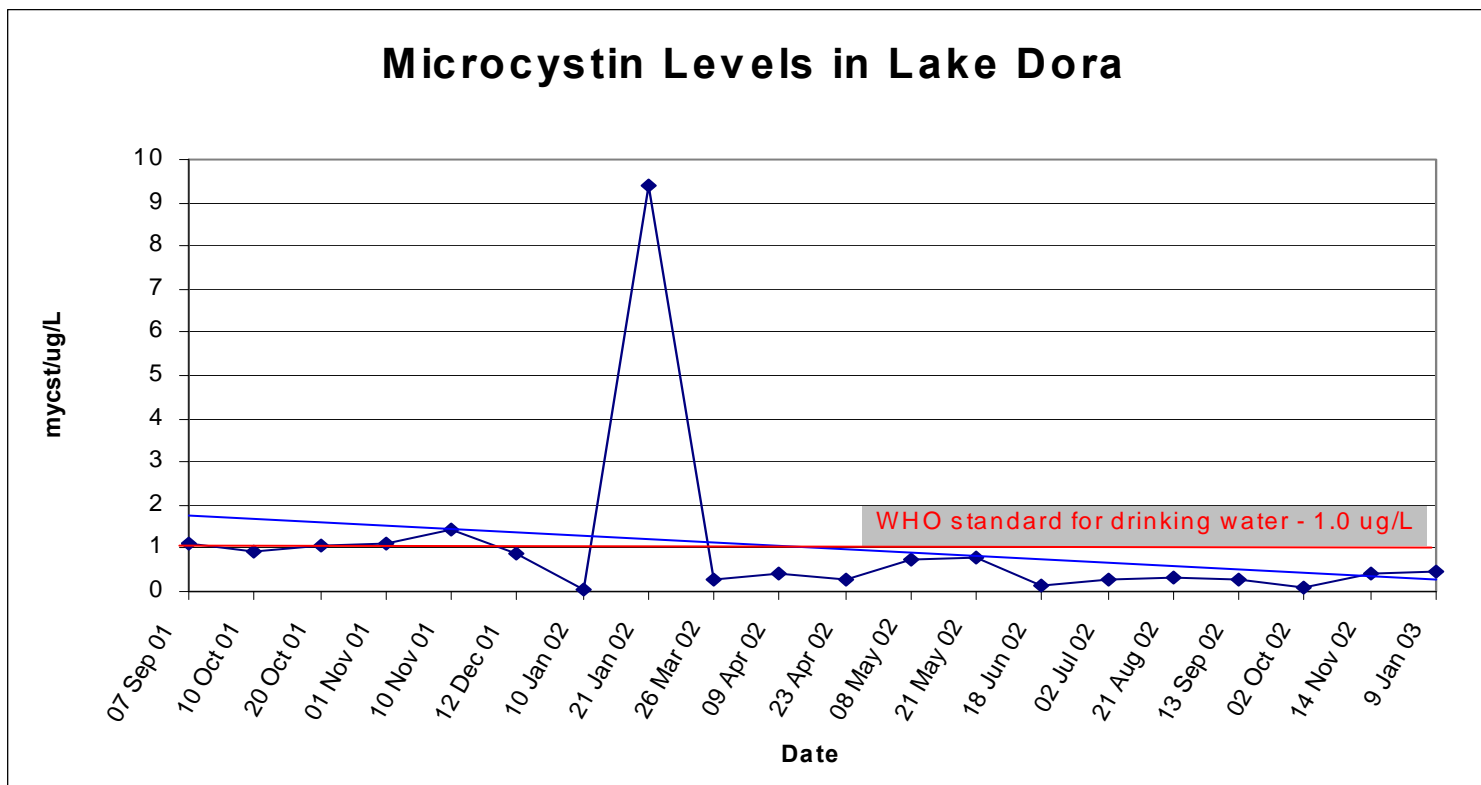
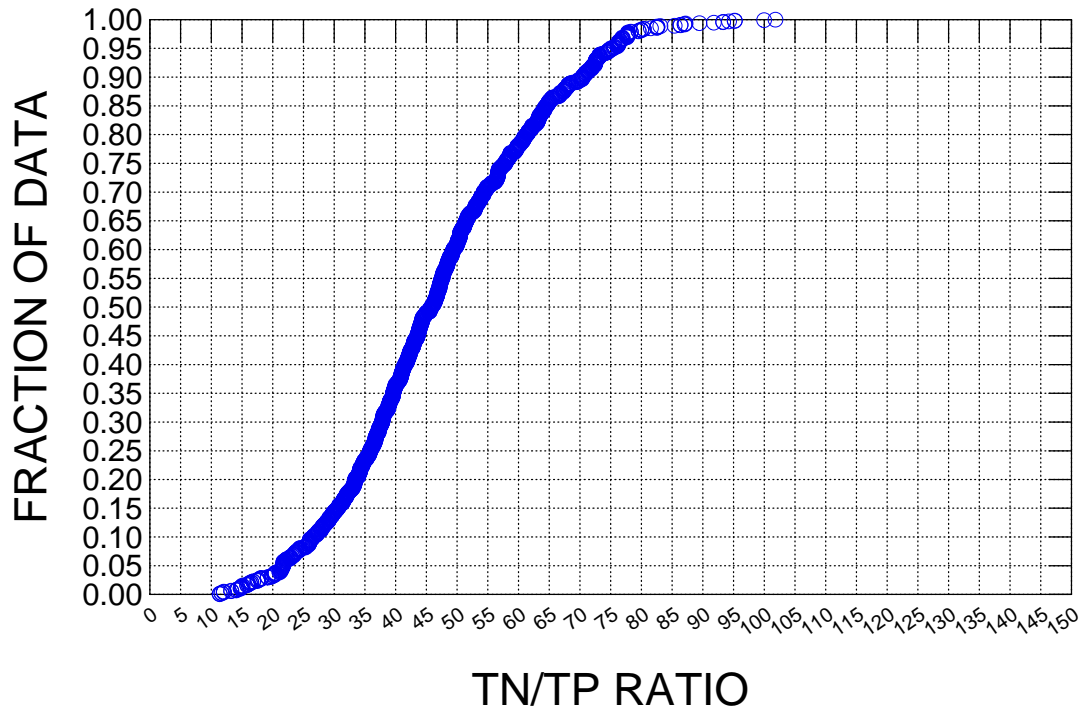
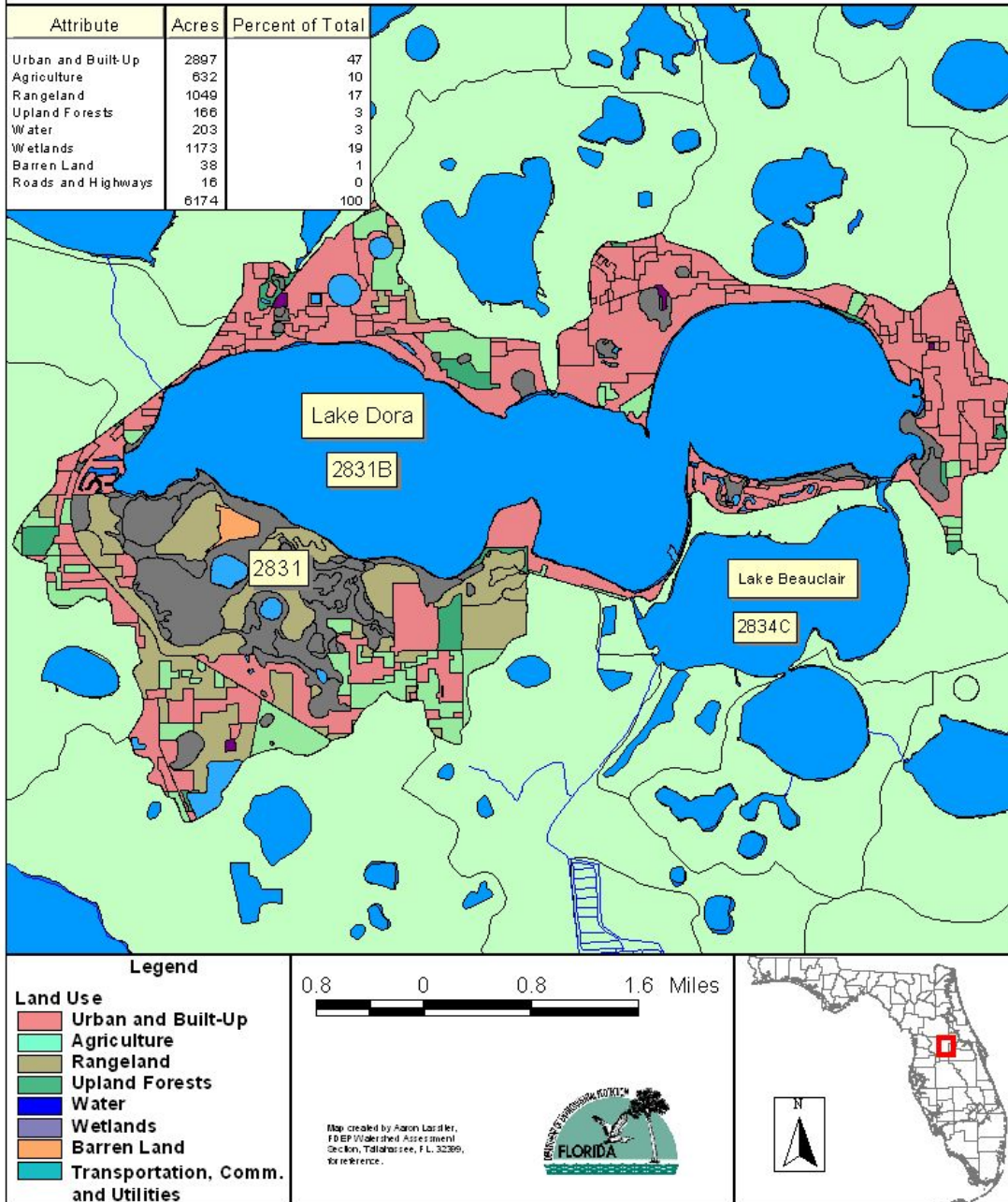


Figure 6. TN/TP cumulative frequency distribution for measurements in Lake Dora over the 1989 – 2002 period.



# Figure 7: Lake Dora Landuse





**Table 1. Lake Dora and Dora Canal dissolved oxygen, un-ionized ammonia, Chlorophyll a and/or TSI assessments under the IWR.**

Parameter of concern	Dora Canal	Lake Dora
Annual Chlorophyll <u>a</u> or TSI	Chlorophyll <u>a</u> (ug/l)	Trophic State Index
1989		83.1
1990		83.6
1991		83.8
1992		82.1
1993		82.2
1994		86.1
1995		80.6
1996		82.3
1997		88.3
1998		81.8
1999		88.9
2000	157.7	86.6
2001	124.5	83.6
Dissolved Oxygen	PP – 1/4 Insufficient data VP – 11/27 Verified	PP – 6/140 Not Impaired VP – 6/110 Not Impaired
Un-ionized Ammonia	PP – 0/4 Insufficient data VP – No data	PP – 26/79 Potentially impaired VP – 9/30 Verified
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 Dora (WBID 2831B) over the 1989 – 2002 period.**

	CHLA	CHLAC	DO	DOSAT	NH4
N of cases	919	168	199	118	132
Minimum	0.010	0.010	3.000	38.478	0.000
Maximum	347.000	286.902	15.580	189.744	1.470
Median	174.000	118.100	9.430	109.389	0.054
Mean	169.730	121.900	9.370	112.474	0.153
Standard Dev	58.590	55.025	2.178	25.952	0.212

	NO2	NO3	NO2O3	ORGN	PH
N of cases	0	0	199	50	204
Minimum	.	.	-0.003	0.000	6.200
Maximum	.	.	16.300	4.890	9.400
Median	.	.	0.010	3.640	8.605
Mean	.	.	0.100	3.508	8.608
Standard Dev	.	.	1.155	0.895	0.423

	PO4	TKN	TN	TP	TURBIDITY
N of cases	0	148	1436	1524	194
Minimum	.	0.000	0.010	0.010	2.000
Maximum	.	6.270	6.281	0.445	30.100
Median	.	4.070	3.730	0.083	13.800
Mean	.	3.935	3.677	0.088	14.105
Standard Dev	.	1.023	0.675	0.034	5.719

	UNNH4	TNTPRATIO
N of cases	79	1343
Minimum	0.000	11.394
Maximum	0.304	101.842
Median	0.011	45.914
Mean	0.032	46.961
Standard Dev	0.053	16.091

**Table 2b. Summary statistics of key water quality parameters for Dora Canal (WBID 2831A) over the 1989 – 2002 period.**

	TEMP	TRANSM	COLOR	DO	DOSAT
N of cases	32	32	16	32	4
Minimum	15.060	0.200	4.000	2.280	57.204
Maximum	30.650	0.740	150.000	10.160	856.363
Median	26.095	0.300	30.000	6.575	102.586
Mean	24.897	0.310	38.375	6.542	279.685
Standard Dev	4.403	0.096	32.613	2.372	385.060

	PH	TSS	TN	AMMONIA	UNNH3
N of cases	32	30	28	27	4
Minimum	7.580	8.000	0.250	0.006	0.000
Maximum	25.000	64.000	6.262	1.075	0.013
Median	8.230	24.500	4.472	0.147	0.000
Mean	8.831	25.493	4.358	0.221	0.003
Standard Dev	2.985	10.576	1.115	0.262	0.006

	TKN	NO2NO3	TP	ORTHOP	CHLA
N of cases	31	32	27	28	31
Minimum	2.253	0.002	0.041	0.001	27.146
Maximum	6.250	0.102	0.111	0.017	295.725
Median	4.500	0.010	0.078	0.005	146.174
Mean	4.428	0.016	0.078	0.007	144.672
Standard Dev	0.802	0.018	0.018	0.005	51.267

	CHLAC	TURBIDITY	TNTPRATIO
N of cases	30	15	1
Minimum	24.389	5.900	3.968
Maximum	286.580	27.600	3.968
Median	136.833	18.600	3.968
Mean	134.152	17.107	3.968
Standard Dev	52.089	5.514	.

**Table 3. Ammonia Concentration (in mg/l as N) that results in un-ionized ammonia of 0.02 mg/l as NH<sub>3</sub>**

PH (s.u.)	Water Temperature ( <sup>o</sup> 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 Dora (WBID 2831B).

	YEAR	MONTH	CHLA	CHLAC	DO
YEAR	1.000				
MONTH	-0.075	1.000			
CHLA	0.279	0.122	1.000		
CHLAC	0.116	0.094	0.953	1.000	
DO	-0.037	-0.249	0.088	0.042	1.000
DOSAT	0.103	-0.094	-0.060	-0.183	0.905
NH4	-0.204	0.044	-0.037	0.044	-0.068
NO2	.	.	.	.	.
NO3	.	.	.	.	.
NO2O3	-0.021	-0.024	0.098	0.107	0.104
ORGN	-0.169	-0.249	-0.647	.	-0.017
PH	0.137	-0.088	-0.040	0.015	0.287
PO4	.	.	.	.	.
TKN	0.143	0.099	0.611	0.528	0.023
TN	0.328	0.144	0.704	0.191	0.641
TP	-0.004	-0.243	-0.090	-0.042	-0.022
TURBIDITY	0.071	0.106	0.516	0.644	-0.009
UNNH4	-0.113	0.132	-0.189	-0.007	-0.125
TNTPRATIO	0.162	0.290	0.245	-0.089	0.241

	DOSAT	NH4	NO2	NO3	NO2O3
DOSAT	1.000				
NH4	-0.128	1.000			
NO2	.	.	1.000		
NO3	.	.	.	1.000	
NO2O3	0.176	-0.052	.	.	1.000
ORGN	-0.175	-0.052	.	.	-0.076
PH	0.414	-0.181	.	.	-0.286
PO4	.	.	.	.	.
TKN	0.069	0.217	.	.	0.033
TN	.	.	.	.	0.470
TP	-0.069	-0.030	.	.	-0.125
TURBIDITY	-0.061	-0.012	.	.	0.031
UNNH4	0.038	0.705	.	.	-0.082
TNTPRATIO	.	.	.	.	-0.487

	ORGN	PH	PO4	TKN	TN
ORGN	1.000				
PH	0.086	1.000			
PO4	.	.	1.000		
TKN	.	0.043	.	1.000	
TN	.	-0.465	.	0.999	1.000
TP	0.144	-0.033	.	-0.098	-0.062
TURBIDITY	0.322	0.042	.	0.505	-0.341
UNNH4	0.037	0.382	.	-0.123	.
TNTPRATIO	.	-0.134	.	-0.087	0.470

	TP	TURBIDITY	UNNH4	TNTPRATIO
TP	1.000			
TURBIDITY	-0.102	1.000		
UNNH4	-0.035	-0.020	1.000	
TNTPRATIO	-0.787	-0.198	.	1.000

Table 4a. Continued. Pairwise frequency table

	YEAR	MONTH	CHLA	CHLAC	DO
YEAR	1699				
MONTH	1699	1699			
CHLA	919	919	919		
CHLAC	168	168	82	168	
DO	199	199	98	120	199
DOSAT	118	118	74	49	118
NH4	132	132	89	81	103
NO2	0	0	0	0	0
NO3	0	0	0	0	0
NO2O3	199	199	90	128	165
ORGN	50	50	6	0	28
PH	204	204	97	120	198
PO4	0	0	0	0	0
TKN	148	148	83	129	136
TN	1436	1436	805	18	17
TP	1524	1524	894	128	165
TURBIDITY	194	194	87	125	162
UNNH4	79	79	56	48	79
TNTPRATIO	1343	1343	804	18	17

	DOSAT	NH4	NO2	NO3	NO2O3
DOSAT	118				
NH4	80	132			
NO2	0	0	0		
NO3	0	0	0	0	
NO2O3	94	130	0	0	199
ORGN	28	48	0	0	50
PH	117	102	0	0	167
PO4	0	0	0	0	0
TKN	66	84	0	0	146
TN	0	0	0	0	18
TP	95	131	0	0	197
TURBIDITY	95	126	0	0	192
UNNH4	79	79	0	0	77
TNTPRATIO	0	0	0	0	18

	ORGN	PH	PO4	TKN	TN
ORGN	50				
PH	28	204			
PO4	0	0	0		
TKN	0	138	0	148	
TN	0	18	0	18	1436
TP	50	167	0	147	1343
TURBIDITY	48	164	0	144	18
UNNH4	28	79	0	51	0
TNTPRATIO	0	18	0	18	1343

	TP	TURBIDITY	UNNH4	TNTPRATIO
TP	1524			
TURBIDITY	193	194		
UNNH4	78	78	79	
TNTPRATIO	1343	18	0	1343

Table 4b. Pearson correlation matrix for Dora Canal (WBID 2831A).

	YEAR	TEMP	TRANSM	COLOR	DO
YEAR	1.000				
TEMP	-0.337	1.000			
TRANSM	0.130	0.057	1.000		
COLOR	-0.130	0.326	-0.371	1.000	
DO	-0.018	-0.421	-0.395	-0.135	1.000
DOSAT	.	-0.032	-0.879	-0.096	-0.195
PH	0.045	-0.109	0.003	-0.053	0.223
TSS	-0.285	0.171	-0.411	0.495	0.371
TN	-0.006	.	.	.	.
AMMONIA	0.119	-0.510	0.286	-0.385	-0.172
UNNH3	.	-0.603	0.522	-0.132	0.687
TKN	0.255	-0.273	-0.443	0.041	0.253
NO2NO3	0.140	-0.305	-0.109	-0.151	0.103
TP	0.208	-0.494	-0.268	-0.312	0.367
ORTHOP	0.510	-0.062	-0.217	-0.254	0.227
CHLA	0.166	-0.347	-0.416	0.210	0.602
CHLAC	0.262	-0.384	-0.340	0.182	0.655
TURBIDITY	0.520	-0.563	-0.481	-0.131	0.452
TNTPRATIO	.	.	.	.	.

	DOSAT	PH	TSS	TN	AMMONIA
DOSAT	1.000				
PH	-0.138	1.000			
TSS	0.423	0.348	1.000		
TN	.	.	.	1.000	
AMMONIA	.	-0.256	-0.252	.	1.000
UNNH3	-0.300	0.821	-0.251	.	.
TKN	0.647	0.010	0.222	.	0.141
NO2NO3	0.972	-0.056	-0.198	.	0.044
TP	.	0.018	0.255	.	0.116
ORTHOP	.	-0.093	0.184	.	0.091
CHLA	-0.995	0.226	0.194	.	-0.284
CHLAC	-0.938	0.226	0.154	.	-0.288
TURBIDITY	-0.342	0.090	-0.173	.	-0.091
TNTPRATIO	.	.	.	.	.

	UNNH3	TKN	NO2NO3	TP	ORTHOP
UNNH3	1.000				
TKN	-0.726	1.000			
NO2NO3	-0.069	0.073	1.000		
TP	.	0.488	-0.164	1.000	
ORTHOP	.	0.501	0.344	0.269	1.000
CHLA	-0.545	0.447	0.117	0.335	0.041
CHLAC	0.160	0.391	0.101	0.361	0.038
TURBIDITY	-0.707	0.440	0.594	0.055	0.372
TNTPRATIO	.	.	.	.	.

	CHLA	CHLAC	TURBIDITY	TNTPRATIO
CHLA	1.000			
CHLAC	0.999	1.000		
TURBIDITY	0.629	0.653	1.000	
TNTPRATIO	.	.	.	1.000

**Table 4b. Continued. Pairwise frequency table**

	YEAR	TEMP	TRANSM	COLOR	DO
YEAR	59				
TEMP	32	32			
TRANSM	32	32	32		
COLOR	16	16	16	16	
DO	32	32	32	16	32
DOSAT	4	4	4	4	4
PH	32	32	32	16	32
TSS	30	30	30	14	30
TN	28	1	1	1	1
AMMONIA	27	27	27	12	27
UNNH3	4	4	4	4	4
TKN	31	31	31	16	31
NO2NO3	32	32	32	16	32
TP	27	27	27	12	27
ORTHOP	28	28	28	12	28
CHLA	31	31	31	15	31
CHLAC	30	30	30	14	30
TURBIDITY	15	15	15	15	15
TNTPRATIO	1	1	1	1	1

	DOSAT	PH	TSS	TN	AMMONIA
DOSAT	4				
PH	4	32			
TSS	4	30	30		
TN	0	1	1	28	
AMMONIA	1	27	25	0	27
UNNH3	4	4	4	0	1
TKN	4	31	29	1	27
NO2NO3	4	32	30	1	27
TP	0	27	25	1	26
ORTHOP	0	28	26	1	26
CHLA	3	31	29	1	27
CHLAC	3	30	29	1	26
TURBIDITY	4	15	14	1	11
TNTPRATIO	0	1	1	1	0

	UNNH3	TKN	NO2NO3	TP	ORTHOP
UNNH3	4				
TKN	4	31			
NO2NO3	4	31	32		
TP	0	27	27	27	
ORTHOP	0	27	28	27	28
CHLA	3	30	31	27	28
CHLAC	3	29	30	26	27
TURBIDITY	4	15	15	11	11
TNTPRATIO	0	1	1	1	1

	CHLA	CHLAC	TURBIDITY	TNTPRATIO
CHLA	31			
CHLAC	29	30		
TURBIDITY	14	14	15	
TNTPRATIO	1	1	1	1



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

Nutrient Source	Lake Dora		Lake Dora	
	Mean TP load 1991-2000		Mean TN load 1991-2000	
	kg/year	%	kg/year	%
Low density residential	29.8	0.17%	319.7	0.11%
Medium density residential	153.7	0.85%	1,174.6	0.39%
High density residential	128.6	0.72%	652.1	0.22%
Low density commercial	12.6	0.07%	112.4	0.04%
High density commercial	311.3	1.73%	2094.4	0.69%
Industrial	53.0	0.29%	351.7	0.12%
Mining	0.0	0.00%	0.0	0.00%
Openland/recreational	1.1	0.01%	26.2	0.01%
Pasture	3.3	0.02%	24.1	0.01%
Cropland	2.0	0.01%	13.8	0.00%
Tree crops	3.1	0.02%	45.3	0.01%
Feeding Operations	0.0	0.00%	0.0	0.00%
Other agriculture	2.1	0.01%	17.9	0.01%
Forest/rangeland	7.8	0.04%	181.1	0.06%
Water	15.8	0.09%	467.3	0.15%
Wetlands	123.6	0.69%	2,739.1	0.90%
Septic tanks	187.0	1.04%	3,301.7	1.09%
Precipitation	239.4	1.33%	8,569.7	2.83%
Dry deposition	335.0	1.86%	2,498.1	0.83%
Lake Beauclair discharge	16,333.3	90.82%	279,032.5	92.15%
Lake Eustis discharge	6.1	0.03%	562.0	0.19%
Domestic WWTP spills	0.1	0.00%	0.5	0.00%
Tavares-Caroline St WWTP runoff	16.9	0.09%	295.5	0.10%
Mt Dora WWTP runoff	18.6	0.10%	325.1	0.11%
<b>Total</b>	<b>17,984.4</b>	<b>100.00%</b>	<b>302,805.1</b>	<b>100.00%</b>

## 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.