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**Total Maximum Daily Loads**

**For the**

**Lake Alfred (WBID 1488D),  
Crystal Lake (WBID 1497A), and  
Lake Ariana North (WBID 1501B)**

**Nutrients**

**June 2010**



In compliance with the provisions of the Federal Clean Water Act, 33 U.S.C §1251 et. seq., as amended by the Water Quality Act of 1987, P.L. 400-4, the U.S. Environmental Protection Agency is hereby establishing the Total Maximum Daily Load (TMDL) for nutrients in the Upper Peace River Basin (WBIDs 1488D, 1497A, 1501B). Subsequent actions must be consistent with this TMDL.

\_\_\_\_\_  
/s/

\_\_\_\_\_  
8/23/2010

James D. Giattina, Director  
Water Protection Division

Date

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## SUMMARY SHEET

### Total Maximum Daily Load (TMDL)

1. 303(d) Listed Segment:      WBID – 1488D: Lake Alfred  
  WBID – 1497A: Crystal Lake  
  WBID – 1501B: Lake Ariana North
  
2. TMDL Endpoints/Targets:    Total Nitrogen and Total Phosphorus
  
3. TMDL Technical Approach    Calibration of a watershed and water quality model  
  to current conditions, load reduction scenarios to  
  meet water quality standards.
  
4. TMDL Waste Load and Load Allocation:
  
  
  
  
  
  
  
  
  
  
5. Endangered Species Present: No
  
  
  
  
  
  
  
  
  
  
6. USEPA Lead TMDL or Other: USEPA
  
  
  
  
  
  
  
  
  
  
7. TMDL Considers Point Sources/Non-Point Sources: MS4 and Non-Point Source
  
  
  
  
  
  
  
  
  
  
8. Major NPDES Discharges to surface waters addressed in USEPA TMDL: None

## 1. Introduction

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Listed waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those water bodies that are not meeting water quality standards. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources (USEPA, 1991).

The State of Florida Department of Environmental Protection (FDEP) developed a statewide, watershed-based approach to water resource management. Under the watershed management approach, water resources are managed on the basis of natural boundaries, such as river basins, rather than political boundaries. The watershed management approach is the framework FDEP uses for implementing TMDLs. The state's 52 basins are divided into five groups. Water quality is assessed in each group on a rotating five-year cycle. Sarasota – Peace – Myakka is a Group 3 basin; it was designated for TMDL development by a consent decree. FDEP established five water management districts (WMD) responsible for managing ground and surface water supplies in the counties encompassing the districts. Lake Alfred, Crystal Lake, and Lake Ariana reside mostly in the Southwest Florida Water Management District (SWFWMD).

For the purpose of planning and management, the WMDs divided the district into planning units defined as either an individual primary tributary basin or a group of adjacent primary tributary basins with similar characteristics. These planning units contain smaller, hydrological based units called drainage basins, which are further divided by FDEP into “water segments”. A water segment usually contains only one unique waterbody type (stream, lake, canal, etc.) and is about five square miles. Unique numbers or Waterbody Identification Units (WBIDs) numbers are assigned to each water segment.

## 2. Problem Definition

Florida's final 1998 Section 303(d) list identified numerous WBIDs in the Sarasota – Peace – Myakka Basin as not supporting water quality standards (WQS). The TMDLs addressed in this document are being established pursuant to USEPA commitments in the 1998 Consent Decree in the Florida TMDL lawsuit (Florida Wildlife Federation, et al. v. Carol Browner, et al., Civil Action No. 4: 98CV356-WS, 1998). After assessing all readily available water quality data, USEPA is responsible for developing TMDLs in several WBIDs (Figure 1-3). The parameters addressed in these TMDLs are nutrients.



Most water bodies in the Sarasota – Peace – Myakka Basin are designated as Class III waters having a designated use for recreation, and propagation and maintenance of a healthy, well-balanced population of fish and wildlife. The level of impairment is denoted as threatened, partially or not supporting designated uses. A water body that is classified as threatened currently meets WQS but trends indicate the designated use may not be met in the next listing cycle. A water body classified as partially supporting designated uses is defined as somewhat impacted by pollution and water quality criteria are exceeded on some frequency. For this category, water quality is considered moderately impacted. A water body that is categorized as not supporting is highly impacted by pollution and water quality criteria are exceeded on a regular or frequent basis. In such water bodies, water quality is considered severely impacted.

To determine the status of surface water quality in the state, three categories of data – chemistry data, biological data, and fish consumption advisories – were evaluated to determine potential impairments. The level of impairment is defined in the Identification of Impaired Surface Waters Rule (IWR), Section 62-303 of the Florida Administrative Code (F.A.C.). The IWR defines the threshold for determining if waters should be included on the state’s planning list and verified list. Potential impairments are determined by assessing whether a water body meets the criteria for inclusion on the planning list. Once a water body is on the planning list, additional data and information will be collected and examined to determine if the water should be included on the verified list.



Figure 1 Lake Alfred Location Map



Figure 2 Crystal Lake Location Map

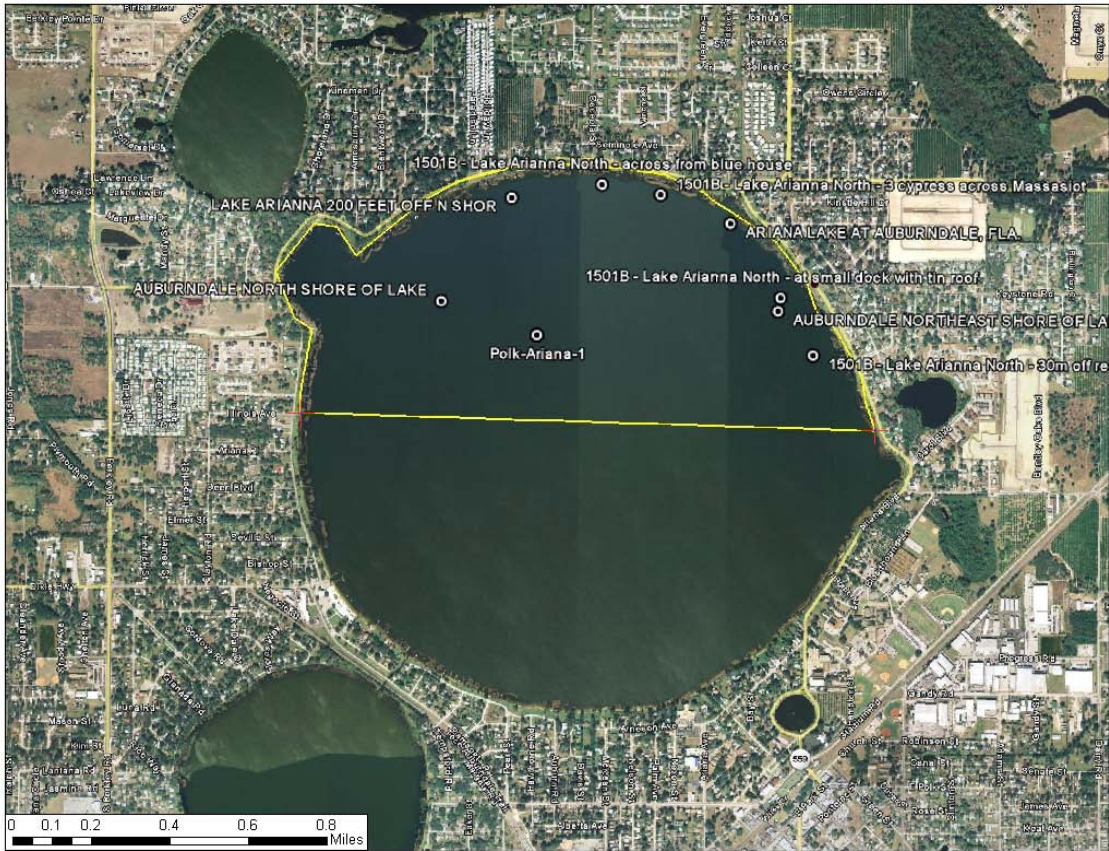


Figure 3 Lake Ariana North Location Map

### 3. Watershed Description

Lake Alfred lies in central Polk County and borders the City of Lake Alfred, FL to the southeast. Its watershed is part of the larger Peace River watershed. This WBID contains three separate lakes: Lake Alfred, Lake Griffin, and Lake Eva. Lakes Griffin and Eva both drain to Lake Alfred. Wetlands make up the largest land use within this WBID, with agriculture and transitional lands being the other largest. Lake Alfred itself covers 727 acres, with lakes Griffin (15.6 acres) and Eva (20.5 acres) being much smaller.

Crystal Lake lies in western Polk County and is situated within the City of Lakeland, FL. Its watershed is part of the larger Peace River watershed. High intensity residential, commercial and services make up the entire land use within this WBID. Crystal Lake itself covers 27 acres.

Lake Ariana lies in central Polk County and is located in the City of Auburndale, FL. Its watershed is part of the larger Peace River watershed. Residential and transitional lands make up the largest land use within this WBID. Lake Ariana itself covers 928 acres.

## 4. Water Quality Standards/TMDL Targets

The water bodies in the Lake Alfred, Crystal Lake, and Lake Ariana watersheds are Class III Freshwater with a designated use of Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife. Designated use classifications are described in the Florida Administrative Code (F.A.C.), Section 62-302.400(1), and water quality criteria for protection of all classes of waters are established in F.A.C. 62-302.530. Individual criteria should be considered in conjunction with other provisions in water quality standards, including Section 62-302.500 F.A.C. [Surface Waters: Minimum Criteria, General Criteria] that apply to all waters unless alternative criteria are specified in F.A.C. Section 62-302.530. Several WBIDs were listed due to elevated concentrations of chlorophyll *a*. While there is no water quality standard specifically for chlorophyll *a*, elevated levels of chlorophyll *a* are frequently associated with a violation of the narrative nutrient standard, which is described below.

### 4.1. *Nutrients:*

The nutrient criterion in Rule 62-302, F.A.C., is expressed as a narrative:

In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna [Note: For Class III waters in the Everglades Protection Area, this criterion has been numerically interpreted for phosphorus in Section 62-302.540, F.A.C.].

To assess whether this narrative criterion was being exceeded, the IWR provides thresholds for nutrient impairment in estuaries based on annual average chlorophyll *a* levels. The following language is found in Rule 62-303, F.A.C.:

#### **62-303.351 Nutrients in Streams.**

A stream or stream segment shall be included on the planning list for nutrients if the following biological imbalances are observed:

(1) Algal mats are present in sufficient quantities to pose a nuisance or hinder reproduction of a threatened or endangered species, or

(2) Annual mean chlorophyll *a* concentrations are greater than 20 ug/l or if data indicate annual mean chlorophyll *a* values have increased by more than 50% over historical values for at least two consecutive years.

#### **62-303.450 Interpretation of Narrative Nutrient Criteria.**

(1) A water shall be placed on the verified list for impairment due to nutrients if there are sufficient data from the last five years preceding the planning list assessment, combined with historical data (if needed to establish historical chlorophyll *a* levels or historical Trophic State Index (TSI)), to meet the data sufficiency requirements of subsection 62-

303.350(2), F.A.C. If there are insufficient data, additional data shall be collected as needed to meet the requirements. Once these additional data are collected, the Department shall determine if there is sufficient information to develop a site-specific threshold that better reflects conditions beyond which an imbalance in flora or fauna occurs in the water segment. If there is sufficient information, the Department shall re-evaluate the data using the site-specific thresholds. If there is insufficient information, the Department shall re-evaluate the data using the thresholds provided in Rules 62-303.351-.353, F.A.C., for streams, lakes, and estuaries, respectively. In any case, the Department shall limit its analysis to the use of data collected during the five years preceding the planning list assessment and the additional data collected in the second phase. If alternative thresholds are used for the analysis, the Department shall provide the thresholds for the record and document how the alternative threshold better represents conditions beyond which an imbalance in flora or fauna is expected to occur.

The IWR Rule 62-303.350 and 62-303.352, F.A.C., (Nutrients in Lakes) states that a lake with a mean color greater than 40 platinum cobalt units, is impaired when any annual mean TSI during the verified period exceeds 60, unless paleolimnological information indicates the lake was naturally greater than 60. Additionally a lake can be impaired, if data indicate that annual mean TSIs have increased over the assessment period, as indicated by a positive slope in the means plotted versus time, or the annual mean TSI has increased by more than 10 units over historical values. When evaluating the slope of mean TSIs over time, the Department shall require at least a 5 unit increase in TSI over the assessment period. The IWR Rule allows use of additional information indicating imbalance of flora or fauna due to nutrient enrichment. These include algal blooms, changes in alga species richness, excessive macrophyte growth, a decrease in the areal coverage or density of seagrasses or other submerged aquatic vegetation, and excessive diel oxygen variation. Lake Alfred, Crystal Lake, and Lake Ariana are all considered to be “clear” lakes and must achieve a TSI of 40. Sufficient data were available for each lake to calculate a TSI at several times throughout the period of record. Any single year with a TSI greater than 40 would result in a determination that the Lake is impaired for nutrients. The lake TSI exceeded 40 in every year during the period of measured data. If the water body is verified as impaired (as is the case for Lake Alfred, Crystal Lake, and Lake Ariana with numerous TSI values over 40 in the verified period) then the target for TMDL development is the impairment threshold (40) minus 5 TSI units. The TMDL target of 35 is selected as a 5 TSI unit reduction from the impairment threshold. This 5 TSI unit reduction accounts for the assimilative capacity of the lake, allows for future growth, and contributes to the margin of safety. For the purposes of developing the TMDL, and to be conservative, the TSI of 35 is the target for all three lakes.

## **5. Water Quality Assessment**

WBID 1488D Lake Alfred, WBID 1497A Crystal Lake, and WBID 1501B Lake Ariana North were listed as not attaining their designated uses on Florida’s 1998 303(d) list for nutrients.

To determine impairment an assessment of available data was conducted. The source for current ambient monitoring data for WBIDs 1488D, 1497A, and 1501B was the Impaired Waters Rule (IWR) data Run 35 as well as data from Lakewatch and the Southwest Florida Water Management District (SWFWMD).

### 5.1. Water Quality Data

The tables and figures below presents the station locations and time series data for dissolved oxygen, total nitrogen, total phosphorus, chlorophyll *a* as well as the calculated TSI values for each lake.

Table 1 provides a list of the water quality monitoring stations in the WBIDs including the date range of the observations and the number of observations.

**Table 1 Water Quality Monitoring Stations for WBID 1488D: Lake Alfred**

Station ID	Begin Date	End Date	# of Observations
25020258	8/19/1998	8/19/1998	3
Alfred	4/26/1985	10/6/1992	191
Alfred1	5/3/1999	3/9/2009	435
STA0008000000800	2/14/2000	2/26/2003	35

**Table 2 Water Quality Monitoring Stations for WBID 1497A: Crystal Lake**

Station ID	Begin Date	End Date	# of Observations
03100101-CL-01	2/15/1996	2/15/1996	5
03100101-CL-02	2/15/1996	2/15/1996	5
Crystal1	4/14/1992	11/8/2007	352
Crystal2	4/14/1992	11/24/1999	154
Crystal3	5/8/2000	5/9/2001	49
Crystal5	5/8/2000	5/9/2001	37

**Table 3 Water Quality Monitoring Stations for WBID 1501B: Lake Ariana North**

Station ID	Begin Date	End Date	# of Observations
14564	10/17/2002	10/17/2002	9
25020208	2/17/1976	10/25/1979	38
Ariana	4/25/1985	10/5/1992	206
Ariana1	3/29/1993	6/17/2009	529
Ariana-Polk	9/8/1999	2/28/2001	51
STA0369000037000	2/14/2000	3/6/2003	38



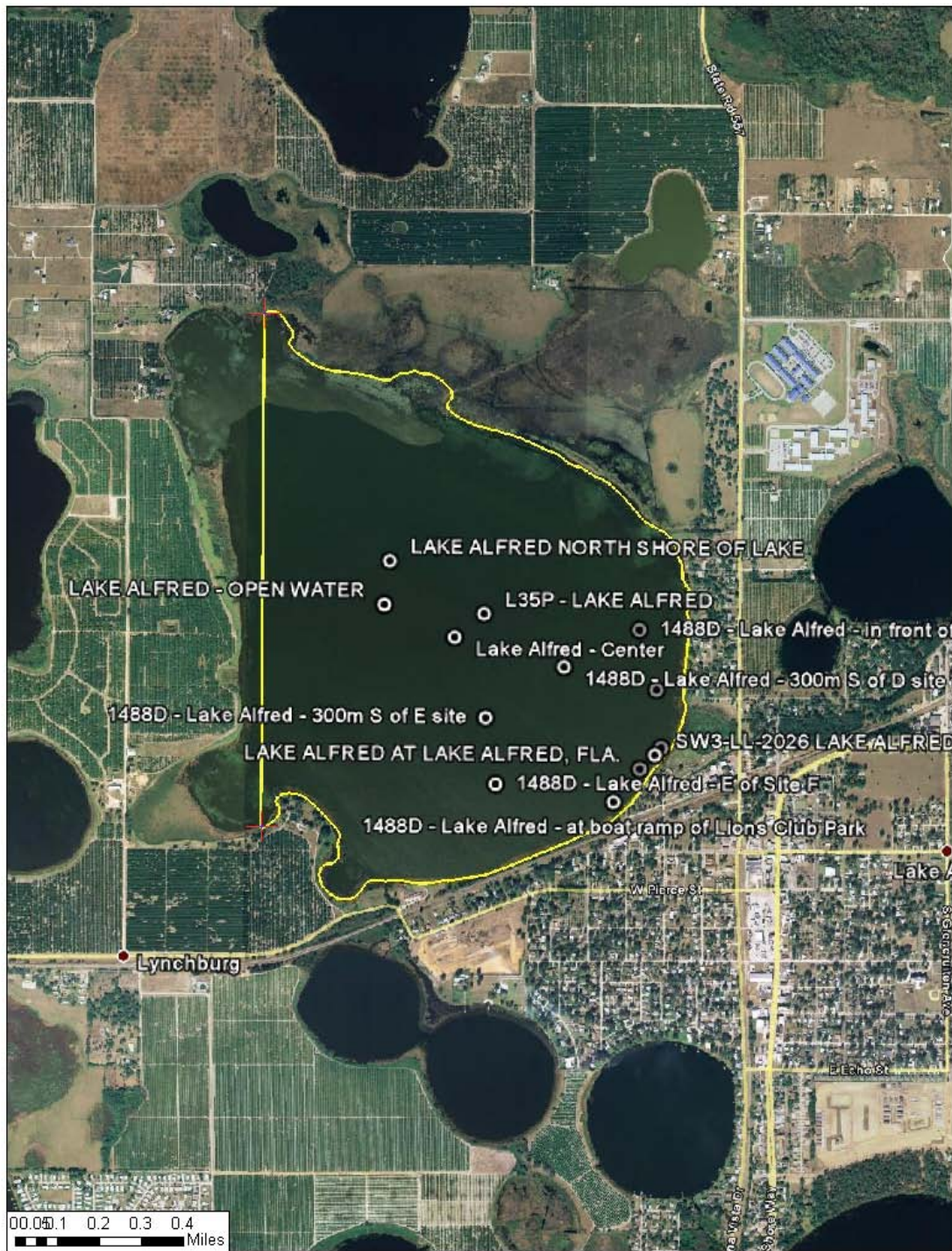


Figure 4 Station Locations for WBID: 1488D Lake Alfred



Figure 5 Station Locations for WBID: 1497A Crystal Lake

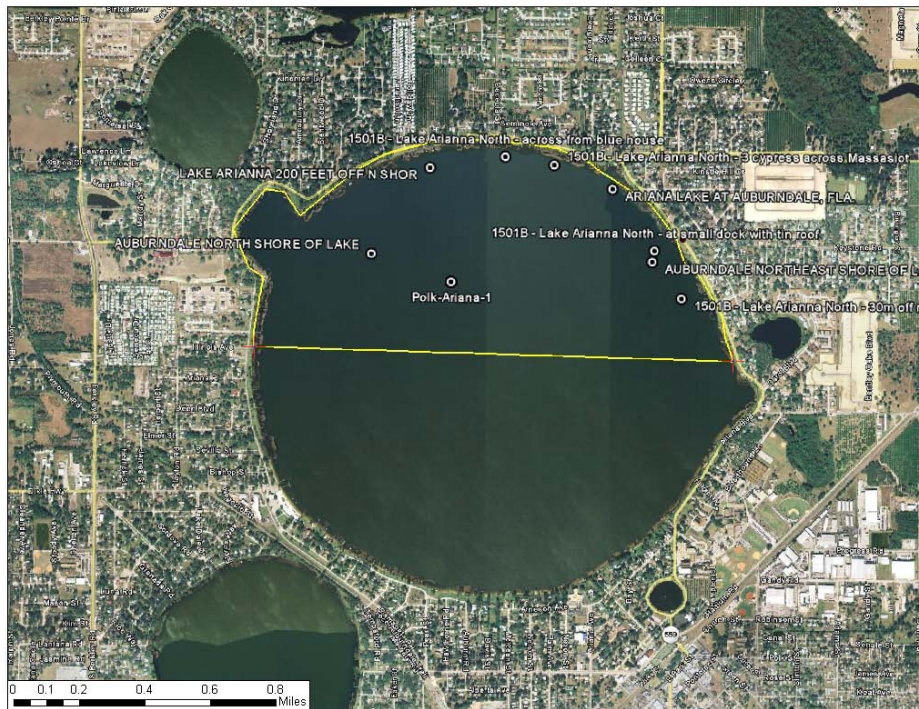


Figure 6 Station Locations for WBID: 1501B Lake Ariana North

### 5.1.1. Nutrients

For the nutrient assessment the monitoring data for total nitrogen, total phosphorus and chlorophyll *a* are presented. While Florida is currently working on the development and promulgation of numeric nutrient criteria, the current standard for nutrients is a narrative. The purpose the nutrient assessment is to present the range, variability and average conditions for the WBID.

Figure 7 through 9 provide a time series plot for the measured ammonia concentrations in each lake. Figure 10 through 12 provide a time series plot for the measured nitrate plus nitrite concentration.

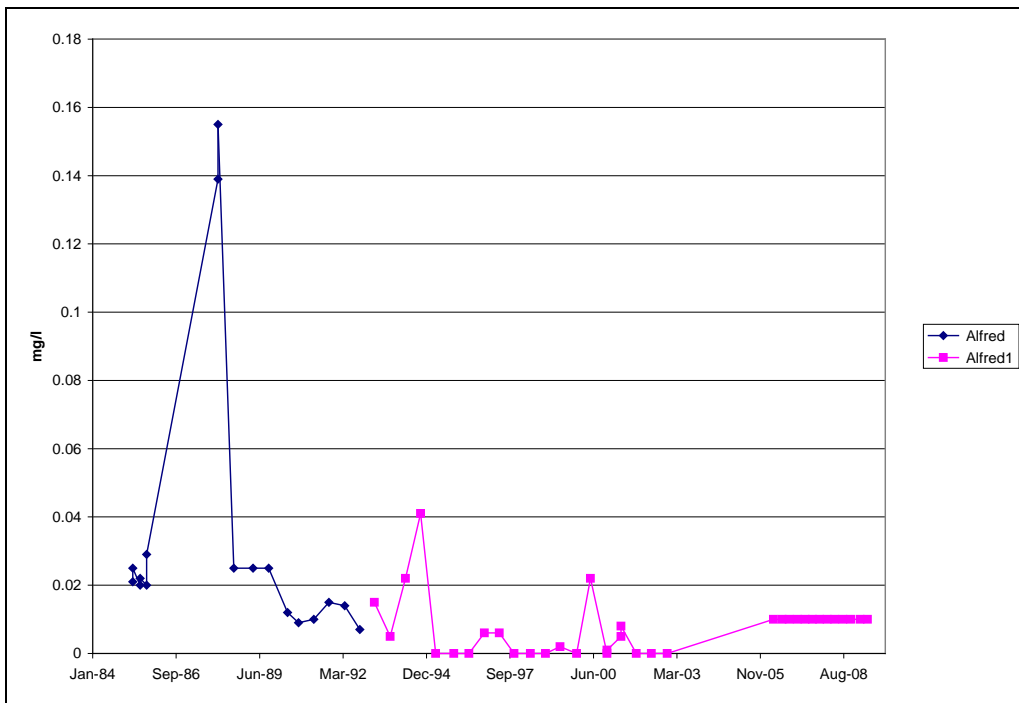


Figure 7 WBID: 1488D Lake Alfred Measured Ammonia

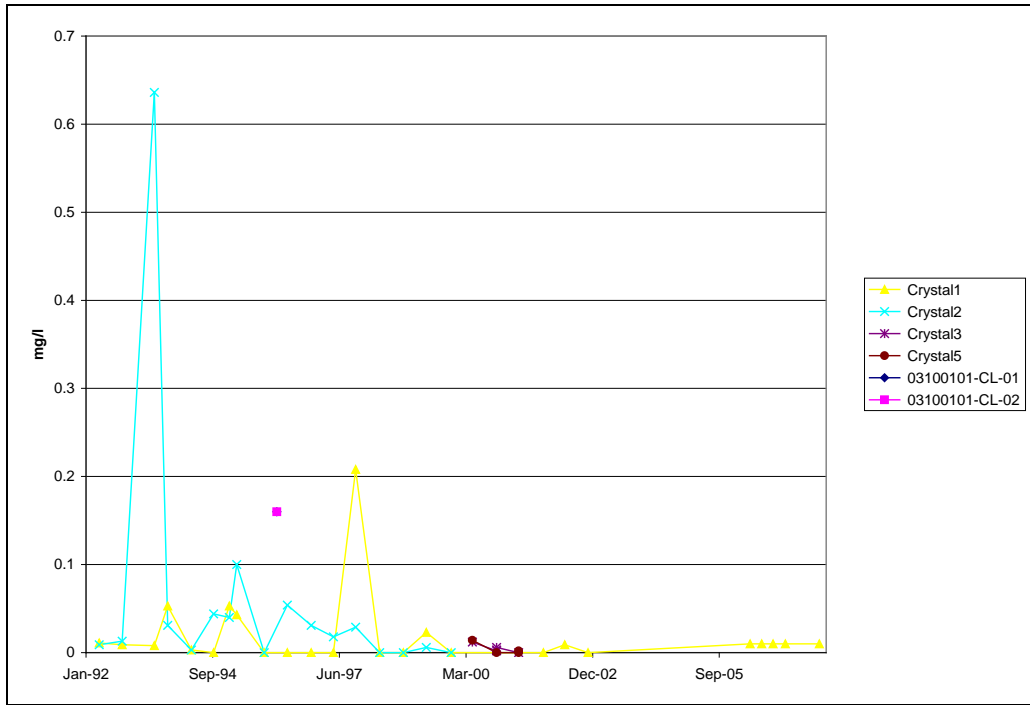


Figure 8 WBID: 1497 Crystal Lake Measured Ammonia

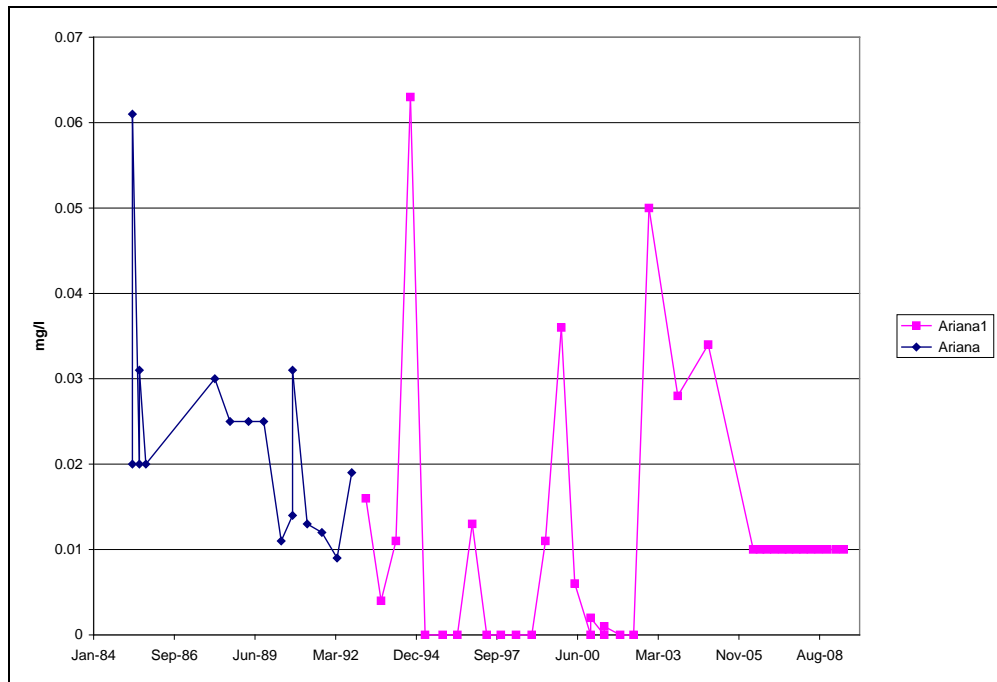


Figure 9 WBID: 1501B Lake Ariana Measured Ammonia

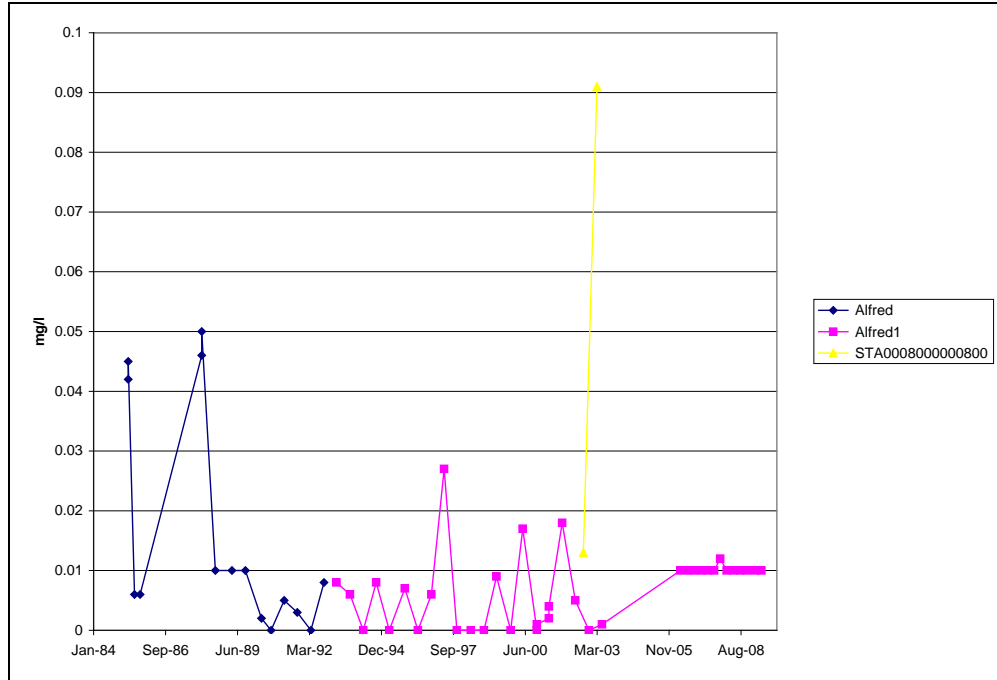


Figure 10 WBID: 1488D Lake Alfred Measured Nitrate plus Nitrite

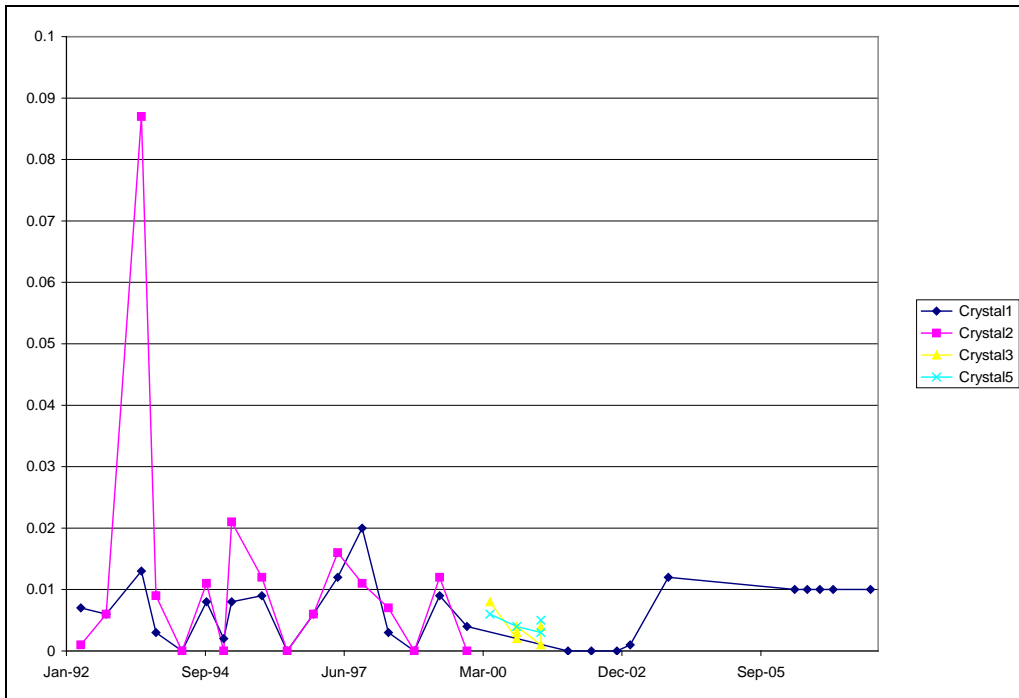


Figure 11 WBID: 1497A Crystal Lake Measured Nitrate plus Nitrite

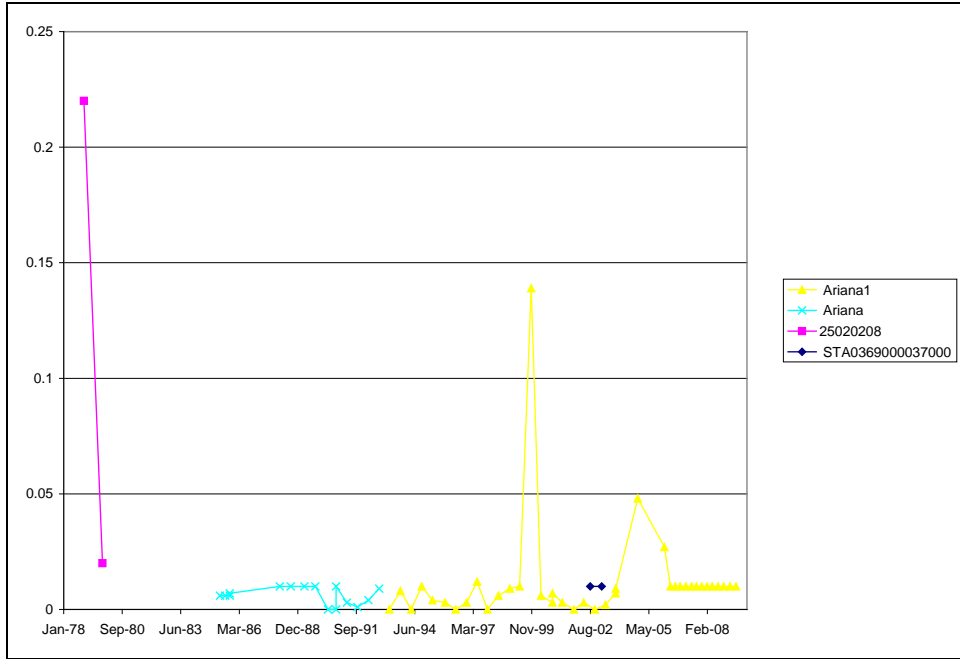


Figure 12 WBID: 1501A Lake Ariana North Measured Nitrate plus Nitrite

Figure 13 through 15 provide a time series plot for the measured total phosphorus concentrations in each lake.

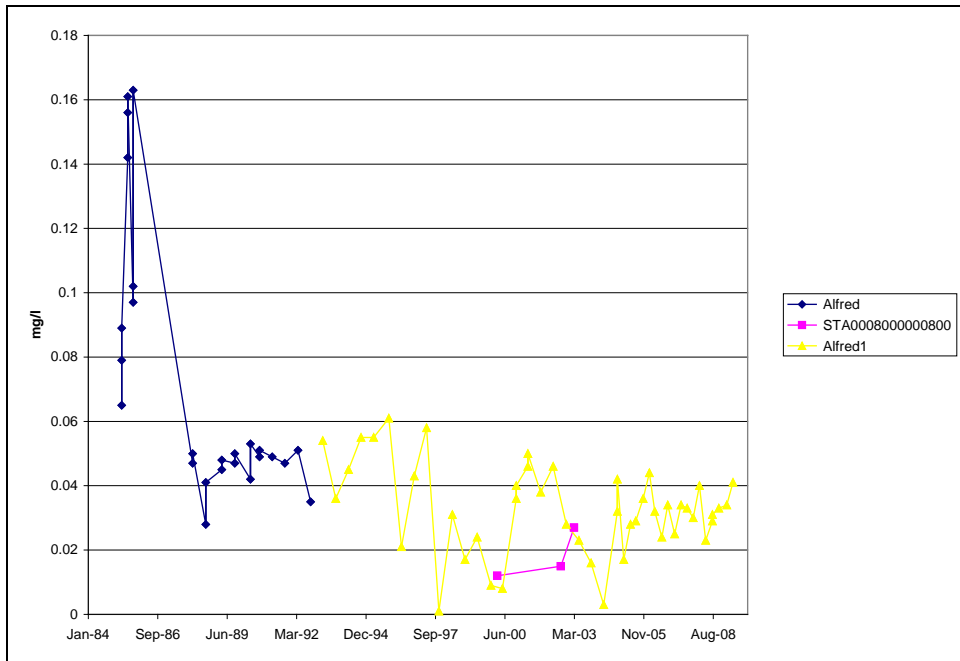


Figure 13 WBID: 1488D Lake Alfred Measured Total Phosphorus

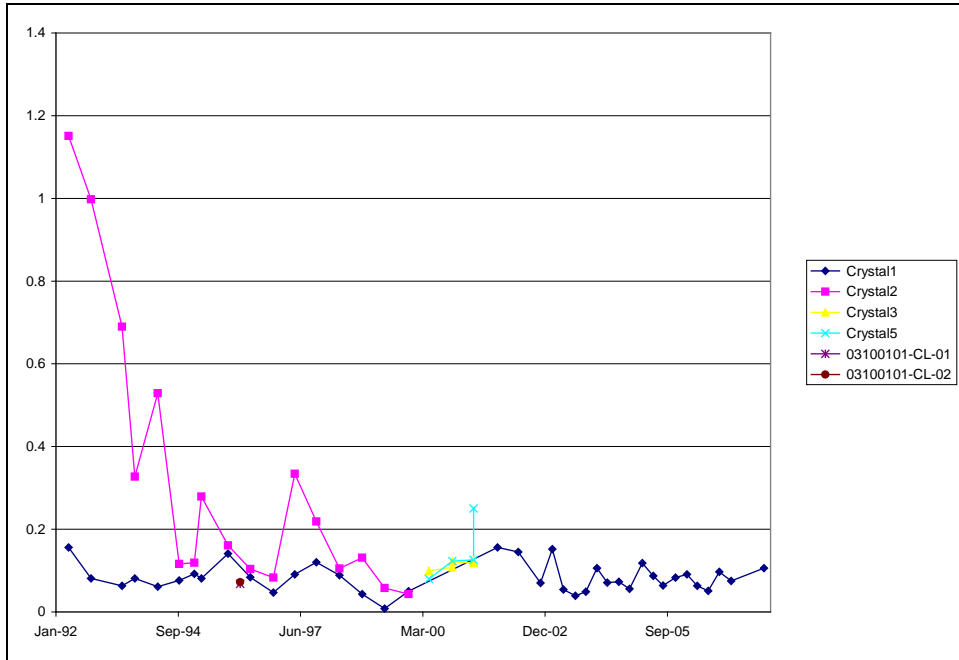


Figure 14 WBID: 1497A Crystal Lake Measured Total Phosphorus

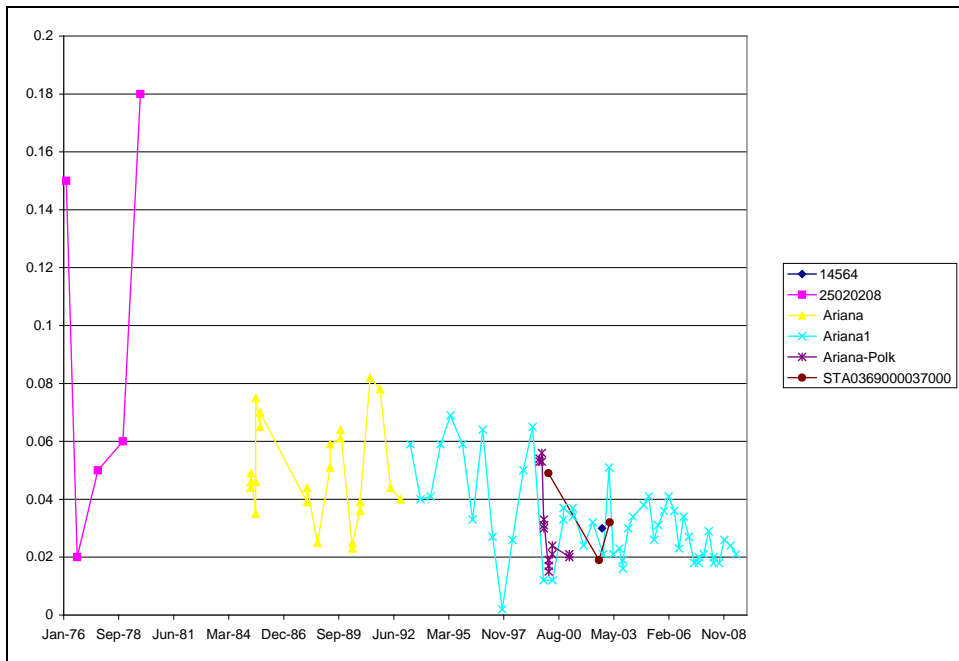


Figure 15 WBID: 1501B Lake Ariana North Measured Total Phosphorus

Figure 16 through 18 provide a time series plot for corrected chlorophyll *a* concentrations in each lake.

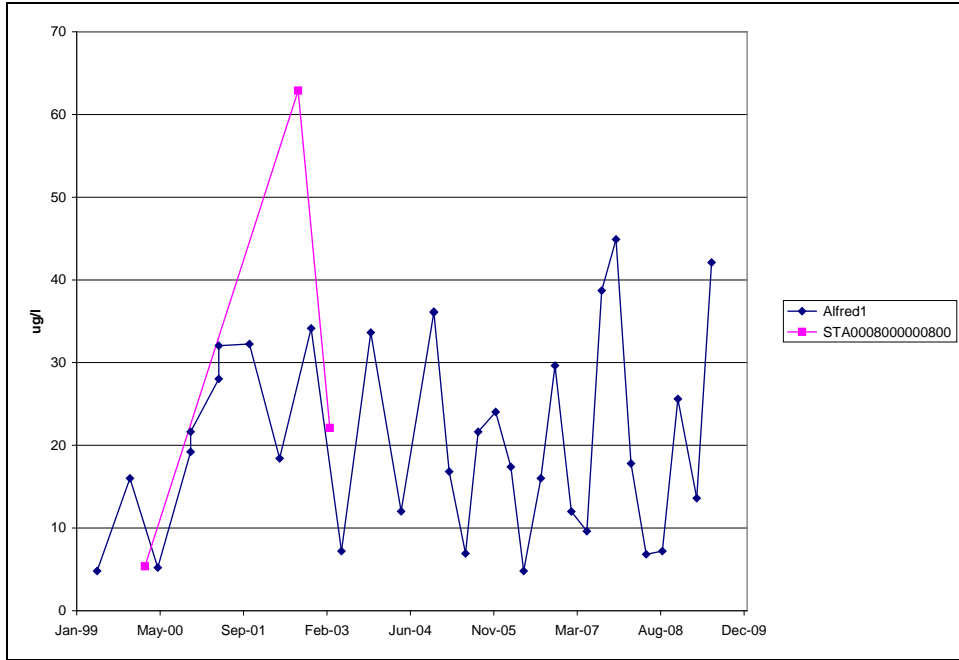


Figure 16 WBID: 1488D Lake Alfred Measured Chlorophyll *a* Concentrations

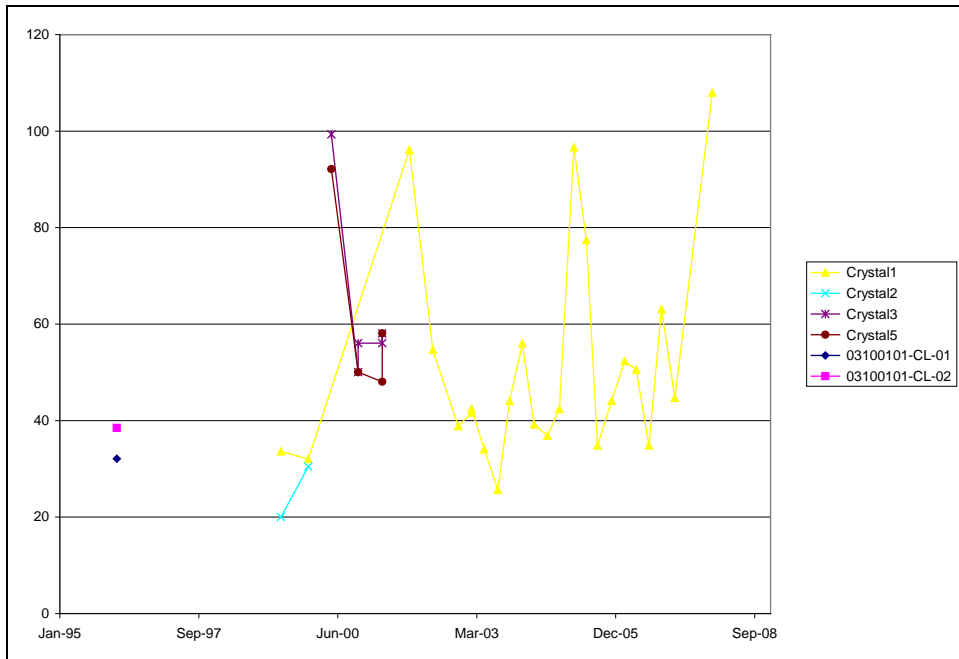


Figure 17 WBID: 1497A Crystal Lake Measured Chlorophyll *a* Concentrations



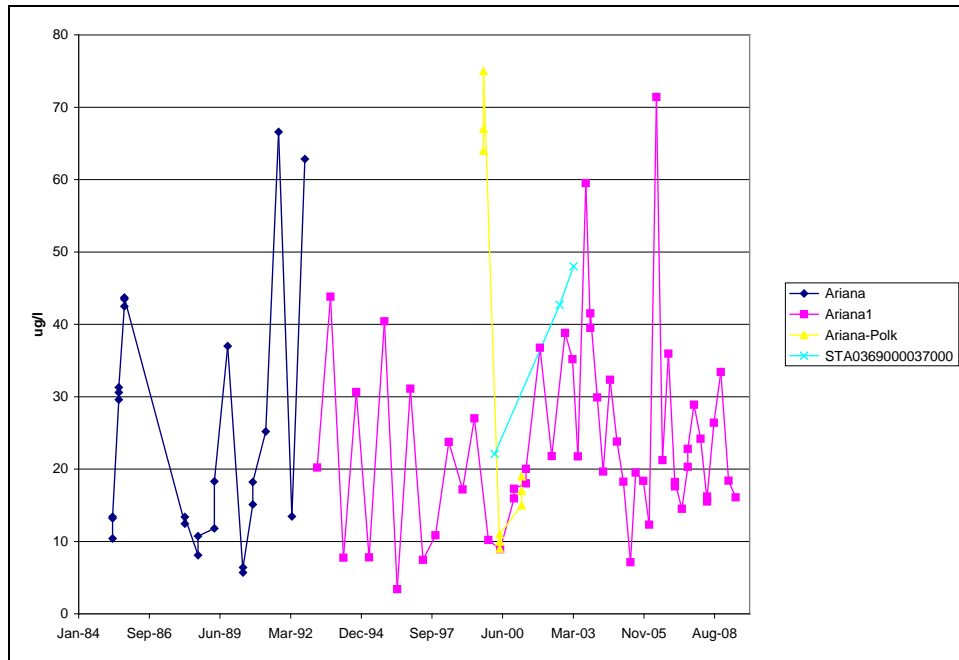


Figure 18 WBID: 1501B Lake Ariana North Measured Chlorophyll *a* Concentrations

### 5.1.2. Trophic State Index

The Trophic State Index (TSI) is an expression of Florida's lakes and estuaries trophic state. The three major trophic states are oligotrophy, mesotrophy, and eutrophy. The TSI procedures provide an effective method of classifying lakes and estuaries based on their chlorophyll *a* concentration, Secchi depth, and nitrogen and phosphorous concentrations. The TSI was developed under contracts with the University of Florida in 1982 in response to the federal Clean Lakes Program. Criteria were developed for the four index components based on a regression analysis of data on 313 Florida lakes. The lake criteria cutoff values for the four components and the overall TSI are 0-60 for good quality, 60 to less than 70 for fair quality and 70 to 100 for poor quality. The index was also applied to Florida estuaries to describe estuarine water quality. The estuarine criteria cutoff values are 10 points less than the lake criteria (i.e., good is 0 to <50, fair is 50 to <60, poor is 60-100).

To calculate the TSI, Total Nitrogen, Total Phosphorus, and Chlorophyll *a* values, either instantaneous or averaged as needed. Individual values are calculated for each constituent, the ratio of total nitrogen to total phosphorus will control which regression will be used in the final overall TSI calculation.

To calculate the chlorophyll *a* component use Equation 1, LN stands for the Natural Log, Chla is the chlorophyll *a* concentration in  $\mu\text{g/l}$ .

$$\text{Chla}_{\text{TSI}} = 16.8 + (14.4 * \text{LN}(\text{Chla}))$$

Equation 1

To calculate the Total Nitrogen to Total Phosphorus use Equation 2, where the units of TN and TP are mg/l.

$$\text{Ratio} = \text{TN}/\text{TP}$$

**Equation 2**

If Ratio is > 30 Then  $\text{Nutrient}_{\text{TSI}} = \text{TP}_{2\text{TSI}}$

$$\text{TP}_{2\text{TSI}} = 10 * (2.36 * \text{LN}(\text{TP} * 1000) - 2.38)$$

**Equation 3**

If Ratio is < 10 Then  $\text{Nutrient}_{\text{TSI}} = \text{TN}_{2\text{TSI}}$

$$\text{TN}_{2\text{TSI}} = 10 * (5.96 + 2.15 * \text{LN}(\text{TN} + 0.0001))$$

**Equation 4**

If Ratio is > 10 and <30 Then  $\text{Nutrient}_{\text{TSI}} = (\text{TP}_{\text{TSI}} + \text{TN}_{\text{TSI}})/2$

$$\text{TN}_{\text{TSI}} = 56 + (19.8 * \text{LN}(\text{TN}))$$

**Equation 5**

$$\text{TP}_{\text{TSI}} = (18.6 * \text{LN}(\text{TP} * 1000)) - 18.4$$

**Equation 6**

Depending upon the Total Nitrogen to Total Phosphorus ratio, the overall TSI value is calculated as presented in Equation 7.

$$\text{TSI} = (\text{CHLA}_{\text{TSI}} + \text{Nutrient}_{\text{TSI}})/2$$

**Equation 7**

Figure 19 through 21 present the calculated TSI values for each of the stations where total nitrogen, total phosphorus and chlorophyll *a* observations were available.

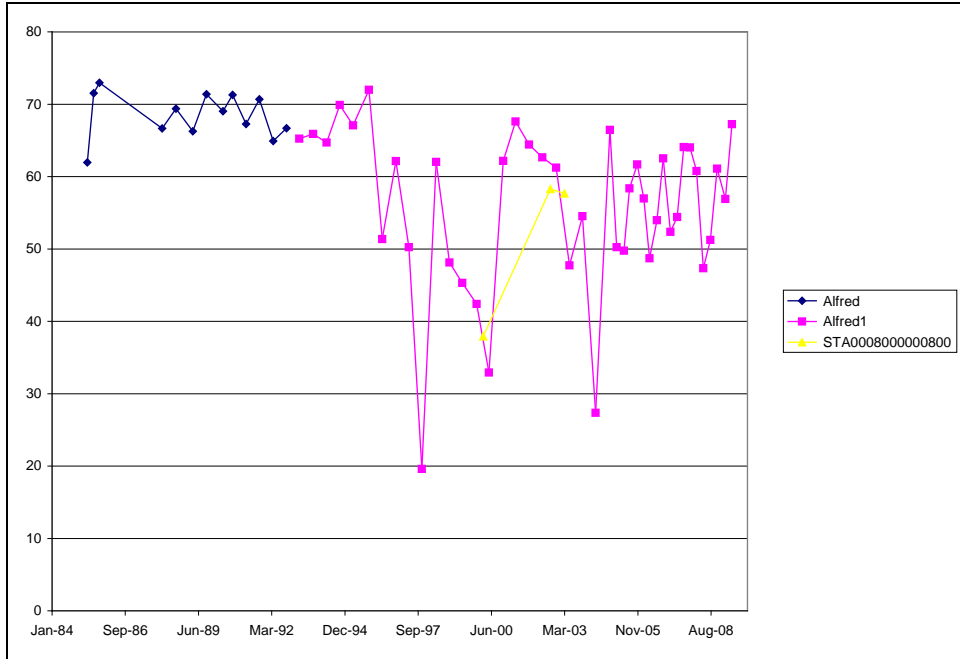


Figure 19 Trophic State Index Calculation for WBID 1488D: Lake Alfred Stations

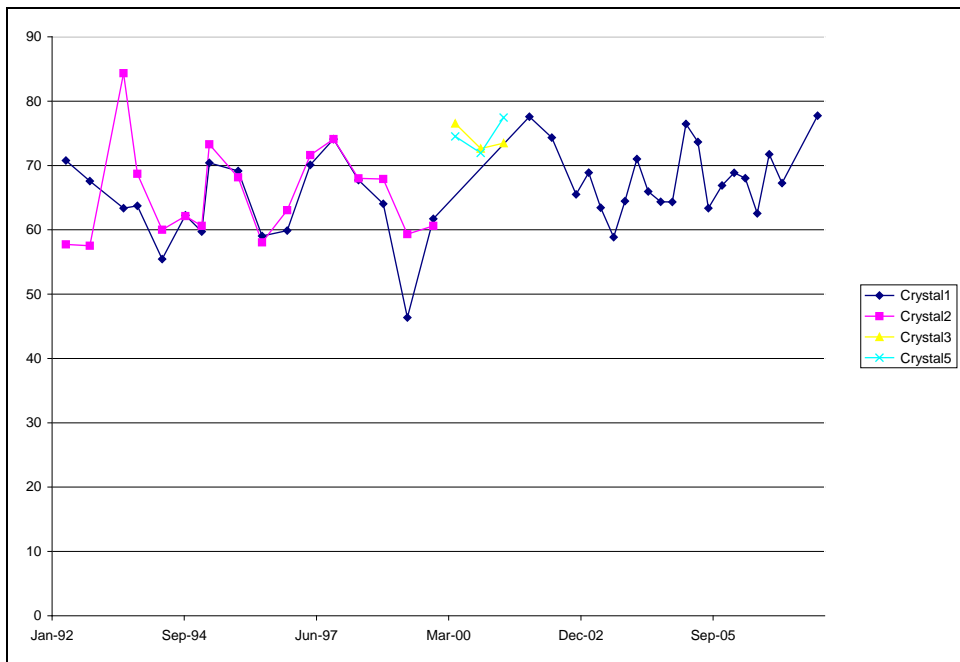


Figure 20 Trophic State Index Calculation for WBID 1497A: Crystal Lake Stations

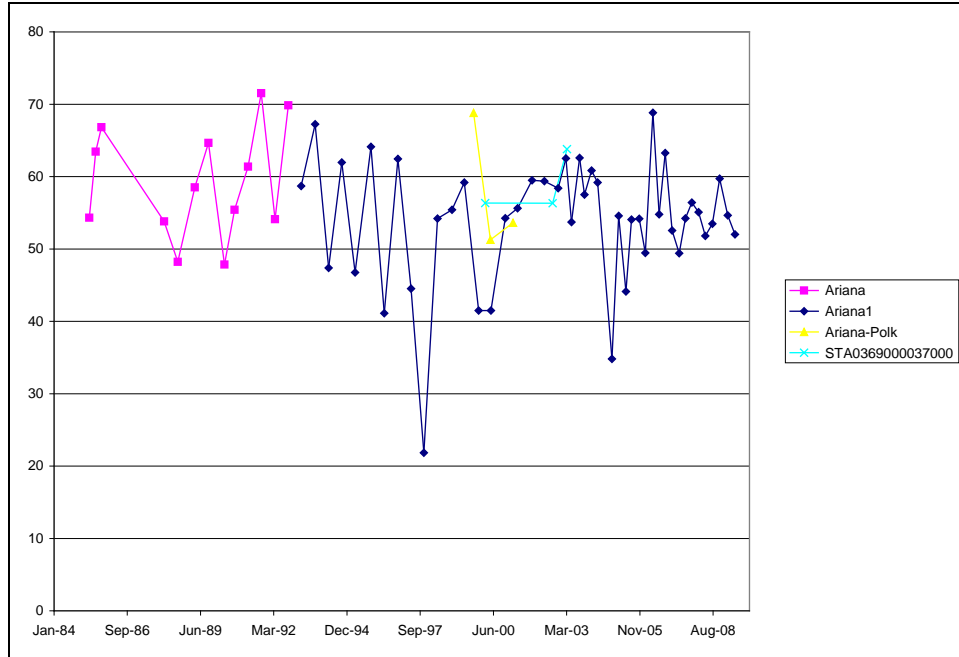


Figure 21 Trophic State Index Calculation for WBID 1501: Lake Ariana North Stations

## 6. Source and Load Assessment

An important part of the TMDL analysis is the identification of source categories, source subcategories, or individual sources of pollutants in the watershed and the amount of loading contributed by each of these sources. Sources are broadly classified as either point or non-point sources. Nutrients can enter surface waters from both point and non-point sources. A point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Point source discharges of industrial wastewater and treated sanitary wastewater must be authorized by National Pollutant Discharge Elimination System (NPDES) permits. NPDES permitted facilities, including certain urban stormwater discharges such as municipal separate stormwater systems (MS4 areas), certain industrial facilities, and construction sites over one acre, are stormwater driven sources considered “point sources” in this document.

Non-point sources of pollution are diffuse sources that cannot be identified as entering a water body through a discrete conveyance at a single location. For nutrients, these sources include runoff of agricultural fields, golf courses, lawns, septic tanks, and residential developments outside of MS4 areas. Non-point sources generally, but not always, involve accumulation of nutrients on land surfaces and wash-off as a result of rainfall events.

## **6.1. Point Sources**

Point source facilities are permitted through the Clean Water Act National Pollutant Discharge Elimination System (NPDES) Program. There are no NPDES waste water dischargers, but there is one NPDES MS4 point source in the Lake Alfred, Crystal Lake, or Lake Ariana watershed.

### **6.1.1. Municipal Separate Stormwater System Permits**

Municipal Separate Stormwater Systems (MS4s) are point sources also regulated by the NPDES program. According to 40 CFR 122.26(b)(8), a municipal separate storm sewer (MS4) is “a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):

- (i) Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law)...including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the Clean Water Act that discharges into waters of the United States.
- (ii) Designed or used for collecting or conveying storm water;
- (iii) Which is not a combined sewer; and
- (iv) Which is not part of a Publicly Owned Treatment Works.”

MS4s may discharge nutrients and other pollutants to water bodies in response to storm events. In 1990, USEPA developed rules establishing Phase I of the National Pollutant Discharge Elimination System (NPDES) stormwater program, designed to prevent harmful pollutants from being washed by stormwater runoff into MS4s (or from being dumped directly into the MS4) and then discharged from the MS4 into local water bodies. Phase I of the program required operators of “medium” and “large” MS4s (those generally serving populations of 100,000 or greater) to implement a stormwater management program as a means to control polluted discharges from MS4s. Approved stormwater management programs for medium and large MS4s are required to address a variety of water quality related issues including roadway runoff management, municipal owned operations, hazardous waste treatment, etc.

Phase II of the rule extends coverage of the NPDES stormwater program to certain “small” MS4s. Small MS4s are defined as any MS4 that is not a medium or large MS4 covered by Phase I of the NPDES stormwater program. Only a select subset of small MS4s, referred to as “regulated small MS4s”, requires an NPDES stormwater permit. Regulated small MS4s are defined as all small MS4s located in “urbanized areas” as

defined by the Bureau of the Census, and those small MS4s located outside of “urbanized areas” that are designated by NPDES permitting authorities.

There is one permitted MS4s in the Lake Alfred, Crystal Lake, and Lake Ariana Watershed (Table 4).

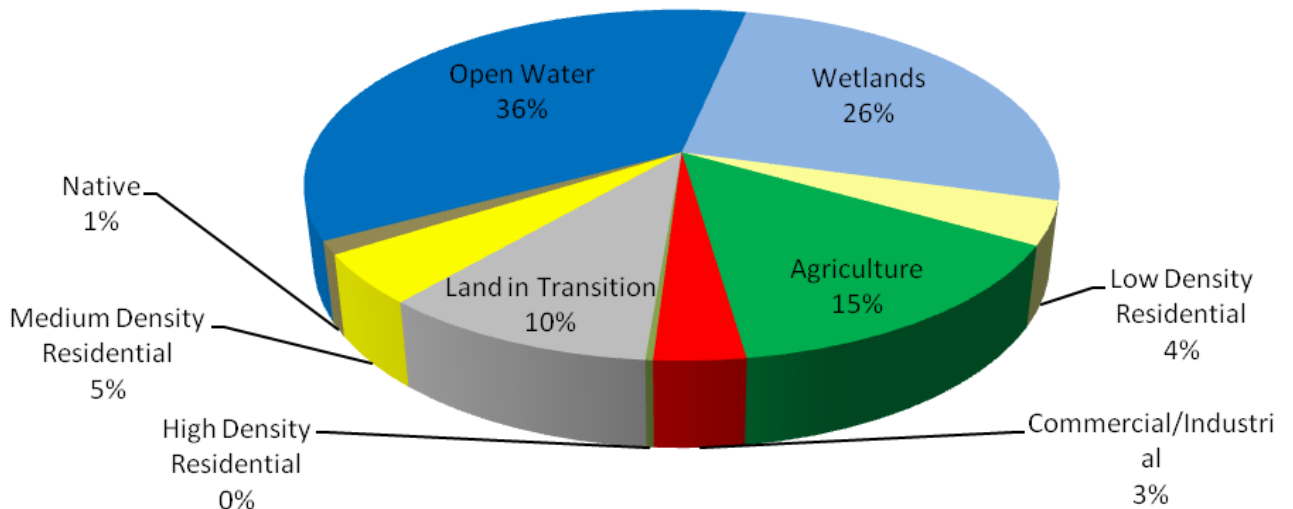
**Table 4 MS4 Permits Potentially Impacted by TMDL**

Permit Name	Permit Number	County
Polk County & Co-Permittees	FLS000015	Polk

**6.2. Non-Point Sources**

Non-point source pollution generally involves a buildup of pollutants on the land surface that wash off during rain events and as such, represent contributions from diffuse sources, rather than from a defined outlet. Potential non-point sources are commonly identified, and their loads estimated, based on land cover data. Most methods calculate non-point source loadings as the product of the water quality concentration and runoff water volume associated with certain land use practices. The mean concentration of pollutants in the runoff from a storm event is known as the Event Mean Concentration, or EMC.

Figure 22 through 27 provide the land use distribution for each watershed. The latest land use coverages were obtained from the Southwest Florida Water Management District (SFWMD). The land uses are described using the Florida Land Use Classification Code (FLUCC) Level 4.



**Figure 22 Lake Alfred Basin Land use**

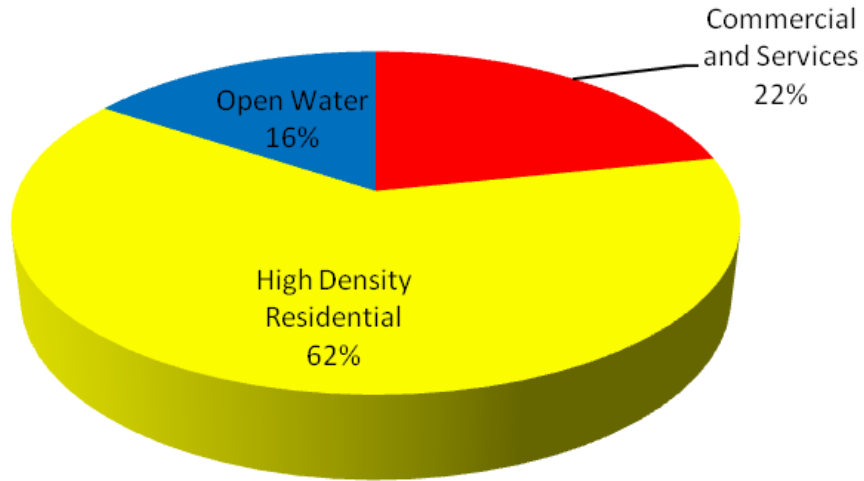


Figure 23 Crystal Lake Basin Land use

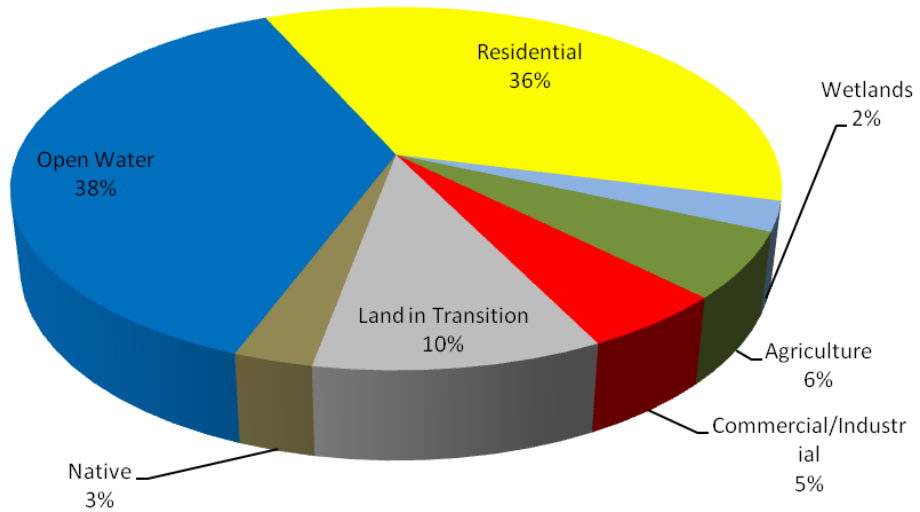


Figure 24 Lake Ariana Basin Land use

Figure 25 shows the land uses in the TMDL watersheds.

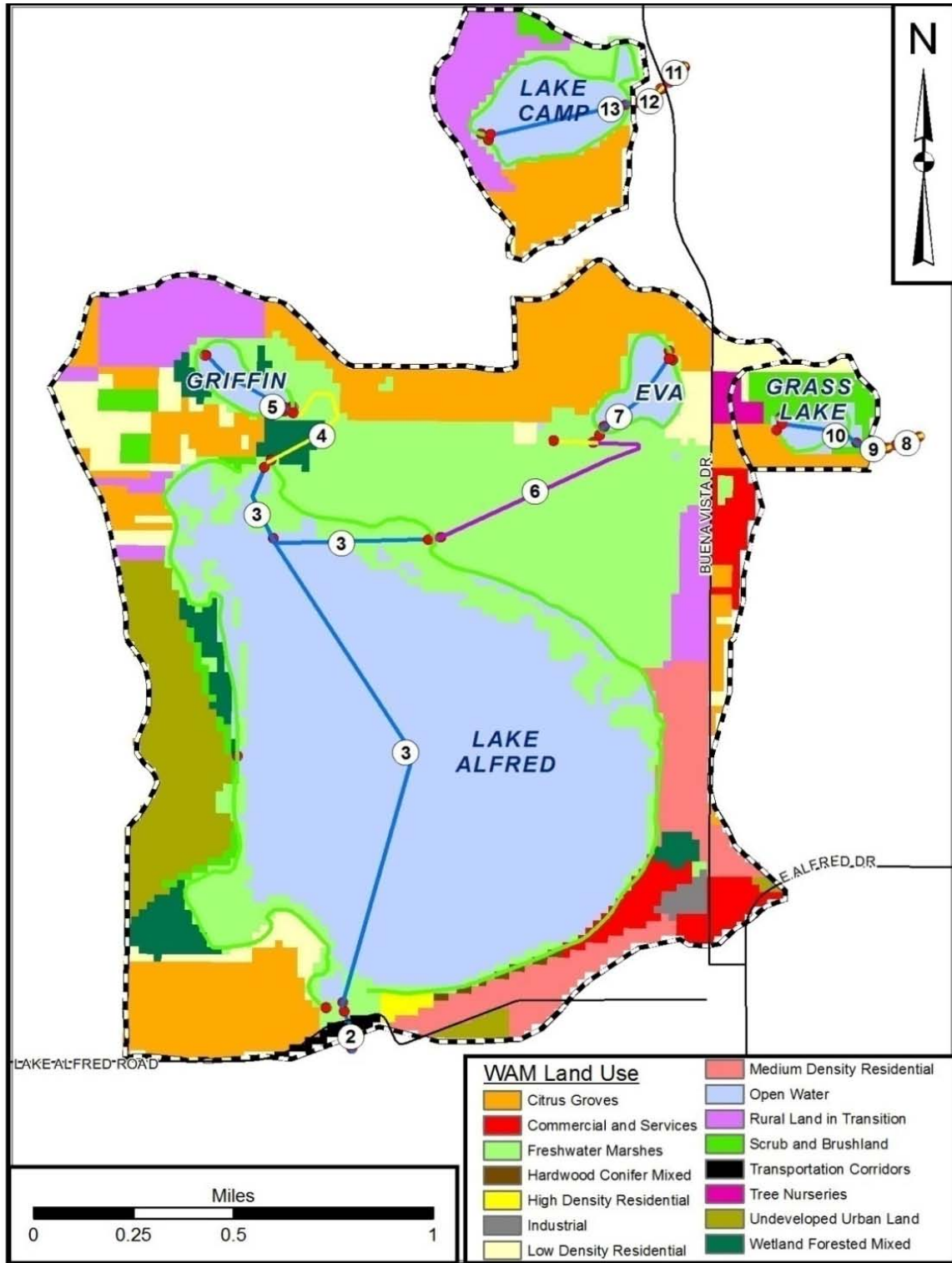


Figure 25 Lake Alfred Land use Distribution



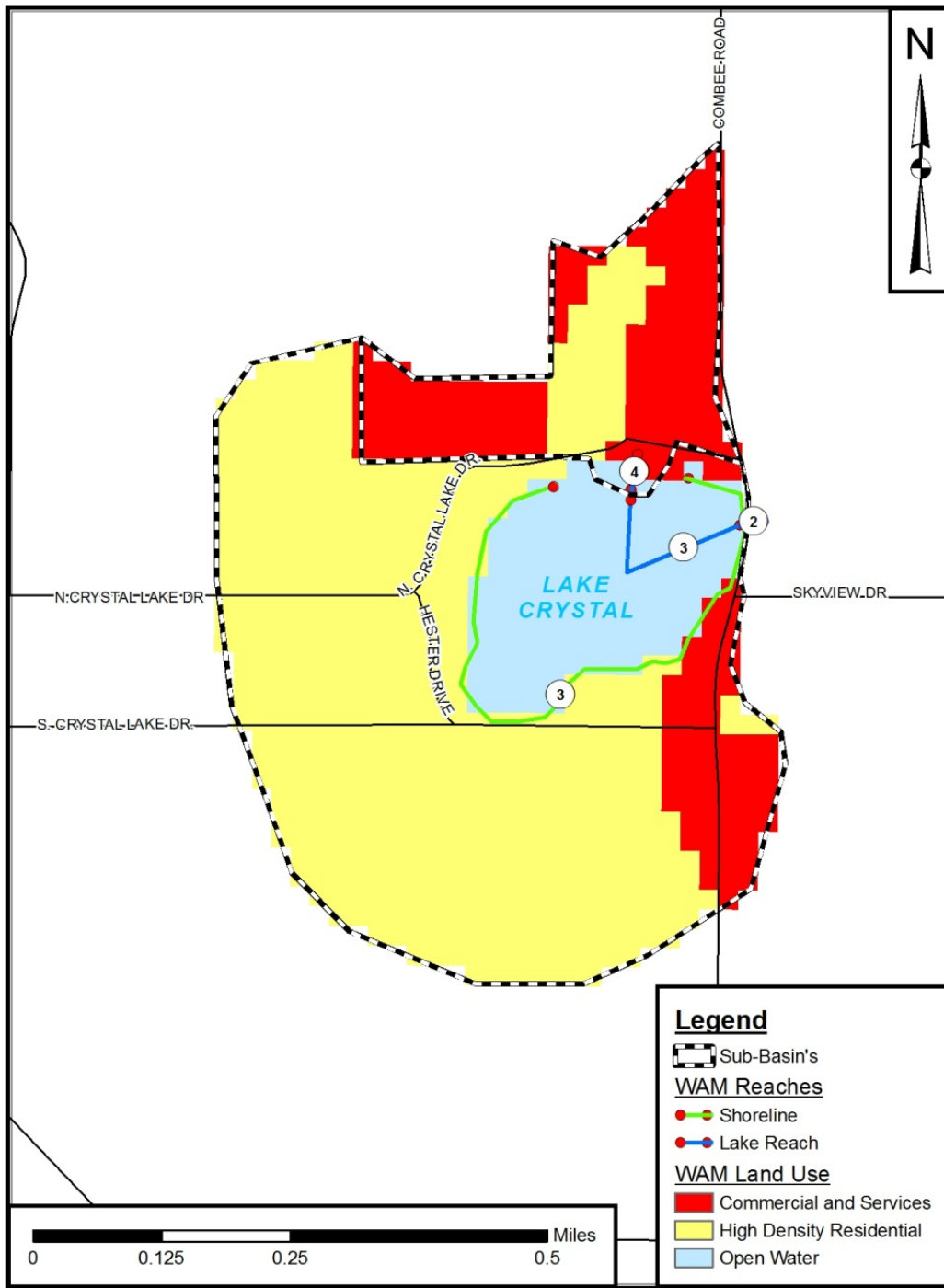


Figure 26 Crystal Lake Land use Distribution



Figure 27 Lake Ariana North Land use Distribution

### **6.2.1. Urban Areas**

Urban areas include land uses such as residential, industrial, extractive and commercial. Land uses in this category typically have somewhat high total nitrogen event mean concentrations and average total phosphorus event mean concentrations. Nutrient loading from MS4 and non-MS4 urban areas is attributable to multiple sources including stormwater runoff, leaks and overflows from sanitary sewer systems, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, leaking septic systems, and domestic animals.

In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of non-point source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as outlined 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, F.A.C.

Florida's stormwater program is unique in having a performance standard for older stormwater systems that were built before the implementation of the Stormwater Rule in 1982. This rule states: "the pollutant loading from older stormwater management systems shall be reduced as needed to restore or maintain the beneficial uses of water" (Section 62-4-.432 (5)(c), F.A.C.).

Nonstructural and structural BMPs are an integral part of the State's stormwater programs. Nonstructural BMPs, often referred to as "source controls", are those that can be used to prevent the generation of non-point source pollutants or to limit their transport off-site. Typical nonstructural BMPs include public education, land use management, preservation of wetlands and floodplains, and minimization of impervious surfaces. Technology-based structural BMPs are used to mitigate the increased stormwater peak discharge rate, volume, and pollutant loadings that accompany urbanization.

### **6.2.2. Agriculture**

Agricultural lands include improved and unimproved pasture, row and field crops, citrus, and specialty farms. The highest total nitrogen and total phosphorus event mean concentrations are associated with agricultural land uses.

### **6.2.3. Rangeland**

Rangeland includes herbaceous, scrub, disturbed scrub and coastal scrub areas. Event mean concentrations for rangeland are about average for total nitrogen and low for total phosphorus.

#### **6.2.4. Upland Forests**

Upland forests include flatwoods, oak, various types of hardwoods, conifers, and tree plantations. Event mean concentrations for upland forests are low for both total nitrogen and total phosphorus.

#### **6.2.5. Water and Wetlands**

These occur throughout the watershed and have very low event mean concentrations down to zero.

#### **6.2.6. Barren Land**

Barren land includes beaches, borrow pits, disturbed lands and fill areas. Barren lands comprise only a small portion of any of the watersheds. Event mean concentrations for barren lands tend to be higher in total nitrogen.

#### **6.2.7. Transportation, Communications and Utilities**

Transportation uses include airports, roads and railroads. Event mean concentrations for these types of uses are in the mid-range for total nitrogen and total phosphorus.

### **7. Analytical Approach**

In the development of TMDL there needs to be a method for relating current loadings to the observed water quality problem. This relationship could be: statistical (regression for a cause and effect relationship), empirical (based on observations not necessarily from the water body in question) or mechanistic (physically and/or stochastically based) that inherently relate cause and effect using physical and biological relationships.

Two mechanistic models will be used in the development of the TMDL for each lake. The first model is a dynamic watershed model that predicts the quantity of water and pollutants that are associated with runoff from rain events. The second model is a dynamic water quality model that is capable of integrating the loadings from the watershed model to predict the water quality in the receiving water body.

The period of simulation that is being considered in the development of this TMDL is January 1, 1996 to December 31, 2008. The models will be used to predict time series for total nitrogen, total phosphorus, BOD, dissolved oxygen, and chlorophyll *a*. The models will be calibrated to current conditions and then will be used to predict improvements in water quality as function of reductions in loadings.

More details on the model application in the development of the TMDLs are presented in Appendix A.

## **7.1. Watershed Assessment Model (WAM)**

The Watershed Assessment Model (WAM) is a Geographical Information System (GIS) model that assesses the water quantity and quality responses to land use management practices within watersheds. WAM was developed to allow users to assess the water quantity and quality of both surface water and groundwater based on the detailed physical properties of the watershed and the underlying hydrogeological system. The model simulates the primary physical processes important for watershed hydrologic and pollutant transport, originating on individual fields or land uses and then dynamically routing the flows and constituents throughout the stream system.

WAM uses a GIS grid based (raster) representation to model the physical characteristics of the land surface. Depending on the combination of input GIS datasets (land use, soil type, presence of a wastewater service area, and rainfall zones), unique cells, or cell groupings, are determined that characterize distinctive conditions. Based on the land use and soil characteristics of the unique cell, an appropriate field-scale model is selected that will simulate the daily surface and groundwater constituents originating from the cell and will be transported to the respective stream reaches. Once the daily outputs from each cell, which includes surface and groundwater flows and constituent concentrations, are simulated they are routed to the nearest stream based on topological gradient flow path distances. While being routed to the nearest stream the constituents are attenuated based on features encountered such as wetlands and depressions. The attenuated flows are delivered to the appropriate stream reach within the watershed's hydrographic system using separate unit hydrographs and delay factors for surface and groundwater.

The water and constituents reaching a stream are routed hydrodynamically through the watershed stream network, to the ultimate basin outfall. WAM has the ability to model complex hydrology and can be set-up to routinely manage hydraulic structures and, looping, and tidally influenced boundary areas. In addition, shorelines can be assigned as reaches for a more precise delivery of constituents to large rivers, lakes and estuaries resulting in realistic modeling. Closed basins and depressions are handled routinely. An appropriate attenuation algorithm for the constituents is applied as water is being routed based on flow rate and land use conditions along the flow path.

The model outputs can be viewed in several formats (tables, graphs, and maps) including the daily time-series of source cell outputs or individual tributary reaches and source cells or subbasin constituent loading maps for surface and ground water for both attenuated and unattenuated loads. The user interface can also produce constituent load ranking tables of land uses and comparative displays of different BMP/Management Scenarios.

## **7.2. Water Quality Analysis Simulation Program (WASP)**

The Water Quality Analysis Simulation Program— (WASP7), is a dynamic compartment-modeling program for aquatic systems, including both the water column and the underlying benthos. The time-varying processes of advection, dispersion, point and diffuse mass loading and boundary exchange are represented in the basic program.

The conventional pollutant model within the WASP framework is capable of predicting time varying concentrations for chlorophyll *a*, dissolved oxygen, nutrients (nitrogen, phosphorus) as function of loadings, flows, and environmental conditions.

WASP was calibrated to the current conditions of Lake Alfred, Crystal Lake, and Lake Ariana watersheds using known meteorology, predicted loadings from the WAM models and constrained by observed data in each lake. Furthermore, WASP was used in determining the load reductions that would be needed to achieve the water quality standards and nutrient targets for Lake Alfred, Crystal Lake, and Lake Ariana.

### 7.3. Scenarios

Several modeling scenarios were developed and evaluated in this TMDL determination. The results of these scenarios are presented in Appendix E of the modeling report.

#### 7.3.1. Current Condition

The first scenario is to model the current conditions of the watersheds. This included the development of a watershed and water quality model. The watershed model is parameterized using the current land uses and measured meteorological conditions to predict the current loadings of nitrogen and phosphorus. These predicted loadings and flow time series are passed on to the water quality model where the predicted algal, nitrogen, phosphorus, BOD and dissolved oxygen concentrations are predicted over time. The models (watershed and water quality) are calibrated to a thirteen year period of time to take into account varying environmental, meteorological or hydrological conditions on water quality. Table 5 presents the simulated annual average loadings for total nitrogen and total phosphorus.

**Table 5 Current Conditions TMDL Lake Watershed Nutrient Loads**

Lake	Total N (kg/d)	Total P (kg/d)
Alfred	5.356	0.077
Ariana	4.378	0.051
Crystal	0.633	0.122

The current condition simulation will be used to determine the base loadings for each watershed. These base loadings, compared with the TMDL scenario will be used to determine the percent reduction in nutrient loads that will be needed to achieve water quality standards.

#### 7.3.2. Natural Condition

The natural condition scenario is developed to estimate what water quality conditions would exist if there were little to no impact from anthropogenic sources. There are no

point source dischargers in any of the watersheds. Any land use that is associated with man induced (urban, agriculture, transportation, barren lands and rangeland) activities gets converted to its native undisturbed land use for the purpose of this analysis and the associated event mean concentration for nitrogen and phosphorus are used. These natural condition loadings from the watershed model are passed onto the water quality model where natural water quality conditions are predicted. The natural condition watershed loadings are presented in Table 2.

**Table 2 Natural Condition Annual Average Nutrient Loads**

Lake	Total N (kg/d)	Total P (kg/d)
Alfred	0.79040	0.06690
Ariana	0.70749	0.04791
Crystal	0.45345	0.02382

The purpose of the natural conditions scenario is to determine whether water quality standards can be achieved without abating the naturally occurring loads from the watershed.

### 7.3.3. TMDL

The TMDL scenario determines how much the current loadings would need to be reduced to achieve the applicable water quality standards and nutrient (nitrogen and phosphorus) interpretation of the narrative to protect against imbalance of flora and fauna. Because these are lakes, the trophic state index will be one of the indicators of a balanced system. The predicted loading from the current conditions watershed model are incrementally reduced in the receiving water body model until the average calculated trophic state index is 35. TMDL annual average loads are presented in Table 7.

Benthic nutrient fluxes occur once nutrients from a watershed enter a water body and settle to the bottom. After the settling process occurs these pollutants become available for macrophyte utilization, and can lead to eutrophication. Over time the contribution coming from benthic fluxes gets very large, and will slowly decrease as loading decreases. For this TMDL, benthic nutrient fluxes were also targeted as needing reductions. Benthic flux reductions needed to meet the TMDL are provided in Table 8. A summary table for all reductions is provided in Table 9.

**Table 7 TMDL Annual Average Nutrient Loads**

Lake	Loading Type	Total N	Total P
		(kg/year)	(kg/year)
Alfred	Upland	288	24
	Benthic	1706	90
	<b>Total</b>	<b>1994</b>	<b>115</b>
Ariana	Upland	258	17
	Benthic	4548	328
	<b>Total</b>	<b>4806</b>	<b>346</b>
Crystal	Upland	166	9
	Benthic	56	4
	<b>Total</b>	<b>221</b>	<b>12</b>

**Table 8 TMDL Benthic Flux Nutrient Reductions**

Lake	Benthic Flux Reduction to meet TMDL
Alfred	60%
Ariana	50%
Crystal	75%

**Table 9 Nutrient Loading Summary**

Lake	Loading Type	Average Daily Nutrient Load					
		Current Conditions		To Meet TMDL*		Reductions Required	
		Total N (kg/day)	Total P (kg/day)	Total N (kg/day)	Total P (kg/day)	Total N (kg/day)	Total P (kg/day)
Alfred	Upland	5.4	0.077	0.8	0.067	4.6	0.010
	Benthic	11.7	0.618	4.7	0.247	7.0	0.371
	<b>Total</b>	<b>17.0</b>	<b>0.696</b>	<b>5.5</b>	<b>0.314</b>	<b>11.6</b>	<b>0.381</b>
Ariana	Upland	4.4	0.051	0.7	0.048	3.7	0.003
	Benthic	24.9	1.800	12.5	0.900	12.5	0.900
	<b>Total</b>	<b>29.3</b>	<b>1.851</b>	<b>13.2</b>	<b>0.948</b>	<b>16.1</b>	<b>0.903</b>
Crystal	Upland	0.6	0.122	0.5	0.024	0.2	0.099
	Benthic	0.6	0.041	0.2	0.010	0.5	0.031
	<b>Total</b>	<b>1.2</b>	<b>0.163</b>	<b>0.6</b>	<b>0.034</b>	<b>0.6</b>	<b>0.129</b>



## 8. TMDL Determination

A total maximum daily load (TMDL) for a given pollutant and water body is comprised of the sum of individual wasteload allocations (WLAs) for point sources, and load allocations (LAs) for both non-point sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving water body. Conceptually, this definition is represented by the equation:

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

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body and still achieve water quality standards and the water bodies designated use. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be set and thereby provide the basis to establish water quality-based controls. These TMDLs are expressed as annual mass loads, since the approach used to determine the TMDL targets relied on annual loadings. The TMDLs targets were determined to be the conditions needed to restore and maintain a balanced aquatic system. Furthermore, it is important to consider nutrient loading over time, since nutrients can accumulate in water bodies.

The TMDLs were determined for the loadings coming from the upstream watersheds and watersheds that directly drain to each lake. The allocations are given in Table 10. The MS4 service area is expected to reduce its loadings at the same percentage as the load allocations.

**Table 10 TMDL Load Allocations for TMDL WBIDs**

Lake	Existing Conditions				TMDL Condition				Percent Reduction	
	WLA		LA + MS4		WLA		LA + MS4		MS4 & LA	
	Total N (kg/yr)	Total P (kg/yr)	Total N (kg/yr)	Total P (kg/yr)	Total N (kg/yr)	Total P (kg/yr)	Total N (kg/yr)	Total P (kg/yr)	Total N	Total P
Alfred	N/A	N/A	6219	254	N/A	N/A	1994	115	67.9	54.8
Ariana	N/A	N/A	10694	676	N/A	N/A	4806	346	55.1	48.8
Crystal	N/A	N/A	455	60	N/A	N/A	221	12	51.3	79.2

### 8.1. Critical Conditions and Seasonal Variation

USEPA regulations at 40 CFR 130.7(c)(1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The critical condition is the combination of environmental factors creating the "worst case" scenario of water quality conditions in the waterbody. By achieving the water quality standards at critical conditions, it is expected that water quality standards should be achieved during all other times. Seasonal variation must also be considered to ensure that water quality standards will be met during all seasons of the year, and that the TMDLs account for any seasonal change in flow or pollutant discharges, and any applicable water quality criteria or designated uses (such as swimming) that are expressed on a seasonal basis.

The critical condition for non-point source loadings is typically an extended dry period followed by a rainfall runoff event. During the dry weather period, nutrients build up on the land surface, and are washed off by rainfall. The critical condition for continuous point source loading typically occurs during periods of low stream flow when dilution is minimized. Although loading of non-point source pollutants contributing to a nutrient impairment may occur during a runoff event, the expression of that nutrient impairment is more likely to occur during warmer months, and at times, when the waterbody is poorly flushed. Because of the thirteen year simulation period used in the model development, it encompasses both critical and seasonal variations to determine the annual average allowable load.

## **8.2. Margin of Safety**

The Margin of Safety accounts for uncertainty in the relationship between a pollutant load and the resultant condition of the waterbody. There are two methods for incorporating a MOS into TMDLs (USEPA, 1991):

- Implicitly incorporate the MOS using conservative model assumptions to develop allocations
- Explicitly specify a portion of the total TMDL as the MOS and use the remainder for allocations

This TMDL uses an explicit margin of safety as a targeted TSI value of 35 was used in the reduction scenario. In Florida, a TSI value of 40 or less is indicative of a balanced lake system.

## **8.3. Waste Load Allocations**

Only MS4s and NPDES facilities discharging directly into lake segments (or upstream tributaries of those segments) are assigned a WLA. The WLAs, if applicable, are expressed separately for continuous discharge facilities (e.g., WWTPs) and MS4 areas, as the former discharges during all weather conditions, whereas the later discharges in response to storm events.

### **8.3.1. NPDES Dischargers**

There are no NPDES waste water dischargers in the watershed, therefore there are no allocations specified.

### **8.3.2. Municipal Separate Storm System Permits (MS4)**

The WLA for MS4s are expressed in terms of percent reductions equivalent to the reductions required for non-point sources. Given the available data, it is not possible to estimate loadings coming exclusively from the MS4 areas. Although the aggregate wasteload allocations for stormwater discharges are expressed in numeric form, i.e. percent reduction, based on the information available today, it is infeasible to calculate

numeric WLAs for individual stormwater outfalls because discharges from these sources can be highly intermittent, are usually characterized by very high flows occurring over relatively short time intervals, and carry a variety of pollutants whose nature and extent varies according to geography and local land use. For example, municipal sources such as those covered by these TMDLs often include numerous individual outfalls spread over large areas. Water quality impacts, in turn, also depend on a wide range of factors, including the magnitude and duration of rainfall events, the time period between events, soil conditions, fraction of land that is impervious to rainfall, other land use activities, and the ratio of stormwater discharge to receiving water flow.

These TMDLs assume for the reasons stated above that it is infeasible to calculate numeric water quality-based effluent limitations for stormwater discharges. Therefore, in the absence of information presented to the permitting authority showing otherwise, these TMDLs assume that water quality-based effluent limitations for stormwater sources of nutrients derived from this TMDL can be expressed in narrative form (e.g., as best management practices), provided that: (1) the permitting authority explains in the permit fact sheet the reasons it expects the chosen BMPs to achieve the aggregate wasteload allocation for these stormwater discharges; and (2) the state will perform ambient water quality monitoring for nutrients for the purpose of determining whether the BMPs in fact are achieving such aggregate wasteload allocation.

The percent reduction calculated for non-point sources is assigned to the MS4 as loads from both sources typically occur in response to storm events. Permitted MS4s will be responsible for reducing only the loads associated with stormwater outfalls which it owns, manages, or otherwise has responsible control. MS4s are not responsible for reducing other non-point source loads within its jurisdiction. All future MS4s permitted in the area are automatically prescribed a WLA equivalent to the percent reduction assigned to the LA. Best management practices for the MS4 service should be developed to meet the percent reduction for both nitrogen and phosphorus as prescribed in Table 10.

#### **8.4. Load Allocations**

The load allocation for non-point sources was assigned a percent reduction from the current loadings coming into all three lakes.

## 9. References

Florida Administrative Code. Chapter 62-302, Surface Water Quality Standards.

Florida Administrative Code. Chapter 62-303, Identification of Impaired Surface Waters.