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FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Division of Water Resource Management, Bureau of Watershed Management

NORTHEAST DISTRICT • SUWANNEE RIVER BASIN • SANTA FE RIVER PLANNING
UNIT

TMDL Report

**Nutrient and DO TMDLs
For Alligator Lake
(WBID 3516A)**

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August 2008

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Web sites

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION, BUREAU OF WATERSHED MANAGEMENT

TMDL Program

<http://www.dep.state.fl.us/water/tmdl/index.htm>

Identification of Impaired Surface Waters Rule

<http://www.dep.state.fl.us/water/tmdl/docs/AmendedIWR.pdf>

STORET Program

<http://www.dep.state.fl.us/water/storet/index.htm>

2000 305(b) Report

<http://www.dep.state.fl.us/water/305b/index.htm>

Criteria for Surface Water Quality Classifications

<http://www/dep.state.fl.us/legal/legaldocuments/rules/ruleslistnum.htm>

Basin Status Report for the Suwannee Basin

<http://www.dep.state.fl.us/water/basin411/suwannee/status.htm>

Assessment Report for the Suwannee Basin

<http://www.dep.state.fl.us/water/basin411/suwannee/assessment.htm>

Allocation Technical Advisory Committee (ATAC) Report

<http://www.dep.state.fl.us/water/tmdl/docs/Allocation.pdf>

U.S. ENVIRONMENTAL PROTECTION AGENCY, NATIONAL STORET PROGRAM

<http://www.epa.gov/storet/>

Chapter 1: INTRODUCTION

1.1 Purpose of Report

This report presents the TMDLs for nutrients and dissolved oxygen for Alligator Lake, located in Columbia County, within the Suwannee River Basin, and the Santa Fe Planning Unit. Alligator Lake was verified as impaired by excessive nutrients and low dissolved oxygen using the methodology in the Identification of Impaired Surface Waters Rule (IWR, Rule 62-303, Florida Administrative Code), and was included on the Verified List of impaired waters for the Suwannee River Basin that was adopted by Secretarial Order on June 3, 2008. These TMDLs establish the allowable loadings to the lake that would restore the waterbody so that it meets its applicable water quality narrative criteria for nutrients and dissolved oxygen.

1.2 Identification of Waterbody

Two reports prepared by Robert Mattson and published by the Suwannee River Water Management District (SRWMD) form the basis for this description of Alligator Lake. The reports are titled, *Biological Communities of Alligator Lake* (SRWMD, 1993) and *Biological Characteristics of Alligator Lake* (SRWMD, 2000). Alligator Lake (~center at Latitude 30° 09' 59.37", Longitude 82° 37' 55.45") is located in central Columbia County, in the southern portion of Lake City, Florida. Alligator Lake is the largest lake in Columbia County, with a drainage area of about 15.4 square miles (SRWMD, 1988). The lake consists of two unequal basins oriented in a north (larger basin) to south arrangement (**Figure 1.1**). While the average surface area of the Lake has been reported as 338 acres (Florida Board of Conservation, 1969), this does not account for major areas of the "natural" lake that were historically diked, drained, and farmed. The agricultural activities within these diked areas resulted in the loss of about 500 acres of productive wetland and shallow lake bottom habitat. As part of the restoration of the lake, these areas are being restored. The only major drainage feature is Price Creek, which drains much of the eastern portion of the lake watershed. Until recently, the majority of the flow from Price Creek had been diverted away from the lake into an adjacent watershed (Clay Hole Creek). Currently, four 48-inch culverts have been installed in the dike/berm along the north side of Price Creek, redirecting more of the flow from the creek back into Alligator Lake. Additionally, two small, unnamed streams drain into the lake from the northern portion of the north basin of the lake.

For assessment purposes, the Department has divided the Suwannee River Basin into water assessment polygons with a unique **waterbody identification** (WBID) number for each water segment or stream reach. Alligator Lake has been given the WBID number of 3516A. The Alligator Lake WBID and its sampling/monitoring stations are within the Santa Fe River Planning Unit as illustrated in **Figure 1.1**.

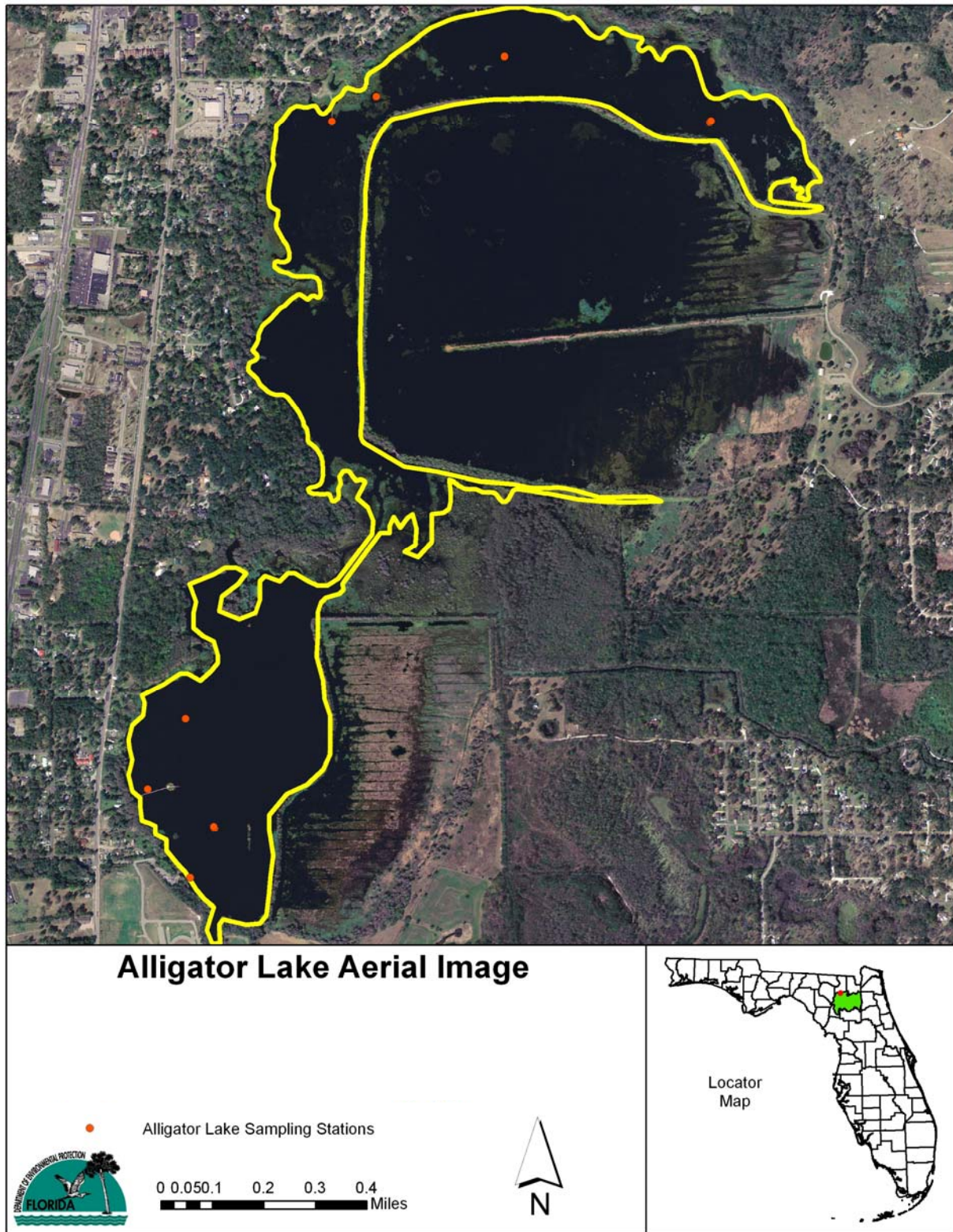


Figure 1.1 Location of Alligator Lake WBID and Water Quality Sampling Stations Listed in the Florida STORET (STORage and RETrieval) within the Santa Fe River Planning Unit .

1.3 Alligator Lake Water Quality Trends

Long-term water quality data between 1965 and 2007 obtained from Florida STORET and calculated TSI values for Alligator Lake are presented in **Figures 1.2 through 1.8**. The Alligator Lake watershed is depicted on **Figure 1.9**. Water quality stations and individual water quality measurements (raw data) for total nitrogen (TN) from 1967-2007, total phosphorus (TP) from 1968-2007, chlorophyll *a* (Chla) from 1980-2007, color from 1965-2007, and dissolved oxygen (DO) from 1967-2007 used in this report are available upon request. A total of seven water quality sampling stations are listed in Florida STORET. Regular recurring measurements for Chla, TN, TP, and DO were not made until 1989.

In general, the historical water quality trends of TN, TP, and Chla concentrations as shown in **Figures 1.2, 1.3, and 1.4** indicate that in-lake concentrations slightly decreased over the period of record through 2005 (no Chla data until 1980), with an increase in concentration in all three constituents in 2006 and 2007. Phaeophyton is a degradation product of chlorophyll that also absorbs light at the same wavelength, impeding the measurement of chlorophyll. Accurate lab analysis accounts for phaeophyton by subtracting it from the chlorophyll concentration. The result is referred to as the corrected Chla. **Figure 1.4** shows both uncorrected Chla (containing phaeophyton) and corrected Chla (ChlaC). **Figure 1.5** depicts the TN to TP ratios. The mean TN/TP ratio over the period 1973-1999 (no paired TN and TP data until 1973) is 9.4 and for the verified period 2000 – 2007 it is 10.4. These data indicate that the lake regularly alternates between nitrogen limitation and co-limitation. **Figure 1.6** depicts the relationship between Chla and the TN/TP ratio. It appears from this graph that the higher Chla concentrations are associated with periods when the TN/TP ratio is close to 10. The IWR methodology for calculating TSI requires at least one set of data for TN, TP, and Chla in each calendar quarter of a year. The methodology and basis for calculating TSI is provided in Chapter 2 and 3. Sufficient data exist to calculate TSIs for 1989 (86.3), 1990 (87.6), 1997 (67.1), 2000 (61.9), 2001 (63.9), 2002 (64.2), 2004 (67.0), 2005 (64.5), and 2006 (80.3). These TSI data (**Figure 1.7**) reflect the same trend as the TN, TP, and Chla data, that is a general decline from 1989 – 2005 with an increase in 2006 (insufficient data to calculate annual TSI for 2007). The data for DO is depicted on **Figure 1.8**. These data indicate that while there are frequent periods when the DO is less than the criterion of 5.0 mg/L, the majority of the data are above the criterion value. **Figure 1.9** shows the boundary of the watershed over an aerial photo of the area. The red lines internal to the watershed boundaries on **Figure 1.9** represent the outlines of the land uses on **Figure 4.2**.

Table 1.1 shows summary statistics of historical water quality variables observed over the period from 1965 to 1999. Although the regular Chla data gathering did not begin until 1989, most of the other water quality variables were regularly collected beginning in the mid 1970's. During this period, the concentrations of Chla averaged 54.1 ± 18.0 ug/L ($n=136$), TN averaged about 2.0 ± 0.19 mg/L ($n = 438$), while concentrations of TP averaged 0.3 ± 0.03 mg/L ($n = 444$). In comparison, recent (2000-2007) observations for water quality variables during the verified period are summarized in **Table 1.2**, concentrations of TN over the period of 2000-2007 have increased to an average of 3.0 ± 1.82 mg/L ($n = 124$). TP concentrations have remained about the same, exhibiting an average of 0.3 ± 0.13 mg/L ($n = 129$). Chla concentrations have increased with an average of 69.4 ± 60.2 ug/L, associated with increased TN concentrations in the lake. Concentrations in parenthesis in **Table 1.2** represent values for the censored data set used to develop the multi-variable regression equation discussed in Chapter 5. The verified period data was censored by removing the data collected on March 29, 2007. Using best professional judgment, these data were not considered representative of conditions in the lake. This data reduction was used to reduce the statistical noise in the long-term data. The censored data set was used to create the graphs, to calculate the annual TSI values in the

report, and develop the regression equation for the TMDL. **Figure 1.8** shows that while DO values less than the 5 mg/L criterion have occurred throughout the period of record, the majority of the results are greater than the criterion. Over time, it appears that the average DO has been decreasing. This report will evaluate the relationship between the current nutrient loading from the watershed and the observed concentrations in the lake and propose the load reductions required for Alligator Lake to meet water quality standards.

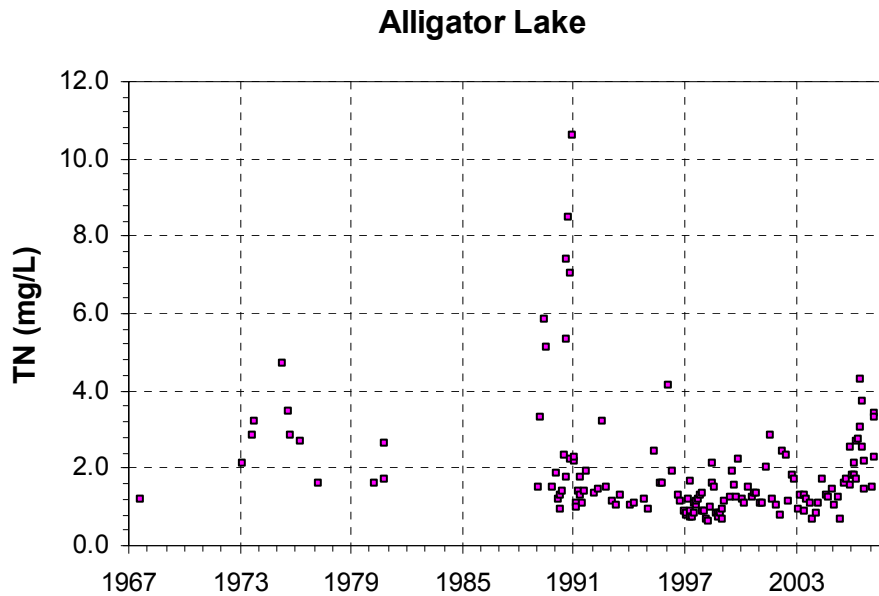


Figure 1.2 Total Nitrogen Concentrations Measured for Alligator Lake from 1973 to 2007

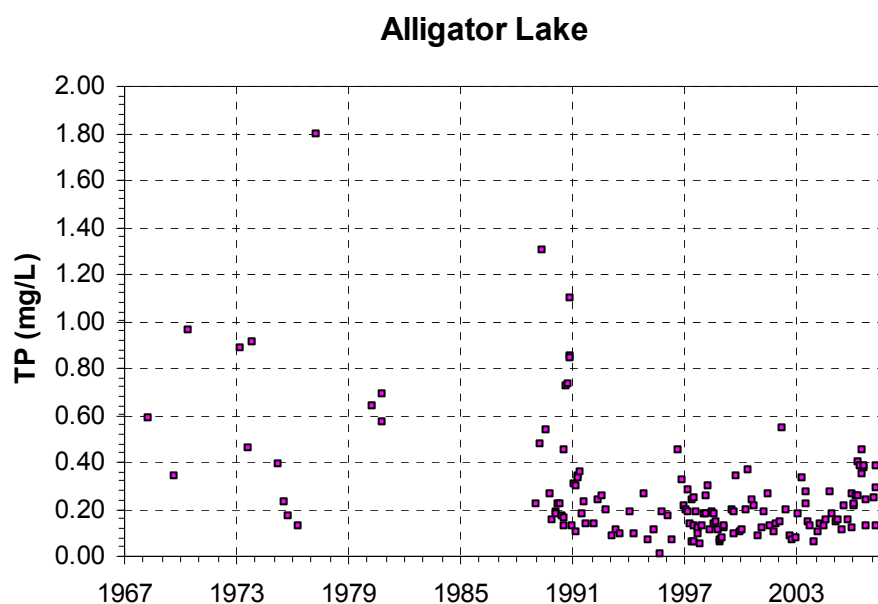


Figure 1.3 Total Phosphorus Concentrations Measured for Alligator Lake from 1973 to 2007

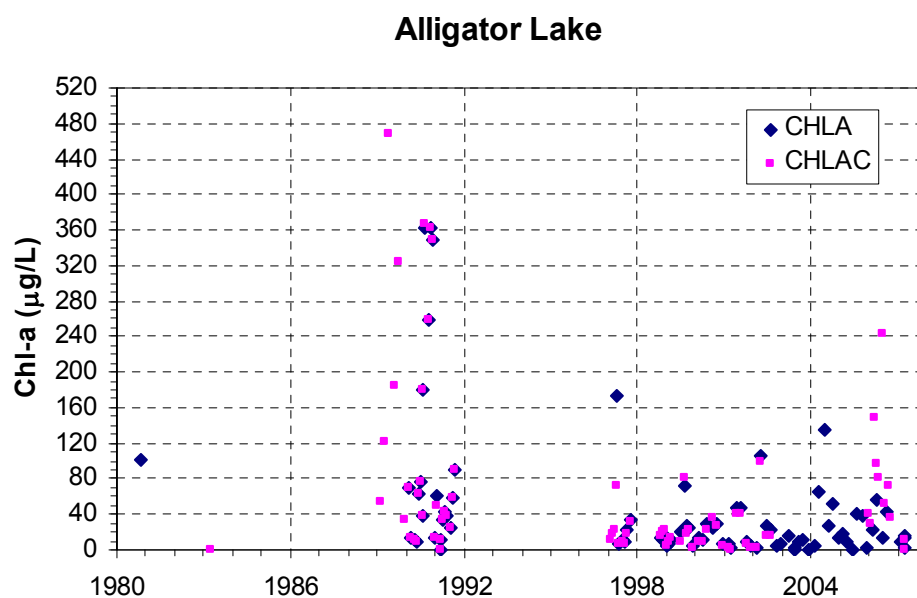


Figure 1.4 Corrected and Uncorrected Chlorophyll a Concentrations Measured for Alligator Lake from 1980 to 2007

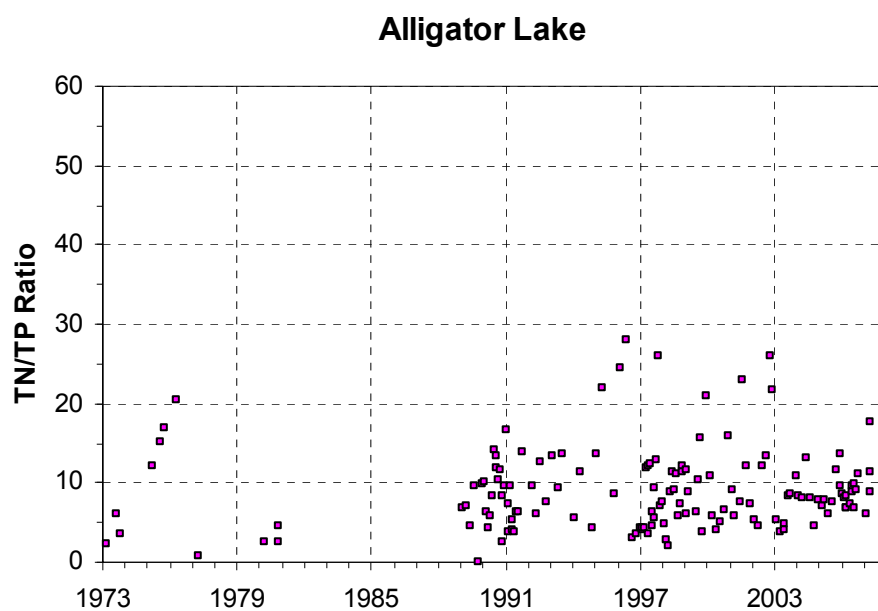


Figure 1.5 Ratios of Total Nitrogen to Total Phosphorus for Alligator Lake from 1973 to 2007

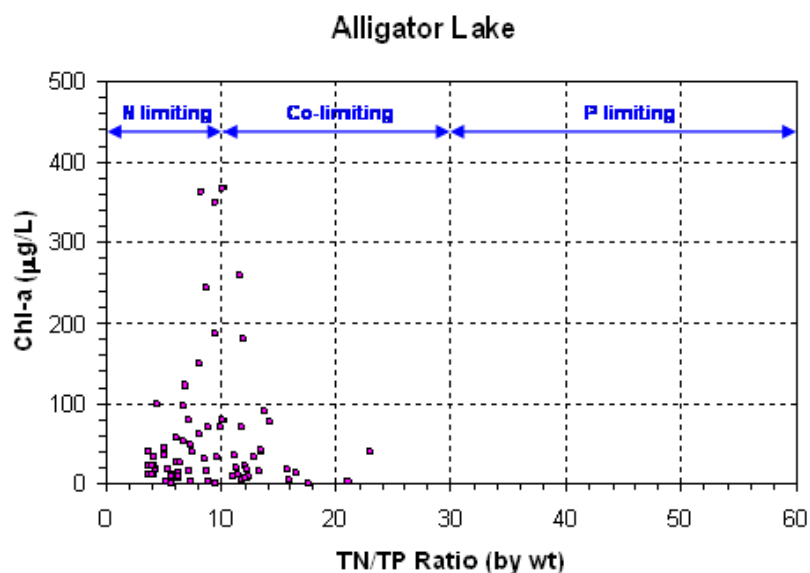


Figure 1.6 Relationship between Corrected Chlorophyll a Concentration versus TN/TP Ratio Observed for Alligator Lake (1972-2007).

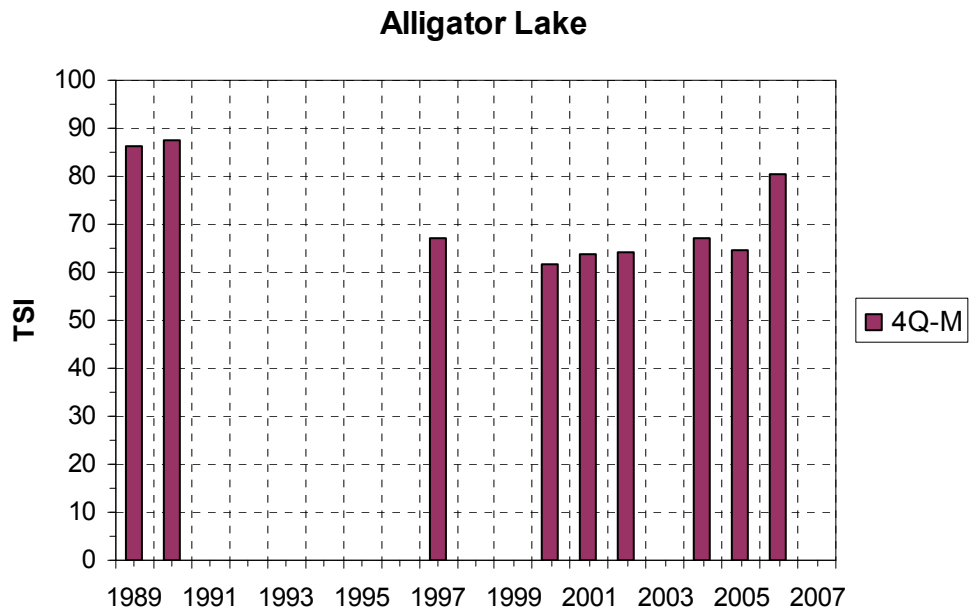


Figure 1.7 Annual Mean TSIs for Alligator Lake from 1989 to 2007 (insufficient data 1991, 1998, 1999, 2003, & 2007, no chla data 1992-1996).
*4QM = TN, TP, and Chla data from all 4 calendar quarters used in calculation of annual mean

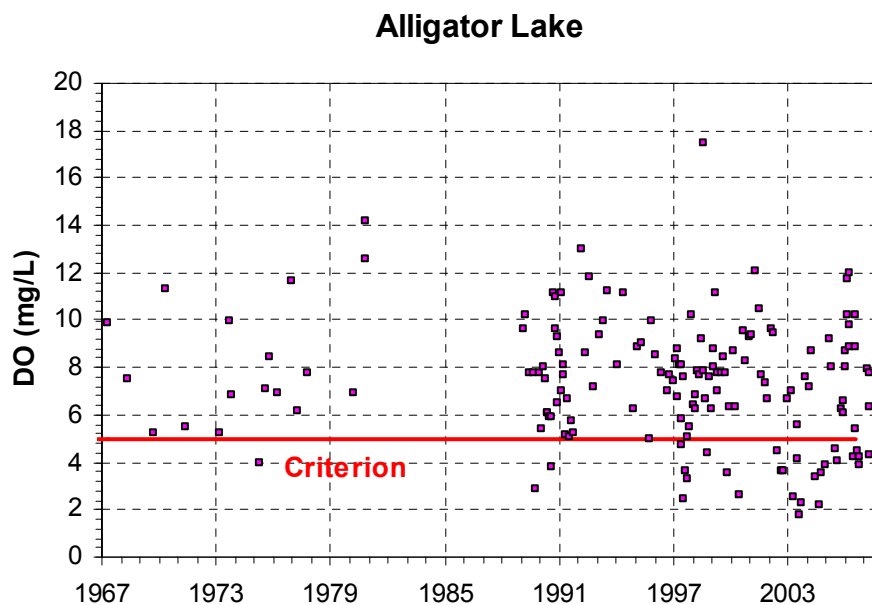


Figure 1.8 Concentrations of Dissolved Oxygen measured for Alligator Lake from 1967 to 2007

Table 1.1 Summary Statistics of Water Quality Variables in Alligator Lake over the Period of 1965 - 1999.

Water Quality Variable	Unit	Number of Observation	Mean	Standard Deviation	Minimum	Maximum	Coefficient Variation
Chlorophyll <u>a</u>	µg/L	136	54.1	107.1	1.0	699.0	2.0
Total Nitrogen	mg/L	438	2.0	2.1	0.5	19.0	1.2
Total Phosphorus	mg/L	444	0.3	0.3	0.0	2.1	1.1
DO	mg/L	494	7.3	3.2	0.1	31.2	0.4
BOD	mg/L	247	10.7	55.7	0.7	620.0	5.2
Color	Pt-Co	438	62.8	45	13.0	360.0	0.7
TN/TP Ratio	no unit	422	9.4	8.5	0.9	134.0	0.9

Table 1.2 Summary Statistics of Water Quality Variables in Alligator Lake over the Verified Period of 1/1/2000 - 6/30/2007. Values in () represent results with data from March 29, 2007 removed.

Water Quality Variable	Unit	Number of Observation	Mean	Standard Deviation	Minimum	Maximum	Coefficient Variation
Chlorophyll <u>a</u>	µg/L	101 (98)	69.4 (26.4)	308.6 (43.5)	1.0 (1.0)	2400.0 (260)	4.4 (1.6)
Total Nitrogen	mg/L	124 (121)	3.0 (1.8)	10.3 (0.9)	0.4 (0.4)	110.0 (4.6)	3.5 (0.5)
Total Phosphorus	mg/L	129 (126)	0.3 (0.2)	0.8 (0.1)	0.01 (0.01)	8.3 (0.7)	2.5 (0.6)
DO	mg/L	141	6.7	3.3	0.2	13.9	0.5
BOD	mg/L	29 (26)	12.0 (9.8)	10.1 (4.8)	4.3 (4.3)	45.0 (23)	0.8 (0.5)
Color	Pt-Co	129	78.4	57.9	15.0	300.0	0.7
TN/TP Ratio	no unit	125	10.4	14.6	2.6	165.0	1.4

1.4 Alligator Lake Background Information

Alligator Lake is located along the Cody Scarp within the Hawthorne Formation, and is thought to have formed through dissolution and collapse of the underlying limestone giving rise to the northern and southern lake basins (Meyer, 1962; Hunn and Slack, 1983). There are two primary sink holes, one in each lake basin. These sink hole features open during periods of low ground water levels, allowing water in the lake to drain into the Floridian Aquifer. Additionally, there are depressions in the lake bottom along the west shore.

Most of the lake's 15.4 square mile watershed lies within the Northern Highlands physiographic province (Meyer, 1962). The drainage area is comprised primarily of sandy soils in the Blanton, Surrency and Plummer series (SCS, 1984). The Alligator Lake watershed is part of the Northern Peninsula Karst Plain lake ecoregion (Griffith, et al. 1997). Griffith (1997) and Canfield (1981) characterize lakes within this ecoregion as slightly acidic, with low to moderate alkalinity, moderately colored, and generally with high nutrient levels.

As reported by SRWMD (2000), the lake stage varies widely. The median lake stage is given as approximately 96 feet MSL (this excludes intervals when the lake drained through the sinkholes). The maximum lake stages are usually recorded during the winter months associated with colder temperatures, reduced evapotranspiration, and passage of temperate cold fronts from the north, with seasonally greater rainfall. Large storm events can periodically produce high lake stages in the fall.

In addition to the alterations discussed above (diking/farming/diversion of Price Creek), the lake has been impacted by other human activities. As depicted on **Figure 4.1** and tabulated in **Table 4.2**, a large portion of the watershed adjacent to the lake has been developed as residential subdivisions. Additionally, the lake has historically received direct discharge of wastewater effluent from the Lake City Waste Water Treatment Facility, and two mobile home parks. The direct discharge from the City was terminated in 1987 and the mobile home parks all currently use rapid infiltration basins. The most developed area of Lake City was built prior to state-wide stormwater regulations, during a time when diverting runoff directly to the local lake was an acceptable practice. As a result, the lake also receives large amounts of urban stormwater runoff. These physical alterations to the lake and its watershed in combination with the land use activities described above have resulted in the lake being classified as one of the 50 worst water quality lakes in the state (Myers and Edmiston, 1983).

It is reported in SRWMD 2000, that at average lake stage, the majority of the lake (68%) is less than 6 feet deep with depths in the sink features running 10 to 18 feet. The generally shallow nature of the lake limits opportunities for thermal stratification, may place the majority of the water column in the euphotic zone, which taken together may allow for heightened biological production (Wetzel, 1975). The shallow depths also provide conditions supporting the extensive aquatic macrophyte growth, often recorded in the Lake. The report by SRWMD (2000) cites Moss, et al. (1996) as noting "that nutrient-rich, shallow lakes such as Alligator Lake may alternate between two "alternative stable states:" a phytoplankton bloom-dominated system or a macrophyte-dominated system. Over the past 10 years, the lake has appeared to alternate between these two states, depending upon antecedent conditions and management activities."

Sampling of the phytoplankton communities by the SRWMD has revealed that both the north and south lake basins have similar species richness (157 and 146 taxa, respectively) with both areas dominated by blue-green and green algae, (total taxa richness and abundance). The data reviewed by SRWMD (2000) indicates that the northern lake basin may have higher organic material and nutrient levels than the southern lake basin. While the south lake basin

had higher median algal abundance, suggesting more persistent or more frequent occurrence of algal blooms in this lake, versus a more variable phytoplankton population in the north lake. SRWMD (2000) concluded that both lakes were dominated by blue-green and green algae and that phytoplankton communities in the Lake are representative of a eutrophic, hardwater lake, dominated by blue-green and green algae, and subjected to periodic blooms of N-fixing blue-greens such as *Anabaena* spp.

SRWMD (2000) reports that sediments in both lake basins (one station in each basin) are composed of coarse and medium sands, with mean sediment organic content of the north basin of 20.1% and 25.1% for the south basin.

1.5 TMDL Background Information

The TMDL Report for Alligator Lake is part of the implementation of the Florida Department of Environmental Protection's (Department) watershed management approach for restoring and protecting water resources and addressing Total Maximum Daily Load (TMDL) Program requirements. The watershed approach, which is implemented using a cyclical management process that rotates through the state's fifty-two river basins over a five-year cycle, provides a framework for implementing the requirements of the 1972 federal Clean Water Act and the 1999 Florida Watershed Restoration Act (Chapter 99-223, Laws of Florida). A TMDL represents the maximum amount of a given pollutant that a waterbody can assimilate and still meet the water body's designated uses. A waterbody that does not meet its designated uses is defined as impaired. TMDLs must be developed and implemented for each of the state's impaired waters, unless the impairment is documented to be a naturally occurring condition that cannot be abated by a TMDL or unless a management plan already in place is expected to correct the problem.

The development and implementation of a Basin Management Action Plan, or BMAP, to reduce the amount of pollutants that caused the impairment will follow this TMDL Report. These activities will depend heavily on the active participation of Columbia County, the water management district, local governments, local businesses, and other stakeholders. The Department will work with these organizations and individuals to undertake or continue reductions in the discharge of pollutants and achieve the established TMDLs for the impaired lake.

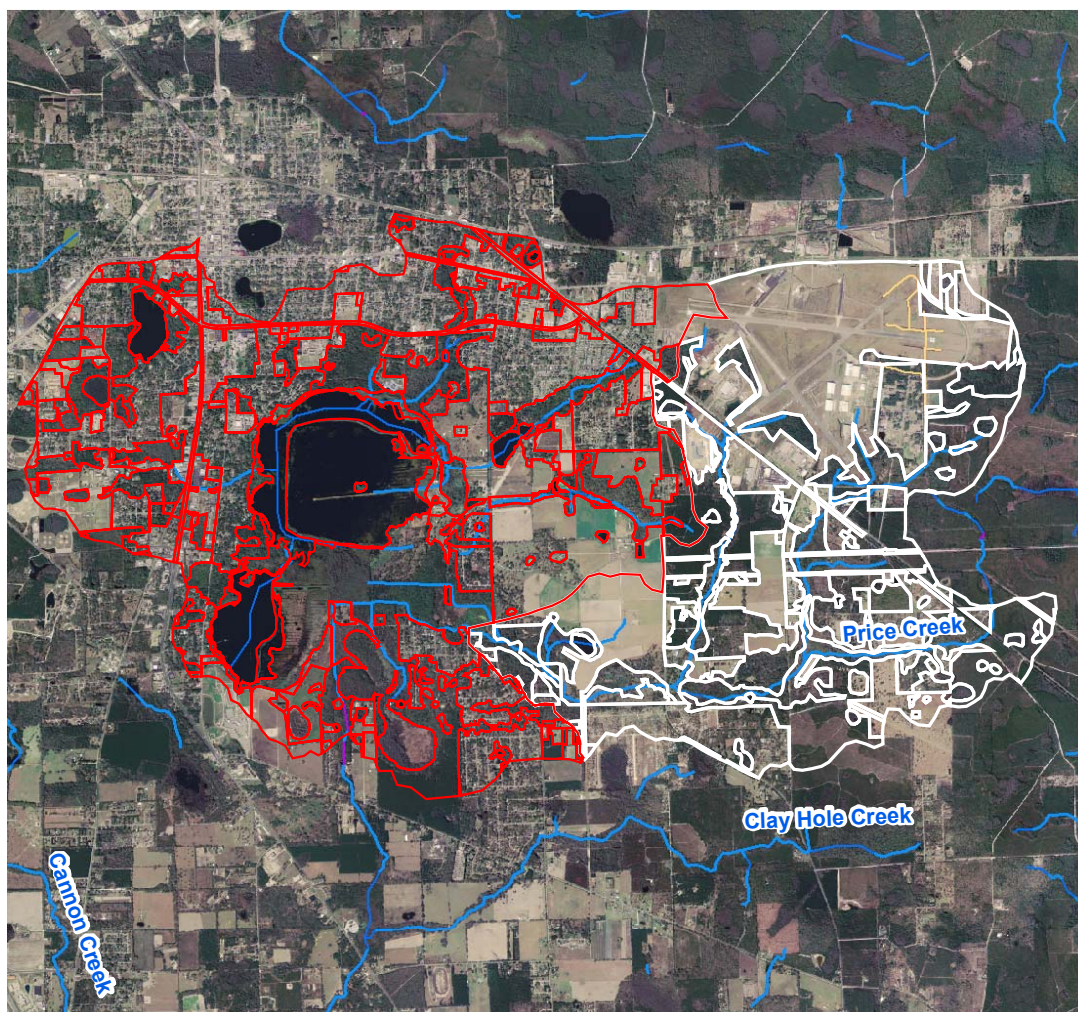


Figure 1.9 Alligator Lake Watershed Boundary and the Surrounding Areas.

Alligator Lake Subbasin on left (thin line in red), Price Creek Subbasin on right (thick white line)

Chapter 2: STATEMENT OF WATER QUALITY PROBLEM

2.1 Legislative and Rulemaking History

Section 303(d) of the federal Clean Water Act requires states to submit to the EPA a list of surface waters that do not meet applicable water quality standards (impaired waters) and establish a TMDL for each pollutant causing the impairment of the listed waters on a schedule. The Department has developed such lists, commonly referred to as 303(d) lists, since 1992. The list of impaired waters in each basin, referred to as the Verified List, is also required by the Florida Watershed Restoration Act (Subsection 403.067[4]) Florida Statutes [F.S.], and the state's 303(d) list is amended annually to include basin updates.

Alligator Lake is on Florida's 1998 303(d) list. However, the FWRA (Section 403.067, F.S.) stated that all previous Florida 303(d) lists were for planning purposes only and directed the Department to develop, and adopt by rule, a new science-based methodology to identify impaired waters. The Environmental Regulation Commission adopted the new methodology as Chapter 62-303, Florida Administrative Code (FAC) (Identification of Impaired Surface Waters Rule, or IWR), in April 2001 and amended in 2006 and January 2007.

2.2 Information on Verified Impairments

Nutrients

The Department used the IWR to assess for water quality impairments in Alligator Lake. The lake was verified as impaired for nutrients based on an elevated annual average Trophic State Index (TSI) value over the verification period (the Planning Period for the Group 1 basins is from January 1, 1995 – June 30, 2004 and the Verified Period is from January 1, 2000 – June 30, 2007). The IWR methodology uses the water quality variables; total nitrogen (TN), total phosphorus (TP), and chlorophyll *a* (Chl*a*) (a measure of algal mass, corrected and uncorrected) in calculating annual TSI values and in interpreting Florida's narrative nutrient threshold. According to the IWR 62-303.352, FAC, exceeding a TSI of 60 in any one year of the verified period is sufficient in determining nutrient impairment for a lake with color greater than 40. For Alligator Lake, water quality data obtained by the IWR Run31_1 and summarized in **Table 2.1** indicated that the mean color for the verified period was 78.4 Pt-Co (n = 129), resulting in a TSI of 60 for the threshold of lake nutrient impairment.

To calculate the TSI for a given year under the IWR, there must be at least one sample of TN, TP, and Chl*a* taken within the same quarter (each season) of the year. The absence of data for at least one of the four seasons for a year will cause the elimination of the year from the analysis of TSI. As can be seen in **Figure 2.1**, the TSIs in Alligator Lake exceeded the threshold of 60 in each year of the verified period for which a TSI could be calculated [2000 (61.9), 2001 (63.9), 2002 (64.2), 2004 (67.0), 2005 (64.5), and 2006 (80.3)]. Exceeding the threshold of 60 in any year of the verified period would result in placing the lake on the verified list of impaired waters. Alligator Lake exceeded this threshold value in six of the seven years (insufficient data was available to calculate a TSI for 2003). It should be noted that the last year of the verified period is not a complete year.

The TSI is calculated based on concentrations of TP, TN, and Chl a as follows:

$CHLA_{TSI} = 16.8 + 14.4 * LN(Chl\ a)$	Chl a in $\mu g/L$
$TN_{TSI} = 56 + 19.8 * LN(N)$	N in mg/L
$TN2_{TSI} = 10 * [5.96 + 2.15 * LN(N + 0.0001)]$	
$TP_{TSI} = 18.6 * LN(P * 1000) - 18.4$	P in mg/L
$TP2_{TSI} = 10 * [2.36 * LN(P * 1000) - 2.38]$	
<i>If $N/P > 30$, then $NUTR_{TSI} = TP2_{TSI}$</i>	
<i>If $N/P < 10$, then $NUTR_{TSI} = TN2_{TSI}$</i>	
<i>if $10 < N/P < 30$, then $NUTR_{TSI} = (TP_{TSI} + TN_{TSI})/2$</i>	
$TSI = (CHLA_{TSI} + NUTR_{TSI})/2$	(TSI has no units)

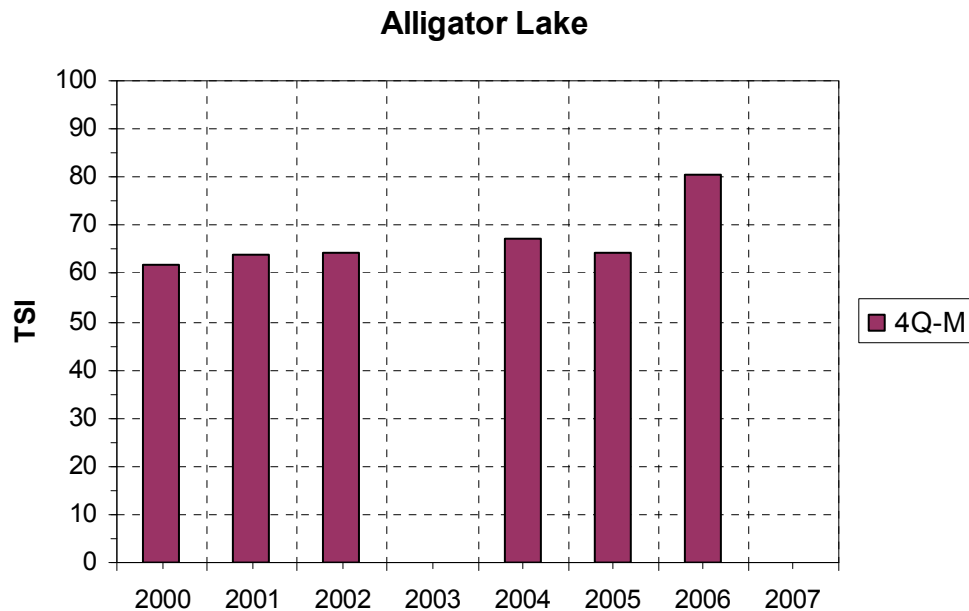


Figure 2.1 Annual Mean TSIs for Alligator Lake from 2000 to 2007
(insufficient data 2003 & 2007)

4QM = TN, TP, and Chla data from all 4 calendar quarters used in calculation of annual mean

Dissolved Oxygen

The Department used the IWR to assess water quality impairments in Alligator Lake (WBID 3516A) and verified the impairment for low DO, with nutrients as the causative pollutant. Data in **Table 2.1** contains the median values as opposed to data summarized in **Table 1.2**, which represent the mean values. The summary of DO and potential causative pollutant concentrations for sampling during the verified period is shown in **Table 2.1**. Using the IWR methodology, given 123 sampling events there would need to be at least 18 exceedances to be considered as impaired. DO exceeded the criterion for 37 out of 123 sampling events. Based on these data and the requirements of the IWR, Alligator Lake was listed as impaired for DO.

Table 2.1. Summary of DO, BOD, TP, and TN Exceedances During the Verified Period (2000–2007) of Alligator Lake in the IWR Database.

Parameter of Concern	Number of Samples	IWR Required Exceedances (for impairment)	Actual Number of Exceedances	Median
DO (mg/L) (IWR Run 33-1)	123	18	37	6.7*
BOD (mg/L)	29	*	*	9.1
TP (mg/L)	129	*	*	0.2
TN (mg/L)	124	*	*	1.5

* = Not Applicable

Chapter 3. DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND TARGETS

3.1 Classification of the Waterbody and Criteria Applicable to the TMDL

Florida's surface water is protected for five designated use classifications, as follows:

Class I	Potable water supplies
Class II	Shellfish propagation or harvesting
Class III	Recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife
Class IV	Agricultural water supplies
Class V	Navigation, utility, and industrial use (there are no state waters currently in this class)

Alligator Lake is classified as a Class III freshwater waterbody, with a designated use of recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife. The Class III water quality criteria applicable to the observed impairments [nutrients and dissolved oxygen] for Alligator Lake is the state of Florida's narrative nutrient criterion [Rule 62-302.530(48) (b), FAC] and the dissolved oxygen criterion [Rule 62-302.530(30), FAC].

3.2 Interpretation of the Narrative Nutrient Criterion for Lakes

To place a waterbody segment on the Verified List for nutrients, the Department must identify the limiting nutrient or nutrients causing impairment as required by the IWR. The following method is used to identify the limiting nutrient(s) in streams and lakes.

The individual ratios over the entire verified period (i.e., January 1, 2000 to June 30, 2007) are evaluated to determine the limiting nutrient(s). If all the sampling event ratios are less than 10, nitrogen is identified as the limiting nutrient, and if all the ratios are greater than 30, phosphorus is identified as the limiting nutrient. Both nitrogen and phosphorus are identified as limiting nutrients if the ratios are between 10 and 30. For Alligator Lake, the median TN/TP ratio during the verified period was 8.3, indicating TN limitation for the lake. It should be noted that about half the time the TN/TP ratio is less than 10 and half the time the ratio is between 10 and 30. It appears that the lake is flipping between nitrogen limitation and co-limitation.

Florida's nutrient criterion is narrative only, i.e., 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. Accordingly, a nutrient-related target was needed to represent levels at which an imbalance in flora or fauna is expected to occur. While the IWR provides a threshold for nutrient impairment for lakes based on annual average TSI levels, these thresholds are not standards and are not required to be used as the nutrient-related water quality target for TMDLs. In recognition that the IWR thresholds were developed using statewide average conditions, the IWR (Subsection 62-303.450, FAC) specifically allows the use of alternative, site-specific thresholds that more accurately reflect conditions beyond which an imbalance in flora or fauna occurs in the waterbody.

The TSI originally developed by R. E. Carlson (1977) was calculated based on Secchi depth, chlorophyll concentration, and total phosphorus concentration and was used to describe a lake's

trophic state. Carlson's TSI was developed based on the assumption that the lakes were all phosphorus limited. In Florida, because the local geology produced a phosphorus rich soil, nitrogen can be the sole or co-limiting factor for phytoplankton population in some lakes. In addition, because of the existence of higher color lakes in the state, using Secchi depth as an index to represent lake trophic state can produce misleading results.

Therefore, the TSI was revised to be based on total nitrogen, total phosphorus, and Chla concentrations. This revised calculation for TSI now contains a TN -TSI, TP -TSI, and Chla-TSI. As a result, there are three different ways of calculating a final in-lake TSI. If the TN to TP ratio is equal to or greater than 30, the lake is considered phosphorus limited and the final TSI is the average of the TP -TSI and the Chla-TSI. If the TN to TP ratio is 10 or less, the lake is considered nitrogen limited and the final TSI is the average of the TN -TSI and the Chla-TSI. If the TN to TP ratio is between 10 and 30, the lake is considered co-limited and the final TSI is the result of averaging the Chla-TSI with the average of the TN and TP TSI's.

The Florida-specific TSI was determined based on the analysis of data from 313 Florida lakes. The index was adjusted so that a Chla concentration of 20 µg/L was equal to a Chla-TSI value of 60. The final TSI for any lake may be higher or lower than 60 depending on the TN -TSI and the TP -TSI values. A TSI of 60 was then set as the threshold for nutrient impairment for most lakes (for those with a color higher than 40 platinum cobalt units) because, generally, the phytoplankton may switch to communities dominated by blue-green algae at Chla levels above 20 µg/L. These blue-green algae are often an unfavorable food source to zooplankton and many other aquatic animals. Some blue-green algae may even produce toxins, which could be harmful to fish and other animals. In addition, excessive growth of phytoplankton and the subsequent death of these algae may consume large quantities of dissolved oxygen and result in anaerobic conditions in lakes, which makes conditions in the impacted lake unfavorable for fish and other wildlife. All of these processes may negatively impact the health and balance of native fauna and flora.

Because of the amazing diversity and productivity of Florida lakes, some lakes have a natural background TSI that is different from 60. In recognition of this natural variation, the IWR allows for the use of a lower TSI (40) in very clear lakes, a higher TSI if paleolimnological data indicate the lake was naturally above 60, and the development of site-specific thresholds that better represent the levels at which nutrient impairment occurs.

For the Alligator Lake TMDL, the Department applied the Watershed Management Model (WMM) to simulate runoff, TN, and TP loadings to the lake. A regression model was developed from in-lake concentrations of TN, TP, and Chla to represent the eutrophication processes in the lake and to determine the appropriate nutrient target. Background was established by setting land uses to natural or forested land. The WMM model was used to estimate existing and background loadings to the lake from the watershed. It is the Department's practice, once the background TSI has been determined, to establish the target for TMDL development as an increase of 5 TSI units above the background TSI.

3.3 Narrative Nutrient Criteria Definitions

Chlorophyll *a*

Chlorophyll is a green pigment found in plants and is an essential component in the process of converting light energy into chemical energy. Chlorophyll is capable of channeling the energy of sunlight into chemical energy through the process of photosynthesis. In photosynthesis, the energy absorbed by chlorophyll transforms carbon dioxide and water into carbohydrates and

oxygen. The chemical energy stored by photosynthesis in carbohydrates drives biochemical reactions in nearly all living organisms. Thus, chlorophyll is at the center of the photosynthetic oxidation-reduction reaction between carbon dioxide and water.

There are several types of chlorophyll; however, the predominant form is chlorophyll *a* (Chla). The measurement of Chla in a water sample is a useful indicator of phytoplankton biomass, especially when used in conjunction with analysis concerning algal growth potential and species abundance. The greater the abundance of Chla, typically the greater the abundance of algae. Algae are the primary producers in the aquatic food web, and thus are very important in characterizing the productivity of lakes and streams. As noted earlier, Chla measurements are also used to estimate the trophic conditions of lakes and lentic waters.

Nitrogen Total as N (TN)

Total nitrogen is the combined measurement of nitrate (NO_3), nitrite (NO_2), ammonia, and organic nitrogen found in water. Nitrogen compounds function as important nutrients to many aquatic organisms and are essential to the chemical processes that exist between land, air, and water. The most readily bio-available forms of nitrogen are ammonia and nitrate. These compounds, in conjunction with other nutrients, serve as an important base for primary productivity.

The major source of excessive amounts of nitrogen in surface water are the effluent from municipal treatment plants and runoff from urban and agricultural sites. When nutrient concentrations consistently exceed natural levels, the resulting nutrient imbalance can cause undesirable changes in a water body's biological community and drive an aquatic system into an accelerated rate of eutrophication. Usually, the eutrophication process is observed as a change in the structure of the algal community and includes severe algal blooms that may cover large areas for extended periods. Large algal blooms are generally followed by depletion in dissolved oxygen concentrations as a result of algal decomposition.

Phosphorus Total as P (TP)

Phosphorus is one of the primary nutrients that regulates algal and macrophyte growth in natural waters, particularly in fresh water. Phosphate, the form in which almost all phosphorus is found in the water column, can enter the aquatic environment in a number of ways. Natural processes transport phosphate to water through atmospheric deposition, ground water percolation, and terrestrial runoff. Municipal treatment plants, industries, agriculture, and domestic activities also contribute to phosphate loading through direct discharge and natural transport mechanisms. The very high levels of phosphorus in some of Florida's streams and estuaries are usually caused by phosphate mining and fertilizer processing activities.

High phosphorus concentrations are frequently responsible for accelerating the process of eutrophication, or accelerated aging, of a waterbody. Once phosphorus and other important nutrients enter the ecosystem, they are extremely difficult to remove. They become tied up in biomass or deposited in sediments. Nutrients, particularly phosphates, deposited in sediments generally are redistributed to the water column. This type of cycling compounds the difficulty of halting the eutrophication process.

3.4 Dissolved Oxygen

Florida's DO criterion for Class I and III freshwater bodies states that DO "shall not be less than 5.0 mg/L, and the normal daily and seasonal fluctuations above this levels shall be maintained."

However, DO concentrations in ambient waters can be controlled by many factors, including the DO solubility, which is controlled by temperature and salinity; DO enrichment processes influenced by reaeration, which is controlled by flow velocity; photosynthesis of phytoplankton, periphyton, and other aquatic plants; DO consumption from the decomposition of organic materials in the water column and sediment and oxidation of some reductants such as ammonia and metals; and respiration by aquatic organisms.

Alligator Lake has a variable color ranging between 13 platinum cobalt units (PCU) and 360 PCU (1965-2007) with an average value of 66.4. The DO concentration in some seasons could be naturally low because of the high bacteria respiration supported by a large and constant supply of dissolved organic carbon (DOC) originating from the wetland areas that discharge into the lake. Although the major portion of the DOC pool is usually recalcitrant to most bacteria species, some bacteria species adapted to living in blackwater systems can readily use this DOC pool to support their growth. Bacteria activities can be significantly stimulated if nitrogen and phosphorus are added into the system because they provide bacteria with nutrients. Further stimulation of bacteria activities can be observed if DOCs of human origin (usually represented with the biochemical oxygen demand – BOD) are added to the system. Human DOCs are usually easy to decompose and can be readily used by bacteria. These DOCs not only can enhance the metabolic activities of bacteria species that use recalcitrant DOCs, but also provide the carbon source to those bacteria species that can not use recalcitrant DOCs. Therefore, input of human sources of DOC into a blackwater system should be properly controlled to improve the DO condition in these waters.

Another source of DO consumption may originate from the organic materials accumulated in the lake over time. Due to the limited amount of time available to this study, factors that control DO concentration in the lake were not examined by measuring the actual DO consumption rate from each source. Instead, TN, TP, Chla, and BOD concentrations were treated as the focus of this study.

Chapter 4: ASSESSMENT OF SOURCES

4.1 Overview of Modeling Process

A watershed is the land area which catches rainfall and eventually drains or seeps into a receiving waterbody such as a stream, lake, or groundwater (EPA, 1997). A watershed is often referred to as a drainage basin, and the boundaries between watersheds can be determined by ridges of higher ground based upon topographic elevations. The watershed, where appropriate, can be further divided into sub watersheds by drainage area for watershed modeling purposes.

Land use pollution loading models have been often used to assess watershed impacts on water quality of a receiving waterbody when data limitation and time constraint preclude a complex watershed model. Such a simple model would be beneficial to estimate nutrients loads from potential sources in the watershed to predict algal responses in the receiving waterbody where the time scale of actual biological responses to nutrient loading from the watershed is at least equal to or less than that of the model prediction (EPA 1997).

The Watershed Management Model (WMM), developed by Camp Dresser and McKee (CDM) for the Florida Department of Environmental Protection, is a land use pollution loading model to estimate annual or seasonal pollutant loading from pollution sources (i.e., nonpoint and point source) in a watershed or a sub basin (WMM User's manual version 4.1, 1998). The loading estimation using the WMM can be executed based upon event mean concentrations of pollutants, land use, percent impervious, and annual rainfall. The model also can address watershed management needs for identified nonpoint source pollution as a part of Best Management Practices (BMPs). However, accuracy of estimated pollution loads can be limited when default parameters are substitute for site-specific data such as event mean concentrations, percent imperviousness, and runoff coefficient for each land use, etc (EPA, 1997).

The WMM estimates annual pollution loads for each land use based upon event mean concentrations (EMC) for different pollutants and average annual surface runoff from land use. The EMCs used for this project are listed in **Table 4.1**. The pollution loading (M_L in the unit of lbs/ac/yr) is then computed for each land use by the following equation:

$$(1) \quad M_L = EMC_L * R_L * K$$

Where:

- M_L = loading factor for land use L (lbs/ac/yr);
- EMC_L = event mean concentration of runoff from land use L (mg/L); EMC varies by land use and pollutant;
- R_L = total average annual surface runoff from land use L (in/yr); and
- K = 0.2266, a unit conversion constant.

Annual runoff volumes for each sub basin can be estimated from constructing site-specific rainfall and runoff relationships. Runoff and rainfall relationships may vary depending on rainfall intensity and duration, sub basin characteristics (e.g., soil type, size, vegetation, and slope), percent imperviousness, and antecedent moisture conditions (reference Brezonik and Stadelmann, 2002). Without site-specific data for these variables, total average annual surface runoff from each land use type can be estimated as follows (WMM, 1998):

$$(2) \quad R_L = [C_p + (C_i - C_p) IMP_L] * I$$

Where:

- R_L = total average annual surface runoff from land use L (in/yr);
 IMP_L = fractional imperviousness of land use L;
 I = long-term average annual precipitation (in/yr);
 C_p and C_i = runoff coefficients for pervious area and impervious area, respectively.

The percent imperviousness for each land use category can be determined using 1 inch per 200 feet enlargements of USGS DOQQs aerial photographs. Literature values for the impervious area can be used when specific data are limited. In general, pervious areas are dominant for rural and agricultural land uses compared to urban settings, producing reduction of runoff volume. Additionally, **Table 4.1** shows the relationship between the TN/TP ratio in runoff (EMCs) from various land uses. From these data, it appears that the loadings from residential, commercial and services, cropland and pasture, and transportation land uses are contributing to nitrogen limitation, while loads from tree crops/citrus, rangeland, upland forest/rural open, water, and wetland land uses are contributing to co-limitation. **Table 4.2** contains the percent imperviousness used (as DCIA) for each land use in the model and runoff coefficients respectively. Runoff coefficients (**Table 4.3**) are important parameters to estimate runoff volume. Typically, a runoff coefficient of 0.20 can be used for pervious areas whereas a coefficient of 0.90 is for impervious areas (WMM, 1998). For use in the Alligator Lake watershed, the governing equations from WMM were incorporated into an EXCEL spreadsheet. To model the Price Creek sub-basin, runoff coefficients were first adjusted to calibrate to the measured annual flow of Price Creek. Then the calibrated coefficients were applied to the entire watershed of Alligator Lake.

Table 4.1 WMM Event Mean Concentrations (EMC) Input Parameters.

Land Use Category	TN (mg/L)	TP (mg/L)	TN/TP
Low density residential	1.61	0.191	8.4
Medium density residential	2.07	0.327	6.3
High density residential	2.32	0.520	4.5
Commercial and Services	1.18	0.179	6.6
Cropland and Pastureland	3.06	0.604	5.1
Tree Crops/Citrus	2.24	0.183	12.2
Rangeland	1.15	0.055	20.9
Upland Forests/Rural Open	1.15	0.055	20.9
Water	1.60	0.067	23.9
Wetlands	1.01	0.090	11.2
Transportation	1.64	0.220	8.3

Note: 1) Values for the EMCs are obtained from Table 4-17 from Harper and Baker (2007) Cropland/pasture EMC is the average of pasture and cropland. Water and Wetland EMC's are from Harper and Baker (2003).

Table 4.2 Percentage of Directly Connected Impervious Area (DCIA) Used in the WMM.

FLUCC	Land Use Category	Alligator Basin (acre)	Price Creek Basin (acre)	Percent DCIA (%)
1100	Low density residential	147.2	166.7	14.7% ¹⁾
1200	Medium density residential	1417.8	250.2	18.7% ²⁾
1300	High density residential	100.4	11.6	29.6% ²⁾
1400	Commercial and Services	680.9	257.8	44.38% ³⁾
2100	Cropland and Pastureland	707.0	542.4	0.0% ¹⁾
2200	Tree Crops/Citrus	8.0	0.0	0.0% ¹⁾
3000	Rangeland	123.3	105.0	0.5% ¹⁾
4000	Upland Forests/Rural Open	901.1	1290.9	0.5% ¹⁾
5000	Water	463.6	19.3	30.0% ⁴⁾
6000	Wetlands	898.1	395.5	30.0% ⁴⁾
8200	Transportation	194.4	973.1	36.2% ²⁾

¹⁾Percent DCIA referred to Harper and Baker (2003)

²⁾Percent DCIA referred to Brown (1995)

³⁾Percent DCIA referred to WMM (1998)

⁴⁾Percent DCIA referred to Harper and Livingston (1999)

Table 4.3 Runoff Coefficients By Year Used in the WMM.

Year	Impervious (*)	Pervious (*)
2000	0.8	0.04
2001	0.8	0.02
2002	0.8	0.07
2003	0.99	0.37
2004	0.99	0.27
2005	0.99	0.27
2006	0.8	0.07
2007	0.8	0.04

*Runoff Coefficients are a fractional percentage of 1.

4.2 Potential Sources of Nutrients in the Alligator Lake Watershed

An important part of the TMDL analysis is the identification of pollutant source categories, source subcategories, or individual sources of the pollutant of concern 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, agriculture, silviculture, and 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 the EPA’s National Pollutant Discharge Elimination System (NPDES). These nonpoint sources included certain urban stormwater discharges, including those from local government master drainage systems, construction sites over five acres, and a wide variety of industries (see **Appendix A** for background information on the federal and state 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. 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.

4.2.1 Point Sources

There are no NPDES permitted wastewater treatment facilities or industrial wastewater facilities that discharge directly to Alligator Lake. The non-NPDES facilities listed in **Table 4.4** and depicted on **Figure 4.1** are within the Alligator Lake watershed, but were not included in the model as they do not discharge to surface water. The NPDES permitted facility (Mead Westvaco) was not included in the model, as the permit is for the discharge from a groundwater remediation site that is not expected to contribute nutrient loadings to the lake or otherwise lower DO in the lake.

Table 4.4 Federal NPDES and State Permitted Facilities

NPDES Permit ID	Facility Name	Receiving Water	Permitted Capacity (mgd)	Downstream Impaired WBID	Comments
FL0038300 (NPDES)	Mead Westvaco Corp.	Unnamed ditch to Alligator Creek to Alligator Lake	0.0482	3516A	Maybe ground water remediation site
FLA113956 (not NPDES)	Lake City WWTF	None	3.0	3516A	Holding Pond to Spray Field
FLA011402 (not NPDES)	Eastside Village Mobile Home Park WWTF	None	0.025	3516A	Rapid Infiltration Basin
FLA011406 (not NPDES)	Pondview Mobile Home Park WWTF	None	0.009	3516A	Rapid Infiltration Basin
FLA011398 (not NPDES)	Paradise Village Mobile Home Park	None	0.0075	3516A	Rapid Infiltration Basin

Permitted Facilities in the Alligator Lake watershed

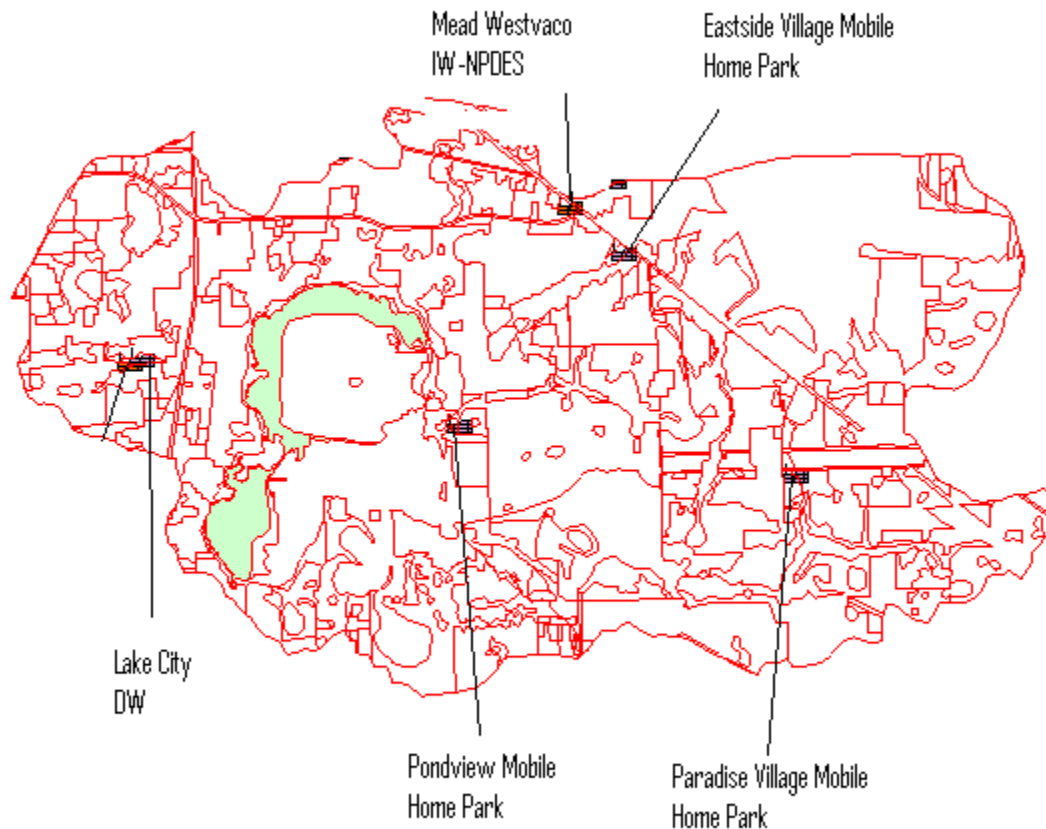


Figure 4.1 Federal NPDES and State Permitted Facilities within the Alligator Lake Watershed

Municipal Separate Storm Sewer System Permittees

Like other nonpoint sources of pollution, urban stormwater discharges are associated with land use and human activities, and are driven by rainfall and runoff processes leading to the intermittent discharge of pollutants in response to storms. The 1987 amendments to the Clean Water Act designated certain stormwater discharges from urbanized areas as point sources requiring NPDES stormwater permits. In October 2000, US EPA authorized the Department to implement the NPDES stormwater program in all areas of Florida except Indian Tribal lands. The Department's authority to administer the NPDES program is set forth in Section 403.0885, Florida Statutes. The three major components of the NPDES stormwater regulations are:

- Municipal Separate Storm Sewer Systems (or MS4) permits that are issued to entities that own and operate master stormwater systems, primarily local governments. Permittees are required

to implement comprehensive stormwater management programs designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable.

- Stormwater Associated with Industrial Activities, which is regulated primarily by a multisector general permit that covers various types of industrial facilities. Regulated industrial facilities must obtain NPDES stormwater permit coverage and implement appropriate pollution prevention techniques to reduce contamination of stormwater.
- Construction activity generic permits for projects that ultimately disturb one or more acres of land and which require the implementation of stormwater pollution prevention plans to provide for erosion and sediment control during construction.

In addition to the NPDES stormwater construction permitting regulations, Florida was the first state in the country to require the treatment of stormwater for all new developments with the adoption of the State Stormwater Rule in late 1981. The Stormwater Rule is a technology-based program that relies on 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, FAC. In 1994, state legislation created the Environmental Resource Permitting program to consolidate stormwater quantity, stormwater quality, and wetlands protection into a single permit. Presently, the majority of environmental resource permits are issued by the state's water management districts, although DEP continues to do the permitting for specified projects.

The NPDES stormwater program was implemented in phases, with Phase I MS4 areas including municipalities having a population above 100,000. Because the master drainage systems of most local governments in Florida are interconnected, EPA implemented Phase 1 of the MS4 permitting program on a countywide basis, which brings in all cities, Chapter 298 urban water control districts, and the Florida DOT throughout the fifteen counties meeting the population criteria. Phase II of the NPDES Program was expanded in 2003 and requires stormwater permits to construction sites between one and five acres, local governments with as few as 10,000 people or discharge into Class I or II waters, or Outstanding Florida Waters.

Although MS4 discharges are technically referred to as "point sources" for the purpose of regulation, they are still diffuse sources of pollution that cannot be easily collected and treated by a central treatment facility. All Phase 1 MS4 permits issued in Florida include a re-opener clause allowing permit revisions for implementing TMDLs once they are formally adopted by rule. Florida's Phase II MS4 Generic Permit has a "self-implementing" requirement once TMDLs are adopted that requires the MS4 permittee to update its stormwater management program as needed to meet its TMDL allocations. All future areas with populations meeting the MS4 requirements will be required to achieve the allocations presented in the TMDL. In addition, Florida may designate an area as a regulated Phase II MS4 in accordance with Rule 62-624.800, FAC.

Based on information received from EPA, and the Florida Department of Transportation, Columbia County and Lake City do not have MS4 permitted stormwater collection systems in the Alligator Lake watershed.

4.2.2 Nonpoint Sources and Land Uses

Unlike traditional point source effluent loads, nonpoint source loads enter at so many locations and exhibit such large temporal variation that a direct monitoring approach is often infeasible. For the Alligator Lake TMDL, all nonpoint sources were evaluated by use of a watershed model and a regression model for the lake. Land use coverages for the watershed were aggregated

using the Florida Land Use, Cover and Forms Classification System (FLUCCS, 1999) into eleven different land use categories. These categories are cropland/improved pasture, tree crops, unimproved pasture/rangeland, upland forests/rural open, commercial/industrial, transportation, high density residential (HDR), low density residential (LDR), medium density residential (MDR), water, and wetlands. The spatial distribution and acreage of different land use categories for WMM were identified using the 2004 land use coverage (scale 1:24,000) provided by the Suwannee River Florida Water Management District (SRWMD).

Table 4.5 shows the existing area of the various land use categories in the Alligator Lake sub-basin, Price Creek sub-basin and the total Alligator Lake watershed. **Figure 4.2** shows the drainage area of the Alligator Lake watershed and the spatial distribution of the land uses shown in **Table 4.5**.

Figure 4.3 depicts the land uses for the Alligator Lake sub-basin and **Figure 4.4** depicts the land uses for the Price Creek sub-basin. Alligator Lake is within the Alligator Lake sub-basin. The combined sub-basins form the Alligator Lake watershed. As shown in **Figure 4.5**, the predominant land coverages for the Alligator Lake watershed include upland forest/rural open (22.7%), MDR (17.3%), wetland (13.4%), cropland/pastureland (12.9 %), and transportation (12.1%). Other uses include: commercial/industrial (9.7%), water [not including Alligator Lake (5.0%), LDR (3.3%), rangeland (2.4%), HDR (1.2%), and tree crops (0.1%).

- Low Density Residential (LDR),
- Medium Density Residential (MDR)
- High Density Residential (HDR)
- Commercial/industrial,
- Cropland and Pastureland,
- Tree Crops/Citrus,
- Rangeland,
- Upland Forest/Rural Open
- Water,
- Wetlands, and
- Transportation.

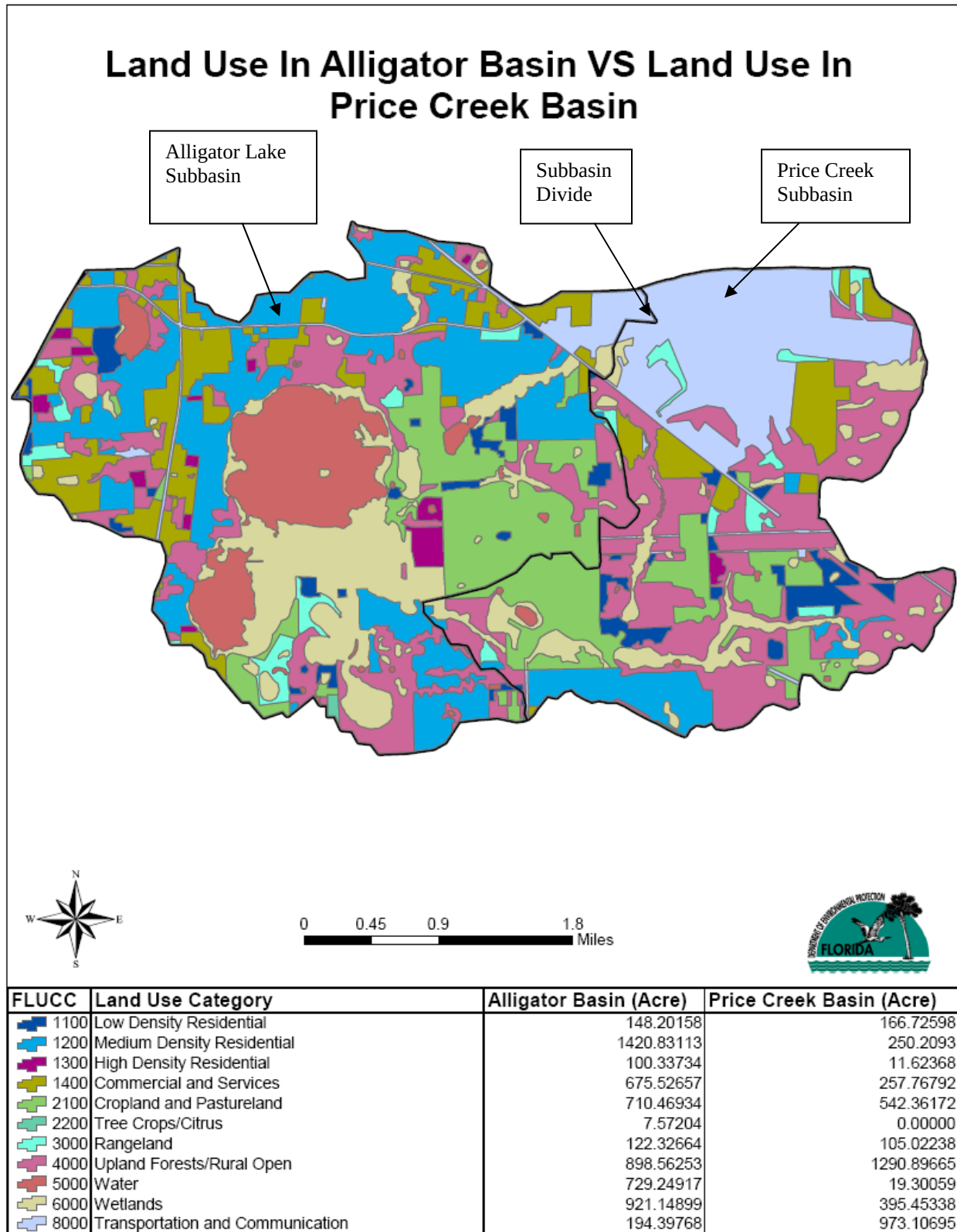
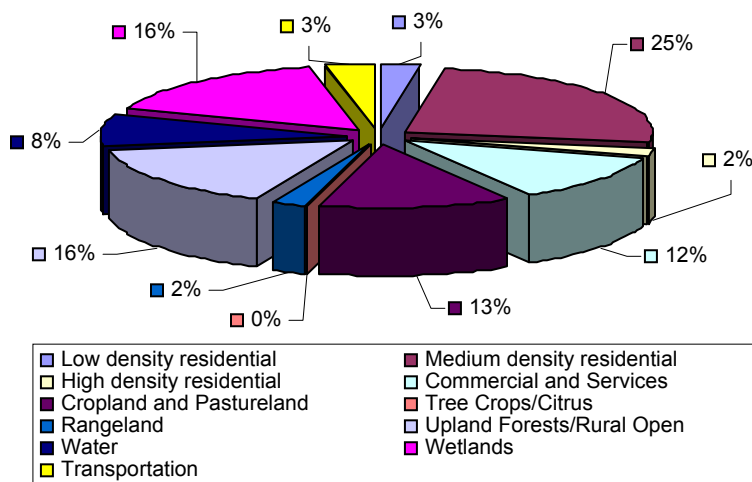


Figure 4.2 Alligator Lake Watershed Existing Land Use Coverage

Table 4.5 Total and Percent Acreage of the Various Land Use Categories in the Alligator Lake Sub-Basin, Price Creek Sub-Basin and the Total Watershed.

Land Use Code	Attribute	Alligator Lake Basin, Area (acres)	Price Creek Basin, Area (acres)	Alligator Lake Basin, Percent of Total Land Use (%)	Price Creek Basin, Percent of Total Land Use (%)	Total Basin Land Use (acres)	Total Basin, Percent Land Use (%)
1100	Low Density Residential	147.2	166.7	2.6	4.2	313.9	3.3
1200	Medium Density Residential	1417.8	250.2	25.1	6.2	1668.0	17.3
1300	High Density Residential	100.4	11.6	1.8	0.3	112.0	1.2
1400	Commercial and Services	680.9	257.8	12.1	6.4	938.7	9.7
2100	Cropland and Pastureland	707.0	542.4	12.5	13.5	1249.4	12.9
2200	Tree Crops/Citrus	8.0	0.0	0.1	0.0	8.0	0.1
3000	Rangeland	123.3	105.0	2.2	2.6	228.4	2.4
4000	Upland Forests/Rural Open	901.1	1290.9	16.0	32.2	2192.0	22.7
5000	Water	463.6	19.3	8.2	0.5	482.9	5.0
6000	Wetlands	898.1	395.5	15.9	9.9	1293.5	13.4
8200	Transportation	194.4	973.1	3.4	24.3	1167.5	12.1
TOTAL		5641.8	4012.5	100.0	100.0	9654.3	100.0

Alligator Lake Basin**Figure 4.3 Percent Acreage of the Various Land Use Categories in the Alligator Lake Sub-Basin.**

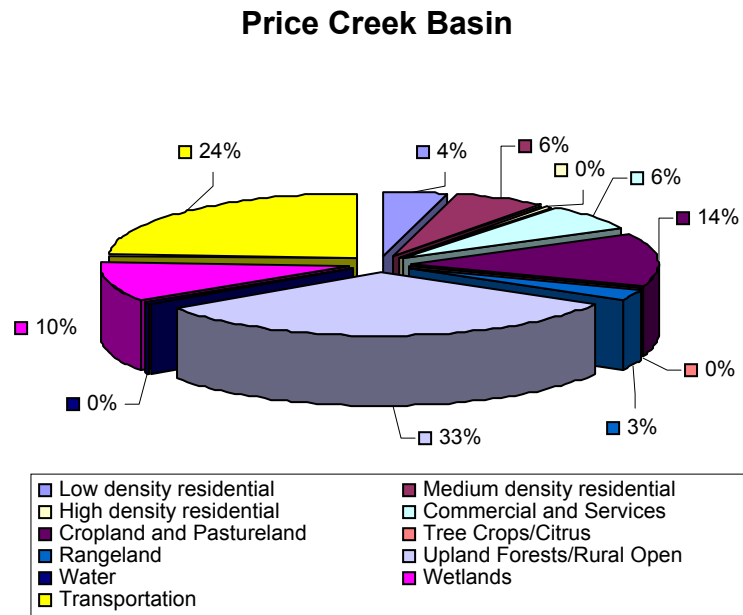


Figure 4.4 Percent Acreage of the Various Land Use Categories in the Price Creek Sub-Basin

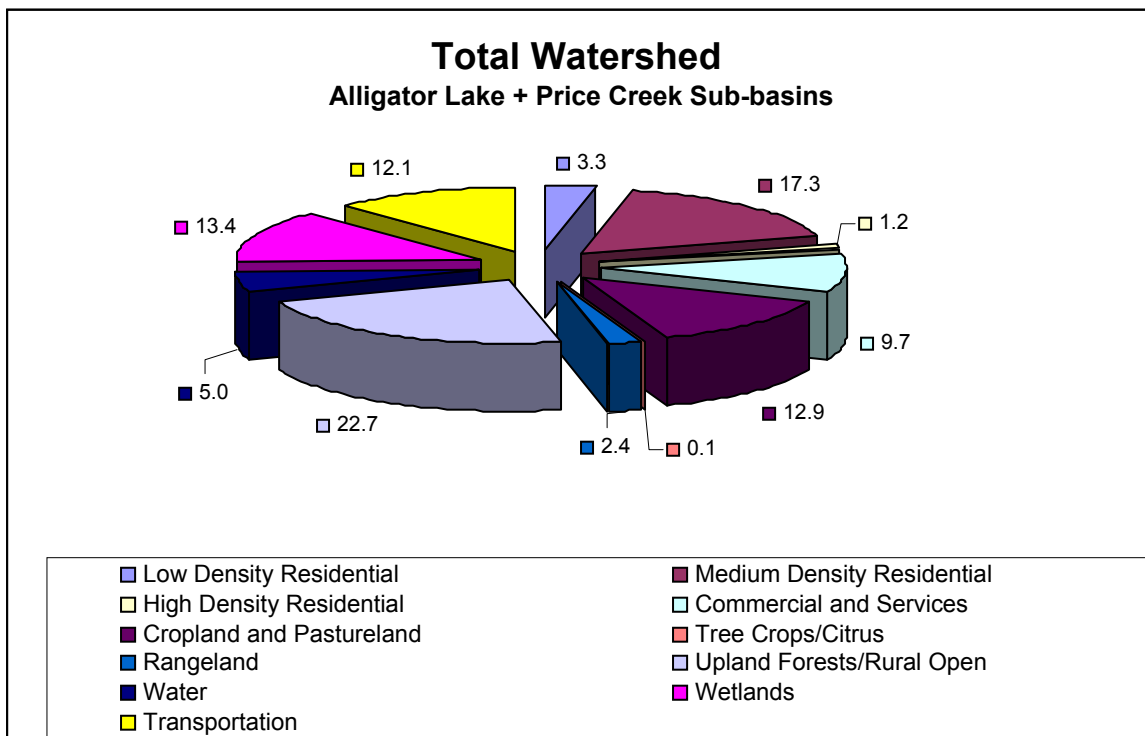


Figure 4.5 Percent Acreage of the Various Land Use Categories in the Alligator Lake Watershed

Columbia County Population

According to the U.S. Census Bureau, the county occupies an area of approximately 797.05 square miles (sq mi). The total 2000 population estimated for Columbia County, which includes (but is not exclusive to) the Alligator Lake watershed, was 56,513. The population density in Columbia County, in the year 2000, was at or less than 70.9 people per sq mi. The estimated population for 2006 is 67,007, a 13.2% increase from 2000. For all of Columbia County (2006), the Bureau reported a total occupied number of housing units as 25,530 for a housing density of 32 housing units per sq mi. Columbia County is well below the average housing density for Florida counties of 158 housing units per sq mi (U. S. Census Bureau Web site, 2008).

Septic Tanks

Onsite sewage treatment and disposal systems (OSTDSs), including septic tanks, are commonly used where providing central sewer is not cost-effective or practical. When properly sited, designed, constructed, maintained, and operated, OSTDSs are a safe means of disposing of domestic waste. The effluent from a well-functioning OSTDS is comparable to secondarily treated wastewater from a sewage treatment plant. When not functioning properly, however, OSTDSs can be a source of nutrients (nitrogen and phosphorus), pathogens, and other pollutants to both ground water and surface water.

Septic tank effluent (STE) characteristics and loading rates have been reported in several studies (CHEC, 2003; CDM, 1991; IFAS, 1984). STE contains varied concentrations of nitrogen, phosphorus, chloride, sulfate, sodium, detergent surfactants, and pathogenic bacteria and viruses. OSTDS use soil adsorption capabilities to remove nutrients and bacteria from the treated effluent. Removal of TN in soils could vary from 40 to 60 percent (CHEC, 2003; IFAS, 1984) before reaching the water table. Once the nitrogen has reached the form of nitrate (NO_3) in the water table, it remains stable as it is transported to a water body. Phosphorus is removed from the STE at a higher rate, 50 to 98 percent (CHEC, 2003; CDM, 1991; IFAS, 1984), and from the ground water by sorption and precipitation. Phosphorus-contaminated water bodies from OSTDS are indicative of proximity of these systems, usually less than 150 ft (CHEC, 2003; IFAS, 1984). When at least two feet of unsaturated soil exist between the infiltration system and the water table, BOD_5 removals of > 90%, TSS removals of > 95% and fecal coliform reductions of > 99% (CDM, 2008) can be expected for a functional and properly maintained septic tank. Bacteria and viruses are effectively removed by adsorption and sorption processes in the ground water and are not transported far from the STE source.

IFAS (1984) estimated 11 to 18 lb/yr/capita of TN loading factor to the water table; whereas, Anderson *et al.* (1994), as reported by CHEC (2003) and EPA (2002), estimated a 9.2 lb/yr/capita. Likewise for TP, the estimated per capita loading factors were 0.4 to 1.6 and 1.2 lb/yr, respectively. The difference relies on the decreasing loading rate of nutrients present in the current composition of detergent supplies that were implemented in recent years.

WMM does not directly account for the impacts of failing septic tanks. Loadings from septic

tanks were included in the results from WMM by increasing the total TN and TP loads from low density residential land use by two percent.

Columbia County Septic Tanks

As of 2007, Columbia County had a cumulative registry of 23,490 septic systems. Data for septic tanks are based on 1970 – 2007 census results, with year-by-year additions based on new septic tank construction. The data do not reflect septic tanks that have been removed going back to 1970. From fiscal years 1991–2007 (no data for 1992 or 1993), an average of 230 permits/year for repairs was issued in Columbia County (Florida Department of Health, 2008). Based on the number of permitted septic tanks estimated for 2006 (23,490) and housing units (25,530) located in the county, approximately 8 percent of the housing units are connected to a central sewer line (i.e., wastewater treatment facility), with the remaining 92 percent utilizing septic tank systems.

4.3 Estimating Point and Nonpoint Source Loadings

4.3.1 Model Approach

The equations from WMM were incorporated into an EXCEL spreadsheet and utilized to estimate the nutrient loads within the Alligator Lake watershed as described previously. The results from the modeling are discussed in Chapter 5.

Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Determination of Loading Capacity

Nutrient enrichment and the resulting problems related to eutrophication tend to be widespread and are frequently manifested far (in both time and space) from their source. Addressing eutrophication involves relating water quality and biological effects (such as photosynthesis, decomposition, and nutrient recycling), as acted upon by hydrodynamic factors (including flow, wind, tide, and salinity) to the timing and magnitude of constituent loads supplied from various categories of pollution sources. The assimilative capacity should be related to some specific hydro-meteorological condition such as an 'average' during a selected time span or to cover some range of expected variation in these conditions.

The goal of this TMDL development is to identify the maximum allowable TN and TP loadings from the watershed, so that Alligator Lake will meet the narrative nutrient water quality and dissolved oxygen criteria and thereby maintain its function and designated use as a Class III water. In order to achieve the goal, the Department selected the WMM model to predict nutrient loadings from the watershed to the lake. A multi-variable empirical equation was then developed to relate the watershed loadings from WMM to the measured in-lake concentrations of Chla, TN, and TP. Annual Chla responses in the lake are predicted as a function of TN and TP concentrations proportional to watershed nutrient loads and to ultimately estimate the assimilative capacity of the lake.

5.1.1 Meteorological and Stage Data

Daily rainfall data for Alligator Lake were obtained from three different stations (**Table 5.1**) within the vicinity of Alligator Lake. **Figure 5.1** shows the annual average rainfall for each year of the verified period. The annual average rainfall contained in **Table 5.2** was used in the model.

Table 5.1 General Information on Weather Station for Alligator Lake

Location Name	Start Date	End Date	Frequency	Facility	County	Comment
Lake City 2 E	01/01/2000	12/31/2007	Daily	NOAA	Columbia	No data available for July 2000
02322601	07/20/2002	12/31/2007	Daily	SRWMD	Columbia	
Alachua	01/01/2000	12/31/2007	Daily	FWAN	Alachua	Data used for July, 2000

Table 5.2 Annual Rainfall Used in the Model

Year	Rainfall (inches)
2000	36.7
2001	42.3
2002	49.1
2003	58.9
2004	70.8
2005	56.7
2006	45.7
2007	38.3
average	49.8
Std*	11.7

* Std = standard deviation

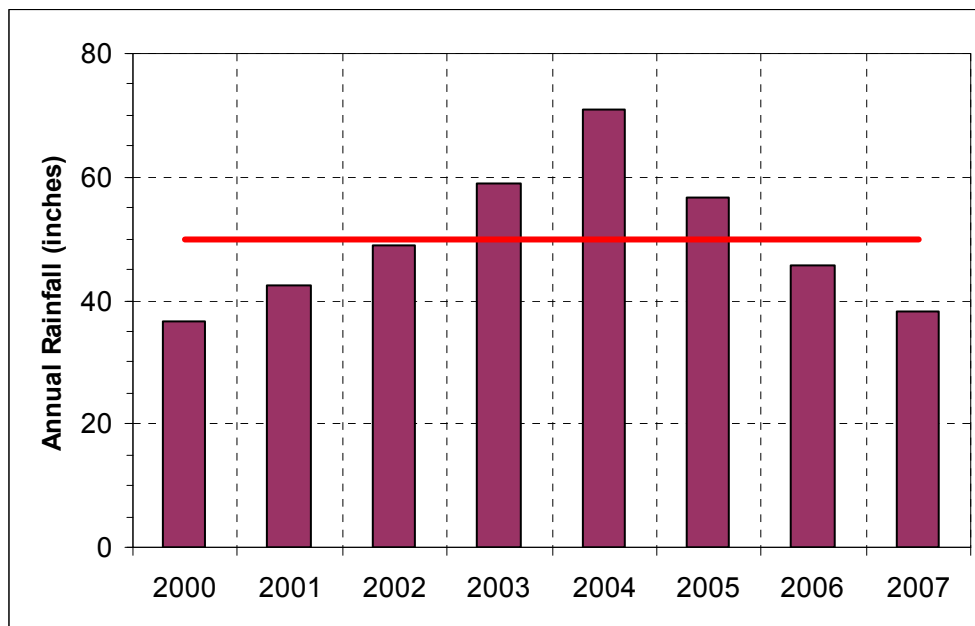


Figure 5.1 Total Annual Rainfall (Inches) Observed during the Verified Period of 2000-2007.

5.1.2 Model Calibration

Using the annual rainfall data, the WMM spreadsheet model was used to estimate the volume of water and the loading of TN and TP from the watershed. First, the annual runoff volume from the Price Creek Basin was modeled for the verified period of 2000-2007. Observed flow data was available for Price Creek for the years 2000 – 2004. The measured annual runoff volumes

varied significantly over the observed period, ranging from 1947 ac-ft/yr to 9421 ac-ft/yr (**Table 5.3**). These measured volumes are in good agreement with the simulated runoff volumes from the model as shown in **Table 5.3**. For the calibration, the calibrated runoff coefficients ranging from 0.80-0.99 for impervious areas and from 0.02-0.37 for pervious areas were used for the Price Creek Basin. Subsequent to the calibration of flows from the Price Creek sub-basin, the same DCIA and runoff coefficients (per each land use) were applied to the entire Alligator Lake watershed (Alligator Lake and Price Creek sub-basins) to produce runoff volumes, as shown in **Table 5.4** and TN and TP loads as shown in **Table 5.5**.

Table 5.3 Measured and Simulated Flows for the Price Creek Sub-Basin

Year	Price Crk Measured Flow (ac-ft/year)	Price Crk Basin Simulated Runoff (ac-ft/year)	Difference (ac-ft/yr)	% error (%)
2000	2016.1	2054.7	-38.6	1.91
2001	1947.0	2132.8	-185.8	9.54
2002	3028.9	3090.5	-61.6	2.03
2003	9420.6	9334.4	86.2	0.91
2004	9247.2	9249.9	-2.7	0.03
2005	N/A	7407.8	N/A	N/A
2006	N/A	2876.5	N/A	N/A
2007	N/A	2144.3	N/A	N/A
Average	5132.0	5172.5	-40.5	0.79
Std*	3860.2	3782.9		

* Std = standard deviation

Table 5.4 Simulated Flows for the Alligator Lake Watershed

Year	Alligator Lake Basin Simulated Flow (ac-ft/year)
2000	5307.8
2001	5562.3
2002	7907.1
2003	22936.0
2004	22921.4
2005	18356.6
2006	7359.6
2007	5539.2
Average	11986.2
Std*	7978.0

* Std = standard deviation

Table 5.5 Simulated TN and TP Loads for the Alligator Lake Watershed

Year	TN (lbs/yr)	TP (lbs/yr)
2000	21872	2864
2001	22653	2958
2002	32970	4328
2003	100476	13330
2004	99384	13157
2005	79591	10537
2006	30687	4028
2007	22825	2988
Average	59491	7862
Std*	37818	5032

* Std = standard deviation

Given the flows and loads calculated above, an empirical multi-variable equation was developed to predict the assimilative capacity of the lake, using the long-term water quality data from 1989 – 2007. During review of the data several results were identified as possible outliers. In order to reduce the statistical noise these data introduced into the overall data set, four of 237 sampling events (1.7%) for Chla were censored. For example, on March 29, 2007, the Chla data indicate the same lake had concentrations ranging from 1 ug/L to 1400 ug/L corrected Chla. Only one sampling event out of ~ 567 events (0.1%) was censored for TN and TP. Using best professional judgment, these data, contained in **Table 5.6**, were removed from the overall data set used to develop the multi-variable equation. Additionally, there were no corrected Chla results from August 2002 through December 2005, and for selected dates during 2006 and 2007. The uncorrected Chla results were incorporated with the TN and TP data for these dates. **Table 5.7** depicts the uncorrected Chla data as highlighted, while **Figures 5.4** and **5.5** depict the uncorrected Chla data as UChla. The equation was derived from the Chla to TN to TP relationship, showing that Chla is well correlated to TN and TP with $r = 0.852$ for n equals 94. Based on the equation below, Chla can be predicted (as well as TSI) as a function of the TN and TP concentrations proportional to the TN and TP loadings to the lake.

$$\text{Equation Chla} = 29.74 \cdot \text{TN} + 91.66 \cdot \text{TP} - 30.0$$

Table 5.6 Data Not Used In Development of the Multi-Variable Regression Equation

Parameter	Station	Date	Depth	Method	Result	Units
CHLAC	21FLBRA 3516A-B	3/29/2007	0.20	32209	1400	ug/L
CHLAC	21FLBRA 3516A-B	3/29/2007	0.20	32209	91	ug/L
CHLAC	21FLBRA 3516A-A	3/29/2007	0.20	32209	1	ug/L
TN	21FLBRA 3516A-B	3/29/2007	0.20	600	110.0	mg/L
TN	21FLBRA 3516A-B	3/29/2007	0.20	600	40.0	mg/L
TN	21FLBRA 3516A-A	3/29/2007	0.20	600	1.71	mg/L
TP	21FLBRA 3516A-B	3/29/2007	0.20	665	8.3	mg/L
TP	21FLBRA 3516A-B	3/29/2007	0.20	665	3.5	mg/L
TP	21FLBRA 3516A-A	3/29/2007	0.20	665	0.49	mg/L
CHLAC	21FLSUW ALL010C1	11/19/1990	0.66	32211	1	ug/L
CHLAC	21FLSUW ALL030C1	12/3/1990	0.33	32211	36.4	ug/L
CHLAC	21FLSUW ALL020C1	12/3/1990	0.33	32211	661	ug/L
CHLAC	21FLSUW ALL030C1	6/5/1989	0.66	32211	67	ug/L
CHLAC	21FLSUW ALL020C1	6/5/1989	1.97	32211	810	ug/L
CHLAC	21FLSUW ALL020C1	6/5/1989	0.66	32211	530	ug/L

Table 5.7 Chla data. Highlighted Data are Uncorrected Chla Results. All other Results are Corrected Chla

Date	CHLA	Date	CHLA	Date	CHLA
2/6/1989	54.08333	7/23/1997	6.75	4/1/2003	15.2
4/3/1989	121.15	8/8/1997	17.7	6/16/2003	2.67
8/7/1989	185	10/3/1997	32.5	8/11/2003	7.99
12/4/1989	33.26667	10/19/1998	15.075	10/1/2003	10.965
2/5/1990	70.4	11/10/1998	20.17333	2/12/2004	4.003333
3/5/1990	13.26667	12/8/1998	21.9	4/5/2004	66.2025
4/9/1990	11.36667	1/18/1999	4.333333	6/17/2004	134.805
5/7/1990	10.06	2/1/1999	8.325	8/17/2004	26.43333
6/4/1990	62.668	3/1/1999	14.43333	10/11/2004	52.325
7/9/1990	77.45	7/7/1999	9.8	12/8/2004	13.85667
8/6/1990	39	8/10/1999	80	2/15/2005	18.05667
8/7/1990	180	9/7/1999	17	4/5/2005	9.5475
9/4/1990	366.775	10/20/1999	21.66667	6/13/2005	1.023333
10/8/1990	258.6	12/8/1999	1.3	8/3/2005	39.96667
11/5/1990	362.3	2/14/2000	8.6	10/10/2005	39.225
12/3/1990	348.7	4/5/2000	9.5	12/8/2005	2.646667
1/7/1991	13.2	6/6/2000	21.7	12/28/2005	41
2/4/1991	49.424	8/15/2000	35.6	1/18/2006	30.06667
3/4/1991	10.635	10/2/2000	26.3	2/14/2006	21.76667
4/8/1991	34.26	12/7/2000	4.6	3/22/2006	148.6667
5/6/1991	43.16667	2/14/2001	2.8	4/3/2006	56.55
6/3/1991	38.82	6/14/2001	39.4	4/4/2006	97.66667
7/8/1991	25.75	8/7/2001	39.7	5/9/2006	80.66667
8/5/1991	57.83333	10/16/2001	7.1	6/20/2006	243.3333
9/19/1991	90.83333	12/11/2001	3.2	6/26/2006	13.55
1/31/1997	10.45	2/18/2002	1.6	7/26/2006	52.25
2/24/1997	18.65	4/1/2002	98.46667	8/7/2006	42.72667
3/21/1997	22.625	6/19/2002	16.75	9/13/2006	71
4/15/1997	71	8/19/2002	15.55	10/3/2006	35.5
5/16/1997	6.93	10/16/2002	4.4	2/19/2007	8.283333
6/18/1997	8.5625	12/10/2002	5.87	4/2/2007	14.8
				4/5/2007	12

Figure 5.2 depicts a strong relationship (R^2 0.63) between Chla and TP in the lake. **Figure 5.3** depicts an even stronger relationship (R^2 0.72) between Chla and TN in the lake. **Figure 5.4** compares the results from predicting Chla from TN to the measured Chla concentration. This graph supports a conclusion that the equation is well calibrated. **Figure 5.5** compares the results of predicting Chla from TP to the measured Chla concentration. This graph supports a conclusion that the equation is well calibrated.

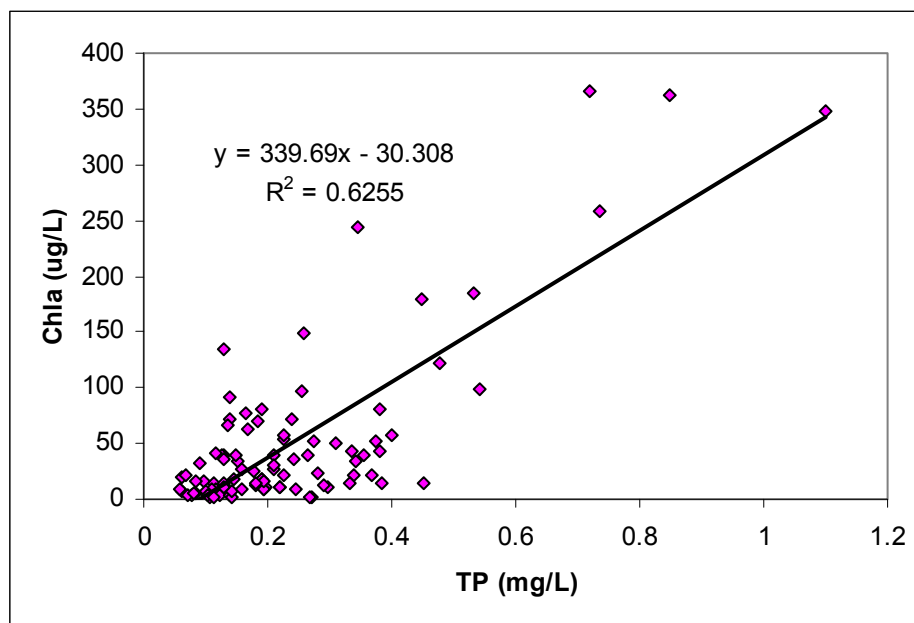


Figure 5.2. Relationship between Chla and TP observed in Alligator Lake from February, 1989 to April, 2007

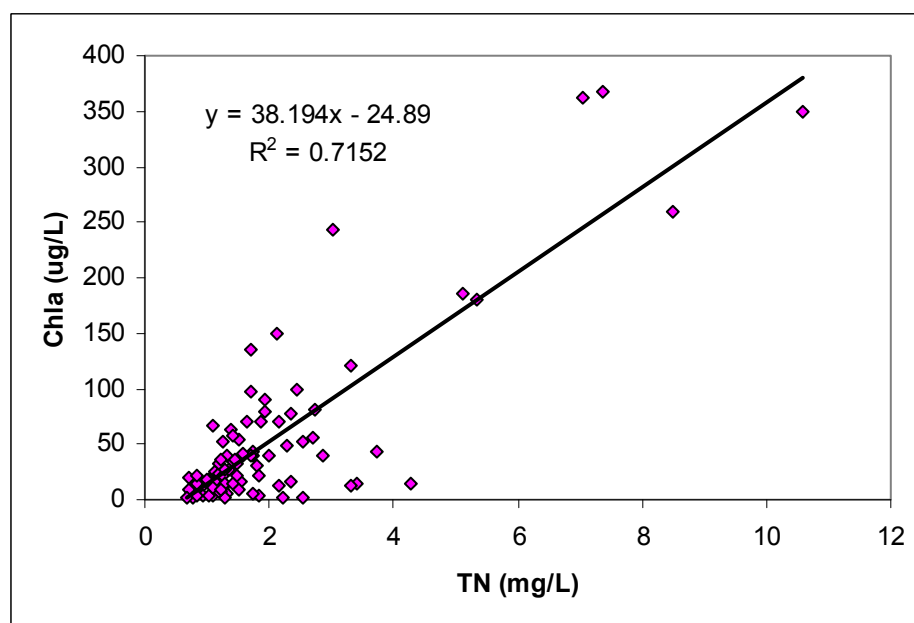


Figure 5.3 Relationship between Chla and TN observed in Alligator Lake from February, 1989 to April, 2007

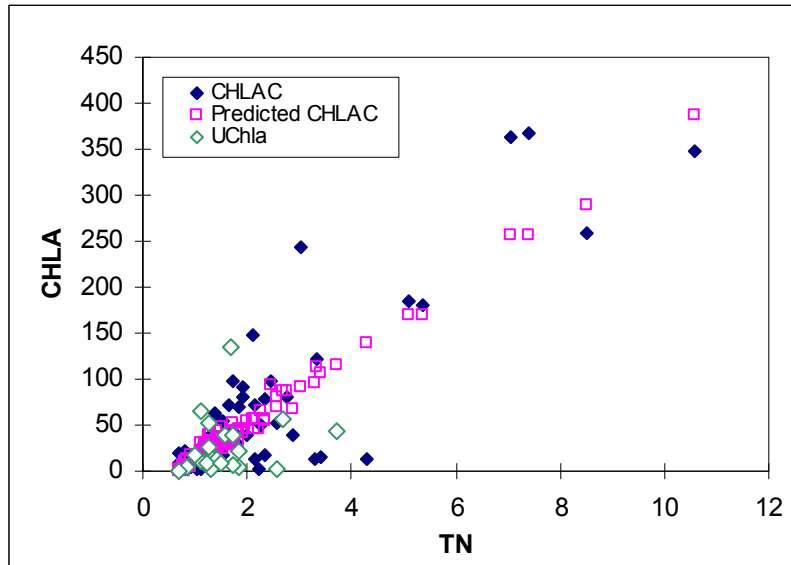


Figure 5.4 Predicted versus Observed Chla as a function of observed TN concentration
 * UChla = uncorrected Chla values

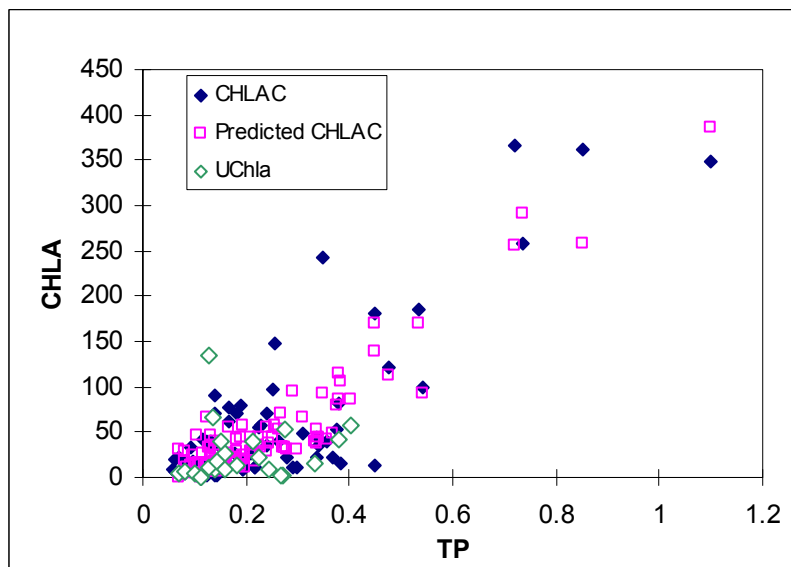


Figure 5.5 Predicted versus Observed Chla as a function of observed TP concentration
 * UChla = uncorrected Chla values

5.2 Selection of TMDL Target

Using the WMM based spreadsheet model and the Chla predictive equation developed for existing conditions, all human land uses in the watershed were assigned a natural land use category based on the current proportion of natural land uses in the watershed and the models were run for the natural land use background condition. The results for existing measured condition, existing calibrated models, and the natural land use condition are in **Table 5.8**.

Table 5.8
Measured Data, Regression Model, Natural Land Use
Chla, TN, TP, and TSI

Scenario	Chla (ug/L)	TN (mg/L)	TP (mg/L)	TSI	TN/TP
Existing Measured Data	33.5	1.62	0.191	68.7	8.5
Existing Model Predicted	35.7	1.62	0.191	69.1	8.5
Natural Land Use	6.9	1.06	0.059	51.0	17.9

Table 5.9 contains the acreages of natural land uses incorporated into the natural background loading analysis. **Table 5.10** contains the estimated TN and TP loadings to Alligator Lake under natural land use conditions.

Table 5.9
Natural Background Land Use

Land Use Category	Area (acres)
Upland Forest/Open	5329
Water*	1178
Wetland	3147

*Note: Acreage of water does not include area of Alligator Lake

As explained in Section 3.2, the Department has selected the TSI plus 5 from the natural land use predictions ($51.0 + 5 = 56.0$) as the target for TMDL development.

Table 5.10 Natural Background Annual TN and TP loads

Year	TN (lbs/yr)	TP (lbs/yr)
2000	13518	914
2001	13732	949
2002	20767	1374
2003	68094	4147
2004	66381	4110
2005	53161	3292
2006	19329	1279
2007	14107	954
Average	39275	2464
Std*	26140	1557

* Std = standard deviation

5.3 Simulations for TMDL Load Reduction

The load reductions were obtained from the difference in the loads between the existing conditions versus the background land use conditions. Then the percent reductions were applied to get the TN and TP concentrations predicted for the natural background conditions. Based on the multiple regression equation ($Chla = 29.74 \cdot TN + 91.66 \cdot TP - 30.0$) and estimated TN and TP load reductions under different scenarios, TSI for Alligator Lake was thereby calculated using predicted Chla, TN and TP until the TSI of 56.0 was achieved. The in-lake concentrations for Chla, TN, and TP that result in attaining the target TSI are 11.3 ug/L, 1.16 mg/L, and 0.074 mg/L respectively. The load reduction required to achieve the TSI target of 56.0 (assuming loading is proportional to the in-lake concentrations of TN and TP) is 28.4 percent for TN and 61.2 percent for TP. The existing annual average load for TN is 59,491 lbs/year. A 28.4 percent reduction of TN is 16,895 lbs/year, resulting in an annual average allowable TN load of 42,595 lbs/year or 116.7 lbs/day. The existing annual average load for TP is 7,862 lbs/year. A 61.2 percent reduction of TP is 4,811 lbs/year, resulting in an annual average allowable TP load of 3,050 lbs/year or 8.36 lbs/day.

Chapter 6: DETERMINATION OF THE TMDL

6.1 Expression and Allocation of the TMDL

A TMDL can be expressed as the sum of all point source loads (wasteload allocations or WLAs), nonpoint source loads (load allocations or LAs), and an appropriate margin of safety (MOS) that takes into account any uncertainty about the relationship between effluent limitations and water quality:

As mentioned previously, 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 also differs from the permitting of most wastewater point sources. Because stormwater discharges cannot be centrally collected, monitored, and treated, they are not subject to the same types of effluent limitations as wastewater facilities, and instead are required to meet a performance standard of providing treatment to the “maximum extent practical” through the implementation of Best Management Practices.

This approach is consistent with federal regulations [40 CFR § 130.2(I)], which state that TMDLs can be expressed in terms of mass per time (e.g. pounds per day), toxicity, or **other appropriate measure**. The TMDL for Alligator Lake is expressed in terms of pounds per year (converted from kilograms per year as shown in Chapter 5) and percent reductions, and represent the long-term annual average load of TN and TP the waterbody can assimilate and maintain the Class III narrative nutrient criterion (**see Table 6.1**).

Table 6.1 Alligator Lake TMDL Load Allocations

WBID	Parameter	WLA		LA (lbs/year)	MOS	TMDL (lbs/year)	Percent Reduction
		Wastewater (lbs/year)	Stormwater (% reduction)				
3516A	TN	N/A	N/A	42,595	Implicit	42,595	28.4 %
3516A	TP	N/A	N/A	3,050	Implicit	3,050	61.2 %

N/A – Not Applicable

*The load reductions of TN and TP will correct the impairments for nutrients and dissolved oxygen. The allowable loads as pounds/day are for TN 116.7 lbs/day and for TP 8.36 lbs/day. Achieving a long-term TSI of 56.0 results in an average Chla of 11.3 ug/L, TN of 1.16 mg/L, TP of 0.074 mg/L, and a TN/TP ratio of 15.7.

6.2 Load Allocation (LA)

The allowable LA is 42,595 lbs/year for TN and 3,050 lbs/year for TP. This corresponds to reductions from the existing loadings of 28.4 percent for TN and 61.2 percent for TP. It should be noted that the LA may include loading from stormwater discharges regulated by the Department and the Water Management District that are not part of the NPDES Stormwater Program (see **Appendix A**).

6.3 Wasteload Allocation (WLA)

NPDES Wastewater Discharges

As noted in Chapter 4, Section 4.2.1, there are no active National Pollutant Discharge Elimination System (NPDES) permitted facilities that have a direct surface water discharge to Alligator Lake. The only NPDES surface water discharger within the watershed is Westvaco (FL) located along the edge of the watershed. The permit describes the discharge as part of a ground water remediation project with a discharge to a ditch, to a creek that then runs to Alligator Lake. It is not anticipated that the discharge from this facility is impacting Alligator Lake and therefore no reductions for TN or TP are proposed.

NPDES Stormwater Discharges

There are no known NPDES stormwater dischargers covered under any MS4 permit. Any future MS4 permittee will need to meet the TMDL load reductions in **Table 6.1**. It should be noted that any MS4 permittee will only be responsible for reducing the loads associated with stormwater outfalls that it owns or otherwise has responsible control over, and it is not responsible for reducing other nonpoint source loads in its jurisdiction.

6.4 Margin of Safety (MOS)

TMDLs must address uncertainty issues by incorporating a MOS into the analysis. The MOS is a required component of a TMDL and accounts for the uncertainty about the relationship between pollutant loads and the quality of the receiving waterbody [Clean Water Act, Section 303(d)(1)(c)]. Considerable uncertainty is usually inherent in estimating nutrient loading from nonpoint sources, as well as predicting water quality response. The effectiveness of

management activities (e.g., stormwater management plans) in reducing loading is also subject to uncertainty.

The MOS can either be implicitly accounted for by choosing conservative assumptions about loading or water quality response, or explicitly accounted for during the allocation of loadings. Consistent with the recommendations of the Allocation Technical Advisory Committee (Florida Department of Environmental Protection, February 2001), an implicit margin of safety (MOS) was used in the development of the Alligator Lake TMDL. An implicit MOS was used because the TMDL was based on the conservative decisions associated with a number of the modeling assumptions and allowing only a 5 TSI unit increase in trophic state above natural background conditions. The IWR allows for a 10 TSI unit increase over background conditions. Therefore, establishing the TMDL TSI target with only a 5 TSI unit increase incorporates an additional 5 TSI units into the margin of safety and to allow for future changes in determining the assimilative capacity (i.e., loading and water quality response) for Alligator Lake. Additionally, the estimates of septic tank failures were set to the maximum values instead of the mean values.

6.5 Evaluation of TMDL on Dissolved Oxygen

Alligator Lake is expected to attain water quality standards following implementation of the TMDL for nutrients, because the Lake TMDL will require a 28.4 percent reduction in TN loadings, a 61.2 percent reduction in TP loadings, and result in a 66.4 percent reduction in Chla (from 33.5 ug/L to 11.3 ug/L). These reductions will significantly improve overall water quality in the Lake, including DO levels. For example, the proposed nutrient reductions for the Lake are predicted to decrease algal biomass from the current Chla average in the Lake of 33.5 µg/L to approximately 11.3 µg/L. This will have a positive affect on reducing the diurnal fluctuations in DO and improve the DO levels of water in the lake. These in-lake reductions in algal biomass (66.4%) will reduce the DO fluctuations and the BOD that results from the breakdown of the algal cells in the lake by a relative amount. As the total BOD is composed of both a carbonaceous fraction and a nitrogenous fraction, additional reductions in BOD will occur as a result of reducing the mass of TN entering the Lake by 28.4 percent.

6.6 Evaluation of TMDL on BOD

The high BOD's measured in Alligator Lake are contributing to the low DO. These high values could in part be related to the occasionally high Chla concentrations measured in the lake. The lake is described as containing large areas of emergent vegetation; it could be that some fraction of the total BOD is also related to senescing "natural" macrophyte derived biomass. Once, the external sources of BOD and nutrients (from stormwater, agricultural, and any remaining wastewater contributions) are reduced through implementation of the TMDL, it is expected that the in-lake BOD concentrations will be reduced to levels that attain water quality standards.

Chapter 7: 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 Alligator Lake watershed. 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 (BMAP) 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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Appendices

Appendix A: Background Information on Federal and State Stormwater Programs

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, F.S., was established as a technology-based program that relies on 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. In 1994, the Department's stormwater treatment requirements were integrated with the stormwater flood control requirements of the state's water management districts, along with wetland protection requirements, into the Environmental Resource Permit regulations.

Chapter 62-40, F.A.C., also requires the state's 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.

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 permitting program to designate certain stormwater discharges as "point sources" of pollution. The EPA promulgated regulations and began implementation of the Phase I NPDES stormwater program in 1990. 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, the EPA implemented Phase I of the MS4 permitting program on a countywide basis, which brought in all cities (incorporated areas), Chapter 298 urban water control districts, and the Florida Department of Transportation throughout the fifteen counties meeting the population criteria. EPA authorized the Department to implement the NPDES stormwater program (with the exception of Indian lands) in October 2000.

An important difference between the NPDES and other state stormwater permitting programs is that the NPDES program covers both new and existing discharges, while the other state programs focus on new discharges only. Additionally, Phase II of the NPDES Program, implemented in 2003, expands the need for these permits to construction sites between one and five acres, and to local governments with as few as 1,000 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 cannot be easily collected and treated by a central treatment facility similar to other point sources of pollution, such as domestic and industrial wastewater discharges. It should be noted that all MS4 permits issued in Florida include a re-opener clause that allows permit revisions to implement TMDLs when the implementation plan is formally adopted.

Appendix B: TN, TP, Chlorophyll a Raw Data, and WMM input information used in the TMDL Analysis for Alligator Lake

All data, copies of the model and model input decks used to produce the Alligator Lake TMDL report are available upon request.

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