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FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Division of Water Resource Management, Bureau of Watershed Management

SOUTHWEST DISTRICT • LAKE HANCOCK BASIN • PEACE RIVER PLANNING UNIT

TMDL Report

Nutrient TMDL For Lake Bonny

WBID 1497E

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Acknowledgments

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Identification of Impaired Surface Waters Rule

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Chapter 1: INTRODUCTION

1.1 Purpose of Report

This report presents the TMDL for nutrients for Lake Bonny. The lake was verified as impaired by nutrients 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 Lake Hancock Basin that was adopted by Secretarial Order on June 17, 2005. The TMDL establishes the allowable loadings to the lake that would restore the waterbody so that it meets its applicable water quality criteria for nutrients.

1.2 Identification of Waterbody

Lake Bonny is located inside the City of Lakeland, Polk County, Florida, at Latitude 28^{o} 02” 21’ and Longitude 81^{o} 55” 38’, Section 20, Township 28 S, Range 24 E (**Figure 1.1**). The lake is in the Lake Parker sub-basin, which is located in the Lake Hancock Basin, which in turn contributes to the Lower Saddle Creek watershed and ultimately the Upper Peace River, Charlotte Harbor and the Gulf of Mexico. The estimated surface area of the Lake is 370 acres, with an average lake volume of 1,475,940 m^3 (389,943,348 gal). Lake Bonny’s surface area includes Little Lake Bonny and the marsh on the west side of the lake. The surface area for Lake Bonny alone is approximately 246 acres. Average depth of the lake is 3.2 ft (0.9 m), with maximum depths ranging from 8 – 10 ft. The surface water drainage basin area of the lake is approximately 2.4 square miles or 1,512 acres. The historic average topographic elevation of the water surface is 129.4 feet National Geodetic Vertical Datum (NGVD).

For assessment purposes, the Department has divided the Lake Hancock Basin into watershed assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or stream reach. Lake Bonny has been given the WBID number 1497E. The Lake Bonny WBID and its sampling/monitoring stations are illustrated in **Figure 1.2.**

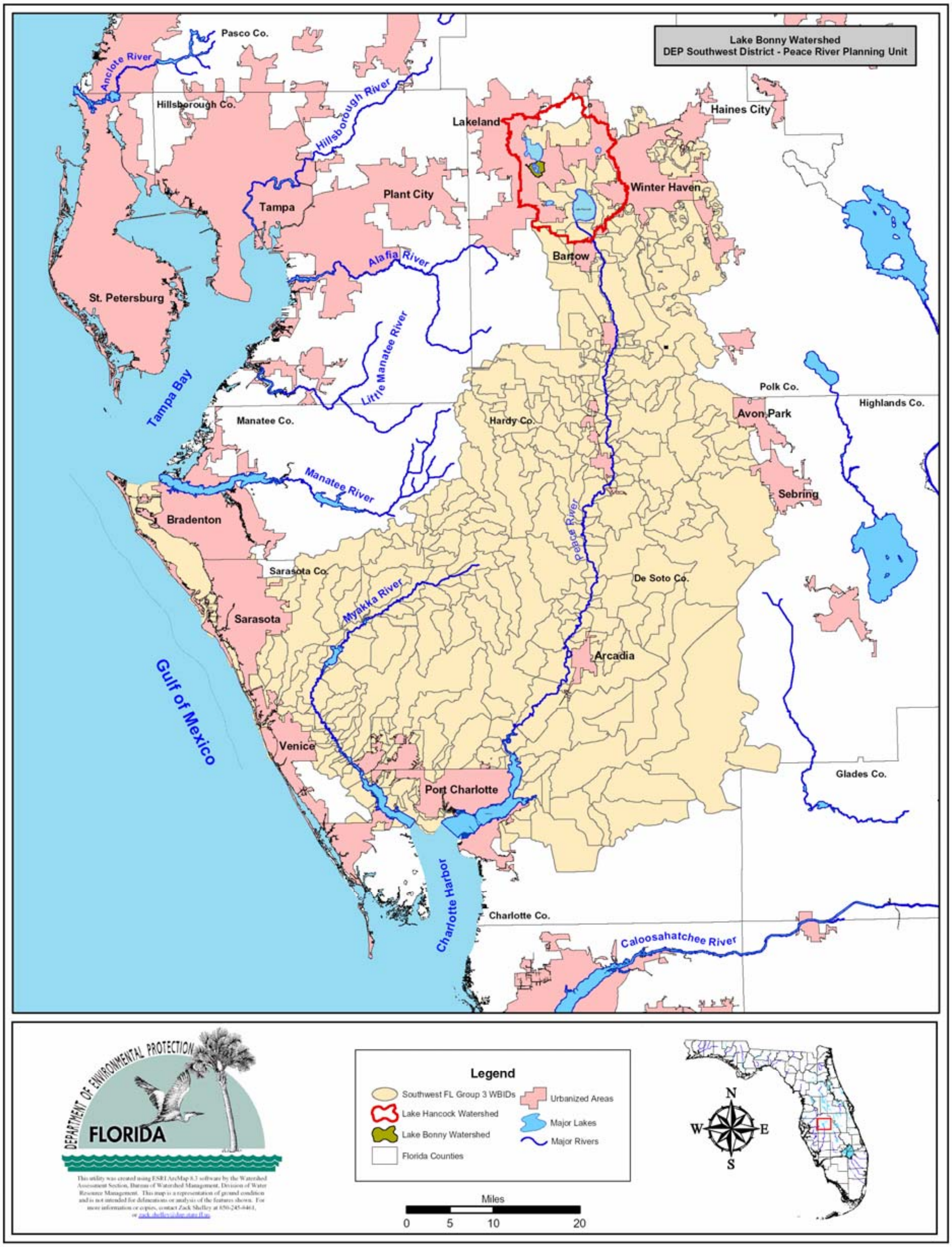

Figure 1.1 Southwest Florida Group 3 WBIDs and Major Metropolitan Areas Surrounding the Lake Hancock Watershed and the Lake Bonny Watershed

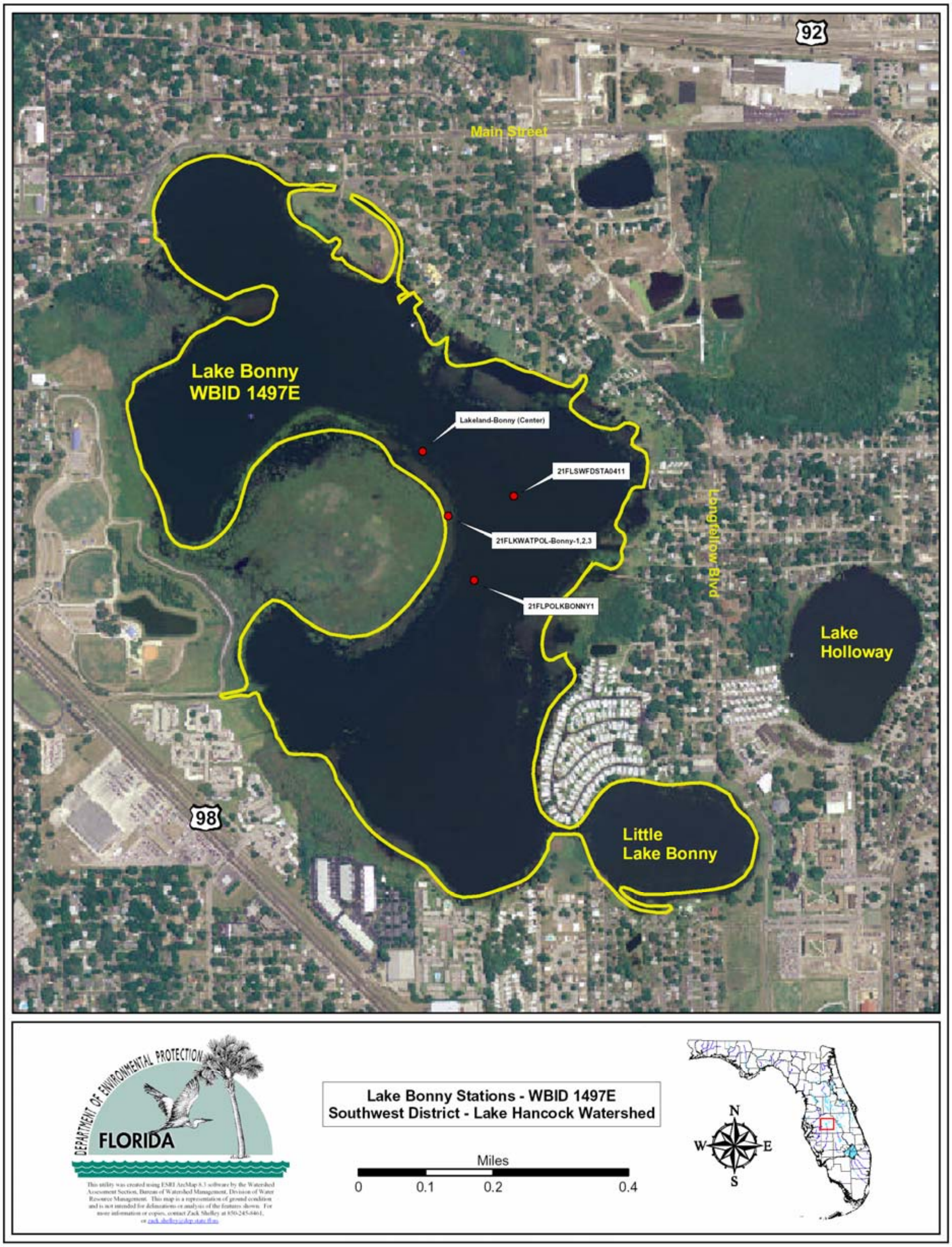

Figure 1.2 Lake Bonny WBID 1497E and Monitoring Stations

1.3 Background Information

Historically, Lake Bonny and Little Lake Bonny were naturally land-locked and disconnected seepage lakes. However, in the mid 1920's, Lake Bonny and Little Lake Bonny were connected to each other and Lake Parker via canals. Little Lake Bonny receives inflow from Lake Holloway via a pipe, with Lake Bonny discharging into Lake Parker. A small unnamed canal connects with Lake Bonny in the southwest sector of the lake. A public park and boat ramp are located on the north shore of the lake with another park located on the west shore (City of Lakeland, 2001).

For TMDL modeling purposes, Lake Bonny and its watershed were incorporated into the Lake Parker sub-basin. The Lake Bonny and Parker watersheds contribute water quantity and quality to Lake Hancock and Lower Saddle Creek. The Lake Parker sub-basin is one of nine major sub-basins delineated for modeling in the Lake Hancock Basin (see **Figure 1.3**). The Lake Parker sub-basin (which includes Lake Bonny) has a surface water drainage area of approximately 23.8 square miles or 15,231 acres. The TMDL development methodology for Lake Bonny is described in Chapter 4.

The TMDL Report for Lake Bonny 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 waterbody'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 the South Florida Water Management District (SWFWMD), Polk County, 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.

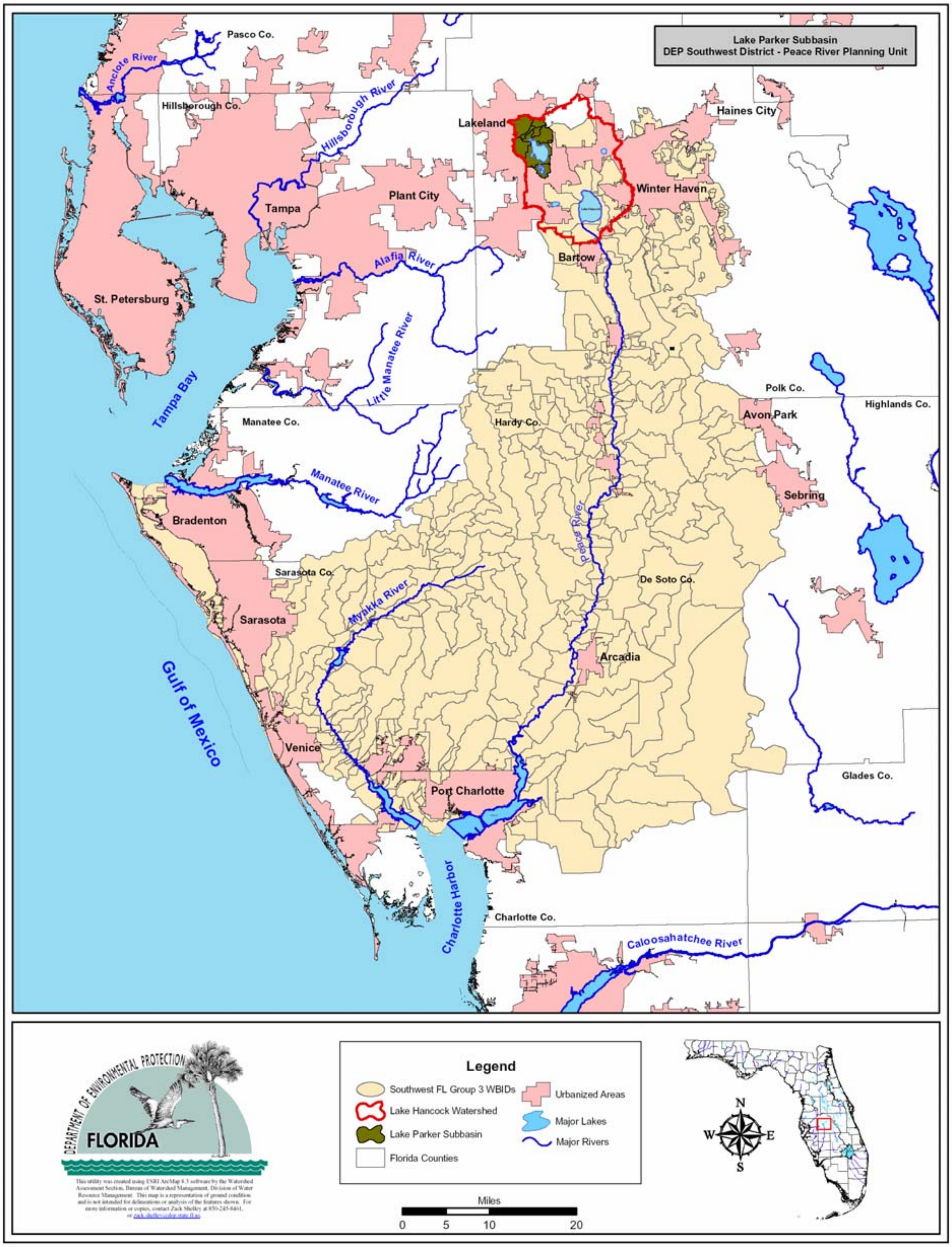

Figure 1.3 Southwest Florida Group 3 WBIDs and Major Metropolitan Areas Surrounding the Lake Hancock Watershed and the Lake Parker Sub-basin

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 Florid 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.

Florida's 1998 303(d) list included 52 waterbodies in the Peace River Planning Unit with 11 of those waterbodies in the Lake Hancock Basin. 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. After a long rulemaking process, the Environmental Regulation Commission adopted the new methodology as Chapter 62-303, Florida Administrative Code (F.A.C.) (Identification of Impaired Surface Waters Rule, or IWR), in April 2001.

2.2 Information on Verified Impairment

The Department used the IWR to assess water quality impairments in Lake Bonny, and the lake was verified as impaired for nutrients based on elevated annual average Trophic State Index (TSI) values over the verification period (the Verified Period for the Group 3 basins is from January 1, 1997 to June 30, 2004). The IWR methodology uses the water quality variables total nitrogen (TN), total phosphorus (TP), and chlorophyll a (a measure of algal mass, corrected and uncorrected) in calculating annual TSI values and in interpreting Florida's narrative nutrient threshold. The TSI is calculated based on concentrations of TP, TN, and chlorophyll a as follows:

TSI Formula

$CHLA_{TSI} = 16.8 + 14.4 * LN(Chl\ a)$ — Chlorophyll a in µg/L
$TN_{TSI} = 56 + 19.8 * LN(N)$ — Nitrogen in mg/L
$TN2_{TSI} = 10 * [5.96 + 2.15 * LN(N + 0.0001)]$ — Phosphorus in mg/L
$TPTSI = 18.6 * LN(P * 1000) – 18.4$
$TP2_{TSI} = 10 * [2.36 * LN(P * 1000) – 2.38]$

If N/P > 30, *then* $NUTR_{TSI} = TP2_{TSI}$
If N/P < 10, *then* $NUTR_{TSI} = TN2_{TSI}$
if 10< N/P < 30, *then* $NUTR_{TSI} = (TP_{TSI} + TN_{TSI})/2$

$TSI = (CHLA_{TSI} + NUTR_{TSI})/2$ — Note: TSI has no units

For modeling purposes, the analyses of the eutrophication-related data for Lake Bonny used "all" of the available data from 1984 – 2004 for which records of TP, TN, and chlorophyll *a* were sufficient to calculate seasonal and annual average conditions. However, to calculate the TSI for a given year under the IWR, there must be at least one sample of TN, TP, and chlorophyll *a* taken at the same time period in each season of the year. The absence of data from all four seasons for the planning and verified periods caused the elimination of the years 1992 to 1995 and 2003 from the analysis of TSI for Lake Bonny.

Figure 2.1 displays annual average TSI values for all data (which includes Lakewatch data) from 1984 to 2004, and IWR planning and verified period TSI values from 1996 to 2002 (does not include Lakewatch data). As the verified period ends in June of 2004, annual averages were not calculated for 2004 in the assessment used to prepare the verified list, but are displayed in **Figure 2.1** for review. Planning and verified period annual average TSI values exceeded the IWR threshold level of 60 from 1996 to 2002 and averaged 76.71 for those seven years. Exceeding 60 in any one year of the verified period is sufficient in determining the impairment for a lake for nutrients. For Lake Bonny, all annual mean TSI values (1996 to 2002) exceeded 60.

Monthly and annual average TN results for Lake Bonny from 1992 to 2004 are displayed in **Figures 2.2** and **2.3,** respectively. Monthly and annual average TP results from 1992 to 2004 are displayed in **Figures 2.4** and **2.5**. Monthly and annual average chlorophyll *a* results from 1992 to 2004 are displayed in **Figures 2.6** and **2.7**. Values for TN for Lake Bonny from 1992 to 2004 were typically highest during the months of March, June and September. Values for TP were highest during the months of March, June, and September. Values for Chlorophyll *a* were highest during the months of June and September.

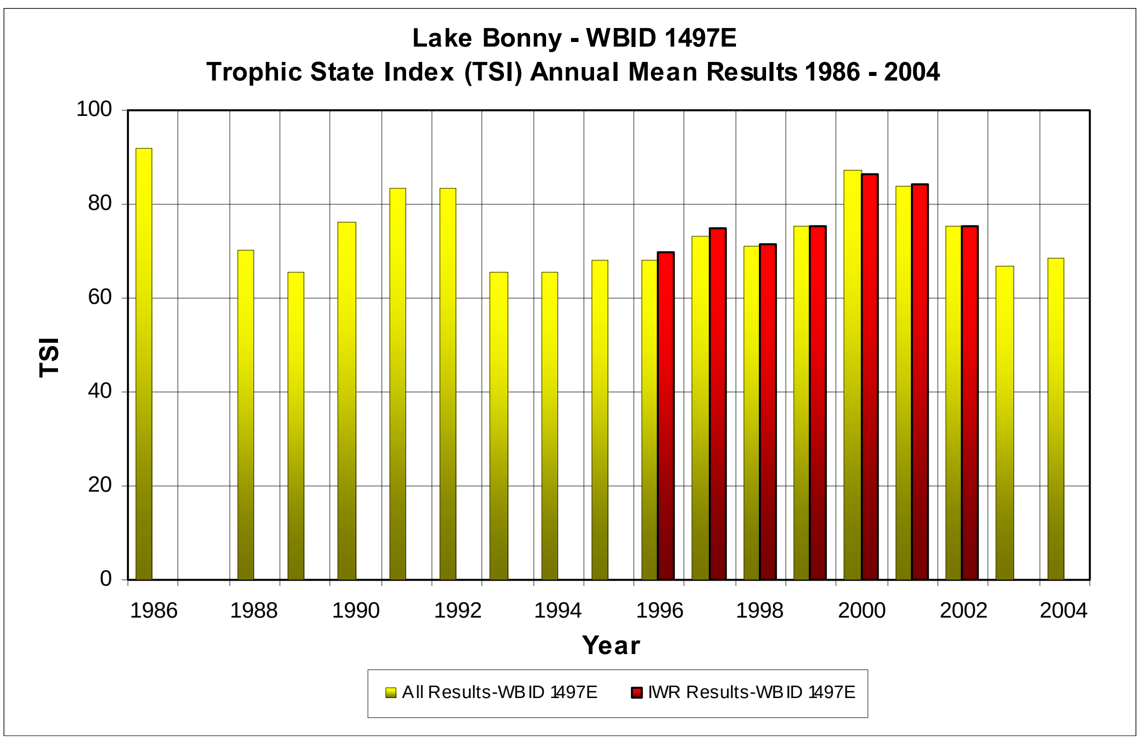

Figure 2.1 TSI Results for Lake Bonny Calculated from Annual Average Concentrations of TP, TN, and Chlorophyll *a* from 1986 to 2004.

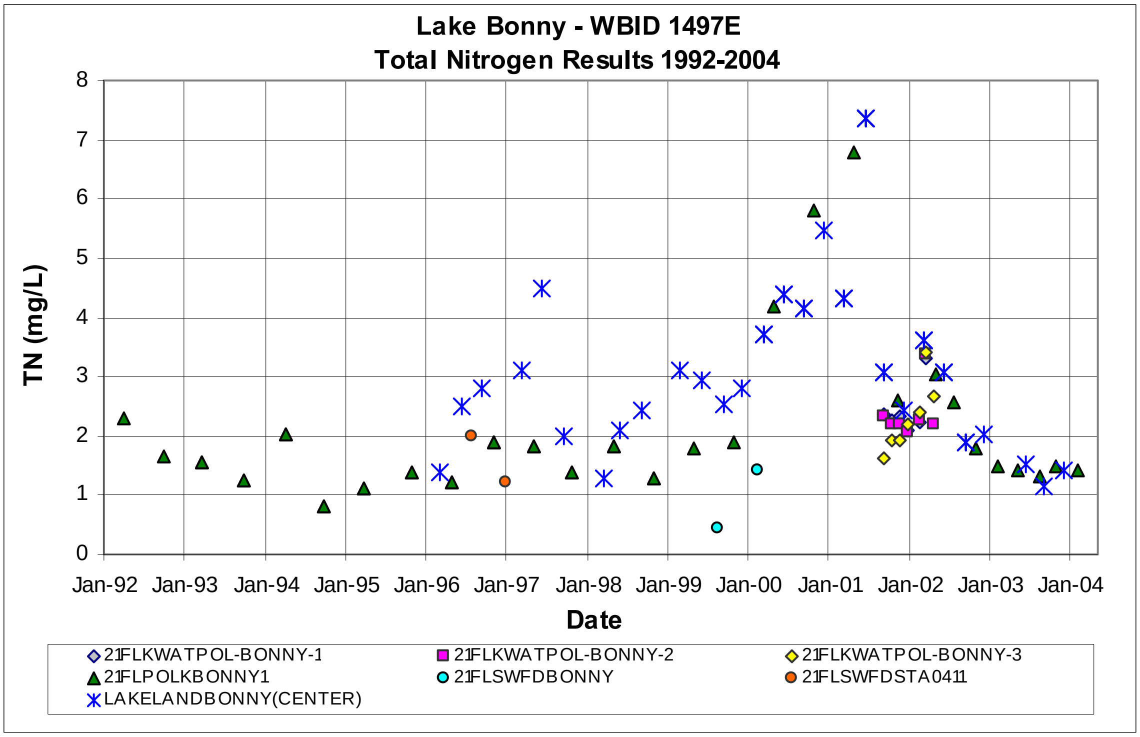

Figure 2.2 Total Nitrogen Monthly Results for Lake Bonny from 1992 to 2004

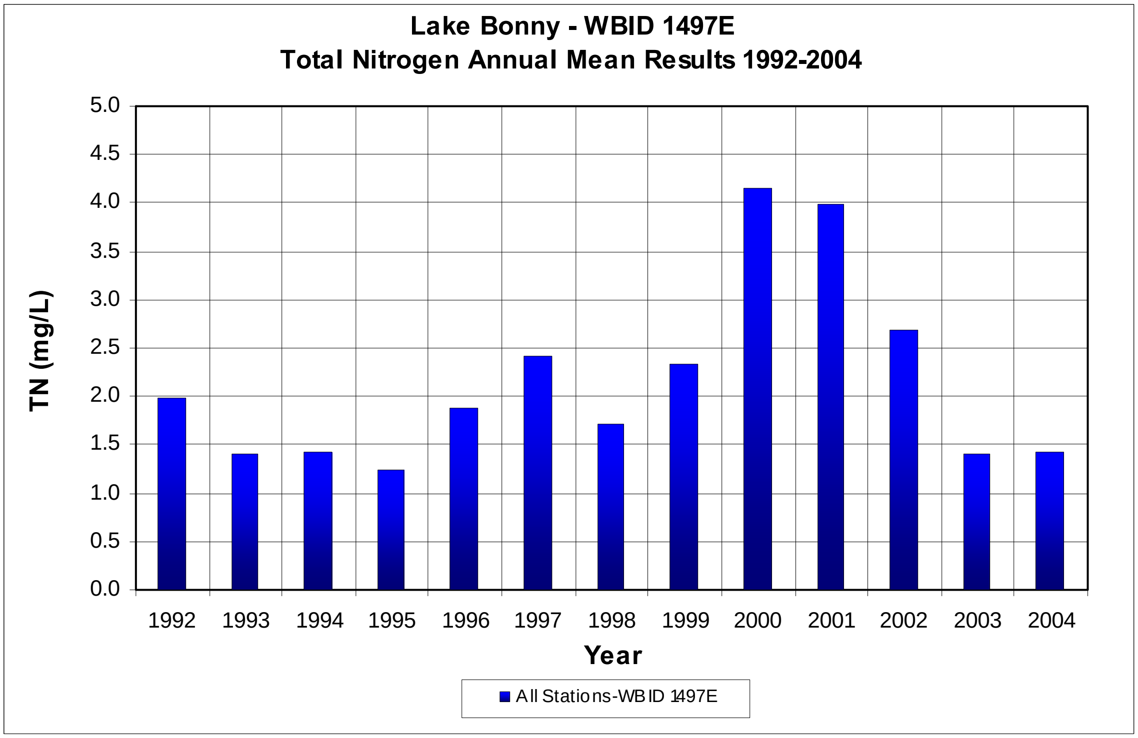

Figure 2.3 Total Nitrogen Annual Mean Results for Lake Bonny from 1992 to 2004

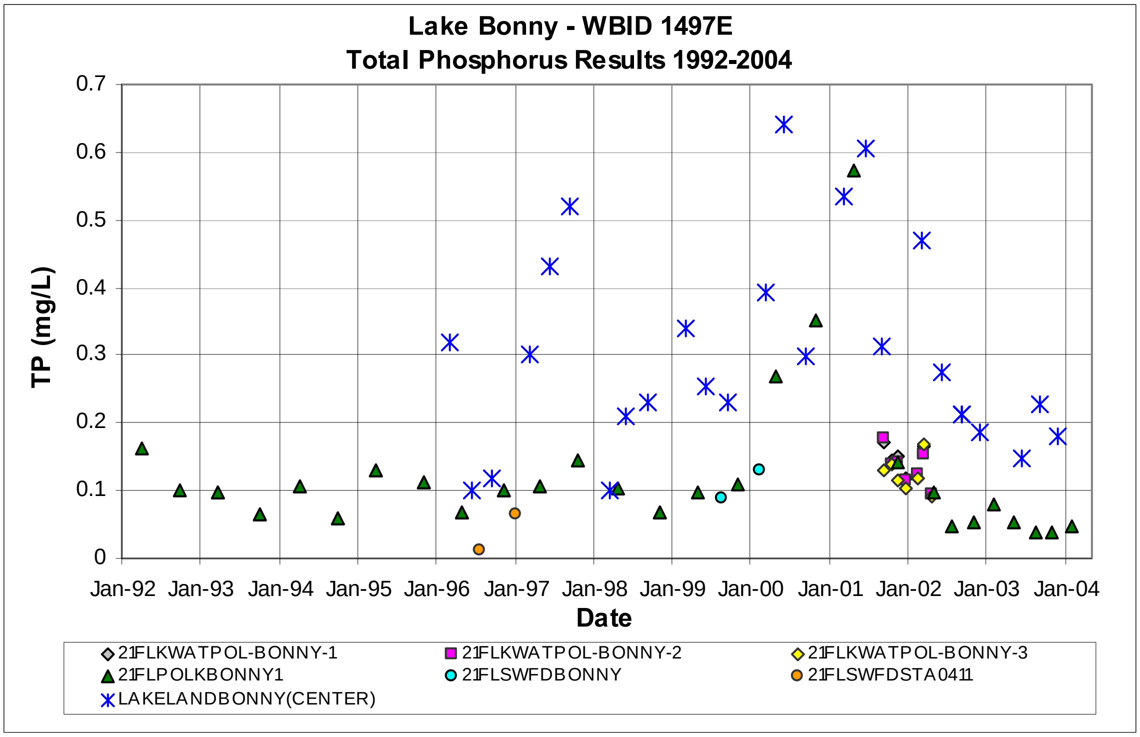

Figure 2.4 Total Phosphorus Monthly Results for Lake Bonny from 1992 to 2004

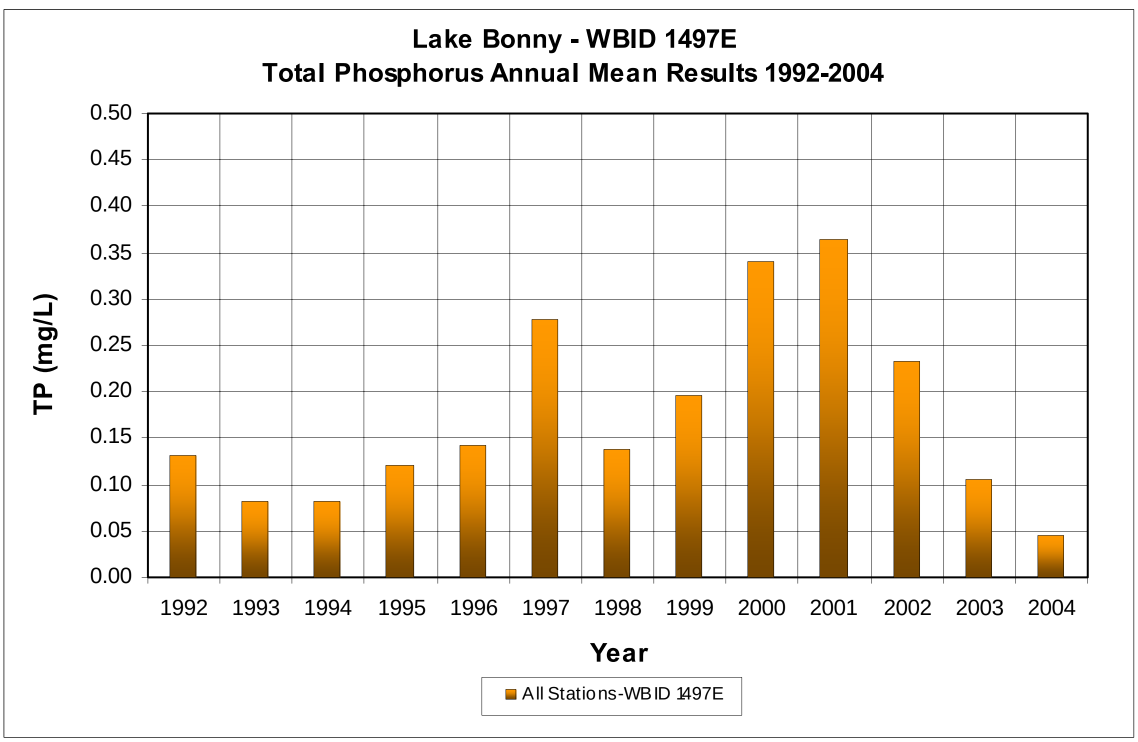

Figure 2.5 Total Phosphorus Annual Mean Results for Lake Bonny from 1992 to 2004

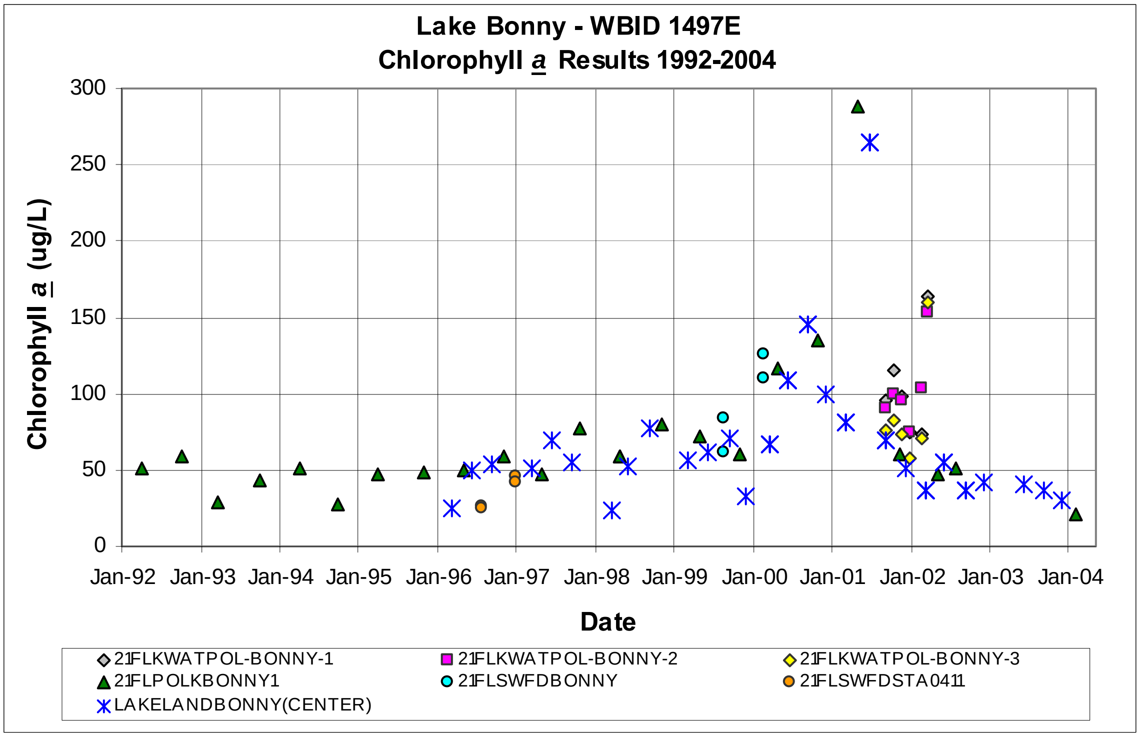

Figure 2.6 Chlorophyll a Monthly Results for Lake Bonny from 1992 to 2004

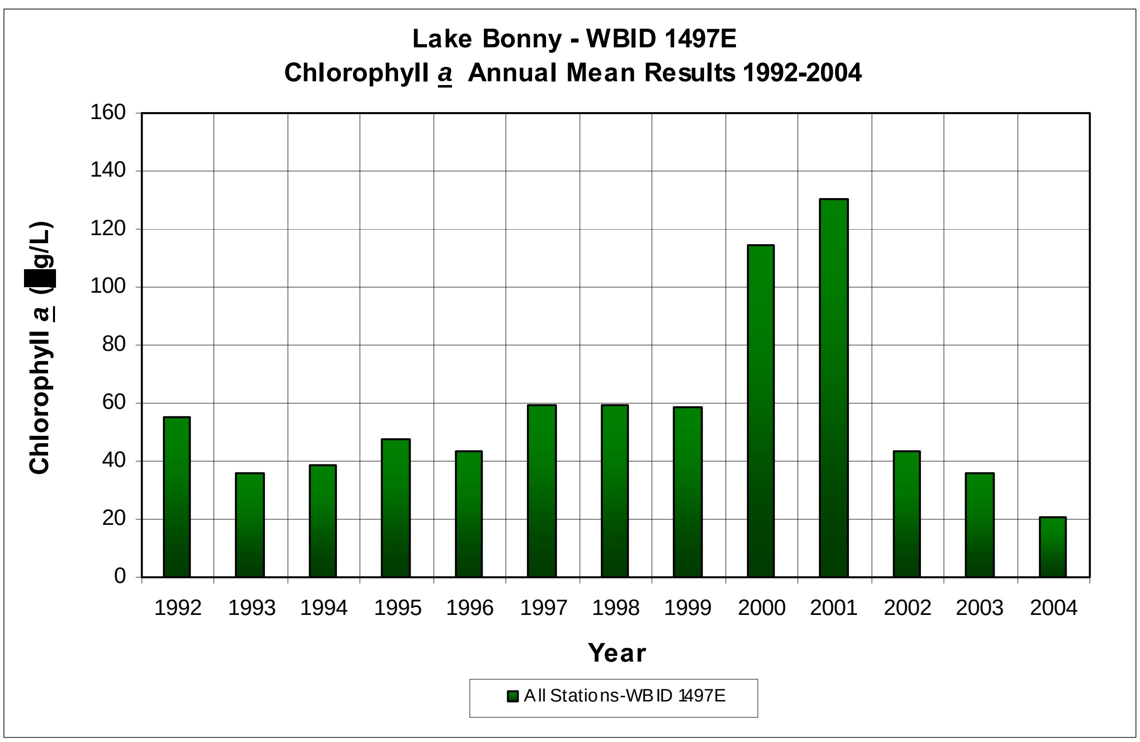

Figure 2.7 Chlorophyll a Annual Mean Results for Lake Bonny from 1992 to 2004

Table 2.1 provides summary statistics for the lake for TN, TP, and chlorophyll a from 1992 to 2004. Individual water quality measurements for TN, TP, and chlorophyll a used in the assessment are provided in **Appendix B.**

Table 2.1 Water Quality Summary Statistics for TN, TP, and Chlorophyll a from 1992 to 2004 for Lake Bonny (WBID 1497E)

Waterbody	Water Variable	# of Samples	Minimum	Mean	Median	Maximum
Lake Bonny	Total Nitrogen (mg/L)	72	0.45	2.40	2.04	7.33
Lake Bonny	Total Phosphorus (mg/L)	70	0.01	0.19	0.14	0.64
Lake Bonny	Chlorophyll a (µg/L)	68	20.95	0.14	58.77	288.40

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)**

Lake Bonny is classified as 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 criterion applicable to the observed impairment for Lake Bonny is the state of Florida's narrative nutrient criterion [Rule 62-302.530(48) (b), FAC].

3.2 Interpretation of the Narrative Nutrient Criterion for Lakes

To place a waterbody segment on the Verified List for nutrients, the Department checks against the appropriate impairment threshold identified in the IWR. In addition, the limiting nutrient or nutrients causing impairment must also be identified. 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 1997 to June 2004) 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. A median TN/TP ratio of 11.7 mg/L for the verified period was recorded for Lake Bonny, suggesting that TN and TP are co-limiting for the lake.

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, F.A.C.) 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 dark-water 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 chlorophyll a concentrations. This revised calculation for TSI now contains a TN -TSI, TP -TSI, and Chlorophyll a -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 Chlorophyll a -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 Chlorophyll a -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 Chlorophyll a -TSI with the average of the TN and TP TSI's.

The Florida-specific TSI for Lakes was determined based on the analysis of data from 313 Florida lakes. The index was adjusted so that a chlorophyll a concentration of 20 μg/L was equal to a Chlorophyll a -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 chlorophyll a 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 condition 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 Lake Hancock Basin and Lake Bonny TMDL, the Department applied the Watershed Assessment Model (WAM) (Soil and Water Engineering Technology, Inc., 2005) and the BATHTUB model (Quantitative Environmental Analysis, LLC, 2005) to simulate water quality discharges and eutrophication processes to determine the appropriate TSI target. The WAM model was used to estimate the natural background nutrient loadings by setting land uses to natural or forested land, and then the natural loadings were input into BATHTUB to determine the natural background TSI. If the natural background TSI can be determined, then an increase of 5 TSI units above natural background will be used as the water quality target for the TMDL. Otherwise, the IWR threshold TSI of 60 will be established as the target for TMDL development. The estimated natural background TSI for Lake Bonny is 61 with a target TMDL TSI of 66.

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 (CO_2) and water (H_2O) into carbohydrates and oxygen (O_2). 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_. The measurement of chlorophyll _a_ 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 chlorophyll _a_, typically the greater the abundance of algae. Algae are the primary producers in the aquatic web, and thus are very important in characterizing the productivity of lakes and streams. As noted earlier, chlorophyll _a_ 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 (NH_3 + NH_4^+), and organic nitrogen (NH_2) 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 bioavailable 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 agricultural sites. When nutrient concentrations consistently exceed natural levels, the resulting nutrient imbalance can cause undesirable changes in a waterbody'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 a 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.

Chapter 4: ASSESSMENT OF SOURCES

4.1 Overview of Modeling Process

Lake Bonny and the Lake Parker sub-basin are a part of a larger network of lakes and streams that drain to Lake Hancock, which discharges to Lower Saddle Creek, the Peace River, and ultimately, Charlotte Harbor and the Gulf of Mexico. As there are several other lakes in the network for which TMDLs are being developed, the Department modeled the entire Lake Hancock Basin. A primary basin setup was used to create an ArcView project file for Lake Hancock, which was designated the primary basin. The term “primary basin” in WAM refers to a collection of sub-basins or basins that discharge to a single receiving waterbody. The primary basin setup procedure used to model Lake Bonny, and ultimately, Lake Hancock is described in detail in “The WAM Watershed Assessment Final Report of the Lake Hancock Basin” (see **Appendix C**). The WAM model was then linked to the BATHTUB model. The BATHTUB model simulates nutrients in reservoirs and lakes based on annual average inputs. The BATHTUB model is described in detail in “The BATHTUB Framework for the Lake Hancock Basin, Florida, Final Report” (see **Appendix D**).

The external load assessment conducted by the Watershed Assessment Model (WAM) and BATHTUB models was intended to determine the loading characteristics of the various sources of pollutants to the Lake Bonny watershed and eventually Lake Hancock and Lower Saddle Creek. For modeling purposes, Lake Bonny is considered to be a part of the Lake Parker sub-basin. Assessing the external load entailed assessing land use patterns, soils, topography, hydrography, point sources, service area coverages, climate, and rainfall to determine the volume, concentration, timing, location, and underlying nature of the point, nonpoint, and atmospheric sources of nutrients to the lake.

WAM is a tool that has been shown to be useful in the assessment of watershed-related properties. WAM was developed to allow engineers and planners to assess the water quality of both surface water and ground water. The model simulates the primary physical processes important for watershed hydrologic and pollutant transport. The model assesses the hydrology of the watershed using imbedded models including “Ground Water Loading Effects of Agricultural Management Systems” (GLEAMS; Knisel, 1993), “Everglades Agricultural Area Model” (EAAMod; Botcher et al., 1998; SWET, 1999), and two submodels written specifically for WAM to handle wetland and urban landscapes. Dynamic routing of flows is accomplished through the use of an algorithm that uses a Manning’s flow equation-based technique (Jacobson et al., 1998).

BATHTUB is a U. S. Army Corps of Engineers steady-state model (W. W. Walker, 1999; 2004). The model incorporates several empirical equations of nutrient settling and algal growth to predict steady-state nutrient and chlorophyll *a* concentrations based on waterbody characteristics, hydraulic characteristics, and nutrient loadings. BATHTUB is capable of predicting concentrations of chlorophyll *a*, total nitrogen (TN), total phosphorus (TP) and transparency in a waterbody under different loading conditions (QEA, LLC, 2005).

4.2 Potential Sources of Nutrients in the Lake Bonny 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 Program (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 (see **Section 6.1**). 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 permitted NPDES wastewater treatment or industrial wastewater facilities that discharge nutrient loads into Lake Bonny or the Lake Bonny watershed.

Municipal Separate Storm Sewer System Permittees

Municipal separate storm sewer systems (MS4s) may discharge nutrients to waterbodies in response to storm events. To address stormwater discharges, the EPA developed the National Pollutant Discharge Elimination System (NPDES) stormwater permitting program in two phases. Phase I, promulgated in 1990, addresses large and medium MS4s located in incorporated places and counties with populations of 100,000 or more. Phase II permitting began in 2003. Regulated Phase II MS4s, which are defined in Section 62-624.800, F.A.C., typically cover urbanized areas serving jurisdictions with a population of at least 10,000 or discharges into Class I or Class II waters, or Outstanding Florida Waters.

The stormwater collection systems in the Lake Bonny watershed, which are owned and operated by Polk County, in conjunction with the Florida Department of Transportation (FDOT), are covered by a NPDES Phase I MS4 permit. The Lake Bonny watershed is located within the Lake Hancock watershed. The Lake Hancock watershed is situated between the cities of Lakeland, Winterhaven, Auburndale, and Bartow. All of these cities are Phase I MS4 co-permittees, with City of Lakeland having portions of their jurisdiction located within the segment.

At this time, it is unknown if any local governments in the lake's sub-basin have applied for coverage under a Phase II NPDES MS4 permit. Currently, there are no stormwater Capital Improvement Projects (CIPs) in the Lake Bonny 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 Lake Bonny TMDL, all nonpoint sources were evaluated by use of a watershed and lake modeling approach. **Table 4.1** shows the existing area of the various land use categories in the Lake Bonny watershed. **Table 4.2** shows the existing area of the various land use categories examined and modeled for the Lake Parker sub-basin. **Figure 4.1** shows the drainage area of Lake Bonny, and the spatial distribution of the land uses are shown in **Table 4.1. Figure 4.2** shows the drainage area of the Lake Parker sub-basin, and the spatial distribution of the land uses are shown in **Table 4.2.**

The predominant land coverages for the Lake Bonny watershed include low, medium, and high density residential (36.9%); followed by commercial, industrial, and transportation (18.1%); and educational facilities (6.2%). These coverages account for 61.2 percent of the land use in the sub-basin. The lake and interconnected waterways/streams/wetlands etc. account for 29.3 percent of the sub-basin. The areas occupied by anthropogenic land uses account for 62.3 percent of the watershed.

The predominate land coverages for the Lake Parker sub-basin include low, medium, and high density residential (28.4%); followed by commercial, industrial, and transportation (13.8%); and recreation (10.4%). These coverages account for 57.6 percent of the land use in the sub-basin. The lake and interconnected waterways/streams/wetlands etc. account for 30.5 percent of the sub-basin. The areas occupied by anthropogenic land uses account for 57.6 percent of the watershed.

Land use coverages in the watershed and sub-basin were aggregated using the Florida Land Use, Cover and Forms Classification System (FLUCCS, 1999). The spatial distribution and acreage of different land use categories for WAM were identified using the 1999 land use coverage (scale 1:24,000) provided by the Southwest Florida Water Management District (SWFWMD) contained in the Lake Hancock Basin WAM model developed by Soil and Water Engineering Technology, Inc. (2005).

Table 4.1 Lake Bonny Watershed Existing Land Use Description

FLUCCS ID	Lake Bonny Watershed Existing Land Use Coverage	Acres	Sq Miles	Percent
1300	High Density Residential, Fixed Single Family Units	318.76	0.498	21.08%
5201	Interconnected Lakes	313.82	0.490	20.75%
1200	Medium Density Residential, Fixed Single Family Units	214.98	0.336	14.22%
1400	Commercial and Services	158.15	0.247	10.46%
1700	Educational Facilities	93.90	0.147	6.21%
1500	Industrial	88.96	0.139	5.88%
6410	Freshwater Marshes	79.07	0.124	5.23%
2600	Old Field	49.42	0.077	3.27%
6440	Emergent Aquatic Vegetation	37.07	0.058	2.45%
1900	Undeveloped Land	32.12	0.050	2.12%
8100	Transportation	27.18	0.042	1.80%
1100	Low Density Residential, Fixed Single Family Units	24.71	0.039	1.63%
6300	Wetland Forested Mixed	17.30	0.027	1.14%
5300	Reservoirs	14.83	0.023	0.98%
5200	Lakes	12.36	0.019	0.82%
2210	Citrus Groves	12.36	0.019	0.82%
2100	Pastures and Fields	7.41	0.012	0.49%
6150	Stream and Lake Swamps (Bottomland)	4.94	0.008	0.33%
8300	Utilities	2.47	0.004	0.16%
4340	Hardwood - Conifer Mixed	2.47	0.004	0.16%
Sum		**1,512.3**	**2.4**	**100%**

FLUCCS: Florida Land Use, Cover, and Forms Classification System, 1999.

Table 4.2 Lake Bonny and Lake Parker Sub-basin Existing Land Use Description

FLUCCS ID	Lake Parker Sub-basin Existing Land Use Coverage	Acres	Sq Miles	Percent
5201	Interconnected Lakes	3167.87	4.950	20.80%
1200	Medium Density Residential, Fixed Single Family Units	2935.60	4.587	19.27%
1800	Recreation	1588.88	2.483	10.43%
1400	Commercial and Services	1482.62	2.317	9.73%
1300	High Density Residential, Fixed Single Family Units	1003.24	1.568	6.59%
5300	Reservoirs	691.89	1.081	4.54%
1700	Educational Facilities	533.74	0.834	3.50%
2100	Pastures and Fields	496.68	0.776	3.26%
8300	Utilities	467.03	0.730	3.07%
8100	Transportation	434.90	0.680	2.86%
6150	Stream and Lake Swamps (Bottomland)	425.02	0.664	2.79%
1100	Low Density Residential, Fixed Single Family Units	383.01	0.598	2.51%
6410	Freshwater Marshes	308.88	0.483	2.03%
1900	Undeveloped Land	252.05	0.394	1.65%
1500	Industrial	185.33	0.290	1.22%
4340	Hardwood - Conifer Mixed	182.86	0.286	1.20%
2210	Citrus Groves	121.08	0.189	0.79%
4200	Upland Hardwood Forest	113.67	0.178	0.75%
2600	Old Field	111.20	0.174	0.73%
6440	Emergent Aquatic Vegetation	96.37	0.151	0.63%
3200	Prairies	84.02	0.131	0.55%
4100	Upland Coniferous Forests	46.95	0.073	0.31%
6300	Wetland Forested Mixed	37.07	0.058	0.24%
5200	Lakes	27.18	0.042	0.18%
6530	Inland Shores/Ephemeral Ponds	14.83	0.023	0.10%
3300	Mixed Rangeland	12.36	0.019	0.08%
6430	Wet Prairies	12.36	0.019	0.08%
8200	Communications	9.88	0.015	0.06%
6200	Wetland Coniferous Forest	4.94	0.008	0.03%
Sum		**15,231.5**	**23.8**	**100%**

FLUCCS: Florida Land Use, Cover, and Forms Classification System, 1999.

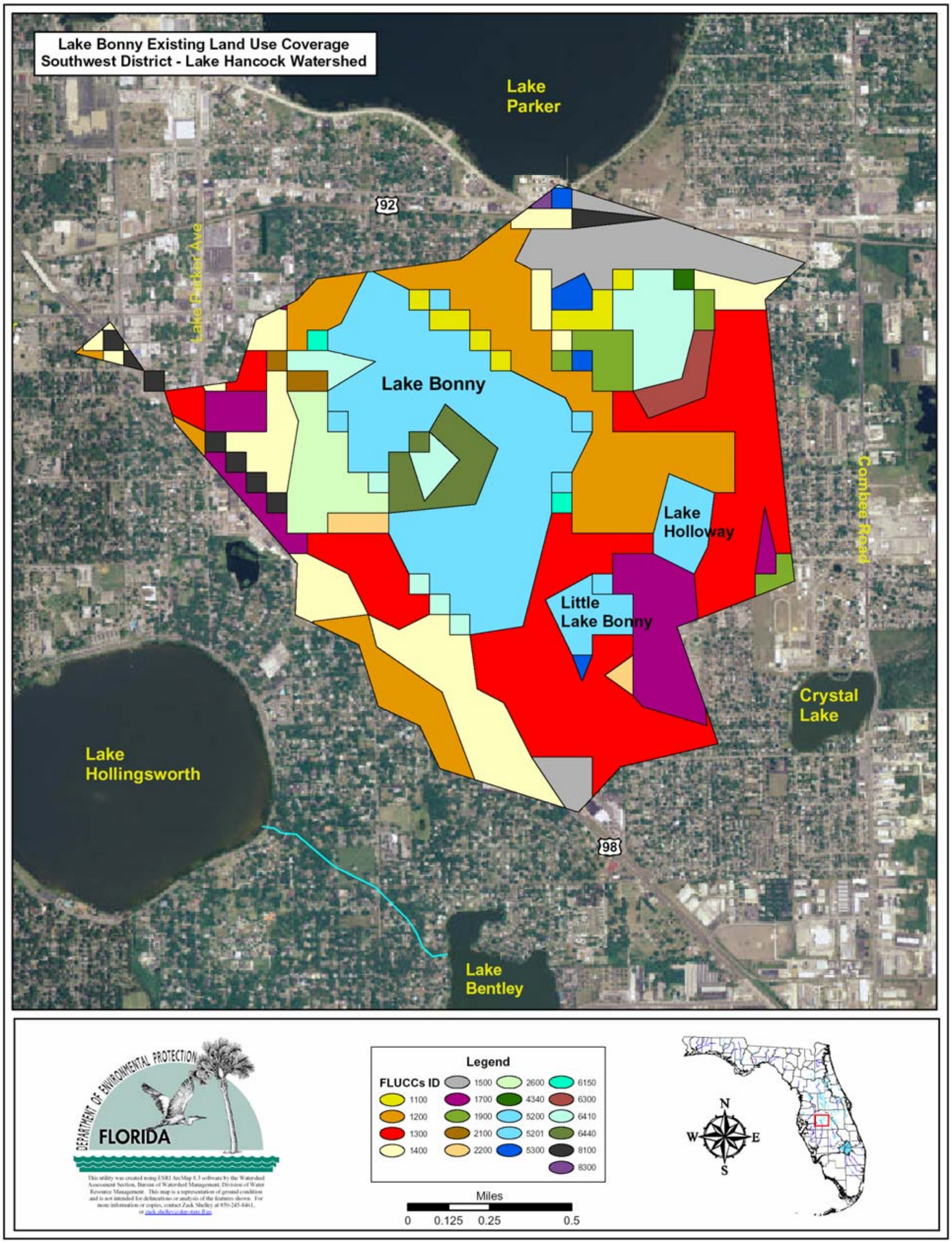

Figure 4.1 Lake Bonny Watershed Existing Land Use Coverage

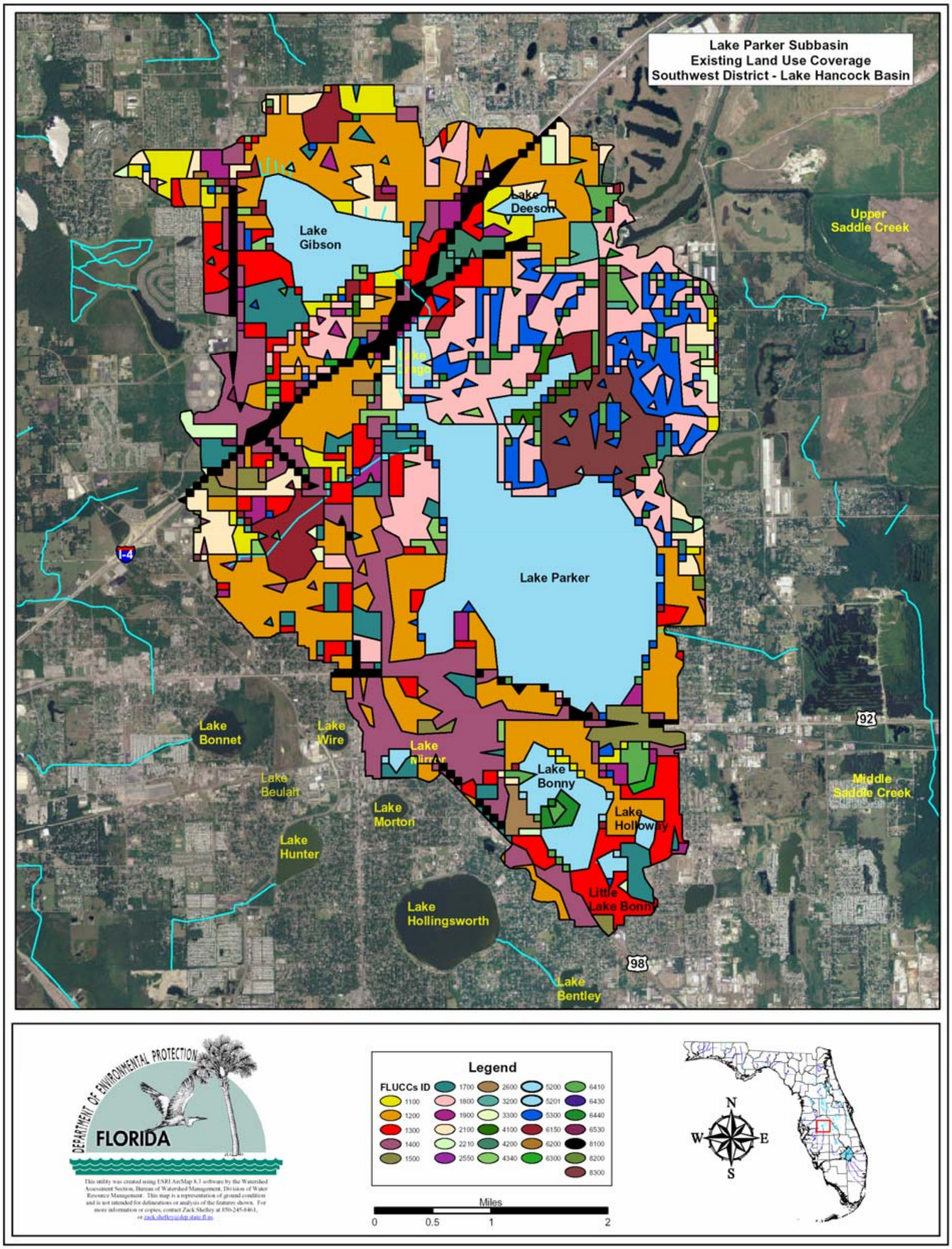

Figure 4.2 Lake Bonny and Lake Parker Sub-basin Existing Land Use Coverage

Polk County Population

According to the U.S Census Bureau, the population density in Polk County, in the year 2000, was at or less than 258.2 people per square mile. The Census Bureau reports that the total population in 2000 for Polk County, which includes (but is not exclusive to) the Lake Bonny watershed, was 483,924, with 226,376 housing units. Polk County occupies an area of approximately 2,009 square miles. For all of Polk County, the Bureau reported a housing density of 120.8 houses per square mile. Polk County is just below the average housing density for Florida counties with 134.3 housing units per square mile. (U. S. Census Bureau Web site, 2004).

Polk County 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.

As of 2001, Polk County had a cumulative registry of 112,848 septic systems. Data for septic tanks are based on 1970 – 2001 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 1993–2004, 1,151 permits for repairs were issued in Polk County (Florida Department of Health, 2004). Based on the number of permitted septic tanks and housing units (226, 376) located in the county, approximately 50 percent of the housing units are connected to a central sewer line (i.e., wastewater treatment facility), with the remaining 50 percent utilizing septic tank systems.

4.3 Estimating Nonpoint Source Loadings

Model Approach

The Watershed Assessment Model (WAM) was utilized to estimate the nutrient loads within and discharged from the Lake Hancock Basin. WAM is a Geographic Information System (GIS) based model that allows the Department to interactively simulate and assess the environmental effects of various land use changes and associated land use practices.

WAM utilizes ESRI™ ArcView 3.2 with Spatial Analyst 2.0 to analyze and display model input and output using grids. Grid datasets, as opposed to polygon datasets, spatially represent geographic data as a collection of raster cells. Each cell contains attributes of the dataset, e.g. land use code numbers that can be overlaid with cells of other grids. The benefits of using grids over polygons include computational speed and output resolution. Output can be displayed by grid cell as opposed to by sub-basin polygon. The cell size is dependant on the desired resolution. A grid cell size of one hectare was chosen, with the intent that this would adequately characterize the land use and capture linear features such as highways (SWET, 2005).

The water quality parameters (impact parameters) simulated within the model for Lake Bonny and its Lake Parker sub-basin included: water quantity, soluble nitrogen (N) forms (ammonia, soluble organic, nitrate), particulate N, ground water N, soluble phosphorus (P), particulate P, ground water P, sediment, 5-day biochemical oxygen demand (BOD_5), and dissolved oxygen. GIS datasets of land use, soils and rainfall are used to calculate the combined impact of the watershed characteristics for a given grid cell. Once the combined impact for each unique cell within a watershed is determined, the cumulative impact for the entire watershed is determined by attenuating the constituent to the sub-basin outlets. Constituents are attenuated based upon the flow distances (overland to nearest water body, through wetlands or depressions and within streams to the sub-basin outlet), flow rates in each related flow path and the type of wetland or depression encountered. **Figure 4.3** shows the conceptual routing schemes and flow distances that are calculated for each cell (SWET, 2005).

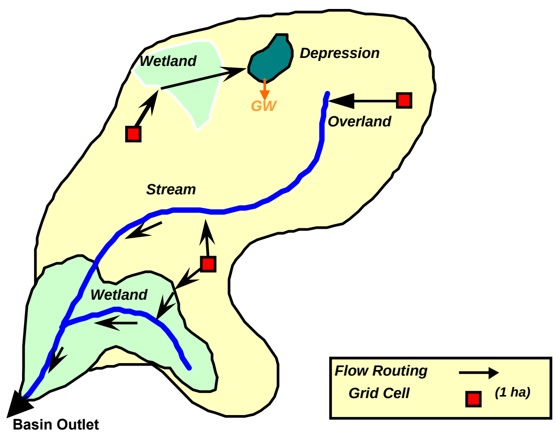

Figure 4.3 WAM Conceptual Routing Diagram (SWET, 2005)

A portion of the flow in each cell is converted to ground water based on the soil type and amount of imperviousness estimated for each land use. Surface flow that enters depressions is also converted to ground water. Ground water is routed to the nearest stream unless directed otherwise.

The hydrologic contaminant transport modeling is accomplished by first simulating all of the unique grid cell combinations of land use, soils, and rainfall by using one of several source cell models including GLEAMS (Knisel, 1993), EAAMOD (Bottcher et al., 1998; SWET, 1999), a wetland module, and an urban module. The time series outputs for each grid cell is then routed and attenuated to the nearest stream and then through the entire stream network of the watershed. Dynamic routing of flows is accomplished through the use of an algorithm, BLASROUTE.exe, that uses a non-linear reservoir technique (Jacobson et al., 1998). **Figure 4.4** below shows a flow diagram of the hydrologic contaminant transport modeling component of the overall WAM model.

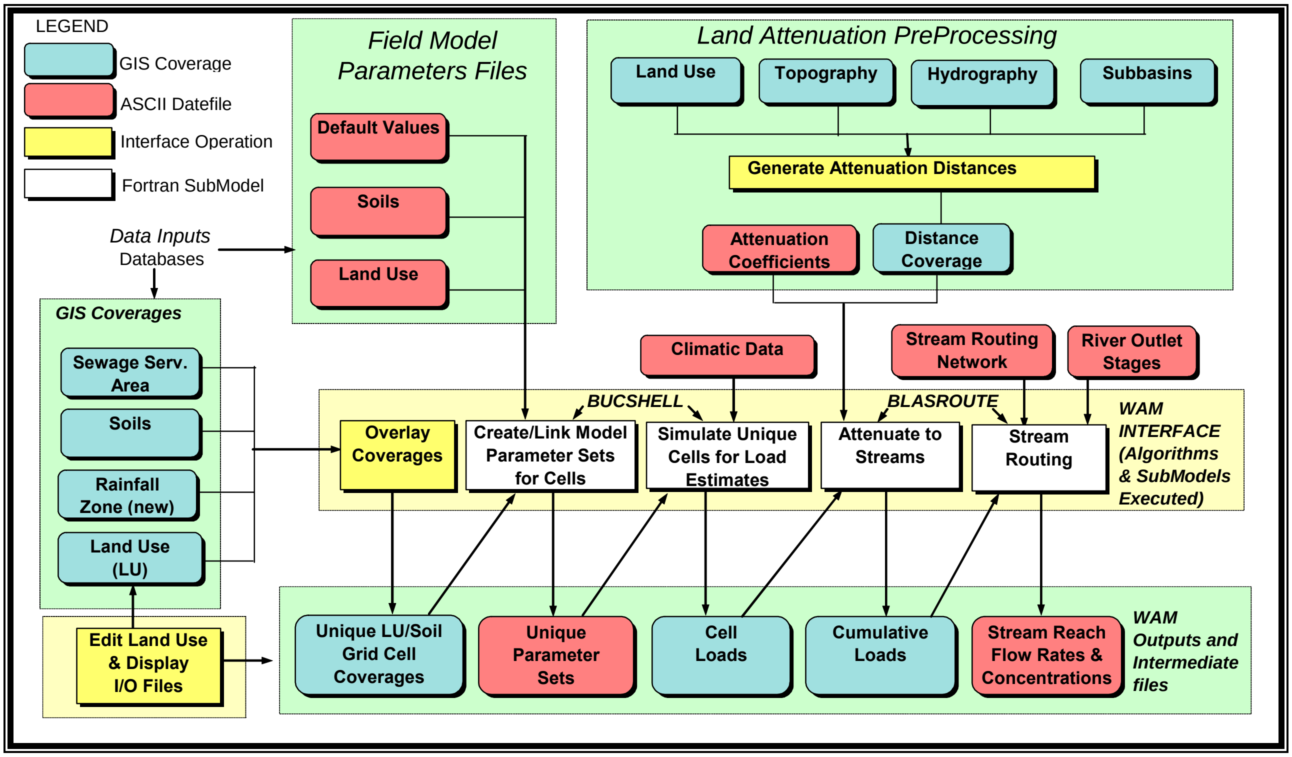

Figure 4.4 Dynamic Modeling Approach (SWET, 2005)

While BATHTUB has the capability to simulate large, sinuous reservoirs and lakes using multiple model cells, the size and nature of the eleven lakes evaluated supported the designation of one BATHTUB segment for each lake. However, because of the interconnectedness of the eleven lakes, all eleven lakes, including Lake Bonny were incorporated into a single BATHTUB model framework containing eleven linked segments. The outflow from each lake enters the next lake downstream.

Surface water and ground water inputs are designated as tributaries in the model (one set to each lake). These inputs are provided by WAM, which was explicitly set up to output the incremental surface water and ground water quantity and quality flowing into each of the BATHTUB-simulated lakes. That is, the tributaries designated in the BATHTUB model have flows and concentrations that reflect their local upstream (between lakes) sources only. Ground water seepage from each lake is simulated using BATHTUB's channels. A schematic of the model framework is shown in **Figure 4.5**. All flows that do not point to a lake represent flows that are lost to the system. Daily WAM results were computed for the time period 1994 to 2003. The WAM results were averaged on an annual basis to develop eleven separate BATHTUB model scenarios, one for each year (QEA, LLC, 2005).

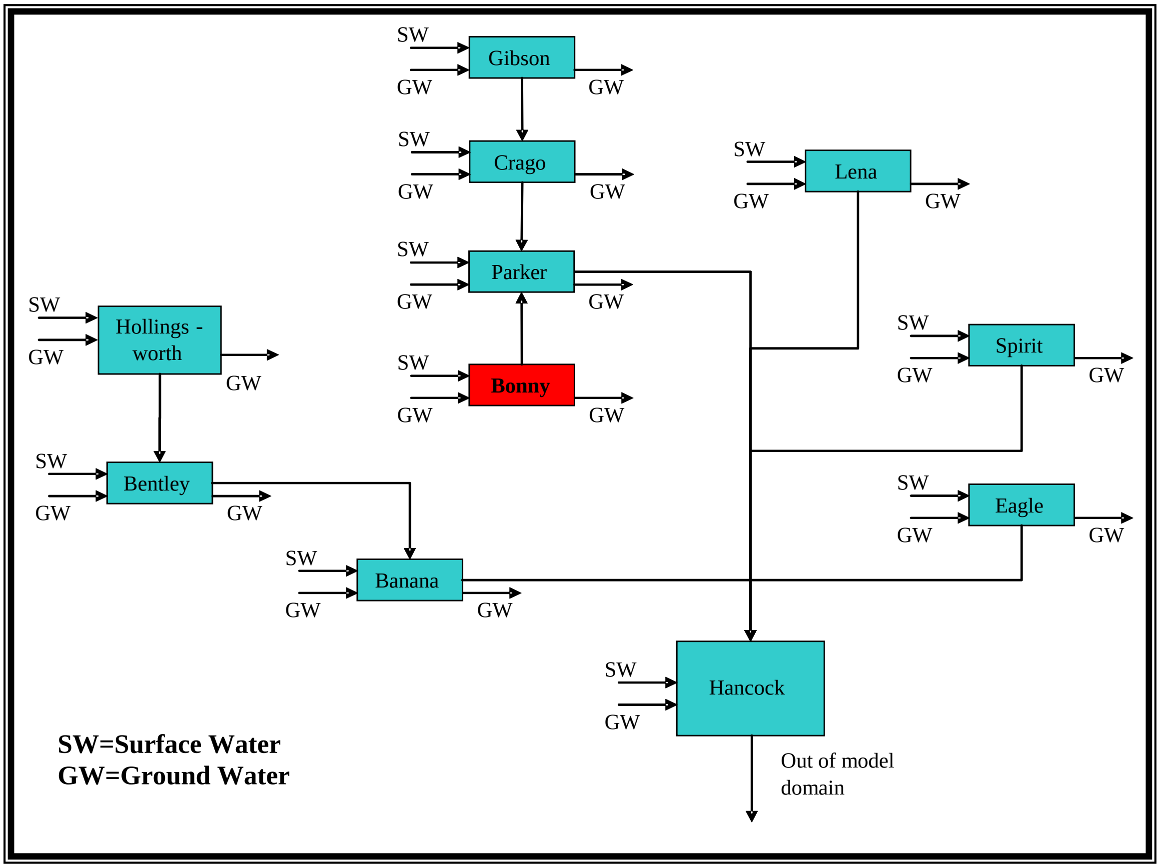

Figure 4.5 Model Schematic Depicting the Interconnected Eleven Lakes Modeled for The Lake Hancock Watershed (QEA, 2005)

GIS and model data set inputs for WAM included land use, soils, topography and depressions, hydrogaphy, USGS gage and flow data, septic tanks, water use pumpage, point sources, rainfall, ground water, atmospheric deposition, solar radiation, control structures, attenuation distances, and stream reaches.

The inputs required for the BATHTUB model included annual data for rainfall (rain amount and TN and TP concentrations), evaporation, surface water inflow volumes and TN and TP loads, ground water inflow volumes and TN and TP loads, and leakage volume. Because BATHTUB is unable to vary the rainfall rate between lakes, it was decided that WAM would include rain inputs as part of its surface reach loads, so that the rain zones could be represented. Therefore, BATHTUB inputs show no rainfall. BATHTUB has been set up to simulate Lake Bonny and its upstream watershed. The flow routing to and between lakes is built into both WAM and BATHTUB. Bathtub will route flow and constituents between lakes, but requires WAM to provide all flow and constituents generated above and between lakes (SWET, 2005).

Lake Bonny Existing Land Use Loadings

The total loadings of nitrogen and phosphorus for Lake Bonny were estimated using the WAM and BATHTUB models. Modeling frameworks were designed to simulate the period 1994 through 2003. This time period had the best available seasonal data for the sub-basin and also represented the verified period for Group 3 waterbodies located in the Lake Hancock Basin.

Based on the hydrology, and lake and stream interconnected reaches, nine major sub-basins were delineated in making up the Lake Hancock and Saddle Creek watershed. The nine sub-basins include Banana Lake and Banana Lake Canal, Cabbage Branch, Eagle Lake, K-Ville Branch, Lake Lena and Lake Lena Run/Creek, Lake Parker (which includes Lake Bonny), Lower Saddle Creek, Middle Saddle Creek, and Upper Saddle Creek. Within the nine sub-basins making up the Lake Hancock watershed, eleven lakes were targeted and modeled based on nutrient impairment and the interconnected nature of the waterbodies contributing runoff and loadings to Lake Hancock. The eleven lakes are Lake Gibson, Lake Crago, Lake Bonny, Lake Parker, Lake Lena, Lake Hollingsworth, Lake Bentley, Banana Lake, Spirit Lake, Eagle Lake, and Lake Hancock.

All of these lakes are impaired for nutrients based on the Department's Impaired Waters Rule methodology. Each lake was modeled separately to determine individual contributions to Lake Hancock. **Table 4.2** illustrates the total water volume and loadings for TN and TP going into Lake Bonny from 1994 to 2003 based on the WAM and BATHTUB model results under current/existing land use conditions. Loads were estimated based on lake surface rainfall, surface water inflow, ground water inflow and septic inflow. Ground water loss/leakage from each lake was also calculated and subtracted from the total inflow volume.

Table 4.3 Lake Bonny Existing Land Use Water Volume and Loadings for TN and TP from 1994 to 2003

Lake Bonny Loadings					
Year	**Water** (hm^3)	**TN** (kg)	**TN** (lbs)	**TP** (kg)	**TP** (lbs)
1994	3.860	3,832.237	8,448.639	448.501	988.775
1995	4.097	5,263.843	11,604.790	472.178	1,040.974
1996	3.031	2,429.424	5,355.965	359.054	791.579
1997	4.913	6,951.277	15,324.945	629.305	1,387.381
1998	4.010	4,339.992	9,568.046	467.664	1,031.023
1999	2.582	2,514.276	5,543.031	308.207	679.481
2000	2.007	2,468.325	5,441.726	238.048	524.807
2001	2.618	3,400.399	7,496.598	333.452	735.136
2002	4.794	4,674.098	10,304.625	579.203	1,276.925
2003	4.105	5,095.399	11,233.433	447.757	987.135
94-03 Mean	3.6	4,096.9	9,032.2	428.3	944.3
94-03 Totals	36.0	40,969.3	90,321.797	4,283.4	9,443.2

hm^3: Cubic Hectometers
kg: Kilograms
lbs: Pounds

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.

As discussed in Chapter 4, the WAM model was selected as the watershed model. It was run dynamically through the ten-year period of record, with all lakes linked together in their current configuration. BATHTUB was selected as the lake model. It was set up with all the lakes linked together, and the model calibrated based on the annual average output from WAM and run year-by-year (1994 – 2003) for all eleven lakes.

5.1.1 Rainfall

The long-term average for the two rainfall gages used in the model [Bartow (COOP: 080478) and Lakeland (COOP: 084797 and COOP: 084802) National Weather Service stations] was 52.01 inches/year. The 10-year average rainfall for the study period (1994 – 2003) was 55.23 inches for Lakeland (60th percentile of the Lakeland long-term record) and 55.19 inches for Bartow (71st percentile of the Bartow long-term record) (see **Table 5.1**). Therefore, the study period represented a wetter than average period. However, it contained a very dry year, the year 2000, that was the driest year with 38.3 inches of rain recorded in Lakeland (10th percentile of the long-term record) and with 35.9 inches recorded at Bartow (~ the 1st percentile of the long-term record). In 2000, evaporation exceeded rainfall, and this created a year with very high in-lake concentrations in both the current condition and natural land use background scenario.

Table 5.1 Bartow and Lakeland, Florida, Rainfall Stations Used for Model Loading and Calibration

Rainfall from Bartow and Lakeland		
Bartow	1900-2004 average = 53.7”	
Lakeland	1949-2004 average = 50.33”	
Year	**Lakeland**	**Bartow**
1994	67.13	60
1995	48.47	60.31
1996	52.85	46.1
1997	58.14	60.2
1998	54.41	62.33
1999	48.66	42.29
2000	38.26	35.87
2001	57.67	49.56
2002	66.58	71.44
2003	60.13	63.83
‘94-’03 Average	55.23”	55.19”

Note: Lakeland stations missing data from September and October 1995.

5.1.2 Model Calibration

Watershed Assessment Model (WAM)

WAM was calibrated by consultants to existing/current conditions for the years 1994 – 2003. Calibration consisted of a water balance approach to match the measured in-lake stages and flows at flow measuring points. An Access database tool was created to aggregate the daily predictions for surface water and ground water (flows and TN, TP concentrations) up to annual average conditions in a format compatible with the requirements of the BATHTUB model. For details on the WAM model see “WAM Watershed Assessment Model, Model Documentation and Users Manual,” Soil and Water Engineering Technology, Inc., 2005 (**Appendix C**). For details on model calibration see Final Report September 2005 (**Appendix D**).

BATHTUB Model

The consultant provided the Department with copies of ten BATHTUB input decks (one for each year 1994 – 2003) set up for current conditions but not calibrated. The Department calibrated the BATHTUB model. BATHTUB calibration consisted of running each model year through all of the model options in BATHTUB to determine which set of models provided the best uncalibrated fit to the measured data. As a result of running through these models, it became apparent that, for many of the lake/year combinations, the watershed model was not delivering enough mass to match the measured data for either TN or TP. However, in other lake/year combinations, there was too much mass. Once a set of models was selected, the primary calibration for TN and TP was achieved by invoking BATHTUB’s internal loading rate functions for both TN and TP to match the measured in-lake mass. This Internal Loading rate (IL) integrates all the missing mass. It is not proposed that the IL rate represents only those in-lake processes that either recycle mass within the lake or fix nitrogen from the atmosphere; it also includes all other missing mass. As such, it will be referred to as the 'missing mass.' Chlorophyll a was calibrated using the BATHTUB calibration coefficient. Each lake/year combination was calibrated individually, but once the chlorophyll a calibration was set, it remained unchanged for all other BATHTUB simulations (background and TMDL development).

The phosphorous model that best fit Lake Bonny was Model 1, Second-Order, Available P model. The nitrogen model selected was Model 1, Second-Order, Available N model. The chlorophyll a model selected was Model 1, for P, N, Light and Flushing. Details regarding the selected models can be found in the BATHTUB Users Manual (U.S. Army Corps of Engineers, 1999; Walker, W.W., 2004). **Figures 5.1** through **5.4** illustrate the measured, un-calibrated, and calibrated data for TN, TP, Chlorophyll a, and TSI respectively for Lake Bonny for the ten-year modeled period (1994 – 2003).

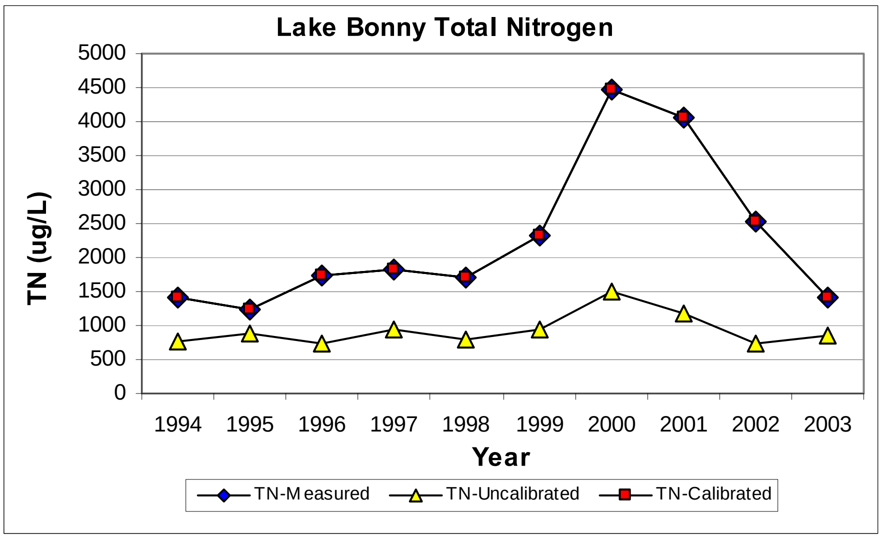

Figure 5.1 Lake Bonny Total Nitrogen Measured, Un-Calibrated, and Calibrated Data from 1994 to 2003

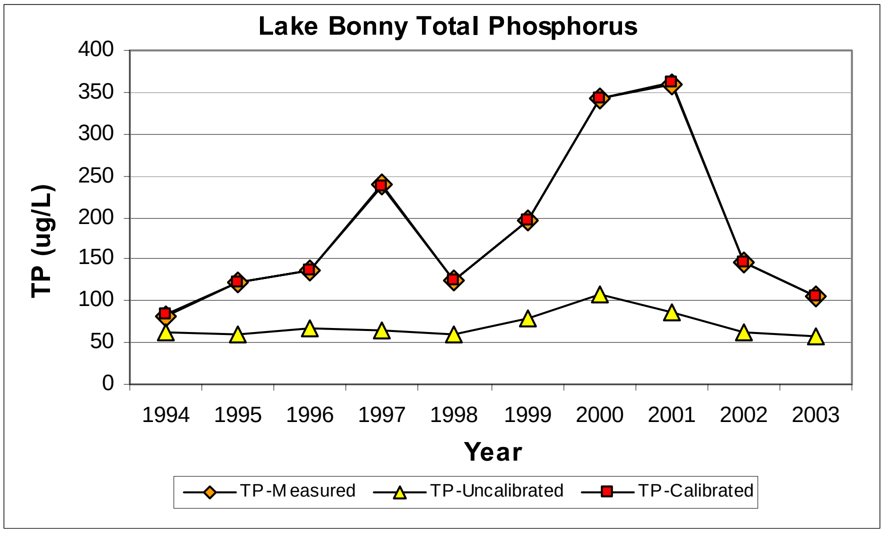

Figure 5.2 Lake Bonny Total Phosphorus Measured, Un-Calibrated, and Calibrated Data from 1994 to 2003

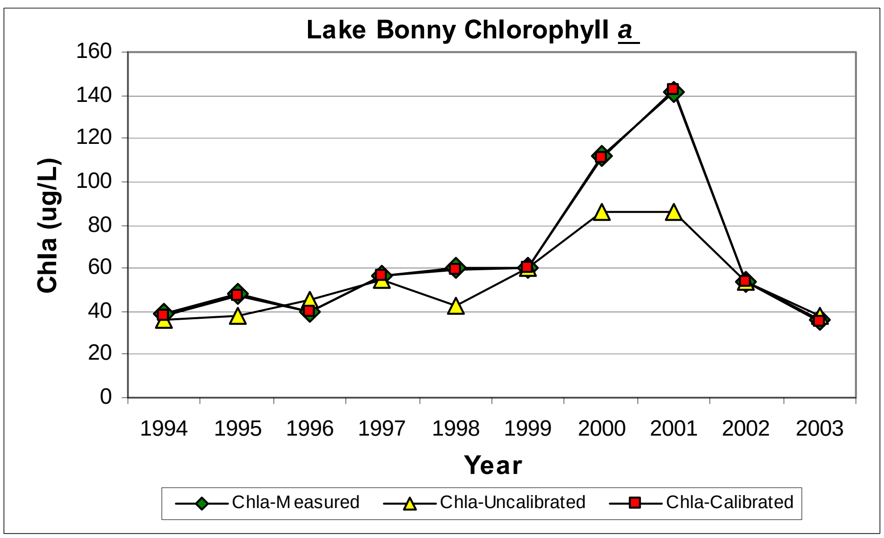

Figure 5.3 Lake Bonny Chlorophyll a Measured, Un-Calibrated, and Calibrated Data from 1994 to 2003

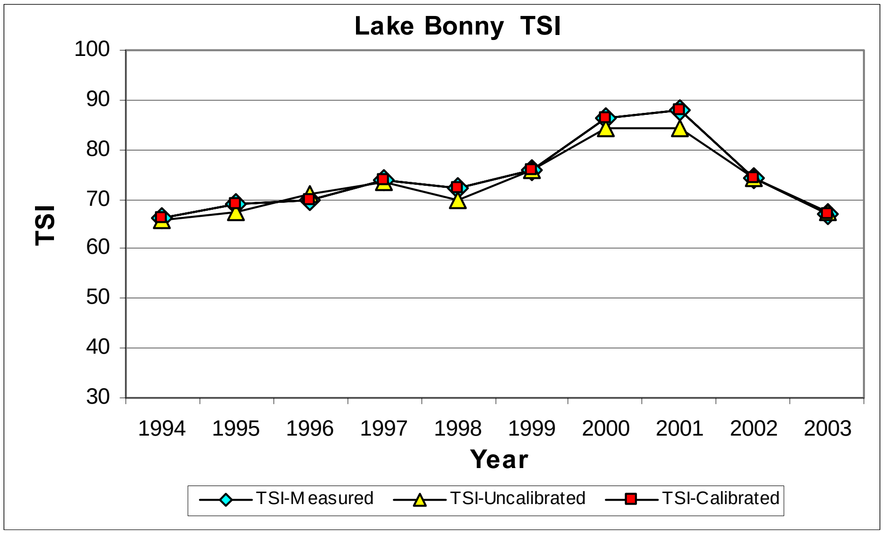

Figure 5.4 Lake Bonny TSI Measured, Un-Calibrated, and Calibrated Data from 1994 to 2003

5.1.3 Background Conditions

WAM Model

WAM was used to describe and evaluate the "natural land use background condition" for the entire Lake Hancock watershed, including Lake Bonny. For this simulation, all current land uses were 'reassigned' to a mixture of Herbaceous, Prairies, Other Shrubs and Brush, Upland Coniferous Forest, Pine Flatwoods, Upland Hardwoods Forest, Hardwood Conifer Mix (the majority), Lakes, Interconnected Lakes, Reservoirs, Mixed Wetland Hardwoods, Streams and Lakes Swamps (bottomlands), Wetland Coniferous Forest, Cypress, Wetland Forested Mix, Freshwater Marshes, Wet Prairies, Emergent Aquatic Vegetation, Inland Shores and Ephemeral Ponds. The current condition was maintained for all waterbody physical characteristics. From this point forward, the natural land use background will be referred to as "background."

At first, the WAM was run with current rates of seepage around waterbodies and leakance from inside waterbodies. This resulted in such a large reduction in the total water flowing into the lakes that even with the significant reduction in external watershed loading, several lake/year combinations had higher concentrations of TN, TP, and chlorophyll *a* than under current conditions as the evaporation of 1.32 m nearly exceeded inflow and the lakes dried up. To account for this water loss in the background condition, seepage around the lakes was adjusted back to background conditions in the model and leakance was adjusted down (50 percent of current rate) until the lake stages and surface areas approximated current conditions. Even under this scenario the total water inflowing to the lakes under the background scenario was less than current conditions, particularly in the drier years (1996 and 2000). Again, this resulted in concentrations for some lake/year combinations being as great as they are under current conditions. In other words, the watershed model is indicating that under 'natural land use' dry conditions the lakes would have a trophic state similar to that today. Conversely, under average or wet conditions the natural land use trophic states were significantly less than current conditions.

BATHTUB Model

After achieving acceptable WAM background results, the BATHTUB model was run with no reduction in the total amount of missing mass (internal loading rate). As expected, with the reduction in total flow for the background condition and with no attenuation of the missing mass, many of the lake/year combinations did not improve. In fact, for the dry years the background condition was still worse than the current condition. In an effort to find the natural background, reductions in the missing mass were made. First, the BATHTUB model was used to identify the total external load of TN and TP under both the current condition and the background condition. Then the ratio of the change in external load between the background condition and the current condition (background/current) was applied to the missing mass (internal loading rate). This was called the attenuated case (A). This brought the in-lake trophic states down in the average and wet years, but many of the dry year lake trophic states remained higher in the background condition than in the current condition. As a result, the remaining missing mass was reduced until the worst case dry year trophic state was below the current conditions. This required an additional 75 percent reduction in the missing mass remaining after attenuation. The modeling abbreviations used in the tables, figures and report are explained below:

Abbreviations Used

L 100 = leakance at current conditions (calibrated model)
L50 = leakance reduced from current conditions by 50 percent
L0 = leakance reduced to near zero (0.01 m)
PC = results from calibrated BATHTUB model
IL = missing mass (used internal loading rate to achieve mass balance in model calibration)
ILA = missing mass changed by the ratio of the change in external mass of background/current condition.
IL50 = ILA plus an additional 50 percent reduction in missing mass
IL75 = ILA plus an additional 75 percent reduction in missing mass
ILNIL = all missing mass eliminated (loading rate = 0.0)

5.2 Selection of the TMDL Target

It should be recognized that the direct application of natural background as the target TSI would not allow for any assimilative capacity to be made available. The IWR uses as one measure of impairment in lakes, a 10 unit change in TSI from "historical" levels. This 10 unit increase is assumed to represent the transition of a lake from one trophic state (say mesotrophic) to another nutrient enriched condition (eutrophic). The Department has assumed that allowing a 5 unit increase in TSI over the natural background condition would prevent a lake from becoming impaired (changing trophic states) and reserve 5 TSI units to allow for future changes in the basin and as part of the implicit margin of safety in establishing the assimilative capacity.

After examining the background runs for Lake Bonny, it was decided that the scenario with leakance set at 50 percent of the current condition and the attenuated missing mass reduced by an additional 75 percent represented the natural land use background condition. This resulted in an estimated natural background TSI of 61 units. As has been Department practice, when acceptable background conditions can be established the target for TMDL development becomes the background TSI plus 5 TSI units. This raises the target TSI for Lake Bonny to 66.0 (61.0 + 5 TSI units).

Based on achieving the TMDL targets for each year of the ten-year period of record, a long-term annual average TMDL for TSI was set at 65.6. The range in TSI TMDL targets was between 57.2 and 84.2. Once the target TSI was established (a TSI of 66), BATHTUB was rerun with decreasing loads until the target TSI was met. The required annual average percent reduction for TN coming into Lake Bonny was 57.7 percent with an allowable long-term annual average loading of 6,587.6 kg/year (14,523.2 lbs/year). The required annual average percent reduction for TP coming into the lake was 57.7 with an allowable long-term annual average loading of 871.2 kg/year (1,920.7 lbs/year).

The annual percent reductions for TN and TP ranged between 25 and 77. These reductions correspond to a range in loadings of 3,902.3 kg/year (8,603.1 lbs/year) to 12,531.7 kg/year (27,627.7 lbs/year) for TN and between 327.2 kg/year (721.4 lbs/year) to 1,521.5 kg/year (3,354.3 lbs/year) for TP. Maintaining the long-term annual average loadings for TP and TN established as this TMDL should result in attaining the annual average TSI of 65.6 (with a target of 66).

Table 5.2 shows the TSI for the calibrated model (PC), the background model (IL75), the TMDL Target TSI, TMDL-TSI, and the percent reduction. **Table 5.3** shows the mass for TN and TP for the calibrated model, TMDL, and percent reductions. **Table 5.4** shows the annual average concentrations for TN, TP, and chlorophyll a. **Figures 5.5** through **5.8** illustrate the TMDL target, calibrated data, and L50-IL75 for TN, TP, chlorophyll a, and TSI respectively for Lake Bonny for the ten-year modeled period (1994 – 2003).

Table 5.2 Lake Bonny TSI for PC, Background, TMDL Target, and TSI-Unit Reduction

TSI for Measured, PC, Background, TMDL Target, TMDL, and TSI-unit Percent Reduction Based on Background L50-IL75						
Year	Measured	PC	Background IL75	Target IL75+5	TMDL	Percent Reduction
1994	66.4	66.2	53.3	58.3	58.3	54.5
1995	69.0	68.9	54.7	59.7	59.5	54.5
1996	69.9	70.0	62.4	67.4	67.6	25.0
1997	73.7	73.7	53.4	58.4	58.2	77.0
1998	72.3	72.2	56.4	61.4	61.3	69.0
1999	76.0	76.0	62.2	67.2	67.0	66.0
2000*	86.3	86.3	82.1	84.2	84.1	28.0
2001	87.8	87.8	74.8	79.8	79.7	68.0
2002	74.2	74.2	58.3	63.3	63.1	72.0
2003	67.0	66.9	52.2	57.2	57.1	63.0
Minimum	66.4	66.2	52.2	57.2	57.1	25.0
Maximum	87.8	87.8	82.1	87.1	84.1	77.0
Average	74.3	74.2	61.0	66.0	65.6	57.7

* Target for year 2000 was set at half the difference between IL75 and PC due to a dry year in the background condition.

Table 5.3 Lake Bonny Mass for TN and TP for Calibrated Model, TMDL, and Percent Reduction

Mass for TN and TP for Calibrated Model and TMDL, with Mass Percent Reductions (kg/year)						
Year	TN-MASS Calibrated	TN-MASS TMDL	TN-MASS % Reduction	TP-MASS Calibrated	TP-MASS TMDL	TP-MASS % Reduction
1994	10,059.0	4,576.8	54.5	719.2	327.2	54.5
1995	9,062.8	4,123.6	54.5	1,605.6	730.5	54.5
1996	10,031.4	7,523.5	25.0	1,241.1	930.8	25.0
1997	20,827.0	4,790.2	77.0	6,615.3	1,521.5	77.0
1998	15,320.9	4,749.5	69.0	1,706.9	529.1	69.0
1999	11,479.9	3,903.2	66.0	1,568.9	533.4	66.0
2000*	17,405.3	12,531.7	28.0	2,030.3	1,461.8	28.0
2001	29,067.4	9,301.6	68.0	4,604.5	1,473.4	68.0
2002	35,883.1	10,047.3	72.0	2,597.4	727.3	72.0
2003	11,699.1	4,328.5	63.0	1,287.9	476.5	63.0
Minimum	9,062.8	3,903.2	25.0	719.2	327.2	25.0
Maximum	35,883.1	12,531.7	77.0	6,615.3	1,521.5	77.0
Average	17,083.6	6,587.6	57.7	2,397.7	871.2	57.7

* Target for year 2000 was set at half the difference between IL75 and PC due to a dry year in the background condition.

Table 5.4 Lake Bonny Annual Average Concentrations for TN, TP, and Chlorophyll a

Annual Average Concentrations for TN, TP, and Chlorophyll a (µg/L)									
Year	Measured TN	Calibrated TN	TMDL TN	Measured TP	Calibrated TP	TMDL TP	Measured Chl a	Calibrated Chl a	TMDL Chl a
1994	1,417.8	1,418.0	869.9	82.5	82.9	51.9	38.7	35.7	23.8
1995	1,238.5	1,238.9	754.7	121.5	121.4	77.7	47.7	37.8	29.4
1996	1,723.9	1,724.5	1,459.4	137.3	137.2	117.1	40.0	45.6	35.7
1997	1,834.5	1,834.3	729.4	238.5	238.1	106.4	56.3	54.7	25.9
1998	1,692.5	1,692.7	831.4	125.3	125.4	64.5	59.9	43.0	32.3
1999	2,331.3	2,331.4	1,244.8	195.8	195.3	108.1	60.2	60.0	38.9
2000*	4,471.3	4,470.8	3,744.1	341.4	341.8	287.6	111.8	86.4	104.4
2001	4,053.8	4,053.8	2,145.7	359.9	360.6	196.7	141.5	86.1	105.3
2002	2,542.5	2,542.0	1,197.6	145.6	145.4	70.3	53.2	53.6	30.8
2003	1,420.1	1,420.6	767.7	105.9	105.5	59.5	35.7	37.9	20.1
Minimum	1,238.5	1,238.9	729.4	82.5	82.9	51.9	35.7	35.7	20.1
Maximum	4,471.3	4,470.8	3,744.1	359.9	360.6	287.6	141.5	86.4	105.3
Average	2,272.6	2,272.7	1,374.5	185.4	185.3	114.0	64.5	54.1	44.7

* Target for year 2000 was set at half the difference between IL75 and PC due to a dry year in the background condition.

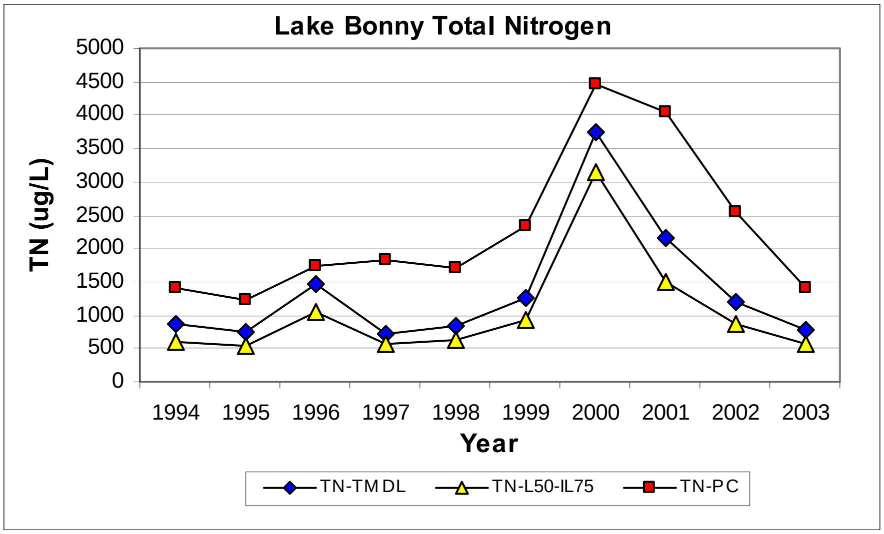

Figure 5.5 Lake Bonny Total Nitrogen Target TMDL, L50-IL75, and Background Calibration from 1994 to 2003

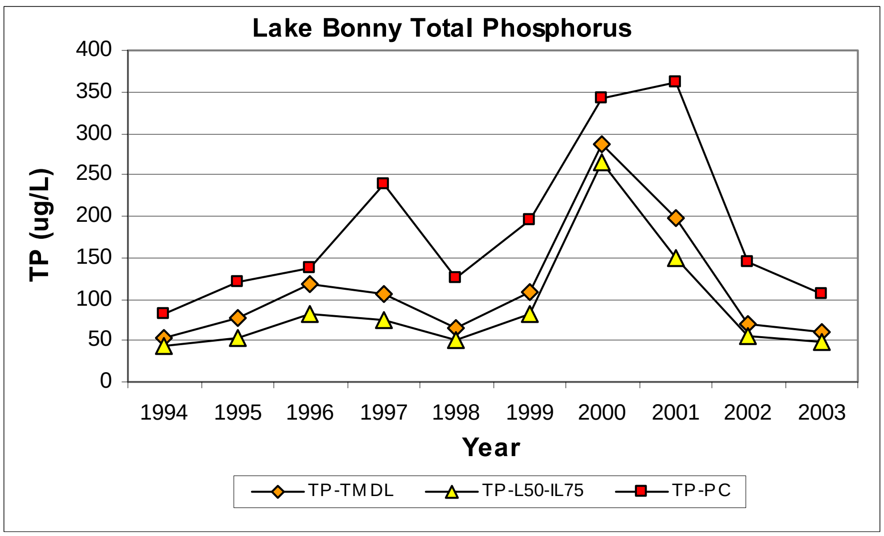

Figure 5.6 Lake Bonny Total Phosphorus Target TMDL, L50-IL75, and Background Calibration from 1994 to 2003

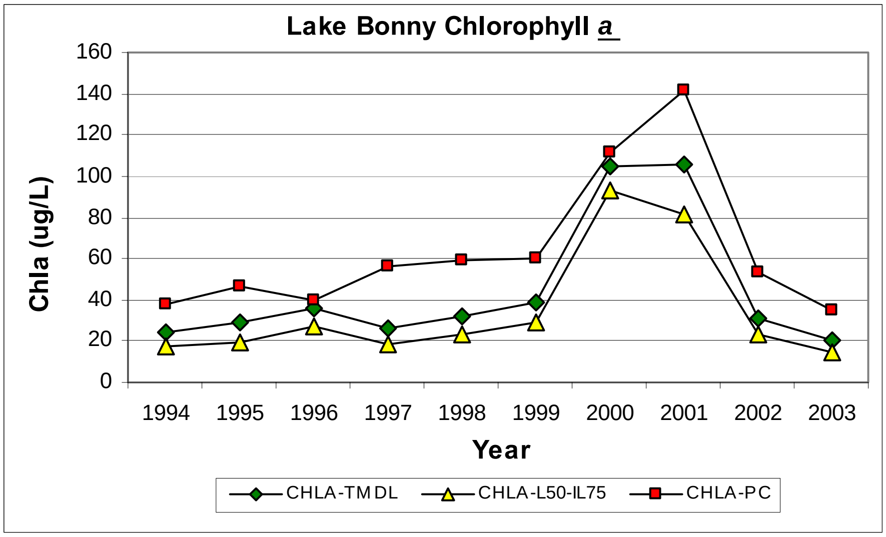

Figure 5.7 Lake Bonny Chlorophyll a Target TMDL, L50-IL75, and Background Calibration from 1994 to 2003

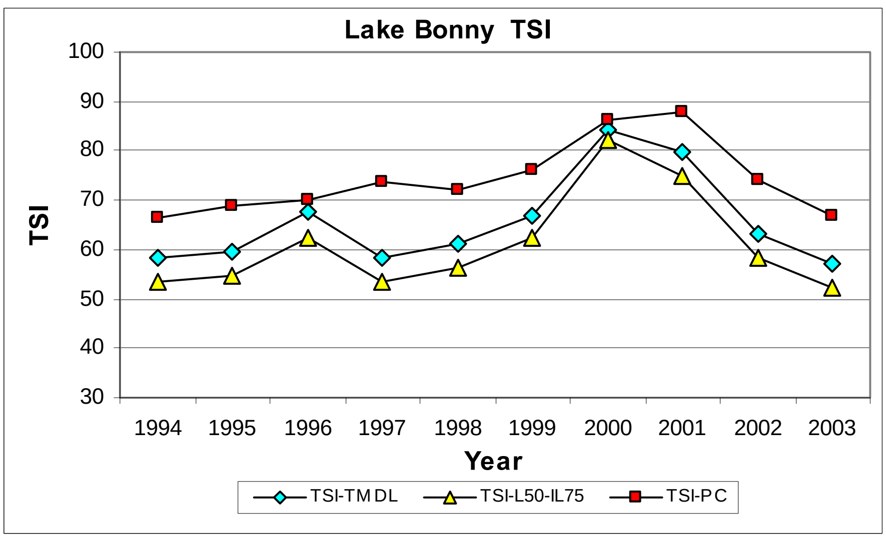

Figure 5.8 Lake Bonny TSI Target TMDL, L50-IL75, and Background Calibration from 1994 to 2003

5.3 Critical Conditions

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

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:

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

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

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

This approach is consistent with federal regulations [40 CFR § 130.2(I)], which state that TMDLs can be expressed in terms of mass per time (e.g. pounds per day), toxicity, or **other appropriate measure**. The TMDL for Lake Bonny is expressed in terms of pounds (lbs) 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 Lake Bonny TMDL Load Allocations

WBID	Parameter	WLA		LA (lbs/year)	MOS	TMDL (lbs/year)	Percent Reduction
		Wastewater (lbs/year)	Stormwater (% reduction)				
1497E	TN	NA	57.7%	14,523.2	Implicit	14,523.2	57.7%
1497E	TP	NA	57.7%	1,920.7	Implicit	1,920.7	57.7%

6.2 Load Allocation (LA)

The required long-term annual average allowable LA is 14,523.2lbs/year for TN and 1,920.7lbs/year for TP. This corresponds to reductions from the existing loadings of 57.7 percent for TN and 57.7 percent for TP. Maintaining the long-term annual average loadings for TP and TN established as this TMDL should result in attaining the target annual average TSI of 66. 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

There are no wastewater or industrial NPDES facilities that discharge directly to Lake Bonny or its watershed. As such, the $WLA_{wastewater}$ for the Lake Bonny TMDL is not applicable.

NPDES Stormwater Discharges

The wasteload allocation for stormwater discharges is a 57.7 percent reduction in loading for both TN and TP, which is the required percent reduction in nonpoint sources. It should be noted that any MS4 permittee will only be responsible for reducing the loads associated with stormwater outfalls for which it owns or otherwise has responsible control, and is not responsible for reducing other nonpoint source loads within its jurisdiction.

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 Lake Bonny 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 for a10 TSI unit increase (5 TSI units above natural background conditions and an additional 5 TSI units to allow for future changes) in determining the assimilative capacity (i.e., loading and water quality response) of the lake.

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 Lake Bonny and its 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.

The rule 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. To date, stormwater PLRGs have been established for Tampa Bay, Lake Thonotosassa, the Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka. At this time, no PLRG has been developed for Lake Bonny.

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. The Department received authorization to implement the NPDES stormwater program in 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. 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. 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, and Chlorophyll *a* Raw Data Used in the TMDL Analysis for Lake Bonny

Lake Bonny Total Nitrogen Data

WBID	Station	Date	Time	Depth (ft)	Storet Code	TN	R-Code
1497E	21FLPOLKBONNY1	4/8/1992	1450	3.61	600	2.30	
1497E	21FLPOLKBONNY1	10/7/1992	1250	10.50	600	1.65	
1497E	21FLPOLKBONNY1	3/31/1993	1130	1.60	600	1.56	
1497E	21FLPOLKBONNY1	10/6/1993	1340	1.40	600	1.25	
1497E	21FLPOLKBONNY1	4/12/1994	910	1.40	600	2.02	
1497E	21FLPOLKBONNY1	10/5/1994	957	1.50	600	0.82	
1497E	21FLPOLKBONNY1	4/5/1995	920	1.50	600	1.11	
1497E	21FLPOLKBONNY1	11/8/1995	1157	1.50	600	1.37	
1497E	LAKELANDBONNY(CENTER)	3/13/1996	811	0.50	600	1.40	
1497E	21FLPOLKBONNY1	5/8/1996	920	1.50	600	1.21	
1497E	LAKELANDBONNY(CENTER)	6/19/1996	800	0.50	600	2.50	
1497E	21FLSWFDSTA0411	8/1/1996	1110	0.50	600	2.00	
1497E	LAKELANDBONNY(CENTER)	9/18/1996	800	0.50	600	2.79	
1497E	21FLPOLKBONNY1	11/13/1996	1010	1.30	600	1.89	
1497E	21FLSWFDSTA0411	1/8/1997	2500	0.50	600	1.21	+
1497E	LAKELANDBONNY(CENTER)	3/18/1997	850	0.50	600	3.11	
1497E	21FLPOLKBONNY1	5/7/1997	928	0.90	600	1.81	
1497E	LAKELANDBONNY(CENTER)	6/18/1997	850	0.50	600	4.48	
1497E	LAKELANDBONNY(CENTER)	9/23/1997	824	0.50	600	2.00	
1497E	21FLPOLKBONNY1	10/30/1997	912	1.40	600	1.38	
1497E	LAKELANDBONNY(CENTER)	3/24/1998	808	0.50	600	1.27	
1497E	21FLPOLKBONNY1	5/5/1998	900	1.20	600	1.81	
1497E	LAKELANDBONNY(CENTER)	6/9/1998	820	0.50	600	2.06	
1497E	LAKELANDBONNY(CENTER)	9/14/1998	1110	0.50	600	2.40	
1497E	21FLPOLKBONNY1	11/10/1998	840	1.40	600	1.27	
1497E	LAKELANDBONNY(CENTER)	3/8/1999	810	0.50	600	3.11	
1497E	21FLPOLKBONNY1	5/10/1999	900	1.00	600	1.79	
1497E	LAKELANDBONNY(CENTER)	6/15/1999	802	0.50	600	2.93	
1497E	21FLSWFDBONNY	8/25/1999	1140	0.50	600	0.45	J
1497E	LAKELANDBONNY(CENTER)	9/22/1999	815	0.50	600	2.52	
1497E	21FLPOLKBONNY1	11/8/1999	930	1.20	600	1.91	
1497E	LAKELANDBONNY(CENTER)	12/7/1999	845	0.00	600	2.82	
1497E	21FLSWFDBONNY	2/24/2000	840	0.50	600	1.42	+
1497E	LAKELANDBONNY(CENTER)	3/21/2000	830	0.50	600	3.68	
1497E	21FLPOLKBONNY1	5/2/2000	815	0.80	600	4.17	
1497E	LAKELANDBONNY(CENTER)	6/13/2000	850	0.50	600	4.37	
1497E	LAKELANDBONNY(CENTER)	9/18/2000	905	0.50	600	4.14	
1497E	21FLPOLKBONNY1	11/2/2000	853	0.40	600	5.81	
1497E	LAKELANDBONNY(CENTER)	12/12/2000	945	0.00	600	5.46	
1497E	LAKELANDBONNY(CENTER)	3/13/2001	839	0.50	600	4.33	
1497E	21FLPOLKBONNY1	5/3/2001	1030	0.50	600	6.79	
1497E	LAKELANDBONNY(CENTER)	6/28/2001	908	0.50	600	7.33	
1497E	LAKELANDBONNY(CENTER)	9/11/2001	902	0.50	600	3.06	

WBID	Station	Date	Time	Depth (ft)	Storet Code	TN	R-Code
1497E	21FLKWATPOL-BONNY-1	9/17/2001	0	0.50	600	2.35	
1497E	21FLKWATPOL-BONNY-2	9/17/2001	0	0.50	600	2.32	
1497E	21FLKWATPOL-BONNY-3	9/17/2001	0	0.50	600	1.63	
1497E	21FLKWATPOL-BONNY-1	10/21/2001	0	0.50	600	2.26	
1497E	21FLKWATPOL-BONNY-2	10/21/2001	0	0.50	600	2.21	
1497E	21FLKWATPOL-BONNY-3	10/21/2001	0	0.50	600	1.92	
1497E	21FLPOLKBONNY1	11/20/2001	1045	0.50	600	2.59	
1497E	21FLKWATPOL-BONNY-1	11/24/2001	0	0.50	600	2.33	
1497E	21FLKWATPOL-BONNY-2	11/24/2001	0	0.50	600	2.19	
1497E	21FLKWATPOL-BONNY-3	11/24/2001	0	0.50	600	1.94	
1497E	LAKELANDBONNY(CENTER)	12/11/2001	0	0.50	600	2.45	
1497E	21FLKWATPOL-BONNY-1	12/29/2001	0	0.50	600	2.10	
1497E	21FLKWATPOL-BONNY-2	12/29/2001	0	0.50	600	2.05	
1497E	21FLKWATPOL-BONNY-3	12/29/2001	0	0.50	600	2.18	
1497E	LAKELANDBONNY(CENTER)	3/18/2002	0	0.50	600	3.62	
1497E	21FLPOLKBONNY1	5/9/2002	815	0.50	600	3.04	
1497E	LAKELANDBONNY(CENTER)	6/11/2002	0	0.50	600	3.06	
1497E	21FLPOLKBONNY1	8/1/2002	1255	0.50	600	2.56	
1497E	LAKELANDBONNY(CENTER)	9/19/2002	0	0.50	600	1.89	
1497E	21FLPOLKBONNY1	11/7/2002	1345	0.50	600	1.78	
1497E	LAKELANDBONNY(CENTER)	12/11/2002	855	0.50	600	2.00	
1497E	21FLPOLKBONNY1	2/11/2003	855	0.50	600	1.50	
1497E	21FLPOLKBONNY1	5/13/2003	930	0.50	600	1.42	
1497E	LAKELANDBONNY(CENTER)	6/17/2003	850	0.50	600	1.51	
1497E	21FLPOLKBONNY1	8/26/2003	1325	0.50	600	1.33	
1497E	LAKELANDBONNY(CENTER)	9/11/2003	943	0.50	600	1.14	
1497E	21FLPOLKBONNY1	11/6/2003	825	0.50	600	1.49	
1497E	LAKELANDBONNY(CENTER)	12/9/2003	850	0.50	600	1.43	
1497E	21FLPOLKBONNY1	2/11/2004	1130	0.50	600	1.43	+

J: Estimated; Value shown is not a result of analytical measurement.
+: Calculated value.

Lake Bonny Total Phosphorus Data

WBID	Station	Date	Time	Depth (ft)	Storet Code	TP	R-Code
1497E	21FLPOLKBONNY1	4/8/1992	1450	3.61	665	0.163	
1497E	21FLPOLKBONNY1	10/7/1992	1250	10.50	665	0.099	
1497E	21FLPOLKBONNY1	3/31/1993	1130	1.60	665	0.097	
1497E	21FLPOLKBONNY1	10/6/1993	1340	1.40	665	0.066	
1497E	21FLPOLKBONNY1	4/12/1994	910	1.40	665	0.106	
1497E	21FLPOLKBONNY1	10/5/1994	957	1.50	665	0.059	
1497E	21FLPOLKBONNY1	4/5/1995	920	1.50	665	0.13	
1497E	21FLPOLKBONNY1	11/8/1995	1157	1.50	665	0.113	
1497E	LAKELANDBONNY(CENTER)	3/13/1996	811	0.50	665	0.318	
1497E	21FLPOLKBONNY1	5/8/1996	920	1.50	665	0.067	
1497E	LAKELANDBONNY(CENTER)	6/19/1996	800	0.50	665	0.099	
1497E	21FLSWFDSTA0411	8/1/1996	1110	0.50	665	0.012	
1497E	LAKELANDBONNY(CENTER)	9/18/1996	800	0.50	665	0.118	

WBID	Station	Date	Time	Depth (ft)	Storet Code	TP	R-Code
1497E	21FLPOLKBONNY1	11/13/1996	1010	1.30	665	0.099	
1497E	21FLSWFDSTA0411	1/8/1997	2500	0.50	665	0.064	
1497E	LAKELANDBONNY(CENTER)	3/18/1997	850	0.50	665	0.302	
1497E	21FLPOLKBONNY1	5/7/1997	928	0.90	665	0.107	
1497E	LAKELANDBONNY(CENTER)	6/18/1997	850	0.50	665	0.43	
1497E	LAKELANDBONNY(CENTER)	9/23/1997	824	0.50	665	0.52	
1497E	21FLPOLKBONNY1	10/30/1997	912	1.40	665	0.144	
1497E	LAKELANDBONNY(CENTER)	3/24/1998	808	0.50	665	0.1	
1497E	21FLPOLKBONNY1	5/5/1998	900	1.20	665	0.102	
1497E	LAKELANDBONNY(CENTER)	6/9/1998	820	0.50	665	0.21	
1497E	LAKELANDBONNY(CENTER)	9/14/1998	1110	0.50	665	0.23	
1497E	21FLPOLKBONNY1	11/10/1998	840	1.40	665	0.069	
1497E	LAKELANDBONNY(CENTER)	3/8/1999	810	0.50	665	0.341	
1497E	21FLPOLKBONNY1	5/10/1999	900	1.00	665	0.096	
1497E	LAKELANDBONNY(CENTER)	6/15/1999	802	0.50	665	0.253	
1497E	21FLSWFDBONNY	8/25/1999	1140	0.50	665	0.088	
1497E	LAKELANDBONNY(CENTER)	9/22/1999	815	0.50	665	0.231	
1497E	21FLPOLKBONNY1	11/8/1999	930	1.20	665	0.108	
1497E	21FLSWFDBONNY	2/24/2000	840	0.50	665	0.13	
1497E	LAKELANDBONNY(CENTER)	3/21/2000	830	0.50	665	0.393	
1497E	21FLPOLKBONNY1	5/2/2000	815	0.80	665	0.27	
1497E	LAKELANDBONNY(CENTER)	6/13/2000	850	0.50	665	0.64	
1497E	LAKELANDBONNY(CENTER)	9/18/2000	905	0.50	665	0.297	
1497E	21FLPOLKBONNY1	11/2/2000	853	0.40	665	0.352	
1497E	LAKELANDBONNY(CENTER)	3/13/2001	839	0.50	665	0.536	
1497E	21FLPOLKBONNY1	5/3/2001	1030	0.50	665	0.574	
1497E	LAKELANDBONNY(CENTER)	6/28/2001	908	0.50	665	0.606	
1497E	LAKELANDBONNY(CENTER)	9/11/2001	902	0.50	665	0.312	
1497E	21FLKWATPOL-BONNY-1	9/17/2001	0	0.50	665	0.171	
1497E	21FLKWATPOL-BONNY-2	9/17/2001	0	0.50	665	0.178	
1497E	21FLKWATPOL-BONNY-3	9/17/2001	0	0.50	665	0.13	
1497E	21FLKWATPOL-BONNY-1	10/21/2001	0	0.50	665	0.144	
1497E	21FLKWATPOL-BONNY-2	10/21/2001	0	0.50	665	0.14	
1497E	21FLKWATPOL-BONNY-3	10/21/2001	0	0.50	665	0.138	
1497E	21FLPOLKBONNY1	11/20/2001	1045	0.50	665	0.142	
1497E	21FLKWATPOL-BONNY-1	11/24/2001	0	0.50	665	0.151	
1497E	21FLKWATPOL-BONNY-2	11/24/2001	0	0.50	665	0.142	
1497E	21FLKWATPOL-BONNY-3	11/24/2001	0	0.50	665	0.116	
1497E	21FLKWATPOL-BONNY-1	12/29/2001	0	0.50	665	0.119	
1497E	21FLKWATPOL-BONNY-2	12/29/2001	0	0.50	665	0.115	
1497E	21FLKWATPOL-BONNY-3	12/29/2001	0	0.50	665	0.102	
1497E	LAKELANDBONNY(CENTER)	3/18/2002	850	0.50	665	0.469	
1497E	21FLPOLKBONNY1	5/9/2002	815	0.50	665	0.096	
1497E	LAKELANDBONNY(CENTER)	6/11/2002	843	0.50	665	0.275	
1497E	21FLPOLKBONNY1	8/1/2002	1255	0.50	665	0.047	
1497E	LAKELANDBONNY(CENTER)	9/19/2002	0	0.50	665	0.214	
1497E	LAKELANDBONNY(CENTER)	9/19/2002	840	0.50	665	0.214	

WBID	Station	Date	Time	Depth (ft)	Storet Code	TP	R-Code
1497E	21FLPOLKBONNY1	11/7/2002	1345	0.50	665	0.054	
1497E	LAKELANDBONNY(CENTER)	12/11/2002	855	0.50	665	0.187	
1497E	21FLPOLKBONNY1	2/11/2003	855	0.50	665	0.081	
1497E	21FLPOLKBONNY1	5/13/2003	930	0.50	665	0.054	
1497E	LAKELANDBONNY(CENTER)	6/17/2003	850	0.50	665	0.149	
1497E	21FLPOLKBONNY1	8/26/2003	1325	0.50	665	0.039	
1497E	LAKELANDBONNY(CENTER)	9/11/2003	943	0.50	665	0.226	
1497E	21FLPOLKBONNY1	11/6/2003	825	0.50	665	0.038	
1497E	LAKELANDBONNY(CENTER)	12/9/2003	850	0.50	665	0.179	
1497E	21FLPOLKBONNY1	2/11/2004	1130	0.50	665	0.046	

Lake Bonny Chlorophyll *a* Data

WBID	Station	Date	Time	Depth (ft)	Storet Code	Chl(a)	R-Code
1497E	21FLPOLKBONNY1	4/8/1992	1450	3.61	32210	51.1	
1497E	21FLPOLKBONNY1	10/7/1992	1250	10.50	32210	58.6	
1497E	21FLPOLKBONNY1	3/31/1993	1130	5.25	32210	28.2	
1497E	21FLPOLKBONNY1	10/6/1993	1340	4.59	32210	43.8	
1497E	21FLPOLKBONNY1	4/12/1994	910	4.59	32210	50.5	
1497E	21FLPOLKBONNY1	10/5/1994	957	4.92	32210	26.9	
1497E	21FLPOLKBONNY1	4/5/1995	920	4.92	32210	46.9	
1497E	21FLPOLKBONNY1	11/8/1995	1157	4.92	32210	48.4	
1497E	LAKELANDBONNY(CENTER)	3/13/1996	811	0.50	32210	25.3	
1497E	21FLPOLKBONNY1	5/8/1996	920	4.92	32210	50.4	
1497E	LAKELANDBONNY(CENTER)	6/19/1996	800	0.50	32210	49.8	
1497E	21FLSWFDSTA0411	8/1/1996	1110	0.50	32211	25.5	
1497E	LAKELANDBONNY(CENTER)	9/18/1996	800	0.50	32210	53.5	
1497E	21FLPOLKBONNY1	11/13/1996	1010	4.26	32210	58.9	
1497E	21FLSWFDSTA0411	1/8/1997	2500	0.50	32211	42.2	
1497E	LAKELANDBONNY(CENTER)	3/18/1997	850	0.50	32210	50.7	
1497E	21FLPOLKBONNY1	5/7/1997	928	2.95	32210	47.2	
1497E	LAKELANDBONNY(CENTER)	6/18/1997	850	0.50	32210	69.8	
1497E	LAKELANDBONNY(CENTER)	9/23/1997	824	0.50	32210	55.3	
1497E	21FLPOLKBONNY1	10/30/1997	912	4.59	32210	77.2	
1497E	LAKELANDBONNY(CENTER)	3/24/1998	808	0.50	32210	23.7	
1497E	21FLPOLKBONNY1	5/5/1998	900	1.20	32210	58.5	
1497E	LAKELANDBONNY(CENTER)	6/9/1998	820	0.50	32210	52.2	
1497E	LAKELANDBONNY(CENTER)	9/14/1998	1110	0.50	32210	77.7	
1497E	21FLPOLKBONNY1	11/10/1998	840	4.59	32210	79.8	
1497E	LAKELANDBONNY(CENTER)	3/8/1999	810	0.50	32210	56.9	
1497E	21FLPOLKBONNY1	5/10/1999	900	1.00	32223	72.1	
1497E	LAKELANDBONNY(CENTER)	6/15/1999	802	0.50	32210	61.2	
1497E	21FLSWFDBONNY	8/25/1999	1140	0.50	32211	61.8	
1497E	LAKELANDBONNY(CENTER)	9/22/1999	815	0.50	32210	70.3	
1497E	21FLPOLKBONNY1	11/8/1999	930	1.20	32223	60.1	
1497E	LAKELANDBONNY(CENTER)	12/7/1999	845	0.00	32210	32.4	

WBID	Station	Date	Time	Depth (ft)	Storet Code	Chl(a)	R-Code
1497E	21FLSWFDBONNY	2/24/2000	840	0.50	32211	110.0	
1497E	LAKELANDBONNY(CENTER)	3/21/2000	830	0.50	32210	67.0	
1497E	LAKELANDBONNY(CENTER)	3/21/2000	830	0.50	32210	67.0	
1497E	21FLPOLKBONNY1	5/2/2000	815	0.80	32223	116.1	
1497E	LAKELANDBONNY(CENTER)	6/13/2000	850	0.50	32210	108.5	
1497E	LAKELANDBONNY(CENTER)	9/18/2000	905	0.50	32210	145.6	
1497E	21FLPOLKBONNY1	11/2/2000	853	0.40	32223	135.5	
1497E	LAKELANDBONNY(CENTER)	12/12/2000	945	0.50	32210	99.9	
1497E	LAKELANDBONNY(CENTER)	3/13/2001	839	0.50	32210	81.4	
1497E	21FLPOLKBONNY1	5/3/2001	1030	0.50	32223	288.4	
1497E	LAKELANDBONNY(CENTER)	6/28/2001	908	0.50	32210	264.6	
1497E	LAKELANDBONNY(CENTER)	9/11/2001	902	0.50	32210	69.6	
1497E	21FLKWATPOL-BONNY-1	9/17/2001	0	0.50	32210	96.0	
1497E	21FLKWATPOL-BONNY-2	9/17/2001	0	0.50	32210	91.0	
1497E	21FLKWATPOL-BONNY-3	9/17/2001	0	0.50	32210	76.0	
1497E	21FLKWATPOL-BONNY-1	10/21/2001	0	0.50	32210	115.0	
1497E	21FLKWATPOL-BONNY-2	10/21/2001	0	0.50	32210	100.0	
1497E	21FLKWATPOL-BONNY-3	10/21/2001	0	0.50	32210	82.0	
1497E	21FLPOLKBONNY1	11/20/2001	1045	0.50	32223	60.1	
1497E	21FLKWATPOL-BONNY-1	11/24/2001	0	0.50	32210	98.0	
1497E	21FLKWATPOL-BONNY-2	11/24/2001	0	0.50	32210	96.0	
1497E	21FLKWATPOL-BONNY-3	11/24/2001	0	0.50	32210	73.0	
1497E	LAKELANDBONNY(CENTER)	12/11/2001	0	0.50	32210	51.3	
1497E	21FLKWATPOL-BONNY-1	12/29/2001	0	0.50	32210	75.0	
1497E	21FLKWATPOL-BONNY-2	12/29/2001	0	0.50	32210	75.0	
1497E	21FLKWATPOL-BONNY-3	12/29/2001	0	0.50	32210	57.0	
1497E	LAKELANDBONNY(CENTER)	3/18/2002	850	0.50	32210	37.0	
1497E	21FLPOLKBONNY1	5/9/2002	815	0.50	32223	47.0	
1497E	LAKELANDBONNY(CENTER)	6/11/2002	843	0.50	32210	54.6	
1497E	21FLPOLKBONNY1	8/1/2002	1255	0.50	32223	50.5	
1497E	LAKELANDBONNY(CENTER)	9/19/2002	840	0.50	32210	36.5	
1497E	LAKELANDBONNY(CENTER)	12/11/2002	855	0.50	32210	42.2	
1497E	LAKELANDBONNY(CENTER)	6/17/2003	850	0.50	32210	40.2	
1497E	LAKELANDBONNY(CENTER)	9/11/2003	943	0.50	32210	36.5	
1497E	LAKELANDBONNY(CENTER)	12/9/2003	850	0.50	32210	30.3	
1497E	21FLPOLKBONNY1	2/11/2004	1130	0.50	32210	21.0	

Appendix C: SWET Watershed Assessment Model (WAM) Final Report for the Lake Hancock and Saddle Creek Basin (available upon request)

Appendix D: QEA, LLC, BATHTUB Model Final Report for the Lake Hancock and Saddle Creek Basin (available upon request)