FINAL

TOTAL MAXIMUM DAILY LOAD (TMDL)

For

Biochemical Oxygen Demand, Dissolved Oxygen, and Nutrients

In the

Lake Okeechobee Tributaries

Osceola, Polk, Okeechobee, Highlands, Glade, and Martin, Florida

Prepared by:

US EPA Region 4

61 Forsyth Street SW

Atlanta, Georgia 30303

June 2008

United States Environmental Protection Agency

In compliance with the provisions of the Federal Clean Water Act, 33 U.S.C §1251 et. seq., as amended by the Water Quality Act of 1987, P.L. 400-4, the U.S. Environmental Protection Agency is hereby establishing Total Maximum Daily Loads (TMDLs) for biochemical oxygen demand, dissolved oxygen, and nutrients in the Lake Okeechobee tributaries. Subsequent actions must be consistent with these TMDLs.

James D. Giattina
Director
Water Management Division

Date

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AFO	Animal Feeding Operation
AgNMP	Agricultural Nutrient Management Plan
BAT	Best Available Technology
BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
CAFO	Confined Animal Feeding Operation
CFS	Cubic Feet per Second
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
EAA	Everglades Agricultural Area
EOF	Edge-of-Field/Farm
F.A.C.	Florida Administrative Code
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
GIS	Geographic Information System
HAB	Harmful Algae Bloom
HUC	Hydrologic Unit Code
IWR	Impaired Waters Rule
LA	Load Allocation
LOPP	Lake Okeechobee Protection Plan
LOWP	Lake Okeechobee Watershed Project
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer Systems
Mton	Metric Ton
NPDES	National Pollutant Discharge Elimination System
PLRG	Pollutant Load Reduction Goal
PPB	Parts Per Billion (equivalent to 1 ug/L)
PPM	Parts Per Million (equivalent to 1 mg/L)
RASTA	Reservoir Assisted Stormwater Treatment Area
SFWMD	South Florida Water Management District
SOD	Sediment Oxygen Demand
SSAC	Site Specific Alternative Criteria
STA	Stormwater Treatment Area
TCNS	Taylor Creek Nubbin Slough
TN	Total Nitrogen
TP	Total Phosphorus
WBID	Water Body Identification
WLA	Waste Load Allocation

SUMMARY SHEET

1. Florida 1998 303(d) Listed Waterbody Information

WBID	Segment Name	Classification	Constituent	County	HUC
3186B	Kissimmee River	3F	DO, BOD	Osceola	03090101
3186C	Blanket Bay Slough	3F	Nutrients, DO	Osceola	03090101
3186D	Eight Mile Slough	3F	DO	Polk	03090101
3188	Farm Area	3F	Nutrients, DO	Okeechobee	03090101
3188A	Chandler Slough	3F	Nutrients, DO	Okeechobee	03090101
3192C	Oak Creek	3F	Nutrients, DO	Okeechobee	03090101
3199B	Chandler Hammock Slough	3F	Nutrients, DO	Okeechobee	03090102
3203A	Nubbin Slough	3F	Nutrients, DO	Okeechobee	03090102
3203B	Mosquito Creek	3F	Nutrients, DO	Okeechobee	03090102
3204	Harney Pond Canal	3F	Nutrients, DO	Highlands/Glade	03090103
3205	Taylor Creek	3F	Nutrients, DO	Okeechobee	03090101
3205D	Otter Creek	3F	Nutrients, DO	Okeechobee	03090101
3206	Indian Prairie Canal	3F	Nutrients, DO	Highlands/Glade	03090103
3209	Kissimmee River	3F	Nutrients, DO	Glades	03090101
3213A	Lettuce Creek	3F	Nutrients, DO	Okeechobee/Martin	03090102
3213B	Henry Creek	3F	Nutrients, DO	Okeechobee	03090102
3213C	S-135	3F	Nutrients, DO	Martin	03090102
3213D	Myrtle Slough	3F	Nutrients, DO	Martin	03090102
1436	Horseshoe Creek	3F	Nutrients, DO	Polk	03090101
3248	N. New River Canal (S-2 Basin)	3F	Nutrients, DO	Palm Beach	03090202
3251	S-3 Basin	3F	Nutrients, DO	Palm Beach	03090202

3246	East Caloosahatchee (S-4 Basin)	3F	Nutrients, DO	Hendry	03090202

2. Water Quality Standards:

BOD Levels shall not be increased to exceed values which would cause dissolved oxygen to be depressed below the limit established for each class and, in no case, shall it be great enough to produce nuisance conditions. See 62-302.530(12), F.A.C.

DO Dissolved oxygen shall not be less than 5.0 mg/l. Normal daily and seasonal fluctuations above these levels shall be maintained. See 62-302.530(31), F.A.C.

Nutrients The discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in this chapter. Man induced nutrient enrichment (total nitrogen and total phosphorus) shall be considered degradation in relation to the provisions of Section 62-302.300, 62-302.700, and 62-4.242, F.A.C. See 62-302.530(48)(a), F.A.C.

In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna. See 62-302.530(48)(b), F.A.C.

It should be noted that FDEP has efforts ongoing to develop numeric criteria for nutrients applicable to inland waters which are expected to be adopted into state water quality standards at a future date according to a schedule described in the state of Florida's *Numeric Nutrient Criteria Development Plan* (FDEP, 2007a).

3. TMDL Approach

Nutrients: The TMDLs target both Total Phosphorus (TP) and Total Nitrogen (TN) based on considerations described in Section 4 of this report. An instream TP target of 113 ug/L was selected to provide protection of aquatic life within each tributary and a TP load consistent with the loads prescribed in the Lake Okeechobee Protection Plan (LOPP) was assigned at the pour point of each of the WBIDs comprising a LOPP basin. An instream target of 1.2 mg/L TN was selected to provide protection of aquatic life within each tributary and to meet downstream uses. The TMDL targets were developed to support the state of Florida's narrative water quality standard for nutrients by not causing an imbalance in natural populations of aquatic flora or fauna and also to not produce or contribute to conditions that violate the state's standard for dissolved oxygen. Control of both nutrients, TN and TP, in upstream waters provides additional assurance that excess productivity will remain in control, and avoids pollutant-caused depressions of DO. The TMDL will ensure protection for aquatic life in the tributary WBIDs and will not contribute to water quality impairments in the downstream waters of Lake Okeechobee and its subsequent drainage to the coastal estuaries of St. Lucie and Caloosahatchee.

Dissolved Oxygen. In WBIDs impaired for both DO and nutrients, it is assumed the TMDLs for TP and TN will address the DO impairment. When BOD data are available and a correlation can be determined between DO and BOD (e.g., WBID 3186B), a TMDL for BOD is provided. The state should consider establishing a site specific criterion for DO for waters that exhibit naturally low DO concentrations.

BOD: A regression analysis correlating BOD to DO was developed to determine the BOD concentration necessary to maintain DO levels that attain the water quality standard.

4. TMDL Allocation for Total Phosphorus in WBIDs Impaired by Nutrients and DO:

LOPP Basin/WBIDs	WLA	LA (ppb)	MOS	TMDL		% Reduction	
				Lake Load (Mton/yr)	WBID Conc. (ppb)	Lake	WBID
S-65A ,B, C, D, E				19.25		76%	
3188	0	113	Implicit		113		76%
3188A	0	113	Implicit		113		41%
3186C	0	113	Implicit		113		0%
3186D	0	113	Implicit		113		58%
3192C	0	113	Implicit		113		76%
Taylor Creek / Nubbin Slough (S-191)				19.01		76%	
3205	0	113	Implicit		113		76%
3205D	0	113	Implicit		113		82%
3203A	0	113	Implicit		113		77%
3203B	0	113	Implicit		113		88%
3213A	0	113	Implicit		113		75%
3213B	0	113	Implicit		113		74%
3213D	0	113	Implicit		113		90%
C-40 Basin (S-72)				2.32		76%	
3206	0	113	Implicit		113		39%
C-41 Basin (S-71)				6.17		76%	
3204	0	113	Implicit		113		25%
L59-E				0.36		76%	
3209	0	113	Implicit		113		0%

LOPP Basin/WBIDs	WLA	LA (ppb)	MOS	TMDL		% Reduction	
				Lake Load (Mton/yr)	WBID Conc. (ppb)	Lake	WBID
S-135 Basin				0.82		76%	
3213C	0	113	Implicit		113		0%
S-154 Basin				5.72		76%	
3199B	0	113	Implicit		113		93%
S-65 (Lake Kissimmee)				16.96		76%	
1436	0	113	Implicit		113		0%
S-2 Basin (includes WBID 3248)				1.98		76%	
S-3 Basin (includes WBID 3251)				0.56		76%	
S-4 Basin (includes WBID 3246)				1.67		76%	

Notes: 1) A daily TP concentration of 113 ug/L is based on an annual average of the measured days taking into account natural variability; 2) WBIDs requiring a higher percent reduction than in the LOPP basins are highlighted in bold font. Additional best management practices beyond those proposed in the Lake Okeechobee Protection Plan should be implemented in these WBIDs; and 3) the loads allocated to the S-2, S-3 and S-4 LOPP basins, which have the potential to back pump flood waters into Lake Okeechobee, are consistent with the loads assigned to the LOPP. EPA is not establishing instream targets for the WBIDs containing these structures, as work is ongoing to quantify nutrient concentrations that are protective of the EAA canals. Once this work is complete, the TMDLs for these WBIDs may be revised as necessary to reflect those target concentrations.

5. TP Allocations for Lake Okeechobee Protection Plan Basins Expressed as Daily Loads:

LOPP Basin	WLA (lb/day)	LA (lb/day)	TMDL (lb/day)
S-65A, B, C, D, E	0	116.19	116.19
Taylor Creek / Nubbin Slough (S-191)	0	114.74	114.74
C-40 Basin (S-72)	0	14	14
C-41 Basin (S-71)	0	37.24	37.24
L59-E	0	2.17	2.17
S-135 Basin	0	4.95	4.95

LOPP Basin	WLA (lb/day)	LA (lb/day)	TMDL (lb/day)
S-154 Basin	0	34.50	34.50
S-65	0	102.37	102.37

lb/day = Mton/yr * yr/365.25 day * 2204.623 lb/Mton.

Note: Achievement of the annual load would imply achievement of the daily load averaged through the year; therefore, implementation should target the annual load.

6. TMDL Allocation for Total Nitrogen for WBIDs Impaired by Nutrients and DO:

WBID	WLA (lb/day)	LA (lb/day)	MOS	TMDL (lb/day)	% Reduction
3188	0	600.09	Implicit	600.09	32%
3188A	0	65.08	Implicit	65.08	15%
3186C	0	98.73	Implicit	98.73	35%
3186D	0	149.39	Implicit	149.39	0%
3192C	0	62.98	Implicit	62.98	39%
3205	0	400.12	Implicit	400.12	34%
3205D	0	74.48	Implicit	74.48	43%
3203A	0	115.64	Implicit	115.64	25%
3203B	0	50.72	Implicit	50.72	54%
3213A	0	23.65	Implicit	23.65	35%
3213B	0	120.90	Implicit	120.90	42%
3213D	0	123.41	Implicit	123.41	54%
3206	0	145.32	Implicit	145.32	31%
3204	0	444.90	Implicit	444.90	39%
3209	0	57.13	Implicit	57.13	27%
3213C	0	170.44	Implicit	170.44	29%
3199B	0	115.19	Implicit	115.19	60%

WBID	WLA (lb/day)	LA (lb/day)	MOS	TMDL (lb/day)	% Reduction
1436	0	240.37	Implicit	240.37	30%

Note: The expressed daily TN load is based on an annual average of the measured days taking into account natural variability.

7. TMDL Allocation for BOD:

WBID	TMDL (lb/day)	WLA (lb/day)	LA (lb/day)	Percent Reduction
3186B	811.13	0	811.13	38%

8. Endangered Species (yes or blank): Yes

9. EPA Lead on TMDL (EPA or blank): EPA

10. TMDL Considers Point Source, Nonpoint Source, or both: Both

11. Major NPDES Discharges to surface waters: None

12. MS4 Jurisdictions:

MS4	NPDES ID
City of Davenport/Polk County	FLS000015

Note: The MS4 is responsible for controlling pollutant loads from the urban areas within its jurisdiction. WBID 1436, Horseshoe Creek, is located in Polk County, but this area is not covered by the Polk County MS4 permit due to low population density. All future areas with population densities meeting the MS4 requirements will be required to implement control strategies to reduce nutrient loadings.

1 INTRODUCTION

Section 303(d) of the Clean Water Act requires states to list waters within its boundaries for which technology based effluent limitations are not stringent enough to protect water quality standards. Listed waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those water bodies that are not meeting water quality standards. The TMDL process establishes allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions. States establish water quality based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of their water resources (USEPA, 1991). The United States Environmental Protection Agency (EPA) is establishing these TMDLs pursuant to commitments in the 1999 Consent Decree in the Florida TMDL lawsuit. See Florida Wildlife Federation, et al. v. Carol Browner, et al., No. 4: 98CV356-WS (N.D. Fla., Tallahassee Division, April 22, 1998).

The Florida Department of Environmental Protection (FDEP) developed a statewide, watershed-based approach to water resource management. Under this approach, water resources are managed on the basis of natural boundaries, such as river basins, rather than political boundaries. The state's 52 basins are divided into 5 groups with water quality assessed in each group on a rotating five-year cycle. The Lake Okeechobee Watershed includes the Lake Okeechobee Basin located in Group 1, the Caloosahatchee and Lake Worth Lagoon-West Palm Beach Coast Basins located in Group 3, the Fisheating Creek Basin and the Kissimmee Basin located in Group 4 and the Everglades Basin located in Group 5. The Florida Legislature established five water management districts (WMDs) responsible for managing ground and surface water supplies in the counties encompassing the districts. The Lake Okeechobee tributaries are managed through the South Florida Water Management District (SFWMD).

For the purpose of planning and management, the WMDs divide the district into planning units defined as either an individual primary tributary basin or a group of adjacent primary tributary basins with similar characteristics. These planning units contain smaller, hydrological based units called drainage basins, which are further divided into "water segments" with each assigned a unique Waterbody IDentification (WBID) number. A water segment usually contains only one unique waterbody type (stream, lake, cannel, etc.).

In September 2006, EPA proposed TMDLs for impaired WBIDs located both north and south of Lake Okeechobee. After consideration of public comments, EPA is finalizing TMDLs for those WBIDs located north of the lake. EPA is also establishing allocations to the WBIDs south of Lake Okeechobee to the extent that those WBIDs act as tributaries to the lake. Thus, this TMDL allocates loads at pump structures that have the potential to back pump flood waters into Lake Okeechobee (i.e., S-2, S-3, and S-4 basins). The loads allocated to these pump structures are consistent with the loads assigned in the Lake Okeechobee Protection Plan (LOPP).

EPA concurs with the public comment that waters south of the Lake in the Everglades Agricultural Area (EAA) are hydrologically different than waters north of the Lake and, therefore, different TMDL targets are appropriate for instream protection of those Lake Okeechobee WBIDs that are located in the EAA. EPA intends to finalize the TMDLs for those WBIDs located in the EAA when it finalizes TMDLs for the more similar waters addressed in the EAA TMDL proposed in September 2007.

EPA is finalizing TMDLs for several of the impaired WBIDs (i.e., WBID 3205, 3205A, 3204, 3186C, and 3186D) in advance of the Consent Decree schedule to encourage implementation of the TMDLs through a watershed approach.

The planning unit and basin group of each impaired WBID are identified in Table 1. All segments are classified as freshwater streams. The locations of impaired WBIDs in the Upper Kissimmee River basin are shown in Figure 1. The location of impaired WBIDs below Lake Kissimmee are shown in Figure 2. The Lake Okeechobee Watershed Project (LOWP) boundaries are overlain with WBID boundaries in Figure 2, and for purposes of this report, the LOWP boundaries are the same as the LOPP basins.

Table 1. Planning Unit and Basin Group of Impaired WBIDs

WBID	Segment Name	Planning Unit	Basin Group
3186B	Kissimmee River	Lower Kissimmee	4
3186C	Blanket Bay Slough	Lower Kissimmee	4
3186D	Eight Mile Slough	Lower Kissimmee	4
3188	Farm Area	Lower Kissimmee	4
3188A	Chandler Slough	Lower Kissimmee	4
3192C	Oak Creek	Lower Kissimmee	4
3199B	Chandler Hammock Slough	CTP Complex	1
3203A	Nubbin Slough	NHLMS Complex	1
3203B	Mosquito Creek	NHLMS Complex	1
3204	Harney Pond Canal	Northwest Lake Okeechobee	4

WBID	Segment Name	Planning Unit	Basin Group
3205	Taylor Creek	TOL63 Complex	1
3205D	Otter Creek	TOL63 Complex	1
3206	Indian Prairie Canal	Northwest Lake Okeechobee	4
3209	Kissimmee River	Lower Kissimmee	4
3213A	Lettuce Creek	NHLMS Complex	1
3213B	Henry Creek	NHLMS Complex	1
3213C	S-135	NHLMS Complex	1
3213D	Myrtle Slough	NHLMS Complex	1
1436	Horseshoe Creek	Upper Kissimmee	4
3248	N. New River Canal (located in S-2 basin)	Everglades Agricultural Area	5
3251	S-3	Everglades Agricultural Area	5
3246	East Caloosahatchee (located in S-4 basin)	East Caloosahatchee	3

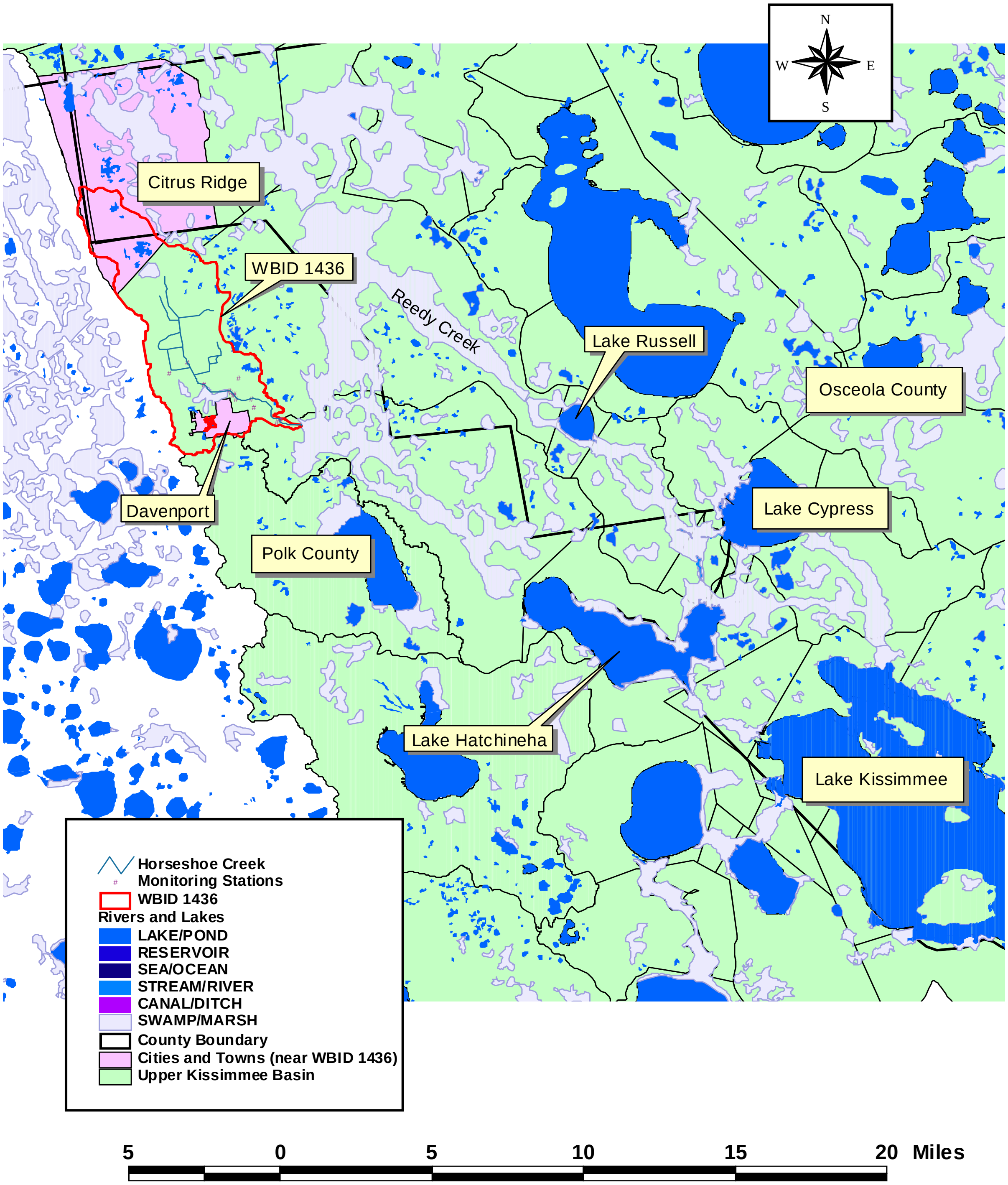


Figure 1. Location of Horseshoe Creek (WBID 1436) in the Upper Kissimmee River Basin

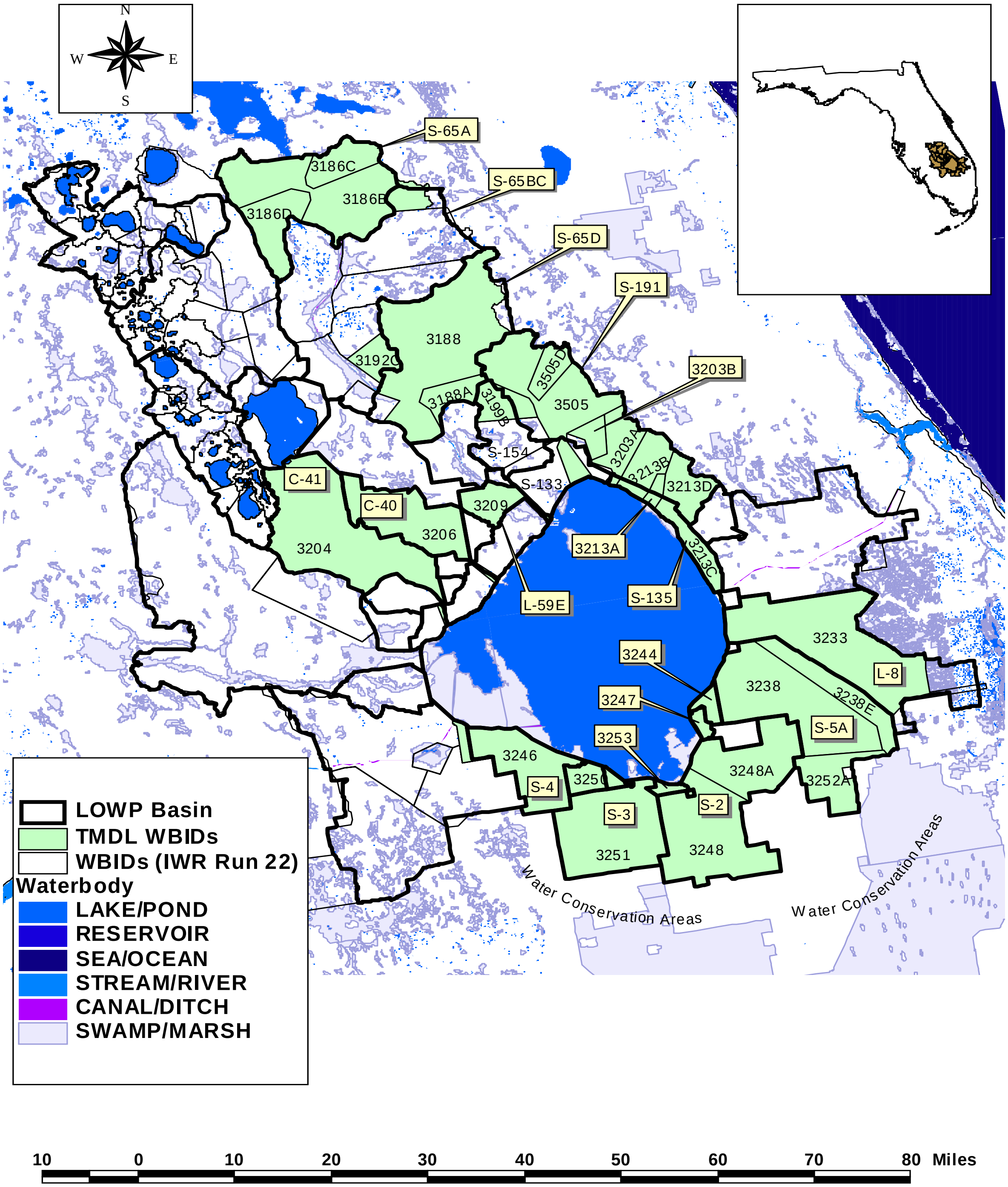


Figure 2. Location of Impaired WBIDs below Lake Kissimmee

1.1 Purpose of Report

This document establishes TMDLs for pollutants contributing to the 1998 listed impairments (i.e., nutrients, DO, and BOD) in the tributaries to Lake Okeechobee. The tributaries were identified as impaired by nutrients, BOD, and/or DO. Load reductions of Total Phosphorus (TP) and Total Nitrogen (TN) should result in the attainment of the designated use of the streams and not contribute to impairments in downstream waters (i.e., Lake Okeechobee and St. Lucie and Caloosahatchee Estuaries).. A TMDL is also established for BOD in WBID 3186B to meet the applicable water quality criteria.

1.2 Previous Studies in the Lake Okeechobee Watershed

Lake Okeechobee TMDL:

The total phosphorus TMDL for Lake Okeechobee was adopted by FDEP in May 2001 and was approved by EPA in October 2001 (FDEP, 2001a). The TMDL establishes an annual load of 140 Mtons of phosphorus to Lake Okeechobee to achieve an in-lake target phosphorus concentration of 40 ppb in the pelagic zone of the Lake. The target was developed using chlorophyll a as an indicator of algal biomass, which in turn acts as a surrogate for indicating excessive nutrient concentrations. The TMDL is allocated to atmospheric deposition (35 Mtons) and to the sum of all nonpoint surface water inputs to the Lake (105 Mtons). No portion of the TMDL was allocated to point sources. Several point sources exist in the Lake Okeechobee watershed; however, none of these sources discharge directly to Lake Okeechobee. The TMDL report states that attainment of the TMDL will be calculated using a 5-year rolling average of monthly loads calculated from measured flow and concentration values. The 40 ppb goal for the entire pelagic zone is considered a conservative goal that introduces an implicit margin of safety into the TMDL. This reflects the fact that under high lake conditions, total phosphorus concentrations are relatively homogeneous across the open water region, but when lake stages are low, the near shore area displays considerably lower total phosphorus than the open water zone. Hence if 40 ppb is met at the pelagic stations (which represent mid-lake), the total phosphorus concentrations should be below 40 ppb in the near shore area during certain years.

Lake Okeechobee Protection Program: Lake Okeechobee Protection Plan:

The Lake Okeechobee Protection Act (LOPA, Chapter 00-103, Laws of Florida) was passed by the 2000 Legislature to establish a restoration and protection program of Lake Okeechobee. Restoration and protection of the Lake is to be accomplished by achieving and maintaining compliance with state water quality standards in Lake Okeechobee and its tributary waters through a watershed-based, phased, comprehensive and innovative protection program designed to reduce phosphorus loads and implement long-term solutions, based upon the Lake's phosphorus TMDL and considering the establishment of TMDLs for the tributaries of Lake Okeechobee. This program set forth a series of activities and deliverables for the following coordinating agencies: the South Florida Water Management District, the Florida Department of Environmental Protection and the Florida Department of Agriculture and Consumer Services. Elements specifically required by the legislation include a formal Lake Okeechobee Protection Plan (LOPP). The LOPP identifies alternative plans, schedules and costs to meet the established TP TMDL for Lake Okeechobee (LOPP, 2004). The TMDLs contained in this report are consistent with the LOPP and, therefore, the established Lake Okeechobee TP TMDL.

The original LOPP Project Area was composed of thirty-four basins that define the Lake Okeechobee watershed. The basins are essentially the same as the basins used in the Surface Water Improvement and Management Plan (SWIM) developed by the [SFWMD]. In 2005, the project boundaries were extended to the north to include the Upper Kissimmee River basin. The approximate project boundaries are shown in Figure 1. Often more than one WBID will be contained within an LOPP basin. The location of the original basins relative to the impaired WBIDs is shown in Figure 2. A listing of impaired WBIDs within each LOPP basin and the percent of area these WBIDs encompass is provided in Table 2.

TP loads allocated in the LOPP to the basins are summarized in Table 3. The column, "Target Based on Load," depicts the loads necessary to achieve the Lake Okeechobee TMDL. The column, "Target Concentration Based on Load," represents the annual average TP concentration corresponding to the load required at the pour point of each basin to comply with the LOPP.

A comparison of LOPP loads and WBID loads is provided in Table 4. WBID loads are based on a TP concentration of 113 ug/L. This table also identifies some of the control strategies planned for the various LOPP basins (FDEP et. al., 2008). A complete listing of the control strategies planned for the various basins can be found in FDEP's Lake Okeechobee Watershed Construction Plan (FDEP et. al., 2008). In cases where the loads required by the TMDL for the WBIDs are less than the LOPP load, additional BMPs should be implemented. WBID loads in Table 4 are based on estimated flows as derived in Section 7 of this report. This table indicates that to achieve the LOPP loads, flows may need to be reduced below existing conditions or TP concentrations may need to be reduced below the target, or a combination of both.

Table 2. Comparison of LOPP Basins and Impaired WBIDs

LOPP Basin	LOPP Basin Area (acres)	Impaired WBIDs	Impaired WBID Area (percentage)
C-40 Basin	43,964	3206	100%
C-41 Basin	94,928	3204	100%
L-59E	14,409	3209	100%
Taylor Creek/Nubbin Slough	120,754	3205, 3205D, 3203A, 3203B, 3213A, 3213B, 3213D	99%

LOPP Basin	LOPP Basin Area (acres)	Impaired WBIDs	Impaired WBID Area (percentage)
S-135 Basin	25,408	3213C	75%
S-154 Basin	24,630	3199B	38%
S-65 A, B, C, D, E	427,913	3188, 3188A, 3186B, 3186C, 3186D, 3192C	53%
S-65	1,021,674	1436	0.3%
S-2	31,399	3248, 3248A	100%
S-3	9794	3251	100%
S-4	29,164	3246	100%

Note: Impaired WBIDs listed for S-65 basin are Group 4 WBIDs in the Consent Decree schedule.

Comprehensive Everglades Restoration Plan (CERP):

The Comprehensive Everglades Restoration Plan (CERP) provides a framework and guide to restore the south Florida ecosystem including the Everglades. The conceptual plan for the Lake Okeechobee watershed consists of construction of stormwater treatment areas (STAs) and reservoirs; restoration of wetlands; and removal of phosphorus-laden sediment from tributaries. The Taylor Creek/Nubbin Slough (WBIDs 3505 and 3203A) Reservoir-assisted Stormwater Treatment Area (RASTA) is one of ten initially authorized projects. The SFWMD purchased pastureland located adjacent to Taylor Creek and converted the land to a reservoir suitable for storage and water quality treatment. The Taylor Creek RASTA is estimated to remove about 3 to 5 Mtons of phosphorus each year. The Nubbin Slough STA is constructed wetlands for treating stormwater runoff before it enters Lake Okeechobee. The STA is estimated to remove about 22 to 24 Mtons of phosphorus per year. Other phosphorus reduction projects are planned for the watershed and should result in improved water quality in both the impaired waterbodies and Lake Okeechobee.

Florida Geological Study:

Howard T. Odum investigated phosphorus levels in Florida streams in the 1950's as part of a Florida Geological Survey study (Odum, 1953). This was one of the first studies in Florida on the behavior of phosphorus in water and the impact it has on aquatic growth. Water samples were collected throughout the state from streams, lakes and springs for the purpose of correlating TP levels in water to geological conditions and levels of pollution. A limited number of samples were collected in

Lake Okeechobee and the Kissimmee River watershed as part of the canals and rivers of south Florida region. In June 1952, a limited number of samples in the tributaries represented TP concentrations ranging from 0.031 ppm in Fisheating Creek; 0.057 ppm in Taylor Creek; 0.060 ppm in the Kissimmee River below Lake Kissimmee; and 0.097 in St. Lucie Canal. While these values are informative, the samples are too limited (spatially and temporally) to represent historic water quality conditions of the waterbodies.

1.3 Identification of Impaired Waterbodies

The Lake Okeechobee watershed consists of the entire area that contributes surface water flow and total phosphorus (TP) and total nitrogen (TN) loads to Lake Okeechobee. TMDLs for the impaired WBIDs included in this report are located north of Lake Okeechobee, and represent the largest contribution of flow and nutrients to the lake. The following watershed descriptions are taken from the Basin Status Reports developed by FDEP.

Land cover distribution cited in the planning unit descriptions is from 1999 color infrared imagery downloaded from the SFWMD web page. The LOPA requires that "Prior to authorizing a discharge into works of the District, the District shall require responsible parties to demonstrate that proposed changes in land use will not result in increased phosphorus loading over that of existing land uses." Table 5 is a summary of land cover in the impaired WBIDs.

1.3.1 Lake Okeechobee Basin

Lake Okeechobee is a large, shallow eutrophic lake located in south central Florida that is designated a Class I water (potable water supply). The lake is the largest body of freshwater in the southeastern United States and covers a surface area of 730 mi^2 with an average depth of 8.6 ft. The Lake is a major feature of the Kissimmee-Okeechobee-Everglades system, which is a continuous hydrologic system extending from Central Florida south to Florida bay. The watershed of the Lake stretches from just south of Orlando to areas that border the Lake on the south, east and west and covers 3.5 million acres. The Lake provides a number of values to society and nature including water supply for agriculture, urban areas, and the environment; flood protection; a multi-million dollar sport fishery; and habitat for wading birds, migratory waterfowl, and the federally endangered Everglades Snail Kite. These values of the lake have been threatened in recent decades by excessive phosphorus (P) loading, harmful high water levels, and rapid expansion of exotic plants (FDEP, 2001b). Two hundred years ago, a large percentage of the lake bottom may have been covered with sand. Today organic mud overlies much of the bottom. The upper 10 centimeters of that mud are estimated to contain more than 30,000 Mtons of phosphorus. The rate of mud sediment accumulation and phosphorus deposition has increased significantly over the past 50 years.

The surface hydrology in the Lake Okeechobee watershed is largely governed by man-made systems. A system of encircling levees impounds the Lake's waters, creating a reservoir used for navigation, water supply, flood control, and recreation. Pumping stations and control structures in the levees along Lake Okeechobee are designed to move water either into or out of the Lake as needed, permitting water levels to fluctuate greatly with flood and drought conditions and the demand for water (see Figure 3). The major inflows into the Lake include rainfall (39 percent), the

Kissimmee River (31 percent), and numerous smaller inflows (all 5 percent or less) from Fisheating Creek, and Taylor Creek/Nubbin Slough (TCNS), and numerous smaller inflows, such as discharges from the Everglades Agricultural Area. Major outflows include evapotranspiration (66 percent), the Caloosahatchee River to the west (12 percent), the St. Lucie Canal (C-44) to the east (4 percent), and four major agricultural canals (the Miami, New River, Hillsboro, and West Beach Canals) that drain south and southeast (18 percent).

The Lake Okeechobee Tributaries that directly affect the Lake are included in the Lake Okeechobee Basin, St. Lucie-Loxahatchee Basin, Upper Kissimmee and Fisheating Creek Basin, Caloosahatchee River Basin and the Everglades Basin. The Lake Okeechobee Basin is divided into three planning units: the CTP Complex, the TOL63 Complex and the NHLMS Complex. The following description of the planning units is from the SFWMD Lake Okeechobee Basin Status Report (FDEP, 2001b).

Table 3. Summary of TP Loads Discharging into Lake Okeechobee (SFWMD, 2004)

								LOWP Design Loads (Mtons/yr)	
Basin	**LOPP Implementation AREA (acres)**	**Average Annual Discharge (1991-2000) (Acre-ft)**	**Average Annual P Load (1991-2000) (Mtons)**	**Target Load Based on Flow (Mtons)**	**Target Based on Load (Mton)**	**Target conc. based on flow (ug/L)**	**Target conc. based on load (ug/L)**	**Alt 1 through 6 (Higher of Remain. Load, Adjusted Remain. Load, and targets)**	**Alt 1 through 7 (Higher of Remain. Load, Adjusted Remain. Load, and targets)**
715 Farms (Culv 12A)	3,295	12,045	1.67	0.56	0.41	37.91	27.32	0.59	0.59
C-40 Basin (S-72)	43,964	16,266	9.58	0.76	2.32	37.91	115.81	6.98	6.02
C-41 Basin (S-71)	94,928	49,799	25.45	2.33	6.17	37.91	100.49	17.14	13.82
S-84 Basin (C41A)	58,488	51,791	9.06	2.42	2.20	37.91	34.40	6.47	5.31
S-308C (St. Lucie-C-44)	129,428	55,880	11.23	2.61	2.72	37.91	39.53	9.86	8.09
East Beach DD (Culv 10)	5,275	11,815	8.73	0.55	2.12	37.91	145.35	2.12	2.12
East Shore DD (Culv 12)	8,416	14,432	3.10	0.67	0.75	37.91	42.24	0.89	0.89
Fisheating Creek	289,366	200,766	40.97	9.38	9.93	37.91	40.13	32.99	31.81
Industrial Canal	8,232	23,337	2.99	1.09	0.73	37.91	25.23	2.24	2.24
L-48 Basin (S-127)	20,774	23,040	6.58	1.08	1.59	37.91	56.14	5.03	4.97
L-49 Basin (S-129)	12,093	13,189	1.69	0.62	0.41	37.91	25.18	1.31	1.29
L-59E	14,409	6,395	1.48	0.30	0.36	37.91	45.55	1.20	1.20
L-59W	6,440	8,319	1.93	0.39	0.47	37.91	45.74	1.55	1.55
L-60E	5,038	1,236	0.25	0.06	0.06	37.91	39.20	0.21	0.21
L-60W	3,271	419	0.07	0.02	0.02	37.91	31.67	0.05	0.05
L-61E	14,286	6,997	1.13	0.33	0.27	37.91	31.80	0.93	0.93
L-61W	13,567	10,646	1.27	0.50	0.31	37.91	23.39	1.08	0.90
Taylor Creek/Nubbin Slough (S-191)	120,754	101,946	78.40	4.77	19.01	37.91	151.22	24.03	19.01
S-131 Basin	7,164	9,490	1.28	0.44	0.31	37.91	26.58	0.89	0.83
S-133 Basin	25,660	26,478	6.99	-	1.69	0.00	51.92	5.13	4.62
S-135 Basin	18,089	25,408	3.39	1.19	0.82	37.91	26.25	2.62	2.29
S-154 Basin	33,798	24,630	23.59	1.15	5.72	37.91	188.33	8.36	5.72
S-2	106,044	31,399	8.16	1.47	1.98	37.91	51.12	1.98	1.98

								LOWP Design Loads (Mtons/yr)	
Basin	**LOPP Implementation AREA (acres)**	**Average Annual Discharge (1991-2000) (Acre-ft)**	**Average Annual P Load (1991-2000) (Mtons)**	**Target Load Based on Flow (Mtons)**	**Target Based on Load (Mton)**	**Target conc. based on flow (ug/L)**	**Target conc. based on load (ug/L)**	**Alt 1 through 6 (Higher of Remain. Load, Adjusted Remain. Load, and targets)**	**Alt 1 through 7 (Higher of Remain. Load, Adjusted Remain. Load, and targets)**
S-3	64,630	9,794	2.33	0.46	0.56	37.91	46.73	0.56	0.56
S-4	39,673	29,164	6.87	1.36	1.67	37.91	46.35	1.67	1.67
S-65A,B,C,D,E	427,913	291,845	79.41	13.64	19.25	37.91	53.50	25.02	19.25
South FL Conservancy DD (S-236)	2,364	10,345	1.42	0.48	0.34	37.91	26.92	0.57	0.57
South Shore/So. Bay DD (Culv 4A)	2,947	8,151	1.07	0.38	0.26	37.91	25.87	0.40	0.40
Nicodemus Slough (Culv 5)	25,641	3,371	0.25	0.16	0.06	37.91	14.54	0.20	0.20
S65 (Lake Kissimmee) **	1,021,674	856,146	69.95	40.02	16.96	37.91	16.07	52.46	52.46
Lake Istokpoga (S-68)**	393,276	247,718	14.95	11.58	3.62	37.91	11.87	14.95	14.95
S5A Basin (S-352-WPB Canal)	120,798	11	0.00	0.00	0.00	37.91	59.91	0.00	0.00
East Caloosahatchee (S-77) ***	200,993	205	0.01	0.01	0.00	37.91	12.13	0.01	0.01
L-8 Basin (Culv 10A)	108,402	63,865	7.81	2.99	1.89	37.91	24.06	6.98	6.53
Total	**3,451,087**	**2,246,336**	**433.09**	**103.76**	**105.00**	**37.46**	**37.91**	**236.49**	**213.03**

Table 4. Comparison of LOPP and WBID Loads

LOPP Basin	LOPP Load[1] (Mtons/yr)	WBID(s) Load[2] (Mtons/yr)	Basin Implementation Strategies to Reduce TP Loads[3]
S-65A, B, C, D, E	19.25	40.65	Kissimmee River Restoration Project; Kissimmee Reservoir; Istokpoga Canal RASTA; Kissimmee East Storage; and alternative water storage facilities (Kissimmee Prairie State Park)
Taylor Creek Nubbin Slough (S-191 Basin)	19.01	14.20	Impaired WBIDs discharge to TCNS Critical Project STA; and Brady Ranch STA (located in TCNS basin) receive discharge; Taylor Creek STA (planned to receive flows from Taylor Creek and Kissimmee East Reservoir); TCNS Reservoir; and other nutrient control technologies
C-40 Basin	2.32	2.27	Discharge from basin to be routed to Istokpoga Reservoir and STA before entering the lake
C-41 Basin	6.17	6.94	Discharge from basin to be routed to Istokpoga Reservoir and STA before entering the lake; Seminole Brighton aquifer storage and recovery (ASR) wells planned
L-59E Basin	0.36	0.89	Discharge from basin to be routed to Istokpoga Reservoir and STA before entering the lake; Paradise Run 10 ASR Well System
S-135 Basin	0.82	2.66	Discharge from the basin will be routed to Lakeside Ranch STA (located in TCNS basin)
S-154 Basin	5.72	1.31	Priority basin for TP reductions through BMPs; deep well injection
S-65 Basin	16.96	3.75	Discharge from basin flows into Lake Kissimmee and then through downstream restoration areas before flowing into the lake.

Notes: 1) LOPP loads are the sum of all allowable loads discharging from the WBID(s) comprising an LOPP basin as described in the LOPP report. 2) WBID loads are based on estimated annual average flow from each WBID(s) within an LOPP basin (see Table 9) and a TP target concentration of 113 ug/L. The WBID loads assume the peak flow is not reduced; however, this and/or a reduction in TP concentration may be necessary in order to achieve the LOPP load. 3) The BMPs and the source control regulatory programs identified in the LOPP will be implemented throughout the entire watershed.

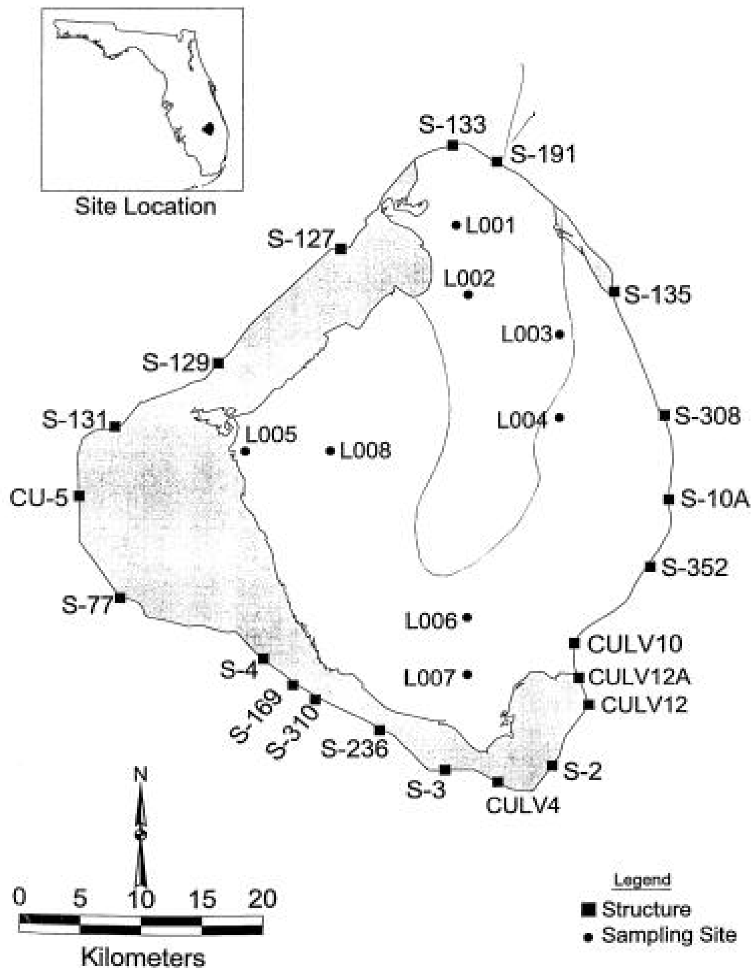


Figure 3. Control Structures and Sampling Stations in Lake Okeechobee

NHLMS Complex:

The NHLMS Complex includes Nubbin Slough (WBID 3203A), Henry Creek (WBID 3213B), Lettuce Creek (WBID 3213A), Mosquito Creek (WBID 3203B), Myrtle Slough (WBID 3213D), and waters within the drainages leading to the South Florida Water Management District's structures S-135 (WBID 3213C) and S-153 (WBID 3219). These structures do not have NPDES permits and are not assigned WLAs in this TMDL. The NHLMS Complex covers about 131 square miles and contains about 29 miles of streams. It consists of a collection of small tributary streams along the northeast shore of Lake Okeechobee that once flowed directly into the lake. The tributaries are now intercepted by canals prior to reaching the Hoover Dike/Levee. Land uses in all WBIDs include dairies, pasture, and low-density residential housing.

Flows in Mosquito Creek, Nubbin Slough, Henry Creek, Lettuce Creek and Myrtle Slough are intercepted by the L-63 Canal, which transports water to the rim canal and the S-191 structure, which ultimately discharge into the lake (see Figure 4). Mosquito Creek is four miles long and flows from northeast to southwest. Nubbin Slough is about 7 miles long and flows to the southwest. Henry Creek is four miles long and flows from northeast to southwest. Lettuce Creek is located on the northeast side of Lake Okeechobee and near the small community of Upthegrove Beach. The surface of the shallow, turbid, eutrophic creek is covered with dense mats of aquatic plants. Myrtle Slough is about 4 miles long and flows to the southwest. The slough is part of a network of interconnecting small canals constructed to drain a low-lying area so that it may be used for agricultural purposes, mostly pastures. High levels of inorganic nitrogen have been measured in the slough indicative of runoff containing animal waste.

To achieve the load at the pour point of the LOPP basin, water discharging from the impaired WBIDs will be routed through Stormwater Treatment Areas (STAs) in the TCNS basin prior to discharging into Lake Okeechobee. Additional BMPs such as edge-of-field/farm (EOF) treatment technologies have been implemented in the basin to control high nutrient concentrations discharging from agricultural practices in the WBIDs. Innovative nutrient control technologies such as construction of an algal turf scrubber nutrient recovery facility is planned to reduce nutrient loadings from the basin.

CTP Complex:

The CTP Complex includes the S-154 basin and part of the S-133 basin. It covers about 86 square miles and contains about 11 miles of streams. Chandler Hammock Slough (WBID 3199B), located in the S-154 basin, is the only impaired WBID on the 1998 303(d) list within the CTP Complex. Chandler Hammock Slough flows southward into Turkey Slough (WBID 3199A), which flows into Popash Slough (WBID 3205C). The rim canal around Lake Okeechobee collects the flow from these connected sloughs (see Figure 3). Depending on lake stage, water can flow from the rim canal into the lake through hurricane gate structure 6. Water can also be pumped through S-133 into the lake. Land cover in Chandler Hammock Slough is predominately agriculture, accounting for approximately 83% (or 10,645 acres) of land, followed by wetlands (1584 acres or 12.3%) and pasture (491 acres or 3.8%).

The LOPP identifies the S-154 Basin as a priority basin for TP reductions through BMPs. FDEP is considering deep well injection as an option for achieving additional TP reductions in the basin; however, at this time this option is conceptual.

TOL63 Complex:

The TOL63 Complex covers 108 square miles and contains 45 miles of streams and canals, and includes part of the S-191 basin and the eastern portion of the S-133 basin. Taylor Creek (WBID 3205) and Otter Creek (WBID 3205D), located in the S-191 basin are the two impaired WBIDs within the complex. Otter Creek flows about 3.5 miles southwesterly before joining Taylor Creek. Taylor Creek is 29 miles long. Flows from Taylor Creek are diverted into the L-63 North Canal (WBID 3203C) at structure S-192 north of the town of Okeechobee. The Taylor Creek channel below the S-192 diversion carries flow in a southeast direction until it reaches the rim canal (C-59) and discharges by gravity into Lake Okeechobee at structure S-191 (see Figure 4). Land cover in Taylor and Otter creeks is predominately agriculture, followed by wetlands and pastures.

The primary strategy in the LOPP for controlling phosphorus from Taylor Creek (WBID 3505) and Otter Creek (WBID 3505D) has been the implementation of basin-wide BMPs. According to the LOPP, Level I BMPs have resulted in about a 30 percent reduction basin-wide in phosphorus concentration and loads. All dairies within the impaired watersheds are required to comply with the DER Dairy Rule. FDEP anticipates further phosphorus reductions will be achieved through the routing of stormwater through the Taylor Creek STA. A 30,000 acre-feet (ac-ft) reservoir is planned to intercept flow from the Taylor Creek watershed, resulting in additional phosphorus reductions.

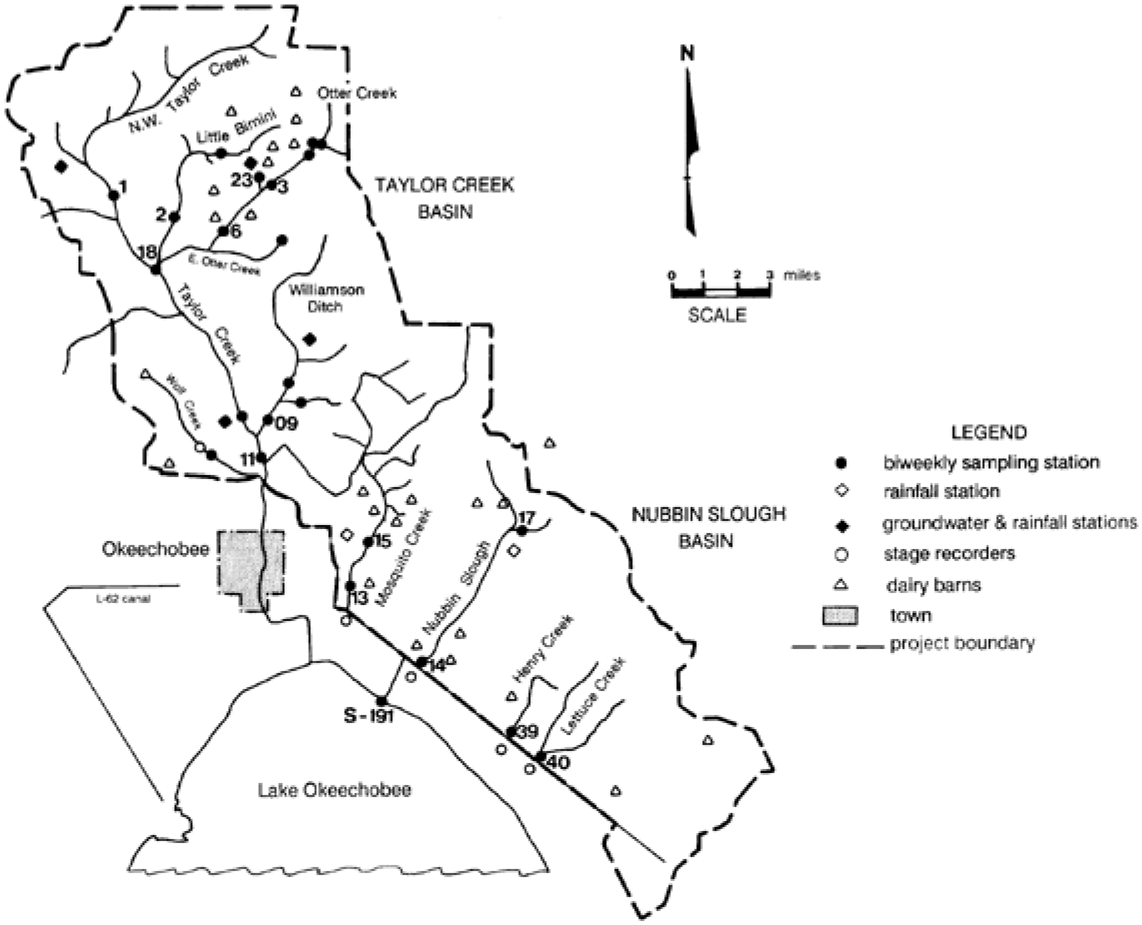


Figure 4. Taylor Creek and Nubbin Slough Basins

1.3.2 Kissimmee River Basin

The Kissimmee River Basin flows into Lake Okeechobee and is part of the Everglades ecosystem. The Kissimmee River Basin is 2,940 square-miles and extends from Orlando southward to Lake Okeechobee. The Kissimmee River is the largest source of surface water to Lake Okeechobee, is about 105 miles long and has a maximum width of 35 miles. The Kissimmee River Basin contains four planning units: Upper Kissimmee, Lower Kissimmee, Lake Istokpoga, and Lake Placid. None of the impaired WBIDs discussed in this report are within either the Lake Istokpoga or Lake Placid basins. A discussion of water quality in these basins can be found in the Kissimmee River and Fisheating Creek Basin Status Report (FDEP, 2004).

Lake Kissimmee is the geographic divide between the Upper and Lower Kissimmee planning units. Lake Kissimmee outflow is regulated through structure S-65. Based on flow data from 1972 through April 30, 2005, the annual average outflow from the lake was 719,120 acre-ft (FDEP, 2006). During the 2004 hurricane season the flow volume from the lake was over 1.9 times the historical average flow.

Upper Kissimmee Planning Unit:

The Upper Kissimmee Planning Unit includes portions of Orange, Osceola, and Polk Counties from Orlando southward to the southern tip of Lake Kissimmee. Hundreds of lakes, ranging in size from small sinkholes to large lakes dot the planning unit. The many lakes and swampy areas in the planning unit provide a relatively large storage capacity which retards drainage and results in relatively slow runoff rates. Water in the planning unit generally flows southward to Lake Kissimmee, then onward to Lake Okeechobee via the Kissimmee River (a.k.a. C-38 Canal). Horseshoe Creek (WBID 1436) is the only WBID in the Upper Kissimmee Planning Unit addressed in this report and represents less than 1% of the drainage area in the planning unit.

Horseshoe Creek is located west of Reedy Creek in the northeastern part of Polk County. The upstream half of the creek is channelized, fed by a number of small canals dug to drain wetlands. The lower half of the creek is unmodified. Discharge from the creek flows to a portion of the Reedy Creek swamp known as the Huckleberry Islands, an extensive wetland area in Osceola County connecting Reedy and Snell Creeks. The city of Davenport is located south of Horseshoe Creek. The creek drains a predominantly agricultural area; however, urbanized areas, especially some medium density residential areas, are primarily located in the southern part of the drainage basin.

Lower Kissimmee Planning Unit:

The Lower Kissimmee Planning Unit is 722 square miles and encompasses portions of Polk, Osceola, Highlands, and Okeechobee Counties. There are no significant urban areas in the planning unit as the area is entirely rural in nature; however, portions of an active military bombing test range (Avon Park Air Force Range) is located in the northern portion of the planning unit near the Polk-Highland County line. Impaired WBIDs in the planning unit include: Kissimmee River (WBIDs 3209 and 3186B), Blanket Bay Slough (WBID 3186C), and Eight Mile Slough (WBID 3186D), Oak Creek (WBID 3192C), Farm Area (WBID 3188), and Chandler Slough (WBID 3188A). Land cover in these WBIDs is predominately agriculture followed by wetlands.

Historically, the Kissimmee River meandered approximately 103 miles with a 1- to 2-mile-wide floodplain. During the historic period of hydrologic record (1934-1960) the river moved very slowly, with normal river velocities averaging less than 2 feet per second. A severe hurricane occurred within the basin in 1947 resulting in extensive property damage from flooding. The State responded with a request to the federal government to design a flood control plan for central and southern portion of the state. Between 1962 and 1971, the Kissimmee River was channelized and transformed into a series of impounded reservoirs. Inflow from the basin was regulated by six water control structures (S-65 and S-65 A, B, C, D, and E). The Upper Kissimmee Basin (S-65) and Kissimmee River (S-65A, B, C, D, E Basin) contribute about 51 percent of the total surface water inflow to Lake Okeechobee, over 1.1 million acre-feet per year. These basins also contribute 34 percent of the phosphorus load to the lake.

The Kissimmee River Restoration and the Kissimmee River Headwater Revitalization projects were jointly authorized in the 1992 Water Resources Development Act (FDEP, 2006). The primary goal of the Kissimmee River Restoration project is to reestablish the ecological integrity of the river-floodplain system. Restoration efforts require reconstruction of the physical form of the river and reestablishment of pre-channelization hydrologic conditions. Once the project is complete, water quality improvements should be achieved in the WBIDs in the S-65 A, B, C, D, and E basins.

The primary purpose of the Kissimmee River Headwater Revitalization Project is to provide the water storage and regulation schedule modifications needed to approximate the historical flow characteristics of the Kissimmee River system. Structures and canals in the upper basin will be modified to accommodate the increased capacity associated with the increased lake storage volumes needed to fully meet the requirements of the restoration.

The primary strategy identified in the LOPP for controlling phosphorus from the impaired WBIDs has been the implementation of basin-wide BMPs targeted at agricultural activities. The Kissimmee River Restoration project should improve the assimilation capacity of the Kissimmee River resulting in reduced nutrient loads discharging into Lake Okeechobee. One management alternative being considered by FDEP is a Kissimmee Reservoir project for the Lower Kissimmee Basin designed to receive flows from and discharge back to the Kissimmee River. This reservoir will result in some phosphorus reductions. Stored water can potentially be diverted to STAs in the TCNS basin for treatment resulting in additional phosphorus reductions.

1.3.3 Fisheating Creek Basin

The Fisheating Creek Basin is located to the west of Lake Okeechobee, adjacent to the Kissimmee River Basin and is part of the Everglades ecosystem. The basin is about 849 square miles and extends from west central Highlands County southward into northern portion of Glades County, and then eastward towards Lake Okeechobee. The basin includes two planning units: Fisheating Creek and Northwest Lake Okeechobee. Of the five major basins draining into Lake Okeechobee, Fisheating Creek is the least impacted by humans in terms of hydrology and land uses, and still contains many areas suited for preservation (SFWMD, 2004).

There are two stream segments listed as impaired in the Fisheating Creek Basin. Both the Harney Pond Canal (WBID 3204) and Indian Prairie Canal (WBID 3206) are tributaries to Fisheating Creek and are located in the Northwest Lake Okeechobee Planning Unit. Harney Pond Canal and Indian Prairie Canal corresponds to LOPP SWMM basin C-40 and C-41, respectively. Fisheating Creek drains via gravity flow into Lake Okeechobee on the west shore, near Moore Haven. Land cover in the impaired WBIDs is predominately agriculture followed by wetlands.

FDEP is considering a RASTA (Reservoir-Assisted Stormwater Treatment Area) for the Fisheating Creek watershed for the purpose of maximizing TP load reductions and water storage in the LOPP. This RASTA will receive flows from the impaired WBIDs as well as other tributaries draining to Fisheating Creek. This reservoir could potentially store lake waters, if necessary. BMPs targeted at agricultural activities continue to be the primary strategy for reducing phosphorus loadings from the basin.

1.3.4 Everglades Agricultural Area (EAA)

The EAA is comprised of highly productive agricultural land located directly south of Lake Okeechobee within eastern Hendry and western Palm Beach counties. The drainage system of the EAA is a complicated network of canals, levees, control structures and pumps. The low topographic relief and the wide seasonal variation in rainfall within the EAA necessitate extensive drainage during the wet season and irrigation during the dry season. TMDLs are finalized for EAA WBIDs 3248, 3251, and 3246. Three major pump stations (i.e., S-2, S-3 and S-4) are located in these WBIDs. The TMDLs allocate the allowable load for pumping stormwater into Lake Okeechobee and do not allocate loads for water flowing south into the Everglades for WBIDs 3248 and 3251or into the Caloosahatchee River for WBID 3246. The pump stations are not required to obtain National Pollutant Discharge Elimination System (NPDES) permits and are, therefore, not assigned WLAs in these TMDLs.

Table 5. Summary of Land Cover in Impaired WBIDs

WBID	Residential		Commercial, Industrial, Public		Agriculture		Rangeland		Forest		Water		Wetlands		Barren & Extractive		Transportation & Utilities		Total (acres)
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	
Lake Okeechobee Basin																			
3199B	106	0.8	0	0.0	10645	82.6	491	3.8	19	0.2	26	0.2	1584	12.3	0	0.0	21	0.2	12893
3203B	353	5.2	37	0.6	5352	79.6	136	2.0	55	0.8	15	0.2	644	9.6	3	0.0	128	1.9	6724
3213A	49	1.6	26	0.8	2618	83.5	77	2.4	71	2.3	73	2.3	109	3.5	70	2.2	42	1.3	3135
3213B	400	2.5	25	0.2	11410	71.2	151	0.9	832	5.2	246	1.5	2703	16.9	134	0.8	129	0.8	16030
3213C	109	0.8	0	0.0	10746	79.1	393	2.9	260	1.9	510	3.8	1056	7.8	508	3.7	0	0.0	13582
3213D	13	0.1	0	0.0	11945	73.0	856	5.2	1583	9.7	30	0.2	1767	10.8	20	0.1	146	0.9	16361
3203A	551	3.6	33	0.2	12676	82.7	510	3.3	44	0.3	121	0.8	1203	7.8	121	0.8	74	0.5	15332
3205	2003	3.8	792	1.5	41876	78.9	1958	3.7	1252	2.4	594	1.1	4402	8.3	96	0.2	76	0.1	53049
3205D	34	0.3	42	0.4	8499	86.1	263	2.7	97	1.0	48	0.5	405	4.1	87	0.9	400	4.0	9875
Kissimmee River Basin																			
3209	14	0.1	65	0.4	9723	67.5	88	0.6	51	0.4	805	5.6	2699	18.7	970	6.7	0	0.0	14414

WBID	Residential		Commercial, Industrial, Public		Agriculture		Rangeland		Forest		Water		Wetlands		Barren & Extractive		Transportation & Utilities		Total (acres)
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	
3186B	1590	2.3	106	0.2	31778	46.9	10356	15.3	8165	12.1	521	0.8	14539	21.5	591	0.9	43	0.1	67689
3186C	6	0	0	0.0	12389	76.5	127	0.8	30	0.2	30	0.2	3622	22.4	0	0.0	0	0.0	16203
3186D	0	0	0	0.0	3059	12.5	8863	36.1	8385	34.2	4	0.0	4194	17.1	13	0.1	0	0.0	24518
3192C	0	0	0	0.0	8784	85.0	0	0.0	0	0.0	0	0.0	1551	15.0	0	0.0	0	0.0	10335
3188	297	0.3	2	0.0	57417	58.3	15793	16.0	1217	1.2	1216	1.2	21937	22.3	516	0.5	91	0.1	98485
3188A	29	0.3	6	0.1	7383	69.1	6	0.1	130	1.2	58	0.5	3005	28.1	52	0.5	12	0.1	10680
1436	255	8.5	6	0.2	1305	43.4	729	24.3	42	1.4	113	3.7	348	11.6	50	1.7	158	5.2	3004
Fisheating Creek Basin																			
3204	898	0.9	42	0.0	70990	73.9	4845	5.0	3177	3.3	783	0.8	13994	14.6	1258	1.3	126	0.1	96114
3206	36	0.1	8	0.0	37629	84.7	19	0.0	442	1.0	472	1.1	5406	12.2	388	0.9	6	0.0	44406
Everglades Agricultural Area																			
3248	444	0.7	451	0.7	62306	95.4	168	0.3	4	0.0	476	0.7	454	0.7	439	0.7	593	0.9	65336
3251	65	0.1	43	0.1	63148	97.7	39	0.1	43	0.1	397	0.6	335	0.5	513	0.8	56	0.1	64638
3246	1815	4.3	1134	2.7	35397	82.9	679	1.6	437	1.0	673	1.6	1163	2.7	408	1.0	1000	2.3	42706

2 STATEMENT OF WATER QUALITY PROBLEM

Section 303(d) of the Clean Water Act requires states to submit to EPA lists of waters that are not fully meeting their applicable water quality standards. FDEP has developed such lists, commonly referred to as section 303(d) lists, since 1992. As part of that process, tributaries in the Lake Okeechobee watershed were included on Florida's 1998 section 303(d) list as impaired by excess nutrients, depressed dissolved oxygen (DO), and BOD.

The most common water quality problems in the Lake Okeechobee Basin are elevated levels of nutrients and low DO. TP and TN levels are higher than statewide medians, and most of the DO observations fall below the statewide water quality criterion of 5.0 mg/l. Many of the impaired waterbodies have been channelized or are canals. In constructed waterbodies it is difficult to consistently meet DO standards developed for natural water systems. In addition, there is an ongoing aquatic weed control program in the basin, which is necessary to allow the waterbodies to efficiently transport water. However, this weed control program exacerbates DO problems due to the decaying plant material.

In addition to nutrients and BOD, water temperature, flow velocity, and sediment oxygen demand (SOD), can influence the DO concentration in a creek. Temperature can influence DO concentration by influencing the solubility of DO in the water, the metabolic activities of organisms (for example, respiration rate), and to a lesser extent, the rates at which oxygen consumption chemical reactions are taking place (organic materials oxidization). Theoretically, the difference in water temperature at different stations can be caused by differences in canopy coverage. SOD data were not available in the impaired WBIDs. Flow velocities can influence the accumulation of organic sediments, the DO reaeration, and water residence time in a given creek. Many of the impaired WBIDs are characterized as wide swampy areas, which diminish the momentum of the stream flow and cause the flow velocity to decrease resulting in depressed DO concentrations.

3 WATER QUALITY STANDARDS

Water quality criteria established by the state of Florida are set out in the Florida Administrative Code (F.A.C.), Section 62-302.530. The individual criteria should be considered in conjunction with other provisions in water quality standards, including Section 62-302.500 F.A.C. [Surface Waters: Minimum Criteria, General Criteria] that apply to all waters unless alternative or more stringent criteria are specified in F.A.C. Section 62-302.530.

Lake Okeechobee tributaries are Class III water bodies, with a designated use of recreation and propagation and maintenance of a healthy, well-balanced population of fish and wildlife. The Class III water quality criteria applicable to the impairments addressed by this TMDL are the DO criterion, BOD criterion and the narrative nutrient criterion.

3.1 Nutrient Criterion

The designated use of Class III waters is recreation, propagation and maintenance of a healthy, well balanced population of fish and wildlife. FDEP has not adopted a numeric nutrient criterion for Class III waters. Therefore, the Class III narrative criterion applies to the Lake Okeechobee tributaries:

> The discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in this chapter. Man induced nutrient enrichment (total nitrogen and total phosphorus) shall be considered degradation in relation to the provisions of Section 62-302.300, 62-302.700, and 62-4.242, F.A.C. 62-302.530(48) (a), F.A.C.
>
> In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna. 62-302.530(48)(b), F.A.C.

It should be noted that FDEP has efforts ongoing to develop numeric criteria for nutrients applicable to inland waters which are expected to be adopted into state water quality standards at a future date according to a schedule described in the state of Florida's *Numeric Nutrient Criteria Development Plan* (FDEP, 2007a).

Until numeric nutrient criteria are developed and adopted, nutrient TMDL targets are developed as translations or quantifications of the narrative criterion. Nutrient targets represent the levels below which an imbalance in flora or fauna would be expected to occur.

3.2 Dissolved Oxygen Criterion

> Freshwater: Dissolved Oxygen (DO) shall not be less than 5.0 (milligrams/liter). Normal daily and seasonal fluctuations above these levels shall be maintained. 62-302.530(31), F.A.C.

3.3 Biochemical Oxygen Demand Criterion

> BOD values shall not be increased to exceed values which would cause DO to be depressed below the limit established for each class or a natural condition concentration and, in no case shall it be great enough to produce nuisance conditions. 62-302.530(12), F.A.C.

3.4 Natural Conditions

In addition to the standards for nutrients, DO and BOD described above, Florida's standards include provisions that address waterbodies which do not meet the standards due to natural background conditions.

Florida's water quality standards provide a definition of natural background:

> "Natural Background" shall mean the condition of waters in the absence of man-induced alterations based on the best scientific information available to the Department. The establishment of natural background for an altered waterbody may be based upon a similar unaltered waterbody or on historical pre-alteration data. 62-302.200(15), FAC.

Florida's water quality standards also provide that:

> Pollution which causes or contributes to new violations of water quality standards or to continuation of existing violations is harmful to the waters of this State and shall not be allowed. Waters having water quality below the criteria established for them shall be protected and enhanced. However, the Department shall not strive to abate natural conditions. 62-302.300(15) FAC

4 TARGET IDENTIFICATION

A TMDL is the maximum loading of a pollutant that that a waterbody can receive and still meet the applicable water quality standard. Additionally, TMDL allocations must not result in, or contribute to, any violation of other water quality standards for the waterbody or downstream waterbodies.

Nutrients, such as phosphorus and nitrogen, present a special challenge in TMDL development. Nutrients drive a process known as primary productivity that occurs throughout an entire network of interconnected waterbodies. Therefore, TMDLs for nutrients should consider the near-field, intermediate and far-field impacts of excess nutrients and the associated excess biomass. In order to develop nutrient TMDLs for the Lake Okeechobee tributaries that will result in the attainment of applicable water quality standards including protection of downstream uses, these TMDLs address both phosphorus and nitrogen.

4.1 Basis and Rationale For Nutrient Targets

Numeric nutrient targets for this TMDL are developed to be protective of aquatic life in the tributary WBIDs, and the downstream waters of Lake Okeechobee and its subsequent drainage through the St. Lucie Canal and the Caloosahatchee River to their downstream coastal estuaries. The targets of this TMDL will meet the state of Florida's narrative water quality standard for nutrients which requires levels of nutrients that do not cause an imbalance in natural populations of aquatic flora or fauna and do not produce or contribute to conditions that violate the DO standard, including exceeding natural conditions.

Aquatic life becomes impaired by nutrients when excess amounts of nutrients are expressed in excess primary productivity. Primary productivity refers to the collective actions of plants (autotrophs) to utilize the energy of sunlight through the process of photosynthesis to fix carbon and available nutrients into biomass of living organisms. This is, of course, an essential process on which all plants and animals depend, and it serves as an intersection of the global cycles of critical elements carbon, hydrogen, oxygen, nitrogen, and phosphorus (C, H, O, N, & P).

In aquatic systems, the normal cycles of C, H, O, N, and P can be distorted by anthropogenic activities in the watershed which generate extra N and P that can enter adjacent waterbodies by surface runoff and/or ground water inflow. These excess nutrients will then drive excess primary productivity. This extra accumulated biomass is seen as an over-abundance of aquatic plants, i.e., algal blooms and/or increased macrophyte vegetation. This can produce nuisance conditions which affect aesthetic values and recreation. When certain algal species are involved which are able to produce toxins, as in Harmful Algal Blooms (HABs), human health can be affected by exposure through drinking water, direct contact, or inhalation.

Aquatic life use can be impacted directly by excess algal blooms and/or macrophyte abundance through loss of habitat or other competitive disadvantages. But even more widespread impact occurs indirectly through depression or depletion of dissolved oxygen that occurs when excess primary production eventually decomposes and creates a demand for dissolved oxygen. This lowers the available oxygen for other aquatic life. Most aquatic life becomes stressed by chronic low oxygen conditions and is virtually eliminated when oxygen depletion persists for a significant period of time. Impairment of aquatic life use is the common result of excess eutrophication of a waterbody.

Primary production in excess results directly from excess available nutrients. As such, protection of aquatic life requires control of available nutrients in order to restrict primary productivity. Productivity may lag introduction of nutrients in time and space, and that fact must be considered when correlating nutrient levels and response. Proximal production may be temporarily suppressed by limitation of light, the amount of one or both nutrients, high velocity/turbulence, or the lack of suitable substrate, but transported bio-available nutrients will be utilized at some point. Whenever excess nutrients are expressed, excess productivity will result adversely affecting aquatic life in that location. The frequency and extent of low oxygen events affects organisms differently; non-motile and long-lived organisms are among the most sensitive.

Primary productivity as a process is driven by a number of factors, and moderated by others. The major nutrients, nitrogen and phosphorus (N and P), along with certain minor nutrients, are required as inputs for intermediary metabolic steps associated with photosynthesis. Since these steps are a series of chemical reactions, their net stoichiometry ultimately determines the utilization of the inputs to the process. These stoichiometric relationships provide some explanation for the ratios originally reported by Redfield, and widely used today to interpret aquatic nutrient dynamics and manage water quality.

The Redfield ratio for nitrogen and phosphorus is given as a molar ratio of N : P = 16 : 1 (or alternately, a weight ratio of N : P = 7.2 : 1). In general practice, a functional range is used with a ratio greater than 30 considered P limited, between 30 and 10 considered co-limited, and less than 10 considered nitrogen limited. This practice allows for a wide mid-range of co-limitation where neither nutrient conclusively controls primary production, and the process can proceed until limited by something else. Limiting nutrient analysis by Redfield ratio comparison can be a useful tool for insight into nutrient limitation, but it should be applied with understanding of its limitations. Appendix A contains the limiting nutrient analysis for existing as well as TMDL conditions.

Limiting nutrient analysis is fundamentally based on "Liebig's Law of the Minimum," which is strictly applicable only under steady-state conditions, that is, when inflows balance outflows of energy and materials. The practice of identifying only a single nutrient target to address a problem of excess cultural eutrophication presumes that the system is, and will remain, in steady state equilibrium, an oversimplification whose weakness has been noted before. In 1971, Dr. Eugene P. Odum in Fundamentals of Ecology, stated "Since cultural eutrophication usually produces a highly "unsteady" state, involving severe oscillations (i.e., heavy blooms of algae followed by die-offs, which in turn trigger another bloom on release of nutrients), then the "either/or" argument may be highly irrelevant because phosphorus, nitrogen, carbon dioxide and many other constituents may rapidly replace one another as limiting factors during the course of transitory oscillations. Accordingly, there is no theoretical basis for any "one factor" hypothesis under such transient-state conditions" (Odum, 1971).

Further, it is important to realize that the Redfield ratio is a generalization that is thought to capture stoichiometry of reactions that occur inside of cells, and that the actual uptake of nutrients by cells (or organisms), may be moderated by adaptation for things like storage capability/capacity or alternative biochemistry, which, it should be noted, often operate counter to water column Redfield ratios. These adaptations can be particularly effective in highly enriched situations. In addition, aquatic macrophytes can respond differently than algae to nutrient limitation ratios in the water column, and often exactly opposite. This could be important in cases where impairment can involve either algae, macrophytes, or both; and the overall effect on nutrient dynamics should not be underestimated.

Calculation of Redfield ratios from an existing data set of ambient grab samples by averaging over time and space tends to over-simplify the system. While this will effectively characterize a prevailing pattern of nutrient limitation, it may not reflect periods or events of shorter duration when very different nutrient conditions exist. Nutrient dynamics in aquatic systems are complex, with often considerable fluctuation in the water column concentrations of nutrients, and therefore, the ratio of nutrient concentrations varies. As previously noted, over-enriched aquatic systems are not steady state systems; they are dynamic systems, and a very complex dynamic at that.

Traditionally, many nutrient TMDLs have relied on comparing calculated nutrient ratios in available water column data to the Redfield ratio in order to identify the limiting nutrient as a target and then to manage that nutrient over an averaging period to control productivity. Doing so, mistakenly assumes a steady state for the diagnosis, and then again for the application of the remedy. This increases the risk that excess productivity will not always be controlled, and during shifts in limitation, short term events would be allowed within the averaging period that would not sufficiently protect aquatic life use. To illustrate this point, a daily Redfield ratio was calculated for each WBID where both TP and TN measurements were taken. The percent of time the ratio was P-limited, co-limited, and N-limited was calculated by dividing the number of times the WBID was limited by the total number of sampling events. Results of this analysis for existing conditions for those WBIDs impaired for both nutrients and DO are shown in Table 6.

When one nutrient is identified as limiting, by default the other nutrient is identified as the excess nutrient. Transport of un-reacted nutrients, as well as products of excess production, must be considered when determining appropriate protection of downstream waterbody conditions, both immediate downstream and distant downstream. As described above, the expression of bio-available nutrients in primary productivity may be delayed, conditions commonly change over space and time, and nutrient limitation can easily shift. Even short duration events of excess production can very significantly affect forms of aquatic life that cannot be sustained over long term averaging periods.

While aggressive control of one nutrient can restrict productivity, control of both nutrients, N and P, in upstream waters can also provide additional assurance that excess productivity will remain under control. In a highly enriched system, it is important to avoid even brief episodes that can escape the prevailing control during periods of weakened limitation of one nutrient. The resulting additional biomass is the product of excess productivity initially driven by excess nutrients and should not be ignored. Even if less significant locally, it will be transported downstream, and because it represents additional biomass for instream processing, it may continue to burden the normal dynamics as it cycles, and recycles downstream. This spiraling effect can be underestimated in its effect on aquatic life in the intermediate and far-field.

Under conditions of phosphorus limitation, the excess nutrient, nitrogen, is exported in unreacted state, because there would not have been the opportunity for its uptake in biomass. In such a situation, a strategy where phosphorus reduction alone is relied upon to control the majority of local excess primary productivity, there will be a consequent increase in the export of the excess nutrient, nitrogen. The larger the excess of nitrogen, the greater the contribution to nitrogen sensitive downstream systems; therefore, concurrent reduction of nitrogen in the basin is often warranted in order to protect downstream use. Also, in these situations, there may be additional near-field justification for nitrogen control, arising from the fact that at those times when local primary productivity is being effectively suppressed by applied phosphorous limitation, additional biological uptake of N is restricted, which may leave the chemically reduced constituents of the nitrogen series, i.e., ammonia and organic N, to directly exert their oxygen demand in a setting that is already under oxygen stress.

In a situation where a phosphorus only control strategy has previously been established to limit excess algae and macrophyte growth in a downstream lake, the success of that strategy might be jeopardized by not controlling both nutrients upstream of the lake. If nitrogen inputs to the lake are left uncontrolled, there can remain a risk of excess primary production when residual phosphorus in the lake sediments becomes available, or in localized areas where nitrogen limitation occurs. And in such a situation, if phosphorus levels are expected to remain high for some time, it can be prudent to lower prevailing nitrogen levels. Any uncertainty in the estimation of prevalence of phosphorus limiting conditions would pose greater risk to control if nitrogen is allowed in abundance. It has been observed that primary production in lakes often responds more significantly to phosphorus reduction when nitrogen is also reduced.

Table 6. Existing Limiting Condition in Impaired WBIDs (based on TP and TN data)

WBID	Average Condition	Limiting Condition (% of time)		
		Phosphorus	Nitrogen	Co-Limited
3186C	Co-Limited	4%	50%	46%
3186D	P-Limited	73%	8%	19%
3188	N-Limited	19%	40%	42%
3188A	Co-Limited	25%	9%	66%
3192C	Co-Limited	28%	11%	61%

WBID	Average Condition	Limiting Condition (% of time)		
		Phosphorus	Nitrogen	Co-Limited
3199B	N-Limited	2%	86%	12%
3203A	N-Limited	6%	67%	27%
3203B	N-Limited	1%	82%	18%
3205	N-Limited	2%	62%	36%
3205D	N-Limited	8%	58%	34%
3213A	N-Limited	0.5%	40.3%	59.2%
3213B	Co-Limited	15%	37%	48%
3213D	N-Limited	2%	83%	16%
3204	Co-Limited	61%	0%	39%
3213C	P-Limited	67%	1%	32%
3206	Co-Limited	34%	4%	62%
3209	P-Limited	70%	2%	27%
1436	P-Limited	98%	0%	2%

4.2 Nutrient Target Development

The Lake Okeechobee drainage basin is a highly enriched system with elevated levels of both TP and TN throughout, and conditions of low DO are common in the impaired WBIDs. This is evident from ambient monitoring data and general observations, as well as both quantitative and qualitative evidence in downstream waters. In this situation, control of both TP and TN as nutrient inputs is necessary to prevent adverse impacts of nutrient over-enrichment in both near-field and far-field waters.

A TMDL must have a quantified target for the subject parameter which represents a level that fully supports the designated use of the waterbody in question and does not result in any violation of water quality standards downstream of that waterbody. Florida currently has only narrative water quality standards for nutrients; therefore, determination of appropriate targets for nutrient TMDLs requires a numerical translation of the State's narrative criteria.

FDEP has invested considerable time and resources in an ongoing effort to develop numeric criteria for nutrients applicable to all inland waters which the State expects to adopt into state water quality standards at some future date. At that time, those criteria will require full EPA review and must be approved by EPA before they are effective for Clean Water Act purposes. Until EPA receives a formal water quality standards submittal of those criteria with sufficient supporting documentation they cannot be determined to be sufficiently protective of the use and otherwise consistent with the CWA.

While FDEP's criteria development process is ongoing and incomplete, the State offered EPA certain preliminary information for consideration as targets for this TMDL. FDEP adapted the EPA Ecoregion Reference Condition approach, applied it to the Central Peninsula Bioregion, and projected a range of values for TN and TP that the State considers protective of aquatic life in streams of that bioregion (FDEP, 2007b). EPA considers the State's approach to have considerable technical merit, and while EPA encourages the State to continue refinement of the approach, EPA views the preliminary values projected from the process to represent the best information currently available on a level of nutrients protective of aquatic life in streams of the Central Peninsula Bioregion of Florida. EPA is using these values in conjunction with other factors to assure downstream use protection in choosing appropriate targets for this TMDL.

The reference approach described in the FDEP Technical Support Document (FDEP, 2007b) results in a proposed range of values for TP of 84 ug/L to 128 ug/L; and a range of values for TN of 1.3 mg/L to 2.0 mg/L. In this document, FDEP states that it is very confident the native flora or fauna are fully protected within these ranges of concentrations.

A TP target of 113 ug/L as an annual average concentration within the WBIDs was selected from a range of TP values provided by FDEP to protect aquatic life in the tributaries. To ensure protection of downstream uses, TP loads consistent with those prescribed in the LOPP are assigned at the pour point of the WBIDs comprising an LOPP basin.

A TN target of 1.2 mg/L as an annual average concentration within the WBIDs was selected to protect aquatic life in the tributaries and to protect the downstream uses. This value is slightly below the lower value in the range of TN values provided by FDEP to protect of aquatic life in the tributaries. The lower value of 1.2 mg/L was selected based on an interim TN target for the St. Lucie Estuary of 0.74 mg/L at the Roosevelt Bridge provided by FDEP in a recent (June 3, 2008) memorandum**.** EPA reviewed TN data from Lake Okeechobee, the C-44 canal and the St. Lucie Estuary to determine a TN target for the tributaries that would achieve the interim TN target proposed by FDEP for the St. Lucie estuary. This target determination takes into account assimilation of TN in the surface water system between Lake Okeechobee and the St. Lucie Estuary and dilution of TN with the tidal system. Based on the best currently available information, a value of 1.2 mg/L annual average TN protects aquatic life in the tributary WBIDs and provides protection of downstream uses. Additional information on the derivation of the TN target analysis is provided in Appendix B.

The TMDL report allocates loads to TP and TN. The dissolved inorganic fraction of total nitrogen (i.e., ammonia (NH_3) and nitrite-nitrate (NO_2-NO_3)) is more immediately bioavailable than organic nitrogen, and therefore, more directly enhances the growth of primary producers such as algae and other plants. Inorganic nitrogen is found in animal wastes, artificial fertilizers, and other anthropogenic sources. Specific controls of dissolved inorganic nitrogen in implementation of this TMDL could be most effective for reducing massive algae blooms that cause severe drops in DO levels.

Use of these values as targets for this TMDL does not, nor should it in any way, be interpreted to constitute an approval, or conditional approval of these values as Florida water quality standards. At this time, EPA's satisfaction with the use of these values as interim TMDL targets is based on limited information and does not reflect an in-depth review or judgment of the values as numeric criteria that will, or will not be protective, or otherwise consistent with the CWA.

4.3 Nutrient Target Application

The averages of existing nutrient values for each WBID were used to calculate a Redfield ratio to determine the prevailing nutrient limitation condition of that WBID. There were four P-limited WBIDs, six co-limited WBIDs, and eight N limited WBIDs in the existing conditions scenario. After the P target was applied, all but two WBIDs were P limited with existing levels of N (see Appendix A). However, it is understood that with variation in nutrient concentration the ratio will change and limitation will shift accordingly. Targeting only the limiting nutrient, without addressing the other can be expected to restrain primary production only as long as that nutrient is clearly limiting.

If P is targeted in all WBIDs at a level that will maintain or establish P limitation in each, then excess primary production should be controlled over the averaging period, as long as clear P limitation is maintained throughout the WBID. Under those circumstances, the WBID should be protected in the near-field and P transport reduced downstream to Lake Okeechobee (where primary productivity is to be controlled by a TMDL for P). However, this approach would be incomplete without an assessment of N for several reasons. Forms of N available for primary productivity can remain in excess and directly exert a negative influence on DO.

High levels of excess N can have a direct effect on DO. During the majority of the time under P limitation, when local primary productivity is being effectively suppressed by control of P, biological uptake of N is restricted. This may leave the chemically reduced constituents of the nitrogen series, i.e., ammonia and organic N, to more directly exert their oxygen demand in WBIDs that are already under oxygen stress.

In many of these WBIDs with high ambient N concentrations there is significant animal agriculture in the watershed, which could be expected to increase the organic N and ammonia fractions of total N delivered to the waterbody. News reports of oxygen depletion fish kills associated with agricultural runoff are easy to find. This potential for increased nitrogenous oxygen demand and allochthonous carbonaceous oxygen demand under P limitation provides justification for concurrent reduction of N. Additional rationale for controlling nitrogen can be found in Appendix C.

In the near field, with P only control, there may also be high levels of N present. Many WBIDs have such significant P limitation precisely because of existing high levels of N. Allowing these high ambient levels of N increases the risk of failure of the control scheme. The strength of P limitation can be expected to vary during the averaging period, and shifts to co-limiting conditions with high N present may result in loss of control of primary production. During these times, events of short duration could significantly affect aquatic life. In order to minimize the risk of water quality standards violation, concurrent control of N may be warranted in these WBIDs.

Additionally, N can, or will be, the excess nutrient in all P limited WBIDs, and as such remains in the watershed for transportation downstream while productivity is restrained by P control. The far-field effects of exported N from WBIDs under P only control must be considered if downstream uses are to be adequately protected. Under conditions of P limitation, with local excess primary production controlled to a large extent by P reductions alone, there will be consequent export of the excess nutrient, N, which will impact nitrogen sensitive downstream systems. Without concurrent control, the larger the excess of N, the greater will be the impact.

There are documented nutrient impairments in the downstream estuaries of the St. Lucie (USEPA, 2006) and the Caloosahatchee River (SFWMD, 2005) with excess nitrogen loading attributed to discharge from Lake Okeechobee. To avoid contributing to violations of water quality standards in these downstream waters, concurrent control of N is warranted. With control targets for tributaries based upon estimations of least impacted conditions, nutrient levels should be acceptable for transport to Lake Okeechobee.

4.4 DO and BOD Target

In waterbodies listed for both nutrients and DO, controlling nutrients should result in improved DO conditions. In most of the WBIDs, insufficient data are available to correlate elevated BOD concentrations with depressed DO levels, with the exception of WBID 3186B which is listed for DO and BOD and not nutrients. In that case, a regression analysis between DO and BOD was performed using the limited data available in the WBID (see Appendix D). The analysis was conducted at both a single station and using all data collected in the WBID. Although DO and BOD measurements are collected at several stations within the WBID, only data collected at Station 21FLSFWMKRFNC38 include times when DO criteria are achieved in the stream. This station is located upstream of Kissimmee River Restoration project and was the only station where a range of BOD and DO measurements were collected. The data were filtered to remove non-detect samples. Using the trend line equation shown on this plot, the BOD concentration corresponding to the DO criterion of 5 mg/l is about 2.36 mg/l and is used as the target in this WBID.

Elevated chlorophyll levels are an indication of nutrient productivity; however, insufficient data are available in most WBIDs to indicate a correlation between these parameters. An assumption in these TMDLs is DO conditions will improve when management strategies are implemented to reduce nutrients loadings.

5 WATER QUALITY RESULTS

Data collected during the Group 4 listing cycle were used to assess water quality in the impaired waterbodies to determine if the waterbody is impaired and if a TMDL is needed. EPA confirmed the impairment status using FDEP's current assessment methodology contained in the Impaired Waters Rule (IWR) and determined that TMDLs are needed in the impaired WBIDs. Data compiled in IWR Run 24 were used in the data analysis and are summarized in Table 7 and Table 8. IWR Run 24 covers water quality data collected between 1993 and 2004. For WBIDs listed for nutrients, TN, TP, chlorophyll-a and unionized ammonia data are reported. A summary of BOD and DO data for WBIDs listed for DO is shown in Table 8.

WBIDs 3186B and 3186D are listed for DO and/or BOD. Samples collected at the same station and on the same day and analyzed for DO, BOD, Chl-a, TP, TN, and temperature are plotted to determine a correlation, if any, between these parameters. Select correlation plots for WBID 3186B and 3186D are provided in Appendix E. As expected, DO has a negative correlation with temperature, most likely a benefit of tree canopy. In these WBIDs, DO does not have a strong correlation with Chl-a or any of the nutrient parameters.

WBID 3186D does not have sufficient data collected at any station to correlate depressed DO concentrations with either BOD or chlorophyll-a. Chlorophyll concentrations measured in the WBID are low (maximum value is 6 μg/l) and would not be indicative of nutrient rich waters. WBID 3186D is predominately forest and rangeland. The correlation between DO and TN for WBID 3186D is shown in Appendix E. The correlation is weak, but in general, as TN concentrations decrease, DO concentrations increase.

Table 7. Summary of Nutrient Data for WBIDs Impaired by both Nutrients and DO

WBID	TP (mg/l)				TN (mg/l)				Chlorophyll -a(µg/l)				Unionized Ammonia (mg/l)			
	Obs	Mean	Min	Max	Obs	Mean	Min	Max	Obs	Mean	Min	Max	Obs	Mean	Min	Max
3186C	46	0.39	0.01	1.49	45	1.86	0.84	9.51	20	29.17	1.4	365.07	1	0	0	0
3186D	45	0.07	0.01	1.08	43	1.08	0.33	3.8	17	2.4	1	6.3	-	-	-	-
3188	711	0.47	0	3.92	258	1.77	0.5	8.4	23	7.24	1	74	13	0	0	0
3188A	152	0.19	0.03	1.19	108	1.42	0.52	4.64	6	83.02	1	480	-	-	-	-
3192C	18	0.27	0.04	1.3	18	1.98	1.11	4.71	12	30.03	1	150	-	-	-	-
3199B	104	1.587	0.05	5.78	92	2.99	0.92	11.00	14	157.77	6.00	979.36	-	-	-	-
3203A	2,869	0.484	0.01	15	557	1.6	0.78	11.36	3	13.78	3.89	26.67	191	0	0	0.02
3203B	591	0.943	0.19	3.72	203	2.6	1.04	9.68	3	5.28	4.41	6.17	2	0	0	0
3204	988	0.15	0	0.73	987	1.96	0.07	6.41	21	51.55	1	440	399	0	0	0.01
3205	567	0.48	0.02	1.47	405	1.83	0.51	7.91	23	50.32	1	370	1	0.01	0.01	0.01
3205D	500	0.63	0.02	5.83	369	2.1	0.57	27.85	21	12.52	1	210	2	0.02	0.01	0.03
3206	444	0.185	0.04	1.93	444	1.73	0.062	5.07	23	24.72	1	62	199	0	0	0.07
3209	3,453	0.107	0	2.59	1588	1.64	0.035	13.62	233	10.28	1	69.3	552	0	0	0.01
3213A	203	0.455	0.07	1.76	200	1.86	0.48	3.87	8	19.83	1	67	2	0.01	0.01	0.01
3213B	272	0.438	0	2.11	245	2.07	0.134	23.38	65	38.65	3.8	144.8	34	0	0	0

WBID	TP (mg/l)				TN (mg/l)				Chlorophyll -a(µg/l)				Unionized Ammonia (mg/l)			
	Obs	Mean	Min	Max	Obs	Mean	Min	Max	Obs	Mean	Min	Max	Obs	Mean	Min	Max
3213C	422	0.109	0	2.11	397	1.69	1.06	5.07	68	39.43	3.8	144.8	89	0	0	0.01
3213D	179	1.096	0.09	3.92	8	2.6	0.8	3.68	4	3.98	1	8.92	1	0.01	0.01	0.01
1436	56	0.068	0.01	0.24	56	1.71	0.59	4.42	16	3.06	1	15.65	10	0	0	0

Table 8. Summary of DO and BOD Data in WBIDs Impaired For DO

WBID	DO (mg/l)				BOD (mg/l)			
	Obs	Mean	Min	Max	Obs	Mean	Min	Max
3186B	616	4.42	0.01	12.81	60	3.81	2	14.6
3186C	46	4.11	0.61	7.6	16	2.91	0.7	7.4
3186D	43	4.49	0.13	9.16	15	2.05	2	2.2
3188	608	3.53	0.11	14.02	23	2.23	0	8.5
3188A	137	3.18	0.42	8.43	6	2.43	0	8.3
3192C	19	2.46	0.17	7.6	12	5.72	1	20.1
3199B	92	2.57	0.18	8.61	-	-	-	-
3203A	1050	3.38	0	15.43	-	-	-	-
3203B	519	3.76	0.44	9.41	-	-	-	-
3204	949	4.31	0.2	11.63	19	3.55	0	19.2
3205	413	4.24	0.33	11.3	-	-	-	-
3205D	1079	3.76	0.1	12.6	13	1.31	0.41	3.8
3206	435	4.19	0.13	10.69	29	2.21	0	6.1
3209	1379	5.34	0	13.42	8	2.49	2	3.4
3213A	197	4	0.69	10.5	-	-	-	-
3213B	240	3.98	0.09	10.8	-	-	-	-
3213C	400	4.67	0.09	13.93	-	-	-	-
3213D	168	2.57	0.3	9.16	-	-	-	-
1436	68	3.75	0.14	8.9	25	2.01	1.1	3.6

6 SOURCE ASSESSMENT

An important part of the TMDL analysis is the identification of source categories and the amount of pollutant loading contributed by these sources. Sources are broadly classified as either point or nonpoint sources. Phosphorus originating from atmospheric deposition is allocated to background loads. Several of the WBIDs are also impaired for dissolved oxygen and one is listed for DO and BOD only. The sources contributing to nutrient impairment also contribute to the low DO and elevated unionized ammonia levels. Low DO concentrations can also be attributed to hydromodification associated with channelization.

6.1 Background Loads

Dry and wet atmospheric deposition of phosphorus is considered background. Atmospheric phosphorus loading in South Florida is monitored through the Florida Atmospheric Mercury Study (FAMS). Wet deposition phosphorus loading rates average about 10 mgP/m^2-yr, while dry deposition phosphorus loading rates range from 10 mgP/m^2-yr to 20 mgP/m^2-yr (FDEP, 2001b). The Lake Okeechobee Technical Advisory Committee recommended that 18 mgP/m^2-yr is an appropriate atmospheric loading of phosphorus over the open lake. This rate is used to estimate background loads of phosphorus in the impaired tributaries in the Lake Okeechobee watershed. The LOPP allocates 35 Mtons to atmospheric deposition.

6.2 Permitted Point Sources

A point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Point source discharges of industrial wastewater and treated sanitary wastewater must be authorized by National Pollutant Discharge Elimination System (NPDES) permits. NPDES permitted facilities discharging treated sanitary wastewater or stormwater are typically considered primary sources of nutrients. Waste Load Allocations (WLAs) are assigned to all NPDES permits discharging to surface waters.

Several domestic and industrial wastewater point sources exist in the watershed; however, most of these sources do not discharge to surface waters. Animal Feeding Operations (AFOs) are located in WBIDs 3505 and 3505D, but they land apply the wastewater and are not expected to discharge to surface waters. H.W. Rucks Dairy Barn #1(FLA139173) and #2 (FLA139165) are located in WBIDs 3505 and 3505D, respectively, and rely on BMPs to control phosphorus at the source.

FDEP regulates dairy farms and other confined animal operations located in the Lake Okeechobee watershed under State Law, Chapter 62-670.500, F.A.C. (Dairy Rule). The purpose of the rule is to control pollution of waters of the state due to the discharge of wastewater and runoff from dairies and other confined animal operations. Additionally, EPA reinterpreted its federal rules regarding NPDES permitting of Concentrated Animal Feeding Operations (CAFOs). The state was required to implement these federal rules by December 2004. Based on EPA's CAFO rule, all CAFOs located within the Lake Okeechobee watershed must obtain NPDES permits. The permit for the dairy farms does not allow discharge to surface waters except under extreme rainfall events. For purposes of the TMDL, the WLA for these facilities is 0 lb/day. The permitting requirements include the development and implementation of a nutrient management plan, record keeping, transfer of waste to third parties, and annual reporting (FDEP, 2006).

6.2.1 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. 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 multi-sector general permit that covers various types of industrial manufacturing facilities and requires the implementation of stormwater pollution prevention plans.

- Construction activity generic permits for projects that 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 and the treatment and management of stormwater to minimize pollution and flooding.

In October 2000, USEPA authorized FDEP to implement the NPDES stormwater program in all areas of Florida except Indian Tribal lands. FDEP's authority to administer the NPDES program is set forth in Section 403.0885, Florida Statutes. The Stormwater Rule 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 Stormwater 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.

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, FDEP 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, and to local governments with as few as 10,000 people.

An important difference between federal and state stormwater permitting programs is the federal program covers both new and existing discharges, while the state program focuses on new discharges. 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. Most MS4 permits issued in Florida include a re-opener clause allowing permit revisions for implementing TMDLs once they are formally adopted by rule.

Polk County and the City of Davenport in the Horseshoe Creek basin (WBID 1436) are covered by a Phase I MS4 permit (FLS000015). Polk County is the "unofficial" lead permittee. The Department of Transportation is a co-permittee to this permit. Osceola County (FLR04E063) and Martin County (FLR04E013) are of sufficient population density to require a Phase II MS4 permit. There are no urban areas in the impaired WBIDs of sufficient populations in Polk, Osceola, or Martin counties covered by an MS4 permit; therefore, a WLA of 0 lb/day is assigned to WBIDs located in these counties.

MS4 permittees will only be responsible for reducing the anthropogenic loads associated with stormwater outfalls owned or otherwise controlled by the permittee. MS4 permittees are not responsible for reducing other nonpoint source loads in their jurisdiction. All future areas with populations meeting the MS4 requirements will be required to achieve the percent reductions assigned to the WBIDs in the TMDL.

6.3 Nonpoint Sources

Unlike traditional point source effluent loads, nonpoint source loads are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. These sources generally, but not always, include accumulation of nutrients on land surfaces and wash off as a result of storm events. Nonpoint sources of phosphorus and nitrogen loadings in the Lake Okeechobee watershed include: agriculture (cattle and truck crops), wildlife, residential and urban development (septic systems), and stormwater runoff. Nutrients associated with residential and urban development is from landscape fertilization, accumulation of nutrients in drain fields and septic tanks, municipal sludge from wastewater treatment plants and landfills. The single greatest contributor to increased N in most ecosystems is fertilizer use, with other factors including deforestation, fossil fuel burning, increased planting of nitrogen fixing crops, and oxidation of organic soils (SFWMD, 2002).

Major outflows from Lake Okeechobee include evapotranspiration (66 percent), the Caloosahatchee River to the west (12 percent), St. Lucie Canal to the east (4 percent) and the four major agricultural canals (the Miami, New River, Hillsboro, and West Palm Beach Canals) that drain south and southeast (18 percent). The lake contributes poor water quality to these waterbodies. Implementation of control strategies outlined in the LOPP should result in improved water quality discharging from the lake.

Depressed DO concentrations in many of the canals are a result of transporting nutrient-rich waters. Despite reductions in the organic load carried in the canals, the physical nature of the canals may not result in DO concentrations above Class III water quality criteria. Site specific alternative DO criteria may be necessary for many of the canals in the watershed.

A summary of anthropogenic nonpoint sources found in the Lake Okeechobee watershed is presented below. A detail discussion of these sources and remediation actions planned for the watershed can be found on FDEP's webpage.

6.3.1 Agriculture

Agricultural activities are the principle land uses in the impaired WBIDs and are responsible for discharging large quantities of nutrients to the waterbodies through stormwater runoff. Cattle and dairy pasturelands are the primary agriculture activities north and northwest of Lake Okeechobee, while cropland (sugarcane and vegetables) dominates to the south and east of the lake. The most intensive land use in the watershed is dairy farming, which began in the 1950's. The TCNS watershed contains almost half (11,085 acres) of the dairy land in the entire Lake Okeechobee watershed and contributes almost 24 percent of the TP load to the lake (FDEP et al, 2008).

In 1987, FDEP adopted Chapter 62-670 to establish treatment requirements to reduce total phosphorus concentrations in runoff originating from AFOs and dairy farms in the Lake Okeechobee watershed. Waste treatment systems were to be constructed to treat runoff and wastewater from barns and high-intensity milk herd holding areas. According to the Dairy Rule, all 49 dairies in the Lake Okeechobee drainage basin had to sell and remove their cattle or else comply with the rule by 1991. The Dairy Buy-Out-Program allowed owners of dairies to sell their dairy if they were unable or unwilling to comply with the rule. In 1997, 23 dairies were eliminated, while 26 came into compliance with the rule.

The importation of phosphorus as feed, fertilizer and detergents, to support agricultural activities is a major source of phosphorus, nitrate, nitrite, and ammonia to the watershed. Ninety-eight percent of the phosphorus imported to the watershed supports agricultural activities while the remaining two percent supports human activities. Land use activities that are responsible for the largest percentage of annual phosphorus imports to the watershed include: improved and unimproved pasture, dairies, agriculture (citrus and caladium farms), sugarcane, sod farms, and row crops.

6.3.2 Sediment

Another factor that controls phosphorus in the waterbodies involves the internal phosphorus loading from sediments that accumulates in the waterbodies. Phosphorus is typically bound to calcium, other organic matter, or iron at the surface of the sediments. The diffusive flux of phosphorus between the surface and water column is controlled by iron solubility. Under conditions of low dissolved oxygen (iron is in the form of Fe^{2+}), phosphorus is released at high rates from the sediment in the water column and could increase from 50 ug/L to over 1 mg/L. This condition could contribute to algal blooms that occur in the summer months.

Dairies and sludge applications are significant sources of nutrients (N and P) in the Okeechobee watershed. Most of the P control measures enacted in response to the Dairy Rule, especially holding more water and containing cattle waste, yield significant N control. An estimated 11,914 tons of sludge was applied in Okeechobee County in 1999, containing an estimated 275 tons of N and 133 tons of P. Large chicken farms near Indiantown transported nitrogen-rich chicken manure into Okeechobee's watershed through 2001. A partial moratorium on sludge application was called in 2001 and BMPs for sludge application for agriculture were developed by the Florida Department of Agriculture and Consumer Services (Audubon of Florida, 2005).

Nutrient impairment in Lettuce Creek (WBID 3213A) is attributed to high dissolved phosphorus fraction attached to sediment particles. Baffle boxes were installed in the creek as part of the Tributary Sediment Removal Project to evaluate the phosphorus reduction benefits that could be achieved by removing sediment loads from a stream. This type of traditional sediment trap was ineffective at removing phosphorus due to the small diameter particles discharging into Lettuce Creek. The study concluded a simple settling pond with chemical coagulation would be more efficient and cost effective at removing particulate phosphorus than baffle boxes.

6.3.3 Septic Systems

Residential septic tank systems and small package plants deliver contaminants (bacteria and toxic household chemicals) and nutrients to the impaired waterbodies. While urban areas comprise about 10 percent of the land uses in the basin, they only contribute 3 percent of the total phosphorus load in the watershed (FDEP, 2001b). Wastewater master plans were completed in January 2004 to address the need for connecting septic system and package plants to a central sewer system.

6.3.4 Stormwater Runoff

Stormwater runoff from agricultural and urban land cover represents a significant portion of the nutrient loadings to the impaired streams. Numerous Best Available Technologies (BATs) projects have been initiated in the Lake Okeechobee watershed to reduce phosphorus loadings in stormwater runoff. In May 2004, the SFWMD completed construction of edge-of-farm stormwater treatment BATs on select dairy properties in the watershed, one of which was on property located in WBIDs 3213A and 3203A. Dairy BATs projects consist of capturing stormwater runoff from high nutrient pasture areas; reusing the runoff onsite in current operations (if possible); and if offsite discharge is necessary, chemically treating the runoff prior to its release.

Reducing nutrients entering stormwater in urbanized areas is essential to achieving the goals of the LOPP. Public education through the Florida Yards and Neighborhood Program provides weekly newspaper articles addressing proper lawn maintenance practices. The program encourages the use of low- or no-phosphorus fertilizers for urban lawns and golf courses.

7 TMDL DEVELOPMENT

The TMDLs for the Lake Okeechobee tributaries are based on achieving nutrient concentrations that protect the tributaries and achieve the nutrient load to Lake Okeechobee consistent with the allocations outlined in the LOPP. The LOPP allocates an annual average load of 35 Mtons to background (i.e., atmospheric deposition) and 105 Mtons/yr between point and nonpoint sources. To achieve the TP load in the lake, the basins discharging into the lake are each allocated a load such that the total annual load from all waterbodies (impaired and not impaired) does not exceed 105 Mtons. Details of the development of the target TP load for Lake Okeechobee can be found in the LOPP (SFWMD, 2004). The TMDLs also target TN as described in Section 4 of this report.

An assumption in these TMDLs is DO conditions will improve when management strategies are implemented to reduce nutrients loadings. WBID 3186B is listed for DO and BOD, and the TMDL for this WBID allocates loading of BOD to achieve water quality standards.

7.1 Nutrient TMDL

Nutrient enrichment and the resulting problems related to eutrophication tend to be widespread and are frequently manifested some distance (in both time and space) from their source. Addressing eutrophication involves relating water quality and biological effects (photosynthesis, decomposition, nutrient recycling, etc.), as acted upon by hydrodynamic factors (flow, wind, tide, salinity, etc.) to the timing and magnitude of constituent loads supplied from various categories of pollution sources. Dynamic computer simulation models have become indispensable tools to describe these relationships. Calibrated models also provide opportunities to predict water quality conditions under alternative constituent loadings.

FDEP's TMDL for Lake Okeechobee used the watershed model WAMVIEW to develop baseline discharge and TP loads into the lake. The model time period was 1991-2003 and included both the worst drought in recent history (2000) and extremely wet years (1998 and 2003). The LOPP describes how model results were used to assign annual TP loads to each of the 34 basins in the Lake Okeechobee watershed. TP loads allocated to each basin were calculated by multiplying the annual discharge (acre-ft) at each basin outflow structure, the observed flow-weighted TP concentration (mg/l), and a conversion factor (1.233×10^{-3} m^3 Mton acre-ft^{-1} mg^{-1}).

Table 9 is a summary of impaired WBIDs located within each LOPP basin, the drainage area associated with each WBID, and the annual average discharge from each WBID. These values represent baseline conditions (1991-2000) against which alternative TP reduction plans are compared. The annual average flow for WBID 1436 is based on WAMVIEW model output at the downstream end of the WBID. Flow from WBID 1436 drains to a swamp before entering Lake Kissimmee.

For all other WBIDs addressed in this report, the annual average discharge values assigned to each WBID are area-weighted based on the percentage of area the WBID covers in an LOPP basin. For example, the drainage area of WBID 3205 is about 44 percent of the total drainage area of the S-191 basin. This percentage is multiplied by the total flow from the S-191 basin to estimate flow in WBID 3205.

In most cases WBID boundaries align with LOPP basins, but in some instances the areas differ. An LOPP basin may include areas from WBIDs not on the 303(d) list. Impaired WBIDs in the S-65 A, B, C, D, E basin account for about 53 percent of the flow from the watershed. The TMDL allocates loads to the impaired WBIDs but not to the non-listed waterbodies in the watershed. The non-listed waterbodies are expected to meet the goals for TP reduction outlined in the LOPP.

The SFWMD developed a spreadsheet to evaluate the impact alternative BMPs would have on achieving the TP TMDL for Lake Okeechobee. Criteria used to evaluate the BMPs included protection of native flora or fauna in the lake and watershed, achievement of water quality standards, and cost impacts on land owners and the regional economy. A summary of estimated load reductions resulting from current BMP activities and future tools necessary to achieve the TMDL are shown in Table 3.

Table 9. Area and Inflows for Impaired WBIDs and LOPP Basins (Baseline Conditions)

LOPP Basin	WBID	Drainage Area		Annual average Discharge (acre-ft/yr)
		Acres	% of Basin comprised by WBID	
S-65 A, B, C, D, E Basin		***427,913***		***291,845***
	3188	98,485	23.0%	67,169
	3188A	10,680	2.5%	7284
	3186B	67,689	15.8%	46,165
	3186C	16,203	3.8%	11,051
	3186D	24,518	5.7%	16,722
	3192C	10,335	2.4%	7049
Non-Listed Areas		200,003	46.7%	136,406
Taylor Creek/Nubbin Slough (S-191)		***120,754***		***101,946***
	3205	53,049	43.9%	44,786

LOPP Basin	**WBID**	**Drainage Area**		**Annual average Discharge (acre-ft/yr)**
		Acres	**% of Basin comprised by WBID**	
	3205D	9875	8.2%	8337
	3203A	15,332	12.7%	12,944
	3203B	6724	5.6%	5677
	3213B	16,030	13.3%	13,533
	3213A	3135	2.6%	2647
	3213D	16,361	13.5%	13,813
Non-Listed Areas		248	0.2%	209
C-40 Basin (S-72)		***43,964***		***16,266***
	3206	44,406	100%	16,266
C-41 Basin (S-71)		***94,928***		***49,799***
	3204	96,114	100%	49,799
L-59E		***14,409***		***6395***
	3209	14,414	100%	6395
S-135 Basin		***18,089***		***25,408***
	3213C	13,582	75.1%	19,078
Non-Listed Areas		4,507	24.9%	6331
S-154		***33,798***		***24,630***
	3199B	12,893	38.1%	9396
Non-Listed Areas		20,905	61.9%	15234

LOPP Basin	WBID	Drainage Area		Annual average Discharge (acre-ft/yr)
		Acres	% of Basin comprised by WBID	
S-65		***1,021,674***		
	1436	3004	0.3%	26,905
Other Areas (includes impaired WBIDs not in the Group 4 Basin)		862,069		

Existing conditions for TP are expressed as concentrations and represent the mean value calculated from all stations in the WBID (see Table 7). The TP baseline load assigned to each LOPP basin represents existing conditions for all WBIDs discharging into that basin.

Existing conditions for TN are expressed as loads. TN loads are calculated using the mean concentration measured in the WBID and area-weighted flows estimated from the LOPP.

Load (Mton/yr) = Flow (acre-ft/yr) * Conc. (mg/l) * 1.2326E-03 (Equation 2)

In Equation 2, flow is the annual average flow estimated for the WBID and concentration is the mean value calculated using all observation data collected in the WBID. Existing conditions for total nitrogen are summarized in Table 10.

Table 10. Summary of Existing Conditions for Total Nitrogen

WBID	Average TN Concentration (mg/l)	Flow (acre-ft/yr)	TN Load (lb/day)
3186C	1.86	11,051	153.03
3186D	1.08	16,722	134.45
3188	1.77	67,169	885.123
3188A	1.42	7284	77.01
3192C	1.98	7049	103.91
3199B	2.99	9396	287.01

WBID	Average TN Concentration (mg/l)	Flow (acre-ft/yr)	TN Load (lb/day)
3203A	1.60	12,944	154.19
3203B	2.60	5677	109.89
3205	1.83	44,786	610.18
3205D	2.10	8337	130.34
3213A	1.86	2647	36.65
3213B	2.07	13,533	208.56
3213D	2.60	13,813	267.38
3204	1.96	49,799	726.68
3213C	1.69	19,078	240.04
3206	1.73	16,266	209.50
3209	1.64	6395	78.08
1436	1.71	26,905	342.53

7.2 BOD TMDL

A regression analysis using DO and BOD data collected in the upper portion of the WBID was used to develop the DO TMDL for WBID 3186B. The data are graphed and a trend line is drawn through the data points. The trend line equation was then used to solve for a BOD concentration that would meet the DO criterion of 5 mg/l. The TMDL is calculated using this BOD concentration of 2.36 mg/l and an estimate of annual average flow in the WBID. Existing BOD load assigned to WBID 3186B is calculated using the average BOD measurement collected from all stations in the WBID. Existing and TMDL loads are 1309 and 811.13 lb/day, respectively. BOD load calculations are provided in Appendix D.

8 TMDL ALLOCATION

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and allocates loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved.

8.1 Allocation

A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations or WLA), nonpoint source loads (Load Allocations or LA), and an appropriate margin of safety (MOS), which accounts for uncertainty concerning the relationship between effluent limitations and water quality:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

Federal regulations provide that TMDLs can be expressed in terms of mass per time (e.g. pounds per day), toxicity, or other appropriate measure (40 C.F.R.§ 130.2(i)). Allocations are to both TP and TN to ensure complete protection of aquatic use support in the tributaries and downstream waters. TMDLs for TP are expressed as annual average loads consistent with the loads prescribed in the LOPP. Strategies implemented in the watershed to achieve the nutrient TMDLs should result in attainment of DO and BOD water quality standards.

The TMDL components for TP are expressed as concentration at the WBID scale and as loads at the LOPP basin scale expressed in units of Mtons/year and pounds/day. Annual average LOPP basin loads are divided by 365 days/yr to obtain daily loads. The TMDL components for TN and BOD are expressed in terms of daily loads in units of lb/day based on average annual flows calculated for each WBID. The target TP and TN concentrations represent annual average values. TMDLs should be implemented to achieve the annual average concentrations and LOPP loads. TMDL components for TP, TN, and BOD are provided in Table 11, Table 12, and Table 13, respectively. LOPP basin loads converted to daily loads are provided in Table 14. An implicit Margin of Safety (MOS) is assumed in all TMDLs as described in Section 8.4. The percent reduction required to achieve water quality standards is calculated using the following equation:

$$\%\ Reduction = (existing\ load - TMDL) / (existing\ load) * 100 \qquad \text{(Equation 3)}$$

In several of the WBIDs a greater reduction is needed to meet the LOPP basin loads than what is required to achieve the TP target protective of the individual tributaries. EPA is relying on the best management practices (BMPs) and control strategies FDEP is designing for these LOPP basins to achieve the loads protective of Lake Okeechobee. In other WBIDs a greater reduction is needed to achieve the instream TP target for the tributaries than what is required to achieve the LOPP load at the pour point of the basins. Additional BMPs for these WBIDs, beyond those planned for the LOPP, will be needed to control nonpoint source runoff to achieve the load allocation described in this TMDL report. The WBIDs where instream TP targets require greater reductions than provided for in the LOPP are located in the TCNS and S-135 basins and are highlighted in bold font in Table 11.

Table 11. TMDL Components for Total Phosphorus

LOPP Basin/WBIDs	WLA	LA (ppb)	MOS	TMDL		% Reduction	
				Lake Load (Mton/yr)	WBID Conc. (ppb)	Lake	WBID
S-65A ,B, C, D, E				19.25		76%	
3188	0	113	Implicit		113		76%
3188A	0	113	Implicit		113		41%
3186C	0	113	Implicit		113		0%
3186D	0	113	Implicit		113		58%
3192C	0	113	Implicit		113		76%
Taylor Creek / Nubbin Slough (S-191)				19.01		76%	
3205	0	113	Implicit		113		76%
3205D	0	113	Implicit		113		82%
3203A	0	113	Implicit		113		77%
3203B	0	113	Implicit		113		88%
3213A	0	113	Implicit		113		75%
3213B	0	113	Implicit		113		74%
3213D	0	113	Implicit		113		90%
C-40 Basin (S-72)				2.32		76%	
3206	0	113	Implicit		113		39%
C-41 Basin (S-71)				6.17		76%	
3204	0	113	Implicit		113		25%

LOPP Basin/WBIDs	WLA	LA (ppb)	MOS	TMDL		% Reduction	
				Lake Load (Mton/yr)	WBID Conc. (ppb)	Lake	WBID
L59-E				0.36		76%	
3209	0	113	Implicit		113		0%
S-135 Basin				0.82		76%	
3213C	0	113	Implicit		113		0%
S-154 Basin				5.72		76%	
3199B	0	113	Implicit		113		93%
S-65 (Lake Kissimmee)				16.96		76%	
1436	0	113	Implicit		113		0%

1. Reductions proposed are based on achieving 113 ug/L as an annual average of measured days. Lake reduction based on achieving the load allocated in LOPP.
2. WBIDs requiring a higher percent reduction than the LOPP are highlighted in bold font.
3. Implicit MOS based on conservative assumptions including using all data collected in the WBID to determine existing conditions rather than considering one time period (season or year). Data represents all flow conditions including drought (1999-2002) and hurricane years (2004).

Table 12. TMDL Components for Total Nitrogen

WBID	WLA (lb/day)	LA (lb/day)	MOS	TMDL (lb/day)	% Reduction

WBID	WLA (lb/day)	LA (lb/day)	MOS	TMDL (lb/day)	% Reduction
3188	0	600.09	Implicit	600.09	32%
3188A	0	65.08	Implicit	65.08	15%
3186C*	0	98.73	Implicit	98.73	35%
3186D	0	149.39	Implicit	149.39	0%
3192C*	0	62.98	Implicit	62.98	39%
3205	0	400.12	Implicit	400.12	34%
3205D	0	74.48	Implicit	74.48	43%
3203A*	0	115.64	Implicit	115.64	25%
3203B*	0	50.72	Implicit	50.72	54%
3213A	0	23.65	Implicit	23.65	35%
3213B	0	120.90	Implicit	120.90	42%
3213D*	0	123.41	Implicit	123.41	54%
3206*	0	145.32	Implicit	145.32	31%
3204*	0	444.90	Implicit	444.90	39%
3209	0	57.13	Implicit	57.13	27%
3213C	0	170.44	Implicit	170.44	29%
3199B*	0	115.19	Implicit	115.19	60%
1436	0	240.37	Implicit	240.37	30%

Note: The daily TN load should be achieved based on an annual average of the measured days recognizing natural variability.

Allocations for WBIDs marked with an asterisk in Table 12 are provided primarily for the purpose of protecting downstream waterbodies. While LOPP nutrient reduction projects are currently designed to implement phosphorus removal, EPA recognizes that projects can legitimately be designed, located, and implemented downstream in the future for treatment of nitrogen to address estuary impairments in lieu of implementing nitrogen reductions in the waterbodies. At such time, the nitrogen allocations in this TMDL report can be revised to account for those projects. Implementation of this TMDL, or the St. Lucie estuary TMDL, can include such treatment projects. Practices for reduction of nitrogen in agricultural lands are identified in Section 9 TMDL Implementation.

Table 13. TMDL Components for BOD

WBID	TMDL (lb/day)	WLA (lb/day)	LA (lb/day)	Percent Reduction
3186B	811.13	0	811.13	38%

Table 14. TP Allocations for LOPP Basins Expressed as Daily Loads

Basin	WLA (lb/day)	LA (lb/day)	TMDL (lb/day)
S-65A, B, C, D, E	0	116.19	116.19
Taylor Creek / Nubbin Slough (S-191)	0	114.74	114.74
C-40 Basin (S-72)	0	14	14
C-41 Basin (S-71)	0	37.24	37.24
L59-E	0	2.17	2.17
S-135 Basin	0	4.95	4.95
S-154 Basin	0	34.50	34.50
S-65	0	102.37	102.37

8.2 Load Allocation

The LA includes nonpoint source loads from air deposition and unimpaired tributaries. The LA assigns necessary reductions expected in the upstream load from areas above Lake Kissimmee. However, the LA does not take into account changes in nonpoint source loads due to projected changes in land use. The LOPP states changes in land use cannot result in increased phosphorus loading over existing conditions.

8.3 Wasteload Allocations

The WLA is a combination of the WLAs for all of the NPDES wastewater facilities and the stormwater discharge from MS4 entities. There are no NPDES facilities discharging to surface waters or MS4 jurisdictions within the boundaries of the impaired WBIDs. Urban stormwater from smaller municipalities not yet covered under Phase II of the NPDES stormwater program are included in the LA component. All future point sources discharging to surface waters impacting the impaired WBIDs will be required to meet the loads established in these TMDLs.

8.4 Margin of Safety

An implicit MOS was provided in the TMDL analysis, as long term data were used to quantify existing conditions. These data includes time periods of both high and low flow conditions over a range of rainfall events.

8.5 Seasonal Variability

Seasonal variability was addressed in the selection of the nutrient target concentrations by considering data collected during all seasons. The data used in the TMDL analysis were collected during both drought (2000-2001) and wet conditions (1998). South Florida experienced an extremely rare occurrence of a series of hurricanes during August and September 2004. High rainfall, high surface water flows, and rises in water levels in lakes were experienced during the events and following months. Water quality data collected in the fall of 2004 reflects the devastation caused by these events.

9 TMDL IMPLEMENTATION

Section 303(d)(2) of the Clean Water Act requires states to incorporate TMDLs established by EPA into its continuing planning process, pursuant to subsection 303(e) of the Act. A state can establish its own procedures for implementation. Federal regulations provide direction on implementation of TMDLs in the permitting process. At a minimum, NPDES permits must include a permit limit consistent with the assumptions and requirements of an approved wasteload allocation. See 40 C.F.R. § 122.44(d)(1)(vii)(B). However, a state may also establish a compliance schedule to provide time for implementation of effluent limits more stringent than currently permitted.

Control of nonpoint sources is much more dependant on local efforts to reduce pollution. There are many methods for controlling nonpoint sources. The predominant land use in the areas covered by this TMDL is agriculture. For guidance on controlling nonpoint loading into waterbodies from agricultural sources, please refer to EPA's guidance, National Management Measures to Control Nonpoint Source Pollution from Agriculture, http://www.epa.gov/owow/nps/agmm/index.html. EPA also recently published a report, "Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness: A Review of Current Science and Regulations", which provides a synthesis of existing scientific literature on the effectiveness of riparian buffers to improve water quality through their inherent ability to process and remove excess anthropogenic nitrogen from surface and ground waters (USEPA, 2005).

FDEP and the SFWMD have conducted numerous studies to evaluate implementation levels and costs to achieve TMDL targets for phosphorus (SWET, 2008). Implementation of a modest “typical” BMP program was found to be the most cost effective initial phosphorus control practice for the watershed. Edge-of-field/farm (EOF) systems for high phosphorus source areas are the most cost effective control practices that can implemented. Control of nutrients from residential land uses includes site and EOF systems. Site level practices are typically landscape management BMPs, such as fertilization and water management practices. EOF systems for urban areas include standard stormwater retention/detention practices and possible chemical treatment for pass-thru waters. In-field soil amendments (e.g., lime, iron salts, gypsum, etc.) are effective at raising the pH of the soil to enhance phosphorus binding or to directly bind phosphorus with the applied compound. Soil amendments can significantly reduce phosphorus but they have disadvantages that greatly limit their effectiveness for controlling phosphorus. Disadvantages of the using soil amendments include the costs, difficulty in getting the amendments mixed into the soil adequately to maximum their effectiveness and some amendments (e.g., lime and iron salts) being vulnerable to remobilization.

Agricultural nutrient management plans (AgNMPs) have been developed by the FDACS to assist dairies with designing BMPs for their farms. The AgNMPs are designed to bring the dairies into a closer balance in terms of phosphorus import and export. The plans prescribe reduced phosphorus content of imported materials, recycling of phosphorus through spray fields, stormwater retention, and EOF treatment including chemical coagulants. Retained or chemically treated phosphorus will need to be periodically removed from settling basins and properly disposed of (SWET, 2008).

REFERENCES

Audubon of Florida, 2005. Lake Okeechobee: A synthesis of information and recommendations for its restoration. P.N. Gray, C.J. Farrell, M.L. Krauss, and A.H. Gromnicki, Eds., Audubon of Florida, Miami. 106 pp. + appendices.

Florida Administrative Code (F.A.C.) 62-302.530. Criteria for Surface Water Quality Classifications.

FDEP, SFWMD, and FDACS, 2008. Lake Okeechobee Watershed Construction Project Phase II Technical Plan, prepared by South Florida Water Management District, Florida Department of Environmental Protection, and Florida Department of Agriculture and Consumer Services, February 2008.

FDEP, 2008. Nutrient Targets for the St. Lucie Estuary, Florida Department of Environmental Protection Memorandum to Drew Bartlett from Kristina Laskis, Rob McTear, and Keith Parmer, June 3, 2008.

FDEP, 2007a. *State of Florida - Numeric Nutrient Criteria Development Plan*, Tallahassee, FL, September 2007.

FDEP, 2007b. Technical Support Document: Derivation of the Numeric Nutrient Thresholds for Total Nitrogen and Total Phosphorus in the Lake Okeechobee Tributaries, May 2007.

FDEP, 2006. Water Quality Assessment Report, Kissimmee River and Fisheating Creek. Division of Water Resources Bureau of Watershed Management. March 2006.

FDEP, 2005. 2005 South Florida Environmental Report, Chapter 3: Lake Okeechobee Annual Report.

FDEP, 2004. Water Quality Status Report Kissimmee River and Fisheating Creek. Division of Water Resource Management, South and Central Districts, Group 4 Basin, 2004.

FDEP, 2001a. Total Maximum Daily Load for Total Phosphorus – Lake Okeechobee, Florida. Submitted to the USEPA Region 4. Tallahassee, FL.

FDEP, 2001b. Basin Status Report, Lake Okeechobee. Division of Water Resource Management, Southeast District, Group 1 Basin, 2001.

Harper, H. H. and D.M. Baker. 2003. Evaluation of Alternative Stormwater Regulations for Southwest Florida. Environmental Research & Design, Inc.

Odum, Eugene P., 1971. Fundamentals of Ecology, Third Edition. WB. Saunders Company, Philadelphia, PA.

Odum, Howard T., Dissolved Phosphorus in Florida Waters. Department of Biology, College of Arts and Sciences, University of Florida, Report to Florida Geological Survey, January 9, 1953.

SFWMD, 2004. Lake Okeechobee Protection Plan (LOPP), South Florida Water Management District, Florida Department of Environmental Protection, and Florida Department of Agriculture and Consumer Affairs. January 1, 2004.

SFWMD, 2002. Lake Okeechobee Surface Water Improvement and Management Plan (SWIM), Division of Water Resources Management, Southeast District, 2002.

SWET, 2008. Task 3 Legacy P Abatement Plan for Project Entitled Technical Assistance in Review and Analysis of Existing Data for Evaluation of Legacy Phosphorus in the Lake Okeechobee Watershed, draft report prepared for South Florida Water Management District by Soil and Water Engineering Technology, Inc (SWET) in association with JGH Engineering, April 14, 2008.

University of Florida, 2001. Florida Water Resources. University of Florida Extension Institute of Food and Agricultural Sciences WQ101. Gainesville, FL April 2001.

USEPA, 2006. Proposed Total Maximum Daily Load (TMDL) for Dissolved Oxygen and Nutrients in North St. Lucie River (WBID 3194), St. Lucie Estuary (WBID 3194B), and C-24 Canal Watershed (WBID 3197), USEPA Region 4, Atlanta, GA. September 2006.

USEPA, 2005. Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness: A Review of Current Science and Regulations. USEPA, National Risk Management Research Laboratory, Office of Research and Development, Cincinnati, OH EPA/600/R-05/118, October 2005.

USEPA, 2000. Nutrient Criteria Technical Guidance Manual, Rivers and Streams. USEPA, Office of Water, Washington, DC EPA-822-B-00-002.

USEPA, 1991. Guidance for Water-Quality Based Decisions: the TMDL Process. USEPA, Office of Water, Washington, DC EPA-440/4-91-001. April 1991.

Appendix A: Calculation of Limiting Nutrient

Table B- 1. Limiting Nutrient Conditions for Existing and Single Nutrient Control (P only)

WBID	Existing Conditions (ave. values)			Single Nutrient Control (P=113 ug/L)		
	TN	TP	Limiting Nutrient/value	TN	TP	Limiting Nutrient/value
3186C	1.86	0.39	Co-Limiting / 10.56	1.86	0.113	Phosphorus /36.45
3186D	1.08	0.07	Phosphorus / 33.85	1.08	0.113	Co-Limiting /21.16
3188	1.77	0.47	Nitrogen / 7.02	1.77	0.113	Phosphorus /34.68
3188A	1.42	0.19	Co-Limiting / 16.55	1.42	0.113	Co-Limiting /27.83
3192C	1.98	0.27	Co-Limiting / 17.47	1.98	0.113	Phosphorus /38.80
3199B	2.99	1.59	Nitrogen / 4.14	2.99	0.113	Phosphorus /58.59
3203A	1.6	0.5	Nitrogen / 8.86	1.6	0.113	Phosphorus /31.35
3203B	2.6	0.94	Nitrogen / 5.14	2.6	0.113	Phosphorus /50.95
3204	1.96	0.15	Co-Limiting / 28.64	1.96	0.113	Phosphorus /38.41
3205	1.83	0.48	Nitrogen / 8.63	1.83	0.113	Phosphorus /35.86
3205D	2.1	0.63	Nitrogen / 7.80	2.1	0.113	Phosphorus /41.15
3206	1.73	0.19	Co-Limiting / 19.93	1.73	0.113	Phosphorus /33.90
3209	1.64	0.11	Phosphorus / 33.82	1.64	0.113	Phosphorus /32.14
3213A	1.86	0.45	Nitrogen / 9.15	1.86	0.113	Phosphorus /36.45
3213B	2.07	0.39	Co-Limiting / 11.47	2.07	0.113	Phosphorus /40.56
3213C	1.69	0.109	Phosphorus/ 34.33	1.69	0.113	Phosphorus /33.12
3213D	2.6	1.1	Nitrogen / 3.86	2.6	0.113	Phosphorus /50.95
1436	1.71	0.07	Phosphorus / 53.46	1.71	0.113	Phosphorus /33.51

Limiting nutrient calculations are based on molar ratio of average TN to TP concentrations measured at all stations in the WBID. Concentrations are converted to molar values by dividing TN and TP concentrations by their molecular weight, or 14 for Nitrogen and 31 for Phosphorus. An example calculation is as follows:

WBID 3186C: TN/TP = (1.86/14) / (0.39/31) = 0.1328/0.0126 = 10.56 Co-limited

For TMDL conditions (control both N & P): TN/TP = (1.2/14) / (0.113/31) = 23.5 Co-limited

Appendix B: Derivation of TN Target

FDEP has proposed an interim TN target for the St. Lucie estuary of 0.74 mg/l at the Roosevelt Bridge (FDEP, 2008). EPA is establishing a TMDL for TN for the tributaries draining to Lake Okeechobee that protects aquatic life in the tributaries and protects the downstream uses in the St. Lucie Estuary and Caloosahatchee River. An analysis was made to determine the concentration of TN in the tributaries that would achieve the interim total nitrogen target proposed by FDEP for the St. Lucie estuary. This concentration, established by the target for the TMDL, takes into account assimilation and dilution associated with a tidal system. Long term data was extracted from the Impaired Waters Rule Database (Citation IWR31) for the following stations and given in Table B-1: 1) WBID 3212E Lake Okeechobee closest to C-44 structure, 2) WBID 3218 S-80 Structure and 3210 West of Roosevelt Bridge.

Table B- 1. Total Nitrogen analysis for target development

Station	Average Value Total N (mg/l)
21FLSFWML004 (Lake Okeechobee)	1.6
21FLSFWMC44S80 (St. Lucie Canal)	1.4
21FLSFWMSE03 (St. Lucie Estuary)	1.08

Using the average total nitrogen values calculated at each station for the period of 1996-2007, a dilution factor/assimilation factor of 0.675 was calculated by dividing 1.08 (observed in estuary) by 1.6 (observed in Lake Okeechobee). Using this dilution factor and considering the total nitrogen target of 0.74 mg/l total nitrogen, the concentration at the C-44 structure in Lake Okeechobee tributaries would have to discharge 1.10 mg/l total nitrogen. To meet the 1.10 mg/l total nitrogen in Lake Okeechobee WBID 3212E the discharge from the tributaries to lake should be 1.2 mg/l total nitrogen which will account for processing within the lake.

Appendix C: Rationale for Controlling Nitrogen in Impaired WBIDs

The rationale for controlling nitrogen in the impaired WBIDs involved the following three steps.

Step one: If the DO is not meeting the water quality standard for the WBID based on the verified list binomial test or, if the data set is too small, greater than 10% of the samples violate, then a regression analysis is run to determine if nitrogen has an effect on DO. If so, nitrogen will be controlled. If not, step two is applied (which would also apply if the DO were meeting the water quality standard because it targets control of primary productivity throughout the year).

Step two: If a phosphorus only TMDL results in phosphorus limitation for less than 90% of the time using the TMDL target concentration as the phosphorus condition, nitrogen will be controlled. This avoids the risk associated with dependence on a single nutrient control approach where that condition would be expected for less than 90% of the time. Inherent fluctuation in phosphorus levels will still be observed post TMDL implementation.

Step three: A third check will be made to ensure that excess nitrogen, post TMDL implementation, is not delivered downstream recognizing that there are documented nitrogen caused impairments in the St. Lucie and Caloosahatchee Bay. If the target condition in Lake Okeechobee expressed as a median is less than the median of existing TN concentrations in the WBID, nitrogen will be controlled. As expected, the concentrations of nitrogen in Lake Okeechobee inflows are not significantly different, after mixing, than those in Lake Okeechobee outflows.

Results of this analysis are provided in Table C- 1. If any one of the three conditions presented in this table were true, controlling total nitrogen was considered essential to meeting the designated use in the WBID.

Table C- 1. Decision Rationale for Controlling Nitrogen in Lake Okeechobee Tributaries

WBID	Does DO Correlate with Nitrogen (see note 1)	Is TP Limiting Condition LESS than 90% time (see note 2)	Is TN_{WBID} > TN_{TARGET} (see note 3)
3186B	No	Yes – control N (TP limited 71% of time)	No
3186C	No	No	Yes – control N (TN: 1.61 > 1.2)
3186D	No	Yes – control N (TP limited 49% of time)	No
3188	No	Yes – control N (TP limited 84% of time)	Yes – control N (TN: 1.55 > 1.2)

WBID	Does DO Correlate with Nitrogen (see note 1)	Is TP Limiting Condition LESS than 90% time (see note 2)	Is TN_{WBID} > TN_{TARGET} (see note 3)
3188A	No	Yes – control N (TP limited 83% of time)	Yes – control N (TN: 1.37 > 1.2)
3192C	No	No	Yes – control N (TN: 1.81 > 1.2)
3199B	No	No	Yes – control N (TN: 2.66 > 1.2)
3203A	No	No	Yes – control N (TN: 1.54 > 1.2)
3203B	No	No	Yes – control N (TN: 2.37 > 1.2)
3204	No	No	Yes – control N (TN: 1.76 > 1.2)
3205	No	Yes – control N (TP limited 85% of time)	Yes – control N (TN: 1.73 > 1.2)
3205D	No	Yes – control N (TP limited 89% of time)	Yes – control N (TN: 1.73 > 1.2)
3206	No	No	Yes – control N (TN: 1.60 > 1.2)
3209	No	Yes – control N (TP limited 78% of time)	Yes – control N (TN: 1.36 > 1.2)
3213A	Yes (control N)	No	Yes – control N (TN: 1.79 > 1.2)
3213B	Yes (control N)	No	Yes – control N (TN: 1.75 > 1.2)
3213C	Yes (control N)	No	Yes – control N (TN: 1.58 > 1.2)
3213D	No	No	Yes – control N (TN: 2.14 > 1.2)
1436	Yes (control N)	Yes – control N (TP limited 88% of time)	Yes – control N (TN: 1.63 > 1.2)

1. Data indicates correlation with ammonia, nitrate-nitrite, and/or total nitrogen
2. TP limiting condition reflects Post TMDL condition for implementing TP controls only

WBIDs showing a correlation between DO and Nitrogen are illustrated below.

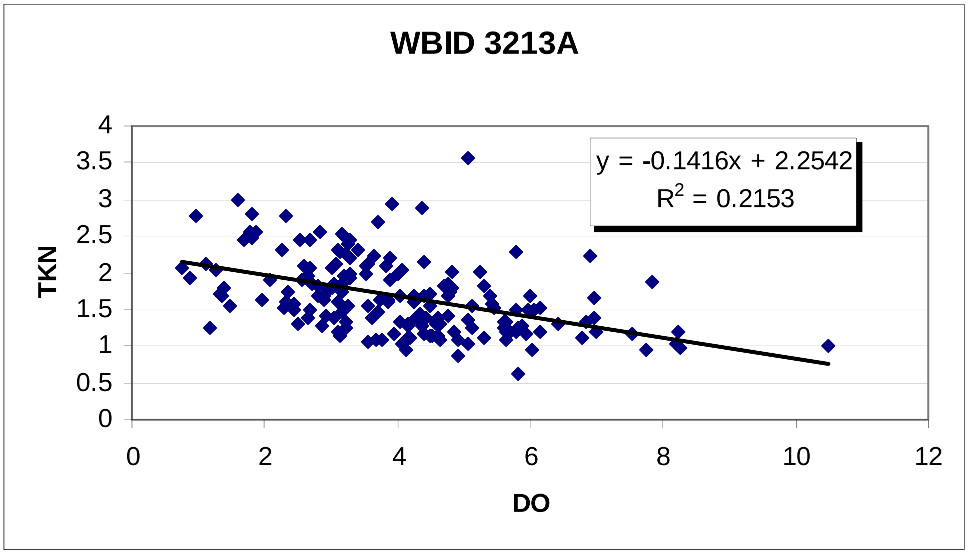


Figure C- 1. Correlation between DO and TKN in WBID 3213A

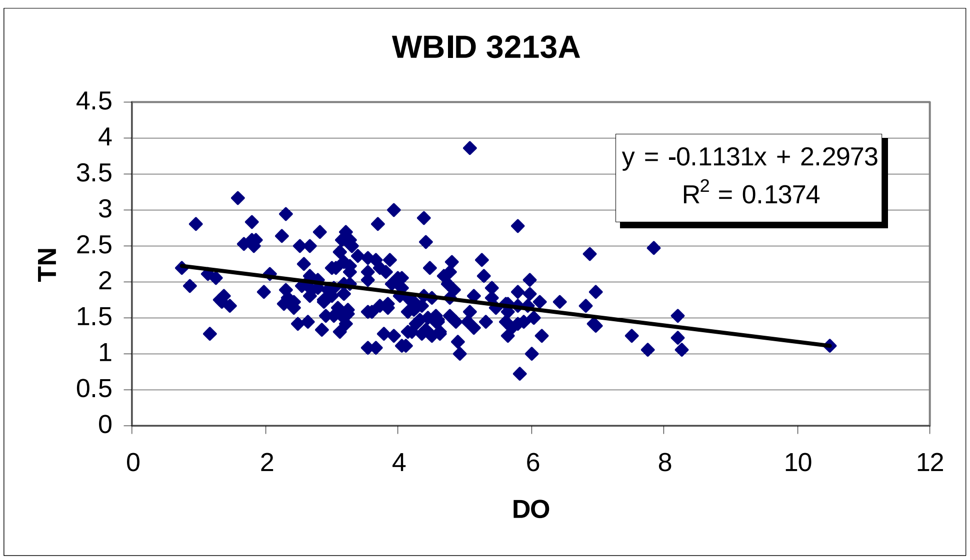


Figure C- 2. Correlation between DO and TN in WBID 3213A

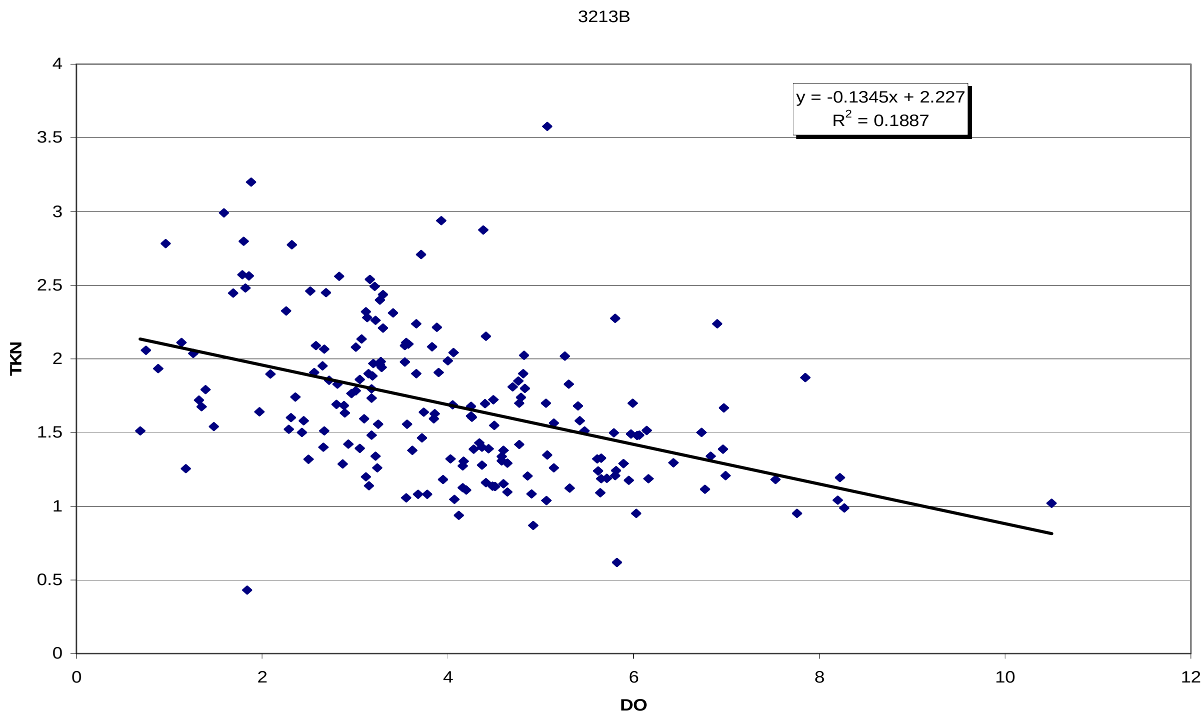


Figure C- 3. Correlation between DO and TKN in WBID 3213B

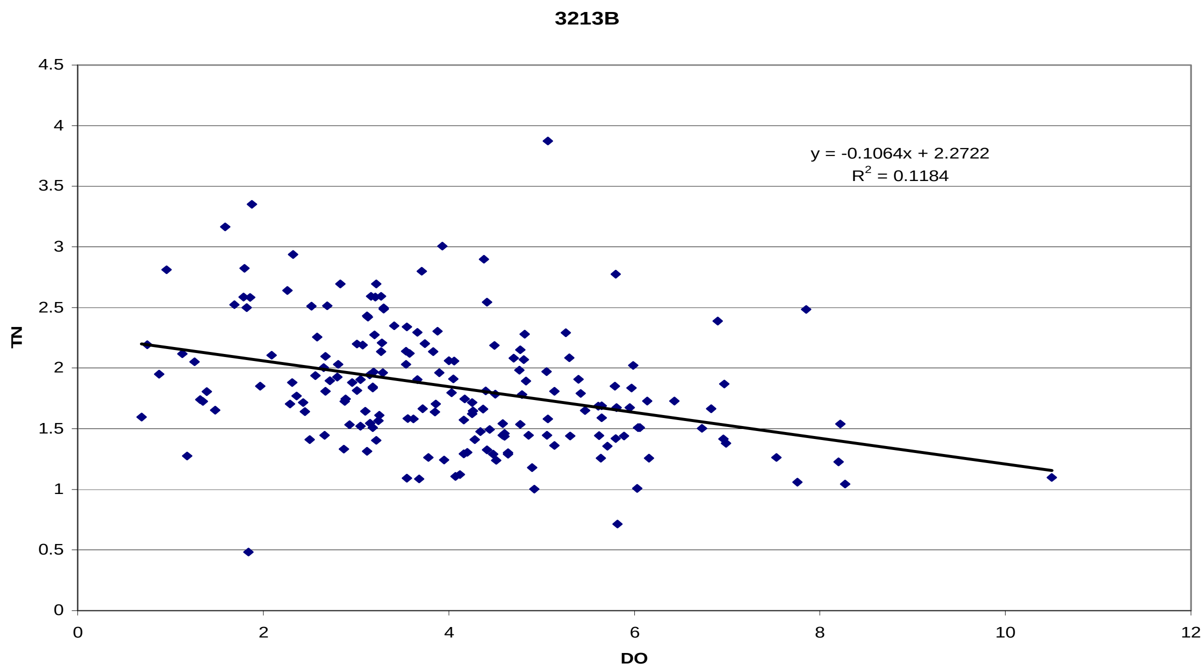


Figure C- 4. Correlation between DO and TN in WBID 3213B

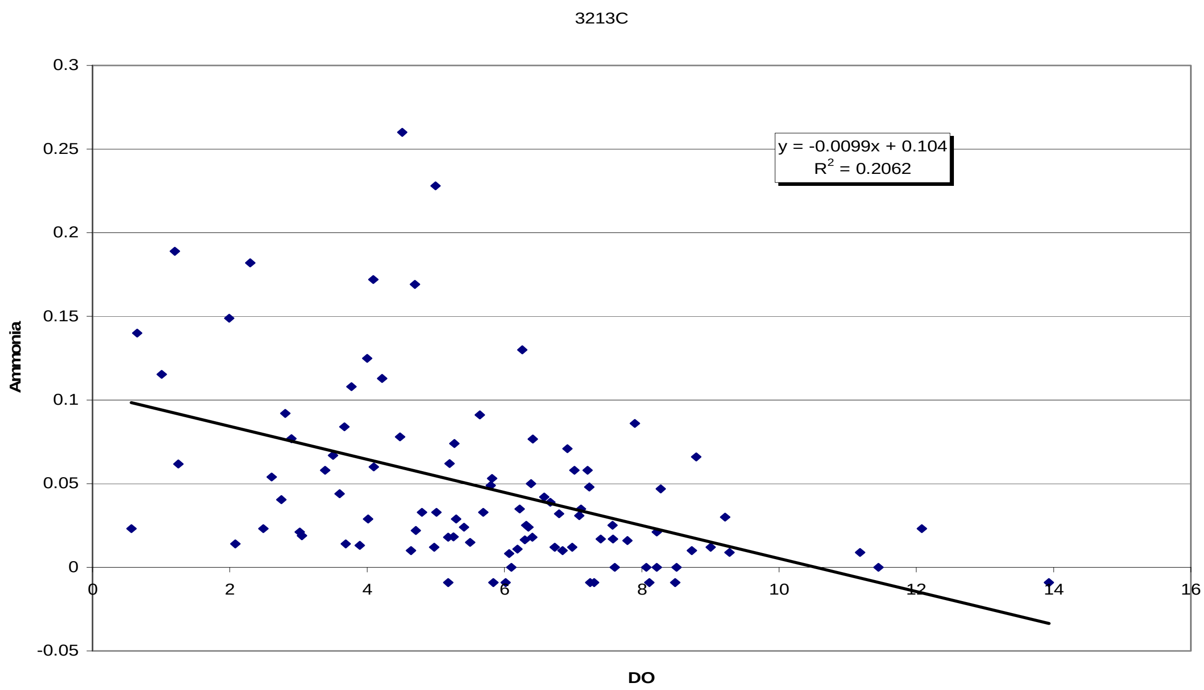


Figure C- 5. Correlation between DO and Ammonia in WBID 3213C

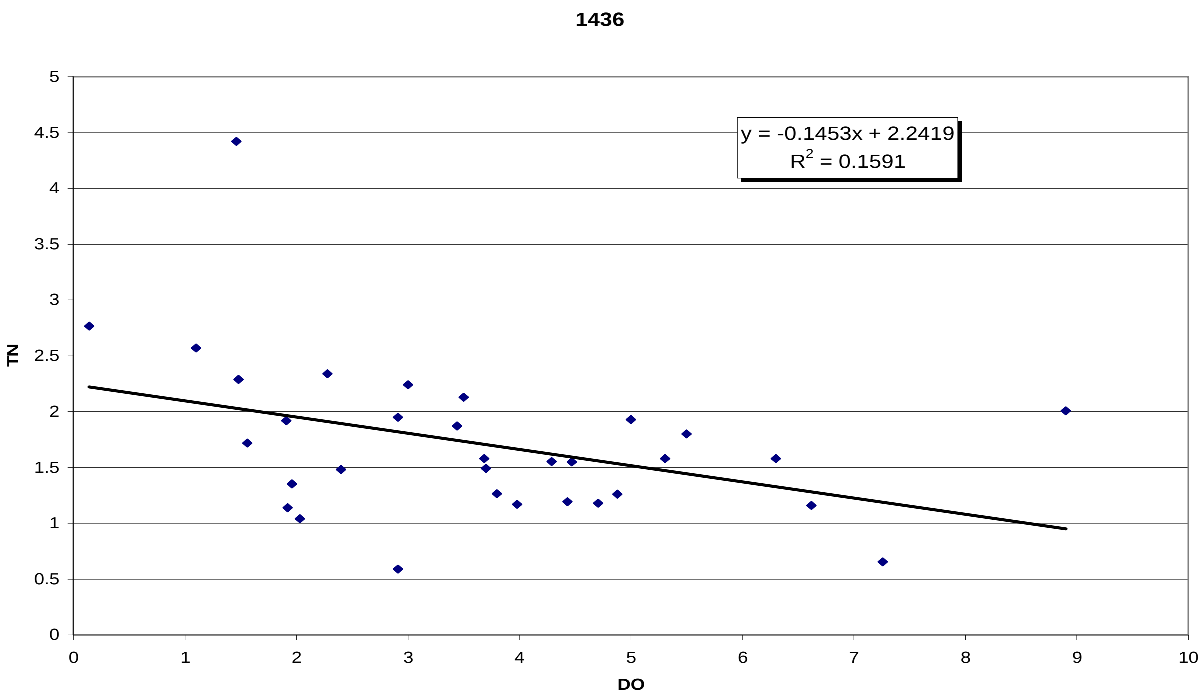
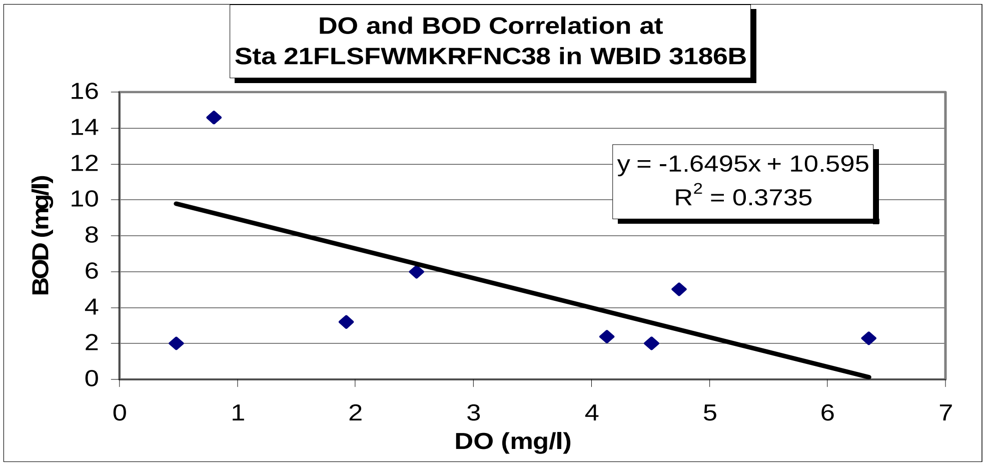


Figure C- 6. Correlation between DO and TN in WBID 1436

Appendix D: Calculation of BOD TMDL



The trendline equation shown in the above plot is used to determine the BOD target.
To maintain DO levels above 5 mg/l, BOD would need to be equal to or less than:

BOD = -1.6495x + 10.595
BOD = -1.6495 (5) + 10.595
BOD = 2.3655 mg/l

Average Annual Flow estimated for WBID 3186B is:	46165 acre-ft/yr	[LOPP, 2003]
Average Annual BOD load is:	134.291 Mton/yr	
Daily BOD load is:	811.1263 lb/day	

Conversion Factors: 2204.623 lb/Mton

Existing Conditions:

Existing BOD loads are calculated using the average concentration measured at all stations in the WBID between 1998 and 2001. This concentration is multiplied by the annual average flow and converted to load as follows:

Mean BOD concentration = 3.81 mg/l

Existing Load = 3.81 mg/l * 46165 acre-ft/yr * 0.0012326 = 216.8 Mton/yr

Existing Load (lb/day) = 216.8 Mton/yr * yr/365.25 day * 2204.623 lb/Mton = 1309 lb/day

Conversion Factor: mg/L*acre-ft/yr * 43560 ft^2/acre*28.317 L/cf * Mton/10^9mg = 0.0012326

Percent Reduction:

% Reduction = (Existing Load – TMDL Load) / Existing Load * 100

% Reduction = (216.8 – 134.291) / 216.8 = 38%

APPENDIX E: Water Quality Plots

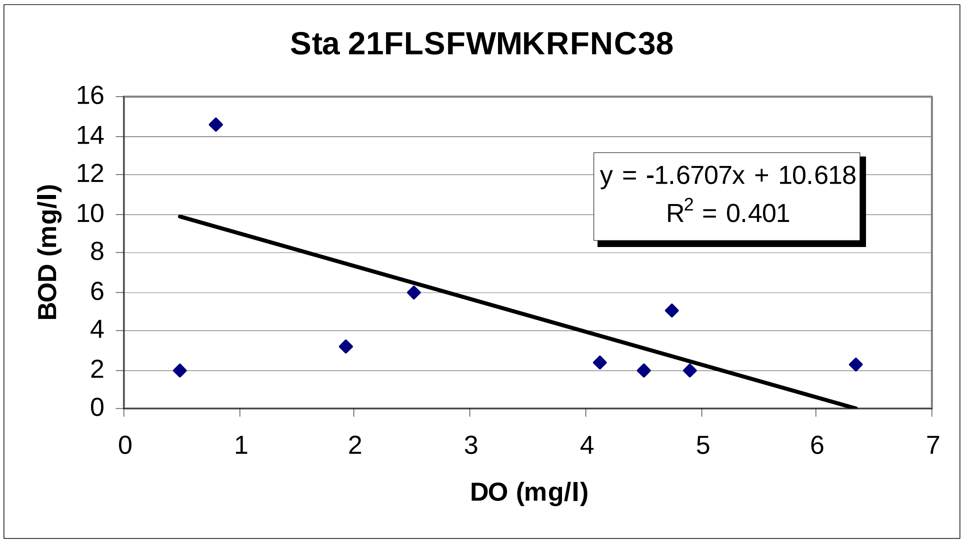


Figure E-1. Correlation between DO and BOD in WBID 3186B

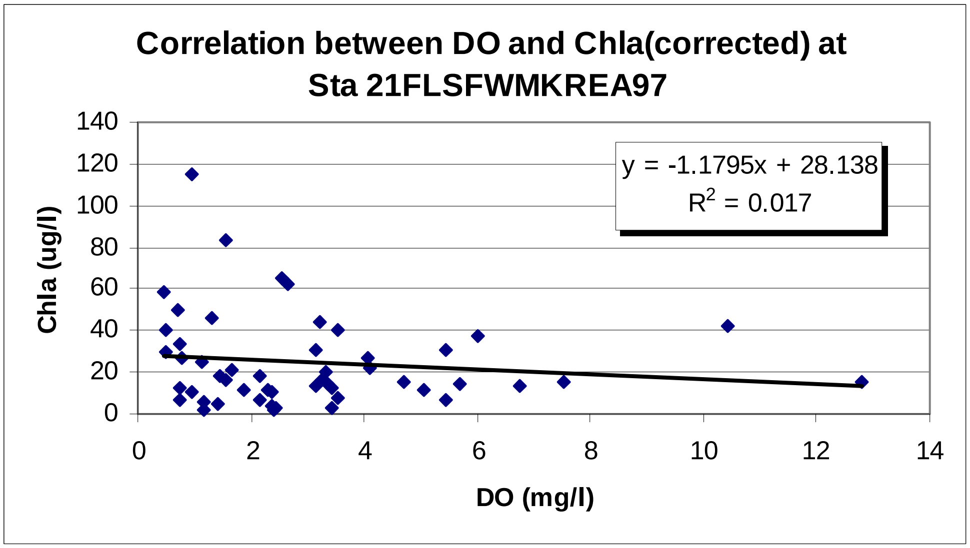


Figure E-2. Correlation between DO and Chlorophyll-a in WBID 3186B

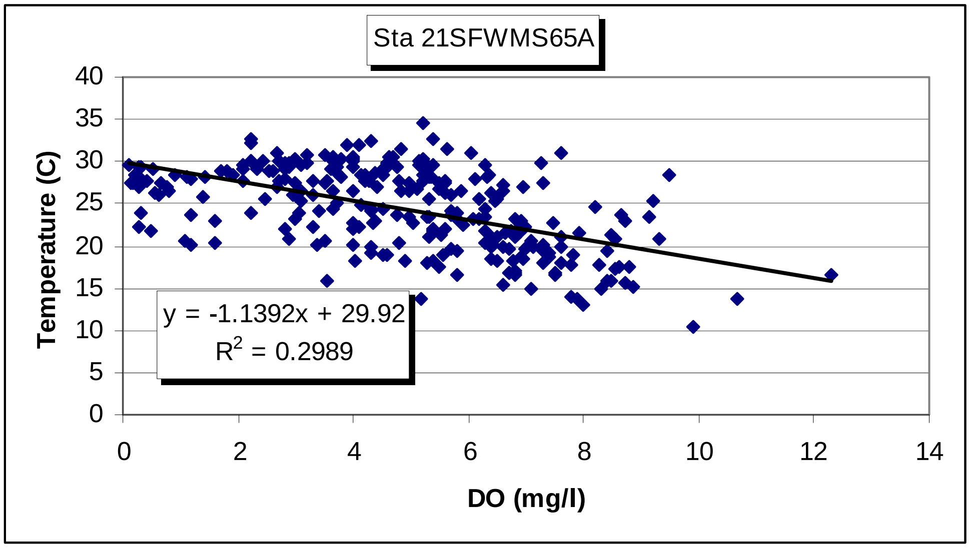


Figure E- 3. Correlation between DO and Temperature in WBID 3186B

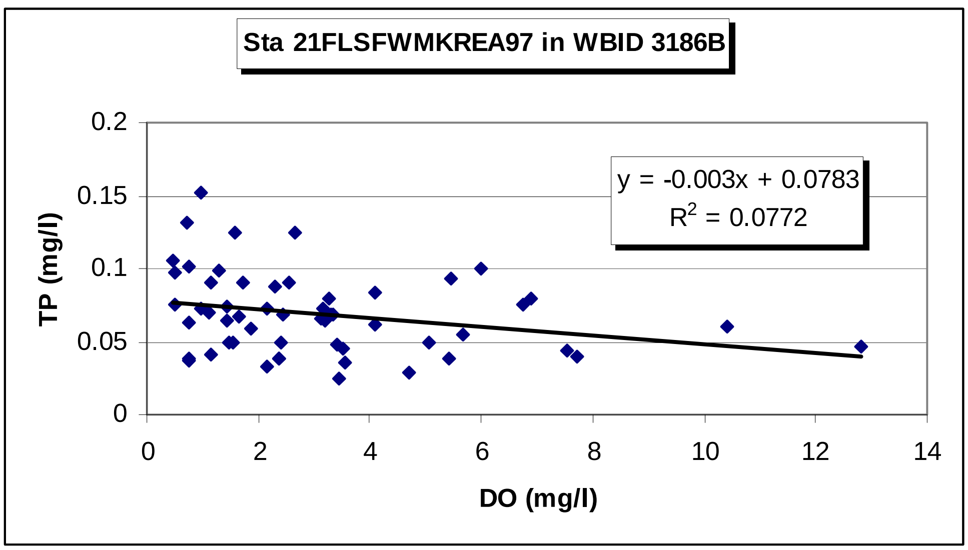


Figure E- 4. Correlation between DO and TP in WBID 3186B

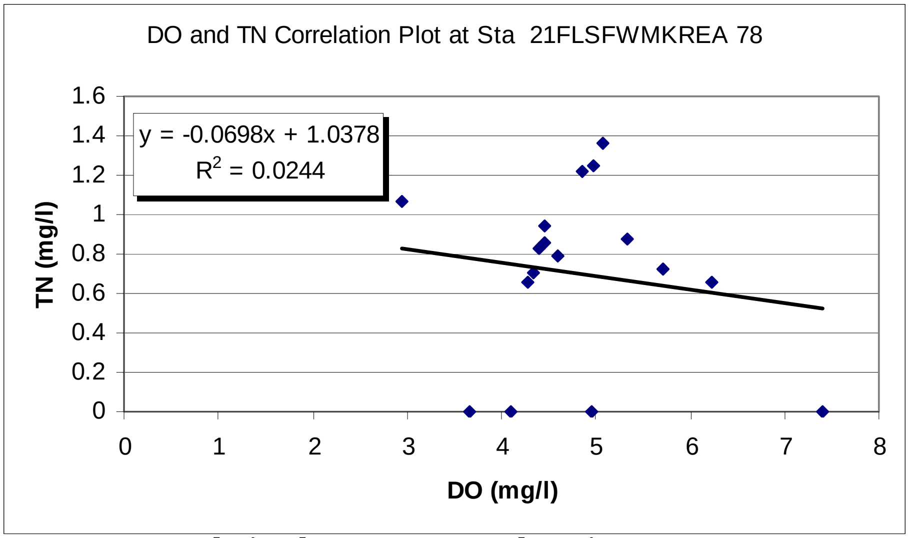


Figure E- 5. Correlation between DO and TN in WBID 3186D

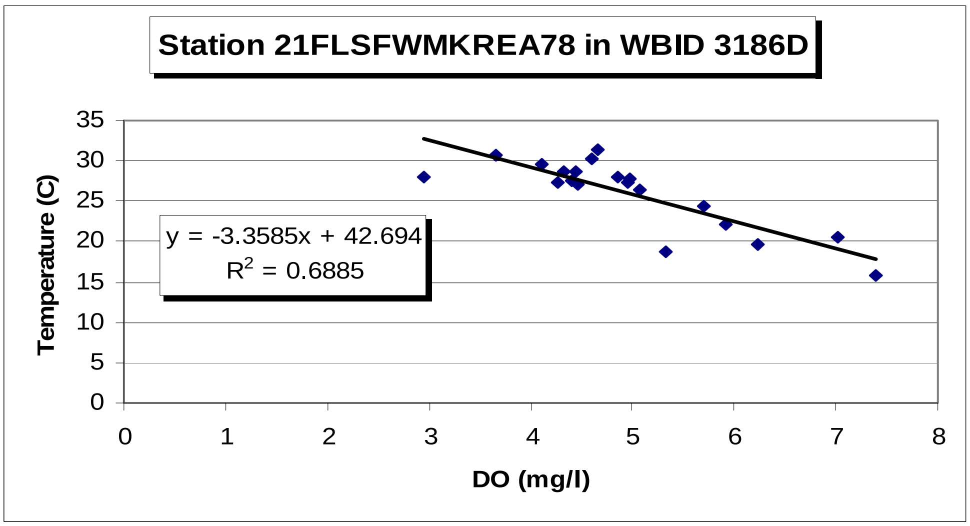


Figure E- 6. Correlation between Temperature and DO in WBID 3186D