Central District • Middle St. Johns Basin

Final Report

Nutrient TMDLs for Louise Lake (Lower Segment) (WBID 2902) and Documentation in Support of the Development of Site-Specific Numeric Interpretations of the Narrative Nutrient Criterion

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Executive Summary

This report presents the total maximum daily loads (TMDLs) developed to address the nutrient impairment of Louise Lake. The lake is located in Volusia County between Lake George and Crescent Lake.

Louise Lake (the segment with waterbody identification [WBID] number 2902) was identified as impaired for nutrients based on chlorophyll *a*, total nitrogen (TN), and total phosphorus (TP) because the annual geometric mean for each parameter exceeded the applicable numeric nutrient criteria. The waterbody was added to the 303(d) list of impaired waters by Secretarial Order in April 2020.

TMDLs for TN and TP have been developed. **Table EX-1** lists supporting information for the TMDLs. Pursuant to Paragraph 62-302.531(2)(a), Florida Administrative Code (F.A.C.), these TMDLs will constitute the site-specific numeric interpretations of the narrative nutrient criterion set forth in Paragraph 62-302.530(48)(b), F.A.C., that will replace the otherwise applicable numeric nutrient criteria in Subsection 62-302.531(2), F.A.C. The TMDLs were developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by the U.S. Environmental Protection Agency.

Table EX-1. Summary of TMDL supporting information for Louise Lake

Type of Information	Description
Waterbody name (WBID)	Louise Lake, Lower Segment (WBID 2902)
Hydrologic Unit Code (HUC) 8	03080101
Use classification/ Waterbody designation	Class III Freshwater
Targeted beneficial uses	Fish consumption, recreation, and propagation and maintenance of a healthy, well-balanced population of fish and wildlife.
303(d) listing status	Verified List of Impaired Waters for the Group 2 basins (Middle St. Johns) adopted via Secretarial Order dated April 2020.
TMDL pollutants	Total nitrogen (TN) and total phosphorus (TP)
TMDLs and site-specific interpretations of the narrative nutrient criterion	**Louise Lake (WBID 2902):** **Chlorophyll *a*:** 6 micrograms per liter (µg/L), expressed as an annual geometric mean (AGM) concentration not to be exceeded more than once in any 3-year period. **TN:** 6,034 pounds per year (lbs/yr), expressed as a 7-year rolling average load not to be exceeded. **TP:** 347 lbs/yr, expressed as a 7-year rolling average load not to be exceeded.
Load reductions required to meet the TMDLs	**WBID 2902:** A 38 % TN reduction and a 37 % TP reduction to achieve the applicable AGM chlorophyll *a* criterion for low-color, low-alkalinity lakes.
Concentration-based lake restoration targets (For informational purposes only)	**WBID 2902:** The nutrient concentrations corresponding to the applicable chlorophyll *a* numeric nutrient criterion and the loading-based criteria are a TN AGM of 0.67 milligrams per liter (mg/L) and a TP AGM of 0.017 mg/L, not to be exceeded more than once in any consecutive 3-year period.

Acknowledgments

This analysis was accomplished thanks to significant contributions from staff in the Florida Department of Environmental Protection (DEP) Division of Environmental Assessment and Restoration, specifically, the Office of Watershed Services, Watershed Assessment Section, Standards Development Section, Water Quality Restoration Program, Central Regional Operations Center, and Watershed Evaluation and TMDL Section.

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µg/L	Micrograms Per Liter
µmhos/cm	Micromhos/Centimeter
ac-ft	Acre-Feet
ac-ft/yr	Acre-Feet Per Year
AGM	Annual Geometric Mean
AMC	Antecedent Moisture Condition
$ASRC_{wb}$	Average Stormwater Runoff Coefficient
BMAP	Basin Management Action Plan
BMP	Best Management Practice
$CaCO_3$	Calcium Carbonate
CFR	Code of Federal Regulations
Chla	Chlorophyll *a*
cm	Centimeter
CWA	Clean Water Act
DCIA	Directly Connected Impervious Area
DEP	Florida Department of Environmental Protection
DO	Dissolved Oxygen
EMC	Event Mean Concentration
EPA	U.S. Environmental Protection Agency
° F.	Degrees Fahrenheit
F.A.C.	Florida Administrative Code
FDOH	Florida Department of Health
FDOT	Florida Department of Transportation
FL	Florida
F.S.	Florida Statutes
FWRA	Florida Watershed Restoration Act
FWS	U.S. Fish and Wildlife Service
GIS	Geographic Information System
hm^3/yr	Hectometers Per Year
HSPF	Hydrological Simulation Program – FORTRAN
HUC	Hydrologic Unit Code
in/yr	Inches Per Year
IPaC	Information for Planning and Conservation
IWR	Impaired Surface Waters Rule
LA	Load Allocation
lbs	Pounds
lbs/yr	Pounds Per Year
m/yr	Meters Per Year

mg/L	Milligrams Per Liter
$mg/m^2/yr$	Milligrams Per Square Meter Per Year
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System
NA	Not Applicable
ND	No Data
NDCIA	Nondirectly Connected Impervious Area
NMFS	National Marine Fisheries Service
NNC	Numeric Nutrient Criteria
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OSTDS	Onsite Sewage Treatment and Disposal System
PCU	Platinum Cobalt Units
PET	Potential Evapotranspiration
PLRG	Pollutant Load Reduction Goal
PLSM	Pollutant Load Screening Model
PO_4	Orthophosphate
POR	Period of Record
PRC	Proportional Runoff Coefficient
ROC	Runoff Coefficient
SJRWMD	St. Johns River Water Management District
SWIM	Surface Water Improvement and Management (Program)
TDN	Total Dissolved Nitrogen
TDP	Total Dissolved Phosphorus
TIGER	Topologically Integrated Geographic Encoding and Referencing
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
U.S.	United States
USACE	U.S. Army Corps of Engineers
WBID	Waterbody Identification (Number)
WLA	Wasteload Allocation
WQS	Water Quality Standards
WRF	Weighted Runoff Coefficient
WWTF	Wastewater Treatment Facility

Chapter 1: Introduction

1.1 Purpose of Report

This report presents the total maximum daily loads (TMDLs) developed to address the nutrient impairment of Louise Lake, located in the Middle St. Johns Basin. Pursuant to Paragraph 62-302.531(2)(a), Florida Administrative Code (F.A.C.), the TMDLs will also constitute the site-specific numeric interpretations of the narrative nutrient criterion set forth in Paragraph 62-302.530(48)(b), F.A.C., that will replace the otherwise applicable numeric nutrient criteria (NNC) in subsection 62-302.531(2), F.A.C. The waterbody was verified as impaired for nutrients using the methodology in the Identification of Impaired Surface Waters Rule (IWR) (Chapter 62-303, F.A.C.) and was included on the Verified List of Impaired Waters for the Middle St. Johns Basin adopted by Secretarial Order in April 2020.

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and provides water quality targets needed to comply with applicable water quality criteria based on the relationship between pollutant sources and water quality in the receiving waterbody. The TMDLs establish the allowable loadings to Louise Lake that would restore the waterbody so that it meets the applicable water quality criteria for nutrients.

1.2 Identification of Waterbody

For assessment purposes, the Florida Department of Environmental Protection (DEP) divided the Middle St. Johns Basin (Hydrologic Unit Code [HUC] 8 – 03080101) into watershed assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or surface water segment. Louise Lake is WBID 2902. **Figure 1.1** shows the location of the waterbody in the basin and major geopolitical and hydrologic features in the region, and **Figure 1.2** contains a more detailed map of the waterbody.

Louise Lake is located in the Town of Seville, in Volusia County, between Lake George and Crescent Lake. The lake has a surface area of 250 acres, with an average depth of 5.7 feet.

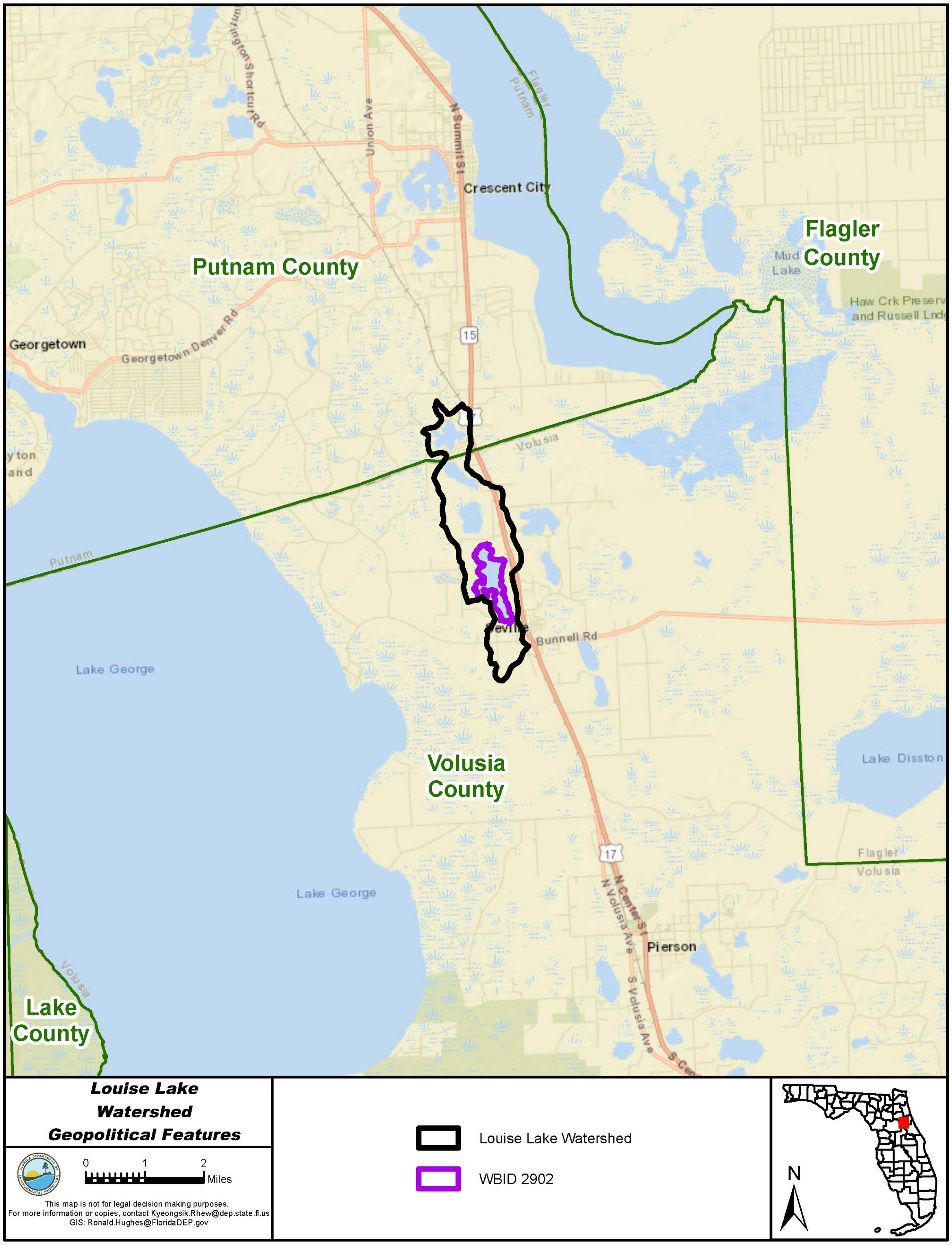


Figure 1.1. Location of the Louise Lake (WBID 2902) Watershed in the Middle St. Johns Basin and major geopolitical features in the area

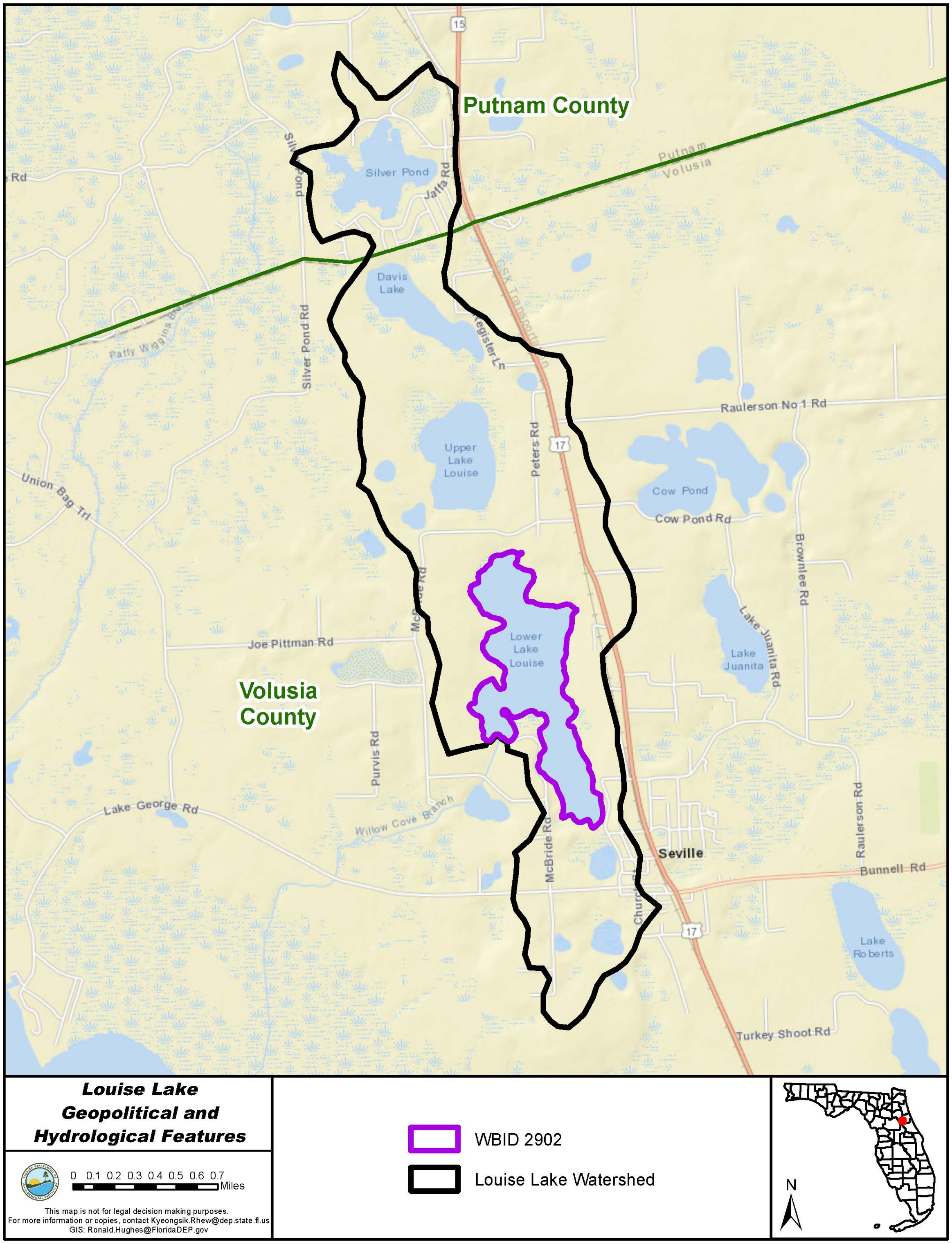


Figure 1.2. Louise Lake (WBID 2902) Watershed and major hydrologic and geopolitical features in the area

1.3 Watershed Information

1.3.1 Population and Geopolitical Setting

Louise Lake and its surrounding watershed cover an area of 2,144 acres. The lake is located entirely in Volusia County, but the upper portion of the watershed is situated in Putnam County. Volusia County and Putnam County had populations of 553,284 and 74,521, respectively, as of 2019 (U.S. Census Bureau 2019). U.S. Route 17 runs through the east side of the watershed. A large portion of the watershed is composed of agricultural land use, along with water and wetlands. The watershed also includes some residential and small areas of other land uses (**Chapter 4** provides detailed summaries of land uses in the watershed).

1.3.2 Topography

Louise Lake and its watershed are located in the Crescent City/Deland Ridges Lake Region (75-11), which includes sandy upland ridges and thick sandy soils (Griffith et al. 1997). Many of this region's lakes range from clear, acidic, and oligotrophic lakes having low mineral content to mesotrophic lakes having moderate mineral content that receive inputs of groundwater (Griffith et al. 1997). Louise Lake falls into the category of clear lakes found at the north of the ridges. Elevation in the Louise Lake Watershed ranges from 35 to 65 feet. The lowest elevation contour of 35 feet surrounds Louise Lake itself in the southern portion of the watershed, while the highest elevation contours are found along the eastern edges of the watershed.

From north to south, the watershed contains several small lakes and ponds, such as Silver Pond, Davis Lake, and Upper Lake Louise. Lower Lake Louise (Louise Lake) is located at the southernmost point and the lowest elevation in the watershed. Louise Lake discharges into Willow Cove Branch, which flows into Lake George. Lake George discharges into the St. Johns River, which flows north to its mouth in the Atlantic Ocean.

1.3.3 Hydrogeological Setting

The Louise Lake Watershed is located in a humid subtropical climate zone characterized by hot and humid summers, mild winters, and a wet season between June and September. The watershed's long-term average rainfall was 52 inches per year (in/yr) from 1914 to 2019. Rainfall data were obtained from the Northeast Regional Climate Center Online Weather Data (2020) at the Crescent City weather station. The annual average temperature was 71.6 degrees Fahrenheit (° F.).

The Louise Lake Watershed comprises Hydrologic Soil Groups A, A/D, B/D, and unclassified lake bottom. These groups are based on the National Cooperative Soil Survey. Group A soils range from sandy to loamy in texture, characterized by low runoff potential and increased infiltration rates. Soils in Group B range from silty to loamy soil textures and have moderate drainage. Group C soils have low infiltration rates when saturated and are moderately well drained to well drained. Soils in Group D contain higher amounts of clay, often 40 % or more, and have high runoff potential. When unsaturated, Group A/D, B/D, and C/D soils are characteristic of Group A, B, and C soils, respectively, and when saturated they are more characteristic of Group D soils.

Table 1.1 lists the soil hydrologic groups in the Louise Lake Watershed. Based on the percent acreage of these groups and the soil characteristics of the areas shown in **Figure 1.3**, soils in the watershed are mostly well drained to moderately drained. These drainage characteristics are a significant factor when calculating surface runoff and are described in more detail in **Section 4.4**.

Table 1.1. Acreage of hydrologic soil groups in the Louise Lake Watershed

Soil Hydrologic Group	Acreage	% Acreage
A	1,173.7	55
A/D	411.6	19
B/D	41.1	2
Unclassified	517.6	24
Total	**2,144.1**	**100**

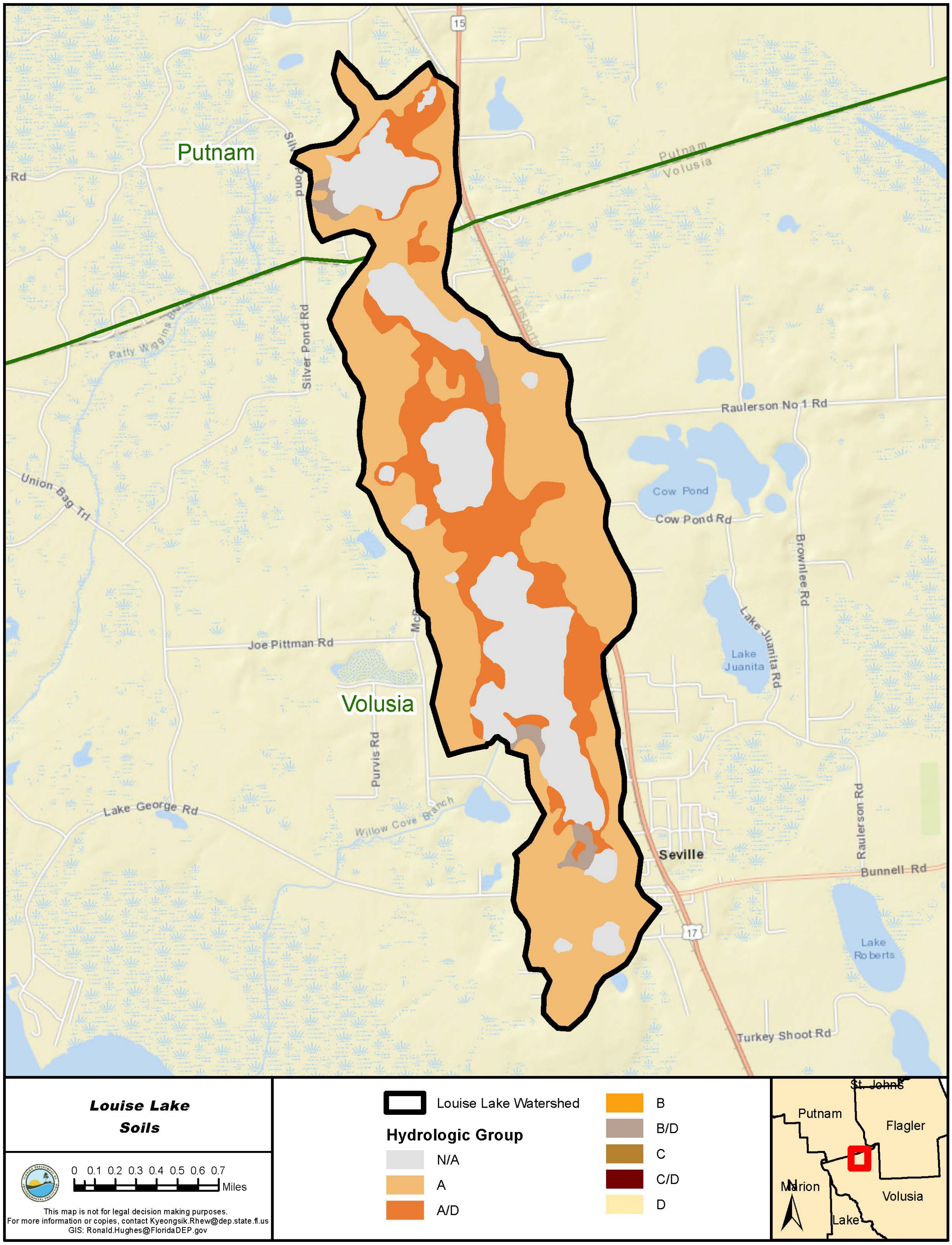


Figure 1.3. Hydrologic soil groups in the Louise Lake Watershed

Chapter 2: Water Quality Assessment and Identification of Pollutants of Concern

2.1 Statutory Requirements and Rulemaking History

Section 303(d) of the federal Clean Water Act (CWA) requires states to submit to the U.S. Environmental Protection Agency (EPA) lists of surface waters that do not meet applicable water quality standards (impaired waters) and establish a TMDL for each pollutant causing the impairment of listed waters on a schedule. DEP has developed such lists, commonly referred to as 303(d) lists, since 1992.

The Florida Watershed Restoration Act (FWRA) (Section 403.067, Florida Statutes [F.S.]) directed DEP to develop, and adopt by rule, a science-based methodology to identify impaired waters. The Environmental Regulation Commission adopted the methodology as Chapter 62-303, F.A.C. (the IWR), in 2001. The rule was amended in 2006, 2007, 2012, 2013, and 2016.

The list of impaired waters in each basin, referred to as the Verified List, is also required by the FWRA (Subsection 403.067[4], F.S.). The state's 303(d) list is amended annually to include basin updates.

2.2 Classification of the Waterbody and Applicable Water Quality Standards

Louise Lake is a Class III (fresh) waterbody, with a designated use of fish consumption, recreation, and propagation and maintenance of a healthy, well-balanced population of fish and wildlife. The Class III water quality criterion applicable to the verified impairment (nutrients) for the lake is Florida's nutrient criterion in Rule 62-302.531, F.A.C. Florida adopted NNC for lakes, spring vents, and streams in 2011. These were approved by the EPA in 2012 and became effective in 2014.

The applicable lake NNC are dependent on alkalinity, measured in milligrams per liter as calcium carbonate (mg/L $CaCO_3$) and true color (color), measured in platinum cobalt units (PCU), based on long-term period of record (POR) geometric means. For the purpose of subparagraph 62-302.531(2)(b)1., F.A.C., color shall be assessed as true color and shall be free from turbidity. Lake color and alkalinity shall be the long-term geometric mean of all data for the POR, based on a minimum of 10 data points over at least 3 years with at least 1 data point in each year.

If insufficient alkalinity data are available, long-term geometric mean specific conductance values of all data for the POR shall be used, with a value of ≤100 micromhos/centimeter (µmhos/cm) used to estimate the 20 mg/L $CaCO_3$ alkalinity concentration until alkalinity data are available. Long-term geometric mean specific conductance shall be based on a minimum of 10 data points over at least 3 years with at least 1 data point in each year.

Using these thresholds and data from IWR Database Run 59, Louise Lake is classified as a low-color (≤40 PCU), low-alkalinity (≤ 20 $CaCO_3$) lake, as shown in **Table 2.1**.

Table 2.1. Louise Lake POR long-term geometric means for color and alkalinity

Parameter	Long-Term Geometric Mean	Number of Samples
Color (PCU)	34	17
Alkalinity (mg/L $CaCO_3$)	11	16

The chlorophyll *a* NNC for low-color, low-alkalinity lakes is an annual geometric mean (AGM) value of 6 micrograms per liter (µg/L), not to be exceeded more than once in any consecutive 3-year period. The associated total nitrogen (TN) and total phosphorus (TP) criteria for a lake can vary annually, depending on the availability of data for chlorophyll *a* and the chlorophyll *a* concentrations in the lake.

If there are sufficient data to calculate an AGM for chlorophyll *a* and the mean does not exceed the chlorophyll *a* criterion for the lake type in **Table 2.2**, then the TN and TP numeric interpretations for that calendar year are the AGMs of lake TN and TP samples, subject to the minimum and maximum TN and TP limits in the table. If there are insufficient data to calculate the AGM for chlorophyll *a* for a given year, or if the AGM for chlorophyll *a* exceeds the values in the table for the lake type, then the applicable numeric criteria for TN and TP are the minimum values in the table. **Table 2.2** lists the NNC for Florida lakes specified in subparagraph 62-302.531(2)(b)1., F.A.C.

Table 2.2. Chlorophyll *a*, TN, and TP criteria for Florida lakes (Subparagraph 62-302.531[2][b]1., F.A.C.)

[1] For lakes with color > 40 PCU in the West Central Nutrient Watershed Region, the maximum TP limit shall be the 0.49 mg/L TP streams threshold for the region.

Long-Term Geometric Mean Color and Alkalinity	AGM Chlorophyll *a*	Minimum NNC AGM TP	Minimum NNC AGM TN	Maximum NNC AGM TP	Maximum NNC AGM TN
> 40 PCU	20 µg/L	0.05 mg/L	1.27 mg/L	0.16 mg/L[1]	2.23 mg/L
≤ 40 PCU and > 20 mg/L $CaCO_3$	20 µg/L	0.03 mg/L	1.05 mg/L	0.09 mg/L	1.91 mg/L
≤ 40 PCU and ≤ 20 mg/L $CaCO_3$	6 µg/L	0.01 mg/L	0.51 mg/L	0.03 mg/L	0.93 mg/L

2.3 Determination of the Pollutant of Concern

2.3.1 Data Providers

Table 2.3 lists the data provider for Louise Lake, including corresponding stations and monitoring beginning and ending dates.

Table 2.3. Louise Lake data provider

Sampling Station	Data Provider	Activity Beginning Date	Activity Ending Date
21FLGW 47381	DEP	2015	2015
21FLCEN G2CE0065	DEP	2017	2019

At Louise Lake, DEP (21FLCEN) was the primary data provider for the assessment. **Figure 2.1** shows the lake sampling locations.

The individual water quality measurements discussed in this report are available in IWR Run 56 and are available on request.

2.3.2 Information on Verified Impairment

During the Group 2, Cycle 4 assessment, the NNC were used to assess Louise Lake using data collected during the verified period (January 1, 2013–June 30, 2019) based on data from IWR Run 58. Louise Lake was determined to be verified impaired for chlorophyll *a*, TN, and TP because the AGMs exceeded the NNC more than once in a three-year period. **Table 2.4** lists the AGM values for chlorophyll *a*, TN, and TP during the 2013–19 verified period for Louise Lake.

Table 2.4. Louise Lake AGM values for the 2013–19 verified period

ND = No data
Note: Values shown in boldface type and shaded cells are greater than the NNC of 6 µg/L chlorophyll *a*, 0.51 mg/L TN, and 0.01 mg/L TP. Since chlorophyll *a* does not exceed the NNC in 2017, the maximum NNC of 0.93 mg/LTN and maximum NNC of 0.03 mg/L TP are applied. Rule 62-302.531, F.A.C., states that the applicable numeric interpretations for TN, TP, and chlorophyll *a* shall not be exceeded more than once in any consecutive 3-year period.

Year	Chlorophyll *a* (µg/L)	TN (mg/L)	TP (mg/L)
2013	ND	ND	ND
2014	ND	ND	ND
2015	ND	ND	ND
2016	ND	ND	ND
2017	6	**0.95**	0.03
2018	**9**	**0.88**	**0.02**
2019	**11**	**0.84**	**0.02**

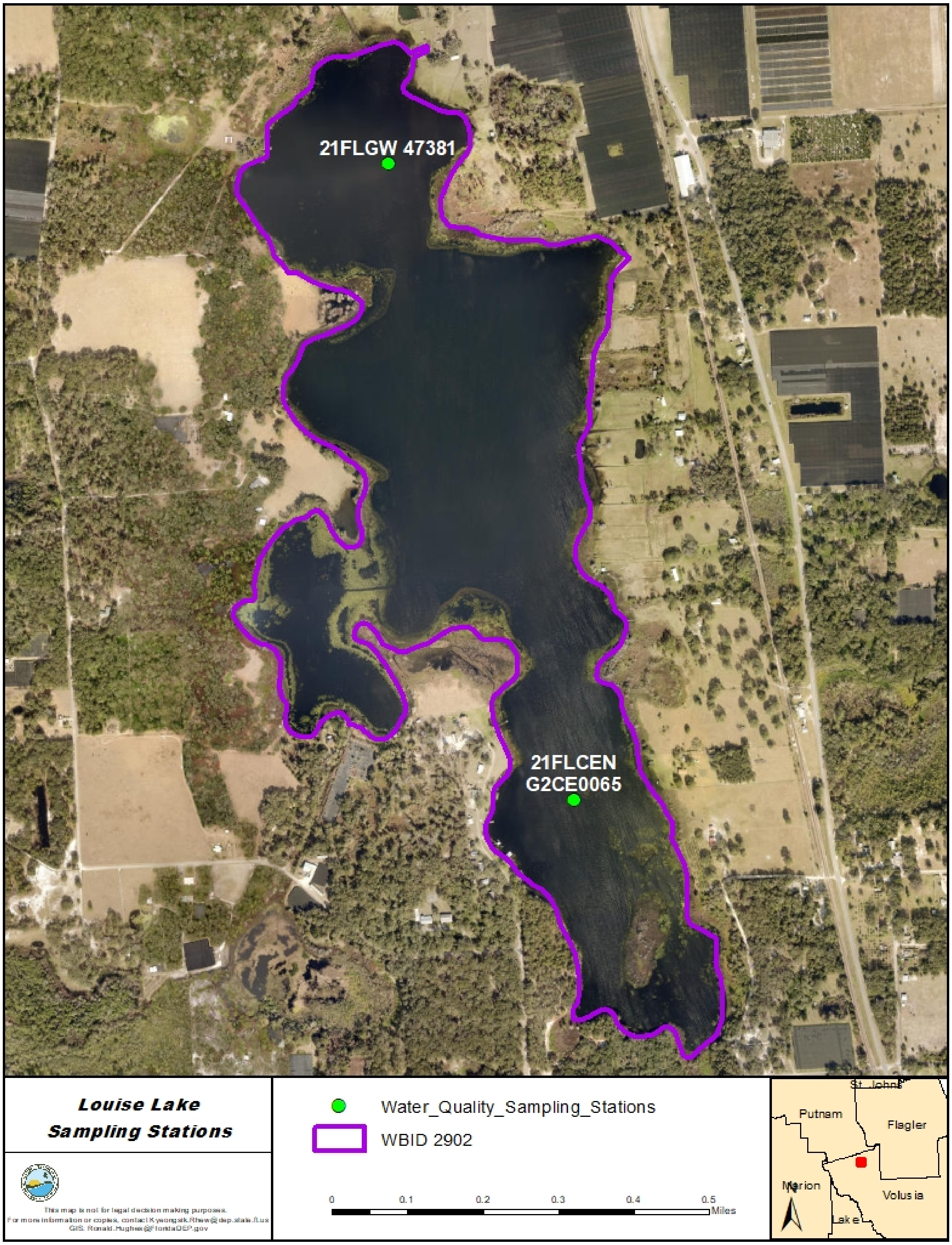


Figure 2.1. Monitoring stations in Louise Lake

2.4 Relationships Between Water Quality Variables

For Louise Lake, simple linear regression analyses were used to evaluate the relationships between the pollutant variables (TN and TP) and the response variable (chlorophyll *a*). **Figures 2.2** and **2.3** show the relationships between chlorophyll *a* and TN and TP daily values.

There were no significant relationships between chlorophyll *a* and TN ($R^2 = 0.11$, $p = 0.194$), and chlorophyll *a* and TP ($R^2 = 0.05$, $p = 0.38$).

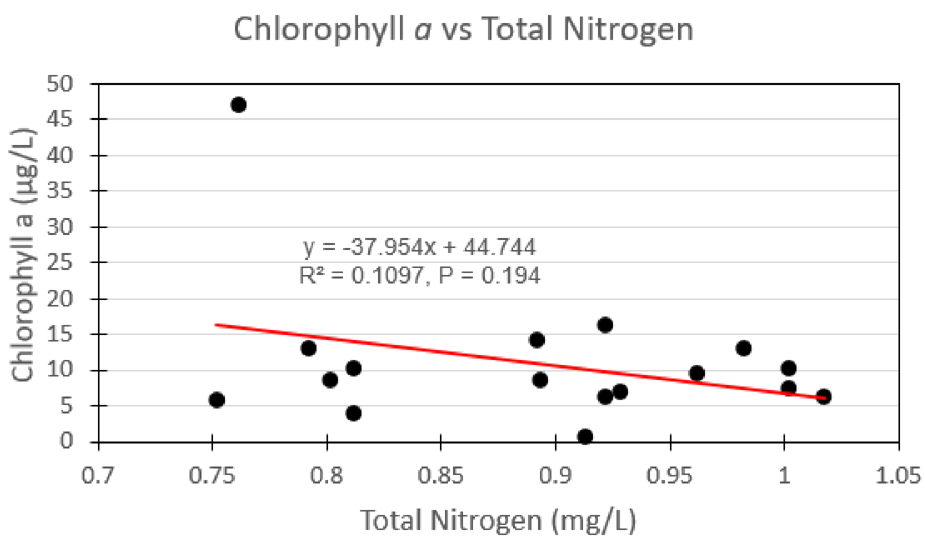


Figure 2.2. Louise Lake daily chlorophyll *a* vs. TN

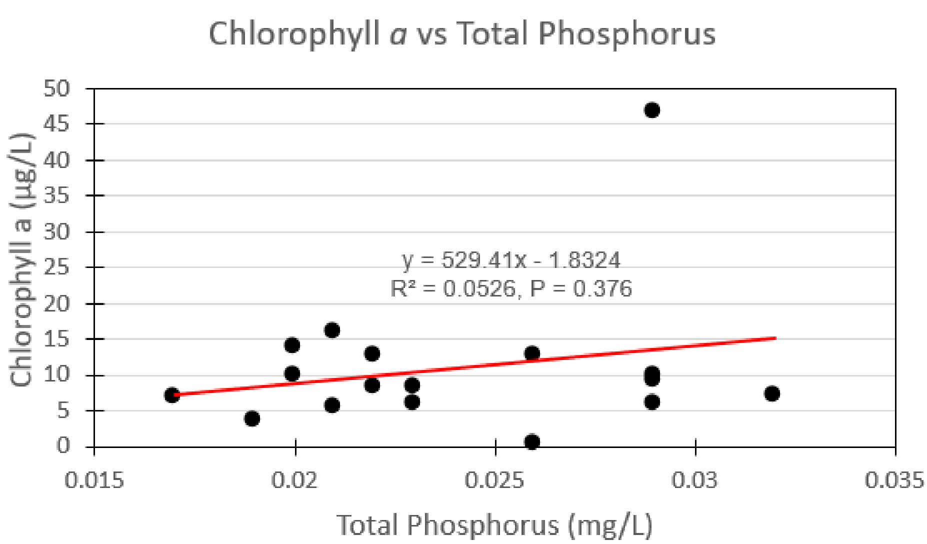


Figure 2.3. Louise Lake daily chlorophyll *a* vs. TP

Chapter 3: Site-Specific Numeric Interpretation of the Narrative Nutrient Criterion

3.1 Establishing the Site-Specific Interpretation

Pursuant to paragraph 62-302.531(2)(a), F.A.C., the nutrient TMDLs presented in this report, upon adoption into Chapter 62-304.505, F.A.C., will constitute the site-specific numeric interpretations of the narrative nutrient criterion set forth in Paragraph 62-302.530(48)(b), F.A.C., and will replace the otherwise applicable NNC from subparagraph 62-302.531[2][b]1., F.A.C. **Table 3.1** lists the elements of the nutrient TMDLs that constitute the site-specific numeric interpretations of the narrative nutrient criterion. **Appendix B** summarizes the relevant details to support the determination that the TMDLs provide for the protection of Louise Lake for the attainment and maintenance of water quality standards in downstream waters (pursuant to subsection 62-302.531[4], F.A.C.), and to support using the nutrient TMDLs as the site-specific numeric interpretations of the narrative nutrient criterion.

When developing TMDLs to address nutrient impairment, it is essential to address those nutrients that typically contribute to excessive plant growth. In Florida waterbodies, nitrogen and phosphorus are most often the limiting nutrients. A limiting nutrient is a chemical that is necessary for plant growth, but available in quantities smaller than those needed for algae, represented by chlorophyll *a*, and macrophytes to grow. In the past, management activities to control lake eutrophication focused on phosphorus reduction, as phosphorus was generally recognized as the limiting nutrient in freshwater systems.

Recent studies, however, have supported the reduction of both nitrogen and phosphorus as a better approach to controlling algal growth in aquatic systems (Conley et al. 2009; Paerl 2009; Lewis et al. 2011; Paerl and Otten 2013). Furthermore, the analysis used in the development of the Florida lake NNC supports this idea, as statistically significant relationships were found between chlorophyll *a* values and both nitrogen and phosphorus concentrations (DEP 2012).

3.2 Site-Specific Response Variable Target Selection

The generally applicable chlorophyll *a* criteria for lakes were established by taking into consideration an analysis of lake chlorophyll *a* concentrations statewide, comparisons with a smaller population of select reference lakes, paleolimnological studies, expert opinions, user perceptions, and biological responses. Based on these resources, DEP concluded that an AGM chlorophyll *a* of 6 µg/L in low-color, low-alkalinity lakes is protective of the designated uses of recreation and aquatic life support (DEP 2012). Color and alkalinity were used as morphoedaphic factors to predict the natural trophic status of lakes. DEP developed a chlorophyll *a* criterion of 6 µg/L for low-color (≤ 40 PCU), low-alkalinity (≤ 20 $CaCO_3$) lakes.

There are no available data suggesting that Louise Lake differs from the reference lakes used to develop the NNC. Therefore, DEP has determined that the generally applicable chlorophyll *a* NNC for low-color, low-alkalinity lake is the most appropriate TMDL target for the lake (and will remain the applicable water quality criterion).

3.3 Numeric Expression of the Site-Specific Numeric Interpretation

Numeric site-specific interpretations of the narrative nutrient standard for Louise Lake were determined for TN and TP using the modeling approach discussed in **Chapter 5** to determine the nutrient loads that resulted in the lake attaining the chlorophyll *a* criterion. The modeling related annual watershed TN and TP loading to in-lake chlorophyll *a*, TN, and TP concentrations. For Louise Lake, nutrient and chlorophyll concentrations were simulated from 2010 to 2019.

The model was used to determine annual TN and TP loads necessary to meet the target chlorophyll *a* criterion of 6 µg/L in every simulated year. DEP then calculated a rolling 7-year average loading for each parameter. The site-specific interpretations of the narrative nutrient criterion were then set for each parameter at the maximum 7-year rolling average load for Louise Lake. **Section 5.5** discusses in more detail the method used to determine these loading values.

Site-specific interpretations for Louise Lake are expressed as a 7-year rolling annual average load not to be exceeded. **Table 3.1** summarizes the site-specific interpretations for TN and TP for Louise Lake.

Table 3.1. Louise Lake site-specific interpretations of the narrative nutrient criterion

lbs/yr = Pounds per year

Waterbody	WBID	7-Year Annual Average TN (lbs/yr)	7-Year Annual Average TP (lbs/yr)
Louise Lake	2902	6,034	347

DEP also calculated the in-lake TN and TP concentrations corresponding to the load-based TN and TP site-specific interpretations of the narrative criterion that attain the target chlorophyll *a* concentration of 6 µg/L. For Louise Lake, the TN and TP AGM concentrations of 0.67 and 0.017 mg/L, respectively, are not to be exceeded more than once in any consecutive 3-year period. These concentration-based restoration targets are provided for informational purposes only and will be used to help evaluate the effectiveness of restoration activities. The loads listed in **Table 3.1** are the site-specific interpretations of the narrative criterion for the lake.

3.4 Downstream Protection

Louise Lake discharges into Willow Cove Branch in the Louise Lake Drain (WBID 2902A), which flows into Lake George (WBID 2893A). Louise Lake Drain is not verified impaired for nutrients. The target concentrations of Lake George for TN and TP are 1.14 and 0.06 mg/L, respectively (Magley 2018). In comparison, the target concentrations of Louise Lake for TN and TP are 0.67 and 0.017 mg/L, respectively. Since the nutrient targets for Louise Lake are based on the natural background condition and are lower than those for downstream waters, the TMDLs for Louise Lake are inherently protective of Lake George.

3.5 Endangered Species Consideration

Section 7(a)(2) of the Endangered Species Act requires each federal agency, in consultation with the services (i.e., U.S. Fish and Wildlife Service [FWS] and National Oceanic and Atmospheric Agency [NOAA] National Marine Fisheries Service [NMFS]), to ensure that any federal action authorized, funded, or carried out is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of designated critical habitat. The EPA must review and approve changes in water quality standards (WQS) such as setting site-specific criteria.

Prior to approving WQS changes for aquatic life criteria, the EPA will prepare an Effect Determination summarizing the direct or indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action. The EPA categorizes potential effect outcomes as either (1) "no effect," (2) "may affect, not likely to adversely affect," or (3) "may affect: likely to adversely affect."

The service(s) must concur on the Effect Determination before the EPA approves a WQS change. A finding and concurrence by the service(s) of "no effect" will allow the EPA to approve an otherwise approvable WQS change. However, findings of either "may affect, not likely to adversely affect" or "may affect: likely to adversely affect" will result in a longer consultation process between the federal agencies and may result in a disapproval or a required modification to the WQS change.

The FWS online Information for Planning and Conservation (IPaC) tool (see **Appendix B**) identifies terrestrial species potentially affected by activities in the watershed. DEP is not aware of any aquatic, amphibious, or anadromous endangered species present in the Louise Lake Watershed. Furthermore, it is expected that restoration efforts and subsequent water quality improvements will positively affect aquatic species living in the lake and its watershed.

Chapter 4: Assessment of Sources

4.1 Types of Sources

An important part of the TMDL analysis is the identification of pollutant source categories, source subcategories, or individual sources of the pollutant of concern in the target watershed and the amount of pollutant loading contributed by each of these sources. Sources are broadly classified as either point sources or nonpoint sources. Historically, the term "point sources" has meant discharges to surface waters that typically have a continuous flow via a discernable, confined, and discrete conveyance, such as a pipe. Domestic and industrial wastewater treatment facilities (WWTFs) are examples of traditional point sources. In contrast, the term "nonpoint sources" was used to describe intermittent, rainfall-driven, diffuse sources of pollution associated with everyday human activities, including runoff from urban land uses, agriculture, silviculture, and mining; discharges from septic systems; and atmospheric deposition.

However, the 1987 amendments to the CWA redefined certain nonpoint sources of pollution as point sources subject to regulation under the EPA's National Pollutant Discharge Elimination System (NPDES) Program. These nonpoint sources included certain urban stormwater discharges, such as those from local government master drainage systems, construction sites over five acres, and a wide variety of industries (see **Appendix A** for background information on the federal and state stormwater programs).

To be consistent with CWA definitions, the term "point source" is used to describe traditional point sources (such as domestic and industrial wastewater discharges) and stormwater systems requiring an NPDES stormwater permit when allocating pollutant load reductions required by a TMDL (see **Section 6.1** on **Expression and Allocation of the TMDLs**). However, the methodologies used to estimate nonpoint source loads do not distinguish between NPDES and non-NPDES stormwater discharges, and as such, this source assessment section does not make any distinction between the two types of stormwater.

4.2 Point Sources

4.2.1 Wastewater Point Sources

There are no NPDES-permitted wastewater facilities discharging to Louise Lake or to its watershed.

4.2.2 Municipal Separate Storm Sewer System (MS4) Permittees

Volusia County has a Phase II-C MS4 permit (FLR04E033), and the Florida Department of Transportation (FDOT) District 5 has an MS4 permit (FLR04E024) covering the urbanized area of Volusia County. According to Chapter 62-624, F.A.C., MS4 permit requirements apply to urbanized areas. Based on the 2010 Topologically Integrated Geographic Encoding and

Referencing (TIGER) Census urbanized area coverage data, none of the Louise Lake Watershed is located in the urban area. Neither MS4 permit covers the watershed. Areas under the jurisdiction of Volusia County may be required to implement stormwater treatment projects in the future as part of a TMDL implementation strategy. For more information on MS4s in the watershed, send an email to: NPDES-stormwater@dep.state.fl.us.

4.3 Nonpoint Sources

Nutrient loadings to Louise Lake are primarily generated from nonpoint sources. Nonpoint sources addressed in this analysis mainly include loadings from surface runoff based on land use, onsite sewage treatment and disposal systems (OSTDS), groundwater seepage entering the lake, and precipitation directly onto the lake surface (atmospheric deposition).

4.3.1 Land Uses

Land use is one of the most important factors in determining nutrient loadings from the Louise Lake Watershed. Nutrients can be flushed into a receiving water through surface runoff and stormwater conveyance systems during stormwater events. Both human land use areas and natural land areas generate nutrients. However, human land uses typically generate more nutrient loads per unit of land surface area than natural lands can produce. **Table 4.1** lists land uses in the watershed from 2015, based on data from the St. Johns River Water Management District (SJRWMD), and **Figure 4.1** shows the information graphically.

Table 4.1 and **Figure 4.1** show the breakdown of the various land use categories in the Louise Lake Watershed. Agriculture predominates, with 45 % coverage. Water is the second most common land use (19 %), followed by wetlands (15 %), urban and built-up (14 %), and forest/rangeland (7 %).

Table 4.1. Land use in the Louise Lake Watershed, SJRWMD, 2015

Land Use Type	Acreage	% Acreage
Low-Density Residential	166.0	8
Medium-Density Residential	52.4	2
High-Density Commercial	12.1	1
Open Land/Recreational	15.4	1
Low-Density Commercial/Institutional	46.5	2
Pasture	425.6	20
Cropland	137.3	6
Tree Crops	1.5	0
Other Agriculture	403.6	19
Forest/Rangeland	147.8	7
Water	417.3	19
Wetlands	318.6	15
Total	**2,144.1**	**100**

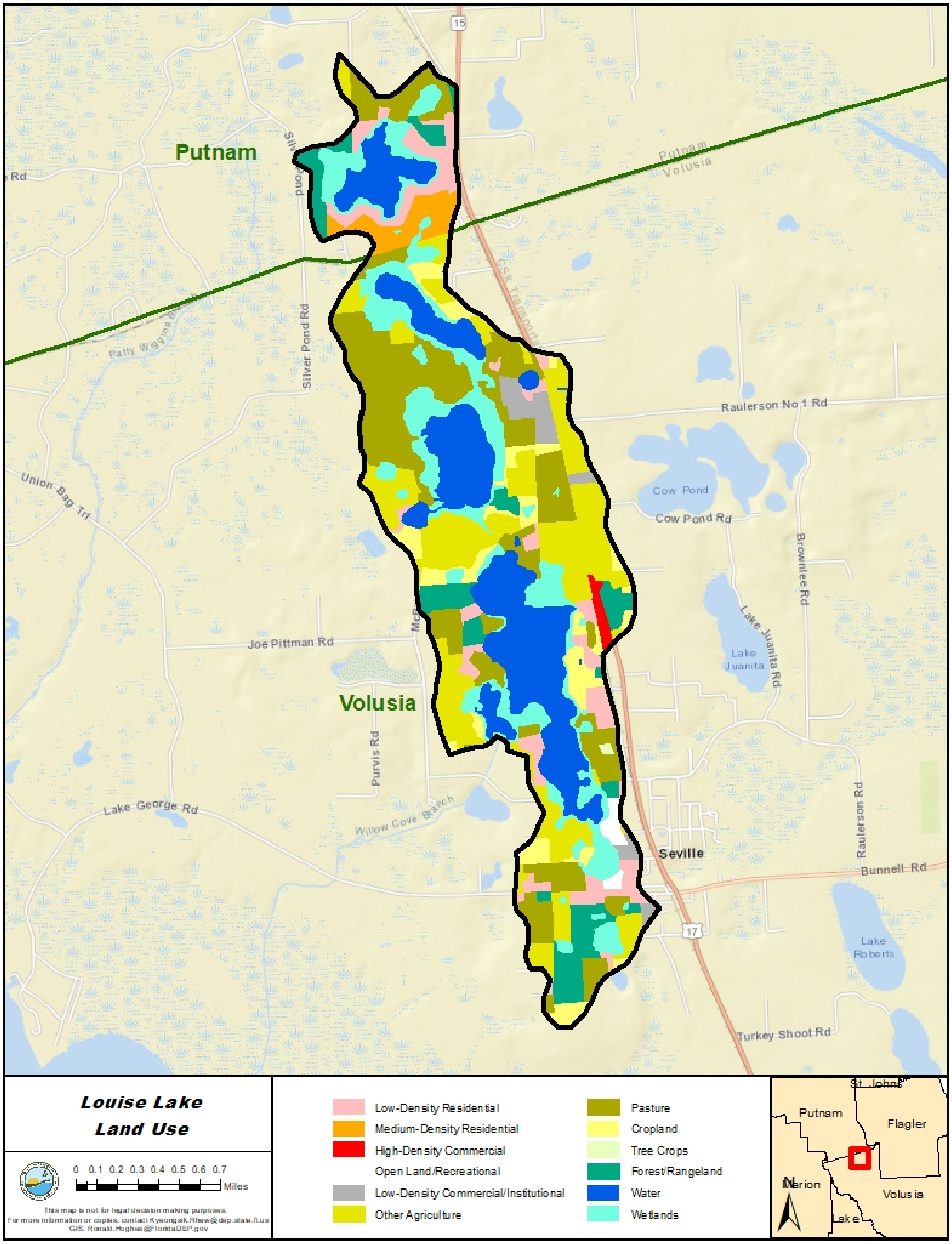


Figure 4.1. Land use in the Louise Lake Watershed, 2015

4.3.2 OSTDS

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

The Florida Department of Health (FDOH) maintains a list of septic tanks by county. The Putnam and Volusia Counties 2018 Database was used to determine the number of septic tanks in the Louise Lake Watershed. There are 215 known septic tanks. **Figure 4.2** shows the OSTDS locations in the watershed.

4.3.3 Atmospheric Deposition

Nutrient loadings from the atmosphere are an important component of the nutrient budget in many Florida lakes. Nutrients are delivered through two pathways: wet atmospheric deposition with precipitation and dry particulate-driven deposition. Atmospheric deposition to terrestrial portions of the Louise Lake Watershed is assumed to be accounted for in the loading rates used to estimate the watershed loading from land. There are no known complete atmospheric deposition data for Louise Lake. Therefore, loading from atmospheric deposition directly onto the water surface was estimated based on SJRWMD data collected in Lake Apopka. These included both wet and dry atmospheric deposition data.

The dry deposition portion is expressed as a per area loading rate (areal loading rate) on an annual scale. Wet deposition is delivered by precipitation, and annual wet deposition is therefore expressed as a concentration of solutes in precipitation multiplied by the total volume of precipitation. Both the wet and dry components of the calculated atmospheric nutrient deposition (**Table 4.2**) were added to the waterbody model for Louise Lake. The table also shows annual TN and TP atmospheric loads to the lake surface.

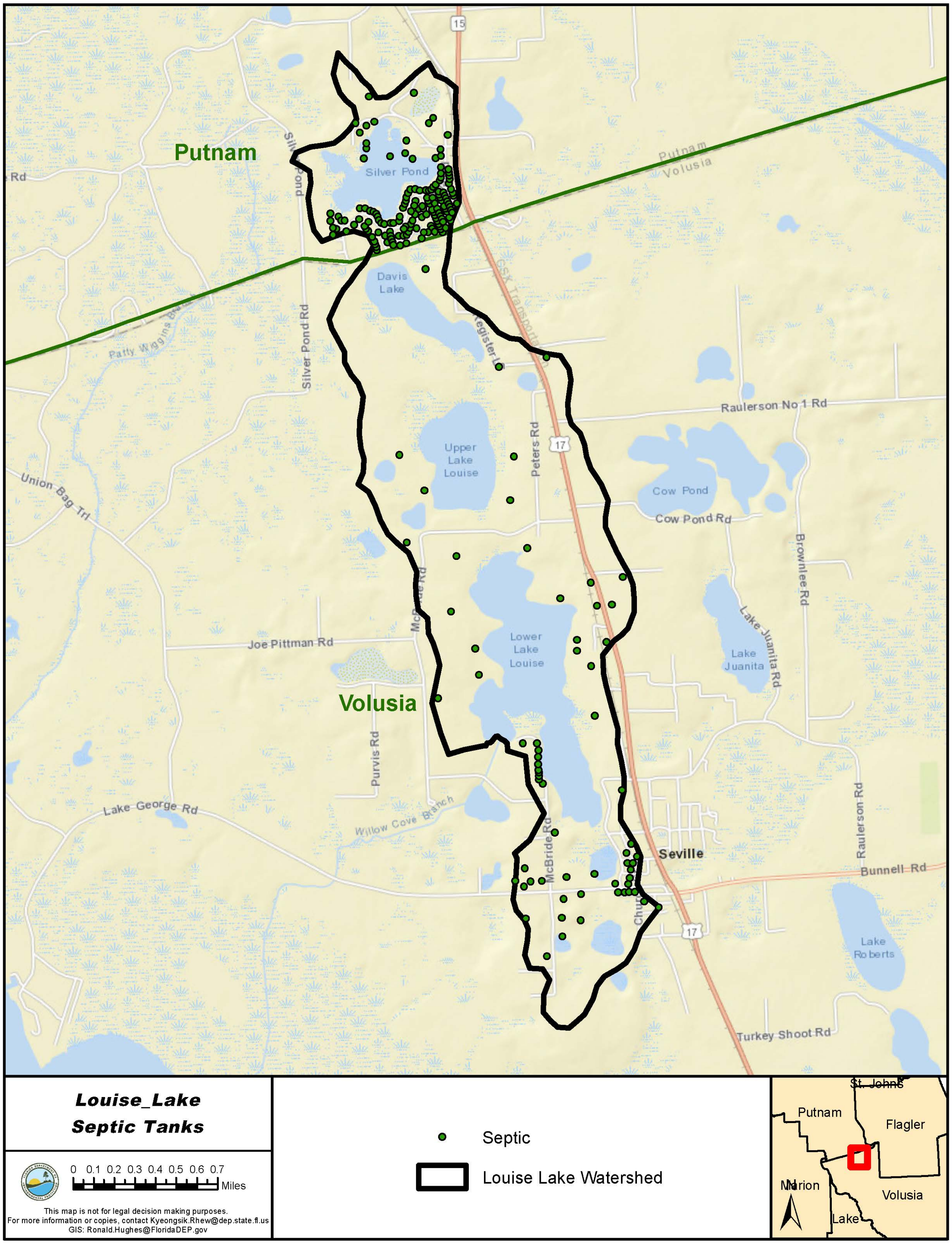


Figure 4.2. OSTDS in the Louise Lake Watershed

Table 4.2. Calculated atmospheric deposition in Louise Lake based on field measurements in Lake Apopka, 2010–19

mg/m²/yr = Milligrams per square meter per year
lbs/yr = Pounds per year

Year	Dry Deposition TN (mg/m²/yr)	Dry Deposition TP (mg/m²/yr)	Wet Deposition TN (mg/m²/yr)	Wet Deposition TP (mg/m²/yr)	Total Deposition TN (mg/m²/yr)	Total Deposition TP (mg/m²/yr)	TN loads to Lake surface (lbs/yr)	TP loads to Lake surface (lbs/yr)
2010	167	30	448	14	615	44	1,372	98
2011	136	19	563	19	698	39	1,557	87
2012	296	48	881	30	1,177	78	2,626	174
2013	146	18	592	15	739	33	1,649	74
2014	147	22	598	14	744	36	1,660	80
2015	181	29	501	22	682	51	1,522	114
2016	170	24	581	18	751	42	1,676	94
2017	244	32	607	19	851	51	1,899	114
2018	129	16	583	17	712	33	1,588	74
2019	103	14	483	17	586	31	1,307	69

4.4 Estimating Watershed Loadings

To simulate nutrient loading from the Louise Lake Watershed, the Natural Resources Conservation Service (NRCS) curve number model approach was used, following the procedure in Fulton et al. (2004) (**Appendix C**). This approach estimates runoff volume by taking into consideration the land use type, soil type, imperviousness of the watershed, and antecedent moisture condition of the soil. Curve numbers from 20 to 100 are assigned to different land use–soil combinations to represent different runoff potentials.

Rainfall is the driving force of the curve number simulation. The rainfall data used in this TMDL analysis were from the Crescent City Weather Station. The stormwater runoff volume was estimated using the same spreadsheet model created by SJRWMD. The annual runoff volume in the Louise Lake Watershed ranged from 1,235 to 3,031 acre-feet (ac-ft) from 2010 through 2019 (**Table 4.3**). The long-term average annual runoff is 1,985 ac-ft.

The nutrient loads from the watershed were calculated by multiplying runoff volume from the land use area and the TN and TP event mean concentrations (EMCs), and also by taking into account the percentage of these nutrients in dissolved fraction and flow path distance (**Appendix C**). EMCs were based on general land use descriptions and were spatially averaged data in Florida (Harper 2012; 1994).

Table 4.3. Runoff volume (ac-ft/yr) from the Louise Lake Watershed

Year	Runoff Volume
2010	1,235
2011	1,912
2012	1,828
2013	1,887
2014	1,909
2015	1,517
2016	2,278
2017	3,031
2018	2,367
2019	1,885
Average	**1,985**

Table 4.4 list the stormwater runoff TN and TP loads from the Louise Lake Watershed estimated using the procedures described in **Appendix C**.

Table 4.4. Runoff TP and TN annual loads (lbs/yr) from the Louise Lake Watershed

Year	TP	TN
2010	111	2,512
2011	274	4,540
2012	260	4,320
2013	264	4,437
2014	185	3,969
2015	149	3,167
2016	420	5,990
2017	636	8,455
2018	320	5,493
2019	253	4,359
Average	**287**	**4,724**

To simulate groundwater hydrology in the Louise Lake Watershed, the Hydrological Simulation Program – FORTRAN (HSPF) model was used. The U.S. Army Corps of Engineers (USACE) developed and calibrated the model only for hydrology (modeling period 2004–15) and not for water quality, to assist in evaluating salinity for the Jacksonville Harbor Navigation Project (Taylor Engineering Inc. 2017). In the project, SJRWMD and USACE applied HSPF to develop a comprehensive hydrologic model of the entire St. Johns River Basin. DEP already used a portion of this model to develop the dissolved oxygen (DO) TMDL for Haw Creek (Rhew 2020).

For the groundwater flow simulation for the Louise Lake Watershed, Patty Wiggins Branch RCHRES (5C5) in the Lake George Subwatershed of the HSPF model was used. Land use was changed based on data for the Louise Lake Watershed. The HSPF model simulates groundwater output by land use. Therefore, the runoff coefficients for each land use obtained by the curve number approach were applied to calculate the groundwater flow rate. Since the modeling periods for the HSPF model and this TMDL analysis differ, the mean value of the flow rate (0.88 cubic hectometers per year [hm^3/yr]) was applied to the BATHTUB model in developing these TMDLs.

Groundwater nutrient concentration data were obtained at 21 groundwater sampling stations from 11 WBIDs in the Lake George Subwatershed between 2005 and 2017. Median values for TN (0.364 mg/L) and TP (0.067 mg/L) were applied to the BATHTUB model. **Table 4.5** lists the estimated nutrient loads to Louise Lake from groundwater.

Table 4.5. Nutrient loads to Louise Lake from groundwater

Waterbody	TP Load (lbs/yr)	TN Load (lbs/yr)
Louise Lake	130	760

4.4.1 Estimating Septic Tank Flow Rate and Nutrient Loadings

Flow was estimated to include septic tank contributions in the watershed loading. To estimate flow, the following equation was used:

$$S * P * W * flr * 365 = \text{Flow rate (gallons/year)}$$

Where:

S = Number of known septic tanks within 200 meters.
P = Average number of people per household.
W = Individual water consumption (70 gallons/day).
flr = Flow loss rate (15 %).

There are 143 and 44 known septic tanks within 200 meters of major ponds and lakes in Putnam and Volusia Counties, respectively, in the Louise Lake Watershed. According to the U.S. Census Bureau, Putnam and Volusia Counties average 2.52 and 2.43 people per household, respectively. Each individual uses approximately 70 gallons of water per day, with a flow loss rate of 15 % (EPA 2002; Tetra Tech 2017). The number of septic tanks, the number of people per household, the individual water consumption, and a value of 0.85 were multiplied to calculate the total flow rate for septic tanks. Flow rates were converted to cubic hectometers for modeling. The lake has a septic tank flow of 0.0384 hm^3/yr.

Seepage from septic tanks may contribute nutrients to the waterbody. Inorganic nutrients, such as nitrate nitrogen and ammonia, are the main nutrients associated with septic tanks, since the majority of phosphorus loads to groundwater from septic tanks are adsorbed onto soil particles immediately or very soon after discharge. For modeling purposes, these various forms of nutrients are referred to as TN. The following flow equation was used to estimate TN loading from septic tanks in the watershed:

$$S * P * I * L = Total\ TN\ (lbs)\ from\ septic\ tanks$$

Where:

S = Number of known septic tanks in groundwater zones.
P = Average number of people per household.
I = Number of pounds of TN per person per septic tank.
L = Percentage of TN lost during seepage.

The number of septic tanks was multiplied by the number of people per household. These values were then multiplied by 9.012, which is the number of pounds of TN per person seeping from a septic tank per year (EPA 2002; Toor et al. 2019), and by 0.50, which accounts for the 50 % nitrogen loss that occurs as septic tank effluent moves through the unsaturated zone to groundwater. **Figure 4.2** shows the locations of the known septic tanks, and **Table 4.6** lists the estimated TN load for the watershed.

Table 4.6. Septic tank loads from the watershed

Waterbody	Flow Rate (hm^3/yr)	TN Concentration (mg/L)	TN Load (lbs/yr)
Louise Lake	0.0384	24.862	2,105

4.4.2 Nutrient Loadings from Various Sources

Based on calculation and simulation, the long-term mean of the total annual TP loading from various sources to Louise Lake was 515 lbs/yr. Surface runoff was the largest source of phosphorus loading to Louise Lake, representing 56 % of long-term total TP loading, followed by groundwater and atmospheric deposition (**Table 4.7**).

According to **Table 4.8**, the long-term mean of total TN loading from various sources to Louise Lake was 9,221 lbs/yr. The surface runoff to the lake water was the largest nitrogen loading source, representing 51 % of long-term total TN loading, followed by septic tanks, atmospheric deposition, and groundwater (**Table 4.8**).

Table 4.7. Long-term mean annual TP loading from different sources into Louise Lake, 2010–19 (lbs/yr)

Value	Atmospheric Deposition	Surface Runoff	Groundwater	Total
Long-Term Mean Annual	98	287	130	515
%	19	56	25	100

Table 4.8. Long-term mean annual TN loading from different sources into Louise Lake, 2010–19 (lbs/yr)

Value	Atmospheric Deposition	Surface Runoff	Groundwater	Septic Load	Total
Long-Term Mean Annual	1,686	4,724	706	2,105	9,221
%	18	51	8	23	100

Chapter 5: Determination of Assimilative Capacity

5.1 Determination of Loading Capacity

Nutrient enrichment and the resulting problems related to eutrophication tend to be widespread and are frequently manifested far (in both time and space) from their sources. Addressing eutrophication involves relating water quality and biological effects such as photosynthesis, decomposition, and nutrient recycling as acted on by environmental factors (rainfall, point source discharge, etc.) to the timing and magnitude of constituent loads supplied from various categories of pollution sources. Assimilative capacity should be related to some specific hydrometeorological condition during a selected period or to some range of expected variation in these conditions.

The goal of this TMDL analysis is to determine the assimilative capacity of Louise Lake and to identify the maximum allowable TN and TP loadings from the watershed, so that the waterbody will meet the TMDL targets and thus maintain its function and designated uses as a Class III water.

5.2 Evaluation of Water Quality Conditions

From 2017 to 2019, Louise Lake chlorophyll *a* AGMs varied from 6 µg/L in 2017 to 11 µg/L in 2019. TN AGMs ranged from 0.84 mg/L in 2019 to 0.95 mg/L in 2017. TP AGMs ranged from 0.023 mg/L in 2018 to 0.025 mg/L in 2017.

5.3 Critical Conditions and Seasonal Variation

The estimated assimilative capacity is based on annual conditions, rather than critical/seasonal conditions, because (1) the methodology used to determine assimilative capacity does not lend itself very well to short-term assessments, (2) DEP is generally more concerned with the net change in overall primary productivity in the segment, which is better addressed on an annual basis, (3) the chlorophyll *a* criterion used as the TMDL target is expressed as an AGM, and (4) the methodology used to determine impairment is based on annual conditions (AGM values).

5.4 Water Quality Modeling to Determine Assimilative Capacity

To represent water quality processes occurring in Louise Lake, the USACE BATHTUB model was used (Walker 1987; 1999). The model simulates steady-state lake conditions and is set up to simulate water quality based on long-term receiving water conditions. It is designed to represent reservoirs and other large waterbodies with relatively stable water levels.

5.4.1 Water Quality Model Description

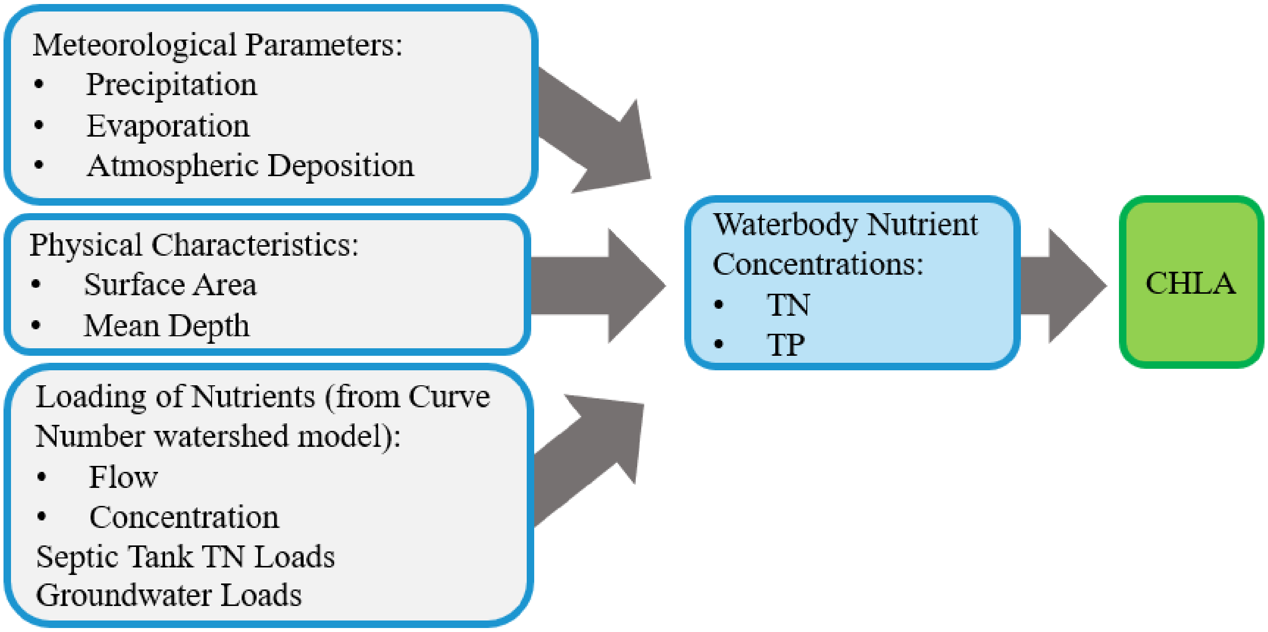
BATHTUB runs on a modeling framework that uses empirical relationships between nutrient loading, meteorological conditions, and physical parameters to estimate algal growth. The model's hydrologic framework includes lakes and lake segments, which may be directly or indirectly connected. Other inputs include the atmospheric deposition of nutrients, rainfall, and evaporation directly on the lake surface. Calculations also include the internal loading of nutrients in lakes.

The primary goal of the BATHTUB model is to estimate nutrient concentrations and algal biomass as they relate to nutrient loadings. Walker (1999) describes methods for choosing the appropriate models for producing these nutrient estimates for different waterbodies. Two categories of models are used to empirically predict lake eutrophication, and this process usually occurs in two stages. The nutrient balance model describes the relationships between nutrient concentrations in the lake to external nutrient loadings, morphometry, and lake hydraulics. The eutrophication response model relates eutrophication indicators in the lake, including nutrient levels, chlorophyll *a*, hypolimnetic oxygen depletion, and transparency (Walker 1999).

The nutrient models in BATHTUB assume that the net accumulation of nutrients in a lake is the difference between nutrient loadings into the lake from various sources and nutrients carried out through outflow, and nutrient losses through whatever decay processes occur in the lake. BATHTUB includes a suite of phosphorus and nitrogen sedimentation, chlorophyll, and Secchi depth models.

Figure 5.1 shows the scheme used to relate these various models in BATHTUB. According to this scheme, external nutrient loading, physical characteristics, and meteorological parameters are all applied to the in-lake nutrient concentrations. The physical, chemical, and biological response of the lake to the level of nutrients then produces waterbody nutrient concentrations, and finally chlorophyll *a* growth. In BATHTUB, other limiting factors can be applied, such as nitrogen, phosphorus, light, or flushing, depending on which chlorophyll model is selected.

Louise Lake was represented as one waterbody in the BATHTUB model because the lake is relatively small and is spatially homogeneous because of its geometry. The waterbody was modeled yearly, with inputs including the watershed nutrient delivery from the curve number approach, atmospheric deposition, groundwater, and septic tank flux (see **Sections 4.4** and **4.3**).



CHLA = Chlorophyll *a*

Figure 5.1. BATHTUB concept scheme

5.4.2 Morphologic Inputs

The physical characteristics of the lake were input for each year in BATHTUB. Two processes—residence time and nutrient fate and transport—vary based on these physical features. Louise Lake has an average depth of 5.7 feet, a surface area of 250 acres, and a lake length of 1.4 miles.

5.4.3 Meteorological Data

Rainfall

Rainfall data (2010–19) for the Louise Lake Watershed were provided by the Northeast Regional Climate Center from the Crescent City, FL weather station (**Table 5.1**).

Evaporation

SJRWMD obtained the potential evapotranspiration (PET) data (2010–18) from the Lisbon weather station. The data were converted to lake evaporation by multiplying by a pan coefficient of 0.76 (**Table 5.1**). The value in 2019 was calculated using an average of the available data period.

Table 5.1 lists the annual rainfall and evaporation values used in calibrating the BATHTUB model for Louise Lake.

Table 5.1. Annual rainfall and lake evaporation rates for the Louise Lake BATHTUB model calibration

m/yr = Meters per year

Year	Annual Rainfall (m/yr)	Lake Evaporation (m/yr)
2010	0.938	1.006
2011	1.308	1.080
2012	1.253	1.045
2013	1.302	1.011
2014	1.431	0.965
2015	1.135	1.018
2016	1.428	1.043
2017	1.792	1.095
2018	1.648	1.457
2019	1.313	1.054

Atmospheric Deposition

Atmospheric deposition rates (total deposition of TN and TP) were applied to global variables for the Louise Lake model. These rates were calculated based on data collected by SJRWMD in Lake Apopka (see **Section 4.3.3**) that included both wet and dry atmospheric deposition (see **Table 4.2**).

5.4.4 Watershed Nutrient Inputs

The curve number approach was used to simulate surface runoff (see **Section 4.4**). Loading rates from this approach were entered for the watershed tributaries in the BATHTUB model for yearly simulations. Loading rates from septic tank and groundwater (see **Section 4.4**) for the watershed tributaries were also entered in the model.

5.4.5 BATHTUB Model Calibration

The BATHTUB model was set up to simulate in-lake TN, TP, and chlorophyll *a* concentrations. AGMs for chlorophyll *a,* TN, and TP were input into the model as observed values from 2017 to 2019. These values were used to calibrate the BATHTUB model and guided the selection of the appropriate nitrogen, phosphorus, and chlorophyll models.

For the model calibration, Model Option 03 (2nd Order, Fixed) was used for TP, Model Option 05 (Bachman Flushing) was used for TN, and Model Option 01 (P, N, Light, Flushing) was used for chlorophyll *a*. The P. N. Light, T chlorophyll *a* model assumes that phytoplankton growth is limited by not only both phosphorus and nitrogen but also light. Calibration factors were used to fit the Louise Lake model predictions to the observed TN, TP, and chlorophyll *a* data. Calibration factors of 2.0, 0.5, and 0.76 were applied for TP, TN, and chlorophyll *a*, respectively, to fit the Louise Lake model predictions to all modeling years.

Figures 5.2, **5.3**, and **5.4** show the model-predicted results and observed concentrations for chlorophyll *a*, TN, and TP, respectively, for Louise Lake. To evaluate the model performance, the difference between the average simulated and observed AGM values was calculated for the model period for the lake. The average annual percent difference for the model period of predicted and observed chlorophyll *a*, TN, and TP was 12 %, 3 %, and 6 %, respectively (**Table 5.2**).

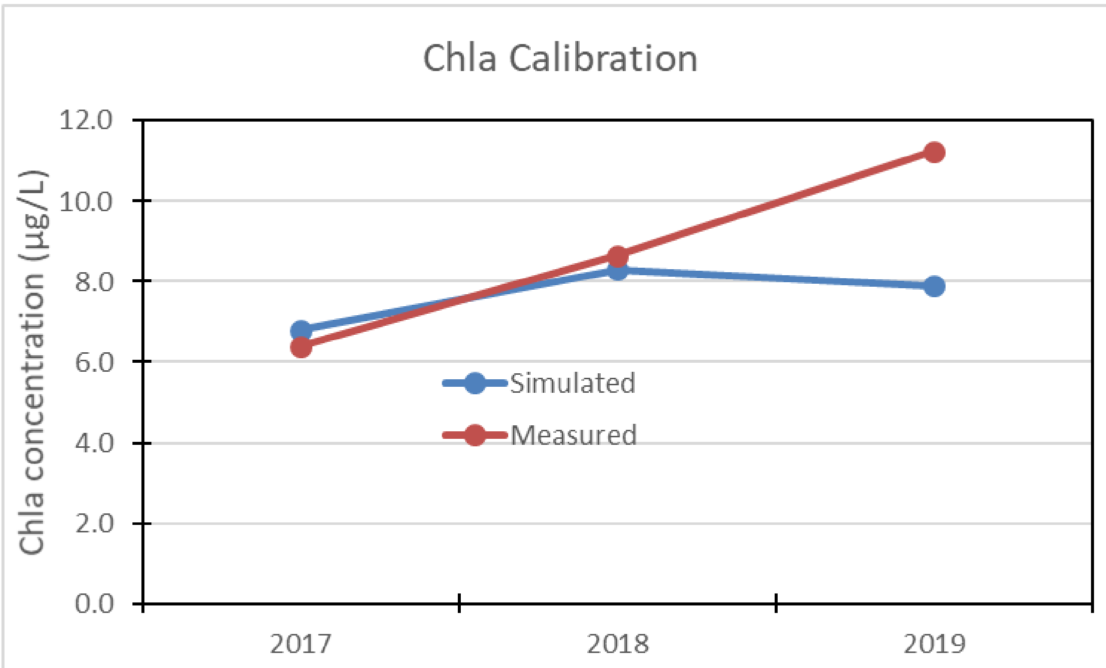


Figure 5.2. Louise Lake chlorophyll *a* observed and BATHTUB-simulated annual average results, 2017–19

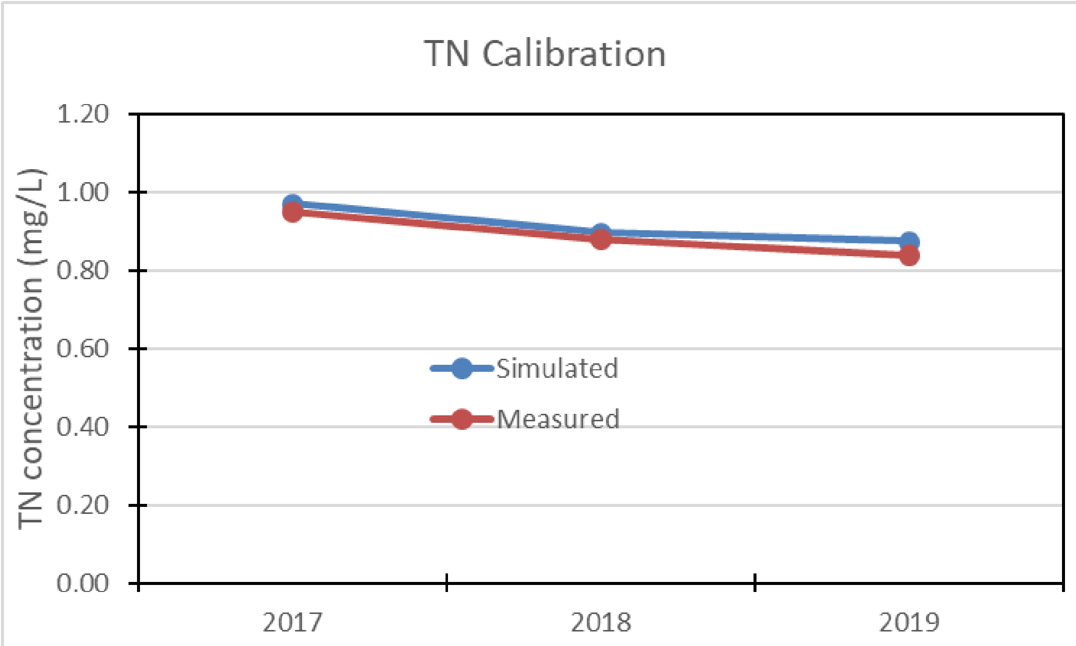


Figure 5.3. **Louise Lake TN observed and BATHTUB-simulated annual average results, 2017–19**

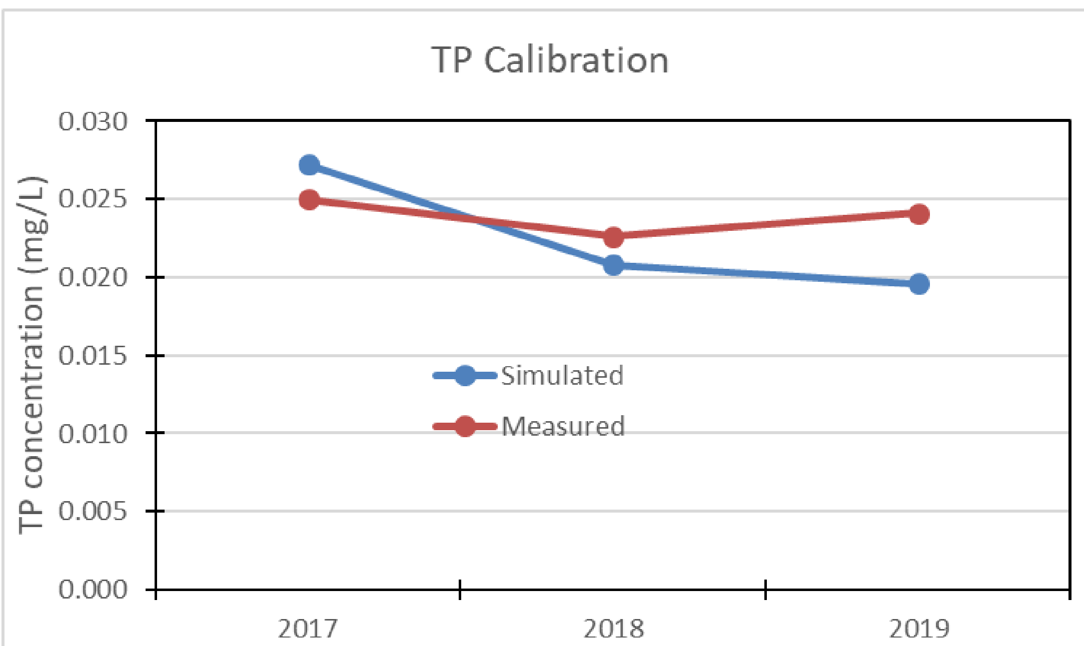


Figure 5.4. **Louise Lake TP observed and BATHTUB-simulated annual average results, 2017–19**

Table 5.2. Model performance statistics for nutrient parameter calibrations

Year	Simulated Chlorophyll *a* (µg/L)	Measured Chlorophyll *a* (µg/L)	Simulated TN (mg/L)	Measured TN (mg/L)	Simulated TP (mg/L)	Measured TP (mg/L)
2017	6.8	6.4	0.97	0.95	0.027	0.025
2018	8.3	8.6	0.90	0.88	0.021	0.023
2019	7.9	11.2	0.88	0.84	0.020	0.024
Mean	7.7	8.8	0.91	0.89	0.023	0.024
% Difference		**12%**		**-3%**		**6%**

5.4.6 Determining Existing and Natural Background Conditions and Setting Target Concentrations

Using the BATHTUB model setup for the calibration, simulations for chlorophyll *a*, TN, and TP were extended back to 2010 (**Figures 5.5, 5.6,** and **5.7**).

To ensure that the site-specific target would not abate the natural background conditions, the natural background conditions for Louise Lake were determined using the curve number method and the BATHTUB model. To establish the natural background conditions, all anthropogenic land uses in the current condition curve number spreadsheet were converted into forest. Wetland and water land uses remained unchanged when developing the natural background. The watershed background loadings were then added to the background BATHTUB model file. OSTDS loadings from the watershed were not included in the background model runs.

For Louise Lake, the modeled chlorophyll *a* concentration under the natural background condition is lower than or equal to the generally applicable chlorophyll *a* criterion (6 µg/L), except for 2012, when it was 6.5 µg/L (**Figure 5.5; Table 5.3**). Therefore, 6 µg/L of chlorophyll *a*, which is the natural background condition, was selected as the target, which is an AGM not to be exceeded more than once in any consecutive 3-year period. Since DEP has demonstrated that the chlorophyll *a* criterion of 6 µg/L and natural background condition are protective of designated uses and maintain a balanced aquatic flora and fauna (DEP 2012), this value will be used as the water quality target to address the nutrient impairment for the low-color, low-alkalinity lake. The TN and TP targets were selected as the simulated in-lake TN and TP concentrations corresponding to the target chlorophyll *a* concentration of 6 µg/L. These restoration concentrations are 0.67mg/L of TN and 0.017 mg/L of TP, which are AGMs not to be exceeded more than once in any consecutive 3-year period (**Figures 5.6** and **5.7**; **Table 5.3**).

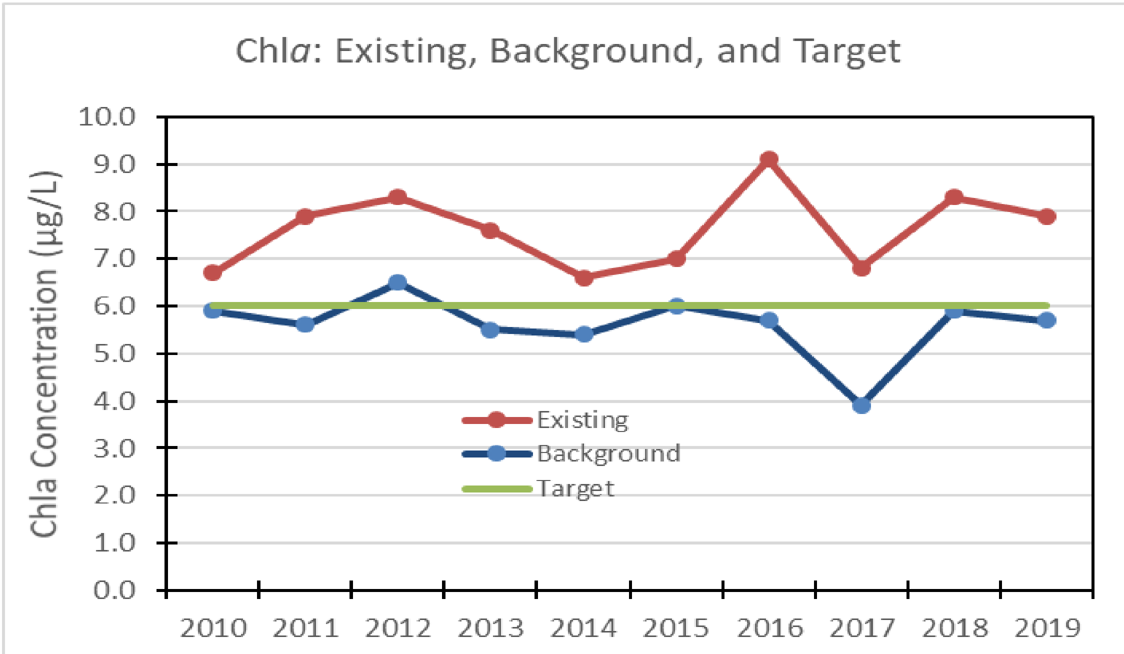


Figure 5.5. Chlorophyll *a* concentrations in existing, natural background, and target conditions in Louise Lake during the BATHTUB modeling period, 2010–19

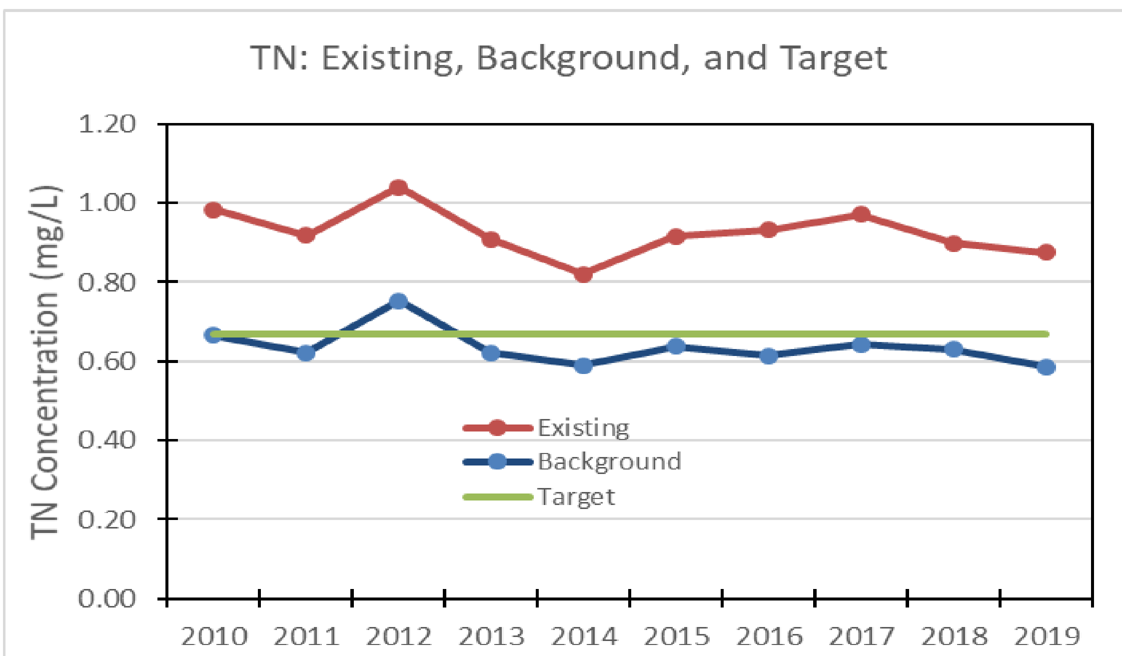


Figure 5.6. TN concentrations in existing, natural background, and target conditions in Louise Lake during the BATHTUB modeling period, 2010–19

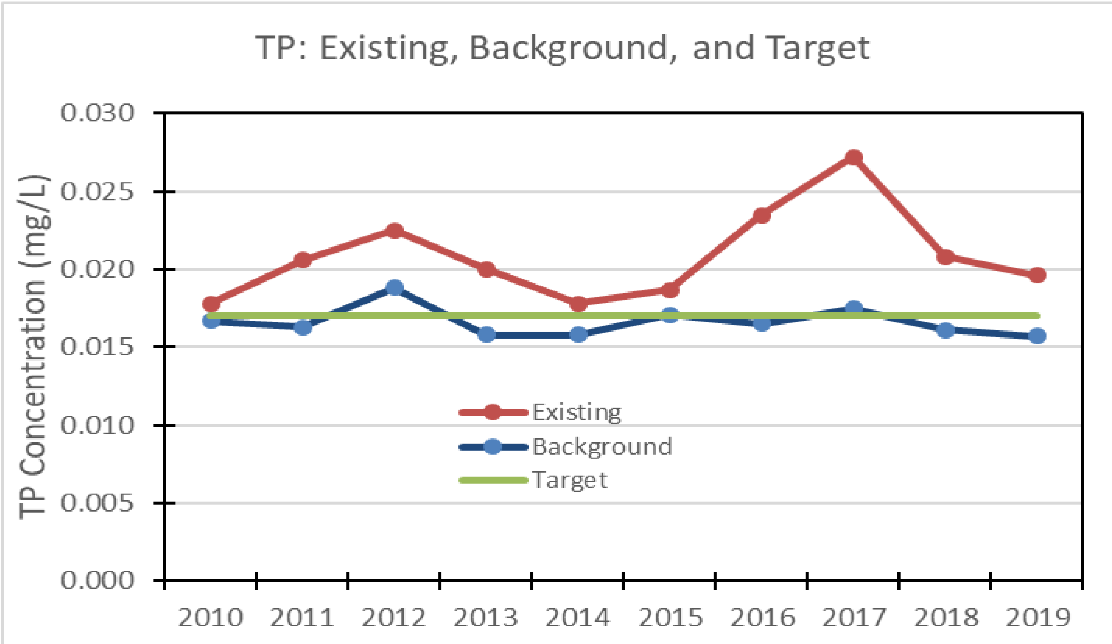


Figure 5.7. TP concentrations in existing, natural background, and target conditions in Louise Lake during the BATHTUB modeling period, 2010–19

Table 5.3. Chlorophyll *a*, TP, and TN concentrations in existing and natural background conditions during the simulation period and target concentrations

Year	Modeled Existing Chlorophyll *a* (µg/L)	Modeled Existing TN (mg/L)	Modeled Existing TP (mg/L)	Modeled Background Chlorophyll *a* (µg/L)	Modeled Background TN (mg/L)	Modeled Background TP (mg/L)
2010	6.7	0.98	0.018	5.9	0.67	0.017
2011	7.9	0.92	0.021	5.6	0.62	0.016
2012	8.3	1.04	0.023	6.5	0.75	0.019
2013	7.6	0.91	0.020	5.5	0.62	0.016
2014	6.6	0.82	0.018	5.4	0.59	0.016
2015	7.0	0.92	0.019	6.0	0.64	0.017
2016	9.1	0.93	0.024	5.7	0.61	0.017
2017	6.8	0.97	0.027	3.9	0.64	0.018
2018	8.3	0.90	0.021	5.9	0.63	0.016
2019	7.9	0.88	0.020	5.7	0.59	0.016
Target				**6.0**	**0.67**	**0.017**

5.5 Calculation of the TMDLs

To determine the nutrient loads that achieve the target chlorophyll *a* concentration of 6 µg/L, the anthropogenic TN and TP loads were reduced to the natural background condition. The final reductions to establish the TMDLs for Louise Lake were calculated by using the maximum 7-year average of both the existing and TMDL condition TN and TP loads. The maximum 7-year averages for TN existing loads and TMDL condition loads for the lake are 9,732 and 6,034 lbs/yr, respectively. The maximum 7-year averages for TP existing loads and TMDL condition loads for the lake are 552 and 347 lbs/yr, respectively (**Table 5.4**). The general equation used to calculate the percent reductions based on maximum 7-year averages is as follows:

$$\frac{\text{Existing Load} - \text{TMDL Condition Load}}{\text{Existing Load}} * 100$$

To meet the TMDL loads for Louise Lake, the required percent reductions for the TN and TP existing loads are 38 % and 37 %, respectively (**Table 5.4**). The TN and TP TMDLs of 6,034 and 347 lbs/yr, respectively, which are expressed as a 7-year average load, not to be exceeded, address the anthropogenic nutrient inputs contributing to the exceedances of the chlorophyll *a* restoration target. **Table 5.4** lists the nutrient loads under the TMDL condition for Louise Lake from 2010 to 2019.

Table 5.4. Louise Lake TMDL condition nutrient loads, 2010–19

Note: Values shown in boldface type and shaded cells represent the maximum 7-year averages, the 7-year loads used for the calculations, and percent reductions.

Year	Modeled Existing Condition TN Loads (lbs/yr)	7-Year Rolling Average TN Loads (lbs/yr)	Modeled TMDL Condition TN Loads (lbs/yr)	7-Year Rolling Average TN Loads (lbs/yr)	Modeled Existing Condition TP Loads (lbs/yr)	7-Year Rolling Average TP Loads (lbs/yr)	Modeled TMDL Condition TP Loads (lbs/yr)	7-Year Rolling Average TP Loads (lbs/yr)
2010	6,695		4,246		339		298	
2011	8,909		5,388		492		317	
2012	**9,757**		**6,316**		**564**		**400**	
2013	**8,897**		**5,506**		**466**		**305**	
2014	**8,440**		**5,672**		**396**		**316**	
2015	**7,499**		**4,848**		**393**		**328**	
2016	**10,477**	8,668	**6,108**	5,441	**644**	471	**345**	330
2017	**13,164**	9,592	**7,573**	5,916	**880**	548	**406**	345
2018	**9,892**	**9,732**	**6,218**	**6,034**	**524**	**552**	**330**	**347**
2019	8,477	9,550	5,136	5,866	452	536	300	333
Maximum 7-Year Average		**9,732**		**6,034**		**552**		**347**
% Reduction				**38**				**37**

Chapter 6: Determination of Loading Allocations

6.1 Expression and Allocation of the TMDL

The objective of a TMDL is to provide a basis for allocating loads to all the known pollutant sources in a watershed so that appropriate control measures can be implemented and water quality standards achieved. A TMDL is expressed as the sum of all point source loads (wasteload allocations, or WLAs), nonpoint source loads (load allocations, or LAs), and an appropriate margin of safety (MOS), which accounts for uncertainty in the relationship between effluent limitations and water quality:

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

As discussed earlier, the WLA is broken out into separate subcategories for wastewater discharges and stormwater discharges regulated under the NPDES Program:

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

It should be noted that the various components of the revised TMDL equation may not sum up to the value of the TMDL because (1) the WLA for NPDES stormwater is typically based on the percent reduction needed for nonpoint sources and is also accounted for in the LA, and (2) TMDL components can be expressed in different terms (for example, the WLA for stormwater is typically expressed as a percent reduction, and the WLA for wastewater is typically expressed as mass per day).

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

This approach is consistent with federal regulations (40 Code of Federal Regulations [CFR] § 130.2[I]), which state that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or other appropriate measure. The TMDLs for Louise Lake are expressed in terms of lbs/yr and percent reduction of TN and TP and represent the loads of TN and TP that the waterbody can assimilate while maintaining balanced communities of aquatic flora and fauna (see **Table 6.1**). These TMDLs are based on 7-year rolling averages of simulated loads from 2010 to 2019. For the TMDLs, the restoration goal is to achieve the generally applicable chlorophyll *a* criterion of 6 µg/L, which is expressed as an AGM not to be exceeded more than once in any consecutive 3-year period, thus meeting the water quality criteria and protecting designated uses for Louise Lake.

Table 6.1 lists the TMDLs for the Louise Lake Watershed. The TN and TP loads for the lake will constitute the site-specific numeric interpretations of the narrative nutrient criterion set forth in Paragraph 62-302.530(48)(b), F.A.C., that will replace the otherwise applicable NNC in Subsection 62-302.531(2), F.A.C., for the lake.

Site-specific interpretations for Louise Lake are expressed as a 7-year rolling annual average load not to be exceeded.

Table 6.1. TMDL components for nutrients in Louise Lake (WBID 2902)

Note: The TMDL daily load for TN is 17 lbs/day and for TP 1 lb/day.
NA = Not applicable
* The required percent reductions listed in this table represent the reduction from all sources.

Waterbody (WBID)	Parameter	TMDL (lbs/yr)	WLA Wastewater (% reduction)	WLA NPDES Stormwater (% reduction)*	LA (% reduction)*	MOS
2902	TN	6,034	NA	38	38	Implicit
2902	TP	347	NA	37	37	Implicit

6.2 Load Allocation

To achieve the LA for Louise Lake, 38 % and 37 % reductions in current TN and TP loads, respectively, will be required.

The TMDLs are based on the percent reduction in total watershed loading of TN and TP from all anthropogenic sources. However, it is not DEP's intent to abate natural conditions. It should be noted that the LA includes loading from stormwater discharges regulated by DEP and the water management district that are not part of the NPDES stormwater program (see **Appendix A**).

6.3 Wasteload Allocation

6.3.1 NPDES Wastewater Discharges

As noted in **Chapter 4**, no active NPDES-permitted facilities in the Louise Lake Watershed discharge either into the lake or the watershed. Therefore, a WLA for wastewater discharges is not applicable.

6.3.2 NPDES Stormwater Discharges

Volusia County has a Phase II-C MS4 permit (FLR04E033), and FDOT District 5 has an MS4 permit (FLR04E024) covering the urbanized area of Volusia County. Based on the 2010 TIGER

Census urbanized area coverage data, none of the Louise Lake Watershed is located in the urban area. It should be noted that any MS4 permittee is only responsible for reducing the anthropogenic loads associated with stormwater outfalls that it owns or otherwise has responsible control over, and it is not responsible for reducing other nonpoint source loads in its jurisdiction.

6.4 MOS

The MOS can either be implicitly accounted for by choosing conservative assumptions about loading or water quality response, or explicitly accounted for during the allocation of loadings. Consistent with the recommendations of the Allocation Technical Advisory Committee (DEP 2001), an implicit MOS was used in the development of these TMDLs. The MOS is a required component of a TMDL and accounts for the uncertainty about the relationship between pollutant loads and the quality of the receiving waterbody (CWA, Section 303[d][1][c]). An implicit MOS was used because the TMDLs were based on the conservative decisions associated with a number of the modeling assumptions in determining assimilative capacity (i.e., loading and water quality response). The TMDLs were developed using the maximum seven-year averages for TN existing loads to calculate the percent reductions and requiring the TMDL loads not to be exceeded in any one year.

Chapter 7: Implementation Plan Development and Beyond

7.1 Implementation Mechanisms

Following the adoption of a TMDL, implementation may take place through various measures, including specific requirements in NPDES wastewater and MS4 permits, and, as appropriate, local or regional water quality initiatives or basin management action plans (BMAPs).

Facilities with NPDES permits that discharge to the TMDL waterbody must implement the permit conditions that reflect target concentrations, reductions, or WLAs identified in the TMDL. NPDES permits are required for Phase I and Phase II MS4s as well as domestic and industrial wastewater facilities. MS4 Phase I permits require a permit holder to prioritize and act to address a TMDL unless management actions to achieve that particular TMDL are already defined in a BMAP. MS4 Phase II permit holders must also implement the responsibilities defined in a BMAP or other form of restoration plan (e.g., a reasonable assurance plan).

Given the nature of the loading to Louise Lake, nonpoint source reductions are required to reach the TMDL target. In the Louise Lake Watershed, runoff from agricultural areas would be the leading non-point sources for the nutrients. The SJRWMD annually provides an Agricultural Cost-Share Program of its districtwide. The purpose of the program is to engage farmers, growers, and ranchers with SJRWMD in the shared goals of water conservation and reduction of nutrient run-off.

Volusia County has adopted fertilizer ordinances to protect the county's surface waters from nutrient pollution. The county has also conducted the education and outreach efforts on septic tank maintenance to reduce nutrient loading to waterbodies.

7.2 BMAPs

Information on the development and implementation of BMAPs is found in Section 403.067, F.S. (the FWRA). DEP or a local entity may initiate and develop a BMAP that addresses some or all of the contributing areas to the TMDL waterbody. BMAPs are adopted by the DEP Secretary and are legally enforceable.

BMAPs can describe the fair and equitable allocations of pollution reduction responsibilities to the sources in the watershed, as well as the management strategies that will be implemented to meet those responsibilities, funding strategies, mechanisms to track progress, and water quality monitoring. Local entities—such as wastewater facilities, industrial sources, agricultural producers, county and city stormwater systems, military bases, water control districts, state agencies, and individual property owners—usually implement these strategies. BMAPs can also identify mechanisms to address potential pollutant loading from future growth and development.

7.3 Implementation Considerations for the Waterbody

In addition to addressing reductions in watershed pollutant contributions to impaired waters during the implementation phase, it may also be necessary to consider the impacts of internal sources (e.g., sediment nutrient fluxes or the presence of nitrogen-fixing cyanobacteria) and the results of any associated remediation projects on surface water quality. Other factors—such as the calibration of watershed nutrient loading, sediment nutrient fluxes, and/or nitrogen fixation—also influence lake nutrient budgets and the growth of phytoplankton. Approaches for addressing these potential factors should be included in a comprehensive management plan for the lake.

Additionally, the current water quality and water level monitoring of Louise Lake should continue and be expanded, as necessary, during the implementation phase to ensure that adequate information is available for tracking restoration progress.

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Appendices

Appendix A: Background Information on Federal and State Stormwater Programs

In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as authorized in Chapter 403, F.S., was established as a technology-based program that relies on the implementation of BMPs designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Chapter 62-40, F.A.C. In 1994, DEP stormwater treatment requirements were integrated with the stormwater flood control requirements of the water management districts, along with wetland protection requirements, into the Environmental Resource Permit regulations, as authorized under Part IV of Chapter 373, F.S.

Chapter 62-40, F.A.C., also requires the state's water management districts to establish stormwater pollutant load reduction goals (PLRGs) and adopt them as part of a Surface Water Improvement and Management (SWIM) Program plan, other watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation part of a TMDL. To date, they have been established for Tampa Bay, Lake Thonotosassa, the Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka.

In 1987, the U.S. Congress established Section 402(p) as part of the federal CWA Reauthorization. This section of the law amended the scope of the federal NPDES permitting program to designate certain stormwater discharges as "point sources" of pollution. The EPA promulgated regulations and began implementing the Phase I NPDES stormwater program in 1990 to address stormwater discharges associated with industrial activity, including 11 categories of industrial activity, construction activities disturbing 5 or more acres of land, and large and medium MS4s located in incorporated places and counties with populations of 100,000 or more.

However, because the master drainage systems of most local governments in Florida are physically interconnected, the EPA implemented Phase I of the MS4 permitting program on a countywide basis, which brought in all cities (incorporated areas), Chapter 298 special districts; community development districts, water control districts, and FDOT throughout the 15 counties meeting the population criteria. DEP received authorization to implement the NPDES stormwater program in 2000. The authority to administer the program is set forth in Section 403.0885, F.S.

The Phase II NPDES stormwater program, promulgated in 1999, addresses additional sources, including small MS4s and small construction activities disturbing between 1 and 5 acres, and urbanized areas serving a minimum resident population of at least 1,000 individuals. While these urban stormwater 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, as are other point sources of pollution such as domestic and industrial wastewater discharges. It should be noted that Phase I MS4 permits issued in Florida include a reopener clause that allows permit revisions to implement TMDLs when the implementation plan is formally adopted.

Appendix B: Information in Support of Site-Specific Interpretations of the Narrative Nutrient Criterion

Table B-1. Spatial extent of the numeric interpretation of the narrative nutrient criterion

Location	Description
Waterbody name	Louise Lake
Waterbody type(s)	Lake
WBID	Louise Lake (WBID 2902) (see **Figure 1.1** of this report)
Description	Louise Lake is located in Volusia County, between Lake George and Crescent Lake. The lake and its surrounding watershed cover an area of 2,144 acres. Louise Lake has a surface area of 250 acres, with an average depth of 5.7 feet. Agriculture is the predominant land use in the Louise Lake Watershed, with 45 % coverage. **Chapter 1** of this report describes the Louise Lake system in more detail.
Specific location (latitude/longitude or river miles)	The center of Louise Lake is located at N: 29°19'55.2"/W: -81°30'12.2." The site-specific criteria apply as a spatial average for the lake, as defined by WBID 2902.
Map	**Figure 1.2** shows the general location of Louise Lake and its associated watershed, and **Figure 4.1** shows the land uses in the watershed.
Classification(s)	Class III Freshwater
Basin name (HUC 8)	Middle St. Johns River Basin (03080101)

Table B-2. Description of the numeric interpretation of the narrative nutrient criterion

Numeric Interpretation of Narrative Nutrient Criterion	Information on Parameters Related to Numeric Interpretation of the Narrative Nutrient Criterion
NNC summary: Generally applicable lake classification (if applicable) and corresponding NNC	Louise Lake is a low-color, low-alkalinity lake, and the generally applicable NNC, expressed as AGM concentrations not to be exceeded more than once in any 3-year period, are chlorophyll *a* of 6 µg/L, TN of 0.51 to 0.93 mg/L, and TP of 0.01 to 0.03 mg/L.
Proposed TN, TP, chlorophyll *a*, and/or nitrate + nitrite concentrations (magnitude, duration, and frequency)	Numeric interpretations of the narrative nutrient criterion: For Louise Lake the 7-year rolling average TN and TP loads are 6,034 and 347 lbs/yr, respectively. Nutrient concentrations are provided for informational purposes only. The in-lake TN and TP AGM concentrations for Louise Lake at the allowable TMDL loading are 0.67 and 0.017 mg/L, respectively, not to be exceeded more than once in any 3-year period. These restoration concentrations represent the in-lake concentrations that would still meet the target chlorophyll *a* concentration of 6 µg/L with a 1-in-3-year exceedance rate.
Period of record used to develop numeric interpretations of the narrative nutrient criterion for TN and TP	The criteria were developed based on the application of the curve number method and the BATHTUB model, which simulated hydrology and water quality conditions from 2010 to 2019 for Louise Lake. The primary datasets for this period include water quality data from IWR Run 59, Northeast Regional Climate Center Online Weather Data, and 2015 SJRWMD land use coverage. **Sections 2.3** and **4.4** of this report provide a complete description of the data used in the derivation of the proposed site-specific criteria.
How the criteria developed are spatially and temporally representative of the waterbody or critical condition	The model simulated the 2010–19 period for Louise Lake. The period for the lake included wet and dry years. Long-term average rainfall for the Louise Lake Watershed from 1914 to 2019 was 52 inches per yr. This period captures the hydrologic variability of the system. The model simulated the entire watershed to evaluate how changes in watershed loads impact lake nutrient and chlorophyll *a* concentrations. **Figure 2.1** shows the locations of the sampling stations in Louise Lake. Monitoring stations were located across the spatial extent and represent the spatial distribution of nutrient dynamics in the lake.

Table B-3. Summary of how designated use(s) are protected by the criterion

Designated Use Requirements	Information Related to Designated Use Requirements
History of assessment of designated use support	DEP used the IWR Database to assess water quality impairments in Louise Lake (WBID 2902). During the Cycle 4, Group 2 assessment, the NNC were used to assess Louise Lake during the verified period (January 1, 2012–June 30, 2019), based on data from IWR Run 59. Louise Lake was determined to be verified impaired for chlorophyll *a*, TN, and TP. **Table 2.4** lists the AGM values for chlorophyll *a*, TN, and TP during the verified period for the waterbody.
Basis for use support	The basis for use support is the NNC chlorophyll *a* concentration of 6 µg/L, which is protective of designated uses for low-color, low-alkalinity lakes. Based on the available information, there is nothing unique about Louise Lake that would make the use of the chlorophyll *a* threshold of 6 µg/L inappropriate for the lake.
Approach used to develop criteria and how it protects uses	For the Louise Lake nutrient TMDLs, DEP created loading-based criteria using the curve number method to simulate loading from the Louise Lake Watershed, and this information for the lake was input into BATHTUB. DEP established the site-specific TN and TP loadings using the calibrated models to achieve an in-lake chlorophyll *a* AGM concentration of 6 µg/L. The maximum of the 7-year rolling averages of TN and TP loadings to achieve the chlorophyll *a* target was determined by decreasing TN and TP loads from anthropogenic sources into the lake until the chlorophyll *a* target was achieved. **Chapter 3** of this report describes the derivation of the TMDLs and criteria.
How the TMDL analysis will ensure that nutrient-related parameters are attained to demonstrate that the TMDLs will not negatively impact other water quality criteria	Model simulations indicated that the target chlorophyll *a* concentration (6 µg/L) in the lake will be attained at the TMDL loads for TN and TP. DEP notes that no other impairments were verified for Louise Lake that may be related to nutrients (such as DO or un-ionized ammonia). Reducing the nutrient loads entering the lake will not negatively affect other water quality parameters in the lake.

Table B-4. Documentation of the means to attain and maintain water quality standards for downstream waters

Protection of Downstream Waters and Monitoring Requirements	Information Related to Protection of Downstream Waters and Monitoring Requirements
Identification of downstream waters: List receiving waters and identify technical justification for concluding downstream waters are protected	Louise Lake discharges into Willow Cove Branch in the Louise Lake Drain (WBID 2902A), which flows into Lake George (WBID 2893A). Louise Lake Drain is not verified impaired for nutrients. The target concentrations of TN and TP for Lake George are 1.14 and 0.06 mg/L, respectively (Magley 2018). In comparison, the target concentrations of Louise Lake for TN and TP are 0.67 and 0.017 mg/L, respectively. Since the nutrient targets of Louise Lake are based on the natural background condition and lower than those for downstream waters, the TMDLs for Louise Lake are inherently protective.
Summary of existing monitoring and assessment related to the implementation of Subsection 62-302.531(4), F.A.C., and trends tests in Chapter 62-303, F.A.C.	Volusia County and DEP conduct routine monitoring of Louise Lake. The data collected through these monitoring activities will be used to evaluate the effect of BMPs implemented in the watershed on lake TN and TP loads in subsequent water quality assessment cycles.

Table B-5. Documentation of endangered species consideration

Administrative Requirements	Information for Administrative Requirements
Endangered species consideration	DEP is not aware of any aquatic, amphibious, or anadromous endangered species present in the Louise Lake Watershed. Furthermore, it is expected that restoration efforts and subsequent water quality improvements will positively affect aquatic species living in the lake and its watershed.

Table B-6. Documentation that administrative requirements are met

Administrative Requirements	Information for Administrative Requirements
Notice and comment notifications	DEP published a Notice of Development of Rulemaking on March 29, 2019, to initiate TMDL development for impaired waters in the Middle St. Johns Basin. A rule development public workshop for the TMDLs was held on January 27, 2021.
Hearing requirements and adoption format used; responsiveness summary	Following the publication of the Notice of Proposed Rule, DEP will provide a 21-day challenge period and a public hearing that will be noticed no less than 45 days prior.
Official submittal to EPA for review and General Counsel certification	If DEP does not receive a rule challenge, the certification package for the rule will be prepared by the DEP program attorney. DEP will prepare the TMDLs and submittal package for the TMDLs to be considered as site-specific interpretations of the narrative nutrient criterion and will submit these documents to the EPA.

Appendix C. Estimating the Runoff Volume and Nutrient Loads from the Louise Lake Watershed

A. NRCS Curve Number Approach

The stormwater runoff volume for these TMDLs was estimated using the same spreadsheet model created by SJRWMD (Fulton et al. 2004). The key function of this spreadsheet model is to estimate the annual average runoff coefficient for each land use–soil type combination for each year. Once the runoff coefficient is decided, the runoff volume can be calculated as the product of rainfall, runoff coefficient, and acreage of the land use–soil type combination.

SJRWMD's runoff volume spreadsheet model was built based on a 15-land use classification system. Each land use was associated with 4 soil hydrologic groups (Types A, B, C, and D), resulting in a total of 60 land use–soil type combinations. To calculate the runoff volume for the entire Louise Lake Watershed and, at the same time, quantify the runoff contribution from each land use area, the runoff coefficient for each land use–soil type combination must be estimated. SJRWMD's runoff model achieved this goal by estimating a watershed-basin average stormwater runoff coefficient ($ASRC_{wb}$) first, and then derived the runoff coefficient for land use–soil type combination.

The NRCS curve number approach estimates the runoff volume from a given land surface using **Equation 1**:

$$Q = \frac{\left(P - 0.2 * S\right)^2}{P + 0.8 * S} \qquad \textbf{Equation 1}$$

Where,

Q = Runoff volume (inches).
P = Rainfall amount (inches).
S = Potential soil storage (inches), which can be calculated using **Equation 2**:

$$S = \frac{1000}{CN} - 10 \qquad \textbf{Equation 2}$$

Where,

CN = Curve number.

The curve number is a dimensionless value ranging from 0 to 100. It is used in the runoff equation to characterize the runoff potential for different land use–soil combinations. Specific curve numbers are assigned to different combinations. In addition, curve numbers are influenced by the antecedent moisture condition (AMC) of the soil. **Table C-1** lists the curve numbers used in developing these TMDLs. These numbers were cited in Suphunvorranop (1985) and were also used by SJRWMD in developing the nutrient PLRG for the Upper Ocklawaha Chain of Lakes.

The curve numbers listed in **Table C-1** are established for the average soil AMC, which is commonly referred to as AMC II. The low and high soil AMCs are usually referred to as AMC I and AMC III, respectively. In the curve number approach, the soil AMC status is judged by comparing the total amount of rainfall a given watershed area received for a total of five days with a set of five-day threshold rainfall values in either the dormant season or the growth season. **Table C-2** lists the five-day threshold rainfall values used to determine the soil AMC for these TMDLs. **Table C-3** lists the curve numbers under the AMC I and AMC III corresponding to each curve number value under the AMC II condition.

Table C-1. Curve numbers by hydrologic soil groups and land use types

Land Use	Soil Group A	Soil Group B	Soil Group C	Soil Group D
Low-density residential	51	68	79	84
Medium-density residential	57	72	81	86
High-density residential	77	85	90	92
Low-density commercial	77	85	90	92
High-density commercial	89	92	94	95
Industrial	81	88	91	95
Mining	32	58	72	79
Open land/recreational	49	69	79	84
Pasture	47	67	81	88
Cropland	64	75	82	84
Tree crops	32	58	72	79
Other agriculture	59	74	82	86
Forest/rangeland	36	60	73	79
Water	98	98	98	98
Wetlands	89	89	89	89

Table C-2. Threshold five-day antecedent rainfall volume (inches) for AMC classification

Soil AMC Classification	Dormant Season (November–March)	Growth Season (April–October)
I	< 0.5	< 1.4
II	0.5 – 1.1	1.4 – 2.1
III	> 1.1	> 2.1

Table C-3. Relationship between curve numbers under AMCs I, II, and III

AMC I	AMC II	AMC III
0	0	0
2	5	17
4	10	26
7	15	33
9	20	39
12	25	45
15	30	50
19	35	55
23	40	60
27	45	65
31	50	70
35	55	75
40	60	79
45	65	83
51	70	87
57	75	91
63	80	94
70	85	97
78	90	98
87	95	99
100	100	100

One common practice to calculate runoff volume from a given watershed using the curve number approach is to calculate the runoff from the pervious and impervious areas, and then add the runoff volumes from these two areas together to determine total watershed runoff. To apply this method, the impervious areas are usually divided into two types: directly connected impervious area (DCIA) and nondirectly connected impervious area (NDCIA). The DCIA represents the areas that are directly connected to the stormwater drainage system. It is typically assumed that 90 % of the rainfall that falls on the DCIA will become runoff.

In contrast, the runoff created from the NDCIA will reach the pervious area and contributes to pervious area runoff. Therefore, the NDCIA typically is not considered a part of the impervious area. Instead, it is usually considered a part of the pervious area. **Table C-4** lists the percent areas occupied by DCIA, NDCIA, and pervious areas for each land use type used in developing the TMDLs. SJRWMD used these percent area values in developing the nutrient PLRG for the Upper Ocklawaha Chain of Lakes. The values included in the table were assembled by Camp Dresser and McKee (CDM) (1994).

The total runoff from a watershed can be represented using **Equation 3**:

$$Q = Q_{Pervious} + Q_{DCIA}$$ **Equation 3**

Where,

Q = Total runoff from the watershed area (centimeters [cm]).
$Q_{Pervious}$ = Runoff from the pervious area (cm).
Q_{DCIA} = Runoff from the DCIA (cm).

Table C-4. Land use–specific percent DCIA, NDCIA, and pervious area

Note: This table was cited from SJRWMD's nutrient PLRG for the Upper Ocklawaha River Basin. Data were assembled by CDM (1994).

Land Use	DCIA	NDCIA	Pervious Area	Sum of NDCIA and Pervious Area
Low-density residential	5	10	85	95
Medium-density residential	15	20	65	85
High-density residential	25	40	35	75
Low-density commercial	40	40	20	60
High-density commercial	45	35	20	55
Industrial	50	30	20	50
Mining	1	1	98	99
Open land/recreational	1	1	98	99
Pasture	1	1	98	99
Cropland	1	1	98	99
Tree crops	1	1	98	99
Other agriculture	1	1	98	99
Forest/rangeland	1	1	98	99
Water	85	15	0	15
Wetland	75	0	25	25

Q_{DCIA} can be calculated using **Equation 4**:

$$Q_{DCIA} = P * 0.9 * (\frac{DCIA}{TotalArea})$$ **Equation 4**

Where,

P = Rainfall (cm).
$DCIA$ = Area of DCIA.
$TotalArea$ =Total watershed area.

$Q_{Pervious}$ can be calculated using **Equation 5**:

$$Q_{Pervious} = \frac{\left(P' - 0.2 * S\right)^2}{P' + 0.8 * S} * \left(\frac{PerviousArea}{TotalArea}\right)$$ **Equation 5**

Where,

> P' = Adjusted rainfall (centimeters [cm]).
> S = Potential soil storage of rainfall (cm).
> *PerviousArea* = Acreage of the pervious area in the watershed.

Measured rainfall was adjusted in **Equation 5** to account for rain falling in the NDCIA. It was assumed that rainfall on these areas would reach and uniformly spread out onto the pervious area. To account for rainfall to the NDCIA, the measured rainfall was adjusted using **Equation 6**.

$$P' = \frac{P * PerviousArea + P * NDCIA}{PerviousArea}$$ **Equation 6**

Where,

> *NDCIA* = Area of NDCIA.

Equation 6 can be simplified to **Equation 7**:

$$P' = P * \left(1 + \frac{NDCIA}{PerviousArea}\right)$$ **Equation 7**

The potential soil storage can be calculated using **Equation 8**:

$$S = \frac{1000}{CNpervious} - 10$$ **Equation 8**

Where,

> $CN_{Pervious}$ = Curve number for the pervious area.

$CN_{Pervious}$ can be derived from the watershed average curve number, calculated using **Equation 9**:

$$CN_{Watershed} = \frac{\sum (Area * CN)}{TotalArea}$$ **Equation 9**

Where,

$CN_{Watershed}$ = Watershed average curve number.
CN = Land use–soil combination specific curve number listed in **Table 4.3**.
$Area$ = Area occupied by a specific land use–soil combination.
$TotalArea$ = Total area of the entire watershed.

$CN_{Watershed}$ can also be represented using **Equation 10**:

$$CN_{Watershed} = \frac{(CN_{DCIA} * Area_{DCIA}) + (CN_{Pervious} * Area_{Pervious})}{TotalArea} \quad \textbf{Equation 10}$$

Where,

CN_{DCIA} = Curve number of the DCIA.
$Area_{DCIA}$ = Acreage occupied by the DCIA.
$Area_{Pervious}$ = Acreage of the watershed occupied by both the NDCIA and pervious area.

Equation 10 can be rewritten to solve for $CN_{Pervious}$ as **Equation 11**:

$$CN_{Pervious} = \frac{(CN_{Watershed} * TotalArea) - (CN_{DCIA} * Area_{DCIA})}{Area_{Pervious}} \quad \textbf{Equation 11}$$

With all the above equations, the watershed runoff volume Q defined in **Equation 4** can be calculated. The watershed-basin average $ASRC_{wb}$ can be calculated as the quotient between the watershed runoff volume and rainfall to the watershed.

$ASRC_{wb}$ can also be represented using **Equation 12**:

$$ASRC_{wb} = \frac{(DCIA * 0.9) + (PerviousArea * WRC_{Pervious})}{TotalArea} \quad \textbf{Equation 12}$$

Equation 12 can be rewritten to solve for the weighted runoff coefficient (WRF) for the pervious area (**Equation 13**):

$$WRC_{Pervious} = \frac{(ASRC_{wb} * TotalArea) - (DCIA * 0.9)}{PerviousArea} \quad \textbf{Equation 13}$$

When developing the nutrient PLRG for the Upper Ocklawaha Chain of Lakes, SJRWMD assumed that Type D soil would have four times the runoff compared with Type A (Fulton et al.

2004). This assumption was made based on the typical depth to groundwater and the resultant soil storage (**Table C-5**).

Table C-5. Groundwater depth and soil runoff potential

PRC = Proportional runoff coefficient

Soil Type	Depth to Groundwater (meters)	Runoff Ratio	Soil Type Coefficient
A	>1.2	1	PRC
B	0.9	2	2*PRC
C	0.6	3	3*PRC
D	0.3	4	4*PRC

Based on this assumption, $WRC_{Pervious}$ can also be represented using **Equation 14**:

$$WRC_{Pervious} = \frac{PRC * Area_{Asoil} + 2PRC * Area_{Bsoil} + 3PRC * Area_{Csoil} + 4PRC * Area_{Dsoil}}{PerviousArea}$$

Equation 14

Where,

PRC = Proportional runoff coefficient.
$AreaAsoil$ = Area occupied by Type A soil.
$AreaBsoil$ = Area occupied by Type B soil.
$AreaCsoil$ = Area occupied by Type C soil.
$AreaDsoil$ = Area occupied by Type D soil.

Equation 14 can be rewritten to solve for PRC (**Equation 15**):

$$PRC = \frac{PerviousArea * WRC_{Pervious}}{Area_{Asoil} + 2 * Area_{Bsoil} + 3 * Area_{Csoil} + 4 * Area_{Dsoil}}$$ **Equation 15**

The final area weighted runoff coefficient for each land use–soil combination ($ASRC_{LS}$) is calculated using **Equation 16**:

$$ASRC_{LS} = \frac{(DCIA_{LS} * 0.9) + (PerviousArea_{LS} * n * PRC)}{TotalArea_{LS}}$$ **Equation 16**

Where,

$DCIA_{LS}$ = DCIA occupied by a specific land use–soil type combination.

PerviousArea$_{LS}$ = Pervious area (including the NDCIA) occupied by a specific land use–soil type combination.

n = Runoff ratio listed in **Table C-5**. The n values for Type A, B, C, and D soils are 1, 2, 3, and 4, respectively.

TotalArea$_{LS}$ = Total area occupied by a specific land use–soil type combination.

Rainfall data from the Crescent City station were used in calculating the runoff coefficient and runoff volume for the TMDLs. **Table 4.3** summarizes the annual rainfall to the Louise Lake Watershed for each year from 2010 to 2019. **Table C-6** lists the runoff coefficients for each land use–soil type combination for each year from 2000 to 2012. **Table 4.4** lists the annual runoff volume from different land use areas in the Louise Lake Watershed.

Table C-6. Runoff coefficient for different land use–soil type combinations for each year from 2010 to 2019

NA = Not applicable because there is no such land use or soil type.

Land Use	Soil	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Low-density residential	A	0.046	0.062	0.062	0.061	0.048	0.048	0.078	0.089	0.059	0.059
Low-density residential	B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Low-density residential	C	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Low-density residential	D	0.047	0.114	0.113	0.108	0.055	0.056	0.175	0.219	0.102	0.102
Medium-density residential	A	0.136	0.150	0.150	0.149	0.137	0.138	0.164	0.174	0.148	0.148
Medium-density residential	B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Medium-density residential	C	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Medium-density residential	D	0.137	0.196	0.195	0.192	0.144	0.145	0.251	0.291	0.186	0.186
High-density residential	A	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
High-density residential	B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
High-density residential	C	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
High-density residential	D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Low-density commercial	A	0.360	0.371	0.371	0.370	0.362	0.362	0.381	0.388	0.369	0.369
Low-density commercial	B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Low-density commercial	C	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Low-density commercial	D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
High-density commercial	A	0.405	0.415	0.425	0.414	0.407	0.407	0.424	0.430	0.413	0.413
High-density commercial	B	NA	NA	0.445	NA	NA	NA	NA	NA	NA	NA
High-density commercial	C	NA	NA	0.465	NA	NA	NA	NA	NA	NA	NA
High-density commercial	D	0.406	0.445	0.485	0.442	0.411	0.412	0.480	0.506	0.438	0.438
Industrial	A	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Industrial	B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Industrial	C	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Industrial	D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mining	A	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mining	B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mining	C	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mining	D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Open land/recreational	A	0.010	0.027	0.027	0.025	0.012	0.012	0.043	0.054	0.024	0.024
Open land/recreational	B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Open land/recreational	C	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Land Use	Soil	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Open land/recreational	D	0.011	0.080	0.079	0.075	0.020	0.021	0.145	0.191	0.069	0.068
Pasture	A	0.010	0.027	0.027	0.025	0.012	0.012	0.043	0.054	0.024	0.024
Pasture	B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pasture	C	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pasture	D	0.011	0.080	0.079	0.075	0.020	0.021	0.145	0.191	0.069	0.068
Cropland	A	0.010	0.027	0.027	0.025	0.012	0.012	0.043	0.054	0.024	0.024
Cropland	B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cropland	C	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cropland	D	0.011	0.080	0.079	0.075	0.020	0.021	0.145	0.191	0.069	0.068
Tree crop	A	0.010	0.027	0.027	0.025	0.012	0.012	0.043	0.054	0.024	0.024
Tree crop	B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tree crop	C	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tree crop	D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other agriculture	A	0.010	0.027	0.027	0.025	0.012	0.012	0.043	0.054	0.024	0.024
Other agriculture	B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other agriculture	C	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other agriculture	D	0.011	0.080	0.079	0.075	0.020	0.021	0.145	0.191	0.069	0.068
Forest/rangeland	A	0.010	0.027	0.027	0.025	0.012	0.012	0.043	0.054	0.024	0.024
Forest/rangeland	B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Forest/rangeland	C	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Forest/rangeland	D	0.011	0.080	0.079	0.075	0.020	0.021	0.145	0.191	0.069	0.068
Water	A	0.765	0.768	0.768	0.767	0.765	0.765	0.770	0.772	0.767	0.767
Water	B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	C	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water	D	0.765	0.776	0.776	0.775	0.767	0.767	0.786	0.793	0.774	0.774
Wetland	A	0.675	0.680	0.679	0.679	0.676	0.676	0.684	0.686	0.679	0.679
Wetland	B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wetland	C	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wetland	D	0.676	0.693	0.693	0.692	0.678	0.678	0.709	0.721	0.690	0.690

B. Estimating Runoff Nutrient Loads

The runoff nutrient loads from a watershed are calculated by multiplying the runoff volume from the land use area by runoff TN and TP concentrations specific to the land use type. These runoff nutrient concentrations are commonly referred to as EMCs. EMCs can be determined through stormwater studies, in which both runoff volume and runoff nutrient concentrations are measured during the phases of a given stormwater event. The EMC for the stormwater event is then calculated as the mean concentration weighted for the runoff volume. The TN and TP EMCs (**Table C-7**) used in this TMDL analysis were based on general land use descriptions and were spatially averaged data in Florida (Harper 1994; 2012).

Nutrient removal by stormwater treatment facilities in urban areas was also considered in simulating watershed nutrient loads. It was assumed that all urban construction after 1984, when Florida implemented the Stormwater Rule, had some type of stormwater treatment facilities to remove TN and TP loads at certain removal efficiencies. To identify the construction taking place after 1984, the watershed land use distribution data from 2015 were compared with the land use distribution geographic information system (GIS) shape file of 1988, which was the earliest land use GIS shape file available in DEP's GIS DataMiner.

It was assumed that the urban land use areas included in the 1988 land use shape file did not have any stormwater treatment facilities required by the state Stormwater Rule. This assumption should be close to reality because the 1988 land use shape file was created based on 1987 land use aerial photography. Compared with the period from 1984 to 2015, the chances of missing some urban construction taking place between 1984 and 1987 were relatively small and therefore should not cause significant errors for nutrient load simulation. Any urban land areas that did not appear in the 1988 land use shape file but appeared in the 2015 land use shape files were considered new construction with stormwater treatment facilities.

When calculating watershed nutrient loads, the loads from these urban land use areas are subject to the stormwater treatment and TN and TP removal at certain percentages. Based on studies of 13 stormwater treatment systems, it was assumed that these urban stormwater facilities can remove 63 % of the phosphorus load and 42 % of the nitrogen load (Fulton et al. 2004).

Table C-7. EMCs of TN and TP for different land use types

Land Use	TP EMC (mg/L)	TN EMC (mg/L)
Low-density residential	0.178	1.51
Medium-density residential	0.301	1.87
High-density residential	0.497	2.10
Low-density commercial	0.179	1.07
High-density commercial	0.213	1.635
Industrial	0.213	1.19
Mining	0.150	1.18
Pasture	0.621	3.30
Tree crops	0.152	2.07
Cropland	0.621	3.30
Other agriculture	0.152	2.07
Open land/recreational	0.301	1.87
Forest/rangeland	0.055	1.15
Wetlands	0.055	1.15
Water	0.025	0.716

Another aspect of the nutrient load simulation was the effective delivery of nutrient to the receiving water after going through the overland transport process. In this TMDL analysis, all dissolved components of TN and TP were considered to reach the receiving water without any loss, while particulate fractions of TN and TP were considered subject to loss through the overland transport process. Therefore, the amount of nutrients eventually reaching the receiving water includes two components: the unattenuated dissolved fraction (T) and the particulate fraction that is attenuated through the overland transport process. The portion of the nutrients that eventually reaches the receiving water can be represented using **Equation 7**, which is a function established in the Reckhow *et al.* (1989) analyses.

$$D = (1-T) * e^{(1.01-0.34*\ln(L))} + T$$ **Equation 17**

Where,

D = Amount of nutrients that eventually reaches the receiving water.
T = Dissolved fraction of the total nutrient (TN and TP) concentrations.
(1-T) = Particulate fraction of the total nutrient (TN and TP) concentrations.
The exponential portion of the equation represents the delivery ratio of the particulate nutrients.
L = Length of the overland flow path.

The percent dissolved TN and TP concentrations for different land uses used in this TMDL analysis were cited from SJRWMD's Upper Ocklawaha Chain of Lakes PLRG report (Fulton et al. 2004). These numbers were created by comparing concentrations of TN, TP, orthophosphate (PO_4), total dissolved phosphorus (TDP), and total dissolved nitrogen (TDN) from several studies on stormwater runoff conducted in Florida (Dierberg 1991; Fall 1990; Fall and Hendrickson 1988; German 1989; Harper and Miracle 1993; Hendrickson 1987; Izuno et al. 1991). **Table C-8** lists the percent concentration of dissolved phosphorus and nitrogen for different land uses.

The length of the overland flow path was estimated by randomly picking 20 transects of the watershed and measuring the distance between the boundary of the watershed and the boundary of the lake. The final length of the overland flow path was calculated as the mean values of the lengths of these 20 transect measurements. For the Louise Lake Watershed, the average length of the overland flow path was estimated this way as 2,903 meters.

Table 4.4 lists the stormwater runoff TN and TP loads from the Louise Lake Watershed estimated using the procedures described above.

Table C-8. Dissolved fraction of TN and TP concentrations for different land uses

Land Use	Dissolved Phosphorus (%)	Dissolved Nitrogen (%)
Low-density residential	50.1	75.3
Medium-density residential	50.1	75.3
High- density residential	50.1	75.3
Low-density commercial	41.4	65.7
High- density commercial	76.7	76.7
Industrial	76.1	76.1
Mining	46.7	65.7
Pasture	72.2	90.8
Tree crop	62.9	90.8
Cropland	60.0	90.8
Other agriculture	68.7	90.8
Open land/recreational	50.1	75.3
Forest/rangeland	50.1	75.3
Wetlands	50.7	77.5
Water	11.8	41.3

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