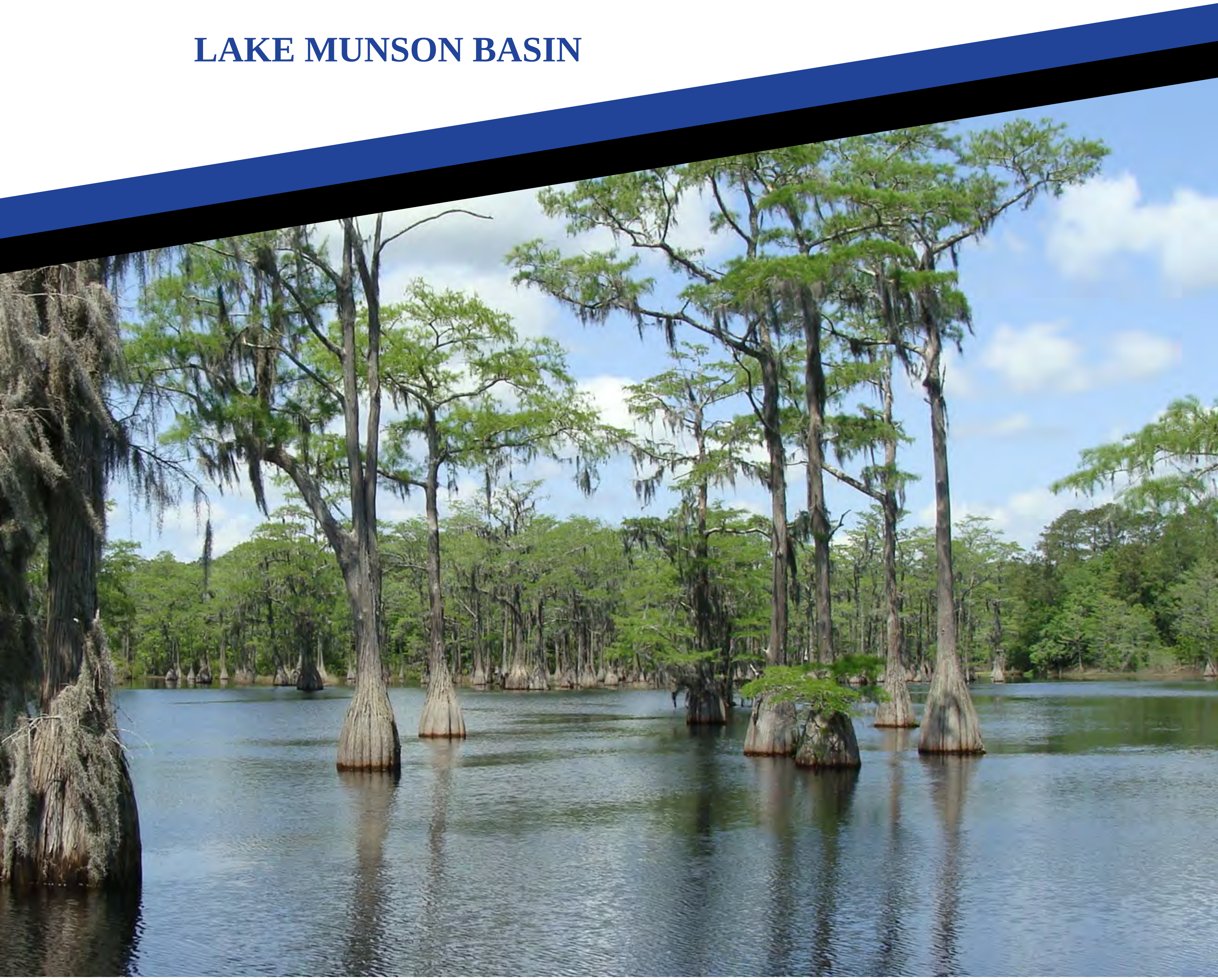
TALLAHASSEE MASTER PLAN – SURFACE WATER (TMaPS): VOLUME 3

CITY OF TALLAHASSEE

LAKE MUNSON BASIN



Submitted by:
Geosyntec Consultants, Inc.
2039 Centre Point Blvd, Suite 103
Tallahassee, Florida 32308

Geosyntec consultants
engineers | scientists | innovators

July 2025

TMaPS: VOLUME 3

LAKE MUNSON BASIN

CITY OF TALLAHASSEE

Prepared for

City of Tallahassee
300 South Adams Street
Tallahassee, Florida 32301

Prepared by

Geosyntec Consultants, Inc.
2039 Centre Point Blvd
Suite 103
Tallahassee, Florida 32308

Project Number: FW7714

July 2025

TMaPS: VOLUME 3

LAKE MUNSON BASIN

CITY OF TALLAHASSEE

The engineering material and data contained within the enclosed report was prepared by Geosyntec Consultants, Inc. for sole use by the City of Tallahassee. This report was prepared under the supervision and direction of the respective undersigned, whose seal as a registered professional engineer is affixed below.

Mike D. Hardin, Ph.D., PE, CFM
Principal
Florida PE# 74749

Prepared for

City of Tallahassee
300 South Adams Street
Tallahassee, Florida 32301

Prepared by

Geosyntec Consultants, Inc.
2039 Centre Point Blvd
Suite 103
Tallahassee, Florida 32308

Mike Hardin, PhD, P.E., CFM
Principal Engineer

Steve Peene, PhD
Senior Principal

Nico Pisarello, GISP
Professional Scientist

Jovana Radovanovic
Sr. Staff Scientist

Lexie Foos
Staff Scientist

Project Number: FW7714
July 2025

Geosyntec consultants

Tallahassee Master Plan – Surface Water (TMaPS)

Volume 1: Executive Summary

Volume 2: Background & Approach

Volume 3: Lake Munson Basin

Volume 4: Lake Jackson Basin

Volume 5: Lake Lafayette Basin

Volume 6: Wakulla Springs and Lake Talquin

Volume 7: Non-Structural and Structural Project Development

Volume 8: Regulatory Review

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Geosyntec consultants

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ACRONYMS AND ABBREVIATIONS

AGM	annual geometric mean
BMAP	basin management action plan
BMP	best management practice
BOD	biochemical oxygen demand
CDA	Concentrated Discharge Areas
cfs	cubic feet per second
Chl-a	chlorophyll a
CN	curve number
City	City of Tallahassee
DCIA	directly connected impervious area
DEM	digital elevation model
DO	dissolved oxygen
E. coli	*Escherichia coli*
EMC	event mean concentration
EPA	U.S. Environmental Protection Agency
ERP	Environmental Resource Permit
F.A.C.	Florida Administrative Code
FAMU	Florida Agricultural and Mechanical (A&M) University
FDEP	Florida Department of Environmental Protection
FDOH	Florida Department of Health
FDOT	Florida Department of Transportation
FGS	Florida Geologic Survey
FIB	Fecal Indicator Bacteria
FLUCCS	Florida Land Use Cover Classification System
FSQAH	Florida Stormwater Quality Applicants Handbook
FSU	Florida State University
ft	feet
FWC	Florida Fish and Wildlife Conservation Commission
GIS	geographic information system
HA	Habitat Assessment
HSG	hydrologic soil group

ID	identification
IWR	Impaired Waters Rule
lb/yr	pounds per year
LDI	Landscape Development Intensity
LVI	Lake Vegetation Index
MARC	mean annual runoff coefficient
MARS	Megginnis Arm Regional Stormwater
mg/L	milligrams per liter
MGD	million gallons per day
mL	milliliter
MPN	most probable number
NADP	National Atmospheric Deposition Program
NAVD88	North American Vertical Datum of 1988
NHD	National Hydrological Dataset
NNC	numeric nutrient criteria
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
NWFWMD	Northwest Florida Water Management District
OSTDS	onsite sewage treatment and disposal systems
PCB	polychlorinated biphenyl
PCU	platinum-cobalt units
QAPP	Quality Assurance Project Plan
SCI	Stream Condition Index
SIMPLE	Spatially Integrated Model for Pollutant Loading Estimates
SSO	sanitary sewer overflow
SWFWMD	Southwest Florida Water Management District
SWMF	Stormwater Management Facility
SWMM	Stormwater Management Model
TKN	total Kjeldahl nitrogen
TMaPS	Tallahassee Master Plan - Surface Water
TMDL	total maximum daily load
TN	total nitrogen

TP	total phosphorus
TSI	Trophic State Index
TSS	total suspended solids
µg/L	micrograms per liter
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WBID	waterbody identification

3 Lake Munson Basin

3.1 Basin Overview and Project Waterbodies

The Lake Munson basin is located in Leon County, FL north of Tallahassee and encompasses the township and ranges of: 001N 002W, 001N 001W, 001N 001E, 001S 002W, 001S 001W, 001S 001E, and 002S 001W. **Figure 3-1** shows the location of the Lake Munson basin in relation to the City of Tallahassee (City) limits and within the Leon County boundary. The basin covers approximately 42,500 acres (66.5 square miles), of which 95 percent (40,400 acres) is land cover and the remaining 5 percent (2,100 acres) is surface water. **Exhibit 3-1** presents a map showing basin boundaries, waterbodies that are part of this study (termed primary waterbodies), tributary inputs, the extents of the City incorporated area, and smaller watershed areas that drain to Lake Munson, which is the primary receiving waterbody in the basin.

Major water features within the Lake Munson basin include West Drainage Ditch, East Drainage Ditch, Central Drainage Ditch, Bradford Chain of Lakes, Munson Slough, Lake Munson, and Ames Sink. Forty-five percent of the basin is within the City's incorporated area, approximately 19,000 acres (30 square miles). Looking at drainage to the lake (**Exhibit 3-1**), the entire basin drains into Lake Munson through the lower portion of Munson Slough [downstream of the Lake Henrietta Stormwater Management Facility (SWMF)]. To understand water quality aspects of Lake Munson, it is important to also understand Munson Slough. The slough and its heavily urbanized tributaries drain a large portion of the City. The slough flows south (through the Lake Henrietta SWMF) into and out of Lake Munson, then continues to Eight Mile Pond. After exiting Eight Mile Pond, the slough flows under Oak Ridge Road and enters Ames Sink, which is connected to Wakulla Spring.

For the Lake Munson basin, six primary waterbodies were identified for evaluation of potential pollutant loads and development of structural and non-structural projects to improve their water quality (as needed):

- Lake Munson and Munson Slough (downstream of Lake Henrietta SWMF)
- Bradford Chain of Lakes (Lake Bradford, Lake Hiawatha, and Cascade Lake)
- Silver Lake

These waterbodies are highlighted in **Exhibit 3-1** and are the focus of the analyses in the sections following this introduction.

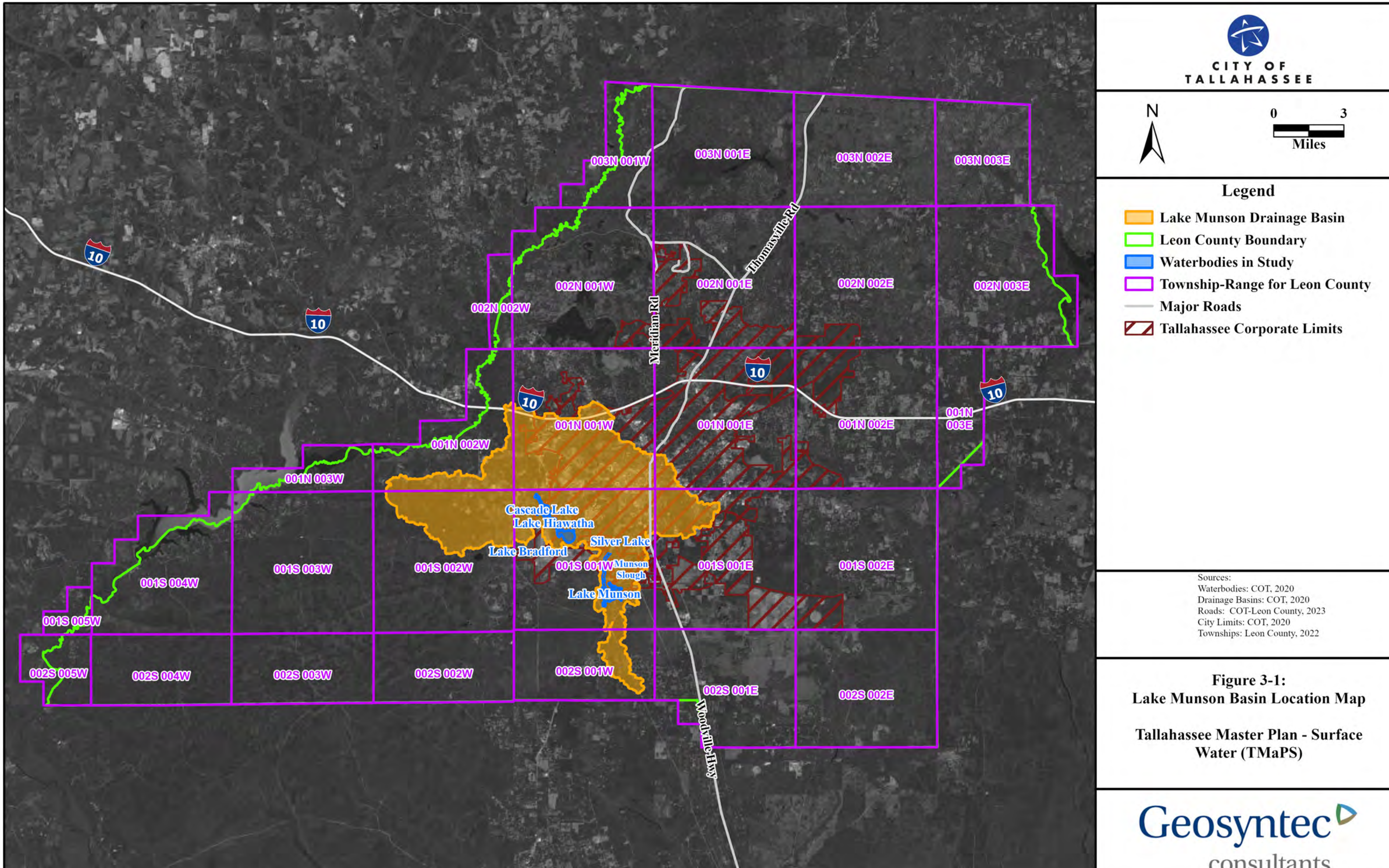
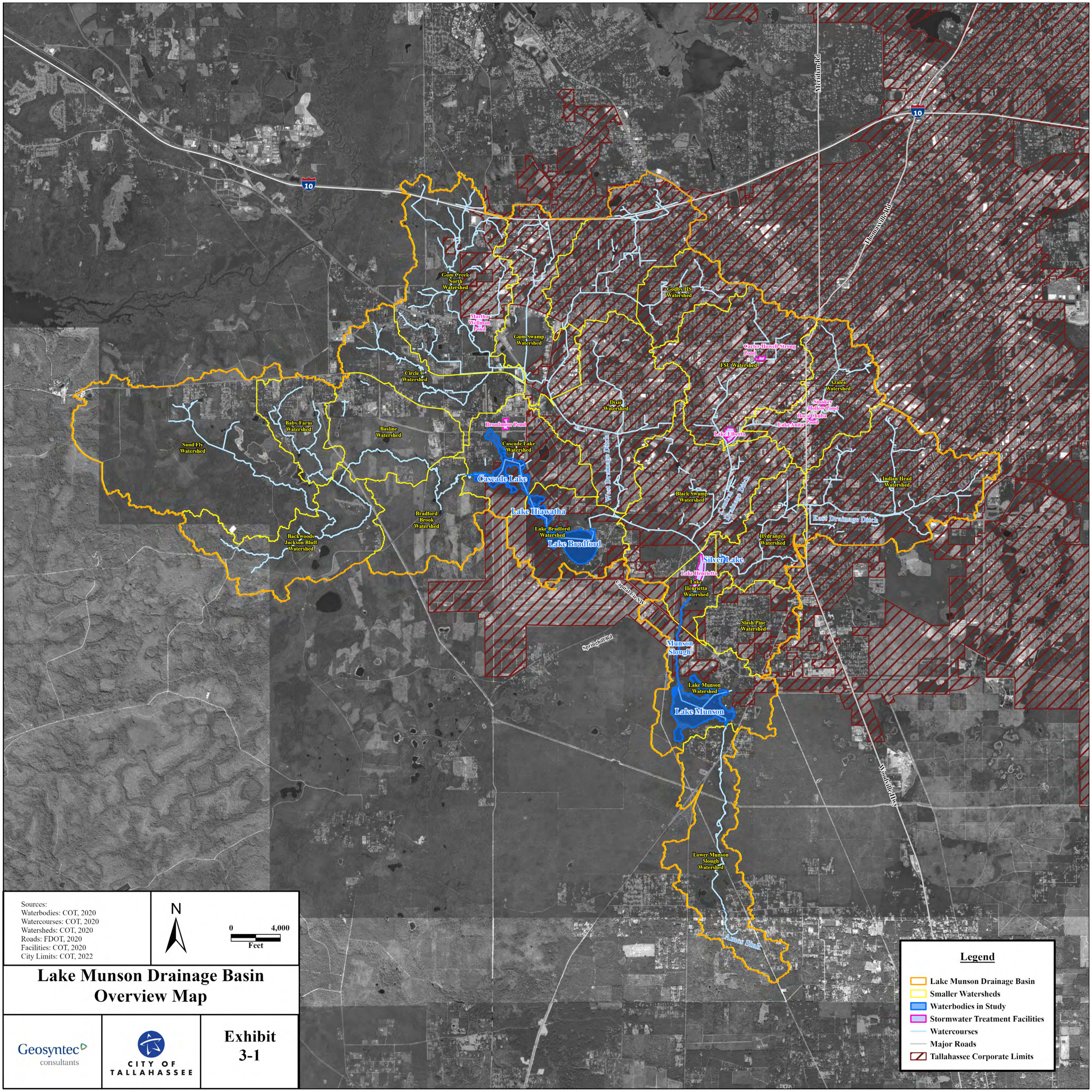


Figure 3-1:
Lake Munson Basin Location Map

Tallahassee Master Plan - Surface Water (TMaPS)


10
Meridian Rd
Thomasville Rd
Gum Creek North Watershed
Martha Wellman Pond
Gum Swamp Watershed
Godby HS Watershed
Carter-Howell-Strong Pond
FSU Watershed
Azalea Watershed
Smokey Hollow Pond
Boca Chuba Pond
Lake Anita
Lake Elberta
Circle G Watershed
Dixie Watershed
Baby Farm Watershed
Basline Watershed
Broadmoor Pond
Cascade Lake Watershed
Sand Fly Watershed
Cascade Lake
Lake Hiawatha
West Drainage Ditch
Black Swamp Watershed
Indian Head Watershed
East Drainage Ditch
Bradford Brook Watershed
Lake Bradford Watershed
Lake Bradford
Backwoods Jackson Bluff Watershed
Hydrangea Watershed
Silver Lake
Lake Henrietta
Lake Henrietta Watershed
Capital Cir SW
Springhill Rd
Slash Pine Watershed
Munson Slough
Lake Munson Watershed
Lake Munson
Woodville Hwy
Lower Munson Slough Watershed
Ames Sink
Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Watersheds: COT, 2020
Roads: FDOT, 2020
Facilities: COT, 2020
City Limits: COT, 2022
N
0
4,000
Feet
Lake Munson Drainage Basin
Overview Map
Geosyntec
consultants
CITY OF TALLAHASSEE
Exhibit
3-1
Legend
Lake Munson Drainage Basin
Smaller Watersheds
Waterbodies in Study
Stormwater Treatment Facilities
Watercourses
Major Roads
Tallahassee Corporate Limits

3.2 Report Review Summary

For the Lake Munson basin, a series of reports was reviewed that provided the history and background of the basin and its waterbodies, along with data and other information to support the identification of potential sources and structural and non-structural projects to improve water quality. **Table 3-1** presents a list of the reports and other information reviewed.

The reports/information range in time from the 1970s through the present and include water quality studies on the various lakes and causes of water quality degradation; analyses of measured hydrologic, water quality, and biological data; management plans to address restoration of Lake Munson and other waterbodies within the basin; lake sediment studies; fish and benthic studies; grant documents; National Pollutant Discharge Elimination System (NPDES) permits; and presentations on Lake Munson and other waterbodies within the basin.

Table 3-1: Lake Munson Basin Reference List

Report Name	Author	Year
Report on Lake Munson Leon County, Florida, EPA Region IV, Working Paper No. 268 (National Eutrophication Survey)	EPA	1977
Water Quality Evaluation of Lake Munson, Leon County, Florida Water Resources Assessment 88-1	NWFWMD	1988
Stormwater Management Plan Volume VI - Technical Report	NWFWMD	1991
City Of Tallahassee and Leon County Stormwater Management Plan Volume I: Executive Summary (Water Resources Assessment 91-1)	NWFWMD	1992
City of Tallahassee and Leon County Stormwater Management Plan, Volume II: Lake Munson Basin Plan. Water Resources Assessment 91-2	NWFWMD	1992
Figure 5. Lake Munson Basin Recommended Structural and Non-Structural Alternatives	Lake Munson Action Team	1993
1994 Lake Munson Management Plan	Map	1994
Lake Munson Restoration	Leon County Public Works	1997
Final Report - FY97 Section 319 Grant Program	Leon County Public Works	1997
Sediment Investigation: Lake Munson Enhancement Project	Leon County/ESG	2005
Correlation of Environmental Analysis - Lake Munson Sediment Samples	ESG	2007
Final TMDL Supplemental Information Report for Munson Slough/Lake Munson, WBIDs 807, 807C, and 807D	FDEP	2010

Table 3-1: Lake Munson Basin Reference List

Report Name	Author	Year
FINAL TMDL REPORT: TMDLs for Munson Slough, WBID 807D (Dissolved Oxygen); Lake Munson, WBID 807C (Dissolved Oxygen, Nutrients [Trophic State Index], and Turbidity); and Munson Slough below Lake Munson, WBID 807 (Dissolved Oxygen and Un-ionized Ammonia)	FDEP	2013
Lake Munson: Spatial and Temporal Changes in Characteristics of Sediment Nutrients during an Extreme Drawdown Event (text)	DEAR	2013
Spatial and Temporal Changes in Nutrient Characteristics of Sediments during an Extreme Drawdown Event in Lake Munson, Florida, USA	FDEP	2014
Evaluation of the Feasibility of Sediment Nutrient Inactivation in Lake Munson. Final Report	ERD	2016
Lake Munson Seminar, June 9, 2016 [both PowerPoint (City LakeMunsonSeminar) and PDF (Heidecker Lake Munson Seminar) saved]	City	2016
Significance of Internal Recycling in Lake Munson and Feasibility of Sediment Inactivation Using Alum, Lake Munson Summit [both PPT (Harper_Lake MunsonSeminar) and PDF (Harper_LakeMunsonSeminar) saved]	ERD	2016
Recommendations for the Lake Munson Basin (Powerpoint) And text summary titled BMP Recommendations for the Lake Munson Basin	Theresa Heiker	2016
Conservation and Other Land Uses Within the Lake Munson Watershed	Leon County Planning Department)	2016
Discussion topics from the Lake Munson Meeting; June 9, 2016 with editorial notes from meeting	WML	2016
Lake Munson	Leon County Public Works	2016
Summary of Lake Munson Presentation 2016	Leon County Public Works	2016
Ames Sink Acquisition Proposal	Stevenson (florida_springs@comcast.net)	2016
Leon County Science Advisory Committee, Lake Munson Meeting (6/6/2016) Summary of the FWC Presentation	BJ Jamison (DFFM), Derek Fussell (IPM) and Megan Keserauskis & BJ Jamison (AHRE)	2016

Table 3-1: Lake Munson Basin Reference List

Report Name	Author	Year
Lake Munson: Spatial and Temporal Changes in Nutrient Characteristics of Sediments During a Drawdown Event (ppt)	DEAR	2016
Lake Munson	FWC: HSC, AHRE, IPM DFFM	2016
Lake Munson Meeting June 9, 2016	Science Advisory Committee	2016
Science Advisory Committee Meeting presentation	Charles Hargraves and Gary Phillips	2016
City of Tallahassee – Lake Munson Presentation Summary	City	2016
City of Tallahassee MS4 As it Relates to the DEP Assessment of Surface Waters & Strategic Monitoring	City	2017
Ground Penetrating Radar Survey of Lake Munson	FGS	2018
Lake Munson Sediment Sampling and Analysis Project	FGS	2019
Letter of Support to NWFWMD re: FDEP Office of Ecosystem Projects Harmful Algal Bloom Innovative Technology Grant for Lake Munson	City	2019
Project Information Proposal For Grant Funding Consideration: Intact Cellular Algae Harvesting with Simultaneous Nutrient Export in Lake Munson to Mitigate Harmful Algae Blooms and Reduce Direct Nutrient Enrichment of the Floridan Aquifer.	NWFWMD	2019
Toxicology Consult for Lake Munson	FDOH	2020
Approved Wastewater Discharge Permit Facility Project – Lake Munson Tallahassee FL. AECOM Permit # 20200507-003 for Lake Munson Tallahassee FL. / Gil Waters Preserve Park, 5800 Crawfordville Road (30.365140 84.302403)	City	2020
Conceptual Approval ERP Leon County Central Drainage Ditch ERP Permit No.: 0391181-001-EC/37	FDEP	2020
Lake Munson Sediment Sampling and Analysis Project Review	Terracon Consultants	2021
Waterbody Summary for Lake Munson	Leon County	2021

3.3 Volume Outline

The sections that follow present the results from the completion of work tasks to date including: an overview of available data; assessment of the water quality conditions in the primary waterbodies and the tributaries that drain into them; development of potential pollutant loads; identification of "hot spot" areas, by waterbody, to target for structural and non-structural projects within the Lake Munson basin; and recommendations for additional data collection or studies to fill data gaps and support assessment of specific stressors to the primary waterbodies. The specific tasks, with a description of the work, include the following.

- Task 1 – Data Collection
  - Collection and review of data for use in project analyses.
- Task 2 – Waterbody Data Review and Summary
  - Evaluation of existing water quality conditions and general health of target waterbodies using available data and studies.
  - Qualitative assessment for each waterbody to identify pollutant loading sources to focus on.
- Task 3 – Water Quality Assessment
  - Calculation of pollutant load estimates to the target waterbodies (where data allow) including stormwater runoff, groundwater impacted by onsite sewage treatment and disposal systems (OSTDS), point sources, lake inflow, internal recycling, and atmospheric deposition.
  - Identification of hotspots within each drainage basin and prioritization of waterbodies to target for restoration efforts.
- Task 4 – Water Quality Study Identification and Prioritization
  - Identification of potential data collection or water quality improvement studies needed to address data gaps.

Section 3.4 through **Section 3.6** present an overview and history for each of the primary waterbodies along with the findings and results from Tasks 1 through 3. **Section 3.7** presents a basin-wide assessment of hot spot areas as outlined in Task 3 to target for structural and non-structural projects based on the data and analyses presented in **Section 3.4** through **Section 3.6**. **Section 3.8** presents a summary of potential stressors within target waterbodies and recommendations on data collection or studies.

3.4 Lake Munson and Munson Slough Downstream of Lake Henrietta SWMF

This section presents the results from Tasks 1 through 3 for Lake Munson and Munson Slough downstream of Lake Henrietta SWMF. This includes an overview and history of the lake and basin, present impairment status of waterbodies in the basin, an overview of available data, a qualitative assessment of potential pollutant sources, and calculation of potential pollutant loads.

3.4.1 Overview and History

Lake Munson is a 255-acre shallow manmade lake that was a cypress swamp with pockets of open water prior to dam construction. The earliest documented use of Lake Munson was in 1704 by the Spanish Deputy Governor who ordered men to go up the St. Marks and Wakulla River by canoe up to a landing place near the Saint Luis Fort (Lake Munson Action Group, 1993). An 1840 map shows Munson's Mill Pond, and by 1883, maps show Munson Lake. In the 1900s, the lake was used as a hunting area for waterfowl and identified as a good Cracker fishing lake. In the 1950s, the swamp was impounded through the construction of a dam with several control structures to alleviate flooding downstream. It is noted that, according to the 1993 Lake Munson Action Group report, some form of structure to impound the lake may have been present as early as 1840.

In more recent times, a modern dam control structure was constructed to replace the 1950s dam. **Photo 3-1** through **Photo 3-8** present aerial photographs of Lake Munson from 1937 through 2020. The photos show that overall, the lake has retained it general shape and open water area. The introduction of the dam in the 1950s appears to create a larger permanent pool area than is seen in the 1930s photo. **Photo 3-9** and **Photo 3-10** show the lake and the control structure respectively in 2021. Lake Munson discharges to lower Munson Slough, Eight Mile Pond, and Ames Sink. Recharge from Ames Sink emerges at Wakulla Spring and flows to the Gulf of Mexico. Dye trace studies have confirmed a direct connection between Ames Sink and Wakulla Spring (Stevenson, 2016).

The lake receives the majority of its water from Munson Slough and its tributaries, which drain a significant portion of the City's incorporated area (**Exhibit 3-1**). There are four primary drainageways that flow together into Munson Slough prior to discharging (through Lake Henrietta SWMF) into Lake Munson. The East Drainage Ditch is located entirely within the City's incorporated boundaries and drains approximately 3,800 acres including the Hydrangea and Indian Head watersheds. The Central Drainage Ditch, also fully within the City's incorporated boundaries, drains approximately 4,800 acres including the Azalea, Florida State University (FSU) and Black Swamp watersheds. The Central Drainage Ditch is almost entirely located within the highly urbanized downtown areas of Tallahassee. The West Drainage Ditch, located within both incorporated and unincorporated areas, drains approximately 6,700 acres including the Dixie, Gum Swamp, Solstice, Gum Creek North, and Circle C watersheds. Finally, Bradford Brook, which passes through the Bradford Chain of Lakes, drains an area of approximately 12,600 acres, including the Lake Bradford, Cascade Lake, Bradford Brook, Baseline, Baby Farm, Sand Fly, and Backwoods Jackson Bluff watersheds, which are mostly within unincorporated Leon County and the bulk of the western portions within the Apalachicola National Forest.

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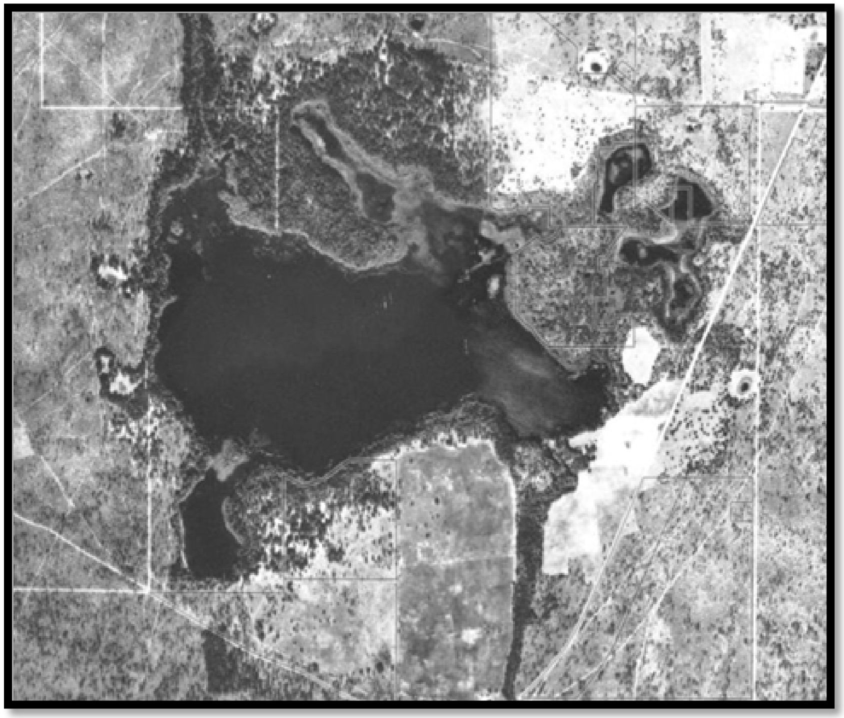

Photo 3-1: Lake Munson Aerial – 1937

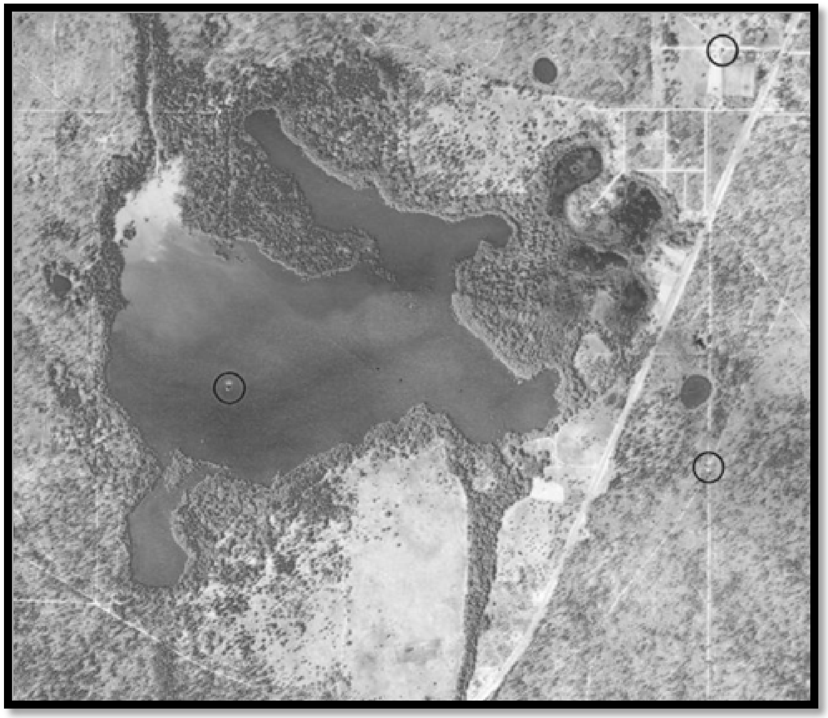

Photo 3-2: Lake Munson Aerial – 1949

Photo 3-3: Lake Munson Aerial – 1954

Photo 3-4: Lake Munson Aerial – 1970

Photo 3-5: Lake Munson Aerial – 1983

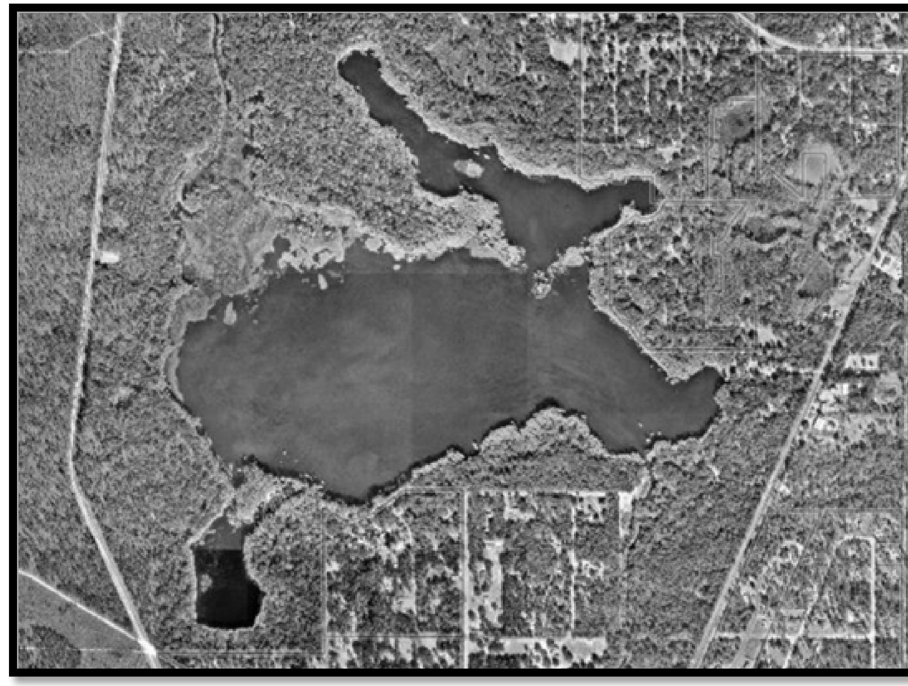

Photo 3-6: Lake Munson Aerial – 1996

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Photo 3-7: Lake Munson Aerial – 2007

Photo 3-8: Lake Munson Aerial – 2020

Photo 3-9: Lake Munson (2021)

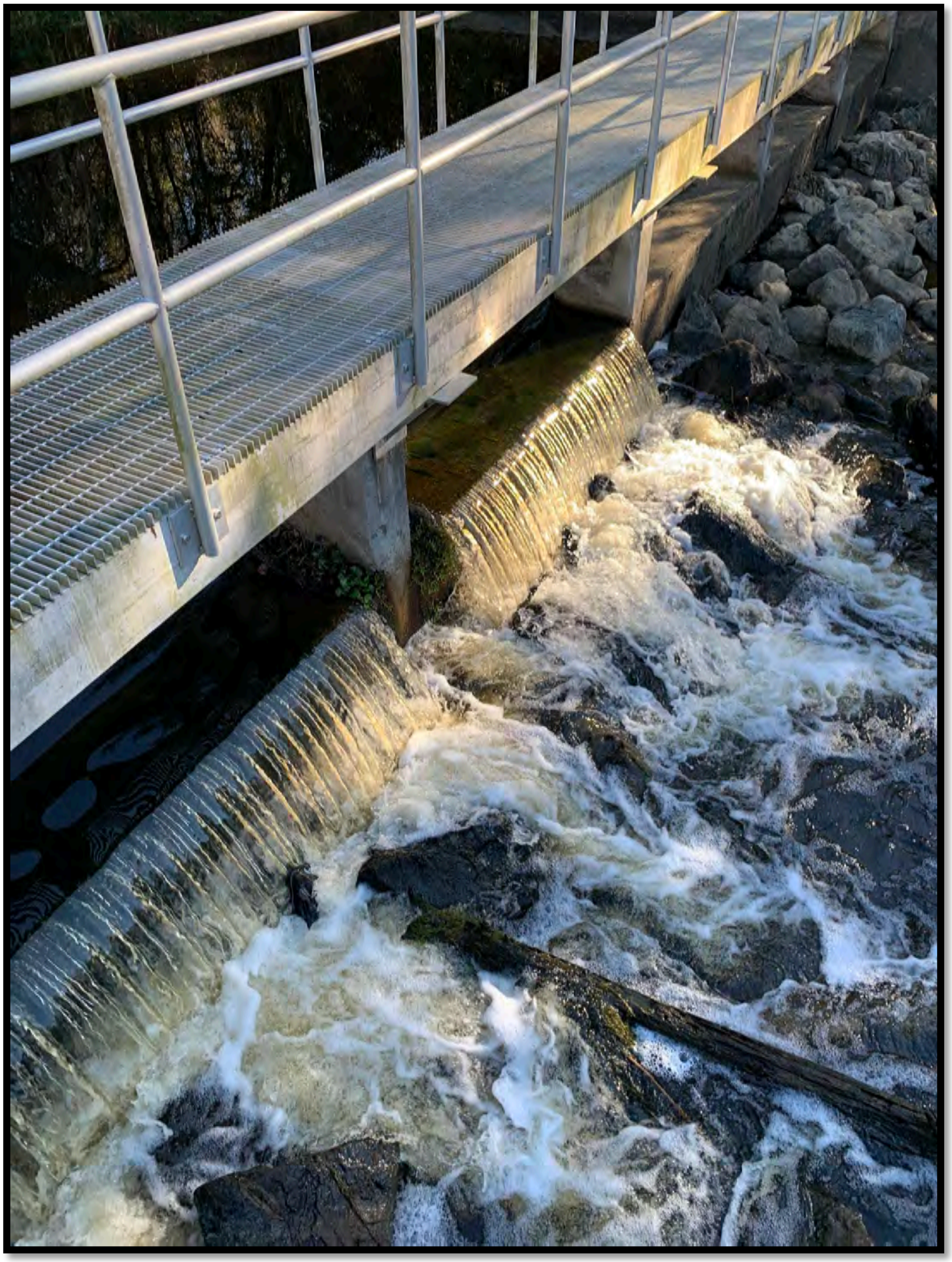


Photo 3-10: Lake Munson Dam Control Structure (2021)

The Dale Mabry wastewater treatment facility was built in the 1930s and discharged primary treated effluent to the Central Drainage Ditch upstream of Lake Munson. The Lake Bradford wastewater treatment facility was built in the 1950s and also discharged treated effluent upstream of the lake. Following the introduction of the wastewater discharges, Lake Munson, including Munson Slough, experienced nutrient enrichment, low dissolved oxygen (DO), algal blooms, high bacteria levels, and degraded sediment conditions. The first reports of massive algal blooms and fish kills in the lake date as early as 1956 [Northwest Florida Water Management District (NWFWMD), 1988]. As part of the National Eutrophication Survey initiated in 1972, Lake Munson was ranked 39th out of 41 lakes for lake water quality in Florida [U.S. Environmental Protection Agency (EPA), 1977]. The EPA report identified that Lake Munson was nitrogen limited and calculated that 46 percent of the total phosphorus (TP) load and 44 percent of the total nitrogen (TN) load to the lake was from wastewater plants. The 1988 Water Quality Evaluation by the NWFWMD noted that in 1982 Lake Munson was classified as hypereutrophic and ranked the seventh most degraded lake in the state. The City constructed a wastewater sprayfield in 1984, which resulted in removal of the direct discharges and improved water quality in the lake. Afterward, the lake was classified as eutrophic and ranked the fifty-second most degraded lake in the state.

While the removal of the direct wastewater discharges significantly decreased nutrient loads reaching the lake, the lake continued to receive nutrient loads from stormwater runoff primarily originating in urban areas and conveyed to the lake via Munson Slough and its tributaries. A study conducted by NWFWMD (1988), following the removal of the direct discharges, identified significant loading of sediments, biochemical oxygen demand (BOD), TN and TP. Using inflow, in-lake, and outflow concentration data, NWFWMD estimated that the lake retained 95 percent of the sediments, 20 percent of the BOD, 31 percent of the nitrogen, 64 percent of the phosphorus, and over 70 percent of various metals. Tests conducted in the lake indicated significant release of orthophosphate from the sediments and metal concentrations in the sediments 10 to 100 times higher than other lakes.

In the early 1990s, a Stormwater Management Plan was developed by the City and Leon County to evaluate stormwater treatment and flood reduction options (NWFWMD, 1991). The plan identified a series of structural projects to treat the stormwater loads and reduce flooding as well as non-structural alternatives to support restoration of water quality and preservation of sensitive areas. Structural project recommendations included:

- East Drainage Ditch stormwater facilities,
- Jim Lee Road Pond on the East Drainage Ditch,
- Vega Drive Pond on the West Drainage Ditch,
- FSU Pond on the Central Drainage Ditch,
- Orange Avenue Pond on the East Drainage Ditch,
- Eisenhower Avenue facility on the West Drainage Ditch, and
- Culvert enlargements at various areas locations along the East and West Drainage Ditches.

Non-structural recommendations included:

- Acquisition and protection around Gum Swamp,
- Restoration of Lake Henrietta SWMF,
- Restrictions and preservation efforts around Black Swamp,

- Development restrictions in sensitive areas around Lake Bradford and Bradford Brook,
- Detailed studies to support direct efforts on Lake Munson restoration and monitoring,
- Development restrictions around Grassy Lake, and
- Restrictions on encroachment and development within sensitive wetland areas within the basin.

Following the development of the Stormwater Management Plan, the Lake Munson Action Team provided additional recommendations to support improved water quality in Lake Munson (Lake Munson Action Group, 1993). The recommendations included:

- Fully implement Lake Munson Projects in the Stormwater Management Plan;
- Repair the dam at the southern end of Lake Munson;
- Remove organic muck after stormwater projects completed;
- Routine winter drawdowns to oxidize and consolidate organic sediments;
- Increase protection of wetlands within the basin;
- Increase inspection and maintenance of all stormwater treatment facilities;
- Develop more stringent limits on impervious area within the basin;
- Continue to control exotic aquatic plants with the judicious use of herbicides;
- Address litter and trash through a combination of legislative programs, social programs, and structural best management practices (BMPs);
- Increase lake shore protection and public access through acquisition of lakefront property, coordination with lakefront property owners on restoration activities, and developing and managing facilities in an environmentally sensitive manner; and
- Acquire sensitive areas such as Blackwater Swamp.

In general, the planned approach to the restoration of Lake Munson included two phases. Phase one was to first reduce the loading of sediments, nutrients and other pollutants to the lake through Munson Slough to levels able to be naturally assimilated. And then, following completion of projects to reduce loads, phase two was to address legacy loads and internal recycling within the lake.

Phase one began immediately following the aforementioned planning efforts. Since the 1990s, more than 70 projects to reduce stormwater loads and alleviate flooding have been completed within the basin, at a cost of more than $285 million dollars. Notable stormwater treatment facilities are identified in **Exhibit 3-1** and discussed below. Additional discussions on facilities located within the Bradford Chain of Lakes and Silver Lake watersheds are presented and discussed in **Section 3.5** and **Section 3.6**, respectively.

Due to its highly urbanized nature, the Central Drainage Ditch, and the historic St. Augustine Branch which flows into the Central Ditch, contain a number of larger regional facilities. The Carter-Howell-Strong Pond (**Photo 3-11**), located in the upper end of the Central Ditch is a 5-acre wet detention facility that receives drainage from portions of FSU and surrounding residential areas. Lake Elberta (**Photo 3-12**) is a 17-acre wet detention facility at the confluence of the Central and St. Augustine Branch. A series of treatment facilities is located along the historic St. Augustine Branch. These include the Cascade Park stormwater treatment facilities including two wet detention ponds (1 acre and 2 acre) and other treatment components (**Photo 3-13**), Lake Anita (**Photo 3-14**) a 2-acre wet detention facility along FAMU Way, and a 1.2-acre wet pond near Railroad Square Park (**Photo 3-15**).

Photo 3-11: Carter-Howell-Strong Wet Detention Pond

Photo 3-12: Lake Elberta Wet Detention Pond

Photo 3-13: Boca Chuba Wet Detention Pond in Cascade Park

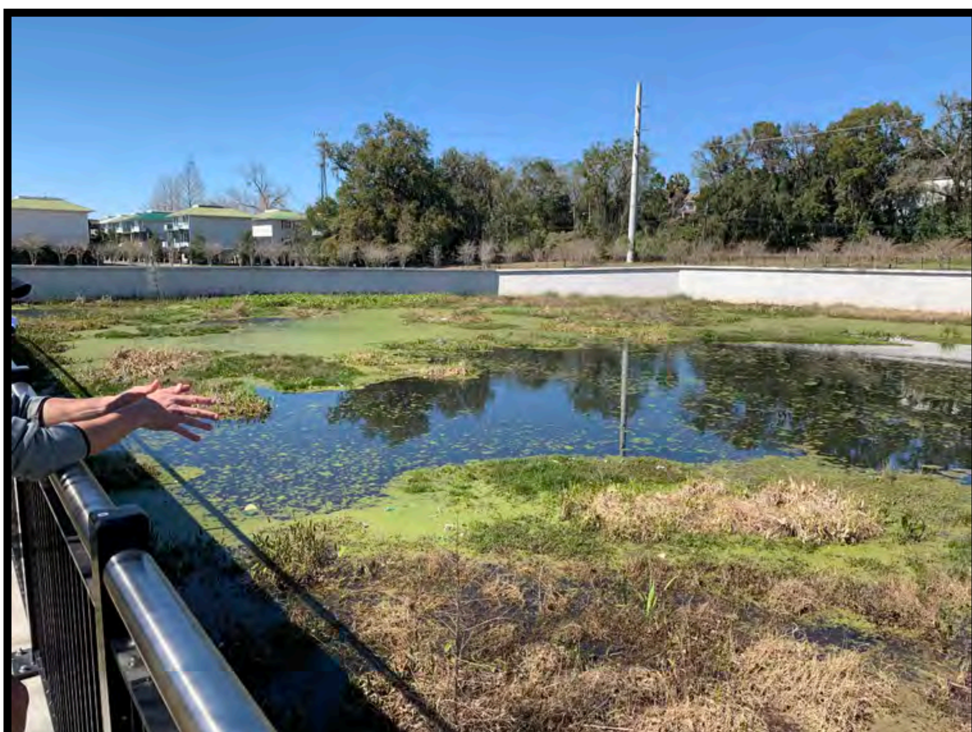


Photo 3-14: Lake Anita Wet Detention Pond

Photo 3-15: Wet Detention Pond near Railroad Square Park

Treatment facilities within the West Drainage Ditch are generally smaller stormwater treatment facilities constructed to support land development and are maintained by the City and the Florida Department of Transportation (FDOT). Numerous FDOT-maintained facilities are located around I-10 and Capital Circle in the upper portions of the West Drainage Ditch. One larger facility, maintained by Leon County, is Martha Wellman Pond, a 13-acre wet pond near the intersection of Capital Circle SW and West Tennessee (**Photo 3-16**).

Photo 3-16: Martha Wellman Wet Detention Pond

The largest stormwater facility within the Lake Munson basin is the Lake Henrietta SWMF, which was constructed in 2000 and is located at the confluence of Munson Slough and the East Drainage Ditch. Lake Henrietta was historically a wetland system that was altered through the construction of a mosquito control ditch and berm, and ongoing sedimentation and pollutant discharge from Munson Slough. As part of the Leon County Lake Munson restoration, the altered wetland system was converted to a 25-acre wet detention treatment facility with trash traps to reduce sediments, slow runoff, and reduce trash before water enters the restored and stabilized channel north of Lake Munson (**Photo 3-17** and **Photo 3-18**).

In addition to treatment facilities, projects have been constructed to stabilize channels to reduce erosion and the transport of sediments to downstream waterbodies. **Photo 3-19** shows a bank stabilization project along the Central Drainage Ditch. Ongoing erosion issues still exist at various locations throughout the drainage system. **Photo 3-20** shows a portion of the Central Drainage Ditch along Eppes Drive where bank erosion can be seen.

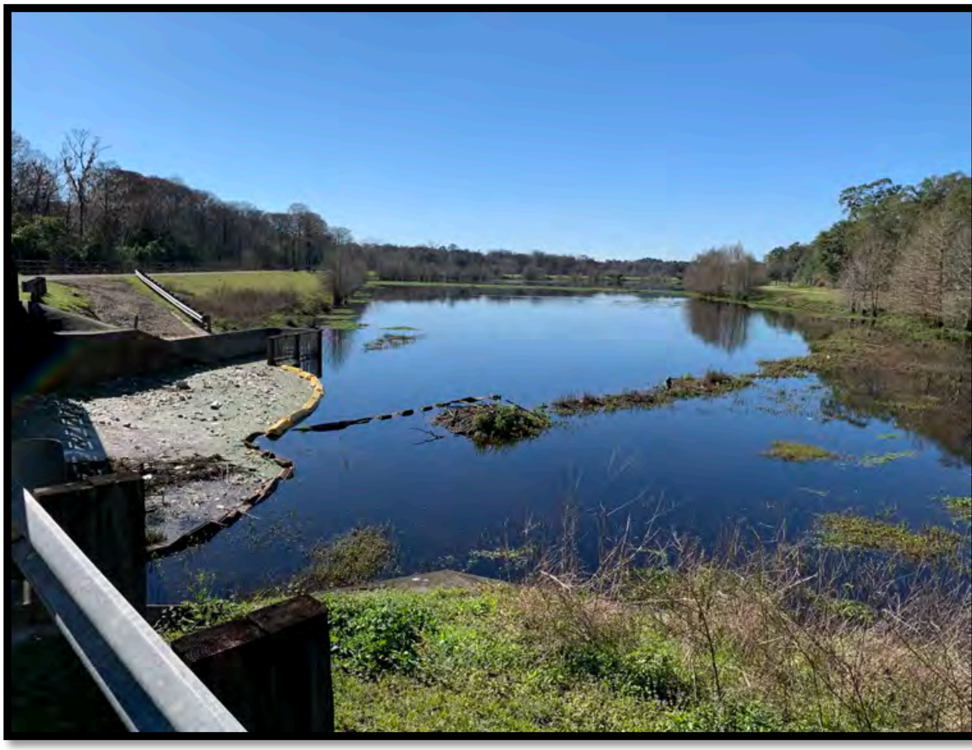


Photo 3-17: Lake Henrietta SWMF Regional Treatment Pond, North End Facing South

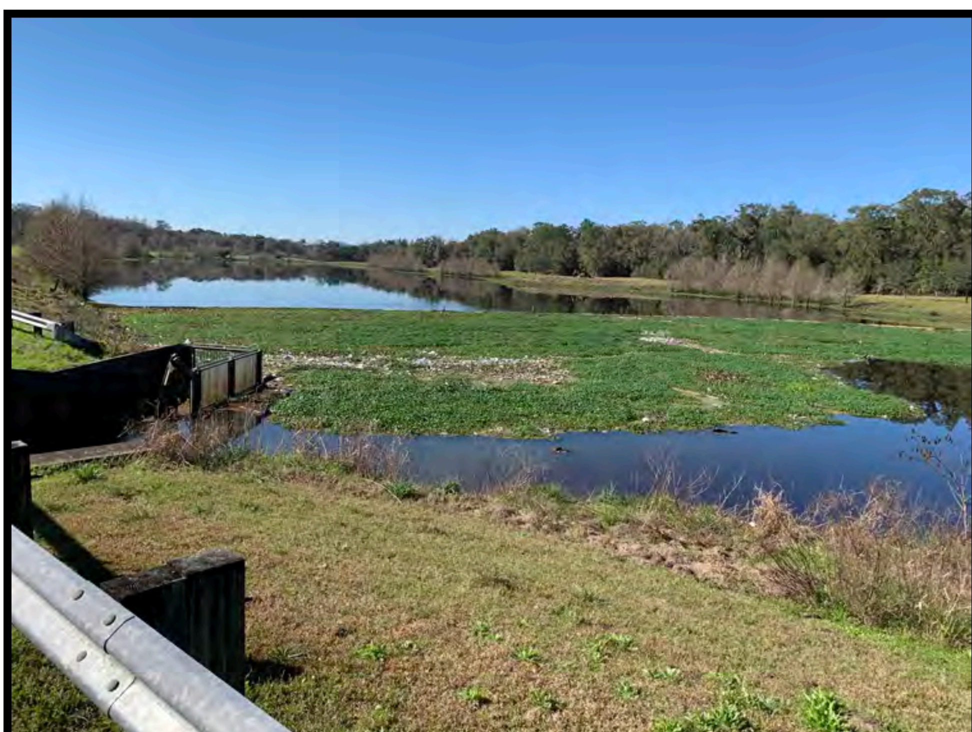


Photo 3-18: Lake Henrietta SWMF Regional Treatment Pond, Middle and South Sections Facing South

Photo 3-19: Channel Stabilization Project along Central Ditch

Photo 3-20: Central Ditch Bank Conditions near Epps Drive

Like previously mentioned, phase two of the Lake Munson restoration plan was to focus on internal recycling of nutrients and nutrient flux from sediments due to legacy loading. The buildup of in-lake nutrient loads has been identified in numerous studies as a significant loading source to the lake. Leon County conducted a sediment study in 2005 taking 125 borings throughout the lake (Leon County, 2005). They identified the natural soils as having relatively low organic content (1 to 3 percent), with other sediments found in the lake with organic contents upwards of 60 percent. An analysis of sediment data from 1997 and 2005 by Leon County and the Florida Fish and Wildlife Conservation Commission (FWC) evaluated the feasibility of disposal of sediments once removed (Leon County and FWC, 2007). The analyses determined that the sediments could be put in a nearby disposal facility so long as it was capped to prevent runoff of polychlorinated biphenyls (PCBs). A key consideration was the level of disturbance (suspension) of the sediments during removal and the transportation/dewatering.

To date, the main activities completed to address in-lake loads have been periodic drawdowns for the purpose of oxidizing and consolidating the sediments and reducing long-term fluxes. Drawdowns occurred in 1977 and 2010. The 2010 drawdown commenced on October 18, 2010, and continued until June 14, 2011 (**Photo 3-21**).

A 2014 Florida Department of Environmental Protection (FDEP) sediment biogeochemical study to quantify temporal and spatial changes in nutrient characteristics of the lake sediments in response to the 2010 drawdown indicated that significant removal of TN occurred but TP removal was not as significant (FDEP, 2014). The study identified that a combination of planting and harvesting could maximize TN and TP removal from the exposed lake sediments through proper management of the drawdown.

Photo 3-21: Lake Munson during Drawdown (2011)

A 2016 evaluation of the feasibility of sediment nutrient inactivation in Lake Munson determined that significant buildup of nutrients has occurred within the sediments due to 50 years of nutrient-rich inflows (ERD, 2016). Analyses of concentrations between the inflow and outflow of the lake indicated significant internal recycling. The study concluded that the 2010 drawdown appeared to have little impact on the in-lake water quality, and that sediment inactivation using alum could be successful in reducing internal recycling of phosphorus. To date, however, sediment inactivation has not been employed as a treatment strategy in Lake Munson.

In 2018, Leon County and the Florida Geologic Survey (FGS) initiated a sediment study where cores were collected and analyzed at 37 locations throughout Lake Munson, Munson Slough and Lake Henrietta SWMF (FDEP-FGS, 2019). The analyses focused primarily on contaminants in the sediments relative to removal and disposal. A 2021 review of the data collected in 2018 (Terracon, 2021), indicated that ongoing and continued contaminant releases into Lake Munson are not occurring because only the most persistent organic and inorganic contaminants are prevalent. The study identified that the compounds in the lake accumulated from activities prior to the mid-1990s and continue to persist due to their resistance to or inability to break down.

In addition to drawdowns, NWFWMD recently entered into a contract with AECOM for a pilot study of algae harvesting in Lake Munson for removal of in-lake nutrient loads. NWFWMD postulated that the root cause of the lake's continued water quality problems are legacy nutrients contained within the lake sediments and surrounding soils that release nutrients in the lake's water column. Algae harvesting can reduce in-lake nutrient concentrations by directly removing a nutrient sink and reducing the release of legacy nutrients by reducing oxygen demand. The pilot algae harvesting system was established near the lake's control structure and operated from 2021 to 2022. It is noted that minimal algae harvesting occurred due to insufficient algae growth, so the pilot project location was moved to an alternative waterbody. No data was available at the time of this report to evaluate the effectiveness of the harvesting.

At present, the City and County plan for additional stormwater retrofit and improvement projects within the basin. Several future projects are described in a 2020 FDEP conceptual Environmental Resource Permit authorizing activities along the Central Drainage Ditch, specifically: Capital Cascades Trail Segment 4, Rerouting Untreated Stormwater to the Lake Elberta Regional Stormwater Facility, and Expansion of the Lakes Stormwater Management Facility. FWC also continues aquatic plant management on Lake Munson. Leon County has continued periodic drawdowns with a recent drawdown between November of 2022 to December of 2023.

3.4.2 Regulatory Status

EPA is authorized under Section 303(d) of the Clean Water Act to assist states in the identification of impaired waterbodies and the calculation of total maximum daily loads (TMDLs) to these waterbodies. FDEP administers the 303(d) program in Florida. A waterbody on the FDEP's 303(d) list falls into one of several categories:

Category 4a **–** The waterbody is impaired but does not require TMDL development because a TMDL has already been completed.

Category 4b **–** The waterbody is impaired but will not require a TMDL to be developed because the waterbody will attain standards due to existing or proposed measures.

Category 4c **–** The waterbody is impaired, but the impairment is not caused by a pollutant and therefore does not require a TMDL.

Category 4d **–** The waterbody is impaired but the pollutant causing impairment is not known. A TMDL cannot be calculated until the pollutant is identified.

Category 4e **–** The waterbody is impaired, but ongoing or recently completed restoration activities are underway to restore designated uses, so a TMDL calculation is not necessary.

Category 5 **–** The waterbody is impaired, and a TMDL will be calculated.

Waterbodies in Florida on the FDEP's 303(d) list are impaired. Waterbodies classified in Category 5 are placed on FDEP's comprehensive Verified List. When a waterbody is placed on the Verified List, FDEP is required by law to develop a TMDL. Waterbodies classified on Categories 4a through 4e are not on the comprehensive Verified List but are considered impaired. Generally, this means that more study is needed (4d) or FDEP has identified that local efforts are expected to restore the waterbody (4b and 4e).

FDEP has the option to develop basin management action plans (BMAPs) for waterbodies that have adopted TMDLs. A BMAP is a framework for water quality restoration in various forms containing commitments at local and state levels. These broad-based plans are developed with local stakeholders, including cities and counties. Once these plans are adopted by FDEP Secretarial Order, they are legally enforceable. FDEP also has a process by which local entities can initiate restoration activities in lieu of development of a TMDL. This type of activity fits under the 4e and 4b categories. These are locally driven restoration efforts with a goal to meet water quality standards. This process is often favored because it puts control in the hands of the local stakeholders to determine what is needed to restore their waterbodies rather than FDEP dictating the terms of a load reduction. The process is also much faster than the traditional TMDL/BMAP pathway, which can take more than a decade.

FDEP finalized TMDLs for Lake Munson and Munson Slough upstream and downstream of Lake Munson in 2008 and 2013. The TMDLs were established for DO, nutrients/Trophic State Index (TSI) (for the lake), fecal coliform, and un-ionized ammonia. The specific impairments include:

- Munson Slough above Lake Munson [waterbody identification (WBID) 807D] – fecal coliform, DO.
- Lake Munson (WBID 807C) – DO, nutrients (TSI), and turbidity.
- Munson Slough below Lake Munson (WBID 807) – DO and un-ionized ammonia.

Exhibit 3-2 provides a map and table outlining the WBIDs and parameters. The TMDL completed in 2008 was for fecal coliform which is no longer the standard for bacteria. The TMDL completed in 2013 established in-lake and in-stream alternate numeric nutrient criteria (NNC) for Munson Slough above Lake Munson and Lake Munson. These TN and TP targets are discussed in more detail in **Section 3.4.3.7**. In the 2020-2022 Biennial Assessment, FDEP determined that the TMDL for Munson Slough is being met and placed that WBID in Category 2t. Lake Munson was also placed in Category 2t for turbidity.

In addition, there are multiple verified impairments within the Lake Munson basin at present. **Exhibit 3-2** displays the verified impaired WBIDs inside the Lake Munson Drainage Basin. The verified impairments are summarized below.

- Godby Ditch (WBID 820) and East Drainage Ditch (WBID 916) are verified impaired for fecal coliform. However, fecal coliform is no longer the applicable bacteria parameter for its waterbody classification. *Escherichia coli* (*E. coli*) will be included in the upcoming Strategic Monitoring Plan to collect the new applicable bacteria parameter data while the WBID remains on the Verified List for a fecal coliform impairment.
- Lake Munson (WBID 807C), Munson Slough downstream of Lake Munson (WBID 807), Munson Slough upstream of Lake Munson (WBID 807D), Lake Bradford (WBID 878A), and Cascade Lake (WBID 878D) are impaired for lead. In the most recent assessment, Munson Slough upstream of Lake Munson did not exceed the standard for lead but could not be delisted because there are not enough sample events meeting the standard to support delisting.

3.4.3 Waterbody Data Review and Summary

This section presents an overview of available data and data sources for Lake Munson and the Lake Munson basin including bathymetry, land use, soils, septic systems, hydrologic measurements, surface water quality, groundwater quality, biological, stormwater treatment facilities, and atmospheric deposition. Based on the timing of when data was acquired from the

City and/or downloaded and evaluated for this study, December 31, 2020, was the general cutoff date for data acquisition and presentation for this study.

3.4.3.1 Bathymetry

The best available bathymetric information for Lake Munson was developed from a survey completed for FWC in 2005 (**Figure 3-2**). The bathymetric map was developed by Environmental Geotechnical Consultants and may not fully reflect conditions in the lake today.

Based on the 2005 data, the average depth of Lake Munson is around 4 feet (ft) with the deepest portions at around 6 ft and shallow areas along the sides.

3.4.3.2 Land Use

Land use is the term used to describe the general purpose or function of a given area of land. It can represent economic and cultural activities, or it can depict the physical nature of the land (known as land cover). Land use categorization is used for planning and regulation purposes and assists agencies in keeping track of geographic areas for their respective organization purposes, such as zoning or environmental management. Impacts to waterbodies from watershed loading are evaluated, in part, as a function of land use. Event mean concentrations (EMCs) are utilized for simulating water quality concentrations in stormwater runoff. Pollutant loads are a function of pollutant concentration and volume of runoff. Land use types are used to determine appropriate EMCs when assessing water quality impacts from stormwater.

For the purpose of this study, the Level 2 Florida Land Use Cover Classification System (FLUCCS) codes were used to be consistent with classifications used to generate EMC values, which dictate pollutant loading with respect to precipitation and land use types. **Exhibit 3-3** presents a map of the Level 2 land uses within the Lake Munson basin. Tables are provided for both the Level 2 and grouped Level 1 land uses including overall acreages and percent cover. The largest land use types within the Lake Munson Drainage Basin per the grouped Level 1 categories are Urban and Built Up (45 percent) and Upland Forest (31 percent). Within the Urban Built Up category, Medium-Density Residential is the most common. In general, anthropogenic land uses are clustered within the City's incorporated area and along primary roadway corridors on the western side.

3.4.3.3 Soils

Soil classifications for the study were determined from the area's hydrologic soil group category. Hydrologic soil groups are based on estimates of runoff and infiltration potential. The Natural Resource Conservation Service (NRCS), an agency of the U.S. Department of Agriculture (USDA), delineates four primary soil groups (A, B, C, and D) as well as three dual classes (A/D, B/D, and C/D). Group A soils are characterized as having high infiltration rates with low runoff potential, and each subsequent group is characterized by an iteratively lower infiltration rate and higher runoff potential, ending with Group D soils being designated as having very low infiltration rates with high runoff potential. The dual classes represent conditions where infiltration rates under dry conditions would be per the primary soil type, but due to high groundwater levels in these areas, infiltration is low.

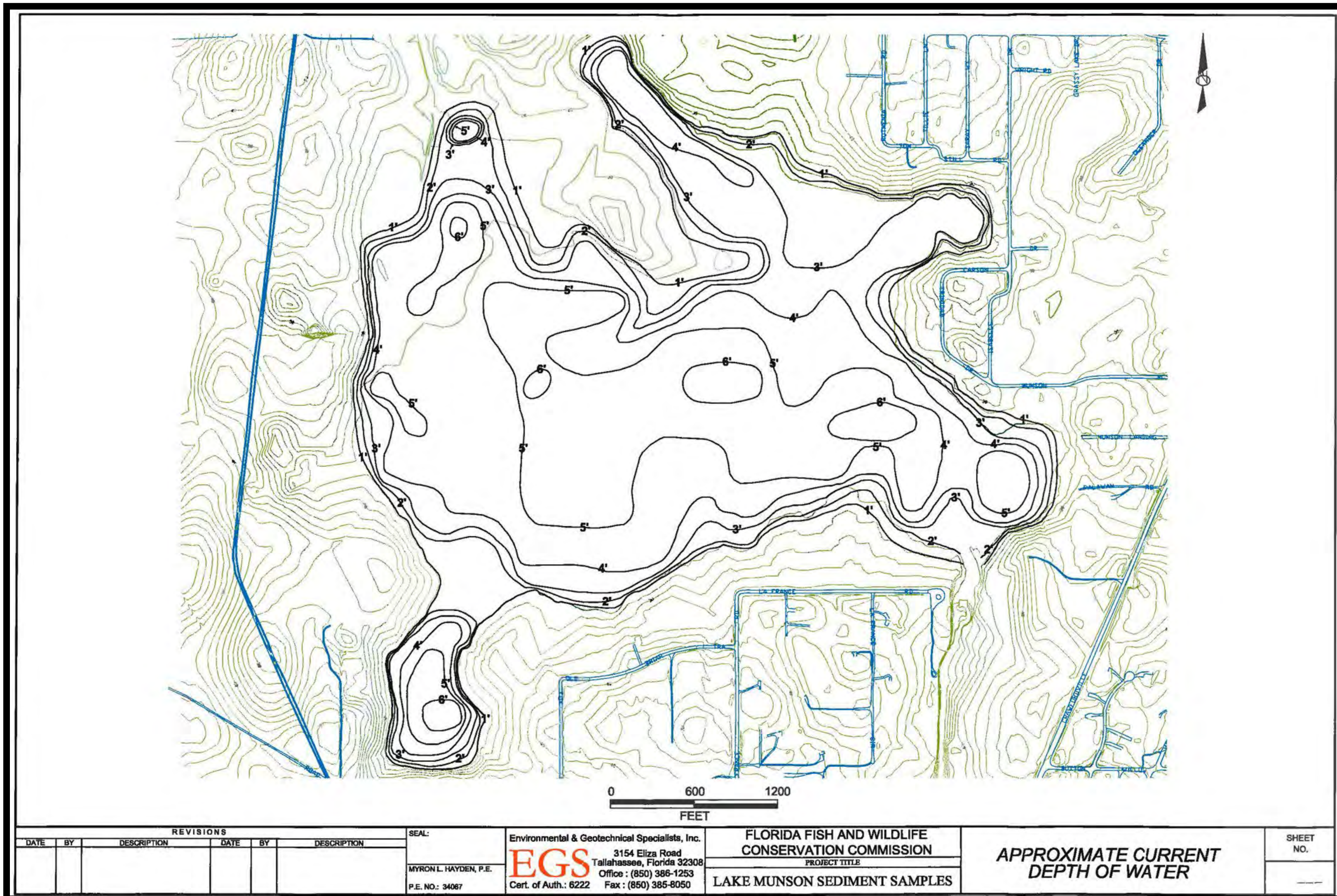


Figure 3-2: Bathymetry in Lake Munson

The most prevalent soil group in the Lake Munson Drainage Basin is Group A (41 percent) and is almost entirely on the western and southern sides of the basin (**Exhibit 3-4**). Group A soils have a high rate of infiltration. The urbanized areas within the City boundaries are predominantly B soils (20 percent). Group B soils have moderate rates of infiltration. Some clusters of A/D or B/D soils are found within low lying tributary sections throughout the basin. These soil groups have high to moderate infiltration potential, but due to elevated groundwater table conditions, will act more similarly to soils with low infiltration potential.

3.4.3.4 Septic Systems

An estimated 4,123 septic tank units are within the boundaries of the Lake Munson Drainage Basin based on the Florida Department of Health (FDOH) septic tank layer (**Exhibit 3-5**). Effluent from septic tanks that are in good condition should be comparable to secondarily treated wastewater effluent from sewage treatment plants. However, septic systems can be a source of pollutants, pathogens, and nutrients and are identified by FDEP as a potential source of bacteria and nutrients to waterbodies in its assessment processes. Within the Lake Munson basin, septic systems are generally clustered within neighborhoods outside of the City's incorporated area (**Exhibit 3-5**) but some are found within the City's incorporated areas.

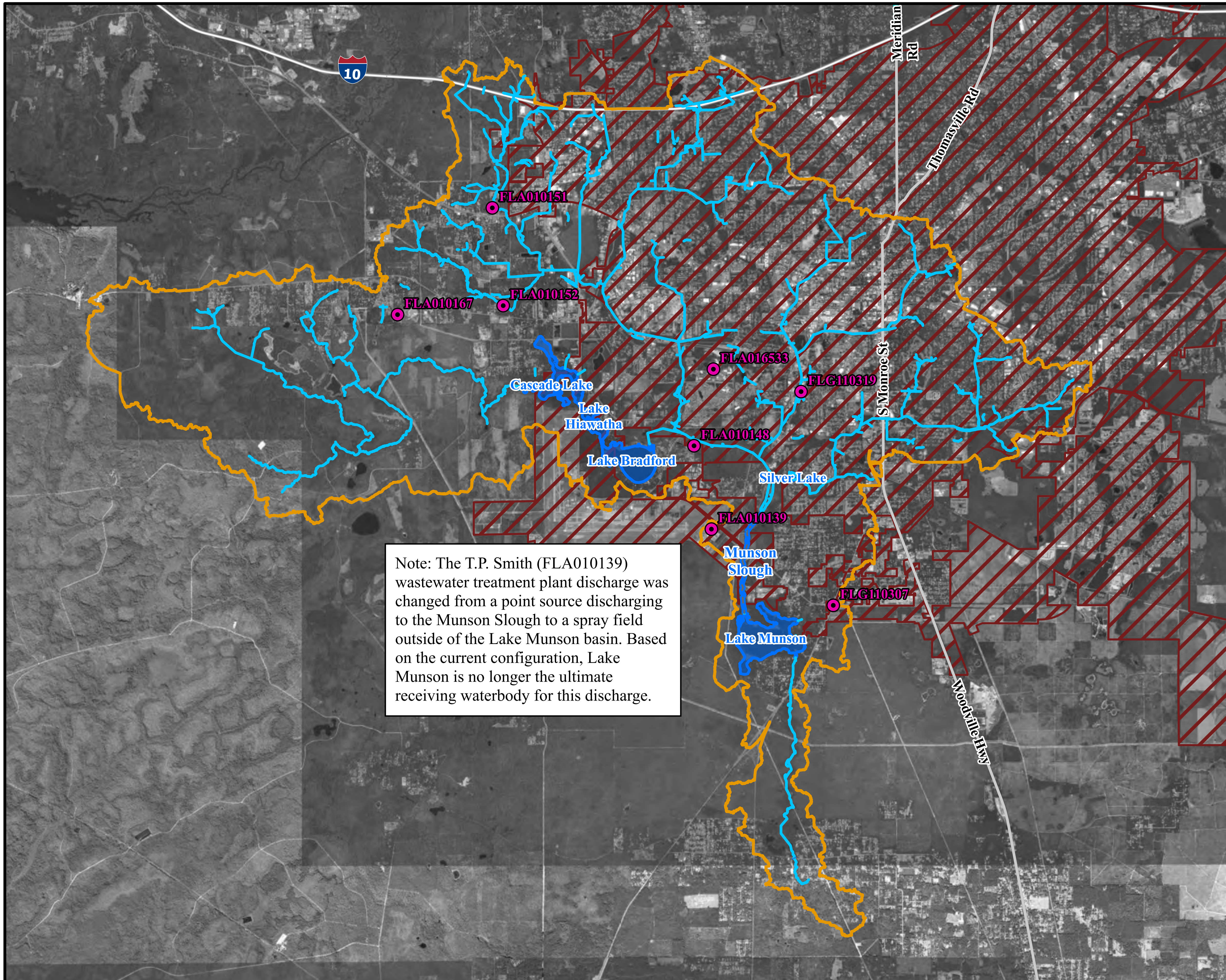
Nutrient loads to a waterbody are a function of the number of septic units, the number of people per household, the soil conditions in the area, groundwater table conditions, and if the systems are working properly. As discussed in **Section 3.4.3.3**, the predominant soil types within the areas where septic systems are clustered are Type A which have high infiltration potential. However, there are approximately 360 septic systems in areas of A/D or B/D soils which have low infiltration potential due to high groundwater tables.

3.4.3.5 Point Sources

Permitted facilities within the Lake Munson basin were identified based on a facilities list provided by the City and information from FDEP's Oculus platform. **Figure 3-3** presents the locations of active permitted facilities identified within the Lake Munson basin. **Table 3-2** outlines the key facility attributes, including facility name, permit number, and the type of discharge (point discharge or land application). While the City's Thomas P. Smith Water Reclamation Facility is identified on the map due to its proximity to the Lake Munson basin, the associated sprayfield discharge is not within the basin and does not contribute to Lake Munson.

Table 3-2: Summary Table of Active Point Source Facilities within the Lake Munson Basin

Site Name	Permit Number	Discharge Type
Grand Village Mobile Home Park WWTP	FLA010151	Land
Lake Bradford Estates MHP WWTP	FLA010148	Land
National High Magnetic Field Lab FSU	FLA016533	Land
Sandstone Ranch WWTF	FLA010167	Land
Smyrna Ready Mix Concrete LLC SRM Plant 103	FLG110319	Point
Smyrna Ready Mix Concrete LLC SRM Plant 104	FLG110307	Point
TP Smith Water Reclamation Facility	FLA010139	Land
Western Estates MHP WWTP	FLA010152	Land



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Legend

- Lake Munson Drainage Basin
- Waterbodies in Study
- Watercourses
- Tallahassee Corporate Limits
- Point Source Facilities

Sources:
Waterbodies: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Point Source Facilities: COT, 2020

Figure 3-3:
Active Point Source Facilities within the Lake Munson Basin

Tallahassee Master Plan - Surface Water (TMaPS)

Geosyntec consultants

3.4.3.6 Hydrologic Data

Exhibit 3-6 presents the locations of hydrologic data stations utilized for this study within the Lake Munson basin per the NWFWMD database. The exhibit shows the types of data available for each location, i.e. precipitation, stage, and/or flow. A table is provided on the exhibit that lists the station number, station name, type of data, and the start and end of the available record. For any station, there may be data gaps in the period of record identified.

There are four stations within the boundaries of the Lake Munson Drainage Basin that were utilized for precipitation data from the NWFWMD database (**Exhibit 3-6**). The station with the longest record of available data is Station 011284, which is located in the immediate vicinity of Munson Slough and Lake Munson (**Exhibit 3-6**). While other stations in the area have a longer record (airport), the period of record for this station was of sufficient length for the purposes of this report.

Figure 3-4 presents the annual precipitation from 1987 through 2020 for Station 011284. Where gaps in the data at this station were found, they were filled in with data from the other stations where available. The data show that annual precipitation ranged from lows around 40 inches in various years up to a maximum of more than 80 inches in 2003. The average precipitation over this period was 59.5 inches.

There are eight stations within the Lake Munson basin that were utilized for this study from the NWFWMD database **(Exhibit 3-6**). Of those eight stations, six are located along tributaries and two are located within lakes (Lake Munson, Lake Bradford). For the purposes of this report, stage data are only presented and discussed for the lakes. Flow data from the tributaries (calculated from measured stage) are presented and discussed below and in later sections.

The Lake Bradford stage data are presented and discussed in **Section 3.5.3.5**. Stage data for Lake Munson were available after 2013. **Figure 3-5** presents the measured water levels in the lake from 2013 through 2020. The influence of the control structure [shown as red line at 26.1 ft referenced to the North American Vertical Datum of 1988 (NAVD88)] can be seen in **Figure 3-5**, which shows levels relatively stable between 26 and 27 ft-NAVD88.

Dry-down periods can be seen in the latter part of 2015 and 2016 lasting between 2 and 3 months. Dry-down periods are defined as periods of time where the water elevation experienced a significant decrease below typical levels that are not intentional drawdown events. Typically, these are a result of periods of lower-than-normal rainfall or other environmental factors. Another dry-down period appears in 2020 but the data for that event is incomplete. In addition to periods of dry-down, at times the lake has been intentionally drawn down to oxidize sediments for the purpose of reducing internal loads to the lake. One such drawdown occurred around 2011 although data were not available for lake stage during that time period. Drawdown events typically bring water levels down to around 20.5 ft-NAVD88, well below the dry-down period levels shown in **Figure 3-5**.

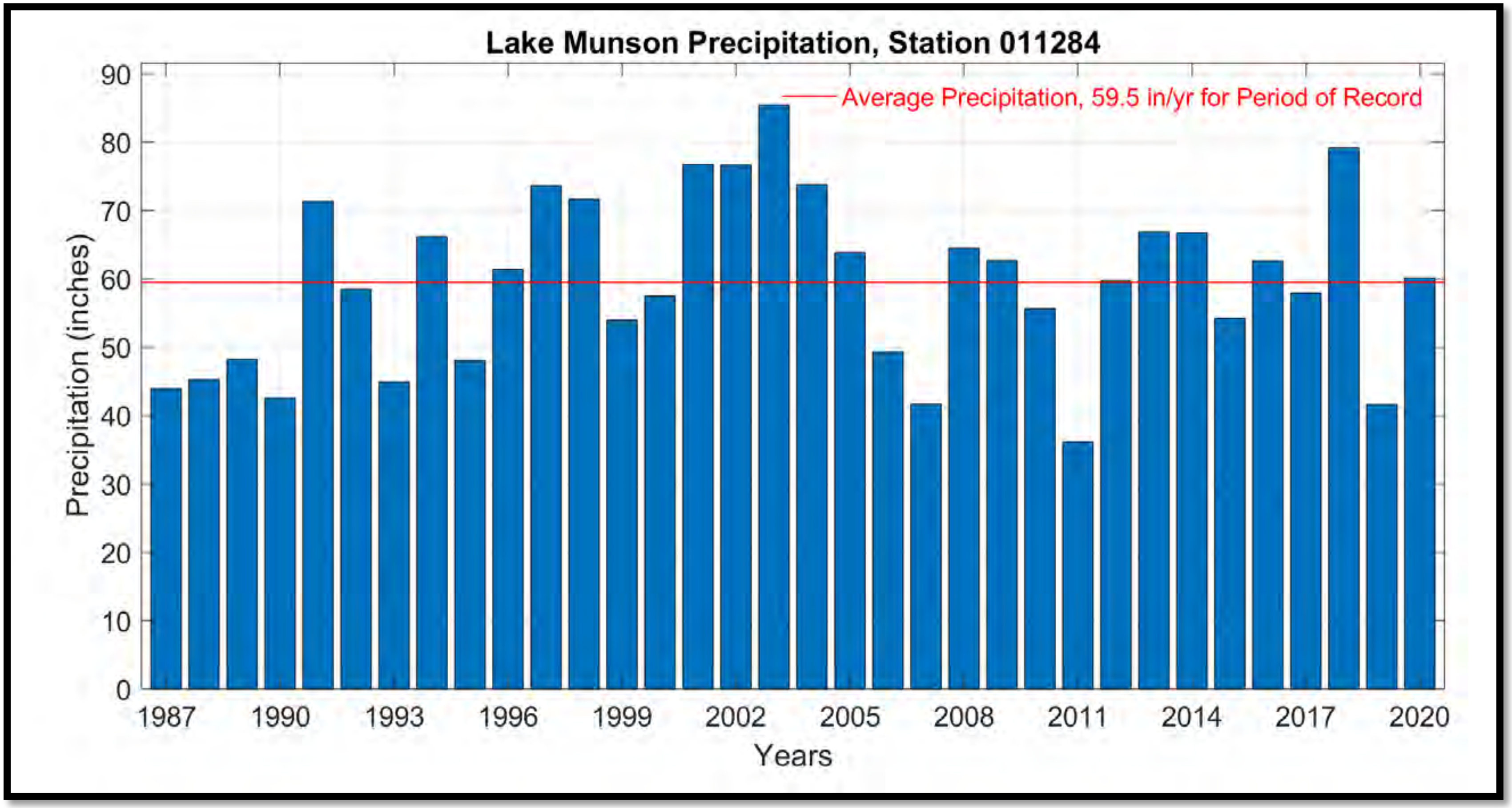


Figure 3-4: Annual Precipitation from Lake Munson Stations (1987 to 2020)

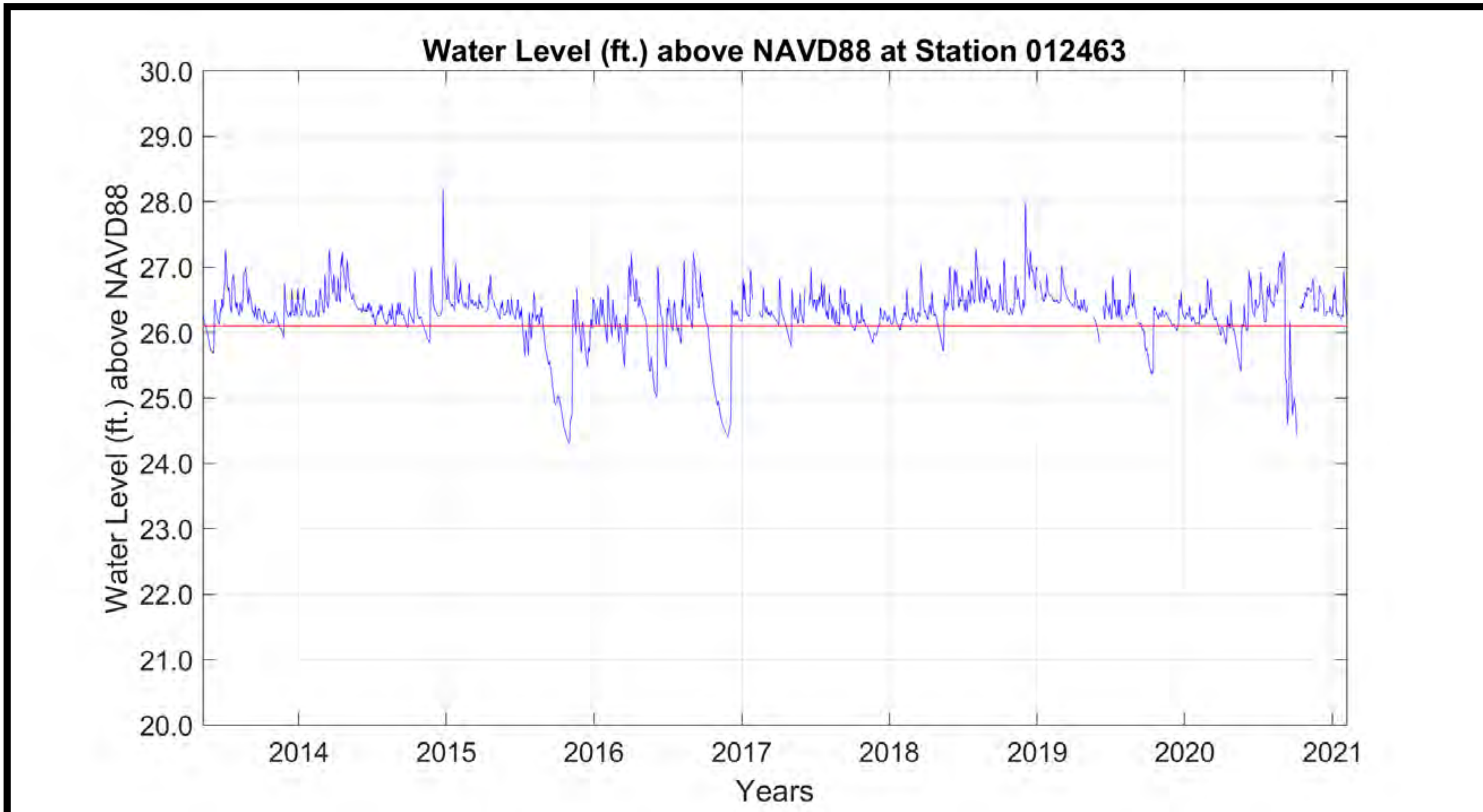


Figure 3-5: Measured Water Levels in Lake Munson (2013 to 2020) (Control Structure Elevation as Red Line)

Continuous flow data, calculated from measured stage and rating curves, were utilized from the NWFWMD database at six locations (**Exhibit 3-6**):

- Bradford Brook upstream of Cascade Lake along Aenon Church Road (008445),
- West Ditch at US 90 (008449),
- West Ditch at Rockerts Ave (008466),
- East Drainage Ditch at Adams St (008481),
- Munson Slough at Capitol Circle (008434), and
- Munson Slough at Oak Ridge Road (007736).

Flow data for these stations ranges from as early as 1987 up to the present. Some stations have significant data gaps over their period of record. Bradford Brook (008445) and East Drainage Ditch (008481) flows are presented and discussed in **Section 3.5.3.5** and **Section 3.6.3.5**, respectively. For the purposes of this section, flow data are presented for the stations upstream of Lake Munson along Munson Slough and within the West Ditch (008449, 008466, and 008434).

Figure 3-6 through **Figure 3-8** present plots of the calculated daily average flows at the three stations upstream of Lake Munson. The rapid hydrologic response of the basin ("flashiness") is immediately evident in the flow data for the stations. However, with such a large basin and the large amount of hydraulic storage available within manmade stormwater facilities (like Lake Henrietta SWMF) and natural depression areas (like Black Swamp), flow responses can vary widely from gauge to gauge. Examination of the calculated flows on Munson Slough downstream of Lake Henrietta shows flows as high as 1800 cubic feet per second (cfs), with peak flows generally ranging between 200 cfs and 600 cfs. On the West Ditch at the downstream station, peak flows are as high as 1,000 cfs, with peak flows generally ranging between 200 cfs to 600 cfs. Upstream peak flows are proportionally similar.

The provided gauged flows are estimated from stage recordings and single-value (stage-flow) rating curves, which are unable to account for hysteresis. Due to the nature of the watershed, significant hysteresis is often present in flow response from a single storm event, meaning multiple flow rates are likely to occur at any given stage. These characteristics of the data development limit the accuracy of the flow data. Determinations made using the flow data must consider these known limitations.

3.4.3.7 Surface Water Quality Data

The water quality data used for this study were retrieved from the FDEP Impaired Waters Rule (IWR) and City databases. The IWR outlines FDEP's methodology to identify waters that will be included in the 303(d) list. The IWR database is a collection of stations that are used to assess ambient water quality of surface waterbodies. The stations are not necessarily managed by FDEP, but any relevant data from various agencies are included for the purpose of collecting pertinent information for a given body of water.

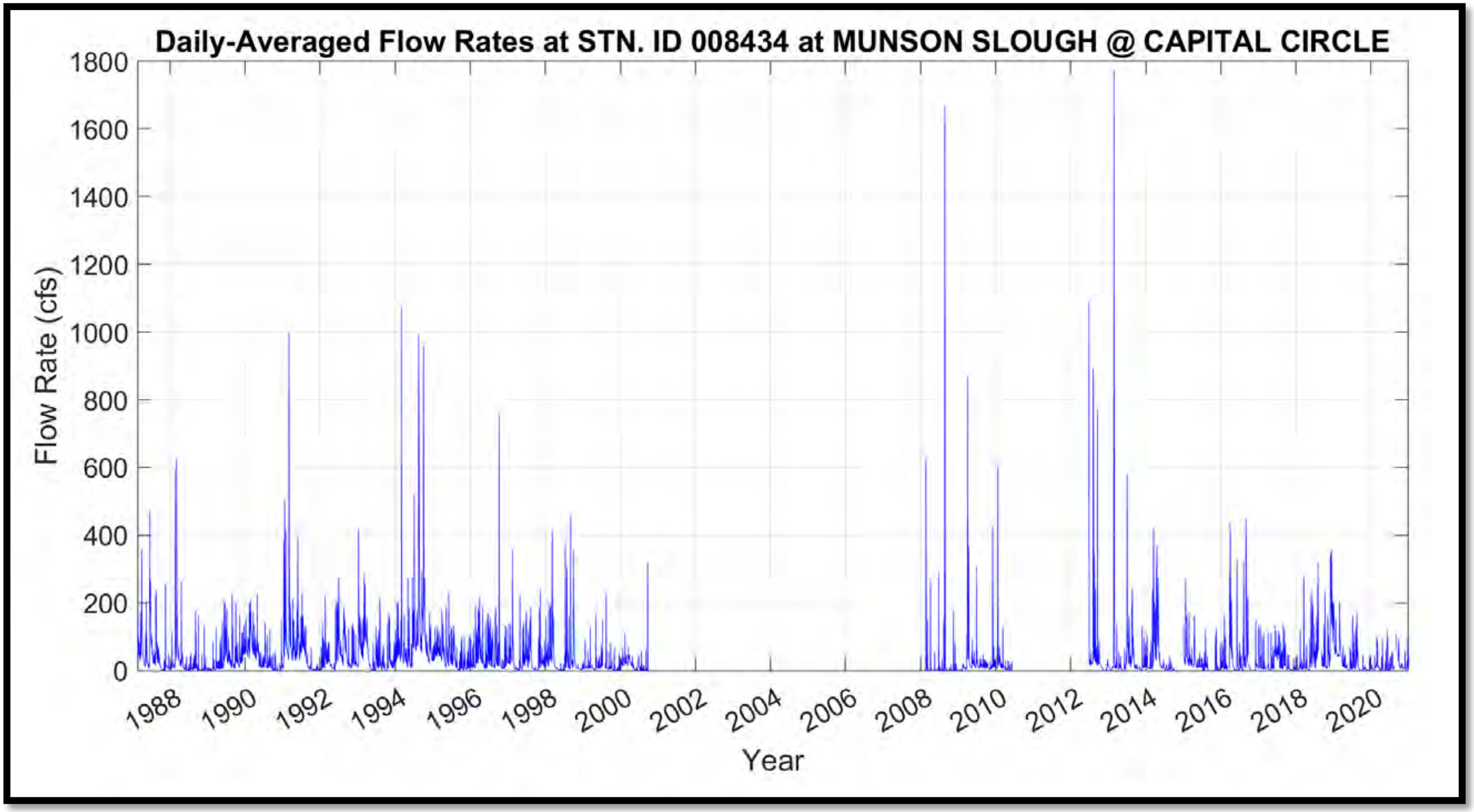


Figure 3-6: Daily Average Flows in Munson Slough Above Lake Munson (Station 008434) (1987 to 2020)

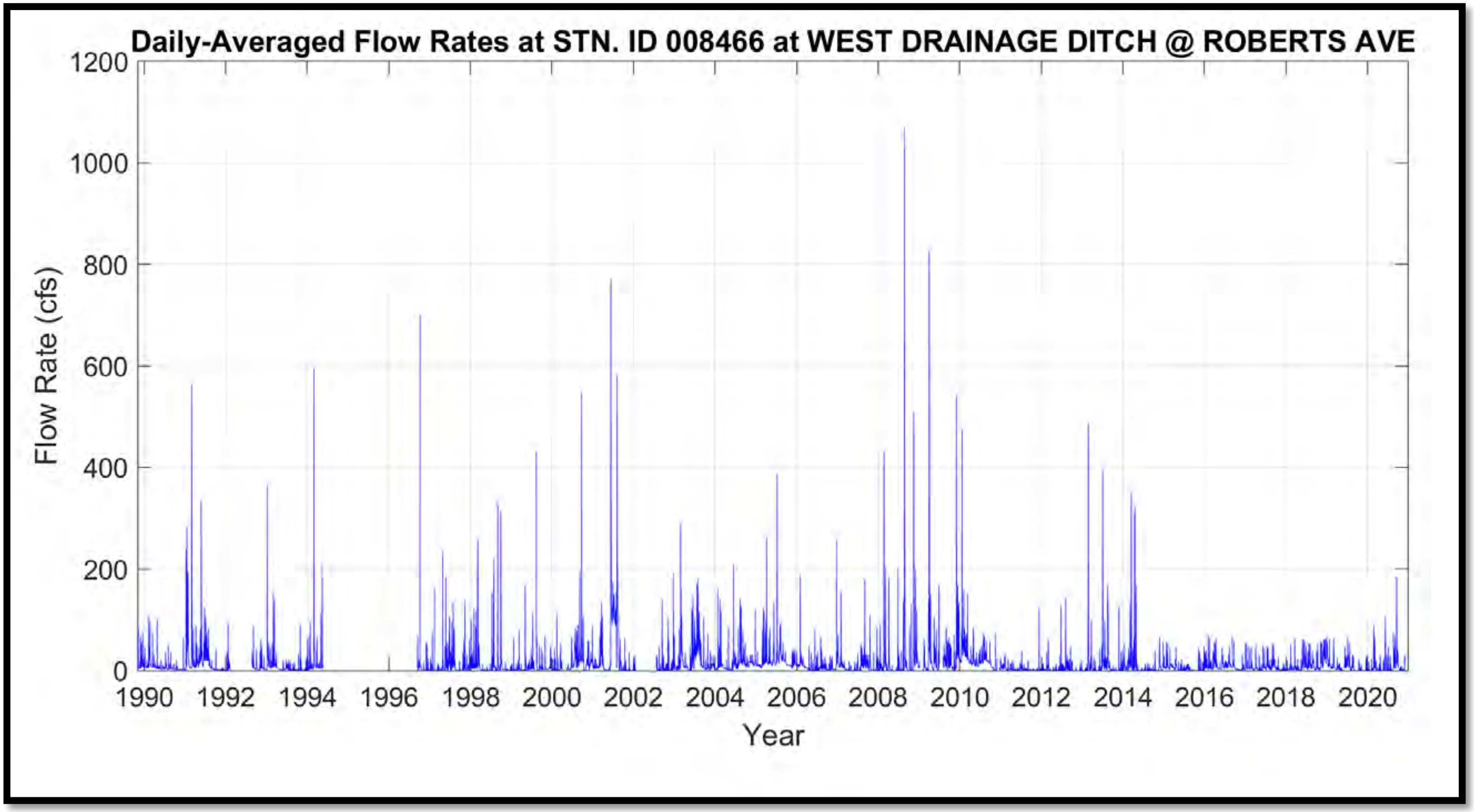


Figure 3-7: Daily Average Flows in West Drainage Ditch (Station 008466) (1990 to 2020)

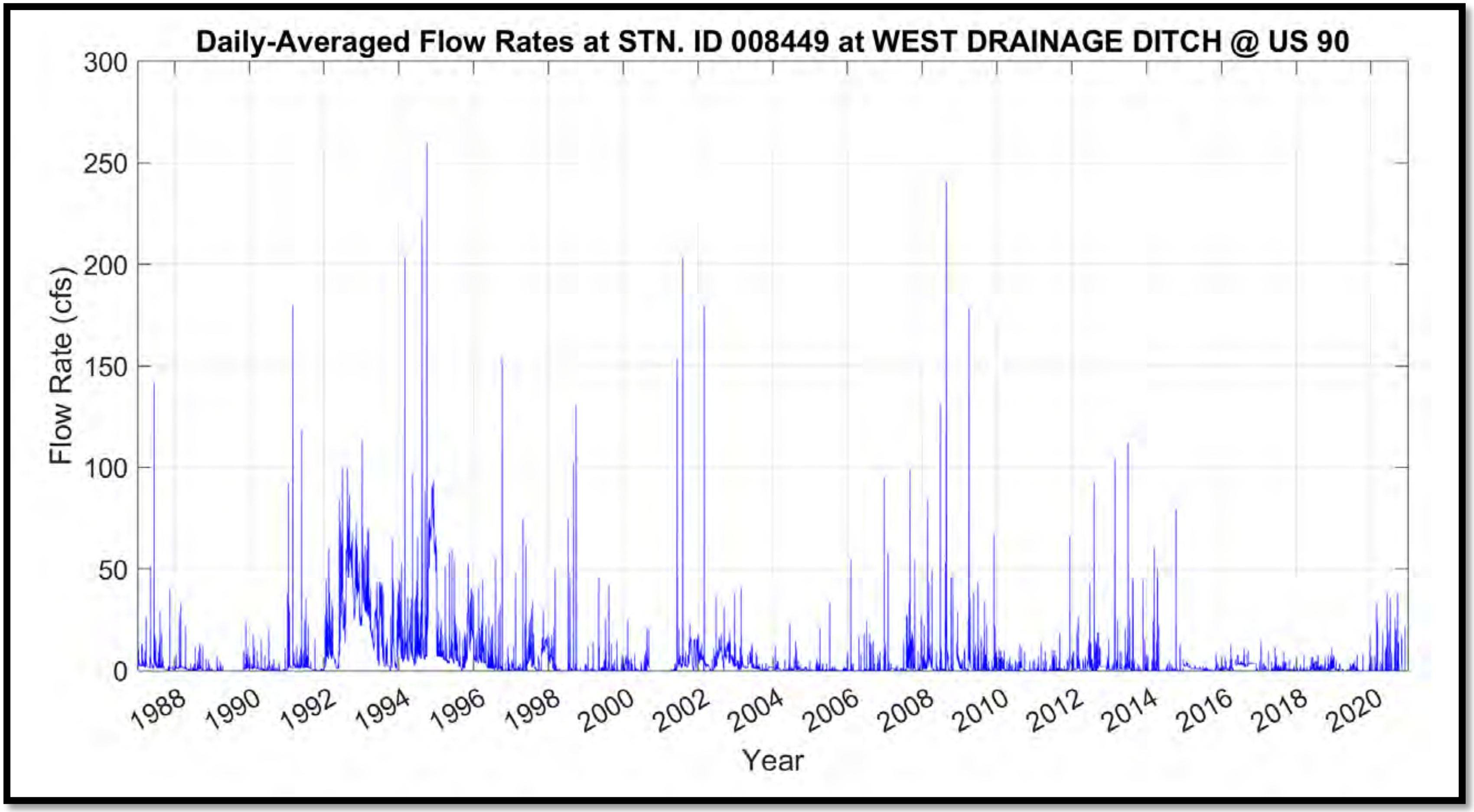


Figure 3-8: Daily Average Flows in West Drainage Ditch (Station 008449) (1987 to 2020)

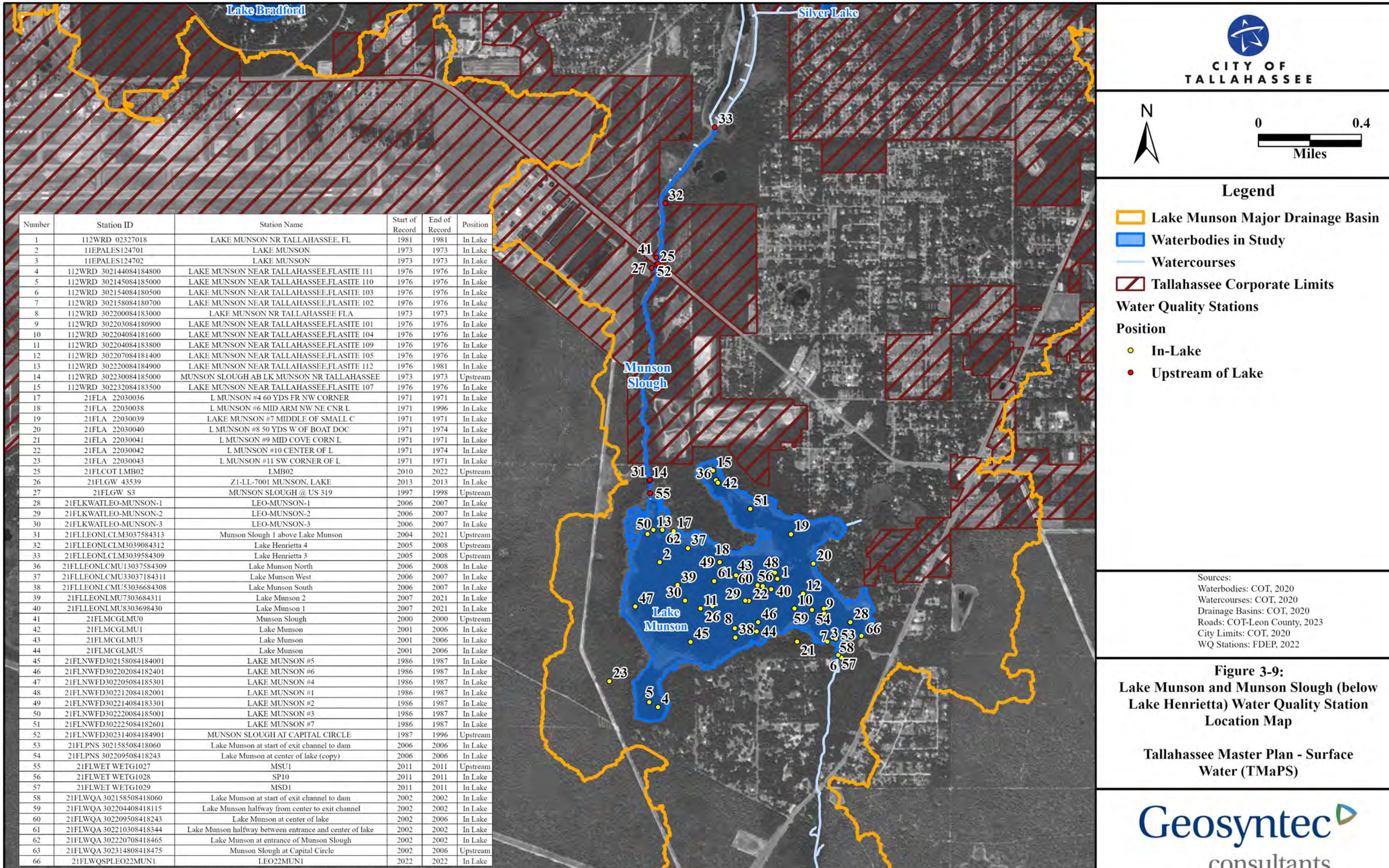
The water quality dataset for Lake Munson (WBID 807C) and Munson Slough (downstream of Lake Henrietta SWMF, part of WBID 807D) spans from 1971 to 2022 and includes contributions from local, state, and national agencies. The IWR contains multiple parameters that are monitored. For the purposes of this study, the primary parameters will be nutrients (and nutrient-related parameters) and fecal indicator bacteria (FIB). **Figure 3-9** presents the locations of in-lake water quality monitoring stations for Lake Munson (yellow), along with stations that provide water quality data along Munson Slough downstream of Lake Henrietta SWMF (red). A table is provided in **Figure 3-9** that shows the station identification (ID), station name, period of record, sample count, data source, and if the station represents in-lake or inflowing tributary data (upstream of the lake). The station locations are based on the latitude and longitude within the IWR database and at times are not fully accurate (see lake stations located on land in **Figure 3-9**).

Based on the number of stations and the length of the station IDs, station IDs were not provided directly on the figure, rather each of the stations is given a number and the numbers correspond to stations in the table. Stations within or upstream of other waterbodies in the Lake Munson basin that are targeted for evaluation in this study (**Exhibit 3-1**) are not shown in **Figure 3-9** (i.e., stations related to the Bradford Chain of Lakes or Silver Lake). These stations will be presented along with the discussions for the individual waterbodies in the sections to follow. Additionally, data upstream of Lake Henrietta SWMF are not presented because the target waterbodies (Munson Slough downstream of Lake Henrietta SWMF and Lake Munson) are downstream of the Lake Henrietta SWMF.

Figure 3-9 shows that there are stations located throughout Lake Munson from near the Munson Slough inflow on the northwestern side down to near the outfall on the southeast side. There are a few stations within the lobe on the northern side of the lake. Within Munson Slough (downstream of Lake Henrietta SWMF) there are a group of stations just upstream of where the slough flows into the lake with other stations downstream of Lake Henrietta SWMF down to the Capital Circle SW crossing. However**,** much of the data are older. Of the 56 in-lake stations only 4 (station numbers 26, 39, 40, 66) have data after 2010, and these are located in the west-central and east-central parts of the lake. No lake data after 2010 are available at the outfall or near the inflow of Munson Slough. In Munson Slough, data after 2010 are available at the Capital Circle SW crossing and just upstream of where the slough enters the lake.

For the surface water quality data plots and analyses, only data after 2010 are presented and analyzed since the focus of this master plan is present conditions. Therefore, only data from January 1, 2010, to December 31, 2020, were considered to best represent the waterbodies as they exist today and in the immediate past. Some discussions of the historical measurements are provided in the text that follows where significant changes have occurred.

Initial plots of the available data in Lake Munson and Munson Slough (downstream of Lake Henrietta SWMF) are provided below. This includes plots of the data and analyses of annual geometric means (AGM) against NNC criteria for both the lake and stream segments. As nutrients are the primary constituent of interest relative to water quality conditions in Lake Munson and Munson Slough (downstream of Lake Henrietta SWMF), plots are provided for the key parameters related to potential nutrient impairment. These include TN, TP, chlorophyll a (Chl-a), and TSI for Lake Munson and TP and TN for Munson Slough (downstream of Lake Henrietta SWMF).



Number	Station ID	Station Name	Start of Record	End of Record	Position
1	112WRD 02327018	LAKE MUNSON NR TALLAHASSEE, FL	1981	1981	In Lake
2	11EPALES124701	LAKE MUNSON	1973	1973	In Lake
3	11EPALES124702	LAKE MUNSON	1973	1973	In Lake
4	112WRD 302144084184800	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 111	1976	1976	In Lake
5	112WRD 302145084185000	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 110	1976	1976	In Lake
6	112WRD 302154084180500	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 103	1976	1976	In Lake
7	112WRD 302158084180700	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 102	1976	1976	In Lake
8	112WRD 302200084183000	LAKE MUNSON NR TALLAHASSEE FLA	1973	1973	In Lake
9	112WRD 302203084180900	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 101	1976	1976	In Lake
10	112WRD 302204084181600	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 104	1976	1976	In Lake
11	112WRD 302204084183800	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 109	1976	1976	In Lake
12	112WRD 302207084181400	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 105	1976	1976	In Lake
13	112WRD 302220084184900	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 112	1976	1981	In Lake
14	112WRD 302230084185000	MUNSON SLOUGH AB LK MUNSON NR TALLAHASSEE	1973	1973	Upstream
15	112WRD 302232084183500	LAKE MUNSON NEAR TALLAHASSEE,FLASITE 107	1976	1976	In Lake
17	21FLA 22030036	L MUNSON #4 60 YDS FR NW CORNER	1971	1971	In Lake
18	21FLA 22030038	L MUNSON #6 MID ARM NW NE CNR L	1971	1996	In Lake
19	21FLA 22030039	LAKE MUNSON #7 MIDDLE OF SMALL C	1971	1971	In Lake
20	21FLA 22030040	L MUNSON #8 50 YDS W OF BOAT DOC	1971	1974	In Lake
21	21FLA 22030041	L MUNSON #9 MID COVE CORN L	1971	1971	In Lake
22	21FLA 22030042	L MUNSON #10 CENTER OF L	1971	1974	In Lake
23	21FLA 22030043	L MUNSON #11 SW CORNER OF L	1971	1971	In Lake
25	21FLCOT LMB02	LMB02	2010	2022	Upstream
26	21FLGW 43539	Z1-LL-7001 MUNSON, LAKE	2013	2013	In Lake
27	21FLGW S3	MUNSON SLOUGH @ US 319	1997	1998	Upstream
28	21FLKWATLEO-MUNSON-1	LEO-MUNSON-1	2006	2007	In Lake
29	21FLKWATLEO-MUNSON-2	LEO-MUNSON-2	2006	2007	In Lake
30	21FLKWATLEO-MUNSON-3	LEO-MUNSON-3	2006	2007	In Lake
31	21FLLEONLCLM3037584313	Munson Slough 1 above Lake Munson	2004	2021	Upstream
32	21FLLEONLCLM3039084312	Lake Henrietta 4	2005	2008	Upstream
33	21FLLEONLCLM3039584309	Lake Henrietta 3	2005	2008	Upstream
36	21FLLEONLCMU13037584309	Lake Munson North	2006	2008	In Lake
37	21FLLEONLCMU33037184311	Lake Munson West	2006	2007	In Lake
38	21FLLEONLCMU53036684308	Lake Munson South	2006	2007	In Lake
39	21FLLEONLMU7303684311	Lake Munson 2	2007	2021	In Lake
40	21FLLEONLMU8303698430	Lake Munson 1	2007	2021	In Lake
41	21FLMCGLMU0	Munson Slough	2000	2000	Upstream
42	21FLMCGLMU1	Lake Munson	2001	2006	In Lake
43	21FLMCGLMU3	Lake Munson	2001	2006	In Lake
44	21FLMCGLMU5	Lake Munson	2001	2006	In Lake
45	21FLNWFD302158084184001	LAKE MUNSON #5	1986	1987	In Lake
46	21FLNWFD302202084182401	LAKE MUNSON #6	1986	1987	In Lake
47	21FLNWFD302205084185301	LAKE MUNSON #4	1986	1987	In Lake
48	21FLNWFD302212084182001	LAKE MUNSON #1	1986	1987	In Lake
49	21FLNWFD302214084183301	LAKE MUNSON #2	1986	1987	In Lake
50	21FLNWFD302220084185001	LAKE MUNSON #3	1986	1987	In Lake
51	21FLNWFD302225084182601	LAKE MUNSON #7	1986	1987	In Lake
52	21FLNWFD302314084184901	MUNSON SLOUGH AT CAPITAL CIRCLE	1987	1996	Upstream
53	21FLPNS 302158508418060	Lake Munson at start of exit channel to dam	2006	2006	In Lake
54	21FLPNS 302209508418243	Lake Munson at center of lake (copy)	2006	2006	In Lake
55	21FLWET WETG1027	MSU1	2011	2011	Upstream
56	21FLWET WETG1028	SP10	2011	2011	In Lake
57	21FLWET WETG1029	MSD1	2011	2011	In Lake
58	21FLWQA 302158508418060	Lake Munson at start of exit channel to dam	2002	2002	In Lake
59	21FLWQA 302204408418115	Lake Munson halfway from center to exit channel	2002	2002	In Lake
60	21FLWQA 302209508418243	Lake Munson at center of lake	2002	2006	In Lake
61	21FLWQA 302210308418344	Lake Munson halfway between entrance and center of lake	2002	2002	In Lake
62	21FLWQA 302220708418465	Lake Munson at entrance of Munson Slough	2002	2002	In Lake
63	21FLWQA 302314808418475	Munson Slough at Capital Circle	2002	2006	Upstream
66	21FLWQSPLEO22MUN1	LEO22MUN1	2022	2022	In Lake

Figure 3-9:
Lake Munson and Munson Slough (below Lake Henrietta) Water Quality Station Location Map

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Additionally, based on interest in the area relative to septic systems and other sources, FIB, specifically *E. coli*, are included. Through the analysis of the TN data for this study, issues were identified relative to how certain total Kjeldahl nitrogen (TKN) data were used in the calculation of TN. **Appendix A** presents a short write up of the issues encountered and how they were rectified to get the TN levels utilized in the analyses below. Additional data plots and analyses are also provided as part of the qualitative assessment of sources in **Section 3.4.4**.

Figure 3-10 through **Figure 3-12** presents plots of the measured TN, TP, and Chl-a data. Examination of the plots shows that the lake saw a significant shift in nutrient and Chl-a concentrations after 2016. For all three parameters, the data after 2016 show significant reductions and downward trends, with the lowest values generally seen in the latter years up to 2020.

Figure 3-13 and **Figure 3-14** present plots of the measured TN and TP data for Munson Slough downstream of Lake Henrietta SWMF. Examination of the plots shows that like the lake data, there are clear downward trends in the TN and TP coming into the lake after 2016. The changes are not as pronounced as those seen in the lake, and the changes tend to be seen after 2017.

Under FDEP's NNC, Lake Munson is defined as a high color system with a long-term geomean true color above 40 platinum-cobalt units (PCUs). Based on this designation, the AGM threshold for Chl-a is 20 micrograms per liter (µg/L). For TN and TP, a range of concentrations are allowed, based on maintaining Chl-a concentrations below 20 µg/L. For TN, the range is 1.27 milligram per liter (mg/L) to 2.23 mg/L. For TP, the range is 0.05 mg/L to 0.16 mg/L. If Lake Munson did not have site-specific alternative nutrient criteria (see discussion below), TN or TP levels below the minimum indicate the system is not impaired for either parameter, levels above the maximum would indicate impairment, measurements in between would be allowable so long as the Chl-a levels that coincide with the nutrient concentrations are below the 20 µg/L threshold.

If Munson Slough did not have site-specific alternative nutrient criteria (see discussion below), the NNC criteria for a stream segment within the Panhandle East Nutrient Region would apply. These are TN below 1.03 mg/L and TP below 0.18 mg/L. It should also be noted that for a stream segment to be deemed impaired, biological data [Stream Condition Index (SCI)] would also need to indicate the system is imbalanced.

Historically, FDEP utilized TSI as a metric for determination of lake impairment due to nutrients. TSI is a classification system designed to "rate" lakes based on the amount of biological productivity occurring in the waterbody, with higher TSI values indicative of more productive lakes. The calculations are based on a scale from 1 to 100. Lakes with TSI values less than 60 were considered good, lakes with values between 60 and 69 were considered fair, and lakes with values greater than 70 were considered poor. While no longer utilized for assessment of impairment, the TSI index remains a tool for evaluating potential nutrient enrichment and biological productivity. Therefore, data on TSI are presented against the thresholds listed above.

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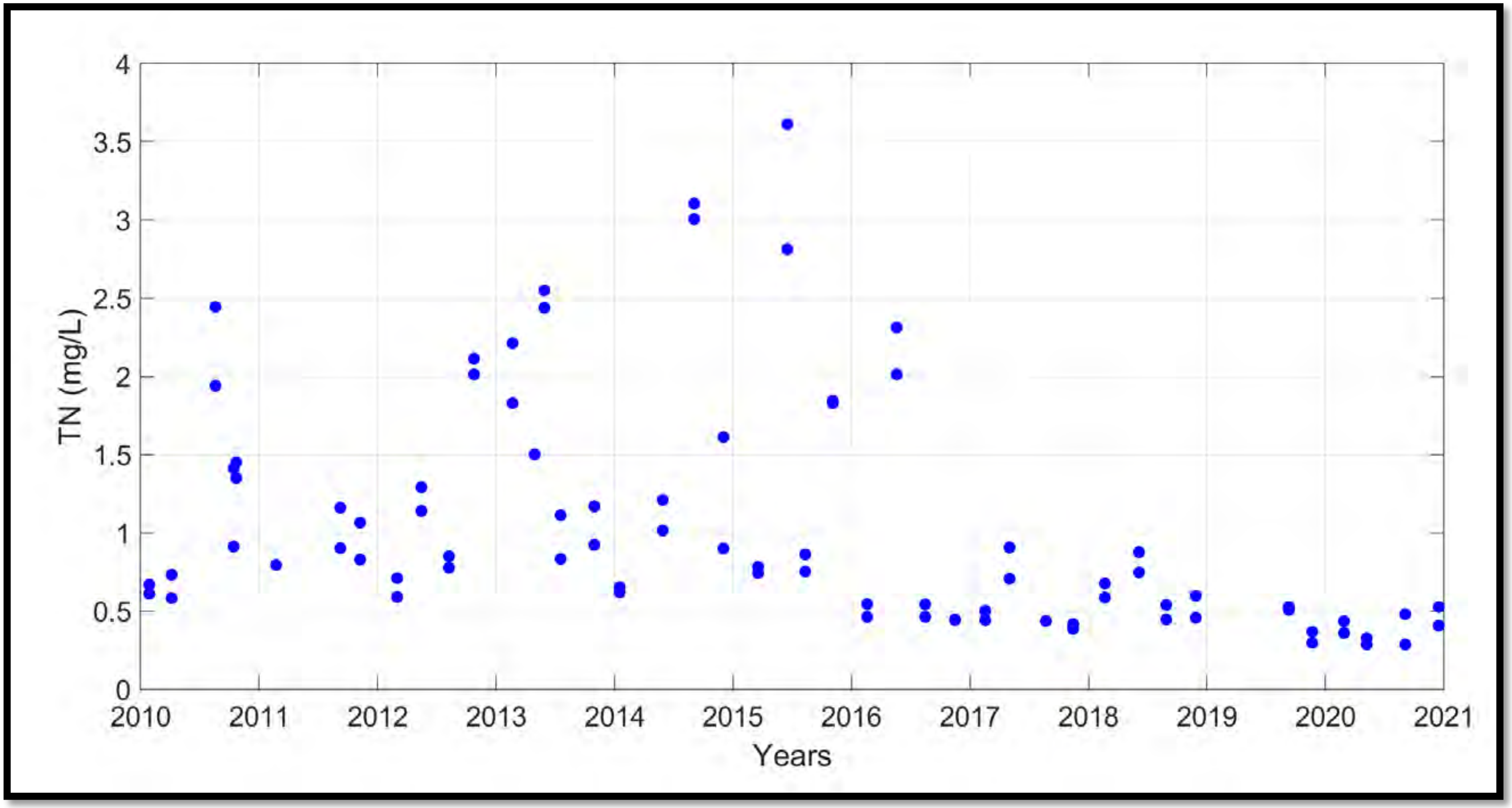


Figure 3-10: Plot of Measured TN in Lake Munson

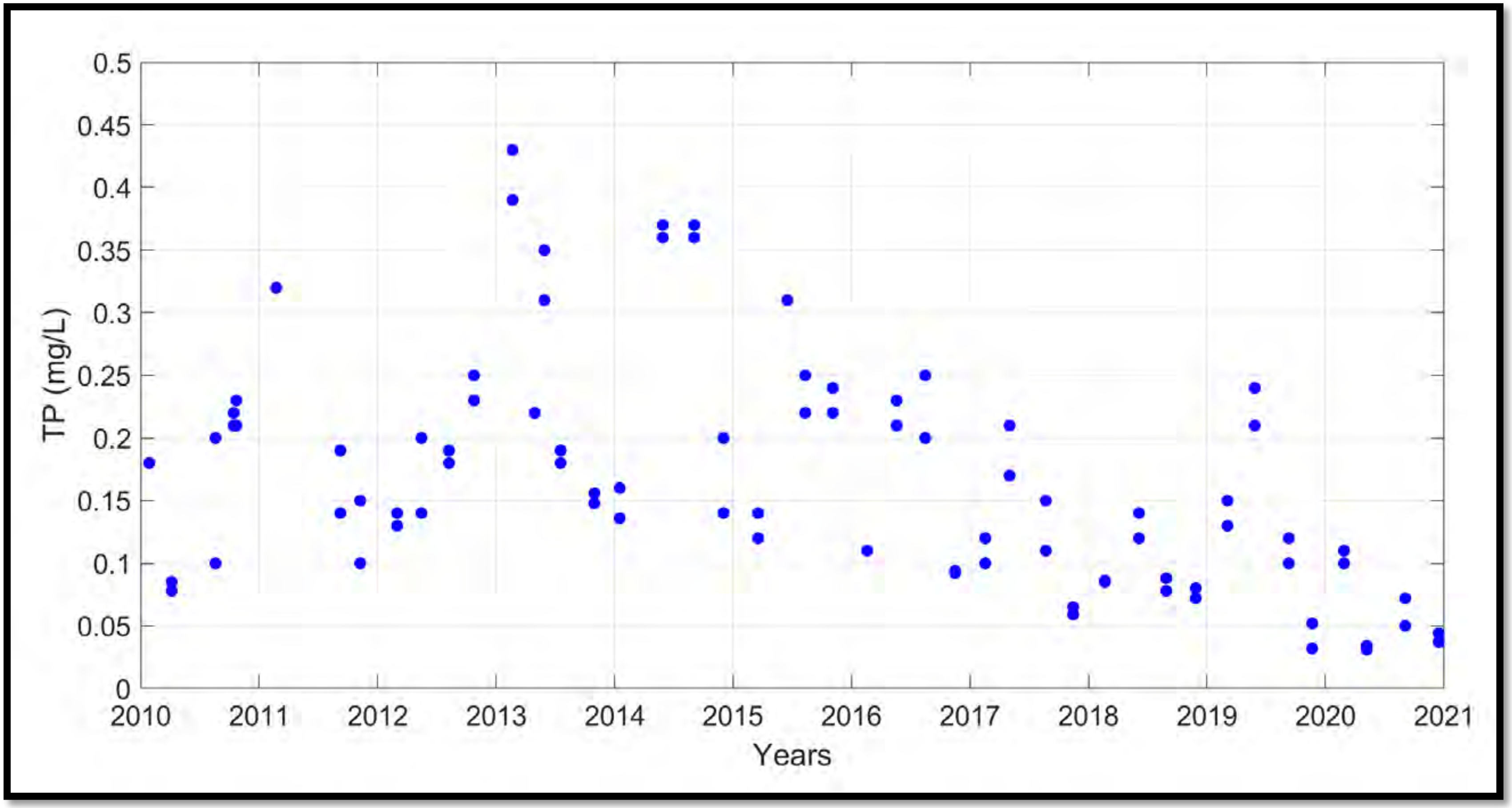


Figure 3-11: Plot of Measured TP in Lake Munson

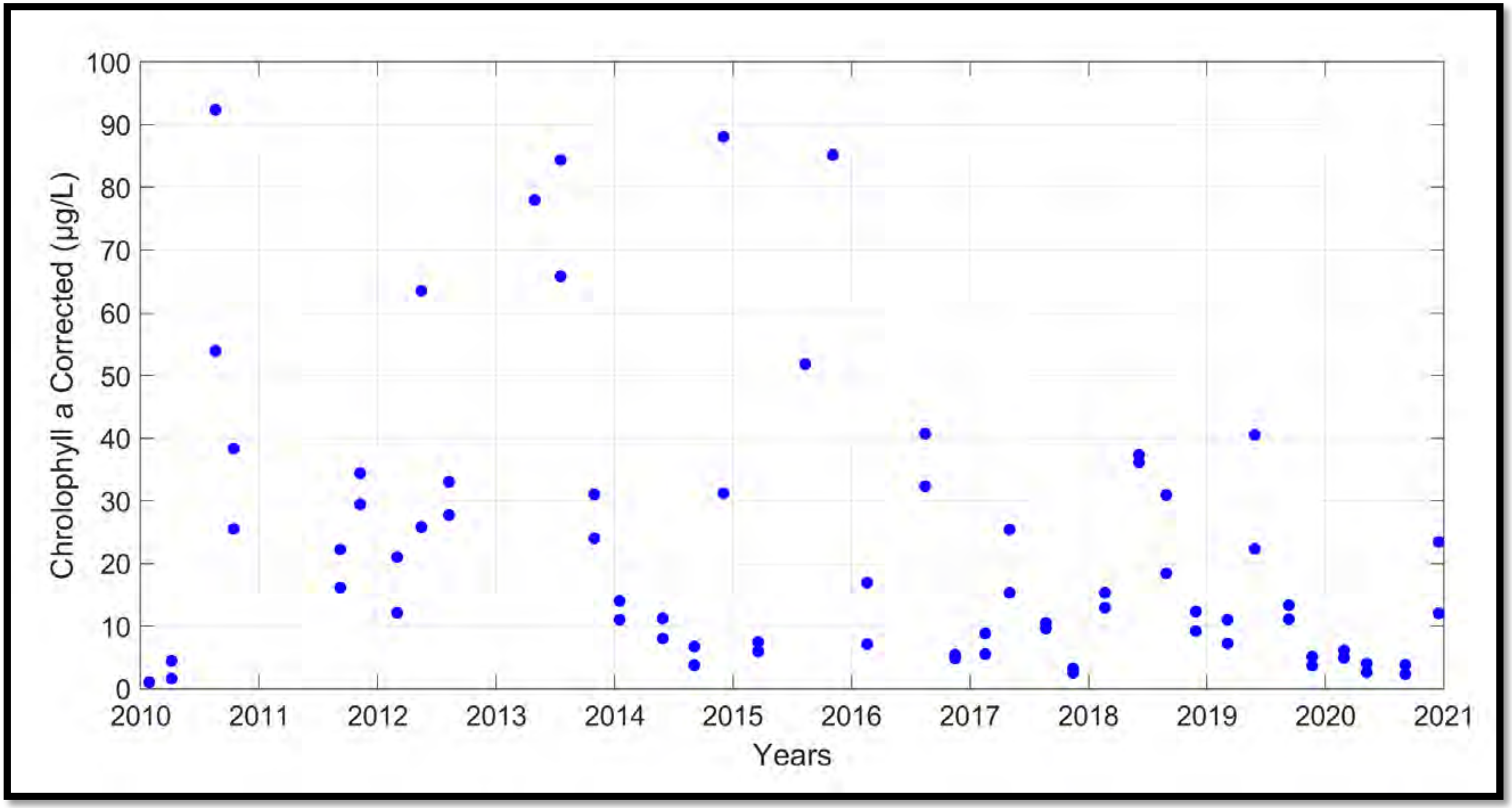


Figure 3-12: Plot of Measured Chl-a Lake Munson

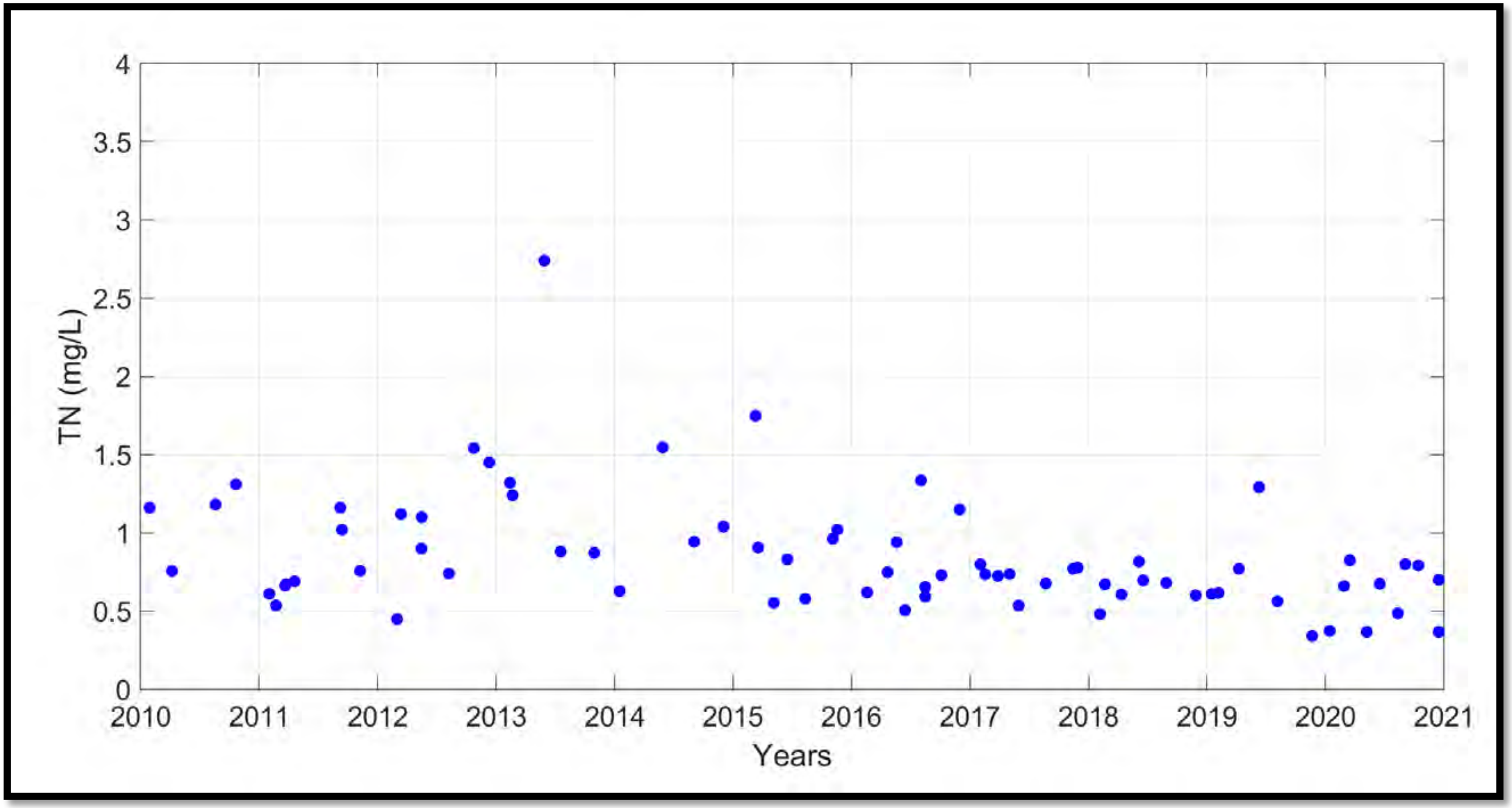


Figure 3-13: Plot of Measured TN in Munson Slough downstream of Lake Henrietta SWMF

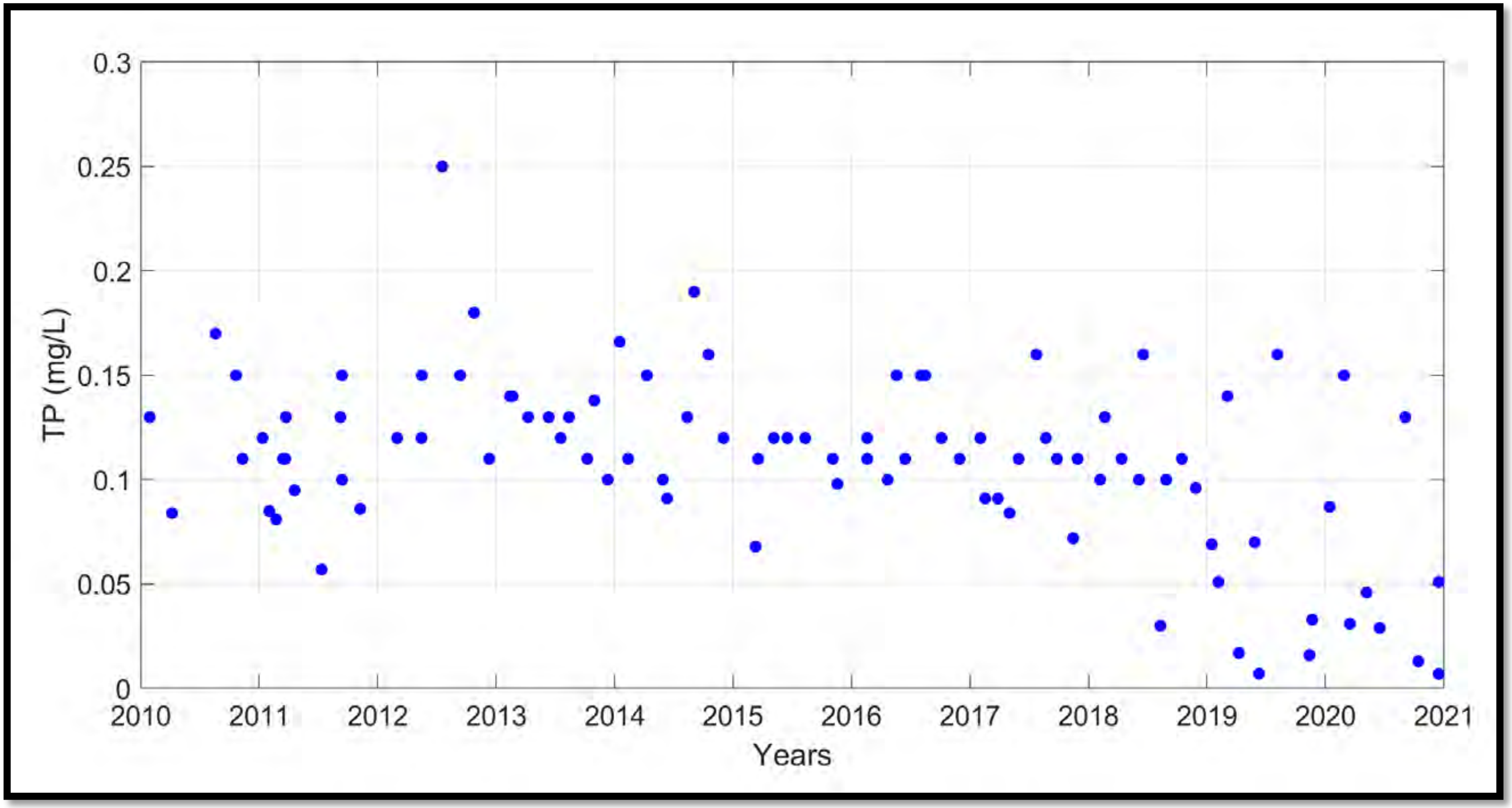


Figure 3-14: Plot of Measured TP in Munson Slough downstream of Lake Henrietta SWMF

As identified above, NNC criteria can be replaced by site-specific criteria developed in a TMDL. This is the case for Lake Munson and Munson Slough. The TMDLs for Lake Munson (WBID 807C) and Munson Slough (above and below Lake Munson, WBID 807D and WBID 807) (FDEP 2013) targeted DO in Munson Slough above Lake Munson, DO, nutrients (TSI), and turbidity in Lake Munson, and DO and un-ionized ammonia for Munson Slough below Lake Munson. The TMDLs within Munson Slough utilized EPA reference stream targets for TN and TP. The TMDL targets for Munson Slough above Lake Munson were 0.72 mg/L TN and 0.15 mg/L TP (**Table 3-3**). For the TMDL for Lake Munson, relationships were developed between TN, TP and Chl-a based on observed data from 2004 to 2008 along with loading from a spreadsheet model of the basin between 2000 and 2007. Based on achieving a targeted TSI of 56 and a TN:TP ratio of 17, the targets for in-lake concentrations for the TMDL were 0.044 mg/L TP, 0.76 mg/L TN and 21.7 µg/L Chl-a (**Table 3-3**). The targeted TSI for the lake was 56, which is just below the TSI threshold of 60 discussed above. The TMDL targets for TN and TP are below the presently defined minimums under the NNC for Lake Munson (0.05 mg/L TP and 1.27 mg/L TN).

Table 3-3: Comparison of TMDL and NNC Targets and Basis for Munson Slough and Lake Munson

Parameter	Waterbody	TMDL Target/Basis	NNC Targets
TN	Munson Slough	0.72 mg/L	1.03 mg/L
TP	Munson Slough	0.15 mg/L	0.18 mg/L
TN	Lake Munson	0.76 mg/L	1.27 – 2.23 mg/L
TP	Lake Munson	0.044 mg/L	0.05 – 0.16 mg/L
Chl-a	Lake Munson	21.7 µg/L (basis)	20 µg/L
TSI	Lake Munson	56 (basis)	<60 (old rule)

For *E. coli*, the criteria are monthly geometric means below 126 colonies per 100 milliliters (mL) of water and less than 10 percent of samples above 410 colonies per 100 mL of water in any 30-day period. Generally, insufficient samples are available to assess the monthly geometric means, therefore, the criteria most used for assessing *E. coli* is the 410 colonies per 100 mL. For the purposes of this report, the *E. coli* are presented against the 410 threshold to see if more than 10 percent of the available data are above it.

TN, TP, and Chl-a AGMs for Lake Munson and Munson Slough are plotted in **Figure 3-15** through **Figure 3-19.** For Munson Slough, only TN and TP are provided as they are the primary constituents for assessing loading to Lake Munson. Where sufficient data are available (based generally on the IWR rule requirements) to assess the AGMs, the levels are provided. The Chl-a threshold and the minimum and maximum thresholds for TN and TP relative to the NNC are provided on each of the graphs as pink dashed lines and listed in **Table 3-3**. Additional threshold lines are provided for the TMDL targets.

Examination of the TN plot for Lake Munson **(Figure 3-15**) shows that between 2010 and 2015, the AGM values were just above or below the minimum NNC criteria but above the TMDL target. After 2015, the TN levels in the lake drop significantly such that all of the calculated AGMs were below the TMDL threshold. Historically, prior to removal of the wastewater treatment facility discharges (around 1980), TN levels were significantly higher than the levels shown in **Figure 3-15**. Following removal, the levels dropped down to between the minimum and maximum NNC thresholds.

TP AGMs (**Figure 3-16**) show a similar pattern, with values from 2010 to 2015 at or above the NNC maximum threshold (0.16 mg/L). After 2015, the levels drop steadily, with values between the minimum and maximum NNC threshold up to 2020, where the levels were right around the minimum NNC threshold (0.05 mg/L) and the TMDL target (0.044 mg/L). As with the TN levels, prior to the removal of wastewater discharges, TP levels were well above the NNC maximum threshold and have been dropping since, although levels were somewhat steady between 1996 and 2015 before continuing to decrease.

The corrected Chl-a plot (**Figure 3-17**) shows that since 2010, the Chl-a AGMs have fluctuated significantly, with levels well above the 20 µg/L threshold to values below the threshold. Since 2015, the levels have remained lower, with the values from 2017 to 2020 below the 20 µg/L such that in the recent years, the 20 µg/L target has been met despite the TP TMDL threshold of 0.044 mg/L not being met. This conflict in meeting thresholds might suggest that Lake Munson is nitrogen limited, which is discussed further with the TSI plots below. It is noted that in a 2016 study of Lake Munson performed by ERD, the TN/TP ratios at the time were within the range that favors cyanobacteria growth, which is a nitrogen fixer. The study noted that due to the significantly elevated TP concentrations, nitrogen limited conditions are unlikely to occur.

The TN plot for Munson Slough downstream of Lake Henrietta SWMF **(Figure 3-18**) shows that between 2010 and 2016, the AGMs were above the TMDL threshold of 0.72 mg/L, while above and below the NNC threshold of 1.03 mg/L. Between 2017 and 2020, all the AGMs were below the TMDL threshold. As discussed in **Section 3.4.2**, based on the AGM values below the TMDL threshold, Munson Slough was placed in Category 2t as meeting the TMDL.

Historically, following the removal of the wastewater discharges, the TN levels in Munson Slough have been low (generally below the maximum NNC threshold and at times below the minimum).

The TP plot for Munson Slough downstream of Lake Henrietta SWMF **(Figure 3-19**) shows that TP AGMs in Munson Slough (downstream of Lake Henrietta SWMF) have in all but one year been below the TMDL threshold of 0.15 mg/L. All AGMs are below the NNC stream threshold (0.18 mg/L). In 2019 and 2020, the AGMs have been near the lake TMDL target and NNC minimum threshold of 0.044 mg/L and 0.05 mg/L, respectively. Historically, following the removal of the wastewater discharges, the TP levels in Munson Slough dropped significantly. Since that time (after 1990), levels have generally been dropping (with some low years), with levels after 2000 below the NNC threshold.

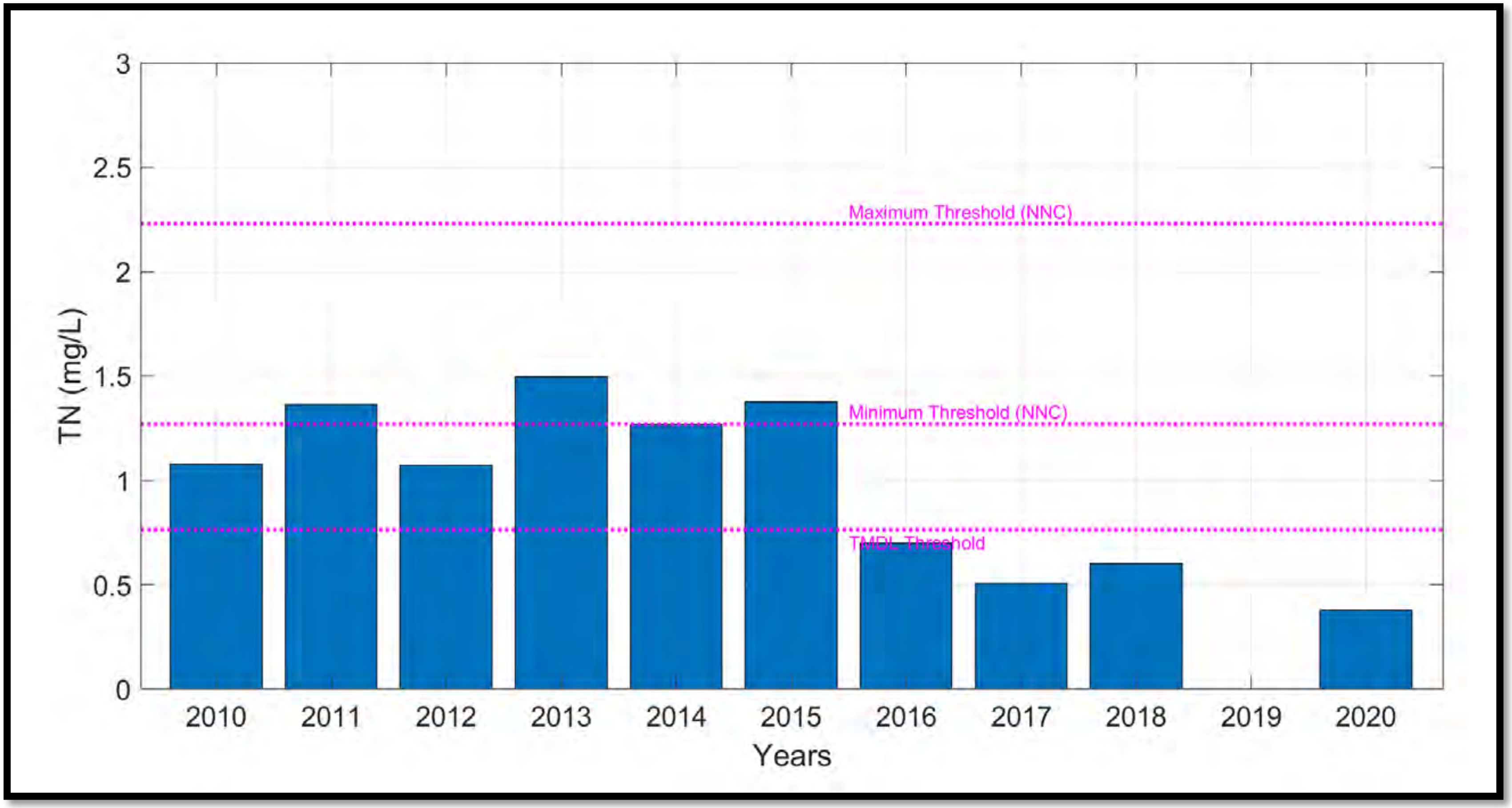


Figure 3-15: Plot of Annual Geometric Means for TN with NNC Criteria for Lake Munson

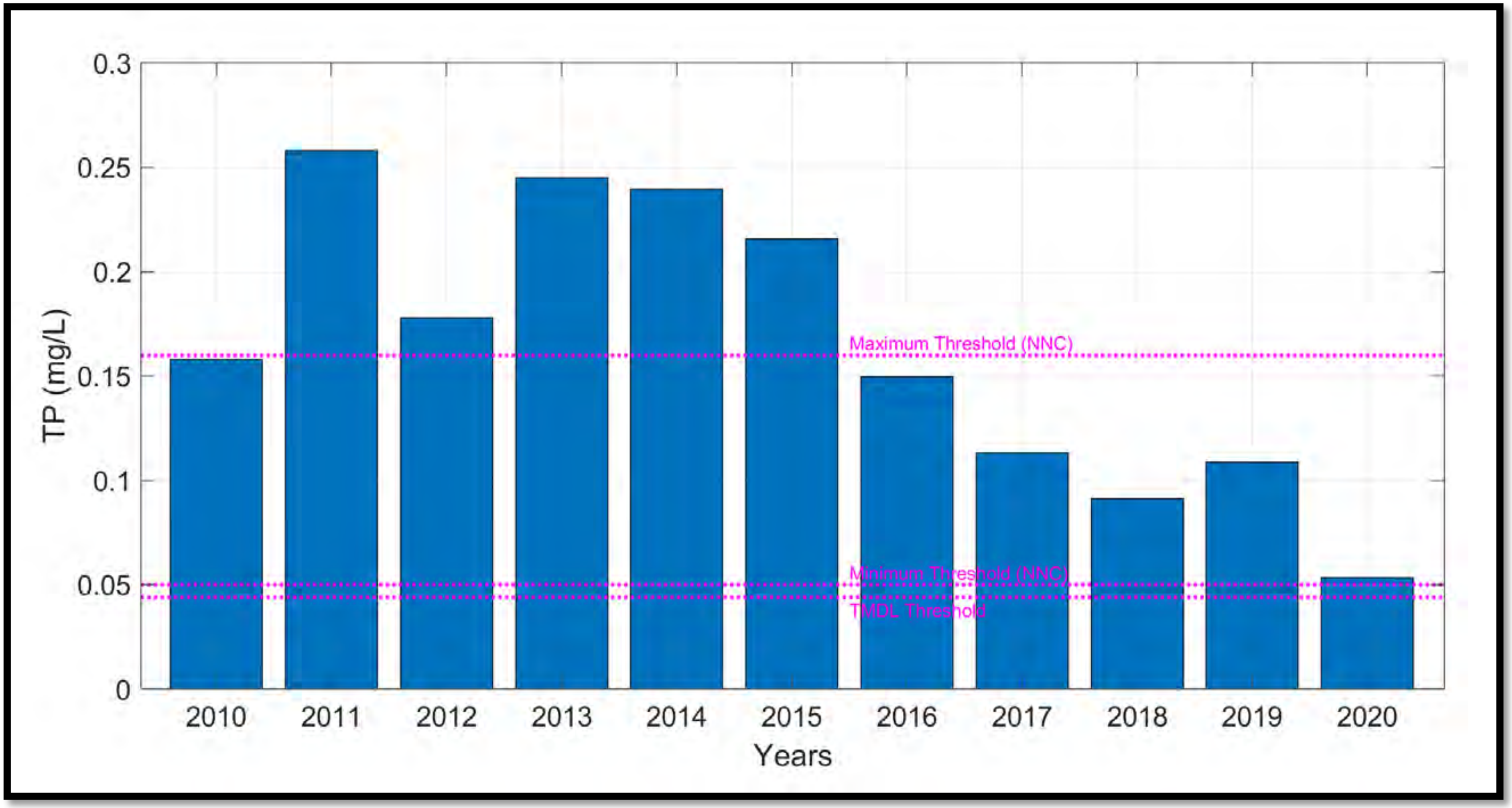


Figure 3-16: Plot of Annual Geometric Means for TP with NNC Criteria for Lake Munson

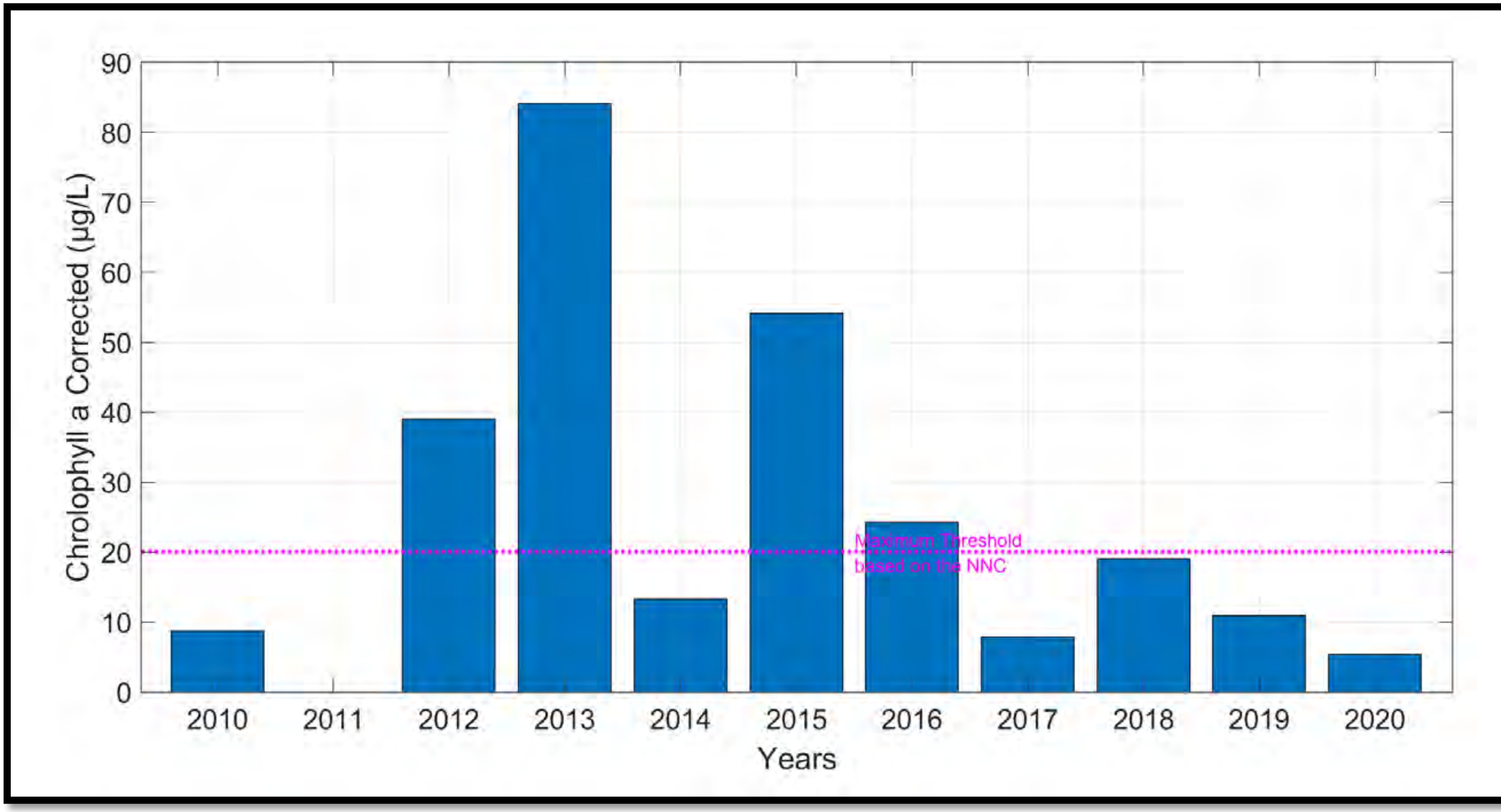


Figure 3-17: Plot of Annual Geometric Means for Chl-a with NNC Criteria for Lake Munson

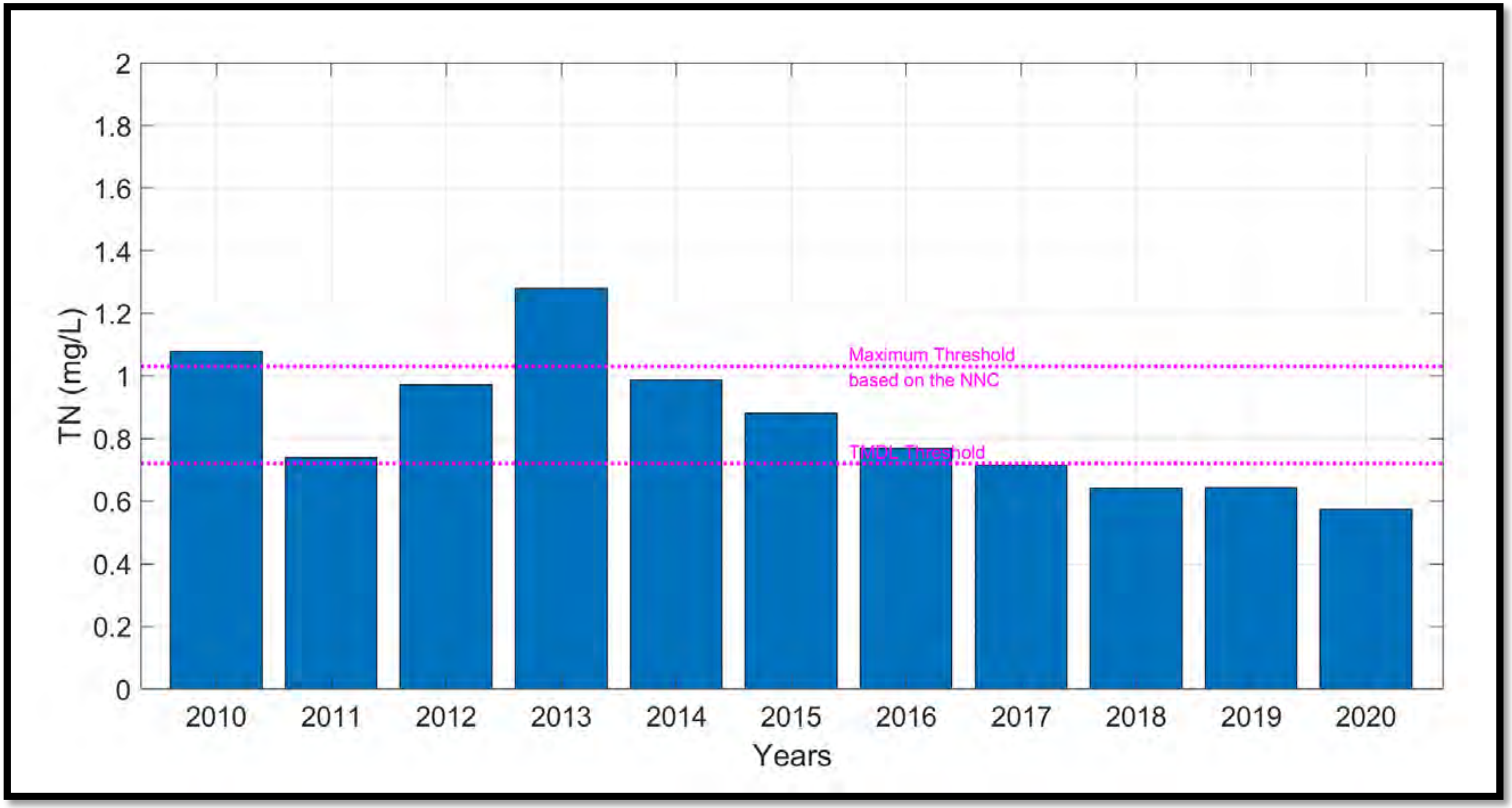


Figure 3-18: Plot of Annual Geometric Means for TN with NNC Criteria for Munson Slough downstream of Lake Henrietta SWMF

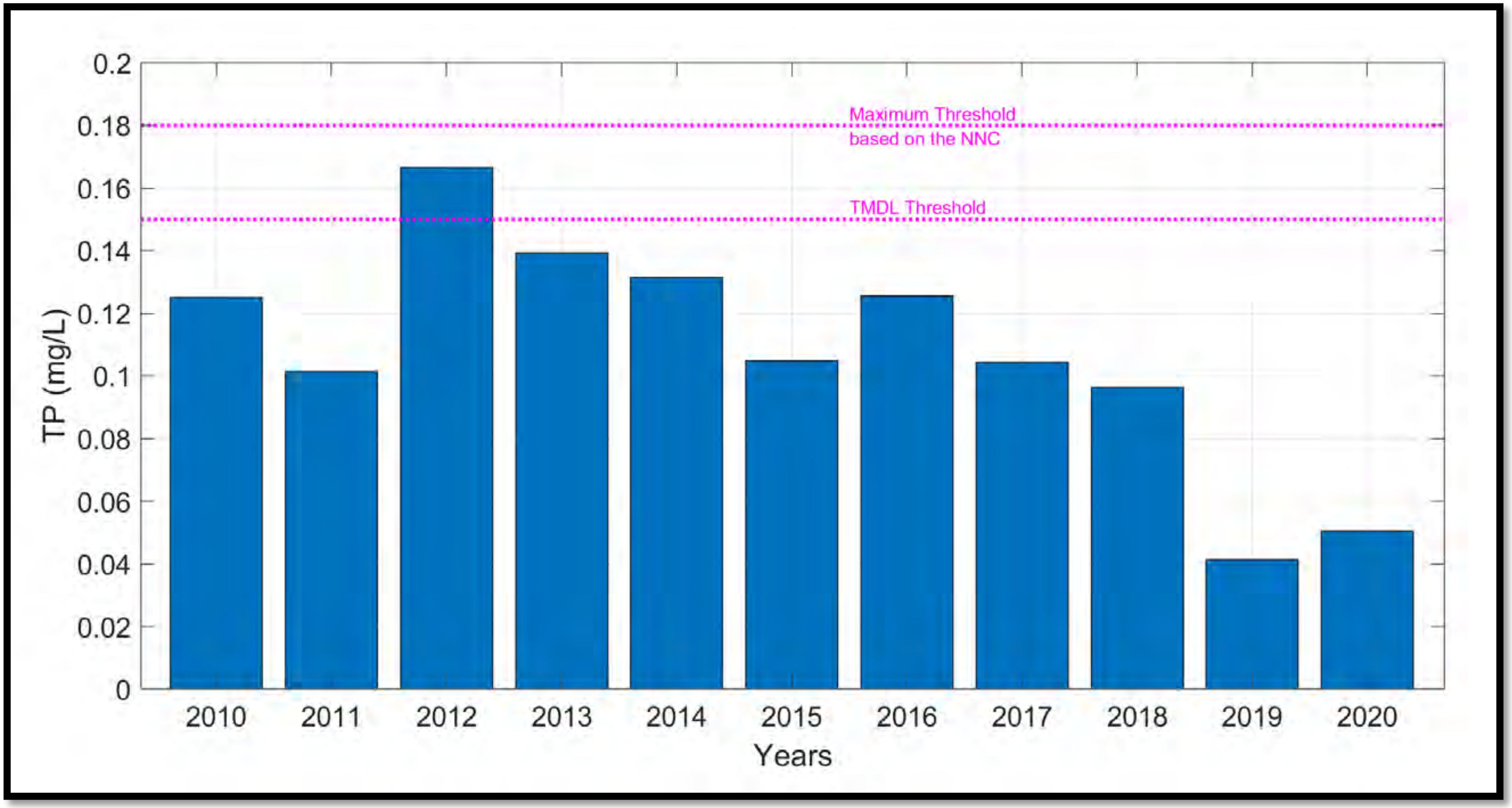


Figure 3-19: Plot of Annual Geometric Means for TP with NNC Criteria for Munson Slough downstream of Lake Henrietta SWMF

Figure 3-20 presents a plot of calculated TSI values in the lake. Examination of the TSI plot shows that between 2010 and 2016, the TSI levels fluctuated between good to poor, with some levels up as high as over 90. Between 2016 through 2020 (as was seen in the nutrient and Chl-a levels), the TSI values have steadily dropped to where after mid-2018, all values are good. The data indicate nitrogen limited conditions in the lake as constant over time, with only a few times where it moved into the area of nutrient balanced. At no time from 2010 through 2020 do the TSI data indicate TP limitation. The nitrogen limited determinations based on TSI may not be representative of the in-lake nutrient dynamics due to the identification of nitrogen fixing bacteria in the lake.

Figure 3-21 presents a plot of *E. coli* data for the available period of record (2014 to 2020) for Lake Munson. The *E. coli* plot shows that no measurements exceeded the less than 10 percent of samples above 410 colonies per 100 mL criteria for Class III freshwaters, and values within the lake are generally low. **Figure 3-22** presents a plot of *E. coli* data for the available period of record (2014 to 2020) for Munson Slough downstream of Lake Henrietta SWMF. The plot shows that only a few measurements from 2014 to 2020 exceeded the 410 colonies per 100 mL threshold, and values within Munson Slough are generally low.

The basis for the TMDL in Lake Munson comes from relationships between Chl-a and TN, TP using data from 2004 to 2008. Two concerns are identified relative to the application of these targets today. First, the data used for those relationships reflects conditions in the lake between 2004 and 2008. Examination of the TN, TP, and Chl-a AGM and raw data plots discussed above shows that conditions in the lake have changed significantly. Secondly, examination of the graphs provided in the TMDL and the calculations of correlation coefficients shows that the data in the analyses had significant variation, and the significance of the relationships was somewhat limited (especially for TP). Comparatively, when focused on the present conditions, the lake is meeting the Chl-a target of 20 µg/L relative to the in-lake TP levels. Given the TMDL targets were developed from prior conditions and the supporting analyses' weak correlation to TP, statewide NNC may be a more appropriate water quality target for Lake Munson. Moreover, given that the present levels of TP and TN in the lake meet respective NNC targets (based on Chl-a levels below 20 µg/L), the current water quality characteristics may prove to be supportive of Lake Munson's designated use in the coming years.

3.4.3.8 Groundwater Data

Groundwater is water that has infiltrated to fill spaces between sediments and cracks in rock. Groundwater is fed by precipitation and eventually resurfaces to replenish surface water, including lakes through seepage from the surficial aquifer and, at times, from inputs from the Floridan aquifer. For Lake Munson and Munson Slough downstream of Lake Henrietta SWMF, the surficial aquifer could be a source of water and/or nutrients through direct seepage into the lake or slough. Therefore, analysis of surficial groundwater data can be beneficial in evaluating potential seepage into the lake and its impacts on water quality.

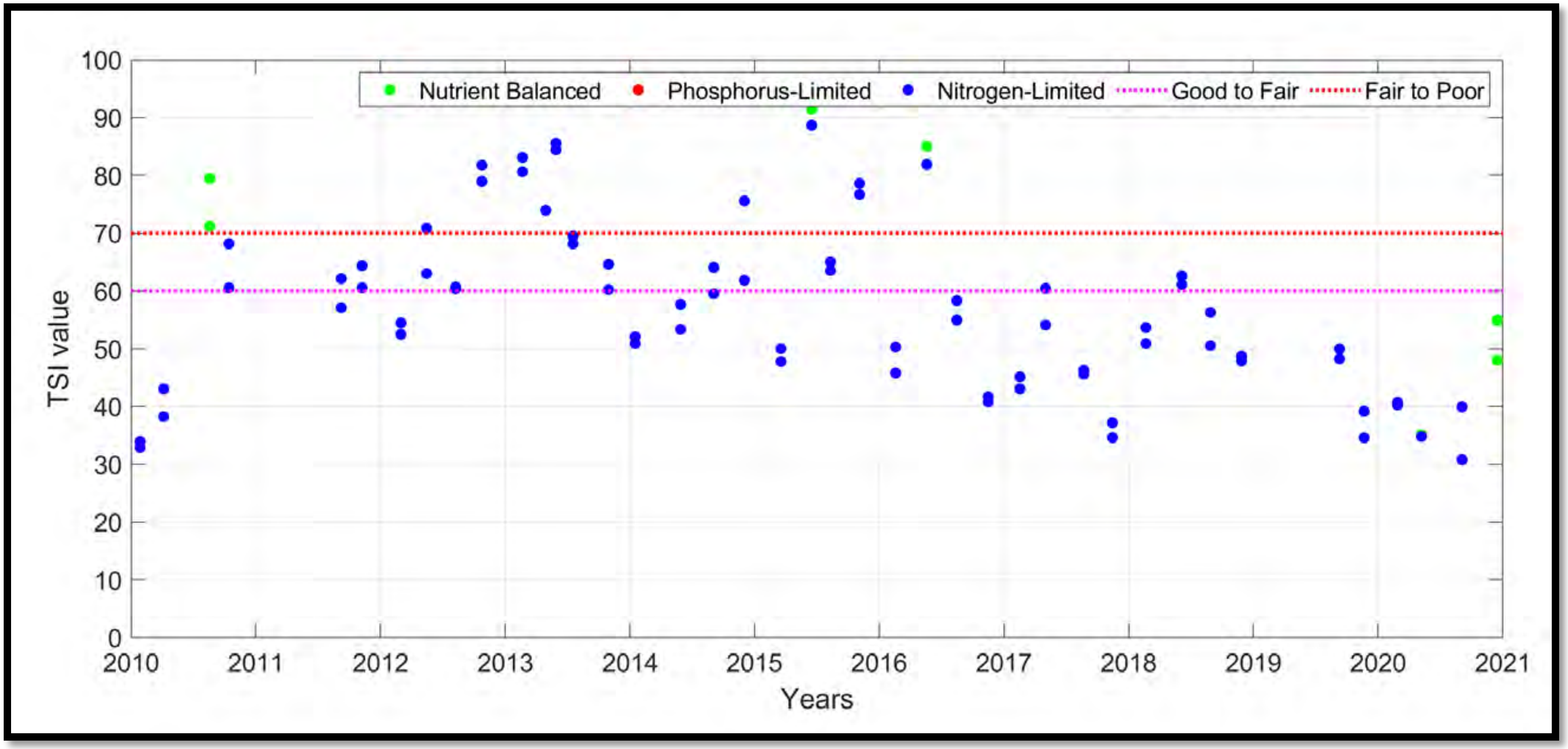


Figure 3-20: Trophic State Index for Lake Munson

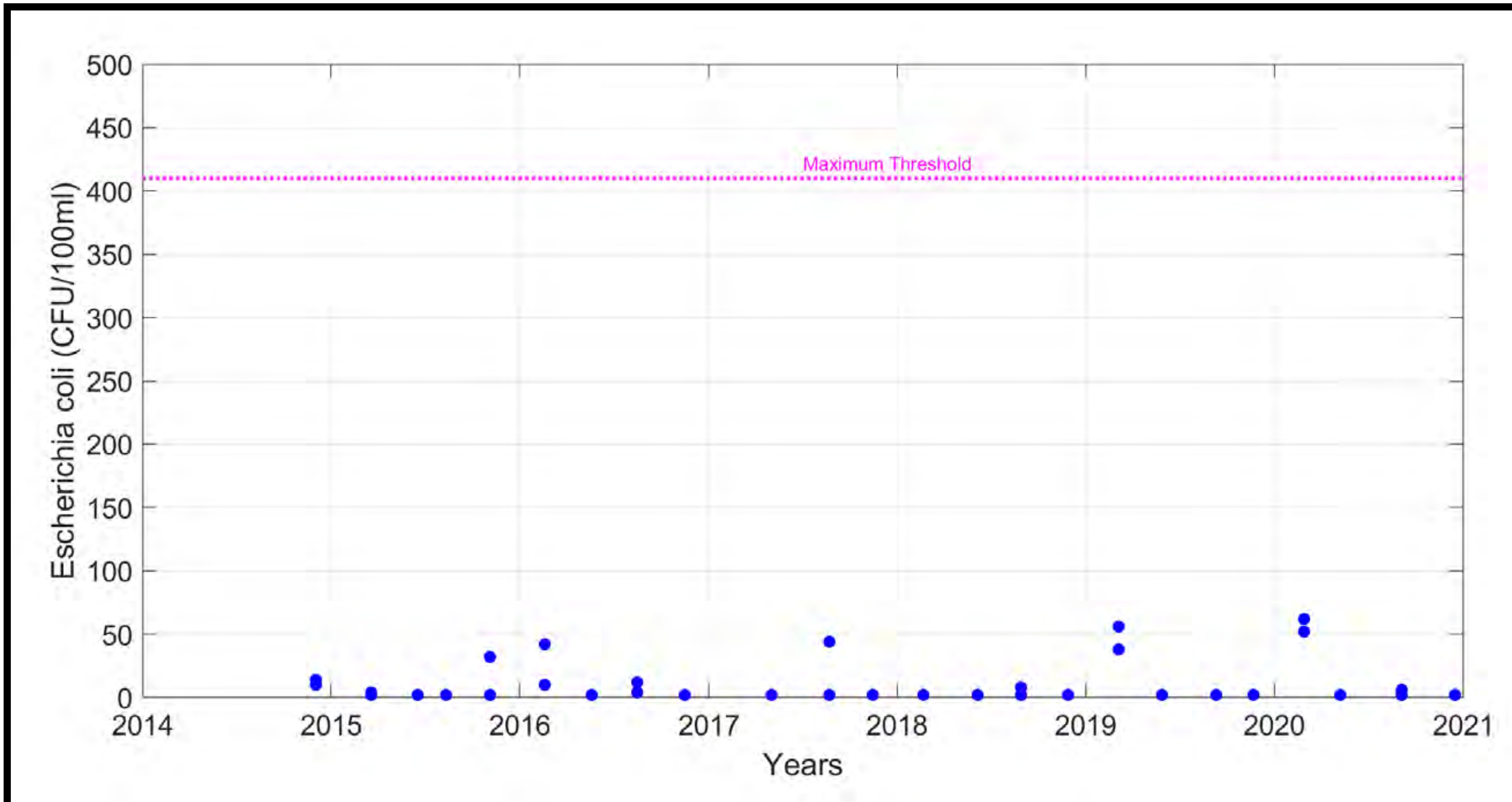


Figure 3-21: Plot of *E. coli* for Lake Munson

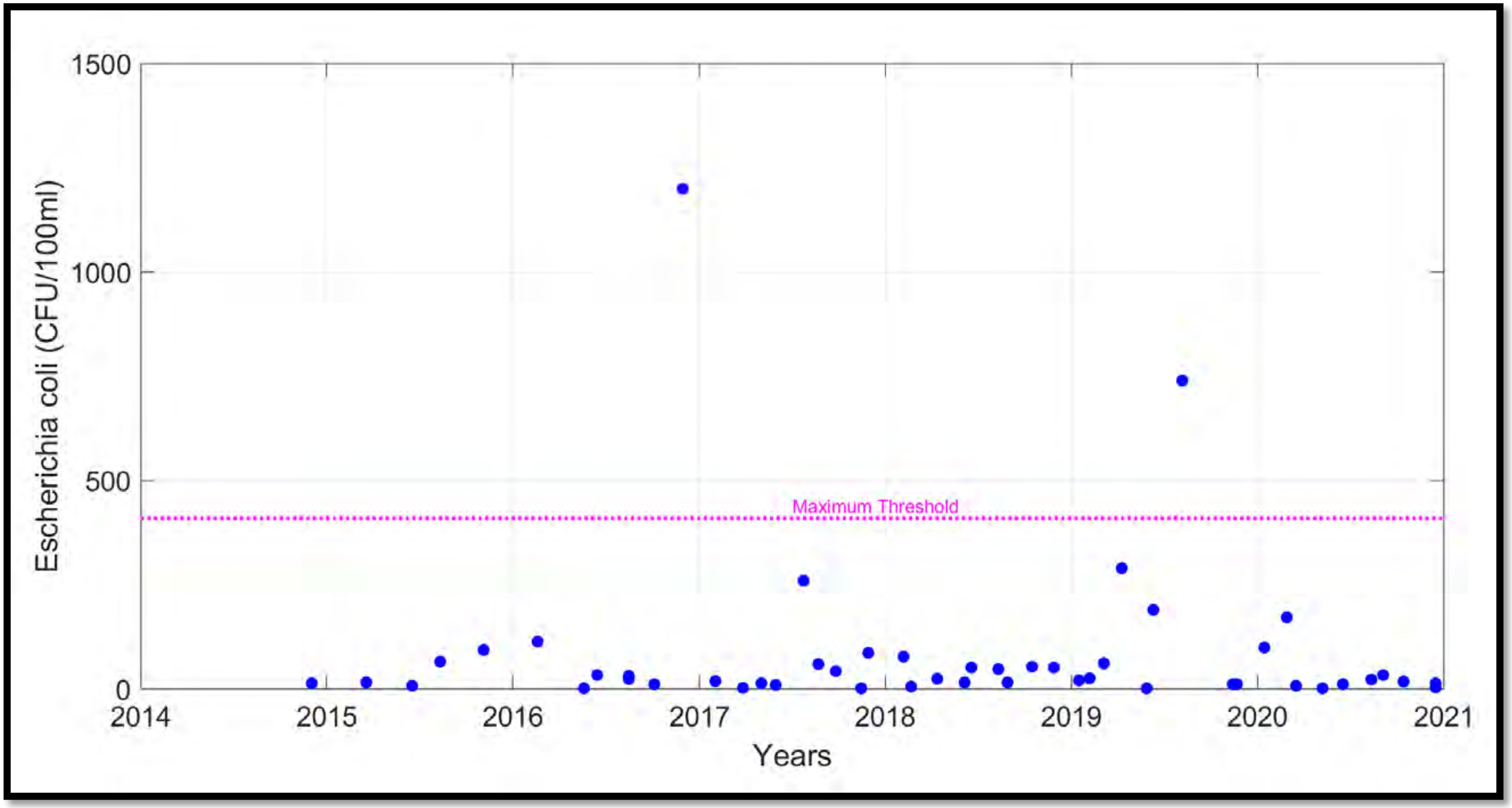


Figure 3-22: Plot of *E. coli* for Munson Slough

Two surficial aquifer groundwater sampling wells are within the boundaries of the Lake Munson Drainage Basin, Station AAA0291 and Station AAD5312 (**Figure 3-23**). These wells are located on the far western side of the basin within the Apalachicola National Forest (AAA0291) and within Lake Bradford Estates a mobile home community to the east of Lake Bradford (AAD5312). As shown in the figure, data are available from 1993 to 1999 for the station in the Apalachicola National Forest. For the station near Lake Bradford Estates, data only from 2000 is available. The available groundwater quality data in the area limits the assessment of potential seepage issues into Lake Munson under present conditions.

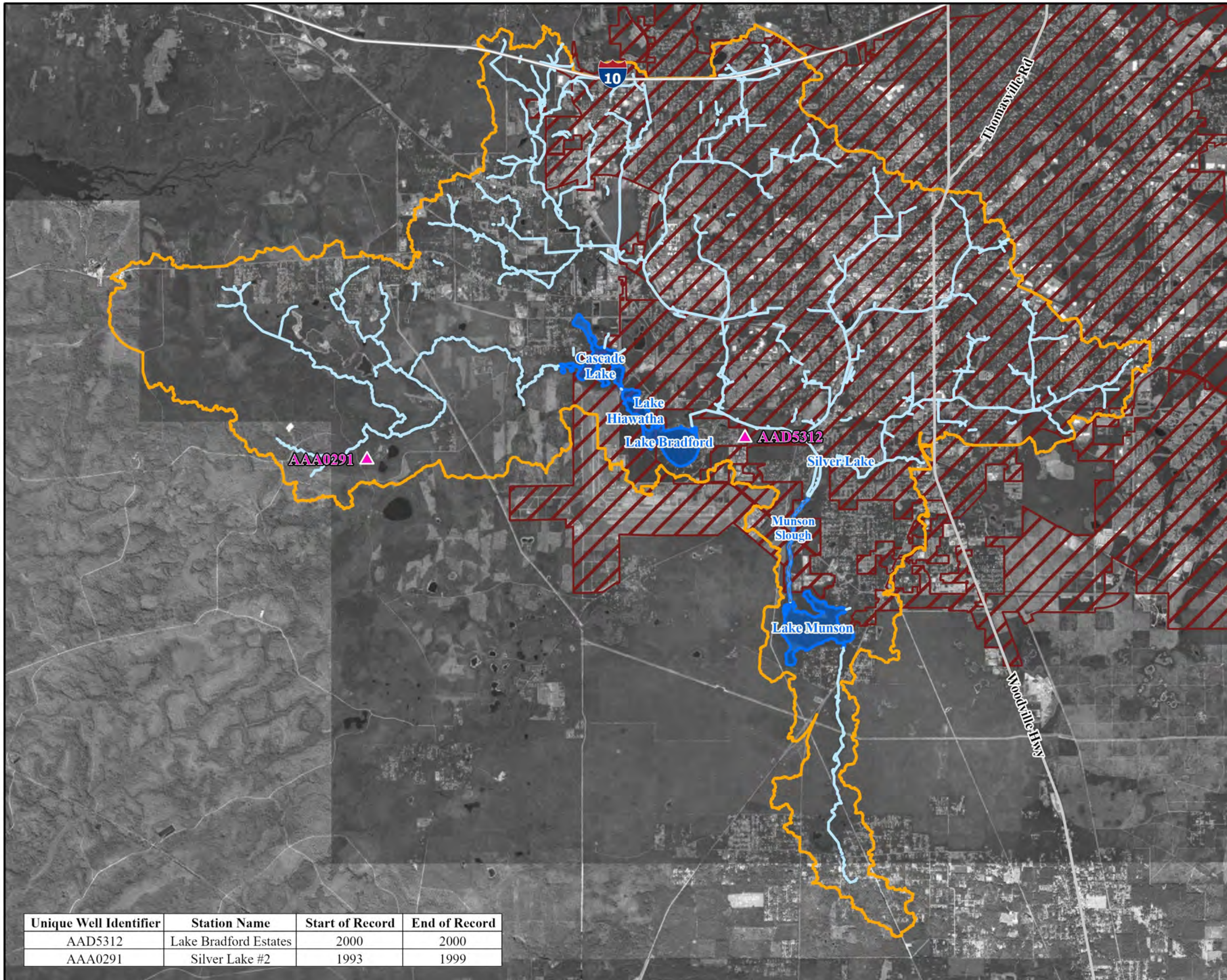
3.4.3.9 Biological Data

The Lake Vegetation Index (LVI) is a bioassessment procedure that analyzes the health of the plant communities in freshwater surface waterbodies. FDEP performs sampling and calculations for waterbodies to interpret LVI values with respect to how closely they resemble the levels of a lake under conditions of minimal human disturbance. The LVI methodology was developed in 2005 in the pursuit of relating plant metrics to human disturbance. The LVI assesses factors such as the presence of exotic species and their ratio to native plant species, lakeshore alterations, and chemical disturbances such as excessive nutrients from surrounding land uses.

For lakes in Florida, an LVI range of 79 to 100 is considered exceptional, a range of 43 to 78 is considered healthy, and any values below 42 are deemed impaired. **Table 3-4** presents LVI data for Lake Munson from 2010 to the present. Based on the data presented, there have been no instances in which the LVI assessments were at or below the 42 threshold, meaning overall, per the plant community distribution, lake conditions are healthy. However, the LVI measurements do exhibit a somewhat decreasing trend over time.

Table 3-4: Summary of LVI Results for Lake Munson

Date	Station ID	LVI	Aquatic Life Use Category
5/21/2010	21FLLEONLEONLVI008	61	Healthy
9/14/2012	21FLLEONLEONLVI008	68	Exceptional
6/17/2013	21FLGW 43539	60	Healthy
7/25/2013	21FLLEONLEONLVI008	61	Healthy
5/8/2014	21FLLEONLEONLVI008	57	Healthy
7/31/2015	21FLLEONLEONLVI008	58	Healthy
8/25/2016	21FLLEONLEONLVI008	54	Healthy
7/24/2018	21FLLEONLEONLVI008	57	Healthy
7/24/2019	21FLLEONLEONLVI008	56	Healthy
9/22/2020	21FLLEONLEONLVI008	53	Healthy



Unique Well Identifier	Station Name	Start of Record	End of Record
AAD5312	Lake Bradford Estates	2000	2000
AAA0291	Silver Lake #2	1993	1999

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Legend

- Lake Munson Drainage Basin
- Waterbodies in Study
- Watercourses
- Major Roads
- Tallahassee Corporate Limits
- Groundwater Sampling Sites

Sources:
Waterbodies: COT, 2020
Wells: Leon County, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
City Limits: COT, 2020

Figure 3-23:
Surficial Ground Water Sampling Wells

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Biological assessment methods for stream segments include Habitat Assessment (HA) and SCI. Some historical biological assessments on Munson Slough were conducted in the upstream reaches around Gum Swamp. In 2020, HA and SCI assessments were performed on Munson Slough below Lake Henrietta just upstream of the confluence with Lake Munson. The HA scores reflected marginal to poor conditions based on issues related to riparian width and vegetation quality, smothering, velocity and substrate availability. The SCI score for that evaluation was 44, which is at the low end of healthy conditions.

3.4.3.10 Stormwater Treatment Facilities

In assessing potential sources of pollutants to Lake Munson, and ultimately for targeting nutrient reduction projects, it is important to identify existing treatment facilities adjacent to and along tributaries flowing into the downstream waterbodies. In **Section 3.4.1** some discussion of larger regional facilities within the Lake Munson basin was provided.

Exhibit 3-7 presents a map of stormwater treatment facilities (ponds) within the Lake Munson basin boundaries, based on available data from the City, Leon County, and FDOT. As the exhibit shows, there are extensive treatment facilities located throughout the urbanized areas of the East Ditch, Central Ditch and West Ditch. Facilities in the western side of the basin within the more natural areas are generally limited to neighborhoods and significant roadways.

3.4.3.11 Atmospheric Deposition Data

Atmospheric deposition is the loading contained in rainfall that falls directly onto the open water lake surface or that falls onto the surface as dry deposition. Stations are maintained throughout Florida that collect atmospheric deposition data. **Figure 3-24** shows the location of the nearest atmospheric deposition station to Lake Munson. The station is in Quincy (FL14) and has been collecting data since 1984.

3.4.3.12 Data Summary

For the purposes of the qualitative analysis of sources of pollutants to Lake Munson and Munson Slough downstream of Lake Henrietta SWMF (**Section 3.4.4),** the available data are reasonable. There are sufficient active surface water quality stations within the lake and along Munson Slough downstream of Lake Henrietta SWMF to support the qualitative assessment. The following outlines limitations in the available data. Specific recommendations on additional data collection efforts are provided in **Section 3.8**.

- There are limited data to evaluate the potential for seepage of pollutants to the lake from the surficial aquifer, i.e., surficial groundwater sampling stations around the lake and along the slough.
- The measured water quality data in Munson Slough are generally collected during baseflow conditions rather than during storm events, which bring the bulk of the flow and potential load into the lake.
- The data reflecting the conditions within the lake at the location of the inflow from Munson Slough and directly at the outfall are old, with no data since 2010 at these locations.

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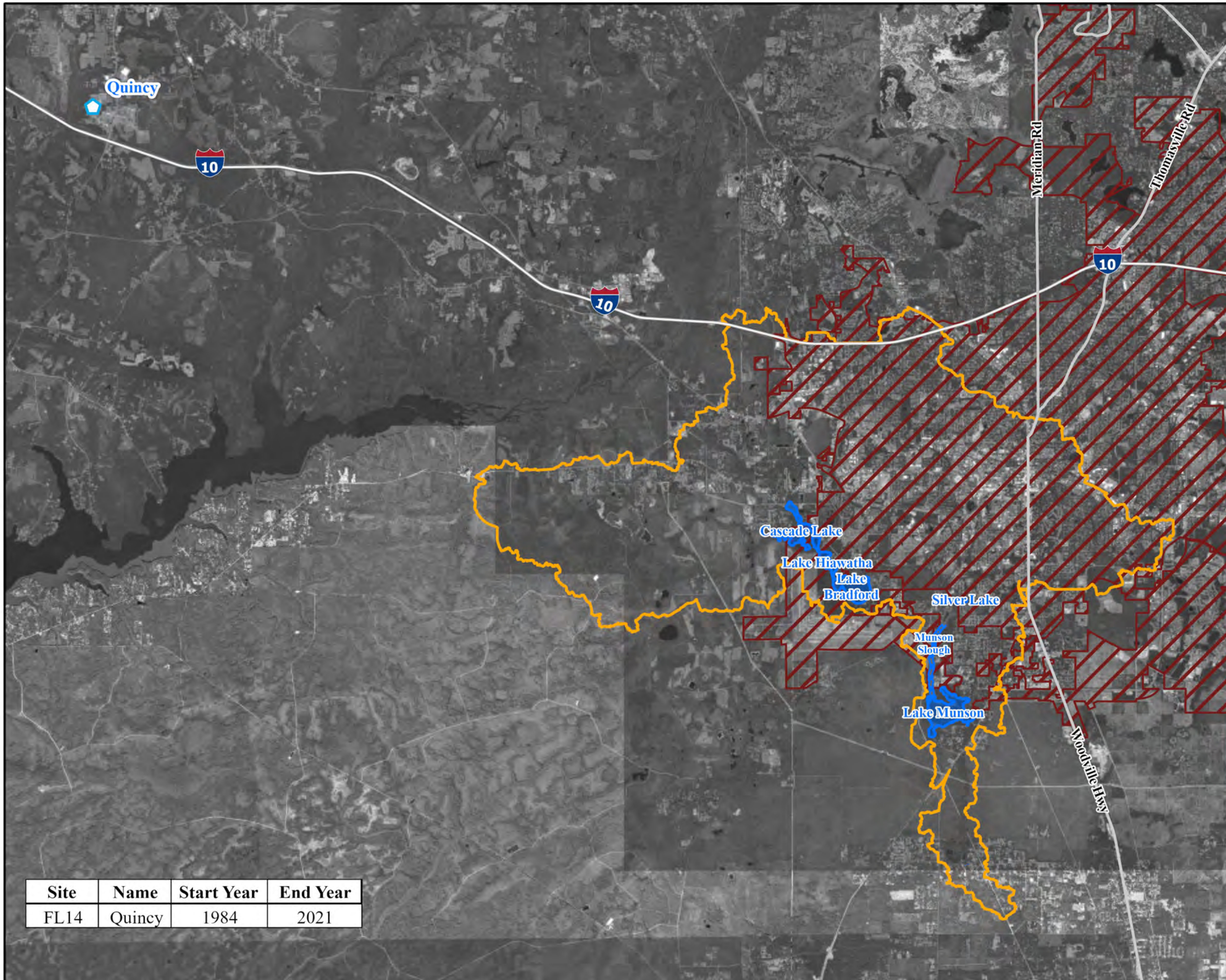

Site	Name	Start Year	End Year
FL14	Quincy	1984	2021

Legend

- Lake Munson Drainage Basin
- Waterbodies in Study
- Major Roads
- Tallahassee Corporate Limits
- Atmospheric Deposition Station

Sources:
Waterbodies: COT, 2020
Station: NADP, 2022
Drainage Basin: COT, 2020
Roads: COT-Leon County, 2023
City Limits: COT, 2022

Figure 3-24:
Location of Atmospheric Deposition Station Relative to Lake Munson

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- No direct measurements of internal nutrient flux within Lake Munson have been completed that reflect the internal loading conditions that exist today.

3.4.4 Qualitative Assessment of Sources

Prior to performing loading calculations and other analyses to quantify existing pollutant sources to Lake Munson and Munson Slough downstream of Lake Henrietta SWMF, it is important to analyze available data and summarize findings from historical studies to support identification of the pathway and magnitude of potential sources. This aids in the determination of sources by providing a more complete understanding of the lake's water quality response and (where data and historical studies are available) highlights the degree to which inflow from Munson Slough and other inputs contribute as sources. Additionally, the determination of potential sources must take into account existing water quality treatment infrastructure and how their location and function mitigate conditions prior to discharge to the lake and slough.

For Lake Munson and Munson Slough downstream of Lake Henrietta SWMF, the sources that were evaluated include the following:

- Stormwater runoff
- Septic systems
- Internal recycling and seepage
- Wastewater
- Atmospheric deposition
- Interconnected flows (inflows from other connected lakes)

An overview of the analyses and findings for each of the sources listed above is provided in the following sections. Prior to the discussions of each of the potential sources, analyses examining the spatial variation of the parameters of interest within the lake and the slough downstream of Lake Henrietta SWMF are provided to support determination of key sources to focus on. Following the discussions for each source type, a summary of findings for the qualitative assessment is provided.

3.4.4.1 In-Lake and Munson Slough (Downstream of Lake Henrietta SWMF) Water Quality

In-lake spatial variation was evaluated for the following parameters:

- Color
- Alkalinity
- Total Phosphorus
- Total Nitrogen
- Chl-a

- Trophic State Index
- *E. coli*

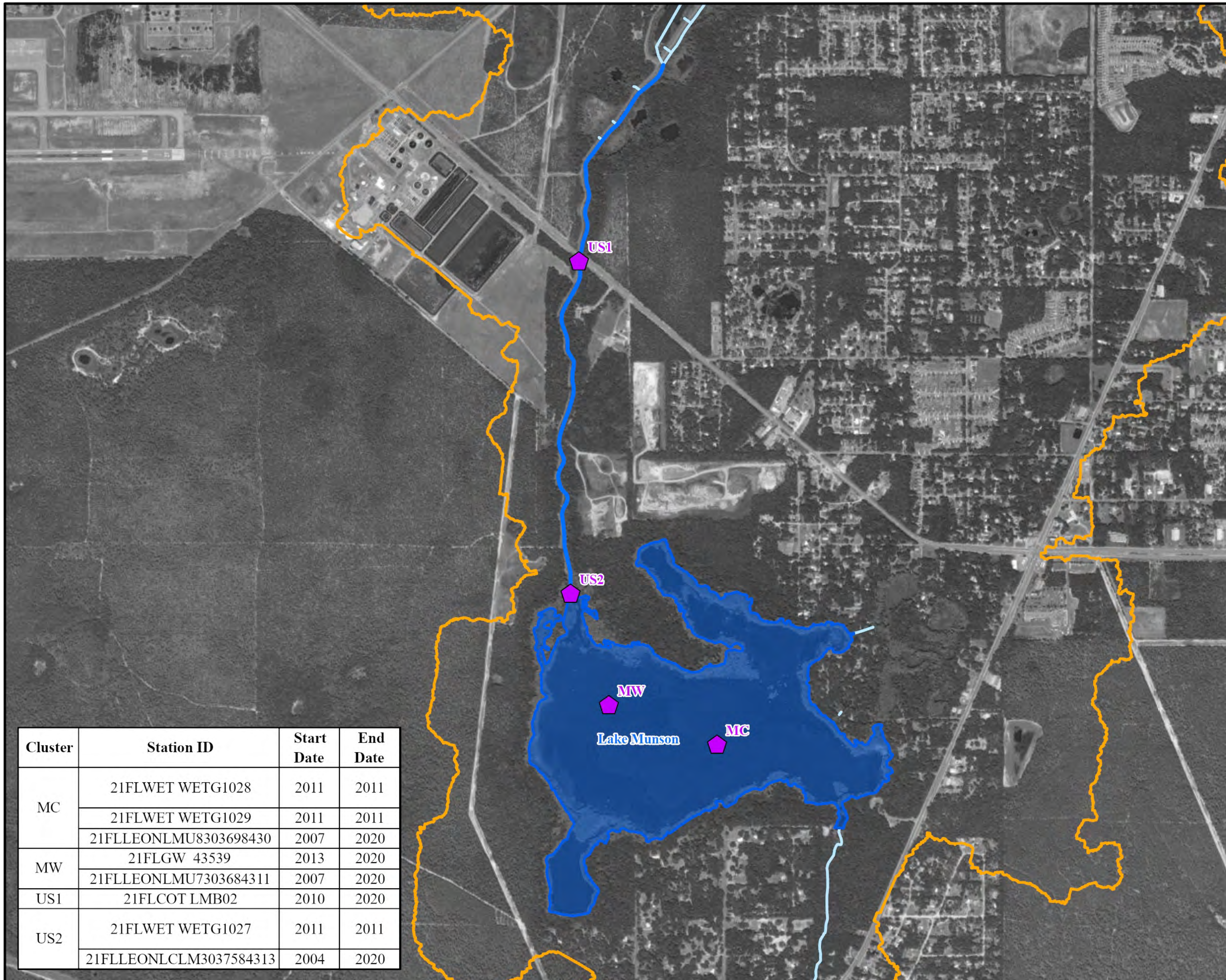
Spatial variation within Munson Slough (downstream of Lake Henrietta SWMF) was evaluated for the following parameters:

- Total Nitrogen
- Total Phosphorus
- Total Suspended Solids
- *E. coli*

To maximize available data for use in the spatial analyses, data stations were clustered to represent general areas of the lake such as stations nearer to the inflow and outflow. Additionally, stations were clustered along Munson Slough downstream of Lake Henrietta SWMF to identify any changes moving downstream from the treatment at Lake Henrietta SWMF and to provide comparisons with in-lake data. Analyses were then performed on the collective data for those general locations. **Figure 3-25** presents the data clustering locations and the specific water quality stations where data were pulled for that specific cluster for Lake Munson and Munson Slough downstream of Lake Henrietta SWMF. A total of two clusters were identified in Lake Munson and two along Munson Slough.

The spatial analyses were performed using data only after 2010 to represent recent conditions. Any station that had data after 2010 was assigned one of the cluster locations and a collective data set developed for that cluster. As such, all data available within the lake and the slough (downstream of Lake Henrietta SWMF) after 2010 were utilized in the spatial analyses. As discussed in **Section 3.4.3.7**, while historically data have been collected throughout the lake, including in the immediate area of the inflow and at the outflow structure, data since 2010 have been collected primarily within two areas more central to the lake. The two clusters (**Figure 3-25**) are MW closer to the inflow and MC closer to the outflow, but both are generally located within the lake center. Having clusters that are generally only within the center of the lake does limit some of the effectiveness of the spatial evaluation. Along Munson Slough downstream of Lake Henrietta SWMF, data are available at a station downstream of Lake Henrietta SWMF, where the slough crosses Capital Circle (US1) and just prior to flowing into the lake (US2), providing a more robust evaluation of changes in concentrations following discharge from Lake Henrietta SWMF.

Figure 3-26 through **Figure 3-33** present the results of the spatial analyses. For all parameters (other than *E. coli*), the annual geomeans for the period of record from 2010 to 2020 were averaged to calculate the cluster values. For *E. coli*, the 90th percentile of the data was calculated. Each of the clusters had data that spanned the full period from 2010 to 2020, providing greater confidence in the comparisons between stations.



Cluster	Station ID	Start Date	End Date
MC	21FLWET WETG1028	2011	2011
	21FLWET WETG1029	2011	2011
	21FLLEONLMU8303698430	2007	2020
MW	21FLGW 43539	2013	2020
	21FLLEONLMU7303684311	2007	2020
US1	21FLCOT LMB02	2010	2020
US2	21FLWET WETG1027	2011	2011
	21FLLEONLCLM3037584313	2004	2020

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023

Figure 3-25:
Station Clustering for Spatial Analyses to Lake Munson

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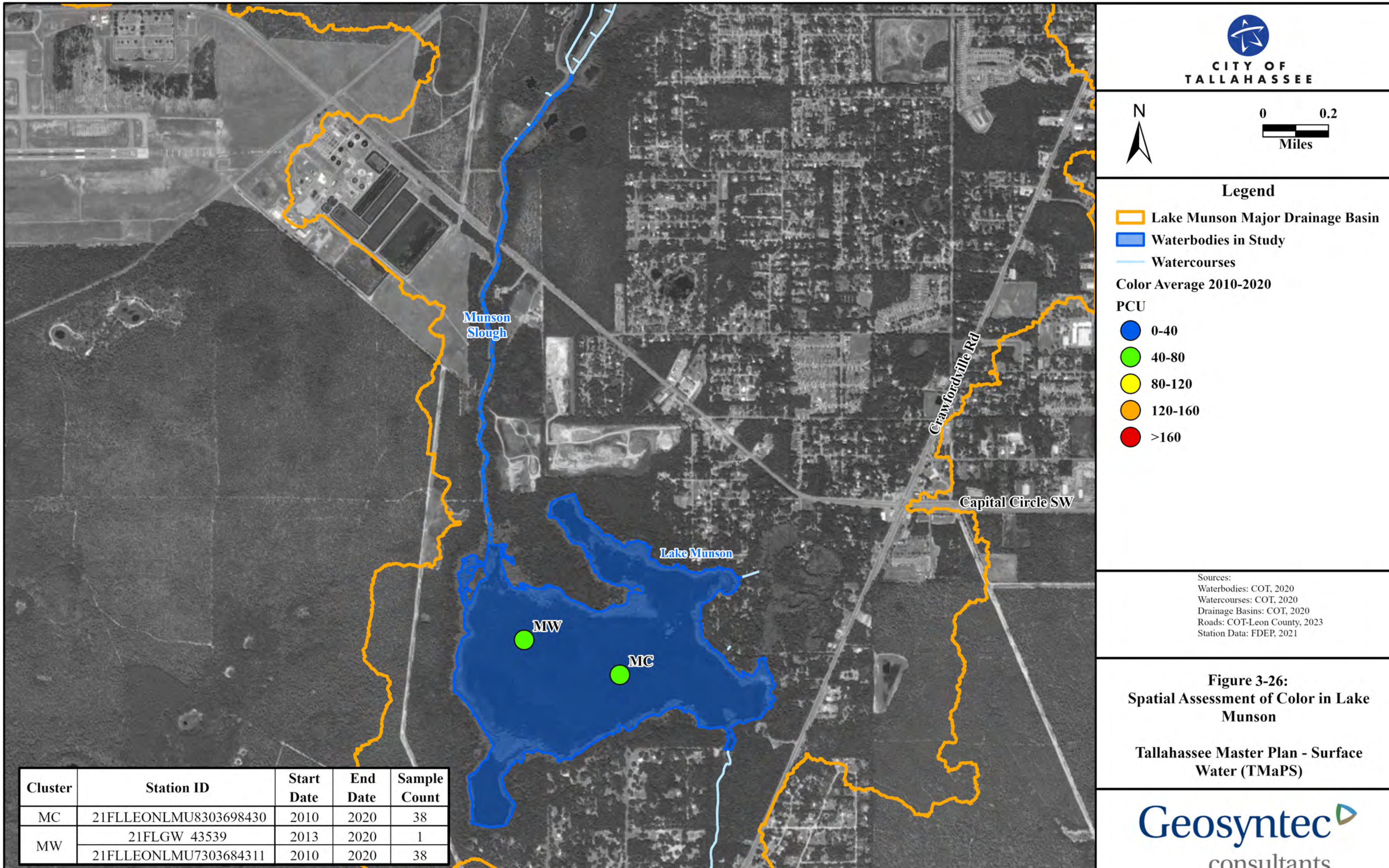
The results at each cluster of stations are presented as colored symbols representing ranges of calculated values. For nutrients and Chl-a, analyses the TMDL criteria/thresholds were used to define breakpoints for the color transitions. For color and alkalinity in the lake, the NNC thresholds defining lake type were utilized. For *E. coli*, the stream and lake criteria were utilized.

For all parameters with maximum thresholds, the transition from orange to red was set at the criteria/threshold. The other four levels were then evenly divided down from the maximum to 0.

- For Lake Munson alkalinity, the cutoff from orange into red was set to 20 mg/L based on the NNC threshold for lake type.
- For Lake Munson color, the cutoff from blue to green was set at 40 PCUs based on the NNC threshold for lake type.
- For Lake Munson TN and TP, cutoffs were set for orange to red at the TMDL targets of 0.76 mg/L and 0.044 mg/L respectively.
- For Munson Slough TN and TP, cutoffs were set for orange to red at the TMDL targets of 0.72 mg/L and 0.15 mg/L respectively.
- For Chl-a, the cutoff from orange to red was set at the criteria for Lake Munson (20 µg/L).
- For TSI, the cutoff was set to 60 from orange to red, based on the transition from mesotrophic to eutrophic conditions.
- For *E. coli*, the transition from orange to red was set at 410 most probable number (MPN)/100 mL.

The analyses presented herein are not meant to indicate conditions of impairment or non-impairment per FDEP rules and criteria. The criteria/thresholds are to aid in assessing general conditions in the lake and spatial variation, and the thresholds provide baselines to evaluate against and to aid in defining potential target areas for water quality improvement projects. Additionally, the analyses represent average conditions from 2010 through 2020 and do not account for trends or changes during that time period. This is important relative to Lake Munson and Munson Slough due to the changes seen in the data after 2016, as discussed in **Section 3.4.3.7**.

Figure 3-26 and **Figure 3-27** present the variations in color and alkalinity. The color data show similar levels between the two lake clusters, with average color values just above the 40 PCU NNC threshold for lake type (MW=41 PCU, MC=45 PCU). Alkalinity also does not show significant variation between the two clusters, with values well above the 20 mg/L NNC threshold (MW=37 mg/L, MC=39 mg/L).



Cluster	Station ID	Start Date	End Date	Sample Count
MC	21FLLEONLMU8303698430	2010	2020	38
MW	21FLGW 43539	2013	2020	1
	21FLLEONLMU7303684311	2010	2020	38

Figure 3-26: Spatial Assessment of Color in Lake Munson

Tallahassee Master Plan - Surface Water (TMaPS)

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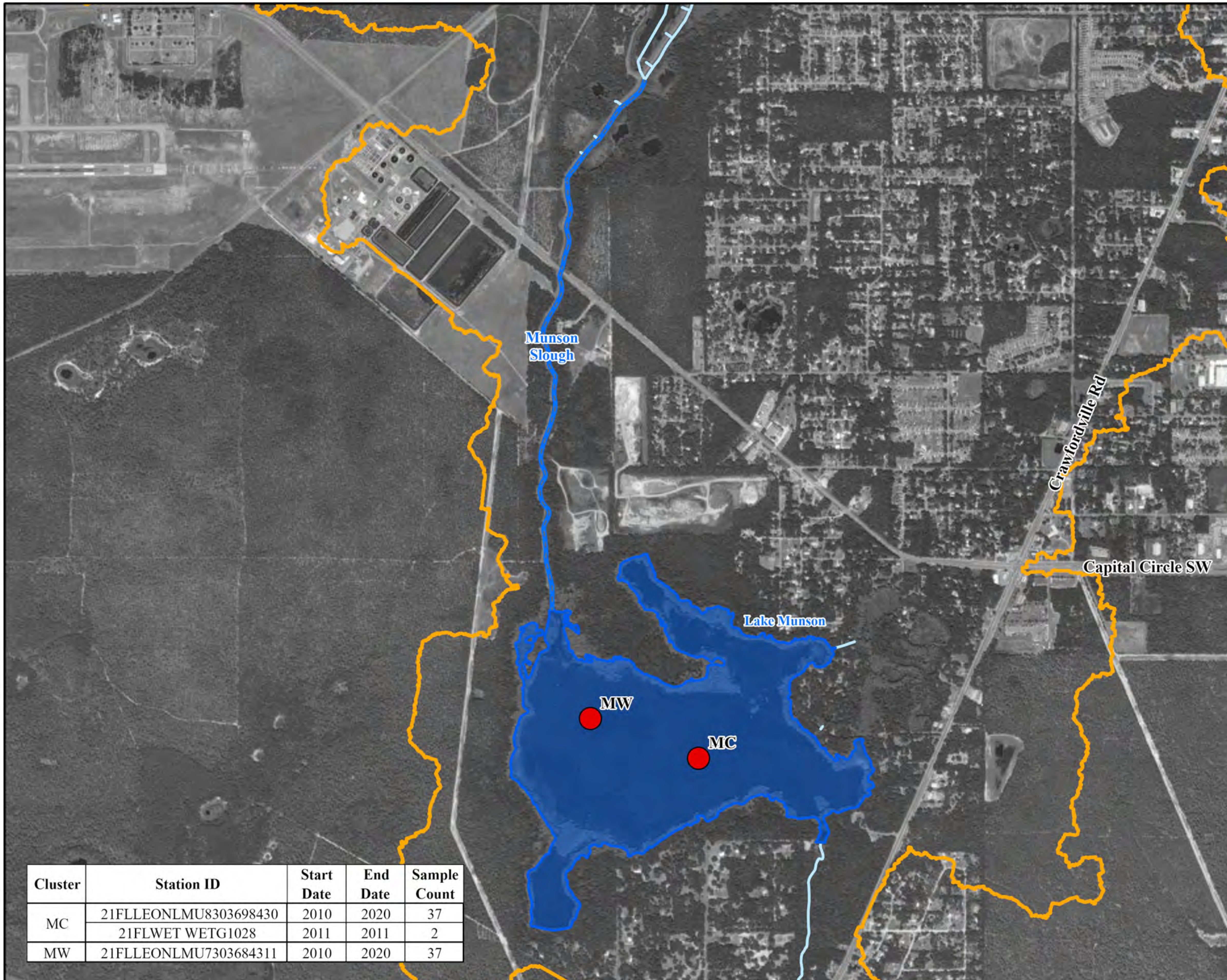

Cluster	Station ID	Start Date	End Date	Sample Count
MC	21FLLEONLMU8303698430	2010	2020	37
	21FLWET WETG1028	2011	2011	2
MW	21FLLEONLMU7303684311	2010	2020	37

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N

0 0.2
Miles

Legend

- Lake Munson Major Drainage Basin
- Waterbodies in Study
- Watercourses

Alkalinity Average 2010-2020
mg/L

- 0-5
- 5-10
- 10-15
- 15-20
- >20

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-27:
Spatial Assessment of Alkalinity in Lake Munson

Tallahassee Master Plan - Surface Water (TMaPS)

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Figure 3-28 and **Figure 3-29** present the variations in TN and TP, respectively, within Lake Munson and Munson Slough downstream of Lake Henrietta SWMF. The TN averages are all above the TMDL thresholds of 0.72 mg/L for the lake and 0.76 mg/L for the slough. The high averages are primarily due to the data prior to 2016. The TN averages looking from upstream in the slough down through the lake (US1=0.79 mg/L, US2=0.74 mg/L, MW=0.84 mg/L, MC=0.87 mg/L) do not show significant spatial variation, with the inflowing concentrations slightly lower than the lake values.

The TP averages are above the TMDL threshold of 0.044 mg/L for the lake but below the TMDL threshold for the slough (0.16 mg/L). As with TN, the high averages are primarily due to the data prior to 2016. The TP averages looking from upstream in the slough down through the lake (US1=0.10 mg/L, US2=0.12 mg/L, MW=0.16 mg/L, MC=0.19 mg/L) show a general increase moving down the slough through the lake. The lake averages are higher than those seen coming in from the slough. The higher values in the lake indicate internal sources are likely contributing to the load, based on the data from 2010 to 2020. Again, this result is driven by the data prior to 2016.

Figure 3-30 and **Figure 3-31** present the variations in Chl-a and TSI within the lake. These parameters represent the biological response to nutrient loading. The Chl-a data show similar levels between the two lake clusters, with both stations showing averages above the 20 µg/L threshold (MW=29 µg/L, MC=28 µg/L). TSI also does not show significant variation between the two clusters, with values right around the 60 threshold from good to fair (MW=62 mg/L, MC=58 mg/L).

Figure 3-32 and **Figure 3-33** present the variations in *E. coli*. within the lake and slough and total suspended solids (TSS) within the slough. The *E. coli* 90^{th} percentiles are all well below the 410 MPN/100 mL threshold in both the slough and lake (US1=48 MPN/100 mL, US2=16 MPN/100 mL, MW=6 MPN/100 mL, MC=4 MPN/100 mL), decreasing moving from upstream in the slough through the lake. TSS averages in the slough are also low, both upstream and downstream (US1=5.4 mg/L, US2=6.5 mg/L).

3.4.4.2 Stormwater Runoff

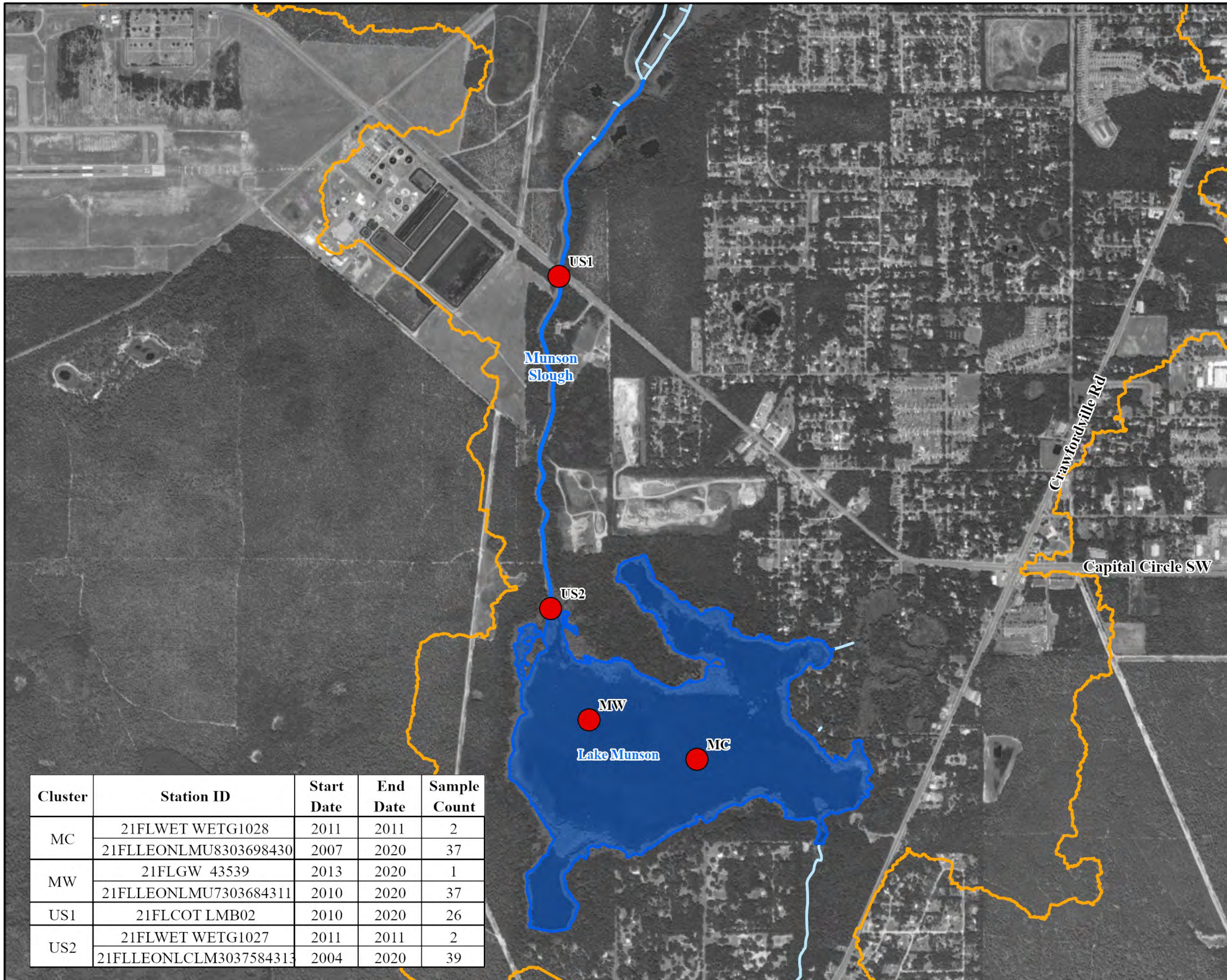
To assess stormwater runoff as a potential source of pollutant loads to Lake Munson, a number of analyses were conducted. First, calculations of Landscape Development Intensity (LDI) Index by sub-watershed were performed. LDI is an estimate of the intensity of human land use based on nonrenewable energy flow (Brown and Vivas, 2005). The LDI is calculated as the percentage area within a catchment of particular types of land use, multiplied by the coefficient of energy associated with that land use, summed over all land use types in the catchment.

$$LDI = \sum (LDI_i * \%LU_i)$$

Where:

LDI_i = the nonrenewable energy land use for land use i, and

$\%LU_i$ = the percentage of land area in the catchment with land use i.



Cluster	Station ID	Start Date	End Date	Sample Count
MC	21FLWET WETG1028	2011	2011	2
	21FLLEONLMU8303698430	2007	2020	37
MW	21FLGW 43539	2013	2020	1
	21FLLEONLMU7303684311	2010	2020	37
US1	21FLCOT LMB02	2010	2020	26
US2	21FLWET WETG1027	2011	2011	2
	21FLLEONLCLM3037584313	2004	2020	39

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-28:
Spatial Assessment of TN in Lake Munson and Munson Slough Below Lake Henrietta

Tallahassee Master Plan - Surface Water (TMaPS)

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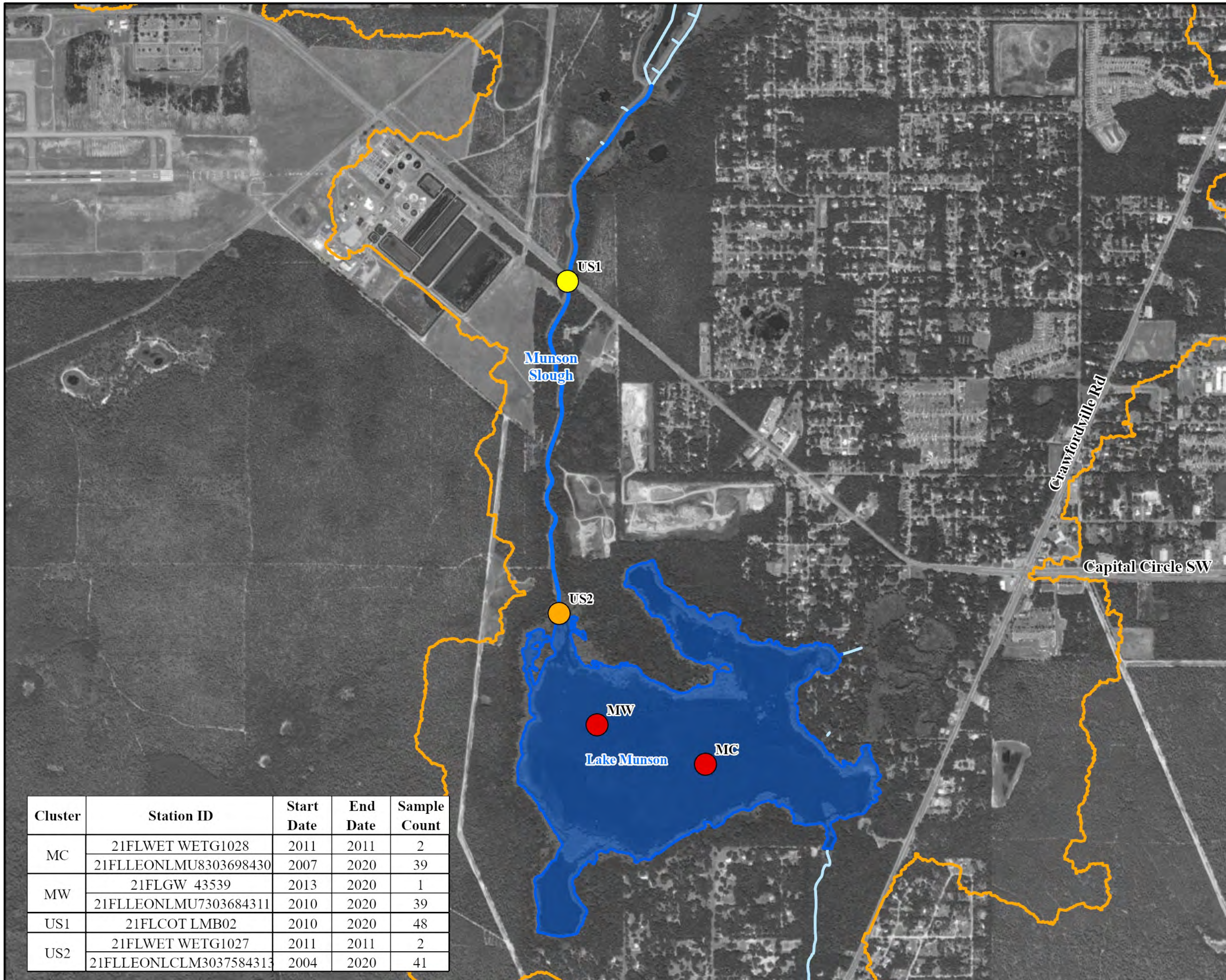

Cluster	Station ID	Start Date	End Date	Sample Count
MC	21FLWET WETG1028	2011	2011	2
	21FLLEONLMU8303698430	2007	2020	39
MW	21FLGW 43539	2013	2020	1
	21FLLEONLMU7303684311	2010	2020	39
US1	21FLCOT LMB02	2010	2020	48
US2	21FLWET WETG1027	2011	2011	2
	21FLLEONLCLM3037584313	2004	2020	41

N

0 0.2
Miles

Legend

- Lake Munson Drainage Basin
- Munson Slough
- Waterbodies in Study
- Watercourses

In-Lake TP Average 2010-2020
mg/L

- 0-0.014
- 0.014-0.025
- 0.025-0.036
- 0.036-0.044
- >0.044

Stream TP Average 2010-2020
mg/L

- 0-0.05
- 0.05-0.8
- 0.08-0.12
- 0.12-0.15
- >0.15

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-29:
Spatial Assessment of TP in Lake Munson and Munson Slough Below Lake Henrietta

Tallahassee Master Plan - Surface Water (TMaPS)

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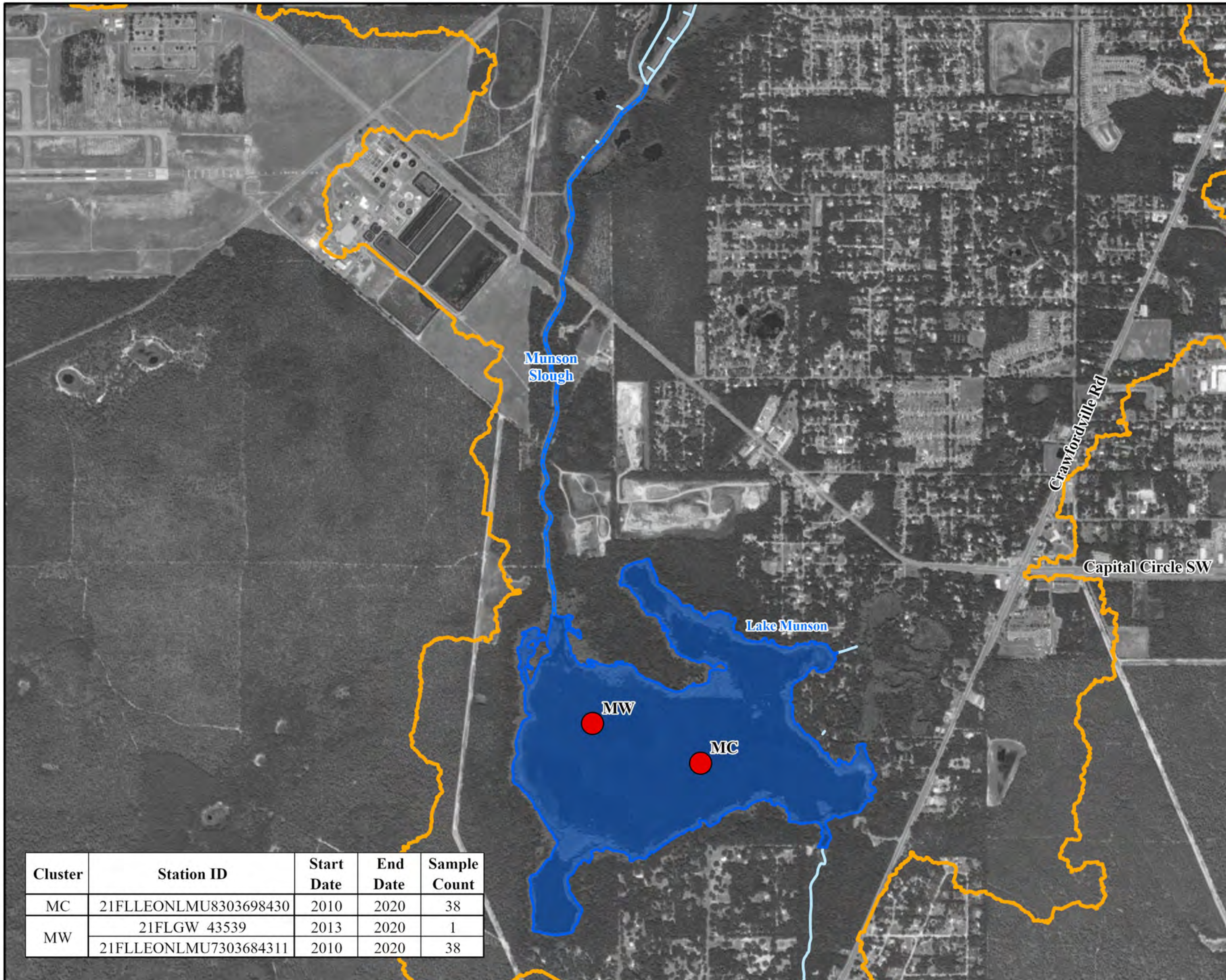

Cluster	Station ID	Start Date	End Date	Sample Count
MC	21FLLEONLMU8303698430	2010	2020	38
MW	21FLGW 43539	2013	2020	1
	21FLLEONLMU7303684311	2010	2020	38

CITY OF TALLAHASSEE

N

0 0.2
Miles

Legend

- Lake Munson Major Drainage Basin
- Waterbodies in Study
- Watercourses

Chl a Average 2010-2020
µg/L

- 0-5
- 5-10
- 10-15
- 15-20
- >20

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-30:
Spatial Assessment for Chl a in Lake Munson

Tallahassee Master Plan - Surface Water (TMaPS)

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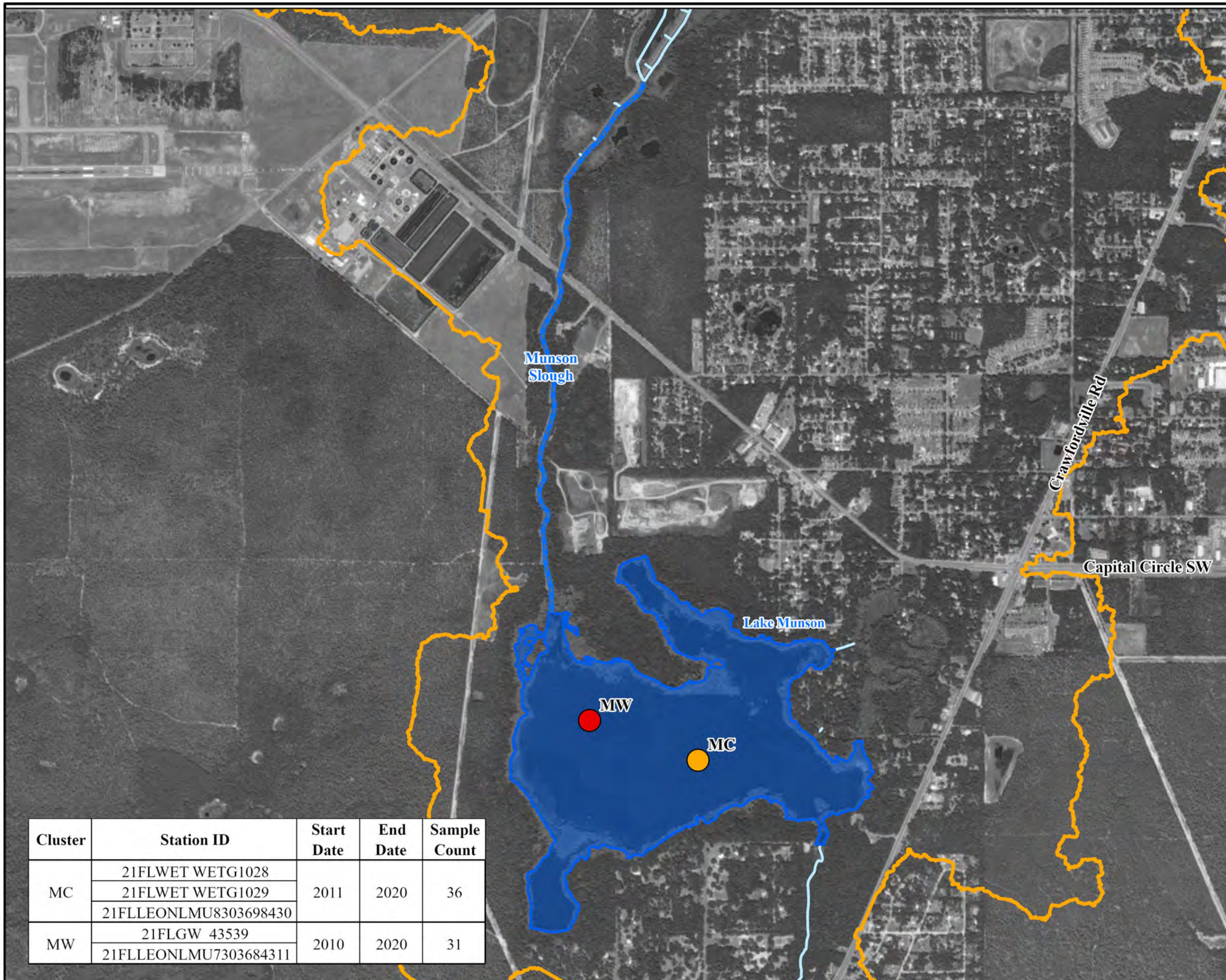

Cluster	Station ID	Start Date	End Date	Sample Count
MC	21FLWET WETG1028	2011	2020	36
	21FLWET WETG1029			
	21FLLEONLMU8303698430			
MW	21FLGW 43539	2010	2020	31
	21FLLEONLMU7303684311			

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-31: Spatial Assessment of TSI in Lake Munson

Tallahassee Master Plan - Surface Water (TMaPS)

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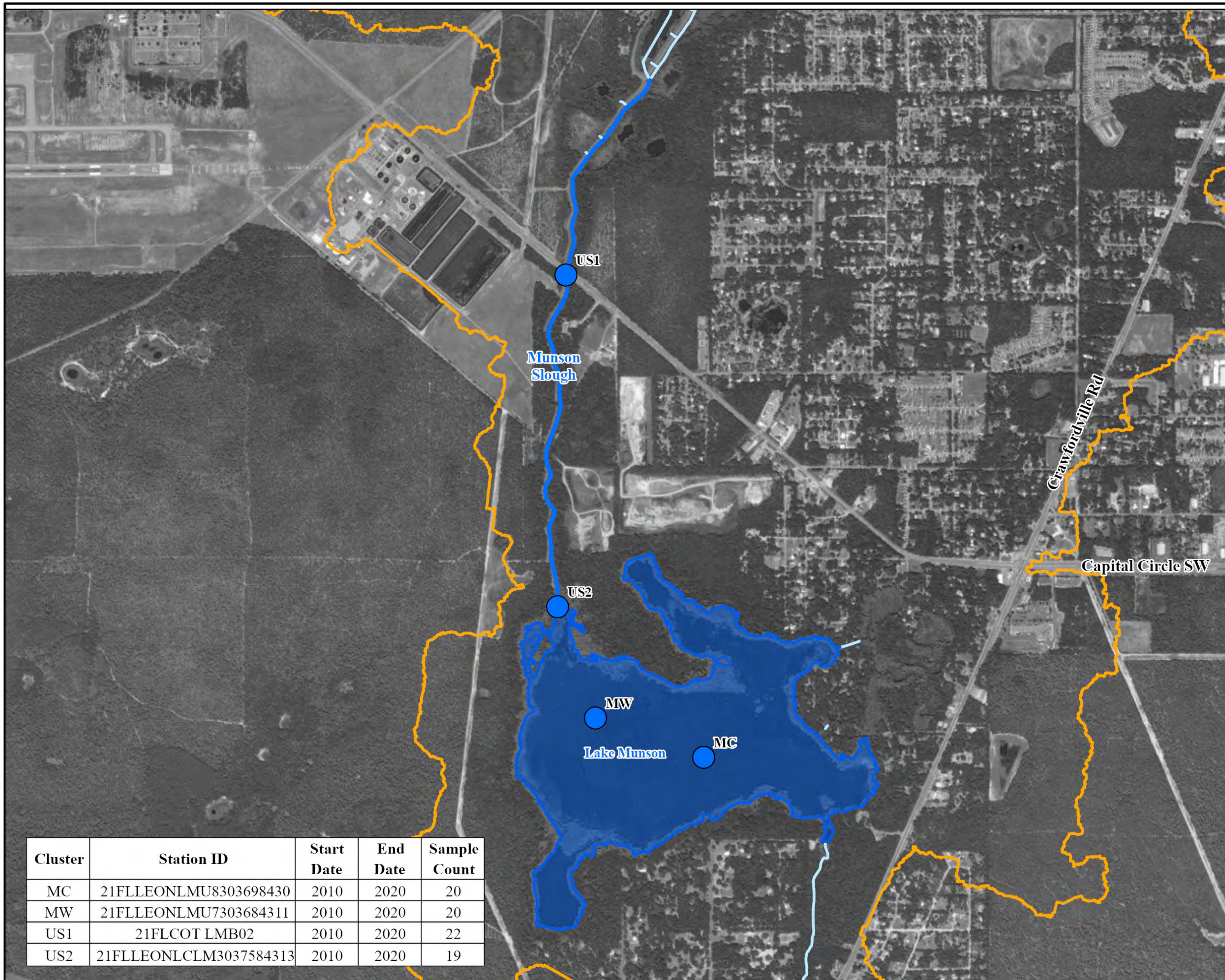

Cluster	Station ID	Start Date	End Date	Sample Count
MC	21FLLEONLMU8303698430	2010	2020	20
MW	21FLLEONLMU7303684311	2010	2020	20
US1	21FLCOT LMB02	2010	2020	22
US2	21FLLEONLCLM3037584313	2010	2020	19

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-32: Spatial Assessment of E. coli in Lake Munson and Munson Slough Below Lake Henrietta

Tallahassee Master Plan - Surface Water (TMaPS)

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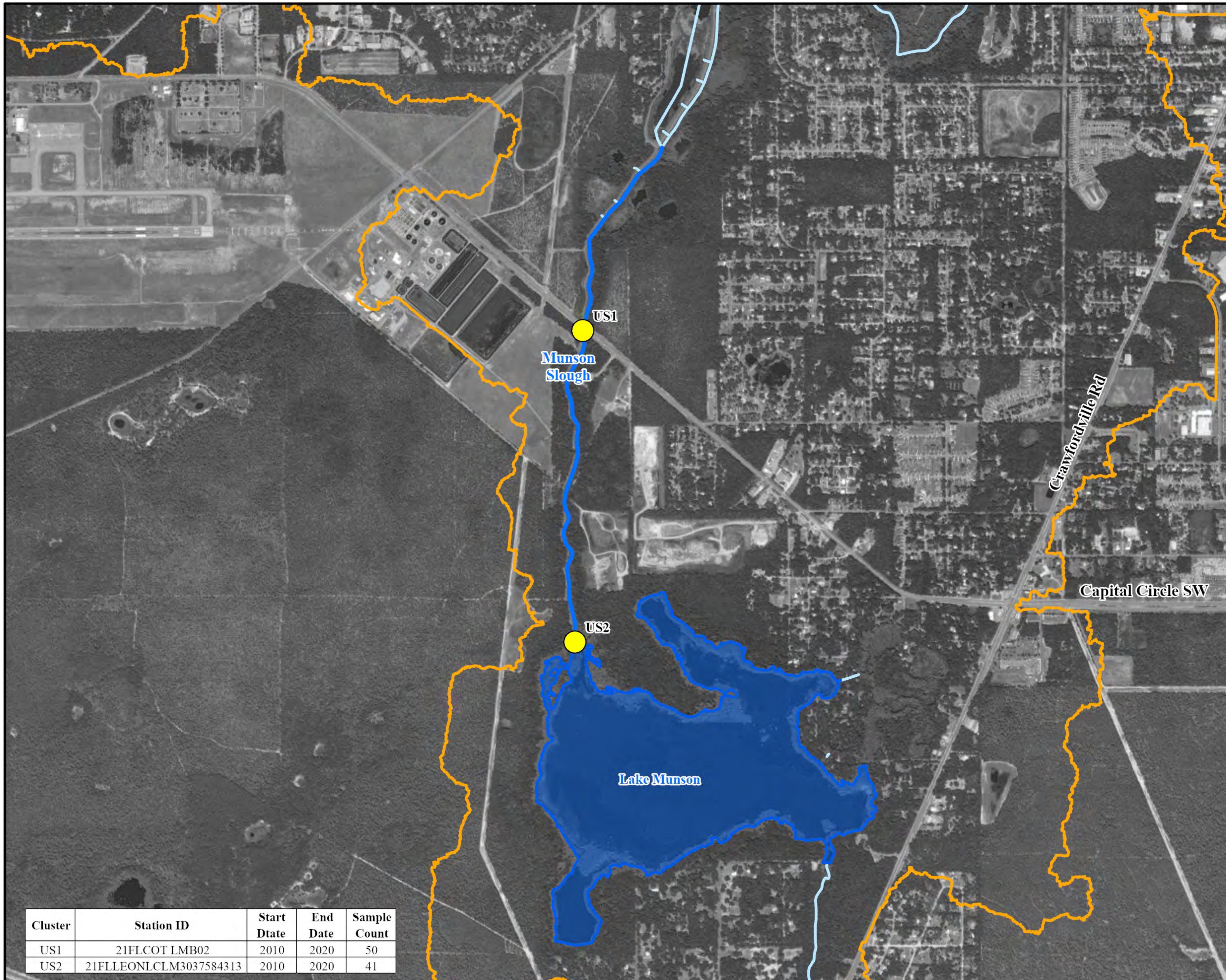

Cluster	Station ID	Start Dtate	End Date	Sample Count
US1	21FLCOT LMB02	2010	2020	50
US2	21FLLEONLCLM3037584313	2010	2020	41

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
Station Data: FDEP, 2021

Figure 3-33:
Spatial Assessment of TSS in Munson Slough Below Lake Henrietta

Tallahassee Master Plan - Surface Water (TMaPS)

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The LDI coefficients are provided in **Table 3-5**.

Table 3-5: Landscape Development Intensity Index Coefficients

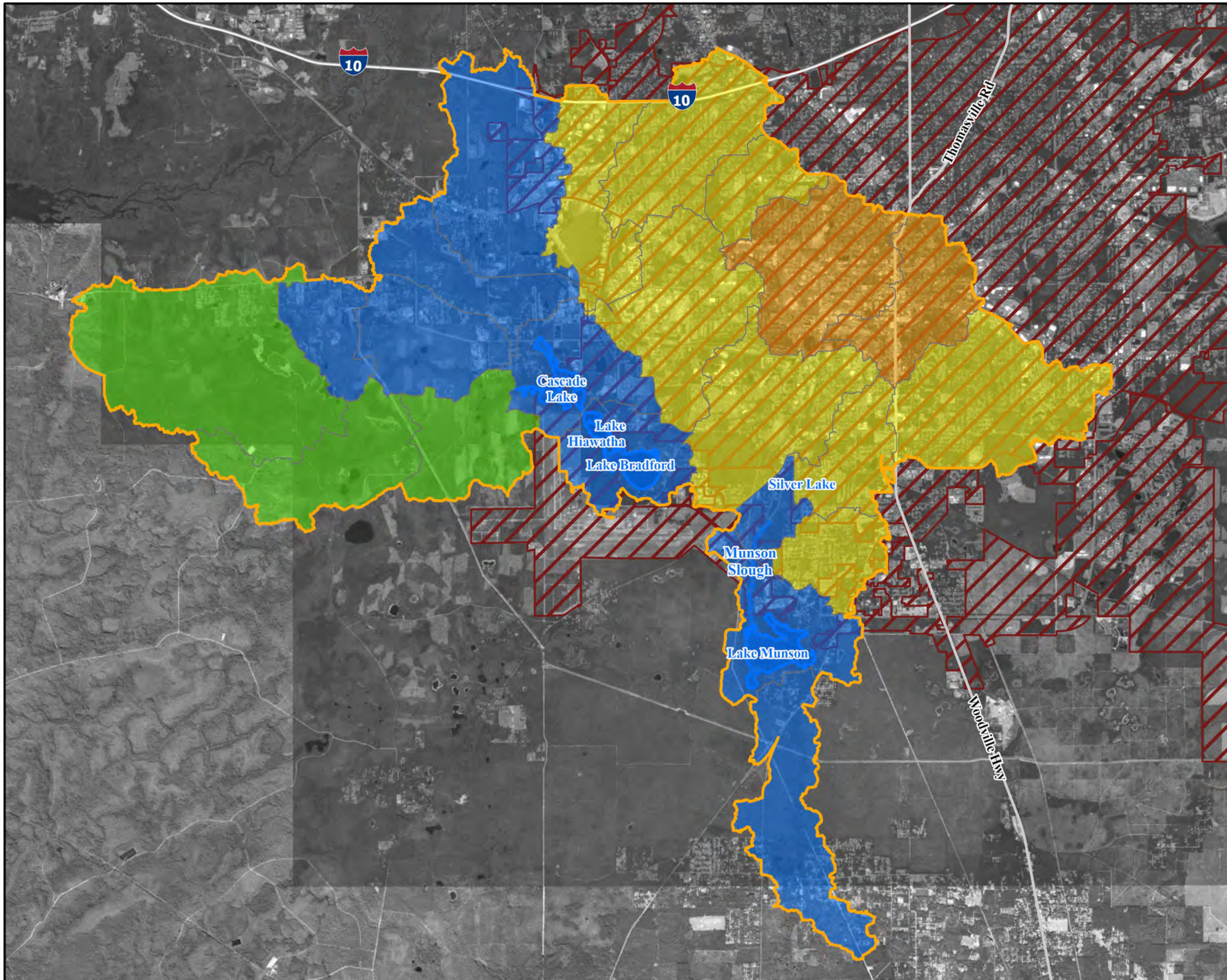
Category	Coefficient
Natural System	1
Pine Plantation	1.6
Pasture	3.4
Row Crops	4.5
Residential (low)	6.8
Residential (high)	7.6
Commercial	8.0
Industrial	8.3
Commercial (high)	9.2
Business District	10.0

FDEP uses the LDI as a tool to estimate potential adverse human effects from various land uses on adjacent waterbodies, such as streams, lakes, and wetlands. Based on the LDI score, the catchment area is rated as excellent (1 to 2), good (3 to 4), moderate (5 to 6), poor (7 to 8), or very poor (9 to 10) in relation to its potential for adverse impacts or loadings to waterbodies that receive runoff (FDEP, 2020).

Figure 3-34 presents the calculated LDIs by sub-watershed throughout the Lake Munson basin. The boundaries of the watersheds evaluated are thin grey lines in the figure. The results show the distinct spatial differences in land use and runoff loading potential in the basin. The LDI analyses do not account for treatment that occurs within the various watersheds but rather reflect the potential for pollutant load in stormwater runoff from the various land uses.

The eastern side of the basin reflects conditions within the City's incorporated area with LDIs ranging from moderate to poor. These areas drain to Silver Lake (via the East Drainage Ditch) and Munson Slough (via the Central Drainage Ditch and portions of the West Drainage Ditch). Moving west, LDI values are good for areas draining to Munson Slough (via the upper portion of the West Drainage Ditch), the Bradford Chain of Lakes, and areas downstream of Lake Henrietta SWMF along Munson Slough. In the westernmost parts of the basin, within the Apalachicola National Forest, LDI values are excellent.

The second analysis was based on data presented in **Section 3.4.3.7** and **Section 3.4.4.1**, which quantified the concentrations coming into Munson Slough out of Lake Henrietta SWMF. As the Lake Henrietta SWMF takes in flows from 95 percent of the major drainages upstream of Lake Munson, these data reflect the stormwater runoff entering Lake Munson under ambient and low flow conditions.



CITY OF TALLAHASSEE

N

0 1.4

Miles

Legend

- Lake Munson Drainage Basin
- Waterbodies in Study
- Tallahassee Corporate Limits

Land Development Index

- Excellent
- Good
- Moderate
- Poor
- Very Poor

Sources:
Waterbodies: COT, 2020
Drainage Basins: COT,2020
Roads: COT-Leon County, 2023
City Limits: COT, 2020

Figure 3-34: Land Development Index by Sub-Watershed within Lake Munson Drainage Basin

Tallahassee Master Plan - Surface Water (TMaPS)

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The analyses showed that TN and TP concentrations coming out of Lake Henrietta SWMF and flowing into Lake Munson (especially in recent years) are at levels below the TMDL targets established for the slough and lake, which indicates that for present conditions, stormwater loading, while likely the largest load to the lake, is not creating conditions that would degrade lake quality and designated uses. However, again, the data utilized in this analysis were generally collected under non-storm event conditions and may not fully reflect the concentrations during less frequent discharges from large rain events.

3.4.4.3 Septic Systems

Figure 3-35 presents a map showing the septic tank densities by watershed to aid in identifying the areas more likely to be sources of loading to Lake Munson and Munson Slough downstream of Lake Henrietta SWMF as well as other waterbodies targeted in this study. Septic densities around the basin are low, with the bulk of the basin having less than 1 unit per 5 acres. This low density is due to the extent of the City's incorporated area, where most residences are connected to central sewer, and the extent of undeveloped area in the western portion of the basin.

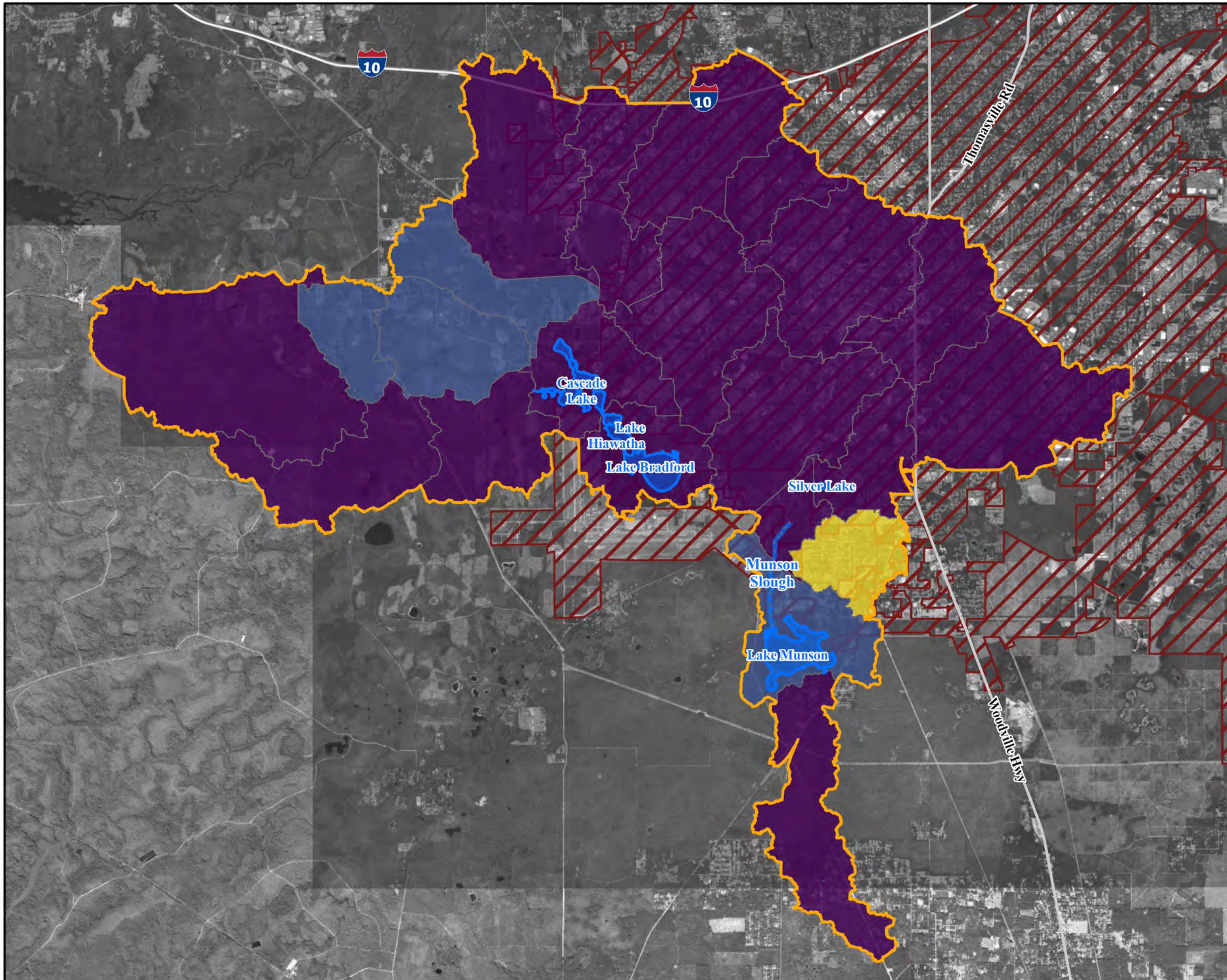
Only a few areas stand out as having higher densities. The highest density is found within a watershed to the east of Munson Slough downstream of Lake Henrietta SWMF. A significant portion of this basin has been identified as closed and not directly connected to Munson Slough or Lake Munson. Based on this, and the distance between this basin and the slough or lake, this area would not be deemed a significant source. The other areas of somewhat higher densities include the western portion of the basin in watersheds that include neighborhoods along State Road 20 and areas directly surrounding Lake Munson. Two of the watersheds shown drain through the Bradford Chain of Lakes, and their potential septic loads will be addressed as part of the Bradford Chain of Lakes evaluation (**Section 3.5.4.3**). The remaining watershed drains to Munson Slough (via the upper portions of the West Drainage Ditch). However, based on the distance from this watershed to Lake Munson, and the treatment from the Lake Henrietta SWMF, this watershed is not deemed a significant source to Lake Munson or Munson Slough downstream of Lake Henrietta SWMF. Furthermore, bacteria data within the slough and lake are not indicative of a wastewater source. Overall, the qualitative analyses indicate that septic loads are not a significant source. Given the readily available data, this determination will be substantiated through calculation of septic loads in **Section 3.4.5.2**.

3.4.4.4 Internal Recycling and Seepage

<u>Internal Recycling</u>

Section 3.4.1 presented an overview of studies conducted in Lake Munson to characterize sediments and assess the degree to which internal recycling, or nutrient flux, plays a role in the nutrient budget of the lake. Key studies and their findings are detailed in the following list.

- A NWFWMD study in 1988 showed that significant percentages of the sediment load, nutrients, and other contaminants were retained in the lake sediments. The study also identified a significant release of ortho-phosphorus from the sediments.



CITY OF TALLAHASSEE

N

0 1.4 Miles

Legend

- Lake Munson Drainage Basin
- Waterbodies in Study
- Tallahassee Corporate Limits

Septic Tank Density

Units/Acre

- 0 - 0.15
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 0.75
- >0.75

Sources:
Waterbodies: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Septic Tanks: COT, 2020

Figure 3-35: Septic Tank Density by Sub-Basin within Lake Munson Drainage Basin

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- In 2005, Leon County conducted borings throughout the lake and identified extensive areas of high organic content soils, with upwards of 60 percent organic content in some areas.
- A 2014 FDEP sediment biogeochemical study to quantify temporal and spatial changes in nutrient characteristics of the lake sediments in response to the 2010 drawdown indicated that significant removal of TN occurred, but TP removal was not as significant.
- A 2016 evaluation of the feasibility of sediment nutrient inactivation in Lake Munson determined that significant internal recycling was occurring based on analyses of concentrations between the inflow and outflow of the lake. The study also identified that the drawdown that occurred in 2010 did not appear to have a significant impact on TP concentrations in the lake.

Based on these studies and other work conducted on the lake, it is clear that internal nutrient flux has played a significant role in the nutrient budget. However, to date, the studies conducted have not directly quantified the rate of nutrient flux. Recent data collection efforts and analyses of soils by FGS have been focused more on characterization of the sediments for disposal, if sediments were removed.

The 2016 ERD study identified that significant internal recycling was occurring based on analyses of concentrations between the inflow and outflow of the lake. To assess conditions today, a similar evaluation was performed, including more recent data. The analyses looked at TN and TP annual geomeans from three locations, Munson Slough downstream of the Lake Henrietta SWMF (representing inflowing TN and TP), in Lake Munson (representing in-lake TN and TP concentrations), and from the Leon County station located below the dam (representing outflowing TN and TP concentrations). **Figure 3-36** and **Figure 3-37** present graphs comparing the TN and TP AGMs from the three locations from 2010 to 2021, respectively. The graphs show that prior to 2016 (the time period of the ERD assessment), the in-lake and outflowing TN and TP concentrations exceed the inflow concentrations, supporting the assertion at that time that internal loading was a significant source. Examination of the data after 2016 presents a different story. For both TN and TP, the outflowing concentrations are at (for TP) or below (for TN) the inflowing concentrations. This would indicate that in the more recent years, internal loading has decreased. This is supported by the recent in-lake Chl-a responses, which are below the TMDL and NNC target AGM of 20 µg/L.

<u>Seepage</u>

As outlined in the data summary (**Section 3.4.3.9**), there are very few surficial sampling wells in the area that might provide direct data on the potential for seepage as a source to Lake Munson or Munson Slough downstream of Lake Henrietta SWMF. **Figure 3-23** identified two surficial sampling wells in the Lake Munson basin. Both stations are within the Bradford Chain of Lakes watersheds and do not have data after 2000. Based on the data analyses in the lake and slough (**Section 3.4.3.7** and **Section 3.4.4.1**), along with the analyses presented above for internal flux, baseflow driven by seepage does not appear to be a significant source of nutrients or bacteria.

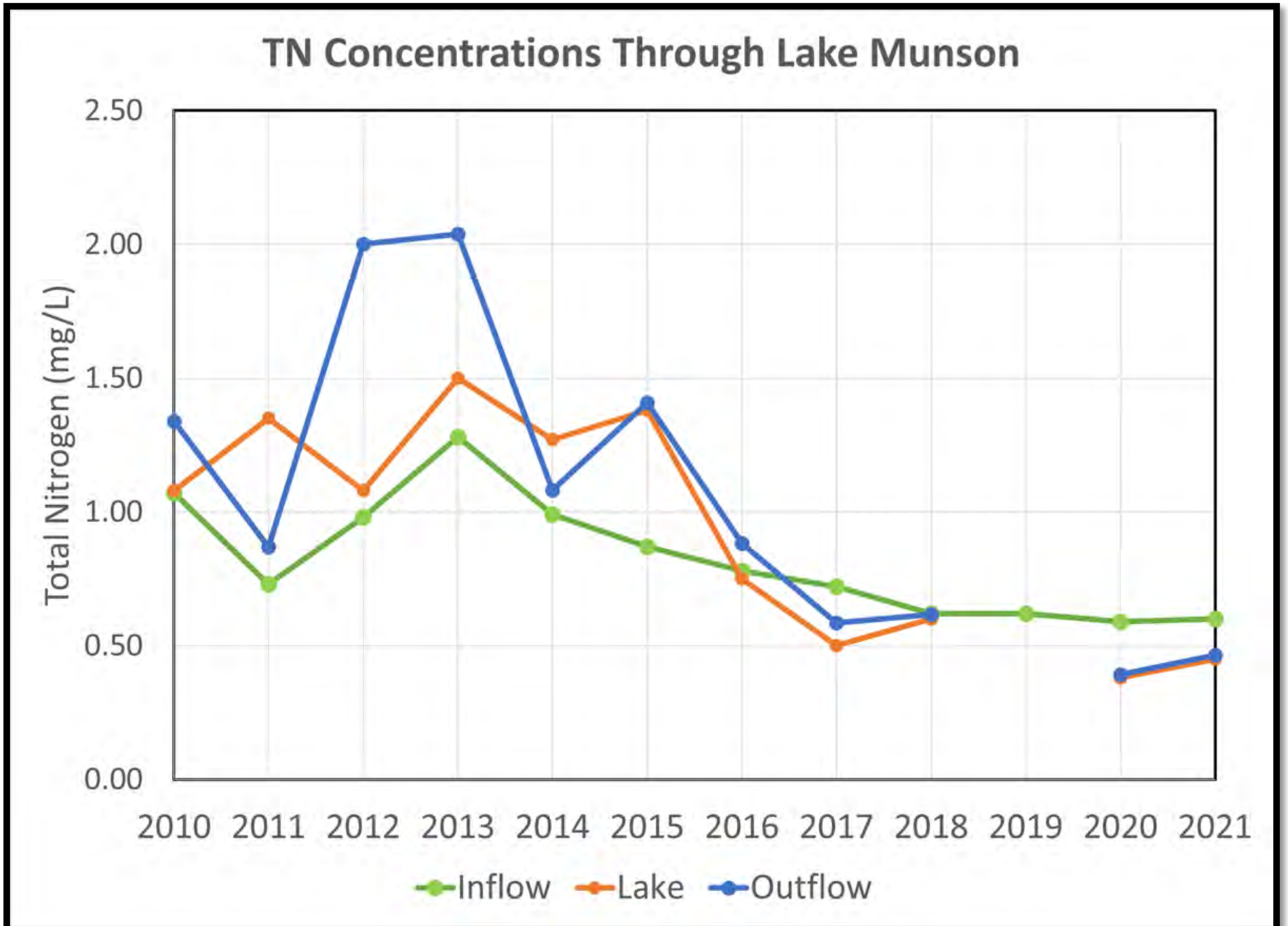


Figure 3-36: Comparison of TN AGMs Moving through Lake Munson (2010 to 2021)

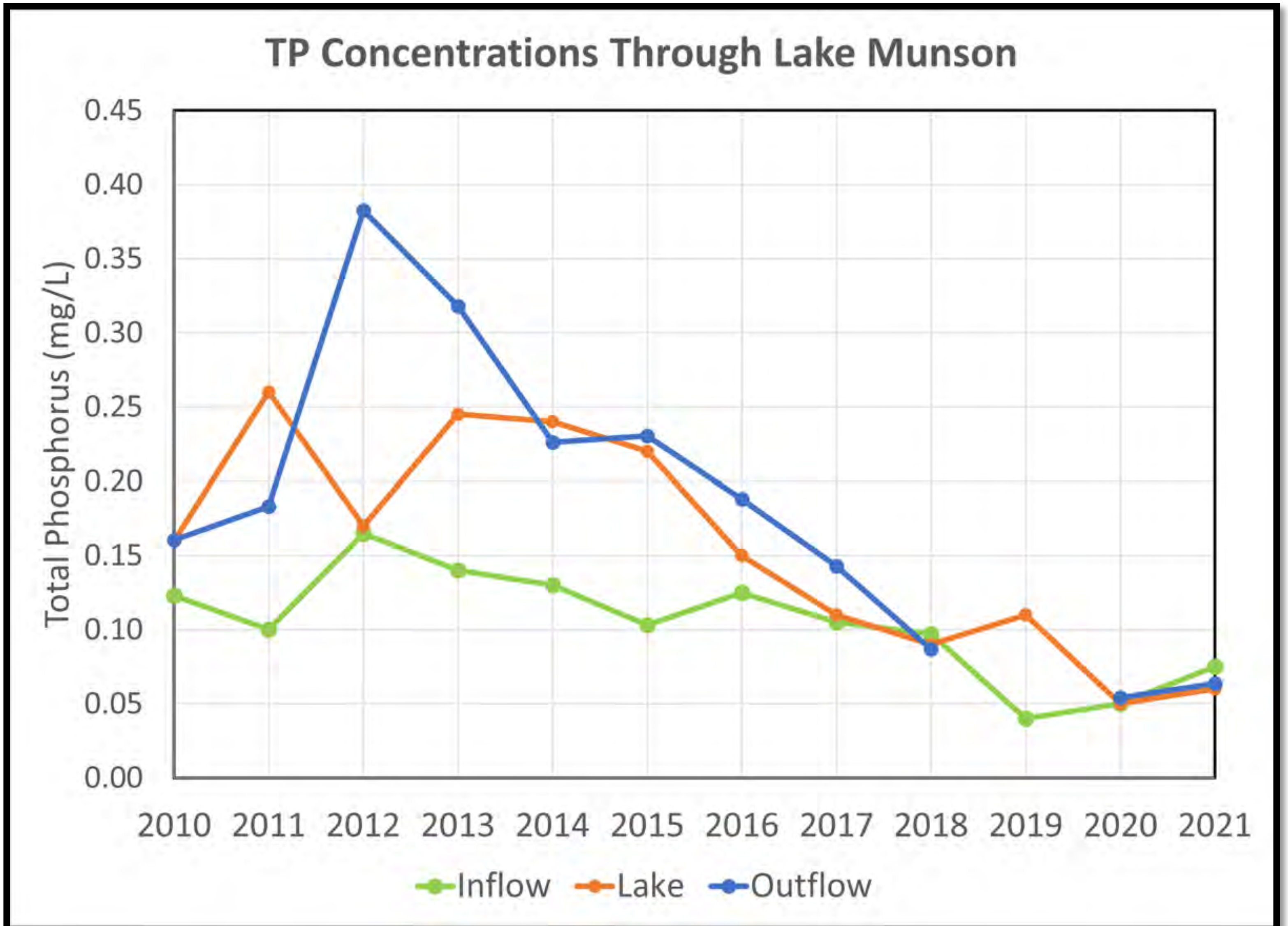


Figure 3-37: Comparison of TP AGMs Moving through Lake Munson (2010 to 2021)

3.4.4.5 Wastewater

A source of pollution that is discretely identifiable and from which pollutants are discharged is known as a "point source." Common types of point sources include facilities like factories, paper/pulp mills, and water treatment plants. Effluent from these facilities can be discharged either directly to a waterbody or via land application on designated sprayfields. In either case, these discharges pose the potential to be a source of pollutants to waterbodies in the basin. This section of the report focuses on known point sources within the Lake Munson basin and reviews their potential for impacting water quality within the study waterbodies as a function of loading, with a focus on TN and TP.

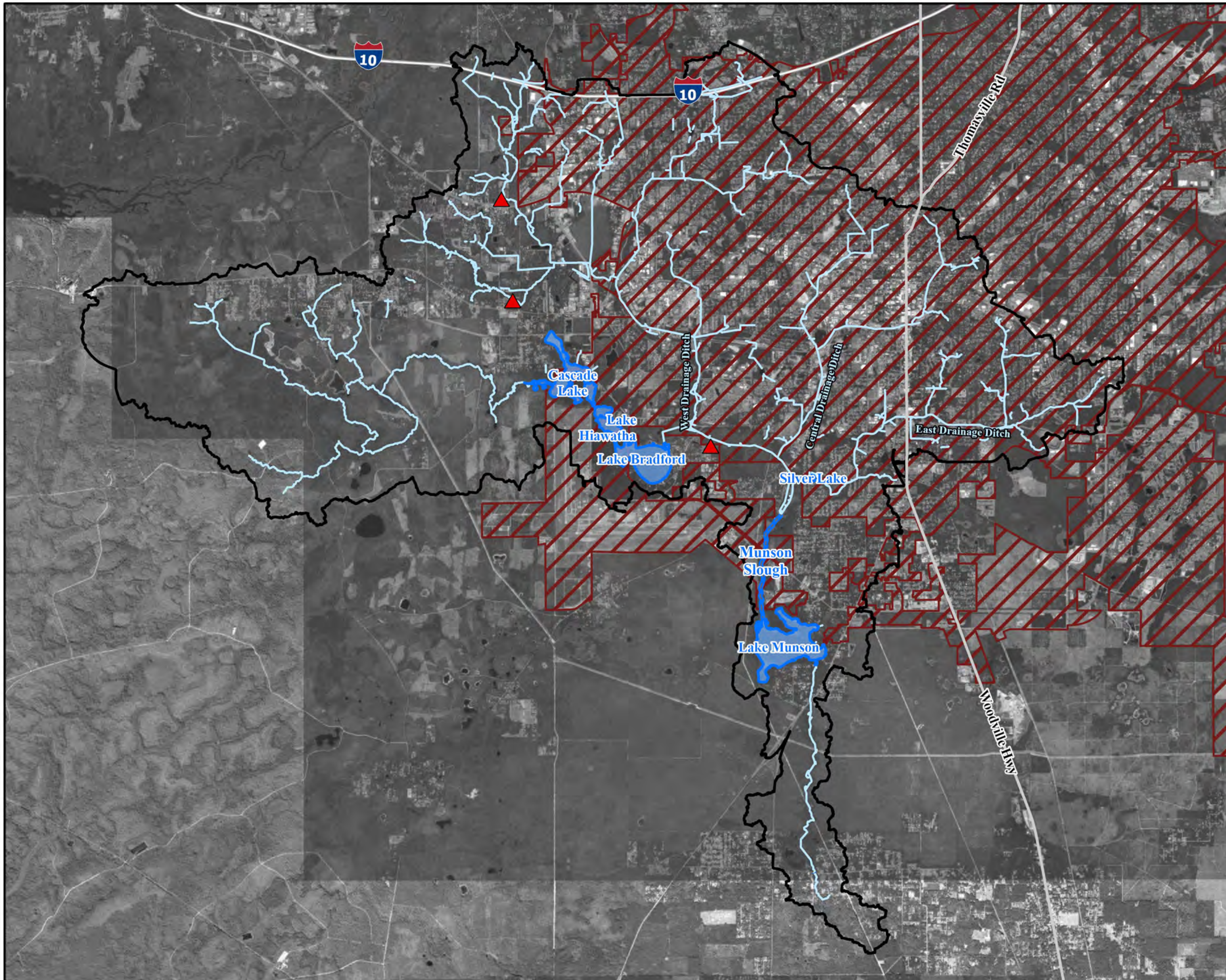
Figure 3-3 in **Section 3.4.3.5** identified active permitted point source discharges in the Lake Munson basin. A total of seven facilities are wholly or partially located within the basin boundaries. Of these seven facilities, only one is located downstream of the Lake Henrietta SWMF. That facility is the TP Smith Water Reclamation Facility. As discussed in **Section 3.4.3.5**, the sprayfield for the TP Smith facility is not within the basin and does not contribute to Lake Munson. The remaining six facilities discharge to sprayfields in areas draining to Munson Slough (upstream of the Lake Henrietta SWMF).

Section 3.4.3.5 presented a map of the active point source discharges within the Lake Munson basin, and **Table 3-2** provided descriptions of the discharges. For each of the facilities, the location of land application was referenced against proximity to stream segments as was done for the septic load calculations presented earlier. If the discharge was greater than 200 meters from a watercourse, it was not considered for load evaluation purposes.

Figure 3-38 presents the remaining facilities following the screening process outlined above. The three facilities include Grand Village wastewater treatment plant (WWTP), Western Estates WWTP, and Lake Bradford Estates WWTP. These facilities are all located upstream of Lake Henrietta SWMF. Therefore, their loads are treated by the facility prior to entering the designated portion of Munson Slough (downstream of Lake Henrietta SWMF). As such, their load is included in the loading calculated for the outflow from Lake Henrietta SWMF (**Section 3.4.5.1**). However, for completeness, brief descriptions of the three facilities are presented below.

Grand Village is the farthest upstream of the point sources. It is a privately owned facility that lies roughly 7.6 miles upstream of the Lake Henrietta SWMF. The WWTP has a flowrate of 0.025 million gallons per day (MGD) and has an associated land application area of approximately 1.12 acres. The facility recently underwent permit renewal in 2022, which included an Operations and Maintenance Performance Report detailing the state of the facility and its activities in keeping pollutant levels low.

Western Estates Mobile Home Park WWTP is located approximately 6.6 miles upstream of the Lake Henrietta SWMF. The WWTP has a flowrate of 0.02 MGD and has an associated land application area of approximately 0.13 acre. As of the latest evaluation in February 2022, the WWTP at Western Estates is in full compliance per FDEP's Compliance Assurance Program.



CITY OF TALLAHASSEE

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Miles

Legend

- Lake Munson Drainage Basin
- Waterbodies in Study
- Watercourses
- Major Roads
- Tallahassee Corporate Limits
- Point Sources

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Point Sources: COT, 2020

Figure 3-38:
Point Source Loads to Munson Slough and the West Drainage Ditch

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Lake Bradford Estates is the nearest to the designated reach of Munson Slough, at roughly 1.3 miles upstream of the Lake Henrietta SWMF. The WWTP has a flowrate of 0.043 MGD and has three associated absorption beds with each at an area of roughly 0.14 acre (0.41 acre total). As of the latest evaluation in November 2021, the WWTP at Lake Bradford Estates is in full compliance per FDEP's Compliance Assurance Program.

Based on the permitted flow rates, their location upstream of treatment, and method of discharge (sprayfields), point sources are not identified as significant sources to Lake Munson or Munson Slough downstream of the Lake Henrietta SWMF, and the loads are not calculated in **Section 3.4.5**.

Figure 3-39 presents a map of the Lake Munson basin boundaries in relation to sewer service areas. Sewer infrastructure within the basin is located throughout the central and easter portions of the basin and nearly all the drainage areas to Silver Lake (via the East Ditch) and Munson Slough (via the Central Ditch and West Ditch).

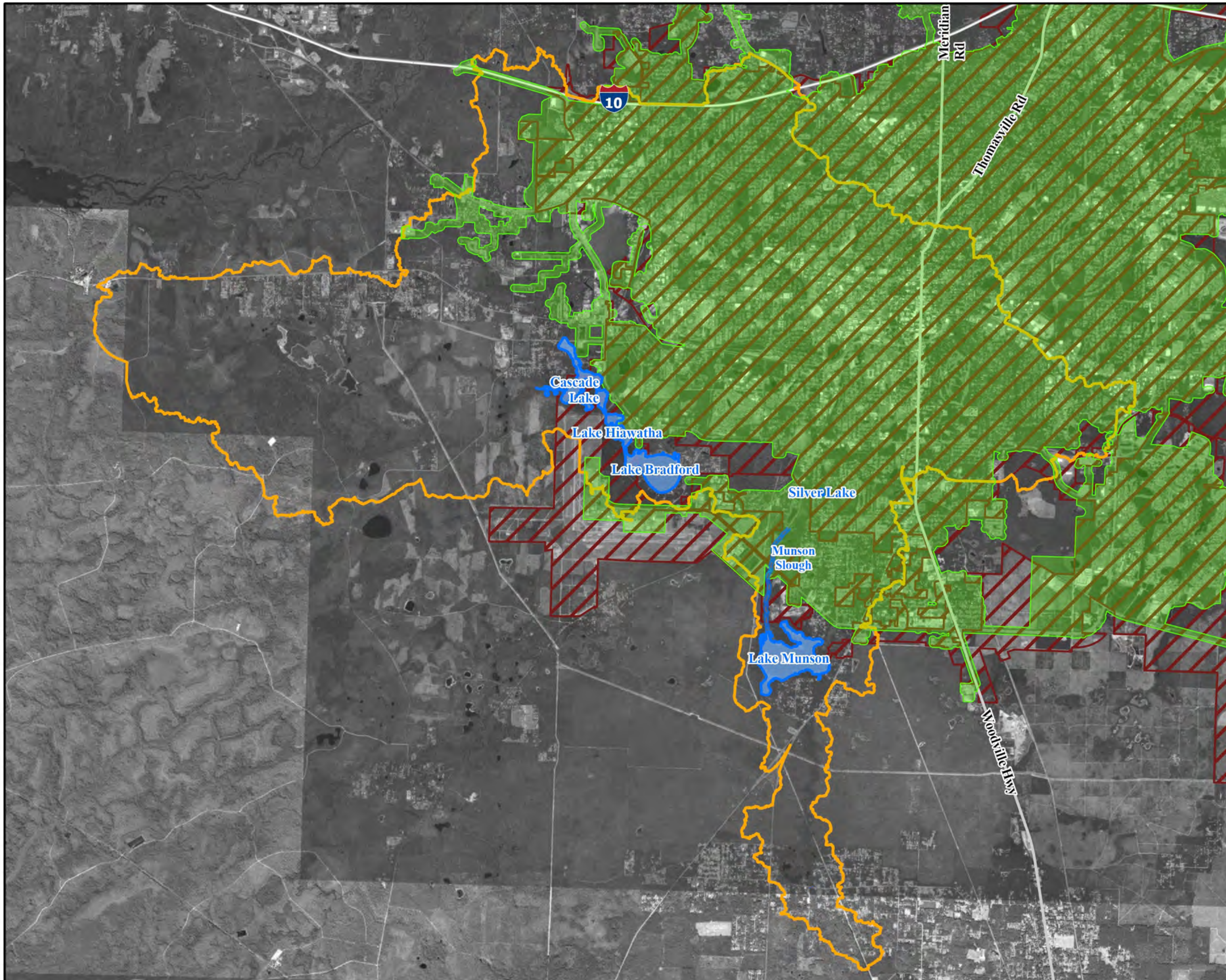
Within Munson Slough downstream of the Lake Henrietta SWMF, the available data from the tributaries did not show elevated nutrient or bacteria levels, indicating that there is not a persistent source of wastewater leakage in this area that reaches these waterbodies. While sanitary sewer overflows (SSOs) occur from time to time, SSOs are acute events with impacts lasting for relatively short periods of time (hours to several days), depending on magnitude and environmental conditions. The mechanism for abatement would not be treatment projects but rather any needed maintenance to sewer infrastructure. The City presently tracks, reports, and addresses these issues as they arise.

3.4.4.6 Atmospheric Deposition

Atmospheric deposition is the load that falls directly onto the earth's surface. For this and future analyses, atmospheric deposition will be accounted for both indirectly within stormwater runoff and directly as a load to the lake surface. In watersheds with a larger ratio of watershed to lake area (such as Lake Munson), atmospheric deposition directly to the lake does not play a significant role in overall loading. As such, while it will be considered in the assessment of loads to the lake, and given the readily available data will be calculated, it is not deemed a significant source of load to Lake Munson. It is important to note that project-specific recommendations made within this report will not address direct deposition on the lake surface as a source, but its quantification relative to other sources is important.

As outlined in **Section 3.4.3.11**, there is an atmospheric deposition station in the vicinity of Tallahassee. This station is the Quincy station (FL14). Data from this station is utilized to calculate the atmospheric deposition to Lake Munson and other lakes within the basin.

Atmospheric deposition is a function of air quality that is able to be improved through regulation and public outreach. Analysis of reductions in atmospheric deposition is outside of the project scope and, therefore, is not assessed in this report.



CITY OF TALLAHASSEE

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Miles

Legend

- Lake Munson Drainage Basin
- Waterbodies in Study
- Tallahassee Corporate Limits
- Sewer Service Areas

Sources:
Waterbodies: COT, 2020
Drainage Basins: COT, 2020
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Waste Water: COT, 2020

Figure 3-39: City of Tallahassee Wastewater Service Areas within Lake Munson Drainage Basin

Tallahassee Master Plan - Surface Water (TMaPS)

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3.4.4.7 Interconnected Flows

For Lake Munson, there is one primary interconnected flow (flows coming in from other lakes) downstream of the Lake Henrietta SWMF, which is the flow from Cypress Lake into Lake Munson. Cypress Lake has a surface area of about 28 acres and is mostly surrounded by residential land use. Water from Cypress Lake discharges from the western portion of the waterbody and travels through a ditch less than 350 ft long before entering Lake Munson from the northeastern part of the lake. There is no current water quality data within Cypress Lake or the discharge ditch, so pollutant loads cannot be calculated for the inflow. Based on the size of the contributing area, general land use conditions surrounding Cypress Lake, the nature of the lake, and the connection to Lake Munson, Cypress Lake is not likely a potential significant contributor of anthropogenic nutrient or bacteria loading, so interconnected flows are not further evaluated.

3.4.4.8 Summary of Findings for Qualitative Assessment of Sources

Based on the discussions above, and data and information presented in **Section 3.4.3**, no sources of load have been identified as targets for load reduction for Lake Munson or Munson Slough. This is based on the system meeting the TMDL target for Chl-a in recent years, the discussions presented earlier on shortcomings of the TMDL relative to application today (**Section 3.4.3.7**), Munson Slough being below both the TMDL and NNC targets for TN and TP, and assessments of changes in TN and TP concentrations through the lake that indicate internal loads are no longer significant. The following outlines the findings for each of the potential pollutant sources discussed above.

- Stormwater Runoff – Stormwater runoff as assessed for Munson Slough downstream of Lake Henrietta SWMF meets TMDL targets and, therefore, likely is not a source to target for reduction. Due to availability of models and data, the load is quantified in **Section 3.4.5.1** to provide comparison with other loads.
- Septic Systems – Loads from septic system are not identified as a significant potential source of pollutants to Lake Munson. Based on availability of data, loads are calculated in **Section 3.4.5.2** to support this determination.
- Interconnected Flows – Loads from the adjacent lake (Cypress) that drains to Lake Munson are not deemed a significant source to Lake Munson.
- Internal Recycling – Based on recent data presented in **Section 3.4.4.4** (**Figure 3-36** and **Figure 3-37)** internal recycling in Lake Munson has decreased in recent years. At this time, no direct measurements of internal load that reflect present conditions have been conducted. Internal recycling is identified as a potential load, but direct measurements are needed to quantify the significance of the impacts and need for additional remediation.
- Seepage – While no data on seepage into the lake is available, it is assumed that the primary source of seepage loads would be septic systems, which are assessed separately.
- Wastewater – The permitted point sources presently located within the Lake Munson basin are not deemed a significant source of load to the lake based on location (upstream

of treatment) and method of discharge (sprayfields). SSOs can contribute to loading but are short-term events that are typically addressed fairly quickly. Based on the available data and locations of sewer infrastructure, SSOs were not identified as a potential significant source.

- Atmospheric Deposition – Based on the relatively high ratio of the direct watershed discharge to Lake Munson area, atmospheric deposition is not identified as a potentially significant load. While this load is quantified for comparison to other loads in **Section 3.4.5.6**, no recommendations will be made relative to potential reductions.

3.4.5 Calculation of Potential Nutrient Loads

This section presents calculations of potential nutrient (TN and TP) loads to Lake Munson and Munson Slough downstream of the Lake Henrietta SWMF for the sources identified for calculation in **Section 3.4.4.8**. These include stormwater runoff, septic systems, and atmospheric deposition. Where loads were not calculated, the following sections provide brief discussions. The load calculations are for the purpose of comparing the potential magnitudes of each source relative to one another.

3.4.5.1 Stormwater Pollutant Load

To calculate the potential stormwater TN and TP loads to Lake Munson, Munson Slough downstream of Lake Henrietta SWMF, and other waterbodies within the Lake Munson basin, average annual pollutant load modeling was performed. The goal was to identify areas that are contributing higher TN and TP loads relative to others within the drainage area to the waterbody and estimate a potential total load for comparison to other loading sources. TN and TP loads were calculated using the Spatially Integrated Model for Pollutant Loading Estimates (SIMPLE-Seasonal) model. The approach described below was used for all project waterbodies within the Lake Munson basin. Pollutant load models, such as the SIMPLE model, calculate loads by determining a volume of runoff from a specified area and then multiplying the runoff volume by EMCs. EMCs are concentrations of constituents (TN and TP in this case) that are found in runoff based on specified land uses.

<u>SIMPLE-Seasonal Model Methodology</u>

Pollutant loads from direct runoff for each subbasin are calculated using the SIMPLE-Seasonal model, originally developed by Jones Edmunds and Associates (Jones Edmunds) for Sarasota County and the Southwest Florida Water Management District (SWFWMD). The complete model development is documented in *Sarasota County County-Wide Non-Point Source Pollutant Loading Model* prepared by Jones Edmunds in August 2005. The model operates within a geographic information system (GIS) framework and calculates pollutant loading over large areas with spatially variable characteristics, leveraging the runoff excess estimation methods described by Harper and Baker, 2007.

For the purposes of this project, the model was set up following the procedure outlined in the Hernando County guidance document developed by Jones Edmunds (Hernando County, 2013). It should be noted that when running the SIMPLE-Seasonal model, Geosyntec utilized default model values to account for seasonal variability of rainfall. The model includes BMP, EMC, runoff, basins, septic, and point source feature classes. For the purposes of this project, the septic and point source feature classes were not utilized since those loads are quantified separately. TN and TP reductions due to the different types of BMPs are assigned in the BMP shapefile. The EMC shapefile includes the TN and TP EMCs based on the land use types. The runoff shapefile includes the land use, hydrologic soil group (HSG), and the average annual runoff coefficient, defined as the fraction of average annual rainfall volume converted to runoff. Finally, the basin shapefile includes the total acreages of each subbasin. It is noted that no base flow was assigned for this analysis. The calculation of the pollutant load associated with the runoff was based on the Harper and Baker (2007) method of rainfall excess determination and pollutant loading. This method uses an average annual rainfall volume, which is multiplied by an average annual runoff coefficient to determine the average annual runoff volume. The average annual runoff coefficient is based on the percent directly connected impervious area (DCIA) and the non-DCIA curve number (CN), which are determined based on the land use and soil conditions. The average annual loading is determined by multiplying the average annual volume of runoff and the pollutant EMC.

The average annual rainfall depth for this watershed was estimated to be 59 inches using the *Florida State University – Office of Institutional Research Tallahassee/Leon County, Florida.*

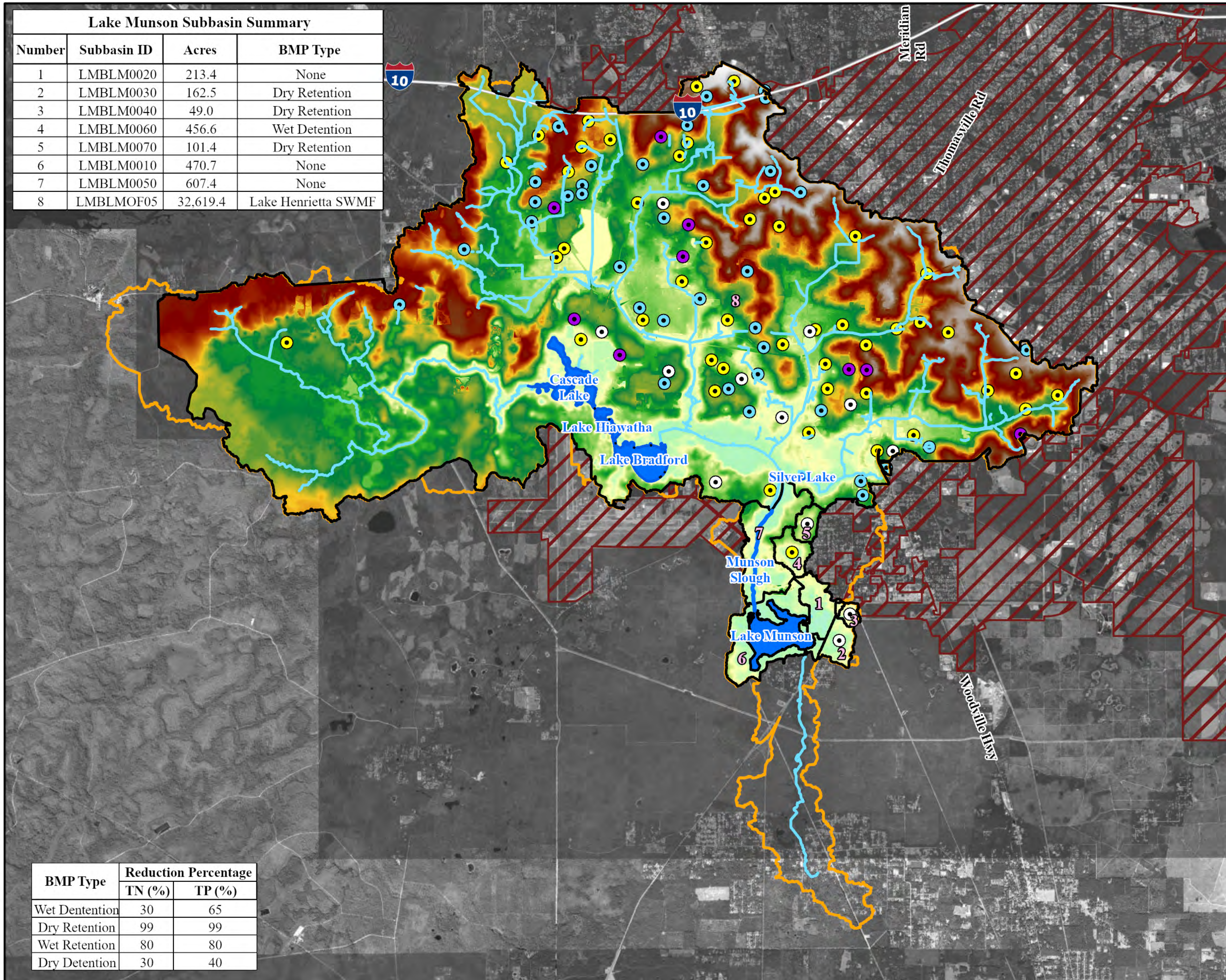
The topography for the study area was analyzed via a Digital Elevation Model (DEM) from Leon County (2018). The elevations within the watershed range from approximately 255 ft down to approximately 17 ft. All elevation data presented in this report are expressed in ft-NAVD88 (**Figure 3-40**). The highest elevations appear in the northeast side of the basin, with the lowest values around and below Lake Munson.

Subbasins were initially provided by the City within the Lake Munson basin. For modeling purposes, subbasins were delineated to the BMP and the outfall level to define where stormwater is generated and where it accumulates. The runoff volumes are estimated along with the associated pollutant loads. A total of 85 subbasins were delineated throughout the Lake Munson basin using the 2018 Leon County DEM and the flowlines from the U.S. Geological Survey (USGS) National Hydrological Dataset (NHD) (2020). The NHD represents the water drainage network within the study area, such as conduits, inlets, and junctions, and is used to delineate the watershed in a manner appropriate for the level of detail required for this study. The final contributing drainage area, based on the delineations, is presented in **Figure 3-40**. Additionally, the treatment percentages utilized for each BMP type are presented. For the purposes of the Munson Slough and Lake Munson stormwater load calculations, the subbasins upstream of the Lake Henrietta SWMF were merged into one single subbasin representing the inflow to the Lake Henrietta SWMF (**Figure 3-40**). The remaining subbasins (where applicable) were utilized in the stormwater load calculations for the other target waterbodies in **Section 3.5.5** and **Section 3.6.5**.

The land use data used for this modeling effort referenced the 2019 NWFWMD feature class presented in **Section 3.4.3.2**. The data were manipulated for the purposes of this analysis as described as follows. First the NWFWMD land use data were aggregated into simplified land use categories as presented in the SIMPLE guidance document (Hernando County, 2013). This was done to generalize the watershed's land uses into 13 land use categories (**Figure 3-41**), which corresponded to available EMC data. A summary of how the land uses were aggregated is presented in **Table 3-6**.

Lake Munson Subbasin Summary

Number	Subbasin ID	Acres	BMP Type
1	LMBLM0020	213.4	None
2	LMBLM0030	162.5	Dry Retention
3	LMBLM0040	49.0	Dry Retention
4	LMBLM0060	456.6	Wet Detention
5	LMBLM0070	101.4	Dry Retention
6	LMBLM0010	470.7	None
7	LMBLM0050	607.4	None
8	LMBLMOF05	32,619.4	Lake Henrietta SWMF



BMP Type	Reduction Percentage	
	TN (%)	TP (%)
Wet Dentention	30	65
Dry Retention	99	99
Wet Retention	80	80
Dry Detention	30	40

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Legend

- Lake Munson Drainage Basin
- Subbasins
- Waterbodies in Study
- Watercourses
- Tallahassee Corporate Limits

Topographic Elevations

Value

250

17

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Subbasins: Geosyntec, 2023
Roads: COT-Leon County, 2023
City Limits: COT, 2020
BMPs: Geosyntec, 2023

Elevation: COT-Leon County, 2018

Figure 3-40:
Lake Munson Subbasin Delineation and BMPs

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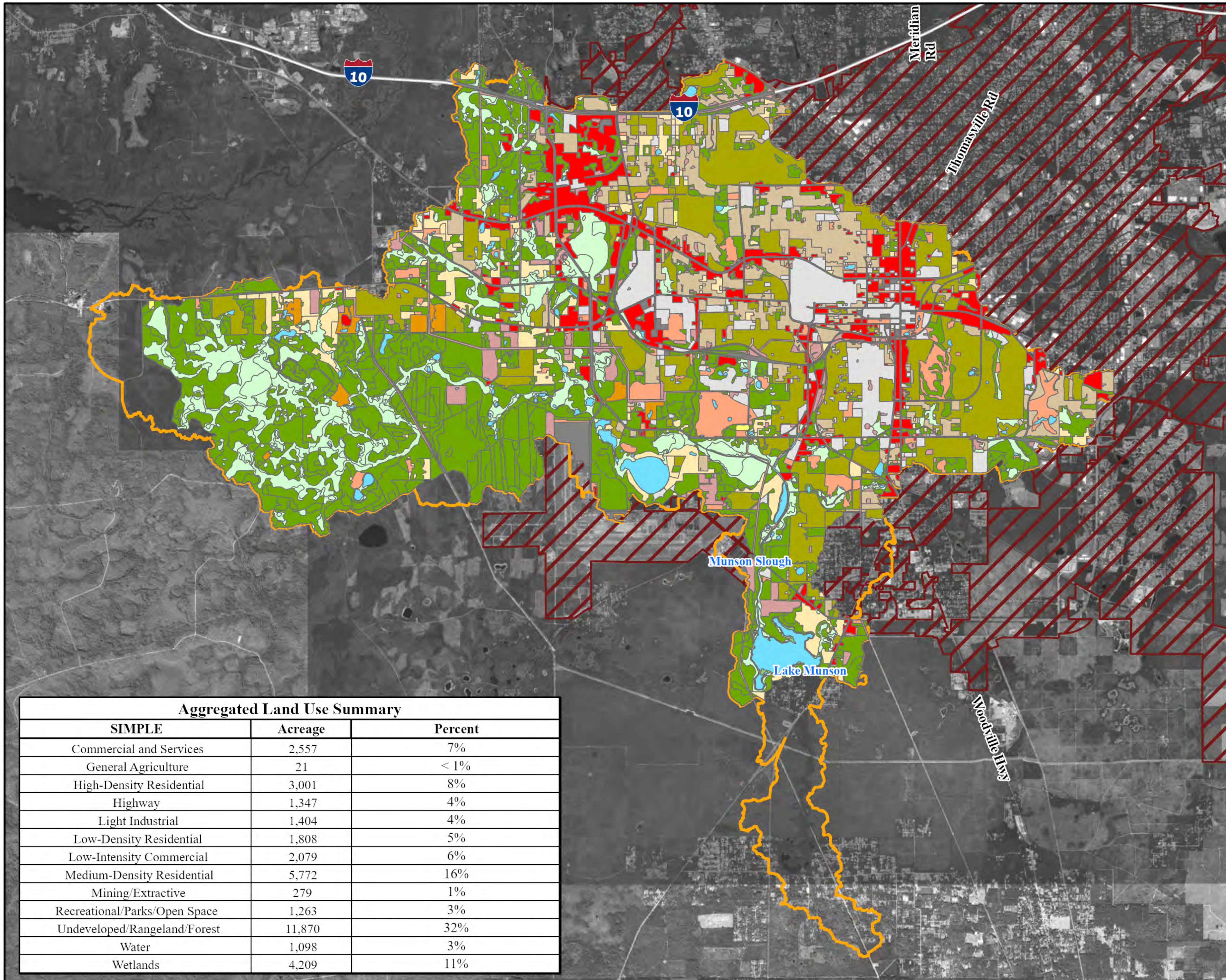


Aggregated Land Use Summary

SIMPLE	Acreage	Percent
Commercial and Services	2,557	7%
General Agriculture	21	< 1%
High-Density Residential	3,001	8%
Highway	1,347	4%
Light Industrial	1,404	4%
Low-Density Residential	1,808	5%
Low-Intensity Commercial	2,079	6%
Medium-Density Residential	5,772	16%
Mining/Extractive	279	1%
Recreational/Parks/Open Space	1,263	3%
Undeveloped/Rangeland/Forest	11,870	32%
Water	1,098	3%
Wetlands	4,209	11%

Sources:
Waterbodies: COT, 2020
Land Use: Geosyntec, 2023
Roads: COT-Leon County, 2023
City Limits: COT, 2020

Figure 3-41:
Lake Munson and Munson Slough below Lake Henrietta Aggregated Land Use

Tallahassee Master Plan - Surface Water (TMaPS)

Geosyntec consultants

Table 3-6: Aggregated Land Use

FLUCCS Code	FLUCCS Description	SIMPLE-Seasonal Aggregated Description
1100	Low-Density Residential	Low-Density Residential
1200	Medium-Density Residential	Medium-Density Residential
1300	High-Density Residential	High-Density Residential
1400	Commercial and Services	Commercial and Services
1500	Other Light Industrial	Light Industrial
1600	Reclaimed Lands	Mining/Extractive
1700	Institutional	Low-Intensity Commercial
1800	Community Recreational Facilities	Recreational/Parks/Open Space
1900	Open Land	Recreational/Parks/Open Space
2100	Cropland and Pastureland	Undeveloped/Rangeland/Forest
2400	Nurseries and Vineyards	General Agriculture
2600	Other Open Lands (Rural)	Undeveloped/Rangeland/Forest
3100	Range Land, Herbaceous (Dry Prairie)	Undeveloped/Rangeland/Forest
3200	Shrub and Brushland	Undeveloped/Rangeland/Forest
3300	Mixed Rangeland	Undeveloped/Rangeland/Forest
4100	Upland Coniferous Forests	Undeveloped/Rangeland/Forest
4200	Upland Hardwood Forests	Undeveloped/Rangeland/Forest
4300	Hardwood Coniferous - Mixed	Undeveloped/Rangeland/Forest
4400	Forest Regeneration Areas	Undeveloped/Rangeland/Forest
5100	Streams and Waterways	Water
5200	Lakes	Water
5300	Reservoirs	Water
5600	Slough Waters	Water
6100	Wetland Hardwood Forests	Wetlands
6200	Wetland Coniferous Forests	Wetlands
6300	Wetland Forested Mixed	Wetlands
6400	Vegetated Non-Forested Wetlands	Wetlands
6500	Non-Vegetated Wetlands	Wetlands
7400	Disturbed Lands	Undeveloped/Rangeland/Forest
8100	Transportation	Highway
8200	Communications	Light Industrial
The person f 8300	Utilities	Light Industrial

Note:

1. The aggregated descriptions are based on guidance from the SIMPLE-Seasonal model guidance document.

As previously mentioned, the SIMPLE-Seasonal model uses the Harper and Baker (2007) method to determine stormwater pollutant loads. Specifically, a mean annual runoff coefficient (MARC) and the average annual rainfall depth are used to estimate average annual runoff volumes. The MARCs for all land use categories were developed based on the annual runoff coefficients for Meteorological Zone 1 in the draft *Florida Stormwater Quality Applicants Handbook* (FSQAH) (FDEP, 2010). The MARCs are assigned based on the DCIA and the non-

DCIA CN. Impervious areas within representative areas for each simplified land use type were digitized to estimate representative DCIA and impervious percentages. The representative percentages were used for each land use, with the values used provided in **Table 3-7**.

Table 3-7: Land Use DCIA and Non-DCIA Percentages

FLUCCS Code	FLUCCS Description	% Impervious	% DCIA	% Pervious
1100	Low-Density Residential	11	3	89
1200	Medium-Density Residential	37	12	63
1300	High-Density Residential	38	18	62
1400	Commercial and Services	58	58	42
1700	Institutional	44	38	56
1800	Community Recreational Facilities	29	18	71
1900	Open Land	0	0	100
2100	Cropland and Pastureland	0	0	100
2200	Tree Crops	0	0	100
2500	Specialty Farms	0	0	100
3100	Range Land, Herbaceous (Dry Prairie)	0	0	100
3200	Shrub and Brushland	0	0	100
3300	Mixed Rangeland	0	0	100
4100	Upland Coniferous Forests	0	0	100
4200	Upland Hardwood Forests	0	0	100
4300	Hardwood Coniferous – Mixed	0	0	100
4400	Forest Regeneration Areas	0	0	100
5200	Lakes	100	100	0
5300	Reservoirs	100	100	0
6100	Wetland Hardwood Forests	100	100	0
6200	Wetland Coniferous Forests	100	100	0
6300	Wetland Forested Mixed	100	100	0
6400	Vegetated Non-Forested Wetlands	100	100	0
6500	Non-Vegetated Wetlands	100	100	0
7400	Disturbed Lands	4	0	96
8100	Transportation	72	38	28
8200	Communications	12	1	88
8300	Utilities	22	22	78

The non-DCIA CNs were calculated based on the percent impervious, minus the DCIA percentage, and the pervious fractions, which were based on open space in good condition and the soil hydraulic group. The impervious areas were assigned a CN value of 98. A lookup table was developed to relate soil hydrologic group to pervious area CNs [see **Table 3-8**, which were referenced from the USDA Urban Hydrology for Small Watersheds (TR-55) (June 1986)]. The overall non-DCIA CNs were then determined by taking an area-weighted average of the impervious and pervious fractions of the non-DCIA CNs.

Table 3-8: Curve Number Lookup Table

Land Use	A	B	C	D	W
Open Space in Good Condition (Grass Cover > 75%)	39	61	74	80	100
Water	100	100	100	100	100
Wetlands	100	100	100	100	100

The soils data used for this modeling effort were presented in **Section 3.4.3.3**. Stormwater runoff is generated when the rate of rainfall exceeds the infiltration capacity of the site soils, resulting in water flow along the land surface. For pits and urban land, soil types were assumed to be HSG D soil group. When dual HSGs were found, an average value was assigned (i.e., soils A/D were assigned a B runoff potential, soils B/D were assigned a C runoff potential, soils C/D were assigned a D runoff potential). This assumption is appropriate because the SIMPLE-Seasonal model is based on an average annual analysis and dual classed soils will sometimes behave as one hydrologic group and other times behave as the other. If the worst-case hydrologic group is taken, as is done for event-based floodplain modeling, it would result in an over estimation of volume of stormwater generated and thus pollutant loading.

Pollutant loads for direct runoff are determined by multiplying the average annual runoff volumes by the appropriate EMCs. The EMC values used for this study were a combination of values determined by the City (2015) and those reported by Harper and Baker (2007). Water and wetland land use types were assigned a value of zero (0) as they are assumed in this analysis to not contribute pollutants but act as a pollutant sink. **Table 3-9** shows the EMC values used for the SIMPLE-Seasonal model. Mean annual runoff coefficients were calculated for each polygon resulting from the intersection of the land use layer and the soils layer, based on the FSQAH (FDEP, 2010).

Table 3-9: Event Mean Concentration by Land Use

SIMPLE-Seasonal Aggregated Description	TP (mg/L)	TN (mg/L)	Reference
General Agriculture	0.94	1.32	City, 2015
High-Density Residential	0.43	1.58	City, 2015
Commercial and Services	0.22	1.05	City, 2015
Highway	0.22	1.64	Harper, 2007
Light Industrial	0.13	1.22	City, 2015
Low-Density Residential	0.27	1.18	City, 2015
Low-Intensity Commercial[1]	0.18	1.18	Harper, 2007
Medium-Density Residential	0.43	1.58	City, 2015
Water[2]	0.0	0.0	-
Wetlands[2]	0.0	0.0	-
Undeveloped/Rangeland/Forest	0.11	0.79	City, 2015
Recreational/Parks/Open Space	1.13	2.33	City, 2015

Note:
1. Low-intensity commercial land use type was used for institutional land use type.
2. EMCs assumed to be zero (0) since water bodies and wetlands are typically assumed to be sinks and not sources of pollutant loads within a watershed.

Water quality treatment provided by existing BMPs within the subbasins was considered as part of this analysis. Runoff BMPs were identified and classified as wet detention, wet retention, dry retention, or dry detention. Aerial imagery, 2018 Leon County DEM, and BMP shapefiles from the City, Leon County, and FDOT were reviewed to identify BMPs within the subbasins draining to Lake Munson and Munson Slough downstream of Lake Henrietta SWMF greater than 1 acre. **Figure 3-40** shows the BMPs by subbasin. The BMPs were assigned a removal efficiency based on the type of practice. The removal efficiencies for BMPs are provided in **Table 3-10** and also on **Figure 3-40**. The values were based on the study conducted by Harper and Baker (2007) and based on the draft Environmental Resource Permit (ERP) Applicant's Handbook Volume I Section 8 from FDEP (2022). Based on guidance from the City, all the dry detention ponds were assumed to have sand filters due to local land development regulations.

Table 3-10: Direct Runoff BMP Removal Efficiencies

BMP Type	TN (%)	TP (%)
Wet Detention[1]	30	65
Wet Retention[2]	80	80
Dry Retention[1]	99	99
Dry Detention[1]	30	40

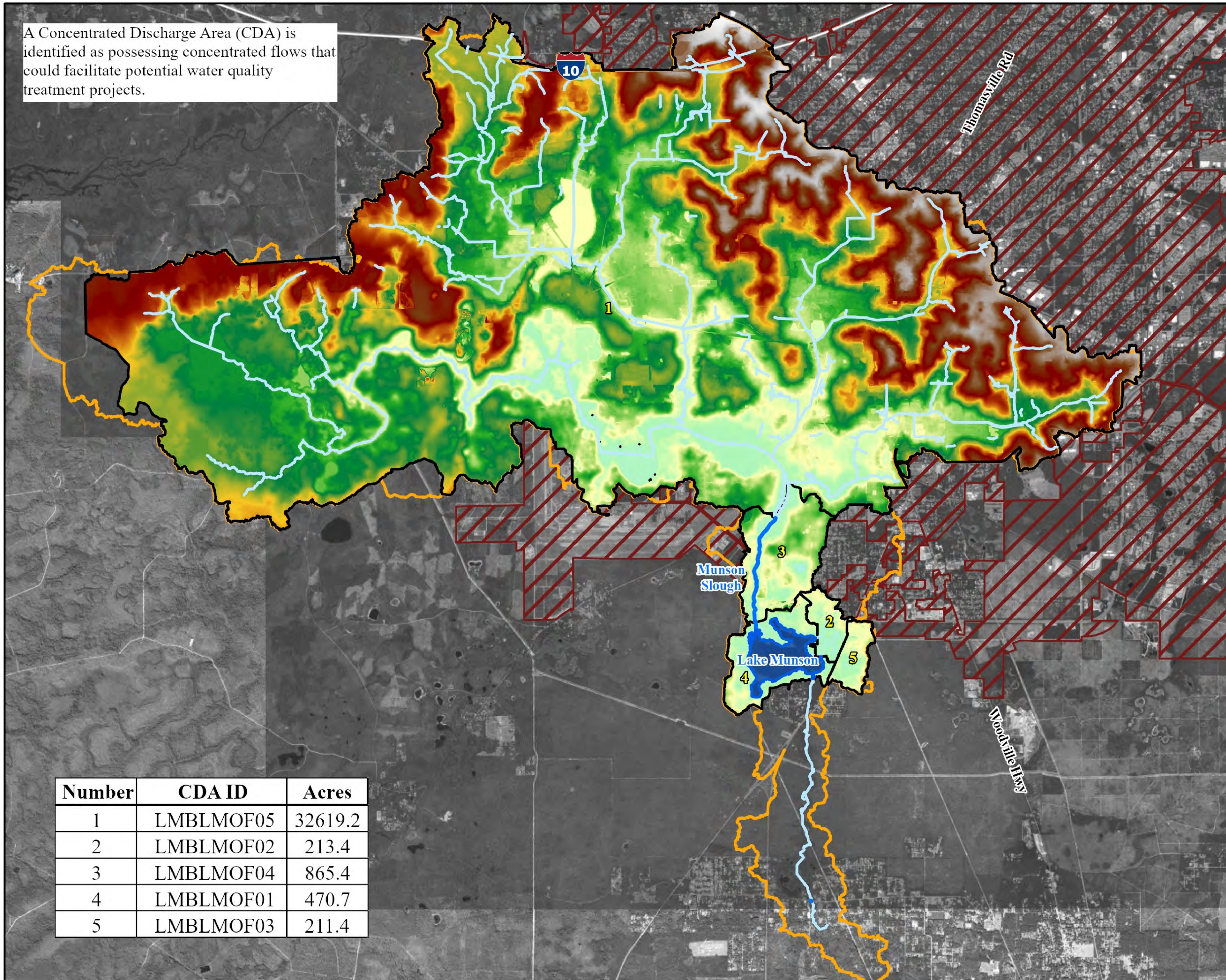
Note:

1. The values were from H. Harper and D. Baker, *Evaluation of current Stormwater Design Criteria within the State of Florida* (June 2007).
2. Stormwater quality nutrient permitting requirements (FDEP 2022)

Natural depressions, wetlands, and natural water bodies were not included as BMPs since removal efficiencies are based on retaining a certain design volume from engineered systems. Additionally, as outlined previously, any BMP less than 1 acre was not considered due to the scale of this study. Based on the assumptions outlined above, the SIMPLE modeling presented for Lake Munson, Munson Slough downstream of Lake Henrietta SWMF, and subsequent waterbodies has the potential to calculate high load values due to not considering removal associated with natural features and small local BMPs as well as other processes. As such, the purpose of the SIMPLE model is to provide total loads and per acre loading for comparison between contributing areas around the waterbody, and total loads for comparison to other loading sources to the waterbody.

For the purposes of the loading calculations, the subbasins were grouped into Concentrated Discharge Areas (CDAs) that represent discrete areas of loading to Lake Munson and Munson Slough downstream of Lake Henrietta SWMF. The loads from the subbasins were then summed for each of the CDAs. **Figure 3-42** presents the CDAs along with their associated acreage. The CDAs represent the discrete areas upon which evaluations of total loading and per acre loading are presented below.

A Concentrated Discharge Area (CDA) is identified as possessing concentrated flows that could facilitate potential water quality treatment projects.



Number	CDA ID	Acres
1	LMBLMOF05	32619.2
2	LMBLMOF02	213.4
3	LMBLMOF04	865.4
4	LMBLMOF01	470.7
5	LMBLMOF03	211.4

CITY OF TALLAHASSEE

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Legend

- Lake Munson Drainage Basin
- Lake Munson
- Munson Slough
- Concentrated Discharge Areas
- Tallahassee Corporate Limits
- Watercourses

Topographic Elevations
ft NAVD88
250
17

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
CDAs: Geosyntec, 2023
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Elevation: COT-Leon County, 2018

Figure 3-42: Lake Munson and Munson Slough below Lake Henrietta Concentrated Discharge Areas

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Utilizing the calculated total loads and the per acre loads, the various CDAs were ranked. The approach for the ranking was to order the total loads and the per acre loads from lowest to highest and assign a numeric order number for each waterbody where the highest load would receive the higher numeric order number and the lowest load would receive the lower. This represents a score that can be used to identify CDAs of interest. The two scores were then added together (total load rank and per acre load rank) to get a total score. These were then ordered from highest to lowest value to define the ranking. The goal was for the ranking to consider both the total load from an area (which allows focus on areas with significant load) along with the per acre loading (which allows focus on areas with high discharge concentrations or greater anthropogenic impact). The combining of the two allows focus on both available load for reduction and targeted higher concentration areas which represent greater opportunity for treatment.

Stormwater Nutrient Loads to Lake Munson and Munson Slough Downstream of Lake Henrietta SWMF

For the load coming into Lake Munson through Munson Slough, measured water quality data immediately downstream of the Lake Henrietta SWMF was used for the load calculation out of CDA LMBLMOF05 (1 on **Figure 3-42**). The data were collected at Station LMB02 and were part of the data sets presented in previous sections. The water quality at this station is representative of discharge from the Lake Henrietta SWMF, and those that bypass the facility, as it flows down Munson Slough prior to entering Lake Munson. The runoff volume calculated from the SIMPLE-Seasonal model upstream of LMB02 was used as the volume discharged from the system (**Table 3-11**). Using the measured flows presented in **Section 3.4.3.6** at LMB02 (Station 008434 on **Exhibit 3-6**) total annual flow volumes were calculated for years since 2010 where sufficient data were available. The total volumes ranged from 18,000 acre-ft up to 35,000 acre-ft. The 34,610 acre-ft modeled flow is high but within the range of measured values. The calculated loads should be considered in this context.

Table 3-11: Concentration Data, Volumes, and Calculated Loads Representing the Discharge from the Lake Henrietta SWMF

Station ID LMB02	Concentration (mg/L)	Year of data	Volume (ac-ft/yr)[1]	Loads (lb/yr)
Total N	0.618	2018-2020	34,610	58,142
Total P	0.058	2018-2020	34,610	5,449

Note:
1. The value was calculated in SIMPLE-Seasonal model.

The TN and TP loads were then calculated by multiplying the modeled volume by the measured average TN and TP concentrations (**Table 3-11**). The average value of the most recent 3 years of geometric mean TN and TP data were used for the load calculations. No data earlier than 2017 were used for this analysis to best represent current conditions.

This approach is different than the SIMPLE modeling approach presented previously as it accounts for the removal processes that occur upstream and within the Lake Henrietta SWMF. The approach is appropriate because of the nature of the Lake Henrietta SWMF as a significant and unique regional treatment system, along with the availability of sufficient water quality data to perform the calculation.

Figure 3-43 presents the distribution of the ranking of the CDAs for TN along with the total load and per acre loads (see the table on **Figure 3-43**). The rankings are color coded, with the highest ranked CDAs in dark green moving down to the lowest ranked in pale yellow. The calculated total stormwater TN loads from the CDAs ranged from as low as 3.4 pounds per year (lb/yr) up to 58,142 lb/yr. The per acre loads ranged from near 0 lb/acre/yr up to 2.2 lb/acre/yr. The highest ranked CDAs were the overall drainage basin upstream of the Lake Henrietta SWMF (LMBLMOF05) and a small CDA immediately adjacent to Lake Munson (LMBLMOF02). The total potential stormwater runoff load for TN is 60,135 lb/yr. While the area above the Lake Henrietta SWMF is ranked highest, the per acre load along with the average concentrations as listed in **Table 3-11** would not indicate significant need for additional stormwater load reduction for TN.

Figure 3-44 presents the distribution of the ranking of the CDAs for TP along with the total load and per acre loads (see the table on **Figure 3-44**). The calculated total stormwater TP loads from the CDAs ranged from as low as 0.6 lb/yr up to 5,450 lb/yr. The per acre loads ranged from near 0 lb/acre/yr up to 0.2 lb/acre/yr. The total potential stormwater runoff load for TP is 5,840 lb/yr. The TP per acre loads from upstream of Lake Henrietta SWMF are generally lower and, therefore, despite its very high total load, the area above Lake Henrietta SWMF ranked lower relative to TP loading, which is likely a function of treatment for TP from the Lake Henrietta SWMF and the multiple other facilities upstream. The highest ranked CDAs were the ones downstream of Lake Henrietta SWMF that flow directly to Munson Slough and Lake Munson but have limited facilities for their immediate drainage areas. As with TN, the per acre TP load out of the Lake Henrietta SWMF along with the average concentrations as listed in **Table 3-11** would not indicate significant need for additional stormwater load reduction for TP.

3.4.5.2 Septic Load

<u>Methodology</u>

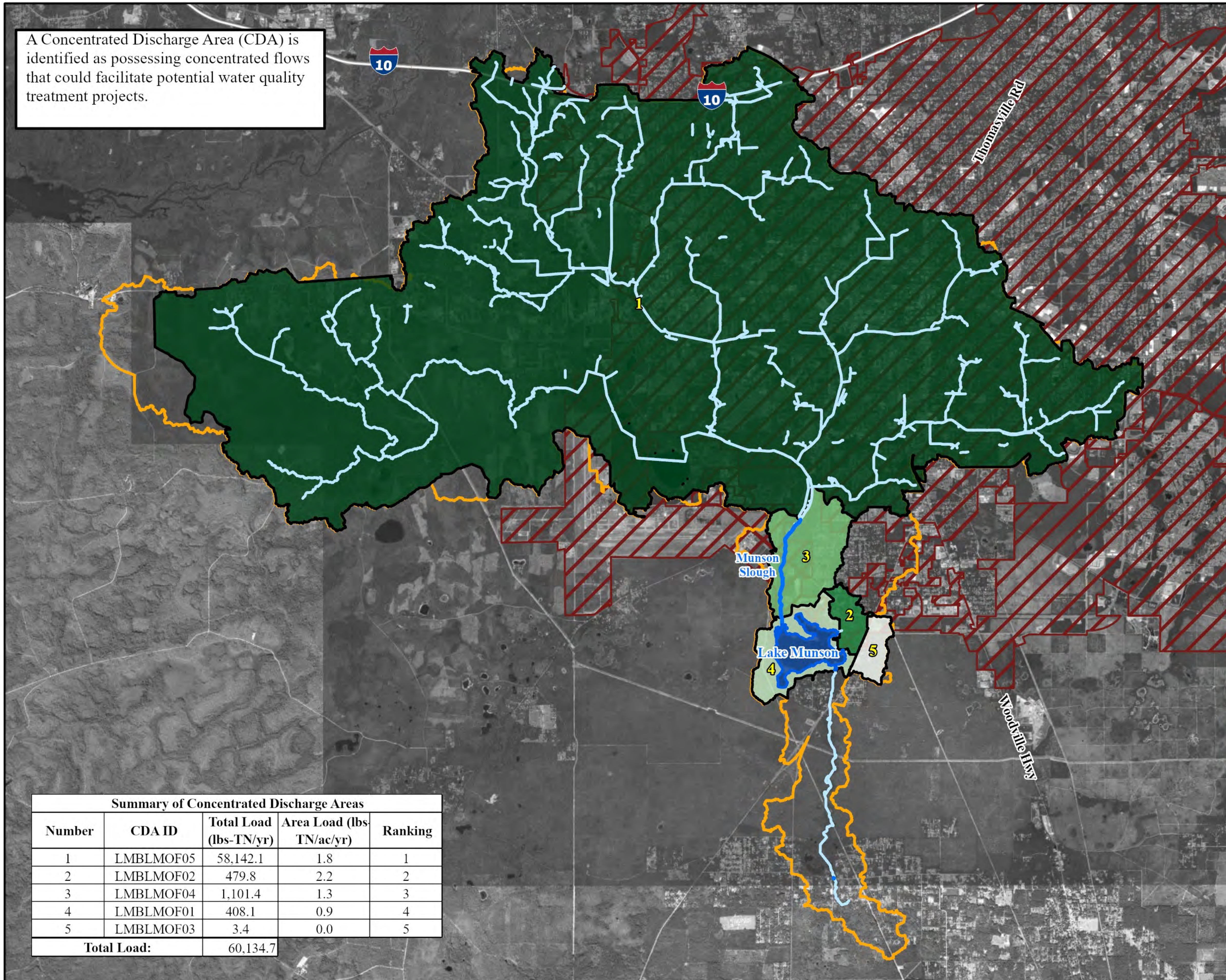
To quantify the potential nutrient load from septic tank units to Lake Munson and Munson Slough downstream of Lake Henrietta SWMF and other waterbodies within the Lake Munson basin, the SPIL method, as adopted by FDEP, was utilized. The SPIL method calculates the TN load based on the number of septic tanks within a specified distance to the waterbody and an assumed loading of 9.012 lb of TN per person per year. Additionally, per the SPIL method, a percent loss of 50 percent is assumed as septic tank effluent moves through the unsaturated zone to groundwater.

The equation for estimating potential loading is:

S * P * I * L = Total TN (lb) per year

Where:

> **S** = Number of known septic tanks within 200 meters of a waterbody
> **P** = Average number of people per household
> **I** = Constituent annual load
> **L** = Percentage of nutrient loss during seepage



Summary of Concentrated Discharge Areas

Number	CDA ID	Total Load (lbs-TN/yr)	Area Load (lbs-TN/ac/yr)	Ranking
1	LMBLMOF05	58,142.1	1.8	1
2	LMBLMOF02	479.8	2.2	2
3	LMBLMOF04	1,101.4	1.3	3
4	LMBLMOF01	408.1	0.9	4
5	LMBLMOF03	3.4	0.0	5
Total Load:		60,134.7		

Figure 3-43: Lake Munson and Munson Slough below Lake Henrietta Concentrated Discharge Areas-Total Nitrogen

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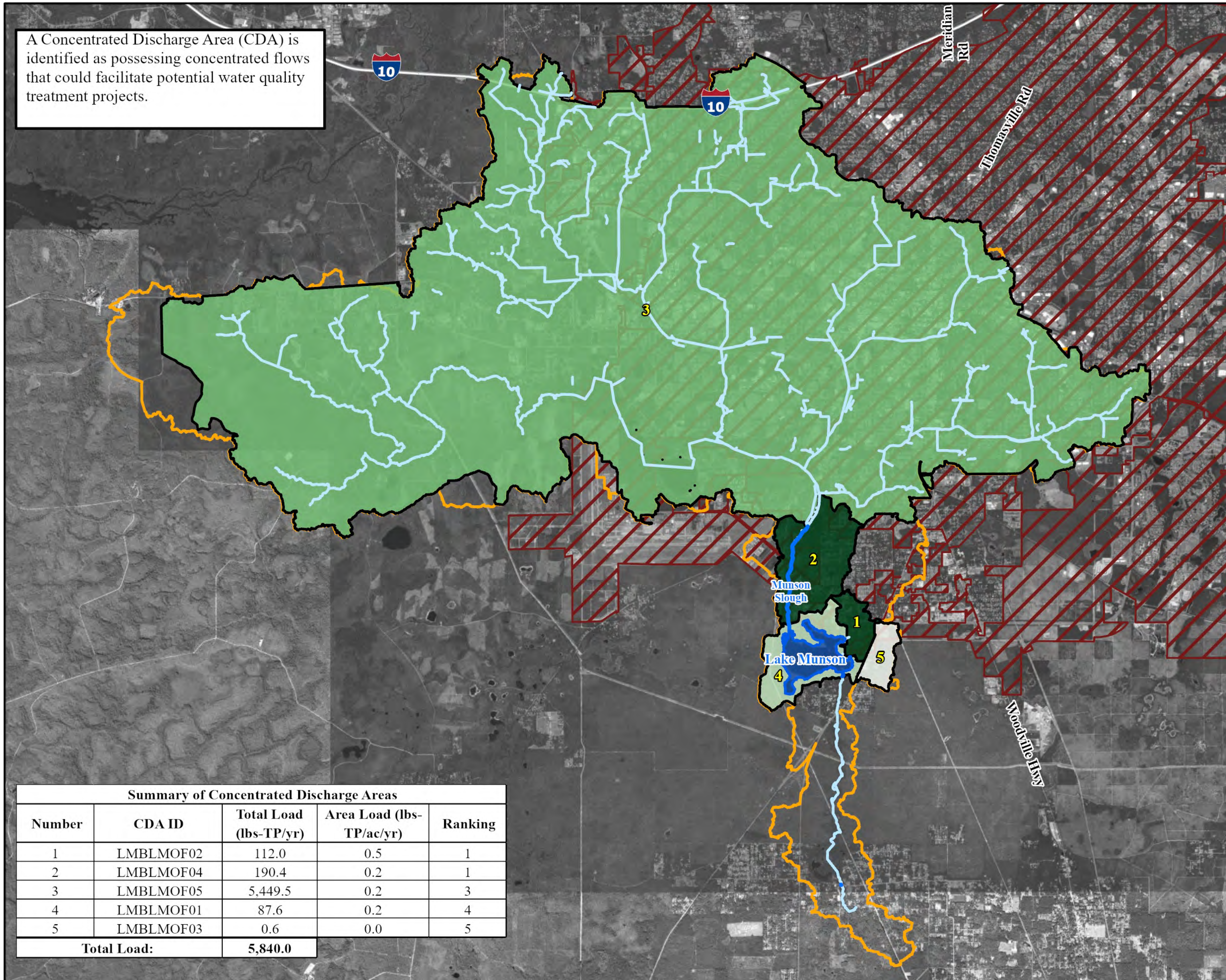

A Concentrated Discharge Area (CDA) is identified as possessing concentrated flows that could facilitate potential water quality treatment projects.

Summary of Concentrated Discharge Areas

Number	CDA ID	Total Load (lbs-TP/yr)	Area Load (lbs-TP/ac/yr)	Ranking
1	LMBLMOF02	112.0	0.5	1
2	LMBLMOF04	190.4	0.2	1
3	LMBLMOF05	5,449.5	0.2	3
4	LMBLMOF01	87.6	0.2	4
5	LMBLMOF03	0.6	0.0	5
Total Load:		5,840.0		

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N

0 1.2 Miles

Legend

- Lake Munson Drainage Basin
- Lake Munson
- Munson Slough
- Concentrated Discharge Areas
- Watercourses
- Tallahassee Corporate Limits

Ranking

- High (1)
- Low (5)

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
CDAs: Geosyntec, 2023
Roads: COT-Leon County, 2023
City Limits: COT, 2020
Elevation: COT-Leon County, 2018

Figure 3-44: Lake Munson and Munson Slough below Lake Henrietta Concentrated Discharge Areas-Total Phosphorus

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The latest available census data was utilized, which estimates 2.4 persons per household within Leon County. The buffer zone for selecting septic tanks was also applied to tributaries discharging to the waterbody of interest, as delineated by the City. The inclusion of the tributaries in the loading calculation deviates from the approach utilized by FDEP, but based on internal project team discussion, was felt to be a reasonable addition as these represent a direct connection to the waterbody.

The FDEP method only calculates TN load since the majority of phosphorous in septic tank effluent is assumed to be adsorbed onto soil particles before reaching the groundwater table. Published studies on phosphorus attenuation in groundwater show that phosphorus plumes from septic units typically do not extend beyond 50 meters, with approximately 96 percent of phosphorus removal occurring within the first 10 meters (Corbett et al., 2002; Robertson et al., 2019). Therefore, FDEP's decision to not include TP was followed in this study.

The literature review also indicated that the 200-meter buffer around waterways that FDEP uses to capture septic tank TN contributions is a conservative approach. The literature suggests that most of the TN attenuation takes place within the first 10 meters (Corbett et al., 2022; Robertson et al., 2019; Van Stempvoort et al., 2021). For the purpose of identifying potential problem areas, and based on general soil characteristics in and around tributaries and the lake (higher water table conditions), the 200-meter buffer (as defined by FDEP) for TN contributions was maintained. The watercourse layer provided by the City was used to assess the 200-meter buffer.

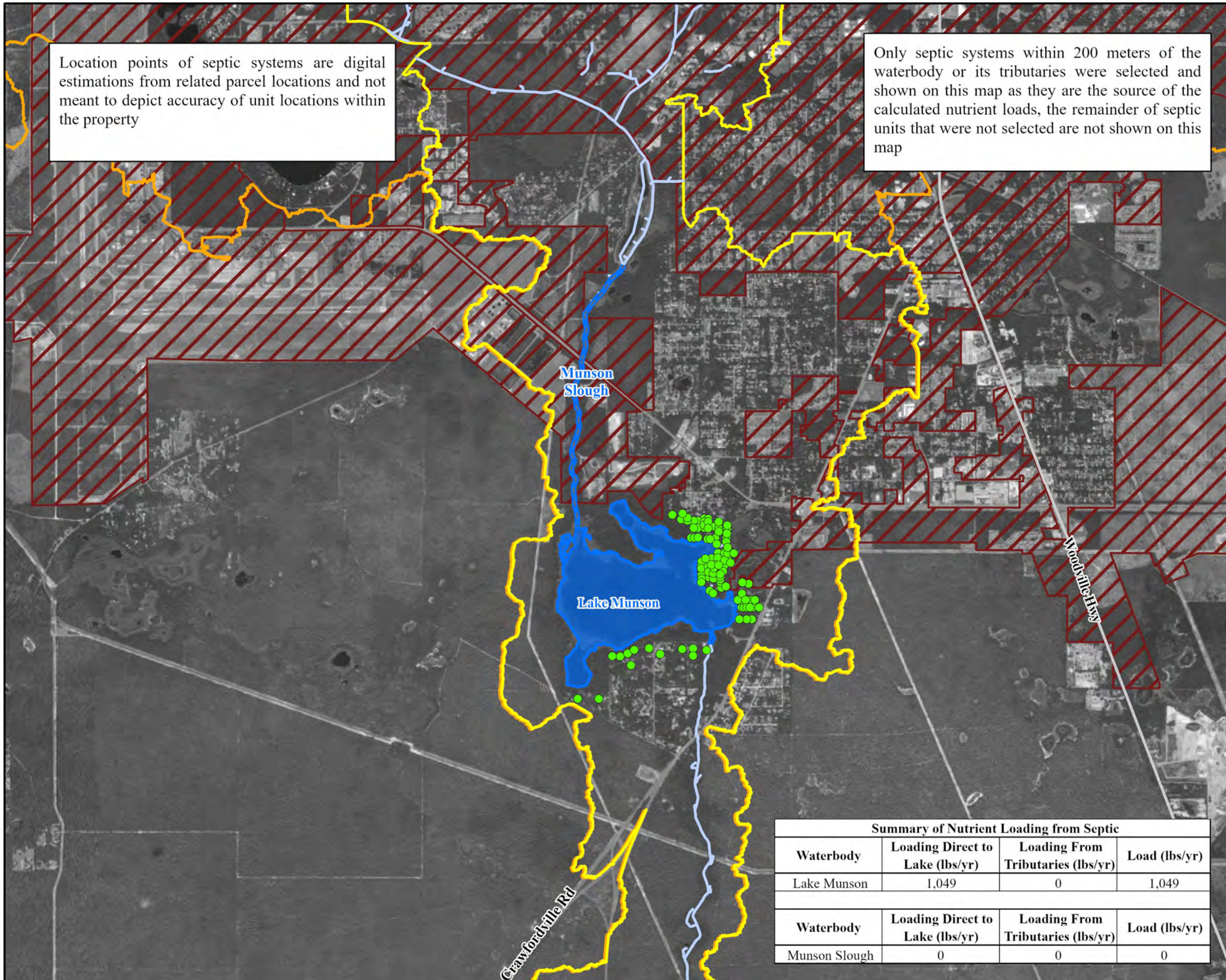
Based on the available literature on septic movement, it is understood that the approach presented herein may overpredict the nitrogen load to the waterbodies and, therefore, potentially represents a conservative potential load. Further study is needed to better quantify septic loading to the lake and other waterbodies in the basin.

<u>Results</u>

An estimated 100 septic tank units were identified within 200 meters of Lake Munson, with zero units within 200 meters of Munson Slough downstream of Lake Henrietta SWMF. **Figure 3-45** shows the septic systems utilized in this analysis, with green representing those associated with direct loading to the waterbody. A table provided in the figure summarizes the calculated nutrient load from septic units. Lake Munson has an estimated annual TN load of 1,049 lb/yr, all from units directly on the lake. Munson Slough downstream of Lake Henrietta SWMF has a load of 0 lb/yr.

3.4.5.3 Wastewater Load

The assessment provided in **Section 3.4.4.5** identified that wastewater loads are accounted for in the load calculation out of Lake Henrietta SWMF presented in **Section 3.4.5.1**. Additionally, point source loads were not determined to be a significant source based on flow rates and discharge methods. As such, wastewater loads were not calculated.



Summary of Nutrient Loading from Septic			
Waterbody	Loading Direct to Lake (lbs/yr)	Loading From Tributaries (lbs/yr)	Load (lbs/yr)
Lake Munson	1,049	0	1,049
Waterbody	Loading Direct to Lake (lbs/yr)	Loading From Tributaries (lbs/yr)	Load (lbs/yr)
Munson Slough	0	0	0

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N

0 0.5 Miles

Legend

- Lake Munson Major Drainage Basin
- Lake Munson Drainage Basin
- Lake Munson
- Munson Slough
- Watercourses

Relevant Septic Sites

- Lake

Sources:
Waterbodies: COT, 2020
Watercourses: COT, 2020
Septic Systems: COT, 2020
Watershed: COT, 2020
Roads: COT-Leon County, 2023

Figure 3-45:
Septic Loading to Lake Munson and Munson Slough below Lake Henrietta

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3.4.5.4 Lake Inflow Load

Methodology

Surface water connections between waterbodies are inherently potential sources of pollutants to a downstream waterbody. This section, and others to follow, focuses on the interconnectivity of lakes within the Lake Munson basin and their potential for impacting water quality as a function of loading from one lake to another. Estimation of this loading requires having flow out of and water quality data within the upstream lake. When assessing the potential for inter-lake loading to Lake Munson and other lakes within the basin, the analyses will focus on nutrient loading (TN and TP) and considerations of impairment and nutrient concentrations in the upstream and downstream lakes.

At present, there are no direct flow measurements immediately downstream of the lakes discussed as sources in this and subsequent sections. Therefore, to calculate annual nutrient loads out of the lakes (where nutrient concentration data are available), an average annual flow volume out must be calculated. To this end, the results from the SIMPLE-Seasonal modeling performed as part of the analysis presented in **Section 3.4.5.1** were used to estimate the annual average flows into the upstream lakes. The average annual flow into the lakes was then assumed to be equivalent to the average annual flow out (rainfall and evaporation generally being equivalent on an average annual basis). The calculated flows were then multiplied by TN and TP concentrations in the upstream lake. The TN and TP concentrations represent averages of the latest 3 years of geomeans, with no data prior to 2017 utilized. This approach was utilized for all the lake loading calculations within the Lake Munson basin where recent lake nutrient concentration data are available and direct inflows have been calculated using the SIMPLE-Seasonal model.

Results

Cypress Lake is the only direct source of lake inflow to Lake Munson. **Section 3.4.4.7** identified that the inflow from this lake would not be deemed a significant source of anthropogenic load, therefore, no load is calculated here.

3.4.5.5 Internal Lake Load

Internal recycling loads represent fluxes from benthic substrate that build up from the deposition of ongoing or legacy loads coming into a waterbody. Additionally, buildup can also occur through the accumulation of organic material that settles following algal blooms. These algal blooms occur due to excess nutrient loading to the water column that results in a positive feedback loop of benthic nutrient releases followed by algal blooms. Nutrients are bound into the benthic substrate and, under different conditions (depending upon the nature of the nutrients in the sediments), can be released into the water column. In many lakes within Florida, benthic flux, or internal recycling, can be a significant portion of the nutrient budget. While naturally occurring flux does occur, it is the portion caused by the excessive historical and/or ongoing anthropogenic impacts that would require remediation. In this and sections that follow, the internal recycling loads for waterbodies in the Lake Munson basin are summarized based on the data and analyses presented in **Section 3.4.4.4** as well as through additional analyses where available data/studies support.

While no direct measurements of internal load to Lake Munson have been performed, analyses of data presented in **Section 3.4.4.4** provided an evaluation of potential historical and present significance of internal nutrient loads to the lake. The data analyses, along with other historical studies, identified that prior to 2016, internal loading of nutrients played a significant role in the lake dynamics. The analyses also demonstrated that since 2016, internal loading has played a lesser role. Based on improving water quality conditions evaluated through 2021, the internal lake load is not quantified.

3.4.5.6 Atmospheric Deposition

To calculate the atmospheric deposition loading for nutrients to Lake Munson, the data from the Quincy station (FL14), identified in earlier sections and shown on **Figure 3-24**, were utilized. The National Atmospheric Deposition Program (NADP) provides a clearinghouse for deposition data. The NADP sites collect nitrogen data but not phosphorus, as such, only TN is available. **Table 3-12** presents the annual TN loads per acre from 2010 to 2020. No data were available at the Quincy station for 2020 so the value from the next nearest station (Sumatra – FL23) was utilized. Averaging the annual load per acre over the 10-year period gives a value of 2.56 lb/acre/yr. Multiplying the 2.56 lb/acre/yr TN load by the acreage of Lake Munson (255 acres) gives a total average TN load of 653 lb/yr.

Table 3-12: Annual Atmospheric TN Load per Acre from Quincy Station

Year	TN (lb/acre)
2010	2.19
2011	2.31
2012	2.20
2013	2.57
2014	4.95
2015	2.57
2016	2.47
2017	2.31
2018	2.40
2019	1.97
2020*	2.16*

*Data from NADP Website Sumatra Station

3.4.5.7 Summary of Calculated Loads

Nutrient loads to Lake Munson and Munson Slough downstream of Lake Henrietta SWMF were calculated for stormwater runoff, septic systems, and atmospheric deposition. **Table 3-13** presents the calculated total loads to the lake for TN and TP. For septic systems and atmospheric deposition, only TN loads were calculated (see **Section 3.4.5.2** and **Section 3.4.5.6**, respectively, for explanation).

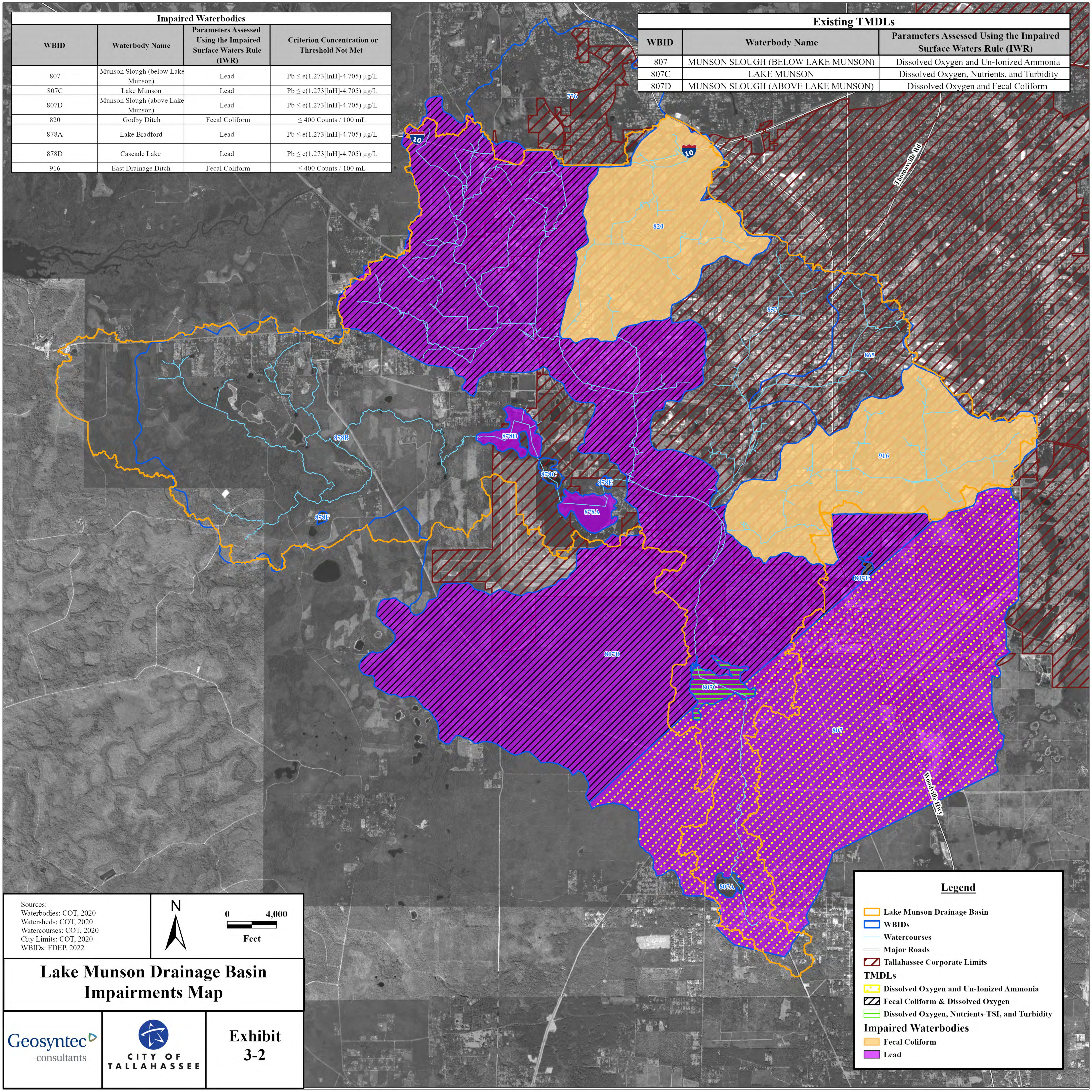
Table 3-13: Summary of Calculated Loads to Lake Munson and Munson Slough downstream of Lake Henrietta SWMF

Source	Lake Munson		Munson Slough downstream of Lake Henrietta SWMF	
	TN (lb/year)	TP (lb/year)	TN (lb/year)	TP (lb/year)
Stormwater Runoff	60,134	5,840	59,244	5,640
Septic Systems	1,049	ND	0	0
Atmospheric Deposition	563	ND	NA	NA

ND – No data to support calculation, NA – Load calculation not applicable

Impaired Waterbodies			
WBID	**Waterbody Name**	**Parameters Assessed Using the Impaired Surface Waters Rule (IWR)**	**Criterion Concentration or Threshold Not Met**
807	Munson Slough (below Lake Munson)	Lead	Pb ≤ e(1.273[lnH]-4.705) μg/L
807C	Lake Munson	Lead	Pb ≤ e(1.273[lnH]-4.705) μg/L
807D	Munson Slough (above Lake Munson)	Lead	Pb ≤ e(1.273[lnH]-4.705) μg/L
820	Godby Ditch	Fecal Coliform	≤ 400 Counts / 100 mL
878A	Lake Bradford	Lead	Pb ≤ e(1.273[lnH]-4.705) μg/L
878D	Cascade Lake	Lead	Pb ≤ e(1.273[lnH]-4.705) μg/L
916	East Drainage Ditch	Fecal Coliform	≤ 400 Counts / 100 mL

Existing TMDLs		
WBID	**Waterbody Name**	**Parameters Assessed Using the Impaired Surface Waters Rule (IWR)**
807	MUNSON SLOUGH (BELOW LAKE MUNSON)	Dissolved Oxygen and Un-Ionized Ammonia
807C	LAKE MUNSON	Dissolved Oxygen, Nutrients, and Turbidity
807D	MUNSON SLOUGH (ABOVE LAKE MUNSON)	Dissolved Oxygen and Fecal Coliform



Sources:
Waterbodies: COT, 2020
Watersheds: COT, 2020
Watercourses: COT, 2020
City Limits: COT, 2020
WBIDs: FDEP, 2022

Lake Munson Drainage Basin Impairments Map

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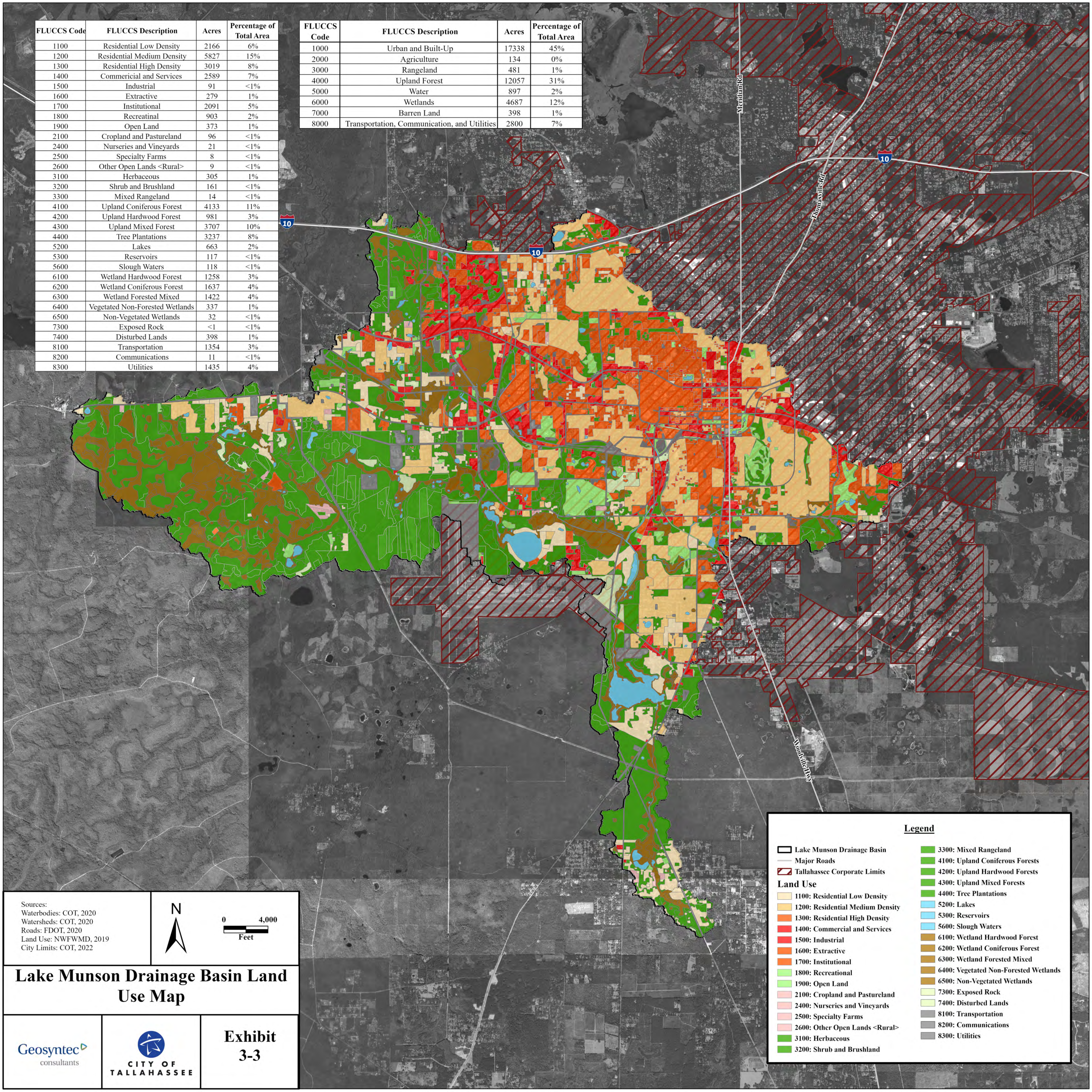
Exhibit 3-2

Lake Munson Drainage Basin Land Use Map

Exhibit 3-3

FLUCCS Code	FLUCCS Description	Acres	Percentage of Total Area
1100	Residential Low Density	2166	6%
1200	Residential Medium Density	5827	15%
1300	Residential High Density	3019	8%
1400	Commericial and Services	2589	7%
1500	Industrial	91	<1%
1600	Extractive	279	1%
1700	Institutional	2091	5%
1800	Recreatinal	903	2%
1900	Open Land	373	1%
2100	Cropland and Pastureland	96	<1%
2400	Nurseries and Vineyards	21	<1%
2500	Specialty Farms	8	<1%
2600	Other Open Lands <Rural>	9	<1%
3100	Herbaceous	305	1%
3200	Shrub and Brushland	161	<1%
3300	Mixed Rangeland	14	<1%
4100	Upland Coniferous Forest	4133	11%
4200	Upland Hardwood Forest	981	3%
4300	Upland Mixed Forest	3707	10%
4400	Tree Plantations	3237	8%
5200	Lakes	663	2%
5300	Reservoirs	117	<1%
5600	Slough Waters	118	<1%
6100	Wetland Hardwood Forest	1258	3%
6200	Wetland Coniferous Forest	1637	4%
6300	Wetland Forested Mixed	1422	4%
6400	Vegetated Non-Forested Wetlands	337	1%
6500	Non-Vegetated Wetlands	32	<1%
7300	Exposed Rock	<1	<1%
7400	Disturbed Lands	398	1%
8100	Transportation	1354	3%
8200	Communications	11	<1%
8300	Utilities	1435	4%

FLUCCS Code	FLUCCS Description	Acres	Percentage of Total Area
1000	Urban and Built-Up	17338	45%
2000	Agriculture	134	0%
3000	Rangeland	481	1%
4000	Upland Forest	12057	31%
5000	Water	897	2%
6000	Wetlands	4687	12%
7000	Barren Land	398	1%
8000	Transportation, Communication, and Utilities	2800	7%



Sources:
Waterbodies: COT, 2020
Watersheds: COT, 2020
Roads: FDOT, 2020
Land Use: NWFWMD, 2019
City Limits: COT, 2022

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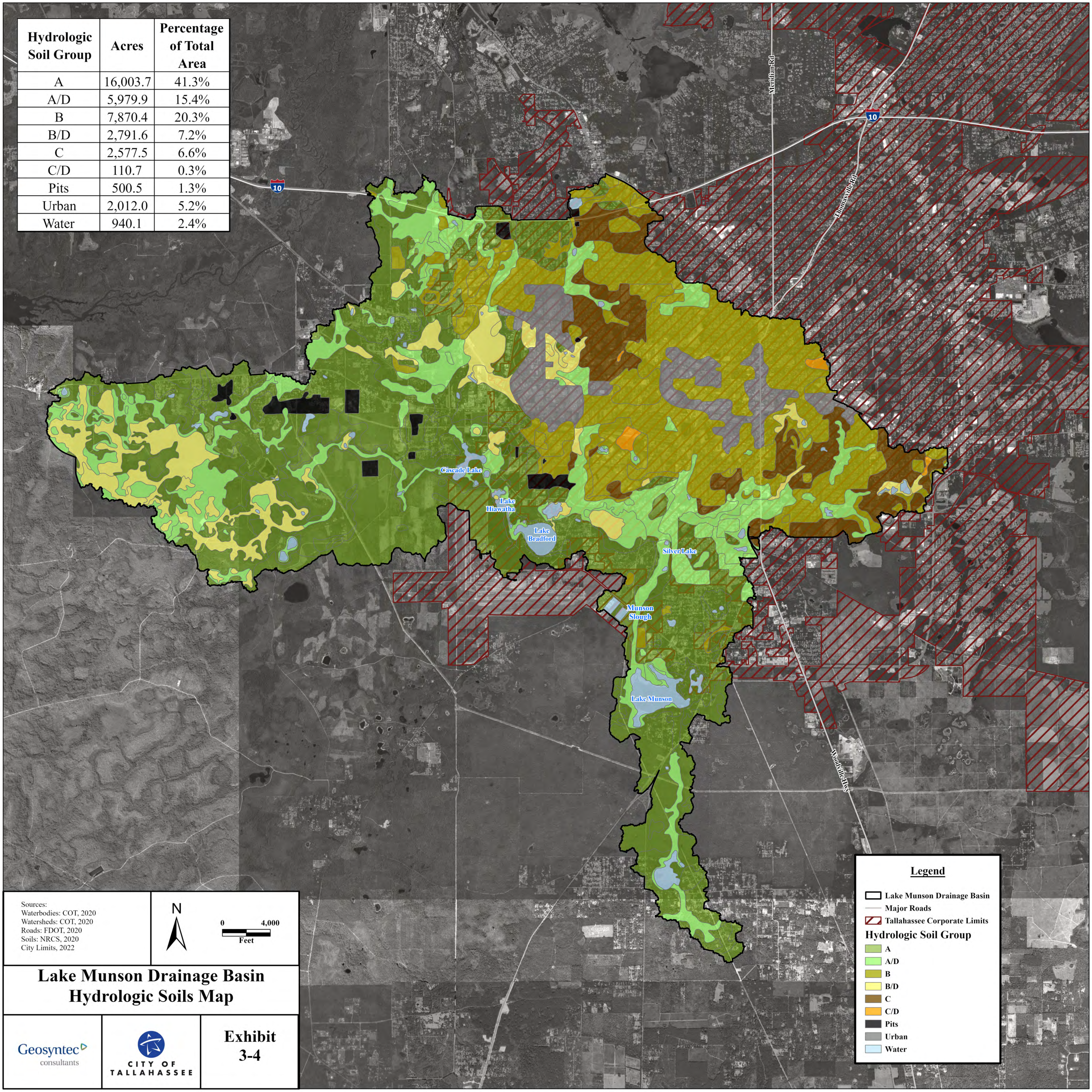
Hydrologic Soil Group	Acres	Percentage of Total Area
A	16,003.7	41.3%
A/D	5,979.9	15.4%
B	7,870.4	20.3%
B/D	2,791.6	7.2%
C	2,577.5	6.6%
C/D	110.7	0.3%
Pits	500.5	1.3%
Urban	2,012.0	5.2%
Water	940.1	2.4%



Sources:
Waterbodies: COT, 2020
Watersheds: COT, 2020
Roads: FDOT, 2020
Soils: NRCS, 2020
City Limits, 2022

Lake Munson Drainage Basin Hydrologic Soils Map

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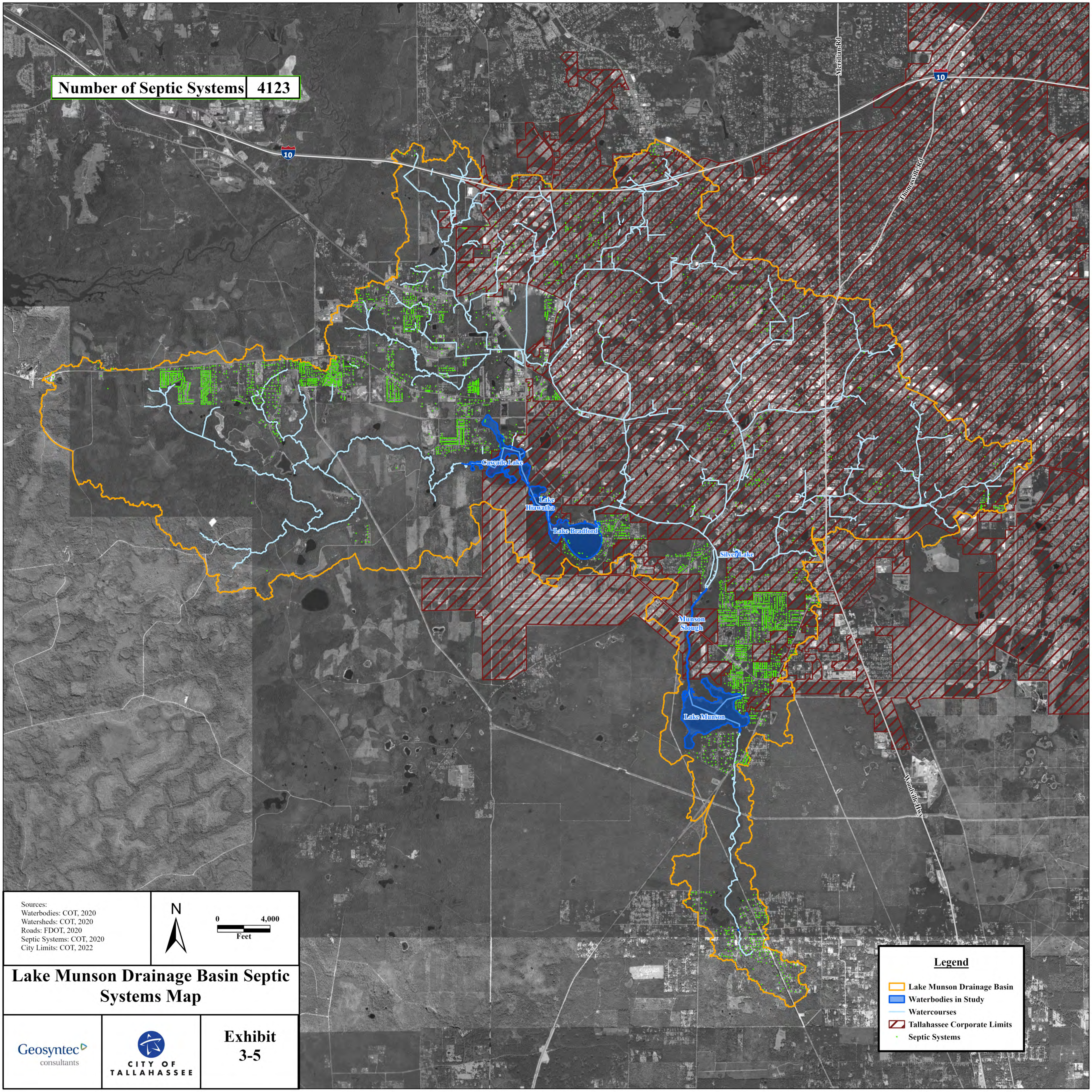
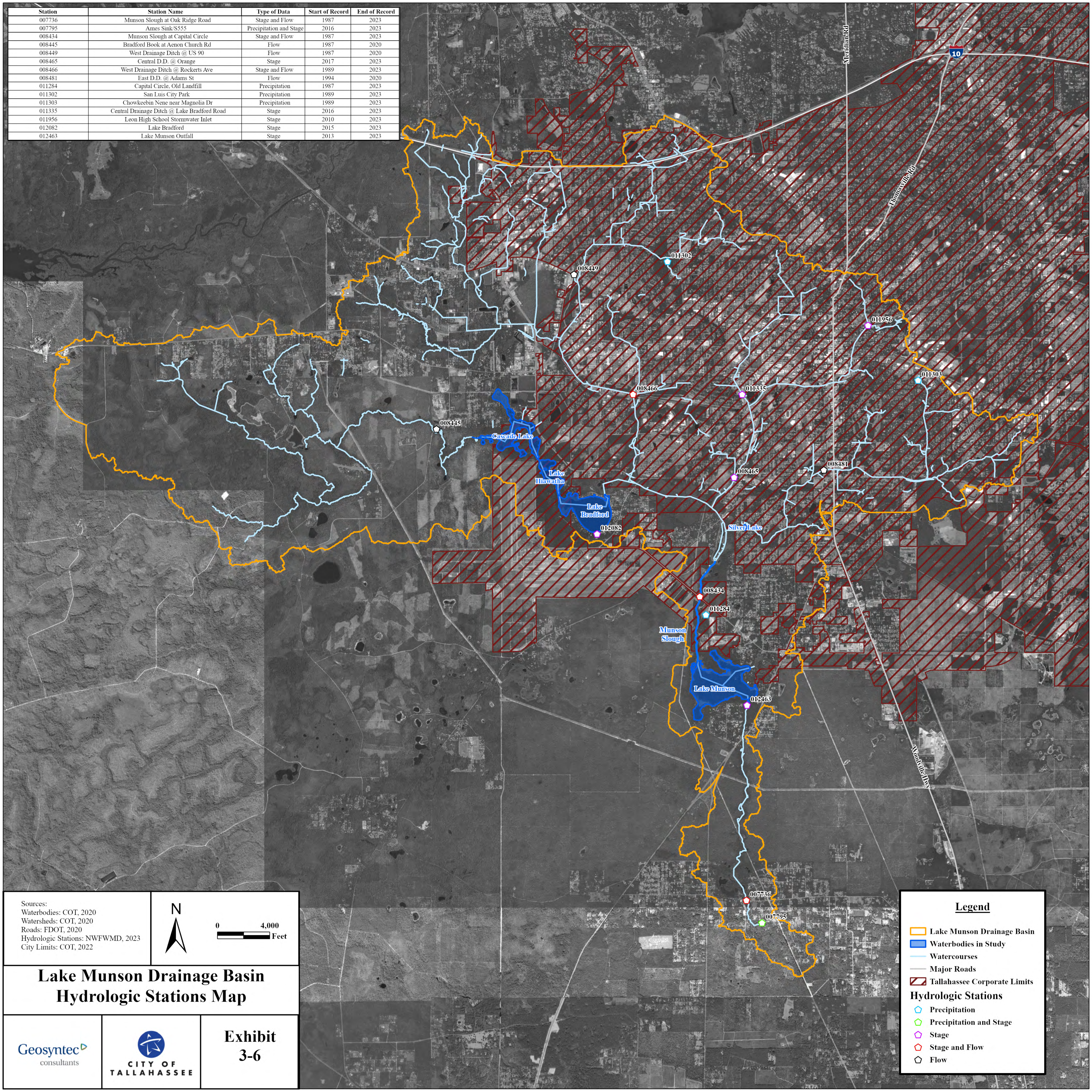
Exhibit 3-4



Lake Munson Drainage Basin Septic Systems Map

Exhibit 3-5



Station	Station Name	Type of Data	Start of Record	End of Record
007736	Munson Slough at Oak Ridge Road	Stage and Flow	1987	2023
007795	Ames Sink/S555	Precipitation and Stage	2016	2023
008434	Munson Slough at Capital Circle	Stage and Flow	1987	2023
008445	Bradford Book at Aenon Church Rd	Flow	1987	2020
008449	West Drainage Ditch @ US 90	Flow	1987	2020
008465	Central D.D. @ Orange	Stage	2017	2023
008466	West Drainage Ditch @ Rockerts Ave	Stage and Flow	1989	2023
008481	East D.D. @ Adams St	Flow	1994	2020
011284	Capital Circle, Old Landfill	Precipitation	1987	2023
011302	San Luis City Park	Precipitation	1989	2023
011303	Chowkeebin Nene near Magnolia Dr	Precipitation	1989	2023
011335	Central Drainage Ditch @ Lake Bradford Road	Stage	2016	2023
011956	Leon High School Stormwater Inlet	Stage	2010	2023
012082	Lake Bradford	Stage	2015	2023
012463	Lake Munson Outfall	Stage	2013	2023

Lake Munson Drainage Basin Hydrologic Stations Map

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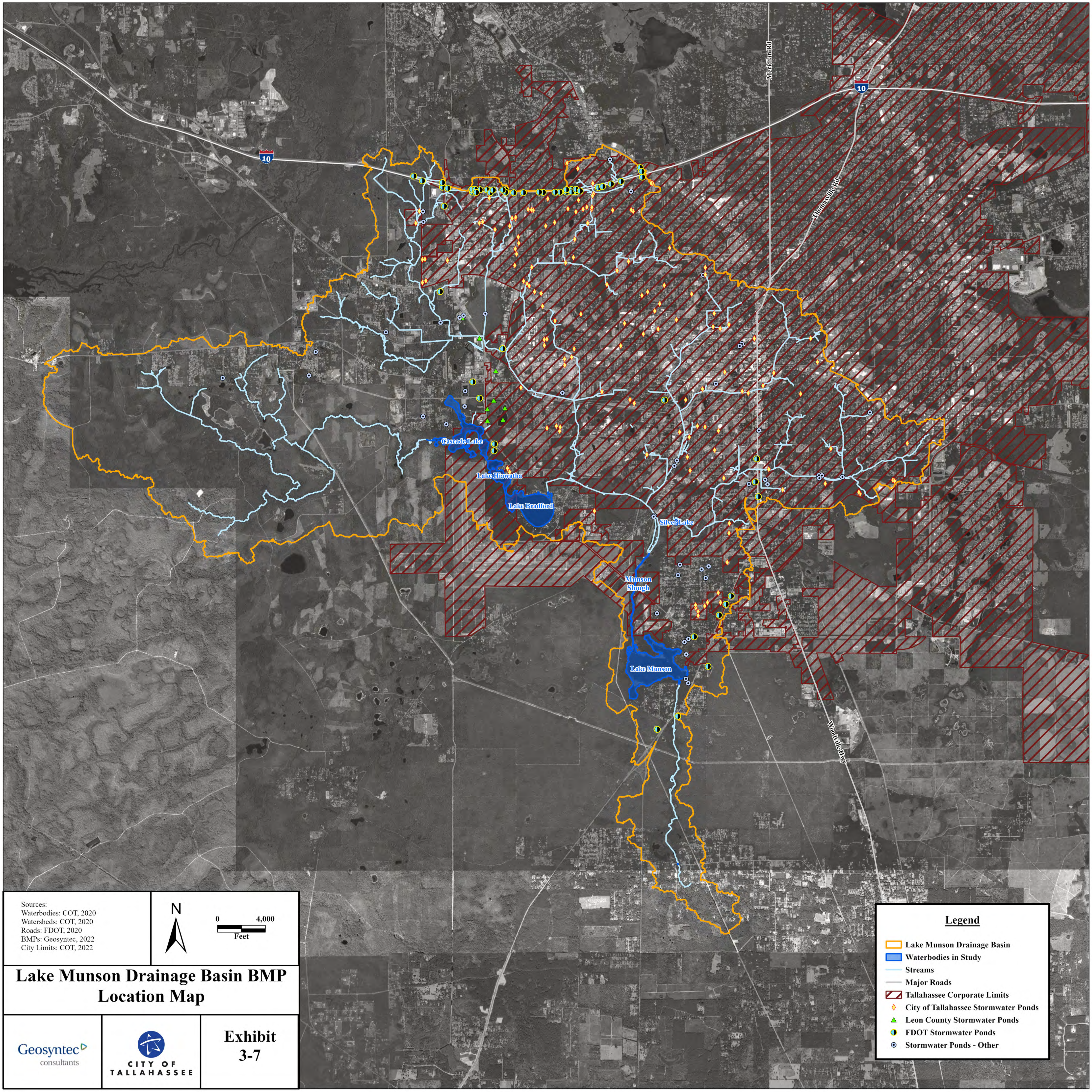
Exhibit 3-6



Lake Munson Drainage Basin BMP Location Map

Exhibit 3-7