Lura Lake

Final

Total Maximum Daily Load Study

Excess Nutrients

December 2013

Submitted by:

Minnesota State University Mankato – Water Resources Center

Minnesota Pollution Control Agency

Minnesota State University Mankato

CLEAN WATER LAND & LEGACY AMENDMENT

wq-iw7-38e

TMDL Summary Table

EPA/MPCA Requirement	Summary	Page #
303(d) Listing Information	Impaired Water- Lura Lake Lake ID# 07-0079-00 Affected designated use- Aquatic recreation Pollutant or Stressor – Nutrient/Eutrophication Biological indicators TMDL pollutant of concern - Phosphorus TMDL start date – 2009, Target end date - 2011	2
Location	Lura Lake is located in southern Blue Earth County and northern Faribault County within the Le Sueur River watershed of south central Minnesota.	4
Water Quality Standards	The applicable standards are the shallow lakes water quality standards for the Western Corn Belt Plains at 90 ppb of Total Phosphorus, $\leq$ 30ppb Chlorophyll and $\geq$ 0.7m Secchi depth. For the modeled standard values, refer to Section 5 – Margin of Safety	13
Seasonal Variation	All target reductions are calculated for the total nutrient budget of the lake. This budget is developed using annual loading data, and targets are determined based on the highest loading periods (typically the summer months). Using these methods, seasonal variation is accounted for within the annual loading calculation.	15
Loading Capacity	Using BATHTUB and a 10 percent Margin of Safety, the loading capacity was calculated at 5.83 lbs phosphorus/day.	27
Wasteload Allocation	No existing permitted sources for nutrient loading exist within the lake watershed or contributing areas. Construction stormwater was estimated at 1 percent of the total Load Allocation (assuming no more than 1 percent of the watershed would be under construction at any one time) and calculated at 0.05 lbs/day.	27
Load Allocation	Load allocation values are spread out among nonpoint loading sources. The load allocation values were not subdivided to individual loading sources and calculated at 5.20 lbs/day.	28
Margin of Safety	The MOS was set at 10 percent of the total allocation and used to develop the TMDL value. The MOS was 0.58 lbs/day.	31
Implementation	A general list of implementation activities has been included within the TMDL. A more specific Lura Lake Excess Nutrient Implementation plan will be developed as part of the LeSueur River Watershed Restoration and Protection plan (WRAP). This implementation plan will cover more specific practices, goals, and targeted areas.	33
Monitoring	Monitoring will include existing programs including the State of Minnesota 10-year watershed approach and Intensive Watershed Monitoring (IWM). Other programs and resources may be utilized for implementation effectiveness monitoring.	37
Reasonable Assurance	To address the major loading portion of the TMDL, the nonpoint source allocations, a wide variety of management practices will need to be considered and implemented to address the loading issues. The state of Minnesota requires that an "Implementation Plan" be developed to address the impairment and the methods best suited to meet the goals of the TMDL.	39
Public Participation	This report includes a list of meetings and events related to public and technical team involvement with the TMDL.	40

Executive Summary

The Federal Clean Water Act (CWA) requires states to adopt water-quality standards to protect surface waters from pollution. These standards define how much of a pollutant can be in a water body and still allow the water body to meet its designated uses, such as drinking water, fishing and swimming. A water body is "impaired" if it fails to meet one or more water quality standards.

Section 303(d) of the CWA requires that states develop Total Maximum Daily Load (TMDL) studies for surface waters that do not meet and maintain applicable water quality standards. The TMDL is the sum of all Waste Load Allocations (point source) and Load Allocations (nonpoint source) with the inclusion of a margin of safety. A TMDL reviews the conditions of a water body, determines the loading of a given pollutant from point and nonpoint sources, and determines the carrying capacity or necessary reductions to eliminate the impairment of that surface water's designated use.

Lura Lake is located in southern Blue Earth County and northern Faribault County within the Le Sueur River watershed of south central Minnesota. Lura Lake's nearly 1:1 watershed to lake surface area ratio provides a unique opportunity to implement lake management and upland best management practices to examine effectiveness and improve water quality within the system.

Lura Lake was placed on the impaired waters list in 2002 following a monitoring program developed by the Minnesota Pollution Control Agency (MPCA). A body of water is placed on the impaired waters list (the 303(d) list per the Clean Water Act) when the water body is deemed "unable to support aquatic recreation use" through the evaluation of the water in reference to regional standards. Data collected and observations recorded from the early 1980s through the mid-1990s indicated that Lura Lake consistently maintained high levels of nutrients and overall, a low Secchi disk transparency. Additional data collected between 1997 and 2006 indicated mean total phosphorous (TP) of 191 ppb (±48), chlorophyll-a of 28.5 ppb (±4), and Secchi disk transparency of 1.0 m (±0.1). Based on sample data and analysis, the limiting nutrient in the system is phosphorus.

The MPCA TMDL program provided assistance to the Water Resources Center at Minnesota State University - Mankato (WRC-MSUM), landowners and interested stakeholders in data collection, analysis and TMDL development. Following completion of a TMDL study, TMDL implementation funds will be available to the local government organizations, lake associations, and other entities on a competitive basis.

Information utilized for this project included existing monitoring data to create a nutrient budget, GIS analysis of the watershed, vegetation surveys of the lake, and studies related to ongoing watershed projects. Point sources such as wastewater treatment, construction, industrial stormwater, and Municipal Separate Storm Sewer Systems (MS4) were reviewed based on permitted and actual discharge values. Due to the nature of the watershed and the lack of a Waste Water Treatment Plant (WWTP), the only calculated point source discharge is based on construction stormwater permits.

Nonpoint pollutant sources are addressed relative to modeled contributions within the watershed including natural and anthropogenic sources. Internal nutrient release and cycling was considered when calculating loading for the lake system. Releases from vegetation and sediment are suspected to be a major driver in the internal loading. A 10 percent margin of safety was used within the loading calculations to account for any uncertainty within the TMDL process. In summary, the TMDL values were calculated as follows:

TMDL=Loading Capacity (LC) = ∑ Waste Load Allocation (WLA) + ∑ Load allocation (LA) + Margin of Safety (MOS)

TMDL = LC = 5.83 lbs/day

∑WLA = 0.05 lbs/day [NPDES values (0.00) + Construction stormwater (.05 lbs/day or 1 percent)]

∑LA = 5.20 lbs/day [nonpoint sources as listed above. No specific allocations for each area.]

∑MOS = 0.58 lbs/day

Existing monitoring programs under the Minnesota Watershed Approach will be used to track progress made toward meeting the Minnesota surface water quality standards. State and Federal supported BMPs designed to reduce in-lake nutrient loads, soil erosion and nutrient transport are recommended. A general outline of BMPs and programs to improve water quality is offered in the implementation section. The implementation strategy for Lura Lake will be included in the LeSueur Watershed Restoration and Protection (WRAP) report to be completed in 2013.

The land use changes within the Lura Lake watershed that have contributed to water quality impairments took place over the course of decades. It is likely that changes necessary to improve water quality will also take an extended amount of time. In order to reach the reductions needed, a variety of management options will need to be considered. In-lake water quality may not improve unless there is a decrease in the amount of nutrient loading received by the lake from its watershed. Additionally, the recycling of nutrients in the lake will need to be reduced through restoration techniques. A combination of altering land use practices within the watershed while addressing macrophyte issues within the lake will likely decrease in-lake nutrient cycling.

Causes for excessive nutrient loading range from natural loading to hydrologic modification and land use/cover changes. Additional site specific examination/research would be beneficial in targeting specific areas for remediation, in particular the relationships of the aquatic plant community and its effect on nutrient cycling. Consideration of existing hydrology and ground water influence would also help to improve the understanding of water quality issues. Any implementation will likely need to be handled in a phased approach, allowing for adjustments in new information, technology, and demands on the landscape and water resources.

Acknowledgements

Project Sponsor
Water Resources Center,
Minnesota State University, Mankato
Shannon Fisher, Director

Project Coordinator
Scott Bohling

MPCA Project Manager
Paul Davis

With assistance from
Scott MacLean

Technical Support
John Erdmann

MPCA TMDL Website
Megan Pavek

Acronyms and Glossary

BMP –Best Management Practice
CREP –Conservation Reserve Enhancement Program
CRP –Conservation Reserve Program
CSMP –Citizen Stream Monitoring Program
CSP –Conservation Security Program
CWA –Clean Water Act
CWP –Clean Water Partnership
DNR –Department of Natural Resources
EPA –Environmental Protection Agency
GBERB –Greater Blue Earth River Basin
GBERBA –Greater Blue Earth River Basin Alliance
GIS –Geographic Information System
LA –Load Allocation
MOS –Margin of Safety
MPCA –Minnesota Pollution Control Agency
MS4 –Municipal Separate Storm Sewer System
NPDES –National Pollution Discharge Elimination System
NPS –Nonpoint source
QAQC –Quality Assurance Quality Control
QAPP –Quality Assurance Protection Plan
RC –Reserve Capacity
RGA –Rapid Geomorphic Assessment
TMDL –Total Maximum Daily Load
TSS –Total Suspended Solids
USDA –United State Department of Agriculture
USGS –United State Geologic Survey
WLA –Waste Load Allocation

Table of Contents

Table of Figures

Table of Tables

1 Introduction

Overview and Purpose

The Federal Clean Water Act (CWA) requires states to adopt water-quality standards to protect surface waters from pollution. These standards define how much of a pollutant can be in a water body and still allow the water body to meet its designated uses, such as drinking water or aquatic recreation. A water body is "impaired" if it fails to meet one or more water quality standard.

Section 303(d) of the Clean Water Act requires that states develop Total Maximum Daily Load (TMDL) studies for surface waters that do not meet and maintain applicable water quality standards (Figure 1). Lura Lake was placed on the impaired waters list in 2002 following a monitoring program developed by the MPCA. A water body is placed on the impaired waters list (the 303(d) list per the Clean Water Act) if it is determined that the water body is unable to support its designated use through the evaluation of the water body in reference to applicable water quality standards. According to the MPCA, "impaired lakes exceed the aquatic recreation use support thresholds when sufficient data are available to make an assessment of such aquatic recreation use". These standards and thresholds typically use a minimum of 10 observations on the following parameters: chlorophyll-a, total phosphorous, and Secchi disk.

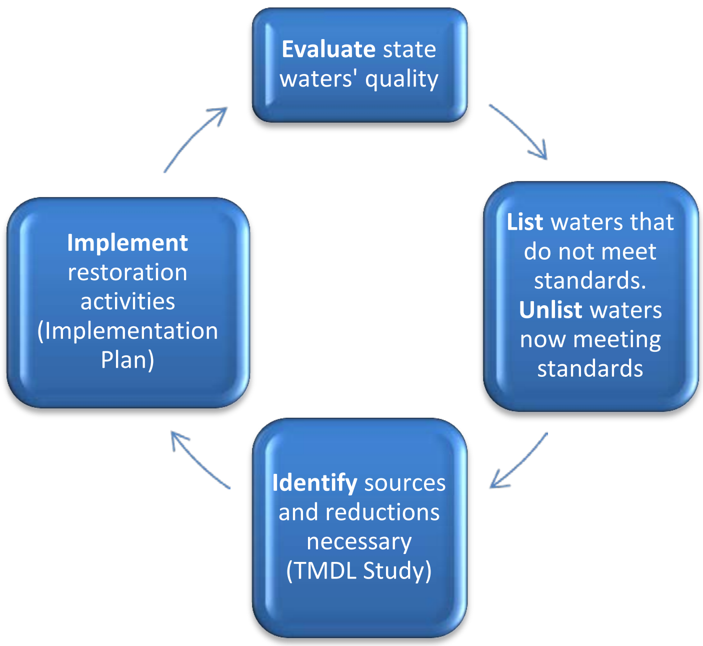


Figure 1: The TMDL Process

The TMDL by definition (40 CFR Part 130, section 130.2, 130.7, and 130.10) is the sum of all Waste Load Allocations (point source) and Load Allocations (nonpoint source) with the inclusion of a margin of safety and reserve capacity.

A TMDL reviews the conditions of a water body, determines the loading of a given pollutant from natural, point and nonpoint sources, and determines the carrying capacity or necessary reductions to eliminate the impairment of that surface water's designated use. This TMDL investigated the mechanisms of nutrient loading within the watershed, calculate the reductions necessary to meet the water quality standards, and propose practices to help reduce and control the loading related to the impairment.

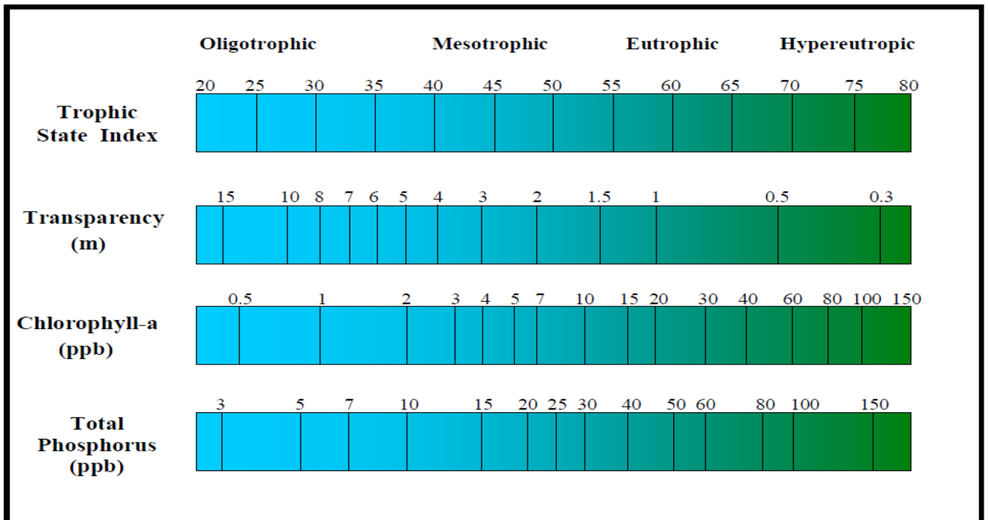
Problem Statement

Data collected and observations recorded from the early 1980s through the mid-1990s indicated that Lura Lake consistently maintained high levels of nutrients and overall, a low Secchi disk transparency. Additional data collected between 1997 and 2006 indicated mean total phosphorous (TP) of 191 ppb (±48), chlorophyll-a of 28.5 ppb (±4), and Secchi disk transparency of 1.0 m (±0.1).

The Carlson Trophic Status Index (TSI) was utilized to summarize the data from Lura Lake. This index was developed to rank the algae and macrophyte growth potential within a lake. It is broken down into the three following categories:

- *Oligotrophic* - Generally very little or no aquatic vegetation, high water clarity
- *Mesotrophic* - Moderate aquatic vegetation, with moderate water clarity.
- E*utrophic* - Abundant aquatic vegetation, with lower water clarity.

Lakes with extreme trophic indices may be considered *hyperoligotrophic* or *hypereutrophic.* Hypereutrophic lakes are typically shallow and rich in nutrients such as phosphorus. Phosphorus is generally the limiting factor in algae and plant growth in a lake. The TSI scale and relevant parameters are shown in Figure 2.



After Moore, 1. And K. Thornton, [Ed.]1988. Lake and Reservoir Restoration Guidance Manual. USEPA>EPA 440/5-88-002.

Figure 2: Carlson Trophic Status Index

Lura Lake was listed on the 303(d) Impaired Waters List in 2002 based on water quality data that included mean concentration of total phosphorous (TP) 191ppb (TSI score of 80), a chlorophyll-a concentration of 28.5 ppb (TSI score of 63), and a Secchi disk mean of 1.0m (TSI score of 60). The Lura Lake watershed was given priority for TMDL development due to the impairment impacts on public health and aquatic life, the public value of the impaired water and the likelihood of completing the TMDL within a reasonable time frame. As a popular spot for aquatic recreation and having a strong base of existing data and the technical capability of local partners, the TMDL development is the start to improve water quality within the Lura Lake watershed. This TMDL calculates acceptable nutrient loading based on the best available data and modeling information.

2 Background Information

Landscape and Setting

Watershed and Lake Description

Lura Lake is located in southern Blue Earth County and northern Faribault County within the Le Sueur River watershed of south central Minnesota. The lake is located near the towns of Amboy, Mapleton, and Delavan. Lura Lake has a watershed area and surface water area of approximately 1300 acres each, a ratio of nearly 1:1. The lake has a mean depth of approximately 4.7 feet (1.4 m), with a maximum depth of 9 feet (2.7 m). With this shallow mean depth, most of the lake bottom can potentially support rooted vegetation.

Like many lakes in Minnesota, Lura Lake was formed as an irregular deposition of glacial till that created a "closed" basin, or one without an obvious inlet and outlet (Zumberge, 1952). The native vegetation of the watershed, following the last glacial event, was dominated by prairie with some wet prairie and wooded areas (Marschner, 1930). Over time, the natural vegetation development and lake and wetland processes created the enriched soils now utilized for agricultural production.

Historically, Lura Lake has undergone significant changes. Water levels have fluctuated as a result of climactic variation as well as human alteration. Hydrologic modification to the watershed include: land conversion to agriculture; road construction; drainage; and individual home site construction. The alterations to the landscape have played a role in nutrient transport and in lake processes as compared to the natural condition. The initial survey of the area by the U.S Surveyor General's office in 1856 shows the shoreline and surface area that's similar to the lake today. The lake essentially disappeared in the 1920's and 30's and much of the lake bed was used for pasture. It is believed locally that a large magnitude earthquake in Alaska in 1964 caused several springs within the lake system to increase in flow volume, causing the lake levels to rise again. Drought and climactic variations may have played a role in the changing lake level. Construction of roads and levees has altered the natural outflow of the lake system and the existing outlet of the lake was constructed to reduce the likelihood of flooding at high water levels. The Minnesota Department of Natural Resources (DNR) has established the ordinary high water level at 1033 feet.

Past Reclamation Efforts

The term "reclamation" is used to describe direct efforts to significantly modify the aquatic plant and fish community of a lake. In 1994, the DNR completed a rotenone treatment to eliminate the rough fish species and re-establish a new aquatic community via stocking efforts. The Minnesota Pollution Control Agency (MPCA) reviewed the lake as part of the Lake Assessment Program (LAP) in 1995 to examine the water quality, aquatic vegetation, potential pollution sources, and future goals for the lake system. Water quality parameters improved dramatically, with the visual depth range increasing from <0.3 meters in 1993 and 1994 to 2.4 meters in 1995 as measured using a Secchi disk. Rough fish species reduction was noted as a major contributor to this improvement. Over time undesirable fishes reentered the lake (e.g. black bullhead and carp). Water transparency again started to decline between 2004 and 2007 with Secchi disk measurements falling in the range of 0.8 to 1.3 meters.

Following the reclamation efforts in 1994, desirable and undesirable rooted submergent vegetation increased dramatically. Curly-Leaf pondweed, an invasive aquatic plant species, is now present in high density generally from ice out through late June of each year. The die off in late June causes floating surface mats of decaying vegetation, dramatically impacting recreation and lowering dissolved oxygen levels, potentially causing fish kills. This annual macrophyte die off is suspected to cause substantial releases of nutrients into the water column, contributing to the algal blooms that occur. The lake also contains Eurasian Milfoil, another exotic invasive plant species. Four vegetation surveys were completed during the TMDL project to investigate the plant communities and possible connections to water quality impairments.

Modern Land Use and Cover

Minnesota is divided into seven ecoregions based on vegetation, soil types, geology, and climate. The Lura Lake Watershed is located in the Western Corn Belt Plains Ecoregion. The dominant land use in this region is agricultural, followed by mixed wetland types, pasture and forest.

Approximately 70 percent of the watershed land use is agricultural. The remaining acres include farmsteads, cabins, forests, and Daly Park (Blue Earth County). Lura Lake is an important resource to local residents. Historically, the Lura Lake Association has been very active in promoting conservation and recreation efforts, and is an important entity behind the diffusion of educational materials and the efforts to reduce shore land erosion.

All land use data is based on the 2009 National Agricultural Statistics Service (NASS) land use statistics, the most current available during the creation of the TMDL. The NASS data set is created based on the National Land Cover Dataset (NLCD), defining agricultural acreage specifically by crop and nonagricultural as defined under the NLCD definitions.

Land use remains relatively stable within the watershed. There has been limited lakeshore development and the majority of land use adjacent to the lake remains in agricultural production. The population in the rural area continues to maintain or decline and may affect future development opportunity.

The land use characteristics for the Lura Lake watershed are summarized in
Table 1 and Figure 3. For descriptions see Appendix B – Land Use Classification Definitions.

Table 1: Summary of Land Use within Lura Lake Watershed (NASS, 2009)

Land Use	Acres	Land Use	Acres
Open Water	1347.6	Peas	43.4
Corn	490.5	Pasture/Grass	29.4
Soybeans	341.7	Herbaceous Grassland	24.8
Developed - Open Space	102.3	Shrubland	2.3
Woody Wetlands	96.9	Wetlands	1.5
Herbaceous Wetlands	59.7	Developed - Low Intensity	1.5
Deciduous Forest	58.1	Mixed Forest	0.8
Pasture/Hay	58.1		

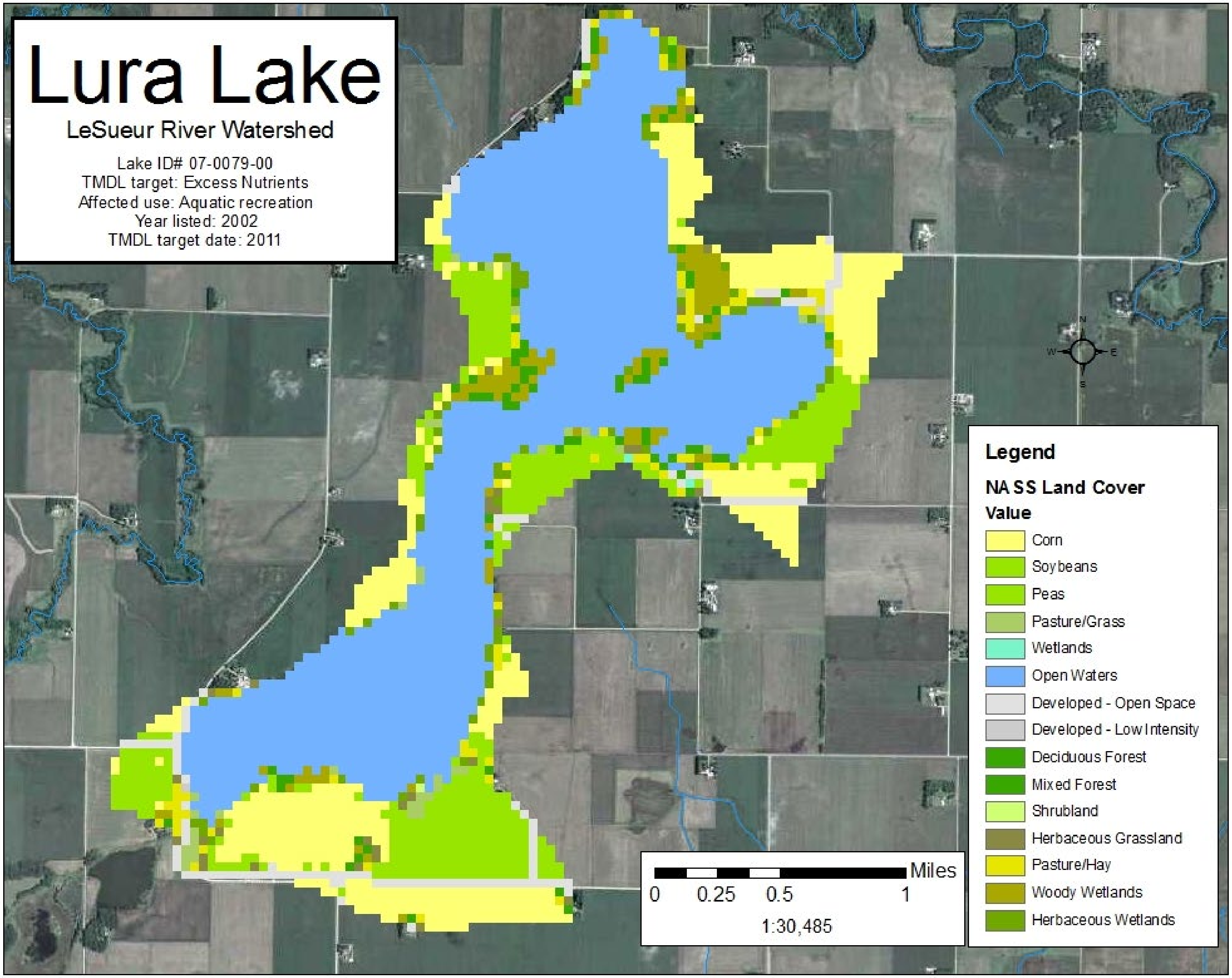


Figure 3: Land Use within the Lura Lake Watershed (NASS, 2009)

Climate

Climate greatly affects the conditions of the lake and watershed. Rainfall affects the amount of water supplied to the system and the potential runoff from the watershed. Seasonal water temperatures impact the timing and amount of algae production.

Temperature

Average monthly air temperatures in the Lura Lake watershed are presented in Table 2. Spring melt typically occurs between the end of March and early April, affecting lake levels. Temperatures reach peak levels during July/August and then gradually decline.

While nutrient loading is not directly related to temperature, some relationship exists due to seasonal variation. High loading concentrations may occur with rising spring temperatures and snow melt, increased run off and potential bank erosion.

Increased algae production occurs as ambient water temperatures reach 16-27 °C (60-80 °F) with 18-20 °C (64 - 68°F) being the optimal range for high algal productivity (Food and Agriculture Organization of the United Nation, 1991). Other parameters influencing algal productivity include exposure to sunlight, pH and the availability of nutrients (phosphorus).

Table 2: Average Monthly Temperature in Southern Minnesota (MN Climatology Working Group, 1970-2010)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp (◦F)	13.1	20.0	32.1	46.3	59.4	68.5	72.6	70.0	61.0	48.6	32.5	18.6

Precipitation

Based on data from the National Weather Service (NWS) and the National Oceanic Atmospheric Administration (NOAA), average precipitation is 27-28 inches per year Figure 4. This value is similar to the findings from the Minnesota Climatology Working Group and the Blue Earth County Township Rain Monitoring System data.

Figure 4: Average Monthly Precipitation in South Central Minnesota 1970-2010

Soils

The nature of the soils within a watershed plays a role in land use, drainage, and other factors related to nutrient transport within the watershed system. Hydric and drained soils release nutrients under certain conditions. Wetlands typically act as natural settling/storage basins, but when drained or altered, the stored nutrients can be leached from the soil and moved through the basin.

The five most common soil types found within the watershed are as follows: Beauford Clay (310), Marna silty clay loam (110), Shorewood silty clay loam (286), Baroda silty clay loam (316) and Shorewood silty clay (311) Figure 5. Each of these soil types are described as needing drainage for production and have high soil fertility and high organic content.

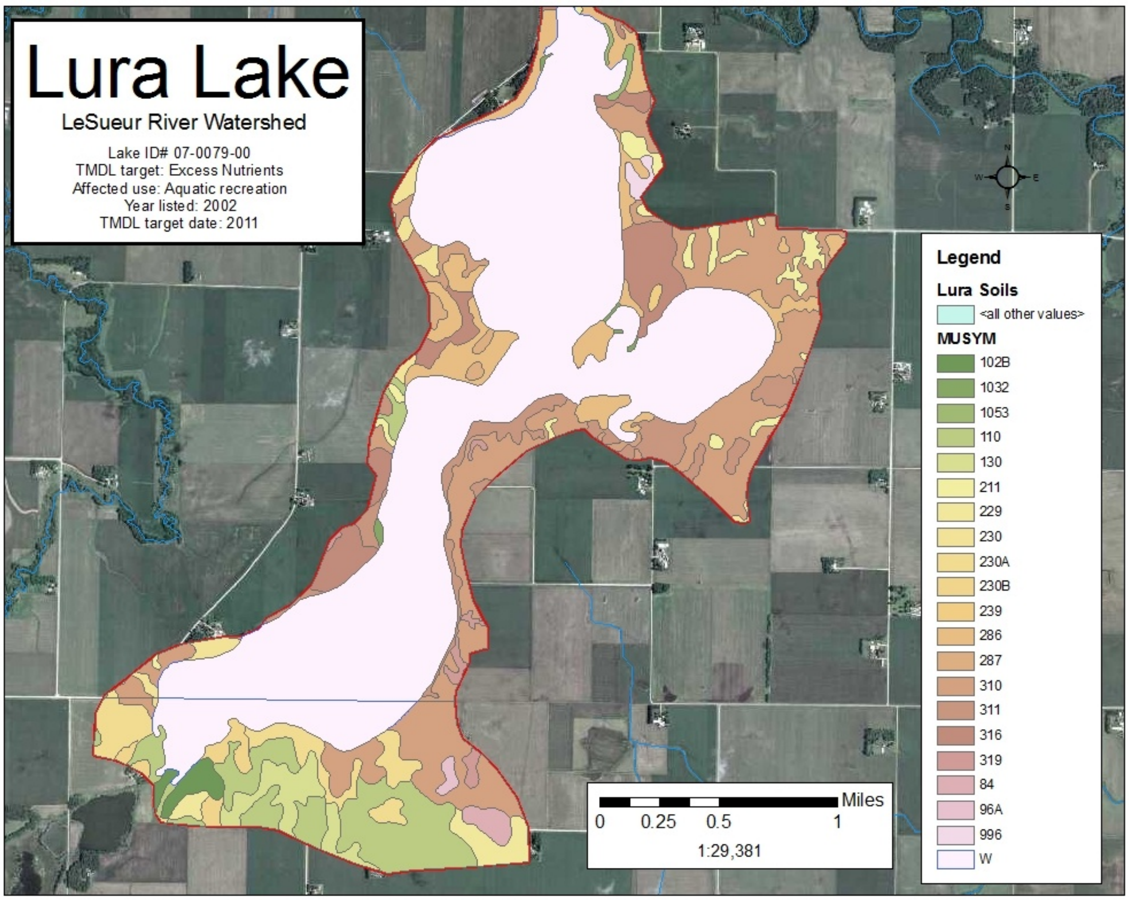


Figure 5: Lura Lake Watershed Soils

Three of the most common soils are hydric and considered poorly drained, requiring drainage for production. Several tile lines were identified entering the lake from the watershed. The land use and cover change along with subsurface drainage can provide nutrient transport to the lake under certain conditions. Substantial loss of agricultural nutrients and contaminants to surface and ground waters is possible through complex changes in hydrology and geomorphology relative to pre-drained conditions (Blann et all, 2008). Attempts to monitor tile were unsuccessful due to lake elevation changes and placement of tile outlets at the shoreline.

Aquatic Vegetation

The littoral zone of the lake, according to the DNR, is defined as that portion of the lake that is less than 15 feet in depth. At or above this depth the majority of the aquatic plants are found due to the availability of sunlight to allow plant growth. With a maximum depth of approximately 10-11', depending on lake conditions, Lura Lakes littoral zone covers the entire lake.

Aquatic vegetation surveys have been utilized for assessment purposes within Lura Lake by the MPCA, the DNR, and the MSU-WRC. These assessments are used to examine the number of plant species available as well as estimating the population and density of the plants throughout the lake.

Several native species have been observed including: Ceratophyllum (commonly known as Fanwort or Coontail), Elodea Canadensis (commonly known as Elodea) and Potamogeton Pedctinatus (commonly known as Sago pondweed). These plants are shown in Figure 6.



Figure 6: Coontail, Elodea, and Sago Pondweed

Native lake vegetation is important, providing essential spawning habitat for fish, habitat for macroinvertebrates, and for stabilizing the sediments and near shore environments of the lake.

Several non-native species are present in Lura Lake. Potamogeton crispus, (commonly known as curly-leaf pondweed) and Myriophyllum spicatum (commonly known as Eurasian Milfoil) are spread throughout the lake. Both plants are present in Lura Lake from accidental introduction.

Curly-leaf pondweed was the dominate plant found during the vegetation surveys conducted for the TMDL study. The plant thrives in conditions normally less habitable to native plant species. It out competes native species by its ability to germinate under the ice. Curly-leaf affects aquatic recreation with the formation of large mats of vegetation at or near the surface during its growth and senescence Figure 7.

The presence of curly-leaf pondweed alone does not have negative effects on the lake system. The amount of production and its density can be highly variable and create water quality issues. Two vegetation surveys were completed in the spring of 2009 and 2010. Density differences between the two years affected the aesthetic qualities of the lake and the observed phosphorus levels. Two maps Figure 8 and Figure 9 show the difference in plant surveys between 2009 and 2010.

Figure 7: Curly-Leaf Pond Weed Mats

Eurasian Milfoil was also documented during the surveys, though not present anywhere near the levels as curly-leaf. Eurasian Milfoil is an invasive species, and its presence in the lake has caused Lura Lake to be listed on the “Designated Infested Waters” list maintained by the DNR.

Aquatic vegetation likely plays a major role in the loading and nutrient cycling in Lura Lake. This is discussed further in the Allocation Section.

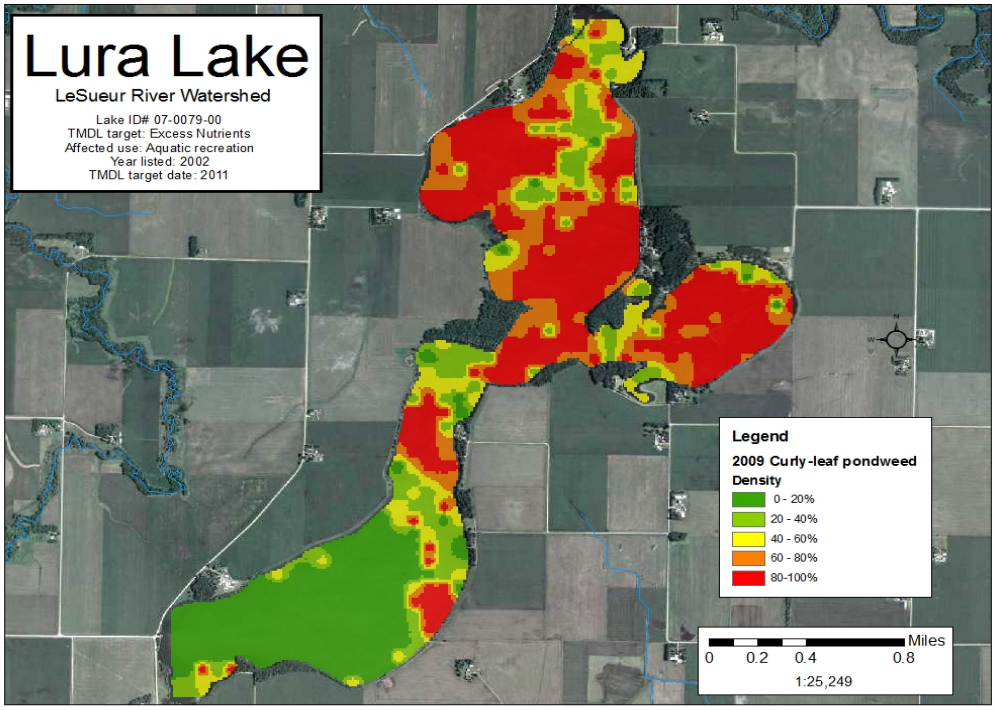


Figure 8: 2009 Curly-leaf Density Map

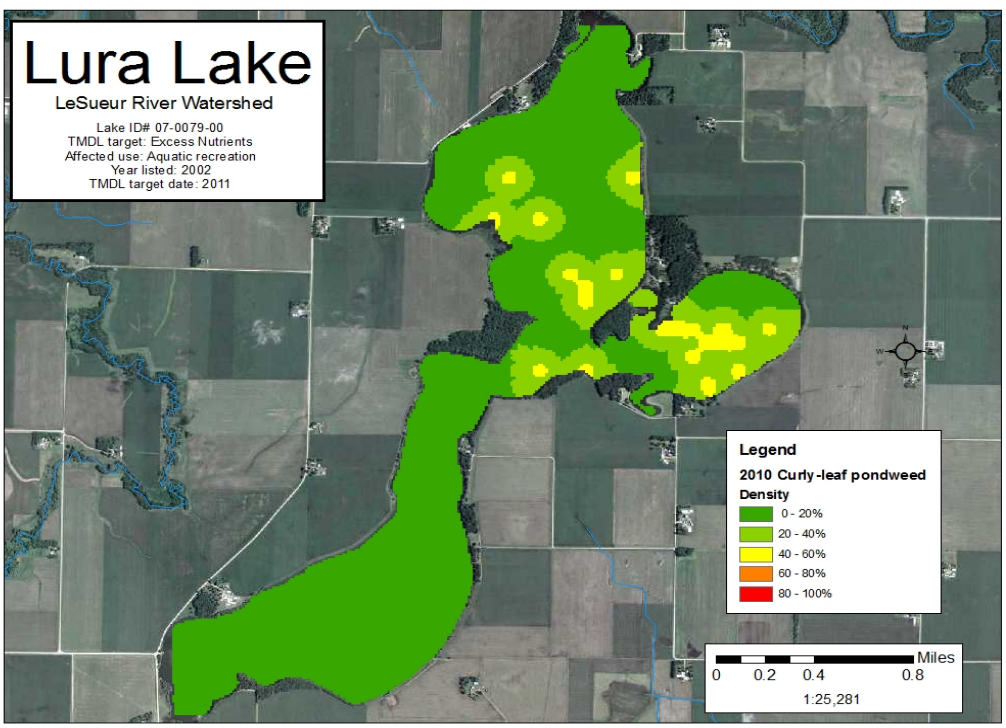


Figure 9: 2010 Curly-leaf Density Map

Fisheries Status and Recreation

The DNR periodically conducts fishery surveys on selected Minnesota Lakes. A 2008 Lura Lake survey assessed the status of the fish community as well as general lake conditions. Based on the survey, several sport fish populations remained stable, with several of the species increasing in average size. Game fish documented during the survey were Walleye, Northern Pike, Largemouth Bass, Blue Gill, and Crappie. Populations of Black Bullhead and Common Carp were shown to be increasing. Walleye stocking continues within the lake.

As noted by the DNR (2008), Lura Lake was the subject of the reclamation in 1994. The following notes were recorded regarding the effort and effectiveness of the reclamation:

> Lake reclamations are thought to keep undesirable fish species at manageable levels for around 15 years. In 2009, Lura Lake will reach its 15th anniversary since the 1994 reclamation. Carp and bullhead levels are reaching pre-reclamation numbers. Reclamation options may be examined in coming years, although there is still some interest in bass, pike, and walleye angling. Water quality and shoreline erosion continue to be two large issues within Lura Lake.

Bass fishing continues to be an important aspect of the recreation on Lura Lake. The DNR's fishery report found that: "Eight year classes were found in the lake, with fish from 4 to 20 inches in total length. Lura Lake is known to have a population of older, larger individuals".

The condition of the lake continues to be a concern to area residents and organizations. Issues with water quality can not only impact the aquatic life and recreational opportunities on the lake system, it can also negatively impact the property values of lakeshore owners (Krysel et al., 2003).

3 Applicable Water Quality Standards and Numeric Targets

Excess Nutrients

Phosphorus (P) and nitrogen (N) are the primary nutrients, that in excessive amounts, pollute lakes, streams, and wetlands (MPCA, 2008). While nitrogen and phosphorus are elements of the impaired waters listing, phosphorus is the focus of this TMDL.

Phosphorus is an essential nutrient for plant and algal growth and development within a lake, as it is necessary for the conversion of sunlight into usable energy for cellular reproduction and growth. However, the actual amount of phosphorus available for biological uptake depends on its chemical form. While ortho-phosphorus is the form most readily available to plant life, total phosphorus values are used for modeling to predict lake behavior and condition. The two types of phosphorus sampled within Lura Lake are total phosphorus (TP) and ortho-phosphorus (OP).

In Lura Lake, TP concentrations averaged 165 ppb (Parts per billion (ppb) = micrograms per liter (µg/L)) during the 2009 and 2010 monitoring seasons. This value is high when compared to similar lakes in the region, and well above the Western Corn Belt Plain ecoregion total phosphorous water quality standard of 90ppb.

Chlorophyll–a is a pigment produced by algae. By measuring chlorophyll-a concentration, algal production in a lake can be estimated. Concentrations from 10-20 ppb are perceived as a mild algal bloom, while concentrations greater than 30 ppb are generally perceived as severe nuisance conditions (Heiskary and Walker, 1988). Lura Lake chlorophyll values indicate severe nuisance algae levels occurred throughout the 2009 sampling. During the monitoring seasons of 2009 and 2010, the average Chlorophyll–a concentrations were 47.3 ppb.

Secchi transparency measurements provide an indirect measure of the amount of suspended material in the water, in particular algae. Secchi transparency tends to decrease throughout the summer as algae concentrations increase within a lake. Secchi data is used in modeling efforts to help understand responses to nutrient loading. The standard for the Western Corn Belt Plains region is 0.7meters or approximately 2.3 feet.

Applicable Minnesota Water Quality Standards

The MPCA uses ecoregion-based total phosphorus guidelines in conjunction with Carlson's Trophic State Index (TSI) to classify a lake's suitability for aquatic recreation. The standards are presented in Table 3. The standards for Lura Lake are represented in the highlighted section for the Western Corn Belt Plains (WCP) and Northern Glaciated Plains (NGP).

Table 3: Applicable Minnesota Water Quality Standards

Ecoregion	TP	Chl-a	Secchi
	ppb	ppb	meters
NLF – Lake trout (Class 2A)	< 12	< 3	> 4.8
NLF – Stream trout (Class 2A)	< 20	< 6	> 2.5
NLF – Aquatic Rec. Use (Class 2B)	< 30	< 9	> 2.0
CHF – Stream trout (Class 2a)	< 20	< 6	> 2.5
CHF – Aquatic Rec. Use (Class 2b)	< 40	< 14	> 1.4
CHF – Aquatic Rec. Use (Class 2b) Shallow lakes	< 60	< 20	> 1.0
WCP & NGP – Aquatic Rec. Use (Class 2B)	< 65	< 22	> 0.9
WCP & NGP – Aquatic Rec. Use (Class 2b) Shallow lakes	< 90	< 30	> 0.7

Water quality standards have existed in Minnesota since 1967, and have been periodically updated or added to with new standards and regulation. Minnesota's water quality standards meet or exceed federal requirements (MPCA, 2008). While water quality standards include several components, this TMDL is primarily concerned with "beneficial uses" and "numeric standards".

Beneficial Uses

"Beneficial use" is the designated use of a water resource for people and wildlife and is determined by the MPCA. While this classification is performed by the state, the process is governed by federal rules contained within the CWA. Seven beneficial uses are defined in Minn. R. 7050.0200. These uses and the use-class designations are listed below. The class numbers 1–7 are not intended to imply a priority ranking to the uses (MPCA, 2008).

Class 1: Domestic Consumption
Class 2: Aquatic Life and Recreation
Class 3: Industrial Consumption
Class 4: Agriculture and Wildlife
Class 5: Aesthetic Enjoyment and Navigation
Class 6: Other Uses
Class 7: Limited Resource Value

The primary waters concerning this TMDL are water bodies classified as 2B. Class 2 relates to aquatic life and recreation while subclass B refers to cool/warm water fisheries that are not protected as a drinking water source. Class 2 waters are formally defined as: "the waters of the state that are necessary for the aquatic life and recreation designated public uses and benefits" (MORS, 2008).

Numeric Standards

Numeric Standards are the allowable concentrations of specific pollutants in a waterbody and are established to protect the beneficial use of a water body. Minnesota's water quality standards include a numeric criterion for a nutrient impairment as a measure of whether a water body meets its designated uses. Specifically, Minn R. ch. 7050.0220, Specific Standards of Quality by Associated Use Classes, states:

... "The numerical and narrative water quality standards in parts 7050.0221 to 7050.0227 prescribe the qualities or properties of the waters of the state that are necessary for the designated public uses and benefits. If the standards in this part are exceeded, it is considered indicative of a polluted condition which is actually or potentially deleterious, harmful, or injurious with respect to designated uses or established classes of the waters of the state."

The numeric and narrative water quality standards describe the qualities and properties of the waters of the state that are necessary for the aesthetic enjoyment and navigation for the public.

Seasonality

Nutrient loading can vary greatly due to seasonal influences. Based on data collected within the lake system, phosphorus levels in Lura Lake typically start near or below the lake standards in the spring and continue to climb, reaching their peak in early July. Similar results are seen with chlorophyll–a, with the peak occurring in late July and into August. These loading levels are typically the result of the growth, decay and release of the algae as the temperature of the lake water warms.

Water quality monitoring in Lura Lake suggests the in-lake TP concentrations vary over the course of the growing season (June-September), generally peaking in mid to late summer. The MPCA eutrophication water quality guideline for assessing TP is defined as the June through September mean concentration. The BATHTUB model was used to calculate the load capacities of the lake incorporating mean growing season TP values. TP loadings were calculated to meet the water standards during the summer growing season, the most critical period of the year. Calibration to this critical period will provide adequate protection during times of the year with reduced loading.

4 Water Quality Data

Data Collection

The water quality of Lura Lake has been the subject of multiple studies. A lake assessment was conducted by the MPCA through the Lake Assessment Program (LAP) in 1995. This report examined the levels of various nutrients within the lake as well as the lake's response to the reclamation efforts performed by the Minnesota DNR in 1994. The lake was also examined in the journal article, "Seasonal biomass and carbohydrate allocations in southern Minnesota curly-leaf pondweed populations", in the Journal of Aquatic Management in 2003.

TMDL Monitoring in 2009 and 2010 was completed to continue assessing the current water quality and gather data to be used for the BATHTUB modeling program. Data collected for the TMDL was gathered by the Water Resources Center at Minnesota State University Mankato. Data has also been collected through the MPCAs Citizen Lake Monitoring Program (CLMP).

The TMDL study collected water quality data at three points on the lake near the center of each of the three major bays. These points were previously used in the 1995 LAP report and provide information on how the lake has changed over time. The points are mapped in Figure 10.

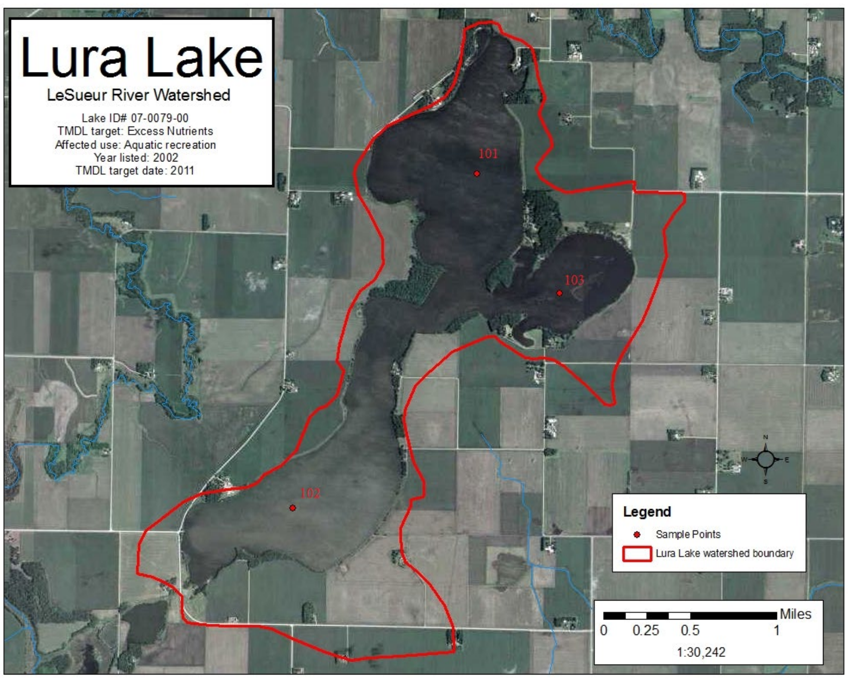


Figure 10: Monitoring Locations within Lura Lake

Several studies concerning lake water quality were reviewed to provide insight for the Lura Lake TMDL study. Many of these studies have investigated similar problems including sediment and nutrient loading. Information from these studies is valuable to the TMDL research and helps to investigate how the lake has changed over time.

All data collected for this TMDL study (2009-2010) was submitted to the STORET database and is available for download through the MPCAs Environmental Data Access (EDA) website.

Monitoring Parameters

Phosphorus

Phosphorus data was collected via grab samples using sterile bottles supplied through Minnesota Valley Testing Laboratories (MVTL). Lake samples were taken using a depth integrated sampler at a geo-located position to develop an accurate representation of the lake conditions. The phosphorus samples were delivered to MVTL in New Ulm and analyzed for Total and Ortho phosphorus concentrations.

Nitrogen

Nitrogen samples were collected and analyzed similar to the phosphorus samples with below surface samples at the lake sites. The nitrate samples were analyzed for Nitrate-Nitrite, the two common forms of Nitrogen.

Chlorophyll A

Chlorophyll-a data was collected at the Lura Lake sites using the below surface sample method for phosphorous and nitrogen. Chlorophyll measurements indicate algal development within the lake and can be related to Secchi depth measurements. Samples collected were temporarily stored in opaque plastic or amber glass bottles to prevent development or breakdown of the Chlorophyll within the sample.

Temperature and Dissolved Oxygen

Temperature and Dissolved Oxygen (DO) data was collected using an YSI Professional Plus multi-parameter meter with an YSI Quattro multi-parameter probe, allowing instant calibration as well as data recording features to check field notes.

Secchi Depth

The Secchi disk, a flat, circular object was used to measure water transparency in the lake. Secchi depth was measured by lowering the disk into the lake until the pattern on the disk is no longer visible. The depth is recorded as a measure of the transparency of the water.

Table 4 is a summary table of sample containers, necessary preservatives (if any), holding time, and methods used to analyze the sample.

Table 4: Monitoring Methods

Analyte	Sample Quantity	Sample Container	Preservative	Holding Time	Analytical Method
Chlorophyll a	1 L	Amber glass	Cool to 4°C	4 H†	SM* 10200 H
Total Phosphorus	500 mL	Plastic	H_2SO_4 to pH <2, Cool to 4°C	28 D	EPA 365.1 Rev 2.0
Ortho-Phosphorus	500 mL	Plastic	Cool to 4°C	2 D	EPA 365.1 Rev 2.0
Nitrate + Nitrite	250 mL	Plastic	H_2SO_4 to pH <2, Cool to 4°C	28 D	EPA 353.2 Rev 2.0
Total Suspended Solids	500 mL	Plastic	Cool to 4°C	7 D	USGS I-3765-85

†May be stored on ice in the dark for up to 48 hours prior to analysis, otherwise, filter within 48 hours and store frozen at ≤ -20.

TMDL Study Data Summary

Monitoring the inputs to Lura Lake provided challenges as the lake had limited surface inflow and no major outflow depending on seasonal conditions and lake elevation. Lura Lake's water chemistry varied within the three bays monitored; differences were reflected by various stressors and responses to vegetation. Each basin had a similar substrate, typically a "muck" bottom, with sandy soils near the shore areas. Basins varied in depth and aquatic vegetation (type and density) which likely affected the nutrient levels observed in the lake. The similarities and differences between the bays were visible within the sample data.

The three sample locations within the lake each had different characteristics. While site 101 (North Lobe) and 102 (South Lobe) are similar in terms of depth and substrate, the abundance of aquatic vegetation at site 101 is significantly greater than site 102, particularly in 2009. The highest level of phosphorous monitored at Site 101 was related to the curly-leaf pond weed matting and die off.

Sites 101 and 103 (East Lobe) had large, dense populations of aquatic vegetation, primarily curly-leaf pondweed. Sample data between the two sites was similar in 2009, with increases and decreases in the observed levels of TP following a similar trend. Site 103 had a large spike in TP following the die off of the curly-leaf pondweed and subsequent algal bloom. Site 103 is the shallowest bay of the three, and had the highest peak and average concentrations of TP in 2009.

The levels of all the parameters measured varied greatly between 2009 and 2010. The average TP concentrations decreased in 2010 and were typically less than half of the average values measured in 2009. The percent of 2010 samples meeting the standards and physical and aesthetic appearance of the lake improved dramatically throughout the season. The dense mats of dead or dying curly-leaf pondweed were not observed at the 101 and 103 samples sites, and over all the recreational suitability rated higher that year.

The change in water quality from 2009 to 2010 was likely due to the seasonal variation observed between these years. Heavy snow cover on the lake may have limited sunlight penetration, potentially impacting the early growth of curly-leaf pond weed. The slowed growth of the curly-leaf pondweed appeared to allow greater native plant species growth. The curly-leaf pondweed observed in the 2010 vegetation surveys was frequently stressed, with brown leaves and plants were typically found at depth as opposed to being at the surface. Elodea and other native plants were observed at a higher frequency and created mats near sample points 103 and 102.

Even with the decrease in TP in 2010, the chlorophyll-a levels had higher average values at sites 101 and 102. Similarly, the Secchi values at site 101 and 102 also showed a decrease in the overall transparency of the water. Algae was observed earlier in the year, which is likely the cause of the increased Chlorophyll-a and decreased Secchi values. Table 5 shows the phosphorus values recorded at each site in 2009 and 2010 and Figure 11 presents collective TP sample data.

Table 5: Summary of Total Phosphorus Data in Lura Lake in 2009 and 2010

Site	Year	Number of Samples	Average (ppb)	Min (ppb)	Max (ppb)	% of samples not meeting standards
101	2009	21	160	53	350	66%
	2010	20	80	21	200	40%
102	2009	22	180	64	270	81%
	2010	20	80	36	206	35%
103	2009	22	210	50	560	73%
	2010	20	70	20	150	30%

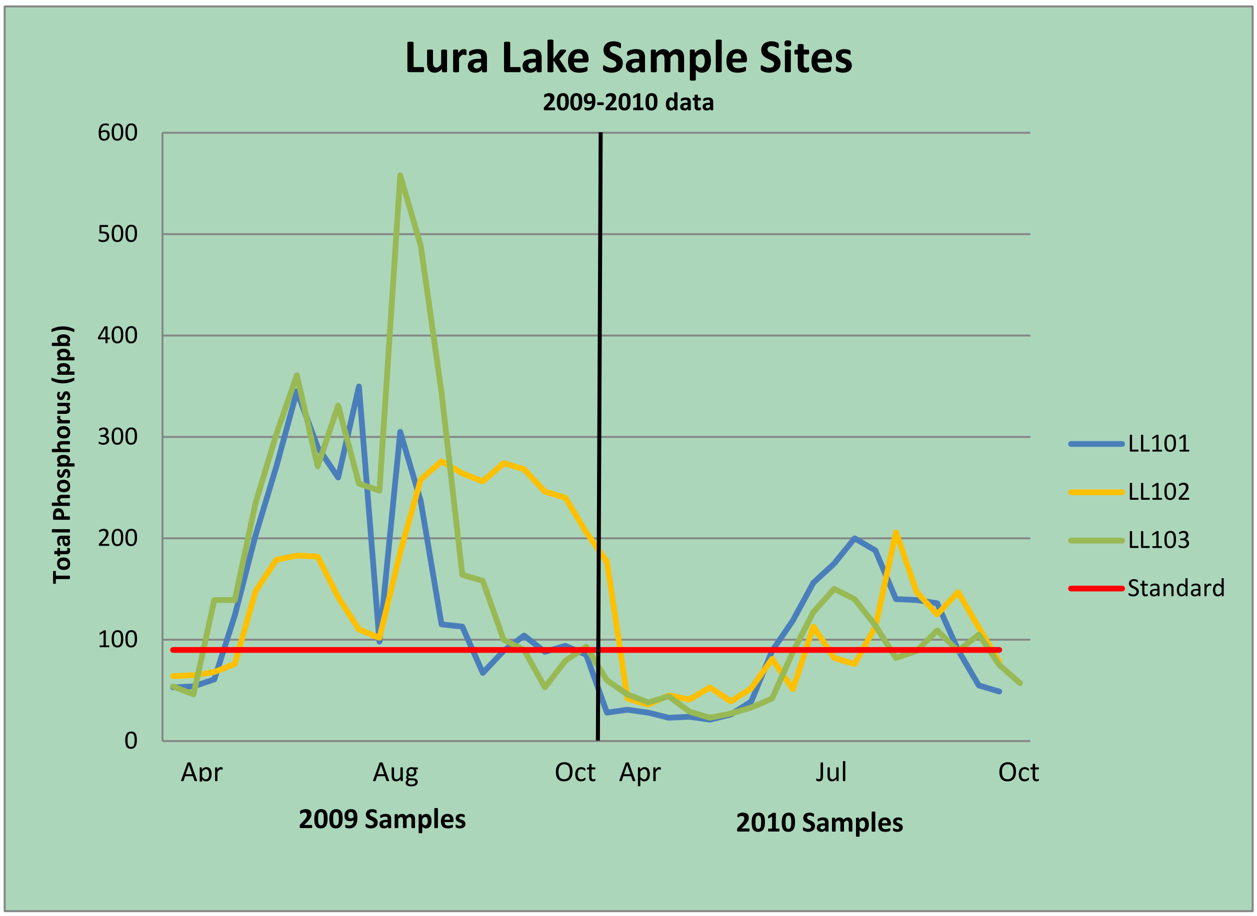


Figure 11: Observed Total Phosphorus in Lura Lake over 2009 and 2010

The average Secchi depth at site 101 and 102 was less in 2010 than 2009 Table 6 even though the average TP values were lower. Site 103 had a higher average Secchi depth. The increase in clarity at 103 may be related to the increase in elodea and a decrease in curly-leaf pondweed. Without the curly-leaf pondweed, the nutrient cycling and phosphorus levels were likely reduced. The phosphorus data observed at site 103 supports this hypothesis.

Table 6: Summary of Secchi Disc Data in Lura Lake over 2009 and 2010

Site	Year	Number of Samples	Average (m)	Min (m)	Max (m)	% of samples not meeting standards
101	2009	21	1.55	.61	2.74	9%
	2010	20	1.49	.30	3.05	35%
102	2009	21	1.49	.61	2.44	5%
	2010	20	1.43	.30	2.74	20%
103	2009	21	1.34	.61	2.13	14%
	2010	20	1.65	.61	2.13	5%

The sample data collected for Chlorophyll-a Table 7 shows a relationship to the Secchi data. This supports the earlier observed presence of algae in the lake system accounting for the higher Chlorophyll-a values, which would also account for the decrease in average Secchi depth measurements. The observed values can be used to calculate the TSI value Figure 12 (See Appendix C). Since TSI values are a reflection of algal production, the TSI value is calculated using data collected for Chlorophyll-a,TP and Secchi values.

Table 7: Summary of Chlorophyll-A Data in Lura Lake over 2009 and 2010

Site	Year	Number of Samples	Average (ppb)	Min (ppb)	Max (ppb)	% of samples not meeting standards
101	2009	21	39.3	1	468	19%
	2010	20	74.3	1.1	207	45%
102	2009	21	19.25	1.2	101	23%
	2010	20	45.9	1.4	255	40%
103	2009	21	50.2	1.5	380	23%
	2010	20	28.3	1	250	15%

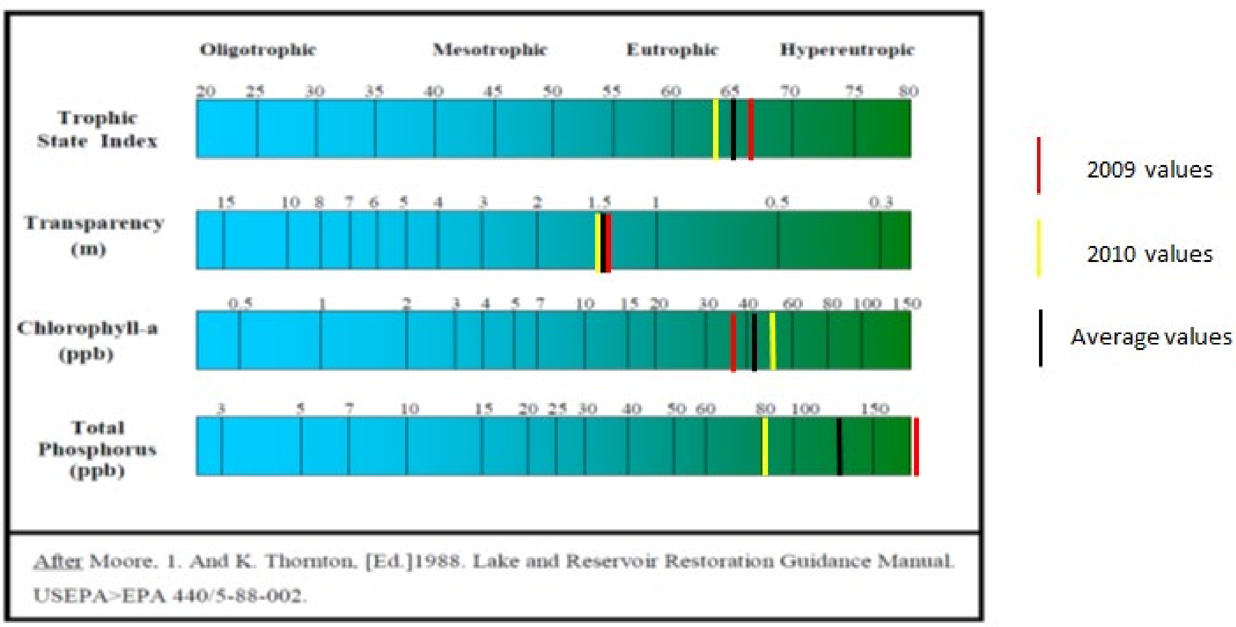


Figure 12: Calculated TSI Values of Lura Lake for 2009 and 2010

Watershed Modeling and Data Analysis

Three lake models of increasing complexity were used to estimate phosphorus loads and in-lake response for Lura Lake. Descriptions of the models, initial data results, and modeled results after calibration are discussed below.

MINLEAP Model

The Minnesota Lake Eutrophication Analysis Procedure (MINLEAP) model, developed by Bruce Wilson and Dr. William Walker Jr., uses the Canfield Bachmann equation (Canfield and Bachmann, 1981) to predict hydrologic and eutrophication indicators (total phosphorus, chlorophyll-a and transparency) based on watershed, lake morphometry and ecoregion. MINLEAP requires minimal inputs and relies on ecoregion values for stream phosphorus concentration, precipitation, evaporation and runoff developed from reference lakes within each ecoregion. Because of its simplicity, MINLEAP is best thought of as a screening tool to identify lakes that have significantly different water quality than a hypothetical lake with the same characteristics (ecoregion, depth, volume). The model tests for significant differences between the observed and predicted eutrophication indicators using a t-test. Table 8 shows the MINLEAP estimates of phosphorus dynamics and water balance for Lura Lake.

Table 8: MINLEAP Predicted Annual Phosphorus and Discharge for Lura Lake with Default Stream P Value

Average Total Phosphorus Inflow (µg/L)	Total Phosphorus Load (kg/yr)	Phosphorus Retention Coefficient	Lake Outflow (hm3/yr)	Residence Time (yr)	Areal Water Load (m/yr)
548	547	0.9	1	7.5	0.19

Table 9 shows the observed in-lake conditions as compared to the predictions generated by MINLEAP. These results indicate Lura Lake exhibits higher in-lake total phosphorus and chlorophyll-a concentrations than predicted based on ecoregion reference lakes. A t-test absolute value equal to or greater than two indicates a significant difference between the observed and predicted indicator. Therefore, Lura Lake's observed total phosphorus concentration was significantly greater than the prediction. The modeled/predicted values suggest a lake with Lura's morphometry and watershed characteristics should meet water quality standards, further illustrating the lake's impairment.

Table 9: Comparison of MINLEAP Predicted and Observed Water Quality Parameters

Variable	Observed	Modeled/Predicted	T-Test
Total Phosphorus (µg/L)	165	57	2.36
Chlorophyll-a (µg/L)	47.3	23.9	0.9
Secchi disk (m)	1.3	1.2	0.21

While MINLEAP has been demonstrated to perform well in the Northern Lake/Forest and Northern/Central Hardwood forest areas, lakes in the WCP typically exhibit high levels of internal loading /nutrient cycling and/or macrophyte (aquatic vegetation) production and require additional modeling to better understand nutrient loading of the system. The difference between the observed and predicted eutrophication indicators suggest the MINLEAP model does not account for all of Lura Lake's phosphorus dynamics. Therefore, additional models were used to establish a TMDL.

Reckhow -Simpson Model

The Reckhow-Simpson model (Reckhow and Simpson, 1980) uses the Canfield Bachmann equation to estimate in-lake phosphorus concentration using inputs specific to the lakeshed. The modeler can specify a range of phosphorus export coefficients to apply to different lakeshed land covers as well as climatological, runoff and morphometry characteristics of the lake. The Reckhow-Simpson model accounts for phosphorus loads from septics through shore land residence estimates and soil retention coefficients. The model can also provide estimates of loading from livestock based on the number of animal units in the lakeshed.

The phosphorous coefficients used for each land cover and the ranges considered are shown in Table 10. Each of the coefficients is applied to the associated land cover areas to estimate the phosphorus load coming from each land cover.

Table 10: Reckhow-Simpson Model Runoff Coefficients

Land Cover	P export coefficient (kg/ha) range
Forest	0.1-0.15
Cultivated	0.2-0.8
Urban	0.5-1.25
Wetland/Open Water	0.1
Pasture/Open	0.2-0.4

Some field scale studies indicate higher P export coefficients can occur under certain circumstances (Harmel, et al., 2008). For example, a rainfall simulation study on cropland found TP runoff rates ranging from 0.1 to 1.7 kg/ha TP as a function of different swine manure and fertilizer practices (Daverede et al., 2004).

A median water runoff value of 0.12 m was used based on Figure 5 in Heiskary and Wilson (1994). This value is consistent with Hydrological Simulation Program – Fortran (HSPF) modeling that has been completed on the Le Sueur major watershed. Average precipitation (0.77 m) and average evaporation (0.99 m) were calculated for the same time period (1981 – 2010) using data from the University of Minnesota's Climatology Lab and the University of Minnesota's Southern Research and Outreach Center, respectively. There are no permitted point sources within the Lura Lake watershed.

The Reckhow-Simpson model allows the modeler to input livestock information specific to the lake watershed to estimate the amount of livestock associated P produced in the watershed and an estimate of the P delivery from livestock. Phosphorus generation from livestock is based on values provided by Midwest Plan Service (1985). Assuming a range of kilograms of phosphorus produced by each animal type per year, the mass of phosphorus produced annually in the Lura Lake watershed is presented in Table 11.

Table 11: Phosphorus Production of Livestock in the Lura Lake Watershed

Livestock	Animal Units	Total Phosphorus Produced (kg)		
		Low	Medium	High
Pigs	768.5	692	1,230	2,920

These values represent an estimate of the phosphorus produced by livestock in the watershed, not the amount that is delivered to the lake. If we assume the medium phosphorus production estimate of 1,230 kg/yr and 5 percent delivery, an additional 61 kg of phosphorus enters Lura Lake every year.

Table 12: Phosphorus Export Coefficients and Expected Variability

Phosphorus Source	P Export Coefficient (kg/yr)		
	Low	Medium	High
Forest	2	3	4
Cultivated	71	142	283
Urban	21	42	53
Wetland/Open Water	6	6	6
Pasture/Open	9	14	19
Precipitation	157	157	262
Onsite septics	5	5	5
Livestock	61	61	61
Total P flux	332	430	693

Using these values and the P export ranges from Table 12, the Reckhow-Simpson model predicts phosphorus loads to Lura Lake as shown in Table 13. The low to high estimates capture the variability by showing the broadest range of likely possibilities. The upper end loading is likely higher than what would be expected when averaged across the watershed. Even under the high P export scenario, the model predicts lower in-lake phosphorus concentration than was observed. This suggests that to achieve a modeled in-lake phosphorus concentration equal to the observed mean phosphorus concentration, there is a phosphorus source for which we have not accounted. Internal loading might account for some of the additional phosphorus load required to reach the observed in-lake concentration (Hoverson, 2008; Welch and Cooke, 1995).

Table 13: Comparison of Observed and Reckhow-Simpson Model Predicted Water Quality Parameters

Parameter	Observed Value	Predicted Value		
		Low	Medium	High
Total Phosphorus (µg/L)	165	44	51	67
Chlorophyll-a (µg/L)	47.3	16.6	20.6	30.6
Secchi transparency (m)	1.3	1.5	1.3	1
Total phosphorus TSI	78	59	61	65
Chlorophyll-a TSI	68	58	60	64
Secchi transparency TSI	56	54	56	60

BATHTUB Model

The BATHTUB model version 6.14 (Walker, 1999) was developed by William Walker of the US Army Corp of Engineers Waterways Experimental Station. BATHTUB has been widely used to model nutrient balance calculations and nutrient sedimentation dynamics within lake and reservoir systems. It is designed to handle simultaneous modeling and analysis of the basin to help ensure accurate representation of processes occurring within the system. The model is primarily used to perform diagnostic analysis of the current conditions of the basin and/or to predict impact of potential changes within the system.

BATHTUB generates outputs and calculates confidence levels by performing error analysis using water quality inputs. The model predicts eutrophication status based on water quality parameters including total phosphorus, total nitrogen, chlorophyll *a,* transparency, organic nitrogen, non ortho-phosphorus, and hypolimnetic oxygen depletion rate. Outputs are predicted using empirical relationships developed and tested for in reservoir applications (Walker, 1985).

The BATHTUB model allows continuous calibration by comparing predicted nutrient loading with observed data collected through grab samples. The model can be calibrated to individual data points or all data points in a global calibration by changing model inputs such as levels of internal loading or nutrient residence time.

The model requires that all areas contributing to the lake be designated as segments or tributaries. Segments are useful when the lake has connected areas that cannot be spatially separated due to the nature of flows within the system. Tributaries allow the model to use runoff coefficients and runoff data to model nonpoint and point source data. Three "tributaries" were identified in the Lura Lake model. The lake watershed as a nonpoint source was considered the first tributary. Phosphorus loading from the watershed was estimated from land cover and phosphorus export coefficients specific to the land covers. Land cover was divided into the categories of forest, cultivated, urban, wetland/open water and pasture/open. The medium land cover P export coefficients from the Reckhow-Simpson model were converted from kg/ha to ppb and applied to the BATHTUB model. As described in the Reckhow-Simpson section, a runoff value of 0.12 m, an average precipitation of 0.77 m and an average evaporation value of 0.99 m were used as global variables for the BATHTUB model.

Onsite septic systems were considered the second tributary. Phosphorus loading from septics was estimated from the Reckhow-Simpson model. A flow rate of 0.01 hm^3/yr and a phosphorus concentration of 500 ppb were applied. While these values likely do not reflect actual conditions, they force the BATHTUB model to deliver the 5 kg P/yr that was estimated in the Reckhow-Simpson model.

Livestock sources of phosphorus were considered the third tributary. A flow rate of 0.01 hm^3/yr and a concentration of 6,100 ppb were applied. As with septic systems, these values do not reflect actual conditions, but they force the model to deliver the 61 kg P/yr that was estimated from the Reckhow-Simpson model.

BATHTUB Model Results

The BATHTUB program contains multiple models allowing for different methods of calculating loading using the watershed and observed water quality data. The following model options provided the best agreement with observed water quality conditions:

a. Conservative substances – Not computed
b. P balance – Several models were tested. The Canfield and Bachmann Lakes option yielded the best agreement with the observed in-lake phosphorus concentration.
c. N balance – not computed

d. Chlorophyll-a – The P, Light, T (default) option yielded the best agreement with the observed in-lake chl-a concentration.
e. Transparency – VS Chl-a and turbidity option (default)
f. Dispersion – Fischer numeric (default)
g. P calibration - Decay rates (default)
h. N calibration – Decay rates (default)
i. Error analysis – Model and data (default); used estimates of coefficient of variation of the mean for observed data.
j. Availability factors – Ignore (default)
k. Mass balance tables – Use estimated concentrations (default)

Using these model options, BATHTUB predicted phosphorus concentrations and annual loads as shown in Table 14.

Table 14: BATHTUB model output versus observed data

Observed Mean P (µg/L)	Predicted Mean P (µg/L)	Predicted Annual P (kg)
165	59	429.9

The Canfield Bachmann lakes model underestimates the observed phosphorus concentration. Lura Lake's watershed to lake ratio is too small to provide the total phosphorous load contribution seen in the monitoring efforts. With the amount of vegetative production and potential for nutrient loading after die off, the discrepancy between predicted and observed is likely the result of in-lake processes.

To model internal processes in BATHTUB, the phosphorus sedimentation coefficient can be reduced. The default BATHTUB phosphorus sedimentation coefficient of 1.0 can be adjusted to reduce sedimentation and increase in-lake phosphorus concentration. The Canfield Bachmann Lakes model requires reducing the P sedimentation coefficient to 0.4 in order to approximate the observed conditions.

The internal load can also be modified within the model to approximate the in-lake phosphorus concentration. An internal load of 1.38 mg/m^2 day within the Canfield Bachmann lakes model results in an estimated lake phosphorus concentration matching the observed lake condition (165 µg/L) Table 15.

Table 15: Predicted water quality with additional internal phosphorus load

Observed Mean P (µg/L)	Predicted Mean P (with additional internal load) (µg/L)	Predicted Annual P (with additional internal load) (kg)
165	165	3,070.6

The internal load values used to calibrate the models are similar to values computed in several Wisconsin lake studies. Blumer (2009) estimated senescence of curly-leaf pondweed contributed 0.87 mg P/m^2–day and bottom sediments released 1.38 mg P/m^2 –day in Wisconsin's Big Chetek Lake. James et al (2006) observed oxic sediment P release rates within a range of 0.1 to 2.9 mg P/m^2–day in Shawano Lake. The Lura Lake TMDL does not have independent measurements of internal phosphorus loading. Therefore it is not possible to quantify the internal phosphorus dynamics within Lura Lake. Rather this modeling exercise illustrates the relative importance of internal processes in Lura Lake with respect to the observed water quality. A moderate to large amount of internal load would be required to produce the observed lake conditions. This appears to be a reasonable assumption given the large internal phosphorus concentration variability associated with annual curly-leaf pondweed density. Therefore, the Canfield Bachmann Lakes model with 1.38 mg P/m^2–day additional internal load was used to model observed conditions in Lura Lake. As internal load appears to be the largest contributor of phosphorus to the lake, this would need to be addressed for the lake to meet its water quality goal. However, for the long term health of Lura Lake all potential sources of phosphorus should be addressed.

To estimate the phosphorus loading capacity of Lura Lake, loads were reduced until the estimated in-lake phosphorus concentration matched the standard Table 16. To accomplish the load reduction, internal load was reduced from 1.38 mg P/m^2–day to 0.28 mg P/m^2–day.

Table 16: Lura Lake Modeled to Meet Phosphorus Standard

Observed Mean TP (µg/L)	TP Standard (µg/L)	Annual Load Capacity to Meet Standard (kg) (Canfield Bachmann Lakes Model)
165	90	965.7

In order to provide for a 10 percent margin of safety (MOS), the total maximum annual phosphorus load was reduced by 10 percent yielding an annual maximum load of 869.1 kg P/yr. Annual and daily load capacities are shown in Table 17. Based on the model, the total annual phosphorus load that would allow Lura Lake to meet standards is 1,916 lbs/year, or approximately 5.25 lbs/day.

Table 17: Annual and Daily Phosphorus Load to be assigned to WLA & LA

Annual P Load (to WLA &LA)		Daily P Load (to WLA &LA)	
(kg/yr)	(lbs/yr)	kg/day	lbs/day
869.1	1,916	2.38	5.25

In developing the lake nutrient standards for Minnesota lakes (Minn.Rule 7050), the MPCA evaluated data from a large cross-section of lakes within each of the state's ecoregions (Heiskary and Wilson, 2008). Clear relationships were established between the causal factor total phosphorus and the response variables chlorophyll-a and Secchi disk. Based on these relationships it is expected that by meeting the phosphorus target of 90 µg/L for Lura Lake the chlorophyll-a and Secchi standards (30 µg/L and 0.7 m, respectively) will likewise be met.

5 TMDL Allocation

The TMDL establishes the allowable loading of pollutants for a waterbody from point and nonpoint pollution sources based on water quality standards. In general, the process is described by the following equation:

TMDL = LC = ∑WLA + ∑LA + MOS

Where:

LC = loading capacity, or the maximum amount of loading a water body can receive without violating water quality standards;

WLA = Waste load allocation, or the portion of the TMDL allocated to existing or future point sources;

LA = Load allocation, or the amount of the TMDL allocated to existing or future nonpoint sources;

MOS = margin of safety, or an accounting of uncertainty about the relationship between pollutant loads and the receiving water quality;

Within the WLA, LA, and MOS, there are additional categories and values taken into account.

Waste Load Allocation

The waste load allocation is the sum of all the permitted discharges within the impaired watershed. Permitted sources are designed to not exceed the nutrient standards through permit limits and must be considered when calculating loading within the system.

The WLA includes three subcategories: Municipalities subject to MS4 NPDES permit requirements; wastewater treatment and industrial facilities, construction and industrial stormwater (NPDES).

Municipalities subject to MS4 NPDES permit requirements – Urban development creates drainage alterations that can vary volumes of stormwater delivery to streams and rivers. Municipalities meeting size or density conditions or that are located in sensitive areas are subject to Municipal Separate Storm Sewer Systems (MS4) rules (Minnesota Rules, Chapter 7090). No municipalities exist within the Lura Lake watershed, therefore no MS4 WLA loading is considered.

Wastewater treatment and industrial – Permitted wastewater treatment facilities (Waste Water Treatment Plants (WWTP) or Water Treatment Plants (WTP)) and Industrial facilities with permitted nutrient limits are reviewed as part of the TMDL process. The Lura Lake watershed includes no permitted facilities and no loading is included as part of the WLA.

Construction and industrial stormwater (NPDES) – Construction and industrial stormwater permits were reviewed in the MPCA's DELTA database. A permit is required for any construction activities disturbing: one acre or more of soil; less than one acre of soil if that activity is part of a "larger common plan of development or sale" that is greater than one acre; or less than one acre of soil, but the MPCA determines that the activity poses a risk to water resources.

Although stormwater runoff at construction sites with inadequate runoff controls can be significant sources of sediment and nutrients on a per acre basis (MPCA Stormwater web page, 2006), MPCA records show that the number of projects within the watershed are relatively small. Over the most recent 10 year period, only four construction projects requiring a permit were issued. In order to avoid a zero allocation for construction an estimate of 1 percent was used, assuming that no more than 1 percent of the total watershed (approximately 13 acres) would ever be permitted or under construction at one time. The construction stormwater is then considered 1 percent of the total load allocation.

The permitted facilities within the watershed are feedlot or animal confinement operations, which while permitted, have no nutrient or flow discharges, and therefore no loading. In the event that new NPDES-permitted sources occur in the watershed, pollutant load would be transferred from the LA. The overall TMDL does not change with the reassignment of pollutant loads if consistent with the allocation method used for the TMDL.

For the purposes of the TMDL, the WLA includes the following:

∑WLA = NPDES Permitted values (0.00) + Construction stormwater (0.049 or 1 percent)

∑WLA= 0.05 lbs/day

While no permitted nutrient sources currently exist in the watershed (with the exception of construction stormwater), it is important that the allocation exists to account for potential businesses and industry development. New business or industry would be required to meet discharge standards within the TMDL values. Due to the small area of the total watershed, it is likely that any new industry would discharge outside of the Lura Lake watershed.

Load Allocation

The load allocation (LA) provides the total nutrient loading capacity assigned to nonpoint and natural background sources. While substantial research has been conducted to estimate nutrient contributions from different nonpoint or natural sources, the allocations in this report do not subdivide the LA. There are several reasons for this. First, current research is not sufficient to precisely define either nonpoint or natural background sources. Second, sub-division of the LA is not required by the EPA. Discussion on targeting nonpoint or natural background sources is typically addressed through the implementation process as opposed to specific numeric targets and goals due to the variable nature of nutrient loading.

The LA is composed of the different sources listed below:

Natural Background

When addressing natural background loading levels within a TMDL study, the *Lakes Nutrient TMDL Protocol and Submittal Requirements* (MPCA 2007) makes the following statement:

Natural background load is a portion of the watershed loading and internal loading, and should be defined as precisely as possible. This will range from having paleolimnologic data (as derived from sediment cores) for the TMDL lake to using ecoregion ranges for lakes of a similar type.

Existing methods, such as core data or diatom reconstruction, could potentially define a general value for natural background in the watershed but determining a specific percentage that would be an accurate and defensible value or calculation method within an individual watershed is difficult. Impacts within individual watersheds could include unique stressors, such as elevation changes, channel alteration, upland management practices and other factors which lead to differing rates of natural and/or accelerated nutrient loading.

During the development of the Minnesota Lake Water Quality Assessment Report: Developing Nutrient Criteria (MPCA 2005), the study sought out and carefully identified "ecoregion reference lakes", which were used within the development of the standards applied within this TMDL. This study included diatom/TP reconstruction, and other recommended methods. The reference ecoregion data prepared in the report are used to identify and examine the suspected natural loading levels.

For the purposes of the TMDL, it was decided that a numerical value or percentage attributed to natural background is not required by the EPA as a submittal requirement, and a specific value would not be defensible or ultimately beneficial to the final TMDL project. The load allocation within this TMDL is a combination of all nonpoint sources, including natural background. Future implementation planning will consider ongoing research and theories of related source contributions to the nutrient impairment including the levels of natural background.

Overland Flow/Runoff Loading

This category considers both surface and subsurface drainage systems. Monitored loading from subsurface drainage was not possible during the TMDL. The position and flow conditions of the tile outlets (frequently angled up, with little to no flow under dry conditions and below the lake surface during wet conditions) made it impossible to accurately monitor outflow and loading. For this reason, all watershed data is calculated using runoff coefficients related to the land use within the basin.

With a small contributing watershed, the calculated nutrient loading from runoff is not predicted to be the primary cause of the lake's degraded water quality. Although it's not assumed to be the primary loading mechanism, controlling nutrient runoff and leaching is important to Lura Lake as reducing external inputs slows the gradual buildup of excess phosphorus within the lake system. Lake conditions are generally a symptom of the overall landuse and activities within the supplying watershed.

Internal Loading/Bioturbation

Internal loading (nutrient resuspension/recycling from the bottom sediments) of phosphorus is likely a large source of the nutrients for Lura Lake. Modeling and vegetation survey work indicates that loading from in lake sources plays an important role in nutrient cycles and algae development. Internal P load is a self-enhancing process that fertilizes water systems (Nurnberg and Peters, 1984).

Phosphorus can be concentrated in sediments from settling and fixing by aquatic vegetation. Releases from the sediments occur through a number of processes including diffusion, anoxic conditions, wind and wave action, lake system exchange, and bioturbation from bottom feeding fish. The presence of benthic fish (bottom feeders) has been shown to contribute nutrients to the water column (NALMS, 1988). The impact from rough fish, carp and black bullhead, were a major concern in the reclamation efforts. According to the DNR fish survey, carp and bullhead numbers are nearing the levels recorded before the last reclamation. (DNR fisheries survey, 2008).

Internal load appears to be an important source of phosphorous in Lura Lake. BATHTUB model runs that were not calibrated significantly underestimated in-lake phosphorous concentration. In order to calibrate the model, internal loading was adjusted to equal the observed conditions. By increasing the internal value to 1.38mg/m^2/day (.0123 lbs/acre/day) the model estimates equal the water quality monitoring data. This is similar to values found by Hoverson (2008). This value converts to 15.93 lbs/day, exceeding the TMDL value by nearly three times. It is important to note that this modeling process was utilized to qualify the relative importance of internal load for Lura Lake and not to quantify the actual internal load. This exercise helps to inform and develop implementation practices to control internal inputs.

Treatment and reduction of internal loading should be a priority for Lura Lake. The “closed basin” nature of Lura Lake means that nutrients entering the system are likely settled and can be trapped within the lake sediments. Finding ways to control nutrient cycling is a key to improving water quality within the lake.

Urban and Residential Sources

Untreated stormwater runoff is a potential contributor of nutrients to Lura Lake. Stormwater transports materials such as sediment, fertilizers, vehicle fluids/chemicals, leaves and grass clippings. Entry of these materials into the lake system causes breakdown and release additional nutrients.

Stormwater loading was calculated using the area of total developed spaces, and multiplying them by the run off coefficients ranging from .5 to 1.25 kg/ha (.45 to 1.11 lbs/acre) and recorded climatic data. This estimate is likely high compared to any actual stormwater impact due to the very limited development and impervious surfaces in the area. Reducing nutrient inputs from current and future impervious surfaces through stormwater management should be considered in implementation activities.

Failing Subsurface Sewer Treatment Systems

Failing Subsurface Sewer Treatment Systems (SSTS) and/or “straight pipe systems” (systems without proper holding/discharge areas) around Lura Lake are also potential sources of nutrients. Leeching of septage (partially treated sewage), may be considerable even under low flow conditions, providing nutrients in the form of ortho-phosphorus, a pollutant type that is more readily available for uptake and use by algae.

Proactive implementation and rule enforcement within Blue Earth and Faribault County has significantly reduced the number of failing or straight pipe SSTS within the watershed. It is likely that nutrient input from septic systems is minimal relative to other sources to Lura Lake but should not be ruled out. Continued implementation at the county level will further reduce this potential nutrient source, and should be considered within planning activities.

Due to the uncertainty, SSTS and straight pipe contributions were not accounted for directly in the TMDL nutrient budget. Additionally, any discharge from a straight pipe or non-compliant septic system is illegal, and as such is not given a load allocation value.

Atmospheric Loading

Additional loading results from trace levels of phosphorus carried by precipitation. This type of phosphorus enters the lake via direct input (rain falling on the lake surface).

The levels of phosphorus delivered from precipitation are difficult to quantify, but best efforts have been made to calculate the loading based on runoff coefficients found in literature. The levels of atmospheric deposition vary based on the quantities of rainfall and climate conditions in an area, considering wet and dry deposition rates. These levels are discussed in the MPCA report, “Detailed Assessment of Phosphorus Sources to Minnesota Watersheds” (Barr Engineering, 2004).

For the purposes of this TMDL the rate is estimated to be 30 mg/m^2/year (.27 lbs/acre/year). Atmospheric loading is a small portion of the overall nutrient load when compared to the external and internal loading sources. It is important to recognize this value for consideration in the overall budget as this loading source is not possible to control.

Based on the estimated rate, the total atmospheric loading value is 157.2 kg/year, or .95 lbs/day.

∑LA = nonpoint sources as listed above. No specific allocations for each area.

∑LA= 5.20 lbs/day

Margin of Safety

The third component, Margin of Safety (MOS), is the allocation that accounts for uncertainty within the calculation methods, sample data, or the allocations which will result in attainment of water quality standards. Figure 13 lists a few approaches and considerations when addressing the MOS which are either explicit or implicit.

Figure 13 - Margin of Safety

Type of Margin of Safety	Approaches
Explicit	• Set numeric targets at more conservative levels than analytical results indicate • Add a safety factor to pollutant loading estimates • Do not allocate part of available loading capacity; reserve for MOS
Implicit	• Conservative assumptions in derivation of numeric targets • Conservative assumptions when developing numeric model applications • Conservative assumptions when analyzing prospective feasibility of practices and restoration activities.

For the purposes of this TMDL, an explicit 10 percent MOS was selected due to the potential variability of the monitored parameters from spatial, temporal and seasonal changes seen within the lake. The explicit MOS also allows for some uncertainty in the modeling process relating to several variables including: atmospheric loading; evaporation; surface runoff; and in particular internal loading. After modeling to the standard, 10 percent of the load value was used for the Lura Lake MOS.

MOS=0.58 lbs/day

Total TMDL and Summary

In summary, the TMDL value is calculated at the following:

TMDL = LC = ∑WLA + ∑LA + MOS

TMDL = LC = 5.83 lbs/day

∑WLA = 0.05 lbs/day [NPDESvalues (0.00) + Construction stormwater (0.05 lbs/day or 1 percent)]

∑LA = 5.20 lbs/day [nonpoint sources as listed above. No specific allocations for each area.]

MOS = .58 [10 percent of total load.]

Necessary Reductions

While not required within the context of the TMDL, it is helpful to look at the loading reductions necessary to meet the standards. The reductions needed for Lura Lake will come from nonpoint sources, internal and external.

Modeled estimation of the internal loading for the lake exceeds the daily loading values calculated for the TMDL study. Internal loading must be further investigated if any water quality improvements are to be made. External sources and internal processes need further understanding to develop implementation activities to reduce phosphorous loading.

Reductions needed are substantial. Monitored water quality information estimates the yearly phosphorous load at 6,756 pounds. Modeling to the standard of 90ppb calculates a loading capacity of 2,128 pounds and with the margin of safety deducted, the necessary loading to meet standards is estimated at 1,916 pounds.

Targeting reductions are being considered in the development of the LeSueur River Watershed Restoration and Protection Strategy. Additional modeling may be needed to determine what is feasible and practical to meet reduction goals. Any significant reduction in loading requires aggressive implementation to achieve the reduction necessary to meet the TMDL values.

6 Implementation Activities

With a small watershed to surface water ratio, Lura Lake is an ideal candidate for lake management and upland best management practice implementation to examine the effectiveness on water quality improvement. Several internal processes could be contributing to Lura Lake's elevated phosphorus concentrations. Bioturbation, wind and reduced phosphorus sedimentation could each impact phosphorus levels in the lake. Anaerobic release of phosphorus is likely not a major contributor to summer phosphorus concentrations as Lura Lake is shallow and does not stratify. Winter anaerobic conditions could be occurring, though the lake is equipped with an aeration system to avoid winter fish kills.

In order to improve water quality, in terms of reduction in the frequency of algae blooms, increased transparency, and over all nutrient concentration within Lura Lake, a large reduction to in-lake phosphorus cycling will be necessary. Similarly, reduction of inputs into the lake from the surrounding watershed should be utilized to prevent any accelerated increase to the in lake concentrations.

Lura Lake is somewhat unique as its watershed to lake ratio is approximately one to one. The watershed has limited external inputs to the lake, primarily overland flows and tile drainage and the lake outflow is controlled by an elevated outlet. These conditions have the potential to allow nutrients entering into the lake to settle and be retained, as opposed to flowing out of the system.

An implementation strategy is being developed as part of the LeSueur River Watershed Restoration and Protection (WRAP) plan to be completed in 2013. This plan includes practices, goals and areas targeted to improve the lake water quality. The development of a strategy for implementation planning and action is essential. Local government and stakeholder viewpoints and perspectives are included in the WRAP process. If they are to be the principal agents for achieving results, the plan, targets, and goals must be acceptable to the community within the watershed.

Counties have developed Water Plans that focus on local issues of importance when dealing with water. These chapters will be referenced and used when developing the implementation strategy, especially when dealing with target areas or area goals.

Implementation activity should utilize existing conservation programs and rules established by state, county, or local ordinances. Existing rules/programs include USDA programs (such as CRP, CREP, RIM, and EQIP), DNR programs and setbacks and State, county, or local ordinances concerning shore land, ditches, or riparian areas.

Best Management Practices (BMPs) are designed and used as a means for improving agricultural or urban discharges. The majority of these practices are researched, field tested designs and are individually designed to ensure proper function in the areas where they are installed.

Rural BMPs

Best management practices (BMP's) have been used in agriculture for several decades to greatly reduce levels of soil erosion and transport. Traditionally BMP funding comes through the various governmental organizations to landowners in rural, agricultural settings.

Federal guidance for agricultural BMPs is available from the Natural Resource Conservation Service (NRCS) in the Field Office Technical Guide (FOTG). The FOTG is available online, or from the local NRCS office. These guides are often county specific, and offer design specifications suited to the area.

Most BMPs are related to erosion and water quality and assist in reducing the nutrient loading. These BMPs (with NRCS program code numbers) include, but are not limited to:

Conservation Cover (327),Conservation Crop, Rotation (328), Contour Farming (330), Contour Strip Cropping (585), Cover Crop (340), Critical Area Planting (340), Cross Wind Strip-cropping (589B),Cross Wind Trap Strip (589), Dike (356), Diversion (362), Filter Strip (393), Grade Stabilization Structure (410), Grassed Waterway (412), Heavy Use Area Protection (561), Lined Waterway or Outlet (468), Mulching (484), Residue Management programs, Riparian Forest Buffer (391), Riparian Herbaceous Cover (390), Roof Runoff Management (558), Runoff Management System (570), Sediment Basin (558), Stream Channel Stabilization (584), Stream Habitat Improvement and Management (395), Structure for Water Control (587), Terrace (600), Vegetative buffers (601), Wetland Creation (658), Wetland Enhancement (659) and Wetland Restoration (657).

In-Lake Treatments

Due to the high nutrient levels coming from internal loading, in lake treatments of phosphorus will be necessary.

Based on observations and sample data, the high levels of phosphorus and exceedance of the standards typically correspond with the maturation and subsequent die off of curly-leaf pondweed (*Potamogeton crispus)*. The effect of this senescence has been documented in other lake systems with large populations of curly-leaf pondweed (Hoverson, 2008).

Due to its growth cycle, curly-leaf pondweed can be difficult to control. The plants remain active during the winter months and are often the first to appear after ice out, quickly forming dense mats giving this species a competitive advantage over native aquatic plants (Catling and Dobson 1985 as cited by Capers et al. 2005). These rhizomatous plants reproduce through turions (overwintering bud produced by aquatic herbs). Numerous turions are produced by each plant, and often the turions have a germination rate between 60 and 80 percent (Indiana Department of Natural Resources, 2008).

Curly-leaf pondweed does provide positive effects in some instances. The natural respiring of the plants increases oxygen levels and provides shelter for small fish and aquatic insects, which provide food for larger fish and amphibians (USDA, NRCS 2008). However, when growing in heavy stands, it can make aquatic recreation difficult if not impossible, and plant death and decay has negative effects on water quality through the reduction of oxygen available in the water column, as well as the release of phosphorus.

Eurasian milfoil is also present in Lura Lake. This invasive plant can also form dense mats at the surface of lakes, causing problems with recreation and impacting the aquatic ecosystem. Milfoil is often difficult to control as its reproduction method of fragmentation allows small sections of the plant to survive and grow new plants.

Similar to curly-leaf pondweed, Eurasian milfoil has adapted for growth early in spring. Several portions of the plant persist over winter and store the nutrients necessary to allow the milfoil to form a dense leaf canopy that shades out native aquatic plants.

The level of Eurasian Milfoil has not yet been a major problem in Lura Lake based on observations during the vegetation surveys. Milfoil should continue to be monitored to see how quickly it spreads within the system.

While preventing an invasive species infestation is the most efficient line of attack, Lura Lake has established populations of curly-leaf and milfoil. Once multiple invasive species exist various control options should be considered. It should be noted that all methods of control would be subject to review and authorization from the DNR. The control and/or removal of aquatic vegetation are typically subject to a permit.

Key to curly-leaf pondweed control is the removal of the plant before turion production takes place. This disrupts the life cycle of the plant, eliminating potential offspring. It is important to note that turions may become buried or lay dormant for a few years. For this reason multiple treatments would be necessary to reduce the "turion bank" in the lake and allow effective population control.

Plant removal can be accomplished by mechanical weed removal, hand cutting, raking, or weed screening. Plants removed should be taken as close to the lake bottom as possible to prevent regrowth and turion production and all plant debris should be removed entirely from the lake system and disposed of through composting, burning or burying. Care should be taken to leave native plant species when harvesting, so selective harvesting methods would be preferred as opposed to mechanical harvest.

Early spring treatments using contact herbicides with active ingredients of diquat or endothall have shown positive effects in reducing curly-leaf pondweed shoot and root biomass as well as suppressing turion production (Indiana Department of Natural Resources, 2009). Research has shown that a chemical application of diquat or endothall should occur when the water temperature is around 50 to 55 degrees to greatly reduce turion production (Poovey et al, 2002). Additionally, the chemical Fluridone has been shown to inhibit turion production when applied in the spring. All treatment options should be used cautiously and appropriately, with careful attention concerning the size of the areas treated and the potential impacts on native aquatic species.

Due to the reproduction methods of Eurasian milfoil, control can be difficult. Mechanical harvest and removal may cause increased shoot fragmentation, which increases the dispersal of the plant. Selective harvest and screening have been demonstrated to be effective and produce minimal fragmentation within the plants when care is used. Selective harvest methods typically include hand cutting in shallow areas, or pulling when possible, and are time consuming.

In smaller waterbodies (350 acres or less), some success using an aquatic herbicide called Sonar® to remove milfoil and the selective herbicides 2,4-D and triclopyr-TEA shows promise in managing milfoil infestations (Department of Ecology, Washington State, 2010). Similar to curly-leaf pondweed, using an herbicide to control the population should be done as carefully as possible to ensure minimum disruption to the native plant populations.

Additional steps should be taken to prevent the spread of invasive species into and out of Lura Lake. The "Stop Aquatic Hitchhikers" program is being promoted through the DNR, and a warning has been posted at the public access points on Lura Lake. It is important to follow the laws and recommendations in Minnesota regarding invasive species control. A summary of the laws as taken from the DNR's website is included in Appendix D.

In lake treatments, including Alum, may be beneficial once external phosphorous sources have been reduced. Treatments bind and settle available phosphorus and create a layer on the lake bottom that may help reduce nutrient cycling. While beneficial, this is not a permanent solution. Substantial costs are associated with each treatment method described.

Control of fish species is also important in reducing nutrient cycling. Rough fish and other bottom feeders cause nutrient release through regular feeding activities. Treatments, like rotenone, can be used to reclaim the lake but will cause the existing fish community to collapse. These treatments may be controversial and should be handled by the DNR after discussion with area residents and stakeholders. The 1994 reclamation efforts have demonstrated that by removing the rough fish population, observed average TP levels were reduced and met the shallow lake standards for several years.

It is important to restate that while focusing on the internal nutrient cycling through various treatment options would likely result in improved water quality, it is also important to deal with external nutrient loading. By not addressing the external loading, all in lake treatments or reclamations duration of effectiveness would be substantially shortened.

Urban/Developed Area BMPs:

Additional BMP and implementation activity should focus on urban and stormwater issues. While development around Lura Lake is minimal, it is important to consider in the event of future development. Stormwater can have serious consequences on the quality of lakes, streams and rivers if it is not treated or managed. Often associated with impervious areas and urban development, stormwater often contains oil, chemicals, excess phosphorous, toxic metals, litter, and potentially disease-causing organisms and bacteria.

Because of the potential for impact from stormwater, the MPCA, BWSR, and many local government units have developed rules, programs or suggestions when dealing with stormwater management. The MPCA covers construction and industrial stormwater under the NPDES permit program with the following language:

Construction Stormwater

Construction stormwateractivities are considered in compliance with provisions of the TMDL if they obtain a Construction General Permit under the NPDES program and properly select, install and maintain all BMPs required under the permit, including any applicable additional BMPs required in Appendix A of the

Construction General Permit for discharges to impaired waters, or meet local construction stormwater requirements if they are more restrictive than requirements of the State General Permit.

Industrial Stormwater

Industrial stormwater activities are considered in compliance with provisions of the TMDL if they obtain an industrial stormwater general permit or general Sand and Gravel Permit (MNG49) under the NPDES program and properly select, install and maintain all BMPs required under the permit.

The “Minnesota Stormwater Manual” details the effects and lists several alternative methods of dealing with stormwater though alternative designs, BMPs, and other options.

Educational materials and programs, like the DNR’s “Restore your shore”, should be promoted and used. Demonstration sites prove that a natural shore not only has a positive effect on the lake, but can also be aesthetically pleasing and help control wildlife issues.

Lawn fertilizers too are a source of nitrogen and phosphorus. They are not recommended for use around lakes. Per Minnesota Law 18C.60 (2006), Minnesota Statutes state that all fertilizers containing phosphorus are banned from use on lawns in Minnesota, with an exception if soils can be proven to be phosphorus deficient (by way of a soil test) or in the establishment of a new lawn.

A buffer of unfertilized natural vegetation should be maintained along the shoreline to help control erosion as well as trap some of the nutrients that may run off lawns and into the lake. Grass clippings and leaves should be removed before they end up in the lake where they are a source of nutrients and organic matter.

Effectiveness Monitoring/Monitoring Plan

Monitoring related to TMDLs should include three components in order to effectively track progress. The monitoring plan should include tracking the adoption of implementation activities, monitoring the effectiveness of individual and/or sets of implementation measures, and resource monitoring for evaluating progress toward restoration.

The Lake Nutrient TMDL Protocols and Submittal Requirements (MPCA, 2007) made the following statement and recommendation regarding monitoring:

At this time, the responsibility and source of funds for doing implementation and post implementation monitoring has not been defined. Monitoring occurring during an implementation project is apt to be funded as part of the implementation project, especially if funded with 319 or state funds.

Existing programs and projects will be leveraged when dealing with monitoring. These programs include, but are not limited to the following:

319 Grants

Within the CWA, the Nonpoint Source (NPS) Management Program was introduced in 1987 as section 319. Under section 319, federal grant money is distributed to States, Territories and Tribes. These grants can be applied for under criteria established by the agency holding the dollars. Typically the focus of these projects includes technical and financial assistance, outreach and education, and project implementation and evaluation.

Citizen Lake Monitoring Program (CLMP)

The CLMP is a cooperative program combining the technical resources of the MPCA and the volunteer efforts of citizens to collect water quality data on their lakes. These volunteers assist in determining the condition of Minnesota lakes by expanding our water-quality monitoring network. The program provides the opportunity for anyone interested to participate in a basic, centrally administered and interpreted monitoring program. Increased monitoring helps identify problems, develop strategies and prioritize activities for improving water quality, and tracks progress toward improvement.

Watershed Approach

Intensive watershed monitoring will occur within the LeSueur River Watershed on a ten year basis. Lura Lake was not included in the 2008 round of monitoring as it was already started as an individual lake TMDL project before the watershed work had begun. The implementation plan for Lura Lake is included in the Watershed Restoration and Protection Strategy to be completed in 2013. The lake will again be monitored and assessed in 2018 with the beginning of the second cycle of the watershed approach.

7 Reasonable Assurance

The US EPA requests that TMDL studies provide reasonable assurance that practices and programs have the ability to reduce loading levels to meet/exceed and maintain water quality standards. Due to the lack of permitted sources, this TMDL deals exclusively with nonpoint sources and loading. Reasonable assurances in these types of TMDLs allow the MPCA to evaluate the potential options available to enable reductions from nonpoint sources.

The MPCA and other state and federal agencies have limited regulatory authority over the majority of the nutrient sources in this TMDL report. To address the major loading portion of the TMDL, from nonpoint source and internal loading, a wide variety of management practices need to be considered and implemented. Ideally, the implementation plan needs to be iterative and adaptive in nature, providing a method to explore the effectiveness of the practices installed and track changes within the system allowing continued targeting to the most sensitive areas with the best suited practice. All BMPs and practices aimed at improving water quality should also be implemented in a phased approach. This requires the understanding that solving water quality issues within the lake system is a long term goal, best attained using numerous, incremental gains, as opposed to looking for a single “silver bullet” fix.

The Lura Lake Sportsman’s Association has provided shoreline erosion protection through rip rapping areas of concern to reduce potential sediment and phosphorous loading. They also provide educational and outreach activities to local schools and organizations. The DNR continues to stock game fish for recreational opportunities and conducts lake surveys. These surveys provide information on vegetation issues and for consideration of future rehabilitation efforts to remove rough fish to control re-suspension of sediment that can contribute to phosphorous loading. The MPCA will work with the Lake Association, DNR and County staff to develop plans and research funding potential for implementation activities that control rough fish populations and weed management activities to reduce the internal loading to Lura Lake.

Blue Earth and Faribault County SWCD’s have and continue to work with individual landowners to implement BMP’s that help to manage land for crop production while reducing nutrient losses. These land use practices are described in the implementation section and are done on an individual landowner and voluntary basis. In-lake treatments of invasive species need to be considered for future lake management. Working with local and state groups to develop funding strategies for these options will need to be considered. Promotion of these practices has to be encouraged by the Lake Association and the Local and State Agencies. This work and funding opportunities for lake restoration efforts requires assistance from MPCA, BWSR and the DNR.

The reduction needs demonstrated by the TMDL to meet water quality standards represent aggressive goals. These goals need to reflect realistic social and economic consideration when addressing implementation. In order to reach the reductions, a variety of landuse and lake management changes are needed. Targeting of practices is critical in terms of maximizing water quality benefit while minimizing financial inputs.

The changes within the Lura Lake system that have contributed to water quality impairments took place over the course of decades, so it is highly likely the changes necessary to improve water quality will also take an extended amount of time.

8 Public Participation

The Lura Lake TMDL project worked with county, state and citizen groups and organizations. The outreach portion of this TMDL project was handled differently from other TMDLs completed in the Greater Blue Earth River Basin. The Lura Lake watershed is relatively small with a limited number of landowners. Given the nature of this project the technical and stakeholder committees were not formed. Individual meetings with stakeholders, including landowners (most of who belong to the Lura Lake Association), agency representatives, and County and SWCD staff were conducted. Public notice was announced to the general public to include those who wished to be involved with the TMDL process from outside the watershed.

The MSUM Water Resources Center provided regular updates on aspects of the TMDL, data collections, and products, largely through e-mail, regular mail, telephone, and personal visits. All landowner information was collected through the public tax records of Blue Earth and Faribault counties. Each landowner was contacted via mail to alert them of the TMDL project. This contact included basic information as to what a TMDL is, why the TMDL is occurring, and what the timeline was.

A meeting was held in Mapleton to discuss the findings of the TMDL after the first year, and to assess landowner views on the condition of the lake. The general consensus was that the lake does occasionally have issues with excessive plants and algae, but generally the lake is in good condition. When the lake is not in good condition, the time frame is usually brief and the issues clear up before the end of the year.

Many of the landowners would like to control some of the weed issues, but they fear that the fish community may be negatively impacted if too much is done. More than one landowner stated that the bass population is in very good condition, and some even speculated that Lura has a chance to produce a state record.

The local landowners were also proud of the work that has been done on the lake shore and additional work done within the watershed. The majority of the shoreline on the lake has been rip rapped. This was done to prevent wind and wave erosion. The funds used to pay for this work were acquired through grant applications submitted by the Lura Lake Association. The Lake Association is not as active as it once was, but land owners and the public are interested in working to protect the lake.

The report for the Lura Lake Excess Nutrients TMDL study were formally noticed from Sept 23rd, 2013 to Oct. 22nd 2013.

9 References

Barr Engineering. 2004. *Detailed Assessment of Phosphorus Sources in Minnesota Watersheds*. Minnesota Pollution Control Agency, St. Paul, Minnesota.

Blann, K., et al 2009 *Effects of Agricultural Drainage on Aquatic Ecosystems: A Review* Critical Reviews in Environmental Science and Technology. Issue 39

Krysel, C., Boyer, E., Parson, C., Welle, P., 2003. *Lakeshore Property Values and Water Quality: Evidence from Property Sales in the Mississippi Headwaters Region*, Submitted to the Legislative Commission on Minnesota Resources by the Mississippi Headwaters Board and Bemidji State University.

Heiskary, S.A. and Wilson, C.B., 2005. *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment*. Minnesota Pollution Control Agency, St. Paul, Minnesota.

Heiskary, S.A. and Walker, W.W., 1988 *Developing Phosphorus Criteria for Minnesota Lakes* Minnesota Pollution Control Agency, St. Paul, Minnesota.

Hoverson, D. 2008 *Phosphorus Release from sediments in Shawano Lake, Wisconsin* College of Natural resources, University of Wisconsin - Stevens Point.

Food and Agriculture Organization of the United Nations Fisheries - Fisheries and Aquaculture Department, 1996. *Manual on the production and use of live food for aquaculture* <http://www.fao.org/fishery/en>

Minnesota Department of Natural Resources (MDNR). *Lura Lake Information Report.* <http://www.dnr.state.mn.us/lakefind/showreport.html?downum=07007900>

Minnesota Office of the Revisor of Statutes (MORS, 2008). Chapter 7050, Waters of the State. < https://www.revisor.leg.state.mn.us/rules/?id=7050&view=chapter#rule.7050.0150>

Nurnberg, G.K. and Peters, RH.. 1984. *The importance of internal phosphorus load to the eutrophication of lakes with anoxic hypolimnia*. 22: 190- *1* 94.

Niirnberg G.K., 1994 *Phosphorus Release from Anoxic Sediments: What we know and How we can deal with it.* Lirnnet~ca.1 0 (I) **:** 1-4

Sheilds, M. and Hieskary, S., 1995 *Lake Assessment Program report 1995 Lura Lake* Minnesota Pollution Control Agency, St Paul MN

Sondergaard, M.J., et al., 2001. *Retention and internal loading of phosphorus in shallow eutrophic lakes*. The Scientific World, 1: 427–442

Steinman, A., et al 2004 *The Reduction of Internal Phosphorus Loading Using Alum in Spring Lake, Michigan* Journal of Environmental Quality. 33:2040–2048

Walker, William W. 1999. *Simplified Procedures for Eutrophication Assessment and Prediction*: User Manual. USACE Report w-96-2.R-C

Wilson, C. B. and W.W. Walker Jr. 1989. *Development of lake assessment methods based upon the aquatic ecoregion concept*. Lake and Reservoir Management. 5(2): 11-22

Natural Resource Conservation Service (NRCS) in the Field Office Technical Guide (FOTG).

Bentrup, G., and J.C. Hoag. 1998. The Practical Streambank Bioengineering Guide - User's Guide for Natural Streambank Stabilization Techniques in the Arid and Semiarid Great Basin and Intermountain West. Interagency Riparian/Wetland Plant Development Project. USDA-NRCS, Aberdeen, ID.

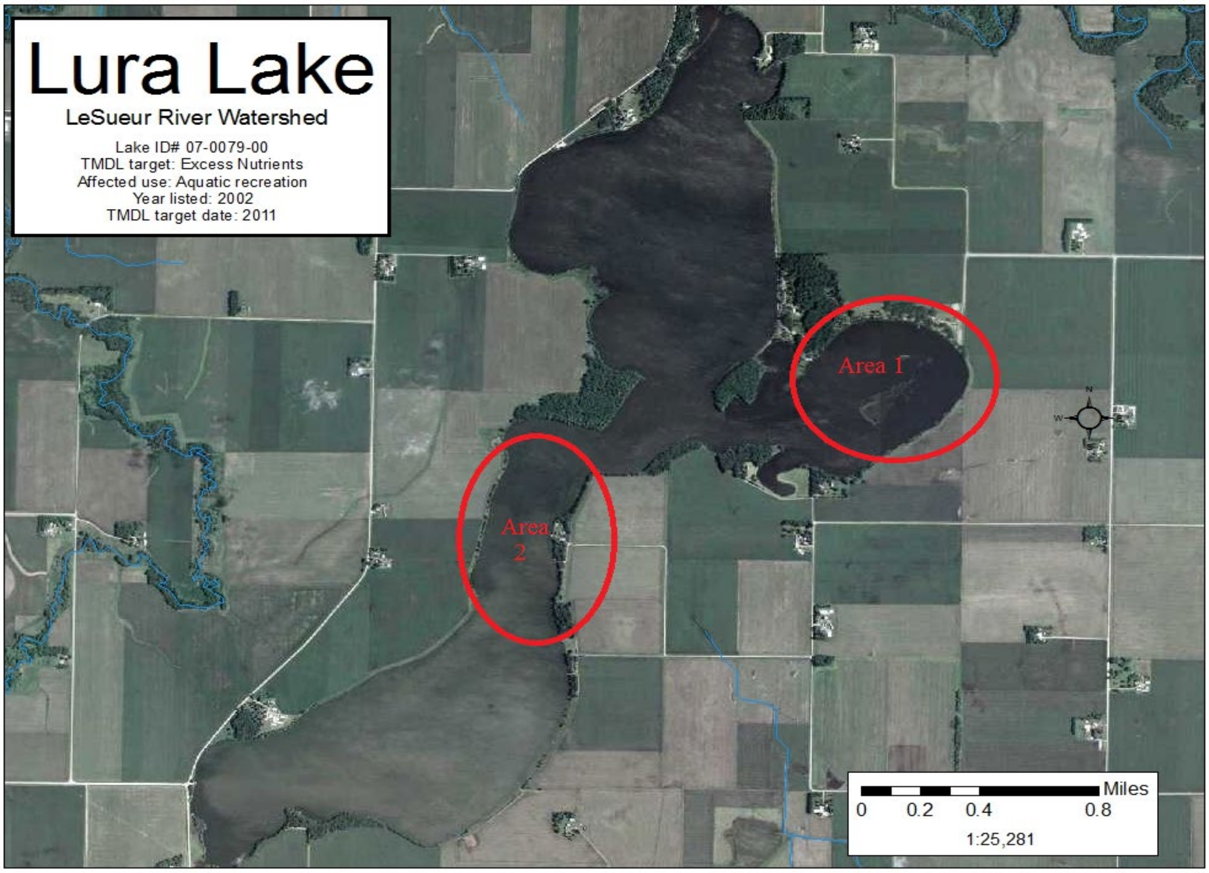
Protocol for developing nutrient TMDL's (first edition). 1999. USEPA Office of Water. EPA 841-B-99-007.

10 Appendix

Appendix A – Algal Bloom Photos
Appendix B – Land Use Classification Definitions
Appendix C – TSI Calculation Methods
Appendix D – DNR Invasive Species Information

Appendix A – Algal Bloom Photos

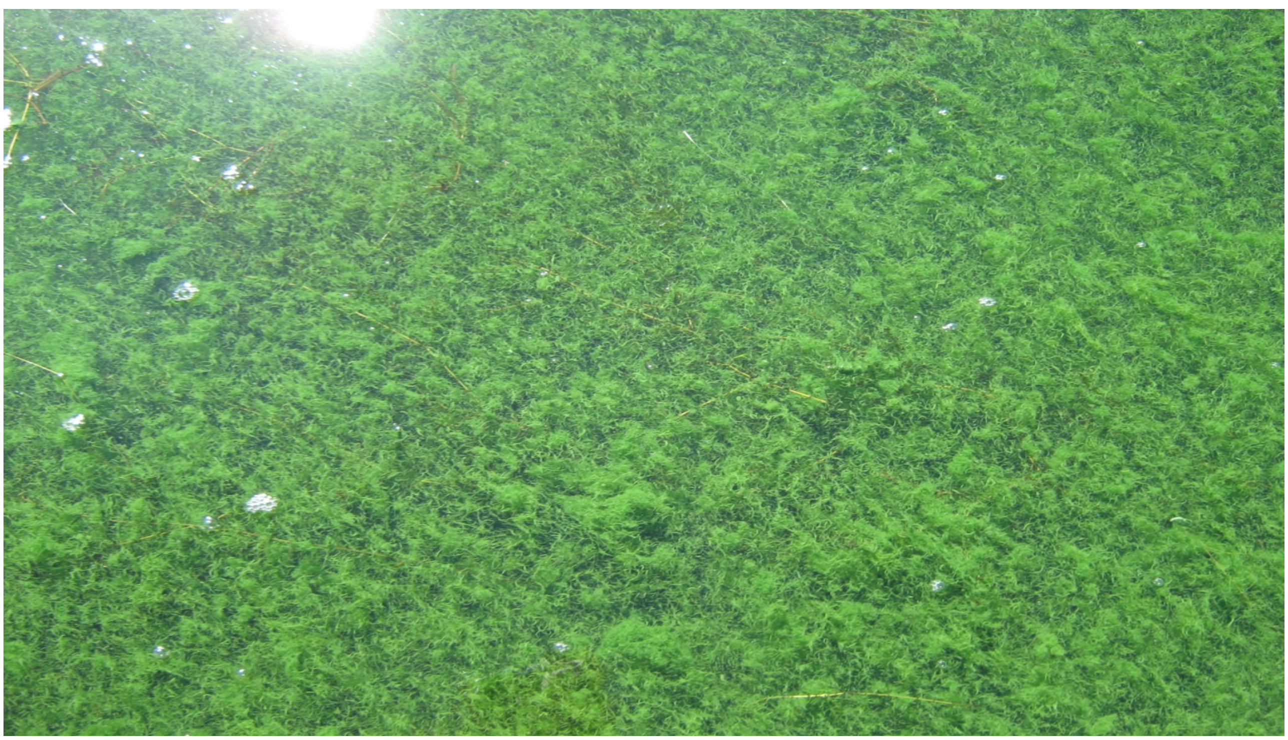
On August 6th, numerous areas of algal mats were found in Lura Lake. The mats were primarily found in the Eastern bay and in the narrow portion of the lake that connects the southern bay. The areas are circled on the image below. The eastern bay is referred to as area 1, and the narrow section is referred to as area 2.



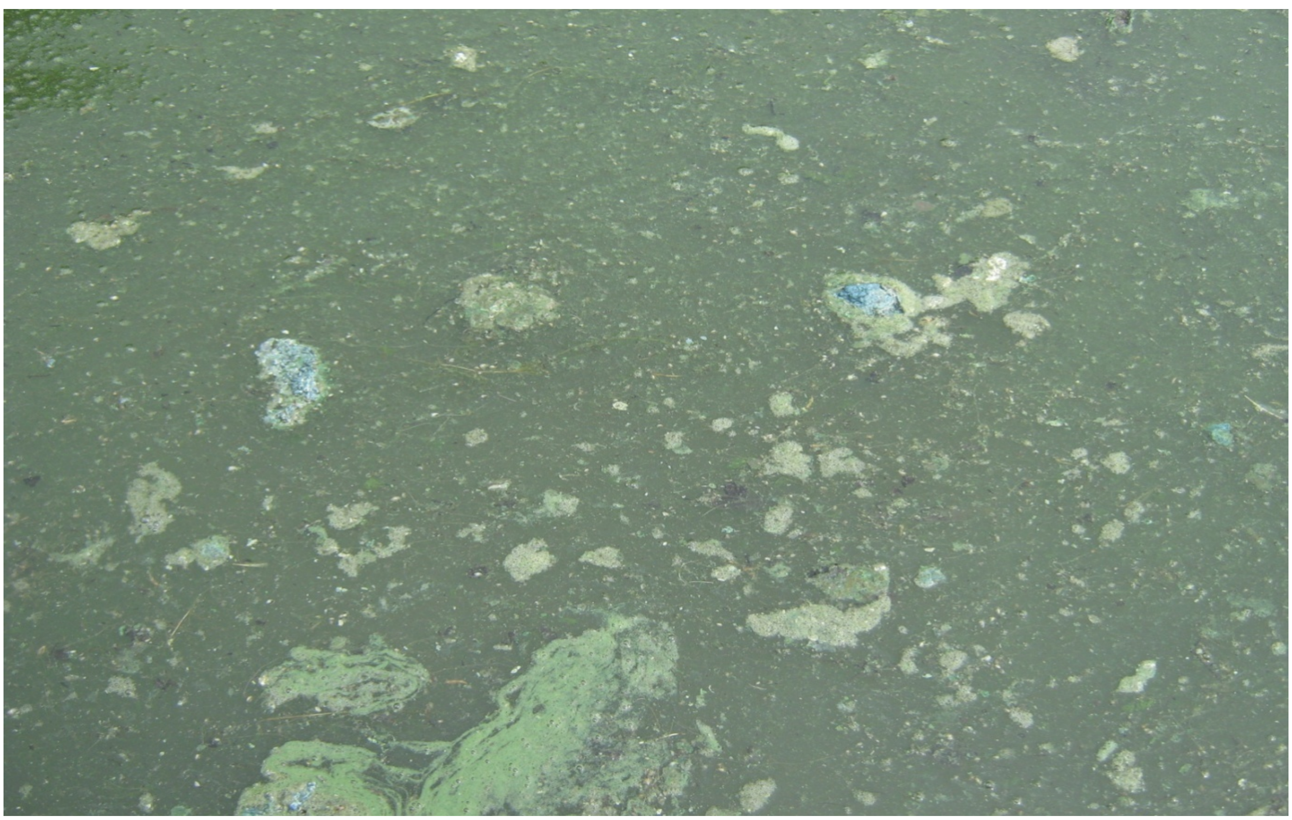
The eastern bay, area 1, is the shallowest portion of the Lake. A very high density of Curly-leaf pondweed was seen early in the monitoring season, forming mats shown in the photo at right. Filamentous algae were also present in large quantities. As the curly-leaf died off, aphanizomenon algae increased dramatically. As algal levels increased, new algae forms began to appear as mats on the surface. Various images of the algae production are included.

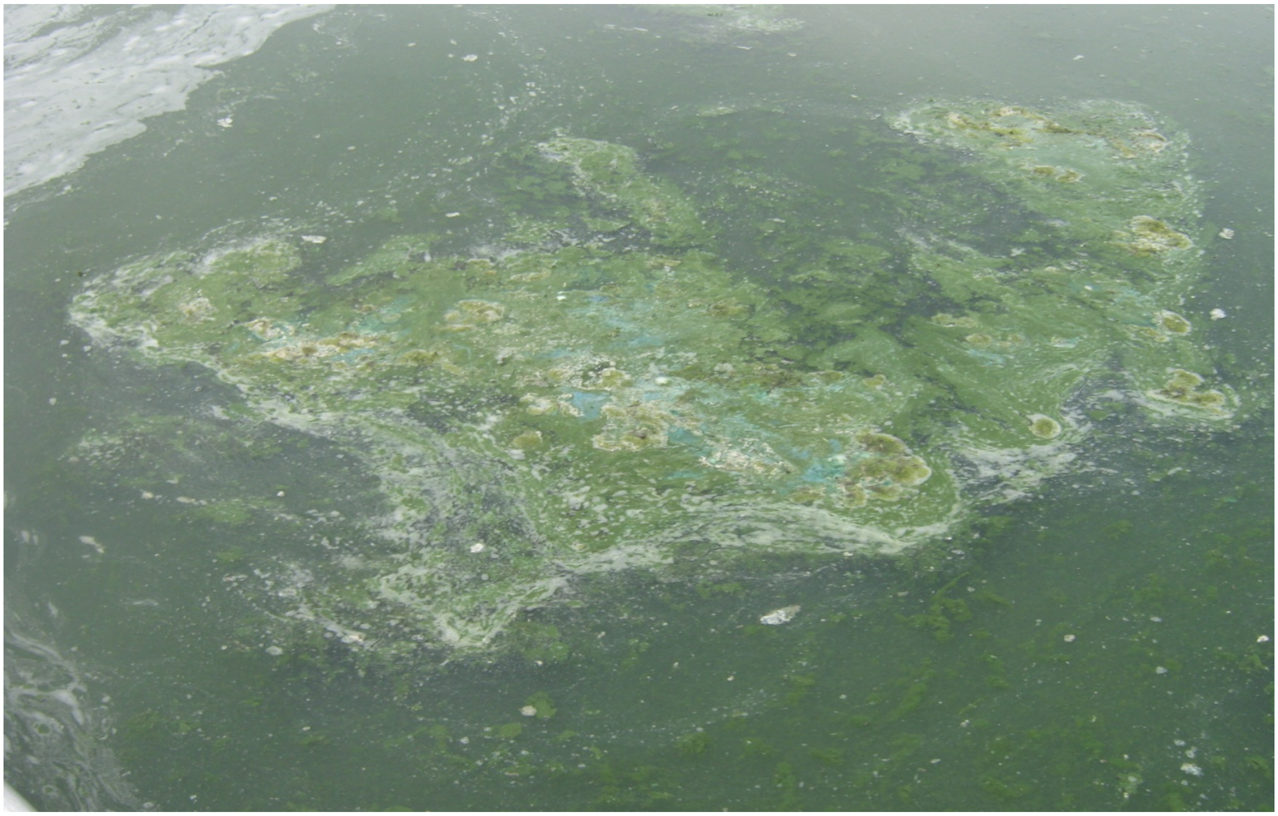
Filamentous algae and curly-leaf mats

Aphanizomenon Algae

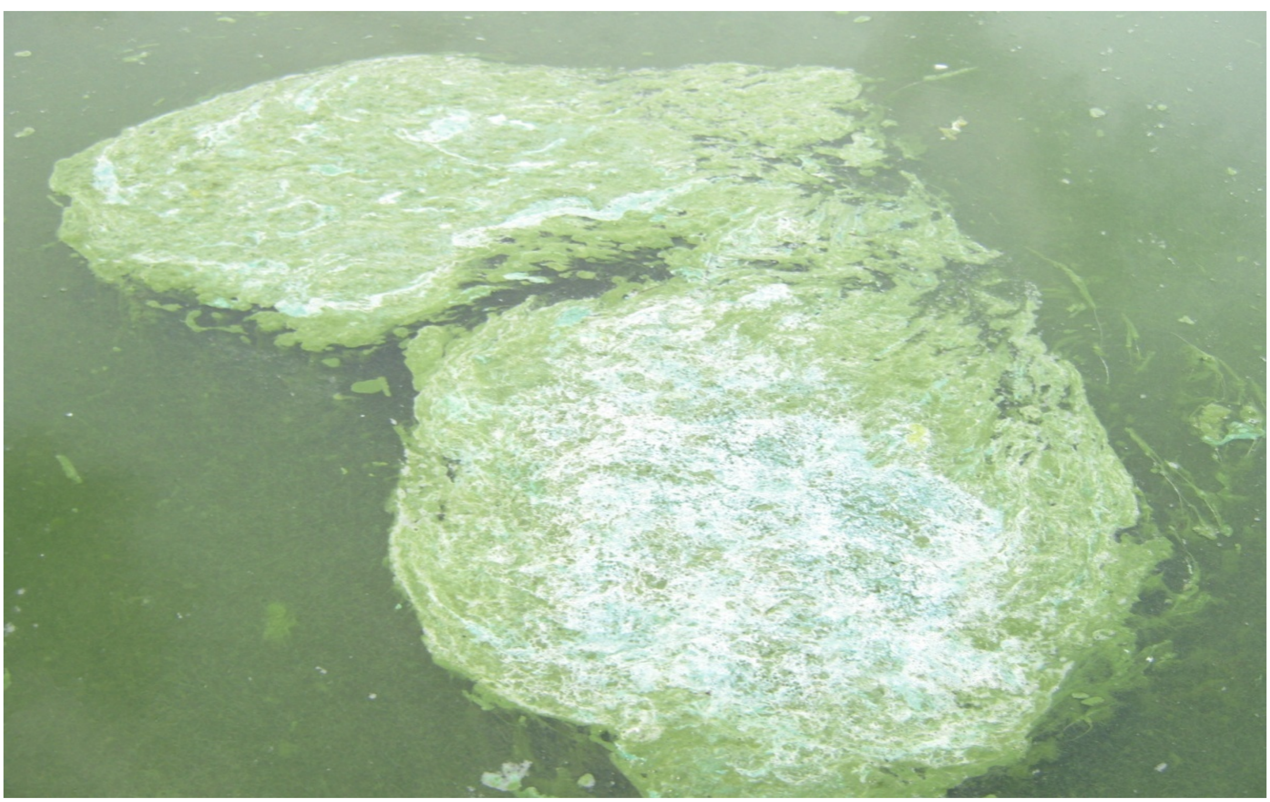


Various images of algae found on August 6th, 2009.





On the same day the portion of the lake labeled as area two also had numerous algal mats. Several of the mats are shown below. The bloom had dispersed within a week's time, likely due to a storm event with high winds.



Appendix B – Land Use Classification Definitions

The Land use definitions used within this TMDL are taken from the 2009 National Agricultural Statistics Service (NASS). The NASS land cover data is developed by the United States Department of Agriculture, and uses a combination of NASS specific land covers and information developed by the National Land Cover Dataset (NLCD). The NASS land cover breaks agricultural areas into specific crop or cover types in addition to the Typical NLCD classifications. The NASS definitions are as follows:

Value	Classification
1	Corn
5	Soybeans
12	Sweet Corn
23	Spring Wheat
24	Winter Wheat
37	Other Hays
41	Sugar beets
53	Peas
62	Pasture/Grass
111	NLCD - Open Water
121	NLCD - Developed/Open Space
122	NLCD - Developed/Low Intensity
123	NLCD - Developed/Medium Intensity
124	NLCD - Developed/High Intensity
131	NLCD - Barren
141	NLCD - Deciduous Forest
171	NLCD - Grassland Herbaceous
181	NLCD - Pasture/Hay
190	NLCD - Woody Wetlands
195	NLCD - Herbaceous Wetlands

NLCD classifications are then altered by placing a "1" in front of the typical numeric classification. For example, 11 – open water becomes 111 – open water, and 21 – Low intensity development becomes 121 – Low Intensity development. The NLCD classifications are as follows:

Water - All areas of open water or permanent ice/snow cover.

11. Open Water - All areas of open water; typically 25 percent or greater cover of water (per pixel).

12. Perennial Ice/Snow - All areas characterized by year-long cover of ice and/or snow.

Developed - Areas characterized by a high percentage (30 percent or greater) of constructed materials (e.g. asphalt, concrete, buildings, etc).

21. Low Intensity Residential - Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.

22. High Intensity Residential - Includes highly developed areas where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20 percent of the cover. Constructed materials account for 80 to100 percent of the cover.

23. Commercial/Industrial/Transportation - Includes infrastructure (e.g. roads, railroads, etc.) and all highly developed areas not classified as High Intensity Residential.

Barren - Areas characterized by bare rock, gravel, sand, silt, clay, or other earthen material, with little or no "green" vegetation present regardless of its inherent ability to support life. Vegetation, if present, is more widely spaced and scrubby than that in the "green" vegetated categories; lichen cover may be extensive.

31. Bare Rock/Sand/Clay - Perennially barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, beaches, and other accumulations of earthen material.

32. Quarries/Strip Mines/Gravel Pits - Areas of extractive mining activities with significant surface expression.

33. Transitional - Areas of sparse vegetative cover (less than 25 percent of cover) that are dynamically changing from one land cover to another, often because of land use activities. Examples include forest clearcuts, a transition phase between forest and agricultural land, the temporary clearing of vegetation, and changes due to natural causes (e.g. fire, flood, etc.).

Forested Upland - Areas characterized by tree cover (natural or semi-natural woody vegetation, generally greater than 6 meters tall); tree canopy accounts for 25-100 percent of the cover.

41. Deciduous Forest - Areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.

42. Evergreen Forest - Areas dominated by trees where 75 percent or more of the tree species maintain their leaves all year. Canopy is never without green foliage.

43. Mixed Forest - Areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.

Shrubland - Areas characterized by natural or semi-natural woody vegetation with aerial stems, generally less than 6 meters tall, with individuals or clumps not touching to interlocking. Both evergreen and deciduous species of true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions are included.

51. Shrubland - Areas dominated by shrubs; shrub canopy accounts for 25-100 percent of the cover. Shrub cover is generally greater than 25 percent when tree cover is less than 25 percent. Shrub cover may be less than 25 percent in cases when the cover of other life forms (e.g. herbaceous or tree) is less than 25 percent and shrubs cover exceeds the cover of the other life forms.

Non-natural Woody - Areas dominated by non-natural woody vegetation; non-natural woody vegetative canopy accounts for 25-100 percent of the cover. The non-natural woody classification is subject to the

availability of sufficient ancillary data to differentiate non-natural woody vegetation from natural woody vegetation.

61. Orchards/Vineyards/Other - Orchards, vineyards, and other areas planted or maintained for the production of fruits, nuts, berries, or ornamentals.

Herbaceous Upland - Upland areas characterized by natural or semi-natural herbaceous vegetation; herbaceous vegetation accounts for 75-100 percent of the cover.

71. Grasslands/Herbaceous - Areas dominated by upland grasses and forbs. In rare cases, herbaceous cover is less than 25 percent, but exceeds the combined cover of the woody species present. These areas are not subject to intensive management, but they are often utilized for grazing.

Planted/Cultivated - Areas characterized by herbaceous vegetation that has been planted or is intensively managed for the production of food, feed, or fiber; or is maintained in developed settings for specific purposes. Herbaceous vegetation accounts for 75-100 percent of the cover.

81. Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.

82. Row Crops - Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.

83. Small Grains - Areas used for the production of graminoid crops such as wheat, barley, oats, and rice.

84. Fallow - Areas used for the production of crops that are temporarily barren or with sparse vegetative cover as a result of being tilled in a management practice that incorporates prescribed alternation between cropping and tillage.

85. Urban/Recreational Grasses - Vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.

Wetlands - Areas where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al.

91. Woody Wetlands - Areas where forest or shrubland vegetation accounts for 25-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

92. Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

Appendix C – TSI Calculation Methods

The following information was taken from the EPA TSI guidance webpage. This website site can be accessed at the following location:

http://www.epa.gov/bioiweb1/aquatic/carlson.html

Trophic State Index

Carlson's index EXIT Disclaimer uses a log transformation of Secchi disk values as a measure of algal biomass on a scale from 0 - 110. Each increase of ten units on the scale represents a doubling of algal biomass. Because chlorophyll a and total phosphorus are usually closely correlated to Secchi disk measurements, these parameters can also be assigned trophic state index values. The Carlson trophic state index is useful for comparing lakes within a region and for assessing changes in trophic status over time. Thus it is often valuable to include an analysis of trophic state index values in summary reports of a volunteer monitoring program. The program manager must be aware, however, that the Carlson trophic state index was developed for use with lakes that have few rooted aquatic plants and little non-algal turbidity. Use of the index with lakes that do not have these characteristics is not appropriate.

TSI = 60 - 14.41 ln Secchi disk (meters)
TSI = 9.81 ln Chlorophyll a (ug/L) + 30.6
TSI = 14.42 ln Total phosphorus (ug/L) + 4.15

where:

TSI = Carlson trophic state index
ln = natural logarithm

The formulas for calculating the Carlson Trophic State Index EXIT Disclaimer values for Secchi disk, chlorophyll *a*, and total phosphorus are presented below. Also presented is a table that lists the trophic state values and the corresponding measurements of the three parameters. Ranges of trophic state index values are often grouped into trophic state classifications. The range between 40 and 50 is usually associated with mesotrophy (moderate productivity). Index values greater than 50 are associated with eutrophy (high productivity). Values less than 40 are associated with oligotrophy (low productivity).

Appendix D – DNR Invasive Species Information

It is ***unlawful*** to:

- transport aquatic plants, round goby, zebra mussels, or other prohibited species on public roads
- launch a watercraft with aquatic plants, zebra mussels, or prohibited/regulated invasive species attached
- transport water from infested waters in boats, live wells, and bait containers
- transport watercraft without removing the drain plug and opening water-draining devices

REQUIRED ACTIONS

Inspect all watercraft, trailers, and equipment; **remove** any visible aquatic plants, zebra mussels, and other prohibited invasive species before leaving any water access.

Drain water from boat, live well, bilge, and impellor **before** leaving any water access. Also, drain bait containers at infested waters. If you want to keep your live bait when leaving infested waters, you must replace water in bait containers with tap or spring water.

Dispose of unwanted bait in the trash. It is illegal to release live bait into a waterbody or release aquatic animals from one waterbody into another.

RECOMMENDED ACTIONS

Some species are small and difficult to see at the access, so to remove or kill them **before** transporting your watercraft to other waters, either:

Rinse your boat and boating equipment with hot tap water (over 120º F); or

Spray your boat and trailer with a high pressure sprayer. (The hot water sprayers at a car wash can be used); or

Dry your boat and equipment for at least 5 days.

REPORT new sightings of aquatic invasive species. If you suspect a new infestation of an invasive plant or animal, save a specimen and report it to a local natural resource office.

ADDITIONAL STEPS

Recommended for the following activities:

Shore and fly-fishing: *Remove* aquatic plants, animals, and mud from waders and hip boots. *Drain* water from bait containers.

Personal watercraft: *Avoid* running engine through aquatic plants. *Run engine* for 5-10 seconds on the trailer to blow out excess water and vegetation from internal drive, then turn off engine. *Remove* aquatic plants and animals from water intake grate, steering nozzle, watercraft hull, and trailer.

Sailing: *Remove* aquatic plants and animals from hull, centerboard or bilge board wells, rudderpost area, and trailer.

Scuba diving: *Remove* aquatic plants, animals, and mud from equipment. *Drain* water from buoyancy compensator (bc), regulator, tank boot, and other containers. *Rinse* suit and inside of bc with hot water.

Waterfowl hunting: *Remove* aquatic plants, animals, and mud from boat, motor, trailer, waders or hip boots, decoy lines, and anchors (elliptical and bulb-shaped anchors can help reduce snagging aquatic plants). *Cut cattails* or other plants above the waterline when they are used for camouflage or blinds.