# KETTLE RIVER WATERSHED

12/31/2019

Kettle River Watershed Community Outreach and Engagement

## Grant project summary

Project title: Kettle River Watershed Community Outreach and Engagement

Organization (Grantee): Carlton County Soil and Water Conservation District

Project start date: 07/01/2017 Project end date: 12/31/2019 Report submittal date: 1/29/20

Grantee contact name: Melanie Bomier Title: Water Resources Technician

Address: 808 3rd Street

City: Carlton State: MN Zip: 55718

Phone number: 218-384-3891 Fax: Email: melanie.bomier@carltonswcd.org

Basin (Red, Minnesota, St. Croix, etc.) /Watershed & 8 digit HUC:: St. Croix Basin — Kettle (07030003) County: Carlton

**Project type** (check one):

☒ Education/Outreach/Engagement

## Grant funding

Final grant amount: $88,708 Final total project costs: $57,698.00

Matching funds: Final cash: Final in-kind: N/A Final Loan: N/A

MPCA project manager: Timothy Schwarz

## Executive summary of project (300 words or less)

### Problem (one paragraph)

Beginning in the summer of 2016, an intensive water quality monitoring and assessment program began in the Kettle River Watershed, to be complete in 2018. Information from the study was used to develop water quality restoration and protection plans for the Kettle Watershed. However, in addition to having a good understanding of water quality conditions and a toolbox of potential action steps, a serious and concerted effort must be made to integrate the involvement and engagement of watershed residents in the watershed project. Without a local understanding of water quality problems and local ownership of potential solutions to those problems, we are unlikely to be able to address water quality issues in an effective or sustainable manner.

### Waterbody improved (one paragraph)

This project helps the Carlton County Soil and Water Conservation District (SWCD) initiate a broader citizen participation process in the Kettle River Watershed than has been possible before. This proposed project enables Carlton County SWCD staff to inspire a greater degree of public interest in and awareness of the general health of the watershed. It also takes this work to the next step, by laying the foundation for greater citizen involvement in the planning and implementation of restoration and protection activities in the watershed. These efforts will help them to identify interested and motivated local leaders that are ready to work collaboratively with the District to address specific water quality problems.

### Project highlights (one paragraph)

Project highlights include an educational watershed tour, culvert workshop and three monitoring events. Materials including news articles, factsheets and an online application were also created. Articles were printed in local newspapers, shared through the St. Croix 360 website and also on the SWCD Social Media page. Factsheets were shared at watershed events including Barnum Spring Fever Days, Breakfast on the Farm and the Culvert Workshop. Based on the results of the watershed monitoring, we concluded that two audiences should be targeted to work towards E. coli reductions in impaired streams and protect water quality in our senstive Cisco Lakes. To accomplish this, we developed outreach lists in two key areas: forestry and agriculture and planned events to occur after this grant ends.

### Results (one paragraph)

Through this grant, Cartlon SWCD was able to build relationships with watershed residents and landowners, the Hanging Horn Lake Association, Barnum School District and Ag producers. We encouraged new citizen montiors and engaged about 125 children through water monitoring events. Five articles published in local newspapers helped educate and inspire stakeholders on important watershed issues. Events, including a Watershed Tour and Culvert Workshop, helped educate stakeholders and help build collaboration between Carlton & Pine Counties and SWCDs. The project culminatedwith an online Story Map to help tell the watershed's story and inspire action by watershed stakeholders. The work completed as part of this project will result in upcoming events in 2020 (funded outside of this grant) and beyond to further target outreach on key watershed issues, concerns and oppurtunities.

### Partnerships (Name all partners and indicate relationship to project)

Hanging Horn Area Lakes Association

Pheasants Forever

Carlton and Pine County Zoning & Environmental Services

Carlton County Transportation Department

Pine County Townships

Barnum Community Club

Barnum School District

Kettle River Watershed Ag Producers

MPCA Citzen Monitoring Program Staff and Volunteers

Pine SWCD

### Pictures

# Kettle River Watershed

**KETTLE RIVER WATERSHED COMMUNITY OUTREACH AND ENGAGEMENT**

**Section 1. Work Plan Review**

## Objective One: Build Citizen Capacity

### TASK A: EXPAND VOLUNTEER RECRUITMENT

Volunteer monitoring was recognized as a method to engage citizens in water quality and provide them with a way to connect to the watershed. Working with the MPCA Citizen Monitoring program, we looked at new ways to reach more volunteers.

**Subtask 2:** Conversations with the MPCA Citizen monitoring Program coordinators led to ideas on how we could recruit new volunteers.

**Subtask 1:** We received outreach materials to use at events where we promoted the program. A newspaper article was written by one of the Carlton SWCD Board Supervisors about the program and included interviews from both a lake and stream volunteer. After the article was published, we received several phone calls from people interested in participating, and we referred them to the program. We also presented at a local Kiwanis Club meeting about the program and why it was important. A local family who are stream volunteers were co-presenters. About 20 people were in attendance.


**MPCA Citizen Monitoring Program volunteers assisting with lake water monitoring.**

BUSINESS

**Samuelson column: Take the plunge into water monitoring**

Well, I did it. I took the plunge! The water's great and I aim to help keep it that way! No, I didn't "literally" jump into the water, especially this time of year. But after thinking about it for several years, I decided that now was the time to...

Written By: Kim Samuelson | Apr 29th 2019 - 7am.

Torina Stark uses a bucket to get water to pour into a Secchi tube. Photo courtesy of Carlton SWCD

Well, I did it. I took the plunge! The water's great and I aim to help keep it that way!

No, I didn't "literally" jump into the water, especially this time of year. But after thinking about it for several years, I decided that now was the time to put away "all talk, no action" and jump into

**Article from the local Pine Journal encouraging volunteers for the MPCA Citizen Monitoring Program**

## TASK B: DEVELOP OUTREACH MATERIALS, EVENTS AND WATERSHED TOURS

Throughout this grant, we explored different ways to connect with watershed residents.

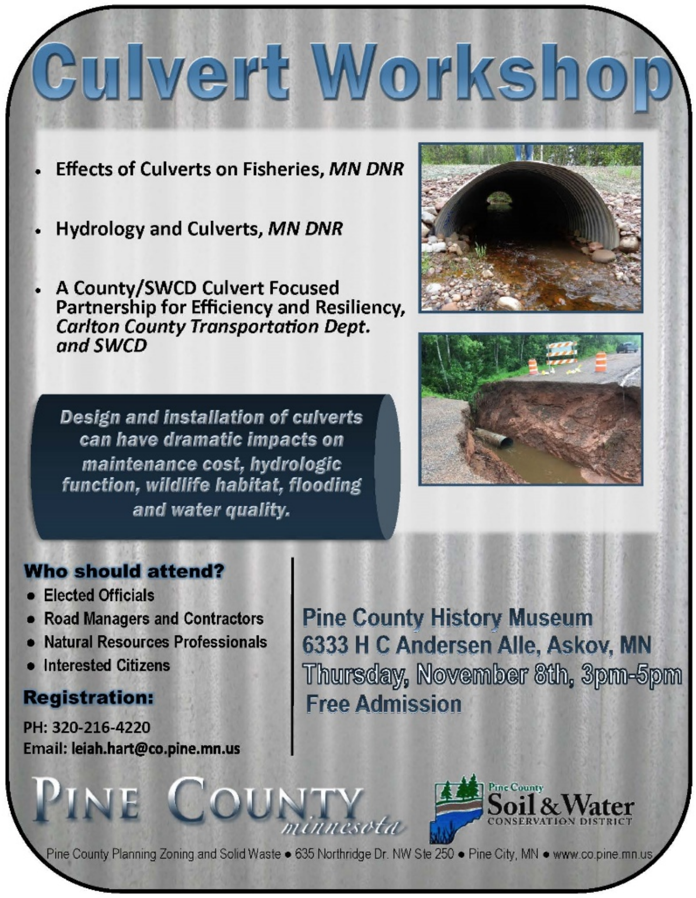
**Subtask 4:** In June 2018, we organized a watershed tour to highlight watershed resources and projects, including stream restoration, forestry, lake water quality, culverts and stream connectivity, wild rice and cisco. We discussed some of the waters that would be added to the impaired waters list and possible stressors in the watershed. We received positive feedback from the 23 attendees who represented a variety of stakeholder interests. Pine SWCD partnered with the tour.

**Subtask 1**: Factsheets were prepared for the tour that covered topics including: Stream restorations, culverts and forestry.




**Photos from the 2018 Kettle River Watershed Tour. Stops included forestry, stream restorations, lake concerns and more. Clockwise starting top left: A stop at a recent early successional habitat project near Mahtowa where attendees learned the value of forests and proper forest management in keeping our waters healthy. Kris Larson from Pine SWCD talks about a recently restored stream reach on the Kettle River near the Moose Horn River convergence. Karola Dalen from the Carlton County Environmental Services office educates participants on AIS and lakeshore management at Bear Lake near Barnum. Melanie Bomier from the Carlton SWCD talks about possible stressors to our biologically impaired streams near the headwaters of the Kettle River.**

Because of the great discussion from the culvert stop on our tour, we were asked to present to Pine County Townships on the value of fish-friendly culverts. About 15 township and county representatives attended the presentation in November 2018.




**Flyer from the November 2018 Culvert Workshop in Pine County where elected officials and road maintenance managers learned about the value of properly sized culverts for water quality, aquatic organism habitat and public safety.**

**Subtask 2:** In June of 2019, we showcased the Kettle River Watershed at Spring Fever Days in Barnum. We used macroinvertebrate identification to draw families into learning about the watershed and water quality. Bug samples were collected from the Moose Horn River, and children and adults helped sort and identify them using an Audubon Society Application called Creek Critters. We explained how bugs are a good indicator of how healthy a stream is, and we also learned that the Moose Horn River is a healthy stream. In addition to macroinvertebrate sampling, we set up a display of maps with the proposed impairments, photos of watershed characteristics and information about the citizen monitoring program. Secchi disks and tubes were on hand to demonstrate water clarity monitoring, along with water clarity samples from area waters so that people could compare different local streams. About 30 children and their parents participated.

**Photos from the Barnum Spring Fever Days event where we introduced children to aquatic macroinvertebrates to help them learn about water quality in the nearby Moose Horn River. We also displayed a watershed map and citizen monitoring program handouts.**

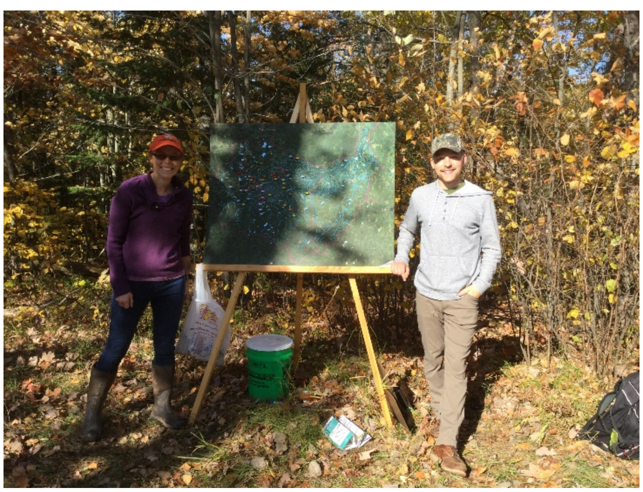
Also in June, we attended Carlton County's Breakfast on the Farm, where we helped with a rain simulator demonstration, showing the value of soil health in water quality. We also discussed watersheds with attendees. Approximately 200 people attended.


**Photos from Breakfast on the Farm where we shared watershed and soil health information using the NRCS rainfall simulator.**

July of 2019, we co-presented at Camp Connect in Kerrick. Building off our success at Spring Fever Days, we used macroinvertebrates collected from the Willow River to get kids excited about water quality. About 25 children, along with several high-school counselors and parents, attended. We partnered with Pine SWCD at the event.

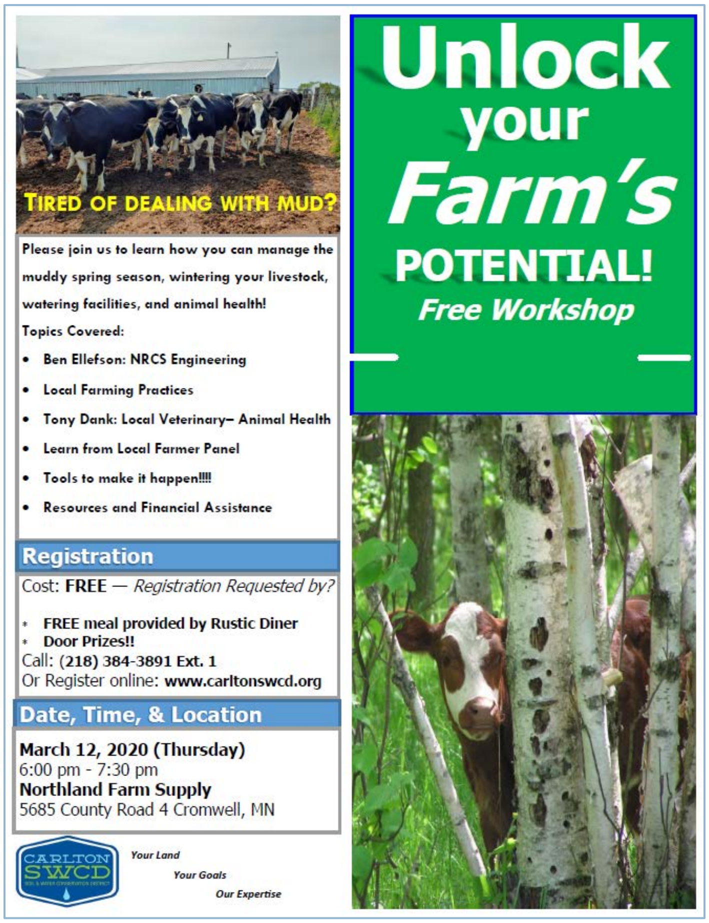
**Photo from Camp Connect in Kerrick where children learned about water quality in the Willow River.**

Building off our connections from Spring Fever Days and Camp Connect, we were asked to assist the Barnum High School to collect macroinvertebrate samples and conduct water monitoring as part of the River Watch Program. We presented information about watersheds and what students can do to protect water quality to approximately 70 students.



**Photos from the Barnum High School River Watch event where we talked about watersheds and stressors to water quality. Students collected water quality samples and macroinvertebrates.**

Two outreach campaigns were initiated towards the end of the grant. Based on E. coli results, we wanted to target feedlot landowners to help educate them on management strategies and share programs that are available to help them get started on implementation. We worked with the Minnesota Agriculture Certainty Program to organize an event on March 12th 2020 that will occur after this grant has ended. The focus will be on feedlot and livestock Best Management Practices (BMPs). The event will be held in the watershed at a local feedstore and speakers will include a local large animal veterinarian, NRCS engineering staff, a local farmer panel who are already implementing BMPS and MN Department of Agriculture and SWCD technical staff. A mailing list was developed using the GIS dataset developed as part of the WRAPS process that identified possible feedlot locations by air photo review. The non-registered feedlots will be invited along with registered feedlot operators. These individuals will be personally invited through a door-knocking campaign along with postcard/flyer mailings.

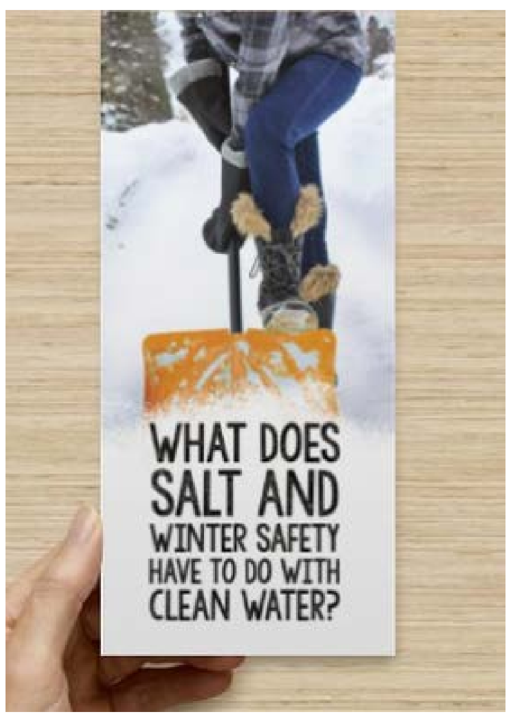



**Flyer that will be sent to potential feedlot owners in conjunction with a door-knocking campaign and postcard mailings.**

In addition, we saw the need to protect the Kettle River Watershed's forest from conversion to other land use types. In November 2019, we received a GIS analysis of forested land within the watershed, along with landowner contact tables. The tables provided multiple opportunities to target landowners for different reasons (drinking water protection, trout streams, riparian areas). We initiated targeted mailings from this list to encourage forest management and protection. Additional outreach was prepared for large parcel forest landowners near the watershed's lakes. These cards were mailed in 2019, but the work to protect forests will occur after the grant has ended.


**Example of a postcard mailing encouraging forest landowners to update their forest stewardship plan. This is the first step in protecting land through Sustainable Forestry Incentives Act (SFIA) program.**

Our final targeted audience was the urban area around Moose Lake. We wanted to connect city residents to their local lake (Moosehead Lake), explaining how their actions could impact water quality. Educational cards were created, and we plan to display these at the local library.



**Educational card connecting urban watershed residents' actions with their surrounding water resources.**

**Subtask 2**: One goal of this project was to create a Watershed Report Card based on the outcomes from the Intensive Watershed Monitoring and use them in pubic events and in meetings with local decision makers. Although we received a list of impairments, the results of the Stressor ID were not available until December 2019. We created maps showing the impairments and shared in general what the causes of these impairments might be, but without the in-depth Stressor ID report, it was difficult to create a report card that would help stakeholders understand their role in water quality or what actions could help make a difference.

## TASK C: DEVELOP ARTICLES FOR LOCAL MEDIA TO EDUCATE AND INFORM WATERSHED RESIDENTS

**Subtask 1-3**: Throughout the grant, Kettle River Watershed articles were submitted to local news media for publication. Topics included: an introduction to the watershed, feedlots, forestry, culverts and wetlands. Some of these articles were republished on the St. Croix 360 website.

Farmers partner with conservation district to reduce runoff into Kettle River tributary

Moose Lake farm works toward state water certification by collaborating with local agency to make numerous improvements.

BY KIM SAMUELSON | NOVEMBER 8, 2019 | 6 MINUTE READ

Facebook Twitter Email Print More

Ryan Clark, ag water quality certification specialist with the Carlton Soil and Water Conservation District, far left, with Russ and Renee Peterson. (Photo courtesy of the Carlton SWCD)

When it comes to soil health and water quality, farmers have always been some of the

SCIENCE AND NATURE

Samuelson column: Digging into culvert issues a win for humans, nature

Carlton SWCD, Transportation Department create culvert inventory with goal to responsibly use taxpayer funds for road maintenance

Written By: Kim Samuelson | Sep 23rd 2019 - 7pm.

Melanie Bomier of the Carlton Soil and Water Conservation District works on the culvert inventory. (Photo courtesy of Carlton SWCD)

Several weeks ago, the Carlton County Soil and Water Conservation District

BUSINESS

**Samuelson column: Farms important in water quality question**

It's finally springtime, and after a long winter, many people want to get outside and get busy with outdoor projects. That includes local farmers. For them, spring means that after a long winter of mostly barn living, and their animals can finall...

Written By: Kim Samuelson | Mar 26th 2019 - 11am.

A competed and in-use manure pit. Submitted photo

It's finally springtime, and after a long winter, many people want to get outside and get busy with outdoor projects. That includes local farmers.

BUSINESS

**Samuelson: Forestry education in action**

One of the main purposes of the Carlton County Soil and Water Conservation District is to teach people how to care for the natural environment. Throughout this past year, Kelly Smith, Carlton SWCD forestry technician, was instrumental in coordina...

Written By: Kim Samuelson | Dec 27th 2018 - 7am.

The summer "Walk in the Woods" was in Bob Asproth's forest near Mahtowa. Pictured, the group checks out a half-acre patch cut. Birch and maple seed trees are on the edge. Photo courtesy of Kim Samuelson

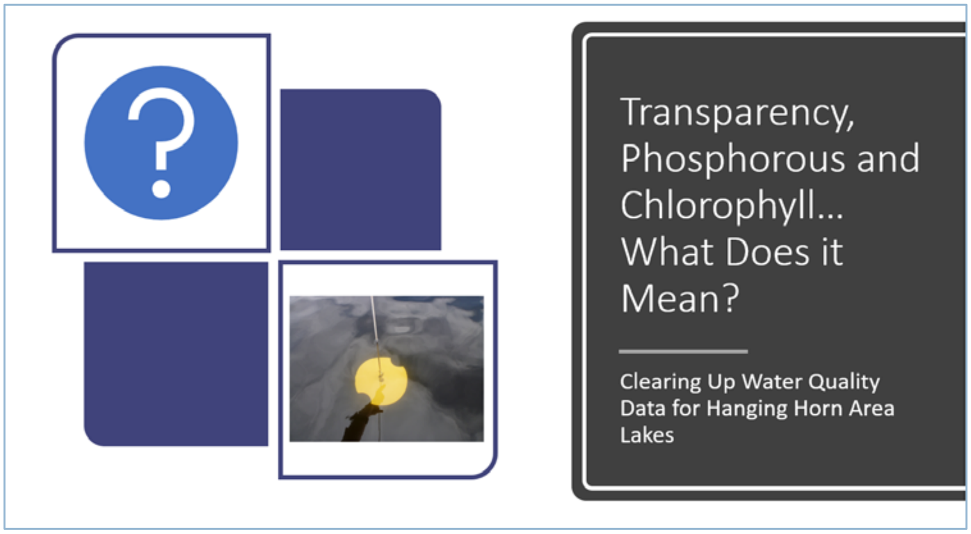
One of the main purposes of the Carlton County Soil and Water Conservation District is to teach people how to care for the natural environment.

**Articles published in the local Pine Journal to encourage good stewardship in the Kettle River Watershed.**
**Wetlands:** https://www.pinejournal.com/news/science-and-nature/4802475-Samuelson-column-Finding-gems-in-the-swamp
**Farms:** https://www.pinejournal.com/news/science-and-nature/4746637-Samuelson-column-How-farmers-can-improve-water-quality, https://www.pinejournal.com/business/agriculture/4588266-samuelson-column-farms-important-water-quality-question
**Culverts:** https://www.pinejournal.com/news/science-and-nature/4667472-Samuelson-column-Digging-into-culvert-issues-a-win-for-humans-nature
**Water Monitoring:** https://www.pinejournal.com/business/agriculture/4605022-samuelson-column-take-plunge-water-monitoring
**Forestry:** https://www.pinejournal.com/business/agriculture/4546176-samuelson-forestry-education-action
**Kettle River Watershed:** https://www.pinejournal.com/outdoors/nature/4215916-part-1-kettle-river-watershed-scenic-wild-and-unique , https://www.pinejournal.com/outdoors/nature/4220127-part-ii-two-important-minnesota-natives-call-kettle-river-home

## TASK D: STAKEHOLDER ENGAGEMENT

**Subtask 2:** Lake Associations are a valuable partner for lake water quality, and we were interested in learning how we could collaborate with them on future projects. In June 2018, we invited the Hanging Horn Lake Association (Hanging Horn, Little Hanging Horn, Edy and Bear Lakes) to a Lake Association Sharing event in Tamarack, MN. The goal of this event was to bring lake associations from around the region together to discuss their challenges and successes. In addition, speakers shared how to use social and print media to get their message out.

In 2019, we presented at the annual Hanging Horn Lake Association meeting, explaining water quality results for Hanging Horn, Little Hanging Horn, Bear and Eddy Lakes. In addition, we emphasized the importance of volunteer citizen monitoring to help us track water quality trends and included a guest speaker to talk about AIS. About 25 people were in attendance.




**Subtask 1**: The Water Resource Technician took the lead working with the Lake Association. The SWCD Administrator was not available to meet one-on-one during the grant period.

**Title slide for the annual Hanging Horn Lake Association presentation from June 2019.**

## TASK E: DEVELOP KEY WATER QUALITY MESSAGES

**Subtask 1:** In order to organize information on Kettle River Lakes, we contracted with RMB labs to produce lake-specific reports for lakes with enough data. These reports included watershed information, water quality trends and helpful maps. Not only were these reports valuable for lake residents and associations, but they also provided locations and projects to target protecting and improving water quality.

**Subtask 2:** Near the end of the project, we developed an online StoryMap to describe the watershed's valuable resources, water quality concerns and solutions that watershed stakeholders could implement on their own properties. The Kettle River Watershed WRAPS Story Map is available through the Carlton SWCD website: https://carltonswcd.org/kettle-river-watershed and was advertised on the Carlton SWCD Facebook page.

# Objective 2: Project Management

## TASK A: PROJECT ADMINISTRATION

The project budget was tracked, and timely submission of invoices was completed.

## TASK B: SEMI-ANNUAL PROGRESS REPORTS

A semi-annual progress report was submitted January 2018 and 2019 and July 2018 and 2019 as required.

# TASK C: FINAL REPORT

This final report was completed and submitted.

## Section II – Grant Results

Several deliverables were created as part of this project including:

- Additional citizen monitoring sites added on Echo Lake, Kettle River, Moose Horn River and Split Rock River.
- 2 phone meetings with the Carlton SWCD and the MPCA Citizen Monitoring Program staff
- 6 water quality factsheets created
- Kettle River Watershed Lake report card plus 5 report cards for individual lakes
- An educational bus tour of the watershed
- 7 Kettle River watershed articles
- A meeting with the Hanging Horn Area Lakes Association
- An ArcGIS Story Map that shares key water quality messages

Partnerships built during this project include:

- Hanging Horn Area Lakes Association
- Pheasants Forever
- Carlton and Pine County Zoning & Environmental Services
- Carlton County Transportation Department
- Pine County Townships
- Barnum Community Club
- Barnum School District
- Kettle River Watershed Ag Producers
- MPCA Citizen Monitoring Program Staff and Volunteers

Long Term results include:

- A feedlot workshop planned for March 2020
- Targeted forestry outreach to increase forestry protection in 2020

## Section III: Challenges

Although the project ran smoothly for the most part, there were a few challenges with staff turn-over both locally at the SWCD and MPCA offices. Luckily these transitions went relatively smoothly, resulting in our project ultimately being successful.

One deliverable not completed during the project was the watershed report card. The goal of this report card was to communicate the outcomes from the Intensive Watershed Monitoring process at public events. Although we were able to share impairment information through maps at our events and in our StoryMap and talk in general about what may be causing them, we did not receive the draft Stressor ID report until December 2019. This report is the basis for understanding why a water may be impaired, which we felt was an important component of a report card.

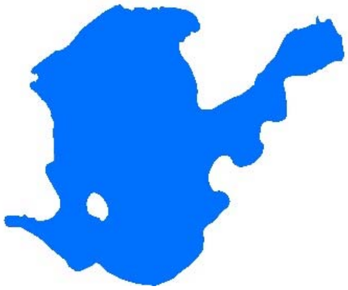
The SWCD Administrator was not available to meet one-on-one with Lake Associations during the grant period. Instead, the Water Resources Technician took the lead and presented water quality information to them.

## Section IV: Final Expenditures

See attached sheet.

# Bear Lake

**09-0034-00 Carlton County**



Bear Lake is located 0.5 miles southeast of Barnum, MN in Carlton County. It is a small lake covering 90 acres (Table 1).

Bear Lake has two minor inlets and one outlet, which classify it as a drainage lake. Water enters Bear Lake from groundwater streams in the south and northeast and flows out through Cub lake to the Moose Horn River. Since the inlet streams are intermittent, there is likely some groundwater interaction as well.

Water quality data have been collected on Bear Lake from 1996-2001 and from 2009-2016 (Tables 2 & 3). These data show that the lake is mesotrophic (TSI = 49) with moderately clear water conditions most of the summer.

There is a joint Lake Association on Bear, Eddy, Hanging Horn and Little Hanging Horn lakes. They have an organized golf tournament and are involved in lake monitoring and education.

Table 1. Bear Lake location and key physical characteristics.

| Location Data | |
|---|---|
| MN Lake ID: | **09-0034-00** |
| County: | **Carlton County** |
| Ecoregion: | **Northern Lakes and Forests** |
| Major Watershed: | **Kettle River** |
| Latitude/Longitude: | **46.497713, -92.677686** |
| Invasive Species: | **Eurasian Watermilfoil** |

| Physical Characteristics | |
|---|---|
| Surface area (acres): | **90.4** |
| Littoral area (acres): | **62.5** |
| % Littoral area: | **69.1%** |
| Max depth (ft), (m): | **31, 9.45** |
| Inlets: | **2** |
| Outlets: | **1** |
| Public Accesses: | **1** |

Table 2. Availability of primary data types for Bear Lake.

| Data Availability | | |
|---|---|---|
| Transparency data | | **Good** |
| Chemical data | | **Good – multiple years, but with gaps between the years** |
| Inlet/Outlet data | -- | **Not necessary** |
| Recommendations | | **For recommendations refer to page 15.** |

## Lake Map

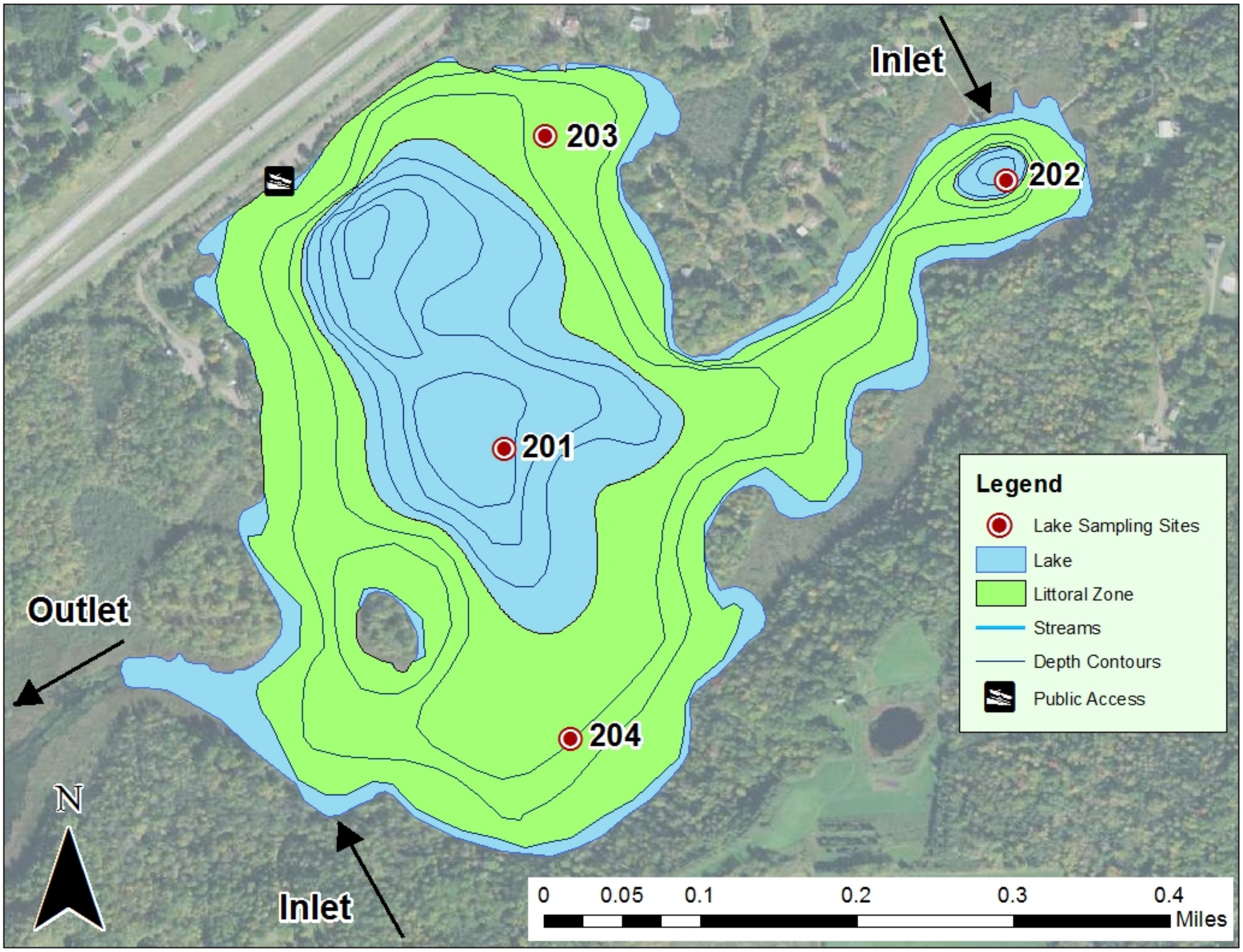



*Figure 1. Map of Bear Lake with 2010 aerial imagery and illustrations of lake depth contour lines, sample site locations, inlets and outlets, and public access points. The light green areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom, allowing aquatic plants to grow.*

*Table 3. Monitoring programs and associated monitoring sites. Monitoring programs include the Citizen Lake Monitoring Program (CLMP), Mississippi River-Grand Rapids Carlton SWCD (SWCD), and MPCA Lake Monitoring Program (MPCA).*

| Lake Site | Depth (ft) | Monitoring Programs |
|---|---|---|
| 201* Primary site | 30 | CLMP: 1996-2000, 2010-2016; SWCD: 2009-2010, 2016; MPCA: 1982, 1997 |
| 202 | 25 | CLMP: 2000-2001 |
| 203 | 15 | CLMP: 2001 |
| 204 | 15 | CLMP: 2001 |

## Average Water Quality Statistics & Comparisons

The information below describes available chemical data for Bear Lake through 2017 (Table 4). Data for total phosphorus, chlorophyll *a*, and Secchi depth are from the primary site 201.

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation and geology. The Minnesota Pollution Control Agency (MPCA) has developed a way to determine the "average range" of water quality expected for lakes in each ecoregion[1] (Table 4). Bear Lake is in the Northern Lakes and Forests Ecoregion (Figure 2).

The MPCA has developed Impaired Waters Standards for lakes in each ecoregion to determine if a lake is impaired for excess phosphorus/eutrophication (Table 4). Lakes that are over the impaired waters standards are placed on the state's Impaired Waters List[2].


*Figure 2. Minnesota ecoregions.*

*Table 4. Water quality means compared to ecoregion ranges and impaired waters standard.*

| Parameter | Mean | Ecoregion Range[1] | Impaired Waters Standard[2] | Interpretation |
|---|---|---|---|---|
| Total phosphorus (ug/L) | 25.2 | 14 – 27 | > 30 | Results are within the expected range for the Northern Lakes and Forests Ecoregion and the lake is not impaired for excess phosphorus. |
| [3]Chlorophyll *a* (ug/L) | 7.2 | 4 – 10 | > 9 | |
| Chlorophyll *a* max (ug/L) | 21.9 | < 15 | | |
| Secchi depth (ft) | 9.2 | 8 – 15 | < 6.5 | |
| Dissolved oxygen | *See page 8* | | | Dissolved oxygen depth profiles show that the lake mixes in spring and fall (dimictic). |
| Total Kjeldahl Nitrogen (mg/L) | 0.62 | <0.4 – 0.75 | | Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms. |
| Alkalinity (mg/L) | 57.8 | 40 – 140 | | Indicates a low sensitivity to acid rain and a good buffering capacity. |
| Color (Pt-Co Units) | 26 | 10 – 35 | | Indicates mostly clear water with some tannins (brown stain). |
| pH | 8.8 | 7.2 – 8.3 | | Indicates a hard water lake. Lake water pH less than 6.5 can affect fish spawning and the solubility of metals in the water. |
| Chloride (mg/L) | 29.1 | 0.6 – 1.2 | | Above the expected range for the ecoregion and could be due to the proximity of the city of Barnum the I35 Freeway and road salts. |
| Total Suspended Solids (mg/L) | 3.5 | <1 – 2 | | Above the expected range for the ecoregion, but still considered low level. |
| Specific Conductance (umhos/cm) | 186.7 | 50 – 250 | | Within the expected range for the ecoregion. |
| TN:TP Ratio | 24.6:1 | 25:1 - 35:1 | | Shows the lake is phosphorus limited. |

[1]The ecoregion range is the 25th-75th percentile of summer means from ecoregion reference lakes: https://www.pca.state.mn.us/quick-links/eda-guide-typical-minnesota-water-quality-conditions
[2]For further information regarding the Impaired Waters Assessment program, refer to http://www.pca.state.mn.us/water/tmdl/index.html
[3]Chlorophyll *a* measurements have been corrected for pheophytin
Units: 1 mg/L (ppm) = 1,000 ug/L (ppb)

## Water Quality Characteristics - Historical Means and Ranges

*Table 5. Water quality means and ranges for primary sites.*

| Parameters | Primary Site 201 | Site 202 | Site 203 | Site 204 |
|---|---|---|---|---|
| **Total Phosphorus Mean (ug/L):** | 25 | | | |
| Total Phosphorus Min: | 8 | | | |
| Total Phosphorus Max: | 43 | | | |
| Number of Observations: | 22 | | | |
| **Chlorophyll *a* Mean (ug/L):** | 7 | | | |
| Chlorophyll-a Min: | 1 | | | |
| Chlorophyll-a Max: | 22 | | | |
| Number of Observations: | 23 | | | |
| **Secchi Depth Mean (ft):** | 9.2 | 5.8 | 7.5 | 7.2 |
| Secchi Depth Min: | 2.0 | 3.0 | 5.5 | 5.5 |
| Secchi Depth Max: | 15.0 | 7.5 | 10.0 | 10.5 |
| Number of Observations: | 168 | 6 | 5 | 5 |

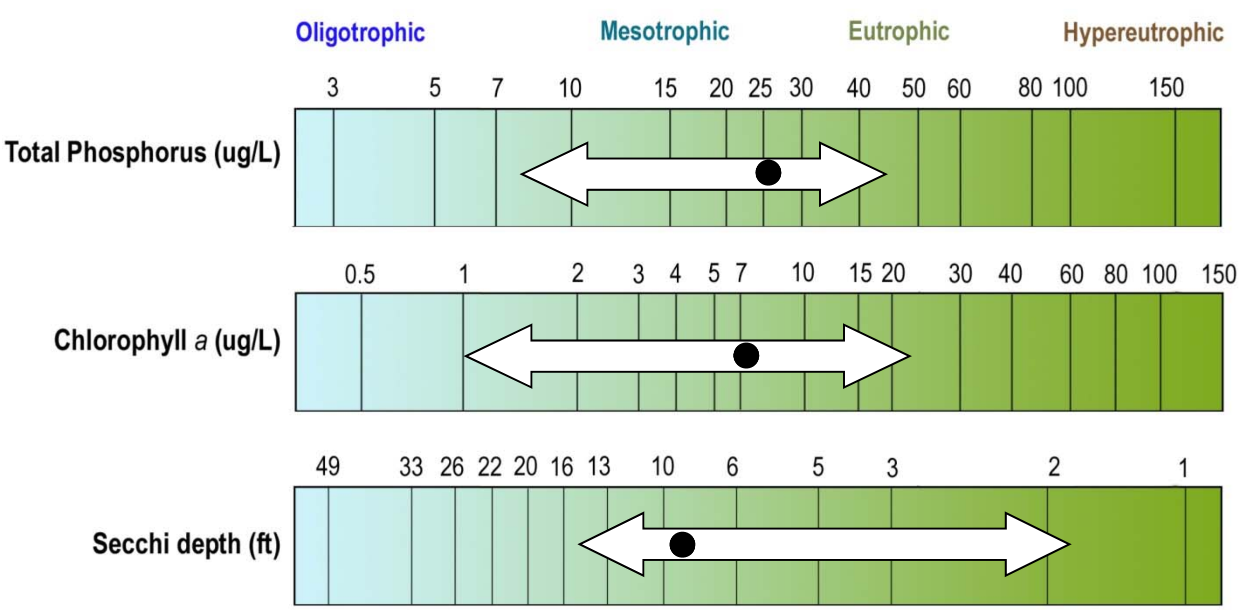



*Figure 3. Bear Lake total phosphorus, chlorophyll a and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 201). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. EPA 440/5-88-002)*

## Transparency (Secchi Depth)

Transparency is how easily light can pass through a substance. In lakes it is how deep sunlight penetrates through the water. Plants and algae need sunlight to grow, so they are only able to grow in areas of lakes where the sun penetrates. Water transparency depends on the number of particles in the water. An increase in particulates results in a decrease in transparency. The transparency varies year to year due to changes in weather, precipitation, lake use, flooding, temperature, lake levels, etc.

The annual mean transparency in Bear Lake ranges from 6.6 to 11.1 feet (Figure 4). The annual means hover up and down around the long-term mean. For trend analysis, see page 10. Transparency monitoring should be continued annually at site 201 in order to track water quality changes.

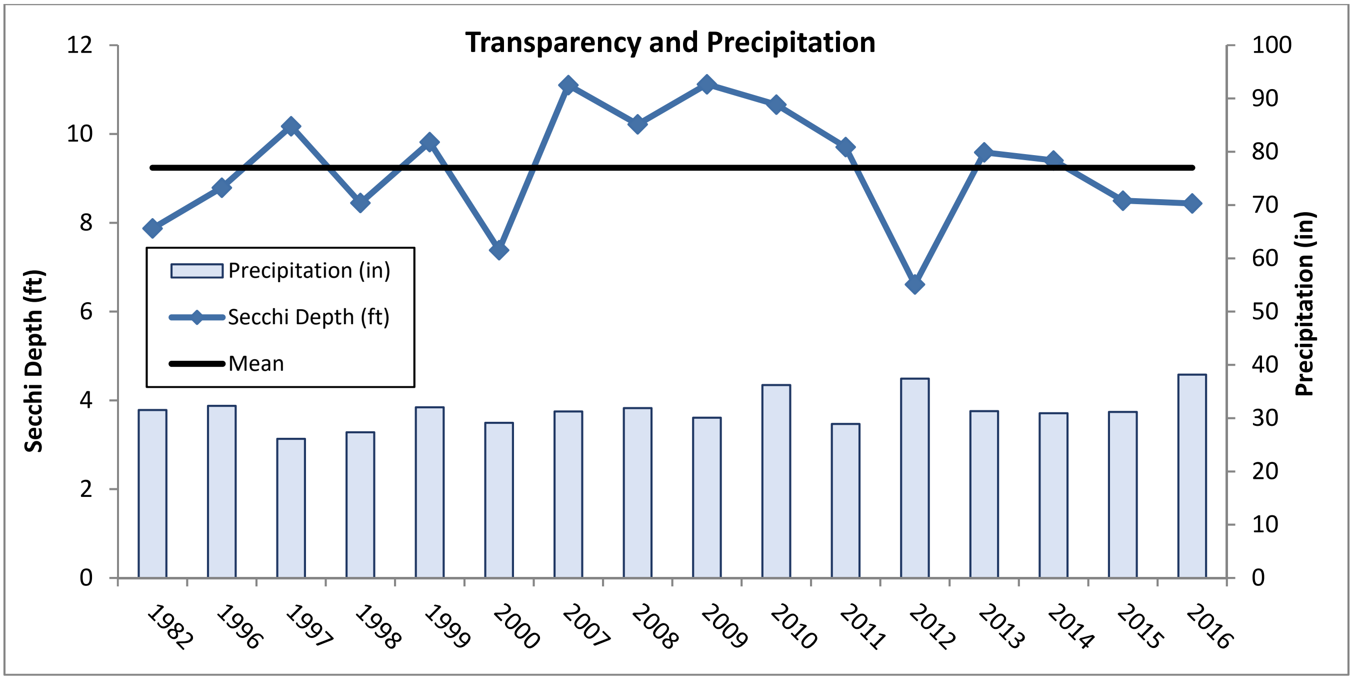


*Figure 4. Annual mean transparency compared to long-term mean transparency*

Bear Lake transparency ranges from 2.0 to 15.0 ft at the primary site (Table 5). Figure 5 shows the seasonal transparency dynamics. The maximum Secchi reading is usually obtained in early summer. Bear Lake transparency is high in May and June, and then declines through August. This transparency dynamic is typical of a Minnesota lake. The dynamics have to do with algae and zooplankton population dynamics, and lake turnover.

It is important for lake residents to understand the seasonal transparency dynamics in their lake so that they are not worried about why their transparency is lower in August than it is in June. It is typical for a lake to vary in transparency throughout the summer.

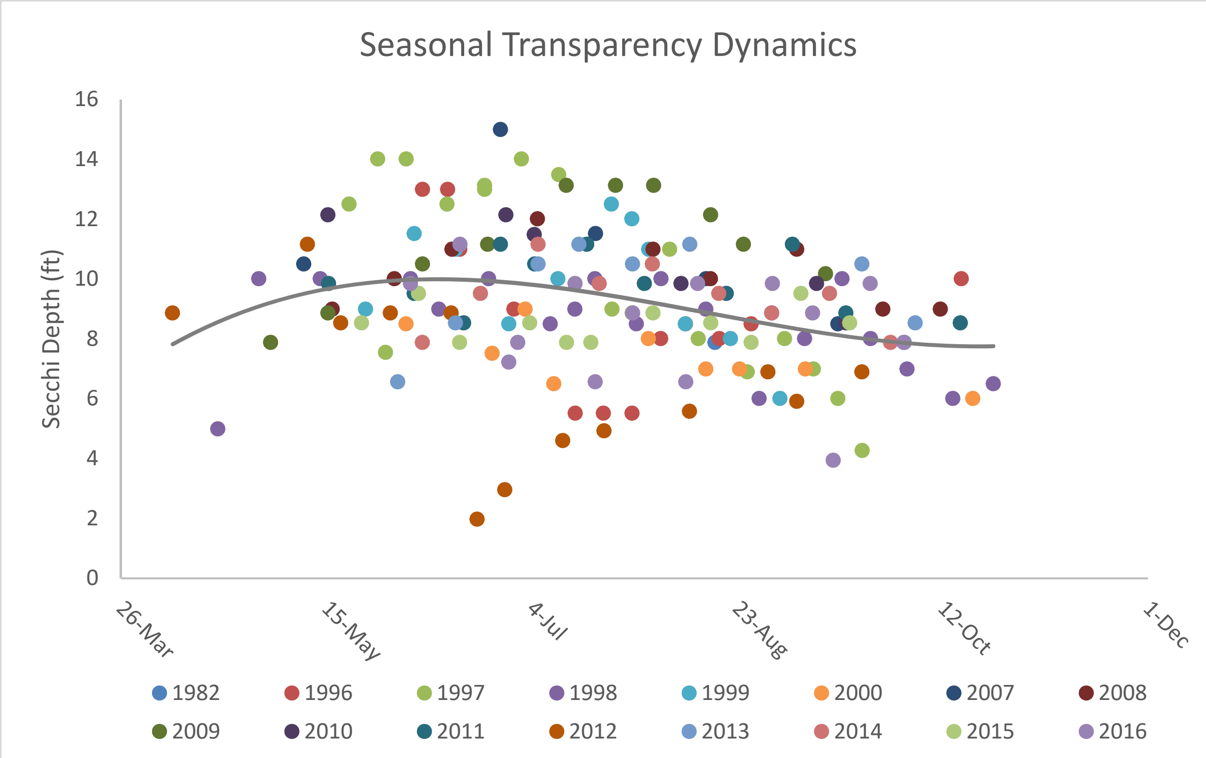



*Figure 5. Seasonal transparency dynamics and year to year comparison (Primary Site 201). The gray line represents the pattern in the data.*

## User Perceptions

When volunteers collect Secchi depth readings, they record their perceptions of the water based on the physical appearance and the recreational suitability. These perceptions can be compared to water quality parameters to see how the lake "user" would experience the lake at that time. Looking at transparency data, as the Secchi depth decreases the perception of the lake's physical appearance and recreational suitability decreases (Figures 6-7).

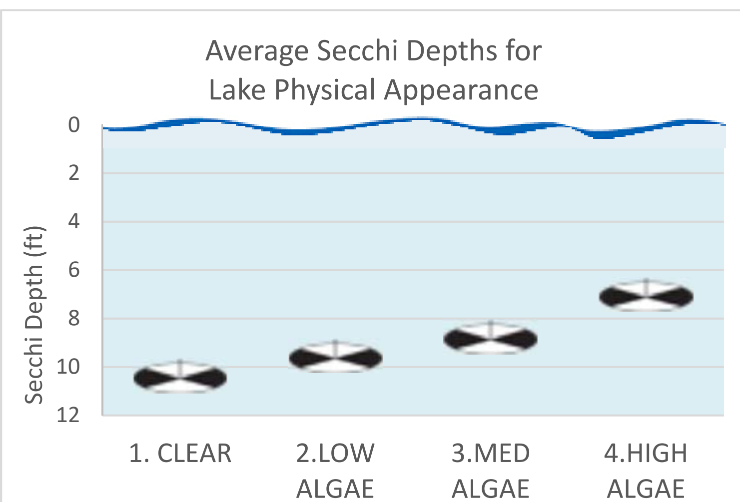



*Figure 7. Average Secchi depth (ft) for each lake physical appearance rating.*

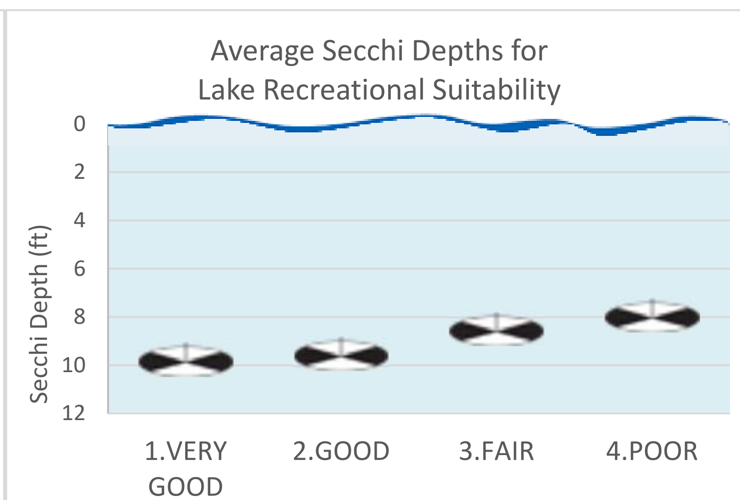



*Figure 6. Average Secchi depth (ft) for each lake recreational suitability rating.*

## Algae

Chlorophyll *a* is the pigment that makes plants and algae green. Chlorophyll *a* is tested in lakes to determine the algae concentration or how "green" the water is.

Chlorophyll *a* concentrations greater than 10 ug/L are perceived as a mild algae bloom, while concentrations greater than 20 ug/L are perceived as a nuisance.

Chlorophyll *a* was evaluated in Bear Lake at site 201 in 1982, 1997, 2009-2010, and 2016 (Figure 8). Chlorophyll *a* concentrations went above 10 ug/L in 2010 and 2016, indicating minor algae blooms. Chlorophyll *a* concentrations were above 20 ug/L in 1997, indicating a major algae bloom. There was not much variation over the years monitored and chlorophyll *a* concentrations are usually highest in late summer.

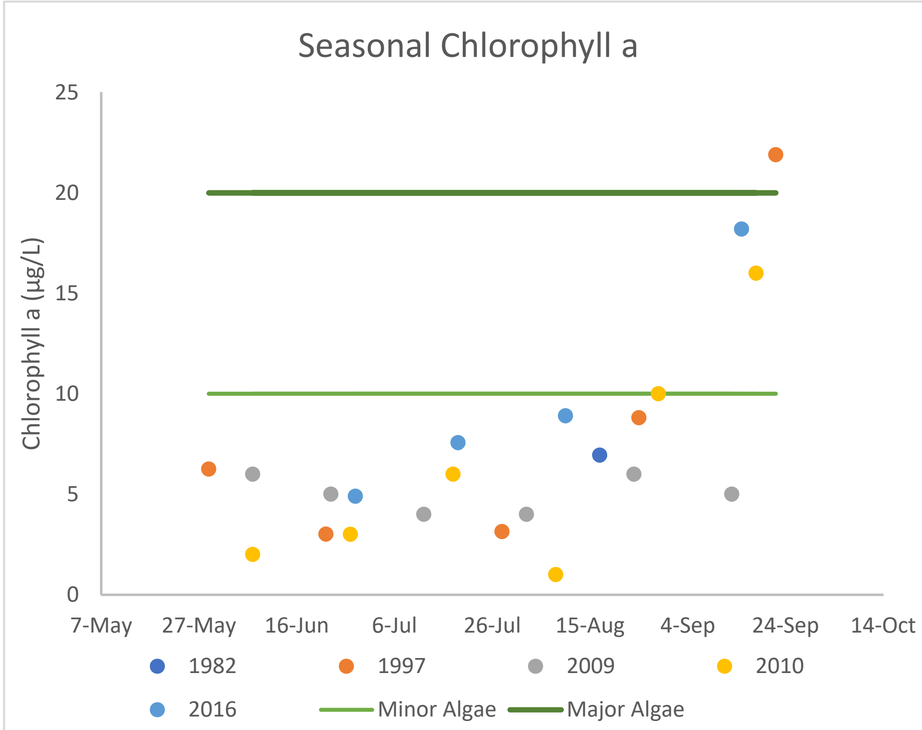



*Figure 8. Chlorophyll a concentrations (ug/L) for Bear Lake at site 201.*

## Phosphorus

Bear Lake is phosphorus limited, which means that algae and aquatic plant growth is dependent upon available phosphorus.

Total phosphorus was evaluated in Bear Lake in 1997, 2009-2010, and 2016. The data do not indicate much seasonal variability. The majority of the data points fall into the mesotrophic or eutrophic ranges (Figure 9).

Phosphorus should continue to be monitored to track any future changes in water quality.

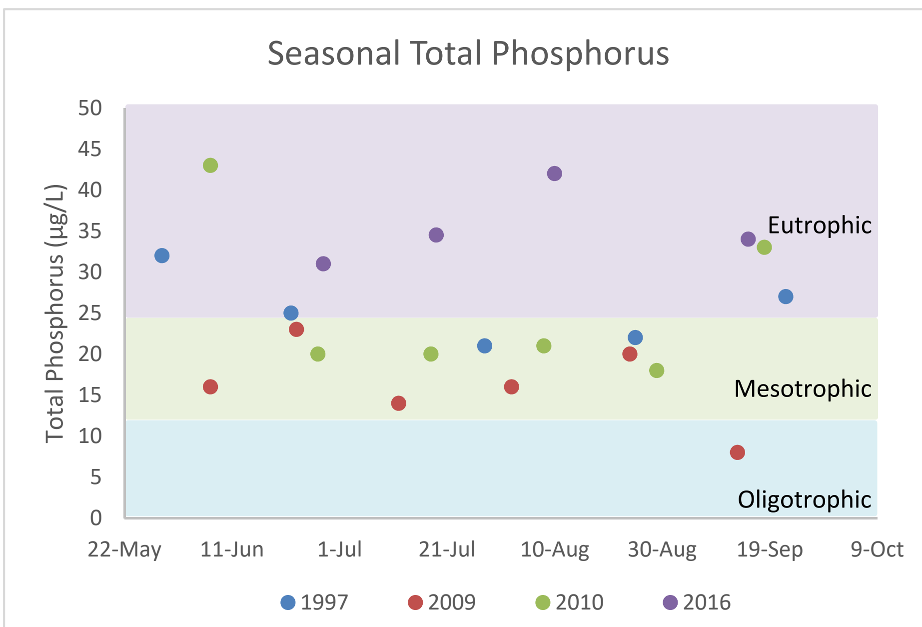
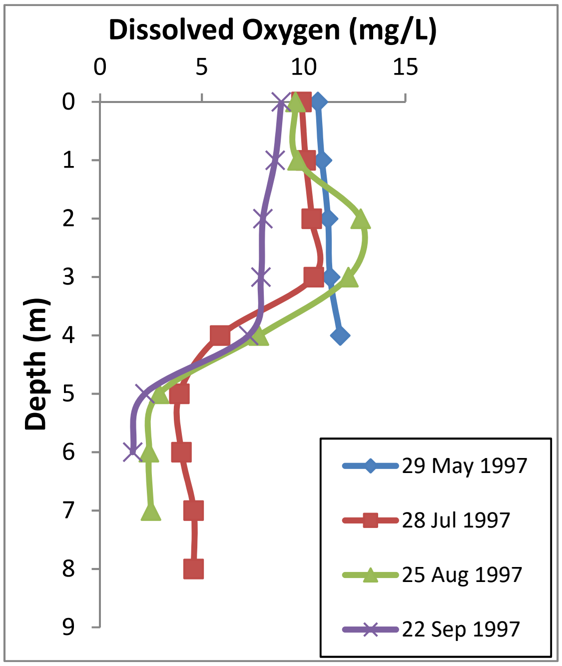



*Figure 9. Historical total phosphorus concentrations (ug/L) for Bear Lake site 201.*

## Oxygen




Dissolved Oxygen (DO) is the amount of oxygen dissolved in lake water. Oxygen is necessary for all living organisms to survive except for some bacteria. Living organisms breathe in oxygen that is dissolved in the water. Dissolved oxygen levels of <5 mg/L are typically avoided by game fisheries.

Bear Lake is a moderately shallow lake, with a maximum depth of 31 feet. Dissolved oxygen profiles from data collected in 1997 at site 201 show stratification developing during the summer (Figure 10). The thermocline in 1997 was around 3 meters (10 feet). Dissolved oxygen was below 5 mg/L in August and September meaning gamefish will likely be scarce in the deeper water at that time.

*Figure 10. Representative dissolved oxygen profiles from 1997 in Bear Lake.*

## Trophic State Index (TSI)

TSI is a standard measure or means for calculating the trophic status or productivity of a lake. More specifically, it is the total weight of living algae (algae biomass) in a waterbody at a specific location and time. Three variables, chlorophyll a, Secchi depth, and total phosphorus, independently estimate algal biomass.

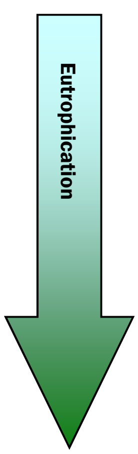
If all three TSI numbers are within a few points of each other, they are strongly related. If they are different, there are other dynamics influencing the lake's productivity, and TSI mean should not be reported for the lake. Bear Lake falls into the mesotrophic range (Tables 6, 7).

*Table 6. Trophic State Index for Bear Lake.*

| **Trophic State Index** | |
|---|---|
| **TSI Phosphorus** | 51 |
| **TSI Chlorophyll-a** | 50 |
| **TSI Secchi** | 45 |
| **TSI Mean** | 49 |
| **Trophic State:** | Mesotrophic |

*Numbers represent the mean TSI for each parameter.*

*Table 7. Trophic state index attributes and their corresponding fisheries and recreation characteristics.*




**Bear Lake**

| TSI | Attributes | Fisheries & Recreation |
|---|---|---|
| <30 | **Oligotrophy:** Clear water, oxygen throughout the year at the bottom of the lake, deep cold water. | Trout fisheries dominate. |
| 30-40 | Bottom may become anoxic (no oxygen). | Trout fisheries in deep lakes only. Walleye, Cisco present. |
| 40-50 | **Mesotrophy:** Water moderately clear most of the summer. May be "greener" in late summer. | No oxygen at the bottom of the lake results in loss of trout. Walleye may predominate. |
| 50-60 | **Eutrophy:** Algae and aquatic plant problems possible. "Green" water most of the year. | Warm-water fisheries only. Bass may dominate. |
| 60-70 | Blue-green algae dominate, algal scums and aquatic plant problems. | Dense algae and aquatic plants. Low water clarity may discourage swimming and boating. |
| 70-80 | **Hypereutrophy:** Dense algae and aquatic plants. | Water is not suitable for recreation. |
| >80 | Algal scums, few aquatic plants. | Rough fish (carp) dominate; summer fish kills possible. |

Source: Carlson, R.E. 1997. A trophic state index for lakes. *Limnology and Oceanography*. 22:361-369.

## Trend Analysis

For detecting trends, a minimum of 8-10 years of data with 4 or more readings per season are recommended. Minimum confidence accepted by the MPCA is 90%. This means that there is a 90% chance that the data are showing a true trend and a 10% chance that the trend is a random result of the data. Only short-term trends can be determined with just a few years of data, because there can be different wet years and dry years, water levels, weather, etc, that affect the water quality naturally.

Bear Lake had enough data to perform a trend analysis on transparency (Table 8). The data was analyzed using the Mann Kendall Trend Analysis.

*Table 8. Trend analysis for Bear Lake.*

| Lake Site | Parameter | Date Range | Trend |
|---|---|---|---|
| 201 | Total Phosphorus | 1997-2016 | No significant trend |
| 201 | Chlorophyll *a* | 1982-2016 | No significant trend |
| 201 | Transparency | 2007-2016 | No significant trend |

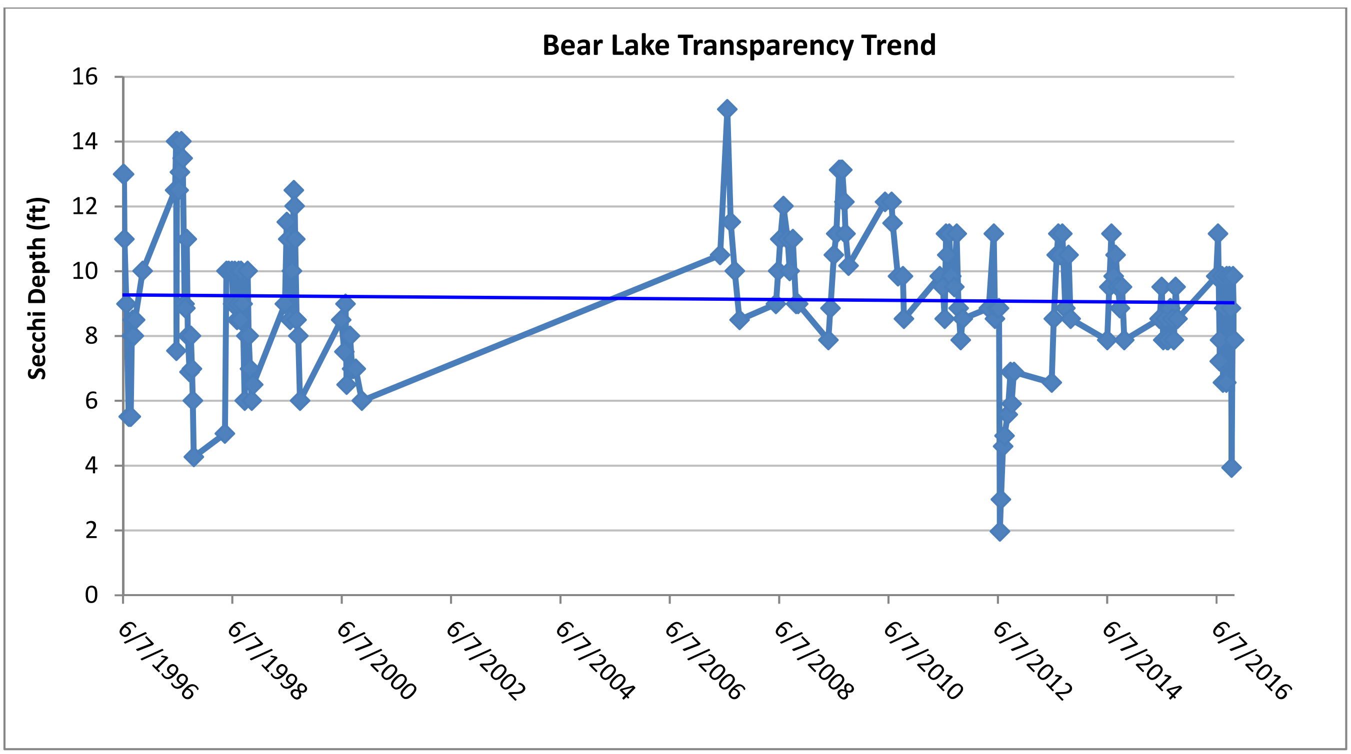



*Figure 11. Transparency (feet) trend for site 201 from 1996-2016.*

Bear Lake shows insufficient evidence for a transparency trend (Figure 11). There was a large gap in data between 2000-2006. Since then, 2012 had much lower transparency than average, but it improved again after 2012. See the recommendations section for more explanation (page 15). Transparency monitoring should continue so that this trend can be tracked in future years.

## Lakeshed

Understanding a lakeshed requires an understanding of basic hydrology. A watershed is defined as all land and water surface area that contribute excess water to a defined point. The MN DNR has delineated three basic scales of watersheds (from large to small): 1) basins, 2) major watersheds, and 3) minor watersheds.

The Kettle River Major Watershed is one of the watersheds that make up the St. Croix River Basin, which drains south to the Gulf of Mexico (Figure 12).

The MN DNR also has evaluated catchments for each individual lake with greater than 100 acres surface area. These lakesheds (catchments) are the "building blocks" for the larger scale watersheds. Bear Lake falls within lakeshed 3502400 (Figure 12). Though very useful for displaying the land and water that contribute directly to a lake, lakesheds are not always true watersheds because they may not show the water flowing into a lake from upstream streams or rivers. While some lakes may have only one or two upstream lakesheds draining into them, others may be connected to a large number of lakesheds, reflecting a larger drainage area via stream or river networks.

In an effort to prioritize protection and restoration efforts of fishery lakes, the MN DNR has developed a ranking system by separating lakes into two categories based on their lakeshed, those needing protection and those needing restoration. Modeling by the DNR Fisheries Research Unit suggests that total phosphorus concentrations increase significantly over natural concentrations in lakes that have watershed with disturbance greater than 25%. Therefore, lakes with watersheds that have less than 25% disturbance need protection and lakes with more than 25% disturbance need restoration (Table 9). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land, public surface waters, wetlands, or conservation easement.

*Table 9. Suggested approaches for watershed protection and restoration of DNR-managed fish lakes in Minnesota.*

| Watershed Disturbance (%) | Watershed Protected (%) | Management Type | Comments |
|---|---|---|---|
| < 25% | > 75% | Vigilance | Sufficiently protected -- Water quality supports healthy and diverse native fish communities. Keep public lands protected. |
| | < 75% | Protection | Excellent candidates for protection -- Water quality can be maintained in a range that supports healthy and diverse native fish communities. Disturbed lands should be limited to less than 25%. |
| 25-60% | n/a | Full Restoration | Realistic chance for full restoration of water quality and improve quality of fish communities. Disturbed land percentage should be reduced and BMPs implemented. |
| > 60% | n/a | Partial Restoration | Restoration will be very expensive and probably will not achieve water quality conditions necessary to sustain healthy fish communities. Restoration opportunities must be critically evaluated to assure feasible positive outcomes. |

The next step was to prioritize lakes within each of these management categories. DNR Fisheries identified high value fishery lakes, such as cisco refuge lakes. Ciscos (*Coregonus artedi)* can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. These watersheds with low disturbance and high value fishery lakes are excellent candidates for priority protection measures, especially those that are related to forestry and minimizing the effects of landscape disturbance. Forest stewardship planning, harvest coordination to reduce hydrology impacts and forest conservation easements are some potential tools that can protect these high value resources for the long term.

Bear Lake's lakeshed is classified with having 52% of the watershed protected and 13% of the watershed disturbed (Figure 13). Therefore, this lakeshed should have a protection focus. Goals for the lake should be to limit any increase in disturbed land use and to maintain current protection levels. Bear Lake is a headwaters lakeshed, which means that no other lakesheds flow into it (Figure 12).

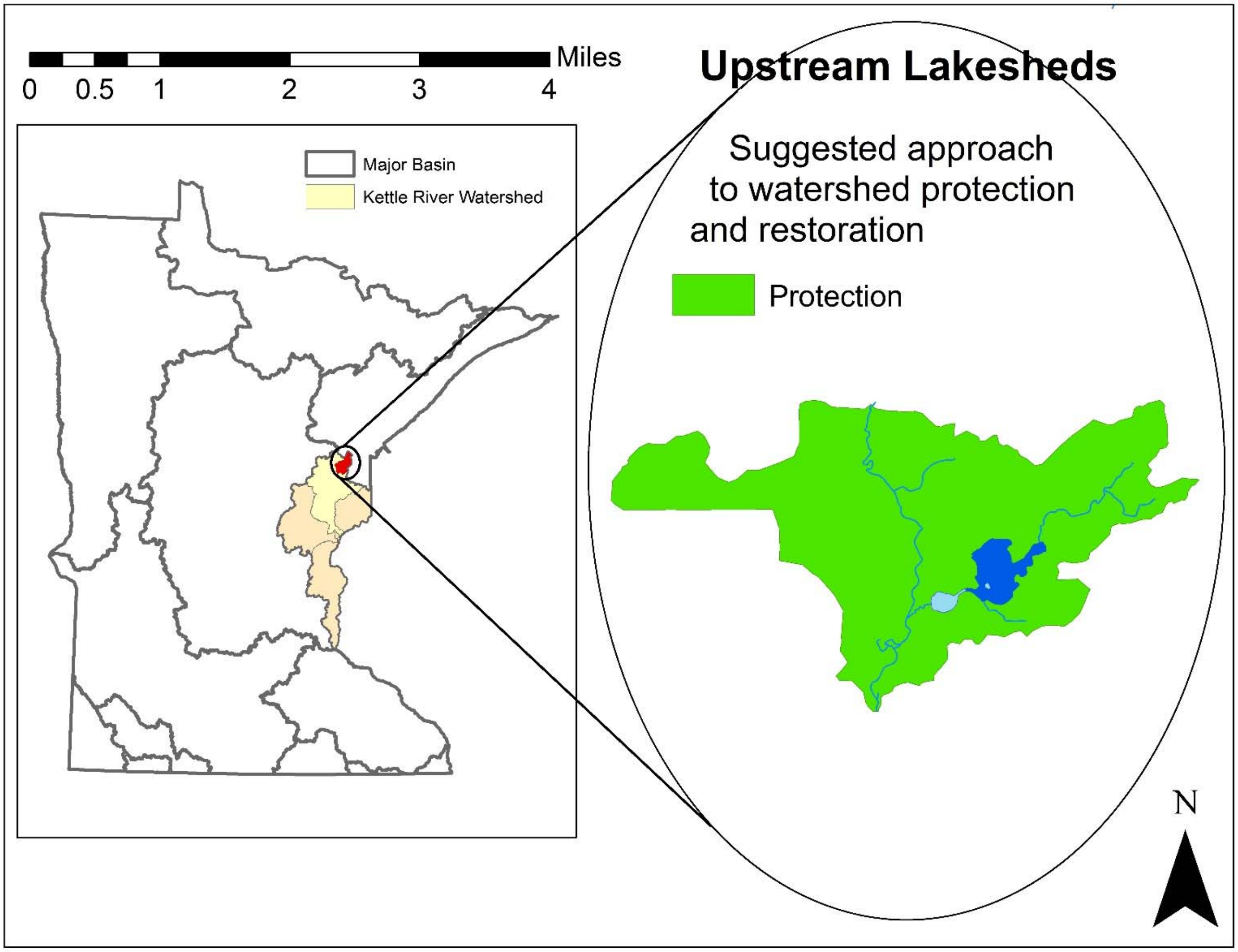



*Figure 12. Kettle River major watershed and MN basins (left), and Bear Lake lakeshed and upstream catchments with protection suggestions (right).*

## Land use and Ownership

Activities that occur on the land within the lakeshed can greatly impact a lake. Land use planning helps ensure the use of land resources in an organized fashion so that the needs of the present and future generations can be best addressed.

Over half (52%) of the Bear Lake lakeshed is protected (Figure 13). This total includes water, wetlands, and publicly owned land. There is one parcel along the lakeshore which has conservation potential. It is private land over 20 acres which is less than 50% developed or agriculture.

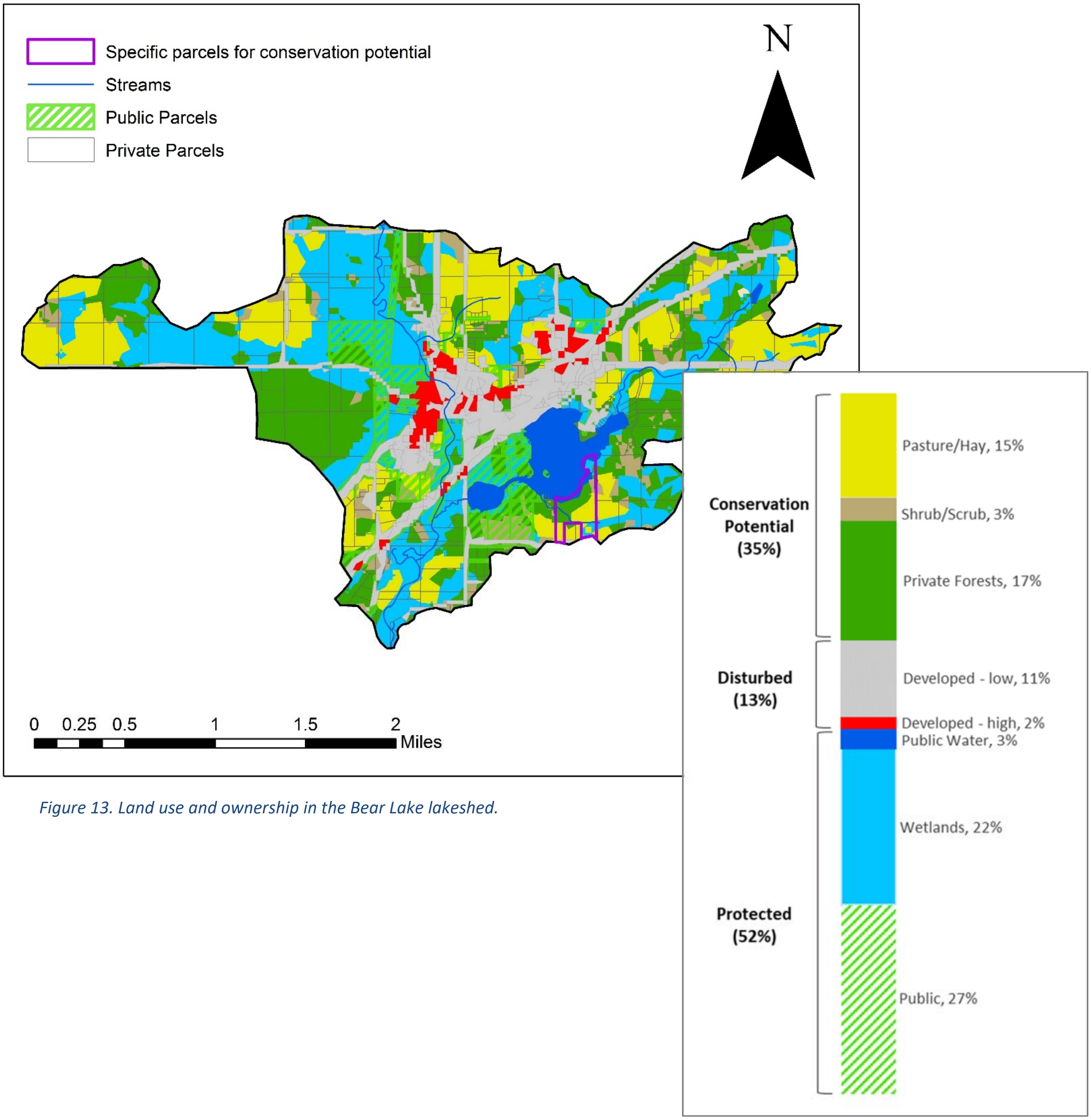



*Figure 13. Land use and ownership in the Bear Lake lakeshed.*

The lakeshed vitals table identifies where to focus organizational and management efforts for each lake (Table 10). Criteria were developed using limnological concepts to determine the effect to lake water quality.

**KEY**

Possibly detrimental to the lake

Warrants attention

Beneficial to the lake

*Table 10. Bear Lake lakeshed vitals table.*

| Lakeshed Vitals | | Rating |
|---|---|---|
| **Lake Area** | 90.4 acres | descriptive |
| **Littoral Zone Area** | 62.5 acres | descriptive |
| **Lake Max Depth** | 31 ft. | descriptive |
| **Lake Mean Depth** | 11 ft. | Warrants attention |
| **Water Residence Time** | NA | Not available |
| **Miles of Stream** | 6.7 | descriptive |
| **Inlets** | 2 | Warrants attention |
| **Outlets** | 1 | Beneficial to the lake |
| **Major Watershed** | 35 – Kettle River | descriptive |
| **Minor Watershed** | 35024 | descriptive |
| **Lakeshed** | 3502400 | descriptive |
| **Ecoregion** | Northern Lakes and Forest | descriptive |
| **Total Lakeshed to Lake Area Ratio** (total lakeshed includes lake area) | 34:1 | Warrants attention |
| **Standard Watershed to Lake Basin Ratio** (standard watershed includes lake areas) | 34:1 | Beneficial to the lake |
| **Wetland Coverage** | 26.3% | Beneficial to the lake |
| **Aquatic Invasive Species** | Eurasian Watermilfoil | Possibly detrimental to the lake |
| **Public Drainage Ditches** | None | Beneficial to the lake |
| **Public Lake Accesses** | 1 | Warrants attention |
| **Miles of Shoreline** | 2.61 | descriptive |
| **Shoreline Development Index** | 1.59 | Beneficial to the lake |
| **Public Land to Private Land Ratio** | 0.2:1 | Warrants attention |
| **Development Classification** | Recreational Development | Warrants attention |
| **Miles of Road** | 23.0 | descriptive |
| **Municipalities in lakeshed** | Barnum | Possibly detrimental to the lake |
| **Forestry Practices** | None | Beneficial to the lake |
| **Feedlots** | None | Beneficial to the lake |
| **Sewage Management** | Compliance inspections are required for subsurface sewage treatment systems at point-of-sale or permit application in shoreland areas. | Beneficial to the lake |
| **Lake Management Plan** | None | Warrants attention |
| **Lake Vegetation Survey/Plan** | DNR, 2016 | Beneficial to the lake |

## Bear Lake, Status of the Fishery (DNR, 8/3/2015)

A standard survey was conducted on Bear Lake during the summer of 2015 to update information about fish populations. Walleye is the primary management species for Bear Lake and fingerlings are stocked during even numbered years. Walleye abundance of 1.0 per gillnet lift was average compared to other Minnesota lakes of similar type. Walleye average length was large at 20.1 inches. Two year-classes were represented, and both corresponded to stocked year-classes.

Angling opportunities for Largemouth Bass are notable in Bear Lake with fish up to 20.6 inches sampled. The Largemouth Bass electrofishing catch rate was 29.0 fish per hour, which is average compared to other Duluth Area Largemouth Bass populations. Mean length of sampled bass was good at 14.6 inches.

Panfish population density was average compared to other similar Minnesota lakes. Black Crappie average length was 6.8 inches but only 10% exceeded eight inches. Bluegill averaged 6.3 inches with some quality fish available up to 8.5 inches. Yellow Perch were scarce and small.

Northern Pike abundance of 7.0 per gillnet lift was above average compared to other Minnesota lakes of similar type. Mean length was 22.8 inches and over 50% of the fish captured exceeded 24 inches long.

Eurasion water milfoil was identified in Bear Lake during this survey. The infestation was well established and was very thick in the immediate vicinity of the public access, among other areas. The lake has been designated as infested waters and signs were posted to notify those using the public water access. Designation of the lake as an infested water prohibits the transport of water and harvest of bait. Extreme care must be exercised by thoroughly cleaning boats and trailers when leaving the lake to avoid spreading the aquatic invasive species to other waterbodies.

Development pressure is increasing around the shorelines and within the watersheds of many Minnesota lakes. This development can degrade water quality and impact valuable shoreline habitat. Native shoreline vegetation provides habitat for fish and wildlife, filters harmful nutrients, and protects against shoreline erosion. Lakeshore owners can minimize their impact on the shoreline and maintain a more natural setting while actually decreasing annual maintenance. For more information on how to accomplish this, contact the nearest Area Fisheries office or go to the following website: www.dnr.state.mn.us/shorelandmgmt

See the link below for specific information on gillnet surveys, stocking information, and fish consumption guidelines. http://www.dnr.state.mn.us/lakefind/showreport.html?downum=09003400

## Key Findings and Recommendations

**Monitoring Recommendations**
Transparency monitoring at site 201 should be continued annually. It is important to continue transparency monitoring weekly or at least bimonthly every year to enable year-to-year comparisons and trend analyses. Phosphorus and chlorophyll a monitoring should continue at site 201, as the budget allows, to track future water quality trends.

**Overall Conclusions**
Bear Lake is a mesotrophic lake (TSI = 49) with insufficient evidence of a long-term trend in water clarity. The total phosphorus, chlorophyll *a* and transparency ranges are within the ecoregion ranges (Table 4).

Over half of the Bear Lakeshed is protected (52%), which includes public ownership, wetlands, and open water, and 17% of the lakeshed land area is forested. Only 13% of the lakeshed is disturbed, which includes high and low levels of development (Figure 13).

The city of Barnum and Interstate 35 are adjacent to Bear Lake. Chloride concentration in the lake was monitored in 1997 and 2016 and is higher than expected for the region (Table 4). The chloride is still under the state standard though; the state standard is 207 mg/L and Bear Lake is 29 mg/L. This higher chloride could be due to road salt use in Barnum and on I35. More information about chloride monitoring and guidelines can be found at the Minnesota Pollution Control Agency's website here: https://www.pca.state.mn.us/water/chloride-salts. Stormwater from the city and Interstate 35 could be diverted to a sediment basin before running into Bear Lake to protect the lake from chloride runoff.

**Phosphorus Loading and Priority Impacts**
Bear Lake is at an advantage because the lake is a headwaters lake, which means no additional water flows into this lake from upstream lakes or rivers. The inlets to the lake are intermittent and groundwater and/or wetland fed. (Figure 1). This means that the land practices around Bear Lake and in it's lakeshed are the main impacts to the lake (Figure 13).

*Table 11. Watershed characteristics.*

| | |
|---|---|
| **Lakeshed to Lake Area Ratio** (lakeshed includes lake area) | 34:1 |
| **Watershed to Lake Area Ratio** (watershed includes lake areas) | 34:1 |
| **Number of Upstream Lakes** | 0 |
| **Headwaters Lake?** | Yes |
| **Inlets / Outlets** | 2 / 1 |
| **Water Residence Time** | NA |

Bear Lake has insufficient evidence for a strong trend in transparency from 2007-2016 (Table 8, Figure 11), but the graph shows much lower than average transparency in 2012. Water level monitoring shows an increase of five feet over the ordinary high water mark in 2012, which could have caused the lower transparency (Figure 14). High water can cause shoreline erosion and cause decreased water transparency. Maintaining wetlands in the lakeshed help with water storage and can decrease the impact from high water events.

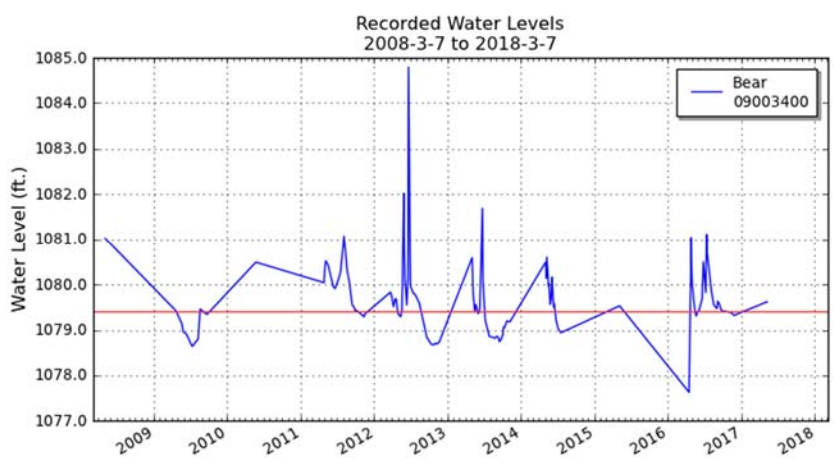



*Figure 14. Monitored water levels in Bear Lake, Source: MN DNR Lakefinder.*

**Best Management Practices Recommendations**
The management focus for Bear Lake should be to protect the current water quality and the lakeshed. Efforts should be focused on managing and/or decreasing the impact caused by current and additional development, including second tier development, and impervious surface area. Project ideas include protecting land with conservation easements, enforcing county shoreline ordinances, shoreline restoration, rain gardens, and septic system maintenance.

## Bear Lake Goals

1. Protection Focus: minimize disturbed land uses and maintain protected lands
2. Manage phosphorus loading from **nearshore**, Table 12
3. Focused BMPs per land type: Table 12

*Table 12. Best Management Practices Table specific to Bear Lake (refer to Figure 13 for locations).*

| Category | Land use type | Conservation project ideas | Results | Who | Contact for help |
|---|---|---|---|---|---|
| Conservation Potential Land (35%) | private forests (17%, 528 acres) | Forest stewardship planning, 3rd party certification, SFIA, local woodland cooperatives | Conserve and protect current forest cover | • Individual Property Owners | Carlton SWCD (218) 384-3891 https://carltonswcd.org/ |
| | pasture/hay (15%, 466 acres) | Conservation Reserve Program (CRP), maintain vegetative cover, plant trees, conservation easements, grassed waterways, ditch buffers, maintain/restore wetlands. | Reduce water runoff and soil erosion, better water storage | • Individual Property Owners | Natural Resources Conservation Service 123-4567-8910, info@swcd.org |
| Disturbed Land (13%) | developed, low intensity (11%, 144 acres) | Shoreline buffers, rain gardens | Reduce water runoff and shoreline erosion. | • Individual Property Owners | Carlton SWCD (218) 384-3891 https://carltonswcd.org/ |
| | developed, high intensity (2%, 26 acres) | Sediment basins, rain gardens, shoreline buffers, stormwater retention. | Reduce water runoff into streams and lakes. | • Individual Property Owners<br>• Cities<br>• Lake Associations | Carlton SWCD (218) 384-3891 https://carltonswcd.org/ |

The publicly owned land at the lake's outlet is a good location for land protection (Figure 13). Although the impervious surface from the city of Barnum and I35 can't be removed, runoff from it can be managed so that it doesn't impact water quality. See table 12 for project ideas.

The current lakeshore homeowners can lessen their negative impact on water quality by installing or maintaining the existing trees on their properties. Forested uplands contribute significantly less phosphorus (lbs/acre/year) than developed land cover (Table 12).

One sixth of the lakeshed is privately owned forested uplands (Table 12). Forested uplands can be managed with Forest Stewardship Planning, 3rd party certification, SFIA, and local woodland cooperatives. Contact the Soil and Watershed Conservation District for options for managing private forests.

The lakeshed still has a couple of large undeveloped shoreline parcels (Figure 13). Because a lot of undeveloped private land still exists, there is a great potential for protecting this land with conservation easements and aquatic management areas (AMAs). Conservation easements can be set up easily and with little cost with help from organizations such as the Board of Soil and Water Resources and the Minnesota Land Trust. AMAs can be set up through the local DNR fisheries office.

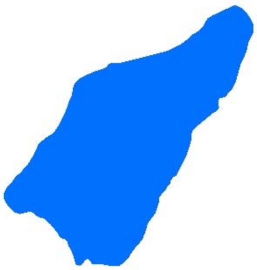
Native aquatic plants stabilize the lake's sediments and tie up phosphorus in their tissues. When aquatic plants are uprooted from a shallow lake, the lake bottom is disturbed, and the phosphorus in the water column gets used by algae instead of plants. This contributes to "greener" water and more algae blooms. Protecting native aquatic plant beds will ensure a healthy lake and healthy fishery. If a swimming area is necessary in front of people's docks, clear only a small area of plants. Clearing a whole 100 foot frontage is not necessary and can contribute to additional algae blooms.

*Table 13. Organizational contacts and reference sites*

| Organizational contacts and reference sites | |
|---|---|
| Hanging Horn Lakeshore Management Association | P.O. Box 192 Barnum, MN 55707 |
| DNR Fisheries Office | 5351 North Shore Drive, Duluth, MN 55804<br>218-302-3264, duluth.fisheries@state.mn.us |
| Regional Minnesota Pollution Control Agency Office | 525 Lake Avenue South, Suite 400, Duluth, MN 55802<br>218-723-4660<br>https://www.pca.state.mn.us/about-mpca/duluth-office |
| Carlton County Soil and Water Conservation District | 808 3rd St, Carlton, MN 55718<br>(218) 384-3891, https://carltonswcd.org/ |
| Carlton County | 301 Walnut Ave, Carlton, MN 55718<br>http://carltoncountymn.govoffice3.com/ |

# Eddy Lake

## 09-0039-00 Carlton County



Eddy Lake is located 2 miles south of Barnum, MN in Carlton County. It is a small lake covering 23 acres (Table 1).

Eddy Lake has two inlets and one outlet, which classify it as a drainage lake. Water enters Eddy Lake from Mud Lake in the south and Moose Horn River in the north. The Moose Horn River exits the lake on the west side of Eddy Lake and carries water south to Mississippi River.

Water quality data have been collected on Eddy Lake from 1995-2016 (Tables 2 & 3). These data show that the lake is mesotrophic (TSI = 48) with moderately clear water conditions most of the summer and good recreational opportunities.

There is a joint Lake Association on Bear, Eddy, Hanging Horn and Little Hanging Horn lakes. They have an organized golf tournament and are involved in lake monitoring and education.

Table 1. Eddy Lake location and key physical characteristics.

| Location Data | |
|---|---|
| MN Lake ID: | **09-0039-00** |
| County: | **Carlton County** |
| Ecoregion: | **Northern Lakes and Forests** |
| Major Watershed: | **Kettle River** |
| Latitude/Longitude: | **46.476069, -92.711404** |
| Invasive Species: | **None** |

| Physical Characteristics | |
|---|---|
| Surface area (acres): | **23.5** |
| Littoral area (acres): | **9.5** |
| % Littoral area: | **40.3** |
| Max depth (ft), (m): | **36.3, 11.1** |
| Inlets: | **2** |
| Outlets: | **1** |
| Public Accesses: | **0** |

Table 2. Availability of primary data types for Eddy Lake.

| Data Availability | |
|---|---|
| Transparency data | **Good, enough for trend analysis** |
| Chemical data | **Low – only one year of data** |
| Inlet/Outlet data | **A volunteer is monitoring the inlet for transparency.** |
| Recommendations | **For recommendations refer to page 15.** |

## Lake Map

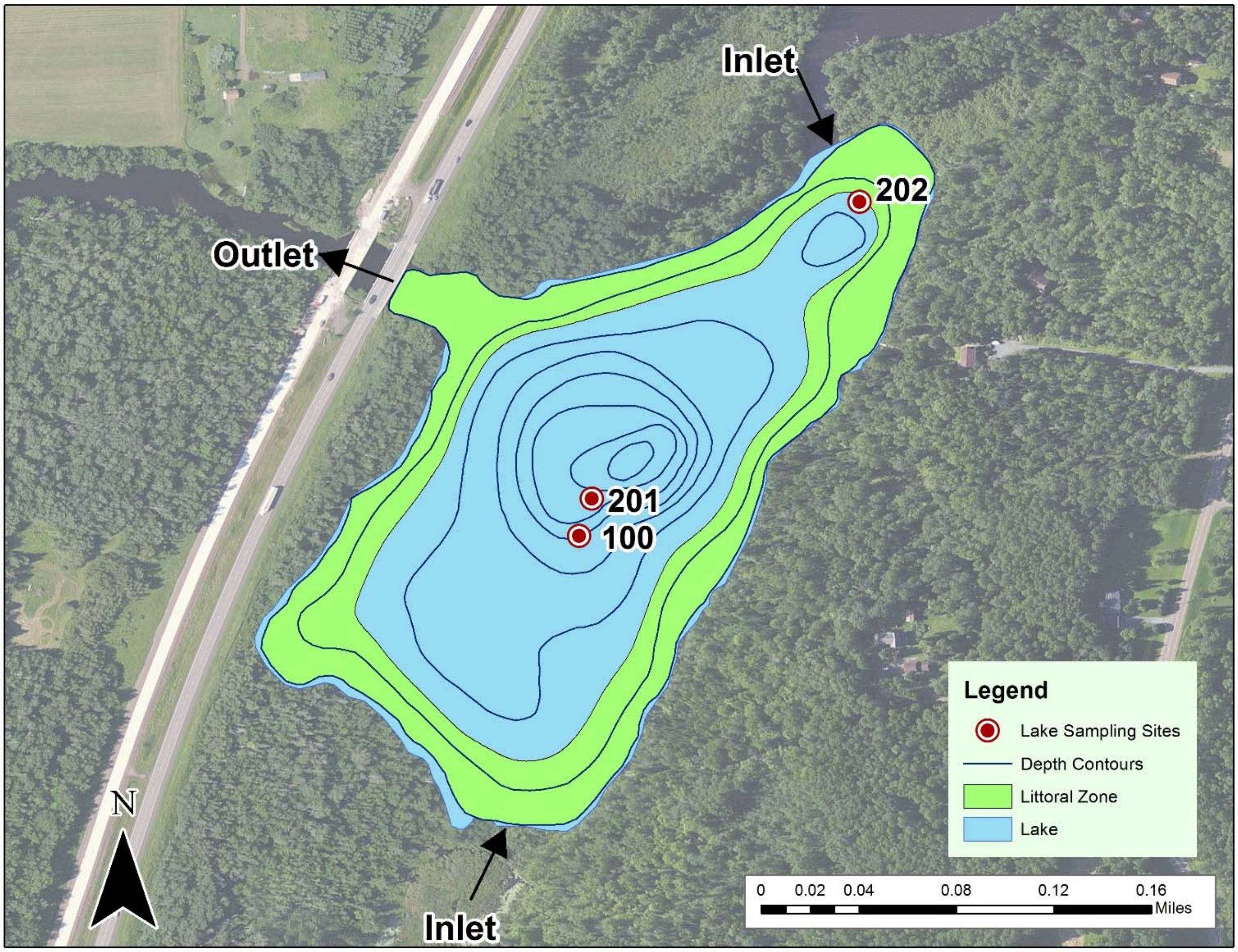



*Figure 1. Map of Eddy Lake with 2010 aerial imagery and illustrations of lake depth contour lines, sample site locations, inlets and outlets, and public access points. The light green areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom, allowing aquatic plants to grow.*

*Table 3. Monitoring programs and associated monitoring sites. Monitoring programs include the Citizen Lake Monitoring Program (CLMP), MPCA Lake Monitoring Program (MPCA), and Citizens Monitoring Bacteria (CMB).*

| Lake Site | Depth (ft) | Monitoring Programs |
|---|---|---|
| 100 | 20 | MPCA: 1997 |
| 201*Primary site | 30 | CLMP: 1995-2016 |
| 202 | 15 | CMB: 2007 |

## Average Water Quality Statistics & Comparisons

The information below describes available chemical data for Eddy Lake through 2017 (Table 4). Data for total phosphorus, chlorophyll *a*, and Secchi depth are from the primary site 201.

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation and geology. The Minnesota Pollution Control Agency (MPCA) has developed a way to determine the "average range" of water quality expected for lakes in each ecoregion[1] (Table 4). Eddy Lake is in the Northern Lakes and Forests Ecoregion (Figure 2).

The MPCA has developed Impaired Waters Standards for lakes in each ecoregion to determine if a lake is impaired for excess phosphorus/eutrophication (Table 4). Lakes that are over the impaired waters standards are placed on the state's Impaired Waters List[2].


*Figure 2. Minnesota ecoregions.*

*Table 4. Water quality means compared to ecoregion ranges and impaired waters standard.*

| Parameter | Mean | Ecoregion Range[1] | Impaired Waters Standard[2] | Interpretation |
|---|---|---|---|---|
| Total phosphorus (ug/L) | 21.2 | 14 – 27 | > 30 | Phosphorus and chlorophyll *a* results are within the expected range for the Northern Lakes and Forests Ecoregion. |
| [3]Chlorophyll *a* (ug/L) | 4.4 | 4 – 10 | > 9 | |
| Chlorophyll *a* max (ug/L) | 7.9 | < 15 | | |
| Secchi depth (ft) | 6.3 | 8 – 15 | < 6.5 | |
| Dissolved oxygen | *See page 8* | | | Dissolved oxygen depth profiles show that the lake typically mixes throughout the summer, but can periodically stratify. |
| Total Kjeldahl Nitrogen (mg/L) | 0.58 | <0.4 – 0.75 | | Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms. |
| Alkalinity (mg/L) | 40.4 | 40 – 140 | | Indicates a low sensitivity to acid rain and a good buffering capacity. |
| Color (Pt-Co Units) | 70 | 10 – 35 | | Indicates water with high levels of tannins (brown stain). |
| pH | NA | 7.2 – 8.3 | | Data not available |
| Chloride (mg/L) | 2.9 | 0.6 – 1.2 | | Slightly above the expected range for the ecoregion, but still considered low level. |
| Total Suspended Solids (mg/L) | 1.6 | <1 – 2 | | Within the expected range for the ecoregion. |
| Specific Conductance (umhos/cm) | 80 | 50 – 250 | | Within the expected range for the ecoregion. |
| TN:TP Ratio | 27.5:1 | 25:1 - 35:1 | | Within the expected range for the ecoregion, and shows the lake is phosphorus limited. |

[1]The ecoregion range is the 25th-75th percentile of summer means from ecoregion reference lakes: https://www.pca.state.mn.us/quick-links/eda-guide-typical-minnesota-water-quality-conditions
[2]For further information regarding the Impaired Waters Assessment program, refer to http://www.pca.state.mn.us/water/tmdl/index.html
[3]Chlorophyll *a* measurements have been corrected for pheophytin
Units: 1 mg/L (ppm) = 1,000 ug/L (ppb)

## Water Quality Characteristics - Historical Means and Ranges

*Table 5. Water quality means and ranges for primary sites.*

| Parameters | Primary Site 201 |
|---|---|
| **Total Phosphorus Mean (ug/L):** | 21.2 |
| Total Phosphorus Min: | 15.0 |
| Total Phosphorus Max: | 26.0 |
| Number of Observations: | 5 |
| **Chlorophyll *a* Mean (ug/L):** | 4.3 |
| Chlorophyll-a Min: | 1.4 |
| Chlorophyll-a Max: | 7.9 |
| Number of Observations: | 5 |
| **Secchi Depth Mean (ft):** | 6.3 |
| Secchi Depth Min: | 4.9 |
| Secchi Depth Max: | 8.5 |
| Number of Observations: | 362 |

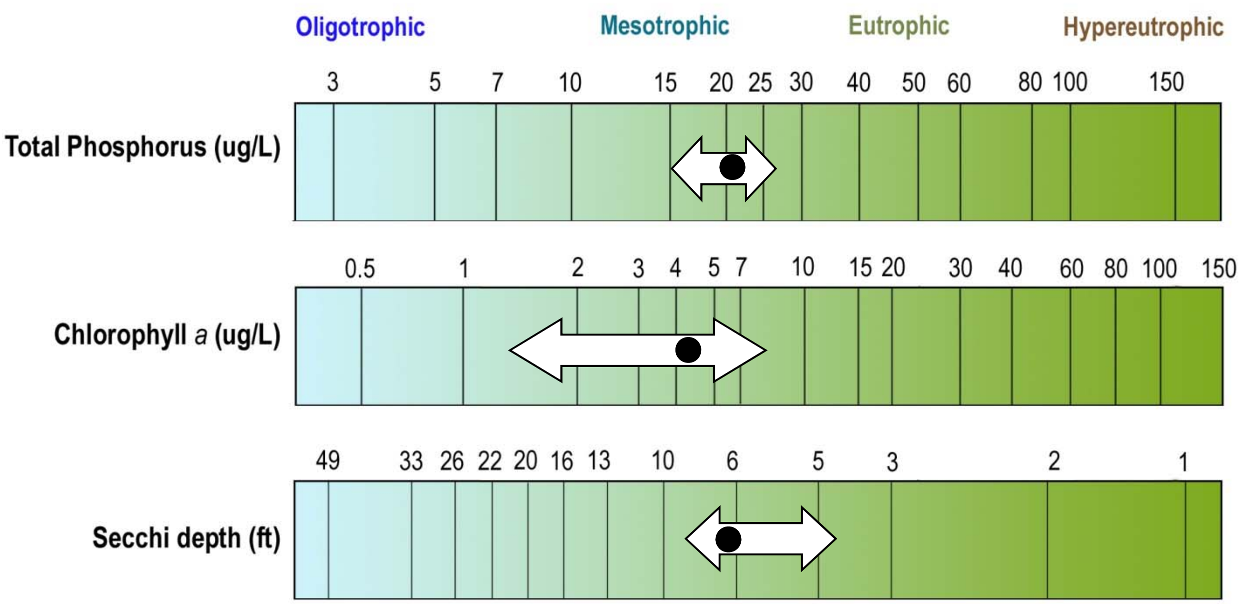



*Figure 3. Eddy Lake total phosphorus, chlorophyll a and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 201). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. EPA 440/5-88-002)*

## Transparency (Secchi Depth)

Transparency is how easily light can pass through a substance. In lakes it is how deep sunlight penetrates through the water. Plants and algae need sunlight to grow, so they are only able to grow in areas of lakes where the sun penetrates. Water transparency depends on the number of particles in the water. An increase in particulates results in a decrease in transparency. The transparency varies year to year due to changes in weather, precipitation, lake use, flooding, temperature, lake levels, etc.

The annual mean transparency in Eddy Lake ranges from 5.7 to 7.1 feet (Figure 4). The annual means hover fairly close to the long-term mean. For trend analysis, see page 10. Transparency monitoring should be continued annually at site 201 in order to track water quality changes.

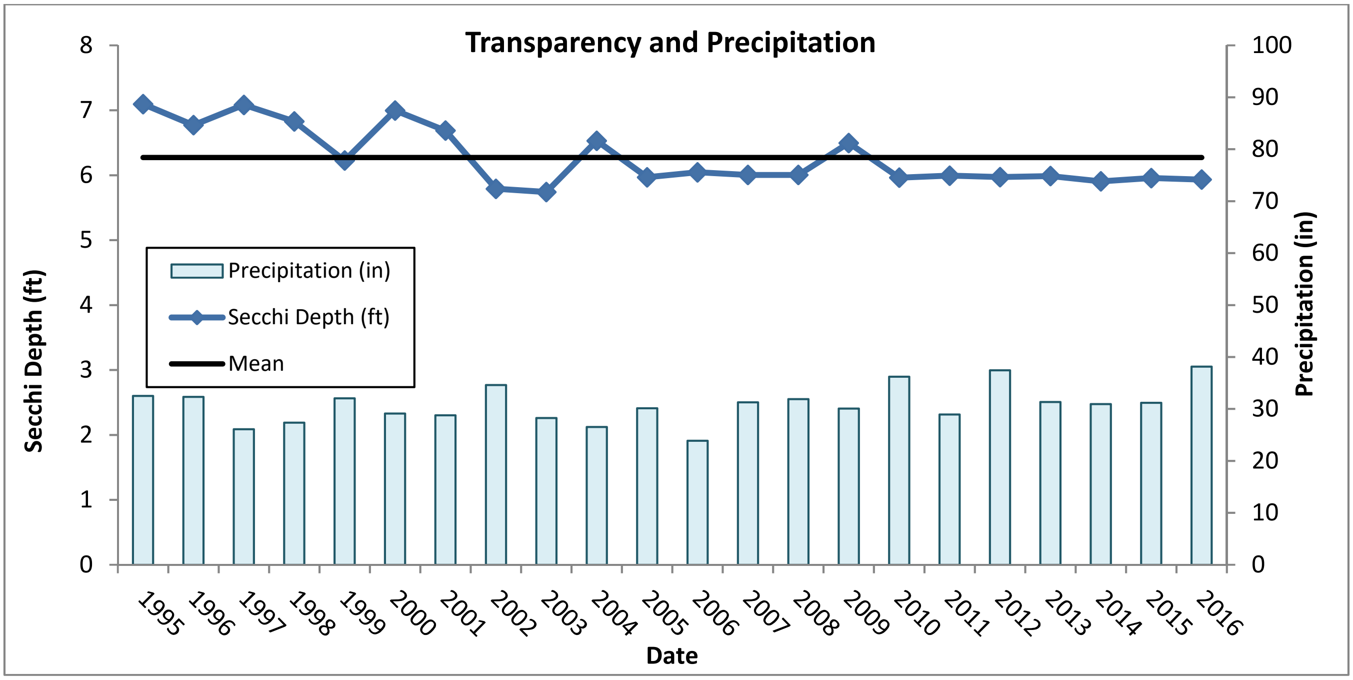



*Figure 4. Annual mean transparency compared to long-term mean transparency*

Eddy Lake transparency ranges from 4.9 to 8.5 ft at the primary site (Table 5). Figure 5 shows the seasonal transparency dynamics. Eddy Lake transparency is consistent throughout the summer and fall. This pattern could be influenced by tannins (brown stain) in the water and/or the lake's intermediate depth. During calm periods, the lake can stratify, which would show higher transparencies in May and June, declining through August. The dynamics have to do with algae and zooplankton population dynamics, and lake turnover.

It is important for lake residents to understand the seasonal transparency dynamics in their lake so that they are not worried if their transparency is lower in August than it is in June. It is typical for a lake to vary in transparency throughout the summer.

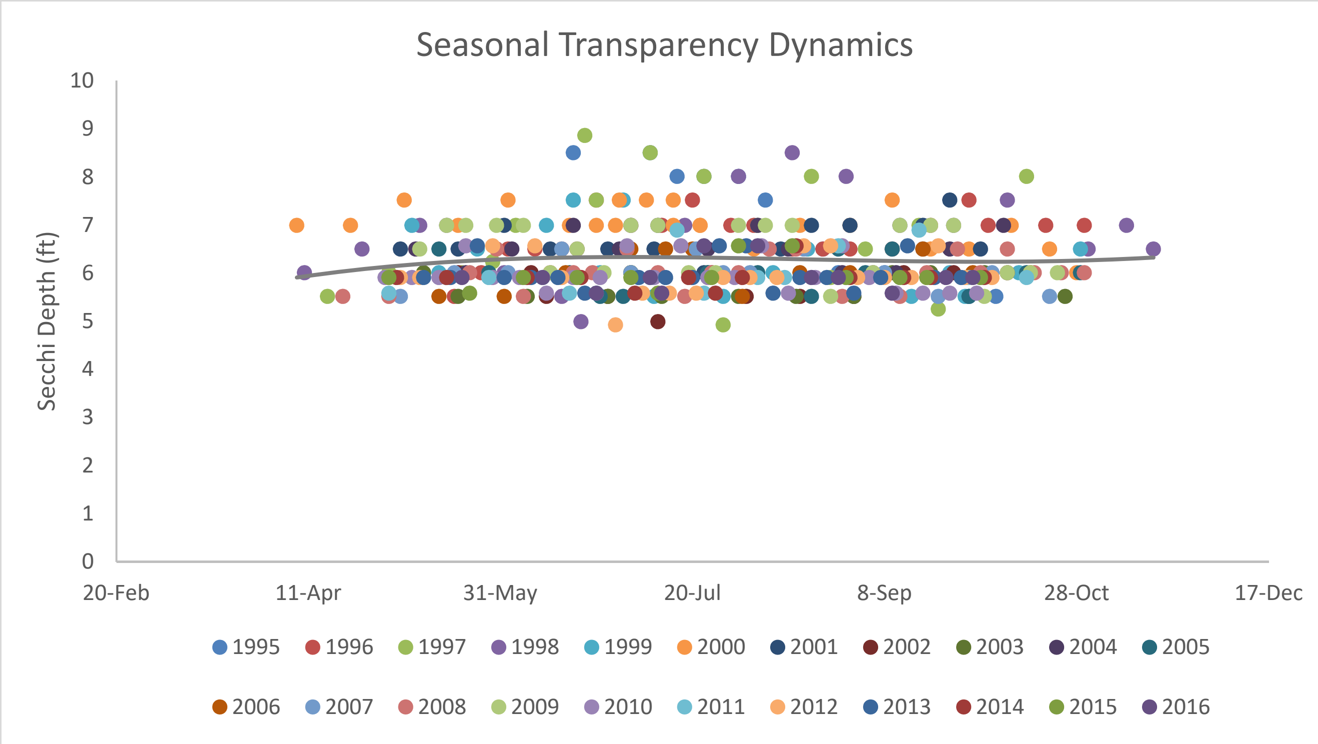



*Figure 5. Seasonal transparency dynamics and year to year comparison (Primary Site 201). The gray line represents the pattern in the data.*

## User Perceptions

When volunteers collect Secchi depth readings, they record their perceptions of the water based on the physical appearance and the recreational suitability. These perceptions can be compared to water quality parameters to see how the lake "user" would experience the lake at that time. Looking at transparency data, as the Secchi depth decreases the perception of the lake's physical appearance and recreational suitability decreases (Figures 6-7).

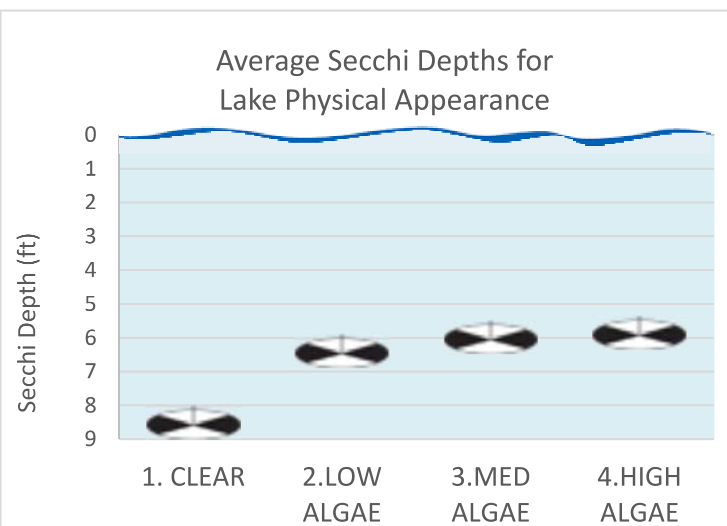



*Figure 6. Average Secchi depth (ft) for each lake physical appearance rating.*

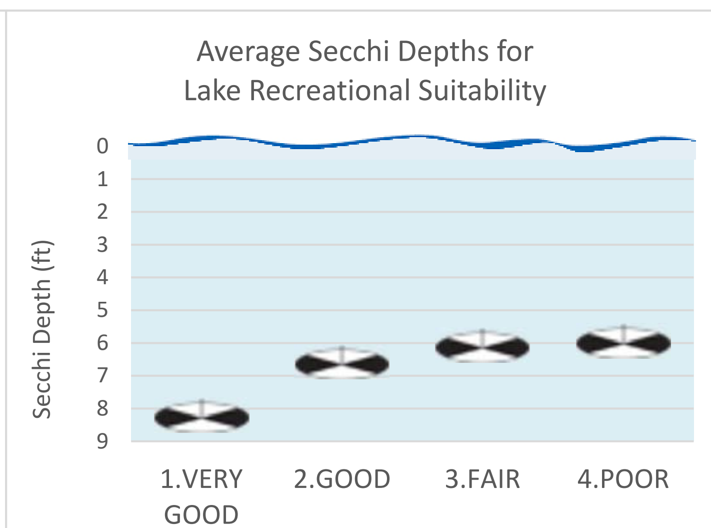



*Figure 7. Average Secchi depth (ft) for each lake recreational suitability rating.*

## Algae

Chlorophyll *a* is the pigment that makes plants and algae green. Chlorophyll *a* is tested in lakes to determine the algae concentration or how "green" the water is.

Chlorophyll *a* concentrations greater than 10 ug/L are perceived as a mild algae bloom, while concentrations greater than 20 ug/L are perceived as a nuisance.

Chlorophyll *a* was evaluated in Eddy Lake at site 201 in 1997 (Figure 8). Chlorophyll *a* concentrations did not go above 10 ug/L that year, indicating no algae blooms. The chlorophyll *a* concentrations increased toward the end of the summer.

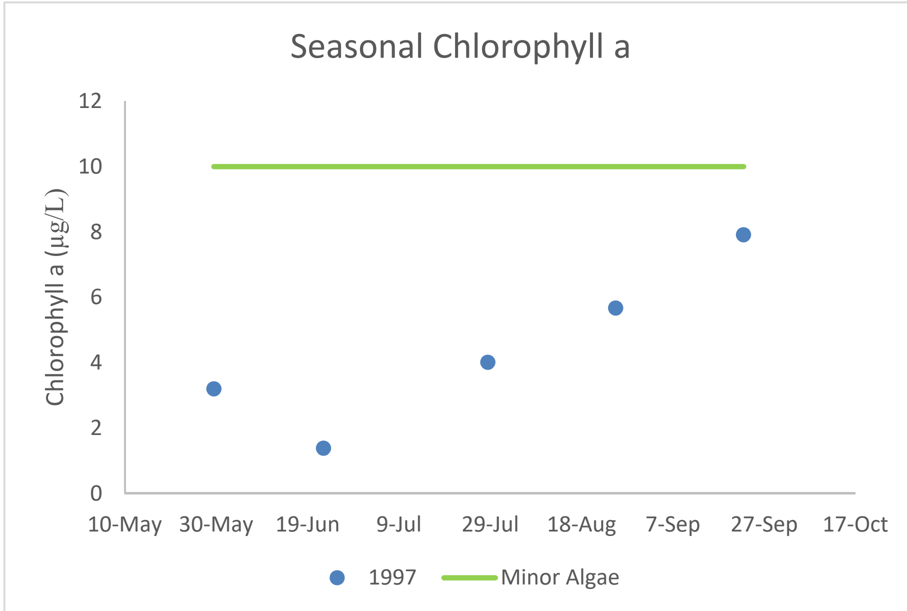



*Figure 8. Chlorophyll a concentrations (ug/L) for Eddy Lake at site 201 in 1997.*

## Phosphorus

Eddy Lake is phosphorus limited, which means that algae and aquatic plant growth is dependent upon available phosphorus.

Total phosphorus was evaluated in Eddy Lake in 1997. The data shows some seasonal variability, with the highest phosphorus in July. The majority of the data points fall into the mesotrophic range (Figure 9).

Phosphorus should continue to be monitored to track any future changes in water quality.

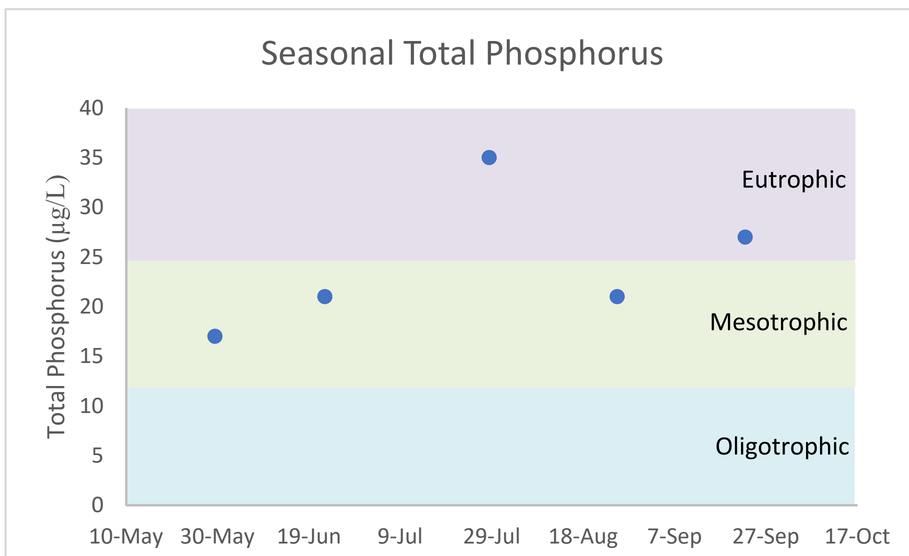
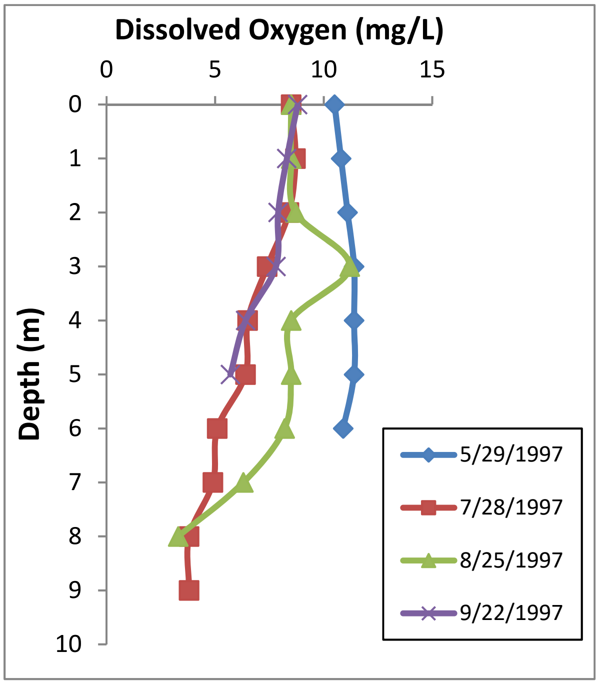



*Figure 9. Historical total phosphorus concentrations (ug/L) for Eddy Lake site 201 in 1997.*

## Oxygen




Dissolved Oxygen (DO) is the amount of oxygen dissolved in lake water. Oxygen is necessary for all living organisms to survive except for some bacteria. Living organisms breathe in oxygen that is dissolved in the water. Dissolved oxygen levels of <5 mg/L are typically avoided by game fisheries.

Eddy Lake is a moderately shallow lake, with a maximum depth of 36 feet. Dissolved oxygen profiles from data collected in 1997 at site 201 show periodic stratification developing mid-summer (Figure 10). In a moderately shallow lake, the water column never completely stratifies. Any windy day can mix up the water column causing phosphorus from the anoxic lake bottom to re-suspend into the water. This phenomenon is known as internal loading.

*Figure 10. Representative dissolved oxygen profiles from 1997 in Eddy Lake.*

## Trophic State Index (TSI)

TSI is a standard measure or means for calculating the trophic status or productivity of a lake. More specifically, it is the total weight of living algae (algae biomass) in a waterbody at a specific location and time. Three variables, chlorophyll a, Secchi depth, and total phosphorus, independently estimate algal biomass.

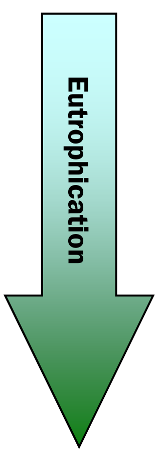
If all three TSI numbers are within a few points of each other, they are strongly related. If they are different, there are other dynamics influencing the lake's productivity, and TSI mean should not be reported for the lake. Eddy Lake falls into the mesotrophic range (Tables 6, 7). The secchi TSI is higher possibly due to tannins (brown stain) in the lake.

*Table 6. Trophic State Index for Eddy Lake.*

| Trophic State Index | |
|---|---|
| **TSI Phosphorus** | 48 |
| **TSI Chlorophyll-a** | 45 |
| **TSI Secchi** | 51 |
| **TSI Mean** | 48 |
| **Trophic State:** | Mesotrophic |

*Numbers represent the mean TSI for each parameter.*

*Table 7. Trophic state index attributes and their corresponding fisheries and recreation characteristics.*




**Eddy Lake**

| TSI | Attributes | Fisheries & Recreation |
|---|---|---|
| <30 | **Oligotrophy:** Clear water, oxygen throughout the year at the bottom of the lake, deep cold water. | Trout fisheries dominate. |
| 30-40 | Bottom may become anoxic (no oxygen). | Trout fisheries in deep lakes only. Walleye, Cisco present. |
| 40-50 | **Mesotrophy:** Water moderately clear most of the summer. May be "greener" in late summer. | No oxygen at the bottom of the lake results in loss of trout. Walleye may predominate. |
| 50-60 | **Eutrophy:** Algae and aquatic plant problems possible. "Green" water most of the year. | Warm-water fisheries only. Bass may dominate. |
| 60-70 | Blue-green algae dominate, algal scums and aquatic plant problems. | Dense algae and aquatic plants. Low water clarity may discourage swimming and boating. |
| 70-80 | **Hypereutrophy:** Dense algae and aquatic plants. | Water is not suitable for recreation. |
| >80 | Algal scums, few aquatic plants. | Rough fish (carp) dominate; summer fish kills possible. |

Source: Carlson, R.E. 1997. A trophic state index for lakes. *Limnology and Oceanography*. 22:361-369.

## Trend Analysis

For detecting trends, a minimum of 8-10 years of data with 4 or more readings per season are recommended. Minimum confidence accepted by the MPCA is 90%. This means that there is a 90% chance that the data are showing a true trend and a 10% chance that the trend is a random result of the data. Only short-term trends can be determined with just a few years of data, because there can be different wet years and dry years, water levels, weather, etc, that affect the water quality naturally.

Eddy Lake had enough data to perform a trend analysis on transparency (Table 8). The data was analyzed using the Mann Kendall Trend Analysis.

*Table 8. Trend analysis for Eddy Lake.*

| Lake Site | Parameter | Date Range | Trend | Probability |
|---|---|---|---|---|
| 201 | Total Phosphorus | 1997 | Insufficient Data | - |
| 201 | Chlorophyll *a* | 1997 | Insufficient Data | - |
| 201 | Transparency | 1995-2015 | Decreasing Trend | 99.9% |
| 201 | Transparency | 2003-2015 | Decreasing Trend | 90.0% |

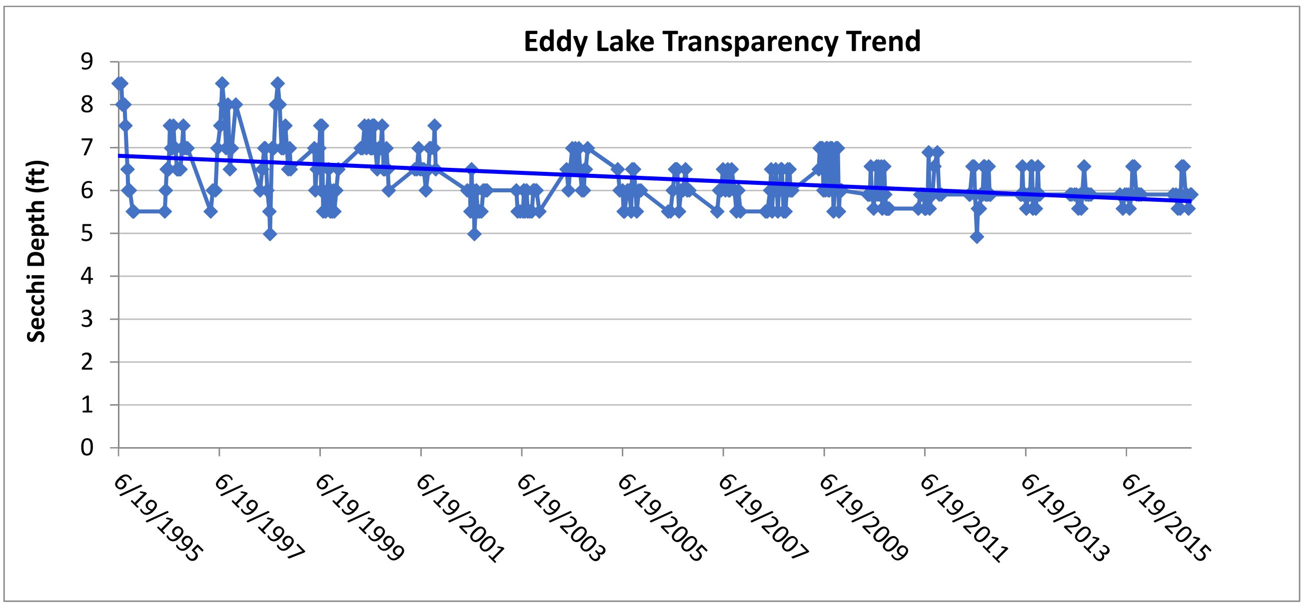



*Figure 11. Transparency (feet) trend for site 201 from 1995-2016.*

Eddy Lake shows very strong evidence for a declining transparency trend (Figure 11). It appears that since around 2002 the transparency has been lower than in the 1990s. Transparency monitoring should continue so that this trend can be tracked in future years.

## Lakeshed

Understanding a lakeshed requires an understanding of basic hydrology. A watershed is defined as all land and water surface area that contribute excess water to a defined point. The MN DNR has delineated three basic scales of watersheds (from large to small): 1) basins, 2) major watersheds, and 3) minor watersheds.

The Kettle River Major Watershed is one of the watersheds that make up the St. Croix River Basin, which drains south to the Gulf of Mexico (Figure 12).

The MN DNR also has evaluated catchments for each individual lake with greater than 100 acres surface area. These lakesheds (catchments) are the "building blocks" for the larger scale watersheds. Eddy Lake falls within lakeshed 3502400 (Figure 16). Though very useful for displaying the land and water that contribute directly to a lake, lakesheds are not always true watersheds because they may not show the water flowing into a lake from upstream streams or rivers. While some lakes may have only one or two upstream lakesheds draining into them, others may be connected to a large number of lakesheds, reflecting a larger drainage area via stream or river networks.

In an effort to prioritize protection and restoration efforts of fishery lakes, the MN DNR has developed a ranking system by separating lakes into two categories based on their lakeshed, those needing protection and those needing restoration. Modeling by the DNR Fisheries Research Unit suggests that total phosphorus concentrations increase significantly over natural concentrations in lakes that have watershed with disturbance greater than 25%. Therefore, lakes with watersheds that have less than 25% disturbance need protection and lakes with more than 25% disturbance need restoration (Table 9). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land, public water, wetlands, or conservation easement.

*Table 9. Suggested approaches for watershed protection and restoration of DNR-managed fish lakes in Minnesota.*

| Watershed Disturbance (%) | Watershed Protected (%) | Management Type | Comments |
|---|---|---|---|
| < 25% | > 75% | Vigilance | Sufficiently protected -- Water quality supports healthy and diverse native fish communities. Keep public lands protected. |
| | < 75% | Protection | Excellent candidates for protection -- Water quality can be maintained in a range that supports healthy and diverse native fish communities. Disturbed lands should be limited to less than 25%. |
| 25-60% | n/a | Full Restoration | Realistic chance for full restoration of water quality and improve quality of fish communities. Disturbed land percentage should be reduced and BMPs implemented. |
| > 60% | n/a | Partial Restoration | Restoration will be very expensive and probably will not achieve water quality conditions necessary to sustain healthy fish communities. Restoration opportunities must be critically evaluated to assure feasible positive outcomes. |

The next step was to prioritize lakes within each of these management categories. DNR Fisheries identified high value fishery lakes, such as cisco refuge lakes. Ciscos (*Coregonus artedi)* can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. These watersheds with low disturbance and high value fishery lakes are excellent candidates for priority protection measures, especially those that are related to forestry and minimizing the effects of landscape disturbance. Forest stewardship planning, harvest coordination to reduce hydrology impacts and forest conservation easements are some potential tools that can protect these high value resources for the long term.

Eddy Lake's lakeshed is classified with having 43% of the watershed protected and 6% of the watershed disturbed (Figure 13). Therefore, this lakeshed should have a protection focus. Goals for the lake should be to limit any increase in disturbed land use and maintain protected lands. Eddy Lake is a drainage lakeshed, which means that other lakesheds flow into it (Figure 12).

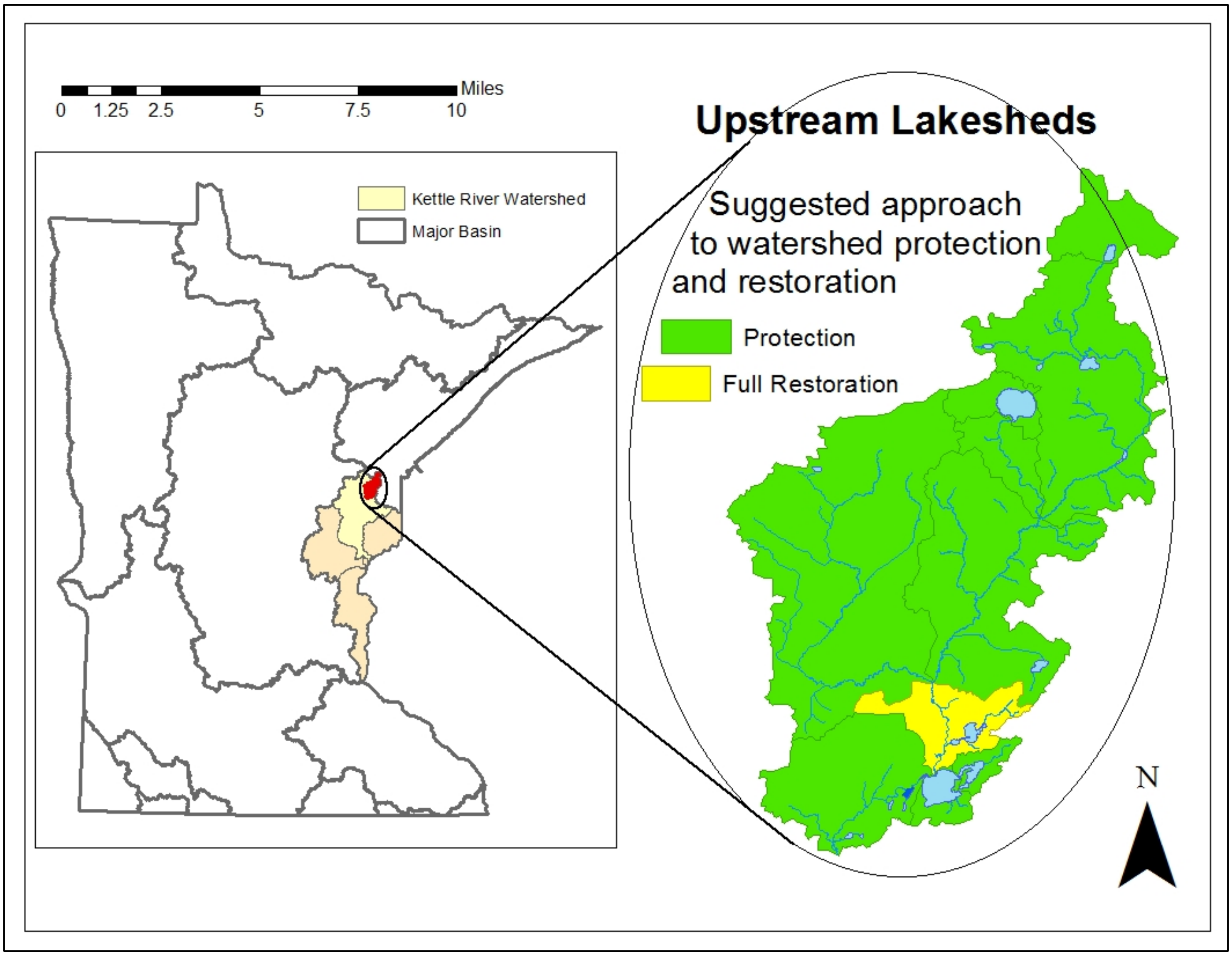



*Figure 12. Kettle River major watershed and MN basins (left), and Eddy Lake lakeshed and upstream catchments with protection suggestions (right).*

## Land use and Ownership

Activities that occur on the land within the lakeshed can greatly impact a lake. Land use planning helps ensure the use of land resources in an organized fashion so that the needs of the present and future generations can be best addressed. The Lake Eddy lakeshed receives water from the Moose Horn River through Hanging Horn Lake. This lakeshed map includes outflow from Eddy down the river to the town of Moose Lake.

Almost half (43%) of the Eddy Lake lakeshed is protected. This total includes water, wetlands, and publicly owned land. There are two parcels near the lakeshore that have conservation potential. They are private land over 20 acres that are less than 50% developed or agriculture. There are three animal feedlots in the lakeshed (Figure 13).

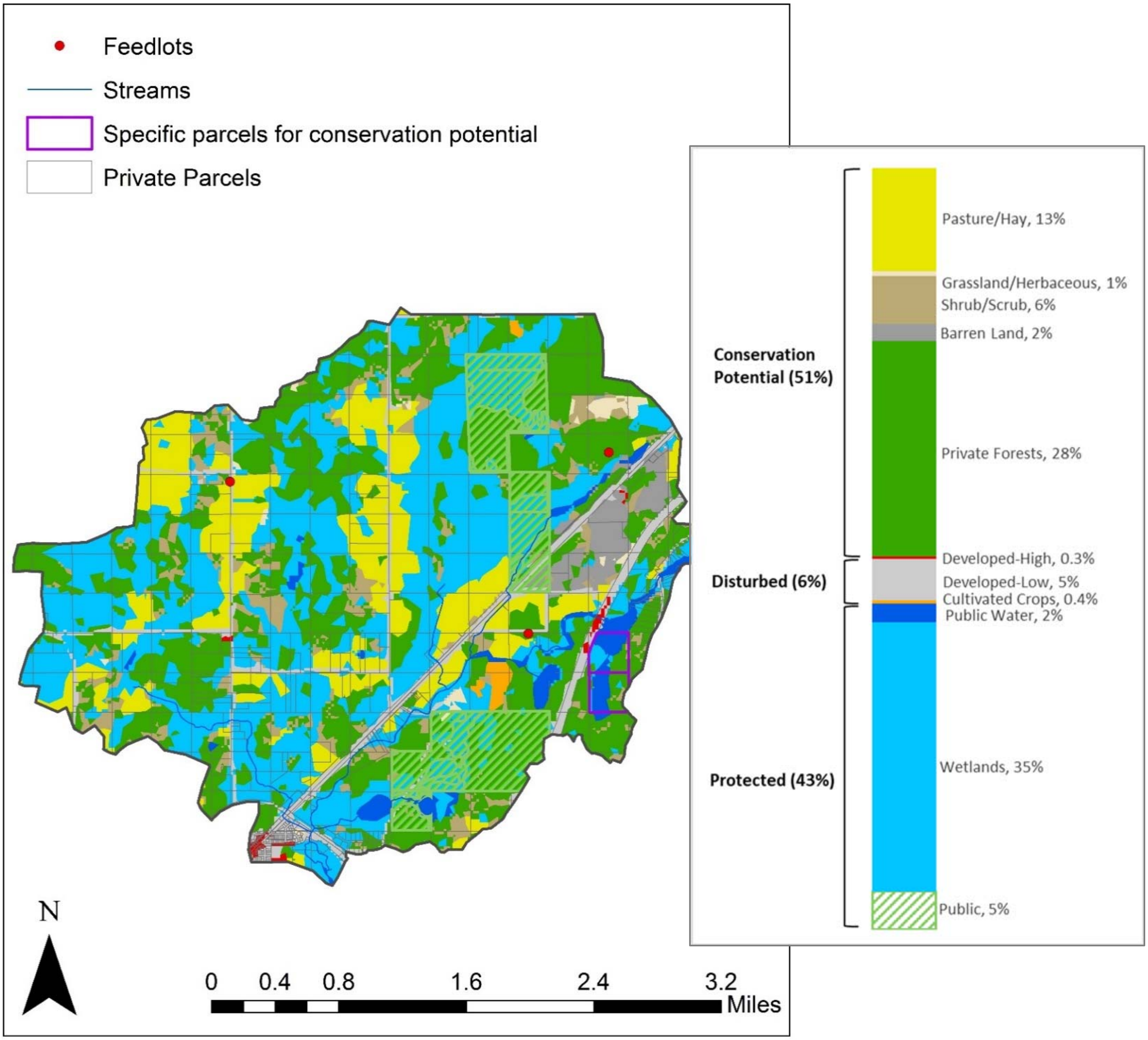



*Figure 13. Land use and ownership in the Eddy Lake lakeshed.*

The lakeshed vitals table identifies where to focus organizational and management efforts for each lake (Table 10). Criteria were developed using limnological concepts to determine the effect to lake water quality.

**KEY**
● Possibly detrimental to the lake
◍ Warrants attention
○ Beneficial to the lake

*Table 10. Eddy Lake lakeshed vitals table.*

| Lakeshed Vitals | | Rating |
|---|---|---|
| **Lake Area** | 23.5 acres | descriptive |
| **Littoral Zone Area** | 9.5 acres | descriptive |
| **Lake Max Depth** | 36.3 ft. | descriptive |
| **Lake Mean Depth** | NA | Not available |
| **Water Residence Time** | NA | Not available |
| **Miles of Stream** | 8.6 | descriptive |
| **Inlets** | 2 | ◍ |
| **Outlets** | 1 | ○ |
| **Major Watershed** | 35 – Kettle River | descriptive |
| **Minor Watershed** | 35023 | descriptive |
| **Lakeshed** | 3502300 | descriptive |
| **Ecoregion** | Northern Lakes and Forest | descriptive |
| **Total Lakeshed to Lake Area Ratio** (total lakeshed includes lake area) | 14:1 | ◍ |
| **Standard Watershed to Lake Basin Ratio** (standard watershed includes lake areas) | 270:1 | ● |
| **Wetland Coverage** | 35% | ○ |
| **Aquatic Invasive Species** | None | ○ |
| **Public Drainage Ditches** | None | ○ |
| **Public Lake Accesses** | 0 | ○ |
| **Miles of Shoreline** | 0.9 | descriptive |
| **Shoreline Development Index** | 1.37 | ○ |
| **Public Land to Private Land Ratio** | 0.1:1 | ◍ |
| **Development Classification** | Natural Environment | ○ |
| **Miles of Road** | 19.5 | descriptive |
| **Municipalities in lakeshed** | Moose Lake | ● |
| **Forestry Practices** | None | ○ |
| **Feedlots** | 3 | ● |
| **Sewage Management** | Compliance inspections are required for subsurface sewage treatment systems at point-of-sale or permit application in shoreland areas | ○ |
| **Lake Management Plan** | None | ◍ |
| **Lake Vegetation Survey/Plan** | None | ◍ |

## Eddy Lake, Status of the Fishery (DNR, 8/3/1998)

Eddy lake is 23 acres and is located 3 miles north of Moose Lake, MN along Interstate Highway 35. Access is via the Moose Horn River from Hanging Horn Lake, however this access can be difficult during low water periods. The maximum depth is 37 feet with 83 percent of the lake being less than 15 feet deep. Population assessments have been conducted on Eddy Lake in 1974 and 1980, and an initial survey was conducted in 1967. The fish population is mainly comprised of bluegill, pumpkinseed sunfish, and white sucker. Both catch rates and growth rates are typical for bluegill when compared to populations from other lakes in the Duluth area. There is a strong year class which should recruit into the fishery in 2000. Twenty-six percent of the bluegills sampled were 6.0 inches or longer and the average size of all bluegills sampled was 5.4 inches. Pumpkinseed sunfish were the most abundant fish sampled. Scale samples were not taken and growth parameters were not evaluated. However, 18 percent of the pumpkinseed sunfish sampled were 6.0 inches or greater and the average size was 5.0 inches. Northern pike and black crappie populations are currently low, however, both species have historically been more abundant. Catch from the one-quarter inch trapnets suggests that largemouth bass, black crappie, and yellow perch had successful reproduction in 1998. Adult largemouth bass have never been captured in standard sampling gear in any of the previous assessments or surveys. Other species sampled during this survey include green sunfish, rock bass, common shiner, spottail shiner, shorthead redhorse, silver redhorse, and yellow bullhead.

Development pressure is increasing around the shorelines and within the watersheds of many Minnesota lakes. This development can degrade water quality and impact valuable shoreline habitat. Native shoreline vegetation provides habitat for fish and wildlife, filters harmful nutrients, and protects against shoreline erosion. Lakeshore owners can minimize their impact on the shoreline and maintain a more natural setting while actually decreasing annual maintenance. For more information on how to accomplish this, contact the nearest Area Fisheries office or go to the following website: www.dnr.state.mn.us/shorelandmgmt

See the link below for specific information on gillnet surveys, stocking information, and fish consumption guidelines. http://www.dnr.state.mn.us/lakefind/showreport.html?downum=09003900

## Key Findings and Recommendations

**Monitoring Recommendations**
Transparency monitoring at site 201 should be continued annually. It is important to continue transparency monitoring weekly or at least bimonthly every year to enable year-to-year comparisons and trend analyses. Phosphorus and chlorophyll a monitoring should continue at site 201, as the budget allows, to track future water quality trends.

**Overall Conclusions**
Eddy Lake is a mesotrophic lake (TSI = 48) with evidence of a declining long-term trend in water clarity. The total phosphorus, chlorophyll *a* and transparency ranges are within the ecoregion ranges (Table 4).

About a third (33.4%) of the lakeshed land area is forested. Almost half of the lakeshed is protected (43%), which includes public ownership, wetlands, and open water. Only 6% of the lakeshed is disturbed, which includes high and low levels of development (Figure 13).

**Phosphorus Loading and Priority Impacts**
Eddy Lake is at a disadvantage because it has such a large watershed, which means there are additional lakesheds that contribute water from upstream areas. It also has the Moose Head River flowing through it. This means that the land practices upstream are likely the main impact to the lake's water quality.

With the river flowing through the lake, it likely has a short residence time, which means that many of the nutrients flowing into the lake also flush out.

*Table 11. Watershed characteristics.*

| | |
|---|---|
| **Lakeshed to Lake Area Ratio** (lakeshed includes lake area) | 14:1 |
| **Watershed to Lake Area Ratio** (watershed includes lake areas) | 270:1 |
| **Number of Upstream Lakes** | 13 |
| **Headwaters Lake?** | No |
| **Inlets / Outlets** | 2 / 1 |
| **Water Residence Time** | NA |

A third of the lakeshed is covered with wetlands, which is good for water storage and filtration (Figure 13). Protecting the wetlands will help maintain water levels and water storage, reduce flooding, and filter runoff during large storm events.

It is difficult to determine what could be causing the declining trend in transparency. Data show that since 2002 the transparency has been lower than it was in the 1990s (Figure 11). A trend analysis of more recent data (2003-2015) also shows a declining trend (Table 8). One possible cause could be the cumulative effects from the large watershed and land practices within it.

Figure 13 shows the city of Moose Lake in the Eddy Lakeshed, but it is downstream from Eddy Lake, so likely does not impact Eddy Lake.

**Best Management Practices Recommendations**
The management focus for Eddy Lake should be to protect the current water quality and the lakeshed. Efforts should be focused on managing and/or decreasing the impact caused by current and additional development, including second tier development, and impervious surface area. Project ideas include protecting land with conservation easements, enforcing county shoreline ordinances, shoreline restoration, rain gardens, and septic system maintenance.

## Eddy Lake Goals

1. Protection Focus: minimize disturbed land uses and maintain protected lands
2. Manage phosphorus loading from **the watershed**, Table 12
3. Focused BMPs per land type: Table 12

*Table 12. Best Management Practices Table specific to Eddy Lake (refer to Figure 13 for locations)*

| Category | Land use type | Conservation project ideas | Results | Who | Contact for help |
|---|---|---|---|---|---|
| Conservation Potential Land | Private forests (28%, 1834 acres) | Forest stewardship planning, 3rd party certification, SFIA, local woodland cooperatives. | Conserve and protect current forest cover. | • Individual Property Owners | Carlton SWCD<br>(218) 384-3891<br>https://carltonswcd.org |
| | Pasture/hay (13%, 871 acres) | Conservation Reserve Program (CRP), maintain vegetative cover, plant trees, conservation easements, grassed waterways, ditch buffers, maintain/restore wetlands. | Reduce water runoff and soil erosion, better water storage. | • Individual Property Owners | Natural Resources Conservation Service<br>218-720-5209 |
| Disturbed Land | Cultivated crops (0.4%, 29 acres) | Restore wetlands; Conservation Reserve Program (CRP), Cover Crops, | Reduce water runoff and soil erosion, better water storage. | • Individual Property Owners | Natural Resources Conservation Service<br>218-720-5209 |
| | Developed, low intensity (5.5%, 355 acres) | Shoreline buffers, rain gardens. | Reduce water runoff and shoreline erosion. | • Individual Property Owners | Carlton SWCD<br>(218) 384-3891<br>https://carltonswcd.org |
| | Developed, high intensity (0.3%, 19 acres) | Sediment basins, rain gardens, shoreline buffers, stormwater retention. | Reduce water runoff into streams and lakes. | • Individual Property Owners<br>• Cities<br>• Lake Associations | Carlton SWCD<br>(218) 384-3891<br>https://carltonswcd.org |

The current lakeshore homeowners can lessen their negative impact on water quality by installing or maintaining the existing trees on their properties. Forested uplands contribute significantly less phosphorus (lbs/acre/year) than developed land cover (Table 12).

Over a quarter of the lakeshed is privately owned forested uplands (Table 12). Forested uplands can be managed with Forest Stewardship Planning, 3rd party certification, SFIA, and local woodland cooperatives. Contact the Soil and Watershed Conservation District for options for managing private forests.

The lakeshed still has large undeveloped shoreline parcels (Figure 13). Because a lot of undeveloped private land still exists, there is a great potential for protecting this land with conservation easements and aquatic management areas (AMAs). Conservation easements can be set up easily and with little cost with help from organizations such as the Board of Soil and Water Resources and the Minnesota Land Trust. AMAs can be set up through the local DNR fisheries office.

Native aquatic plants stabilize the lake's sediments and tie up phosphorus in their tissues. When aquatic plants are uprooted from a shallow lake, the lake bottom is disturbed, and the phosphorus in the water column gets used by algae instead of plants. This contributes to "greener" water and more algae blooms. Protecting native aquatic plant beds will ensure a healthy lake and healthy fishery. If a swimming area is necessary in front of people's docks, clear only a small area of plants. Clearing a whole 100 foot frontage is not necessary and can contribute to additional algae blooms.

*Table 13. Organizational contacts and reference sites*

| Organizational contacts and reference sites | |
|---|---|
| Hanging Horn Lakeshore Management Association | P.O. Box 192 Barnum, MN 55707 |
| DNR Fisheries Office | 5351 North Shore Drive, Duluth, MN 55804<br>218-302-3264, duluth.fisheries@state.mn.us |
| Regional Minnesota Pollution Control Agency Office | 525 Lake Avenue South, Suite 400, Duluth, MN 55802<br>218-723-4660<br>https://www.pca.state.mn.us/about-mpca/duluth-office |
| Carlton County Soil and Water Conservation District | 808 3rd St, Carlton, MN 55718<br>(218) 384-3891, https://carltonswcd.org/ |
| Carlton County | 301 Walnut Ave, Carlton, MN 55718<br>http://carltoncountymn.govoffice3.com/ |

# Hanging Horn Lake 09-0038-00 Carlton County

Hanging Horn Lake is located 4.5 miles north of Moose Lake, MN in Carlton County. It is a round lake covering 409 acres (Table 1).

Hanging Horn Lake has four inlets and one outlet, which classify it as a drainage lake. Water enters Hanging Horn Lake from ground-fed streams in the south, from Little Hanging horn in the east, and from Moose Horn River in the north. Moose Horn River exits the lake on the west side of Hanging Horn Lake and carries water southwest to the Kettle River.

Water quality data have been collected on Hanging Horn Lake from 1983-2016 (Tables 2 & 3). These data show that the lake is mesotrophic (TSI = 49) which is characteristic of mostly clear water throughout the summer and good fisheries.

Hanging Horn Lake has an organized association that is involved in activities such as water quality monitoring, golf tournaments, and education.

Table 1. Hanging Horn Lake location and key physical characteristics.

| Location Data | |
|---|---|
| MN Lake ID: | **09-0038-00** |
| County: | **Carlton** |
| Ecoregion: | **Northern Lakes and Forests** |
| Major Watershed: | **Kettle River** |
| Latitude/Longitude: | **46.477886, -92.694706** |
| Invasive Species: | **None** |

| Physical Characteristics | |
|---|---|
| Surface area (acres): | **408.7** |
| Littoral area (acres): | **65.4** |
| % Littoral area: | **16%** |
| Max depth (ft), (m): | **84, 25.6** |
| Inlets: | **4** |
| Outlets: | **1** |
| Public Accesses: | **1** |

Table 2. Availability of primary data types for Hanging Horn Lake.

| Data Availability | |
|---|---|
| Transparency data | **Excellent CLMP data from 2002-2016.** |
| Chemical data | **Data from 1993, 1997, and 2016.** |
| Inlet/Outlet data | **Moose Horn River was monitored in Barnum from 2016-2017.** |
| Recommendations | **For recommendations refer to page 15.** |

## Lake Map

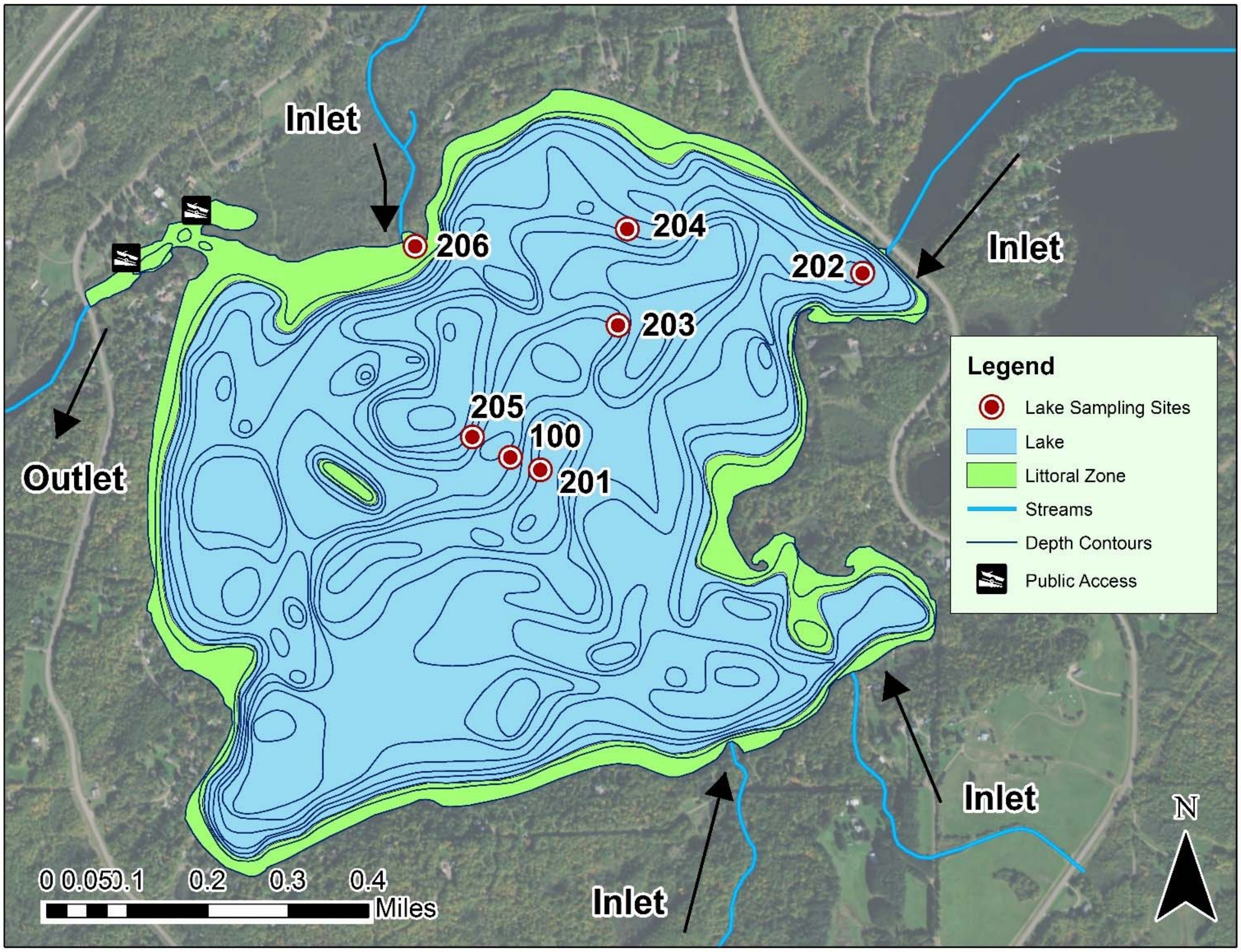



*Figure 1. Map of Hanging Horn Lake with 2010 aerial imagery and illustrations of lake depth contour lines, sample site locations, inlets and outlets, and public access points. The light green areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom, allowing aquatic plants to grow.*

*Table 3. Monitoring programs and associated monitoring sites. Monitoring programs include the Citizen Lake Monitoring Program (CLMP), MPCA Lake Monitoring Program Project (MPCA), Mississippi River-Grand Rapids Carlton SWCD (SWCD), and Citizens Monitoring Bacteria (CMB).*

| Lake Site | Depth (ft) | Monitoring Programs |
|---|---|---|
| 100 | 35 | MPCA: 1993-1994 |
| 201 | 70 | CLMP: 1983-1997, 2011 |
| 202 | 40 | CLMP: 1991; MPCA: 1984, 1997 |
| 203 | 50 | CLMP: 1999 |
| 204 | 40 | CLMP: 2000-2001, 2005-2016 |
| 205 | 50 | CLMP: 2002-2016; SWCD: 2016 |
| 206 | 5 | CMB: 2007 |

## Average Water Quality Statistics & Comparisons

The information below describes available chemical data for Hanging Horn Lake through 2017 (Table 4). Data for total phosphorus, chlorophyll *a*, and Secchi depth are from the primary site 205.

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation and geology. The Minnesota Pollution Control Agency (MPCA) has developed a way to determine the "average range" of water quality expected for lakes in each ecoregion[1] (Table 4). Hanging Horn Lake is in the Northern Lakes and Forests Ecoregion (Figure 2).

The MPCA has developed Impaired Waters Standards for lakes in each ecoregion to determine if a lake is impaired for excess phosphorus/eutrophication (Table 4). Lakes that are over the impaired waters standards are placed on the state's Impaired Waters List[2].


*Figure 2. Minnesota ecoregions.*

*Table 4. Water quality means compared to ecoregion ranges and impaired waters standard.*

| Parameter | Mean | Ecoregion Range[1] | Impaired Waters Standard[2] | Interpretation |
|---|---|---|---|---|
| Total phosphorus (ug/L) | 27.1 | 14 – 27 | > 30 | Results are within the expected range for the Northern Lakes and Forests Ecoregion and the lake is not impaired for excess phosphorus. |
| [3]Chlorophyll *a* (ug/L) | 9.1 | 4 – 10 | > 9 | |
| Chlorophyll *a* max (ug/L) | 14.2 | < 15 | | |
| Secchi depth (ft) | 7.5 | 8 – 15 | < 6.5 | |
| Dissolved oxygen | *See page 8* | | | Dissolved oxygen depth profiles show that the lake mixes in spring and fall (dimictic). |
| Total Kjeldahl Nitrogen (mg/L) | 0.8 | <0.4 – 0.75 | | Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms. |
| Alkalinity (mg/L) | 45.6 | 40 – 140 | | Within the expected range for the ecoregion. |
| Color (Pt-Co Units) | 60 | 10 – 35 | | Indicates tannins (brown stain) in the water. |
| pH | 7.2 | 7.2 – 8.3 | | Within the expected range for the ecoregion. Lake water pH less than 6.5 can affect fish spawning and the solubility of metals in the water. |
| Chloride (mg/L) | 2.9 | 0.6 – 1.2 | | Slightly over the expected range for the ecoregion, but still considered low level. |
| Total Suspended Solids (mg/L) | 1.8 | <1 – 2 | | Within the expected range for the ecoregion. |
| Specific Conductance (umhos/cm) | 70.8 | 50 – 250 | | Within the expected range for the ecoregion. |
| TN:TP Ratio | 33:1 | 25:1 - 35:1 | | Within the expected range for the ecoregion, and shows the lake is phosphorus limited. |

[1]The ecoregion range is the 25th-75th percentile of summer means from ecoregion reference lakes: https://www.pca.state.mn.us/quick-links/eda-guide-typical-minnesota-water-quality-conditions
[2]For further information regarding the Impaired Waters Assessment program, refer to http://www.pca.state.mn.us/water/tmdl/index.html
[3]Chlorophyll *a* measurements have been corrected for pheophytin
Units: 1 mg/L (ppm) = 1,000 ug/L (ppb)

# Water Quality Characteristics - Historical Means and Ranges

*Table 5. Water quality means and ranges for primary sites.*

| Parameters | Primary Site 205 | Site 204 |
|---|---|---|
| **Total Phosphorus Mean (ug/L):** | 27.1 | NA |
| Total Phosphorus Min: | 18 | |
| Total Phosphorus Max: | 39 | |
| Number of Observations: | 7 | |
| **Chlorophyll *a* Mean (ug/L):** | 9.1 | NA |
| Chlorophyll-a Min: | 4 | |
| Chlorophyll-a Max: | 14.2 | |
| Number of Observations: | 7 | |
| **Secchi Depth Mean (ft):** | 7.5 | 7.3 |
| Secchi Depth Min: | 3.6 | 3.9 |
| Secchi Depth Max: | 10.5 | 10 |
| Number of Observations: | 107 | 102 |

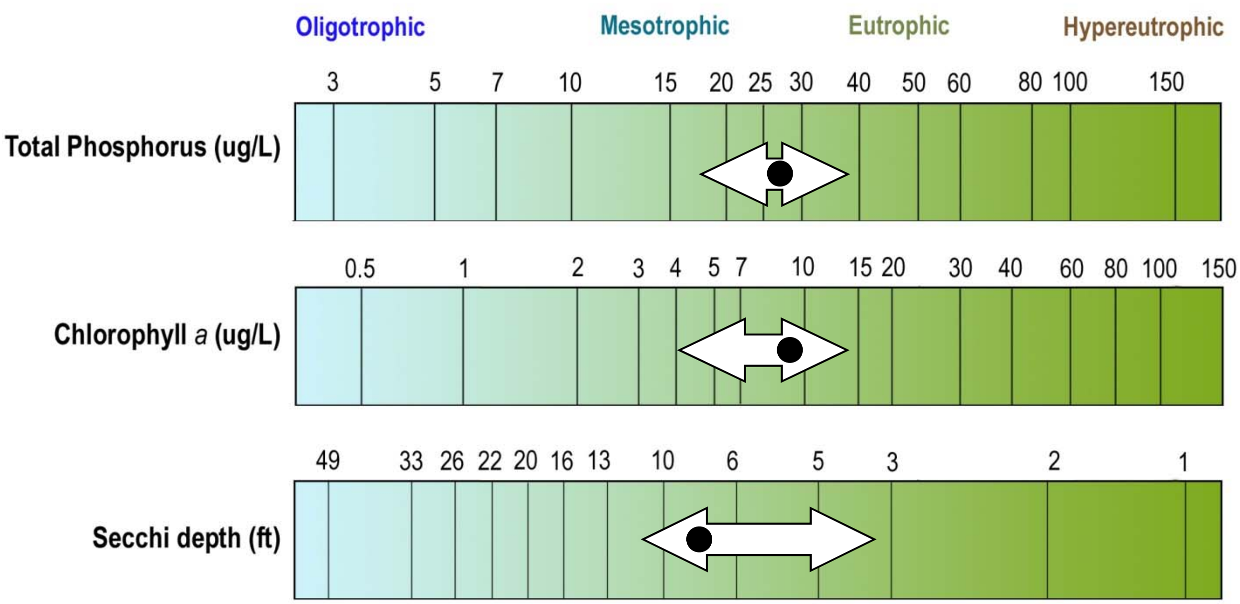



*Figure 3. Hanging Horn Lake total phosphorus, chlorophyll a and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 205). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. EPA 440/5-88-002)*

## Transparency (Secchi Depth)

Transparency is how easily light can pass through a substance. In lakes it is how deep sunlight penetrates through the water. Plants and algae need sunlight to grow, so they are only able to grow in areas of lakes where the sun penetrates. Water transparency depends on the number of particles in the water. An increase in particulates results in a decrease in transparency. The transparency varies year to year due to changes in weather, precipitation, lake use, flooding, temperature, lake levels, etc.

The annual mean transparency in Hanging Horn Lake ranges from 5.2 to 13.9 feet (Figure 4). The annual means hover fairly close to the long-term mean except for 2016, which was lower. For trend analysis, see page 10. Transparency monitoring should be continued annually at site 205 in order to track water quality changes.

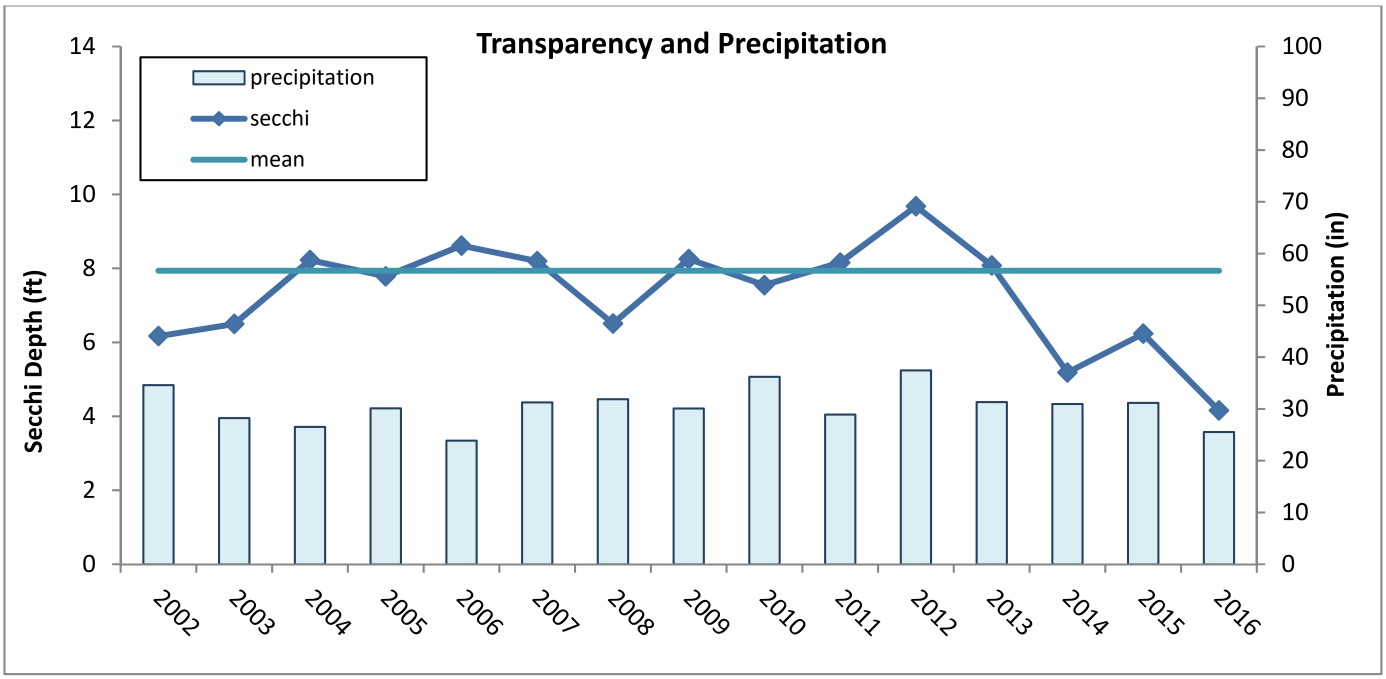



*Figure 4. Annual mean transparency compared to long-term mean transparency*

Hanging Horn Lake transparency ranges from 3.6 to 10.5 ft at the primary site (Table 5). Figure 5 shows the seasonal transparency dynamics. Hanging Horn Lake transparency is relatively consistent throughout the summer and varies a lot year to year (Figure 5). This pattern could be due to the brown stain from tannins. The dynamics have to do with algae and zooplankton population dynamics, and lake turnover.

It is important for lake residents to understand the seasonal transparency dynamics in their lake so that they are not worried about why their transparency is lower at certain times of the year. It is typical for a lake to vary in transparency throughout the summer.

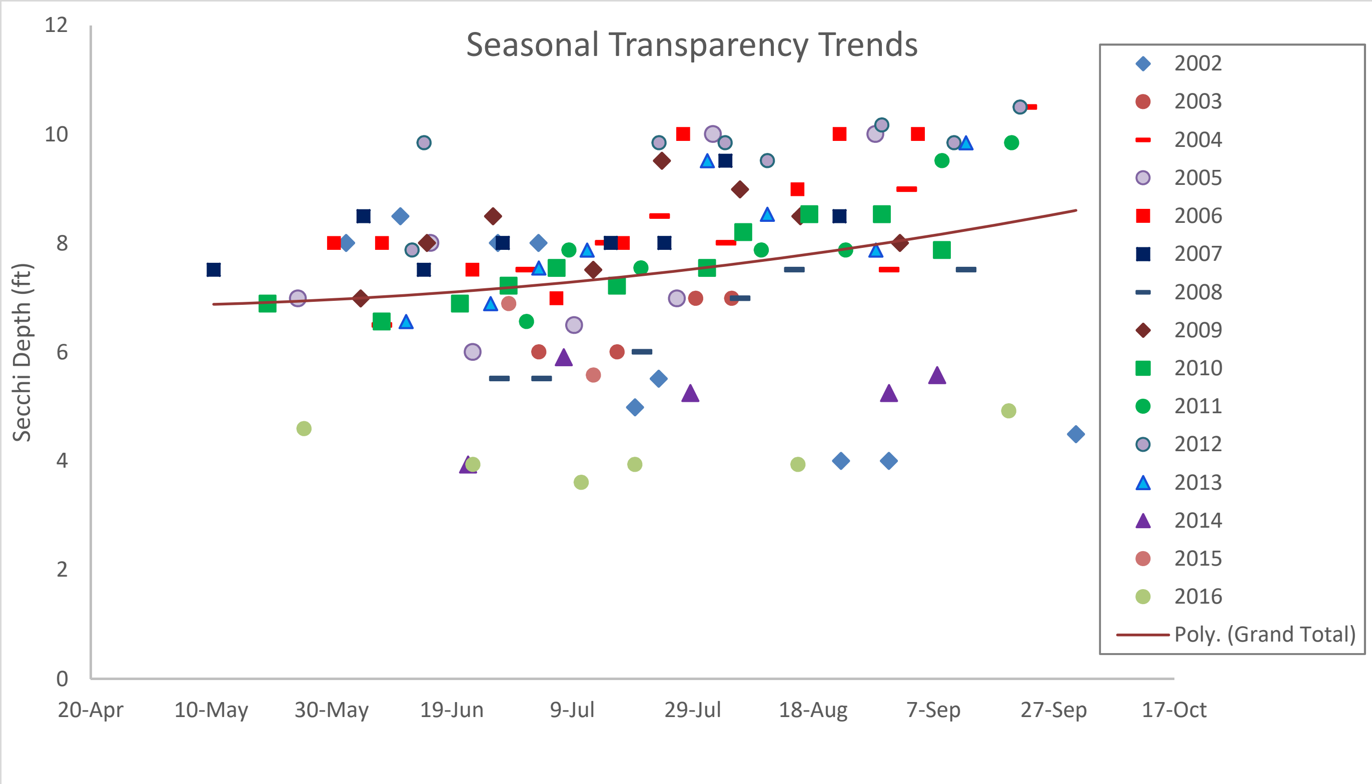



*Figure 5. Seasonal transparency dynamics and year to year comparison (Primary Site 205). The black line represents the pattern in the data.*

## User Perceptions

When volunteers collect Secchi depth readings, they record their perceptions of the water based on the physical appearance and the recreational suitability. These perceptions can be compared to water quality parameters to see how the lake "user" would experience the lake at that time. Looking at transparency data, as the Secchi depth decreases the perception of the lake's physical appearance and recreational suitability decreases (Figures 5-6).

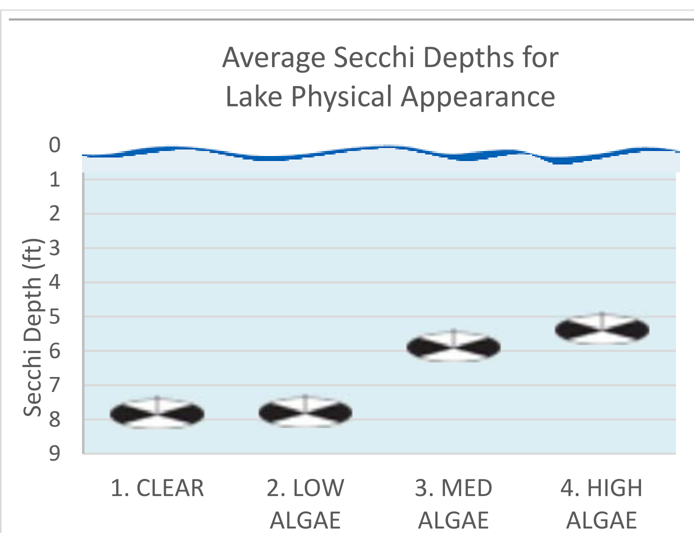



*Figure 7. Average Secchi depth for each lake physical appearance rating.*

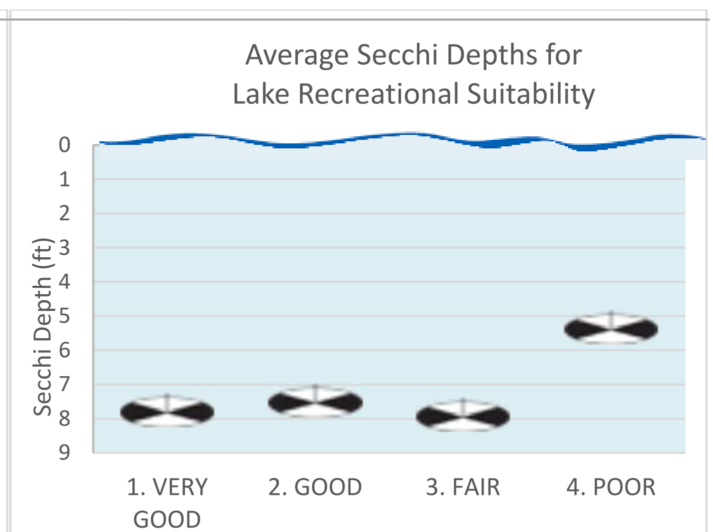



*Figure 6. Average Secchi depth (ft) for each lake recreational suitability rating.*

## Algae

Chlorophyll *a* is the pigment that makes plants and algae green. Chlorophyll *a* is tested in lakes to determine the algae concentration or how "green" the water is.

Chlorophyll *a* concentrations greater than 10 ug/L are perceived as a mild algae bloom, while concentrations greater than 20 ug/L are perceived as a nuisance.

Chlorophyll *a* was evaluated in Hanging Horn Lake 1993,1997, and 2016 (Figure 8). Chlorophyll *a* concentrations went above 10 ug/L from July to September of 2016, indicating minor algae blooms.

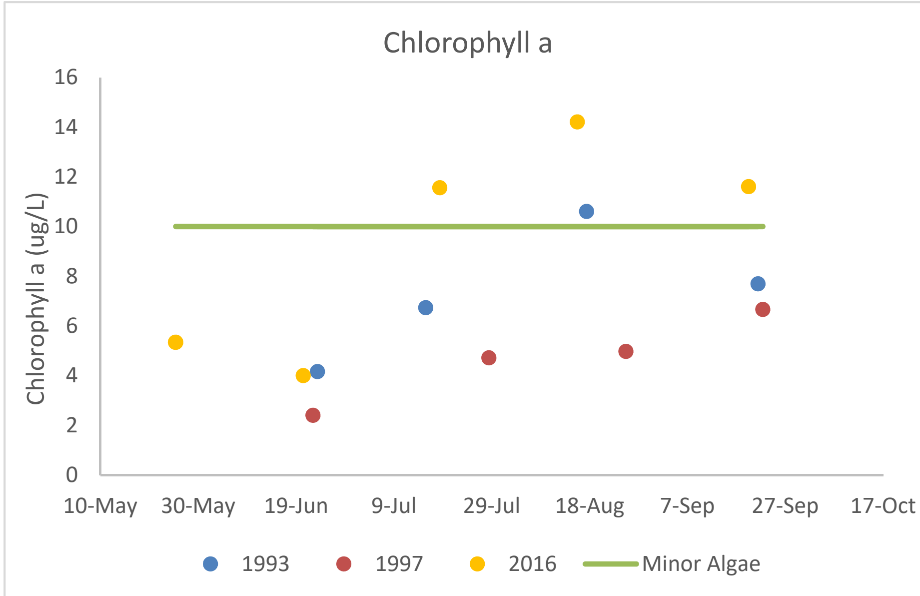



*Figure 8. Chlorophyll a concentrations (ug/L) for Hanging Horn Lake at site 205.*

## Phosphorus

Hanging Horn Lake is phosphorus limited, which means that algae and aquatic plant growth is dependent upon available phosphorus.

Total phosphorus was evaluated in Hanging Horn Lake in 1993, 1997, 2005, and 2016. The data do not indicate much seasonal variability. The majority of the data points fall into the mesotrophic range (Figure 9).

Phosphorus should continue to be monitored to track any future changes in water quality.

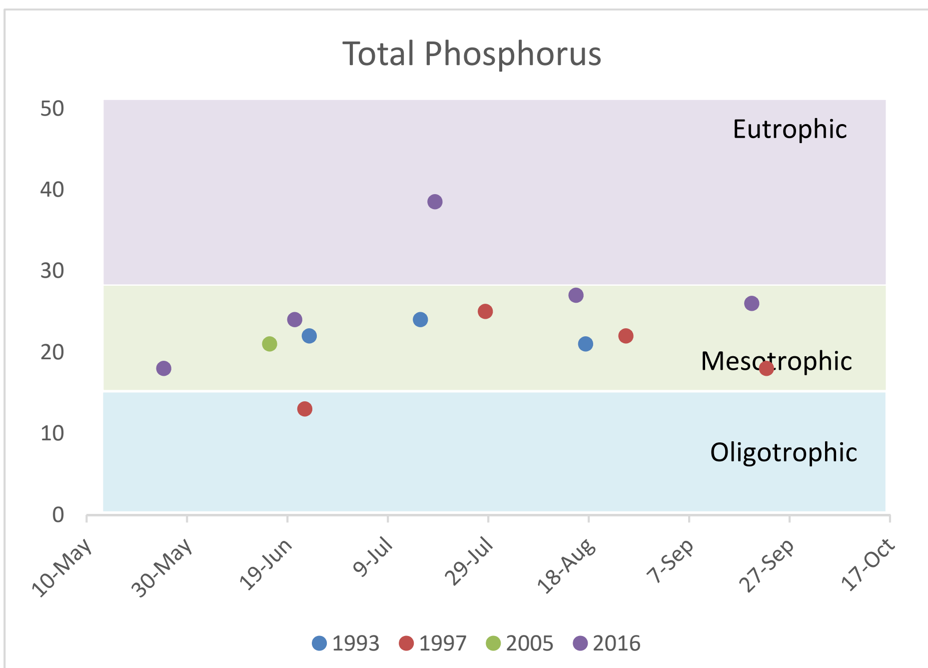
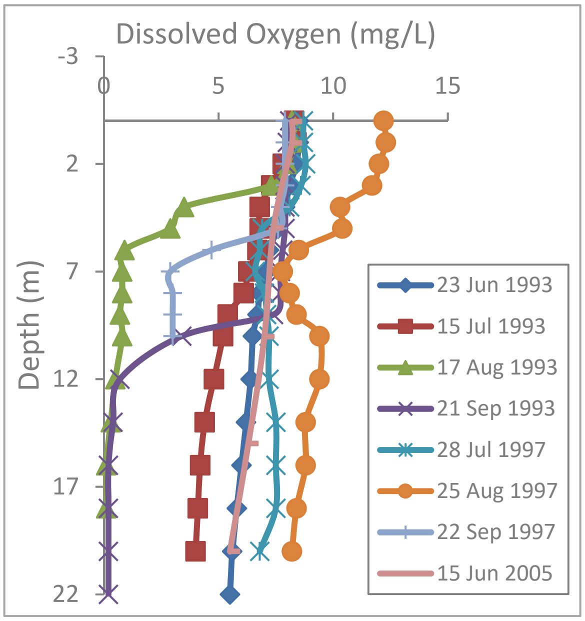



*Figure 9. Historical total phosphorus concentrations (ug/L) for Hanging Horn Lake site 205.*

## Oxygen




Dissolved Oxygen (DO) is the amount of oxygen dissolved in lake water. Oxygen is necessary for all living organisms to survive except for some bacteria. Living organisms breathe in oxygen that is dissolved in the water. Dissolved oxygen levels of <5 mg/L are typically avoided by game fisheries.

Hanging Horn Lake is a deep lake, with a maximum depth of 84 feet. Dissolved oxygen profiles from data collected in 1993, 1997 and 2005 at site 205 show stratification developing mid-summer (Figure 10). The thermocline was around 5 meters (16.4 feet), and much of the summer dissolved oxygen levels are higher than 5 mg/L, which supports ciscoes. DNR Fisheries lists Hanging Horn Lake as a cisco refuge lake. Lake Trout are also stocked in Hanging Horn Lake.

*Figure 10. Representative dissolved oxygen profiles from 1993, 1997, and 2005 in Hanging Horn Lake.*

## Trophic State Index (TSI)

TSI is a standard measure or means for calculating the trophic status or productivity of a lake. More specifically, it is the total weight of living algae (algae biomass) in a waterbody at a specific location and time. Three variables, chlorophyll a, Secchi depth, and total phosphorus, independently estimate algal biomass.

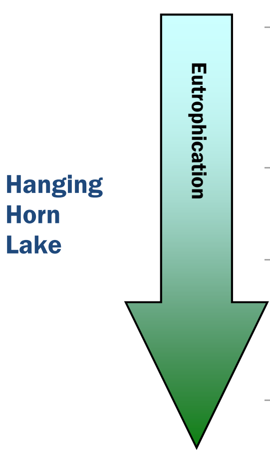
If all three TSI numbers are within a few points of each other, they are strongly related. If they are different, there are other dynamics influencing the lake's productivity, and TSI mean should not be reported for the lake. Hanging Horn Lake falls into the mesotrophic range (Tables 6, 7).

*Table 6. Trophic State Index for Hanging Horn Lake.*

| Trophic State Index | |
|---|---|
| TSI Phosphorus | 49 |
| TSI Chlorophyll-a | 50 |
| TSI Secchi | 48 |
| TSI Mean | 49 |
| Trophic State: | Mesotrophic |

*Numbers represent the mean TSI for each parameter.*

*Table 7. Trophic state index attributes and their corresponding fisheries and recreation characteristics.*




| TSI | Attributes | Fisheries & Recreation |
|---|---|---|
| <30 | **Oligotrophy:** Clear water, oxygen throughout the year at the bottom of the lake, deep cold water. | Trout fisheries dominate. |
| 30-40 | Bottom may become anoxic (no oxygen). | Trout fisheries in deep lakes only. Walleye, Cisco present. |
| 40-50 | **Mesotrophy:** Water moderately clear most of the summer. May be "greener" in late summer. | No oxygen at the bottom of the lake results in loss of trout. Walleye may predominate. |
| 50-60 | **Eutrophy:** Algae and aquatic plant problems possible. "Green" water most of the year. | Warm-water fisheries only. Bass may dominate. |
| 60-70 | Blue-green algae dominate, algal scums and aquatic plant problems. | Dense algae and aquatic plants. Low water clarity may discourage swimming and boating. |
| 70-80 | **Hypereutrophy:** Dense algae and aquatic plants. | Water is not suitable for recreation. |
| >80 | Algal scums, few aquatic plants. | Rough fish (carp) dominate; summer fish kills possible. |

Source: Carlson, R.E. 1997. A trophic state index for lakes. *Limnology and Oceanography*. 22:361-369.

## Trend Analysis

For detecting trends, a minimum of 8-10 years of data with 4 or more readings per season are recommended. Minimum confidence accepted by the MPCA is 90%. This means that there is a 90% chance that the data are showing a true trend and a 10% chance that the trend is a random result of the data. Only short-term trends can be determined with just a few years of data, because there can be different wet years and dry years, water levels, weather, etc, that affect the water quality naturally.

Hanging Horn Lake had enough data to perform a trend analysis on transparency (Table 8). The data was analyzed using the Mann Kendall Trend Analysis.

*Table 8. Trend analysis for Hanging Horn Lake.*

| Lake Site | Parameter | Date Range | Trend |
|---|---|---|---|
| 205 | Total Phosphorus | 2016 | Insufficient Data |
| 205 | Chlorophyll *a* | 2016 | Insufficient Data |
| 205 | Transparency | 2006-2016 | No trend |

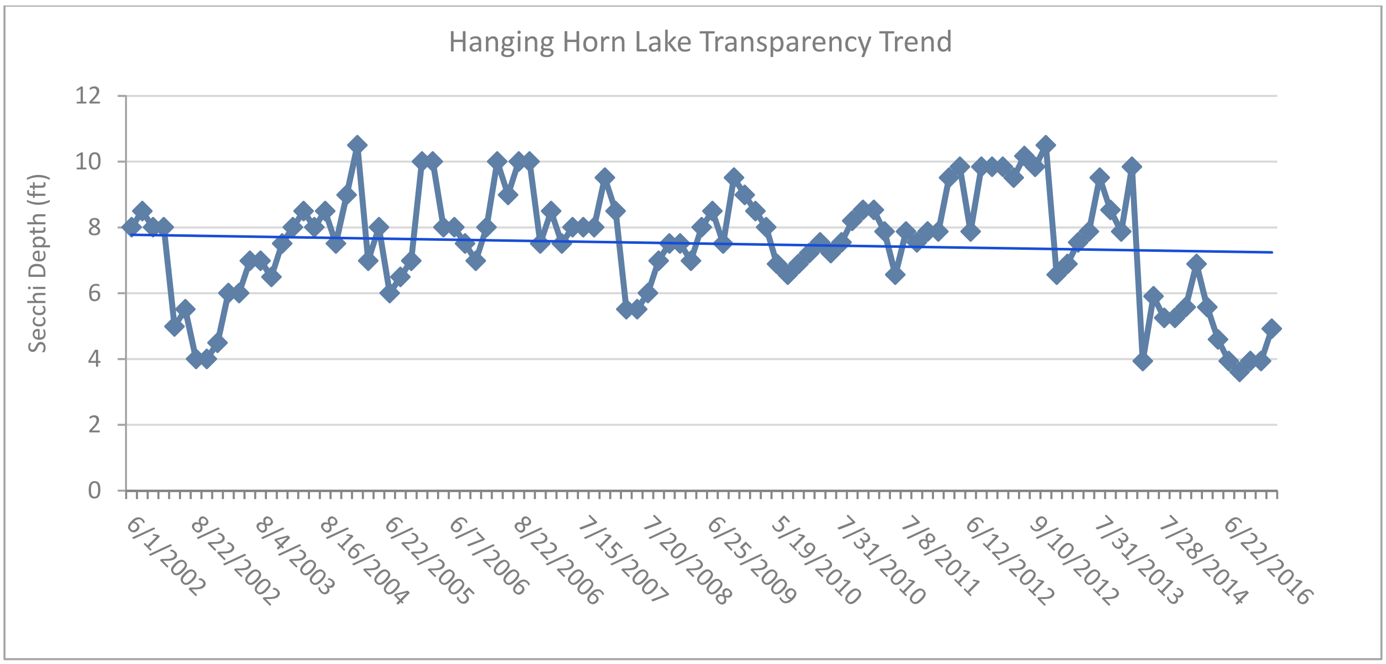



*Figure 11. Transparency (feet) trend for site 205 from 2002-2016.*

Hanging Horn Lake shows insufficient evidence for a transparency trend (Figure 11); however, since 2013 the transparency is lower than before 2013. Transparency monitoring should continue so that this trend can be tracked in future years.

## Lakeshed

Understanding a lakeshed requires an understanding of basic hydrology. A watershed is defined as all land and water surface area that contribute excess water to a defined point. The MN DNR has delineated three basic scales of watersheds (from large to small): 1) basins, 2) major watersheds, and 3) minor watersheds.

The Kettle River Major Watershed is one of the watersheds that make up the St. Croix River Basin, which drains south to the Gulf of Mexico (Figure 12).

The MN DNR also has evaluated catchments for each individual lake with greater than 100 acres surface area. These lakesheds (catchments) are the "building blocks" for the larger scale watersheds. Hanging Horn Lake falls within lakeshed 3502302 (Figure 16). Though very useful for displaying the land and water that contribute directly to a lake, lakesheds are not always true watersheds because they may not show the water flowing into a lake from upstream streams or rivers. While some lakes may have only one or two upstream lakesheds draining into them, others may be connected to a large number of lakesheds, reflecting a larger drainage area via stream or river networks.

In an effort to prioritize protection and restoration efforts of fishery lakes, the MN DNR has developed a ranking system by separating lakes into two categories based on their lakeshed, those needing protection and those needing restoration. Modeling by the DNR Fisheries Research Unit suggests that total phosphorus concentrations increase significantly over natural concentrations in lakes that have watershed with disturbance greater than 25%. Therefore, lakes with watersheds that have less than 25% disturbance need protection and lakes with more than 25% disturbance need restoration (Table 9). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land, public water, wetlands, or conservation easement.

*Table 9. Suggested approaches for watershed protection and restoration of DNR-managed fish lakes in Minnesota.*

| Watershed Disturbance (%) | Watershed Protected (%) | Management Type | Comments |
|---|---|---|---|
| < 25% | > 75% | Vigilance | Sufficiently protected -- Water quality supports healthy and diverse native fish communities. Keep public lands protected. |
| | < 75% | Protection | Excellent candidates for protection -- Water quality can be maintained in a range that supports healthy and diverse native fish communities. Disturbed lands should be limited to less than 25%. |
| 25-60% | n/a | Full Restoration | Realistic chance for full restoration of water quality and improve quality of fish communities. Disturbed land percentage should be reduced and BMPs implemented. |
| > 60% | n/a | Partial Restoration | Restoration will be very expensive and probably will not achieve water quality conditions necessary to sustain healthy fish communities. Restoration opportunities must be critically evaluated to assure feasible positive outcomes. |

The next step was to prioritize lakes within each of these management categories. DNR Fisheries identified high value fishery lakes, such as cisco refuge lakes. Ciscos (*Coregonus artedi)* can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. These watersheds with low disturbance and high value fishery lakes are excellent candidates for priority protection measures, especially those that are related to forestry and minimizing the effects of landscape disturbance. Forest stewardship planning, harvest coordination to reduce hydrology impacts and forest conservation easements are some potential tools that can protect these high value resources for the long term. Hanging Horn Lake is a cisco refuge lake.

Hanging Horn Lake's lakeshed is classified with having 50% of the watershed protected and 6% of the watershed disturbed (Figure 13). Therefore, this lakeshed should have a protection focus. Goals for the lake should be to limit any increase in disturbed land use and maintain protected land. Hanging Horn Lake is a drainage lakeshed, which means that other lakesheds flow into it (Figure 12). It has a large watershed because the Moose Horn River flows through it.

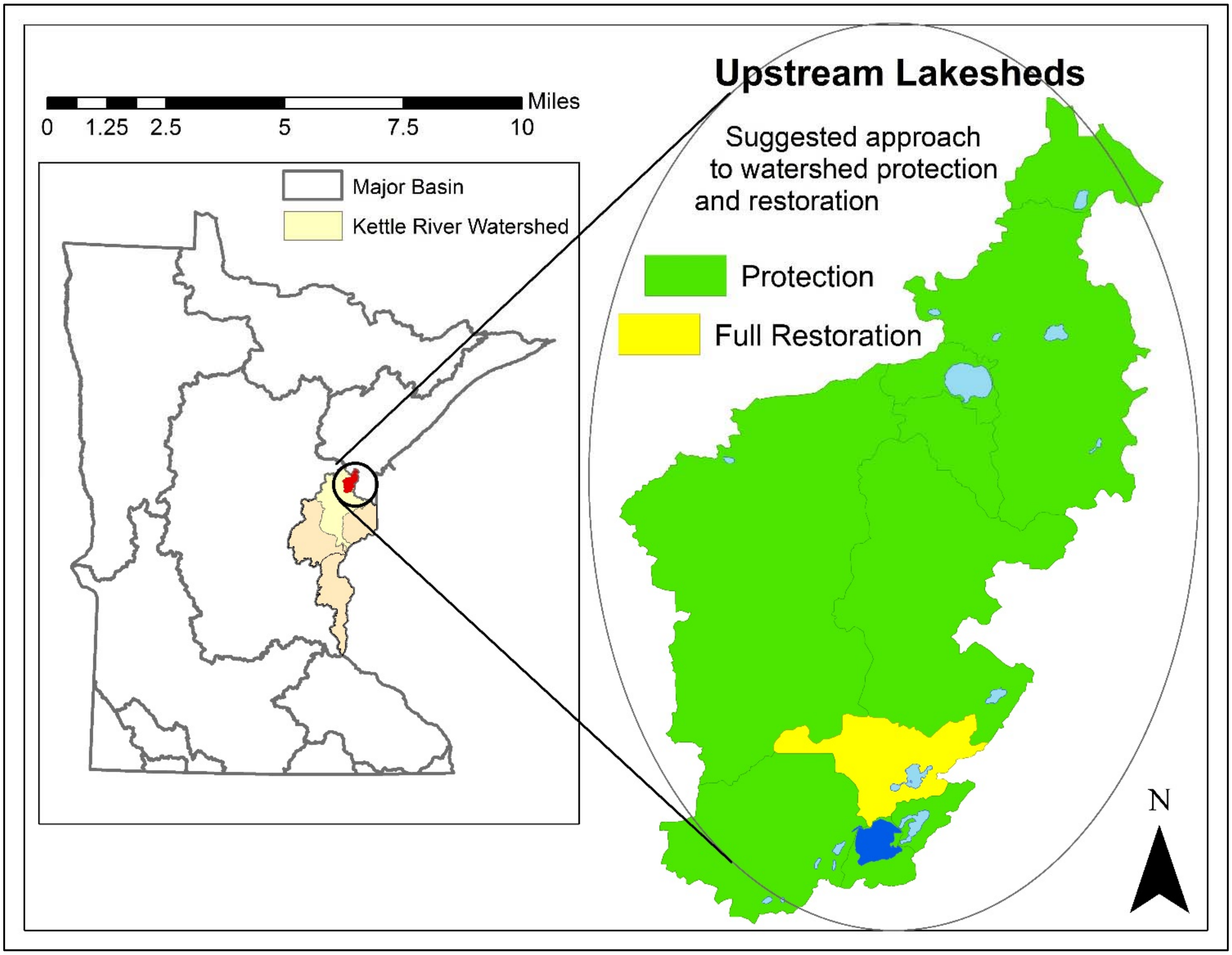



*Figure 12. Kettle River major watershed and MN basins (left), and Hanging Horn Lake lakeshed and upstream catchments with protection suggestions (right).*

## Land use and Ownership

Activities that occur on the land within the lakeshed can greatly impact a lake. Land use planning helps ensure the use of land resources in an organized fashion so that the needs of the present and future generations can be best addressed.

Half of the Hanging Horn Lake lakeshed is protected. This total includes water, wetlands, and publicly owned land. There are two parcels along the lakeshore which have specific conservation potential. They are both private land over 20 acres which are less than 50% developed or agriculture. There are no animal feedlots in the lakeshed (Table 10).

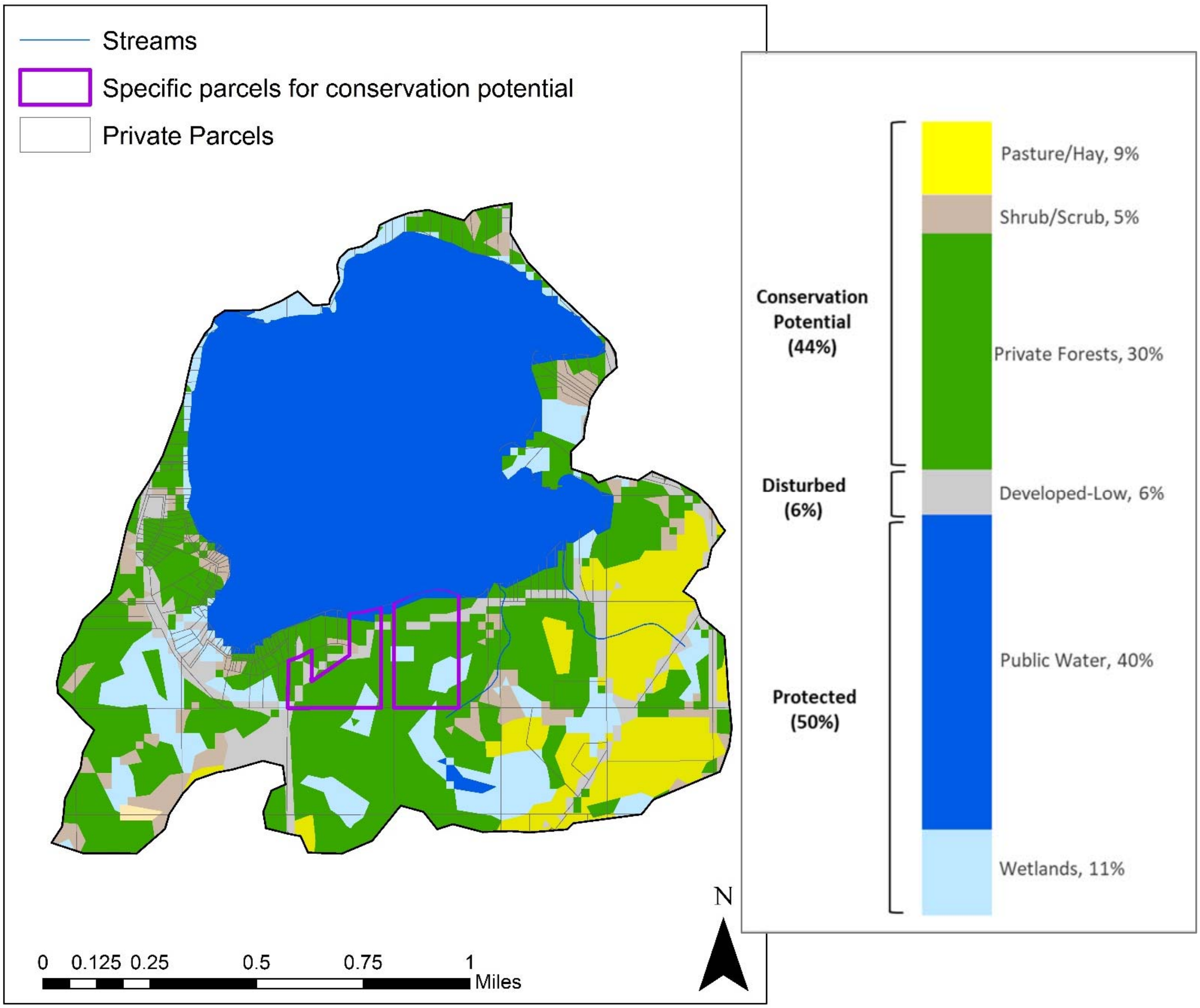



*Figure 13. Land use and ownership in the Hanging Horn Lake lakeshed.*

The lakeshed vitals table identifies where to focus organizational and management efforts for each lake (Table 10). Criteria were developed using limnological concepts to determine the effect to lake water quality.

**KEY**

● Possibly detrimental to the lake
◉ Warrants attention
○ Beneficial to the lake

*Table 10. Hanging Horn Lake lakeshed vitals table.*

| Lakeshed Vitals | | Rating |
|---|---|---|
| **Lake Area** | 408.7 acres | descriptive |
| **Littoral Zone Area** | 65.4 acres | descriptive |
| **Lake Max Depth** | 84 ft. | descriptive |
| **Lake Mean Depth** | 32 ft. | ○ |
| **Water Residence Time** | NA | Not available |
| **Miles of Stream** | 0.9 | descriptive |
| **Inlets** | 4 | ◉ |
| **Outlets** | 1 | ○ |
| **Major Watershed** | 35 – Kettle River | descriptive |
| **Minor Watershed** | 35023 | descriptive |
| **Lakeshed** | 3502302 | descriptive |
| **Ecoregion** | Northern Lakes and Forest | descriptive |
| **Total Lakeshed to Lake Area Ratio** (total lakeshed includes lake area) | 3:1 | ◉ |
| **Standard Watershed to Lake Basin Ratio** (standard watershed includes lake areas) | 134:1 | ● |
| **Wetland Coverage** | 6.5% | ○ |
| **Aquatic Invasive Species** | None | ○ |
| **Public Drainage Ditches** | None | ○ |
| **Public Lake Accesses** | 1 | ◉ |
| **Miles of Shoreline** | 4.6 | descriptive |
| **Shoreline Development Index** | 1.62 | ○ |
| **Public Land to Private Land Ratio** | 0:1 | ◉ |
| **Development Classification** | Recreational Development | ◉ |
| **Miles of Road** | 4.1 | descriptive |
| **Municipalities in lakeshed** | None | ○ |
| **Forestry Practices** | None | ○ |
| **Feedlots** | None | ○ |
| **Sewage Management** | Compliance inspections are required for subsurface sewage treatment systems at point-of-sale or permit application in shoreland areas. | ◉ |
| **Lake Management Plan** | None | ◉ |
| **Lake Vegetation Survey/Plan** | DNR, 1997 | ○ |

## Hanging Horn Lake, Status of the Fishery (DNR, 7/20/2015)

A standard survey was conducted on Hanging Horn Lake during the summer of 2015 to evaluate and update information about fish populations and to evaluate the effectiveness of the Lake Trout stocking program.

Lake Trout is the primary management species for Hanging Horn Lake. Over 25,000 yearling Lake Trout have been stocked into the lake since 2007. Zero Lake Trout were captured in 2015 for a gillnet abundance of 0.0 per lift.  Six special deep water gillnets were also set targeting Lake Trout. No Lake Trout were captured in the deep gillnets either. The 2010 assessment captured two Lake Trout for a deep gillnet abundance of 0.3 per lift, but both specimens were age-1 and had been recently stocked. The lack of Lake Trout captured suggests that Hanging Horn is unsuitable for Lake Trout management. Lake Trout likely are not surviving the warm summer months due to low dissolved oxygen levels and thermal stress in the deeper areas of the lake.

Walleye abundance of 1.1 per gillnet lift was average compared to other Minnesota lakes. Walleye average length was 12.5 inches and 1.7 pounds. Several year-classes of young walleye were evident in the sample suggesting angling for Walleye may improve in the next few years as these year-classes mature.

Tullibee/Cisco abundance of 36.1 per gillnet lift was well above average compared to other Minnesota lakes. Tullibee gillnet average length was 10.6 inches. Angling and/or sport netting opportunities for Cisco are exceptional in Hanging Horn Lake. Hanging Horn consistently has the highest abundance of Cisco in the Duluth Area.

Northern Pike abundance of 0.9 per gillnet lift was below average compared to other Minnesota Lakes. However, average size was good at 26.4 inches with fish up to 38.7 inches present. Although Northern Pike are present in low abundance, quality size fish are available in Hanging Horn Lake.

Black Crappie abundance of 3.7 per trapnet lift was above average compared to other Minnesota lakes. Average length was 8.1 inches with fish up to 10 inches sampled. Bluegill abundance was average at 11.8 per trapnet lift. Average length was 6.7 inches but only 12% exceeded 8 inches.

One Brook Trout was captured for a gillnet abundance of 0.1 per lift. The fish was 13.7 inches in length and was from the 2011 year-class. The origin of this fish is unknown but it likely emigrated from a cold water stream connected to the Moosehorn River which flows through Hanging Horn Lake. Historically, one other Brook Trout was captured in Hanging Horn during an assessment in 1993.

See the link below for specific information on gillnet surveys, stocking information, and fish consumption guidelines. http://www.dnr.state.mn.us/lakefind/showreport.html?downum=09003800

## Key Findings and Recommendations

**Monitoring Recommendations**
Transparency monitoring at site 205 should be continued annually. It is important to continue transparency monitoring weekly or at least bimonthly every year to enable year-to-year comparisons and trend analyses. Phosphorus and chlorophyll a monitoring should continue at site 205, as the budget allows, to track future water quality trends.

**Overall Conclusions**
Hanging Horn Lake is a mesotrophic lake (TSI = 48) with insufficient evidence of a long-term trend in water clarity. The clarity in 2016 was lower than other years, so it should continue to be monitored in the future to document any changes. The total phosphorus, chlorophyll *a* and transparency ranges are within the ecoregion ranges (Table 4).

A third of Hanging Horn Lake's lakeshed is forested, none of the lakeshed is in public ownership, and 50% of the lakeshed is protected, while only 6% of the lakeshed is disturbed (Figure 13).

Hanging Horn Lake is one of several connected lakes joined via the Moose Horn River. The total watershed area for Hanging Horn Lake is very large (Table 11), therefore disturbances beyond the immediate lakeshed can adversely impact Hanging Horn's water quality.

Hanging Horn Lake is managed by DNR Fisheries for a cold water fishery, including ciscoes and lake trout. Dissolved oxygen profiles show hospitable oxygen levels for ciscoes in the summer (Figure 10). The DNR Fisheries summary on page 14 reports that cisco populations are above average for the area, but lake trout may not be surviving in the lake.

**Phosphorus Loading and Priority Impacts**
Hanging Horn Lake is at a disadvantage because it has a very large watershed (Table 11). Upstream land use in the watershed is likely the main impact to the lake's water quality.

With the Moose Horn River flowing through the lake, it likely has a short residence time, which means that many of the nutrients flowing into the lake also flush out.

*Table 11. Watershed characteristics.*

| | |
|---|---|
| **Lakeshed to Lake Area Ratio** (lakeshed includes lake area) | 3:1 |
| **Watershed to Lake Area Ratio** (watershed includes lake areas) | 134:1 |
| **Number of Upstream Lakes** | 9 |
| **Headwaters Lake?** | No |
| **Inlets / Outlets** | 4 / 1 |
| **Water Residence Time** | NA |

Hanging Horn Lake's trophic state (TSI=48) is a bit higher than expected for a deep lake that supports cold water fisheries, but that is likely due to its large watershed. Working to protect the land upstream and around the shoreline will help maintain Hanging Horn Lake's water quality.

**Best Management Practices Recommendations**

The management focus for Hanging Horn Lake should be to protect the current water quality and the lakeshed. Efforts should be focused on managing and/or decreasing the impact caused by current and additional development, including second tier development, and impervious surface area. Project ideas include protecting land with conservation easements, enforcing county shoreline ordinances, shoreline restoration, rain gardens, and septic system maintenance.

## Hanging Horn Lake Goals

1. Protection Focus: minimize disturbed land uses and maintain protected lands
2. Manage phosphorus loading from **upstream in the watershed**, Table 12
3. Focused BMPs per land type: Table 12

*Table 12. Best Management Practices Table specific to Hanging Horn Lake (refer to Figure 13)*

| Category | Land use type | Conservation project ideas | Results | Who | Contact for help |
|---|---|---|---|---|---|
| Conservation Potential Land | private forests (30%, 313 acres) | Forest stewardship planning, 3rd party certification, SFIA, local woodland cooperatives | Conserve and protect current forest cover | • Individual Property Owners | Carlton SWCD<br>(218) 384-3891<br>https://carltonswcd.org |
| | pasture/hay (9%, 95.8 acres) | Conservation Reserve Program (CRP), maintain vegetative cover, plant trees, conservation easements, grassed waterways, ditch buffers, maintain/restore wetlands. | Reduce water runoff and soil erosion, better water storage. | • Individual Property Owners | Natural Resources Conservation Service<br>218-720-5209 |
| | shrub/scrub (5%, 50.7 acres) | Maintain vegetative cover, plant trees, conservation easements, grassed waterways, buffers. | Reduce water runoff and soil erosion, better water storage. | • Individual Property Owners | Natural Resources Conservation Service<br>218-720-5209 |
| Disturbed Land | developed, low intensity (6%, 60.5 acres) | Shoreline buffers, rain gardens. | Reduce water runoff and shoreline erosion in lakes and streams. | • Individual Property Owners<br>• Lake Associations | Carlton SWCD<br>(218) 384-3891<br>https://carltonswcd.org |

The current lakeshore homeowners can lessen their negative impact on water quality by installing or maintaining the existing trees on their properties. Forested uplands contribute significantly less phosphorus (lbs/acre/year) than developed land cover (Table 12).

A third of the lakeshed is privately owned forested uplands (Table 12). Forested uplands can be managed with Forest Stewardship Planning, 3rd party certification, SFIA, and local woodland cooperatives. Contact the Soil and Watershed Conservation District for options for managing private forests.

The lakeshed still has a couple of large undeveloped shoreline parcels (Figure 13). Because a lot of undeveloped private land still exists, there is a great potential for protecting this land with conservation easements and aquatic management areas (AMAs). Conservation easements can be set up easily and with little cost with help from organizations such as the Board of Soil and Water Resources and the Minnesota Land Trust. AMAs can be set up through the local DNR fisheries office.

Native aquatic plants stabilize the lake's sediments and tie up phosphorus in their tissues. When aquatic plants are uprooted from a shallow lake, the lake bottom is disturbed, and the phosphorus in the water column gets used by algae instead of plants. This contributes to "greener" water and more algae blooms. Protecting native aquatic plant beds will ensure a healthy lake and healthy fishery. If a swimming area is necessary in front of people's docks, clear only a small area of plants. Clearing a whole 100 foot frontage is not necessary and can contribute to additional algae blooms.

*Table 13. Organizational contacts and reference sites*

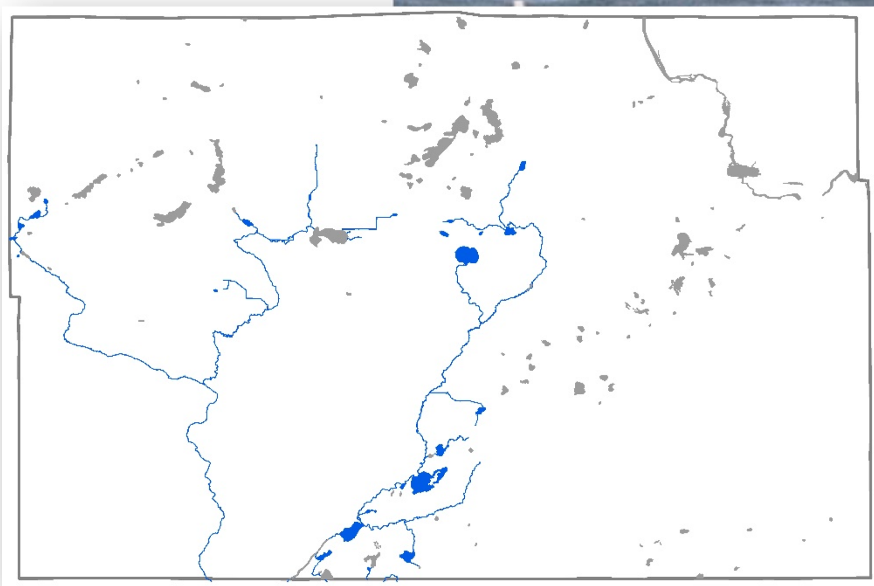
## Organizational contacts and reference sites

| | |
|---|---|
| Hanging Horn Lakeshore Management Association | P.O. Box 192 Barnum, MN 55707 |
| DNR Fisheries Office | 5351 North Shore Drive, Duluth, MN 55804<br>218-302-3264, duluth.fisheries@state.mn.us |
| Regional Minnesota Pollution Control Agency Office | 525 Lake Avenue South, Suite 400, Duluth, MN 55802<br>218-723-4660<br>https://www.pca.state.mn.us/about-mpca/duluth-office |
| Carlton County Soil and Water Conservation District | 808 3rd St, Carlton, MN 55718<br>(218) 384-3891, https://carltonswcd.org/ |
| Carlton County | 301 Walnut Ave, Carlton, MN 55718<br>http://carltoncountymn.govoffice3.com/ |

# Kettle River Watershed, Carlton County

## Lake Prioritization and Protection Planning Document

**2018**



CARLTON SWCD
SOIL & WATER CONSERVATION DISTRICT

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Date: March 8, 2018

To: Carlton County Soil & Water Conservation District
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Subject: Kettle River Watershed, Carlton County, Lake Prioritization and Planning Document

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## Acknowledgements

**Organization and oversight**
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**Funding provided by**
Carlton County Soil and Water Conservation District
Minnesota Pollution Control Agency

**Organizations contributing data and information**
Minnesota Department of Natural Resources (DNR)
Minnesota Pollution Control Agency (MPCA)
Carlton County Soil and Water Conservation District (SWCD)
Lake Associations

# Table of Contents

## Introduction

The Kettle River Watershed covers 672,235 acres in northeast Minnesota and lies within Northern Lakes and Forests ecoregion. Parts of Aitkin, Carlton, Kanabec, and Pine counties are in the Kettle River watershed. The headwaters for the Kettle River begin in Carlton County, and the river flows 104 miles south to its confluence with the St. Croix River south of Hinckley.

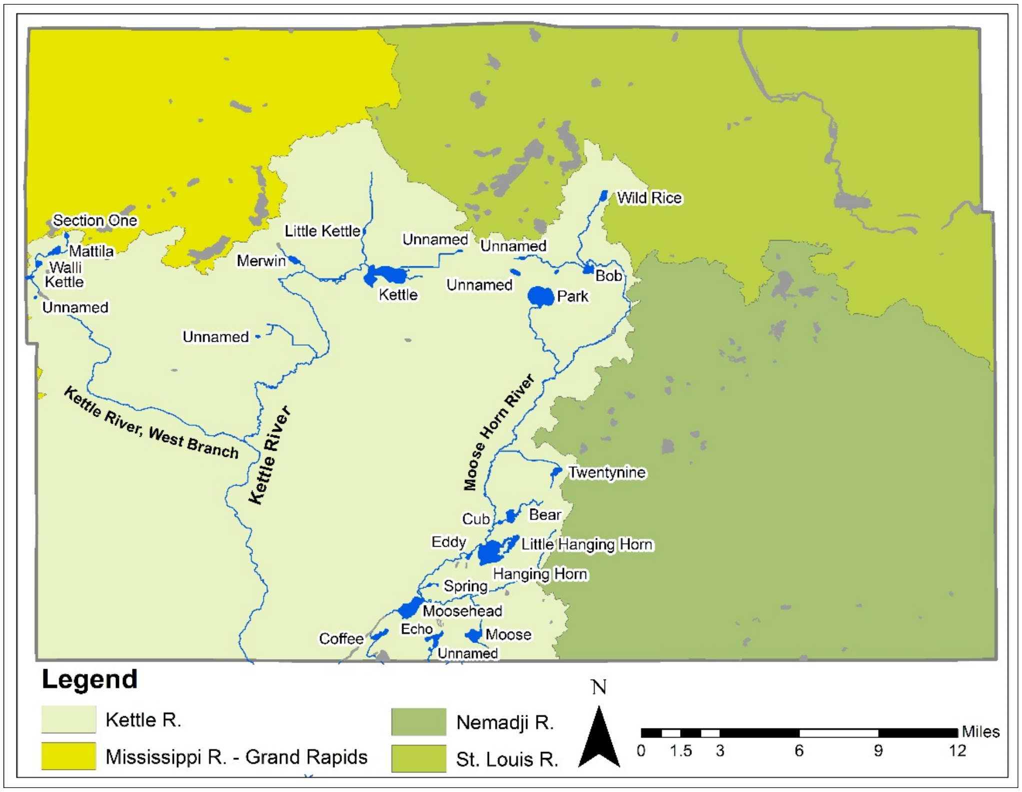



Figure 1. Lakes of Carlton County and the Kettle River Watershed. Lakes evaluated in this report are in dark blue, while each major basin is highlighted in a different color.

In 2018 the Carlton Soil and Water Conservation District (SWCD) decided to evaluate the water quality of the lakes in the Kettle River Watershed in Carlton County as civic engagement outreach. There are 29 lakes in the Kettle River Watershed and they are indicated in dark blue in Figure 1 and listed in Table 1.

Carlton County lakes have been monitored off and on between the 1970s and 2017. This monitoring has been completed by numerous organizations including Lake Associations, Minnesota Pollution Control Agency, Minnesota Department of Natural Resources, and Carlton SWCD.

The purposes of this report were to compile all available data for these lakes from all the different sources, evaluate the data quality, identify data gaps, assess the data, and look for water quality trends, and prioritize lakes for management. This report contains a summary of the current state of selected Kettle River Watershed Lakes in Carlton County and recommendations for future monitoring. Individual lake reports follow with more in-depth assessments and recommendations.

Table 1. Data availability for Carlton County Lakes.

| Prioritization and Potential Lake Impacts | | |
|---|---|---|
| Transparency data |  | Secchi disk data have been collected extensively and should continue annually since it is relatively easy and inexpensive. |
| Chemical data (phosphorus) |  | Most large Carlton County lakes have at least two years of water quality data in the past 10 years. They don't have long-term data sets for trend analysis. |
| Inlet/Outlet data |  | Inlet/outlet data have been collected as part of the Kettle River Watershed Restoration and Protection Strategy. |

Table 2. Lakes assessed in the 2018 lake assessment.

| Lake Name | Lake ID | Lake Size (acres) |
|---|---|---|
| Bob | 09-0026-00 | 75.2 |
| Bear | 09-0034-00 | 90.4 |
| Coffee | 09-0045-00 | 71.1 |
| Cub | 09-0118-00 | 17 |
| Echo | 09-0044-00 | 108.3 |
| Eddy | 09-0039-00 | 23.5 |
| Hanging Horn | 09-0038-00 | 408.7 |
| Kettle | 09-0049-00 | 503.3 |
| Kettle | 09-0074-00 | 22.1 |
| Little Hanging Horn | 09-0035-00 | 114.4 |
| Little Kettle | 09-0077-00 | 14 |
| Mattila | 09-0070-00 | 65.4 |
| Merwin | 09-0058-00 | 52.6 |
| Moose | 09-0043-00 | 132.7 |
| Moosehead | 09-0041-00 | 274.8 |
| Park | 09-0029-00 | 381.3 |
| Section One | 09-0069-00 | 20.1 |
| Spring | 09-0094-00 | 18.1 |
| Twentynine | 09-0022-00 | 51.8 |
| Unnamed | 09-0027-00 | 16.9 |
| Unnamed | 09-0028-00 | 37.2 |
| Unnamed | 09-0075-00 | 6.3 |
| Unnamed | 09-0078-00 | 10.4 |
| Unnamed | 09-0092-00 | 12.4 |
| Unnamed | 09-0093-00 | 8.9 |
| Unnamed | 09-0124-00 | 12.4 |
| Unnamed | 09-0145-00 | 196.2 |
| Walli | 09-0071-00 | 32.8 |
| Wild Rice | 09-0023-00 | 55.3 |

## Trophic State Index

Trophic State Index (TSI) is a standard measure or means for estimating the amount of algae in a lake. The TSI is used to classify the "trophic state" of a lake, which broadly includes three categories: oligotrophic (little algae), mesotrophic (moderate algae), and eutrophic (high algae).

Many lakes, over long periods of time naturally "age" as runoff from adjacent lands adds nutrients into a lake. Young lakes start off oligotrophic and become eutrophic as they age, a process called "eutrophication". When human use of lakes increases the rate of nutrients into lakes, above background rates, for example through agriculture, sewage leakage, lawn fertilization, or more, lakes are said to undergo "cultural eutrophication". While preventing natural eutrophication is difficult, through modifying behavior and lake use, people can slow the rate of cultural eutrophication. Typical characteristics of these trophic states as well as some finer trophic state divisions are given in Table 4.

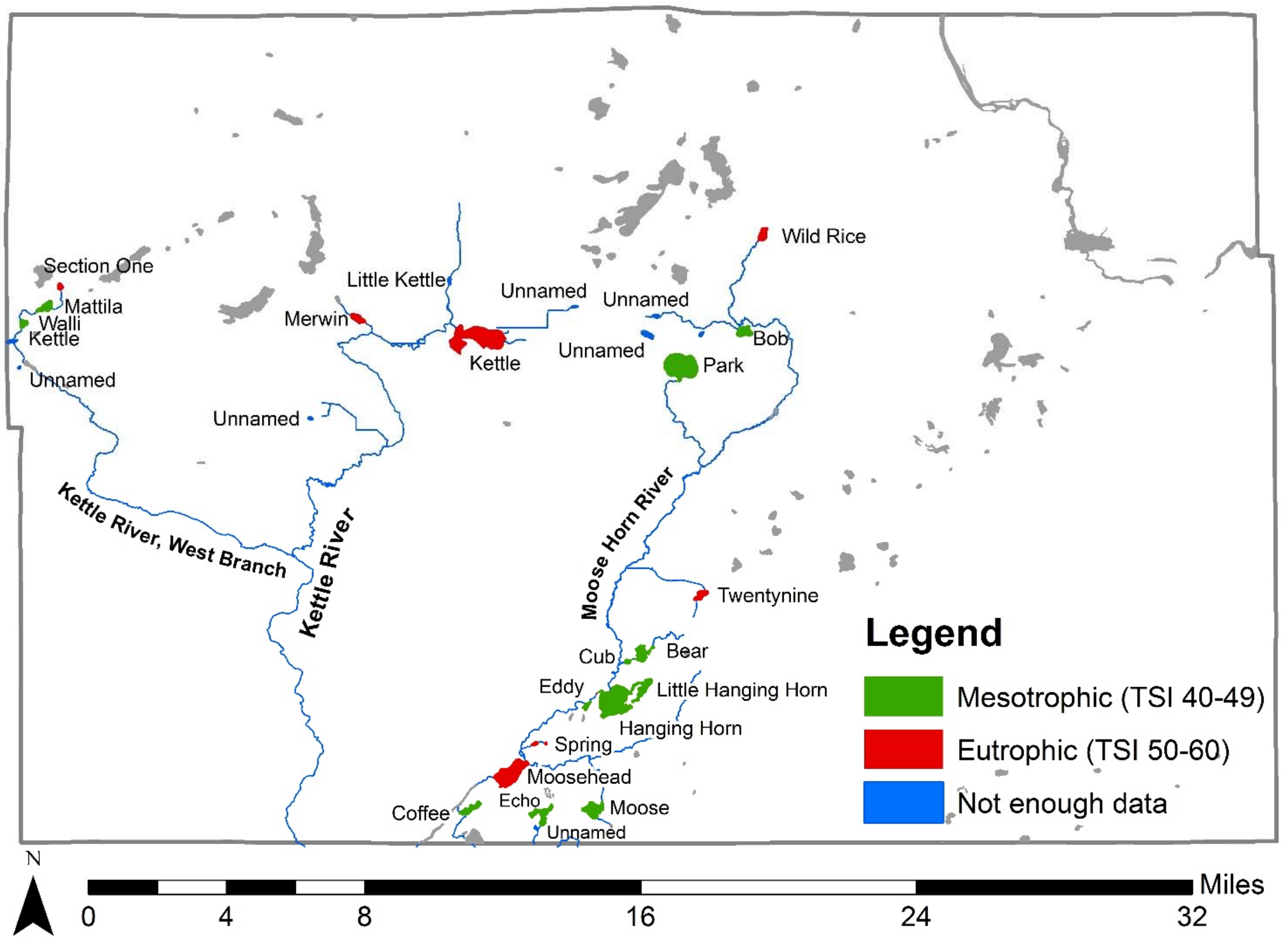



Figure 2. Trophic state index of selected lakes in the Kettle River Watershed in Carlton County

Phosphorus (a nutrient), chlorophyll *a* (an indication of algal concentration) and Secchi depth (transparency measure of water transparency/clarity) are usually related and are the primary measurements used to determine a lake's TSI. The more phosphorus that is available, the more algae that can grow. As algal concentrations increase, it causes water to become turbid or murky, which results in the water becoming less transparent and subsequently, the Secchi depth decreases.

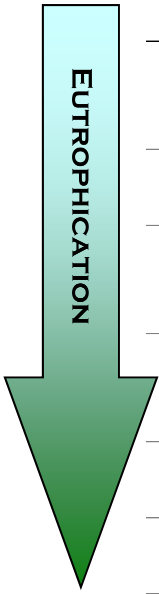
The TSI is unitless but can range from 0 (as oligotrophic as possible) to 100 (as eutrophic as possible). In real terms, a TSI of 0 would have a Secchi depth of approximately 210 feet while a TSI of 100 would have a TSI of approximately 3 inches. For every increase of 10 units in the TSI, the Secchi depth halves and the phosphorus doubles. Most of the large Carlton County lakes fall into the mesotrophic category (Table 3, Figure 2).

Table 3. Trophic state and trophic state index for Kettle River Watershed lakes in Carlton County.

| Lake | Mean TSI | Trophic State | Mean TSI Secchi | Mean TSI Phosphorus | Mean TSI Chlorophyll *a* |
|---|---|---|---|---|---|
| Echo | 41 | Mesotrophic | 32 | 45 | 47 |
| Park | 43 | Mesotrophic | 42 | 44 | 44 |
| Bob | 44 | Mesotrophic | 38 | 45 | 50 |
| Little Hanging Horn | 44 | Mesotrophic | 42 | 46 | 43 |
| Coffee | 45 | Mesotrophic | 39 | 47 | 50 |
| Moose | 46 | Mesotrophic | 36 | 50 | 53 |
| Eddy | 48 | Mesotrophic | 51 | 48 | 45 |
| Kettle (0049) | 48 | Mesotrophic | 51 | 53 | 42 |
| Bear | 49 | Mesotrophic | 45 | 51 | 50 |
| Hanging Horn | 49 | Mesotrophic | 48 | 49 | 50 |
| Mattlia* | See Secchi | Mesotrophic | 44* | | |
| Cub* | See Secchi | Mesotrophic | 46* | | |
| Walli* | See Secchi | Mesotrophic | 49* | | |
| Merwin | 51 | Eutrophic | 39 | 57 | 57 |
| Moosehead | 55 | Eutrophic | 56 | 55 | 55 |
| Twentynine | 56 | Eutrophic | 52 | 62 | 55 |
| Section One* | See Secchi | Eutrophic | 50* | | |
| Spring* | See Secchi | Eutrophic | 53* | | |
| Wild Rice* | See Secchi | Eutrophic | 55* | | |

**No water quality data exist for these lakes, but transparency TSI can be estimated from the University of Minnesota Remote Sensing Lab 2008 data. http://lakes.rs.umn.edu/*

Table 4. Trophic states and corresponding lake and fisheries conditions.




| TSI | Attributes | Fisheries & Recreation |
|---|---|---|
| <30 | **Oligotrophy:** Clear water, oxygen throughout the year at the bottom of the lake, very deep cold water. | Trout fisheries dominate. |
| 30-40 | Bottom of shallower lakes may become anoxic (no oxygen). | Trout fisheries in deep lakes only. Walleye, Tullibee present. |
| 40-50 | **Mesotrophy:** Water moderately clear most of the summer. May be "greener" in late summer. | No oxygen at the bottom of the lake results in loss of trout. Walleye may predominate. |
| 50-60 | **Eutrophy:** Algae and aquatic plant problems possible. "Green" water most of the year. | Warm-water fisheries only. Bass may dominate. |
| 60-70 | Blue-green algae dominate, algal scums and aquatic plant problems. | Dense algae and aquatic plants. Low water clarity may discourage swimming and boating. |
| 70-80 | **Hypereutrophy:** Dense algae and aquatic plants. | Water is not suitable for recreation. |
| >80 | Algal scums, few aquatic plants. | Rough fish (carp) dominate; summer fish kills possible. |

Source: Carlson, R.E. 1997. A trophic state index for lakes. *Limnology and Oceanography*. 22:361-369.

## Water Quality Trends

In assessing water quality, agencies and other lake data users want to know if the amount of algae has been changing over time. Scientists test hypotheses using statistics, and the hypothesis used in a trend analysis is that no trend exists. In other words, we begin with the assumption that there is no trend. We collect data and use statistics to determine the probability of collecting our data if this hypothesis of no trend is indeed true. The output from a statistical test is called the probability value (or p-value for short) of collecting data given the hypothesis of no trend is true. The smaller this probability value, the more likely the null hypothesis of no trend can be rejected. The MPCA has set the acceptable p-value to be less than 10%. In other words, if $p < 0.10$ we reject the hypothesis of no trend and accept that a trend likely exists. Another way to think of this is to say that there is in reality an existing trend, there is a 90% chance we would have collected the data we collected and that a 10% chance that the trend is a random result of the data.

For detecting trends, a minimum of 8-10 years of data with four or more readings per season are recommended by the MPCA. Where data does not cover at least eight years or where there are only few samples within a year, trends can be misidentified because there can be different wet years and dry years, water levels, weather, and etc., that affect the water quality naturally.

The lakes in Table 5 had sufficient transparency data to perform a statistical trend analysis (Table 5). The data were analyzed using the Mann Kendall Trend Analysis. The lakes in Table 6 had insufficient data to perform a statistical trend analysis.

Table 5. Kettle River Carlton County lakes with enough data to determine trends in transparency.

| Lake Name | Lake ID | Years | Trend |
|---|---|---|---|
| Eddy | 09-0039-00 | 1995-2015 | Declining Trend |
| Little Hanging Horn | 09-0035-00 | 2006-2016 | Improving Trend |
| Bear | 09-0034-00 | 1996-2000, 2006-2016 | No Trend |
| Hanging Horn | 09-0038-00 | 2006-2016 | No Trend |
| Moosehead | 09-0041-00 | 2012-2017 | Improving Trend |
| Park | 09-0029-00 | 1985-2010 | No Trend |

Table 6. Kettle River Carlton County lakes with insufficient data to determine trends in transparency.

| Lake Name | Lake ID | Years | Trend |
|---|---|---|---|
| Bob | 09-0026-00 | 1982, 2016 | Insufficient Data |
| Coffee | 09-0045-00 | 2014-2016 | Insufficient Data |
| Cub | 09-0118-00 | NA | Insufficient Data |
| Echo | 09-0044-00 | 2016 | Insufficient Data |
| Kettle | 09-0049-00 | 2004, 2016-2017 | Insufficient Data |
| Kettle | 09-0074-00 | NA | Insufficient Data |
| Little Kettle | 09-0077-00 | NA | Insufficient Data |
| Mattila | 09-0070-00 | NA | Insufficient Data |
| Merwin | 09-0058-00 | 2016 | Insufficient Data |
| Moose | 09-0043-00 | 2016 | Insufficient Data |
| Section One | 09-0069-00 | NA | Insufficient Data |
| Spring | 09-0094-00 | NA | Insufficient Data |
| Twentynine | 09-0022-00 | 2016 | Insufficient Data |
| Unnamed | 09-0027-00 | NA | Insufficient Data |
| Unnamed | 09-0028-00 | NA | Insufficient Data |
| Unnamed | 09-0075-00 | NA | Insufficient Data |
| Unnamed | 09-0078-00 | NA | Insufficient Data |
| Unnamed | 09-0092-00 | NA | Insufficient Data |
| Unnamed | 09-0093-00 | NA | Insufficient Data |
| Unnamed | 09-0124-00 | NA | Insufficient Data |
| Unnamed | 09-0145-00 | NA | Insufficient Data |
| Walli | 09-0071-00 | NA | Insufficient Data |
| Wild Rice | 09-0023-00 | NA | Insufficient Data |

## Ecoregion Comparisons

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation and geology. The MPCA has developed a way to determine the "average range" of water quality expected for lakes in each ecoregion. The MPCA evaluated the lake water quality for reference lakes. These reference lakes are not considered pristine, but are considered to have little human impact and therefore are representative of the typical lakes within the ecoregion. The "average range" refers to the 25th - 75th percentile range for data within each ecoregion.

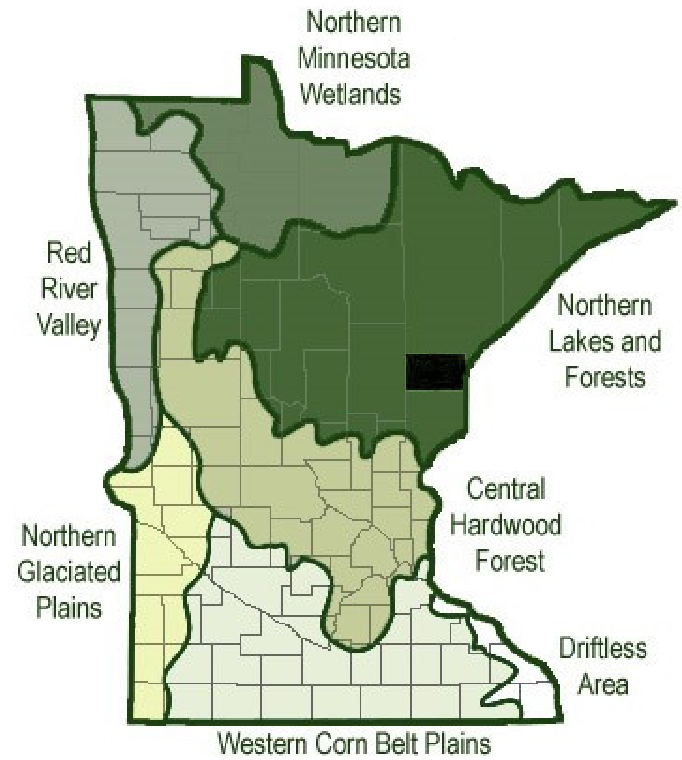



Figure 3. Minnesota Ecoregions. Carlton County is indicated in black.

All of Carlton County is in the Northern Lakes and Forests (NLF) Ecoregion (Figure 3). This heavily forested ecoregion is made up of steep, rolling hills interspersed with pockets of wetlands, bogs, lakes and ponds. Lakes are typically deep and clear, with good gamefish populations. These lakes are very sensitive to damage from atmospheric deposition of pollutants (mercury), storm water runoff from logging operations, urban and shoreland development, mining, inadequate wastewater treatment, and failing septic systems. Agriculture is somewhat limited by the hilly terrain and lack of nutrients in the soil, though there are some beef and dairy cattle farms.

Most of the lakes evaluated in this report fall within the expected ecoregion ranges for the Northern Lakes and Forests Ecoregion (Table 7). The lakes that don't fit these ranges are very small and shallow, and aren't as comparable to these ranges: Twentynine and Moosehead.

Table 7. Ecoregion ranges.

| Ecoregion | Total Phosphorus (ug/L) | Chlorophyll *a* (ug/L) | Secchi Depth (ft) |
|---|---|---|---|
| Northern Lakes and Forest (NLF) | 14 - 27 | <10 | 8 - 15 |

## DNR Fisheries Approach to Lake Protection and Restoration

*Credit: Peter Jacobson and Michael Duval, Minnesota DNR Fisheries*

In an effort to prioritize protection and restoration efforts of fishery lakes, the MN DNR has developed a ranking system by separating lakes into two categories, those needing protection and those needing restoration. Modeling by the DNR Fisheries Research Unit suggests that total phosphorus concentrations increase significantly over natural concentrations in lakes that have watershed with disturbance greater than 25%. Therefore, lakes with watersheds that have less than 25% disturbance need protection and lakes with more than 25% disturbance need restoration (Table 8). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land or conservation easement.

Table 8. Suggested approaches for watershed protection and restoration of DNR-managed fish lakes in Minnesota.

| Watershed Disturbance (%) | Watershed Protected (%) | Management Type | Comments |
|---|---|---|---|
| < 25% | > 75% | Vigilance | Sufficiently protected -- Water quality supports healthy and diverse native fish communities. Keep public lands protected. |
| | < 75% | Protection | Excellent candidates for protection -- Water quality can be maintained in a range that supports healthy and diverse native fish communities. Disturbed lands should be limited to less than 25%. |
| 25-60% | n/a | Full Restoration | Realistic chance for full restoration of water quality and improve quality of fish communities. Disturbed land percentage should be reduced and BMPs implemented. |
| > 60% | n/a | Partial Restoration | Restoration will be very expensive and probably will not achieve water quality conditions necessary to sustain healthy fish communities. Restoration opportunities must be critically evaluated to assure feasible positive outcomes. |

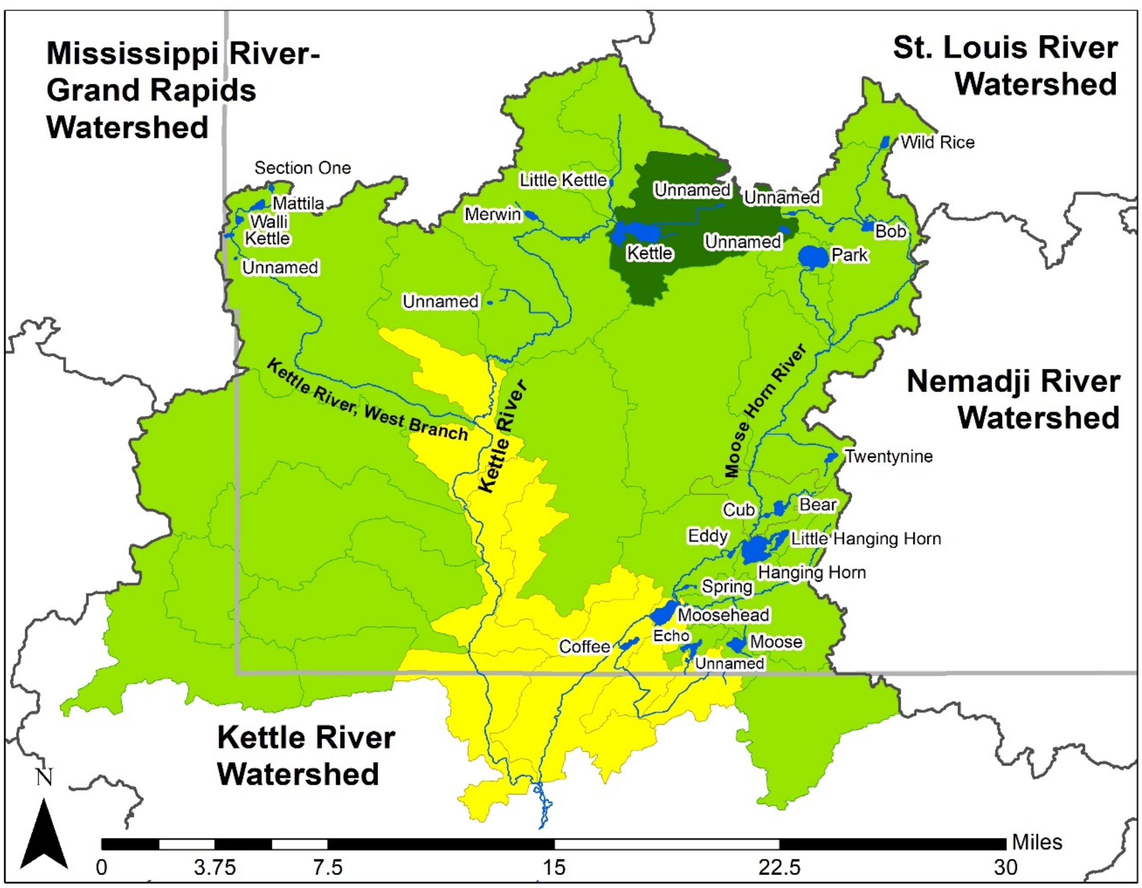



Figure 5. Map of lakesheds color-coded with management focus (Table 8).

Most of the lakes evaluated in this report have a protection management focus (light green, Figure 5, Table 8).

The next step was to prioritize lakes within each of these management categories. DNR Fisheries identified high value fishery lakes, such as cisco refuge lakes. Ciscos (*Coregonus artedi)* can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. These watersheds with low disturbance and high value fishery lakes are excellent candidates for priority protection measures, especially those that are related to forestry and minimizing the effects of landscape disturbance. Forest stewardship planning, harvest coordination to reduce hydrology impacts and forest conservation easements are some potential tools that can protect these high value resources for the long term. There are two Carlton County Lakes in the Kettle River Watershed evaluated in this report that are listed as Cisco refuge lakes: Hanging Horn and Little Hanging Horn (Table 9).

Table 9. Carlton County Lakes evaluation of watershed protection and disturbance.

| Lake Name | MN Lake ID | Management Focus | Cisco Refuge Lakes |
|---|---|---|---|
| Bob | 09-0026-00 | Protection | |
| Bear | 09-0034-00 | Full Restoration | |
| Coffee | 09-0045-00 | Full Restoration | |
| Cub | 09-0118-00 | Full Restoration | |
| Echo | 09-0044-00 | Protection | |
| Eddy | 09-0039-00 | Protection | |
| Hanging Horn | 09-0038-00 | Protection | Tier 2 |
| Kettle | 09-0049-00 | Vigilance | |
| Kettle | 09-0074-00 | Protection | |
| Little Hanging Horn | 09-0035-00 | Protection | Tier 2 |
| Little Kettle | 09-0077-00 | Protection | |
| Mattila | 09-0070-00 | Protection | |
| Merwin | 09-0058-00 | Protection | |
| Moose | 09-0043-00 | Protection | |
| Moosehead | 09-0041-00 | Full Restoration | |
| Park | 09-0029-00 | Protection | |
| Section One | 09-0069-00 | Protection | |
| Spring | 09-0094-00 | Protection | |
| Twentynine | 09-0022-00 | Protection | |
| Unnamed | 09-0027-00 | Protection | |
| Unnamed | 09-0028-00 | Vigilance | |
| Unnamed | 09-0075-00 | Protection | |
| Unnamed | 09-0078-00 | Protection | |
| Unnamed | 09-0092-00 | Protection | |
| Unnamed | 09-0093-00 | Full Restoration | |
| Unnamed | 09-0124-00 | Vigilance | |
| Walli | 09-0071-00 | Protection | |
| Wild Rice | 09-0023-00 | Protection | |

## Aquatic Invasive Species

Invasive species are a large threat to Minnesota's lakes. Invasive species can get out of control because there is nothing in the ecosystem naturally to keep the population in check. They can also replace native beneficial species and change the lake's ecosystem.

As of 2018, Carlton County has some infestations, mostly Eurasian watermilfoil (Figure 6). There are currently no lakes infested with zebra mussels.

At boat landings, there are usually DNR signs telling which invasive species are present in the waterbody and how to prevent their spread. Boaters should be educated about how to check for invasive species before moving from lake to lake. Care should be taken to protect Carlton County's water resources from future aquatic invasive species infestations.

For a current list of the infested waters in Minnesota, visit the DNR's website:
http://www.dnr.state.mn.us/invasives/ais/infested.html

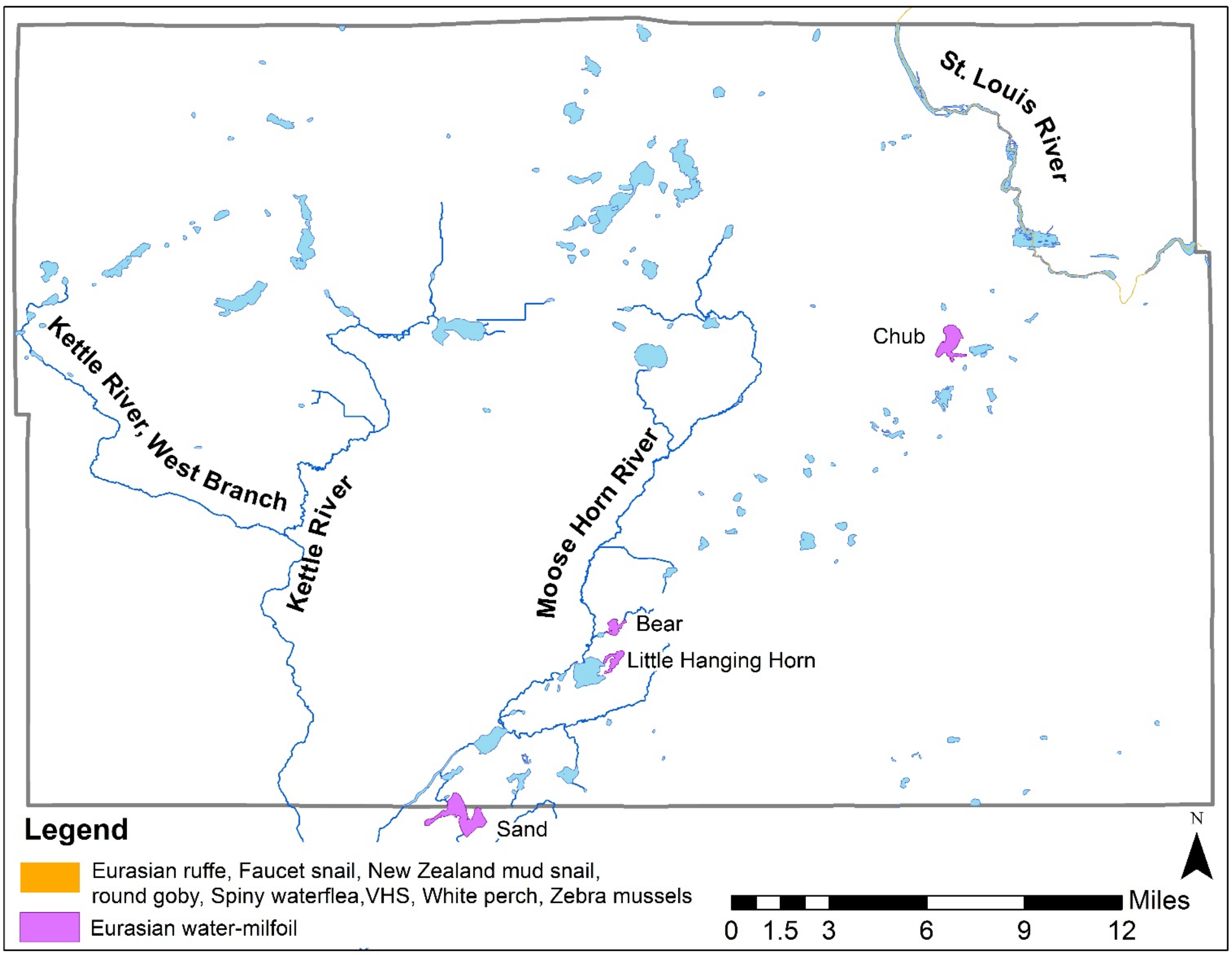



Figure 6. Carlton County lakes with invasive species as of February 2018.

# Prioritization and Potential Lake Impacts

## Prioritization

On a county-wide basis, it is helpful to prioritize lakes for projects and management. Due to their water quality and good fisheries, Hanging Horn and Little Hanging Horn lakes are highly developed and highly used for recreation and fishing. They are also classified as cisco refuge lakes by the DNR. These would likely be the top priority lakes for protection in the Kettle River Watershed in Carlton County. The other lakes that had more than a few years of water quality data and shoreline development include Bear Lake, Moosehead Lake and Park Lake. These would be the next priority. The lakes that did not have much or any water quality data or shoreline development would be the third priority.

Tier 1 Priority

- Hanging Horn Lake
- Little Hanging Horn Lake

Tier 2 Priority

- Bear Lake
- Moosehead Lake
- Park Lake

Tier 3 Priority

- All other lakes

Since not all lakes in the Kettle River Watershed in Carlton County had enough water quality data for a full analysis, a table was put together to summarize all the lakes (Table 11). Using information about the lake and its watershed, the lakes were separated into a nearshore focus or a watershed focus for best management practices.

## Nearshore Impacts Focus

Lakes with small watershed to lake area ratios (<10:1) and no inlets have a near shore focus. This means that the main impact to the lake's water quality is from land practices directly around the shoreline. Best management practices specific to nearshore impacts include:

- Evaluate the shoreline with Score Your Shore: http://www.dnr.state.mn.us/scoreyourshore/index.html
- Shoreline Restoration
- Rain Gardens
- Septic System Maintenance
- Plant Trees
- Establish Conservation Easements, Forest Stewardship Plans, and Aquatic Management Areas

## Watershed Impacts Focus

Lakes with large watersheds, inlets, and connections with upstream lakes have a watershed focus. This means that the main impact to the lake's water quality is the accumulation of nutrients from the whole watershed, and land practices upstream. Best management practices specific to watershed impacts include:

- Look at a map and identify all possible organizations in the watershed including lake associations, counties, national wildlife refuges, etc. Organize a "get to know your watershed" summit to brainstorm how to work together.
- Work with upstream partner organizations and the county as a whole to implement projects.
- Form a watershed district or lake improvement district, which provides additional funding for projects (tax funding).
- Encourage all riparian land owners to follow the best management practices in the nearshore section above.
- Enforce county shoreline and riparian ordinances to protect sensitive areas.

Table 10. Definitions of the column headings for Table 11.

| Column Heading | Definition |
|---|---|
| DOW | Lake Identification Number assigned by the DNR Division of Waters. |
| % Lakeshore Private | The percentage of the lakeshore that is in private ownership. Private land owners can implement best management practices on their own property with help from the SWCD. |
| # Inlets | The number of inlets to the lake. Inlets can bring nutrients and invasive species into a lake. |
| # Outlets | The number of outlets to a lake. If a lake doesn't have outlets it can experience high water levels. |
| Watershed to Lake Area Ratio | The standard watershed to lake area ratio shows how much total land area (including water features) that may drain to a lake outlet compared to the size of the lake. Lakes with very large ratios (>50) have increased risk for nutrient loading from upstream. |
| Tribal Land | This is a yes/no on if there is Tribal Land within the lakeshed. This could indicate shared management of the water body. |
| Notable Characteristics | These are special classifications for lakes that have specific management from the DNR or MPCA. |
| BMP Focus | This rating provides guidance as to where to focus best management practices (BMPs) for protecting the lake. Lakes with small watershed to lake area ratios and no inlets have a near shore focus, lakes with large watersheds and inlets have a watershed focus. |

Table 11. Summary table of lake characteristics with recommendations for management focus.

| Lake Name | DOW | % Lakeshore Private | # Inlets | # Outlets | Watershed: Lake Area Ratio | Tribal Land | Notable Characteristics | Notes on possible water quality impacts | BMP Focus |
|---|---|---|---|---|---|---|---|---|---|
| Bear | 09003400 | 99.5% | 2 | 1 | 574:1 | no | Shallow Lake | City of Barnum | Nearshore & Watershed* |
| Bob | 09002600 | 100% | 1 | 1 | 195:1 | yes | Wild Rice | | Watershed |
| Coffee | 09004500 | 100% | 1 | 1 | 1,270:1 | no | | Feedlot on the SE shore | Watershed |
| Cub | 09011800 | 0% | 2 | 1 | 3,056:1 | no | | | Watershed |
| Echo | 09004400 | 29% | 0 | 1 | 9:1 | no | Shallow Lake | | Nearshore |
| Eddy | 09003900 | 100% | 2 | 1 | 2,563:1 | no | | feedlot about 750 feet upstream of lake in lakeshed | Watershed |
| Hanging Horn | 09003800 | 100% | 4 | 1 | 131:1 | no | Cisco Refuge Lake Tier 2, Lake Trout | | Watershed |
| Kettle | 09007400 | 100% | 1 | 1 | 1,135:1 | yes | Wild Rice | | Watershed |
| Kettle | 09004900 | 4% | 4 | 1 | 23:1 | no | Priority Shallow Lake, Wild Rice, WMA | | Watershed |
| Little Hanging Horn | 09003500 | 100% | 1 | 1 | 6:1 | no | Cisco Refuge Lake Tier 2 | | Nearshore |
| Little Kettle | 09007700 | 21% | 1 | 1 | 875:1 | no | | | Watershed |
| Mattlia | 09007000 | 100% | 1 | 1 | 383:1 | no | Shallow Lake | | Watershed |
| Merwin | 09005800 | 100% | 1 | 1 | 771:1 | no | | Feedlot on the NW shore | Watershed |
| Moose | 09004300 | 100% | 1 | 1 | 7:1 | no | Shallow Lake, Wild Rice | | Watershed |
| Moosehead | 09004100 | 98.8% | 3 | 1 | 260:1 | no | Wild Rice | City of Moose Lake | Nearshore & Watershed* |
| Park | 09002900 | 100% | 0 | 1 | 4:1 | no | NA | Feedlot west of the lake | Nearshore |
| Section One | 09006900 | 76% | 0 | 1 | 1,247:1 | no | | | Nearshore** |
| Spring | 09009400 | NA | 1 | 1 | 3,328:1 | no | Priority shallow Lake | | Watershed |
| Twentynine | 09002200 | 29% | 1 | 1 | 566:1 | no | | | Watershed |
| Walli | 09007100 | 100% | 1 | 1 | 764:1 | no | | | Watershed |
| Wild Rice | 09002300 | 86% | 0 | 1 | 47:1 | yes | Priority Shallow Lake, Wild Rice | | Nearshore** |

*Table continued on next page…*

*Bear and Moosehead Lakes have a BMP focus of nearshore and watershed because they have cities adjacent to the lake.

**These lakes have large watersheds, but no inlets so their BMP focus is nearshore.

Table 11 continued. Summary table of lake characteristics with recommendations for management focus.

| Lake Name | DOW | % Lakeshore Private | # Inlets | # Outlets | Watershed: Lake Area Ratio | Tribal Land | Notable Characteristics | Notes on possible water quality impacts | BMP Focus |
|---|---|---|---|---|---|---|---|---|---|
| Unnamed | 09002800 | 100 | 0 | 0 | 314 | yes | | | Nearshore** |
| Unnamed | 09012400 | 0 | 0 | 1 | 942 | yes | | | Nearshore** |
| Unnamed | 09009200 | 86 | 0 | 1 | 1184 | yes | | | Nearshore** |
| Unnamed | 09007800 | 23 | 0 | 0 | 3902 | no | | | Nearshore** |
| Unnamed | 09007500 | 50 | 0 | 1 | 3981 | no | | | Nearshore** |
| Unnamed | 09009300 | 100 | 1 | 1 | 450 | no | | | Watershed |
| Unnamed | 09002700 | 79 | 1 | 1 | 714 | yes | | | Watershed |
| Unnamed | 09014500 | 58 | 2 | 1 | 74 | no | Wild Rice | | Watershed |

**These lakes have large watersheds, but no inlets so their BMP focus is nearshore.

Table 12 outlines best management practices for different land use types around the lakes, along with who can do the project and who can help with expertise and funding.

Table 12. Best Management Practices for different land use types.

| Category | Land use type | Conservation project ideas | Results | Who | Contact for help |
|---|---|---|---|---|---|
| Conservation Potential Land | private forests | Forest stewardship planning, 3rd party certification, SFIA, local woodland cooperatives | Conserve and protect current forest cover | • Individual Property Owners | Carlton SWCD<br>(218) 384-3891<br>https://carltonswcd.org/ |
| | pasture/hay | Conservation Reserve Program (CRP), maintain vegetative cover, plant trees, conservation easements, grassed waterways, ditch buffers, maintain/restore wetlands. | Reduce water runoff and soil erosion, better water storage | • Individual Property Owners | Natural Resources Conservation Service<br>218-720-5209 |
| Disturbed Land | developed, low intensity | Shoreline buffers, rain gardens | Reduce water runoff and shoreline erosion. | • Individual Property Owners | Carlton SWCD<br>(218) 384-3891<br>https://carltonswcd.org/ |
| | developed, high intensity | Sediment basins, rain gardens, shoreline buffers, stormwater retention. | Reduce water runoff into streams and lakes. | • Individual Property Owners<br>• Cities<br>• Lake Associations | Carlton SWCD<br>(218) 384-3891<br>https://carltonswcd.org/ |
| | cultivated crops | Restore wetlands; Conservation Reserve Program (CRP), Cover Crops. | Reduce water runoff and soil erosion, better water storage. | • Individual Property Owners | Natural Resources Conservation Service<br>218-720-5209 |

## Summary and Recommendations

### Overall Conclusions

Overall, the lakes in Carlton County that were evaluated in this report have good water quality and are in good condition.

Six of the lakes evaluated had enough transparency data to perform a trend analysis. Overall, 2 lakes had improving water quality trends, one lake had a declining trend, and the rest had no trends (Tables 5-6).

Two of the lakes evaluated in this report are designated as Cisco refuge lakes by the DNR: Hanging Horn and Little Hanging Horn lakes. Ciscos (*Coregonus artedi)* can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. Cisco refuge lakes are usually deep and have good oxygen levels. Protecting the water quality and lakesheds of these lakes will help ensure the Cisco's survival.

Shoreline development and land disturbance seems to be the largest overall human-caused impact and risk to the lakes in Carlton County. From looking at GIS mapping layers over time, it appears that development on lakes in Carlton County has increased significantly since 1980. Once the second tier around the lake is developed, the drainage in the lakeshed changes and more runoff reaches the lake from impervious surface and lawns. See project ideas for nearshore best management practices on page 14.

Another potential lake impact is the size of the watershed. Lakes with large watersheds receive nutrients cumulatively from the entire upstream area. See project ideas for watershed best management practices on page 14.

### Monitoring Recommendations

At a minimum, every lake of significance to the county should have one primary site (recommended in each individual report) that should be monitored for transparency with a Secchi disk weekly or bimonthly every summer. This monitoring is free and is tracked through the Minnesota Pollution Control Agency's Citizen Lake Monitoring Program (CLMP, https://www.pca.state.mn.us/water/resources-volunteers). After 8-10 years of consecutive data, a trend analysis can be completed for each lake.

Large lakes with significance to the county and shoreline development should be monitored for phosphorus and chlorophyll a at least 2 years in every decade. This allows for MPCA Assessment.

To determine the phosphorus loading from the watershed, the inlets could be monitored during baseline and peak flow events (spring thaw and heavy rains). Lakes with possible inlet and watershed loading are identified in Table 11.

### Shallow Lakes

Shallow lakes usually have a maximum depth around 20 feet deep or less and don't completely stratify all summer. A healthy shallow lake should have clear water and abundant aquatic plants. Native aquatic plants stabilize the lake's sediments and tie up phosphorus in their tissues. When aquatic plants are uprooted from a shallow lake, the lake bottom is disturbed, and the phosphorus in the water column gets used by algae instead of plants. This contributes to "greener" water and more algae blooms. Protecting native aquatic plant beds will ensure a healthy lake and healthy fishery.

Studies have shown that large boat motors can re-suspend the phosphorus from the lake's sediment and cause algae blooms. Boaters should be encouraged to drive slowly through areas shallower than 10 feet.

The shallow lakes evaluated in this report are listed in Table 11.

## Stormwater Management

Stormwater management is an issue anywhere there is concentrated development. Any impervious surface, including driveways, roads, roofs and patios cause the rain to run off of them instead of soaking into the ground. Turf grass does not sufficiently infiltrate rainwater either. Rain gardens and wetlands can be good areas for storm water storage and infiltration. For lakes located adjacent to a town, such as Bear and Moosehead, investigate specifically where storm water drains so that it is not impacting the lake. Towns have a high density of impervious surface. It is not possible to remove this impervious surface, but it is possible to install stormwater management practices to prevent the stormwater from running into the lakes.

## Future Studies

Future studies that would better pinpoint the impacts on the lake include a shoreline inventory, monitoring stream inlets, monitoring for internal loading, and a watershed flow analysis. The shoreline inventory would consist of driving around the lake and rating each parcel as to how much of the frontage has a vegetative buffer.

To determine the phosphorus loading from the watershed, the inlets could be monitored during baseline and peak flow events (spring thaw and heavy rains). The inlets could also be ground-truthed, which entails walking them to look for erosion and insufficient vegetative buffers.

Monitoring for internal loading involves collecting hypolimnion water samples (water samples taken 1 foot above the lake's bottom) and corresponding dissolved oxygen profiles.

A watershed flow analysis would be done using GIS software to see the areas of heaviest runoff into the lake. This analysis would also help where stormwater mitigation, rain gardens and shoreline restoration would have the most positive impact on the lake.

## Grant and Cost Share Possibilities

*BWSR Clean Water Grants:* These grants can be used for a variety of "on-the-ground" projects, where citizens and local governments are installing conservation practices to improve the quality in lakes, rivers and wetlands.
http://www.bwsr.state.mn.us/grants/index.html

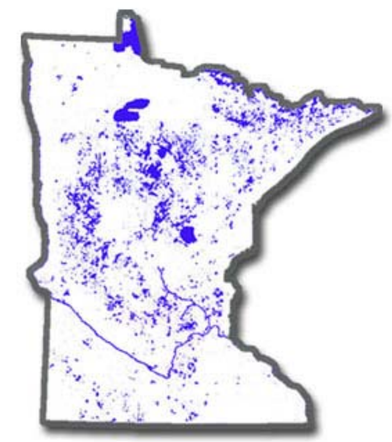
*DNR Conservation Partners Legacy Grant Program:* These grants can be used for projects that restore, enhance and/or protect habitats for MN's fish, game, and wildlife.
http://www.dnr.state.mn.us/grants/habitat/cpl/index.html

*DNR Forest Stewardship Program:* This program has a cost share for landowners to protect and manage forests on private lands.
http://www.dnr.state.mn.us/woodlands/cost-share.html

*Minnesota Land Trust Conservation Easements*: This program is for landowners to donate land into conservation easements, which protects them perpetually.
http://www.mnland.org/conservation-options

# Appendix I: Lake Education

## Lake Water Quality: the natural factors and the human factors



There are many factors that contribute to a lake's current condition, including natural factors and human factors. Once these factors are understood, a better understanding of past, present and future lake water quality is possible.

Most of the lakes in Minnesota were formed as glaciers receded during the last ice age. Approximately 15,000 years ago to about 9,000 years ago, glaciers alternately retreated and advanced over the landscape, carving out holes and leaving behind ice chunks. As these ice chunks melted in the holes left behind, lakes were formed. Northern Minnesota was scraped fairly clean down to the bedrock, with boulders, sand and clay left behind, while southern Minnesota was left with a rich, fine prairie (now agricultural) soil.

The first thing that goes into understanding a lake is what sort of geological area it is in. Northern Minnesota lakes are commonly very deep, rocky lakes in forested areas. These lakes have very clear water and characteristically low phosphorus and algae concentrations due to the abundance of sandy, relatively infertile soil. The lakes in southwestern Minnesota are shallower prairie lakes surrounded by fertile soil. Lakes in this area tend to have more nutrients available for plants and algae to grow, and therefore get "greener" in the summer.

The geology and glacial formation of a lake usually determines its shape, size and depth. These factors contribute to nearly all physical, chemical and biological properties of a lake. Lake users such as fishermen are probably aware of these characteristics already because they also determine where the fish are. A lake that is one large round hole is different than a lake that has a lot of bays, points and bottom structure. A long narrow lake is more affected by wind (which mixes the lake) than a round lake. Deep lakes have different dynamics than shallow lakes, and most of all, deep lakes have more water. The more water a lake has (volume), the better it is able to dilute what runs into it.

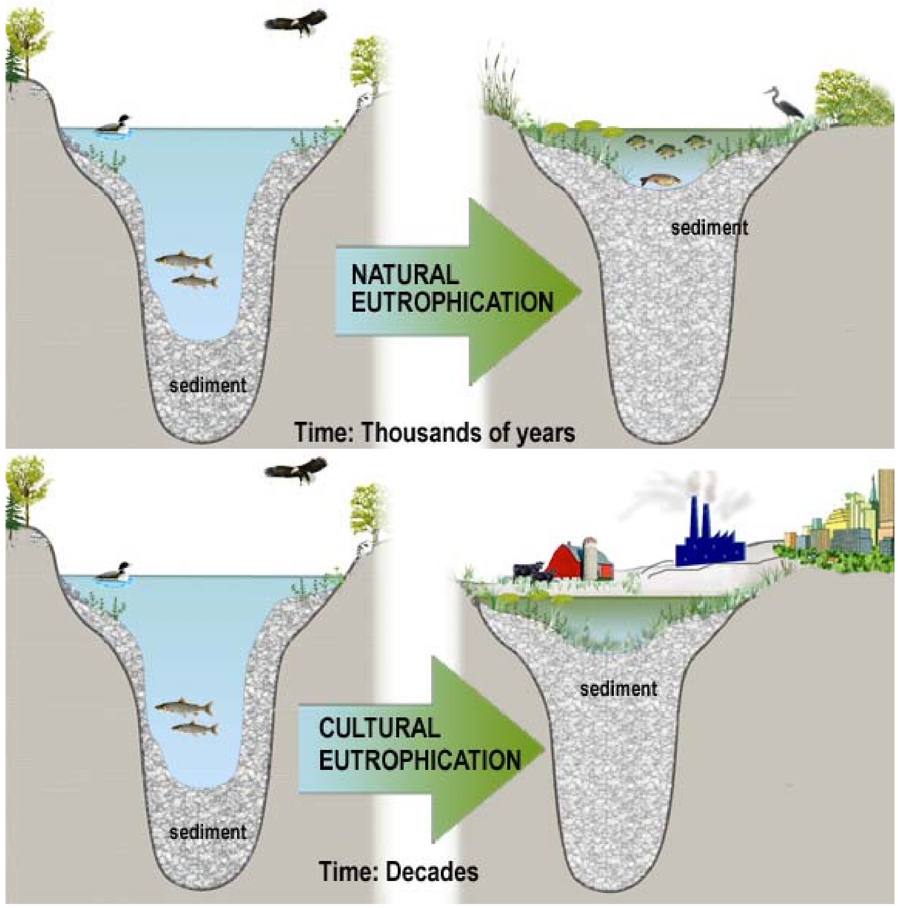
Shallow lakes are lakes where the sunlight can reach the entire bottom. Generally, this corresponds to about 15 feet deep or less. Since the sunlight can reach the bottom, aquatic plants are able to grow there. In deep lakes, the bottom does not receive sunlight, so no plants grow there and it stays dark and cold.

Another major factor affecting lake condition is the size of its watershed and where the lake sits within the watershed. A watershed is an area of land where all the water drains into the same river system. These watershed areas are defined by topography, or ridges of elevation. Therefore, watersheds are mainly driven by gravity – water runs down hill.

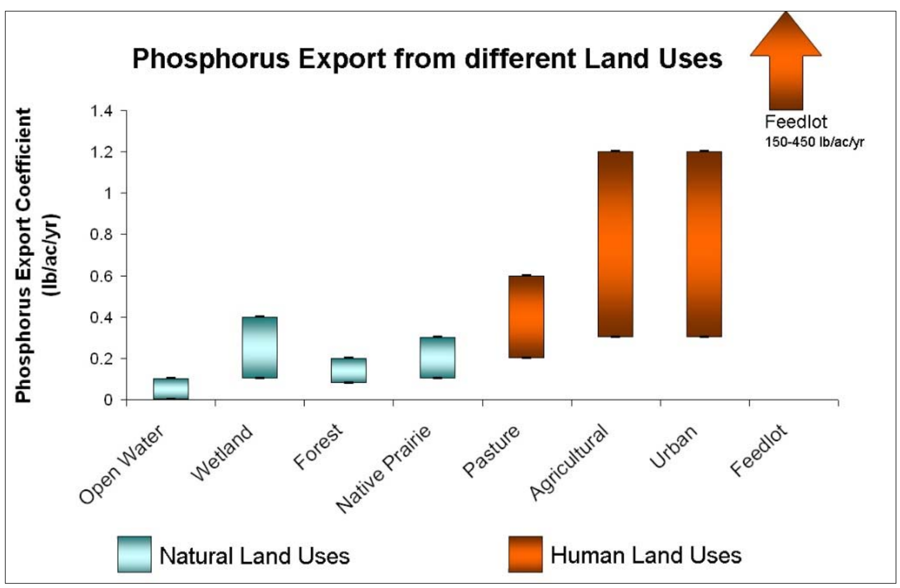
If a lake has a very small watershed or is at the top of a watershed (in topography terms), the lake usually has better water clarity than a lake at the bottom of a large watershed. As water flows downhill through a watershed it picks up sediment from erosion and nutrients from runoff. This sediment and nutrients can feed algae and cause the lake to become "greener".

Lakes go through a natural ageing process where they gradually receive nutrients (phosphorus and nitrogen) and sediment from erosion in the surrounding watershed and become more fertile and shallow. This process is called eutrophication. Eutrophication is a natural process that a lake goes through over thousands of years.

Humans can speed up the process of eutrophication by adding excess nutrients and sediment quickly, where the lake will change trophic states in a matter of decades instead of centuries. This type of eutrophication is called cultural eutrophication because humans cause it. We have changed the landscape around lakes, which changes their water quality and speeds up eutrophication.




Around lakes, we have added a lot of impervious surface. Impervious surface is any surface on land that is impenetrable to water and prevents its absorption into the ground. Examples include rooftops, sidewalks, parking lots, and roads. The more impervious surface in a concentrated area, the less surface there is for rain to be absorbed into the ground. Instead, it ends up running into lakes and streams and carrying nutrients and sediment from the land it flows over.




Land practices such as urban areas, factories, agriculture, animal feedlots contain very concentrated amounts of nutrients. These nutrients wash into lakes and streams during heavy rains or through storm sewers. The additional nutrients that run into lakes and streams cause algal blooms and additional plant growth.

When erosion occurs along a lakeshore or a stream bank of a lake inlet, that extra soil can get washed into the lake. The extra soil particles cause cloudier water and eventually settle on the bottom of the lake making it mucky and less stable. The soil also carries with it nutrients such as phosphorus and nitrogen.

Eutrophication can be slowed if the inputs of nutrients (especially phosphorus) and sediment are slowed. Creating natural vegetation buffers along lakeshores and streams soak up nutrients and filter runoff. When planning new construction near water, make sure erosion is prevented by silt fences and minimize creating more impervious surface.

So how can one tell if the lake's water quality is declining or improving? The best way to determine long-term trends is to have 8-10 years of lake water quality data such as clarity (secchi disk), phosphorus, and chlorophyll-a (algae concentration). Only short-term trends can be determined with just a few years of data, because there can be different wet years, dry years, weather, water levels, etc. that affect the water quality naturally. The data needs to be analyzed with a statistical test (i.e.: Mann Kendall Trend Analysis) to be confident in a true trend.

In summary, lakes start out with a certain natural condition that depends on their location, their watershed size, and their area, depth and shape. Then we humans add to that by what type of land practices we implement near the lake and upstream from the lake. Lakes that are in more heavily populated areas usually have had more cultural eutrophication than lakes that are in sparsely populated areas.

When it comes to protecting our lakes, stewardship is an attitude. It is the understanding that what we do on land and in the water affects the lake. It is recognition that lakes are vulnerable and that in order to make them thrive, citizens, both individually and collectively, must assume responsibility for their care. Once you learn more about all the factors that potentially affect your lake, you can practice preventative care of your lake, and hopefully avoid costly problems.

*"In the end, we will conserve only what we love; we will love only what we understand; and we will understand only what we have been taught."* - Baba Dioum, a Senegalese ecologist.

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# Appendix II: Phosphorus Export Educational Summary

## Introduction

The purpose of lakeshed assessment is to develop an inventory and assess the resources within each lakeshed. The assessment can then be used as a tool to evaluate issues and create a framework of goals and strategies for citizens, as well as representatives from local units of government and resources agencies in the region. This information helps support the continued commitment to a collaborative effort to protect and improve water quality of Minnesota lakes and manage our limited resources.

Understanding a lakeshed requires the understanding of basic hydrology. A watershed is the area of land that drains into a surface water body such as a stream, river, or lake and contributes to the recharge of groundwater. There are three categories of watersheds: 1) basins, 2) major watersheds, and 3) minor watersheds.

Within this watershed hierarchy, lakesheds also exist. A lakeshed is defined simply as the land area that drains to a lake. While some lakes may have only one or two minor watersheds draining into them, others may be connected to a large number of minor watersheds, reflecting a larger drainage area via stream or river networks.

This summary includes educational information about phosphorus and nutrient transport in watersheds and lakesheds. For each individual lakeshed assessment, conclusions can be drawn as to the best way to protect and conserve land within the lakeshed. See individual lake reports for specific recommendations. Overall recommendations include:

- Continue to follow BMPs (Best Management Practices) in the lakeshed:
  - Plant natural vegetation along the shoreline
  - Protect and extend low phosphorus land covers wherever possible (forest/wetland)
  - Surface water onsite management (rain gardens, drainage, etc.)

- For lakes located near a town, investigate where storm water drains so that it is not impacting the lake. Rain gardens and wetlands can be good areas for storm water storage and infiltration.

## Phosphorus

Phosphorus is a nutrient important for plant growth. In most lakes, phosphorus is the limiting nutrient, which means that everything that plants and algae need to grow is available in excess (sunlight, warmth, water, nitrogen, etc.), except phosphorus. This means that phosphorus has a direct effect on plant and algal growth in lakes – the more phosphorus that is available, the more plants and algae there are in the lake. Phosphorus originates from a variety of sources, many of which are related to human activities. Major sources include human and animal wastes, soil erosion, detergents, septic systems and runoff from farmland or fertilized lawns.

Phosphorus is usually measured in two ways in lakes, ortho-phosphate (soluble reactive phosphorus) and total phosphorus. Ortho-phosphate (soluble reactive phosphorus) is the chemically active, dissolved form of phosphorus that is taken up directly by plants. Ortho-phosphate levels fluctuate daily, and in lakes there usually isn't a lot of ortho-phosphate because it is incorporated into plants quickly. Total phosphorus (TP) is a better way to measure phosphorus in lakes because it includes both ortho-phosphate and the phosphorus in plant and animal fragments suspended in lake water. TP levels are more stable and an annual mean can tell you a lot about the lake's water quality and trophic state, as shown in Figure 1.

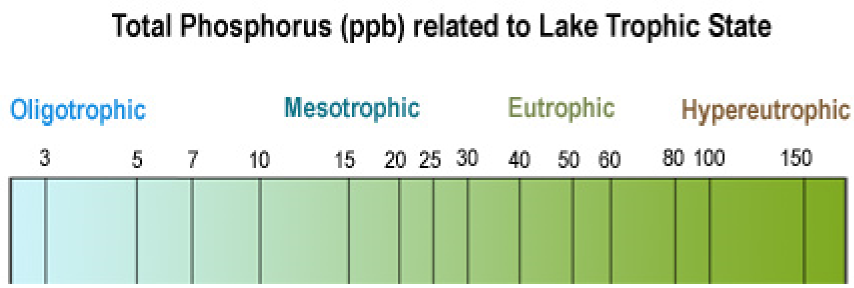


Figure 1. Phosphorus concentration (ppb) related to lake trophic state.

If phosphorus inputs are decreased or eliminated, less plants and algae are able to grow and water quality can improve.

## Nutrient Export to Lakes

Phosphorus export, which is the main cause of lake eutrophication, depends on the type of land use occurring in the lakeshed. Phosphorus export (in lbs/acre/year) can be estimated from different land uses using the phosphorus export coefficient. Figure 2 shows the phosphorus export from the natural landscape versus human land uses. Humans alter the landscape, thereby adding more phosphorus to the lake than would occur naturally.

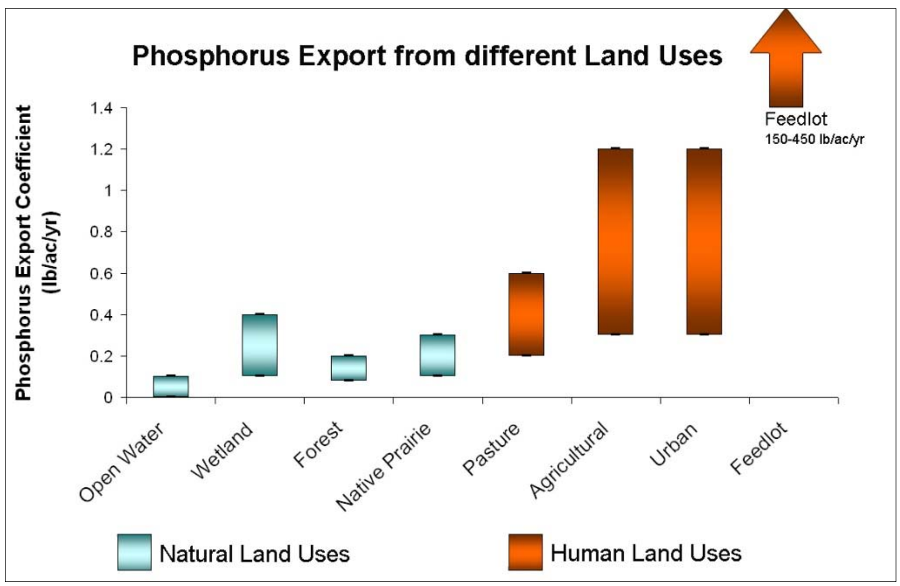


Figure 2. Phosphorus export coefficient for natural vs human land uses.

Stormwater is an all-inclusive term that refers to any of the water running off of the land's surface after a rainfall or snowmelt event. Stormwater carries nutrients and other pollutants, the largest being phosphorus. Around lakes, urban development is one of the largest contributors of phosphorus. Prior to development, stormwater is a small component of the annual water balance. However, as development increases, the paving of pervious surfaces (that is, surfaces able to soak water into the ground) with new roads, shopping centers, driveways and rooftops all adds up to mean less water soaks into the ground and more water runs off. Figure 2 is a variation on a classic diagram that has appeared in many documents describing the effects of urbanization. This adaptation from the University of Washington shows how the relative percentages of water soaking into the ground change once development begins in a forested area. Note that the numbers assigned to the arrows depicting the movement of water will vary depending upon location within Minnesota (MPCA 2008).

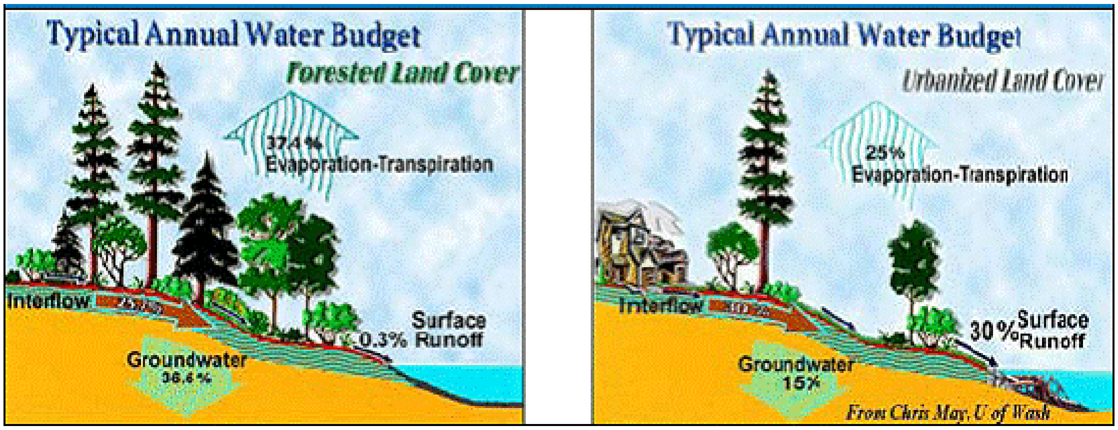
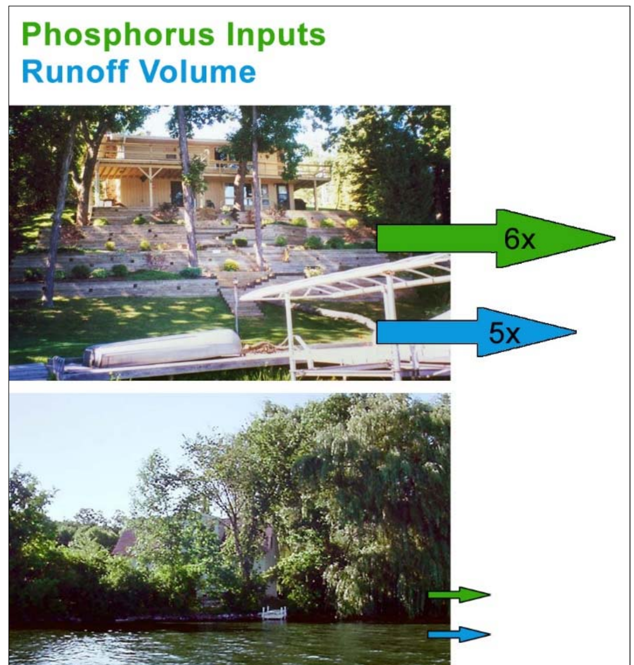



Figure 3. Differences in annual water budget from natural land cover to urbanized land cover (Source: May, University of Washington).

The changes in the landscape that occur during the transition from rural and open space to urbanized land use have a profound effect on the movement of water off of the land. The problems associated with urbanization originate in the changes in landscape, the increased volume of runoff, and the quickened manner in which it moves (Figure 3). Urban development within a watershed has a number of direct impacts on downstream waters and waterways, including changes to stream flow behavior and stream geometry, degradation of aquatic habitat, and extreme water level fluctuation. The cumulative impact of these changes should be recognized as a stormwater management approach is assembled (MPCA 2008).




(adapted from Wisconsin DNR, photos from University of Wisconsin Extension)

Figure 4. The effects of development on the amount of phosphorus and total runoff from a shoreland property. A large landscaped lot with a manicured lawn, a beach, and a retaining wall can increase total runoff volume by 500% and the phosphorus inputs to the lake by 600% (University of Wisconsin–Extension and Wisconsin Department of Natural Resources. 2002).

## References

Minnesota Pollution Control Agency (MPCA). 2008. Minnesota Stormwater Manual Version 2. January 2008. Minnesota Pollution Control Agency, St. Paul, MN 55155-4194

University of Wisconsin–Extension and Wisconsin Department of Natural Resources. 2002. A guide to environmentally sound ownership. A publication of the Southeast Wisconsin Fox River Basin Partnership Team, University of Wisconsin–Extension, and Wisconsin Department of Natural Resources.

## Appendix III: Glossary of Terms

**Anoxic:** without oxygen. Organisms cannot survive in prolonged periods of anoxia.

**Chlorophyll-a:** the pigment that makes plants and algae green. Chlorophyll-a is measured in lakes to determine algal concentration.

**Dissolved oxygen:** oxygen that is dissolved in the water column. Aquatic organisms (zooplankton, aquatic invertebrates and fish) need this oxygen to survive.

**Epilimnion:** The top layer of a lake where the sunlight penetrates and provides energy for plants and algae to grow.

**Eutrophic:** A lake that has low water clarity and high productivity (phosphorus and chlorophyll-1). Eutrophic lakes have a Trophic State Index between 50 and 70, an anoxic hypolimnion in the summer, algal and aquatic plants are prevalent, and can only support warm water fish.

**Fall turnover:** when the summer stratification layers of a lake mix due to the cooling epilimnion (upper layer of the lake). This mixing distributes all the nutrients evenly through the water column.

**Fertility:** the amount of plant and animal life that can be produced within a lake. Fertility is directly related to the amount of nutrients present in the lake to "feed" plants and animals (phosphorus, nitrogen).

**Hypereutrophic:** A lake that has very low water clarity and very high productivity (phosphorus and chlorophyll-a). Hypereutrophic lakes have a Trophic State Index over 70, and usually have heavy algal blooms and very dense aquatic plants.

**Hypolimnion:** The deep part of a lake that is cold and dark due to no sunlight penetration. This area of a lake can be anoxic in the summer due to stratification and decomposition.

**Littoral area:** the area around a lake that is shallow enough to support plant growth (usually less than 15 feet). This part of the lake also provides the essential spawning habitat for most warm water fishes (e.g. bass, walleye, and panfish).

**Mesotrophic:** A lake that has moderate water clarity and productivity (phosphorus and chlorophyll-a). Mesotrophic lakes have a Trophic State Index between 30 and 50, and the hypolimnion can become anoxic during the summer.

**Nitrogen:** a nutrient important for plant growth. Nitrogen can enter a lake through groundwater, surface runoff and manure.

**Oligotrophic:** A lake that has very clear water and very low productivity (phosphorus and chlorophyll-a). Oligotrophic lakes have a Trophic State Index under 30, the hypolimnion contains oxygen throughout the year and can support trout.

**OP (Ortho Phosphate):** the amount of inorganic phosphorus within a lake. Inorganic phosphorus is readily usable by algae and plants for growth.

**Phosphorus:** a nutrient needed for plant growth. Phosphorus can enter a lake through runoff from manure and fertilizer or through seepage from leaking septic and holding tanks.

**Productivity:** the amount of plant and animal life that can be produced within a lake. Productivity is directly related to the amount of nutrients present in the lake to "feed" plants and animals (phosphorus, nitrogen).

**Secchi Depth:** a measure of water clarity that can indicate the overall health of a lake. A black and white metal disc is lowered into the water on a rope until it can't be seen anymore and raised to the point it can be seen. The depth of the disk to the surface of the water is the Secchi Depth.

**Spring turnover:** when the ice melts off the lake in the spring and cold water on the top of the lake sinks. This mixing distributes all the nutrients evenly through the water column.

**Stratification:** The process in which most Minnesota lakes separate into three layers during the summer. The upper layer (epilimnion) becomes warm and is penetrated by sunlight, the lower layer (hypolimnion) is cold and dark and the middle area (thermocline) separates the top and bottom layers. Warm water is less dense than cold water, which is why the upper layer floats on top of the bottom layer and does not mix in the summer. Minnesota lakes mix in the spring and the fall, when the top layer of the lake cools off.

**Thermocline:** The area between the warm top layer of a lake and the cold bottom part of the lake. The thermocline is characterized by a sharp drop in temperature.

**TP (Total Phosphorus):** the total amount of organic and inorganic phosphorus within a lake. Organic phosphorus includes detritus, feces, dead leaves and other organic matter.

**TMDL (Total Maximum Daily Load):** the amount of a particular pollutant that a body of water can handle without violating state water quality standards.

**Trend Analysis (Mann Kendall statistic):** a way to test the probability of a trend being real versus just happening by chance. A trend probability of 90% (minimum probability used by MPCA) means that there is a 90% probability that the observed trend is real and a 10% probability that the observed trend is just from random chance.

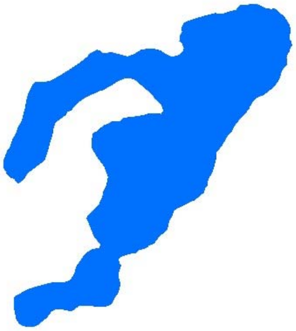
**Trophic State**: Trophic states are defined divisions of a continuum in water quality. The continuum is Total Phosphorus concentration, Chlorophyll a concentration and Secchi depth. Scientists define certain ranges in the above lake measures as different trophic states so they can be easily referred to. See Oligotrophic, Mesotrophic, Eutrophic, Hypereutrophic.

**TSI:** Trophic State Index is a measurement of overall lake productivity (nutrient enrichment). The overall TSI of a lake is the average of the TSI for phosphorus, chlorophyll-a and secchi depth.

**Turbidity:** refers to how clear the water is. Cloudiness (turbidity) in the water can be due to suspended matter such as silt, clay, plankton and other organic matter. The more turbid the water is, the less sunlight can pass through.

**Watershed:** the area of land that drains into a lake directly or by way of a stream that flows into the lake. The land use practices of an entire watershed can affect the water quality of a lake.

# Little Hanging Horn Lake 09-0035-00 Carlton County



Little Hanging Horn Lake is located 4.5 miles north of Moose Lake, MN in Carlton County. It has many long bays covering 114 acres (Table 1).

Little Hanging Horn has one inlet and one outlet, which classify it as a drainage lake. Water enters Little Hanging Horn from a ground-fed stream in the northeast. Moose Horn River exits the lake on the south side of Little Hanging Horn and carries water westward to the Kettle River.

Water quality data have been collected on Little Hanging Horn from 1983-2016 (Tables 2 & 3). These data show that the lake is mesotrophic (TSI = 44) with moderately clear water conditions most of the summer and excellent recreational opportunities.

Little Hanging Horn has an organized association that is involved in activities such as water quality monitoring, golf tournaments, and education.

Table 1. Little Hanging Horn location and key physical characteristics.

| Location Data | | Physical Characteristics | |
|---|---|---|---|
| MN Lake ID: | **09-0035-00** | Surface area (acres): | **114.4** |
| County: | **Carlton** | Littoral area (acres): | **51.7** |
| Ecoregion: | **Northern Lakes and Forests** | % Littoral area: | **45.2%** |
| Major Watershed: | **Kettle River** | Max depth (ft), (m): | **70, 21.3** |
| Latitude/Longitude: | **46.481728, -92.676767** | Inlets: | **1** |
| Invasive Species: | **Eurasian Watermilfoil** | Outlets: | **1** |
| | | Public Accesses: | **0** |

Table 2. Availability of primary data types for Little Hanging Horn.

| Data Availability | | |
|---|---|---|
| Transparency data | | **Excellent CLMP data from 1983-2016** |
| Chemical data | | **Good data from 1993, 1997, 2009-2010, and 2016, but there are gaps.** |
| Inlet/Outlet data | -- | **Inlet/outlet data is not necessary.** |
| Recommendations | | **For recommendations refer to page 15.** |

## Lake Map

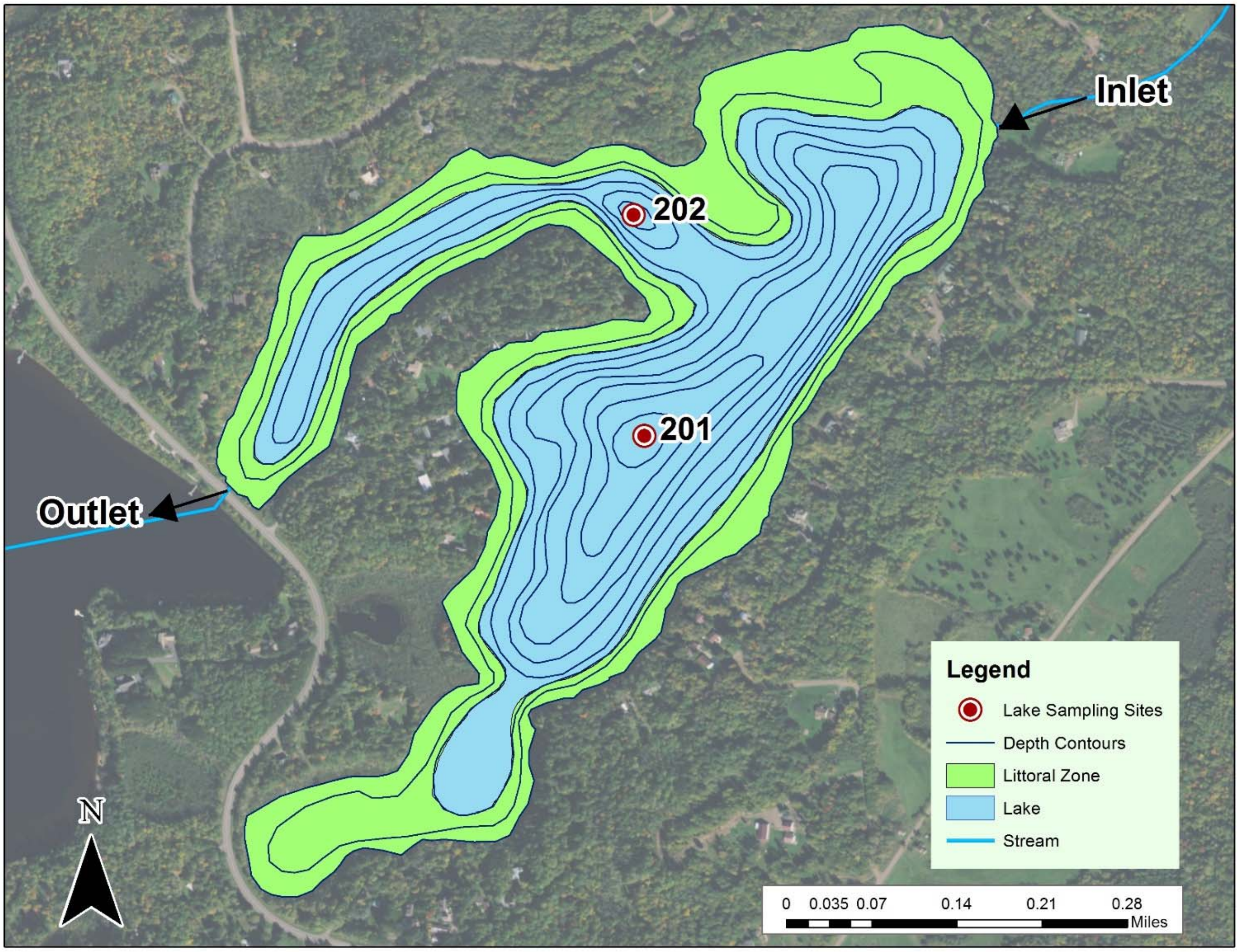



*Figure 1. Map of Little Hanging Horn with 2010 aerial imagery and illustrations of lake depth contour lines, sample site locations, inlets and outlets, and public access points. The light green areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom, allowing aquatic plants to grow.*

*Table 3. Monitoring programs and associated monitoring sites. Monitoring programs include the Citizen Lake Monitoring Program (CLMP), Clean Water Legacy Surface Water Monitoring, Clearwater County Lake Monitoring Program (LMP), Clearwater County Local Water Monitoring, and RMB Environmental Laboratories Lakes Program (RMBEL).*

| Lake Site | Depth (ft) | Monitoring Programs |
|---|---|---|
| 201 | 70 | CLMP: 1983-2016; SWCD: 2009-2010, 2016; MPCA: 1993, 1997 |
| 202 | 40 | CLMP: 1986-2016; SWCD: 2009 |

## Average Water Quality Statistics & Comparisons

The information below describes available chemical data for Little Hanging Horn through 2017 (Table 4). Data for total phosphorus, chlorophyll *a*, and Secchi depth are from the primary site 201.

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation and geology. The Minnesota Pollution Control Agency (MPCA) has developed a way to determine the "average range" of water quality expected for lakes in each ecoregion[1] (Table 4). Little Hanging Horn is in the Northern Lakes and Forests Ecoregion (Figure 2).

The MPCA has developed Impaired Waters Standards for lakes in each ecoregion to determine if a lake is impaired for excess phosphorus/eutrophication (Table 4). Lakes that are over the impaired waters standards are placed on the state's Impaired Waters List[2].


*Figure 2. Minnesota ecoregions.*

*Table 4. Water quality means compared to ecoregion ranges and impaired waters standard.*

| Parameter | Mean | Ecoregion Range[1] | Impaired Waters Standard[2] | Interpretation |
|---|---|---|---|---|
| Total phosphorus (ug/L) | 18.5 | 14 – 27 | > 30 | Results are within the expected range for the Northern Lakes and Forests Ecoregion and the lake is not impaired for excess phosphorus. |
| [3]Chlorophyll *a* (ug/L) | 3.5 | 4 – 10 | > 9 | |
| Chlorophyll *a* max (ug/L) | 7.1 | < 15 | | |
| Secchi depth (ft) | 11.4 | 8 – 15 | < 6.5 | |
| Dissolved oxygen | *See page 8* | | | Dissolved oxygen depth profiles show that the lake mixes in spring and fall (dimictic). |
| Total Kjeldahl Nitrogen (mg/L) | 0.62 | <0.4 – 0.75 | | Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms. |
| Alkalinity (mg/L) | 44.6 | 40 – 140 | | Within the expected range for the ecoregion. |
| Color (Pt-Co Units) | 40 | 10 – 35 | | Indicates some tannins (brown stain) in the water. |
| pH | 7.7 | 7.2 – 8.3 | | Within the expected range for the ecoregion. Lake water pH less than 6.5 can affect fish spawning and the solubility of metals in the water. |
| Chloride (mg/L) | 4.4 | 0.6 – 1.2 | | Slightly above the expected range for the ecoregion, but still considered low level. |
| Total Suspended Solids (mg/L) | 1.5 | <1 – 2 | | Within the expected range for the ecoregion. |
| Specific Conductance (umhos/cm) | 96.7 | 50 – 250 | | Within the expected range for the ecoregion. |
| TN:TP Ratio | 29.8:1 | 25:1 - 35:1 | | Within the expected range for the ecoregion, and shows the lake is phosphorus limited. |

[1]The ecoregion range is the $25^{th}$-$75^{th}$ percentile of summer means from ecoregion reference lakes: https://www.pca.state.mn.us/quick-links/eda-guide-typical-minnesota-water-quality-conditions
[2]For further information regarding the Impaired Waters Assessment program, refer to http://www.pca.state.mn.us/water/tmdl/index.html
[3]Chlorophyll *a* measurements have been corrected for pheophytin
Units: 1 mg/L (ppm) = 1,000 ug/L (ppb)

## Water Quality Characteristics - Historical Means and Ranges

*Table 5. Water quality means and ranges for primary sites.*

| Parameters | Primary Site 201 | Site 202 |
|---|---|---|
| **Total Phosphorus Mean (ug/L):** | 18.5 | NA |
| Total Phosphorus Min: | 10 | |
| Total Phosphorus Max: | 34 | |
| Number of Observations: | 17 | |
| **Chlorophyll *a* Mean (ug/L):** | 3.5 | NA |
| Chlorophyll-a Min: | 1 | |
| Chlorophyll-a Max: | 7.1 | |
| Number of Observations: | 18 | |
| **Secchi Depth Mean (ft):** | 11.4 | 11.1 |
| Secchi Depth Min: | 5.9 | 5.9 |
| Secchi Depth Max: | 17.5 | 16 |
| Number of Observations: | 163 | 159 |

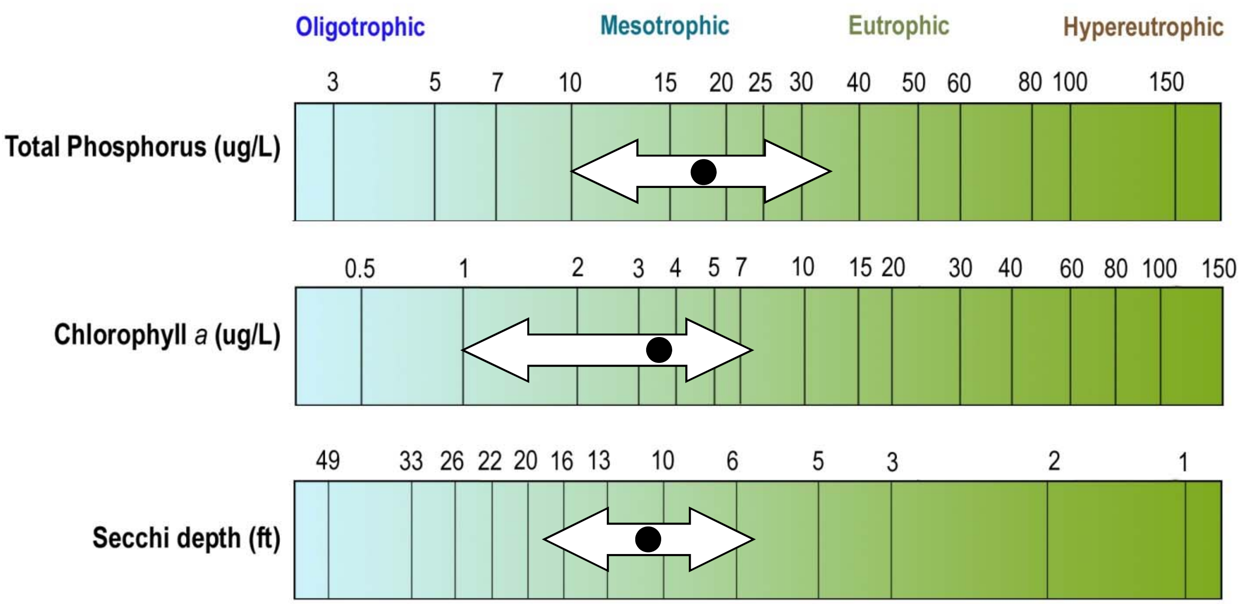



*Figure 3. Little Hanging Horn total phosphorus, chlorophyll a and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 201). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. EPA 440/5-88-002)*

## Transparency (Secchi Depth)

Transparency is how easily light can pass through a substance. In lakes it is how deep sunlight penetrates through the water. Plants and algae need sunlight to grow, so they are only able to grow in areas of lakes where the sun penetrates. Water transparency depends on the number of particles in the water. An increase in particulates results in a decrease in transparency. The transparency varies year to year due to changes in weather, precipitation, lake use, flooding, temperature, lake levels, etc.

The annual mean transparency in Little Hanging Horn ranges from 5.9 to 13.7 feet (Table 5). The annual means hover fairly close to the long-term mean. For trend analysis, see page 10. Transparency monitoring should be continued annually at site 201 in order to track water quality changes.

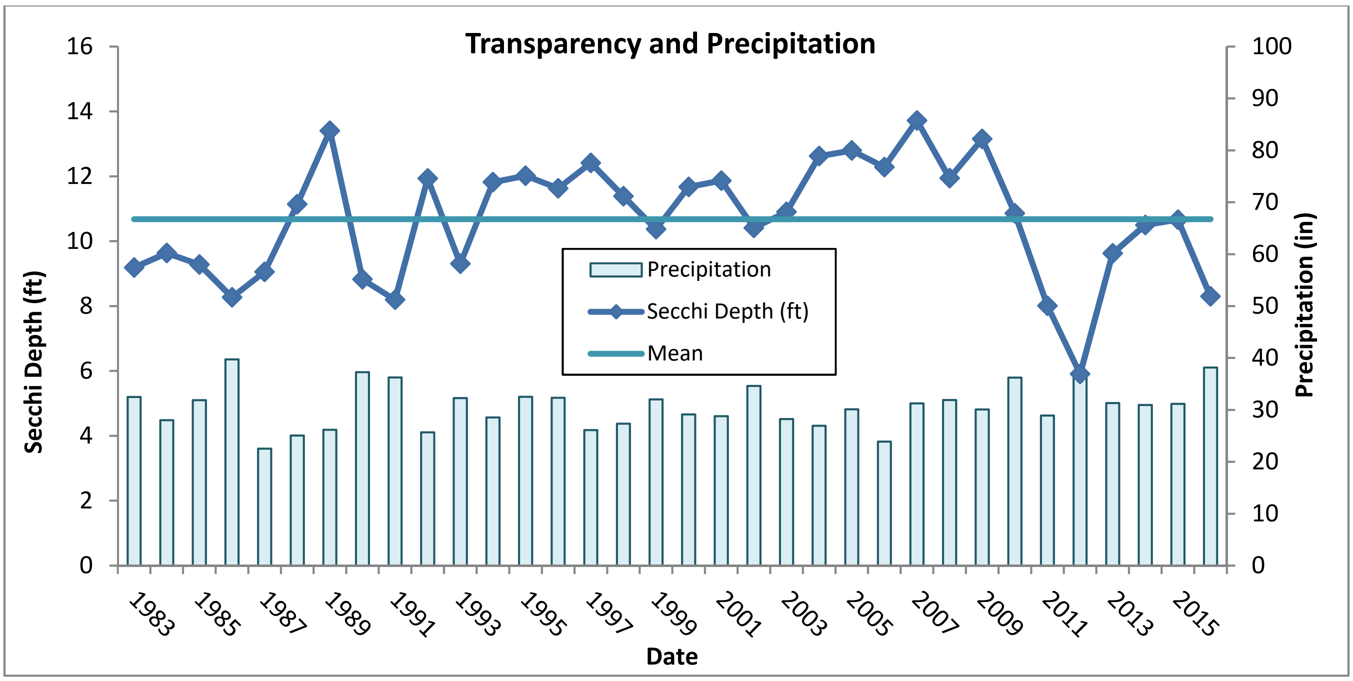



*Figure 4. Annual mean transparency compared to long-term mean transparency*

Little Hanging Horn transparency ranges from 5.9to 17.5 ft at the primary site (201). Figure 5 shows the seasonal transparency dynamics. The maximum Secchi reading is usually obtained in early summer. Little Hanging Horn transparency is high in June and July, and then declines through September. This transparency dynamic is typical of a Minnesota lake. The dynamics have to do with algae and zooplankton population dynamics, and lake turnover.

It is important for lake residents to understand the seasonal transparency dynamics in their lake so that they are not worried about why their transparency is lower in September than it is in June. It is typical for a lake to vary in transparency throughout the summer.

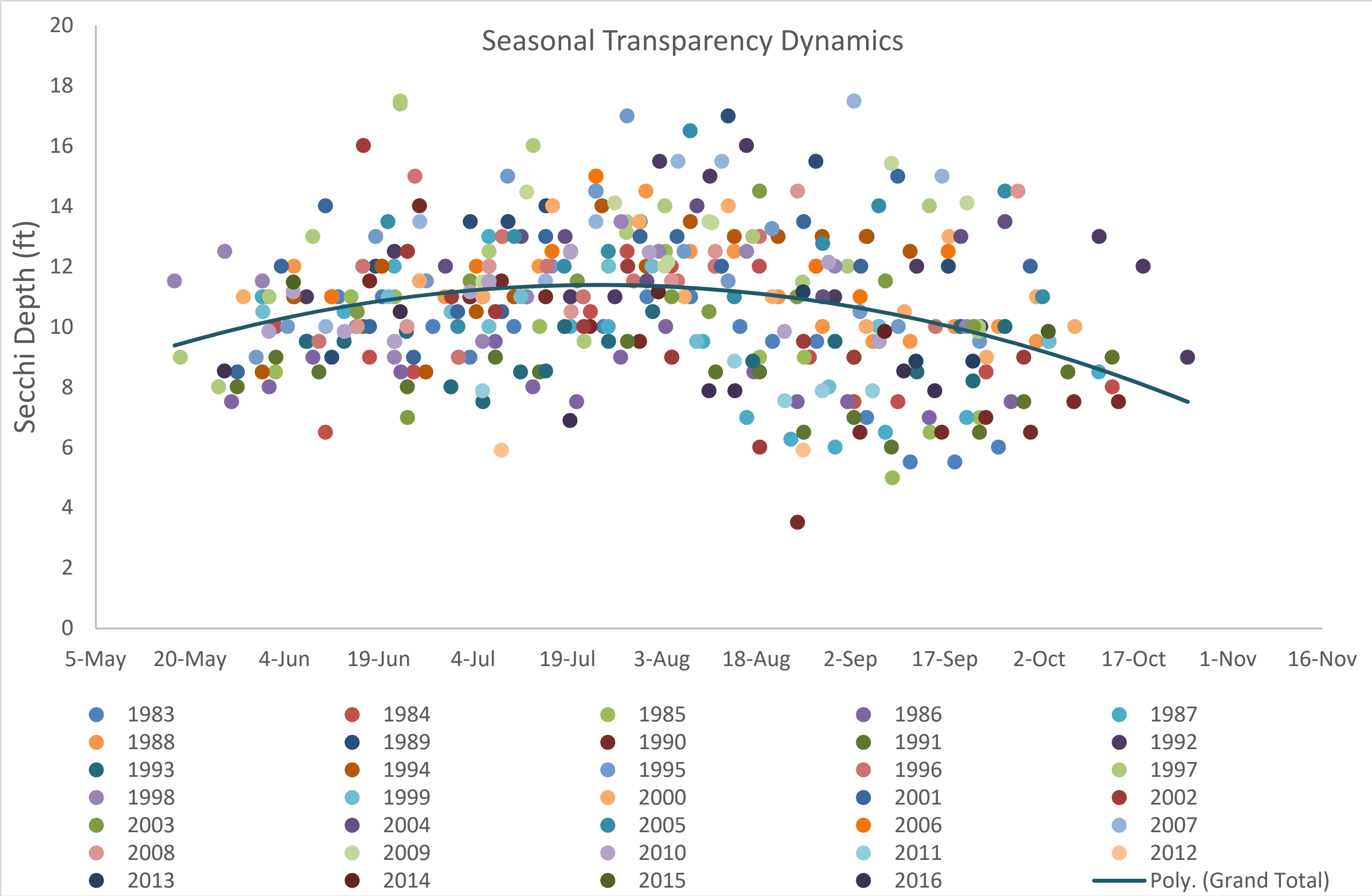



*Figure 5. Seasonal transparency dynamics and year to year comparison (Primary Site 201). The black line represents the pattern in the data.*

## User Perceptions

When volunteers collect Secchi depth readings, they record their perceptions of the water based on the physical appearance and the recreational suitability. These perceptions can be compared to water quality parameters to see how the lake "user" would experience the lake at that time. Looking at transparency data, as the Secchi depth decreases the perception of the lake's physical appearance and recreational suitability decreases (Figures 5-6).

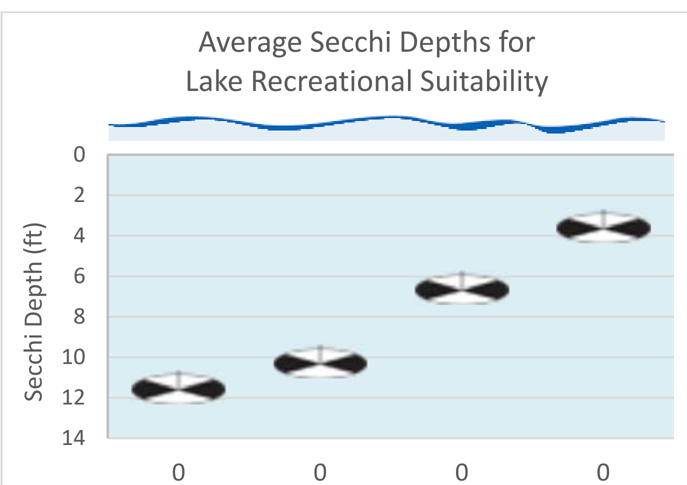



*Figure 7. Average Secchi depth (ft) for each lake recreational suitability rating.*

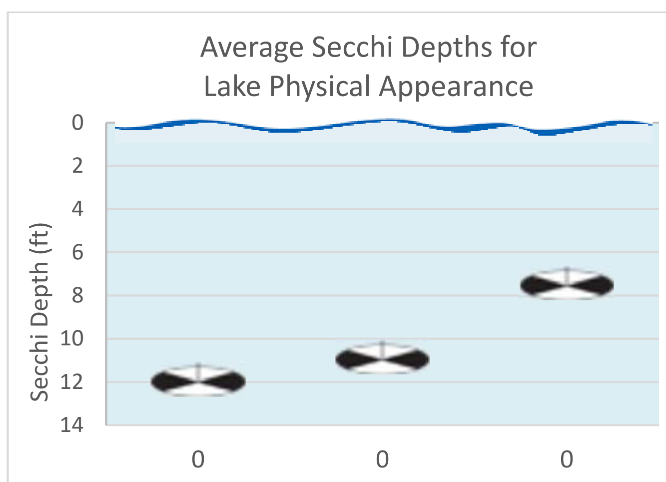



*Figure 6. Average Secchi depth for each lake physical appearance rating.*

## Algae

Chlorophyll *a* is the pigment that makes plants and algae green. Chlorophyll *a* is tested in lakes to determine the algae concentration or how "green" the water is.

Chlorophyll *a* concentrations greater than 10 ug/L are perceived as a mild algae bloom, while concentrations greater than 20 ug/L are perceived as a nuisance.

Chlorophyll *a* was evaluated in Little Hanging Horn at site 201 in 1993, 1997, 2009-2010, and 2016 (Figure 8). Chlorophyll *a* concentrations never went above 10 ug/L, indicating no minor algae blooms. There was not much variation over the years monitored and chlorophyll *a* concentrations remained relatively steady over the summer.

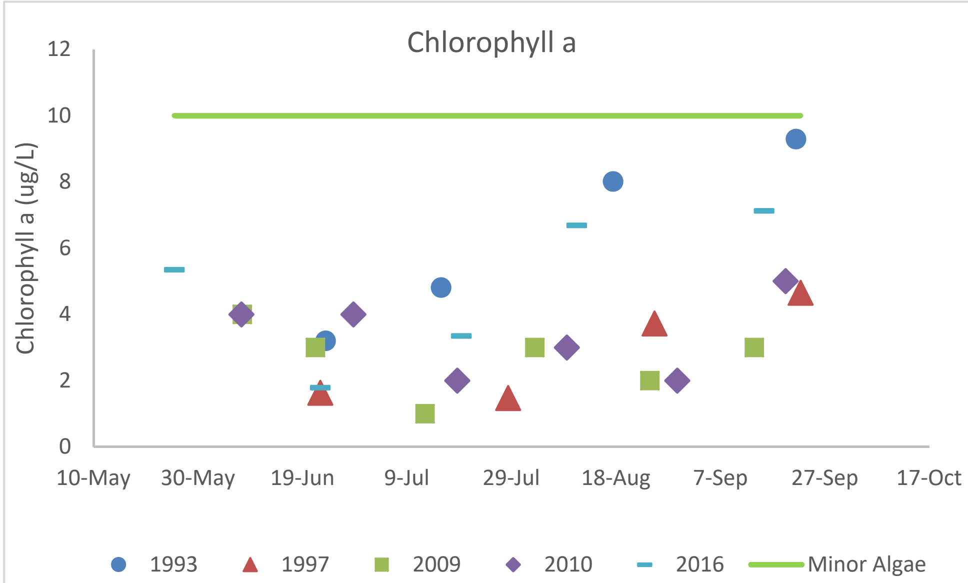



*Figure 8. Chlorophyll a concentrations (ug/L) for Little Hanging Horn at site 201.*

## Phosphorus

Little Hanging Horn is phosphorus limited, which means that algae and aquatic plant growth is dependent upon available phosphorus.

Total phosphorus was evaluated in Little Hanging Horn in 1993, 1997, 2009-2010, and 2016. The data do not indicate much seasonal variability. The majority of the data points fall into the mesotrophic range (Figure 9). There were some higher data points in 2016.

Phosphorus should continue to be monitored to track any future changes in water quality.

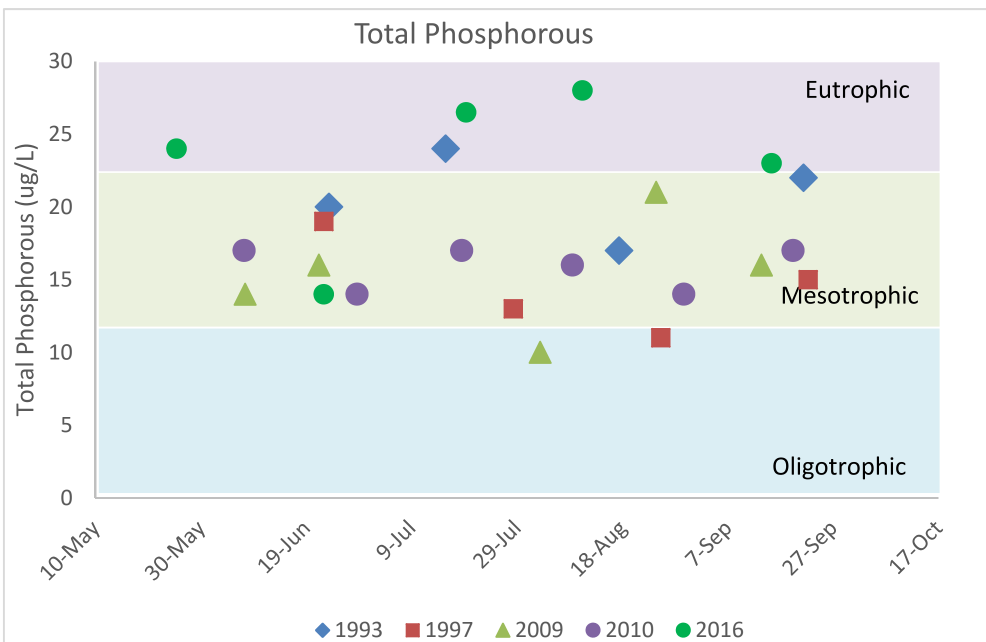
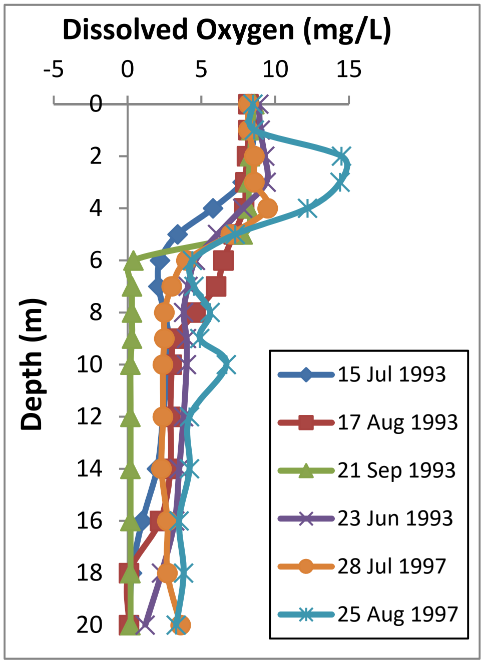



*Figure 9. Historical total phosphorus concentrations (ug/L) for Little Hanging Horn site 201.*

## Oxygen




Dissolved Oxygen (DO) is the amount of oxygen dissolved in lake water. Oxygen is necessary for all living organisms to survive except for some bacteria. Living organisms breathe in oxygen that is dissolved in the water. Dissolved oxygen levels of <5 mg/L are typically avoided by game fisheries.

Little Hanging Horn is a deep lake, with a maximum depth of 70 feet. Dissolved oxygen profiles from data collected in 1993 and 1997 at site 201 show stratification developing mid-summer (Figure 10). The thermocline is located around 5-6 meters (16-19 feet). In mid to late summer, there is still dissolved oxygen at the bottom of the lake, which is hospitable habitat for ciscoes. Little Hanging Horn Lake is managed as a cisco refuge lake by DNR Fisheries.

*Figure 10. Representative dissolved oxygen profiles from 1993 and 1997 in Little Hanging Horn.*

## Trophic State Index (TSI)

TSI is a standard measure or means for calculating the trophic status or productivity of a lake. More specifically, it is the total weight of living algae (algae biomass) in a waterbody at a specific location and time. Three variables, chlorophyll a, Secchi depth, and total phosphorus, independently estimate algal biomass.

If all three TSI numbers are within a few points of each other, they are strongly related. If they are different, there are other dynamics influencing the lake's productivity, and TSI mean should not be reported for the lake. Little Hanging Horn falls into the mesotrophic range (Tables 6, 7).

*Table 6. Trophic State Index for Little Hanging Horn.*

| Trophic State Index | |
|---|---|
| TSI Phosphorus | 46 |
| TSI Chlorophyll-a | 43 |
| TSI Secchi | 42 |
| TSI Mean | 44 |
| Trophic State: | Mesotrophic |

*Numbers represent the mean TSI for each parameter.*

*Table 7. Trophic state index attributes and their corresponding fisheries and recreation characteristics.*

| | TSI | Attributes | Fisheries & Recreation |
|---|---|---|---|
| | <30 | **Oligotrophy:** Clear water, oxygen throughout the year at the bottom of the lake, deep cold water. | Trout fisheries dominate. |
| | 30-40 | Bottom may become anoxic (no oxygen). | Trout fisheries in deep lakes only. Walleye, Cisco present. |
| Little Hanging Horn | 40-50 | **Mesotrophy:** Water moderately clear most of the summer. May be "greener" in late summer. | No oxygen at the bottom of the lake results in loss of trout. Walleye may predominate. |
| | 50-60 | **Eutrophy:** Algae and aquatic plant problems possible. "Green" water most of the year. | Warm-water fisheries only. Bass may dominate. |
| | 60-70 | Blue-green algae dominate, algal scums and aquatic plant problems. | Dense algae and aquatic plants. Low water clarity may discourage swimming and boating. |
| | 70-80 | **Hypereutrophy:** Dense algae and aquatic plants. | Water is not suitable for recreation. |
| | >80 | Algal scums, few aquatic plants. | Rough fish (carp) dominate; summer fish kills possible. |

Source: Carlson, R.E. 1997. A trophic state index for lakes. *Limnology and Oceanography*. 22:361-369.

## Trend Analysis

For detecting trends, a minimum of 8-10 years of data with 4 or more readings per season are recommended. Minimum confidence accepted by the MPCA is 90%. This means that there is a 90% chance that the data are showing a true trend and a 10% chance that the trend is a random result of the data. Only short-term trends can be determined with just a few years of data, because there can be different wet years and dry years, water levels, weather, etc, that affect the water quality naturally.

Little Hanging Horn had enough data to perform a trend analysis on transparency (Table 8). The data was analyzed using the Mann Kendall Trend Analysis.

*Table 8. Trend analysis for Little Hanging Horn.*

| Lake Site | Parameter | Date Range | Trend | Probability |
|---|---|---|---|---|
| 201 | Total Phosphorus | 1993, 1997, 2009-2010, 2016 | Insufficient Data | |
| 201 | Chlorophyll *a* | 1993, 1997 | Insufficient Data | |
| 201 | Transparency | 2006-2016 | Improving | 99% |

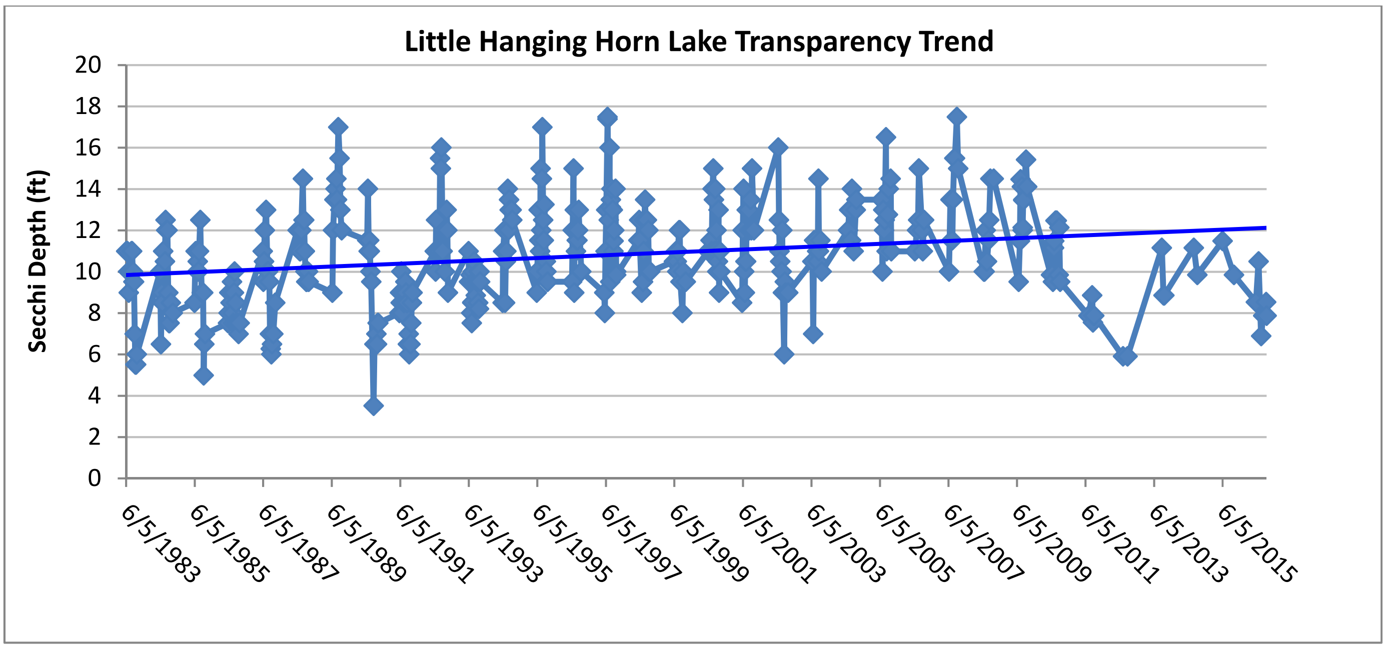



*Figure 11. Transparency (feet) trend for site 201 from 1983-2016.*

Little Hanging Horn shows evidence of an improving transparency trend (Figure 11). Since 1989, the clarity minimums are higher overall than before 1989, showing less algae blooms. Transparency was lower in 2013-2015, however. Transparency monitoring should continue so that this trend can be tracked in future years.

## Lakeshed

Understanding a lakeshed requires an understanding of basic hydrology. A watershed is defined as all land and water surface area that contribute excess water to a defined point. The MN DNR has delineated three basic scales of watersheds (from large to small): 1) basins, 2) major watersheds, and 3) minor watersheds.

The Kettle River Major Watershed is one of the watersheds that make up the St. Croix River Basin, which drains south to the Gulf of Mexico (Figure 12).

The MN DNR also has evaluated catchments for each individual lake with greater than 100 acres surface area. These lakesheds (catchments) are the "building blocks" for the larger scale watersheds. Little Hanging Horn falls within lakeshed 3502301 (Figure 12). Though very useful for displaying the land and water that contribute directly to a lake, lakesheds are not always true watersheds because they may not show the water flowing into a lake from upstream streams or rivers. While some lakes may have only one or two upstream lakesheds draining into them, others may be connected to a large number of lakesheds, reflecting a larger drainage area via stream or river networks.

In an effort to prioritize protection and restoration efforts of fishery lakes, the MN DNR has developed a ranking system by separating lakes into two categories based on their lakeshed, those needing protection and those needing restoration. Modeling by the DNR Fisheries Research Unit suggests that total phosphorus concentrations increase significantly over natural concentrations in lakes that have watershed with disturbance greater than 25%. Therefore, lakes with watersheds that have less than 25% disturbance need protection and lakes with more than 25% disturbance need restoration (Table 9). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land, public water, wetland, or conservation easement.

*Table 9. Suggested approaches for watershed protection and restoration of DNR-managed fish lakes in Minnesota.*

| Watershed Disturbance (%) | Watershed Protected (%) | Management Type | Comments |
|---|---|---|---|
| < 25% | > 75% | Vigilance | Sufficiently protected -- Water quality supports healthy and diverse native fish communities. Keep public lands protected. |
| | < 75% | Protection | Excellent candidates for protection -- Water quality can be maintained in a range that supports healthy and diverse native fish communities. Disturbed lands should be limited to less than 25%. |
| 25-60% | n/a | Full Restoration | Realistic chance for full restoration of water quality and improve quality of fish communities. Disturbed land percentage should be reduced and BMPs implemented. |
| > 60% | n/a | Partial Restoration | Restoration will be very expensive and probably will not achieve water quality conditions necessary to sustain healthy fish communities. Restoration opportunities must be critically evaluated to assure feasible positive outcomes. |

The next step was to prioritize lakes within each of these management categories. DNR Fisheries identified high value fishery lakes, such as cisco refuge lakes. Ciscos (*Coregonus artedi)* can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. These watersheds with low disturbance and high value fishery lakes are excellent candidates for priority protection measures, especially those that are related to forestry and minimizing the effects of landscape disturbance. Forest stewardship planning, harvest coordination to reduce hydrology impacts and forest conservation easements are some potential tools that can protect these high value resources for the long term.

Little Hanging Horn's lakeshed is classified with having 33% of the watershed protected and 8% of the watershed disturbed (Figure 13). Therefore, this lakeshed should have a protection focus. Goals for the lake should be to limit any increase in disturbed land use and maintain protected lands. Little Hanging Horn is a headwaters lakeshed, which means that no other lakesheds flow into it (Figure 12).

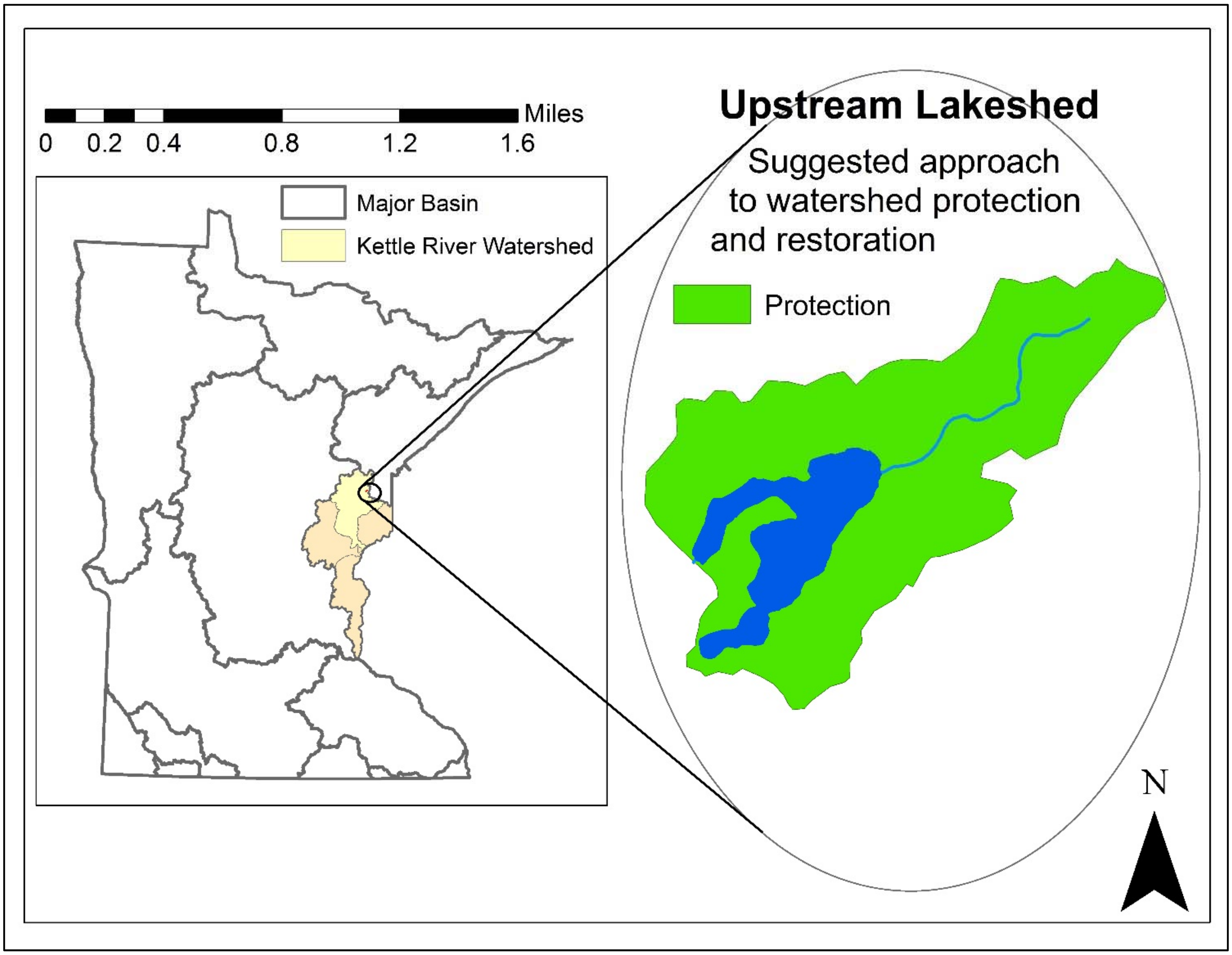



*Figure 12. Kettle River major watershed and MN basins (left), and Little Hanging Horn lakeshed and upstream catchments with protection suggestions (right).*

## Land use and Ownership

Activities that occur on the land within the lakeshed can greatly impact a lake. Land use planning helps ensure the use of land resources in an organized fashion so that the needs of the present and future generations can be best addressed.

A third of the Little Hanging Horn lakeshed is protected. This total includes water and wetlands. There is no publicly owned land. There are five parcels on an upstream river which have conservation potential. They are private land over 20 acres which are less than 50% developed or agriculture.

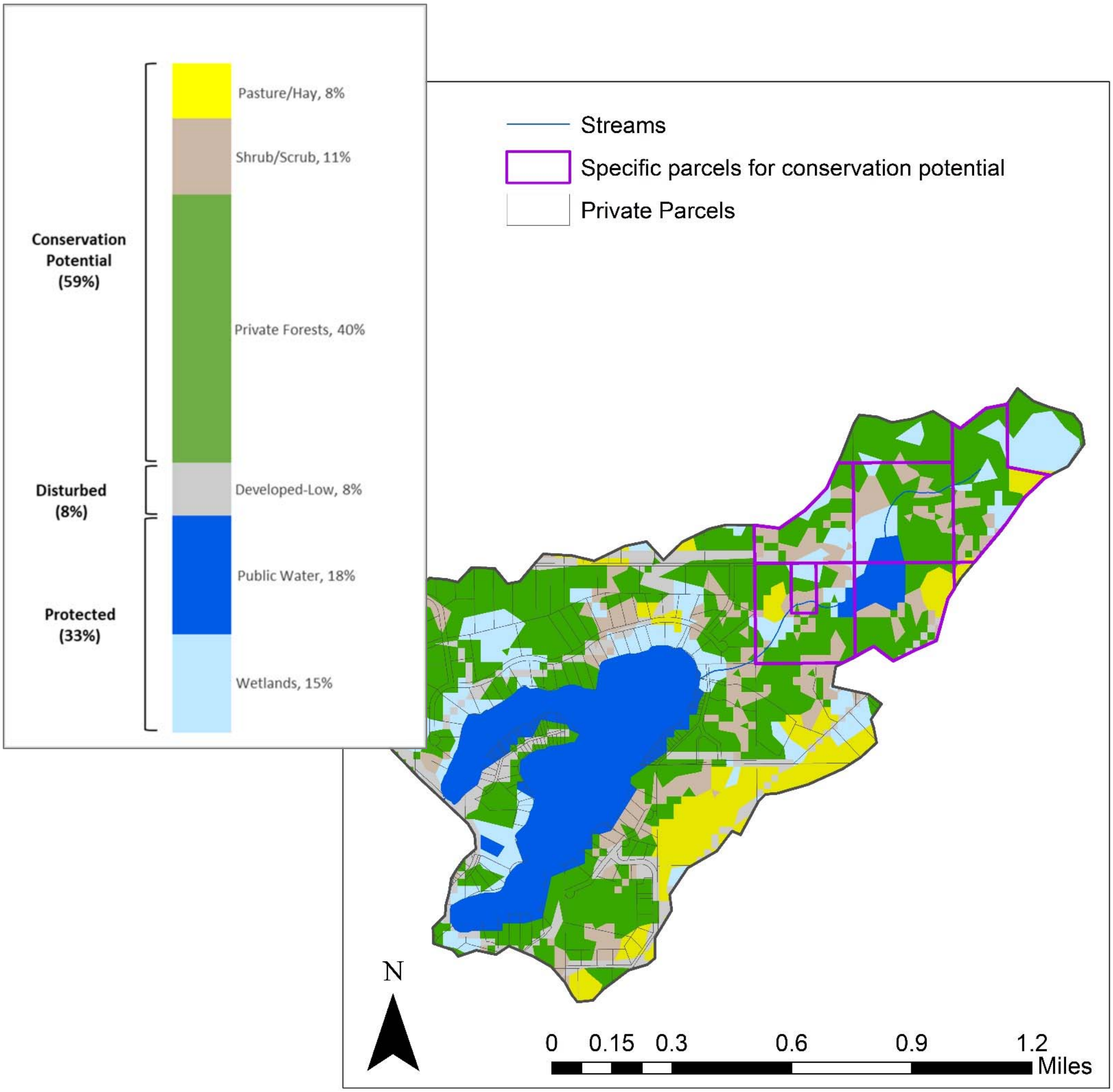



*Figure 13. Land use and ownership in the Little Hanging Horn lakeshed.*

The lakeshed vitals table identifies where to focus organizational and management efforts for each lake (Table 10). Criteria were developed using limnological concepts to determine the effect to lake water quality.

**KEY**

● Possibly detrimental to the lake
◉ Warrants attention
○ Beneficial to the lake

*Table 10. Little Hanging Horn lakeshed vitals table.*

| Lakeshed Vitals | | Rating |
|---|---|---|
| **Lake Area** | 114 acres | descriptive |
| **Littoral Zone Area** | 51.7 acres | descriptive |
| **Lake Max Depth** | 70 ft. | descriptive |
| **Lake Mean Depth** | NA | ○ |
| **Water Residence Time** | NA | Not available |
| **Miles of Stream** | 1.0 | descriptive |
| **Inlets** | 1 | ◉ |
| **Outlets** | 1 | ○ |
| **Major Watershed** | 35 – Kettle River | descriptive |
| **Minor Watershed** | 35023 | descriptive |
| **Lakeshed** | 3502301 | descriptive |
| **Ecoregion** | Northern Lakes and Forest | descriptive |
| **Total Lakeshed to Lake Area Ratio** (total lakeshed includes lake area) | 6:1 | ◉ |
| **Standard Watershed to Lake Basin Ratio** (standard watershed includes lake areas) | 6:1 | ○ |
| **Wetland Coverage** | 9.8% | ○ |
| **Aquatic Invasive Species** | Eurasian Watermilfoil | ● |
| **Public Drainage Ditches** | None | ○ |
| **Public Lake Accesses** | 0 | ○ |
| **Miles of Shoreline** | 3.23 | descriptive |
| **Shoreline Development Index** | 2.15 | ○ |
| **Public Land to Private Land Ratio** | 0:1 | ● |
| **Development Classification** | Recreational Development | ◉ |
| **Miles of Road** | 4.3 | descriptive |
| **Municipalities in lakeshed** | None | ○ |
| **Forestry Practices** | None | ○ |
| **Feedlots** | None | ○ |
| **Sewage Management** | Compliance inspections are required for subsurface sewage treatment systems at point-of-sale or permit application in shoreland areas. | ○ |
| **Lake Management Plan** | None | ◉ |
| **Lake Vegetation Survey/Plan** | DNR, 1997 | ○ |

## Little Hanging Horn, Status of the Fishery (DNR, 8/14/2000)

Little Hanging Horn is a 117 acre lake with 51 (44%) acres of littoral aea and a maximum depth of 70 feet. Little Hanging Horn is located just southeast of Barnum, MN off Highway #13. Little Hanging Horn has a Township administered public access at the northern most point of the lake. Access can also be gained at the Highway #13 causeway at the south corner of the west arm.

Walleye fingerlings have been stocked in 1998, 1995, 1993 and 1991. Walleye fry have been stocked in 1989 and 1987. Fish population investigations have been conducted in 1959, 1971, 1983, 1986, 1990, 1996 and 2000. Largemouth bass have been sampled with electrofishing in 1992, 1996 and 2000. Walleye abundance indexed with assessment nets was 0.5 per lift. This index value was below average when compared to other Minnesota lakes of similar type. Too few walleye were sampled to make an accurate determination of size and growth rate. From a sample of aged walleye it was determined that 2 of 6 were born in years that walleye fingerlings were stocked.

Northern pike abundance indexed with assessment nets was 6.3 per lift. This value was near average when compared to other Minnesota lakes of similar type. Size of northern pike was poor and growth was slow. Mean length of sampled northern pike was 19.3 inches and length at the beginning of their fifth year of life was 19.4 inches. From a sample of aged northern pike it was determined that 69% were born in 1997 or 1998.

Black crappie abundance indexed with assessment nets was 1.8 per lift. This index value was near average compared to other minnesota lakes of similar type. Size of black crappie was poor but growth was fast. Mean length of sampled black crappie was 6.5 inches and length at the beginning of their fifth year of life was 8.5 inches. From a sample of aged black crappie it was determined that no crappie were older than age IV.

Bluegill abundance indexed with assessment nets was 6.3 per lift. This index value was much below average when compared to other Minnesota lakes of similar type. Size of bluegill was poor and growth was very slow. Mean length of sampled bluegill was 5.0 iches and length at the beginning of their fifth year of life was 3.4 inches. From a sample of aged bluegill it was determined that 1995 and 1997 were strong year classes.

Largemouth bass were sampled during a spring electrofishing assessment conducted on the night of 5/22/2000. A total of 28 largemouth bass were sampled for a catch rate of 57.7 per hour of electrofishing. Size was good and growth rate was fast. Mean length of sampled bass was 11.8 inches and length at the beginning of their fifth year of life was 12.5 inches. A sample of aged largemouth bass showed every year class from 1992 through 1999 represented.

Other fish species sampled included pumpkinseed sunfish, rock bass, tullibee/cisco, white sucker, green sunfish, silver redhorse, yellow bullhead, yellow perch, common shiner and spottail shiner. Cisco are much less abundant in Little Hanging Horn than Big Hanging Horn.

See the link below for specific information on gillnet surveys, stocking information, and fish consumption guidelines. http://www.dnr.state.mn.us/lakefind/showreport.html?downum=09003500

## Key Findings and Recommendations

**Monitoring Recommendations**
Transparency monitoring at sites 201 and 202 should be continued annually. It is important to continue transparency monitoring weekly or at least bimonthly every year to enable year-to-year comparisons and trend analyses. Phosphorus and chlorophyll a monitoring should continue at site 201, as the budget allows, to track future water quality trends.

**Overall Conclusions**
Little Hanging Horn Lake is a mesotrophic lake (TSI = 44) with evidence of an improving long-term trend in water clarity. The total phosphorus, chlorophyll *a* and transparency ranges are within the ecoregion ranges (Table 4).

Little Hanging Horn's lakeshed has no public ownership, 40% forest coverage, 33% is protected, while only 8% disturbed (Figure 13). Forests and wetlands are generally good for water quality.

Little Hanging Horn Lake is one of several connected lakes joined via the Moose Horn river. It is not directly connected to the river though, it flows into Hanging Horn Lake, which is connected to the river. The total watershed area for Little Hanging Horn is very small, therefore disturbances in surrounding lakesheds do not adversely affect Little Hanging Horn Lake's water quality. The relatively short water residence time, however, may inhibit accumulation of nutrients and other contaminants from upstream sources.

Hanging Horn Lake is managed by DNR Fisheries as a cisco refuge lake. Dissolved oxygen profiles show borderline hospitable oxygen levels for ciscoes in the summer (Figure 10). The DNR Fisheries summary on page 14 reports that ciscoes are present in the lake, but at lower numbers than Hanging Horn Lake.

**Phosphorus Loading and Priority Impacts**
Little Hanging Horn is at an advantage because the lakeshed is a headwaters catchment, which means no additional water flows into this lakeshed from upstream areas. This means that the land practices around the lake are the main impact to the lake's water quality.

Figure 13 shows development around the first tier of the lake and into the second tier to the north. Development of the second tier around a lake can significantly change the drainage around a lake. See Table 12 for project ideas.

*Table 11. Watershed characteristics.*

| | |
|---|---|
| **Lakeshed to Lake Area Ratio** (lakeshed includes lake area) | 6:1 |
| **Watershed to Lake Area Ratio** (watershed includes lake areas) | 6:1 |
| **Number of Upstream Lakes** | 0 |
| **Headwaters Lake?** | Yes |
| **Inlets / Outlets** | 1 / 1 |
| **Water Residence Time** | NA |

**Best Management Practices Recommendations**

The management focus for Little Hanging Horn should be to protect the current water quality and the lakeshed. Efforts should be focused on managing and/or decreasing the impact caused by current and additional development, including second tier development, and impervious surface area. Project ideas include protecting land with conservation easements, enforcing county shoreline ordinances, shoreline restoration, rain gardens, and septic system maintenance.

## Little Hanging Horn Goals

1. Protection Focus: minimize disturbed land uses and maintain protected lands
2. Manage phosphorus loading from **nearshore**, Table 12
3. Focused BMPs per land type: Table 12

*Table 12. Best Management Practices Table specific to Little Hanging Horn (refer to Figure 13)*

| Category | Land use type | Conservation project ideas | Results | Who | Contact for help |
|---|---|---|---|---|---|
| Conservation Potential Land | private forests (40%, 305.6 acres) | Forest stewardship planning, 3rd party certification, SFIA, local woodland cooperatives. | Conserve and protect current forest cover. | • Individual Property Owners | Carlton SWCD (218) 384-3891 https://carltonswcd.org |
| | pasture/hay (63%, 8 acres) | Conservation Reserve Program (CRP), maintain vegetative cover, plant trees, conservation easements, grassed waterways, ditch buffers, maintain/restore wetlands. | Reduce water runoff and soil erosion, better water storage. | • Individual Property Owners | Natural Resources Conservation Service 218-720-5209 |
| | shrub/scrub (11%, 87 acres) | Maintain vegetative cover, plant trees, conservation easements, grassed waterways, buffers. | Reduce water runoff and soil erosion, better water storage. | • Individual Property Owners | Natural Resources Conservation Service 218-720-5209 |
| Disturbed Land | developed, low intensity (60%, 8 acres) | Shoreline buffers, rain gardens. | Reduce water runoff and shoreline erosion in lakes and streams. | • Individual Property Owners | Carlton SWCD (218) 384-3891 https://carltonswcd.org |

The current lakeshore homeowners can lessen their negative impact on water quality by installing or maintaining the existing trees on their properties. Forested uplands contribute significantly less phosphorus (lbs/acre/year) than developed land cover (Table 11).

Almost half (40%) of the lakeshed is privately owned forested uplands (Table 12). Forested uplands can be managed with Forest Stewardship Planning, 3rd party certification, SFIA, and local woodland cooperatives. Contact the Soil and Watershed Conservation District for options for managing private forests.

The lakeshed still has many large, undeveloped shoreline parcels (Figure 13). Because a lot of undeveloped private land still exists, there is a great potential for protecting this land with conservation easements and aquatic management areas (AMAs). Conservation easements can be set up easily and with little cost with help from organizations such as the Board of Soil and Water Resources and the Minnesota Land Trust. AMAs can be set up through the local DNR fisheries office.

Native aquatic plants stabilize the lake's sediments and tie up phosphorus in their tissues. When aquatic plants are uprooted from a shallow lake, the lake bottom is disturbed, and the phosphorus in the water column gets used by algae instead of plants. This contributes to "greener" water and more algae blooms. Protecting native aquatic plant beds will ensure a healthy lake and healthy fishery. If a swimming area is necessary in front of people's docks, clear only a small area of plants. Clearing a whole 100 foot frontage is not necessary and can contribute to additional algae blooms.

*Table 13. Organizational contacts and reference sites*

## Organizational contacts and reference sites

| | |
|---|---|
| Hanging Horn Lakeshore Management Association | P.O. Box 192 Barnum, MN 55707 |
| DNR Fisheries Office | 5351 North Shore Drive, Duluth, MN 55804<br>218-302-3264, duluth.fisheries@state.mn.us |
| Regional Minnesota Pollution Control Agency Office | 525 Lake Avenue South, Suite 400, Duluth, MN 55802<br>218-723-4660<br>https://www.pca.state.mn.us/about-mpca/duluth-office |
| Carlton County Soil and Water Conservation District | 808 3rd St, Carlton, MN 55718<br>(218) 384-3891, https://carltonswcd.org/ |
| Carlton County | 301 Walnut Ave, Carlton, MN 55718<br>http://carltoncountymn.govoffice3.com/ |

# Moosehead

## 09-0041-00 Carlton County

Moosehead is located within the city limits of Moose Lake, MN in Carlton County. It is a shallow, oval lake covering 279 acres (Table 1).

Moosehead has three inlets and one outlet, which classify it as a drainage lake. Water enters Moosehead from the Moose Horn River and Portage River in the northeast.

Water quality data have been collected on Moosehead from 2002-2003, 2012-2017 (Tables 2 & 3). These data show that the lake is eutrophic (TSI = 55) which is characteristic of a shallow lake with abundant aquatic plants and algae, and bass fisheries.

Table 1. Moosehead location and key physical characteristics.

| Location Data | |
|---|---|
| MN Lake ID: | **09-0041-00** |
| County: | **Carlton** |
| Ecoregion: | **Northern Lakes and Forests** |
| Major Watershed: | **Kettle River** |
| Latitude/Longitude: | **46.446078, -92.767696** |
| Invasive Species: | **None as of 2018** |

| Physical Characteristics | |
|---|---|
| Surface area (acres): | **279.24** |
| Littoral area (acres): | **261** |
| % Littoral area: | **93.5%** |
| Max depth (ft), (m): | **18, 5.5** |
| Inlets: | **3** |
| Outlets: | **1** |
| Public Accesses: | **1** |

Table 2. Availability of primary data types for Moosehead.

| Data Availability | |
|---|---|
| Transparency data | **Fair, 8 years of data with one large gap** |
| Chemical data | **Good** |
| Inlet/Outlet data | **Some data available.** |
| Recommendations | **For recommendations refer to page 15.** |

## Lake Map

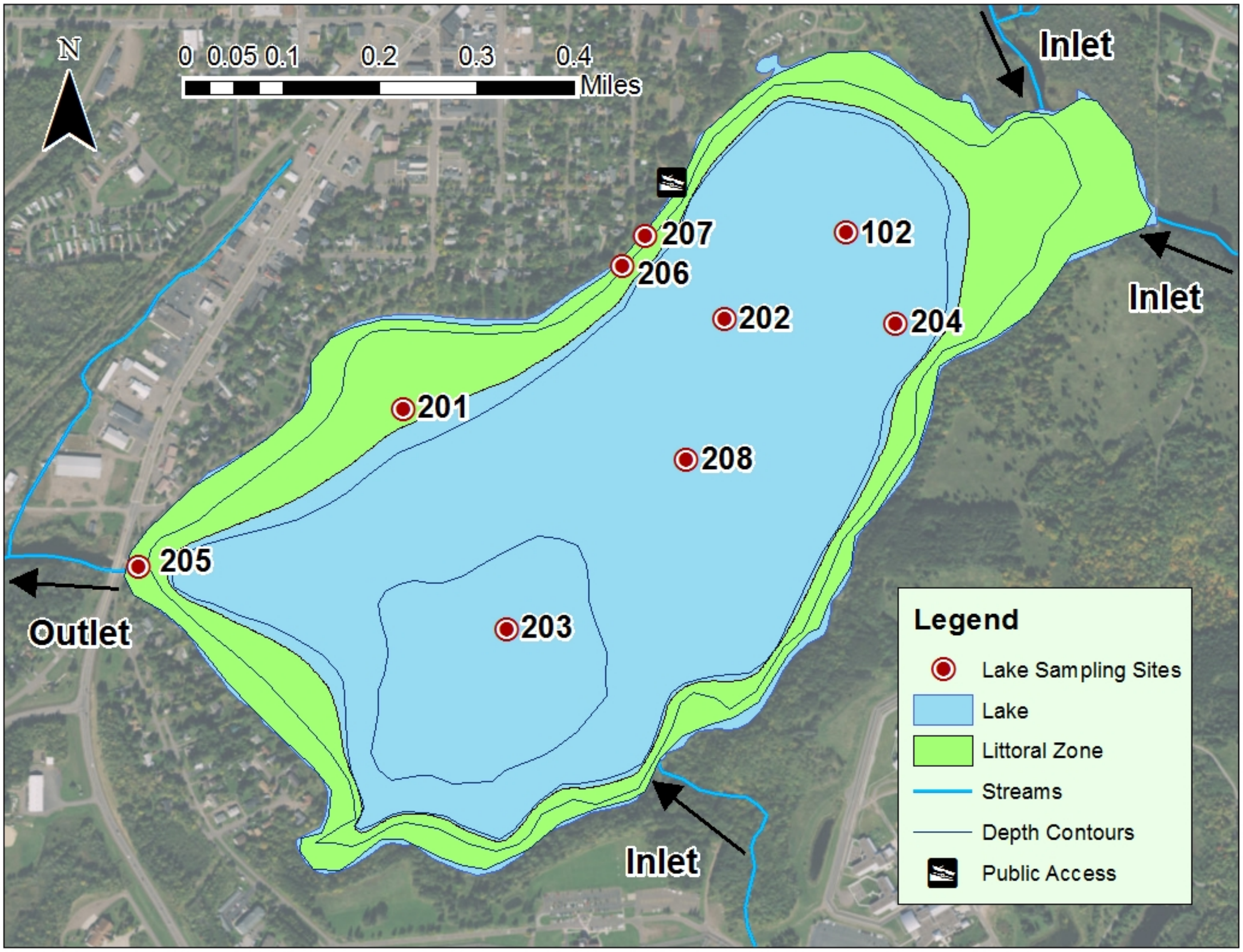



*Figure 1. Map of Moosehead Lake with 2010 aerial imagery and illustrations of lake depth contour lines, sample site locations, inlets and outlets, and public access points. The light green areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom, allowing aquatic plants to grow.*

*Table 3. Monitoring programs and associated monitoring sites. Monitoring programs include the Citizen Lake Monitoring Program (CLMP), Clean Water Legacy Surface Water Monitoring (CWL), Lake Assessment Program (LAP).*

| Lake Site | Depth (ft) | Monitoring Programs |
|---|---|---|
| 203* Primary | 18 | CLMP: 1977, 1986, 2002-2006, 2012-2015; CWL: 2012, 2016; LAP: 2003 |
| 202 | 10 | CLMP:1977, 1986, 2002-2006, 2012-2015; CWL: 2012, 2016 |
| 102 | 10 | LAP: 2003; CWL: 2012, 2016 |
| 201 | 5 | CLMP; 1977, 1986, 2002-2006, 2012-2015 |
| 204 | 10 | CLMP; 2002-2003 |
| 205, 206, 207, 208 | 10 | CWL: 2012 |

## Average Water Quality Statistics & Comparisons

The information below describes available chemical data for Moosehead through 2017 (Table 4). Data for total phosphorus, chlorophyll *a*, and Secchi depth are from the primary site 203.

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation and geology. The Minnesota Pollution Control Agency (MPCA) has developed a way to determine the "average range" of water quality expected for lakes in each ecoregion[1] (Table 4). Moosehead is in the Northern Lakes and Forests Ecoregion (Figure 2).

The MPCA has developed Impaired Waters Standards for lakes in each ecoregion to determine if a lake is impaired for excess phosphorus/eutrophication (Table 4). Lakes that are over the impaired waters standards are placed on the state's Impaired Waters List[2].


Figure 2. Minnesota ecoregions.

Table 4. Water quality means compared to ecoregion ranges and impaired waters standard.

| Parameter | Mean | Ecoregion Range[1] | Impaired Waters Standard[2] | Interpretation |
|---|---|---|---|---|
| Total phosphorus (ug/L) | 33.7 | 14 – 27 | > 30 | Results are above the expected range for the Northern Lakes and Forests Ecoregion and the average for the lake is over the impaired waters standard. |
| [3]Chlorophyll *a* (ug/L) | 10.5 | 4 – 10 | > 9 | |
| Chlorophyll *a* max (ug/L) | 23.8 | < 15 | | |
| Secchi depth (ft) | 4.4 | 8 – 15 | < 6.5 | |
| Dissolved oxygen | *See page 8* | | | Dissolved oxygen depth profiles show that the lake mixes periodically in summer. |
| Total Kjeldahl Nitrogen (mg/L) | 0.84 | <0.4 – 0.75 | | Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms. |
| Alkalinity (mg/L) | 44.2 | 40 – 140 | | Indicates a low sensitivity to acid rain and a good buffering capacity. |
| Color (Pt-Co Units) | NA | 10 – 35 | | No data available. |
| pH | 7.3 | 7.2 – 8.3 | | Within the expected range for the ecoregion. Lake water pH less than 6.5 can affect fish spawning and the solubility of metals in the water. |
| Chloride (mg/L) | 5.15 | 0.6 – 1.2 | | Above the expected range for the ecoregion, but still considered low level. |
| Total Suspended Solids (mg/L) | 3.5 | <1 – 2 | | Above the expected range for the ecoregion, but still considered low level. |
| Specific Conductance (umhos/cm) | 93.4 | 50 – 250 | | Within the expected range for the ecoregion. |
| TN:TP Ratio | 40:1 | 25:1 - 35:1 | | Shows the lake is phosphorus limited. |

[1]The ecoregion range is the 25th-75th percentile of summer means from ecoregion reference lakes: https://www.pca.state.mn.us/quick-links/eda-guide-typical-minnesota-water-quality-conditions
[2]For further information regarding the Impaired Waters Assessment program, refer to http://www.pca.state.mn.us/water/tmdl/index.html
[3]Chlorophyll *a* measurements have been corrected for pheophytin
Units: 1 mg/L (ppm) = 1,000 ug/L (ppb)

## Water Quality Characteristics - Historical Means and Ranges

Table 5. Water quality means and ranges for primary sites.

| Parameters | Primary Site 203 | Site 202 | Site 201 | Site 102 |
|---|---|---|---|---|
| **Total Phosphorus Mean (ug/L):** | 33.7 | - | - | 40.4 |
| Total Phosphorus Min: | 18.0 | | | 29 |
| Total Phosphorus Max: | 50.0 | | | 51 |
| Number of Observations: | 16 | | | 5 |
| **Chlorophyll *a* Mean (ug/L):** | 10.5 | - | - | 9.8 |
| Chlorophyll-a Min: | 4.97 | | | 5.1 |
| Chlorophyll-a Max: | 23.8 | | | 14.2 |
| Number of Observations: | 14 | | | 4 |
| **Secchi Depth Mean (ft):** | 4.4 | 4.7 | 4.6 | 4.2 |
| Secchi Depth Min: | 2.6 | 2.5 | 2.5 | 3.9 |
| Secchi Depth Max: | 6.2 | 6.0 | 7.5 | 4.6 |
| Number of Observations: | 51 | 36 | 38 | 3 |

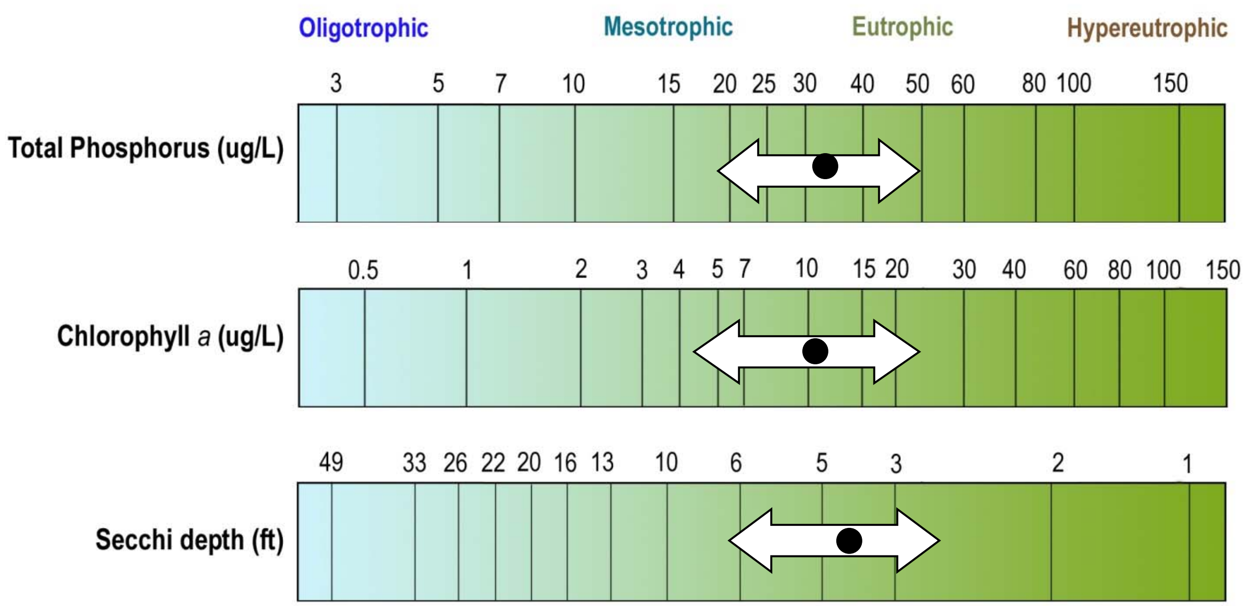



*Figure 3. Moosehead Lake total phosphorus, chlorophyll a and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 203). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. EPA 440/5-88-002)*

## Transparency (Secchi Depth)

Transparency is how easily light can pass through a substance. In lakes it is how deep sunlight penetrates through the water. Plants and algae need sunlight to grow, so they are only able to grow in areas of lakes where the sun penetrates. Water transparency depends on the number of particles in the water. An increase in particulates results in a decrease in transparency. The transparency varies year to year due to changes in weather, precipitation, lake use, flooding, temperature, lake levels, etc.

The annual mean transparency in Moosehead ranges from 3.5 to 5.5 feet (Figure 3). The annual means hover fairly close to the long-term mean. For trend analysis, see page 10. Transparency monitoring should be continued annually at site 203 in order to track water quality changes.

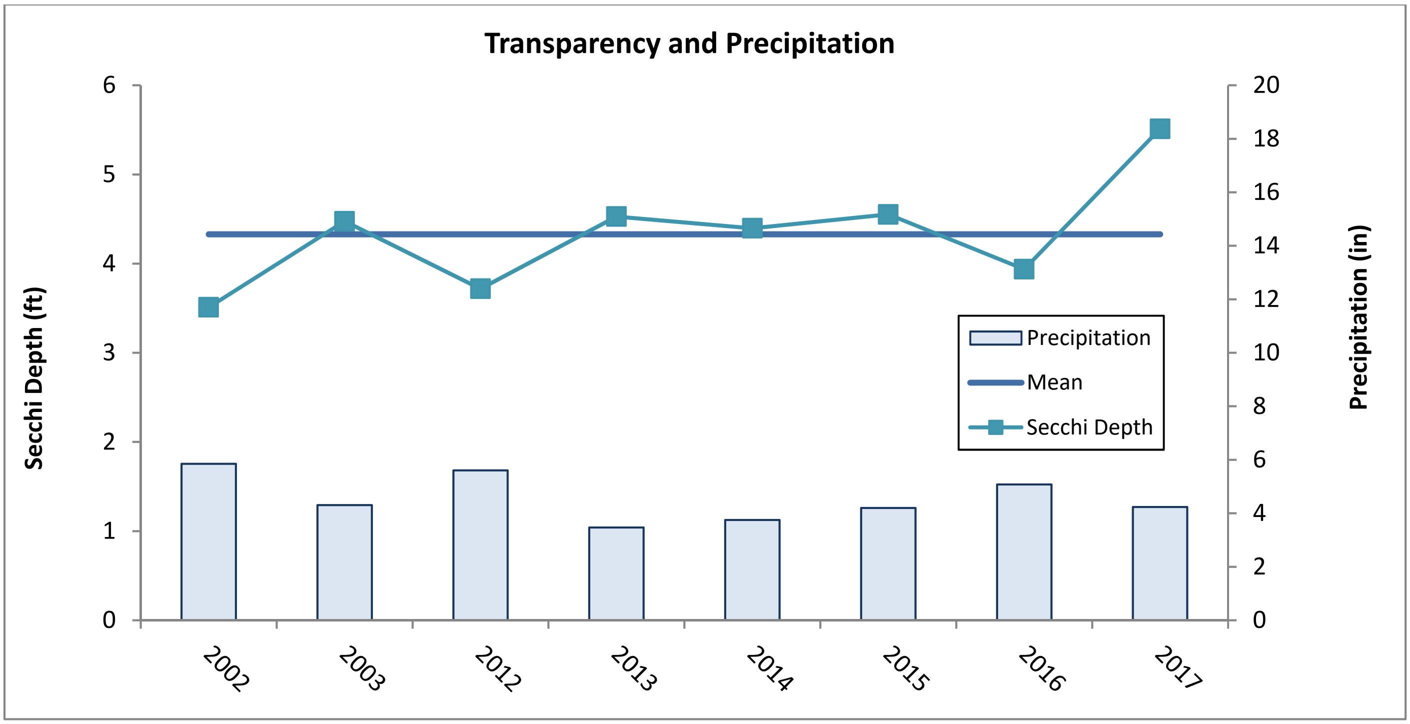



*Figure 4. Annual mean transparency compared to long-term mean transparency*

Moosehead transparency ranges from 2.6 to 6.2 ft at the primary site (Table 5)). Figure 4 shows the seasonal transparency dynamics. The maximum Secchi reading is usually obtained in early summer. Moosehead transparency is high in May and June, and then declines through August. The transparency then rebounds in October after fall turnover. This transparency dynamic is typical of a Minnesota lake. The dynamics have to do with algae and zooplankton population dynamics, and lake turnover.

It is important for lake residents to understand the seasonal transparency dynamics in their lake so that they are not worried about why their transparency is lower in August than it is in June. It is typical for a lake to vary in transparency throughout the summer.

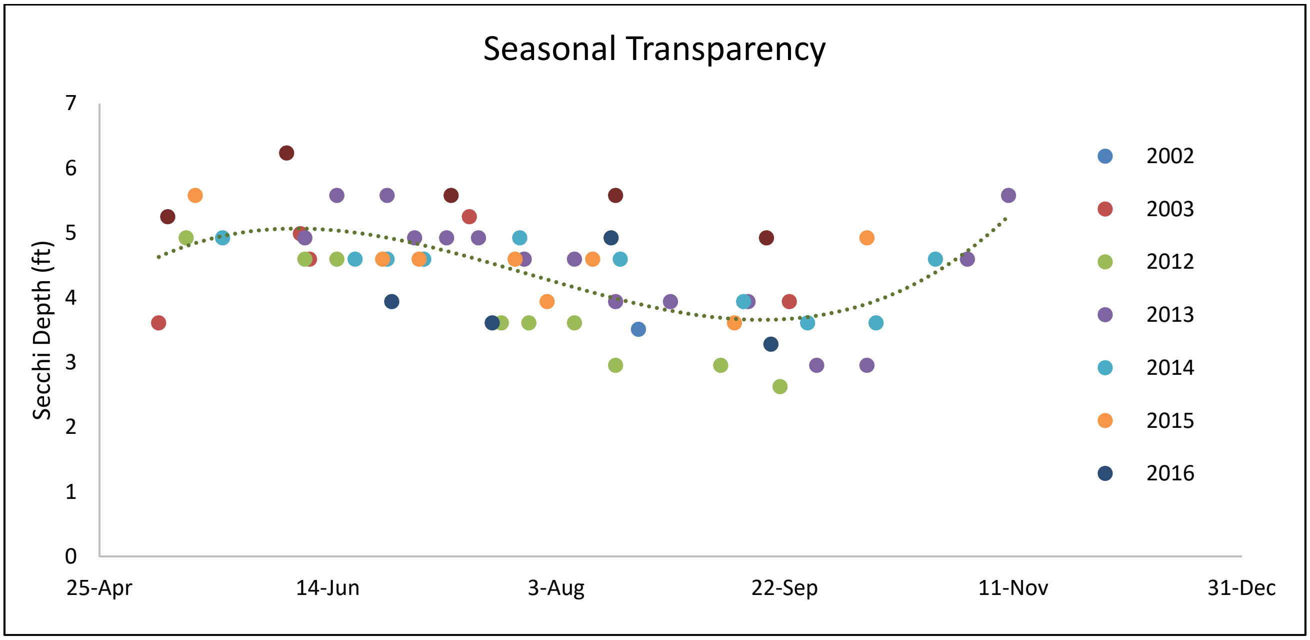



*Figure 5. Seasonal transparency dynamics and year to year comparison (Primary Site 203). The black line represents the pattern in the data.*

## User Perceptions

When volunteers collect Secchi depth readings, they record their perceptions of the water based on the physical appearance and the recreational suitability. These perceptions can be compared to water quality parameters to see how the lake "user" would experience the lake at that time. Looking at transparency data, as the Secchi depth decreases the perception of the lake's physical appearance and recreational suitability decreases (Figures 6-7).

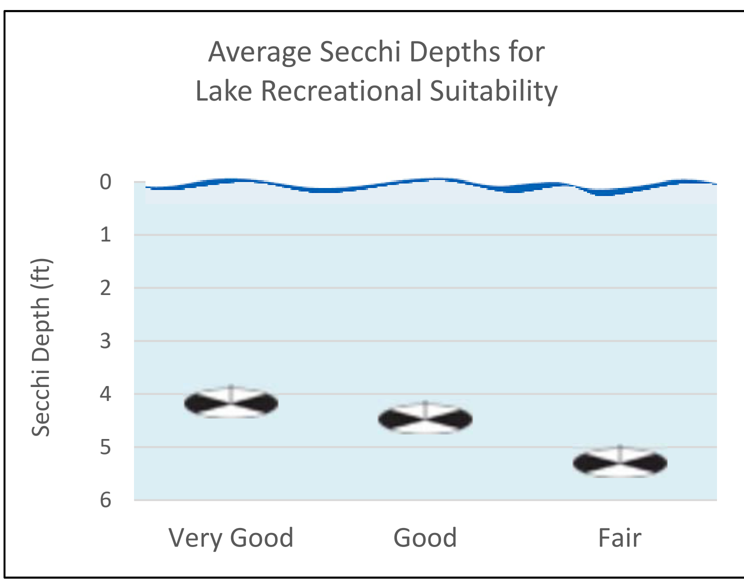



*Figure 6. Average Secchi depth (ft) for each lake recreational suitability rating.*

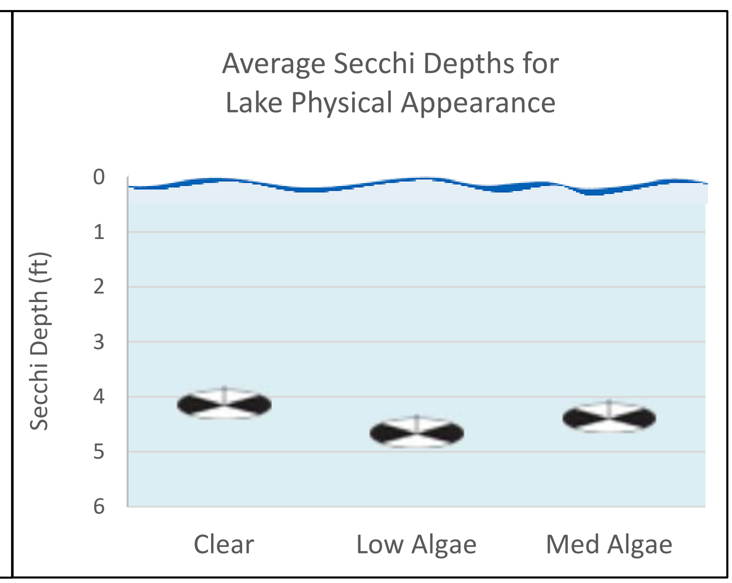



*Figure 7. Average Secchi depth for each lake physical appearance rating.*

## Algae

Chlorophyll *a* is the pigment that makes plants and algae green. Chlorophyll *a* is tested in lakes to determine the algae concentration or how "green" the water is.

Chlorophyll *a* concentrations greater than 10 ug/L are perceived as a mild algae bloom, while concentrations greater than 20 ug/L are perceived as a nuisance.

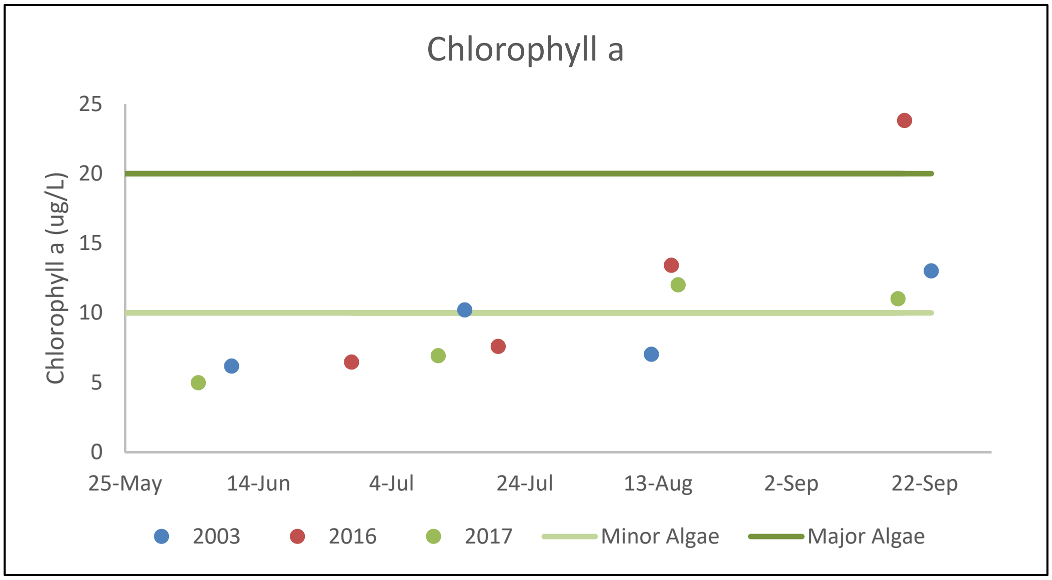



*Figure 8. Chlorophyll a concentrations (ug/L) for Moosehead Lake at site 203.*

Chlorophyll *a* was evaluated in Moosehead at site 203 in 2003, 2016-2017 (Figure 8). Chlorophyll *a* concentrations went above 10 ug/L in all three years, indicating minor algae blooms.

## Phosphorus

Moosehead is phosphorus limited, which means that algae and aquatic plant growth is dependent upon available phosphorus.

Total phosphorus was evaluated in Moosehead in 2003, 2016-2017. The data are highly variable, which is common for a shallow lake. Most of the data points fall into the mesotrophic/eutrophic border (Figure 7).

Phosphorus should continue to be monitored to track any future changes in water quality.

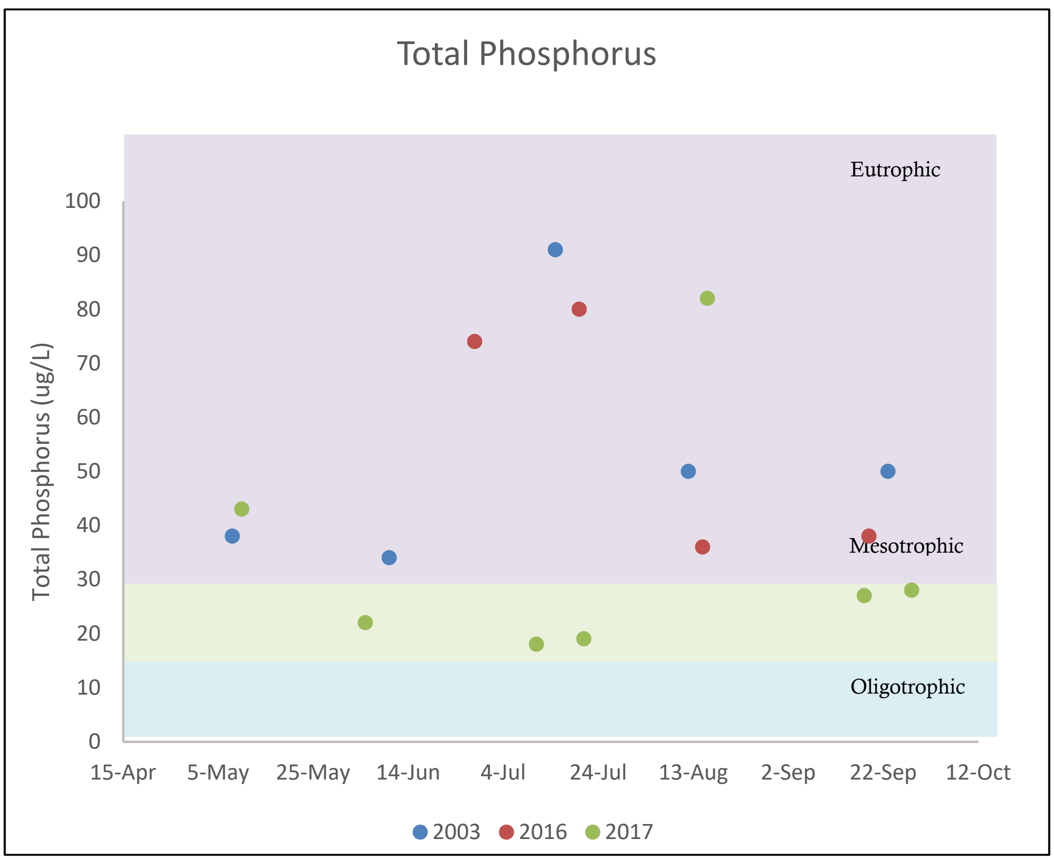
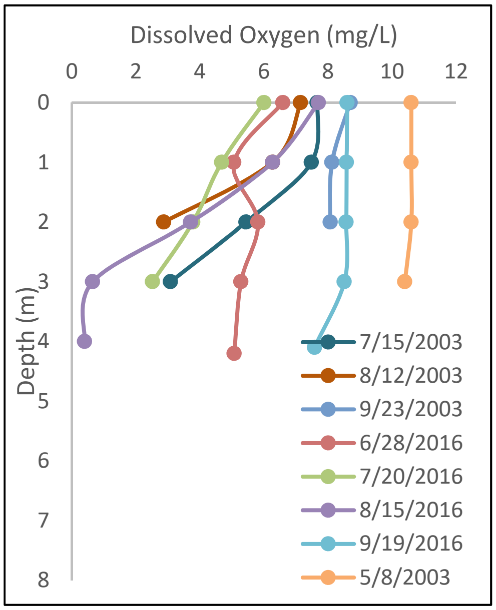



*Figure 9. Historical total phosphorus concentrations (ug/L) for Moosehead Lake site 203.*

## Oxygen




Dissolved Oxygen (DO) is the amount of oxygen dissolved in lake water. Oxygen is necessary for all living organisms to survive except for some bacteria. Living organisms breathe in oxygen that is dissolved in the water. Dissolved oxygen levels of <5 mg/L are typically avoided by game fisheries.

Moosehead is a shallow lake, with a maximum depth of 18 feet. Dissolved oxygen profiles from data collected in 2003 and 2016 at site 203 show periodic mixing (Figure 10). In a shallow lake, the water column never completely stratifies. Any windy day can mix up the water column causing phosphorus from the anoxic lake bottom to re-suspend into the water. This phenomenon is known as internal loading.

*Figure 10. Representative dissolved oxygen profiles from 2003 and 2016 in Moosehead Lake.*

## Trophic State Index (TSI)

TSI is a standard measure or means for calculating the trophic status or productivity of a lake. More specifically, it is the total weight of living algae (algae biomass) in a waterbody at a specific location and time. Three variables, chlorophyll a, Secchi depth, and total phosphorus, independently estimate algal biomass.

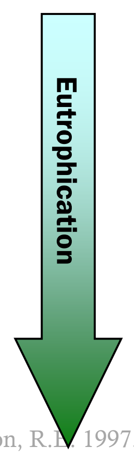
If all three TSI numbers are within a few points of each other, they are strongly related. If they are different, there are other dynamics influencing the lake's productivity, and TSI mean should not be reported for the lake. Moosehead falls into the mesotrophic range (Tables 6, 7).

Table 6. Trophic State Index for Moosehead.

| **Trophic State Index** | |
|---|---|
| **TSI Phosphorus** | **55** |
| **TSI Chlorophyll-a** | **55** |
| **TSI Secchi** | **56** |
| **TSI Mean** | **55** |
| **Trophic State:** | **Eutrophic** |

*Numbers represent the mean TSI for each parameter.*

*Table 7. Trophic state index attributes and their corresponding fisheries and recreation characteristics.*




| | TSI | Attributes | Fisheries & Recreation |
|---|---|---|---|
| | <30 | **Oligotrophy:** Clear water, oxygen throughout the year at the bottom of the lake, deep cold water. | Trout fisheries dominate. |
| | 30-40 | Bottom may become anoxic (no oxygen). | Trout fisheries in deep lakes only. Walleye, Cisco present. |
| | 40-50 | **Mesotrophy:** Water moderately clear most of the summer. May be "greener" in late summer. | No oxygen at the bottom of the lake results in loss of trout. Walleye may predominate. |
| **Moosehead** | 50-60 | **Eutrophy:** Algae and aquatic plant problems possible. "Green" water most of the year. | Warm-water fisheries only. Bass may dominate. |
| | 60-70 | Blue-green algae dominate, algal scums and aquatic plant problems. | Dense algae and aquatic plants. Low water clarity may discourage swimming and boating. |
| | 70-80 | **Hypereutrophy:** Dense algae and aquatic plants. | Water is not suitable for recreation. |
| | >80 | Algal scums, few aquatic plants. | Rough fish (carp) dominate; summer fish kills possible. |

Source: Carlson, R.E. 1997. A trophic state index for lakes. *Limnology and Oceanography*. 22:361-369.

## Trend Analysis

For detecting trends, a minimum of 8-10 years of data with 4 or more readings per season are recommended. Minimum confidence accepted by the MPCA is 90%. This means that there is a 90% chance that the data are showing a true trend and a 10% chance that the trend is a random result of the data. Only short-term trends can be determined with just a few years of data, because there can be different wet years and dry years, water levels, weather, etc, that affect the water quality naturally.

Moosehead had enough data to perform a trend analysis on transparency (Table 8). The data was analyzed using the Mann Kendall Trend Analysis.

Table 8. Trend analysis for Moosehead.

| Lake Site | Parameter | Date Range | Trend | Probability |
|---|---|---|---|---|
| 203 | Total Phosphorus | 2003, 2016-2017 | Insufficient data | - |
| 203 | Chlorophyll *a* | 2003, 2016-2017 | Insufficient data | - |
| 203 | Transparency | 2012-2017 | Improving | 80% |

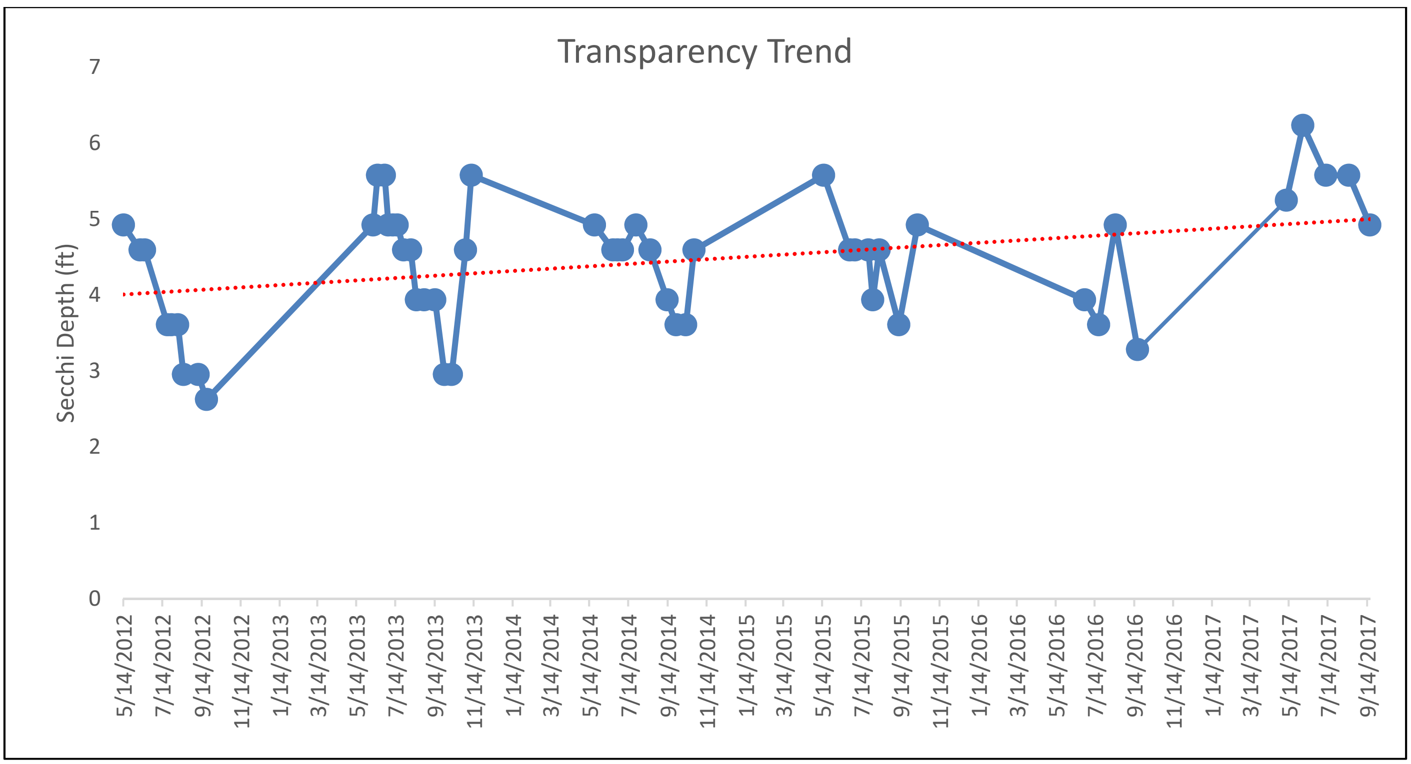



*Figure 11. Transparency (feet) trend for site 203 from 2002-2003, 2012-2017.*

Moosehead shows weak evidence of an improving transparency trend (Figure 11). Since 2012, the clarity maximums getting higher as well. Transparency monitoring should continue so that this trend can be tracked in future years.

## Lakeshed

Understanding a lakeshed requires an understanding of basic hydrology. A watershed is defined as all land and water surface area that contribute excess water to a defined point. The MN DNR has delineated three basic scales of watersheds (from large to small): 1) basins, 2) major watersheds, and 3) minor watersheds.

The Kettle River Watershed is one of the watersheds that make up the St. Croix River Basin, which drains north to Hudson's Bay (Figure 12). Moosehead is located in minor watershed 35022 (Figure 12)

The MN DNR also has evaluated catchments for each individual lake with more than 100 acres surface area. These lakesheds (catchments) are the "building blocks" for the larger scale watersheds. Moosehead falls within lakeshed 35022 (Figure 12). Though very useful for displaying the land and water that contribute directly to a lake, lakesheds are not always true watersheds because they may not show the water flowing into a lake from upstream streams or rivers. While some lakes may have only one or two upstream lakesheds draining into them, others may be connected to a large number of lakesheds, reflecting a larger drainage area via stream or river networks. For further discussion of Moosehead 's watershed, containing all the lakesheds upstream of the Moosehead lakeshed, see page 11. The data interpretation of the Moosehead lakeshed includes only the immediate lakeshed as this area is the land surface that flows directly into Moosehead.

In an effort to prioritize protection and restoration efforts of fishery lakes, the MN DNR has developed a ranking system by separating lakes into two categories, those needing protection and those needing restoration. Modeling by the DNR Fisheries Research Unit suggests that total phosphorus concentrations increase significantly over natural concentrations in lakes that have watershed with disturbance greater than 25%. Therefore, lakes with watersheds that have less than 25% disturbance need protection and lakes with more than 25% disturbance need restoration (Table 9). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land, public water, wetlands, or conservation easement.

*Table 9. Suggested approaches for watershed protection and restoration of DNR-managed fish lakes in Minnesota.*

| Watershed Disturbance (%) | Watershed Protected (%) | Management Type | Comments |
|---|---|---|---|
| < 25% | > 75% | Vigilance | Sufficiently protected -- Water quality supports healthy and diverse native fish communities. Keep public lands protected. |
| | < 75% | Protection | Excellent candidates for protection -- Water quality can be maintained in a range that supports healthy and diverse native fish communities. Disturbed lands should be limited to less than 25%. |
| 25-60% | n/a | Full Restoration | Realistic chance for full restoration of water quality and improve quality of fish communities. Disturbed land percentage should be reduced and BMPs implemented. |
| > 60% | n/a | Partial Restoration | Restoration will be very expensive and probably will not achieve water quality conditions necessary to sustain healthy fish communities. Restoration opportunities must be critically evaluated to assure feasible positive outcomes. |

The next step was to prioritize lakes within each of these management categories. DNR Fisheries identified high value fishery lakes, such as cisco refuge lakes. Ciscos (*Coregonus artedi)* can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. These watersheds with low disturbance and high value fishery lakes are excellent candidates for priority protection measures, especially those that are related to forestry and minimizing the effects of landscape disturbance. Forest stewardship planning, harvest coordination to reduce hydrology impacts and forest conservation easements are some potential tools that can protect these high value resources for the long term.

Moosehead's lakeshed is classified with having 49% of the watershed protected and 32% of the watershed disturbed (Figure 13). Therefore, this lakeshed should have a full restoration focus. Goals for the lake should be to manage water runoff from disturbed land uses and work to limit any increase in disturbed land use. Moosehead has a large watershed, with numerous lakesheds flowing into it (Figure 12).

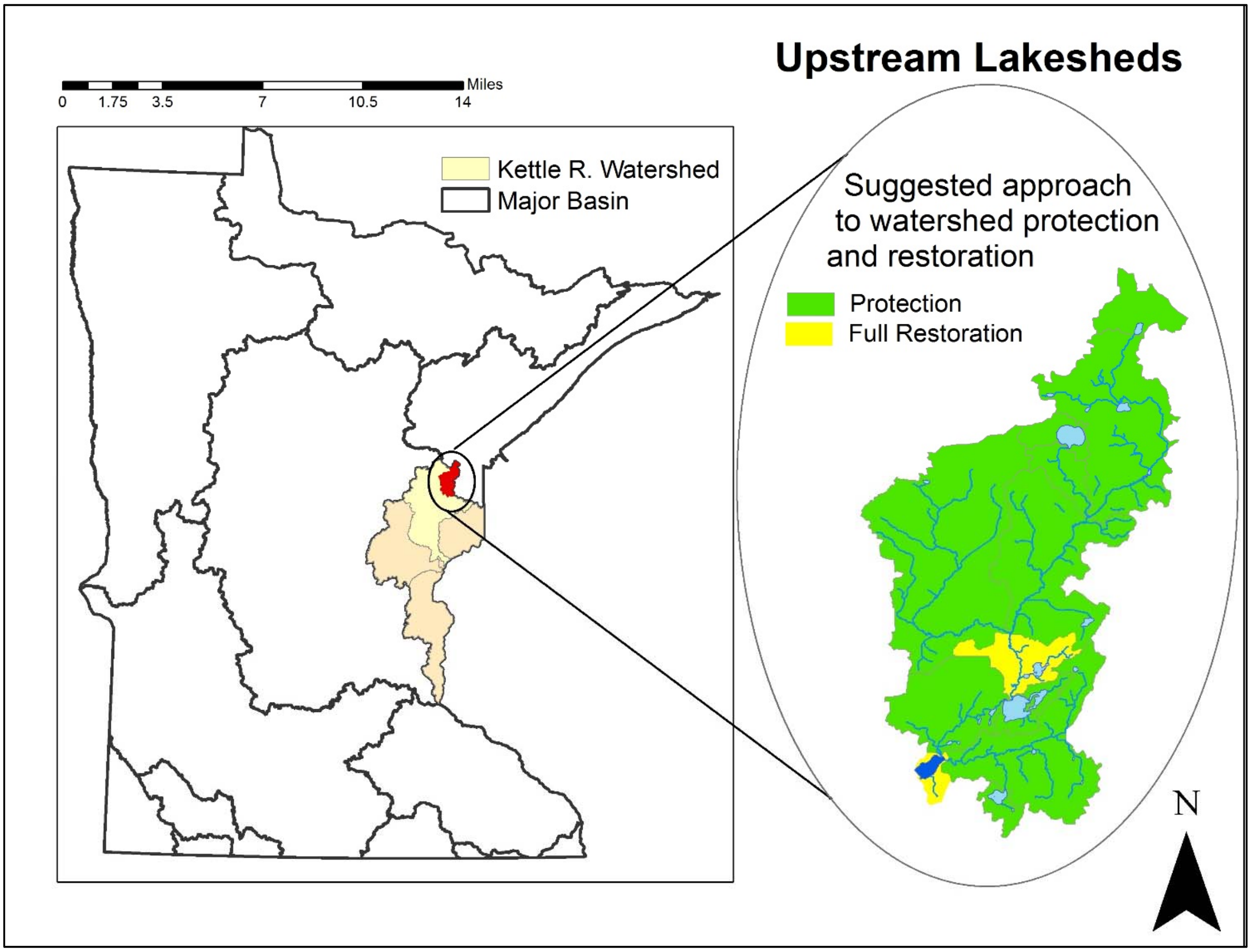



*Figure 12. Kettle River major watershed and MN basins (left), and Moosehead Lake lakeshed and upstream catchments with protection suggestions (right).*

## Land use and Ownership

Activities that occur on the land within the lakeshed can greatly impact a lake. Land use planning helps ensure the use of land resources in an organized fashion so that the needs of the present and future generations can be best addressed.

Half of the Moosehead Lake lakeshed is protected (Figure 13). This total includes water, wetlands, and publicly owned land. There are two parcels along the lakeshore which have conservation potential. They are both private land over 20 acres which are less than 50% developed or agriculture.

Moosehead lake is within the city of Moose Lake, so there is a lot of concentrated development around the lake and a third of the lakeshed is disturbed (Figure 13). See the recommendations on page 15 for specific project ideas.

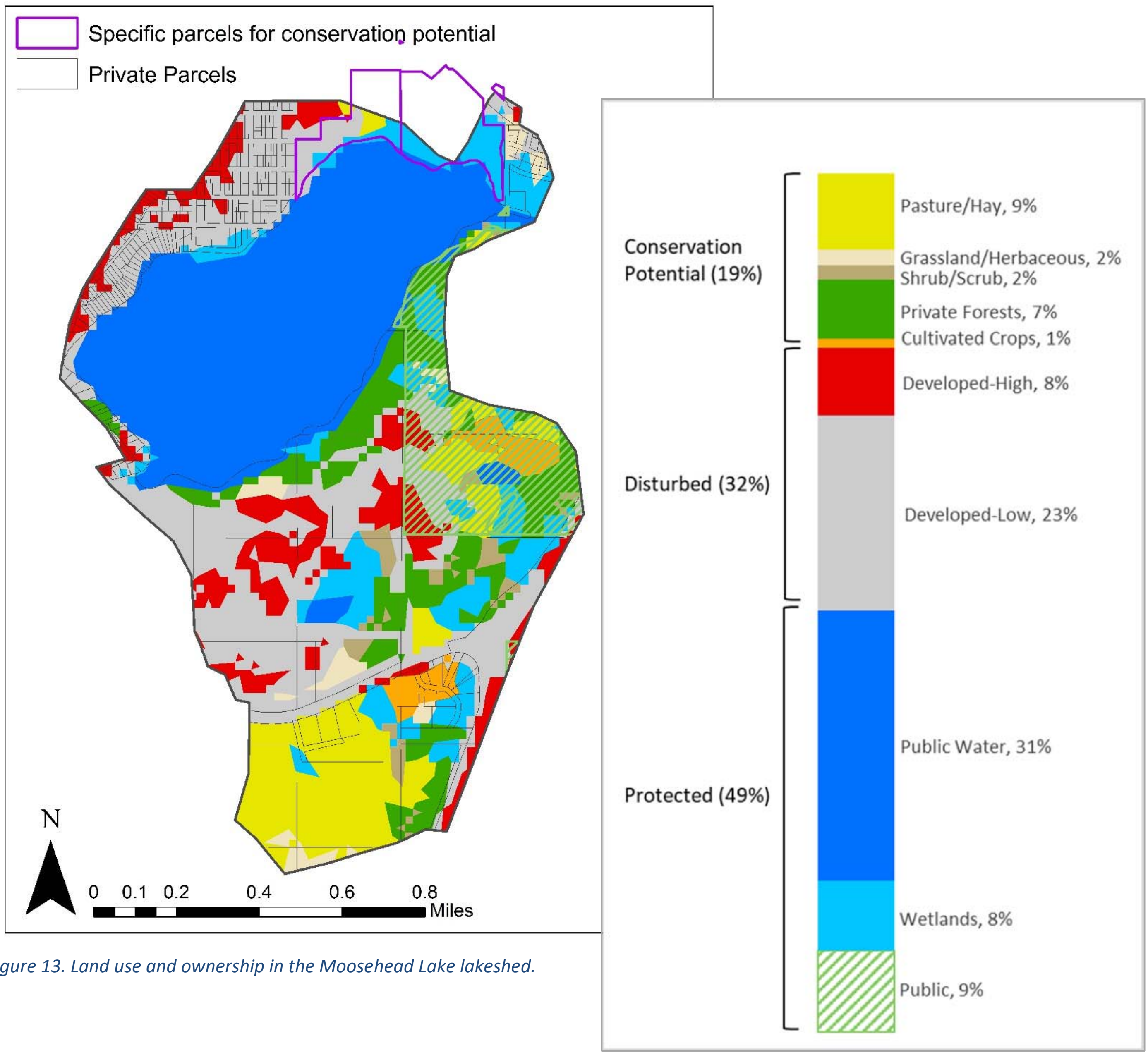



*Figure 13. Land use and ownership in the Moosehead Lake lakeshed.*

The lakeshed vitals table identifies where to focus organizational and management efforts for each lake (Table 10). Criteria were developed using limnological concepts to determine the effect to lake water quality.

**KEY**
● Possibly detrimental to the lake
◐ Warrants attention
○ Beneficial to the lake

*Table 10. Moosehead Lake lakeshed vitals table.*

| Lakeshed Vitals | | Rating |
|---|---|---|
| **Lake Area** | 279.24 acres | descriptive |
| **Littoral Zone Area** | 261 acres | descriptive |
| **Lake Max Depth** | 18 ft. | descriptive |
| **Lake Mean Depth** | 12 ft. | ◐ |
| **Water Residence Time** | NA | Not available |
| **Miles of Stream** | 1.1 | descriptive |
| **Inlets** | 3 | ◐ |
| **Outlets** | 1 | ○ |
| **Major Watershed** | 35 – Kettle River Watershed | descriptive |
| **Minor Watershed** | 35022 | descriptive |
| **Lakeshed** | 3502201 | descriptive |
| **Ecoregion** | Northern Lakes and Forest | descriptive |
| **Total Lakeshed to Lake Area Ratio** (total lakeshed includes lake area) | 3:1 | ◐ |
| **Standard Watershed to Lake Basin Ratio** (standard watershed includes lake areas) | 255:1 | ● |
| **Wetland Coverage** | 8% | ○ |
| **Aquatic Invasive Species** | None | ○ |
| **Public Drainage Ditches** | None | ○ |
| **Public Lake Accesses** | 1 | ◐ |
| **Miles of Shoreline** | 3.18 | descriptive |
| **Shoreline Development Index** | 1.32 | ○ |
| **Public Land to Private Land Ratio** | 1:18 | ◐ |
| **Development Classification** | General Development | ● |
| **Miles of Road** | 7.5 | descriptive |
| **Municipalities in lakeshed** | Moose Lake | ● |
| **Forestry Practices** | None | ○ |
| **Feedlots** | None | ○ |
| **Sewage Management** | Compliance inspections are required for subsurface sewage treatment systems at point-of-sale or permit application in shoreland areas. | ○ |
| **Lake Management Plan** | None | ◐ |
| **Lake Vegetation Survey/Plan** | DNR, 1997 | ○ |

## Moosehead Lake, Status of the Fishery (DNR, 7/21/2014)

Moosehead is a 292 acre lake with 261 (89%) acres of littoral area and a maximum depth of 18 feet. The lake is located immediately east of Moose Lake, MN and has a city administered, concrete, back-in access. A public swimming beach is adjacent to the access. Moosehead Lake has not been actively managed with fish stocking since 1985. Moosehead Lake was surveyed in 2014 to update information on fish populations and aquatic habitat.

Walleye abundance of 1.7 per gillnet lift was down from 2006 (3.3) but still average compared to other Minnesota lakes of similar type. Walleye abundance has ranged from 2.5 to 3.3 per lift during four previous investigations from 1972 through 2006. Average size was 16.6 inches and growth was average compared to other Duluth Area lakes. Age analysis revealed inconsistent recruitment with six missing year-classes from 2002-2013. Black Crappie abundance of 8.7 per trapnet lift was up from 2006 (1.7) and above average compared to other Minnesota lakes of similar type. Average size of 8.6 inches was large and growth was average compared to other Duluth Area lakes. Age analysis revealed a strong 2010 year-class and consistent recruitment with all year-classes from 2006 through 2012 represented.

Bluegill abundance of 8.4 per trapnet lift was up from 2006 (5.1) and above average compared to other Minnesota lakes of similar type. Average size was 6.7 inches and growth was average compared to other Duluth Area lakes. Age analysis revealed strong 2007 and 2011 year-classes and all year-classes from 2005 through 2012 were represented.

A total of 5 Largemouth Bass were sampled with electrofishing equipment. Bass electrofishing was not attempted in previous investigations but Largemouth Bass were sampled with regular assessment gear in 1977 and 1989. The Largemouth Bass catch rate of 4.1 fish per hour of electrofishing on-time was below average compared to other Duluth Area populations. Largemouth Bass average length was 15.8 inches. Not enough individuals were captured to evaluate stock density or growth, but recruitment appears sporadic with two missing year-classes from 2004-2010.

Northern Pike abundance of 6.0 per gillnet lift was down from 2006 (9.0) and average compared to other Minnesota lakes of similar type. Average size was 21.6 inches. Northern Pike were not aged for this assessment. Yellow Perch abundance of 11.0 was up from 2006 (7.0) but was still average compared to other Minnesota lakes of similar type. Average size was 6.1 inches. Yellow Perch were not aged for this assessment.
Lake Sturgeon have been documented in gillnet samples from investigations conducted in 1989 and 1999. There are also anecdotal reports of spawning activity in the Moosehead River near the Highway #61 Bridge at the outlet of Moosehead Lake. Anglers have reported catching large Lake Sturgeon in Moosehead Lake. No Lake Sturgeon were encountered during this survey.

Other fish species sampled during this investigation include Pumpkinseed Sunfish, Shorthead Redhorse, Silver Redhorse, White Sucker and Yellow Bullhead.

A substantial percentage (31%) of lakeshore homeowners on Moosehead Lake have open yards extending to the shoreline. Lakeshore owners can prevent excessive nutrient loading which leads to excessive plant growth and poor water quality by avoiding lawn fertilization, limiting aquatic vegetation removal, and implementing riparian best management practices. Results of laboratory water analysis indicate Moosehead is a slightly acidic, moderately hard water lake of low fertility.

Information was also collected on aquatic vegetation. Thirty-five aquatic plant species or species groups were identified along 134 sampling points. Water (wild) celery was the most frequently found plant (17% of stations sampled) followed by clasping-leaf pondweed (15%) and bushy pondweed (14%). One invasive plant was identified at low abundance (reed canary grass) but this species is common in emergent wetland plant communities and has become well-established in Minnesota. These data can be compared to future aquatic plant surveys of Moosehead Lake to estimate how the plant community may be changing.

See the link below for specific information on gillnet surveys, stocking information, and fish consumption guidelines. http://www.dnr.state.mn.us/lakefind/showreport.html?downum=09004100

## Key Findings and Recommendations

**Monitoring Recommendations**
Transparency monitoring at site 203 should be continued annually. It is important to continue transparency monitoring weekly or at least bimonthly every year to enable year-to-year comparisons and trend analyses. Phosphorus and chlorophyll a monitoring should continue at site 203, as the budget allows, to track future water quality trends.

**Overall Conclusions**
Moosehead Lake is a eutrophic lake (TSI = 55) with weak evidence (80%) of an improving long-term trend in water clarity. The total phosphorus, chlorophyll *a* and transparency ranges are higher than the expected ecoregion ranges and over the impaired waters standard (Figure 4). The Minnesota Pollution Control Agency is currently assessing the Kettle River Watershed and will decide whether to put Mooshead Lake on the Impaired Waters List.

Moosehead's lakeshed lies within the city limits of Moose lake Minnesota and 7% of the lakeshed land area is forested. Almost half of the Moosehead Lakeshed (49%) is protected, which includes public ownership, wetlands and open water. A third (32%) of the lakeshed is disturbed, which includes developed and highly developed land (Figure 13). DNR Fisheries estimates that over 25% disturbance in a lakeshed can affect water quality, and Moosehead Lake is over that threshold.

Moosehead Lake is one of several connected lakes joined via the Moose Horn River. The total watershed area for Hanging Horn Lake is very large (Table 11), therefore disturbances beyond the immediate lakeshed can adversely impact Moosehead's water quality.

**Phosphorus Loading and Priority Impacts**
Moosehead Lake is at a disadvantage because it has a very large watershed (Table 11). Upstream land use in the watershed is likely the main impact to the lake's water quality.

With the Moose Horn River flowing through the lake, it likely has a short residence time, which means that many of the nutrients flowing into the lake also flush out.

*Table 11. Watershed characteristics.*

| | |
|---|---|
| **Lakeshed to Lake Area Ratio** (lakeshed includes lake area) | 3:1 |
| **Watershed to Lake Area Ratio** (watershed includes lake areas) | 255:1 |
| **Number of Upstream Lakes** | 7 |
| **Headwaters Lake?** | No |
| **Inlets / Outlets** | 3 / 1 |
| **Water Residence Time** | NA |

In addition to a large watershed, the city of Moose Lake is adjacent to Moosehead Lake. Heavy development and impervious surface change the drainage around the lake to allow more direct runoff. Although the impervious surface area can't be removed in most cases, the storm water can be captured and mitigated. See Table 12 on the next page for specific project ideas.

**Best Management Practices Recommendations**
The management focus for Moosehead Lake should be to protect the current water quality and restore the lakeshed. Efforts should be focused on managing and/or decreasing the impact caused by current and additional development, including second tier development, and impervious surface area. Project ideas include protecting land with conservation easements, enforcing county shoreline ordinances, shoreline restoration, rain gardens, and septic system maintenance.

## Moosehead Lake Goals

1. Protection Focus: minimize disturbed land uses and maintain protected lands
2. Manage phosphorus loading from the **watershed** and **lakeshed**, Table 12
3. Focused BMPs per land type: Table 12

*Table 12. Best Management Practices Table specific to Moosehead Lake (refer to Figure 13)*

| Category | Land use type | Conservation project ideas | Results | Who | Contact for help |
|---|---|---|---|---|---|
| Conservation Potential Land | private forests (7%, 66.2 acres) | Forest stewardship planning, 3rd party certification, SFIA, local woodland cooperatives. | Conserve and protect current forest cover. | • Individual Property Owners | Carlton SWCD (218) 384-3891 https://carltonswcd.org |
| | pasture/hay (9%, 104.0 acres) | Conservation Reserve Program (CRP), maintain vegetative cover, plant trees, conservation easements, grassed waterways, ditch buffers, maintain/restore wetlands. | Reduce water runoff and soil erosion, better water storage. | • Individual Property Owners | Natural Resources Conservation Service 218-720-5209 |
| Disturbed Land | developed, low intensity (23%, 217.5 acres) | Shoreline buffers, rain gardens. | Reduce water runoff and shoreline erosion in lakes and streams. | • Individual Property Owners<br>• Lake Associations | Carlton SWCD (218) 384-3891 https://carltonswcd.org |
| | Developed, high intensity (8%, 75.6 acres) | Sediment basins, rain gardens, shoreline buffers, stormwater retention. | Reduce water runoff into streams and lakes. | • Individual Property Owners<br>• Cities<br>• Lake Associations | Carlton SWCD (218) 384-3891 https://carltonswcd.org |
| | cultivated crops (1%, 9.5 acres) | Restore wetlands; Conservation Reserve Program (CRP), Cover Crops. | Reduce water runoff and soil erosion, better water storage. | • Individual Property Owners | Natural Resources Conservation Service 218-720-5209 |

The current lakeshore homeowners can lessen their negative impact on water quality by installing or maintaining the existing trees on their properties. Forested uplands contribute significantly less phosphorus (lbs/acre/year) than developed land cover (Table 10).

Some of the lakeshed (7%) is privately owned forested uplands (Figure 13). Forested uplands can be managed with Forest Stewardship Planning, 3rd party certification, SFIA, and local woodland cooperatives. Contact the Soil and Watershed Conservation District for options for managing private forests.

The lakeshed still has large undeveloped shoreline parcels (Figure 13). Because a lot of undeveloped private land still exists, there is a great potential for protecting this land with conservation easements and aquatic management areas (AMAs). Conservation easements can be set up easily and with little cost with help from organizations such as the Board of Soil and Water Resources and the Minnesota Land Trust. AMAs can be set up through the local DNR fisheries office.

Native aquatic plants stabilize the lake's sediments and tie up phosphorus in their tissues. When aquatic plants are uprooted from a shallow lake, the lake bottom is disturbed, and the phosphorus in the water column gets used by algae instead of plants. This contributes to "greener" water and more algae blooms. Protecting native aquatic plant beds will ensure a healthy lake and healthy fishery. If a swimming area is necessary in front of people's docks, clear only a small area of plants. Clearing a whole 100 foot frontage is not necessary and can contribute to additional algae blooms.

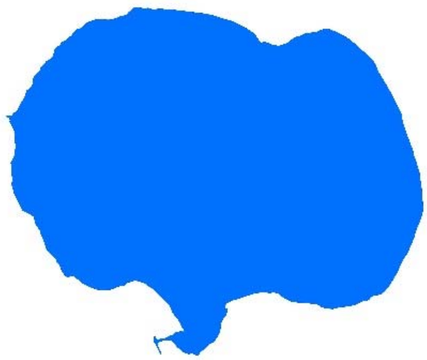
*Table 13. Organizational contacts and reference sites*

## Organizational contacts and reference sites

| | |
|---|---|
| Moosehead Lake Association | No contact info. |
| DNR Fisheries Office | 5351 North Shore Drive, Duluth, MN 55804<br>218-302-3264, duluth.fisheries@state.mn.us |
| Regional Minnesota Pollution Control Agency Office | 525 Lake Avenue South, Suite 400, Duluth, MN 55802<br>218-723-4660<br>https://www.pca.state.mn.us/about-mpca/duluth-office |
| Carlton County Soil and Water Conservation District | 808 3rd St, Carlton, MN 55718<br>(218) 384-3891, https://carltonswcd.org/ |
| Carlton County | 301 Walnut Ave, Carlton, MN 55718<br>http://carltoncountymn.govoffice3.com/ |

# Park Lake

## 09-0029-00 Carlton County



Park Lake is located 3.4 miles Northwest of Mahtowa, MN in Carlton County. It is a round lake covering 381.28 acres (Table 1).

Park Lake has no inlets and one outlet, which classifies it as a groundwater drainage lake. Because it has an outlet, Park Lake isn't subject to the water level problems that other groundwater lakes experience.

Water quality data have been collected on Park Lake from 1985-2016 (Tables 2 & 3). These data show that the lake is mesotrophic (TSI = 43) with moderately clear water conditions most of the summer and excellent recreational opportunities.

Table 1. Park Lake location and key physical characteristics.

| Location Data | |
|---|---|
| MN Lake ID: | **09-0029-00** |
| County: | **Carlton** |
| Ecoregion: | **Northern Lakes and Forests** |
| Major Watershed: | **Kettle River** |
| Latitude/Longitude: | **46.618554, -92.652941** |
| Invasive Species: | **None as of 2018** |

| Physical Characteristics | |
|---|---|
| Surface area (acres): | **381.28** |
| Littoral area (acres): | **375.8** |
| % Littoral area: | **98.6 %** |
| Max depth (ft), (m): | **16** |
| Inlets: | **0** |
| Outlets: | **1** |
| Public Accesses: | **1** |

Table 2. Availability of primary data types for Park Lake.

| Data Availability | | |
|---|---|---|
| Transparency data | | **Good** |
| Chemical data | | **Good** |
| Inlet/Outlet data | -- | **Not necessary** |
| Recommendations | | **For recommendations refer to page 15.** |

## Lake Map

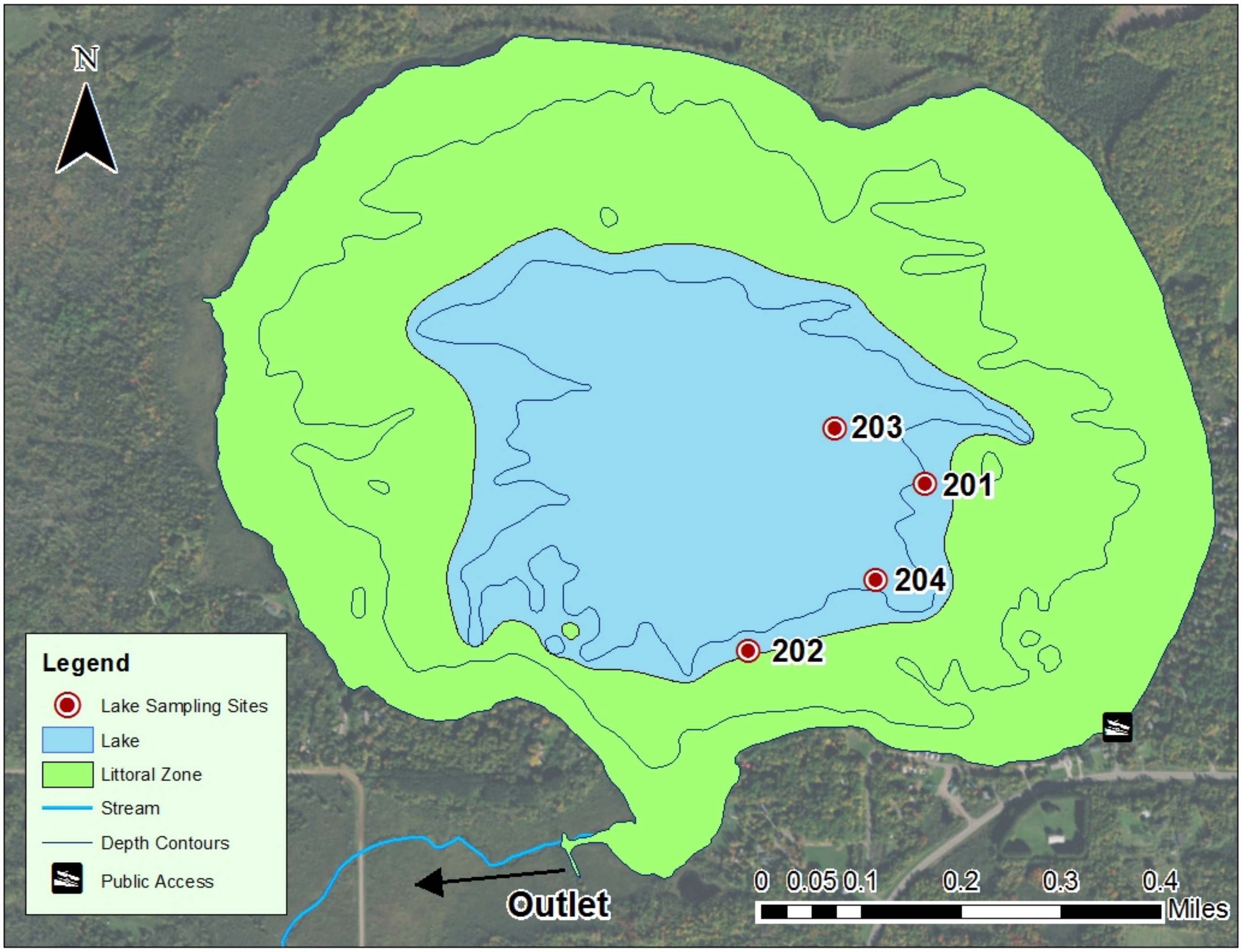



*Figure 1. Map of Park Lake with 2010 aerial imagery and illustrations of lake depth contour lines, sample site locations, inlets and outlets, and public access points. The light green areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom, allowing aquatic plants to grow.*

*Table 3. Monitoring programs and associated monitoring sites. Monitoring programs include the Citizen Lake Monitoring Program (CLMP), Clean Water Legacy Surface Water Monitoring (CWLSWM), Carlton Soil and Water Conservation District (SWCD), Minnesota Pollution Control Agency (MPCA).*

| Lake Site | Depth (ft) | Monitoring Programs |
|---|---|---|
| 203 | 10 | CLMP: 1985-2008; CWLSWM: 2016; SWCD: 2009-2010; MPCA: 1982 |
| 204 | 14 | CLMP: 2011-2014 |
| 201 | 10 | CLMP: 1974-1975 |
| 202 | 10 | CLMP: 1984 |

## Average Water Quality Statistics & Comparisons

The information below describes available chemical data for Park Lake through 2017 (Table 4). Data for total phosphorus, chlorophyll *a*, and Secchi depth are from the primary site 203.

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation and geology. The Minnesota Pollution Control Agency (MPCA) has developed a way to determine the "average range" of water quality expected for lakes in each ecoregion[1] (Table 4). Park Lake is in the Northern Lakes and Forests Ecoregion (Figure 2).

The MPCA has developed Impaired Waters Standards for lakes in each ecoregion to determine if a lake is impaired for excess phosphorus/eutrophication (Table 4). Lakes that are over the impaired waters standards are placed on the state's Impaired Waters List[2].


*Figure 2. Minnesota ecoregions.*

*Table 4. Water quality means compared to ecoregion ranges and impaired waters standard.*

| Parameter | Mean | Ecoregion Range[1] | Impaired Waters Standard[2] | Interpretation |
|---|---|---|---|---|
| Total phosphorus (ug/L) | 16.1 | 14 – 27 | > 30 | Results are within the expected range for the Northern Lakes and Forests Ecoregion and the lake is not impaired for excess phosphorus. |
| [3]Chlorophyll *a* (ug/L) | 3.8 | 4 – 10 | > 9 | |
| Chlorophyll *a* max (ug/L) | 7.0 | < 15 | | |
| Secchi depth (ft) | 10.0 | 8 – 15 | < 6.5 | |
| Dissolved oxygen | *See page 8* | | | Dissolved oxygen depth profiles show that the lake mixes periodically in summer. |
| Total Kjeldahl Nitrogen (mg/L) | 0.53 | <0.4 – 0.75 | | Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms. |
| Alkalinity (mg/L) | 37 | 40 – 140 | | Indicates some sensitivity to acid rain and soft water. |
| Color (Pt-Co Units) | 45 | 10 – 35 | | Indicates some tannins (brown stain). |
| pH | 8.3 | 7.2 – 8.3 | | Within the expected range for the ecoregion. Lake water pH less than 6.5 can affect fish spawning and the solubility of metals in the water. |
| Chloride (mg/L) | 2.9 | 0.6 – 1.2 | | Slightly above the expected range for the ecoregion, but still considered low level. |
| Total Suspended Solids (mg/L) | 1.7 | <1 – 2 | | Indicates low suspended solids and clear water. |
| Specific Conductance (umhos/cm) | 89.7 | 50 – 250 | | Within the expected range for the ecoregion. |
| TN:TP Ratio | 30:1 | 25:1 - 35:1 | | Within the expected range for the ecoregion, and shows the lake is phosphorus limited. |

[1]The ecoregion range is the 25th-75th percentile of summer means from ecoregion reference lakes: https://www.pca.state.mn.us/quick-links/eda-guide-typical-minnesota-water-quality-conditions
[2]For further information regarding the Impaired Waters Assessment program, refer to http://www.pca.state.mn.us/water/tmdl/index.html
[3]Chlorophyll *a* measurements have been corrected for pheophytin
Units: 1 mg/L (ppm) = 1,000 ug/L (ppb)

## Water Quality Characteristics - Historical Means and Ranges

*Table 5. Water quality means and ranges for primary sites.*

| Parameters | Primary Site 203 | Site 201 | Site 202 | Site 204 |
|---|---|---|---|---|
| **Total Phosphorus Mean (ug/L):** | 16.1 | - | - | - |
| Total Phosphorus Min: | 10.0 | | | |
| Total Phosphorus Max: | 24.0 | | | |
| Number of Observations: | 18 | | | |
| **Chlorophyll *a* Mean (ug/L):** | 3.8 | - | - | - |
| Chlorophyll-a Min: | 2.0 | | | |
| Chlorophyll-a Max: | 7.0 | | | |
| Number of Observations: | 18 | | | |
| **Secchi Depth Mean (ft):** | 10.0 | 8.2 | 7.0 | 11.3 |
| Secchi Depth Min: | 17.0 | 7.5 | 6.0 | 6.9 |
| Secchi Depth Max: | 5.5 | 9.5 | 8.0 | 15.4 |
| Number of Observations: | 284 | 15 | 4 | 37 |

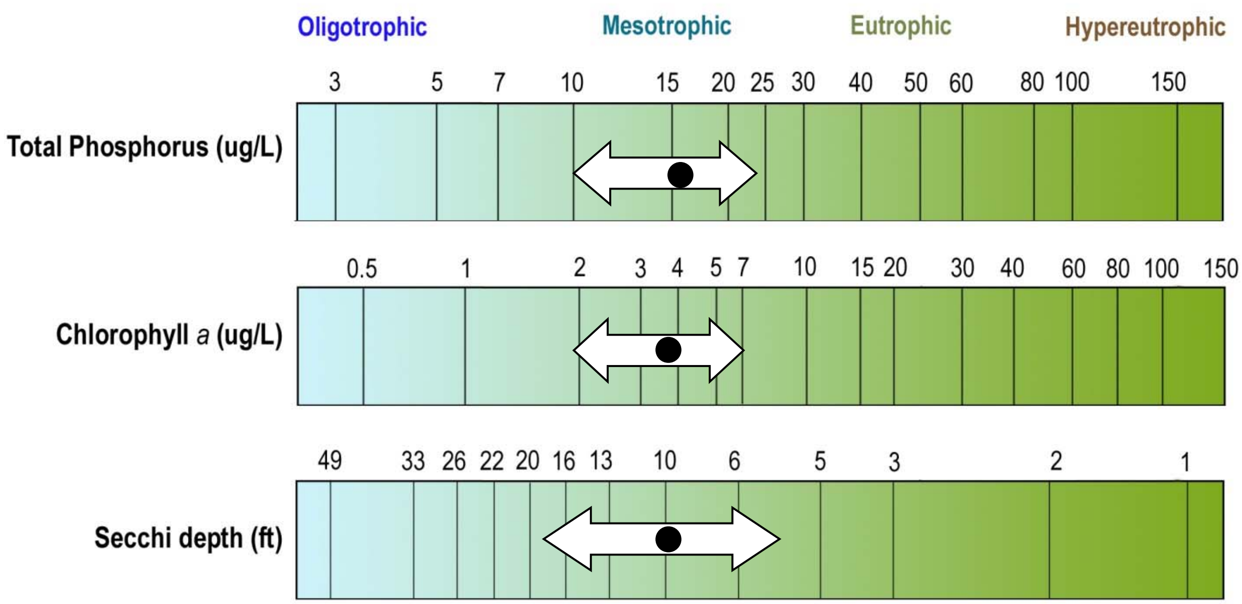



*Figure 3. Park Lake total phosphorus, chlorophyll a and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 203). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. EPA 440/5-88-002)*

## Transparency (Secchi Depth)

Transparency is how easily light can pass through a substance. In lakes it is how deep sunlight penetrates through the water. Plants and algae need sunlight to grow, so they are only able to grow in areas of lakes where the sun penetrates. Water transparency depends on the number of particles in the water. An increase in particulates results in a decrease in transparency. The transparency varies year to year due to changes in weather, precipitation, lake use, flooding, temperature, lake levels, etc.

The annual mean transparency in Park Lake ranges from 8.0 to 12.0 feet (Figure 4). The annual means hover fairly close to the long-term mean. For trend analysis, see page 10. Transparency monitoring should be continued annually at site 203 to track water quality changes.

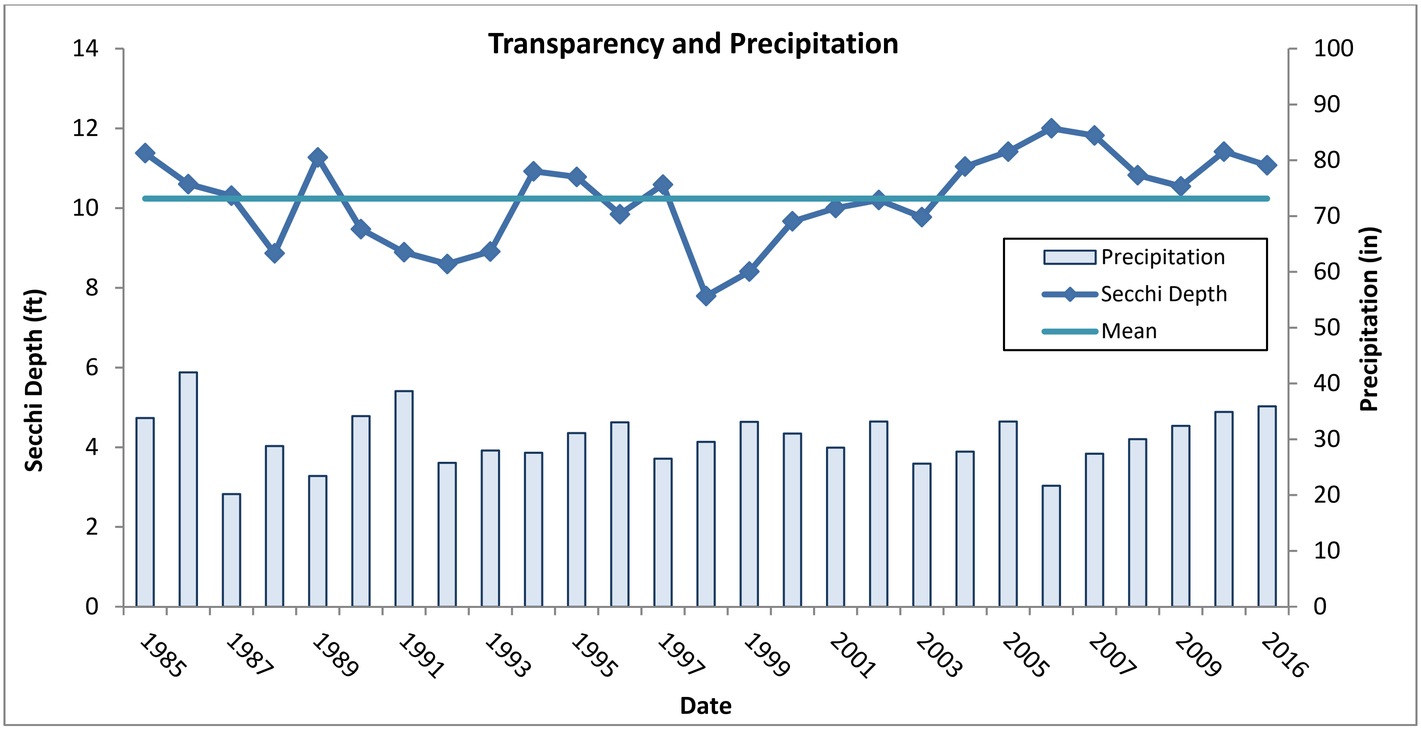



*Figure 4. Annual mean transparency compared to long-term mean transparency*

Park Lake transparency ranges from 5.5 to 17.0 ft at the primary site (203). Figure 5 shows the seasonal transparency dynamics. The maximum Secchi reading is usually obtained in early summer. Park Lake transparency is high in May. It then declines through June, July, and August. The transparency then rebounds in September and October after fall turnover. This transparency dynamic is typical of a Minnesota lake. The dynamics have to do with algae and zooplankton population dynamics, and lake turnover.

It is important for lake residents to understand the seasonal transparency dynamics in their lake so that they are not worried about why their transparency is lower in August than it is in June. It is typical for a lake to vary in transparency throughout the summer.

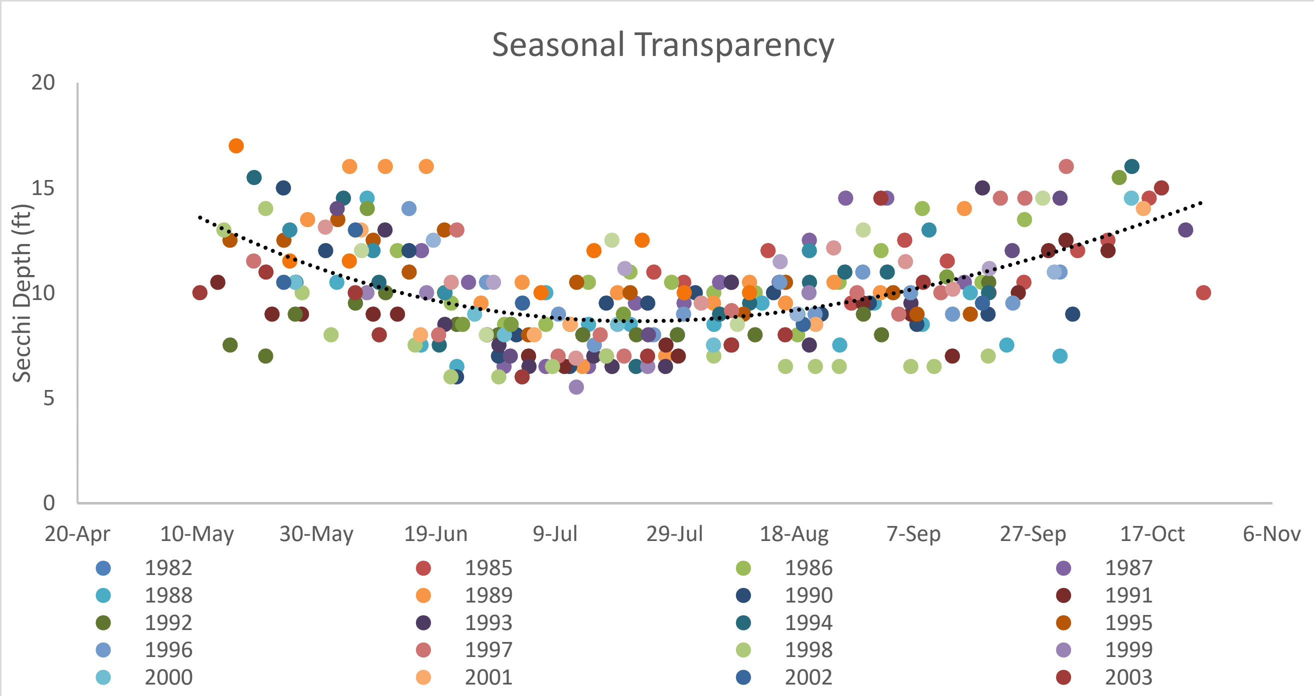



*Figure 5. Seasonal transparency dynamics and year to year comparison (Primary Site 203). The black line represents the pattern in the data.*

## User Perceptions

When volunteers collect Secchi depth readings, they record their perceptions of the water based on the physical appearance and the recreational suitability. These perceptions can be compared to water quality parameters to see how the lake "user" would experience the lake at that time. Looking at transparency data, as the Secchi depth decreases the perception of the lake's physical appearance and recreational suitability decreases (Figures 6-7).

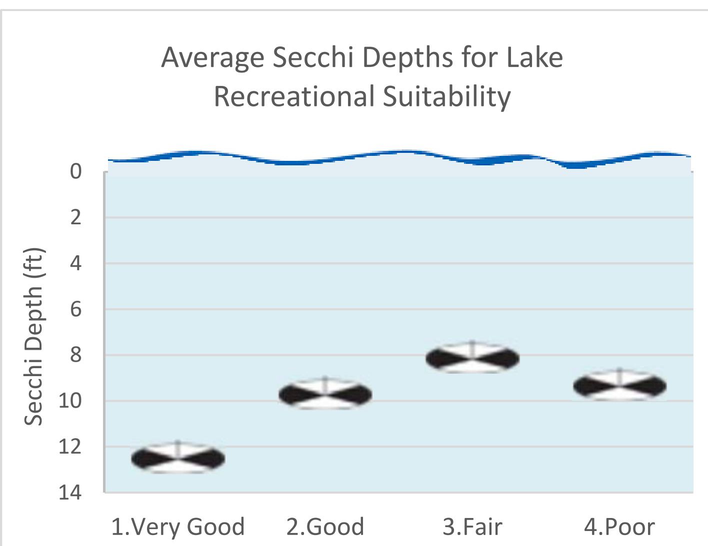



*Figure 6. Average Secchi depth (ft) for each lake recreational suitability rating.*

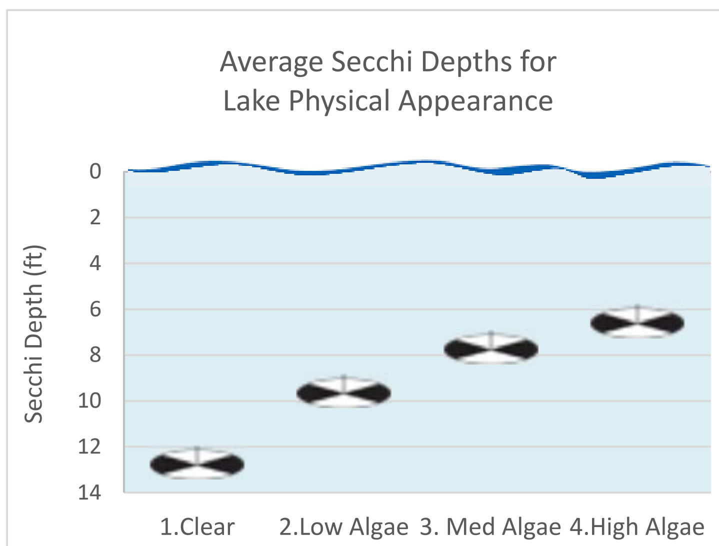



*Figure 7. Average Secchi depth for each lake physical appearance rating.*

## Algae

Chlorophyll *a* is the pigment that makes plants and algae green. Chlorophyll *a* is tested in lakes to determine the algae concentration or how "green" the water is.

Chlorophyll *a* concentrations greater than 10 ug/L are perceived as a mild algae bloom, while concentrations greater than 20 ug/L are perceived as a nuisance.

Chlorophyll *a* has been consistently low in Park lake throughout the four years of monitoring. (Figure 8).

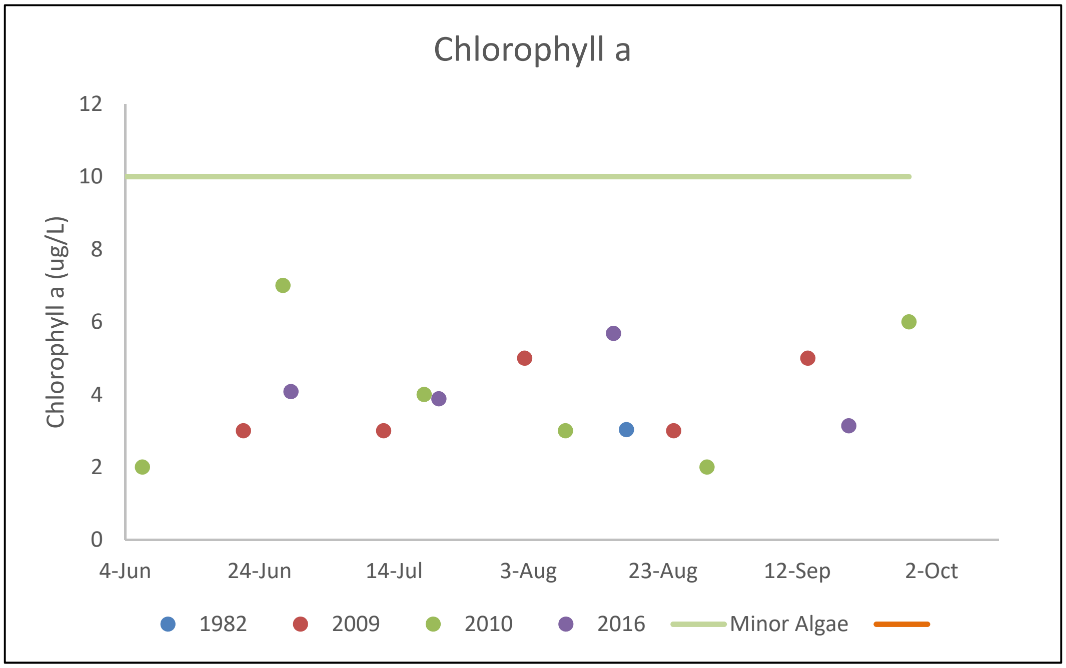



*Figure 6. Chlorophyll a concentrations (ug/L) for Park Lake at site 203.*

Chlorophyll *a* concentrations did not exceed 10 ug/L, indicating clear water for most of the summer. There was not much variation over the years monitored and chlorophyll *a* concentrations remained relatively steady over the summer.

## Phosphorus

Park Lake is phosphorus limited, which means that algae and aquatic plant growth is dependent upon available phosphorus.

Total phosphorus was evaluated in Park Lake in 2009-2010, 2016. The data do not indicate much seasonal variability. All the data points fall into the mesotrophic range (Figure 9).

Phosphorus should continue to be monitored to track any future changes in water quality.

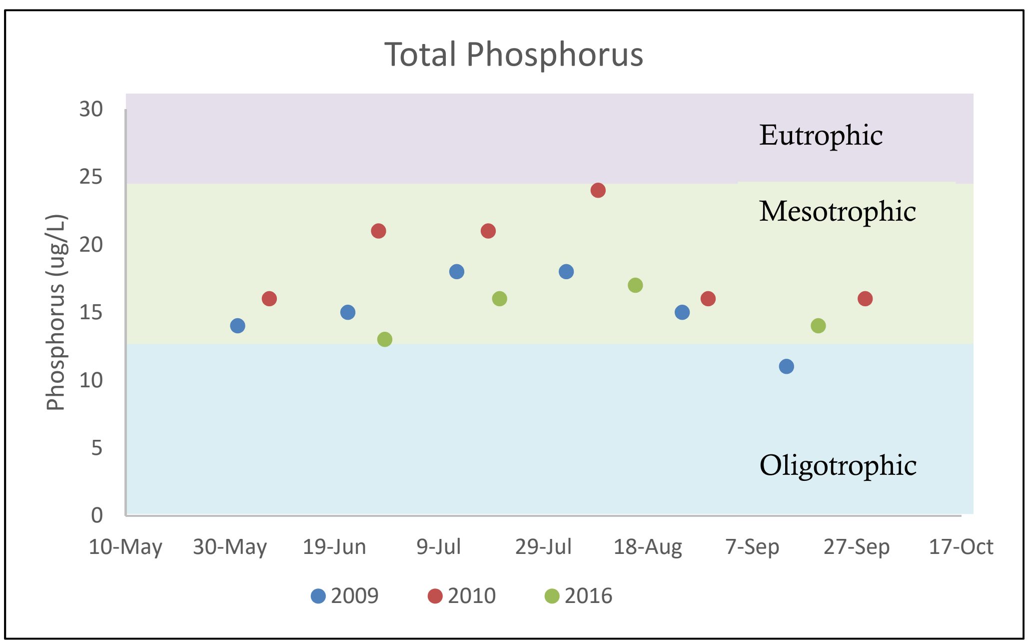



*Figure 7. Historical total phosphorus concentrations (ug/L) for Park Lake site 203.*

## Oxygen

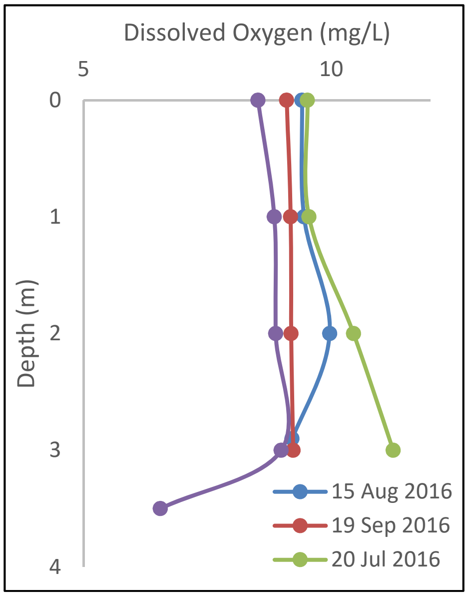



*Figure 8. Representative dissolved oxygen profiles from 2016 in Park Lake.*

Dissolved Oxygen (DO) is the amount of oxygen dissolved in lake water. Oxygen is necessary for all living organisms to survive except for some bacteria. Living organisms breathe in oxygen that is dissolved in the water. Dissolved oxygen levels of <5 mg/L are typically avoided by game fisheries.

Park Lake is a shallow lake, with a maximum depth of 16 feet. Dissolved oxygen profiles from data collected in 2016 at site 203 show the lake mixes throughout the summer (Figure 10). In a shallow lake, the water column never completely stratifies. Any windy day can mix up the water column causing phosphorus from the anoxic lake bottom to re-suspend into the water. This phenomenon is known as internal loading.

## Trophic State Index (TSI)

TSI is a standard measure or means for calculating the trophic status or productivity of a lake. More specifically, it is the total weight of living algae (algae biomass) in a waterbody at a specific location and time. Three variables, chlorophyll a, Secchi depth, and total phosphorus, independently estimate algal biomass.

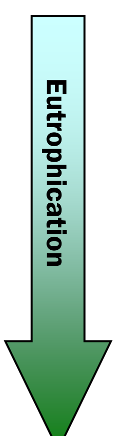
If all three TSI numbers are within a few points of each other, they are strongly related. If they are different, there are other dynamics influencing the lake's productivity, and TSI mean should not be reported for the lake. Park Lake falls into the mesotrophic range (Tables 6, 7).

*Table 6. Trophic State Index for Park Lake.*

| **Trophic State Index** | |
|---|---|
| **TSI Phosphorus** | 44 |
| **TSI Chlorophyll-a** | 44 |
| **TSI Secchi** | 42 |
| **TSI Mean** | 43 |
| **Trophic State:** | Mesotrophic |

*Numbers represent the mean TSI for each parameter.*

*Table 7. Trophic state index attributes and their corresponding fisheries and recreation characteristics.*




**Park Lake**

| TSI | Attributes | Fisheries & Recreation |
|---|---|---|
| <30 | **Oligotrophy:** Clear water, oxygen throughout the year at the bottom of the lake, deep cold water. | Trout fisheries dominate. |
| 30-40 | Bottom may become anoxic (no oxygen). | Trout fisheries in deep lakes only. Walleye, Cisco present. |
| 40-50 | **Mesotrophy:** Water moderately clear most of the summer. May be "greener" in late summer. | No oxygen at the bottom of the lake results in loss of trout. Walleye may predominate. |
| 50-60 | **Eutrophy:** Algae and aquatic plant problems possible. "Green" water most of the year. | Warm-water fisheries only. Bass may dominate. |
| 60-70 | Blue-green algae dominate, algal scums and aquatic plant problems. | Dense algae and aquatic plants. Low water clarity may discourage swimming and boating. |
| 70-80 | **Hypereutrophy:** Dense algae and aquatic plants. | Water is not suitable for recreation. |
| >80 | Algal scums, few aquatic plants. | Rough fish (carp) dominate; summer fish kills possible. |

Source: Carlson, R.E. 1997. A trophic state index for lakes. *Limnology and Oceanography*. 22:361-369.

## Trend Analysis

For detecting trends, a minimum of 8-10 years of data with 4 or more readings per season are recommended. Minimum confidence accepted by the MPCA is 90%. This means that there is a 90% chance that the data are showing a true trend and a 10% chance that the trend is a random result of the data. Only short-term trends can be determined with just a few years of data, because there can be different wet years and dry years, water levels, weather, etc, that affect the water quality naturally.

Park Lake had enough data to perform a trend analysis on transparency (Table 8). The data was analyzed using the Mann Kendall Trend Analysis.

*Table 8. Trend analysis for Park Lake.*

| Lake Site | Parameter | Date Range | Trend |
|---|---|---|---|
| 203 | Total Phosphorus | 2009-2010, 2016 | Insufficient Data |
| 203 | Chlorophyll *a* | 2009-2010, 2016 | Insufficient Data |
| 203 | Transparency | 1985-2010 | No Trend |

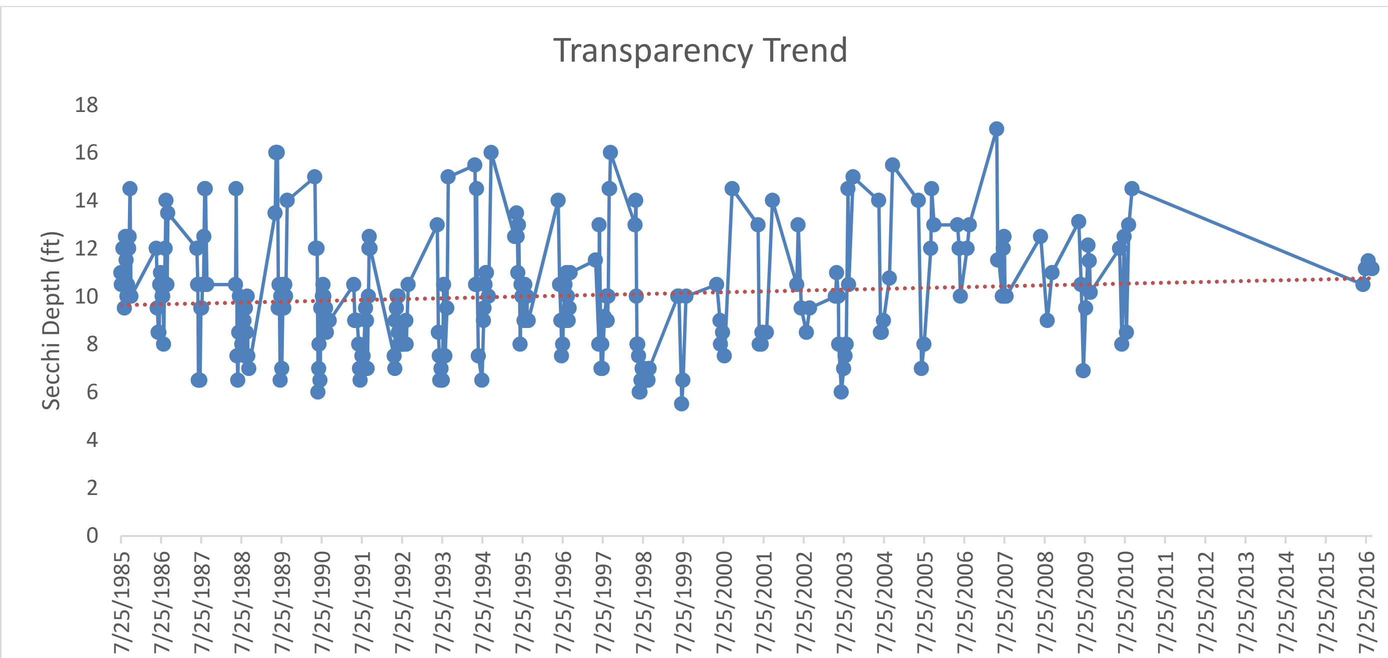



*Figure 9. Transparency (feet) for site 203 from 1985-2010, 2016.*

Park Lake shows insufficient evidence of a transparency trend through 2010 (Figure 11). There was a gap in monitoring from 2010 to 2016. Transparency monitoring should continue so that this trend can be tracked in future years.

## Lakeshed

Understanding a lakeshed requires an understanding of basic hydrology. A watershed is defined as all land and water surface area that contribute excess water to a defined point. The MN DNR has delineated three basic scales of watersheds (from large to small): 1) basins, 2) major watersheds, and 3) minor watersheds.

The Kettle River Major Watershed is one of the watersheds that make up the St. Croix River Basin, which drains south to the Gulf of Mexico (Figure 14).

The MN DNR also has evaluated catchments for individual lakes with greater than 100 acres surface area. These lakesheds (catchments) are the "building blocks" for the larger scale watersheds. Park Lake falls within lakeshed 3501201 (Figure 12). Though very useful for displaying the land and water that contribute directly to a lake, lakesheds are not always true watersheds because they may not show the water flowing into a lake from upstream streams or rivers. While some lakes may have only one or two upstream lakesheds draining into them, others may be connected to a large number of lakesheds, reflecting a larger drainage area via stream or river networks.

In an effort to prioritize protection and restoration efforts of fishery lakes, the MN DNR has developed a ranking system by separating lakes into two categories based on their lakeshed, those needing protection and those needing restoration. Modeling by the DNR Fisheries Research Unit suggests that total phosphorus concentrations increase significantly over natural concentrations in lakes that have watershed with disturbance greater than 25%. Therefore, lakes with watersheds that have less than 25% disturbance need protection and lakes with more than 25% disturbance need restoration (Table 9). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land, public water, wetlands, or conservation easement.

*Table 9. Suggested approaches for watershed protection and restoration of DNR-managed fish lakes in Minnesota.*

| Watershed Disturbance (%) | Watershed Protected (%) | Management Type | Comments |
|---|---|---|---|
| < 25% | > 75% | Vigilance | Sufficiently protected -- Water quality supports healthy and diverse native fish communities. Keep public lands protected. |
| | < 75% | Protection | Excellent candidates for protection -- Water quality can be maintained in a range that supports healthy and diverse native fish communities. Disturbed lands should be limited to less than 25%. |
| 25-60% | n/a | Full Restoration | Realistic chance for full restoration of water quality and improve quality of fish communities. Disturbed land percentage should be reduced and BMPs implemented. |
| > 60% | n/a | Partial Restoration | Restoration will be very expensive and probably will not achieve water quality conditions necessary to sustain healthy fish communities. Restoration opportunities must be critically evaluated to assure feasible positive outcomes. |

The next step was to prioritize lakes within each of these management categories. DNR Fisheries identified high value fishery lakes, such as cisco refuge lakes. Ciscos (*Coregonus artedi)* can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. These watersheds with low disturbance and high value fishery lakes are excellent candidates for priority protection measures, especially those that are related to forestry and minimizing the effects of landscape disturbance. Forest stewardship planning, harvest coordination to reduce hydrology impacts and forest conservation easements are some potential tools that can protect these high value resources for the long term.

Park Lake's lakeshed is classified with having 68% of the watershed protected and 3% of the watershed disturbed (Figure 13). Therefore, this lakeshed should have a protection focus. Goals for the lake should be to limit any increase in disturbed land use. Park Lake is a headwaters lakeshed, which means that no other lakesheds flow into it (Figure 12).

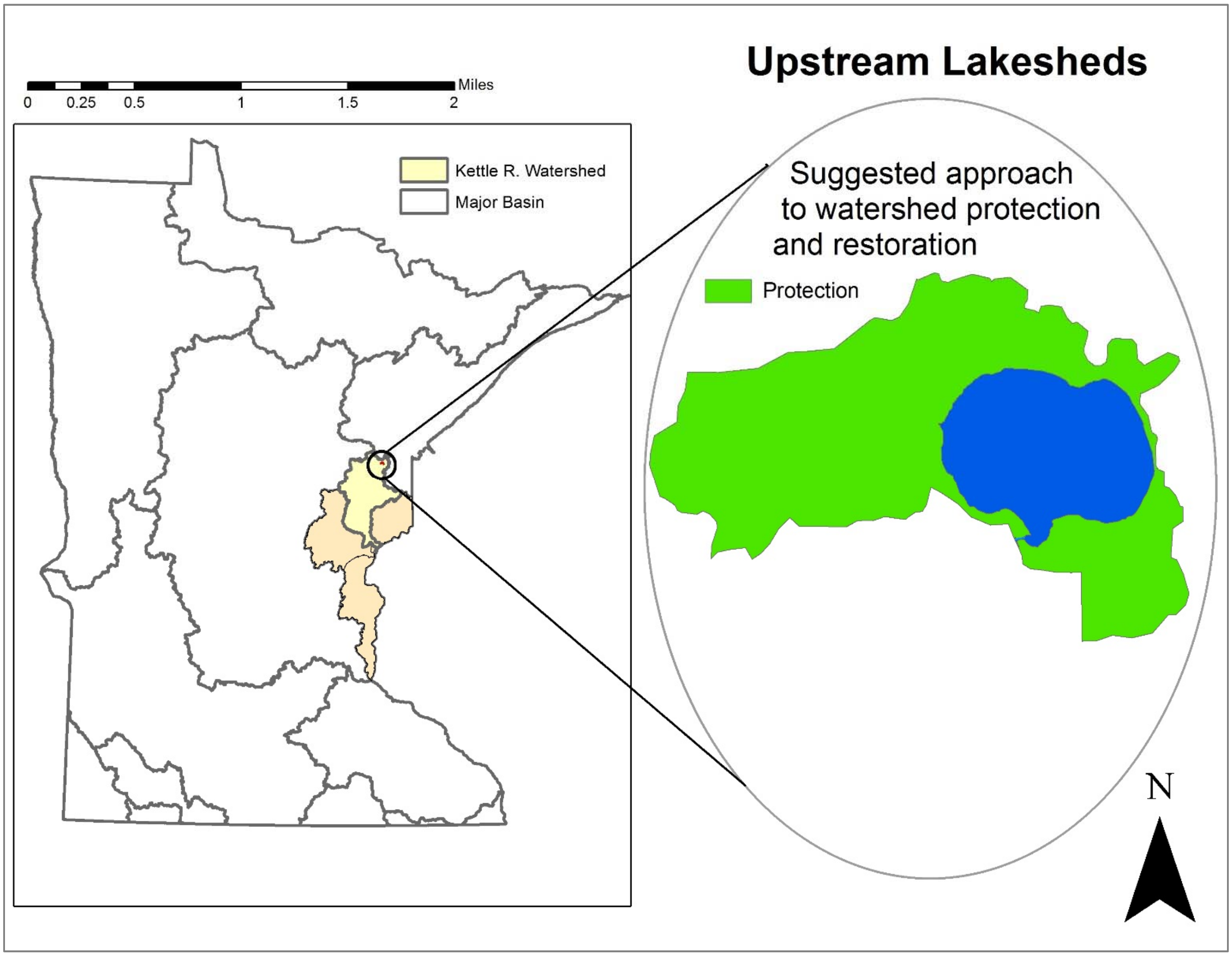
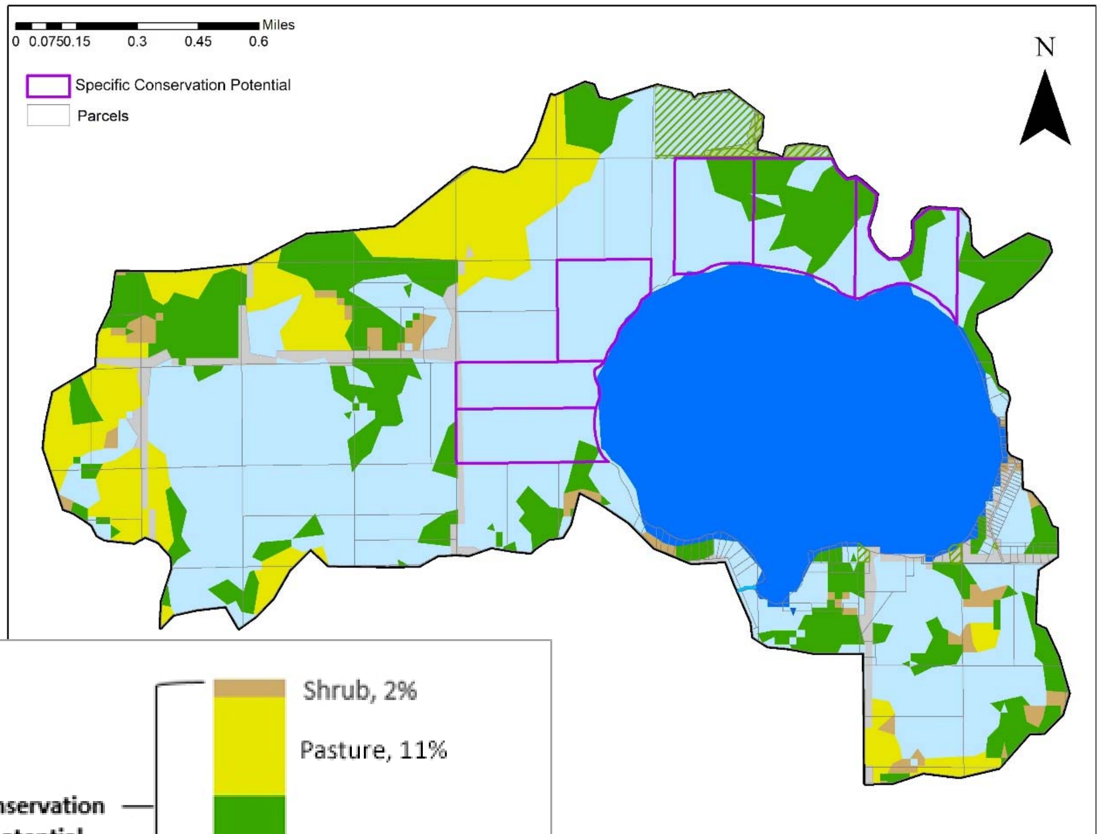



*Figure 10. Kettle River major watershed and MN basins (left), and Park Lake lakeshed and upstream catchments with protection suggestions (right).*

## Land use and Ownership

Activities that occur on the land within the lakeshed can greatly impact a lake. Land use planning helps ensure the use of land resources in an organized fashion so that the needs of the present and future generations can be best addressed.

More than half (68%) of the Park Lake lakeshed is protected. This total includes water, wetlands, and publicly owned land. There are six parcels along the lakeshore which have conservation potential. They are privately-owned parcels with over 20 acres that are less than 50% developed or agriculture.



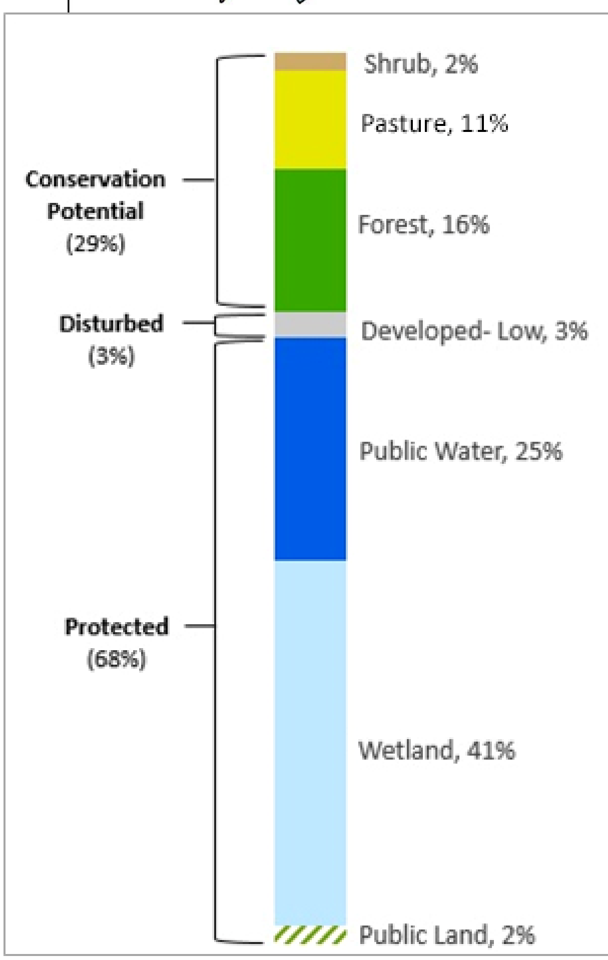




*Figure 11. Land use and ownership in the Park Lake lakeshed.*

The lakeshed vitals table identifies where to focus organizational and management efforts for each lake (Table 10). Criteria were developed using limnological concepts to determine the effect to lake water quality.

**KEY**

● Possibly detrimental to the lake
◐ Warrants attention
○ Beneficial to the lake

*Table 10. Park Lake lakeshed vitals table.*

| Lakeshed Vitals | | Rating |
|---|---|---|
| **Lake Area** | 381.28 acres | descriptive |
| **Littoral Zone Area** | 375.8 acres | descriptive |
| **Lake Max Depth** | 16 ft. | descriptive |
| **Lake Mean Depth** | 5 ft. | ◐ |
| **Water Residence Time** | N/A | Not Available |
| **Miles of Stream** | 0.05 | descriptive |
| **Inlets** | 0 | ○ |
| **Outlets** | 1 | ○ |
| **Major Watershed** | 35- Kettle River | descriptive |
| **Minor Watershed** | 35012 | descriptive |
| **Lakeshed** | 3501201 | descriptive |
| **Ecoregion** | Northern Lakes and Forest | descriptive |
| **Total Lakeshed to Lake Area Ratio** (total lakeshed includes lake area) | 4:1 | ◐ |
| **Standard Watershed to Lake Basin Ratio** (standard watershed includes lake areas) | 4:1 | ○ |
| **Wetland Coverage** | 41% | ○ |
| **Aquatic Invasive Species** | None | ○ |
| **Public Drainage Ditches** | None | ○ |
| **Public Lake Accesses** | 1 | ◐ |
| **Miles of Shoreline** | 3.4 | descriptive |
| **Shoreline Development Index** | 1.2 | ○ |
| **Public Land to Private Land Ratio** | 0:1 | ◐ |
| **Development Classification** | Recreational Development | ◐ |
| **Miles of Road** | 3.2 | descriptive |
| **Municipalities in lakeshed** | None | ○ |
| **Forestry Practices** | None | ○ |
| **Feedlots** | 1 | ● |
| **Sewage Management** | Compliance inspections are required for subsurface sewage treatment systems at point-of-sale or permit application in shoreland areas. | ◐ |
| **Lake Management Plan** | None | ◐ |
| **Lake Vegetation Survey/Plan** | DNR 1997, 2016 | ○ |

## Park Lake, Status of the Fishery (DNR, 9/10/2012)

Park Lake is a 376 acre lake located near Mahtowa, Minnesota with 100% littoral area and a maximum depth of 16 feet. Park Lake is accessible on the southeastern corner of the lake off county road 7. Park Lake is primarily managed for walleye and largemouth bass. More than 54,000 walleye fingerlings and 1,000 yearlings were stocked between 1990 and 2012. Park was last assessed in 2004. Park was assessed in 2012 to help evaluate the walleye fingerling stocking program as well as update information on other fish populations.

Walleye fingerlings are stocked into Park Lake at a rate of one pound per littoral acre (376 pounds) during even years. Walleye abundance of 0.8 per gillnet lift was down from 2004 (1.1) and below average compared to other Minnesota lakes of similar type. Walleye gillnet CPUE from six investigations since 1979 have ranged from 0.2 to 1.6 per lift. Not enough individuals were sampled to evaluate stock density or growth. All of the walleye sampled (7) were aged to years that walleye were stocked. Despite stocking numerous year-classes since 1990, the success of the biennial fingerling stocking program appears limited.

A total of 47 largemouth bass were sampled by electrofishing. The largemouth bass catch rate of 86.2 fish per hour of electrofishing was up from 2004 (19.6). Largemouth bass average length was 12.9 inches and growth was slow compared to other Duluth Area lakes. All year-classes from 2001 through 2010 were represented except 2008.

Northern pike abundance of 12.7 per gillnet lift was down from 2004 (13.2) and above average compared to other Minnesota lakes of similar type. Average size was 18.9 inches and growth was slow compared to other Duluth Area lakes. All year-classes from 2003 to 2011 were represented, except 2004.

Bluegill abundance of 9.2 per trapnet lift was down slightly from 2004 (9.4) and was average when compared to other Minnesota lakes of similar type. Average length of sampled bluegills was 6.8 inches and growth was slow compared to other Duluth Area lakes. All year-classes from 2003 to 2011 were represented, except 2008.

Black crappie abundance of 1.0 per lift was up slightly from 2004 (0.9) and was average compared to other Minnesota lakes of similar type. Average size was 6.5 inches but not enough individuals were captured to evaluate stock density or growth. All year-classes from 2003 to 2011 were represented, except 2006 and 2008.

Yellow perch abundance of 29.2 per gillnet lift was down from 2006 (120.2) and above average compared to other Minnesota lakes of similar type. Average length was 6.1 inches and growth was average compared other Duluth Area lakes. All year-classes from 2002 through 2008 were represented.

Other fish species sampled include black, brown and yellow bullhead, Iowa darter, Johnny darter, central mudminnow, bluntnose minnow, fathead minnow, rock bass, white sucker, hybrid sunfish and pumpkinseed sunfish.

Park Lake was included in an index of biotic integrity (IBI) assessment in 2012. In addition to standard gillnets and trapnets, beach seines and backpack electrofishing equipment were used to index species richness of the nearshore lake habitat.

See the link below for specific information on gillnet surveys, stocking information, and fish consumption guidelines. http://www.dnr.state.mn.us/lakefind/showreport.html?downum=09029000

## Key Findings and Recommendations

**Monitoring Recommendations**
Transparency monitoring at sites 203 should be continued annually. It is important to continue transparency monitoring weekly or at least bimonthly every year to enable year-to-year comparisons and trend analyses. Phosphorus and chlorophyll a monitoring should continue at site 203, as the budget allows, to track future water quality trends.

**Overall Conclusions**
Park Lake is a mesotrophic lake (TSI = 44) with insufficient evidence of a long-term trend in water clarity. The total phosphorus, chlorophyll *a* and transparency ranges are within the ecoregion ranges (Table 4).

Park's lakeshed lies next to the Kettle Lake State Wildlife Management Area; 16 % of the lakeshed land area is forested and 41% of the lakeshed is wetlands, which is generally good for water quality. Sixty-eight percent (68%) of the lakeshed is lakeshed is protected, while only 3% of the lakeshed is disturbed (Figure 13).

**Phosphorus Loading and Priority Impacts**
Park Lake is at an advantage because the lakeshed is a headwaters catchment, which means no additional water flows into this lakeshed from upstream areas. This means that the land practices around the lake are the main impact to the lake's water quality.

Almost half (40%) of the lakeshed is wetlands, which is good for water storage and water quality. Wetlands function to hold extra water during high water levels and filter water before it flows downstream.

*Table 11. Watershed characteristics.*

| | |
|---|---|
| **Lakeshed to Lake Area Ratio** (lakeshed includes lake area) | 4:1 |
| **Watershed to Lake Area Ratio** (watershed includes lake areas) | 4:1 |
| **Number of Upstream Lakes** | 0 |
| **Headwaters Lake?** | Yes |
| **Inlets / Outlets** | 0 / 1 |
| **Water Residence Time** | N/A |

Development appears to be fairly light around Park Lake, with it mostly being concentrated on the eastern and southern shores. Figure 13 shows the presence of large parcels on the north and western shores that would be good candidates for conservation easements and/or aquatic management areas (AMAs). Conservation easements can be set up easily and with little cost with help from organizations such as the Board of Soil and Water Resources and the Minnesota Land Trust. AMAs can be set up through the local DNR fisheries office.

Park Lake is located a the top of the watershed, which means that the water storage of the wetlands and lack of heavy development benefits downstream water bodies.

**Best Management Practices Recommendations**
The management focus for Park Lake should be to protect the current water quality and the lakeshed. Efforts should be focused on managing and/or decreasing the impact caused by current and additional development, including second tier development, and impervious surface area. Project ideas include protecting land with conservation easements, enforcing county shoreline ordinances, shoreline restoration, rain gardens, and septic system maintenance.

## Park Lake Goals

1. Protection Focus: minimize disturbed land uses and maintain protected lands
2. Manage phosphorus loading from **nearshore**, Table 12
3. Focused BMPs per land type: Table 12

*Table 12. Best Management Practices Table specific to Park Lake (refer to Figure 13)*

| Category | Land use type | Conservation project ideas | Results | Who | Contact for help |
|---|---|---|---|---|---|
| Conservation Potential Land | private forests (16%, 246.6 acres) | Forest stewardship planning, 3rd party certification, SFIA, local woodland cooperatives. | Conserve and protect current forest cover | • Individual Property Owners | Carlton SWCD (218) 384-3891 https://carltonswcd.org |
| | pasture/hay (11%, 169.6 acres) | Conservation Reserve Program (CRP), maintain vegetative cover, plant trees, conservation easements, grassed waterways, ditch buffers, maintain/restore wetlands. | Reduce water runoff and soil erosion, better water storage. | • Individual Property Owners | Natural Resources Conservation Service 218-720-5209 |
| Disturbed Land | developed, low intensity (3%, 46.2 acres) | Shoreline buffers, rain gardens | Reduce water runoff and shoreline erosion in lakes and streams. | • Individual Property Owners | Carlton SWCD (218) 384-3891 https://carltonswcd.org |

The current lakeshore homeowners can lessen their negative impact on water quality by installing or maintaining the existing trees on their properties. Forested uplands contribute significantly less phosphorus (lbs/acre/year) than developed land cover (Table 12).

About 16% of the lakeshed is privately owned forested uplands (Table 12). Forested uplands can be managed with Forest Stewardship Planning, 3rd party certification, SFIA, and local woodland cooperatives. Contact the Soil and Watershed Conservation District for options for managing private forests.

Native aquatic plants stabilize the lake's sediments and tie up phosphorus in their tissues. When aquatic plants are uprooted from a shallow lake, the lake bottom is disturbed, and the phosphorus in the water column gets used by algae instead of plants. This contributes to "greener" water and more algae blooms. Protecting native aquatic plant beds will ensure a healthy lake and healthy fishery. If a swimming area is necessary in front of people's docks, clear only a small area of plants. Clearing a whole 100 foot frontage is not necessary and can contribute to additional algae blooms.

*Table 13. Organizational contacts and reference sites*

| Organizational contacts and reference sites | |
|---|---|
| DNR Fisheries Office | 5351 North Shore Drive, Duluth, MN 55804<br>218-302-3264, duluth.fisheries@state.mn.us |
| Regional Minnesota Pollution Control Agency Office | 525 Lake Avenue South, Suite 400, Duluth, MN 55802<br>218-723-4660<br>https://www.pca.state.mn.us/about-mpca/duluth-office |
| Carlton County Soil and Water Conservation District | 808 3rd St, Carlton, MN 55718<br>(218) 384-3891, https://carltonswcd.org/ |
| Carlton County | 301 Walnut Ave, Carlton, MN 55718<br>http://carltoncountymn.govoffice3.com |

# Keeping our Streams Connected

## Culverts and Stream Health

While driving down the road, it's easy to overlook how many culverts are in our county. Culverts are used not only for stream crossings but also to pass water between wetland areas and ditches. The placement and sizing of culverts can have a big impact on water resources. Culverts that are too small can speed up the flow of water, making it difficult or impossible for fish and bugs to move up or downstream, which can lead to a stream becoming impaired. They also contribute to sediment pollution by causing erosion. That's why the county is working towards replacing old, undersized culverts with fish friendly options.

### Reduced Maintenance Cost

Although a larger culvert has a higher price tag initially, there will be a savings in the long run. The cost of replacing a culvert or lost road bed materials can be very expensive, especially as we are seeing more frequent high rain fall events. We must also consider the impact to local residents and businesses when a road has to be closed until repairs can be completed.

**Improved Safety** - Culverts that fail during storm events present a safety hazard. Drivers may be unaware of a washed out road and many flood deaths occur because people attempt to cross a flooded roadway. When roads are closed due to flood events, it can take much longer for emergency personal to assist with medical and fire emergencies.

**Water Quality** - When culverts fail or streams and rivers wash out a road, several tons of road material are washed down stream. This material not only becomes a major source of sediment throughout the watershed but also covers up stream and wetland plants. Valuable wetlands and wildlife habitat may be lost. Properly sized culverts help us keep the road and road materials where it's supposed to be….on the road!

### *Did You Know?*

This culvert on CSAH 13 has washed out 3 of the last 5 years! After the 2018 flood, the 30" pipe was replaced with a 72" Pipe Arch Culvert with a natural bottom. At the same time, 5 truck loads of road material and gravel were removed from the stream and adjacent wetland. The cost of replacing the undersized culvert with an appropriate sized culvert cost $3800 less than repairing damage from the flood.


808 3rd Street | Carlton MN 55718 | 218-384-3891

## What makes a culvert fish friendly?

Newly sized culvert in Scanlon

A fish friendly culvert is sized to be as wide as the stream during a storm event. This size is known as bank-full width. These culverts tend to be many times wider than the culverts they replace and during "normal" or "low flow" may seem very large indeed! But, sizing in this manner slows the water down and ensures that high flow water, debris and organisms can pass under the road.

*Scanlon public works supervisor holding a rescued trout during construction.*

Bed material in the culvert helps reduce the energy of the water, reduces the wear on the culvert bottom, maintains the culvert elevations, and provides wildlife habitat. In some cases, a flood plain culvert that only flows during very high water may be added, so the stream will have access to the floodplain during a flood event. The bottom line is that a fish friendly culvert will look similar to the stream as it passes under the road.

## *Carlton SWCD and Carlton County Transportation Department Culvert Focused Partnership for Efficiency and Resiliency*

In 2016, Carlton SWCD applied for a grant to fund a culvert inventory. The SWCD was interested in culverts due to the role culverts play in water quality, especially in the more challenging red-clay areas. Past inventories, although useful in many ways, were flawed because they were immediately out of date as soon as they were completed. We wanted an inventory that would stay relevant, but in order to do that, we needed the support and buy-in of the road authority. That is how this partnership was started. The Transportation Department saw the value in an online inventory to help prioritize projects.

In 2017, the Carlton County Transportation Department and Carlton SWCD piloted a culvert inventory on all county maintained roads. The goal of this project was to evaluate the location, condition and biological/water quality impact of every culvert.

In 2018, the inventory was used after a 500 year flood washed away many culverts in the southern portion of the county. Pre-storm measurements were used to replace culverts that better matched the stream where possible. It was noted that culverts sized to the stream survived the flood with little damage and prevented the waters from overtopping the road. This saved money in costly repairs and allowed county residents to continue using the roads after the flood.

*Updated October 2018*

# Conservation Practice Fact Sheet

## Forest Habitat RIM (Reinvest in Minnesota)

**Reinvest In Minnesota (RIM) Program** is a longstanding conservation easement program that has successfully protected fragile farmland and wetland resources in Minnesota. Expansion of the program to include forestland easements will protect rare and fragile wild rice lakes from development. Easements would be offered to landowners of priority parcels selected through a local screening process. A RIM formula using average township land values would be used to calculate payments for landowners.

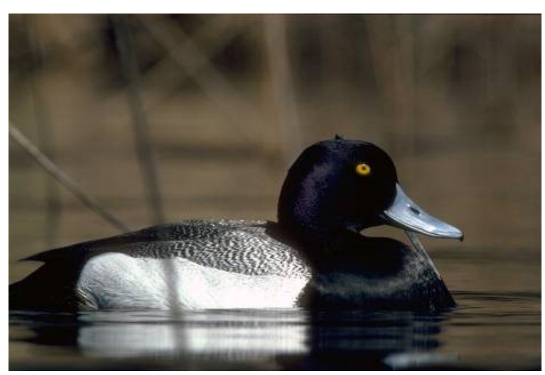
### Benefits

- A plan protects unique riparian forest parcels and waterfowl habitat on rare wild rice lakes.
- Easement purchases permanent protection from subdivision and development rights.
- Land stays on the tax rolls of local government.
- Private easements enhance adjacent public holdings.
- Forest stewardship plans (available through the county SWCD) maintain working forest capacity.

### Protecting Wild Rice Habitat

Northern Minnesota is home to over 100 shallow wild rice lakes that have been identified as priority lakes within the eight county project area. These shallow wild rice lakes are some of the most important and unique wildlife habitats in Minnesota. The RIM Wild Rice Lake Program is funded by the Lessard-Sams Outdoor Heritage Council and includes Aitkin, Carlton, Cass, Crow Wing, Hubbard, Itasca, St. Louis and Wadena counties.

***Did You Know?***
Through the RIM program, the land stays on the tax rolls of the local government and the owner retains access rights.



If you would like additional information on RIM or would like to speak to a conservation specialist contact the Carlton SWCD at 218-384-3891.

808  3rd Street
Carlton MN 55718

Visit us on the web:
http://carltonswcd.org

Find us on Facebook

## Protecting Wild Rice Habitat

Minnesota has more acres of natural wild rice than any other state in the country.  Wild rice is a persistent annual grass that reproduces each year from seed stock deposited in the fall.  The plant typically grows in shallow to moderate water depths (1-3 feet) and is affected by water flow, turbidity, water quality and water level fluctuations.  Wild rice attracts many wild birds especially waterfowl and red-winged blackbirds.  It also provides nesting cover for waterfowl.

The goal of RIM is to protect wild rice habitat by placing a permanent easement on a property which prevents it from being developed.  Less development equals less wild rice disturbance.  The easement allows landowners to continue to actively manage the land and public access is not required.  The easement only restricts division and development of the tract.

## Getting Started

The first step in getting started is to contact the Carlton SWCD  to discuss the goals and objectives for your land.  Call 218-384-3891 to get started today!

***Preventing development and protecting the lakes through a conservation easement will go a long way in maintaining their outstanding resource value well into the future.***

# Stream Restoration Fact Sheet

## What is a Stream Restoration?

Many streams in our county have problems with bank instability. Some have been modified over time by human intervention, either by ditching or the creation of dams. Whatever the reason, these changes often result in water quality or habitat problems in our streams. A stream restoration is sometimes planned to help resolve these water quality problems. In general, the goal of any stream restoration is to return the stream to its natural state, stabilizing it using natural methods. This can be accomplished using several different techniques, and often several methods are used on each project. Some of these methods include:

**Toe Wood**: Logs or root wads are installed into banks to help protect them from erosion. They are often used where streams bend or where undercutting banks make the shore unstable. The wood provides natural habitat for fish and other aquatic species, but also enough strength to hold soil in place. Often, living plants are also installed so that new roots can grow and further protect the shoreline.

**Flood Plain**: Flood plains give stream water a place to go during high flow events. These benches help reduce the speed of the water by spreading it out over a larger area (think about the force of water flowing through a small hose compared to a larger one). They are designed to provide both a low flow channel so that fish have enough water to travel during dryer periods, but also an additional higher elevation channel for the water to spill over during spring run off or big rains.

***Did You Know?*** The Carlton SWCD partners with several agencies and grant funders to complete stream restorations in Carlton County.

808 3rd Street | Carlton MN 55718 | 218-384-3891

**Rock Structures**: Large rocks can be strategically placed in the stream bed to help direct the flow of water away from eroding banks. The size and placement of the rocks is determined by the size of the stream. In smaller streams with lower peak flow events, wood can sometimes be used in place of rock.

**Meanders**: Adding curves to a stream increases the stream length, and this results in a slower flow. It takes more time to move from one place to another if you zig zag than if you follow a straight line. These meanders also often form pools where the streams bend, providing cool places for fish to stay during hot summer days. Slower water has less power, and therefore causes less erosion.

## Why Restoration?

There are many ways streams can be stabilized including the use of riprap or concrete, and these were the "go-to" methods in the past. These more rigid installations seem like they would be stronger and stand the test of time. But streams are dynamic and powerful, and overtime concrete and riprap fail unless they are constantly maintained. A stream restoration is designed to create a stable stream channel that is supported by natural structures and living plants, requiring little to no maintenance once the plants are established. In addition to reducing future maintenance costs, they also provide important habitat to fish and other aquatic organisms. A properly designed and installed stream restoration will have a lower cost over time, while benefiting both water quality and habitat… a win-win for the resource!

***Past Project:*** The Elim Creek Restoration project in the Skunk Creek Watershed, had direct fish habitat impact with over 1/2 mile of stream restored to viable brook trout habitat. The project addressed over 300 tons of existing soil loss and another 950 tons of potential soil loss. That's over 100 - 10 yard dump trucks of soil! MN DNR fisheries will be stocking this stream with brook trout and monitoring establishment efforts. The project was recognized by the Minnesota Erosion Control Association (MECA) for its innovation and water quality results.

*Updated January 2018*

# The Forest - Water Connection

## Healthy Forests Equal Healthy Waters

When we think about protecting water quality by managing land, we often think about the land directly adjacent to a lake or stream. Restoring shorelines, managing run-off, and reducing erosion can all have a great positive impact on water quality. However, land use changes many miles away can play a big role on a lake or stream's health depending on the watershed. Carlton County is in the Northern Lakes and Forests Region, and our waters are the healthiest when our forests are healthy. But what makes a forest healthy?

### **Forest Diversity**:

A healthy forest is a diverse forest. Diverse forests are at a lower risk for disease, invasive species/pest outbreaks, storm damage and are more adaptable to climate change. You've most likely heard the old saying: "don't put all your eggs in one basket"; this saying applies to your forest because diversity allows the forest to naturally cope with a wide variety of challenges.

Diverse and healthy forests are also good for water quality. They reduce run-off by increasing and maintaining healthy canopy cover and soil infiltration. Healthy trees, a variety of shrubs and understory plant cover also provide deep roots that can hold the soil in place. It's like having a giant water treatment system on your land!

Healthy forests also provide habitat for a larger variety of wildlife. Having a nice mix of young, mid, and old forest produces different types of habitat for all sorts of species.

Forest diversity comes not only from a diversity of tree species but also from a diversity of ages. Different aged trees provide layers of cover, food, and habitat for nesting and feeding for: birds, Fishers, Pine Martens and amphibians. Like all living things, trees have a life expectancy and given the passage of time, forests will mature. Thus, without some sort of disturbance forest health and diversity will start to decline.

***Did You Know?***

Cisco tend to be an undervalued, but very important fish for several lakes in Carlton County. This fish is an important food source for walleye, muskies and lake trout but is sensitive to warm waters and run-off. Did you know Hanging Horn Lake in Carlton County consistency has the highest abundance of Cisco in the Duluth area? It is a cold, deep lake, but is at risk of declining water quality because it has a very large contributing watershed. Protecting forests throughout the watershed will

808 3rd Street | Carlton MN 55718 | 218-384-3891

## The Importance of Young Forests:

Many species of birds need young forests during part of their life cycle. Before European Settlement, young forests were created by forest fires (many intentionally set) beaver activity, pest outbreaks, and storms. In modern times, we largely rely on wood harvests to create new young forest habitat. The wood products industry plays an important role in keeping populations of Warblers, Woodcock, and Grouse alive.

## Managing Your Forest

If you own forested land in Carlton County, you are playing an important role in keeping our lakes and streams clean. Managing your forest will help ensure it stays healthy into the future. A Forest Management Plan can help you create the sort of disturbance that would have been common on the landscape prior to settlement.

A Registered Forester can help! Foresters can assist in developing a Forest Management Plan that describes the current status of your forest, along with things that can be done to keep it healthy and provide habitat to different species, but most importantly, they can help put your plan into action! Make sure to discuss implementation with them when they visit your land.

## *What happens when forests are not managed?*

You may have witnessed a forest decline if you've driven the North Shore and noticed all the dying birch trees. There may be many contributing factors to their decline, but a lack of management, coupled with a very high deer population are major factors. As your forest matures and trees become less healthy, your management options become more difficult and more expensive. Getting started on a plan now will give you and future generations the most options when considering different practices you can implement.

**It's important to remember that nature is dynamic and even the "do nothing" option has consequences for the future!**

*Updated July2018*

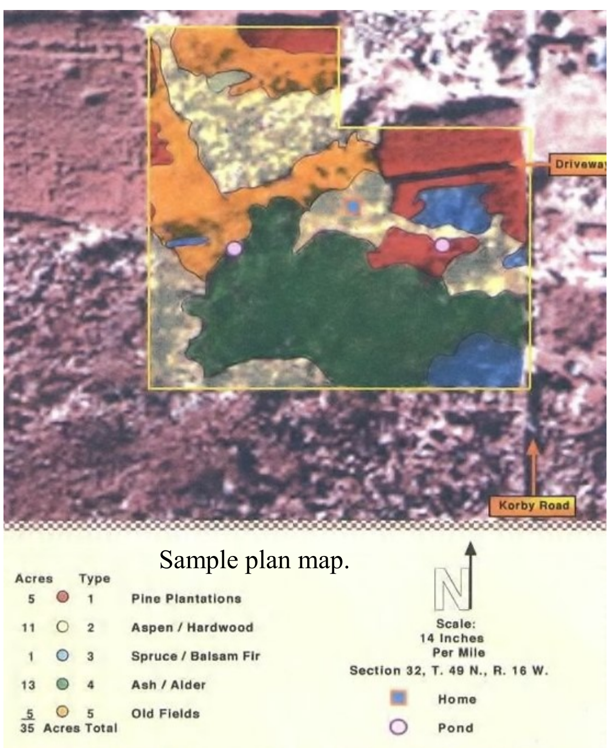
# Conservation Practice Fact Sheet

## Forest Stewardship Planning

**A Forest Stewardship Plan** is a specific kind of woodland management plan prepared by a natural resource professional. The plan provides technical advice and long-range forest management planning to interested landowners. A qualified natural resource professional will meet with you, conduct a field inventory, assess specific land factors and complete the plan. Plans are designed to meet your goals while maintaining the sustainability of the land.

### Why have a plan?

- A Forest Stewardship plan helps you plan for the future condition of your forest.
- A qualified natural resource professional walks your woods with you to discuss your goals and answer your questions.
- Current plans are needed to be eligible for property tax relief assistance.
- Funding may be available for some projects such as wildlife habitat improvement or forest management.




Sample plan map.

### What will my plan look like?

The plan provides a comprehensive overview of your land including an aerial photo, a map of the timber types and plant communities. The plan outlines your goals, the resources on your land and recommends management options such as:

- Planting trees
- Building trails
- Enhancing wildlife habitat
- Thinning and release cutting
- Harvesting timber

These recommendations are built around your goals and the natural capacity of the land.

*A sample plan map is shown to the left.*

***Did You Know?***

Landowners with forest stewardship plans are eligible for cost-share and tax reduction programs. Some of the programs can provide funds for wildlife habitat improvement or erosion control. Ask your plan preparer for details.

808 3rd Street
Carlton, MN 55718

## Who qualifies and what is the cost?

Landowners with 20 or more acres of forest, brushland, or unused fields qualify for a plan.

## I have my plan; now what?

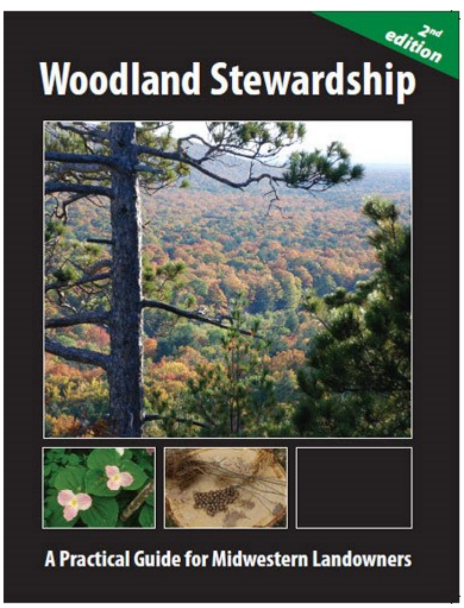
After your plan is completed your plan preparer can help with implementing your plan's goals and recommendations.

## What are my obligations when I have a plan?

None. And you keep control of what's done and who has access. If you pursue further assistance beyond your stewardship plan there may be requirements to meet.

*Typical forest stewardship lands: unused fields , brushland, and woods.*

***A forest stewardship plan is a must for every landowner of 20 or more wooded acres, and it is very affordable.***




## *Updating an Existing Plan*

Landowners with plans over 10 years old are encouraged to update their plans with a qualified natural resource professional to continue to be eligible for property tax relief programs. New and updated plans include the book, ***Woodland Stewardship: A Practical Guide for Midwestern Landowners***, with chapters on wildlife habitat, tax tips and timber harvest.

## *Did you Know?*

Turkey and grouse are attracted to high bush cranberry, oak and American hazelnut. There are several programs available to help with implementing plan goals including wildlife habitat and erosion control.

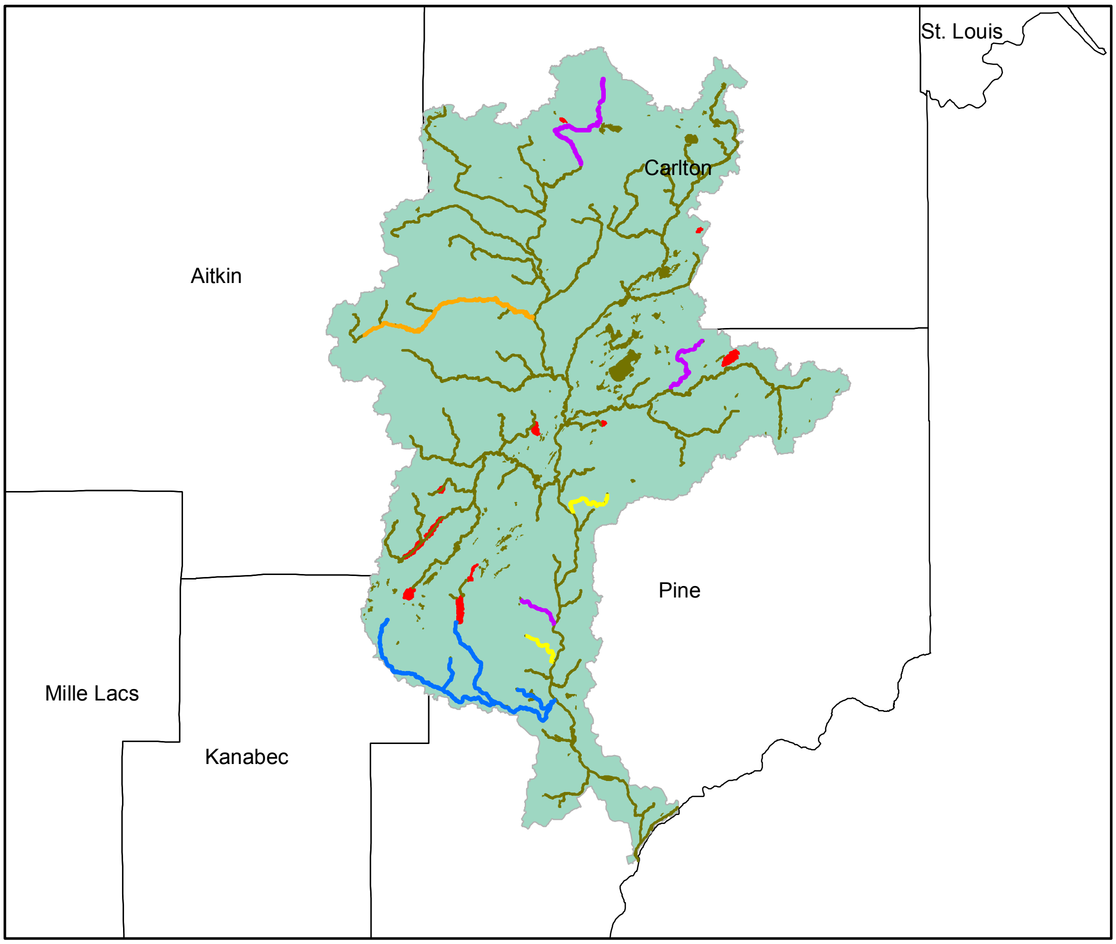
*Visit us at www.carltonswcd.org and find us on Facebook*

## Getting Started Managing your Forest

The first step in getting started is to schedule a free site visit with a Carlton SWCD conservation technician to discuss the goals and objectives for your land. Learn more about the various programs available to individual landwoners by **calling 218-384-3891** and get started today!

*Updated January 2018*

# Proposed Impaired Lakes and Streams in the Kettle River Watershed




Proposed impaired lakes

Unimpaired waters

## Stream Impairments

Aquatic macroinvertebrate and Fishes bioassessments

Bacteria, Fishes bioassessments

Fishes bioassessments

Bacteria

CLEAN WATER LAND & LEGACY AMENDMENT

Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, MN 55155-4194

**Reimbursement Invoice Spreadsheet**

**Submit to: MPCA.AP@state.mn.us.**

**Kettle River Watershed Community Outreach and Engagement**

**Local Project Manager: Melanie Bomier**
**MPCA Project Manager: Timothy Schwarz**

**Invoice #:**
**Invoice Date:**
**Invoice Period:**

**MPCA SWIFT ID:**
**MPCA CR#:**

| Project Budget | | | MPCA Grant Funds Available | Hours Invoice 1 | Funds Invoice 1 | Hours Invoice 2 | Funds Invoice 2 | Hours Invoice 3 | Funds Invoice 3 | Hours Invoice 4 | Funds Invoice 4 | Hours Invoice 5 | Funds Invoice 5 | Hours Invoice 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| **Objective 1: Civic Engagement** | **Rate** | **Hours/Qty** | | | | | | | | | | | | |
| Task A Volunteer Recruitment WRT Hours | $47.00 | 140 | $6,580.00 | 1.50 | $70.50 | 11.5 | $540.50 | | | | | | | 39 |
| Task B Outreach Materials WRT Hours | $47.00 | 560 | $26,320.00 | 12.00 | $564.00 | 15 | $705.00 | 75 | $3,525.00 | 1 | $47.00 | 29 | $1,363.00 | 99 |
| Task B: Outreach Materials Manager Hours | $80.00 | 40 | $3,200.00 | 0.00 | $0.00 | | | | | | | | | |
| Task B: Outreach Materials Tech Hours | $60.00 | 60 | $3,600.00 | 0.00 | $0.00 | | | | | | | | | |
| Task B: Outreach Materials Admin Assist Hours | $50.00 | 150 | $7,500.00 | 0.50 | $25.00 | 2 | $100.00 | | | 1 | $50.00 | | | |
| | | | | | | | | | | | | | | |
| Task C: Develop media articles WRT Hours | $47.00 | 40 | $1,880.00 | 0.00 | $0.00 | 1.5 | $70.50 | 5.5 | $258.50 | | | | | 21 |
| Task D: Stakeholder engagement WRT Hours | $47.00 | 140 | $6,580.00 | 0.00 | $0.00 | | | 22.5 | $1,057.50 | 4.5 | $211.50 | | | 1 |
| Task D: Stakeholder Engagement Manager Hours | $80.00 | 120 | $9,600.00 | 0.00 | $0.00 | | | | | | | | | |
| Task E: Develop Key Water Quality Messages WRT | $47.00 | 90 | $4,230.00 | 0.00 | $0.00 | | | | | | | | | 3.5 |
| RMB Lake Assessment | $60.00 | 230.8333 | $13,970.00 | 0.00 | $0.00 | 232.8 | $13,850.00 | | | | | | | |
| | | | | | | | | | | | | | | |
| **Objective 2: Project Management** | | | | | | | | | | | | | | |
| Task A: Project Administration WRT | $47.00 | 40 | $1,880.00 | 4.50 | $211.50 | 1.5 | $70.50 | 5 | $235.00 | 4.5 | $211.50 | 1 | $47.00 | 3 |
| Task B: Semi-annual Progress Report WRT | $47.00 | 30 | $1,410.00 | 0.00 | $0.00 | 3 | $141.00 | 1 | $47.00 | 0.5 | $23.50 | | | 2.5 |
| Task C: Final Report WRT | $47.00 | 20 | $940.00 | 0.00 | $0.00 | | | | | | | | | |
| Outreach Event Expences | $812.00 | | $812.00 | 0.00 | $0.00 | | | | $264.94 | | $392.00 | | | |
| Outreach Printing | $100.00 | | $100.00 | 0.00 | $0.00 | | | | $100.00 | | | | | |
| Mileage | $106.00 | | $106.00 | 0.00 | $0.00 | | | | $106.00 | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| **COLUMN TOTAL** | | | **$88,708.00** | **18.50** | **$871.00** | **267.3** | **$15,477.50** | | **$5,593.94** | **11.5** | **$935.50** | **30** | **$1,410.00** | **169** |

# Invoice Reimbursement

CWP

*Doc Type: Invoice*

**Final**

**10/01/2019 through 12/31/201**

**125141**

**9038**

| Funds Invoice 6 | Hours Invoice 7 | Funds Invoice 7 | Retained Funds Invoice 7 | Total Requested Funds 7 | Hours Invoice 8 | Funds Invoice 8 | Retained Funds Invoice 8 | Total Requested Invoice 8 Funds | Hours Invoice 9 (Final) | Funds Invoice 9 (Final) | Total Requested Final Invoice Funds + Retained Funds | Total Funds Expended | Total Remaining Balance | % Budget Expended |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| $1,833.00 | 8.5 | $399.50 | $39.95 | | 12.5 | $587.50 | $58.75 | | 6 | $282.00 | | $3,713.00 | $2,867.00 | **56%** |
| $4,653.00 | 95 | $4,465.00 | $446.50 | | 6.5 | $305.50 | $30.55 | | 219 | $10,293.00 | | $25,920.50 | $399.50 | **98%** |
| | | | | | | | | | | | | $0.00 | $3,200.00 | **0%** |
| | | | | | | | | | 40.5 | $2,430.00 | | $2,430.00 | $1,170.00 | **68%** |
| | | | | | | | | | 75 | $3,750.00 | | $3,925.00 | $3,575.00 | |
| | | | | | | | | | | | | | | |
| $987.00 | 2 | $94.00 | $9.40 | | 1 | $47.00 | $4.70 | | 2 | $94.00 | | $1,551.00 | $329.00 | **83%** |
| $47.00 | 16.5 | $775.50 | $77.55 | | | | | | | | | $2,091.50 | $4,488.50 | **32%** |
| | | | | | | | | | | | | $0.00 | $9,600.00 | **0%** |
| $164.50 | | | | | | | | | 18 | $846.00 | | $1,010.50 | $3,219.50 | **24%** |
| | | | | | | | | | | | | $13,850.00 | $120.00 | **99%** |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| $141.00 | 3 | $141.00 | $14.10 | | 3 | $141.00 | $14.10 | | 0.5 | $23.50 | | $1,222.00 | $658.00 | **65%** |
| $117.50 | | | | | 1 | $47.00 | $4.70 | | | | | $376.00 | $1,034.00 | **27%** |
| | | | | | | | | | 15.5 | $728.50 | | $728.50 | $211.50 | **78%** |
| | | $89.03 | $8.90 | | | | | | | $66.03 | | $812.00 | $0.00 | **100%** |
| | | | | | | | | | | | | $100.00 | $0.00 | **100%** |
| | | | | | | | | | | | | $106.00 | $0.00 | **100%** |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| **$7,943.00** | **125** | **$5,964.03** | **$596.40** | **$5,367.63** | **24** | **$1,128.00** | **$112.80** | **$1,015.20** | **376.5** | **$18,513.03** | **$19,222.23** | **$57,836.00** | **$30,872.00** | 65% |

**Articles published in the local Pine Journal to encourage good stewardship in the Kettle River Watershed.**

**Wetlands**: https://www.pinejournal.com/news/science-and-nature/4802475-Samuelson-column-Finding-gems-in-the-swamp

**Farms**: https://www.pinejournal.com/news/science-and-nature/4746637-Samuelson-column-How-farmers-can-improve-water-quality, https://www.pinejournal.com/business/agriculture/4588266-samuelson-column-farms-important-water-quality-question

**Culverts**: https://www.pinejournal.com/news/science-and-nature/4667472-Samuelson-column-Digging-into-culvert-issues-a-win-for-humans-nature

**Water Monitoring**: https://www.pinejournal.com/business/agriculture/4605022-samuelson-column-take-plunge-water-monitoring

**Forestry:** https://www.pinejournal.com/business/agriculture/4546176-samuelson-forestry-education-action

**Kettle River Watershed:** https://www.pinejournal.com/sports/4215916-part-1-kettle-river-watershed-scenic-wild-and-unique

https://www.pinejournal.com/sports/4220127-part-ii-two-important-minnesota-natives-call-kettle-river-home

# Samuelson column: Digging into culvert issues a win for humans, nature

Several weeks ago, the Carlton County Soil and Water Conservation District (SWCD) sponsored a tour of the Nemadji Watershed to highlight the parts of a watershed and how they work together. Stops included looking at forests, streams, farms and culverts.

I can hear you asking, "What do culverts have to do with a watershed?" And the answer is, "Quite a lot, actually."

Culverts are something that most of us seldom think about or even notice in our surroundings. Most culverts are just there, not doing anything, and at this time of year, many culverts are hidden by tall grasses.

Culverts are barely given a glance by people unless they are plugged by debris or blocked by ice. When that happens, everyone notices that there is a culvert with a problem and it affects everyone trying to pass through that area.

Culverts can be made from plastic pipe or metal or concrete. They can range from just a few inches to over 10 feet in diameter. But all culverts do the same thing — they transport water from one side of a barrier to the other side. The barrier is usually a road or a driveway, and if culverts didn't transport it, the water would definitely move over the barrier and likely take quite a bit of the gravel or dirt with it.



Culverts are a very important in keeping water from streams or wetlands or fields moving on down to its final destination in rivers or lakes or oceans. However, if a culvert is in the wrong place, facing the wrong direction, or of the wrong dimension, that culvert could instead help the water cause a lot of damage.

“From June 2017 to December 2018, over 2,000 culverts in Carlton County were located and assessed. ”

**First**, according to Melanie Bomier, Carlton SWCD's water resource technician, when a culvert fails to do its job and a stream or river washes out a road, several tons of road material can be washed downstream.

"This material not only adds more sediment into the watershed, but also covers up stream and wetland plants," Bomier said. "Valuable wetlands and wildlife habitat may be lost."

**Second**, culverts that fail during storms present a safety hazard. Many flood deaths occur because drivers attempt to cross a flooded roadway and may be unaware of the washed out road hidden by the water. In addition, when roads are closed due to flooding, "it can take much longer for emergency personnel to assist with medical and fire emergencies," Bomier said.

**Third**, if a larger culvert is the correct size needed, it may have a higher price tag initially, but "there will be a savings in the long run," Bomier said. "The cost of replacing a culvert or lost road bed materials can be very expensive."

In addition, we also "must consider consider the financial and time impact to local residents and businesses when a road has to be closed until repairs are completed," she said.

Because of the role culverts play in water quality, especially in the more challenging red clay areas, the SWCD applied for a grant in 2016 to fund a culvert inventory.

Decline Devine, Carlton Soil and Water Conservation District apprentice from Conservation Corps of Minnesota, measures a "hidden" culvert for the culvert inventory. (Photo courtesy of Carlton SWCD)

"Past inventories, although useful in many ways, were flawed because they were immediately out of date as soon as they were completed," Bomier said. "We wanted an inventory that would stay relevant and we needed the support and buy-in of the road authority," which in this case was the Carlton County Transportation Department.

The Transportation Department was very interested in the project, according to Will Bomier of the Transportation Department (who, coincidentally, is also Melanie's husband). Thus, an SWCD-Carlton County partnership was launched in 2017 to conduct a culvert inventory on all county-maintained roads. The goal was to evaluate the location, condition and biological and water quality impact of every culvert.

An Enbridge Ecofootprint grant was received to fund not only the culvert project, but also engineered designs of four high-priority culvert replacements. The inventory was conducted by Carlton SWCD staff, as well as SWCD interns from the Conservation Corps of Minnesota and by Carlton County Transportation Department staff and summer interns.

From June 2017 to December 2018, over 2,000 culverts in Carlton County were located and assessed.

One result of the culvert inventory was discovery of a series of undersized and perched culverts on Stony Brook, a tributary of the South Fork Nemadji River. Because of these particular culverts, Stony Brook did not have trout living in it like the neighboring Anderson Creek did even though they had similar habitat with cold water and adequate flow.

The Transportation Department replaced the furthest downstream culvert in 2017 and the Enbridge grant funded the design for the remaining upstream undersized and perched culverts.

One specific culvert had a history of repeated maintenance, and during the 2018 flood, the culvert washed out completely. This culvert's history of road washouts, according to Bomier, "led to approximately 200 cubic yards of road gravel (equal to 20 dump truck loads) washing into the stream."

This gravel "enlarged the stream channel so that during low water flows, the stream was too shallow for adequate aquatic organism (including fish) passage," she said.

A culvert with a natural bottom. (Photo courtesy of Carlton SWCD)

In 2018, the Carlton Transportation Department removed the gravel from the stream and restored the channel. The culvert is due to be replaced by the Transportation Department this year using FEMA funding, and the remaining upstream perched culverts will also be replaced using regular maintenance funds.

Thus, by next year, over 2 miles of Stony Brook should be reconnected and restored, based on data collected through the inventory, and hopes are high for the natural return of trout within the next five years.

The culvert inventory project has been a huge success and a very valuable and essential tool for everyone in Carlton County, especially the Transportation Department, for three main reasons:

**First**, the culvert inventory is "always up-to-date and actually reflects the culvert at that (particular) site. Our maintenance crews update the inventory when they replace culverts in the field," stated Will.

**Secondly**, as Will Bomier noted, "it helps to know where these culverts are and what shape they're in so that we can replace them before they fail and we have to close a road for costly emergency repairs. We can quickly run reports, identify potential problems, and then prioritize to get them addressed."

In addition, he added that tracking information with the inventory provides for "better planning and cost savings."

"We can input information about how many times we've repaired a culvert or other costs associated with the site, which helps us track how much an undersized or poorly-placed culvert is actually costing us and if it makes sense to get that culvert replaced sooner rather than later," he said.

**Lastly**, the culvert inventory is an essential tool for emergency response.

Eimy Quispe, Carlton Soil and Water Conservation District apprentice from Conservation Corps of Minnesota, does survey work for the culvert inventory. (Photo courtesy of Carlton SWCD)

"During the 2018 flood," Will Bomier explained, "we were able to quickly look at the inventory to determine the existing and the needed sizes for replacement culverts. This saved the department a lot of time and allowed us to get these culverts replaced right the first time. Thus, we didn't have to go back and replace any of the culverts that were emergency replacements after the flood because we got them replaced correctly the first time."

As an example, a culvert on County State-Aid Highway 13 has washed out three of the last five years.

"After the 2018 flood, the 30-inch pipe was replaced with a 72-inch pipe arch culvert with a natural bottom. At the same time, five truck loads of road material and gravel were removed from the stream and the adjacent wetland," Melanie

Bomier said. "The cost of replacing the undersized culvert with an appropriately-sized culvert cost $3,800 less than repairing the damage from the flood."

Due to the hard work of the staff of the Carlton SWCD and the Carlton County Transportation Department, the newly created culvert inventory will continue to be an updated and valuable resource to help the county in its goal to responsibly use taxpayer funds to keep our county roads in good shape.

Side benefits will be safer driving during high water events as well as less sediment washed into our rivers and watersheds. By seriously looking at culverts that are hidden in plain view, that's a win for all of us — people and nature included.

*Kim Samuelson is Carlton Soil and Water Conservation District's elected supervisor for District 4. For more information about the culvert inventory project or the importance of culverts, contact Melanie Bomier at the SWCD at 218-384-3891. You can also check out Carlton SWCD on Facebook and at carltonswcd.org.*

# Samuelson column: How farmers can improve water quality

When it comes to soil health and water quality, farmers have always been some of the most conscientious and concerned people. This is due to their deep, hands-on connections with soil and water and nature.

Farmers physically feel their soil and can tell if it is too wet or too dry for tilling, planting and harvesting. They test their soil to make sure it has the necessary minerals in order to produce good quality crops to sell and eat. They regularly check their water to ensure its safety for the life and health of their families and the animals they raise. And they know that their land practices, the way they farm, can greatly affect the health of the soil and the quality of the water not only on their land, but also on surrounding land, rivers and lakes.

During the drought and Dust Bowl of the 1930s, it was because of farmers, their concern, and their farming practices, that the U.S. Congress passed the Soil Conservation Act. This led to state governments creating Soil and Water Conservation Districts (SWCD) to teach and encourage farmers and landowners how to develop land practices that would conserve and more wisely use soil and water resources for the benefit of everyone.

Leading the way to improvements in land practices and water quality is the Minnesota Agricultural Water Quality Certification Program (MAWQCP) through the Minnesota Department of Agriculture (MDA). This voluntary program gives farmers and agricultural landowners the opportunity, according to the MDA website, to "take the lead in implementing conservation practices that protect our water."

Ryan Clark, ag water quality certification specialist with the Carlton SWCD, reports there are 15 farms in Carlton County that have completed ag water quality certification. In addition, there are five farms that are working toward certification by implementing a variety of projects, several of which are partially funded by grants through MAWQCP. One of those farms working toward certification, just west of Moose Lake, is owned by Russ and Renee Peterson.

The Petersons raise beef cows and calves on an 80-acre farm that has been in Russ's family for many years. However, it had not been a working farm for a number of years, except for the few head of cattle they raised on the farm before they bought it from his mother in 2007.

With guidance from Troy Salzer, who was then employed with the University of Minnesota Extension in Carlton County, the Petersons started their quest in 2010 by contacting the Natural Resources Conservation Service (NRCS) to help with several projects. Each of those four projects helped quite a bit to protect water quality, according to Clark.

The fencing project created separate paddocks that "allow the Petersons to rotational graze and improve forage production all while improving water and soil quality."

The travel lane project, added Clark, allowed the Petersons to "move cattle around on pasture while protecting the sensitive areas near the stream running through the length of the pasture. This stable surface prevented soil degradation and runoff to the stream."

Lastly, NRCS helped them "install a stream crossing in the pasture by providing a solid rock base for crossing the cattle in a designated spot. This further protects the stream from runoff and pollution from cattle activity."

Aravel and recycled asphalt pad is installed for the hay bale storage area. (Photo courtesy of Carlton SWCD)

The completed gravel and recycled asphalt pad for the hay bale storage area. (Photo courtesy of the Carlton SWCD)

In early 2019, the Petersons contacted the Carlton SWCD seeking MAWQCP certification for water quality and to discover ways to further improve their land. They discovered that they could receive additional assistance to improve the conditions on their farm, especially during the winter and mud seasons when several head of cattle have to be kept in pens adjacent to the old dairy barn.

During these seasons, significant amounts of rain water was flowing down the barn and shed roofs, through these pens, and into the stream that runs nearby.

With financial help from a MAWQCP grant and funds through the Carlton SWCD Cost-Share program, the SWCD, along with NRCS engineering technician Ben Ellefson, worked with the Petersons on two additional projects to help lessen these problems and further protect water quality.

Perforated drain tile is laid in the roof runoff structure's trench to carry clean rainwater from the roof to the stream, thus bypassing the cow yard. (Photo courtesy Carlton SWCD)

First, they designed and installed "roof runoff structures," which, according to Clark, "involved digging a trench and burying perforated drain tile under rock to collect and carry clean rainwater from the barn roofs around or under the cow yard rather than through the manure and into the stream." This project, which was completed several weeks ago in mid-September, has already improved the mud situation and has removed some of the polluted runoff to the stream.

Second, a heavy use area protection practice was designed and installed in early October for a hay bale storage area.

"This entailed building a gravel pad to provide adequate drainage and a stable surface for storing and moving hay bales for winter feeding. This area previously contributed some sediment runoff to the same stream from the bare soil conditions and tire rutting," Clark said.

Future plans for the Petersons include a new ag waste storage facility so they can "abandon their pens near the stream for a concrete slab for feeding cattle and storing manure under a roof in a more appropriate location," according to Clark. "This will allow them to store manure more effectively and further prevent rain water from carrying bacteria and nutrients to the stream and ultimately to the Kettle River."

*Kim Samuelson is Carlton Soil and Water Conservation District's elected supervisor for District 4. For more information about the culvert inventory project or the importance of culverts, contact Melanie Bomier at the SWCD at 218-384-3891. You can also check out Carlton SWCD on Facebook and at carltonswcd.org.*

# Samuelson column: Farms important in water quality question

It's finally springtime, and after a long winter, many people want to get outside and get busy with outdoor projects. That includes local farmers.

For them, spring means that after a long winter of mostly barn living, and their animals can finally get out, kick up their heels and enjoy the spring grasses and sunny weather.



However, we have to get through the spring rain and snowmelt season first. And with the thoughts of flood waters come the question of what each of us can do to help prevent pollution and environmental hazards from flowing down or leaching into our local rivers and lakes.

Farms and farmers are an important part of these thoughts and actions. The decisions farmers, especially those with cattle, make regarding animal manure can have huge impacts, either negatively or positively, on water quality.

There are usually two ways that livestock are raised: either open grazing (in a pasture where there is enough grass to feed them) or in feedlots (which, according to the State of Minnesota, is an area where livestock are fed and housed long enough to produce a manure stockpile).

In Carlton County, according to Ryan Clark, ag water quality certification specialist for the Carlton Soil and Water Conservation District (SWCD): "Most farms could be classified as a feedlot since livestock are not grazing year-round and must be fed stored hay and/or feed during the winter. The manure from this scenario is stockpiled until it can be spread on the fields."

Most local farmers, however, would describe their livestock area as the "wintering area," "barnyard" or "lot area."

Whether livestock are open grazed or kept in feedlots/barnyards, serious consideration must be given to protecting the quality of ground and surface waters, which is one of the most important concerns for most environmental professionals. According to Melanie Bomier, water quality technician for Carlton SWCD: "E. coli is used by the Minnesota Pollution Control Agency (MPCA) as an indicator species. E. coli indicates that the water may be contaminated with fecal waste, and these wastes may also contain pathogens that can cause illness."

Bomier added: "It would be very expensive to test for all possible disease-causing pathogens, so we measure for E. coli instead. High E. coli levels don't necessarily mean the water will make you sick, but it does indicate that we need to take a closer look at where it's coming from."

In some areas of Carlton County, E. coli levels are higher after rainfall events which, Bomier suggests is "running off from somewhere," which could include from pastures and barnyards.

Both open grazing and barnyard methods have positives and negatives when it comes to handling animal manure, and farmers may need a little assistance in analyzing the situation and making choices or changing operations. The following are a few of the best management practices (BMPs) and regulations that farmers, whether they have just a few or many animals, should consider in relation to manure storage and dispersal.

Open grazing, according to advocates, is better for animals and humans than feedlots/barnyards. However, open grazing can also do consistent and considerable damage to the environment, especially for those farms in which pastureland is adjacent or close to a waterway, river, pond or lake.

Open-grazed livestock defecate wherever and whenever, and their manure is usually dealt with gradually by Mother Nature. Where pastures are fenced so that livestock have access to drink from lakes, rivers, streams or ponds, there is a big chance that much of the fecal waste and bacteria will end up in the water, either by livestock directly dropping it or the rains washing it to the river or lake, etc.

Although the farmer has the right to use the water resources within his pasture lands for his livestock, he also has the responsibility to protect the quality of that water.

In many cases, controlled access to the water source can prevent much of the animal manure from contaminating the water. Controlled access means that fencing is generally used to restrict livestock access to that water.

The ag professionals at Carlton SWCD and USDA Natural Resources Conservation Service (NRCS) can help farmers look at their pasture and water situation and identify the best choice for protecting the water as well as making sure the cattle have the best possible access to food and water and the farmer is able to reduce the cost and inconvenience of drastic changes to their system.

The open pasture method can also be used during the winter, according to Clark, by "outwintering, where the cattle are fed stored hay out on the pasture during the winter. The manure, then, is applied to its final placement by the animals. These farmers will rotate or alternate areas on their pasture where this out-wintering occurs to evenly spread the manure nutrients. This pasture-based winter feeding eliminates the need to store and haul manure."

In the use of feedlots or barnyards, the manure has to be manually moved, stored, and eventually dealt with, and there are a lot of regulations to follow. In fact, the MPCA has ruled that any feedlot with 10 animal units (AU) in any area outside of shoreland must be registered with MPCA. (One AU equals 1,000 pounds, based loosely on one beef cow, and shoreline is defined by land 1,000 feet from a lake and 300 feet from a stream or river.)

"This regulation involves an inspection to ensure no runoff conditions exist that would pollute surface waters," Clark said. "MPCA will work with a violating feedlot to come up with a plan to address runoff issues, and SWCD and NRCS have funding options for these projects and practices."

Clark also shared the following BMPs for typical feedlot/barnyard situations that require manure spreading. "Farmers should avoid winter hauling and spreading of manure at all costs. This can lead to manure runoff problems when the snow melts." (This is under the assumption that there is sufficient manure storage space available.)

He added that farmers should "store manure until appropriate timing for crop uptake of manure nutrients. They should apply manure in the fall or the spring when soil temperatures are below 50 degrees or in the growing season when crops are actively growing."

When it comes to application, Clark said that farmers should "apply manure at agronomic rates for specific crops, i.e. in regards to pounds of nitrogen and phosphorus per acre required for crop production." And they should "incorporate the manure into tillable ground by injection or tilling in as soon as possible when conventional tillage is used. This practice will reduce the chance of environmental loss of nitrogen."

Most farmers who have feedlots or barnyards have had manure pits constructed. These are ideal for storing manure, which is considered a hazardous waste, until it can be safely applied to pasture or cropland. However, just like anything else, manure pits can reach the end of their design life or may not be needed anymore if a farmer decides to stop raising cattle or sell his property. MPCA requires that within one year of ceasing operation, farmers must remove all manure in the pit, apply it to land at the agronomic rates, and fill the pit in with dirt.

The ag professionals at Carlton SWCD and NRCS are available to help farmers with the huge undertaking of dealing with abandoned manure pits. They can provide financial and technical assistance to farmers and landowners who want to properly fill in these pits. They will inspect the site, check original designs on file, create a closure design and calculate quantities and cost estimates.

They will also walk the farmers through all of the paperwork and regulations, and help them to find financial assistance from NRCS and the Minnesota Department of Agriculture to help fund the cost of the closure.

*Kim Samuelson is Carlton SWCD's elected supervisor for District 4. For more information about the Carlton SWCD and any of the staff's or supervisors' work with natural resources, call 218-384-3891. Find more information about Carlton SWCD on Facebook and at carltonswcd.org.*

# Samuelson: Forestry education in action

One of the main purposes of the Carlton County Soil and Water Conservation District is to teach people how to care for the natural environment.

Throughout this past year, Kelly Smith, Carlton SWCD forestry technician, was instrumental in coordinating a series of "Walk in the Woods" events for local landowners to learn how to care for their forests.



During the walks, sponsored by the Kettle River Woodland Council, a chapter of the Minnesota Forestry Association, Smith and other forestry professionals brought information about the many decisions and activities needed to plant, care for, use and harvest trees.

Landowners visited Alan Finifrock's property east of Moose Lake last spring. Originally owned and farmed by his parents, Finifrock learned as a child how to plant and care for trees after his parents decided the land was better suited as a forest. These early experiences started an annual tradition of tree plantings and other forest projects Finifrock has shared with family, friends and neighbors.

In fact, during the walk, two other attendees, Will Salo and John Schwock, recounted stories of Finifrock's forest projects: Salo helped with harvesting aspen 30 years ago, and Scwock assisted in planting 10,000 spruce and pine trees in 1997.

Several of Finifrock's projects have required outside funding and labor assistance. According to Smith, "there is funding assistance available to help get forest management projects done. Red pine thinning and young forest habitat are two of the eligible practices."

Red pines planted in the early 1950s on Finifrock's land were thinned in 1991 to improve the health and growth rate of the remaining trees. And last winter, with assistance from the USDA Natural Resources Conservation Service, Finifrock worked with logger Justin Salmela to harvest 11 acres of aspen to create a forest habitat for Golden-winged warblers and other birds and forest creatures.

Annual tradition, fueled by enjoyment of the land, plays a huge part in carrying out Finifrock's projects. The biggest benefits for Finifrock are the ability to ski and hike in his forest, the chances to observe wildlife, and the feelings of peace, quiet and satisfaction from a lifetime of work, growth, family and friendship.

The summer "Walk in the Woods" was held in Bob Asproth's forest near Mahtowa and emphasized how to steer the direction a forest takes by determining the time of year and the amount of area where timber is harvested.

The fall "Walk in the Woods" was on property along the Kettle River, just upstream of Rutledge, owned by Paul Dickson, a knowledgeable and experienced consulting forester and owner of Dickson Forestry, Inc.

Dickson enrolled his property in a 50-year Sustainable Forest Incentive Act covenant "to keep this property from being subdivided and developed," Smith noted. The annual payments are enough to cover Dickson's property taxes on this land.

While landowners enjoy being able to hunt, walk and explore their forests, Smith emphasizes that "all of us are benefiting from the wood products," as well as the benefits to rivers, lakes and wildlife.

"These woods walks provided forest landowners the contacts with forestry professionals, information on project assistance, and the ability to share experiences with other forest landowners," Smith said.

*Kim Samuelson is Carlton Soil and Water Conservation District's elected supervisor for District 4. If you would like to host or attend a future "Walk in the Woods," or would like more information about managing and generating income from your forest and how Carlton SWCD can help, contact Kelly Smith at 218-384-3891.*

# Part 1: The Kettle River watershed is scenic, wild and unique

KETTLE RIVER WATERSHED PART I:

Eighty major watersheds cover every square inch of the whole state of Minnesota. Carlton County has multiple watersheds within its boundaries, each one unique: The Mississippi River-Grand Rapids Watershed drains the northwest portion of Carlton County; the St. Louis River Watershed drains the northeast part; the Nemadji River Watershed drains the middle- and southeastern portions, and the fourth, the Kettle River Watershed, drains the middle and southwestern part of Carlton County.



In recent years, the first three watersheds have had major water monitoring and some assessments done, along with a variety of environmental projects completed. However, monitoring and assessment just started in the Kettle River Watershed. Through this article, Carlton County Soil and Water Conservation District (SWCD) will introduce you to the Kettle River, its watershed, and its river designations. In Part 2 next week, the focus will switch to two of the river's unusual "residents."

Kettle River's name came from the English translation of the Dakota word, Cega watpa, and the Anishinaabe word, Akikko-ziibi, which both mean "Kettle River." They refer to the large number of "kettles," or large rounded holes, the swirling river waters carved out of sandstone in and around the lower portions of the river.

From its headwaters in Carlton County, the Kettle River Watershed drains 672,235 acres along its 104-mile route until 10 miles northeast of Pine City, where its waters become part of the St. Croix River system.

The main branch of the Kettle River originates from the small, slow-flowing bog streams east of Cromwell, while the west branch starts in the swampy areas southwest of Wright. The west branch joins the main Kettle River northeast of the intersection of Highway 73 and Carlton County Road 131. A little further downriver, where the Kettle River crosses County Road 131 in Kalevala Township, the river becomes large enough to support gamefish, the larger fish suitable for fishing.

The width of the Kettle River ranges from 75 feet at the beginning of the navigable portion to more than 250 feet in the lower sections of the river. There are also some very deep sections of the river with pools reaching over 100 feet deep. Because of this astounding depth as well as the generally good water quality, the river has a good-sized population of gamefish, including lake sturgeon.

Although the Kettle River and many of the lakes in the watershed do have some mercury and bacteria impairment, the river's water quality is relatively good. The amber-colored water may look polluted, but don't worry! The tint of the water comes from the tannins (leaf colorings) of the wetlands which drain into the river. The wetlands themselves are good and needed for filtering runoff and stabilizing base flow.

Last year, Carlton SWCD began monitoring work in the Kettle River Watershed to "identify the different water quality impairments and figure out where they originate," according to SWCD Manager Brad Matlack. This monitoring work is part of the Minnesota Pollution Control Agency's (MPCA) Watershed Restoration and Protection Strategy (WRAPS) Program, a 10-year assessment that will identify the problems, what needs to be protected, and how to engage landowners to help with restoration and protection.

Most of the Kettle River Watershed is private land (74 percent) with much of rest state-owned (22 percent). About 34 percent of the watershed is in Carlton County with the rest in Aitkin (10 percent), Pine (53 percent), and Kanabec (3 percent). Most of the watershed is forested (55 percent) with the remainder as wetlands (19 percent), grass pasture/hay (20 percent), and residential or commercial developed (3.4 percent). The Kettle River is also heavily bounded by forests of black spruce, fir, aspen, maple, ash, and elm with some red, white and jack pines scattered throughout.

Working with the landowners is important to the Carlton SWCD as the healthier the forests, farmlands, wetlands and soils are, the healthier the river will be.

The Kettle River Watershed includes 23 lakes (greater than 100 acres in size), including the Hanging Horn, Sand, Grindstone, Sturgeon, and Island lakes. Some of the tributaries that feed into the Kettle River include the Dead Moose and Split Rock rivers, which join the river in Carlton County, and the Moose Horn, Willow, Pine and Grindstone rivers, which join in Pine County. Wolf Creek joins the Kettle River in Banning State Park after passing over a beautiful 12-foot waterfall.

Since much of the river's water comes from runoff, the Kettle River is subject to low flow waters, especially in the upper portions of the river and particularly later in the summer. The river can be reduced to a trickle during dry, hot summer days and then rise to whitewater torrents after a few days of heavy rain.

These whitewater torrents and rapids are one of the Kettle's best features. The Minnesota Department of Natural Resources classified the Kettle River State Water Trail as "one of the best whitewater rivers in the Midwest." Most of the rapids are Class I (easy rapids with small waves and few obstructions) during low water. However, some parts of the river reach Class II (rapids with waves up to three feet high) or Class III (difficult rapids with high, irregular waves capable of swamping an open canoe) during high water. Class III is usually considered the limit for experienced paddlers in open canoes.

The upper section of the Kettle River, above Banning State Park, has generally quick-moving waters with riffles and a few Class I rapids. As the river flows through Banning State Park, however, its character changes quickly due to river drops through a series of Class I to Class IV (long and turbulent) whitewater rapids known as "Hell's Gate." Some of the rapids are easily run by canoeists when water levels are low to moderate. However, during very high water, they can become extremely dangerous, even to experienced whitewater kayakers and rafters, especially because of the steep rocky sides of the river, the undercut banks and the kettles.

After the river leaves Banning State Park, it quiets down significantly before it reaches Big Spring Falls, which were re-created in 1995 when the Sandstone Dam was removed to restore the natural river system. Between the falls and the river's merger with the St. Croix River, the Kettle River continues to drop at a moderate rate with frequent riffles and occasional Class I rapids.

Because of these rapids, and other physical attributes of the Kettle River, part of the river was also designated a Minnesota Wild and Scenic River in 1975. The Kettle River is one of only two rivers with Minnesota Wild River designation, described on the DNR website as "those that exist in a free-flowing state with excellent water quality and with adjacent lands that are essentially primitive...."

The "wild" portion of the river is from the old Sandstone dam site and downstream to the river's mouth at the St. Croix River. This final section of the Kettle River has some of the best canoeing available in the state, with its manageable rapids, good fishing, frequent wildlife sightings and absence of people.

The "scenic" portion of the river is from the Carlton-Pine county line downstream to the old Sandstone dam site. This section includes the rapids in Banning State Park, as well as the impressive steep and rocky sides, the "kettles," and the sandstone formations. According to the DNR website, "scenic rivers...exist in a free-flowing state and with adjacent lands that are largely undeveloped" (i.e., they still present an overall natural character but may have been developed for agricultural, residential, or other land uses).

The Kettle River is one of six Minnesota rivers, including the St. Croix River, with this designation.

Finally, according to the National Park Service, once the Kettle River joins the St. Croix River, it becomes part of another designation, the St. Croix National Scenic Riverway: 250 miles of clean water that glides and rushes through wild and beautiful forested landscapes.

Now you have met the beautiful Kettle River and its watershed. Next week, meet two of the Kettle River's most unusual residents: lake sturgeon and wild rice.

# Part II: Two important Minnesota natives call Kettle River home

Last week, readers got to know the Kettle River and its watershed. This week, we'll look at two of the river's more unusual residents: lake sturgeon and wild rice. Monitoring work and projects in the watershed, done by the Carlton County Soil and Water Conservation District (SWCD) and other organizations, will help to protect and preserve the watershed's clean water and greatly benefit these two popular residents.

Lake sturgeon are one of 34 species of fish that the Minnesota Department of Natural Resources (DNR) found during a 2002 survey of the Kettle River.



"The Kettle River is an important resource to Minnesota fisheries as it is one of few rivers where lake sturgeon live and spawn," said SWCD manager Brad Matlack.

Lake sturgeon, Acipenser fulvescens, are very special fish. One of the oldest species on earth, they still look like their dinosaur ancestors. Sturgeon are also one of the longest-living freshwater fish in the world; the oldest one on record was 152 years old. They are also the largest fish in the Great Lakes with some having grown to nine feet long and weighing over 300 pounds. In fact, the largest fish ever caught in Minnesota was a 70 inch, 94-pound lake sturgeon caught in 1994 in the Kettle River. That's a lot of "records" for one fish!

Living in both lakes and rivers, at one time sturgeon were found throughout the Great Lakes, Hudson Bay and Mississippi River basins from Canada to Alabama. However, by the early 1900s, lake sturgeon populations were severely decimated due to pollution, dams and overfishing. Lake sturgeon were popular gamefish not only because of their size and looks, but also because of their delicious meat and eggs (caviar).

Because of this popularity, the Minnesota DNR paid attention in the early 1990s when fishermen reported catching considerably fewer lake sturgeon in the area, particularly in the Kettle River. Thus, in 1992, Hinckley DNR fisheries personnel started tagging lake sturgeon in the Kettle River, not only to assess the population, but also to acquire much needed information about the life of sturgeon in the river system.

In 2003, after 11 years of tagging, fisheries personnel discovered interesting information about 571 lake sturgeon, of which 370 were recaptured two or more times. The largest number (439) of those fish were caught in the Kettle River. The largest sturgeon caught was 63.5 inches long and weighed 56 pounds, and the oldest was 43 years old. The tagging process also gave biologists information about how fast lake sturgeon grow in length and weight, how they migrate, their estimated population size, what condition the fish were in, and more.

Biologists were very surprised to find that the lake sturgeon population in the Kettle River is a resident, year-round population, which is very unique as most sturgeon live in the lake and only return to the river to spawn. Although there are no physical barriers between the Kettle and St. Croix rivers, most of these sturgeon appear to stay in the Kettle River the entire year. They also migrate between systems as one lake sturgeon that was originally tagged in the Kettle River was also caught on the St. Croix River.

Besides moving downstream, lake sturgeon also move upstream, as noted by studies after the 1995 removal of the old Sandstone dam. The dam removal unfortunately released years of accumulated sediment that covered known spawning sites and filled in important deep pools. However, the removal also opened the entire range of the Kettle River to sturgeon which were previously restricted by the dam.

Recent evidence of lake sturgeon migrating upstream came from one of last year's greatest fishing stories. On June 26, 2016, Barnum's Dale Smith caught a whopper of lake sturgeon on Big Hanging Horn Lake. The trophy fish was 59 inches long and weighed 50 pounds, just shy of the Minnesota record! It was a wonderful surprise for everyone to find a lake sturgeon that far upriver in the Kettle River system.

According to Hinckley's DNR fisheries website, the outlook for lake sturgeon in the Kettle River looks bright due to cleaner water, regulated harvest, and more access to habitat. Although it will take decades more to bring lake sturgeon back to the historic numbers seen decades ago, the website notes: "If things go right, our grandchildren may have a chance to actually catch a 100-pound sturgeon instead of just seeing old pictures."

MINNESOTA'S STATE GRAIN

The other unusual resident in the Kettle River watershed is wild rice, "Zizania aquatica," an annual water-grass seed that is Minnesota's official state grain. Besides being good human food and providing needed habitat for waterfowl and birds, wild rice provides high-quality, high protein food, especially for "refueling" waterfowl during fall migrations.

In past years, many of our northern lakes grew abundant wild rice. Recent years, though, have found the plants starting to disappear from more area lakes and rivers.

There are several good wild rice growing areas in Carlton County.

However, Jacob Granfors, a biologist with Pheasants Forever and Quail Forever, has only found two areas in the Kettle River Watershed with prime wild rice stands. One is the Kettle Lake southeast of Cromwell near the head of the Kettle River. The other is the Moosehorn River south of Moose Lake where the river widens on its way to Pine County. Working through a grant acquired by Carlton and Aitkin SWCDs, Granfors is identifying and acquiring easements to protect and preserve prime wild rice stands. So far, two private property easements on the Moosehorn have been enrolled to protect a total of 43.75 acres and 5,000 feet of riverfront.

Why is wild rice so special and in need of protection? For several reasons actually.

First, wild rice only grows in northern lakes, marshes or streams, and the plants need calm, clear water six inches to three feet deep. If the water is too deep, the sun's rays cannot reach the seed during germination. If the water is too shallow, the plant develops a weak stem.

Second, wild rice needs a consistent water depth, especially during the spring after germination when roots are anchoring the seedling plant. During this critical time, if the water level rises, the stalk is pulled up as it is still too weakly rooted. And if the water level drops, the stalk can collapse as it is still too weak.

Third, during August, if the temperatures and humidity levels are both very high at the same time, it can create ideal conditions for the Helminthosporium disease that can wipe out a wild rice stand in a matter of days.

Fourth, during the September harvest, if a frost occurs, the crop is lost. And if a storm with winds comes up, the rice can easily "shatter" and fall immediately to the ground or water. A whole crop can be wiped out within a day from either of these weather occurrences.

Finally, if a wild rice crop makes it from germination to harvest, the wild rice yield is meager compared to traditional white rice. While white rice harvests yield 4,000 to 6,000 pounds per acre, wild rice only yields 100 to 200 pounds per acre.

All of this makes wild rice a very special and valuable crop for northern Minnesota, one that the Carlton County SWCD is working with landowners to preserve and protect.

# Samuelson column: Take the plunge into water monitoring

Well, I did it. I took the plunge! The water's great and I aim to help keep it that way!

No, I didn't "literally" jump into the water, especially this time of year. But after thinking about it for several years, I decided that now was the time to put away "all talk, no action" and jump into being a citizen water monitor (CWM) volunteer. Join with me as I find out what being a CWM is all about.



Like with any job, especially volunteer work, you have to learn what and how to do it, where to do it, why it needs to be done and why you should do it. And the best people to learn from are the ones who have been or are currently doing that kind of work. So I went searching for CWMs to answer my four questions.

To answer my first question: Why does monitoring work need to be done?

I started with Melanie Bomier, water resource technician at the Carlton Soil and Water Conservation District. Bomier has done water monitoring for several years through grants received by the SWCD. She has also trained and directed CWMs.

To answer the question of "why," Melanie said: "Citizen monitoring is so important because it helps us understand lake and stream trends.

"We usually only have grants to monitor a lake or stream for a couple of years and may not have another opportunity to monitor it again for another 10 years," she said. "In the meantime, we might be working on projects to improve water quality or find that major changes are happening in the watershed, but it's hard to know what effect these changes are having without the monitoring data."

Byron Kuster, a resident on Coffee Lake, south of Moose Lake, has been a CWM on that lake for four years. A licensed teacher of physics and chemistry, Kuster monitors "to see what changes happen with the lake. If all of a sudden there were differences, it would indicate something is going on."

Torina Stark, a CWM monitor on the Nemadji River and Rock Creek, added that "the MPCA (Minnesota Pollution Control Agency) relies on data from citizen water monitors all over the state to gauge the health of our water systems and determine what needs to be studied further."

This brings us to the second question: What do CWMs do and how do they do it?

For over 40 years, MPCA has recruited and worked with CWM volunteers and they have set up a simple and easy system. CWMs don't need experience or training. MPCA provides the volunteers with everything they need except for the bucket or the boat.

Those who monitor lakes will need access to a boat, canoe or kayak. Those who monitor streams or rivers will do their work from the riverbank or a bridge crossing, usually using a bucket to collect water.

If they are volunteering on a grant project, the CWM may have to take samples of water and deliver them to a location where they will be delivered to a testing site. However, most CWMs are simply asked to conduct water clarity tests once a week, or at least twice a month, from the end of April to the end of September.

Third: Where are CWMs needed? According to the MPCA website, there are over 400 CWM volunteers monitoring over 500 stream sites in Minnesota. Most of us who live in Carlton County live within a short distance from one or more water bodies.

Finally, why should you, or I, do water monitoring?

Kuster continues CWM work because "I'm measuring the water quality on the lake I live on. It takes minimal effort to have some basic data on this lake."

That answers my questions! I will be heading to the river soon and will get my family involved in helping me monitor.

Melanie, Byron, Torina and I, along with hundreds of CWMs around the state, invite you to get out and "take the plunge." The water in Carlton County is great!

*Kim Samuelson is Carlton Soil and Water Conservation District's elected supervisor for District 4.*

*For more information about the Citizen Water Monitoring program, contact Melanie Bomier, Carlton SWCD water resource technician, at 218-384-3891, or visit pca.state.mn.us/water/about-programs.*

*For more information about Carlton SWCD, go to facebook.com/CarltonSWCD or carltonswcd.org.*

# Samuelson column: Finding gems in the swamp

Just about everyone values spending time in nature, enjoying the flowers and trees around us, the rivers, lakes, waterfalls, cliffs and valleys. Most, however, don't like wetlands, what many call the "swamp."

"Swamp" is a word that conjures up negative thoughts and feelings. A place filled with dirty, dank, dark water. An area that is almost impassable and can literally suck your shoes right off. That swampy place where tons of much-hated mosquitos and swamp critters live and breed. A scary place full of the maybe "dangerous" unknown.

Most landowners consider wetlands as useless areas they have to mow or drive or plow around, the soggy areas that make their work harder and take longer. Many want to fill in and actually do something with these wetland areas. And over the years, to the detriment of our ecosystem, many acres of wetlands have been filled in and used for something.

However, the truth is that most don't know wetlands are some of the most important and productive ecosystems in the world. Thankfully, wetlands are finally being recognized for what they are and what they do, and efforts are being made to preserve wetlands and recreate them in areas where they were removed and are now needed and important.

According to Alyssa Alness, conservation technician with Carlton Soil and Water Conservation District (SWCD), "Wetlands play a very important role in our water quality. Protecting and enhancing wetlands is one of the most challenging and rewarding parts of my job." The following information will hopefully give you an understanding of how important wetlands are and why we need to protect them.



In the U.S., wetlands (also known as riparian wetlands, estuaries, bogs, marshes and swamps) are defined as "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions."

What does that mean? Simply put, wetlands don't always have to be wet, but do need to consistently have periodic saturation to support the soggy soils, water-loving plants and animal life that depend on these wetland conditions.

Each wetland area is different from the others. Each has its own unique ecosystem, its own complex relationship between the immense variety of species of microbes, plants, insects, amphibians, reptiles, birds, fish and mammals that live in that particular place under those particular conditions (taking into account the climate, shape of land, geology, amount and movement of water, etc.).

## Just what exactly do wetlands do?

An open water wetland near the headwaters of the Nemadji watershed. Some wetlands are big like this one, but there are many small ones that are less visible. (Photo courtesy of Kim Samuelson)

Here are six "pictures" of the major benefits of wetlands that may make it easier to remember the benefits of wetlands.

**First**, one of the most important jobs and benefits of wetlands is their ability to act as "kidneys" for the surrounding landscape. This means that the soils, vegetation and aquatic life in wetlands naturally improve water quality by filtering water and absorbing nutrients and contaminants. Wetlands work hard by "removing nitrogen, phosphorus, and other pollutants before they enter a nearby lake, river, or, most importantly, our groundwater," commented Alness. Wetlands are important in keeping our water clean and safe for drinking, bathing, and swimming. In fact, once acre of wetlands can filter about 7.3 million gallons of water every year!

**Second**, wetlands store water in their watersheds, acting like "sponges" that trap and then slowly release surface water, rain, snowmelt and floodwaters.

"Wetlands play an important role in providing a place for water to flow and be stored during our large rain events," like the floods that Carlton County has seen the last few years, Alness said. The trees, roots and vegetation in wetlands slow the speed of floodwaters and distributes them more slowly onto the floodplain. This combined action of storing water and slowing it down can greatly lower the height of floods.

This is especially important in urban areas where wetlands are very valuable in helping to control the increased rate and volume of surface runoff from buildings and pavement during high rainfall or snowmelt conditions. Unfortunately, many urban wetlands have, through the years, been drained or filled. In many cases, in order to control flooding, communities have had to pay for expensive dredge operations or to construct man made dikes and/or levees.

**Third**, and also related to flood control, is that wetlands act as "brakes" in controlling or eliminating erosion. Rapidly moving waters in floods are the biggest cause of erosion on land and along shorelines, and erosion is the biggest cause of increased silt that degrades our rivers, streams and lakes and reduces the habitat for aquatic animals and fish. By "braking" or slowing down the impact of flood waters, wetlands are a key player in the work of erosion control.

**Fourth**, wetlands are "life centers" for fish, waterfowl and wildlife. Many species depend on wetlands for not only their water, but also their food and habitat. The shallow water, organic matter, and high levels of nutrients are ideal for the development of the organisms on the bottom of the food chain.

"You wouldn't think it," Alness said, "but the water is teaming with tiny organisms that so many species rely on for a food source."

These organisms then become food for the upper levels of insects, shellfish, and small fish, which in turn become food for amphibians, reptiles, larger fish, birds, waterfowl, and other wildlife, especially during migrating and breeding times. Wetlands along migration routes are so important that an international agreement to protect these wetlands is in place. Many migratory birds are completely dependent on these wetlands that, if destroyed, could cause these birds to become extinct.

In fact, the reduction and destruction of wetlands around the U.S. have put many animals on the threatened and endangered list. Over half of the animals on these lists use wetlands at some point in their lives, and more than a third of them live only in wetlands. In addition, a third of all endangered plants are also dependent on wetlands.

There are many fish, birds and animals that need wetlands to breed and raise their young, including ducks, geese, woodpeckers, hawks, and songbirds. Many more wildlife need wetlands for a major part of their food and habitat. Some, like wood ducks and muskrats, can only live in wetlands. Others, like the black bear, raccoon, deer, otter, peregrine falcon and striped bass, need the wetlands to provide most of their water, food and shelter. There is even one mammal, the beaver, that will create its own wetlands!

**Fifth**, wetlands are important "one-stop shops" for mankind. We harvest a wealth of natural products from wetlands, including fish, shellfish, blueberries, cranberries, wild rice, and timber. Many commercial and recreational fishing and shellfishing industries harvest fish and shellfish that depend on coastal wetlands and marshes. Wetlands are also important for those who hunt waterfowl and those who trap muskrats, beaver, and mink. In addition, some of our medicines are made from wetlands soils and plants. All of these products are not only much needed for human life, but also very important for the local economy.

**Lastly**, wetlands are a "playground" for many people. From bird watching to hiking, hunting to fishing, photography shoots to artistic pursuits, wetlands are filled with a vast variety of colors, textures, sights, smells, and sounds. Wetlands are very valuable for the recreational and aesthetic opportunities for everyone brave enough to explore them.

A forested wetland just upstream of Lac La Belle. These areas are often undervalued "swamps," but are essential in protecting water quality by holding back pollutants and slowing the flow of water. (Photo courtesy of Kim Samuelson)

"One of my favorite landscapes to explore are wetlands," Alness said. "The diverse plant and animal communities are so unique. Quite a few of these species are extremely rare. The identification of an orchid, whose seeds are literally as small as a particle of dust, or the spotting of the tiny marsh bird, yellow rail, is like Christmas!"

Wetlands, contrary to what many believe, are not bad, scary places filled with swamp creatures that rise out of the muck. They are, in fact, among the hardest-working, productive, beautiful and diverse ecosystems in the world. Visiting a wetlands is equal to visiting a mini-rainforest or coral reef.

"Getting a landowner excited about the wetland on their property is so rewarding," Alness said. "Quite a few folks don’t realize they have a 'gem' on their property."

The Carlton SWCD urges you to get out and explore your local wetlands. And we encourage landowners to work with us to prevent our important and precious wetlands from being destroyed and filled in.

Our county's wetlands are very useful and well-worth preservation and appreciation.

*Kim Samuelson, the elected supervisor for Carlton SWCD's District 4, encourages you to contact the SWCD for information and assistance regarding wetlands on private lands, which are regulated under Minnesota's Wetland Conservation Act and administered in Carlton County by the Carlton SWCD in conjunction with Carlton County Zoning and the City of Cloquet. You can reach the SWCD at 218-384-3891, through the Carlton SWCD Facebook page or at carltonswcd.org.*