Cedar Lake
Lake Management Plan

July 2013 (Draft)

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Grant Support	Wisconsin Department of Natural Resources
Plan Writing and Facilitation	Harmony Environmental
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Introduction

This comprehensive lake management plan establishes strategic direction for Cedar Lake. The Cedar Lake Protection and Rehabilitation District (the Lake District) initiated the project with guidance from the Wisconsin Department of Natural Resources (DNR). Lake and community residents representing a variety of civic groups, local governments, and businesses made up the Advisory Committee. A Lake Protection Grant from the DNR funded the lake study and a Lake Planning Grant partially funded the lake management plan development. The Lake District provided remaining funding.

Cedar Lake has been on the Wisconsin list of impaired waters since 1998 because of high total phosphorus levels. Phosphorus leads to heavy growth of algae in the lake. Impairment of recreation uses was added to the list of water quality impairments for Cedar Lake because of excess algae growth in 2012. This plan includes management efforts to address lake impairments.

Plan Scope

The plan presents information about Cedar Lake water quality, fisheries, aquatic plants, and the available lake management methods. The lake is part of the Wisconsin Department of Natural Resources Long Term Lake Trend Monitoring Program. As a result, the DNR gathered information about fisheries, aquatic plants, and water quality regularly over the past several years. Extensive new information gathered as part of this planning process included lake and tributary water quality testing and analysis, estimates of pollutant loading from the watershed and lake sediments, and lake water quality response modeling.

The plan is intended to meet EPA requirements for watershed planning for impaired waters. It is also written to meet WDNR requirements for lake management planning to establish eligibility for Wisconsin Lake Protection Grants. The planning period is from 2014 through 2023. Results of ongoing evaluation and monitoring and availability of new management information will likely lead to adaptations in plan actions as the plan is implemented.

The Advisory Committee identified priority issues of concern, and recommended management actions to address these issues.

Understanding the Plan

For those unfamiliar with lake management, Appendix B. *Understanding Lake Information* is highly recommended reading. The glossary in Appendix D will also help with understanding of unfamiliar terms.

Cedar Lake 2020 Future Vision

Cedar Lake is a healthy lake that provides clear water, excellent aquatic and nearshore fish and wildlife habitat, and quality recreation.

The Cedar Lake Management Plan guides an active Protection and Rehabilitation District Board and a broad range of partners.

Lake and watershed residents and lake visitors practice good lake and watershed management.

Lake Management Goals

The following goals will guide management efforts for Cedar Lake.

Goal 1. Prevent the introduction of aquatic invasive species and effectively manage those introduced into the lake.

Goal 2. Achieve and maintain clear water throughout the summer.

Goal 3. Maintain a high quality sport fishery in Cedar Lake.

Goal 4. Protect and improve near shore habitat both in the water and on the land.

Goal 5. Balance recreational uses so that residents and lake users can enjoy the natural benefits Cedar Lake provides.

Cedar Lake Protection and Rehabilitation District

The Cedar Lake Protection and Rehabilitation District is a special unit of government formed under Chapter 33 Wisconsin State Statutes. Property owners living within the district boundaries may be assessed fees as part of the property tax levy. The lake district addresses lake management issues. Lake districts can act together with other municipalities, agencies, and organizations to undertake lake protection and rehabilitation projects. This plan seeks partnerships between the lake district and other organizations for plan implementation.

Needs Assessment

Concerns of Lake Residents

Concerns of lake residents were gathered in a variety of ways. These included a public opinion survey, Advisory Committee meetings, the annual lake district meeting, and public draft plan review.

Public Opinion Survey

A lake property owner survey was distributed in early March 2013. As of April 3, 2013, 159 out of 298 surveys were completed and returned, a return rate of 53%. The results of the survey are discussed below and are found in Appendix A. The degree of participation in lake activities is summarized in Figure 1 below. Relaxing and observing wildlife are the most frequent lake activities followed by motor boating, swimming, and socializing at the sand bar.

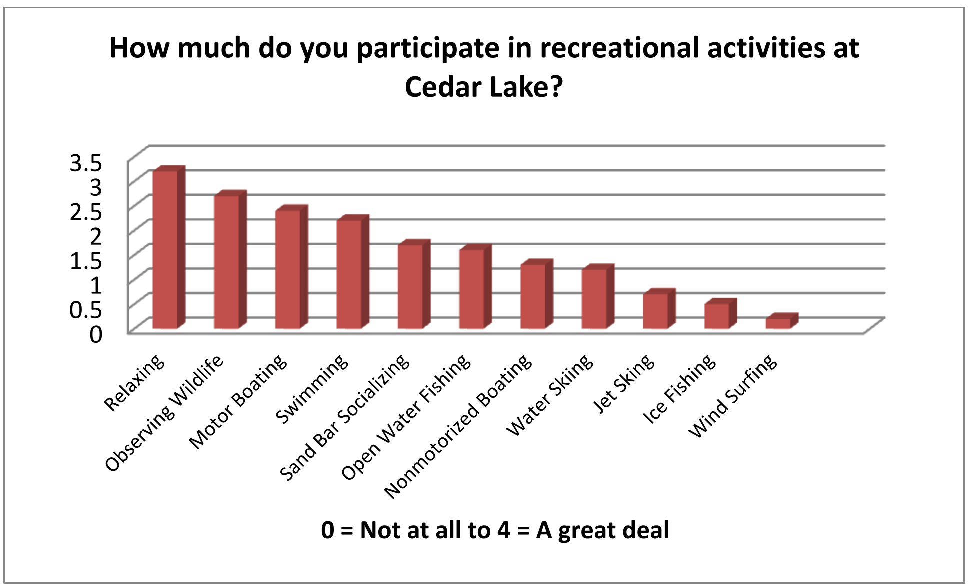

Figure 1. Survey Response: Recreational Activity Participation at Cedar Lake

Additional survey results indicated a range of concerns and priorities from lake residents. The top problems related to owning waterfront property identified in the survey were lack of water clarity in front of owner's property, potentially toxic algae blooms, protecting the lake environment, and maintaining the investment value of property. These all rated as having a medium to large impact as shown in

Figure 2. Algae growth clearly ranked as having the highest negative impact on lake use (Figure 3).

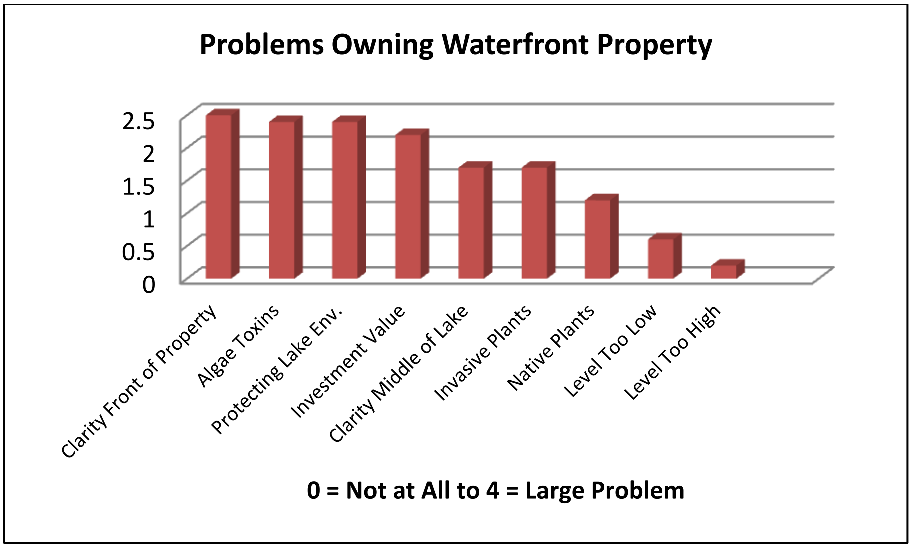

Figure 2. Survey Response: Problems Owning Waterfront on Cedar Lake

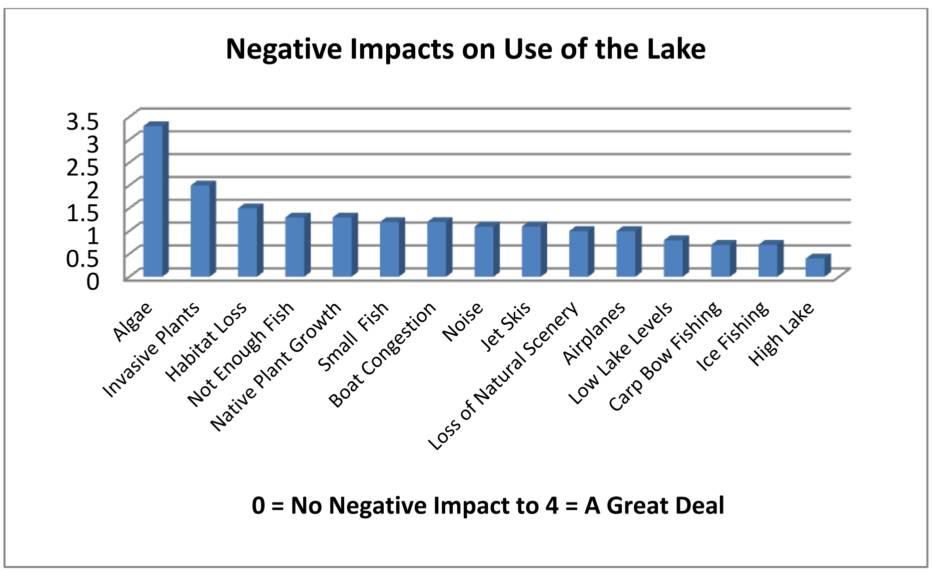

Figure 3. Survey Response: Negative Impacts on Use of the Lake

Lake Management Plan Advisory Committee

The Advisory Committee met four times in May and June 2013 to identify lake management concerns, learn more about priority lake issues, and to develop lake management goals, objectives, and actions.

The Advisory Committee priority concerns are reflected in the goals and objectives in this plan. The committee considered the survey results and developed the plan goals.

Public Review

The draft plan will be made available for public comment on the web site: cedarlake-wi.org beginning July 15, 2013 with comments accepted through August 3, 2013. The lake management plan will be discussed at the Lake District annual meeting on August 3, 2013.

Lake District Plan Approval: .

DNR Plan Approval: .

Lake Overview

Cedar Lake is located in the Lower Apple River Watershed within the St. Croix River Basin. The lake spans the town of Alden in Polk County (S34 and 35, T32N, R 18W) and the town of Star Prairie in St. Croix County, WI (S2 and 3, T31-32N, R18W). Its water body identification code is 2615100. It is a 1,118 acre lake with a maximum depth of 34 feet. Cedar Lake is a drainage lake with Horse Creek flowing into the lake at the north end and Cedar Creek flowing from the lake in the southeast corner. A map of the lake is included as Figure 5.

A dam on Cedar Creek maintains the lake within a required level through the use of four aluminum stop logs. The lake level is held at 96.62 feet (maximum 97.15 feet) by order of the Wisconsin Department of Natural Resources. All stop logs are removed between November 1 and 15 to prevent shoreline ice damage in the winter. (WDNR 1987)

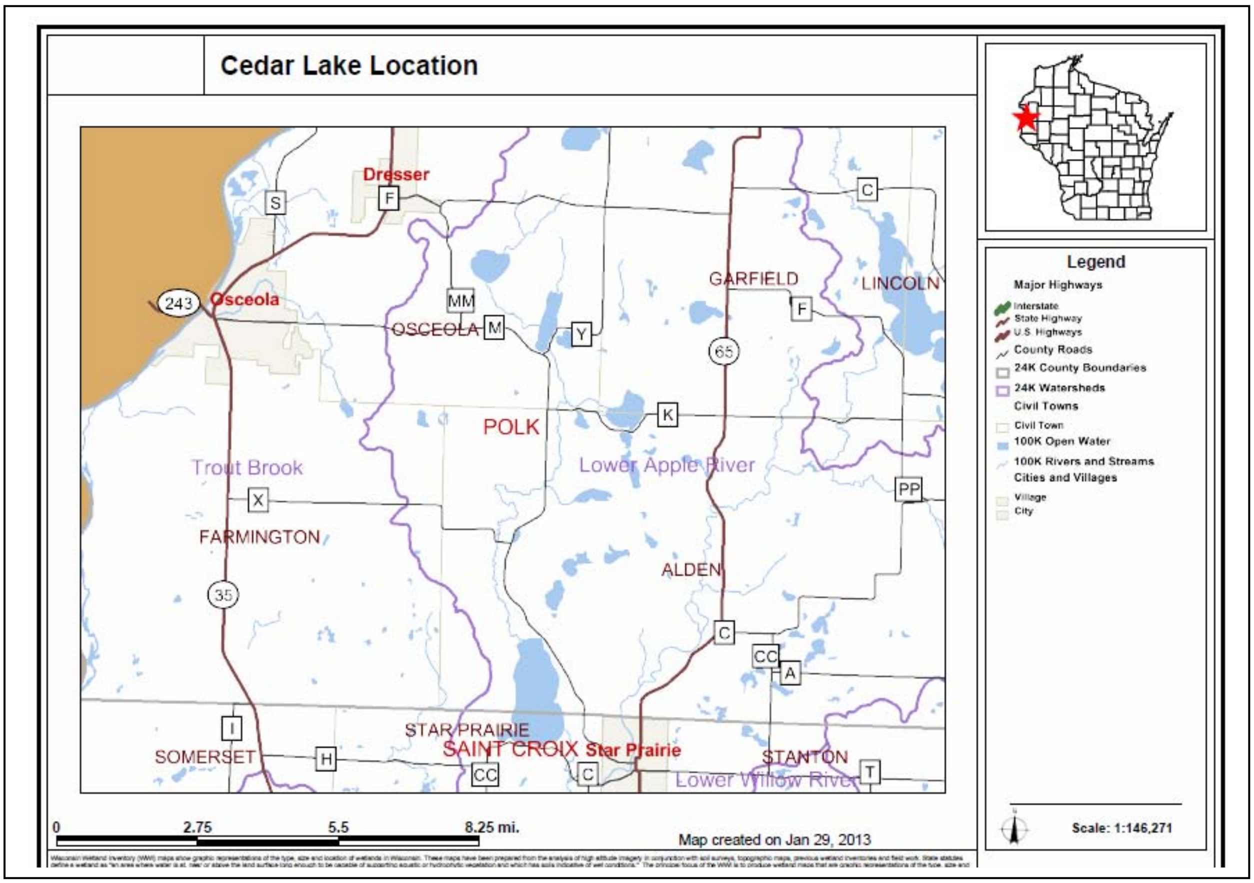

Figure 4. Cedar Lake Location

Table 1. Cedar Lake Characteristics

Surface Area	4,522, 767 m^2	1,118 acres
Volume	25,235,867 m^3	20,459 acre feet
Mean Depth	5.78 m	18.96 feet
Maximum Depth	10.4 m	34.12 feet
Maximum Fetch	3.5 km	2.17 miles

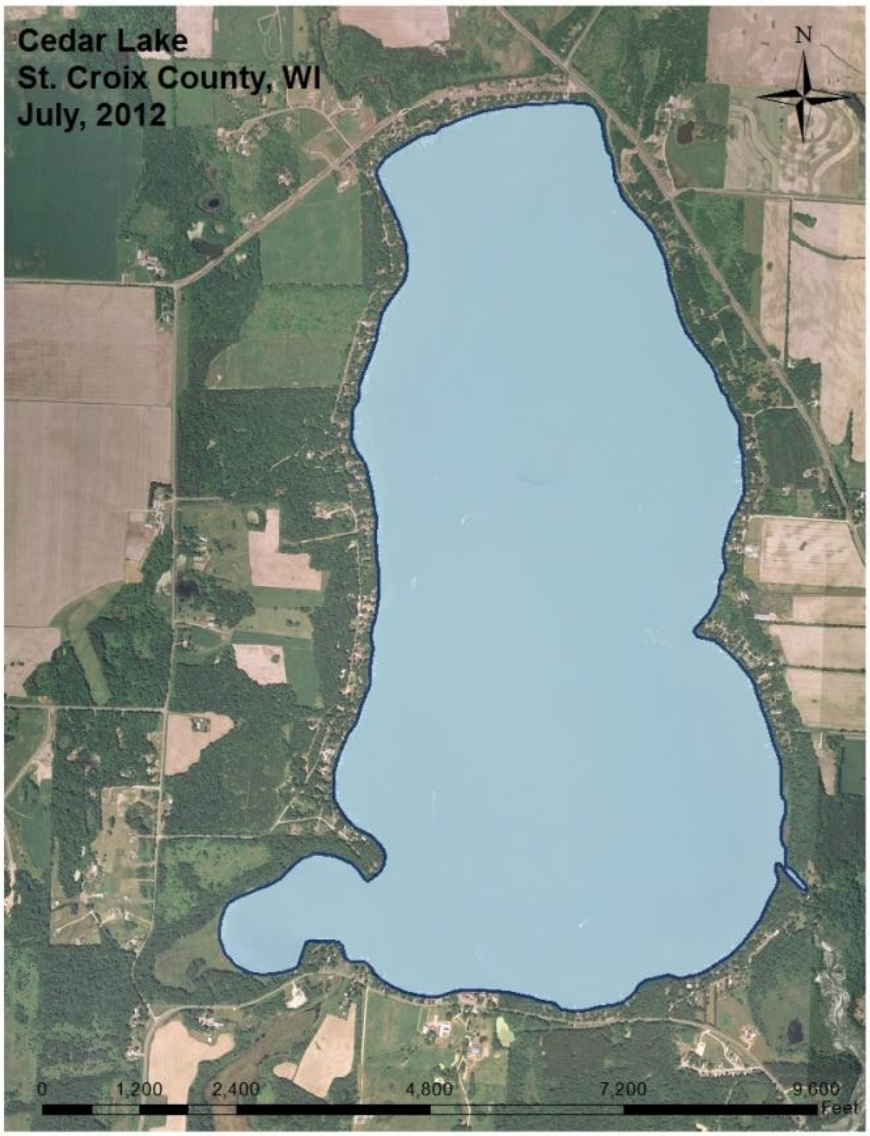

Figure 5. Cedar Lake Map

Historic and Current Lake Use

Lake sediment cores provide historical information about land use and impacts to the lake from these uses over many decades. A sediment core was collected from Cedar Lake in June 1997. The core was dated, and the sedimentation rate was analyzed. Sediment increased as the area was plowed for agriculture in the late 1800s. After a subsequent decline, sedimentation rates again increased beginning around 1960 through 2000. From 1980-2000, potassium increased more than aluminum indicating an increase in the use of commercial fertilizers. Increased phosphorus in sediments over the years is probably from both increased loading from the watershed and increased internal loading from the lake sediments (Garrison 2002).

Cedar Lake algae blooms have been documented since the 1930's. Copper sulfate was used on the lake since the 1940's to provide short term relief of nuisance algae blooms. (Sorge May 1989).

Changes in the lake environment have led to some changes in recreational use. One major change in the lake is the complete lack of emergent vegetation. Historically, there were small isolated patches of emergent vegetation found around the shoreline - particularly in the southwest corner of the lake. Previous attempts to plant emergent vegetation have been unsuccessful (Lepsch March 2013). Loss of aquatic plant beds, loss of bulrush stands, and removal of woody debris result in loss of fish habitat in Cedar Lake. Introduction of carp and white bass has also displaced native fish species (Engel 2009).

There are three public and one private location where the public has access to the lake. The north access parking lot is owned by the Department of Natural Resources and the boat ramp itself is owned by the Town of Alden. The DNR purchased the Cedar Lake School and parking area in 2011. The Cedar Lake Community Club has an agreement with DNR to use the building for 5 years from 2011 with an option to renew for 5 years. The Town of Alden formally agreed to operate and maintain the boat ramp and parking area through 2030.

The Star Prairie Land Preservation Trust owns the South Cedar Bay Landing where there is parking, but access is for non-motorized boats only. The Town of Star Prairie owns a winter access (just 4 lots west of the S Cedar Bay Access) with no parking available. Jackelen's is a private boat landing on the south end of the lake. No wake areas are established on the lake including in the south bay.

Fishing tournaments have been popular for many years on Cedar Lake. Meister's Bar and Restaurant sponsored ice fishing tournaments in the 1950's and 60's. The New Richmond Athletic Department sponsored tournaments in recent years. The Indianhead Bassers have an annual tournament on the lake. While heavy algae growth tends to limit lake use, pontoon boating, fishing, personal watercraft use (i.e., jet skis), kayaking, and water skiing are popular lake activities.

Water Quality Information

Cedar Lake is eutrophic to hypereutrophic with summer algae blooms that result in odors and unsightly build up of algae along the shorelines. The lake is phosphorus limited meaning it is the concentration of phosphorus which controls the level of algae growth.

Lake sediments release phosphorus when oxygen levels decrease at the lake bottom. The lake periodically mixes with high summer winds and cool conditions bringing phosphorus-rich water to the surface and increasing algae growth. In addition to this internal loading of phosphorus, phosphorus input to the lake comes from the watershed, direct rainfall, and groundwater.

Previous Lake Studies

The Department of Natural Resources completed a variety of water quality studies and management plans to increase understanding of the water quality of the lake. Summaries of previous studies are included in Appendix C.

Lake Self-Help Monitoring Results[1]

Secchi depths have been collected on Cedar Lake since 1986, and July and August averages are reported in Figure 6 below. Secchi depths measure water clarity. The Secchi depth reported is the depth at which the eight inch black and white Secchi disk is no longer visible when it is lowered into the water. Greater Secchi depths occur with greater water clarity. Cedar Lake has had relatively poor summer water clarity ranging from an average of 2 to 6 feet for many years.

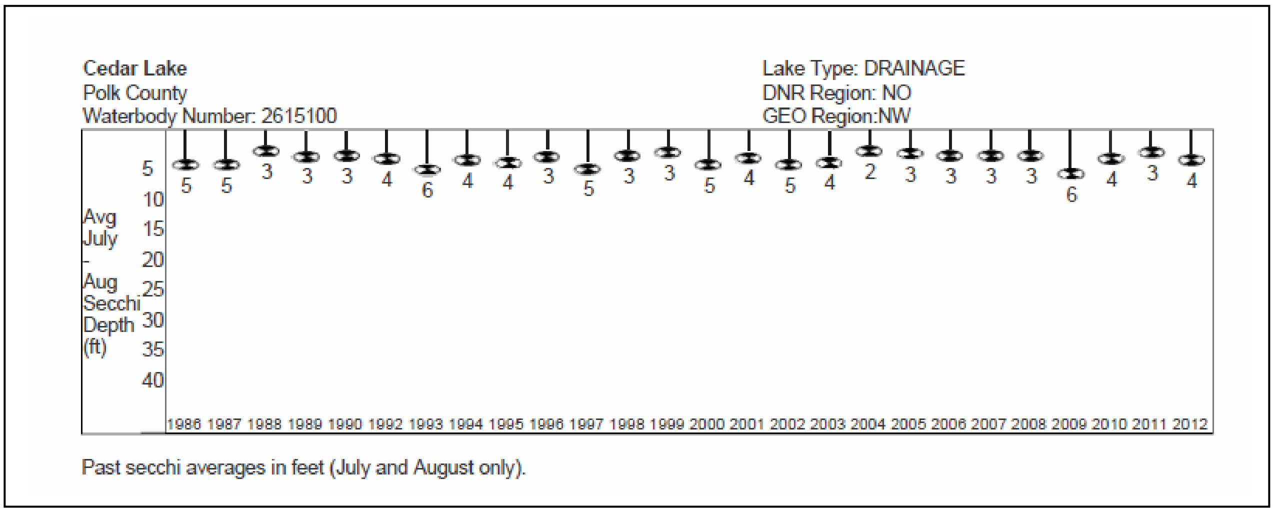

Figure 6. Cedar Lake July and August Secchi Depth 1986 - 2012

Water quality measures using trophic state indexes (TSI) calculated from secchi depth, chlorophyll (a measure of algae growth) and total phosphorus are shown in Figure 7. TSI values are generally in the eutrophic to hypereutrophic range. This shows that Cedar Lake is a very productive lake with heavy algae growth. For more information about trophic state indexes see Appendix B.

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[1] Wisconsin Department of Natural Resources. Citizen Lake Monitoring Data. http://dnr.wi.og/lakes/CLMN/

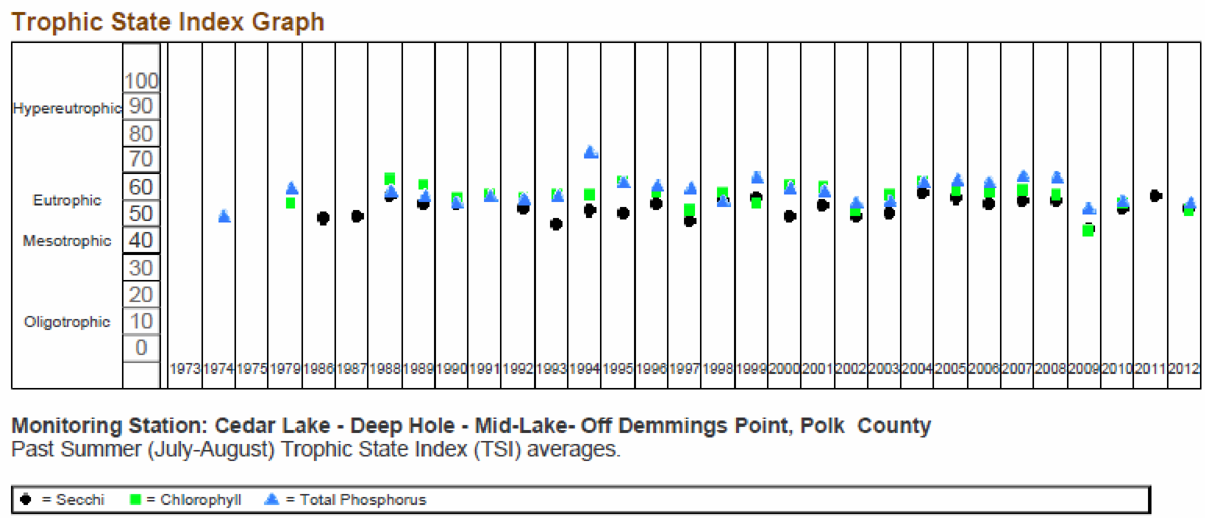


Figure 7. Cedar Lake July and August Trophic State Indexes 1974 to 2012

Blue Green Algae

Blue green algae (or cyanobacteria) are of concern because algae blooms can produce neural and liver toxins that may be harmful to human and animal health. Algae blooms can occur at any time during the growing season, but are most common in late summer. Blooms can look like foam, scum, or mats that float on the surface of the water, but some blooms are present as a thick "pea-soup" without a scum layer. The scum layer can be blue, bright green, brown, or red. Human and animal exposure may result in breathing problems, ear and eye irritation, vomiting or skin rashes. Pets, livestock or wildlife such as birds and fish can also be sensitive to blue green algae toxin exposure. Individuals with suspected exposure should seek medical attention (http://dhs.wisconsin.gov/eh/bluegreenalgae 2009).

Cyanobacterial toxins are classified as neurotoxins and hepatotoxins. Neurotoxins are produced by *Anabaena* and *Oscillatoria* species. Symptoms of exposure include muscle cramps, twitching, paralysis, cardiac or respiratory failure, and death in animals. Hepatotoxins are produced by *Microcystis* and *Cylidrospermopsis* species (Cyanobacteria and Human Health June 2004). *Gloeotrichia* species produce toxins that can cause skin irritation and liver damage (King 2005).

Cyanobacteria overwhelmingly dominated algae abundance in Cedar Lake during the summers of 2009-11. They were most abundant during the fall turnover period in mid-August through September when potential toxin-producing species dominated.

Established World Health Organization guidelines for actions at various cell densities of cyanobacteria are reported in Table 2 below.

Table 2. Summary Table of WHO Guidelines for Cyanobacteria Levels in Water

Risk Category	Cell Density (cells/mL)	Action Recommended
Low	20,000 – 100,000	None
Moderate	>100,000	Advisory and Possible Closure
High	Visible Scum Layer	Closure

Watershed

The Horse Creek watershed is 140 km^2 (54 mi^2). It has gently rolling terrain. Upper reaches of the watershed contain numerous small lakes that are not connected by streams to Cedar Lake. This internally drained area makes up 41 percent of the watershed (57 km^2 or 22 mi^2). Internally drained areas tend to be further away from Horse Creek. They are illustrated in Figure 10 with bright green shading. High retention areas (in yellow) hold water in ponds or small lakes, but flow over during high water periods.

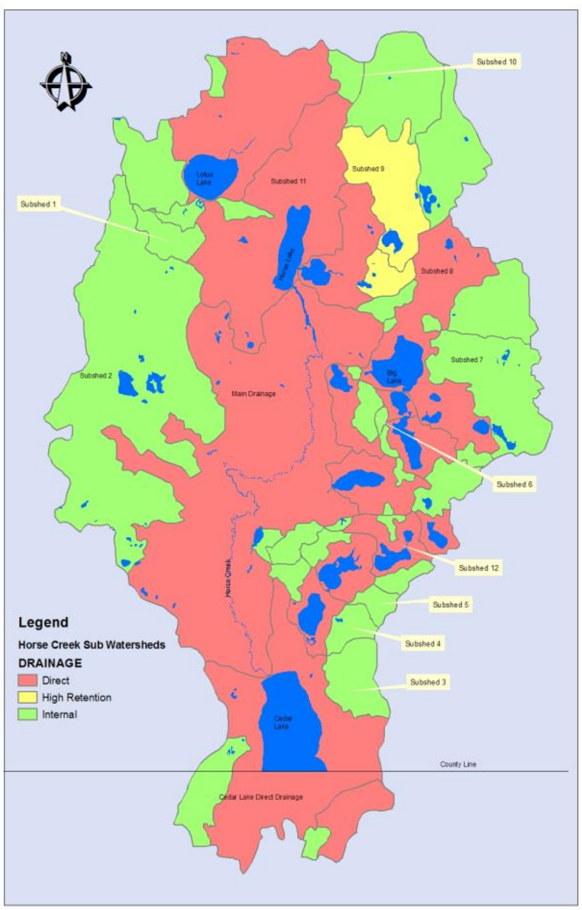


Figure 8. Horse Creek Subwatershed Drainage (Wojchik 2013)

Within the watershed direct drainage and high retention areas, land cover is mostly forest, grassland, open water and wetlands (66%). These land covers generally deliver low levels of pollutants in runoff to lakes and streams. Row crop and forage (hay) fields account for 34% of the land cover (Horse Creek Priority Watershed Nonpoint Source Pollution Management Plan 2001). Within the Horse Creek main drainage only, cropland covers 51% of the land. In the Cedar Lake direct drainage only, crop fields cover 28% of the land. Because of soil disturbance and fertilization, these land covers tend to generate higher levels of pollutants to lakes and streams than undeveloped land.

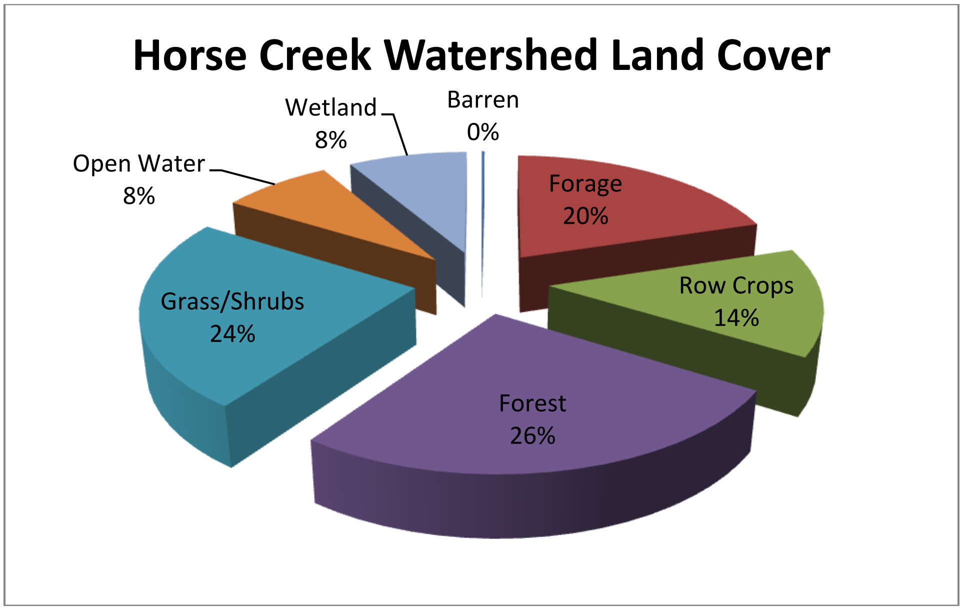


Figure 9. Horse Creek Watershed Land Cover

There are six known active dairy farms within the watershed and a few additional small operations. Small hobby beef and horse operations are also present. (Wojchik 2013)

Horse Creek Priority Watershed Appraisal

The amount of phosphorus that is contained in runoff as estimated for the Horse Creek Priority Watershed Appraisal is included in Table 3 below. Calculated cropland phosphorus export rates varied with manure applications, length and steepness of slope, and distance to channelized flow. The water quality appraisal estimated a total phosphorus load to Cedar Lake of 3,200 kg (7,040 lbs.). The historic load prior to development was estimated to be 957 kg (2,106 lbs.).

Table 3. Phosphorus Export Rates by Land Use (Cahow 1999)

Land Use Type/Source	**Phosphorus Export Rate (kg/ha/year)**	**Phosphorus Export Rate (lb/ac/year)**
Cropland	0.5 – 2.10	0.45 – 1.9
Pasture/grassland	0.3	0.3
Farmstead	0.8	0.7
Rural Residential	0.4	0.4
Lakeshore Residential	0.5	0.45
Wetland	0.05	0.04
Woodland	0.1	0.09
Construction	4.0	3.7
Commercial	1.0	0.9
Atmospheric Deposition	0.3	0.3

Horse Creek Priority Watershed Plan

The Horse Creek Priority Watershed Plan identifies phosphorus sources to Cedar Lake as 80% agriculturally-related, 8% from disturbed lands, 6% from open space, and the remainder from miscellaneous land covers. The plan calls for a 15% reduction in watershed phosphorus. (Horse Creek Priority Watershed Nonpoint Source Pollution Management Plan 2001) This project ended in 2009. The watershed final report lists best management practices installed as part of the project. They included many agricultural practices such as nutrient management (over 5,000 acres), high residue management (over 1,300 acres), pesticide management (over 3,700 acres), gully stabilization in a farm field, and animal waste storage system abandonment (2). Unfortunately, measured soil erosion rates from crop fields (in tons/acre) increased over the course of the project. This was attributed to increased row cropping and decreases in acres planted to hay for dairy cattle. (Horse Creek Priority Watershed Final Report)

Water Quality Study

Study Purpose

The Department of Natural Resources and the Cedar Lake Protection and Rehabilitation District commissioned a comprehensive water quality study to estimate phosphorus loading from Horse Creek and Cedar Lake sediments. A water quality model was used to predict in-lake effects of management efforts. Bill James, University of Wisconsin Stout, conducted the water quality study with data gathered from 2009 through 2011 and analyzed data and reported results in 2012 and 2013 (James 2013). Information in text boxes is added to help understand the study results.

<u>The study included:</u>

- Weekly to bi-weekly grab samples in specific tributary locations below Horse Lake (County K) and above Cedar Lake (10^{th} Avenue). (2009 – 2011). (See map in Figure 10) Nutrients (nitrogen and phosphorus) were analyzed from these samples.
- Flow measurements of Horse Creek and Cedar Creek.
- Lake samples at 1 meter intervals between the lake surface and 0.2 meter above the lake bottom: analyzed nutrients, algal pigments (chlorophyll), and iron.
- Temperature and oxygen profiles assessed stratification and oxygen levels. Included years when the aerator was off (2009 and 2010) and on (2011).
- Secchi depths measured lake water clarity.
- Two models predicted in-lake effects from reducing watershed (external) and sediment (internal) phosphorus loads. This information helps to establish feasible water quality targets based on management efforts.
- Laboratory lake sediment studies assessed sediment characteristics, calculated alum dosage, provided treatment area options, and estimated costs.
- Identification of algae assemblage in lake surface waters (0-3 m) monthly.

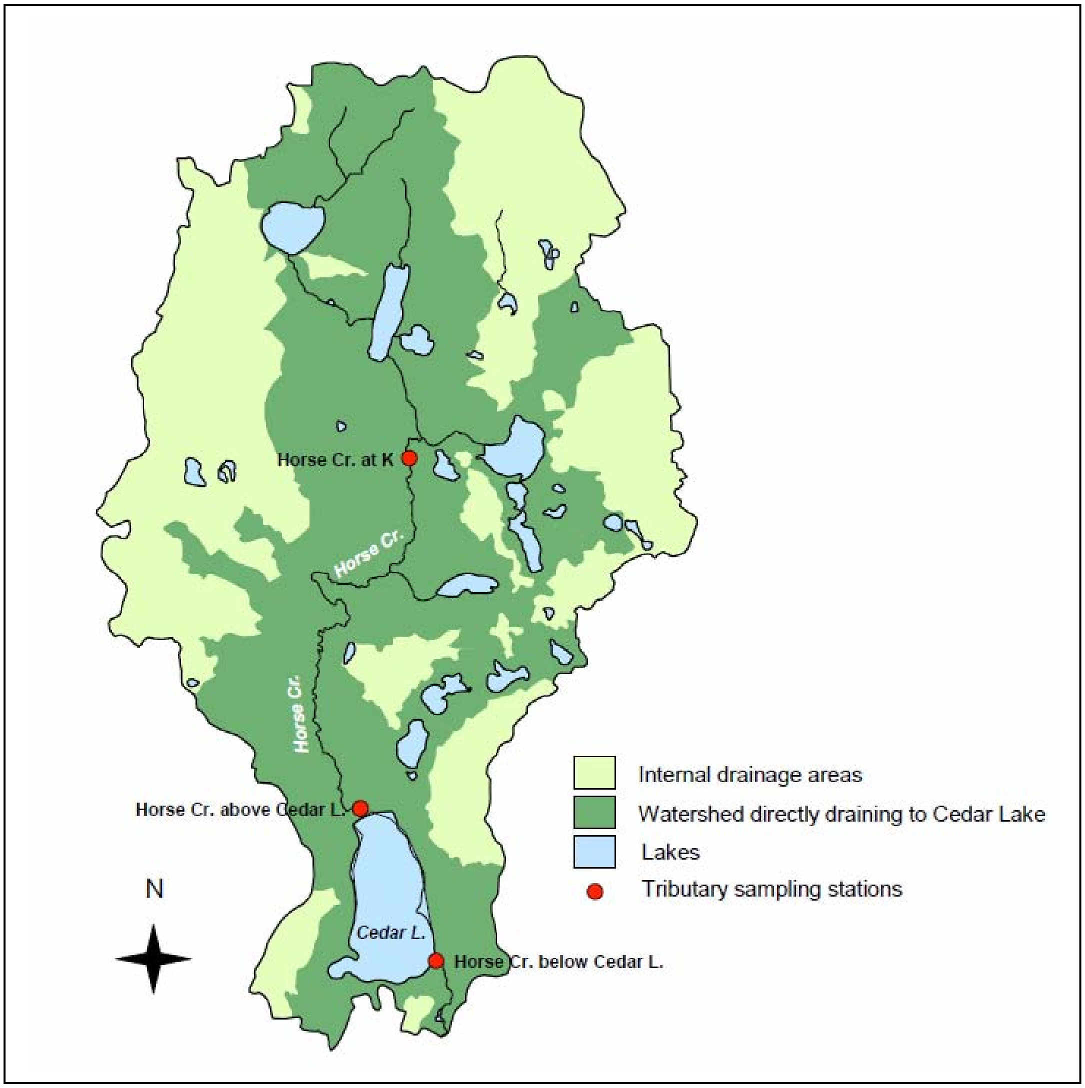


Figure 10. Tributary Sampling Locations

Nutrient Loading from Tributaries – External Phosphorus Load

> *Phosphorus was the focus of the water quality study because it is phosphorus which leads to algae growth in Cedar Lake and most lakes in the region. Analysis of other nutrients helps to identify the source of pollutants to the lake. Total phosphorus includes both dissolved (or soluble reactive phosphorus) and phosphorus attached to sediment particles and contained in algae. SRP or dissolved phosphorus is found in fertilizers and manures.*
>
> *Analysis of phosphorus in Horse Creek tells us what is coming from the watershed. We call this an external source of phosphorus because it comes from outside the lake.*

Total phosphorus (TP) (0.089 mg/L) and Soluble Reactive Phosphorus (SRP) (0.031 mg/L)[2] concentrations were high in Horse Creek above Cedar Lake (10th Avenue). In this location, SRP made up about 35% of the phosphorus load. Phosphorus concentrations were highest during snowmelt and spring and fall storms.

Much further upstream at County K below Horse Lake, TP concentration were similar, but SRP was much lower at 0.010 mg/L. Increases in SRP from County K to 10th Avenue suggest that TP may transform to SRP, phosphorus attached to particles may settle in the creek, and a net loading of SRP likely occurs from the watershed. The source of high nitrate-nitrogen in runoff to 10th Avenue is likely from agricultural sources such as crop fertilization in the watershed. Best management practices should therefore target these sources in the watershed below County K.

Cedar Creek, the outflow from Cedar Lake, generally had lower concentrations of total phosphorus than the inflow. This means that phosphorus is captured in Cedar Lake. The exception occurred in mid-August to September when lake phosphorus was especially high due to phosphorus release from lake sediments.

[2] Annual flow-weighted.

Nutrient Loading from Lake Sediments – Internal Phosphorus Load

Cedar Lake's sediments have accumulated for thousands of years. In the past 200 years, agricultural use has increased the nutrient levels of these sediments. Sediment increased as the area was plowed for agriculture in the late 1800s. After a subsequent decline, sedimentation rates again increased beginning around 1960 through 2000. From 1980-2000, an increase in the use of commercial fertilizers is evident. Increased phosphorus in sediments over the years is probably from both increased loading from the agricultural watershed and increased internal loading from the lake sediments (Garrison 2002).

When anoxia (low oxygen) occurs near the lake bottom, phosphorus is released from the lake sediment. If the lake water stratifies (forms layers of water based on temperature) this phosphorus is held in colder bottom layers. Mixing of a lake generally occurs in the spring and fall when lake temperatures equalize. During mixing, phosphorus held in bottom waters is brought to the surface. The lake can also mix due to aeration or high winds. In Cedar Lake, stratification was weakened when the aerator was turned on, so the lake mixed more readily and algae growth increased during summer months.

Algae growth (as measured by chlorophyll a) is highest in late August through October because mixing brings phosphorus-rich waters to the surface. Phosphorus then fuels algae growth.

Water at the bottom of Cedar Lake lacked oxygen at 6 meters (20 feet) and deeper in 2009 and 2010 when the aerator was off. This anoxia lasted about 47 days. In 2011, when the aerator was on, the bottom lacked oxygen beginning at 7 meters (23 feet) and lasted 36 days.

Even without the aerator, Cedar Lake is susceptible to mixing because it is long and narrow and relatively shallow. The aerator made lake mixing even more likely. Stratification, which prevents mixing, was strongest during 2010 when it was warm. In 2009 the lake mixed more frequently with the passage of summer cold fronts. Lake stratification was very weak in 2011 when the aerator was on. The lake mixed frequently bringing phosphorus to the surface in the 2011. Therefore, the aerator actually increased phosphorus loading.

Potentially toxin forming algae were highest in number during the fall turnover periods in mid-August through September.

Internal loading from lake sediments dominated phosphorus loading to Cedar Lake in all study years, contributing 60 to 90 percent of the summer and annual P loads to the lake.

Phosphorus Contributions to Cedar Lake

Contributions from the external and internal load varied each year with changes in temperature, precipitation, and wind. Estimates for overall loading to the lake in 2009 and 2010 when the aerator was not turned on are shown in Figure 11 below. In 2010, a year with nearly normal precipitation, the external made up about 34% and internal load made up about 66% of the annual phosphorus budget.

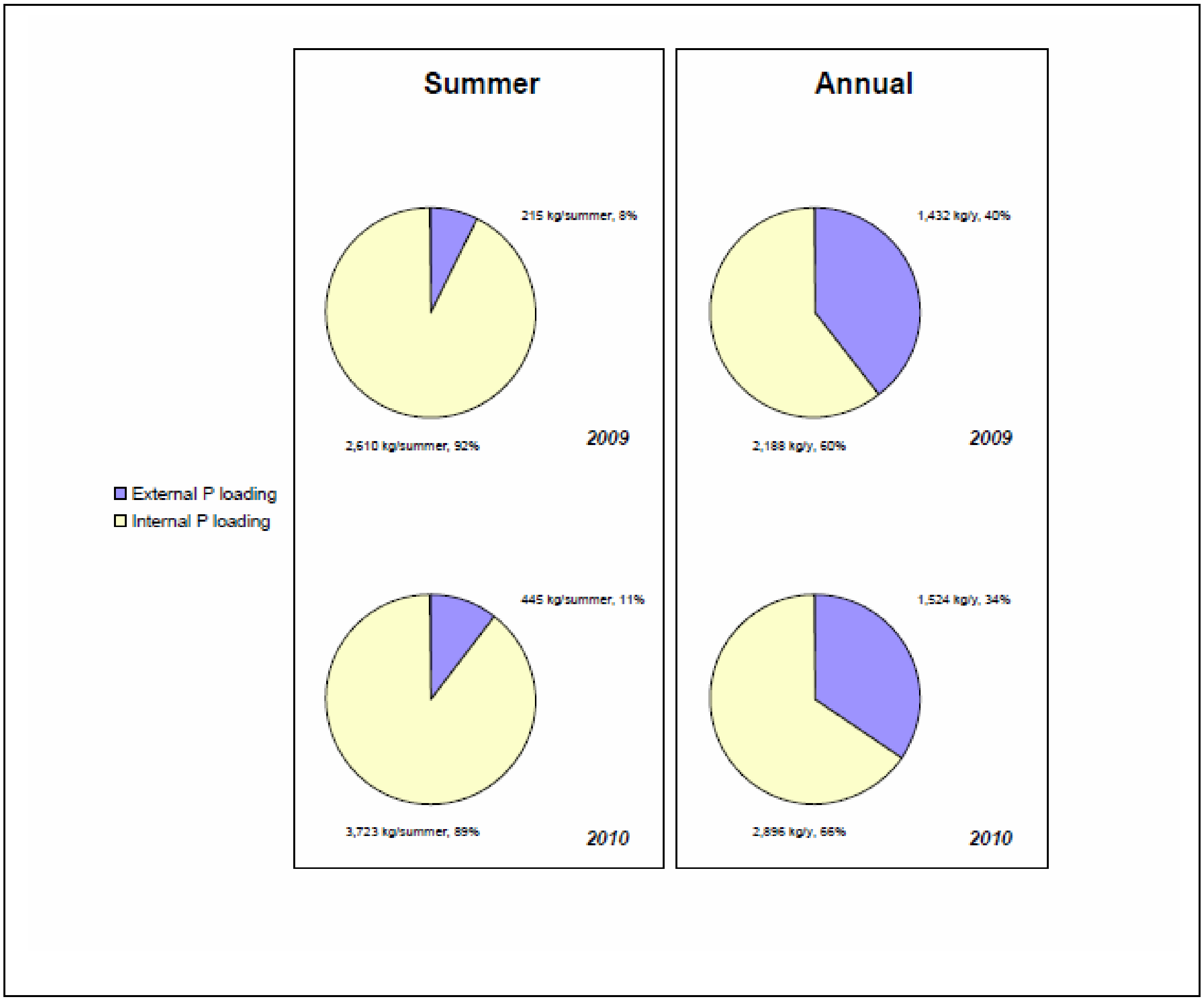


Figure 11. Cedar Lake Summer (June through October) and Annual Phosphorous Load Showing External and Internal Sources

Predicting Management Results

Water quality models are used to predict changes to in-lake water quality that result from management methods which reduce the internal and external phosphorus load to the lake. The study used Bathtub (1996) and Nurenburg (1998) models to make water quality predictions. The ranges shown below are a result of the two models used.

Lake water quality is measured in a variety of ways. This report focuses on the following:
TP - Total phosphorus concentration during the growing season;
Chla - Chlorophyll a concentration is a measure of the algae contained in the water column; and
Secchi depth – A measure of water clarity indicated by when the 8 inch black and white disc is no longer visible when lowered into the water.

<u>Measured Cedar Lake Conditions (2009-2010)</u>
Annual TP – 0.052 to 0.068 mg/L
Summer Chla – 27 to 39 ug/L
Nuisance Algae Bloom Frequency[3]: 31 – 55% of the summer
Secchi Depth (mean summer[4]): 1.6 to 2.4 meters (5.2 to 7.9 feet)

<u>Following 30% Reduction in Watershed P loading only</u>
Annual TP – 0.044 - .064
Summer Chla – 20 to 35 ug/L
Nuisance Algae Bloom Frequency: 22-47% of the summer
Summer Secchi Depth (summer)1.8 to 2.9 meters (5.9 to 9.5 feet)

<u>Following an Alum Treatment only</u>
Annual TP – 0.030 – 0.039 mg/L
Summer Chla – 12 – 17 ug/L
Nuisance Algae Bloom Frequency: 8 – 11% of the summer
Summer Secchi Depth (summer): 3.1 to 4.4 meters (10.1 to 14.4 feet)

<u>Following an Alum Treatment and 30% Reduction in Watershed P loading</u>
Annual TP - <0.030 mg/L
Chla - <13 ug/L
Nuisance Algae Bloom Frequency: < 5% of the summer
Summer Secchi Depth (summer): 3.9 to 5.7 meters (13 to 19 feet)

[3] Nuisance algae blooms occur when Chla is >30 ug/L.
[4] June through October

Recommendations

Controlling Internal Loading

Alum or aluminum sulfate can be used to effectively control the internal phosphorus load from lake sediments. More information is available in the DNR fact sheet (Alum Treatments to Control Phosphorus in Lakes 2003) *and Cedar Lake Alum Questions and Answers handout. Both are found in Appendix G.*

An alum treatment is recommended to bind phosphorus in the lake sediments. This is the top priority recommendation. External watershed P loads should be reduced for better results and to ensure the longevity of the alum treatment.

Figure 12. Alum Application at Half Moon Lake in Eau Claire, Wisconsin

Alum should be applied at rates from 100 to 130 g Al/m^2 based on the alum dosage studies. Further measurement of the alkalinity levels in the lake will establish what the maximum dosage can be. Alkalinity (calcium carbonate) helps to keep pH levels in a safe range.

The maximum concentration of alum should be applied at the 25 foot contour and deeper. Approximately 60% of the sediment area is greater than 25 feet. A lower dosage (100 g Al/m^2) could be used between the 20- and 25-foot contour (Treatment Scenario 1) or between 15- and 25-foot contour (Treatment Scenario 2). These two treatment scenarios are illustrated in *Figure 13* and *Figure 14*. The 15-foot depth represents the maximum extent of anoxia while the 20-ft depth represents the average depth on anoxia in the lake. Alum dosages are calculated based on the need to treat the upper 6-8 cm of sediment.

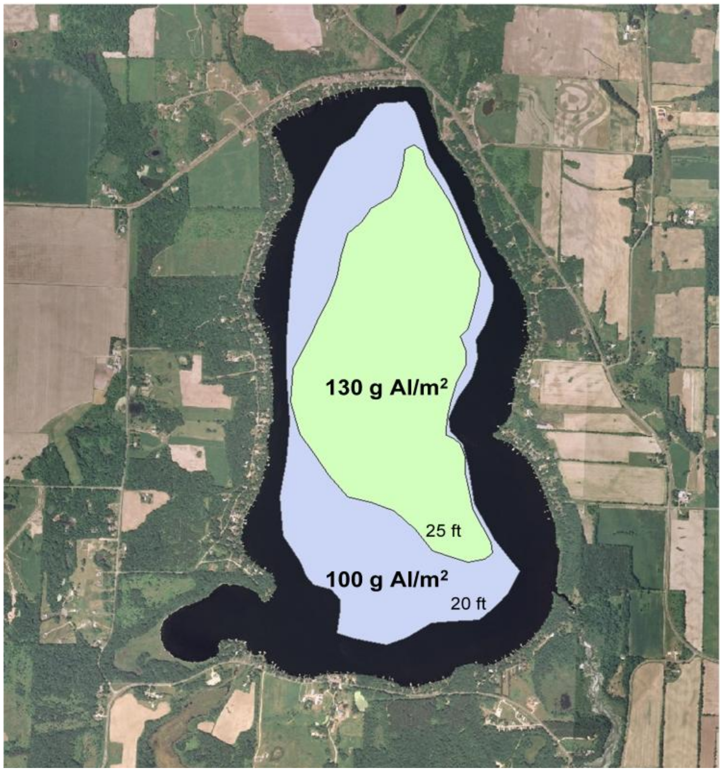


Figure 13. Alum Treatment Scenario 1: 130 g Al/m^2 to 25 feet and 100g Al/m^2 to 20 feet

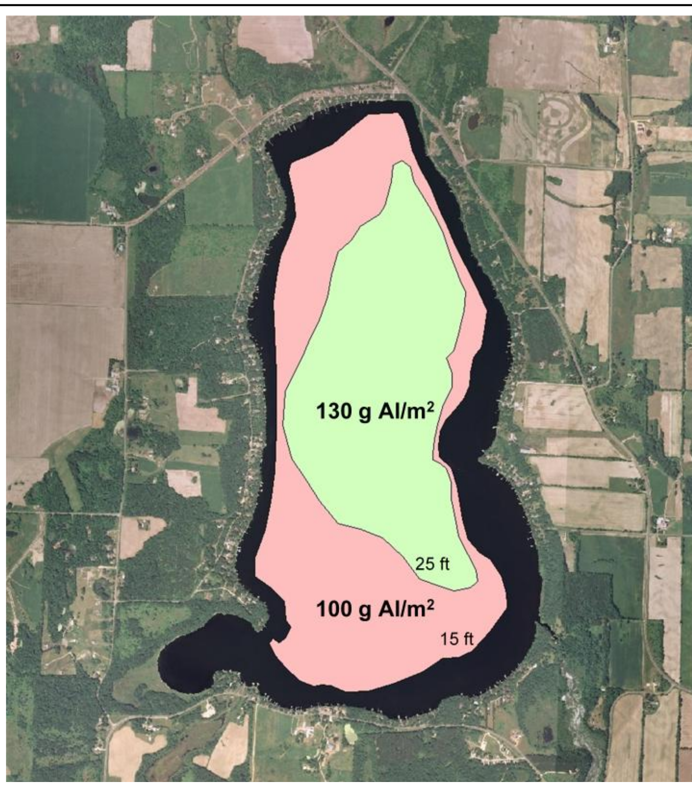


Figure 14. Alum Treatment Scenario 2: 130 g Al/m2 to 25 feet and 100 g Al/m2 to 15 feet

It is important to maintain pH above 6 during an alum application. Because of this concern, pH and alkalinity (*the ability to buffer low pH*) must be measured prior to and at the time of treatment. If pH is likely to be too low with the recommended alum application, buffered alum can be used. However, this option is significantly more expensive. Another way to alleviate pH concerns is to treat the lake using multiple alum applications at 2-3 year intervals. Overall estimated alum treatment costs for Cedar Lake range from $2 to $2.5 million.

Controlling External Loading

External P loading that flows to the lake from Horse Creek should also be managed. Watershed best management practices should target reducing runoff of soluble phosphorus from areas that have a high runoff potential. These include areas with steep slopes, low soil infiltration rates, inadequate crop cover, and tillage practices that result in bare soil. These characteristics are especially important to target in areas with high soil phosphorus closest to stream flow which is connected to Horse Creek.

Soil Fertility and Phosphorus Index Assessment

The Polk County Land and Water Resources Department conducted an assessment of soil fertility and phosphorus delivery from cropland to Horse Creek and Cedar Lake as part of this project. The objectives of this work were to gather field soil test data, model phosphorus delivery from fields, identify areas of concern, and identify strategies to reduce nutrient runoff. The main drainage to Horse Creek was the priority area of study.

Soil test data was collected from all subwatersheds to calculate average soil phosphorus levels. Fields adjacent to Horse Creek had the highest average soil test phosphorus levels at 52.4 ppm. However, because of field management practices and field characteristics, delivery of phosphorus to Horse Creek was estimated to be quite low at 1 lb. per acre. Many of these fields have conservation or no till cropping practices which minimize the potential of phosphorus and sediment delivery to water resources.

Recommendations

1. Continue data collection. More data is needed over a longer period of time.

2. Compare modeled data with edge-of-field monitoring data to verify model estimates.

3. Emphasize more complete nutrient management plans and planning. Implement plans!

4. Inform agricultural community of elevated soil test levels in the main drainage and work to lower them slightly to optimum levels (18-35 ppm).

5. Soil test residential lots to complete direct drainage sampling. This is underway in the summer of 2013.

6. Use conservation practices to reduce watershed loading by up to 30%. These practices include conservation and no tillage, edge of field filter strips, strip cropping, and farming

on the contour. The Upper Horse Creek Watershed is designated by USDA-NRCS as a priority in the National Water Quality Initiative. This will enhance cost sharing opportunities for producers in the watershed.

7. Support and encourage the implementation of the Horse Creek Farmer-Led Watershed Council

Horse Creek Farmer-Led Watershed Council

The Horse Creek Watershed is home to one of only four farmer-led watershed management pilot projects across the state. Farmers in the watershed are using information from an inventory conducted by the Polk County Land and Water Resources Department to develop incentives for on-farm measures for water quality improvements. The inventory found that phosphorus levels leaving farm fields and draining directly to Horse Creek average only about 1/6 of the allowed state standard.

The primary goal of the pilot project is to allow members of the agricultural community an opportunity to become actively involved in the process of developing a strategy to improve water quality, adopting that strategy, and ensuring its success.

Cedar Lake Fishery

There are a variety of game fish in Cedar Lake. Walleye are abundant; muskie and northern pike are common. Largemouth bass, smallmouth bass and pan fish are also present.

Walleye are the predominant game fish in Cedar Lake They were originally stocked in the lake. Walleye tend to do well in algae-dominated lakes because algae shields walleye fry from predation. The population is self-sustaining, but subject to annual variation. Because of concerns related to over-harvest, a 14-18 inch protected slot limit was instituted in 2008. Initial indications are this slot limit has resulted in greater numbers of adult walleye per acre. It takes ten years after instituting slot limits to fully assess effectiveness (Engel 2009).

Table 4. Game Fish Sampled by Netting and Electrofishing May 2009

Species	Size Range	Average Size	Population Estimate/Notes
Walleye	10.7 to 27.2 inches	15.1 inches	5,838
Musky	16.0 to 43.7 inches	34.2 inches	stable, stocked alternate years
Northern Pike	9.3 to 36.9 inches	20.1 inches	low levels
LM Bass	12.5 to 17.9 inches	14.1 inches	small population
SM Bass	6.5 to 17.9 inches	12.5 inches	small population
Yellow Perch	3.4 to 10.8 inches	4.1 inches	stable
Bluegill	to 8.8 inches	5.3 inches	slowly increasing since 2004

Historical Fisheries Information*

- 1938 - Poor water quality reported with pea soup conditions
- 1941 - First fish survey - cisco common, white bass present, no smallmouth or musky, otherwise the same species as today
- 1946 - Musky first planted
- 1947 - Cisco disappear, carp present
- 1950's - Water level manipulation
- 1953 - Walleye stocking ended
- 1960 - Carp a problem, commercial fishing followed
- 1981 - Complaints of aquatic vegetation disappearing, copper sulfate treatments blamed
- 1990 - Native Americans begin spearing
- 2002 - Spring viremia results in large carp kill
- 2004 - Smallmouth bass present
- 2009 - Bulrush beds gone
- 2013 - Rusty crayfish present
- 2013 Excellent game and pan fishing, carp population low!

* Summarized by Marty Engel, DNR Fisheries Biologist

Loss of aquatic plant beds, loss of bulrush stands, and removal of woody debris resulted in loss of fish habitat in Cedar Lake. Introduction of carp and white bass has also displaced native species. There are few options for habitat improvement on Cedar Lake. Cost effective carp control measures are not available. However, recent outbreak of disease caused the collapse of the carp and white bass populations. Fish cribs have been installed to compensate for the loss of woody debris in the lake. The 224 cribs placed in colonies throughout the lake created new habitat. Improvements in pan fishing can be attributed to these cribs.

Fish Habitat Recommendations

Re-establishment of bulrush stands may require lowering lake levels, an option that is politically infeasible (Engel 2009).

Carp Management

Carp have been implicated for poor water quality (Sorge May 1989) and removal of aquatic vegetation (Konkel 2003) (McComas 1998) on Cedar Lake for many years. Carp are bottom feeders, and bottom feeding releases significant amounts of nutrients to the water column as these fish feed and digest plant material. Harvesting carp has increased water clarity in some lakes (Managing Lakes and Reservoirs 2001). Numerous commercial carp fishing operations in Cedar Lake from 1959 – 1998 proved unsuccessful at carp control. It is difficult to quantify carp populations and subsequently reduce their density. Quantifying carp requires a mark and recapture population estimate.

The Cedar Lake P&R District (Jim Brockpahler) installed a carp barrier at the dam (the lake outlet) around 1997.[5] A new lake map was developed in 1998. Potential snags that might interfere with carp fishing were recorded on the map. Carp fishing was encouraged. A carp round up to attempt population estimates was unsuccessful. Lack of success was due to low capture rates and the presence of snags.

Frustrations with carp management efforts were minimized when a natural die off of carp occurred in 2002. An estimated 1,500 carp died in Cedar Lake over a 6 week period from late April through the first week in June. This was the first report of spring viremia of carp virus in wild carp in North America. (Dekkeboom 2004) The population of carp in Cedar Lake remains low through 2013.

Aquatic Plants

The aquatic plant community of a lake is full of complex interactions that contribute to the overall health of a lake. Every level of the aquatic food chain from bacteria and invertebrates to fish and waterfowl are dependent upon aquatic plants to some degree for their survival. Aquatic plants stabilize sediments and absorb wave action which in turn prevents turbidity caused by suspended sediments. (Lepsch March 2013)

Cedar Lake has an average to below-average plant community, but still a good diversity of plants. The community is not overly dominated by a single species.

One invasive species, curly leaf pondweed (*Potamogeton crispus),* was present at low levels when measured in July 2012. It was present at 3% of sites over the entire lake and at 11% of sites in the littoral zone (the area where plants grow).

One change in the lake that is particularly troublesome is the complete lack of emergent vegetation. Historically there were small isolated patches of emergent vegetation found around the shoreline - particularly in the southwest corner of the lake. Previous attempts to plant emergent vegetation have been unsuccessful.

Plants grow to about 10 feet deep in Cedar Lake. Increases in water clarity will increase light penetration and open a large portion of the lake to vegetation. With a increase from an average 5 foot to 10 foot secchi depth, plant growth is predicted to increase to about 15 feet.[6] There will likely be an increase in the number of species and the percent of the lake with vegetation. A more robust plant community will lead to a healthier aquatic ecosystem.

[5] Stuart Nelson. Personal Communication March 15, 2013.
[6] Predicted rooting depth (ft.) = (Secchi Disc (ft.) * 1.22) + 2.73. (from Dunst, 1982)

Sensitive Habitats and Species

A sensitive area survey was conducted on Cedar Lake in 2002 (Designation of Sensitive Areas in Cedar Lake, St. Croix County 2003).

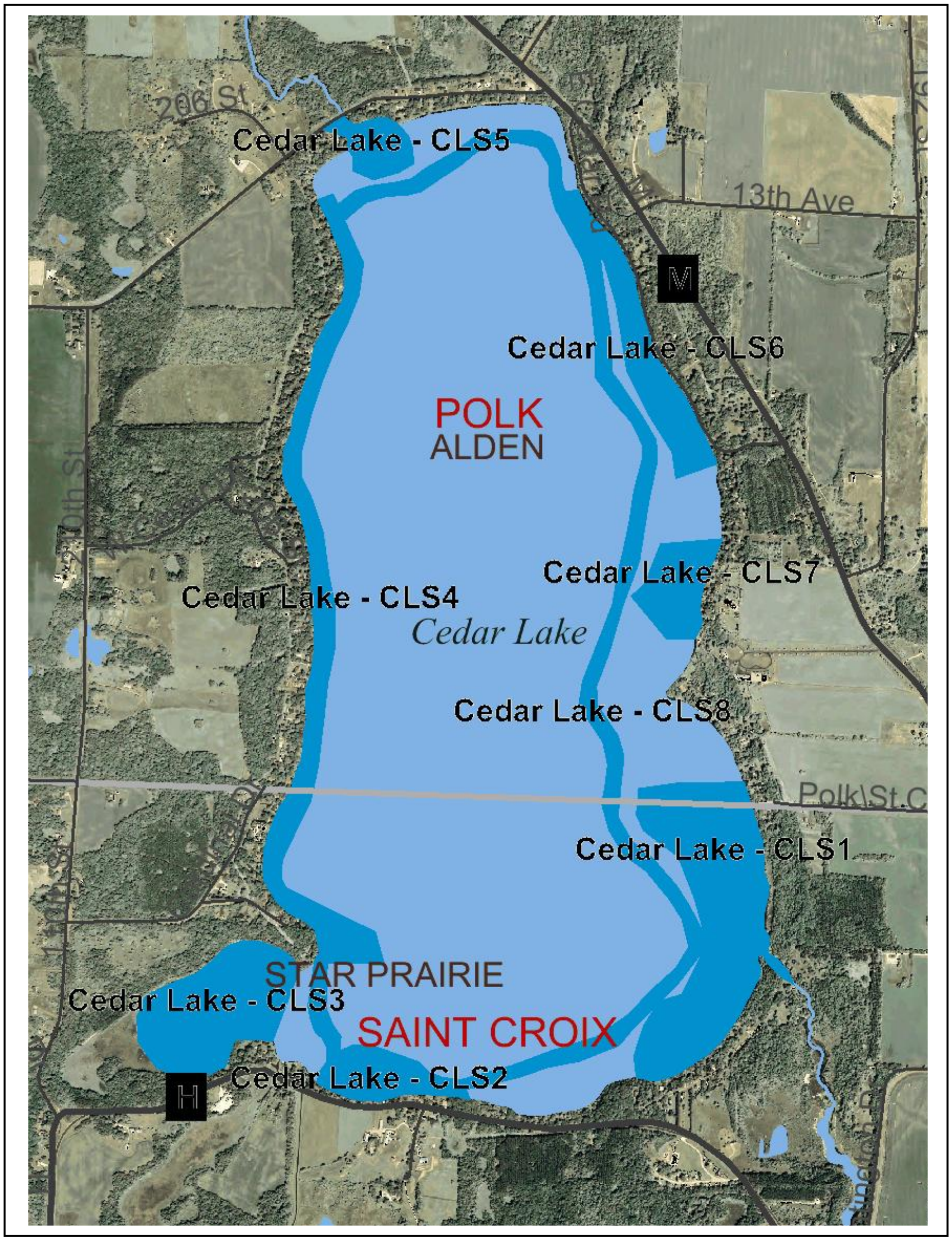


Figure 15. Cedar Lake Sensitive Areas

Table 5. Sensitive Area Descriptions

Sensitive Area	Location/description	Importance
CLS1	Historic Bulrush Site – 2000 feet	Includes emergent vegetation and scattered submergent vegetation. Mostly undeveloped shoreline.
CLS2	South Shore Site – 500 feet	Submergent vegetation. Walleye spawning area.
CLS3	Southwest Bay	11-acre bay supports fish and wildlife. Area of natural beauty.
CLS4	West Shore Spawning Beds – 4500 feet	Premier walleye spawning site on the lake.
CLS5	Horse Creek Inlet – 600 feet along shoreline and 300 feet up creek	Fish spawning and nursery area.
CLS6	East Shore Gravel Beds – 2000 feet	Wooded steep shoreline, fish spawning and nursery area.
CLS7	Deep Hole Site – 300 feet	Extensive tamarack bog and woodland with fallen woody cover.
CLS8	Break Zone – 8 to 12 foot depth contour around the lake	Aquatic plant community provides valuable fish habitat.

Cedar Lake sensitive area descriptions from 2002 are included in Table 5. Sensitive areas are the sensitive and fragile areas that support wildlife, fish and aquatic habitat, protect water quality, and preserve aesthetic beauty. Management restrictions in sensitive areas may include limits on grading, dredging, and boat ramp placement.

Recommendations for sensitive areas generally involve limiting the impact of human use and development by restoring and maintaining in-lake and shoreline vegetation, leaving fallen trees in the lake, limiting the installation of piers, protecting undeveloped areas, and not allowing permits for dredging or bank grading.

Since the sensitive area report was completed, the Menke family donated 63 acres with over 1,000 feet of shoreline along CLS1 to the Star Prairie Land Preservation Trust with support from the Cedar Lake P&R District, Star Prairie Fish and Game, and the Department of Natural Resources. The land trust received support from the Town of Star Prairie, Star Prairie Fish and Game, St. Croix County, and the DNR to purchase and develop a nonmotorized access and wildlife observation point to CLS3.

Invasive Species[7]

When non-native plants, animals, or pathogens rapidly take over a new location and alter the ecosystem, they are considered invasive species**.** Invasive species can sometimes take over and spread rapidly and widely causing major harm to the native ecosystem or humans. One of the reasons that invasive species are able to succeed is that they lack natural predators and competitors. Without these checks and balances, they are able to reproduce rapidly and out-compete native species.

Invasive species can alter ecological relationships among native species and can affect ecosystem function, economic value of ecosystems, and human health. Humans have created conditions where plants and animals can aggressively invade and dominate natural areas and water bodies in three ways:

- introducing exotic species (from other regions or countries);
- disrupting the delicate balance of native ecosystems by changing environmental conditions -- e.g., stream sedimentation, ditching, building roads or restricting or eliminating natural processes such as fire; and
- spreading invasive species through various methods:
    - moving watercrafts between waterbodies without removing invasive plants and animals;
    - carrying seeds of invasive plants on footwear or pet fur;
    - mowing along roadsides;
    - importing firewood and leaving in campgrounds;
    - driving and biking with invasive seeds in tire treads.

The net result of invasive species spread is a loss of diversity of native plants and animals. About forty-two percent of the species on the Federal Threatened or Endangered species lists are at risk primarily because of invasive species.

Preventing Invasive Species

There are five major elements the Cedar Lake P&R District and others can consider to prevent invasive species: education to lake users, Clean Boats Clean Waters program, landing surveillance cameras, lake monitoring, and a rapid response strategy for any new invasive species.

Education to Lake Users

Education efforts focus on identification and prevention of new invasive species. Activities might include aquatic invasive species (AIS) information presented at annual meetings and workshops, signage at the public landings and private boat launch areas, lake maps and brochures with AIS messages, and web site and newsletter information.

[7] Information from the Wisconsin Department of Natural Resources web site: http://dnr.wi.gov/topic/Invasives

Clean Boats Clean Waters (CBCW) Program

Clean Boats Clean Waters educators provide boaters with information on the threat posed by Eurasian Milfoil and other invasive species. They offer tips on how to keep boats, trailers, and equipment free of aquatic hitchhikers. They also collect information on boater behavior, concerns, and knowledge of existing local and state laws related to anti-AIS measures. Staff were hired by the Beaver Creek Preserve on behalf of the Cedar Lake District in 2012. Two student staffers were also hired directly by the Lake District.

Landing Surveillance Cameras

Some lake organizations use video cameras at public landings to record landing activity. Videos are reviewed, and if watercraft are launched with vegetation attached, action is taken. Violations of the ordinance and state rule which prohibits transporting and launching boats and trailers with vegetation attached can be enforced by local law enforcement officers. The camera also serves as a reminder for boaters to check their equipment.

Lake Monitoring

The objective of lake monitoring is to look for new invasive species. Monitoring for invasive species is generally focused around boat landings and other areas of high public use. Trained volunteers or consultants may complete the monitoring. Divers may be used. It is critical to complete aquatic invasive species visual surveys when algae growth is low and visibility is good.

Rapid Response for New Invasive Species

The activity is intended to control any new invasive species that are found in the lake. Rapid response protocols include the following:

- monitoring for invasive species
- education of lake residents and visitors
- contacts to confirm invasive species identification
- procedures for notification
- plans for removal and control
- funding contingencies and grants.

Invasive Species Information is available on the DNR website http:/dnr.wi.gov/invasives.

Lake Management Activities

A range of management activities are available to address water quality and habitat concerns. Categories for consideration include the following:

- Information and Education
- Incentives
- Conservation Practices
- Land Preservation
- Enforcement/Land Use Planning
- Lake Studies/Evaluation
- In-Lake Management

Information and Education

Providing information and education to lake residents, visitors, and policymakers is an important component of any lake management program. There is an abundance of printed and web information to help explain lake ecology and management methods. The University of Wisconsin Extension (http://learningstore.uwex.edu) and the Wisconsin Department of Natural Resources (http://dnr.wi.gov/lakes/publications) have many resources available. Lake organizations also develop informational materials specific to their lake and management program.

Information can be distributed using a variety of methods including:

- Packets of information for new homeowners
- Notebooks with pertinent information
- Brochures
- Web sites
- Newsletters
- Newspapers
- Workshops and training sessions

Distributing information can certainly increase knowledge. A key consideration is that sometimes people have the knowledge of lake concerns, but still don't make desired behavioral changes. It is important to identify the specific behaviors to be changed and the barriers to those behavioral changes, then to design programs that overcome these barriers. For example, concerns about native vegetation blocking views to water where children are swimming can be a barrier to the installation of shoreland buffers. To address this concern, information about shoreland buffers can emphasize planting lower growing plants and maintaining viewing corridors so the waterfront is still visible.

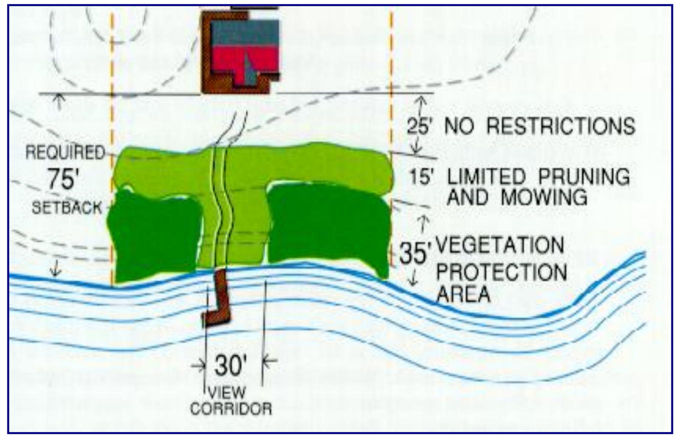


Figure 16. Example Shoreland Buffer Diagram

Incentives

Incentives are frequently provided along with information and education to encourage behavior changes. Examples of incentives include payments, tax credits, and recognition. The Burnett County Shoreland Incentive Program uses cost sharing, an annual property tax rebate, participation shirts and hats, and shoreline signs as incentives to encourage participation. Enrollment in the program involves signing a perpetual covenant to restore and maintain a shoreland buffer on a waterfront property in Burnett County.

Conservation Practices

Conservation practices, frequently called best management practices, are installed to reduce pollutants. For lake management, conservation practices tend to focus on reducing erosion, slowing water flow, and encouraging infiltration. Many times these practices use native vegetation to accomplish pollutant reduction objectives. For the most effective installation of conservation practices, the most likely participants where significant sources of pollution can be addressed are targeted.

Installation of conservation practices is likely to require some form of technical assistance. For simple practices, this assistance might be in the form of a guidebook. Many practices will require on-site visits with designs prepared by technicians. More complicated practices may require design by professional engineers.

Large scale practices and multiple small scale practices are likely to require significant funding for design and installation. Some lake organizations provide direct financial and technical assistance. It is more common for lake organizations to work together with a county and/or another nonprofit organization. DNR Lake Protection Grants are available for both small and large-scale practices with Lake Management Plan approval. Because of watershed land use and pollutant load identification, conservation practices for Cedar Lake are likely to focus on reducing runoff and pollutant loading from agricultural crop fields and/or waterfront property.

Agricultural Best Management Practices

Large-scale best management practices might involve changing tillage practices, implementing nutrient management plans, converting a crop fields to a more permanent vegetative cover, restoring wetlands, and/or constructing sedimentation basins. A list of potential agricultural best management practices is included as Table 6.

Table 6. Selected Agricultural Best Management Practices[8]

Practice	Description
Conservation Tillage	Any tillage or planting system that maintains at least 30% of the soil surface covered by residue after planting to reduce soil erosion by water. Examples of conservation tillage include no-till, strip-till, or vertical-tillage.
Crop Rotation	Reduces soil erosion and nutrient applications by alternating row crops with forage crops such as alfalfa.
Cover Crops	Reduces soil erosion and improves soil tilth and structure by providing vegetative cover on fields in the fall after harvest and before spring planting.
Detention/Sedimentation Basin	Reduces the flood peak, sediment, nutrient and contaminant loading by retaining runoff and letting soil particles and attached nutrients and contaminants settle out in the basin.
Grassed Waterways	Reduces erosion, nutrient, and contaminant loading by having runoff flow over a grassy area as it moves toward a waterbody. Soil is protected and grass helps utilize nutrients and trap contaminants.
Integrated Pest Management	Reduces pesticide applications, improves effectiveness of application, and uses more pest-resistant cultivars.
Livestock Fencing	Livestock exclusion from concentrated flow areas and other surface waters eliminates erosion and provides vegetated buffer areas to intercept nutrient laden surface runoff before it enters flow areas or surface water.
Nutrient Management Planning	Reduces nutrient loading by managing proper timing, amount, and form of fertilizer and manure application to fields.

Promoting nutrient management is recommended within the Cedar Lake watershed. Nutrient management planning helps to manage the amount, source, placement, form, and timing of the application of nutrients and soil amendments. All nutrient sources, including soil reserves, commercial fertilizer, manure, organic byproducts, legume crops, and crop residues are accounted for and properly utilized. These criteria are intended to minimize nutrient entry into

[8] Adapted from Managing Lakes and Reservoirs, (pg. 187) North American Lake Management Society, 2001.

surface water, groundwater, and atmospheric resources while maintaining and improving the physical, chemical, and biological condition of the soil.

A detention/sedimentation basin can be an effective way to treat agricultural and urban pollutants when treatment near the source is not possible. Sedimentation basins were used in nearby Deer Lake subwatersheds both to settle out sediment from farm fields and to reduce the flow rate in intermittent streams where erosion was occurring.

Figure 17. A Sedimentation Basin in a Deer Lake Subwatershed

Funding for agricultural best management practices may be available through the Polk County Land and Water Resources Department which receives funding from the Department of Agriculture, Trade and Consumer Protection. Federal funding sources include the Farm Services Agency and Natural Resources Conservation Service. A DNR Lake Protection Grant or Targeted Runoff Management Grant may also fund some agricultural projects. Local tax revenue could also be used for agricultural projects.

Waterfront Runoff Practices

Waterfront runoff practices include rock pits or trenches, rain gardens, and shoreline buffers. It may be appropriate for Cedar Lake to consider offering design assistance and cost sharing for these practices. Nearby Deer Lake, Bone Lake, Balsam Lake, and Burnett County offer programs and education materials to encourage waterfront runoff practices. These programs could be used as examples, and educational materials developed for these programs could be used on Cedar Lake.

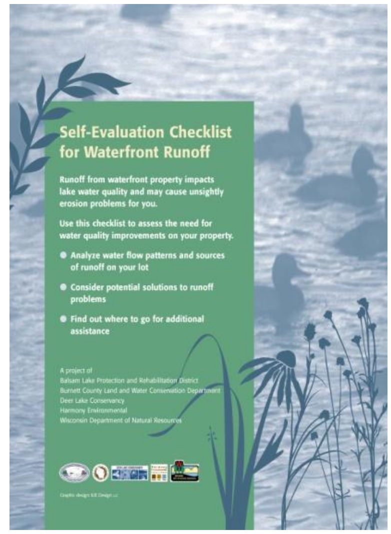


Figure 19. A Guidebook for Waterfront Runoff Management

Figure 18. Rain Gardens Collect and Infiltrate Runoff Water (photo by Steve Palmer)

Land Preservation

Land preservation involves purchasing land or putting land in conservation easements to preserve natural areas or to ensure that conservation practices will remain in place. A conservation easement is a voluntary legal agreement that restricts some land uses to protect important conservation values.

There are several nearby examples of land preservation donations, purchases and conservation easements. The Cedar Lake Protection and Rehabilitation District and Star Prairie Fish and Game helped the Star Prairie Land Preservation Trust accept the donation of sixty-three acres of land with 1400 feet of Cedar Lake shoreline in 2005. To ensure that conservation practices remain in place, the Deer Lake Conservancy has easements or owns land where the practices are installed. In some cases, the Deer Lake Conservancy purchased highly erodible crop lands planted to row crops and converted the fields to native prairie. The Half Moon Lake Conservancy accepted donation of forty acres of natural area along Harder Creek, the largest tributary flowing into the lake.

Figure 20. McMurtrie Preserve during a Cedar Lake Winter (photo by Dan Davison)

District Involvement in Planning and Zoning

Lake District involvement in enforcement of state and local regulations and planning activities can help to protect lakes. Local regulations and plans are summarized in Appendix E. Lake District members can report potential violations of regulations and ordinances to assist with appropriate enforcement. However, it is important to note that the Lake District cannot establish or enforce laws (except for boating laws under certain circumstances). Involvement in planning activities can help to ensure that land uses that protect the lake are in place in the watershed. Plans might be developed at the town, county, or state level.

The Cedar Lake Protection and Rehabilitation District has one seat on the board of directors for representatives appointed by the Polk County Board of Supervisors and another representative from the Town of Alden. These individuals help to bring concerns related to local planning and zoning to the Lake District board. As concerns are identified, commissioners may attend related meetings and hearings to express concerns and gather information.

Choosing Management Options

To choose from the many management options that are available, it is important to do the following:

- Set clear goals and objectives
- Understand potential results
- Prioritize activities
- Consider social and political feasibility
- Investigate funding possibilities
- Seek available assistance

The goals, objectives, and action items in the implementation plan seek to incorporate the above considerations.

Public Survey Results

A single question in the public survey asked lake residents what they thought about a list of eighteen activities. For each activity, residents were asked if the Lake District should pursue an activity. The range of responses began and definitely no = 0 to definitely yes = 4. The most positive responses are reported below. A full list of responses is shown in Appendix A.

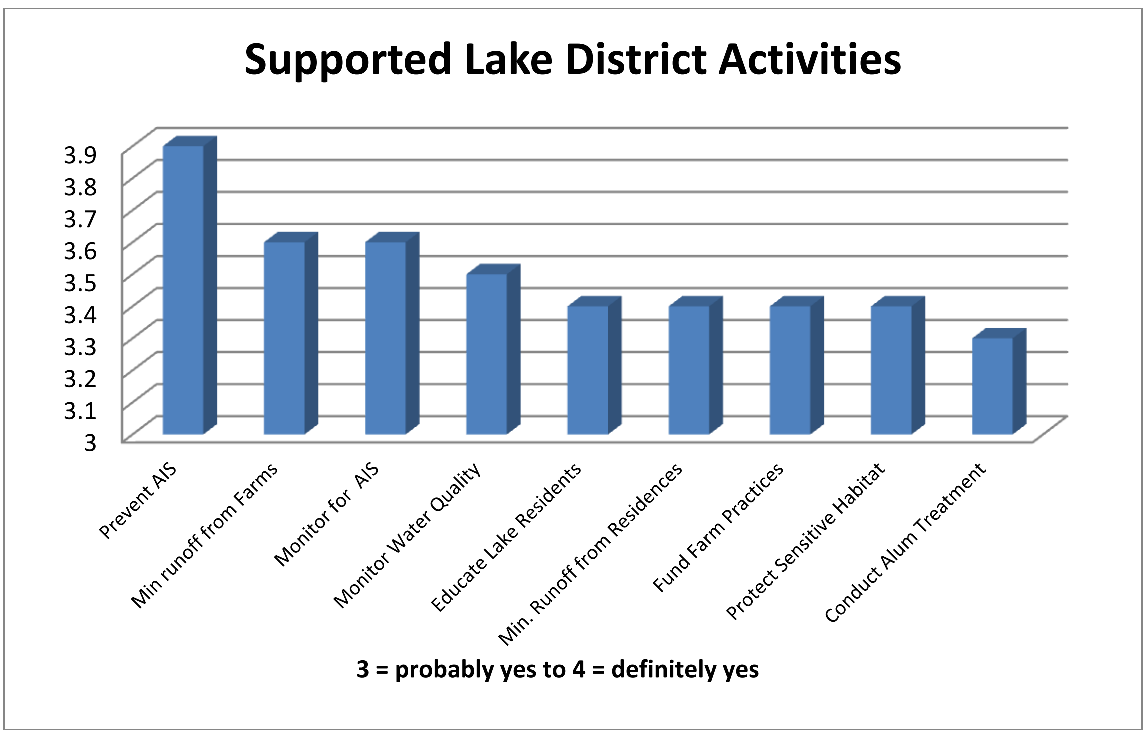


Figure 21. Survey Response: Should the Lake District Pursue These Activities?

Implementation Plan

Advisory Committee Recommendations

The advisory subcommittee examined consultant and advisor recommendations and analyzed available information to make recommendations regarding ways to improve the water quality of the lake. Potential management activities and their impacts were considered in the development of the recommendations that follow. Management actions chosen by the advisory committee are included below.

Water Quality Recommendations

A two-pronged approach is recommended for improving water quality in the lakes. Reducing external load is important for improving localized lake characteristics, and for maintaining effectiveness of internal load management. However, it is recognized that significant water clarity improvement will not occur without reducing the phosphorus load from lake sediments – the internal load. It is valid to assume that a high reduction in internal loading will cause the biggest, quickest change. It would NOT be prudent to ignore the external loading because reducing the external load will increase the longevity of internal load reductions.

Plan Timeframe

This plan covers a ten year time frame. As new knowledge is acquired and events unfold, it will be updated as appropriate.

Implementation Plan Updates

An implementation plan is found in the following section. The implementation plan or work plan details how action steps will be carried out over the next two year period. This implementation plan will be updated annually in June to keep actions and budgets current.

Funding Plan Implementation

The implementation charts later in this section list potential funding sources for plan implementation.

Lake District Funding

Costs for plan implementation over the next ten years are expected to be $2.2 million. Virtually all of the cost is for an alum treatment. Grants will be sought to pay for the alum treatment and other program costs. However, grants from the Wisconsin Department of Natural Resources (the most likely funding source) are available on a reimbursement basis. This means that money must be available for the alum treatment up front.

After careful investigation, a municipal loan was determined to be the most cost effective option for the following reasons:

- Favorable interest rate climate
- Ten-year amortization
- No pre-payment penalties

- Audited financial statements not required
- Semi-annual assessment based on property equalized value.

Grant Sources

The DNR Lake Management Grant Program has two main types of lake management grants: planning and lake protection grants. Lake planning grants are available at two scales – large scale up to $25,000 and small scale up to $3,000. These applications are accepted twice each year on February 1 and August 1. DNR lake protection grants for plan implementation have a maximum grant amount of $200,000. These grants are due each year by May 1. Plan activities will be eligible for lake protection grant funds following approval by the DNR.

The Department of Natural Resources also manages Targeted Runoff Management (TRM) grants for urban and agricultural practices as described in the state runoff rule: NR151. Cities, villages, towns, counties, regional planning commissions, tribal governments, and special purpose districts such as lake, sewerage, and sanitary districts are eligible to apply for TRM grants.

DNR Lake Planning Grants (up to 67% state share)

Large scale – up to $25,000
Small scale – up to $3,000

Applications due February 1 and August 1
These grant applications could proceed without final plan approval.

DNR Lake Protection Grants (up to 75% state share)

Up to $200,000
Requires DNR approval of tasks in the comprehensive plan (allow 60 days)

Applications due May 1

DNR Targeted Runoff Management (up to 70% state share)

Small Scale: Up to $150,000 (only land purchase and structural practices)
Large Scale: Typically $500,000 to $1 million (cropping practices and staffing costs also eligible)
Agricultural activities in this plan may be eligible. Projects must address state agricultural performance standards.

Application due April 15th

EPA 319 Funds

Cedar Lake Management Implementation Plan

Planning Timeframe – 2014-2023

The Vision for Cedar Lake in the Year 2030

Cedar Lake is a healthy lake that provides clear water, excellent aquatic and nearshore fish and wildlife habitat, and quality recreation.

The Cedar Lake Management Plan guides an active Protection and Rehabilitation District Board and a broad range of partners.

Lake and watershed residents and lake visitors practice good lake and watershed management.

GOALS, OBJECTIVES, and ACTIONS

Goal 1. Prevent the introduction of aquatic invasive species and effectively manage those introduced into the lake.

Objectives

A. Prevent the introduction of non-native, invasive species not yet found in Cedar Lake.

B. Monitor and minimize spread of known invasive species present: rusty crayfish and curly leaf pondweed.

Actions

1. Carry out educational activities to reach residents and visitors to the lake.
    - Use existing resources when available.
    - Emphasize sources of concern: boats and trailers, aquarium plants and water, ornamental fish from ponds and aquariums, and fishing bait.

2. Continue a Clean Boats, Clean Waters Program at the North Boat Landing.
    - Hire student staff through Beaver Creek Reserve. Beaver Creek has grant funds that Lake District matches.
    - Hire staff directly to conduct CBCW or supplement Beaver Creek program.

3. Monitor the lake for aquatic invasive species in areas of high public use.
    - Continue as part of the Beaver Creek Reserve aquatic invasive species program.
    - Consider volunteers or professional monitoring if Beaver Creek program is no longer available.

4. Develop a Rapid Response Protocol for newly introduced invasive species.
    - Develop lake district protocol and contingency fund

5. Control terrestrial invasive species in the shoreland zone.

Actions considered but not selected for initial implementation. These actions may be added during the plan implementation period.
- Landing Surveillance Cameras
- Boat Washing Station at North Landing

Monitoring/Evaluation Needed

6. Conduct point intercept aquatic plant surveys (DNR conducts every 5 years).

Goal 2. Achieve and maintain clear water throughout the summer.

Objective A. Achieve and maintain a summer[9] total phosphorus mean of less than 40 ug/L.

Notes: The summer 2010 annual total phosphorus (TP) mean was 68 ug/L. 2010 had nearly normal precipitation.

The water quality modeling predicted the following annual TP. According to Bill James, the summer TP can be expected to be lower than the annual TP.
Following an Alum Treatment only
Annual TP= 30 – 39 ug/L
Following an Alum Treatment and 30% Reduction in Watershed P loading
Annual TP <30 ug/L

EXPECTED RESULTS

It is difficult to predict water quality results in lakes for a given time period because there is so much variation in rainfall, temperature, wind and natural systems. Over the long term, if phosphorus reductions are reached the following are predicted:

- Summer water clarity will increase from an average summer[10] secchi depth of 5 feet (2010) to 10 to 16 feet.
- The frequency of nuisance summer algae blooms will decrease from 55% of the time to 5% of the time.
- The presence of toxin-producing algae blooms will be minimized.

[9] June 1 – September 15
[10] June through October

Objective B. Decrease the internal phosphorus load from lake sediments by 90 percent.

Action[11]

*** 1. Conduct an alum treatment.
- Application rate of 130g Al/m2 at depths greater than 25 feet and 100g Al/m2 at depths between 20 and 25 feet
- Apply alum in May or early June
- Apply in 2 doses to eliminate concerns regarding low pH during alum application with a year or two between applications.
- Monitor sediment alum in between alum doses at least 100 days following treatment.

Objective C. Decrease watershed phosphorus loading by 30 percent.

Actions

** 2. Support the Horse Creek Farmer-Led Council to carry out recommended activities.
- Recognize their efforts
- Partner on activities when possible
- Consider incentives for the council to administer

  The farmer-led council is currently in early stages of development.

3. Promote state and federal cost sharing for best management practices.

Recommended agricultural watershed activities
- Continue crop field data collection. More data is needed over a longer period of time.
- Compare modeled data with edge-of-field monitoring data to verify model estimates.
- Better understand delivery of dissolved vs. particulate phosphorus.
- Emphasize more complete nutrient management plans and planning. Implement plans!
- Inform agricultural community of elevated soil test levels in the main drainage and work to lower them slightly to optimum levels (18-35 ppm).

[11] High priority actions are indicated with ***. Medium high priority actions are indicated with **.

** 3. Encourage residential best management practices.
    - Provide how-to information to install best management practices including discouraging geese on the lake.
    - Use soil test results to discuss phosphorus use.
    - Consider lake resident-led incentive program and small scale cost sharing.

Actions considered but not selected for initial implementation. These actions may be added during the plan implementation period.

- Design and cost share assistance

Monitoring/Evaluation Needed

4. Monitor Secchi depth, Total Phosphorus, Chla (every other week, from ice-out to turnover)
5. Identify algae species
6. Monitor carp population to assess impact on water quality.
7. Complete sediment cores to assess alum treatment efficacy.

Goal 3. Maintain a high quality sport fishery in Cedar Lake.

Objectives[12]

A. Improve and support fish habitat.
B. Meet species-specific management objectives.

Actions

1. Use effective regulations to improve game and pan fish populations/size structure.
** 2. Complete fish habitat improvement projects.
3. Stock musky in alternate years

Monitoring/Evaluation

4. Maintain Cedar Lake as a "Trend Monitoring" lake with fish population monitoring every four years. (2017)
5. Conduct a creel survey to assess the results of pan fish habitat improvement actions and angler walleye harvest. (2017). (Approval for survey is through DNR's treaty assessment team.)

[12] High priority actions are indicated with ***. Medium high priority actions are indicated with **.

Cedar Lake Detailed Fisheries Recommendations

Walleye Management
- Maintain a high quality walleye fishery with at least 2 adults per acre.
- Maintain safe harvest levels.
  - Change walleye bag limits as needed to adjust for treaty harvest.
- Evaluate the effectiveness of the walleye slot size limit implemented in 2008 with electrofishing in 2017 and 2021.

Musky Management
- Provide a low density, high quality, trophy musky fishery.
  - Alternate year stocking of 1,000 large fingerling.
  - Monitor every four years

Northern Pike Management
- Maintain a low density, high quality, self sustaining population
- Promote musky over northern pike

Pan Fish Management
- Improve pan fish populations through habitat enhancement and regulations.
- Complete creel survey in 2017 to evaluate the effectiveness of a 2004 bag limit reduction and the 2004-2013 installation of fish cribs.

Goal 4. Protect and improve near shore habitat both in the water and on the land.

Actions

*** 1. Encourage restoration of near shore (shoreline) habitat.
2. Provide education about the importance of maintaining vegetation on the land and in the water.
3. Encourage installation of woody habitat/fish sticks and leaving trees that fall in the water
for low energy sites not impacted by ice push.
4. Protect existing high quality shoreline habitat through land purchase, donation, or conservation easements.

Goal 5. Balance recreational uses so that residents and lake users can enjoy the natural benefits Cedar Lake provides.

Objective. Lake users follow existing state and local regulations.
Objective. Participants with varied recreational interests are respectful of other users and residents.
Objective. Lake recreation occurs without negative impact to the lake environment.

Actions

1. Institute slow no-wake at north landing
2. Encourage enforcement of existing regulations

***3. Education (signs, web, brochures) [13]

4. Improve parking at north landing
5. Engage lake users

Goal 6. Carry out the Cedar Lake Management Plan effectively and efficiently with a cooperative spirit.

Objective. Support and strengthen the leadership of the Cedar Lake P&R District.
Objective. Build and support partnerships.
Objective. Lake residents are informed about plan activities.
Objective. Select cost effective implementation actions.

Actions

1. Support board with education and recruitment
    - Education methods
        - Conferences
        - Lake Leadership participation
        - Encourage use of available resources (people, print, and web)
    - Recruitment
        - Establish board expectations

***2. Outreach to lake residents
- Education methods
    - Welcome packet
    - Newsletters
    - Committees
    - Annual plan update meeting

3. Engage youth

[13] High priority actions are indicated with ***. Medium high priority actions are indicated with **.

Goal 1. Prevent the introduction of aquatic invasive species and effectively manage those introduced into the lake.					
Actions[14]	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties/ Partners**[15]	**Funding Sources**
1. Educational activities (newsletter, web site, boat landing education)	Ongoing	$250	40	CLPRD WDNR UWEX	CLPRD AIS Grant, Lake Protection Grant
2. Clean Boats, Clean Waters	Summer	$2,500	10	CLPRD Beaver Creek Reserve	CLPRD Beaver Creek AIS Grant
3. Monitor for aquatic invasive species	Summer	$0 (included w/above)	10	CLPRD Beaver Creek Reserve	CLPRD Beaver Creek AIS Grant
4. Develop a rapid response protocol for new invasive species	2014	$800	20	CLPRD WDNR Consultant	CLPRD AIS Grant
5. Control terrestrial invasive species in the shoreland zone	Ongoing	$?	10	Polk County LWRD CLPRD	DNR AIS Grant
SUBTOTAL		$3,550	80		

14 See previous pages for action item detail. Estimates are for annual budgets once implementation begins.
15 CLPRD = Cedar Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources

Goal 2. Achieve and maintain clear water throughout the summer. ***Objective. Decrease internal phosphorus load from lake sediments.***					
Actions[16]	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties Partners**[17]	**Funding Sources**
Conduct an alum treatment	May/June 2015 and 2016	$1.1 million per treatment	80	CLPRD DNR UW Stout	CLPRD WDNR Targeted Runoff Management Grant WDNR Lake Protection Grant Private and other grants
a. Apply for TRM grant	April 15, 2014	$2,500		CLPRD WDNR Consultant	CLPRD
b. Apply for Lake Protection grant	May 1, 2014	$2,500		CLPRD WDNR Consultant	CLPRD
c. Investigate private foundations and other grants	2014	$4,000		CLPRD Consultant	CLPRD
SUBTOTAL					

16 See previous pages for action item detail. Estimates are for annual budgets once implementation begins.
17 CLPRD = Cedar Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources

Goal 2. Achieve and maintain clear water throughout the summer. ***Objective. Decrease watershed phosphorus load.***					
Actions[18]	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties[19]**	**Funding Sources**
Support Horse Creek Farmer Led Watershed Council	Ongoing	?	?	Watershed Council UWEX Polk County LWRD	DATCP CLPRD
Promote state and federal cost sharing for agricultural best management practices	Ongoing	?	?	Polk County LWRD FSA NRCS	DATCP FSA NRCS
Encourage residential best management practices a. educate lake residents (newsletter, web site, boat landing education) b. conduct soil samples c. provide incentives	b. August/ Sept. 2013 Remaining: Ongoing	?	?	Polk County LWRD WDNR	WDNR Lake Protection Grant
SUBTOTAL					

[18] See previous pages for action item detail. Estimates are for annual budgets once implementation begins.
[19]CLPRD = Cedar Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources
DATCP = Department of Agriculture, Trade, and Consumer Protection
FSA = Farm Services Agency
NRCS = Natural Resources Conservation Service

Goal 2. Achieve and maintain clear water throughout the summer. ***Monitoring and evaluation***					
Actions[20]	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties[21]**	**Funding Sources**
Monitor secchi depth, total phosphorus, chlorophyll a	Ongoing		80	WDNR CLPRD Citizen Lake Monitor	WDNR
Identify algae species	2017	$?	?	WNDR CLPRD	WDNR
Monitor carp populations	2017	$?	?	WDNR	WDNR
Monitor sediment in between alum treatments	September/ October 2015	$?	?	UW Stout DNR CLPRD	CLPRD WDNR Targeted Runoff Management Grant WDNR Lake Protection Grant
SUBTOTAL					

[20] See previous pages for action item detail. Estimates are for annual budgets once implementation begins.
[21] CLPRD = Cedar Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources

Goal 3. Maintain a high quality sport fishery in Cedar Lake.					
Actions[22]	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties**[23]	**Funding Sources**
1. Use effective regulations	Ongoing	$0	20	WDNR	WDNR
2. Fish habitat improvement projects	Ongoing	$?	40	CLPRD SPFG WDNR	WDNR SPFG
3. Stock musky in alternate years	Alternate years	$?	0	WDNR	WDNR
4. Maintain Cedar Lake as a trend monitoring lake	Ongoing	$?	0	WDNR	WDNR
5. Conduct a creel survey	2017	$0	0	WDNR	WDNR
SUBTOTAL					

[22] See previous pages for action item detail. Estimates are for annual budgets once implementation begins.
[23]CLPRD = Cedar Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources
SPFG = Star Prairie Fish and Game

Goal 4. Protect and improve near shore habitat both in the water and on the land.					
Actions[24]	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties**[25]	**Funding Sources**
Encourage restoration of shoreline habitat a. consider cost sharing mini-plantings	Ongoing a. 2014	$3,000 (2014)	40	CLPRD LWRD SPFG WDNR	CLPRD WDNR LWRD SPFG
Provide education about the importance of habitat (newsletter, web site, handouts)	Ongoing	$250	20	CLPRD LWRD SPFG WDNR	CLPRD WDNR LWRD SPFG
Encourage installation of woody habitat	Winter	$?	20	CLPRD LWRD SPFG WDNR	CLPRD WDNR LWRD SPFG
Protect high quality shoreline	Ongoing	$?	20	CLPRD SPLPT WNDR	CLPRD SPLPT WNDR
SUBTOTAL					

[24] See previous pages for action item detail. Estimates are for annual budgets once implementation begins.
[25]CLPRD = Cedar Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources
SPFG = Star Prairie Fish and Game
SPLPT = Star Prairie Land Preservation Trust

Goal 5. Balance recreational uses so that residents and lake users can enjoy the natural benefits Cedar Lake provides.					
Actions[26]	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties[27]**	**Funding Sources**
Slow no-wake at the north landing	2016	$0	40	CLPRD Town of Alden WDNR	
Encourage enforcement of existing regulations	Ongoing	$0	20	CLPRD WDNR Polk County St. Croix County	
Education (newsletter, web site, handouts) Engage lake users	Ongoing	$250	40	CLPRD WDNR Polk County St. Croix County	CLPRD WDNR Polk County St. Croix County
Improve parking at north landing	2017	$?	20	CLPRD Town of Alden WDNR	WDNR CLPRD Town of Alden
SUBTOTAL					

[26] See previous pages for action item detail. Estimates are for annual budgets once implementation begins.
[27]CLPRD = Cedar Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources

Goal 6. Carry out the Cedar Lake Management Plan effectively and efficiently with a cooperative spirit.					
Actions[28]	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties**[29]	**Funding Sources**
Support board with education/recruitment	Ongoing	$500	80	CLPRD WDNR	CLPRD WDNR
Outreach to lake residents (newsletter, web site, handouts)	Ongoing	$500	40	CLPRD WDNR	CLPRD WDNR
Engage youth	Ongoing	$0	40	CLPRD WNDR School Districts Youth Organizations SPLPT	
SUBTOTAL					

[28] See previous pages for action item detail. Estimates are for annual budgets once implementation begins.
[29]CLPRD = Cedar Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources
SPLPT = Star Prairie Land Preservation Trust

Appendix A. Public Opinion Survey Results

Cedar Lake Property Owner Survey

Please complete and return in the enclosed self-addressed stamped envelope to:
Harmony Environmental
516 Keller Ave. S
Amery, WI 54001
One survey response per household, please.
159 RESPONSES/298 MAILED 53% Response Rate

1. Is your Cedar Lake property your permanent residence? **(Circle one)**
   Yes **(41%)** No **(58%)** No response **(1%)**

If your answer is yes, skip to question 3 below.

2. Which of the following best describes how often you stayed at your lake property last year? **(Check one.)**

7% a. For most of the year, such as for more than three months at a time
6% b. For a single season, such as three months during the summer
19% c. Mostly during the weekends in the summer, for vacations, and on holidays
14% d. Mostly on weekends during the summer
7% e. Mostly on weekends throughout the year
2% f. Mostly on vacations and holidays
6% g. Other (describe)____________________________________

3. How long have you owned property on Cedar Lake? (if less than 1 year, please write "1")

Ave 23; Range = 0 to 68 Years

4. How much do you participate in the following recreational activities at Cedar Lake?
   (Circle appropriate response for each item.)

	Not at all	A little	Some	Quite a bit	A great deal	Resp.
Relaxing	0	1	2	3 **3.2**	4	**152**
Open-water fishing	0	1	**1.6** 2	3	4	**153**
Ice fishing	0 **0.5**	1	2	3	4	**148**
Personal watercraft (jet skis)	0 **0.7**	1	2	3	4	**150**
Motor boating	0	1	2 **2.4**	3	4	**151**
Non-motorized boating	0	1 **1.3**	2	3	4	**146**
Observing wildlife	0	1	2 **2.7**	3	4	**152**
Wind surfing	0 **0.2**	1	2	3	4	**148**
Swimming	0	1	2 **2.2**	3	4	**151**
Water skiing	0	1 **1.2**	2	3	4	**149**
Sand bar socializing	0	1	**1.7** 2	3	4	**152**
Other (list)	0	1	2	3	4	

5. To what extent is each of the following a problem for you regarding owning waterfront property on Cedar Lake? **(Circle appropriate level of problem for each item. "Not present" means you believe the issue does not exist on Cedar Lake. "No problem" means the issue may exist on Cedar Lake, but it is not a problem for you.)**

Level of Problem

	Not Present	No Problem	Small	Medium	Large	**Resp**
Lack of water clarity in the middle of the lake	X	0	1 **1.7**	2	3	**147**
Lack of water clarity in front of my property	X	0	1	2 **2.5**	3	**152**
Invasive aquatic plant growth in the lake	X	0	1 **1.7**	2	3	**138**
Not enough native aquatic plant growth in the lake	X	0	1 **1.2**	2	3	**135**
Potentially toxic algae blooms	X	0	1	2 **2.4**	3	**144**
Maintaining the investment value of my property	X	0	1	2 **2.2**	3	**151**
Protecting the lake environment	X	0	1	2 **2.4**	3	**149**
Lake levels too high	X	0 **0.2**	1	2	3	**112**
Lake levels too low	X	0 **0.6**	1	2	3	**120**
Other (list)	X	0	1	2	3	
Other (list)	X	0	1	2	3	

6. Please indicate how much each of the following **negatively** impacts your use of the lake. **(Circle appropriate level of negative impact for each item. "Not present" means you believe the issue does not exist on Cedar Lake. "No negative impact" means the issue may exist on Cedar Lake, but it is not a problem for you.)**

Level of Negative Impact

	Not present	No negative impact	A little	Some	Quite a bit	A great deal	**Number of Responses**
Algae growth	X	0	1	2	3 **3.3**	4	**152**
Small fish size	X	0	1 **1.2**	2	3	4	**140**
Not enough fish	X	0	1 **1.3**	2	3	4	**136**
Lake level too high	X	0 **0.4**	1	2	3	4	**98**
Lake level too low	X	0 **0.8**	1	2	3	4	**114**
Native aquatic plant growth	X	0	1 **1.3**	2	3	4	**136**
Invasive aquatic plant growth	X	0	1	2 **2.0**	3	4	**134**
Loss of wildlife habitat	X	0	1 **1.5**	2	3	4	**136**
Boat congestion	X	0	1 **1.2**	2	3	4	**130**
Noise	X	0	1 **1.1**	2	3	4	**137**
Loss of natural scenery	X	0	1 **1.0**	2	3	4	**129**
Airplane landing and takeoff	X	0	1 **1.0**	2	3	4	**136**
Carp bow fishing	X	0 **0.7**	1	2	3	4	**133**
Ice fishing activity	X	0 **0.7**	1	2	3	4	**136**
Personal watercraft (jet skis)	X	0	1 **1.1**	2	3	4	**137**
Other (list)	X	0	1	2	3	4	

Other (list)	X	0	1	2	3	4

7. Please describe how much each of the following water quality changes would benefit you.
(Circle appropriate response for each lake and item.)

Degree of Benefit

	Not at all	A little	Somewhat	Quite a bit	A great deal	**Number of Responses**
Algae blooms that begin later in the summer	0	1	2	**2.8** 3	4	**143**
Algae blooms that are **not** potentially toxic	0	1	2	**2.8** 3	4	**146**
Reduced algae blooms in May	0	1	2	**2.7** 3	4	**146**
Reduced algae blooms in June	0	1	2	3 **3.1**	4	**145**
Reduced algae blooms in July	0	1	2	3 **3.4**	4	**147**
Reduced algae blooms in August	0	1	2	3 **3.3**	4	**145**
Reduced algae blooms in September	0	1	2	3 **3.0**	4	**145**

8. Below is a list of activities intended to improve our lake. Please tell us if you think each activity should be pursued by the Lake District. **(Circle a response for each item.)**

	Definitely no	Probably no	Unsure	Probably yes	Definitely yes	**Resp.**
Educate residents about lake issues	0	1	2	3 **3.4**	4	**150**
Minimize nutrient runoff from farms	0	1	2	3 **3.6**	4	**151**
Minimize runoff from residences	0	1	2	3 **3.4**	4	**150**
Add more fish cribs	0	1	2 **2.5**	3	4	**149**
Plant native aquatic plants	0	1	2 **2.5**	3	4	**150**
Be involved in local planning and zoning	0	1	2 **2.6**	3	4	**151**
Encourage installation of shoreland practices	0	1	2 **2.8**	3	4	**150**
Pursue funding for shoreland practices	0	1	2 **2.6**	3	4	**150**
Encourage farm conservation practices	0	1	2 **2.6**	3	4	**152**
Pursue funding for farm conservation practices	0	1	2	3 **3.4**	4	**149**
Monitor lake water quality	0	1	2	3 **3.5**	4	**153**
Monitor for aquatic invasive species	0	1	2	3 **3.6**	4	**152**
Prevent aquatic invasive species introduction	0	1	2	3	**3.9** 4	**151**
Protect sensitive habitat areas	0	1	2	3 **3.4**	4	**151**
Increase boating regulation enforcement	0	1	2 **2.3**	3	4	**149**
Assist in acquiring property to protect the lake	0	1	2 **2.3**	3	4	**146**
Create new"slow no-wake" zones	0	1	**1.9** 2	3	4	**150**
Conduct an alum treatment (see definition)	0	1	2	3 **3.3**	4	**146**
Other (list)	0	1	2	3	4	
Other (list)	0	1	2	3	4	
Other (list)	0	1	2	3	4	

9. The Lake District will pursue grant funding to cover the costs associated with water quality improvements, but grants are unlikely to cover all costs. We are hoping that property owners will also be willing to support water quality improvements for Cedar Lake. Your response is not a measure of commitment but rather will help us gauge potential support from property owners. How much, if anything, would you be willing to contribute on an annual basis for long-term water quality improvements in Cedar Lake?

   $ AVE:$231 RANGE: $0-$2,000 (113 responses) (each year)

In the space below, please include any other comments you may have regarding the lake, or the activities of the lake district.

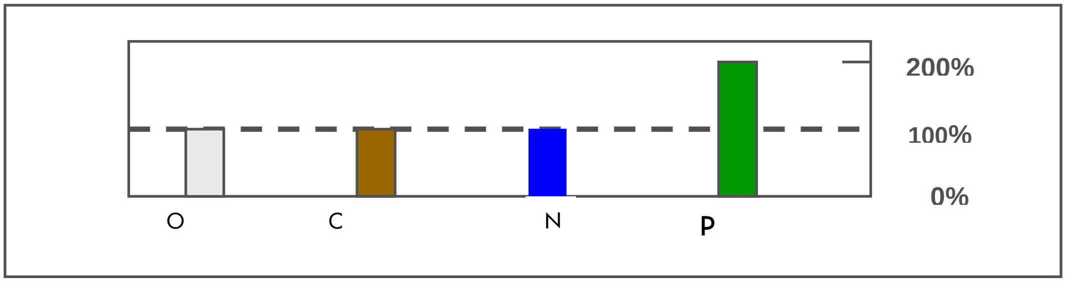
THANKS FOR TAKING THE TIME TO COMPLETE THIS SURVEY!!

Appendix B. Understanding Lake Information

To help understand the water quality study results in this plan, an introduction of limnology - the study of lakes - follows.

Importance of Phosphorus

The two nutrients of greatest interest in lakes are nitrogen and phosphorus. Both are required for plant and algae growth, but phosphorus is the most common limiting nutrient in lakes. "Limiting" means that of all nutrients available, phosphorus will be the first to run out and therefore limit plant growth. Therefore, increasing phosphorus can result in increases in plant and algae growth. Because algae absorb phosphorus directly from the water column, they will often respond most dramatically to increases in phosphorus availability.



This graph shows the resultant algae growth by adding 0.05 micrograms per liter (ppb) of each nutrient in an unproductive (low nutrient) lake[30]. As can be observed in the graph, in a phosphorus-limited lake, raising the phosphorus by 0.05 micrograms per liter can double the algae growth while there is no increase with addition of the other nutrients. In a lake setting, increasing phosphorus content by l pound can result in 500 pounds of algae growth.

Aquatic plants will also respond to increases in phosphorus, but many are rooted and absorb the phosphorus from the sediment. As a result, they may not reflect increases in phosphorus concentrations in the water as quickly (except for plants such as coontail which doesn't need to root).

Forms of Phosphorus

Phosphorus usually exists in the form of phosphate (PO_4^{-3}). Phosphate can exist in various forms: organic, inorganic, soluble, and insoluble. The first important form is referred to as soluble reactive phosphorus (SRP) - a common form of phosphorus in fertilizers. This form is dissolved readily in the water and is immediately available for plant and algae growth.

The second important form is total phosphorus (TP). This is the measurement of all forms of phosphorus in the water. Total phosphorus is important because it reflects the

[30] From *Water on the Web*. University of Minnesota. 2008.

amount of phosphorus potentially available for plant and algae growth. Phosphorus has a propensity to bind to sediments. If an increased amount of sediment is introduced in a lake, the TP will most likely rise as well. Phosphorus can also be contained in the tissue of microorganisms and algae which would also be reflected in TP. A high TP value does not necessarily indicate immediate algae growth since some or much of the total phosphorus may not be in the usable, SRP form.

If a large amount of the TP in runoff to the lake is SRP, it is mostly likely coming from sources such as sewage, fertilizers, and manure. If the TP has very little SRP in it, then most of the phosphorus is in other forms such as those tied to sediment or present in plant tissue. Phosphorus in an unusable form must be converted by biological or chemical reactions before it is available as SRP.

Sources of Phosphorus

Phosphorus can come from many sources. Any tissue or waste from living or once living organisms can be a source of phosphorus. Therefore, any human or animal waste (from septic systems and manure) contains phosphorus. Any leaves or grass clippings can also contain phosphorus. Decomposition of dead plants and animals releases phosphorus.

As mentioned earlier, phosphates tend to bind to sediment. Whether water carrying sediment runs directly from the land into the water, or is carried in streams to the lake, it is a source of phosphorus. High levels of erosion can create significant phosphorus loads.

Phosphorus is also concentrated in raindrops. Raindrops pick up dust and other particulate matter in the air and deposit the phosphorus into the lake as precipitation. In many lakes, this can be a significant source of phosphorus, especially in more pristine lakes that receive little phosphorus from other sources.

As precipitation hits the land around the lake (the watershed), some of the rain will infiltrate into the soil and some will run-off. As the water runs off of the land, it can pick up sediments, dead and living matter, and dissolved forms of phosphorus. When this water reaches the lake, it brings the phosphorus with it. The amount of rain, soil type, the topography, and the degree of vegetative cover will affect the concentration of phosphorus carried in runoff water. When the land is covered with forest, the soil is more stable. The raindrops dissipate and infiltrate into the soil, and therefore, the runoff volume and phosphorus content is low. On the contrary, a row crop field such as a cornfield will not dissipate the raindrops, and the exposed soil will be much less stable. This results in increased erosion and runoff volume and therefore, higher phosphorus concentration and higher phosphorus loads into the lake.

Another source of phosphorus in a lake is the release from the lake bottom sediments. As decomposers break down the dead organic matter in the lake bottom sediment, phosphorus is released. Much of the sediment in lakes will bind phosphorus just as on land. The major contributor to this binding is iron. When iron is in high enough oxygen conditions, it has a +3 charge and therefore binds the phosphate (which has a -3 charge) forming an insoluble particle and remaining in the sediment. When the oxygen content decreases, the iron is reduced to a +2 charge, becomes soluble, and tends to release the phosphate ions. As a result, the sediment can release very large amounts of phosphorus into the water column. Phosphorus release occurs at a threshold of low dissolved oxygen – referred to as anoxia - of 1 mg/l or less. The length of time the sediment is anoxic and the size of the area that goes anoxic determines the amount of phosphorus released. Release of phosphorus from lake bottom sediment is one component of the lake's internal load.

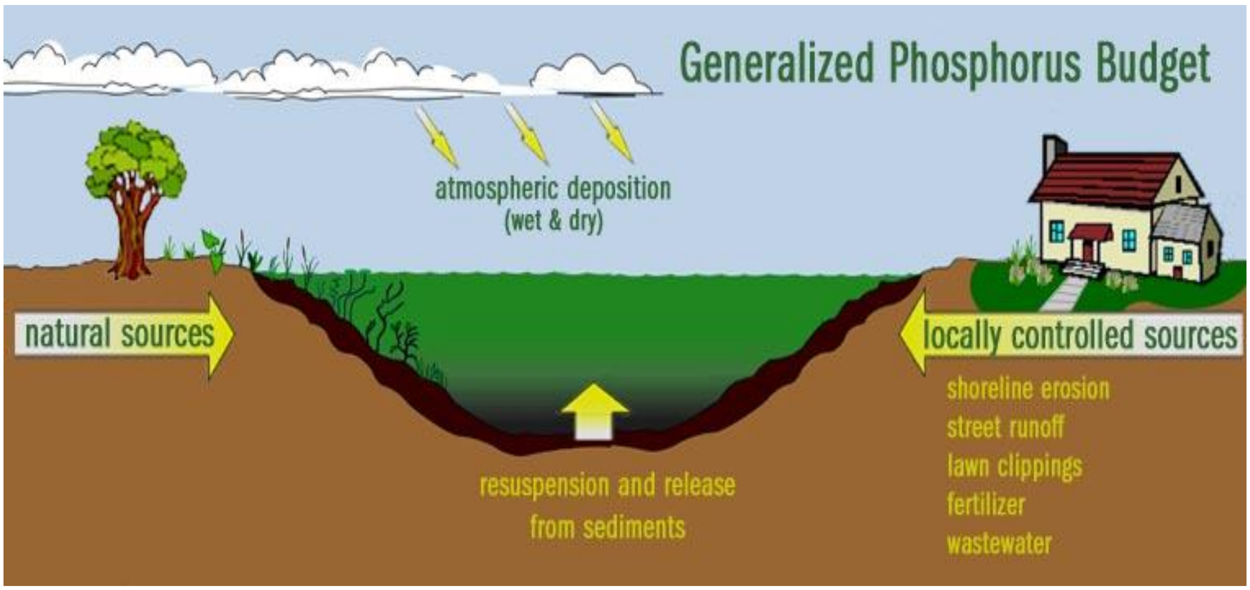
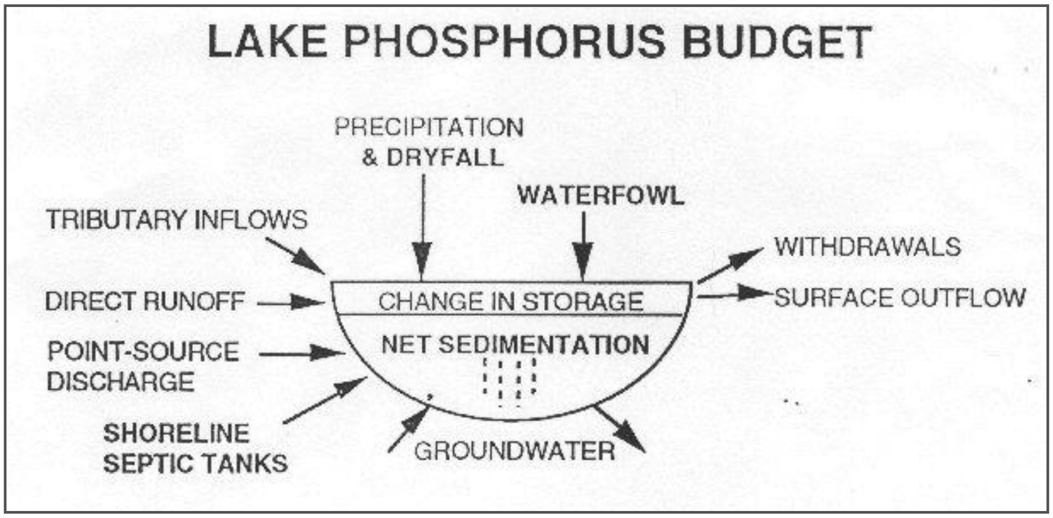


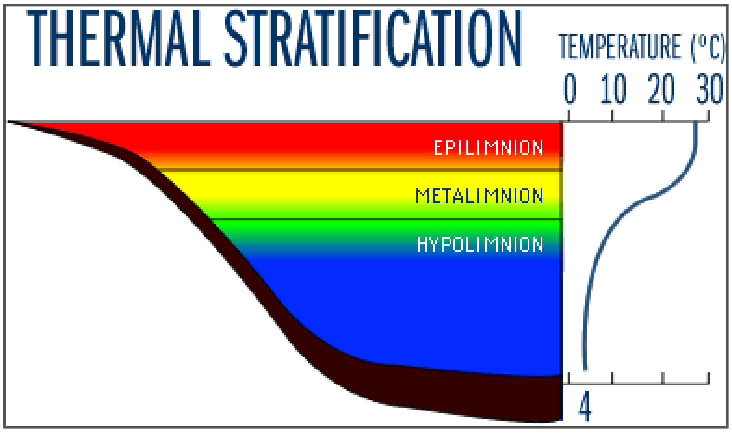
Figure obtained from "Water on the Web" (www.waterontheweb.org) an educational website of the University of Minnesota.

A summary of the phosphorus sources and losses are outlined in the diagram below. [31]



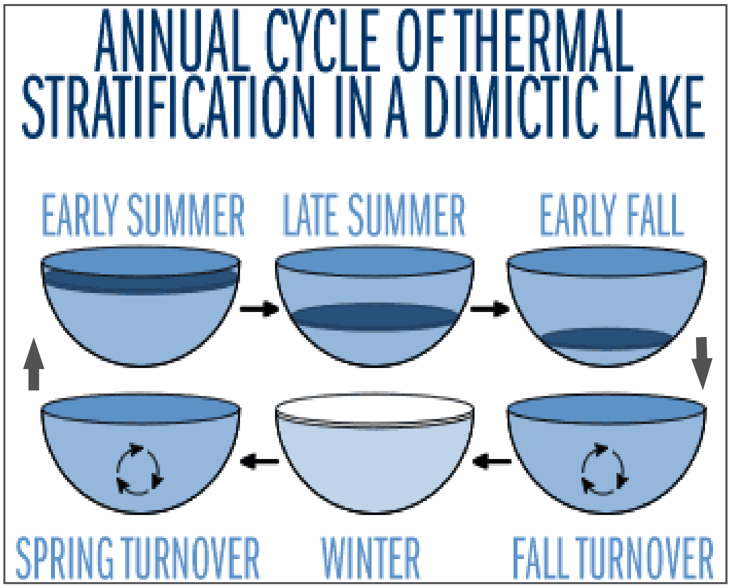
In many cases, a lake will stratify during the summer months. When a lake stratifies, the colder water stays on the bottom (hypolimnion) of the lake while the warmer water remains on the surface (epilimnion). If this stable situation remains, the lake water does not mix. The phosphorus released from the bottom sediment (where low oxygen levels occur) remains in the hypolimnion until the lake turns over in the fall. If the lake if weakly stratified, the lake may mix prior to the fall turnover. With anoxic conditions that release phosphorus, phosphorus will be mixed into the water column where it is available for uptake by algae.

Photosynthesis and wave action are major contributors of oxygen to a lake. When a lake stratifies, however, there is no opportunity for oxygen to get to the bottom of the deep portions of the lake. On the bottom, microorganisms will use and deplete the oxygen during respiration. If the lake doesn't mix and has no photosynthesis, the lake will tend to reach anoxic conditions. The rate of stratification and the rate of respiration (from breaking down organic matter) will determine how early in the summer the lake will go into anoxia on the bottom.



[31] From *Water on the Web*. University of Minnesota. 2008.

As the water cools in the fall, that water becomes denser and sinks, mixing the lake. This process is called fall turnover. When the lake freezes, the ice floats. In the spring when the ice melts, the cold water sinks, again mixing the lake (spring turnover). If anoxic conditions occurred during the summer months, a phosphorus load will usually be released in the water column during fall turnover. In Cedar Lake, anoxic conditions develop and mixing occurs periodically throughout the summer.

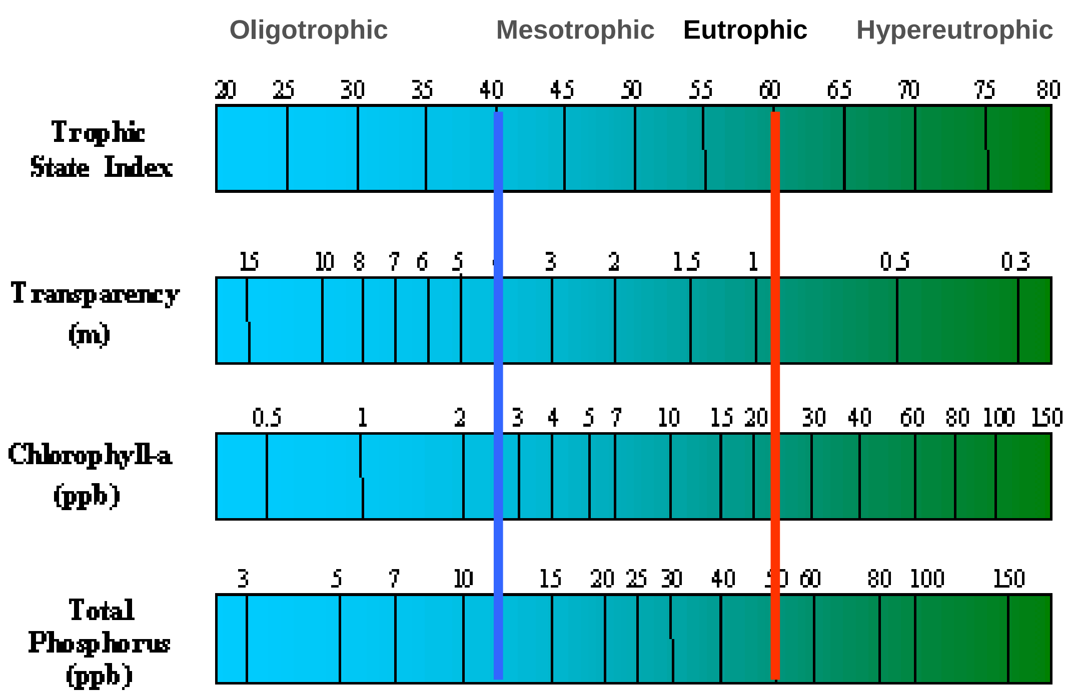


Trophic State

Trophic state describes the productivity of a lake. The least productive lakes are oligotrophic. The most productive lakes are referred to as eutrophic. Those in the middle are called mesotrophic. The more nutrients available in a lake, the more productive the lake will be. If a watershed with little runoff and phosphorus loading surrounds a lake, the water will tend to have low phosphorus levels. This will result in limited plant and algae growth, causing it to be classified as an oligotrophic lake.

Trophic state can be measured and the lake given a trophic state value (the Carlson Trophic State Index). This value can be based upon three measurements: total phosphorus, Secchi depth, and chlorophyll a. If the phosphorus is high, the algae will grow more, resulting in high chlorophyll a and reduced water clarity. Water clarity is measured by the Secchi disk reading. If there is limited phosphorus, the water will have little algae growth, and therefore low chlorophyll a readings and high Secchi depths. This table shows the Carlson Trophic State value in the left column and the characteristics of each lake type in the right column.

Index Value	Trophic State and Description
<40	Oligotrophic: clear water; high hypolimnetic O_2 year-round but possible anoxia in the deeper hypolimnion part of year
40-50	Mesotrophic: moderately clear water; possible hypolimnetic anoxia in summer and/or under ice. Fully supportive of all swimmable /aesthetic uses; possible cold-water fishery
50-60	Mildly eutrophic: decreased secchi; anoxic hypolimnion; possible heavy aquatic plant growth; warm-water fishery; supportive of all swimmable /aesthetic uses but "threatened"
60-70	Eutrophic: blue-green algal dominance with scums possible; extensive aquatic plant growth; not supportive of all beneficial uses
>70	Hypereutrophic: heavy blooms and scums in summer likely; dense "weed" beds; hypereutrophic; possible fish kills; fewer plant beds due to high algae; not supportive of many beneficial uses



Management of Phosphorus

Some sources of phosphorus can be managed very effectively, while other sources can't be managed. Atmospheric deposition is not manageable since it is carried from other locations and deposited via rain. However, when sources of phosphorus are from the watershed, various management options are available. Any practice that can reduce runoff and retain the water or infiltrate the water into the soil is very beneficial. Because phosphorus is tied to sediment, phosphorus loading can be reduced by preventing water with sediment and dissolved phosphorus from making its way into the lake. If the water is infiltrated, it will return to the water table, and the soil it filters through will remove the phosphorus. Land cover with significant vegetation will slow the runoff of water and help reduce phosphorus loading.

For these reasons, restoring areas that contain exposed soil, have vegetation with very shallow root structure, or are prone to erosion and the release of sediment can significantly reduce phosphorus loading. Many agricultural and lawn care practices involve fertilizing with soluble phosphorus. As a result, these areas can greatly increase phosphorus loading. However, if the water runoff can be reduced by planting buffers of taller vegetation or changing agricultural practices to grow crops such as grasses, the phosphorus can be retained and not reach the lake as readily.

Impervious surfaces are those that do not allow water to soak in and result in increased runoff. Roads, driveways, roofs, sidewalks and parking lots are all examples of impervious surfaces. Large amounts of sediment, and therefore phosphorus, are carried to the lake when significant impervious surfaces are present. If that water can be slowed, or better yet, infiltrated into the soil, the loading can be significantly reduced.

In this photo, a sediment plume is very evident. Notice the degree of development and the large amount of impervious surfaces.

Septic system malfunctioning can also cause loading of phosphorus. A typical septic system relies on the soil's ability to retain the nutrients from human waste by infiltrating the water in a drain field. If the system is not functioning properly and lacks the infiltration and ultimate phosphorus removal, the nutrients can reach the lake. Holding tanks that don't leak and are routinely pumped can reduce failure and therefore phosphorus inputs.

Appendix C. Summaries of Previous Cedar Lake Water Quality Studies

Sorge, Buzz and Marty Engel. Wisconsin Department of Natural Resources. *Cedar Lake Management Plan.* May 1989.

Cedar Lake algae blooms have been documented since the 1930's. Copper sulfate was used on the lake since the 1940's to provide short term relief of nuisance algae blooms. This study (and a previous study in 1977/1980) identified sources of excess nutrients as carp, bottom sediments, and watershed.

Carp estimates were made with a mark/recapture study conducted in 1987-88. Carp numbers and weight were estimated to contribute 4463 pounds (2024 kg)/year.

Bottom sediment contributions were estimated from information collected in summer of 1987. Anoxia occurred in all areas of the lake deeper than 23 feet. This area is 545 acres which releases 59 lbs./day. Annual estimate for sediment was 4431 pounds (2010 kg)/year.

Table 1. Estimated Annual Phosphorus Inputs.

SOURCE	Kg/Yr	Lbs/Yr	Percent
Carp Population	2024	4463	36.4
Bottom Sediments	2010	4431	36.1
Watershed	1300	2860	23.3
Atmospheric	150	330	2.7
Groundwater	54	119	1.0
Septic System	30	66	< 1
Total	5568	12,269	

Modeling results indicated that multiple sources of phosphorus must be controlled to significantly reduce algae populations. An objective is a 50% reduction in phosphorus load.

Carp Reduction Goal: Reduce carp populations by 75%. A variety of methods are proposed including biomanipulation and carp harvest.

Bottom Sediments: Reduce phosphorus inputs from bottom sediments by 80%. An aerator is proposed to accomplish this goal.

Watershed: Reduce loading from the watershed by 30 to 50%. A process to encourage a priority watershed project is described.

Copper treatment is discouraged with evaluation of treatment effectiveness required.

→ **The aerator was installed in 1991.**

Sorge, Buzz, *Memorandum re: Cedar Lake Management Plan Update.* September 19, 1996.

A plan update is recommended along with an overview of current implementation status.

- An aeration system has been installed.
- Horse Creek (Cedar Lake) priority watershed selected and in planning stage.
- Carp study planned for 1997.

<u>Needs identified:</u>
Update of carp recommendations and harvesting plan
Lake level manipulation was raised as a concern for aquatic plants
Task force for plan development to include broader user groups
Study of aquatic plant declines is needed
AIS prevention should be a focus
Watershed based educational strategy
Develop deep water habitats through placement of cribs
Demonstrate shoreland restoration techniques
Conduct a feasibility study for restoration of emergent aquatic plants
Map walleye spawning sites
Involvement in Horse Creek watershed project
Encourage implementation of water quality-based building, zoning and land use regulations
Conduct a sanitary survey around the lake.

Summary of highest priority future activities identified through public meetings for Cedar Lake

Develop more deep-water habitat and improve overall lake habitat.

Continue to develop and implement carp control strategies.

Support activities designed to improve water quality.

Support the development of water quality friendly shoreland uses.

Continue to look for funding and financial support.

Complete investigations into the role of on-site waste disposal.

The Cedar Lake P&R District (Jim Brockpahler) installed a carp barrier at the dam (the lake outlet) around 1997.[32]

Wisconsin Department of Natural Resources. *Cedar Lake Management Plan Amendment.* May 17, 2001.
No progress evident toward meeting 50% phosphorus reduction goal.

Fisheries progress includes:

- Walleye and other game fish populations estimates:
- Increased size limits on largemouth, bass (1989), Walleye (1990 and 2008), and Musky,
- Musky stocking (1000 every other year)

Aerator is deemed successful at reducing 66% of sediment phosphorus load

Priority watershed plan has begun.

Garrison, Paul. Wisconsin Department of Natural Resources. Bureau of Science Services. *Cedar Lake, Polk Co. Destratification Report.* April 2002.
A destratification system was installed in Cedar Lake in 1991 to reduce internal loading from the lake sediments. The system included an air compressor and a delivery system of perforated plastic pipe.

The destratification system appeared to increase the lake's water clarity. Prior to installation, the lake would stratify for periods of a few days to a month or more from June to August. During this time, the bottom would become anoxic and P would be released from the sediments. In the first 2 years of operation, periods of stratification

[32] Stuart Nelson. Personal Communication March 15, 2013.

were reduced, and the release of P from the sediments was reduced by 70%. Macrophyte coverage also increased in the lake.

A February 1996 report from DNR Bureau of Integrated Services concluded that the aeration system did not prevent lake stratification but did reduce contact of anoxic water with lake sediments and therefore reduced migration of P from lake sediments. (from Sorge 2001 summary).

Garrison, Paul. Wisconsin Department of Natural Resources. *Cedar Lake, Polk County Sediment Core Results.* April 2002.
A sediment core was collected from Cedar Lake in June 1997. The core was dated, and the sedimentation rate was analyzed. Sediment increased as the area was plowed for agriculture in the late 1800s. After a subsequent decline, sedimentation rates again increased beginning around 1960 through 2000. From 1980-2000, potassium has increased more than aluminum indicating an increase in the use of commercial fertilizers. Increased phosphorus in sediments is probably from both increased loading from the watershed and increased internal loading from the lake sediments.

Wisconsin Department of Natural Resources. *Cedar Lake Phosphorus TMDL*. July 2003.
The Cedar Lake TMDL was the first TMDL approved by EPA in Wisconsin.[33]

The TMDL draws upon data and modeling results from the WDNR Cedar Lake Management Plan (1989) and watershed analysis and implementation for the Horse Creek Priority Watershed Nonpoint Source Control Plan (2001).

The TMDL uses narrative water quality standards contain in NR102.04 at the time. The narrative standards are used as a guide to establish a site specific growing season (June through October) total phosphorus goal of 50 ug/L in the epilimnion (surface water) of Cedar Lake. The standard is based upon the ability to control nonpoint sources of phosphorus.

Targeted phosphorus load reductions included: watershed 30% reduction, carp 50% reduction, sediment release 40% reduction. These reductions would lead to an overall phosphorus load reduction of 40 percent.

[33] Buzz Sorge, DNR, Personal Communication via email. April 22, 2013.

Appendix D. Glossary

Aeration — To add air (oxygen) to the water supply. Generally used in lake management to reduce the release of phosphorus from lake sediments or to prevent fish kills.

Algae — Small aquatic plants without roots that contain chlorophyll and occur as single cells or multi-celled colonies. Algae form the base of the food chain in aquatic environments.

Algal bloom — Heavy growth of algae in and on a body of water resulting from high nutrient concentrations.

Alluvium — Clay, silt, sand, gravel, or similar detrital material deposited by running water.

Alkalinity — The acid combining capacity of a (carbonate) solution, also describes its buffering capacity.

Animal waste management — A group of practices including barnyard runoff management, nutrient management, and manure storage facilities designed to minimize the negative effects of animal manure on surface and groundwater resources.

Aquatic plant survey — A systematic mapping of types and location of aquatic plants in a water body, usually conducted in a boat. Survey information is presented on an aquatic plant map.

Aquifer — A water-bearing stratum of permeable rock, sand, or gravel.

Anoxic — Without oxygen. Lake water is generally considered anoxic at mg/l or less oxygen.

BMP's (Best Management Practices) — Practices or methods used to prevent or reduce amounts of nutrients, sediments, chemicals or other pollutants from entering water bodies from human activities. BMP's have been developed for agricultural, silvicultural, construction, and urban activities.

Bathymetric map — A map showing depth contours in a water body. Bottom contours are usually presented as lines of equal depth, in meters or feet.

Benchmark — A mark of reference indicating elevation or water level.

Benthal — Bottom area of the lake

Biocontrol — Management using biological organisms, such as fish, insects or micro-organisms like fungus.

Biomass — The total organic matter present

Bottom barriers — Synthetic or natural fiber sheets of material used to cover and kill plants growing on the bottom of a water body; also called sediment covers.

Buffer strips - Strips of grass, shrubs, trees, and other vegetation between disturbed areas and a stream, lake, or wetland.

Cluster development - Grouping homes on part of a property while maintaining a large amount of open space on the remaining land.

Chlorophyll — The green pigments of plants.

Conservation easement — A legal document that restricts the use of land to farming, open space, or wildlife habitat. A landowner may sell or donate an easement to a government agency or a private land trust.

Consumers — Organisms that nourish themselves on particulate organic matter.

Contact herbicide — An herbicide that causes localized injury or death to plant tissues it contacts. Contact herbicides do not kill the entire plant.

Cost effective — A level of treatment or management with the greatest incremental benefit for the money spent.

Decomposers — Organisms, mostly bacteria or fungi, that break down complex organic material into its inorganic constituents.

Detritus — Settleable material suspended in the water. Organic detritus comes from the decomposition of the broken down remains of organisms. Inorganic detritus comes from settleable mineral materials.

Dissolved oxygen — A measure of the amount of oxygen gas dissolved in water and available for use by microorganisms and fish.

Dissolved Phosphorus (SRP) — Phosphorus dissolved in water. Soluble reactive phosphorus is a form of dissolved phosphorus readily available for uptake by algae and aquatic plants.

Drainage basin — The area drained by, or contributing to, a stream, lake, or other water body (see watershed).

Drawdown — Decreasing the level of standing water in a water body to expose bottom sediments and rooted plants. Water level drawdown can be accomplished by physically releasing a volume of water through a controlled outlet structure or by preventing recharge of a system from a primary external source.

Dredging — Physical methods of digging into the bottom of a water body to remove sediment, plants, or other material. Dredging can be performed using mechanical or hydraulic equipment.

Ecology — Scientific study of relationships between organisms and their surroundings (environment).

Ecosystems — The interacting system of a biological community and its nonliving surroundings.

Emergent plants — Aquatic plants that are rooted or anchored in the sediment around shorelines, but have stems and leaves extending well above the water surface. Cattails and bulrushes are examples of emergent plants.

Endothall — The active chemical ingredient of the aquatic contact herbicide Aquathol®.

Environmental Protection Agency — The federal agency responsible for enforcing federal environmental regulations. The Environmental Protection Agency delegates some of its responsibilities for water, air, and solid waste pollution control to state agencies.

Epilimnion — The uppermost, warm, well-mixed layer of a lake.

Eradication — Complete removal of a specific organism from a specified location, usually refers to a noxious, invasive species. Under most circumstances, eradication of a population is very difficult to achieve.

Erosion — The wearing away of the land surface by wind or water.

Eutrophic — Refers to a nutrient-rich lake. Large amounts of algae and weeds characterize a eutrophic lake (see also "Oligotrophic" and "Mesotrophic").

Eutrophication — The process of nutrient enrichment of a lake leading to increased production of aquatic organisms. Eutrophication can be accelerated by human activity such as agriculture and improper waste disposal.

Exotic — Refers to species of plants or animals that are not native to a particular region into which they have moved or invaded. Eurasian watermilfoil is an exotic plant invader.

Fecal coliform — A group of bacteria used to indicate the presence of other bacteria that cause disease. The number of coliform is particularly important when water is used for drinking and swimming.

Floating-leafed plant — Plants with oval or circular leaves floating on the water surface, but are rooted or attached to sediments by long, flexible stems. Waterlilies are examples of rooted floating-leafed plants.

Fluridone — The active chemical ingredient of the systemic aquatic herbicide SONAR®.

Flushing rate — Term describing rate of water volume replacement of a water body, usually expressed as basin volume per unit time needed to replace the water body volume with inflowing water. The inverse of the flushing rate is the (hydraulic) detention time. A lake with a flushing rate of one lake volume per year has a detention time of one year.

Food chain — A sequence of organisms where each uses the next as a food source.

Freely-floating plants — Plants that float on or under the water surface, unattached by roots to the bottom. Some have small root systems that simply hang beneath the plant. Water hyacinth and tiny duckweed are examples of freely-floating plants.

Glyphosate — The active chemical ingredient of the systemic herbicide RODEO®.

Ground-truthing —Close or on-the-ground observation used to test the validity of observations made at a distance as in aerial or satellite photography

Groundwater — Water which fills internal passageways of porous geologic formations (aquifers) underground. Groundwater flows in response to gravity and pressure, and is often used as the source of water for communities and industries.

Habitat — The place or type of site where a plant or animal naturally lives and grows.

Herbicide — A chemical used to suppress the growth of or to kill plants.

Habitat — The physical place where an organism lives.

Hydraulic detention time — The period of detention of water in a basin. The inverse of detention time is flushing rate. A lake with a detention time of one year has a flushing rate of one lake volume per year.

Hypolimnion — The cold, deepest layer of a lake that is removed from surface influences.

Integrated aquatic plant management — Management using a combination of plant control methods to maximize beneficial uses, minimize environmental impacts and optimize overall costs.

Limiting nutrient — Essential nutrient needed for growth of a plant organism which is the most scarce in the environment. Oftentimes, in freshwater systems, either phosphorus or nitrogen is the limiting nutrient for plant growth.

Limnology — The study of inland waters.

Littoral zone — The region of a body of water extending from shoreline outward to the greatest depth occupied by rooted aquatic plants.

Loam — A soil consisting of varying proportions of sand, clay, and silt. Generally well-suited for agriculture.

Loess — A loamy soil deposited by wind.

Macrophyte — Large, rooted or floating aquatic plants that may bear flowers and seeds. Some plants, like duckweed and coontail, are free-floating and are not attached to the bottom. Occasionally, filamentous algae like *Nitella* sp. can form large, extensive populations and be an important member of the aquatic macrophyte community.

Mesotrophic — Refers to a moderately fertile nutrient level of a lake between the oligotrophic and eutrophic levels. (See also "Eutrophic" and "Oligotrohpic.")

Milligrams per liter (mg/l) — A measure of the concentration of substance in water. For most pollution measurements this is the equivalent of "parts per million" (ppm).

Mitigation — The effort to lessen the damages from a particular project through modifying a project, providing alternatives, compensating for losses, or replacing lost values.

Morphology — Study of shape, configuration, or form.

Navigable waters — A water body with a bed and a bank that can float a watercraft at any point in the year.

Natural beauty — (as defined by Bone Lake Comprehensive Lake Management Plan Advisory Committee) Wildlife, plants, trees, clear water, quiet solitude, and a variety of scenery, views of the lake. Where development occurs, it is preferable to have minimal views of buildings.

Niche — The position or role of an organism within its community and ecosystem.

Nitrogen — A chemical constituent (nutrient) essential for life. Nitrogen is a primary nutrient necessary for plant growth.

Nonpoint source pollution (NSP) — Pollution whose sources cannot be traced to a single point such as a municipal or industrial wastewater treatment plant discharge pipe. Nonpoint sources include eroding farmland and construction sites, urban streets, and barnyards. Pollutants from these sources reach water bodies in runoff. They can best be controlled by proper land management.

Non-target species — A species not intentionally targeted for control by a pesticide or herbicide.

Nutrient — Any chemical element, ion, or compound required by an organism for the continuation of growth, reproduction, and other life processes.

Nutrient management plan — A guidance document that provides fertilizer and manure spreading recommendations for crop fields based upon soil test results and crop needs. Plans are sometimes referred to as NRCS 590 plans for the Natural Resources Conservation Service Standard that guides their preparation.

Oligotrophic — Refers to an unproductive and nutrient-poor lake. Such lakes typically have very clear water. (See also "Eutrophic" and "Mesotrophic.")

Ordinary high water mark — The point on the bank or shore up to which the water leaves a distinct mark on the shore or bank from its presence, wave action, or flow. The mark may be indicated by erosion, destruction of or change in vegetation, or another easily recognizable characteristic.

Oxidation — A chemical process that can occur with the uptake of oxygen.

pH — The negative logarithm of hydrogen ion activity. pH values range from 1-10 (low pH values are acidic and high pH levels are alkaline).

Peat — Soil material formed by partial decomposition of plant material.

Pesticide — Any chemical agent used to control specific organisms, such as insecticides, herbicides, fungicides, etc.

Phosphorus — A chemical constituent (nutrient) essential for life. Phosphorus is a primary nutrient necessary for plant growth. When phosphorus reaches lakes in excess amounts, it can lead to over-fertile conditions and algae blooms.

Photosynthesis — Production of organic matter (carbohydrate) from inorganic carbon and water in the presence of light.

Phytoplankton — Free floating microscopic plants (algae).

Point (pollutant) source — A source of pollutants or contaminants that discharges through a pipe or culvert. Point sources, such as an industrial or sewage outfall, are usually readily identified.

Pollution — The presence of materials or energy whose nature, location, or quantity produces undesired environmental effects. Pollutants can be chemicals, disease-producing organisms, silt, toxic metals, and oxygen-demanding materials, to name a few.

Primary production — The rate of formation of organic matter or sugars in plant cells from light, water, and carbon dioxide. Algae are primary producers.

Problem statement — A written description of important uses of a water body that are being affected by the presence of problem aquatic plants.

Producers — Organisms able to build up their body substance from inorganic materials.

Productivity — A measure of the amount of living matter which is supported by an environment over a specific period of time. Often described in terms of algae production for a lake.

Public awareness/outreach — Programs designed to share technical information and data on a particular topic, usually associated with activities on or around a water body.

Recruitment — The process of adding new individuals to a population.

Residence time — The average length of time that water or a chemical constituent remains in a lake.

Riparian — Belonging or relating to the bank of a lake, river, or stream.

Riprap — Broken rock, cobbles, or boulders placed on the bank of a stream to protect it against erosion.

Rotovation — A mechanical control method of tilling lake or river sediments to physically dislodge rooted plants. Also known as bottom tillage or derooting.

Runoff — Water from rain, snowmelt, or irrigation that flows over the ground surface and returns to streams and lakes. Runoff can collect pollutants from air or land and carry them to receiving waters.

Secchi depth — A measure of transparency of water (the ability of light to penetrate water) obtained by lowering an eight inch secchi disc into the water until it is no longer visible. Measured in units of meters or feet.

Secchi disc — A 20-cm (8-inch) diameter disc painted white and black in alternating quadrants. It is used to measure light transparency in lakes.

Sediment — Soil particles suspended in and carried by water as a result of erosion.

Sensitive areas — Plant communities and other elements that provide important fish and wildlife habitat as designated by the Wisconsin Department of Natural Resources.

Septic system — Sewage treatment and disposal for homes not connected to sewer lines usually with a tank and drain field. Solids settle to the bottom of the tank. Liquid percolates through the drain field.

Standing crop — The biomass present in a body of water at a particular time.

Storm sewers — A system of sewers that collect and transport rain and snow runoff. In areas that have separated sewers, such stormwater is not mixed with sanitary sewage.

Stratification — Horizontal layering of water in a lake caused by temperature-related differences in density. A thermally stratified lake is generally divided into the epilimnion (uppermost, warm, mixed layer), metalimnion (middle layer of rapid change in temperature and density) and hypolimnion (lowest, cool, least mixed layer).

Submersed plants — An aquatic plant that grows with all or most of its stems and leaves below the water surface. Submersed plants usually grow rooted in the bottom and have thin, flexible stems supported by the water. Common submersed plants are milfoil and pondweeds.

Susceptibility — The sensitivity or level of injury demonstrated by a plant to effects of an herbicide.

Suspended solids (SS) — Small particles of solid pollutants suspended in water.

Systemic herbicide — An herbicide in which the active chemicals are absorbed and translocated within the entire plant system, including roots. Depending on the active ingredient, systemic herbicides affect certain biochemical reactions in the plant and can cause plant death. SONAR® and RODEO® are systemic herbicides.

Thermal stratification — Horizontal layering of water in a lake caused by temperature-related differences in density. A thermally stratified lake is generally divided into the epilimnion (uppermost, warm, mixed layer), metalimnion (middle layer of rapid change in temperature and density), and hypolimnion (lowest, cool, least mixed layer).

Thermocline — Zone (horizontal layer) in a water body in which there is a rapid rate of temperature decrease with depth. Also called the metalimnion, it lies below the epilimnion.

Tolerable soil loss — The tolerable soil loss rate, commonly referred to as "T," is the maximum average annual rate of soil erosion for each soil type that will permit a high level of crop productivity to be sustained economically and indefinitely (ATCP 50.01(16)).

Topographic map — A map showing elevation of the landscape in contours of equal height (elevation) above sea level. This map can be used to identify boundaries of a watershed.

Total maximum daily loads — The maximum amount of a pollutant that can be discharged into a stream without causing a violation of water quality standards.

Total Phosphorus (TP) —A measure of all the phosphorus in a sample of water. In many cases total phosphorus is the preferred indicator of a lake's nutrient status because it remains more stable than other forms over an annual cycle.

Transect lines — Straight lines extending across an area to be surveyed.

Tributaries — Rivers, streams, or other channels that flow into a water body.

Trophic state — The level of growth or productivity of a lake as measured by phosphorus content, algae abundance, and depth of light penetration. Lakes are classified as oligotrophic (low productivity, "good" water quality), mesotrophic (moderate productivity), or eutrophic (high productivity; "poor" water quality).

Turbid — Lack of water clarity. Turbidity is closely related to the amount of suspended materials in water.

Uniform dwelling code — A statewide building code specifying requirements for electrical, heating, ventilation, fire, structural, plumbing, construction site erosion, and other construction related practices.

University of Wisconsin Extension (UWEX) — A special outreach and education branch of the state university system.

Vascular plant— A vascular plant possesses specialized cells that conduct fluids and nutrients throughout the plant. The xylem conducts water and the phloem transports food.

Variance — Governmental permission for a delay or exception in the application of a given law, ordinance, or regulation. Also, see water quality standard variance.

Waste — Unwanted materials left over from manufacturing processes; refuse from places of human or animal habitation.

Water body usage map — A map of a water body showing important human use areas or zones (such as swimming, boating, fishing) and habitat areas for fish, wildlife, and waterfowl.

Water quality criteria — A measure of the physical, chemical, or biological characteristics of a water body necessary to protect and maintain different water uses (fish and aquatic life, swimming, etc.).

Water quality management area (WQMA) — The area within 1,000 feet from the ordinary high water mark of navigable waters that consists of a lake, pond or flowage; the area within 300 feet from the ordinary high water mark of navigable waters that consist of a river or stream; and a site that is susceptible to groundwater contamination, or that has the potential to be a direct conduit for contamination to reach groundwater. (NR 151.015(24))

Watershed — The entire surface landscape that contributes water to a lake or river.

Watershed management — The management of the natural resources of a drainage basin for the production and protection of water supplies and water-based resources.

Wetland — Areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a variety of vegetative or aquatic life. Wetland vegetation requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas.

Wisconsin administrative code — The set of rules written and used by state agencies to implement state statutes. Administrative codes are subject to public hearing and have the force of law.

Zooplankton — Microscopic animal plankton in water (Gr. *zoion* animal). *Daphnia* sp. or water fleas are freshwater zooplankton.

Glossary sources: Washington State Department of Ecology; Maribeth Gibbons Jr.; Wisconsin priority watershed planning guidance.

Appendix E. Related Plans, Regulations, and Ordinances

As described previously, knowledge of and involvement in development and implementation of local plans and ordinances can assist the Cedar Lake Protection and Rehabilitation District in achieving the goals of this Lake Management Plan.

Polk County

Comprehensive Land Use Planning

The Polk County Comprehensive Land Use Plan was adopted in 2009. The plan includes an analysis of population, economy, housing, transportation, recreation, and land use trends. It also reports the physical features of Polk County. The purpose of the land use plan is to provide general guidance to achieve the desired future development of the county and direction for development decisions. The lakes classification outlines restriction on development according to lake features. Plan information is available online at http://www.co.polk.wi.us/landinfo/PlanningCompPlan.asp

Town, City and Village Comprehensive Plans are available at:
http://www.co.polk.wi.us/landinfo/PlanningCompPlans.asp

Smart growth is a state mandated planning requirement to guide land use decisions and facilitate communication between municipalities. Wisconsin's Comprehensive Planning Law (Statute 66.1001, Wis. Stats.) was passed as part of the 1999 Budget Act. The law requires that if a local government engages in zoning, subdivision regulations, or official mapping, those local land use regulations must be consistent with that unit of local government's comprehensive plan beginning on January 1, 2010. The law defines a comprehensive plan as having at least the following nine elements:

- ✓ Issues and opportunities
- ✓ Housing
- ✓ Transportation
- ✓ Utilities and community facilities
- ✓ Agricultural, natural, and cultural resources
- ✓ Economic development
- ✓ Intergovernmental cooperation
- ✓ Land use
- ✓ Implementation
- ✓ Polk County added "Energy and Sustainability"

Polk County Comprehensive Land Use Ordinance

The Polk County Comprehensive Land Use Ordinance**,** more commonly known as the Zoning Ordinance, is currently being updated due to the passage of the Comprehensive Plan. 17 of Polk County's 24 Towns have adopted county zoning, including: the Towns of Alden, Apple River, Beaver, Black Brook, Clam Falls, Clayton, Clear Lake, Eureka, Georgetown, Johnstown, Lincoln, Lorain, Luck, McKinley, Milltown, Osceola, and West Sweden. The Towns of Farmington, Garfield, and St Croix Falls have adopted Town

Zoning and the Towns of Balsam Lake, Bone Lake, Laketown, and Sterling have no town or county zoning other than the state-mandated shoreland zoning. Land use regulations in the zoning ordinance include building height requirements, lot sizes, permitted uses, and setbacks among other provisions. The current Comprehensive Zoning Ordinance is available at:
http://www.co.polk.wi.us/landinfo/pdfs/Ordinances/ComprehensiveLandUse.pdf

Shoreland Protection Zoning Ordinance

The State of Wisconsin's Administrative Rule NR115 dictates that counties must regulate lands within 1,000 feet of a lake, pond or flowage and 300 feet of a river or stream. The Shoreland Protection Zoning Ordinance is also currently being rewritten due to the Comprehensive Plan and the State of Wisconsin passing a new version of NR 115 in 2010. Polk County passed an update of the current Shoreland Ordinance in 2002 and again in 2008. These updates put in place standards for impervious surfaces, a phosphorus fertilizer ban for shoreland property, and lakes classification and setback standards. The current ordinance is available online at:
http://www.co.polk.wi.us/landinfo/pdfs/Ordinances/ShorelandOrdinance.pdf
Updates to the Shoreland Protection Ordinance and the Comprehensive Land Use Ordinance will be completed in 2013. The old and new version of the ordinances will be available at: http://www.co.polk.wi.us/landinfo/ordinances.asp

Subdivision Ordinance

The subdivision ordinance, adopted in 1996 and updated in 2005, requires a recorded certified survey map for any parcel less than 19 acres. The ordinance requires most new plats to incorporate storm water management practices with no net increase in runoff from development. The ordinance is available online at:
http://www.co.polk.wi.us/landinfo/PDFs/Ordinances/Subdivision%20Ordinance%202005-07-01.pdf

Animal Waste

The Polk County Manure and Water Quality Management Ordinance was revised in January 2000. A policy manual established minimum standards and specifications for animal waste storage facilities, feedlots, degraded pastures, and active livestock operations greater than 300 animal units for livestock producers regulated by the ordinances. The Land and Water Resource Department's objective was to have countywide compliance with the ordinance by 2006. The ordinance is available online at: http://www.co.polk.wi.us/landwater/MANUR21A.htm.

Storm Water and Erosion Control

The ordinance, passed in December 2005, establishes planning and permitting requirements for erosion control on disturbed sites greater than 3,000 square feet, where more than 400 cubic yards of material is cut or filled, or where channels are used for 300 feet more of utility installation (with some exceptions). Storm water plans and implementation of best management practices are required for subdivisions, survey plats, and roads where more than ½ acre of impervious surface will result. The Polk County Land and Water Resources Department administers the ordinance. The ordinance is a local mechanism to implement the Wisconsin Non-agricultural Runoff Performance Standards found in NR 151.

WI Non-Agricultural Performance Standards (NR 151)

Construction Sites >1 acre – must control 80% of sediment load from sites

Storm water management plans (>1 acre)

- Total Suspended Solids
- Peak Discharge Rate
- Infiltration
- Buffers around water

Developed urban areas (>1000 persons/square mile)

- Public education
- Yard waste management
- Nutrient management
- Reduction of suspended solids

Polk County Land and Water Resources Management Plan

The Polk County Land and Water Resources Management Plan describes the strategy the Land and Water Resources Department (LWRD) will employ from 2010-2018 to address agriculture and non-agriculture runoff management, stormwater discharge, shoreline management, soil conservation, invasive species and other environmental degradation that affects the natural resources of Polk County. The plan specifies how the LWRD will implement NR 151 (Runoff Management). It involves identifying critical sites, offering cost-share and other programs, identifying BMP's monitoring and evaluating projects for compliance, conducting enforcement activities, tracking progress, and providing information and education.

Polk County has local shoreland protection, zoning, subdivision, animal waste, and non-metallic mining ordinances. Enforcing these rules and assisting other agencies with programs are part of LWRD's ongoing activities. Other activities to implement the NR 151 Standards include information and education strategies, write nutrient management plans, provide technical assistance to landowners and lakeshore owners, perform lake studies, collaborate with other agencies, work on a rivers classification system, set up demonstration sites of proper BMP's, control invasive species, and revise ordinances to offer better protection of resources.

WI Agricultural Performance Standards (NR 151)

For farmers who grow agricultural crops

- Meet "T" on cropped fields
- Starting in 2005 for high priority areas such as impaired or exceptional waters, and 2008 for all other areas, follow a nutrient management plan designed to limit entry of nutrients into waters of the state

For farmers who raise, feed, or house livestock

- No direct runoff from feedlots or stored manure into state waters
- No unlimited livestock access to waters of the state where high concentrations of animals prevent the maintenance of adequate or self sustaining sod cover
- Starting in 2005 for high priority areas, and 2008 for all other areas, follow a nutrient management plan when applying or contracting to apply manure to limit entry of nutrients into waters of the state

For farmers who have or plan to build a manure storage structure

- Maintain a structure to prevent overflow, leakage, and structural failure
- Repair or upgrade a failing or leaking structure that poses an imminent health threat or violates groundwater standards
- Close a structure according to accepted standards
- Meet technical standards for a newly constructed or substantially-altered structure

For farmers with land in a water quality management area (defined as 300 feet from a stream, or 1,000 feet from a lake or areas susceptible to groundwater contamination)

- Do not stack manure in unconfined piles
- Divert clean water away from feedlots, manure storage areas, and barnyards located within this area

St. Croix County

A summary of St. Croix County ordinances from the county web site is included below.

Land Division

The Community Development Department is required to administer the Land Division ordinance in order to regulate and control subdivision development within St. Croix County. There are two types of land divisions - Certified Survey Maps (CSM's) - 4 lots or less and considered minor subdivisions. A major subdivision is a plat of 5 lots or more.

If you are intending to either sell or purchase property, please contact the Community Development office to insure that the correct procedures are being followed to create a legal lot. A surveyor will draft your map and assist in the subdivision process.

Applications are due the first Monday of every month. The Technical Review Committee, made up of staff, will hold two meetings per month to process and approve applications.

Sanitary Program – Private On-site Wastewater Treatment System

A State sanitary permit is required for the installation of a private on-site wastewater treatment system (POWTS) and may only be submitted by a licensed plumber. A County sanitary permit is required for the repair, reconnection, or rejuvenation of a POWTS or for the installation of non-plumbing sanitation (i.e. privy, composting toilet, etc).

A sanitary permit is required prior to obtaining a building permit from the Town. Staff will conduct at least one inspection for all work requiring a sanitary permit.

The proper maintenance of a POWT's is essential to ensure the longevity of your private sewage system and to avoid premature failure. When obtaining a sanitary permit you are required to submit a signed agreement indicating that as the property owner you will maintain your septic system properly and report this maintenance to the Community Development Office.

Zoning

Special Exception permits are required for a use that is listed as a "Special Exception" within a zoning district. A list of possible special exceptions are included in the St. Croix County Zoning Ordinance under each Zoning District. A special exception request is reviewed by the Board of Adjustment. It is strongly recommended the applicant meet with staff to discuss the request before an application is submitted. Applications are due the first Monday of the month.

Variances allow development that is inconsistent with the dimensional standards contained in the ordinance, variances cannot be issued to approve uses that are inconsistent with the ordinance. The Board of Adjustment is authorized by statute to grant variances to the strict terms of the Land Use Ordinance only when certain criteria exist. It is the applicant's responsibility to prove that those criteria exist at the site and that a variance can be granted. Staff should be contacted if you believe you have a valid request for a variance. Applications are due the first Monday of every month.

Non-Metallic Mining

Non-metallic mining is part of the Special Exception permit process, but it has it's own St Croix County Ordinance, Chapter 14 Non-metallic mining. A Non-metallic Mining Supplemental Information Sheet is helpful in filling out the permit application.

Enforcement

When a violation of the Land Use Ordinance is discovered, staff will take all possible measures to rectify the problem. Individuals who feel that a violation of a Land Use Ordinance exists may file a complaint. Submit as much supporting evidence (i.e. photos, documents, etc.) as possible in support of the complaint.

Please be advised that under Wisconsin's Public Records Law, Wis. Stats. §19.31, et al., the complaint and supporting evidence will be available for public review upon request. Only in an exceptional case may access be denied.

Town of Alden

The Town of Alden regulates land divisions and driveways. Go to Town of Alden for more information.

Town of Star Prairie

The Town of Star Prairie regulates building permits and subdivisions. Go to Town of Star Prairie for more information.

Boating Regulations

The Department of Natural Resources regulates boating in the state of Wisconsin.[34] Wisconsin conservation wardens enforce boating regulations. A few highlights of boating regulations are found below.

- ✓ Personal watercrafts (PWCs) may not operate from sunset to sunrise.
- ✓ PWC operators must be at least 12 years old.
- ✓ There are 100-foot restrictions between boats or PWCs and water skiers, towropes, and boats towing skiers.
- ✓ It is unlawful to operate within 100 feet of shore or of any dock, raft, pier, or buoyed restricted area at a speed in excess of "slow-no-wake." Boats have specific lighting requirements after dark.
- ✓ Speed must be reasonable and prudent under existing conditions to avoid colliding with any object or person.

A town or village may delegate the authority to adopt lake use regulations to a lake district. These may include regulation of boating equipment, use, or operation; aircraft; and travel on ice-bound lakes.[35] Local ordinances may now extend the slow-no-wake zone to within 200 feet of shore with passage of WI Act 31.

Dredging Regulations (Sec 30.20 Wis. Stats.)[36]

A general permit or an individual permit is required to dredge material from the bed of a navigable waterway. Local zoning permits and U.S. Army Corps of Engineers permits may also be required.

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[34] Boating regulations may be found online at www.dnr.wi.us/org/es/enforcement/docs/boating regs.pdf.
[35] Chapter 33. Wisconsin State Statutes.
[36] Information from http://dnr.wi.gov.org/water/fhp/waterway/dredging.

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Appendix G. Alum Information

ALUM TREATMENTS TO CONTROL PHOSPHORUS IN LAKES

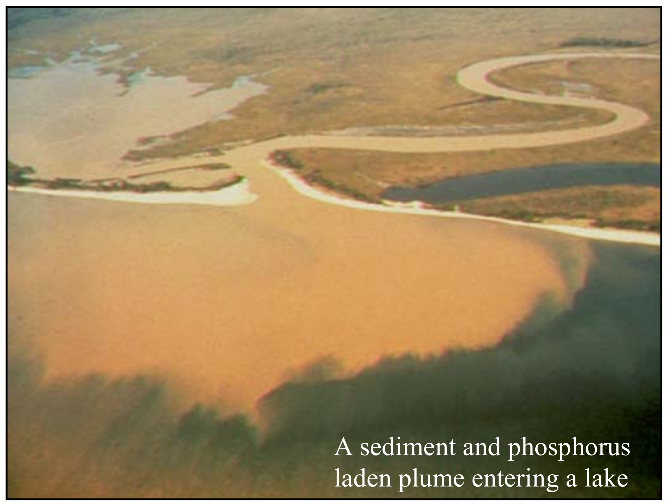
March 2003

What is alum and how does it work?

ALUM (aluminum sulfate) is a nontoxic material commonly used in water treatment plants to clarify drinking water. In lakes alum is used to reduce the amount of the nutrient **phosphorus** in the water. Reducing phosphorus concentrations in lake water can have a similar clarifying effect by limiting the availability of this nutrient for algae production. Phosphorus enters the water either **externally**, from run-off or ground water, or **internally**, from the nutrient rich sediments on the bottom of the lake. Phosphorus is released from the sediments under anoxic conditions that occur when the lake stratifies and oxygen is depleted from the lower layer. Even when external sources of phosphorus have been curtailed by best management practices, the internal recycling of phosphorus can continue to support explosive algal growth. Alum is used primarily to control this internal recycling of phosphorus from the sediments of the lake bottom. On contact with water, alum forms a fluffy aluminum hydroxide precipitate called **floc**. Aluminum hydroxide (the principle ingredient in common antacids such as Maalox) binds with phosphorus to form an aluminum phosphate compound. This compound is insoluble in water under most conditions so the phosphorus in it can no longer be used as food by algae organisms. As the floc slowly settles, some phosphorus is removed from the water. The floc also tends to collect suspended particles in the water and carry them down to the bottom, leaving the lake noticeably clearer. On the bottom of the lake the floc forms a layer that acts as a phosphorus barrier by combining with phosphorus as it is released from the sediments.

Why treat a lake with alum?

Increased nutrient loading, particularly phosphorus has accelerated eutrophication of lakes and consequently reduced their ecological health and recreational value. Frequent and pervasive algal blooms, low water transparency, noxious odors, depletion of dissolved oxygen, and fish kills frequently accompany cultural eutrophication. External sources of phosphorus delivered in run-off from the watershed are often the main contributor of excessive phosphorus to lakes.



A sediment and phosphorus laden plume entering a lake

Typically, the first steps taken in a lake rehabilitation effort target the control the external sources of phosphorus and can include: encouraging the use of phosphorus free fertilizers; improving agricultural practices, reducing urban run-off; and restoring vegetation buffers around waterways.

Lake researchers have learned that lakes are very slow to recover after excessive phosphorus inputs have been eliminated. Furthermore, it's extremely difficult to achieve recovery of lake conditions without additional in-lake management. This is due to the fact that lake sediments become phosphorus rich and can deliver excessive amounts of phosphorus to the overlying water. When dissolved oxygen levels decrease in the bottom waters of the lake (anaerobic conditions), large amounts of phosphorus trapped in the bottom sediments are released into the overlying water. This process is often called **internal** nutrient loading or recycling.

Is alum toxic to aquatic life?

Some studies have been conducted to determine the toxicity of aluminum for aquatic biota. Freeman and Everhart (1971) used constant flow bioassays, to determine that concentrations of dissolved aluminum below 52 μg Al/L had no obvious effect on rainbow trout. Similar results have been observed for salmon. Cooke, et al (1978) adopted 50 mg Al/L as a safe upper limit for post-treatment dissolved aluminum concentrations. Kennedy and Cooke (1982) indicate that: Since, based on solubility, dissolved aluminum concentrations, regardless of dose, would remain below 50 μg Al/L in the pH range 5.5 to 9.0, a dose producing post treatment pH in this range could also be considered environmentally safe with respect to aluminum toxicity. Guidelines for alum application require that the ph remain with the 5.5-9.0 range.

According to Cooke et al (1993) the most detailed study of the impact of alum treatments on benthic insects was that of Narf (1990). He assessed the long term impacts on two soft water and three hardwater Wisconsin lakes. He found that benthic insect populations either increased in diversity or remained at the same diversity after treatment. The treatment of lakes with alkalinities above 75 mg/L as $CaCO_3$ are not expected to have chronic or acute effects to biota. Fish related problems associated with alum treatments have been primarily documented in soft water lakes. However, many softwater lakes have been successfully treated with alum, when the treatments are ph buffered.

Health concerns for people?

Concerns about a connection between aluminum and Alzheimer's have been debated for some time. More recent research points to a gene rather than aluminum as the cause. In addition, aluminum is found naturally in the environment. Some foods, such as tea, spinach and other leafy green vegetables, are high in aluminum. Use of aluminum cookware has not been found to contaminate food sources.

How much does an alum treatment cost?

Costs of alum application are primarily dependent on the form of alum used (wet or dry), dosage rate, area treated, equipment rental or purchase, and labor. Liquid alum has been used when large alum doses were needed. Treatment costs range from $280/acre to $700/acre ($450=approximate average) depending on the dosage requirements and costs to mobilize equipment.

How effective are alum treatments, and how long do they last?

A number of case studies have been conducted on lakes that have undergone nutrient inactivation with alum. Eugene Welch and Dennis Cooke (1995) evaluated the effectiveness and longevity of treatments on twenty one lakes across the United States. They concluded that the treatments were effective in six of the nine shallow lakes, controlling phosphorus for at least eight years on average. Applications in stratified lakes were highly effective and long lasting. Percent reduction in controlling internal phosphorus loading has been continuously above eighty percent. The study did however find that alum treatment of lakes with high external loading was not effective.

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Alum Questions and Answers

Why are we trying to reduce algae growth in Cedar Lake? What are the values of decreased algae growth and increased clarity for lake residents?

Lower algae growth will make Cedar Lake a better place to live, recreate, and own property. Excessive algae growth limits recreational uses such as swimming; increases toxins produced by algae blooms; produces undesirable odors; and because algae limits light penetration, decreases native aquatic plant growth. Algae growth was by far the top negative impact to Cedar Lake expressed by property owners in a recent survey.[1]

Clearer water will mean that a greater diversity of beneficial native plants can grow in the lake. Native aquatic plants provide important lake functions including providing fish and wildlife habitat, stabilizing lake bottom sediments, reducing erosion, and taking up nutrients. DNR biologists identify the decline in aquatic plant growth as a serious detriment to lake health.

Lower amounts of algae growth will mean that fewer toxin producing blooms will result. The lake will be a safer place for your family and pets!

Finally, clearer water leads to increased property values. A recent Minnesota study found land values increased $50 to $60 per foot of lake frontage when lake clarity improved by about 3 feet. For Leech Lake near Walker, they predicted a $423 increase per foot of frontage if clarity improved from 10 feet to 13 feet.[2] *Earlier studies in Maine found that a decline in water clarity can reduce property values by as much as $200 per frontage foot, representing hundreds of millions of dollars in lost property values.*[3] *More recent research on 36 lakes in 4 regional groups in Maine took another look at how water clarity changes property values. It found that properties on lakes with 3 feet greater clarities have higher property values in the range of 2.6% ($2,563) to 6.5% ($9,271) depending on the market. Likewise, a 3 feet decrease in minimum transparencies causes property values to decrease anywhere in the range of 3.1% ($3,084) to 8.5% ($12,050).*[4]

How does alum work?

The Department of Natural Resources Fact Sheet does an excellent job explaining how alum works. Please read this handout for more information

Alum would be applied on the deepest parts of the lake only. There will be a higher application rate at depths greater than 25 feet and a lower application rate at depths between 20 and 25 feet. This is a cost effective approach because it targets only the sediment area which is devoid of oxygen and therefore releases phosphorus to the water column.

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[1] *Cedar Lake Comprehensive Lake Management Plan. Appendix A*. Harmony Environmental. 2013.

[2] Charles Parson and Patrick Welle. Bemidji State University. *Lakeshore Property Values and Water Quality*. Values from 1,205 residential property sales from 1996 to 2001.

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Are there examples of successful alum projects?

The DNR Fact Sheet mentions several successful projects reported through 2003. More recent information is reported below.

Four lakes of the Minneapolis Chain of Lakes treated with alum (Harriet and Calhoun in 2001 and Cedar Lake and Lake of the Isles in 1996) all showed water clarity improvements for at least 6 years. Harriet, Calhoun, and Cedar were at or below historical total phosphorus levels through at least 2005. Lake of the Isles received the lowest treatment dose, and the lake returned to pretreatment conditions after six years.[5]

With the careful science behind this project, we are counting on the fact that the Cedar Lake alum application would be a successful example to share with the over 200 lakes with similar characteristics in the state of Wisconsin.

What is the likelihood of success of alum application on Cedar Lake?

Good candidate lakes for alum treatment include those with low external and high internal phosphorus loads. High alkalinity is also desirable to balance the pH when alum is used.

Cedar Lake's sediments contribute from 60-66% of the lakes' annual phosphorus load, making control of sediment phosphorus critical for water quality improvements. The external or watershed load must also be limited for long-term success of an alum treatment.

What environmental and/or health concerns result from alum applications?

Please see the DNR Fact Sheet for more information. The aluminum in alum is cause for concern with low pH (below 5.5) or very high pH (above 9) near the bottom of the lake where alum settles.

Cedar Lake tends to have a high pH and moderate alkalinity available to buffer an alum application. Buffering agents can be added during alum application to alleviate concerns related to low pH. Alum applications can also be divided with half applied one year and the remaining in a later year to minimize pH changes with application.

How much is alum treatment likely to cost? What are some options for financing?

The alum treatment is projected to cost $2.2 million. This investment can effectively reduce 90 percent of the internal phosphorus load with a predicted increase in lake water clarity of about 5 to 11 feet over the growing season.

With approval of the lake management plan, Wisconsin Department of Natural Resources grants are available for plan implementation on a competitive basis. Additional grant sources may be available. Lake District borrowing must be approved at an annual or special meeting. Lake District annual budgets are voted on at each annual meeting.

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[5] Brian Huser, Patrick Bezonik & Raymond Newman. *Effects of alum treatment on water quality and sediment in the Minneapolis Chain of Lakes, Minnesota, USA.* Lake and Reservoir Management. Volume 27, Issue 3, 2011. Pages 220-228.

What management efforts has the Cedar Lake Protection and District undertaken to manage the phosphorus load in the lake? Have they been successful?

An aeration system was installed in the lake in 1991 and maintained through 2008. Initial indications were that aeration helped to reduce the release of P from the sediments. However, the recent lake study showed that while a smaller area of lake sediments lacked oxygen and released phosphorus with the aerator on, the lake was more likely to mix and bring released phosphorus to the surface. This resulted in poorer water quality with the aerator compared with years when it was off.

Attempts to reduce carp numbers through netting have been met with limited success. However, a viral disease drastically reduced carp numbers in Cedar Lake in 2002.

The Polk County Land and Water Resources and Department of Natural Resources Horse Creek Priority Watershed Project provided funds to reduce the external loading of phosphorus from the watershed with installation of conservation practices from 2009 through 2006.

Do we still need to consider pollutants that flow to the lake from the watershed?
Definitely, in fact, DNR funding will not likely be made available until external loads are managed. The lake management plan provides recommended steps toward external load management.

What happens next? When might we be ready to consider in-lake management as part of a lake district budget?
The lake management plan is carefully considered and its implementation is laid out in a step wise manner. The implementation plan chart lays out planned steps in a simple, yet comprehensive manner. It is available on our web site http://cedarlake-wi.org

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