

Magnor Lake
Lake Management Plan, 2021-2026



Prepared by
Katelin Anderson and Colton Sorensen
Polk County Land and Water Resources Department
100 Polk County Plaza, Suite 120, Balsam Lake, WI 54810

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We would like to thank the following for their contributions to this project. Asterisks indicate members of the Lake Planning Committee.

Magnor/Barbo Lake District

Tom Bolles *

Karen Buelow *

Sheri Christopherson *

Bob Fisher *

Rob Johnson *

Tracy LaBlanc

Diana Lillicrap *

Matt Nelsen *

Brent Norberg

Kermit Paulson *

Karen Schnell *

John Stansbury

Nancy Walz*

Duane Wienke *

Kathy Wienke *

Wisconsin Department of Natural
Resources

Alex Smith

Jordan Petchenik

Polk County Land Information
Department

Steve Geiger

Michael Markee

St. Croix Watershed Research Station,
Science Museum of Minnesota

Mark Edlund

Joy Ramstack Hobbs

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Purpose of the Study

In December 2017, the Polk County Land and Water Resources Department applied for a Wisconsin Department of Natural Resources Lake Planning Grant in partnership with the Magnor/Barbo Lake District. The grant was awarded and data collection occurred in 2018 and 2019.

Methods and activities completed through this grant award include:

- ✓ Lake resident survey
- ✓ Lake level and precipitation monitoring data
- ✓ In-lake physical and chemical data
- ✓ Phytoplankton
- ✓ Tributary physical and chemical data
- ✓ Spring and fall point intercept plant surveys
- ✓ Shoreline inventory
- ✓ Watershed delineation and boundaries
- ✓ Watershed modeling
- ✓ No-till and cover crop inventory
- ✓ Sediment core
- ✓ Pontoon classroom

The following report details the methods and activities completed through this grant award.

Executive Summary

- Magnor Lake is 229 acres in size with a maximum depth of 26 feet. Inlets from Barbo Lake (Nepadoggen Creek, southwest side of the lake) and Mud Lake (Unnamed, southeast side of the lake) flow into Magnor Lake. The outlet (Nepadoggen Creek) is on the northeast side of Magnor Lake.
- A lake resident survey completed by 65 property owners (52% response rate) ranked top concerns for Magnor Lake as: excessive algae blooms, decrease in overall lake health, excessive aquatic plant growth, new invasive species entering the lake, lack of water clarity or quality, increased nutrient pollution, poor water quality, and decreased fisheries.
- Overall, Magnor Lake has a very well-rounded fishery. Magnor Lake is a popular fishing lake and receives a fair amount of angling effort. Magnor Lake is on a 9-year rotation for comprehensive fisheries surveys and will be surveyed next in 2028.
- In 2018 and 2019, the upper two meters of Magnor Lake were well oxygenated and the bottom waters became anoxic.
- The trophic state is a measure of a lakes health which relates to the amount of algae in the water. The average summer trophic state over the last 5 years in Magnor Lake was 64 (eutrophic). For a deep lowland lake, this is considered poor.
- The average summer index period (July 15th – September 15th) trophic status was 59 in 2018 (mildly eutrophic) and 65 in 2019 (eutrophic).
- Historic data (2001-2019) for total phosphorus, chlorophyll a, and secchi depth indicate a trend of increasing water quality in Magnor Lake.
- Magnor Lake is listed on the 303(d) Impaired Waters List for chlorophyll a and total phosphorus for recreation use and fish and aquatic life use.
- The state standard for total phosphorus in streams is set at 75 µg/L. In 2018 and 2019, both inlets to Magnor Lake exceeded the standard (Inlet from Barbo: 207 µg/L and Inlet from Mud: 200 µg/L).

- Sixteen different aquatic plant species were found in Magnor Lake. Based on relative frequency, the dominant species in Magnor Lake were fern pondweed, common waterweed, nitella, and spiny hornwort. In June, plant growth covered 19% of the lake and in August plant growth covered 25% of the lake.
- A shoreline inventory indicated that 72% of the shoreline of Magnor Lake is disturbed. The dominant shoreland vegetation and ground cover on Magnor Lake was mowed vegetation (53%).
- The Magnor Lake watershed is 5,930 acres in size. The most common land uses in the Magnor Lake Watershed are forest and row crops (24% each), followed by mixed agriculture (16%), and wetland (9%).
- The annual phosphorus load to Magnor Lake is 2,513 pounds of phosphorus per year. To achieve the phosphorus standard for Magnor Lake (30 µg/L) the external phosphorus load to Magnor Lake would need to be reduced by 68%, from 2,513 to 794 pounds of phosphorus per year.
- Overall, internal loading is predicted to be insignificant to the nutrient budget for Magnor Lake.
- The Magnor Lake Watershed was divided into five subwatersheds: Southern, South Central, Direct, Greeley Lake, and East. The subwatershed contributing the greatest phosphorus load to Magnor Lake are the Southern and East Subwatersheds.
- The agricultural land base in the Magnor Lake watershed consists primarily of row crops (51%) and perennial vegetation (41%). Conventional tillage is common in the watershed (47% of agricultural fields). Adoption of no-till planting and cover crops is currently low. If all suitable acres in 2018 had been planted using no-till and cover crops, phosphorus loading in the Magnor Lake Watershed would have been reduced by 37%.
- The Agriculture Conservation Planning Framework was used to prioritize conservation practices on agricultural lands in the Magnor Lake Watershed. The program recommended and prioritized a variety of conservation practices for implementation including: water and sediment control basins, contour buffer strips, grass waterways, farm ponds, and riparian attribute polygons.

- A sediment core collected on Magnor Lake provided over 150 years of data for the lake. Historic total phosphorus estimates generated using a diatom-total phosphorus model suggest that Magnor Lake total phosphorus levels have increased from 10-12 µg/L (pre-Euromerican settlement) to current levels of 31-38 µg/L.
- In winter 2020/2021, stakeholders met to develop an implementation plan for Magnor Lake which included five goals:
 - Goal 1. Improve water quality in Magnor Lake to reduce nuisance algae blooms
 - Goal 2. Protect, maintain, and enhance native fish and wildlife habitat and diversity while enhancing the scenic beauty of Magnor Lake
 - Goal 3. Maintain and improve navigation routes in Magnor Lake while protecting the natural functions of native plants
 - Goal 4. Implement an aquatic invasive species (AIS) monitoring, prevention, and control program on Magnor Lake
 - Goal 5. Use multiple strategies to ensure the goals of the plan are met
- Many of the goals in the implementation plan are eligible for grant funding through the Wisconsin Department of Natural Resources Surface Water Grants program. In 2017, the Magnor/Barbo Lake Protection and Rehabilitation District was formed. The District is eligible to receive funding through the Surface Water Grants program.

Background Information on Lakes, Studies, and Management Plans

Lakes are a product of the landscape they are situated in and of the actions that take place on the land which surrounds them. Factors such as lake size, lake depth, water sources, and geology all cause inherent differences in lake quality. As a result, lakes situated near one another can differ profoundly in the uses they support.

A landscape can be divided into watersheds and sub watersheds. These areas define the land that drains to a particular lake, flowage, stream, or river. Watersheds that preserve native vegetation and minimize impervious surfaces (cement, concrete, and other materials that water can't permeate) are less likely to result in negative impacts on lakes, rivers, and streams. This arises because rain and melting snow eventually end up in lakes and streams through surface runoff or groundwater infiltration. Rain and melting snow entering a waterbody are not inherently problematic. However, water has the ability to carry nutrients, bacteria, sediments, and chemicals into a waterbody. These inputs can impact aquatic organisms such as insects, fish, and wildlife and—especially in the case of the nutrient phosphorus—fuel problematic algae blooms.

Lake studies examine the underlying factors that impact a lake's health, such as lake size, depth, water sources, and the land use in a lake's watershed. Many forms of data can be collected and analyzed to gauge a lake's health including: physical data (oxygen, temperature, etc.), chemical data (including nutrients such as phosphorus and nitrogen), biological data (algae, zooplankton, and aquatic plants), geological data (soils, glacial till, and sediment chemistry) and land use within a lake's watershed. Sediment cores can be used to determine how a lake has changed over the course of hundreds of years.

Lake studies identify challenges and threats to a lake's health along with opportunities for improvement. Studies identify practices already being implemented by watershed residents to improve water quality and areas providing benefits to a lake's ecosystem, and quantify practices or areas in the watershed which have the potential to negatively impact the health of a lake and identify best management practices for improvement.

The end product of a lake study is a Lake Management Plan which identifies goals, objectives, and action items to either maintain or improve the health of a lake. Goals should be realistic based on inherent lake and watershed characteristics (lake size, depth, land use etc.) and should align with the goals of watershed residents. Lake management plans are designed to be working documents that are used to guide the actions which take place to manage a specific lake.

Introduction to Magnor Lake

Magnor Lake is located in the Town of Clayton in Polk County Wisconsin, approximately 50 miles northeast of the Minneapolis/St. Paul MN metropolitan area. Clayton is 34 square miles in size and inhabited by less than 1,000 people. According to Natural Heritage Inventory data, there are no rare species that occur in the Town of Clayton. The Magnor Lake Sensitive Area Survey Report identified five areas that merit special protection of aquatic habitat.

Magnor Lake is 229 acres in size with a maximum depth of 26 feet. Inlets from Barbo Lake (Nepadoggen Creek, southwest side of the lake) and Mud Lake (Unnamed, southeast side of the lake) flow into Magnor Lake. The outlet (Nepadoggen Creek) is on the northeast side of Magnor Lake.

The area of land that drains to a lake is called a watershed. Magnor Lake is situated within the Beaver Brook Watershed which is 44,483 acres and extends into Barron County. The watershed has 75 miles of streams and rivers, 1,801 acres of lakes, 5,965 acres of wetlands, and is dominated by forest (31%), agriculture (26%), and grassland (22%).¹

On a smaller scale, the area of land that drains to an individual lake, or the Magnor Lake Watershed, is also defined. This study used ArcMap and LiDAR data to delineate the Magnor Lake Watershed, which is 5,930 acres. Land use in the Magnor Lake watershed is primarily forest (24%), agriculture (24%), mixed agriculture (16%), and wetland (9%).

Lakes are hydrologically classified according to their primary source of water and how that water enters and leaves the system. Magnor Lake is classified as a deep (stratified)² lowland drainage lake with a maximum depth of 26 feet. Deep/stratified lakes have the potential for the bottom waters to become devoid of oxygen and release nutrients from sediments back into the water column. Lakes are classified as lowland lakes if the watershed draining to the lake is greater than or equal to four square miles. Drainage lakes receive most of their water from the surrounding watershed in the form of stream drainage, have a prominent inlet and outlet that move water through the system, and commonly have high nutrient levels due to inputs from the watershed.

¹ <https://dnr.wi.gov/water/watershedDetail.aspx?key=924836>

² Calculated with the Lathrop/Lillie equation.

Polk County owns a parcel of land on the south end of the lake that includes a public access and a picnic area. Polk County and the Richardson Sportsmen Club maintain the landing. The Town of Clayton and Sportsmen Club own and maintain a parcel of land reaching the water's edge on the east side of the lake called the Magnor Lake Park. The park is bordered by a parcel owned by the Village of Clayton, and features a shelter with electricity, restrooms, a fishing pier, swimming, and parking lot. The Town owns two additional parcels reaching the water's edge, one of which is defined as an access.

Four invasive species (banded mystery snail, Chinese mystery snail, curly-leaf pondweed, and purple loosestrife) have been documented on Magnor Lake.

The trophic state is a measure of a lakes health which relates to the amount of algae in the water. The average summer trophic status over the last 5 years in Magnor Lake was 64 (eutrophic). For a deep lowland lake, this is considered poor. Magnor Lake is listed on the 303(d) Impaired Waters List for chlorophyll and total phosphorus thresholds for recreation use and fish and aquatic life use. Volunteers have monitored the lake from 2000 to 2017.

In 2001, a study was completed on Magnor Lake by the Polk County Land and Water Resources Department and in 2005 a study was completed by Cedar Corp.

In 2017, the Magnor/Barbo Lake Protection and Rehabilitation District was formed.

Lake Classification

Lake classification in Polk County is a relatively simple model that considers:

- ✓ Lake surface area
- ✓ Maximum depth
- ✓ Lake type
- ✓ Watershed area
- ✓ Shoreline irregularity
- ✓ Existing level of shoreline development

These parameters are used to classify lakes as class one, class two, or class three lakes. Magnor Lake is classified as a class one lake with low vulnerability and high development.

Class one lakes are large and highly developed.

Class two lakes are less developed and more sensitive to development pressure.

Class three lakes are usually small, have little or no development, and are very sensitive to development pressure.

Magnor Lake Characteristics ³

Area: 229 acres

Maximum depth: 26 feet

Mean depth: 10 feet

Bottom: 60% sand, 15% gravel, 5% rock, and 20% muck

Waterbody type: lake

Hydrologic lake type: drainage

Invasive species: banded mystery snail, Chinese mystery snail, curly-leaf pondweed, and purple loosestrife.

Fish: panfish, largemouth bass, northern pike and walleye

Trophic Status: eutrophic

Oligotrophic lakes are generally clear, deep, and free of plants and large algae blooms.

Mesotrophic lakes lie between oligotrophic and eutrophic lakes. They usually have productive fisheries, healthy plant life, and occasional algae blooms.

Eutrophic lakes are generally high in nutrients and support a large number of plant and animal populations. They are usually very productive and subject to frequent algae blooms.

Hypereutrophic lakes are characterized by dense algae communities and can experience heavy blooms throughout the summer.

³ <https://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=2624600&page=facts>

Impaired Waters

Wisconsin lakes, rivers, and streams are managed to determine if their conditions are meeting state and federal water quality standards. Water samples are collected through monitoring studies and results are compared to guidelines designed to evaluate conditions as compared to state standards. General assessments place waters in four different categories: poor, fair, good, and excellent. The results of assessments can be used to determine which actions will ensure that water quality standards are being met (anti-degradation, maintenance, or restoration).

If a waterbody does not meet water quality standards, it is placed on Wisconsin's Impaired Waters List under the Federal Clean Water Act, Section 303(d). Every two years the State of Wisconsin is required to submit list updates to the United States Environmental Protection Agency for approval.

Waterbodies are listed as impaired based on pollutants including total phosphorus, total suspended solids, and metals. Waters are assigned four uses (fish and aquatic life, recreation, public health and welfare, and wildlife) that carry with them a set of goals.

Impairment thresholds vary for each use and vary based on lake characteristics such as whether a waterbody is shallow or deep and whether a waterbody is a drainage or seepage lake. Magnor Lake is classified as a deep (stratified) lowland drainage lake.⁴

- ✓ Natural community: deep lowland
- ✓ Stratification status: stratified
- ✓ Hydrology: lowland drainage

Magnor Lake was first placed on the Impaired Waters List in 2010 for total phosphorus. The lake was most recently assessed in 2020 and listed as impaired for total phosphorus and chlorophyll a for both recreation use and fish and aquatic life use. The impairment threshold for total phosphorus is greater than or equal to 30 µg/L for both recreational use and fish and aquatic life use. The impairment threshold for chlorophyll a is met when greater than 5% of days in the sampling season have moderate algae levels (greater than 20 µg/L) for recreational use. The impairment threshold for chlorophyll a for fish and aquatic life use is greater than or equal to 27 µg/L.⁵

⁴ Listing thresholds are found in Wisconsin 2020 Consolidated Assessment and Listing Methodology Clean Water Act Section 303(d) and 305(b) Integrated Reporting, Wisconsin Department of Natural Resources, April 2019

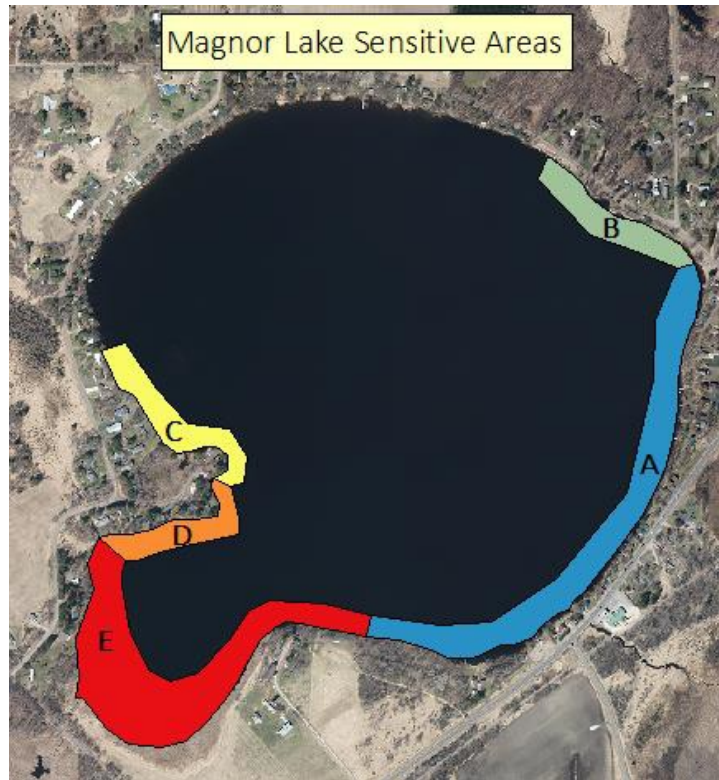
⁵ The exceedance frequency is lower bound 90% confidence interval of the mean exceeds the threshold

Previous Lake Studies

Past studies and grant awards on Magnor Lake include:

Magnor Lake Sensitive Area Survey Report and Management Guidelines, 2001

This survey identified five areas along the shoreline of Magnor Lake that merit special protection of aquatic habitat. Four of the sensitive areas (B, C, D, and E) contain aquatic plant communities that provide important fish and wildlife habitat and shoreline stabilization and two of the sensitive areas (A and C) provide habitat necessary for the spawning success of walleye.



The report documents that dredging, structures, or deposits should not occur in sensitive areas A and C. In areas B, C, D, and E chemical treatments and harvesting are strongly discouraged, with any historical treatments being limited to navigation channels.

Magnor Lake Planning Study, 2001

In 2001 the Polk County Land and Water Resources Department conducted a two phase study on Magnor Lake.

The study concluded that secchi depth, total phosphorus, and chlorophyll a indicated a eutrophic state, with a trophic state index value of 69. A sociological survey indicated that a majority of survey respondents (63%) described the water quality of the lake as below or far below average.

Transect surveys were completed for terrestrial and aquatic species. An invasive species inventory found Canada thistle, common reed, garlic mustard, purple loosestrife, and wild parsnip.

The dominant land uses in the Magnor Lake watershed were: cropland (44%), forest (17%), and wetland (15%). Other land use included: other surface water (12%), residential (3%), open land (3%), pasture (2%), farmstead (2%), and urban (2%). Modeling indicated that 12.5% of the phosphorus load is from internal loading and that a 45% phosphorus reduction would be necessary for the lake to be removed from the impaired waters list.

The final product of this project included a list of actions that can be taken to improve and protect Magnor Lake. Actions included: reducing impacts from agricultural lands, increasing communication with the lake association, monitoring/removing purple loosestrife, reducing wave action that stirs up sediment, improving walleye habitat, controlling pollution from Hwy 63, protecting wetlands, controlling snails, adding signage at the boat landing, and being mindful of water quality when developing the shoreline.

Magnor Lake/Watershed Management Master Plan and Sediment Core Project, 2005
In 2006, Cedar Corporation completed a management plan for Magnor lake that took into consideration previous lake/watershed data along with collecting additional data. The Wisconsin DNR pulled a sediment core in August of 2005 to address concerns with internal phosphorus loading from the bottom of the lake and determine if an alum treatment would be an effective treatment to reduce internal phosphorus loading. The results of the study were inconclusive. The sediment core indicated that there has been a significant increase in phosphorus levels in the lake over the past 100 years.

The final report included recommendations on how to improve the water quality of the lake. Recommendations included: implementing shoreline best management practices, controlling residential lawn runoff, street sweeping, installing curb and gutter, adopting a stormwater and erosion control ordinance, increasing frequency of curbside pickup of lawn debris, encouraging lawn debris disposal, considering limitations on phosphorus-based fertilizers, installing proposed BMP's for new development areas, constructing wet detention facilities, implementing swale easements in natural drainage ways, and implementing BMP's around wetlands and their tributaries.

Lake Magnor Association Healthy Lakes Study, 2017

In 2017 a Healthy Lakes grant was received for Magnor Lake to install best management practices. Practices eligible for funding include: fish sticks, 350 square foot native plantings, diversions, rock infiltration, and rain gardens.

Lake Resident Survey

A Wisconsin Department of Natural Resources approved survey was mailed to one hundred twenty-four property owners on and around Magnor and Barbo Lake in spring of 2018. Sixty-five surveys were returned (52% response rate) and data was entered and analyzed.

Survey respondents have owned their property on Magnor and Barbo Lake for an average of 21 years. Combined, the majority of respondents use their property part time either as a weekend, vacation, and/or holiday residence (48%) or as a seasonal residence (8%). Fewer property owners use their property as a year round residence (38%). On average, properties on Magnor and Barbo Lake are used 170 days per year and occupied by 2.5 people.

The majority of respondents own property on the shoreline of Magnor or Barbo Lake (89%). The survey asked respondents to describe the first 35 feet of their shoreland (the area located directly adjacent to the lake). Approximately three-quarters of respondents indicated that this area of their property contained mowed lawn (81%). Around one-third of respondents indicated that their shoreline contained un-mowed vegetation (40%) and shrubs/trees (33%) and a smaller number of respondents indicated their shoreland has undisturbed woods (14%) and a buffer zone or shoreland restoration (12%). Over half of respondents indicated that they had a dock or pier (59%) and one-third indicated they had stabilizing rock/rip rap (36%).

The survey asked respondents which activities they enjoy on Magnor and Barbo Lake. The most popular activities enjoyed on the lakes include: enjoying peace and tranquility (94%), enjoying the scenic view (86%), open water fishing (83%), motorized boating (75%), observing birds/wildlife (73%), swimming (54%), ice fishing (48%), and non-motorized boating (41%).

The survey also asked how many days a month property owners use the Magnor Lake boat landing during the open water season and during the ice on season. More respondents use the boat landing in the open water season (42%) as compared to the ice on season (18%). However, the average days per month the landing was used was higher during the ice on season (4.2 days) as compared to the open water season (2.6 days).

A small portion of survey respondents (14%) do not use watercraft on Magnor and Barbo Lake. Around half of respondents use motorboats/pontoons that are 21-50 HP (55%) and

paddleboats/rowboats (41%). About a third of respondents use canoes/kayaks on the lake (39%) and fewer respondents use motorboats/pontoons that are 1-20 HP (11%), motorboats/pontoons that are greater than 50 HP (13%), and jet skis (9%).

To quantify risk of spreading aquatic invasive species, survey respondents were asked if the watercrafts they use on Magnor and Barbo Lake are used on other waterbodies. Only a small portion of boats that are used on Magnor and Barbo are used on different waterbodies (15%), with the majority of boats (85%) only being used on Magnor and Barbo Lake. Survey participants were also asked to describe their typical cleaning routine after using watercraft on water other than Magnor and Barbo Lake. Most respondents removed aquatic hitchhikers (89%) and drained their bilge (78%). Fewer respondents rinsed their boat (33%), air dried their boat for 5 or more days (33%), or power washed their boat (22%). No respondents indicated that they do not clean their boat.

Respondents were asked to rank their degree of concern with fifteen issues as high, medium, low, issue exists but isn't a concern, and issue doesn't exist. Responses for this question were analyzed using a point system. Each issue ranked as high received 4 points, as medium received 3 points, as low received 2 points, as exists but not a concern 1 point, and as not an issue received 0 points. Total points were averaged to determine a final rank.

Issues with a final ranking of high to medium concern included: excessive algae blooms, decrease in overall lake health, excessive aquatic plant growth, new invasive species entering the lake, lack of water clarity or quality, increased nutrient pollution, poor water quality, and decreased fisheries. The remaining issues ranked as lower concerns.

What is your degree of concern with each issue listed below?	Rank
Excessive algae blooms	3.5
Decrease in overall lake health	3.3
Excessive aquatic plant growth	3.3
New invasive species entering the lake	3.3
Lack of water clarity or quality	3.2
Increased nutrient pollution	3.2
Poor water quality	3.1
Decreased fisheries	3.0
Decreased property values	2.6
Loss of natural scenery/beauty	2.3

Unsafe use of motorized watercraft	2.3
Decreased wildlife populations	2.1
Excessive noise level on the lake	2.1
Increased development	2.0
Disregard for slow-no-wake zones	1.9

Lake levels can vary over the course of the year and from year to year. Residents were asked to describe the current lake level of Magnor and Barbo Lake. Nearly two-thirds of respondents (65%) described the current lake level as just right. More respondents described the lake as too low (14%) as compared to too high (5%).

When asked to describe the current water quality on Magnor and Barbo Lake, nearly half of respondents described it as fair (49%). More respondents described water quality as very poor/poor (26%) as compared to very good/good (18%). Survey respondents were fairly divided in describing how the water quality has changed since they've lived on or near Magnor and Barbo Lake. Nearly a quarter of respondents either hadn't been on the lakes long enough to notice a change (20%) or described the change as somewhat degraded (25%) or somewhat improved (23%). However, more respondents described the change as severely degraded (13%) as compared to greatly improved (6%).

The survey also asked respondents what they think of when assessing water quality. Over three-quarters of respondents think of algae blooms (88%), water clarity (clearness of water) (82%), smell (75%), and water color (74%). Around half of respondents think of aquatic plant growth (58%) and fish kills (54%) when assessing water quality.

The survey asked a variety of questions regarding algae and aquatic plants. Respondents were asked to describe the amount of aquatic plants in Magnor and Barbo Lake, what months during the open water season algae and aquatic plants are a problem, and what uses are impaired as a result of algae and aquatic plants.

A large majority of respondents consider algae to be problematic in August (81%), and July (76%). A quarter of respondents consider algae to be problematic in June (25%) and September (25%). Over three quarters of respondents indicated that overall enjoyment of the lake (89%) and swimming (76%) are impaired by algae. Around half of respondents indicated that fishing (65%), boating (54%), and dogs/animals using the water (47%) are impaired by algae. Nearly a third of respondents indicated that navigation (30%) is impaired by algae.

Over half of survey respondents described the amount of aquatic plants on the lakes as too many (52%) and around a quarter described the amount of aquatic plants as healthy (24%). Nearly two-thirds of respondents indicated that aquatic plant growth is a problem in August (62%) and July (60%). Around a quarter of respondents considered aquatic plant growth to be a problem in June (30%) and September (21%).

Over three-quarters of respondents indicated that swimming (85%), fishing (82%), overall enjoyment of the lake (80%), boating (77%) and navigation (77%) are limited by aquatic plants.

Earlier in the survey, 81% of respondents indicated that the area 35 feet back from their shoreline contained mowed lawn. Later, the survey asked respondents to describe the current amount of mowed lawn across the entire shoreline of Magnor and Barbo Lake. Nearly a half of respondents described the amount of lawn as just right (49%). More respondents indicated that the amount of lawn was too much (22%) as compared to not enough (6%). Just under a quarter of respondents (22%) were unsure how to describe the amount of lawn.

The survey asked respondents what impact, if any, that landowner landscaping practices such as shoreline buffers, rain gardens, and native vegetation plantings have on the water quality of Magnor and Barbo Lake. Half of respondents indicated that the practices have a positive impact, regardless of how many property owners participate (50%). Nearly a quarter were unsure of how to respond the question (23%), while the other portion believe there is a positive impact only if all property owners are involved (16%), or that there is no impact (9%).

On a positive note, two-thirds of respondents do not use fertilizer on their property (66%) and over a quarter use zero phosphorus fertilizer (30%). A small minority use fertilizer but are unsure of its phosphorus content (5%).

Survey respondents were asked how they prefer to receive information from the Magnor/Barbo Lake Protection and Rehabilitation District. Respondents indicated that the most preferred method of communication was a newsletter (75%), followed by email (45%). Fewer respondents preferred an annual meeting (33%) and a website (25%) as a means to receive information. A small percentage of respondents would like to receive information through Facebook (9%).

The survey asked respondents to indicate which actions should be completed by the Magnor/Barbo Lake Protection and Rehabilitation District to manage the lakes. Over three-fourths of respondents supported programs to prevent and monitor invasive species (88%) and practices to enhance fisheries (75%). Over half of respondents supported offering incentives for property owners to install farmland conservation practices (60%), offering incentives for upgrades to non-conforming septic systems (57%), and the installation of shoreline buffers/rain gardens (58%). Fewer respondents supported opening up the access between Magnor and Barbo Lake (47%), lake fairs and workshops to share information (41%), and enforcement of slow-no-wake zones (36%).

The survey asked respondents which activities they were interested in participating in to improve Magnor and Barbo Lake. Half of respondents were interested in learning how to monitor water quality (50%) and approximately one-third of respondents were interested in learning how to identify invasive species (39%) and learning how to monitor for aquatic invasive species (32%). A quarter of respondents were interested in serving on a committee to develop an action plan for improving Magnor and Barbo Lake (23%), installing a buffer on their property (21%), and installing a rain garden on their property (18%). A quarter of respondents were not interested in participating in any of the listed projects (25%).

Fisheries⁶

The most recent fisheries survey conducted on Magnor Lake was in 2019 (boom shocker and fyke net).

During the 2019 survey, the walleye population was above average for a stocking-dependent lake with an adult density of 3.2 fish per acre. A fair northern pike population was present with desirable size structure. Magnor Lake has a strong bluegill population. The majority of bluegills sampled ranged from 6-7.5 inches, but larger fish up to 9.5 inches were also collected. Black crappie were considered abundant and their size ranged from 7-10.5 inches. Pumpkinseed and yellow perch were also present in lower numbers, but both likely supplement the overall panfish fishery in terms of angling catch and harvest. Largemouth bass were fairly abundant and had excellent size structure ranging from 9 to 18.5 inches. Of the largemouth bass collected during the electrofishing survey, 46% of them were 14 inches or greater, which is good for a Polk County Lake.

Overall, Magnor Lake has a very well-rounded fishery. Magnor Lake is a popular fishing lake and receives a fair amount of angling effort. Magnor Lake is on a 9-year rotation for comprehensive surveys and will be surveyed next in 2028.



⁶Information provided by Aaron Cole, Fisheries Biologist, Wisconsin DNR

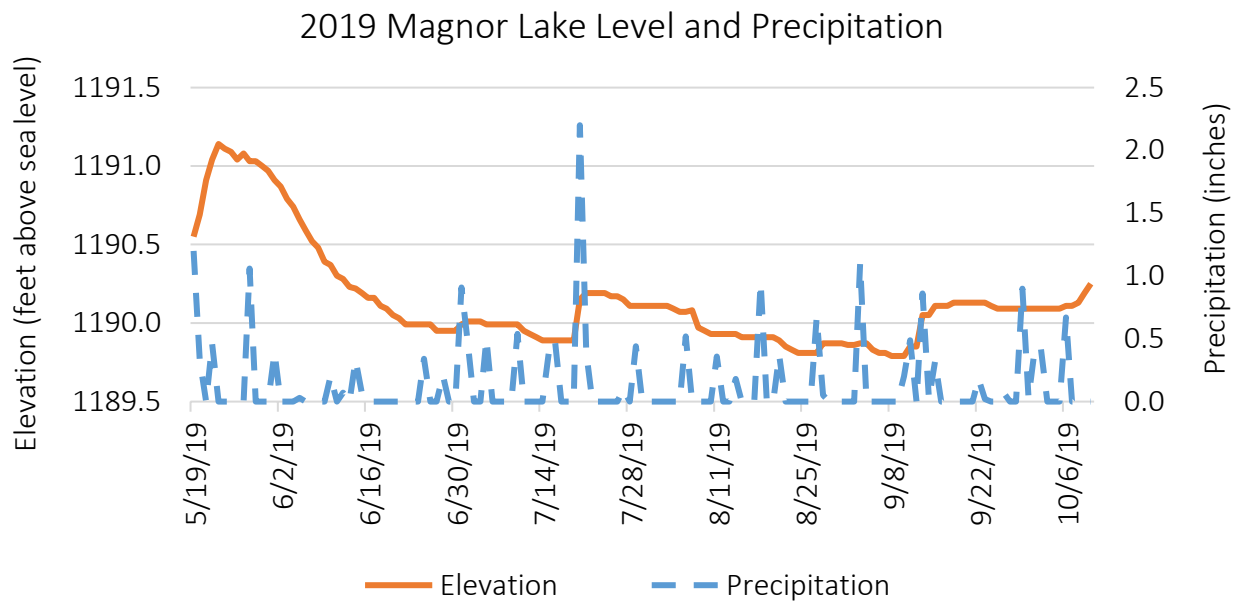
Lake Level and Precipitation Monitoring

Lake water-level fluctuations are important to lake managers, lakeshore property owners, developers, and recreational users because they can have significant impacts on lake water quality and usability. Although lake levels naturally change from year to year, extreme high or low levels can present problems such as restricted water access, flooding, shoreline and structure damage, and changes in near shore vegetation.

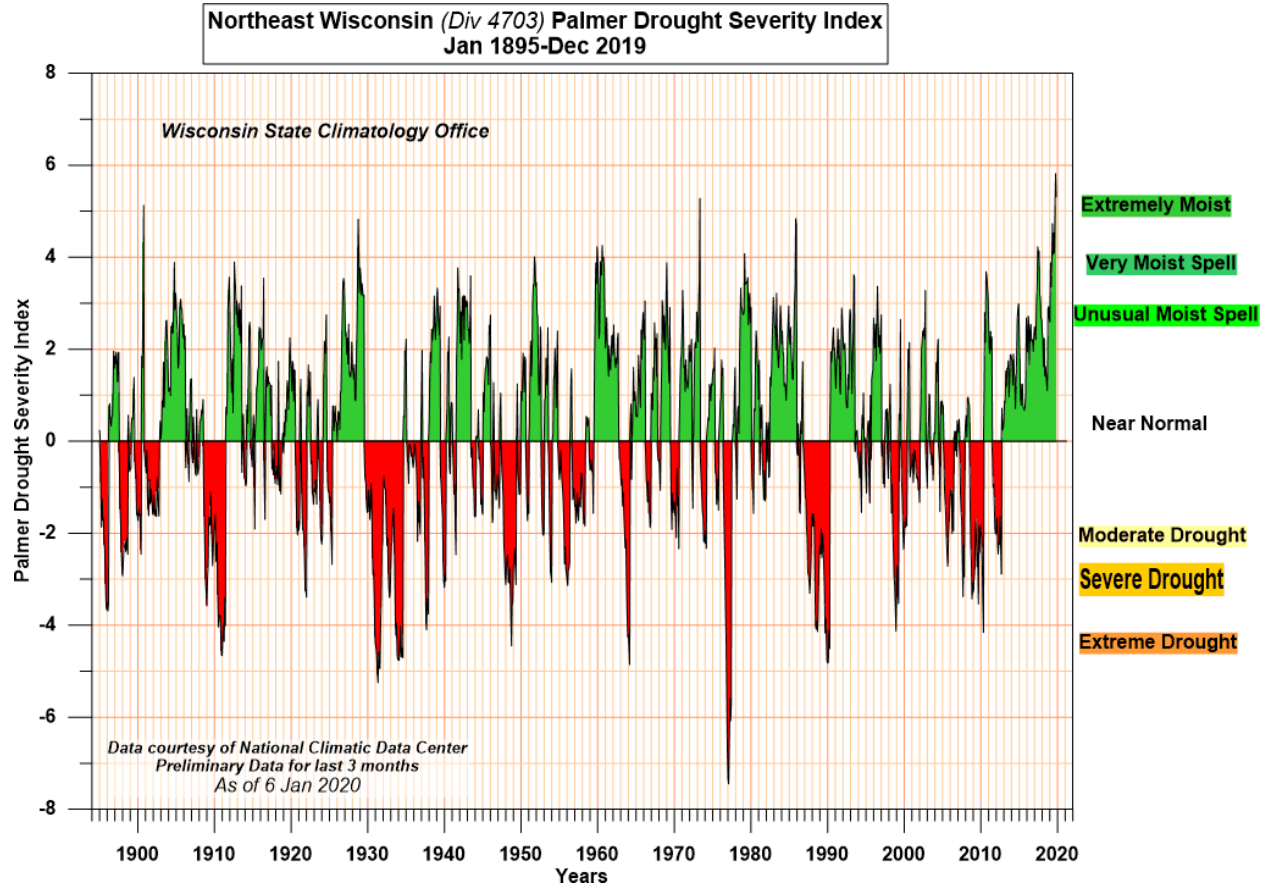
Records of lake water elevations can be very useful in understanding changes that may occur in lakes. While some lakes respond almost immediately to precipitation, other lakes do not reflect changes in precipitation until months later.

A volunteer monitored lake level and precipitation on Magnor Lake in 2019. Polk County Land and Water Resources Department provided training on data collection. The Polk County Surveyor calibrated the staff gauge by referencing the numbered height on the gauge to the surveyed elevation of the water when the gauge was installed in the spring and prior to removal in the fall. Monitoring began in the spring and continued through fall.

Seasonal precipitation on Magnor Lake totaled 19.9 inches in 2019 (145 sampling days, May 19th through September 10th). Lake level did respond to precipitation events, with levels increasing following rainfall events. In the spring, lake level on Magnor Lake was about a foot higher than it was during the remainder of the growing season.



Wisconsin State Climatology Office data indicate that 2018 and 2019 were years of very moist and extremely moist conditions.



Lake Mixing and Stratification

Water quality is affected by the degree to which the water in a lake mixes. Within a lake, mixing is most directly impacted by the temperature-density relationship of water. When comparing why certain lakes mix differently than others, lake area, depth, shape, and position in the landscape become important factors to consider.

Water reaches its greatest density at 3.9°C (39°F) and becomes less dense as temperatures increase and decrease. Compared to other liquids, the temperature-density relationship of water is unusual: liquid water is more dense than water in its solid form (ice). As a result, ice floats on liquid water.

When ice melts in the early spring, the temperature and density of the water will be constant from the top to the bottom of the lake. This uniformity in density allows a lake to completely mix. As a result, oxygen is brought to the bottom of a lake, and nutrients are re-suspended from the sediments. This event is termed spring turnover.

As the sun's rays warm the surface waters in the spring, the water becomes less dense and remains at the surface. Warmer water is mixed deeper into the water column through wind and wave action. However, these forces can only mix water to a depth of approximately twenty to thirty feet. Generally, in a shallow lake, the water may remain mixed all summer. However, a deeper lake usually experiences layering based on temperature differences, called stratification.

During the summer, lakes have the potential to divide into three distinct zones: the epilimnion, thermocline or metalimnion, and the hypolimnion. The epilimnion describes the warmer surface layer of a lake and the hypolimnion describes the cooler bottom area of a lake. The thermocline, or metalimnion, describes the transition area between the epilimnion and hypolimnion.

As surface waters cool in the fall, they become more dense and sink until the water temperature evens out from top to bottom. This process is called fall turnover and allows for a second mixing event to occur. Occasionally, algae blooms can occur at fall turnover when nutrients from the hypolimnion are made available throughout the water column.

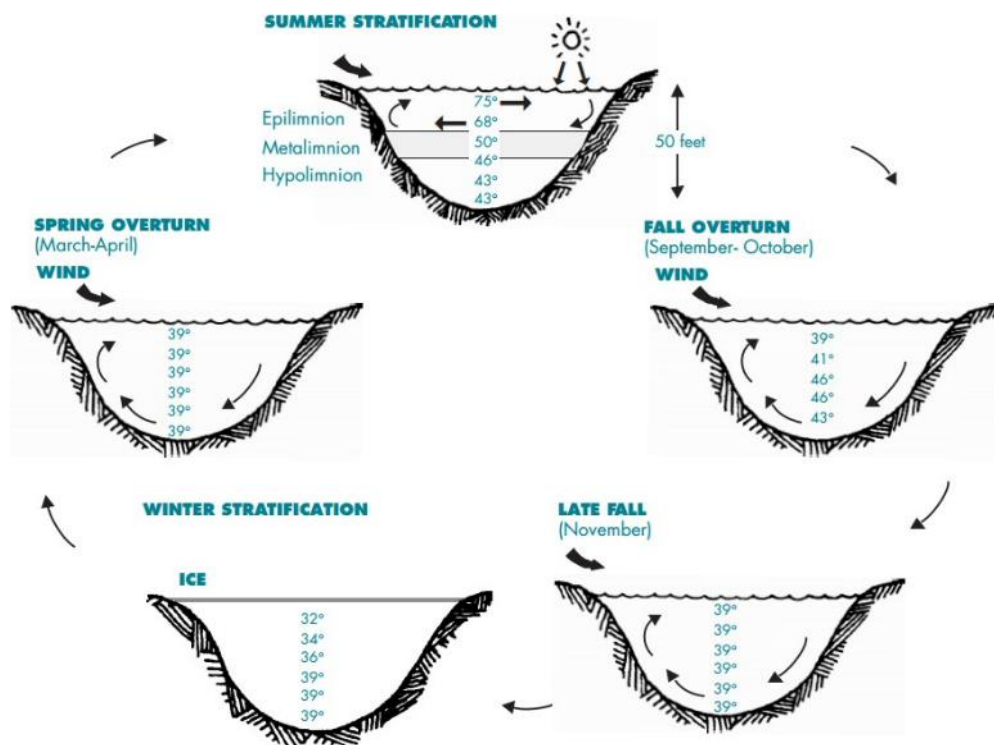
Variations in density arising from differences in water temperatures can prevent warmer water from mixing with cooler water. As a result, nutrients released from the sediments can become trapped in the hypolimnion of a lake that stratifies. Additionally, since

mixing is one of the main ways oxygen is distributed throughout a lake, lakes that don't mix have the potential to have very low levels of oxygen in the hypolimnion.

If oxygen is available in the hypolimnion, iron forms sediment particles that store phosphorus in the sediments. However, when lakes lose oxygen in the winter or when the hypolimnion becomes anoxic in the summer, these particles dissolve and phosphorus is redistributed throughout the water column with strong wind action or turnover events.

The absence of oxygen in the hypolimnion can have adverse effects on fisheries. Species of cold water fish require the cooler waters that result from stratification. Cold water holds more oxygen as compared to warm water. As a result, the cooler waters of the hypolimnion can provide a refuge for cold water fisheries in the summer as long as oxygen is present. Respiration by plants, animals, and especially bacteria is the primary way oxygen is removed from the hypolimnion. A large algae bloom can cause oxygen depletion in the hypolimnion as algae die, sink, and decay.

In the winter, stratification remains constant because ice cover prevents mixing by wind action.



7

⁷ Figure from Understanding Lake Data (G3582), UW-Extension, Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004

Deep Hole Sampling Procedure

In-lake data was collected by the Polk County Land and Water Resources Department during the 2018 and 2019 growing season.

Lake profile monitoring

Dissolved oxygen, temperature, conductivity, specific conductance, and pH were recorded at meter increments with a Hanna Instruments 9828 multi-parameter probe biweekly in 2018 and a YSI Professional Series Pro DSS.

Secchi depth

Secchi depth was recorded with an eight inch diameter round disk with alternating black and white quadrants called a secchi disk. To record secchi depth, the disk was lowered into the lake on the shady side of a boat until just before it disappeared from sight. This depth was measured in feet and recorded as the secchi depth. Data was collected biweekly to correspond with lake profile monitoring readings.

Chemistry and chlorophyll a

Top samples were collected once a month with a composite sampler and bottom samples were collected once a month with a Van Dorn sampler. Water samples were analyzed at the Water and Environmental Analysis Lab. Top samples were analyzed for total phosphorus, soluble reactive phosphorus, nitrate/nitrite, ammonium, total Kjeldahl nitrogen, total suspended solids, chloride, and chlorophyll a. Bottom samples were analyzed for total phosphorus, soluble reactive phosphorus, iron, and sulfate.

Citizen Lake Monitoring Network

Volunteers collected secchi depth samples as part of the Citizen Lake Monitoring Network program.

Dissolved Oxygen

Oxygen is required by all aquatic organisms for survival. The amount of oxygen dissolved in water depends on temperature, the amount of wind mixing that brings water into contact with the atmosphere, the biological activity that consumes or produces oxygen within a lake, and the composition of groundwater and surface water entering a lake.

In a process called photosynthesis, plants use carbon, water, and the sun's energy to produce simple sugars and oxygen. Chlorophyll, the pigment in plants that captures the light energy necessary for photosynthesis, is the site where oxygen is produced. Since photosynthesis requires light, the oxygen producing process only occurs during the daylight hours and only at depths where sunlight can penetrate. Plants and animals also use oxygen in a process called respiration. During respiration, sugar and oxygen are used by plants and animals to produce carbon dioxide and water.

Cold water has a higher capacity for oxygen than warm water. Although temperatures are coolest in the deepest part of a lake, these waters often do not contain the most oxygen. This arises because in the deepest parts of lakes, oxygen producing photosynthesis is not occurring, mixing is unable to introduce oxygen, and the only reaction occurring is oxygen consuming respiration. Therefore, it is not uncommon for oxygen depletion to occur in the hypolimnion.

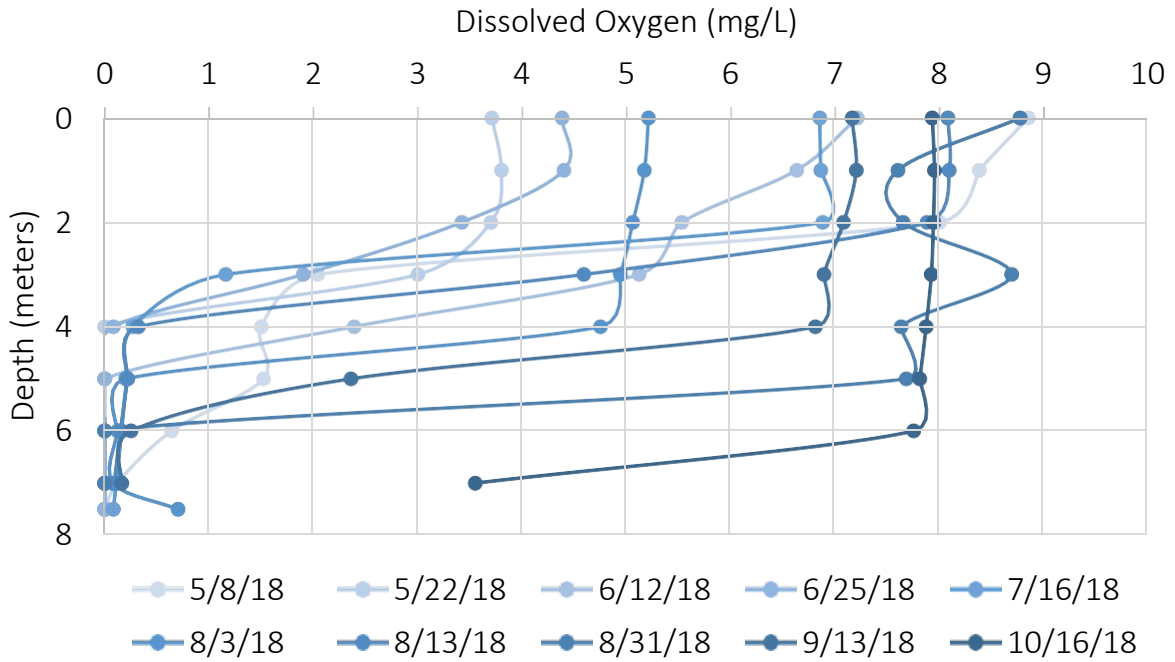
During the sunlight hours, when photosynthesis is occurring, dissolved oxygen levels at a lake's surface may be quite high. Conversely, at night or early in the morning (when photosynthesis is not occurring), the dissolved oxygen values can be expected to be lower.

A water quality standard for dissolved oxygen in warm water lakes and streams is set at 5 mg/L. This standard is based on the minimum amount of oxygen required by fish for survival and growth. For cold water lakes supporting trout, the standard is set even higher at 7 mg/L.

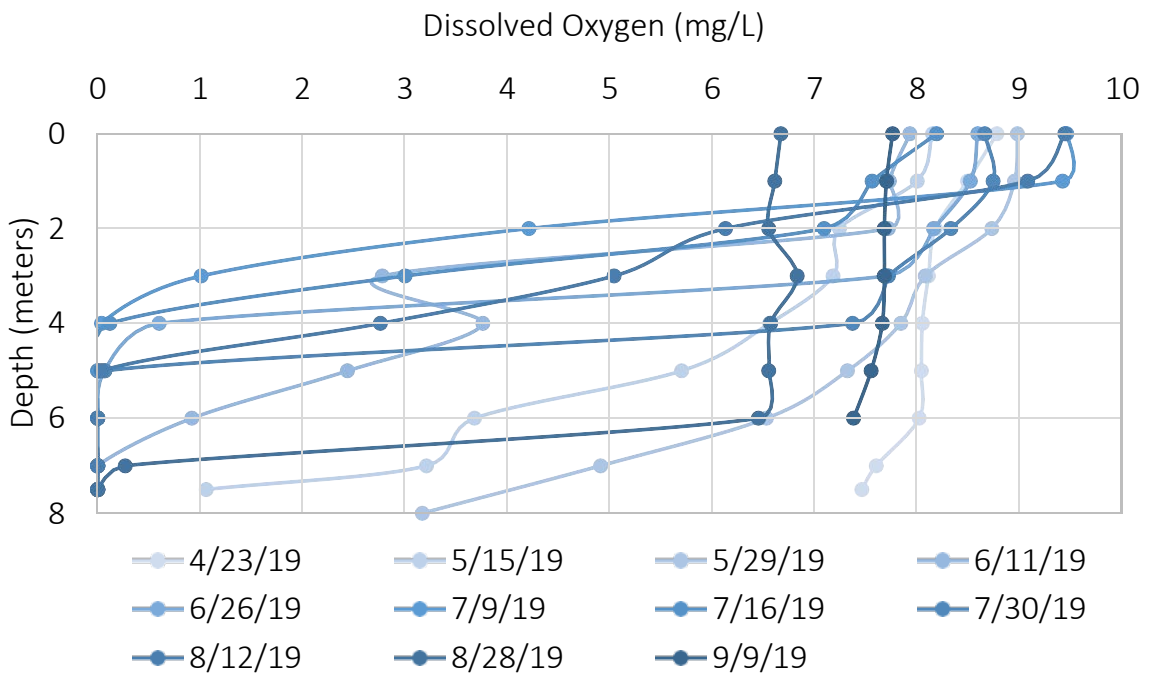
The Land and Water Resources Department probe used for this study was sent off for repairs due to a faulty dissolved oxygen sensor in July 2018.

During both years of the study, the upper two meters of Magnor Lake were well oxygenated and the bottom waters became anoxic.

2018 Magnor Dissolved Oxygen



2019 Magnor Dissolved Oxygen



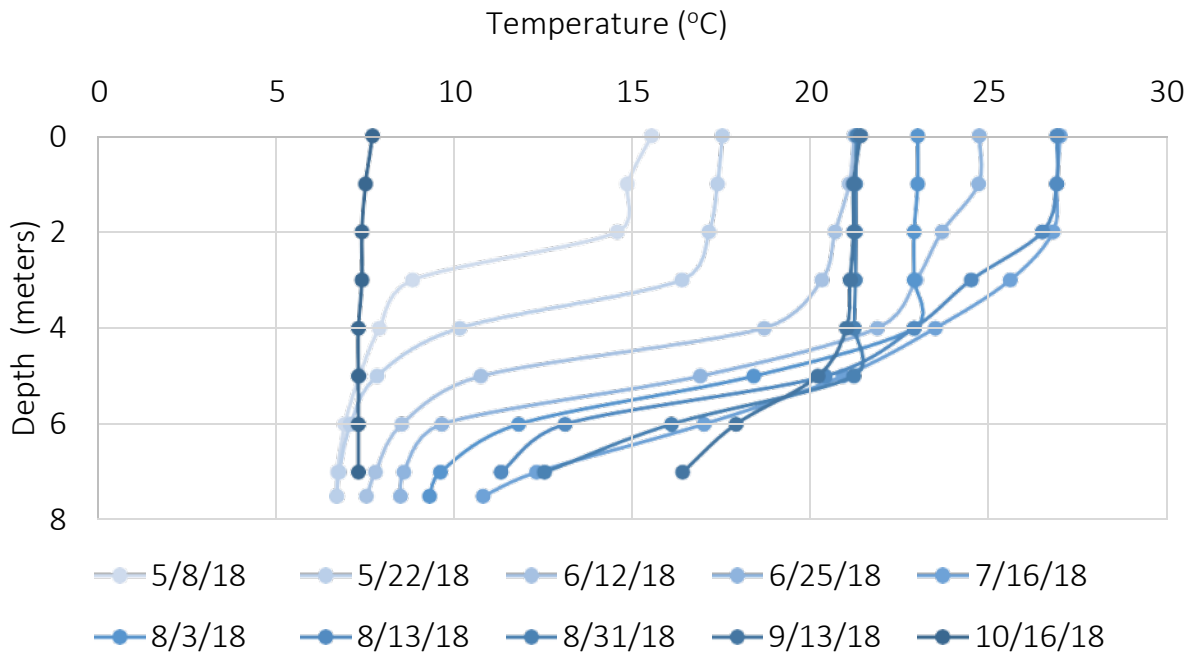
Temperature

Magnor Lake stratified, or set up density dependent layers, during each year of the study. The upper level of the lake, or the epilimnion, reached to a depth of two to three meters during the majority of the growing season. The water in this area of the lake is warmer and is well mixed by wind and wave action. The cooler bottom area of the lake, or the hypolimnion, does not mix with the waters of the epilimnion.

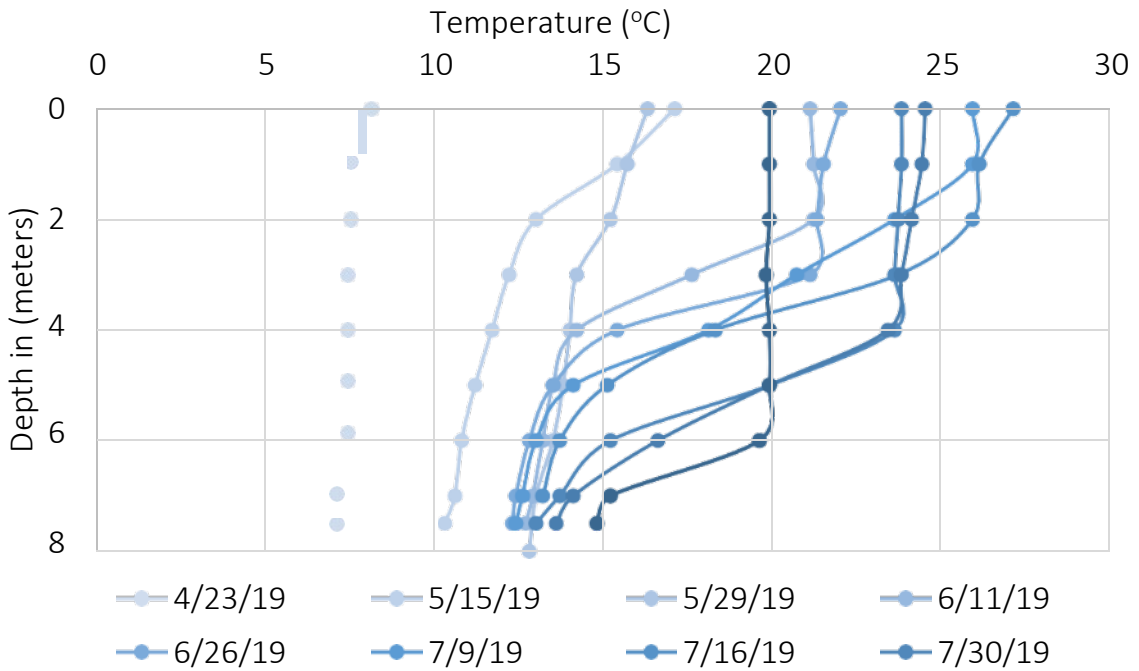
The surface temperature was greatest in July and August across both years of the study.

Surface Temperature on Magnor Lake (°C)	
5/8/18	15.53
5/22/18	17.52
6/12/18	21.22
6/25/18	24.73
7/16/18	27.0
8/3/18	23.0
8/13/18	26.9
8/31/18	21.29
9/13/18	21.4
10/16/18	7.7
4/23/19	8.1
5/15/19	17.1
5/29/19	16.3
6/11/19	21.1
6/26/19	22.0
7/9/19	25.9
7/16/19	27.1
7/30/19	23.8
8/12/19	24.5
8/28/19	19.9
9/9/19	18.4

2018 Magnor Lake Temperature



2019 Magnor Lake Temperature



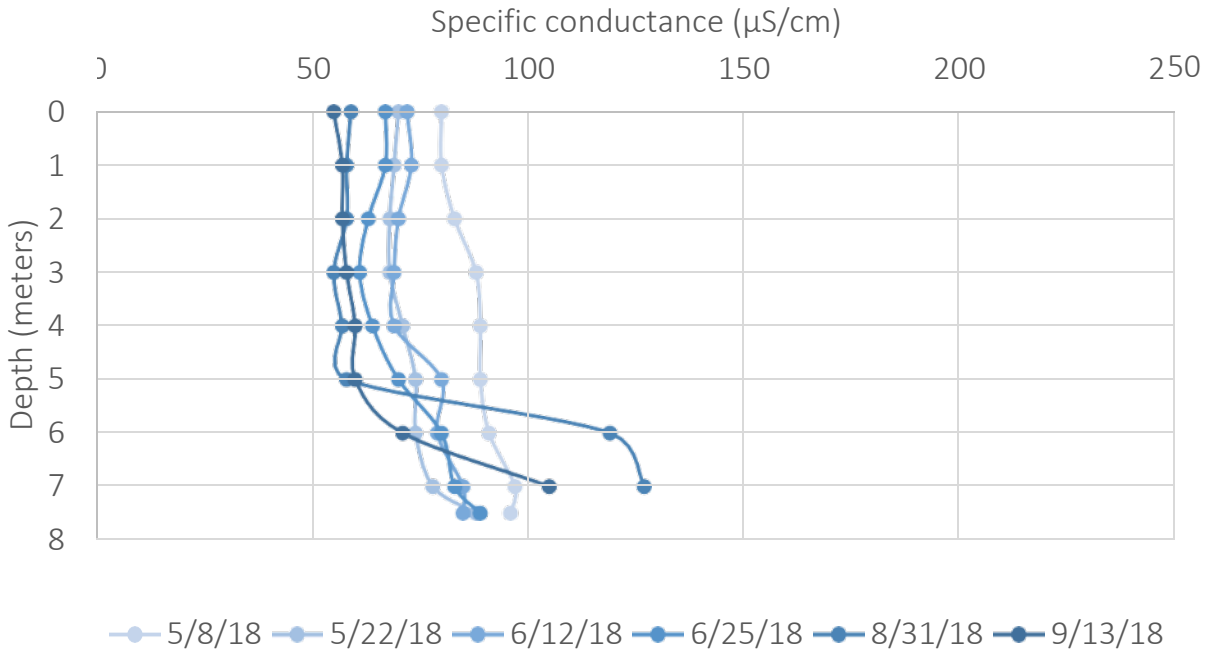
Specific Conductance (Conductivity)

Conductivity is the measure of the ability of water to conduct an electrical current and serves as an indicator of the concentration of total dissolved inorganic chemicals in the water. Since conductivity is temperature related, reported values are normalized at 25°C and termed specific conductance. Specific conductance increases as the concentration of dissolved minerals in a lake increase.

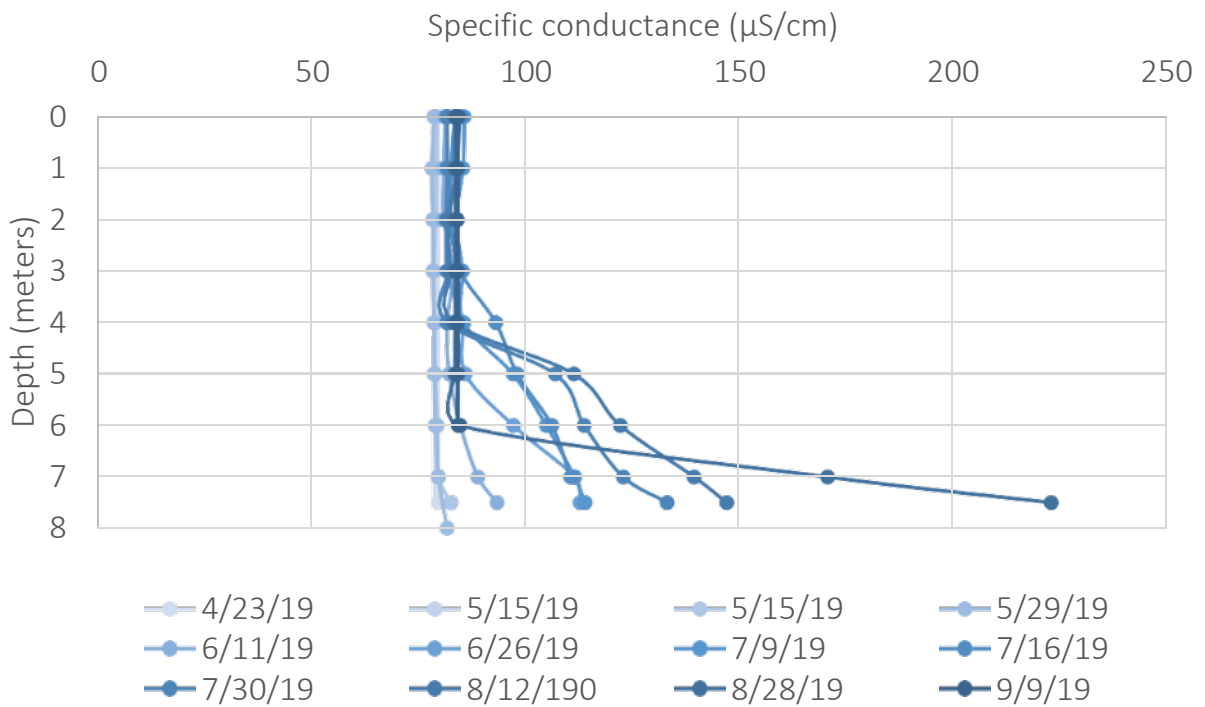
In general, specific conductance values at the surface were between 50 and 100 $\mu\text{S}/\text{cm}$ in Magnor Lake. Specific conductance increased in the bottom meter of the lake during the growing season.

When watersheds contain easily dissolved carbonate rocks, lakes are more likely to have higher conductivity. In contrast, watersheds that contain slow-to-dissolve rocks, such as granite, are more likely to have lower conductivity. Lakes with especially low conductivity are also more likely to be precipitation dominated (rather than groundwater or runoff dominated), because precipitation contains very little dissolved minerals.

2018 Magnor Lake Specific Conductance



2019 Magnor Lake Specific Conductance



pH

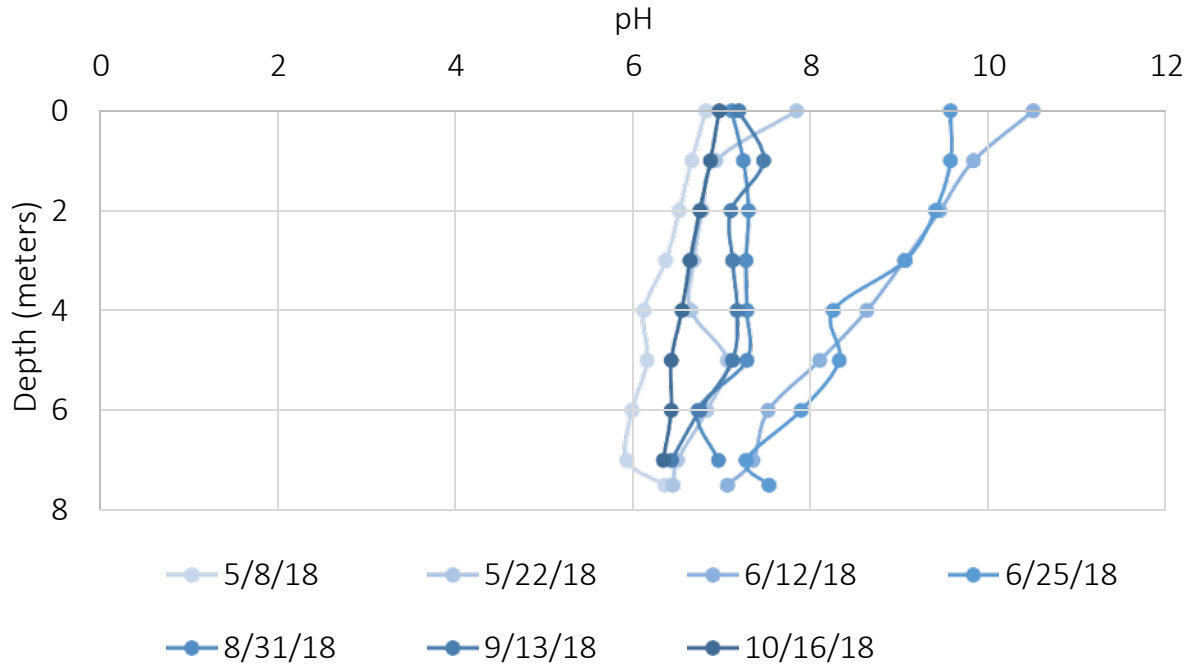
An indicator of acidity, pH is the negative logarithm of the hydrogen ion (H⁺) concentration. Lower pH waters have more hydrogen ions and are more acidic, and higher pH waters have less hydrogen ions and are less acidic.

A pH value of seven is considered neutral. Values less than seven indicate acidic conditions; whereas, values greater than seven indicate alkaline conditions. A single pH unit change represents a tenfold change in the concentration of hydrogen ions. As a result, a lake with a pH value of eight is ten times less acidic than a lake with a pH value of seven. Across Wisconsin lakes, pH values can range from 4.5 (acid bog lakes) to 8.4 (hard water, marl lakes).

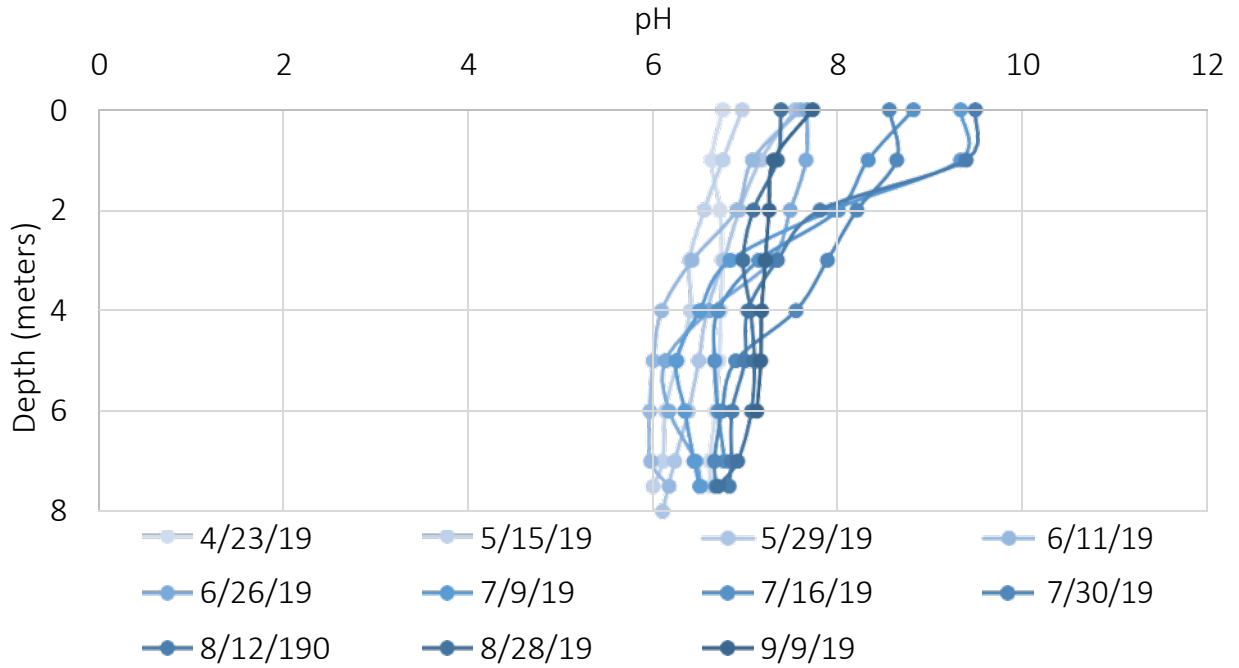
Through the removal of CO₂ from the water column, photosynthesis has the effect of increasing pH. As a result, pH generally increases during the day and decreases at night. Under conditions such as high temperature, high nutrients, and dense algae blooms, pH levels can increase.

In 2018, pH on Magnor Lake was between 6 and 8 in May, August, and September and around 10 in June. In 2019, pH was between 6 and 8 in June, early July, and late August and between 8 and 10 in late July and early August. In general, pH was higher at the surface as compared to the bottom of the lake.

2018 Magnor Lake pH



2019 Magnor Lake pH



Chloride ⁸

Although chloride does not directly negatively impact plants, algae, or aquatic organisms, elevated levels of chloride in a lake can indicate possible water pollution.

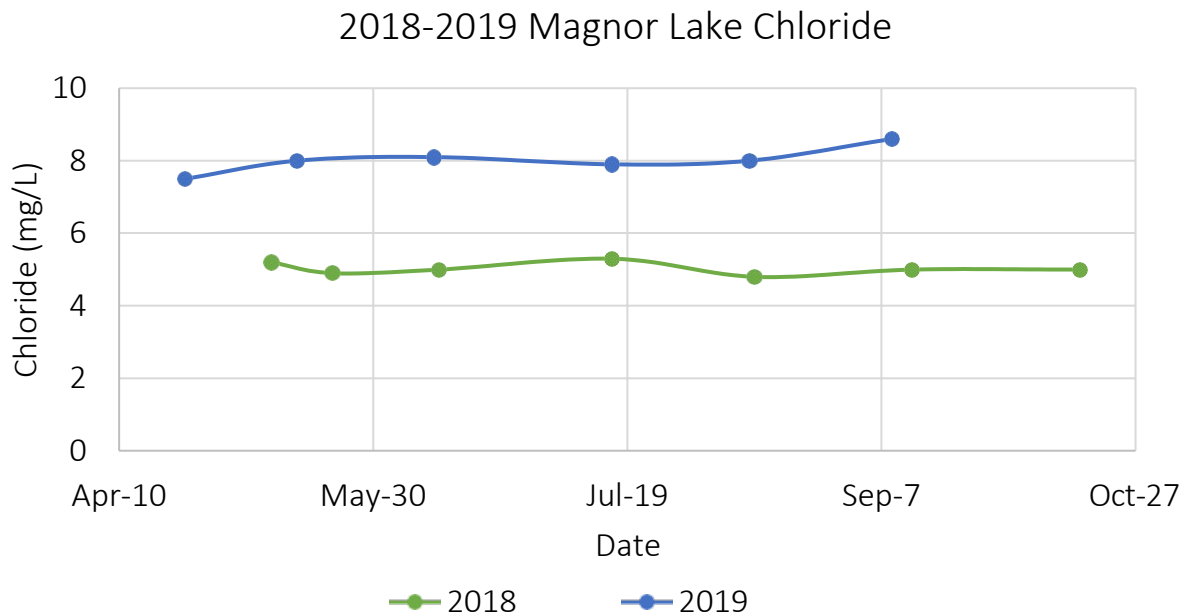
With the exception of limestone deposits, chloride is uncommon in Wisconsin soils, rocks, and minerals. Background levels of chloride are generally found in small quantities in nearly every Wisconsin lake and can be introduced to waterways through rainwater.

The watershed for Magnor Lake is located in an area of Wisconsin where chloride concentrations can be expected to range from three to ten mg/L or greater than ten mg/L. In both 2018 and 2019 chloride concentrations were below ten mg/L on all sampling dates. Chloride concentrations were elevated in 2019 as compared to 2018.

Growing season average chloride (May-September) was 5.0 mg/L in 2018 and 8.1 mg/L in 2019. Average summer index period chloride (July 15-September 15) was 5.0 mg/L in 2018 and 8.2 mg/L in 2019.



CHLORIDE CONCENTRATIONS (mg/l)
□ >10 □ >3 - 10 □ <3



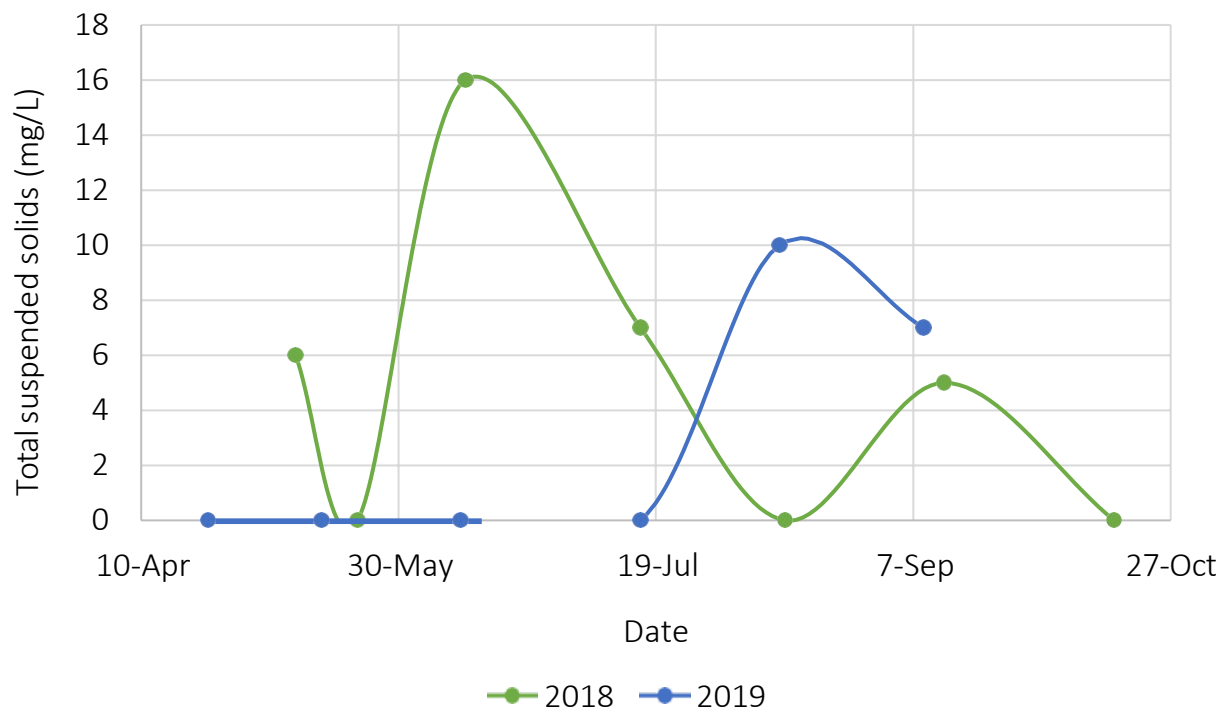
⁸ Figure from Understanding Lake Data (G3582), UW-Extension, Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004

Total Suspended Solids

Total suspended solids quantify the amount of inorganic matter that is floating in the water column. Wind, waves, boats, and even some fish species can stir up sediments from the lake bottom re-suspending them in the water column. Fine sediments, especially clay, can remain suspended in the water column for weeks. These particles scatter light and decrease water transparency.

Growing season average (May-September) total suspended solids were 9.3 mg/L in 2018 and 8.5 mg/L in 2019. The average summer index period total suspended solids (July 15-September 15) was 6.0 mg/L in 2018 and 8.5 mg/L in 2019. Total suspended solids levels were below the limit of detection (4 gm/L) on 43% of the sampling dates in 2018 and 67% of the sampling dates in 2019.

2018-2019 Magnor Lake Total Suspended Solids



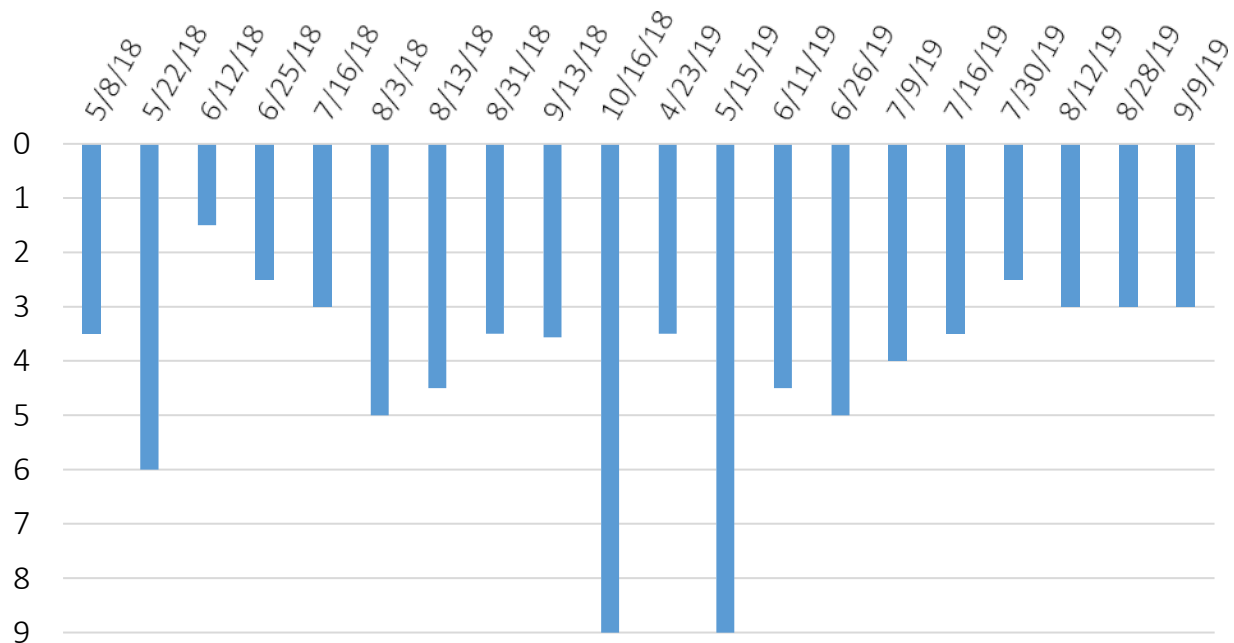
Secchi Depth

The depth which light can penetrate into lakes is affected by suspended particles, dissolved pigments, and absorbance by water. Often, the ability of light to penetrate the water column is determined by the abundance of algae or other photosynthetic organisms in a lake.



One method of measuring light penetration is with a secchi disk. A secchi disk is an eight inch diameter round disk with alternating black and white quadrants that is used to provide a rough estimate of water clarity. The depth at which the secchi disk is just visible is defined as the secchi depth. A greater secchi depth indicates greater water clarity.

2018 and 2019 Magnor Lake Secchi Depth (ft)



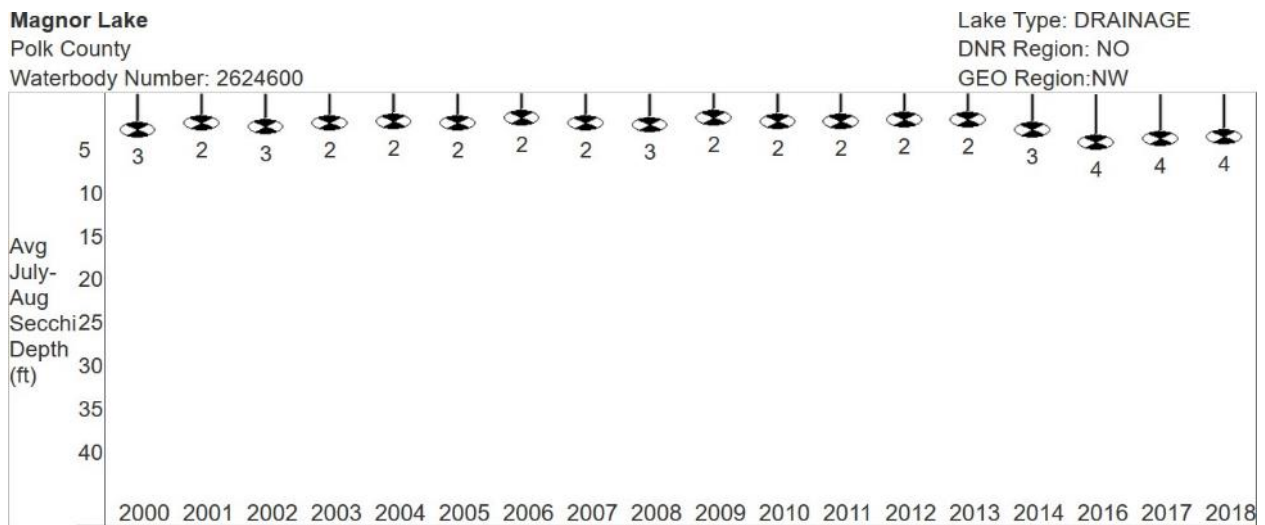
Secchi depth values on Magnor Lake ranged from a low of 1.5 feet to a high of 9 feet over the course of this study.

Growing season average secchi depth (May-September) was 3.7 feet in 2018 and 4.2 feet in 2019.

Summer index period average secchi depth (July 15-September 15) was 3.9 feet in 2018 and 3.0 feet in 2019.

The Wisconsin Department of Natural Resources website provides historic secchi depth averages for the months of July and August. This data exists for Magnor Lake from 2000 to 2018. Over this timeframe, average secchi depth has ranged from 2 to 4 feet.

The average summer secchi depth (July and August) for the Northwest geo-region was 8.2 feet in 2016, 8.1 feet in 2017, and 8.5 feet in 2018. In each year of this study, secchi depth on Magnor Lake was well below the geo-region average.



Past secchi averages in feet (July and August only).

Phosphorus

Phosphorus is an element present in lakes which is necessary for plant and algae growth. It occurs naturally in soil and rocks and in the atmosphere in the form of dust.

Phosphorus can make its way into lakes through groundwater and human induced disturbances such as soil erosion. Additional sources of phosphorus inputs into a lake can include external sources such as fertilizer runoff from urban and agricultural settings and internal sources such as release from sediment at the bottom of a lake.

Phosphorus does not readily dissolve in water, instead it forms insoluble precipitates with calcium, iron, manganese, sulfur, and aluminum. If oxygen is available in the hypolimnion, iron forms sediment particles that store phosphorus in the sediments. However, when lakes lose oxygen in the winter or when the hypolimnion becomes anoxic in the summer, these particles dissolve and phosphorus is redistributed throughout the water column with strong wind action or turnover events.

Phosphorus is necessary for plant and animal growth. Excessive amounts can lead to an overabundance of growth which can decrease water clarity and lead to nutrient pollution in lakes.

Total phosphorus is 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.

In lakes, a healthy limit of total phosphorus is set at 20 µg/L. If a value is above the healthy limit it is more likely that a lake could support nuisance algae blooms. On all sampling dates, surface phosphorus was above the healthy limit on Magnor Lake.

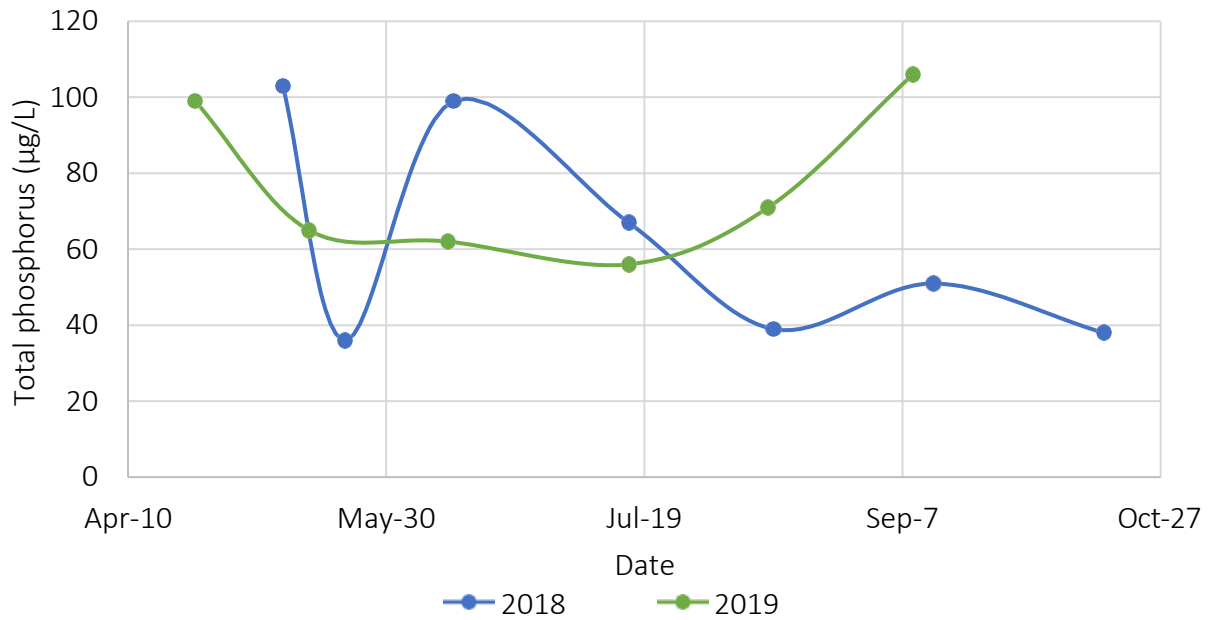
Growing season average surface total phosphorus (May-September) on Magnor Lake was 58 µg/L in 2018 and 72 µg/L in 2019.

Summer index period (July 15-September 15) average surface phosphorus on Magnor Lake was 52 µg/L in 2018 and 78 µg/L in 2019.

Growing season average bottom phosphorus on Magnor Lake was 286 µg/L in 2018 and 376 µg/L in 2019.

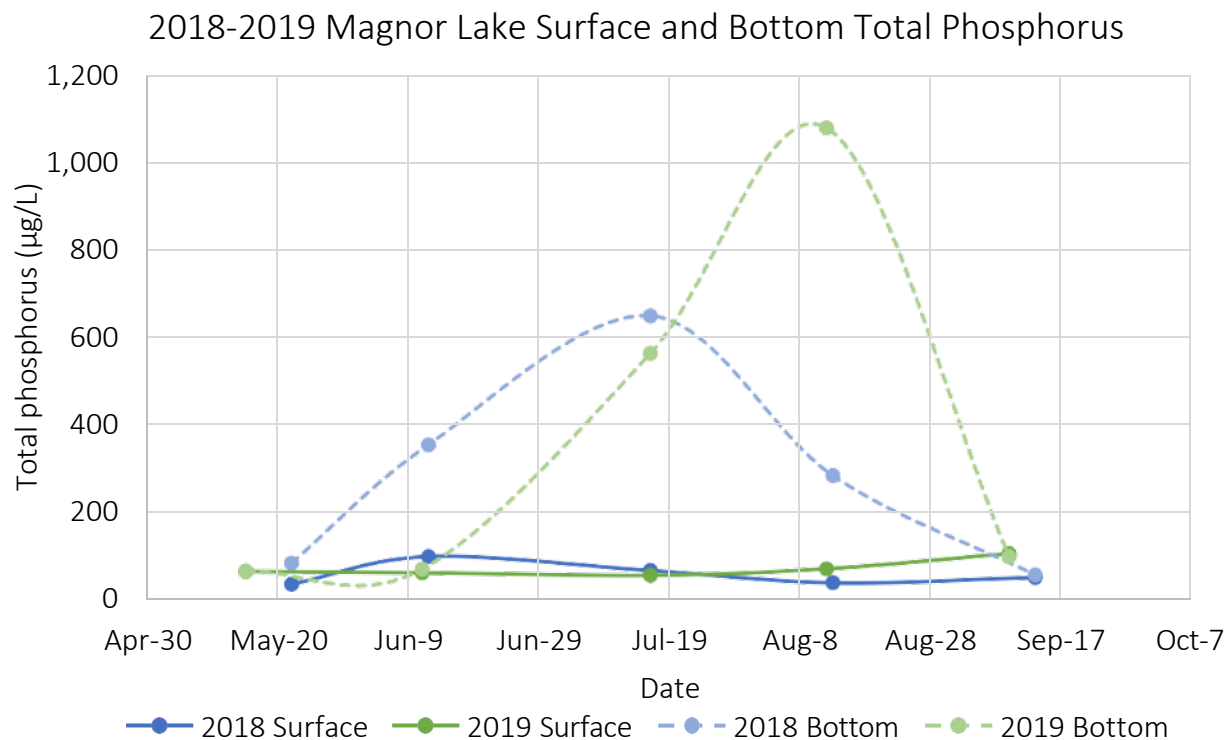
Summer index period (July 15-September 15) average bottom phosphorus on Magnor Lake was 330 µg/L in 2018 and 581 µg/L in 2019.

2018-2019 Magnor Lake Surface Total Phosphorus



With the exception of September 2019, total phosphorus levels at the bottom of Magnor Lake were higher than at the surface. This difference was most pronounced in July and August in both years of the study. The data suggests that under anoxic conditions, phosphorus is being released from the sediments into the bottom waters of Magnor Lake.

Date	Surface Total Phosphorus (µg/L)	Bottom Total Phosphorus (µg/L)	Percent change
5/22/18	36	84	133%
6/12/18	99	355	259%
7/16/18	67	650	870%
8/13/18	39	284	628%
9/13/18	51	57	12%
05/15/19	65	66	2%
06/11/19	62	70	13%
07/16/19	56	564	907%
08/12/19	71	1080	1421%
09/09/19	106	99	-7%



Soluble reactive phosphorus includes forms of phosphorus that are dissolved in the water and are readily available for uptake by algae and aquatic plants.

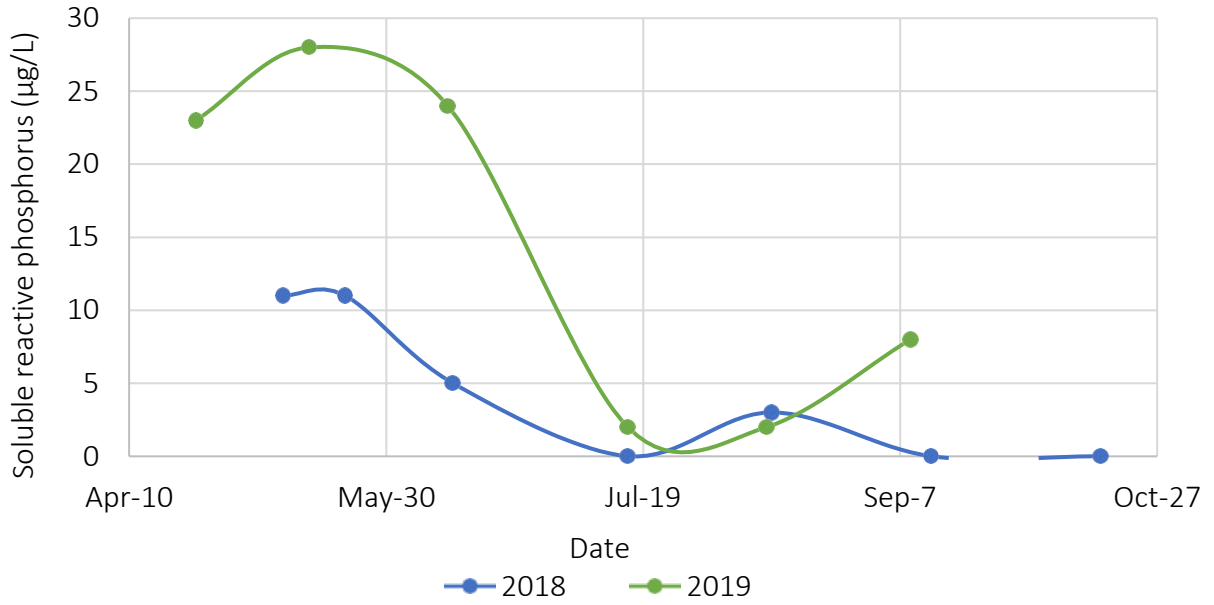
In lakes, a healthy limit of soluble reactive phosphorus is set at 10 µg/L. If a value is above the healthy limit it is more likely that a lake could support nuisance algae blooms. Surface soluble reactive phosphorus was above the healthy limit in May of 2018 and in May and June of 2019. Bottom soluble reactive phosphorus was above the healthy limit on all sampling dates with the exception of the September sampling dates.

Growing season average surface soluble reactive phosphorus on Magnor Lake was 6 µg/L in 2018 and 13 µg/L in 2019.

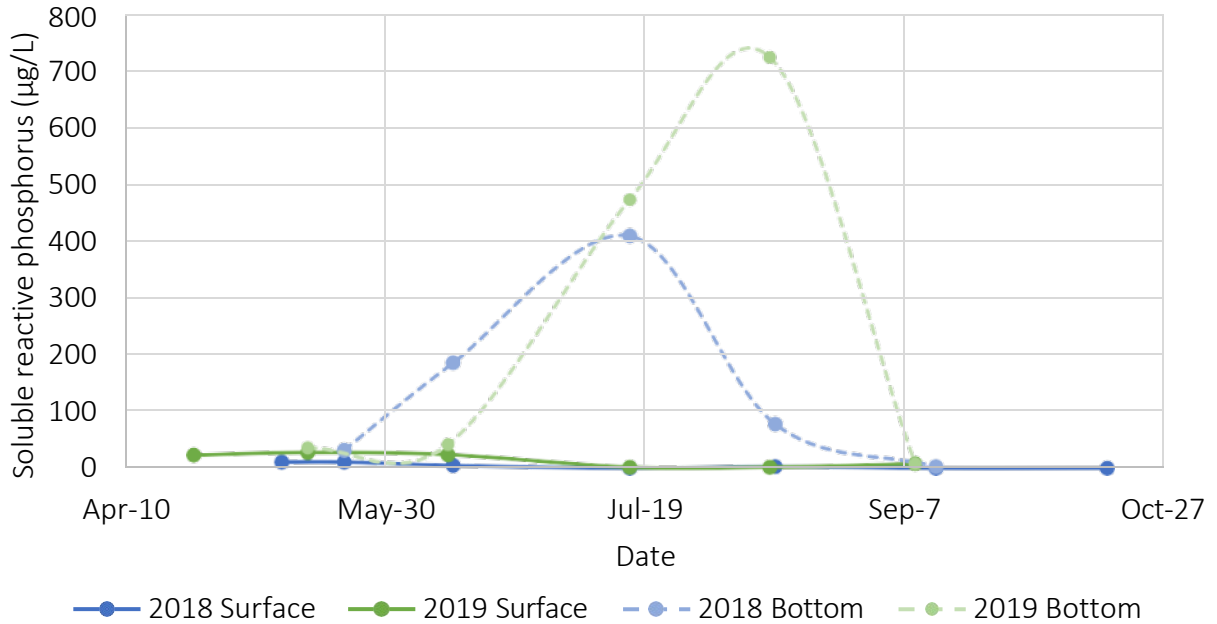
Summer index period (July 15-September 15) average surface soluble reactive phosphorus on Magnor Lake was 3 µg/L in 2018 and 4 µg/L in 2019.

Similar to total phosphorus, soluble reactive phosphorus levels at the bottom of Magnor Lake were higher than at the surface on all sampling dates with the exception of September 2019. This difference was most pronounced in July of 2018 and July and August in 2019.

2018-2019 Magnor Lake Surface Soluble Reactive Phosphorus

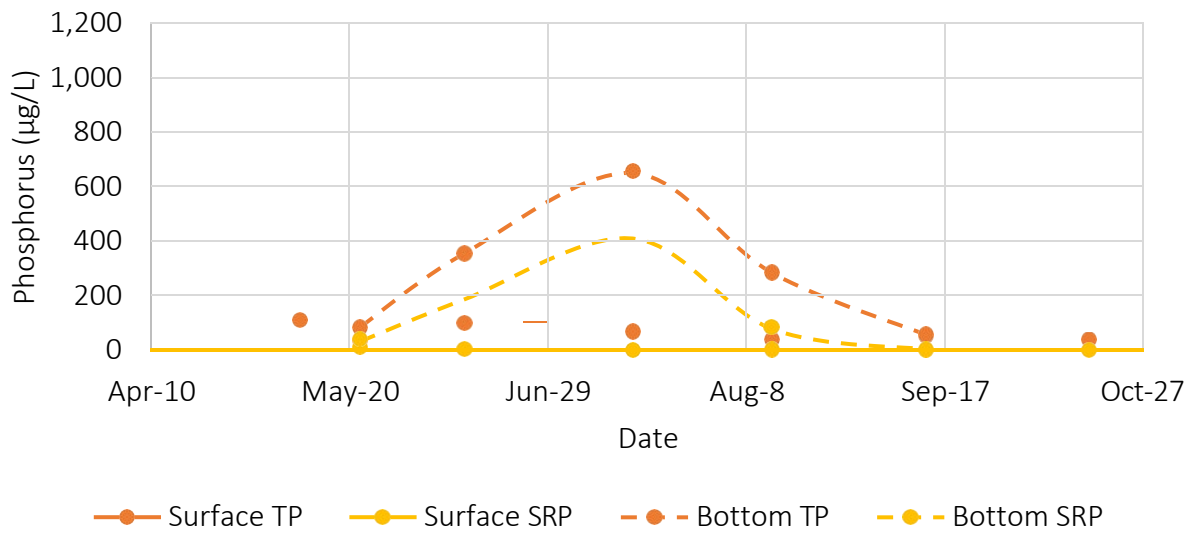


2018-2019 Magnor Lake Surface and Bottom Soluble Reactive Phosphorus

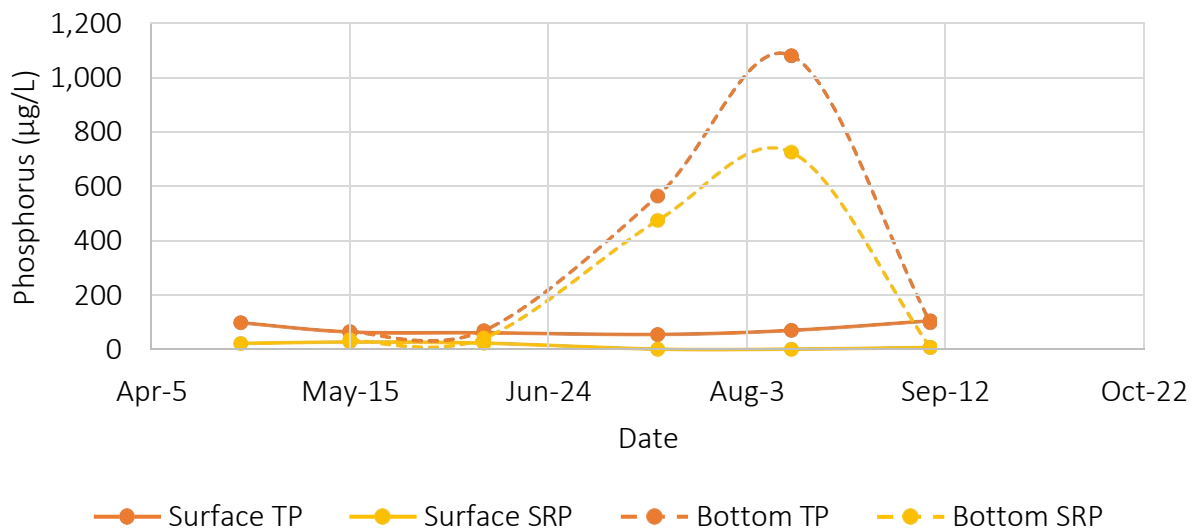


Over the majority of the growing season in 2018 and 2019, phosphorus (total and soluble reactive) were greater at the bottom of the Magnor Lake as compared to the surface. Additionally, total phosphorus was greater than soluble reactive phosphorus at both the surface and bottom of Magnor Lake. Bottom phosphorus (total and soluble reactive) reached their highest levels in July in 2018 and in August in 2019.

2018 Magnor Lake Surface and Bottom Total Phosphorus and Soluble Reactive Phosphorus



2019 Magnor Lake Surface and Bottom Total Phosphorus and Soluble Reactive Phosphorus



Nitrogen

Nitrogen, like phosphorus, is an element necessary for plant growth. Nitrogen sources in a lake can vary widely. Nitrogen does not occur naturally in soil minerals; however, it is a major component of all plant and animal matter. The decomposition of plant and animal matter releases ammonia, which is converted to nitrate in the presence of oxygen. This reaction accelerates when water temperatures increase. Nitrogen can also be introduced to a lake through rainfall, in the form of nitrate and ammonium, and through groundwater in the form of nitrate.

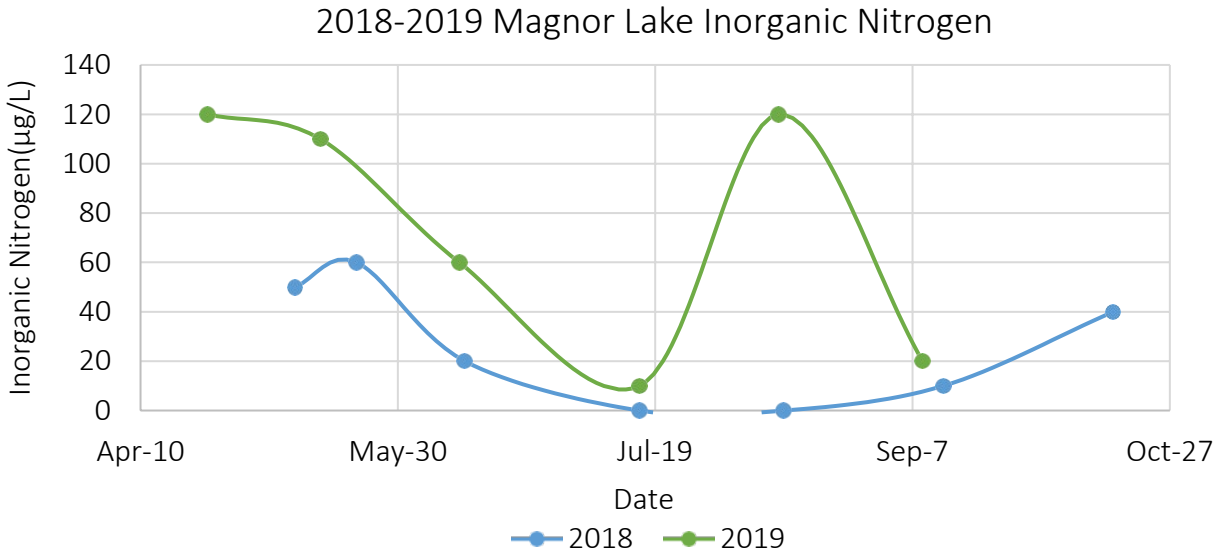
In most instances, the amount of nitrogen in a lake corresponds to land use. Nitrogen can enter a lake from surface runoff or groundwater sources as a result of fertilization of lawns and agricultural fields, animal waste, or human waste from septic systems or sewage treatment plants. During spring and fall turnover events, nitrogen is recycled back into the water column, which can cause spikes in ammonia levels. Under low oxygen circumstances, nitrogen can be lost from a lake system through a process called denitrification. Under these conditions, nitrate is converted to nitrogen gas. Additionally, nitrogen can be lost through permanent sedimentation.

Nitrogen comprises the majority (78%) of the gases in the Earth's atmosphere. As with other gases, nitrogen is more soluble in cooler water as compared to warmer water. Nitrogen gas is not readily available to most aquatic plants, with the exception of blue green algae.

Nitrogen is divided into many components. In this study nitrate/nitrite, ammonium, and total Kjeldahl nitrogen were analyzed.

Nitrate/nitrite and ammonium are inorganic forms of nitrogen which can be used by aquatic plants and algae. Inorganic nitrogen concentrations above 300 µg/L can support summer algae blooms.

Nitrate/nitrite was below the limit of detection (or less than 100 µg/L) on all sample dates with the exception of April and August 2019. Inorganic nitrogen concentrations were well below 300 µg/L during the course of this study.

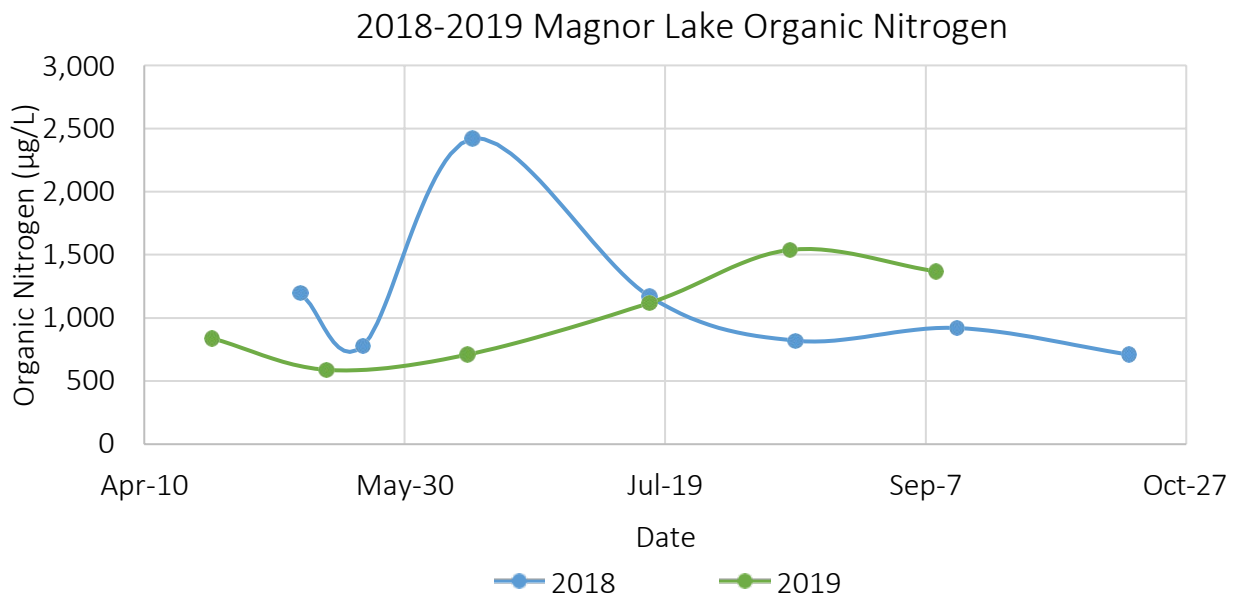


Total Kjeldahl Nitrogen is a measure of organic nitrogen plus ammonium. By subtracting the ammonium concentration from total Kjeldahl nitrogen, the organic nitrogen concentration found in plants and algae can be found.

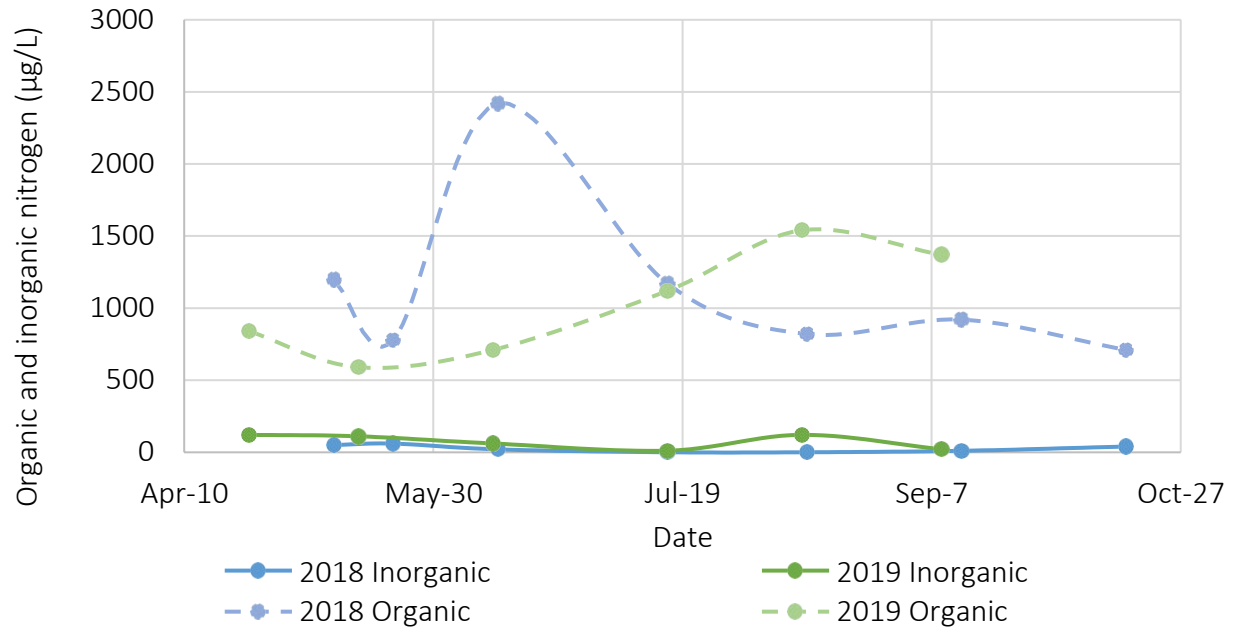
Growing season average organic nitrogen on Magnor Lake was 1,222 µg/L in 2018 and 1,066 µg/L in 2019.

Summer index period (July 15-September 15) average organic nitrogen on Magnor Lake was 970 µg/L in 2018 and 1,343 µg/L in 2019.

Organic nitrogen was greatest in June in 2018 and greatest in August in 2019.



2018-2019 Magnor Lake Organic and Inorganic Nitrogen



Total Nitrogen to Total Phosphorus Ratio

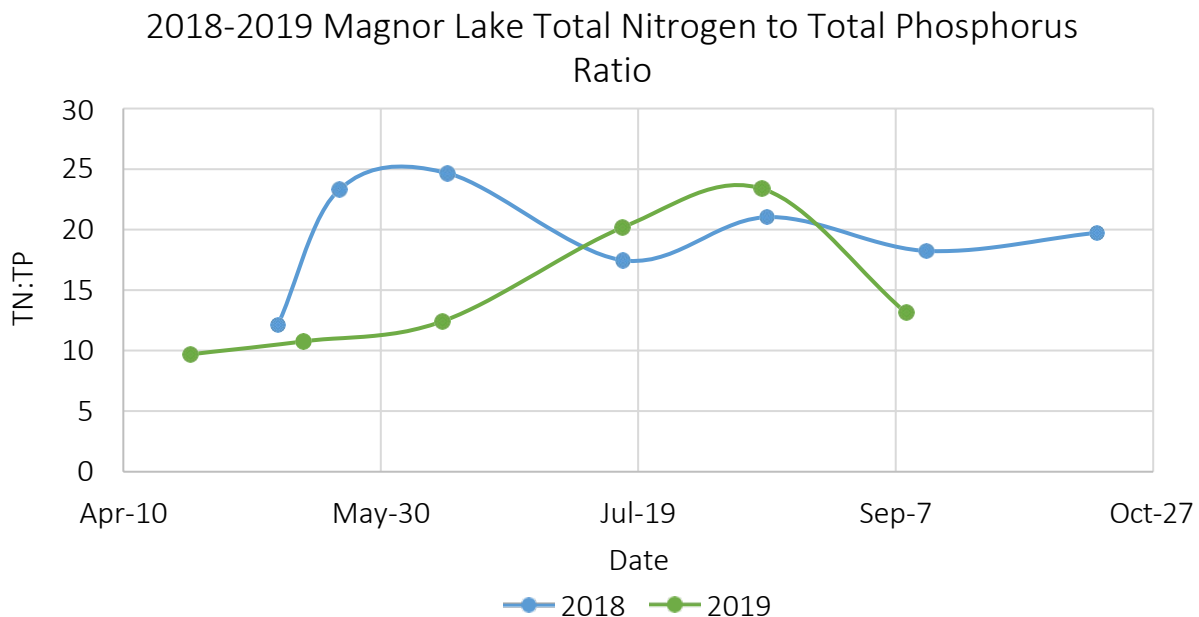
The total nitrogen to total phosphorus ratio (TN:TP) is a calculation that depicts which nutrient limits algae growth in a lake.

Lakes are considered nitrogen limited, or sensitive to the amount of nitrogen inputs, when TN:TP ratios are less than 10. Only about 10% of Wisconsin lakes are limited by nitrogen. In contrast, lakes are considered phosphorus limited, or sensitive to the amount of phosphorus inputs into a lake, when the TN:TP ratio is above 15. Lakes with values between 10 and 15 are considered transitional. In transitional lakes it is impossible to determine which nutrient (nitrogen or phosphorus) is limiting algae growth.

Total nitrogen is found by adding nitrate/nitrite to total Kjeldahl nitrogen. As previously mentioned, nitrate/nitrite concentrations were below the limit of detection or less than 100 µg/L on all but two sampling dates. As a result, total nitrogen is largely reflective of total Kjeldahl nitrogen.

Magnor Lake was in a transitional state at spring turnover in 2018 and on the May, June, and September 2019 sampling dates. The lake was in a nitrogen limited state at spring turnover in 2019. Magnor Lake was in a phosphorus limited state during the remainder of the growing season (May-October 2018 and July and August 2019).

During the growing season (May-September) Magnor Lake was phosphorus limited on 100% of the sampling dates in 2018 and 40% of the sampling dates in 2019.

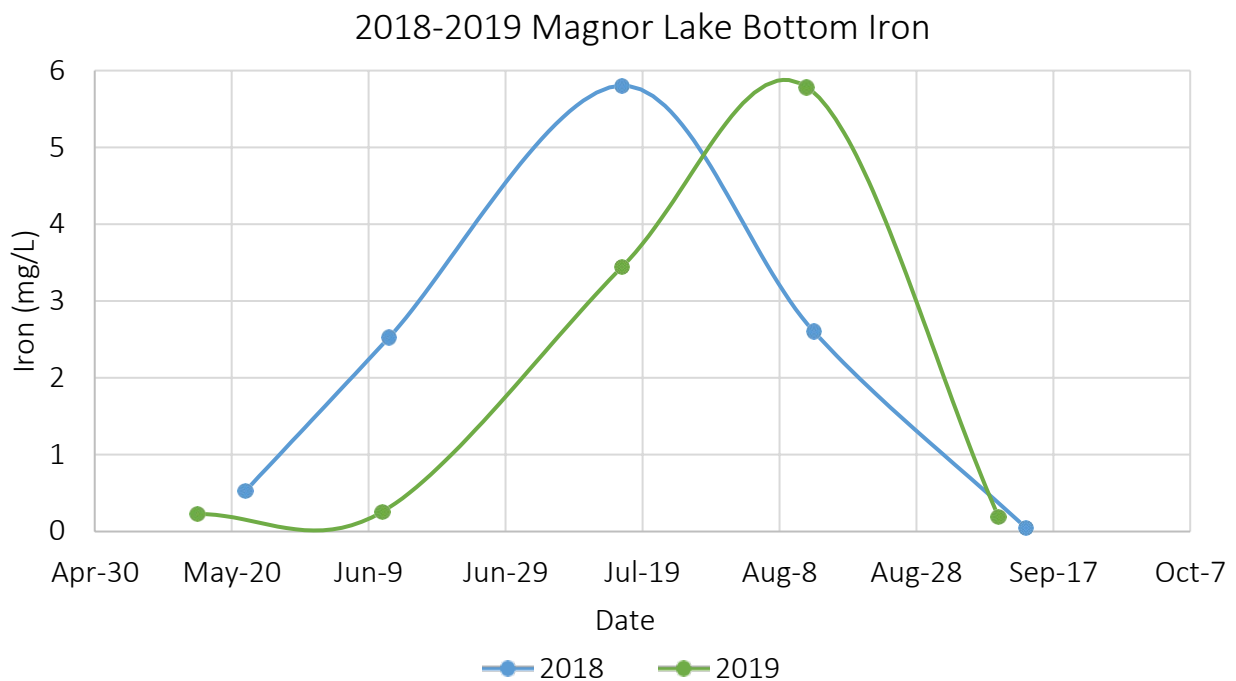


Iron

Iron is a micronutrient required by living organisms in lakes. It is an abundant metal in the Earth's crust although its concentration in lakes is typically low due to low solubility.

In the presence of oxygen, iron and phosphorus bind to one another in lake sediments. Under low oxygen conditions, iron and phosphorus are released into the water column from the bottom sediments.

Bottom iron levels increased over the course of the growing season in both 2018 and 2019. The peak occurred earlier in 2018 (July) as compared to 2019 (August).

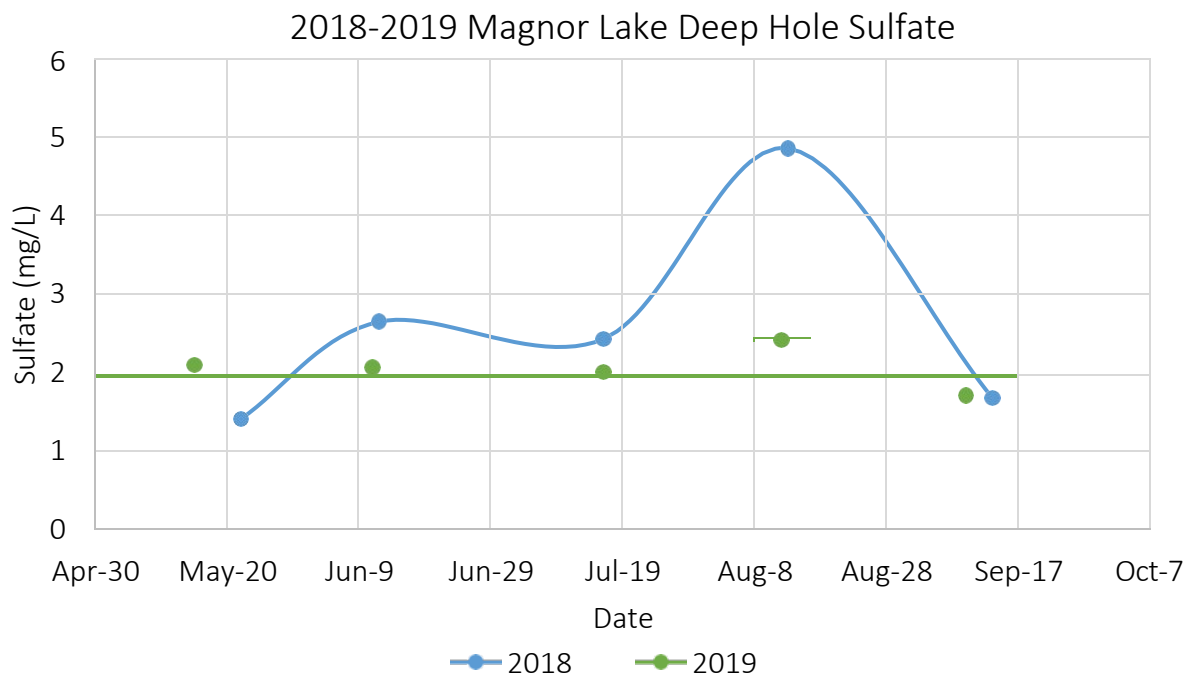


Sulfate

Sulfate concentrations in lakes are most directly related to the types of minerals found in the watershed and to acid rain. Coal burning facilities that release sulfur compounds into the atmosphere can enter lakes via rainfall. In general, sulfate concentrations are higher in the southeastern portion of the state where mineral sources of sulfate and acid rain are more common.

When lakes are depleted of oxygen the interplay between phosphorus, iron, and sulfate becomes important. In the presence of oxygen, iron and phosphorus bind to one another and phosphorus becomes unavailable for plants and algae. Under low oxygen conditions, the bond between iron and phosphorus is broken and phosphorus becomes available for plants and algae. Additionally, as oxygen is depleted sulfate is reduced to hydrogen sulfide. Hydrogen sulfide binds with iron and forms insoluble precipitates. If large amounts of iron and sulfide precipitate, then less iron is available to bind with phosphorus even after oxygen is introduced back into the water column.

In Polk County, sulfate concentrations are generally less than 10 mg/L. Sulfate was below 10 mg/L over the course of the study.



Chlorophyll a

Chlorophyll a is a pigment in plants and algae that is necessary for photosynthesis and is an indicator of water quality in a lake. Chlorophyll a gives a general indication of the amount of algae growth in a lake, with greater values for chlorophyll a indicating greater amounts of algae. However, since chlorophyll a is present in sources other than algae—such as decaying plants— it does not serve as a direct indicator of algae biomass.

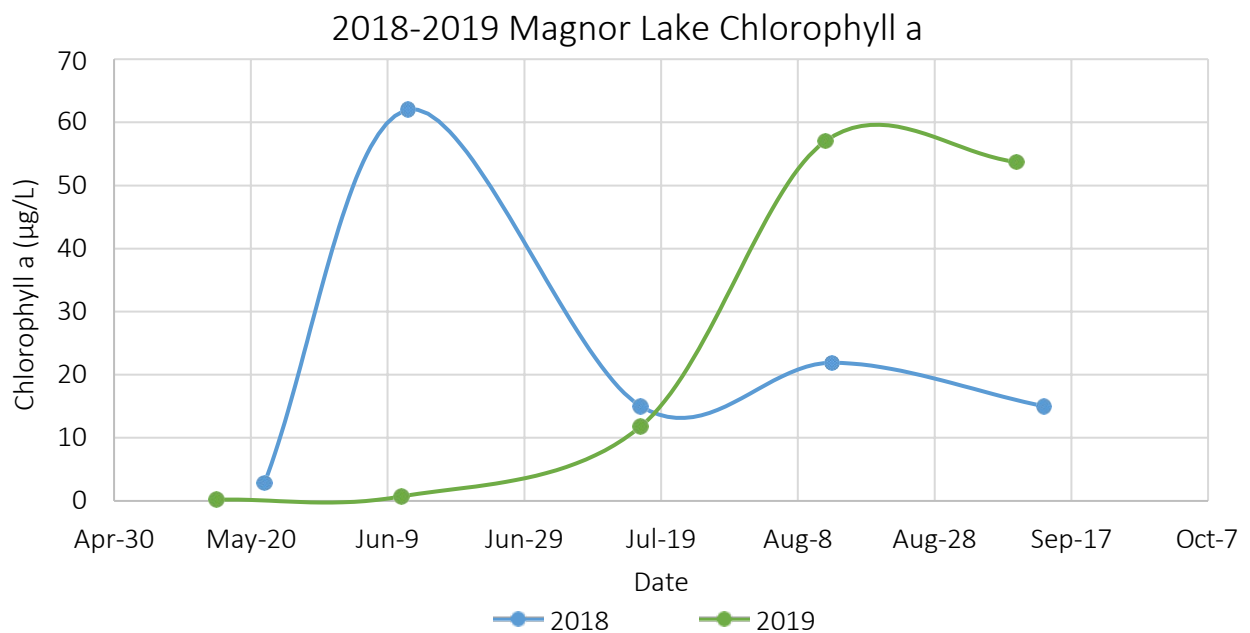
Chlorophyll a seems to have the greatest impact on water clarity when levels exceed 30 µg/L. Lakes which appear clear generally have chlorophyll a levels less than 15 µg/L.

Growing season average chlorophyll a on Magnor Lake was 23.4 µg/L in 2018 and 24.7 µg/L in 2019.

Summer index period (July 15-September 15) average chlorophyll a on Magnor Lake was 17.3 µg/L in 2018 and 40.8 µg/L in 2019.

Chlorophyll a was less than or equal to 15 µg/L in May, July, and September of 2018 and in May through July of 2019. Chlorophyll a levels were greatest in June of 2018; whereas the greatest levels weren't reached until August in 2019.

Chlorophyll a exceeded 30 µg/L in June of 2018 and August and September of 2019.



Trophic State Index

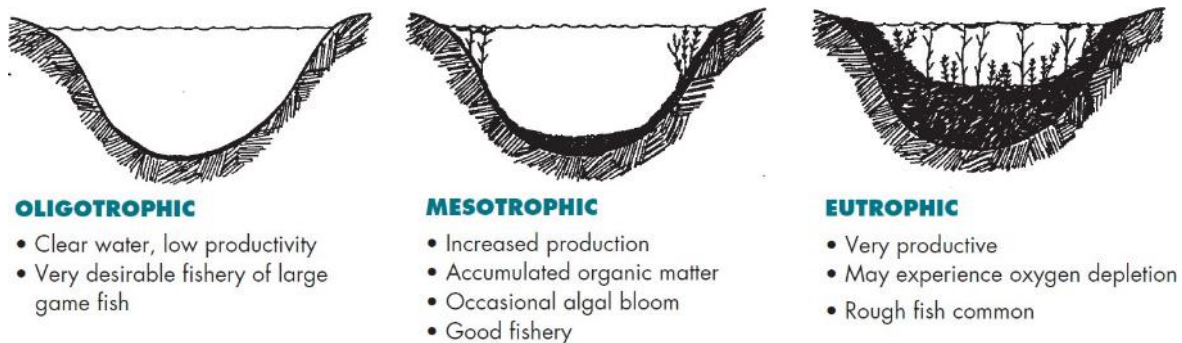
Lakes are divided into three categories based on their trophic states: oligotrophic, eutrophic, and mesotrophic. These categories reflect a lake's nutrient and clarity level and serve as an indicator of water quality. Each category is designed to serve as an overall interpretation of a lake's primary productivity.

Oligotrophic lakes are generally clear, deep, and free of weeds and large algae blooms. These types of lakes are often poor in nutrients and are unable to support large populations of fish. However, oligotrophic lakes can develop a food chain capable of supporting a desirable population of large game fish.

Eutrophic lakes are generally high in nutrients and support a large number of plants and animals. They are usually very productive and subject to frequent algae blooms. Eutrophic lakes often support large fish populations, but are susceptible to oxygen depletion.

Mesotrophic lakes lie between oligotrophic and eutrophic lakes. They usually have good fisheries and occasional algae blooms.

All lakes experience a natural aging process which causes a change from an oligotrophic to a eutrophic state. Human influences that introduce nutrients into a lake (agriculture, lawn fertilizers, and septic systems) can accelerate the process by which lakes age and become eutrophic.



A common method of determining a lake's trophic state is to compare total phosphorus (important for algae growth), chlorophyll a (an indicator of the amount of algae present), and secchi disk readings (an indicator of water clarity). Although many factors influence

⁹ Figure from Understanding Lake Data (G3582), UW-Extension, Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004

these relationships, the link between total phosphorus, chlorophyll a, and secchi disk readings is the basis of comparison for the trophic state index (TSI).

TSI is determined using a mathematic formula and ranges from 0 to 110. Lakes with the lowest numbers are oligotrophic and lakes with the highest values are eutrophic.

Three equations for summer index period TSI were examined for Magnor Lake.

$$\text{TSI (P)} = 14.42 * \text{Ln [TP]} + 4.15 \text{ (where total phosphorus is in } \mu\text{g/L)}$$

$$\text{TSI (C)} = 30.6 + 9.81 \text{ Ln [Chlor-a]} \text{ (where chlorophyll a is in } \mu\text{g/L)}$$

$$\text{TSI (S)} = 60 - 14.41 * \text{Ln [Secchi]} \text{ (where secchi depth is in meters)}$$

Magnor Lake 2018 and 2019 respectively

Average summer index period TSI (total phosphorus) = 61 and 67

Average summer index period TSI (chlorophyll a) = 59 and 67

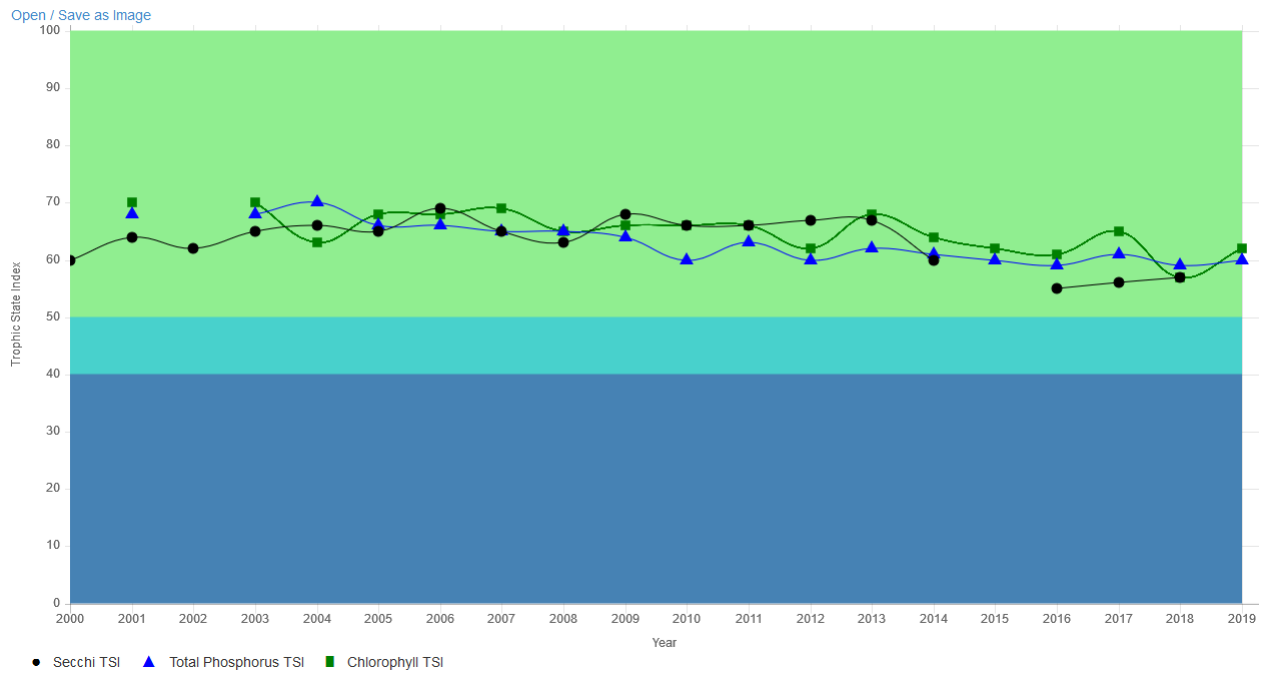
Average summer index period TSI (secchi depth) = 58 and 61

Average summer index period TSI = 59 and 65 = Mildly eutrophic and eutrophic

TSI	General Description
<30	Oligotrophic clear water, high dissolved oxygen throughout the year/lake
30-40	Oligotrophic clear water, possible periods of oxygen depletion in the lower depths of the lake
40-50	Mesotrophic moderately clear water, increasing chance of anoxia near the bottom of the lake in summer, fully acceptable for all recreation/aesthetic uses
50-60	Mildly eutrophic decreased water clarity, anoxic near the bottom, may have macrophyte problem, warm-water fisheries only
60-70	Eutrophic blue-green algae dominance, scums possible, prolific aquatic plant growth, full body recreation may be decreased
70-80	Hypereutrophic heavy algal blooms possible throughout the summer, dense algae and macrophytes
>80	Algal scums, summer fish kills, few aquatic plants due to algal shading, rough fish dominate

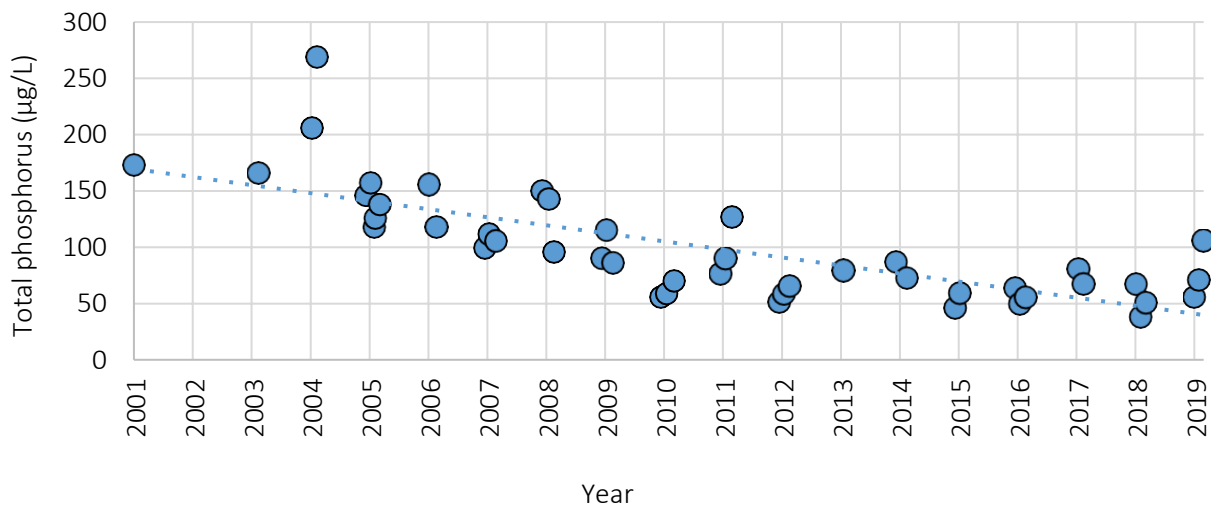
Monitoring the trophic state index of a lake gives stakeholders a method by which to gauge lake productivity over time. TSI data exists for Magnor Lake for 2000-2019. The historic data indicates a eutrophic state in Magnor Lake.

Trophic State Index Graph: Magnor Lake - Deep Hole, Polk County



Historic data for total phosphorus, chlorophyll a, and secchi depth (June 15-September 15) indicate a trend of increasing water quality in Magnor Lake. Since 2001, total phosphorus and chlorophyll a values have shown a decreasing trend and since 2000, secchi depth has shown an increasing trend.

Historic Total Phosphorus ($\mu\text{g}/\text{l}$) June 15 - September 15



Phytoplankton

Algae, also called phytoplankton, are microscopic plants that convert sunlight and nutrients into biomass. They can live on bottom sediments and substrate, in the water column, and on plants and leaves. Algae are the primary producers in an aquatic ecosystem and can vary in form. Zooplankton, are small aquatic organisms that feed on algae. The size and shape of algae determine which types of zooplankton—if any—can consume them.

Algae have short life cycles. As a result, changes in water quality are often reflected by changes in the algal community within a few days or weeks. The number and types of algae in a waterbody can provide useful information for environmental monitoring programs, impairment assessments, and the identification of best management strategies.

The types of algae in a lake will change over the course of a year. Typically, there is less algae in winter and spring because of ice cover and cold temperatures. As a lake warms up and sunlight increases, algae communities begin to increase, particularly diatoms. Their short life span quickly cycles the nutrients in a lake and affects nutrient dynamics.

The types of algae present in a lake are influenced by environmental factors like climate, phosphorus, nitrogen, silica and other nutrient content, carbon dioxide, grazing, substrate, and other factors in the lake. When high levels of nutrients are available, blue green algae often become predominant and create light limited conditions for other groups of algae. Additionally, under nitrogen limited conditions, blue green algae have a competitive advantage over other algae because of their unique ability to fix nitrogen from the atmosphere.

Chlorophyll a is a pigment in plants and algae that is necessary for photosynthesis. Chlorophyll a gives a general indication of the amount of algae growth in the water column; however, it is not directly correlated with algae biomass. To obtain accurate algae data, composite samples from a two meter water column were collected monthly, preserved with glutaraldehyde, placed on ice, and sent to UW-Oshkosh for identification and enumeration of algae species. Sampling was conducted in 2018.

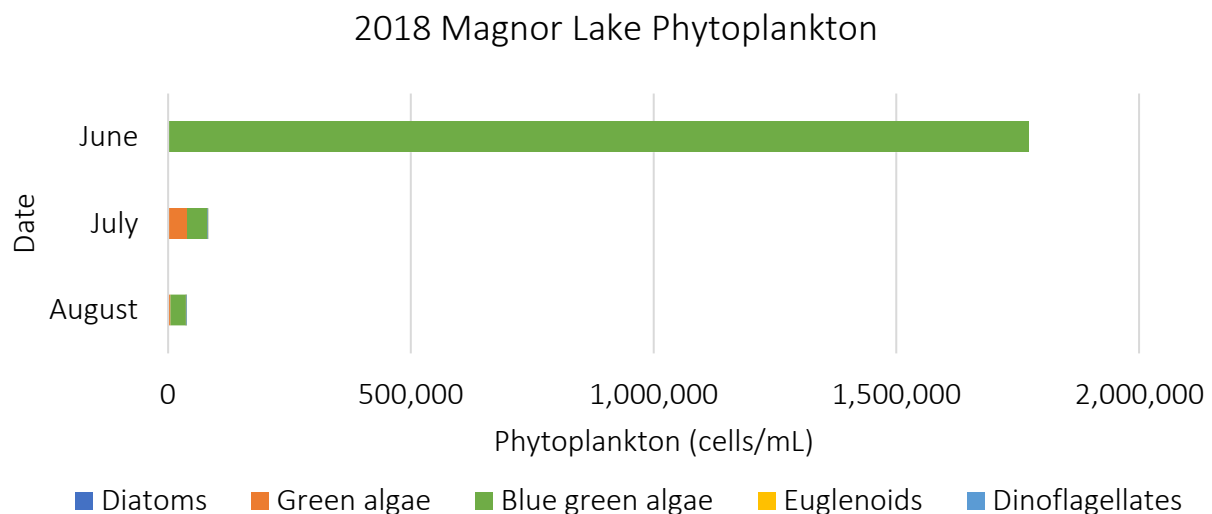
Algae were identified to the lowest taxonomic level, and a relative concentration and cell count was made to describe the algae community throughout the growing season. This

method of sampling also allows for the identification of any species of concern which might be present.

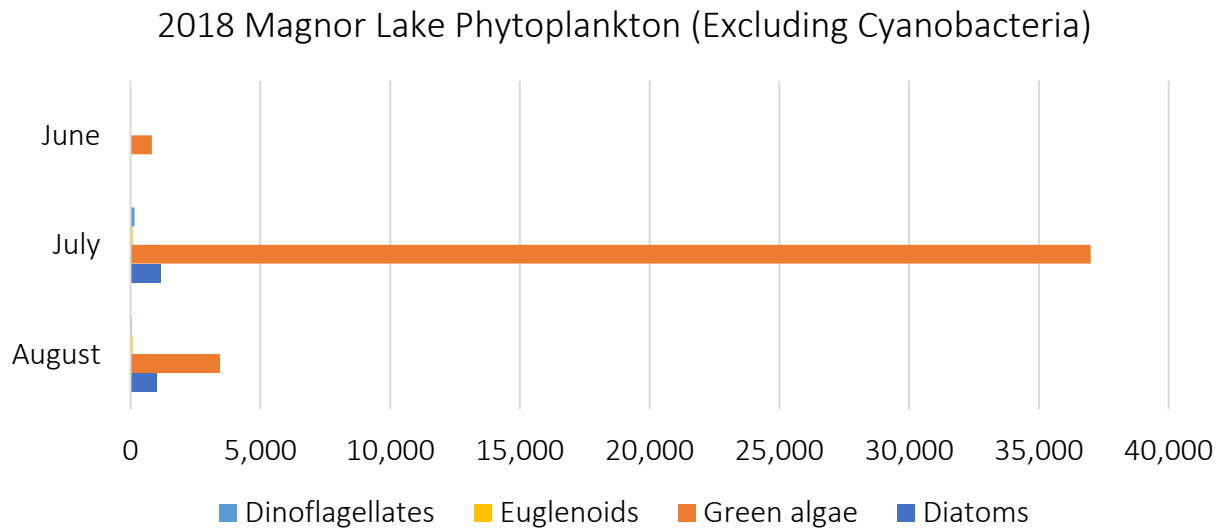
Five algal divisions were found in Magnor Lake.

Algal Divisions	Common Name	Characteristics
Bacillariophyta	Diatoms	Sensitive to chloride, pH, color, and total phosphorus in water. As total phosphorus increases, diatoms decrease. Generally larger in size. Tend to be highly present in spring and late fall.
Chlorophyta	Green algae	Provide high nutritional value to consumers. Can be filamentous and intermingle with macrophytes.
Cyanophyta	Blue green algae	Prevail in nutrient-rich standing waters. Blooms can be toxic to zooplankton, fish, livestock, and humans. Can be unicellular, colonial, planktonic, or filamentous. Can live on almost any substrate. More prevalent in late to mid-summer.
Euglenophyta	Euglenoids	Commonly found in freshwater that is rich in organic materials. Most are unicellular.
Pyrrhophyta	Dinoflagellates	Have starch food reserves and serve as food for grazers.

Blue-green algae (cyanophyta) were the most abundance division of algae in Magnor Lake in 2018.



Of the other divisions of algae present in Magnor Lake, the green algae (chlorophyta) and diatoms (bacillariophyta) formed the largest components of the algal community.



Magnor Lake reached its peak algal cell density in June and declined through the months of July and August. In June the lake was dominated by *Aphanizomenon* and to a lesser degree *Anabaena*. These blue-green algae are both able to fix nitrogen which suggests that the lake was nitrogen limited in the early part of the summer. *Aphanizomenon* were not present in July and August. There was a mid-summer bloom of green algae which was dominated by the planktonic algae *Dictyosphaeria* and *Scenedesmus*.

Blue Green Algae Toxin Risk

Blue green algae, or cyanobacteria, have been around for billions of years and typically bloom during the summer months. However, blue-green algae blooms become more frequent as a result of increased nutrient concentrations.

In addition to the negative aesthetics posed by algae, blue green algae are of specific concern because of their ability to produce toxins that when ingested or inhaled can cause short and long term health effects. Toxin producing taxa such as *Aphanizomenon*, *Microcystis*, and *Anabaena* were present during the 2018 sampling season. Toxin data was not collected as part of this study.

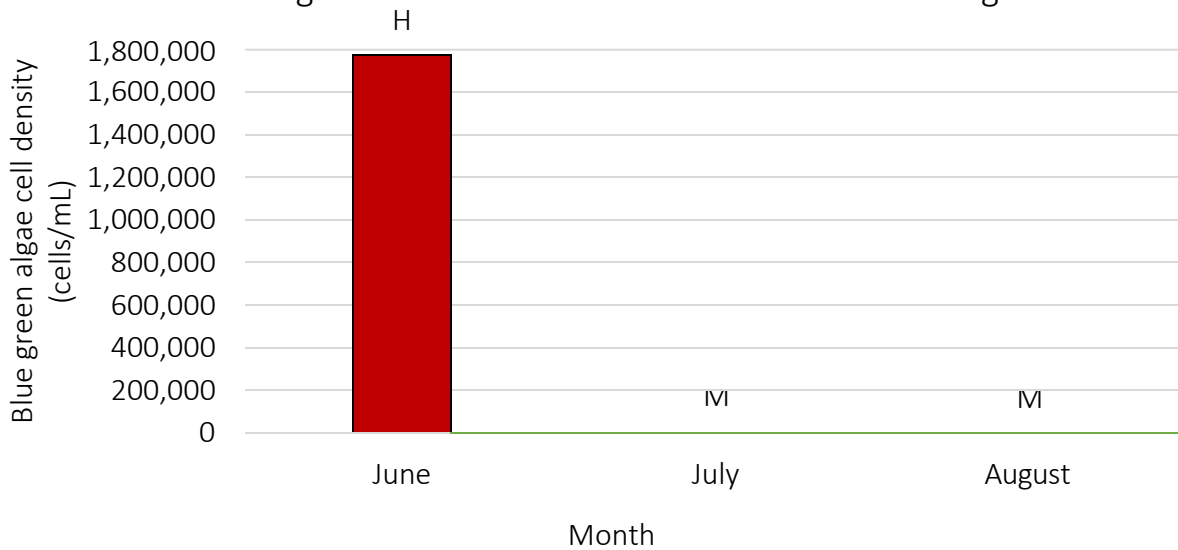
It is not known which environmental conditions cause the production of cyanotoxins, but scientists have found that when blue green algae is present at concentrations over 100,000 cells/mL toxin production is more likely to occur.

Federal guidelines for blue green algae cell densities and chlorophyll a concentrations do not exist. The Wisconsin Harmful Algal Bloom (HAB) Surveillance Program uses guidelines of the World Health Organization to determine risks from blue green algae.

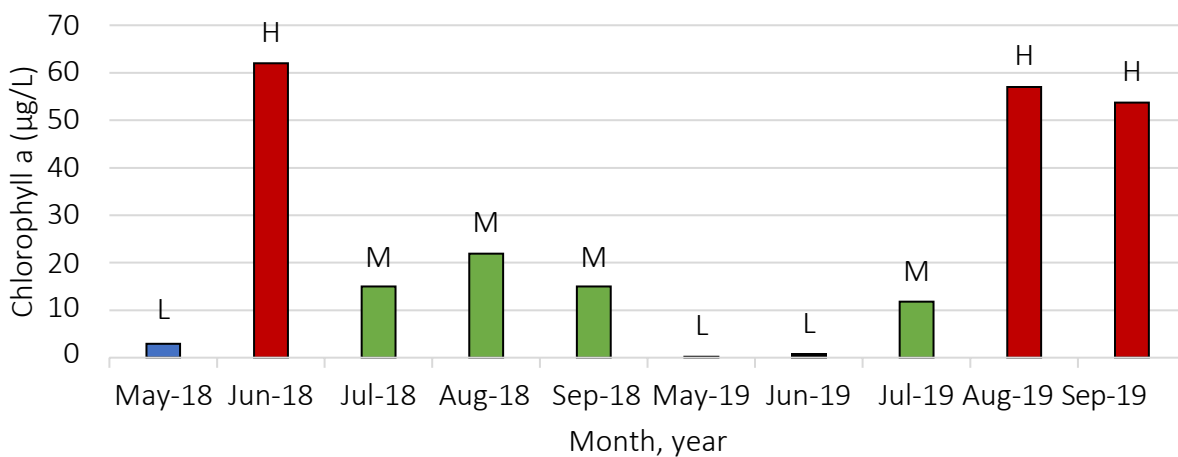
Blue green algae cell density (cells/mL)	Chlorophyll a ($\mu\text{g/L}$)	Risk
Less than 20,000	Less than 10	Low
20,000 to 100,000	10 to 50	Moderate
Greater than 100,000	Greater than 50	High

Based on chlorophyll a and blue green algae cell density, the risk of toxin production was low in May, high in June, and moderate in July, August, and September of 2018. In 2019, the risk of toxin production based on chlorophyll a was low in May and June, moderate in July, and high in August and September. Risk to toxin production was low on 30% of the sample dates, moderate on 40% of the dates, and high on 30% of the sampling dates.

2018 Magnor Lake Toxin Risk Based on Blue Green Algae



2018-2019 Magnor Lake Toxin Risk Based on Chlorophyll a

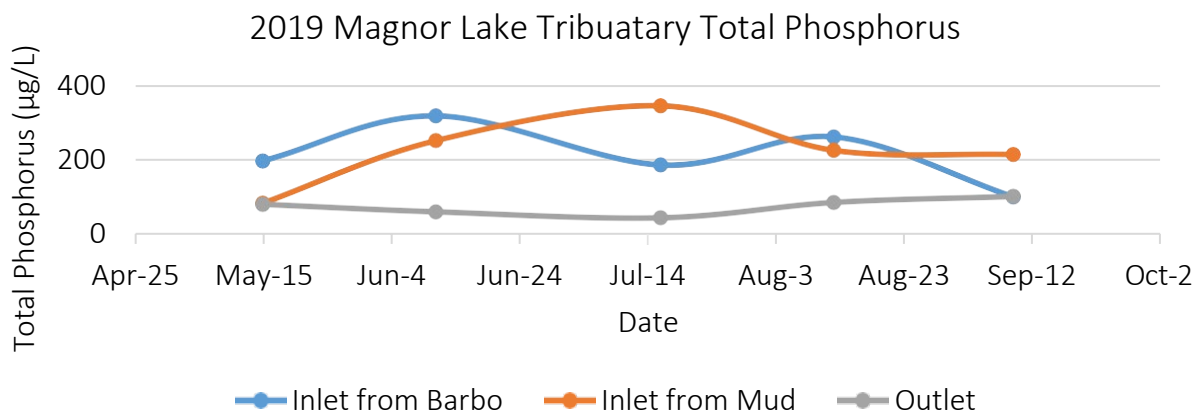
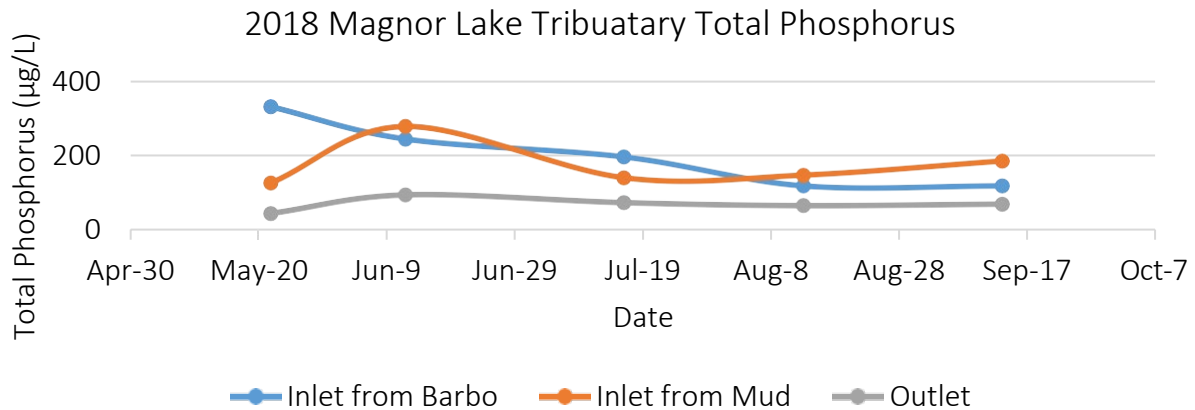


Tributary Monitoring

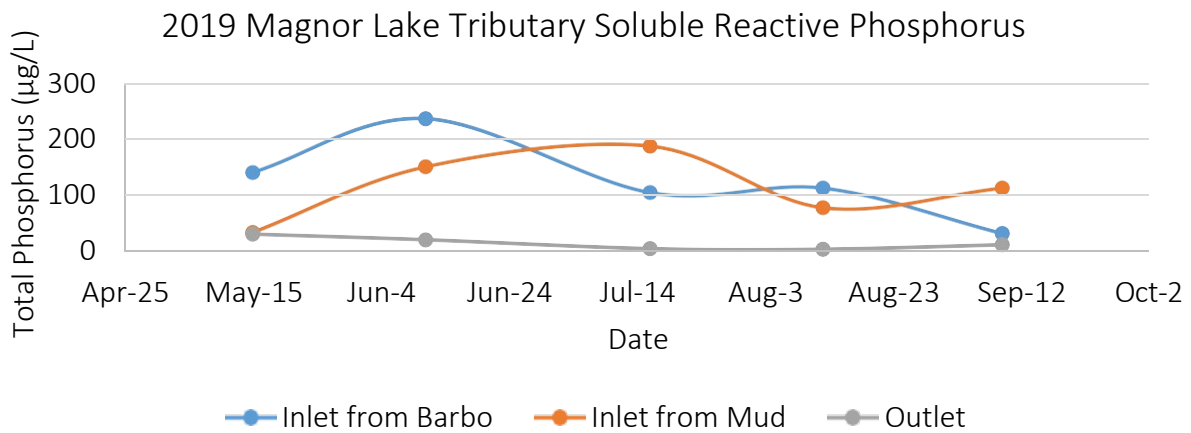
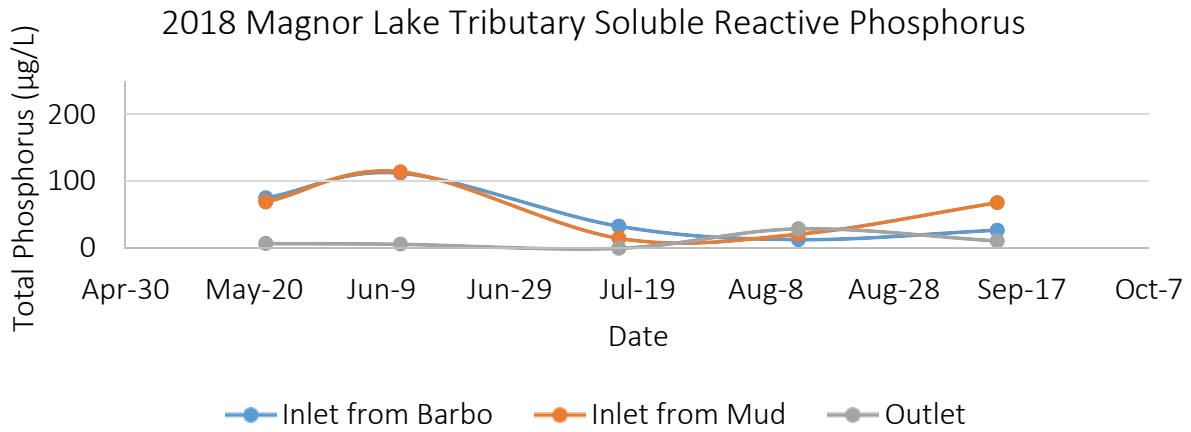
The Polk County Land and Water Resources Department collected data on the tributaries of Magnor Lake.

Flow data was collected bi-weekly at each tributary (Magnor Outlet, Inlet from Mud Lake, and Inlet from Barbo) with a Marsh McBirney Flo-Mate™ velocity flowmeter. At each foot interval across each of the tributaries depth (feet) and velocity (m/s) were measured. Grab samples were collected once a month on each tributary. Samples were analyzed at the Water and Environmental Analysis Lab for total phosphorus, soluble reactive phosphorus, and total suspended solids.

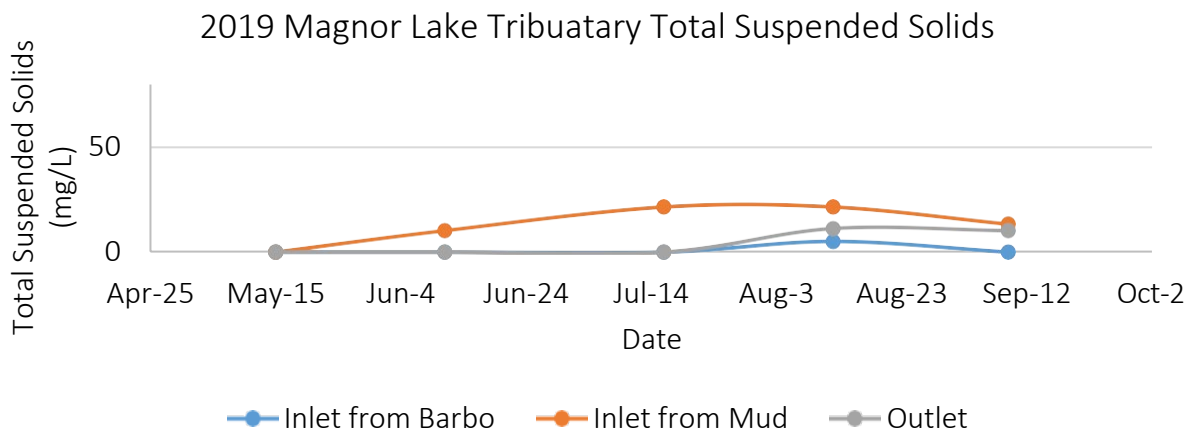
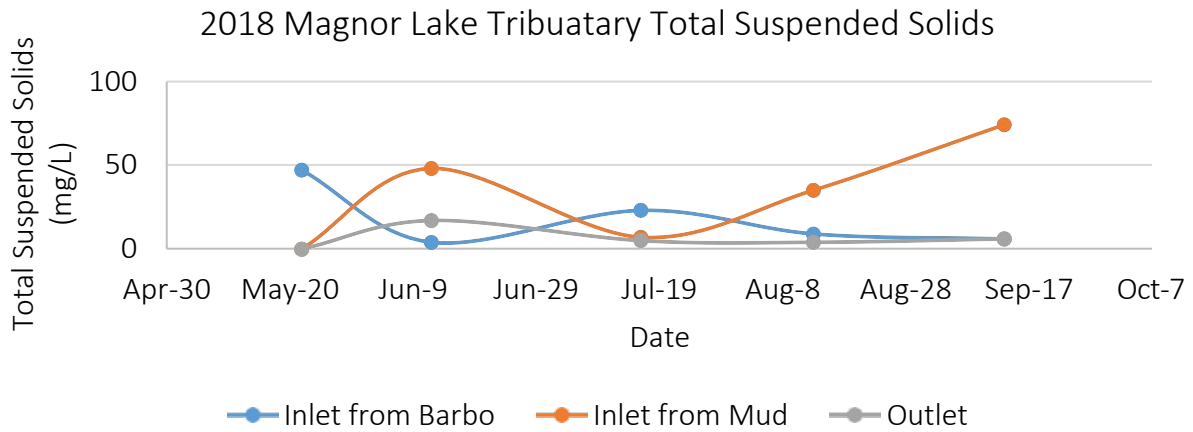
In 2018, growing season average total phosphorus was 201 µg/L in the inlet from Barbo Lake, 175 µg/L in the inlet from Mud Lake, and 69 µg/L in the outlet. In 2019 growing season average total phosphorus was 212 µg/L in the inlet from Barbo Lake, 224 µg/L in the inlet from Mud Lake, and 75 µg/L in the outlet. In 2018, tributary total phosphorus concentrations were highest in May (Barbo) and June (Mud); whereas, in 2019 concentrations were highest in June (Barbo) and July (Mud).



In 2018, growing season average soluble reactive phosphorus was 52 $\mu\text{g/L}$ in the inlet from Barbo Lake, 57 $\mu\text{g/L}$ in the inlet from Mud Lake, and 13 $\mu\text{g/L}$ in the outlet. In 2019, growing season average soluble reactive phosphorus was 125 $\mu\text{g/L}$ in the inlet from Barbo Lake, 112 $\mu\text{g/L}$ in the inlet from Mud Lake, and 14 $\mu\text{g/L}$ in the outlet. In 2018, tributary soluble reactive phosphorus concentrations were highest in June (Barbo and Mud) and in 2019 concentrations were highest in June (Barbo) and July (Mud).



In 2018, growing season average total suspended solids were 18 mg/L in the inlet from Barbo Lake, 41 mg/L in the inlet from Mud Lake, and 8 mg/L in the outlet. In 2019, growing season average total suspended solids were 5 mg/L in the inlet from Barbo Lake, 16 mg/L in the inlet from Mud Lake, and 11 mg/L in the outlet. In 2018, tributary total suspended solids concentrations were highest in September (Mud) and May (Barbo); whereas, in 2019 concentrations were highest in July (Mud) and August (Barbo).

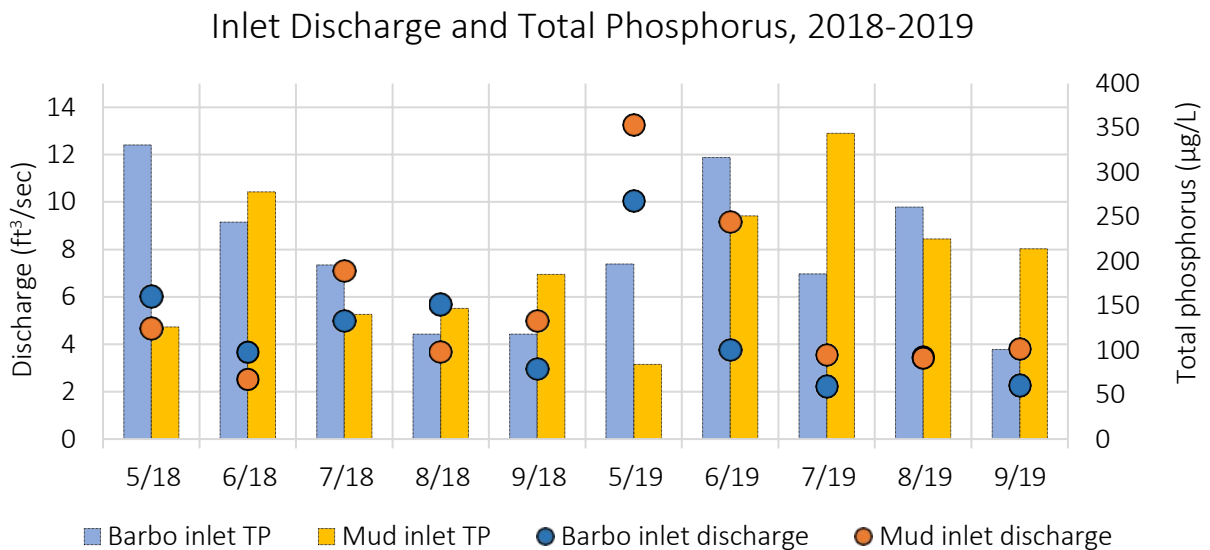


Tributary Annual Phosphorus Load

The phosphorus data collected is specific to date and location and can be used to predict how much phosphorus is entering and leaving Magnor Lake through tributaries. At each of the two inlets, an average discharge was calculated and an average total phosphorus concentration was determined.

The analysis of this data allows for areas of phosphorus loading to be identified. Once areas of phosphorus loading are identified, the land use and geology of these areas can be investigated for their total phosphorus contribution and best management recommendations can be made. The discharge and total phosphorus concentrations for the two inlets to Magnor Lake are relatively similar. Both inlets are well above the state standard for streams, set at 75 µg/L.

Site	Year	Average Total Phosphorus (µg/L)	Average Discharge (ft ³ /sec)
Inlet from Barbo	2018	201	4.67
Inlet from Barbo	2019	212	4.36
Inlet from Mud	2018	175	4.59
Inlet from Mud	2019	224	6.64



Spring and Fall Point Intercept Plant Surveys




Full point intercept aquatic macrophyte surveys were conducted on Magnor Lake on August 29th, 2019 (fall survey) and June 2nd and 3rd, 2020 (spring survey) using the Jessen and Lound Rake Method.

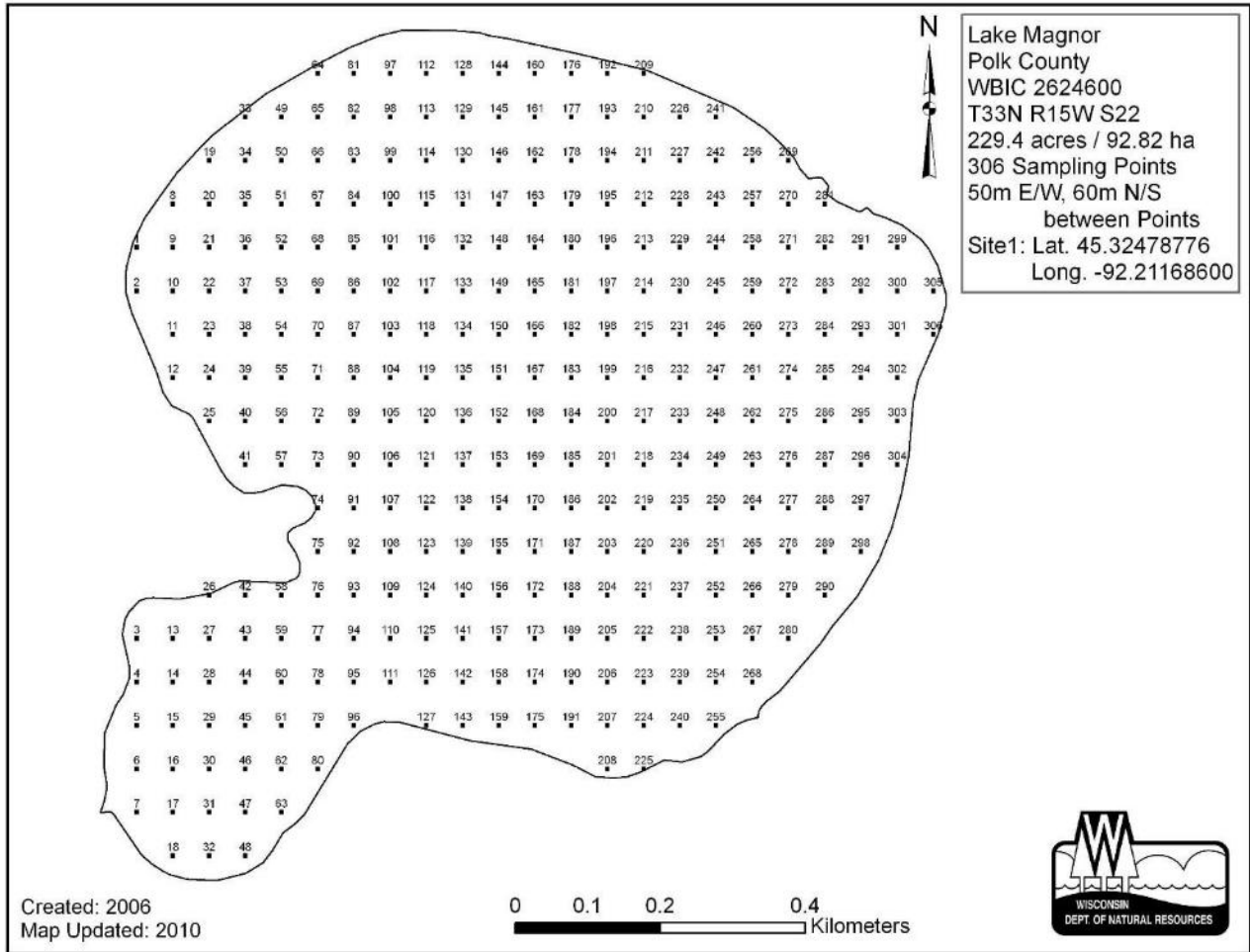
Three hundred and six sampling points were established in Magnor Lake by the Wisconsin Department of Natural Resources using a standard formula that takes into account the shoreline shape and length, water clarity, depth, and total lake acres. Sampling points were generated in ArcGIS and downloaded to a GPS unit.

A GPS unit was used to locate each sampling point in the field. At each sampling point a depth finder was used to determine depth and a pole or rope rake was used to sample the plant community of an approximately one meter section of the benthos.

All plants on the rake, as well as any that were dislodged by the rake, were identified to species and assigned a rake fullness value of 1 to 3 to estimate abundance. Visual sightings of plants within six feet of the sample point were also recorded. The lake bottom substrate was assigned at each sampling point where the bottom was visible or it could be reliably determined using the rake.

Data was collected at each sampling point, with the exception of those that were too shallow or terrestrial. Although three hundred six sampling points were established in Magnor Lake, it was only possible to sample three hundred and five points during the fall survey. All sites were sampled in the spring survey.

<u>Rating</u>	<u>Coverage</u>	<u>Description</u>
1		A few plants on rake head
2		Rake head is about 1/2 full Can easily see top of rake head
3		Overflowing Cannot see top of rake head



Data collected was entered into a standard spreadsheet for analysis. The following statistics were generated from the spreadsheet:

- Maximum depth of plants
- Sample points with vegetation
- Species richness
- Number of species per site
- Number of sites where each species was found
- Average rake fullness
- Frequency of occurrence
- Relative frequency
- Simpson's Diversity Index
- Floristic Quality Index

The following are explanations of the various analyses with data from Magnor Lake.

Maximum depth of plants

All lakes have a maximum depth at which plants are present. Typically, clearer lakes have a greater depth at which plants can exist, since sunlight can penetrate to greater depths. In Magnor Lake, the maximum depth of plants was 11 feet in the spring survey and 8.5 feet in the fall survey.

Sample points with vegetation

This value shows the number of sites where plants were collected and gives an approximation of the plant coverage of a lake. If 10% of all sample points had vegetation, then it is implied that approximately 10% of the lake is covered with plants.

Fifty-nine sample sites had plants present in June, indicating that plant growth covered approximately 19% of the entire lake. Seventy-seven sample sites had plants present in August, indicating that plant growth covered approximately 25% of the entire lake.

In June, one hundred and eighty-five sample sites were shallower than the maximum depth of plants. Plant growth covered approximately 32% of the area of the lake with depths 11 feet or less. In August, one hundred and forty-nine sample sites were shallower than the maximum depth of plants. Plant growth covered approximately 52% of the area of the lake with depths of 8.5 feet or less.

Species richness

Species richness is a measure of the number of different species found in a lake. Species richness can be computed based on plants sampled or based on plants sampled/visually located during the survey.

Sixteen species were found in Magnor Lake in the spring survey and eighteen were found in the fall survey. Of these species only twelve were on the rake head during the spring survey and only seventeen were on the rake head during the fall survey.

Number of species per site

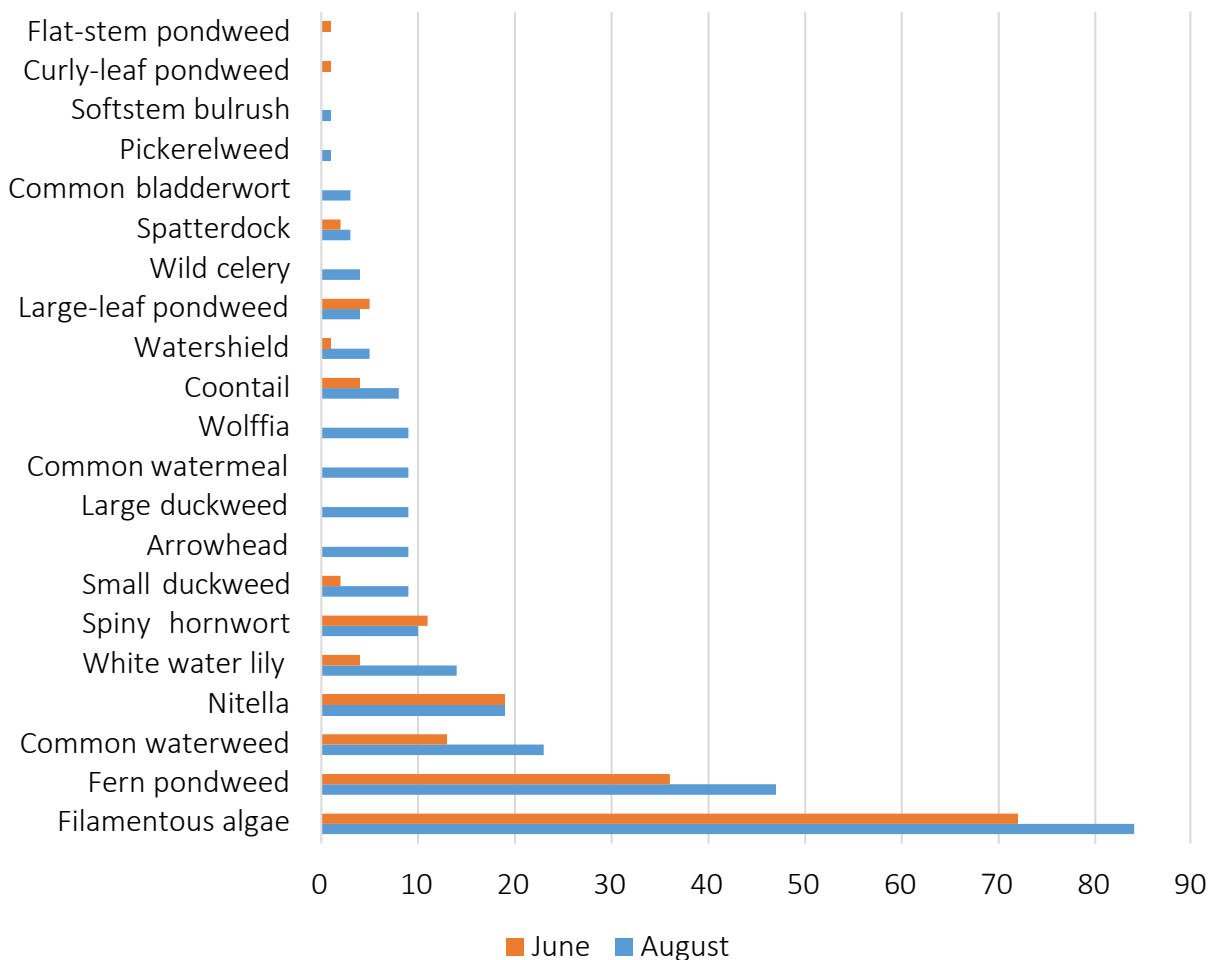
In June, an average of 0.54 species were present at sites 11 feet in depth or less and an average of 1.68 species were present at the fifty-nine sample sites where plants were found. In August, an average of 1.19 species were present at sites 8.5 feet in depth or less and an average of 2.31 species were present at the seventy-seven sample sites where plants were found.

Number of sites where each species was found

Fern pondweed, the most common species in Magnor Lake, was found at 36 sites in June and 47 sites in August. Common waterweed, nitella, white water lily, and spiny hornwort were the next most common species, being found at between 10 and 20 sites.

Filamentous algae was found at 72 sites in June and 84 sites in August. Curly-leaf pondweed, the only invasive species found in the survey, was found at one site during the June survey.

Number of sites where each species was found



Average rake fullness

The average rake fullness value was greatest for flat-stem pondweed in June (3). However, this species was found at only one site. Species with average rake fullness values greater than 1 include: watershield (August), white water lily, fern pondweed, spatterdock (August), common waterweed, nitella, arrowhead (August), filamentous algae (August), and spiny hornwort (June).

Species	June Average Rake Fullness	August Average Rake Fullness
Flat-stem pondweed	3.0	
Watershield	1.0	1.6
White water lily	1.5	1.6
Fern pondweed	1.3	1.3
Spatterdock	1.0	1.3
Common waterweed	1.1	1.2
Nitella	1.2	1.1
Arrowhead		1.1
Filamentous algae	1.0	1.1
Coontail	1.0	1.0
Curly-leaf pondweed	1.0	
Spiny hornwort	1.1	1.0
Small duckweed	1.0	1.0
Pickerelweed		1.0
Large-leaf pondweed	1.0	1.0
Softstem bulrush		1.0
Large duckweed		1.0
Common bladderwort		1.0
Wild celery		1.0
Wolffia, sp.		1.0

Frequency of occurrence

Two values are computed for frequency of occurrence: the frequency of occurrence within vegetated areas and the frequency of occurrence at sites shallower than the maximum depth of plants. In both instances, the greater the value, the more frequently the plant would be encountered in the lake.

Frequency of occurrence within vegetated areas is defined as the number of times a species was sampled in a vegetated area divided by the total number of vegetated sites. This value shows how often the plant would be encountered everywhere vegetation was found in the lake.

Frequency of occurrence at sites shallower than the maximum depth of plants is defined as the number of times a species was sampled divided by the total number of sites shallower than the maximum depth of plants. This value shows how often the plant would be encountered within the depths plants can potentially grow (11 feet or less in June and 8.5 feet or less in August).

In June, the most frequent species found was fern pondweed, occurring at 61% of the sites with vegetation and 19% of the sites where plants could potentially grow. Other frequent species were nitella (32% and 10%), common waterweed (22% and 7%), and

spiny hornwort (19% and 6%) (sites with vegetation and sites where plants could potentially grow, respectively).

In August, the most frequent species found was fern pondweed, occurring at 61% of the sites with vegetation and 32% of the sites where plants could potentially grow. Other frequent species were common waterweed (30% and 15%) and nitella (25% and 13%) (sites with vegetation and sites where plants could potentially grow, respectively).

Relative frequency

Relative frequency is the frequency of a particular plant species relative to other plant species. This value is independent of the number of points sampled. Relative frequency can be used to show which plants are the dominant species in a lake. The higher the value a species has for relative frequency, the more common the species is compared to others. The relative frequency of all plants will always add up to 100%. If species A has a relative frequency of 30%, this species occurred 30% of the time compared to all the species sampled or makes up 30% of all species sampled.

Relative frequency example: Suppose 10 points were sampled in a very small lake with the following results: plant A present at 3 sites, plant B present at 5 sites, plant C present at 2 sites, and plant D present at 6 sites

Plant D is the most frequently sampled at all sites, with 60% (6/10) of the sites having plant D. However, the relative frequency allows us to see what the frequency of plant D is compared to other plants, without taking into account the number of sites. This value is calculated by dividing the number of times a plant is sampled by the total of all plants sampled. All the individual frequencies added together (3+5+2+6) gives a sum of 16.

Relative frequency can be calculated by dividing the individual frequency by the sum of all frequencies:

Plant A = $3/16 = 0.1875$ or 18.75%

Plant B = $5/16 = 0.3125$ or 31.25%

Plant C = $2/16 = 0.1250$ or 12.50%

Plant D = $6/16 = 0.3750$ or 37.50%

Now the plants can be compared to one another. Plant D is still the most frequent, but the relative frequency tells us that of all plants sampled 37.50% of them are Plant D. This is much lower than the frequency of occurrence (60%) because although Plant D was sampled at 6 of 10 sites, many other plants were also sampled.

The most dominant plant species in Magnor Lake as indicated by relative frequency were fern pondweed (36% and 26%), common waterweed (13% and 13%), nitella (19% and 11%), and spiny hornwort (11% and 6%) (June and August values, respectively).

Species	June FOC vegetated areas (%)	Aug FOC vegetated areas (%)	June FOC max depth (%)	Aug FOC max depth (%)	June RF (%)	Aug RF (%)
Filamentous algae	122	109	39	56		
Fern pondweed	61	61	19	32	36	26
Common waterweed	22	30	7	15	13	13
Nitella	32	25	10	13	19	11
Spiny hornwort	19	13	6	7	11	6
White water lily	7	18	2	9	4	8
Coontail	7	10	2	5	4	4
Large duckweed		12		6		5
Arrowhead		12		6		5
Small duckweed	3	12	1	6	2	5
Common watermeal		12		6		5
Curly-leaf pondweed	2		1		1	
Watershield	2	6	1	3	1	3
Large-leaf pondweed	8	5	3	3	5	2
Wild celery		5		3		2
Spatterdock	3	4	1	2	2	2
Common bladderwort		4		2		2
Pickerelweed		1		1		1
Softstem bulrush		1		1		1
Flat-stem pondweed	2		1		1	

Simpson's Diversity Index

Simpson's Diversity Index¹⁰ is used to determine how diverse a plant community in a lake is by measuring the probability that two individuals randomly selected from a sample will belong to the same species. The Simpson's Diversity Index ranges from zero to one, with greater values representing more diverse plant communities.

In theory, the value for Simpson's Diversity Index is the chance that two species that are sampled will be different. An Index of one means that the two plants sampled will *always*

¹⁰ Simpson's Diversity Index can be calculated by using the equation:

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

Where: D = Simpson's Diversity Index;

n= the total number of organisms of a particular species; and

N=the total number of organisms of all species

be different (very diverse) and an Index of zero means that the two plants sampled will *never* be different. The Simpson's Diversity Index on Magnor Lake was 0.79 in June and 0.88 in August.

Floristic Quality Index

The Floristic Quality Index (FQI)¹¹ is designed to evaluate the closeness of the flora in an area to that of an undisturbed condition. The Floristic Quality Index takes into account the species of aquatic plants found and their tolerance for changing water quality and habitat modification.

Each plant species has an assigned coefficient of conservatism which ranges from 1 to 10. A high value indicates a plant is intolerant of change and a low value indicates a plant is tolerant of change. Plants with higher values are more likely to respond adversely to water quality and habitat changes. Invasive species have a conservatism value of 0. A higher FQI indicates a healthier plant community.

Summary of North Central Hardwood Forest values for Floristic Quality Index:

Mean species richness = 14

Mean average conservatism = 5.6

Mean Floristic Quality = 20.9

Summary of Magnor Lake values for Floristic Quality Index:

Mean species richness = 11 and 18

Mean average conservatism = 6.0 and 6.1

Mean Floristic Quality = 19.9 and 25.9

The FQI for Magnor Lake was less than the mean for the ecoregion in spring, but greater than the mean for the ecoregion in the fall.



¹¹ The Floristic Quality Index can be calculated using the equation: $I = \frac{\bar{C}}{\sqrt{N}}$

Where: I is the Floristic Quality Index;

\bar{C} is the average coefficient of conservatism (<http://www.botany.wisc.edu/wisflora/FloristicR.asp>); and \sqrt{N} is the square root of the number of species

Land Use and Water Quality

The health of water resources depends largely on the decisions that landowners make on their properties. When waterfront lots are developed, a shift from native plants and trees to impervious surfaces and lawn often occurs. Impervious surfaces are hard, man-made surfaces such as rooftops, paved driveways, and concrete patios that make it impossible for rainwater to infiltrate into the ground.

By making it impossible for rainwater to infiltrate into the soil, impervious surfaces increase the volume of rainwater that washes over the soil surface and runs off directly into lakes and streams.

Rainwater runoff can carry pollutants such as sediment, lawn fertilizers, and car oils directly into a lake. Native vegetation can slow the speed of rainwater, giving it time to soak into the soil where it is filtered by soil microbes.

In extreme precipitation events, erosion and gullies can result. The signs of erosion are unattractive and can cause decreases in property values. Sediment can also have negative impacts on aquatic life. Fish eggs will die when covered with sediment and sediment influxes to a lake can decrease water clarity making it difficult for predator fish species to locate food.

Increases in impervious surfaces and lawns cause a loss of habitat for birds and other wildlife. Over ninety percent of all lake life is born, raised, and fed in the area where land and water meet. Overdeveloped shorelines remove critical habitat which species such as loons, frogs, songbirds, ducks, otters, and mink depend on. Impervious surfaces and lawns can be thought of as biological deserts which lack food and shelter for birds and wildlife. Nuisance species such as Canada geese favor lawns over taller native grasses and flowers. Lawns provide geese with a ready food source (grass) and a sense of security from predators (open views).

Additionally, fish species depend on the area where land and water meet for spawning. The removal of coarse woody habitat, or trees and branches that fall into a lake, cause decreases in habitat for fish and aquatic organisms.





Common lawn species, such as Kentucky bluegrass, are often dependent on chemical fertilizers and require mowing. Excess chemical fertilizers are washed directly into the adjacent water during precipitation events. The phosphorus and other nutrients in fertilizers, which produce lush vegetative growth on land, are the same nutrients which fuel algae blooms and decrease water clarity in a lake. Additionally, since common lawn species have very shallow root systems, when lawns are located on steep slopes, soil capacity is reduced and the impacts of erosion can be intensified.

Avoiding establishing lawns can provide direct positive impacts on lake water quality. The creation of a buffer zone of native grasses, wildflowers, shrubs, and trees where the land meets the water can provide numerous benefits for water quality and restore valuable bird and wildlife habitat.

Wisconsin Administrative Code Chapter NR 115 requires a 35 foot deep shoreline buffer running parallel to the ordinary high water mark¹² on navigable lakes, rivers, and streams. No more than 30 feet per 100 feet of shoreline may be clear-cut for the establishment of a viewing corridor. These rules are in place largely to protect water quality and also provide benefits in terms of natural beauty, and bird and wildlife viewing opportunities.

If the area of land directly adjacent to the lake, stream, or river was mowed lawn prior to the passage of Administrative Code Chapter NR 115, it is considered a “developed” lot and a nonconforming use and can be maintained as lawn. However, if mowing ceases for one year, then the vegetative buffer zone must be allowed to reestablish and be maintained. The WDNR offers up to \$1,000 for landowners to install a 350 square foot shoreline buffer through the Healthy Lakes grant program. Larger plantings can be funded at 75% through the WDNR Lake Protection grant program

¹² The ordinary high water mark is defined as the point on the bank or shore up to which the water leaves a distinct mark (erosion, change in vegetation, etc.).

Shoreline Inventory

A shoreline inventory was completed using methodology developed by the University of Wisconsin Stevens Point Center for Watershed Science and Education. Land and Water Resources Department completed the Shoreland Vegetation Survey and Shoreland Disturbance Survey Above and Below the Ordinary High Water Mark on September 17th, 2019.

In the Shoreland Vegetation Survey, the general shoreline condition was characterized as disturbed or undisturbed, the dominant short vegetation ground condition was determined¹³, the presence or absence of each short shoreland vegetation ground condition was characterized, and it was established if tall shoreland vegetation was present or absent.

Using the Shoreland Vegetation Survey and Shoreland Disturbance Survey Above and Below the Ordinary High Water Mark, the survey established the presence of shoreland alterations¹⁴, determined presence of erosion (undercut banks/slumping and furrows/gullies), characterized the areas below the ordinary high water mark¹⁵, and documented culvert size, shape, and material.

¹³ Short shoreland vegetation ground conditions include: organic-leaf pack/needles, barren/bare dirt (erosion), new shoreland restoration, mowed vegetation, short un-mowed vegetation < 3 feet tall, and impervious surface

¹⁴ Shoreland alterations include: dock/pier, seawall, rip-rap, artificial beach, boat landing, and dam/spillway

¹⁵ The presence of the following were characterized for the area below the ordinary high water mark: cut/mowed area >30 feet wide, tilled/erosion, motor vehicle tire imprints, and woody structure

The shoreline of Magnor Lake is primarily disturbed (72%) as compared to undisturbed (28%).

Magnor Lake Shoreland Vegetation Survey



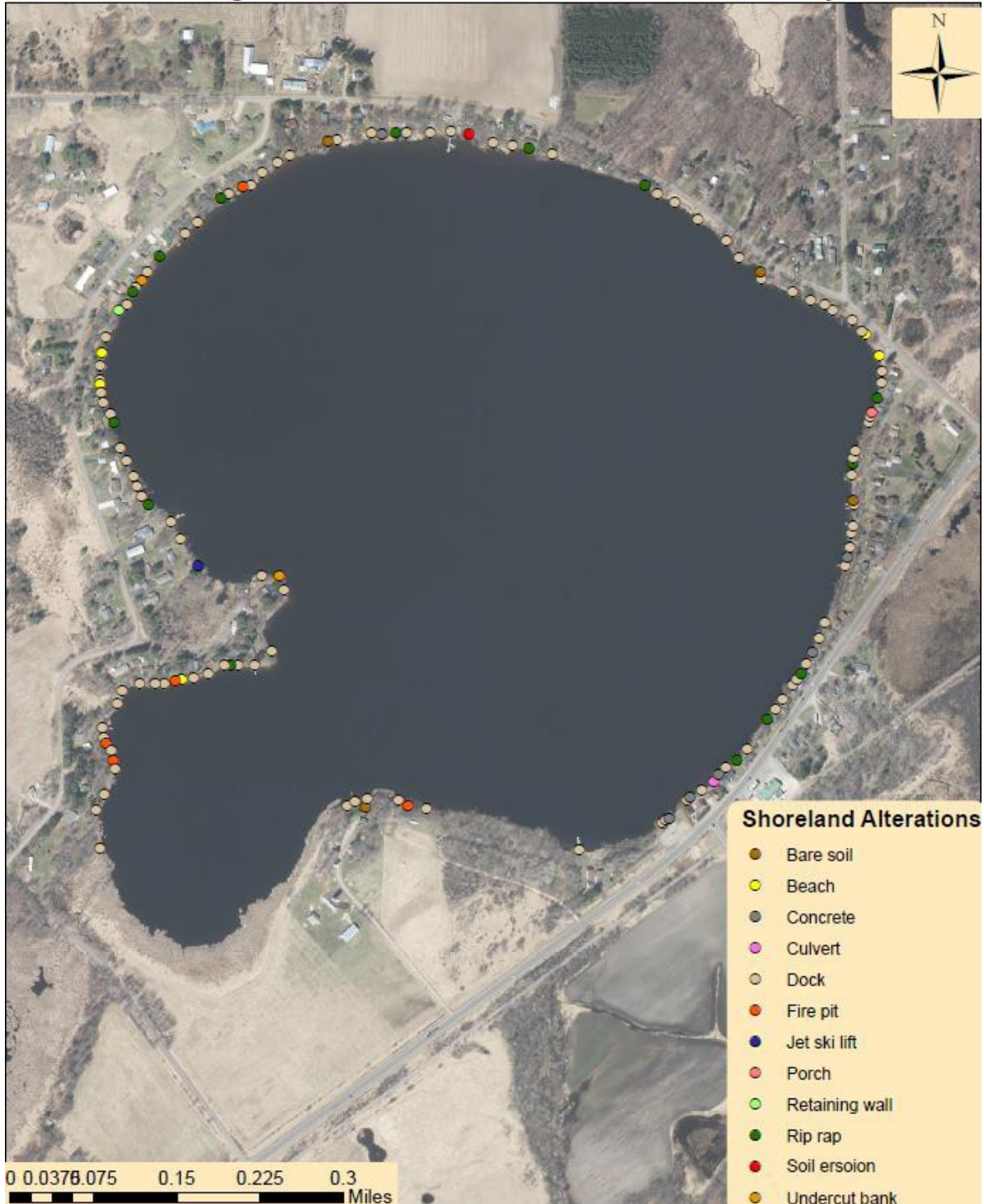
The dominant shoreland vegetation and ground cover on Magnor Lake was mowed vegetation (53%), followed by short unmowed vegetation (23%), organic-leaf pack/needles (17%), impervious surface (5%), and bare soil (1%).

Magnor Lake Shoreland Vegetation Survey



The shoreline inventory characterized disturbances around Magnor Lake. There were a total of ninety-four docks, fourteen stretches of riprap, six areas of concrete, five beaches, five fire pits, four areas of bare soil, two undercut banks, one culvert, one jet ski lift, 1 porch, 1 retaining wall, and 1 area of soil erosion along the shoreline.

Magnor Lake Shoreland Disturbance Survey



There were seven downed trees, or coarse woody structures, along the shoreline of Magnor Lake (about 2.5 trees per mile of shoreline). When trees fall into a lake, fish and aquatic organisms use them as habitat. Over time, humans have greatly reduced the number of trees along the shoreline of lakes. Undeveloped lakes have nearly 900 logs per mile of shoreline.

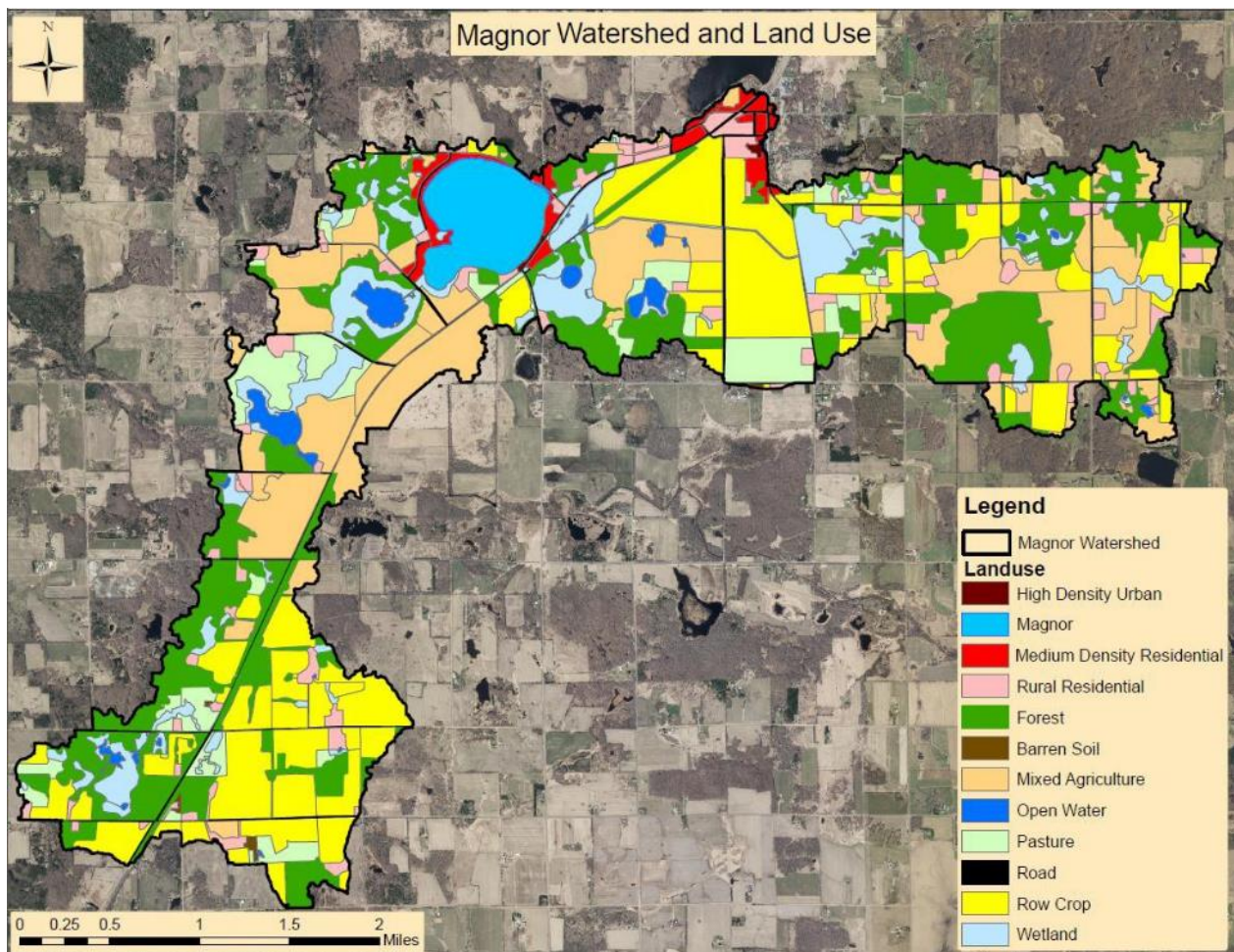
Magnor Lake Woody Structure



Land Use in the Magnor/Barbo Lake Watershed

The area of land that drains to a lake is called a watershed. The ArcGIS Spatial Analysis Toolbox and LiDAR elevation data was used to delineate the watershed for Magnor Lake. The identification of culverts underneath roads is an important aspect of watershed delineation. When delineating watersheds from elevation data, computer software perceives roads as dams which prevent the flow of water. Field verification was used to identify culvert locations within the watershed to allow for accurate watershed delineation. The Magnor Lake watershed is 5,930 acres in size.

Land use in the Magnor Lake Watershed was delineated using spring 2015 high-resolution aerial imagery. The most common land uses in the Magnor Lake watershed are forest and row crops (24% each), followed by mixed agriculture (16%), wetland (9%), pasture (7%), rural residential (5%), and mixed grasses (5%).



Watershed Modeling and Nutrient Reductions

The Wisconsin Lake Modeling Suite (WiLMS) was used to model current conditions for Magnor Lake, verify monitoring, and estimate land use nutrient loading for the watershed. Phosphorus is the key parameter in the modeling scenarios used in WiLMS because it is the limiting nutrient for algae growth in most lakes. WiLMS can be used to estimate the amount of phosphorus being contributed from the watershed (external load) and the amount of phosphorus being released from the lake sediments (internal load).

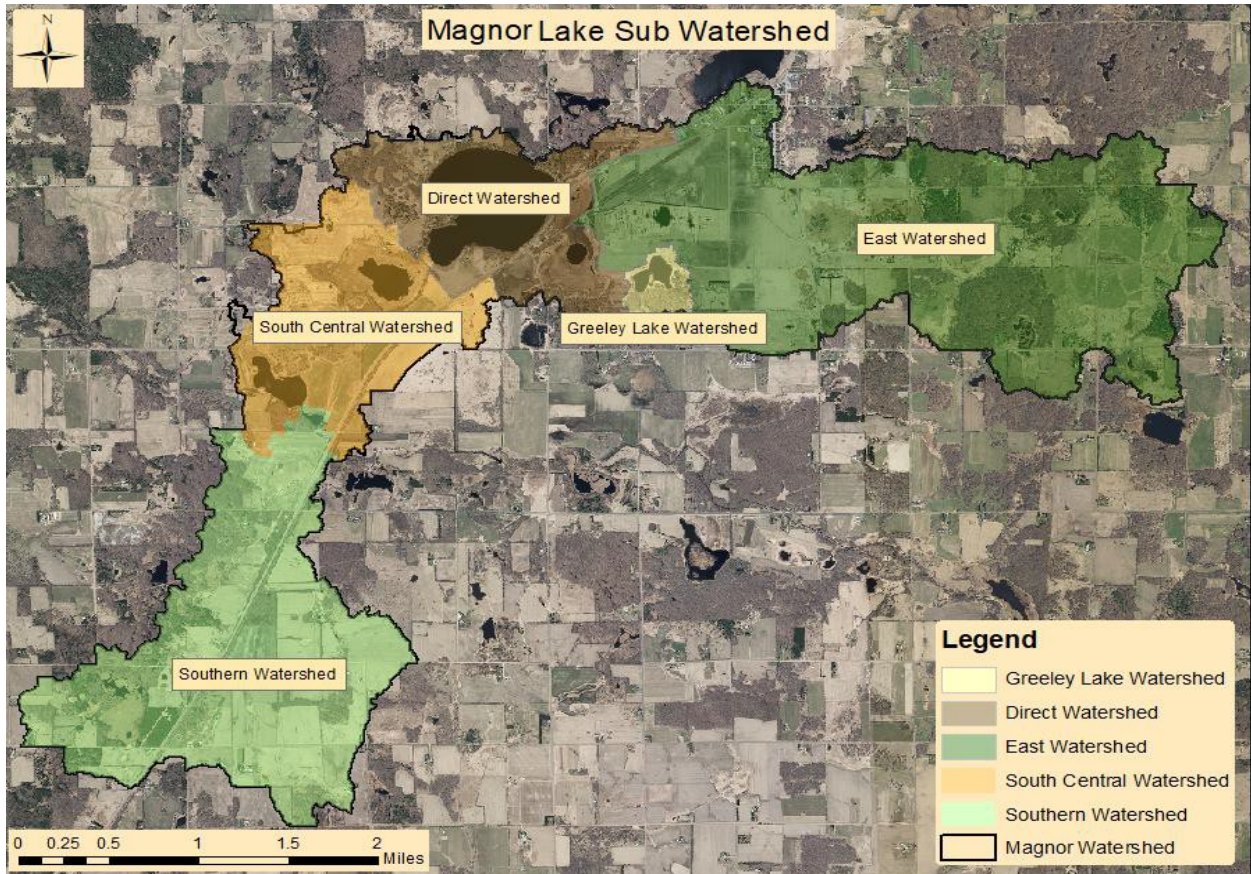
WiLMS uses average evaporation and precipitation data along with runoff coefficients for various land uses to determine the annual nonpoint source load of phosphorus to a lake. WiLMS determined the annual phosphorus load to Magnor Lake as 2,513 pounds of phosphorus per year. Overall, internal loading is predicted to be insignificant to the nutrient budget for Magnor Lake.

Land Use	Acres	Acres (%)	Phosphorus Load (lb/yr)	Phosphorus Load (%)
Row crop	1,414	24%	1,261	50%
Mixed agriculture	964	16%	688	27%
Pasture/grass	658	11%	176	7%
High density urban	6	0%	9	0%
Medium density urban/road	243	4%	108	4%
Rural residential	293	5%	26	1%
Wetlands/open water	674	11%	60	2%
Forest	1,439	24%	115	5%
Livestock	8	0%	7	0%
Lake surface	231	4%	62	3%
Total	5,930	100%	2,513	100%

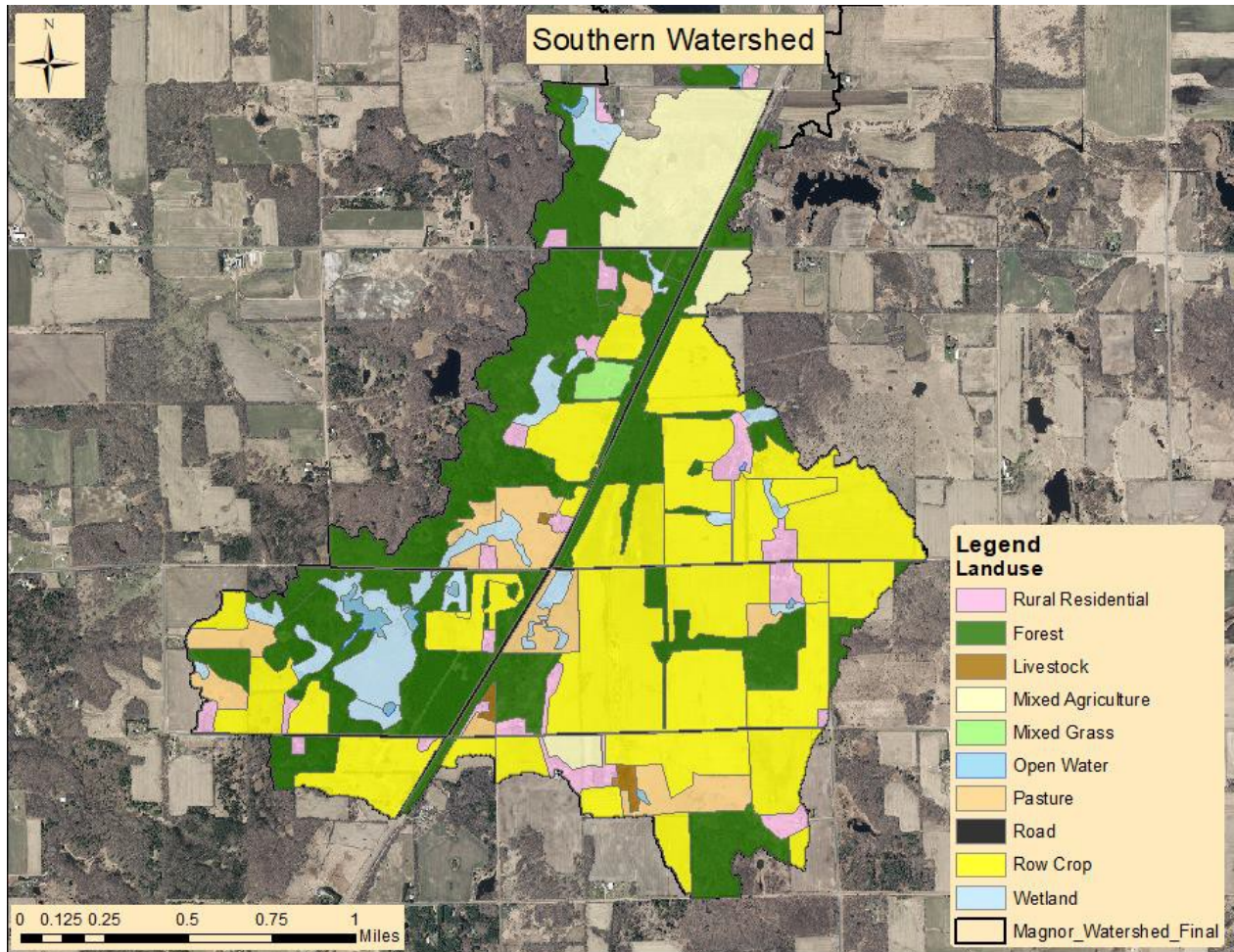
The Lake Phosphorus Models with the best fit for Magnor Lake included: Rechow 1979 General, Vollenweider 1982 Combined OECD, Canfield-Bachmann 1981 Artificial Lake, and Vollenweider 1982 Shallow Lake/Reservoir. When averaged, these models predict that to achieve the phosphorus standard for Magnor Lake (30 µg/L) the external phosphorus load to Magnor Lake would need to be reduced by 68%, or by 1,709 pounds per year. This would be a reduction from 2,513 to 794 pounds of phosphorus per year.

Subwatershed Modeling

Due to the large size of the watershed of Magnor Lake, land use and phosphorus loads for each of the sub-watersheds were calculated in order to prioritize where the District should allocate efforts and/or money when available. The Magnor Lake Watershed was divided into five subwatersheds: Southern, South Central, Direct, Greeley Lake, and East.

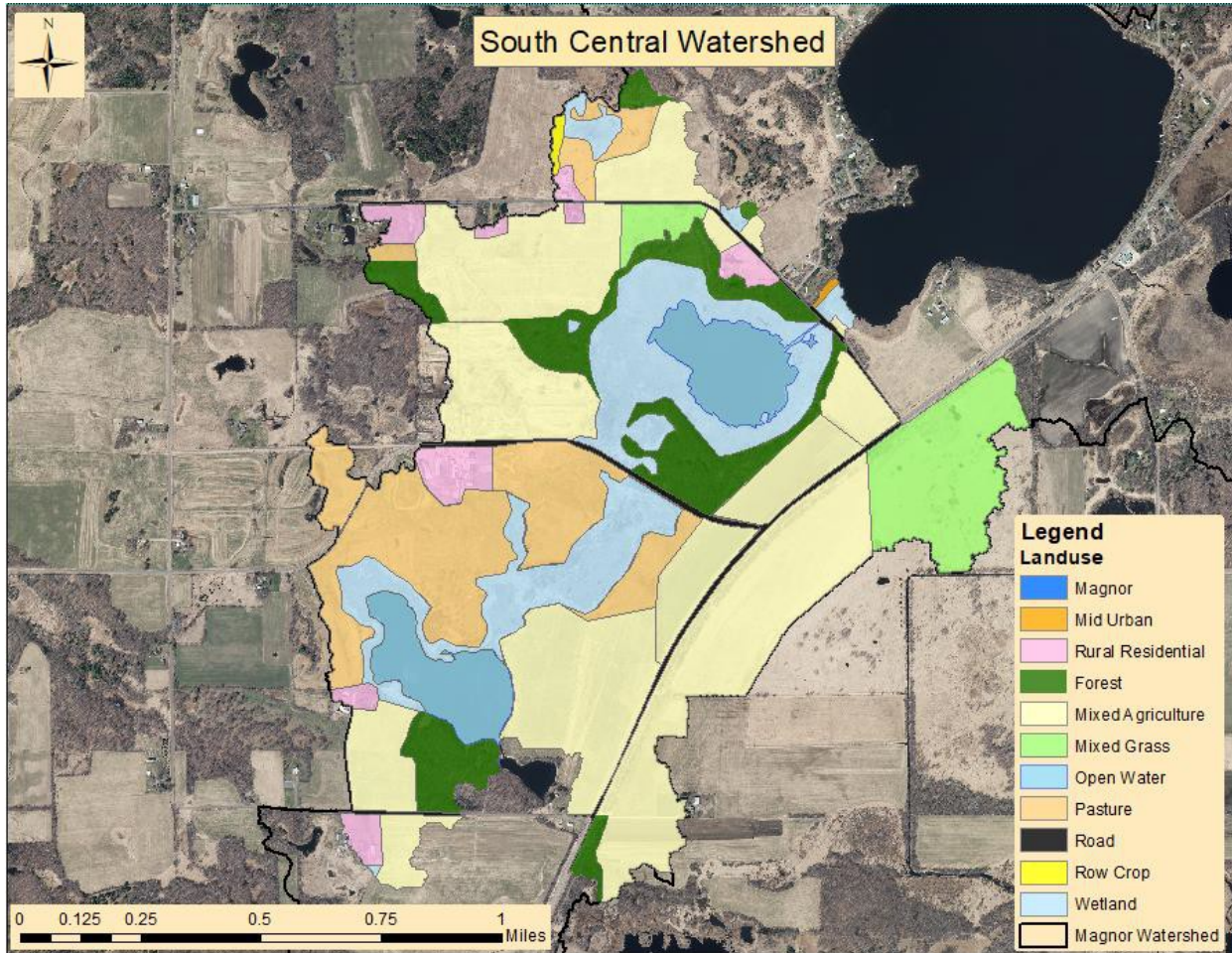


The Southern Subwatershed is primarily row crop (40%) and forest (31%). The annual phosphorus load from this subwatershed is 794 pounds per year. Row crop is responsible for 74% of the phosphorus load in this subwatershed.



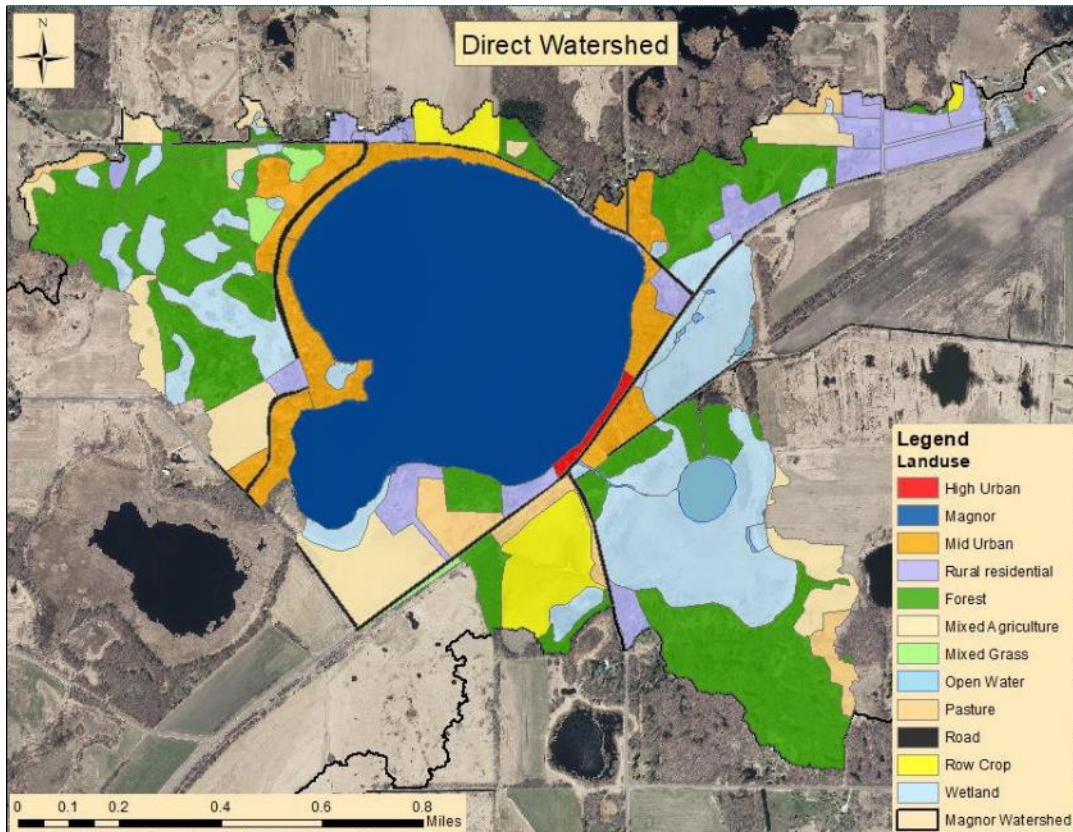
Land Use	Acres	Acres (%)	Phosphorus Load (lb/yr)	Phosphorus Load (%)
Row crop	658	40%	586	74%
Mixed agriculture	133	8%	95	12%
Pasture/mixed grass	115	7%	31	4%
Road	34	2%	15	2%
Rural residential	73	4%	7	1%
Wetland/open water	115	7%	11	1%
Forest	515	31%	42	5%
Livestock	7	0%	7	1%
Total	1650	100%	794	100%

The South Central Subwatershed includes Barbo and Paulson Lakes and is located southwest of Magnor Lake. The subwatershed is primarily mixed agriculture (41%), pasture/mixed grass (22%), and wetland/open water (22%). The annual phosphorus load from this subwatershed is 326 pounds per year. Mixed agriculture is responsible for 75% of the phosphorus load from the south central subwatershed.



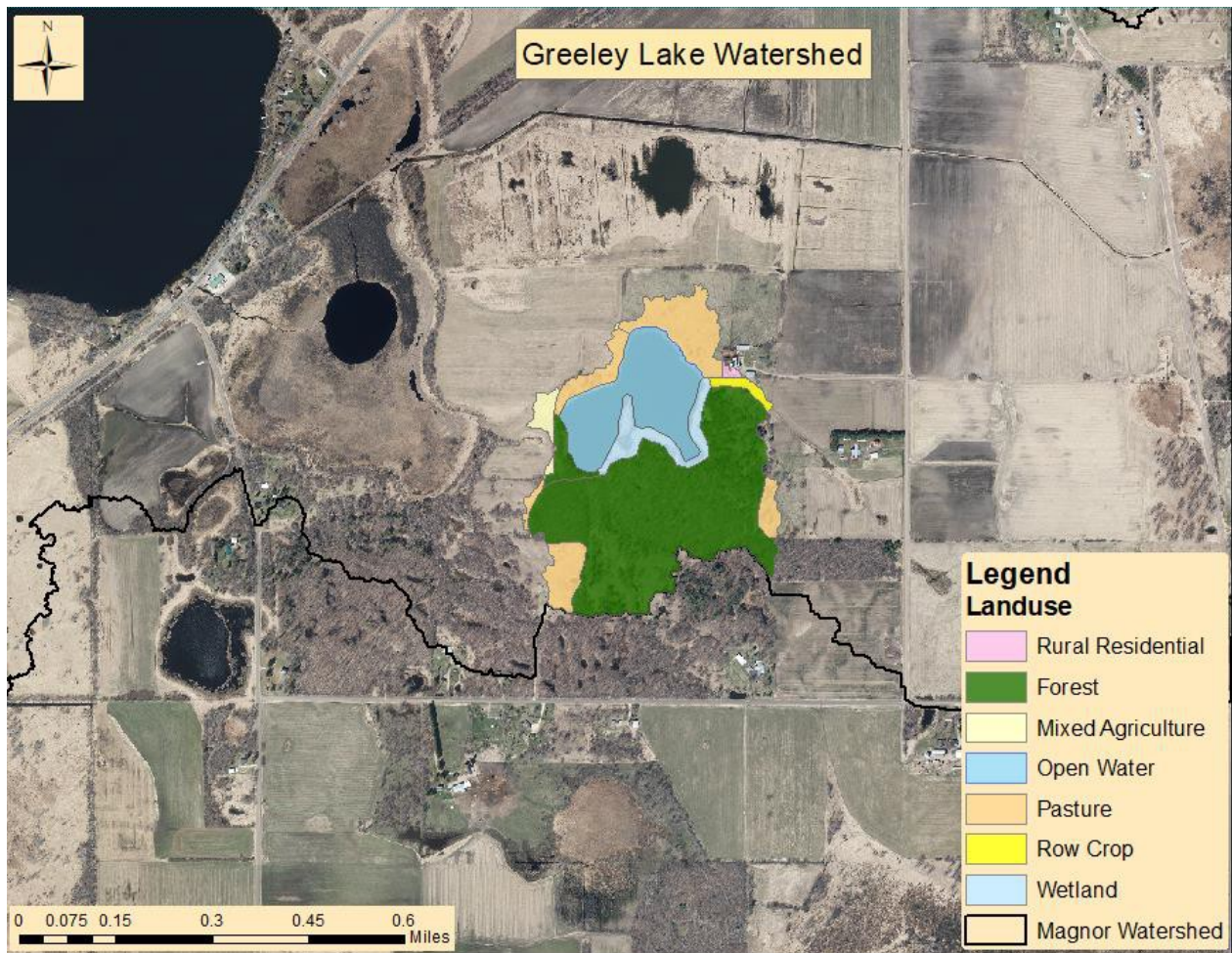
Land Use	Acres	Acres (%)	Phosphorus Load (lb/yr)	Phosphorus Load (%)
Row crop	1	0%	0	0%
Mixed agriculture	343	41%	245	75%
Pasture/mixed grass	185	22%	49	15%
Medium density urban/road	18	2%	9	3%
Rural residential	32	4%	2	1%
Wetland/open water	185	22%	15	5%
Forest	81	10%	7	2%
Total	845	100%	326	100%

The Direct Subwatershed includes Magnor Lake. The subwatershed is primarily forest (32%), wetlands/open water (24%), and medium density urban/road (14%). The annual phosphorus load from this subwatershed is 150 pounds per year. Annual phosphorus load in the direct subwatershed originates primarily from mixed agriculture (28%), medium density urban/road (24%), and row crop (19%).



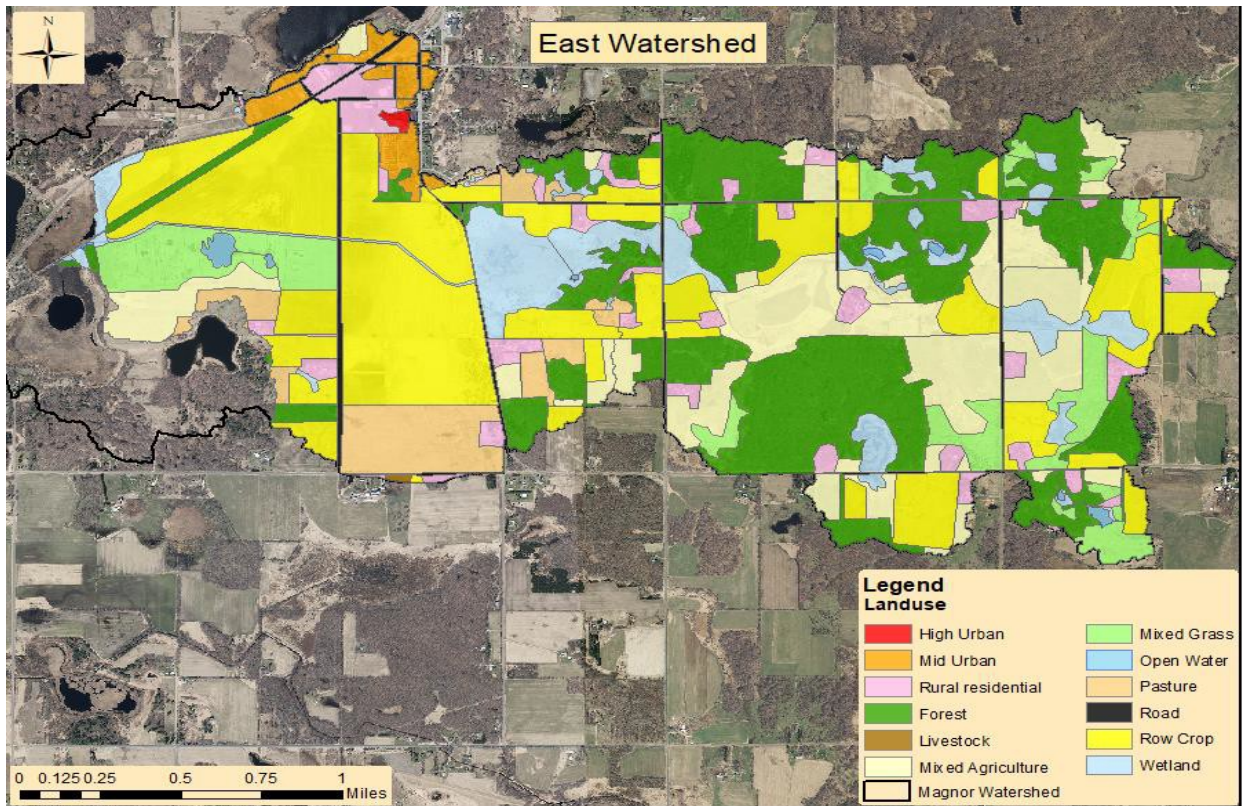
Land Use	Acres	Acres (%)	Phosphorus Load (lb/yr)	Phosphorus Load (%)
Row crop	31	5%	29	19%
Mixed agriculture	60	11%	42	28%
Pasture/mixed grass	27	5%	7	4%
High density urban	3	1%	4	3%
Medium density urban/road	78	14%	35	24%
Rural residential	49	9%	4	3%
Wetland/open water	138	24%	13	9%
Forest	181	32%	15	10%
Total	567	100%	150	100%

The Greeley Lake Subwatershed is the smallest subwatershed at 87 acres and includes Greeley Lake. Over half of the land use in the subwatershed is forest (55%), a quarter is wetland/open water (25%), and 16% is pasture/mixed grass. The annual phosphorus load from this subwatershed is 13 pounds per year. The majority of the phosphorus load is coming from forest and pasture/mixed grass (34% each), and wetland/open water and mixed agriculture (17% each).



Land Use	Acres	Acres (%)	Phosphorus Load (lb/yr)	Phosphorus Load (%)
Row crop	1	1%	0	0%
Mixed agriculture	2	2%	2	17%
Pasture/mixed grass	14	16%	4	34%
Wetland/open water	22	25%	2	17%
Forest	48	55%	4	34%
Total	87	100%	13	102%

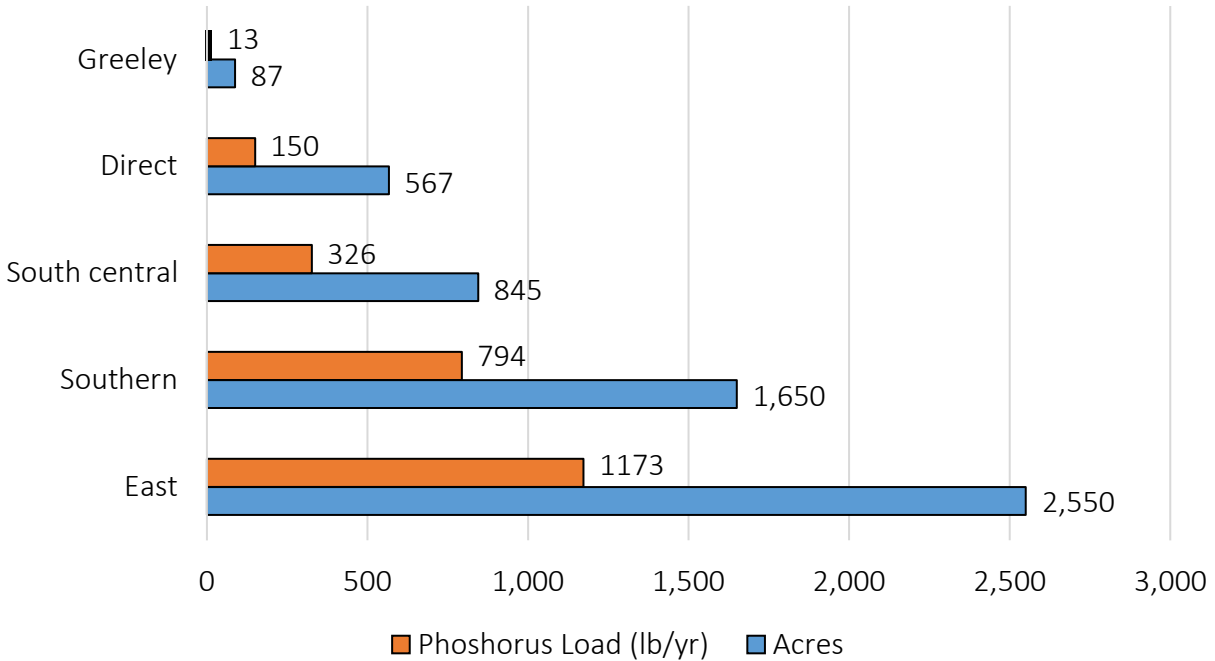
The East Subwatershed is the largest subwatershed at 2,550 acres. Row crop and forest each make up about a quarter of the land use in this subwatershed (28% and 24%, respectively). Mixed agriculture accounts for 17% of the land use and pasture/mixed grass makes up 12% of the land use. The annual phosphorus load from this subwatershed is 1,173 pounds per year. Over half of the load comes from row crop (55%) and a quarter originates from mixed agriculture (26%).



Land Use	Acres	Acres (%)	Phosphorus Load (lb/yr)	Phosphorus Load (%)
Row crop	723	28%	646	55%
Mixed agriculture	426	17%	304	26%
Pasture/mixed grass	318	12%	86	7%
High density urban	3	0%	4	0%
Medium density urban/road	114	4%	51	4%
Rural residential	138	5%	13	1%
Wetland/open water	214	8%	20	2%
Forest	613	24%	49	4%
Livestock	1	0%	0	0%
Total	2,550	100%	1,173	100%

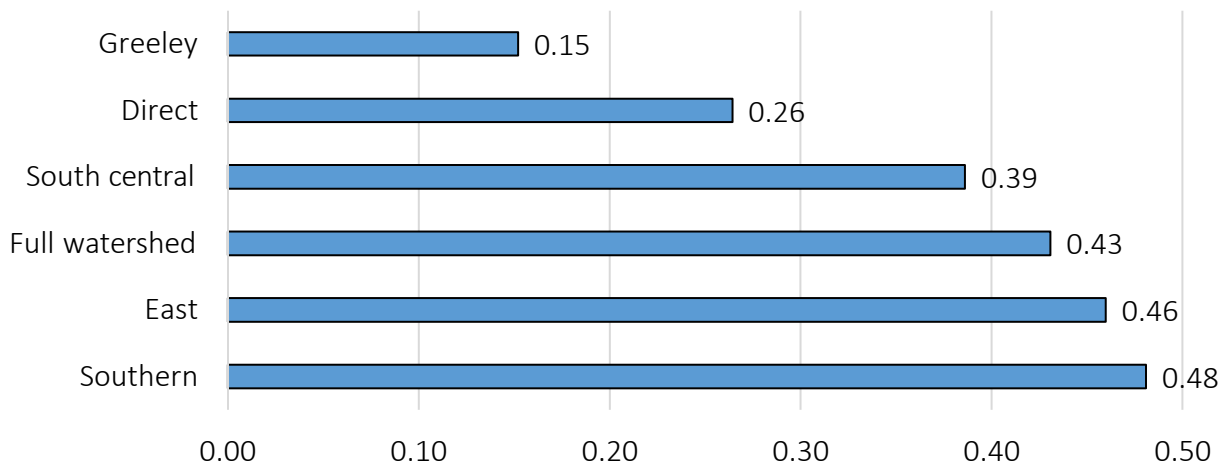
The phosphorus load from each subwatershed is related to the size of the subwatershed. As the size of the watershed increases, the annual phosphorus load increases.

Acres and Phosphorus Load (lb/yr) by Subwatershed



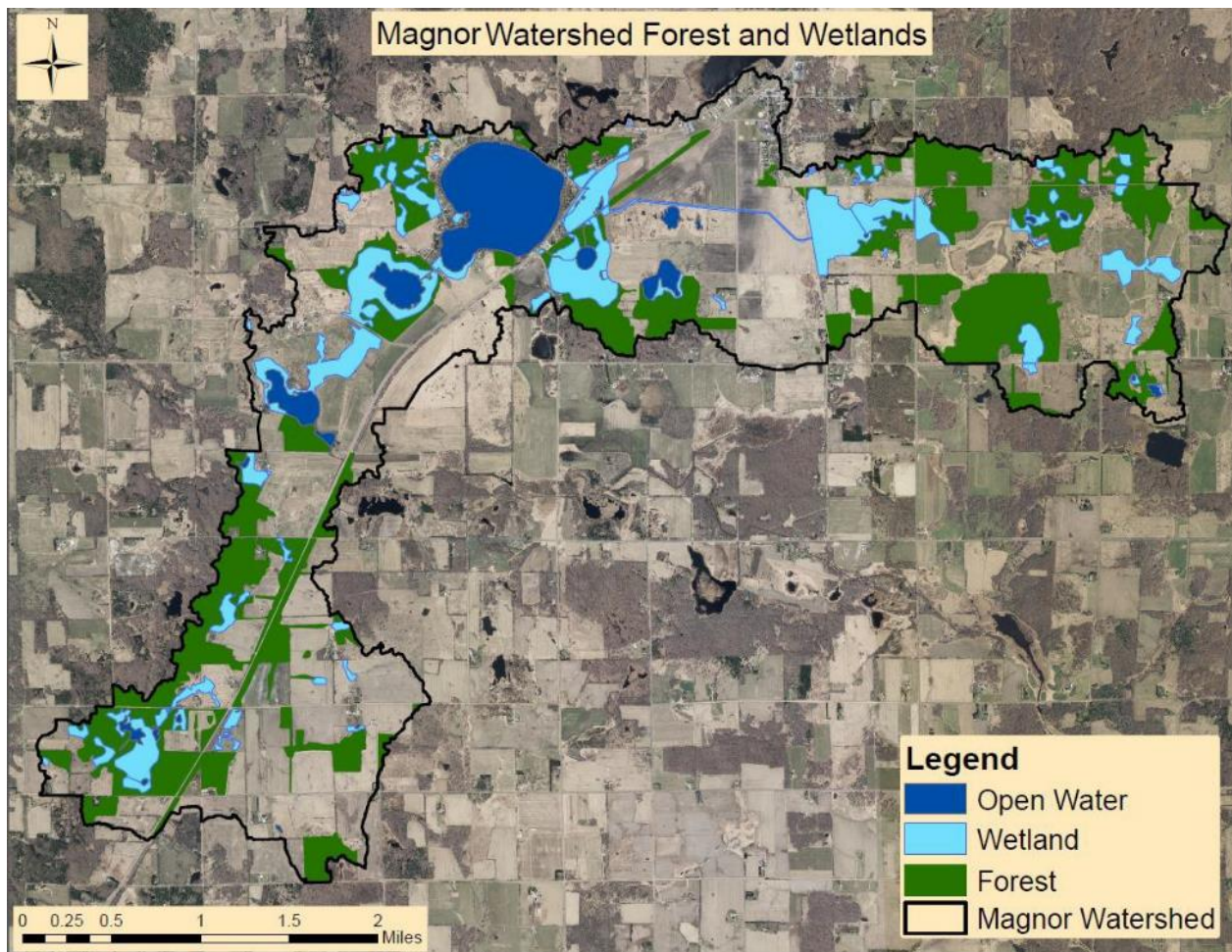
When the data is shown as the annual pounds of phosphorus loading to Magnor Lake as pounds per acre it is evident that the District should focus watershed improvement efforts in the Southern and East Subwatersheds. Each of these subwatersheds contribute more phosphorus (pound/acre/year) to Magnor Lake as compared to the load from the full watershed.

Phosphorus Load (lb/acre/yr)



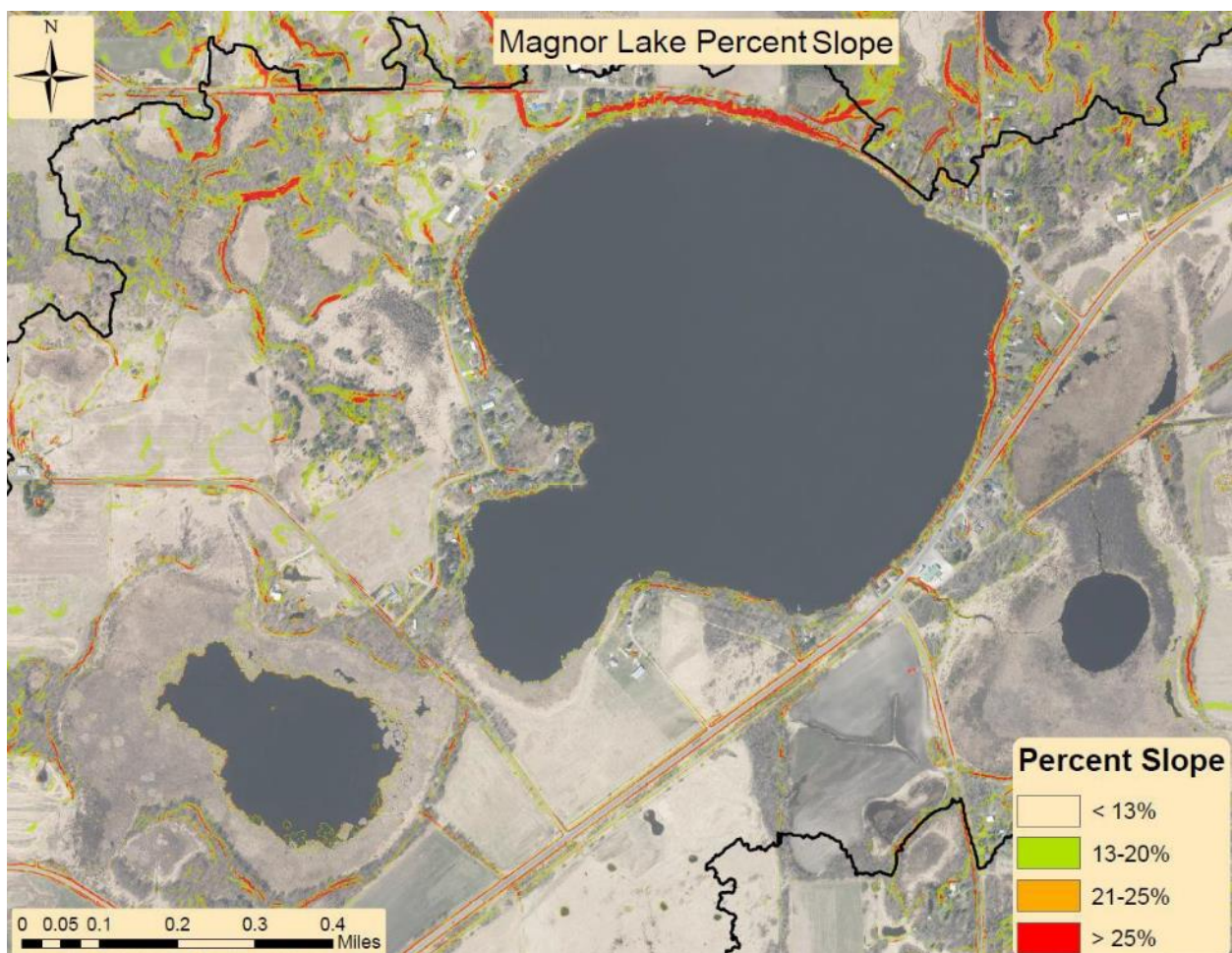
Areas Providing Water Quality Benefits to Magnor Lake

Natural areas such as forests and wetlands allow for more infiltration of precipitation when compared with conventionally tilled row cropped fields and developed residential sites containing lawns, rooftops, sidewalks, and driveways. This occurs because dense vegetation lessens the impact of raindrops on the soil surface, thereby reducing erosion and allowing for greater infiltration of water. Additionally, wetlands provide extensive benefits through their ability to filter nutrients and allow sediments to settle out before reaching lakes and rivers. In the Magnor Lake watershed 24% of the land use is forest and 9% is wetland.



Slope

Steep slopes occur in areas where the gradient of land is 13% or greater. Areas having steep slopes can be categorized into three levels: 13-20%, 21-25%, and greater than 25%. Much of the shoreline on the north end of Magnor Lake has a slope greater than 25%. A slope map can be used to prioritize areas that are prone to erosion and would benefit from establishment of perennial vegetation. Areas of likely gully erosion can also be identified from a slope map. Establishment of perennial vegetation will require landowner participation and in the case of gully erosion, it is likely an engineer would need to be hired to address problem areas.



Agricultural Land Use Inventory

An agricultural land use inventory was conducted across the Magnor Lake Watershed to establish a baseline understanding of the types of agricultural practices currently being used in the watershed and to identify conservation practices that could be adopted that would have a positive impact on water quality. The inventory identified the type of crops being produced, tillage practices used in crop production, and the use of cover crops. The current utilization of conservation practices was identified and the potential to expand the use of conservation practices was determined.

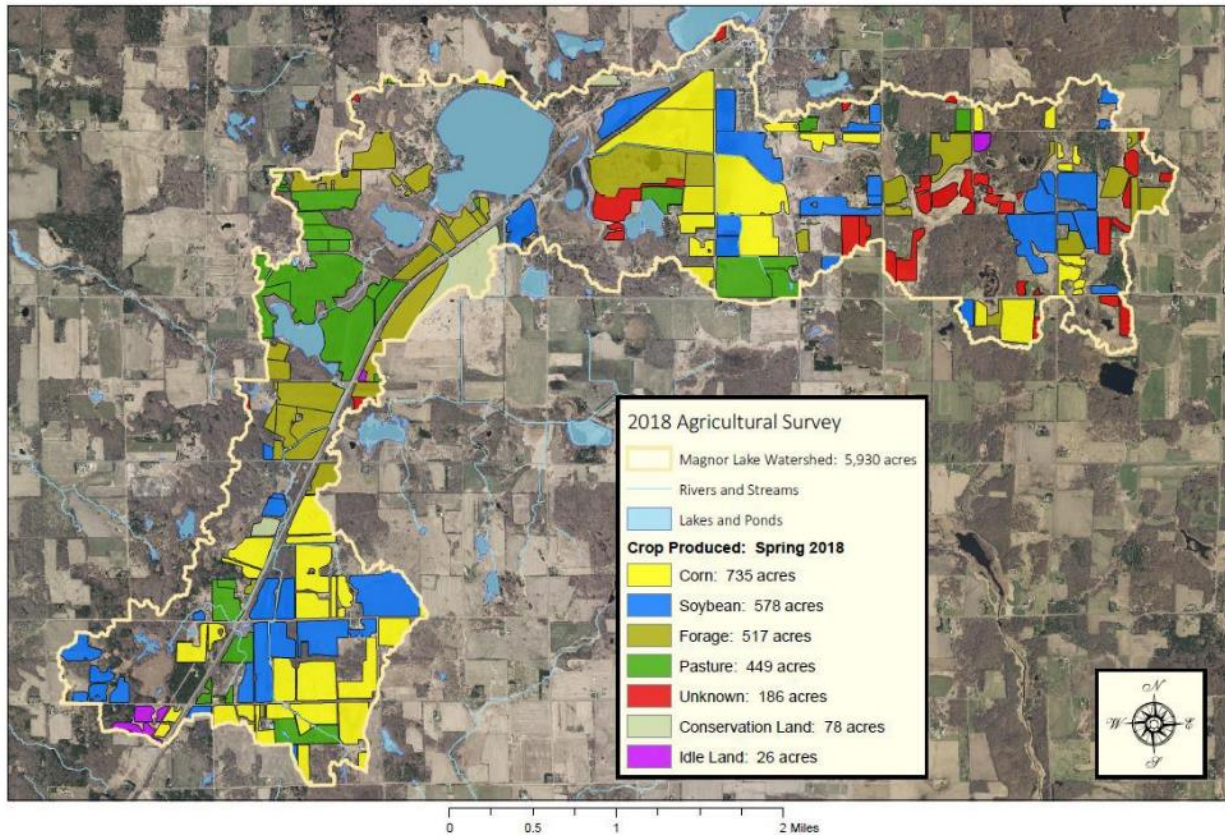
Two windshield surveys were conducted to assess the utilization of two agricultural conservation practices (no-till and cover crops) in the watershed. An early summer inventory in 2018 documented the type of crops being grown and whether conventional or no-till practices were utilized. The second survey was conducted in the spring of 2019 to document the use of cover crops.

No-till planting is a conservation practice where crops are grown without the use of tillage. Soil tillage is a common agricultural practice used to loosen soil, incorporate crop residue and plant nutrients, and prepare a suitable seed bed. However, tillage also increases the potential of soil erosion and nutrient runoff. Tillage breaks soil structure, inhibits the process of soil aggregation, and reduces surface crop residue. Soil is left exposed and more susceptible to the erosive forces of wind and water. Soil erosion from agricultural landscapes can be a major source of sediment and nutrients in lakes and rivers causing decreased water quality. The adoption of no-till planting reduces the potential for soil erosion and nutrient loss, thus minimizing agriculture's impact on water quality.

Planting cover crops is another conservation practice that can reduce agriculture's impact on water quality. Cover crops are plants that are grown outside of the main production crop specifically for their benefits to the soil or main crop. The primary benefit of cover crops is the reduction of erosion. Cover crops reduce erosion because the vegetation and roots protect the soil from early spring and late fall rains when the primary crop is not growing. Besides reducing erosion, cover crops can increase infiltration, capture unused nutrients, build soil structure, promote soil bacteria and fungi growth, break compaction layers, suppress weeds, and provide many other benefits to the soil and environment. These benefits can lead to reductions in soil erosion, runoff, and nutrient loss from agricultural fields.

The windshield surveys identified 43% of the land use in the Magnor Lake Watershed as agricultural (2,569 acres). The 2018 survey revealed a diversity of cropping practices throughout the watershed. Four crops were documented in the watershed: corn (735 acres), soybean (578 acres), forage (517 acres), and pasture (449 acres). The remaining agricultural land use consisted of unknown crop (186 acres), conservation land (78 acres), and idle land (26 acres).

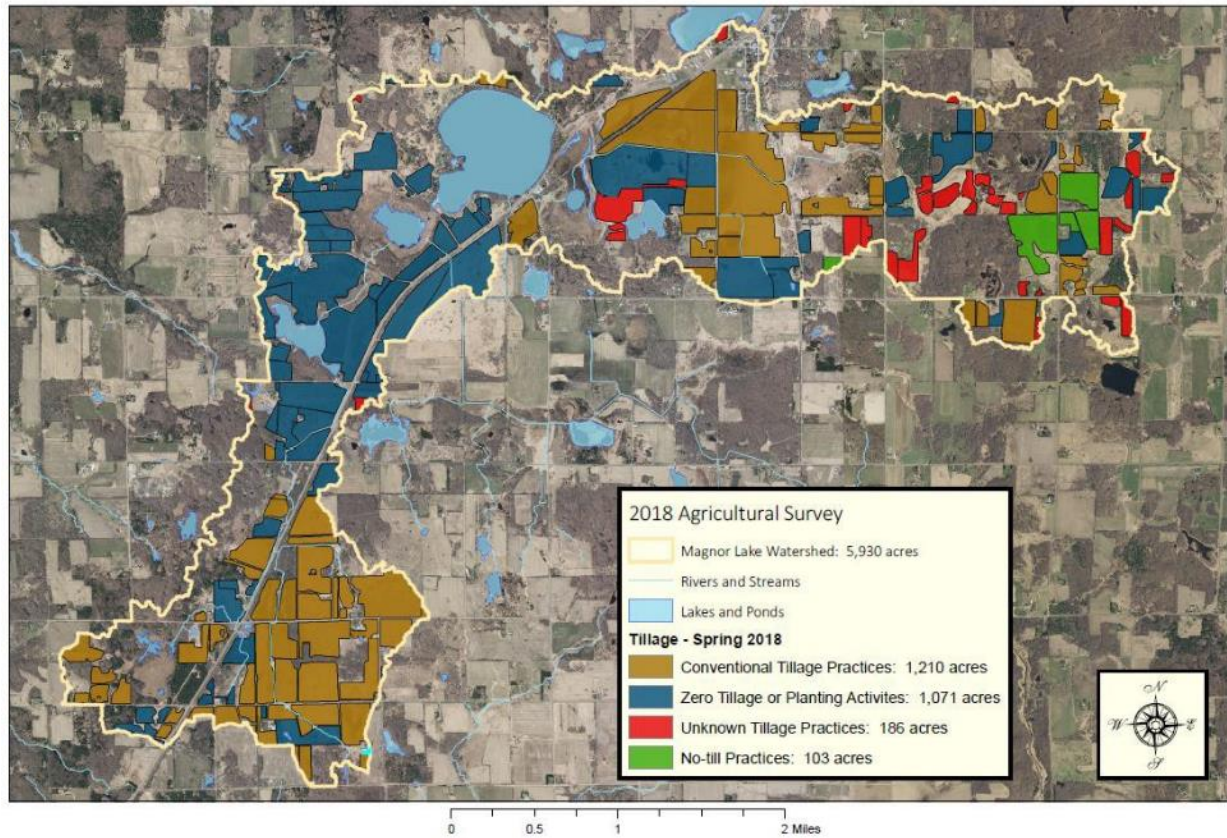
Magnor Lake Watershed: 2018 Crop Inventory



Crop grown in 2018	Acres	Acres (%)
Corn	735	29%
Soybean	578	23%
Forage (grass/forbs primarily harvested mechanically)	517	20%
Pasture (grass/forbs primarily harvested by livestock)	449	17%
Unknown (unable to determine tillage or crop, likely due to obstructed view from roadway)	186	7%
Conservation land (not farmed)	78	3%
Idle land (zero tillage and crop not planted at time of survey)	26	1%
Total	2,569	100%

The tillage survey identified 1,210 acres of conventional tillage, 1,071 acres where zero tillage or planting activities had occurred, 186 acres where tillage practices were unknown, and 103 acres of no-till. Fields that could not be identified from the roadway were documented as unknown crop with unknown tillage. Fields that had not yet been planted were identified as idle land and any tillage was documented.

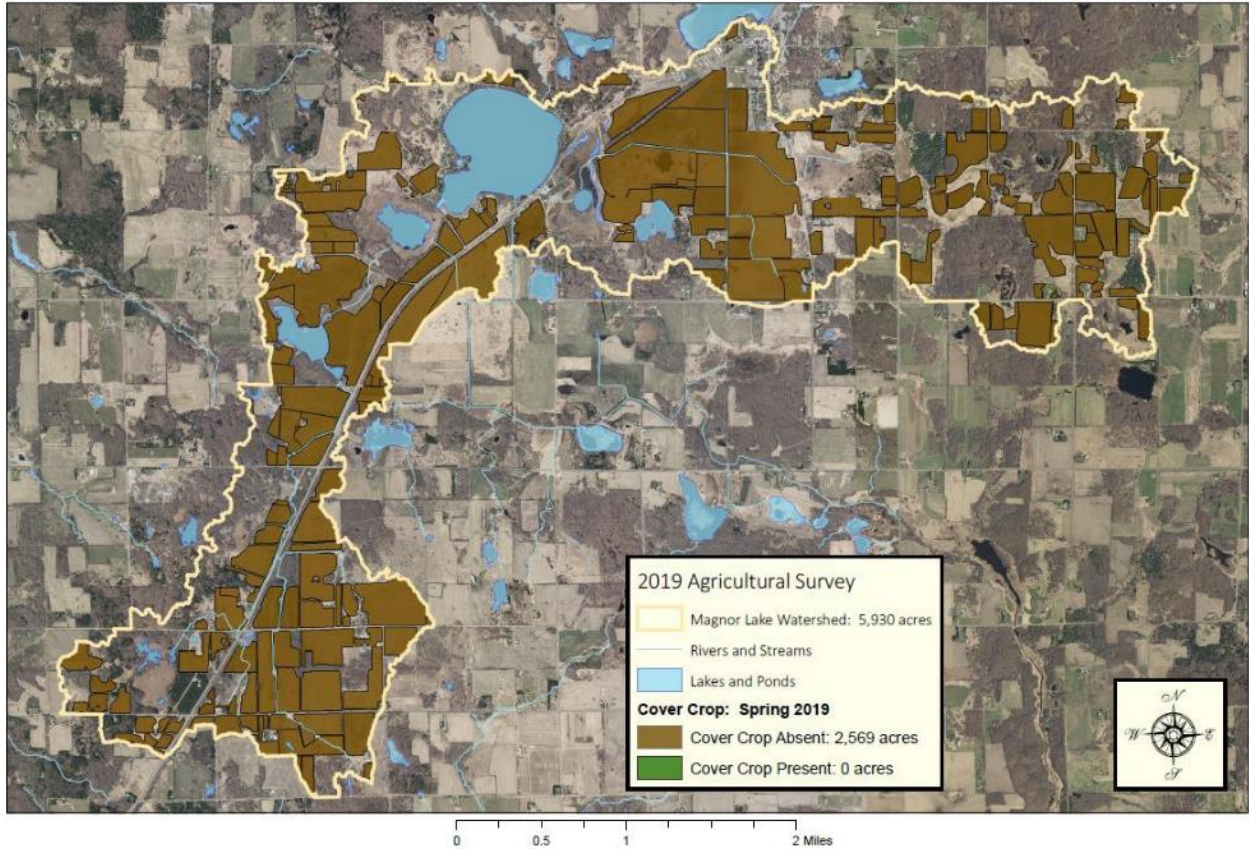
Magnor Lake Watershed: 2018 Tillage Inventory



Tillage practice in 2018	Acres	Acres (%)
Conventional	1,210	47%
Zero tillage (field not tilled due to perennial vegetation present or	1,071	42%
Unknown (unable to determine tillage, likely due to obstructed	186	7%
No-till	103	4%
Total	2,569	100%

The 2019 cover crop survey identified zero acres of cover crops in the Magnor Lake Watershed.

Magnor Lake Watershed: 2019 Cover Crop Inventory



Cover crop in 2019	Acres	Acres (%)
Cover crop absent	2,569	100%
Cover crop present	0	0%
Total	2,569	100%

This inventory is a single year representation of the crops and practices being used in the Magnor Lake Watershed. The crops producers choose to grow and the practices used to grow them can change from year to year due to numerous factors such as commodity prices, feed demand, equipment, and weather.

Additionally, a single field is typically managed using a crop rotation, where a series of different crops are grown over a period of years. The inventory completed in 2018 would represent a single year of a crop rotation. To determine the types of crop

rotations being used in the Magnor Lake Watershed, an inventory would need to span multiple years. Crop rotations common in Wisconsin include row crop rotations and dairy rotations. A typical row crop rotation might involve planting corn in odd numbered years and soybeans in even numbered years. A dairy rotation generally includes corn and soybeans, but also adds several years of perennial vegetation such as grass/alfalfa that is harvested as a forage. Over a seven-year period, a field in a dairy rotation might be planted in alfalfa for the first four years, followed by two years of corn, and one year of soybeans. On the eighth year the rotation would begin again, with four years of alfalfa. Different rotations have varying impacts on water quality based on the crops being grown and the practices used.

A rotation that incorporates perennial vegetation over several years of the rotation would have a lower potential to negatively impact water quality as compared to an excessively tilled field where only row crops are produced. The years of perennial vegetation production offer water quality benefits by eliminating several years of tillage and providing year-round vegetative cover that protects the soil from erosion.

Row crops were the dominant agricultural commodity grown in the Magnor Lake Watershed in 2018 (51%), with the vast number of fields being planted using conventional tillage. These fields may be part of a row crop or dairy rotation. In 2018, a large portion of the agricultural land in the watershed (41%) was in perennial (long term) vegetation (forage, pasture, or conservation land) where soil was not disturbed through tillage. The fields documented as forage are likely in a dairy rotation, where perennial vegetation is grown and harvested in a rotation with row crops. The fields documented as pasture or conservation land are likely never, or vary rarely, tilled and planted into row crops. These fields would provide water quality benefits during the years when perennial vegetation is present as compared to row crops.

Although no fields in the Magnor Lake Watershed had cover crops present during the 2019 survey, two fields that lie just outside the watershed boundary did have cover crops present. The use of cover crops in proximity to the watershed is promising because that landowner or operator may expand the use of cover crops on land they own or operate within the watershed. Neighbors may also be willing to adopt the use of cover crops if they see other producers using them successfully. Based on the 2018 crop survey, cover crops could have been planted on the 1,313 acres where corn or soybeans were present. The absence of cover crops in the watershed is not entirely

surprising. Cover crops are an emerging conservation practice that have many benefits, but also many barriers to adoption.

Agriculture's overall impact on water quality in the watershed can change on a yearly basis. These changes can be influenced by the types of rotations grown, how those rotations are managed, as well as environmental conditions. This land use survey represents a one-year snapshot of agricultural practices being used in the Magnor Lake Watershed. The acres of no-till or cover crops may fluctuate yearly based on multiple factors. Other barriers (equipment, agronomic, environmental, financial, social) may inhibit or prevent producers from implementing conservation practices. Future inventories could be used to gauge long term implementation and trends in practice adoption. Agricultural producers may also be using other practices to reduce erosion or nutrient loss that were not inventoried with this survey. Outreach to producers about how conservation practices can be implemented into their operation is one way to obtain the nutrient and sediment reduction goals of this lake management plan.

The data collected for this agricultural survey was incorporated into the Spreadsheet Tool for Estimating Pollutant Load (STEPL) to determine nitrogen, phosphorous, and sediment load reductions in the Magnor Lake Watershed based on the use of no-till and cover crops. The agricultural survey documented 103 acres of no-till in the watershed in 2018 which resulted in a 1% reduction in nitrogen, 3% reduction in phosphorus, and 3% reduction in sediment loading. No cover crops were identified in the watershed.

Based on the land use and data from the agricultural survey, it can be assumed that 1,511 acres were potentially suitable for no-till and/or cover crop practices in 2018. STEPL was used to predict pollutant load reduction percentages assuming the use of no-till and/or cover crops were implemented on these acres. If no-till was adopted on all suitable acres in 2018 it would have resulted in a 15% reduction in nitrogen, 35% reduction in phosphorous, and 47% reduction in sediment load. If cover crops were planted on all suitable acres it would have resulted in pollutant load reductions of 11% nitrogen, 10% phosphorous, and 9% sediment. In a best-case scenario, all suitable acres would have been no-till planted and planted with a cover crop. This would have reduced nitrogen loading by 19%, phosphorous by 37%, and sediment by 48%. To achieve the 68% phosphorous load reduction necessary to meet the phosphorous standard (30 µg/L), additional conservation practices would need to be implemented on additional acres or on additional land uses (urban, forest, pasture, feedlots).

Agriculture Conservation Planning Framework

The Agriculture Conservation Planning Framework (ACPF) is a toolbox in ArcMap used to identify and prioritize conservation practices on the landscape at a watershed scale.

ACPF uses high resolution LiDAR elevation data and a user supplied culvert inventory to determine flow paths on the landscape. Once the flow paths are created, the program is able to prescribe conservation practices on the landscape based on slope, soils, field boundaries, and relevance to flow paths. This program is agriculture based so the practices suggested are designed for and located within agricultural fields.

ACPF was used to identify and prioritize agricultural conservation practices within the Magnor Lake Watershed. The program recommended a variety of conservation practices for implementation including: water and sediment control basins, contour buffer strips, grass waterways, farm ponds, and riparian attribute polygons. The following summary of each practice will include: how each conservation practice works, in-field examples, and the number of potential practices identified within the Magnor Lake Watershed. ACPF ranks practices based on priority, with adjustable criteria. The practices displayed will be color coordinated based on priority, with green being lowest concern, yellow being moderate concern, and red being high concern. Distance to stream and field runoff risk are used to rank the priority level of conservation practices. ACPF also produces a map showing height above channel, or meters above the surface water elevation.

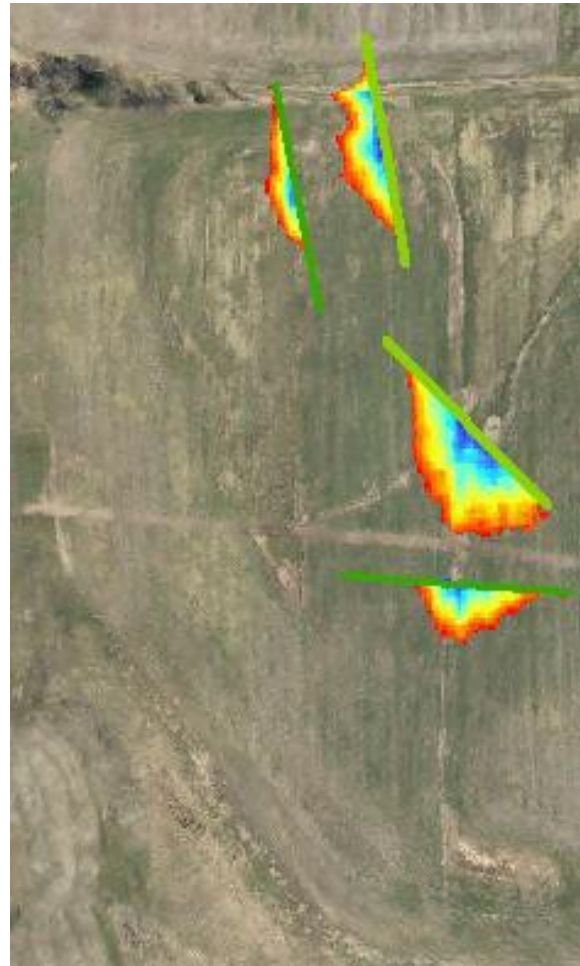
The outputs of ACPF allow for the prioritization of conservation practices that reduce runoff, erosion, and nutrient/sediment loading to surface waters. It is important to consider all the outputs of ACPF when determining where the greatest impact can be achieved through best management practice implementation because the implementation of agricultural best management practices requires landowner participation and can directly impact the yields and economics for an agricultural system. Implementation of best management practices may not be possible on the highest priority areas, so it is important not to overlook lower ranked areas which will still result in a positive impact.

Exact locations of potential practices will not be included in this report to ensure the anonymity of landowners. Information regarding site locations and landowner information will be kept for internal use with Polk County LWRD. Any of the practices suggested with this tool would need to be field verified.

Water and sediment control basin

A water and sediment control basin (WASCOB) is a 3 foot or higher embankment built perpendicular to a drainage way in an agricultural field. During a rainfall event, WASCOBs collect water in a pooling area and then allow the water to slowly flow through a pipe to an area where it can infiltrate. WASCOBs can slow down peak discharge (runoff) and reduce phosphorus loading, sediment erosion, and gully formation.

Locations for 31 WASCOBs were identified in the Magnor Lake Watershed. The image shows the location of four potential WASCOBs in a single field. The green lines indicate the location of the WASCOB embankment, while the rainbow colors indicate the pooling area behind the embankment. The blue color indicates the deepest part of the pooling area, while the red indicates the outer edge of the pooling area.



WASCOBs are ranked by the amount of contributing acres, or area of land that drains to each WASCOB. The four WASCOBs in the image are ranked as low concern (green lines), meaning they have a smaller contributing area.

Contour buffer strips

Contour buffer strips are strips of perennial vegetation planted parallel to the contour line that intercept the flow of surface runoff. Contour buffer strips are often alternated throughout a field to allow for farming practices to continue between the buffer strips. This practice uses permanent vegetation to reduce the overall length of farmed land on a slope which reduces the accumulation and speed of runoff. This practice reduces erosion and overall runoff volume, improves water quality and prevents the formation of gullies.

In the Magnor Lake Watershed 73 contour buffer strips were identified: 10 high priority (red), 27 moderate priority (yellow), and 36 low priority (green). In the examples below, some fields have multiple contour buffer strip locations identified. Although each buffer might be identified as low priority, if all the buffers were installed, runoff would be greatly reduced in a single field.

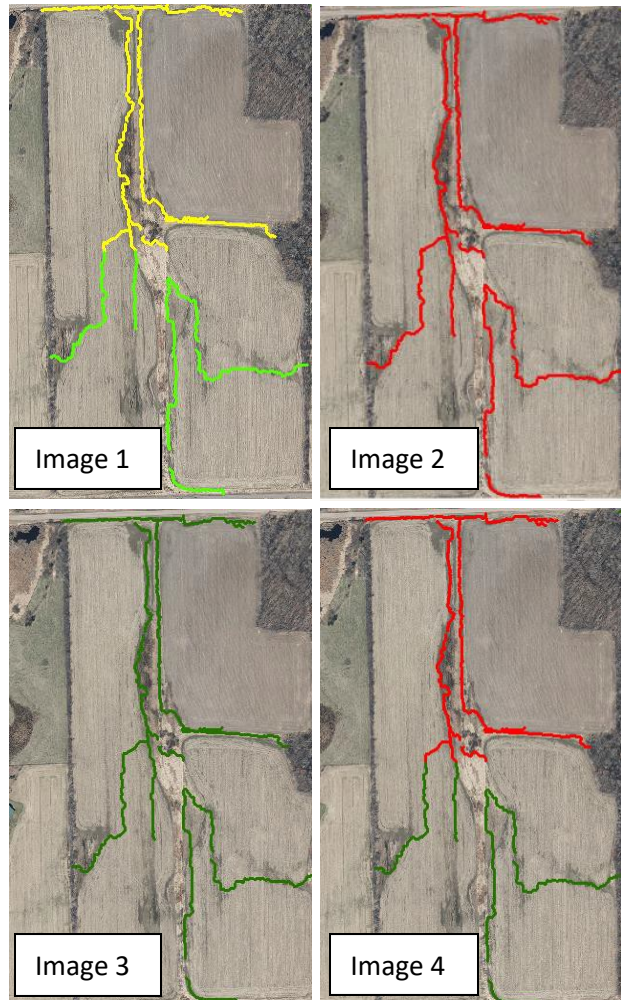


Grass waterways

Grass waterways are installed within a concentrated flow path in an agricultural field where there is a high probability of concentrated runoff. Grass waterways are planted with perennial grasses and are maintained in permanent vegetation. Installing grass waterways in areas where concentrated water flows through a field ensures that water is moving within a vegetated flow path (rather than over bare soil) which reduced the velocity of water and the risk of erosion and gully formation. The deep roots of the grasses keep the soil in place and reduce the amount of soil being transported by water in a runoff event. Grass waterways do not trap and store water or sediment; rather, they are reducing sediment loss where erosion and runoff has a high probability of occurring.

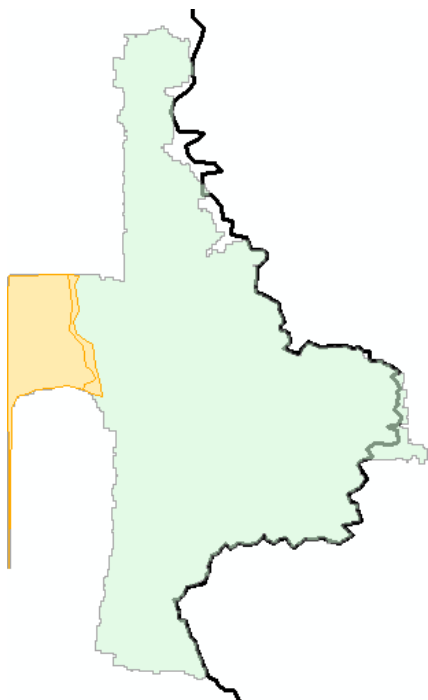
ACPF identified 122 locations within the Magnor Lake Watershed where grass waterways could be implemented. This tool considers many different possibilities when prioritizing the locations of grass waterways.

The image on the right shows four different methods of prioritizing the location of a single grass waterway. In image 1 grass waterways are prioritized by runoff risk potential (which considers slope and stream proximity) , in image 2 by distance to stream, in image 3 by mean slope of 75% of the field, and in image 4 by the sediment delivery ratio (which considers slope, stream proximity, and soil type).



The grass waterway is displaying as high priority in image 2 because it is located near a stream. However, because the field has a gradual slope the waterway is displaying as a low priority in image 3.

Since ACPF ranks grass waterways based on four different criteria, a site visit to higher priority locations would be recommended to determine implementation potential.



Farm ponds

Farm ponds are depressions that are created in areas of higher slopes where other practices are not suitable. They are designed to catch runoff, reduce erosion, and allow for sediment and nutrients to settle out before entering surface waters. These ponds can have 5-100 acres of contributing area, or the area of land that drains to the pond.

There was one area in the Magnor Lake Watershed that ACPF identified as suitable for a farm pond. In the image, the black line represents the watershed boundary, the orange area represents the farm pond, and the green area represents the contributing area.

Riparian attribute polygons

The riparian attribute polygons (RAP) tool splits the two main tributaries in the Magnor Lake Watershed into 200 meter stream corridor segments and creates a 15 meter buffer area on each side of the stream. Three factors are determined for each 200 x 15 meter stream segment: preferred buffer type, desired buffer width, and runoff risk.

The preferred buffer type is determined using slope, land use, and soils. The three main buffer types include: deep rooted vegetation, multiple species vegetation, and stiff stemmed grasses. In areas where the three buffer types are inadequate, the tool classifies areas as either critical zones or those requiring additional bank stabilization.

The tool identified 99 stream corridor segments where deep rooted vegetation is recommended (brown), 28 for multiple species buffers (yellow), 2 for stiff stemmed grasses (green), 11 critical zones (red), and 17 areas requiring stream bank stabilization (gray) (Image 5).



The tool also identified the desired buffer width for each stream corridor segment (image 6). Recommended buffer widths are categorized as 6-33 meters (green), 34-59 meters (yellow), and greater than 60 meters (red).



Lastly, ACPF ranks each stream corridor segment by runoff risk. Based on runoff risk, the tool identified 12 high runoff risk stream corridor segments (red), 29 moderate runoff risk segments (yellow), and 116 low runoff risk segments (green) (Image 7).

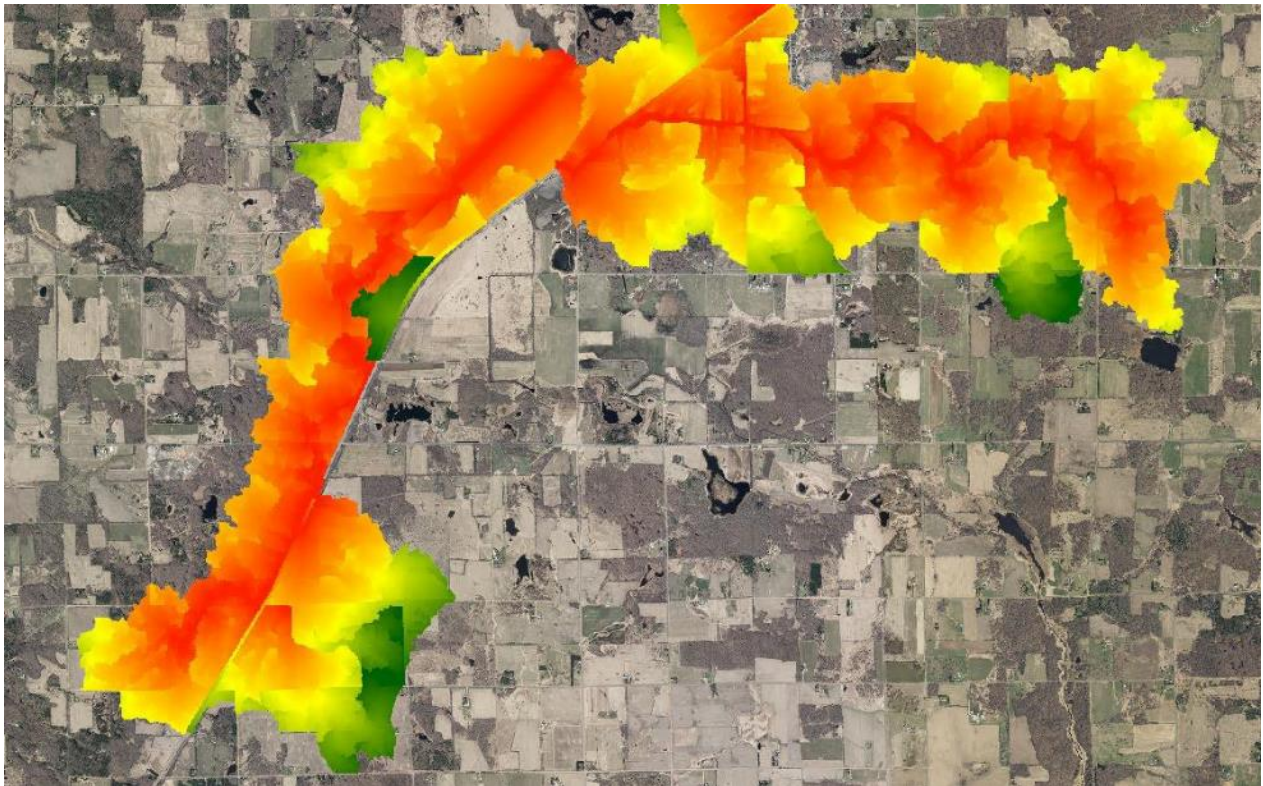


Distance to stream

The distance to stream output uses flow direction, stream reach, and slope to determine relative risk of sediment delivery to Magnor Lake. The tool ranks the land in the watershed according to the distance from the main stream in meters. The darkest red areas represent the main flow path (or tributaries) entering Magnor Lake. The distance to stream is displayed on a scale from red to green, with red areas being closest to the

streams entering Magnor Lake and green areas being furthest from the streams entering Magnor Lake.

The distance to stream map is used to prioritize where to implement conservation practices, with areas in red being the most critical for implementation. Even though the green areas are the farthest from the stream and likely have the lowest impact, they should not be overlooked. Implementation in the green areas could still be very important and beneficial in watershed management.



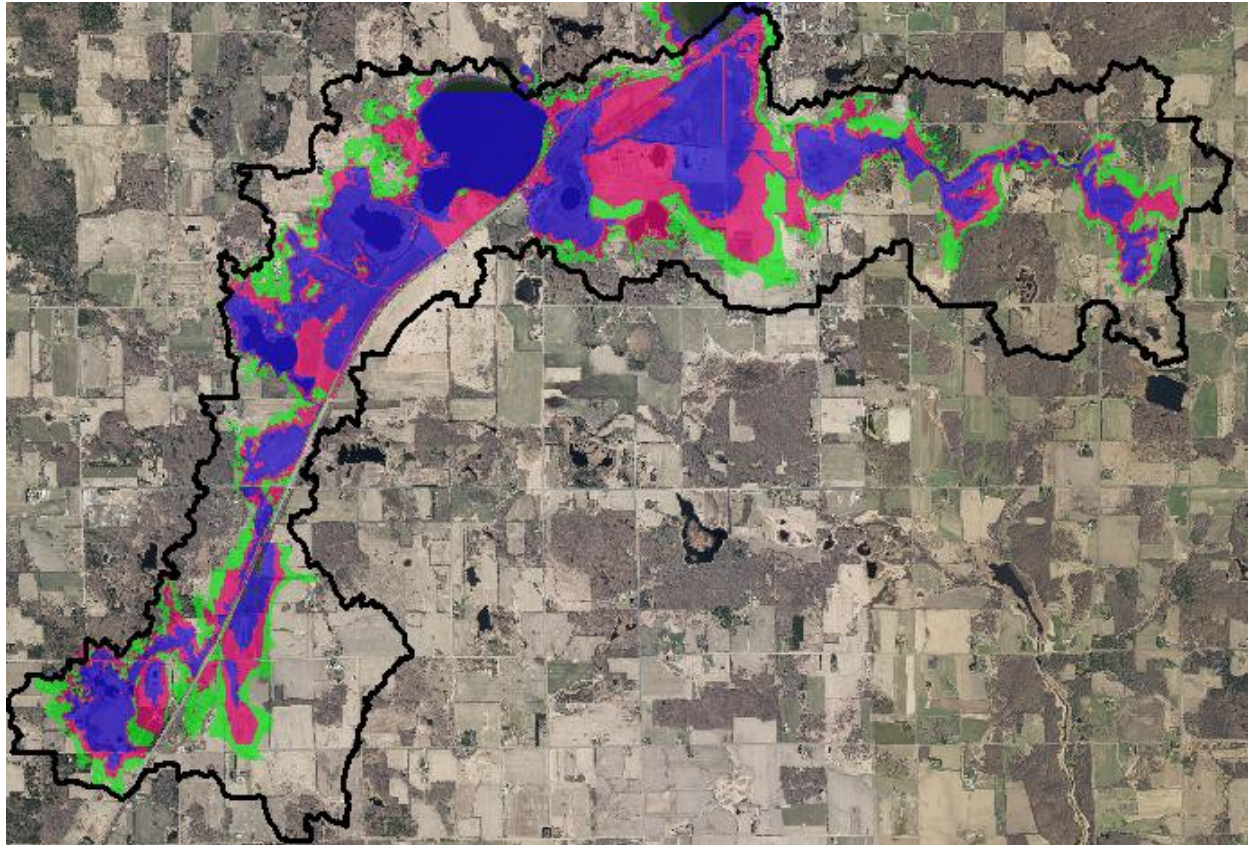
Field runoff risk

The last tool used to identify areas of concern involves ranking agricultural fields based on their runoff risk. This tool takes into consideration slope, soil type, and land use classification (row crop or pasture). Based on field runoff risk, 2 fields were considered very high risk, 19 fields were considered high risk (orange), 19 were considered moderate risk (yellow), and the remaining 48 were considered low risk (green).



Height above channel

The height above channel is used to estimate the extent of low lying areas along the riparian corridor. The map (below) shows areas that are less than 1.5 meters above the surface water elevation (blue), 1.5-3 meters above the surface water elevation (pink), and 3-5 meters above the surface water elevation (green). Areas that are greater than 5 meters above the surface water elevation are not colored. The Magnor Lake Watershed has a significant amount of wetlands and low lying areas.



Sediment Core

The St. Croix Watershed Research Station, Science Museum of Minnesota collected a sediment core on Magnor Lake on October 11th, 2019 with assistance from the Magnor Lake District and Polk County Land and Water Resources Department.

The full report ¹⁶ detailing the methods, results, discussion, summary, and recommendations can be found in Appendix I. The summary and recommendations section of the report can be found below.

Summary and Recommendations

The dated section of the Magnor Lake sediment core provided an over 150-year record of sedimentation, geochemistry, and diatom and algae communities in the lake. Sedimentation rates in the lake increased following Euroamerican settlement and current sedimentation rates are approximately 3-fold greater than pre-settlement levels. Inorganic constituents show the most dramatic



increase in abundance likely reflecting changes in sediment loading following logging and land clearance. Later, shoreline development likely increased nutrient loading marked by greater organic content in the sediment, a marker of increased algal abundance.

Biogenic silica concentrations in the core, a marker of diatom algae abundance, have remained relatively constant; however, the accumulation of biogenic silica increased about 2-fold since the 1960s as diatom algae growth increased in response to greater nutrients in Magnor Lake. The concentration of phosphorus fractions in the Magnor Lake sediment core show general increases toward the core top. Labile or mobile forms of phosphorus including organic forms and iron-bound forms are especially abundant in the upper few cm of sediment and provide an accessible and readily available source of phosphorus to the lake during periods of internal loading.

¹⁶ Edlund, M.B. and Ramstack Hobbs, J.M. 2021. A Paleolimnological Study of Magnor Lake, Polk County, Wisconsin. Final Report to Polk County Land & Water Resources Department. St. Croix Watershed Research Station, Science Museum of Minnesota, Marine on St. Croix, Minnesota. 18 pp

The diatom communities preserved in the four samples analyzed in the Magnor Lake core show that the lake went from being mesotrophic (medium nutrient levels) in pre-Euroamerican settlement times to strongly eutrophic (high nutrient levels) in recent decades. This shift was from a diatom community dominated by mesotrophic *Tabellaria flocculosa*, *Cyclotella stelligera*, *Eunotia zasumenensis*, and *Aulacoseira distans* to a diatom community characteristic of more nutrient-rich waters including *Aulacoseira ambigua*, *A. granulata*, and *Fragilaria crotonensis*. Historical total phosphorus (TP) estimates generated using a diatom-TP model based on 89 Minnesota lakes suggest that Magnor Lake is now a very eutrophic system with estimated TP of 31-38 ppb TP and above Wisconsin's lake nutrient standard of 30 ppb TP. This contrasts with TP levels in pre-Euroamerican settlement times of 10-12 ppb TP. Modeled TP values for the last 10 years (31-38 ppb TP) are slightly lower than Magnor's monitored values from 2018 and 2019 that ranged from 36–106 ppb TP.

Fossil algal pigment data from Magnor Lake show clear signals of change before and after 1960 with greater abundance of all algal groups after the 1960s: diatoms, cyrptophytes, cyanobacteria, green algae, and measures of total algae. This time period corresponds to expanded shoreline development around Magnor Lake as well as extensive agriculture in the basin that likely contributed to nutrient loading to the lake. Improvements in water quality since the early 2000s based on monitoring data are not captured in the pigment data because of limitations in sampling resolution near the core top.

Management recommendations based on this paleolimnological analysis include:

1. There are additional analyses that can be run on the Magnor sediment core. Because only four core samples were analyzed for diatoms, we have no evidence of when total phosphorus began increasing in Magnor Lake nor when the diatom communities shifted from a mesotrophic to a eutrophic community. Understanding the timing of these increases may help guide management actions especially if specific land use changes correspond to timing of nutrient increases. We should note that we are awaiting analysis of fossil pigment data from Magnor Lake that may provide some evidence of the timing of community change among all algal groups.
2. Monitoring data from 2001-2019 record steadily decreasing levels of total phosphorus from well over 100 ppb TP in the 2000s to values that are more commonly measured in the 30–60 ppb TP range. These declines in TP are a testament to successful effort in the watershed to curtail nutrient loading. These efforts should continue with the target of

getting annual mean TP level below the state standard of 30 ppb TP. Lake management is a tool that takes time and the trend in Magnor Lake tells us that we need to keep up the good work and continue all efforts of lakeshore management and nutrient reduction.

3. It is clear from monitoring data that there is both high seasonal and high interannual variation in nutrient levels in Magnor Lake. Many years show increasing TP levels as summer progresses. Understanding the mechanism driving those late summer elevated TP values might help target management efforts. One suggestion would be to deploy a high frequency monitoring buoy for a couple of seasons to get real-time temperature and oxygen profiles from Magnor Lake. Phosphorus fractions in the core suggest that internal loading may be an issue for Magnor and understanding the timing and breakdown of stratification would help in understanding what is fueling Magnor's cyanobacterial blooms (especially their interannual variability). Magnor's depth (max depth ~26 ft) makes it highly susceptible to early breakdown of its thermocline and release of sediment P to the water column. The St. Croix Watershed Research Station could help set up, maintain, and interpret this type of buoy system.

4. Many of Polk County's lake management efforts have benefitted from determining a lake's potential for internal loading using sediment core incubations. Short sediment cores are incubated under oxic and anoxic conditions to determine risk and potential loading P loading rates to the lake. These analyses are available from the St. Croix Watershed Research Station and are especially valuable if alum treatments are necessitated for controlling internal loads to a lake such as Magnor.

Pontoon Classroom

A pontoon classroom opportunity was offered to members of the Magnor/Barbo Lake District when the sediment core was collected on October 11th, 2019. A number of District members attended and were able to experience the sediment core collection process and learn more about the study completed on Magnor Lake.



Polk County Ordinances

One way the Polk County Board establishes policy is by adopting ordinances. Ordinances are local laws prescribing rules of conduct and are enforced by county officials.

Ordinances become a permanent part of the governmental code and may be amended from time to time. Once policy has been approved by the county board of supervisors through plans, budgets, ordinances, and resolutions, it is the responsibility of county staff to implement the decisions of the board. Ordinances relevant to the Magnor Lake Management Plan are administered by the Land and Water Resources Department and the Department of Land Information Zoning and are briefly summarized below.

Land and Water Resources Department

Manure and Water Quality Management Ordinance

The purpose of this ordinance is to enhance public health, prosperity, and welfare by protecting ground and surface water resources by promoting the proper storage and management of animal waste, including the prohibitions found in NR151.08.

Storm Water Management and Erosion Control Ordinance

The general purpose of this ordinance is to establish regulatory requirements for land development and land disturbing activities aimed to minimize the threats to public health, safety, welfare, and the natural resources in Polk County from construction site erosion and post-construction storm water runoff.

Nonmetallic Mining Reclamation Ordinance

The purpose and goal of this ordinance is to ensure the effective reclamation of nonmetallic mining sites after mining operations have ceased. This ordinance adopts and implements the uniform statewide standards for nonmetallic mining reclamation required by Section 295 of Wisconsin Statute and contained in Wisconsin Administrative Code NR 135. The ordinance in effect means that any proposed nonmetallic mining site (sand, gravel, or other nonmetallic minerals) is required to receive an approved reclamation permit to begin nonmetallic mining operations in Polk County. The permit also requires the development of an approved site specific reclamation plan and for the operator to post financial assurance to guarantee the completion of reclamation.

Illegal Transport of Aquatic Plants and Invasive Animals Ordinance

The purpose of this ordinance is to prevent the spread of aquatic invasive species in Polk County and surrounding waterbodies in order to protect property values and the property tax base and ensure quality recreational opportunities. It requires all plants and invasive animals be removed from a boat and trailer prior to entering a public roadway.

Land Information-Zoning

Comprehensive Land Use Ordinance

The purpose of this ordinance is to promote and protect public health, safety, and other aspects of the general welfare. Further purposes of this ordinance are to: aid in the implementation of provisions of the county comprehensive plan; promote planned and orderly land use development; protect property values and the property tax base; fix reasonable dimensional requirements to which buildings, structures, and lots shall conform; prevent overcrowding of the land; advance uses of land in accordance with its character and suitability; provide property with access to adequate sunlight and clean air; aid in protection of groundwater and surface water; preserve water quality, shorelands, and wetlands; protect the beauty of landscapes; conserve flora and fauna habitats; preserve and enhance the county's rural characteristics; protect vegetative shore cover; promote safety and efficiency in the county's road transportation system; define the duties and powers of certain county officers and administrative bodies relative to the application, administration, and enforcement of the ordinance; and prescribe penalties in the form of civic forfeitures for violations of this ordinance and to facilitate enforcement of the provisions of this ordinance by injunctive relief.

Shoreland Protection Ordinance

The purpose of these shoreland regulations is to ensure the proper management and development of the shoreland of all navigable lakes, ponds, flowages, rivers, and streams in the unincorporated areas of Polk County. The intent of these regulations is to further the maintenance of safe and healthful conditions; prevent and control water pollution; protect spawning ground for fish and aquatic life; control building sites, placement of structures, and land uses; and preserve shore cover and natural beauty.

Private Sewage System Ordinance

The underlying principles of this ordinance are basic goals in environment, health, and safety accomplished by proper siting, design, installation, inspection, maintenance, and

management of private on-site waste treatment systems and non-plumbing sanitary systems.

Subdivision Ordinance

The purpose of this ordinance is to regulate and control subdivision development within Polk County to promote public health, safety, general welfare, water quality, and aesthetics. This purpose can be accomplished by requiring an orderly layout and use of land, providing safe access to highways, roads and streets, facilitating adequate provision of water, sewer, transportation and surface drainage systems and parks, playgrounds, and other public facilities.

Lower St. Croix Riverway Ordinance

The purpose of this ordinance is to promote the public health, safety, and general welfare of the public by: reducing the adverse effects of overcrowding and poorly planned shoreline and bluff area development; preventing soil erosion and pollution and contamination of surface water and groundwater; providing sufficient space on lots for sanitary facilities; minimizing flood damage; maintaining property values; and preserving and maintaining the exceptional scenic, cultural, and natural characteristics of the water and related land of the Lower St. Croix Riverway in a manner consistent with the National Wild and Scenic Rivers Act, the Federal Lower St. Croix River Act of 1972, and the Wisconsin Lower St. Croix River Act.

Floodplain Ordinance

This ordinance is intended to regulate floodplain development in order to minimize the potential for damage, the expenditure of public funds for flood control projects, and interruptions to businesses or other land uses.

Related Plans

The Magnor Lake Management Plan is meant to direct the activities of the Magnor/Barbo Lake District through the development of goals, objectives, and activities for a five year timeframe.

However, the planning process is not unique to Magnor Lake and many organizations have plans with goals, objectives, and activities which are related to or align with those of the Magnor Lake Management Plan.

Lake St. Croix Total Maximum Daily Load (TMDL) Implementation Plan, 2013

The St. Croix Lake TMDL plan calls for a 38% reduction in the human-caused phosphorus carried to the rivers and streams of the basin, and eventually entering the St. Croix River and Lake St. Croix. The TMDL sets goals for each watershed in the basin, based on land cover and land uses practices. It also sets a cap on the amount of phosphorus that can be discharged each year by wastewater treatment plants serving communities and industries in the St. Croix Basin. Polk County's phosphorus load is 160,976 pounds of phosphorus per year, which is the largest of any county in the basin.

Subwatershed	Acres in Basin	Loading (lbs/year)	TMDL Load Reduction
Apple	303,298	84,087	28,493
Clam	74,533	14,393	3,733
Trade	60,563	11,607	3,098
Trout	46,172	14,599	5,099
Willow	26,821	9,055	3,350
Wolf	69,725	21,339	7,310
Wood	24,301	5,897	1,676

The Squaw Lake, Lake Mallalieu, and Cedar Lake TMDL also exist within the boundary of the Lake St. Croix TMDL. The Squaw Lake and Cedar Lake TMDL boundary includes land in Polk and St. Croix County and the Lake Mallalieu TMDL includes land in St. Croix, Polk, and Barron County.

Agriculture and Farmland Preservation Plan, 2014

Under Chapter 91, a county must have a certified farmland preservation plan. The Polk County Agricultural and Farmland Preservation Plan identifies the county's goals and policies related to farmland preservation and agricultural development and identifies farmland preservation areas, agricultural enterprise areas, and areas for development within the next 15 years.

Polk County Aquatic Invasive Species Strategic Plan, 2015-2020

This plan provides an overview of aquatic invasive species in Polk County and includes an implementation plan to direct aquatic invasive species work.

Goal 1. Prevent the introduction, establishment, and spread of AIS in Polk County waterbodies

Goal 2. Control populations of aquatic invasive species

Goal 3. Monitor Polk County waterbodies for AIS and document results

Goal 4. Provide AIS information and education in Polk County and surrounding areas

Goal 5. Sustain the implementation of the plan

Polk County Comprehensive Plan, 2009-2029

The Polk County Comprehensive Plan presents a vision for the future of Polk County, with long-range goals, objectives, and policies for housing, transportation, utilities and community facilities, economic development, intergovernmental cooperation, land use, energy and sustainability, and agricultural, natural, and cultural resources.

St. Croix-Red Cedar Cooperative Weed Management Area Strategic Management Plan, 2017

The St. Croix Red Cedar (SCRC) Cooperative Weed Management Area (CWMA) is a partnership of local, state, tribal, and federal agencies, businesses, nonprofits, community organizations, and individuals. Formed in 2013, the group combats invasive species in Washburn, Barron, Burnett, Polk, and St. Croix Counties in northwestern Wisconsin. The SCRC CWMA fosters multi-generational awareness of invasive species and works to prevent and limit their intrusive impacts through partnerships.

Goal 1. Raise public awareness about invasive species through education and outreach efforts

Goal 2. Develop an early detection and management framework

Goal 3. Maintain and build organizational capacity

Polk County Outdoor Recreation Plan, 2014-2019

This plan assesses the existing recreation system in Polk County, identifies recreation needs based upon public input and recreation standards, sets forth goals and objectives to be used as guidelines in formulating recreation plans, and establishes recommendations for improving the recreation system over the next five years.

Polk County Forest Comprehensive Land Use Plan, 2006-2020

The County Forest Comprehensive Land Use Plan seeks to use sustainable forest management practices to protect forestry resources for present and future ecological and socioeconomic needs.

State of the St. Croix Basin, 2002

The Wisconsin Department of Natural Resources prepared the State of the St. Croix Basin in March 2002. The report describes the status of land and water resources in the Wisconsin portion of the basin. Goals for the St. Croix Basin include maintaining and improving water and air quality; maintaining diverse, rich shoreland habitat; preserving large contiguous blocks of forestland; working with the agricultural community to minimize non-point runoff; and working with cities, villages, towns, and counties to help stem urban sprawl.

St. Croix National Scenic Riverway Management Plans

A Cooperative Management Plan was completed for the Lower St. Croix National Scenic Riverway in 2002 and a General Management Plan for the Upper St. Croix and Namekagon Rivers was completed in 1998. The plans describe the direction the National Park Service intends to follow to manage the upper and lower riverways for the next 15-20 years.

Polk County Land and Water Resource Management Plan, 2020-2029

In 1997, a County Land and Water Resource Management Planning Program was created through amendments to Chapter 92.10 of the Wisconsin Statutes in Wisconsin Act 27. Act 27 directed the Wisconsin Department of Natural Resources (WDNR) to prescribe performance standards and prohibitions that farms in Wisconsin need to meet to reduce non-point source pollution and improve water quality. Act 27 also directed the Wisconsin Department of Agriculture, Trade and Consumer Protection (WDATCP) in conjunction with the WDNR to promulgate rules that prescribe technical standards and best management practices agriculture producers must follow to meet the performance standards. In October 2002, the rules were promulgated into law. WDNR administrative code NR 151 identifies the agricultural and urban performance standards for Wisconsin and WDATCP administrative code ATCP 50 sets the technical standards that agriculture producers will need to follow to implement the performance standards. County Land and Water Resource Management (LWRM) Plans are the local mechanism to implement NR 151.

- Goal 1. Protect and improve the water quality of lakes, rivers, and streams
- Goal 2. Protect and improve groundwater quality and quantity
- Goal 3. Sustain and enhance land resources
- Goal 4. Support and develop community stewardship and partnerships to improve our natural resources

Lake Management Plans

Lake studies identify challenges and threats to a lake's health along with opportunities for improvement. These studies identify practices already being implemented by watershed residents to improve water quality and areas providing benefits to a lake's ecosystem. Additionally, these studies quantify practices or areas on the landscape, or within the lake, which have the potential to negatively impact the health of a lake and identify best management practices for improvement.

The end product of most lake studies is a lake management plan which identifies goals, objectives, and action items to either maintain or improve the health of a lake. These goals should be realistic based on inherent lake and watershed characteristics (lake size, depth, land use, etc.) and should align with the goals of watershed stakeholders. Lake management plans are designed to be working documents that are used to guide the actions that take place to manage a specific lake. Additionally, having an approved lake management plan allows lake organizations to apply for WDNR funding to implement improvement projects. WDNR approved Comprehensive Lake Management Plans are usually written for a ten year timeframe and exist for a number of Polk County lakes.

Aquatic Plant Management Plans

In many cases an Aquatic Plant Management plan is required to apply for a permit to remove, add, or control aquatic plants. Generally, Aquatic Plant Management Plans describe the lake, present the aquatic plant management circumstances for a lake, and propose a set of goals and actions for managing aquatic plants in the lake. WDNR approved Comprehensive Aquatic Plant Management Plans are usually written for a five year timeframe and exist for a number of Polk County lakes.

Priority Watershed Plans

Priority watershed plans have been completed for the Balsam Branch Watershed, Horse Creek Watershed, and the Osceola Creek Watershed. Priority watershed planning provided a funding mechanism in the 1980s to begin implementing water quality and habitat improvement activities in these watersheds. Through the Priority Watershed

Planning program, the WDNR ranked watersheds for nonpoint source problems to identify high priority areas under the state's Nonpoint Source Pollution Abatement Program. Today the WDNR uses these watershed and waterbody rankings to direct funding decisions in the Targeted Runoff Management Grant Program and identify specific work tasks needed in the watershed.

Implementation Plan Development

Lake management plans help protect natural resource systems by encouraging partnerships between concerned citizens, lakeshore residents, watershed residents, agency staff, and diverse organizations. They identify concerns of importance and set realistic goals, objectives, and action items to address each concern. Additionally, lake management plans identify roles and responsibilities for meeting each goal and provide a timeline for implementation.

Lake management plans are living documents which are under constant review and adjustment depending on the condition of a lake, available funding, level of volunteer commitments, and the needs of lake stakeholders.

The vision statement, guiding principles, and lake management plan goals presented below were created through collaborative efforts using current and past water quality data and a series of five meetings by the Magnor/Barbo Lake District Plan Committee held in winter for 2020/2021. Key study details were presented to the Magnor/Barbo Lake District over the course of the project. Additionally, the draft vision statement, guiding principles, and lake management plan goals were presented at the March 1st, 2021 Lake District Board Meeting.

The draft plan was posted on the Polk County Land and Water Resources Department website and opened for a 30 day public comment period ending on April 14th, 2021. A notice of public comment was published in the Amery Free Press on March 3rd, 2021 and March 10th, 2021. There was no public comments received. The plan was approved by the Magnor/Barbo Lake District on May 3rd, 2021 and by the Wisconsin Department of Natural Resources on June 22nd, 2021 .

Implementation Plan

Vision an overall statement for what you want Magnor Lake to look like

Magnor Lake is a high quality lake with a healthy ecosystem supporting recreation, fishing, and wildlife while providing the community a family gathering place.

Goal 1. Improve water quality in Magnor Lake to reduce nuisance algae blooms

Goal 2. Protect, maintain, and enhance native fish and wildlife habitat and diversity while enhancing the scenic beauty of Magnor Lake

Goal 3. Maintain and improve navigation routes in Magnor Lake while protecting the natural functions of native plants

Goal 4. Implement an aquatic invasive species (AIS) monitoring, prevention, and control program on Magnor Lake

Goal 5. Use multiple strategies to ensure the goals of the plan are met

Goal 1. Improve water quality in Magnor Lake to reduce nuisance algae blooms

Magnor Lake is listed on the Wisconsin DNR's Impaired Waters List for total phosphorus and chlorophyll a for both recreational use and fish and aquatic life use. This goal will be met when water quality on Magnor Lake reaches a level when it can be removed from the Impaired Waters List: total phosphorus is less than 30 µg/l and chlorophyll a is less than 20 µg/l for 95% of the days during the sampling season. Reaching these thresholds will reduce nuisance algae blooms and help to accomplish further goals in this plan (enhance the fishery and improve wildlife habitat).

Both inlets to Magnor Lake are exceeding the State Standard for total phosphorus and are contributing phosphorus to the lake. The East and Southern Subwatersheds are contributing the highest load per acre of phosphorus to Magnor Lake.

- A. Partner with agricultural landowners to install best management practices that will reduce phosphorus reaching Magnor Lake.

Priority will be given to landowners in the East and Southern Subwatersheds

1. Meet once a year with the Polk County Land and Water Resources Department to identify best management practices prioritized by ACPF
2. Initiate meetings with landowners to discuss options for technical assistance and funding for the installation of best management practices prioritized by ACPF
3. Invite agricultural landowners in the watershed to District meetings
4. Recognize agricultural landowners who have taken steps to reduce phosphorus from reaching Magnor Lake

- B. Install best management practices that will reduce phosphorus entering Magnor Lake from developed sites

1. Partner with Polk County and the Richardson Sportsmen Club to address runoff at the boat landing
2. Partner with the Town to address erosion associated with the culverts on the roads directly surrounding Magnor Lake
3. Partner with the Lake Magnor Store to address runoff to the inlet from Mud Lake

- C. Install best management practices that will reduce phosphorus entering Magnor Lake from shoreline residential properties

1. Provide information on the Healthy Lakes program and the best management practices funded through this program: shoreline native plantings, rain gardens, diversions, and rock infiltration)

2. Identify landowners interested in installing best management practices
 3. Offer site visits to landowners interested in installing best management practices
Prioritize landowners with mowed vegetation at the shore (shoreline survey results) and those with steep slopes (slope map)
 4. Apply for and implement a Healthy Lakes Grant
 5. Offer tours of properties where practices have been installed to generate interest in the program
 6. Recognize landowners who have installed best management practices
 7. Install WDNR signs at Healthy Lakes project sites
- D. Reduce sediment disturbance on Magnor Lake
1. Ensure residents and visitors are aware of the slow-no-wake requirements within 100 feet of the shoreline
 2. Partner with Polk County to install signage at the landing related to power loading
- E. Engage stakeholders in improving water quality by increasing their understanding of the importance of installing best management practices to reduce phosphorus
- Messages to convey*
- *Phosphorus is the nutrient responsible for excessive plant and algae growth in Magnor Lake*
 - *Major sources of phosphorus to a lake include: lawn and agricultural fertilizers, soil erosion, human and animals waste, and runoff from the landscape*
 - *Natural shorelines and vegetated surfaces limit the amount of runoff, soil erosion, and amount of phosphorus that reaches Magnor Lake*
 - *Cover crops, ground cover, and reduced tillage limit runoff, erosion, and phosphorus from agricultural landscapes*
 - *Erosion control practices associated with new development reduce runoff, erosion, and phosphorus*
 - *Wetlands filter sediment and nutrients (including phosphorus) from runoff*
 - *Best management practices exist to reduce the harmful effects of runoff and soil erosion: shoreline restoration, rain gardens, infiltration, diversions, sediment ponds, grassed waterways/buffers, etc.*
 - *Grant funding is available to install best management practices*

Goal 2. Protect, maintain, and enhance native fish and wildlife habitat and diversity while enhancing the scenic beauty of Magnor Lake

Over ninety percent of all lake life is born, raised, and fed in the area where land and water meet. The conversion of natural shorelines to lawns and impervious surfaces removes critical habitat which wildlife depends on. The removal of coarse woody habitat, or trees and branches that fall into a lake, cause decreases in habitat for fish and aquatic organisms. Creating and restoring natural shoreline will provide critical habitat for fish and wildlife while also reducing nutrients entering the lake.

A. Continue to partner with the Richardson Sportsmen Club to stock fish in Magnor Lake

B. Maintain and expand habitat for fish and wildlife

1. Increase native plants on the shoreline of Magnor Lake, see goal 1B
2. Work with WDNR fisheries biologist to identify ideal locations for fish sticks and prepare a Healthy Lakes Grant application to fund installation

The shoreline inventory shows current woody habitat in Magnor Lake. A meeting could be set up with the fisheries biologist to determine locations for fish sticks

3. As undeveloped, highly erodible, and/or ecologically sensitive land in the Magnor Lake Watershed comes up for sale consider the costs and benefits of its purchase

Purchased land could be designated as a public recreational area including: trails, wildlife viewing, etc.

4. Prevent the introduction of invasive species, see goal 4

C. Engage property owners in protecting, maintaining, and enhancing fish and wildlife habitat and diversity by increasing their understanding of the importance of native vegetation and coarse woody habitat

Messages to convey

- *Ninety percent of a lake ecosystem depends on what happens in the littoral zone, or the area of a lake close to shore*
- *Leaving fallen trees in the lake provides habitat for fish and aquatic animals*
- *Natural shorelines reduce nutrients entering a lake and provide critical habitat for fish, wildlife, and pollinators.*

Goal 3. Maintain and improve navigation routes in Magnor Lake while protecting the natural functions of native plants

Significant navigation concerns exist in the southwest bay of Magnor Lake. However, navigation concerns also exist in other parts of the lake. A combination of options (manual removal, harvesting, and chemical control) will be used to manage native vegetation and improve navigation in Magnor Lake. Permits are required for both harvesting and chemical control. Control and removal of native aquatic plants are not eligible for WDNR grant funding. However, control and removal of invasive aquatic plants would be eligible for funding. In 2020 curly-leaf pondweed, an aquatic invasive species, was documented at a single site. Native plants are important for fish and wildlife, nutrient uptake, and protection against the establishment of invasive species.

A. Explore options to improve conditions in the Southwest Bay of Magnor Lake

The Southwest Bay of Magnor Lake is designated as a Sensitive Area (Section 30.01(6b), Wisconsin State Statue), which limits management options.

1. Explore dredging as an option for restoring a sandy bottom in the bay

Determine accurate depths in the Southwest Bay to define where dredging would be permitted.

2. Explore hand removal and herbicide as options for improving navigation in the bay

Management of native plant species is not eligible for grant funding. Two options were prioritized for the Southwest Bay: hand removal and herbicide. The preferred location of a shared navigation channel was determined. Likely herbicide would be the only option available to manage plants in the shared navigation channel (due to depths being less than 3 feet). Plant management will occur only with financial support from the homeowners directly affected.

B. Assess the impacts of plant removal on lake quality and adapt management as needed to address concerns

C. Convey options for plant management for individual riparian access to lake residents

Manual removal of aquatic vegetation can be done where the shore is being used for a dock or swim raft. Removal must be done without the aid of external or auxiliary power and cannot exceed 30 feet in width. The 30 foot zone cannot be moved, relocated, or expanded with the intent to increase size. Wild rice may not be removed.

D. Increase residents' understanding of the role and importance of aquatic plants in Magnor Lake

Messages to convey

- *Aquatic plants create a thriving habitat for animals: they are essential to the spawning success of many fish species, provide shade and refuge for near shore animals, create oxygen for the animals that live in the littoral zone, and their fruits and tubers provide food for mammals, waterfowl, insects, and fish*
- *Aquatic plants filter runoff from uplands to protect lake water quality*
- *Plant roots create networks that stabilize sediments at the water's edge where waves might otherwise erode the lakeshore*
- *Submersed plants use phosphorus and nitrogen, making them less available for nuisance algae*
- *Native aquatic plants can limit aquatic invasive plant growth*

Goal 4. Implement an aquatic invasive species (AIS) monitoring, prevention, and control program on Magnor Lake

The Magnor Lake aquatic invasive species (AIS) program will include: monitoring for new and existing AIS, prevention of AIS, and removal of existing AIS. Current invasive species in Magnor Lake include: curly-leaf pondweed, purple loosestrife, and Chinese mystery snail. Control options exist for curly-leaf pondweed and purple loosestrife but are limited for Chinese mystery snail.

A. Control existing AIS populations

1. Determine a plan of action for curly-leaf pondweed management

Curly-leaf pondweed was found at a single site on Magnor Lake during the spring 2020 plant survey. A monitoring program should be implemented to determine if the population is expanding and if treatment is warranted. Since curly-leaf pondweed is an invasive species, grant funding is available for its control.

2. Engage individual property owners in purple loosestrife removal for single plants and small stands

Purple loosestrife flowers should be cut, bagged, and disposed of to prevent the spread of seed. Plants can be dug or killed with herbicide (follow regulations).

3. Find at least one volunteer to raise and release beetles for purple loosestrife control in the bay on the west side of the lake

Polk County Land and Water Resources Department provides training for this statewide program

4. If a new AIS is found on the lake, research and determine control options

B. Prevent the establishment of AIS

1. Ensure that local ordinance and state prevention AIS signs are installed at the boat landing and in good condition
2. Continue to participate in the statewide WDNR Landing Blitz and Drain Campaign
3. Consider installing a decontamination station at the boat landing
4. Consider initiating a Clean Boats, Clean Waters program

Polk County Land and Water Resources Department provides trainings for this Statewide Program

C. Monitor for new and existing AIS

1. Find at least one volunteer to participate in the AIS Citizen Lake Monitoring Network Program

Polk County Land and Water Resources Department provides training and materials from WDNR for this statewide Program.

2. Maintain up-to-date maps showing the location of curly-leaf pondweed (see goal 4A1) and purple loosestrife
3. Ensure that lake residents and visitors know how to identify common AIS and where to report new findings

New findings can be reported to Polk County Land and Water Resources Department or a lake contact can be designated

D. Engage property owners in monitoring, preventing, and controlling aquatic invasive species

Messages to convey

- *Currently Magnor Lake has populations of three aquatic AIS: curly-leaf pondweed, purple loosestrife, and Chinese mystery snail*
- *It is important that lake residents know how to identify AIS and who to contact if they locate suspected AIS*
- *Polk County and the State of Wisconsin have regulations that make it illegal to transport aquatic species on public roads*
- *Prevention of AIS establishment is easier and more likely to be successful as compared with AIS management*
- *Wisconsin law requires the following prevention strategies: INSPECT your boat, trailer, and equipment, REMOVE any attached aquatic plants or animals (before launching, after loading and before transporting on a public highway), DRAIN all water from boats, motors and all equipment, NEVER MOVE live fish away from a waterbody, DISPOSE of unwanted bait in the trash, and BUY minnows from a Wisconsin bait dealer and use leftover minnows only on the same water or on other waters if no lake or river water or fish were added to their container*
- *Early identification of a small population of AIS increases the likelihood that the AIS can be successfully managed*

Goal 5. Use multiple strategies to ensure the goals of the plan are met

Strategies to ensure the goals of the plan are met include: communicating with lake stakeholders, forming committees to implement the plan, and evaluating the progress of lake management efforts.

A. Engage stakeholders in meeting the goals of the Magnor Lake Management Plan

Messages to convey

- *Lake Management Plans identify goals, objectives, and activities to maintain and improve the health of a lake*
- *Lake Management Plans are designed to be working documents that adapt as new issues and conditions arise*
- *Lake Management Plan implementation success relies on participation by landowners in the Magnor Lake Watershed*
- *Grant funding is available from WDNR to cost share up to 75% of the costs of eligible projects in the Magnor Lake Management Plan*

B. Evaluate the progress of lake management efforts through data collection efforts

1. Ensure that a volunteer is in place to collect phosphorus, chlorophyll a, and secchi disk data each year through the WDNR Citizen Lake Monitoring Network program
2. Conduct a whole lake aquatic plant point intercept survey every 5 years to evaluate environmental impacts of plant management
3. Repeat the 2018-2019 water quality study in ten years

C. Review and summarize the progress of plan implementation

1. Form committees to develop an action plan for each goal
2. Identify current and future barriers to implementing each goal
3. Seek funding through WDNR or other sources to implement the action plan for each goal
4. Report actions completed, in progress, or not completed to the Lake District Board
5. Report progress to Lake District members
6. Adapt the plan as new issues arise

D. Use the information and education strategy to communicate with lake stakeholders

The information and education strategy includes: target audience, messages to convey, and methods used to reach the target audience. Messages to convey are included under each goal.

Target audience

- *Property owners with shoreline*
- *Property owners in the Magnor Lake Watershed*
- *Lake visitors*
- *Local government: Town, Village, County partners*
- *Richardson Sportsmen Club*

Methods to reach the target audience

- *Presentations, workshops and trainings at Lake District Board and Annual Meetings, schools and youth events, and community events,*
- *Attendance at meetings (Town, County, Lake Organization, Richardson Sportsmen Club) and events*
- *Public displays and posters*
- *Signs/information at the boat landing*
- *Brochures (existing and newly designed)*
- *Lake District Facebook page, website, and newsletter*
- *One-on-one site visits, technical assistance, and offer of financial assistance to lakeshore and watershed property owners interested in implementing practices to improve Magnor Lake*
- *Recognition of landowners implementing practices to improve Magnor Lake*
- *Tours and demonstration sites highlighting best management practices*

Acronyms used for partners in the following implementation table

WDNR = Wisconsin Department of Natural Resources

LWRD = Polk County Land and Water Resources Department

MBLD = Magnor/Barbo Lake District

CON = Consultant

Acronyms used for funding sources in the following implementation table

LPL = WDNR Lake Planning Grant Program, funds 67% of eligible projects costs

LPR = WDNR Lake Protection Grant Program, funds 75% of eligible project costs

LPR-HL = WDNR Healthy Lakes Grant Program, funds 75% of eligible project costs

AEPP = WDNR Aquatic Invasive Species Grant Program, funds 75% of eligible project costs

Goal 1. Improve water quality in Magnor Lake to reduce nuisance algae blooms	Priority	\$ Estimate	Volunteer hours	Partners with MBLD	Funding sources
A. Partner with agricultural landowners to install best management practices that will reduce phosphorus reaching Magnor Lake	High	\$ - \$\$\$		LWRD, CON	LPR
1. Meet once a year with the Polk County Land and Water Resources Department to identify best management practices prioritized by ACPF		No cost			
2. Initiate meetings with landowners to discuss options for technical assistance and funding for the installation of best management practices prioritized by ACPF		No cost			
3. Invite agricultural landowners in the watershed to District meetings					
4. Recognize agricultural landowners who have taken steps to reduce phosphorus from reaching Magnor Lake					
B. Install best management practices that will reduce phosphorus entering Magnor Lake from developed sites	Medium	\$ - \$\$\$		LWRD, CON	LPR
1. Partner with Polk County and the Richardson Sportsmen Club to address runoff at the boat landing					
2. Partner with the Town to address erosion associated with the culverts on the roads directly surrounding Magnor Lake					
3. Partner with the Lake Magnor Store to address runoff to the inlet from Mud Lake					
C. Install best management practices that will reduce phosphorus entering Magnor Lake from shoreline residential properties	Low	\$ - \$\$\$		LWRD, CON	LPR, LPR-H
1. Provide information on the Healthy Lakes program and the best management practices funded through this program: shoreline native plantings, rain gardens, diversions, and rock infiltration)		Grant (75%): \$1000/ project			
2. Identify landowners interested in installing best management practices					
3. Offer site visits to landowners interested in installing best management practices					
4. Apply for and implement a Healthy Lakes Grant					

5. Offer tours of properties where practices have been installed to generate interest in the program					
6. Recognize landowners who have installed best management practices					
7. Install WDNR signs at Healthy Lakes project sites					
D. Reduce sediment disturbance on Magnor Lake	Low				
1. Ensure residents and visitors are aware of the slow-no-wake requirements within 100 feet of the shoreline					
2. Partner with Polk County to install signage at the landing related to power loading					
E. Engage stakeholders in improving water quality by increasing their understanding of the importance of installing best management practices to reduce phosphorus	Medium				

Goal 2. Protect, maintain, and enhance native fish and wildlife habitat and diversity while enhancing the scenic beauty of Magnor Lake	Priority	\$ Estimate	Volunteer hours	Partners with MBLD	Funding sources
A. Continue to partner with the Richardson Sportsmen Club to stock fish in Magnor Lake	High				
B. Maintain and expand habitat for fish and wildlife	High				
1. Increase native plants on the shoreline of Magnor Lake, see goal 1B					LPR-H
2. Work with WDNR fisheries biologist to identify ideal locations for fish sticks and prepare a Healthy Lakes Grant application to fund installation		Grant (75%): \$1000/ project		LWRD, WDNR	LPR-H
3. As undeveloped, highly erodible, and/or ecologically sensitive land in the Magnor Lake Watershed comes up for sale consider the costs and benefits of its purchase					
4. Prevent the introduction of invasive species, see goal 4					AEPP
C. Engage property owners in protecting, maintaining, and enhancing fish and wildlife habitat and diversity by increasing their understanding of the importance of native vegetation and coarse woody habitat	Medium				

Goal 3. Maintain and improve navigation routes in Magnor Lake while protecting the natural functions of native plants	Priority	\$ Estimate	Volunteer hours	Partners with MBLD	Funding sources
A. Explore options to improve conditions in the Southwest Bay of Magnor Lake	Medium				
1. Explore dredging as an option for restoring a sandy bottom in the bay		\$\$\$			
2. Explore hand removal and herbicide as options for improving navigation in the bay		\$			
B. Assess the impacts of plant removal on lake quality and adapt management as needed to address concerns	Medium				
C. Convey options for plant management for individual riparian access to lake residents	Low				
D. Increase residents' understanding of the role and importance of aquatic plants in Magnor Lake	Low				

Goal 4. Implement an aquatic invasive species (AIS) monitoring, prevention, and control program on Magnor Lake	Priority	\$ Estimate	Volunteer hours	Partners with MBLD	Funding sources
A. Control existing AIS populations	High				AEPP
1. Determine a plan of action for curly-leaf pondweed management					
2. Engage individual property owners in purple loosestrife removal for single plants and small stands		\$		LWRD	
3. Find at least one volunteer to raise and release beetles for purple loosestrife control in the bay on the west side of the lake		No cost	30/year	LWRD	
4. If a new AIS is found on the lake, research and determine control options					
B. Prevent the establishment of AIS	Medium			LWRD	AEPP
1. Ensure that local ordinance and state prevention AIS signs are installed at the boat landing and in good condition		No cost	1/year		
2. Continue to participate in the statewide WDNR Landing Blitz and Drain Campaign		No cost	10/year		

3. Consider installing a decontamination station at the boat landing		\$			
4. Consider initiating a Clean Boats, Clean Waters program		\$\$			
C. Monitor for new and existing AIS	Medium			LWRD	AEPP
1. Find at least one volunteer to participate in the AIS Citizen Lake Monitoring Network Program		No cost	10/year		
2. Maintain up-to-date maps showing the location of curly-leaf pondweed (see goal 4A1) and purple loosestrife		\$			
3. Ensure that lake residents and visitors know how to identify common AIS and where to report new findings					
D. Engage property owners in monitoring, preventing, and controlling aquatic invasive species	Medium				AEPP

Goal 5. Use multiple strategies to ensure the goals of the plan are met	Priority	\$ Estimate	Volunteer hours	Partners with MBLD	Funding sources
A. Engage stakeholders in meeting the goals of the Magnor Lake Management Plan	High				
B. Evaluate the progress of lake management efforts through data collection efforts	High				LPL
1. Ensure that a volunteer is in place to collect phosphorus, chlorophyll a, and secchi disk data each year through the WDNR Citizen Lake Monitoring Network program		No cost	10/year		
2. Conduct a whole lake aquatic plant point intercept survey every 5 years to evaluate environmental impacts of plant management		\$		LWRD, CON	
3. Repeat the 2018-2019 water quality study in ten years		\$\$		LWRD, CON	
C. Review and summarize the progress of plan implementation	High				
1. Form committees to develop an action plan for each goal					

2. Identify current and future barriers to implementing each goal					
3. Seek funding through WDNR or other sources to implement the action plan for each goal					
4. Report actions completed, in progress, or not completed to the Lake District Board					
5. Report progress to Lake District members					
6. Adapt the plan as new issues arise					
D. Use the information and education strategy to communicate with lake stakeholders	Medium				