Birch Island Lake Water Quality Study

Prepared for
Nine Mile Creek Watershed District

January 2024

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REPORT SUMMARY

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Watershed District

9 MILE CREEK WATERSHED DISTRICT

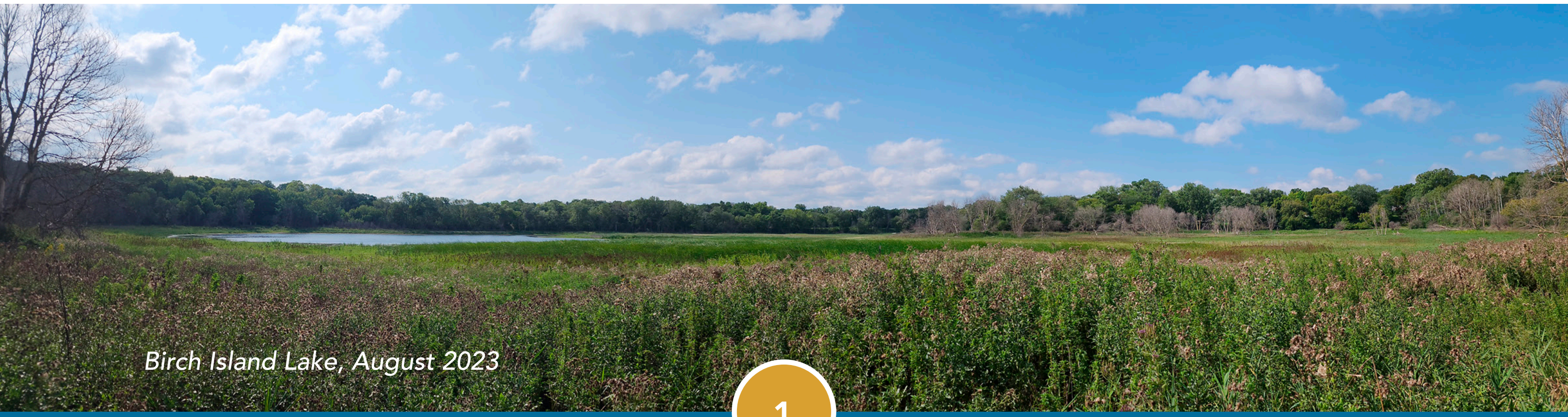
REPORT SUMMARY CONTENTS

- Water Quality Goals to Protect and Enhance Our Lakes
- Current Lake Conditions
- Lake Management Alternatives

Water Quality Goals to Protect and Enhance Our Lakes

Birch Island Lake is a shallow, urban lake located in the northern portion of the city of Eden Prairie, south of County Road 62 and west of Highway 494. Monitoring data collected in the past 5 years indicates degrading water quality conditions. The Nine Mile Creek Watershed District (NMCWD), a local unit of government that works to address water-related problems, conducted a study of Birch Island Lake in 2022–2023 to evaluate current water quality and identify protection and improvement strategies. The study incorporated additional data and advanced modeling and analysis methods to confirm the findings of a 2000 NMCWD study. Additional information on the current lake conditions, water quality challenges, and recommended management strategies, including implementation timelines, are summarized in this project overview.

Protecting and enhancing the water quality of the lakes within the Nine Mile Creek watershed is one of the primary goals of the Nine Mile Creek Watershed District. The NMCWD's lake management program includes data collection (monitoring), assessment (e.g., studies), and implementation of projects and programs to protect and improve water quality and ecosystem health. Using monitoring data collected in recent years (2019 and 2020), the objectives of this study were to assess or "diagnose" the lake's water quality problems, understand the cause or sources of the problems, and recommend management strategies to improve the water quality and overall health of the lake.



Birch Island Lake, August 2023

Birch Island Lake, June 2015

Lake Management Goals

When assessing the ecological health of a lake, it is important to take a holistic approach, considering factors such as in-lake water quality (e.g., phosphorus and nitrogen concentrations), the health and quality of the aquatic communities, and water quantity (see Figure 1). How recreation and wildlife habitat affect and are affected by overall lake health are also considered. Numerical goals exist for some of these factors, such as state water quality standards. However, other factors are assessed relative to narrative criteria that describe the desired condition and do not have strict numerical goals. For this study, the primary goals are to achieve the water quality standards for shallow lakes; attain a diverse, native macrophyte (aquatic plant) population; and support a healthy, balanced aquatic ecosystem.

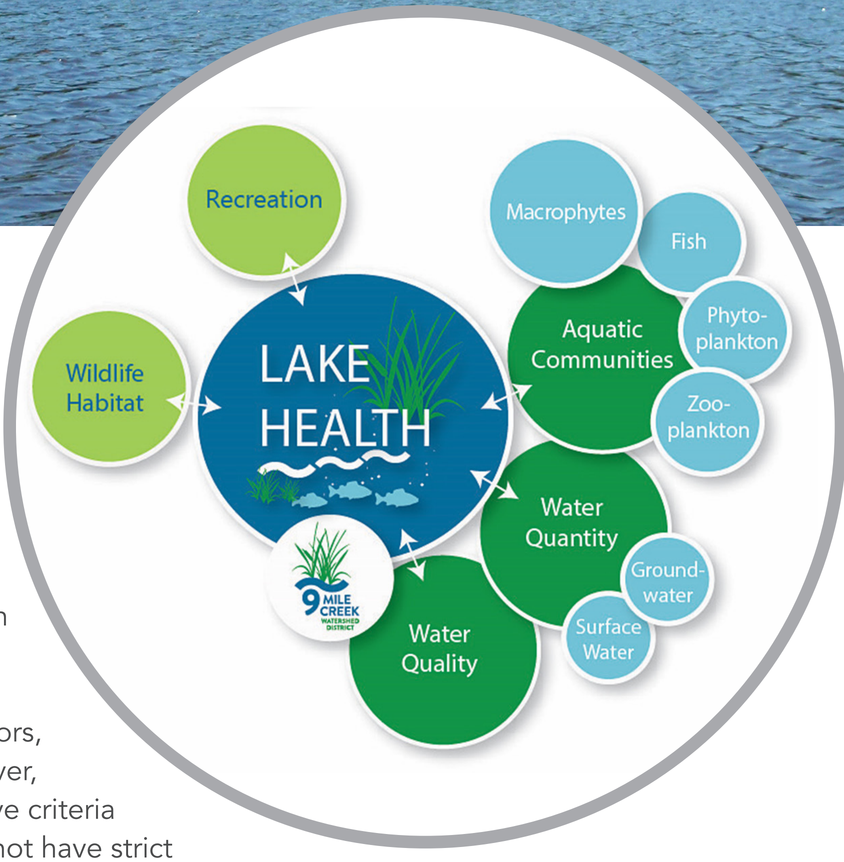


Figure 1
NMCWD Holistic Lake Health Assessment Factors

For this study, the primary goals are to achieve the water quality standards for shallow lakes; attain a diverse, native aquatic plant population; and support a healthy, balanced aquatic ecosystem.

9 MILE CREEK WATERSHED DISTRICT


Birch Island Lake, October 2022

Current Lake Conditions

Currently, the state of Minnesota uses three parameters to indicate lake health and help track and quantify water quality changes. These three parameters include:

1) Total Phosphorus, which is a nutrient that can fuel algae and plant growth (Figure 2)

2) Chlorophyll-*a*, which is a measurement of algae growth (Figure 3)

3) Secchi disk transparency depth, which is a measurement of lake clarity. (Figure 4)

Recent monitoring data indicate that Birch Island Lake is not meeting Minnesota's water quality standards for shallow lakes in the Twin Cities. The observed summer average (June 1 - Sept 30) total phosphorus and chlorophyll-*a* concentrations exceeded Minnesota's shallow lake water quality standards (60 µg/L total phosphorus and 20 µg/L chlorophyll-*a*) in the two most recent monitoring years, 2020 and 2021. Lake water clarity was also poor in 2020 and 2021 with summer average transparency depths below the shallow lake standard of 1 meter. The degrading water quality is primarily due to excess nutrients in the lake, which fuels algal growth and decreases water clarity.

Blue-green algae, or cyanobacteria, have historically been found in Birch Island Lake since monitoring began, with a notable increase in abundance in 2015. Blue-green algae are associated with water quality problems and can be a source of health concerns not only for humans that use the lake, but for wildlife.


Example blue-green algae bloom

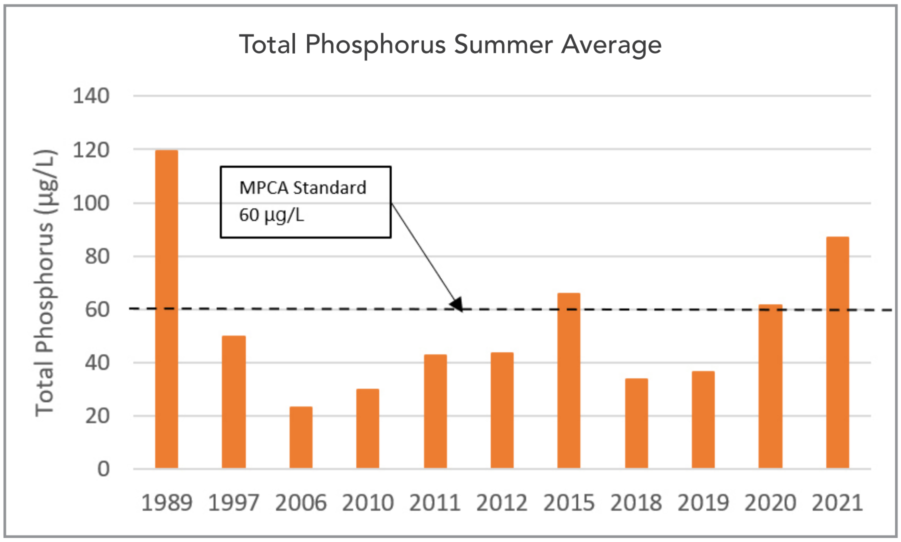


Figure 2
Summer average total phosphorus concentrations measured in Birch Island Lake between 1989 and 2021

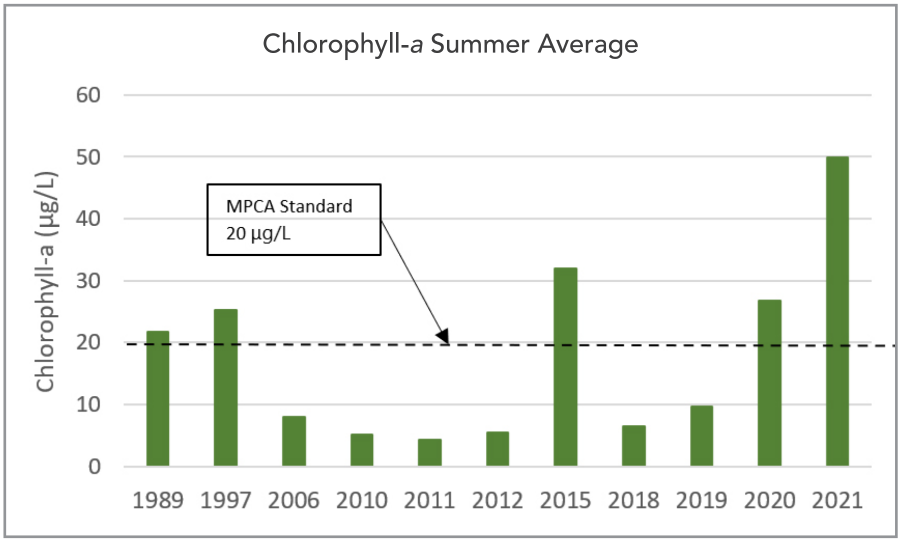
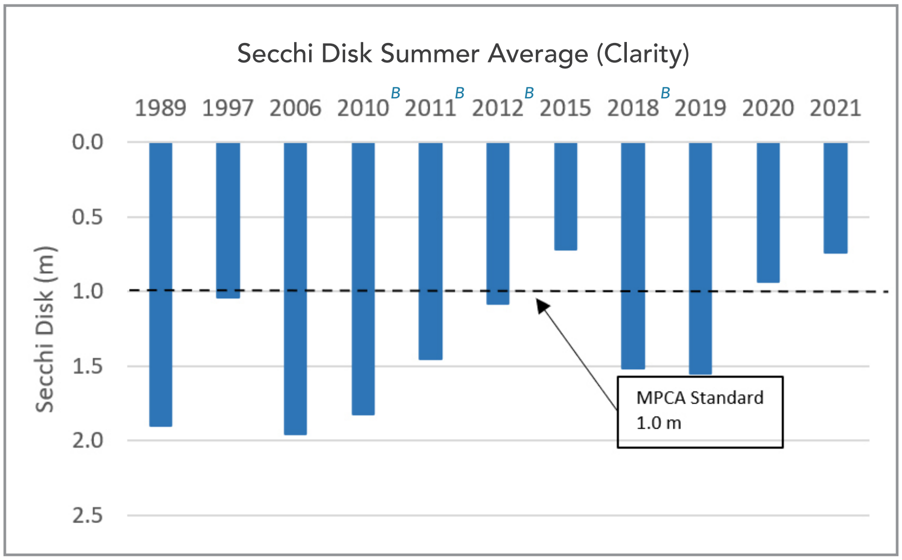


Figure 3
Summer average chlorophyll-a concentrations measured in Birch Island Lake between 1989 and 2021



B = Some SD readings measured at lake bottom at sampling location during these monitoring years.

Figure 4
Summer average Secchi disk transparency depths (clarity) measured in Birch Island Lake between 1989 and 2021

Healthy Shallow Lakes Have…Plants!

Shallow lakes are unique ecosystems that differ from deeper lakes. These lakes have depths that allow for light to reach the lake bottom throughout most or all of the lake (often less than 10 feet deep). Shallow lakes also tend to be more nutrient-rich than deeper lakes, especially in an urban setting where they receive nutrients (e.g., phosphorus and nitrogen) from stormwater. A healthy, shallow, urban lake will have an abundance of aquatic plants growing throughout the entire lake due to the shallowness and higher amounts of nutrients. Aquatic plants, such as coontail, native pondweed, and water lily, can provide excellent habitat for insects, zooplankton, fish, waterfowl, and other wildlife. The plants can also help to take phosphorus and nitrogen from the lake water, reducing the amount of nutrients available for algae growth. However, if nutrients are high enough, excess nutrients can lead to an overabundance of algal growth that creates turbid (murky-looking, low clarity) water. Lake water with low clarity can limit or prevent aquatic plant growth, which can lead to an unhealthy plant community.

To help define the health of a lake's plant community, the Minnesota Department of Natural Resources (MNDNR) has developed an index of biological integrity (IBI), which is a score that compares the types and numbers of plants observed in a lake to what is expected for a healthy lake. Observing 11 or more species in a shallow lake is an indication of a healthier plant community. The plant surveys completed on Birch Island Lake from 1997 through 2021, summarized in Figure 5, indicate that species diversity is likely correlated with water levels. The number of species observed during years with lower water levels ranged from 3 to 5, while the number of species observed during years with higher lake water levels ranged from 6 to 11 species.

In the past decade, the difference between the lowest and highest observed water level in Birch Island Lake is approximately 13.3 feet. The lowest observed water level in 2013 corresponds to an open water area of only 3 acres. The highest observed water level in 2019 corresponds to an open water area of almost 44 acres. This substantial difference in open water area, as shown in Figures 6 and 7, can have a notable influence on long-term health of submerged and emergent plants.

Monitoring data indicate that the number of species observed in Birch Island Lake is likely correlated to water levels with the highest diversity of species observed during years with higher water levels.

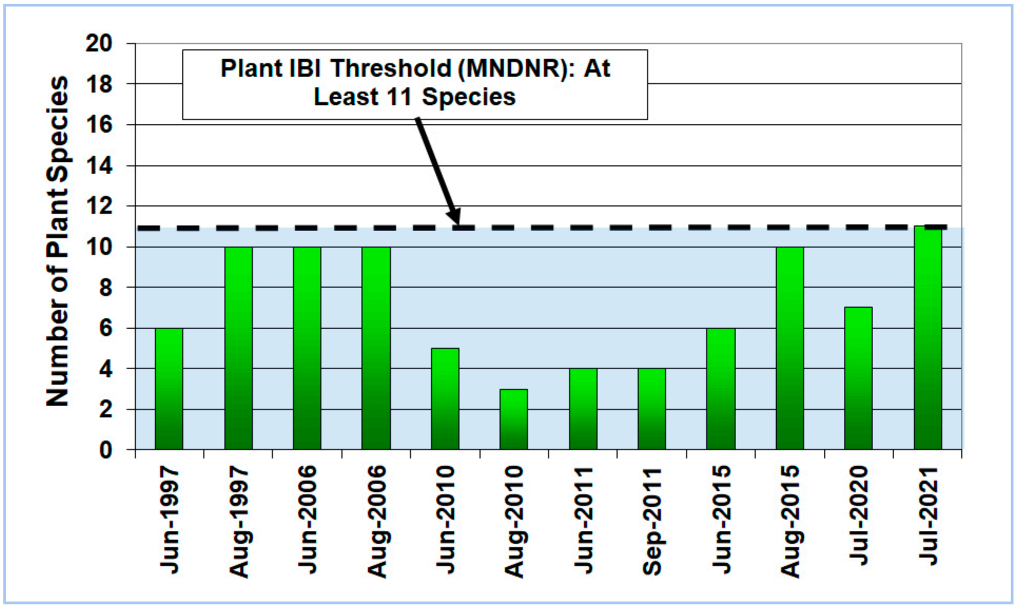


Figure 5 *Birch Island Lake Plant Species Richness compared with MNDNR Plant IBI score, which is an indication of plant health*

Fluctuating Water Levels

Birch Island Lake is generally considered landlocked. A high-level outlet has historically been referenced, but the location has not been confirmed. Given that the lake is generally landlocked, the water level in the lake depends on weather conditions (snowmelt, rainfall, evaporation) and groundwater flow. Birch Island Lake has experienced significant fluctuations in water levels in recent decades, which can pose challenges for water quality and ecosystem health.

Since the construction of County Road 62 in the mid and late 1980s, the normal water level of Birch Island Lake dropped notably lower than what was observed pre-construction. A pipe bypass system was installed in 2007 to help convey stormwater runoff draining north of County Road 62 directly to Birch Island Lake. The effectiveness of the bypass pipe in increasing water levels in Birch Island Lake has been variable, primarily due to frequent clogging of the bypass system from sediment build up.

Sediment clogging of the bypass pipe system is not the only reason for observed fluctuations in lake water levels. High water levels were observed in 2019 and early 2020 because 2019 was the wettest year on record in the Twin Cities metro area (>43 inches of precipitation). However, since 2021, the Twin Cities has experienced significantly lower than average precipitation, especially during the growing season (June–September). For example, from June–September 2022, less than 7 inches of rain fell as shown in Figure 8. Low precipitation coupled with higher evaporation rates during the 2021–2023 growing seasons have resulted in notable water level decreases in many lakes within the Twin Cities metro area.

Figure 6 *September 2013 water levels*

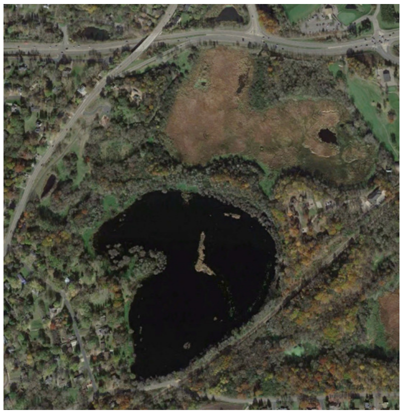


Figure 7 *October 2019 water levels*

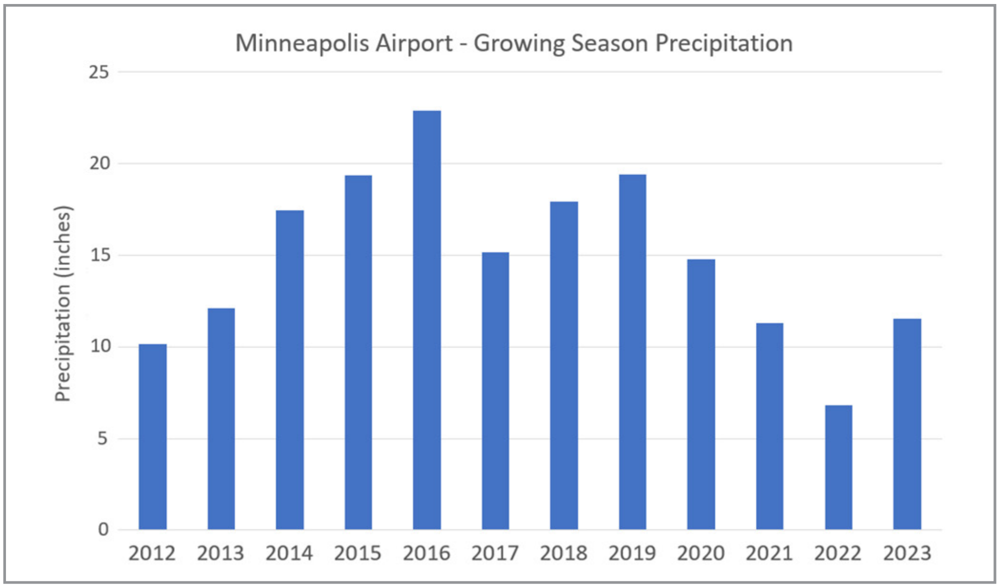


Figure 8 *Precipitation totals at the Minneapolis Airport between 2012 and 2023 during the growing season (June–September)*

Urban Watersheds Transfer Pollutants to Lakes

A lake watershed is all the land area that drains to the lake through overland flow, channels, and storm pipes. Land use practices within a lake's watershed impact the lake and its water quality by altering the amount of stormwater runoff, sediment, and nutrients that reaches the lake. Each type of land use contributes a different amount of runoff and pollutants to the lake, thereby impacting the lake's water quality differently. Land use within the highly developed Birch Island Lake watershed is primarily single family residential. The watershed also includes open water, open space, golf course and public streets/ right-of-way, and to a lesser extent multi-family residential, major highway, railroad, trails, undeveloped/ rural, and institutional (school) land uses.

Birch Island Lake generally has two tributary watershed types where runoff is either (1) tributary via the bypass pipe system where discharge to the lake is dependent on pipe clogging conditions (green watershed in Figure 9) or (2) tributary via non-bypass pipe system routes (e.g., through surface drainage, channels, or other storm sewer networks) (pink watershed in Figure 9).

In recent years, the City of Eden Prairie has increased the inspection and maintenance frequency of the bypass pipe system. The city typically cleans a critical manhole sump 3–4 times a year to remove sediment and reduce pipe clogging. In fall 2022, the city also jetted a portion of the bypass storm sewer pipes to remove sediment and restore flow capacity.

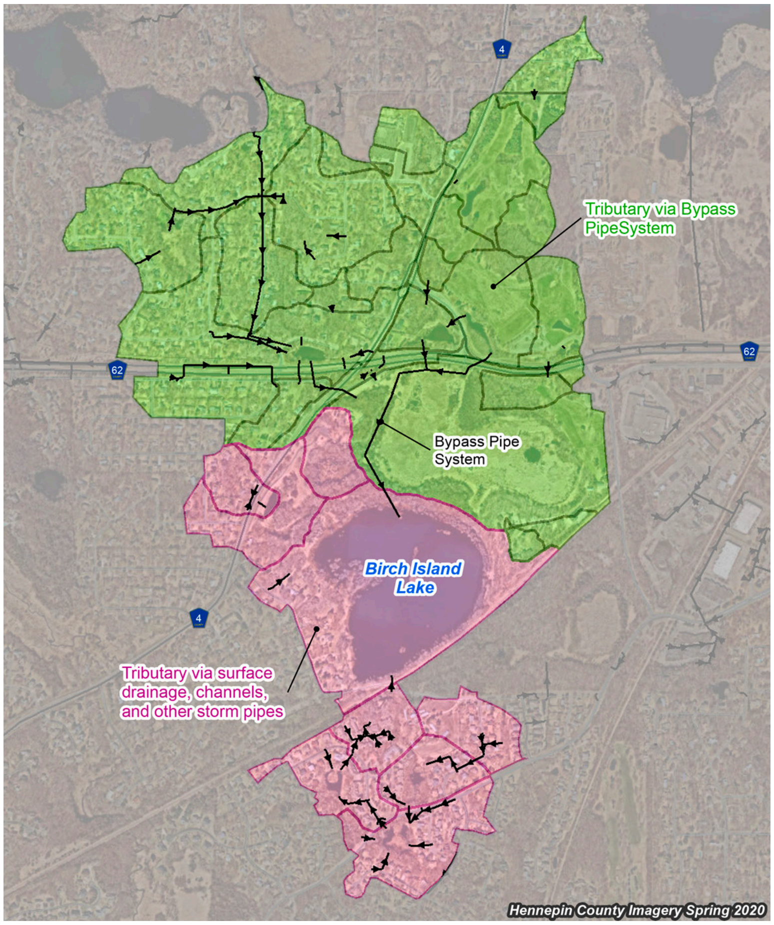


Figure 9 *Map showing the Birch Island Lake watershed*

Sources of Nutrients

Nutrients (phosphorus and nitrogen) are a food source for algae. An overabundance of these nutrients in a lake can result in nuisance algal blooms and threaten the health of the aquatic plant community. In Minnesota, phosphorus is most commonly the "limiting nutrient," although nitrogen can also be limiting for portions of the growing season. The "limiting nutrient" means the available quantity of this nutrient tends to control the amount of algae and aquatic plants produced. The three primary sources of phosphorus are summarized on page 8. The amount of nutrients coming into the lake from each source can vary from year to year as demonstrated by the pie charts for 2019 and 2020. Water quality modeling showed that phosphorus coming from the watershed can vary annually primarily due to the amount of precipitation that falls and how much runoff reaches the lake through the bypass pipe system. Simiarly, phosphorus from lake bottom sediment can vary annually due to changes in the area of sediment covered by water and variation in lake physical and chemical conditions such as the amount of lake mixing, higher temperatures and/or lower oxygen levels.

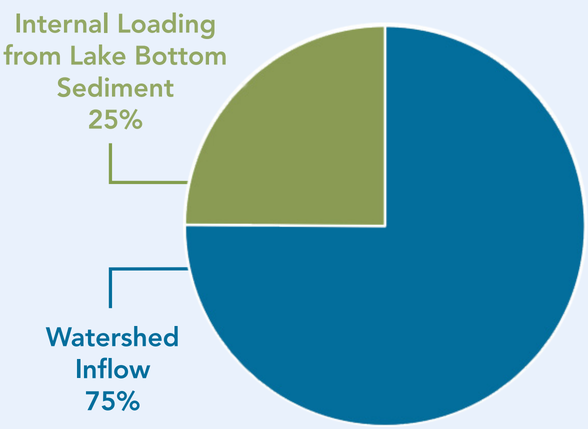
Where are the nutrients in Birch Island Lake coming from?

- **Phosphorus and nitrogen in stormwater runoff from the direct watershed—**Stormwater runoff conveys phosphorus and nitrogen from streets, lawns, driveways and parking lots within the tributary watersheds to Birch Island Lake via a series of drainage channels and storm pipes. This study confirmed that stormwater runoff is a contributor of phosphorus and nitrogen to Birch Island Lake.

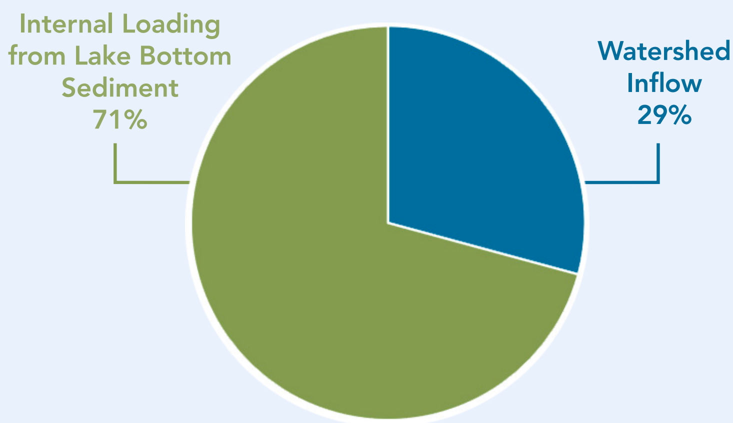
- **Nutrient-rich sediment—**Phosphorus builds up over time in lake bottom sediments as a result of sedimentation and die-off of vegetation and algae. When certain environmental conditions are met, such as low oxygen and/or higher temperatures, phosphorus can release back into the water column from the sediment. This study confirmed that phosphorus release from lake bottom sediments, typically termed "internal loading," is a contributor of phosphorus to Birch Island Lake.

- **Inflow from upstream lakes—**During precipitation and snowmelt events, water levels rise as stormwater runoff discharges from tributary watersheds. When lake levels are high enough, water, along with in-lake nutrients and pollutants, will discharge from upstream lakes and flow towards water bodies further downstream. Three lakes in the City of Minnetonka are upstream of Birch Island Lake (Holiday, Wing, and Rose Lakes). Lake Holiday discharges via pumping to Wing Lake, which then discharges by gravity to Lake Rose. When water levels are high enough, water discharges from Lake Rose via gravity to a stormwater pond located north of County Road 62. If conditions allow, the stormwater pond north of County Road 62 will discharge to the bypass pipe system and ultimately reach Birch Island Lake. Water from Lake Rose has minimally impacted Birch Island Lake in the last two decades because either (1) water levels in Lake Rose have been too low to discharge from the outlet or (2) the bypass pipe has been clogged resulting in flow from Lake Rose entering the wetland north of Birch Island Lake.

Birch Island Lake 2019 Total Phosphorus Sources



Birch Island Lake 2020 Total Phosphorus Sources



Birch Island Lake, August 2015

Lake Management Alternatives

Water quality monitoring in Birch Island Lake indicates degrading characteristics and shows that the lake currently does not meet water quality standards and ecological health goals. Given this, future management efforts should focus on improving lake water quality and ecosystem health, monitoring for changes, and continuing water quality and ecosystem health protection measures as improvements are achieved. The recommended management and protection strategies for Birch Island Lake are summarized on the next page.

Planning-level opinions of probable cost were developed for several new management alternatives evaluated as part of this study. These opinions of cost are intended to provide assistance in evaluating and comparing alternatives and should not be considered as absolute values. All estimated costs are presented in 2023 dollars and include costs for engineering and project administration.

- Lake Bottom Sediment Alum Treatment: $96,000
- Soil Sampling Program for Resident Fertilization Assessment: $22,000

Management/Protection Action		Basis	Estimated Timeline
Address Internal Bottom Sediment Phosphorus Loading	Alum Treatment	Reduce sediment phosphorus load	2025–2029*
	Sediment Release and Water Quality Monitoring	Assess management effectiveness and determine if additional sediment treatment(s) needed	2026–2034+
Address External Watershed Loading	Fertilizer Management Program	Reduce nitrogen sources from excess fertilizer use	2024/2025 (Planning begins)
	Address Channel and Slope Erosion (in Coordination with Hennepin County)	Reduce sediment loading from upland erosion	2024/2025 (Planning begins)
	Enhanced Street Sweeping Program	Reduce pollutant loading from stormwater	Reconsider in the future
	Chloride Monitoring	Continue to identify/track chloride levels from winter salt use	As part of continued lake monitoring program
	Promote NMCWD Cost-Share Grants to Watershed Residents	In a fully developed watershed, opportunities for largescale BMPs are limited	2024+
Manage Aquatic Plants (Macrophytes)	Invasive Species Management	Continue to monitor invasive species growth and manage as needed	2024+
	Promote Native Aquatic Plant Growth	Encourage native plant re-establishment to promote clear water conditions and competition with algae	2024+
Address Lake Level Stabilization	Conduct Lake Level Stabilization and Flood Management Evaluation	Increase runoff volume to lake and/or reduce extreme fluctuations in water levels	2024–2025
	Continue Frequent Inspection and Maintenance of the Bypass Pipes and Structure	Maintain flow capacity to Birch Island Lake and improve water level stability as part of Eden Prairie maintenance program	2024+
Assess Fisheries	Fisheries Management	Promote food web balance by reducing fish predation on zooplankton	2024/2025 (Planning begins)

* Estimated timeline is dependent on several factors, including lake water levels for safe access and results of the feasibility study.

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Acronyms

Acronym	Description
AIS	Aquatic Invasive Species
AACE	Association for the Advancement of Cost Engineering
BMP	Best Management Practice
FQI	Floristic Quality Index
IBI	Index of Biological Integrity
MNDNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
NGVD29	National Geodetic Vertical Datum of 1929
NMCWD	Nine Mile Creek Watershed District
NOAA	National Oceanic and Atmospheric Administration
N-P-K	Nitrogen-Phosphorus-Potassium
P8	Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds
PI	Point-Intercept
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
WHO	World Health Organization
WSE	Water Surface Elevation
UAA	Use Attainability Analysis

1.0 Introduction

The Nine Mile Creek Watershed District (NMCWD) conducted a study of water quality conditions in Birch Island Lake in Eden Prairie, Minnesota. The study is a scientific assessment of the physical, chemical, and biological conditions of the lake, and includes both a water quality assessment and a prescription of protective and/or remedial measures for Birch Lake and the lake's tributary watershed. The work presented in this report provides an update of analyses that were previously completed for a water quality study developed by NMCWD for Birch Island Lake in 2000 (Barr Engineering Co., 2000).

The conclusions and recommendations presented in this report are based on historical water quality data, a fisheries survey conducted in 2022, several years of aquatic plant surveys, and the results of intensive lake water quality monitoring in 2019, 2020 and 2021. Lake water quality and ecological models were developed and calibrated to the 2019 and 2020 datasets to gain a better understanding of the relative and absolute effect of various nutrient (e.g., nitrogen and phosphorus) sources on lake water quality.

1.1 Water Quality Study Approach

The NMCWD has historically used a process referred to as a Use Attainability Analysis (UAA) to assess the water quality condition of its lakes relative to the desired beneficial uses that can be reasonably achieved and maintained with implementation of management recommendations. The objective of a UAA is to provide a scientific foundation for a lake-specific management plan that will permit maintenance of, or attainment of, the intended beneficial uses of a waterbody. The UAA process addresses a wide range of goals (e.g., water quantity, aquatic communities, recreational use, and wildlife), with the primary focus being achievement of water quality goals.

As part of the *Nine Mile Creek Watershed District Water Management Plan* (Plan) adopted in 2017 and amended in 2018, 2019, and 2023 (NMCWD, 2017, amended 2023), the NMCWD adopted the Minnesota eutrophication standards. In addition, the NMCWD expanded its emphasis on the role of ecological indicators (aquatic plants, phytoplankton, fish, etc.) in overall lake health, as well as the feedback mechanisms between these indicators. A properly functioning ecosystem supports the attainment of good water quality.

While the UAA terminology is not included in the title of this water quality study, a similar analysis process was employed, utilizing observed data, watershed modeling and in-lake modeling to understand and diagnose lake health issues and evaluate protective or remedial management activities. The water quality study utilized a watershed runoff model and an in-lake water quality and ecological model to quantify pollutants from various sources and to quantify the benefits of management efforts. The in-lake water quality model predicts changes in lake water quality based on the results of the watershed runoff model (external inputs) as well as internal processes such as sediment phosphorus release due to anoxia, phytoplankton growth and decay, and nutrient settling to lake sediments. Using these models, various watershed and lake management strategies can be evaluated to determine their likely effects on lake water quality. The resulting lake water quality can then be compared with the water quality goals to see if the management strategies are able to produce the desired changes in the lake. Using the modeling tools, the cost-effectiveness of the management strategies can also be evaluated.

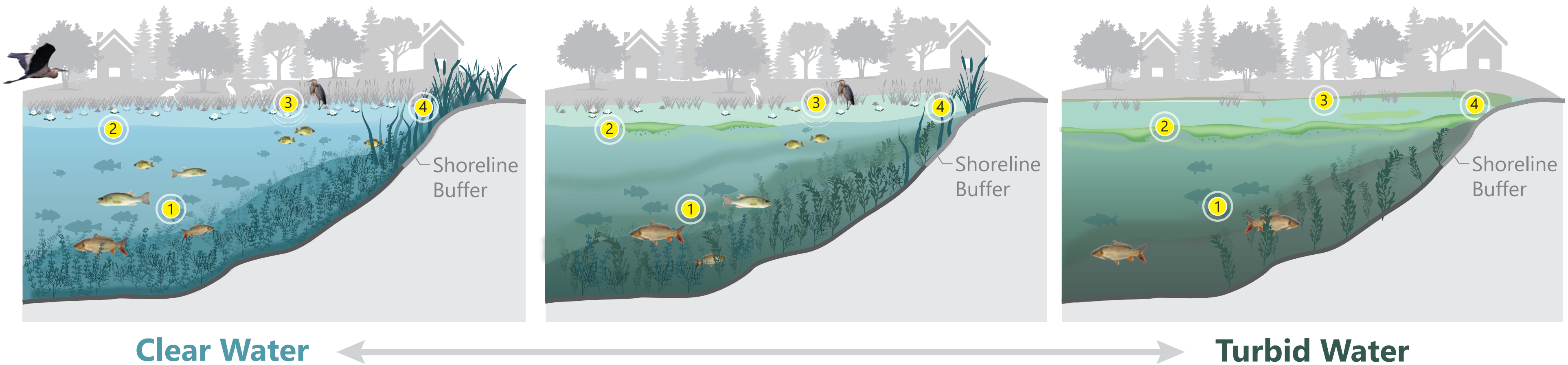
2.0 Shallow Lake Characteristics and Water Quality

Shallow lakes are unique ecosystems that differ from deeper lakes. Shallow lakes are lakes that generally have well mixed water columns throughout most of the year and have depths that potentially allow for light penetration to reach most of the lake bottom. Shallow lakes can support macrophyte growth across the entire lake surface when lake clarity is reasonably high. Shallow lakes classically exist in two states: (1) clear water with extensive coverage of submerged and emergent macrophytes and low phytoplankton (algae) abundance; and (2) turbid water where phytoplankton dominate and macrophyte coverage is limited due to phytoplankton shading. The concentration of nutrients entering the shallow water system (from stormwater or from lake bottom sediments), fishery balance and composition, the presence or absence of invasive species (such as curly-leaf pondweed, carp, and goldfish), and dissolved oxygen concentrations are primary drivers that determine the state of shallow lakes (Figure 2-1).

There are a number of concepts and terminology that are necessary to describe and evaluate a lake's water quality. This section is a brief discussion of those concepts.

2.1 Eutrophication

Eutrophication, or lake degradation, is the accumulation of sediments and nutrients in lakes. As a lake naturally becomes more fertile, biological production enhances and sediment inflow accumulates filling the lake's basin. Over a period of hundreds to thousands of years, a lake can successively become a pond, a marsh and, ultimately, a terrestrial site. This process of eutrophication is natural and results from the normal environmental forces that influence a lake. Cultural eutrophication, however, is an acceleration of the natural processes and is caused by human activities. Nutrient and sediment inputs from stormwater runoff can far exceed the natural inputs to a lake. Nutrient enrichment in lakes often intensifies algal blooms. Enhanced sediment loadings can attenuate light and reduce lake transparency, which can limit macrophyte growth. Since macrophytes assist in creating a stable water state (e.g., improved clarity, reduced sediment resuspension, improved habitat for aquatic organisms), especially in shallow lakes, high suspended sediment and enhanced nutrients can often lead to impaired water quality.



1. Good fishery balance
2. Algae blooms rare
3. Diverse prey options and healthy habitat for birds
4. Numerous and diverse native plants in the lake and within shoreline buffers; low invasive species present

1. Less balanced fishery, more rough fish (e.g., carp)
2. Algae blooms moderate
3. Less prey options and habitat for birds
4. Less diverse native plants in the lake and within shoreline buffers; invasive species present

1. Fishery not balanced, mostly rough fish, winter fish kills
2. Algae blooms dominant, blue-green algae possible
3. Limited prey options and habitat for birds
4. Low diversity and quantity of native plants in the lake and within shoreline buffers; invasive species present

Figure 2-1 Depiction of shallow lake states

2.2 Nutrients

Biological production in an aquatic ecosystem is limited by the concentrations of essential nutrients. The "limiting nutrient" concept is a widely applied principle in ecology and in the study of eutrophication. It is based on the idea that phytoplankton and plants require many nutrients to grow, but the nutrient with the lowest availability, relative to the amount needed by the phytoplankton or plant, will limit growth. It follows then, that identifying the limiting nutrient will point the way to controlling aquatic plant and algal growth. Nitrogen and phosphorus are generally the two growth-limiting macronutrients in most natural waters. Thus, efforts to improve water quality typically focus on reducing the growth-limiting nutrient concentration in the waterbody; however, it is often difficult to identify and control all the nutrient loadings to a specific waterbody.

Two primary sources, external and internal loads, are responsible for elevated nutrient concentrations in lakes. Nutrients that enter lakes through watershed runoff, groundwater inputs, or atmospheric deposition are considered external loads. As urbanization has occurred, more areas of impermeable surfaces have been developed causing increased stormwater runoff and pollutant transport during storm and spring thaw events. In urbanized areas, stormwater runoff typically flows through storm sewer systems to the downstream waterbody, which generally results in faster velocities than natural channel flow and can result in higher suspended loadings. Implementation of the NMCWD's stormwater management rules for new development and redevelopment and efforts to install retrofit best management practices (BMPs) are helping to reduce external loads to nearby waterbodies. However, for many shallow lakes, internal load reduction measures (e.g., alum treatment, aquatic plant management, fish management) are also required to meet water quality goals.

Once external nutrient loads enter a lake, over time, the nutrients accumulate in the sediment through the settling of particulates and through organism decay. Natural lake processes such as sediment resuspension, chemical dissolution, or microbial reduction can reintroduce these nutrients to the overlying water column resulting in internal loading. This is specifically common for phosphorus, which can be found bound to the sediment under oxidized conditions. The binding of phosphorus to iron in sediments allows the sediment to act as a sink or source depending on the lake's physical and chemical conditions. Therefore, understanding the chemical and physical conditions and the timing of these conditions will be important considerations when developing an internal loading management plan.

2.2.1 Stratification Impacts on Internal Phosphorus Loading

Lake stratification, the separating of an upper, well mixed warm layer (epilimnion) from a cool, bottom layer (hypolimnion) (Figure 2-2), can lead to low oxygen concentrations in lake bottom waters and exacerbate internal phosphorus loading. For shallow lakes like Birch Island Lake, stratification is typically irregular and can happen on a daily, weekly, or longer timescale. Mixing likely occurs regularly in Birch Island Lake and phosphorus released from sediments is then made available to phytoplankton during these frequent mixing events.

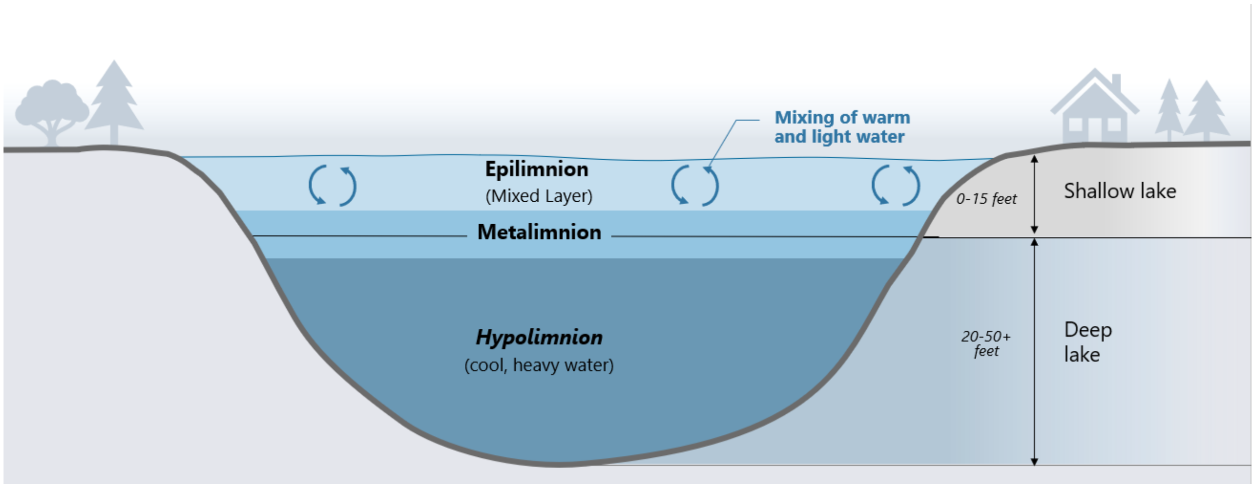


Figure 2-2 Generalized thermal lake stratification diagram

2.2.2 pH Impacts on Internal Phosphorus Loading

The pH of the water column can also play a vital role in affecting the phosphorus release rate under conditions when oxygen is present in the water column (oxic conditions). Photosynthesis by macrophytes (aquatic plants) and algae during the day tend to raise the pH in the water column, which can enhance the phosphorus release rate from the oxic sediment. Enhancement of phosphorus release at elevated pH (pH > 8.2) is thought to occur through replacement of the phosphate ion (PO_4^{-3}) with the excess hydroxyl ion (OH^-) on the oxidized iron compound (James, Barko, & Eakin, 2001). Large increases in pH are often the consequence of phytoplankton blooms (e.g., cyanobacteria harmful algal blooms).

2.2.3 Organism Impacts on Internal Phosphorus Loading

Benthivorous, rough fish, such as carp and bullhead, can have a direct influence on the phosphorus concentration in a lake (LaMarra, 1975). These fish typically feed on decaying plant and animal matter and other organic particulates found at the sediment surface. The fish digest the organic matter, and excrete soluble nutrients, thereby transforming sediment phosphorus into soluble phosphorus available for uptake by algae at the lake surface. Benthivorous (bottom-feeding) fish can also cause resuspension of sediments in shallow ponds and lakes, transporting phosphorus from sediment into the water column, causing reduced water clarity and poor aquatic plant growth, as well as high phosphorus concentrations (Cooke, Welch, Peterson, & Newroth, 1993). In some cases, the water quality impairment caused by benthivorous fish can negate the positive effects of BMPs and lake restoration.

The critical difference between biological (e.g., benthivorous fish feeding) and physical (e.g., wind and waves) sediment resuspension is the area and the frequency to which these components can induce impacts. The volume of sediment impacted by physical resuspension is largely influenced by the geometry of the lake (e.g., size, fetch, bathymetry) and wind events (e.g., direction, velocity). For example, a wind event may develop wave induced sediment resuspension along a portion of the shoreline. However, biological resuspension from feeding or mating activities of fish can occur over a much larger area and is impacted by the number of organisms in the aquatic ecosystem. Additionally, while physical resuspension occurs in a periodic, episodic-based fashion, benthivorous fish resuspension can be more continuous.

2.2.4 Curly-leaf Pondweed Impacts on Internal Phosphorus Loading

Another potential source of internal phosphorus loading is the growth and die-off of curly-leaf pondweed. Curly-leaf pondweed is an invasive and non-native aquatic plant that is common in many Twin Cities metropolitan area lakes. Curly-leaf pondweed grows under the ice during the winter and gets an early start in the spring, crowding out native species. It releases a small reproductive pod called a turion that resembles a small pinecone in late-June, and then begins its die-back in late-June and early-July. The biomass sinks to the bottom of the lake and begins to decay, releasing nutrients into the water column and causing oxygen depletion, exacerbating the internal sediment release of phosphorus. This cycle can result in an increase in nutrient concentrations in the lake in late-June or early-July in lakes with a higher percentage of invasive growth.

2.2.5 Nitrogen Inputs and Limitations

Nitrogen is a nutrient required for phytoplankton growth and hence nitrogen management also needs to be considered as an important component of lake management. Increases in nitrogen concentrations in lakes can be attributed to a combination of factors in the watershed, including increased fertilizer application rates and frequency, increased impervious surface areas, expansion of storm sewer systems, and loss of riparian wetlands. Land use changes and increased nitrogen loading can result in a decreased natural capacity for nitrogen uptake and assimilation by plants and decreased cycling back to the atmosphere as nitrogen gas (N_2) through natural nitrification and denitrification processes. Thus, this can result in high nitrogen concentrations in open water systems.

For the last couple of decades, phosphorus reduction has generally been the primary focus for lake management in Minnesota based on the premise that phosphorus limitation is dominant in freshwater lakes (e.g., reducing phosphorus inputs alone will limit primary productivity and algal bloom growth). While phosphorus management has been successful or partially successful in a number of lake management projects, recent research is showing that nitrogen limitation or dual nitrogen-phosphorus limitation may be more significant than initially anticipated (Paerl et. al, 2016). This is particularly true for shallow lakes. The nutrient that limits phytoplankton/algal growth can vary geographically, but limitation can also vary seasonally in a single lake. Some lakes have been shown to display phosphorus limitation in the spring but switch to nitrogen limitation in the summer and fall. Furthermore, an additional benefit of managing nitrogen in upstream ecosystems is that this reduces some of the burden in vulnerable ecosystems further downstream that are nitrogen limited (e.g., Gulf of Mexico). Given that recent research is showing higher evidence of dual nitrogen-phosphorus limitation in freshwater lakes, there is a benefit for determining whether source control programs that target both phosphorus and nitrogen will provide greater ecosystem benefits.

2.3 Climate Change Considerations

Considerable studies have been devoted to predicting the impacts of a warming climate on the hydrologic cycle. Of particular concern are the changes to atmospheric moisture content, evaporation, precipitation intensity, and the possibility of increased risk for drought and flooding extremes (Trenberth, 1999; Trenberth, Smith, Qian, Dai, & Fasullo, 2003; Giorgi, et al., 2011; Trenberth, 2011).

Alterations to the hydrologic cycle will consequently impact freshwater ecosystems. Observational records and climate model projections show evidence of freshwater vulnerability to a warming climate (Dokulil & Teubner, 2011). Freshwater characteristics such as lake stratification and mixing, ice coverage, and river flow could see discernable changes by the end of the 21st century (Dokulil & Teubner, 2011; Dokulil, 2013). Increases in nutrient loadings and water temperatures, changes to water levels, and amplified eutrophication could impact aquatic organisms and influence biodiversity.

2.3.1 Projected Changes to the Hydrologic Cycle

Larger concentrations of greenhouse gases in the atmosphere, such as carbon dioxide and methane, create an increased downwelling of longwave radiation to the earth's surface (Trenberth, 1999). This enhanced downwelling not only escalates surface temperature warming, but also induces changes to the atmospheric moisture content and evaporation. Higher atmospheric temperatures allow for an expanded water holding-capacity of the atmosphere and enhanced radiation causes elevated rates of evaporation. This results in increases to the atmospheric moisture content, which, consequently, will impact precipitation (Trenberth, 1999; Trenberth, Smith, Qian, Dai, & Fasullo, 2003; Kharin, Zwiers, Zhang, & Wehner, 2013).

While changes to precipitation amounts and intensity are expected on a global scale, the changes will be geographically disproportionate. According to the National Oceanic and Atmospheric Administration's (NOAA's) 2013 assessment of climate trends for the Midwest (NOAA, 2013), upward trends in annual and summer precipitation amounts have been observed. The frequency of higher intensity storms has also been noted. Specifically in Minnesota, climatologists have identified four significant climate trends (MNDNR, 2017):

- Increasing annual precipitation
- Increasing frequency and size of extreme rainfall events
- Increasing temperatures, with winter temperatures warming the fastest
- Decline in severity and frequency of extreme cold weather

Overall, the changes to precipitation induced by atmospheric warming pose difficult challenges. The shift to more frequent, high intensity precipitation events in Minnesota indicates a risk for extreme flood events. Higher intensity precipitation events typically produce more runoff than lower intensity events with similar amounts of precipitation because higher intensity rainfall can overwhelm the capacity of the land surface to infiltrate and attenuate runoff.

Not only do these hydrologic changes pose challenges for agriculture, infrastructure, and human safety; but also has the potential to induce changes to aquatic environments. The subsequent section describes the anticipated impacts to aquatic ecosystems if atmospheric warming trends continue.

2.3.2 Projected Changes to Waterbodies (Physical and Chemical)

In freshwater lakes, one of the most important atmospheric variables influencing the lake's physical and chemical parameters is temperature. Due to enhanced air temperatures and the projected increasing trends, lake water temperature and the number of ice-free days are projected to change in most inland waters globally. Increases in lake temperature will affect mixing regimes, the length and depth of summer stratification, and the oxygen concentration in the hypolimnion (Dokulil, 2013; Dokulil, 2014; Dokulil, 2016), as well as phytoplankton growth rates, and phosphorus cycling (e.g., release of phosphorus from bottom sediments). As water temperature rises, lake stability enhances, which results in longer thermal stratification and prolonged durations between mixing periods (Dokulil, 2013). Resistance to mixing, particularly in deep lakes, between the nutrient rich hypolimnion and nutrient poor epilimnion across the thermocline increases considerably at temperature gradients of only a few degrees Fahrenheit (Sahoo, et al., 2016).

Prolonged lake stability and a lower thermocline may enhance the risk of oxygen depletion in the hypolimnion and near the lake bottom sediment (Jeppesen, et al., 2009; Sahoo, et al., 2016). Anoxic conditions near the lake bottom can cause nutrient release from the sediments. Understanding the extent of nutrient release from sediments due to low oxygen conditions can be especially important in shallow lakes because shallow lakes are more prone to full lake mixing from larger wind or storm events. During these lake mixing events nutrients released from the sediment are mixed into the full water column, which can increase the potential for algal blooms. Furthermore, overall oxygen concentrations in the lake can be reduced as solubility decreases when the water temperature warms, which can impact fishery balance (Dokulil & Teubner, 2011).

In mid-latitudes where precipitation is likely to increase, with the heightened chance for extreme events, other concerns are warranted. Intense rainfalls resulting in flooding could raise the loading of suspended sediments associated with larger areas experiencing soil erosion (Dokulil & Teubner, 2011; Dokulil, 2016). The combination of longer dry periods and extreme precipitation events could create episodic and intense pulse flows affecting aquatic habitats, bank stability, and species (Dokulil, 2016). Additionally, the increase in the number of extreme, high intensity rain events is likely to increase runoff driven phosphorus transfers from the land to the water (Jeppesen, et al., 2009).

2.3.3 Projected Changes to Waterbodies (Biological)

The potential for increased erosion and nutrient inputs from large runoff rates combined with higher water temperatures and prolonged lake stratification in summer could lead to widespread, climate-related eutrophication based on the results of existing studies (Dokulil & Teubner, 2011; Dokulil, 2013). Nutrient enrichment, whether through external or internal loading, stimulates the development of phytoplankton biomass. This resulting surface biomass absorbs light, can shade out benthic algae or macrophytes, and can produce negative lake aesthetics (Dokulil & Teubner, 2011). Unfortunately, not only has previous research projected larger biomasses of phytoplankton in a warmer climate, but research also predicts that a higher proportion of these phytoplankton biomasses will consist of potentially toxic cyanobacteria assemblages (Jeppesen, et al., 2009; Dokulil & Teubner, 2011; Jeppesen, et al., 2014; Dokulil, 2016). Multiple regression analyses on data from 250 Danish lakes sampled during the month of August indicated higher dominance of cyanobacteria with a warming climate. Studies during heat waves in the northern hemisphere also showed that higher percentages of cyanobacteria correlated with rises in temperature (Huisman, Matthijs, & Visser, 2005).

Changes in the seasonal pattern and dynamics of freshwater productivity could also be a consequence of a changing climate. With the earlier onset of warmer air temperatures in the spring, the timing of the phytoplankton peak is likely to shift earlier in the season. If the phytoplankton blooms contain a larger percentage of cyanobacteria species or if the timing of algal production falls out of synchrony with the food demands of zooplankton and fish, then upper levels of the food chain could be negatively impacted (Dokulil, 2016). Enhanced phytoplankton biomasses can also induce thermal feedback mechanisms for lakes. A large area of phytoplankton biomass can result in greater surface temperatures and stronger stratification (Dokulil, 2013). Additionally, increased light attenuation at the surface will reduce light availability at the lake bottom influencing macrophyte growth (Jeppesen, et al., 2014).

This water quality study did not directly assess potential impacts to lake responses due to a changing climate. However, any current and/or future management efforts for waterbodies will be affected by changing climate conditions. Continued monitoring of lake conditions will be important as management efforts are implemented and as changing climate conditions progress. Long-term studies of waterbodies will be essential to create the most effective plans to overcome climate-induced impacts.

3.0 Identification of Goals and Expectations

3.1 NMCWD Goals for Lake Management

The NMCWD's approach to evaluating and improving lake health includes numerous health assessment factors, as illustrated in Figure 3-1. The primary factors identified as affecting lake ecological health include chemical water quality (e.g., nutrient concentrations), aquatic communities, and water quantity (groundwater and surface water). The effects of recreation and wildlife habitat on overall lake health are also considered.

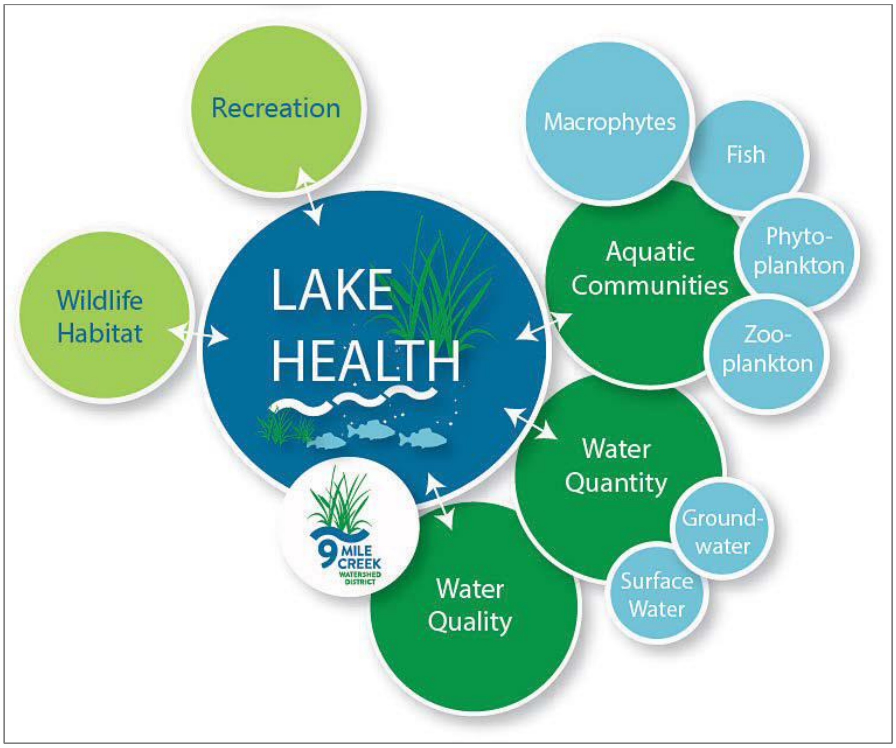


Figure 3-1 NMCWD holistic lake health assessment factors (NMCWD, 2017, amended 2023)

3.1.1 Water Quality Goals

One of the primary goals of the NMCWD is to "ensure the water quality of the lakes and streams of the NMCWD is protected and enhanced." In their 2017 Plan, the NMCWD adopted the state's lake eutrophication standards as their lake water quality goals, as well as the state water quality standards for Escherichia coli and chloride. The state's lake eutrophication water quality standards, established by the Minnesota Pollution Control Agency (MPCA) in 2008, vary by ecoregion and include criteria for both shallow and deep lakes. The MPCA defines "shallow" lakes as having a maximum depth of 15 feet or less or having at least 80% of the lake area shallow enough to support aquatic plants (referred to as "littoral area"). The water quality goals for shallow lakes (including Birch Island Lake) are presented in Table 3-1.

Table 3-1 NMCWD water quality goals for shallow lakes

Water Quality Parameter	Water Quality Standard for Shallow Lakes[1, 2]
Total Phosphorus (summer average, µg/L)	60
Chlorophyll-*a* (summer average, µg/L)	20
Secchi Disk Transparency (summer average, m)	1.0
Total Suspended Solids (mg/L)	NA
Daily Dissolved Oxygen Flux (mg/L)	NA
Biological Oxygen Demand (5 day) (mg/L)	NA
Escherichia coli (# per 100 mL)	126 [3]
Chloride (mg/L)	230[4]

[1] NMCWD goals are based on MPCA standards included in MN Rules 7050. Revisions to MN Rules 7050 will supersede NMCWD standards. Note that MN Rule 7050.0220 includes standards for additional parameters that are enforced by the MPCA.
[2] Shallow lakes have a maximum depth less than 15 feet or littoral area greater than 80% of the total lake surface area.
[3] 126 organisms per 100 mL as a geometric mean of not less than five samples within any month, nor shall more than 10% of all samples within a month exceed 1,260 organisms per 100 mL.
[4] The MPCA has established a chronic exposure chloride standard of 230 mg/L or less and considers two or more exceedances of the chronic standard in three years to be an impairment.

3.1.2 Other Lake Health Goals

In addition to the water quality goals presented in Table 3-1, the NMCWD's 2017 Plan expresses the desire to establish holistic lake health targets for NMCWD-managed lakes. The holistic lake health targets consider a wide range of factors, with an increased emphasis on the role of ecological factors in overall lake health and the interrelated nature of these factors.

Table 3-2 lists the evaluation factors used by the NMCWD to holistically assess lake health. Numerical goals exist for some of the factors presented in this table (e.g., MPCA water quality standards), while other holistic health factors are assessed qualitatively by comparing to narrative criteria. The NMCWD collaborates with stakeholders and regulatory agencies (e.g., MPCA, Minnesota Department of Natural Resources (MNDNR)) to develop lake-specific numerical goals for ecological indicators where appropriate.

Table 3-2 NMCWD holistic lake health assessment evaluation factors

Lake Health Assessment Factors	Evaluation Factors
Chemical Water Quality	• Nutrients • Sediment • Clarity • Chlorophyll-*a* • Chloride
Aquatic Communities	• Aquatic Plant IBI[1]- species richness and floristic quality • Invasive Species Presence • Phytoplankton Populations • Cyanobacteria/Blue-green Algae Presence • Zooplankton Populations
Water Quantity	• Water Levels • Water Level Bounce • Groundwater Levels
Recreation	• Shore Access • Navigation Potential • Aesthetics • Use Metrics
Wildlife	• Upland biodiversity • Buffer extent/width

[1] Lake plant eutrophication Index of Biotic Integrity (IBI) methodology developed by the MNDNR and MPCA

3.2 NMCWD Adaptive Management Approach

The NMCWD implements an adaptive management approach to improve lake health based on water quality and assessment of the other holistic lake health factors. While striving to achieve the state standards for shallow lakes, the NMCWD recognizes that achieving the water quality goals may not be feasible for some lakes or may require a timeframe that extends several decades. For these situations, the NMCWD's objective is to make reasonable and measurable progress towards meeting the water quality goals and other holistic lake health targets.

The NMCWD reviews lake monitoring data annually to assess progress toward lake management goals. For lakes that are meeting the goals, the NMCWD continues periodic monitoring to track variations in water quality and potential trends. If water quality declines or if water quality does not meet NMCWD goals, a lake-specific water quality study is conducted (or updated) to identify additional protection and improvement measures, as is being completed in this report for Birch Island Lake.

4.0 Lake Basin and Watershed Characteristics

The following sections describe the unique characteristics of Birch Island Lake and the lake's tributary watershed. Birch Island Lake is located in the northern portion of the City of Eden Prairie, south of County Road 62, west of Interstate 494 and just east of Eden Prairie Road (County Road 4).

4.1 Basin Characteristics

Birch Island Lake has a water surface area of 26.1 acres, a maximum depth of approximately 14 feet, and a mean depth of 2.5 feet at a 10-year average water surface elevation (WSE) of 880.3 (NGVD29, 2013-2022). At this elevation the lake volume is approximately 66 acre-feet (Figure 4-1). Since 2000, the WSE and corresponding surface area of Birch Island Lake have varied widely based on climatic conditions. The lowest observed WSE of 875.1 (NGVD29) in February 2013 was 13.3 feet below the highest observed WSE of 888.3 (NGVD29) in October 2019. The lowest WSE of 875.1 corresponds to a water surface area of only 3.2 acres compared to a water surface area of 43.7 acres at the highest WSE of 888.3.

Birch Island Lake is generally considered land-locked. A high-level outlet has historically been referenced, but the location has not been confirmed. Given that the lake is generally land-locked, the water level in the lake depends on weather conditions (snowmelt, rainfall, evaporation) and groundwater flow. The stage-storage relationship used in this study is shown in Table 4-1 and was based on depth measurements collected during a 2020 macrophyte point intercept survey completed by the City of Eden Prairie and LiDAR collected in 2011 by the MNDNR. The natural overflow of Birch Island Lake is at an approximate elevation of 901.8 feet (NGVD29).

Since Birch Island Lake is shallow, it may be prone to frequent wind-driven mixing of the lake's shallow waters during the summer. Additionally, lake mixing may be influenced by nighttime cooling. Therefore, one would expect Birch Island Lake to be *polymictic* (mixing many times per year) as opposed to lakes with deep, steep-sided basins that are usually *dimictic* (mixing only twice per year). Daily monitoring of the lake would be necessary to precisely characterize the mixing dynamics of a lake, but data gathered from Birch Island Lake suggest that the lake is generally polymictic. During years when the WSE's are high, such as in 2019 and 2020, Birch Island Lake may weakly or strongly stratify in the deeper depression on the eastern side and the lake may be less prone to frequent mixing.

Table 4-1 Stage-storage relationships for Birch Island Lake

Elevation (NAVD88)	Elevation (NGVD29)	Area (acres)	Cumulative Storage (ac-ft)[1]	Comment
866.8	866.6	0.0	0	Wet Detention Storage Volume
868.0	867.8	0.03	0.02	
869.0	868.8	0.2	0.1	
870.0	869.8	0.5	0.4	
871.0	870.8	0.9	1.1	
872.0	871.8	1.3	2.2	
873.0	872.8	1.9	3.8	
874.0	873.8	2.4	6.0	
875.0	874.8	3.0	8.7	
876.0	875.8	3.7	12.1	
877.0	876.8	6.7	17.3	
878.0	877.8	7.8	24.5	
879.0	878.8	13.6	35.2	
880.0	879.8	23.8	53.9	
880.5	880.3	26.1	66.4	10-year Average WSE (2013-2022)
881.0	880.8	28.4	80.0	Available Live Storage to Natural Overflow
882.0	881.8	30.7	109.6	
883.0	882.8	32.9	141.4	
884.0	883.8	34.8	175.3	
885.0	884.8	36.5	211.0	
886.0	885.8	38.1	248.3	
887.0	886.8	39.8	287.2	
888.0	887.8	42.3	328.2	
889.0	888.8	45.1	371.9	
890.0	889.8	47.6	418.2	
895.0	894.8	58.6	683.7	
900.0	899.8	64.1	990.4	
902.0	901.8	67.2	1121.8	

[1] Stage-storage was based on depth measurements collected during a 2020 macrophyte point intercept survey completed by the City of Eden Prairie and LiDAR collected in 2011 by the MNDNR.

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Bathymetry (NAVD88)*

*Sources: 2011 Hennepin County LiDAR Elevations
2020 Aquatic Plant Point-Intercept Depths

N

0 150 300
Feet

BIRCH ISLAND LAKE BATHYMETRY

FIGURE 4-1

4.2 Watershed Characteristics

Birch Island Lake's direct watershed is approximately 454 acres, including the surface area of the lake (26.1 acres). Runoff from the watershed enters Birch Island Lake through overland flow and from several storm sewer outfalls and stormwater channels at various points along the lakeshore. The lake's subwatersheds and the locations of major stormwater conveyance features are shown in Figure 4-2. Subwatersheds north of County Road 62 are in Minnetonka, whereas subwatersheds south of County Road 62 are in Eden Prairie.

In 2007, the NMCWD installed a storm sewer pipe to convey stormwater runoff from three stormwater ponds north of County Road 62 (694A-1, 714B, 716) to Birch Island Lake, bypassing the wetland north of Birch Island Lake (BIL3A). This bypass storm sewer pipe was installed to address water surface elevation concerns in Birch Island Lake (for additional information see Section 5.4). Although the purpose of the bypass storm sewer pipe is to convey additional water volume to Birch Island Lake under all conditions, maintenance complexities, shallow pipe slopes, and pipe clogging have reduced the effectiveness of the bypass system. In the last 2-3 years, the City of Eden Prairie has increased the inspection and maintenance frequency of the system (e.g., increase sump cleaning and pipe jetting) to improve bypass effectiveness moving forward.

Discharge from Lake Rose is conveyed to Birch Island Lake through storm sewer and a series of upstream stormwater ponds when water surface elevations (WSEs) in Lake Rose are high enough. Monthly WSE observations by NMCWD since 2000 indicate water levels infrequently exceed the Lake Rose outlet elevation (926.6 NGVD29). The average monthly monitored WSE of Lake Rose between 2000 and 2022 was 923.7 (NGVD29). This indicates that discharge from Lake Rose to Birch Island Lake is fairly rare and will likely only occur during above average precipitation years and/or major storm events. If water does discharge from the Lake Rose outlet, the tributary drainage area to Birch Island Lake increases by 670 acres, which is the total watershed area tributary to Lake Holiday, Wing Lake, and Lake Rose. Additional details on the Lake Holiday, Wing Lake, and Lake Rose watersheds and lake conditions can be viewed in the *Lake Holiday, Wing Lake, & Lake Rose Water Quality Study* (Barr Engineering Co., 2022).

4.2.1 Land Use

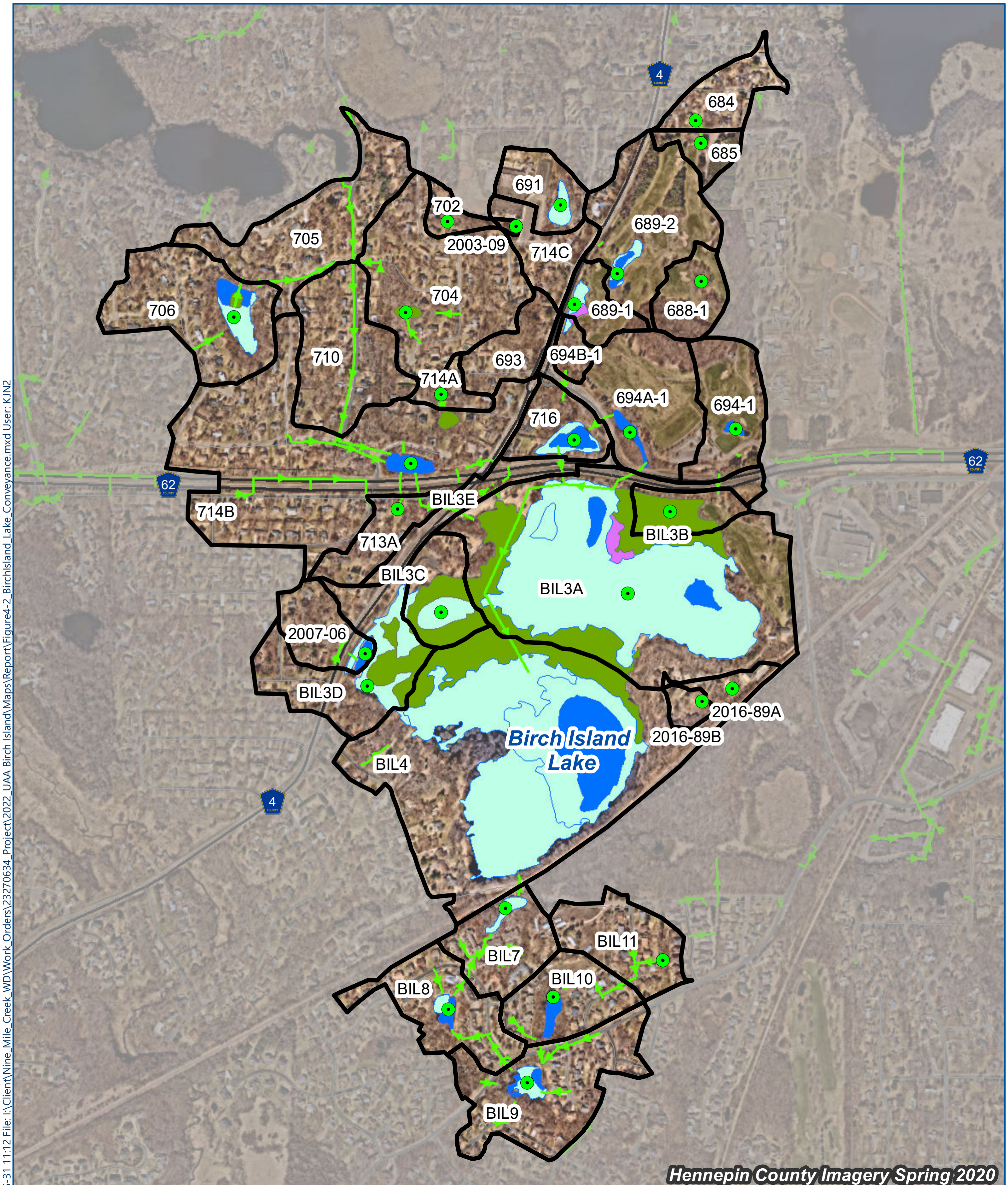
Land use within a lake's watershed impacts the lake and its water quality by altering the volume of stormwater runoff, sediment load, and nutrient load (namely phosphorus and nitrogen) that reach the lake from the lake's watershed. Each land use contributes a different amount of runoff and nutrients to the lake, thereby impacting the lake's water quality differently. As land use changes over time, changes can be expected in downstream water bodies as a result, unless mitigated through stormwater management practices.

Historically, the Birch Island Lake watershed was primarily comprised of basswood, sugar maple, and oak forests. Additionally, based on review of aerial imagery, many of the wetlands that historically comprised the Birch Island Lake watershed are still present especially in the immediate vicinity of the lake. The terrain varies from relatively flat to rolling.

Based on land use data provided by the City of Minnetonka (City of Minnetonka, 2007) and the City of Eden Prairie (City of Eden Prairie, 2019), the watershed of Birch Island Lake is approximately 70% fully developed. The remaining 30% consists of open water, open space, and wetlands. Table 4-2 provides a summary of the land use classifications within the watershed. The major land use classification in the Birch Island Lake watershed is single family residential. The watershed also includes open water, open space, golf course and public streets/right-of-way, and to a lesser extent multi-family residential, major highway, railroad, trails, undeveloped/rural, and institutional (school) land uses. Figure 4-3 shows a map of the land use classifications within the Birch Island Lake watershed.

Table 4-2 Land use classifications in the Birch Island Lake watershed

Land Use Classification	Percent of Watershed
Single Family Residential	33%
Open Water	19%
Open Space	13%
Golf Course	12%
Street Right-of-Way	10%
Multi-Family Residential	5%
Major Highway	3%
Railroad/Public Trail Right-of-Way	2%
Rural/Vacant	2%
Institutional (School)	2%
Total Watershed Area (ac)	453.8



Subwatersheds
Storm Sewer
P8 Model Treatment Devices

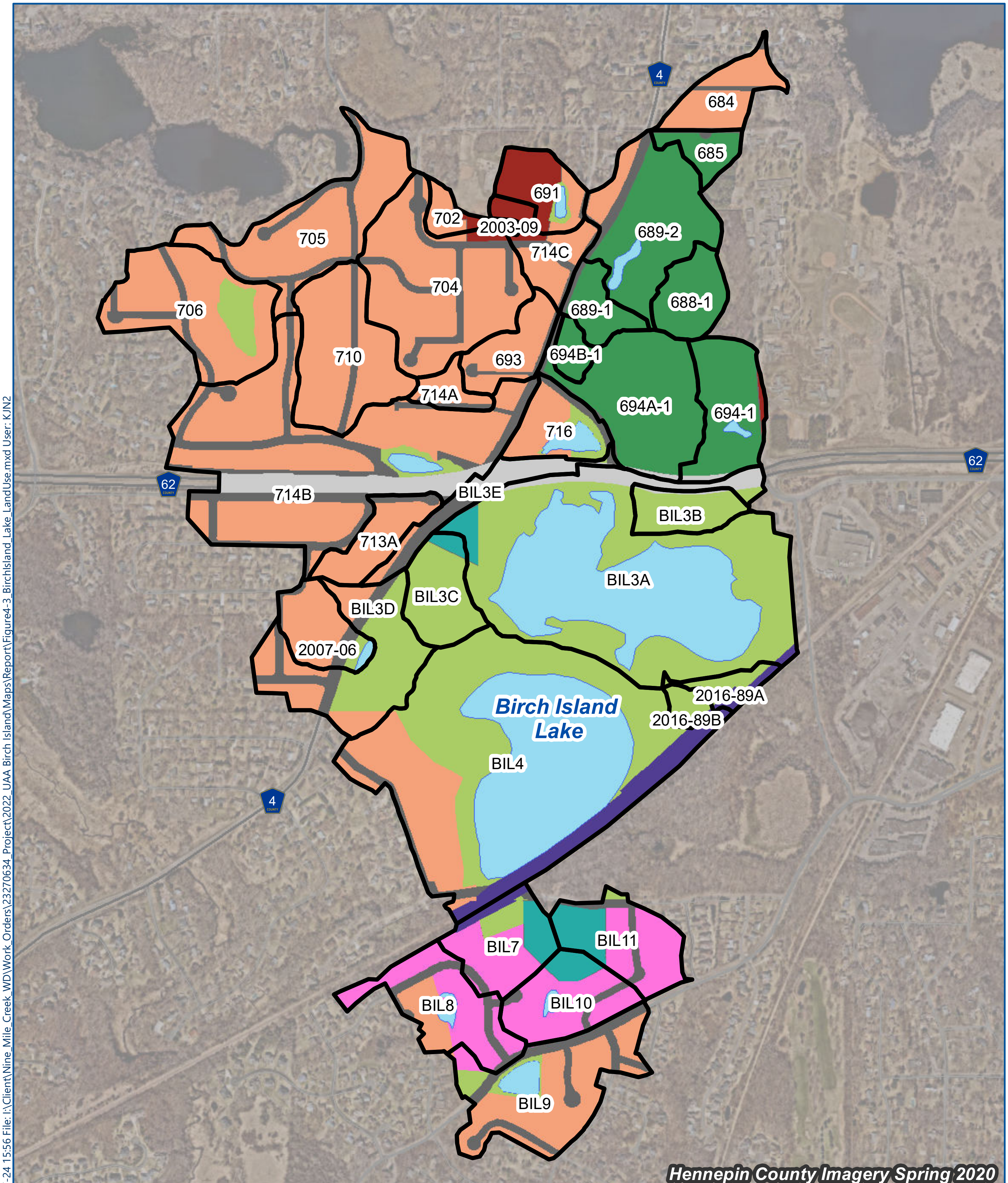
National Wetland Inventory (NWI) Wetlands

Freshwater Emergent Wetland
Freshwater Forested Wetland
Freshwater Pond
Freshwater Shrub Wetland

0 900
Feet

BIRCH ISLAND LAKE SUBWATERSHEDS & STORMWATER CONVEYANCE

FIGURE 4-2



Subwatersheds

Land Use (Minnetonka & Eden Prairie)

- Golf Course
- Institutional
- Major Highway
- Multi Family Residential
- Open Space
- Open Water*
- Railroad ROW
- Rural/Vacant
- Single Family Residential
- Street ROW

0 900 Feet

*Open Water area shown for Birch Island Lake reflects 10-year average monitored water levels.

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LAND USE
BIRCH ISLAND LAKE
WATERSHED

FIGURE 4-3

5.0 Existing Water Quality and Ecological Health

5.1 Water Quality

The NMCWD and the City of Eden Prairie, through assistance from Blue Water Science, have performed water quality monitoring in Birch Island Lake since the late 1980's:

- NMCWD Monitored Years: 1989, 1997, 2006, 2015
- City of Eden Prairie Monitored Years: 2010-2012, 2018-2021

5.1.1 Eutrophication Parameters—Phosphorus, Chlorophyll-*a*, and Clarity

The NMCWD and City of Eden Prairie intensive monitoring programs included the lake eutrophication parameters of total phosphorus (TP), chlorophyll-*a*, and Secchi disk transparency depth to assess water clarity. The data are presented using box plots. The box plots show averages (black 'x'), median values (straight horizontal line), minimum and maximum values (whiskers), outliers (circles), as well as the region where 50 percent of the data lie (the area within the boxes). Box plots shown on Figure 5-1 display the observed summer-average TP and chlorophyll-*a* concentrations and the Secchi disk transparency depths from 1989 through 2021 for Birch Island Lake.

There is variability in TP and chlorophyll-*a* concentrations and the Secchi disk transparency depths in Birch Island Lake from year to year, as well as within a given year. The variability can be a reflection of numerous factors, including climatic variability, changes to aquatic community populations (e.g., algae, plants, zooplankton, fish), management efforts, and changes in external pollutant loadings from the direct watershed.

For Birch Island Lake, observed summer average TP concentrations have been variable since monitoring begin in 1989. The highest summer average TP concentration was observed in 1989 at 119 µg/L, which is notably higher than the MPCA shallow lake water quality standard of 60 µg/L. It is likely that the higher observed TP concentrations are a result of the County Road 62 construction that began in 1985 and continued through the early 1990's. TP concentrations improved between 1997 and 2012 when all observed summer average TP concentrations, ranging from 23-44 µg/L, were below the MPCA shallow lake standard (60 µg/L). In 2015, the summer average TP concentration of 66 µg/L was slightly above the MPCA standard. In 2018 and 2019, summer average TP concentrations fell back below 60 µg/L ranging from 34-36 µg/L. However, the two most recent years of data indicate increasing phosphorus concentrations. In 2020, the summer average TP concentration rose slightly above the MPCA standard at 62 µg/L and in 2021, the summer average TP concentration was notably higher than the MPCA standard at 87 µg/L.

Summer average chlorophyll-*a* concentrations followed a similar pattern as the observed TP concentrations in Birch Island Lake. The observed summer average chlorophyll-*a* concentrations in 1989 and 1997 were slightly above the MPCA shallow lake water quality standard of 20 µg/L ranging from 22-25 µg/L. From 2006 through 2012 all observed summer average TP concentrations, ranging from 4-8 µg/L, were below the MPCA shallow lake standard (20 µg/L). In 2015, the summer average chlorophyll-*a* concentration exceeded the MPCA standard at 32 µg/L. In 2018 and 2019, summer average chlorophyll-*a* concentrations fell back below 20 µg/L ranging from 7-10 µg/L. In 2020, the summer average TP concentration rose slightly above the MPCA standard at 27 µg/L and in 2021, the summer average TP concentration was notably higher than the MPCA standard at 50 µg/L.

Of the eleven years monitored since 1989, only three years had summer average Secchi disk transparency measurements that did not meet the MPCA shallow lake water quality standard of greater than 1 meter depth. The three years that had observed Secchi disk transparency depths less than 1 meter were 2015, 2020, and 2021 with depths ranging between 0.7 and 0.9 meters. The other seven years between 1989 and 2019 had observed Secchi disk transparency measurements ranging from 1.0-2.0+ meters. During the monitoring years of 2010-2012 and 2018 numerous Secchi disk transparency measurements were at the lake bottom at the monitoring location.

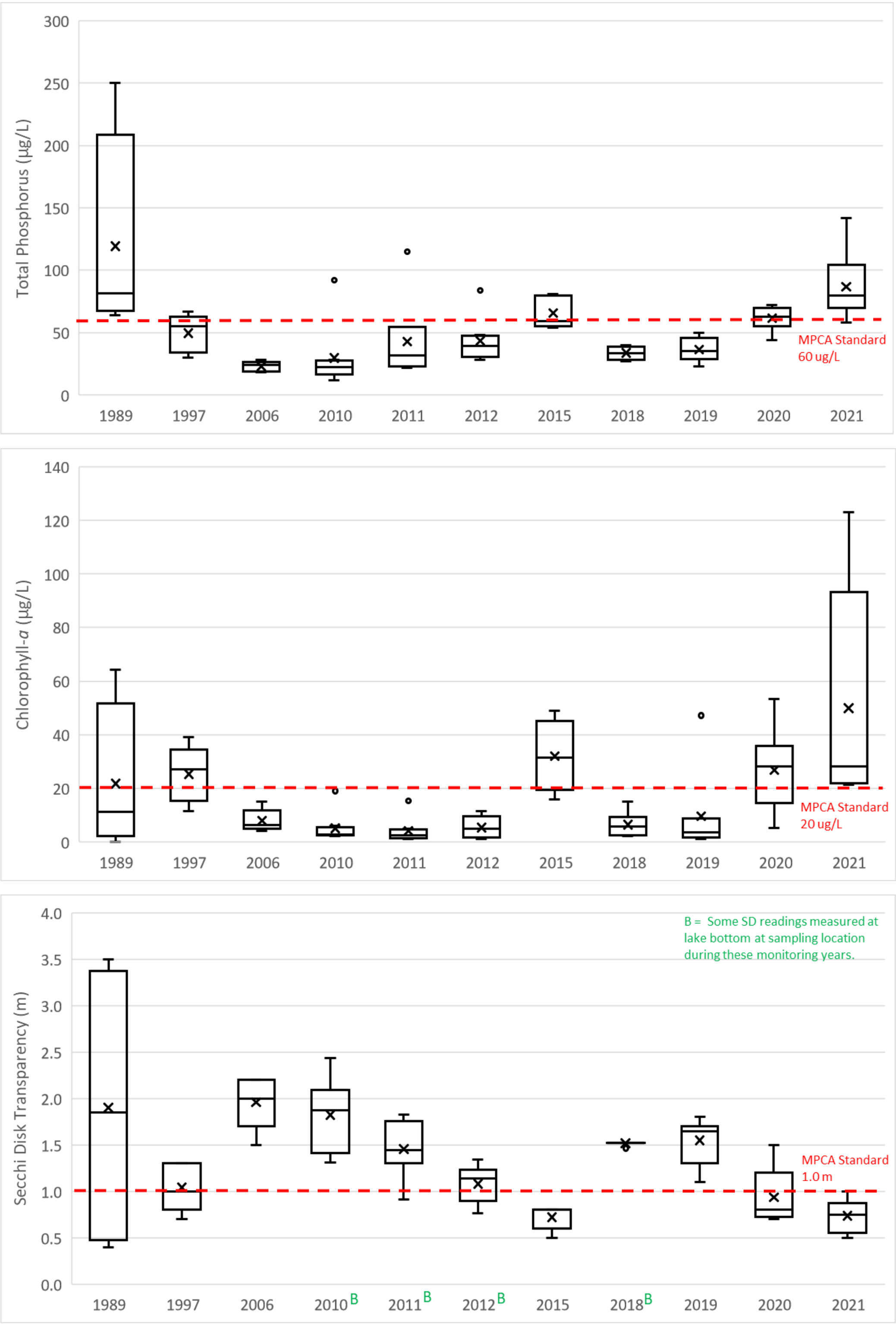


Figure 5-1 **Total phosphorus, chlorophyll-*a*, and Secchi disk transparency from 1989 through 2021.**
The black "x" indicates the summer average (June through September).

5.1.2 Total Phosphorus—Surface, Middle, & Bottom Monitoring

As discussed in Section 5.1.1, the NMCWD and the City of Eden Prairie collect surface total phosphorus (TP) concentrations as a part of their standard monitoring programs to assess lake eutrophication parameters. Along with surface TP concentrations, NMCWD and the City of Eden Prairie also often collect TP samples from the bottom of the lake (e.g., samples collected a few feet above the sediment at the monitoring location). For the most recent monitored years (2020 and 2021), the City of Eden Prairie also collected mid-depth TP samples. Samples are collected from mid-depth and near the bottom of lakes to inform the severity of internal phosphorus loading from lake bottom sediment. If TP concentrations at mid-depth and the bottom of the lake are significantly higher than TP concentrations observed near the surface, this can indicate that internal loading from lake bottom sediments may be causing water quality concerns. Figure 5-2 compares the surface TP concentrations (orange triangles) to the middle (green squares) and bottom TP (blue circles) concentrations observed in Birch Island Lake in 2019, 2020, and 2021.

Monitoring results from 2019 indicate that surface and mid-depth TP concentrations were relatively similar. In 2019, mid-depth TP concentrations were collected at approximately 2 meters below the surface. The greatest variation in TP concentrations occurred in mid-May where the difference between the surface and middle TP concentrations was 95 µg/L. For all other observed data in 2019, the difference between the surface and mid-depth TP concentrations ranged between 0-16 µg/L, where two of the monitored days had higher surface TP concentrations. The surface and mid-depth TP monitoring data collected indicates that Birch Island Lake was relatively well mixed for at least the top 2 meters of the lake. Bottom TP concentrations were not collected in 2019. The lake bottom ranged between 5.0-6.6 meters below the surface during the 2019 monitoring season. Since TP concentrations were not collected at the very bottom of the lake, the degree of internal sediment loading cannot be inferred from the monitoring data. Therefore, review of sediment core data and in-lake model calibration were required to estimate sediment internal loading in 2019. The in-lake model calibration process is discussed in Section 6.3.

The surface, mid-depth, and bottom TP concentrations collected in 2020 show a contrast to the observations in 2019. The bottom TP concentrations are notably higher than the surface concentrations for a large percentage of the monitored days in 2020 from May through October. The highest observed bottom TP concentration was approximately 1,790 µg/L on 7/15/2020, which is about 29 times higher than the observed surface TP concentration of 61 µg/L. The higher bottom TP concentrations observed in Birch Island Lake in 2020 indicate that internal loading is likely impacting the lake's water quality. The higher mid-depth TP concentrations also indicate that TP diffusion across the thermocline and/or periodic lake mixing is introducing TP from lower depths to higher depths in the water column. Temperature profiles indicate that Birch Island Lake was weakly to moderately stratified for a good portion of the growing season in 2020 (Figure 5-3). The weak stratification allows for increased mixing events that may bring up nutrients from the sediments. TP internal loading from lake bottom sediments in 2020 was investigated further during this water quality study using in-lake model calibrations. In-lake model calibration is discussed in detail in Section 6.3. Further discussion on why the internal phosphorus loading from lake bottom sediments was high in 2020 is presented in Sections 5.1.7 and 5.4.

Although the difference between surface and bottom TP concentrations is not as large as in 2020, the TP monitoring data from 2021 also indicate that internal phosphorus loading from lake bottom sediments is likely impacting water quality. The highest observed bottom TP concentration was approximately 409 µg/L on 9/13/2021, which is about 4 times higher than the observed surface TP concentration of 112 µg/L. Temperature profiles indicate that Birch Island Lake was weakly to moderately stratified in 2021 (Figure 5-3). The weaker stratification allows for increased mixing events that may bring up nutrients from the sediments to higher in the water column.

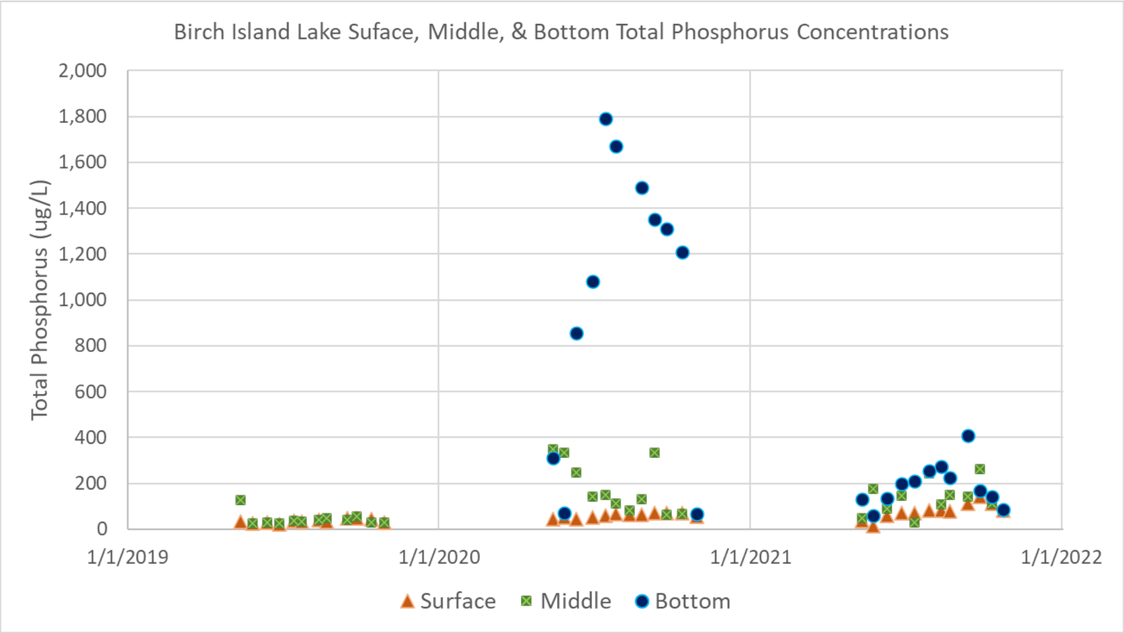


Figure 5-2 Surface, middle, & bottom total phosphorus concentrations

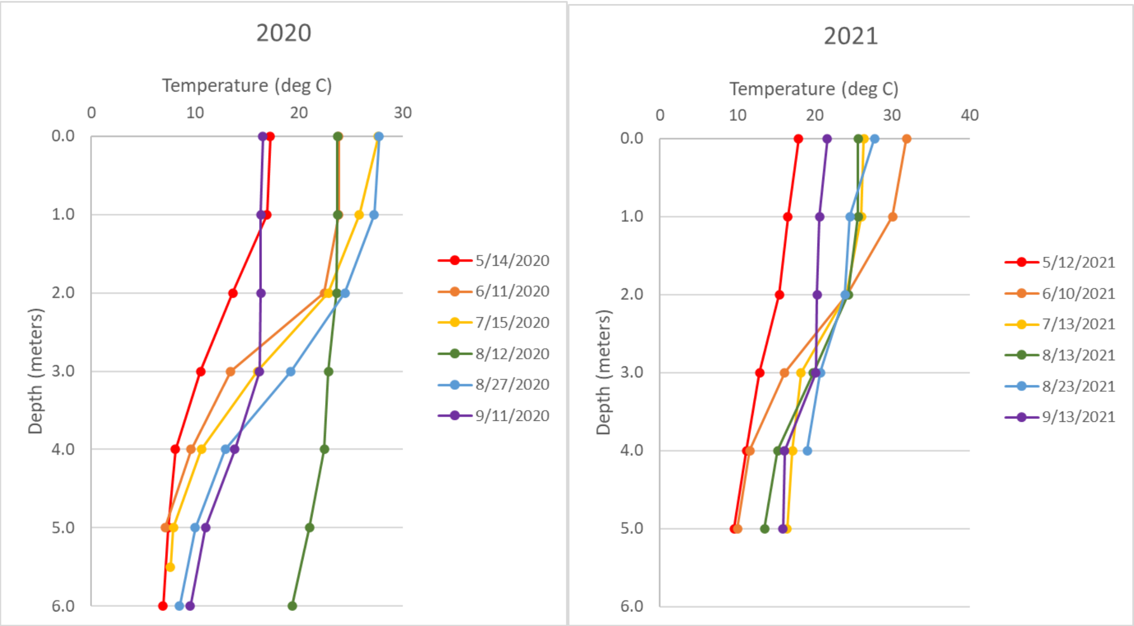


Figure 5-3 Temperature profiles in 2020 and 2021

5.1.3 Chlorophyll-*a*—Surface, Middle, & Bottom Monitoring

As discussed in Section 5.1.1, the NMCWD and the City of Eden Prairie collect surface chlorophyll-*a* concentrations as a part of their standard monitoring programs to assess lake eutrophication parameters. For the most recent monitored years (2020 and 2021), the City of Eden Prairie also collected mid-depth and bottom chlorophyll-*a* samples (Figure 5-4). Higher chlorophyll-*a* concentrations observed at mid-depth and/or the lake bottom can indicate higher concentrations of cyanobacteria. Certain species of cyanobacteria can regulate their buoyancy by adjusting the quantity of gas in their gas vacuoles. This allows these species to access different depths of the water column which can be helpful for acquiring higher nutrient concentrations or escaping unfavorable conditions at the surface. Cyanobacteria buoyancy regulation is a major competitive advantage over other phytoplankton species, such as green algae.

In 2020, 83% of the observed mid-depth and 75% of the observed bottom chlorophyll-*a* concentrations were greater than those observed at the surface. The highest observed mid-depth chlorophyll-*a* concentration was approximately 259 µg/L on 6/11/2020, which is about 17 times higher than the observed surface chlorophyll-*a* concentration of 15 µg/L. In 2021, 75% of the observed mid-depth and 83% of the observed bottom chlorophyll-*a* concentrations were greater than those observed at the surface. The highest observed bottom chlorophyll-*a* concentration was approximately 235 µg/L on 8/23/2021, which is about 5 times higher than the observed surface chlorophyll-*a* concentration of 45 µg/L. This data indicates that Birch Island Lake has cyanobacteria species that can adjust their buoyancies to access phosphorus that is diffusing across the thermocline. Additional discussion on Birch Island Lake phytoplankton and cyanobacteria can be found in Section 5.3.2.

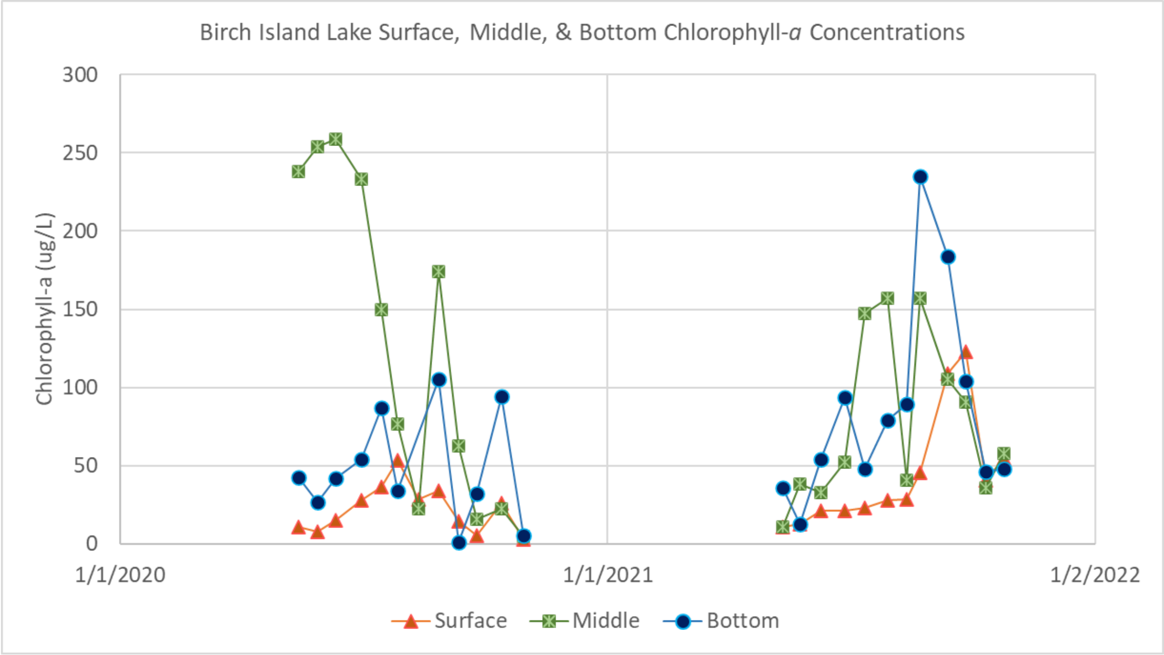


Figure 5-4 Surface, middle, & bottom chlorophyll-*a* concentrations

5.1.4 Nitrogen

Water quality monitoring in 2006, 2012, 2015, 2018 and 2019-2021 included analyses of Total Kjehdahl Nitrogen (TKN). TKN measures the concentration of ammonia and organically bound nitrogen and does not include nitrate or nitrite concentrations. Nitrate/nitrite concentrations were monitored in all the same years except 2012, although all monitored concentrations were below the detection limits. TKN data are presented using box plots. The box plots show averages (black 'x'), median values (straight horizontal line), minimum and maximum values (whiskers), outliers (circles), as well as the region where 50 percent of the data lie (the area within the boxes). Box plots shown on Figure 5-5 display the observed summer average TKN concentrations in between 2006 and 2021 for Birch Island Lake.

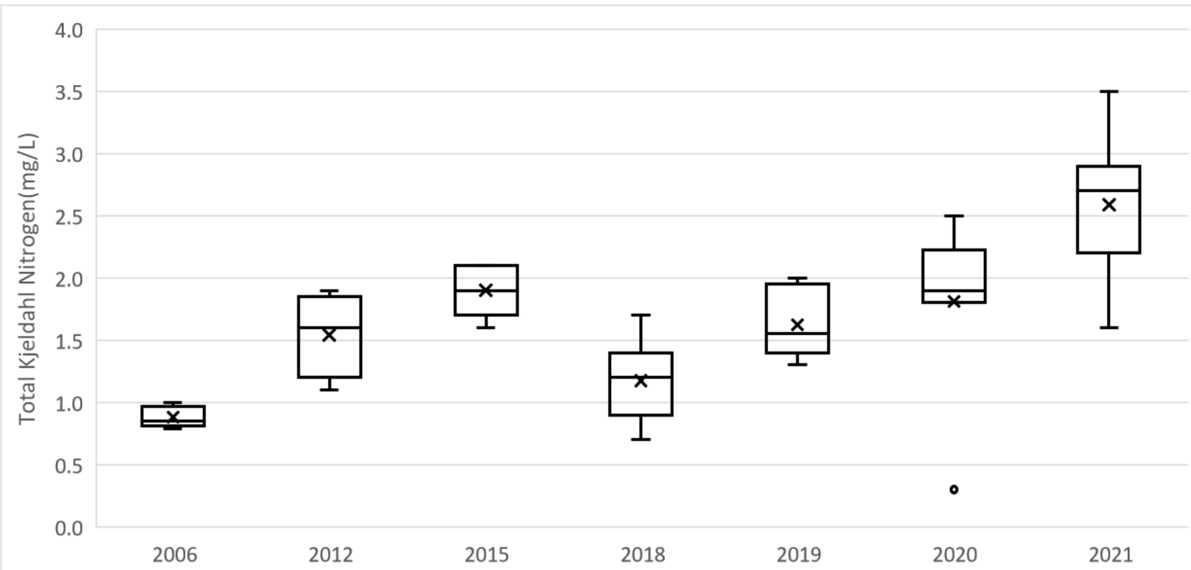


Figure 5-5 Total Kjehdahl Nitrogen 2006 through 2021 in Birch Island Lake. The black "x" indicates the summer-average (June through September).

All observed nitrate/nitrite concentrations in Birch Island Lake were below the detection limit (< 20 µg/L in 2006 and 2015 and <50 µg/L in 2018-2021). Low nitrate/nitrite concentrations can indicate that algae in Birch Island Lake may have periods where growth is limited by the amount of available nitrogen. Algal species that can't fix atmospheric nitrogen (e.g., green algae, diatoms) require a combination of bio-available nitrogen sources including nitrate, ammonium, and dissolved organic nitrogen. Only species that can fix atmospheric nitrogen (e.g., specific species of cyanobacteria) may be able to thrive in conditions of low nitrate/nitrite concentrations.

5.1.5 Chlorides

Chloride concentrations in many area lakes have increased since the early 1990s when many government agencies switched from sand or sand/salt mixtures to salt for winter road maintenance. When snow and ice melts, the salt goes with it, washing into lakes, streams, wetlands, and groundwater. Once chlorides reach downstream waterbodies, they are considered permanent pollutants since there is no way to remove chloride without extensive financial implications.

To protect fish and plant life, the MPCA has established a chronic exposure chloride standard of 230 mg/L or less and considers two or more exceedances of the chronic standard in 3 years to be an impairment. Based on the monitoring data collected in 2015 and 2018-2021, chloride concentrations in Birch Island Lake have not been observed to exceed 230 mg/L. The highest surface concentration recorded was 170 mg/L in August 2018. Monitored surface chloride concentrations from 2015-2021 ranged from 70-170 mg/L, with the lowest concentrations observed during the years with the highest water surface elevations (i.e., more water volume results in lower concentrations). The NMCWD and City of Eden Prairie will continue to periodically monitor for changes in chloride concentrations.

5.1.6 Dissolved Oxygen

Dissolved oxygen concentrations measured in Birch Island Lake in 2015 and 2018-2021 at the monitoring locations ranged from 2.1 to 12.8 mg/L in the surface waters and 0.0 to 9.3 mg/L near the lake bottom as shown in Figure 5-6. Dissolved oxygen concentrations were generally low near the lake bottom in 2015, 2020, and 2021, with only two of the twenty-nine measurements being above 1 mg/L due to fall turnover. Concentrations below 3 mg/L stress most fish species and concentrations that remain below 1-2 mg/L for a few hours can result in fish kills. This monitoring data also indicate that dissolved oxygen concentrations can be low enough for extended periods of the growing season to promote phosphorus release from lake bottom sediments (see Section 5.2 for a more complete discussion of phosphorus release from lake bottom sediments).

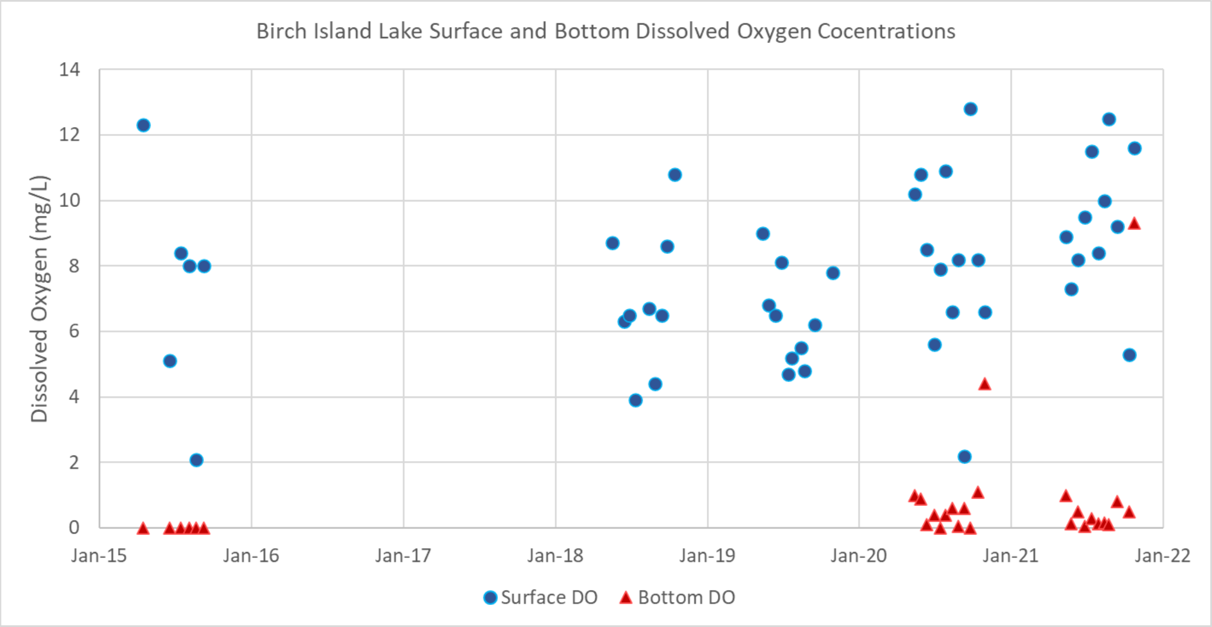


Figure 5-6 **Surface and bottom dissolved oxygen concentrations**

5.1.7 Stratification and Anoxic Factors Analysis

To evaluate stratification in Birch Island Lake, temperature and dissolved oxygen profiles were plotted for the monitoring years where full profiles were collected (2006, 2015, 2020, 2021). The temperature profiles, as shown in Figure 5-7, indicate that Birch Island Lake stratifies only weakly to moderately throughout the growing season. The significant fluctuation in Birch Island Lake's annual water depth can influence the strength of stratification. For example, in 2015 the lake's average maximum depth over the monitoring period was approximately 4 meters (~13 feet), which resulted in weak stratification throughout the monitoring period. As a comparison, in 2020 the lake's average maximum depth over the monitoring period was approximately 6 meters (~20 feet). As such, the lake was more stratified in 2020 from May through July than in 2015; however, the lake was still stratified weakly enough that the lake became fully mixed in mid-August. This likely resulted from a major storm/wind event. A similar influence of lake depth on stratification can be seen in 2006 and 2021.

The dissolved oxygen profiles, as shown in Figure 5-8, demonstrate long periods of anoxia throughout the monitoring periods with the anoxic conditions often shallower than temperature stratification. The dissolved oxygen profile data was used to calculate anoxic factors to further evaluate the role of anoxia in influencing internal sediment TP loading using the method developed by Gertrud Nürnberg (Nürnberg, 1995). An anoxic factor is reported in days and is the number of days an area equal to the lake area is anoxic. For example, if 50% of the lake area is anoxic for half the growing season (122 days), the anoxic factor is 50% of 122 or 61 days. Using the anoxic factor approach allows for an annual comparison of anoxic conditions for the same lake. This approach also allows a comparison among lakes of different sizes, if desired.

Because Birch Island Lake demonstrates weakly to moderately stratified conditions depending on the lake depth and climate conditions, the anoxic factors are variable from year to year (Figure 5-9 shows the anoxic factors for each monitoring period). The 2006 anoxic factor was very low (5), which coincided with improved water quality (e.g., lower TP and chlorophyll-a concentrations and higher clarity). The 2020 anoxic factor was the highest of four monitored years with full profile data (54), coinciding with poorer water quality. However, although 2021 had a low anoxic factor (11) the lake still demonstrated poorer water quality. Therefore, other factors besides anoxia must be considered when defining impacts to lake water quality.

Figure 5-10 shows a comparison of the calculated anoxic factors to the monitored summer average surface and bottom total phosphorus concentrations. The comparison between anoxic factor and bottom TP concentrations indicates that there is a relationship between the severity of anoxia and the concentration of total phosphorus released from lake bottom sediments (R^2 = 0.95). A similar relationship is not observed for the calculated anoxic factor and surface total phosphorus concentrations. This is likely because the surface concentrations are impacted by additional complicating factors (e.g., stormwater runoff, lake mixing dynamics, water depth/volume, uptake during photosynthesis).

Review of the monitored temperature and dissolved oxygen profiles and calculated anoxic factors indicate that the weaker stratification observed in Birch Island Lake can allow for increased mixing events, which may bring up higher TP concentrations from the hypolimnion and the sediment. Weaker stratification coupled with high anoxic factors (prolonged durations of anoxia over larger portions of the lake bottom) can increase the severity of sediment TP loading on lake water quality.

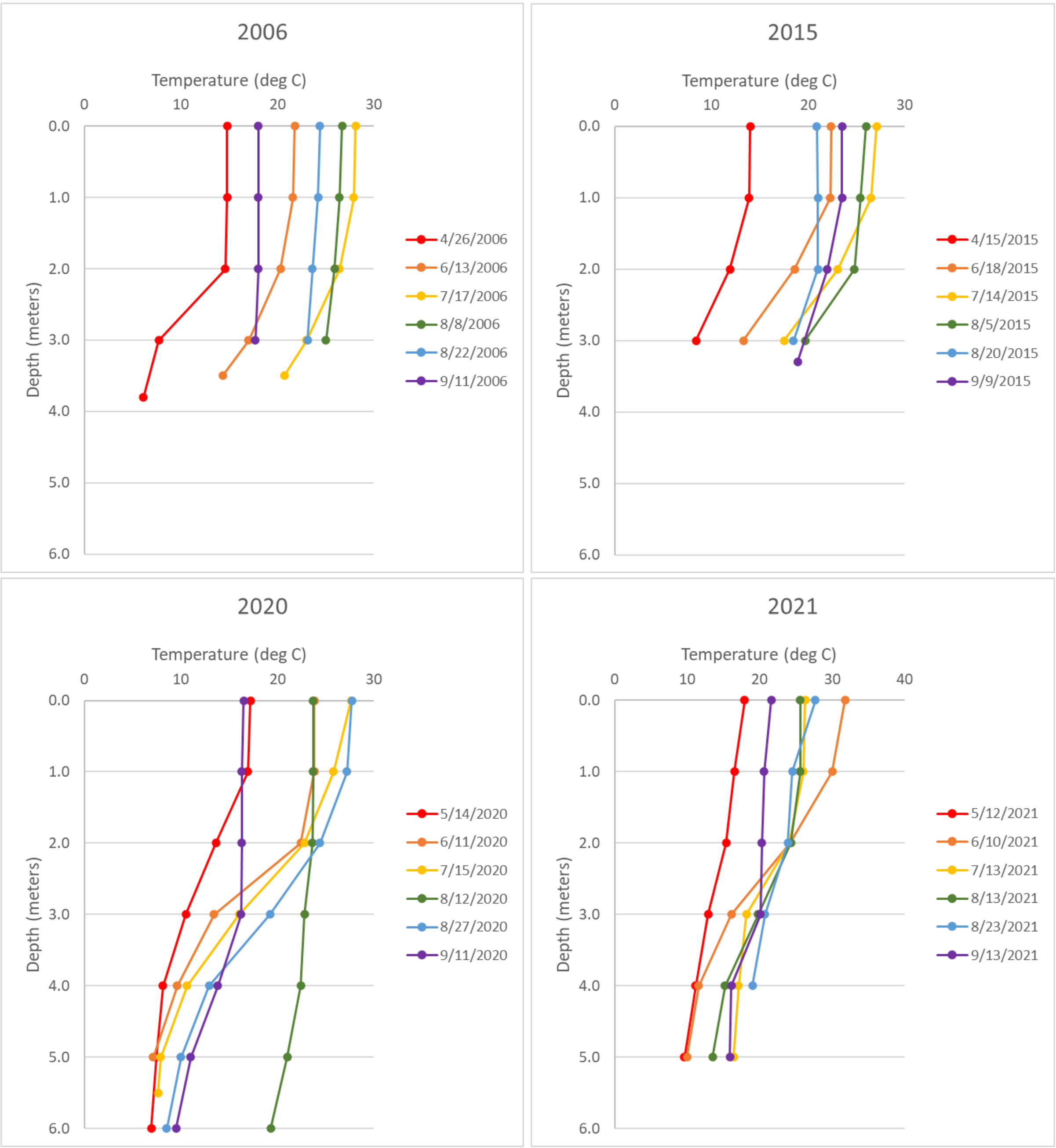


Figure 5-7 Temperature profiles between 2006 and 2021

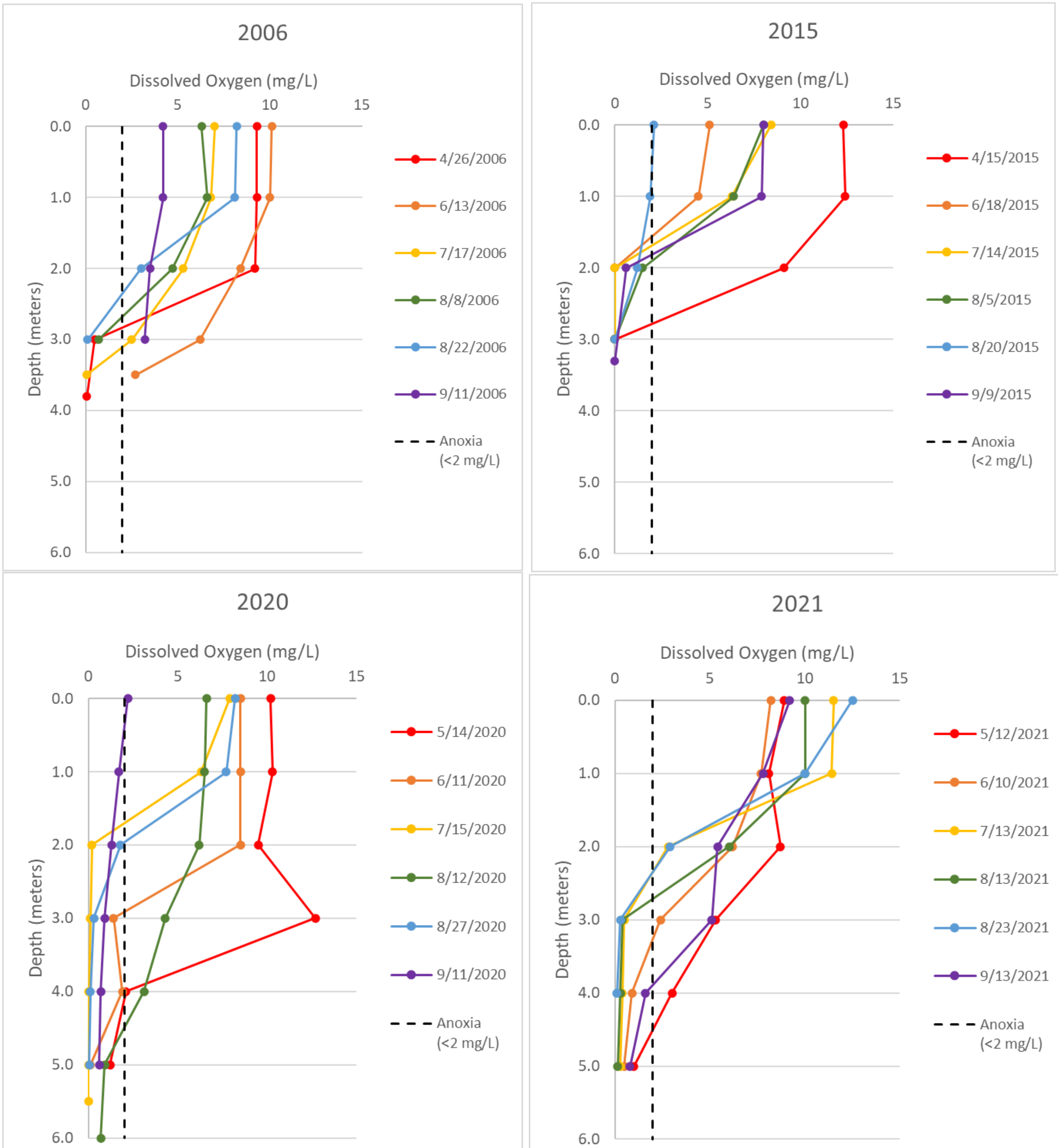


Figure 5-8 Dissolved oxygen profiles between 2006 and 2021

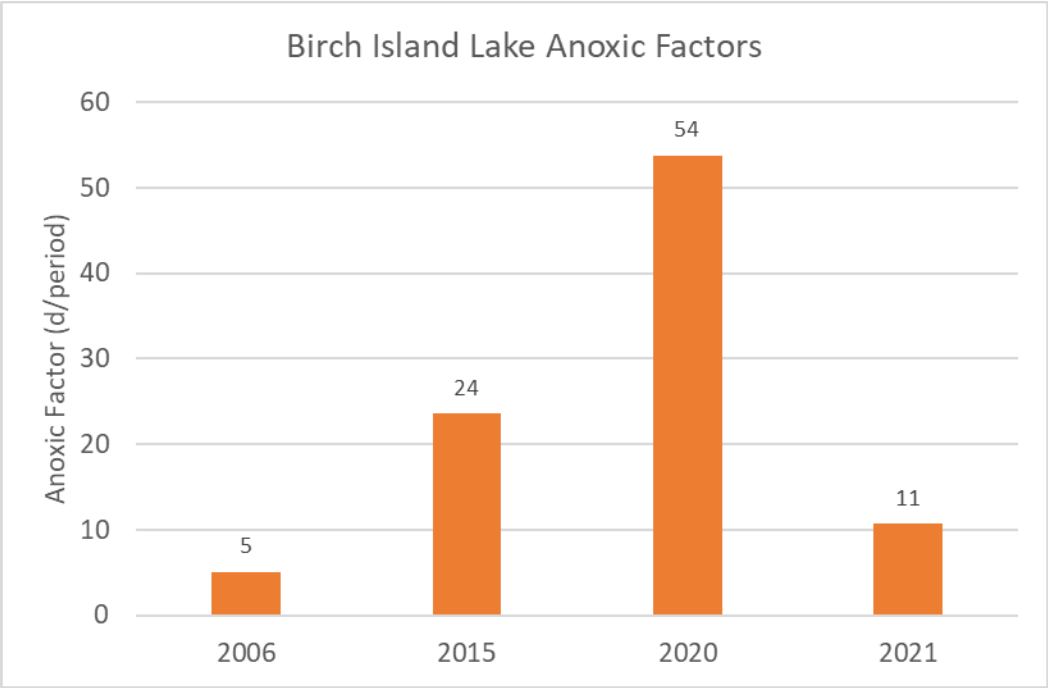


Figure 5-9 **Anoxic factors between 2006 and 2021**

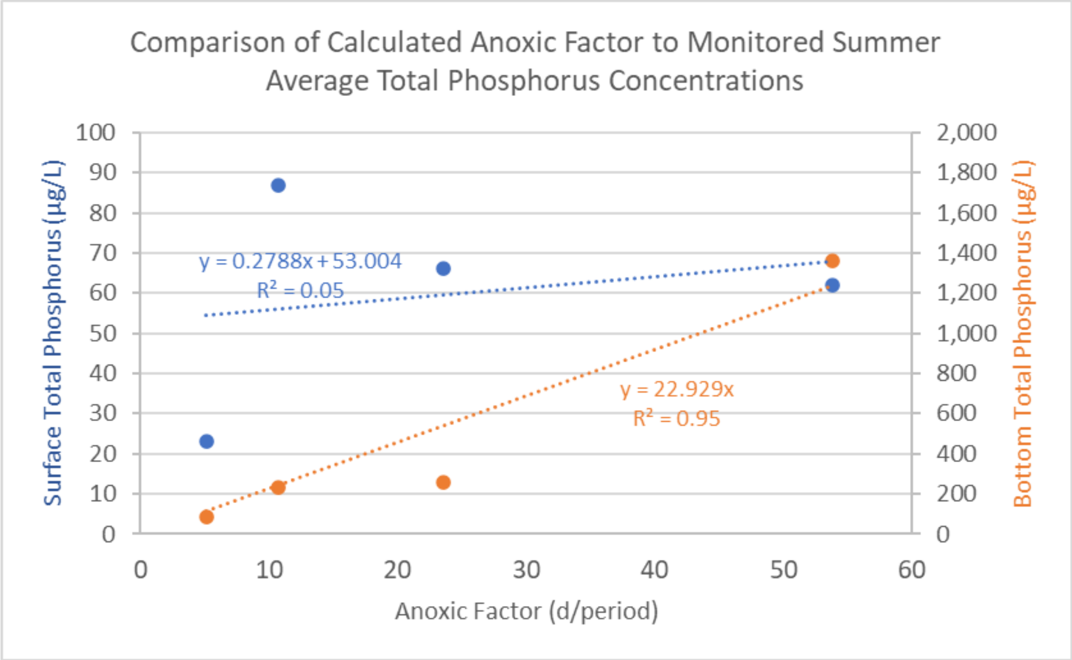


Figure 5-10 **Calculated anoxic factors compared to monitored summer average bottom total phosphorus concentrations**

5.2 Sediment Quality

Phosphorus in lake bottom sediments is often bound to a range of different elements such as iron and manganese (often referred to as mobile phosphorus), aluminum, or calcium. The mobile phosphorus fraction can be released from sediment during low oxygen conditions. Phosphorus can also be found incorporated into organic matter in the sediment (organically bound phosphorus). A portion of the organically bound phosphorus is released into the water column from lake sediments through mineralization, but typically at a slower rate than mobile phosphorus. The mineralization release rate is controlled by lake water temperature and can occur under aerobic or anaerobic conditions. Phosphorus release from sediment is typically termed as "internal phosphorus loading".

Two sediment cores were collected in June 2021 and used to evaluate the internal phosphorus loading potential of the mobile and organically bound phosphorus fractions. The average concentrations of organically bound phosphorus and mobile phosphorus in the top 4 centimeters of three cores taken from Birch Island Lake were 35.0 and 1.5 µg P/cm^3 wet sediment, respectively. These observed concentrations indicate that there is potential for internal phosphorus loading of organically bound phosphorus (organic-P) and minimal potential from mobile phosphorus (mobile-P).

Table 5-1 provides the average maximum potential mobile-P internal loading rate (0.0 mg/m^2-d) for the two sediment cores collected from Birch Island Lake and compares this value with other lakes in the metro area. This mobile phosphorus concentration can be considered "background"; there is minimal potential for release of the mobile phosphorus fraction in the bottom sediments of Birch Island Lake.

The sediment core data collected from Birch Island Lake indicates that internal phosphorus loading from organic-P could be a significant source of phosphorus. Previously, research has focused heavily on mobile-P being the main mechanism of internal phosphorus loading. However, recent research and monitoring data indicate that organic-P, especially organic-P fractions that are susceptible to biological or chemical decomposition (e.g, phosphate esters, phospholipids), can be a significant source of phosphorus and can maintain high productivity in lakes (Wei, et al., 2022). Because Birch Island Lake is shallow and has a small water volume, even a low internal phosphorus loading rate can notably increase phosphorus concentration in the lake water column.

Table 5-1 Maximum potential mobile-p internal loading rate for Birch Island Lake compared to other Twin Cities Metro Area lakes.

Lake	Maximum Potential Internal Phosphorus Load from Mobile-P ($mg/m^2/d$)
Kohlman[1]	17.0
Isles (pre-alum, deep hole)[2]	14.1
Harriett (pre-alum, deep hole) [2]	11.1
Calhoun/Bde Maka Ska (pre-alum, deep) [2]	10.8
Fish E[3]	10.5
Cedar (pre-alum) [2]	9.3
Fish W[3]	8.1
Como[3]	7.6
North Cornelia (pre-alum)[4]	7.6
Calhoun/Bde Maka Ska (pre-alum, shallow) [3]	5.6
Keller[1]	3.5
Parkers[3]	3.5
Phalen[3]	2.3
McCarrons[3]	2.0
Bryant[3]	1.5
South Cornelia (pre-alum)[4]	1.3
Mirror Lake[6]	1.0
Smetana[5]	0.7
Minnewashta[3]	0.2
Birch Island Lake	**0.0**
Edina[4]	0.0
Christmas[3]	0.0

Sources:
[1] (Barr Engineering Co., 2007)
[2] (Huser & Pilgrim, 2014)
[3] (Pilgrim, Huser, & Brezonik, 2007)
[4] (Barr Engineering Co., 2018)
[5] (Barr Engineering Co., 2020)
[6] (Barr Engineering Co., 2023)

5.3 Aquatic Communities

The fish, zooplankton, phytoplankton, and aquatic plants residing in lakes are all linked, and the composition and abundance of biota observed in the lakes provide indication of lake health and if biological management should be considered to improve water quality.

5.3.1 Aquatic Plants

Macrophytes, also called aquatic plants, grow in aquatic systems such as streams and lakes. There is a wide range of macrophytes including species attached to the lake bottom, species unattached and floating, submerged species, and emergent species (e.g., cattails). Macrophytes are an important part of a shallow lake ecosystem and provide critical habitat for aquatic insects and fish. A healthy native plant community contributes to the overall health of the lake. However, a dense non-native plant community can create problems, including recreational use impairment, fluctuating water quality, and a less than ideal fisheries habitat, which has adverse impacts on the fish community. The dense growth can make it difficult for invertebrates and other organisms that fish eat to survive. So, with less to eat and less open water, fish populations decrease (MPCA, Eurasian Water Milfoil, 2019). Dense aquatic plant growth can also make it difficult for fish to catch food. When fish are less effective at controlling prey species, an unbalanced fishery results (Indiana Department of Natural Resources, 2019).

The NMCWD conducted qualitative macrophyte monitoring as part of its routine monitoring of Birch Island Lake in 1997, 2006, and 2015. Plant surveys were conducted in June and August of each of the monitored years, with qualitative notation of plants observed and their density throughout the lake. The aquatic plant maps from 1997, 2006, and 2015 are provided in Appendix A

The City of Eden Prairie conducted point-intercept (PI) macrophyte surveys in early summer and fall 2010 and 2011 and July 2020 and July 2021. The objectives of the PI surveys, conducted by Blue Water Science, were to characterize the plant community and observe non-native species. The PI survey reports from 2020 and 2021 are provided in Appendix A. These reports also include information on the 2010 and 2011 surveys.

A summary of each plant species found and the percent occurrence during the most recent PI survey in July 2021 is summarized in Table 5-2. The highest abundance of native species was found just off the eastern shoreline of the lake in the shallow nearshore region. A maximum of 6 different native species was found in only one of the sample locations. Over 60% of the sample locations observed 0–1 native plant species.

Table 5-2 Submerged and floating plant species—July 2021 point-intercept survey

Plant Taxa	Common Name	% Occurrence July 2021
All Taxa (Combined)		79%
Submerged Taxa		
Utricularia sp.	Bladderwort	67%
Stuckenia pectinata	Sago pondweed	13%
Potamogeton sp.	Stringy pondweed	13%
Myriophyllum sibiricum	Northern Watermilfoil	12%
Najas sp.	Naiads	8%
Potamogeton zosteriformis	Chara	8%
Ceratophyllum demersum	Coontail	6%
Utricularia minor	Lesser Bladderwort	6%
P. praelongus	Whitestem Pondweed	2%
-	Filamentous Algae	6%
Floating Taxa		
Nymphaea sp.	White Waterlilies	2%
Brasenia schreben	Watershield	2%

The Minnesota Department of Natural Resources (MNDNR) developed the Lake Plant Eutrophication Index of Biological Integrity (IBI) to indicate plant health/stress from eutrophication. The Lake Plant Eutrophication IBI includes two metrics to evaluate the response of a lake plant community to eutrophication. The first metric is species richness—the estimated number of species in a lake. The second metric is floristic quality index (FQI), which distinguishes the quality of the plant community and can reflect the quantity of nutrients in the lake.

The MNDNR's Lake Plant Eutrophication IBI was used to assess the health of the Birch Island Lake plant communities based on results of macrophyte surveys. Aquatic plant data collected by NMCWD and the City of Eden Prairie from 1997 through 2021 was used to determine species richness and FQI values. These values were then compared with MNDNR Lake Plant Eutrophication IBI thresholds for shallow lakes (a minimum of 11 species and an FQI score of at least 17.8 for a healthy plant community) to assess the health of the plant communities.

The Birch Island Lake plant community failed to meet the MNDNR Lake Plant Eutrophication IBI threshold for species richness in 1997, 2006, 2010, 2011, 2015, and 2020, with the observed data falling below the desired value of 11 plant species (Figure 5-11). July 2021 was the first time in the observed record that the Birch Island Lake plant community met the MNDNR Lake Plant Eutrophication IBI threshold for species richness with a total of 11 species observed. Prior to 2021, the number of species observed was variable and ranged from 3 to 10 species. A greater number of species were observed in years where the water surface elevations were higher.

The FQI values in Birch Island Lake follow a similar pattern as species richness. Years that had higher water surface elevations typically had higher FQI values. Monitored FQI values were below the MNDNR plant IBI

FQI threshold of 17.8 in June 1997, 2010, 2011, June 2015, and July 2020. FQI values exceeded the MNDNR plant IBI FQI threshold of 17.8 in August 1997, 2006, August 2015, and July 2021. FQI values were the highest in July 2021 at 22.3 (Figure 5-12).

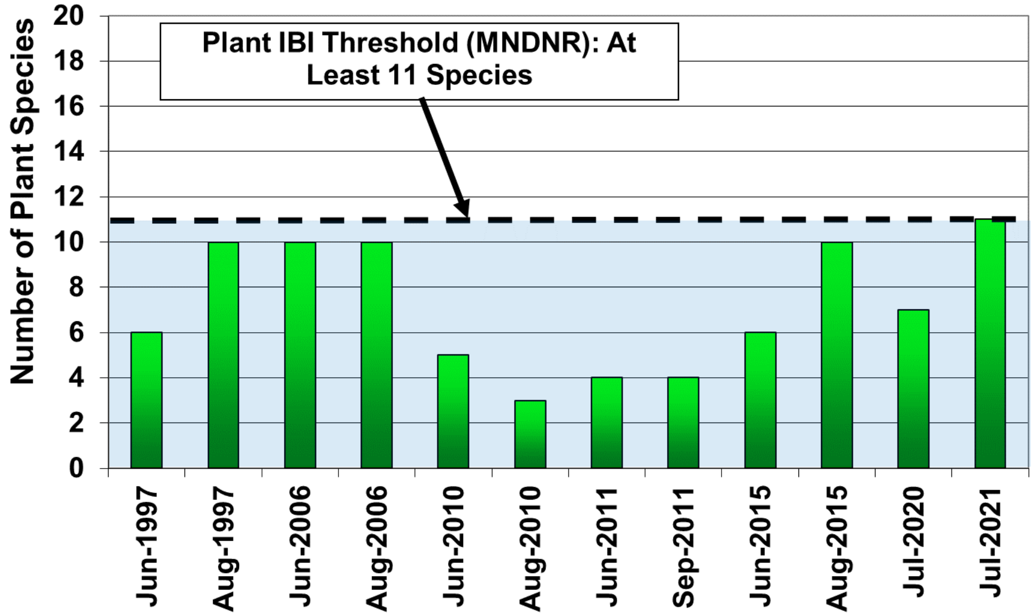


Figure 5-11 Macrophyte species richness compared with plant IBI threshold for species richness

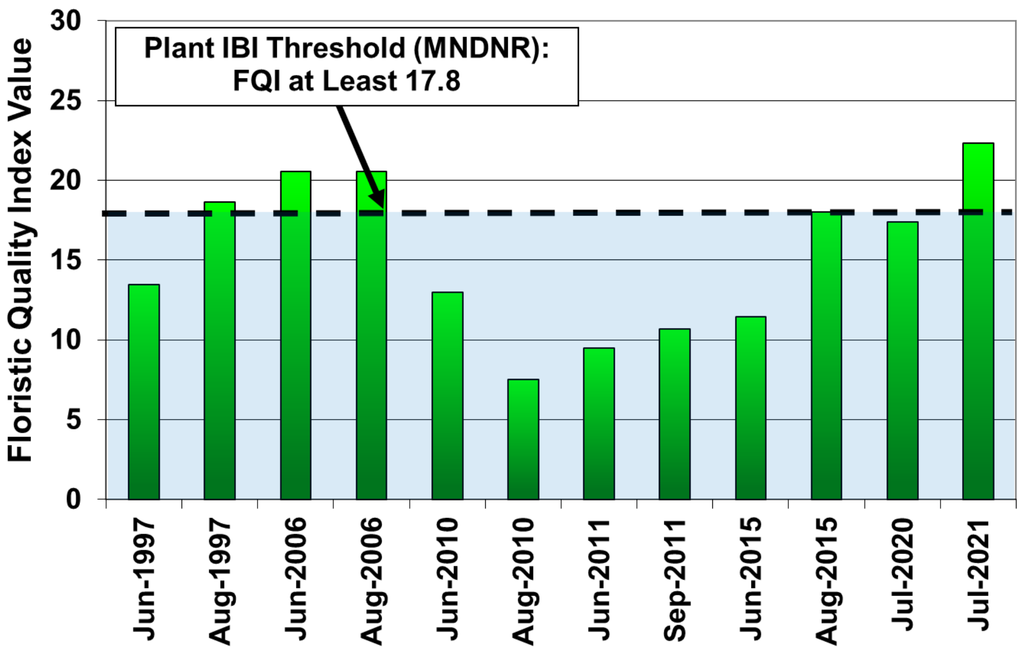


Figure 5-12 Macrophyte species quality compared with plant IBI threshold for Floristic Quality Index (FQI)

One non-native aquatic invasive species (AIS) has been recently observed in Birch Island Lake: Purple loosestrife. Curly-leaf pondweed has been historically observed in Birch Island Lake, but has not been present in the most recent surveys.

Purple loosestrife has been observed along portions of the Birch Island Lake shoreline since the survey completed in June 2006. Purple loosestrife has historically been observed in small areas along the eastern and southwestern shorelines.

Curly-leaf pondweed was observed in two locations at low densities in the June 2006 survey. However, since this survey, curly-leaf pondweed has not been observed. It is possible that the low lake water levels experienced for portions of 2007 through 2014 resulted in the natural management of the AIS by exposing the sediment to freezing conditions and reducing the viability of the curly-leaf pondweed turions. Although curly-leaf pondweed has not been observed in Birch Island Lake in recent years, future surveys should review if curly-leaf pondweed re-establishes, especially since the AIS is in upstream lakes (e.g., Wing Lake and Lake Rose).

5.3.2 Phytoplankton

Samples of phytoplankton, microscopic aquatic algae, were collected from Birch Island Lake in 1989, 1997, 2006, and 2015 as part of NMCWD's routine monitoring to evaluate water quality and the quality of food available to zooplankton (microscopic animals).

The summer average phytoplankton numbers in Birch Island Lake increased during the monitoring period of 1989 through 2015. In 1989, the summer average phytoplankton number was approximately 3,950 per mL. In 2015, the summer average phytoplankton number increased to 53,900 per mL (Figure 5-13). Blue-green algae numbers have also increased from 1989 to 2015. In 1989, the summer average blue-green algae numbers were approximately 230 per mL. In 2015, the blue-green algae summer average numbers increased to approximately 28,800 per mL. The highest observed concentration of blue-green algae from the routine monitoring location was 56,850 per mL in August 2015.

Blue-green algae are associated with water quality problems and can be a source of health concerns due to the possible production of hepatotoxins and neurotoxins. The World Health Organization (WHO) has established the following thresholds for assessing the probability of adverse health effects to lake users from exposure to blue-green algae (World Health Organization, 2003):

- ***Low Probability of Adverse Health Effects:*** Exposure to lakes with blue-green algae density levels between 20,000 and 100,000 cells per milliliter poses a low probability of adverse health effects (i.e., skin irritation or allergenic effects such as watery eyes).
- ***Moderate Probability of Adverse Health Effects:*** Exposure to lakes with blue-green algae densities greater than 100,000 cells per milliliter poses a moderate probability of adverse health effects (i.e., long-term illness from algal toxins is possible).
- ***High Probability of Adverse Health Effects:*** Exposure to lakes with blue-green scum in areas where whole body contact or ingestion/aspiration occur poses a high probability of adverse health effects (i.e., acute poisoning from algal toxins is possible).

Figure 5-14 shows the observed blue-green algae counts in Birch Island Lake in comparison with the WHO thresholds for probability of adverse health effects. In 1989, all observed blue-green algae counts were well below the WHO threshold for low probability of adverse health effects. In 1997 and 2006, all but two of the blue-green algae counts were well below the WHO threshold for low probability of adverse health effects. In September 1997 and late August 2006, the blue-green algae counts exceeded the threshold for low probability of adverse health effects level. Monitoring year 2015 had the highest blue-green algae counts on record. From August through September 2015, observed blue-green algae counts were above the threshold for low probability of adverse health effects level.

The City of Eden Prairie conducted semi-quantitative surveys in May and August 2021 to assess how the relative concentration of phytoplankton changed over the growing season. Blue Water Science collected samples from Birch Island Lake and sent the samples to PhycoTech for identification and counting. A summary of the phytoplankton data can be viewed as a part of the 2021 PI survey report, which is provided in Appendix A. The relative phytoplankton concentrations collected in May and August 2021 are summarized in Figure 5-15. The relative concentration summaries show a higher concentration of green algae in May 2021 as compared to August 2021 when there is a higher concentration of blue-green algae. This pattern was also observed at the NMCWD routine monitoring location from 1989 through 2015.

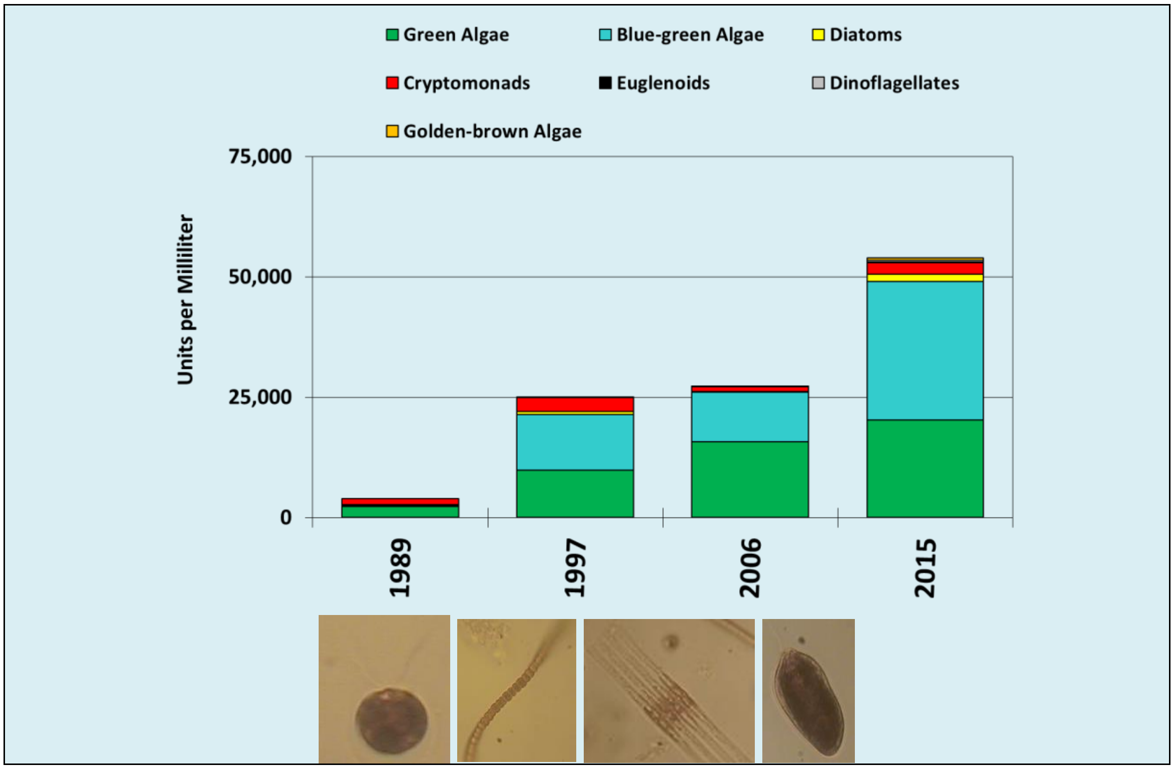


Figure 5-13 Top, 1989-2015 summer average phytoplankton numbers and bottom, microscopic pictures of phytoplankton species, from left to right, Chlamydomonas globosa (green algae) Dolichospermum affine (blue-green algae), Fragilaria crotonensis (diatom), and Cryptomonas erosa (cryptomonad).

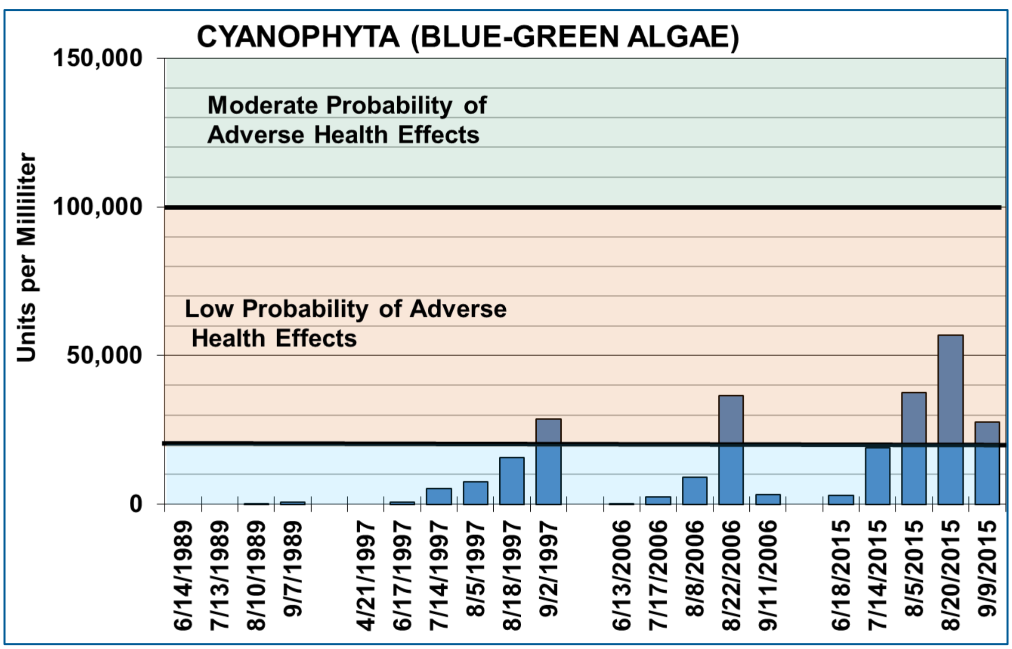


Figure 5-14 Blue-green algae data compared with the World Health Organization's guidelines for adverse health effects

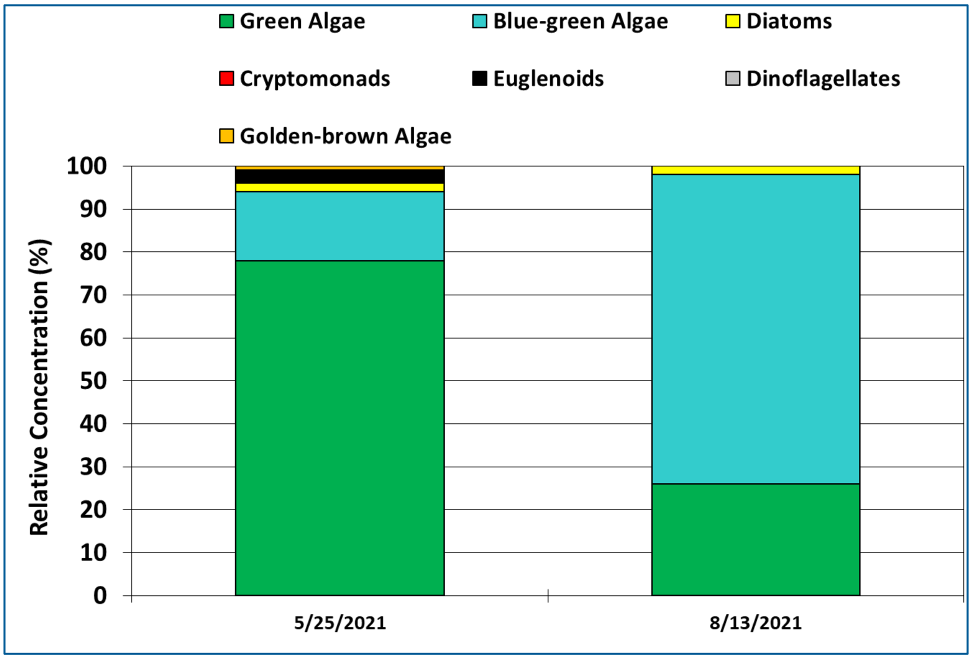


Figure 5-15 2021 relative phytoplankton concentrations

5.3.3 Zooplankton

Zooplankton are microscopic animals that feed on phytoplankton (algae) and organic matter that are a source of food for fish (e.g., bluegills, crappies). Samples of zooplankton were collected from Birch Island Lake in 1989, 1997, 2006, and 2015 as part of NMCWD's routine monitoring program. The City of Eden Prairie conducted zooplankton surveys in May and September 2020 and June and August 2021 (collected by Blue Water Science).

The observed quantity of zooplankton has been variable during the monitoring record, with higher quantities in portions of 1997 and 2015 and lower quantities in 1989, 2006, 2020, and 2021 (Figure 5-16). The highest observed quantity of zooplankton was in June 2015 at approximately 1.1 million per square meter. Lower quantities of zooplankton were especially evident in May 2020 and August 2021 where only 7,250 and 70,400 per square meter were observed, respectively.

Since 1989, the percentages of observed rotifers, copepods, and cladocerans have been variable (Figure 5-16). Rotifers have typically been the most abundant. The summer average quantity of rotifers ranged from 17%-85% of the observed species. Copepods have typically been the second most abundant and represented approximately 14%-81% of the observed species based on summer average concentrations. Cladocerans represented 1%-29% on average of the observed summer average species between 1989 and 2021.

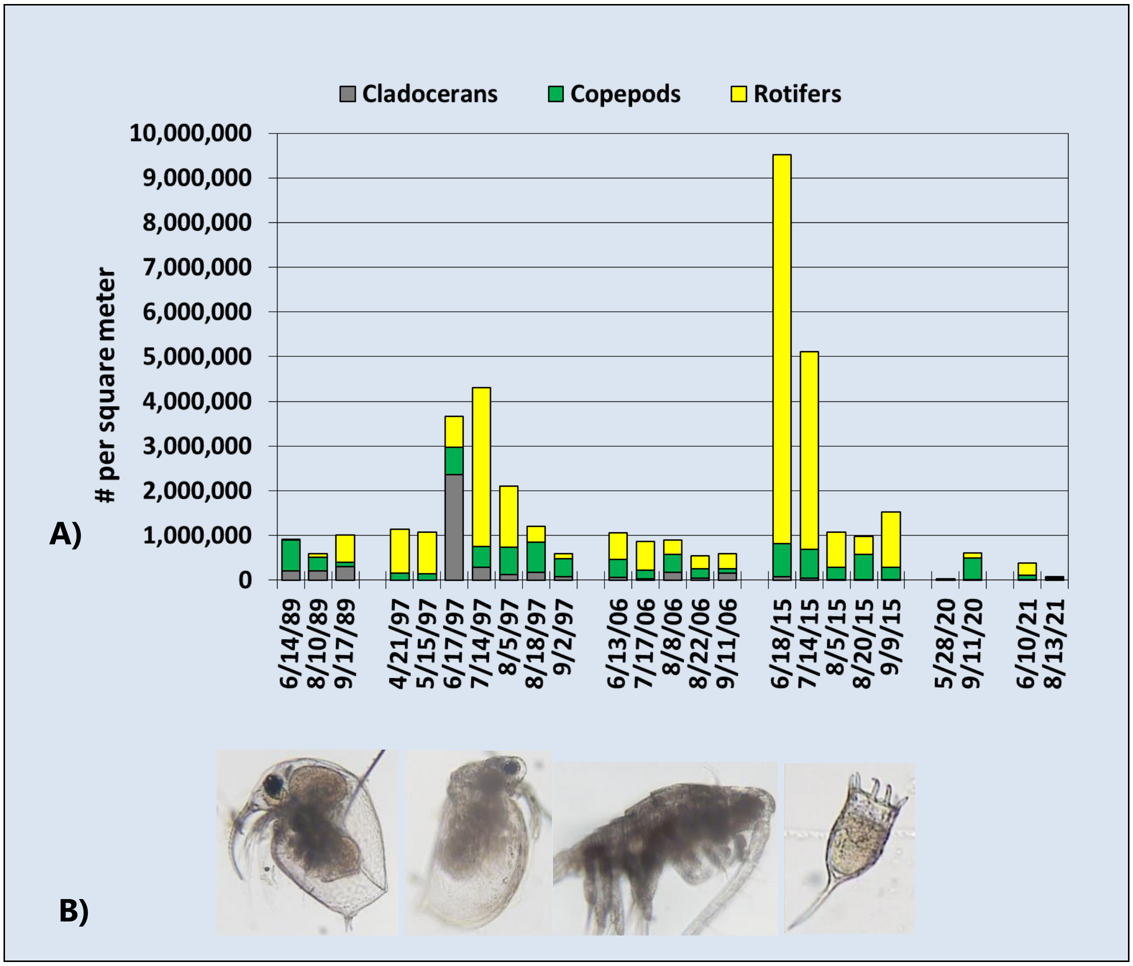


Figure 5-16 **A) 1989-2021 zooplankton numbers and B) microscopic pictures of zooplankton species, from left to right, Bosmina longirostris. (cladoceran), Ceriodaphnia sp. (cladoceran), Diaptomus sp. (copepod), and Keratella cochlearis (rotifer).**

5.3.4 Fish

NMCWD conducted a fisheries assessment of Birch Island Lake in October 2022. The assessment, completed by Blue Water Science, used four mini trap nets which were set along the eastern shoreline on October 11, 2022, and fished the following two days. Only four fish species were observed during the survey. Fathead minnows dominated the fish community with over 21,000 minnows collected over two days (Figure 5-17). Small quantities of the other fish species were observed (2 goldfish, 3 stickleback minnows, and 4 black bullheads). The observed fish species and their sizes indicate winterkill has historically occurred.

Higher quantities of minnows can lead to over-predation of zooplankton. An imbalance in the food web (i.e., lower quantities of zooplankton leading to less predation of algae) can negatively impact water quality. Lower predation of algae can lead to a decrease in water clarity, which can impact plant extent, density, and health over time. It's plausible that the lower quantities of zooplankton observed in 2020 and 2021 were due to higher quantities of minnows and over predation.

The 2022 fisheries assessment report by Blue Water Science can be found in Appendix B.

Figure 5-17 Fathead minnows collected in trap nets during 2022 fisheries assessment (photo by Blue Water Science)

5.4 Water Levels

Birch Island Lake is generally considered land locked. A high-level outlet has historically been referenced, but the location has not been confirmed. Given that the lake is generally land-locked, the water level in the lake depends on weather conditions (snowmelt, rainfall, evaporation) and groundwater flow.

Since the construction of County Road 62 in the mid- and late 1980's, the normal water level of Birch Island Lake has experienced significant changes. As such, several studies have been conducted to identify the problem and projects have been implemented to try to remediate the issue.

Two detailed studies were completed to assess the significant decreases in the Birch Island Lake water levels (Barr Engineering Co., 1992) (Barr Engineering Co., 2005). The studies found that construction of the County Road 62 embankment resulted in increased infiltration from the northern portion of the watershed easterly to an underlying sand lens that is not hydraulically connected to the waterbodies south of County Road 62. Therefore, substantially less runoff volume was reaching Birch Island Lake after the road embankment was installed leading to a decrease in water levels. Figure 5-18 shows that the extent of decrease in water levels experienced in Birch Island Lake in the late 1980's was inconsistent with other study lakes. The study found that Glen, Shady Oak, and Lone Lake had lower water levels due to dry weather but did not experience similar runoff volume and groundwater impacts as Birch Island Lake (Barr Engineering Co., 1992). Prior to installation of the road embankment, Birch Island Lake water surface elevations ranged between 884 and 891 (NGVD29) from 1963 and 1988 depending on climatic conditions.

Within 1-2 years following the road embankment installation, water surface elevations dropped and ranged from 878 to 879 (NGVD29) between 1990 and 1992 (when the study was completed).

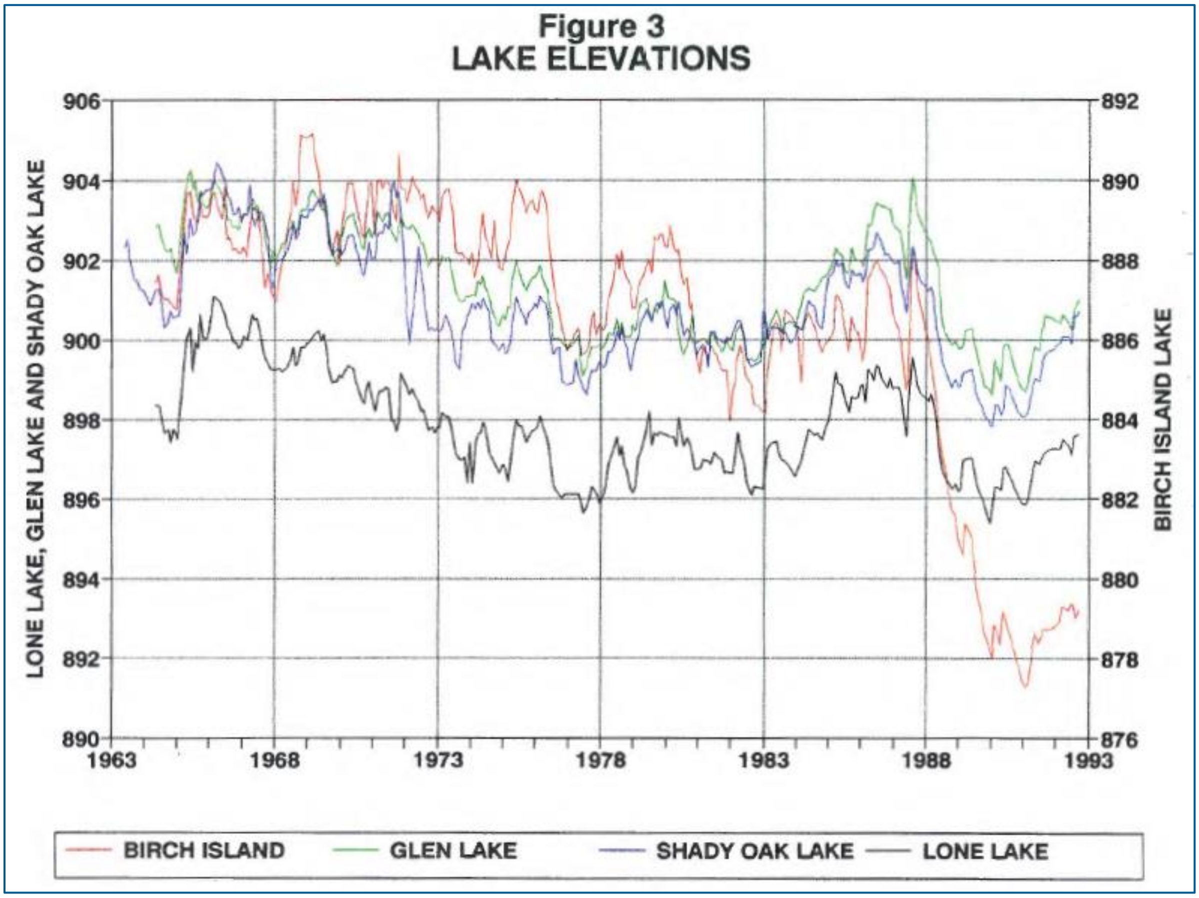


Figure 5-18 **Plot from the 1992 lake level study showing the abrupt drop in Birch Island Lake water levels as compared to other lakes in the study (Barr Engineering Co., 1992).**

Due to the significant drop in water surface elevations following the installation of County Road 62, the *Birch Island Lake Water Level Investigation* study recommended various construction alternatives to deliver additional runoff to Birch Island Lake and help remediate low water levels (Barr Engineering Co., 2005). The selected option included installing a pipe bypass system that conveys drainage from stormwater ponds located north of County Road 62 directly to Birch Island Lake. As designed, runoff that enters the bypass pipe bypasses the wetland directly north of Birch Island Lake. The installed bypass pipe is shown on Figure 4-2.

The bypass pipe was installed by NMCWD in 2007 and is operated by the City of Eden Prairie. Since installation, the bypass pipe and structures have been prone to periodic clogging from sediment. When clogged, runoff from the watersheds north of County Road 62 will discharge first into the wetland north of Birch Island Lake rather than into Birch Island Lake directly (as intended). Water level monitoring data indicates that the northern wetland and Birch Island Lake are not hydraulically connected via groundwater. The wetland water levels typically sit multiple feet above that of Birch Island Lake (Figure 5-19). Therefore, when the bypass pipe becomes clogged, significant volumes of water do not flow from the wetland to Birch Island Lake unless the channel between the two features is utilized (at an approximate elevation of 888 feet (NGVD29)).

The observed water surface elevations in Birch Island Lake monitored between January 2000 and November 2023 are shown in Figure 5-19. Except for 2019 and 2020, the monitored water surface elevations were typically well below the water levels observed prior to the installation of County Road 62. Above average precipitation in 2019 allowed Birch Island Lake to increase in elevation. However, since mid-2020 water surface elevations have been falling due to slightly below average precipitation and bypass pipe clogging in 2020 and significantly below average precipitation in 2021, 2022, and 2023. The observed water surface elevations in the wetland north of Birch Island Lake are also shown in Figure 5-19 demonstrating the hydraulically non-connectivity of these two waterbodies.

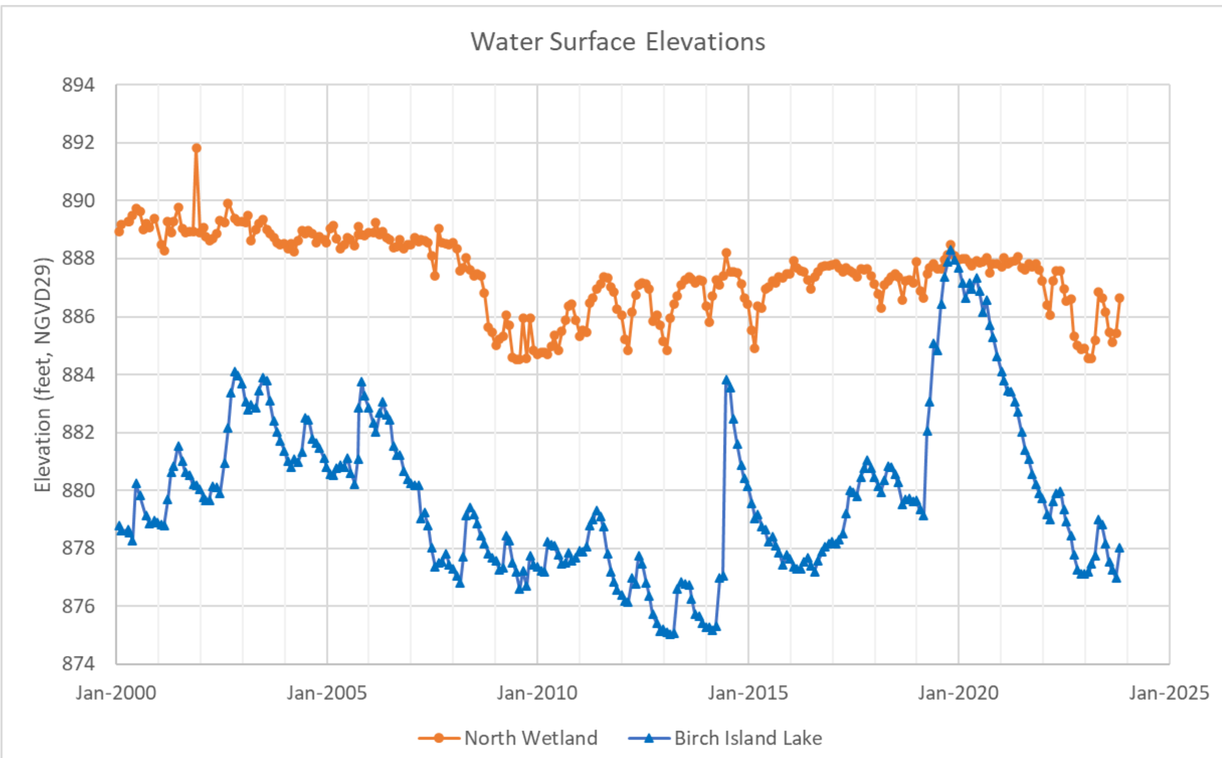


Figure 5-19 Observed water surface elevations, January 2000-November 2023

Since 2000, the lowest observed WSE of 875.1 (NGVD29) in February 2013 was 13.3 feet below the highest observed WSE of 888.3 (NGVD29) in October 2019. The lowest WSE of 875.1 corresponds to a water surface area of only 3.2 acres compared to a water surface area of 43.7 acres at the highest WSE of 888.3. Figure 5-20 shows a comparison of the Birch Island Lake open water area between 2013 and 2019. These radically differing open water areas and depths can influence water quality and ecosystem health.

Figure 5-20 A comparison of the open water area of Birch Island Lake between 2013 and 2019

Periodic drying and rewetting of sediments is a natural phenomenon in shallow lakes. A positive outcome of sediment drying and rewetting can be the consolidation of the sediment. As sediment dries and is exposed to oxygen, the organic matter content decreases through increased decomposition and the sediment density increases. Sediments with high densities and lower organic matter content have demonstrated improved macrophyte growth (James, Eakin, & Barko, 2001). While rewetted, consolidated sediment could have positive impacts on Birch Island Lake native submerged macrophyte growth, water levels are frequently not maintained at high enough levels to support larger areas of submerged macrophyte growth over long durations. In the last two decades, large swings in water levels have resulted in only the smaller, deeper portion of the lake being available for long-term submerged macrophyte growth. As discussed in Section 5.3.1, monitoring data indicates that higher water levels in Birch Island Lake correspond to improved aquatic plant diversity and density, while low water levels result in very few species and low distribution due to limited growth in the deeper depression.

Another positive outcome of sediment drying and rewetting can be the natural control of invasive aquatic plant species, such as curly-leaf pondweed. As mentioned in Section 5.3.1, it is possible that the low lake water levels experienced for portions of 2007 through 2014 resulted in the natural management of the curly-leaf pondweed by exposing the sediment to freezing conditions and reducing the viability of the turions.

While periodic drying and rewetting of sediments can have positive influences on macrophyte health, this process may result in undesirable impacts on water quality. Several studies have shown that drying and/or freezing of sediment can result in enhanced rates of internal nutrient loading upon rewetting during the first 1-2 years. A "pulse" of higher nutrients from sediment rewetting could be from enhanced decomposition of soil organic matter during drying, sediment chemistry changes (e.g., iron crystallization and desorption of phosphorus), and microbial death (McComb & Qiu, 1998) (James, Eakin, & Barko, 2001) (Klotz & Linn, 2001). A notable increase of nutrients following sediment rewetting could result in higher algal production, especially if macrophytes are not well established. It's possible that Birch Island Lake experiences nutrient "pulses" from the sediment quite frequently due to the drastic changes in water levels over short durations. Therefore, the stabilization of water levels may help to reduce the amount of sediment area prone to these episodic "pulsed" nutrient releases and will help to maintain re-established macrophyte species for longer durations.

However, predicting how water quality conditions will change due to lake level stabilization can be difficult. For example, in some lakes, high water levels may result in improved water quality because high water levels correspond to more water volume and lower nutrient concentrations (i.e., nutrients are diluted by more water volume). However, in other lakes, higher water levels may result in degrading water quality because high water levels may increase erosion in upland areas and/or an increase in the overall lake depth may increase lake stability, which may lower bottom dissolved oxygen conditions and exasperate internal sediment loading. Water quality response to changing water levels may also vary from year to year, so adjustments to lake levels should be assessed over time.

Section 8.3 discusses possible management and monitoring recommendations regarding lake levels in Birch Island Lake.

6.0 Water Quality Modeling

Computer modeling was used in this study to estimate stormwater runoff and pollutant contributions from the watershed and link water and nutrient loading to observed nutrient concentrations in the water column of the lake (e.g., total phosphorus, orthophosphate, Total Kjeldahl Nitrogen (TKN), nitrate/nitrite). In-lake modeling included simulation of dynamic internal lake processes such as phosphorus release from lake sediments (internal sediment loads), phytoplankton nutrient uptake, and phytoplankton death and decay. The watershed and in-lake models were used to simulate conditions in 2019 and 2020. Model year 2019 represented a “wet year” condition, where above average precipitation was experienced within the Birch Island Lake watershed. Model year 2020 represented a “dry year” condition. The year 2020 was a dry year for Birch Island Lake specifically because while the growing season precipitation was only slightly below average, water level data and water balance modeling indicate that the bypass pipe to Birch Island Lake was partially clogged, which reduced the volume of runoff reaching the lake.

6.1 P8 Model Runoff and Phosphorus Loading

Central to a lake water quality analysis is the use of a water quality model that has the capacity to predict the amount of runoff and pollutants that reach a lake via stormwater runoff (external loading). The P8 (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds) modeling software was used to estimate watershed runoff and pollutant loads to the lake (I.E.P, Inc., 1990). The P8 model incorporates hourly precipitation and daily temperature data. The P8 model was used to calculate the hourly water volume and nutrient loads introduced from each tributary subwatershed in the Birch Island Lake watershed.

P8 model inputs included:

- **Climate Data:** hourly precipitation (source: NMCWD precipitation gage near Bryant Lake) and daily temperature (source: National Weather Service gage at Minneapolis-St. Paul International Airport, MSP)
- **Watershed:** tributary land areas (both pervious and impervious), soil conditions
- **Conveyance:** storm sewer system
- **Ponds and best management practices:** pond or basin bathymetry

The P8 model was used to simulate watershed runoff for the water years 2019 and 2020.

Since inflow water quantity or quality data were not collected for Birch Island Lake on a subwatershed-scale, detailed calibration of the P8 model was not conducted. Therefore, the accuracy of P8 model outputs, used as inputs for the in-lake model (described below) were critically evaluated through the in-lake modeling process. In-lake model calibrations confirmed that total phosphorus concentrations predicted by the P8 model were best-suited for considering relative changes in loading under varying watershed conditions. However, the total nitrogen and orthophosphate concentrations predicted by the

P8 model needed to be modified during the in-lake calibration process. The inflow orthophosphate concentrations were reduced by 50% in 2019 and 2020 for the entire modeling period (April-October). P8 nitrogen inflow concentrations were increased by applying a multiplier on a month-by-month basis to match in-lake concentrations (e.g., P8 nitrogen inflow concentrations increased by 5-25 times depending on the observed concentrations per month each model year).

6.1.1 P8 Model Updates

The P8 watershed model that was developed for the 2000 Birch Island Lake UAA (Barr Engineering Co., 2000) was used as a starting reference for this water quality study. The P8 model devices were revised to include:

1) New best management practices installed in the watershed since the late 1990's, based on review of NMCWD permit applications.
2) Updated pond storage volumes based on bathymetric surveys completed by Stantec for the City of Eden Prairie (Stantec, 2023)

The P8 model watersheds were revised to reference the most up-to-date land use data sets from Eden Prairie (2019) and Minnetonka (2020-2030 land use). The land use and impervious assumptions used for P8 watershed modeling are shown in Table 6-1.

Table 6-1 P8 model directly-connected, indirectly-connected, and total impervious percentages based on land use within the Birch Island Lake watershed

Land Use Classification	Directly Connected Impervious	Indirectly Connected Impervious	Total Impervious
Single Family Residential	20	20	40
Multi-Family Residential	30	25	55
Golf Course	10	0	10
Institutional	80	10	90
Major Highway	70	0	70
Street Right-Of-Way	50	0	50
Railroad Right-Of-Way	20	0	20
Rural/Vacant	0	2	2
Open Space	0	2	2
Open Water	100	0	100

6.2 Water Balance Calibration

6.2.1 Precipitation and Runoff

The annual water and watershed nutrient loads to Birch Island Lake under existing land use conditions were estimated for model years 2019 and 2020. Precipitation totals during model years 2019 and 2020 are summarized in Table 6-2 (source: NMCWD precipitation gage near Bryant Lake).

Table 6-2 Modeled total precipitation for the 2019 and 2020 growing seasons (May 1 through Sept. 30)

Model Year	Growing Season (May 1 through Sept 30) Precipitation (inches)
2019	35.1
2020	22.6

6.2.2 Stormwater Volume Calibration (Water Balance)

Water balance models were developed for Birch Island Lake. The changes in water volumes of the lake over time were calibrated by matching the modeled surface elevations to monitored data. To translate the water loadings into water surface elevations, a water balance model was utilized. The model uses estimated daily watershed runoff inflows (predicted by P8 models), daily precipitation, daily evaporation, estimated groundwater inflow or outflow, and observed lake levels to estimate changes in the water level of the lake. In 2019, the water balance modeling indicated that Birch Island Lake experienced groundwater inflow through May and increasingly more groundwater outflow starting in June and increasing through September. Birch Island Lake experienced groundwater outflow throughout the entire model period of 2020 based on the water balance calibration.

Assumptions were needed for bypass pipe clogging in 2019 and 2020 because records on bypass maintenance were not available. To match the 2019 monitored water surface elevations of Birch Island Lake, as well as observed water levels in the north wetland (BIL3A in Figure 4-2) and north stormwater pond (716 in Figure 4-2), it was assumed that the bypass pipe was only partially clogged in the P8 model. 100% of the runoff from stormwater pond 716 was directed to Birch Island Lake and 65% of the runoff from stormwater pond 714B was directed to Birch Island Lake. The remaining 35% of runoff from 714B was discharged to the north wetland (BIL3A). To match the 2020 monitored water surface elevations, it was assumed that the bypass pipe was completely clogged. All of the runoff from the upstream stormwater ponds north of County Road 62 were discharged to the north wetland (BIL3A).

Figure 6-1 and Figure 6-2 show the water balance calibrations that were completed for Birch Island Lake for model years 2019 and 2020, respectively. The predicted daily water levels, shown by the orange line on the plot, were calibrated to match as closely as possible to the observed monthly water levels, indicated by the blue circles. Overall, the water balance calibrations for model years 2019 and 2020 correlate well with the observed monitored data. Figure 6-3 provides a water balance volume comparison for 2019 and 2020.

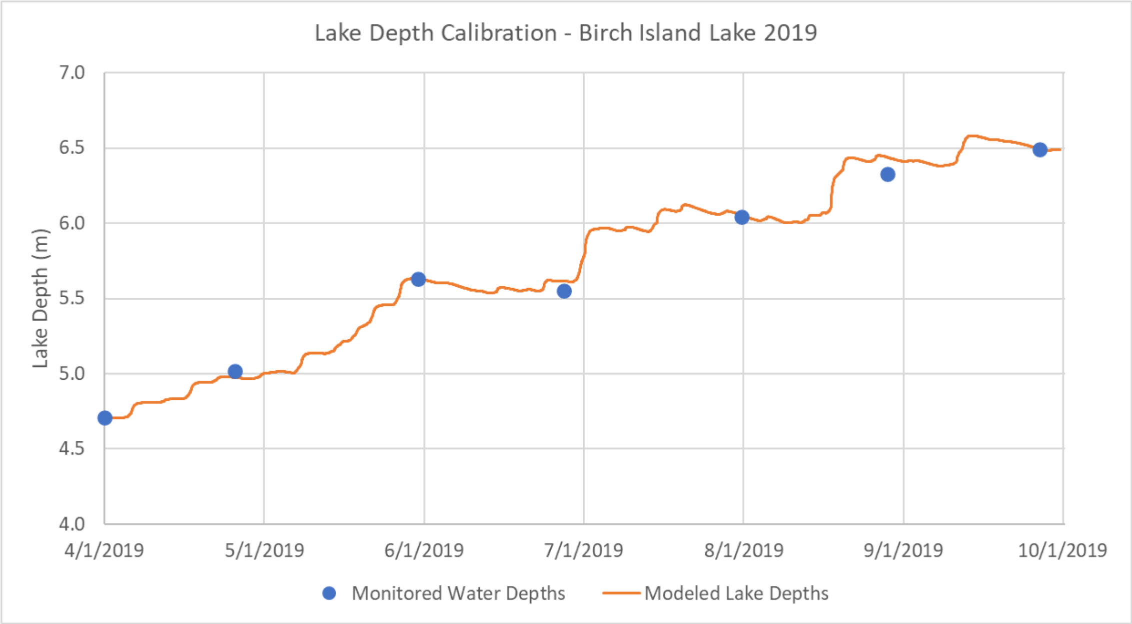


Figure 6-1 2019 calibrated water balance

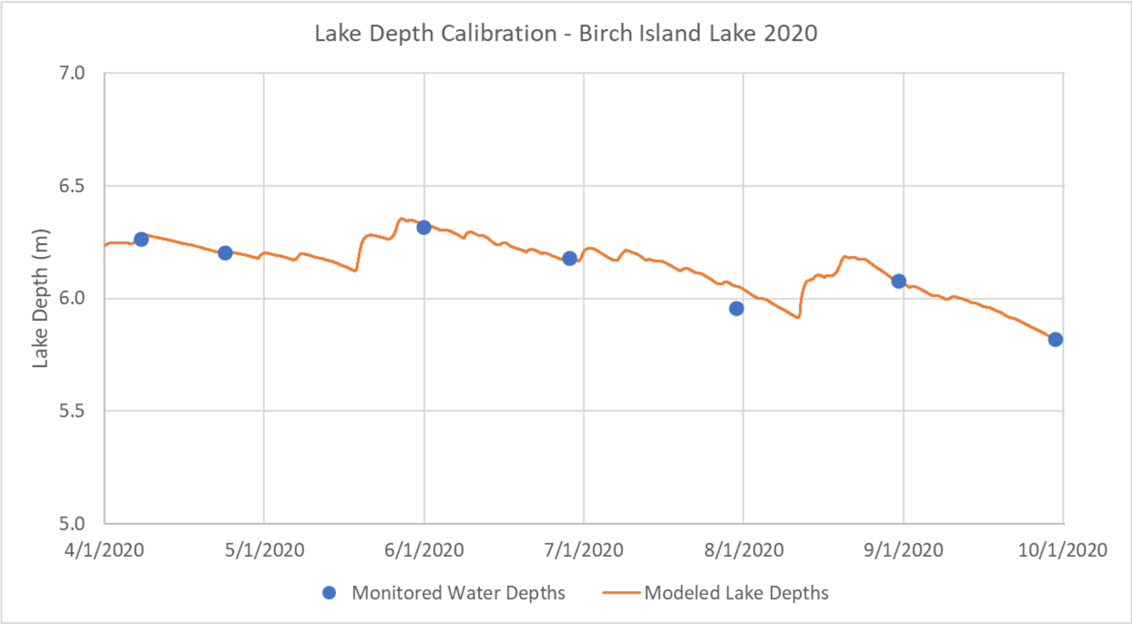
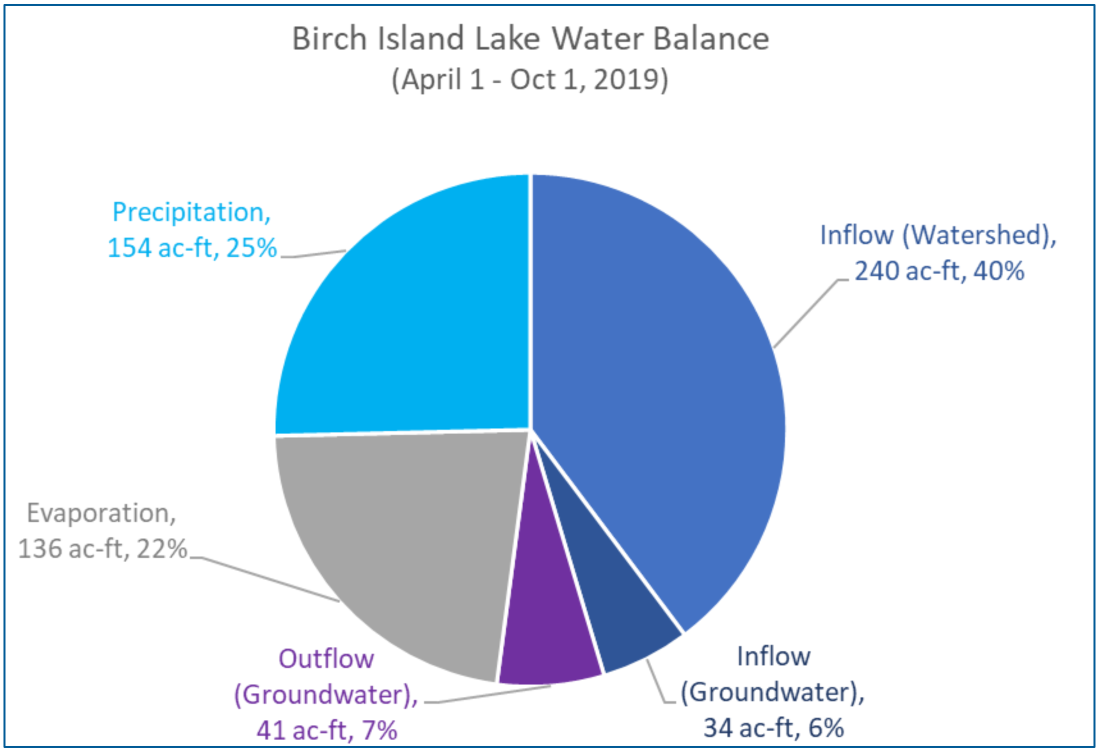


Figure 6-2 2020 calibrated water balance



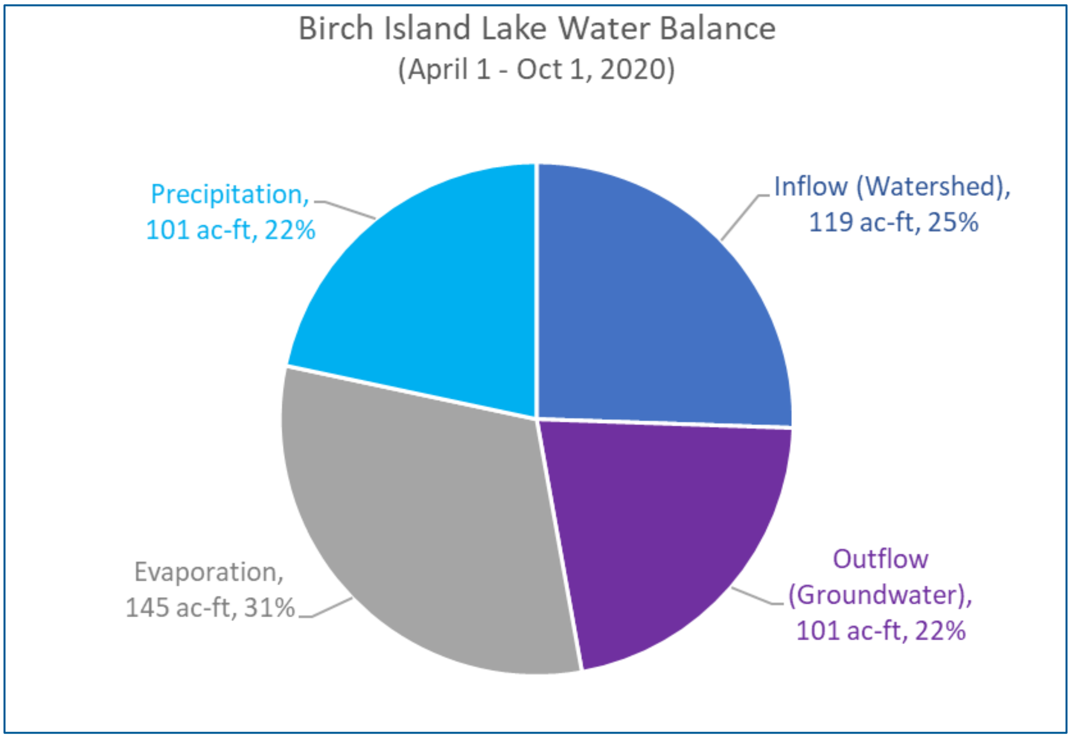


Figure 6-3 2019 and 2020 water balance summaries

6.3 In-Lake Modeling

The purpose of in-lake modeling is to establish a relationship between the amount of nutrients that enter a lake and the concentration of these nutrients that remain in a lake. Generally, for freshwater lakes, phosphorus is the main nutrient of concern and is discussed in greater detail in this report. However, nitrogen also plays a role in limiting algal growth in lakes and is discussed.

There are several processes that dynamically increase or decrease the concentration of phosphorus in the lake water column, including (the "-" or "+" indicates that the mechanism generally either reduces or increases phosphorus):

- **Watershed Runoff (+):** Phosphorus enters the lake through natural channels, sheet flow from turfed backyards, and discharge from storm sewer pipes following precipitation or snow melt events.
- **Atmospheric Deposition (+):** Phosphorus deposits into the water body from the atmosphere
- **Settling (-)**: Phosphorus in phytoplankton and attached to particles settles out of the lake water column to the sediments.
- **Flushing (-)**: Typically represents the phosphorus that is discharged through an outlet structure. For Birch Island Lake, this represents water that is discharged from the lake through groundwater discharge.
- **Lake Bottom Sediment Loading (+)**: Mobile phosphorus from lake bottom sediments may release into the water column during low oxygen conditions. Organic phosphorus will release as bacteria breakdown debris in the lake sediment that contains phosphorus (e.g., decaying leaves, plants, and algae). This is typically referred to as internal loading.
- **Phytoplankton and macrophyte growth (-):** Phosphorus will be removed from the water column and the sediment through uptake by phytoplankton and macrophytes during the growth phase. Due to the low density of macrophytes in Birch Island Lake in 2019 and 2020, macrophytes were not included in the in-lake model and only phosphorus assimilation to phytoplankton was included.
- **Phytoplankton and macrophyte die-off and decay (+):** Phosphorus in the phytoplankton and plant tissues is released into the water column when the species die and decay. Only phytoplankton death and decay were modeled for Birch Island Lake.
- **Curly-leaf pondweed die-off and decay (+)**: Phosphorus in the plant tissue is released into the water column when curly-leaf pondweed dies and decays. Curly-leaf pondweed die-off and decay occurs much earlier than other native plant species (typically in late June and July), so this species is often modeled separately. However, since Birch Island Lake did not have significant curly-leaf pondweed growth during the model periods, curly-leaf pondweed modeling was not used for this water quality study.

The in-lake model used for this study is a finite difference lake model developed by Barr Engineering Co. The model integrates the nutrient inputs and losses described above on an hourly time-step. The lake model is considered to be zero-dimensional, meaning, it is assumed that every input to the model is completely mixed both vertically and horizontally in the lake water column. The growth of biological components, as discussed above, were dependent upon phosphorus, nitrogen, light, and temperature inputs. Biological processes occur at different levels during different periods and hence they are quantified (e.g., calibrated) by matching the in-lake phosphorus, nitrogen, and chlorophyll-*a* concentrations with the field-measured concentrations.

6.3.1 In-Lake Water Quality Model Calibration

Calibration is a process in which model parameters and coefficients are reasonably adjusted such that the model predictions are similar to in-lake measurements. The Birch Island Lake models were calibrated to the following water quality parameters:

- Total Phosphorus (TP)
- Orthophosphate
- Chlorophyll-*a*
- Total Kjeldahl Nitrogen (TKN)

Example in-lake model calibrations for Birch Island Lake are provided below.

Figure 6-4 2020 in-lake calibration of total phosphorus concentrations

and Figure 6-5 show the 2020 calibrations for TP and chlorophyll-*a* concentrations, respectively. The orange line represents the modeled in-lake concentrations, and the blue circles represent the monitored concentrations. Plots showing all parameters used for calibration in 2019 and 2020 can be found in Appendix C.

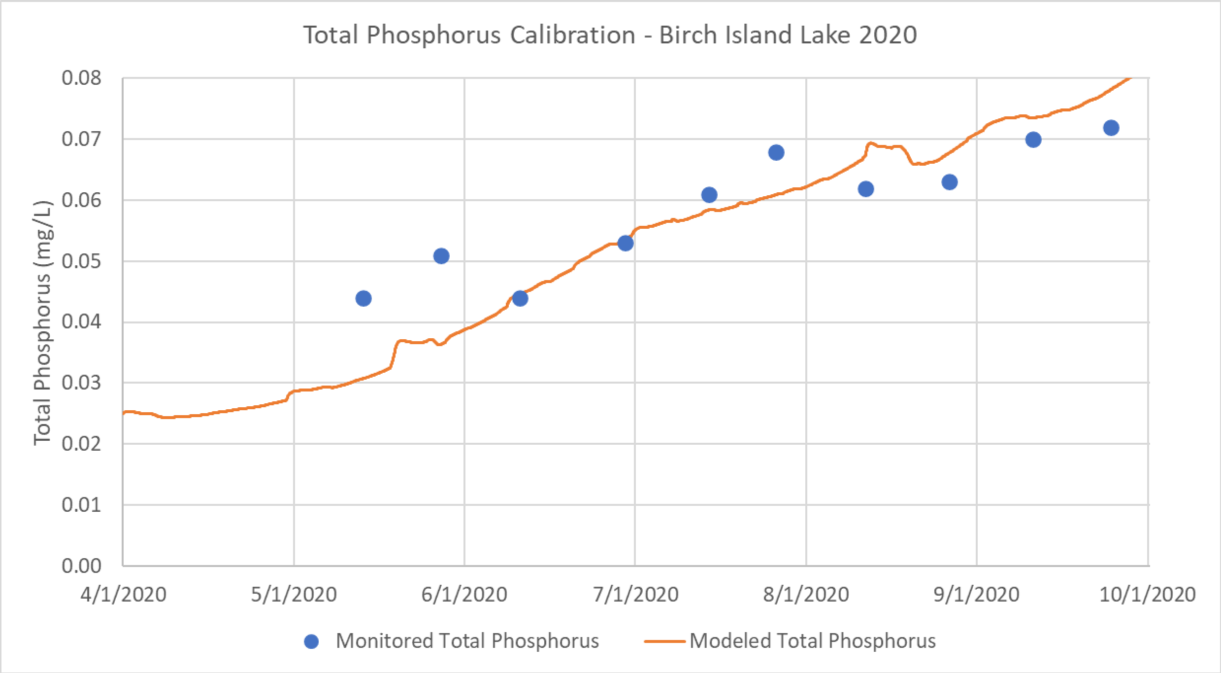


Figure 6-4 2020 in-lake calibration of total phosphorus concentrations

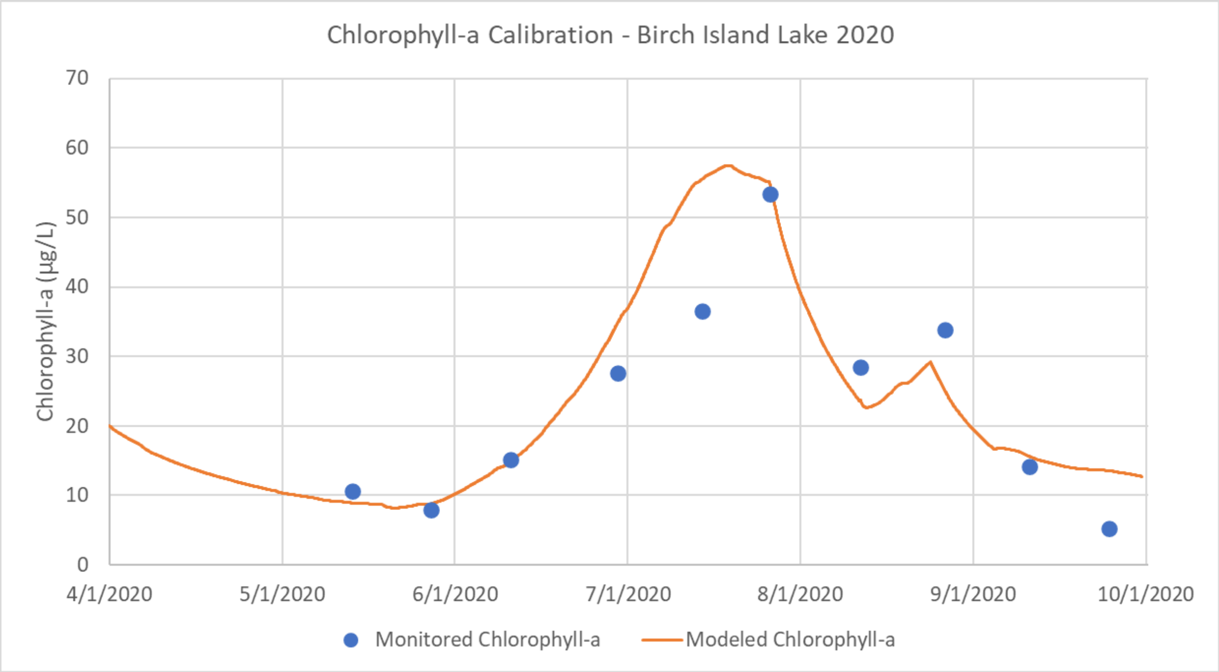


Figure 6-5 2020 in-Lake calibration of chlorophyll-*a* concentrations

6.3.2 In-Lake Water Quality (Phosphorus) Model Calibration Loading Summaries

After the in-lake water quality model calibrations were finalized, phosphorus loading summaries were developed. Figure 6-6 shows the total phosphorus loading summaries during the 2019 and 2020 summer growing periods (June 1-Sept 30).

In 2019 (a wet year), the percentage of total phosphorus loading from watershed runoff was greater than the loading from the lake bottom sediment. The in-lake calibration shows that approximately 75% (69 pounds) of the total phosphorus load to Birch Island Lake between June 1 – September 30, 2019 was from watershed runoff. The remaining 25% (23 pounds) of the total phosphorus load was from lake bottom sediment (internal loading). The total load of phosphorus to Birch Island Lake during the 2019 summer growing period was approximately 92 pounds.

In 2020 (a dry year due to slightly lower than average precipitation and pipe clogging), the percentage of total phosphorus loading from the lake bottom sediment was greater than the watershed loading. The in-lake calibration shows that approximately 71% (62 pounds) of the total phosphorus load to Birch Island Lake between June 1 – September 30, 2020 was from the sediment (internal loading). The remaining 29% (26 pounds) of the total phosphorus load entered from watershed runoff. The total load of phosphorus to Birch Island Lake during the 2020 summer growing period was approximately 88 pounds. There was notably more internal loading from lake bottom sediment in 2020 than in 2019.

The models indicate, depending on the year, that phosphorus loading from both watershed runoff and internal loading from lake bottom sediment can influence in-lake water quality.

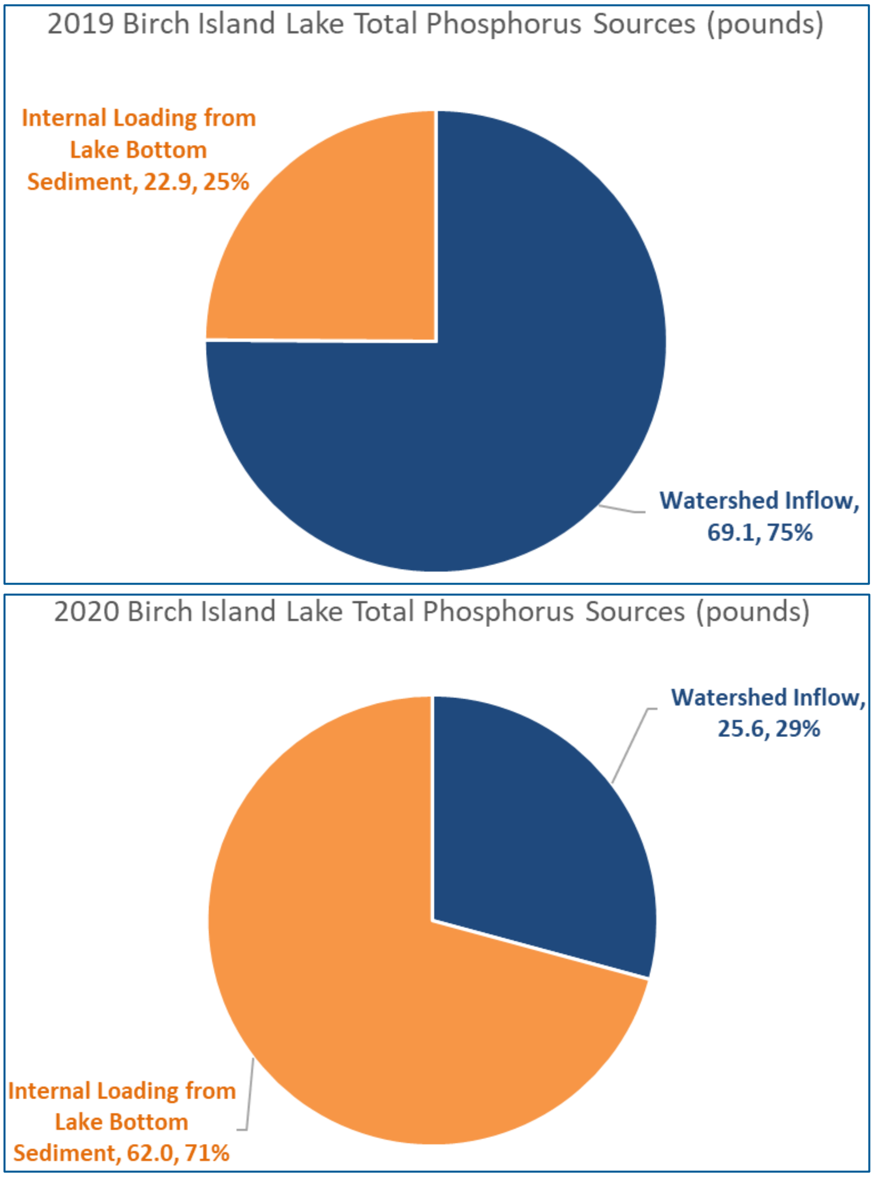


Figure 6-6 2019 and 2020 total phosphorus loading summaries (watershed and internal loading from lake bottom sediment) from in-Lake calibration models

6.3.3 In-Lake Water Quality Additional Observations

6.3.3.1 Macrophyte Health and Lake Levels

Native macrophytes provide many benefits to lake ecosystems, including the uptake of nutrients and the stabilization of the lake sediment. The Birch Island Lake in-lake models for 2019 and 2020 did not include macrophytes due to the low macrophyte density observed in the lake. Water surface elevations (WSEs) in Birch Island Lake have been extremely variable over the observable record. In the past decade, the difference between the lowest and highest observed WSE is approximately 13.3 feet. The lowest observed WSE corresponds to an open water area of only 3.2 acres. The highest observed WSE corresponds to an open water area of 43.7 acres. This substantial difference in open water area can have a notable influence on long-term submerged and emergent native vegetation health. As such, without modifications, water level variation may continue to influence the ability of native macrophytes to utilize nutrients in the lake and provide competition with phytoplankton (algae). Additional information on observed water levels in Birch Island Lake is included in Section 5.4.

6.3.3.2 Phytoplankton Limitation

Throughout the growing season, various factors can influence the rate and volume of phytoplankton growth, such as phosphorus, nitrogen, light, and temperature. The model uses Michaelis Menten kinetics to determine which factor or combination of factors limit growth throughout the modeled time period.

As part of the calibration process, plots were developed that show which factors limited phytoplankton growth over the model period. Figure 6-7 and Figure 6-8 show the phytoplankton limitation plots for Birch Island Lake in 2019 and 2020, respectively. A phytoplankton limitation value of 0 indicates complete limitation and a value of 1 indicates no limitation. Therefore, the closer a line is to the x-axis, the more limiting the factor. The limitation factors summarized include light, temperature, phosphorus (orthophosphate, organic phosphorus), and nitrogen (nitrates).

During 2019, phosphorus limited phytoplankton growth for the entirety of the model period. Nitrogen, temperature, and light limitation did not play as large of a role in controlling phytoplankton growth during the model period.

During 2020, temperature and phosphorus had a similar level of phytoplankton limitation from April through mid-May. From mid-May through August phosphorus and nitrogen had a similar level of phytoplankton limitation. In August, nitrogen limited phytoplankton growth and in September, nitrogen and temperature both limited phytoplankton growth. Light limitation did not play as large of a role in controlling phytoplankton growth during the model period.

Review of the data suggests that the stronger nitrogen limitation in Birch Island Lake during 2020 is likely because the growth rate of phytoplankton is greater than the degradation rate of nitrogen (slow decomposition from organic nitrogen forms to ammonia and/or slow nitrification rate changing ammonia to nitrite and nitrate). In other words, the phytoplankton continue to grow until they have used up nitrate in the water column, which limits how much phytoplankton biomass is produced. Monitoring data in 2019 and 2020 also show high concentrations of total Kjeldahl nitrogen in Birch Island Lake (summer averages ranging from 0.9-2.6 mg/L), which further suggests that the nitrogen limitation in the lake is influenced more by the rate of degradation of nitrogen into different forms rather than the total mass of nitrogen in the lake.

The phytoplankton growth limitations identified during model calibration reflect which parameters are currently limiting growth. As management is implemented, the phytoplankton growth limitations will likely change. For example, if phosphorus loading from lake bottom sediment is reduced, phosphorus limitation may become more dominant throughout the growing season. However, since the calibrated models indicate that the lake can be primarily or partially limited by nitrogen depending on the year, this indicates that nitrogen management can be a complementary management approach along with phosphorus reduction.

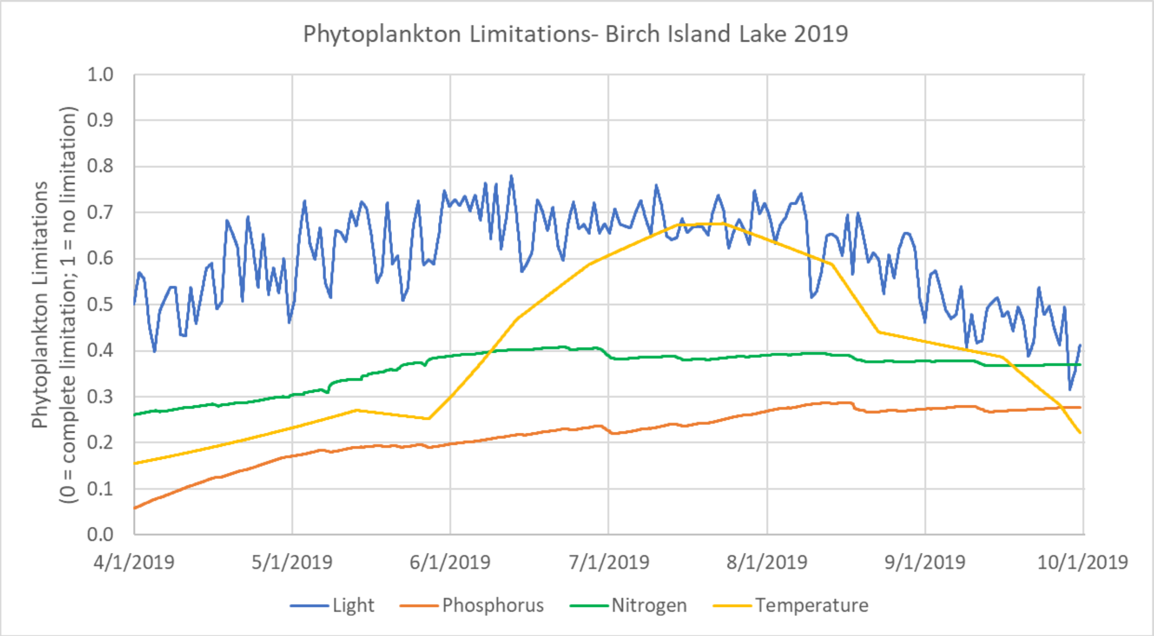


Figure 6-7 Phytoplankton growth limitation in 2019

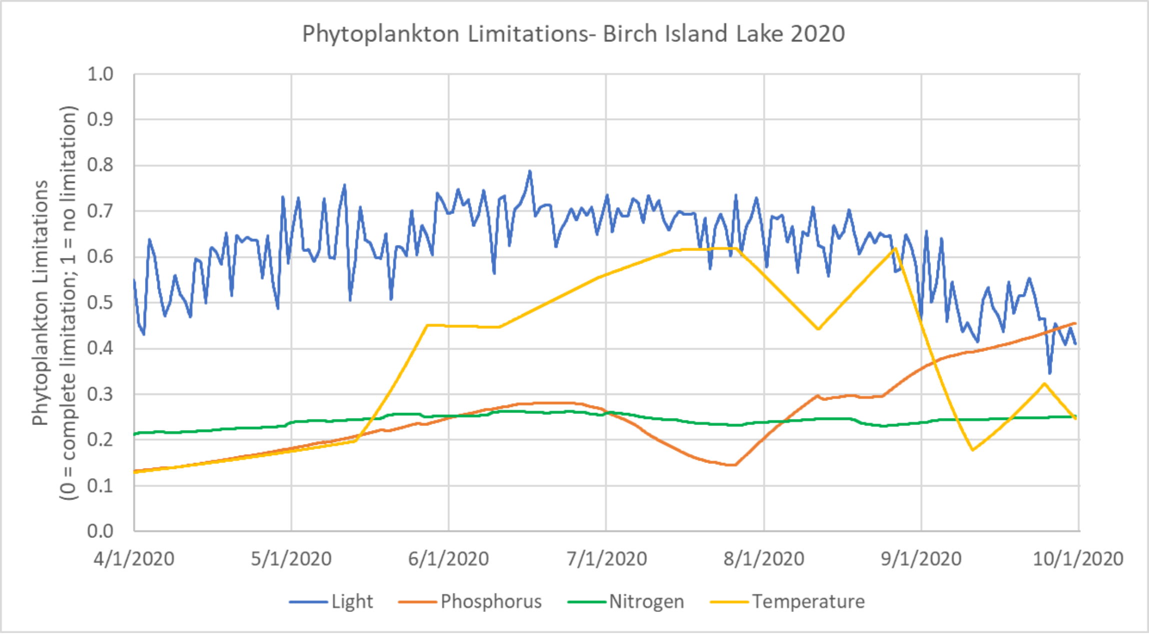


Figure 6-8 Phytoplankton growth limitation in 2020

7.0 Public Engagement

The NMCWD considers public engagement to be an important part of completing lake water quality studies in the Nine Mile Creek watershed. For this study, public engagement included two public meetings and a survey of residents living adjacent to the lake, both discussed further below.

7.1 Resident Survey

NMCWD developed a survey for residents living within the Birch Island Lake subwatershed to better understand residents' lake use, values and perceptions related to the lakes, concerns and issues, current management activities, and willingness to participate in lake improvement efforts. Residents were able to participate in the survey via online submission, which was active from December 19, 2022, through January 31, 2023. A postcard with the online survey link was mailed to 160 properties in mid-December. Of the 160 properties that received postcards requesting voluntary participation in the online survey, 16 responses were received (10% response rate).

A summary of the survey questions and provided responses can be found in Appendix D. Comments provided in the survey were considered during the development of management recommendations and will continue to be considered during implementation of recommended lake management activities.

7.2 Public Stakeholder Meetings

Because the recommendations that stem from this study may impact residents adjacent to Birch Island Lake, input from residents was sought at two public engagement meetings. The meetings allowed NMCWD to gain further insight on lake use and historic management through comments, photos, and data provided by residents. The meetings also presented an opportunity to get feedback from the public on lake management options and willingness to participate in various activities to improve lake water quality.

7.2.1 Public Engagement Meeting #1- January 9, 2023

The first public stakeholder engagement meeting was held at the Eden Prairie City Center in the evening on January 9, 2023. In mid-December 2022, a postcard was mailed to Birch Island Lake residents informing them of a planned community meeting. At this meeting, NMCWD staff and engineers, as well as City of Eden Prairie staff provided an overview of the upcoming study and goals for future management of the lake. Following the background presentation on the study, the remainder of the meeting involved open discussion with residents regarding their observations and concerns regarding lake health. During the meeting, residents were reminded that an online formal survey was available for residents living within the Birch Island Lake subwatershed so that the NMCWD could gather additional feedback from residents. Comments provided during the community meeting in January 2023 were considered during the development of management recommendations and will continue to be considered during implementation of recommended lake management activities.

7.2.2 Public Engagement Meeting #2—January 8, 2024

In December 2023, a postcard was mailed to Birch Island Lake residents informing them of a planned hybrid community meeting held in-person at NMCWD and virtually on January 8, 2024. Six residents attended the meeting in-person and three attended virtually. At this meeting, the NMCWD staff and engineers, as well as City of Eden Prairie staff provided an overview of the study conclusions and anticipated timeline of the proposed lake management activities. Following the background presentation on the study, the remainder of the meeting involved open discussion with residents to answer questions and address concerns. Comments provided during the community meeting were considered during development of the final water quality report and will continue to be considered during implementation of recommended lake management activities.

8.0 Evaluation of Management Practices

Monitoring of Birch Island Lake indicates degraded water quality and shows that the lake has not met water quality standards and ecological health goals in recent years. Given this, future management efforts should focus on improving lake water quality and ecosystem health, monitoring for changes, and continuing water quality and ecosystem health protection measures as improvements are achieved. The following sections summarize the evaluated management and monitoring strategies for Birch Island Lake.

8.1 Reduce Phosphorus Loading from Lake Bottom Sediment (Internal Loading)

In-lake modeling demonstrated that phosphorus release from bottom sediments (typically termed internal phosphorus loading) was the largest source of phosphorus to Birch Island Lake in 2020. Notable internal phosphorus loading was also observed in 2019. The models estimated internal phosphorus loading represented 25% and 71% of the total phosphorus load to Birch Island Lake in 2019 and 2020, respectively, for the summer growing period of June through September.

Phosphorus in lake bottom sediments is often bound to a range of different elements such as iron and manganese (often referred to as mobile phosphorus), aluminum, or calcium. The mobile phosphorus fraction can be released from sediment during low oxygen conditions. Phosphorus can also be found incorporated into organic matter (organically bound phosphorus). A portion of the organically bound phosphorus is released into the water column from lake sediments through mineralization, but typically at a slower rate than mobile phosphorus. The mineralization release rate is primarily controlled by lake water temperature and can be influenced by the dissolved oxygen levels.

Sediment cores were collected in 2022 and used to evaluate internal phosphorus loading potential of the mobile and organically bound phosphorus fractions. The average concentration of organically bound phosphorus and mobile phosphorus in the top 4 centimeters of two cores taken from Birch Island Lake were 35.0 and 1.5 µg P/cm^3 wet sediment, respectively. These observed concentrations indicate that there is potential for internal phosphorus loading of organically bound phosphorus (organic-P) and minimal potential from mobile phosphorus (mobile-P). Also, because Birch Island Lake is shallow and has a small water volume (especially at low water levels), even low internal loading rates can significantly increase phosphorus concentrations in the lake water column.

Because internal sediment loading in Birch Island Lake is primarily due to organic-P, the recommended treatment process could include phases of adaptive sediment treatments and follow-up monitoring. Addressing organic-P loading is more complicated than mobile-P because organic-P fractions don't appear to have the same binding affinity to aluminum as mobile-P. As such it is recommended to initially apply an alum treatment, with an alum dose on the higher end of the typical range, to help strip phosphorus from the water column and target the current pool of organic-P in the top 6-8 cm of the sediment. Subsequent sediment treatments can be adapted based on success of the first treatment and review of the effectiveness of other innovative sediment treatment approaches being conducted on other shallow lakes in the Twin Cities metro area. Examples of adaptive sediment management could include:

1. Applying additional alum at lower doses than the first application to target new organic-P sources and to re-strip phosphorus from the water column.
2. Applying an iron compound such as ferric chloride along with aluminum or stand alone, to provide multiple substrate options for phosphorus binding within the sediment.
3. Consider installing aeration to reduce low oxygen conditions at the sediment surface and enhance phosphorus binding efficiency with iron.

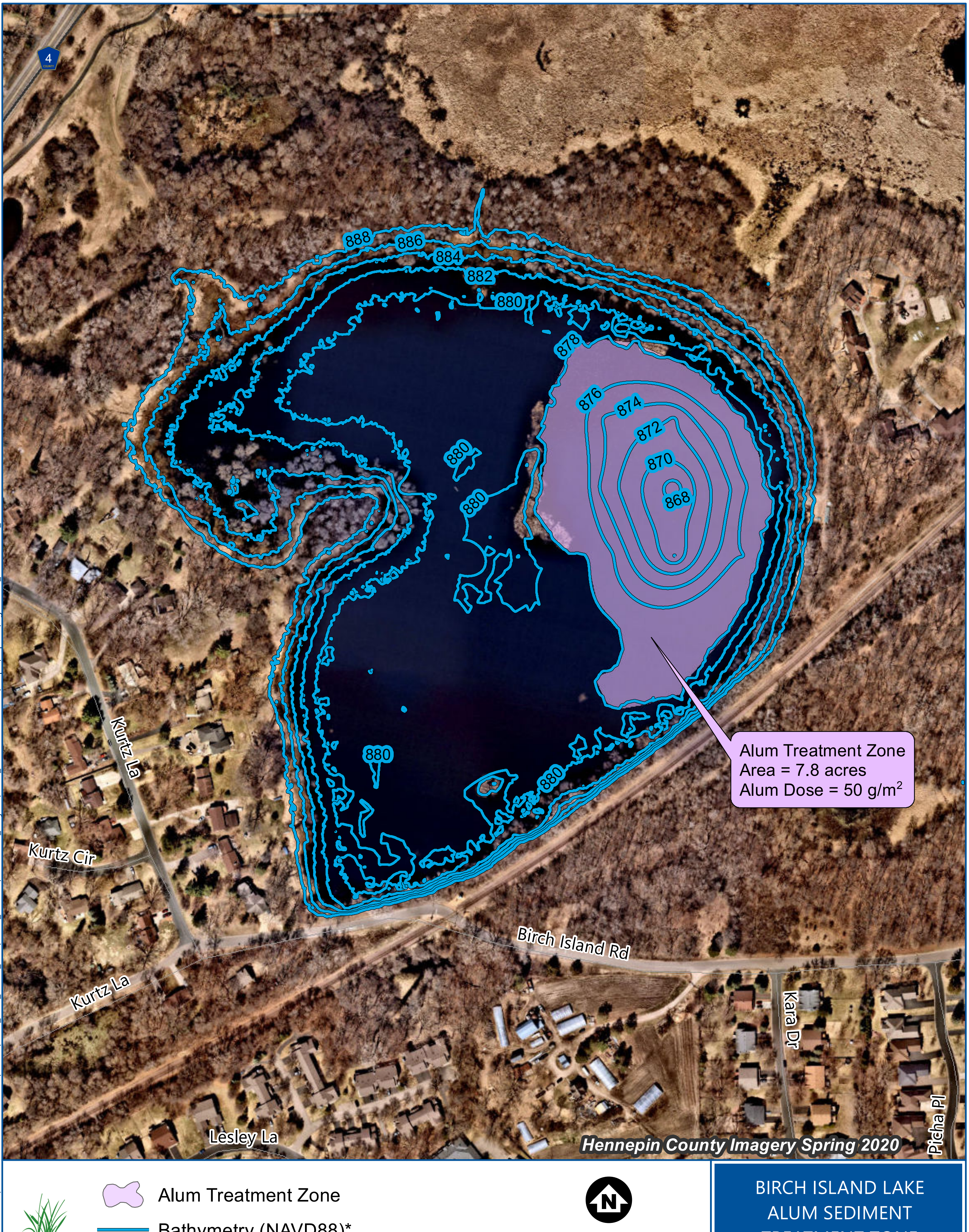
The timeline for subsequent sediment treatment applications should be determined based on water quality monitoring and follow-up sediment core analysis.

The recommendation for an initial alum treatment of Birch Island Lake is summarized below:

- **Year 1 (spring):** Apply alum and sodium aluminate simultaneously to the sediment treatment zone (Figure 8-1) to help strip phosphorus from the water column and target the current pool of mobile-P and organic-P in the top 6-8 cm of the sediment of the treatment zone (water elevations 878 and lower). Apply alum and sodium aluminate at a rate to achieve 50 g-Al/m^2. It is recommended to target the deeper depression first as this is the location where anoxia is experienced more prevalently. Targeting this deeper depression should also help to encourage native plant establishment in this area during lower lake level conditions. Currently, minimal plants grow in this zone due to drastic lake level variations and low water clarity. It's predicted that establishing plants in this area could help stabilize lake clarity conditions even with variations in water levels.

  The feasibility of conducting an alum treatment in Birch Island Lake needs to be further evaluated due to steep slopes and difficult access. It is recommended that the first alum treatment is applied when water surface elevations are high enough for safe access (e.g., from Birch Island Road, Camp Eden Wood).
- **Year 2-5+**: Continue periodic water quality monitoring to assess in-lake conditions.
- **Year 5+:** If monitoring shows that internal sediment loading continues to negatively impact water quality and ecological health consider the following next steps:
  - Collect sediment cores and perform laboratory experiments to better assess the organic-P release rates.
  - Based on laboratory experiments, determine if alum (or another sediment treatment media, such as ferric chloride) should be applied to a larger area of sediment.
  - The timeline for collecting sediment cores and performing subsequent sediment treatment applications may be dependent on water levels.

The goals of the alum treatment(s) are to reduce internal phosphorus loading and improve the water clarity in Birch Island Lake, ultimately promoting native plant re-establishment. As phosphorus is stripped from the water column during an alum application, the clarity of the water should improve, and the area of native plant establishment should increase by allowing plants to grow at greater depths. Native plant re-establishment will be critical to stabilize a clear water condition and compete with algae for in-lake nutrients. Additional discussion on native plant re-establishment is summarized in Section 8.6.2.



Barr Footer: ArcGIS 10.9.1, 2023-08-09 13:55 File: I:\Client\Nine_Mile_Creek_WD\Work_Orders\23270634_Project\2022_UAA Birch Island\Maps\Report\Figure8-2_BirchIsland_AlumTrmnt.mxd User: KJN2

Alum Treatment Zone

Bathymetry (NAVD88)*

*Sources: 2011 Hennepin County LiDAR Elevations
2020 Aquatic Plant Point-Intercept Depths

0 150 300
Feet

BIRCH ISLAND LAKE
ALUM SEDIMENT
TREATMENT ZONE

FIGURE 8-1

The in-lake model for Birch Island Lake was used to predict the effects of implementing the recommended sediment management on lake water quality. Since a sediment management approach that specifically targets organic-P has not been widely applied in Twin Cities lakes, there is some uncertainty regarding effectiveness of the sediment treatments in reducing internal loading. Accordingly, an assumed range of effectiveness (50% and 70% reduction in internal phosphorus loading) was applied to account for the uncertainty, based on best professional judgement. studies.

Table 8-1 summarizes the estimated pounds of phosphorus removed during the 2019 and 2020 summer growing period assuming the application of a sediment treatment. Assuming a 50%-70% reduction in internal loading from sediments, a reduction of 12-43 pounds of total phosphorus loading to Birch Island Lake is estimated based on model results for a wet (2019) and dry (2020) year. This reduction in phosphorus load translates to a reduction in the total phosphorus concentration in the lake, with the 2019 summer average total phosphorus concentration of 35 µg/L reduced to 22-26 µg/L and the 2020 summer average total phosphorus concentration of 62 µg/L reduced to 30-38 µg/L (Table 8-2). The MPCA shallow lake total phosphorus water quality standard is 60 µg/L. Figure 8-2 and Figure 8-3 summarize the predicted reductions in in-lake total phosphorus concentrations for the 2019 and 2020 model years, respectively.

A reduction in total phosphorus concentrations would also likely lead to a reduction in chlorophyll-*a* concentrations (algae) as summarized in Table 8-2. Modeling indicates that the 2019 summer average chlorophyll-*a* concentration of 4 µg/L would be reduced to 1-2 µg/L. Modeling indicates that the 2020 summer average chlorophyll-*a* concentration of 28 µg/L would be reduced to 17-23 µg/L. The MPCA shallow lake chlorophyll-*a* water quality standard is 20 µg/L. Figure 8-4 and Figure 8-5 summarize the predicted reductions in in-lake chlorophyll-*a* concentrations for the 2019 and 2020 model years, respectively. It should be noted that these predicted reductions to chlorophyll- *a* concentrations only represent the impacts incurred by reducing total phosphorus concentrations within the in-lake models. All other variables that impact growth (e.g., nitrogen concentrations, temperature, light, plant competition) remain unchanged. Therefore, while reductions in total phosphorus concentrations can be an indicator of impacts to chlorophyll-*a* concentrations, there are other factors that will impact growth on an annual basis.

Model results indicate that alum sediment treatments may be sufficient to decrease total phosphorus and chlorophyll-*a* concentrations below the MPCA shallow lake eutrophication standards. Water quality monitoring should continue following sediment treatments to assess changes to lake conditions and if additional management practices should be considered.

Table 8-1 Summer growing period estimated pounds of phosphorus removed through management of internal loading from lake bottom sediments

Year	Pounds of Phosphorus Removed (Summer Growing Period – June 1-Sept 30)	
	Reduced Internal Loading from Lake Bottom Sediments by 50%	Reduced Internal Loading from Lake Bottom Sediments by 70%
2019 (wet year)	12	16
2020 (dry year)	31	43
Average	*22*	*30*

Table 8-2 Summer average total phosphorus and chlorophyll-*a* concentrations with management of internal loading from lake bottom sediments

Year	Summer Average Concentrations					
	Total Phosphorus (µg/L)			Chlorophyll-*a* (µg/L)		
	Existing Conditions[1]	Reduced Internal Loading by 50%	Reduced Internal Loading by 70%	Existing Conditions[1]	Reduced Internal Loading by 50%	Reduced Internal Loading by 70%
2019 (wet year)	35	26	22	4	2	1
2020 (dry year)	62	38	30	28	23	17

[1] Existing conditions summer average concentrations are from calibrated in-lake models.

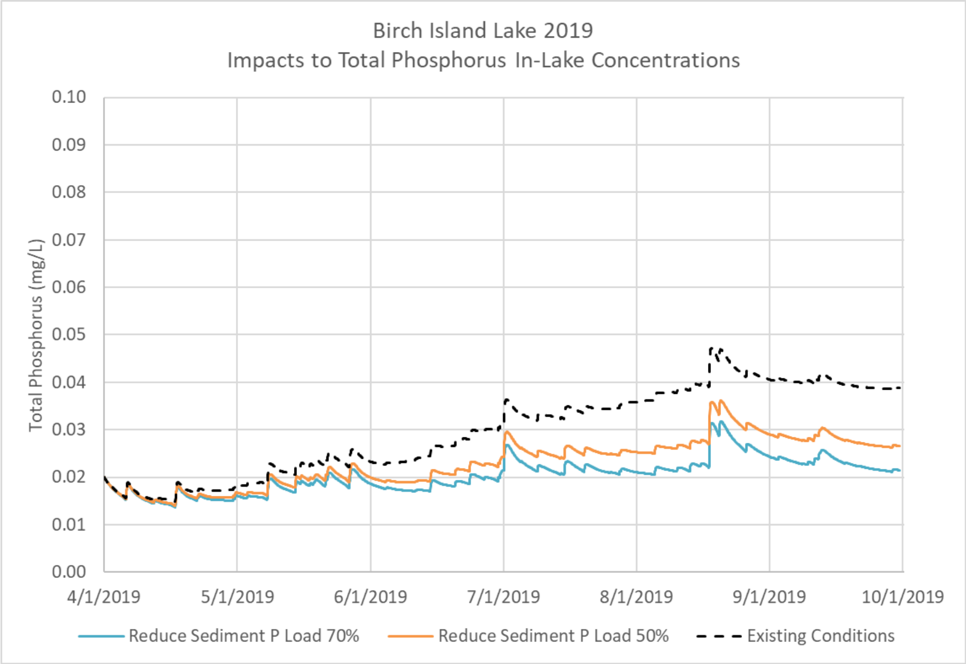


Figure 8-2 **Model predicted reductions in 2019 total phosphorus concentrations assuming 50%-70% reduction in internal loading from lake bottom sediments**

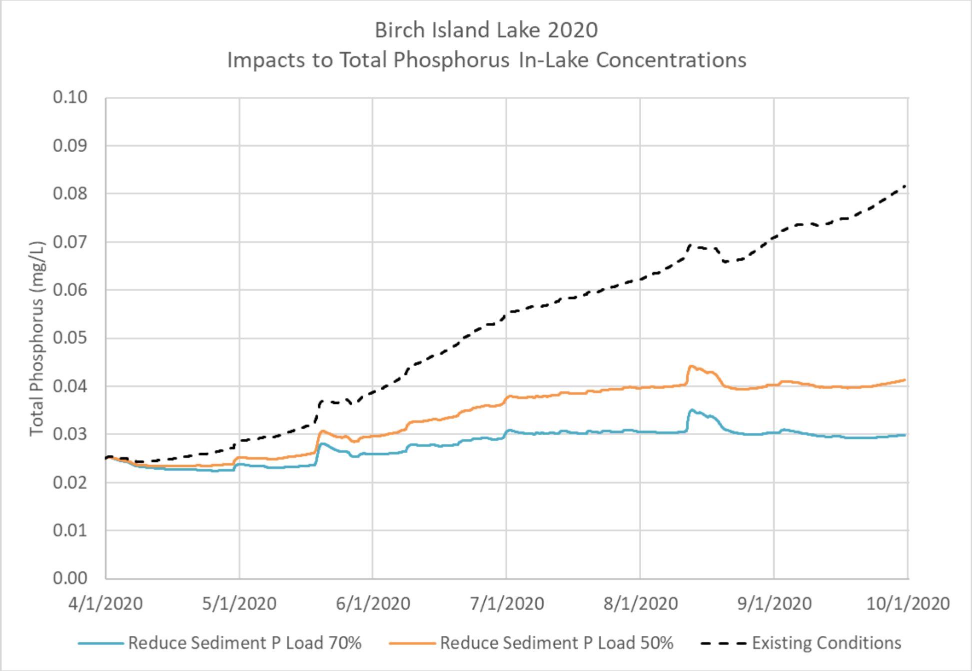


Figure 8-3 **Model predicted reductions in 2020 total phosphorus concentrations assuming 50%-70% reduction in internal loading from lake bottom sediments**

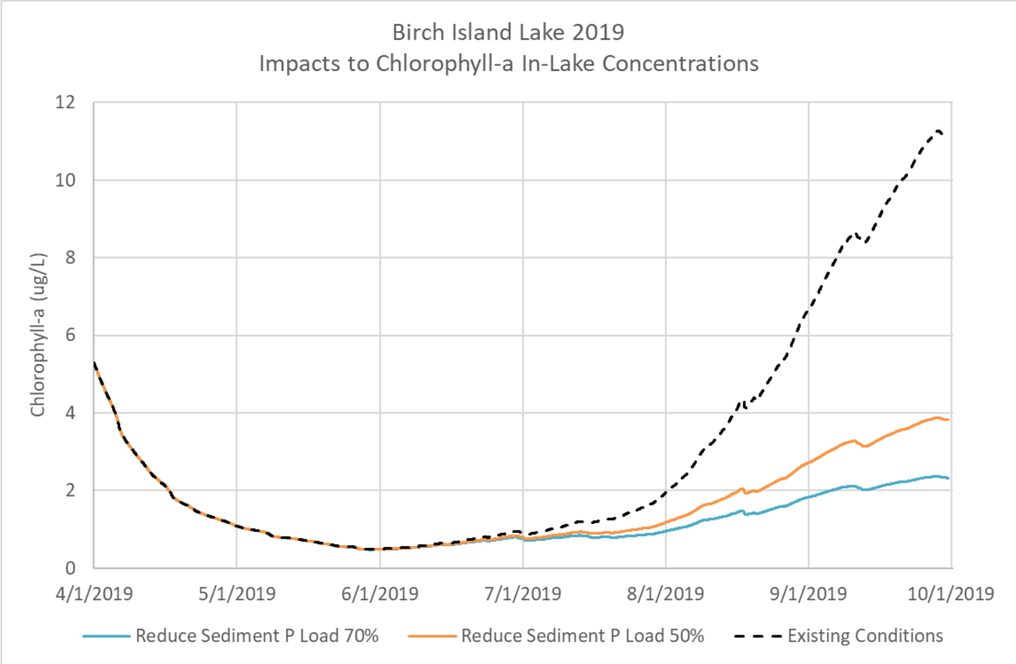


Figure 8-4 **Model predicted reductions in 2019 chlorophyll-*a* concentrations assuming 50%-70% reduction in internal loading from lake bottom sediments**

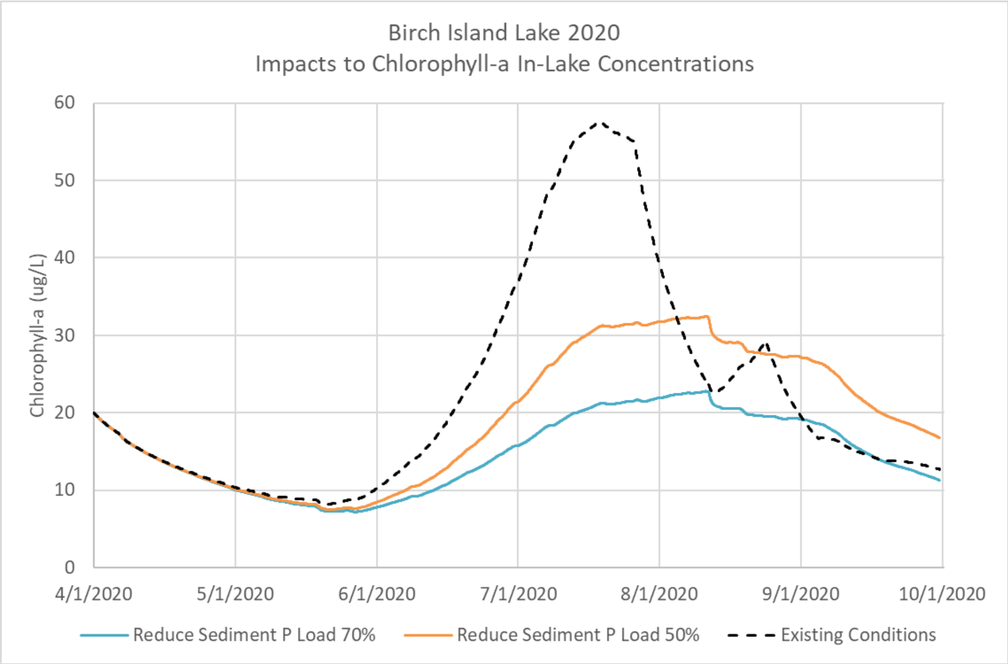


Figure 8-5 **Model predicted reductions in 2020 chlorophyll-*a* concentrations assuming 50%-70% reduction in internal loading from lake bottom sediments**

8.2 Reduce Pollutant Loading from Stormwater Runoff

Although addressing internal phosphorus loading from sediment may be sufficient to reduce concentrations below MPCA shallow lake standards, modeling demonstrated that pollutant loading from the watershed also contributes to water quality concerns in Birch Island Lake. Increased impervious areas and storm sewer systems in the primarily residential watershed allow plant debris, sediment, and fertilizer residuals to flow to the lake at greater volumes.

8.2.1 Reduce External Phosphorus Load

Watershed loading represented approximately 75% and 29% of the total phosphorus load to Birch Island Lake in 2019 and 2020, respectively, during the summer growing period of June-September. This suggests that phosphorus management strategies could also focus on reducing external loading within the direct watershed, when feasible. Since the watershed is mostly fully developed or heavily wetland dominated, the opportunities for external load management are limited.

8.2.1.1 NMCWD Stormwater Regulatory Program

NMCWD has stormwater management rules in place for land development activities. As additional development or re-development occurs in the watershed, it is recommended that NMCWD consider partnering with landowners to add additional and/or enhanced BMPs, where feasible and cost effective. Additionally, close monitoring of construction projects within the watershed is recommended to ensure adequate erosion control practices are in place and maintained. The NMCWD should also consider seeking out and/or prioritizing project opportunities through their cost share program (Section 8.7) and consider seeking out partnerships with private landowners.

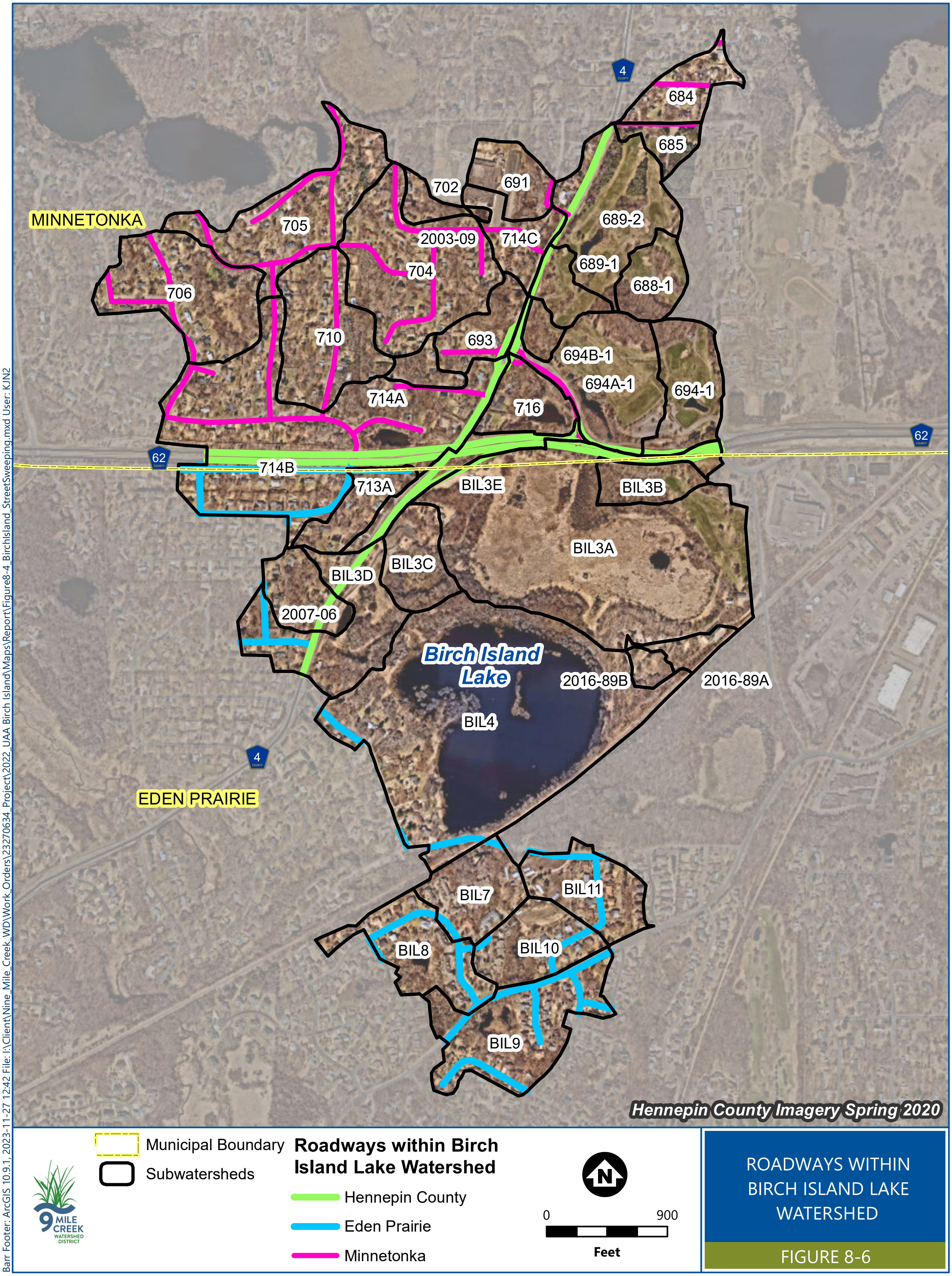
8.2.1.2 Enhanced Street Sweeping

Given the nearly fully-developed, residential nature of the watershed and limited opportunities for constructing stormwater BMPs, a more rigorous street sweeping program within the watershed could be considered if additional management practices are needed. Within the Birch Island Lake watershed there is approximately 16.8 curb miles that are owned and managed by the City of Eden Prairie, the City of Minnetonka, or Hennepin County (Figure 8-6). The City of Eden Prairie owns and manages 28% of the curb miles, while the City of Minnetonka and Hennepin County own and manage 32% and 40%, respectively. Since the City of Eden Prairie owns and manages the smallest proportion of curb miles (4.6 miles), implementing enhanced street sweeping practices on those roads alone may not result in the desired downstream water quality benefits. Additionally, of the 4.6 curb miles owned and managed by the City of Eden Prairie, approximately 4.2 curb miles currently drain to an existing BMP (e.g., stormwater pond, wetland) before discharging to Birch Island Lake. An enhanced street sweeping program could be considered to prolong the life of the existing BMPs by reducing the volume of plant debris and sediment reaching the stormwater features.

Currently the City of Eden Prairie hires a contractor for one week, twice a year (spring/fall) to assist with city-wide sweeping. The contractor and city staff work together during these two weeks to ensure that the entire city is swept at least twice a year. During the summer, the city has one regenerative air sweeper and one mechanical sweeper that is used intermittently to try to sweep the entire city a third time as staff availability allows. The City of Minnetonka currently conducts city-wide street sweeping once a year, in the spring.

Published research on street sweeping effectiveness has largely focused on the mass of solids removed from impervious surfaces rather than impacts to stormwater runoff concentrations and pollutant concentrations in downstream waterbodies. Due to limited quantification of street sweeping's impacts to stormwater runoff concentrations, the effectiveness of street sweeping as a BMP was not applied to the models used in this study.

It is recommended that NMCWD communicate with the Cities of Eden Prairie and Minnetonka and Hennepin County to assess their interest in enhanced sweeping within the Birch Island Lake watershed if additional management practices are needed to improve water quality.



Barr Footer: ArcGIS 10.9.1, 2023-11-27 12:42 File: I:\Client\Nine_Mile_Creek_WD\Work_Orders\23270634_Project\2022_UAA Birch Island\Maps\Report\Figure8-4 BirchIsland_StreetSweeping.mxd User: KJN2

8.2.2 Reduce External Nitrogen Loads

External nitrogen loading, in the form of plant debris and fertilizer residues, can also affect lake water quality by supporting algal growth. A targeted street sweeping program that reduces phosphorus will also reduce nitrogen. See Section 8.2.1.2 for additional discussion on enhanced street sweeping.

Fertilizer application to residential lawns and golf courses (e.g., Glen Lake Golf and Practice Center) is a source of nitrogen to Birch Island Lake and reduced fertilizer application could improve lake water quality. It is recommended that the NMCWD continue to educate residents and property owners on the impacts of fertilization on downstream water resources.

During spring and summer 2023, NMCWD pilot tested a resident fertilizer reduction program within the Holiday-Wing-Rose watershed in Minnetonka. Based on the conclusions of the pilot study, NMCWD could consider expanding and adapting the program for residents within the Birch Island Lake watershed.

The University of Minnesota Soil Testing Laboratory offers lawn analysis testing (regular test $19). Soil samples collected from existing lawns and tested by the laboratory are intended to aid in evaluating the fertility and chemical condition of the soils. Based on the test results, fertilization recommendations are calculated to assist residents to provide adequate levels of nutrients for healthy plant growth without adversely affecting the environment. Fertilization recommendations include:

- Fertilization Ratio (Nitrogen-Phosphorus-Potassium; N-P-K)
- Total amount of each nutrient to apply each year
- Recommendations on when to fertilize and how much to apply each application
- Amount of lime to apply each year

If residents increase their knowledge on existing lawn health, fertilization practices can be reduced and/or optimized in the watershed. The University recommends performing a soil test approximately every 3 years to reassess if lawn management practices should change.

Review of the monitoring and modeling data indicates that when phytoplankton experienced growth limitation due to nitrogen, this correlated with phytoplankton growth rates exceeding nitrogen degradation rates to bioavailable forms rather than the total mass of nitrogen in the lake. As such, decreasing the total nitrogen load from the Birch Island Lake watershed may not result in significant short-term water quality benefits unless notable reductions are achieved due to the higher concentrations already present in the lake. Even if significant external nitrogen reductions are achieved, noteworthy reductions in algal growth will be most prominent during years with a higher occurrence of nitrogen limitation.

Of the two years modeled for this study, the 2020 water quality conditions resulted in a higher level of nitrogen limitation for phytoplankton, especially during August and September. Conversely, the 2019 water quality conditions resulted in phosphorus limitation for the entirety of the growing season (see Section 6.3.3.2 for more discussion on phytoplankton (algal) growth limitations). As such, applying a 20%

reduction in nitrogen loads resulted in notable changes to 2020 chlorophyll-*a* concentrations and minimal changes to 2019 chlorophyll-*a* concentrations despite the 20% reduction in nitrogen load.

A 20% reduction in nitrogen loads results in decreasing the nitrogen loads in 2019 and 2020 by approximately 371 and 498 pounds, respectively. This reduction in nitrogen load translates to a reduction in the summer average total nitrogen and chlorophyll-*a* concentrations. Modeling indicates that the 2019 summer average total nitrogen concentration of 1.6 mg/L in Birch Island Lake would be reduced to 1.3 mg/L. In 2020, modeling indicates that the summer average total nitrogen concentration of 1.7 mg/L would be reduced to 1.5 mg/L. A reduction in total nitrogen concentrations can lead to a reduction in chlorophyll-*a* concentrations if the phytoplankton are highly nitrogen limited. Modeling indicates that the 2019 summer average chlorophyll-*a* concentration of 4 µg/L would be reduced to 3 µg/L due to a lower level of nitrogen limitation. Conversely, in 2020 when nitrogen limitation was more significant, modeling indicates that the 2020 summer average chlorophyll-*a* concentration of 28 µg/L would be reduced to 19 µg/L. Figure 8-7 shows the reduction in chlorophyll-*a* concentrations in the 2020 model from the 20% reduction in nitrogen loads.

It should be noted that these predicted reductions to chlorophyll- *a* concentrations only represent the impacts incurred by reducing nitrogen concentrations within the in-lake models. All other variables that impact growth (e.g., phosphorus concentrations, temperature, light, plant competition) remain unchanged. Therefore, while reductions in nitrogen concentrations can be an indicator of impacts to chlorophyll-*a* concentrations, there are other factors that will impact growth on an annual basis.

Although reductions in watershed nitrogen loading may not result in notable short-term impacts to phytoplankton depending on growth limiting conditions, enacting management efforts to control nitrogen can have long-term water quality benefits, especially when tied with external phosphorus control, such as street sweeping.

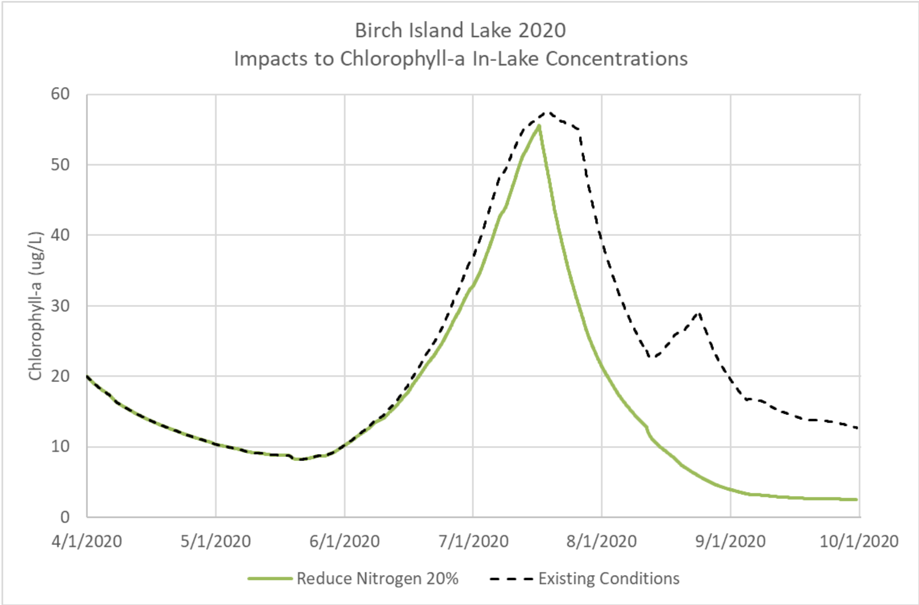


Figure 8-7 **Model predicted reductions in 2020 chlorophyll-*a* concentrations assuming a 20% reduction in nitrogen loads**

8.2.3 Reduce External Chloride Loads

Because high concentrations of chloride can harm fish, plants, and other aquatic life, the MPCA has established a chronic exposure chloride standard of 230 mg/L or less and considers two or more exceedances of the chronic standard in 3 years to be an impairment. Based on the monitoring data collected in 2015 and 2018-2021, chloride concentrations in Birch Island Lake have not been observed to exceed 230 mg/L. The highest surface concentration recorded was 170 mg/L in August 2018. Monitored surface chloride concentrations from 2015-2021 ranged from 70-170 mg/L, with the lowest concentrations observed during the years with the highest water surface elevations (i.e., more water volume results in lower concentrations). Continued periodic water quality monitoring of chloride concentrations is recommended. NMCWD should also consider seeking opportunities to work with Hennepin County, property owners and/or property management companies to reduce winter salt usage.

8.2.4 Reduce External Sediment Loads

As a part of stakeholder meetings for this study, the City of Eden Prairie expressed concerns regarding slope and channel erosion upstream of the Birch Island Lake stormwater bypass pipe system. The City noted that a manhole sump has been filling with sediment faster than anticipated and hypothesizes that upstream erosion may be playing a role.

Two stormwater pipes currently discharge into a channel that drains towards the city's bypass pipe system. These stormwater outfalls are shown as black lines in Figure 8-8. Stormwater discharging from these two outfalls flows through a channel of approximately 570 feet in length before reaching the bypass pipe system shown in yellow in Figure 8-8. Hennepin County owns and operates the most upstream pipe discharging runoff from Eden Prairie Road. The pipe further downstream, which discharges runoff from a stormwater pond north of County Road 62 (stormwater pond 714B), is either owned and operated by Hennepin County or the City of Eden Prairie. Determining ownership of the pipe will be an important next step for management considerations.

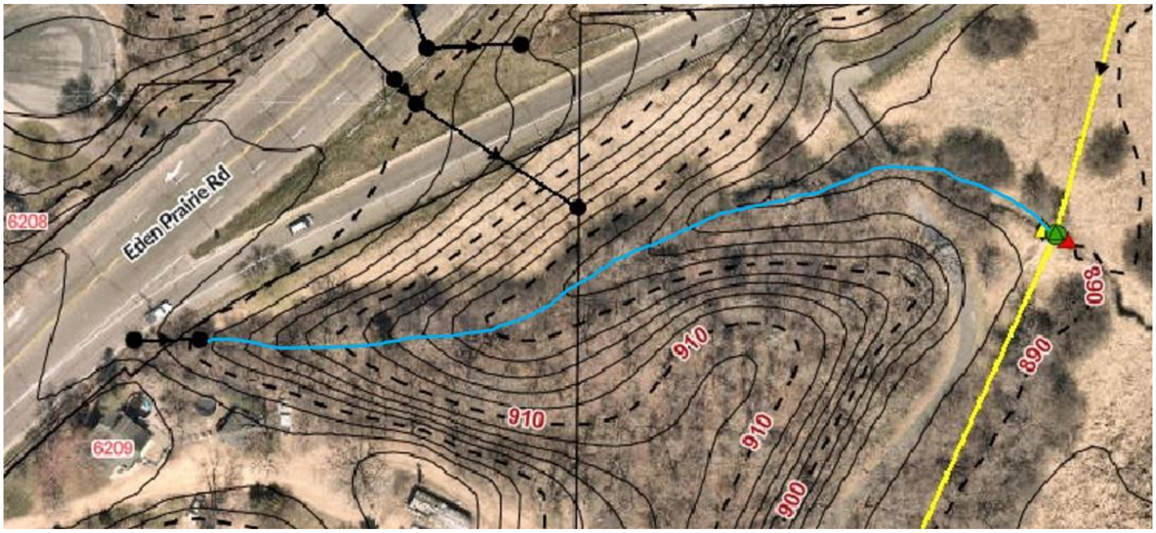


Figure 8-8 **Stormwater channel south of Eden Prairie Road discharging runoff to Birch Island Lake bypass pipe system**

In August 2023, Barr noted the following observations during a site visit of the stormwater channel and surrounding sloped tributary areas:

1. There was notable sand accumulation and deposition within the flatter, downstream portions of the channel from upstream erosion (Figure 8-9).
2. Significant bank erosion and undercutting have occurred (over 50% of bank length) (Figure 8-10).
3. Fallen (or falling) trees in the channel from bank failure (Figure 8-10).
4. Limited undergrowth and open soil within the forested area tributary to the channel. Buckthorn dominates the undergrowth (Figure 8-11).
5. Failure/settling of rip rap at storm sewer end section discharging runoff from Eden Prairie Road (Figure 8-12).

Figure 8-9 Sand deposition and accumulation in flatter, downstream portions of channel

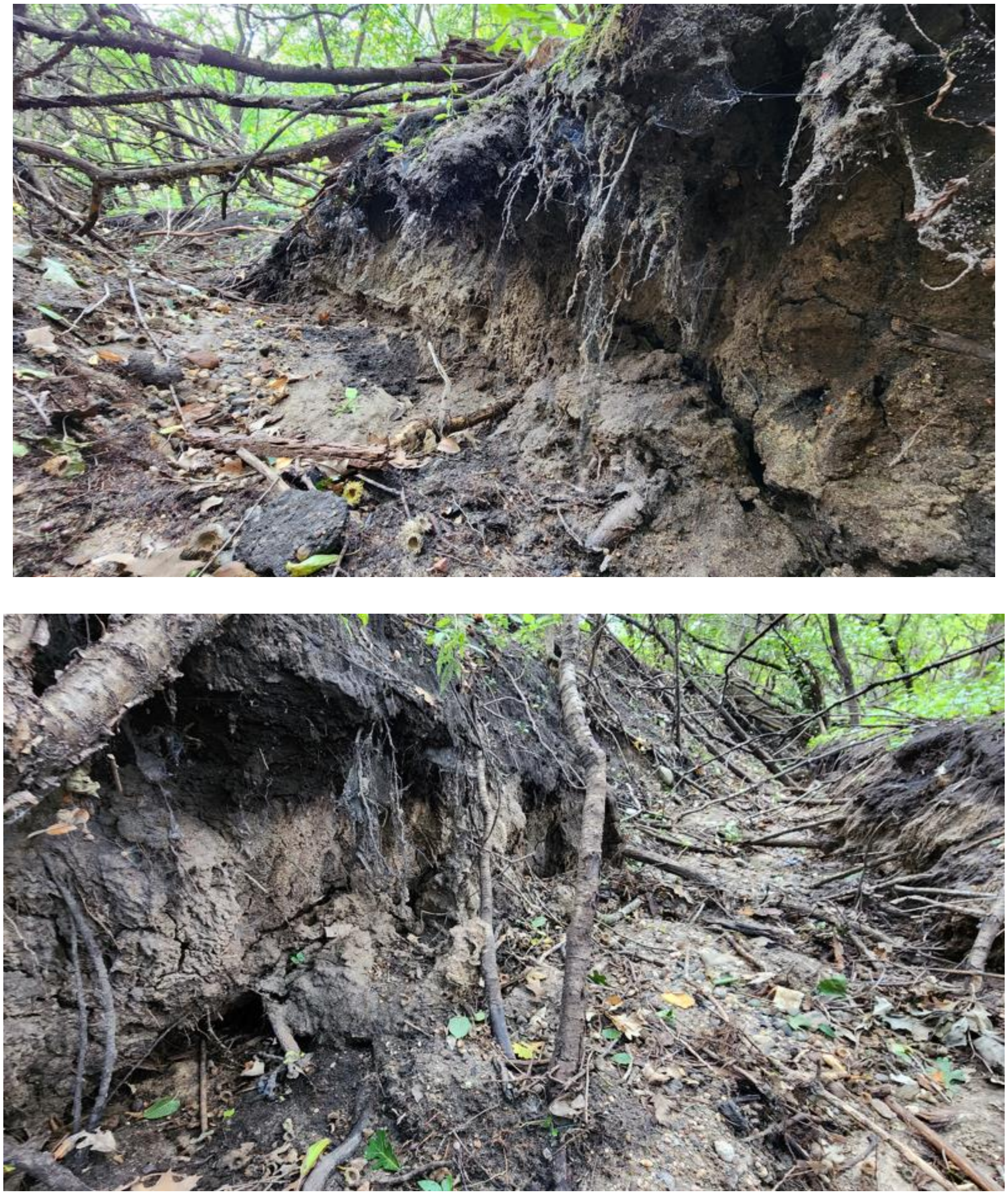


Figure 8-10 Example bank erosion and failure leading to trees falling into channel

**Figure 8-11	Minimal vegetation undergrowth in forested areas adjacent to channel with buckthorn dominated undergrowth**

**Figure 8-12	Failure of rip rap at outlet pipe discharging runoff from Eden Prairie Rd.**

Due to the extent of channel and slope erosion noted in the August 2023 field visit, it is recommended that NMCWD work with the City of Eden Prairie and Hennepin County to discuss options for channel and slope stabilization. Reducing the extent of channel and slope erosion should not only reduce the maintenance needs of the bypass pipe system but will also reduce sediment and contaminant loading (including phosphorus) to downstream waterbodies (e.g., Birch Island Lake, wetland north of Birch Island Lake).

Notable buckthorn growth with minimal vegetation undergrowth was observed in portions of the forested areas immediately surrounding Birch Island Lake. Sparse vegetation undergrowth and open soil conditions is a common detrimental impact of widespread buckthorn growth and can lead to altered hydrology and soil movement/erosion. It is recommended that NMCWD work with the City of Eden Prairie to assess the conditions further and determine if upland erosion, sediment loading, and nutrient loading to Birch Island Lake from the invasive-dominated forested area is an immediate or future concern with a changing climate.

Figure 8-13 Minimal vegetation undergrowth in forested areas adjacent to Birch Island Lake with buckthorn-dominated undergrowth.

8.3 Lake Level Stabilization

Birch Island Lake is generally considered land locked. A high-level outlet has historically been referenced, but the location has not been confirmed. Given that the lake is generally land locked, water levels in the lake depend on climate conditions (snowmelt, rainfall, evaporation) and groundwater flow.

As discussed in Section 5.4, water levels in Birch Island Lake changed significantly (lowered) following the construction of County Road 62 in the mid- and late 1980's. Detailed studies were completed by NMCWD to assess the possible causes and remediation strategies (Barr Engineering Co., 1992) (Barr Engineering Co., 2005). The studies found that the construction of County Road 62 embankment resulted in increased infiltration from the northern portion of the watershed easterly to an existing underlying sand lens. Therefore, significantly less runoff volume has been reaching Birch Island Lake since the road embankment was installed leading to a decrease in water levels. A pipe bypass system was installed by NMCWD in 2007 to help convey drainage from the stormwater ponds north of County Road 62 directly to Birch Island Lake. The effectiveness of the bypass pipe in increasing water levels in Birch Island Lake has been variable, primarily due to frequent clogging of the bypass system from sediment build up.

In addition to concerns with low water levels, Birch Island Lake has also experienced extreme water level fluctuations in recent years. Since the installation of the bypass system in 2007, the lowest observed WSE of 875.1 (NGVD29) in February 2013 was 13.3 feet below the highest observed WSE of 888.3 (NGVD29) in October 2019. The lowest WSE of 875.1 corresponds to a water surface area of only 3.2 acres compared to a water surface area of 43.7 acres at the highest WSE of 888.3 (Figure 5-20).

The fluctuating water depths and open water areas can influence water quality and ecosystem health. Since Birch Island Lake has experienced variable water levels since the early 1980's (following the construction of County Road 62), it is unclear how the lake's water quality and ecological health would respond to more stable water levels. While further analysis would be necessary to better understand the potential impacts, stabilizing the water levels in Birch Island Lake could result in the following impacts:

Potential Benefits:

- Reductions in sediment area exposed to drying, freezing, and reflooding could result in:
  - A smaller amount of nutrient "pulses" from the sediment (see Section 5.4).
  - A healthier aquatic macrophyte community with more sediment area available for prolonged growth.
  - A healthier fishery by providing more habitat for feeding and reproduction.
  - A lower frequency of cattail growth, death, and decay from wet/dry periods.
- More lake water volume and larger surface area could result in:
  - Lower nutrient concentrations (i.e., more water volume per mass of nutrient inputs).
  - More opportunities for passive and active recreation.

Potential Drawbacks:

- o Reductions in sediment area exposed to drying, freezing, and reflooding could result in:
  - An increased extent of invasive macrophyte species due to less sediment area freezing during periodic winters.
  - Less sediment area experiencing periodic consolidation (see Section 5.4).
- o More lake water volume and larger surface area could result in:
  - Elevated lake stability during the summer (i.e., warmer surface layer, cooler bottom layer), which may result in lower dissolved oxygen conditions at the lake bottom and increased internal loading.
  - Increased internal sediment loading from increased inundated sediment area.

It is recommended that NMCWD consider conducting a feasibility study to evaluate options for stabilizing water levels in Birch Island Lake, and associated impacts to water quality and ecosystem health. If pursued, the study should also address flood management considerations.

In the meantime, it is recommended that the flow capacity of the pipe bypass system to Birch Island Lake be maintained as much as practicable. In recent years, the City of Eden Prairie has increased the inspection and maintenance frequency of the bypass pipe system. The city typically cleans a critical manhole sump 3 – 4 times a year to remove sediment and reduce pipe clogging. In fall 2022, the city also jetted a portion of the bypass storm sewer pipes to remove sediment and restore flow capacity. The City of Eden Prairie should continue to inspect and maintain the bypass pipes and structures multiple times per year, as needed to maintain flow capacity to Birch Island Lake from the northern watersheds and improve water level stability. Addressing the upstream sediment load from the existing stormwater conveyance channels (see Section 8.2.4) may help reduce maintenance frequency. If clogging of the bypass system continues to be problematic, options to retrofit the existing bypass storm sewer system with features that have improved sediment and debris storage capacity (e.g., deeper sump, hydrodynamic separator) could be considered to reduce maintenance frequency.

Periodic water quality and ecological health monitoring should continue to help assess the water quality and ecological changes in Birch Island Lake from more stabilized water levels. If higher, more stable water levels are achieved, additional management efforts can be considered (e.g., fisheries, native plant restoration).

8.4 Continue to Monitor Growth and Impacts from Curly-leaf Pondweed

The presence of curly-leaf pondweed and its mid-summer die-off can negatively impact lake water quality. Curly-leaf pondweed was observed at low densities at several locations in Birch Island Lake in the June 2006 survey. However, since this survey, curly-leaf pondweed has not been observed. It is possible that low lake water levels during portions of 2007 through 2014 resulted in the natural management of the AIS through the freezing of turions. Although curly-leaf pondweed has not been observed in Birch Island Lake in recent years, future periodic surveys should review if curly-leaf pondweed re-establishes, especially since curly-leaf pondweed is located in upstream lakes (e.g., Wing Lake and Lake Rose).

8.5 Consider Fisheries Management

Blue Water Science completed a fisheries assessment of Birch Island Lake in October 2022 using four mini trap nets. Fathead minnows dominated the fish community with over 21,000 fathead minnows collected over two days. Small quantities of three other fish species were observed (2 goldfish, 3 stickleback minnows, and 4 black bullheads). The observed fish species and their sizes indicate historical winterkill conditions.

Higher quantities of minnows can lead to over-predation of zooplankton. An imbalance in the food web (i.e., lower quantities of zooplankton leading to less predation of algae) can negatively impact water quality. Lower predation of algae can lead to a decrease in water clarity, which can impact plant extent, density, and health over time.

Besides passive management (i.e., continue to monitor how water quality and ecological health changes over time), fish stocking was a recommended management option by Blue Water Science (see Appendix B for additional details). However, fish stocking was only recommended if Birch Island Lake develops higher, more stable water levels. It is recommended that the NMCWD continue to partner with the City of Eden Prairie on fisheries management options once water levels become more stable in Birch Island Lake.

8.6 Promote Healthy Aquatic and Shoreline Plant Growth

8.6.1 Resident Education

Due to numerous benefits of healthy, native aquatic macrophyte communities (e.g., phytoplankton competition, invasive macrophyte competition, fisheries habitat, increased water clarity), it is recommended that NMCWD and the City continue to educate residents regarding the benefits of native macrophytes in lakes and discourage removal practices. This will be especially important as the native community re-establishes itself as algal concentrations decrease and clarity increases with the implementation of future watershed and/or in-lake management practices.

8.6.2 Submerged Native Plant Restoration

The implementation of watershed and in-lake BMPs (e.g., sediment alum treatment, water level management, AIS control) can result in the natural resurgence of submerged native plants by stabilizing water levels, decreasing algae concentrations, and increasing water clarity. However, if the sequential implementation of different management efforts does not result in an increase in the extent and/or diversity of native plant species, the NMCWD could consider options for native submerged plant restorations. Options to promote native plant species growth include:

- Slowly introducing native plant species from nearby, reference lakes (with no invasive species).
- Performing a full or partial lake fall drawdown to consolidate sediment and re-activate dormant, native seeds.

8.7 Encourage Residents to Apply for NMCWD Cost-Share Grants

Because the Birch Island Lake watershed is almost fully developed and/or has natural open areas with wetlands, opportunities for large-scale external BMPs will be limited. It is recommended that NMCWD continue to promote their cost share grant programs to educate residents, associations, nonprofit organizations, schools, and businesses regarding the benefits of smaller-scale projects. NMCWD Stewardship Grants can help individuals install projects that prevent stormwater pollution to downstream lakes, such as rain gardens, shoreline buffer improvements, and permeable pavers. Native Habitat Restoration Grants are also available to assist with project costs associated with restoring native plant and wildlife habitat, such as prairie and woodland restorations.

Additional information on NMCWD Cost-Share Grants can be found at https://www.ninemilecreek.org/get-involved/grants/

9.0 Cost—Benefit Analysis

9.1 Opinion of Probable Cost

Numerous lake and watershed management strategies were considered as a part of this study to improve the water quality and ecological health of Birch Island Lake. Planning-level opinions of probable cost were developed for two of the evaluated management alternatives that are outside of typical on-going NMCWD monitoring and management programs: conducting an alum treatment to reduce internal loading from lake sediments and developing a soil sampling program, as discussed in Section 8.0. Although upstream channel and slope erosion were identified as a water quality and stormwater infrastructure maintenance concern, prescriptive mitigation measures were not evaluated as part of this study. Accordingly, an opinion of cost was not prepared for addressing the channel and slope erosion, but could be developed as part of a future feasibility study upon further project refinement.

The opinions of probable cost are summarized in Table 9-1 and include estimates for construction, implementation, and engineering/design. Detailed opinions of probable cost are included in Appendix E. These opinions of cost are intended to help evaluate and compare alternatives and should not be assumed as absolute values. The opinions of probable cost generally correspond to standards established by the Association for the Advancement of Cost Engineering (AACE). Class 5 planning-level opinions of costs were used based on the limited project definition, wide-scale use of parametric models to calculate estimated costs (i.e., making extensive use of order-of-magnitude costs from similar projects), and uncertainty, with an acceptable range of between -30% and +50% of the estimated project cost.

Table 9-1 Planning-level cost estimates for evaluated management alternatives.

Description	Planning-Level Cost Estimate[1]	Planning-Level Cost Range (-30%-+50%)[1]	Estimated Life of Project
Sediment Alum Treatment	$96,000	$68,000-$144,000	10 years
Soil Sampling Program for Resident Fertilization Assessment	$22,000	$16,000-$33,000	3 years

[1] Rounded to the nearest $1,000.

9.1.1 Cost Details

9.1.1.1 Lake Bottom Sediment Treatments

The opinion of probable cost for the lake bottom sediment treatment is based on correspondence with alum application contractors and experience from other alum applications. The primary assumptions for the sediment treatment opinions of cost are:

- Alum treatment #1 for 7.8-acre sediment treatment zone (Figure 8-1):
    - 3,097 gallons alum
    - 1,548 gallons sodium aluminate
- 12 hours of field observation during alum applications and data review
- 50 hours for project planning, design, and sub-contracting
- 5 years of annual to bi-annual water quality monitoring and data review
- Post-alum treatment sediment coring and release rate experiments to assess success of alum sediment application in deep depression and to determine if a sediment treatment should be applied in shallow areas.

9.1.1.2 Soil Sampling for Resident Fertilization Assessment

The primary opinion of cost assumptions for the soil sampling program to assess resident fertilization practices and target nitrogen reductions are listed below. These costs may differ depending on details of program implementation (e.g., subcontracted versus in-house). The NMCWD is currently pilot testing a soil sampling program in another watershed. While the opinion of cost for this study assumes contracted labor costs, future application of the program will likely be conducted in-house, lowering the overall cost.

- University of Minnesota Standard Soil Testing per sample = $19/sample
- 15% participation of single-family residents within the tributary watershed to Birch Island Lake (310 total single-family properties within watershed) = 47 residential properties
- 2 hours of labor per residential property needed to provide project background, schedule soil sampling field work, and discuss results summary
- 1 hour of labor per residential property needed to complete field soil sample collection
- 16 hours of project-wide data review
- 24 hours of initial team project planning

9.2 Cost Benefit Analysis

The management strategies considered to help improve water quality in Birch Island Lake range in type, scale, cost, and effectiveness. Some strategies have larger, upfront capital costs, whereas others are more programmatic or may require periodic or annual recurrence. To account for these variations, a comparison of cost-benefit of the potential management strategies was conducted, where reasonably feasible. Results of the cost-benefit analysis can help to understand the value derived and associated costs, for the management practices and combinations thereof.

Estimated costs for the evaluated management activities were annualized to help compare the cost-benefit ratio. The annualized cost for each management alternative is based on anticipated maintenance, replacement costs, and anticipated useful life span of the projects/treatments. A 3% inflation rate was assumed. The annualized cost for each alternative is calculated as the value of 'n' equal, annual payments, where 'n' is the anticipated useful life span of the project or treatment. The annualized cost estimates are summarized in Table 9-2. For the cost-benefit analysis, the benefit is in terms of phosphorus removed (in pounds) during the time period of June through September (i.e., phosphorus that did not enter the lake system as a result of the management practice).

Table 9-2 Cost-benefit summaries for evaluated management alternatives

Description	Management Type	Estimated Annualized Cost	Average Pounds of TP Load Removed (June-Sept)	Annualized Cost per Pound of TP Removed (June-Sept)
Sediment Alum Treatment	Internal	$11,000	22-30	$400-$500
Soil Sampling Program for Resident Fertilization Assessment	External	$8,000	Targets Nitrogen Reduction	-

10.0 Conclusion and Recommendations

10.1 Water Quality and Ecological Health Conclusions

Recent monitoring data indicate that Birch Island Lake is not meeting Minnesota's nutrient water quality standards for shallow lakes. The observed summer average total phosphorus and chlorophyll-*a* concentrations exceeded the MPCA shallow lake water quality standards (60 µg/L TP and 20 µg/L chlorophyll-*a*) in the two most recent monitoring years, 2020 and 2021. Additionally, summer average Secchi disk transparency measurements did not meet the MPCA shallow lake standard of 1 meter in the two most recent monitoring years of 2020 and 2021 (Figure 10-1).

Plant surveys completed periodically from 1997 through 2021 indicate that species diversity and extent in Birch Island Lake are correlated with water levels. The number of species observed during years with lower water levels ranged from 3 to 5. The number of species observed during years with higher lake water levels ranged from 6 to 11 species. Native plants provide many benefits to lake ecosystems, including the uptake of nutrients and the stabilization of the lake sediment. In the past decade, the difference between the lowest and highest observed water level is approximately 13.3 feet. The lowest observed water level corresponds to an open water area of only 3.2 acres. The highest observed water level corresponds to an open water area of 43.7 acres. This substantial difference in open water area can have a notable influence on long-term health of submerged and emergent plants. As such, without water level stabilization, water level fluctuations may continue to influence the ability of submerged plants to utilize nutrients in the lake and provide competition with phytoplankton.

Phytoplankton numbers in Birch Island Lake generally increased during the monitoring period of 1989 through 2015. In 1989, the summer average phytoplankton number was approximately 3,950 per mL. In 2015, the summer average phytoplankton number increased to 53,900 per mL. Blue-green algae numbers have also increased from 1989 to 2015. The highest observed concentration of blue-green algae from the routine monitoring location was 56,850 per mL in August 2015, which is above the World Health Organization (WHO) threshold for low probability of adverse health impacts (>20,000 cells per mL).

A fish survey completed in October 2022 showed that Birch Island Lake does not have a balanced fishery. Only four fish species were observed during the survey. Fathead minnows dominated the fish community with over 21,000 fathead minnows collected over two days. Small quantities of the other fish species were observed (2 goldfish, 3 stickleback minnows, and 4 black bullheads). Higher quantities of minnows can lead to over-predation of zooplankton. An imbalance in the food web (i.e., lower quantities of zooplankton leading to less predation of algae) can negatively impact water quality. Lower predation of algae can lead to a decrease in water clarity, which can impact plant extents, density, and health over time.

This water quality study used watershed and in-lake models to estimate nutrient loadings to Birch Island Lake for two of the most recent monitored years (2019 and 2020). The calibrated model results help determine the relative magnitude of nutrient loadings from both external and internal sources and can help to identify management needs.

In 2019 (a wet year), the percentage of total phosphorus loading from the watershed was greater than the loading from lake bottom sediment. Approximately 75% (69 pounds) of the total phosphorus load to Birch Island Lake during the 2019 summer growing period of June 1 – September 30 was from watershed runoff. The remaining 25% (23 pounds) of the total phosphorus load was from lake bottom sediment (internal loading).

Conversely, in 2020 (a dry year due to bypass pipe clogging), the percentage of total phosphorus loading from the lake bottom sediment was greater than the watershed loading. Approximately 71% (62 pounds) of the total phosphorus load to Birch Island Lake during the 2021 summer growing period of June 1 – September 30 was from the sediment (internal loading). The remaining 29% (26 pounds) of the total phosphorus load entered from watershed runoff.

The models indicate, depending on the year, that phosphorus loading from both watershed runoff and internal loading from lake bottom sediment can influence in-lake water quality.

10.2 Management and Protection Recommendations

A variety of management strategies were evaluated to improve the water quality and varying ecological health conditions in Birch Island Lake. The evaluated management practices primarily targeted sources of phosphorus and nitrogen to Birch Island Lake, with focus on reducing both internal and external loading sources. The recommendations for management and protection strategies are summarized in Table 10-1.

The management and protection recommendations presented in Table 10-1 are intended to be implemented adaptively and success should be demonstrated with follow-up monitoring to assess changes in the lake and overall progress towards water quality goals. Additional details on each recommended management and protection activity and the estimated costs can be reviewed in Sections 8.0 and 9.0.

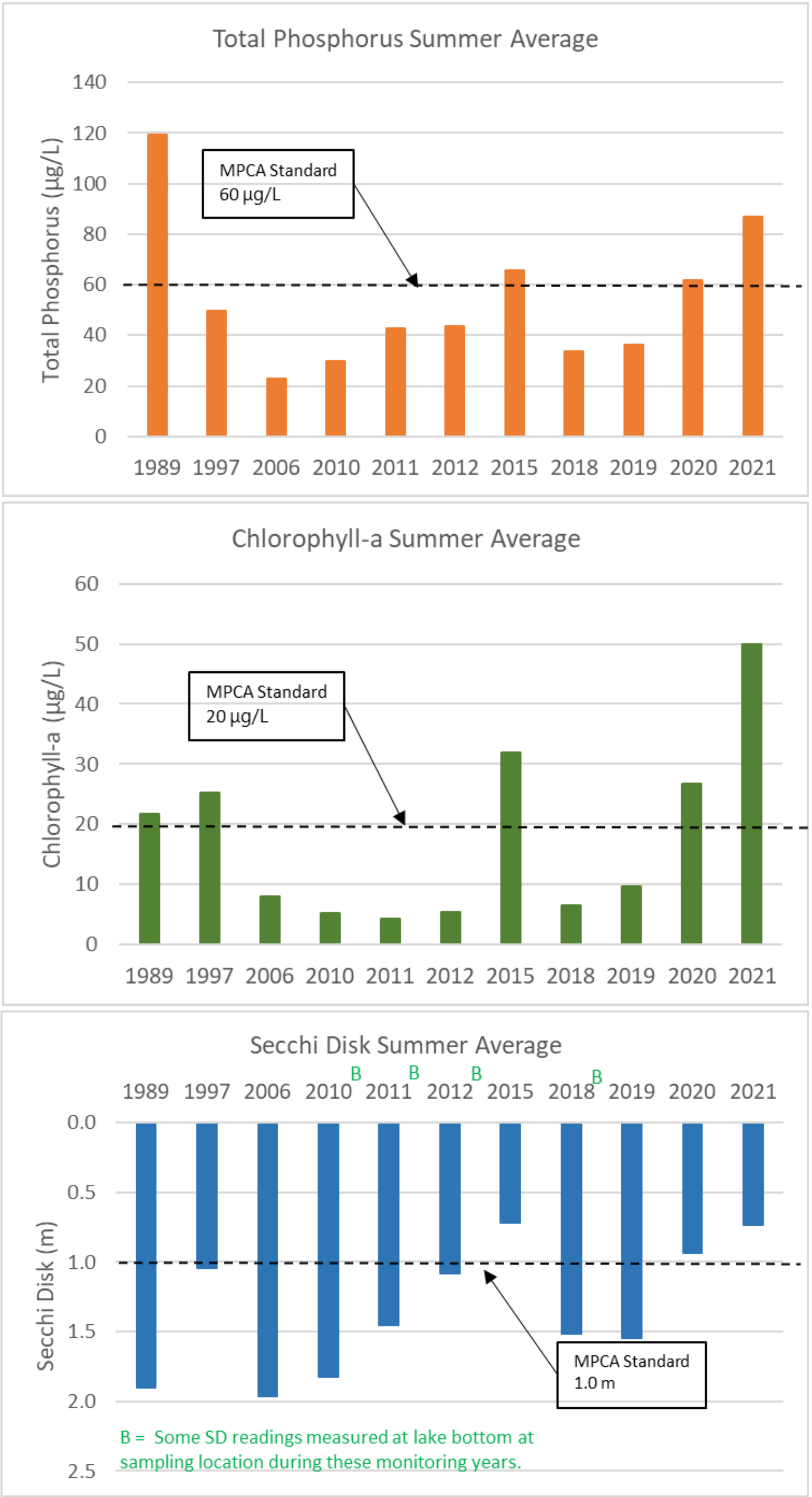


Figure 10-1 **Summer average total phosphorus and chlorophyll-*a* concentrations and Secchi disk depth measured in Birch Island Lake between 1989 and 2021**

Table 10-1 Recommendations for management & protection strategies for Birch Island Lake

Management/Protection Action		Basis	Estimated Timeline	Planning Level Cost Range (-30%-+50%)
Address internal bottom sediment loading	Alum treatment	Reduce sediment phosphorus load	2025-2029*	$96,000 ($68,000-$144,000)
	Sediment release & water quality monitoring	Assess management effectiveness and determine if additional sediment treatment(s) needed	2026-2034+	
Address external watershed loading	Fertilizer management program	Reduce nitrogen sources from excess fertilizer use	2024-2025 (Planning Begins)	$22,000 ($16,000-$33,000)
	Address channel and slope erosion	Reduce sediment loading from upland erosion and protect upland habitats	2024-2025 (Planning Begins)	Coordinate with City of Eden Prairie and Hennepin County on stormwater channel and slope erosion upstream of bypass pipe system and adjacent to Birch Island Lake.
	Enhanced street sweeping program	Reduce pollutant loading from stormwater	Reconsider in the future	
	Chloride monitoring	Continue to identify/track chloride levels from winter salt use	2024+	As part of continued lake monitoring program
	Promote NMCWD cost-share grants to watershed residents	In a fully developed watershed, opportunities for largescale BMPs are limited	2024+	As a part of existing grant programs
Aquatic plants (macrophytes)	Invasive species management	Continue to monitor invasive species growth and consider management, if needed.	2024+	As a part of continued monitoring and management
	Promote native aquatic plant growth	Encourage native plant reestablishment to promote clear water conditions and competition with algae	2024+	To be determined later if native plants do not re-establish following other management activities
Lake level stabilization	Conduct lake level stabilization and flood management evaluation	Increase runoff volume to lake and/or reduce extreme fluctuations in water levels	2024-2025	To be determined later
	Continue frequent inspection and maintenance of the bypass pipes and structure.	Maintain flow capacity to Birch Island Lake and improve water level stability	2024+	As part of City of Eden Prairie stormwater infrastructure maintenance program
Fisheries	Fisheries health	Reduce minnow biomass to limit over predation of zooplankton and consider fish stocking.	2024-2025 (Planning Begins)	Consider fisheries management once water levels are higher and more stable.

* Estimated timeline is based on several factors including lake water levels for safe access and results of the feasibility study.

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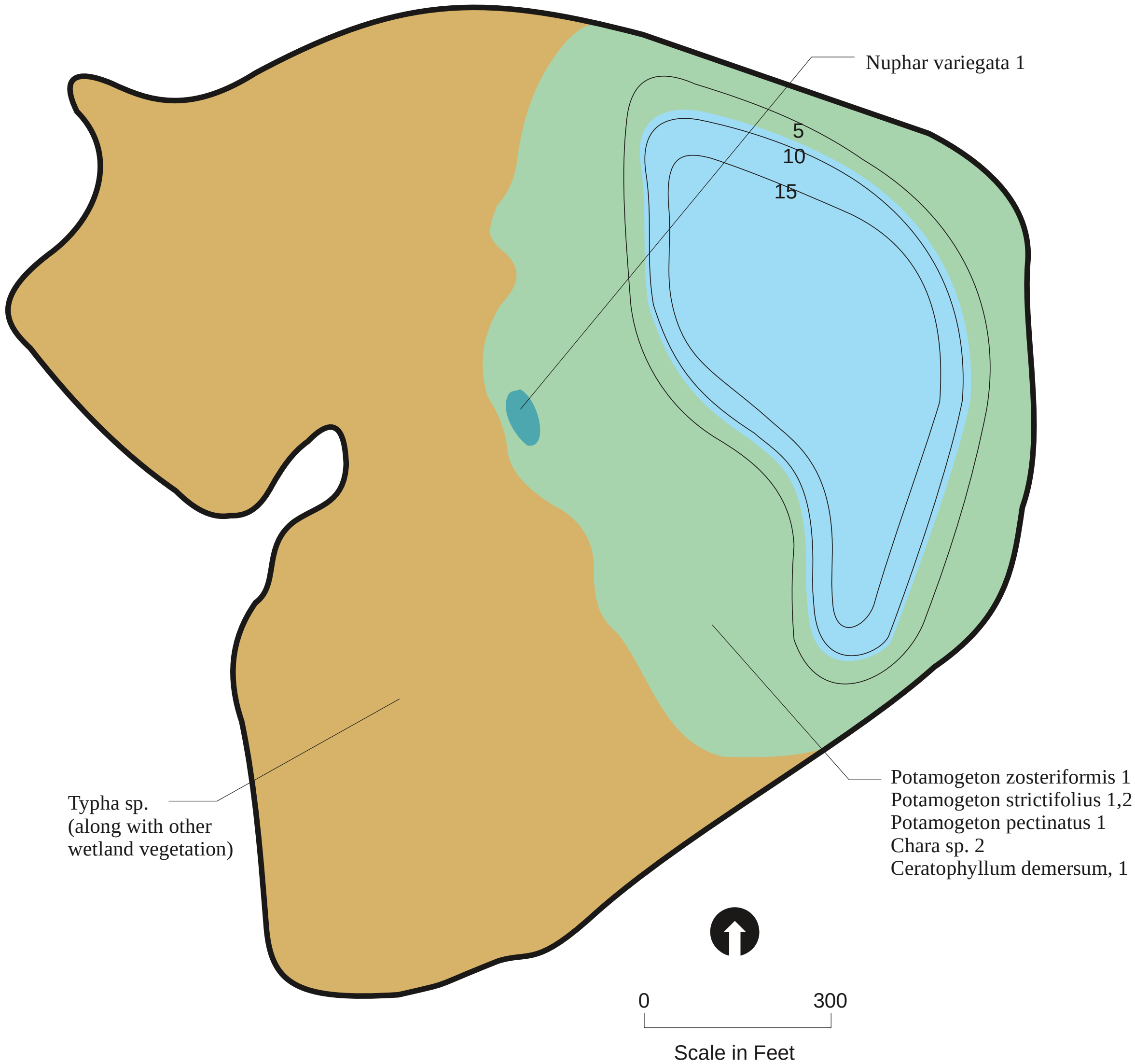
Appendices

Appendix A

Aquatic Plant Surveys



- No macrophytes found in water > 8 - 9 feet
- Macrophyte densities estimated as follows: 1 = light; 2 = moderate; 3 = heavy
- Western 2/3 of lake is Typha sp. (Cattail) and other varities of wetland plants, trees, etc.
- Chara spp. (Muskgrass) is dense in water up to 3-4 feet

	Common Name	Scientific Name
Submerged Aquatic Plants: Aquatic Vegetation:	Stiff pondweed Flatstem pondweed Sago pondweed Coontail Muskgrass	Potamogeton strictifolius Potamogeton zosteriformis Potamogeton pectinatus Ceratophyllum demersum Chara sp.
Floating Leaf:	Yellow waterlily	Nuphar variegata
Emergent:	Cattail	Typha sp.
No Aquatic Vegetation Found:		

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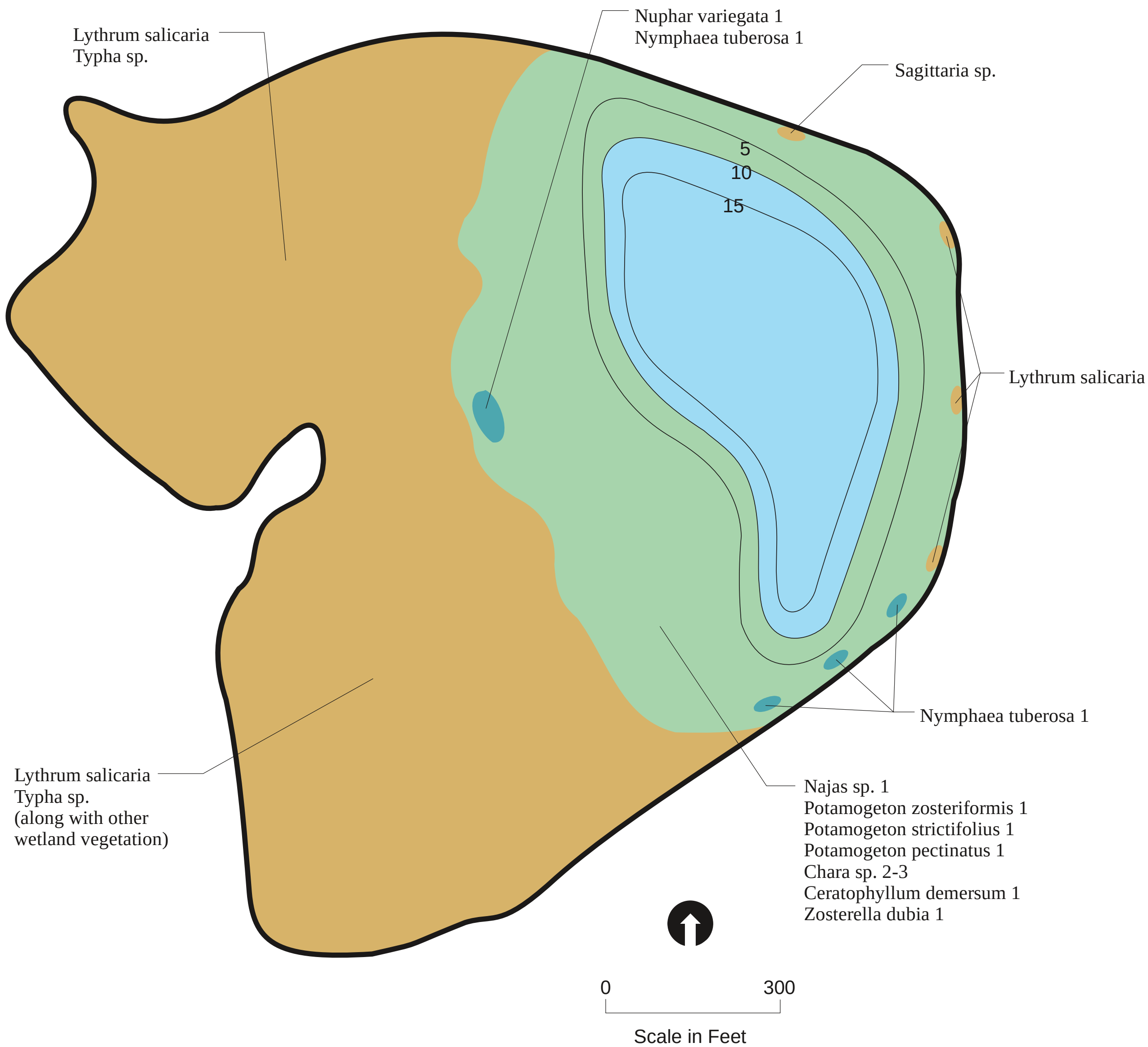
BIRCH ISLAND LAKE
MACROPHYTE SURVEY
JUNE 18, 1997



- No macrophytes found in water > 8 - 9 feet
- Macrophyte densities estimated as follows: 1 = light; 2 = moderate; 3 = heavy
- Western 2/3 of lake is Typha sp. (Cattails), Lythrum salicaria (Purple loosestrife) and other varities of wetland plants, trees, etc.
- Chara spp. (Muskgrass) is dense in water up to 3-4 feet

Aquatic Vegetation:	Common Name	Scientific Name
Submerged Aquatic Plants:	Stiff pondweed Flatstem pondweed Sago pondweed Coontail Muskgrass Bushy pondweed and naiad Water stargrass	Potamogeton strictifolius Potamogeton zosteriformis Potamogeton pectinatus Ceratophyllum demersum Chara sp. Najas sp. Zosterella dubia
Floating Leaf:	Yellow waterlily White waterlily	Nuphar variegata Nymphaea tuberosa
Emergent:	Cattail Purple loosestrife Arrowhead	Typha sp. Lythrum salicaria Sagittaria sp.
No Aquatic Vegetation Found:		

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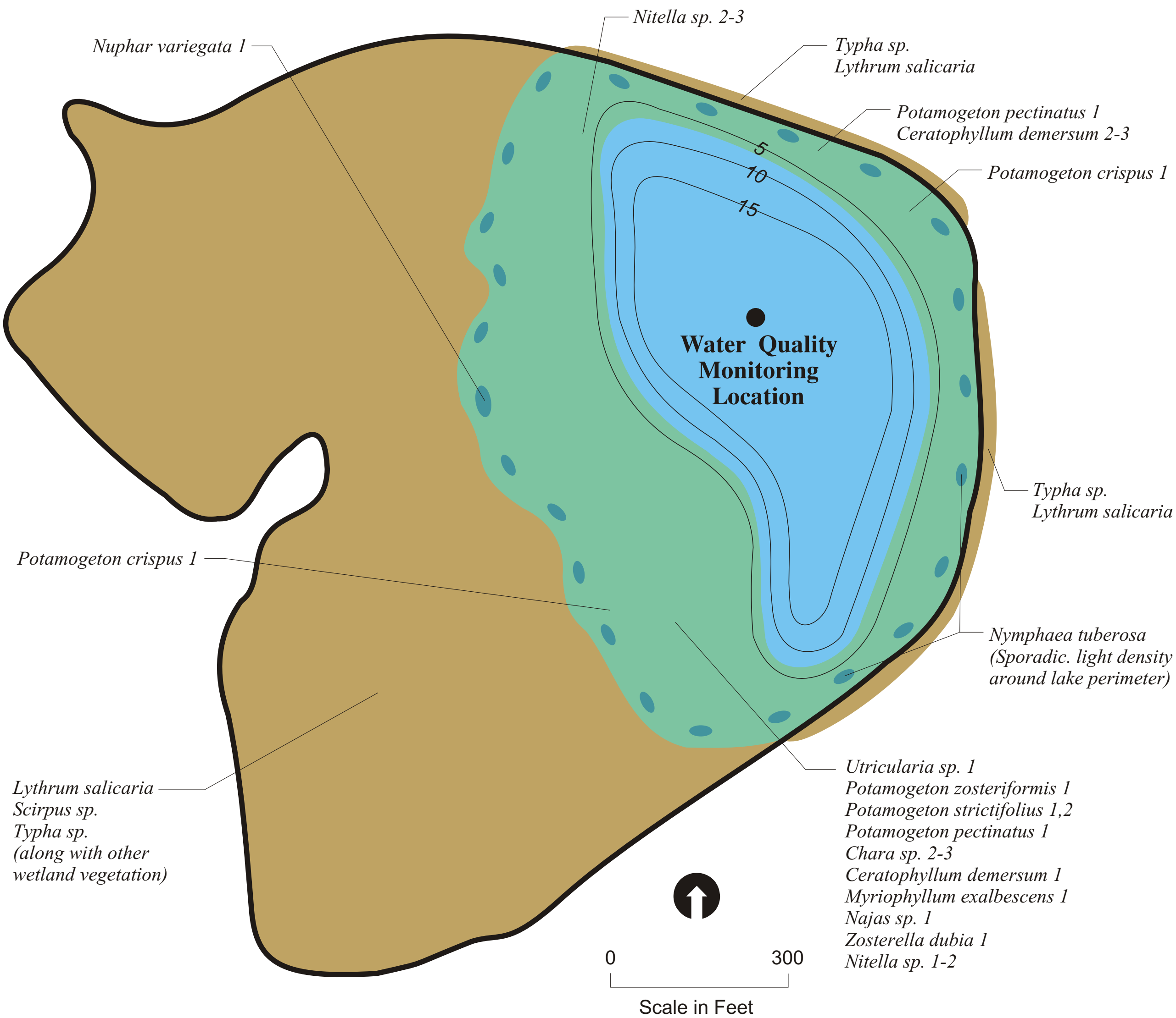
BIRCH ISLAND LAKE MACROPHYTE SURVEY AUGUST 22, 1997



- No macrophytes found in water > 7 - 8 feet (Rooted), *Ceratophyllum demersum* (Coontail) is 10 -12 feet
- Macrophyte densities estimated as follows: 1 = light; 2 = moderate; 3 = heavy
- Western 2/3 of lake is *Typha sp.* (Cattail) and other varities of wetland plants, trees, etc.
- *Chara sp.* (Muskgrass) and *Nitella sp.* (Brittlewort) are dense in water up to 3-4 feet

	Common Name	Scientific Name
Submerged Aquatic Plants:	Northern watermilfoil	*Myriophyllum sibiricum*
	Curlyleaf pondweed	*Potamogeton crispus*
	Narrow leaf pondweed	*Potamogeton sp. (narrowleaf)*
	Flatstem pondweed	*Potamogeton zosteriformis*
	Sago pondweed	*Potamogeton pectinatus*
	Coontail	*Ceratophyllum demersum*
	Muskgrass	*Chara sp.*
	Water stargrass	*Zosterella dubia*
	Bladderwort	*Utricularia sp.*
	Bushy pondweed	*Najas sp.*
	Brittlewort	*Nitella sp.*
Floating Leaf:	Yellow waterlily	*Nuphar variegata*
Emergent:	Cattail	*Typha sp.*
	Bulrush	*Scirpus sp.*
	Purple loosestrife	*Lythrum salicaria*
No Aquatic Vegetation Found:		

BIRCH ISLAND LAKE MACROPHYTE SURVEY JUNE 15,2006

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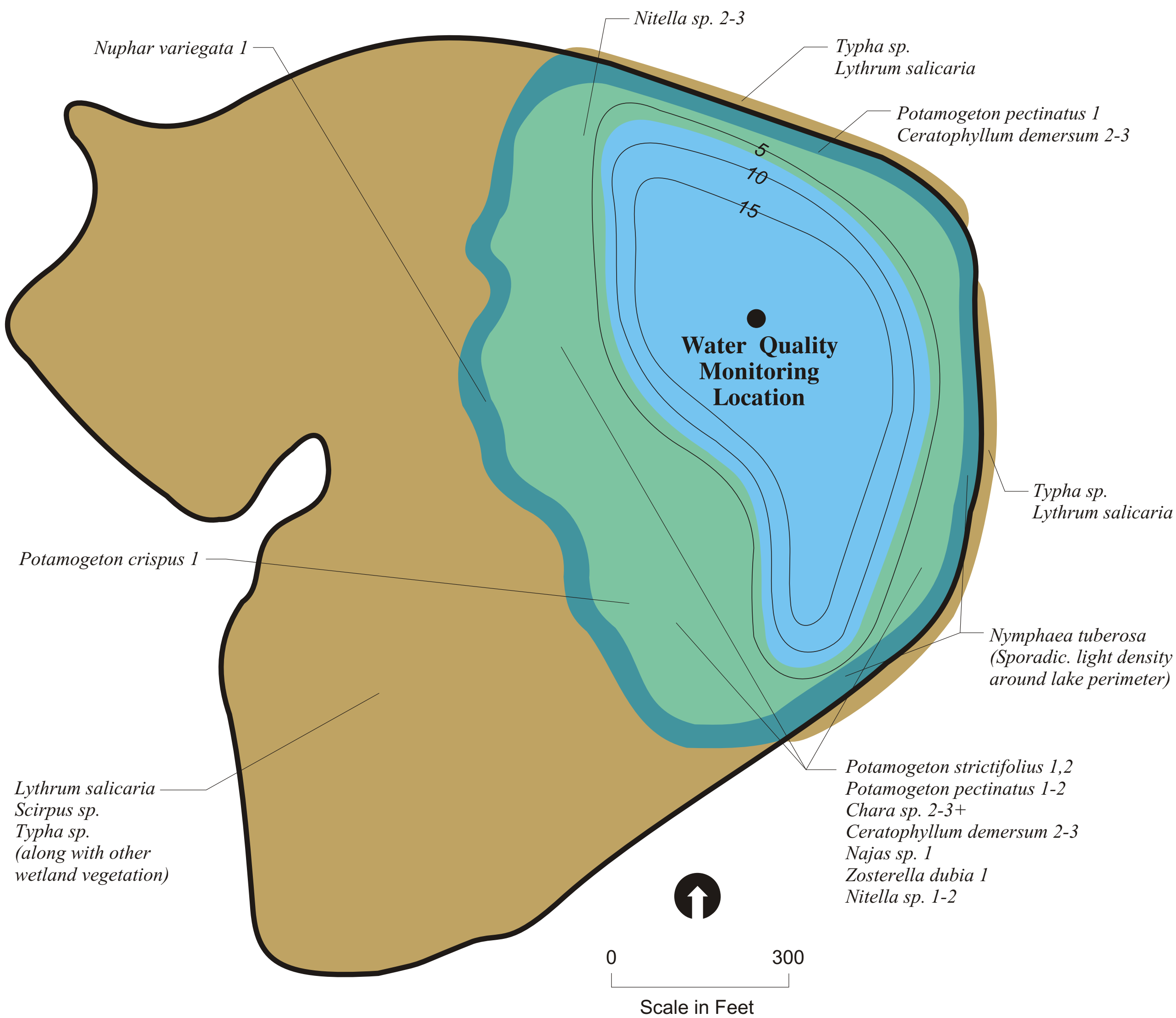

- No macrophytes found in water > 7 - 8 feet (Rooted), *Ceratophyllum demersum* (Coontail) is 10 -12 feet
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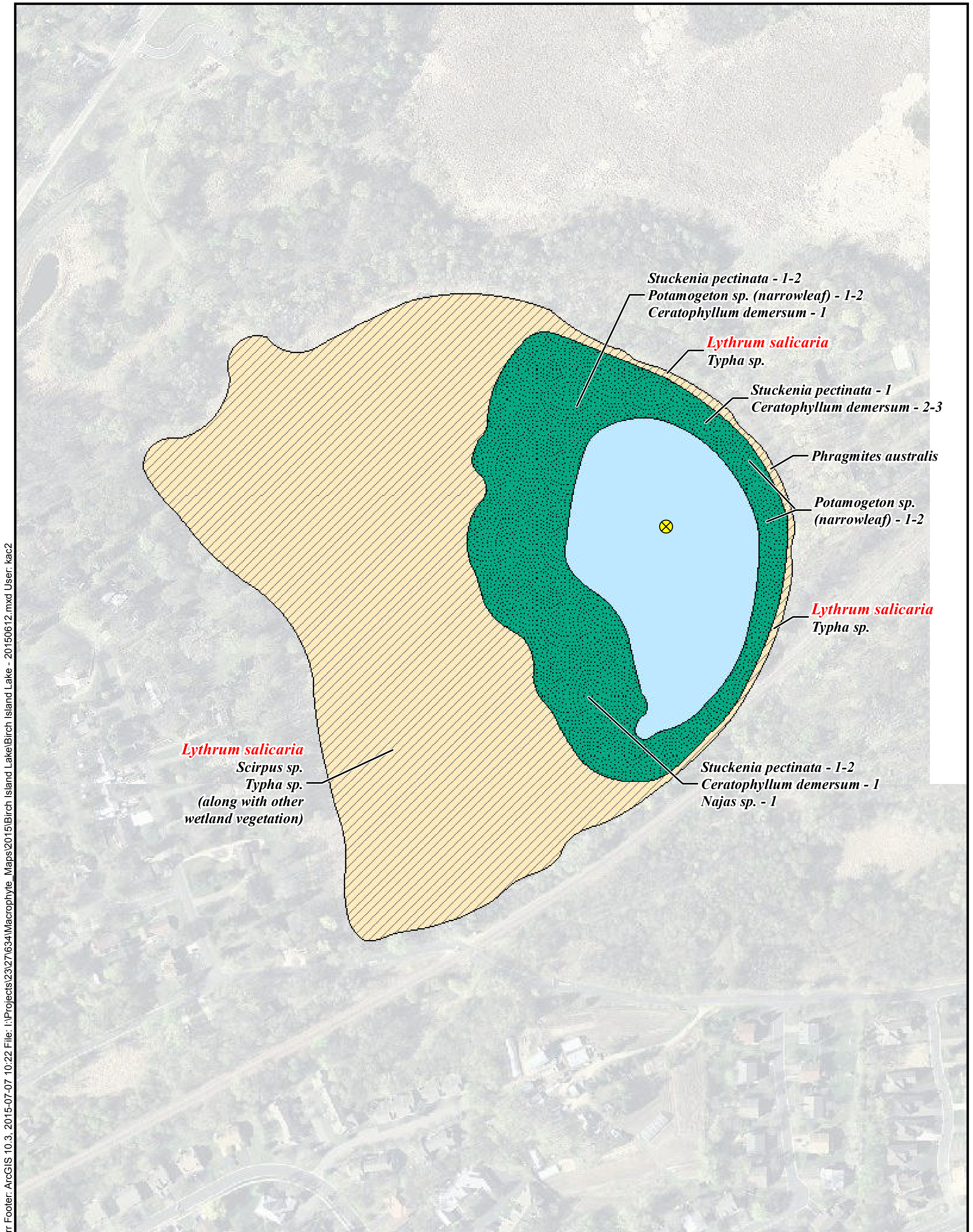
	Common Name	Scientific Name
Submerged Aquatic Plants:	Northern watermilfoil	*Myriophyllum sibiricum*
	Curlyleaf pondweed	*Potamogeton crispus*
	Narrow leaf pondweed	*Potamogeton sp. (narrowleaf)*
	Flatstem pondweed	*Potamogeton zosteriformis*
	Sago pondweed	*Potamogeton pectinatus*
	Coontail	*Ceratophyllum demersum*
	Muskgrass	*Chara sp.*
	Water stargrass	*Zosterella dubia*
	Bladderwort	*Utricularia sp.*
	Bushy pondweed	*Najas sp.*
	Brittlewort	*Nitella sp.*
Floating Leaf:	Yellow waterlily	*Nuphar variegata*
Emergent:	Cattail	*Typha sp.*
	Bulrush	*Scirpus sp.*
	Purple loosestrife	*Lythrum salicaria*
No Aquatic Vegetation Found:		

BIRCH ISLAND LAKE
MACROPHYTE SURVEY
AUGUST 18, 2006

P:23\27\003\LakeMacrophyteMaps\BIRCH\2006\Birch Lake AUGUST 2006.CDR RLG 09-29-06



Submerged Aquatic Plants

Common Name	Scientific Name
Coontail	*Ceratophyllum demersum*
Bushy pondweed	*Najas sp.*
Narrowleaf pondweed	*Potamogeton sp. (narrowleaf)*
Sago pondweed	*Stuckenia pectinata*

Floating Leaf Plants

Common Name	Scientific Name
None Found	

Emergent Plants

Common Name	Scientific Name
Cattail	*Typha sp.*
Purple loosestrife	***Lythrum salicaria***
Giant reed	*Phragmites australis*
Bulrush	*Scirpus sp.*

*Note: Bold red name indicates extremely aggressive/invasive introduced species.

Water Quality Monitoring Location
Emergent Plants
Floating Leaf Plants
Submerged Aquatic Plants
No Aquatic Vegetation

N

0 300 600
Feet

0 80 160
Meters

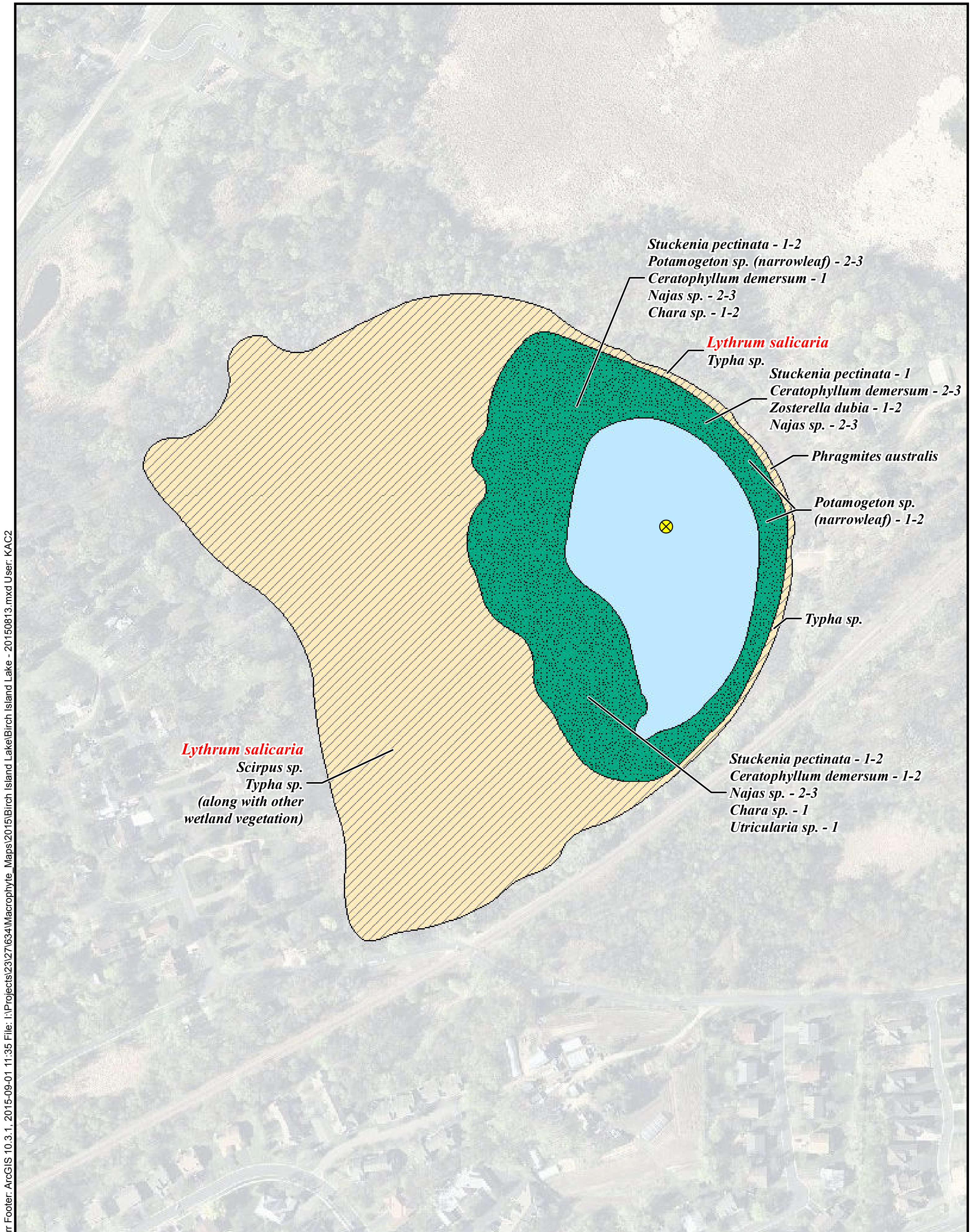
Imagery Source: USGS 2012 Twin Cities (MnGeo WMS)

FIELD NOTES:
- No macrophytes found in water > 6-7 feet.
- Macrophyte densities estimated as follows: 1 = light; 2 = moderate; 3 = heavy
- Western 2/3 of lake is *Typha sp.* (Cattail) and other varieties of wetland plants, trees, etc.
- *Typha sp.* along perimeter of lake is dead with sporadic new growth. Heavy rainfall June, 2014 raised water level approximately 7-9 feet causing *Typha sp.* to die off.

BARR

BIRCH ISLAND LAKE
MACROPHYTE SURVEY

June 12, 2015
Nine Mile Creek Watershed District



Submerged Aquatic Plants

Common Name	Scientific Name
Coontail	*Ceratophyllum demersum*
Muskgrass	*Chara sp.*
Bushy pondweed	*Najas sp.*
Narrowleaf pondweed	*Potamogeton sp. (narrowleaf)*
Sago pondweed	*Stuckenia pectinata*
Bladderwort	*Utricularia sp.*
Water stargrass	*Zosterella dubia*

Floating Leaf Plants

Common Name	Scientific Name
White waterlily	*Nymphaea tuberosa (sparse - present along lake perimeter)*

Emergent Plants

Common Name	Scientific Name
Cattail	*Typha sp.*
Purple loosestrife	***Lythrum salicaria***
Giant reed	*Phragmites australis*
Bulrush	*Scirpus sp.*

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- *Typha sp.* along perimeter of lake is dead with sporadic new growth. Heavy rainfall June, 2014 raised water level approximately 7-9 feet causing *Typha sp.* to die off.
- Filamentous algal mats are present along lake perimeter.
- ***Lythrum salicaria*** plants noted along east side during June survey may have been removed. Not observed during August survey.

BARR

BIRCH ISLAND LAKE
MACROPHYTE SURVEY

August 13, 2015
Nine Mile Creek Watershed District

Birch Island Lake, July 27, 2020

Aquatic Plant Point Intercept Survey for Birch Island Lake, Eden Prairie, Minnesota, 2020

Summer Aquatic Plant Survey: July 27, 2020
Zooplankton and Algae for May and September, 2020
Water Quality Monitoring for May Through October, 2020

Prepared for:
City of Eden Prairie
Eden Prairie, Minnesota

Prepared by:
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St. Paul, MN 55116

March 29, 2021

Aquatic Plant Point Intercept Survey for Birch Island Lake, Eden Prairie, Minnesota, 2020

Summary

Aquatic Plant Survey Overview: An aquatic plant point intercept survey was conducted on Birch Island Lake in the summer of 2020. The objectives of the aquatic plant survey on July 27, 2020 were to characterize the plant community and look for non-native species in the lake. Birch Island lake levels have risen substantially over the past few years. The lake size has increased from approximately 7 acres (2017) of open water to 43 acres (2020) of open water. And the observed max depth has increased from 9 feet (2017) to 22 feet (2020). The changing lake conditions likely also altered the plant community to some degree.

Lake water in Birch Island in July was turbid and the water color had a strong bog stain which likely limited plant growth in the summer. Plants were observed growing out to a water depth of 8 feet. Aquatic plants were present at 19 out of 52 sites. Observed plant abundance was light overall.

Bladderwort was the most common plant and was found at 11 out of 52 sites. Coontail was present at 5 sites. Two species of chara were present in Birch Island lake as well.

No non-native aquatic submerged species were found but purple loosestrife was present around the lake shore as well as present on some floating islands in Birch Island Lake.

Table 1. The percent occurrence of aquatic plants for Birch Island Lake. Percent occurrence is calculated based on the number of times a plant species occurs at a sampling station divided into the total number of stations for the survey. For example, if coontail was found in 8 out of 16 stations, its percent occurrence would be 50%.

Birch Island July 27, 2020	**Occur**	**% Occurrence (n=52 sites)**	**Average Density**
White waterlilies (Nymphaea sp)	1	2	1.0
Coontail (*Ceratophyllum demersum*)	5	10	1.0
Chara (*Chara sp*)	1	2	1.0
Chara (Braun's stonewort) *(Chara braunii)*	2	4	1.0
Naiads *(Najas sp)*	1	2	1.0
Stringy Pondweed *(Potamogeton sp)*	1	2	1.0
Bladderwort (*Utricularia sp*)	11	22	1.0

Aquatic Plant Point Intercept Survey for Birch Island Lake, Eden Prairie, Minnesota

Lake ID: 27-0081
Size: 39 acres (source: MnDNR)
Observed open water in 2020: 34.8 acres (BWS Delineation)
Maximum depth: 22 ft (Observed 2020)

Introduction

Birch Island Lake is located in Eden Prairie, Minnesota. Blue Water Science conducted a point intercept aquatic plant survey using a 50 meter grid on July 27, 2020.

The aquatic plants of Birch Island Lake were sampled to document the extent of native plant coverage as well as look for non-native aquatic species. Previous aquatic plant surveys were conducted by Blue Water Science in 2010 and 2011. Since water levels and lake size have significantly increased over the previous years, a new sampling grid was used to conduct the aquatic plant survey and to evaluate changes in the Birch Island Lake plant community compared to previous surveys.

Figure 1. Sample sites for aquatic plant survey conducted on July 27, 2020.

Methods

Point Intercept Survey: An aquatic plant survey of Birch Island Lake using a point intercept sampling method was conducted on July 27, 2020. A map and sampling grid were prepared by Blue Water Science and a consisted of a total of 52 points that were distributed throughout the lake. Points were spaced 50 meters apart. At each sample point, plants were sampled with a fixed-head rake sampler on a telescoping pole. A plant density rating was assigned to each plant species on a scale from 1 to 3. A density of a “1" indicated sparse growth and a “3" rating indicated heavy plant growth (Figure 2).

Figure 2. Aquatic plant densities rating from 1-3.

Birch Island Lake Plant Survey Results– July 27, 2020

Birch Island Lake plant growth was light and sporadic. Bladderwort was the most common species observed. Plants were common out to water depths of 7 feet and there was only one site where vegetation grew deeper than 7 feet. The Birch Island Lake plant community is undergoing changes, areas that where wetland species such as cattails, once dominated now have open water. Water levels in Birch Island lake increased as much as 10 feet over the previous 3 years, in some areas dead cattail remnants were covering the bottom. Some white lilies were present but submerged beneath the surface due to the water level increase. Even some emergent species, like smartweed were present but fully submerged by water in water depths of 6 feet.

Table 1. Birch Island Lake aquatic plant occurrences and densities for the July 27, 2020 survey based on a total of 52 stations. Density ratings are 1-3 with 1 being low and 3 being most dense.

	All Stations (n=52)		
	Occur	% Occur	Density
White waterlily (*Nymphaea tuberosa*)	1	2	1.0
Coontail (*Ceratophyllum demersum*)	5	10	1.0
Chara (*Chara sp*)	1	2	1.0
Naiad (*Najas sp*)	1	2	1.0
Stringy (*Potamogeton sp*)	1	2	1.0
Bladderwort (*Utricularia sp*)	11	21	1.0

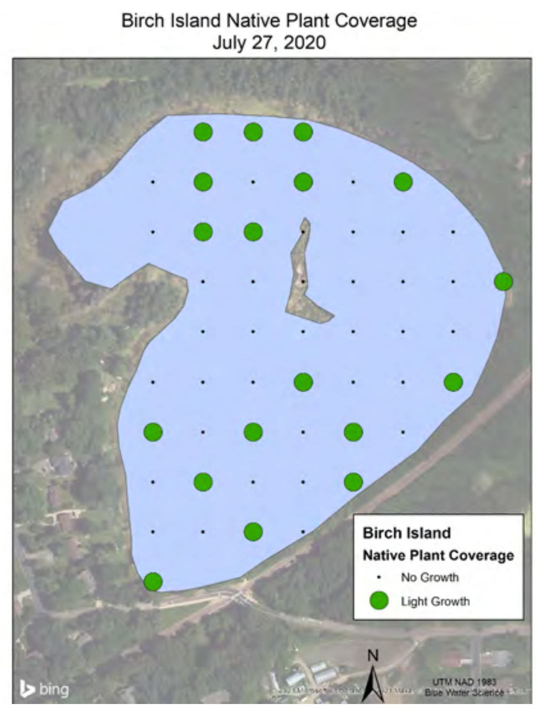


Figure 3. Native aquatic plant coverage map for Birch Lake on July 27, 2020. Green circles = light growth.

Birch Island Lake Aquatic Plant Maps– July 27, 2020

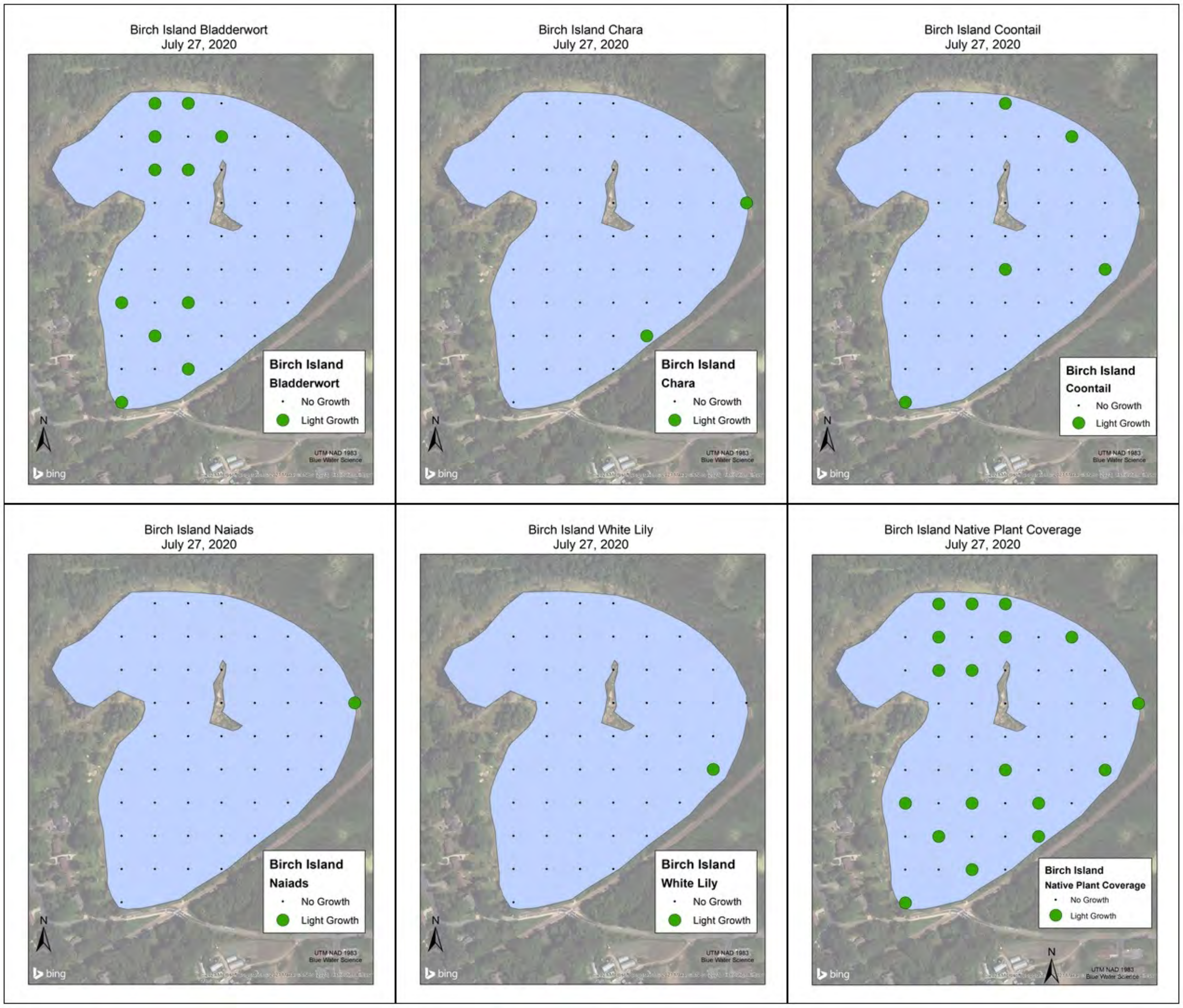


Figure 4. Aquatic plant maps for Birch Island Lake on July 27, 2020.

Aquatic Plant Point Intercept Data

Aquatic plant occurrence and density for individual sites is shown in Table 2. Plant densities were light.

Table 2. Aquatic plant occurrence and density for the point intercept survey (density is on a 1 to 3 scale with 3 the densest).

Site	Depth (ft)	Cattails	Purple loose-strife	White lilies	Bladder wort	Chara	Coontail	Moss	Naiad	NWM	Smart-weed	Stone-wort	Stringy	No plants	Trees/ bush	Old terrestri al	Floating island
1	5			1	1		1										
2	6													1		1	
3	8													1			
4	6				1											1	
5	0		1														
6	5													1			1
7	7				1												
8	7													1			
9	8													1			
10	5											1					
11	7				1												
12	6										1			1			
13	6				1						1						
14	8													1			
15	8												1				
16	7													1			
17	4													1			
18	6													1			
19	5													1			
20	6	1															
21	8													1			
22	16													1			
23	7			1			1										
24	6							1									
25	7													1			
26	6							1									
27	9													1			
28	19																
30	5													1			
30	10													1			
31	6													1			
32	1	1															
33	14													1			
34	20													1			
35	12													1			
36	3		1			1			1			1			1		
37	7													1			
38	7				1												
39	7				1												
40	10													1			
41	13													1			
42	15													1			
43	10													1			1
44	7													1			
45	6				1												
46	8													1			
47	7				1												
48	9													1			
49	8						1										
50	6				1												
51	6				1												
52	6						1										
Average		2	2	2	11	1	3	2	1	0	2	2	1		1.0	2	2
occurrence (52 sites)		2	2	2	11	1	4	2	1	0	2	2	1	29	1	2	2
% occur		4	4	4	21	2	8	4	2	0	4	4	2		2	4	4

Representative Birch Island Lake Photos

Figure 5. Lake photos from the July 27, 2020 aquatic survey.

Previous Survey Data on Birch Island Lake

Comparison of the 2011 to 2010 Aquatic Plant Coverage: The aquatic plant community in 2011 has four species of submerged plants in early summer and four species in late summer. This is a modest plant diversity condition. Aquatic plant coverage is shown in the following pictures.

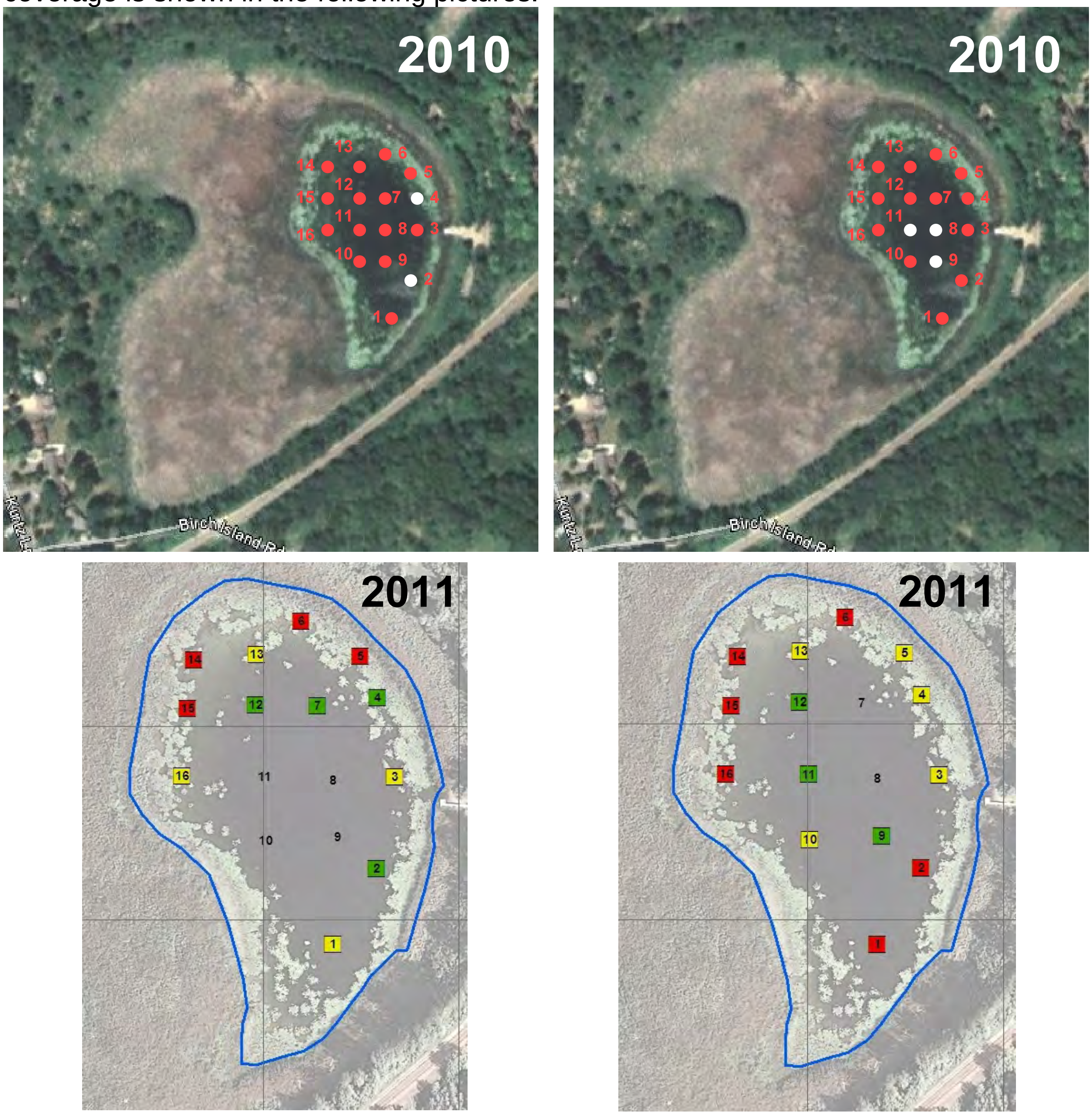


Figure 6. (top-left) Aquatic plant coverage on June 10, 2010. Aquatic plant coverage is shown and covers about 6 acres out of a total of 7 acres of open water (shown in red).
(top-right) Aquatic plant coverage on August 30, 2010. The red area shows coverage of aquatic plants. Plants covered about 5.5 acres.
(bottom-left) Aquatic plant coverage on June 15, 2011. Green square = light growth, yellow squares = moderate growth, and red squares = heavy growth.
(bottom-right) Aquatic plant coverage on September 23, 2011. Green square = light growth, yellow square = moderate growth, and red squares = heavy growth.

Birch Island Lake Aquatic Plant Survey Summaries

Comparison of Early and Late Summer Aquatic Plant Survey: In the early summer of 2011, chara was found pretty much throughout Birch Island Lake, curlyleaf pondweed was not found. In September, chara, coontail, and white waterlilies increased in occurrence (Table 3).

The acreage of aquatic submerged plants in Birch Island Lake from early to late summer changed only slightly. This was due, in part, because water clarity was good and remained constant throughout the summer.

Table 3. The percent occurrence of aquatic plants for Birch Island Lake. Percent occurrence is calculated based on the number of times a plant species occurs at a sampling station div ided into the total number of stations for the survey. For example, if coontail was found in 8 out of 16 stations, its percent occurrence would be 50%.

	June 10, 2010 % Occurrence (16 stations)	Aug 30, 2010 % Occurrence (16 stations)	June 15, 2011 % Occurrence (16 stations)	Sept 23, 2011 % Occurrence (16 stations)	July 27, 2020 % Occurrence (52 stations)
Bullrush (Scirpus sp)	6				
White waterlilies (Nymphaea sp)	50		44	75	2
Coontail (*Ceratophyllum demersum*)	25	63	13	38	10
Chara (*Chara sp*)	69	63	63	81	2
Chara (Braun's stonewort) *(Chara braunii)*					4
Naiads *(Najas sp)*					2
Stringy Pondweed (*Potamogeton sp*)					2
Sago pondweed (*Stuckenia pectinata*)	13	13	25		
Bladderwort (*Utricularia sp*)				25	21

Birch Island Lake Size over the years: 1991-2020

Birch Island Lake Spring 1991

Image from Minnesota Geospatial Image Service

Birch Island Lake Spring 1997

Image from Minnesota Geospatial Image Service

Birch Island Lake Spring 2000

Image from Minnesota Geospatial Image Service

Birch Island Lake Spring 2004

Image from Minnesota Geospatial Image Service

Birch Island Lake Spring 2006

Image from Minnesota Geospatial Image Service

Birch Island Lake Spring 2008

Image from Minnesota Geospatial Image Service

Birch Island Lake Summer 2009

Image from Minnesota Geospatial Image Service

Birch Island Lake Spring 2010

Image from Minnesota Geospatial Image Service

Birch Island Lake Spring 2012

Image from Minnesota Geospatial Image Service

Birch Island Lake 2013-2020

Birch Island Lake Summer 2013

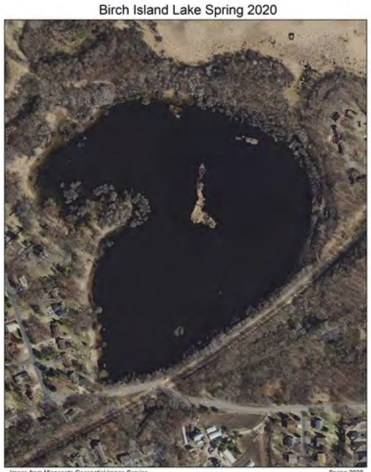
Birch Island Lake Summer 2015

Birch Island Lake Spring 2016

Birch Island Lake Summer/Fall 2017

Birch Island Lake Spring 2018

Birch Island Lake Summer/Fall 2019



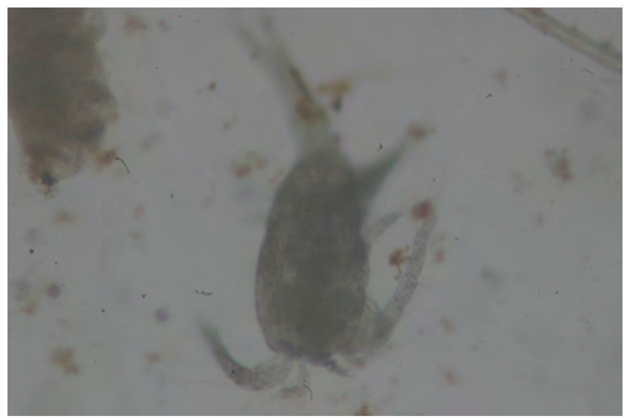
Birch Island Lake Spring 2020

BIRCH ISLAND SUPPLEMENTAL DATA

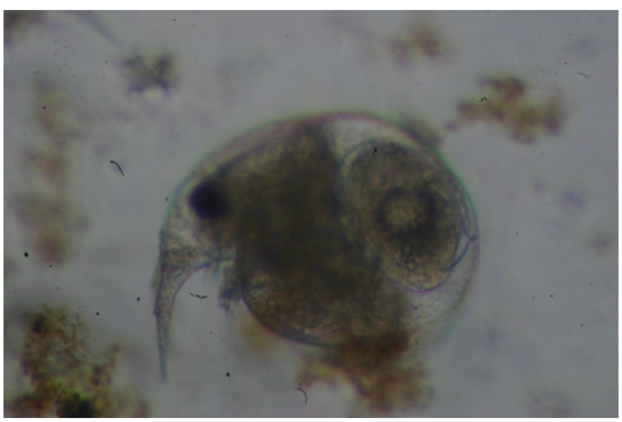
Zooplankton in 2020 (#/l)

	May 28, 2020	September 11, 2020
Daphnids	**1**	**3**
Big		1
Little	1	1
Bosmina		1
Copepods	**14**	**115**
Calonoids	3	17
Cyclopoids	10	76
Nauplii	1	22
Rotifers	**2**	**24**

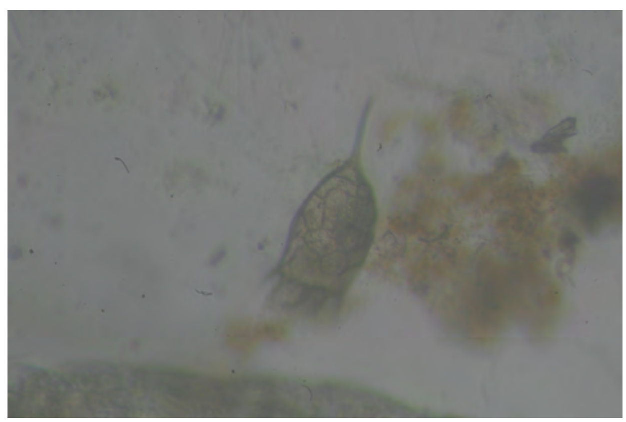
Calonoids



Cyclopoids



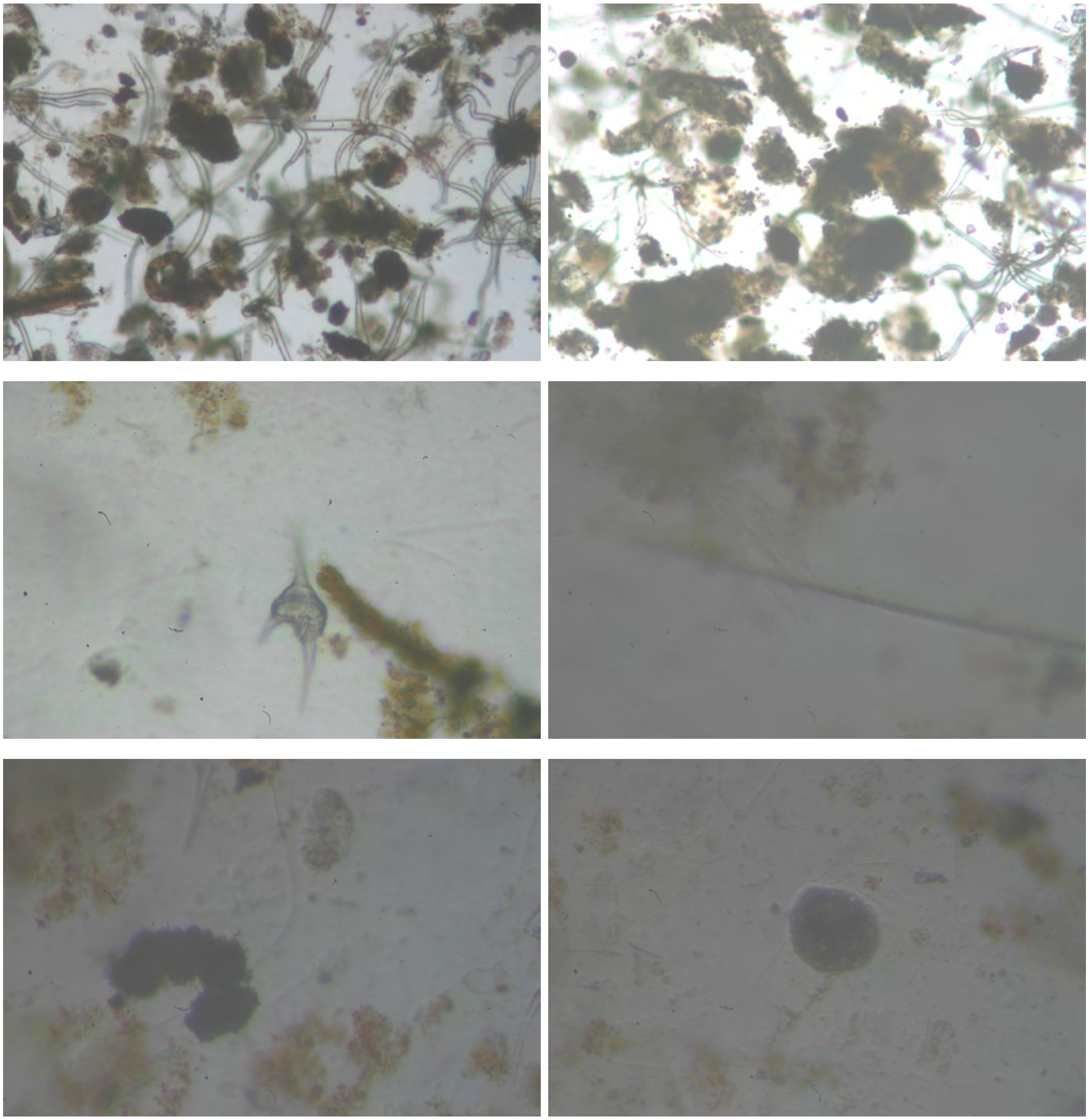
Bosmina



Rotifer

Representative zooplankton from Birch Island Lake in 2020. Copepods were the dominant zooplankter.

Phytoplankton in 2020



Representative algae from Birch Island Lake in 2020.

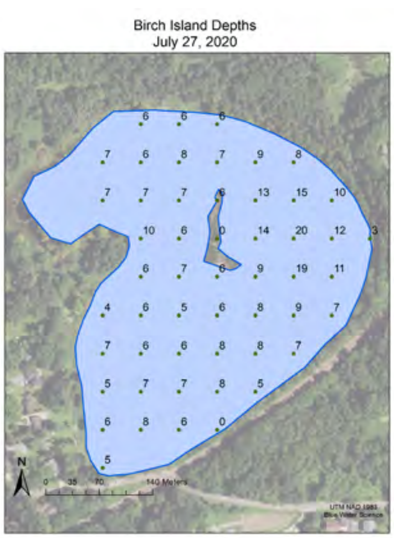
May 28, 2020: Oscillatoria - scarce
Dinoflagellate - present
Colonial coccoid blue-green - present
September 9, 2020: Colonial coccoid blue-green dominant

Birch Island Lake (27-008100), Eden Prairie, Hennepin Co, water quality data for 2020

	Secchi Disc (feet)	Secchi Disc (m)	Total Phos (µg/l)	Chl a (µg/l)	TSS (mg/l)	Total Alkalinity (mg/l)	Total Dissolve Phos (µg/l)	Ortho Phos (µg/l)	Chloride (mg/l)	Nitrate + Nitrite (mg/l)	Ammonia Nitrogen (mg/l)	Kjeldahl Nitrogen (mg/l)	Iron (mg/l)	TP/Chl a Ratio Top
May 14	6.4	2.0	44	10.7	3	170	20	<5	93.3	<0.05	0.30	2.1	0.116	4.1
May 28	5.4	1.6	51	8.0	3	158	15	<5	88.9	<0.05	<0.16	1.6	0.130	6.4
June 11	4.2	1.3	44	15.1	3	161	9	<5	90.1	<0.05	<0.16	0.3	0.096	2.9
June 30	5.0	1.5	53	27.6	<2	160	13	6	9.1	<0.05	<0.16	2.0	0.092	1.9
July 15	2.6	0.8	61	36.5	4	163	36.5	13	95.0	<0.05	<0.16	2.5	0.118	1.7
July 27	2.4	0.7	68	53.4	12	158	9	<5	95.2	<0.05	<0.16	2.3	0.050	1.3
Aug 12	2.9	0.9	62	28.5	6	161	<0.02	<5	87.8	<0.05	0.16	1.9	0.114	2.2
Aug 27	2.4	0.7	63	33.8	4	158	9	20	88.1	<0.05	<0.16	1.8	0.062	1.9
Sept 11	2.6	0.8	70	14.2	5	173	15	28	92.4	<0.05	0.37	1.9	0.205	4.9
Sept 25	2.7	0.8	72	5.3	4	175	17	8	93.5	<0.05	<0.16	1.8	0.061	13.6
Oct 13	3.2	1.0	69	25.8	5	183	15	5	93.7	<0.05	<0.16	1.5	0.119	2.7
Oct 30		0.0	56	2.7	<2	191	30	17	96.6	<0.05	0.66	2.4	0.088	20.7
May-Sep Average	3.7	1.1	59	23.3	4.6	164	14.4	10	83.3	0.05	0.20	1.8	0.104	2.5
Jun-Sept Average	3.1	0.9	62	26.8	5.0	164	13.6	11	81.4	0.05	0.19	1.8	0.100	2.3

*Secchi disc on the bottom

	Total Phos (µg/l) mid	Ortho Phos (µg/l) mid	Total Dissolve Phos (µg/l) mid	Chl a (µg/l) mid	Total Phos (µg/l) bottom	Ortho Phos (µg/l) bottom	Total Dissolve Phos (µg/l) bottom	Chl a (µg/l) bottom	TP/Chl a Ratio Top	TP/Chl a Ratio Mid	TP/Chl a Ratio Bottom
May 14	349	5	35	238	312	109	24	42.7	4.1	1.5	7.3
May 28	334	6	32	254	69	<5	21	26.7	6.4	1.3	2.6
June 11	247	<5	23	259	856	685	530	41.8	2.9	1.0	20.5
June 30	142	<5	17	233	1,080	990	840	54.3	1.9	0.6	19.9
July 15	148	<5	30	150	1,790	1,630	1,330	87.2	1.7	1.0	20.5
July 27	114	<5	14	76.5	1,670	1,530	516	33.8	1.3	1.5	49.4
Aug 12	82	<5	<20	22.3					2.2	3.7	
Aug 27	132	<20	14	174	1,490	1,800	1,250	105	1.9	0.8	14.2
Sept 11	333	54	22	62.7	1,350	660	760	<1	4.9	5.3	1350.0
Sept 25	64	<5	51	16.0	1,310	1,040	940	32.0	13.6	4.0	40.9
Oct 13	67	<5	15	22.2	1,210	491	497	94.3	2.7	3.0	12.8
Oct 30	64	17	32	4.5	67	35	61	5.3	20.7	14.2	12.6
May-Sept Average	195	12	26	149	1103	939	690	47.2	2.5	1.3	23.4
Jun-Sept Average	158	13	24	124	1364	1191	881	50.7	2.3	1.3	26.9



Water depths (feet) of sample locations in Birch Island Lake on July 27, 2020.

Results for temperature (Temp) are in EC and dissolved oxygen (DO) are in ppm. Conductivity (Cond) is reported as mircoSiemens per centimeter (FS), and pH is in standard units.

BIRCH ISLAND LAKE FIELD DATA

5/14/2020

Depth (m)	Temp (C)	DO (mg/L)	pH	Cond (uS)
0	17.2	10.2	7.7	531
1	16.9	10.3		
2	13.6	9.5		
3	10.5	12.7	7.4	618
4	8.1	2.1		
5	7.4	1.2		
6	6.9	1.0	6.8	1047
	SD (ft): 6.4	SD (m): 1.9		

5/28/2020

Depth (m)	Temp (C)	DO (mg/L)	pH	Cond (uS)
0	23.9	10.8	8.6	615
1	23.9	10.9	8.6	618
2	15.9	15.2	8.8	520
3	13.8	12.0	8.1	530
4	12.2	8.7	8.2	540
5	1.1	3.2	8.1	551
6	9.8	0.9	8.1	553
	SD (ft): 5.4	SD (m): 1.6		

6/11/2020

Depth (m)	Temp (C)	DO (mg/L)	pH	Cond (FS)
0	23.8	8.5	8.0	633
1	23.8	8.5	8.0	630
2	22.4	8.5	8.0	624
3	13.4	1.4	7.0	590
4	9.6	1.9	6.7	612
5	7.1	0.1	6.6	450
	SD (ft): 4.2	SD (m): 1.3		

6/30/2020

Depth (m)	Temp (C)	DO (mg/L)	pH	Cond (FS)
0	26.2	5.6	8.4	590
1	25.7	4.4		
2	23.7	0.9		
3	14.7	0.6	7.5	655
4	0.2	0.4		
5	8.2	0.4	6.9	1235
	SD (ft): 5.0	SD (m): 1.5		

7/15/2020

Depth (m)	Temp (C)	DO (mg/L)	pH	Cond (FS)
0	27.6	7.9	8.1	693
1	25.8	6.3	7.9	667
2	22.8	0.2	7.0	702
3	16.0	0.1	6.7	681
4	10.6	0.01	6.6	718
5	7.9	0.00	6.6	967
5.5	7.6	0.00	6.6	1009
	SD (ft): 2.6	SD (m): 0.8		

7/28/2020

Depth (m)	Temp (C)	DO (mg/L)	pH	Cond (FS)
0	27.7	10.9	8.63	693
1	27.5	10.9	8.6	690
2	23.0	6.6	7.8	660
3	18.9	3.6	6.7	696
4	12.4	1.2	6.6	753
5	6.2	0.9	6.6	952
6	7.4	0.4	6.6	1107
	SD (ft): 2.4	SD (m): 0.7		

8/12/2020

Depth (m)	Temp (C)	DO (mg/L)	pH	Cond (FS)
0	23.7	6.6	7.8	601
1	23.7	6.5	7.8	600
2	23.6	6.2	7.8	597
3	22.8	4.3	7.7	580
4	22.4	3.1	7.7	570
5	21.0	0.9	7.6	572
6	19.3	0.7	7.5	569
7	18.6	0.6	7.4	560
SD (ft): 2.9	SD (m): 0.9			

8/27/2020

Depth (m)	Temp (C)	DO (mg/L)	pH	Cond (FS)
0	27.7	8.2	8.3	661
1	27.2	7.7	8.2	654
2	24.4	1.8	7.1	630
3	19.2	0.3	6.6	721
4	12.9	0.1	6.6	804
5	10.0	0.05	6.6	989
6	8.5	0.05	6.5	1096
7	8.0	0.05	6.5	1116
SD (ft): 2.4	SD (m): 0.7			

9/11/2020				
Depth (m)	Temp (C)	DO (mg/L)	pH	Cond (FS)
0	16.5	2.2	7.1	623
1	16.3	1.7		
2	16.3	1.3		
3	16.2	0.9	7.0	889
4	13.8	0.7		
5	11.0	0.6		
6	9.5	0.7		
7	9.1	0.6	6.9	1190
SD (ft): 2.6 SD (m): 0.8				

9/25/2020				
Depth (m)	Temp (C)	DO (mg/L)	pH	Cond (FS)
0	20.9	12.8	8.5	614
1	19.4	8.0	7.9	601
2	17.6	5.1	7.6	576
3	16.5	1.1	7.3	570
4	13.2	0.4	6.7	856
5	10.3	0.03	6.6	1052
6	9.0	0.01	6.6	1130
7	8.8	0.01	6.6	1137
SD (ft): 2.7 SD (m): 0.8				

10/13/2020				
Depth (m)	Temp (C)	DO (mg/L)	pH	Cond (FS)
0	14.6	8.2	7.7	640
1	14.6	8.2		
2	14.5	8.0		
3	14.4	7.0	7.7	637
4	13.6	3.1		
5	12.1	1.5		
6	10.4	1.1	6.7	1036
SD (ft): 3.2 SD (m): 1.0				

10/30/2020				
Depth (m)	Temp (C)	DO (mg/L)	pH	Cond (FS)
0	4.3	6.6	8.0	655
1	4.2	6.4		
2	4.1	6.2		
3	4.1	6.0	7.8	670
4	4.1	5.9		
5	4.1	4.5		
6	4.1	4.4	7.8	672

Birch Island Lake, July 13, 2021

Birch Island Lake Aquatic Plant Point Intercept Survey with Supplemental Data on Algae, Zooplankton, and Water Quality, 2021

Summer Aquatic Plant Survey: July 13, 2021
Zooplankton and Algae Samples for May and August, 2021
Water Quality Monitoring for May Through October, 2021

Prepared for:
City of Eden Prairie
Eden Prairie, Minnesota

Prepared by:
Steve McComas
Jo Stuckert
Connor McComas
Blue Water Science
St. Paul, MN 55116

January 17, 2022

Aquatic Plant Point Intercept Survey for Birch Island Lake, Eden Prairie, Minnesota, 2021

Summary

Aquatic Plant Survey Overview: An aquatic plant point intercept survey was conducted on Birch Island Lake in the summer of 2021. The objectives of the aquatic plant survey on July 13, 2021 were to characterize the plant community and look for non-native species in the lake. Birch Island lake levels have risen substantially over the past few years. The lake size has increased from approximately 7 acres (2017) of open water to 43 acres (2020) of open water. And the observed max depth has increased from 9 feet (2017) to 19 feet (2021). The changing lake conditions likely also altered the plant community to some degree.

Birch Island water clarity in July was turbid and the water color had a strong bog stain which likely limited plant growth in the summer. The seasonal Secchi disk average in Birch Island Lake was 2.7 ft. Plants were observed growing out to a maximum water depth of 7 feet. Aquatic plants were present at 41 out of 52 sites. Observed plant abundance was light overall but aquatic plant distribution and species richness in Birch Island has significantly increased since 2020.

Bladderwort was the most common plant and was found at 35 out of 52 sites. Coontail was present at 3 sites. Two species of bladderwort were present in Birch Island lake as well (Table 1).

Table 1. The percent occurrence of aquatic plants for Birch Island Lake. Percent occurrence is calculated based on the number of times a plant species occurs at a sampling station div ided into the total number of stations for the survey. For example, if coontail was found in 8 out of 16 stations, its percent occurrence would be 50%.

Birch Island July 13, 2021	**Occurrence**	**% Occurrence (n=52 sites)**	**Average Density**
White waterlilies *(Nymphaea sp)*	1	2	1.0
Watershield *(Brasenia schreberi)*	1	2	1.0
Bladderwort (*Utricularia sp*)	35	67	1.5
Coontail (*Ceratophyllum demersum*)	3	6	1.7
Chara *(Chara sp)*	4	8	1.0
Lesser Bladderwort *(Utricularia minor)*	3	6	1.0
Naiads *(Najas sp)*	4	8	1.0
Northern Watermilfoil *(Myriophyllum sibiricum)*	6	12	1.2
Sago Pondweed *(Stuckenia pectinata)*	7	13	1.3
Stringy Pondweed *(Potamogeton sp)*	7	13	1.0
Whitestem Pondweed (P. praelongus)	1	2	1.0

Birch Island Water Quality, Zooplankton, and Phytoplankton for 2021

Water quality monitoring results from May through October are shown in Table 2.

Table 2. Birch Island Lake (27-008100), Eden Prairie, Hennepin Co, w ater quality data for 2021.

	Secchi Disc	Secchi Disc	Total Phos	Chl a	TSS	Total Alkalinity	Total Dissolved Phos	Ortho Phos	Chloride	Nitrate + Nitrite	Ammonia Nitrogen	Kjeldahl Nitrogen	Iron	TP/Chl a Ratio
	(feet)	(meters)	(µg/l)	(µg/l)	(mg/l)	(mg/l)	(µg/l)	(µg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	Top
12-May	4.7	1.4	38	10.7	8	186	14	7	110	<0.05	2.94	2.7	0.119	3.6
25-May		0.0	16	12.5	6	185	16	<5	101	<0.05	<0.16	1.9	0.176	1.3
10-Jun	3.4	1.0	58	21.4		191	13	<5	112	<0.05	<0.16	2.2	0.141	2.7
28-Jun	2.8	0.9	70	21.4	9	191	11	<5	119	<0.05	<0.16	2.2	0.097	3.3
13-Jul	2.4	0.7	70	23.1	10	189	14	<5	120	<0.05	<0.16	1.6	0.075	3.0
30-Jul	2.5	0.8	81	27.6	8	181	14	<5	120	<0.05	<0.16	2.8	0.086	2.9
13-Aug	2.5	0.8	82	28.5	14	175	12	<5	127	<0.05	<0.16	2.9		2.9
23-Aug	2.2	0.7	79	45.4	15	169	16	<5	132	<0.05	<0.16	2.6	0.055	1.7
13-Sep	1.5	0.5	112	109	28	153	12	<5	126	<0.05	<0.16	2.9	0.096	1.0
27-Sep	1.8	0.5	142	123	20	166	16	<5	126	<0.05	<0.16	3.5	0.135	1.2
12-Oct	2.5	0.8	114	40.9	11	174	22	<5	124	<0.05	<0.16	2.9	0.135	2.8
25-Oct	3.6	1.1	83	54.7	12	180	16	31	134	<0.05	<0.16	2.6	0.106	1.5
May-Sept Average	2.6	0.7	74.8	42.3	13.1	179	13.8	<5.2	119	<0.05	<0.44	2.5	0.109	1.8
Jun-Sept Average	2.4	0.7	86.8	49.9	14.9	177	13.5	<5	123	<0.05	<0.16	2.6	0.098	1.7

	Total Phos	Ortho Phos	Total Dissolved Phos	Chl a	Total Phos	Ortho Phos	Total Dissolved Phos	Chl a	TP/Chl a	TP/Chl a	TP/Chl a
	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	Ratio	Ratio	Ratio
	mid	**mid**	**mid**	**mid**	**bottom**	**bottom**	**bottom**	**bottom**	**Top**	**Mid**	**Bottom**
12-May	49	<5	13	10.7	132	<5	19	35.6	3.6	4.6	3.7
25-May	175	<5	21	38.3	58	<5	15	12.5	1.3	4.6	4.6
10-Jun	91	10	16	32.9	133	<5	17	54.3	2.7	2.8	2.4
28-Jun	146	<5	14	52.1	198	<5	15	93.4	3.3	2.8	2.1
13-Jul	28	<5	362	147	209	<5	14	48.1	3.0	0.2	4.3
30-Jul	242	<5	20	157	256	<5	17	79.2	2.9	1.5	3.2
13-Aug	110	<5	11	40.9	273	<5	17	89.4	2.9	2.7	3.1
23-Aug	150	<5	18	157	224	<5	24	235	1.7	1.0	1.0
13-Sep	141	<5	13	105	409	<5	21	184	1.0	1.3	2.2
27-Sep	264	<5	16	90.8	168	<5	16	104	1.2	2.9	1.6
12-Oct	111	<5	21	36	143	<5	20	46.3	2.8	3.1	3.1
25-Oct	81	7	16	57.7	85	<5	16	48.1	1.5	1.4	1.8
May-Sept Average	140	10	50	83	206	<5	18	94	1.8	1.7	2.2
Jun-Sept Average	147	10	59	98	234	<5	18	111	1.7	1.5	2.1

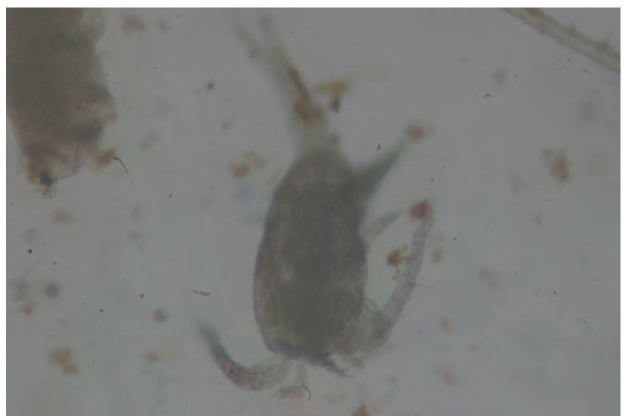
Zooplankton in 2021

Zooplankton tows were done in June and August 2021 to characterize composition changes over the growing season. Many species of zooplankters feed on phytoplankton.

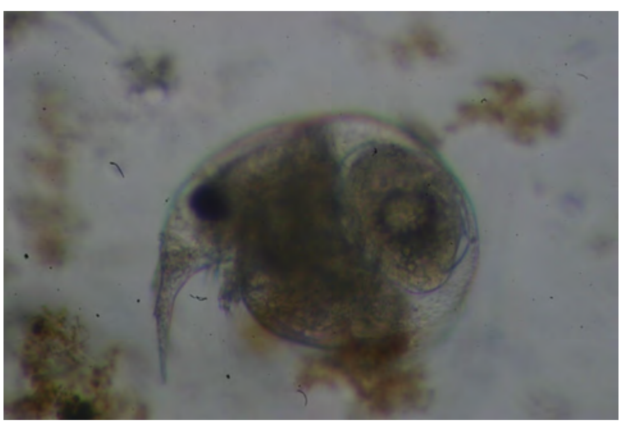
Table 3. Birch Island zooplankton data for 2021.

	June 10, 2021 (#/l)	August 13, 2021 (#/l)
Daphnids	**2.2**	**7.5**
Big	1.1	1.1
Little	0.3	0.8
Bosmina		3.9
Ceriodaphnia	0.8	1.7
Copepods	**25**	**3.7**
Calonoids	16	2.5
Cyclopoids	2.2	0.6
Nauplii	6.7	0.6
Rotifers	**63**	**5.3**

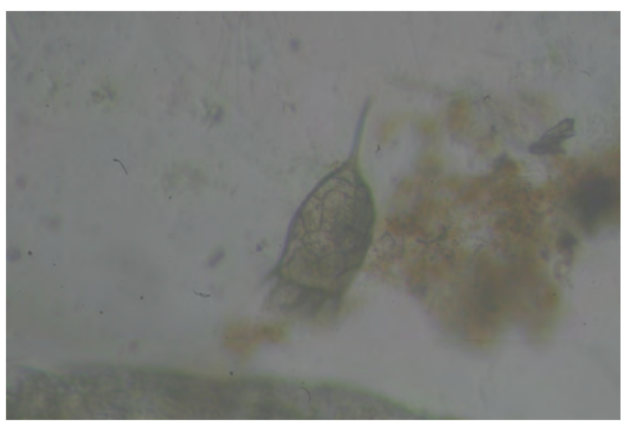
Calonoids



Cyclopoids



Bosmina



Rotifer

Figure 1. Representative zooplankton from Birch Island Lake in 2021. Copepods were the dominant zooplankter.

Phytoplankton in 2021

Phytoplankton (algae) samples were taken in June and August of 2021 to determine how the algae composition changes over the growing season in Birch Island Lake. Samples were sent to an analytical lab, PhycoTech for identification and counting. Green algae dominated in May and cyanobacteria dominated in August which is fairly typical for eutrophic lakes (Table 4 and Figure 3).

Table 4. Phytoplankton data for 2021.

	Birch Island			
	May 25, 2021		August 13, 2021	
	%	Relative Conc	%	Relative Conc
Diatoms	**2**		**2**	
Synedra ulna				1
Cyclotella sp		1		
Fragilaria crotonensis		1		1
Chlorophyta (Greens)	**78**		**26**	
Ankistrodesmus falcatus				1
Botryococcus braunii		2		
Chlamyodomonas		1		
Chlorococcanceae sp				1
Coelastrum astroideum				1
Coelastrum proboscideum				1
Coelastrum quadrata				1
Crucugenia quadrata				1
Deasonia gigantica		1		
Micractinium pusillum				1
Monoraphidium arcuatum		45		1
Monoraphidium capricornutum		11		3
Monoraphidium griffithii		2		1
Mougeotia spp.		1		
Mucidosphaerium pulchellum		1		1
Oocystis parva		1		
Oocystis pusilla		1		
Planctonema spp				1
Quadrigula lacustis				1
Scenedesmus acutus		1		2
Scenedesmus bijuga				4
Scenedesmus opoliensis				2
Scenedesmus serratus		6		2
Schroederia judayi		1		
Sphaerocystis schroeteri		1		
Sphaerocystis spp		1		
Tetrastrum staurogeniaeforme		1		
Tetraedron minimum				1
Chrysophyta	**1**		**0**	
Polygoniochloris circularis		1		
Euglenas	**3**		**0**	
Euglena spp		1		
Trachelomonas spp		2		
Cyanobacteria (Blue-Green)	**16**		**72**	
Aphanizomenon flos-aquae		1		
Aphanocapsa delicatissima		12		
Dolichospermum spp		1		
Dolichospermum macrosporum				2
Microcystis aeruginosa				5
Merismopedia cf danubiana				1
Merismopedia tenuissima				3
Merismopedia warmingiana				1
Planktolyngbya limnetica				23
Planktothrix agardhii				1
Pseudanabaena limnetica		1		35
Raphidiopsis raciborskii				1
Synechocystis spp		1		
Chlorophyll (µg/l)	12.5		28.5	
Secchi disk (ft)	3.4' (est)		2.5'	
Total Phosphorus (ppb)(top/bottom)	16/58		82/273	
TP/Chla	1.3		2.9	

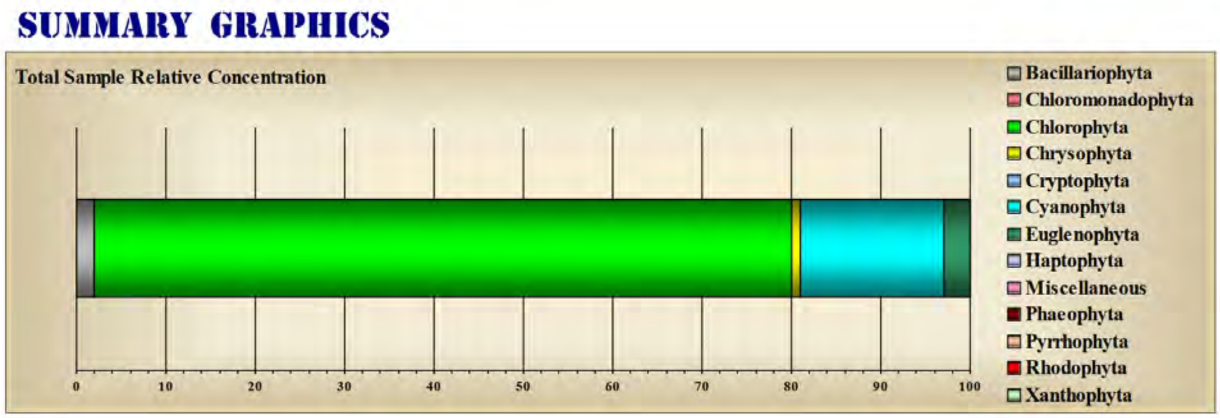


Figure 2. Relative concentration of phytoplankton groups in Birch Island Lake on May 25, 2021. Dominated by green algae.

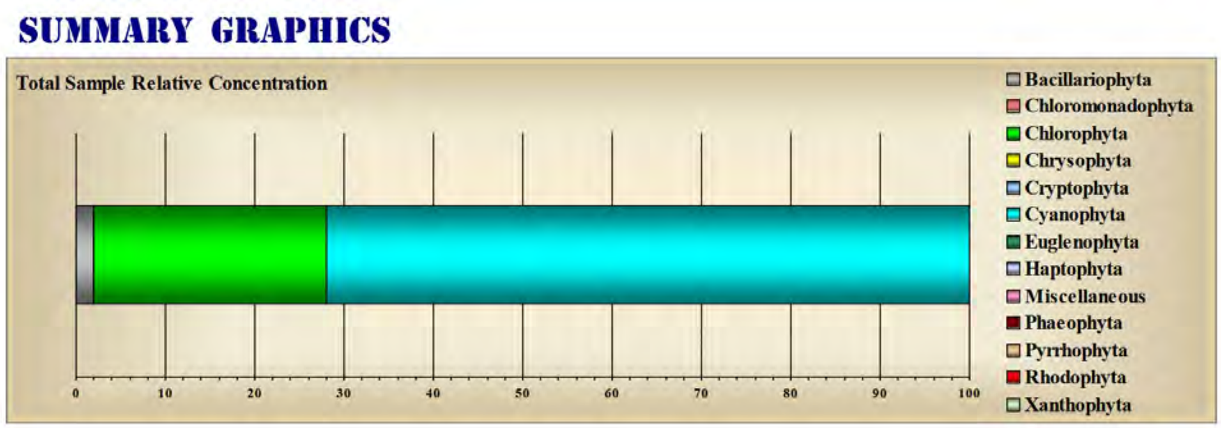


Figure 3. Relative concentration of phytoplankton groups in Birch Island Lake on August 13, 2021. Dominated by cyanobacteria (graph produced by PhycoTech).

Aquatic Plant Point Intercept Survey for Birch Island Lake, Eden Prairie, Minnesota

Lake ID: 27-0081
Size: 39 acres (source: MnDNR)
    Observed open water in 2021: 34.8 acres (BWS Delineation)
Maximum depth: 19 ft (Observed 2021)

Introduction

Birch Island Lake is located in Eden Prairie, Minnesota. Blue Water Science conducted a point intercept aquatic plant survey using a 50 meter grid on July 13, 2021.

The aquatic plants of Birch Island Lake were sampled to document the extent of native plant coverage as well as look for non-native aquatic species. Previous aquatic plant surveys have been conducted by Blue Water Science in 2010, 2011, 2020, and 2021. Since water levels and lake size have significantly increased over the previous years, a new sampling grid was used to conduct the aquatic plant survey and to evaluate changes in the Birch Island Lake plant community compared to previous surveys.

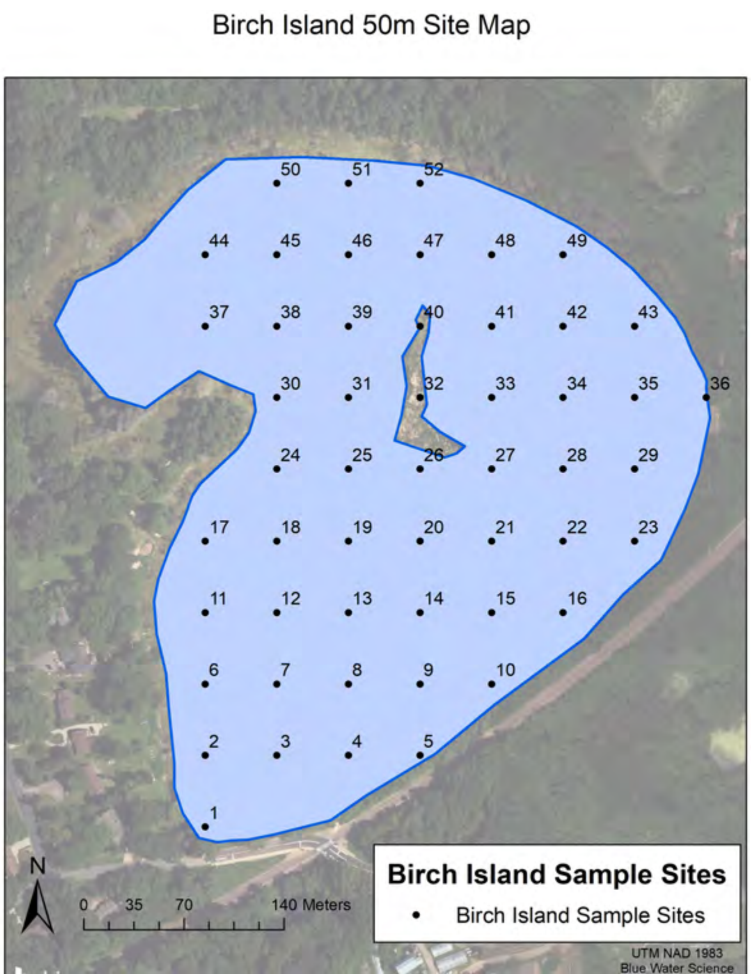


Figure 4. Sample sites for aquatic plant survey conducted on July 13, 2021.

Methods

Point Intercept Survey: An aquatic plant survey of Birch Island Lake using a point intercept sampling method was conducted on July 13, 2021. A map and sampling grid were prepared by Blue Water Science and a consisted of a total of 52 points that were distributed throughout the lake. Points were spaced 50 meters apart using a UTM NAD 1983 datum. At each sample point, plants were sampled with a fixed-head rake sampler on a telescoping pole. A plant density rating was assigned to each plant species on a scale from 1 to 3. A density of a “1" indicated sparse growth and a “3" rating indicated heavy plant growth (Figure 5).

Figure 5. Aquatic plant densities rating from 1-3.


Representative plant species in Birch Island Lake.

Birch Island Lake Plant Survey Results – July 13, 2021

Bladderwort was the most common species observed, found at 67% of sites (Table 5). Plants were common out to water depths of 6 feet. The Birch Island Lake plant community is undergoing changes, areas that where wetland species such as cattails, once dominated now have open water. Water levels in Birch Island lake increased as much as 10 feet over the previous 4 years, in some areas dead cattail remnants were covering the bottom. Some white lilies were present but submerged beneath the surface due to the water level increase. Native aquatic plant coverage is shown in Figure 6.

Table 5. Birch Island Lake aquatic plant occurrences and densities for the July 13, 2021 survey based on a total of 52 stations. Density ratings are 1-3 with 1 being low and 3 being most dense.

	All Stations (n=52)		
	Occur	**% Occur**	**Density**
White waterlilies *(Nymphaea sp)*	1	2	1.0
Watershield *(Brasenia schreberi)*	1	2	1.0
Bladderwort (*Utricularia sp*)	35	67	1.5
Lesser Bladderwort *(Utricularia minor)*	3	6	1.0
Coontail (*Ceratophyllum demersum*)	3	6	1.7
Chara *(Chara sp)*	4	8	1.0
Naiads *(Najas sp)*	4	8	1.0
Northern Watermilfoil *(Myriophyllum sibiricum)*	6	12	1.2
Sago Pondweed *(Stuckenia pectinata)*	7	13	1.0
Stringy Pondweed *(Potamogeton sp)*	7	13	1.0
Whitestem Pondweed (*Potamogeton praelongus)*	1	2	1.0

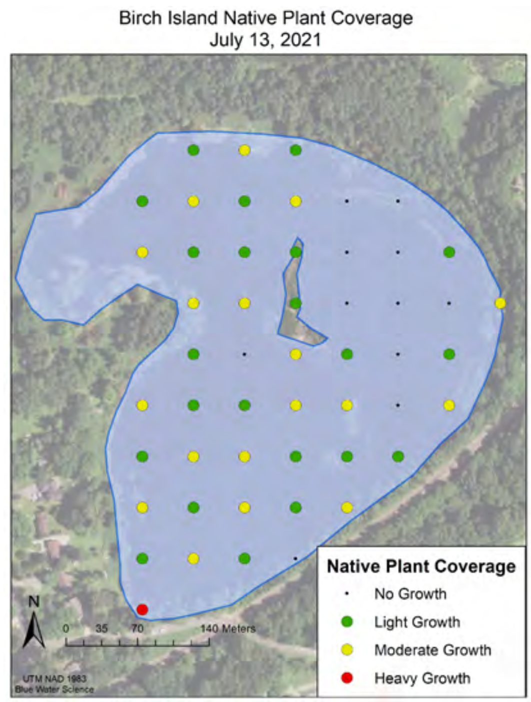


Figure 6. Native aquatic plant coverage map for Birch Lake on July 13, 2021.

Birch Island Lake Aquatic Plant Maps – July 13, 2021

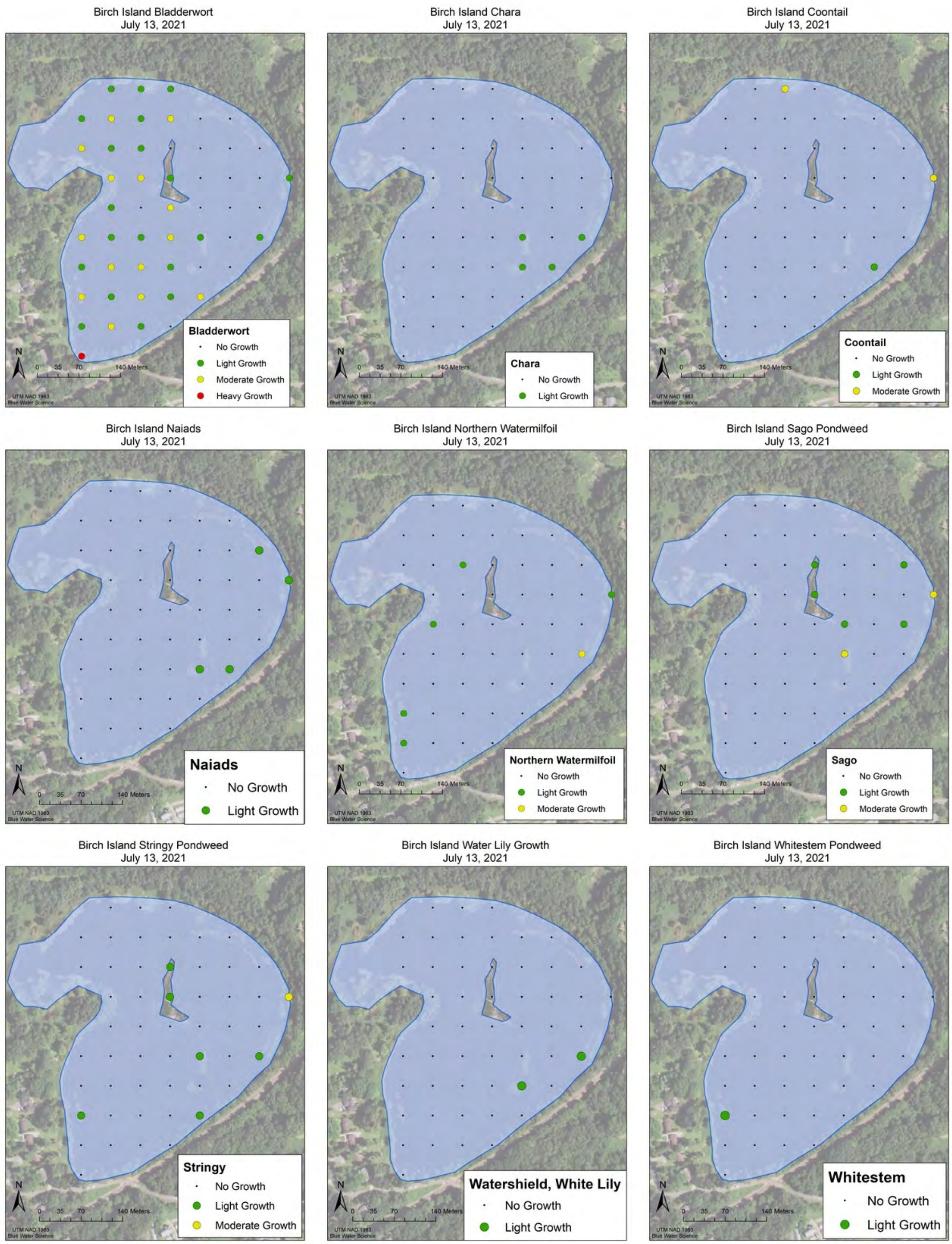


Figure 7. Aquatic plant maps for Birch Island Lake on July 13, 2021.

Aquatic Plant Point Intercept Data

Aquatic plant occurrence and density for individual sites is shown in Table 6.

Table 6. Aquatic plant occurrence and density for the point intercept survey (density is on a 1 to 3 scale with 3 the densest).

Site	Depth (ft)	Cattails - dead	Water-shield	White lilies	Bladder wort	Bladder wort - minor	Chara	Coon-tail	Naiad	NWM	Sago	Stringy	White-stem	Filament ous Algae	No plants
1	1				3										
2	2				1					1					
3	3	1			2										
4	2	1			1	1									
5	land														1
6	2	1			2					1		1	1		
7	2	1			1										
8	3	1			2										
9	3	1			1										
10	1				2							1			
11	2	1			1										
12	3	1			2										
13	3	1			2										
14	3	1			1										
15	4		1				1		1						
16	5						1	1	1						
17	2	1			2										
18	2	1			1										
19	3	1			1	1									
20	3	1			2										
21	3				1		1				2	1			
22	10														1
23	5			1	1		1			2		1			
24	1	1			1					1					
25	4														1
26	3				2	1									
27	6										1				
28	14														1
29	6										1				
30	2	1			2										
31	3	1			2										
32	4				1						1	1			
33	9														1
34	15														1
35	8														1
36	1				1			2	1	1	2	2			
37	2	1			2										
38	2	1			1										
39	3				1					1					
40	4										1	1			
41	9														1
42	9														1
43	5								1		1				
44	1	1			1										
45	2	1			2									1	
46	3	1			1										
47	3	1			2										
48	5														1
49	5														1
50	1	1			1										
51	1	1			1			2						1	
52	1	1			1									1	
Average		1.0	1.0	1.0	1.5	1.0	1.0	1.7	1.0	1.2	1.3	1.1	1.0	1.0	1.0
occur (52 sites)		26	1	1	35	3	4	3	4	6	7	7	1	3	11
% occurrence		50	2	2	67	6	8	6	8	12	13	13	2	6	

Previous Survey Data on Birch Island Lake

2010 and 2011 Aquatic Plant Coverage: The aquatic plant community in 2010 and 2011 had 3 species of submerged plants in early summer and in late summer. This is a modest plant diversity condition. Aquatic plant coverage is shown in Figure 7.

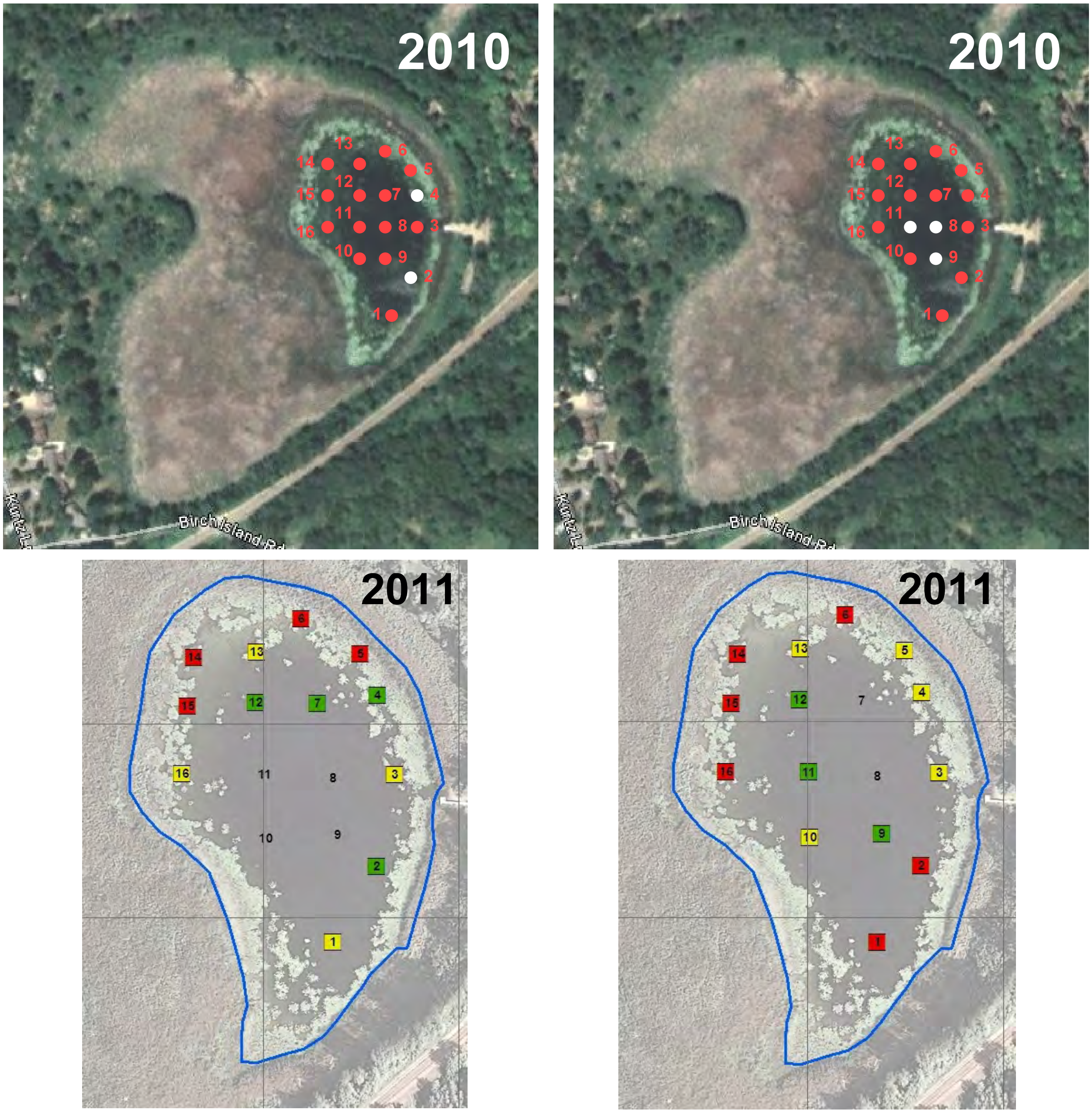


Figure 7. (top-left) Aquatic plant coverage on June 10, 2010. Aquatic plant coverage (shown with red dots) is shown and covers about 6 acres out of a total of 7 acres of open water (shown in red).
(top-right) Aquatic plant coverage on August 30, 2010. The red area shows coverage of aquatic plants. Plants covered about 5.5 acres.
(bottom-left) Aquatic plant coverage on June 15, 2011. Green square = light growth, yellow squares = moderate growth, and red squares = heavy growth.
(bottom-right) Aquatic plant coverage on September 23, 2011. Green square = light growth, yellow square = moderate growth, and red squares = heavy growth.

Birch Island Lake Aquatic Plant Survey Summaries

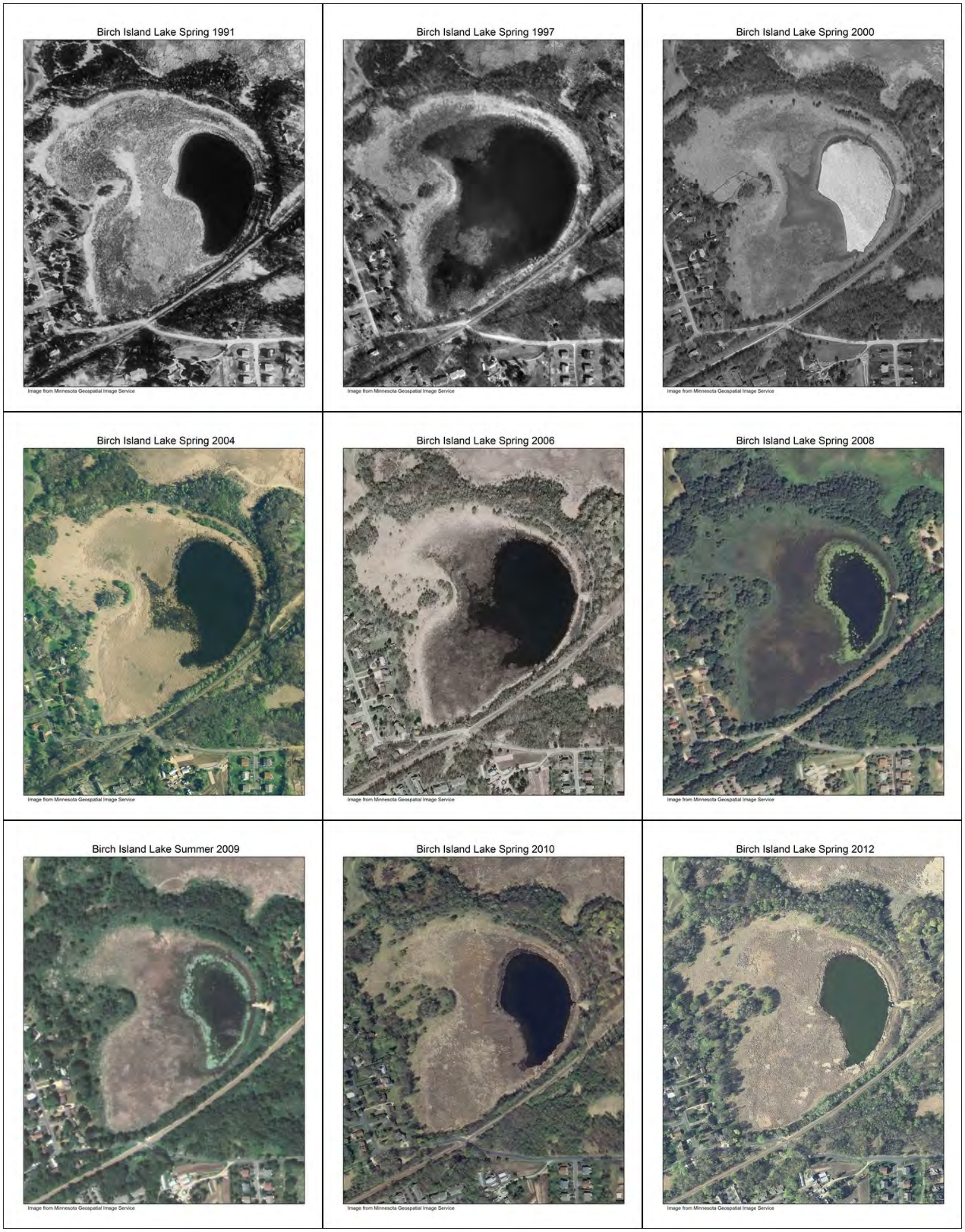
In 2010 and 2011, coontail, chara and white lilies were common with few other species. Since then water levels have dramatically changed and the plant community responded in 2020 and 2021 (Table 8). Bladderwort was the dominant plant in 2010 and 2021.

The acreage of aquatic submerged plants in Birch Island Lake from 2010 to 2021 changed significantly. This was due primarily to an increase in water levels and an increase in lake area.

Table 8. The percent occurrence of aquatic plants for Birch Island Lake. Percent occurrence is calculated based on the number of times a plant species occurs at a sampling station div ided into the total number of stations for the survey. For example, if coontail was found in 8 out of 16 stations, its percent occurrence would be 50%.

	June 10, 2010 % Occur (16 stations)	Aug 30, 2010 % Occur (16 stations)	June 15, 2011 % Occur (16 stations)	Sept 23, 2011 % Occur (16 stations)	July 27, 2020 % Occur (52 stations)	July 13, 2021 % Occur (52 stations)
Bullrush (Scirpus sp)	6					
White waterlilies (Nymphaea sp)	50		44	75	2	2
Watershield (Brasenia schreberi)						2
Bladderwort (*Utricularia sp*)				25	21	67
Coontail (*Ceratophyllum demersum*)	25	63	13	38	10	6
Chara (*Chara sp*)	69	63	63	81	2	8
Chara (Braun's stonewort) *(Chara braunii)*					4	
Lesser bladderwort (*Utricularia minor*)						6
Naiads *(Najas sp)*					2	8
Northern watermilfoil *(Myriophyllum sibiricum)*						12
Stringy pondweed (*Potamogeton sp*)					2	13
Sago pondweed (*Stuckenia pectinata*)	13	13	25			13
Whitestem pondweed (*P. praelongus*)						2
Plant coverage (acres)	**6**	**5.5**	**5**	**6**	**14**	**25**
Number of submerged species	**3**	**3**	**3**	**3**	**6**	**9**

Birch Island Lake Size over the years: 1991-2020



Birch Island Lake 2013-2020

Birch Island Lake Summer 2013

Image from Minnesota Geospatial Image Service

Birch Island Lake Summer 2015

Image from Minnesota Geospatial Image Service

Birch Island Lake Spring 2016

Image from Minnesota Geospatial Image Service

Birch Island Lake Summer/Fall 2017

Image from Minnesota Geospatial Image Service

Birch Island Lake Spring 2018

Image from Minnesota Geospatial Image Service

Birch Island Lake Summer/Fall 2019

Image from Minnesota Geospatial Image Service

Birch Island Lake Spring 2020

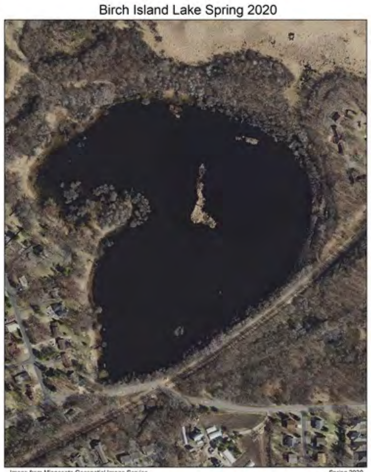


Image from Minnesota Geospatial Image Service Spring 2020

Appendix B

Fisheries Assessment (2022)

Shoreland of the Camp at Birch Island Lake, October, 2022

Fish Survey of Birch Island Lake (ID #27-0081), Hennepin County, Minnesota in 2022

Survey Dates: October 11-13, 2022
MnDNR Permit Number: 34759A

Prepared for:
Birch Island Lake Association and MnDNR

Prepared by:
Steve McComas and Jo Stuckert
Blue Water Science
St. Paul, MN

February 8, 2023

Fish Survey of Birch Island Lake (ID #27-0081), Hennepin County, Minnesota in 2022

Summary

Birch Island Lake has been surveyed on 3 occasions over the past 40 years. The MnDNR surveys were conducted in 1981 and 1992 and Blue Water Science conducted the 2022 fish survey, results from all 3 surveys are summarized in Table 1. Birch Lake fits natural shallow lake criteria and there will be occasional winter fish kills. A significant feature of Birch Island Lake is the dramatic changes in lake levels over the years.

In 1981 and 1992 fish surveys were conducted by the Minnesota Department of Natural Resources. In 1981, the fish survey results found a high density of black bullheads, brown bullheads, and green sunfish. These were the only species sampled. Green sunfish were the dominant species. In 1992, only fathead minnows were sampled.

The 2022 fish survey was conducted by Blue Water Science. The only fish sampled were abundant fathead minnows, several black bullheads, a few goldfish, and a couple of stickleback minnows.

Table 1. Historical trapnet fish survey records.

	Trapnet Results			
	Fish per net 1981 (MnDNR)	**Fish per Net 1992 (MnDNR)**	**Fish per Net 2022 (BWS) (n=8)**	**Normal Range (MnDNR)**
Black bullheads	32.8		**0.5**	1.3 - 26
Brown bullheads	17.40			0.5 - 5.4
Fathead minnow		present	**2,646**	--
Goldfish			**0.4**	--
Green sunfish	168			0.3 - 2.0
Stickleback minnow			**0.4**	--
Turtles - painted				--
Turtles - snapping				--
Crayfish				--
TOTAL FISH	218	0	**2647**	--
Number of Fish Species	3	1	**4**	--

Currently, minnows dominate the fishery. Minnow feeding activities can produce elevated nutrients at high minnow densities resulting in high phosphorus concentrations. However, if aquatic plants are present, this is an indicator that minnows probably are not disrupting sediments in their food search and may have minimal water quality impacts through sediment activities. Still the adverse impact of feeding heavily on zooplankton impacting water quality can't be dismissed.

Management options would appear to be:

1. Passive management. Collect water quality, plant, zooplankton, and fish data. See if surrounding ponds could be contributing to restocking Birch Island with minnows.
2. Fish stocking if lake levels increase 3 feet or more. Stock largemouth bass and crappies the first year and bluegills the following year.
3. If water quality appears impacted by abundant minnows, then conduct minnow removal by trap netting.
4. Install aeration combined with fish stocking.
5. Rotenone and restock.

Because Birch Island water levels are in flux, water quality conditions will not likely stabilize for some time.

We would recommend options 1 and 2. Stock fish and track lake ecosystem changes. We have plant, fish, and water quality data and we could see how water quality could change with fish stocking.

Figure 1. Lake levels have ranged over 13 feet over the years. This grassland area was formerly part of the lake.

Fish Survey of Birch Island Lake (ID #27-0081), Hennepin County, Minnesota in 2022

Introduction

Birch Island Lake (ID: 27-0081) is a 43-acre shallow lake, located in Hennepin County, Minnesota. In October 2022, the City of Eden Prairie sponsored a fish survey conducted by Blue Water Science under permit number 34759A granted from the MnDNR. The objectives were to characterize the fish community in Birch Island Lake.

Methods

Four mini trapnets were sampled for two days for a total of eight lifts to survey fish in Birch Island Lake. The trapnet was a MnDNR-style with a 2 x 3 feet square frame with two funnel mouth openings and a 25-feet lead. Net mesh size was 3/8 inch. Four standard trap nets were set on October 11, 2022. Four nets were fished for the following 2 days (October 12 and 13). Trapnet locations are shown in Figure 2. Birch Island Lake water levels were low in 2022 and the net placement was spaced along only one shoreline by the camp.

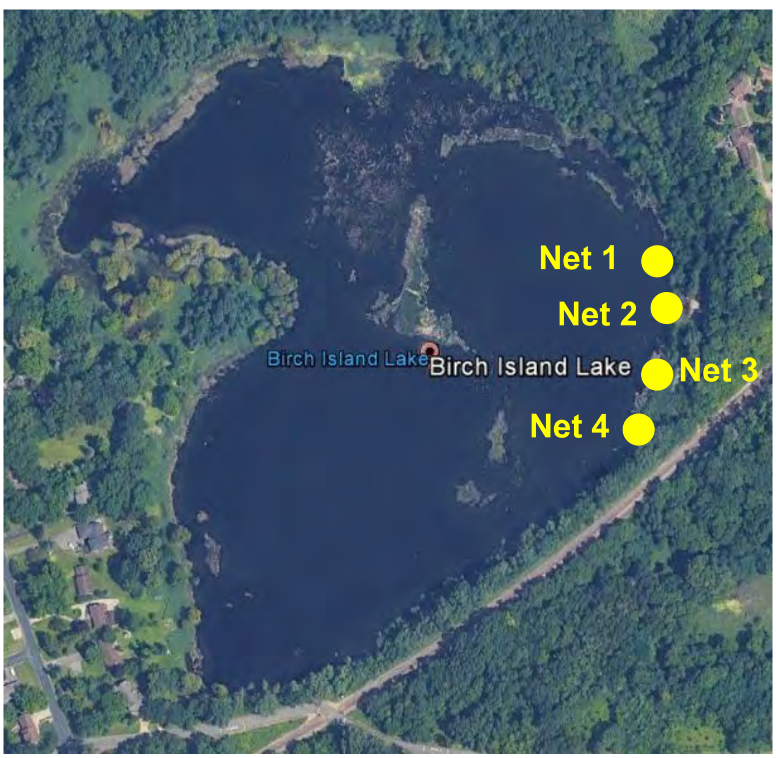


Figure 2. Map of trapnet sets in Birch Island Lake.

Results

Fish Results: Only a few fish species were sampled in Birch Island Lake on October 12-13, 2022 (Table 2). Fathead minnows dominated the fish community. Two small goldfish and 3 stickleback minnows were captured as well as 4 small black bullheads measuring 3.5 to 5 inches.

Thousands of fathead minnows were trapped and no predator fish were captured. This represents a winterkill condition and minnows likely immigrated into Birch Island from adjacent ponds.

Turtle Results: Snapping turtles and painted turtles were also sampled in the trapnets and were common in Birch Island Lake. Painted turtles and snapping turtles likely do well because there is a fair percentage of a natural shoreline area.

Table 2. Birch Island Lake trapnet results for the fish survey conducted in October 2022.

	Fish Captured (October 12-13, 2022)								Total Catch	Fish per Net (n=8)
	Net 1		Net 2		Net 3		Net 4			
	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2		
Black bullheads				2		2			4	**0.5**
Fathead minnow	33	726	210	1,905	130	1,724	15,890	544	21,162	**2645**
Goldfish	1				1				2	**0.3**
Stickleback minnow			2					1	3	**0.4**
TOTAL FISH	34	726	212	1,907	131	1,726	15,890	545	21,171	**2646**
Turtles - painted			8	3	2	3	5		21	**2.6**
Turtles - snapping			2				1		3	**0.4**
Crayfish	2			4	1	2	1		10	**1.3**
Tadpole				1				1	2	**0.3**

Minnows were abundant in the Birch Island Lake fish survey in 2022.

Representative Fish Species of Birch Island Lake


Black Bullhead

Goldfish


Fathead minnow


Fathead minnows


Crayfish


Tadpole


Painted turtle


Painted turtles

Historical Trapnet Fish Survey Records for Birch Island Lake

Birch Island Lake has been surveyed on 3 occasions over the past 40 years. The MnDNR surveys were conducted in 1981 and 1992 and Blue Water Science conducted the 2022 fish survey, results from all 3 surveys are summarized in Table 3. Birch Lake fits natural shallow lake criteria and there will be occasional winter fish kills. The twist is the dramatic changes in lake levels.

Both the 1981 and 1992 fish surveys were conducted by the Minnesota Department of Natural Resources.

In 1981, the fish survey results found a high density of black bullhead, brown bullhead, and green sunfish. These were the only species sampled. Green sunfish were the dominant species.

In 1992, only fathead minnows were sampled.

The 2022 fish survey was conducted by Blue Water Science. The only fish sampled were minnows, goldfish, and black bullheads. Fathead minnows were abundant while the other fish species were low in numbers.

Table 3. Historical trapnet fish survey records.

	Trapnet Results			
	Fish per net 1981 (MnDNR)	Fish per Net 1992 (MnDNR)	Fish per Net 2022 (BWS) (n=8)	Normal Range (MnDNR)
Black bullheads	32.8		0.5	1.3 - 26
Brown bullheads	17.40			0.5 - 5.4
Fathead minnow		present	2,645	--
Goldfish			0.4	--
Green sunfish	168			0.3 - 2.0
Stickleback minnow			0.4	--
Turtles - painted			2.6	--
Turtles - snapping			0.4	--
Crayfish			0.3	
Tadpole			1.3	--
TOTAL FISH	218	0	2646.3	--
Number of Fish Species	3	1	4	--

Conclusions and Recommendations

Currently, minnows dominate the fishery. Minnow feeding activities can produce elevated nutrients at high minnow densities resulting in high phosphorus concentrations. However, if aquatic plants are present, this is an indicator that minnows probably are not disrupting sediments in their food search and may have minimal water quality impacts through sediment activities. Still the adverse impact of feeding heavily on zooplankton impacting water quality can't be dismissed.

Management options would appear to be:

1. Passive management. Collect water quality, plant, zooplankton, and fish data. See if surrounding ponds could be contributing to restocking Birch Island with minnows.
2. Fish stocking if lake levels increase 3 feet or more. Stock largemouth bass and crappies the first year and bluegills the following year.
3. If water quality appears impacted by abundant minnows, then conduct minnow removal by trap netting.
4. Install aeration combined with fish stocking.
5. Rotenone and restock.

Because Birch Island water levels are in flux, water quality conditions will not likely stabilize for some time.

We would recommend options 1 and 2. Stock fish and track lake ecosystem changes. We have plant, fish, and water quality data and we could see how water quality could change with fish stocking.

Appendix A

Minnesota DNR Fish Survey Notification

From: Steve McComas [mailto:mccomas@pclink.com]
Sent: Friday, October 07, 2022 8:17 AM
To: Daryl Ellison; Capt. Jason Peterson
Cc: Lori Haak (LHaak@edenprairie.org)
Subject: Fish survey in Birch Island Lake (27-008100) October 11-13, 2022

Hello all,

Blue Water Science will be conducting a fish survey in Birch Island Lake (MN ID 27-008100), Hennepin County, starting on Tuesday, October 11, 2022. We will set 4 trap nets in the lake. The nets will be monitored daily and removed on Thursday (October 13, 2022) and all fish will be weighed, measured, and returned to the lake. The nets will be removed from the lake on Thursday, October 13, 2022. The fish survey is sponsored by the City of Eden Prairie with the objectives of characterizing the existing fish community structure and assessing potential impacts of fish on water quality.

This survey is being conducted under the permit number: 34759A.

Thank you,
Steve McComas
BLUE WATER SCIENCE
550 South Snelling Avenue
St. Paul, MN 55116
651 690 9602
mccomas@pclink.com

Appendix B - MnDNR Fish Survey Results

DEPARTMENT OF NATURAL RESOURCES

Birch Island (27008100)

Area: 7.26 acres
Littoral Area: 39 acres
Shore Length: 0.42 miles

Mean Depth: N/A
Maximum Depth: 21 feet
Average Water Clarity: N/A

Choose a survey:

Standard Survey (1992-07-22)

Water Access Information:

Administrator	Access Type	Notes	Use Type
Unknown	Other	OFF RAILROAD GRADE	Unknown

Fish Sampled

Filters:

all species

all gear

Species	Gear	CPUE	Normal Range	Avg Weight	Normal Range	Count
no fish samples to display.						

Showing 0 to 0 of 0 entries

Status of the Fishery

ONLY FHM WERE SAMPLED DURING THE SURVEY.

For More Information

West Metro Area Fisheries Area Fisheries Supervisor
7050 E Hwy 101, Suite 100
Shakopee, MN
Phone: 952-236-5170
Email: MetroWest.Fisheries@state.mn.us (mailto:MetroWest.Fisheries@state.mn.us)
Website (/areas/fisheries/westmetro/index.html)

We use JSON (http://www.json.org/), a lightweight data-interchange format, to deliver the lake survey data. If you are an application developer, you can access this data to develop custom reports and products - get the data (https://maps2.dnr.state.mn.us/cgi-bin/lakefinder/detail.cgi?type=lake_survey&id=27008100).

DEPARTMENT OF NATURAL RESOURCES

Birch Island (27008100)

Area: 7.26 acres
Littoral Area: 39 acres
Shore Length: 0.42 miles

Mean Depth: N/A
Maximum Depth: 21 feet
Average Water Clarity: N/A

Choose a survey:

Standard Survey (1981-07-29)

Water Access Information:

Administrator	Access Type	Notes	Use Type
Unknown	Other	OFF RAILROAD GRADE	Unknown

Fish Sampled

Filters:

all species

all gear

Species	Gear	CPUE	Normal Range	Avg Weight	Normal Range	Count
black bullhead	Standard gill nets	74.00	5.2-56.2	0.09	0.2-0.5	74
black bullhead	Standard trap nets	32.80	1.3-26.0	0.14	0.2-0.5	164
brown bullhead	Standard trap nets	17.40	0.5-5.4	0.51	0.4-0.7	87
brown bullhead	Standard gill nets	2.00	0.7-6.2	0.55	0.2-0.6	2
green sunfish	Standard trap nets	168.20	0.3-2.0	0.17	0.1-0.1	841
green sunfish	Standard gill nets	3.00	0.3-1.6	0.13	N/A	3

showing 6 of 6 fish samples

Status of the Fishery

Blk Bullhead, Brn Bullhead and Grn Sunfish were the only fish species found to be present in Birch Island Lake. All exist in extremely high populations as gauged from the trapnet catch rates

Appendix C

In-lake Water Quality Calibration Plots

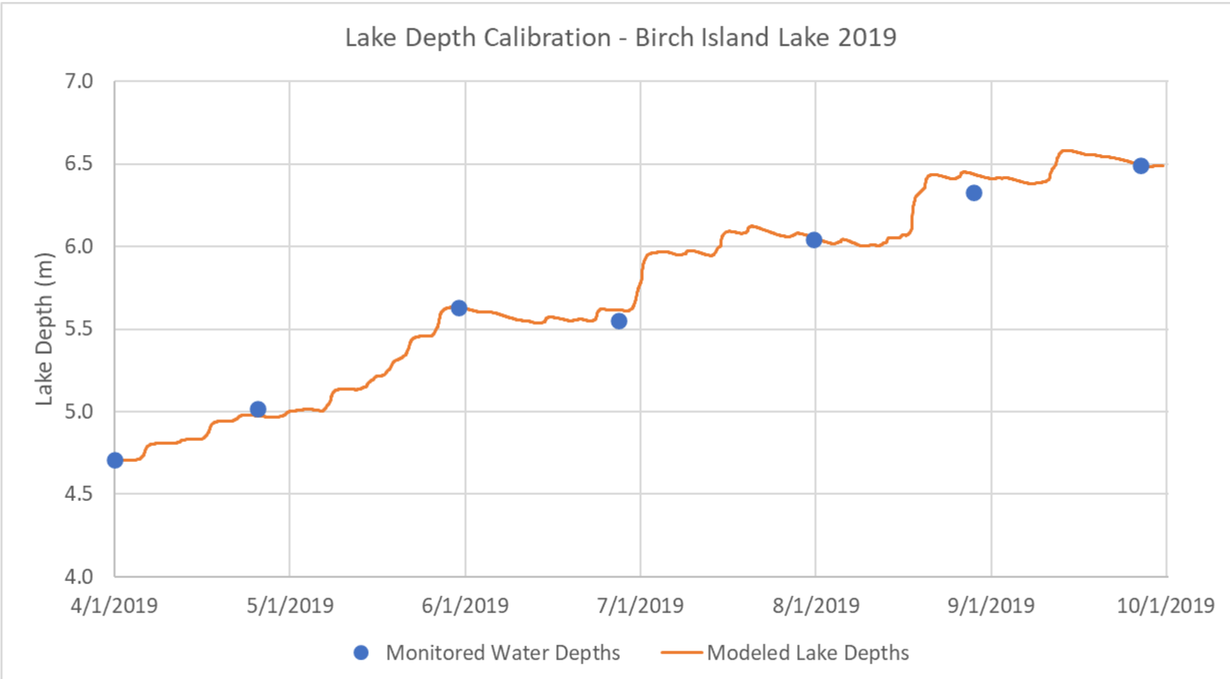


Figure C-1 2019 water surface elevation calibration

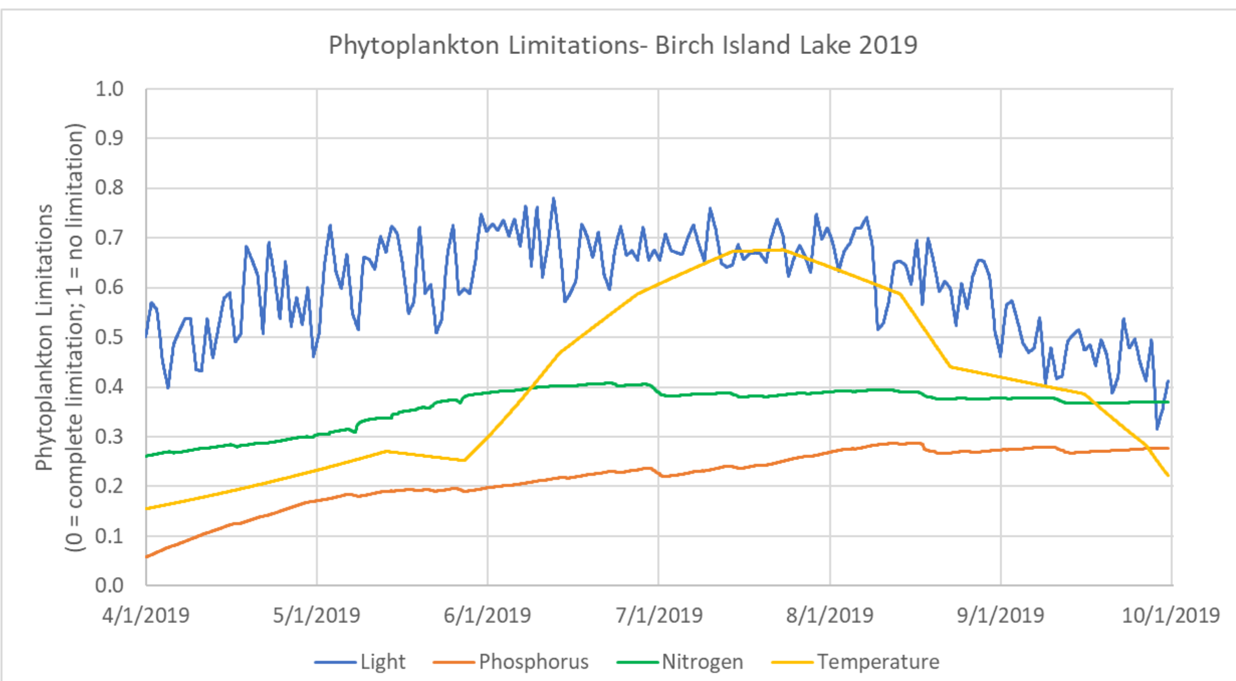


Figure C-2 2019 phytoplankton limitations calibration

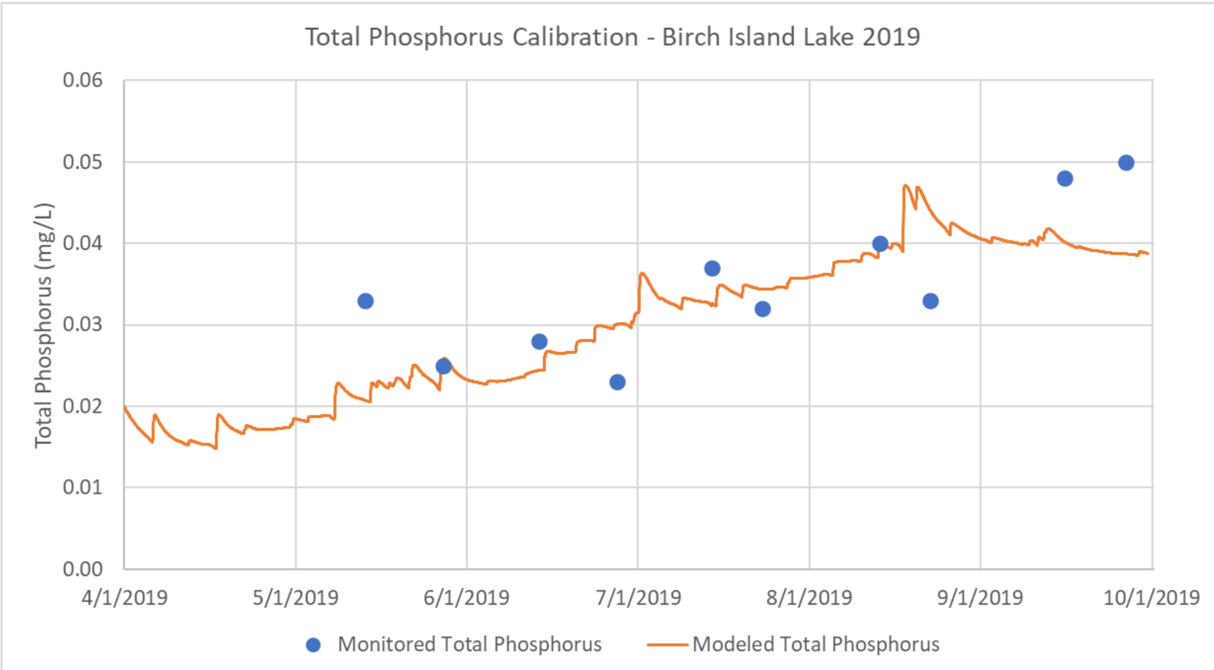


Figure C-3 **2019 total phosphorus calibration**

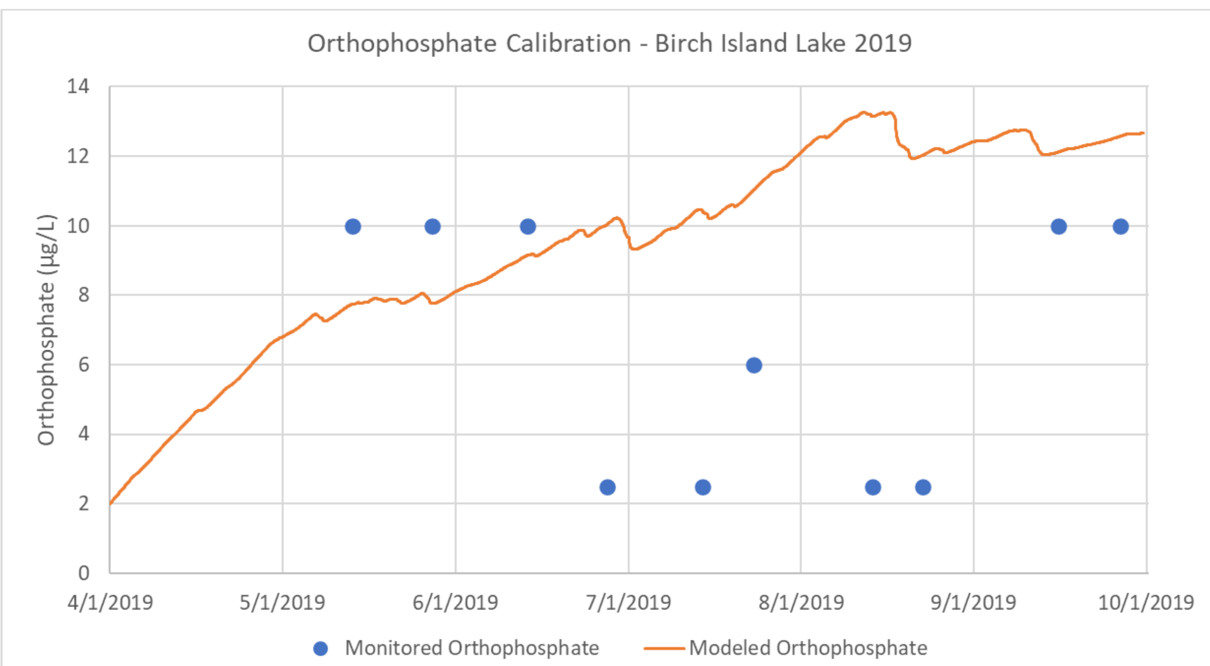


Figure C-4 **2019 orthophosphate calibration**

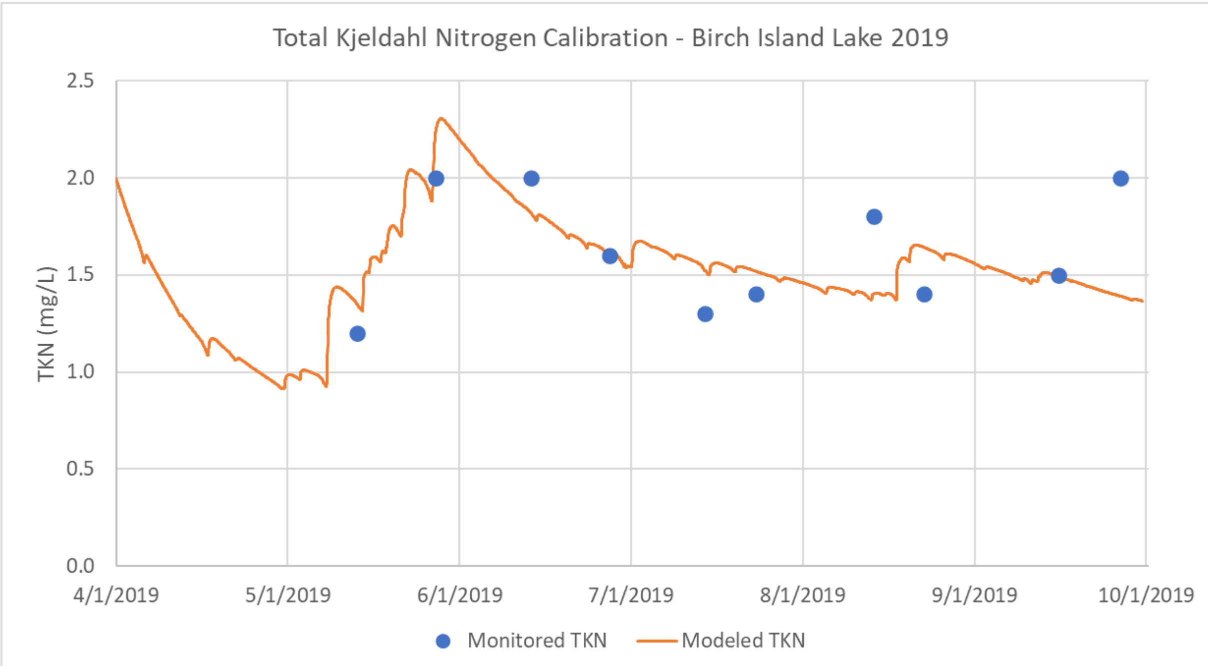


Figure C-5 2019 total kjeldahl nitrogen (TKN) calibration

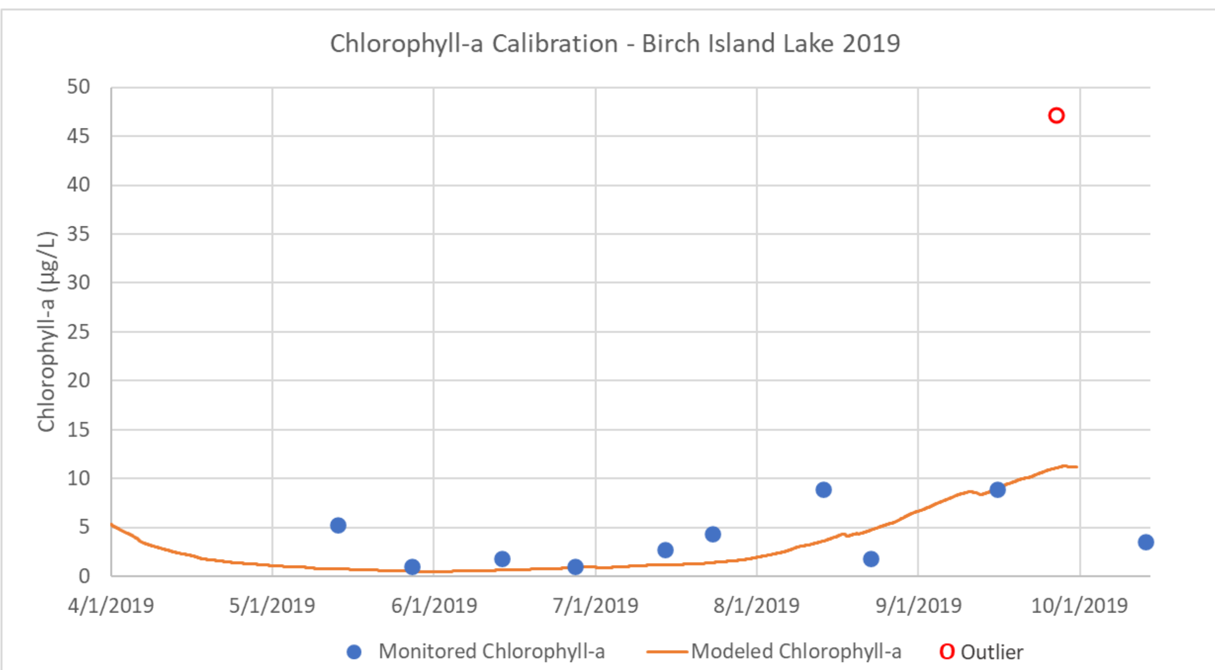


Figure C-6 2019 chlorophyll-*a* calibration

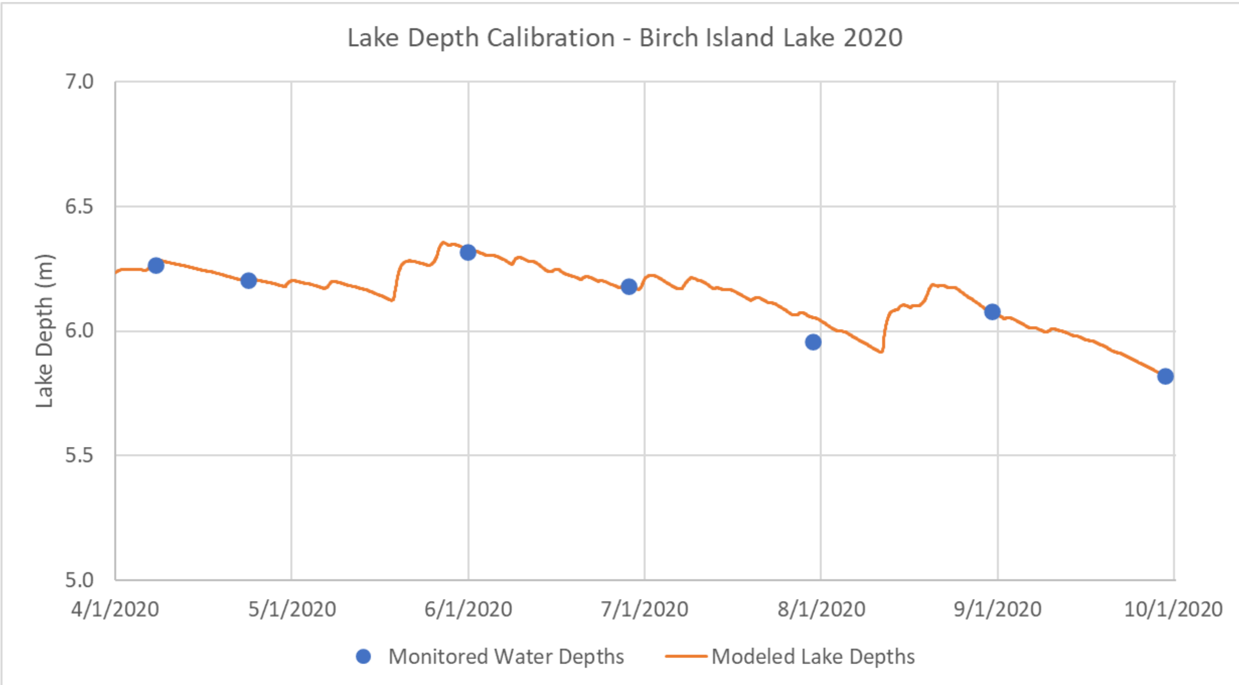


Figure C-7 2020 water surface elevation calibration

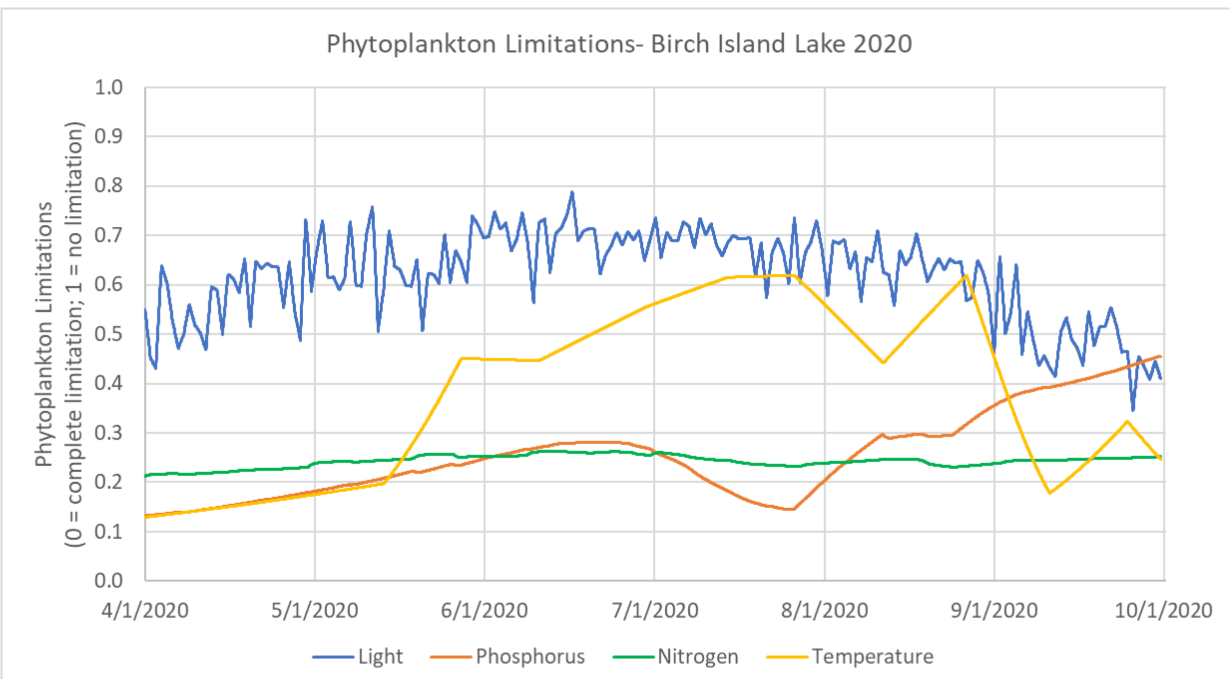


Figure C-8 2020 phytoplankton limitations calibration

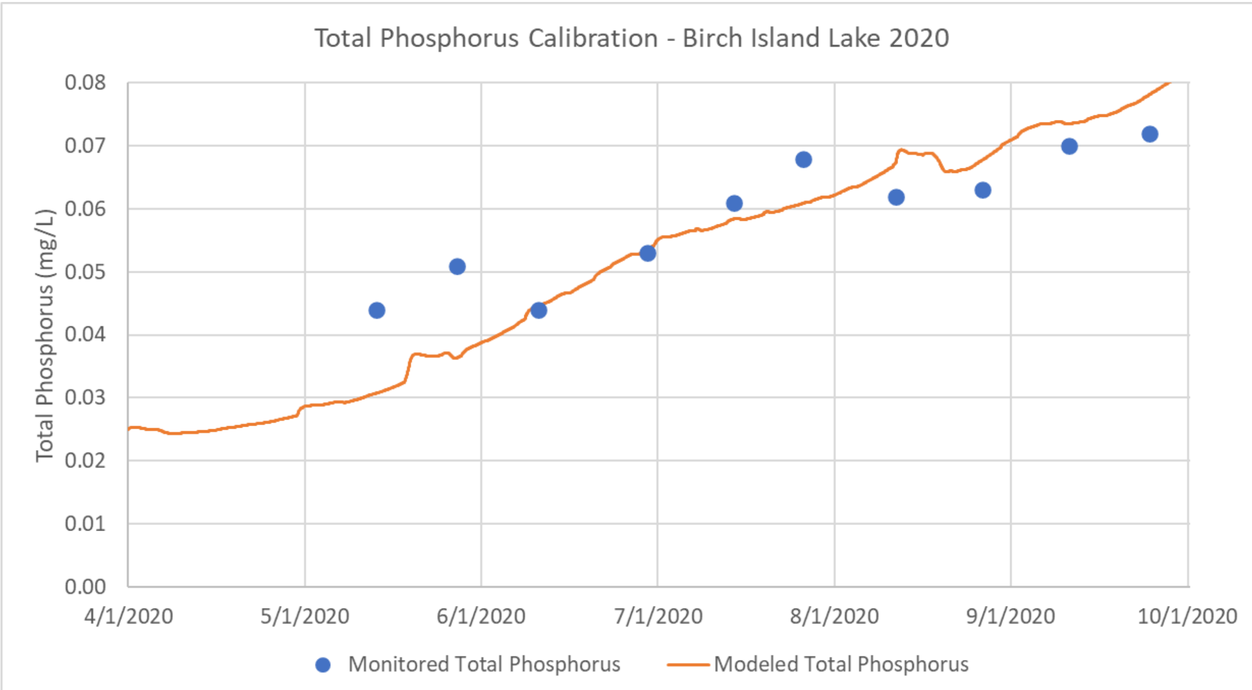


Figure C-9 **2020 total phosphorus calibration**

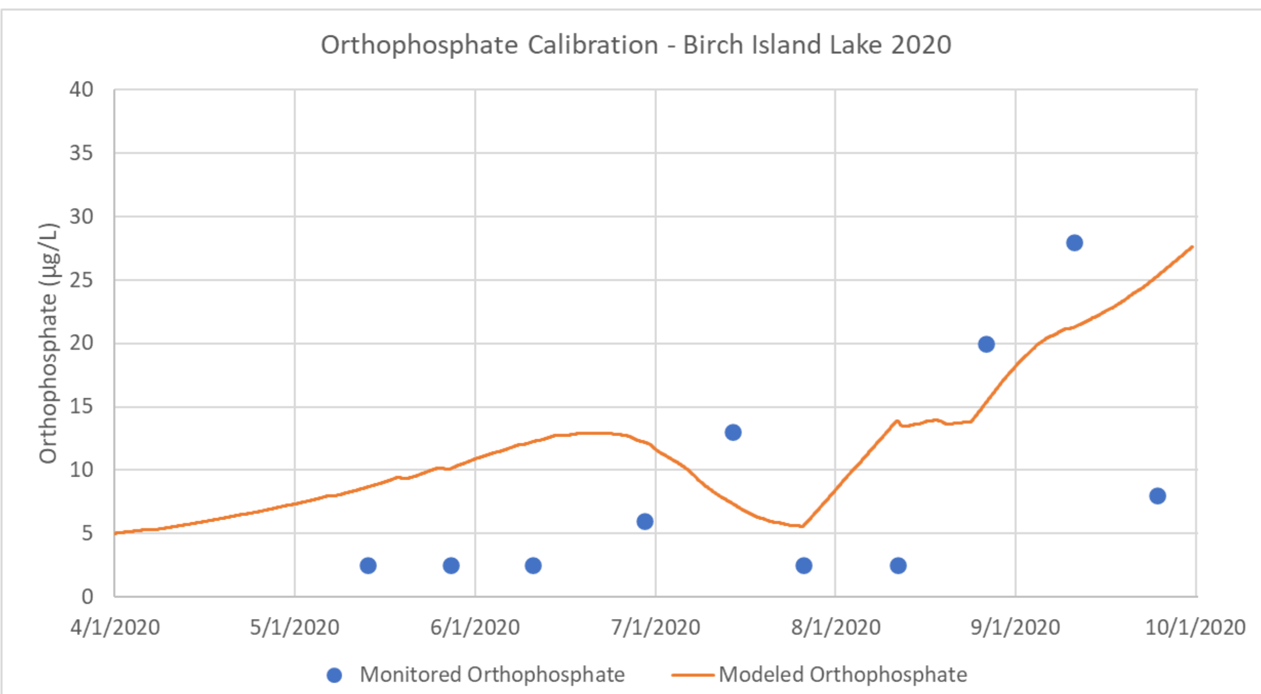


Figure C-10 **2020 orthophosphate calibration**

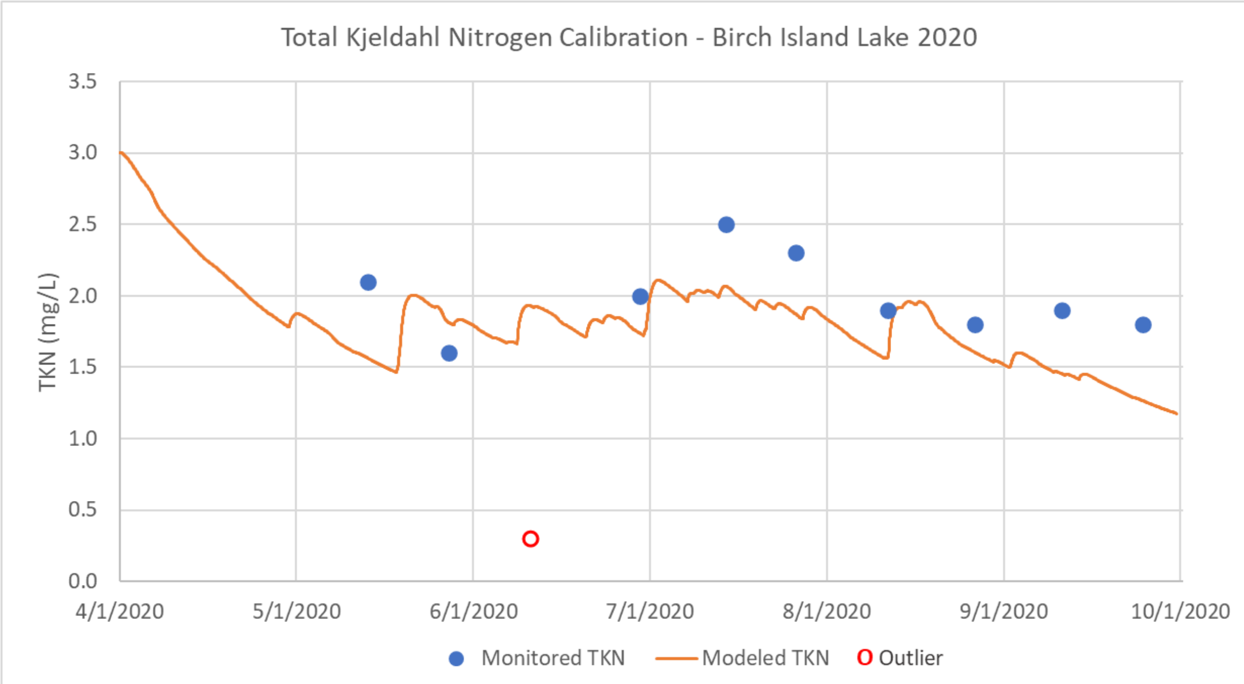


Figure C-11 2020 total kjeldahl nitrogen (TKN) calibration

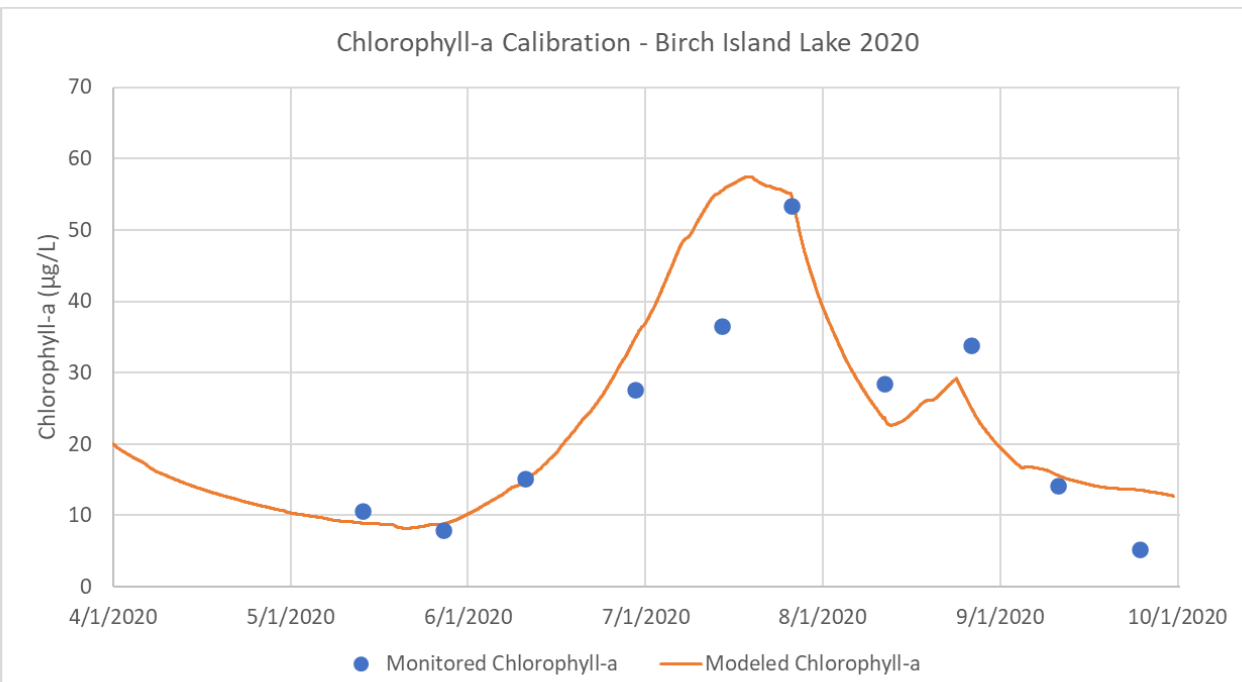


Figure C-12 2020 chlorophyll-*a* calibration

Appendix D

Birch Island Lake Public Survey

Birch Island Lake: Lake User Survey

OVERVIEW

The Nine Mile Creek Watershed District (NMCWD) developed an online survey to gather feedback from stakeholders in the subwatershed of Birch Island Lake in Eden Prairie. The purpose of the survey was to help the watershed district understand existing and past lake conditions from the experience of those that have property on the lake or live near the lake. The watershed district will use the information gathered, in conjunction with other data, to help determine appropriate lake management strategies.

Survey

The lake user survey is meant to provide community feedback to NMCWD staff, engineers, and the board of managers, along with the City of Eden Prairie to assist in the evaluation of management strategies designed to improve the health of Birch Island Lake.

The survey was available December 19th, 2022-January 31, 2023. To encourage stakeholders to take the survey an initial postcard with an online survey link and information about a community meeting regarding the lake was mailed to 160 addresses in the subwatershed of Birch Island Lake on December 20, 2022. Stakeholders that attended the community meeting on January 9, 2023, were also encouraged to take the survey and were emailed the survey link following the meeting. The survey link was also available on the Birch Island Lake study webpage at: www.ninemilecreek.org/whats-happening/current-studies/birch-island-lake-study. 16 survey responses were received.

The survey responses are summarized below or may be found online at: https://ninemilecreek.typeform.com/report/BAOnoyZ7/jqhepDItRAMX0Fbi

Birch Island Lake User Survey

16 responses

What is your connection to Birch Island Lake in Eden Prairie?

16 out of 16 answered

I live or work on Birch Island Lake	8 resp.	50%
I live or work within a mile of Birch Island Lake	8 resp.	50%
I live or work more than a mile away from Birch Island Lake	0 resp.	0%

Below is a list of activities. What activities have you done at Birch Island Lake in the past year?

16 out of 16 answered

Observing birds or other wildlife	16 resp.	100%
Walking/biking by the lake	16 resp.	100%
Visiting Birch Island Park	13 resp.	81.2%
Photographing nature	10 resp.	62.5%
Canoeing or kayaking	4 resp.	25%
Snowshoeing	3 resp.	18.8%
Ice fishing	1 resp.	6.2%
Ice skating or playing hockey on the lake	1 resp.	6.2%
Fishing	0 resp.	0%
Other	1 resp.	6.2%

Walking around the lake

How concerned are you about the current health of Birch Island Lake?

16 out of 16 answered

Extremely concerned	10 resp.	62.5%
Moderately concerned	4 resp.	25%
Slightly concerned	1 resp.	6.2%
Somewhat concerned	1 resp.	6.2%
Not at all concerned	0 resp.	0%

What standards are most important to you when you are judging the overall health of Birch Island Lake?

16 out of 16 answered

Healthy shoreline conditions	7 resp.	43.8%
Presence of native aquatic plants	7 resp.	43.8%
Presence of a diverse fish population	5 resp.	31.2%
Amount of nutrients (like phosphorus and nitrogen) in the lake	4 resp.	25%
Presence of diverse wildlife	4 resp.	25%
Amount of algae present	3 resp.	18.8%
Clear water	3 resp.	18.8%
Color of the water	3 resp.	18.8%
Other	7 resp.	43.8%

depth and breadth of the lake foot footprint

---

water level

Extremely low water level

That there's actually water in the lake

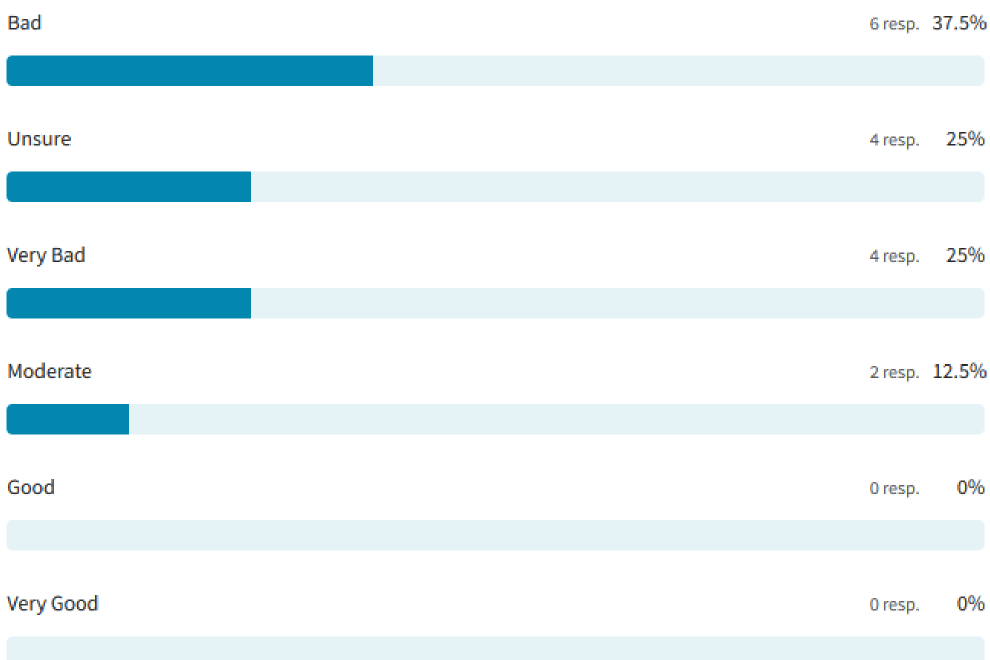
Water level

Water level

It is drying up!! Why?

How do you perceive the current health of Birch Island Lake?

16 out of 16 answered



How do you feel that the health of Birch Island Lake has changed over time?

16 out of 16 answered

It has gotten worse	9 resp.	56.2%
It has gotten much worse	4 resp.	25%
Unsure	3 resp.	18.8%
It has gotten better	0 resp.	0%
It has gotten much better	0 resp.	0%
It has remained constant	0 resp.	0%

What concerns do have about Birch Island Lake?

16 out of 16 answered

Restoration to historic water level.

Fallen trees on the shoreline, and overgrowth of invasive plant species when water levels are non-consistent which promote poor water quality. Unfortunately, the lake appears to be forgotten and left to defend itself. At times it looks like a large retention pond that ebbs and flows with each passing summer instead of something of beauty to be admired and enjoyed.

---

the lake expanded extensively in 2017 and then receded in 2021 or so. What caused this and can it be expected to expand again?

Lake Water Level - Can no longer kayak, can't skate, water smells due to decaying cattails, way less bird diversity since water levels went down (previous to this year there were many more egrets, great blue heron, merganzers, wood ducks, mallards and birds of prey, dead trees lining the lake.

It's a duck swamp, I like that. The section adjoining 62 is over grown w/ cattail. Continue to treat cattail, do burns. Kill the buckthorn , use goats (lolz)& burn it . Spring sandhill crane, egret , ducks & geese. Few nest. Large flocks of mallard winter near by, upwards of 250. I wanted to attend but could not .

My main concern is that Birch Island Lake's water levels are continuing to decline and will never get back to where it once was before the highway 62 construction. I'm concerned that this lake will eventually disappear and not be brought back to what it use to be. I'm concerned that nothing is being done to correct the root cause of Birch Island Lake being drained.

The lake and surrounding land is a treasure for both wildlife and people. I support preserving this area.

I would like to see the water levels rise and be more consistent. I've been told by neighbors that have lived here for a very long time that when hwy 62 (I believe) was expanded that the water access that fed the lake was cut off and the lake lost most of it's water after that. I'm not sure if that's the case or not but it would be nice to see it thrive.

Lack of incoming water and/or retaining the water

The water level is low

Water level

Extremely low water level and concern about dense vegetation on dry lake bed

Water level

Severely low water levels and invasion of non-native plants. Activities we used to be able to enjoy, we can't any longer. We want the lake to be full again so we can enjoy it like we did in the past.

The water level fluctuates and is currently very low. I would like to understand what can be done to retain more water in the lake consistently.

Where did all the water go? What is happening to our lake?

What do you value about Birch Island Lake?

16 out of 16 answered

Low traffic

Green space, beauty when water levels are higher, and wildlife which for the most part is in short supply.

I value the undeveloped setting, the natural beauty& wildlife and the limited access to it. thanks.

---

wildlife presence, calm/serene area, walking paths around lake, minnows (for fishing), kayaking/skating when the water level was higher, and the hope that there would be angling opportunity if the water level held up (had heard it may get stocked with bass/bluegill if the water level had held up)

Great hiking , prickly woods with kids

I value the lake being an excellent habitat to wildlife, local and migratory. I value the lake as an exceptional year round recreational resource for myself and others.

Habitat for animals and green space for walking and enjoying nature.

Everything. It’s a beautiful lake to live on. We love all of the wildlife and nature. Walking around the lake is so peaceful and gorgeous, I feel so lucky to have it in my back yard.

The view, wildlife, plants and recreational opportunities

Nature’s beauty

Local wildlife habit, hiking, scenery

Scenic beauty from Birch Island Woods & Kurtz Ln and healthy wildlife habitat

Scenery and wildlife

It's our home and we love that it's our own little lake. It's peaceful and offers a resting place to migrating birds. I value that no one can build in our backyard.

I value the wildlife that is attracted to the area and the low amount of development around the lake. I would like for there to be better fishing opportunities in the lake.

Beauty, wildlife, nature, great community gem.

Would you like to add any additional comments, information, or stories about Birch Island Lake?

11 out of 16 answered

With over-site and maintenance, a stable return to full lake levels should be achievable.

More needs to be done to repair/stabilize the lake to bring it back to its natural beauty. Installing aquatic plants on the shoreline is not the entire answer here. Dead / fallen trees and invasive plant species need to be removed, reduction of phosphorus and nitrogen levels, and finding a way to add more water to the lake for its overall health and beauty.

In addition to the egrets, herons and swans that sometimes populate the lake area, I have seen(and heard)sand hill cranes that nest near the lake. Summer of 22 they could be heard well into the summer. There used to be pheasants in the lake area in the early 2000's but not any more. The same goes for foxes.

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curious if during times of excessive water, if there is opportunity to divert water from purgatory watershed when it is in flood state into birch island. Wildlife diversity was much greater in 2019, 2020 when water levels were up. Appreciate the focus on the lakes upstream as well as Birch Island. Is there additional opportunity to bring additional runoff water into the birch island ponds which I assume filters the water quite a bit before entering the lake. Not sure in the fish sample if bullhead were caught, in 2021 I observed bullhead being eaten by blue herons several times. Most of the homes along the lakeshore have buffers from their yards which is good to see. Most of us do not use fertilizers that are on the lake side, in my observation. Hennepin county GIS has great imagery

history of the lake going back to the 1940s. in the 40s-60s and in the 1988 image the lake was higher than even in 2020 (to the point that you can even see the island area defined which gave the lake its name). Clearly the 62 work made a huge difference in water making it into the lake as in 1989 it shrunk to nearly nothing (along with the drought that year). While climate change may be a factor, comparing aerial photos of Birch Island, Lake Rose, Wing Lake over the years, (and anecdotally from living at lake rose) Birch Island has suffered greatly from construction and water diversion compared to those lakes in water quality and water levels (seeing algae in the aerials vs not) - wing and rose fluctuated very little vs Birch Island nearly drying up

Needs buckthorn removal plan , lack of tree diversity

There are not many places left that give you the feeling that you are in the wilderness, while still being so close to the city. Birch Island Lake is one of those places. I've heard stories from the old-timers in the neighborhood of how they actually use to fish and water ski on Birch Island Lake. I just hope it can make a comeback to what it once was.

I walk around this lake every day. I consider it a gift to be able to witness wildlife, trees majestic sunrises and sunsets. Many others enjoy this space, although I rarely see more than one or two people a day. Someone (or multiple people) leaves painted rocks, ornaments, mini stained glass windows along the trail. Discovering these treasures brings a smile to my face and delight in humanity.

I would love to see the conditions of the lake improve as it's home to lots of wildlife. Definitely a hidden gem in Eden Prairie.

Please help us keep this lake healthy and beautiful

None

I am extremely concerned about water level. What is affecting this?

Would you like city or watershed district staff to contact you about any of your survey responses?

16 out of 16 answered

Yes 7 resp. 43.8%

No 9 resp. 56.2%

Do you live in the 55346 zip code?

16 out of 16 answered

Yes 16 resp. 100%

No 0 resp. 0%

How long have you lived at your current residence?

16 out of 16 answered

1-5 years	4 resp.	25%
11-15 years	4 resp.	25%
6-10 years	4 resp.	25%
16-20 years	1 resp.	6.2%
21-25 years	1 resp.	6.2%
26-30 years	1 resp.	6.2%
31-35 years	1 resp.	6.2%
36-40 years	0 resp.	0%
41+ years	0 resp.	0%
Does not apply	0 resp.	0%
Less than 1 year	0 resp.	0%

Do you keep leaves and grass clippings off sidewalks, driveways, and roads?

16 out of 16 answered

Yes, I do this	16 resp.	100%
No, and I would not consider doing this	0 resp.	0%
No, but I would consider doing this	0 resp.	0%
This action does not apply to my situation	0 resp.	0%

Do you direct downspouts to green spaces instead of sidewalks driveways, or other hard surfaces?

16 out of 16 answered

Yes, I do this	15 resp.	93.8%
This action does not apply to my situation	1 resp.	6.2%
No, and I would not consider doing this	0 resp.	0%
No, but I would consider doing this	0 resp.	0%

Have you ever had a soil test done to better understand proper fertilization rates for your lawn?

16 out of 16 answered

No, but I would consider doing this — 9 resp. 56.2%

No, and I would not consider doing this — 4 resp. 25%

Yes, I have done this — 3 resp. 18.8%

This action does not apply to my situation — 0 resp. 0%

Do you leave an unmowed edge on the shoreline of Birch Island Lake?

16 out of 16 answered

This action does not apply to my situation — 10 resp. 62.5%

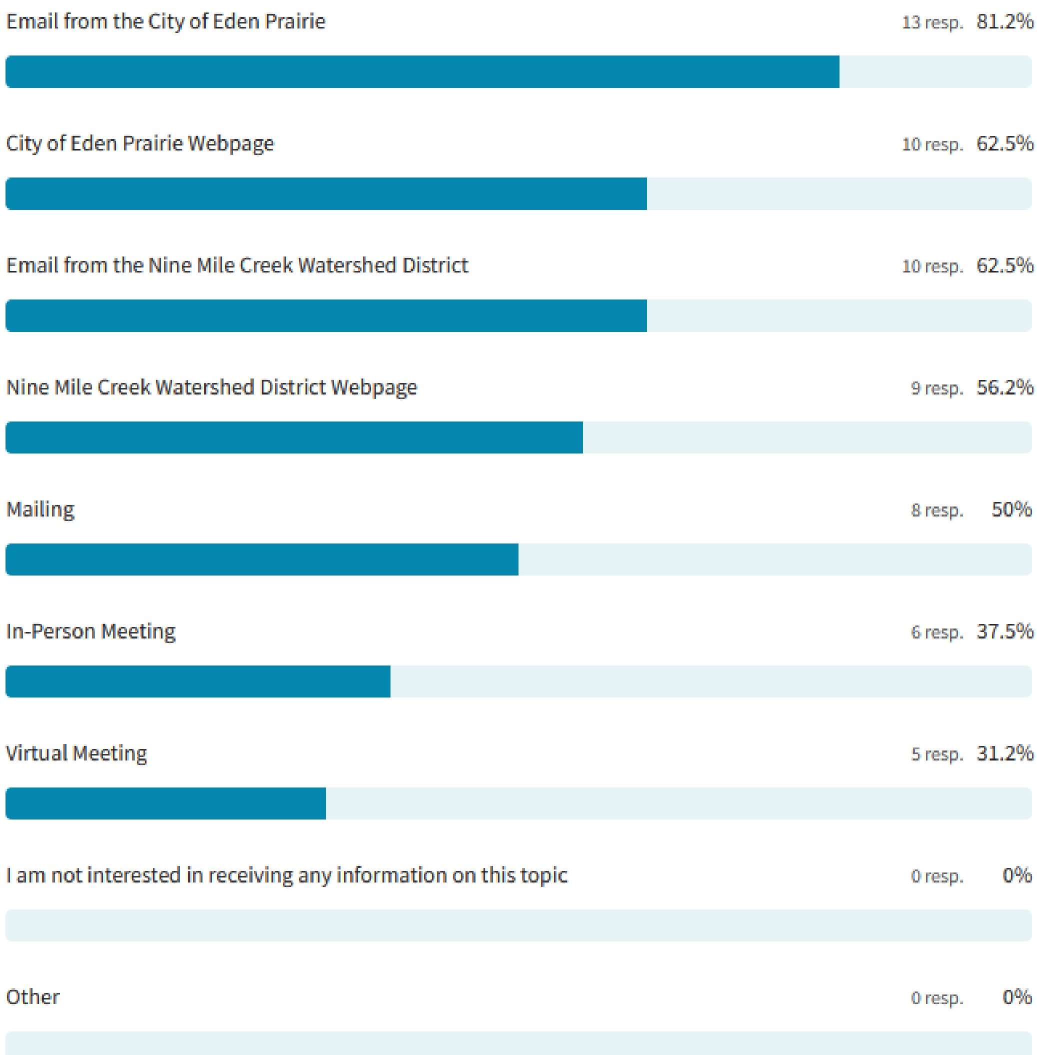
Yes, I do this — 6 resp. 37.5%

No, and I would not consider doing this — 0 resp. 0%

No, but I would consider doing this — 0 resp. 0%

How would you like to receive information about the Birch Island Lake Water Quality Study and any future projects that may result from the study?

16 out of 16 answered



Appendix E

Opinions of Probable Cost

2023 Water Quality Study for Birch Island Lake

ENGINEERS OPINION OF COST

BIRCH ISLAND LAKE SEDIMENT TREATMENT				
ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	COST
Buffered Alum Sediment Treatment (Application 1)	LS	1	$ 43,000.00	$ 43,000.00
Engineer Data Review/Field Observation	HRS	12	$ 170.00	$ 2,040.00
Annual Water Quality Monitoring	YR	5	$ 3,500.00	$ 17,500.00
Sediment Coring	EA	1	$ 15,000.00	$ 15,000.00
Project Planning/Design	HRS	50	$ 170.00	$ 8,500.00
			Subtotal =	$ 87,000.00
			Contingency (10%)	$ 8,700.00
			Total	$ 96,000.00
			-30%	$ 68,000.00
			+50%	$ 144,000.00

Assumptions

- Sediment alum application #1 targets the deep depression in Birch Island Lake
- Annual/bi-annual water quality monitoring to determine if subsequent sediment treatment applications are needed
- Follow up sediment coring to determine if a subsequent sediment treatments are needed and over which area(s)
- Engineering assistance with bid administration and contract documents
- Two engineering staff members to observe sediment treatments and perform pH monitoring.
- Estimated total cost is reported to the nearest thousand dollars

2023 Water Quality Study for Birch Island Lake

ENGINEERS OPINION OF COST

NITROGEN SOIL TESTING				
ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	COST
University of Minnesota Soil Testing	EA	47	$ 19.00	$ 883.50
Resident Correspondence/Coordination	HRS	93	$ 100.00	$ 9,300.00
Soil Sample Collection	HRS	47	$ 100.00	$ 4,650.00
Data Review	HRS	16	$ 130.00	$ 2,080.00
Project Planning	HRS	24	$ 120.00	$ 2,880.00
			Subtotal =	$ 20,000.00
			Contingency (10%)	$ 2,000.00
			Total	$ 22,000.00
			-30%	$ 16,000.00
			+50%	$ 33,000.00

Assumptions

- 15% resident participation (approximately 310 single family residences in tributary watershed)
- 2 hours of communication per resident for project background, soil sampling coordination and results summary
- 16 hours of data review by project engineer to assess results of soil sampling on project-wide basis
- Assuming Class 5 opinion of cost with accuracy range of -30% to +50% standards established by the Association for the Advancement of Cost Engineering (AACE).
- Estimated total cost is reported to the nearest thousand dollars