

Black Lake
Watershed Management Plan
2026

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Watershed Advisory Committee

The Watershed Advisory Committee is composed of individuals representing various agencies, local governments, and organizations. This structure allows us to continue to build relationships, make connections, and work together for the betterment and protection of our water resources.

Watershed Partners:

Black Lake Association
Black Lake Preservation Society
Cheboygan County Planning & Zoning
Cheboygan County Planning Commission
Cheboygan County Road Commission
Headwaters Land Conservancy
Headwaters Trout Unlimited
Huron Pines
Keiser & Associates
Little Traverse Conservancy
Michigan Department of Environment, Great Lakes, and Energy
Michigan Department of Natural Resources
Sturgeon for Tomorrow
Tip of the Mitt Watershed Council
Upper Black River Council
US Fish & Wildlife Service

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Executive Summary

The Black Lake Watershed is a high-quality natural resource that supports ecological, recreational, and community needs throughout northern Michigan. This Watershed Management Plan (Plan) was developed through a collaborative process led by the Tip of the Mitt Watershed Council (TOMWC) and the Black Lake Watershed Advisory Committee which is composed of local governments, landowners, and other partners. Its purpose is to identify priority concerns, outline management strategies, and guide coordinated actions to protect and restore water quality, habitat, and watershed function. The Plan follows the United States Environmental Protection Agency's (EPA) nine-element watershed planning framework and aligns with guidance from the Michigan Department of Environment, Great Lakes, and Energy (EGLE).

Watershed Conditions

Overall, the Black Lake Watershed remains in good condition, with the majority of water bodies meeting state water quality standards. Surface waters support coldwater and warmwater fisheries, recreational uses, and other indigenous aquatic life. Despite generally healthy conditions, the Watershed is vulnerable to nonpoint source pollution and other environmental stressors that could degrade water quality and ecosystem function. Known concerns include nutrient and sediment loading, habitat loss, pathogens, invasive species, and emerging threats such as microplastics, and the impacts of climate change. While no water bodies are currently listed as impaired due to nonpoint sources, several streams are impacted by elevated E. coli or mercury levels, requiring ongoing vigilance.

Critical and Priority Areas

The Plan identifies critical areas where the greatest need for restoration or protection exists. These include high-priority agricultural sites, streambank erosion hotspots, stormwater problem areas, and sensitive shoreline sections around Black Lake. The shoreline is considered a critical zone, as it is particularly vulnerable to erosion, nutrient inputs, septic system impacts, and development pressures. A priority parcel analysis guides where permanent land protection efforts will have the most significant impact. Currently, approximately over half of the watershed is already protected, while remaining parcels are ranked from very low to very high priority for future protection initiatives.

Goals and Actions

Eight overarching goals guide the Plan:

1) Promote a culture of collaborative and comprehensive watershed protection and stewardship
2) Protect and improve water quality to support ecological health and desired uses
3) Protect and enhance recreational opportunities
4) Maintain the watershed's rural character to support water quality protection
5) Prevent and manage the spread of aquatic and riparian invasive species
6) Protect the health, habitat and safety of all watershed inhabitants
7) Make watershed stewardship accessible for everyone
8) Build trust and a sense of shared responsibility

Each goal is supported by clear objectives and actionable strategies, including water quality monitoring, land protection, habitat restoration, best management practices implementation, regulatory approaches, and education and outreach programs.

Implementation and Monitoring

The Plan emphasizes adaptive, data-driven management. Implementation tasks are prioritized based on critical areas, identified threats, and available resources. Monitoring programs track surface water quality, biological indicators, shoreline and streambank conditions, stormwater impacts, land use changes, and emerging threats. Social and economic indicators are also included to evaluate public engagement and the broader impacts of watershed protection activities.

Conclusion

The Black Lake Watershed Management Plan provides a science-based, stakeholder-driven framework to safeguard water quality, habitat, and community values. By focusing on priority areas, engaging partners, and applying adaptive monitoring, the Plan helps ensure that the Black Lake Watershed remains resilient, vibrant, and protected for current and future generations. Its success relies on ongoing collaboration, voluntary stewardship, and coordinated action across the watershed community.

Introduction

Northern Michigan is known for its outstanding lakes and streams, and its water resources are legendary. We depend on these waters for our livelihoods, recreation, and traditions. In return, we must be responsible stewards, working collaboratively and continually to protect these resources for today and for future generations.

Comprehensive water quality monitoring is essential to inform natural resource management, assess lake conditions, and protect public health. While the Michigan Department of Environment, Great Lakes, and Energy (EGLE) is the lead state agency for monitoring and managing surface and groundwater, effective water resource management relies on partnerships among state and federal agencies, local governments, tribes, universities, environmental groups, and citizen volunteers.

The Black Lake Watershed Management Plan is the result of a collaborative approach. Developed by the Tip of the Mitt Watershed Council (TOMWC), the Black Lake Watershed Advisory Committee, and other stakeholders, the Plan integrates aquatic resource inventories, data analysis, and community input into a comprehensive framework for watershed protection. It outlines shared goals, objectives, and implementation tasks designed to maintain high-quality water, restore degraded areas, and guide long-term management decisions.

The Watershed Approach

A watershed approach considers the abundance, location, and condition of aquatic resources within a drainage area, rather than focusing on individual water bodies. This method supports broader landscape functions and enables coordinated management across jurisdictions. According to the United States Environmental Protection Agency (EPA), a watershed plan is a flexible, science-based framework that:

1) Engages stakeholders in decision-making
2) Characterizes existing conditions
3) Identifies and prioritizes problems
4) Defines objectives and management strategies
5) Guides implementation and monitoring

By applying this approach, the Black Lake Watershed Management Plan addresses the sources and causes of priority nonpoint source pollutants and other water quality threats. It identifies the areas most impacted and recommends tasks to protect or enhance water quality. Proactive watershed planning is particularly important for high-quality waters.

This Plan adheres to the EPA nine-element framework required for funding under Section 319 of the Clean Water Act, ensuring it is both scientifically sound and actionable. Development of the Plan began in 2023 with support from EGLE and was completed in 2026 with active involvement from the Advisory Committee. It incorporates nonpoint source pollution inventories, water quality assessments, and strategies for implementation, education, monitoring, and evaluation. It reflects the current conditions and long-term needs of the watershed.

1. WATERSHED CHARACTERIZATION

Introduction

The Black Lake Watershed is home to some of Michigan's most treasured natural resources. Its large, high-quality water bodies, including Black Lake and its surrounding lakes and rivers, provide vital habitat for fish, a wide range of recreational opportunities, and a peaceful natural escape. These resources are essential not only to the thousands of residents who live and recreate within the watershed, but also to the many tourists who visit the area each year. Northern Michigan depends on these natural assets, and their protection is critical to the region's economy, environment, and the health of all living things that rely on them. The Black River Watershed lies within the larger Cheboygan River Watershed (HUC 04070004) (Figure 1), which has approved watershed management plans for Mullett Lake, Lower Black/Cheboygan Rivers (2024), and Burt Lake (2018). As part of the Cheboygan River Watershed, the Black Lake Watershed is 558 square miles comprising 37.7 % of the 1,493-square-mile Cheboygan River Watershed.

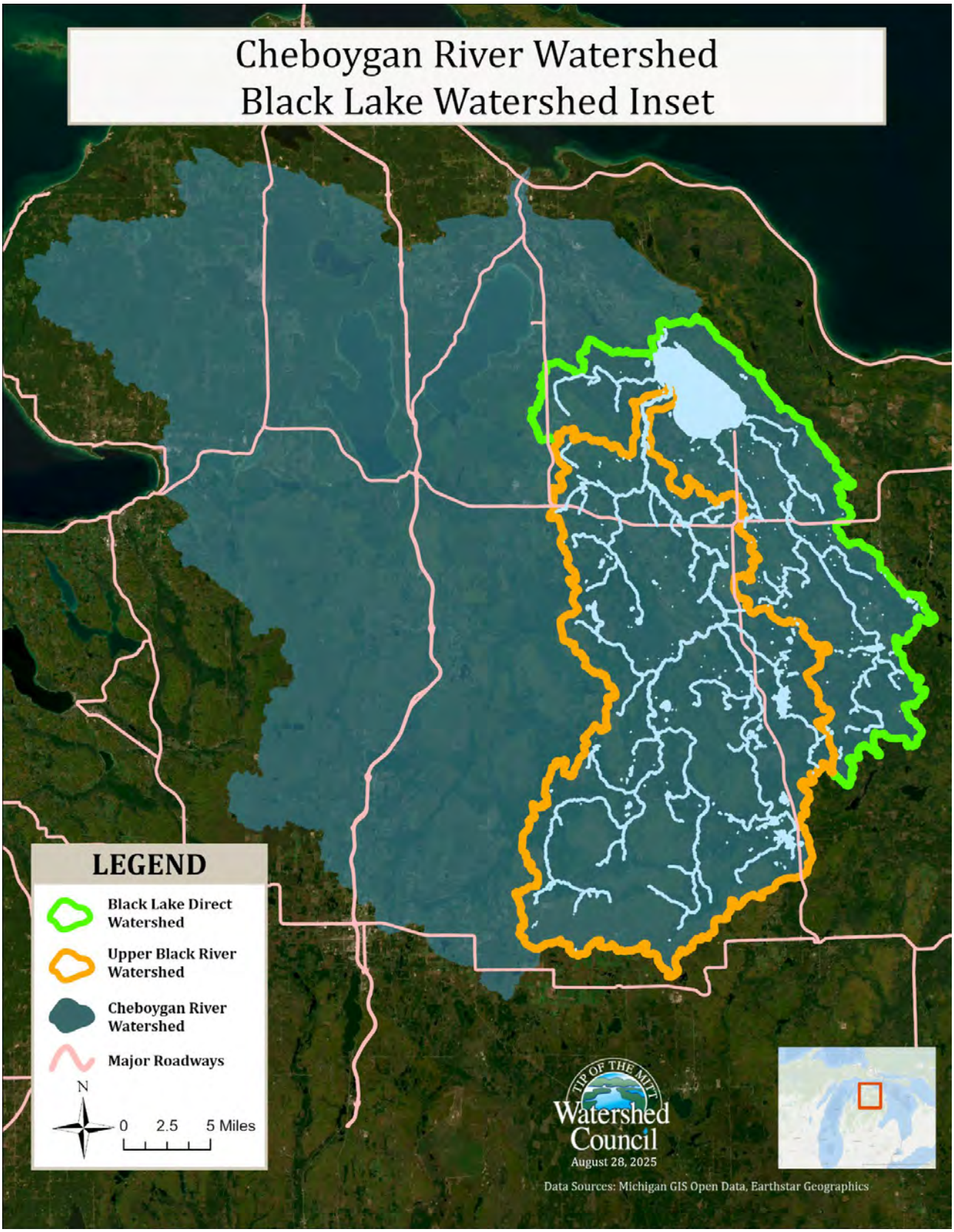


Figure 1. Cheboygan River Watershed

The watershed includes major rivers and tributaries such as Tomahawk Creek, Canada Creek, and the East Branch of the Black River, which are popular for hunting, fishing, hiking, camping, and other outdoor recreation. Canada Creek hosts the Canada Creek Ranch community, where residents live along the riverbank or nearby lakes including Lake Geneva. Kleber and Tower Ponds on the Upper Black River are also heavily used for recreation. Black Lake itself supports a healthy and diverse fishery, including muskellunge, northern pike, yellow perch, walleye, and bass, and is especially noted for its population of self-sustaining lake sturgeon, a state threatened species with a highly regulated February harvest season.

The Black Lake Watershed lies between the Mullett Lake Watershed to the west, the Thunder Bay Watershed to the south, and the Lake Huron Watershed to the north and east. The watershed extends approximately 36 miles north to south and reaches a maximum width of 21 miles in Presque Isle County. A significant portion of the watershed falls within the Pigeon River Country State Forest, which spans about 120 square miles and represents the largest contiguous block of state-owned land in Michigan's Lower Peninsula. This area receives enhanced protection due to its unique ecological features, including Michigan's only elk herd, pristine rivers and lakes, and a distinct wilderness character.

Despite its largely rural character, the watershed's natural systems face increasing pressures from human activities and land-use changes, which can degrade water quality and disrupt ecosystem functions. Continued recreational and economic benefits depend on maintaining clean, healthy water. Through coordinated watershed management, land protection, and community education efforts, these vital ecosystems can be safeguarded and their resilience ensured for generations. As is referenced in later parts of this plan, the Black Lake Watershed has two major subwatersheds (Figure 2).

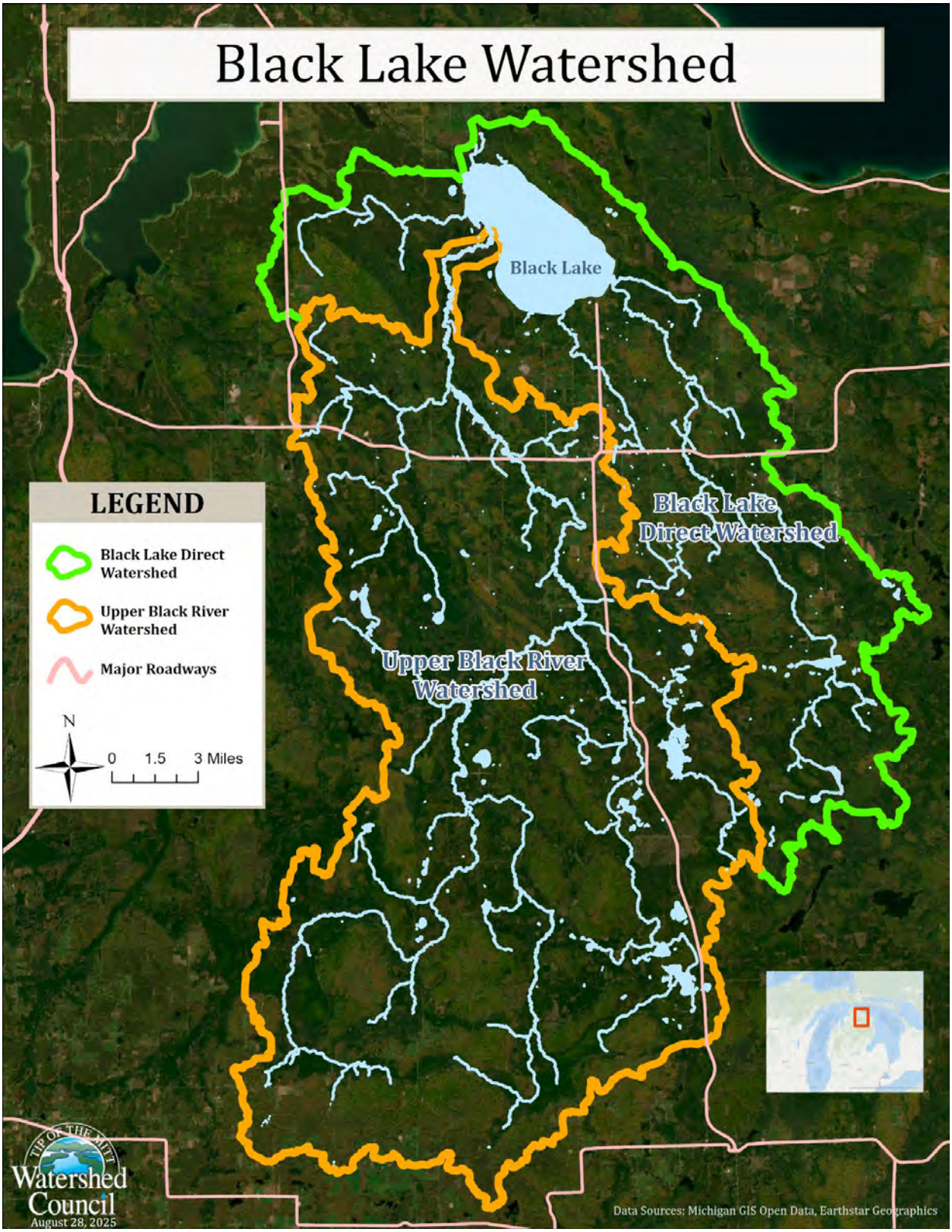


Figure 2. Black Lake Watershed

BLACK LAKE DIRECT SUBWATERSHED:

Lakes: Black Lake, Comstock Lake, Gorman Lakes, Hackett Lake, Healy Lake, Hessler Lake, Krauth Lake, Lower Tomahawk Lake, McAvoy Lake, Mud Lake, Rainbow Lake, Rainy Lake, South Gorman Lake, and Upper Tomahawk Lake

Rivers & Streams: Cains Creek, Cold Creek, Fisher Creek, Little Mud Creek, Little Rainy River, Rainy River, Stewart Creek, Stony Creek, and the Upper Black River

UPPER BLACK RIVER SUBWATERSHED:

Lakes: Bear Den Lake, Bear Lake, Black Lake, Blue Lakes, Clear Lake, Dog Lake, Dollar Lake, Dorsy Lake, Doty Lake, East Town Corner Lake, Foch Lakes, Francis Lake, Gingell Lake, Hardwood Lake, Horsehead Lake, Jackson Lake, Kleber Lake, Lake Geneva, Lake LaBarge, Little Joe Lake, Little Tomahawk Lake, Lloyd Lake, Long Lake, Loon Lake, Lost Lake, Marsh Lake, McLavey Lake, Muskellunge Lake, Osmun Lake, Pug Lakes, Round Lake, Shoepac Lake, Silver Lake, Stewart Lake, Tomahawk Lake, Tower Pond, Town Corner Lakes, Town Line Lakes, Twin Tomahawk Lakes, Upper Tomahawk Lake, Valentine Lake, Virginia Lake, Walled Lake, West Town Corner Lake, Wildfowl Lake

Rivers & Streams: Black River, Canada Creek, East Branch Black River, Gillis Creek, Gokee Creek, Hardwood Creek, Lyons Creek, McMasters Creek, Milligan Creek, Montague Creek, Oxbow Creek, Packer Creek, Rattlesnake Creek, Saunders Creek, Stewart Creek, Stoney Creek, Tomahawk Creek, Upper Black River, Van Helen Creek, and Welch Creek

Land Cover

Land cover refers to the material present at the surface of the earth. Land cover may be either a biological (e.g. grassland or pine forest), physical (e.g. lake or parking lot) or chemical (e.g. concrete or asphalt) categorization of the surface. Although land use/land cover can be (and has been) categorized in great detail, there are four basic land use/cover types: urban, agricultural, wetland, and collectively forest/grass/scrub. The type of land and the intensity of its use will have a strong influence on the receiving water resource. Studies have determined the likely inputs of nutrients and other pollutants from different land uses/cover types.

The Watershed encompasses over 350,000 acres, over half of which is forest/grass/scrub (60%) followed by wetlands with the next highest land use (28%). These high-quality waters are protected by the low impact land use types that make up most of the land use (Table 1) (Figure 3). The National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program shows that between 1985 and 2016, the largest change in land cover occurred in urban areas going from about 5,700 acres to close to 13,000 acres, which is an increase of over 100%.

Table 1. Land Use (1985-2016)

Land use category	1985	2016	% change
Agriculture	19,458.10	17,329.56	−10.94
Barren	241.58	264.72	9.58

Forest/Grassland/Shrub	241,255.81	230,691.25	−4.38
Urban Development	5,723.06	12,890.36	125.24
Water	24,290.60	24,460.63	0.7
Wetland	106,521.62	104,628.37	−1.78

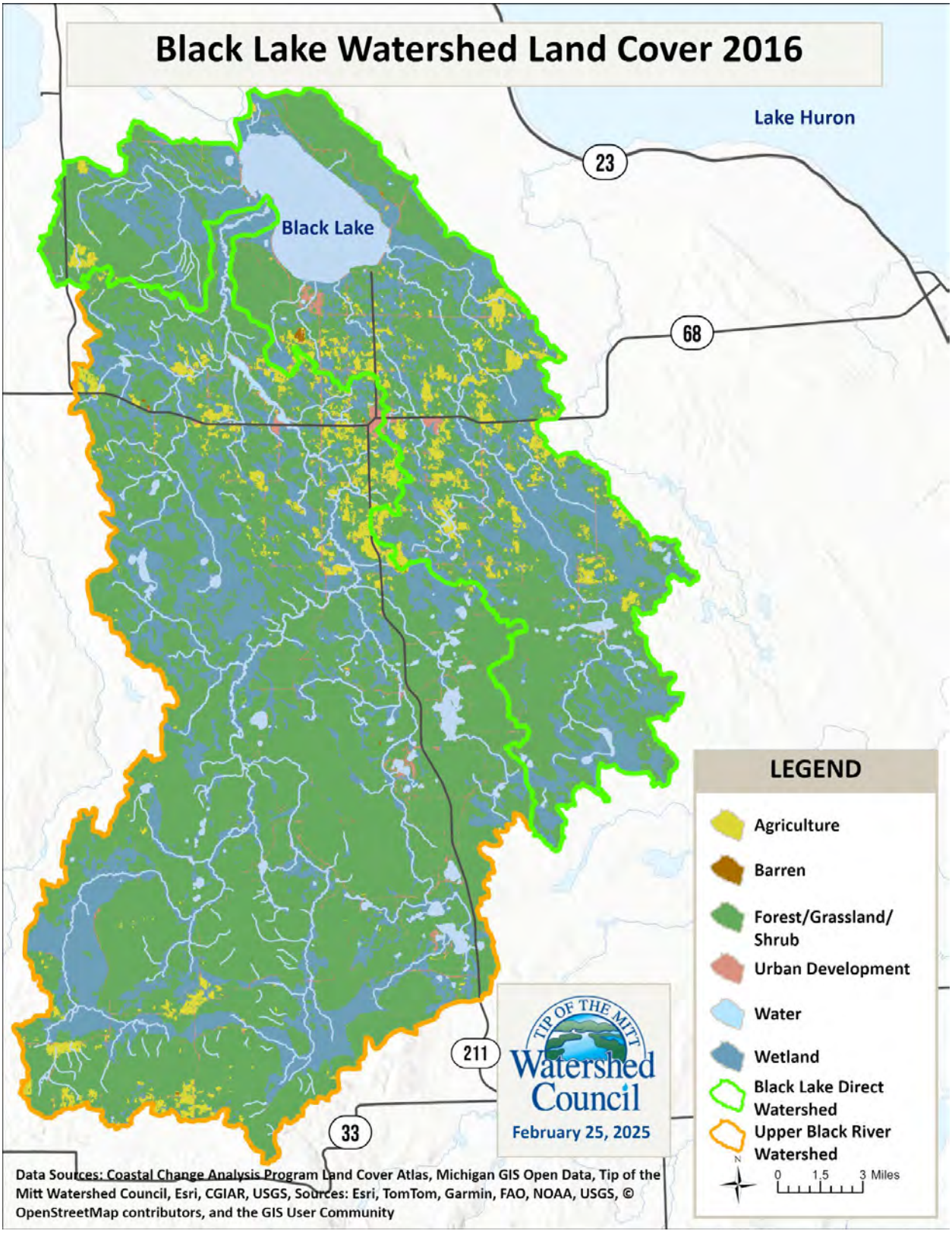


Figure 3. Land Cover 2016

Glacial History

The size, depth, and configuration of the lakes and rivers of the Watershed were shaped in large part by the advance and retreat of vast continental glaciers. The last advance of the glaciers, which covered most of Cheboygan and Emmet counties, was known as the Valders Advance. It left behind deposits of till (material carried and deposited directly by the ice) and outwash (till that has been washed, sorted, and deposited by glacial meltwaters). Many of the high hills in Cheboygan River Watershed are deposits of glacial till called moraines. The thickness of the glacial deposits varies from less than 50 feet to more than 600 feet.

The deep lakes of northern Michigan were formed when huge blocks of ice were left in the area during glacial retreat. As these huge ice blocks melted they left behind the deep basins which now make up the lakes. As the glaciers receded, meltwaters flooded the region. Many of the low-lying wetland areas were once under water. The entire area was part of vast lakes known as Lakes Algonquin and Nipissing, precursors to the modern Great Lakes.

The geology of the region is variable due to its glacial origin. As the glaciers advanced and retreated across the landscape, they deposited the debris scraped from the land surface. In many areas of Northern Michigan, this glacial drift is hundreds of yards thick. It is composed of a mixture of sand, gravel, and rocks in a matrix of silt and clay. These deposits of dolomite, limestone, and shale, overlay limestone bedrock in the watershed. Bedrock is found near the surface in a few areas but is generally more than 300 feet below the surface throughout most of the inland waterway.

The important ground water aquifers of the watershed lie in glacial deposits. The characteristics of these aquifers depend upon the nature and thickness of materials composing the deposits. Silt and clay are less permeable than sand and gravel, and thick deposits have more water holding capacity than thin deposits. Generally, areas of glacial till are less productive aquifers than outwash deposits. Outwash deposits were most commonly formed in glacial meltwater channels and these areas are where most streams are found today.

The generally thick glacial deposits in the watershed result in ample ground water aquifers and a large number of springs and streams with cold, steady, high quality flows of ground water. The bedrock geology and the large amount of limestone in the glacial deposits influences the chemical quality of ground water and most surface waters, resulting in moderately high hardness and alkalinity.

Soils

Soils are an important watershed feature for the determination of types and intensity of land uses and many aspects of water resource management (Figure 4). Soil is the unconsolidated material within six feet of the surface that has been modified from the “parent” glacial deposits by climate, biological processes, and other environmental factors. Water quality is partially based on the nature of the soils and the slope of the land within the drainage basin. These factors determine potential land use, soil infiltration rates, water-holding capacity and soil erodibility and therefore are directly related to the amount of non-point

source pollution in the watershed such as groundwater recharge, septic system performance, and erosion/sedimentation potential.

In the United States, soils are assigned to four hydrologic soil groups, A, B, C, and D (Table 2). This describes their rate of water infiltration when the soils are not protected from vegetation, are thoroughly wet and receive precipitation from long-duration storms. The hydrologic soil groups in the Watershed include largely A groups, followed by B, C and D. Group A consists of soils that have high infiltration rates even when thoroughly wet, because of sandy or gravelly, well-draining soils. Group B has moderate infiltration rates. Groups C and D have respectively slower infiltration rates when thoroughly wet, due to fine texture or clay-rich soils.

Table 2. Hydrologic Soil Groups

Group	Infiltration Rate	Soil Characteristics	Runoff Potential
A	High	Deep, well-drained to excessively drained sands or gravels; rapid water transmission	Low
B	Moderate	Moderately deep/deep, moderately well/well-drained soils; moderately fine to moderately coarse textures	Moderate
C	Slow	Soils with a layer restricting downward water movement OR fine/moderately fine textures	Moderately High
D	Very slow	Clayey soils with high swelling potential, high water table, claypan, or shallow soils over impervious material	High

The Hydrologic Group indicates the expected runoff when soils are saturated, with Group A producing the least runoff and Group D producing the most. Poorly drained soils generally fall into Group D. Certain wet soils are placed in Hydrologic Group D if a water table occurs within 60 centimeters of the surface, even if the soil's natural water transmission is good. If these soils can be properly drained so the water table remains at least 60 centimeters below the surface, they are assigned dual hydrologic soil groups (A/D, B/D, or C/D). In dual groups, the first letter represents the soil's condition when adequately drained, and the second represents the natural, undrained condition.

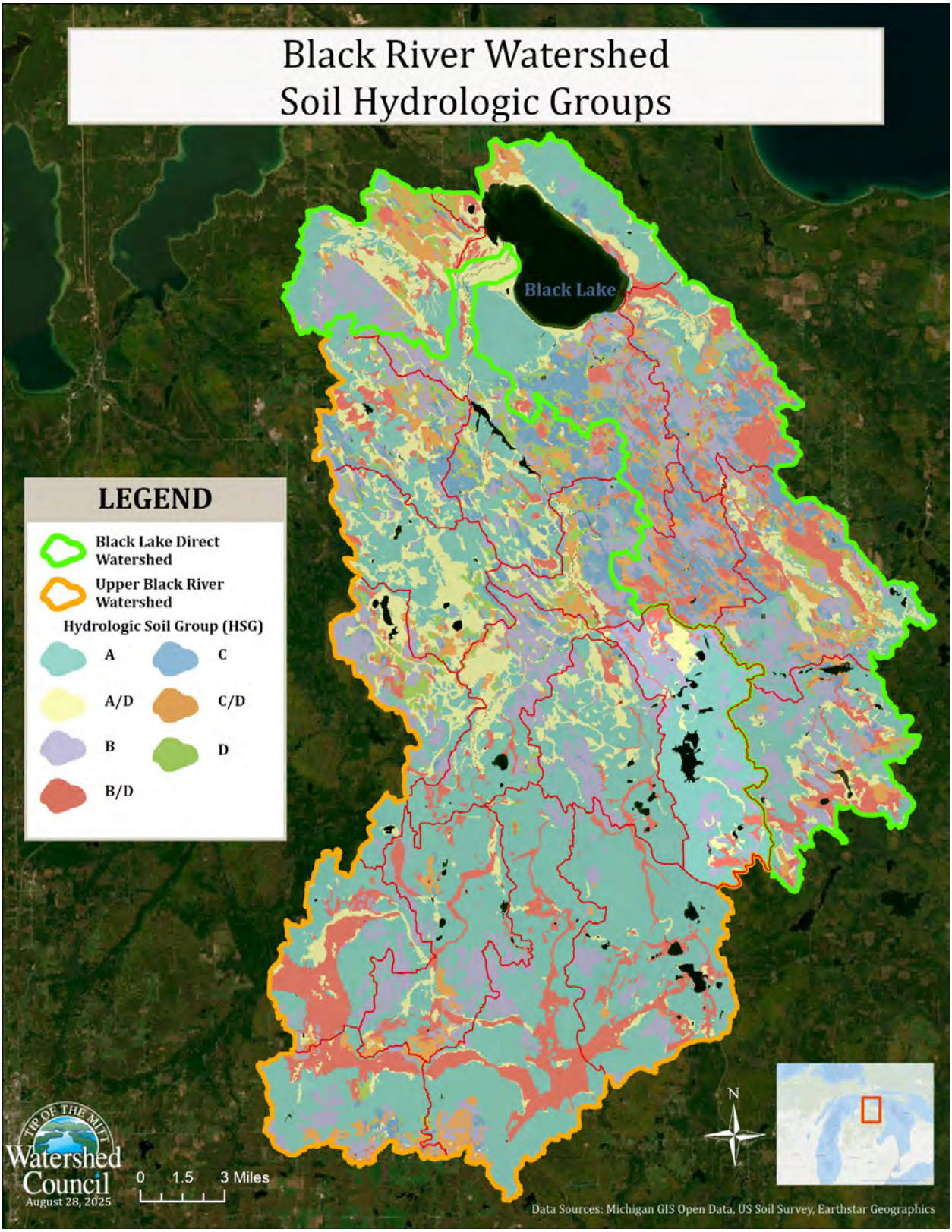


Figure 4. Soil groups

Climate

The local climate for the Watershed varies slightly because of the extensive size and varying topography. In general, summers are mild and winters are snowy and cold. Below are the tables and graphs for Onaway, located at the northern part of the watershed and Gaylord at the southern end (Figure 5 and Figure 6).

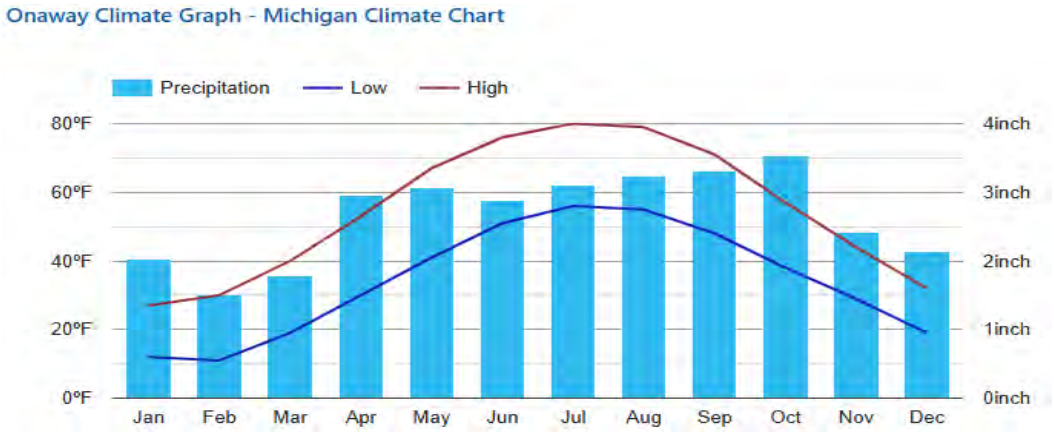


Figure 5. Average temperature and precipitation for Onaway (www.usclimatedata.com)

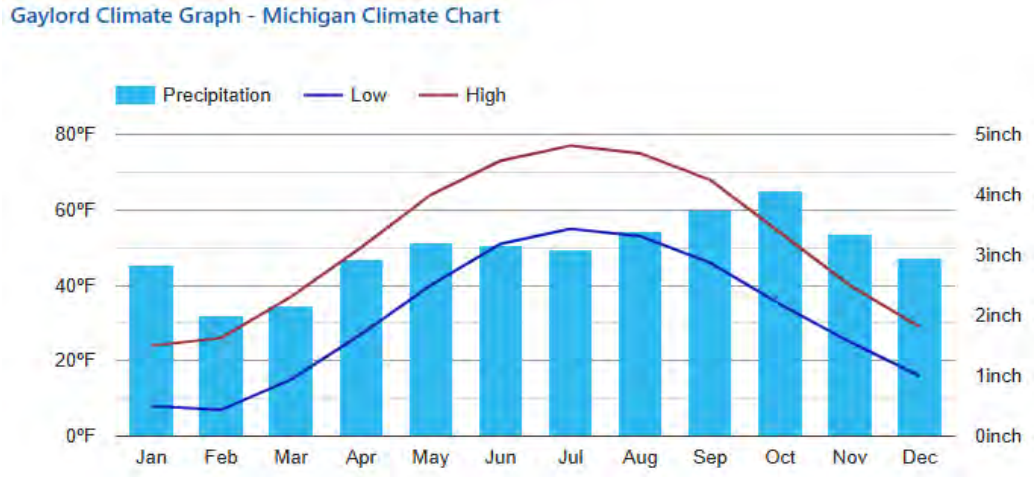


Figure 6. Average temperature and precipitation data for Gaylord (www.usclimatedata.com)

According to GLISA, a partner in NOAA's Great Lakes Climate Adaptation Partnership team, the Great Lakes region is experiencing a 2.9-degree Fahrenheit increase in average temperature, an increase of 18 frost-free days each year, a 15% rise in total precipitation, and a 36% increase in the intensity of heavy precipitation events. Temperature and precipitation departure from the average for Gaylord, Michigan can be found in Figure 7 and Figure 8 .

These changes can lead to a wide range of negative impacts, including effects on public health, extreme weather conditions, snow and ice cover, lake temperatures, and lake levels. They also influence the severity of algal blooms, the health of fish and wildlife populations, forest composition and health, and agricultural productivity, among many other areas.

For the watershed, these trends create significant challenges. Warmer temperatures and reduced ice cover can alter stream flows and water temperatures, stressing cold-water fish species and disrupting ecological balance. More intense and frequent heavy rainfall increases stormwater runoff, which contributes to erosion, sedimentation, and the transport of pollutants into rivers and lakes. Higher precipitation and extreme weather can also overwhelm aging stormwater and wastewater infrastructure, raising the risk of flooding and contamination events. Together, these impacts degrade water quality, harm habitat, and reduce the watershed's resilience to future climate pressures.

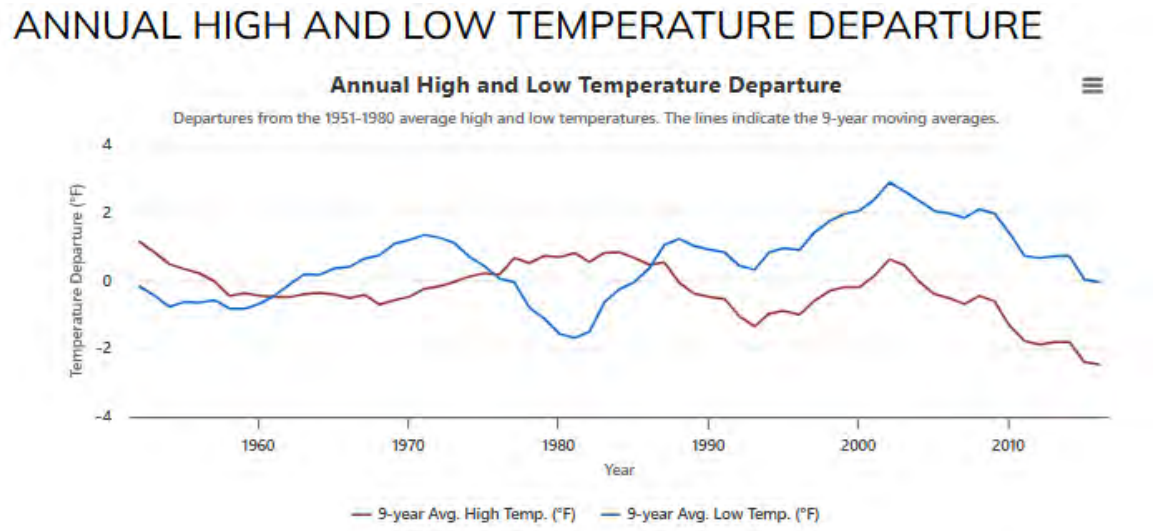


Figure 7. Annual High and Low Temperature Departure for Gaylord, MI (GLISA)

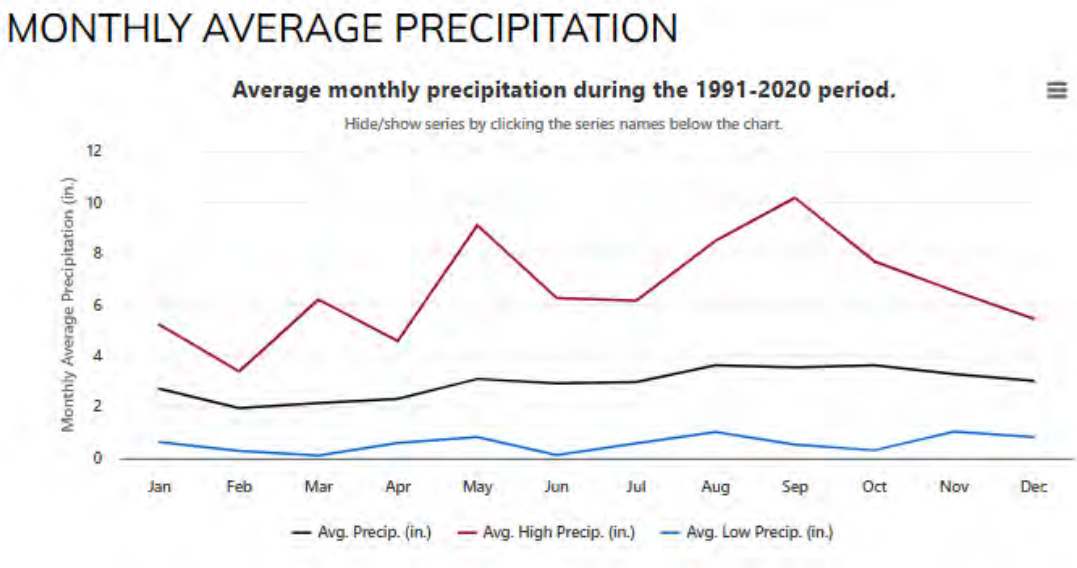


Figure 8. Monthly Average Precipitation for Gaylord, MI (GLISA)

Groundwater

Groundwater is critically important for water quality and ecosystem integrity of lakes, streams, and wetlands. Rain, melting snow, and other forms of precipitation move quickly into and through the ground throughout much of the Watershed due to highly permeable (sandy) soils. Gravity causes vertical migration of groundwater through soils until it reaches a depth where the ground is filled, or saturated, with water. This saturated zone in the ground is called the water table and can vary greatly in depth. Figure 9 illustrates groundwater recharges areas throughout the Watershed based on their respective infiltration rates.

In watershed areas with steep slopes, hillsides intersect the water table, resulting in groundwater expulsion at the land surface (Figure 10). The exposed water table causes horizontal groundwater movement, which releases to create seeps and springs that then form or contribute water to streams and wetlands. The degree of groundwater contributions to surface waters in the Watershed is illustrated in subwatershed maps found in following sections. The data used to generate the maps are based on the Michigan Rivers Inventory subsurface flux model (MRI-DARCY), which uses digital elevation and hydraulic conductivity—inferred from mapped surficial geology—to estimate spatial patterns of hydraulic potential. The model is used to predict groundwater delivery to streams and other surface water systems because biological, chemical, and physical attributes of aquatic ecosystems are often strongly influenced by groundwater delivery.

The surface waters of the Watershed are dependent upon groundwater inputs. This dependency makes it extremely important to protect and conserve groundwater resources in the Watershed. The prevailing sandy soils that facilitate groundwater recharge and expedite groundwater transport to surface waters also present a danger to the aquifers, streams, lakes, and wetlands in the Watershed. Although soils are a natural filtration medium, pollutants associated with agricultural activity (e.g., pesticides, herbicides, nutrients) and the urban or residential environment (e.g., metals, automotive fluids, nutrients) can be transported through the ground and contaminate either drinking water supplies or local surface waters fed by groundwater. Furthermore, expanding development, such as road and house construction, alters the hydrologic cycle by replacing natural land cover with impervious surfaces, which impedes infiltration and groundwater recharge. Therefore, protecting groundwater resources must address both the potential for pollutants to reach and contaminate groundwater and the reduction of groundwater recharge due to development.

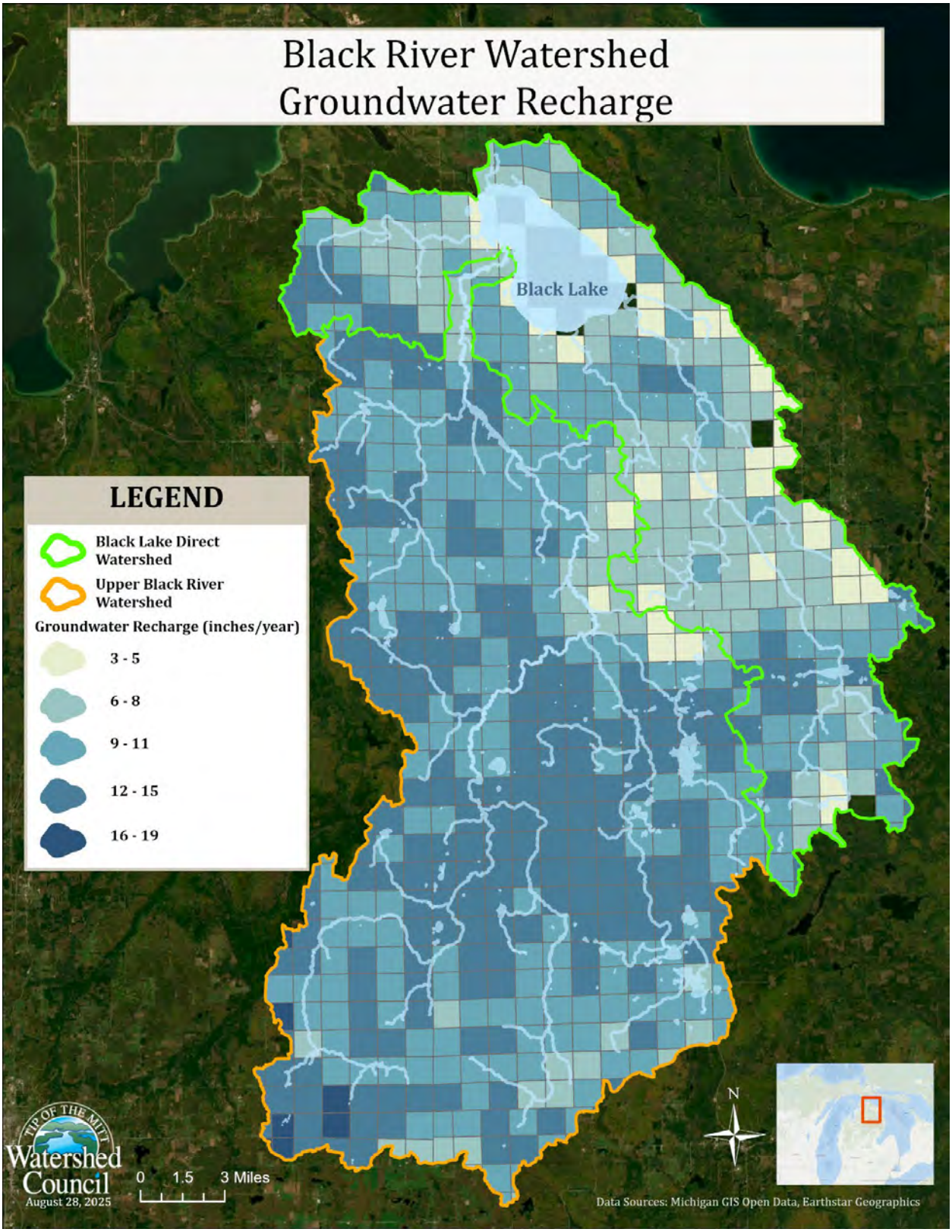


Figure 9. Groundwater recharge

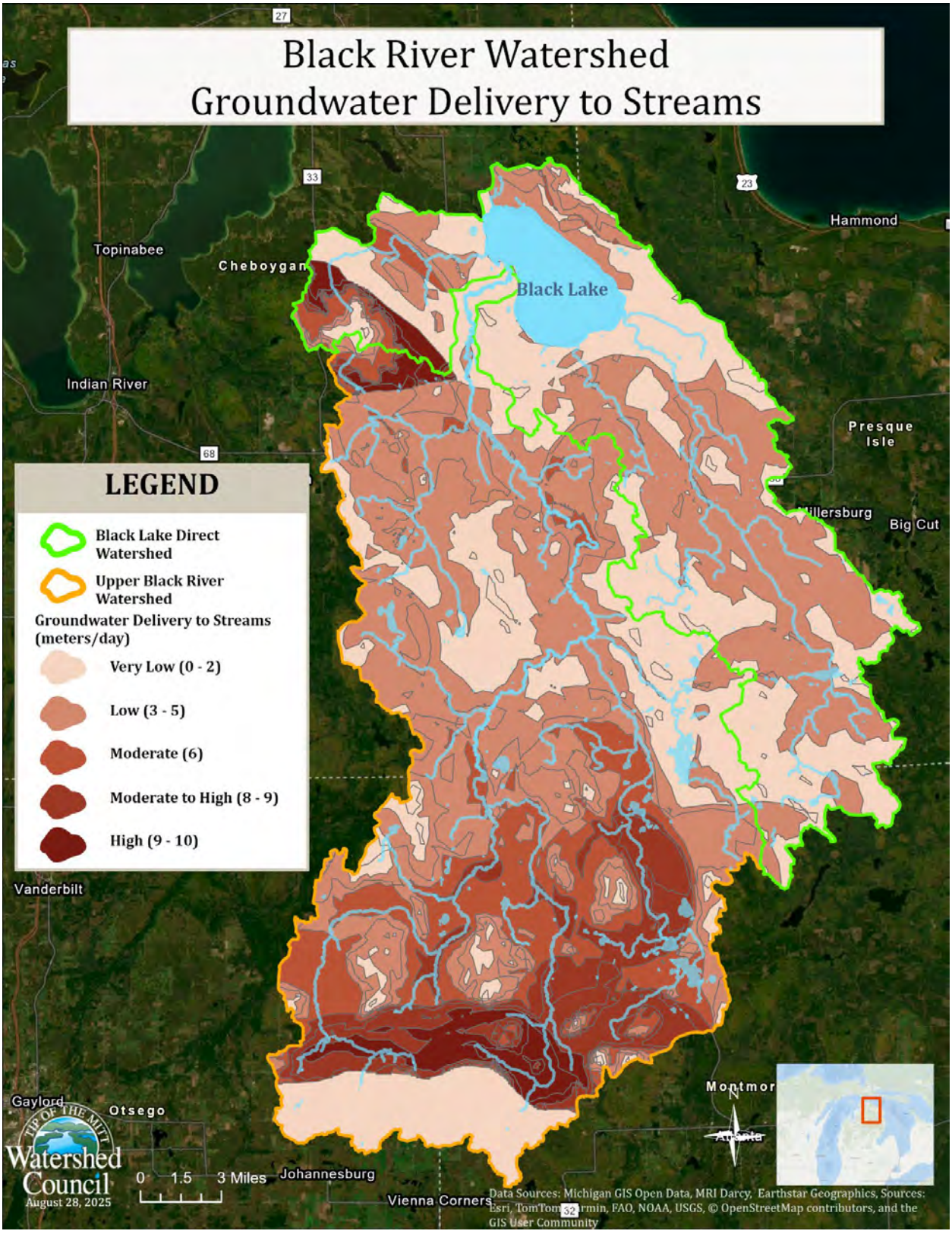


Figure 10. Groundwater delivery to streams

Drinking Water

Groundwater is the drinking water source for all communities within the Black Lake Watershed. Many communities throughout Michigan, in an effort to protect their drinking water systems from many possible contamination sources, have Wellhead Protection Programs (WHPP) and Wellhead Protection Areas (WHPA). These programs are voluntary and designed to be locally initiated and implemented, with EGLE playing a supporting role. The Michigan Rural Water Association (MRWA) provides the expertise of their Groundwater Specialist to aid in the implementation of WHPPs. Michigan also has a Wellhead Protection Grant Program.

A Wellhead Protection Area (WHPA) is defined as the surface and subsurface areas surrounding a water well or well field, which supplies a public water system, and through which contaminants are reasonably likely to move toward and reach the water well or well field within a 10-year time-of-travel. The purpose of developing a WHPP is to identify the WHPA and take the necessary steps to safeguard the area from contaminants. The State of Michigan requires communities to identify seven elements to be included in the WHPP. These elements along with a brief description are below (MRWA 2015).

Roles and Responsibilities: Identify individuals responsible for the development, implementation, and long-term maintenance of the local WHPP.

WHPA Delineation: Determine area that contributes groundwater to the public water supply wells.

Contaminant Source Inventory: Identify known and potential sites of contamination within the WHPA and include in a contaminant source inventory list and map.

Management Strategies: Provide mechanisms that will reduce the risk of existing and potential sources of contamination from reaching the public water supply wells or well field.

Contingency Planning: Develop an effective contingency plan in case of a water supply emergency.

Siting of New Wells: Provide information on existing groundwater availability, the ability of the Public Water Supply System to meet present and future demands and the vulnerability of the existing wells to contamination.

Public Education and Outreach: Generate community awareness in the WHPP by focusing on public education and the dissemination of WHPP information.

There are two wellhead protection areas that lie entirely within the watershed, United Auto Workers Black Lake Conference Center and Onaway, and two that lie on the cusp, Afton (west) and Millersburg (east) (Figure 11).

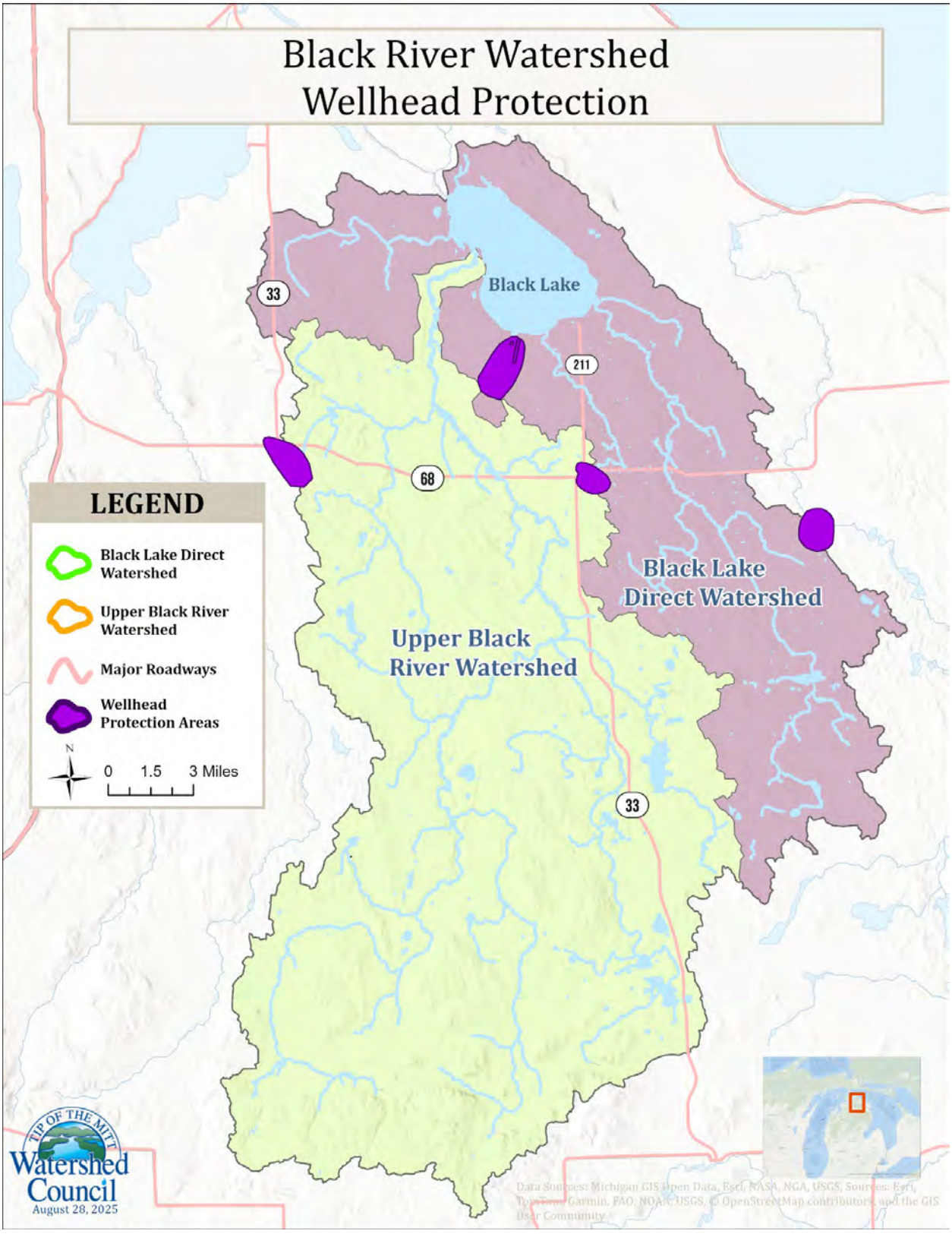


Figure 11. Wellhead protection areas

Ecoregion

Ecoregions are regions that have relatively similar ecological systems. Ecoregions display regional patterns of environmental factors, such as climate, vegetation, soils, geology, physiography, and land use: the same factors that determine water quality within a watershed. Adjacent watersheds may or may not be within the same ecoregion.

The ecoregion concept is not new, having been described as early as 1905. Subsequently, a number of ecoregion classification schemes have been developed. A widely utilized classification scheme identifying 120 ecoregions throughout the continental United States was developed by the EPA in the 1980s. The Cheboygan River Watershed, of which the Black Lake Watershed is included, lies entirely within an ecoregion called “Northern Lakes and Forests” (#50).

The Northern Lakes and Forests ecoregion is characterized by nutrient-poor soils, forests of conifers and northern hardwoods that cover a landscape of undulating till plains, morainal hills, broad lake basins, and extensive sandy outwash plains. Numerous lakes dot the landscape. Farming is not common. Logging and fires in the past have had great impacts on water quality, but the water quality remains high overall. Today, the effects of land use on water quality, especially in streams, are generally minimal. In fact, the portion of this ecoregion at the northern tip of Michigan’s lower peninsula contains lakes that tend to have summer concentrations of total phosphorus less than five parts per million. Few other areas in the upper Midwest have lakes with such high-water quality.

Fisheries

The Watershed includes some of the greatest fisheries within the state, including approximately 60 miles of Blue-Ribbon trout streams (Black River, East Branch Black River, and Canada Creek). Although many segments of coldwater streams are classified as designated trout streams, some are considered Blue Ribbon trout streams because they meet higher standards. These include their capacity to support stocks of wild resident trout, are large enough to permit fly casting but shallow enough to wade, produce diverse insect life and good fly hatches, have earned a reputation for providing a quality trout fishing experience and have excellent water quality. The three Blue-Ribbon trout streams are the Black River, Canada Creek, and the East Branch Black River (Figure 12).

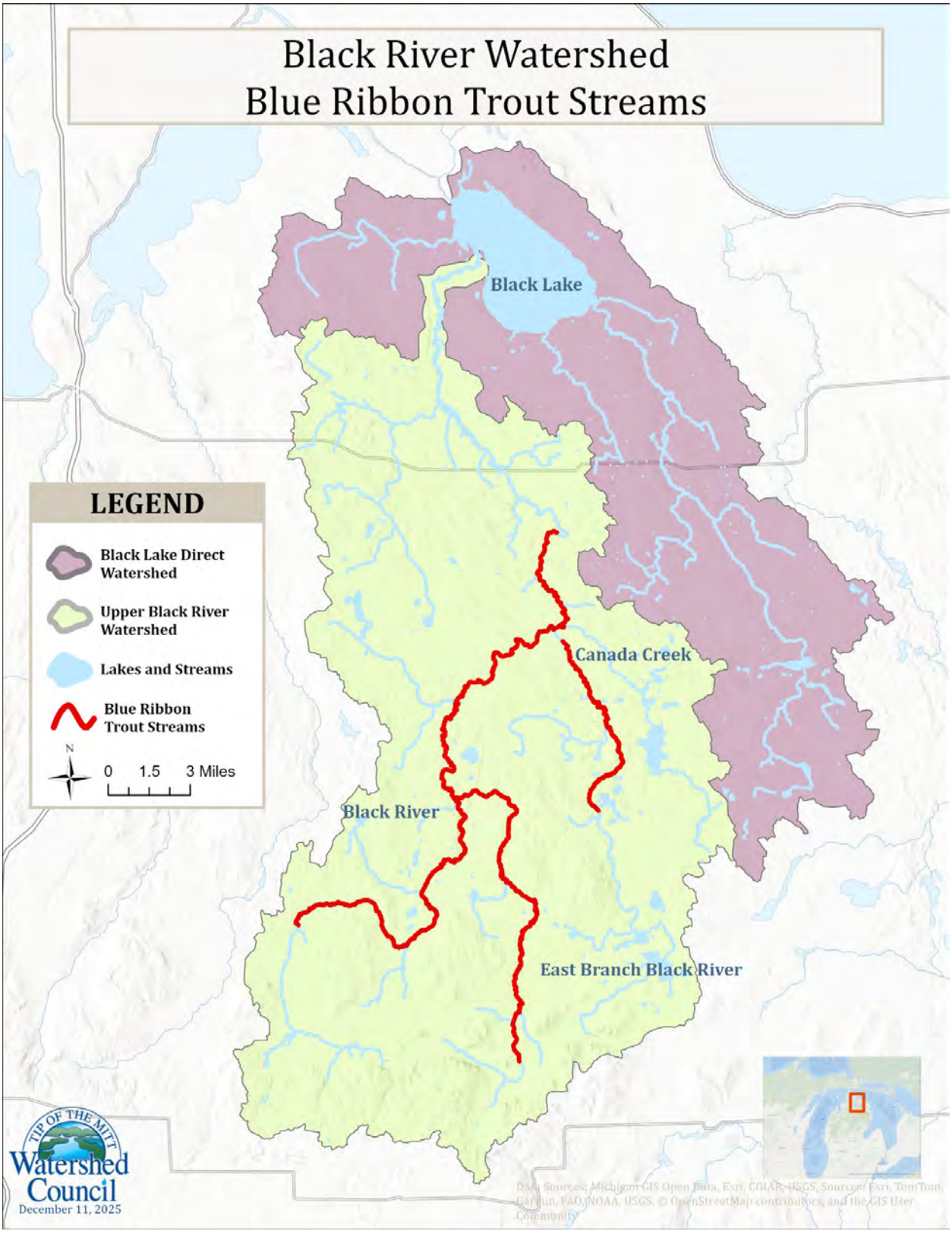


Figure 12. Blue Ribbon Trout streams

Impoundments

Tower and Kleber Dam

The Tower-Kleber Limited Partnership (TKLP) is the current owner and operator of Tower and Kleber dams (Table 3). Wolverine Power Supply Cooperative (WPSC) is the current licensee with FERC for Tower and Kleber dams. WPSC is a member-owned generation and transmission electricity cooperative based in Cadillac, Michigan and has a contract with TKLP that allows TKLP to distribute and transmit electricity generated at Tower and Kleber dams (Wolverine Power Supply Cooperative Inc., 2015).

In 2017, a report titled "An Exploration of Impacts and Stakeholder Interests: Tower and Kleber Dams on the Upper Black River, Northeastern Michigan" provides a comprehensive understanding of the current impacts of Tower and Kleber dams, potential effects of their removal, and key stakeholder concerns for the purpose of informing and guiding the decision-making process regarding the dams' future.

As identified in the report, Tower and Kleber ponds support many types of recreation that are highly valued by the area's residents and visitors. Fishing, as described below, is a common pastime for local residents and visitors. The ponds are also used for many different types of boating including rowboats, jet skis, canoes, kayaks, sailboats, rafts, and stand up paddleboards. Family and community events take place on or around the impoundments. Many residents shared how much swimming goes on in the ponds, especially Tower, where children swim every day in the summer and even jump off the bridge to have fun. During the winter, popular activities include ice skating, ice fishing, and snowmobiling. The full report can be found in appendix A.

Table 3. Tower and Kleber Dam size

Tower Dam	Built: 1918
	Capacity: 560 kW
	Type: Concrete
	Height: 29.3 ft
	Length: 727 ft
	Impoundment: 102 acres
Kleber Dam	Built: 1949
	Capacity: 1200 kW
	Type: Earthen
	Height: 40 ft
	Length: 535ft
	Impoundment: 295 acres

Alverno Dam

The Alverno dam is located south of Cheboygan on the Lower Black River. It is approximately five miles downstream from Black Lake, and is therefore outside the Black Lake Watershed. It does, however, serve as a water control structure for Black Lake.

The dam was built in 1905 and is operated today by Black River Hydro Limited Partnership, licensed by the Federal Energy Regulatory Commission with their license set to expire in 2041. The facility consists of a powerhouse located on the eastern riverbank that is integral with a 360-foot-long earth-filled dam. The dam includes a concrete spillway along the western riverbank. A three-foot wide abandoned log chute and fish ladder is located adjacent to the spillway. The impoundment formed by the dam extends approximately 2.5 miles upstream, just below the Smith Rapids and has a normal surface area of 80 acres and a gross storage capacity of 480 acre-feet. The powerhouse generates 3.8 gigawatt hours (GWh) annually. Approximately two miles upstream from the Alverno project is natural flow constriction in the Black River, known as Smith's Rapids. These rapids are a constriction in the river where the bottom rises significantly and the width of the river and floodplain decreases. Though the Smith Rapids influences watershed hydrology it has been difficult to decipher at which flows the hydraulic control shifts between the dam and the rapids. At some moderate to low flow levels, operation of the dam has a direct influence on the water surface elevation of Black Lake.

Other Dams

There are at least nine other impoundments within the watershed (Table 4), some of which are privately owned and some owned by the State of Michigan's Department of Natural Resources (Figure 13). There are likely other unknown privately-owned dams in the watershed.

Table 4. Other dams in the watershed

Name	Ownership	Structure Type	Structure Length (ft)	Structure Height (ft)	Discharges to
Stony Creek Dam	State	Earthen	761	11.5	Stony Creek
Dog Lake Dam	State	Earthen	620	6.5	McMasters Creek
Tomahawk Creek Flooding	State	Earthen	322	25	Tomahawk Creek
Saunders Dam	State	Gravity fed	300	7	Black River
Foch Lakes Dam	State	Earthen	200	13	E. Br. Black River
Doty Dam	State	Earthen	190	5	Van Hetton Creek
Muskellunge Lake Dam	Private	Earthen	200	7	Canada Creek
Moreau Dam	Private	Earthen		4	Stony Creek
Rainy River Dam	State	Earthen	296	11	West branch Upper Rainy River

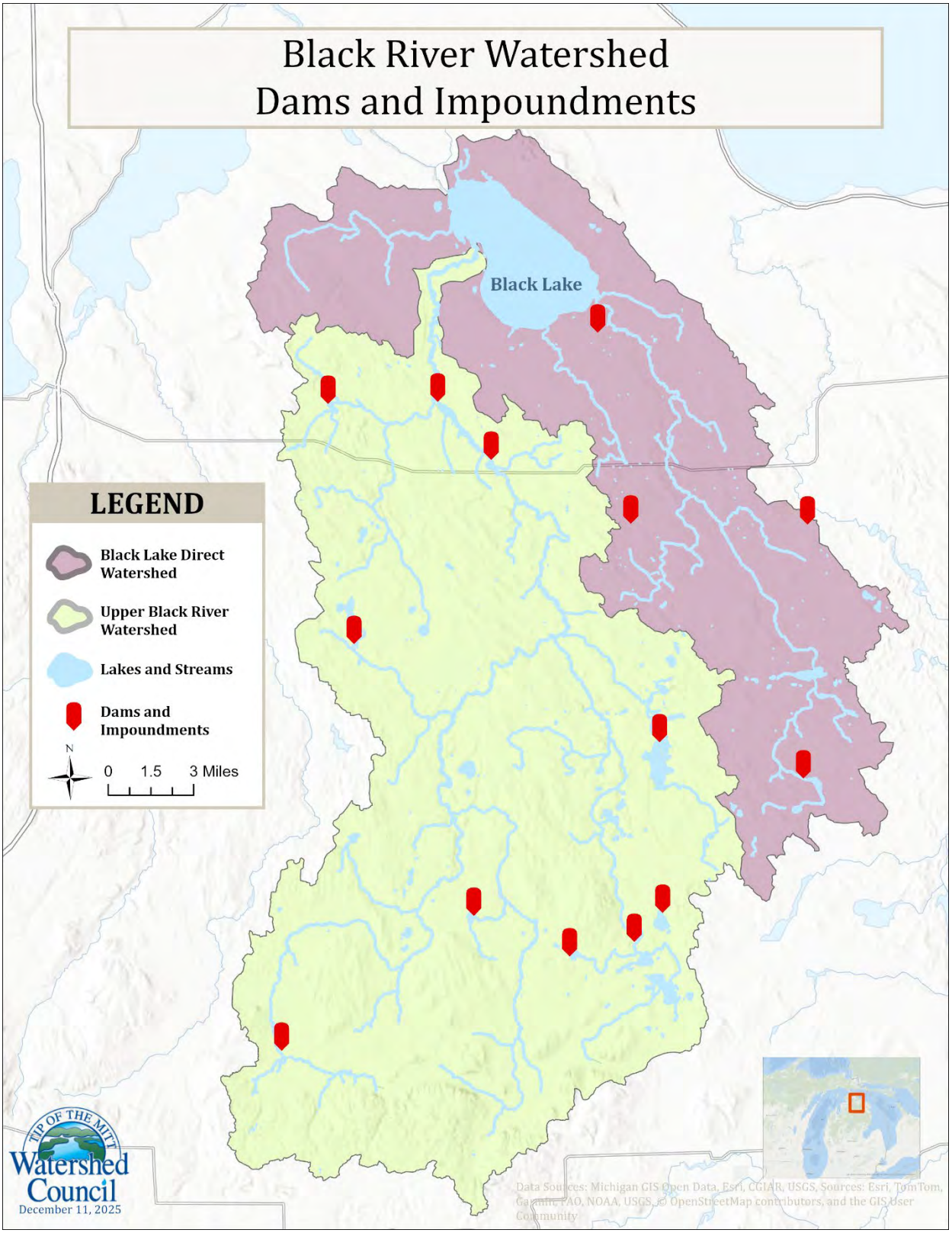


Figure 13. Dams and impoundments

Aquatic Invasive Species

Aquatic invasive species are non-native species introduced to an aquatic ecosystem that causes environmental and/or economic harm. Aquatic invasive species have come to the forefront of issues impacting our lakes, streams, and wetlands.

The Watershed, like many other watersheds, is infested to varying degrees with aquatic invasive species. Some species have been in the Watershed for decades while others are more recent invaders. Furthermore, some invasive species are on the verge of entering the Watershed as they continue to spread. The Great Lakes also remain a potential source of invasive species for inland lakes as many species spread via connecting waterways.

The Watershed is covered by two Invasive Species Networks (ISN). Huron Heartland ISN covers 6 counties, two of which overlap with the Black Lake Watershed: Otsego and Montmorency. Their mission is "...to work collaboratively to prevent the introduction and spread of invasive species and to raise awareness to ensure healthy ecosystems and engaged communities across Northern Michigan." Huron Coastal ISN "...will engage communities and lead them in a strategic and coordinated approach to invasive species management across Northeast Michigan's Lake Huron coastal region."

The following two species are present within the Watershed. While there are many others that are not included here, these species are featured because of their prevalence or the threat they pose. To see a full list of invasive species reports, visit the Midwest Invasive Species Information Network (misin.msu.edu).

Zebra mussels

Zebra mussels (*Dreissena polymorpha)* are freshwater mollusks (Figure 14) that have had a profound impact on the Great Lakes and inland lakes since their introduction in the late 1980s. The sheer number of zebra mussels in combination with their feeding habits has caused severe disruptions in aquatic ecosystems. As filter feeders, each zebra mussel is capable of filtering a liter of water per day; thus, removing almost every microscopic aquatic plant and animal (phytoplankton and zooplankton). The effect of this filtration is increased water transparency, which shows that water has become clearer in lakes infested with the mussels. Increased water clarity allows sunlight to penetrate to greater depths and results in increased growth of rooted aquatic vegetation and bottom-dwelling algae.

Zebra mussels were found in Black Lake for the first time in 2000.

Quagga mussels

Quagga mussels (*Dreissena rostriformis bugensis)* are freshwater mollusks (Figure 14) similar in appearance to zebra mussels. A distinguishing characteristic between the two is when quaggas are placed on a surface they fall over as they lack a flat underside (hinged side), whereas zebra mussels remain stable on the flattened hinge side. Quagga mussels are commonly found in waters more than 90 ft. deep, while zebra mussels are usually found at depth of less than 50 ft. Unlike zebra mussels, quagga mussels can live and thrive directly on a muddy or sandy bottom. They also tolerate a wider range of extremes in temperature and water depth than zebra mussels and spawn at colder temperatures.

There are no known occurrences of quagga mussels in Black Lake, but it has been reported in the greater Cheboygan River Watershed.



Figure 14. Quagga mussel (left) and zebra mussel (Michigan Sea Grant)

Additional known aquatic or riparian species in the watershed are European Frogbit, Asian Clam, Round Goby, Rusty crayfish, narrow-leaved cattail (and hybrid), purple loosestrife, phragmites, reed canary grass, Eurasian Watermilfoil (and hybrid), and various invasive thistles.

Threatened and Endangered Species

Several notable threatened and endangered species inhabit the Black Lake Watershed. The species listed represent only a small portion of the total that are considered threatened, endangered, or species of concern. It is also important to note that the following information often applies to the entire Cheboygan River Watershed, of which the Black Lake Watershed is included.

Lake Sturgeon

Lake Sturgeon (*Acipenser fulvescens*) is a state threatened species in Michigan. Populations in Michigan were estimated to be in the hundreds of thousands but are since believed to be at 1% of their former size (Hay-Chmielewski and Whelan 1997). This is due to exploitation and habitat degradation and loss. Lake sturgeon would have been common throughout the lower reaches of the Cheboygan River Watershed and probably common in Burt, and Black lakes. The species still exists today in each lake, with the largest population found in Black Lake. Hay-Chmielewski and Whelan (1997) consider the Cheboygan River Watershed as highly suitable for future lake sturgeon rehabilitation and enhancement.

Threats to restoration of this fish are physical barriers to migration, loss and degradation of spawning and nursery areas, and fishing pressures (Rochard et al. 1990). Declining water quality, invasive species (such as sea lamprey, zebra mussels, round gobies), and contaminants are additional threats in the Great Lakes (Hay-Chmielewski and Whelan 1997). Stream conservation practices, such as maintaining or establishing sufficient riparian buffers or natural flows, and chemical pollution and exotic species control are important steps to managing for sturgeon populations.

Black Lake Sturgeon Stream Side Research and Rearing Facility

The hatchery and rearing facility located on the Upper Black River at Kleber Dam was built through a partnership among Tower Kleber Limited Partnership (TKLP), Sturgeon for Tomorrow (SFT), the Michigan Department of Natural Resources (MDNR), and Michigan State University (MSU) in response to limitations on natural lake sturgeon reproduction in the Black River. Each year, eggs, milt, and larvae are collected and reared in the streamside facility to increase survivorship. Staff supplement natural reproduction by collecting gametes from spawning adults and capturing larval drift, rearing fish to early juvenile stages, and releasing them into Mullett, Burt, and Black Lakes. Juvenile sturgeon are not incorporated into

population estimates until they reach sexual maturity. Although resident perceptions vary regarding the success of sturgeon recovery efforts, most view the hatchery as a valuable resource and an "added insurance policy" for sustaining the population.

MSU and the MDNR Fisheries Division initiated their collaborative lake sturgeon research and management program in 2002 at Black Lake in Cheboygan County. Since that time, the Black Lake sturgeon facility and its associated streamside research and hatchery station have served as the primary hub for research, monitoring, community outreach, and hatchery production. The program has generated significant advancements in understanding lake sturgeon ecology, the factors limiting natural recruitment, and the population dynamics of the Black Lake stock.

Research has focused extensively on identifying causes of low natural recruitment, including mortality during egg and larval stages. Long-term monitoring of spawning adults and capture-mark-recapture data enabled the development of a novel population estimation method that is now used annually to determine male and female adult abundance and to establish safe harvest quotas. Telemetry studies have documented juvenile movements within the reservoir system and assessed passage and survival rates through hydroelectric facilities. Additional investigations have addressed chemical cues and physiological mechanisms associated with natal imprinting, as well as lake sturgeon pathogens. Researchers and managers from other universities and state, federal, and tribal agencies have collaborated on various initiatives to advance lake sturgeon biology and promote public understanding.

Community outreach and education are also central components of the program. MSU and DNR staff provide streamside tours, facility visits, and public presentations, and they maintain a website that includes K–12 STEM activities (www.glsturgeon.com). Staff have worked with Michigan Sea Grant and MSU Extension to develop a citizen-science e-learning program on predator–prey dynamics, and the Black Lake facility continues to supply juvenile sturgeon for the "Sturgeon in the Classroom" K–12 STEM program.

Hatchery production has been underway since 2003 to offset low natural recruitment in the Cheboygan River watershed. To date, the program has stocked 33,416 juvenile lake sturgeon into the Cheboygan River system. More recently, the facility has produced an additional 500 juveniles annually for release into four tributaries of the Saginaw River. Research at the facility has helped develop best practices for hatchery operations that guide production and release activities of federal, state, and tribal agencies across the Great Lakes.

Hungerford's Crawling Water Beetle

The Black Lake Watershed is one of a few locations that is home to the Hungerford's crawling water beetle (*Brychius hungerfordi*) (Figure 15). The Hungerford's crawling water beetle has been found in the Black River. This species prefers cool water and well-aerated streams with a sand, gravel, and cobble bottom.



Figure 15. Hungerford's crawling water beetle (Roger M. Strand)

Wetlands

Wetlands are a critical component of watershed systems and should be fully integrated into watershed management planning due to their essential role in ecosystem function and watershed dynamics. Wetlands both influence and are shaped by watershed hydrology and water quality, contributing to the overall health and resilience of the watershed through a variety of ecological processes.

Wetlands serve as the interface between land and water, functioning as transitional zones where surface water flow, groundwater movement, nutrient cycling, and solar energy interact to create highly productive ecosystems. These systems are defined by unique hydrologic conditions, hydric soils, and specialized vegetation, making wetlands among the most valuable and influential features within a watershed. According to the United States Environmental Protection Agency, wetlands play a vital role in maintaining watershed integrity.

The Watershed contains a diverse array of wetland types that provide numerous ecological services. Wetlands improve water quality by filtering pollutants and recycling nutrients, reduce flood impacts by storing and slowly releasing stormwater, and recharge groundwater supplies. They also provide essential habitat for a wide range of wetland dependent plant and animal species. In addition, wetlands play an important role in climate change mitigation by sequestering carbon and increasing resilience to extreme weather events.

Despite their value, wetlands have experienced significant losses across Michigan. A 1990 report to Congress by MDNR and the United States Department of the Interior estimated that approximately 50% of Michigan's original wetland resource base had been lost. Within the watershed, pre-settlement conditions included an estimated 40,000 acres of wetlands. As of 2005, approximately 34,071 acres

remained, representing a loss of 5,929 acres, or roughly 15% of the original wetland area, according to EGLE (Figure 16).

In Michigan, wetlands are increasingly being considered within the context of watershed management planning and municipal master planning. Wetland restoration and enhancement are gaining recognition as effective tools that complement or replace traditional best management practices to improve surface water quality and overall watershed health. Understanding the historical extent of wetland loss and degradation provides valuable context for local planners and resource managers, emphasizing the importance of protecting remaining wetlands and guiding future development decisions.

The Watershed includes several high-quality wetland complexes, including the Black River spreads, Mud Creek wetlands, Cold Creek wetlands, and Cains Creek wetlands. These areas provide important water quality, habitat, and hydrologic functions and represent key conservation priorities within the Watershed. Wetland loss can be attributed to natural changes on the landscape, such as forest succession, beaver dams, etc. It is estimated that only a very small %age of wetland loss is due to development.

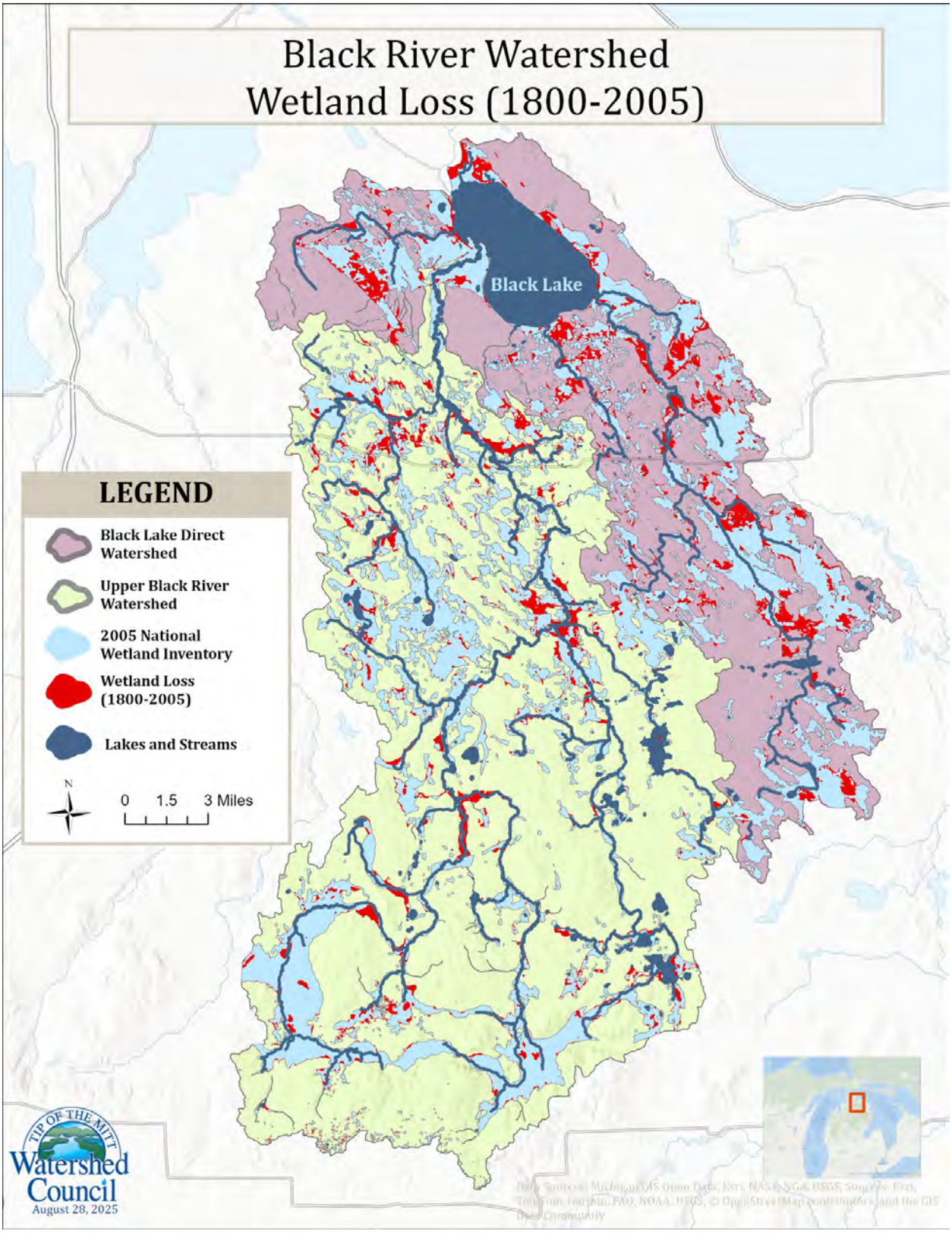


Figure 16. Wetland loss (1800-2005)

The Landscape Level Wetland Functional Assessment tool was developed by EGLE in partnership with state and local agencies, universities, and nongovernmental organizations. The tool identifies existing wetlands and the ecological functions they currently provide. It also identifies historical or former wetlands, defined as areas with hydric soils that no longer function as wetlands, and estimates the functions they would likely perform if restored. Restoring lost wetland function offers significant potential for addressing nonpoint source pollution and other watershed stressors. Although this analysis has not yet been completed for the Watershed, applying the Landscape Level Wetland Functional Assessment tool in the future would strengthen efforts to protect critical wetlands and prioritize sites for restoration.

Cultural History

Long before the arrival of Europeans, the northern portion of Michigan's Lower Peninsula was most recently home to the Anishinaabe. The total population of the Anishinaabe in this region at that time is not known, although the summer population has been estimated to range somewhere between 30,000 and 100,000.

The Anishinaabe made their home here for hundreds of years, maintaining villages along the Lake Michigan shoreline and throughout the watershed. These northern villages were primarily occupied with the tribes traveling to rivers along the southern coast of Lake Michigan during winter. After the spring maple syrup season was completed, the tribes returned north. These villages were connected by a series of footpaths which allowed natives to travel overland (many of today's roads and highways roughly follow these paths). More important than footpaths for travel were the waterways, because large distances could be covered quickly. Native Americans utilized the Inland Waterway, in part, as a means of traveling from Lake Huron to Little Traverse Bay, avoiding the perilous journey through the Straits of Mackinac and around Waugoshance Point. The name Cheboygan likely originated from an Anishinaabe word meaning "a body of water connecting another body of water" though the exact word and translation are unknown. Using birch bark canoes well adapted for rough waters and light enough to carry on portages, Native Americans could quickly travel from Little Traverse Bay to hunting grounds, seasonal fishing spots, and neighboring villages along the Crooked River, Burt Lake, Indian River, Black Lake, and the Cheboygan River.

The marshes, bogs, and swamps throughout the watershed are rich in plants that were utilized by the Anishinaabe for fiber, medicines, and foodstuffs. Bulrushes, grasses, cattails, and sedges found in today's marshes were extensively harvested for baskets, shelter, fish nets, and clothing. Sphagnum moss, a common plant of many wetland environments, was stuffed into boots and clothing for insulation and wetland shrubs such as red-osier dogwood and some common mosses were used for dyes. Numerous wetland plant species were used for their medicinal properties: Labrador tea for the treatment of ulcers, willow for indigestion, balsam fir for headaches, and tamarack for burns.

Waterfowl, which were attracted to the vast wetlands in the area, gathered in great numbers during both the spring and fall migratory seasons and were a primary source of food. Freshwater mussels and clams were harvested from shallow waters and numerous types of fish, from whitefish to lake sturgeon were netted or speared throughout the warm months.

Population

The Watershed today includes a few small towns and villages, but overall the Watershed is mostly rural and lightly populated. Riparian areas tend to be more developed with both permanent and seasonal residences. The population of the three counties in which this watershed lies are: Cheboygan County at 25,579, Presque Isle County at 12, 982 and Montmorency County at 9,153. The population density (people/square mile) of the townships within the watershed can be found in Figure 17. The population density of the City of Onaway is the highest at 500+ people per square mile, while the other townships average 10-20 people per square mile.

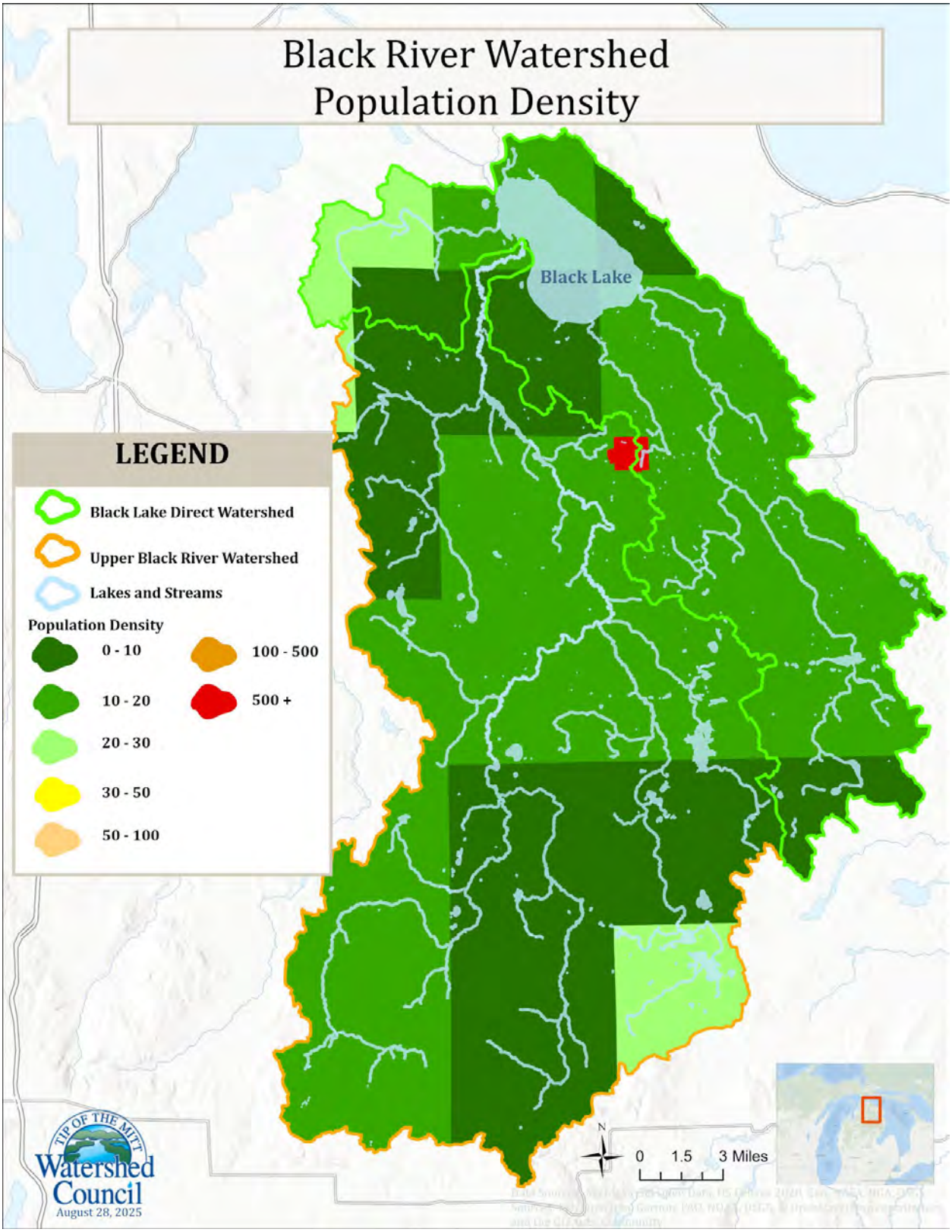


Figure 17. Population density (2020 census)

Enbridge Line 5

Line 5 is a 645-mile petroleum pipeline owned and operated by Enbridge Energy, Limited Partnership. The line runs from Superior, Wisconsin, across Michigan's Upper Peninsula, through Northern Michigan, down to the thumb region, and over to Sarnia, Ontario. Line 5 is 30 inches in diameter, except when crossing the Straits of Mackinac, where it divides into two 20-inch diameter pipes. The line became operational in 1953 and carries up to 540,000 barrels or 22.7 million gallons of light crude oil, synthetic crude, and natural gas liquids per day.

In the Northern Lower Peninsula, Line 5 crosses the Indian River, Little Sturgeon River, Pigeon River, and Upper Black River and traverses within a few miles or less from many inland lakes, including Paradise, Burt, Mullet, and Douglas.

Enbridge monitors these river crossings through a combination of patrols, depth of cover surveys, and site visits. In particular, depth of cover surveys is conducted every 10 years at minor crossings and every 5 years at major crossings.

Zoning

TOMWC produced a Local Ordinance Gaps Analysis for Cheboygan County in 2014. The Gaps Analysis is a review of all the water-related ordinances for the county. The purpose was to evaluate existing ordinances against what should be in place to best protect water resources, and offer recommendations and suggested actions to help local governments strengthen any areas that need improved. It covers ordinances at not only the county level, but also for cities, townships, and villages in the county. A plan was then created for each jurisdiction to enact needed ordinances and improve weaknesses; including a prioritization based not only on need but also the ability to enact or improve quickly due to assets available in specified locations. An example of the analysis can be seen in Figure 18. The full Gaps Analysis can be found on the TOMWC's website (watershedcouncil.org).

As part of Plan development, a review was conducted of local government ordinances in the watershed. Since Cheboygan County has not updated their master plan since the 2014 Gaps report, the recommendations still stand. As the County works towards reviewing and updating their master plan, the TOMWC recommends an emphasis on climate resiliency. The County doesn't have any requirements for shoreline protection and is an area of improvement.

A gaps analysis of Presque Isle and Montmorency counties, and townships that lie within the watershed was conducted in 2025, and is summarized in the following section.

Counties

Both Presque Isle and Montmorency Counties exhibit areas requiring improvement for water quality protection. Presque Isle County has implemented a zoning ordinance that includes a section on greenbelts for shoreline protection, mandating that at least 60% of vegetation be maintained within the buffer zone. However, the ordinance could be strengthened in areas such as impervious-surface reduction, soil-erosion prevention, and stormwater management. Additional zoning provisions addressing water access, including the prohibition of keyhole funneling, would also be beneficial. The most recent master plan for the county appears to have been developed in 2009, but no accessible online version of this document is available. Although Presque Isle County adopted a recreational plan for 2023-2027 that highlights

significant natural features, developing a comprehensive, long-term plan for water resource protection and management remains necessary. The Northeast Michigan Council of Governments (NEMCOG) reviewed the 2009 master plan in 2014, using some gap-analysis questions from TOMWC. NEMCOG found that the 2009 plan provides a complete inventory of surface and groundwater assets in the county, but recommended improvements such as mapping recharge and wetland areas. The plan also identifies stormwater management as a key policy. Additionally, the County would benefit from implementing county-wide septic regulations, such as a point-of-sale inspection requirement.

Montmorency County also lacks an up-to-date master plan. The most recent version is from 2002, and can be found online, but is not listed on the County's website. Upon request for a copy, it appears that Montmorency County does not have a zoning ordinance. The County does have a stormwater ordinance that was last amended in 1999. However, the document is not easily readable and was provided only upon request and payment. The ordinance meets the requirements of Part 91 and requires permit approval before beginning any earth-moving activities. It also requires a plan for the continued maintenance of all soil erosion and stormwater runoff control facilities for activities requiring a permit. Although outdated, the master plan provides a reasonably comprehensive overview of groundwater and surface water resources. It also includes a goal to protect groundwater, surface water, and wetlands. The plan also aims to ensure consistency in zoning across the township's various municipal bodies, particularly regarding greenbelts and water quality buffers. To achieve this goal, the County should consider adopting its own zoning ordinance. The County should also consider a septic ordinance to improve protection of its ground and surface waters.

Townships

Townships within the Counties (Figure 19) vary in their methods for protecting water quality. Of note, Presque Isle Township has an up-to-date Master Plan from 2024 and a zoning ordinance adopted in 2022. Furthermore, the township adopted a comprehensive point-of-sale septic and well-inspection ordinance. Allis Township also developed an adequate Master Plan in 2011, which, while outdated, recognizes the importance of surface and groundwater protection and highlights road/stream crossings as one of the most significant impacts on water quality in the Black Lake Watershed.

In contrast, a handful of Townships lack master plans and zoning ordinances. A consistent issue is a lack of public access to county and township documents. Several townships lack websites, and requests for documents and information went unanswered.

Of Townships with zoning ordinances, most Townships do include an explicit requirement for water runoff to remain on-site of properties unless naturally occurring. However, there could be an improvement in communities requiring pre-winter meetings to ensure that soil cover will provide adequate soil erosion and sedimentation control during winter months for earth-moving projects. There could be further improvements in many Townships to adopt zoning ordinances that better protect shorelines, including buffer zones and adequate setbacks. Finally, as at the county level, Townships would benefit from establishing septic ordinances to further protect water quality in their jurisdictions.

Shorelines

POSSIBLE SCORE: 60
TOTAL SCORE: 8, WEAK

There is very little included in the City's Zoning Ordinance that refers to shoreline protection for either the Great Lake's coastline or inland streams. This is something that should be addressed because the City has great potential to impact these water resources. Shorelines are vital areas to the health of water resources, as noted in the Literature Review.

The Zoning Ordinance does address marinas in section 154.070. This is the Waterfront-Marina District, which places limits on the types of land use and buildings that can be erected within such an area (154.070). This district is "designed to accommodate recreational boating along with activities and services related to harbor and waterway improvements, thereby facilitating navigation and providing safe and economical waterfront, recreational development." (154.070) In addressing where boat repair and maintenance activities can take place, it requires engine and hull repair to take place in completely enclosed buildings, or enclosed with a six feet high masonry wall or 10 foot wide greenbelt [154.070(C)(1)]. It does not have strict requirements for fueling stations, in terms of spill containment, but all boat fuel stations must be located at least 200 feet from any residential district [154.0708(C)(2)].

Shorelines: RECOMMENDATIONS

SUGGESTED ACTION: Require waterfront setbacks and Natural Vegetation Strips for waterfront properties on lakes and streams. Prohibit invasive species from being used in the vegetation strip.

SUGGESTED ACTION: Restrict boat repair and maintenance activities in marinas to clearly marked areas, to prevent contaminants and debris from falling into the water and limit the spread of invasive species. Also, require marina fueling stations to have spill containment equipment that is stored in a clearly marked location. Require a spill contingency plan and post emergency phone numbers in a prominent location. Finally, signs of leakage or spillage should be investigated immediately, and cleaned up in accordance with applicable Best Management Practices (BMPs).

Figure 18. Excerpt from Cheboygan County gaps analysis

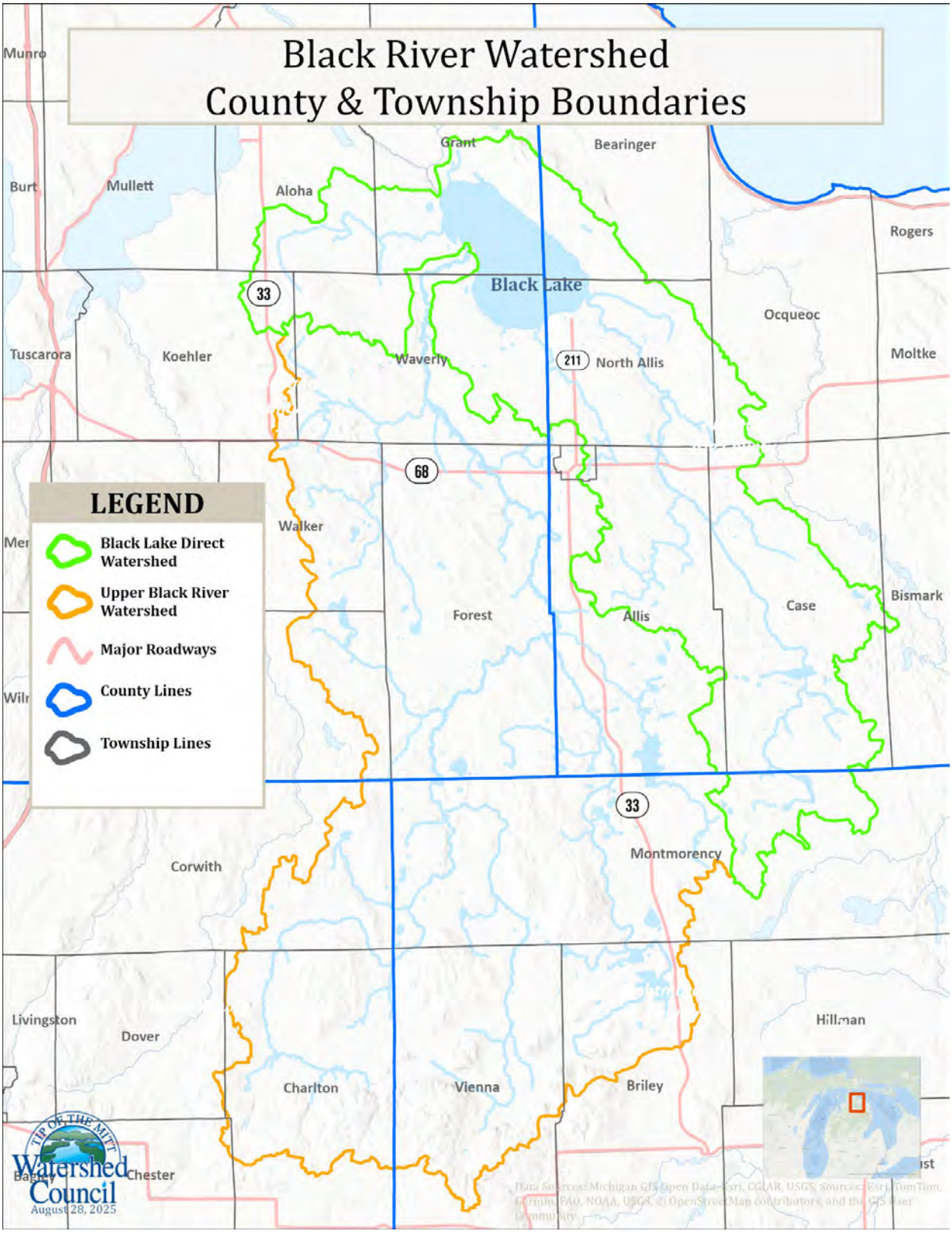


Figure 19. Local government boundaries

Watershed Organizations

The below information includes both general descriptions about these organizations as well as highlights of their recent efforts toward watershed protection.

Black Lake Association

The mission of Black Lake Association is to monitor Black Lake for environmental and ecological changes and to promote activities which will enhance water quality, fishing, boating, safe navigation, swimming, and all activities enjoyed by the users of Black Lake.

Black Lake Preservation Society

The purpose of Black Lake Preservation Society is to represent the best interests of its members, as shall be determined by the Board of Directors, toward the pursuit of practical lake management to protect and preserve the natural character and water quality of Black Lake and its surrounding watershed.

Huron Pines

Huron Pines is a nonprofit conservation organization whose mission is to conserve the forests, lakes, and streams of Northeast Michigan to ensure healthy water, protected places, and vibrant communities. They manage invasive species, protect land, reconnect rivers and streams, and provide education opportunities. To date, Huron Pines has replaced 9 road stream crossings in the Watershed on Black Creek, Pigeon River, and tributaries to the Pigeon River.

Little Traverse Bay Bands of Odawa Indians

The Little Traverse Bay Bands of Odawa Indians is a federally reaffirmed tribe with a robust natural resources department whose service area covers the 1836 ceded territory. They work to protect the environment for the next seven generations through surveys, assessments, protection, and restoration.

Little Traverse Conservancy

The mission of the Little Traverse Conservancy is to protect the natural diversity and beauty of northern Michigan by preserving significant land and scenic areas, and fostering appreciation and understanding of the environment. Their service area includes Chippewa, Mackinac, Emmet, Cheboygan, and Charlevoix counties.

LTC has protected over 8,000 acres of land through direct acquisition, conservation easements on private lands, working forest reserves, and assist projects with local units of government throughout the Watershed. They are actively working with landowners within the Watershed who are in the process of donating conservation easements on their lands.

Northeast Michigan Council of Governments

The Northeast Michigan Council of Governments (NEMCOG) is a multi-service state-designated regional planning agency serving eight counties including Alcona, Alpena, Cheboygan, Crawford, Montmorency, Oscoda, Otsego, and Presque Isle and 103 total governments. NEMCOG assists local governments in

community planning, zoning, recreation planning, grant writing, mapping, economic and community development, transportation planning, recycling programs, community corrections, and other specific programs.

Northern Inland Lakes Citizens Fishery Advisory Committee

The Northern Inland Lakes Citizens Fishery Advisory Committee, established in 2009, provides an excellent opportunity for citizens to become involved with natural resource management within the Cheboygan River Watershed through a multi-agency, multi-organization partnership. Public involvement through the advisory committee, one of its member organizations, or other citizen groups provides the opportunity to open a dialogue on natural resources issues and promotes the exchange of experiences, ideas, and proposals among individuals, communities, interest groups, and government agencies. Numerous opportunities exist for concerned citizens to become involved in issues affecting the Watershed; citizens are encouraged to take advantage of these opportunities for participation.

Sturgeon for Tomorrow

The purposes of Sturgeon for Tomorrow, Inc. (SFT) are to assist fisheries managers in the rehabilitation of the Lake Sturgeon, to advance education, to further other charitable, educational and scientific objectives, to engage in and facilitate scientific research furtherance of such purposes, and SFT, Inc. shall be empowered to engage in such other and further means necessary and proper to accomplish the foregoing objects and purposes.

Upper Black River Council

The Upper Black River Council (UBRC) was established in 1993, forming a unique partnership of local, state and national governmental entities, non-profit conservation and sportsmen's organizations, private landowners and interested citizens dedicated to the restoration and preservation of the Upper Black River watershed as a highly prized, multiple use natural resource.

Tip of the Mitt Watershed Council

Tip of the Mitt Watershed Council (TOMWC) is a not-for-profit organization that is dedicated to protecting and restoring the waters of northern Michigan and the Great Lakes Basin.

A list of monitoring efforts undertaken can be found in Table 5. In addition, TOMWC has performed shoreline assessments, and designed and coordinated numerous bioengineering and greenbelt projects for shoreline properties. TOMWC has developed and distributed many educational and outreach materials that pertain to invasive species, shoreline management, water quality, and other topics that relate to watershed protection.

Table 5. TOMWC's efforts

Project Title	Waterbody
Aquatic Plant Survey	Black Lake (2014)
Shoreline Survey	Black Lake (TOMWC-2017, Freshwater Solutions- 2023)
Tributary Monitoring (2018, 2024-25)	Stony Creek
	Cold Creek

	Fisher Creek
	Cains Creek
	Rainy Creek
	Rainy River
	Stewart Creek
Comprehensive Water Quality Monitoring (Triennial)	Black Lake
	Black River
Volunteer Lake Monitoring (Annual)	Black Lake
Volunteer Stream Monitoring (Annual)	Black River
	Milligan Creek
	Stony Creek

Previous Watershed Management Efforts

Black Lake Watershed Stewardship Initiative

In 2002, a nonpoint source pollution management plan was updated for the Black Lake Watershed. This was an update from 1991 efforts, which spurred the creation of the Upper Black River Watershed Restoration Committee which led to the establishment of the Upper Black River Council as a 501(c)3. Over the years, several habitat focused projects have been carried out on the Upper Black River and its tributaries, completed by several partners.

Black Lake Direct Subwatershed

The Black Lake Direct Watershed is the area of land where water flows into Black Lake and it includes several tributaries. These main tributaries are Mud Creek, Cains Creek, Rainy River, Fisher Creek, Stewart Creek, Stony Creek and Cold Creek.

Landscape, Soils, and Groundwater

The Black Lake Direct subwatershed (Figure 2) encompasses Black Lake and the creeks that directly feed it. On the northwest side of the lake is Mud Creek and Cains Creek on the northeast. All other direct stream discharges enter the lake from the southern end, and Black River enters from the west. From 1985 to 2016, land use around Black Lake changed most noticeably through an increase in urban development, which grew by 86.77 %. Barren land also increased by 30.46 % over the same period. Agriculture declined by 5.48 %, while forest grassland shrub areas decreased by 3.71 %. Wetland area remained relatively stable, with a small decline of 0.61 %, and water area showed almost no change, increasing by only 0.26 %. Overall, these trends indicate expanding development alongside modest reductions in agricultural and natural land cover types (Figure 3). The highest elevations, around 280 meters, can be found in the headwaters of Mud Creek and throughout the southern area of the subwatershed. The soils are largely group A which have high infiltration rates (Figure 4).

The degree of groundwater contributions to surface waters in the Black Lake Direct Watershed is highest in the headwaters of Mud Creek, and low to moderate throughout the rest. Groundwater recharge is about 6-8 inches on average.

Black Lake

The primary inflows to the system include the Upper Black River, Rainy River, Stony Creek, Cold Creek, Stewart Creek, and Cains Creek, while the primary outflow is the Lower Black River. The surface area is approximately 10,143 acres, with a shoreline length of about 19 miles. The maximum recorded depth is 50 feet.

Black Lake is the 9th largest inland lake in the State of Michigan, by surface area. It is located in the northeast corner of the Lower Peninsula, in both Cheboygan and Presque Isle Counties. Although not pronounced, there are two distinguishable basins in Black Lake; the northwest end characterized by broad shallow areas that deepen gradually while the southeast end is much deeper, wider and has a more pronounced drop-off, particularly on the western side (Figure 20).

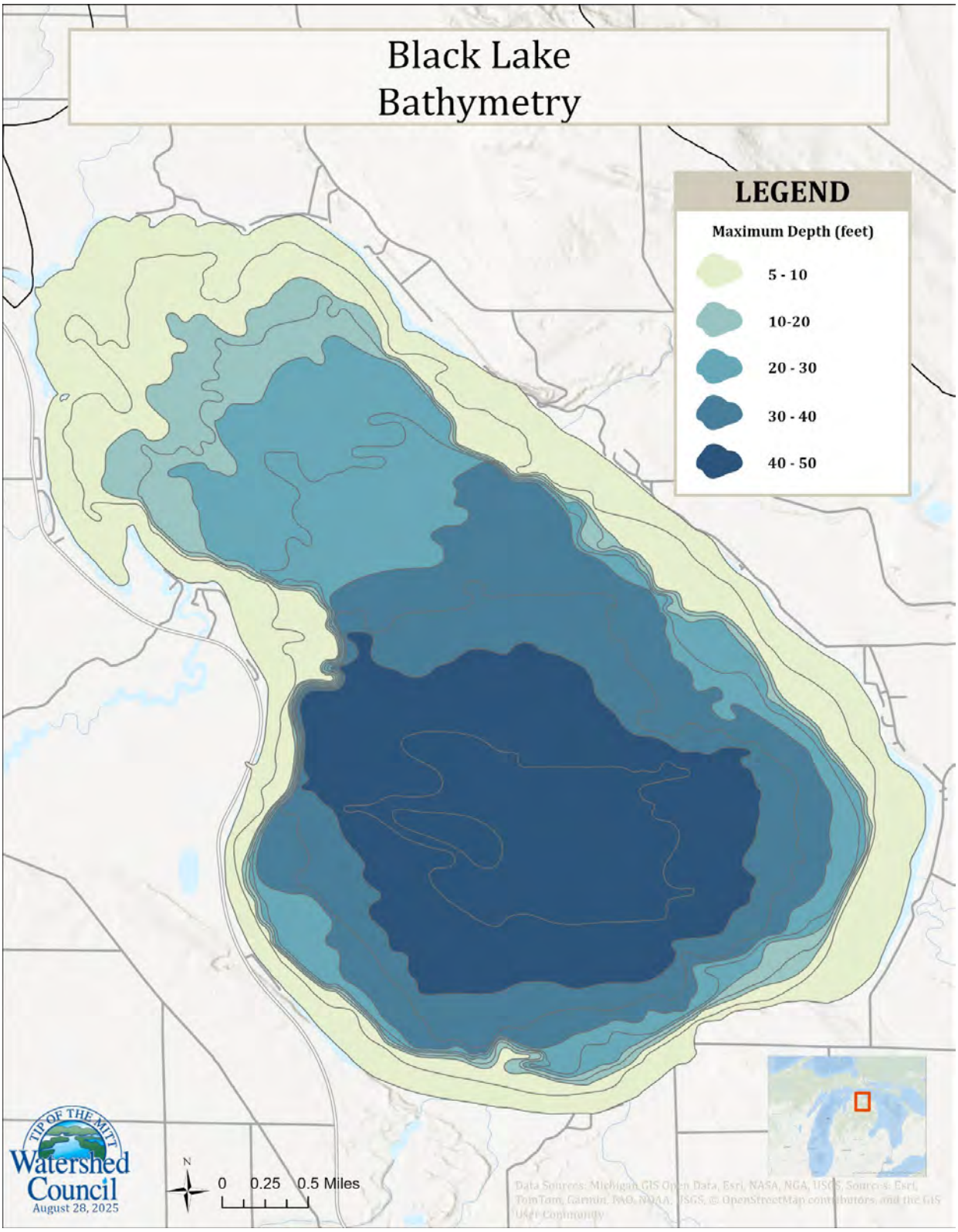


Figure 20. Black Lake bathymetry

The largest inlet to Black Lake is the Upper Black River, which flows in on the west side just north of Five-mile Point. The next largest tributary is the Rainy River, which enters in the southeast corner of the lake. Several smaller streams, including Stony, Stewart, and Fisher Creeks in the south, Mud Creek in the west and Cain's Creek to the north, also flow into Black Lake. These rivers and streams deliver great quantities of dark tannin-stained waters that give the lake its name. Tannins are natural, coming from plants, and do not pose a threat to water quality. The only outlet from the lake is the Lower Black River, which empties out of the northwestern corner of the lake.

Recreational access to Black Lake is available to the public at MDNR boat launches located at Onaway State Park on the southern shore and Black Lake Forest Recreation Area in the northeast corner of the lake. Black Lake is renowned for its thriving lake sturgeon fishery. These invasive mussels disrupt the natural nutrient cycle and food chain dynamics, which results in a loss of primary productivity (planktonic algae) and consequently, leads to reductions in top predator populations, such as walleye and trout.

Harmful Algal Blooms

According to EGLE, harmful algal blooms occur when cyanobacteria, commonly known as blue-green algae, proliferate rapidly in lakes under conditions of warm water, calm weather, and elevated nutrient levels, especially phosphorus and nitrogen. These blooms often produce visible surface scums, mats, or paint-like sheens on the water, but appearance alone cannot confirm the presence of toxins. Some cyanobacteria release cyanotoxins, which can be harmful to humans, pets, or wildlife. Exposure through skin contact, inhalation, or ingestion may cause skin or eye irritation, respiratory symptoms, gastrointestinal distress, and in more serious cases, liver or kidney damage.

Black Lake has experienced confirmed harmful algal bloom events. In September 2020, water sampling identified toxin-producing cyanobacteria, prompting a public health advisory for residents and visitors to avoid water that appears discolored or shows visible scums, mats, or foam. To date, there have been numerous sightings of potential blooms with only some having been confirmed because harmful algal blooms can form, shift location, and dissipate rapidly, sometimes within a single day. State health and environmental agencies recommend avoiding contact with water whenever visible harmful algal blooms appear and reporting suspicious blooms to EGLE for testing.

Black Lake Fisheries

According to A Michigan Department of Natural Resources report (Cwalinski & Hanchin, 2011) walleye are the dominant large predator in Black Lake, but their population has declined due to several consecutive weak year classes, high estimated mortality, and reduced recruitment. Creel surveys from 2005–06 showed extremely low densities of both legal and sublegal fish compared to other large Michigan lakes, indicating a potential future collapse of the fishery without intervention. Contributing factors are likely cumulative and include zebra mussel–driven changes in water clarity and plankton communities, unfavorable spring weather conditions affecting spawning success, possible illegal harvest during spawning runs, and barriers such as Alverno Dam that prevent young river-spawned fish from returning to the lake. While predation by cormorants and commercial minnow harvest appear to play minimal roles, the overall system has undergone ecological changes that reduce survival of young walleye. As natural reproduction continues to falter, temporary stocking has been recommended to stabilize the fishery while managers monitor the success of stocked versus wild fish.

Other predator populations in Black Lake appear healthier. Northern pike have above-average densities of legal-size fish and exhibit stable growth and mortality patterns linked to natural fluctuations in spring water levels. Smallmouth bass, though less abundant than in nearby lakes, are expected to benefit from clearer water and increased crayfish availability following zebra mussel and rusty crayfish invasions. The fish community and fishery of Black Lake, Cheboygan and Presque Isle Counties, Michigan with emphasis on walleye, northern pike, and smallmouth bass. Muskellunge remain rare and under-documented, with future targeted sampling planned to improve population estimates. Overall, aside from walleye, most fish communities fall within natural variability, but ongoing ecological shifts highlight the importance of habitat conditions, spawning success, and adaptive fisheries management in the watershed (Cwalinski & Hanchin, 2011).

Tributaries

Each of these tributaries are unique in their position and role in the Watershed. Both Fisher and Stewart Creeks are small streams which flow through Black Lake Golf Course with a majority of their Watersheds residing within the United Auto Workers Conference Center. Stony Creek is the second-longest of these tributaries. Stony Creek is also the closest tributary to the City of Onaway, and winds through a mixture of wetland, forest, urban, and agricultural areas. Of the tributaries monitored, the Rainy River is the largest and flows through mostly wetland and some agriculture landscapes. The Rainy River eventually connects with Cold Creek near the mouth before entering Black Lake. Cain's Creek and Mud Creek flows through a large wetland area on the northeast and northwest sides of the lake respectively.

Upper Black River Subwatershed

The Upper Black River Watershed (Figure 2) is the area that drains into Black Lake. This area includes the Black River, the Tower and Kleber Impoundments, Milligan Creek, McMasters Creek, Tomahawk Creek, Canada Creek, and the East Branch Black River. The watershed primarily runs north and south, with its headwaters starting in the Gaylord area and feeding northward until it discharges on the east side of Black Lake. From 1985 to 2016, land use in the watershed showed a clear shift toward urban development. Urban land increased substantially by about 152%, growing from approximately 3,366 acres to 8,488 acres. In contrast, agriculture declined by about 16.7%, while barren land decreased by roughly 13.4%. Forest grassland shrub areas experienced a moderate decline of about 4.7%, and wetlands decreased slightly by about 2.5%. Overall, the data indicate increasing development pressure accompanied by gradual reductions in agricultural, forested, and wetland areas (Figure 3). Elevation in the subwatershed averages around highest at the very southern end, in the headwaters of the Upper Black River, reaching up 435 meters. Elevation drops as it gets closer to Black Lake, and has a higher elevation on average than the Black Lake direct subwatershed. The soils are largely group A which have high infiltration rates (Figure 4).

The degree of groundwater contributions to surface waters is highest in the headwaters of Black River and lessen as the River reaches Black Lake, and moderate throughout most. Groundwater recharge is about 12 inches on average, with the highest recharge areas in the middle region of the watershed.

The river runs for 9.5 miles before reaching Kleber dam. This reach is a warm-transitional and runs through largely public lands. Sand is the predominant substrate of this reach but transitions to gravel, cobble and bedrock as it gets closer to the dam. It supports high-quality brook trout populations, with tributaries and

impoundments providing important habitat for several fish species. Tower Pond, a small shallow impoundment on the river, and the lower river reaches may serve as wintering habitat for some brook trout, though the extent of their use by the upstream population is unknown (Cwalinski, 2012).

2. WATER QUALITY STANDARDS, DESIRED AND DESIGNATED USES

The Environmental Protection Agency's Handbook for Developing Watershed Plans to Restore and Protect Our Waters describes water quality standards and designated uses as follows:

• Water quality standards set the goals, pollution limits, and protection requirements for each waterbody. Meeting these limits helps to ensure that waters will remain useful to both humans and aquatic life. Standards also drive water quality restoration activities because they help to determine which waterbodies must be addressed, what level of restoration is required, and which activities need to be modified to ensure that the waterbody meets its minimum standards.

• Standards are developed by designating one or more beneficial uses for each waterbody, establishing a set of measurable criteria that protect those uses and implementing policies and procedures that keep higher-quality waters from degrading.

• Designated or beneficial uses are descriptions of water quality expectations or water quality goals. A designated use is a legally recognized description of a desired use of the waterbody, such as aquatic life support, body contact recreation, fish consumption, or public drinking water supply. State and tribal governments are primarily responsible for designating uses of waterbodies within their jurisdictions.

• Two types of criteria are used to measure whether standards are being met. Numeric criteria set numeric limits for water quality parameters; narrative criteria are nonnumeric descriptions of desirable or undesirable water quality conditions.

State Water Quality Standards

EGLE monitors the waters of the State on a five-year rotating watershed cycle to facilitate effective watershed management. Michigan has 57 major watersheds based on the USGS's 8-digit Hydrologic Unit Codes (HUC). Water quality assessment efforts focus on a subset (approximately 20%) of these major watersheds each year. The Black Lake Watershed, included in the Cheboygan Watershed (HUC#04070004), was last assessed by EGLE in 2025, and is scheduled to be assessed every 5 years.

The State of Michigan has developed water quality standards (WQS) under Part 4 of the Administrative Rules issued pursuant to Part 31 of the Natural Resources and Environmental Protection Act (1994 PA451, as amended). These standards can be found in Table 6. These standards are set to ensure that surface waters maintain their pollution limits and protection requirements. This helps with assessing which restoration activities are needed or what activities (point or nonpoint source) will need to be adjusted to

meet the standards. The State uses numeric and narrative water quality standards to help determine if designated uses are impaired. If a waterbody has multiple designated uses, the most restrictive standards apply. Additionally, if a waterbody has higher water quality than the standards require, they must be maintained at that higher quality.

Table 6. Water Quality Standards

Parameter	Water Quality Standards	Designated Uses Affected
Dissolved Solids	Not to exceed 500 mg/L monthly average or 750 mg/L at any time as a result of controllable point sources	All
pH	Between 6.5 to 9.0	All
Taste or odor producing substances	The surface waters of the state shall contain no taste-producing or odor-producing substances in concentrations which impair or may impair their use for a public, industrial, or agricultural water supply source or which impair the palatability of fish as measured by test procedures approved by the department.	Public Water Supply*
		Industrial Water Supply
		Agricultural Water Supply
		Fish Consumption
Toxic substances (selected shown here; see rule for complete listing)	DDT and metabolites: below 0.00011 µg/L	All but navigation
	Mercury, including methylmercury: below 0.0013 µg/L	
	PCBs (class): below 0.00012 µg/L	
	2,3,7,8 - TCDD: below 0.0000000031 µg/L	
Radioactive substances	Pursuant to U.S. nuclear regulatory commission and EPA standards	All but navigation
Plant nutrients	Phosphorus: 1 mg/L maximum monthly average for permitted point source discharges. Regulation for surface waters is limited to the following narrative standard from Rule 60 (323.1060): "nutrients shall be limited to the extent necessary to prevent stimulation of growth of aquatic rooted, attached, suspended, and floating plants, fungi or bacteria which are or may become injurious to the designated uses of the waters of the state."	All
Chloride	Final Chronic Value: 150 mg/L	All
Microorganisms	30-Day Geometric Mean: below 130 E. coli per 100 ml	Total body contact
	Daily Maximum Geometric Mean: 300 E. coli per 100 ml	Total body contact
	Daily Maximum Geometric Mean: below 1,000 E. coli per 100 ml	Partial body contact
	Human sewage discharges (treated or untreated) below 200 fecal coliform per 100 ml 30-day mean or 400 fecal coliform per 100 ml in 7 days or less	Total body contact
Dissolved oxygen	Minimum 7 mg/L for coldwater designated streams, inland lakes, and Great Lakes/connecting waters; minimum 5 mg/L for all other waters	Cold water fishery
	Minimum 5 mg/L daily average	Warm water fishery

Temperature	Natural daily and seasonal temperature fluctuations shall be preserved:	Cold water fishery Other indigenous aquatic life and wildlife
	Maximum monthly averages for inland lakes (ºF): J F M A M J J A P O N D 45 45 50 60 70 75 80 85 80 70 60 50	
	Maximum monthly averages for warm water streams in this watershed (ºF): J F M A M J J A P O N D 38 38 41 56 70 80 83 81 74 64 49 39	Warm water fishery
	Maximum monthly averages for cold water streams in this watershed (ºF): J F M A M J J A P O N D 38 38 43 54 65 68 68 68 63 56 48 40	Cold water fishery

**All surface waters of the state that are identified in the publication "Public Water Supply Intakes in Michigan," dated December 9, 1999, are designated and protected as public water supply sources at the point of water intake and in such contiguous areas as the department may determine necessary for assured protection.*

Additional Water Quality Reference Conditions

To properly assess water quality health (both physical and chemical) within the Watershed, additional criteria will be utilized. These criteria are derived from the United States Environmental Protection Agency (EPA) ambient water quality recommendations (Table 7) and the Michigan Inland Lakes Trophic Status Classifications (Table 8). Standard parameter values vary based on classification of waterbodies (i.e. lake or stream), type of parameter (i.e. type of nutrient, type of physical parameter, etc.), and EPA ecoregions and subecoregions. An ecoregion refers to specific areas where ecosystems are generally similar. A subecoregion refers to an ecoregion, but on a smaller geographic scale. The waters of the Black Lake Watershed reside in ecoregions V and VIII, and subecoregion 50. Because of the large area covered by this watershed (350,000 acres), standard values are different based on their respective ecoregions, subecoregions, and waterbody types.

Table 7. EPA reference conditions

Parameter	Water Quality Standards	Designated Uses Affected
Total Phosphorus	Subecoregion 50 12 ug/L streams 9.7 ug/L lakes	All
Total Nitrogen	Subecoregion 50 440 ug/L streams 400 ug/L lakes	All

Table 8. Michigan Inland Lakes Trophic Classification Water Quality Standards

Parameter	Water Quality Standards	Designated Uses Affected
Chlorophyll-a	Oligotrophic = < 2.2 ug/L Mesotrophic = 2.2 - 6.0 ug/L Eutrophic = 6.0 - 22.0 ug/L Hypereutrophic = >22.0 ug/L	All
Water Clarity (Carlson Trophic Status Index)	Oligotrophic = Secchi disk depth: > 15.0 ft Chlorophyll-a: < 2.2 ug/L Mesotrophic = Secchi disk depth: 7.5 - 15.0 ft Chlorophyll-a: 2.2 - 6.0 ug/L Eutrophic = Secchi disk depth: 3.0 - 7.5 ft Chlorophyll-a: 6.0 - 22.0 ug/L Hypereutrophic: = Secchi disk depth: < 3.0 ft Chlorophyll-a: > 22.0 ug/L	All

Designated Uses

The State of Michigan has established a set of designated uses that can be measured for impairment based on the water quality standards described in the previous section. Rule 100 (R323.1100) of the water quality standards states that all surface waters of the State are designated for, and shall be protected for, eight particular uses (Table 9).

Table 9. Surface Water Designated Uses of the State

Designated Use	General Definition
Agriculture	Livestock watering, irrigation, and crop spraying
Navigation	Navigation of inland waters
Warm Water fishery	Supports warmwater species
Cold Water fishery	Supports coldwater species
Other Indigenous aquatic life and wildlife	Supports other indigenous animals, plants, and macroinvertebrates
Partial body contact recreation	Supports boating, wading, and fishing activities
Total body contact recreation	Supports swimming activities between May 1 and October 31
Public water supply*	Surface waters meet human cancer and non-cancer values set for drinking water
Industrial water supply	Water utilized in industrial or commercial applications

Fish Consumption	There is a statewide, mercury-based fish consumption advisory that applies to all of Michigan's inland lakes, including those within the Mullett Lake Watershed.

**All surface waters of the state that are identified in the publication "Public Water Supply Intakes in Michigan," dated December 9, 1999, are designated and protected as public water supply sources at the point of water intake and in such contiguous areas as the department may determine necessary for assured protection.*

The Watershed includes both coldwater and warm water fisheries. The coldwater fishery designation differs from the warmwater fishery because there are different water quality standard levels for dissolved oxygen, water temperature, and other chemical, physical, and biological parameters. The coldwater fishery lakes and streams are considered "Designated Trout Streams" or "Designated Trout Lakes" for the State of Michigan.

The Coldwater Fishery designated use only applies to Michigan Department of Natural Resources designated coldwater streams. Coldwater lakes and streams in the State of Michigan are defined under section R323.1100 as:

(4) All inland lakes identified in the publication entitled Coldwater Lakes of Michigan, as published in 1976 by the department of natural resources, are designated and protected for coldwater fisheries. (5) All Great Lakes and their connecting waters, except for the entire Keweenaw waterway, including Portage lake, Houghton county, and Lake St. Clair, are designated and protected for coldwater fisheries. (6) All lakes listed in the publication entitled "Designated Trout Lakes and Regulations," issued September 10, 1998, by the director of the department of natural resources under the authority of part 411 of 1994 PA 451, MCL 324.41101 et seq., are designated and protected for coldwater fisheries. (7) All waters listed in the publication entitled "Designated Trout Streams for the State of Michigan," Director's Order No. DFI-101.97, by the director of the department of natural resources under the authority of section 48701(m) of 1994 PA 451, MCL 324.48701(m) are designated and protected for coldwater fisheries.

Coldwater streams and lakes within the Watershed (Table 10) are therefore designated and protected for coldwater fisheries.

Table 10. Coldwater Lakes and Streams within the watershed

Watershed(s)	Coldwater Rivers and Streams	Coldwater Lakes
Black Lake Watershed	Upper Black River, Rainy River, Canada Creek, Mud Creek, Stony Creek, Stewart Creek, Tomahawk Creek, Milligan Creek, Hardwood Creek, Van Hellens Creek, Rattlesnake Creek, and Packer Creek	None

**As listed in the EGLE WRD Staff report (August 2017)*

The status of a designated use in a watershed can be met, impaired, threatened, or under review/unknown. The use is unimpaired if the available physical and analytical data indicates that all applicable WQS are being consistently met. If the available physical and analytical data indicates that WQS are not being consistently met, then the designated use is considered to be impaired. If an assessment unit is expected to not meet a particular designated use within the next two years (Integrated Report

listing cycle), it is identified as threatened. A use that is designated as under review or unknown means there is insufficient physical or analytical data available to determine a status for the use, and additional studies are necessary.

The Clean Water Act (CWA) requires Michigan to prepare a biennial report on the quality of its water resources as the principal means of conveying water quality protection/monitoring information to the United States Environmental Protection Agency (EPA) and the United States Congress. The Water Quality and Pollution Control in Michigan, Sections 303(d), 305 (b), and 314 Integrated Report (Integrated Report) (EGLE 2020), satisfies the listing requirements of Section 303(d) and the reporting requirements of Section 305(b) and 314 of the CWA. The Section 303(d) list includes Michigan water bodies that are not attaining one or more designated uses and require the establishment of Total Maximum Daily Loads (TMDLs) to meet and maintain Water Quality Standards.

According to EGLE's 2024 Integrated Report, there are a few impairments in the watershed (Table 11). Several water bodies are listed as not meeting the fish consumption designated use because due to elevated fish tissue levels of mercury and PCBs in some species due to atmospheric deposition of these pollutants. This issue is being addressed at the state and regional levels and is beyond the scope of this Watershed Management Plan. There are also threats to total body and partial body contact recreation due to elevated e. coli levels. Additional monitoring would need to be conducted to determine the source.

While the majority of assessed surface waters in the Watershed are currently meeting all of the designated uses of the State, it should be noted that the Watershed remains vulnerable to nonpoint source pollution and other environmental stressors. Existing and future activities will invariably create risk of degradation to some or all of the designated uses and it is critical to enact preventative and restorative actions to ensure future use of watershed resources.

Table 11. Designated Uses Not Being Supported (303d listed)

Designated Use	Water Body	Pollutant	Year Listed
Total Body Contact	Rainy River, Black River, Welch Creek, Bowen Creek, Sturgis Creek, Little Rainy River, Gregg Creek, East Branch Rainy River	E. Coli	2024
Partial Body Contact	Rainy River, Little Rainy River, Gregg Creek, Black River, East Branch Rainy River	E. Coli	2024
Other Indigenous Aquatic Life & Wildlife	Little Rainy River	Mercury	2024
Fish Consumption*	Canada Creek, Montague Creek, Packer Creek, Van Hetton Creek, Oxbow Creek, Tomahawk Creek, Black River, Gokee Creek, Lewis	Mercury (Black River only), and POLYCHLORINATED BIPHENYLS (PCBS)	2022 (Black River mercury only), 2006

	Branch Adair Creek, Milligan Creek, Weed Creek, Gregg Creek, Stony Creek, Bowen Creek, Sturgis Creek, Welch Creek, Mud Creek, Fisher Creek, Stewart Creek, Long Lake Creek, Owens Creek, Myers Creek		

**On statewide Mercury & PCB TMDL*

Desired Uses

Outside of the designated uses of the state, the Watershed has several desired uses as identified by stakeholders. A summary can be found in Table 12.

Table 12. Desired Uses of the Black Watershed.

Desired Use	Explanation
Aesthetics	The Watershed should retain its natural beauty and biodiversity
Recreation	Waters should support the ability to recreate: fishing (including consumption), boating, hiking, camping, birding, wading, etc.
Drinking water	Most of the Watershed residents rely on groundwater for drinking
Habitat	Waters should support a healthy fishery
Responsible Boating	Waters should support responsible boating
Navigation	Waters should support the use of navigation

3. WATER QUALITY

Water quality data for the Watershed, as evaluated below, is data collected by TOMWC under an approved Quality Assurance Project Plan (QAPP) as a part of this Watershed Plan project (referred to as 'targeted monitoring'), unless otherwise noted. Where there were data gaps, data was obtained from EGLE, TOMWC's Comprehensive Water Quality Monitoring Program (CWQMP) or Volunteer Lake Monitoring Program, and the District Health Department Number 4 (Figure 21). Summaries of the most common water quality parameters that are reviewed are provided below. Approved and draft water quality QAPP's can be found in Appendix B. Sampling for CWQMP began in 1987 for Black Lake and 2004 for the Upper Black River. The presence or absence of long-term trends are noted in each section dependent on R-squared values ≥ 0.75 calculated from CWQMP results.

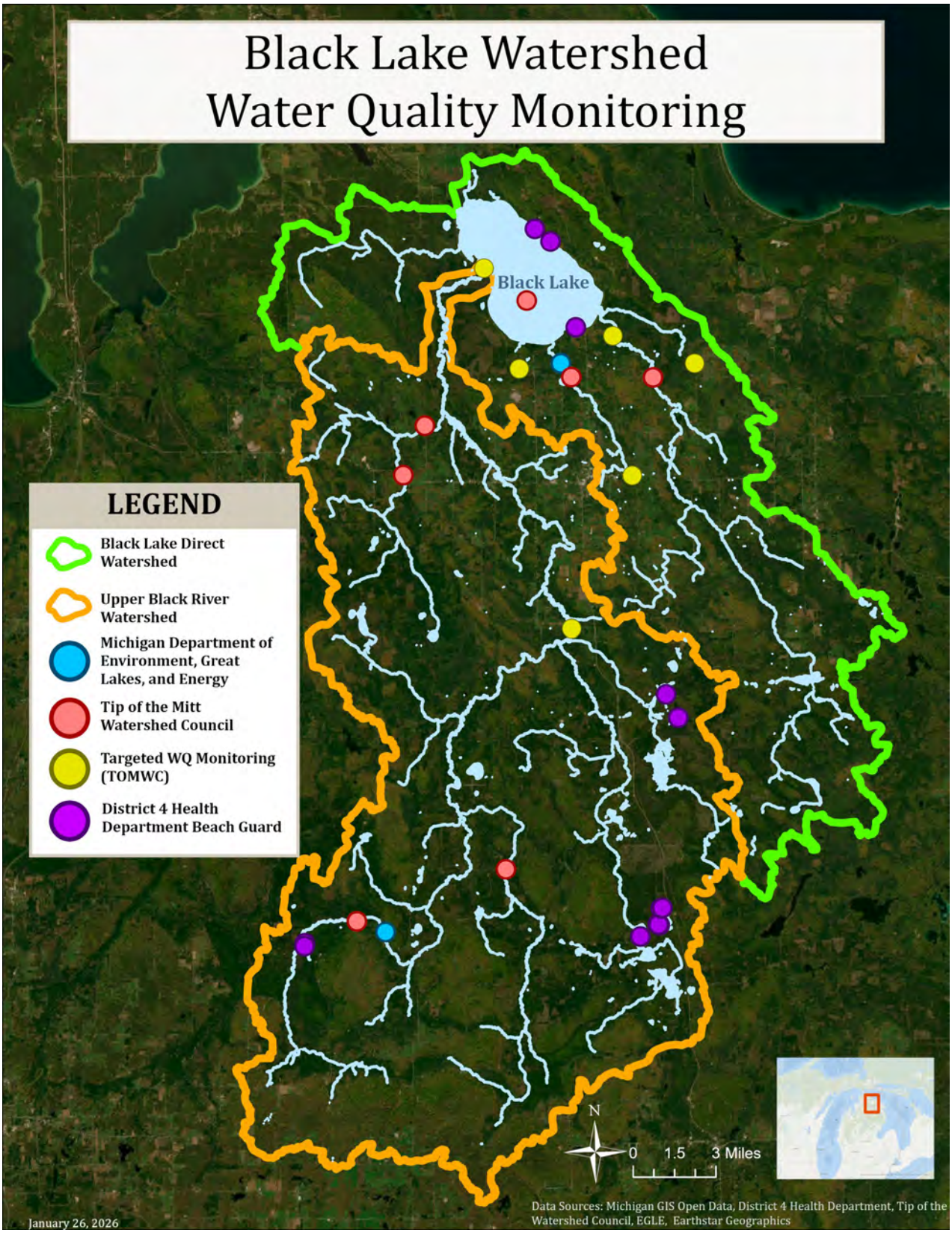


Figure 21. Water quality monitoring locations

Alkalinity, Hardness, and pH

Parameter Description

Alkalinity, Hardness, and pH are important indicators for the acid neutralizing capacity (ANC) of lakes, utility of water, and suitability for aquatic life. pH is a measurement of the acidity or alkalinity of a water body. Distilled water has a pH of 7.0 and is considered pH neutral. Acidic waters have a pH below 7.0, while alkaline waters have a pH above 7.0. EGLE's water quality standard (WQS) for pH is 6.5 to 9.0. Outside of this range, the acidity or alkalinity of the water can become harmful to freshwater organisms. Due to the alkaline limestone bedrock of the region, pH is typically between 7.5 and 8.5.

Alkalinity is a measurement of a water body's pH buffering capacity. It is measured in equivalent mg/L calcium carbonate ($CaCO_3$). The EPA recommendation for aquatic life is an alkalinity concentration above 20 mg/L $CaCO_3$; otherwise, the pH of the water will be highly vulnerable to changes that could become harmful to aquatic life. Waters in the region typically have high alkalinity due to limestone bedrock rich in $CaCO_3$.

Hardness is a measure of the concentration of cations in a water body, such as magnesium, calcium, and iron. Soft water will have low concentrations of these cations, while hard water has high concentrations. Hardness is affected by both geology and pollution in a water body. Hard water can be a nuisance to industry and utilities, as it leaves a scale on equipment and is difficult to clean (hence why many homes use water softeners). Hardness is measured in equivalent mg/L $CaCO_3$. The USGS applies the following classification to water hardness: 0 to 60 mg/L $CaCO_3$ is soft water, 61 to 120 mg/L $CaCO_3$ is moderately hard, 121 to 180 mg/L $CaCO_3$ is hard, and greater than 180 mg/L $CaCO_3$ is very hard.

Summary

pH data for the Watershed's surface waters indicate the water contains relatively high amounts of calcium carbonate ($CaCO_3$), which makes it moderately alkaline with a high buffering capacity (i.e. acid neutralizing), and hard water. Monitoring results show that pH stays fairly consistent, between 7.3-8.4, for all streams, rivers, and lakes and within the WQS. There are no long-term trends for pH in Black Lake and the Upper Black River. The more intensive Black Lake targeted monitoring results are within the range of pH levels from the long-term CWQMP. Tributaries sampled during the 2018 Black Lake Tributary Study had similar results to the targeted monitoring. Stony Creek at M-68 had consistently lower pH than other streams, though there were no exceedances. There was a maximum of 1 unit of pH difference between surface and bottom samples in a given sampling event on Black Lake during the targeted monitoring (Figure 22). Bottom pH appears to decrease during stratification in the summer (Aug lower than July). pH is well within the WQS and is not of concern at this time. pH over 8 typically results in increased bioavailability of P and N, however, we see bottom pH lower than 8 most of the year (Jin et al. 2006). Many streams in this watershed average between 8 and 8.5 pH. If there is significant nutrient loading in these streams, we may expect the loads to flow through to the lake and not be bound to the stream sediments.

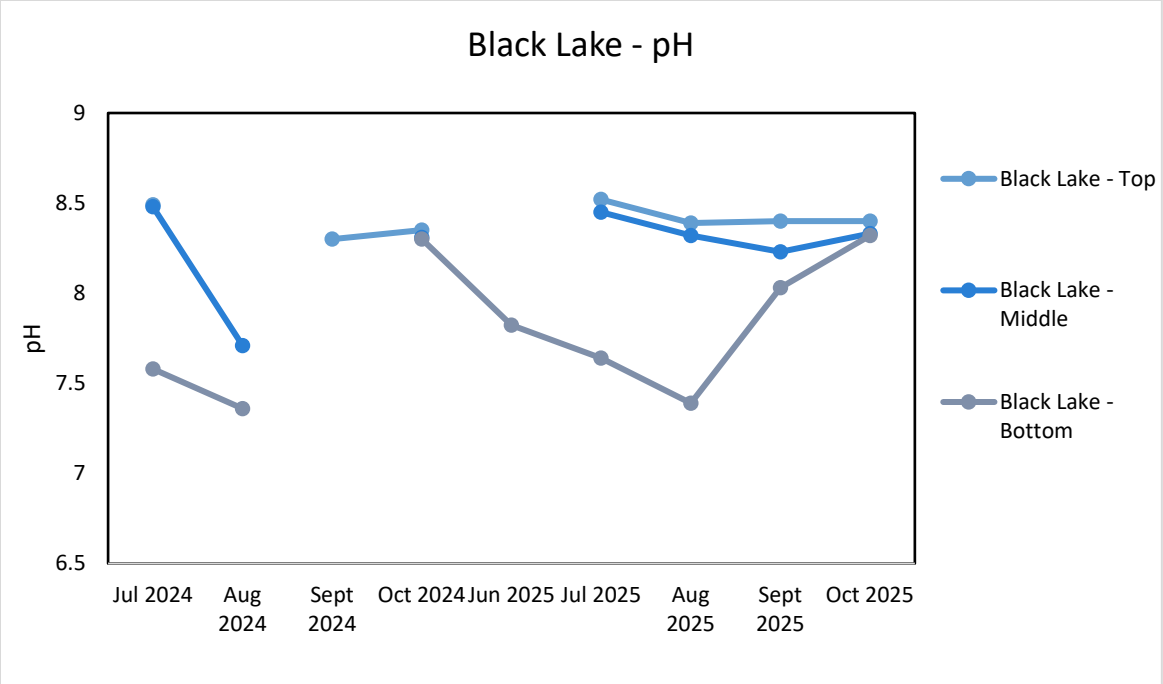


Figure 22. Black Lake pH measurements

Conductivity and Chloride

Parameter Description

Conductivity is a measure of the ability of water to conduct an electric current, which is dependent upon the concentration of charged particles (ions) dissolved in the water. It is measured in micro-Siemens per centimeter (µS/cm). Specific conductance is simply conductivity standardized to a temperature of 25 degrees Celsius. Chloride, a component of salt, is a negatively charged particle that contributes to the conductivity of water. Chloride is a "mobile ion," meaning it is not removed by chemical or biological processes in soil or water. Chloride is measured in mg/L. Many products associated with human activities contain chloride (e.g., deicers, water softeners, fertilizers, and bleach). Conductivity and chloride levels in lakes and streams tend to increase as population and human activity in a watershed increase. Research shows that both conductivity and chloride levels in surface waters are good indicators of human disturbance in a watershed, particularly from urban land use (Jones and Clark 1987, Lenat and Crawford 1994, Herlihy et al. 1988).

EGLE's WQS for chloride is 125 mg/L for waters designated as a public water supply source at the point of intake. Although there is no WQS for specific conductance, higher values can signify an increased likelihood of water quality impairment. Michigan has set values for chloride in surface waters at 150 mg/L for the final chronic value.

Summary

For tributaries, chloride was highest in Stewart Creek, followed by Stony Creek at County Line Road. There were no WQS exceedances for chloride, however, many sites had elevated chloride compared to other Northern Michigan streams (Figure 23). Most sites peaked in Fall 2024 and increased in 2025 up to the

fall concentrations again. Stony Creek, Cold Creek, and Stewart Creek, also sampled during the 2018 Tributary Study, had similar chloride levels between the different sampling events. All targeted monitoring events except the 2025 Summer wet weather event, had flagged chloride data either due to samples being analyzed outside of the hold time or exceeding the relative percent difference between duplicates and routine samples. Cold Creek, Stony Creek, and Stewart Creek regularly have fairly high levels of specific conductivity (Figure 24). All sites peaked in Fall 2024 (dry weather) and appeared to increase in dry weather. For the Fall dry (2024) event, Stewart Creek had elevated conductivity and lower pH indicating a potential influx of pollutants. Stewart Creek goes through a golf course (with ponds), a gravel pit, and agricultural lands.

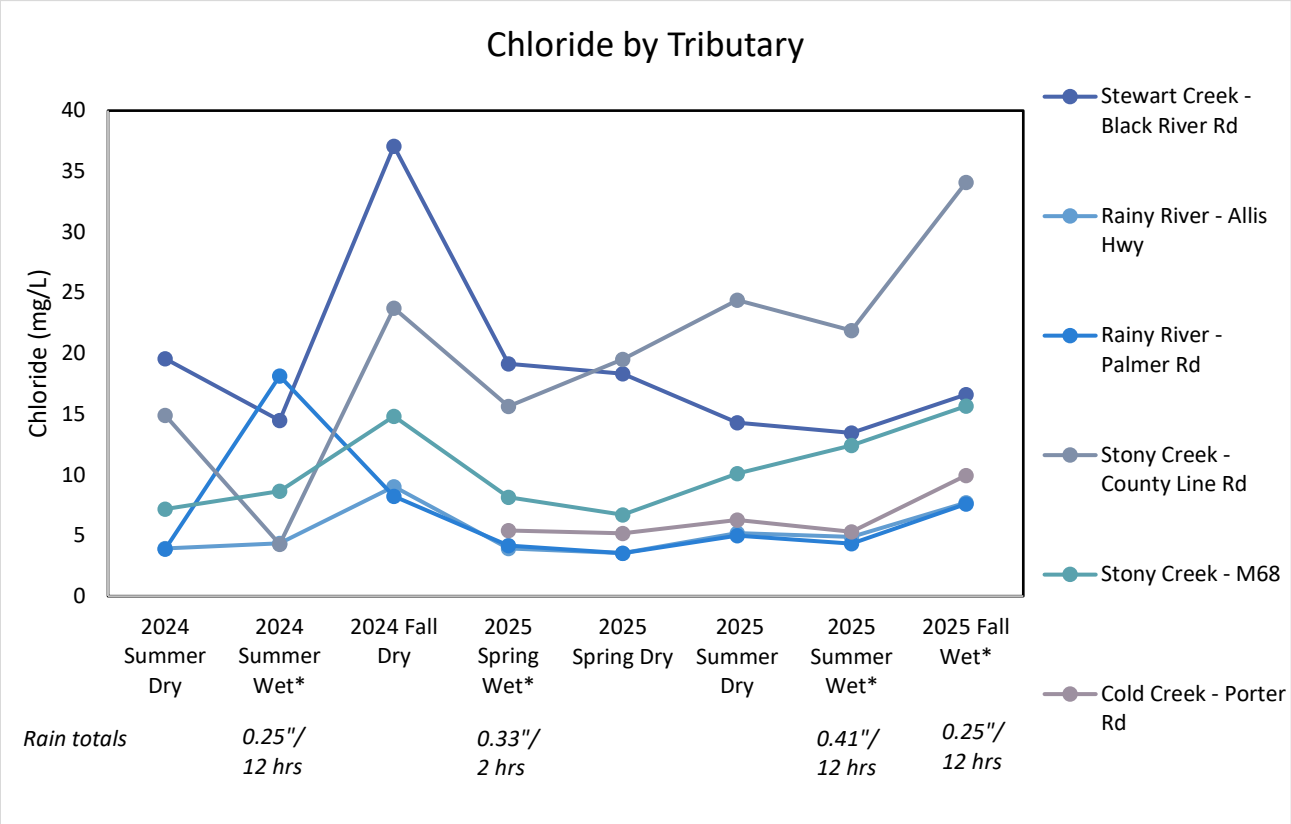


Figure 23. Chloride in Black Lake tributaries

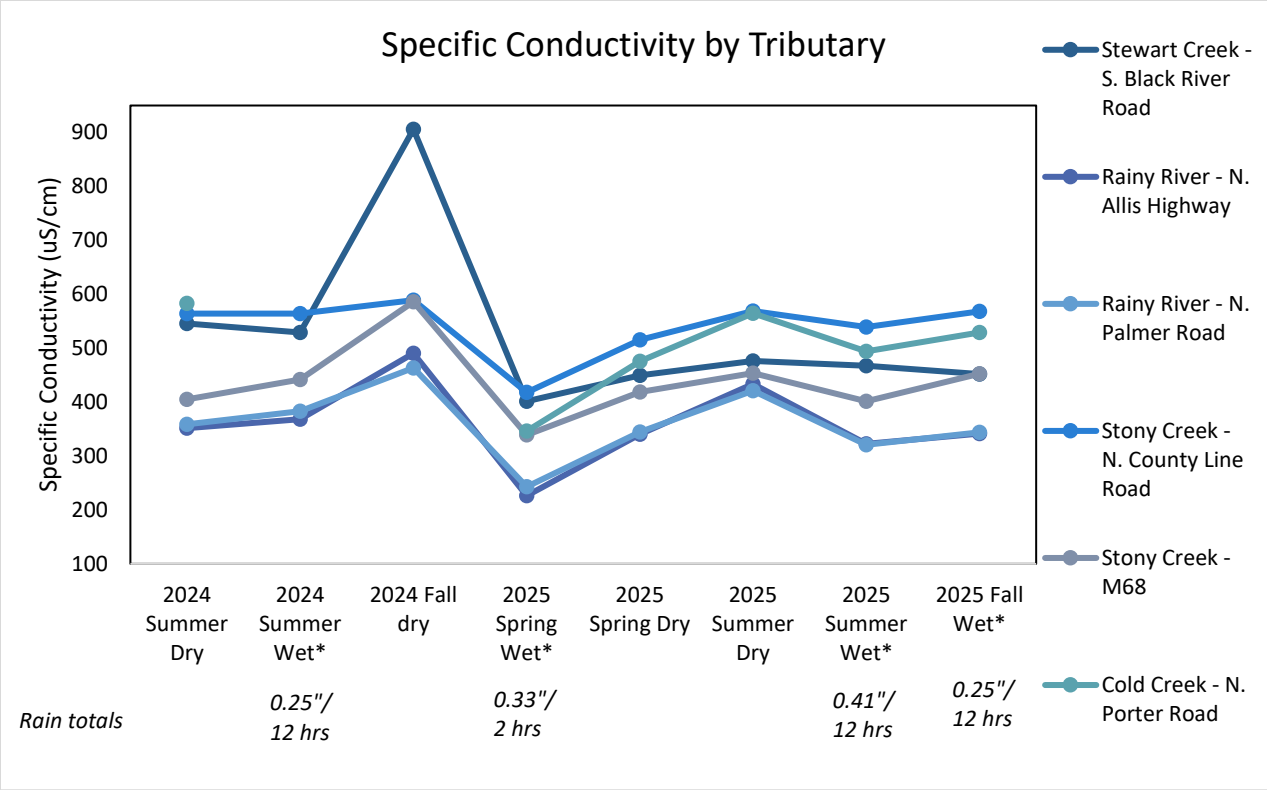


Figure 24. Conductivity in Black Lake tributaries

The Upper Black River has low levels of chloride, and its long-term average is less than 5 mg/L Cl. Targeted monitoring chloride results are consistent with long-term CWQMP results. For conductivity, the Upper Black River has levels within the WQS and a long-term average of less than 290 µS/cm. There are no long-term trends or WQS exceedances for chloride or conductivity. 2024 conductivity levels from targeted monitoring were higher than the range of CWQMP results, however, 2025 levels were within the same range as CWQMP monitoring. Through the targeted monitoring, neither chloride nor conductivity results appeared to be related to wet/dry weather. All targeted monitoring events except the 2025 Summer wet weather event, had flagged chloride data either due to samples being analyzed outside of the hold time or exceeding the relative percent difference between duplicates and routine samples.

Black Lake has low levels of chloride. Its long-term average, less than 6 mg/L, is well within State of Michigan WQS. Chloride has been sampled on Black Lake regularly since 1987 and no long-term trends exist. Conductivity levels are relatively low in Black Lake, with a long-term average less than 280 µS/cm. There are no long-term trends for conductivity. 2024 conductivity levels from the targeted monitoring results were above the range of the long-term data, however, 2025 levels were lower and within the long-term range.

Dissolved Oxygen & Temperature

Parameter Description

Water temperature can be used to help assess habitat suitability for aquatic organisms and to determine if and when a lake is stratified. Dissolved oxygen is one of the most important parameters monitored for assessing water quality. Oxygen is required by almost all organisms, including those that live in the water. Oxygen dissolves into the water from the atmosphere and through photosynthesis of aquatic plants and algae. State law requires that a minimum of 7 mg/L be maintained in lakes and streams designated as a cold-water fishery. However, the hypolimnion (depths below the thermocline) of stratified lakes can have low oxygen due to aerobic decomposition and limited replenishment; these instances aren't necessarily indicative of impairment.

Summary

Lakes

Black Lake is designated as a warmwater fishery; therefore, it requires dissolved oxygen readings of greater than 5 mg/L. The long-term average for dissolved oxygen is over 11 mg/L and there was no long-term trend. Dissolved oxygen and temperature readings varied from the long-term average, which is expected due to stratification, which is not captured in the long-term CWQMP data. Dissolved oxygen does fall below the 5 mg/L WQS during summer stratification, which is common in local lakes (Figure 25). Temperature is well within the State of Michigan's WQS (Figure 26). As shown by temperature and dissolved oxygen profiles, Black Lake is stratified in July and August both years and begins to mix in September. In October, the lake is mixed. In summer, the layer at the bottom of the lake limits fish habitat and likely releases phosphorus from what it's bound to due to its limited oxygen levels. When mixing occurs, the phosphorus comes up and may cause an algae bloom. This is especially a concern if the lake mixes regularly instead of only late in the year, once the lake has already cooled down.

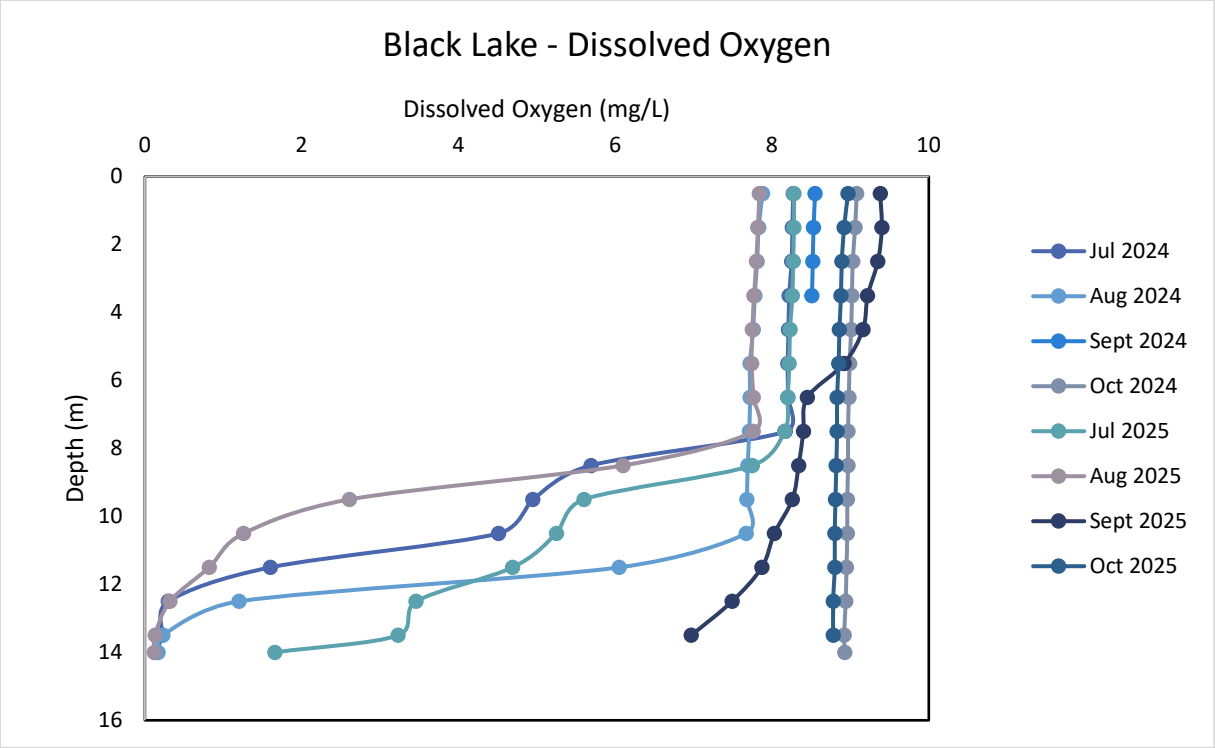


Figure 25. Dissolved oxygen profile for Black Lake

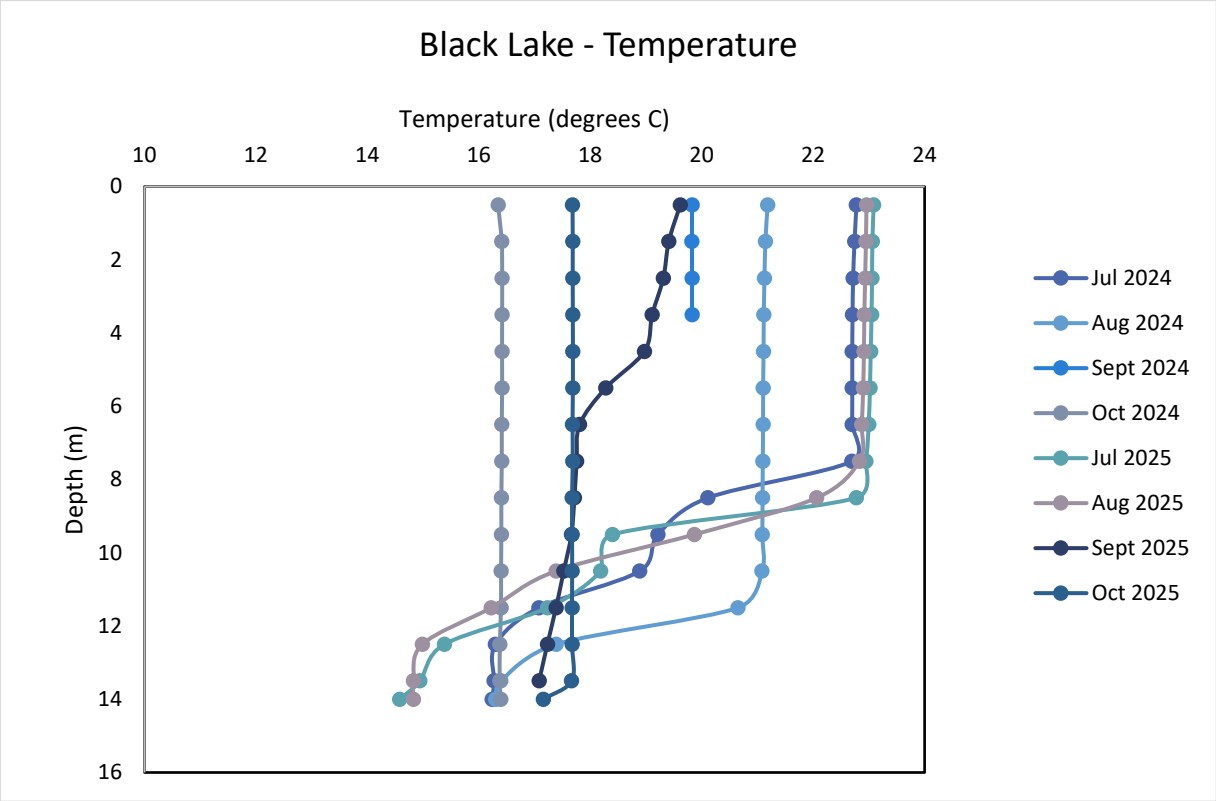


Figure 26. Temperature profile for Black Lake

Rivers and Streams

The Upper Black River has summer temperature exceedances of the 7 mg/L WQS for coldwater streams (Figure 27). Its long-term average temperature was about 12 degrees Celsius and there was no long-term trend. The Upper Black River had no exceedances for dissolved oxygen, and its long-term average was over 10 mg/L. Long-term CWQMP data was comparable to the targeted monitoring results for temperature and dissolved oxygen.

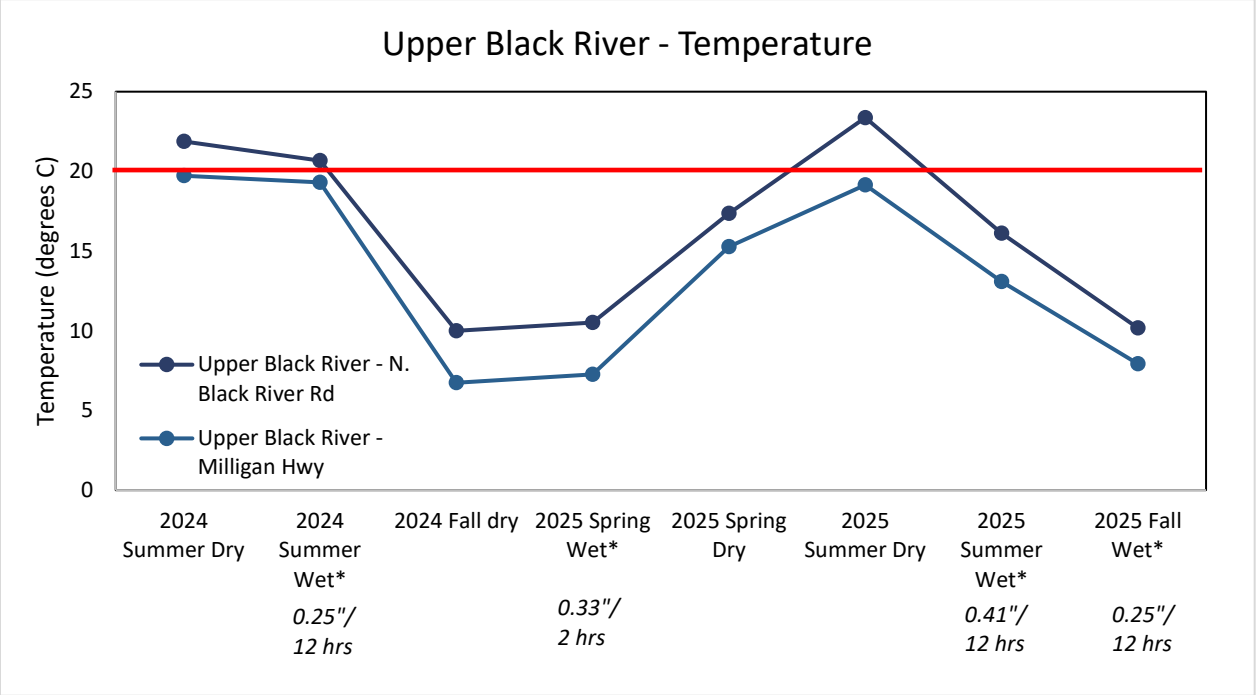


Figure 27. Temperature measurements for Upper Black River

Dissolved oxygen should be at least 7 mg/L for coldwater streams (all streams sampled except Cold Creek) and 5 mg/L for other streams (Cold Creek) (Figure 28). Stony Creek (County Line) fell below this WQS once, while Stony Creek (M68) had consistent dissolved oxygen exceedances which is likely related to having stagnant water during most of the sampling events. Temperature WQS vary by month, but for June through August, the WQS for coldwater streams is 20 degrees C. These were the only months where coldwater streams exceeded the temperature WQS. These streams include Rainy River (both sites), Stony Creek (M68), and Upper Black River (Black River Rd) (Figure 29). Cold Creek is subject to the warmwater temperature WQS and did not exceed the WQS. Sites also sampled in the 2018 Tributary Study (Stony and Stewart Creeks) had similar temperature and dissolved oxygen results.

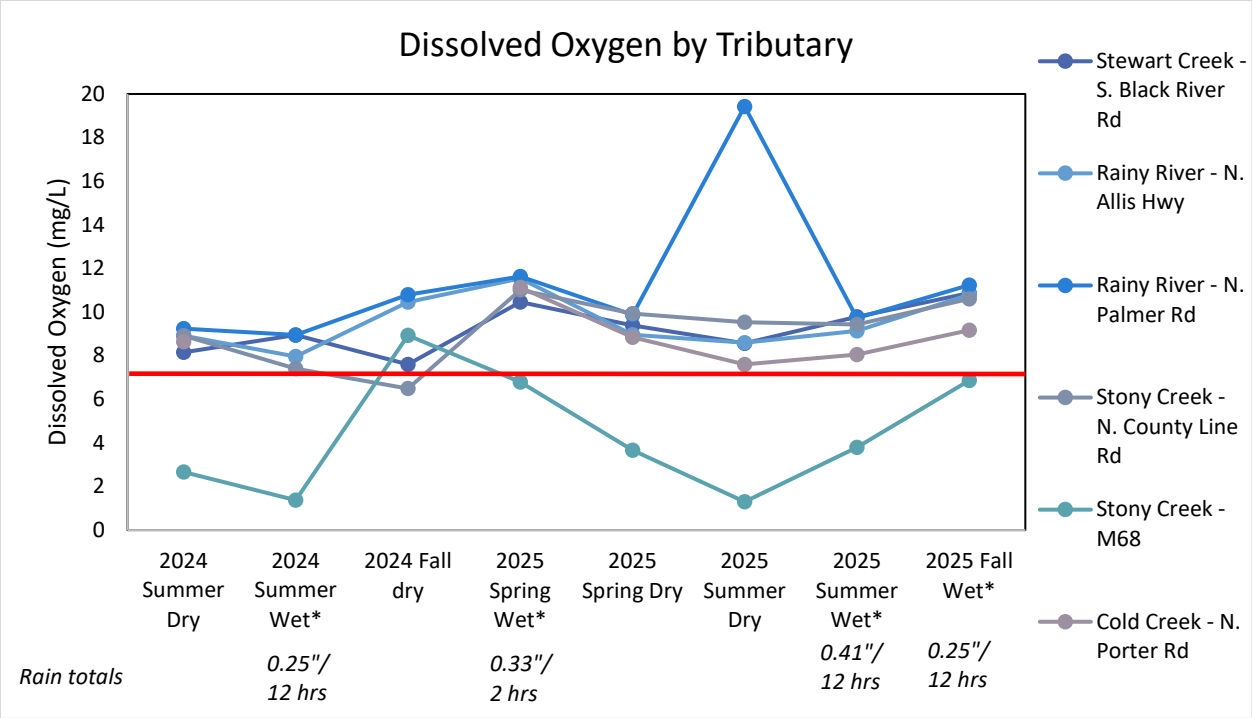


Figure 28. Dissolved oxygen readings for Black River tributaries

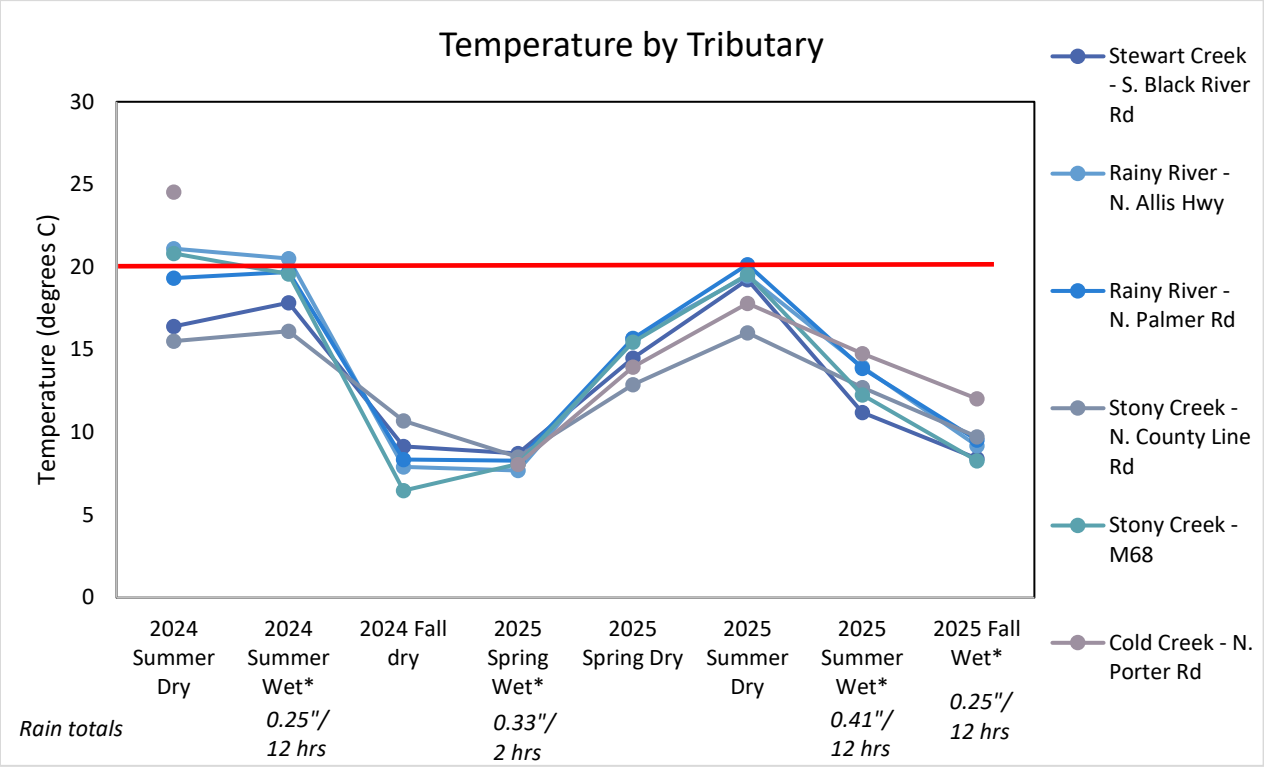


Figure 29. Temperature measurements for Black River tributaries

Nutrients: Phosphorus and Nitrogen

Parameter Description

Nutrients are chemicals needed by organisms to live, grow, and reproduce. Nutrients occur naturally and can be found in soils, water, air, plants, and animals. Phosphorus and nitrogen are essential nutrients for plant growth and important for maintaining healthy, vibrant aquatic ecosystems. However, excess nutrients from sources such as fertilizers, faulty septic systems, and stormwater runoff lead to nutrient pollution, which can have negative impacts on surface waters. Lakes and streams in the region are typically phosphorus limited, meaning that added phosphorus increases growth of aquatic plants and algae while added nitrogen may not increase growth. It has been estimated that one pound of phosphorus could stimulate 500 or more pounds of algae growth (Vallentyne 1974). Therefore, heavy phosphorus inputs to lakes and streams can result in nuisance algae and plant growth, which could, in turn, degrade water quality and alter the natural lake ecosystem.

Michigan WQS do not include a numerical standard for nutrient concentration limits for surface waters. Regulation for surface waters is limited to the following narrative standard from Rule 60 (323.1060): "nutrients shall be limited to the extent necessary to prevent stimulation of growth of aquatic rooted, attached, suspended, and floating plants, fungi or bacteria which are or may become injurious to the designated uses of the waters of the state" [Rule 60(2)]. However, a total phosphorus (TP) concentration of 12 micrograms per liter (µg/L) or less for streams in the Northern Michigan ecoregion is considered the reference condition by the EPA "because it is likely associated with minimally impacted conditions, will be protective of designated uses, and provides management flexibility" (EPA 2001). The EPA reference condition for total nitrogen (TN) for streams in the same ecoregion is 440 µg/L or less. In addition, Michigan drinking water standards require that nitrate-nitrogen concentrations be less than 10 mg/L. For lakes in the same ecoregion the EPA reference conditions are 9.69 µg/L for TP and 400 µg/L for TN (EPA 2000).

Summary

All tributaries had TP levels exceeding the EPA reference condition (Figure 30). TP was highest at Stony Creek at M68, followed by Cold Creek. Dry weather events appeared to have higher TP than wet weather sampling events. When comparing targeted monitoring to 2018 Tributary Study and Stony Creek follow-up study (TOMWC 2022), Stewart Creek had similar levels, Cold Creek had higher levels in targeted monitoring than in 2018, and Stony Creek had fluctuating levels that peaked in 2018. Stony Creek had the highest soluble reactive phosphorus (SRP) levels and was the only tributary that exceeded the EPA reference condition (TP) for soluble reactive phosphorus (Figure 31). In general, soluble reactive phosphorus levels were variable but higher during the summers. There were no tributaries with nitrate concentrations exceeding the WQS (Figure 32). Stewart Creek and Cold Creek had the highest nitrate levels. There was less fluctuation between sampling events of different weather than TP and soluble reactive phosphorus. Monitoring results for TP, soluble reactive phosphorus, and nitrate were flagged for data quality concerns due to samples being analyzed outside of the hold time or exceeding the relative percent difference between duplicates and routine samples, except for the following: TP - targeted monitoring 2025 Summer wet weather, targeted monitoring 2025 Fall wet weather; soluble reactive phosphorus and nitrate - targeted monitoring 2025 Summer wet weather.

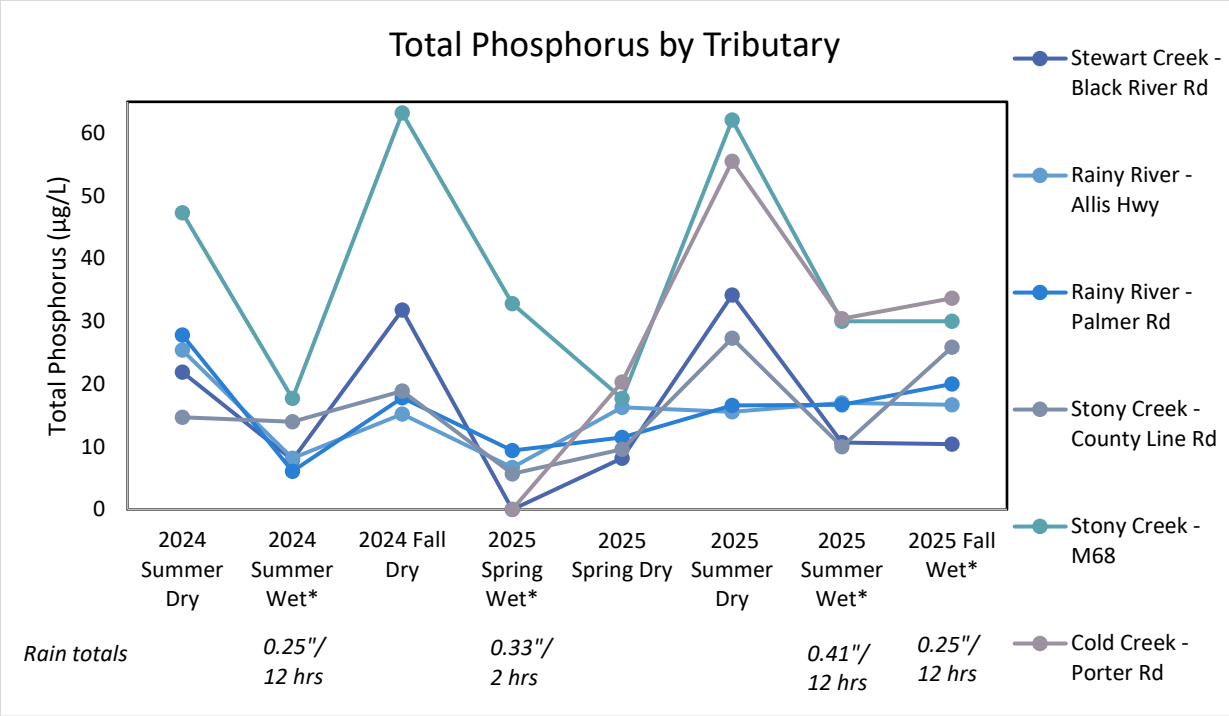


Figure 30. TP in Black Lake tributaries

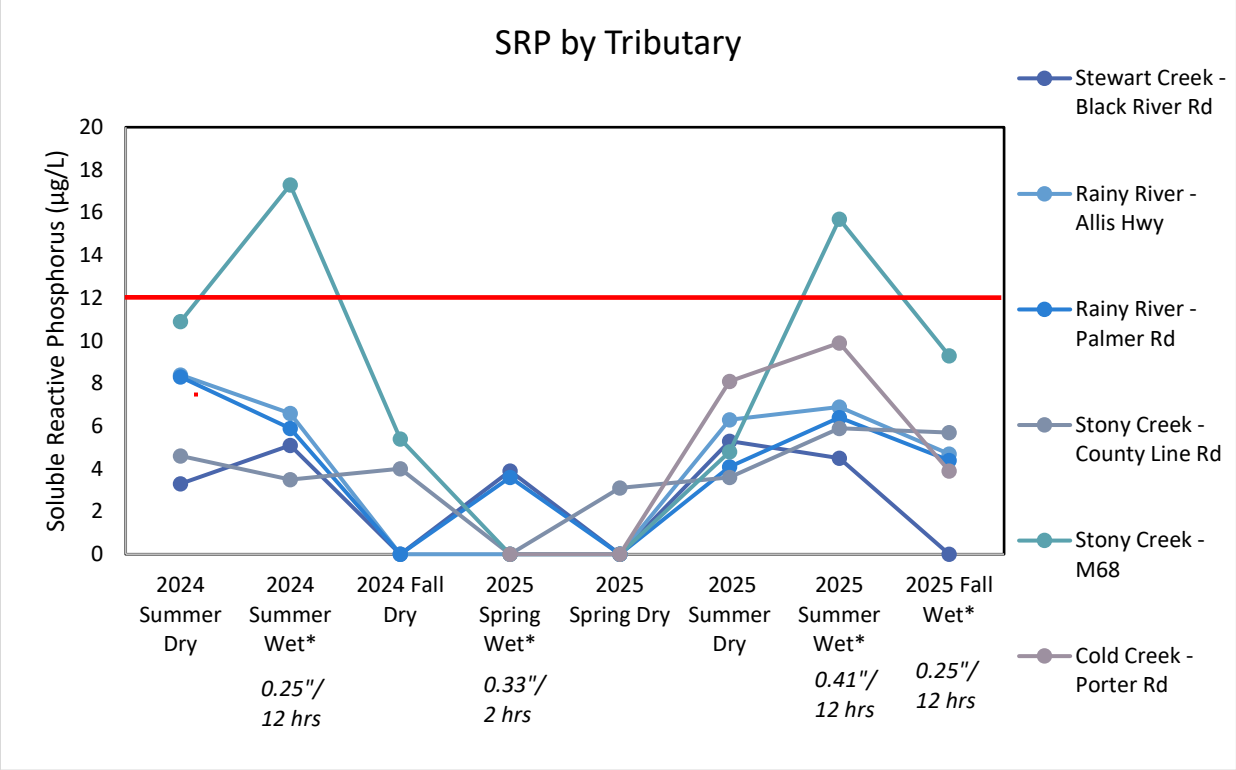


Figure 31. Soluble reactive phosphorus in Black Lake tributaries

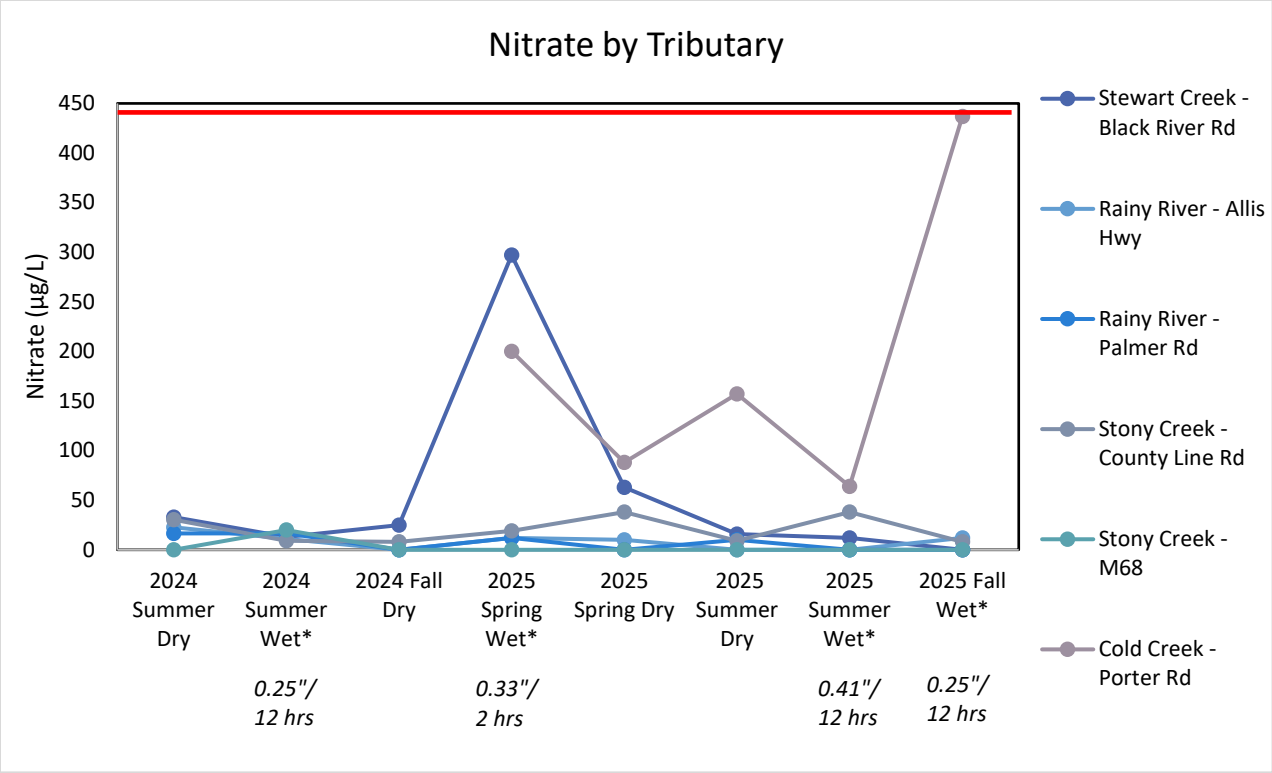


Figure 32. Nitrate in Black Lake tributaries

For the Upper Black River, there were no long-term trends for TP, TN and nitrate. targeted monitoring revealed TP reference condition exceedances for most sampling events in 2024 and 2025 (Figure 33). Targeted monitoring had higher yearly averages for TP than CWQMP, but when comparing the targeted monitoring sample during the same timeframe as CWQMP sampling, the result was comparable. Dry weather sampling results appeared to have higher concentrations of TP than wet weather sampling results. The long-term average for TP was less than 7 µg/L.

No other nutrient results in the Upper Black River had reference condition exceedances. TN and nitrate did not appear to vary with wet or dry weather. The long-term average for TN is 310 µg/L and results were fairly consistent. Over the last 10 years, TP and TN had an inverse relationship. Nitrate results varied widely but were similar between targeted monitoring and CWQMP monitoring. The long-term average for nitrate was less than 25 µg/L. Soluble reactive phosphorus was variable and appeared to be higher during wet weather than dry weather sampling events.

Monitoring results for TP, soluble reactive phosphorus, and nitrate were flagged for data quality concerns due to samples being analyzed outside of the hold time or exceeding the relative percent difference between duplicates and routine samples, except for the following: TP - targeted monitoring 2025 Summer wet weather, targeted monitoring 2025 Fall wet weather, all CWQMP data; TN - all CWQMP data before 2025; soluble reactive phosphorus - targeted monitoring 2025 Summer wet weather; and nitrate - targeted monitoring 2025 Summer wet weather, all CWQMP data.

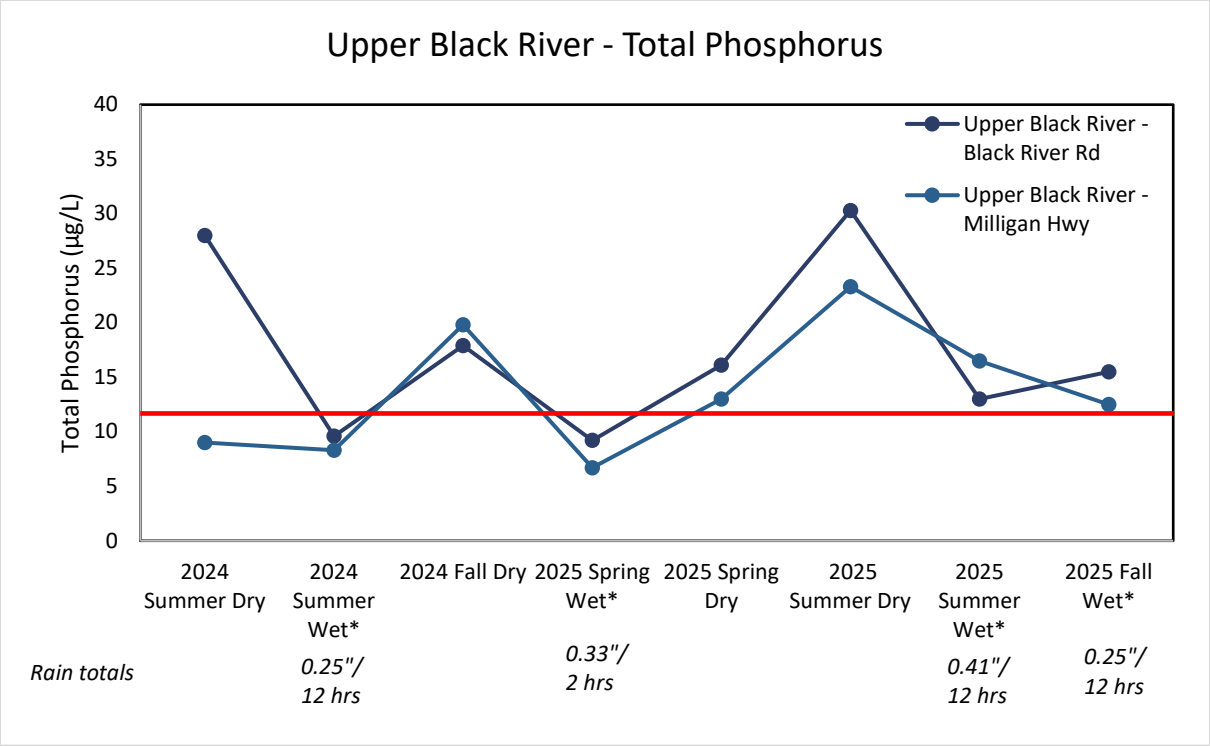


Figure 33. TP in rivers

Nutrient loading for the streams was difficult to compare due to lack of flow for discharge measurements, but with the information given, Rainy River is contributing the highest TP and soluble reactive phosphorus loads, and the Cold Creek is contributing the highest nitrate loads (Figure 34-36). Nutrient loads varied for all three parameters throughout the year and with limited discharge data, annual averages were not calculated. Loading calculations were based on nutrient data described above. Data flagged for quality concerns are described above.

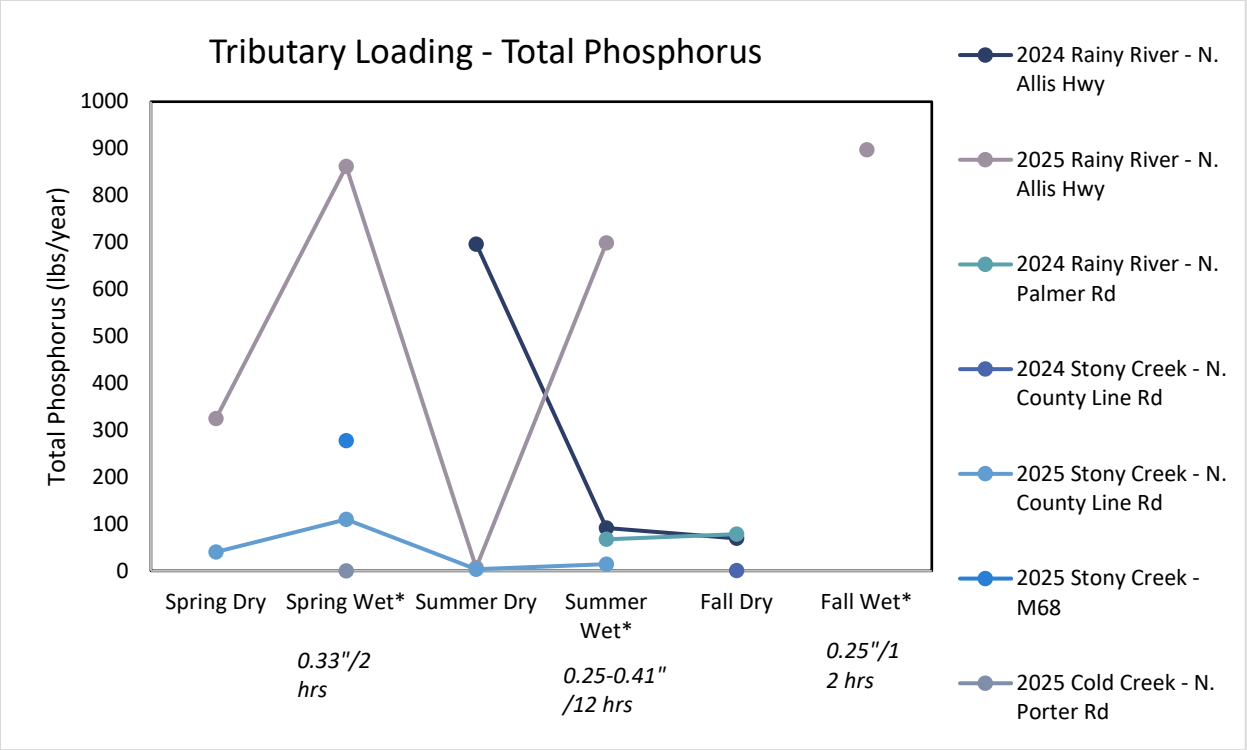


Figure 34. TP loading in tributaries

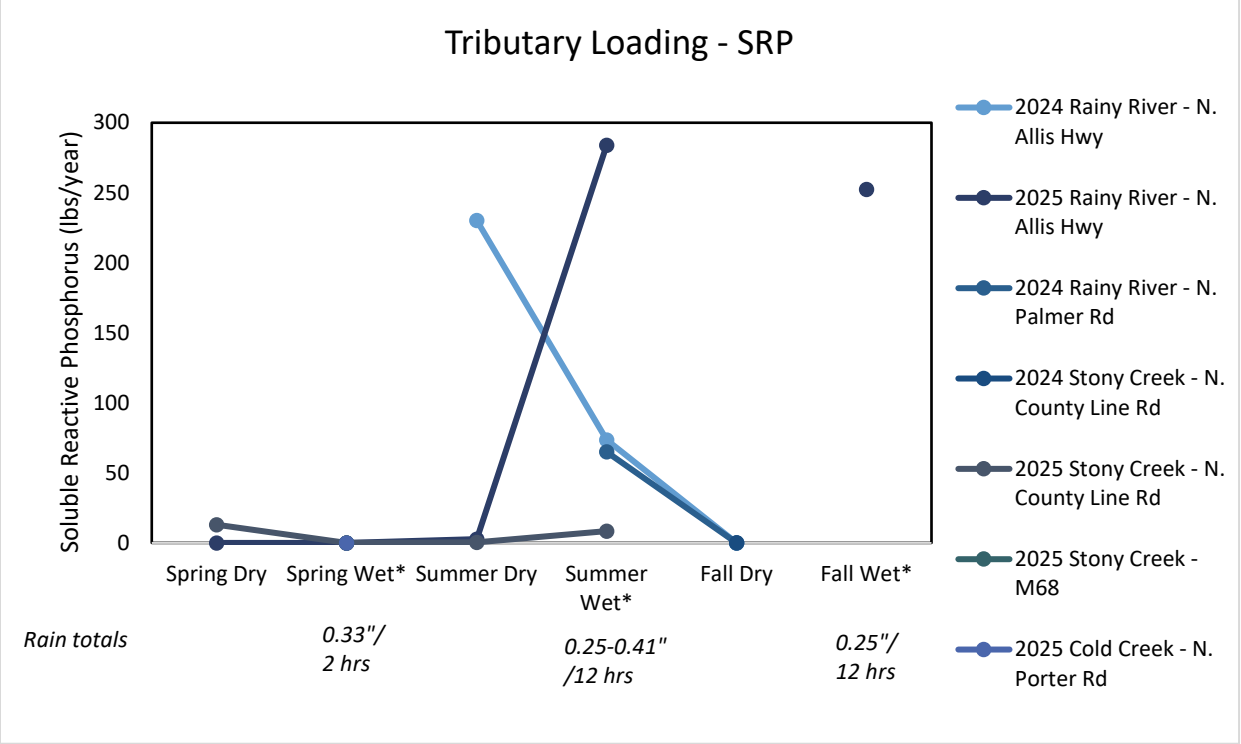


Figure 35. Soluble Reactive Phosphorus loading in tributaries

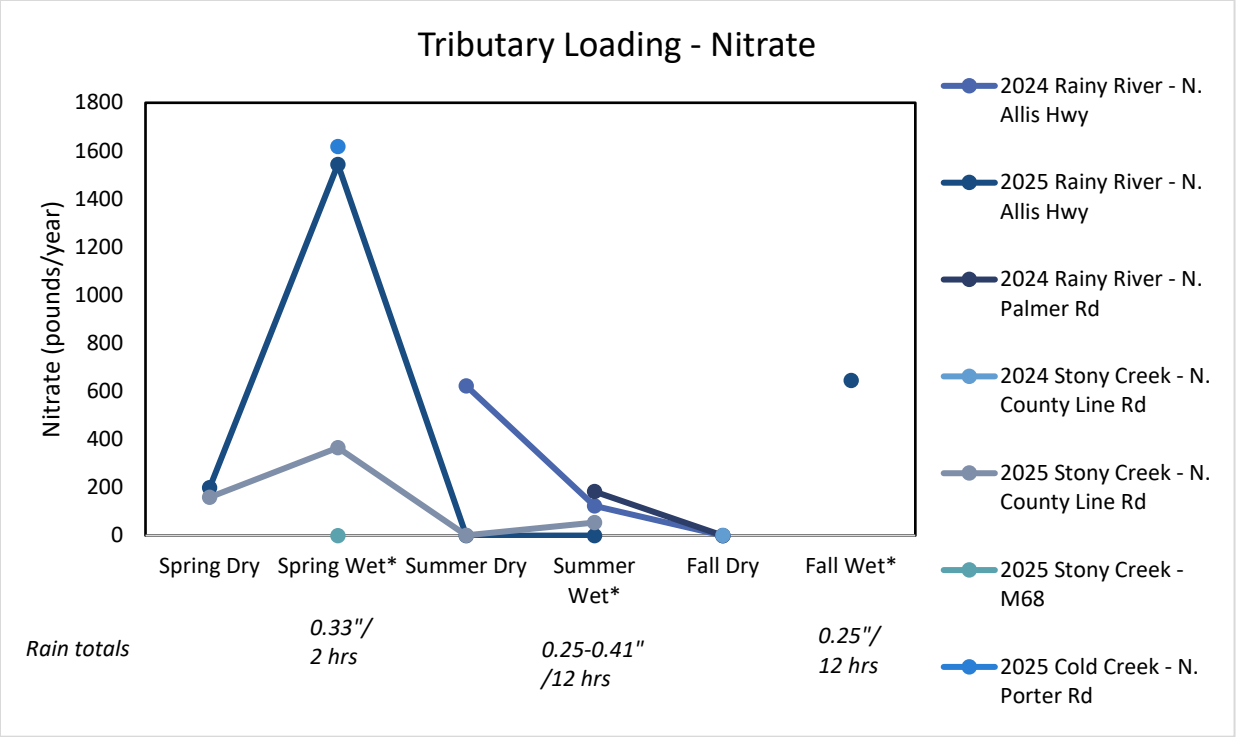


Figure 36. Nitrate loading in tributaries

For Black Lake, there are no long-term trends for TP, TN, and nitrate. The long-term average for TP was less than 7 µg/L. Targeted monitoring events with comparable sampling months were comparable to CWQMP results. For targeted monitoring, TP was lower in 2025 as compared to the same depths in 2024 (Figure 37). TP peaked in 2024 in September below the thermocline, whereas TP peaked in 2025 in July above the thermocline. As expected, the TP above the thermocline increased and meets the TP level below the thermocline in Oct 2024 once the lake is mixed. It is unexpected that TP is highest above the thermocline in 2025 as opposed to below. Typically, once a lake stratifies it will have higher phosphorus levels below the thermocline due to the hypoxic conditions releasing more phosphorus into the water. A factor to consider which may increase the bioavailability of nitrogen and phosphorus above the thermocline is the pH levels over 8 for most of the year in the top and middle depths. In 2024, both the levels above and below the thermocline in September and October exceeded the EPA reference condition. In 2025, July, August, and September levels exceeded the reference condition. There was also an exceedance in 1998.

The long-term average for TN was less than 370 µg/L and there were no long-term trends. TN levels decreased in the late 1980s and 1990s from historical high levels. This crash is likely due to the invasion of zebra mussels. These historically high values and occasional spikes since have exceeded the EPA reference condition, however, current levels average about half the historical high value.

Soluble Reactive Phosphorus (SRP) was also higher in 2024 than 2025 (Figure 38). For all of 2025 and July and August 2024, SRP levels are higher below the thermocline as is expected due to the hypoxic environment. After the lake mixed in 2024, this reversed as the SRP levels above the thermocline were higher than below. There aren't WQS or reference conditions specifically for SRP, but the SRP levels are below the TP reference condition.

The long-term average for nitrate in Black Lake was 56 µg/L. There were no exceedances in long-term nitrate data aside from 1987 which was before nutrient levels crashed, likely due to the invasion of zebra mussels nearer to 2000. Yearly averages from targeted monitoring were much lower than CWQMP results. In 2024 and 2025 targeted monitoring results, there was a summer peak of nitrate concentrations below the thermocline in Black Lake, with the above the thermocline levels being very low or non-detect (Figure 39). There aren't WQS for nitrates in surface water, but the nitrate levels are below the reference condition for TN.

Monitoring results for TP, soluble reactive phosphorus, and nitrate were flagged for data quality concerns due to samples being analyzed outside of the hold time or exceeding the relative percent difference between duplicates and routine samples, except for the following: all CWQMP data; TP - all 2025 targeted monitoring events; soluble reactive phosphorus - targeted monitoring October 2024, and June, August, and October 2025; and nitrate - targeted monitoring October 2024, and June, August, September, and October 2025.

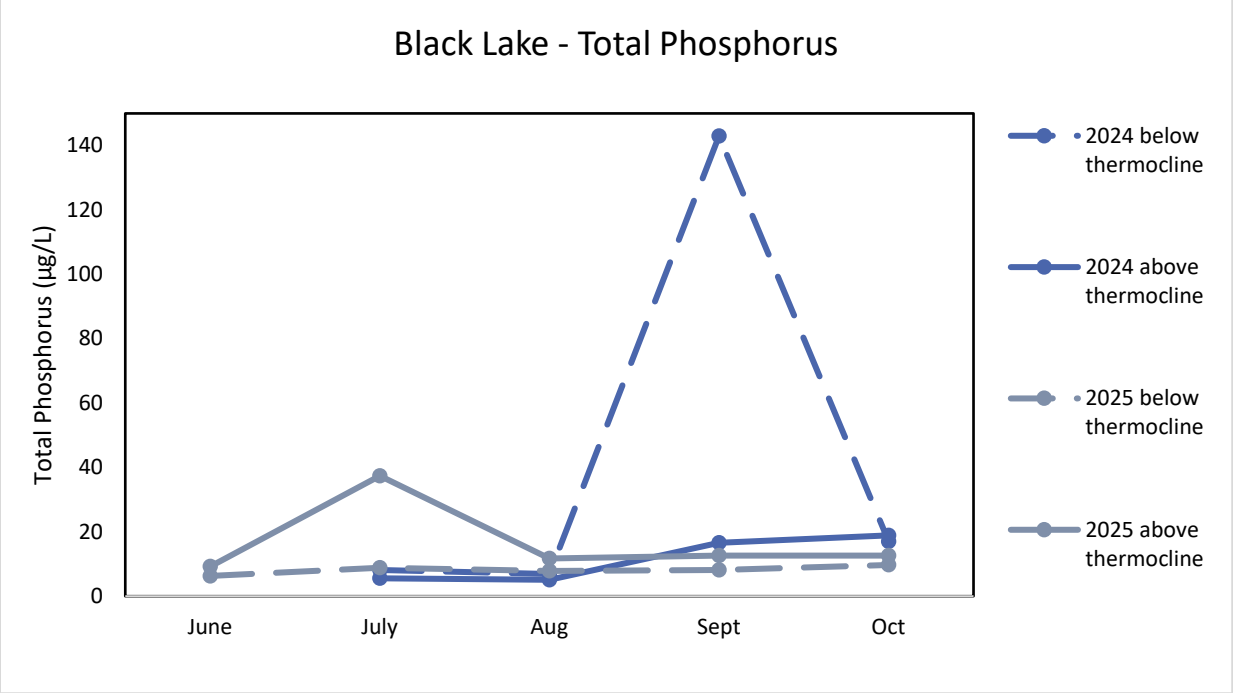


Figure 37. TP in Black Lake

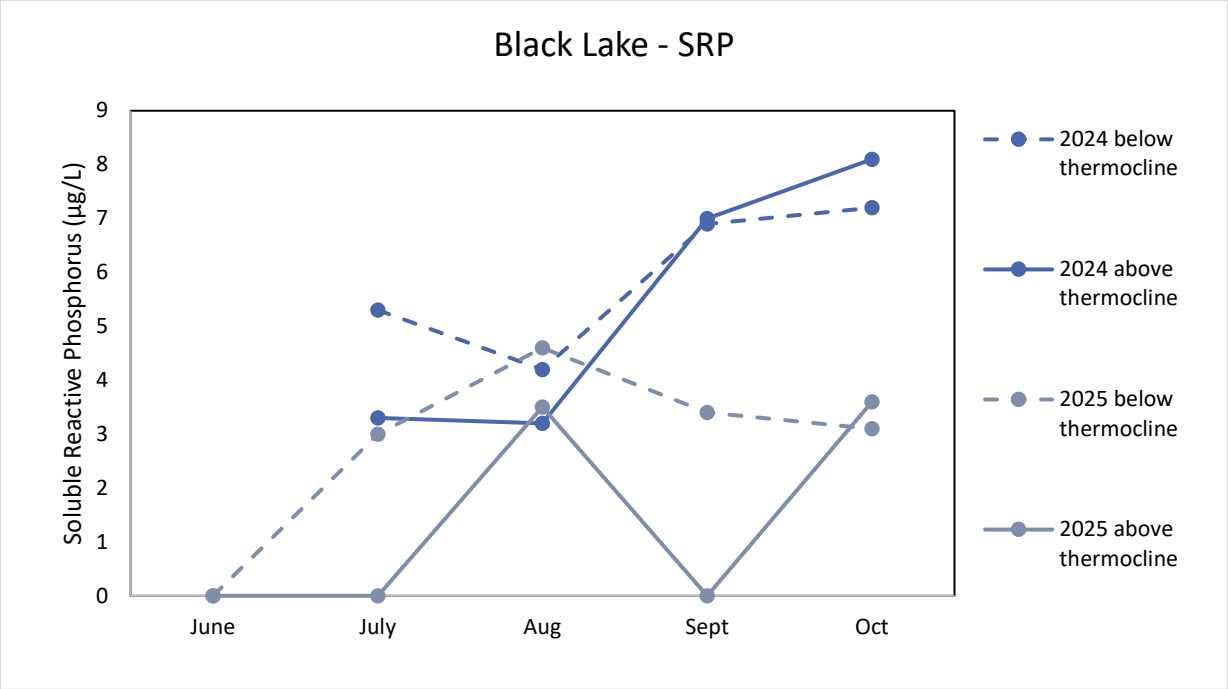


Figure 38. Soluble reactive phosphorus in Black Lake

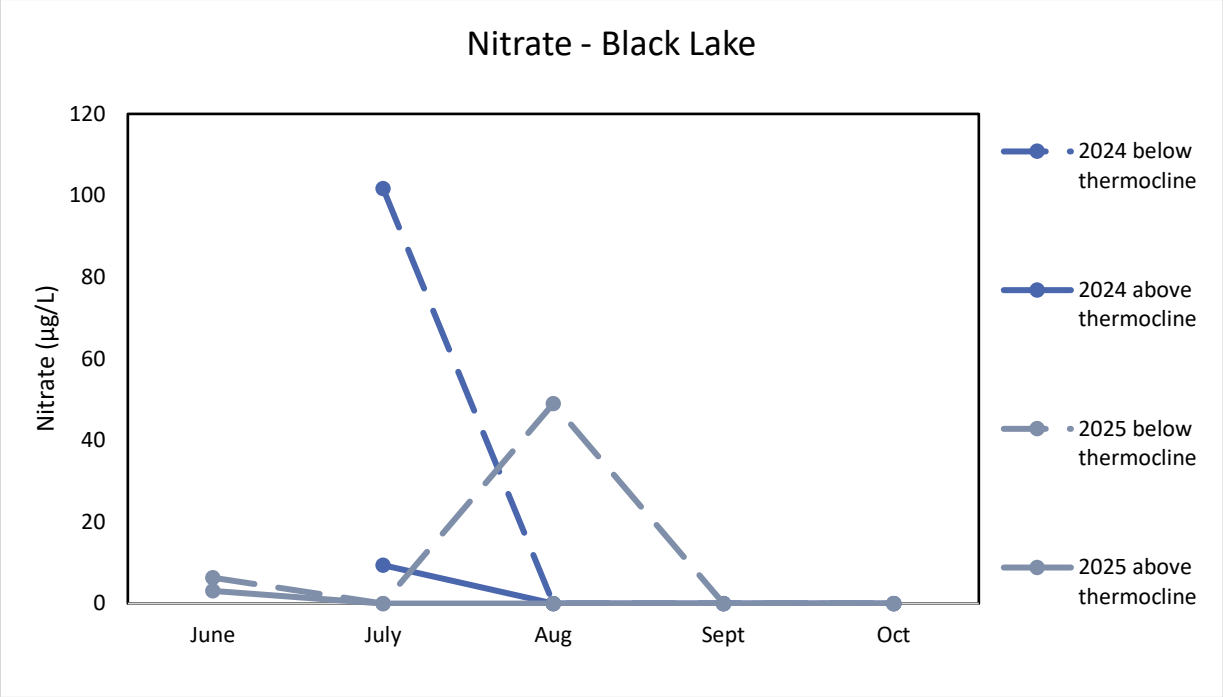


Figure 39. Nitrate in Black Lake

Water Clarity and Trophic Conditions

Parameter Description

Water clarity is a simple and valuable way to assess water quality. The clarity of water is principally determined by the concentration of algae or suspended and dissolved solids in the water. An eight-inch disc with alternating black and white quadrants, called a Secchi disc, is used to measure water clarity by noting the depth at which the disc is no longer visible. Water samples are often collected in conjunction with the Secchi disc measurement for chlorophyll-a analysis; chlorophyll-a is a pigment found in green plants. Chlorophyll-a data provide an approximation of the amount of algae in the water, which is useful for determining whether changes in water clarity are caused by sediments or algae.

Water clarity, chlorophyll-a, and phosphorus data are used to determine the biological productivity, or trophic status, of a lake. The Trophic Status Index (TSI) is a tool developed by Bob Carlson, Ph.D. from Kent State University that utilizes these data to place a water body on a scale of biological productivity (Carlson 1977). TSI values range from zero to 100: lower values (0-38) indicate an oligotrophic or low productive system, medium values (39-49) indicate a mesotrophic or moderately productive system, and higher values (50+) indicate a eutrophic or highly productive system (Table 13). Lakes with greater water clarity and smaller phytoplankton populations would score on the low end of the scale, while lakes with greater turbidity and more phytoplankton would be on the high end. Oligotrophic lakes are characteristically deep, clear, nutrient poor, and with abundant oxygen. On the other end of the spectrum, eutrophic lakes are shallow, nutrient rich, and full of productivity. A highly productive eutrophic lake could have problems with oxygen depletion whereas the low-productivity oligotrophic lake may have a lackluster fishery. Mesotrophic lakes lie somewhere in between and are moderately productive.

Table 13. Trophic state categories

Trophic State	TSI	Chl-a (µg/L)	Secchi (ft)	TP (µg/L)
Oligotrophic	<40	<2.6	>13.1	<12.0
Mesotrophic	40-50	2.6-7.3	6.6-13.1	12.0-24.0
Eutrophic	50-70	7.3-56.0	1.6-6.6	24-96
Hypereutrophic	>70	>56	<1.64	>96

*Carlson, R.E. and J. Simpson. 1996. A Coordinator's Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society. 96 pp.

Depending upon variables such as age, depth, and soils, lakes are sometimes naturally eutrophic. However, nutrient and sediment pollution caused by humans can lead to the premature eutrophication of a lake, referred to as "cultural eutrophication". Cultural eutrophication can affect the fisheries, cause excess plant growth, and result in algal blooms that can be both a nuisance and a public health concern.

Summary

Black Lake is a large, typically oligotrophic lake. Trophic state index (TSI) for Black Lake has remained relatively stable in the oligotrophic range since the early 1990s. 2024 and 2025 chlorophyll results did not pass quality assurance protocols and are not reported here. Black Lake has a long-term average of 1.8 µg/L chlorophyll (Figure 40). There were no long-term trends for secchi-depth, chlorophyll a, or TSI, though secchi depth appears to be increasing over time. This data (secchi depth and chlorophyll *a*) has

been collected through TOMWC's Volunteer Lake Monitoring Program, currently operating under a draft QAPP.

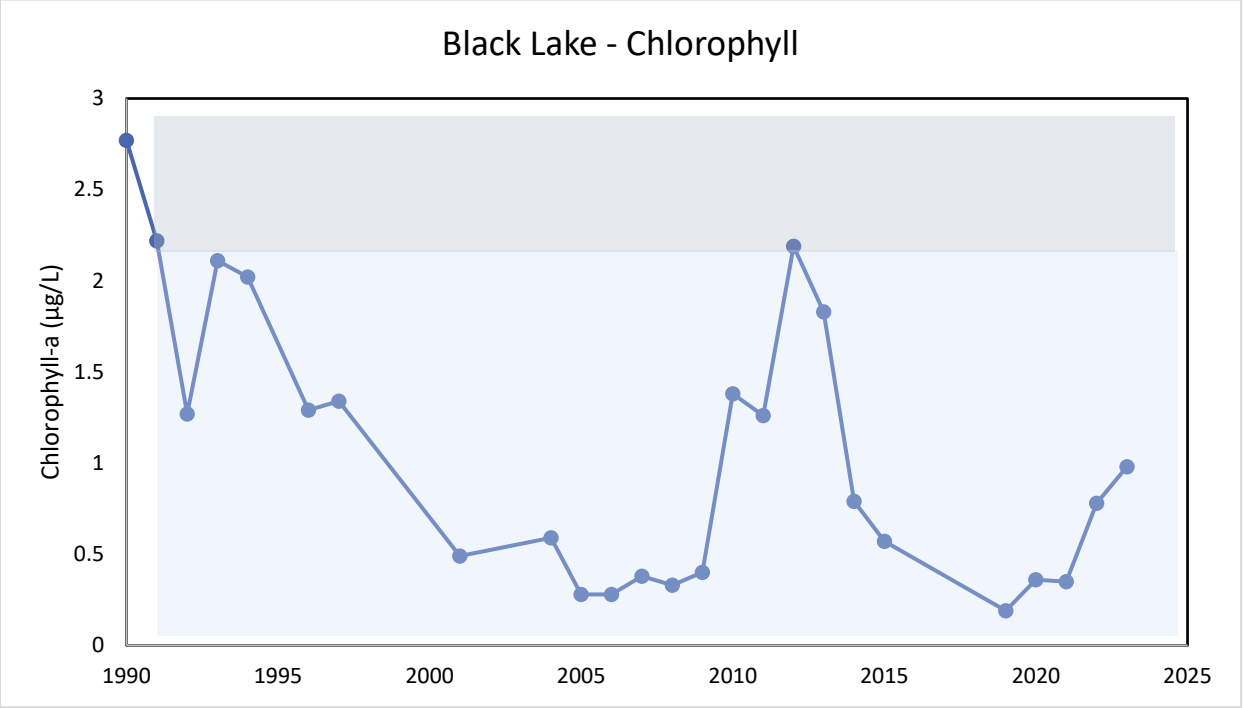


Figure 40. Chlorophyll-a Black Lake

Harmful Algal Bloom Investigation

Keiser & Associates was contracted by Black Lake Preservation Society to investigate potential sources, components, and solutions for the harmful algal blooms (HABs) occurring on Black Lake (Keiser 2025). Starting in 2023, Keiser & Associates sampled lake and tributary surface water and nearshore shallow groundwater, completed phosphorus mass balance, and conducted an online septic system survey. Their results point to septic systems being the main cause of HABs in Black Lake and are continuing to investigate the issue and potential solutions. A report of their findings to date can be found in Appendix C.

Bacteriological Monitoring

Parameter Description

Monitoring for harmful pathogens in a water body is typically performed by monitoring Escherichia coli (E. coli) bacteria at popular access points during the summer. The measurement is the number of E. coli in a 100mL water sample. E. coli bacteria usually do not pose a direct danger, but are rather indicators of the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that originate in human and animal digestive systems. Thus, their presence in surface waters indicates that pathogenic microorganisms might also be found and that there may be health risks associated with full body contact.

Rule 62 (R 323.1062) of EGLE Part 4 Water Quality Standards does have a provision for E. coli concentrations in surface water: "All waters of the state protected for total body contact recreation shall

not contain more than 130 Escherichia coli per 100 milliliters, as a 30-day geometric mean "[Rule 62(1)]. Rule 62 also states: "At no time shall the waters of the state protected for total body contact recreation contain more than a maximum of 300 E. coli per 100 milliliters" [Rule 62(1)]. In addition, the Daily Maximum Geometric Mean for partial body contact is 1,000 E. coli per 100 ml [Rule 62(2)].

Summary

The District Health Department Number 4 monitors some public beaches in the summer months. Sampling typically occurs once a week from mid-June until the end of August on primary beaches, and secondary beaches, or those not as heavily used, are sampled twice in the summer. Results are received from the lab in 24-48 hours.

Eight beaches have been sampled in the past with all having low E. Coli levels. There are no beaches in the watershed that have been sampled since 2019.

Biological Monitoring

Parameter Description

TOMWC

Biological data are collected primarily by sampling macroinvertebrate communities in streams. Healthy streams typically have a high diversity of macroinvertebrates, especially taxa sensitive to pollution. Biological data were assessed using three metrics: 1) total taxa = the total number of macroinvertebrate families found at a site; 2) EPT taxa = the number of families belonging to three insect orders that are largely intolerant of pollution (mayflies, stoneflies, and caddisflies); and 3) sensitive taxa = the number of macroinvertebrate families that are the most intolerant of pollution (those that rate 0, 1, or 2 in PhD William Hilsenhoff's family-level sensitivity classification system). Streams are assigned grades A (excellent) through E (very poor) based on a system that utilizes all 3 index scores.

EGLE

EGLE assesses sites using procedure 51. The macroinvertebrate and fish communities were assessed and scored with metrics that rate water bodies from excellent (+5 to +9) to poor (-5 to -9). Scores from +4 to -4 are rated acceptable. Negative scores in the acceptable range are considered trending towards a poor rating, while positive scores in the acceptable range are trending towards an excellent rating. Habitat evaluations are based on 10 metrics, with a maximum total score of 200. A station habitat score of >154 is characterized as having excellent habitat, 105-154 is good, 56-104 is marginal, and <56 is poor. Where available, macroinvertebrate community scores are used to determine attainment of the Other Indigenous Aquatic Life and Wildlife (OIALW) designated use (MDEQ WRD Staff Report 2017).

Summary

TOMWC Data Summary

As part of TOMWC's Volunteer Stream Monitoring program, which operates under an approved QAPP, there is one stream in the watershed where macroinvertebrate collection actively occurs. However, over the last few years, there's been 4 streams in the watershed where collection has occurred (Figure 41). The Upper Black River has yearly average scores that have increased within the average "A" grade and is the only stream that is still sampled every year. Milligan Creek consistently received an "A" grade and was

sampled from 2008 to 2024. Rainy River increased from a “B” to an “A” grade when it was sampled in 2022-2024. Stony Creek increased from a “C” to a “B” grade when it was sampled in 2020 and 2022-2024.

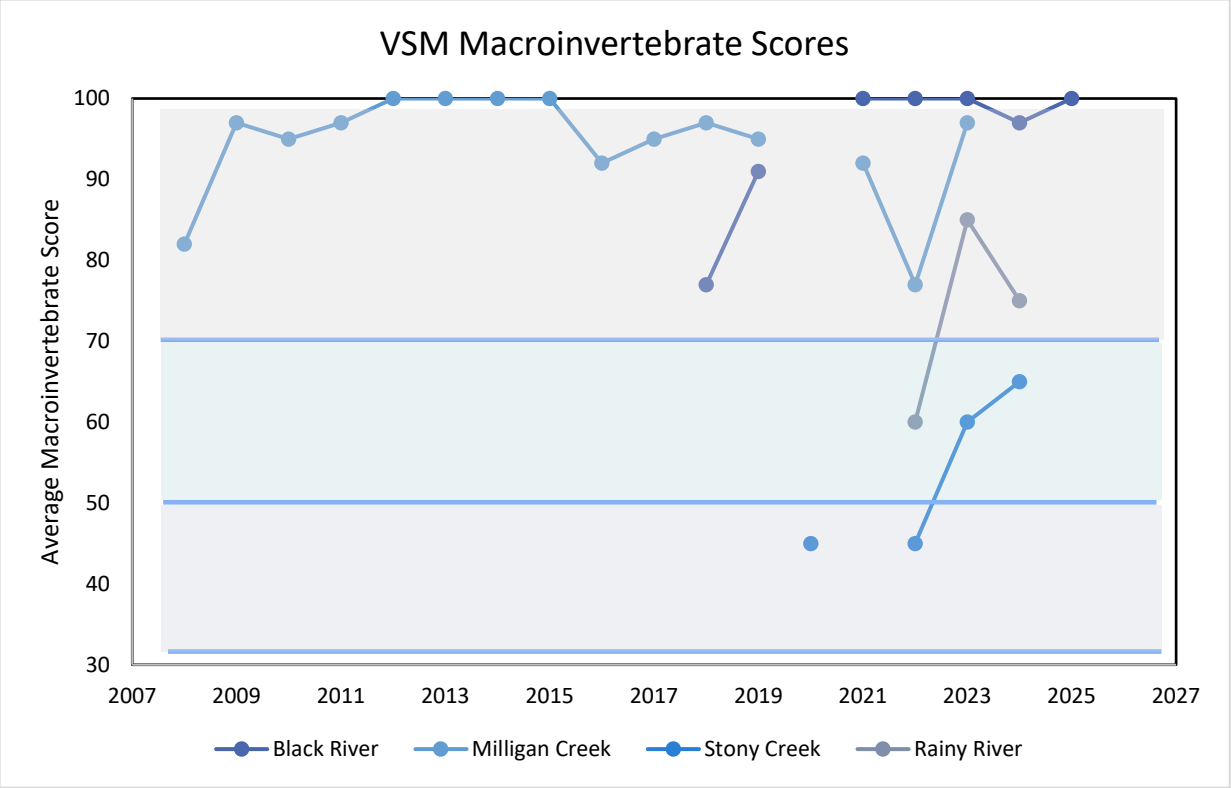


Figure 41 . Yearly average macroinvertebrate scores from VSM

EGLE Data Summary

When sampled in 2020 or 2024 by EGLE staff, the Upper Black River, Stony Creek, Rainy River met the OIALW designated use (Table 14, EGLE Staff Report 2025). When compared to the 2015 survey, the habitat and macroinvertebrate ranks for the Upper Black River were consistent with the 2020 & 2024 ranks (MDEQ WRD Staff Report 2017).

Table 14. 2015 EGLE habitat and macroinvertebrate ranks

Waterbody	Site	Habitat Rank	Macro Rank
Upper Black River	Chandler Dam Road	Excellent	Meets expectations
Upper Black River	Black River Road (Trail)	Excellent	Meets expectations
Upper Black River	Black River Road	Excellent	Meets expectations
Rainy River	Allis Highway	Excellent	Meets expectations
Stony Creek	County Line Road	Excellent	Meets expectations

Water Quality Summary

This chart summarizes the water quality parameters that were assessed as a part of this watershed management plan, and if monitoring events within the past 10 years meet EGLE WQS and/or EPA reference conditions (Table 15). “Some monitoring events met WQS” is defined as 25% and 99% of events

fall within WQS for that parameter. “Few monitoring events met WQS” is defined as less than 25% of events fall within WQS for that parameter.

Table 15. Water quality summary

Site Name	Physical			Chemical			Biological
	Temp	pH	DO	TP	TN	Chloride	Macros
Black Lake							
Cold Creek							
Milligan Creek							
Rainy River							
Stewart Creek							
Stony Creek							
Upper Black River							

All monitoring events met WQS

Some monitoring events met WQS

Few monitoring events met WQS

No Data

Data Quality

Targeted Monitoring QAPP Variations

We met 100% of data quality objectives. There was no Black Lake Deepest Point sampling in June 2024 and sampling was pushed back, as the QAPP was not yet approved. The tributaries lack some discharge readings due to absence of flow/water or the sites being unwadeable. Exact coordinates for the Rainy River/Allis Rd site differ from the original QAPP by 2.4 miles; initial coordinates were not at a stream and may have been a typo. Black Lake Deepest Point does not have physical profile data for the September 2024 sampling event (only had a short multimeter probe cord in the boat), when 0-3.5 m was sampled, and June 2025 (due to staff turnover), when above and below the thermocline was measured.

Targeted Monitoring Data Issues

A significant portion of the data was analyzed outside of the hold time. All samples except TSS samples were frozen until laboratory processing. Many duplicates differed from their associated routine samples more than the 20% threshold allowed in the targeted monitoring QAPP. All of these factors could have impacted the integrity of the data received from the lab and is further described below. TSS and chloride samples should not be impacted by an extended hold time (Nagpal n.d., Oudyn et al. 2012). 2024 and 2025 TSS and chlorophyll results were abnormally high for this region and are not reported here. For TP

and SRP samples, freezing and holding the samples longer than in the approved method likely underestimates the sample values (Jarvie et al. 2002, Massri et al. 2021). The effect of freezing and extended hold times on nitrate samples is unknown based on current research (Moore and Locke 2013). With nearly all TP samples from the targeted monitoring already exceeding the EPA reference condition, it can be inferred that the actual levels were even higher than reported above. Impacted targeted monitoring data mentioned above will be noted.

4. RESOURCE INVENTORIES

Estimated Pollutant Loading

Pollutant loading estimates were calculated using EPA's Pollutant Load Estimation Tool (PLET), a planning level web-based model used to estimate long-term nutrient and sediment loads from different land uses. This tool calculates nutrients (N/P), biological oxygen demand (BOD), and sediment loads by land use type within a watershed. Annual nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water, as influenced by factors like land use. The annual sediment load (sheet and rill erosion only) is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. All these parameters occur naturally in the ecosystem-but are harmful in abundance.

The following table (Table 16) is an estimate of pollutant loads by land use type. Given the high percentage of forestry as land use, it is no surprise that PLET estimates forestry being the highest contributor of N, P, and sediment.

Table 16. Pollutant loading estimates by land use

Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (ton/yr)
Urban	35,923	5,532	134,323	831
Cropland	6,763	1,170	14,173	175
Pastureland	28,599	2,396	91,937	253
Forest	132,429	12,281	32,109	827

When looking at the two distinct subwatersheds of Black Lake Direct and Black River, Black River is estimated to contribute to more pollutants based on land uses (Table 17). This is expected due to the fact that the Black River subwatershed comprises two-thirds of the land in the entire Black Lake Watershed. However, when looking at the top three subwatersheds in a given pollutant category, two of the three are in the Black Lake direct subwatershed.

Table 17. Pollutant loading estimates by subwatershed

Black River Watershed	N Load (lbs/year)	P Load (lbs/year)	BOD Load (lbs/year)	Sediment Load (tons/year)
040700050212 - Milligan Creek	12,214	1,218	13,974	77
040700050213 - Upper Black River	10,556	1,255	20,693	151
040700050211 - Butler Creek-Upper Black River	17,490	1,773	33,638	122

040700050208 - Tomahawk Creek	8,799	1,004	11,698	114
040700050207 - Canada Creek	7,972	945	12,120	111
040700050209 - Silver Lake-Upper Black River	5,443	588	5,206	65
040700050210 - Gokee Creek-Milligan Creek	4,603	475	3,083	50
040700050205 - McMasters Creek	7,112	674	3,164	40
040700050203 - East Branch Black River	12,442	1,331	12,574	136
040700050204 - Stewart Creek-Upper Black River	8,330	861	7,443	89
040700050202 - Round Lake-Upper Black River	4,945	530	4,546	57
040700050201 - Saunders Creek-Upper Black River	6,214	672	8,228	79
040700050206 - Montague Creek-Canada Creek	11,475	1,284	13,664	138
Total	117,595	12,610	150,031	1,229
Black Lake Direct Watershed				
040700050101 - Rainy Lake-Rainy River	6,758	721	6,053	77
040700050103 - East Branch Rainy River-Rainy River	16,678	1,722	25,663	137
040700050102 - Little Rainy River	15,548	1,546	28,280	106
040700050104 - Rainy River	13,357	1,430	17,408	117
040700050301 - Mud Creek	20,686	2,006	22,115	122
040700050302 - Black Lake	14,714	1,874	28,097	296
Total	87,741	9,299	127,616	855

*bold numbers indicate the top 3 subwatersheds by pollutant

Black Lake Aquatic Plant Survey-MSUE 2023

The following information is pulled directly from the Michigan State University Extension report Black Lake, Cheboygan County: 2023 Aquatic Macrophyte Report written by Jeremy Hartsock and Olivia Coskie. The full report can be found in appendix D.

Survey Observations:

The water at Black Lake has a pH of 8.1, electrical conductivity of 315 umho/cm, and total alkalinity is 170 mg/L. From 244 littoral zone sampling points visited (Figure 42), we encountered macrophytes at 99 sampling points (41% of points) (Figure 43). The majority of macrophyte encounters were in the northern portion of the lake near the Upper/Lower Black River entrances, and along the protected western

shoreline. In total, 32 macrophyte species were observed (found in full report), and AIS were not encountered. The highest richness observation at an individual sampling point was 9 species. The most frequently encountered macrophytes were variable-leaf watermilfoil and muskgrass, being present at 22% and 19% of sampling points visited. Overall, the plant community at Black Lake is quite even, with several species having frequency of occurrence above 10%.

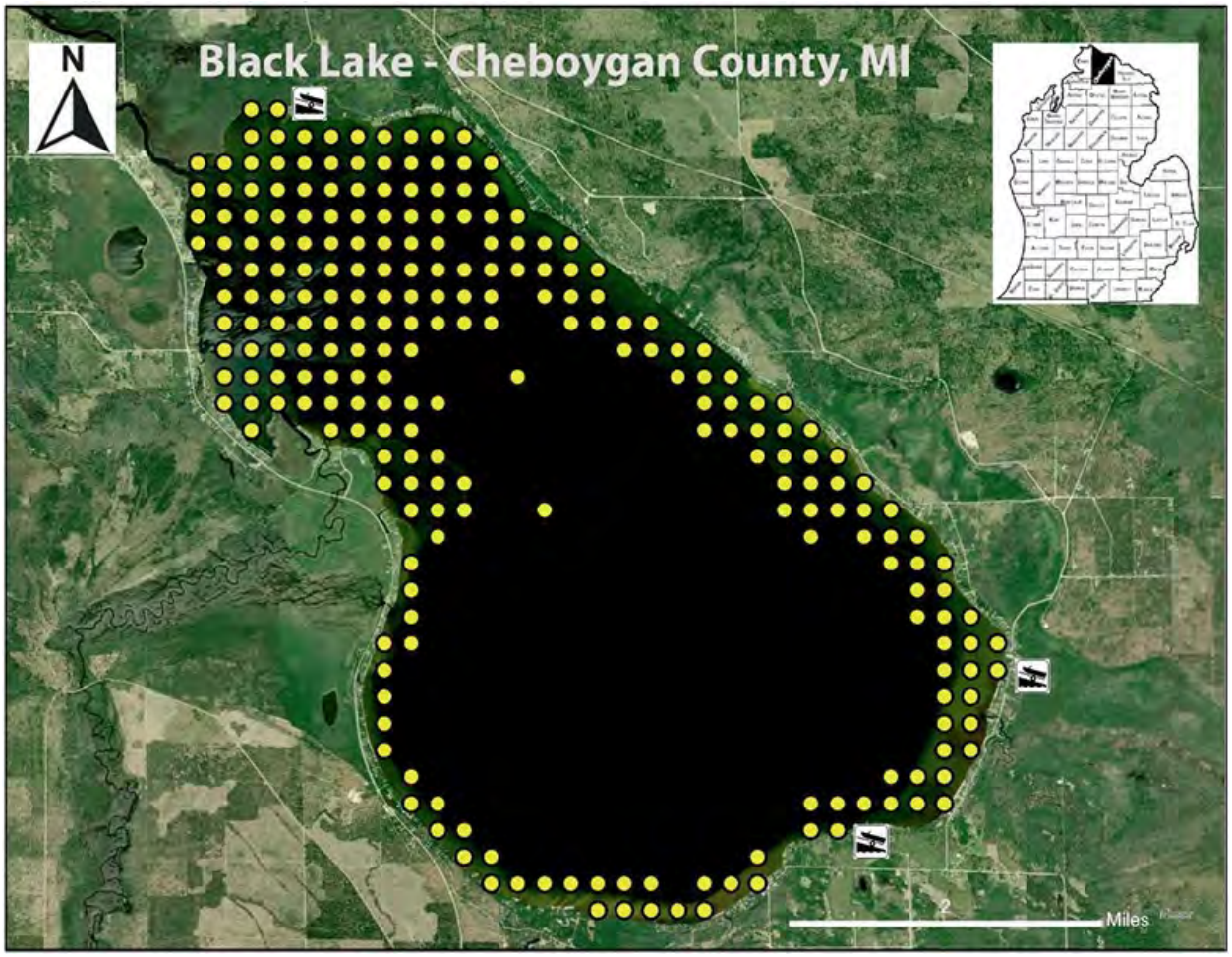


Figure 42. Black Lake (Cheboygan County) littoral zone (0-25 ft) sampling point locations

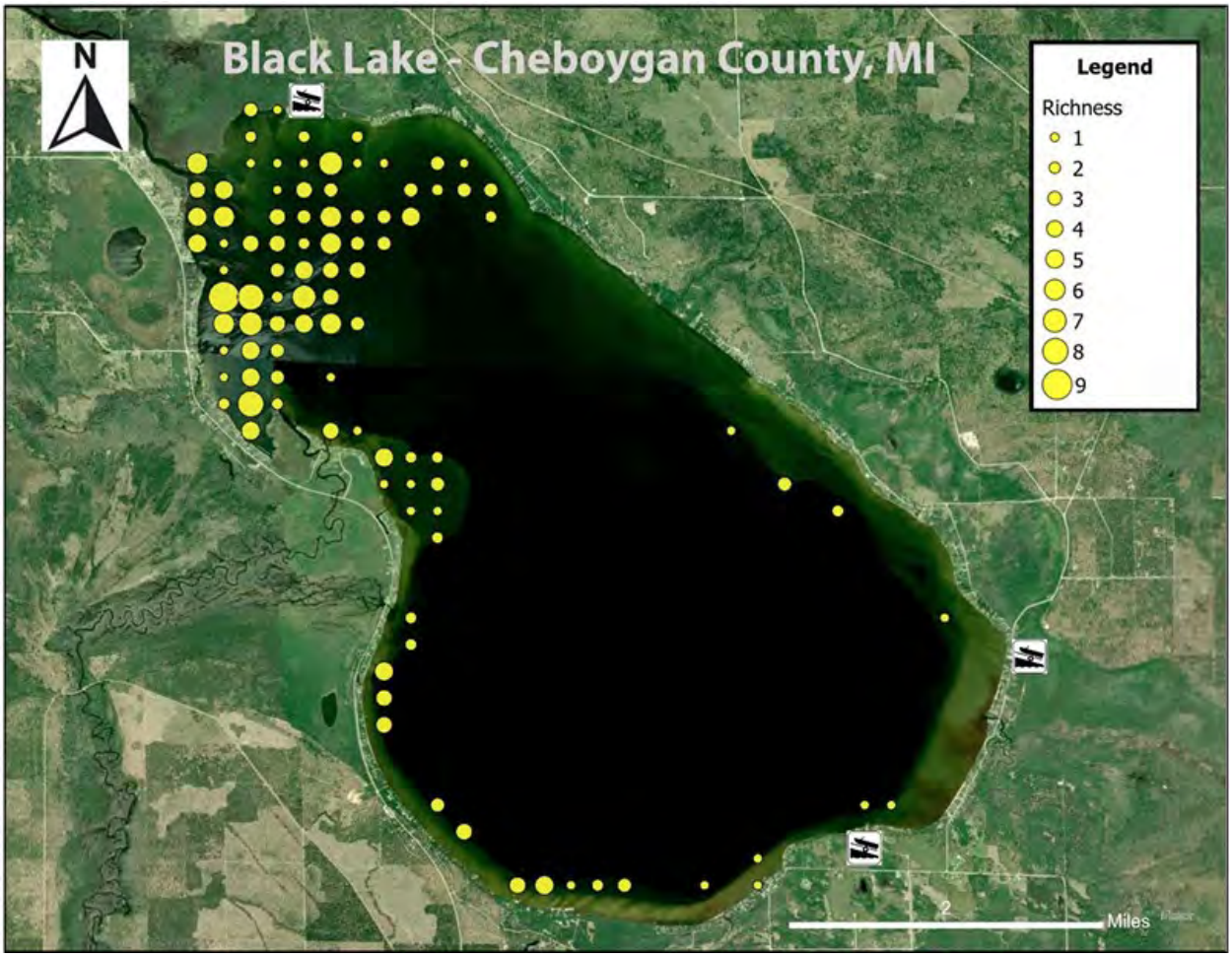


Figure 43. Black Lake species richness distribution (number of aquatic macrophyte species per point).

Black Lake Shoreline Surveys

The following information is pulled directly from the Black Lake Shoreline Survey conducted by TOMWC. Full report can be found in appendix E.

Shoreline surveys are an important lake management tool used extensively on lakes in the Northern Lower Peninsula of Michigan. These surveys involve assessing shoreline properties to document conditions or activities that have the potential to affect water quality and the lake ecosystem. Shoreline surveys commonly include an assessment of:

- *Cladophora* algae growth as a nutrient pollution indicator,
- Erosion
- Alterations (e.g., seawalls)
- Greenbelts (i.e., shoreline vegetation)
- Emergent aquatic plants
- Wetlands
- Tributary inlets and outlets

Survey results provide the means to carry out follow-up actions that address problems in shoreline areas. Through actions such as on-site consultations, problems in shoreline areas that threaten the water quality can be identified and corrected. These solutions are often simple and low cost, such as regular septic system maintenance, shoreline plantings, proper lawn care practices, and low impact development along the shoreline. Problems in shoreline areas can be prevented by providing education and awareness of the survey and ecologically friendly approaches to shoreline property management. Periodic repetition of shoreline surveys is important for identifying new and chronic problem sites, determining long-term trends in near-shore nutrient inputs, greenbelts, erosion, and shoreline alterations associated with land-use changes, and for monitoring and assessing the success of remedial actions.

In 2017, TOMWC completed a comprehensive shoreline survey for Black Lake. A subsequent survey, using different methods, was conducted on Black Lake by ZeroGravity in 2023 and summarized by Freshwater Solutions (appendix F).

Shoreline Development Impacts

Lake shorelines are the critical interface between land and water, where human activity has the greatest potential for degrading water quality. Developing shoreline properties for residential, commercial, or other uses invariably has negative impacts on the lake ecosystem. During the development process, the natural landscape is altered in a variety of ways: vegetation is removed, the terrain is graded, utilities are installed, structures are built, and areas are paved. These changes to the landscape and subsequent human activity in the shoreline area have consequences on the aquatic ecosystem. Nutrients from wastes, contaminants from cars and roads, and eroded soils are among some of the pollutants that reach and negatively impact the lake following shoreline development.

Nutrient pollution can create a recreational nuisance, adversely impact aquatic ecosystems, and lead to conditions that pose a danger to human health. Although nutrients are necessary to sustain a healthy aquatic ecosystem, excess can result in nuisance and potentially harmful algal and aquatic plant growth. Excessive aquatic macrophyte growth (i.e., vascular aquatic plants) and heavy algal blooms that form mats and scum at the lake's surface can become a recreational nuisance. Algal blooms also pose a public health risk as some species produce toxins, including hepatotoxins (toxins that cause liver damage) and neurotoxins (toxins that affect the nervous system). Furthermore, excess algal and aquatic plant growth can degrade water quality by depleting the ecosystem's dissolved oxygen stores. Decomposition of dead algae and plant material reduces dissolved oxygen supplies due to the aerobic activity of decomposers, which is particularly problematic in the deeper waters of stratified lakes. The problem becomes particularly acute during nighttime respiration, when plants compete with other organisms for a limited oxygen supply.

Surface waters receive nutrients through a variety of natural and cultural (human) sources. Natural sources of nutrients include stream inflows, groundwater inputs, surface runoff, organic inputs from riparian (shoreline) areas, and atmospheric deposition. Springs, streams, and artesian wells are often naturally high in nutrients due to the geologic strata they encounter and wetland seepages may discharge nutrients at certain times of the year. Cultural sources include septic and sewer systems, fertilizer application, and stormwater runoff from roads, driveways, parking lots, roofs, and other impervious surfaces. Poor agricultural practices, soil erosion, and wetland destruction also contribute to nutrient pollution. Furthermore, some cultural sources (e.g., malfunctioning septic systems and animal wastes) pose a potential health risk due to exposure to bacteria and viruses.

Severe nutrient pollution is detectable through chemical analyses of water samples, physical water measurements, and the utilization of biological indicators (a.k.a., bio-indicators). Chemical analyses of water samples can be effective, though costlier and more labor intensive than other methods. Typically, water samples are analyzed to determine nutrient concentrations (usually forms of phosphorus and nitrogen), but other chemical constituent concentrations can be measured, such as chloride, which are related to human activity and often elevated in areas impacted by malfunctioning septic or sewer systems. Physical measurements are primarily used to detect leachate from these systems, which can cause localized increases in water temperature and conductivity (i.e., the water's ability to conduct an electric current). Biologically, nutrient pollution can be detected along the lakeshore by noting the presence of *Cladophora* algae.

Cladophora is a branched, filamentous green algal species that occurs naturally in small amounts in Northern Michigan lakes. Its occurrence is governed by specific environmental requirements for temperature, substrate, nutrients, and other factors. *Cladophora* is found most commonly in the wave splash zone and shallow shoreline areas of lakes and can also be found in streams. It grows best on stable substrates such as rocks and logs, though artificial substrates such as concrete or wood seawalls are also suitable. *Cladophora* prefers water temperatures of 50 to 70 degrees Fahrenheit. Consequently, the optimal time for its growth and thus, detection, in Northern Michigan lakes is generally during the months of May, June, September, and October.

The nutrient requirements for *Cladophora* to achieve large, dense growths are typically greater than the nutrient availability in the lakes of Northern Michigan. Therefore, shoreline locations where relatively high concentrations of nutrients, particularly phosphorus, are entering a lake can be identified by noting the presence of *Cladophora*. Documenting the size and density of *Cladophora* helps interpret causal factors on an individual basis. However, the description has limited value when making year-to-year comparisons at a single location or estimating the relative amount of shoreline nutrient inputs because growth features are greatly influenced by current patterns, shoreline topography, size, distribution of substrate, and the amount of wave action on the shoreline. Rather, the presence of any significant growth at a single site over several years is the most indicative of elevated nutrient concentrations in shoreline areas. It can reveal the existence of chronic nutrient loading problems, help interpret the cause of the problems, and assess the effectiveness of any remedial actions. Comparisons of the total number of algal growths can reveal trends in nutrient inputs due to changes in land use or land management practices.

Erosion along the shoreline has the potential to degrade a lake's water quality. Stormwater runoff through eroded areas and wave action along the shoreline contribute sediments to the lake, which negatively impacts the lake ecosystem. Sediments clog the gills of fish, aquatic insects, and other aquatic organisms. Excessive sediments smother fish spawning beds and fill interstitial spaces that provide habitat for a variety of aquatic organisms. While moving through the water column, sediments absorb sunlight energy and increase water temperatures. In addition, nutrients adhere to sediments that wash in from eroded areas.

Shoreline greenbelts are essential for maintaining a healthy aquatic ecosystem. A greenbelt consisting of a variety of native woody and herbaceous plant species provides habitat for near-shore aquatic organisms as well as terrestrial animals. Greenbelts naturally function to control erosion by stabilizing the shoreline with plant root structures that protect against wave action and ice. The canopy of the greenbelt provides shade to near-shore areas, which helps to maintain cooler water temperatures and higher dissolved

oxygen levels. In addition, greenbelts provide a mechanism to reduce overland surface flow and absorb pollutants carried by stormwater from rain events and snowmelt.

Tributaries have great potential for influencing a lake's water quality as they are one of the primary conduits through which water is delivered to a lake from its watershed. Inlet streams may provide exceptionally high-quality waters that benefit the lake ecosystem, but conversely have the potential to deliver polluted waters that degrade the lake's water quality. Outlet streams flush water out of the lake, providing the means to remove contaminants that have accumulated in the lake ecosystem. With regards to shore surveys, noting the location of inlet tributaries is beneficial when evaluating shoreline algae conditions because nutrient concentrations are generally higher in streams than in lakes. The relatively higher nutrient levels delivered from streams often lead to heavier *Cladophora* and other algae growth in nearby shoreline areas.

Responsible, low-impact shoreline property development, and best management practices are paramount for protecting water quality. Maintaining a healthy greenbelt, regular septic tank pumping, treating stormwater with rain gardens, correcting erosion sites, and eliminating fertilizer, herbicide, and pesticide application are among many low-cost best management practices that minimize the impact of shoreline properties on lake water quality. Living in harmony with the lake and practicing responsible stewardship are vitally important for sustaining a healthy and thriving lake ecosystem.

Results

Following are results of the 2017 survey documenting shoreline conditions at 805 parcels on Black Lake. Approximately 88% (705) of shoreline properties on Black Lake were considered developed.

Cladophora

Noticeable growths of Cladophora or other filamentous green algae were found along the shoreline at 214 parcels (27% of total parcels surveyed; Table 18). At properties where Cladophora growth was observed, 70% (150 parcels) consisted of light or very light growth, whereas only 19% (42 parcels) had moderate to heavy growth.

Table 18. Cladaphora Density

Cladophora Density	Parcels	Percent (%)
Very light	92	43
Light	58	27
Light to Moderate	22	10
Moderate	26	12
Moderate to Heavy	11	5
Heavy	4	2
Very Heavy	1	<1

The few moderate to heavy patches of Cladophora growth were located along the western and northern shores of Black Lake (Figure 44). A few parcels along the eastern shoreline contained moderate Cladophora growth. Properties with little to no Cladophora growth were around the lake with large sections along the southern, western, and northern shorelines.

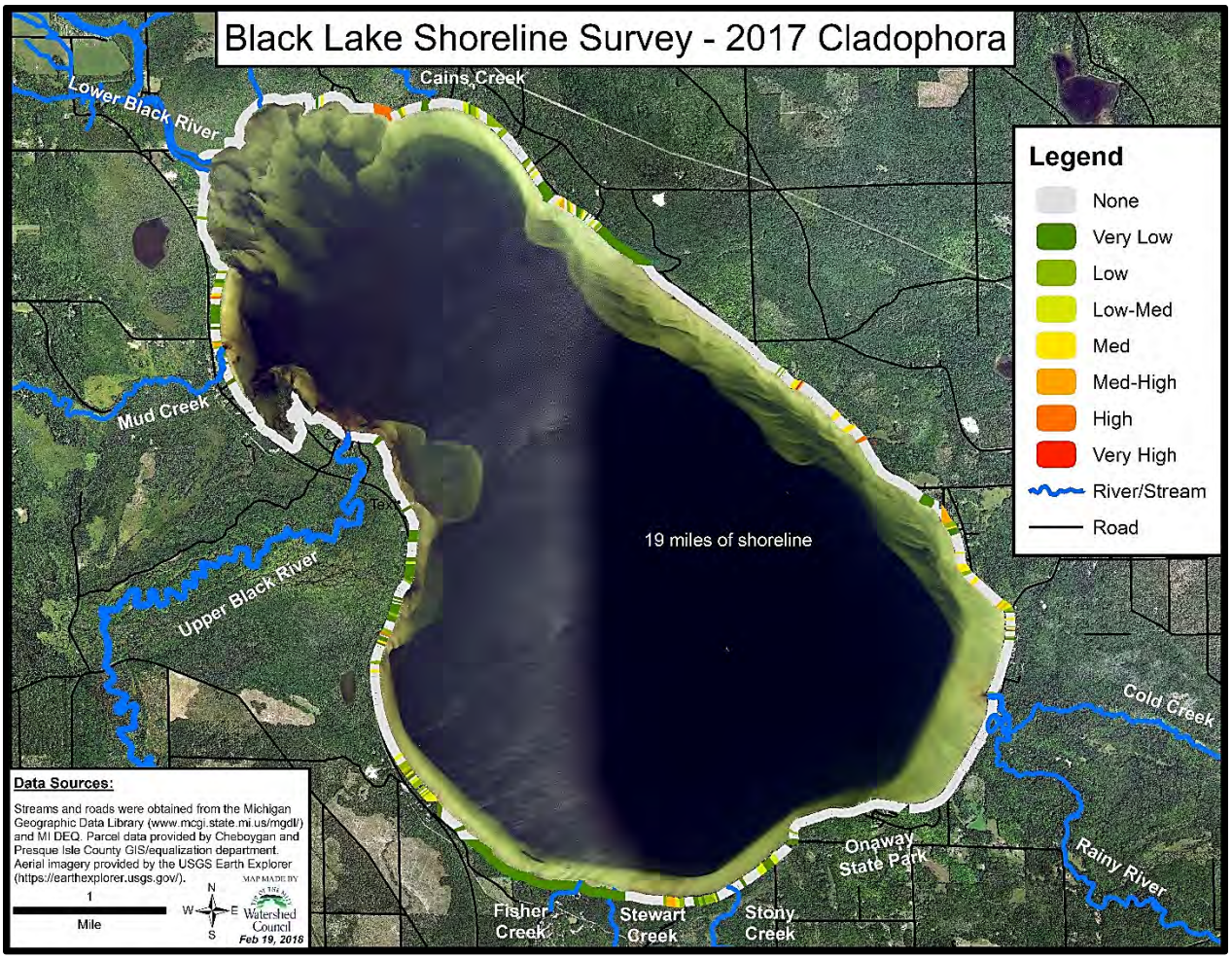


Figure 44. Cladophora density around Black Lake Shoreline

Interestingly, similar areas documenting *Cladophora* in 2018 were identified in the surveys of 1991 and 2001 (Figure 45), as well as 2005. These areas of concern are highlighted along the western shore. However, there appears to be fewer areas towards the south along the western shore.

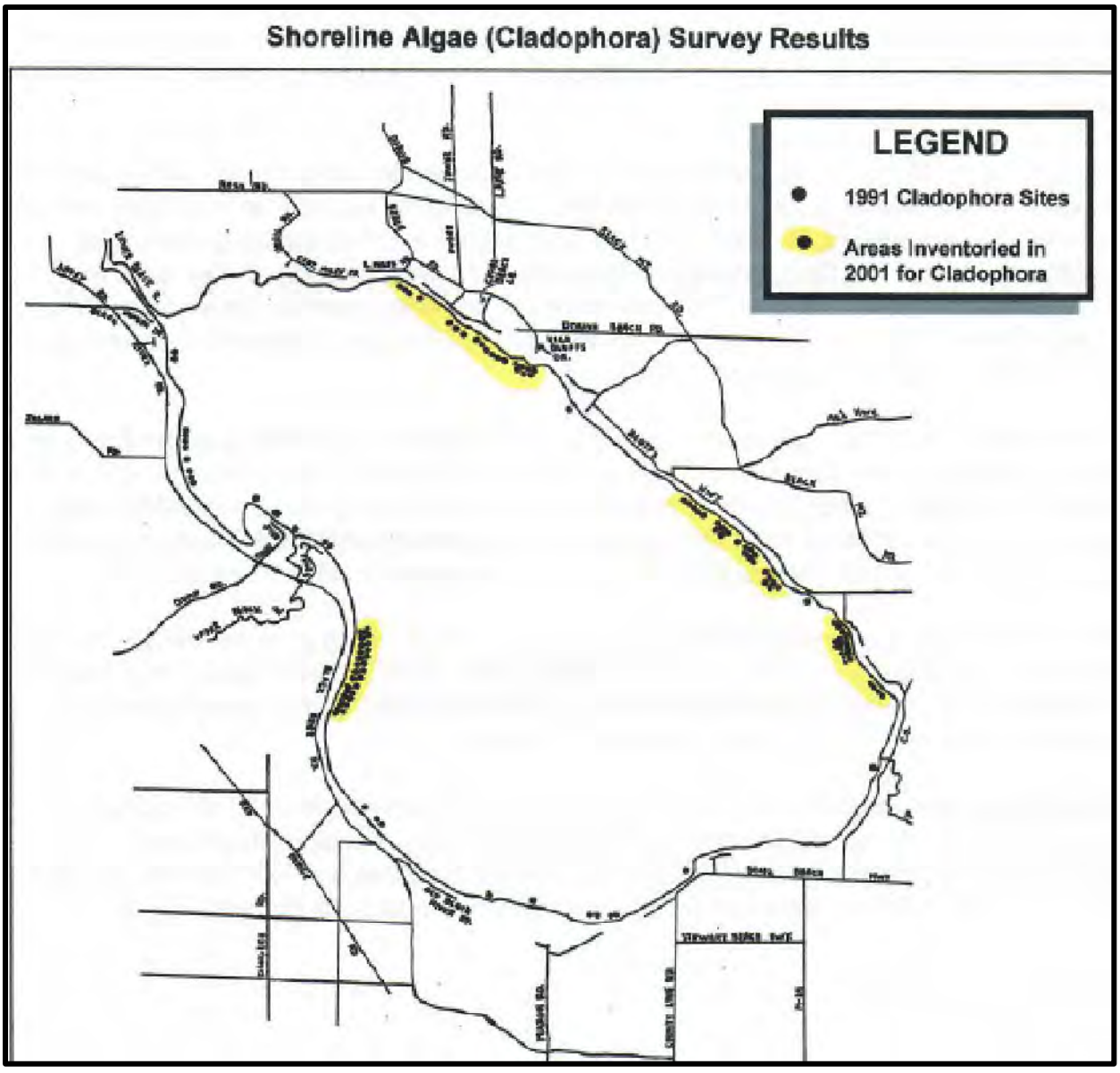


Figure 45. Cladophora from 1991 and 2001 survey

Greenbelt Scores

Greenbelt scores ranged from 0 (little to no greenbelt) to 7 (exemplary greenbelt). Only 30% of shoreline greenbelts along Black Lake were found to be in good or excellent condition (Table 19). Of 805 surveyed, 338 parcels (42%) received a greenbelt rating in the poor or very poor categories.

Table 19. Greenbelt rating results

Greenbelt Rating		Number of Parcels	Percent (%)
0	Very Poor (absent)	139	24
1-2	Poor	145	18
3-4	Moderate	228	28
5-6	Good	153	19
7	Excellent	86	11

Greenbelt status varied around Black Lake. However, many clusters of properties along the northern shoreline were ranked in the very poor (absent) to poor categories (Figure 46). Clusters along the western and southern shoreline were in the moderate to excellent rating.

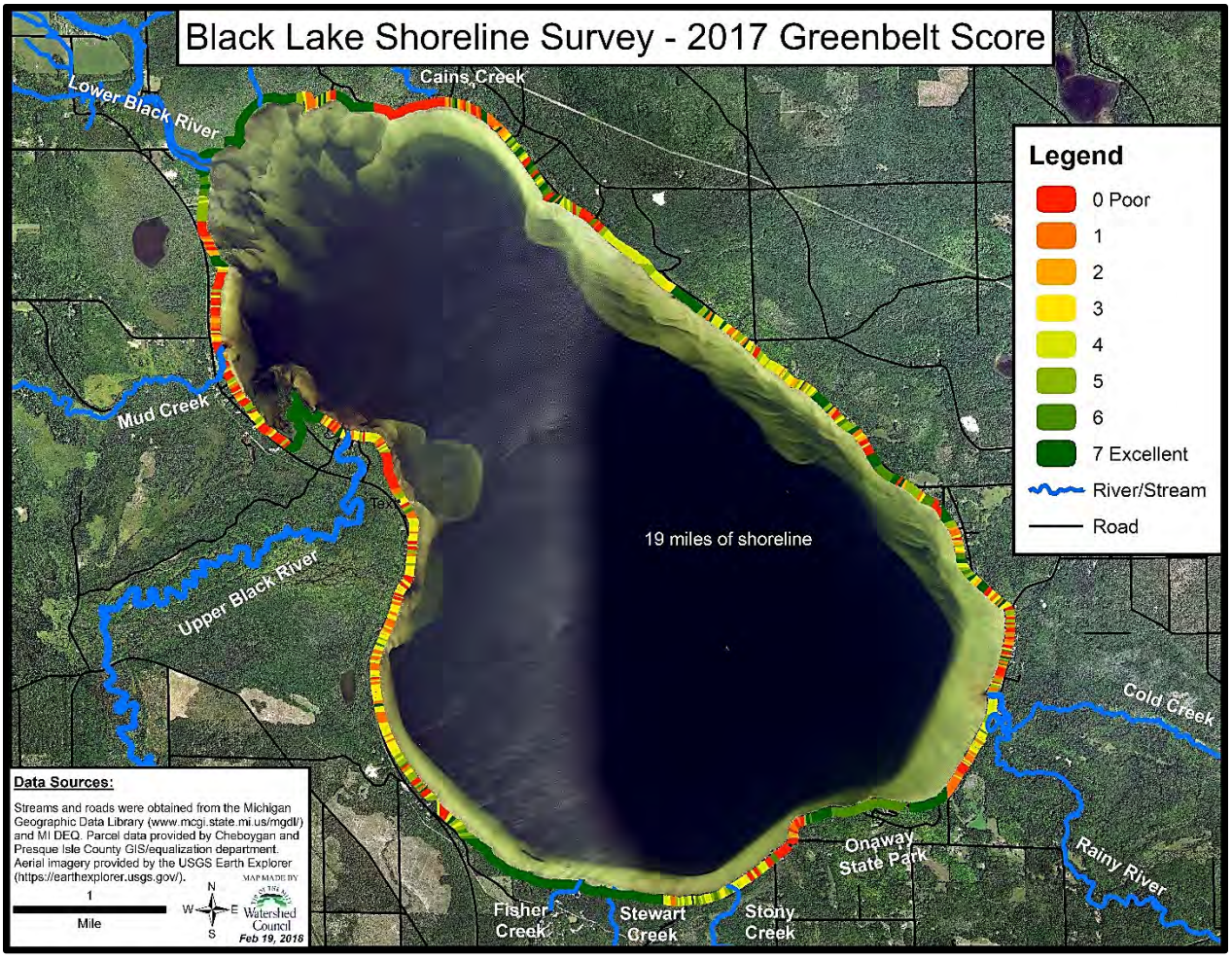


Figure 46. Greenbelt Scores around Black Lake shoreline

Shoreline alterations

Some form of shoreline alteration was noted at 80% of shoreline properties (Table 20). Of the alterations, 30% are riprap, while seawalls (wooden, concrete, or metal), account for

approximately 28% of all shoreline alterations. Artificial beach sand is also noticeable around the shoreline.

Table 20. Shoreline alteration results

Alteration Type	Number of Parcels*	Percent with Alteration (%) *
Riprap (small)	25	3
Riprap (boulder)	105	13
Mixed riprap	115	14
Seawalls	223	28
'Artificial' Beach Sand	225	28
Discharge Pipes	68	8
Unaltered	164	20

**Numbers and percentages quantify alteration type, many parcels had multiple alterations*

Erosion

Erosion was noted at 361 parcels (45%) on the Black Lake shoreline (Table 21). Most of the erosion (37%) was classified as minor in terms of severity, while less than 1% of properties were considered severe (Figure 47).

Table 21. Shoreline erosion severity results

Erosion Category	Number of Properties	Percent of Properties (%)
Minor	295	37
Moderate	56	7
Severe	10	<1
TOTAL	361	45

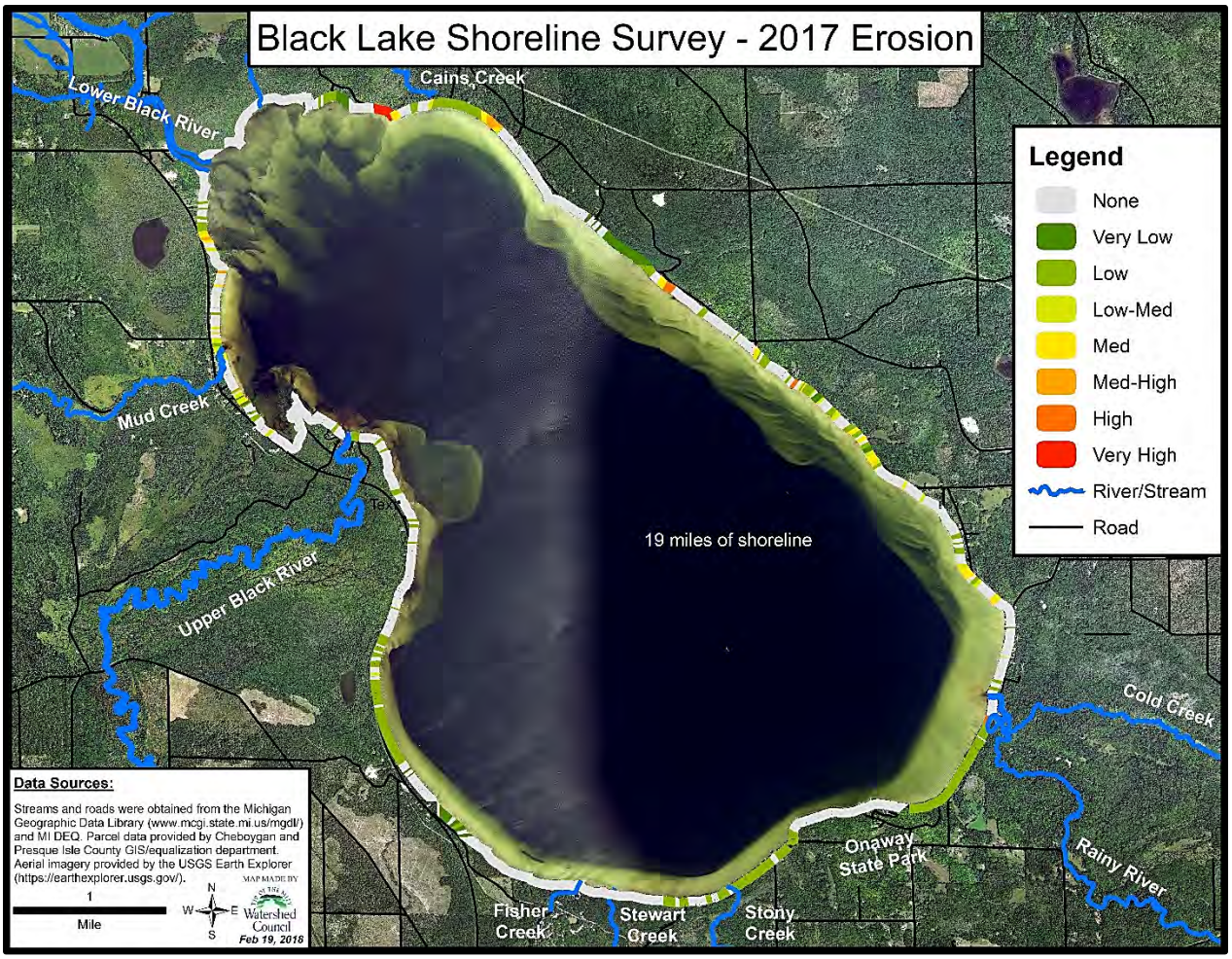


Figure 47. Erosion severity around Black Lake shoreline

Social Indicator Survey

In 2023, University of Michigan School of Environment and Sustainability (SEAS) master's students conducted a social indicator survey, shared via email. Emails were sent through lake association communication methods, and the watershed advisory committee email list. In 2024, TOMWC conducted the same social indicator survey but mailed a QR code of the survey to a random number of households in the watershed. Full survey results can be viewed in appendix G and H. A comparison of results is summarized below.

The emailed survey collected 42 responses, while the 2024 mailed survey reached a broader audience with 77 responses. Respondents from both surveys were similar in age, averaging 63.5 and 64.2 years respectively, but differed significantly in education and background. A substantial 87.1 percent of the emailed respondents held a bachelor's degree or higher, compared to just 51.47 percent in the mailed survey. Interestingly, decision-making authority was slightly more common among the mailed group, with 94 percent, than the emailed group, at 85 percent. Both samples were largely rural, with nearly 60 percent of participants from isolated rural areas. Overall, the emailed survey reached a smaller, more educated and engaged population, while the mailed survey was more representative of the broader community.

Perceptions of the watershed's current health were consistent, with about 73 percent of respondents in both surveys rating it as good or better. However, their views on future trends diverged dramatically. In 2023, over half of the respondents believed the watershed was slowly worsening, whereas only 4.23 percent of the 2024 group shared that view. In contrast, a majority of the mailed survey respondents, 59.15 percent, felt the situation was slowly improving. This shift in perception may reflect improved outreach, increased optimism, or simply a difference in who responded to each survey.

When asked about the consequences of poor water quality, both groups expressed the greatest concern over the presence of excessive aquatic plants or algae and the loss of desirable fish species. Drinking water contamination was consistently ranked as the least concerning issue, suggesting that ecological impacts were more important to respondents than direct health risks.

Awareness of specific water impairments also varied. In 2023, phosphorus was seen as the top concern, while in 2024, invasive species were the biggest concern. The emailed respondents expressed greater concern overall, while the mailed respondents tended to rate impairments with lower severity. For example, trash and salt were lowest on the 2023 list, while sewage discharge and construction erosion were least concerning in 2024. These differences hint at a higher level of familiarity or engagement among the emailed group.

Both surveys identified septic systems and fertilizers as key sources of water pollution. The emailed group emphasized the impact of residential behaviors, particularly lawn fertilizers and pesticides, while the mailed group highlighted septic systems and even natural sources such as waterfowl droppings. Industrial discharge and construction-related pollution consistently ranked low, showing that personal and local sources were considered more relevant than industrial or systemic ones.

Familiarity with water-friendly practices also showed some divergence. The emailed group most commonly used labeled fertilizer and pesticide application methods, while the mailed group favored phosphate-free fertilizers and rain barrels. Less common practices like rain gardens and porous pavement were underused by both groups. Interestingly, the 2024 respondents showed greater awareness but lower usage rates, suggesting a potential disconnect between knowledge and implementation.

Attitudes toward environmental responsibility were strong across both surveys. Nearly all respondents agreed that protecting water quality is a personal responsibility, although emailed participants expressed this more strongly with an average score of 4.7 compared to 4.42. Willingness to pay for improvements was lower overall, particularly among the mailed group, where financial concerns or skepticism may play a role. While both groups showed commitment, practical barriers were more prominent among the broader community.

This pattern extended to septic system maintenance. A striking 94.3 percent of the emailed group expressed willingness to maintain or service their septic systems, compared to just 69.35 percent of the mailed respondents. Similarly, 97.2 percent of the emailed group supported proper septic sizing, versus 67.8 percent in the mailed group. These differences may reflect the higher environmental engagement and resource access among those who participated in the email survey.

When it comes to trusted sources of information, both groups expressed confidence in local environmental organizations and agencies. TOMWC, the Soil and Water District, and university extension services were among the most trusted, while lawn care companies and community leaders ranked lowest.

This indicates a general preference for scientific and conservation-based guidance over commercial or informal sources.

In summary, the emailed survey offered detailed insights from a smaller, more informed audience with stronger environmental values and a greater willingness to act. In contrast, the mailed survey captured broader watershed views, having more optimism but less engagement. Together, the two surveys provide a fuller picture, one of dedicated stakeholders and the other of a diverse public whose support will be crucial for future watershed protection efforts.

The remaining sections are taken directly from the 2024 report "Understanding Nonpoint Source Pollution and Public Perceptions: A Study of the Black Lake Watershed". There were a few modifications for accuracy and clarity. The full report can be found in appendix H.

Road/Stream Crossings (RSX)

Pollutant potential is high at RSXs and increases when their condition deteriorates. When structures, such as culverts, bridges, and fords, begin displaying signs of failure, such as structural problems due to improper installation, all aspects of fluvial ecosystems have the potential to be impacted (Figure 48. Pollution that exists as a result of poor RSX conditions pose health effects to aquatic organisms and has the possibility of introducing metals, bacteria, excessive nutrients, and other nonpoint source pollutants into surrounding streams. Increased sedimentation because of crossings poses the greatest threat to fluvial ecosystems as it worsens water quality as well as impacts the overall habitat.[1] Monitoring RSXs and updating inventories are critical to watershed management to further understand the risks that fluvial ecosystems are exposed to. Information retained from these inventories helps identify sediment pollution that may be entering nearby waterways. Consistently updating these inventories allows for officials to document any changes that may have occurred over time.

Over 200 RSX sites have been identified within the Black Lake Watershed using the Great Lakes Stream Crossing Dashboard (Figure 49), however of these there were only 165 total sites that contained usable data (Figure 50). Usable data means that the Great Lakes Stream Crossing Inventory Protocol was followed when updating sites. Sites are assigned a severity ranking reflecting erosion, pollution potential, and fish passage, automatically calculated based on built-in formulas within the Survey123 app. Of the 165 sites, 64 (38.8%) were considered "minor" severity, 73 (44.2%) were considered "moderate" severity, and 28 (17%) were considered "major" severity. Out of 165 sites, 25 are considered "time sensitive" and should have immediate attention. "Time sensitive" is subjective and manually input into the Survey123 form. Reasoning may be due to possible obstructions to the structure, failing roadways, dangerous risks such as power lines in the stream, the presence of HABs, low fish passage, etc. (Table 22).

[1] Road & Stream Crossings. *Tip of the Mitt Watershed Council*. Retrieved November 25, 2023, from https://watershedcouncil.org/our-work/watershed-protection/fish-passage/crossings/



Figure 48. Examples of RSXs visited

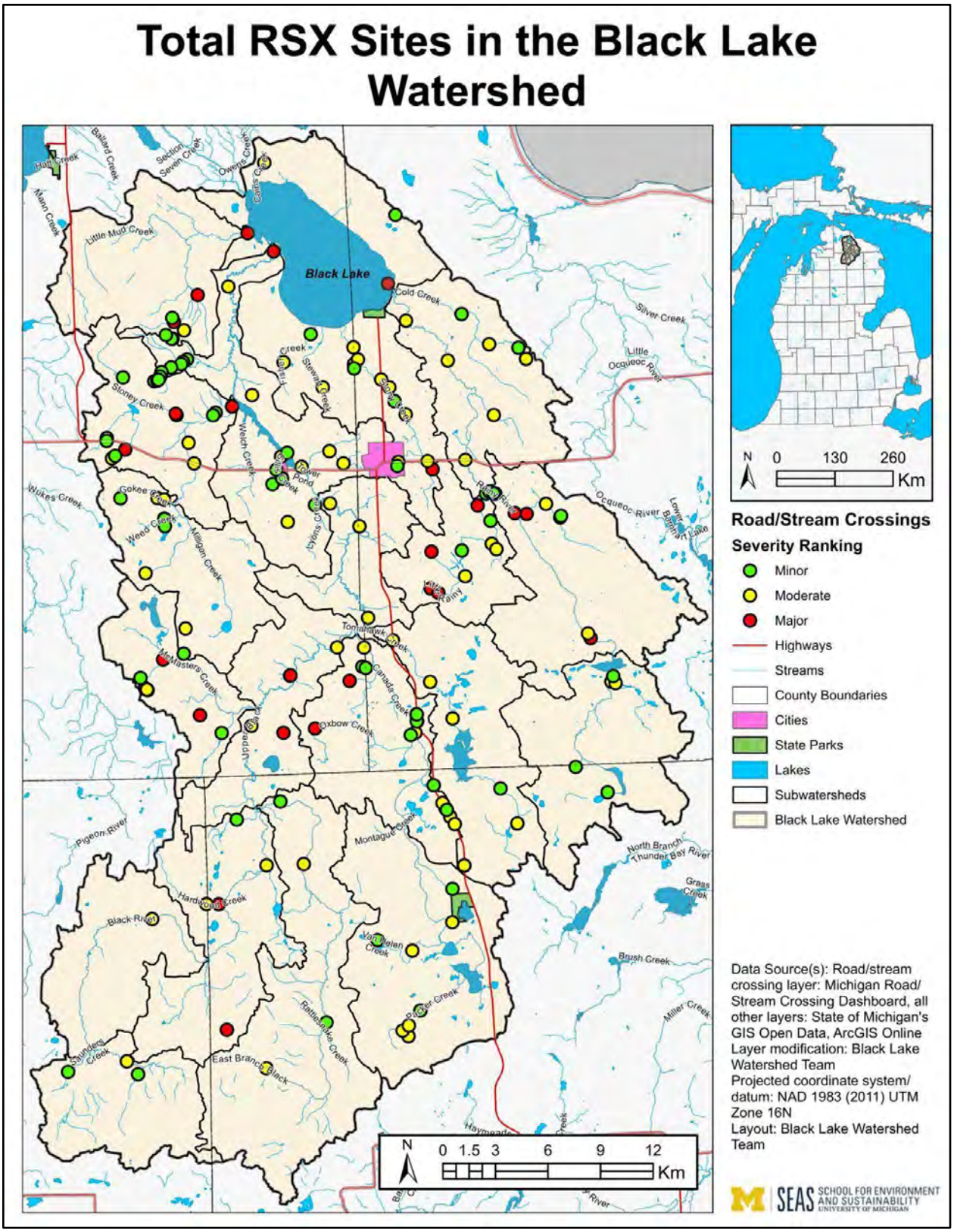


Figure 49. All RSX Sites within the Black Lake Watershed

Table 22. Number of RSX Sites within the subwatersheds for each RSX Severity Ranking (old and new data)

	Road/Stream Crossing Severity Ranking			
Subwatershed	Minor	Moderate	Major	Total
Black Lake**	5	11	3	19
Bowen Creek-Black River**	11	7	1	19
Milligan Creek**	9	4	4	17
Canada Creek**	8	4	2	14
Tomahawk Creek	2	9	0	11
East Brank Rainy River-Rainy River**	4	3	3	10
Little Rainy River**	3	3	4	10
Gokee Creek-Black River	5	4	0	9
Cold Creek-Rainy River**	2	6	0	8
Montague Creek-Canada Creek**	3	5	0	8
McMasters Creek**	2	2	3	7
Mud Creek**	2	2	3	7
Rainy Lake-Rainy River	3	2	0	5
Silver Lake-Black River	0	2	3	5
Stewart Creek-Black River	1	2	2	5
East Branch Black River**	2	2	0	4
Butler Creek-Black River	0	3	0	3
Saunders Creek-Black River**	2	1	0	3
Round Lake-Black River	0	1	0	1
All Subwatersheds	64	73	28	165

***Note: two asterisks denote subwatersheds that contain time sensitive sites*

****Note: "severe" rankings were an option for severity rankings; for simplicity of this project, "severe" rankings were joined with "major" rankings*

RSX Sites Visited

Only 39 of the total 200 RSX sites were visited based on the criteria laid out in the methods section. Of these sites, 35 were able to be successfully updated and were located in 11 of the 19 total subwatersheds. Of the 35 sites, 15 were considered "minor" severity (42.9%), 9 were considered "moderate" severity (25.7%), and 11 were considered "major" severity (31.4%) (Table 24). 25 of the 35 sites visited changed from their previous ranking from the last time they were surveyed (71%). Of the 25, 19 decreased in severity (76%) while 6 increased in severity (24%) (Table 23). The change in ranking is reflected by the colors indicated in the table. Grey sites did not change in ranking, green sites decreased in severity ranking, and red sites increased in severity ranking. 18 of the 35 sites were still deemed time sensitive after further analysis of the collected data.

Table 23. Comparison of Site Rankings Before and After Revisiting

	Road/Stream Crossing Severity Ranking

Site ID	Previous Ranking	Current Ranking
Snake Trail #2**	Major	Major
Logging road south of 68**	Major	Minor
CC04	Major	Moderate
CC06	Moderate	Major
Clark bridge fields access rd	Major	Major
ER01.5	Major	Minor
KC01	Major	Minor
LR00.75	Major	Major
LR01	Moderate	Minor
LR02.7	Moderate	Moderate
LR04	Moderate	Major
LR04.5	Moderate	Major
MB09.5	Major	Major
MB09.7	Major	Minor
MB10.2	Major	Moderate
MB10.3	Major	Moderate
MB10.5	Moderate	Major
MB21	Major	Moderate

MB24	Moderate	Minor
MB26	Moderate	Minor
MB33	Major	Moderate
MC08	Moderate	Minor
MC09	Minor	Minor
RR02	Moderate	Moderate
RR09	Moderate	Major
RR11	Moderate	Minor
SC03	Moderate	Moderate
SC04	Major	Moderate
SC05A	Major	Minor
SC05B	Major	Major
SC08	Moderate	Minor
SC10	Moderate	Major
SC15	Major	Minor
SC16	Moderate	Minor
URB LR03	Minor	Minor

***Note: two asterisks denote sites where there was no Site ID and the Crossing Name was used instead*

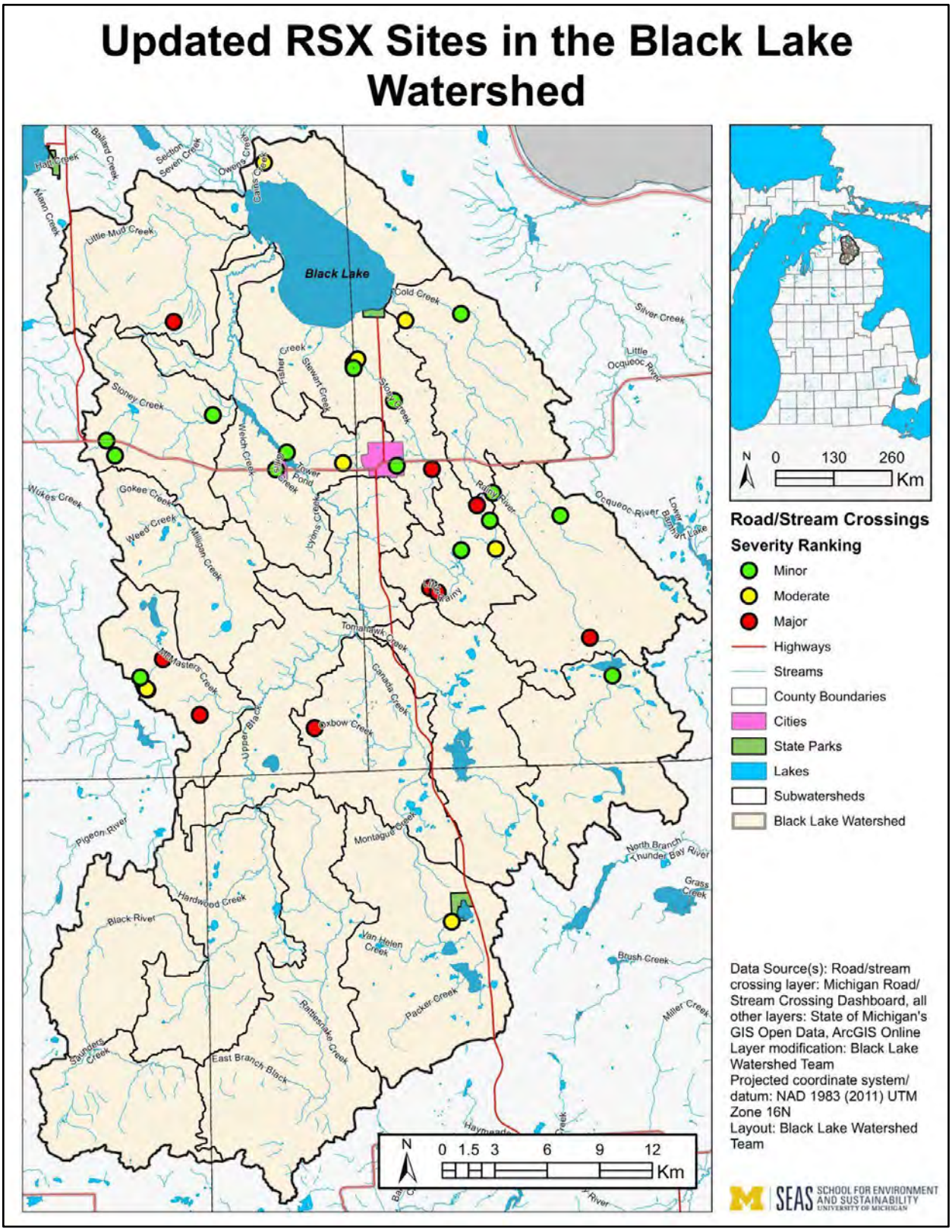


Figure 50. RSX Sites within the Black Lake Watershed that were Updated in 2023

Table 24. RSX Sites Updated in 2023

Road/Stream Crossing Severity Ranking				
Subwatersheds	**Minor**	**Moderate**	**Major**	**Total**
Black Lake**	3	3	2	8
Little Rainy River**	2	1	3	6
McMasters Creek**	1	2	3	6
Bowen Creek-Black River**	2	1	0	3
East Branch Rainy River**	2	0	1	3
Milligan Creek**	3	0	0	3
Cold Creek-Rainy River**	1	1	0	2
Canada Creek**	0	0	1	1
Montague Creek-Canada Creek	0	1	0	1
Mud Creek**	0	0	1	1
Rainy Lake-Rainy River	1	0	0	1
All Subwatersheds	15	9	11	35

***Note: two asterisks denote subwatersheds that contain time sensitive sites*
****Note: "severe" rankings were an option for severity rankings; for simplicity of this project, "severe" rankings were joined with "major" rankings*

RSXs are imperative to the survival of aquatic species. Because of the risks that impacted crossings pose towards aquatic life, i.e. interfering with travel, mating, resource availability, and risk to additional dangers, fish passage is recorded to determine aquatic organisms' ability to freely move amongst the site. These variables at a site are measured and given fish passage scores. Scores can be interpreted as follows: "0" = most species and life stages cannot pass at most flows; "0.5" = some species and life stages cannot pass at most flows; "0.9" = barrier at high flows; "1" = not a barrier. Of the 35 RSX sites visited, only 11.4% of sites posed no barrier at any time. 34.3% of the time there was a barrier at high flows, with over half (54.3%) threatening some or all species from passing regardless of flow (Table 25).

Table 25. Fish Passage Score Rankin of RSX Sites Updated in 2023

Fish Passage Scores				
Subwatershed	**Score: 0**	**Score: 0.5**	**Score: 0.9**	**Score: 1**
Black Lake	2	4	2	0
Little Rainy River	1	0	5	0
McMasters Creek	3	2	1	0
Bowen Creek-Black River	0	0	2	1
East Branch Rainy River	0	1	2	0
Milligan Creek	1	1	0	1
Cold Creek-Rainy River	1	0	0	1
Canada Creek	0	0	0	1
Montague Creek	1	0	0	0
Mud Creek	1	0	0	0
Rainy Lake-Rainy River	1	0	0	0
All Subwatersheds	11	8	12	4

Pollutant loading estimates (Sediment Tons/yr) were automatically generated within the Survey123 app for the Great Lakes Road/Stream Crossing Inventory. Pollutant loading estimates for Phosphorus lbs/year were calculated by applying an overall phosphorus concentration of 0.0005 lbP/lb of soil. Pollutant loading estimates for Nitrogen lbs/year were calculated by applying an overall nitrogen concentration of 0.001 lbN/lb of soil. The texture of soil influences the nutrient holding capacity, therefore to better estimate pollutant loadings of phosphorus and nitrogen, a correction factor of 0.85 was used to represent the dominant soil texture (sand/silty loam).[2] Notably, the Little Rainy River subwatershed had the highest pollutant loading and the Gokee Creek-Black River subwatershed had the second highest. The Round Lake-Black River subwatershed reported no pollutant loadings (Table 26).

Table 26. Pollutant Loading for all RSX Sites within Subwatersheds in the Black Lake Watershed

	Pollutant Loading Estimate		
Subwatershed	Sediment tons/yr	Phosphorus lb/yr	Nitrogen lb/yr
Little Rainy River	52	44	88
Gokee Creek-Black River	40	34	67
Black Lake	35	29	59
Stewart Creek-Black River	27	23	46
Silver Lake-Black River	26	22	44
Bowen Creek-Black River	19	17	33
Milligan Creek	16	13	27
East Branch Rainy River-Rainy River	16	13	26
Canada Creek	14	12	24
Tomahawk Creek	14	12	24
Montague Creek-Canada Creek	12	10	21
Cold Creek-Rainy River	11	9	19
East Branch Black River	11	9	18
Mud Creek	6	5	10
McMasters Creek	5	4	8
Saunders Creek-Black River	4	4	7
Butler Creek-Black River	2	2	3
Rainy Lake-Rainy River	2	2	3
Round Lake-Black River	0	0	0
Total	312	264	527

Forestry

As discussed in the methods section under Forestry, a desktop inventory was performed on forested areas within the Black Lake watershed. This inventory aimed to locate forested lands enrolled within management programs. The programs observed were the Qualified Forest Program (QFP) and the Commercial Forest Program (CFP). These are voluntary tax incentive programs for private landowners offered through the Michigan Department of Agriculture and Rural Development (MDARD) and the

[2] Streambank Erosion. *NRCS, WI.* Field Office Technical Guide.

Michigan Department of Resources (MDNR). Information was collected from the Michigan Geographic Data Library as well as correspondence with MDARD.

Figure 51 presents all forest cover within the Black Lake watershed. The forest types range from deciduous, mixed and evergreen forest, accounting for 47% of the watershed's land cover.

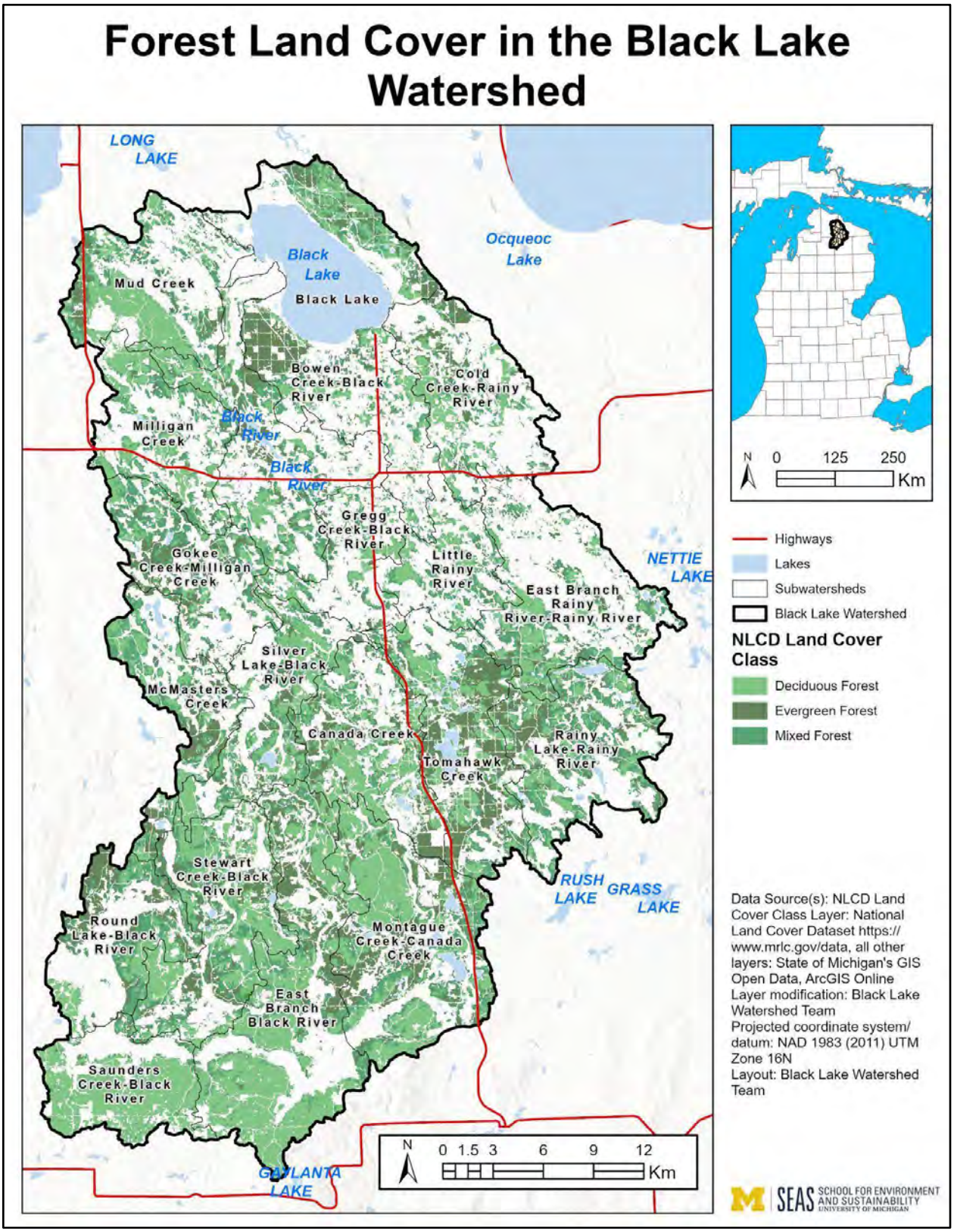


Figure 51. Forest Land Cover of the Black Lake Watershed

There are no national forest lands within the watershed, therefore only state land was included. QFP and CFPs on private land account for 12,463.5 acres of the Black Lake Watershed. In total, CFPs, QFPs and state land combined account for about 203,141.86 acres of managed forest land out of 230,691.25 acres of forest/grassland/shrub land cover (2016). Therefore, 88% of all forested land is managed through those three indicators. The managed forest land can be found below in Table 27 and seen in Figure 52.

The Department of Natural Resources manages 93.9%, or 190,678 acres in the Watershed. The Commercial Forest Program accounted for 0.3% of the managed forest in Black Lake's watershed, or 630.54 acres within 12 parcels in the southern end of the watershed. Qualified Forest Program accounted for 5.8%, or 11,832.97 acres, managed through the state or two private programs.

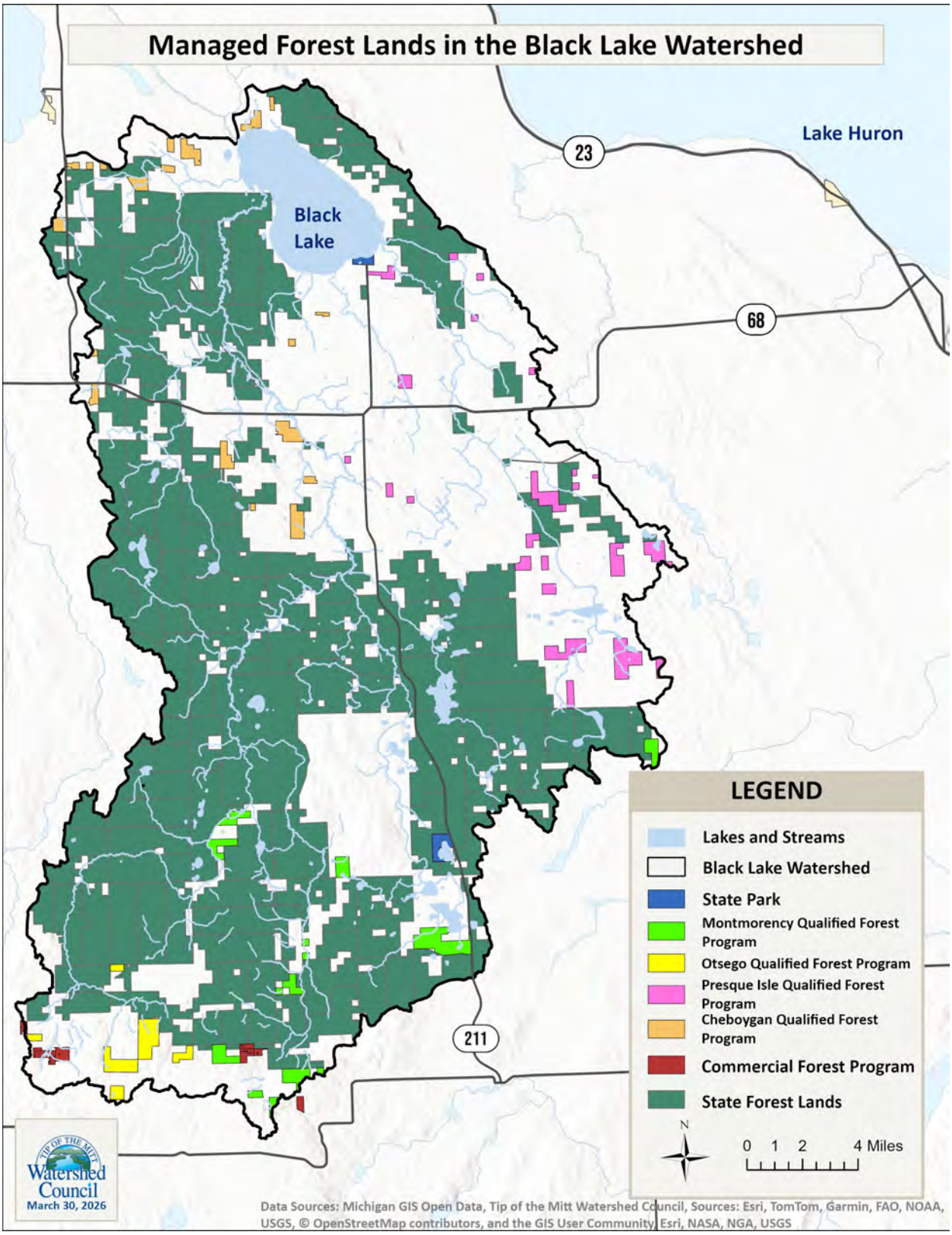


Figure 52. Managed forest land in the Black Lake Watershed

Table 27. Management type, county, acres and parcels enrolled within the watershed

Form of Management	County	Acres	Parcels Enrolled	Total Acres
State Land	Otsego	29915	NA	190,678.36
	Cheboygan	85544	NA	
	Montmorency	75198.6	NA	
	Presque Isle	35668.6	NA	
Qualified Forest Program	Presque Isle	4288.45	57	11,832.97
	Cheboygan	2485.92	35	
	Otsego	1722.18	10	
	Montmorency	3336.42	49	
Commercial Forest Program	Presque Isle	0	0	630.54
	Cheboygan	0	0	
	Otsego	403.54	6	
	Montmorency	227	6	
Total Acres Managed within the watershed				203,141.87

Stream Bank Erosion

Streambank erosion is a naturally occurring process that removes sediment and other materials from the bank of a stream. When this process is accelerated, the stream system can be altered and can have detrimental impacts on the health of the stream and the watershed as a whole[3]. The inventory conducted in the Black Lake Watershed provides insight into where streambank erosion is occurring and provides guidance on where targeted action can be taken to address pollutant loading from streambank erosion within the watershed. As stated in our methods, a desktop analysis of Fisher Creek, Stewart Creek and Stony Creek was performed and identified erosion spots along these creeks were visited along with the shoreline of the Upper Black River between Kleber Dam and Tower Pond.

Upper Black River

2022 Surveys

In 2022, Huron Pines conducted a streambank erosion survey on the Upper Black River. Two stretches were surveyed: Red Bridge Road to Hutchinson Highway, and South Black River Road to Clark Bridge Road (Figure 53). Of the 29 erosion sites identified, 2 were severe, 6 were moderate, and 21 were minor.

[3] Stream Bank Erosion and Control. (n.d.). WASHTENAW COUNTY CONSERVATION DISTRICT. Retrieved March 3, 2024, from https://www.washtenawcd.org/stream-bank-erosion-and-control.html

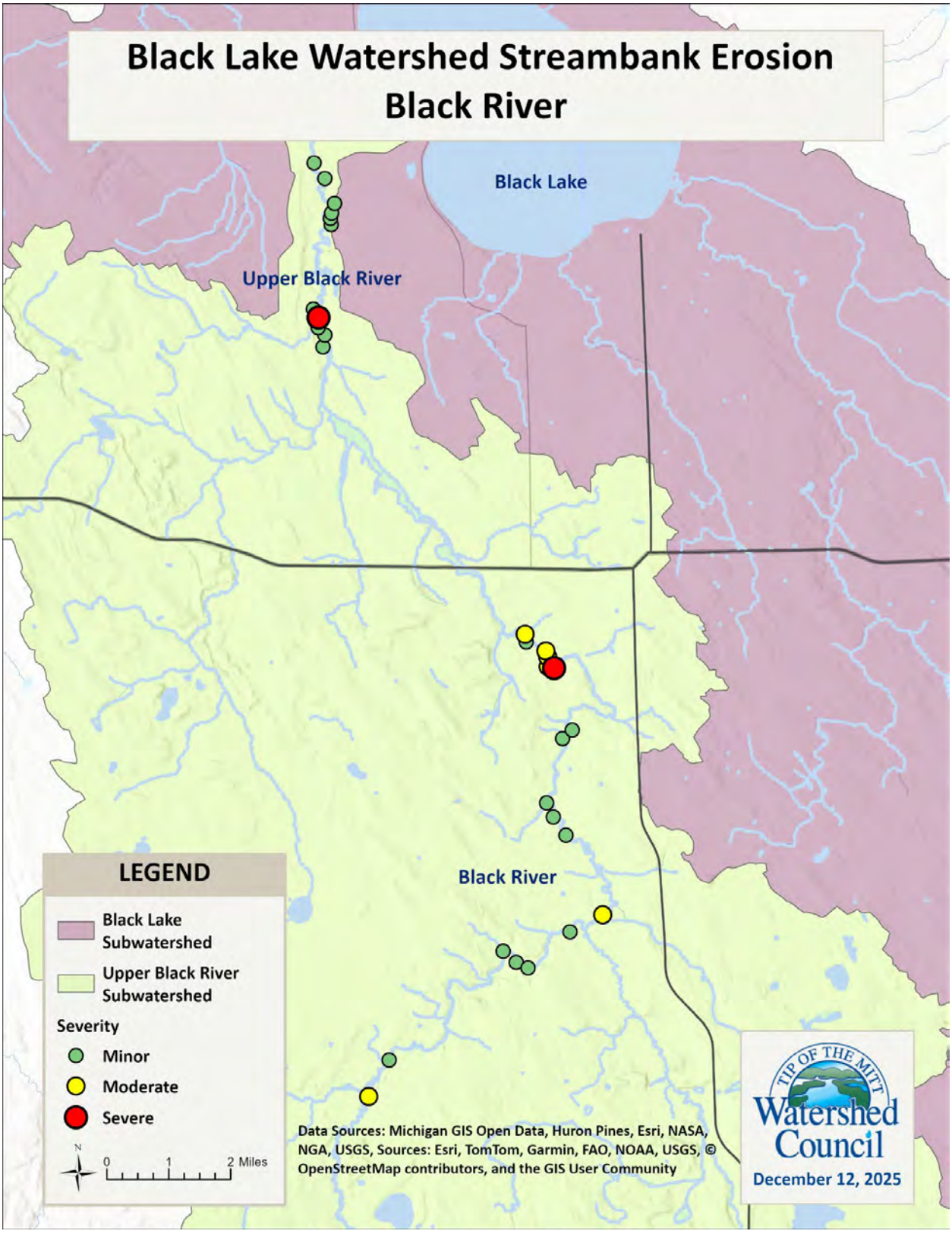


Figure 53. Upper Black streambank erosion sites (2022, Huron Pines)

2023 Surveys

A total of 43 sites were identified to have erosion occurring along the Upper Black River between Tower Pond and Kleber Dam (Figure 54). Of these sites, a majority (72%) had 51-100% bank vegetation cover and 81% had an increasing erosion trend (Figure 55). None of the sites along the Upper Black River had a decreasing erosion trend, but eight of them had a stable trend. One or more streambank structures were present at 33 sites, with 24 having a dock and 15 having riprap present (Figure 56).

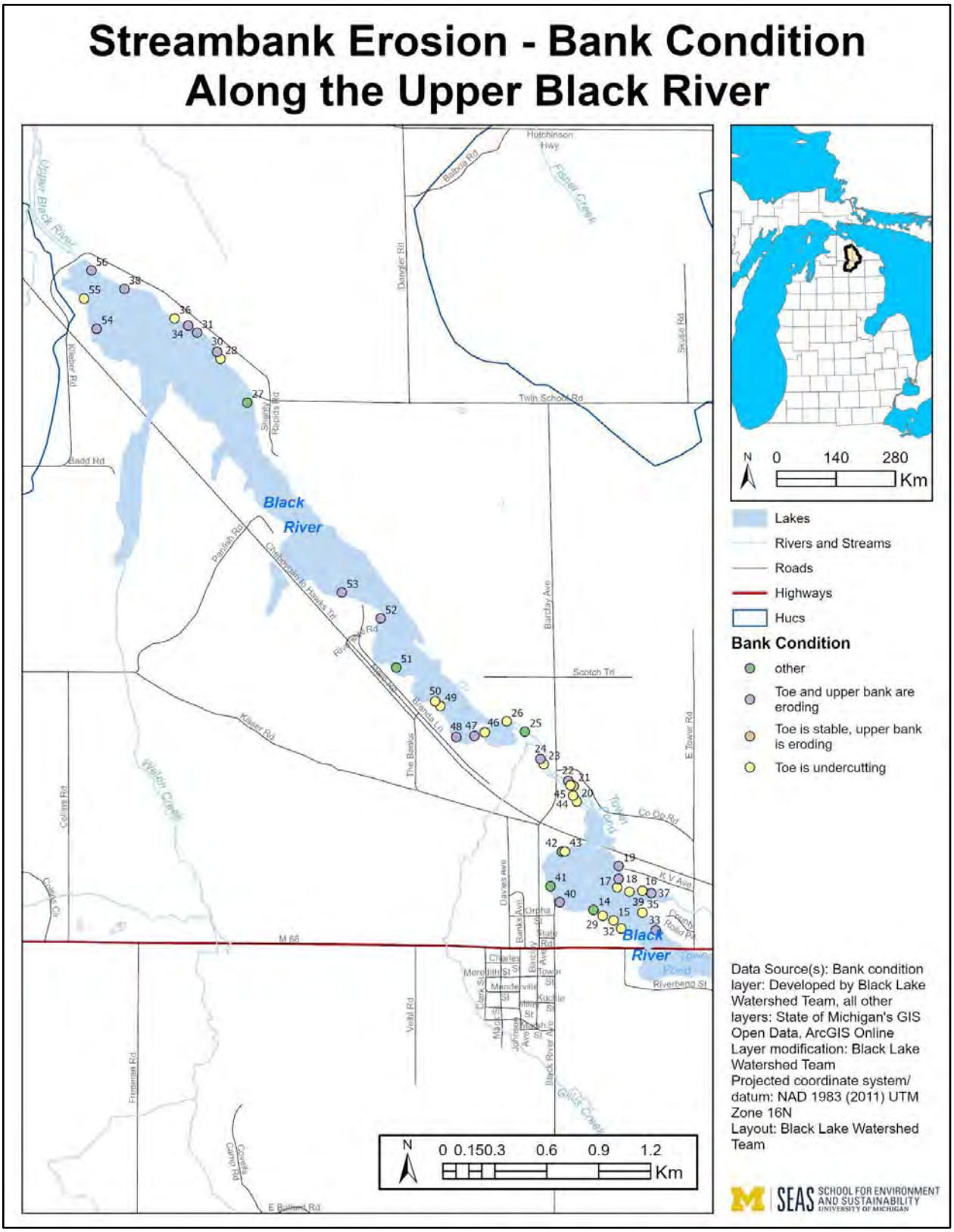


Figure 54. Bank condition for streambank erosion sites located along the Black River

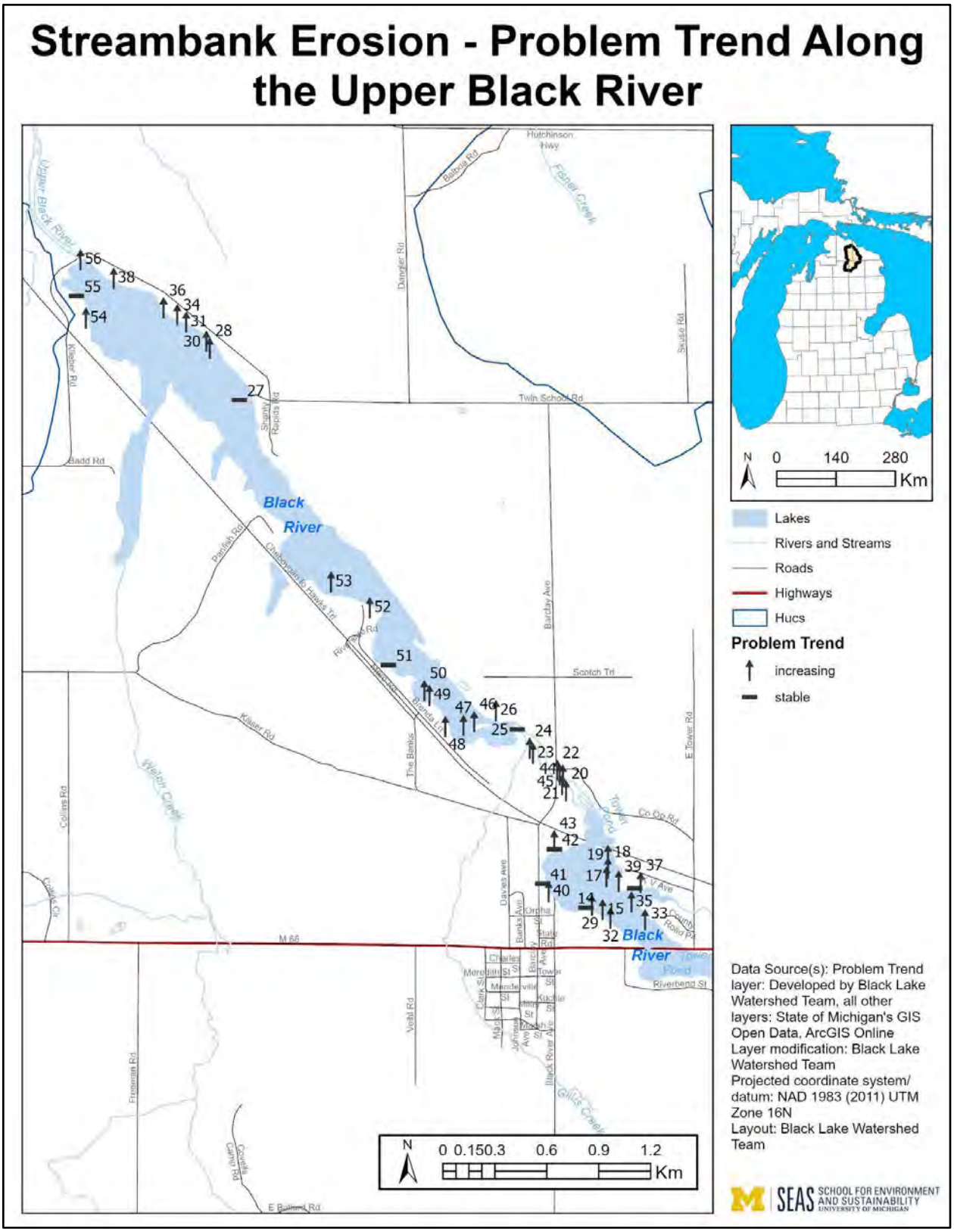


Figure 55. Bank condition for streambank erosion sites located along the Black River

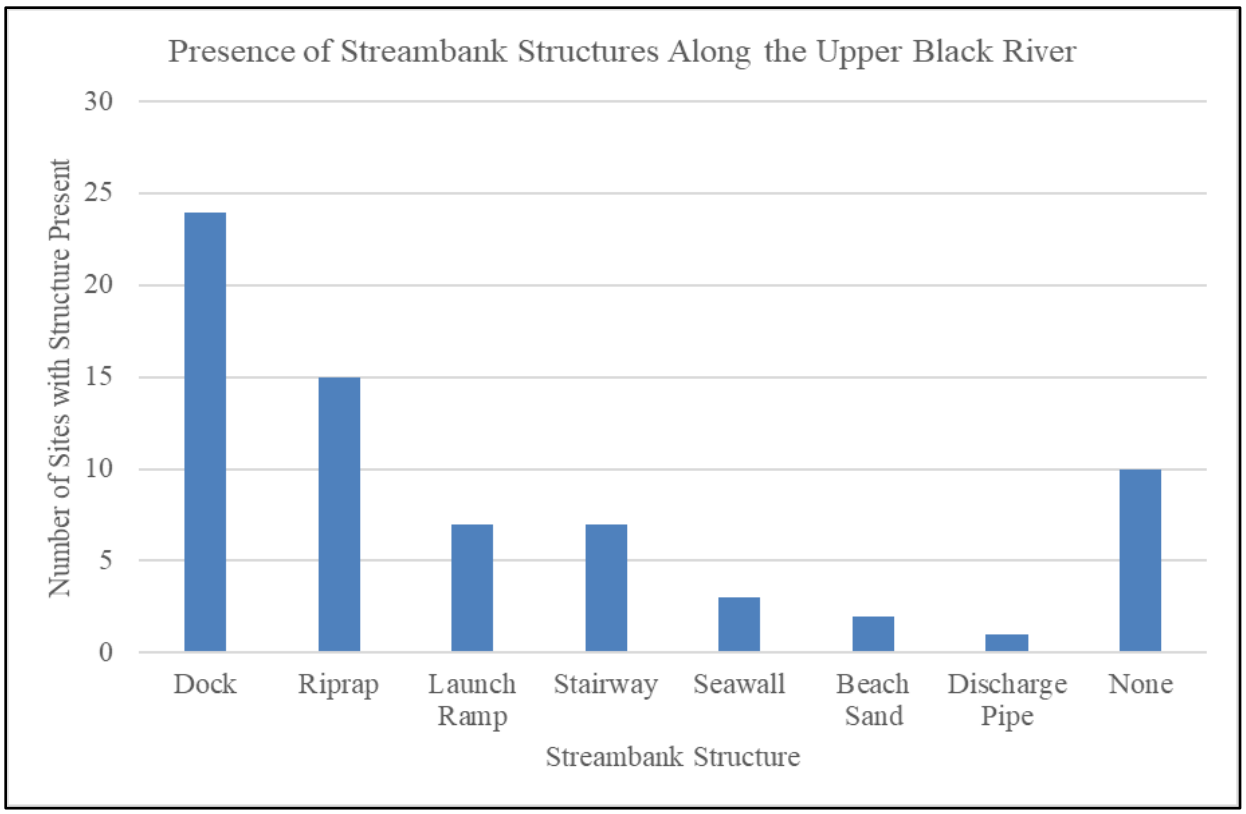


Figure 56. Presence of streambank structures at erosion sites along the Upper Black River

Greenbelt scores were given to all sites based on what percentage of the shoreline the greenbelt covered. For the purpose of this inventory, greenbelts were defined as a buffer of vegetation along the streambank between the water and shoreline development. The two most common scores were 0 (no greenbelt present) and 3 (extends 25-75% of shoreline) which 12 sites had (Figure 57).

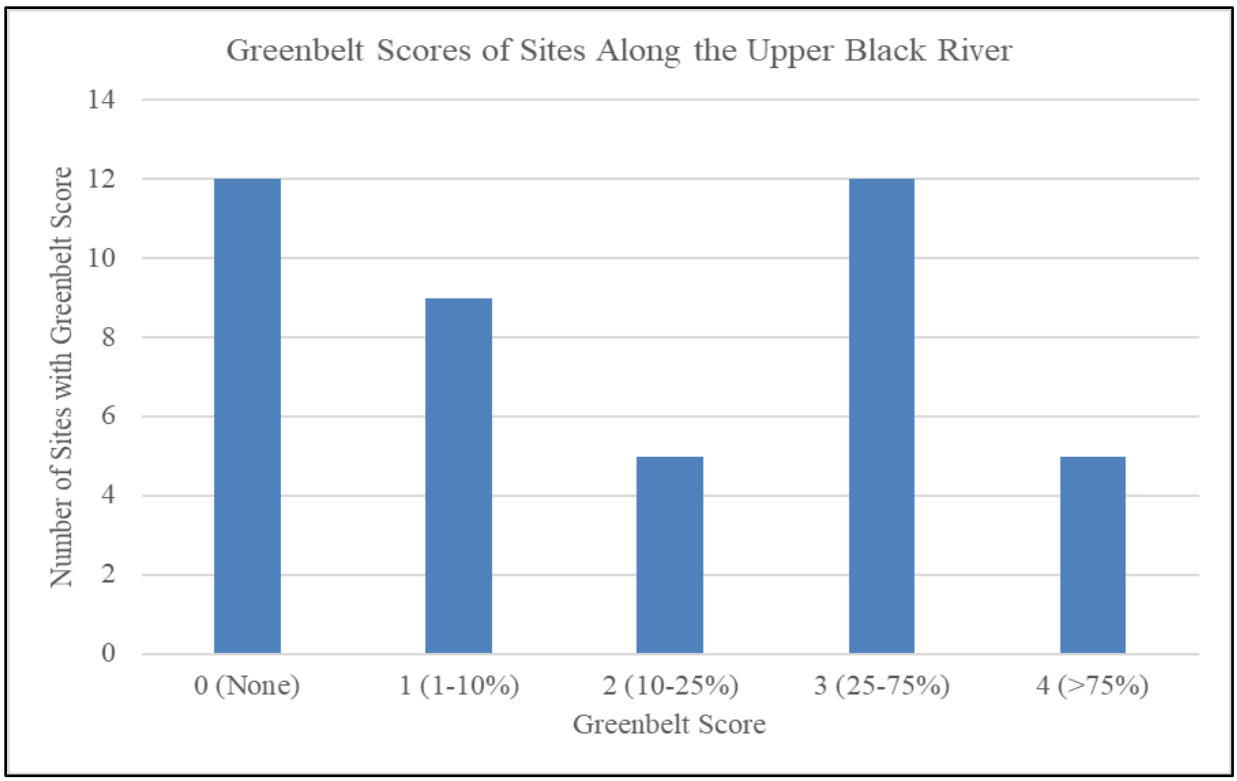


Figure 57. Greenbelt scores based upon the percentage of the shoreline the greenbelt extends for sites along the Upper Black River

Rainy River

The desktop analysis that was performed for the tributaries in the Black Lake Watershed found eight sites of erosion along the Rainy River (Figure 58). All eight of these sites were visited during August 2023 and any erosion present was documented. Seven of the eight sites had erosion occurring, with five of them having 0-10% of vegetation present on the bank. The erosion trend for six out of the eight sites is increasing, with only one site decreasing and another site seeing a combination of increasing and decreasing at the site (Table 28).

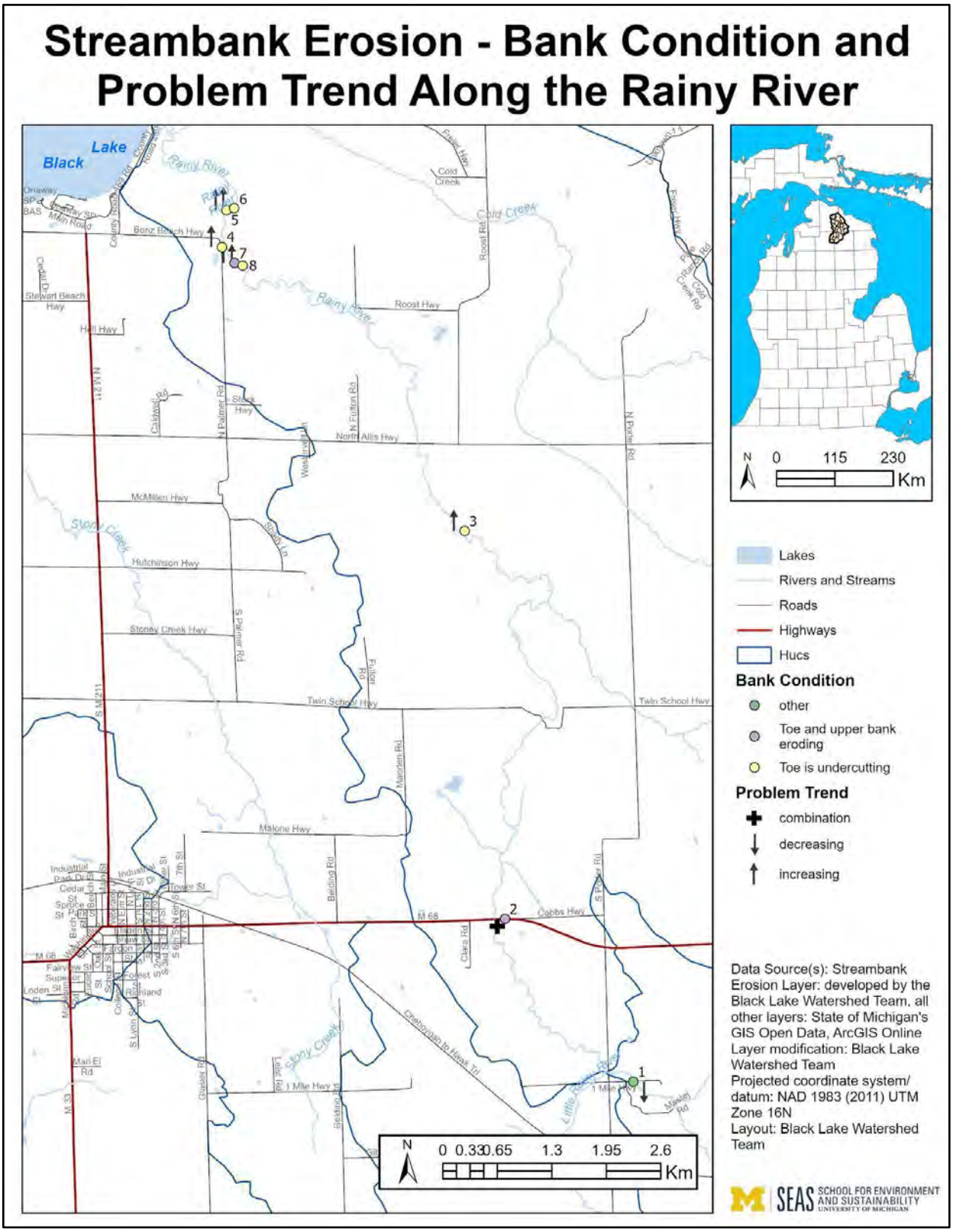


Figure 58. Bank condition and erosion trend for streambank erosion sites located along the Rainy River

Table 28. Percentage of bank with vegetation, bank condition and erosion trend of erosion sites along the Rainy River

Site ID	Bank Vegetation Cover	Bank Condition	Erosion Trend
1	51-100%	no erosion	decreasing
2	11-50%	toe and upper bank are eroding	combination
3	51-100%	toe is undercutting	increasing
4	0-10%	toe is undercutting	increasing
5	0-10%	toe is undercutting	increasing
6	0-10%	toe is undercutting	increasing
7	0-10%	toe and upper bank are eroding	increasing
8	0-10%	toe is undercutting	increasing

Fisher Creek, Stewart Creek and Stony Creek

The desktop analysis performed for the tributaries in the Black Lake Watershed found two sites of erosion along Fisher Creek, two sites of erosion along Stewart Creek and one site of erosion along Stony Creek (Figure 59). All of these sites were visited in August of 2023. All of these sites had 51-100% vegetation bank cover. Only two of the sites saw erosion occurring, one on Fisher Creek and one on Stewart creek, all of the others saw no erosion occurring with a decreasing or stable erosion trend. The erosion occurring at the Fisher Creek site has a decreasing erosion trend and the erosion occurring at the Stewart Creek site has an increasing erosion trend (Table 29).

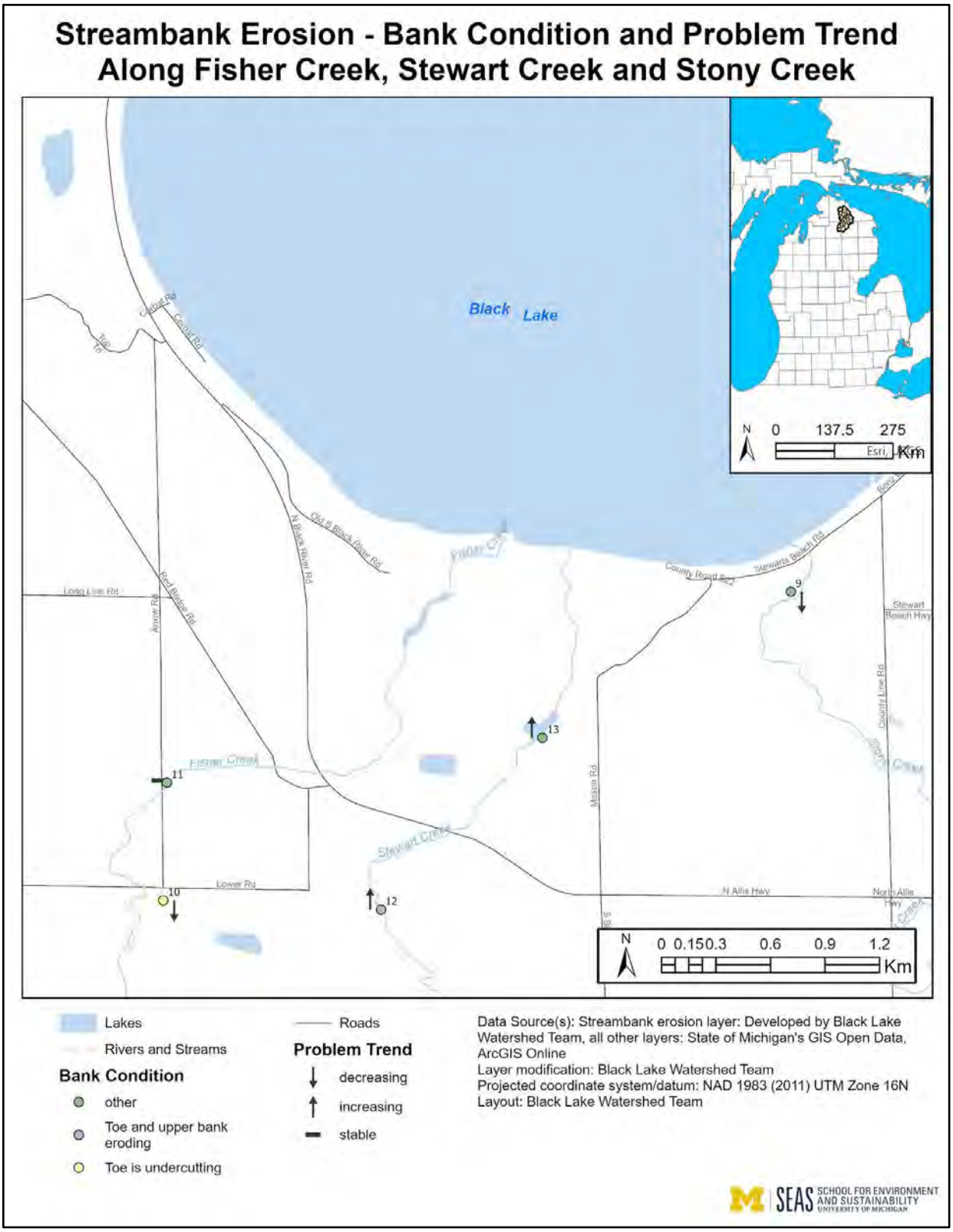


Figure 59. Bank condition and erosion trend for streambank erosion sites located along Fisher Creek, Stewart Creek, and Stony Creek.

Table 29. Percentage of bank with vegetation, bank condition and erosion trend of streambank erosion sites

Site ID	Stream	Bank Vegetation Cover	Bank Condition	Trend
9	Stony Creek	51-100%	no erosion	decreasing
10	Fisher Creek	51-100%	toe is undercutting	decreasing
11	Fisher Creek	51-100%	no erosion	stable
12	Stewart Creek	51-100%	toe and upper bank are eroding	increasing
13	Stewart Creek	51-100%	no erosion	increasing

Severity of erosion was given a ranking of minor, moderate or severe based upon our scoring criteria described in the methods section. These incorporated various aspects of the site to come up with a total score, with total scores below 30 being deemed minor, total scores between 30 and 36 being deemed moderate and total scores above 36 being deemed severe. Of the 56 sites visited within the watershed, only two sites were given a ranking of severe. A majority of the sites, 38, were given a ranking of minor and 16 were given a ranking of moderate (Table 30).

Table 30. Total number of sites of erosion severity ranking for each tributary surveyed

	Severity of Erosion		
Tributary	Minor	Moderate	Severe
Upper Black River	31	11	1
Rainy River	2	5	1
Fisher Creek	2	0	0
Stewart Creek	2	0	0
Stony Creek	1	0	0
Total Sites	38	16	2

Sediment loadings were calculated for each site using a direct volume method. This was then used to determine estimated pollutant loadings from phosphorus and nitrogen. Upper Black River has the most amount of pollutant loadings, with more nitrogen loadings. The total amount of pollutant loading from streambank erosion in the Black Lake Watershed was 229.76 pounds per year of phosphorus and 459.53 pounds per year of nitrogen (Table 31).

Table 31. Sediment and nutrient loadings for each tributary surveyed in 2023

Tributary	Number of Sites	Sediment Loads (tons/year)	Phosphorus Loads (lbs/year)	Nitrogen Loads (lbs/year)
Upper Black River	43	257.62875	218.9844375	437.968875
Rainy River	8	12.5	10.625	21.25
Fisher Creek	2	0.03	0.0255	0.051
Stewart Creek	2	0.15	0.1275	0.255
Stony Creek	1	0.00105	0.0008925	0.001785
Total		270.3098	229.76333	459.52666

Agriculture

The agriculture inventory consisted of a desktop analysis of the 2008 common land units showing individual contiguous farming parcels in the Black Lake Watershed, as laid out in our methods section (see SEAS report appendices). This inventory aims to identify where agriculture activity is present and determine the associated potential locations of nonpoint source pollution.

150 parcels were found to contain agricultural activity, with the majority of sites concentrated in the northern part of the Black Lake Watershed, just south of Black Lake. The Black Lake subwatershed had the most amount of agricultural activity, with 29 sites identified. Gregg-Creek Black River, Little Rainy River, and Bowen Creek-Black River had the next highest number of sites with 22, 20 and 19 sites respectively (Figure 60)

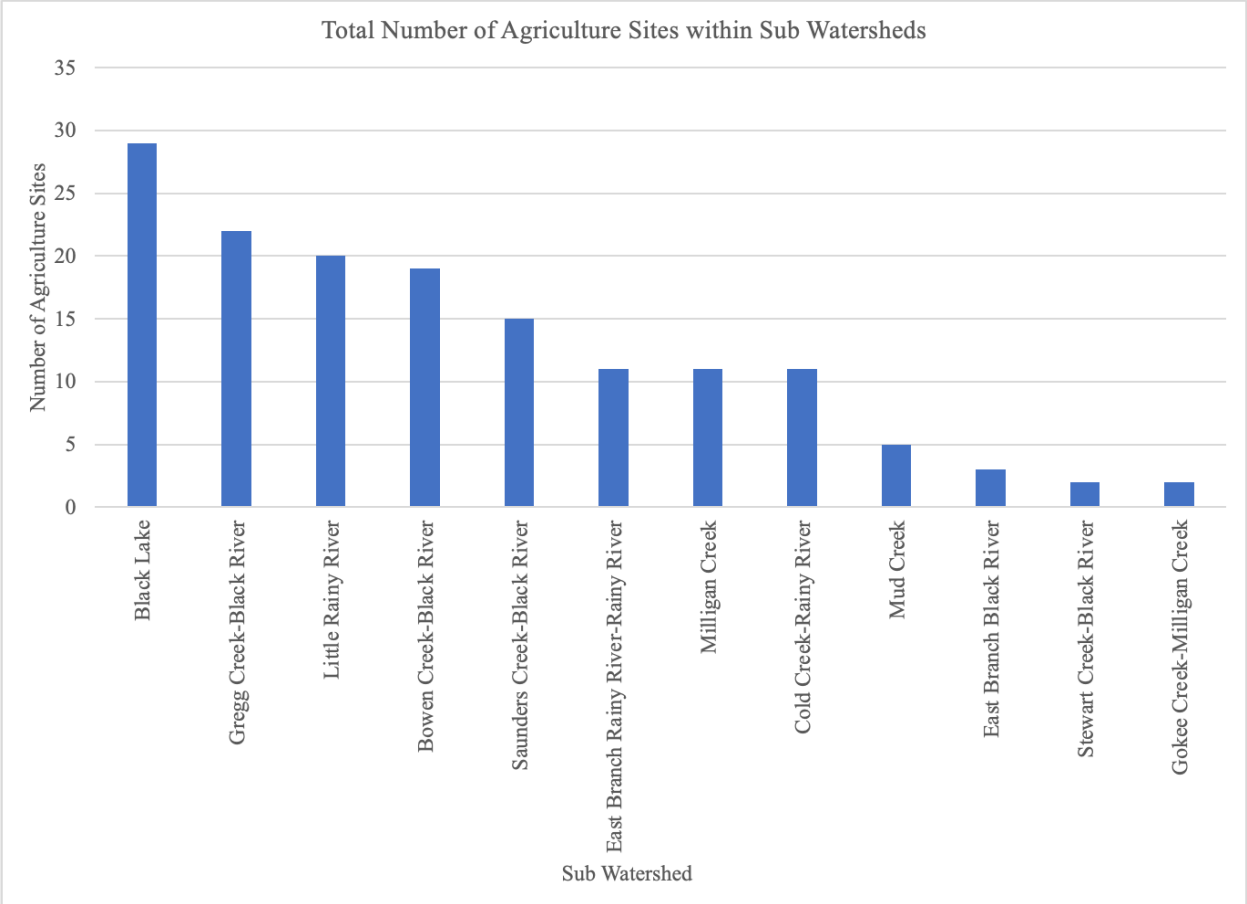


Figure 60. Total number of agriculture sites within sub watersheds of the Black Lake Watershed

Of the 150 sites identified, 93 of them were located adjacent to a body of water. 17 of these sites were located adjacent to the Rainy River. The Black River and Little Rainy River each had 12 located adjacent to them. The operation type of the identified site and an associated size of operation was given to all sites (Figure 61). The most common operation was unknown operation, which were parcels that had agricultural activity present in the form of animals and structures, but were unable to identify what kind of operation was being run. There were 34 hobby operations, 5 beef operations and one dairy operation. The size of the operations were determined by the number of animals and buildings seen at the site in the aerial imagery as described in the appendices of SEAS 2024 report. The most common size was also unknown, which were operations that spanned multiple overlapping parcels or where we were unable to identify the number of buildings located within the parcels. There was one large sized operation, 16 medium sized operations, 49 small sized operations, and 29 hobby operations (Table 32).

Table 32.Number of agricultural sites for each operation type and size

	Size of Operation					
Type of Operation	**Hobby**	**Large**	**Medium**	**Small**	**Unknown**	**Grand Total**
Beef			4	1		5

Dairy				1		1
Hobby	25			5	4	34
Unknown	4	1	12	42	51	110
Grand Total	29	1	16	49	55	150

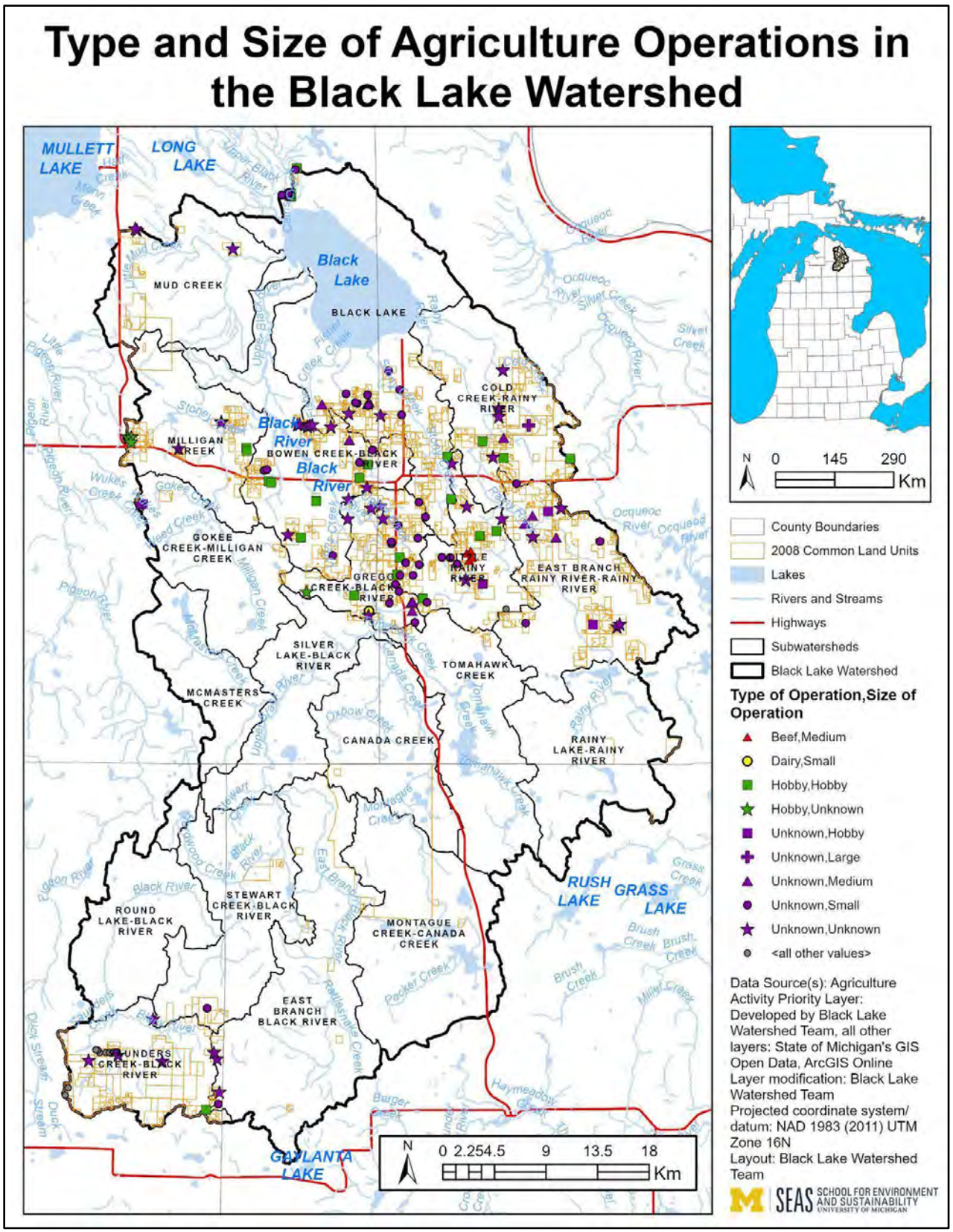


Figure 61. Type and size or operations at agriculture sites within the Black Lake Watershed

The quality of manure storage structures present at the site and the maintenance of the site were also evaluated using the methods outlined in the appendices of the SEAS 2024 report. Most of the sites had good or fair storage quality, 51% and 30% of sites respectively. Of the 22 sites with poor storage quality, 19 of them were adjacent to a body of water and 32% of those were located adjacent to the Rainy River. Most of the sites also had good or fair maintenance quality, 37% and 39% of sites respectively. Of the 29 sites with poor maintenance quality, 27 of them were located adjacent to a body of water. Of these sites, 22% of those were located adjacent to the Rainy River and 15% were located adjacent to Tower Pond.

A ranking of priority was given to all agricultural sites identified based upon the type and size of operation at the site, the adjacency to a body of water and the quality of storage and maintenance. Of the 150 sites, 68 were given low priority, 45 were given medium priority and 37 were given high priority (Figure 62). All of those deemed high priority are located adjacent to a body of water and 16% of those also have poor maintenance and storage quality. 30% of the sites ranked high priority are located adjacent to the Rainy River, which are 11 of the total 17 sites located adjacent to the Rainy River.

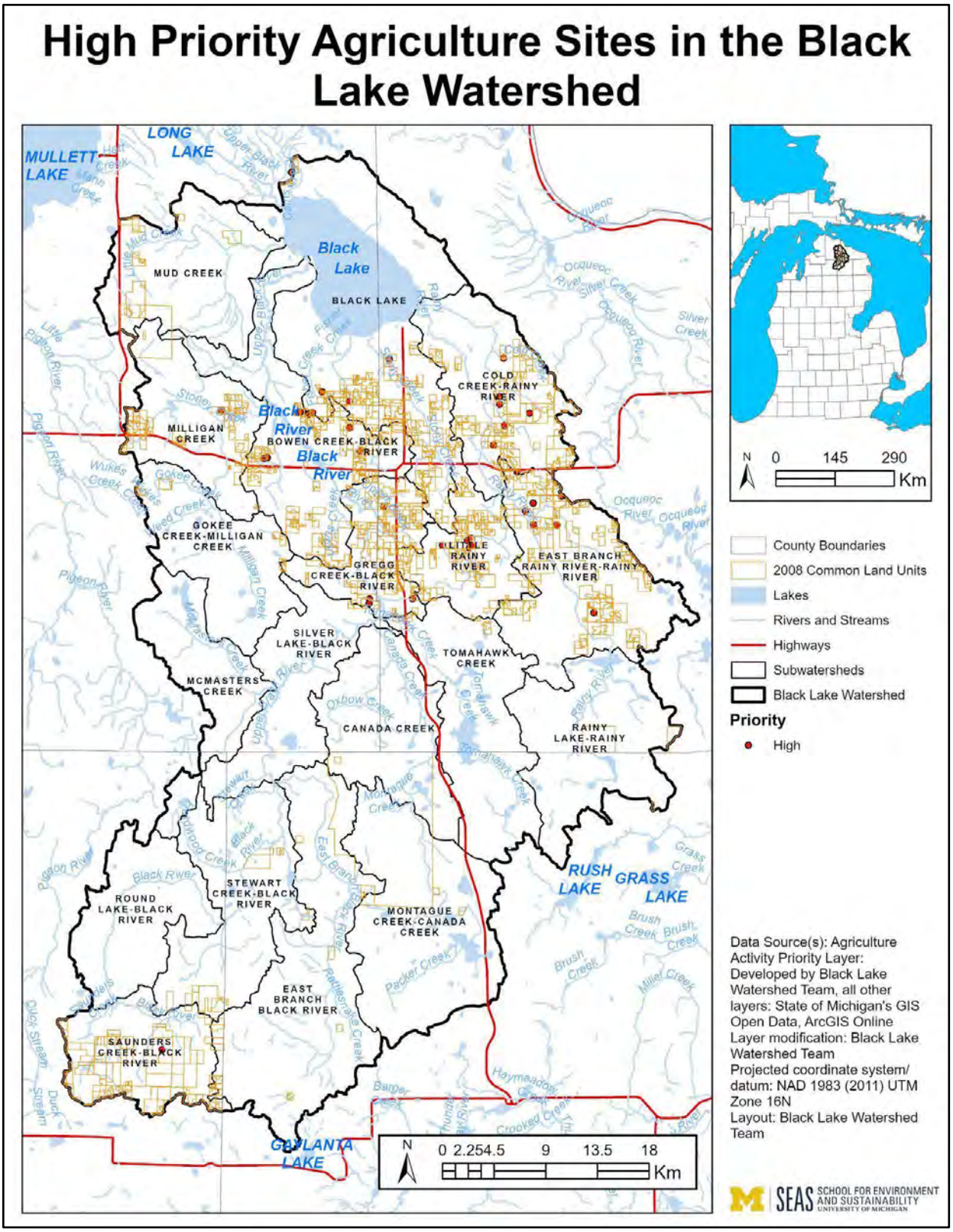


Figure 62. All high priority agriculture sites within subwatersheds in the Black Lake Watershed

5. WATER QUALITY THREATS

As detailed in previous chapters, different land uses (sources) and activities (causes) have the potential to impact water quality, and subsequently, threaten the designated uses of a water body. It is critical to identify and understand the link between the source of nonpoint source pollutants and the potential cause. It is this understanding that forms the framework for developing the goals, objectives, and implementation tasks of the Watershed Management Plan.

Sediment Sources and Causes

Sediment pollution comes from a variety of sources and causes.

Sources of sediment can include lakeshores and streambanks, road/stream crossings, agricultural practices, construction, logging, and others.

Causes of sediment pollution range as well and oftentimes include:

- Lakeshore and streambank erosion- a result of the removal or loss of shoreline vegetation.
- Improperly sized culvert and lack of runoff diversions- main reason for erosion and sedimentation associated with road/stream crossings.
- New construction in the shoreline area can also contribute sediment, particularly if inadequate erosion controls are used.
- Motorboats travelling at excessive speeds in no-wake areas cause erosion and sedimentation.
- Not maintaining buffer strips during logging can also contribute to erosion and sedimentation.
- Livestock access to streams for a watering source can destroy the bank and cause erosion and sedimentation.

Nutrient Sources and Causes

Nutrient pollution may also be derived from a variety of sources, and oftentimes is linked with sediment pollution because nutrients attach to sediment particles.

Sources of nutrient pollution include shoreline and streambank erosion, road crossings, turf management, failing septic systems, agricultural practices, stormwater discharges in urban areas, manure application and management, golf course management, and new construction. Consequently, shoreline, streambank, and road/stream crossing erosion contribute sediment and nutrient pollution.

Causes of nutrient pollution oftentimes mirror that of sediment pollution. They may include:

- Lakeshore and streambank erosion are often a result of the removal of shoreline vegetation.

- Improperly sized culverts and lack of runoff diversions are the main reason for erosion and sedimentation associated with road/stream crossings.
- Livestock access to streams for a watering source can destroy the bank and cause erosion and sedimentation. In addition, manure may be directly entering the stream.
- Outdated, poorly maintained, and improperly designed septic systems discharge nutrients.
- Improper (overuse, wrong formulation, etc.) application of fertilizers on agricultural fields, golf courses, and residential lawns.
- Urban stormwater carries pet waste and other nutrient sources and is discharged to a lake or stream without treatment.

Sources and Causes of Other Pollutants

Sources of oils, grease, and heavy metals include stormwater discharges in urban areas and road/stream crossings.

Sources of pesticides include agricultural fields and residential, commercial, and municipal turf management.

Sources of bacteria include stormwater discharges in urban areas, manure application and storage, septic systems, and livestock access to streams.

Causes may include:

- Outdated, poorly maintained, and improperly designed septic systems discharge bacteria and other pathogens.
- Urban stormwater carries bacteria, oils, grease, and heavy metals and is then discharged to a lake or stream without treatment.
- Unrestricted livestock access to a stream allows waste to enter the stream directly.
- Over application of pesticides on residential, commercial, and municipal properties, as well as agricultural fields.

Other Environmental Stressors

Habitat Degradation

The disruption of a water body's hydrology can cause systemic problems that affect water quality and habitat. The most common sources of these disruptions are road/stream crossings and dams. Road/stream crossings, if designed or installed improperly, can restrict flow and create upstream flooding and downstream erosion. Downstream reaches can become sediment starved due to the interference of sediment transport. Water temperatures can increase from upstream impounding. Excess sediments and nutrients can enter a stream more readily due to localized erosion. Road/stream crossing can also create physical barriers to upstream passage of aquatic organisms due to perched culverts or accelerated velocity of water through the structure. Dams can result in many of the same conditions stated above, including disturbance of sediment transport, increased water temperatures, downstream erosion, and as barriers to aquatic organism passage.

Invasive Species

Invasive species can have a profound impact on water resources. Whether fully aquatic species, such as Eurasian watermilfoil (*Myriophyllum spicatum*), or semi-aquatic species, such as common reed (*Phragmites australis),* once a noxious invasive species becomes established within or around a waterbody, the impacts are far-reaching. Native plant communities can become outcompeted by more aggressive invasive species thereby limiting the availability of food and shelter to local wildlife. Local hydrology can change and lead to flooding and erosion. Recreation can become impaired from excess growth of plants that limit swimming, boating, etc. Decomposition of dead and decaying plant matter can deplete dissolved oxygen, which then affects fish and other aquatic organisms.

Thermal Pollution

Thermal pollution is caused when surface waters are unnaturally warmed from either a warm water discharge, such is the case when stormwater flows directly into a lake or stream, or when sunlight is allowed to penetrate deeper into the water column due to increased water clarity or impounding of water. Increased water temperatures can affect aquatic life as some species have limited tolerance for even very small increases in water temperature due to less dissolved oxygen and other factors.

Climate Change

Although climate change is not a nonpoint source pollutant, cause, or source of nonpoint source pollution, it does factor into watershed protection. Climate change predictions indicate that the Earth's average temperature will increase, which will subsequently influence the patterns and amounts of global precipitation. Sea levels will rise, ice and snow cover will be reduced, and there will be more frequent and extreme weather events. Given these predictions, it is critical that high-quality water resources are protected to maintain their resilience in the face of climate change. As described earlier, the Burt Lake Watershed includes some of the most pristine lakes, streams, and wetlands within Michigan. Protecting them now will help to mitigate not only the local effects of climate change, but also on a regional scale.

Summary

Reducing and preventing nonpoint source pollutants relies upon addressing the priority pollutants' sources and causes, which have been identified and ranked for the Watershed. The pollutants are ranked according to their potential impact on water quality. Sources are ranked for each pollutant according to their prevalence. Table 33 summarizes pollutant sources, causes, and environmental stressors. Known causes are not ranked any higher than suspected sources because not all sources were able to be investigated. Suspected sources have been widely researched and are known sources, but we have not confirmed with data in this watershed

Table 33. Pollutant Causes and Sources

Pollutant Source	Cause	Status	Data Source if Known	Location in Watershed
1. NUTRIENTS				
Designated Uses Impacted: Coldwater Fishery, Warmwater Fishery, Other Indigenous Aquatic Life, Total/Partial Body Contact				
1- Septic Systems	Old, poorly maintained, or improperly designed systems; illicit connections	K	Mass balance study	Lakefront property
2- Agriculture (Fertilizer, Manure, Livestock)	Improper application, storage, or proximity to water; streamside grazing	S	Agriculture Survey & WQ data	Black Lake Direct subwatershed
3- Lack of Riparian Buffer	Development, lack of setbacks, tree loss from pests/disease, poor landscaping	K	Shoreline Surveys	Black Lake and Black River
4- Reduction of Wetlands	Development, wetland filling, stream degradation	K	LLFWA	Watershed-wide
5- Stormwater (Urban, Agricultural, Rural)	Inadequate practices, development, increased storm frequency and precipitation	S		Lakefront property, Onaway
6- Residential or Commercial Fertilizer Use	Over-application or poor timing/location/method of fertilizer use	S	Shoreline Surveys	Watershed-wide
7- Wastewater Treatment Plants (WWTP)	Discharge of nutrients in wastewater	S		Onaway
2. INVASIVE SPECIES				
Designated Uses Impacted: Coldwater Fishery, Warmwater Fishery, Other Indigenous Aquatic Life, Total/Partial Body Contact				
1- Accidental Introduction	Boat movement, lack of cleaning, habitat changes, intentional release, food web impacts	K	Black Lake Aquatic Plant Survey	Watershed-wide
3. TOXIC SUBSTANCES				
Designated Uses Impacted: Coldwater Fishery, Warmwater Fishery, Other Indigenous Aquatic Life, Total/Partial Body Contact				
1- Harmful Algae Bloom	Excess nutrients	S		Black Lake
2- Road Salt	Runoff from winter de-icing	K	WQ Data	Watershed-wide
3- Pesticides	shoreline/streambank development	S		Lakefront property
4- Stormwater (Urban, Agricultural, Rural)	Poor stormwater management, climate-driven precipitation	S		Watershed-wide
5- Contaminated Sediments/Groundwater	Historical contamination, firefighting foam with PFOAs	K	MDHHS Eat Safe Fish Guide	Watershed-wide
6- Industrial/Municipal Discharges	Violation of discharge limits, contaminated sediment	K		
7- WWTP Discharge	Insufficient treatment technology	S		Onaway WWTP
8- Atmospheric Deposition	Vehicle and industrial emissions, fires, dust storms, firefighting foam with PFOAs	K	EGLE Integrated Report	Watershed-wide
4. HABITAT DEGRADATION				
Designated Uses Impacted: Coldwater Fishery, Warmwater Fishery, Other Indigenous Aquatic Life, Total/Partial Body Contact				
1- Shoreline/Streambank Development	Removal of native shoreline and nearshore habitat, Shoreline alterations	K	Shoreline & Streambank Surveys	Black Lake & Black River
2- Road/Stream crossings	Hydrologic disruption, barrier for aquatic organisms	K	RSX Surveys	Watershed-wide
3- Small dams	Hydrologic disruption, barrier for aquatic organisms	K	DNR	Small dams
5. SEDIMENTS				
Designated Uses Impacted: Coldwater Fishery, Warmwater Fishery, Other Indigenous Aquatic Life				
1- Shoreline/Channel Erosion	Loss of vegetation, boat wakes, high flow velocities, hardened shorelines, urbanization	K	Shoreline Survey	Black Lake and Black River
2- Road-Stream Crossings	Poor design, steep approaches, misaligned or undersized culverts, erosion from sanding	K	RSX Inventory	Watershed-wide
3- Forestry Practices	poor forest management	S	Forestry Survey	Watershed-wide
4- Dams & Lake-Level Controls	Structural failures, dredging issues	S		Alverno, Tower & Kleber dams
5- Wetland Filling	Poor stormwater controls, development, permit non-compliance	S		Watershed-wide
6- Livestock Access	Animals allowed direct access to streams or wetland edges	S	Agriculture Survey & WQ data	Black Lake Direct subwatershed
7- Stormwater (Urban, Agricultural, Rural)	Inadequate practices, increased storm intensity from climate change, snow piles	S		Onaway
6. PATHOGENS				

Designated Uses Impacted: Total/Partial Body Contact Recreation				
1- Septic Systems	Old, unmaintained, or poorly designed systems; illicit connections	K	Mass Balance study	Lakefront property
2- Animal Waste	Shoreline geese/ducks, livestock access, poor livestock management	S		Lakefront
3- Stormwater (Urban, Agricultural, Rural)	Poor stormwater practices, increased storm frequency and precipitation	S		Watershed-wide
7. THERMAL POLLUTION				
Designated Uses Impacted: Coldwater Fishery, Warmwater Fishery, Other Indigenous Aquatic Life				
1- Sedimentation in Stream Channel	See sediment section	S		Watershed-wide
2- Ponds & Impoundments	Top draw structures, low flows, poor maintenance	S		Watershed-wide
3- Lack of Streamside or Shoreline Canopy	Landowner clearing, development, tree loss from pests/disease	S		Watershed-wide
4- Stormwater (Urban, Agricultural, Rural)	Poor stormwater practices, development, storm frequency from climate change	S		Watershed-wide
8. CLIMATE CHANGE				
Designated Uses Impacted: Coldwater Fishery, Warmwater Fishery, Other Indigenous Aquatic Life, Total/Partial Body Contact				
1- More extreme precipitation	Heavier rainfall, stormwater surges, erosion, nutrient and pathogen loading	K	NOAA	Watershed-wide
2- Higher lake and stream levels	Shoreline erosion, overwhelmed culverts, altered habitats	K	NOAA	Watershed-wide
3- Increased drought & low flows	Baseflow reduction, stream warming, habitat loss	K	NOAA	Watershed-wide
4- Reduced snowpack & ice cover	Shorter snow season, loss of snowmelt buffering, streamflow changes	K	NOAA	Watershed-wide
5- Warmer air & water temps	Longer growing season, thermal stress to coldwater species	K	NOAA	Watershed-wide

6. CRITICAL AND PRIORITY AREAS

Critical Areas

The critical areas analysis identified areas throughout the watershed with the greatest need for restoration. As stated in the methods section, areas were determined once all resource inventories were completed. There were 16 identified areas that presented a need for the most restoration and/or need for attention (Figure 63). The 16 areas include three regions of RSXs, three areas with high priority agriculture sites, three streambank erosion areas with increasing erosion trends, two sites that have low greenbelt scores, and five tributary sites that did not meet required water quality standards during the TOMWC tributary study. Areas were identified within 12 of the 19 subwatersheds. Critical RSXs spanned across 9 of the 19 subwatersheds and high priority agricultural sites spanned across 5. The forestry inventory was not included in the analysis as ground truthing is needed to identify possible areas of concern.

The subwatersheds and their respective sources can be seen in Table 34. The critical areas analysis identified three RSX regions that had a high abundance of sites ranking "Major." An area of RSX sites is identified about 10 Km south of Tower. Three different areas with high priority agriculture sites were identified, primarily along the Rainy River. On the Rainy River alone, there are 11 agriculture sites deemed high priority as well as increased streambank erosion trends and "Major" RSX sites. A number of high priority agriculture sites and "Major" RSXs are located along the Little Rainy River. Near the Rainy River-Cold Creek confluence there are several streambank erosion sites with increasing erosion trends as well. Other concerns are seen surrounding Tower and Kleber Pond and neighboring tributaries. Several high priority agriculture sites in addition to low greenbelt scores and RSXs ranking "Major" make up the area seen between the city of Tower and Black Lake's shorelines. Looking at all inventories together, the regions surrounding both the Black River and Rainy River are identified as the most critical areas within the watershed.

Table 34. Critical Areas

Source	Critical Area Subwatershed	Critical Area Location
	Black Lake Direct	Stony Creek
		Little Mud Creek
		Rainy River
		Little Rainy River
	Black River	McMasters Creek

RSX/Hydrologic Disruption		Upper Black River
		Canada Creek
		Milligan Creek
		Upper Black River
		Stoney Creek
		Oxbow Creek
Streambank Degradation	Black Lake Direct	Stewart Creek
		Rainy River
	Black River	Kleber Pond
		Black River
Agriculture	Black Lake Direct	Fisher Creek, Stewart Creek
		Cold Creek
		Rainy River
		Little Rainy River
		Stewart Creek
Harmful Algal Blooms	Black Lake Direct	Black Lake

Critical Zone

In addition to these critical areas, we have also identified the shoreline around Black Lake as a Critical Zone. This designation responds to the varying degrees of shoreline degradation observed around the lake, including erosion, loss of native vegetation and increased development pressure. Shoreline protection areas serve as the first line of defense for lake health by filtering runoff, stabilizing soils, reducing nutrient and sediment inputs and providing important habitat. This zone is also especially vulnerable to impacts from aging or poorly functioning septic systems and from upland runoff that can carry excess nutrients, pollutants and sediments toward the lake. Because these individual shoreline parcels are stewarded at the discretion of several different landowners, we cannot apply a broad-brush designation of all shoreline areas as critical. Instead, best management efforts will be prioritized and tailored based on site specific conditions such as greenbelt status and erosion scores to ensure the most effective and equitable protection of Black Lake. For greenbelt scores, see the resource inventory chapter.

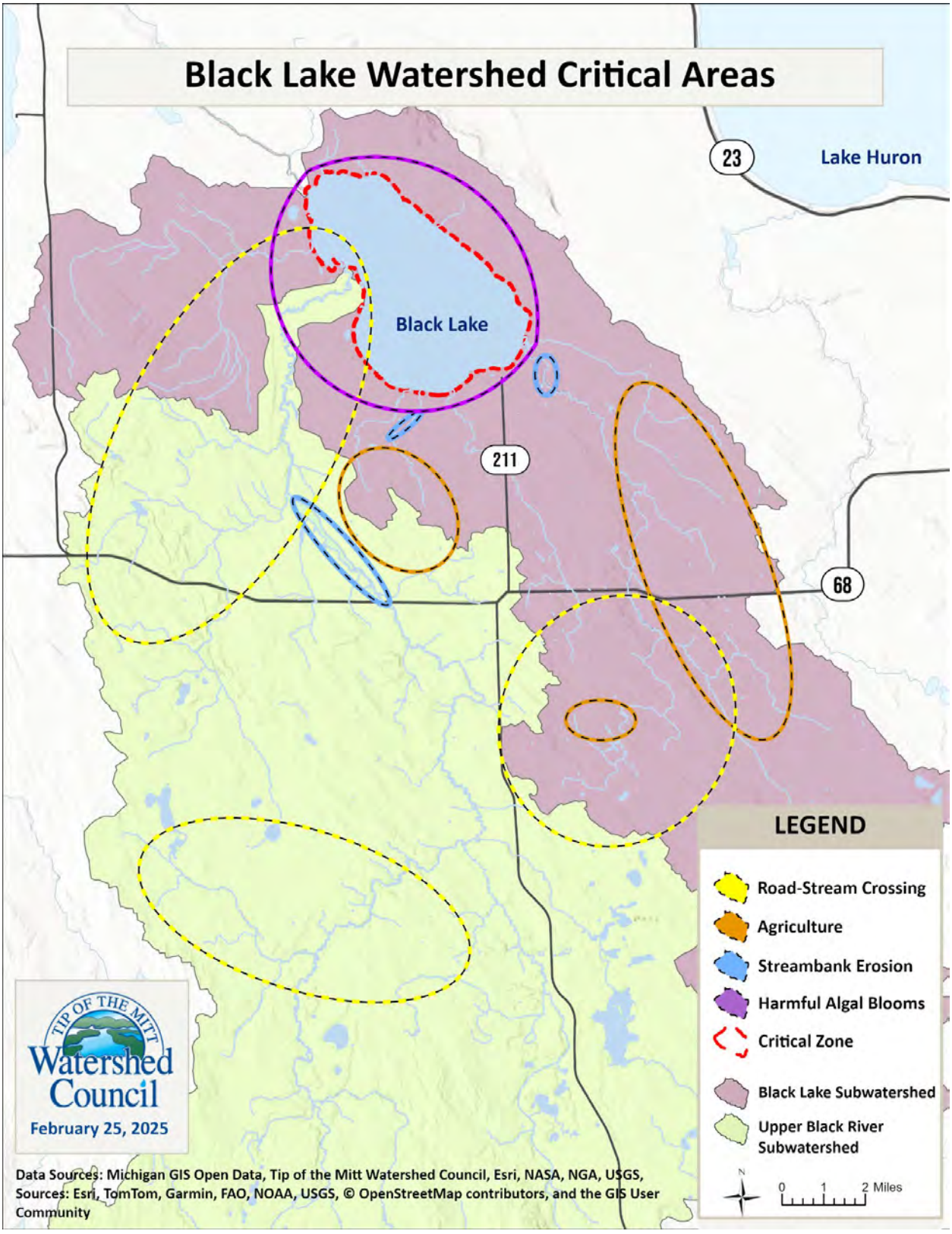


Figure 63. Critical Areas

Priority Areas

Priority areas were identified using a priority parcel analysis that identifies parcels in the watershed that are vulnerable to land use changes and would most benefit the water quality of the watershed if permanently protected by land conservancies, governmental entities, or others with permanent land protection efforts. This analysis guides where protection efforts should be prioritized and gives insight into currently protected lands within the watershed. Criteria selection is summarized in Table 35. The full method can be viewed in appendix H.

Table 35. Priority parcel criteria

Criteria	Description
Parcel Size	Larger, contiguous parcels have greater ecological value and are more efficient to protect. Parcels over 10 acres were prioritized, with size increasing scores.
Groundwater Recharge Potential	Parcels with permeable soils that support groundwater recharge were scored based on acreage, with a one-acre minimum threshold.
Presence of Wetlands	Wetlands provide key ecological functions. Parcels were scored based on wetland acreage, with any presence receiving points.
Lake and Stream Shorelines	Shoreline areas are critical for water quality. Parcels with at least 100 feet of frontage were prioritized and scored by shoreline length.
Steep Slopes	Steep slopes are prone to erosion. Parcels with slopes greater than 20% received points.
Protected Land Adjacency	Parcels adjacent to protected lands increase habitat connectivity. Scores were based on the number of adjoining protected parcels.
Threatened and Endangered Species	Parcels with a high likelihood of supporting listed species, based on the Biorarity Index, received higher scores.
Proximity to Development	Parcels near urban areas were prioritized due to development pressure and public use potential, with scores based on proximity.
Natural Land Cover	Parcels with more than 50% natural land cover were scored higher due to greater ecological integrity.
Drinking Water Protection Areas	Parcels within wellhead protection areas were scored based on the percentage of overlap.
Exceptional Resources	Parcels adjacent to rare or high-value features received a fixed two-point bonus.

The Black Lake Watershed contains 8,308 parcels with an average of 41.69 acres per parcel. A majority of the watershed (66%) is already protected land controlled by various organizations including the Michigan DNR, the US Fish and Wildlife Service, the Little Traverse Conservancy, and Private Landowners easements with Headwaters Land Conservancy or Little Traverse Conservancy (Table 36, Figure 64). Conservation easements were assigned low priority, but were considered protected parcels in the analysis due to land conservancies asking for their easements to be omitted from public maps. Of the 5 priority parcel levels, the largest category is moderate priority which covers 16% of the watershed, followed by low priority with 10% of the watershed. The three least common priority levels are high, very low and very high covering

3%, 2% and 1% of the watershed respectively. The very high parcels have an average parcel size of 467.45 acres, which is 11 times larger than the watershed average.

Table 36. Total number of parcels and acreage of each priority parcel level and corresponding watershed percentage.

Priority Parcel Level	Number of Parcels	Total Acres	Average Acres per Parcel	Percent of Watershed*
Very Low	899	10,230.44	11.38	2.95
Low	3,288	35,059.1	10.66	10.12
Moderate	2,180	56,124.11	25.75	16.20
High	45	11,857.66	263.50	3.42
Very High	8	3,739.63	467.45	1.08
Protected	1,888	229,365	121.49	66.22
Total	8,308	346,375.9	41.69	100

** Percentages based on total acreage*

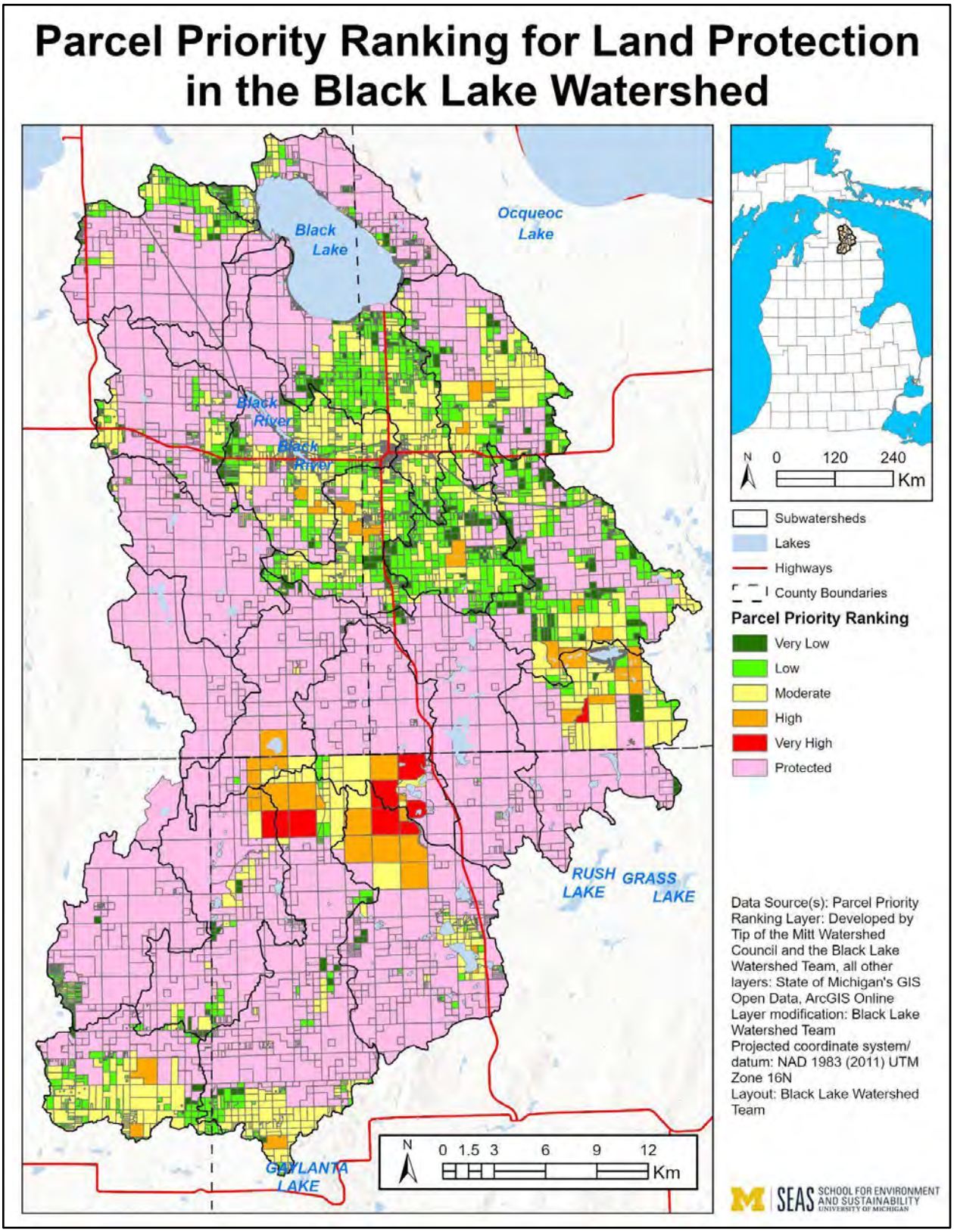


Figure 64. Ranking of priority parcels for land protection in the Black Lake Watershed

Much of the unprotected land is concentrated in the area surrounding Onaway below Black Lake and the parcels deemed very high priority are concentrated in the northern part of Montmorency County. All of the subwatersheds contained protected parcels, with Round Lake-Black River and Tomahawk Creek subwatersheds containing the most protected acreage, containing 22,426 and 20,078 acres respectively. These parcels account for 96% of the Round Lake-Black River subwatershed and 95% of the Tomahawk Creek subwatershed. McMasters Creek subwatershed has the highest percentage of protected acres; 100% of all acres in the subwatershed are protected (Figure 65).

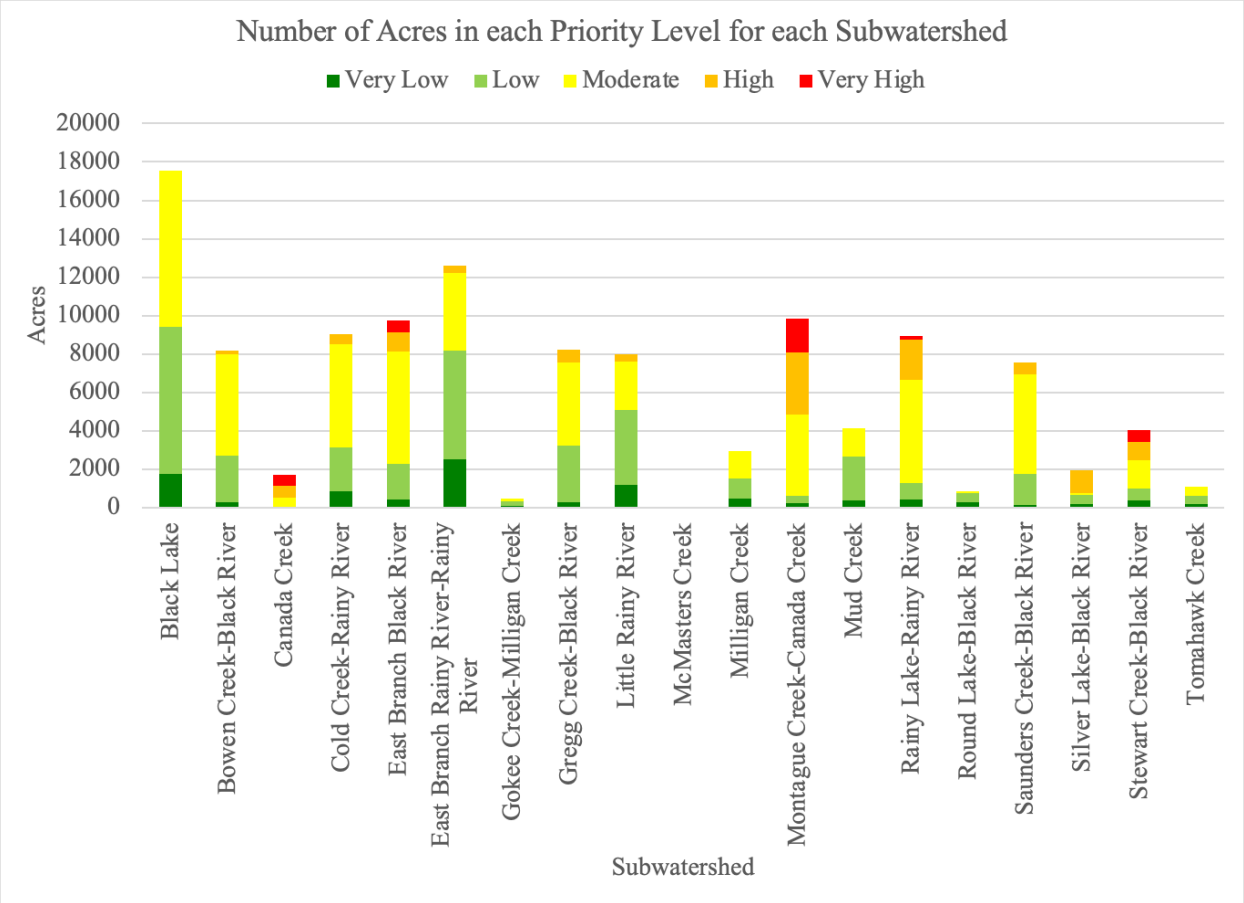


Figure 65. Total number of parcels in each priority level for all sub watersheds in the Black Lake Watershed.

Only 5 subwatersheds contained parcels deemed very high priority. Montague Creek-Canada Creek subwatershed had the highest number with four parcels containing 1,753 acres. East Branch Black River, Stewart Creek-Black River, Canada Creek, and Rainy Lake-Rainy River subwatersheds each contained one parcel with a very high priority level containing 637, 635, 560, and 154 acres respectively. This illustrates only a few areas within the watershed are highly vulnerable to land use changes.

A total of 1886 parcels are currently protected within the Watershed (Table 37). These protected lands are made up of a combination of state land (forests and parks), conservancy preserves, conservation easements, and local government parcels.

Table 37. Protected parcels by subwatershed

Subwatershed	Number of Protected Parcels	%
Black Lake Direct	568	30.11
Upper Black River	1,318	69.88
Total	1,886	

Table 38 illustrates the number of parcels in each ranking category by subwatershed. The analysis highlighted certain areas throughout the Watershed where land protection efforts would achieve the most gains for water resource protection.

Table 38. Parcels by priority

Priority for Protection	Black Lake Direct	%	Upper Black River	%
Very Low (1-6)	609	16.84	287	10.27
Low (7-11)	1824	50.43	1461	52.29
Moderate (12-22)	1167	32.26	1010	36.15
High (23-29)	16	0.44	29	1.038
Very High (30+)	1	0.03	7	0.25
Total	3617		2794	

Implementation tasks have been developed in direct response to the identified critical and priority areas within the watershed. These tasks translate assessment findings into clear, actionable steps that guide protection, restoration, and management efforts. By focusing on locations and issues where risks to water quality, habitat, and ecosystem function are greatest, the implementation tasks help ensure that limited resources are directed where they will have the most meaningful impact. These will be discussed further in chapter 8.

7. GOALS AND OBJECTIVES

Goals and objectives have been identified as part of the Black Lake Watershed Management Plan. Goals and objectives are based upon both the Watershed's natural resources needs, including protection and restoration, as well as the health, livelihoods, recreational needs, and industries of the people that live and visit the Watershed. Goals and Objectives were developed by the Watershed Advisory Committee. Goals are listed in no particular order.

Goals and Objectives

1. **Promote a culture of collaborative and comprehensive watershed protection and stewardship**
   - 1.1. Adopt a shared watershed protection framework or memorandum of understanding (MOU) among key jurisdictions to align actions and responsibilities.
   - 1.2. Facilitate regular meetings to align watershed protection priorities and actions.
   - 1.3. Integrate watershed priorities into local master plans, zoning ordinances, and capital improvement plans.
   - 1.4. Encourage public engagement and education on watershed issues and decision-making processes.
   - 1.5. Build a strong community culture of watershed stewardship by helping shoreline property owners understand their role and encouraging them to take voluntary action to protect the shoreline

2. **Protect and improve water quality to support ecological health and desired uses**
   - 2.1. Continue to implement regular water quality monitoring in tributaries and Black Lake
   - 2.2. Pass, strengthen and enforce local zoning ordinances to reduce impacts of development on water quality.
   - 2.3. Promote green infrastructure and low-impact development practices in new and existing developments.
   - 2.4. Support proper maintenance and upgrade of septic systems to prevent nutrient and pathogen pollution.

2.5. Reduce unnatural nutrient and sediment loading through implementation of nonpoint source best management practices (BMPs).

3. Protect and enhance recreational opportunities

3.1. Preserve the high-quality recreational opportunities that align with rural and natural aesthetics.

3.2. Provide information and technical assistance on land conservation tools, easements, and voluntary protection options.

3.3. Enhance trail access and year-round outdoor recreation in a way that complements natural resource conservation.

3.4. Protect and enhance recreational fishing opportunities

4. Maintain the watershed's rural character to support water quality protection

4.1. Improve protections and conservation of natural lands to retain the watershed's undeveloped character.

4.2. Promote and support land use management practices that limit impervious surfaces and preserve natural hydrology.

4.3. Educate shoreline property owners about the environmental impacts of shoreline hardening and promote natural shoreline alternatives to protect water quality and habitat.

4.4. Collaborate with counties and townships to develop and adopt greenbelt ordinances that discourage sod installation along shorelines and encourage the use of native vegetation buffers.

5. Prevent and manage the spread of aquatic and riparian invasive species

5.1. Monitor and manage invasive species populations that threaten aquatic ecosystems and native species.

5.2. Strengthen education and outreach to prevent new invasive species introductions through recreation and boating.

5.3. Collaborate with partners to implement rapid response strategies for newly detected invasive species.

5.4. Support boat wash stations and other infrastructure that reduces risk of introduction and spread.

6. Protect the health, habitat and safety of all watershed inhabitants

6.1. Prevent pathogen exposure from malfunctioning or failing septic systems, especially in recreational and residential areas.

6.2. Create an outreach campaign about harmful algal blooms (HABs).

6.3. Promote septic system upgrades and management practices that minimize phosphorus discharges to lakes and tributaries.

6.4. Conduct public health outreach to residents and visitors about septic maintenance.

6.5. Protect and improve cold water fishery habitat in the Upper Black River and its tributaries

Information and Education Goals and Objectives

7. **Make Watershed Stewardship Accessible for Everyone**

7.1 Help all residents, no matter their background or property type, get the knowledge, tools, and support they need to take meaningful action to protect water quality.

8. **Build Trust and a Sense of Shared Responsibility**

8.1 Strengthen confidence in local watershed leaders while encouraging a community-wide ethic of stewardship, so residents feel empowered to work together to care for water resources.

8. IMPLEMENTATION STEPS

Overview of Implementation Tasks and Actions

The Black Lake Watershed Management Plan Advisory Committee seeks an integrative approach to reduce existing sources of nonpoint source pollution and prevent future contributions. Effective watershed management must rely upon an integrative approach that includes:

1) Best management practices (BMPs)

2) Partnerships, community consensus building, and work with local governments,

3) Information and education components

The recommended implementation tasks and actions represent the best management practices and initiatives identified by the Advisory Committee as being the most critical for water quality protection within the Watershed.

Proposed Best Management Practices

Best management practices, or BMPs, are techniques, measures, or structural controls designed to minimize or eliminate runoff and pollutants from entering surface and ground waters. Non-structural BMPs are preventative actions that involve management and source controls. These include policies and ordinances that provide requirements and standards to direct growth of identified areas, protection of sensitive areas such as wetlands and riparian areas, and maintaining and/or increasing open space. Other examples include providing buffers along sensitive water bodies, limiting impervious surfaces, and minimizing disturbance of soils and vegetation. Additional non-structural BMPs can be education programs for homeowners, students, businesses, developers, and local officials about everyday actions that protect water quality. Educational efforts are expounded upon in the Information and Education Strategy.

Structural BMPs are physical systems that are constructed to reduce the impact of development and stormwater on water quality. They can include stormwater facilities such as stormwater wetlands; filtration practices such as grassed swales and filter strips; and infiltration practices such as bioretention areas and infiltration trenches.

Structural and non-structural BMPs will be used in combination in the Watershed to obtain the maximum reduction or elimination of NPS pollutants. BMPs should be selected according to their potential to reduce the targeted NPS pollutant, as well as budget, maintenance requirements, available space, and other factors. Some examples of possible BMPs for the most common sources of nonpoint source pollutants are

listed in Table 39. Specific BMP recommendations for the Watershed are located in the Implementation Tasks (Table 43).

Table 39. Structural and nonstructural best management practices (BMPs) (EPA 2008)

	Structural Practices	Nonstructural Practices
Agriculture	Contour buffer strips Grassed waterway Herbaceous wind barriers Mulching Live fascines Live staking Livestock exclusion fence Revetments Riprap Sediment basins Terraces Waste treatment lagoons	Brush management Conservation coverage Conservation tillage Educational materials Erosion and sediment control plan Nutrient management plan Pesticide management Prescribed grazing Residue management Requirement for minimum riparian buffer Rotational grazing Workshops/training for developing nutrient management plans
Forestry	Broad-based dips Culverts Establishment of riparian buffer Mulching Revegetation of fire lines with adapted herbaceous species Temporary cover crops Windrows	Education campaign on forestry-related NPS control Erosion and sediment control plans Forest chemical management Fire management Operation of planting machines along the contour to avoid ditch formation Planning and proper road layout and design Preharvest planning Training loggers and landowners about forest management practices, forest ecology, etc.
Urban	Bioretention cells Breakwaters Brush layering Infiltration basins Green roofs Live fascines Marsh creation/restoration Establishment of riparian buffers Riprap Stormwater ponds Sand filters Sediment basins Tree revetments Vegetated gabions Water quality swales	Planning for disconnection of impervious surface (e.g., eliminating or reducing curb and gutter) Educational materials Erosion and sediment control plan Fertilizer management Ordinances Pet waste programs Pollution prevention plans No-wake zones Setbacks Workshops on proper installation of structural BMPs Zoning overlay districts

Note: Practices listed under one land use category can be applied in other land use settings.

BMP Effectiveness

The actual effectiveness or efficiency of a BMP is determined by the size of the BMP implemented (e.g., feet of vegetated buffer or acres of stormwater detention ponds), and how much pollution was initially coming from the source. Table 40 (Huron River Watershed Council, 2003) lists estimates of pollutant removal efficiencies for stormwater BMPs that may be used in the Watershed.

Information regarding pollutant removal efficiency, designs of BMPs, and costs are continually evolving and improving. As a result, it is critical to research the latest technologies, design, and methodologies before implementing BMPs within the Watershed.

Table 40. Pollutant Removal Efficiencies of Stormwater BMPs

Pollutant Removal Efficiencies						
Management Practice	Total Phosphorus (%)	Total Nitrogen (%)	TSS (%)	Metals (%)	Bacteria (%)	Oil & Grease (%)
High-powered street sweeping	30-90		45-90			
Riparian buffers: Forested: 20-40 m width, Grass: 4-9 m width	Forested: 23-42; Grass: 39-78	Forested: 85; Grass: 17-99	Grass: 63-89			
Vegetated roofs	70-100 runoff reduction, 40-50 of snow/rainfall. 60 temperature reduction. Structural addition of plants over a traditional roof system.					
Vegetated filter strips: 7.5m length, 45m length	40-80	20-80	40-90			
Bioretention	65-98	49	81	51-71	90	
Wet extended detention pond	48-90	31-90	50-99	29-73	38-100	66
Constructed wetland	39-83	56	69	(-80)-63	76	
Infiltration trench	50-100	42-100	50-100			
Infiltration basin	60-100	50-100	50-100	85-90	90	
Grassed swales	15-77	15-45	65-95	14-71	(-50) -(-25)	
Catch basin inlet devices		30-40 sand filter	30-90			
Sand and organic filter	41-84	22-54	63-109	26-100	(-23)-98	
Soil stabilization on construction sites			80-90			
Sediment basins or traps at construction sites			65			
Porous pavement	65	80-85	82-95	98-99		

Information and Education Strategy

Effective watershed protection is most successful when I/E efforts are incorporated into watershed management planning. The I/E Strategy reflects the various watershed audiences and the potential means of informing and educating. The following groups have been identified as the key audiences in which the I/E Strategy is based.

Component 1: General Watershed Community

General watershed protection and resource information should continue to be developed and disseminated through print and social media, websites, and educational events. Information should be general in nature with the following topic areas of focus:

- Water resources and water quality of the Watershed
- Stormwater: what is it, how it affects water quality, and how to manage it
- Cultivating the next generation of watershed stewards
- Boater education: clean boating practices

Component 2: Riparian Education

Riparian owners play an enormous role in watershed protection. Many riparian owners, however, remain unaware of the connection between water quality and riparian management. Focus areas should include what role riparian owners play in resource protection. The Michigan Shoreland Stewards program, an education and outreach component of the Michigan Natural Shoreline Partnership, is a valuable resource that applies to all lakes within the state. Promotion of this program, along with other local initiatives, is key in order to increase awareness of stewardship opportunities. In addition to shoreline management, efforts to increase awareness of aquatic invasive species should be emphasized among riparian owners. Riparian owners should have adequate access to current invasive species information, including identification, current range/distribution, modes of spread, best management practices, and reporting tools such as the Midwest Invasive Species Information Network (MISIN).

Component 3: Targeted Engagement

Efforts to identify, address, and engage with targeted groups should be at the forefront. Examples of these types of targeted groups include private property owners or homeowner associations known to have:

- A small dam
- A particularly threatening invasive species
- Suspected septic system issues
- Other groups may include agricultural producers/farmers, local government officials, septic haulers, engineers, road commissions, and others to encourage best management practices where they are lacking.

Component 4: Black Lake Watershed Advisory Committee

There are many watershed stakeholders given the area of the Watershed. They include local governments, resource agencies, nonprofits, lake associations, and others. Although not unique to this watershed, many of the groups and agencies have overlapping service areas and services. As more watershed protection projects are implemented, it is critical that information is shared among stakeholders to prevent

duplication, assist with prioritization of watershed needs, pool resources, and leverage future opportunities. In order to maintain this important connectivity, the Black Lake Watershed Advisory Committee will continue to meet throughout the year. New committee members should be recruited, particularly from groups that have yet to be represented or those that may have a vested interest in a project.

Implementation Tasks

The following implementation task table (Table 43) includes a comprehensive list of proposed tasks and actions that, if implemented, will result in water quality protection or improvements. Tasks and actions are organized by category to facilitate easy reference. The recommendations are based on a 10-year timeline (2026-2035), a standard duration of time for a watershed management plan. Each task and action identify the following:

Priority Level: Each task and action has been assigned a priority level based on one or more of the following factors:

- Urgency to correct or reduce an existing problem
- Need to enact a specific task or action before a problem develops
- Availability of funds, partner(s), or program(s) ready to implement
- Overall need to balance low, medium, and high priorities over the course of ten years

Unit Cost/Total Cost estimate: An estimated unit cost is provided when applicable. An estimated total cost is provided when applicable and calculable (Table 42).

Milestones: Milestone(s) are identified, when possible, to establish an interim, measurable benchmark for determining progress of a specific task or action.

Timeline: Based on the ten-year span of the Watershed Management Plan, tasks fall into short-term (1-2 years), mid-term (3-5 years), and long-term (5-10 years). When a task or action is ongoing, it is noted as spanning the ten years.

Potential Partners: The potential partners specified are those who have the interest or capacity to implement the task or action (Table 41). They are not obligated to fulfill the task or action. It is expected that they will consider pursuing funds to implement the task or action, work with other identified potential partners, and communicate any progress with the Black Lake Watershed Advisory Committee.

Table 41. Watershed Partners

Watershed Partners	Abbreviation
Tip of the Mitt Watershed Council	TOMWC
Cheboygan/Presque Isle/ Montmorency County Planning & Zoning	Local Government
Cheboygan/Presque Isle/ Montmorency County Road Commission	Road Commissions
Huron Pines	HP
Little Traverse Bay Bands of Odawa Indians	LTBB
Little Traverse Conservancy	LTC

Michigan Department of Environment, Great Lakes, and Energy	EGLE
Michigan Department of Natural Resources	MDNR
Lake Associations and Friends Groups	LA
Local Business	LB
Tribal Government	TG
Michigan Natural Shoreline Partnership	MNSP

Potential Funding Sources: Potential funding sources for each task or action include, but are not limited to:

- Private foundation (PF)
- State grant (SG)
- Federal grant (FG)
- Local government (LG)
- Partner organization (PO)
- Private cost-share (CS)
- Local businesses (LB)

Objectives & Information and Education Objectives Addressed: Each task and action support one or more of the objectives in Chapter 7.

Table 42. Cost estimate by category

Category	Category Total
Water Quality	$311,000.00
Wetlands	$1,325,000.00
Shoreline Protection	$579,000.00
Planning & Zoning	$240,500.00
Land Use	$86,000.00
Road Stream Crossings	$4,045,000.00
Land Protection	$1,232,500.00
Ecosystem Health	$1,075,000.00
Recreation & Human Health	$133,000.00
Hydrology & Groundwater	$63,000.00
Threatened & Endangered Species	$1,500,000.00
Invasive Species	$681,000.00
Septic Systems	$1,095,000.00
Emerging Threats	$450,000.00
Total	**$12,816,000.00**

Table 43. Implementation Tasks

Code	Task	Estimated Cost	Status	Milestone	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Notes
WQ.1	Continue surface water quality monitoring conducted by various agencies, governments, and academic institutions according to their respective programs.	$200,000	High	Ongoing	TOMWC, EGLE, LA	SG, FG, LP	2.1	Various groups monitor according to their individual protocols and monitoring strategy. Data should be made available to the Advisory Committee.
WQ.2	Continue implementing Comprehensive Water Quality Monitoring (CWQM) program every 3 years on Black Lake.	$5,000	High	Ongoing	TOMWC	PF, LP	2.1	TOMWC conducts monitoring, along with entities. Data should be made available to the Advisory Committee.
WQ.3	Continue implementing TOMWC's Volunteer Stream Monitoring (VSM) program and expand to include the two additional tributaries.	$15,000	High	Ongoing	BLPS, TOMWC	SG, PF, LP	2.1	Recruit and maintain new VSM team for two new creeks by year 2; monitor new streams and all currently monitored streams annually.
WQ.4	Continue implementing TOMWC Volunteer Lake Monitoring (VLM) program on Black Lake.	$5,000	High	Ongoing	BLPS, LA	PF, LP	2.1	Recruit and maintain new VLM; monitor annually for 10 years.
WQ.5	Expand monitoring parameters (e.g. PAHs, pharmaceuticals) to address newly emerging water quality threats.	$15,000	Medium	2028-2030, 2031-2035	TOMWC, EGLE, LA	SG, PF, FG	2.1	
WQ.6	Conduct annual water quality and discharge monitoring of all major and minor tributaries to assess the impacts of individual tributaries to Black Lake.	$25,000	High	2026-2027, 2028-2030	TOMWC, EGLE, LA	PF, SG, FG, LP	2.1	Need to be tracked with increasing HABs occurrences data collected to date has several gaps. Specifically, Rainy River had TP exceedances
WQ.7	Monitor total phosphorus on Black Lake throughout the water column during spring, summer, fall.	$2,000	Medium	2026-2027, 2028-2030	LA, TOMWC	PF, SG	2.1	To fill in data gaps
WQ.8	Monitor total phosphorus on Black River throughout spring, summer, fall.	$2,000	Medium	2026-2027, 2028-2030	TOMWC, LA	PF, SG	2.1	To fill in data gaps
WQ.9	Expand as necessary the study of algae in lakes. Provide shoreline property information on the algae and its management.	$25,000	Medium	2026-2027	EGLE, TOMWC, LA	PF, SG, FG, LP	2.1	
WQ.10	Continue the Fish Contaminant Monitoring program in lakes previously monitored and not monitored to date. Continue to report results via the program's online database.	$8,000	Low	Ongoing	EGLE	SG	2.1	
WQ.11	Determine the effectiveness of water quality protection efforts achieved through watershed management plan implementation by using the criteria set forth in the Evaluation Strategy.	$4,000	Low	2031-2035	TOMWC	SG, FG	2.1	
WQ.12	Monitor chloride on Stewart Creek to determine potential source.	$5,000	Medium	2026-2027	TOMWC, EGLE, LA	PF, SG, FG, LP	2.1	
WL.1	Continue to review EGLE Part 303 Wetland Permit Applications to evaluate proposed wetland impacts.	$25,000	High	Ongoing	TOMWC, EGLE	PF, SG	4.2, 1.4	
WL.2	Restore wetlands in critical areas.	$300,000	Low	2031-2035	TOMWC, HP, EGLE, DNR	SG, FG, LP, PF	4.1	Submit comments to EGLE regarding anticipated wetland impacts when appropriate and work with applicants to minimize impacts.
WL.3	Protect wetlands in priority areas.	$1,000,000	High	2028-2030, 2031-2035	LTC	PF, SG, FG, LP	3.2, 4.1	guided by landscape level wetland functional analysis
SP.1	Implement shoreline best management practices (BMPs) on moderate and severe shoreline erosion sites on Black Lake in conjunction with property owner outreach.	$100,000	High	2026-2027	TOMWC, EGLE, LA, MNSP	PF, SG, FG, LP	1.5, 3.2, 4.2, 4.3	Targeting 15 parcels for shoreline improvements.
SP.2	Implement best management practices (BMPs) on moderate and severe shoreline erosion sites on impoundments in conjunction with property owner outreach	$40,000	Low	2031-2035	TOMWC, EGLE, MNSP	PF, SG, FG, LP	3.2, 4.2, 4.3, 7.1	

SP.3	Restore severe streambank erosion sites as identified in the plan.	$75,000	Medium	2028-2030	TOMWC, EGLE, DNR, HP	SG, FG	6.5	
SP.4	Engage property owners and assist them with site assessments as well as coordination on greenbelt development and improvement projects promoting the use of native plants.	$20,000	High	Ongoing	TOMWC, LA, EGLE, DNR, MNSP	SG, FG	1.5, 3.2, 4.3	
SP.5	Provide riparian property owners with assistance and resources as they relate to shoreline and streambank management.	$15,000	High	Ongoing	BLPS, MNSP		3.2, 4.3, 7.1, 8.1	Publications, websites, workshops, and on-site assessments
SP.6	Continue to review all relevant EGLE/USACE Joint Permit Applications to evaluate proposed impacts.	$25,000	High	Ongoing	TOMWC, EGLE	PF, LP	4.1	Submit comments to agencies regarding anticipated impacts when appropriate and work with applicants to minimize impacts.
SP.7	Promote the Michigan Shoreland Stewards (Michigan Natural Shoreline Partnership program).	$10,000	High	Ongoing	BLPS, TOMWC, EGLE, LA, DNR, HP, MNSP	LP	1.5, 3.2, 4.2, 7.1, 8.1	
SP.8	Promote the use of Certified Natural Shoreline Professionals (Michigan Natural Shoreline Partnership program) to riparian owners for bioengineering projects.	$5,000	High	Ongoing	BLPS, MNSP	LP	1.5, 3.2, 4.2, 7.1, 8.1	
SP.9	Repeat streambank inventories on Black River.	$30,000	Low	2031-2035	TOMWC	SG, FG	6.5	
SP.10	Repeat shoreline survey on Black Lake and conduct post-shoreline survey outreach with riparian owners	$25,000	Medium	2031-2035	BLPS, TOMWC, EGLE, LA	SG, FG, LP	7.1, 1.5, 3.2, 4.2, 8.1	
SP.11	Develop outreach materials and presentations on river and stream best management practices for riparian owners	$40,000	Low	2031-2035	TOMWC, EGLE, HP	SG, PF	1.5, 4.2, 7.1, 8.1	
SP.12	Develop and implement cost/share greenbelt program(s) on lakes, including demonstration sites	$50,000	High	2028-2030, 2031-2035	TOMWC, EGLE, LA	PF, SG, CS	1.5, 3.2, 4.3	
SP.13	Establish no-mow zones and native vegetation in public spaces	$4,000	Medium	2031-2035	TOMWC, LA, LG	LP	1.5, 4.1	
SP.14	Establish tree cover on Stoney and Rainy Creeks to reduce temperature.	$20,000	Medium	2028-2030	TOMWC, EGLE, DNR, LA, HP	PF, SG, LP	3.4	
SP.15	Restore flow on Milligan and Stoney Creeks to reduce temperature and low dissolved oxygen.	$20,000	Medium	2028-2030	TOMWC, EGLE, DNR, HP	SG, FG	3.4	
SP.16	Address erosion at Black Lake State Forest Campground lake access road.	$20,000	High	2028-2030	TOMWC, EGLE, DNR	SG, LG	2.5	
SP.17	Address erosion at Onaway State Park pavilion using BMP's.	$20,000	Medium	2028-2030	DNR, TOMWC, EGLE	PF, SG, LP	2.5	
SP.18	Remove seawalls where feasible and restore shoreline with bioengineering techniques	$60,000	High	2028-2030, 2031-2035	TOMWC, EGLE, LA	SG, FG	2.5	
SW.1	Conduct an impervious surface study of the Village of Onaway.	$6,000	Low	2031-2035	TOMWC	SG	2.3, 2.5	
SW.2	Implement GSI practices where feasible to reduce stormwater impacts.	$50,000	Low	2031-2035	TOMWC, EGLE	SG, FG	2.3, 2.5	
PZ.1	Participate in county township and municipal master planning processes to integrate water resource protection policies	$40,000	Medium	2026-2027	TOMWC	LG, SG	1.3, 2.2	Incorporate the EGLE/EPA-approved Watershed Plan
PZ.2	Utilize model zoning standards and the Cheboygan County Gaps Analysis (2014) to strengthen local water quality protections	$50,000	Medium	2028-2030	TOMWC, LA, LG	PF, SG	2.2	
PZ.3	Create and implement an educational campaign promoting natural shorelines and water quality protection to gain public support for adoption of ordinances	$10,000	High	2031-2035	TOMWC	LG, LP, SG	2.2, 7.1, 4.4, 8.1	

PZ.4	Improve public access to county and township planning zoning and ordinance documents	$3,000	Low	2031-2035	TOMWC	LG, LP, SG	2.2	
PZ.5	Utilize site plan checklists and local technical expertise to review development proposals for water quality protections	$15,000	Medium	2028-2030, 2031-2035	TOMWC, LA, LG	PF, LP, LG, SG	2.2	
PZ.6	Enact or strengthen shoreline protection standards including greenbelt and buffer ordinances of at least 25 ft	$50,000	High	2026-2027, 2028-2030, 2031-2035	BLPS, TOMWC, LA	LP, LG, SG	2.2	
PZ.7	Limit impervious surfaces through zoning permitting and site plan review requirements	$2,500	Medium	Ongoing	TOMWC, LG	LP, LG, SG	1.3	
PZ.8	Require wetland identification and mapping and ensure state wetland permits are issued prior to local zoning approval	$5,000	Low	2031-2035	TOMWC, LG	LP, LG, SG	2.2, 1.4	
PZ.9	Adopt or update stormwater and soil erosion ordinances including pre-winter erosion control planning	$5,000	High	2026-2027	TOMWC, LG	LG, LP, SG	2.2	
PZ.10	Work with counties and townships to adopt local septic inspection and maintenance regulations	$20,000	High	2028-2030	TOMWC, LA, LG	LP, LG, SG	2.2, 6.1	Time-of-transfer; mandatory pumping/inspection, and/or; short-term rentals
PZ.11	Update and implement comprehensive county and township master plans with long term water resource protection frameworks	$5,000	Low	2031-2035	TOMWC, LG	LG, LP, SG	2.2	
PZ.12	Establish drainage and special assessment districts including the Black Lake area to fund stormwater and BMP maintenance	$10,000	Medium	2031-2035	TOMWC, LG	LG, LP, SG	2.2, 4.4	
PZ.13	Adopt county or township zoning ordinances where none exist to ensure consistent water quality protections	$10,000	High	2028-2030	TOMWC, LG	LG, LP, SG	2.2	
PZ.14	Require groundwater protection measures for high impact land uses including mining operations	$15,000	Medium	2028-2030	TOMWC, LG	SG, LG, LP	2.2	
LU.1	Implement agricultural BMPs in designated critical areas.	$50,000	Medium	2031-2035	CD	SG, LG	2.5	
LU.2	Promote MAEAP and other BMP programs to agricultural producers.	$10,000	Low	Ongoing	CD	SG, LG	7.1, 8.1	
LU.3	Promote forestry best management practices to practitioners.	$5,000	Low	Ongoing	DNR, CD	SG	7.1, 8.1	
LU.4	Enroll private property owners in Forest Management programs	$2,000	Low	Ongoing	DNR, CD	SG	3.1, 1.5	State of Michigan's Forest Stewardship Program or Natural Resource Conservation Service's Environmental Quality Incentives Program
LU.5	Provide comments that protect and/or increase designation of MDNR Forestry Riparian Management Zones to ensure greater water quality protection.	$1,000	Low	Ongoing	TOMWC, LA	SG, LP	3.1, 1.4	
LU.6	Review and provide comment on DNR State Forest Management Plan	$1,000	Medium	2026-2027	TOMWC, LA, HP	LP	3.1, 1.4	
LU.7	Conduct agricultural ground truthing surveys in the Rainy River subwatershed	$15,000	Low	2031-2035	TOMWC	SG	2.5	
LU.8	Collaborate with local conservation districts to actively promote and assist landowners in enrolling in programs that support best management practices.	$2,000	Low	Ongoing	CD, LTC	LP	1.5, 7.1	Cheboygan, Presque Isle, Montmorency, and Otsego; Great Lakes Restoration Initiative (GLRI) and Regional Conservation Partnership Program (RCPP) through NRCS, the Conservation Reserve Program (CRP) and Conservation Reserve Enhancement Program (CREP) through the USDA Farm Service Agency, and the Michigan Agriculture Environmental Assurance Program (MAEAP) through MDARD.

RX.1	Implement priority RSX projects for improved hydrology, erosion control, and fish passage in the Black Lake Direct Watershed	$1,500,000	Medium	2028-2030	RC, HP, TOMWC, EGLE, DNR	PF, SG, FG, LP	2.5, 3.4, 6.5	Pollutant load reductions would correspond to the pollutant loading summarized in the Resource Inventory chapter for each site, or as identified on https://great-lakes-stream-crossing-inventory-michigan.hub.arcgis.com/
RX.2	Implement priority RSX projects for improved hydrology, erosion control, climate adaptation, road safety, and fish passage in the Black River Watershed	$1,500,000	Medium	2028-2030	RC, HP, TOMWC, EGLE, DNR	PF, SG, FG, LP	2.5, 3.4, 6.5	Pollutant load reductions would correspond to the pollutant loading summarized in the Resource Inventory chapter for each site, or as identified on https://great-lakes-stream-crossing-inventory-michigan.hub.arcgis.com/
RX.3	Address moderate severity RSX throughout the Watershed as resources become available.	$500,000	Medium	2031-2035	RC, HP, TOMWC, EGLE, DNR	PF, SG, FG, LP	2.5, 3.4, 6.5	Pollutant load reductions would correspond to the pollutant loading summarized in the Resource Inventory chapter for each site, or as identified on https://great-lakes-stream-crossing-inventory-michigan.hub.arcgis.com/
RX.4	Repeat road stream crossing inventory every 5-10 years to determine if priorities are the same, and to document newly installed BMPs or improvements.	$15,000	Low	2031-2035	TOMWC, HP	PF, SG	2.5, 3.4, 6.5	
RX.5	Conduct an engineering alternatives study on Tower and Kleber dams to determine the best management approach for the ecosystem benefit and function.	$80,000	Medium	2026-2027	DNR, TG, TOMWC	PF, SG, FG	2.5, 3.4, 6.5	
RX.6	Support efforts for the future management and/or removal of Tower and Kleber dams.	$150,000	Medium	Ongoing	TOMWC, DNR, HP	PF, SG, FG, LP	2.5, 3.4, 6.5	
RX.7	Address minor severity RSX throughout the Watershed as resources become available.	$200,000	Low	2031-2035	TOMWC, HP, EGLE, DNR	PF, SG, FG, LP, LG	2.5, 3.4, 6.5	
RX.8	Address sedimentation concerns at segments of the Black River.	$100,000	Medium	2028-2030	TOMWC, HP, DNR	PF, SG	2.5, 3.4, 6.5	
LP.1	Permanently protect 1500 acres or more of high and very high priority parcels throughout the Watershed	$1,200,000	High	2026-2027	LTC, HP	PF, SG, FG, LP	3.1, 3.2, 3.3	
LP.2	Educate landowners on land protection options	$2,500	High	Ongoing	BLPS, LTC	LP	3.1, 3.2, 3.3, 7.1	
LP.3	Continue to work with MDNR on potential assist and transfer projects on priority sensitive lands in the Watershed.	$20,000	Low	2031-2035	HP, LTC	LP, SG	3.1, 3.2, 3.3	
LP.4	Repeat priority parcel process (PPP) for the entire Watershed to identify additional priority parcels.	$5,000	Low	2031-2035	TOMWC	SG, LP	3.1, 3.2, 3.3	
LP.5	Visit high and very high priority parcels to determine feasibility of protection, giving priority to large parcels near Montague Creek, Canada Creek and East Branch Black River	$5,000	Low	2028-2030	BLPS, LTC	LP	3.1, 3.2, 3.3	
EH.1	Protect and restore critical habitat within the Watershed's priority areas that currently support, or have the potential to support, robust populations of native fish species (e.g. brook trout).	$800,000	Medium	2031-2035	DNR, HP, TOMWC	PF, SG, FG	2.5, 3.4, 6.5	
EH.2	Compile known information about small dams within the Watershed.	$5,000	Low	2031-2035	TOMWC, HP	PF, SG	2.5, 3.4, 6.5	Remotely gather additional information to fill in gaps. Prioritize field assessments and work to meet with property owners to discuss options.
EH.3	Develop and implement outreach and education strategy targeting owners of priority small dams.	$10,000	Low	2031-2035	TOMWC, HP	LP, PF	2.5, 3.4, 6.5	Focus on ecosystem impacts, dam removal options, and available assistance.
EH.4	Remove priority small dams throughout the Watershed where ecosystem benefits outweigh dam utility.	$1,000,000	Low	2031-2035	TOMWC, HP	LP, PF, SG, FG	2.5, 3.4, 6.5	

EH.5	Remove beaver dams negatively impacting water quality and flow on Stony Creek.	$60,000	Medium	2028-2030	TOMWC, DNR, HP	PF, SG, LP	2.5, 3.4, 6.5	
RH.1	Monitor public beaches annually for potential health hazards, report advisories and beach closings via Beachguard.	$60,000	Low	Ongoing	LG, DNR, HD	LG, SG	5.1	
RH.2	Implement stormwater and erosion control BMPs at boat launches and other access points where water quality impacts are noted.	$60,000	Medium	2028-2030	TOMWC, EGLE, DNR	SG, FG, LP	2.5	
RH.3	Promote clean boating practices and state boating regulations at marinas, boat launches, fishing tournaments, events and other public venues.	$5,000	Low	Ongoing	BLPS, LA, TOMWC, DNR, EGLE	SG, LP	5.4, 7.1, 5.2	
RH.4	Provide information and feedback to local and state governments regarding their recreational planning efforts that may impact the Watershed	$3,000	Low	Ongoing	TOMWC, HP	LP	1.4, 2.2	
RH.5	Provide comments to DNR on trails or public access sites where potential to impact water resources is high.	$5,000	Low	Ongoing	TOMWC, HP	LP	1.4, 3.1, 3.3	
HG.1	Compile all existing groundwater information, identify potential problems, determine data gaps, and develop a strategy for long-term monitoring.	$5,000	Low	2031-2035	TOMWC, EGLE, LG	SG, FG	2.1	
HG.2	Monitor groundwater based on strategy (HG.1).	$15,000	Low	2031-2035	TOMWC, LG	SG, FG, LP	2.1	
HG.3	Implement Wellhead Protection Programs (WHPP) in communities where greater protection of groundwater is critical to safeguard against drinking water contamination.	$40,000	Low	2031-2035	LG, EGLE, TOMWC	SG, LG, LP	2.1	
HG.4	Assess changes (net gain or loss) in permanently protected lands in areas with high groundwater recharge rates	$3,000	Low	2031-2035	TOMWC, EGLE, LG	SG, LP	2.1	
TE.1	Protect and restore habitat for state threatened Lake Sturgeon	$1,000,000	High	2028-2030	TOMWC, EGLE, DNR, HP	SG, FG	2.5, 3.4, 6.5	
TE.2	Protect and restore habitat for federally endangered Hungerford's Crawling Water Beetle	$500,000	Medium	2028-2030	TOMWC, HP	SG, FG	2.5, 3.4, 6.5	
IS.1	Implement on-the-ground management projects to stop the introduction, spread, and distribution of priority invasive species within the Watershed.	$300,000	High	2026-2027	BLPS, TOMWC, EGLE, DNR, HP, CD	SG, FG, LP	5.1, 5.3, 5.4	
IS.2	Create an invasive species management plan for Black Lake	$25,000	Medium	2026-2027	TOMWC, LA, BLPS			
IS.3	Monitor the Watershed and implement Early Detection and Rapid Response (EDRR) for aquatic species that pose an imminent threat.	$20,000	High	Ongoing	BLPS, TOMWC, EGLE, HP, CD	SG, FG, LP	5.1	
IS.4	Report introductions and spread of invasive species to MISIN (Midwest Invasive Species Network) website.	$20,000	Low	Ongoing	TOMWC, HP, LA	LP	5.1	
IS.5	Install permanent or access mobile boat cleaning stations for use at public boat launches.	$100,000	Medium	2028-2030, 2031-2035	TOMWC, DNR, LA	PF, LP, SG, FG, LG	5.4	
IS.6	Monitor and manage aquatic and riparian invasive species throughout the Watershed with biological control agent.	$25,000	Medium	Ongoing	LA, TOMWC, HP, CD	PF, LP, LG	5.1	
IS.7	Continue integrating aquatic invasive species training into Volunteer Stream and Lake Monitoring programs.	$10,000	Medium	Ongoing	TOMWC	LP	5.1	
IS.8	Provide property owners with assistance and resources with invasive species management through site assessments, distribution of resources, and other outreach.	$50,000	Medium	Ongoing	BLPS, TOMWC, HP	LP, SG	5.2	

IS.9	Participate in CLMP's Exotic Aquatic Plant Watch	$1,000	Medium	2026-2027	TOMWC, LA	SG	5.1	
IS.10	Install signage at water access locations that highlight Clean Boats, Clean Waters program and message.	$3,000	Medium	2026-2027	TOMWC, LA, DNR	SG	5.2	
IS.11	Monitor forestry invasive species that could impact riparian areas and water quality	$100,000	Low	2028-2030	HP, CD	SG, FG	5.1	
IS.12	Advocate for stronger invasive species management to prevent further habitat degradation	$5,000	High	Ongoing	TOMWC, HP	LP	5.1	
IS.13	Create a volunteer corps for invasive species removal	$15,000	Low	2031-2035	TOMWC, LA, HP	SG, LP	5.1, 5.3	
IS.14	Release *Galerucella* beetles in high priority habitat areas to manage the spread and impact of purple loosestrife.	$5,000	Low	Ongoing	TOMWC, LA, HP	PF, LP	5.1	
IS.15	Enforce Clean, Drain, Dry at public boat launches	$2,000	High	Ongoing	DNR	LP	5.2	
SS.1	Conduct soluble phosphorus bacterial monitoring (E. coli and Total Coliform) of nearshore areas and shallow groundwater to assess septic system discharges	$80,000	High	2026-2027	BLPS, TOMWC, EGLE, KA, HD, LA	LP, PF, SG, FG	6.1, 2.1	
SS.2	Develop septic system outreach campaign for homeowners	$75,000	High	2026-2027	BLPS, TOMWC, EGLE, KA	LP, PF, SG	4.3, 6.4, 7.1, 8.1	
SS.3	Incentivize community pumping and/or inspections	$10,000	High	2026-2027	BLPS, LA	LP, CS	2.4, 4.3, 6.1, 6.3, 6.4	
SS.4	Conduct a preliminary sewer feasibility study	$20,000	Medium	2028-2030	BLPS, KA, LG	LP, SG	2.4, 4.3, 6.1, 6.3, 6.4	
SS.5	Determine the economic cost of water pollution due to septic failure	$5,000	Low	2031-2035	BLPS, TOMWC	LP	4.3, 6.4	Include incentives to/for taking steps to ensure their systems are properly functioning
SS.6	Digitize septic system records	$50,000	Medium	2028-2030	LG, TOMWC, HD	PF, SG	2.4	
SS.7	Septic System Treatment Pilot Options for Near-term Mitigation of Soluble P and Bacterial Water Quality impacts to nearshore areas of Black Lake	$60,000	High	2026-2027	TOMWC, LA, BLPS, KA, EGLE, HD	PF, SG, CS, LP	2.1, 6.1	
SS.8	Pilot Options for Mid- to Long-term Septic System Alternatives to Mitigate P and E. coli loading to Black Lake	$750,000	High	2026-2027, 2028-2030, 2031-2035	TOMWC, EGLE, LA, BLPS, KA, HD	PF, SG, CS, LP	2.1, 6.1	
SS.9	Host hands-on septic workshops: "How to maintain your septic system" – include inspection demos.	$5,000	High	2028-2030	BLPS, TOMWC, EGLE, HD, PB	LP, PF, SG, LG	4.3, 6.4	
SS.10	Create or expand financial support programs for septic maintenance and proper sizing, especially for the broader rural population.	$30,000	Medium	2028-2030	EGLE	SG	2.4, 4.3, 6.1, 6.3, 6.4	
SS.11	On-line Voluntary Septic System Homeowner Volunteer Data Submission	$10,000	Medium	2026-2027	BLPS, KA	PF	1.4, 4.3, 6.4	
ET.1	Advocate for short-term measures that will minimize risks of an oil leak from the Line 5 pipeline.	$10,000	Low	2031-2035	TOMWC	LP, PF	1.4, 4.1	Using information from the state Pipeline Advisory Board, educate partners and local citizens regarding potential long-term solutions, including decommissioning.
ET.2	Mitigate climate change impacts by protecting and restoring vulnerable areas and implementing best management practices throughout the Watershed.	$200,000	Medium	2028-2030, 2031-2035	TOMWC, EGLE, HP, LA	PF, SG, FG, LP	2.5	
ET.3	Conduct watershed outreach with local schools.	$30,000	High	Ongoing	TOMWC	PF, SG, FG, LP	7.1, 8.1	

ET.4	Conduct environmental outreach at local events	$3,000	Medium	Ongoing	TOMWC, LA, EGLE, DNR, HP, LTC	PF, LP	7.1	
ET.5	Build environmental curriculum that aligns with the Next Generation Science Standards	$35,000	Medium	Ongoing	TOMWC, EGLE	LP, PF, SG	8.1, 7.1	
ET.6	Monitor microplastics concentrations as new technology becomes available.	$100,000	Medium	2028-2030	TOMWC, EGLE, LA	PF, SG, FG, LP	2.1	
ET.7	Develop outreach materials and presentations on the effects of plastic in our waters.	$15,000	Low	2031-2035	TOMWC, EGLE	PF, SG, LP	7.1, 8.1	
ET.8	Host a speaker series on water quality issues in pristine, Northern Michigan watersheds, including harmful algal blooms	$2,000	Low	2031-2035, 2028-2030	BLPS, TOMWC, EGLE	LP, SG	7.1, 6.2	
ET.9	Create an education campaign around the impacts of recreation on our waters	$5,000	Low	2031-2035	TOMWC	PF, SG	7.1, 3.1, 8.1	
ET.10	Strengthen partnerships and leverage resources for the protection of the Watershed through a Watershed Committee	$10,000	High	Ongoing	TOMWC, EGLE, LA, DNR, LG, HP, RC, LTC, CD	PF, LP	1.1, 1.2, 1.5	
ET.11	Create an education campaign around HAB's, focused on how to identify	$30,000	High	2026-2027	TOMWC, EGLE, LA	PF, SG, LP	7.1, 6.5, 8.1	
ET.12	Conduct targeted lawn care company education	$10,000	Low	2031-2035	TOMWC, EGLE	PF, SG	7.1, 8.1	

9. MONITORING STRATEGY

Implementation tasks and actions include many different types of monitoring activities. Monitoring is essential in order to evaluate effectiveness of the collective watershed efforts or individual actions. The following narrative details many of the recommended Implementation Tasks, however, these monitoring activities are proposed and will only occur if there is funding available.

Surface Water Quality Monitoring

Surface water quality monitoring will be used to evaluate the overall effectiveness of the nonpoint source watershed management plan and assess changes resulting from specific implementation activities. Water quality data collected by TOMWC, EGLE, USGS, academic institutions, and other sources will be used to assess changes over time in the Watershed where data is available.

TOMWC's Volunteer Lake Monitoring (VLM) program collects baseline data (water transparency, chlorophyll a, temperature) to characterize lake ecosystems, identify specific water quality problems, determine water quality trends, and, most importantly, inform and educate the public regarding water quality issues and aquatic ecology. Black Lake is monitored as a part of the VLM program. During a two-week window in the spring and in the fall, Volunteer Stream Monitoring (VSM) teams collect water temperature, document relative stream conditions, and collect a representative sample of macroinvertebrates. The Upper Black River is monitored annually through the VSM program.

TOMWC's Comprehensive Water Quality Monitoring (CWQM) program collects data for nine parameters (temperature, dissolved oxygen, pH, conductivity, clarity, total phosphorus, total nitrogen, and chloride) on 56 lakes and streams on a triennial basis. The data for lakes and rivers in Northern Michigan has been compiled into a single database that can be used by staff to evaluate aquatic ecosystem health, examine trends within or among water bodies, and identify specific problems. The Upper Black River and Black Lake are monitored as a part of this program.

Physical and chemical parameters to be monitored include, but are not limited to:

Alkalinity	Carbon	Nickel
Suspended solids	Chloride	Sulfate
Temperature	Chromium	Cadmium
Calcium	*E. coli*	Conductivity
Hardness	Nitrogen	Manganese
Chlorophyll-*a*	Phosphorus	Mercury
pH	Turbidity	Lead

Dissolved oxygen	Water clarity	Copper
Dissolved solids	Zinc	Magnesium

Biological monitoring of bacteria, algae, aquatic macrophytes, aquatic macroinvertebrates, fish, and other aquatic organisms will supplement physicochemical data. Discharge will be measured at sites on any lotic systems that are monitored. Additional physical, chemical, or biological parameters will be included in monitoring efforts in response to emerging water quality threats that may include, but is not limited to, the following:

- Pharmaceuticals
- PAH's
- PFAS
- Microplastics

Monitoring water quality does not ensure clean water, but rather provides valuable information to help protect and improve water quality.

Evaluating the effectiveness of improving and maintaining water quality throughout the Watershed will be assessed through the results of monitoring efforts relative to established criteria. In order to accurately assess the state of waters within the Watershed it is necessary to maintain and implement efficient water quality monitoring programs and coordinate efforts. Table 44 outlines current ongoing monitoring efforts in the watershed.

Table 44. Monitoring Activities

Ongoing Monitoring				
Organization	**Program**	**Type of Analysis**	**Frequency**	**Water Body**
Tip of the Mitt Watershed Council	Comprehensive Water Quality Monitoring**	Dissolved oxygen, nitrogen, phosphorus, specific conductance, chloride	Triennial: Spring	Black Lake, Upper Black River
	Volunteer Lake Monitoring (MiCorp)*	Water clarity, chlorophyll a	Annual	Black Lake
	Volunteer Stream Monitoring (MiCorp)*	Benthic macroinvertebrate community	Biannual: Spring and Fall	Upper Black River
Michigan Environment, Great Lakes, and Energy	Biological Sampling and Habitat Assessment	Habitat Assessment, Benthic macroinvertebrate survey	5-year rotation	Upper Black River, East Branch Black River, Milligan Creek
	Fish Contaminant Monitoring Program	Mercury, PCBs, DDT, and others	Varies	Kleber Pond-Black River, Tower Pond - Black River, Twin Tomahawk Lakes

	Targeted Monitoring Request Program	Macroinvertebrate community, bacteria, dissolved oxygen/temperature, fish community, fish contaminants, water chemistry, water toxins, stream nuisance conditions, sediment chemistry, channel morphology	Varies	To be determined; potential monitoring based on external requests
District Health Department #4	Beach Guard	E. coli	Annual: June-August	Black Lake
Additional Monitoring needed as Identified in the Implementation Tasks				
To be determined	Not applicable	Baseline WQ data (physical and chemical parameters)	To be determined	Water bodies not currently monitored
		Monitor public beaches		public beaches
		Monitor for septic failure		Black Lake
		Major and minor tributaries flowing into Black Lake		Watershed
		Emerging water quality threats		
		Update Inventories (streambank, stormwater, shoreline, forestry, agriculture)		
		Monitor stormwater outfalls in Onaway		
		Conduct habitat monitoring		
		Groundwater monitoring (nutrients)		
		Monitor invasive species		
		PFAS/PFOA		
		Microplastics		

Program has a quality assurance project plan housed on TOMWC's servers and are available at request/Program has standard operating procedures*

These monitoring efforts will be reviewed on an annual basis through the Watershed Advisory Committee. One meeting a year will be dedicated to presenting the results of regular water quality monitoring by these groups, or others, that is either ongoing or scheduled to occur. Any results that are showing degradation or improvements, will be discussed in the 5-year review of this plan and may require the addition of new implementation tasks or monitoring efforts. In the event of water quality degradations, it will be important to engage targeted monitoring efforts to collect data using approved methods that can be compared to state standards.

Shoreline and Streambank Surveys

Shoreline protection will be achieved by surveying the shorelines of Black Lake every five to ten years as funding allows. These surveys will be conducted by boat and/or drone (where appropriate). Parameters to be surveyed include indicators of nutrient pollution, erosion, greenbelt health, and shoreline alterations. Streambank surveys will be conducted every five to ten years on the Black River. Smaller streams, such as Fisher Creek, Stewart Creek, Stoney Creek, and Rainy River, will be inventoried every ten years, where stream reaches are navigable. The results of surveys will be used to conduct follow-up activities directed toward riparian property owners, which will identify specific problems and encourage corrective actions. Survey results will also be used for trend analyses to determine if riparian areas are improving or deteriorating over time.

Shoreline protection will also be assessed by monitoring the interest in the Michigan Shoreland Stewards program. Monitoring will consist of reviewing statistics of the lake's riparian owners who take the survey on the Michigan Shoreland Stewards website.

Stormwater Management

Pollutants associated with cars and roads, including metals, chlorides, and Polycyclic Aromatic Hydrocarbons (PAHs), are also commonly found in urban stormwater and warrant monitoring. The EPA lists metals and salts as pollutants associated with urban runoff that "can harm fish and wildlife populations, kill native vegetation, foul drinking water, and make recreational areas unsafe and unpleasant." PAHs are not water-soluble and persist in the environment for long periods, although they can break down from UV light exposure.

A survey of significant stormwater outfalls, generally concentrated in towns and villages, is needed to assess the impacts of stormwater runoff on lakes and streams. Cataloging the location of these areas and sampling water quality at the outfall will provide baseline information on the magnitude and character of stormwater issues. Sampling outfalls in the direct aftermath of storm events will provide critical information about the effectiveness of stormwater infrastructure.

Implementation of green stormwater infrastructure (GSI) projects is an important aspect of stormwater management. As more GSI projects are implemented, public interest, awareness, and familiarity with GSI practices will increase. Tracking the number of implemented projects through Information/Education (I/E) efforts, as well as public interest and awareness, will be ongoing.

Land Use

Land use change and landscape alterations caused by humans will be monitored because of the strong potential to influence nonpoint source pollution. Although primarily done using remotely sensed data in a GIS, field surveys may also be required. Land cover data will be used to assess changes in land use every 10 years. Increases or decreases in land cover associated with development (e.g., agricultural or urban) will be examined in context of changes in water quality and aquatic ecosystem health.

Implementation of both forestry and agriculture BMPs will be monitored through increased enrollment in stewardship-based programs, such as MAEAP and the State of Michigan's Forest Stewardship Program with a focus on enrollment in critical areas.

Road/Stream Crossing Inventories

Road-stream crossings throughout the Watershed will be re-surveyed, following the same protocols, approximately every 10 years to document current conditions, update prioritization, and to evaluate improvements or BMP installations. Priority will be placed on monitoring known problem sites and areas of high or fluctuating streamflow. Data will be uploaded to the Great Lakes Road Stream Crossing Inventory. As is the practice with road/stream crossings, most are not given attention until they fail and create problems. Therefore, monitoring should also include discussion with resource managers and other partners to ascertain whether any road/stream crossings need more immediate attention. The identified top 10 sites will be of priority consideration for structural improvements, but all severe sites must remain in strong consideration.

Land Protection and Management

The priority parcel process is a tool that reduces nonpoint source pollution impacts to water resources by identifying parcels that are high priority for permanent protection based on ecological value and other criteria. These criteria, listed below, are the most important to consider for long-term water quality protection.

- Parcel Size
- Groundwater Recharge Potential
- Wetland Preservation
- Lake Shoreline/Riparian Protection
- River and Stream Shoreline/Riparian Protection
- Steep Slopes for Erosion Prevention
- Proximity to Protected Lands
- Threatened/Endangered Species
- Proximity to Development
- Natural Landcover Types
- Drinking Water Protection Areas
- Exceptional Resources
- Public Visibility

This prioritization process will be carried out approximately every five years to monitor land protection efforts. Parcels will be reevaluated and assigned updated rankings. Progress in land protection will be evaluated by determining change over time in the number of parcels and the total land area in the Watershed considered to be protected from development. Updated prioritization information will be shared with land conservancies that are active in the Watershed to assist with land protection efforts.

Ecosystem Health

Habitat diversity is important for maintaining healthy, vibrant aquatic ecosystems, particularly in small streams and the littoral zone of lakes. Nonpoint source pollution can reduce the variety of available habitat in an aquatic ecosystem through excessive sedimentation and cultural eutrophication. Therefore, monitoring habitat conditions throughout the Watershed is an important component for evaluating the effectiveness of nonpoint source pollution management plans.

Habitat mapping on priority streams known to have robust native fish populations will establish baseline data. Follow-up mapping will occur approximately ten years afterward. Field surveys will be conducted with a particular emphasis on large woody debris, riffle, pool, run, gravel, cobble, and other important aquatic habitat features.

Ecosystem health will also be monitored by gauging the interest in small dam removal. Stakeholders will identify and work with property owners with small dams in order to ultimately remove dams that are affecting ecosystem health.

Recreation, Safety, and Human Health

Monitoring of recreation, human health and safety can be achieved by monitoring health alerts issued by the local health agencies, as well as public concerns and inquiries that are received by agencies. Other threats include avian botulism and swimmer's itch.

E. coli, mercury, and other factors with harmful effects on humans will require additional sampling and it is recommended that further surveys be conducted to assess their impact on the watershed and humans. Although the most significant source of these contaminants in the Watershed is air deposition (which is outside the scope of Watershed Management efforts), monitoring of mercury, PCBs, and PFAS levels in local fish should be a priority for EGLE. Priority will be placed on ensuring the safe recreational use and consumption of water and fish throughout the Watershed, addressing unsafe areas and protecting threatened areas.

Hydrology and Groundwater

Groundwater is susceptible to contamination by nonpoint source pollution. In addition, landscape development and groundwater withdrawals (e.g., agricultural irrigation and drinking water) have the potential to reduce the amount of available groundwater. Therefore, groundwater monitoring is needed to assess the effectiveness of the nonpoint source management plan.

The first step is to compile all existing groundwater information, identify problems, determine data gaps, and develop a strategy for feasible, effective, and long-term groundwater monitoring. This assessment of existing information and development of a monitoring plan should be completed within 10 years.

High groundwater recharge areas are determined by the presence of permeable soils that allow for relatively rapid recharge of groundwater stores. The same permeability that lends itself to high groundwater recharge rates can also result in nonpoint source pollution passing relatively quickly through the soils and contaminating groundwater stores. It is unlikely that these areas will change significantly

moving forward and it is important to collaborate with zoning officials to ensure minimal expansion of impervious surfaces into valuable groundwater recharge areas. Furthermore, increased impervious surface area as a result of landscape development leads to relatively greater decreases in groundwater recharge in areas with highly permeable soils (versus areas with lower soil permeability).

One approach for protecting high groundwater recharge areas is to limit impervious surface coverage. This can be accomplished through various means, such as implementing ordinances that limit the amount of impervious surface area on a parcel or limiting build-out potential through permanent land conservation. Efforts focused on protecting high groundwater recharge areas will be evaluated every ten years by determining changes (net gain or loss) in the extent of permanently protected lands in areas with high groundwater recharge rates.

It is also important to encourage proper maintenance, monitoring, and removal of underground fuel storage tanks, which will be an ongoing process.

Wetlands

Wetland restoration and protection efforts will be monitored by performing land cover change analyses in a GIS. A watershed-level analysis should be performed every 10 years using remote sensing data to determine increases or decreases in wetland acreage throughout the Watershed (WL.2)

High-value wetlands will be identified and mapped out by assessing wetlands throughout the watershed in terms of ecological and environmental values (e.g., habitat value, water quality benefits, and flood control contributions). Following identification and mapping, the areas containing high value wetlands will be calculated every 10 years to determine any net change. Wetlands are also incorporated into the watershed protection priority parcel analysis in an earlier chapter.

Aquatic Invasive Species

Many invasive species have become well established within the Watershed, including invasive Phragmites, purple loosestrife, and zebra mussels. Although eradication of these species is not feasible, efforts to control their spread within the Watershed and throughout Northern Michigan is a priority.

Using databases maintained by TOMWC and Michigan Invasive Species Information Network (MISIN), both the introduction of additional aquatic invasive species and the spread of documented aquatic invasive species within the Watershed will be tracked.

Biological control will be used where applicable. Outreach and education, volunteer programs, technical and financial assistance to property owners, and innovative communication and control measures (e.g. mobile boat washing station) will collectively reduce the spread and thwart the introduction of aquatic invasive species.

Education and outreach campaigns will help increase awareness of new and emerging species of concern to help aid in early detection.

Septic Systems

Options for septic system regulations, including a statewide septic code, will continue to be explored. A septic system outreach campaign, including incentives such as a septic giveaway, free septic evaluations, will continue to be developed. At least one local jurisdiction in the watershed who does not have municipal sewer systems should adopt septic ordinances by year 10, as a means to protect water quality.

Enteric bacteria studies on waters can help identify potential sources of septic failure. Results will help target outreach efforts.

Emerging Threats and Watershed Education

Climate Change

Information and Education programs will continue to bring awareness among all Watershed residents and stakeholders. Programs will highlight the importance of supporting state and federal climate change adaptation initiatives, including the Great Lakes Restoration Initiative and other grant programs that can support local watershed management efforts.

PFAS

Emerging contaminants, such as PFAS will be monitored through updates from EGLE and partner agencies. There are currently no PFAS areas of concern in the Watershed.

Microplastic

Information and Education programs will bring awareness of microplastics to Watershed residents and stakeholders. As minimal data is currently available, microplastic pollution will be monitored through partner sharing and new research.

Education

Continued and expanded engagement with local schools in the watershed will extend education programming to different age groups and schools.

Socio-economic Monitoring

Many projects carried out as a result of the watershed management plan will have social and economic impacts. For example, nonpoint source pollution education of watershed residents may affect behavior and result in a reduction of nonpoint source pollution, or nonpoint source pollution reductions in surface waters may increase local tourism revenues and boost the economy. Therefore, monitoring activities should also include social and economic elements.

There are many methods for monitoring social and economic changes as a result of the management plan. Some of the primary tools for conducting this type of monitoring include surveys and demographic/economic change analyses. To establish relationships between socio-economic factors and nonpoint source pollution, data from other monitoring activities (e.g. surface water quality monitoring) will be incorporated into this monitoring effort.

10. EVALUATION STRATEGY

To ensure that the recommended actions are meeting the goals of the Watershed Plan, an evaluation will be required to determine the progress and effectiveness of the proposed activities. Evaluation is an important part of any watershed planning effort in that it provides feedback on the success of an activity or the project's goals. It also provides communities with important information about how to conduct future efforts, or how to change the approach to a specific problem in order to be more successful the next time. If activities are successful, this will gain more support for future activities amongst decision makers.

Evaluation Strategy for Plan Implementation

TOMWC will act as the lead organization and will oversee both the coordination of the Advisory Committee and the evaluation strategy for Plan implementation. The evaluation strategy will be used to determine progress in completing the recommended actions and tasks identified in the Plan.

After five years, the Advisory Committee will take stock of the progress that had been made on the actions recommended in the Plan; identify the highest priorities for action today, given developments over the past five years; and to get input from partners on how to improve implementation of the Plan. A series of questions will be used to elicit responses from committee members that will gauge their sense of the effectiveness of the Plan, its strengths and weaknesses, areas in need of change, its usefulness, etc. Responses will be compiled into a report of key findings and suggestions. This will help identify changes in staff and funding sources as well as include emerging issues, and the overall status of projects. Updates will include a summary of water quality improvements related to implemented BMPs where applicable. The report will be presented to the watershed advisory committee and the community. The desired outcome is to meet the goals and objectives of this watershed management plan, by achieving water quality that meets the water quality standards in order to support designated and desired uses.

After ten years, the Watershed Advisory Committee will seek funding to update the plan. The resource inventories will be repeated as necessary and included in the update. Any implementation tasks not completed after the first ten years of Plan implementation will be assessed as to their relevance in the Plan update. New implementation tasks will also be developed based on current conditions of the Watershed and the priorities of the Watershed Advisory Committee.

Criteria to determine effectiveness of water quality protection efforts

The evaluation strategy for the overall Management Plan in protecting water quality is based on comparing criteria with monitoring results. The Monitoring Strategy in the previous chapter provides the framework in which to collect the appropriate data. A set of criteria (bold) were developed based on current data averages (where applicable) (*italicized*) to determine if the proposed pollutant reductions in

the Watershed are being achieved and that water quality is being maintained or improved. The water quality criteria for parameters that reflect nutrient and sediment pollution are as follows:

Total phosphorus yearly average concentrations in Black Lake remain below averages.

Data from TOMWC's Comprehensive Water Quality Monitoring (CWQM) program and targeted Black Lake Watershed monitoring show that total phosphorus averages below 7 µg/L over the long-term and below 20 µg/L over the short-term, respectively, for Black Lake.

Total phosphorus yearly average concentrations in tributaries remain below an average of 21 µg/L.

For the Watershed, tributaries sampled through targeted monitoring have total phosphorus concentrations below 21 µg/L.

Total phosphorus yearly average concentrations in the Upper Black River remain below averages.

Total phosphorus concentrations in the Upper Black River averaged below 7 µg/L, through TOMWC's Comprehensive Water Quality Monitoring (CWQM) long-term program. Whereas, the monitoring in 2024 & 2025 through targeted Black Lake Watershed monitoring, the Upper Black River averaged below 16 µg/L.

Total nitrogen yearly average concentrations in Black Lake and rivers should remain below 370 µg/L.

Nitrogen concentrations in surface waters are also not regulated by the State of Michigan or the EPA, though EPA does have reference conditions for each subecoregion. All lakes and rivers within the Watershed have historical averages of total nitrogen concentrations below 370 µg/L which are within the reference condition thresholds.

Total nitrogen yearly average concentrations in streams should remain or be reduced to below 440 µg/L.

Based on TOMWC's 2018 Black Lake Tributary Study, some streams within the Watershed have elevated total nitrogen concentrations.

Maintain dissolved oxygen levels of 7 ppm or higher in Black Lake, the Upper Black River, and the Watershed's coldwater streams.

Dissolved oxygen concentrations in Black Lake, the Upper Black River, and tributaries are typically above the 7 ppm standard that is required by the State of Michigan for water bodies that support coldwater fisheries.

Reduce nutrient inputs from stormwater in urban areas.

Depending on numerous factors, such as drainage area, land-cover type, and period between rain events, nutrient loads in stormwater can vary widely. More data is needed to generate a comprehensive baseline data set and accurately assess stormwater impacts. Once baseline data are available, implementation

projects that aim to reduce nutrient loads from stormwater in urban areas can be assessed through future stormwater monitoring. It is important to note that implementing stormwater management projects prior to baseline data collection will still achieve pollutant reductions; however, site-specific data will result in more targeted efforts.

Maintain or reduce sediment loads in tributaries and stormwater.

Similar to nutrient inputs in stormwater, additional sediment data is needed to generate a comprehensive baseline data set for stormwater impacts. Once baseline data are generated, comparisons can be made to determine changes in time as related to implementation projects.

Maintain pH levels within range of 6.5 to 9.0 in Black Lake, the Upper Black River, and their tributaries as required by the State of Michigan.

Data from TOMWC's Comprehensive Water Quality Monitoring (CWQM) program and targeted Black Lake Watershed monitoring show that pH levels consistently fall within this range.

Maintain the level of conductivity in Black Lake.

Conductivity levels monitored as part of TOMWC's CWQM program and targeted Black Lake Watershed monitoring typically ranged from 225 to 320 µS/cm. Groundwater can range from 300 to 500 µS/cm depending on sub-surface conditions. Therefore, conductivity levels in surface waters should consistently be less than 500 µS/cm.

Maintain or reduce the level of conductivity in the Upper Black River.

Conductivity levels monitored as part of TOMWC's CWQM program and targeted Black Lake Watershed monitoring typically ranged from 250 to 380 µS/cm. Groundwater can range from 300 to 500 µS/cm depending on sub-surface conditions. Therefore, conductivity levels in surface waters should consistently be less than 500 µS/cm.

Maintain or reduce the level of conductivity in Black Lake tributaries.

Conductivity levels monitored as part of targeted Black Lake Watershed monitoring typically ranged from 330 to 660 µS/cm. Groundwater can range from 300 to 500 µS/cm depending on sub-surface conditions. Therefore, conductivity levels in surface waters should consistently be less than 500 µS/cm.

Maintain or reduce low water temperatures in water bodies designated for or capable of sustaining coldwater fisheries.

Within these water bodies, maintain or reduce low water temperatures to sustain the coldwater fishery. Water temperatures should generally not exceed 20° Celsius throughout summer months.

Prevent beach closings due to bacteriological contamination.

Prevent beach closings throughout the Watershed as a result of E. coli levels that exceed the State of Michigan water quality standard for single day (>300 E. coli per 100 ml of water). Prevent extended beach closings that result from a 30-day geometric mean measurement that exceeds State standards (>130 E. coli per 100 ml of water in 5 samples over 30 days). This can be evaluated by tracking health alerts issued by the local health agencies. Oftentimes, health alerts are issued when water-related recreation, such as swimming, is prohibited due to a detected pathogen or other health threat.

Maintain or improve aquatic macroinvertebrate community diversity throughout the watershed.

Aquatic macroinvertebrate diversity in a stream varies depending on many variables, including stream size, stream flow, habitat diversity, water temperature, riparian vegetation, land use, and more. Therefore, aquatic macroinvertebrate diversity at a given location on a stream must be viewed through a lens that accounts for such variables and is best compared with similar stream sites to accurately gauge stream ecosystem health. Reliable baseline data requires monitoring a site for a minimum of three years, after which the site can be compared to others, using diversity indices to determine if the site and stream are normal and healthy. Thereafter, future monitoring can be conducted to assess the benefits of implementation projects to stream ecosystem health.

Reduce Cladophora algae growth that is caused by nutrient pollution on Black Lake where it has been documented.

Cladophora algae occurs naturally in small amounts along the shorelines of Northern Michigan lakes, but grows more extensively and densely as nutrient availability increases. Shoreline surveys conducted on Black Lake documented the occurrence of Cladophora on the shoreline, as well as the density of growth. Results from these surveys illustrate that Cladophora is present and dense, especially along certain shoreline segments. Thus, the same information generated during future surveys can be used to determine if there were reductions in the number of properties with Cladophora growth or the number with heavy-density growth because of implementation projects.

Maintain low chloride or reduce concentrations in surface waters

Data from TOMWC's CWQM program show that chloride concentrations have increased significantly over the last 20 years in most lakes and streams monitored in Northern Michigan. Chloride levels in the Watershed's surface waters average below 10 ppm, with most pristine water bodies averaging below 6 ppm. Chloride is monitored because it is a good indicator of human activity in a watershed, i.e., as human population increases and urban and agricultural land use increases, so do chloride levels. In addition, monitoring chloride is valuable because it indicates that more damaging pollutants associated with chloride, such as leaking fluids and metals from automobiles that accumulate on roads along with deicing salts, are washing into and negatively impacting adjacent surface waters. Although most aquatic life is not affected until chloride reaches very high concentrations (>1000 ppm), some sensitive organisms may be lost at lower levels. Chloride concentrations in the Watershed's surface waters should not exceed the State of Michigan's thresholds: final chronic value of 120 mg/L and aquatic maximum value of 320 mg/L.

Qualitative Criteria

In addition to applying the abovementioned criteria, more qualitative evaluation methods will be used. Field assessments of best management practices (BMPs), such as green infrastructure or streambank or shoreline bioengineering projects, will determine effectiveness by taking photographs, gathering physical, chemical, and/or biological data. Projects will also be documented with photographs to evaluate their effectiveness or need for improvement or modification. For example, shoreline and streambank restoration projects will be photographed before any restoration begins, during project installation, and

after project completion. Other project types that may also warrant photographic documentation include road/stream crossings, stormwater and agricultural BMPs, recreational access sites, etc.

Improve Local Knowledge

The most valuable assets in protecting the Watershed are the residents and tourists who live, work and play within its boundaries. In order to achieve commitment to the large-scale vision laid out within this Plan there will need to be a concerted effort to organize, communicate, and educate community members around the shared vision of protecting water resources. Various delivery methods could be employed such as print/social media, paid advertising, and community events/meetings. Tools for implementation and evaluation of this progress are described in Table 45.

Table 45. Implementation and evaluation tools

Audience	Associated Structural / Action Based Threats	Messages	Potential Evaluation
Households	All		
Riparian property owners	Lake shoreline development/use Impervious surface and stormwater runoff Invasive species Failing septic systems Riverbank development/use Climate change Recreational activity Harmful algal blooms	Eliminate the use of fertilizers and pesticides in lakefront landscaping Properly dispose of medications Properly maintain septic systems Use BMPs to reduce erosion and manage stormwater Reduce carbon footprint Avoid single use plastics Clean, drain, and dry watercrafts, trailers and other boating equipment before entering another waterbody	Social Indicators Survey; minimum response rate of 40% with measurable improvements in knowledge as compared to 2017-2019 surveys. Messages delivered through a minimum of 3 different mechanisms.
Business owners	Lake shoreline development/use Impervious surface and stormwater runoff Invasive species Riverbank development/use Climate change Recreational activity	Eliminate the use of fertilizers and pesticides in lakefront landscaping Use BMPs to reduce erosion and manage stormwater Reduce carbon footprint Avoid single use plastics Clean, drain, and dry watercrafts, trailers and other boating equipment before entering another waterbody	Social Indicators Survey; minimum response rate of 20%. Messages delivered through a minimum of 3 different mechanisms.
Contractors, realtors, developers	Lake shoreline development/use Impervious surface and stormwater runoff Failing septic systems Riverbank development/use	Use BMPs to reduce erosion and manage stormwater Offer alternatives to shoreline hardening Properly maintain septic systems	Social Indicators Survey; minimum response rate of 20%. Messages delivered through a minimum of 3 different mechanisms.
Agriculture industry	Agricultural runoff Climate change	Eliminate the overuse of fertilizers and pesticides Effectively treat animal waste Reduce carbon emissions	Social Indicators Survey; minimum response rate of 15%. Messages delivered through a minimum of 3 different mechanisms.

Tourists	Recreational activity Climate change	Stay on designated trails Use designated restroom facilities Clean, drain, and dry watercrafts, trailers and other boating equipment before entering another waterbody Reduce carbon footprint Avoid single use plastics	Seasonal Surveys; minimum response rate of 15%. Messages delivered through a minimum of 3 different mechanisms.
Boaters	Invasive species Recreational activity	Use designated restroom facilities Clean, drain, and dry watercrafts, trailers and other boating equipment before entering another waterbody Avoid single use plastics Respect designated no wake areas & Michigan boating laws	Seasonal Surveys; minimum response rate of 25%. Messages delivered through a minimum of 3 different mechanisms.
Anglers	Invasive species Recreational activity	Use designated restroom facilities Clean, drain, and dry watercrafts, trailers and other boating equipment before entering another waterbody Avoid single use plastics Respect designated no wake areas Properly dispose of bait	Seasonal Surveys; minimum response rate of 15%. Messages delivered through a minimum of 3 different mechanisms.
Quiet water Recreation enthusiasts	Invasive species Recreational activity	Clean, drain, and dry watercrafts, trailers and other boating equipment before entering another waterbody	Seasonal Surveys; minimum response rate of 15%. Messages delivered through a minimum of 3 different mechanisms.
Local government officials	All	Enforce current laws Strengthen local greenbelt and septic ordinances Incentivize homeowners who apply BMPs Reduce climate emissions Use BMPs to reduce stormwater runoff	Social Indicators Survey; minimum response rate of 40% with measurable improvements in knowledge as compared to 2017-2019 surveys. Messages delivered through a minimum of 3 different mechanisms.

Summary

The evaluation strategy presented here provides a framework for assessing the effectiveness of implementation and monitoring efforts through the watershed. As further issues and information emerge, additional tasks and monitoring efforts will certainly be added to those laid out within this Chapter and those previous. Improving monitoring standards and establishing new programs where necessary will help

develop robust datasets to inform management actions and educate local citizens, officials, and tourists on their role in watershed health.

Advisory committee meetings will be used to address current and emerging issues within the Watershed and assess the ongoing effectiveness of this management plan will be critical in extending the lifespan of its usefulness. The tools presented here and throughout the previous chapters are intended to provide baseline data, decision-making tools, and goals to protect the resources in the Watershed for many years to come.

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APPENDICES

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Appendix A

An Exploration of Impacts and Stakeholder Interests: Tower and Kleber Dams on the Upper Black River, Northeastern Michigan

An Exploration of Impacts and Stakeholder Interests: Tower and Kleber Dams on the Upper Black River, Northeastern Michigan

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Michigan Department of Natural Resources

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School of Natural Resources and Environment

April 2017

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Abstract

Background: Tower and Kleber dams operate on the Upper Black River in Northeastern Michigan and their license is set to expire on April 30, 2024. A decision to relicense or remove the dams will need to be made by the Federal Energy Regulatory Commission and the dam owner, Nelson Turcotte of Tower Kleber Limited Partnership, within the next several years. Our clients, the Michigan Department of Natural Resources and the Grand Traverse Band of Ottawa and Chippewa Indians, asked us to conduct an analysis of the impacts of the dams and explore the range of issues that need to be considered in decision-making.

Project Purpose and Methods: For this analysis, we sought to understand: (1) the current ecological, economic, and social impacts of Tower and Kleber dams; (2) potential impacts of dam removal; (3) key stakeholders, concerns, and considerations to be included in the decision-making process; and (4) information and processes that should be incorporated moving forward. We reviewed published literature and interviewed members of identified stakeholder groups. We also held a large public meeting where we presented our preliminary findings and gathered input from attendees. Our meeting and this final report aim to provide our clients and other stakeholders with a baseline understanding of issues surrounding the dams as they begin the decision-making process regarding the dams' future.

Findings: We determined that the dams are in satisfactory condition and produce expected amounts of electricity. They affect water conditions and habitat for many aquatic species, including lake sturgeon whose current spawning and nursery habitats limit natural reproduction. However, the dams do not have a significant impact on Black Lake water levels. We identified many public concerns that should be addressed moving forward, including pond-front property, fishing opportunities, recreation, and tribal rights. To address misconceptions and confusion about dam impacts, we recommend gathering additional site-specific data and ensuring all information is made publicly available. To help alleviate conflict surrounding the issue, we recommend that our clients and the dam owner clarify the decision-making process, acknowledge concerns and emotions, work directly with landowners, directly involve tribal nations, and develop stakeholder visions for future dam scenarios.

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The Black Lake Preservation Society

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Hometown Inn of Indian River, Michigan

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Acronyms and Abbreviations

ACOE: US Army Corps of Engineers

ASDSO: Association of State Dam Safety Officials

BLA: Black Lake Association

BLPS: Black Lake Preservation Society

BRLP: Black River Limited Partnership

cfs: cubic feet per second

DSSMR: Dam Safety Surveillance and Monitoring Report

EIA: United States Energy Information Administration

FEMA: Federal Emergency Management Agency

FERC: Federal Energy Regulatory Commission

FWS: US Fish and Wildlife Service

GFLT: Great Lakes Fishery Trust

GTB: The Grand Traverse Band of Ottawa and Chippewa Indians

HEC: Hydrologic Engineering Center

HEC-EFM: Hydrologic Engineering Center Ecosystems Functions Model

kW: kilowatt

kWh: kilowatt-hour

LTBB: The Little Traverse Bay Band of Odawa Indians

MDNR: Michigan Department of Natural Resources

MSU: Michigan State University

MW: megawatt

MWh: megawatt-hour

NILCFAC: Northern Inland Lakes Citizen Fishery Advisory Committee

NMMA: National Marine Manufacturers Association

NOAA: National Oceanic and Atmospheric Administration

SFT: Sturgeon for Tomorrow

SNRE: University of Michigan School of Natural Resources and Environment

TKHLP: Tower-Kleber Hydro Limited Partnership

TKLP: Tower-Kleber Limited Partnership

USGS: US Geological Survey

WPSC: Wolverine Power Supply Company



Introduction

Tower and Kleber dams operate on the Upper Black River in Northeastern Michigan. Their license is set to expire on April 30, 2024. A decision to relicense or remove the dams will need to be made by the Federal Energy Regulatory Commission and the dam owner within the next several years. We were asked to conduct a preliminary analysis of Tower and Kleber dams in order to scope the range of issues that need to be considered in future decision-making.

PROJECT CONTEXT

The primary driver for this project and the broader discussion about Tower and Kleber dams is the upcoming formal relicensing process for the dams through the United States (US) Federal Energy Regulatory Commission (FERC) (see Figure 1). These licenses can be between 30 and 50 years in duration and define the operating terms for the licensee. Tower and Kleber dams are on a joint license that was last renewed for 30 years in 1994, meaning that the license is set to expire on April 30, 2024 (FERC, 1994). During the relicensing process, FERC seeks input from the public, non-governmental organizations, Native American tribes, and local, state, and federal agencies to identify environmental impacts and determine what additional studies may be needed to better understand identified issues (FERC, 2016d). In instances of relicensing, which is the case with Tower and Kleber dams, the current licensee must file a notice of intent with FERC at least five years before the existing license expires. This informs stakeholder groups that the more formal process is beginning, and gives those groups an opportunity to get involved in the process. For Tower and Kleber dams, this filing would occur in 2019.

Who is FERC?

The Federal Energy Regulatory Commission (FERC) is an independent federal agency that regulates and oversees the energy industry on behalf of the American people. In this role, FERC promotes development of new energy infrastructure and regulates the operation of existing projects. For hydroelectric dams, FERC issues permits and licenses to allow operation, enforces the conditions of those licenses, and conducts safety and environmental inspections. Source: FERC, 2016d

Negotiations between FERC and the dam owner are standard practice, but other parties can choose to intervene in that process in order to ensure their interests are taken into account. For the 1994 license, in addition to the Michigan Department of Natural Resources (MDNR), other interveners included the Michigan Water Resource Commission, the Anglers of the AuSable, the Great Lakes Council, the Federation of Fly Fishers, the Michigan United Conservation Clubs, and the Michigan Council of Trout Unlimited. One outcome of their involvement was a more explicit consideration of sturgeon management in the operation of the dams, including the creation of the sturgeon hatchery that is now situated next to Kleber dam.

While 2017 may seem early in the process, these discussions are happening now in order to initiate a similar conversation among an even wider and more diverse set of stakeholders. It is important to begin these conversations early to ensure that all stakeholders are involved in the process and their concerns can be addressed in an effective manner.

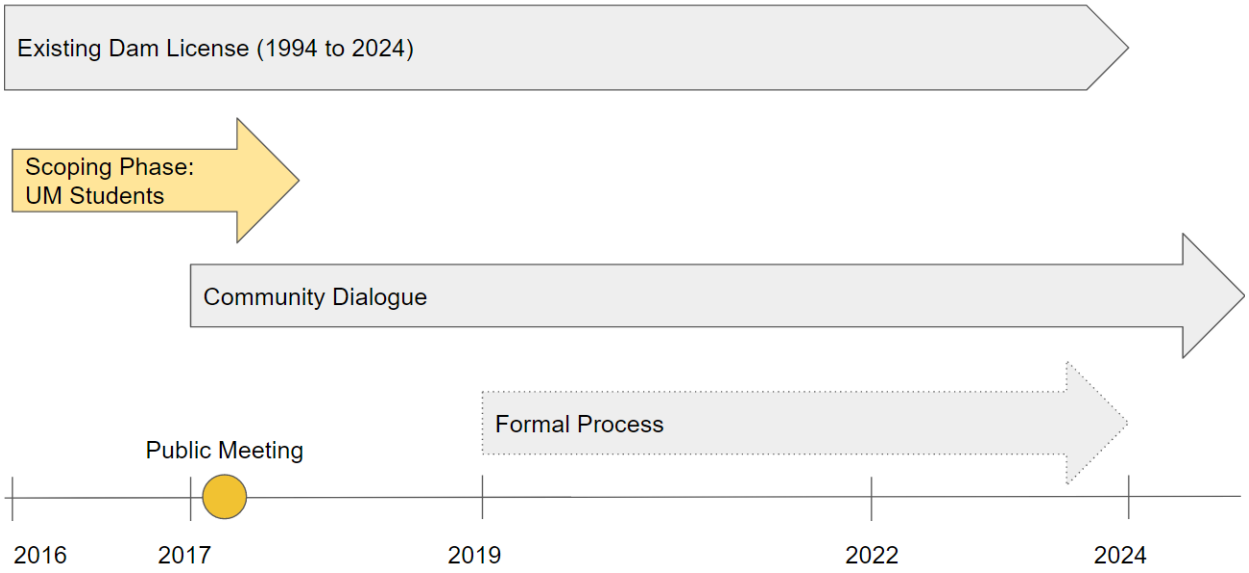


Figure 1. Timeline of the Tower and Kleber Decision-Making Process

Important Considerations and Drivers

As called for in the MDNR Sturgeon Rehabilitation Plan and related efforts to restore Michigan lake sturgeon populations, there has been a push to examine the impacts of existing dams on sturgeon population viability (MDNR, 2012). In addition, in 2015 the Grand Traverse Band of Ottawa and Chippewa Indians (GTB) and the Little Traverse Bay Bands of Odawa Indians (LTBB) issued separate formal motions advocating the removal of the Tower and Kleber dams to restore sturgeon habitat, and by extension, sturgeon populations (see Appendix V). MDNR also has a policy that advocates for removal of dams that are in disrepair, high risk, or no longer serve a purpose for safety, economic, and environmental reasons (MDNR, 2016b). Finally, the dam owner has recently indicated an interest in transferring ownership of the dams, so now is an opportune time to begin the process of reexamining the dams and ensuring that their future is carefully considered.

INTRODUCTION TO THE PLACE

Tower and Kleber dams are located upstream and south of Black Lake along the Upper Black River in Cheboygan County, Michigan. They are part of a three-dam system that includes Alverno Dam; however, Alverno is on a separate license and its impacts are therefore not considered in this project (Figure 3). Tower and Kleber dams have resulted in the formation of Tower Pond and Kleber Pond (Figure 3). The Black River eventually drains into the Cheboygan River before flowing into Lake Huron (Figure 2).

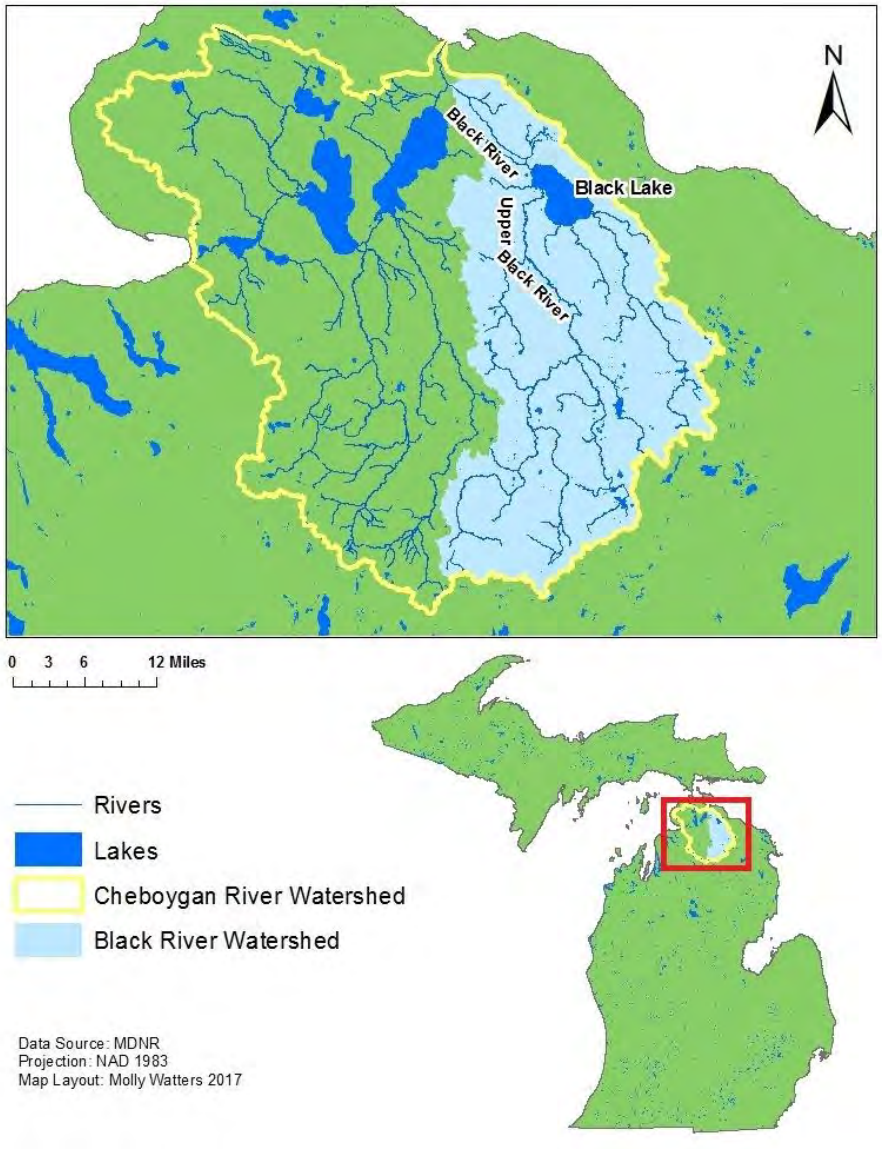


Figure 2. Cheboygan River Watershed

The Cheboygan River watershed covers 900,000 acres over Cheboygan, Presque Isle, Emmet, Charlevoix, Otsego, and Montmorency Counties. Lakes and rivers in the Cheboygan River watershed form the Inland Waterway, including Burt, Mullet, Douglas, Pickerel, Crooked, and Black Lakes. The Black Lake subwatershed drains more than 350,000 acres representing 38% of the entire Cheboygan River watershed (Cwalinski and Hanchin, 2011). Black Lake itself has a surface area of 10,113 acres (Breck, 2004) and is among the ten largest inland lakes in Michigan by surface area. For more information about the Cheboygan River watershed, see Appendix II.

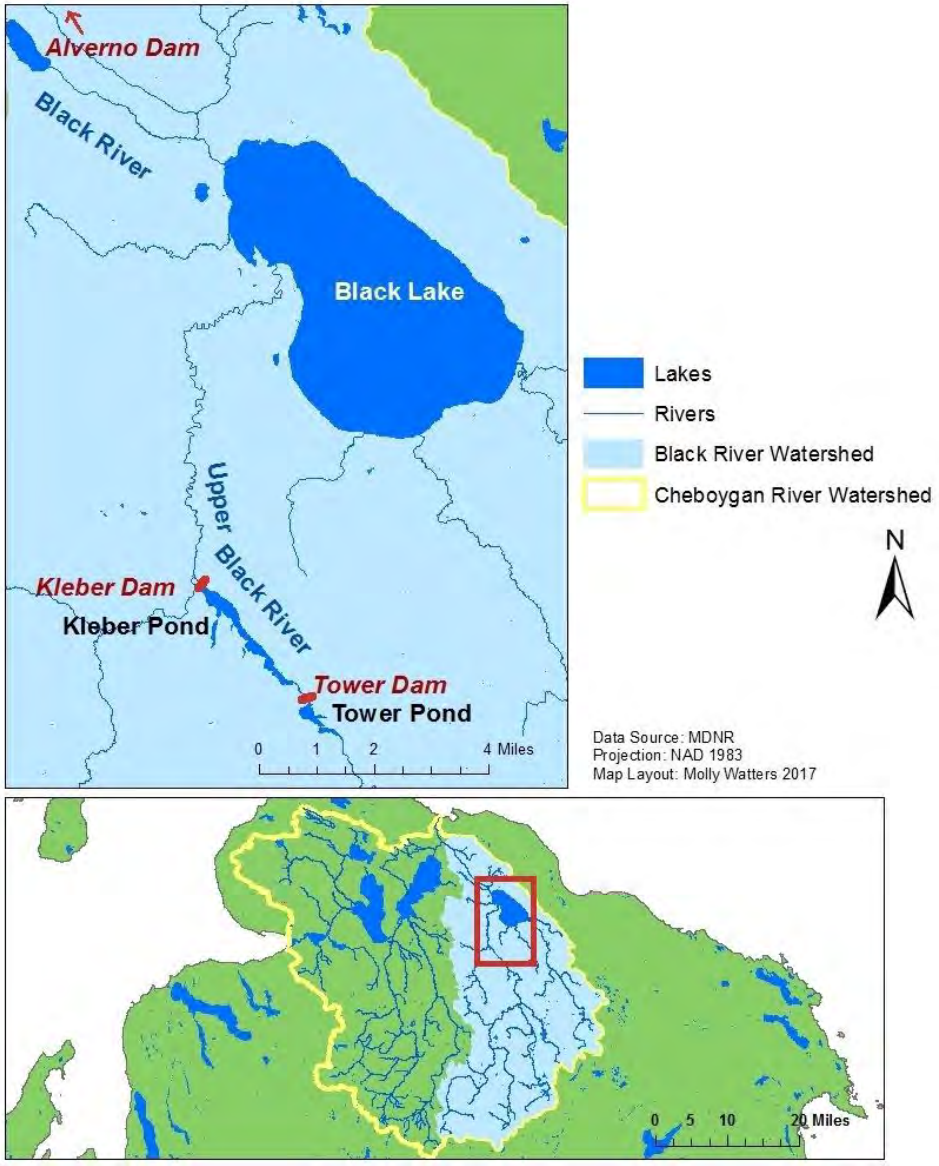


Figure 3. Black River Watershed and Tower, Kleber, and Alverno Dams

Black Lake is fed by the Upper Black River and Rainy River, as well as indirectly by Canada Creek and the East Branch of the Black River.[1] Black Lake watershed is mostly forested and open lands, with a small percentage of agricultural uses (Tip of the Mitt, 2016). The shoreline of Black Lake is mostly private residential land with some public riparian access located in a state park near the Upper Black River and state forest campground on the northeast shore. The water of Black Lake is tannin-stained dark, attributed this to historic logging industry and giving it its name. For more information about the Black Lake watershed, see Appendix II.

[1] Other tributary creeks include Tomahawk Creek, Milligan Creek, Stony Creek, Mud Creek, Hardwood Creek, Van Hellens Creek, Rattlesnake Creek, Packer Creek, and Fast Creek.

PROJECT PURPOSE

The purpose of this project was to answer the following questions to best inform future stakeholder dialogue and the decision-making process:

- What are the current ecological, economic, and social impacts of Tower and Kleber dams?
- What are the potential impacts of dam removal?
- What are the key stakeholders, concerns, and considerations?
- What information and decision-making processes should be incorporated moving forward?

Methods

We used public engagement and literature review to answer the four questions listed above. These methods built on each other iteratively to inform our public meeting and final report. We underwent three phases of public engagement in order to explore the range of interests and issues related to the dams. We explored available data and information specific to the Black Lake watershed as well as external scientific literature related to dam impacts and relevant topics.

Public Engagement

Public engagement allowed us to build a broad and rich understanding of the issues and concerns related to Tower and Kleber dams. First, we identified key stakeholder groups based on conversations with our clients, MDNR and GTB, and our preliminary research into the communities near Tower and Kleber dams. We then conducted scoping interviews with selected contacts through semi-structured phone conversations. In general, this consisted of conversations with biologists, fishermen, sturgeon advocates, local business owners, pond landowners, Black Lake land owners, and individuals with experience in other dam relicensing or removal processes.

Second, we conducted formal interviews by phone and in-person between February 2016 and August 2016.[2] We also conducted phone interviews with additional individuals throughout the duration of the project. Our template interview questionnaire is provided in the Appendix VIII. All interviews were recorded and transcribed. For these formal interviews, we built upon the pool of

[2] We will be referring to these interviews throughout the report, but as these were done confidentially, the identities of interviewees are not included in this report. The authors retain a version of this report that contains the specific attributions of certain facts, quotes, or other statements.

stakeholders we spoke with in our scoping interviews to include additional contacts that emerged through those conversations, literature, and additional research on local communities. In total, we conducted 20 formal interviews.

Finally, we held a public meeting on Saturday, February 11, 2017 from 2 to 5pm in the Forest Township Hall in Tower, Michigan. For this meeting, we developed and circulated a flyer with general information about the meeting location and time, as well as a brief discussion of the project and the meeting purpose (see Appendix IX). Meeting notices were distributed through MDNR to organized stakeholder groups, and we also reached out to previous interviewees and others to help increase awareness of the event. Approximately 120 people attended the meeting. During the meeting, we presented our preliminary findings and then broke into smaller discussion groups, each facilitated by a member of the project team, as well as Patrick Hanchin of MDNR. During these smaller group discussions, we used flipcharts to record key concerns and questions raised by attendees. Building upon our interviews, these comments also allowed us to identify uncertainties and questions that must be answered over the course of the future decision-making process. Discussions were audio-recorded to allow for later review of key statements or important quotes. A list of public input and questions gathered at the public meeting are provided in Appendix X. A recording of the meeting, courtesy of Sunrise Cable Network's David LaClair, is available online here: https://vimeo.com/203940534.

Literature Reviews

Literature review and background research built a baseline understanding of the impacts of dams and dam removal processes, with specific focuses on their potential ecological, economic, social, and cultural impacts. This allowed us to synthesize existing research of relevant topics and compile current conditions of the specific Black River area. We explored two types of literature for this project: site-specific information about the dams and general scientific literature on the impacts of dams and dam removals.

The first was site-specific information about the Black Lake watershed and Tower and Kleber dams. Information was available through FERC, provided to us directly by our clients, or shared through stakeholder groups and interviewees. Site-specific information was mainly targeted to give us an understanding of the conditions of the dams and specific impacts that may have already been studied. Much of this consisted of formal documentation required by FERC, but other data came from surveys conducted by MDNR.

Our broader literature review was focused primarily on scientific studies on the ecological and economic impacts of dams and dam removal processes. We especially focused on research assessing how dams and dam removals affect fish and vegetation communities, lake sturgeon, water quality, sedimentation, invasive species, water levels, and property values.

Finally, we also explored available primary literature, news articles, and websites relating to select dam removal processes that would serve as case studies and provide lessons for Tower and Kleber dams. We primarily identified well-documented and comparable dam removals from the State of Michigan and a prominent out-of-state dam removal. Each of these case studies are intended to inform best practices (see Appendix VII).



Findings

Questions Addressed Below:

- What are the key stakeholders, concerns, and considerations?
- What are the current ecological, economic, and social impacts of Tower and Kleber dams?
- What are the potential impacts of dam removal?

"I believe in free-flowing rivers. I like to see dams eliminated for the most part. But there are lots of factors here. These dams have been here a long time. What about hydropower? Or riparian owners? There's a lot to consider."

– local resident

WHO ARE THE KEY STAKEHOLDERS?

We identified a diverse set of stakeholders likely to be affected by the dam decision. Many of these groups have already expressed interest in becoming directly involved with the decision-making process. Each stakeholder group is described below with a brief explanation of their interests in the dams and/or watershed.

Tower-Kleber Limited Partnership

The Tower-Kleber Limited Partnership (TKLP) is the current owner and operator of Tower and Kleber dams. TKLP is managed by Mr. Nelson Turcotte, the President of Northwoods Hydropower (LinkedIn, 2017).

Wolverine Power Supply Cooperative

Wolverine Power Supply Cooperative (WPSC) is the current licensee with FERC for Tower and Kleber dams. WPSC is a member-owned generation and transmission electricity cooperative based in Cadillac, Michigan and has a contract with TKLP that allows TKLP to distribute and transmit electricity generated at Tower and Kleber dams (Wolverine Power Supply Cooperative Inc., 2015).

Michigan Department of Natural Resources

The Michigan Department of Natural Resources (MDNR) is the state agency responsible for managing and protecting Michigan's natural and cultural resources (MDNR, 2017a). Specifically, MDNR has "considerable management responsibility on rivers" that have FERC-licensed hydroelectric facilities (MDNR, 2017c). In this role, MDNR served as an intervener with FERC's licensing process for Tower and Kleber dams in 1994 to ensure impacts to Michigan's natural resources, such as fisheries, were adequately addressed (FERC, 1994).

MDNR is also the primary client for the SNRE master's project team on this project.

Local Governments

Tower and Kleber dams, along with the broader Black River watershed, cross several government jurisdictional boundaries including (but not limited to) Cheboygan County, Presque Isle County,

Forest Township, Waverly Township, and Allis Township. Tower Village also is located directly on the shores of Tower Pond, and Onaway City is located less than three miles away.

Tribal Nations

Tribal nations with potential interest in the dams include the Grand Traverse Band of Ottawa and Chippewa Indians, the Little Traverse Bay Bands of Odawa Indians, the Sault Ste. Marie Tribe of Chippewa Indians, the Bay Mills Indian Community, and the Little River Band of Ottawa Indians. In spring of 2015, the Tribal Councils of both the Grand Traverse Band of Ottawa and Chippewa Indians (GTB) and the Little Traverse Bay Bands of Odawa Indians (LTBB) approved motions calling for dam removal (GTB, 2015; LTBB, 2015). The language of each motion is nearly identical and advocate for removal of Tower and Kleber dams with the intention of rehabilitating the Black River sturgeon population (see Appendix V).

GTB is also the secondary client to the SNRE master's project team for this project.

Universities and Academic Institutions

Michigan State University has been involved in sturgeon research and restoration since 1997 and currently maintains and runs several research projects out of the streamside sturgeon hatchery next to Kleber dam (Michigan State University).

Environmental Organizations

There are several nonprofit environmental groups that have interests in Tower and Kleber dams. The Black Lake, Michigan chapter of Sturgeon for Tomorrow (SFT) works to improve the Black Lake sturgeon population through education, scientific inquiry, and assisting in management (Sturgeon for Tomorrow, 2017a). SFT also organizes the annual Sturgeon Shivaree that is hosted on Black Lake. The Black Lake Preservation Society (BLPS) consists of local and seasonal sportsmen and local property and business owners with the sole mission of protecting and preserving the ecology of Black Lake, its tributaries and watershed (Black Lake Preservation Society, 2016).

Landowners

There are two primary groups of landowners with interests in Tower and Kleber dams. Over 100 privately owned parcels are located adjacent to the shores of Tower and Kleber ponds. Black

Lake is also home to many homeowners that may be affected by downstream impacts of the dams, and they are represented by the Black Lake Association, (Black Lake Association, 2017). Some landowners adjacent to the ponds and Black Lake use their properties as seasonal residencies; others are year-round.

Fishermen

As discussed below, fishing is an important activity in the Black River watershed. The Michigan Darkhouse Angling Association is an organization focused on protecting "the rights of Michigan residents to harvest legal species by spearing from darkhouses," (Michigan Darkhouse Angling Association, 2016). Darkhouses are a specific type of windowless ice shanty used by spearfishermen that ensure a dark environment that allows them to see into the water.

Tourism Organizations and Local Business

A wide variety of businesses are located in the watershed, including restaurants, hotels, and recreationally oriented businesses (e.g. fishing gear). These businesses are represented by the Onaway Community Chamber of Commerce, which aims to promote businesses in the broader Onaway area (Onaway Community Chamber of Commerce, 2016). As a result of the prominence of outdoor recreation and seasonal residency in the area, as discussed later in this report, tourism is important for local businesses.

WHAT ARE THE IMPACTS OF THE DAMS?

A range of key topics emerged from our research and stakeholder input, which we then explored in greater depth. The following sections are intended to provide a basic understanding of how the dams are operating (**Physical Status of the Dams** and **Electricity Generation**), their impacts on local landowners (**Properties**, **Black Lake Water Level**, and **Sediments**), their impacts on recreational opportunities (**Recreation**), and their impacts on the local ecosystem (**General Ecological Health**, **Fish**, and **Sturgeon**). In each section, we address current conditions with the dams present and how those conditions may change in the case of dam removal. Providing this baseline, shared knowledge of current and future impacts will allow for a more informed dialogue among stakeholders as this decision-making process moves forward.

PHYSICAL STATUS OF THE DAMS

Snapshot of the Dams	
 **Tower Dam**	**Date Built:** 1918 **Nameplate Capacity:** 560 kW **Dam Type:** Concrete **Height:** 29.3 feet **Length:** 727 feet **Impoundment**: 102 acres
 **Kleber Dam**	**Date Built:** 1949 **Nameplate Capacity:** 1200 kW **Dam Type:** Earthen **Height:** 40 feet **Length:** 535 feet **Impoundment:** 295 acres

Physical Condition of the Dams

Despite the age of Tower and Kleber dams, recent records indicate that they are in relatively good shape. One interviewee with knowledge of the dams' conditions indicated that FERC has listed Tower and Kleber as low-hazard dams, which means they only need to be inspected every 2-3 years. This designation is also a reflection of FERC's determination that these dams would result in "no probable loss of human life and low economic and/or environmental losses" in event of failure (FEMA, 2004). In addition, a recent Dam Safety Surveillance and Monitoring Report (DSSMR) by FERC in 2014 stated that, although there are some moderate priority issues at both dams, there were no significant issues or any adverse findings in 2012 and 2013 (TKHLP, 2014). Importantly, Kleber Dam was found to be working "properly," and Tower Dam was found to be working "satisfactorily." Both designations indicate that there are no major concerns regarding the maintenance and integrity of the dams.

However, the inspections did recommend actions related to a few moderate and minor issues (TKHLP, 2014). For example, the inspection identified some moderate concrete deterioration at Tower dam that needed repairs. Based on the DSSMR in 2014, this issue and others were expected to be addressed by the end of 2014. A more recent inspection would be helpful in identifying any new issues, if any, that have occurred since 2014.

Accordingly, the dam owner does seem to perform regular maintenance on the dams. A search in FERC's eLibrary points to several maintenance activities that have been planned or recently completed by the dam owner, including an evaluation of emergency spillway scour, the development of an emergency action plan for Kleber Dam and the installation of signage, an audible alarm, and a strobe light for Tower dam to notify about changes in flow due to operational changes (FERC, 2016; FERC Online eLibrary, 2016; TKHLP, 2016a).

Perceptions of Integrity and Maintenance

Although residents are aware of the issues with generation (inefficiencies, broken turbines, etc.), they appear to trust that the dams will be maintained properly. Through our interviews and other conversations with stakeholders, we did not hear concerns about the structural integrity of Tower and Kleber dams. Local residents appear to trust the dam owner to maintain the dams appropriately and into the future. This may be the result of notification requirements by FERC, as during some repairs on Tower dam on August 13, 2012, the dam owner notified the public prior to and during a temporary drawdown of the water levels to allow for concrete repairs (FERC, 2015c).

Employment at the Dams

In terms of staffing, there are currently two full-time and two part-time employees working at the Tower and Kleber dams. Glassdoor, an online job search and information database, indicates the lock and dam operators at the US Army Corps of Engineers make between $40,000 and $44,000 annually (Glassdoor, 2016). Based on these numbers and an assumption that part-time employment equates to a 50% commitment, the economic value of the dams for employment in the region is between $120,000 and $132,000 per year.

Cost of Operation and Maintenance

Operation and Maintenance Costs

- Annual construction, operation, and maintenance expenses: $9,000
- Comparable dam maintenance costs: $1.24 million ($32,000-$2.9 million)

Although there are no significant issues with either of the dams at this point, there are still issues that would have to be resolved moving forward, in addition to normal operation and maintenance activities, all of which come with associated costs for the dam owner. The dam owner recently reported an annual construction, operation, maintenance expense of $4,500 for each dam, or $9,000 in total each year (FERC, 2015a; FERC, 2015b). Unfortunately, we do not have a good way of estimating the additional costs associated with more extensive maintenance activities. However, maintenance costs for dams in this size range (between 26 and 50 feet in height) range from $32,000 to $2.9 million, depending on maintenance requirements (ASDSO, 2009; ASDSO).

In 1994, FERC estimated a levelized net annual benefit from the dams of $69,350, which was based on a comparison of the cost of the dams ($173,600/year) and the cost of alternative power sources ($242,510/year) (FERC, 1994). Thus, they determined that Tower and Kleber dams are "economically beneficial" to the area. An updated analysis of the potential costs and benefits of the dams, if relicensed, would be necessary to determine how these values may have changed and if the project is still economically beneficial. However, as will be discussed later in Electricity Generation, Tower and Kleber dams may not be providing all the benefits originally anticipated in 1994.

Cost of Dam Removal

The cost of dam removal can range widely depending on the size of the dam (American Rivers, 2016). American Rivers estimates that the cost to remove an individual dam can range from tens of thousands to hundreds of millions of dollars. While these costs can be significant, dam removal costs can be up to five times less costly than what it would cost to repair and then maintain the dam for the duration of a new license (MDNR, 2017b). Based on past dam removal processes in Michigan, the cost of dam removal varies widely depending on the characteristics of the dams (e.g. height, length) (MDNR, 2010). However, a comparably sized dam, the Sturgeon Dam in Dickinson County, was removed in stages from 2003 to 2005, resulting in a cost of approximately $2 million (MDNR, 2010). More recently at the Boardman River Dams Project, the removal of a comparably sized dam (Brown Bridge Dam) cost $4.4 million, and the removal of two other dams

(Boardman and Sabin) is anticipated to cost $12.9 million (MDNR, 2017d). The cost of removal is expected to come from public agencies (MDNR, FWS) and private foundations. More information about the Boardman River Dams Project is available in Appendix VII.

Key Stakeholder Interests

- Dam maintenance needs
- Cost of dam repair versus dam removal
- Dam ownership and sale

Key Questions Moving Forward

- Are there structural issues for the dams that need to be addressed?
- What maintenance will be required and when? How much will long-term maintenance cost?
- Are there differences in maintenance needs and costs because of their structural differences (e.g. Kleber is earthen, while Tower is concrete)?
- What would be the potential cost of removal for these dams?
- Is there a possibility of the dam owner “walking away”? If so, who would be maintaining the dams long-term?
- What is the progress of the sale of the dams, and could information about the sale be made available to the public?

ELECTRICITY GENERATION

Although Tower and Kleber dams fell just short of the overall production target in their 1994 license in 2012, both dams are generating electricity and exhibit a level of reliability that is comparable to the national average for hydroelectric power.

Significance of Electricity Generation

Alverno, Kleber, and Tower dams (in order of downstream to upstream) are all hydroelectric dams. Alverno Dam was constructed in 1903 on the Lower Black River and has a separate FERC license. The Tower and Kleber Dams have nameplate capacities of 1200 kilowatt (kW) and 560 kW, respectively, and were combined into a single FERC license in 1994. The most recent license agreement spans 1994 to 2024.

Several interviewees noted the importance of the dams for electricity generation from the standpoint of reliability (e.g. in the event of an emergency or storm for major city buildings), and they are also considered a greener form of energy than the alternative. On the other hand, there were also respondents who noted that the dams are generally less important for powering this region.

Nameplate Capacity: The maximum rated output for a dam.

> ***"There isn't enough power coming from [the dams] to make a difference […] it isn't going to save me from having electricity or not."***
>
> ***- local resident***

To understand if the dams are producing a significant amount of electricity, we accessed operational data from 2012 through 2013 (MDNR files). Based on the generation data, Tower and Kleber dams generated a total of 6,099.2 megawatt-hours (MWh) in a one-year period from December 8, 2012 to December 8, 2013 (1,673.7 MWh by Tower and 4,425.5 MWh by Kleber) (see Figures 13 and 14 below). Relative to local electricity consumption, this amount does appear to be significant. For the 450 households of Forest Township, projected residential demand for electricity is approximately 4,049.4 MWh per year. This is calculated based on a per-household annual electricity consumption of 8998.69 kilowatt-hours (kWh) from the US Energy Information Administration's (EIA) Residential Electricity Consumption Survey from 2009. While there is likely

to be some loss through transmission, these numbers indicate that the dams produce more electricity than estimated by many of our respondents. Fittingly, some community members did express that they appreciate the hydro-electric power for its reliability and cost benefits.

> ***"Our hydro-electric power is great! It keeps our energy prices low and we never have power outages."***
>
> ***- local resident***

Another way to determine if this generation is significant is to compare it to the 1994 license. In the document, FERC estimated that Tower and Kleber dams would generate 7,498.5 MWh of "clean, domestic, reliable, and renewable energy" each year, which it uses to determine whether the project is economically beneficial. Thus, the dams did not achieve their expected level of annual generation from December, 2012 to December, 2013. Instead, the dams produced 81.3% of that target, which could also reflect a decrease in the economic benefit the dams provide.

Run-of-River Operation at Tower and Kleber Dams

It is also important to note that both Tower and Kleber dams are operated as run-of-river dams instead of releasing water only at peak storage and maximizing generation (FERC, 1994). While run-of-river is ecologically desirable, it can also have impacts on generation of the dams themselves (Jager and Bevelhimer, 2007; Kotchen et al., 2006). Based on studies of other dams, Jager and Bevelhimer (2007) found run-of-river operation to result in an average decrease of 3.6% in generation efficiency, which if applied to Tower and Kleber dams, would be lost generation of approximately 227.8 MWh per year for the dam owner based on the generation data shown above. However, a more thorough investigation of historical generation data for Tower and Kleber dams would be needed to conclude if run-of-river operation has resulted in any change in overall electricity generation.

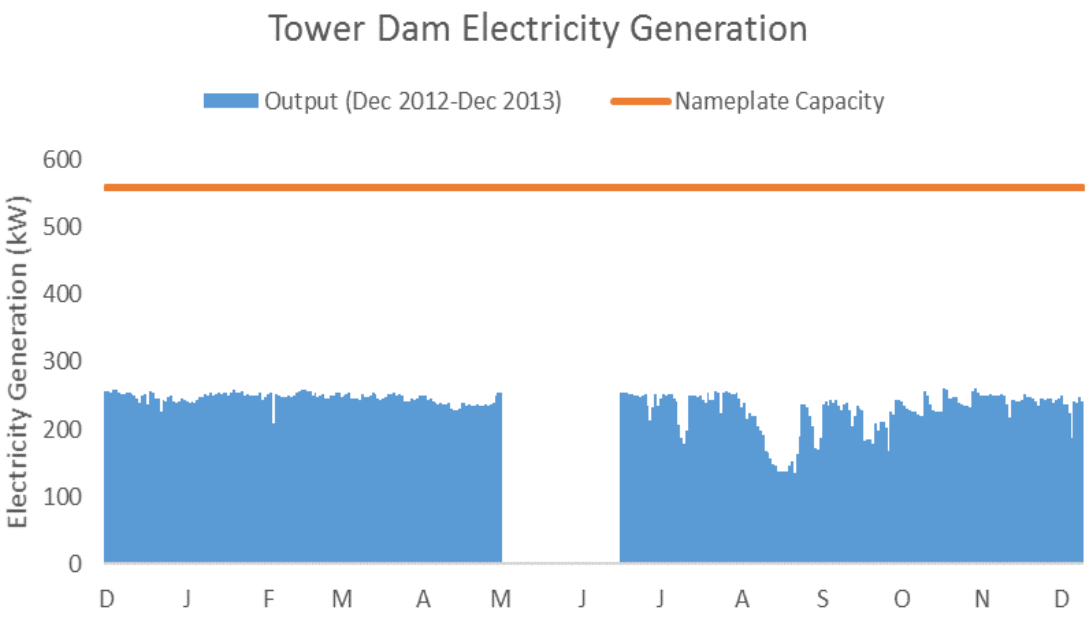


Figure 4. Tower Dam Electricity Generation and Nameplate Capacity from December 2012 to December 2013 (TKHLP, 2014)

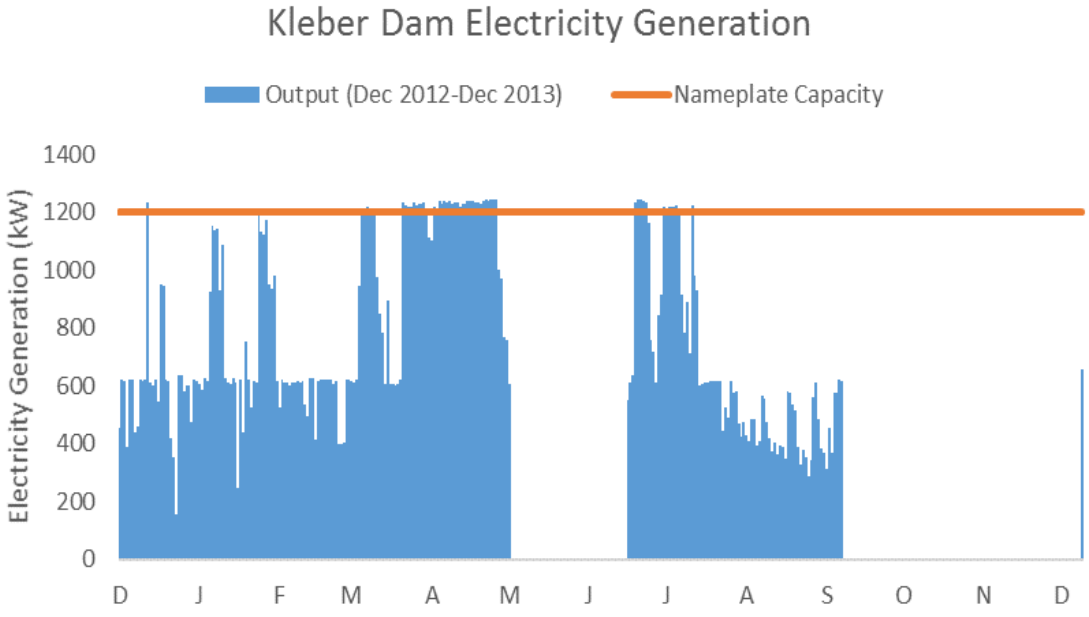


Figure 5. Kleber Dam Electricity Generation and Nameplate Capacity from December 2012 to December 2013 (TKHLP, 2014)

Reliability of Electricity Generation

Capacity Factor: The ratio of the amount of electricity produced by a dam as compared to the theoretical amount of electricity that could have been produced at continuous full power operation during the same time period.

When evaluating the reliability of electricity generation, the EIA reports a power source's capacity factor. The capacity factor is "[t]he ratio of the electrical energy produced by a generating unit for the period of time considered to the electrical energy that could have been produced at continuous full power operation during the same period" (US Energy Information Administration). Therefore, if Tower and Kleber dams were producing at capacity factors of 100%, they would be producing 560 kW and 1200 kW every hour for totals of 4,905.6 MWh and 10,512.0 MWh of electricity each year, respectively. Instead, Tower and Kleber dams produced 1,673.7 MWh and 4,425.5 MWh in 2013 (see Figures Figure 4 and Figure 5). This results in capacity factors of 34.1% and 42.1%, respectively, or a total capacity factor of 39.6% if taken together. While this may seem like an unreliable capacity factor, the nationwide average capacity factor for conventional hydropower was 38.9% in 2013 (and 38.0% in 2016) (US Energy Information Administration, 2017). Therefore, from a reliability standpoint, both Tower and Kleber dams are close to the national average for the reliability of their generation.

The data also point to a key difference in why Tower and Kleber dams are not achieving higher capacity factors. For Tower dam, the data indicate that one of the two turbines is not functioning at all, a finding that is corroborated by observation by local residents and by the DSSMR report discussed in Physical Condition of the Dams (see Figure 6) (TKHLP, 2014). On the other hand, for Kleber Dam the reduced generation does not seem to be due exclusively to a single faulty turbine, as there are instances throughout this period that both turbines are generating at full capacity (see Figure 7).

In addition to evaluating the amount of time the dams are producing no electricity, it is also important to understand how often they are providing only minimal electricity. In fact, one interviewee noted that a previous owner of the dam installed several diesel engines, as well as a jet engine, to deal with times when the dams are not producing sufficient electricity, so it is possible this has been an ongoing issue for the dams. This inconsistency is especially important for facilities that are rely more directly on the dams for electricity. For example, while the sturgeon

hatchery receives free electricity from the dams, they maintain backup power so that their experiments are not negatively impacted by reduced generation.

Efficiency of Tower Dam

- Proportion of nameplate capacity: 34.1% (1,673.7 MWh in 2013 out of 4,905.6 MWh/year)
- Percentage of year operating at <5% capacity: 13.3% in 2013

Efficiency of Kleber Dam

- Proportion of nameplate capacity: 42.1% (4,425.5 MWh in 2013 out of 10,512.0 MWh/year)
- Percentage of year operating at <5% capacity: 26.5% in 2013

To address this question, we evaluated how often the dam were generating at less than 5% of nameplate capacity, since those may be times at which there is insufficient electricity for the hatchery or other facilities directly linked to the dams. Tower dam was generating at less than 5% of nameplate capacity for 13.3% of the year. A similar trend is evident for Kleber Dam as evidenced in Figures Figure 5 and Figure 7, and Kleber Dam generated at less than 5% of nameplate capacity for 26.5% of 2013. From these numbers, there appear to be significant periods of time where Tower and Kleber dams are not providing sufficient electricity for facilities that rely directly on them, which requirements additional investments by those facilities in backup generation capacity, which can be costly. For example, backup generators for homes can cost anywhere from $2,000 to $20,000 depending on the capacity needed and installation costs (Sims, 2015).

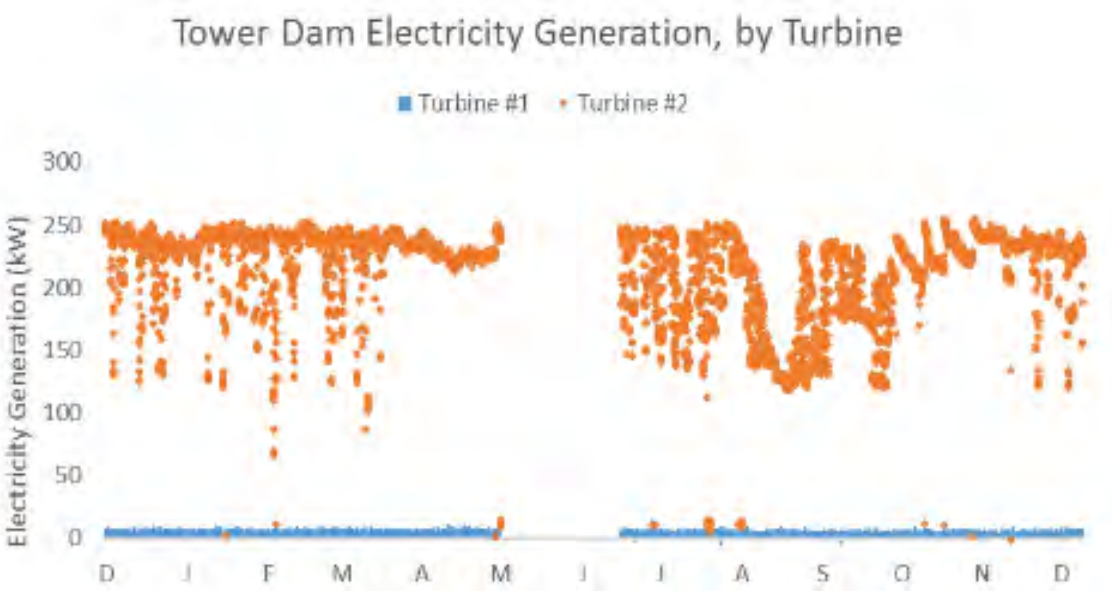


Figure 6. Tower Dam Electricity Generation by Turbine from December 2012 to December 2013 (TKHLP, 2014)

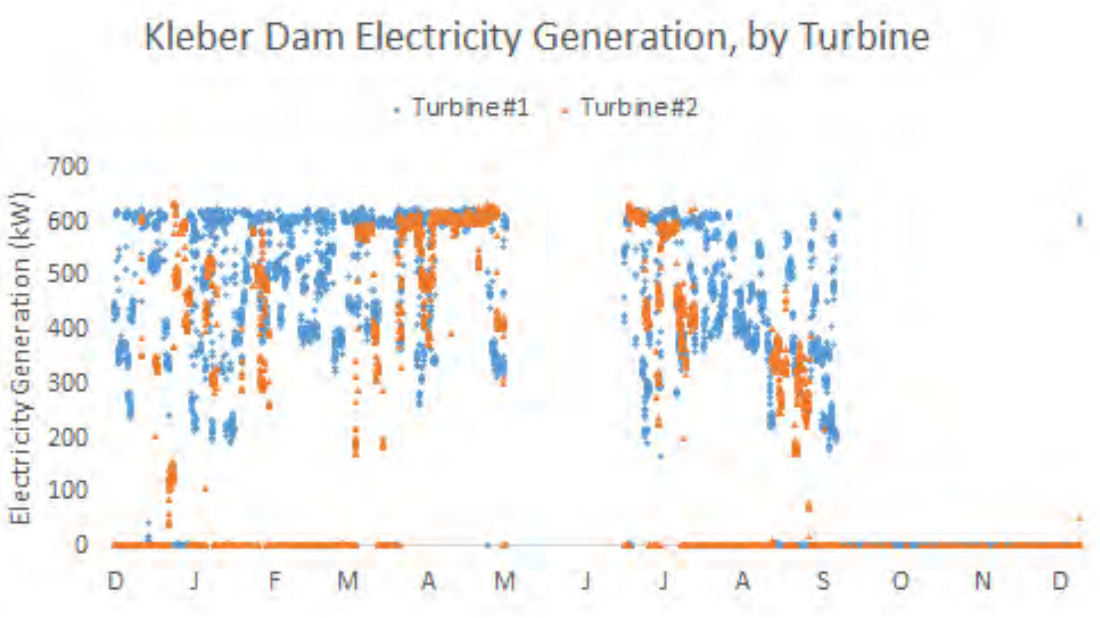


Figure 7. Kleber Dam Electricity Generation and Nameplate Capacity from December 2012 to December 2013 (TKHLP, 2014)

Electricity Transmission

While reliability is important to facilities that receive electricity directly from Tower and Kleber dams, the only facilities that receive electricity directly are the sturgeon facility and the Forest Township Hall. The remaining electricity is distributed to the regional grid and is in fact sold to seven of Wolverine Power Supply Cooperative's (WPSC) nearby wholesale cooperative customers (FERC, 1994). Unfortunately, revenues associated with wholesale distribution into the broader electricity grid were unavailable. However, the cost of transmission that WPSC charges the TKLP to distribute to the grid could be identified. Based on a recent amendment to this distribution agreement, TKLP must pay Wolverine Power $736.07 each month, an increase of 9.1% from their agreement prior to 2014. (Fulbright & Jaworski LLP, 2014; MISO, 2014). This figure, especially if paired with a future understanding of revenue from selling electricity, will give a better understanding of the cost-effectiveness of the dams as sources of electricity generation.

Key Stakeholder Interests

- Reliability of electricity generation
- Cost of hydroelectric power
- Upkeep of dam and impact on electricity production

Key Questions Moving Forward

- How much revenue do the dams generate through electricity production? How is this expected to change in the future based on projected changes to production capacity?
- Why are the dams inconsistent in their generation?
- How is electricity from the dams distributed in the grid?
- What is the impact of losing the electricity the dams provide on the grid (e.g. grid reliability, electricity prices)? How would that loss be offset?

PROPERTIES

When dams are built on a flowing water body, the water level is raised and a portion of the landscape upstream of the dam structure is flooded. This flooding creates a reservoir of water behind the dam, also referred to as a pond or an impoundment. Depending on the local landscape, the flooding can expand the amount of shoreline available for development, and neighborhoods are commonly found along the shores of these man-made ponds. The properties that are developed along the impoundment have access to unique waterfront characteristics that their landowners often point to as reasons for purchasing the property to begin with. These characteristics include the aesthetic value of a waterfront view and direct access to water-based recreation, such as fishing, boating, and swimming. It is crucial to understand the values impoundment landowners place on their properties and, especially, the inherent trade-offs associated with keeping or removing the dams. The following section: (1) examines the potential impacts of dam removal on specific concerns expressed by impoundment landowners, (2) explores the properties along Tower and Kleber ponds, and (3) evaluates the value of properties in this watershed.

Impoundment: a body of water, such as a pond or reservoir, that is formed by obstructing flow in a river.

Impacts of Dam Removal

Overall, the individuals we spoke with had a variety of primary and secondary concerns about a dam removal scenario. Impoundment landowners are generally supportive of keeping the dams because they value their waterfront property and do not want their ponds to disappear. One even told us he "can't imagine the negative impacts of the dams on the area." The section below explores the specific characteristics that were identified and the potential impact of dam removal on those characteristics.

Aesthetics and Recreation

Some of our respondents were especially attached to the ease of access they had to recreational activities from their backyards and attached docks. One landowner also mentioned that there are two side ponds that feed into Kleber Pond and are commonly used for specific types of fishing, which would also be affected if the water were drawn down due to dam removal. Similarly, having bought their property with the current aesthetic (waterfront impoundment land), that aesthetic is something they value, and some indicated a desire to pass that onto their children in the future. Some landowners also expressed a general desire to avoid change in the area.

> ***As you get older, the more sameness you like.***
>
> ***- local resident, in reference to conditions of Tower and Kleber ponds***

If the dams were to be removed, the water levels would decrease, resulting in an increased distance from the water's edge for certain landowners based on where the resulting river established itself. One landowner speculated that the river would end up establishing several hundred feet from their property. This increase in distance could impact their ease of access to recreational activities from their backyards, in addition to changes to the available recreational activities themselves (discussed in the Recreation chapter).

Connectivity of Transportation

Respondents also had concerns related to Kleber Dam and the access road that runs along the top of its structure. This bridge provides public access and community connectivity, and is likely used by many local residents for transportation and commuting. This road is the only one that traverses the western and eastern sides of Black River for several miles along this stretch of the river, providing a more convenient connection between communities on either side of the water. It also provides access to the sturgeon hatchery, which is located on the northern shore of the river. According to one interviewee, this road is currently owned and maintained by the dam owner instead of by the county. Therefore, if Kleber dam is removed, individuals would lose their access to the other side of the Upper Black River. Using Google Maps, we determined that the next nearest crossings across Upper Black Rivers are 2.5 miles upstream (south) and 4 miles downstream (north) of the current crossing over Kleber Dam. Depending on the routes taken, this could add a significant amount of additional travel time.

Property Rights

One of the other concerns several local residents brought up in our interviews was in regards to property rights and boundaries. Some respondents, especially riparian landowners, seemed concerned about who would end up owning the additional exposed land once it is no longer a lakebed. One resident hypothesized that some owners, depending on their distance from the resulting river channel, would gain several hundred feet of property since their ownership rights would extend to the riverbank itself. This hypothesis appears to be supported by a 1995 court holding in *West Michigan Dock and Market Corporation v. Lakeland Investments*. In that case, the court held that ownership goes to riparian landowners adjacent to the inland bottomlands "unless those lands have been sold in fee title." Therefore, unless the landowners (or the original

property developers) explicitly sold their rights to the bottomlands, the exposed lands would go to the property owners currently living adjacent to the water.

However, in other instances of dam removal in Michigan, this expansion of private property ownership has been challenged by local governments, who claim the newly exposed land should be owned by the public instead (Walker, 2009). If local residents do not end up owning the additional land, they may be upset that they not only lost their waterfront aesthetic but also direct, private access to the water.

Property Taxes

On the other hand, some residents may find ownership of additional land to be problematic from a property tax standpoint, as they now will be responsible for payment of additional property taxes. In fact, one waterfront resident indicated concerns about potential increases in property values in the area, which would result in higher property tax payments.

> ***"The worse it looks around here, the better it is for my taxes. It isn't an investment. It's where I live. And I'll keep living here as long as my taxes are less than six, seven hundred, that's just fine with me."***
>
> ***- local resident***

Property Values

On the other hand, some residents indicated during the public meeting that they view their properties as financial investments and are concerned that any impacts on property value, even if temporary, could negatively affect their ability to retire. For example, while studies of similar dam removal scenarios have pointed to either neutral or beneficial impacts on property values (see "Dam Removal and Property Values" below), it is unclear what the consequences would be immediately after removal, especially as some benefits of dam removal (e.g. riparian green spaces) may not be fully realized in a shorter time frame.

Ecological Transition

Some respondents also brought up issues related to the transition period from impoundment to river. If the dam were removed, much of the water in the impoundment would drain down, exposing significant amounts of muddy lakebed. While vegetation would eventually grow, and create a riparian area, residents are unlikely to enjoy looking out at acres of mudflats from their backyards in the interim. Importantly, there is considerable uncertainty about how long this

transition period would be. An analysis of several dam removals in Wisconsin found that the mud flats naturally revegetated between three and 49 years after removal (Lenhart, 2000). On the other hand, two other studies found the area to be covered with vegetation following the first growing season (Orr and Stanley, 2006; Shafroth et al., 2002). Those studies, however, point out that this first-growth of vegetation is generally dominated by plants that grow rapidly, a characteristic that may favor invasive species.

Removal would also affect the water itself. “It would be a similar problem to what happened at the Pigeon River with the Song of the Morning Dam. It took about two years or so to clear up before it ran clean again.” Considering many of the landowners are retirees, there may generally be an aversion to changing conditions, especially if the transition period will take a long time. However, based on experiences from other watersheds, this transition period has generally been relatively short (pers. comm. P. Hanchin).

DAM REMOVAL AND PROPERTY VALUES

Impacts of dam removal on property value was consistently brought up throughout our interviews with impoundment landowners. In order to better understand those financial impacts, we have explored scientific literature for studies that have examined that question in comparable dam removal scenarios. Two key studies are profiled below.

Provencher et al. (2008) compares property values in three different sites in south-central Wisconsin near Madison: 1) those by an intact dam, 2) those by a dam that was removed, and 3) those by a free-flowing river or stream. Their study relied on market sales data from 1993 through 2002. The results of their analysis indicate that dam removal has little impact on property values in the short-run (two years in this study) and can, in fact, increase property values in the long-run as the newly exposed river and riparian zone mature or are managed as open space. It is important to note that waterfront properties in this study gained newly exposed bottomlands following the removal of the dam. For waterfront properties, their direct frontage access to the water converts to a riparian-type frontage, which increases the properties' values.

Lewis et al. (2008) evaluated the effect of removal of the Edwards Dam on properties near the Kennebec River in Augusta, Maine by comparing them to properties upstream near the Ft. Halifax and Lockwood Dams. Their study found that, historically, properties closer to the dams had a property value penalty relative to those further away. Importantly, that penalty decreased over time, and they pointed to the removal of the Edwards Dam as a potential contributing factor. One important caveat to this finding is that this effect may also be part of a broader restoration effort of the Kennebec River, of which the removal was an important part. If the broader restoration is an important factor in improving property values, then those positive benefits may not be realized immediately. In this study, they had data for six years following the removal of the dam.

Properties on Tower and Kleber Ponds

Tower dam creates a 102-acre reservoir while Kleber dam holds a 295-acre reservoir accounting for 2.72 and 6.74 miles of shoreline, respectively (FERC, 2015a; FERC, 2015b). Resulting from

the expanded waterfront area, there has been a significant amount of development on the shorelines, which is especially evidenced along Tower pond (Figure 8). Many of these residents appreciate living on the impoundments because of the ease of access to recreational opportunities, such as boating and fishing, from their backyards. Landowners also appreciate the ponds' and wildlife. The deepest connection these landowners have with their property is the family legacy they have from decades or generations of living there. Since their waterfront property exists because of the dams, impoundment landowners would be disappointed to see the dams removed.

> ***"I've never heard anything negative about [the dam]. It's just an integral part of our community here. It's always been here, and everybody just kind of coalesces around it."***
>
> ***- local resident***

Based on our interviews, some properties are utilized as seasonal homes for individuals who work in other parts of Michigan or other states. These individuals come to this area to spend leisure time with access to outdoor recreation. As such, the property market here is likely different from a typical housing market in that many parcels may still be less developed in order to be used for camping or other temporary and seasonal purpose. However, in some instances some of these seasonal landowners have since retired and built more permanent structures to live on the property year-round.

In total, there are 111 individual private property parcels that are owned by landowners (57 on Tower Pond, and 54 on Kleber Pond), as opposed to parcels owned by the state, the dam owner, the regional utility, or other businesses (Cheboygan County GIS) (see Figure 8 and Figure 9). Based on aerial imagery and parcel data, we were able to distinguish between property parcels that have are developed (e.g. presence of permanent structures) and those that are not, of which there were 75 and 36, respectively (see Figure 10 and Figure 11). Finally, we were able to determine, based on ownership information, that there are 42 parcels (15 on Tower, and 27 on Kleber) that are owned by seasonal residents (individuals whose permanent addresses are elsewhere), making 69 of the impoundment landowners permanent residents of the ponds.[3] Proportionally, it appears that Kleber Pond is a more popular location for seasonal residents, likely

[3] For privacy considerations, we have chosen not to visualize property owned by seasonal residents.

because its neighborhoods are more recent than those along Tower Pond. Of those 42, seven are in fact out-of-state seasonal residents. Finally, 22 of the developed parcels are owned by seasonal residents.

In addition, it appears that much of the shoreline real estate development has also resulted in not only growth but also improvements in the overall housing market in this area by building those neighborhoods outwards. While there are 111 landowner property parcels with direct access to the shores of Tower and Kleber ponds, these properties are part of neighborhoods that at times extend a few blocks off the waterline, although most of the houses within them are still in close proximity to the water (see highlighted parcels in Figure 12). For properties that are within the same neighborhoods but not directly adjacent to the water, they still have access to the ponds but may have to utilize public access points (e.g. state or township lands) instead of private access (see Figure 8 and Figure 9). Therefore, when evaluating the future of the dams, it is important to consider the interests of this set of landowners as well.

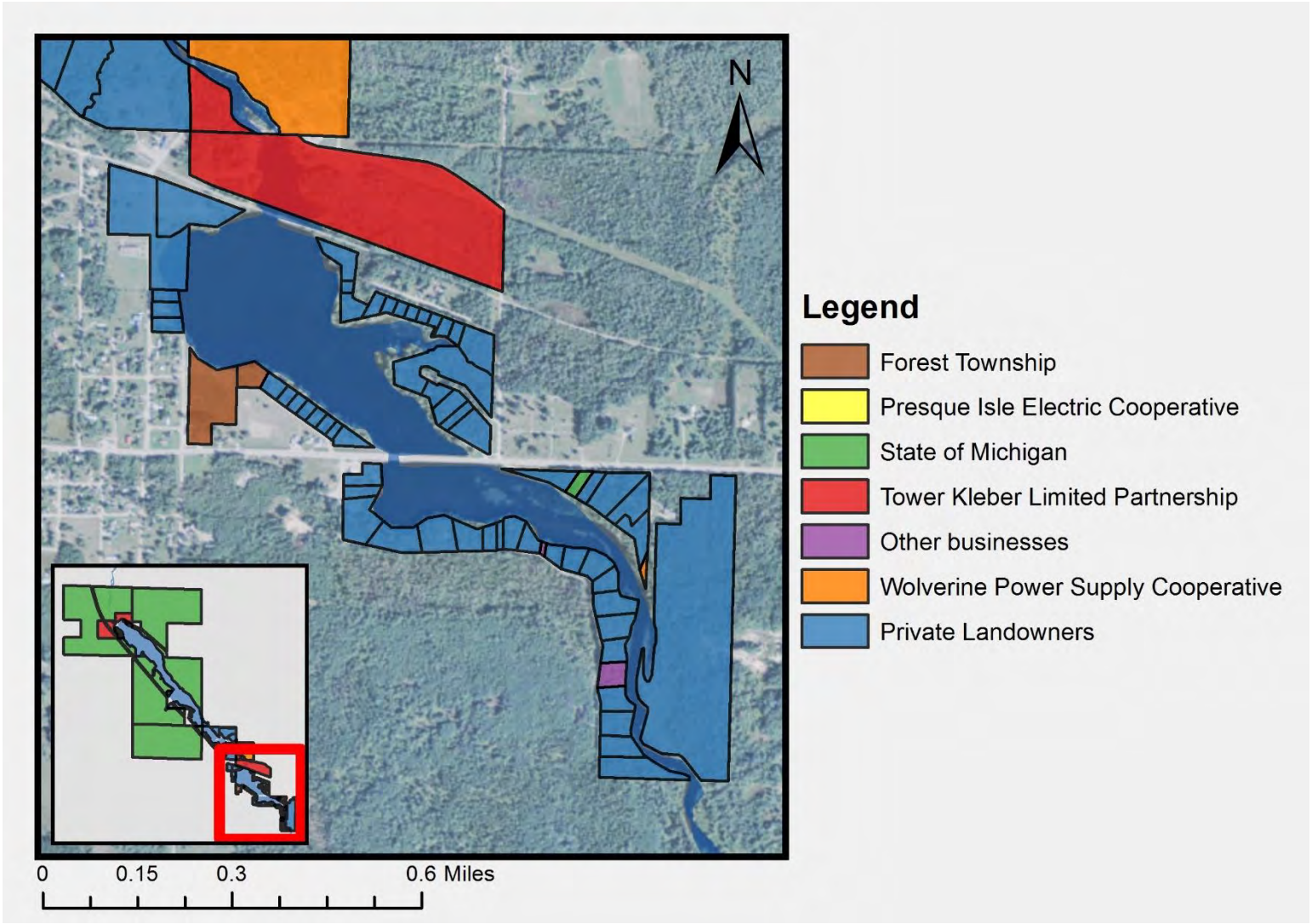


Figure 8. Property Parcel Ownership Along Tower Pond (Cheboygan County GIS)

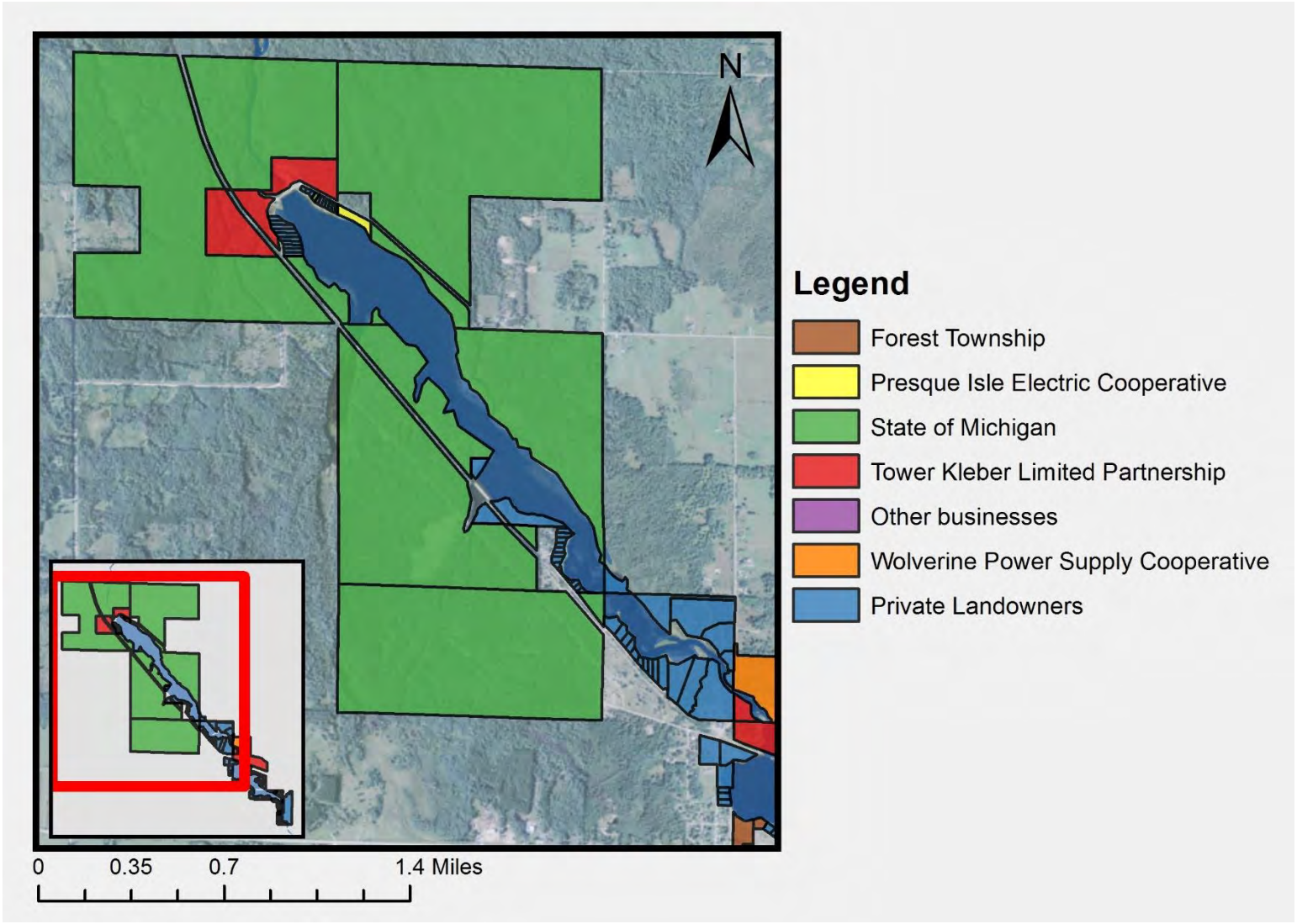


Figure 9. Property Parcel Ownership Along Kleber Pond (Cheboygan County GIS)

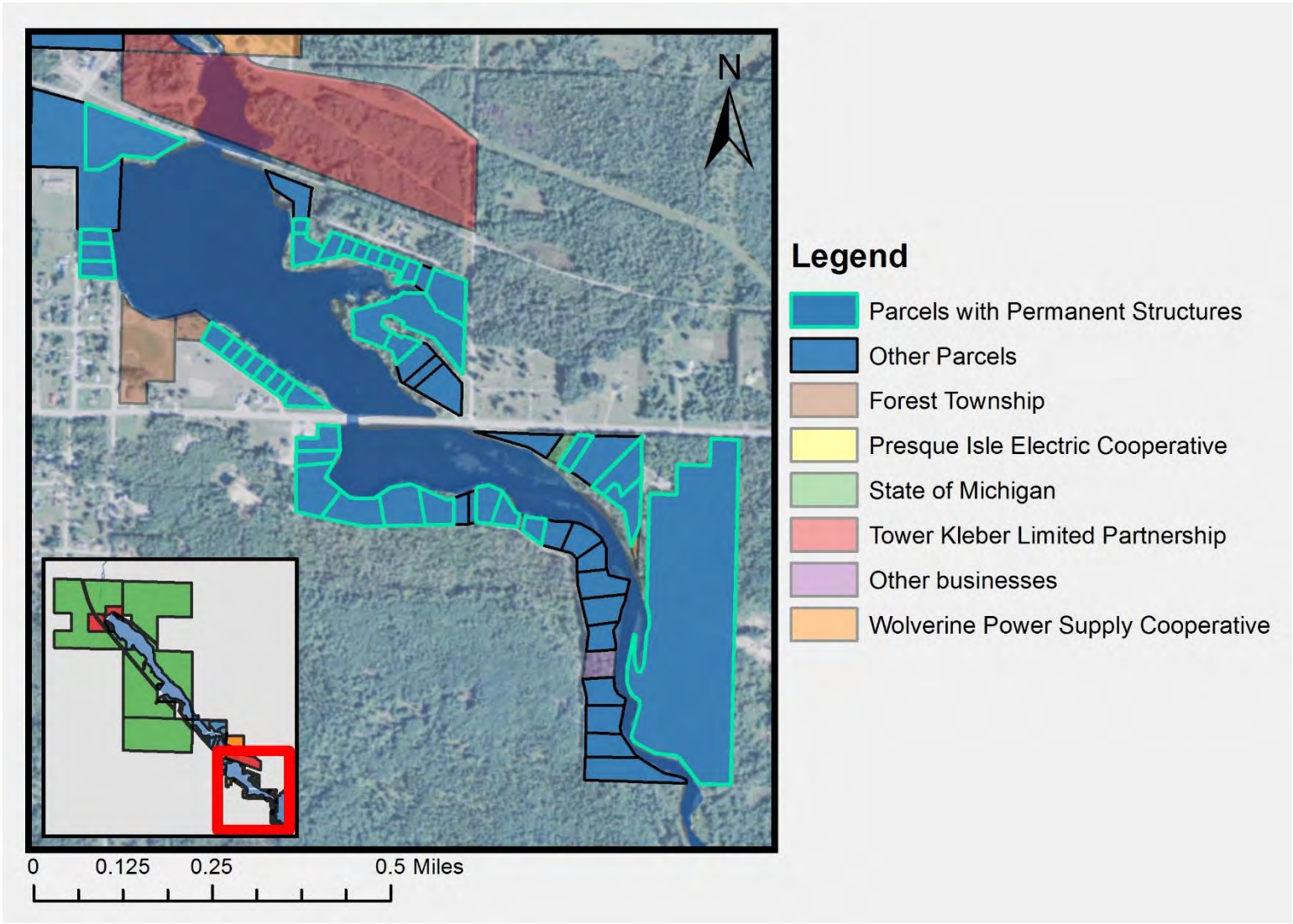


Figure 10. Private Property Parcels with Permanent Structures on Tower Pond (Cheboygan County GIS)

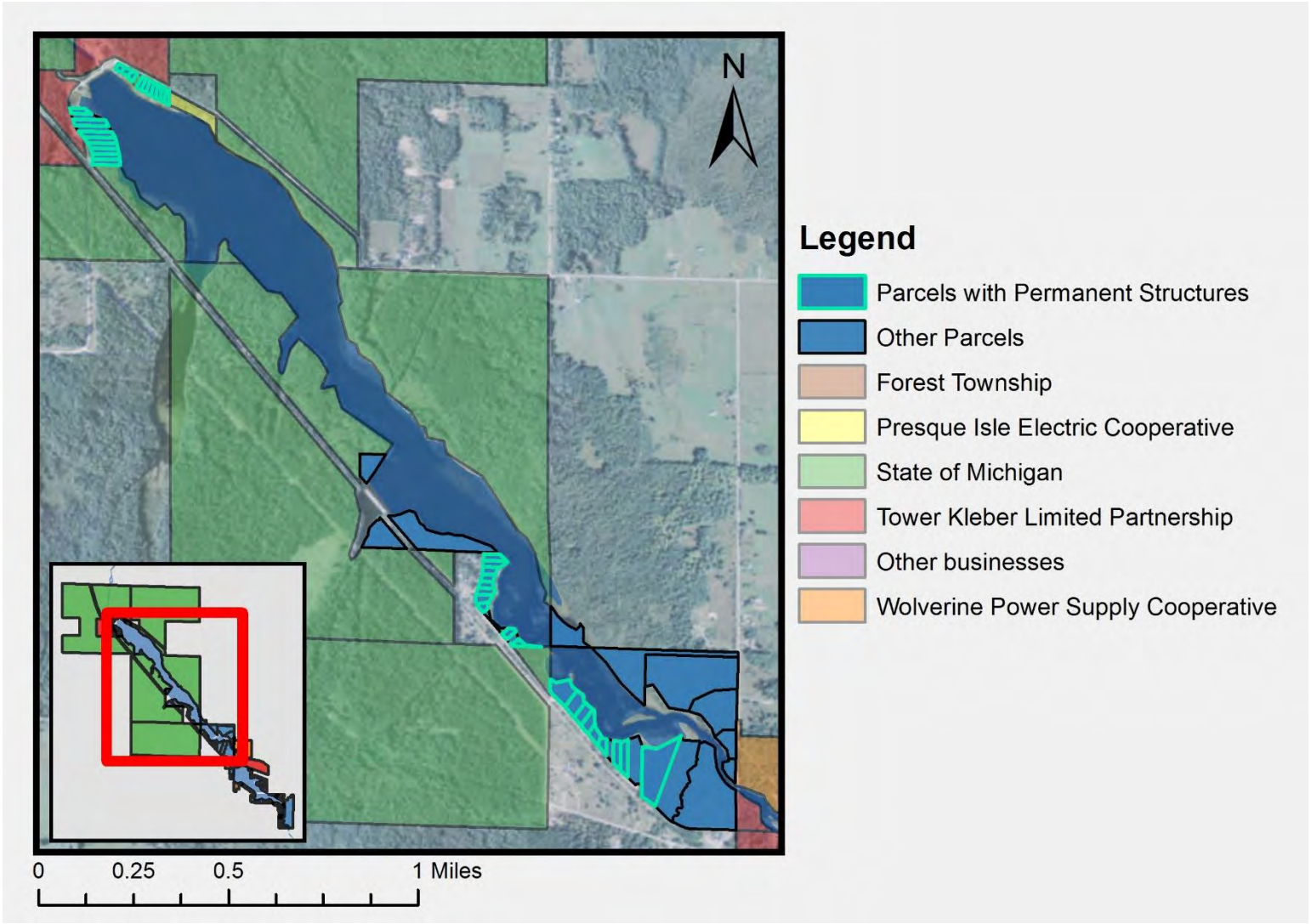


Figure 11. Private Property Parcels with Permanent Structures on Kleber Pond (Cheboygan County GIS)

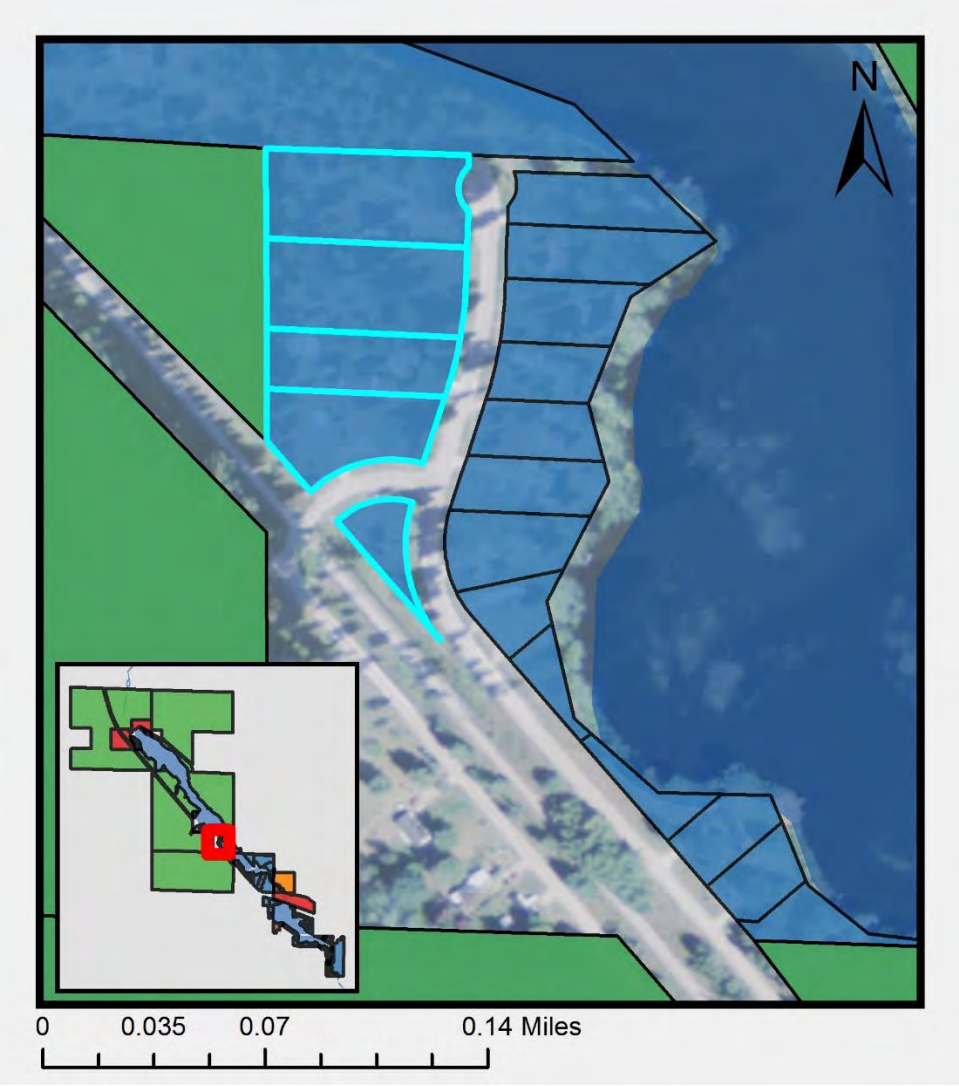


Figure 12. Non-Waterfront Properties in a Neighborhood on Kleber Pond (Cheboygan County GIS)

Value of Waterfront Properties

With the potential impacts of dam removal and extent of property development on Tower and Kleber ponds in mind, we also sought to develop a baseline understanding of property values in the area so that future analyses of the potential impacts of dam removal have a reference point.

Tower and Kleber Pond Property Values

As noted previously, there appears to be a significant amount of property development on the shores of the two ponds. Based on data available on Zillow.com, property on the Tower and Kleber ponds sold for an average of $79,849.89. This points to property as an important investment for local landowners. According to the US Census Bureau (2014), 15.3% of the population in Forest Township[4] is under the poverty line, and the median individual income is $24,778. While this figure encompasses a broader geographic region than just impoundment landowners, it does suggest that properties here serve as significant investments that require multiple years of financial savings.

In evaluating the values of these properties, we also categorized properties based on the impoundment they adjoin and whether they are waterfront or not. As stated earlier, there are distinct differences in the experience of living near the impoundments for those on the water relative to those that must use public access points. Because of this difference in ease of access, we might expect there to be differences in the property values as well. Notably, if those properties are more desirable to the average landowner, we might expect waterfront properties to be more expensive relative to non-waterfront properties, holding other factors equal (Lansford, Jr. and Jones, 1995). In fact, Bohlen and Lewis (2008) project a 15.8% increase in property value for waterfront characteristics.

Average property values

- Waterfront property: $93,858
- Non-waterfront property: $51,833

Average per-acre property values

- Waterfront property: $122,866
- Non-waterfront property: $15,572

Before looking at the Zillow housing transaction data in greater detail, it is important to emphasize that there are not enough recent transactions to make any conclusive statements in comparing property prices related to various

[4] Forest Township encompasses Tower Village, which is the main area of population near the impoundments. More information about Forest Township and the other geographic units are available in Appendix III.

house characteristics. However, the data do suggest a price premium for living closer to the water. The waterfront properties by the impoundments are listed for significantly more ($93,858) than their neighboring properties not along the water ($51,833). Furthermore, the average per acre property value is $122,886 for waterfront properties ($94,350 for Kleber and $137,154 for Tower) but only $15,572 for non-waterfront properties ($29,605 for Kleber and $1,538 for Tower).

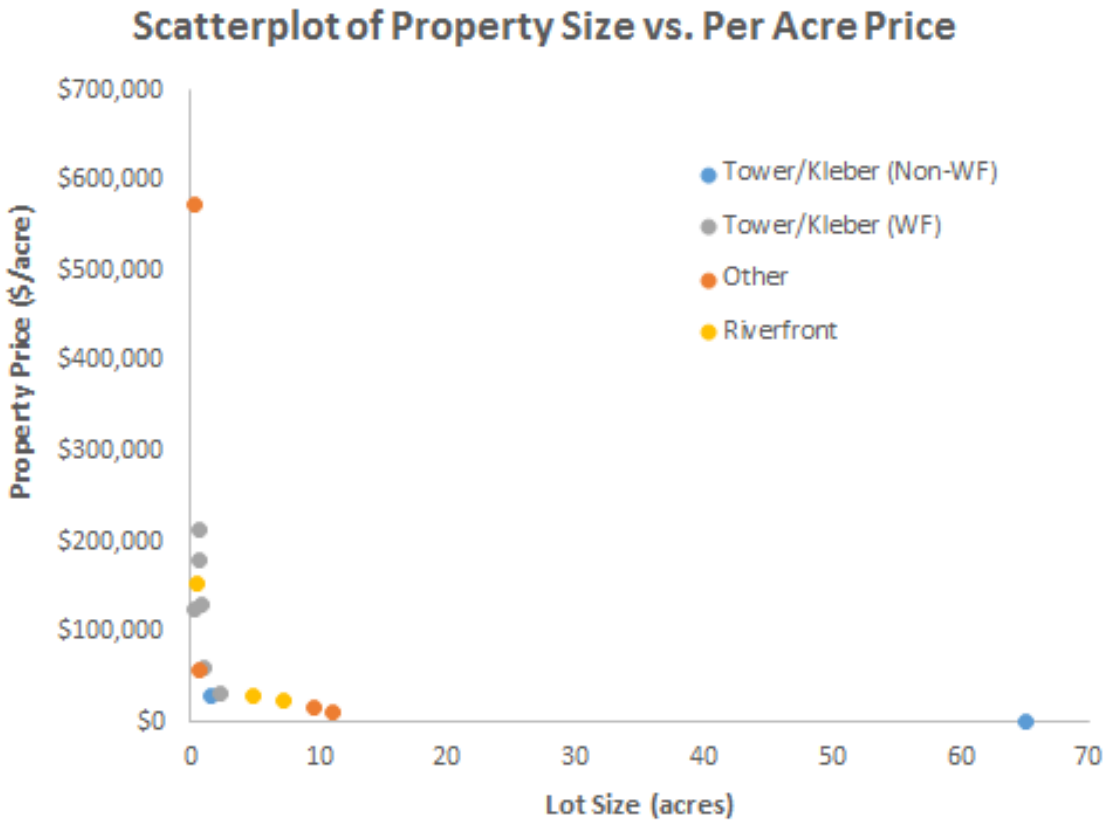


Figure 13. Scatterplot of Property Size vs. Per-Acre Prices for Properties Near Tower and Kleber Ponds

While we do not have enough data to evaluate the reasons underlying this difference, there may be two factors that play into it. Waterfront properties have direct access to recreation on the impoundments, which makes fishing and boating opportunities much more accessible and



convenient as discussed previously. In addition, waterfront properties have frontage, which offers nicer views of the water, and the price difference may represent the value of that aesthetic.

In addition, there are differences between properties near the impoundment and those further away. The average per acre value for non-waterfront properties further away from the impoundments is $164,208 and is $69,330 for properties along riverine portions of Black River upstream of the impoundments. The difference in prices between these properties and those along the Tower and Kleber Ponds may be due to significant differences in the characteristics of those properties, such as greater seclusion and access to land-based recreation (e.g. hunting) or larger contiguous tracts of land. A more detailed study of these property parcels would be necessary to make any conclusive statements about this region.

Black Lake Properties

In addition to properties that are directly along the shores of Tower and Kleber ponds, there is also a significant amount of housing development along the shores of Black Lake. Many of these landowners are concerned about potential downstream impacts of dam removal, as changes to sediment flow or flood control have the potential to influence their properties as well. These perceptions and potential impacts are explored in depth in the following two sections of this report.

Average property values

- Waterfront property: $75,111
- Non-waterfront property: $192,663
- Riverine property: $162,583

Average per-acre property values

- Waterfront property: $511,023
- Non-waterfront property: $23,874
- Riverine property: $70,210

In the past few years, 61 properties were sold along Black Lake (Zillow, 2016). Based on these 61 transactions, property along Black Lake sold for an average of $146,861 between 2013 and

2016 (Zillow, 2016). When equalizing for size, the average per acre value was $259,526. These values are significantly higher than those along Tower and Kleber ponds and are likely a reflection of the higher aesthetic and recreational appeal of living along Black Lake.

Key Stakeholder Interests

- Avoiding ugly and costly transition periods
- Maintaining property rights
- Maintaining property value
- Preventing trespassing
- Having access to information

Key Questions Moving Forward

- Who currently owns the impounded land underneath Tower and Kleber ponds?
- What is the legal status of property rights allocations for newly exposed bottomlands stemming from dam removals in Michigan, and specifically for properties on Tower and Kleber ponds? Where can residents go to find this information?
- Where would the new waterline be? How long would the transition from pond to river take?
- Are there implications for regulatory takings if a dam removal process were to proceed?
- What direct impacts on the housing market could be expected if a dam removal were to move forward?
- What opportunities would there be to restore exposed bottomlands as green space? Who would be responsible for the restoration and costs?
- How would the two ponds be impacted differently? (aesthetics, clarity, rapids, property values, etc.)
- Does dam removal significantly impact neighboring groundwater supply?

BLACK LAKE WATER LEVEL

Many residents and landowners are concerned with the water level in Black Lake and are accustomed to a perceived sense of control offered by Tower and Kleber dams. However, under normal flow conditions, Tower and Kleber dams do not hydraulically control the water levels.

A key concern expressed by residents on both Black Lake and the impoundments, as well as seasonal and recreational visitors, is the ability to maintain water levels in Black Lake and avoid damages to shoreline property. Tower, Kleber, and Alverno dams appear to offer control over the hydrology in the Black Lake watershed and many fear losing the perceived control. However, Tower and Kleber dams may not offer flood protection or hydraulic control over Black Lake water levels. While not a focus of this project and not up for license renewal, we discuss Alverno dam below since it does appear to have hydraulic control on water levels.

A primary concern for riparian landowners and residents on Black Lake is maintaining the proper water levels in Black Lake to avoid damage to property. Rapid fluctuations or high water levels as well as high winds and waves can lead to destructive erosion problems along the shoreline and lake shore. Residents have noted expensive property damage due to ice and high water levels during winter months. During March and April of 2016, property owners experienced damage to shoreline and property due to high water levels, above-average precipitation, and high winds (BPLS, 2016). These property owners express anger and concern about events like these and are vocal about preventing them in the future.

Boaters also expressed interest in maintaining water levels so that they can clear boat hulls, avoid weedy vegetation, and utilize docks in the shallow shoals of Black Lake. Although not directly related to lake levels, similar concerns were expressed by kayakers and canoers regarding water levels in Black River, expecting that water be deep enough for rivercraft. Shallow waters and “washed-up muck” lead to disused beaches. “If they could guarantee that taking out those dams would not affect lake level [or] cause any more problems to the residents around the lake, I’m sure everybody would be happy,” said one resident. To address these concerns, better understanding is needed among community members about the factors influencing Black Lake's water levels.

Effect of Alverno Dam on Water Levels

The primary structure controlling the Black Lake water levels is Alverno Dam, downstream of Black Lake. It is through this structure that the flow coming from Black Lake must pass. The county Drain Commissioner is the "delegated authority" regarding inland lake levels as stated by a statute in the Michigan Environmental Protection Act, Act 451 of 1994. According to the Cheboygan County Drain Commissioner, the Black Lake water level "is controlled at the Alverno Dam in Benton Township" (Jankoviak, 2013). An engineering feasibility study inspected Alverno Dam in 1995 and found that "if Alverno was partially removed, water level would drop 3-4 feet on Black Lake and Black River. If removed entirely, 30% of Black lake would become mud flats" (Fargo, 1995).

Water Levels by Court Order:

- Summer: 612.2 feet
- Winter: 610.2 feet

Transitions periods:

- April 15th to May 15th
- November 1st to November 30th

On August 25, 1964, the State of Michigan Circuit Court in the County of Cheboygan ordered that the legal summer level of Black Lake shall be 612.2 feet above sea level from May 15th through October 31st and that the winter level shall be 610.2 feet above sea level from December 1st through April 15th. It also ordered that the waters be raised from the winter level to the summer level during the period April 15 to May 15th and that the waters shall be lowered to the winter level during the month of November. Control of the water level in Black lake is to be achieved via discharge adjustment through Alverno dam. The FERC-issued dam operation license for Alverno acknowledged that "because the project serves as the hydraulic control for Black Lake at some flow levels, the Alverno Project should be operated to pass more or less than inflow to maintain the water surface elevation of Black Lake" (FERC). Alverno is now operated in a non-peaking, modified run of the river mode in order to maintain court ordered water levels. The Black River Limited Partnership (BRLP), which operates Alverno dam and is also managed by Nelson Turcotte, has received complaint letters regarding the water levels in Black Lake and is working toward compliance despite variables such as temperature, precipitation, and Smith Rapids discharge (TKHLP, 2016b). Black River Limited Partnership and Black Lake Preservation Society both suggest lengthening the period of drawdown to lower Black Lake water level to winter levels (TKHLP, 2016b, BLPS, 2016).

The Smith Rapids, located between Black Lake and Alverno Dam, can hydraulically control the water levels in Black Lake under medium-high flow conditions. Described in a study done by the

Army Corps of Engineers (ACOE) in the 1960s, “the Smith Rapids section is a channel constriction that restricts the flow of water to the point that the Smith Rapids, not the dam, controls the outflow from Black Lake during periods of high water.” From the ACOE report, a discharge value between 0 to 800 cubic feet per second (cfs) passes unconstricted through the rapids, making Alverno dam the hydraulic control structure. Discharges greater than 900 cfs are restricted by the Smith Rapids, thus controlling the water levels (ACOE, 1965). When Smith Rapids are the controlling structure, releasing additional flow from Alverno Dam will not impact the water level in Black Lake. At the time of the court order for water levels, however, it was thought that Smith Rapids would be reconstructed, thus leaving Alverno Dam as the only hydraulic control.

In March of 2017, the Black River Limited Partnership conducted an observational trial to test the hydraulic control of Alverno dam on Black Lake water levels. The goal was to see if drawing down Alverno Pond could drawdown water from Black Lake by allowing for greater discharge (approximately 750 cfs) through the dam. Since this trial was run during warm, spring temperatures, the snowmelt and spring runoff is assumed to be high. BRLP found that Black Lake water levels continued to increase despite the drawdown at Alverno. This implies that Smith Rapids act as the hydraulic control during the time of the trial, at which the discharge was estimated to be 750 cfs. BRLP has since requested that the ACOE reexamine the hydraulics of Black Lake, Smith Rapids, and Alverno to update their understanding from the 1965 report.

Effect of Tower and Kleber Dams on Water Levels

Under normal precipitation and flow conditions, the storage in Black Lake is largely determined by downstream controls, given that Tower and Kleber are operated run-of-river. Run-of-river operation requires that the inflow entering the impoundments be equal to the discharge released out of the dams. According to local perception, the three dams together form a “balancing act” of water level control. The operation of the three dams in respect to each other may affect the water level in Black Lake, however, it is the balance between the inflows and outflow which determine water levels. Inflows include the Upper Black river, Rainy river, and other tributary creeks, all of which have variable discharges related to the rates of precipitation, snowmelt, and infiltration. Black River drains Black lake and flows toward Smith Rapids and Alverno Dam. The discharge from the lake depends on the water surface

Run-of-river operation: operation of a dam such that inflow entering the impoundments is equal to the discharge released out of the dams.

elevation and the relative water surface elevations of the lake, the pond in front of Alverno, and the backwater in front of the rapids.

In the case of a large storm, measured by intensity or duration, the dams could offer storage in the impoundments and the operator's ability to control discharge through the dams has potential to mitigate damage from high water levels. However, Tower and Kleber would only be able to attenuate, or store, some of the peak flow collected by Black River; other inflows to Black Lake would still contribute higher-than-normal flow. Stormwater storage offered by the floodplain of the Upper Black River should be investigated as a potential mitigation for high flows.

Key Stakeholder Concerns

- Maintaining Black Lake water levels
- Preventing flooding (stormwater management)

Key Questions Moving Forward

- What is the extent of control on water level in Black Lake by Tower and Kleber?
- How does Alverno affect Black Lake levels?
- How would Burt and Mullet Lakes water levels be affected by dam removal?
- How do the dams control stormwater flows?
- What storage can the floodplain offer in storm events?

SEDIMENTS

Impoundment landowners and lake residents both express concern regarding the potential for property damage and shoreline erosion. The presence and removal of dams will impact sediment transport locally.

Rivers can shape the landscape on a regional and local scale through erosion and deposition processes (Ligon, 1995). Hydroelectric dams are built to utilize the potential energy in rivers by forcing drops in elevation. This can, however, impact the sediment transport in the river, leading to buildup of sediment before the dam and often scour pits behind (Petts, 1984). Homeowners around the ponds and Black Lake both express concerns related to property damage and shoreline erosion.

Concerns about Sediment

- Build-up and potential release behind dams
- Cost associated with sediment removal
- Shoreline erosion and property damage
- Vegetation growth and effect on recreation
- Inhibited nutrient transport into Black Lake

Even without formally studying the Black River system, residents and river-goers intuitively know this area well. Homeowners are aware of the vegetation growth, varying stream and pond depths, and have watched the erosion and deposition over time. According to some impoundment property owners, they have an idea of where the river would form, if the system returned to free-river system. This idea is largely based on the presence of vegetation growth in areas that have collected sediment build-up, and outline where the deepest part of the river would form. Some residents have an awareness of the transport of sediment in Black River, particularly at depositional sites like the river mouth or erosion sites at certain bends in the river.

Sediment Build-up

Most stakeholder groups expressed concerns regarding silt build-up behind the dams. Many worry about who is responsible for maintaining appropriate water level and capacity in the ponds. Others expressed concerns about the potential for contaminants or toxins to be present in the sediment build-up due to local knowledge of a former landfill site near Tower pond. Additional worries were expressed regarding the physical maintenance of the dams along with addressing the buildup of sediment, to reduce risk of damage in the—albeit unlikely—case of a dam breach. Residents assume the dam owner would cover the cost of maintaining the ponds behind the dams, including removal of sediment; however, the responsibility of who would bear the cost of removal has yet to be determined.

Concerns regarding the transport of sediment and chemical loads are supported by scientific literature. In a free-flowing system, nutrient rich sediments can be carried downstream, and the deposits can offer diverse types of habitat (Eckman, 1983). By introducing a dam and creating an impoundment, the backwater storage allows for sediment and chemicals to settle out behind the dam. Build-up of sediment deposits behind the dam reduces the water-storage capacity, as well as reducing the ability to produce hydroelectric power (Ligon, 1995). This collection of sediment is rich in nutrients and provides substrate for vegetation to grow. In the case of dam removal, the sediment released has potential to alter or burry habitat for spawning, feeding, or staging. Downstream of the dam, the changes to substrate can vary, depending upon the flow regime and can create highly unstable habitat (Bain et al., 1988).

Sediment Removal in Impoundments

Sedimentation was brought up by a few interviewees as a significant issue needing to be addressed, especially in Tower Pond. This not only affects the recreational benefits of the impoundments, but can also result in increased maintenance costs for dam operation itself as sediments damage turbines and other equipment (HydroCoop, 2013). Furthermore, in event of dam removal, sediment must often be managed to minimize downstream sediment loading and resulting ecological impacts, such as fish kills. One method for addressing sedimentation in the reservoir is dredging. This can be a significant expense for dam owners, with estimates at around $6 per cubic yard of material (ASDSO). This value is likely assuming the sediment is free of contaminants. Other reported values for sediment management range from $1-25 per cubic yard for clean sediment and $50-500 per cubic yard for contaminated sediment (Melchior et al.).

To apply the $6 value to Tower and Kleber dams, we determined what a “typical” dam maintenance requires in terms of sediment removal. ASDSO reports that a slightly smaller dam (22 feet high) required removal of a total of 5,000 cubic yards (ASDSO). If we extrapolate this value to Tower and Kleber dams based solely on height (29.3 and 40 feet, respectively), that amounts to a cost of approximately $39,954 and $54,545, respectively (or 6,659 and 9,091 cubic yards). It should be noted, however, that height does not directly correlate to the size of the impoundment itself depending on topography and other factors. As a result, it is important to conduct a more extensive study of the sediment loading for Tower and Kleber dams to better understand the amount of sediment that would need to be removed for maintenance or removal reasons. This study should also attempt to approximate the life-expectancy of the dams in terms of acting as a sediment trap and losing storage capacity.

Given that this is a two-dam system; it is possible the owners would need to dredge both dams separately. However, some interviewees hypothesized that Tower dam functions as a sort of sediment trap which collects sediment before reaching Kleber pond. This seems to be corroborated by a corresponding lack of concern about sedimentation in Kleber pond. Alternatively, the lack of sediment build up in Kleber may simply be a function of the younger age of Kleber pond. However, there is still suspended sediment in the water of Kleber pond, as the sturgeon hatchery notes the importance of filtering out sediment from the water it pumps from the reservoir (MSU, 2017)

Alverno dam also acts as a sediment trap downstream of Black Lake, but does not seem to present cause for concern. In 1995, an engineering feasibility study looked at the status of the Alverno dam and determined that there was a small amount of sediment stored behind dam, which was unlikely to require removal by dredging (Fargo, 1995).

Erosion and Property Damage

Furthermore, residents are concerned about the potential for erosion along the river and have an interest in avoiding damage to their property resulting from stream bank erosion. Downstream of the dam, hydrologists refer to the water as “hungry water” because of its apparent eroding power. The erosion damage is due to the rate of erosion remaining constant, and the rate of deposition decreasing, since material accumulates in the reservoir (Poff and Hart, 2002).

Vegetation Growth

Both seasonal and permanent residents have expressed concerns regarding the rate of vegetation growth in Black Lake along areas of sediment deposition close to the mouth of Black River. The nutrient-rich sediments are deposited at the river mouth and northwestern beaches and provide nutrient-dense substrate for accelerated growth of vegetation. Residents lament over disused beaches, often ignored due to weedy shallows. Boaters are concerned about clearing their propellers and avoiding catching weeds. Vegetation growth is also apparent in the impoundments behind the dams. Residents have noticed Tower pond getting shallower and increased vegetation growth in collected sediment.

Current and Future Research

A research project at the streamside hatchery at Kleber dam is investigating the substrate characteristics of Black River downstream of Kleber dam. Through side-scan sonar techniques, researchers are looking to characterize the substrate along Black River, as well as gather data on depth and bottom hardness, in order to understand the longitudinal pattern. By calibrating readings with known substrates—cobbles, sand, silt, etc.—researchers can create a "map" of the river around the dams. With information about the substrate, cross-sectional depths, and energy requirements for sediment transport, a model may be developed to understand the dynamics of the system given potential future changes. Software programs developed by the Hydrologic Engineering Center (HEC) within ACOE would be useful to visualize the flow regime, sediment distribution, and useable habitat under free-flowing and dam conditions.

Key Stakeholder Interests

- Avoiding sediment deposition and related fish kill
- Avoiding contaminated or toxic sediment

Key Questions Moving Forward

- What would happen to the built-up sediment and who would deal with it?
- Are there toxins or contaminants in the sediment in the ponds? If so, how will they be dealt with and who will deal with them?

RECREATION

Recreation is woven into the character of the Black Lake watershed, where a variety of activities have long been enjoyed by local community members and visitors. This section explores recreation's current use, future considerations, and economic impacts.

Current Recreational Use

The Black Lake watershed currently facilitates a variety of recreational opportunities that provide many social and economic benefits to nearby communities. In the area overall, activities include fishing, boating, hiking, biking, snowmobiling, ATV use, wildlife viewing, and sturgeon-related events. Pond recreation, recreational fishing, and recreational boating are especially rich opportunities that should be considered in the dam decision-making process.

Pond Recreation

Tower and Kleber ponds support many types of recreation that are highly valued by the area's residents and visitors. Fishing, as described below, is a common pastime for local residents and visitors. The ponds are also used for many different types of boating including rowboats, jet skis, canoes, kayaks, sailboats, rafts, and stand up paddleboards. Family or community events, such as the Mother's Day canoe race, take place on or around the ponds. Many residents shared how much swimming goes on in the ponds, especially Tower, where children swim every day in the summer and even jump off the bridge to have fun. During the winter, popular activities include ice skating, ice fishing, and snowmobiling. The dam owner facilitates these recreational activities through public access points and amenities such as boat launches and portages (FERC, 2015a; FERC, 2015b).

In addition to these water-based activities, state land around the ponds offer primitive camping. The local parks and recreation department is currently working on sites around the ponds to turn into community parks. The Rails to Trails program is adding to recreation opportunities in the area, stretching from Detroit all the way to Mackinac. Trails such as the North Eastern State Trail and other nearby trails provide ample



opportunities for snowmobiling, biking, hiking, and ATV use. People also value the ponds for the habitat they provide for wildlife like loons, eagles, and deer.

Dam Owner Recreation Report

Tower Pond (FERC, 2015b)

- 964 total visits in 2015
- Popular recreational amenities: boat launch area, reservoir fishing, trails

Kleber Pond (FERC, 2015a)

- 1,490 total visits in 2015
- Popular recreational amenities: tailwater fishing, visitor center, boat launch area

The dam owner recently reported on recreational use of the Tower and Kleber dams and associated impoundments for FERC (FERC, 2015a; FERC, 2015b). The reported use for these dams is based on a variety of methods, including visitor counts, surveys, attendance records, and staff observation. According to these reports, 95% of the shorelines for each of the impoundments (2.72 miles for Tower and 6.74 miles for Kleber in total) are available for public use, which likely promotes the amount of use reported. In total, there were 1,490 visits to Kleber and 964 visits to Tower in 2015 (FERC, 2015a; FERC, 2015b). During the most popular weekends, there were an average of 63 and 69 visits over a full weekend to Tower and Kleber, respectively. These reports reinforce that the ponds are locations for a lot of recreational use. Some residents noted that recreational use of the ponds has increased over time.

Recreational Fishing

Regardless of their preferred fishing methods, all the fishermen we spoke with agreed on one thing: fishing is important to them for both recreational and cultural reasons. They all mentioned in some way that fishing is woven into the identity of the area, whether the people fishing are local residents or visitors. One resident told us, “The first thing people ask when they find out I’m from here is: how’s the fishing?”

The Black Lake area is home to a passionate and polarized fishing community, which implies differing priorities for fishery management. Fishermen tend to have favorite target species and are generally indifferent toward the others. People also have different views depending on whether they prefer lake or river fishing, bait or fly fishing--the attitude and recreation experience is different for the two methods. Overall, these preferences often seem central to a person's identity as a fisherman, and sometimes is manifest as a rivalrous or negative attitude toward other types of fisherman.

Stream Fishing

The Upper Black River, including Tower and Kleber ponds, is designated as a trout stream (Fisheries Order 210) and is "among the best brook trout streams in Michigan" (MDNR, 2017f; MDNR, 2017g). One seasonal visitor mentioned, "there's great brook trout fishing on the Black River, there's a secret spot I like to go to on the Black. I can't tell anybody about it."

Major Species

- Brook trout
- Bluegill
- Common shiner
- Yellow perch

Fly fishing is commonly done in the Upper Black River; reaches above Tower Pond remain cold and unaffected by beavers and logjams, offering habitat for brook trout. Some enthusiasts describe fly fishing as experiential, challenging, and even spiritual. One seasonal visitor describes his fly-fishing experience on the Black: "It makes it more of a challenge, because to get to those trout, they are embedded under that bank under all these briars growing overhead and there's a river and muck and rocks and stuff and it makes it so hard to get them that, when you do get them, it's just way worth it."

> ***"The Upper Black River has long been considered one of Michigan's finest brook trout fisheries."***
>
> ***- Upper Black River Council***

Although fly fishing can also be a passionate pastime of local residents, fly fishing seems to be more popular with visitors and seasonal residents than with year-round residents. One seasonal resident discussed his love for fly fishing but explained that he has to go to the headwaters: "I'm a fly fisherman, so I love the natural lands at the headwaters of Black River. You can't really find brook trout by the ponds." Fly fishing on the Upper Black has been historically popular as well, with Ernest Hemingway fishing and writing about his experiences there in his 1935 book, "Green Hills of Africa."



> ***"It's just like when we were kids and we heard about a river no one had ever fished [the Black] out on the huckleberry plains beyond the Sturgeon and the Pigeon."***
>
> ***[…]***
>
> ***"Big trout?"***
>
> ***"The biggest kind."***
>
> ***"God save us," said Pop. "What did you do then?"***
>
> ***"Rigged up my rod and made a cast and it was dark and there was a nighthawk swooping around and it was cold as a bastard and then I was fast to three fish the second the flies hit the water."***
>
> ***- Ernest Hemingway, "Green Hills of Africa" (p. 150-151)***

Lake and Pond Fishing

Where fly fishing is described as challenging and engaging, lake or pond bait fishing is described as relaxing, social, and a way to catch your dinner. Landowners along local lakes and impoundments generally prefer bait fishing. Some local residents perceive pond fishing to vary seasonally as well, noting that they see it as most socially and economically important in the winter when ice fishing is possible. One interviewee caught a "29-inch walleye out here ice fishing" and describes how their whole family enjoys the sport: "our kids come up a lot now...ice fishing, they come up just for that."

> ***"Sometimes we've gone up there [Tower] because they have a lot of good bass size. Five-, six-pounders. It's a lot of fun to go up there and try for them there."***
>
> ***- local resident***



K. He

Black Lake offers many opportunities for fishing several types of fish including muskellunge, northern pike, yellow perch, walleye, and bass (Cwalinski and Hanchin, 2011). Black Lake is also known for its short spearfishing season for targeting lake sturgeon. The most popular of these

fisheries in Black Lake are walleye and muskellunge. To indirectly protect other species, the limits on northern pike, a predatory fish, are relaxed to encourage fishing for pike thereby controlling population size. Pike are common in Black Lake in the vegetated shallow areas.

Major Species

- Muskellunge
- Northern pike
- Yellow perch
- Walleye
- Smallmouth bass

Tower pond is included in the Black River system that is known for a wild brook trout population and is currently included in the designated trout stream (Fisheries Order 210; MDNR, 2017g). Designation as a trout stream means that the conditions and habitat support a trout population, which can be fished within limits. These often include relaxed limits on Northern Pike in an attempt to lessen the predatory pressure they place on trout. Tower pond offers open access to all fish from April through September, but remains open to northern pike spearing in winter months (Fisheries Order 214 and 219; MDNR, 2017g). Based on the small number of catch reports from this pond, interest in fishing opportunity in this pond is relatively low. More information on the quantity and economic impact of fishing is described below.



Recreational Boating

Boating is a popular recreational activity in the Black Lake watershed. Similar to fishing, boating experiences are different on a river than on a pond or lake. Pond landowners take their boats out to fish on the ponds. Other types of watercraft used on the ponds include canoes, kayaks, rowboats, jet skis, sailboats, rafts, and stand up paddleboards. Residents seem to have less strong preferences for boating than they do for fishing, and seem more likely to do multiple types of boating. For example, some Black Lake residents take their powerboats or jet skis on Black Lake, but also enjoy kayaking on the Black River.



Other local residents especially enjoy canoeing on the Upper Black River below Kleber dam to see things like fall colors, sturgeon, and wildlife. Kayaking and canoeing is generally more popular on the river than the ponds or Black Lake, especially since most of the land along the river is "natural" undeveloped state land that is considered beautiful for exploring in this type of boat. However, several canoers and kayakers describe current difficulties with navigating the river due low water levels that require dragging boats along the upper reaches of the Upper Black River.

Future Considerations

The decision to relicense or remove the dams would affect the variety of recreation currently occurring at the ponds and surrounding watershed. Tradeoffs would likely occur with new river-based recreation replacing some pond-based activities. Pond property owners, local community members, visitors, and others all express concern for losing pond recreation. However, some also express excitement about new opportunities that could come with dam removal. This section explores those concerns and opportunities.

Stakeholder Concerns

Concerns about Overall Recreation

Recreation is an integral part of why people love living near or visiting the ponds. It follows that there is a great deal of concern over the potential disappearance of the ponds and the activities associated with them. Beyond the social and cultural value, the ponds' recreational opportunities are also important for the local economy. One resident explained that this is especially true for the town of Tower where "there is no economy other than recreation and tourism...if you take away the pond there would be nothing left."

Residents share perceptions of community changes over time, including demographic shift and a decline in industry (see Appendix III), which underlie and likely amplify current concerns. People describe some features no longer present at the Kleber pond, such as a swimming beach, the

Shanty Rapids, and a pavilion. People seem to miss the pavilion, at which dances, parties, and other events were held; it has not been replaced by any new gathering place. Some also perceive, with some disappointment, that Tower pond used to be deeper and cleaner than it is today. These past changes lay the groundwork for strong concerns that more will be lost.

Members of nearby communities express concerns about changes in public access to the ponds with a potential dam removal. Any changes to public access, especially increased land area from potential shoreline or mudflat, should be carefully considered; landowners are worried about increased trespassing, which has been an issue in the past with boaters and fishermen. People also raise the question of how camping and access would change on the state land adjacent to the pond. Several canoers and kayakers, explaining that the Upper Black River is already very shallow and difficult to navigate, wonder how river levels would change and affect boating opportunities. Many people, even those who do not live directly on the ponds, call for decision-makers to give adequate weight to the rights and concerns of pond-front property owners.

Concerns about Fishing

People are concerned about how fish communities would change in the case of dam removal. People who target river species express excitement to see a return to a free-flowing system and an increase in river miles. On the other hand, people who fish the two ponds would be upset if the ponds disappeared. Some pond fishermen have perceived that fishing has already declined, and worry about how future dam scenarios would make that worse. They enjoy fishing the ponds for bluegill, bass, and pike, and are concerned about future management of those species especially if the dams were removed. They also tend to be indifferent to trout or other river fish and do not see those as management priorities that should influence the decision about the dams. Even some local residents who value both types of fishing believe there is already enough river fishing in the area, so the focus should be on managing pond and lake fisheries: “I go a couple miles in any direction and I find all the river fishery I want.” Although they generally favor free-flowing streams, local environmental groups also acknowledge that it is important to consider the benefits the dams bring and the possible impacts of removal. One member of a local environmental organization wondered, “would we have colder water without the dams? Would sturgeon handle it? Would we have trout? Would it be a mixed fishery?” They wonder if the dams might actually benefit fish species they care about by maintaining warmer-water habitat and trapping sediment so that rocky bottom habitat is preserved.

Perceived Opportunities

Dam removal has the potential to bring several new recreational opportunities to the area. New recreation seems to center on increased river mileage, allowing boats to travel farther without portaging and offering fly fishermen access to more trout habitat. Future visions also include the potential emergence of whitewater at the dam sites. These recreational opportunities highlight some social and economic benefits that could be brought about by dam removal.

Increased River Miles

Many fly fishermen seem to be in favor of dam removal because returning to a meandering, free-flowing river could increase trout habitat. A free-flowing river means you can canoe, kayak, or otherwise boat farther. Without Tower and Kleber dams, people would have uninterrupted boating access to more river miles on the Upper Black River. Many local and tourist boaters would be excited to have this opportunity. However, several residents and seasonal visitors express concerns about logjams and shallow stretches below Kleber dam that currently prevent passage and wonder how these would play into a dam removal scenario. Opening additional areas of river including whitewater could add another form of recreation, aesthetic appeal, tourism, and business potential.

Aside from the dam decision, some residents also envision exciting opportunities for marina development on Black Lake and elsewhere that could facilitate increased boating access and popularity. They believe this would expand business opportunities if the relevant towns, organizations, and agencies focused on developing this kind of infrastructure.

Future Whitewater Opportunity

It is also important to understand the state of the river channel under the impoundments. Dams are generally built in river segments with the highest gradient in order to provide the greatest potential for hydropower. It is therefore likely that a significant gradient is submerged beneath one or both of the dams, producing rapids and whitewater.

Some community members remember the Shanty Rapids just upstream of Kleber dam, which would likely be exposed if the pond were drained. They also describe a vertical drop-off or waterfall that would be uncovered at the site of Tower Dam. Many people express excitement in rediscovering the aesthetic and community value of these sites through drawing down Tower Pond. This could present a unique opportunity for communities in the area to add recreational activities, community spaces, and tourism. For example, the City of Petoskey created a whitewater park by removing five dams along a quarter-mile stretch of river through the downtown. The plan for the park, drafted in the 1980s and finished in 2011, was well-supported by community members and has become an exciting community asset for local residents and visitors alike (City of Petoskey).



Future Economic Opportunities

Recreational opportunities for both residents and tourists, especially surrounding boating and fishing, could also help strengthen the local economy. The area's current recreational activities support some businesses, especially related to fishing such as Parrott's Outpost and Northeast Flyfishing in Onaway. However, several respondents expressed that, based on the level of interest in these activities, these types of businesses may be able to expand and grow. Some people in the community even perceive a decrease in tourism lately, which might be related to a decrease in fishing and has led some local businesses to close. Community members have identified a variety of avenues to help expand these businesses. Some people call for the development of boating infrastructure or a Black Lake marina. Whitewater creation and increased river miles could allow for new boating outfitters. Some fishermen say improving fish populations other than sturgeon would help business the most. Other community members believe improving the sturgeon population and habitat would be the biggest benefit based on an associated increase in spawning run tourism.

Economics of Recreational Activities

Since dam removal can create opportunities for new forms of recreation, it is important to understand the potential for dam removal to impact the local economy through those changes to recreational opportunities (Headwaters Economics, 2016). Our analysis relies on the fact that there are already river- and pond-specific forms of recreation in the watershed, as discussed above. Specifically, we focus on our understanding of fishing in the region, as there are data we can use to estimate the relative economic value of river fishing and pond fishing. These estimations are driven by an assumption that the value of river-specific fishing (e.g. flyfishing) can be calculated by subtracting the value of pond fishing from the value of fishing overall in the watershed. Before proceeding, this is purely an illustrative calculation that can, and should, be refined through a clearer understanding of the popularity of these different types of fishing.

These estimates rely on state-level data and are extrapolated to this watershed based on the population of Forest Township (see Appendix III) relative to the statewide population. These numbers are also extrapolated to Tower and Kleber ponds through our understanding of property ownership along their shorelines. It is important to note that Forest Township does not encompass all of Tower and Kleber ponds, so it is technically a mismatch to compare the population of Forest Township overall with that of Tower and Kleber. However, this does allow for an isolation to purely river and pond fishing without taking into account fishing on Black Lake, which is a very prominent recreational destination. This initial analysis provides a gross estimate that can assist with future discussions, especially as these numbers are refined through fishing surveys as noted above.

Watershed-level Estimates

Our first estimate is of the revenue MDNR derives through selling fishing licenses to local residents. In 2015, 696,889 licenses were sold to Michigan residents (pers. comm. P. Hanchin, MDNR). For this calculation, we focus on the "Resident Annual" fishing license[5], which costs $26 per year (eRegulations, 2016). In addition, we assume that a large proportion (50 to 75%), but not all, residents in the area participate in fishing. Therefore, if using the Forest Township population of 1,045 residents, we assume that between 522 to 784 residents purchase fishing licenses annually, resulting in between $13,585 to $20,378 in annual revenue for MDNR (eRegulations, 2016).

[5] There are other types of fishing licenses that are shorter term or for specific demographics that are not included in this calculation in order to make the calculation more simplistic.

In order to estimate the importance of fishing inclusive of its other economic impacts, we can create a rough estimation based on the overall value of recreational fishing in the Great Lakes Basin, which has been studied. A recent literature review of recreational fishing studies in the Great Lakes Basin pegs the net value of recreational fishing at between $20 and $75 per day in 2012 dollars (Poe et al., 2013). Furthermore, the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, as conducted by US Fish and Wildlife Service (FWS) and the US Census Bureau, estimates a total of 19.7 million angler days distributed across 1.7 million anglers, or 11.6 angler days per angler (US Department of Interior et al., 2011). Using the estimate of total fishing participation by local residents, we estimate between 6,055 and 9,082 angler days per year in this watershed, resulting in between $121,097 and $681,171 in economic value to the region (in 2012 dollars).

Impoundment-level Estimates

Using the number of developed parcels along the shores of both impoundments (75) and the average household size of Forest Township (2.32), we estimate that the impoundment population is 174 (US Census Bureau, 2010). For the purposes of this calculation, we do not include non-waterfront landowners or owners of non-developed parcels and assume that between 75 to 100% of these 174 residents fish.[6] Based on those numbers, fishing on the impoundments results in between 130 and 174 licenses, or between $3,393 and $4,524 in annual revenue to MDNR (eRegulations, 2016). When incorporating broader economic impacts associated with fishing, we get a range of between $30,245 and $151,226 annually when using the same method as described above for the watershed-level estimate.

River Fishing Estimates

The economic value of river fisheries varies seasonally, and is highest in the spring when trout season opens. River fisheries provide unique opportunities for local businesses through fishing supply stores or potential local guides to take people out on the river. These opportunities are amplified by river fishing because it entails specialized gear and requires more guidance and

[6] While both of these assumptions may be unreasonable, they likely counteract. Based on our conversations, we do recognize that non-waterfront landowners do engage in fishing on the ponds. Furthermore, it is also possible that waterfront landowners that have not developed their property parcels also engage in fishing, but we are assuming that the addition of permanent structures on a parcel is a signal of an interest in recreational activities specifically on the ponds as opposed to elsewhere. On the other hand, we have already shown that some developed parcels are owned by seasonal residents and may come up to fish infrequently relative to others. Some local residents also indicated that they do engage in fishing beyond the boundaries of the ponds, so attributing their entire fishing to the ponds may also be an overestimate.

support. Unfortunately, as we do not have a way to estimate the number of river fishermen in the area, we are unable to estimate the economic value of this specific fishery from a use standpoint. Instead, if we assume that river fishing is any non-pond fishing that occurs in this watershed, then the value of river fishing is between $90,852 and $529,944 if subtracting the impoundment-level estimates from the watershed-level estimates.

Value of Different Types of Fishing

Another way to compare pond fishing and river fishing is to evaluate the values of different fish. In addition to reporting the value of an average fishing day, Poe et al. (2013) also reported the value per fishing day for specific fish as well. A few categories that are most relevant to this watershed are reported below:

- Trout: $48.30
- Other coldwater: $47.25
- Bass: $67.99
- Walleye: $74.03
- Other warmwater: $50.40

Takeaway

The values presented above are largely speculative and serve as an estimate to better understand the relationship between fishing and its impact on the local economy. Further analysis should compare estimates to other fishing communities and economies and evaluate the importance of riverine fishing (as opposed to impoundment fishing) as well. Furthermore, this initial analysis only explored the relative importance of different forms of fishing, but fishing is only one component of recreation, which is also just one component of the overall economy of the watershed.

Key Stakeholder Interests

- Maintaining ability to fish
- Maintaining/improving pond fish populations
- Improving trout populations
- Ensuring scientifically-sound, balanced fishery management
- Improve fishing tourism
- Maintaining ability to swim
- Maintaining ability to boat on ponds and river
- Maintaining ability to camp
- Maintaining vibrant recreation scene at Tower Pond
- Strengthening/maintaining the economy
- Adding additional recreation opportunities (like whitewater/Shanty Rapids)
- Improving canoe/kayak opportunities and having adequate river depth

Key Questions Moving Forward

- Would boating opportunities increase with dam removal?
- What whitewater opportunities would emerge with dam removal?
- The river is already very shallow for canoeing; what would the new river depth be? How would the channel and velocity change?
- How would fishing access change if dams were removed, especially for pond landowners?

GENERAL ECOLOGICAL HEALTH

Regardless of their specific uses, local groups generally support the broad goals of maintaining a healthy environment, retaining a strong community identity, and fostering a connection to the natural world. Local environmental groups' interests may seem to simultaneously be positively and negatively impacted by the dams, but a closer look may explain nuances. Impacts of dam removal on the overall ecology of Black River and the potential impacts of invasive species should be considered during the decision-making process. Most stakeholder groups express an interest in maintaining overall ecological health and prefer a decision that would improve ecological health or prevent invasive species.

> ***"A healthy stream is an ecosystem that is sustainable and resilient, maintaining its ecological structure and function over time while continuing to meet societal needs and expectations."***
>
> ***- Meyer, 1997***

While there is an interest in improving "ecological health," no formal definition or common understanding was identified. Ecological health is typically understood by ecologists by using indices which account for metrics such as diversity, species richness, or ecosystem function. Indices offer a way to quantify health, which is sometimes described as resilience, or the capability of self-restoration after suffering external disturbances. Often, species that are particularly sensitive to pollutants or other conditions are used as indicator species. As a slow growing species with cultural value, lake sturgeon can also be used as an indicator. Other metrics, like disease, build-up of waste, or loss of key species, serve as indicators of poor health. For river ecosystems, indicators using physicochemical, biological, habitat availability, or flow regime metrics can track changes in health.

Indicator Species: an organism whose presence, absence or abundance reflects a specific environmental condition. May be used as a proxy to diagnose the health of an ecosystem.

Furthermore, the meaning of ecological health may be understood as it relates to the values and interests of communities utilizing the river: "A healthy stream is an ecosystem that is sustainable and resilient, maintaining its ecological structure and function over time while continuing to meet societal needs and expectations" (Meyer, 1997).

Ecological Health and Natural Character

Residents and environmental groups care about water quality criteria, sustainable fish populations, and maintaining the overall natural character of the lake; residents enjoy Black River's recreation opportunity and beauty. As discussed in previous sections, homeowners and tourists feel a deep connection to this area because of the "wildness" and natural character. Regardless of the presence of dams and measures of ecological health, the community craves certain aspects of this area that define their wildness. Residents on the impoundments and Black Lake both take enjoyment from living close to plentiful wildlife, such as wild turkey, deer, songbirds, ducks, wood turtles, and eagles.

Riparian Zone: the interface between land and a river or a stream which serves an important ecological role through soil stabilization, biofiltration of water, and support of biodiversity

Scientific literature on the subject suggests dam removal would benefit ecological health overall, not just for aquatic species (American Rivers, 2002). In free-flowing systems, large precipitation events or rapid spring snowmelt could lead to flooding events, where water spills over the stream bank and inundates the riparian areas. These transitional areas are crucial for ecosystem health due to the heterogeneous habitat provided and ability to support various life-stages for macroinvertebrates, fish, birds, small mammals, etc. Terrestrial species often depend on these species and riparian areas for access to resources and nutrients. Dams allow for water storage during high flow events, a process referred to as peak flow attenuation, which reduces the frequency of inundation of riparian areas and may mean that certain macroinvertebrates and riverside vegetation are less successful (Ligon, 1995). These effects on riparian zones have impacts on terrestrial species like bears and eagles, which residents value for their charismatic value.

The wood turtle, another species valued by community members, could be directly impacted by the presence or removal of dams due to their vulnerability to sediment transport. Wood turtles live in rivers with sandy-bottomed streams and egg-laying occurs in the sunny areas of exposed river sand banks. The population of wood turtles in Michigan has declined in recent years and is now protected by Michigan law as a species of special concern. Wood turtles have seen a reduction of nesting areas through stream bank stabilization, and sedimentation can also impact turtle survival (MDNR, 2017i).

Invasive Species

Often, the presence of aquatic invasive species is used as an indicator for poor ecological health of a river. Invasive species tend to introduce new interactions with native species, typically outcompeting for resources and habitats. Invasive species could potentially have negative impacts on the ecological health overall. Given the negative economic impacts invasive species are reported to have on the interests of various stakeholders in this watershed (e.g. recreational fishing), any potential protection offered by Tower and Kleber dams to the areas upstream of each respective dam could result in positive economic benefit. However, this benefit would only be realized if other exclusion and management techniques were utilized.

Some residents expressed concern regarding the introduction and spread of aquatic invasive species in the Black River system and argue for retaining the dams to protect against invasive species introduction. “The only thing that’d be kind of scary is if, I don’t know how quickly or if it would be possible for (sea) lamprey or other species to invade, I’m not sure if they can invade that far, but I would assume they could…” However, this concern may not be directly addressed by Tower and Kleber dams, as downstream dams may have more influence on excluding invasive species.

Watch List: Invasive species in the Great lakes

- Zebra and Quagga mussels (genus *Dreissena*)
- Rusty crayfish (*Orconectes rusticus)*
- Sea lamprey (*Petromyzon marinus)*
- Round goby (*Neogobius melanostomus*)

In general, the connectivity of rivers is crucial for certain ecological processes in a riverine system; dams can also offer protection from aquatic invasive species by limiting the spread of such species. However, that protection is circumstantial based on current exclusion and management of other modes of introduction. Some invasive species of concern in the Great Lakes area are zebra and quagga mussels (genus *Dreissena*), rusty crayfish (*Orconectes rusticus),* sea lamprey (*Petromyzon marinus)*, and round goby (*Neogobius melanostomus*).

With the introduction of quagga and zebra mussels in inland lakes—including Black Lake—of the Great Lakes basin, increased water clarity allows for vegetation growth, shifting energy flow into the bottom of the food web. Long-term monitoring at Black Lake has shown a general increase in water clarity since 1997 (Tip of the Mitt, 2016). Increased vegetation growth could support macroinvertebrate populations, reducing the foraging effort of benthivores. However, one study

has shown that juvenile lake sturgeon avoid areas with zebra mussels (McCabe et al, 2006), likely due to the complication of foraging by the presence of mussels. Adult lake sturgeon can utilize zebra mussels as a food source, but the hard-shelled zebra mussels are a less energy-dense food source than the typical soft-bodied macroinvertebrate.

The rusty crayfish, a native of the Ohio River Basin, has become a threat to the Great Lakes Basin and native crayfish species. This species is likely to spread throughout the Great Lakes region due to its aggressive and avoidance behavior, ability to withstand colder temperatures, and ability to outcompete native crayfish species for food and habitat (Bobeldyk and Lamberti, 2008). According to current range map by the Tip of the Mitt Watershed council, rusty crayfish are not currently established in the Black River system, disconnected by Alverno dam, but some individuals have been sighted by residents (Tip of the Mitt, 2016).

Sea lamprey are not present in abundance greater than 200 individuals above the dam in Cheboygan (NILCFAC, 2015). Alverno dam also serves as a potential barrier to the Black River system by preventing upstream fish passage on Cheboygan River. While invasive sea lamprey are not yet present in Black River, lamprey removal could be detrimental to lake sturgeon. Lampricide (3-trifluoromethyl-4-nitrophenol, or TFM) treatments are costly, and TFM has both lethal and sub-lethal effects on lake sturgeon (Sakamoto et al., 2016).

Although not currently present above the Cheboygan dam according to the US Geological Survey (USGS) nonindigenous aquatic species register, the impact of round goby would be complex. Round goby would compete for macroinvertebrate food sources and predate on eggs and larvae of fish such as sturgeon, walleye, and trout. Round goby can also contribute to the bioaccumulation of toxic substances through predation on *Dreissena* mussels (Kornis, 2012).

Key Stakeholder Interests

- Maintain species diversity
- Maintaining migratory bird populations
- Prevent invasive species such as lamprey
- Achieving stable new ecosystem
- Avoiding contamination/damage from old landfill
- Maintaining habitat for eagles, wood turtles, ducks, etc.

Key Questions Moving Forward

- How would the larger Cheboygan River watershed be affected by potential dam removal?
- Which measures of ecological health are most important for evaluating dams?
- How do you compare new ecosystems to historical before the dams were built?
- How are the dams impacting terrestrial species?
- To what extent do the dams serve an important barrier to the spread of invasive specie upstream of the dams?
- How does shading from riparian trees and shrub affect the aquatic ecosystem? How would that change in a post-dam removal scenario?

FISH

Fish communities are defined by the assemblages of species and their interactions, and are limited by habitat availability. Habitat selection is based on several factors--water quality, substrate, depth, etc.--and conditions are altered by the presence or absence of the dams.

Fish are the largest and most mobile biological factors in aquatic systems and the assemblages of species can offer insight to the health of the river. Fish contribute to the movement of nutrients through the physical system and food web, and have top-down interactions as opportunistic feeders. Since the fisheries in the Black River system are popular sport fisheries, data from fishing reports can detail current conditions within the Black River system. First, a look at these fish surveys in each respective habitat type will provide an understanding of the current continuum of fish communities. Finally, a discussion of the impact of dams via abiotic and biotic factors on fish communities can illustrate possible outcomes of changes to the system. Understanding how water conditions affect fish species, and how dams affect those conditions, can help predict future dam scenarios for fish communities.

Current Fish Communities

These physical and chemical conditions (listed here) depend on external landscape scale factors like climate region, topography, geology, hydrology, and primary productivity (or plant growth). On a local scale, these conditions can be altered into microhabitats by in-stream structures such as felled trees, root wads, boulders, constructed weirs, or dams. Individuals within fish populations select habitat by physiological tolerance ranges, availability of suitable habitat, and often compete with other individuals within and between species. Water depth, velocity, and substrate type together determine different habitat types within a river reach. Within a river, for example, riffles and coarse cobbles are found together while pools and sandy substrate are correlated. A limiting factor for fish populations is the availability of habitat that satisfies requirements, such that density-dependent effects are avoided.

Conditions of Water:

- Temperature
- Dissolved Oxygen
- Sediment
- Flow regime

Habitat Selection:

- Tolerance (Temperature and Dissolved Oxygen)
- Substrate, Depth, Velocity
- Life History
- Life Stage and Behavior

For a given species, tolerance curves detail the depth, velocity, and substrate types in which habitat is usable. Typically, information is presented for various life stages and sometimes describes certain behaviors. For example, tolerance curves for walleye might show usable habitat for adult (Figure 14) versus juvenile, as well as foraging, spawning, or staging behaviors. The tolerance curves for walleye show that deep (>3 meters) and slow (15 cm/sec) water is most suitable. Additionally, larger substrates seem to be more favorable.

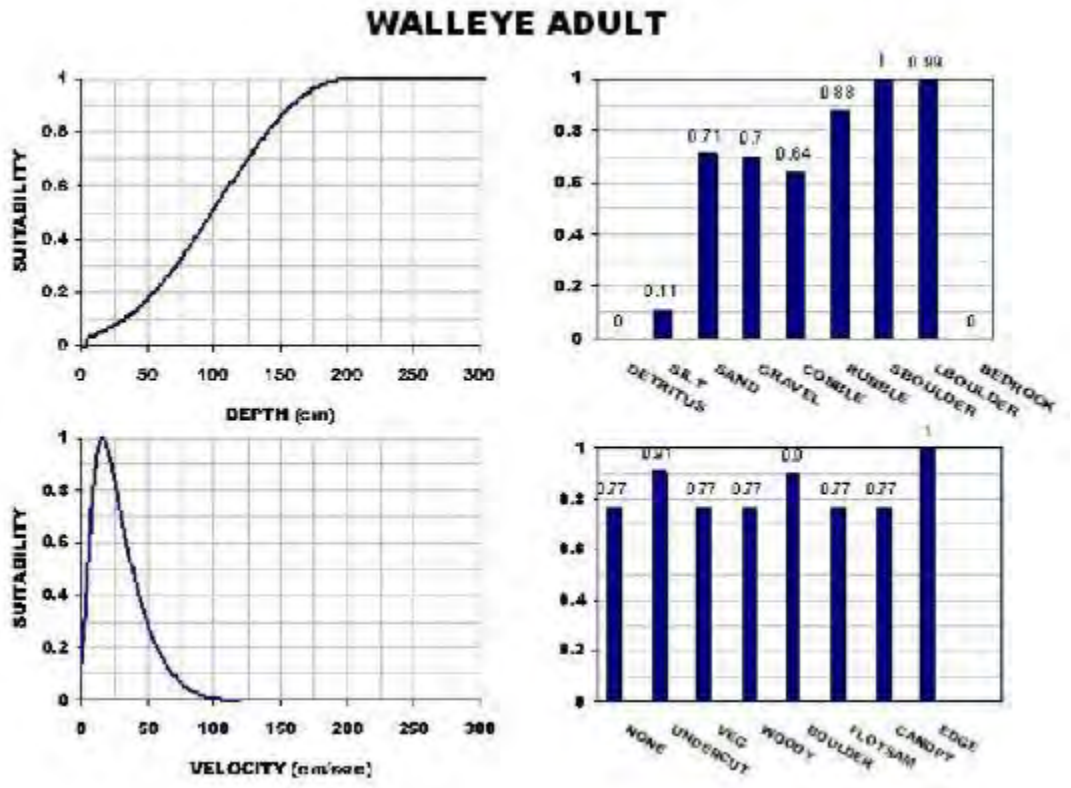


Figure 14. Tolerance curves of adult walleye (Minnesota DNR)

Applying these concepts to the Black River system, longitudinal trends in fish communities can be understood in the context of suitable habitat type availability. Typically, species prefer conditions that are either associated with free-flowing river habitat or deep, slow lake or pond habitat. Some species are generalists and do well in both habitat types.

River: The upper reaches of Black River above Tower dam is known for its high-quality brook trout habitat. Differences in the water temperature between the pond and reaches of the Black River allow for seasonal habitat and refuge for brook trout; Tower pond serves as an overwintering habitat for brook trout (Cwalinski, 2012). According to a survey performed on river habitat between

the Tower dam and Kleber pond, common shiner, smallmouth bass, and yellow perch were the most common. The survey described a large amount of vegetation and high turbidity at the inlet to Kleber pond (Cwalinski, 2016).

Pond: Common species found in Kleber pond were Bluegill, Pumpkinseed, black crappie, yellow perch, and rock bass, comprising 78% of the community (Cwalinski, 2016). Northern pike, walleye, smallmouth and largemouth bass made up 4%. Other species present include black bullhead, common shiner, white sucker, golden shiner, and Iowa darter. Kleber pond has a diverse community, but population growth has been slow. Low numbers of predators lead to good recruitment through natural reproduction (Cwalinski, 2016).

Lake: Black Lake is considered a mesotrophic lake with some data trending toward oligotrophic, which means there is moderate-to-low vegetation growth. Adequate vegetation, depth, space, and prey species allows Black Lake to offer habitat to support fish species in higher trophic levels, such as pike, bass, and muskellunge. The oligotrophic nature of the lake may explain the slow population growth of these predatory species.

Shifting Fish Communities

Within the Black River system, changes in fish communities have been noticed through the years, with emphasized focus on desirable fishes such as walleye, smallmouth bass, and brook trout. Historically, the walleye population was sustained by wild recruitment. As with any naturally reproducing population, fluctuations in numbers are normal due to cyclical good-year classes and bad-year classes. In recent decades, however, the walleye populations became unstable and the age structure was trending toward adult fish, as shown by a survey in 2005 (Cwalinski, 2005). This implies that wild recruitment was becoming less reliable. Consequently, the walleye fishery is supplemented through stocking efforts; MDNR stocks up to 200,000 spring walleye fingerlings in Black lake annually for three out of the last five years (MDNR, 2016a). The decreased effectiveness of natural reproduction could have been influenced by a number of things; a possible connection was drawn between the introduction of zebra and quagga mussels and the competition for zooplankton (BLA, 2015). In response to the age structure becoming older, the stocking efforts were initiated to recreate a stable age structure. Larger walleye populations may impact smallmouth bass and perch populations through competition for resources.

Impacts of Dams on Fish

Dams impact the physical and chemical conditions of the river in ways that alter the distribution of fish species. Both creating a lake system by constructing a dam and returning to a free-flowing system by removing a dam will modify fish communities in predictable ways. For context regarding the spatial scale of Black River, the current total length of river habitat is approximately 7.8 miles with 3 miles of pond habitat (Figure 3). The section lengths are currently as follows: Tower pond: 1 mile (102 acres), Tower dam to Kleber pond: 1 mile, Kleber pond: 2 miles (295 acres), and Kleber dam to Black Lake: 6.8 miles.

Returning to a free-flowing river would imply an increase in the mileage of river habitat, first from conversion of ponds to river and also lengthening due to natural meander. However, this would also imply a trade-off of pond habitat. In addition to the changes in relative amounts of pond and river habitat, the physical and chemical conditions in-stream would be altered in ways that could be predicted using modeling software in future studies. Many fly fishermen express curiosity about dam removal based on the potential to increase trout habitat by returning to a free-flowing river, while others express concerns about losing access to pond habitat species.

Dam impacts on water quality factors:

- Warmed water downstream of dams
- Low dissolved oxygen downstream of dams
- Sediment deposited upstream of dams and erode sediment downstream of dams
- Reduced variability of discharge

Temperature and Dissolved Oxygen

These two water quality criteria are well understood and have clear implications for fisheries; rivers downstream of dams, tend to have higher temperatures and lower dissolved oxygen. Even in shallow ponds, lake stratification can occur due to gradients in temperature and density of water (Branco and Torgersen, 2009). Water held in the impoundments is delayed and warmed at the surface by sunlight. Cooler, denser water tends to sink to lower layers. Effluent temperature, dictated by the height of the intake, can have direct influence on the fish communities throughout the system. Kleber pond does experience some thermal stratification (pers. comm. T. Cwalinski). Tower does not tend to stratify, but still accepts thermal input.

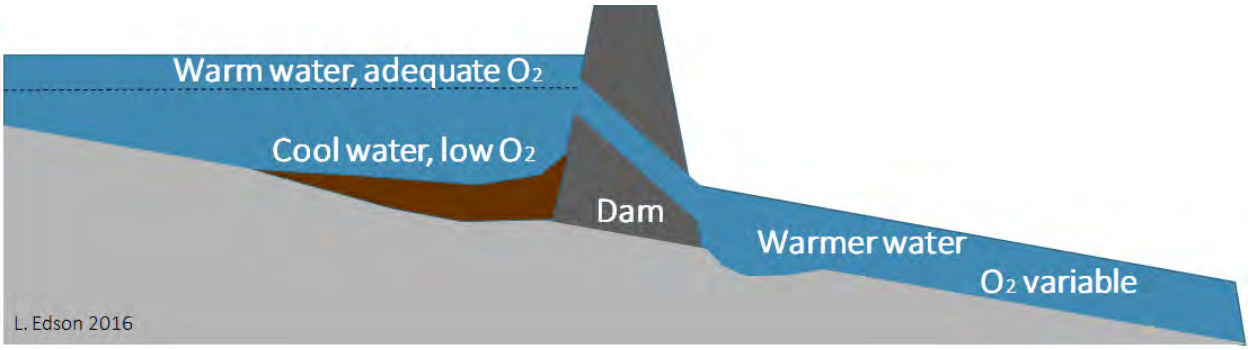


Figure 15. Trend of impact of dams on temperature and dissolved oxygen

In addition to the temperature of the water being impacted by the impoundments, the concentration of dissolved oxygen in the lower portion of water can be affected. If stratification occurs and mixing between layers is reduced, this could imply low concentrations in dissolved oxygen in the effluent, which can directly impact the ecology immediately downstream of the dam. Ensuring the water temperature and dissolved oxygen is appropriate for certain fish species downstream of the dams is an implied concern for stakeholders who express concern for desired target fish.

Sediment and Discharge

Structures in rivers typically result in a transfer from potential energy to kinetic energy and has implications on the ability to transport sediment; rivers will deposit sediment upstream of dams and erode sediment downstream of dams. Additionally, the discharge, or amount of water coming from the dam per unit time, can also influence the suitability of habitat zones for certain species. While the Tower and Kleber dams are operated as run-of-river, there is some attenuation, or storage, of peak flows in storm situations that reduce the variability of flow downstream. Tolerance curves typically describe the habitat requirements by depth and velocity, both of which can be impacted by in-stream structures. Future studies can utilize an understanding of the tolerance curves, sediment transport, and hydrology in order to predict the impacts of dams or dam removal either through general assumptions or by using modeling software such as Hydrologic Engineering Center Ecosystems Functions Model (HEC-EFM).

Key Stakeholder Interests

- Maintaining opportunities for pond fishing
- Improving pond/lake fish populations
- Improving trout populations
- Ensuring scientifically-sound, balanced fishery management

Key Questions Moving Forward

- What are the realities of shifting fisheries and what are the causes?
- How would water temperature, sand traps, and changing habitat affect fish diversity?
- What is stratification like in the ponds and how does it affect fish?

STURGEON



STURGEON SNAPSHOT

Social & Cultural Significance

- Culturally and spiritually important for tribal nations
- A community icon: Shivaree, spawning run, sturgeon in the classroom, hatchery
- Historically fished for subsistence and other products

Life History

- Live up to 100 years
- Late-maturing: 15-20 years for males, 20-25 years for females
- Up to 8 feet and 260 pounds; growth rates depend on temperature, food availability, and water quality
- Bottom-feeders (benthivorous)
- 10-20% of adults migrate into the rivers to spawn in spring

Habitat Preferences

- Dimly lit, moderately turbid, warm (10-16°C), nearshore (15-30 feet deep) water
- Gravel or rapids in rivers for spawning
- Juveniles require sandy habitat to avoid predators
- Relatively tolerant of temperature changes, sensitive to dissolved oxygen decreases

Black Lake

- Population: 1,113 adults based on unpublished data from the 2016 spawning run
- Spear fishing season: quota of ~1.2% (14 individuals in 2016; 7 to state, 7 to tribes)
- Sturgeon currently have access to about 11 km of river upstream of Black Lake
- Challenges: limited spawning and nursery habitat

Rehabilitation Effort

- Threatened in Michigan, Black Lake is home to MI's largest inland lake population
- MDNR's Sturgeon Rehabilitation Plan
- Management Plan for Lake Sturgeon in Black Lake
- Formal statements by the Grand Traverse Band and Little Traverse Bay Band

Lake sturgeon draw attention in the Black Lake area for ecological, social, cultural, and economic reasons. Sturgeon are threatened in Michigan as the result of historic poaching activity, dams, and other pressures, leading to an emphasis on rehabilitation through research, management, and education initiatives by groups such as MDNR and Sturgeon for Tomorrow. This section first describes the social and cultural value of sturgeon, through events like the annual spawning run and spearfishing Shivaree. This is followed by a discussion of the current status of the Black Lake population, with emphasis on habitat limitations, hatchery role, current research, and stakeholder concerns and perceptions. For a scientific background on lake sturgeon, see Appendix IV.

Social and Cultural Value

Sturgeon are a prehistoric creature dating back to the Triassic era, looking something like a cross between a dinosaur and a shark. Reaching six feet long, they are the largest freshwater fish in North America and can live to be about a hundred years old. Their distinctive appearance, ancient history, ecosystem presence, and human-like age and size make sturgeon fascinating and special for local residents and tourists alike. The species has become a community icon in the Black Lake watershed, with Onaway calling itself the "Sturgeon Capital of Michigan." Similarly, tribes such as GTB and LTBB have an interest in sturgeon because of their unique qualities, ancestral connections, totem associations, and implications for fishing rights. Many different groups are excited to witness the seasonal spawning run and care deeply about this fish's survival.



Sturgeon Education

As an iconic local species and important member of the ecosystem, sturgeon also serve an educational role in Michigan communities. Sturgeon in the Classroom, a statewide cooperative initiative between Sturgeon for Tomorrow and MDNR, has been placing young sturgeon in K-12 classrooms since 2013. Schools as far south as Detroit adopt a fingerling raised at the hatchery, manage the feeding, water conditions, and tank maintenance through the year, and release the sturgeon at the end of the school year. The program aims to increase awareness, understanding, and appreciation of sturgeon, while teaching ecology concepts. "By

raising this native fish, students are learning about threatened and endangered species, clean air, clean water and the importance of stewardship" (Sturgeon for Tomorrow, 2017b). Eight classrooms across Michigan participated in the 2015-2016 school year. One Onaway high school service learning class not only raises a sturgeon but takes it to other schools in the area to teach younger kids about the species. Students shared with us how much they love their pet sturgeon named Glacier (pictured above), because they have a personal connection from raising him, think he's the most interesting animal at their school, and appreciate that their home is the "Sturgeon Capital." Sturgeon from this program also serve as a travelling educational exhibit or are permanently housed at museums and the Seaquarium.

The streamside hatchery at Kleber dam also offers educational opportunities through public tours. MDNR provides educational curricula and materials in partnership with FWS, SFT, GTB, and others.

The Spawning Run

Currently, sturgeon spawning season is a unique annual phenomenon drawing locals and tourists alike. Because of dams such as Tower and Kleber, the sturgeon are concentrated to a short segment of the Black River where they congregate to spawn at a few main pools. This means that the fish, normally out of reach in the deep water of lakes, are highly accessible to humans for viewing and researching. People are excited to come from all over the state and country for a chance to see these unique fish.

> ***"I think people just really value the whole experience here. We had a young family from out of town who was camped just up the river [to participate in Sturgeon Guard] with three kids … there's that joy when you see that first fish. Last night we were having dinner at the camper and one of those kids came up and knocked on the door and said, 'we've got fish!' His little sister had heard one splashing, and they were all excited because they hadn't seen one before. … We get people who come back year after year, once they get started, it kind of gets in your bloodstream."***
>
> ***- Sturgeon Guard volunteer***

Due to staging and spawning behavior, groups like MSU and MDNR conduct various sturgeon research studies, further described in the Hatchery Research section below. Fisheries biologists

and managers also have an interest in studying and rehabilitating sturgeon populations as an important piece of the Great Lakes ecosystem through the Lake Sturgeon Rehabilitation Strategy (see Appendix IV).

However, the enhanced access to sturgeon during the spawning run has also historically made for a significant amount of poaching. Sturgeon for Tomorrow has been using their “Sturgeon Guard” program to help protect the fish for over 16 years by providing a watchful eye along the Black River. Several of our respondents indicated that the Sturgeon Guard has contributed to the decline in poaching and has also, through local and regional participation, sparked renewed appreciation for the living fish.

Tourism surrounding the spawning run, especially including Sturgeon Guard participants, has economic as well as social and ecological value. Each year, Sturgeon for Tomorrow recruits and organizes about 400 volunteers to help watch over the sturgeon during the spawning season throughout the stretch of the Upper Black River up until they meet the Kleber dam. While some local residents have taken part in the Sturgeon Guard, the group also pulls interested individuals from throughout the state, who spend a weekend to several weeks camping along the river to prevent poaching. In total, this amounts to over 4,200 hours of time spent by volunteers protecting the sturgeon over the course of the 6-week spawning period. This influx of non-local people can contribute economic activity through food and other purchases in the area, especially when considering the population of all of Forest Township is approximately 1,000 (US Census Bureau, 2010).

Sturgeon Season

Harvesting lake sturgeon is currently allowed in the Black Lake population with strict limits. On Black Lake, the harvest is only open for a short spear fishing season. Each year, the quota is set at approximately 1.2% of the adult population and is to be allocated equally to the tribes and state (MDNR, 2012). In 2016, the quota was set to 7 individuals each for the tribes and state, and the state spearing season lasted under one hour. Sturgeon spear fishing permits are available at all licensed vendors, but anglers must pre-register. Sturgeon for Tomorrow hosts the Sturgeon Shivaree each year at the opening of Black Lake Sturgeon season to spread awareness of conservation efforts focused on lake sturgeon. This family-friendly event, first held in 1961, was



M. Watters

designed to bring families, community members, and regional visitors together to celebrate lake sturgeon and northern Michigan. Black Lake is the only location in Michigan to offer spear fishing of lake sturgeon.

The Shivaree and sturgeon fishing season are important economically as well as culturally. This weekend-long festival brings in a substantial number of local residents as well as people from across Michigan, with 1,500 - 2,200 participants each year. The Shivaree itself generates an additional $25,000 - $30,000 in revenue each year through activities related to the event. The past several years of sturgeon spearing participation is provided in Table 1 (pers. comm. T. Cwalinski, MDNR). While sturgeon spearing licenses do not entail additional charges to the fishermen, they are required to hold all-species fishing licenses, which cost $26 for residents and $68 for non-residents. However, it is highly likely that most participants are also traditional fishermen, so that may not be a new source of revenue for MDNR.

Table 1. Participation in Sturgeon Fishing in the Annual Black Lake Shivaree

Year	Total Registration	Allocation	Voluntary Quota	Actual Harvest
2010	255	5	5	5
2011	330	7	7	11
2012	197	7	2	2
2013	268	7	6	6
2014	228	6	5	6
2015	303	6	5	5
2016	261	7	6	7
2017	332	7	6	8

While these Shivaree numbers are already substantial with regard to a single event, there are some groups that feel that sturgeon spearing quotas (Table 1) could be higher than they are now,

expressing “a limit of 4 or 5 or 6 sturgeon to me is ridiculous, I don’t know how many man-hours the DNR puts into it but it seems like it’s way out of proportion.” Larger quotas would potentially allow for overall greater participation in the Shivaree, resulting in a greater economic impact on the local economy.

Current Population Status

The population in Black Lake has been studied recently with the efforts guided by the streamside hatchery and production facility just downstream of the Kleber dam. In Black Lake, the population of adults was last estimated at 1,113 adults based on unpublished data from the 2016 spawning run. Background information on sturgeon ecology (i.e. life history, reproduction, feeding behaviors, habitat needs, etc.) can supplement an understanding of the Black Lake population (Appendix IV).

Habitat Limitations on Natural Reproduction

Black Lake has been found sufficient to support the growth and gamete production of lake sturgeon (Smith and Baker, 2005). This suggests adult sturgeon are successful in growing to maturity and developing reproductive cells; meaning that Black Lake and the currently accessible Black River is able to facilitate spawning behavior. However, limits to both spawning and nursing habitat in the Upper Black River restrict the success of natural reproduction and self-sustaining nature of the Black Lake sturgeon population.

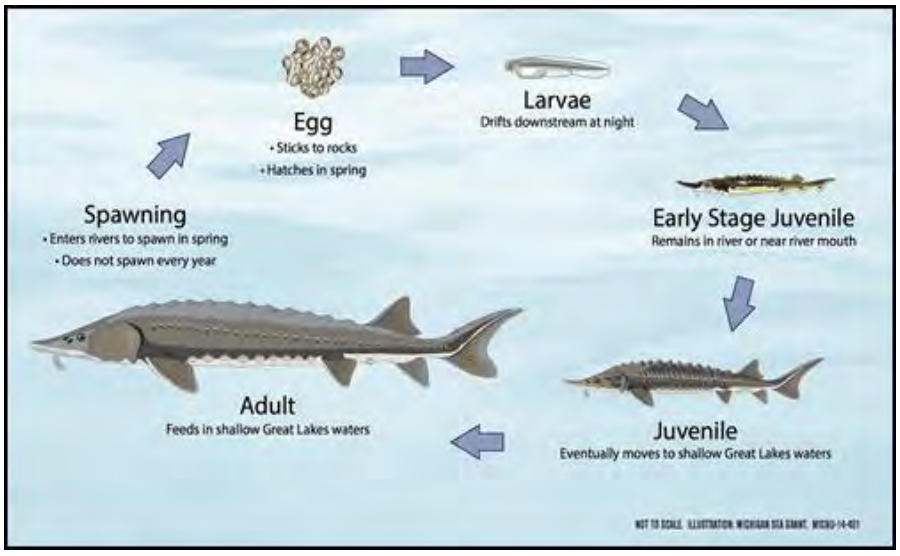


Figure 16. Lake sturgeon Life Cycle (FWS)

Available spawning habitat is limiting adult reproduction opportunities. Research suggests that managers should set the target for combined lake and river habitat at 50 km for restricted self-sustaining populations (Auer, 2011), yet Black Lake sturgeon only have access to 11 km. The Black Lake sturgeon population does not have access to enough river mile habitat to successfully reproduce naturally. Limited spawning habitat means that adult sturgeon must compete spatially and temporally for access to spawning grounds. Additionally, Adult lake sturgeon are most vulnerable during the spawning season; staging in shallow and easily accessible areas and energy allocation to gonad production both reduce defenses against harvest.

Nursery habitat, sandy bottom habitat that allows hatchlings to hide and forage, is also limited. Spawning does not occur far enough upstream to offer river habitat sufficiently long for larval drift, and hatchlings cannot survive to their stronger juvenile stages. Therefore, fisheries managers have expressed that expanding river habitat for sturgeon spawning would be beneficial and reduce the dependence on hatchery function of the Black Lake sturgeon population for reproduction.

Hatchery Role of Supplementing Reproduction

The hatchery and rearing facility was built by TKLP in connection with SFT, MDNR, and MSU, in response to the limitations on natural reproduction of lake sturgeon in the Black River. Each year, eggs, milt, and larvae are collected and reared in the streamside facility to increase survivorship. They supplement natural reproduction by collecting gametes from spawning adult sturgeon, thus increasing effective spawning habitat. The hatchery also fills the life cycle gap by collecting larval drift, rearing to early juvenile stages, and releasing to Mullett, Burt, and Black Lakes (Figure 16). Juvenile sturgeon are not included in the population estimates until reaching sexual maturity. Although resident perceptions vary about the relative success of sturgeon populations, they generally seem to appreciate the hatchery's functions and see it as "an added insurance policy."

Current Research and Hatchery Operations

As discussed above, there are varying perceptions of the state of the Black Lake sturgeon population. A variety of research is being done, both in and outside of the Black Lake population, to help strengthen a collective understanding of sturgeon population dynamics and health.



A number of lake sturgeon populations have been studied in North America and the Great Lakes region. Specifically, populations have been studied in the following areas: Ontario, Lake St Clair/Detroit River, Wisconsin, Menominee River in the western Upper Peninsula. Wisconsin and Michigan both have a management plan specifically for sturgeon. The Great Lakes Restoration Initiative combines a number of partnerships in the Great Lakes basin with the focus being lake sturgeon. Restoration activities such as the construction of artificial reefs have been attempted in southeastern Michigan (Johnson et al., 2006). Research and work from other populations can help inform an understanding and planning effort for the Black Lake area.

In addition to supplementing the natural reproduction of lake sturgeon each year, the streamside rearing facility houses various research projects under Principal Investigator Kim Scribner, several of which are focused on the sturgeon population. One study is looking at adult spawning behavior and the larval development in Black River. Another is looking at predation during larval drift, determining which species predate on sturgeon at this vulnerable life stage. Another study is determining the microbial community in the developing GI tract of larval sturgeon. Finally, the effectiveness of rehabilitation efforts is being documented to transfer to other sturgeon populations.

The streamside hatchery is operated by MSU and MDNR. While we do not have exact cost information, the hatchery receives electricity as part of the operation license for Tower and Kleber dams. The hatchery pumps water from Kleber pond at a depth of approximately 3-4 meters, likely to pull in colder water (MSU, 2017). In addition, supporting research and rearing sturgeon, this

hatchery also provides opportunities for education through free public tours offered each year (Sturgeon for Tomorrow, 2016).

Community Concerns and Perceptions

Dam Impacts

Sturgeon advocates generally believe removing the dams would increase sturgeon spawning and nursery habitat, and would therefore improve the natural reproduction of sturgeon populations. However, there is a general acknowledgement of uncertainty regarding the Black Lake sturgeon population and how dam removal would alter the river. Some advocates fear negative consequences of dam removal, expressing the worry that sediment and other changes from dam removal might actually inhibit sturgeon spawning. They call for more science to determine specific impacts.

From a social perspective, some sturgeon advocates worry that, if the spawning fish were no longer concentrated along such a short stretch of river and in such a high density, it would be more difficult for scientists to research the fish, for the public to view and appreciate them and for Sturgeon Guard volunteers to keep them safe from poachers. On the other hand, biologists and sturgeon advocates believe that the increased spawning grounds would increase the reach and potential of the spawning event. Additionally, if spawning locations shifted to the dam sites, they would be much more accessible to larger audiences. Some people see dam removal as an opportunity to make more area towns the “sturgeon capital of the world” and attract tourism, spark new local businesses, and strengthen community identity. This could help improve local economies and sense of community.

> ***“Would there even be suitable spawning habitat beyond the dams? We don’t know. Would the sturgeon even try to go up there? Would they no longer be concentrated in 2 or 3 spots? Would it make them less vulnerable to poaching because they’d be more spread out? Would there be less predation? Would we have stronger reproductive success if we had more space? This all needs to be researched.”***
>
> ***–local environmental organization member***

Sturgeon Management

Some community members, generally including fishermen and groups with broader interest in ecological health, perceive an overemphasis on sturgeon management. This does not appear to reflect a dislike of sturgeon; some who hold this view say they like and respect sturgeon while others say they "don't much care one way or the other" and "just sort of ignore them." This group also tends to think that sturgeon already have enough habitat, populations are stable, and therefore dam removal isn't necessary to improve their populations. Even if the sturgeon could benefit, several people have expressed that it would *not* be worth removing the dams solely for the sake of improving sturgeon populations.

Many local fishermen express frustration with how much emphasis is being placed on protecting the sturgeon because it is only one of many local fish. Some believe local people in general do not care very much about the sturgeon, and instead the interest in sturgeon is driven by specific groups and tourists from elsewhere. Fishermen, some local residents, and some ecology-based groups all express the wish that there was more emphasis on managing other species, such as walleye. Fishermen point out that there is hardly any sturgeon fishing allowed anyway, whereas fishing a myriad of other species is important for the community and tourism. However, in the past there was no quota at all and sturgeon fishing was much more popular and prevalent (MDNR, 2017h).

People who share this perception of an overemphasis on sturgeon also believe that the fish have enough habitat and are doing fine. Impoundment residents commented, "my feeling is that it [the Black Lake population] is coming back," and "they've got all the spawning beds they need from Kleber dam downstream." One factor in this belief is that the hatchery exports fingerlings to other lakes to help support those populations, so people think the Black Lake population must be stable enough to divert resources and attention elsewhere.

> ***"The massive amount of attention [sturgeon] received has completely turned the population around. We're producing way more fish than the water system needs. We're exporting fish to other water systems. I think it's been a phenomenal turnaround, and I think it's time to take a new realistic look at the species itself, and I think we're kind of overprotecting it, and there's more opportunity there as a fishery right now."***
>
> ***- local resident***

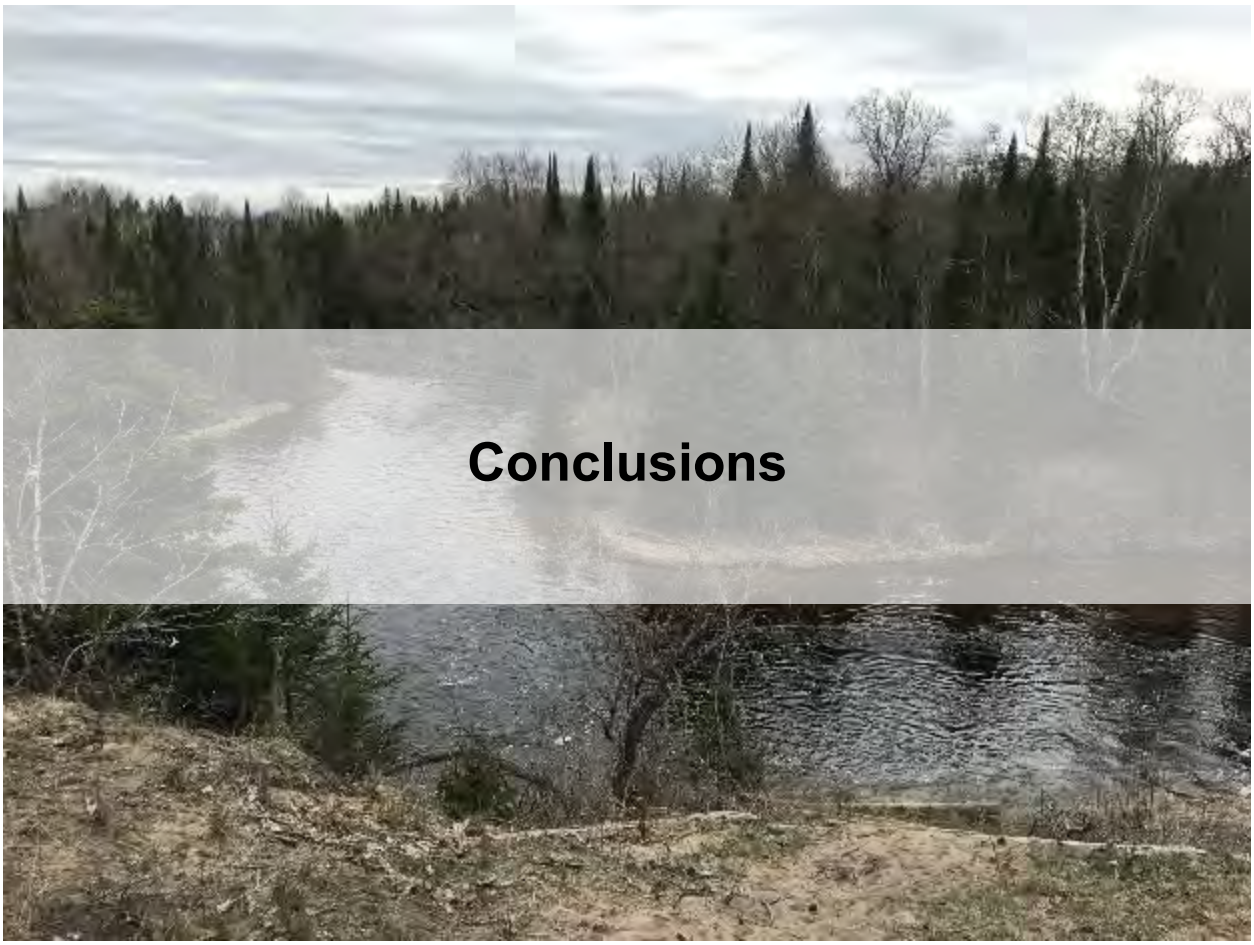
One community member expressed the belief that Sturgeon Guard volunteers are no longer needed to protect the fish from poachers, calling them “sturgeon vigilantes.” People also express the belief that the drop-off river gradient at the dam sites would prevent sturgeon spawning from proceeding even without the dams.

Key Stakeholder Interests

- Maintain cultural significance of sturgeon (tribes and local communities)
- Improve/maintain sturgeon population and habitat
- Increase sturgeon tourism (e.g. increase allowable harvest)

Key Questions Moving Forward

- How would dam removal impact the hatchery’s ability to function and perform research?
- How significant is the subsidization of maintenance and electricity costs for the sturgeon hatchery by the dam owner?
- How would dam removal affect the sturgeon population?
  - How would dam removal impact the amount of accessible sturgeon habitat?
  - How are social or community activities (e.g. Sturgeon Guard and sturgeon tourism) affected by the size and condition of sturgeon habitat?
  - Would rapids/gradient under current dams restrict access to upstream habitat?
- What alternative habitat is offered by other tributary creeks to Black Lake?
- How can results of sturgeon science be better communicated to stakeholders?
  - What research is currently being done that may affect the decision-making?
- Will hunting and fishing rights of sturgeon be renegotiated?



Conclusions

Deciding the future of Tower and Kleber dams will be an ongoing process. In this report, we provide a baseline exploration of the ecological, economic, and community impacts of the dams. We also identify and illustrate the issues and stakeholder concerns that should be involved with the decision. We hope our work can help inform community conversations, further research, and future decision-making processes. To conclude this report, we highlight key findings, provide recommendations for moving forward in the dam decision-making process, and summarize stakeholder interests and questions.

FINDINGS TAKEAWAYS

Based on the background information gathered, interviews with stakeholders, interaction with the community, and input from the public meeting, we have synthesized a set of overarching findings. These findings are grouped by dam status, ecological factors, and public concerns.

Dam Status

Tower and Kleber dams are in satisfactory condition. Neither Tower nor Kleber have significant structural issues, although there are some moderate and minor issues that would need to be addressed in future maintenance activities. The electricity production from both dams is comparable to nationwide efficiency levels but falls slightly short of their documented expectations. Costs of future maintenance and operation are important to compare against the current generation capacities but are not clear at this time.

Dam Impacts on Ecology

Tower and Kleber dams influence water conditions and habitat availability for many species. In-stream structures like dams can affect the local conditions of the water for the following: temperature, dissolved oxygen, sediment load, and flow regime (volume and timing of water). Based on the local changes in these conditions, dams can determine where along the river is favorable habitat for a given species. Some species are particularly sensitive to temperature, like brook trout, whereas other species can require certain water depths or substrate at varying life stages, like lake sturgeon. In creating Tower and Kleber ponds, the dams affect the water conditions of Upper Black River, limiting brook trout habitat to headwaters while allowing for pike and bass habitat in the impoundments.

Tower and Kleber dams do not have much of an impact on water levels in Black Lake. Under normal flow conditions and run-of-river operation, Tower and Kleber dams do not contribute to changes in the water level of Black Lake. Downstream, Alverno dam and Smith Rapids have more control on the output from Black Lake. In storm events, Tower and Kleber ponds would offer minimal storage, while other creeks and surface water inputs to Black Lake would continue to increase water levels.

The sturgeon population is viable with help of the hatchery, but natural reproduction could be improved with dam removal. The hatchery and rearing facility supplements natural

reproduction and mitigate the limits on spawning and nursery habitat due to the presence of Tower and Kleber dams. With the research and operations at the hatchery, the Black Lake sturgeon population is slowly growing; however, with improved natural reproduction, the sturgeon population would be able to self-sustain and fewer resources would need to be devoted to supplemental reproduction.

Public Concerns

Community members are passionate about recreation in their area and are worried about losing those opportunities. Recreation is a key part of why people love living in the Black Lake and Black River area. Whether or not they live directly on the ponds, residents enjoy fishing, boating, and other types of recreation. Removing these opportunities would alter community members' relationship with their home, and would be felt as a powerful loss. Recreation is also intimately tied to the local economy, and people worry that losing pond recreation would accelerate economic decline. New recreational opportunities could emerge with dam removal, such as whitewater kayaking, and could strengthen the social and economic vitality of the community. However, it is difficult for many residents to imagine this making up for a loss of current pond activities.

A passionate and polarized fishing community is interested in differing management priorities, beyond a focus on sturgeon. Both resident and tourist fishermen have different preferences for pond, lake, or river fishing with different target species. These fishermen, especially local residents, care deeply about their fishing opportunities and are concerned about access and maintaining populations of their target species. Because preferred opportunities and species vary, they imply different priorities for fishery management which would become even more controversial and difficult to balance in the case of dam removal.

Landowners that live on Tower and Kleber ponds feel the most threatened by discussions of dam removal. These landowners highly value their current properties for financial, aesthetic, recreational, and other purposes, and, importantly, believe dam removal will result in the loss of these property values. As a result, they may perceive discussions about the future of the dams to be a threat to what they care about.

Black Lake landowners are convinced that Tower and Kleber dams give them protection and control over water levels. While many landowners are aware of the run-of-river operation

of the Tower and Kleber dams, most are in favor of keeping the dams in order to maintain a sense of control over water levels, especially in heavy precipitation and flooding events. In situations where control by Alverno dam is limited, landowners want to have Tower and Kleber in place to provide water storage, even if storage is minor.

There is skepticism about tribal motivations and a lack of understanding of tribal rights. The opinion of tribal nations by local, non-tribal residents appears to be colored by negative experiences in other areas of Michigan. There is also confusion about the role tribal nations have in this decision-making process and their rights to natural resources in the watershed (see Appendix VI for a primer on tribal rights). As a result, local residents around Tower and Kleber dams are suspicious as to why the tribal nations are involved in the discussions about the dams, especially as there seems to be a perception that the tribal nations are trying to be involved from far away.

Some people are excited about the idea of dam removal due to its potential to improve trout habitat, sturgeon populations, and river boating opportunities. Individuals across stakeholder groups express a curiosity and interest in potential improvements to recreational opportunities, especially as it relates to popular fish species. Brook trout populations will likely benefit from dam removal, assuming river habitat will increase and water temperatures remain cool along the Upper Black River. Those that advocate for sturgeon are hopeful that harvest numbers will increase and there will be more interaction with the public after dam removal increases habitat. Dam removal may increase opportunities for river watercraft, as whitewater would likely be exposed, and other recreational improvements can be included in the process.

MOVING FORWARD

There is uncertainty, confusion, and emotion surrounding current impacts of the dams, the idea of dam removal, and the related decision-making process. Steps moving forward should seek to address these as elements of potential conflict by providing information, interpreting science, and acknowledging deeply held concerns.

Information Needs

There are misconceptions and confusion about impacts of the dams on the watershed

It is important for information to be available and accessible to the public. It is important that any information associated with the decision-making process, both existing information and new information gathered in the future, for Tower and Kleber dams are easily available for the public to access. However, it is even more important that that information is developed in a way that is understandable for all audiences. Scientific information about dams and their associated impacts can at times be overly technical. Therefore, a focus on making all findings equally accessible to technical and non-technical audiences will ensure that the decision-making process is fully transparent to all stakeholder groups and the general public.

Site-specific information is needed for ecological and economic impacts. While at times it is necessary to extrapolate findings from studies of other regions of the United States to this locality, some stakeholder groups strongly prefer more site-specific information about the potential impacts of dam removal. For example, although scientific studies may point to positive benefits of dam removal on local property values, local landowners may be skeptical unless the data is site-specific. It would be helpful to work with a locally-knowledgeable real estate agent to establish property value data and predict how these would change in the event of dam removal. We would also suggest creating a hydrologic model to help landowners visualize what changes to their property would look like.

Clarity is needed to gauge if the dams' electricity generation is a net benefit. While the available information about Tower and Kleber dams' electricity generation indicates it is not insignificant, stakeholders may have a hard time understanding how meaningful that generation is without something tangible to compare it to. For example, information about the dams' importance to the regional grid or operational cost information for the dams would serve that purpose.

Process Recommendations

There is confusion, emotion, and conflict surrounding the issue and the decision-making process

Clarify the decision-making process. Our experience throughout this project emphasized in numerous occasions that many of the stakeholder groups are unclear about the decision-making process about the future of Tower and Kleber dams. This has led to a lack of clarity about their roles and ability to be a part of and influence the resulting decision. While there should continue to be an emphasis on the importance of a collaborative process, a first step towards a formal decision-making process is to clarify two key roles: 1) who holds the final decision-making power about the future of the dams, and 2) who has responsibility over bringing together the diverse set of stakeholders. The first role is likely the dam owner and FERC, but this need to be made clearer to all participants. To the second question, MDNR has thus far taken on some of this responsibility, but this should be made more explicit as the process moves forward and ensure that all stakeholders are comfortable with that allocation of responsibility.

Acknowledge the full range of concerns held by stakeholders and validate emotions. There is a wide variety of issues involved with the dam decision that need to be considered moving forward. These issues are associated with fear and deeply held emotions, which could lead to significant conflict. For example, recreation should be a top consideration in future discussions because it is deeply tied to the local community. Discussing all interests and acknowledging associated emotions is important in engaging stakeholders in a productive conversation where everyone feels that their voice is heard and conflict can be avoided. This is the case even if some parties may deem a concern to be less important or scientifically negligible, such as Tower and Kleber dams' influence on Black Lake water levels.

Build visions and scenarios for the future. It appears that many of the stakeholders involved in the process are heavily focused on the negative or potential for loss associated with dam removal, but thus far, there is less discussion of the potential benefits of dam removal for all stakeholders. While this loss-aversion is understandable, a shift in perspective away from the status quo and towards visions of future possibilities (e.g. for recreation or economic growth) may assist in promoting more open-minded, productive conversations across stakeholder groups and decision-makers.

Directly involve tribal nations or otherwise help improve perceptions by non-tribal residents. During our interviews, informal conversations, and feedback at the public meeting, we heard non-tribal residents express skepticism about tribal motivations. There is confusion about tribal rights based on historic treaties and concern about changes to hunting and fishing quotas. Directly involving tribal nations in the dam decision-making process and clarifying tribal goals, roles, and rights may help improve perceptions and relationships between the tribes and non-tribal residents.

SUMMARY OF QUESTIONS AND INTERESTS

The table below consolidates the key questions for future analysis and stakeholder interests that are explored in greater detail in the findings sections above.

Topic	Stakeholder Interests	Questions for Further Analysis
Physical Dam Status	• Dam maintenance needs • Cost of dam repair versus dam removal • Dam ownership and sale	• Are there structural issues for the dams that need to be addressed? • What maintenance will be required and when? How much will long-term maintenance cost? • Are there differences in maintenance needs and costs because of their structural differences (e.g. Kleber is earthen, while Tower is concrete)? • What would be the potential cost of removal for these dams? • Is there a possibility of the dam owner "walking away"? If so, who would be maintaining the dams long-term? • What is the progress of the sale of the dams, and information about the sale is, or could be, available to the public?
Electricity Generation	• Reliability of electricity generation • Cost of hydroelectric power • Upkeep of dam and impact on electricity production	• How much revenue do the dams generate through electricity production? How is this expected to change in the future based on projected changes to production capacity? • Why are the dams inconsistent in their generation? • How is electricity from the dams distributed in the grid? • What is the impact of losing the electricity the dams provide on the grid (e.g. grid reliability, electricity prices)? How would that loss be offset?

Topic	Stakeholder Interests	Questions for Further Analysis
Properties	• Avoiding ugly and costly transition periods • Maintaining property rights • Maintaining property value • Preventing trespassing • Having access to information	• Who currently owns the impounded land underneath Tower and Kleber ponds? • What is the legal status of property rights allocations for newly exposed bottomlands stemming from dam removals in Michigan? For properties on Tower and Kleber ponds? Where can residents go to find this information? • Where would the new waterline be? How long would the transition from pond to river take? • Are there implications of regulatory takings if a dam removal process were to proceed? • What direct impacts on this housing market could be expected if a dam removal were to move forward? • What opportunities would there be to restore exposed bottomlands as green space? Who would be responsible for the restoration and costs? • How would the two ponds be impacted differently? (aesthetically, clarity, rapids, property values, etc.) • Does dam removal impact neighboring groundwater supply?
Water Levels	• Maintaining Black Lake water levels • Preventing flooding (stormwater management)	• What is the extent of control on water level in Black Lake by Tower and Kleber? • How does Alverno affect Black Lake levels? • How would Burt and Mullet Lakes be affected? • How do the dams control stormwater flows? • What storage can the floodplain offer in storm events?
Sediments	• Avoiding sediment deposition and related fish kill • Avoiding contaminated or toxic sediment	• What would happen to the built-up sediment, and who would deal with it? • Are there toxins or contaminants in the sediment in the ponds? If so, how will they be dealt with, and who will deal with them?

Topic	Stakeholder Interests	Questions for Further Analysis
Recreation	• Maintaining ability to fish • Maintaining/improving pond fish populations • Improving trout populations • Ensuring scientifically-sound, balanced fishery management • Improve fishing tourism • Maintaining ability to swim • Maintaining ability to boat on ponds and river • Maintaining ability to camp • Maintaining vibrant recreation scene at Tower Pond • Strengthening/maintaining the economy • Adding additional recreation opportunities (like whitewater/Shanty Rapids) • Improving canoe/kayak opportunities and having adequate river depth	• Would boating opportunities increase with dam removal? • What whitewater opportunities would emerge with dam removal? • The river is already very shallow for canoeing; what would the new river depth be? How would the channel and velocity change? • How would fishing access change if dams were removed, especially for pond landowners?
General Ecological Health	• Maintain species diversity • Maintaining migratory bird populations • Prevent invasive species such as lamprey • Achieving stable new ecosystem • Avoiding contamination/damage from old landfill • Maintaining habitat for eagles, wood turtles, ducks, etc.	• How would the larger Cheboygan River watershed be affected by potential dam removal? • Which measures of ecological health are most important for evaluating dams? • How do you compare new ecosystems to historical before the dams were built? • How are the dams impacting terrestrial species? • To what extent do the dams serve as an important barrier to the spread of invasive species upstream of the dams? • How does shading from riparian trees and shrub affect the aquatic ecosystem? How would that change in a post-dam removal scenario?

Topic	Stakeholder Interests	Questions for Further Analysis
Fish	• Maintaining opportunities for pond fishing • Improving pond/lake fish populations • Improving trout populations • Ensuring scientifically-sound, balanced fishery management	• What are the realities of shifting fisheries and what are the causes? • How would water temperature, sand traps, and changing habitat affect fish diversity? • What is stratification like in the ponds, and how does it affect fish?
Sturgeon	• Maintain cultural significance of sturgeon (tribes and local communities) • Improve/maintain sturgeon population and habitat • Increase sturgeon tourism (e.g. increase allowable harvest)	• How would dam removal impact the hatchery's ability to function and perform research? • How significant is the subsidization of maintenance and electricity costs for the sturgeon hatchery by the dam owner? • How would dam removal impact the sturgeon population? o How would dam removal impact the amount of accessible sturgeon habitat? o How are social or community activities (e.g. Sturgeon Guard and sturgeon tourism) affected by the size and condition of sturgeon habitat? o Would rapids/gradient under current dams restrict access to upstream habitat? • What alternative habitat is offered by other tributary creeks to Black Lake? • How can results of sturgeon science be better communicated to stakeholders? o What research is currently being done that may affect the decision-making? • Will hunting and fishing rights of sturgeon be renegotiated?

About the Authors



The SNRE Team (from left-to-right: Molly Watters, Kevin He, and Lauren Edson)

We are a team of three graduate students from the University of Michigan's School of Natural Resources and Environment (SNRE). SNRE requires its students to complete a "master's project" as a capstone experience. The master's projects are client-based team projects that are sourced from non-profit organizations, private companies, and government agencies. This project was proposed by the Michigan Department of Natural Resources and the Grand Traverse Band of Ottawa and Chippewa Indians.

Lauren Edson: Lauren is a master's student studying conservation ecology at SNRE with a specific focus on water resources. Before coming to SNRE, Lauren studied environmental engineering at the University of Michigan.

Kevin He: Kevin is a master's student studying environmental policy and conservation ecology at SNRE with a focus on land management and conservation. Prior to SNRE, Kevin studied environmental science at Duke University and went on to work as an environmental consultant for the US Environmental Protection Agency and other government agencies.

Molly Watters: Molly is a master's student studying environmental planning and communication at SNRE. Before coming to SNRE, Molly studied environmental studies at Carleton College and worked as an interpretive park ranger for the National Park Service at Homestead National Monument.

Appendix I

GLOSSARY OF TERMS

Nameplate capacity: the maximum rated output of a dam.

Capacity factor: the ratio of the amount of electricity produced by a dam as compared to the theoretical amount of electricity that could have been produced at continuous full power.

Social value: an appreciation for something (e.g. boating) based on an association with friends and family, enjoyable experiences, and fond memories.

Cultural value: an appreciation for something (e.g. Black Lake) based on its connection to personal identity and sense of place.

Attenuation: reduction in the peak of a hydrograph resulting in a broad, flat hydrograph. Storage of storm flows in routing or reservoirs.

Indicator species: an organism whose presence, absence, or abundance reflects a specific environmental condition. May be used as a proxy to diagnose the health of an ecosystem.

Run-of-river: operation of a dam such that inflow entering the impoundments is equal to the discharge released out of the dams.

Watershed: an area or ridge of land that separates waters flowing to different rivers or basins; colloquially used to describe the catchment basin itself, whereas it is truly only the outline.

Catchment basin: the area from which rainfall flows into a river, lake, or reservoir.

Impoundment: a body of water, such as a pond or reservoir, that is formed by obstructing flow in a river.

Riparian zone: the interface between land and a river or a stream which serves an important ecological role through soil stabilization, biofiltration of water, and support of biodiversity.

Appendix II

SUMMARY OF THE WATERSHED

The Cheboygan River Watershed

The Cheboygan River watershed covers 900,000 acres over Cheboygan, Presque Isle, Emmet, Charlevoix, Otsego, and Montmorency Counties. The watershed drains into the Cheboygan River, releasing into Lake Huron, and includes what is known as the Inland Waterway, referring to Burt, Mullet, Douglas, Pickerel, Crooked, and Black Lakes. Other main tributary rivers include Crooked River, Maple River, Sturgeon River, Pigeon River, and Black River.

The topography of this area was defined by glacial movements, scouring and deposition characterize the moraine ridges, glacial till deposits, and kettle lakes. The area has large proportions of forested lands and wetlands. Additionally, the area is home to several endangered or threatened aquatic species, such as the Michigan monkey-flower *(Mimulus glabratus var. michiganensis)*, Hungerford's crawling water beetle *(Brychius hungerfordi)*, and the lake sturgeon *(Acipenser fulvescens)*. These wetlands provide nesting habitat for rare birds such as the bald eagle *(Haliaeetus leucocephalus)*, the common loon *(Gavia immer)* and the black tern *(Chlidonias niger).* (Tip of the Mitt, 2016).

The Black Lake Sub-watershed

The Black Lake watershed drains more than 350,000 acres representing 38% of the entire Cheboygan River watershed (Cwalinski and Hanchin, 2011). Black Lake itself has a surface area of 10,113 acres (Breck, 2004) and is among the ten largest inland lakes in Michigan by surface area. Black Lake is fed by the Upper Black River and Rainy River, as well as indirectly by Canada Creek and the East Branch of the Black River. Other tributary creeks include Tomahawk Creek, Milligan Creek, Stony Creek, Mud Creek, Hardwood Creek, Van Hellens Creek, Rattlesnake Creek, Packer Creek, and Fast Creek. Black Lake watershed is mostly forested and open lands, with a small percentage of agricultural uses (Tip of the Mitt, 2016). The shoreline of Black Lake is mostly private residential land with some public riparian access located in a state park near the Upper Black River and state forest campground on the north east shore. The water of Black Lake is tannin-stained dark, and residents often attribute this to historic logging industry.

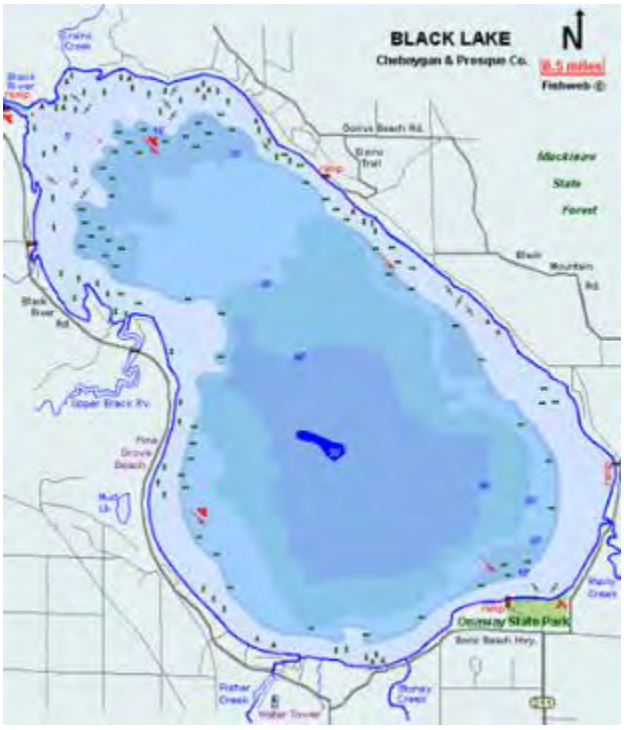


Figure 17. Map of Black Lake

Bathymetry maps show that the greatest depth in Black Lake is 50 ft., while large portions of the lake are considered shallow shoals. Shoal widths average 330-ft. wide up to a quarter mile. The substrate found in the Black is mostly sand, lending to sparse vegetation, with some areas of silt and emergent rush beds. Limnological profiles of the lake reveal that there is a typical declining trend for both dissolved oxygen and temperature and no thermocline. Seasonal variation in solar input likely has impacts on the vertical mixing of the lake. (Cwalinski and Hanchin, 2011).

Appendix III

DECLINING ECONOMY AND ECONOMIC SHIFTS

The communities in this area were settled as logging towns. Several residents have expressed that the communities have faded from what they once were, especially Tower. Logging, which was the prominent industry when the towns were settled, is still active in the area, especially on public lands. For example, the area around the impoundments is scheduled for entry in 2017 (see Figure 18), meaning logging may occur there soon (MDNR, 2015). However, timber in the area is a far less intensive industry than it was in the past. Many residents perceive it as a significant drawback that there is currently no major industry in the immediate area to provide jobs and attract commercial activity: “There’s just not the money up here to hold a lot of people. My son lives in Florida, he started out up here in Michigan but had to shut down.”

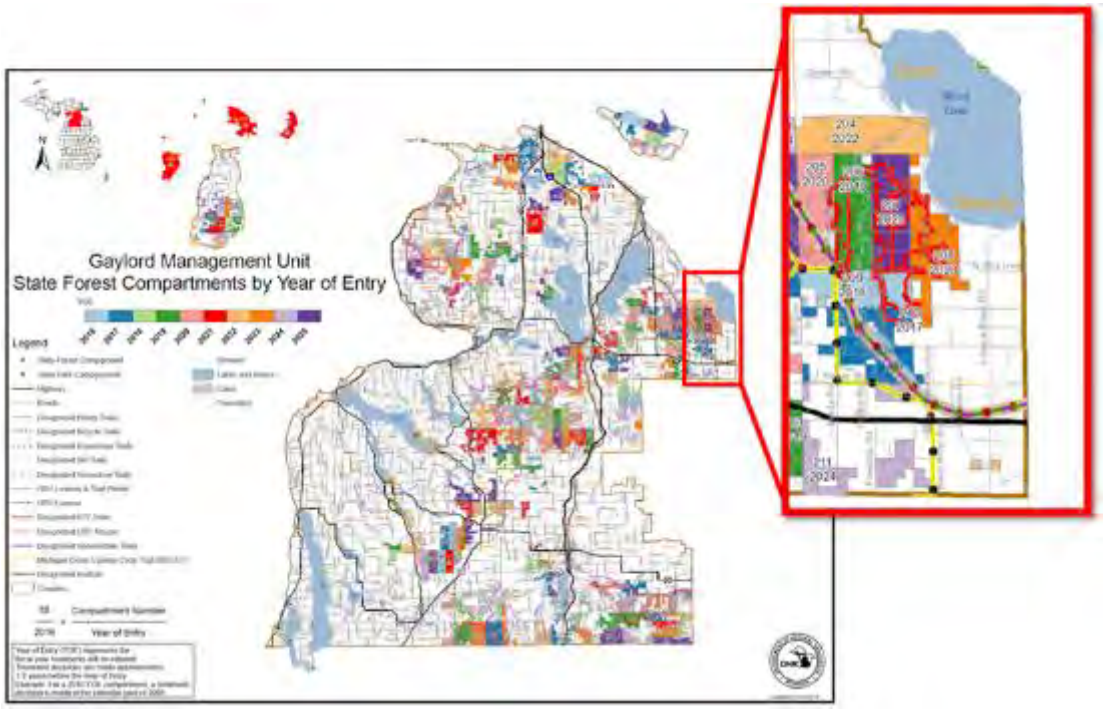


Figure 18. Map of Planned State Forest Activity Near the Tower and Kleber Dams (MDNR, 2016)

Some community members have described a decline in sense of community over time. This has to do with the overall economic decline, a shift in demographics, and a disappearance of community gathering places and events.

The area is attractive to residents because it is affordable, beautiful, peaceful, and full of recreational opportunities. These translate into reasons why many individuals from other parts of the state, such as Southeast Michigan, like to retire in this area. An increasing number of older individuals have been moving there to spend their retirement or have transitioned from living there seasonally to living there permanently or year-round. On the other end, fewer and fewer young people are staying in or moving to the area, which alters the community structure and could have implications for its future. Overall, while the influx of retirees has assisted in improving some of the economic conditions of Tower, it, in combination with the outflow of younger individuals, has also resulted in an older population with many retired households and potentially more limited opportunities for economic growth in non-recreational sectors.

DEMOGRAPHICS AND CURRENT ECONOMIC CONDITIONS

For the purpose of understanding the broader macroeconomic conditions of the Black River watershed, we have profiled below three different units of jurisdiction: Cheboygan County, Forest Township, and Tower Village. While there are other counties, townships, cities, and towns that have interests in this decision-making process, these three overlap the dams most directly, and the information provided may also be illustrative of other nearby geographies.

Cheboygan County

History

Cheboygan County was established in 1853, getting its name from the nearby Cheboygan River, which was named after an Indian word meaning “the river that comes out of the ground” (Cheboygan County, 2016; MIGenWeb Project, 2012a). The area was developed around a variety of natural resource-based extraction, such as furs and timber (MIGenWeb Project, 2012a). By the early 1900s, however, much of the valuable timber had already been logged, resulting in a decline in the regional economy. Today, the tourism economy has helped to revitalize much of the area.

Current Conditions

Cheboygan County consists of nineteen total Townships, two Villages, and the City of Cheboygan (Cheboygan County, 2016). Cheboygan County has a total population of 26,152, amounting to approximately 11,133 households (US Census Bureau, 2010). The median age in the county is 47.1, with a relatively even split across all five-year age groups (Figure 2). The kink between the 15 to 19 and the 20 to 24 age groups is likely indicative of the area’s younger population leaving to pursue advanced education or other opportunities outside Cheboygan County. Economically, the US Census Bureau estimates that 17.8% of the population in Cheboygan County are in poverty and that the median household income is $39,486 (US Census Bureau, 2014).

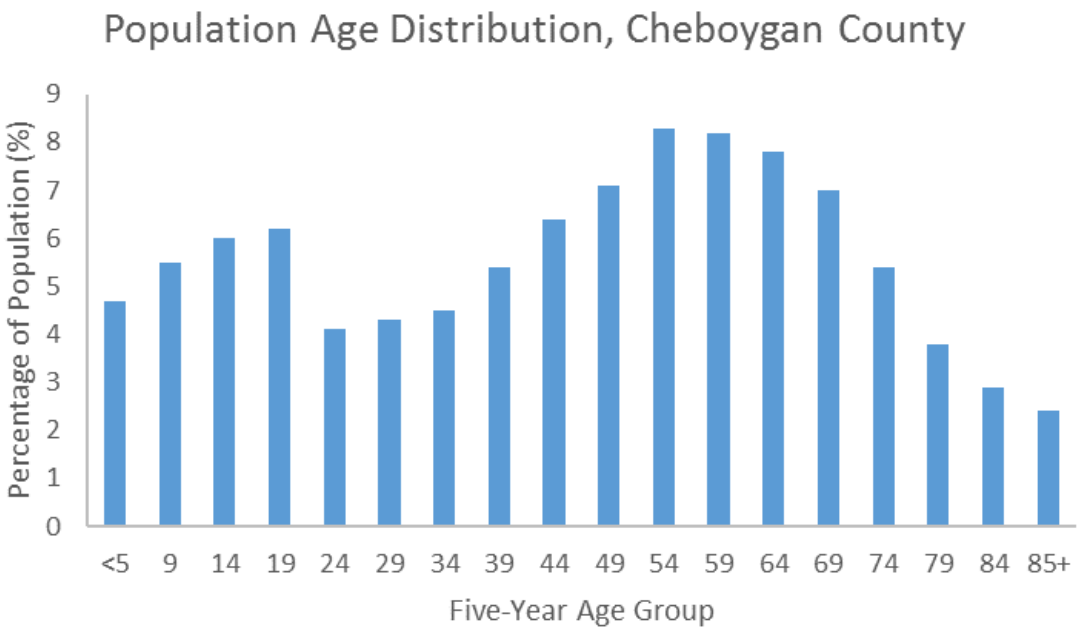


Figure 19. Population Age Distribution for Cheboygan County in 2010 (Source: US Census Bureau, 2010)

Forest Township

Forest Township encompasses the entire Tower Pond area, the majority of the Black River upstream of the dams, as well as a southern portion of the Kleber Pond. As such, Forest Township includes both the town of Tower and nearby unaffiliated residents.

History

The name of this township has roots in its importance to the timber industry beginning in the 19th century.

Current Conditions

The US Census Bureau places Forest Township's population at 1,045 in 2010 (US Census Bureau, 2010). The median age of this population is 48.7 with a similar age distribution to the broader Cheboygan County population. There are a total of 450 households in Forest Township. Economically, the US Census Bureau estimates that 15.3% of the population in Forest Township are in poverty and that the median individual income is $24,778 (US Census Bureau, 2014). The most important industries in terms of employment appear to be retail, manufacturing, education and health care services. There are very few people employed in natural resource-related professions.

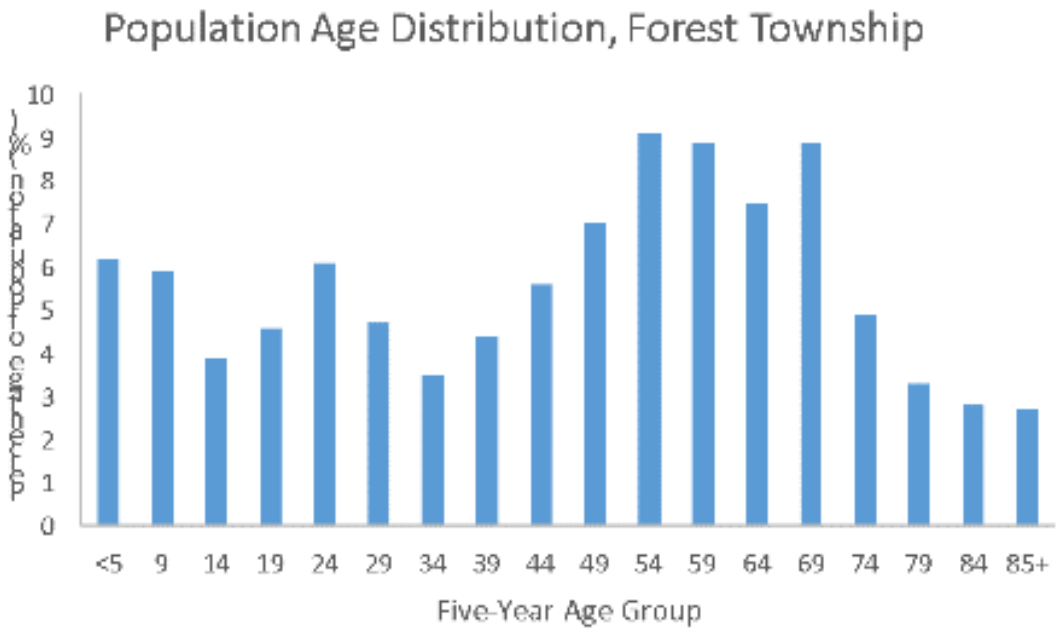


Figure 20. Population Age Distribution for Forest Township in 2010 (Source: US Census Bureau, 2010)

Tower Village

As stated previously, the city of Tower sits right on the shores of Tower Pond (include map here) and is likely to be directly impacted by whatever decision is made to Tower Dam. From our interviews with some local residents, Tower Pond is a prominent facet of the area. Several of Tower's parks are located along the shores of the pond, and residents use the pond for a variety of other recreational activities as well. In addition, having developed alongside the pond, a significant number of residents live along the shores of the impoundment.

History

Broadly, many of the settlements in this region were established in conjunction with the timber industries expansion of activities into the area (MIGenWeb Project, 2012b). In fact, several interviewees have noted that the historical roots of their family in the area was tied to one family member or another working for the timber industry. Tower was originally established in May 20, 1899 and at its height in 1910 had a population of about 800 (MIGenWeb Project, 2012b). However, on July 11, 1911, a large portion of the town burnt down in the Au Sable-Oscoda Fire, which marked the end of the regional timber industry, and Tower never regained its prominence.

Current Conditions

Tower is an unincorporated community and administered by the broader Forest Township governmental unit. The sentiment voiced by several interviewees familiar with Tower and the broader area is that there is little in the way of economic opportunity or growth in the area. Many noted a recent influx of families from southern Michigan into the area for retirement. While this has assisted in improving some of the economic conditions of Tower, it has also resulted in an older population with many retired households. Interestingly, one resident noted during an interview that timber is once again an important component of the local economy.

Appendix IV

SCIENTIFIC BACKGROUND ON STURGEON

Life History

Lake sturgeon (*Acipenser fulvescens*) are long-lived and late-maturing partly cartilaginous fish, aging up to 100 years and reaching sexual maturity at 15-20 years for males and 20-25 years for females. Once at sexual maturity, the males spawn every other year and the females spawn every four years on average (Peterson, 2007). Lake sturgeon can grow up to 260 pounds and 2.4 m in length over their lifetime. Typical lengths for females are between 140-160 cm and between 120-140 cm for males. Early stage and juveniles grow more rapidly in length than in weight, but adult sturgeon tend to grow in weight rather than length (Peterson, 2007)

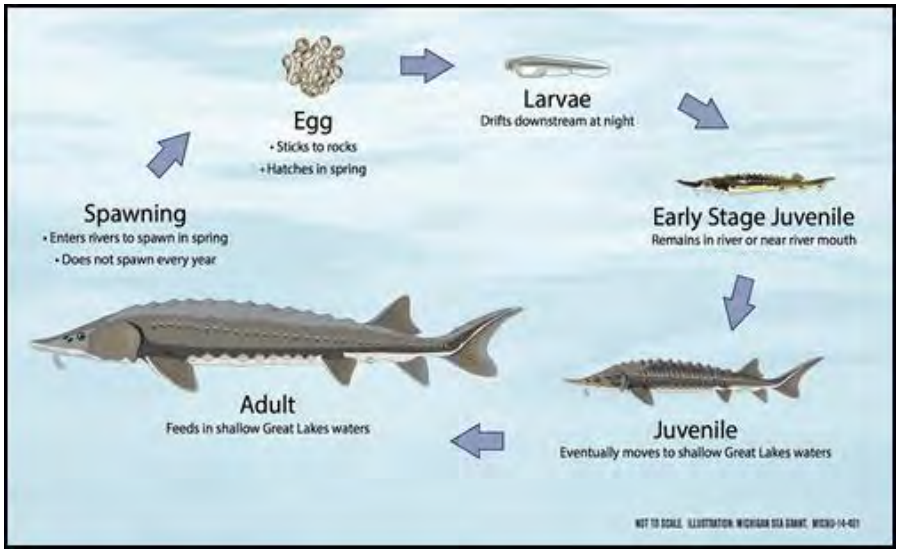


Figure 21. Lake sturgeon Life Cycle (FWS)

Reproduction

Adult lake sturgeon migrate into rivers to spawn from April to June and searches out favorable temperatures and gravel substrate or rapids in order to optimize reproductive success (Auer, 1996). Water temperature serves as an environmental cue for migration into the river reach and

Potamodromous: migrating short distances for spawning purposes, typically lake to stream.

spawning behaviors to begin. Along with the energy required to move upstream, the sturgeon must also dedicate a large proportion of energy to gamete production before a spawning event. Due to the variation in reproductive cycles and the high energy requirement, the spawning population each year represents about 10-20% of the population in a given area (see Figure 22).

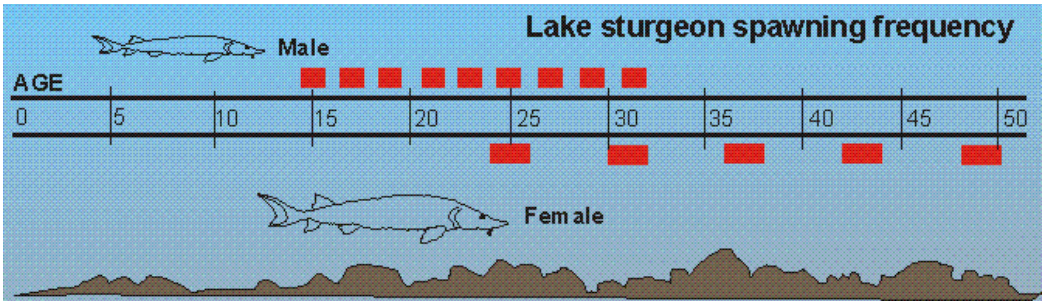


Figure 22. Adult sturgeon spawning frequency (WI DNR)

During a spawning event, a group of male sturgeon will gather upriver in pools close to shallow, rocky, rapids-type areas and wait for ripe females to arrive. This behavior is referred to as staging and conserves energy for reproduction. When the female arrives, spawning bouts begin at a rocky site, during which a single female will release 4,000 to 7,000 eggs per pound of body weight into a cloud of sperm released by two to eight males (Bruch and Binkowski, 2002). The eggs become sticky when exposed to water, allowing for eggs to adhere to the underside of clean rock, rock crevices, or clump together. Each spawning site will be utilized for two to four days, depending on the number of females utilizing the site. The eggs hatch in five to eight days, depending on the water temperature. In 12 to 14 days, the fry (newly hatched fish) are one-inch-long and have fully developed mouths and barbels (Peterson, 2007). Sturgeon will remain in their natal river for the first summer (FWS, 2016) developing from larvae to early juvenile stages while drifting along the reach.

Early Life Stage

Early life stages are the most vulnerable for lake sturgeon. From hatching until scutes have developed, the young sturgeon are vulnerable to predation (Auer and Baker, 2002). Predation avoidance behaviors include drifting at dusk and remaining in gravel during sunlight hours. The mottled appearance of the juveniles is to camouflage with the sandy bottom. During this vulnerable life stage, the larvae will be preyed upon by many opportunistic feeders, with rock bass as the major predator. Juvenile lake sturgeon are more active at night, which serves as predator avoidance and may increase their foraging success (Chiasson, 2011). In addition to being

sensitive to substrate type, juvenile sturgeon are also vulnerable to stress in increasing heat regimes. Activity and foraging behaviors decrease with temperatures much above their tolerance zone (Wilkes, 2011).

Feeding Behavior

Lake sturgeon are benthivorous, meaning they feed on small invertebrates, insect larvae, crayfish, snails, and bloodworms found in sand and clay substrate. Since sturgeon feed on some macroinvertebrates known to be sensitive to water quality, declining water quality would have a direct impact on lake sturgeon growth. While they are opportunistic feeders, sturgeon will primarily forage for macroinvertebrates such as bloodworms (Annelids), midges (Diptera), mayfly larvae (Ephemeroptera), stonefly larvae (Plecoptera), and caddisfly larvae (Trichoptera). Their barbels—four sensory organs before their mouths—allows for navigation and locating food through olfactory, tactile, and chemosensory cues. They can then suck up food like a vacuum with their protruding mouths and prehensile lips (NOAA, 2009). Considering that foraging behavior is closely tied to substrate type, cobble and wood type substrates make foraging difficult for sturgeon (Chiasson, 2011).

Tolerance and Habitat Needs

The tolerance range for any species describes the zone of favorable conditions for various abiotic environmental factors such as temperature, nutrient availability, sunlight, dissolved oxygen, etc. The combination of these tolerance ranges defines the acceptable range for a given species to survive. Alternatively, the “tolerance” for any factor also refers to the ability to endure unfavorable conditions. Tolerance curves are developed for species at differing life stages, as well as various behaviors. The tolerance curves for lake sturgeon are included below (Figure 23 and Figure 24) for adults and during spawning. Suitable habitat for adult lake sturgeon is generally deeper than 3 meters and slow, as in a lake, with sand or gravel substrate. When spawning, however, the suitable habitat is approximately 1.25 meters deep with a velocity of 25 cm/sec over boulders.

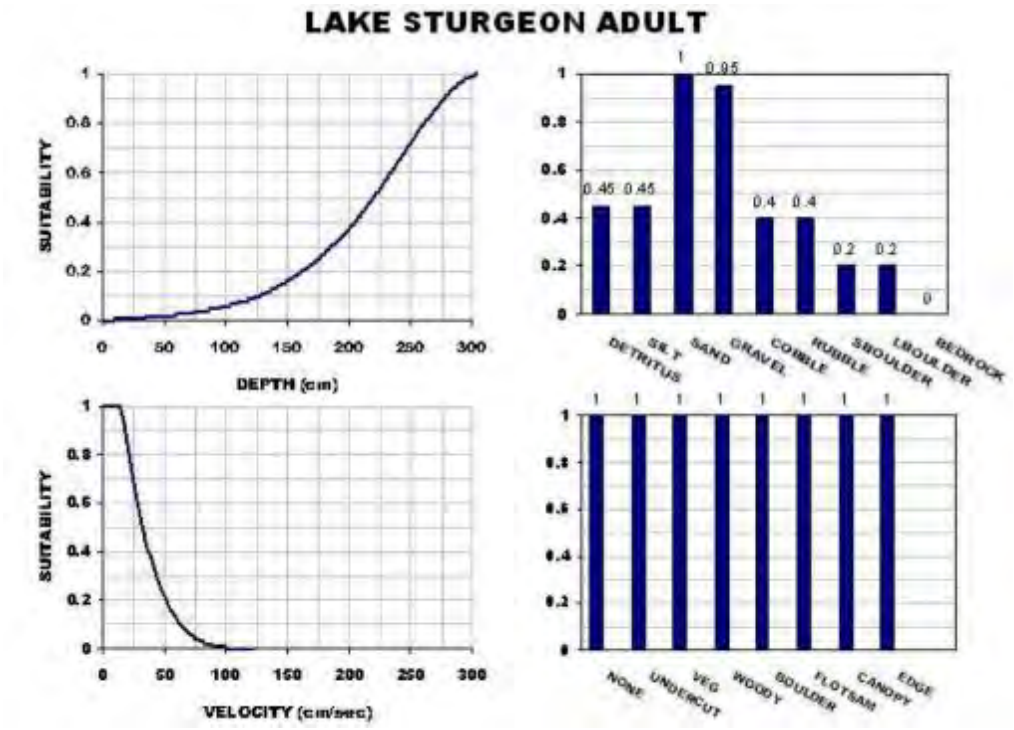


Figure 23. Tolerance curves of adult lake sturgeon (Minnesota DNR)

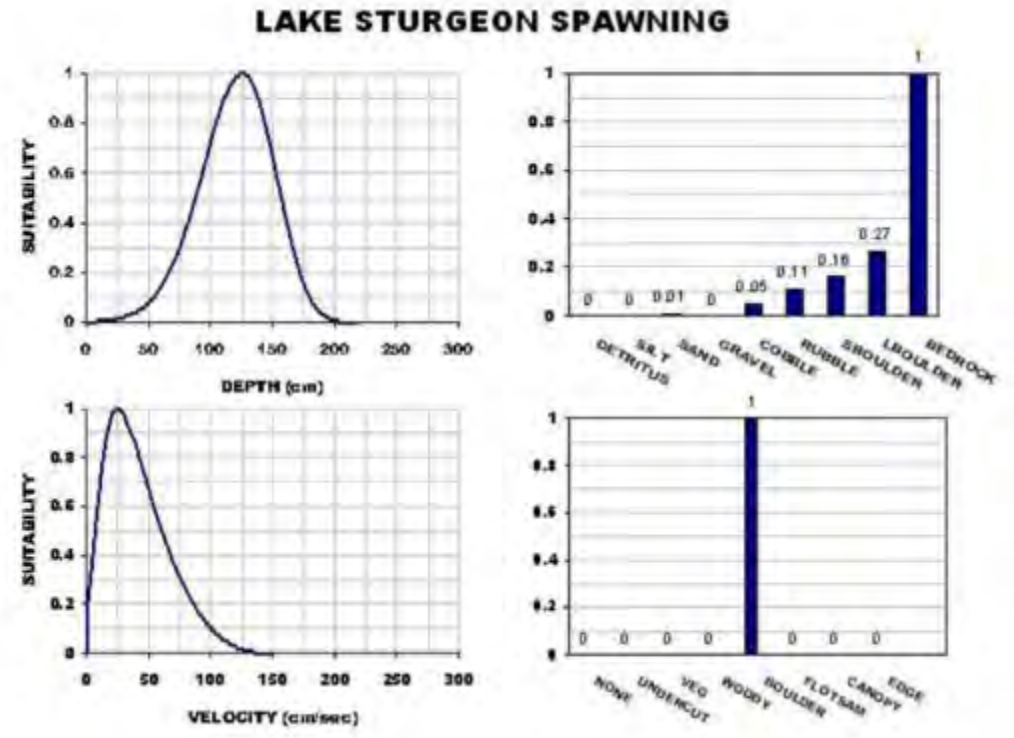


Figure 24. Tolerance curves of spawning lake sturgeon (Minnesota DNR)

To understand the limits on sturgeon, a number of studies have explored the impact of several environmental factors on sturgeon such as: dissolved oxygen, light, temperature, flow regime, and substrate. However, this understanding is complicated by the fact that tolerance ranges changes for different life stages and behavior.

- Dissolved Oxygen: Typically, sturgeon are sensitive to decreases in dissolved O_2 concentration; hypoxic conditions impair their respiratory metabolism, foraging activity, and growth rates (Cech and Doroshov, 2005).
- Light: Daily light cycles appear to regulate growth and reproduction similar to salmonids (Cech and Doroshov, 2005). Light input in shallow waters is related to foraging effort; sturgeon species generally prefer dimly lit, moderately turbid water, which reduces defensive actions by invertebrates.
- Temperature: Low response to temperature change implies they are relatively tolerant to temperature ranges; adult lake sturgeon prefer warm-water in the range of 10-16°C, and juveniles show more activity and growth at 19°C than 6°C (Peake, 1999). Juvenile sturgeon are vulnerable to stress with temperatures outside their tolerance range, leading to decreased activity and foraging behavior (Wilkes, 2011).
- Flow Regime: Adult sturgeon prefer nearshore habitats around 15-30 feet deep and natural hydrograph regimes typically encourage more spawning behavior (Auer, 1996).
- Substrate: Preference for substrate type is related to foraging, spawning, and predator avoidance behavior. Juvenile lake sturgeon significantly prefer a sand substrate, compared with rock or gravel substrates, to avoid predators (Peake, 1999). For spawning, lake sturgeon migrate into rivers and seek favorable temperatures and gravel substrate or rapids where they can have the best chance of reproductive success (Auer, 1996); gravel substrate provides a surface for sticky sturgeon eggs to adhere and temperatures should be adequate for larvae stages during development.

Human-induced Mortality

Although an evolutionarily old fish, the lake sturgeon populations have declined throughout their historic range; 19 out of 20 states in the original range for lake sturgeon now list the species as endangered, threatened, or special concern. This decline is attributed to overharvest, barriers to migration, and disturbance of habitat through pollution (Rochard et al., 1990). Prior to the 1900s, lake sturgeon were caught and killed as a nuisance fish because they would get caught in fishing gear set for other species. When their caviar, meat, and isinglass (a type of gelatin) became specialty products, the lake sturgeon populations were fished heavily, both commercially and

though poaching until collapse in the mid-1900s (Peterson, 2007). A black market was established to sell local lake sturgeon eggs as caviar, which is usually made from Russian beluga sturgeon. Subsistence-based lifestyles historically considered sturgeon as a significant food source in areas with access to sturgeon populations. Due to economic shifts and lifestyle changes harvest and nuisance killing has subsided. The Sturgeon Guard program was also largely responsible for helping to curtail poaching (MDNR, 2017h).

Restoration Efforts

Remnant populations in the Great Lakes basin are slowly rebounding under protection and restoration efforts. The current focus on improving the status of the lake sturgeon is driven by Michigan's Lake Sturgeon Rehabilitation Strategy, which details goals for sturgeon populations in Michigan waterways, management strategies available to fishery managers, and a scheme for prioritization of management actions (MDNR, 2012). The strategy addresses mortality and recruitment limitations, indicating that degradation of spawning and nursery habitat and reduction in habitat connectivity due to hydroelectric dams are major concerns. Rehabilitation efforts and research often consider issues related to hydroelectric dams such as connectivity and habitat restoration.

Since the lake sturgeon are not federally listed under the Endangered Species Act and qualify for conservation status in select states, management plans are largely state efforts. Sturgeon rehabilitation plans have been developed in Ohio, Wisconsin, Minnesota, New York, Michigan, and Ontario (Welsh, 2004). The MDNR Fisheries Division first created a Sturgeon Rehabilitation Strategy in 1997, and updates the strategy every fifteen years (MDNR, 1997). The rehabilitation strategy first identifies the objectives for sturgeon population; conserve self-sustaining populations and rehabilitate depressed populations to be self-sustaining. Then it describes management options through reducing mortality, stocking, and habitat rehabilitation. Management tools focus on: minimizing harvest of populations smaller than 750 adults and maintaining fishing mortality at or below 2%-5% per year; improving habitat conditions, access, and connectivity; supplemental stocking; managing invasive species; and educating the public. Next, the strategy identifies possible site-specific barriers to achieving these objectives, such as fish passage, hatchery needs, and an analysis of the genetic stock (MDNR, 2012).

Furthermore, the Great Lakes Fishery Trust sponsored a workshop in 2011, to bring together forty representatives from natural resource agencies and identify knowledge gaps about sturgeon

status and constraints (GLFT, 2012). The proceedings from this workshop are used to inform strategic funding for research to enhance fish passage at hydroelectric facilities. The Trust is a nonprofit organization, the result of a settlement agreement to mitigate fish loss at the Ludington Pumped Storage Hydroelectric plant, that answers to a Board of Trustees comprised of representatives from state agencies and tribal nations. It provides funding through grants to projects that enhance, protect, and rehabilitate fisheries in the Great Lakes. The goal of the workshop was to refocus research efforts for sturgeon rehabilitation and foster collaboration among resource managers, scientists, planners, and industry. Discussion touched on ways to mitigate the effects of dams on sturgeon, such as blocked migration to spawning habitat and degradation of suitable nursery habitat, but it was clear that current fish passage and knowledge were not sufficient.

Appendix V

THE GRAND TRAVERSE BAND OF OTTAWA AND CHIPPEWA INDIANS' RESOLUTION FOR DAM REMOVAL (GTB, 2015)[7]

WHEREAS: The Grand Traverse Band of Ottawa and Chippewa Indians (GTB) became federally-recognized as an Indian Tribe having a government-to-government relationship with the United States effective May 27, 1980 (see 45 Fed. Reg 18321-322 (March 25, 1980); and

WHEREAS: GTB is organized under a Tribal Constitution approved by the Secretary of the Interior on March 29, 1988; and

WHEREAS: GTB has a full Tribal Council currently consisting of Alvin V. Pedwaydon, Tribal Chairman; JoAnne Cook, Vice Chair; Thomas P. Shomin, Treasurer, Councilor; and Mark L. Wilson, Councilor; and

WHEREAS: the Tribe, in honor of its traditional and cultural heritage places a high priority on the preservation and responsible use of its natural resources in the 1836 Treaty Ceded Territory; and

WHEREAS: the Tribal Council, in awareness of the human, industrial, and commercial impact on the environment, realizes the significant role of protecting the forest, wildlife, fisheries, and water resources for the cultural, spiritual, and continued exercise of Treaty Reserved Rights under the terms of the Consent Decree entered in United States v. Michigan, in 2007 and

WHEREAS: the Black River is located in Cheboygan County which is within the 1836 Ceded Territory; and

WHEREAS: there are three dams located on the Black River: 1) Alverno Dam - Built in 1903 and located downstream in the lower portion of the Black River, 2) Kleber Dam - Built in 1949 and

[7] The Little Traverse Bay Bands of Odawa Indians' motion contains almost identical language, the primary differences stemming from it being a motion as opposed to a resolution and LTBB's later date of recognition by the United States Congress.

located up stream in the up portion of the Black River, 3) Tower Dam - Built in 1918 and located up stream in an upper most portion of the Black River; and

WHEREAS: Tower and Kleber dams (FERC No. 10615) were relicensed 5-11-1994 with a 30 year term to end 4-30-2024 and Alverno dam (FERC No. 11730) was licensed 12-4-2001 for 40 years to expire 11-30-2041; and

WHEREAS: the dams are owned by Nelson Turcotte; and

WHEREAS: the Black Lake System (Black Lake and its out flows and tributaries including Black River) has historically supported a vibrant and robust Lake Sturgeon population; and

WHEREAS: the Black Lake System currently supports a diminished lake sturgeon population almost entirely composed of individuals of hatchery origin; and

WHEREAS: scientific literature, peer-review publications, and Tribal-, state-, and federal-authored technical reports overwhelmingly implicate dams as a primary impediment to lake sturgeon reproduction and recovery; and

WHEREAS: The Upper Black River is 57 Miles long and lake sturgeon only have access to 6.8 miles (or 12%) of the river (From mouth to Kleber Dam) and available habitat for sturgeon and has not allowed for meaningful natural recruitment for more than three decades; and

WHEREAS: the federally entered 2007 Inland Consent Decree states in Section 17.3 that “The state and the Tribes shall discuss strategies for rehabilitating sturgeon populations…”; and

WHEREAS: the State of Michigan and Tribes have established a work group to develop a Black Lake Sturgeon Management Plan in which the Black River dams have been identified as an impediments to a self-sustaining and naturally reproducing Lake Sturgeon population in the Black Lake system; and

NOW THEREFORE BE IT RESOLVED, that the Grand Traverse Band of Ottawa and Chippewa Indians requests that the FERC not relicense the dams upon their expiration dates; nor shall

entertain any proposals requesting an extension of said license beyond the current dates of expiration.

BE IT FURTHER RESOLVED, that the Grand Traverse Band of Ottawa and Chippewa Indians hereby requests that the State of Michigan, the 1836 Treaty of Washington Signatory Tribes, and the owner, begin developing a plan to decommission and remove the dams within one month of the signing of this resolution.

BE IT FURTHER RESOLVED, that the Grand Traverse Band of Ottawa and Chippewa Indians hereby calls for the removal of the dams prior to or immediately upon the expiration of their FERC operating licenses.

Appendix VI

TRIBAL TREATIES

These motions also reference important historical and recent agreements between the five tribal nations (GTB, LTBB, the Sault Ste. Marie Tribe of Chippewa Indians, the Bay Mills Indian Community, and the Little River Band of Ottawa Indians), the federal government, and the State of Michigan as standing for their motions. The 1836 Ceded Territory is in reference to the Treaty of Washington wherein the United States federal government obtained legal title to the land from the headmen of the GTB and LTBB as part of its process of granting Michigan statehood (Bzdok et al., 2008). The boundaries, which cover 13,837,207 acres of lands and inland waters, are formally defined in Article 1 of the Treaty of Washington (Kappler, 1904; MDNR, 2007). This ceded territory is delineated in orange in the map in Figure 7.



Figure 25. Map of 1836 Ceded Territory (Zaid, 2015)

The 2007 Inland Cultural Consent Decree was negotiated in order to resolve one main point of contention related to the 1836 Ceded Territory, which was the question of whether the Ottawas and Chippewas also ceded their right to continue using the land and waters within the ceded boundaries (United States v. Michigan, 2007). The controversy related to the 1836 Ceded Territory was that, although the tribal nations gave the US title to the land, they believe that they had not ceded their right to use the land's natural resources. While a 1979 court decision in US v. Michigan addressed tribal nations' claims to resources in the Great Lakes, it left inland rights unresolved (United States v. Michigan, 1979). In September of 2003, the State of Michigan filed a claim in court to resolve the inland disputes, which eventually concluded on November 2, 2007 with the Consent Decree (GTB NRD, 2008; MDNR, 2007). Broadly, the agreement allows for a more cooperative form of management over joint resources, such as lake sturgeon populations in Black Lake (United States v. Michigan, 2007).

In addition to these agreements between the State of Michigan and the five tribal nations, the United States Federal Government also has policies governing their engagement with tribal governments. On November 5, 2009, President Obama released a memorandum on tribal consultation that charges executive agencies and departments "with engaging in regular and meaningful consultation and collaboration with tribal officials in the development of Federal policies that have tribal implications" (Obama, 2009). In relation to the Tower and Kleber Dams, since the impetus for a decision is related to the FERC license, FERC will need to engage the five tribal nations in a meaningful dialogue as it proceeds in that process.

Appendix VII

LESSONS FROM DAM REMOVAL CASE STUDIES

There is a growing body of literature that details examples of dam removal scenarios, as well as several studies which summarize learnings from dam removals in recent decades (Oliver, 2017; Grant, 2015). In addition to looking at the ecological impacts of dams and dam removal, certain cases demonstrate the respective planning processes and social impacts.

Below, we highlight characteristics of dam removal processes by looking at the following factors: impetus for decision-making process; process structure and parties involved; result of the decision-making process including outcome, costs, and how responsibility was assigned; and subsequent impacts to the ecosystem, amenities, and community perception. An effort was made to describe dam removal processes that addressed similar concerns that were expressed regarding Tower and Kleber dams.

A table, on the following page, highlights some of the key takeaways from each of the dam removal case studies. More in-depth discussions are provided on the subsequent pages.

	Reason for removal	Engagement Processes	Public Support	Ecological Considerations	Who Paid?	Lesson Learned
Bear River Valley Recreation Area Project	Create parks & whitewater, revitalize community	City planners, public meetings	Much community support, voted use of tax dollars	Restore multi-dam area & add enhancing features	City of Petoskey, with tax increment financing	Whitewater can be an exciting & widely valued asset
Song of the Morning Dam, Pigeon River	Dam breach with sediment release & fish kills	Lawsuits, out-of-court settlement, partnerships	Little public support; active opposition by state, Trout Unlimited, residents	"Ugly" transition period & revegetation	Matched funding Golden Lotus Inc. (dam owner) & state grants	Loss of public support led to negative view of dam removal
Menominee/Sturgeon River	Improve sturgeon spawning, create whitewater	Wilderness Shores Settlement Agreement; Menominee River Fish Passage Partnership	Whitewater rafters support; Willing to pay for tradeoffs: hydroelectricity & fish passage	Sturgeon spawning access via fish passage	We Energies (dam owner); MDNR	Retaining dams can also be successful with fish passage
Saunders Dam	Improve brook trout habitat	MDNR acquired land; Partnership formed	Local businesses, Huron Pines, USFWS	Coldwater fish habitat & surrounding State Forest	Matched funding by MDNR & partnership	General support & low cost for small-scale dam removal
Klamath River Dam Removal Project	FERC relicensing process	Public meetings, dedicated website	Large stakeholder engagement	Salmon & steelhead restoration	PacifiCorp ratepayers & the State of California	Good stakeholder involvement & public transparency can allow for buy-in despite conflict and disagreements
Boardman River Dams Project	Owner-initiated due to cost concerns	Multi-agency & organization workgroups, dedicated website	Broad stakeholder engagement, but some critics	Habitat restoration for coldwater species (brook trout, dace, sturgeon)	State & federal agencies, private foundations	MDNR may still play an important role despite not being the final decision-maker for the process

Bear River Valley Recreation Area Project

City-run, publicly supported dam removal and whitewater creation

The dam removal process in Petoskey serves as an example of a City- and resident-initiated project whose purpose was to transform the river into a community asset especially featuring whitewater opportunities. Five dams were built along a quarter-mile stretch of the Bear River through Petoskey's industrial downtown. The largest of these dams was the Mitchell Dam, built in 1901 and upgraded for electricity generation in 1933. By 1973 hydroelectric production on the Mitchell Dam had ceased, three of the five dams had been removed, and the City created a comprehensive master plan for the river valley including a whitewater park. City residents were on board with the plan and voted approval for a Tax Increment Financial Plan to use taxes to help pay for the project. The City removed the remaining dams by 1992 and the $2 million project to create a park and whitewater area, planned with several public meetings, was completed in 2010-2011 (City of Petoskey).


City of Petoskey: T. Knusten

The 36-acre Bear River Valley Recreation Area is a natural park that includes a quarter-mile whitewater boating area, natural forests, trails including the North Country Trail, boardwalks, two shelters, two restrooms, five parking access points, many access points to surrounding neighborhoods, and stormwater improvements (City of Petoskey). The Bear River has more fall than any river in Michigan's Lower Peninsula, and the .25 miles in the new Bear River Valley Recreation Area drops 80 feet and reaches 3-4 class rapids. The new stretch of river was restored after dam removal and enhanced with added features like boulders, logs, rollovers, and ledges (Visit MI Up North). It has become a popular recreation destination for both Petoskey residents and visitors from across the country. The Northern Michigan Paddling Club formed around this new whitewater, and now shares whitewater kayaking safety and opportunities in the area (City of Petoskey). Reviews of the park reveal active tourism and five-star ratings. The City of Petoskey

calls their park a “gem” and the director of Petoskey Parks & Recreation says “it is an asset to our parks system” (Dewey, 2013).

Song of the Morning Dam, Pigeon River

Process initiated by operational failure; Still ecologically transitioning

Song of the Morning Dam removal is an example of a process that left people skeptical toward dam removal. The removal of the Song of the Morning dam on Pigeon River was completed in September of 2016. The project was an agreement between Huron Pines, Pigeon River Country Association, Golden Lotus Inc., Michigan Trout Unlimited, Michigan Department of Natural Resources, and the Great Lakes Fisheries Trust, and was reported to cost $570,000 (Breen, 2016*)*. The removal was jointly funded in equal proportion by the dam owner and through state grants. Pigeon River is a designated Blue Ribbon trout stream and is located near Pigeon River Country State Forest.

However, the impetus for the collaborative project was a response to a failure in dam operation that resulted in release of sediment and fish kills. The public and downstream landowners took notice and the State of Michigan filed suit against the dam owner, with Trout Unlimited and Pigeon River Country Association. Coming to an agreement outside of court proceedings, the collaboration allowed for state funded grants to support the removal.


Huron Pines

Public perception of the sediment release event, court proceedings, and post-removal transition period have left a negative view of dam removal. The drawdown of the 45-acre impoundment released black silt and revealed bottomlands that had been inundated for nearly a century. According to a Huron Pines representative, drawdown is “not going to be pretty; just like any surgery, there’s a little bleeding at first” (Breen, 2016). Plants that vegetate within the first season will have shallow root structure that serve to stabilize the exposed soil until later successional plants can take root (Breen, 2016).

Menominee/Sturgeon River

Rapids for habitat and whitewater; Fish passage alternatives considered

As a result of the Wilderness Shores Settlement Agreement, the removal of Sturgeon Dam is part of a mitigation effort made by the owners, We Energies, federal and state resource agencies, and the Michigan Hydropower Reform Coalition in 2001 (MDNR, 2017d). Sturgeon River Dam, located on Sturgeon River near Norway, MI, was a 45-foot hydropower dam that was removed to provide access to sturgeon spawning habitat and create new recreational whitewater. The removal process was started summer of 2003 and completed autumn of 2005 (MDNR, 2017d).

The removal of this structure occurred in phases over 2003-2005 and opened spawning habitat for lake sturgeon coming up from Menominee River. Phasing the removal allowed for the reservoir to drain and sediment transport to stabilize, reducing impacts to fish and wildlife. Additionally, removal of the Sturgeon Dam has resulted in a new paddling destination, in proximity to other paddling favorites (American Whitewater, 2017). Yielding approximately 0.3-0.6 miles of whitewater located in a scenic gorge, this reach could offer class III and IV rapids during early season and class II and III in summer months.

Downstream of the confluence of Sturgeon River and the Menominee, a series of five dams were recently reevaluated in a relicensing process with a focus on fish passage (MDNR, 2017d). Although these dams, called the Menominee and Park Mill Hydroelectric Projects, had a FERC license that ended in 2015, the decision-making process began ten years prior with the formation of the Menominee River Fish Passage Partnership in 2005. The implementation team, including fish biologists, engineers, ecologists, economists, and regulatory specialists, identified fish passage alternatives and performed a feasibility study with an emphasis on lake sturgeon. Alternatives were screened for effectiveness, efficiency, and acceptability, and now allow for sturgeon to reach historic spawning sites 82 miles upstream while the dams remain in place (FWS, 2015).

Saunders Dam, East Branch of the Upper Black River

Brook Trout Management

The Upper Black River is a well-known Blue Ribbon Trout Stream managed for brook trout; removal of Saunders Dam provides an example of dam removal specifically intended to improve conditions for brook trout, a species that needs cold, oxygen-rich water to thrive. Saunders Dam

impounded a 12-acre area that warmed the river and created an obstruction for trout passage (Engle, 2015).

Removal of the dilapidated 5-ft hydropower dam was completed in 2013 after a 517-acre parcel of land was acquired by MDNR for the purpose of dam removal, habitat improvement, and addition to Pigeon River Country State Forest (MDNR, 2017). Funding for the project, $65,000, was raised and matched by a partnership which included U.S. Fish and Wildlife Service, Huron Pines, Michigan Department of Natural Resources, Upper Black River Watershed Council, and local businesses (Engle, 2015).

Klamath River Dam Removal Project

Good stakeholder engagement and public transparency and involvement

The decision-making process for the Klamath River Hydroelectric Project provides an example of good stakeholder involvement as well as public engagement and transparency. In 2004, PacifiCorp submitted an application for relicensing of the Klamath River Hydroelectric Project, a seven-dam system in California and Oregon (PacifiCorp, 2017). In doing so, they also began to engage in discussions with a wide variety of stakeholders to help resolve long-standing conflicts of water and other natural resources in the Klamath Basin (Oregon Department of Justice, 2016). The resulting negotiations engaged more than 50 different organizations representing conservation groups, Indian tribes, farmers, fishermen, irrigators, counties, and state and federal agencies (KlamathRestoration.gov, “FAQs”). These negotiations resulted in two separate agreements, the Klamath Hydroelectric Settlement Agreement (KHSA) and the Klamath Basin Restoration Agreement (KBRA). These two agreements, in conjunction, formed the framework of questions and goals through which 1) the Secretary of the Interior, would determine whether removal of four dams would be appropriate, and 2) stakeholders would work to restore the basin and ensure all interests were addressed (KlamathRestoration.gov, “FAQs”).

There are several noteworthy characteristics of the Klamath Dam process that can inform discussions of Tower and Kleber dams. First, the dam owner initiated the broader negotiations alongside the relicensing process. This allowed it to leverage other stakeholder interests to reduce costs and risk to itself and its customers (PacifiCorp, 2017). Second, the process engaged a wide variety of stakeholders and therefore a broader set of issues and concerns that had to be negotiated. This, however, was critical in ensuring the longevity of the agreement and preventing future litigation challenges, since many of those interests were addressed and represented in the

process. Finally, the Klamath process did a great job at ensuring transparency to the general public so that the voice of non-organized interests were also represented in final decisions. In addition to more traditional public engagement as required by the National Environmental Protection Act (NEPA), the U.S. Department of Interior also developed a website wholly dedicated to the project, KlamathRestoration.gov. This website serves as a repository for any and all actions related to the projects, such as with formal scientific reports and meeting notes (KlamathRestoration.gov, "Home"). The website also functioned as a way for the public to submit written comments about the project (Klamath Settlement, 2010).

The Boardman River Dams Project

Role of the Michigan Department of Natural Resources in dam removal processes

The Boardman River Dams Project "is the most comprehensive dam-removal and watershed-restoration effort in Michigan's history and represents a model for how diverse organizations can collaborate effectively to work through complex issues that span multiple jurisdictional boundaries" (MDNR, 2017d). A goal of the removal was to restore habitat for cold water species, such as brook trout, dace, and lake sturgeon. This project, in addition to serving as a model of collaborative decision-making that the Tower and Kleber dams process can learn from, is also informative as a demonstration of the role that MDNR has played in past dam removal negotiations.

With Boardman, MDNR served as just one of many members of the "diverse organizations" involved in the Boardman River Dams Project. After the dam owners initiated the process due to economic concerns (the revenue of hydropower production was outweighed by the potential costs of repair and maintenance, $8 million vs. $16 million), MDNR was represented as one of eight members of the "Implementation Team," which provides oversight over the overall process and consists of key government agencies at local, state, and federal levels, as well as other non-governmental stakeholders (The Boardman River Dams Project, "Participation"). Therefore, although MDNR played a key role in the process, they were not an initial decision-maker. Instead, the decision rested in the hands of the dam owners themselves, in this case the City of Traverse City and the Grand Traverse County (The Boardman River Dams Project, "Dam Project"). As of 2009, however, the City of Traverse City and Grand Traverse County passed resolutions to allow the Implementation Team to make recommendations and decisions about the planning and direction of the dam removal project (The Boardman River Dams Project, "Participation").

Appendix VIII

INTERVIEW GUIDE

[Probing questions are provided below in brackets]

A. First, I would like to get a sense of your experience living in the Black River area.

1. Tell me about your connection to this area.
    a. How long have you lived here?
        i. [Tell about your family's history in this area.]
    b. [What sort of activities do you do for work there?]
    c. [What sort of activities do you do for fun there?]
2. Now I'll ask a few questions to see how the community interacts from your perspective. Tell me about the general feel of the community.
    a. What are some things you like about your community?
        i. Can you tell me about any big changes or turning points in your community?
3. We'd like to hear about your relationship with the environment in the area. You mentioned [fun outdoor activity] earlier, could you tell me more about the outdoor activities you do in the area?
    a. We know many people in this area are passionate about fishing. How about you?
        i. [Tell me about what a normal day of fishing is like.]

B. Now that I know a little about your background and perspective, I'd like to narrow in on Black River and the Tower and Kleber Dams.

1. How do you use or otherwise experience Tower Pond? and Kleber Pond?
2. From your perspective, what do you think are some impacts of the dams?
    a. What do you think are some benefits from the dams?
    b. What do you think are some consequences from the dams?
    c. What impacts do you think other community members might see relating to the dams?
        i. Which groups in the community would be particularly affected by the decisions about the dams?
3. The lake sturgeon is considered threatened in Michigan.
    a. How do you feel about the harvest limits?
    b. How do you feel about the rearing facility? Is it worth the money or effort?
    c. How actively involved are you in events related to the lake sturgeon?

C. Now I would like to talk a bit more about the future of the Black River and the Tower and Kleber Dams.

1. A decision about the future of the dams may be made in the next several years. As a member of the community who will have to live with the outcome, what do you want to see considered in that decision?
    a. What other issues do you see in the situation?
    b. What are some of your concerns about addressing the issues?
    c. Where do you feel like your community might disagree on this decision?

2. If the dam(s) were removed, a river fishery might reestablish itself. How would that affect you? How would you feel about that?
3. If a decision is being made, what concerns might you have with the process of making that decision?
    a. How would you like to be involved?
    b. What might stop you from being involved?
    c. Who else should definitely be involved?
4. The Tower and Kleber Dams are up for relicensing in just a few years. If you were the dam owner, what options would you consider for the future of the dams?
    a. What information would you want to know before making that decision?
        i. We are currently in the process of compiling information to give to the public. What would you want us to include?

a. [What alternatives, if any, would you want to see investigated?]
    i. Alternatives could mean managing the sediment, fish passage, or other bypass structure…

D. That about covers my questions, let me see if I got this right:

1. We're trying to understand the full range of opinions; who else do you feel we could talk to about this decision?

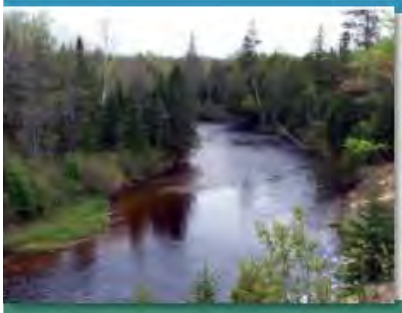
Appendix IX

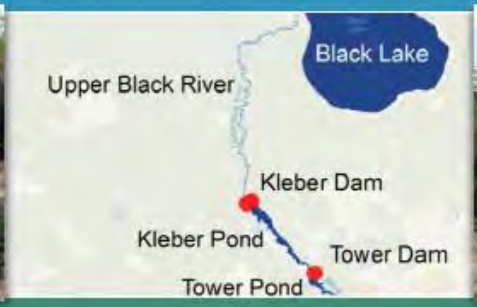
PUBLIC MEETING NOTICE FLYER

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Upper Black River Dams Meeting

Where: Forest Township Hall (located at 9511 M-68)
When: 2 to 5 pm on February 11, 2017







Exploring Impacts of the Tower & Kleber Dams

Come to Forest Township Hall, located at 9511 M-68, on February 11, 2017 from 2 to 5 pm to take part in an important town hall meeting to have your voice heard! If you are not already aware, the license for Tower and Kleber dams is up for renewal in the next several years, and we want to hear your issues and concerns related to the dams at this early phase of the process. The conversation that begins at this meeting will help inform the evaluation of the relicensing effort.

Meeting Goals

- Provide a **brief summary of results** from a University of Michigan scoping effort to examine values and opinions from around the community.
- **Answer clarifying questions** and **get your input** on findings, concerns, and issues to be addressed.
- **Begin a community conversation** that will guide the decision-making process over the next several years.

Topics to be Covered

- Fishing
- Sturgeon
- Impoundment Property
- Dam Infrastructure
- Economy, Recreation, & Tourism
- Black Lake Water Levels
- Ecological Health
- Sedimentation

This meeting is being co-sponsored by the Michigan Department of Natural Resources and the Grand Traverse Band of Ottawa and Chippewa Indians. A team of graduate students affiliated with the University of Michigan School of Natural Resources and Environment is conducting this preliminary phase to inform decision makers about immediate and long-term concerns related to Tower and Kleber dams.

For more information, please email our team at: ***UMBlackRiver@umich.edu***

Appendix X

PUBLIC MEETING COMMENTS AND NOTES

This document provides a list of the key questions and comments posed during the public meeting hosted by the University of Michigan team and MDNR at the Forest Township Hall on February 11, 2017. These notes are based on conversations during the full presentation and the smaller flipchart breakout sessions as well as written comments. These comments were used to inform our final report.

As feasible and appropriate for the scope of our project, comments were directly incorporated into our preliminary findings report. Comments outside the scope of our project, such as questions for future research, inform our recommendations for future stages of the decision-making process.

A recording of our presentation was produced by Sunrise Cable Network's David LaClair and is available online here: https://vimeo.com/203940534.

Tower and Kleber Dams

Dam Ownership

- What is the progress of the sale of the dams since the dam owner has put it on the market? Is there information that is available to the public?
- If the dam owner "walks away" from the dams, would they be operated? Would the County take over ownership and just open the gates and let "mother nature" take over?

Dam Operation

- What is the level of stratification (thermal) in the impoundments? Is there data available? Are they top draw dams?
- Want more information on the cost of repair for the dams relative to the cost of removal

Electricity Generation

- Attendees were concerned about the impact of removing this source of electricity generation on the regional utility.
- The current hydro-electrical generation is great. It saves them from having to deal with future increases in energy prices, they never have power outages

Alverno Dam

- [Written comment] A former Consumers Energy employee also wanted a record of the Alverno meeting and was concerned about what would happen if Alverno was removed or failed.
- [Written comment] A meeting attendee wanted to know about how Alverno dam would affect lake levels in Black Lake.

Dam Removal

Future Scenarios

- Attendees were concerned about the timing of the transition from pond to river
- How much do we know about the historic hydrology in the impoundments? What course would the river take? What is the historic floodplain and would it affect landowners or the public?
- Want more information on the cost of repair for the dams relative to the cost of removal

Example Removal Projects

- Other dam drawdown example: Oneida River in WI
- Suggestion to talk to people at Conservation Resource Alliance (CRA) about the Boardman Experience
    - What were unexpected things that came up?
    - What were the landowner reactions like?

Governance

- Concerned about who will manage the decision and implement what is decided
- [Written comment] “Remember part of Black Lake is in Presque Isle County.”
- Want to know who are all the interested groups in this process: federal, state, tribal, etc.

Tribal Interests

- Concerned about the interests of tribal nations in Tower and Kleber dams due to past experience in Emmet County and perception that they are trying to take over all of the land

    - "Finely define tribal interests [...] The tribes are trying to take all of Emmet County right now [...] Those treaties were so poorly written and poorly defined. It all boils down to who gets the best attorney."
    - Also an associated suspicion or skepticism of the weight and legal standing of treaties
- Local resident expressed concern about renegotiating hunting and fishing rights
    - General tone of skepticism and confusion
- It would be good to have a deep understanding of treaties and legal implications
- Perception that the tribes are one of the main reasons this process is starting and are concerned that they will "kick up dust" if it doesn't go their way
    - "I can't fault them. They may have very legitimate ground to stand on, but my concern is can they do that here? If they are the ones that go this started and it doesn't go their way the first time, you gotta anticipate the next step. Where would the opposing party go next?"

Land Ownership

- Interested about who currently has property rights to different parts of the bottomlands (land underneath Tower and Kleber ponds)
- Want to know exactly what the Tower Kleber Limited Partnership owns
- Want more specifics (property-by-property boundary changes) on who will own what pieces of newly exposed bottomlands if dams are removed
    - Wanted to know who would know that information
    - Interested in having a central location for that information for property owners to look to see what would happen to their land if dams were removed
- Very important to determine where the water line would be and check facts on property extension; whether landowners would get new property to waterline or if the utility would retain it because they own the bottomland of the ponds
- [Written comment] "If removal of dam(s) significantly reduce property ownership-or-increase it… What law(s) govern the change? I.e. lake ownership and trespassing on property or natural waterline is already confusing for inland lakes. Can this be clarified before measures are taken that would alter property and access to public use."
- "The rights of the property owners are extremely important"
- Potential new park property on Tower Pond--how would that be impacted by water line/property ownership changes

Property Value and Aesthetic Concerns

- Concerned about loss of property value if the dams are removed, resulting in muddy areas in their backyards
    - Pointed to instances in the past when ponds were drawn down, resulting in exposed lands that were muddy and buggy: "Last year when they drained the pond, or two years ago, the flies were so horrendous. You couldn't stand it. [...] It was nothing but a mud pit."
- Skeptical of long-term benefits of moving towards riparian ecosystem
    - But also concerned about timing, since if trying to sell property during transition time to fund retirement, reduced aesthetics in the backyard would be problematic: "I've worked 45 years. I want to retire. How am I going to retire if my whole asset went downriver? [...] That is whole my livelihood. What's going to happens to me? If I become ill, I have nothing to sell."
- If the positive impacts of moving towards a riverine system are associated with improved green spaces (due to newly exposed lands), who would be responsible (paying for and maintaining) for restoring that green space?
    - How much would it cost to improve that green space? Concerned about costs since the area is economically depressed
- Since waterfront landowners are currently paying higher taxes since their property values are higher (due to living on the water), would they receive tax reparations if the dams were removed due to loss of property value (or at least loss of the property characteristics they paid for)?
    - "Will they [waterfront residents] get their taxes back? Because they paid for this piece of land that is waterfront property. [...] They pay more because they're on the water and they should be able to get them back because they no longer get waterfront property"
- "Did you get local real estate agents in the area to determine what our property values would increase by by draining that pond?" Want to see a property value assessment by a local realtor for a dam removal scenario
    - Generally skeptical of other studies and would trust the assessment by a local realtor
    - Also want specifics on how much, exactly, property values would change
- "I really question the slide that said property values would remain the same. I totally disagree with that. The real estate community locally has to be consulted, and you have

to have a statement from them saying what they think. They know. It's easy for everybody to get emotional about it, but I can't see property values remaining the same if those ponds [go away]."

- Edge of Tower pond property will probably benefit with increases in beauty, clarity, rapids, but Kleber pond property will decrease in beauty etc.
- Look into the realities of the mud situation
- "This is already a really depressed area. What does it cost per square foot to increase your property value by landscaping it? [...] So I want to put in this whole big green space. Say I gain 50 feet, and I have 750 feet of water frontage. What is it going to cost me?" Concern about the cost associated with improving/restoring the newly exposed lands

Water Levels

Hydrology

- How will the overall hydrology of the watershed be affected if Tower and Kleber dams removed? Would Burt and Mullett lakes be affected in terms of lake levels?
- Attendee wanted to know about how Alverno dam would affect lake levels in Black Lake.
- How would removing Tower and Kleber dams affect the water levels in Black Lake?
- [Written comment] "What is the impact to the water level management throughout the Cheboygan watershed? Kleber and Tower are not major players, but the incremental effect of their lake level management is impactful downstream and upstream. Even through Mullett, Burt, Crooked… Not much. But we need a hydrology engineer :) and spring run-off and fall rain storms especially."
    - Generally trying to get an understanding of how the Tower and Kleber decision will impact the broader watershed's flow regime, especially as it relates to changes in flow during storm events
- Where specifically does the water come from? Only precipitation, or groundwater coming up, bubbling through the sand like a spring?
- What would be the new river depth?
- Concern about the river's water level--right now it's shallow, would it get even more shallow?
    - How would the channel change? What would be the river's velocity? Depth?
- Concern about water levels posing a challenge for kayaking and canoeing

Control over Flooding

- Even if the Tower and Kleber dams are not important to Black Lake water levels in normal operation, they are important in helping address spring runs and associated flooding, which therefore helps mitigate downstream property damage when there is excessive snow melt. Concerned that removing the dams would make them more vulnerable to flood damage.
    - "If they are gone, then there is no control. And we have been here when Kleber has dumped 8 feet of water, and we did not have a front yard. [...] So if those dams are no longer there and we get very much rain, we have absolutely no protection."
- Dams offer control for stormwater flows
- Concern about stormflow and interest in using the floodplain to attenuate peaks
- Resident expressed belief that ponds offer critical storage and removing the dams would be a loss of control over the river

Sediment

- Concerned about silt movement into Black Lake and downriver of the dams
    - Mainly curious about how things would change if the dams were removed
- Want further information about the state-run bi-annual sedimentation management
    - What happens when the sand traps fill up?
- Concern about fish-kill after release of sediment
- Concern about the deposition of sand load at the river mouth (into Black Lake); perceived as an impact on the health of the river
- Want more information on how the silt behind the dams would be managed if the dams were to be removed
- If the dams were removed, where would all of the sediment go?
- What would be the effect of sediment even once it's "stable"--storm impacts

Contaminants in Sediment

- Are there toxic sediments in the impoundments and what is the potential for release of toxic sediments from the impoundments if the dams were removed? Who would pay if there were toxic sediments that needed to be removed?
- What's the state of sediment and potential toxins? What would happen to those if dams were removed? Who deals with it/pays for any management?
- Concern about sediment contamination

- [Written comment] “Will sediment be tested that collects from dam removal for toxins/pollutants. If it must be removed, how and who removes it? Cost of removal is paid by the landowner or ???”

Recreation

- Keep in mind swimming happens in the ponds
- Swimming is also an important recreational activity in the impoundments
- “My grandkids swim there. Everybody.”
- Recreational use of ponds have steadily increased over time
- There is a lot of activity on the ponds:
  - Springtime canoe race
  - Sailboats
  - Stand up paddleboards
  - Rafts
  - Swimming
    - Kids jump off the bridge to swim
    - At least 15 kids swim there every day in the summer
  - The ponds are deep, there’s not much sediment
  - Residents and visitors alike use the ponds
  - There is also wildlife and a rich ecological community: loons, eagles, deer, etc.
- How would all of these things change if the dams were removed?
  - It would be great to develop a projection of what the river would look like
    - Could there be engineered whitewater?
- Concerned about retaining public use of the water in a riparian system
- Tower Pond is especially well-utilized
- Need to consider public access to ponds and how that would change
  - Would a public access corridor be developed around the new waterline? Would the public access get past the mud?
- Concern about current state of the river with sand bars, etc. that make kayaking and canoeing difficult in the upper reaches of Upper Black River (water levels too low?)
- Lots of primitive camping at Kleber Pond on all the state land--how would that change? Would the camping just be far from the water or would new camping options be created at new shoreline?

- Concern about the river's water level--right now it's shallow, would it get even more shallow?
    - This impacts the ability to canoe--people say it'd be great to have more canoeable miles without portage, but it doesn't matter if it's too shallow to canoe and people have to get out and drag canoes anyway, which is currently the case much of the time
- Look at boating/canoeing impacts--trade-offs between current portages (which they say aren't that big a deal) and shallow dragging if river/pond levels are/get low
- Concerned that moving to a river would make it more difficult to canoe: already it seems like they have to get out of the canoe and "push it halfway down the river. So if the dam is removed, how much worse is that?"
- The ponds (especially Tower) brings people into Tower and Onaway, they're key for economy and business
    - "There is no economy there other than tourism" and "if you take away the pond [Tower] there would be nothing left" --the one bait/party store in Tower would be sure to close
- [Written comment] "I don't think that this would be good for our recreation or our fish population. We have a great ecosystem for trout, bluegill, pike, perch, and migratory birds. I also believe it would hurt our economy."
- Need to pay attention to the fact that economic tradeoffs are not equal in this decision. For example being able to have a kayak outfitter shouldn't outweigh people's property loss
- The Shanty Rapids might return! People remember them, or remember their parents talking about how they always used to go to them and they were a central part of the community
- Potential new park property on Tower Pond--how would that be impacted by water line/property ownership changes?

Ecosystem Health

Historic Conditions

- Since the dams have been there for 70-100 years and the ecosystems have become established, how will that be evaluated?
- Historically, Elm and Ash trees shaded the river, helping to cool the water.
- Concern about the old dump/landfill at the upper edge of Tower Pond which operated from 1920-1980 and was started/managed "before they knew how to do it right" so "it's pretty

bad"--it even was deemed a superfund site because of the contaminants, arsenic, batteries, etc.

    - What would happen with this? Would it impact water quality? Would dam removal/pond changes trigger any kind of contaminant release?
- What is the system-wide impact of storage at the ponds and how does it build on each other/synergy/impact things downstream

Future Scenarios

- Hydrology impacts to the larger Cheboygan watershed
- [Written comment] "I have concerns about wood turtles and how the sediment will affect wood turtle habitat."
- If the dams were removed, how long would it take to become a "new ecosystem"? How long would it take new ecosystem dynamics to establish?
- Look into temperature impacts to the river and to trout because the new stretches of river would not be shaded by brush and trees

Fishing

Preferred Target Species

- Desire for better trout habitat in upper reaches of Upper Black River; Concerns for negative impacts on this trout habitat
- Concerns about the impact on species (mentioned: smallmouth bass, trout, pike, and bluegill) found in Tower and Kleber ponds; Interest in *close* proximity to the ponds and access to fishing these.
- Concern for reduced habitat for pike
- How would fishing change on the ponds and creek? Especially pike and baitfish
- "I was born and raised [near Tower pond], lived here all my life. My kids live here as well, grandkids will probably live here as well. They've fished this area, they fish pike, bass, bluegill, trout, everything. They live for that. That's something that they grew up doing. How's that going to affect everything else? Black Lake is one thing but this is our area, this is where we grew up. This is what my kids do."
- The Upper Black River is managed for brook trout. What would the effects of dam removal be on the brook trout population? Don't mess with trout fishing!
    - Desire for a more balanced management strategy; not favoring one species over another

    - Concern for increased predation on trout upstream of ponds, if connectivity is reestablished
- Frustration about the emphasis placed on some species over others (especially sturgeon and trout)
    - Expressed a concern about balancing the needs of other fish; getting the most benefit
- Fishing has been worse on the impoundments and upper Black River recently, what are you going to do about that?
- [Written comment] “I don’t think that this would be good for our recreation or our fish population. We have a great ecosystem for trout, bluegill, pike, perch, and migratory birds. I also believe it would hurt our economy.”

Impacts of Dams on Fishing

- Concerns about water temperature related to sand traps filling up; heating water in shallow areas; changing habitat availability for species
    - Would this lead to only creek chub (or similar species)?
- Confusion about stratification in the ponds, and effect on fish
- If Tower and Kleber dams are removed, how would it affect the potential for fishing from the backyard for residents on the riparian areas of the Upper Black River? Would there be a closure?
- Concern about the potential for Lamprey introduction in Black Lake system; What is the management/exclusion like at Alverno and Cheboygan dams? Grateful for protection offered by Alverno
- General debate about what caused the decline in people coming up there to fish
    - Maybe just a cultural change (people want different vacations, etc.) or maybe it really is worse fishing
    - But some perceive an increase in fly fishing in river and bait fishing in Tower pond

<u>Sturgeon</u>

- Other creeks emptying into Black Lake offer sturgeon spawning habitat too
- Sturgeon don’t only spawn in Black River; they also spawn in the Rainy River
- Resident shares memory of rapids located between Kleber and Tower ponds; Can sturgeon get above these rapids anyway? Will there really be an increase of access or are they blocked by the rapids?

    - Are they physically able to get above the rapids? Not athletic
- Resident believes poaching of sturgeon has greatly declined with the sturgeon guard; How can they continue to protect the sturgeon if they are more spread out upstream?
- [Written comment] “I favor impoundments in the Sturgeon spawning area; good to add access to the additional 7 miles of spawning ground”
- Concern and confusion about sturgeon quota and fishing rights; Will the hunting and fishing rights of the tribes be renegotiated?
- Belief that sturgeon are culturally significant to locals (not just tribes)
    - Economic benefit - tourism, inflow of funds
    - Sense of place - taking care of the species in the river; feeling of connection and protection

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Appendix B

Water Quality Monitoring Quality Assurance Project Plan

QUALITY ASSURANCE PROJECT PLAN (QAPP)

Date: June 27th, 2024

Project Title: Black Lake Watershed Management Planning: EGLE 205j

EGLE Tracking Number: #2022-0108

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Project Abstract

Tip of the Mitt Watershed Council acquired funding from the Michigan Department of Environment, Great Lakes, and Energy (EGLE) to develop a watershed management plan for the Black Lake Watershed

located in the Northern Lower Peninsula of Michigan. The Black Lake Watershed possesses some of the state's greatest natural resources, which support local economies through both tourism and outdoor recreation. Despite low population densities relative to the Southern Lower Peninsula, water resources in the Northern Lower Peninsula are continually threatened by nonpoint source (NPS) pollution. Sources of these nonpoint source pollutants include road/stream crossings, poor riparian zone management, streambank erosion, inadequate and inconsistent water resource protection ordinances, nutrient influx, and stormwater pollution.

The Black Lake Watershed Management Plan will result in a plan to protect a total of 350,000 acres (547 square miles) throughout the watershed. The project will bring together an active group of stakeholders under the unifying element of the watershed management plan process. Goals and objectives include convening a watershed advisory committee, completing resource inventories, strengthening water resource protection ordinances, and development of an EPA/EGLE-approved watershed management plan.

The Watershed Council will complete water quality monitoring in the Black Lake Watershed by monitoring the major tributaries flowing into Black Lake, documenting the water quality of and discharge data concurrently from the mouths of major streams and rivers a total of eight times throughout a two-year period (2024 and 2025). Relative pollutant contributions will be calculated for individual streams. Water quality monitoring will also be conducted at the deepest point of Black Lake through volunteer efforts via the Black Lake Association a total of 16 times throughout a two-year period (2204 and 2025). Prior to conducting any water quality monitoring, a Quality Assurance Project Plan (QAPP) will be written by the Watershed Council, and subsequently approved by EGLE. No water quality monitoring will take place without EGLE approval. This QAPP addresses both physical and chemical water quality monitoring of the Black Lake Watershed.

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Problem Definition and Background

Black Lake Watershed Overview

The Black Lake Watershed, a sub-watershed of the larger Cheboygan River Watershed, encompasses 357,000 acres (558 square miles) in the Northern Lower Peninsula of Michigan (Figure 1). It comprises 37.7 % of the 1,461 square mile Cheboygan River Watershed. The Black Lake Watershed lies between the Mullett Lake Watershed on the west; the Thunder Bay Watershed to the south; and the Lake Huron Watershed to the north and east.

Geographic Description

In the north and northeastern portions of the Black Lake Watershed, the watershed boundary lies about a mile and a half north of the Lake itself, generally following the contour of the shoreline. On the east side, south of the Bearinger-North Allis Township line, the boundary of the watershed extends eastward, reaching its easternmost point about halfway between Rainy and Emma Lakes in the southern part of Presque Isle County. It is here that the watershed reaches its maximum width of 21 miles. The boundary begins to bend back west and south, staying north of Atlanta except for a slight dip south about a mile north of Double Lake in Montmorency County. Here is the southernmost extent of the watershed; it reaches a maximum width of 36 miles. From there, the watershed boundary follows a line almost straight west, through the town of Hetherton and west another six miles. It then bends northward, and the western edge of the watershed runs nearly straight north-south from highway M-32 in Otsego County to Devereaux Lake Road in Cheboygan County. There, it cuts in sharply to the shore of the northwest corner of Black Lake, at the Lower Black River.

Black Lake and Its Tributaries

By surface area, Black Lake is one of the largest inland lakes in the state of Michigan with a surface area of 10,143 acres. However, its maximum depth only reaches approximately 50 feet, with an average depth of 23 feet. Black Lake's headwaters are in the Upper Black River in Montmorency and Otsego Counties. Other tributaries include Fisher, Stewart, and Stony Creeks on the south end, as well as the Rainy River and Cold Creek, which share a mouth on Black Lake. Cains Creek comes in on the north side of the lake and Mud Creek on the west. The lake's outlet is the Lower Black River, which flows towards the Cheboygan River and then into Lake Huron. Other important tributaries include Tomahawk Creek, Milligan Creek, Hardwood Creek, Van Hellens Creek, Rattlesnake Creek, Packer Creek, and Fast Creek. Numerous smaller streams also flow into Black Lake and its tributary rivers. As a drainage lake, Black Lake contains some groundwater input, many important inflows, and one primary outflow. The important inflows and outflow provide a mechanism to flush excess nutrients into and out of the system.

303(d) Statement

Section 303(d) of the Clean Water Act requires the identification of waterbodies that do not meet, or are not expected to meet, water quality standards (i.e. impaired water bodies). The majority of Assessment Unit IDs in the Black Lake Watershed are fully supporting or unassessed for most designated uses. Table 1 (see below) includes listings for non-supporting uses.

***Table 1**. Location, Water Type, Use Names, and Attainment Codes for Waterbodies in the Black Lake Watershed that are on the 303(d) List.*

Location Description	Assessment Unit ID	Water Type Name	Use Name	Attainment Code Name
Includes: Little Rainy River	MI040700050102-01	River	Other Indigenous Aquatic Life and Wildlife	Not Supporting
Includes: Black River, Fisher Creek, Stewart Creek	MI040700050302-02	River	Other Indigenous Aquatic Life and Wildlife	Not Supporting
Includes: Little Rainy River	MI040700050102-01	River	Partial Body Contact Recreation	Not Supporting
Includes: East Branch Rainy River and Rainy River	MI040700050103-01	River	Partial Body Contact Recreation	Not Supporting
Includes: Rainy River	MI040700050104-01	River	Partial Body Contact Recreation	Not Supporting
Includes: Black River and Gregg Creek	MI040700050211-01	River	Partial Body Contact Recreation	Not Supporting
Includes: Little Rainy River	MI040700050102-01	River	Total Body Contact Recreation	Not Supporting
Includes: East Branch Rainy River and Rainy River	MI040700050103-01	River	Total Body Contact Recreation	Not Supporting
Includes: Rainy River	MI040700050104-01	River	Total Body Contact Recreation	Not Supporting

Includes: Black River and Gregg Creek	MI040700050211-01	River	Total Body Contact Recreation	Not Supporting
Includes: Black River, Bowen Creek, and Sturgis Creek	MI040700050213-01	River	Total Body Contact Recreation	Not Supporting
Includes: Black River and Welch Creek	MI040700050213-02	River	Total Body Contact Recreation	Not Supporting

Water quality monitoring in the Black Lake Watershed will address some of these impaired water bodies listed above. As some of the impairments assessed occur at a watershed level, water quality monitoring through this QAPP can be considered more thorough, as monitoring will be conducted at a finer resolution (i.e. tributary level). Additionally, a greater variety of water quality parameters will be monitored (with half of monitoring events occurring during wet-weather conditions). Finally, resource inventory monitoring within the Black Lake Watershed conducted in Summer of 2023 (for which a separate QAPP exists) and EGLE P-51 macroinvertebrate and habitat surveys further addresses the impairments listed above.

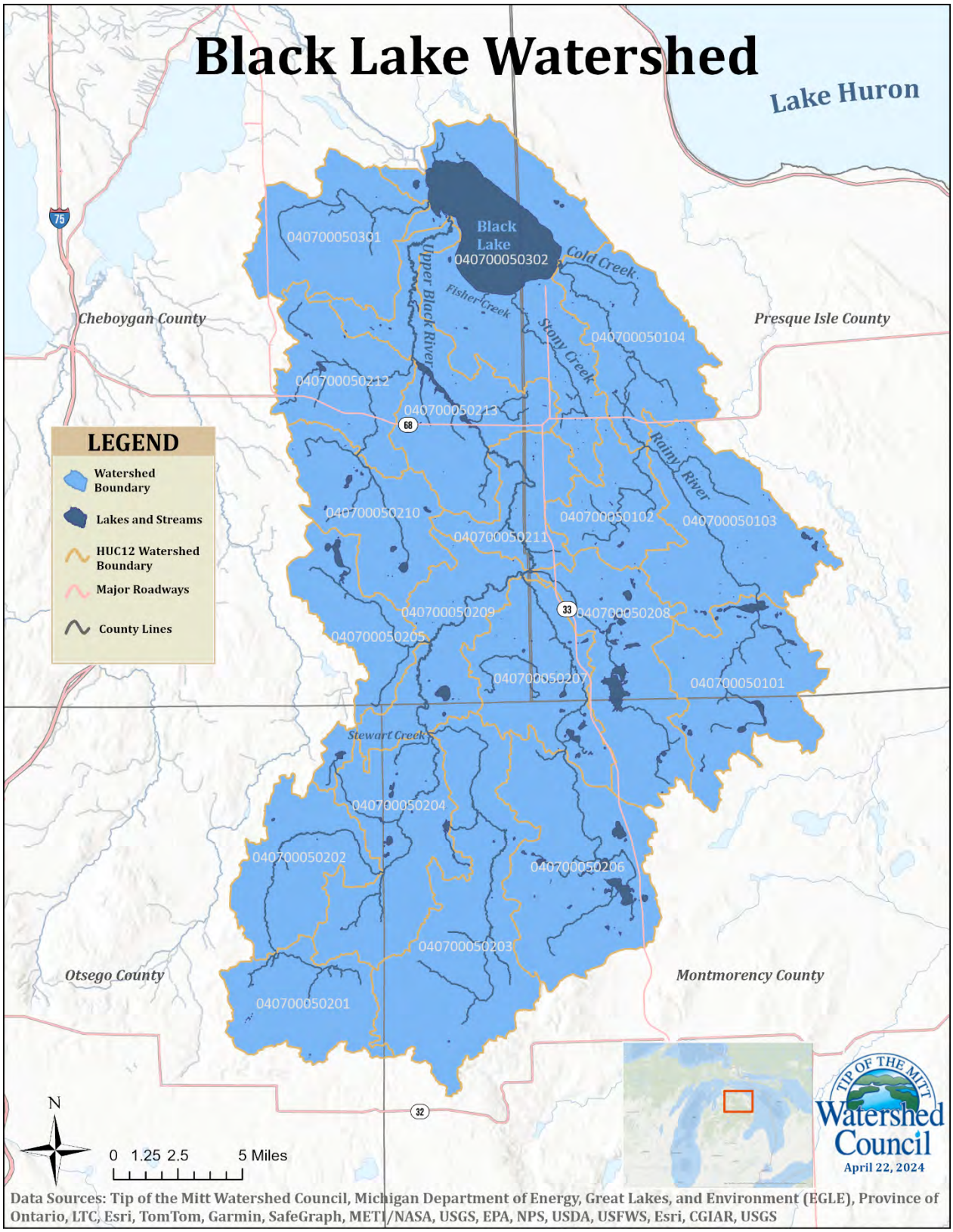


Figure 1. *The Black Lake Watershed.*

Land Use/Land Cover

Fortunately, much of Black Lake's Watershed is forested, undeveloped, and has a protected status (Figure 2). Much of this protected status is through the Pigeon River State Forest. This area is the largest contiguous block of state-owned land in Michigan's Lower Peninsula and is managed separately from other state forest lands in the area. Because of the unique features within the forest (Michigan's only elk herd, numerous high-quality rivers and lakes, and vast expanses of wilderness), more protective land and water management policies are in place than on most state forest lands. Work is ongoing to preserve, protect, and enhance the wildlife corridors and habitat in the area outside of the boundaries of the Pigeon River Country State Forest. Undoubtedly, the pristine landscape's high percentage of forest coverage (43.74%), wetlands (28.13%), and scrub/shrub coverage (9.60%) has helped to maintain high water quality in Black Lake (Table 2).

In contrast to the surrounding watershed, Black Lake itself is more heavily developed. 88% of the shoreline was reported as developed in a 2017 shoreline survey report, along with 81% of the lakefront properties demonstrating some degree of alteration. However, water quality has remained relatively high in recent decades, with few exceedances of nutrients beyond the EPA recommended maximum, and mesotrophic to oligotrophic conditions (Figures 3-5, 7). However, beginning in 2019, annual harmful algal blooms (HABs) have been observed on Black Lake, and a selection of algal samples tested positive for microcystin (a cyanobacterial toxin that can be harmful to both organismal and human health). The Black Lake Watershed Management Plan seeks to protect Black Lake from further nutrient influx as well as identify causes and solutions for the HABs problem.

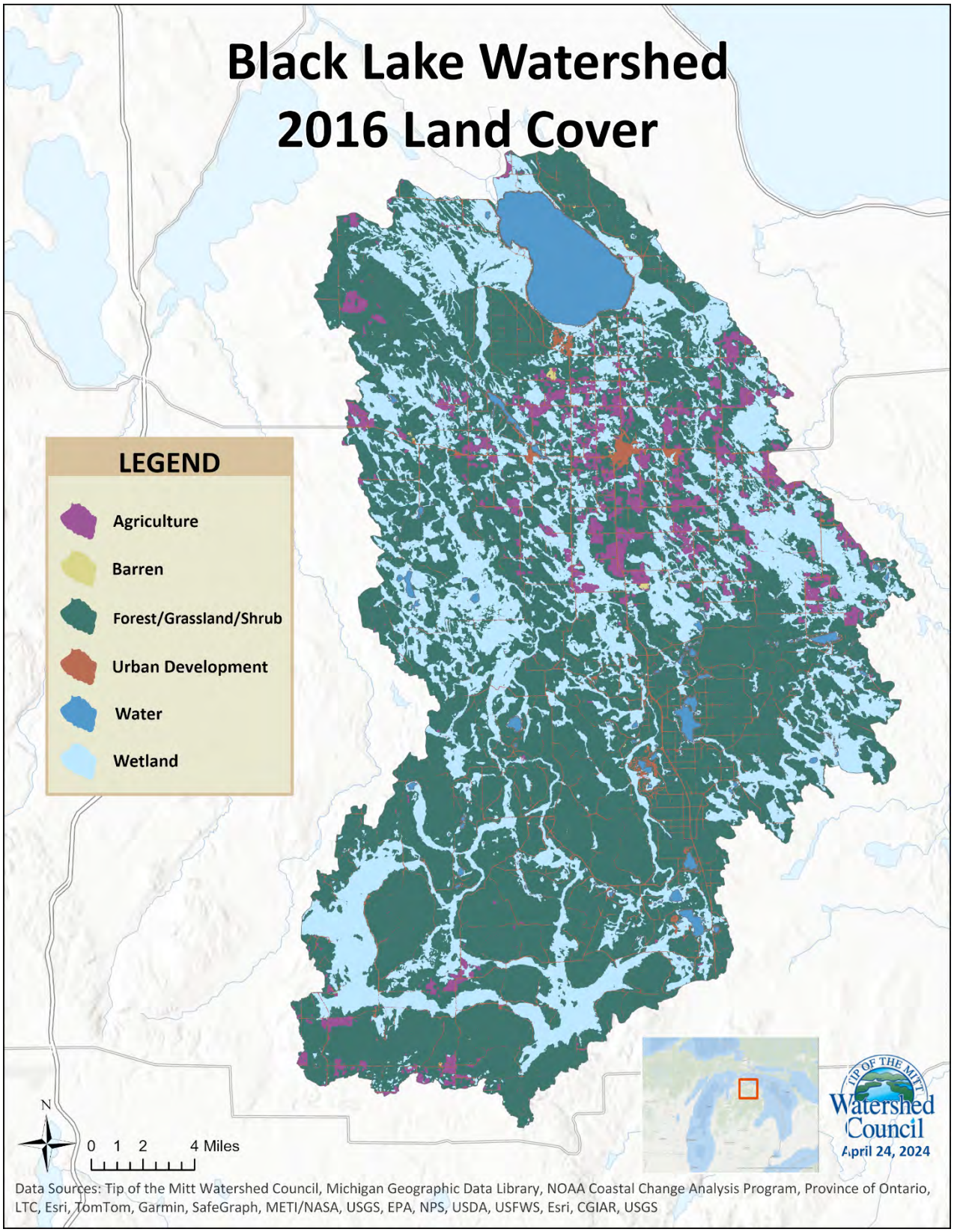


Figure 2. *Land Cover in the Black Lake Watershed as of 2016.*

Table 2*. Land Cover in the Black Lake Watershed from 1975 - 2016.*

Land Cover Type	1975 (%)	2016 (%)	% Change (1975 - 2016)	% Change (2000 - 2016)
Agriculture	4.90	4.24	-0.66	-0.02
Bare Land	0.39	0.51	0.12	0.03
Urban	1.18	1.33	0.15	0.00
Forest	52.91	43.74	-9.17	-4.13
Grassland	4.91	8.58	3.67	0.69
Scrub/Shrub	3.72	9.60	5.88	3.4
Wetland	28.04	28.13	0.09	0.09

Watershed Recreation

The Black Lake Watershed is well known for its recreational opportunities and aesthetic appeal. Boating, swimming, and fishing are popular activities among year-round residents, seasonal residents, and tourists. Not only is Black Lake itself heavily utilized, but many tourists come to the area to enjoy the Pigeon River Country, as well as the multitude of hunting, fishing, and canoeing/kayaking opportunities afforded by the Black River. The major rivers within the watershed are also important recreation areas. Canada Creek has a community of permanent and seasonal residents, called Canada Creek Ranch, who mostly live along the riverbank or on the shoreline property of Lake Geneva and the other small lakes within the development. Kleber and Tower Ponds on the Upper Black River also are heavily used for recreation. Tomahawk Creek, Canada Creek, and the East Branch of the Black River are located in areas favored by hunters and anglers, as well as hikers and campers alike.

Fisheries

According to the Michigan Department of Natural Resources (MDNR), many of the tributaries around Black Lake are important for spawning walleye and brook trout. The lower part of the Rainy River is closed to fishing in the spring to protect spawning walleye. It also provides spawning habitat for suckers. The upper reaches of the Rainy River have cool to warm water, and a few of its tributaries could hold brook trout.

Black Lake itself is also a healthy and diverse fisheries resource. The Lake is famous for its population of lake sturgeon that is self-sustaining but threatened. A very limited fishing season, every February, allows for a small number of lake sturgeon to be harvested. Furthermore, the Black River Sturgeon Hatchery provides a juvenile sturgeon rearing facility alongside education and research opportunities through

public tours. The Lake's fishery also includes muskellunge, northern pike, yellow perch, walleye, and bass.

Nonpoint Source Pollution

Nonpoint source pollution is a continual threat to Michigan's pristine rivers, lakes, and streams. While natural land cover like forests and wetlands in a watershed yields high-quality water downstream via natural ecosystem services (e.g. filtering of excess nutrients, shoreline stabilization, etc.), an altered landscape generally degrades water quality. Nonpoint sources pollutants including nutrients, and soil particles (sediment) from erosion can result in negative impacts to water quality downstream. Contaminants coming from multiple diffuse sources are called nonpoint source pollution, as opposed to a single source, such as a factory. Contaminants can commonly occur in an urbanized setting; some may be related to automobiles while others are related to cleaning or personal care products. Stormwater, often channeled out of city streets and into water bodies, can contain excess nutrients such as phosphorus and nitrogen. Ions such as chloride from road salt application during the winter are captured during snowmelt and can be carried into nearby streams.

Unfortunately, the problem of nonpoint source pollutants is exacerbated by agricultural activities, degradation of road/stream crossings, poor riparian management, urbanization, destruction of natural habitat, stormwater influx, and inadequate and inconsistent water resource protection ordinances. Because the sum of all interactions in each watershed between land and runoff determines the water quality downstream, the waters of any lake are inexorably linked to the watershed by which it is supplied.

Nutrient Pollution

Runoff is frequently attributed to nutrient inflows from common limiting aquatic nutrients (i.e. species of nitrogen and phosphorus). Nitrogen and phosphorus are two nutrients that are inherently connected to water quality. Both are key nutrients that are required for biological growth and can determine overall ecosystem productivity. However, excess concentrations of nitrogen and phosphorus can become ecologically harmful in myriad ways. High nutrient concentrations within a freshwater ecosystem may cause shifts in aquatic food webs, encourage colonization by invasive species (e.g. *Phragmites* and narrow-leaved cattail), and can spur increased aquatic plant and algal growth. Further issues include decreased water clarity, depleted dissolved oxygen levels, mucky lake bottoms, hypoxic zone formation, and death of benthic organisms. 'Cultural eutrophication' refers to pollution occurring as a result of excess nutrients, specifically from anthropogenic activities, and may cause a previously oligotrophic (nutrient-poor, clear waters) or mesotrophic (moderate nutrient levels) system to become eutrophic or even hypereutrophic. Typical contributors to nonpoint source pollution (agricultural and urbanized areas) account for about 5.5% of the total area of the Black Lake Watershed. As previously mentioned, Black Lake has experienced notable issues with harmful algal blooms (HABs) since 2019 in response to freshwater eutrophication occurring within the lake ecosystem (Table 3).

***Table 3**. Reported Potential Harmful Algal Blooms and Toxin Results in Black Lake from the Michigan Department of Health and Human Services.*

Date of Report	Date of Site Visit	Confirmed to be Cyanobacteria?	Toxin Results (PPB)	Location
10/5/2021	10/5/2021	Yes - Visible Cyanobacteria	Microcystin: 10.9	Waverly
10/5/2021	10/5/2021	Yes - Visible Cyanobacteria	Microcystin: 60.4	Waverly Boat Ramp
10/5/2021	10/5/2021	Yes - Visible Cyanobacteria	Microcystin: 2913.1	Birch Ridge Beach
9/30/2021	9/30/2021	Yes - Visible Cyanobacteria	Microcystin: 49.2	Cedar Beach Shore
9/23/2020	9/23/2020	Yes - Visible Cyanobacteria	Microcystin: 53	South Black River Road
9/23/2020	9/23/2020	Yes - Visible Cyanobacteria	Microcystin: 76	South Black River Road
9/23/2020	9/23/2020	Yes - Visible Cyanobacteria	Microcystin: 57	North Black River Road
9/11/2020	9/11/2020	Yes - Visible Cyanobacteria	Microcystin: 210	Silver Beach Road

Previous Efforts

Previous planning and monitoring efforts within the Black Lake Watershed include (1) the 1991 Black Lake Watershed Nonpoint Source Management Plan, (2) the 2002 Black Lake Watershed Stewardship Initiative Nonpoint Source Pollution Management Plan, (3) the 2005 and 2017 Watershed Council Shoreline Surveys, and (4) the 2018 Black Lake Tributary Monitoring Study. The Watershed Council also initiated a Black Lake Watershed Advisory Committee (WAC) in 2021, and the Black Lake Watershed WAC meets three times a year. This committee has secured funding to develop an EGLE/EPA-approved Watershed Management Plan and will begin implementing watershed protection projects and initiatives pending plan approval. Currently, there are existing issues with fish consumption and other indigenous aquatic life and wildlife due to mercury in fish tissue or polychlorinated biphenyls (PCBs) in the water column. Additionally, it should be noted that results from previous shoreline surveys (2005 and 2017) conducted by Tip of the Mitt Watershed Council indicate that human activity along Black Lake shoreline

is likely impacting the lake ecosystem and water quality. Further water quality issues were highlighted in the Black Lake Tributary Study (2018), which highlighted nutrient exceedances, elevated temperatures for cold water fisheries, low dissolved oxygen levels, and more. Data collected by EGLE at numerous Black Lake Watershed sites in 2022 has also indicated *E. coli* exceedances (for both partial body contact (PBC) and total body contact (TBC) water quality standards). Many of these issues will be addressed through further water quality monitoring at problematic sites.

Water Quality Monitoring Data and Concerns

As previously stated, nonpoint source pollution has long been recognized as a water quality problem in the State of Michigan and led to development of numerous watershed management plans. Runoff in urban and agricultural areas contributes nonpoint source pollution to lakes, streams, wetlands and even groundwater, degrading water resources through contaminant inputs (e.g. nutrients, sediments, salts, and metals), thermal pollution, alteration of natural flow regimes and associated channel erosion and habitat loss, and more.

While the Black Lake Watershed is in no way immune to nonpoint source pollution, numerous water quality efforts have been put forth to try and ascertain the overall ecosystem health of the Lake and its tributaries. These efforts are done in part by Tip of the Mitt Watershed Council through programs such as Comprehensive Water Quality Monitoring (CWQM), Volunteer Lake Monitoring (VLM), and Volunteer Stream Monitoring (VSM).

Comprehensive Water Quality Monitoring

The CWQM program was launched by Tip of the Mitt Watershed Council in 1987, with subsequent field data collection occurring every three years. As of the 2022 field season, samples were collected from 104 sites at over 48 different lakes, rivers, and streams. Typically, data for seven aquatic parameters (temperature, dissolved oxygen, pH, conductivity, total phosphorus, total nitrogen, and chloride) are collected at the surface, middle, and bottom of the water column in each water body (Table 4).

Background on Water Chemistry Parameters

Nutrients (such as total phosphorus, total nitrogen, and chloride) are important chemical parameters that are measured through the CWQM program. Total phosphorus is an essential aquatic nutrient required by algae and rooted aquatic plants to facilitate their growth and reproduction. Total phosphorus predicts both biological productivity and current trophic states of freshwater bodies. It can be used to determine whether nutrient pollution is occurring, and to what extent. Nutrient pollution can not only cause increased aquatic plant and algal growth, but can contribute to decreased water clarity, depleted levels of dissolved oxygen, mucky lake bottoms, unstable food chains, hypoxic zone formation, and death of benthic organisms. While not analyzed as part of the CWQM program, soluble reactive phosphorus (SRP) is the form of phosphorus used by plants and algae that is often linked to hyper-

productivity and HABs in freshwater ecosystems. For that reason, it will be analyzed from samples collected at both Black Lake and its tributaries.

Total nitrogen is another essential nutrient found in aquatic ecosystems. Nitrogen contributes to the growth of algae and plants, which provide wildlife habitat. Similar to total phosphorus, excess levels of nitrogen are indicative of a eutrophic ecosystem. Nitrogen-heavy waters may reflect environmental disturbances spurred by anthropogenic activities, such as fertilizer use, stormwater runoff, or wastewater leakage from malfunctioning septic systems. Furthermore, a critical component of total nitrogen is nitrates (NO3-). While not analyzed as part of the CWQM program nitrates are prevalent within aquatic ecosystems and may contribute to water quality issues when introduced in excessive amounts. Retaining safe levels of nitrates in drinking water is critical, as high levels can be harmful to humans when ingested.

Chloride is the third and final nutrient measured through the CWQM program. Chloride occurs naturally in freshwater and is needed by aquatic organisms to carry out basic life functions. However, excess levels of chloride (whether from road salting, brining, drilling of gas and oil wells, and runoff) can pollute freshwater in many ways. For example, chloride can contaminate drinking water, can destabilize aquatic plant community structure, and can be toxic to amphibians and fish. Furthermore, chloride may cause soil to be more sensitive to erosion by affecting its ability to retain water, can corrode infrastructure, and may even cause death if ingested in high amounts by wildlife.

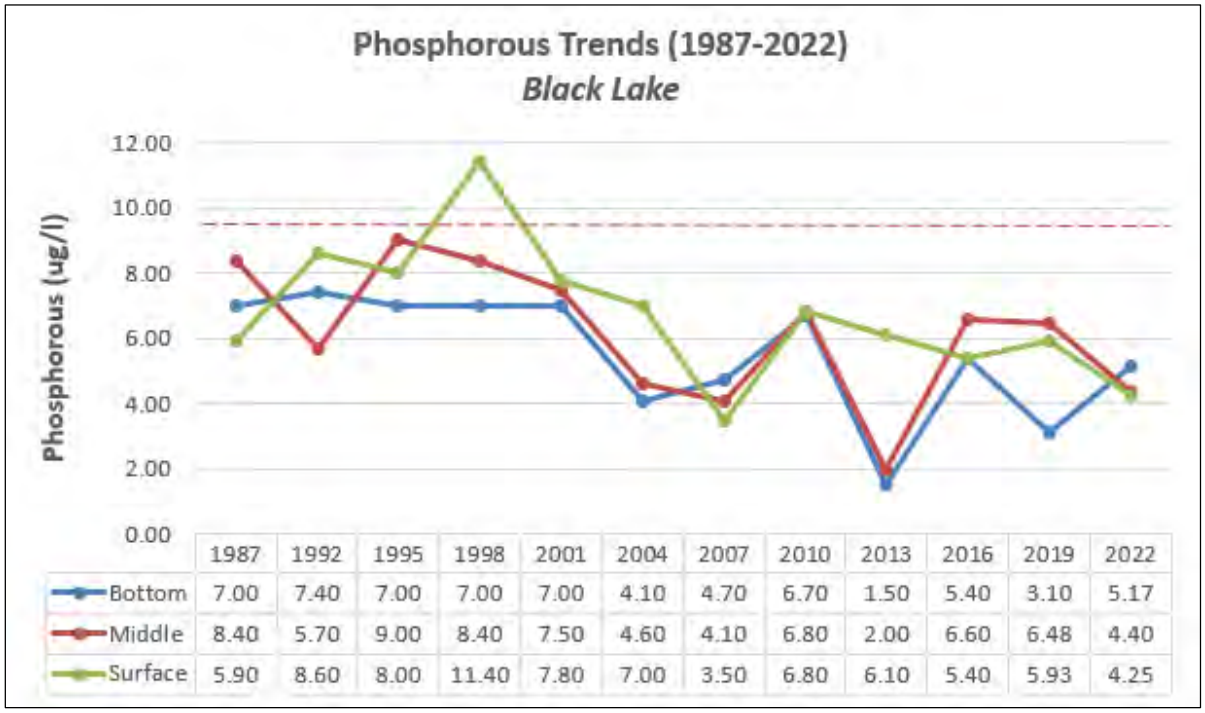
Finally, while not monitored via any Watershed Council programs, total suspended solids (TSS) will be analyzed from samples collected at Black Lake tributaries. TSS refers to the level of suspended particles within the water column, which may result from soil, algae, or the presence of microscopic organisms. High levels of TSS produce turbid (opaque) water, which may have impacts for ecosystem health and freshwater quality. For example, turbidity impacts light penetration and ecological productivity of an aquatic ecosystem. Additionally, increased levels of sediment or silt can have negative impacts for fish or other species. Particulate matter that causes turbid water may also bind to contaminants such as bacteria and metals.

Table 4. *Aquatic parameters measured as part of the Watershed Council's CWQM program.*

Parameter	Standard Value(s)	Source of Standard Values
Total Phosphorus (ug/L)	**Subecoregion 50:** 12 ug/L streams, 9.69 ug/L lakes	U.S. EPA
Total Nitrogen (ug/L)	**Subecoregion 50:** Streams: 440 ug/L streams, 400 ug/L lakes	U.S. EPA
Total Chloride (mg/L)	Aquatic Maximum Value: 320 mg/L	State of Michigan

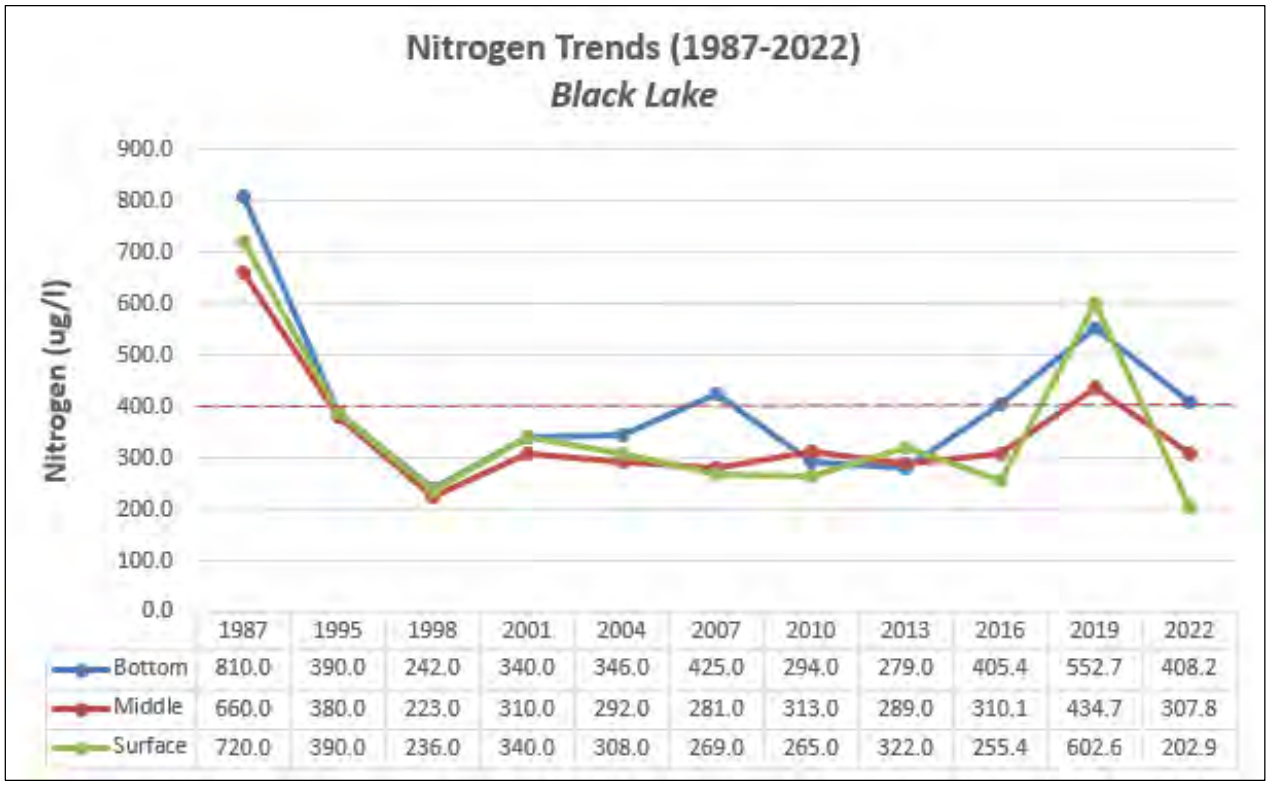
pH	6.0 - 9.0	U.S. EPA
Conductivity (uS/cm)	150 - 800 uS/cm	Huron River Watershed Council
Dissolved Oxygen (mg/L)	7 mg/L for cold water fisheries 5 mg/L for warmwater fisheries	State of Michigan
Temperature (Summer Stratification Period) Average, in °C)	Inland Lakes: 15.55 °C Coldwater streams: 12.22 °C Warmwater Streams: 13.33 °C	State of Michigan

Black Lake has been monitored through the CWQM program since 1987. Results detailing phosphorus, nitrogen, chloride, and specific conductivity trends within the Lake can be viewed below (Figures 3-6).



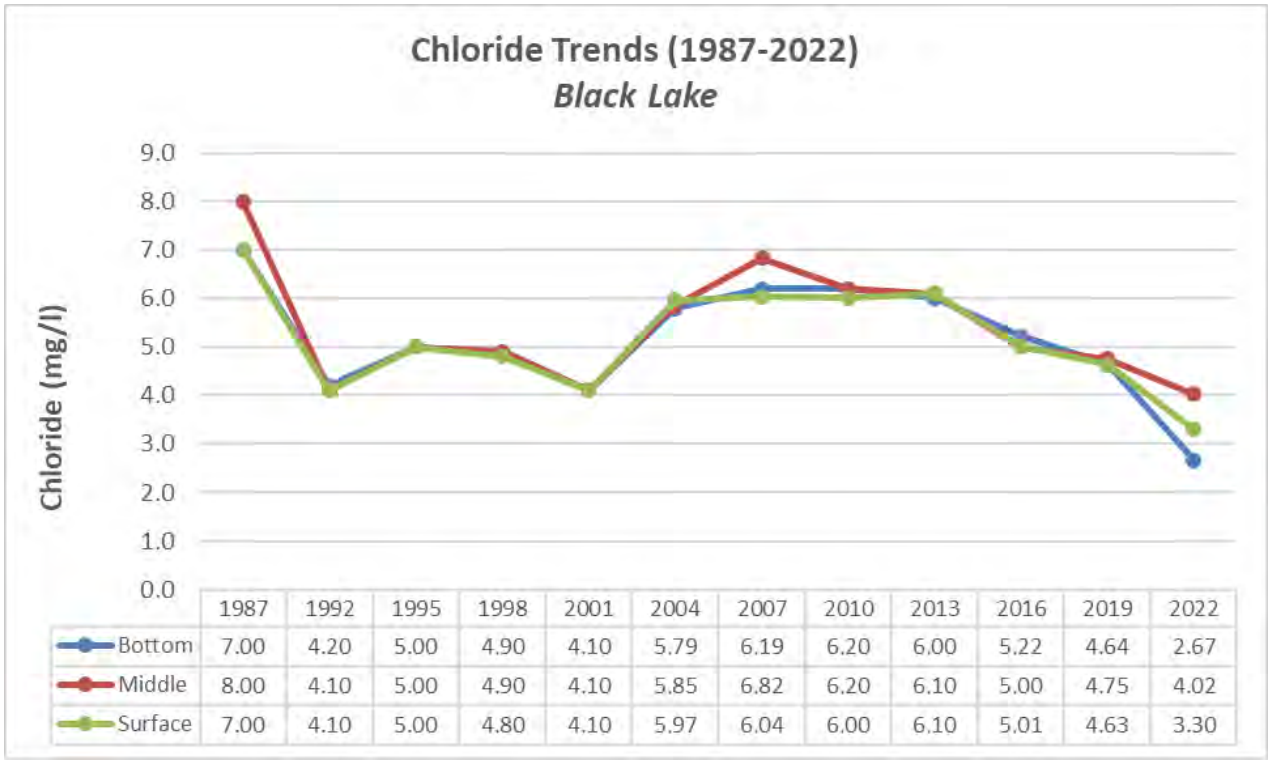
	1987	1992	1995	1998	2001	2004	2007	2010	2013	2016	2019	2022
Bottom	7.00	7.40	7.00	7.00	7.00	4.10	4.70	6.70	1.50	5.40	3.10	5.17
Middle	8.40	5.70	9.00	8.40	7.50	4.60	4.10	6.80	2.00	6.60	6.48	4.40
Surface	5.90	8.60	8.00	11.40	7.80	7.00	3.50	6.80	6.10	5.40	5.93	4.25

Figure 3. *Phosphorus trends in Black Lake from 1987-2022, collected through the Comprehensive Water Quality Monitoring Program. Note: red dashed line indicates EPA recommended maximum value (9.69 ug/L).*



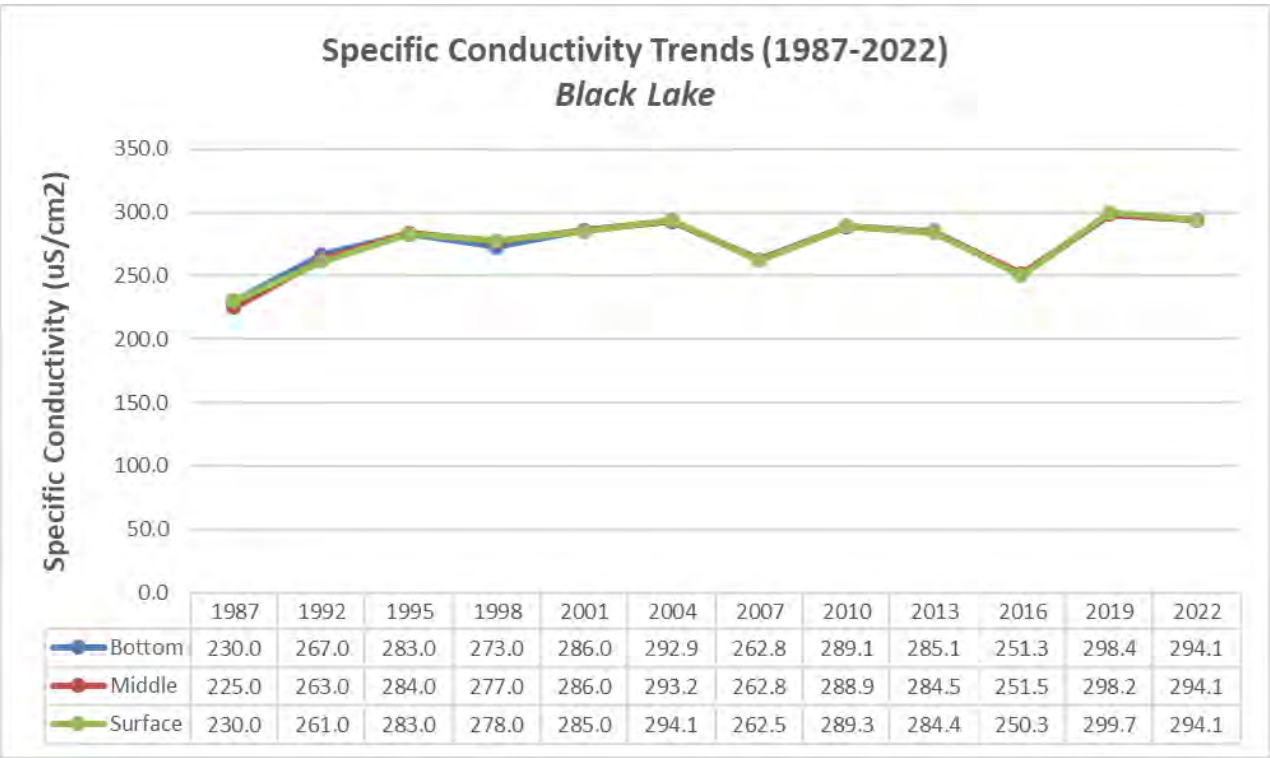
	1987	1995	1998	2001	2004	2007	2010	2013	2016	2019	2022
Bottom	810.0	390.0	242.0	340.0	346.0	425.0	294.0	279.0	405.4	552.7	408.2
Middle	660.0	380.0	223.0	310.0	292.0	281.0	313.0	289.0	310.1	434.7	307.8
Surface	720.0	390.0	236.0	340.0	308.0	269.0	265.0	322.0	255.4	602.6	202.9

Figure 4. *Nitrogen trends in Black Lake from 1987-2022, collected through the Comprehensive Water Quality Monitoring Program. Note: red dashed line indicates EPA recommended maximum value (400 ug/L)*



	1987	1992	1995	1998	2001	2004	2007	2010	2013	2016	2019	2022
Bottom	7.00	4.20	5.00	4.90	4.10	5.79	6.19	6.20	6.00	5.22	4.64	2.67
Middle	8.00	4.10	5.00	4.90	4.10	5.85	6.82	6.20	6.10	5.00	4.75	4.02
Surface	7.00	4.10	5.00	4.80	4.10	5.97	6.04	6.00	6.10	5.01	4.63	3.30

Figure 5. *Chloride trends in Black Lake from 1987-2022, collected through the Comprehensive Water Quality Monitoring Program. Note: no red line present as levels are nowhere near the aquatic maximum value (320 mg/L).*



	1987	1992	1995	1998	2001	2004	2007	2010	2013	2016	2019	2022
Bottom	230.0	267.0	283.0	273.0	286.0	292.9	262.8	289.1	285.1	251.3	298.4	294.1
Middle	225.0	263.0	284.0	277.0	286.0	293.2	262.8	288.9	284.5	251.5	298.2	294.1
Surface	230.0	261.0	283.0	278.0	285.0	294.1	262.5	289.3	284.4	250.3	299.7	294.1

Figure 6. *Specific Conductivity trends in Black Lake from 1987-2022, collected through the Comprehensive Water Quality Monitoring Program. Note: A suitable conductivity range to support freshwater fish populations is 150 - 800 uS/cm.*

Based on the nutrient data collection spanning the years 1987 - 2022, Black Lake has experienced a few notable nutrient concentration exceedances. Phosphorus concentrations exceeded 9.6 ug/L in the year 1998, and nitrogen concentrations fell above the recommended maximum of 400 ug/L in 1987, and then again in 2019. Both chloride and specific conductivity levels were within suitable ranges for ecosystem and fish population health.

Volunteer Lake Monitoring

The Watershed Council's VLM program is the longest standing water quality monitoring program at the organization. This annually conducted program includes data on specific lakes spanning over three decades. The Watershed Council provides training, equipment, and technical support to volunteers each spring. In return, volunteers provide a wealth of data, which is used to assess the water quality and biological productivity of inland lakes in Northern Michigan. The objectives of the program are to collect baseline data, characterize lake ecosystems, identify specific water quality problems, determine water quality trends, and most importantly, inform and educate the public regarding water quality issues and aquatic ecology. In 2023, volunteers monitored 36 sites on 28 lakes. Results detailing Secchi depths, chlorophyll-*a*, and trophic status index values can be viewed below (Figures 7-9), alongside standard values for the parameters measured. It is also important to note that the VLM program currently has a draft Quality Assurance Project Plan updated in spring of 2024 that is currently being reviewed by MiCorp staff.

Background on Biological and Physical Parameters

Chlorophyll-*a* is a photosynthetic pigment found in all green plants, including algae. Chlorophyll-*a* concentrations can be used as a measure of algal biomass in freshwater ecosystems, and can provide an estimate of overall biological productivity, and thus, trophic state. Trophic state essentially refers to the level of biological productivity, and overall nutrient levels, observed in waterbodies. Trophic state is commonly classified into four distinct categories: oligotrophic (nutrient-poor), mesotrophic (moderate nutrient levels), eutrophic (nutrient-enriched), and hypereutrophic (extreme nutrient enrichment). The median value of the summer chlorophyll-*a* monitoring results is used to calculate the Carlson Trophic Status Index (TSI) value for the lake, which is compared with the Secchi disc and total phosphorus TSI values for trophic status determination. The Carlson TSI uses an equation to calculate overall biological productivity and trophic state for any given waterbody.

Physical Parameter

Secchi discs are used to measure water clarity, or transparency, of a lake. Water clarity relates to overall nutrient levels and biological productivity (i.e. the clearer the water, the more nutrient poor), and thus, Secchi discs are used for general assessment of lakes worldwide. The Secchi disc itself has been standardized as an eight-inch (20-centimeter) disc, with four alternating black and white quadrants painted on the surface. To measure the water clarity of a lake, a Secchi disc is attached to a measured line and lowered into the lake until it disappears. The water depth at which the disc disappears is the Secchi disc depth, or value, for the lake. For example, clear, nutrient-poor lakes may have Secchi disc depths reaching up to 50 feet or more, and nutrient-heavy lakes with excess algal blooms may be invisible just a few feet below the water's surface.

Table 5. *Aquatic parameters measured as part of the Watershed Council's VLM program.*

Parameter	Standard Value(s)
Chlorophyll-*a* (maximum value reported, in ug/L)	Oligotrophic = < 2.2 ug/L Mesotrophic = 2.2 - 6.0 ug/L Eutrophic = 6.0 - 22.0 ug/L Hypereutrophic = >22.0 ug/L
Water Clarity (Carlson Trophic Status Index (TSI))	Oligotrophic = ● Secchi disc depth: > 15.0 ft ● Chlorophyll-*a*: < 2.2 ug/L Mesotrophic = ● Secchi disc depth: 7.5 - 15.0 ft ● Chlorophyll-*a*: 2.2 - 6.0 ug/L Eutrophic = ● Secchi disc depth: 3.0 - 7.5 ft ● Chlorophyll-*a*: 6.0 - 22.0 ug/L Hypereutrophic: = ● Secchi disc depth: < 3.0 ft ● Chlorophyll-*a*: > 22.0 ug/L

Table 6. *Trophic State and Corresponding Carlson TSI Values.*

Trophic State	Carlson TSI
Oligotrophic	<38
Mesotrophic	38-48
Eutrophic	48-61
Hypereutrophic	>61

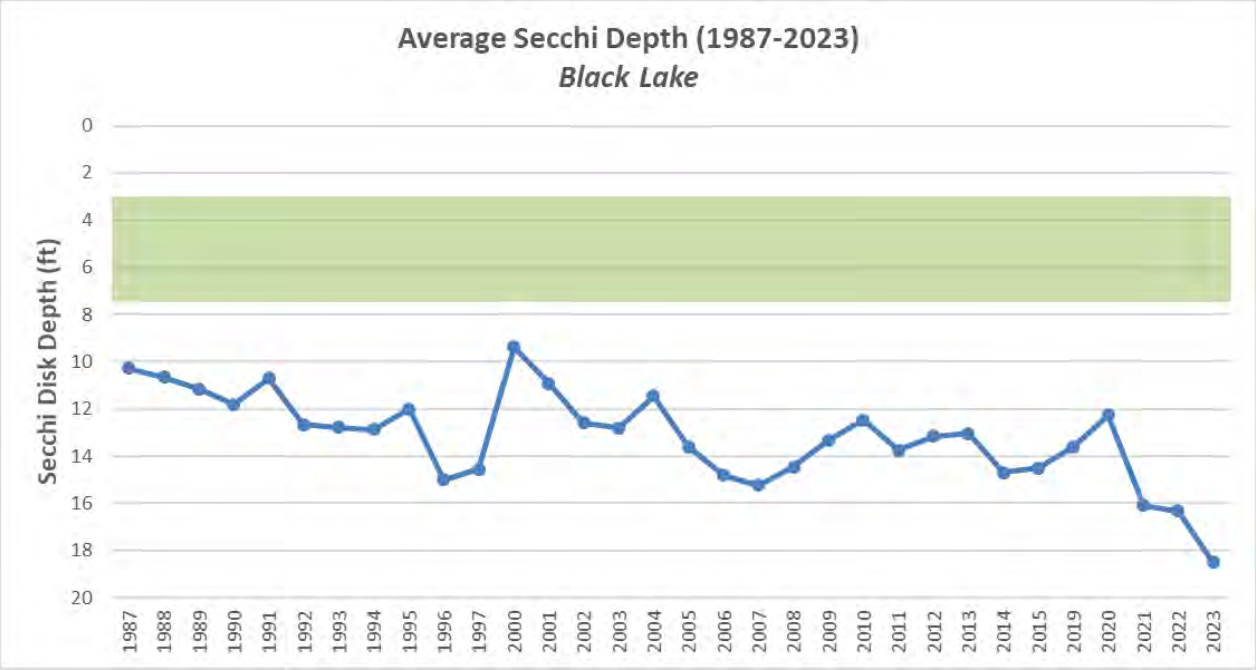


Figure 7. *Secchi disc depth trends in Black Lake from 1987-2023, collected through the Volunteer Lake Monitoring Program. Note: green shaded region indicates a eutrophic ecosystem (Secchi depth readings of 3.0 feet to 7.5 feet). Readings less than 3.0 feet are indicative of a hypereutrophic ecosystem. Secchi disc depths do not infringe on eutrophic or hypereutrophic conditions for Black Lake in the data reflected above.*

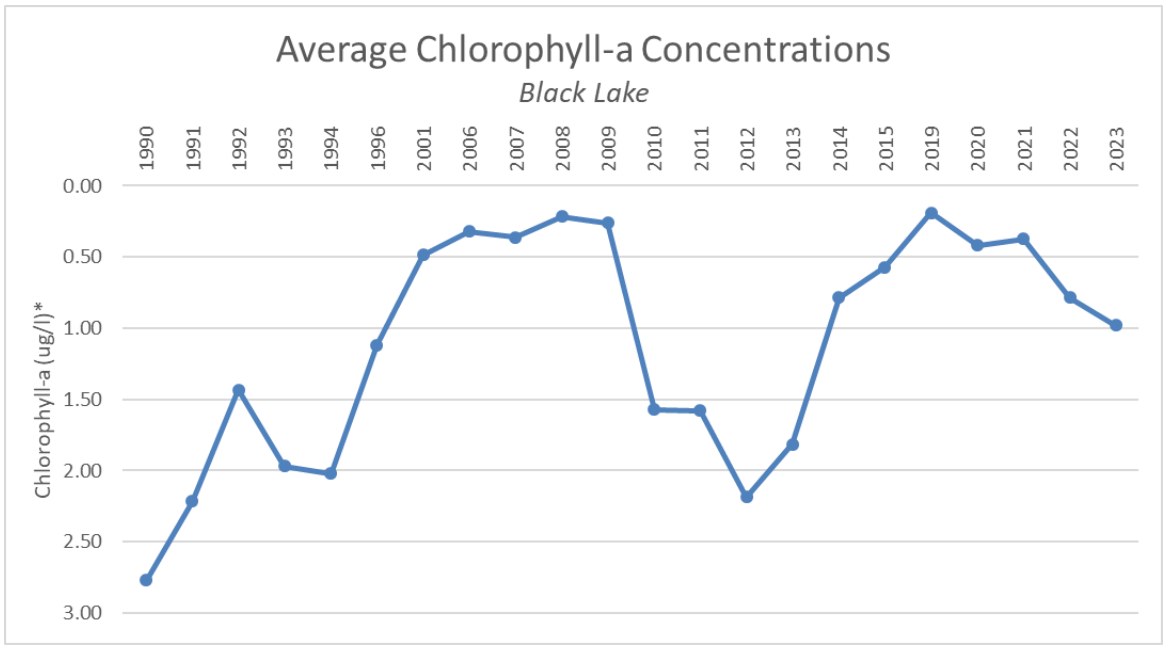


***Figure 8**. Chlorophyll-a trends in Black Lake from 1990-2023, collected through the Volunteer Lake Monitoring Program. Note: eutrophic conditions are indicative of chlorophyll-a concentrations at 6.0 ug/L and above. Levels do not exceed this threshold for Black Lake in the data reflected above.*

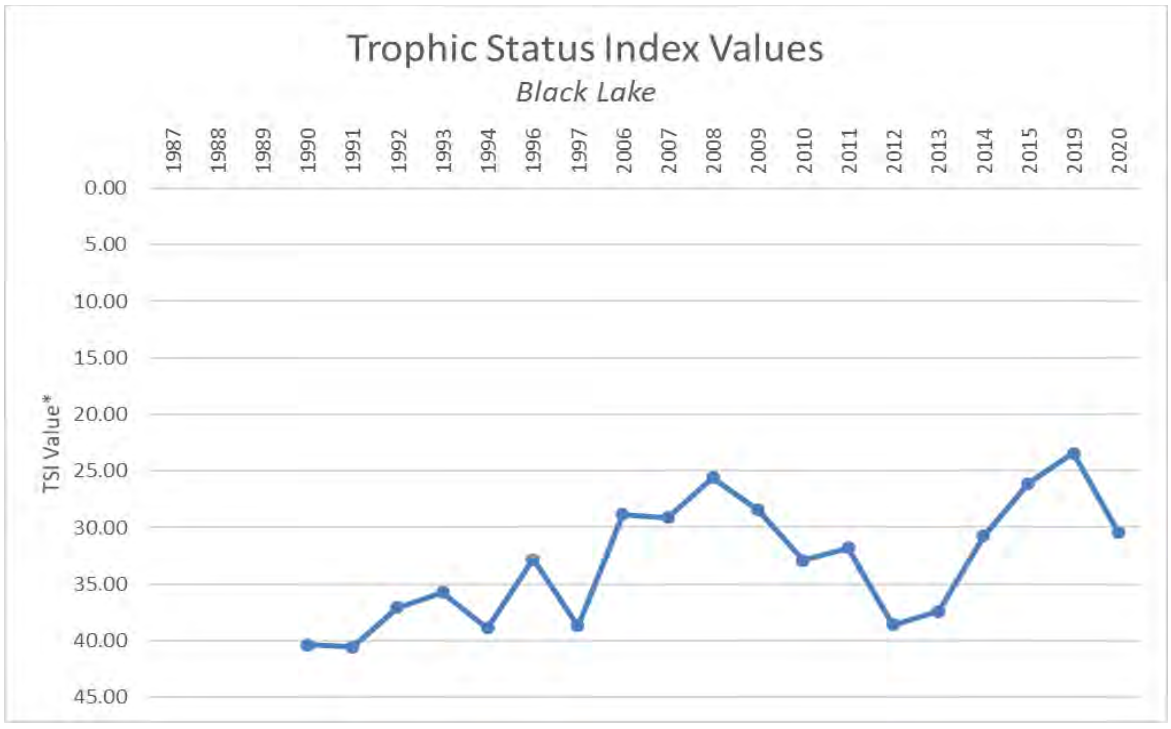


***Figure 9.** Trophic status index trends in Black Lake from 1987-2020, collected through the Volunteer Lake Monitoring Program. Note: eutrophic conditions are associated with a Trophic Status Index value of 48 or higher. Levels do not exceed this threshold for Black Lake in the data reflected above.*

Volunteer Stream Monitoring and Watershed Academy

Rivers and streams within the Black Lake Watershed are monitored through Watershed Council programs as well: The Volunteer Stream Monitoring (VSM) and Watershed Academy (WA) Programs provide valuable macroinvertebrate and water quality data from rivers, streams, and creeks. The Watershed Council's VSM QAPP was initially approved by MiCorp in 2021 but underwent further updates in 2024. It is currently being reviewed by MiCorp staff for approval of the aforementioned updates. Macroinvertebrate community diversity and species sensitivity are key factors in determining water quality. A wide variety of pollution-sensitive stoneflies, mayflies, and caddisflies portrays a healthy ecosystem and high water quality, while a sample with only pollution-tolerant aquatic worms and midges reveals a stream ecosystem that is likely suffering with poor water quality. Results of the biological monitoring performed by volunteers usually show healthy stream ecosystems and excellent water quality.

Fortunately, most waterbodies in the Black Lake Watershed continue to demonstrate excellent water quality. For example, the Black River showed no evidence of any phosphorus/nitrogen or chloride exceedances above the EPA and State of Michigan recommended maximum values through the years 2004-2022. The river health was considered to be 'excellent' (score of 90/100) based on assessment of total macroinvertebrate taxa, EPT (Ephemeroptera, Plecoptera, Trichoptera) families, and sensitive families.

In contrast, there are parts of the watershed experiencing nutrient pollution or degraded water quality. For example, tributaries such as Stony Creek reflected poorer water quality through assessment of macroinvertebrate populations, with a score of only 42/100 in 2023.

External Monitoring Efforts

Additional water quality monitoring and testing has been completed outside of the Watershed Council efforts. For example, suspected harmful algal blooms are reported to EGLE and tested for cyanotoxins through the Michigan Department of Health and Human Services (MDHHS). Microcystin has been detected a total of eight times during 2020 and 2021 from blooms occurring on Black Lake. Additionally, organizations such as the Black Lake Association and Black Lake Preservation Society have conducted data gathering in an effort to further understand lake profile data and nutrient concentrations.

A Harmful Algal Blooms Subcommittee, consisting of partners from the Watershed Council, U.S. Geological Survey, MDHHS, EGLE, Black Lake Association (BLA), and Black Lake Preservation Society (BLPS) formed in 2022. The subcommittee identified water quality monitoring during summer and fall (during HABs blooms) and sediment composition as a data gap. Starting in 2023, Black Lake Association volunteers sampled additional parameters beyond typical Watershed Council Volunteer Lake Monitoring Program sampling. For chlorophyll-*a* sample collection, laboratory instructions from Lake Superior State University were utilized. Additional parameters monitored included temperature profiles, dissolved oxygen profiles, total nitrogen, and total phosphorus. Monitoring for lake profile data (temperature and dissolved oxygen) and nutrients (total nitrogen and total phosphorus) occurred bi-monthly from July - turnover of Black Lake (early October). Total nitrogen and total phosphorus were collected both above

and below the thermocline of Black Lake. Monitoring methodology for Black Lake water quality sampling going forward in 2024 will be described in this QAPP.

BLPS recently pursued extensive research on Black Lake and its tributaries by partnering with Kieser and Associates, LLC. Preliminary findings summarize potential causes of HABs on Black Lake, characterization of total phosphorus inputs to the Lake, and an overview of the Lake phosphorus mass balance resulting from septic systems, atmospheric deposition, sediments, runoff, and tributary inflow. Additionally, data collection in 2023 consisted of lake, groundwater, and tributary sampling to better understand water quality, sediments, and physical parameters such as DO, pH, and conductivity. Additional monitoring on behalf of Kieser and Associates will be occurring throughout 2024 and future results are forthcoming.

BLA recently pursued a drone survey conducted in March 2024 through combined efforts from Freshwater Solutions, LLC, Zero Gravity Aerial, and a Watershed Biologist from Good Harbor Bay. This study was intended to be a comprehensive shoreline analysis of Black Lake and characterized the shoreline in a categorical analysis (i.e. 'natural shoreline', 'greenbelt', 'seawall', 'riprap', 'erosion', and more. Many of the parcels surveyed along the Lake's shoreline consisted of 'no greenbelt', 'beach sanding', or 'riprap' categorical results.

Based on previous water quality monitoring efforts, it is clear that there is a need for further tributary and lake water quality assessment within the Black Lake Watershed. Evidence of nutrient pollution, eutrophication, and degraded ecosystem health is clear, which is why further tributary and lake monitoring will occur through the Black Lake Watershed Management Plan. This data collection and analysis will allow for the characterization of relative pollutant concentrations and prioritization of tributaries. Furthermore, the collection of physio-chemical and biological data will spur the development of management measures needed to protect the critical resources of the Black Lake Watershed.

Project Goals and Objectives

Project Background

The project goals and objectives primarily focus on protection of the Watershed's high-quality water resources through community engagement and outreach, focused resource inventories and water quality monitoring, promotion of water quality protection ordinances, and other planning efforts. Water quality benefits will far exceed project costs due to the value of protecting high-quality water resources through priority projects. Developing a Watershed Management Plan with the potential to implement on-the-ground restoration and protection planning projects, as well as engage with local stakeholders, is vital to preserving Northern Michigan's excellent lakes, streams, and wetlands.

Tip of the Mitt Watershed Council, Black Lake Preservation Society, Black Lake Association, Huron Pines, Sturgeon for Tomorrow, and other stakeholders will continue watershed protection activities in the Watershed and region. With the benefit of a Section 319-approved Watershed Management Plan, stakeholders will pursue project implementation of priority protection projects. The Watershed Council

will continue with water quality monitoring efforts, including Comprehensive Water Quality Monitoring, Volunteer Lake Monitoring, and Volunteer Stream Monitoring programs, in order to maximize the availability of water quality data for current and future water resource protection, education, and preservation.

Measurable Objectives

Measurable objectives relevant to the construction of this Quality Assurance Project Plan are as follows:

(a) Water quality monitoring in Black Lake and its associated tributaries to fill in water quality data gaps and estimate relative pollutant contributions as well as proposed management measures (Table 7).

(b) Dissemination of all water quality monitoring data (in both hard copy and electronic formats, using the EGLE WQX template) to the Watershed Advisory Committee, EGLE, The Watershed Council, and other agencies, organizations, and stakeholders.

Table 7. *Overview of Black Lake Watershed Water Quality Monitoring.*

Purpose of Monitoring:	(1) Determine relative pollutant contribution from tributaries and their subwatersheds. (2) Determine whole lake water quality on Black Lake during Summer through Fall.
Parameters to be Measured:	Tributaries: Temperature, Dissolved oxygen, Specific conductivity, pH, nitrates, TP, SRP, TSS, chloride, and discharge. Lake: Chlorophyll-*a*, Secchi depth, temperature, dissolved oxygen, conductivity, pH, nitrates, TP, SRP.

Number of Locations to be Sampled:	Lake: Black Lake's general water chemistry will be monitored by Watershed Council staff in combination with Roger Bergstedt, Black Lake Association Volunteer. Monitoring of Black Lake will **follow the VLM QAPP** procedures for: (1) chlorophyll-*a* and Secchi depth data collection (through June, July, and August, collected by Black Lake Association volunteer Roger Bergstedt) and will follow procedures **specific to this QAPP only** for: (2) dissolved oxygen, temperature, pH, conductivity, nitrates, TP, and SRP (each collected once per month from June – October each year). Furthermore, additional Secchi and chlorophyll-*a* data will be collected once per month in September and October each year. See Table 8 for full details. Tributaries: 8 sites on 5 tributaries (Rainy River (2), Stony Creek (2), Upper Black River (2), Stewart Creek (1), and Cold Creek (1)) will be monitored for general water chemistry and flow a total of 8 times during the grant period. Monitoring events will occur twice in the spring, four times in the summer, and twice in the fall. Half of the sampling events will be wet weather events. All monitoring will occur over a 2-year period (2024 and 2025).

The environmental monitoring addressed in this QAPP includes *in-situ* physical water quality measurements, water sample collection for nutrient analyses, and discharge measurements. These assessments will describe nonpoint source pollution at the watershed and sub-watershed scale. Subwatersheds that are found to have high pollutant concentrations can then be further assessed to determine pollution sources. Suspected water quality pollutants sources include agricultural practices, degrading road/stream crossings, shoreline management, urban stormwater runoff, and septic systems. Discharge data will also allow for more accurate comparisons between and with other streams and will provide important data for future endeavors to determine watershed fluxes and calibrate hydrologic models.

Watershed Council staff have extensive experience performing nonpoint source pollution assessments and will work alongside water protection summer interns to complete field surveys. The outcome will be

completed water quality monitoring for targeted tributaries and Black Lake, providing critical information for writing effective watershed management plans. Ultimately, the information gathered during these monitoring efforts will be used by the Watershed Advisory Committee, EGLE, The Watershed Council, and other agencies, organizations, and stakeholders to more effectively address problems and reduce nonpoint source pollution in the Black Lake Watershed. The data will be included in the Watershed Management Plan and used to develop recommendations and guide prioritization of the recommendations.

The objectives associated with this Water Quality Monitoring QAPP that fall under this Black Lake Watershed Project include:

Objective #1 – Monitor Water Quality of Major Tributaries Flowing into Black Lake and Assess Relative Impacts

The water quality of major tributaries flowing into the Black Lake Watershed will be monitored to assess relative impacts of each sub-watershed. A combination of physical and chemical data will be collected at each tributary site, with the exception of no discharge data collection occurring at both of the Upper Black River sites (these sites are not suitable for wading). Sampling will be conducted during wet-weather conditions (i.e., following major precipitation events) and dry conditions (base-flow) to capture the full range of discharge variability. For reference, wet-weather conditions are defined as either 1) 0.5" of precipitation over a 24-hour period, or 2) 0.25" of precipitation over a 12-hour period. For water quality monitoring conducted on Black Lake tributaries, either set of criteria may be used, as long as data collection occurs within the recommended time frame.

Data will be collected eight times over the course of the grant period. Data will be collected seasonally each year: two events in spring 2025, two events each summer (4 total summer events), and one event each fall (2 total fall events). All events will fall within 2024 and 2025, as the grant period ends in March 2026. 8 sites on 5 tributaries (Rainy River (2), Stony Creek (2), Upper Black River (2), Stewart Creek (1), and Cold Creek (1)) will be monitored for general water chemistry and flow. Note that discharge data cannot be collected at Upper Black River sites (not suitable for wading). Discharge and pollutant concentration data will be used to calculate instantaneous pollutant concentrations for individual streams. Tributaries will be prioritized for implementation tasks based on average nutrient concentrations.

Objective #2: Monitor Water Quality of Black Lake at its Deepest Point

Though Black Lake has been monitored extensively through the Watershed Council for nutrient, chlorophyll-*a*, and Secchi data since 1987, more information on current water chemistry is needed to effectively design and implement a watershed management plan. Black Lake will be monitored according to the following schedule (Table 8):

Table 8. *Monitoring Schedule and Associated Parameters for Black Lake (Deepest Point) Monitoring conducted by Watershed Council Staff.*

2024 Black Lake Sampling	Chl-*a*	Secchi	DO, pH, conductivity	Temp	Nitrates	TP	SRP
Monitoring Type: VLM	2 samples/month in June, July, August 2024 (Roger Bergstedt)	*A minimum of 2 readings/ month* in June, July, August 2024* (Roger Bergstedt)	N/A	N/A	N/A	N/A	N/A
Monitoring Type: 205j Black Lake	1 sample/month in September and October 2024	1 reading/month in September and October 2024	1 event/month from June - October 2024	1 event/month from June - October 2024	1 event/month from June - October 2024	1 event/month from June - October 2024	1 event/month from June - October 2024

*A minimum of 2 Secchi readings per month from June, July, and August is in accordance with the Watershed Council VLM QAPP Procedures.

Monitoring extends into fall (October) as harmful algal blooms have previously occurred on Black Lake during this time period. Again, Black Lake sampling will follow VLM QAPP protocols for chlorophyll-*a* and Secchi depth monitoring for June, July, and August monitoring. Additional lake sampling of: DO, temperature, pH, conductivity, nitrates, TP, SRP, and chlorophyll-*a* and Secchi in September/October will follow procedures specific only to this QAPP. Water chemistry data will be used to evaluate trophic status/nutrient loading as well as collect further data on physical lake conditions. This information can be utilized to identify priority and critical areas for watershed protection and will be used to develop the Watershed Management Plan.

Objective #3 – Submit All Collected Water Quality Data in both Hard Copy and Electronic Formats

All field data and interpretation of findings will be shared with watershed planning partners to identify and prioritize locations and options for future nonpoint source remedial activities, as well as develop a Watershed Management Plan. Data from the tributary monitoring will be used to identify sub-watersheds that contribute disproportionately high loads of nutrients or high pollutant concentrations. This information, coupled with other inventory and assessment data, including streambank erosion inventories, road-stream crossing inventories, and stormwater runoff assessments will be used to determine critical areas for the watershed management plan and in turn, develop recommendations for addressing specific non-point source pollution problems.

Project Organization, Partners and Roles of Participants

Lead Organization

For 45 years, Tip of the Mitt Watershed Council has worked to protect Northern Michigan's water resources, specifically in Antrim, Charlevoix, Cheboygan, and Emmet Counties. The Watershed Council is a 501(c)(3) organization with around 2,000 individual, business, and organizational members. Multiple watershed management plans have been developed and implemented by the Watershed Council, including, but not limited to, the EGLE and US EPA-approved 2018 Burt Lake Watershed Management Plan, the EGLE AND US EPA-approved 2022 Elk River Chain of Lakes Watershed Management Plan, and, most recently, the EGLE AND US EPA-approved 2023 Mullett Lake, Lower Black and Cheboygan Rivers Watershed Management Plan. Additionally, the Watershed Council coordinates the aforementioned three water quality monitoring programs: the Comprehensive Water Quality Monitoring Program, the Volunteer Lake Monitoring Program, and the Volunteer Stream Monitoring Program. Furthermore, Watershed Council staff members carry out a variety of water quality monitoring or shoreline restoration contractual projects for lake associations, local governments, and coordinate environmental education and outreach events within their service area.

The key staff members who will implement the monitoring portion of this project are Marcella Domka, Water Resources Manager, Anna Watson, Monitoring Coordinator, Emily Johnson, Water Resources Specialist, Calla Beers, Water Resources and Communications Specialist, and Watershed Council Interns (University of Michigan Biological Station CLEAR Fellow and a Water Protection Intern). Marcella Domka has a Bachelor of Science in Environmental Biology (University of Dayton) and a Master of Science in Fisheries and Wildlife with a specialization in Ecology, Evolution, and Behavior (Michigan State University). She has ample experience with water quality monitoring, scientific writing and research, data analysis and management, and environmental education. Anna Watson has a Bachelor of Science in Environmental and Sustainability Studies (Grand Valley State University) with emphasis in Water Resources and Culture and the Built Environment. She has ample experience in water quality monitoring, data analysis and management, water quality reporting, volunteer coordination, and public engagement. Emily Johnson has a Bachelor of Science in Environmental Science with a Geosciences concentration (Eastern Michigan University). She has experience in GIS mapping and analysis, invasive

species, water quality monitoring, and wetlands. Calla Beers has a Bachelor of Arts in Environmental Science specializing in water resources and a Bachelor of Arts in Design (University of Michigan). She is experienced in water quality monitoring, habitat assessments, and scientific communications.

Selected interns will be majoring in a relevant field of study (i.e. Biology, Environmental Biology/Studies, etc.) and will be fully instructed and supervised by Marcella Domka, Water Resources Manager, to ensure that all water quality monitoring is completed in adherence to this Water Quality Monitoring QAPP.

Project Partners

Tip of the Mitt Watershed Council will partner with several different organizations and agencies to complete this project. The Lake Superior State University Center for Freshwater Research and Education (LSSU CFRE) will provide support in the form of laboratory analyses, technical assistance, and monitoring/survey equipment. Black Lake Preservation Society (BLPS) and Black Lake Association (BLA) are both dedicated to keeping Black Lake and its surrounding watershed healthy for generations to come. The Watershed Council will work closely with BLPS and BLA, as well as Sturgeon for Tomorrow, to recruit local government officials, resource groups, and others to carry out the duties of the watershed advisory committee and engage participants in the Watershed Management Planning process. Volunteers from BLPS and BLA will also contribute valuable water quality data by engaging in collection efforts for nutrients, temperature data, dissolved oxygen readings, sediment concentrations, and more. Huron Pines will also participate in the watershed advisory committee and planning development process. The University of Michigan School for Environment and Sustainability (SEAS) masters' students fully developed and implemented the completion of resource inventories in the Black Lake Watershed, for which a separate QAPP exists. Many other stakeholders will be involved with Watershed Management Plan development, including representatives from local governments, state agencies, lake associations, chambers of commerce, and more. All partners are expected to participate in the Watershed Advisory Committee.

Project Administrator: Lauren Dey, Associate Director, Tip of the Mitt Watershed Council

Responsible for administering the project as outlined in the grant agreement and fulfilling the reporting requirements of the granting agency.

Project Manager: Marcella Domka, Water Resources Manager, Tip of the Mitt Watershed Council

Responsible for coordinating/delegating field data collection, coordinating laboratory work and analytical chemistry performed by project partners, analyzing, assessing, and sharing collected data, and writing comprehensive and summary reports.

Quality Assurance Officer: Marcella Domka, Water Resources Manager, Tip of the Mitt Watershed Council

Responsible for assuring data collection and input follow procedures outlined in this QAPP.

Field Activities and Sample Collection: All field activities will be coordinated by the Project Manager. Field activities, including sample collection, will be carried out by Watershed Council staff members Anna Watson, Emily Johnson, Calla Beers, and Watershed Council Interns. Marcella Domka will assist with field activities when/if needed. Roger Bergstedt, BLA, will conduct VLM as he has in previous years. The chlorophyll-*a* and Secchi data that he collects will be used in both the data analysis process and writing of the Black Lake Watershed Management Plan.

Laboratory Analyses: Analytical chemistry for water samples will be performed at the Center for Freshwater Research and Education through LSSU. CFRE staff are responsible for performing analytical chemistry on all water samples collected during the project in adherence to methods outlined in the QAPP (fully updated SOPs).

Special Training Requirements or Certifications

The project monitoring and sampling includes physical measurements using multiparameter probe instrumentation, collection of water samples for chemical analyses, and stream discharge measurements using a flow velocity meter. The Watershed Council staff members performing fieldwork have extensive field experience as it relates to performing the physical water quality monitoring, collecting water samples for chemical analyses, and collecting discharge measurements. Staff involved with monitoring and sample collection will adhere closely to handling, delivery, and chain of custody procedures. Experienced laboratory staff will perform chemical analyses, acting in their professional capacity. No specialized training or certifications are required or necessary.

Note: Roger Bergstedt is a retired PhD fisheries research biologist with a minor in chemistry and has extensive experience in water quality monitoring. He has also served as the Station Chief of the Hammond Bay Biological Station. Roger was trained by Watershed Council staff in VLM methods in 2021 and is fully up to date with all relevant procedures for chlorophyll-*a* and Secchi disc data collection. In summation, Roger has a combination of both formal science education and training conducted by Watershed Council Staff.

Black Lake: Monitoring Schedule, Location, Parameters, and Procedures

Monitoring Schedule, Location, Parameters

Black Lake will be monitored via Watershed Council staff for chlorophyll-*a* and Secchi data in September and October of 2024 and 2025 (deepest point). Black Lake will also be monitored on a monthly basis for dissolved oxygen, temperature, pH, conductivity, nitrates, TP, and SRP from June – October via Watershed Council staff in 2024 and 2025 (deepest point). Monitoring locations and collection equipment of collection can be referenced below (Figure 10, Tables 9, 10).

Black Lake will also be monitored via Roger Bergstedt, BLA, for chlorophyll-a and Secchi during June, July and August (Roger is covering Volunteer Lake Monitoring responsibilities ONLY). A minimum of two chlorophyll-a samples and two Secchi readings will be collected per month (deepest point). This will occur in 2024 and 2025.

NOTE: Please see Table 8 for full details and sampling schedule. All sampling of Black Lake will be completed by Watershed Council staff with the exception of chlorophyll-*a* and Secchi data collected in June, July and August by Roger Bergstedt through the VLM program. The following protocol will be adhered to for collection of physical parameters and nutrients:

Procedures:

Preparing for Lake Monitoring:

(1) Calibrate the YSI EXO 1s Multiparameter Probe according to the user manual. Watershed Council staff have been trained by a Xylem professional to calibrate the EXO 1s probe for all relevant parameters (i.e. pH, conductivity, dissolved oxygen) and have ample experience with probe calibration.
(2) Charge iPads and ensure that FieldMaps data entry boxes/electronic sheets are prepared in advance.
(3) Ensure that the multiparameter probe handheld device has folders created relevant to the monitoring at hand (i.e. a folder for Black Lake – Deepest Point).
(4) Ensure that a map with a list of exact coordinates has been made and is accessible to field staff (only one set of coordinates necessary for Black Lake monitoring).
(5) Collect all equipment related to monitoring and boat operation. Watershed Council staff are experienced with boating, trailering, and have a comprehensive list of materials required for field days.
(6) Weather will be monitored in advance by relevant field staff.

Collecting In-Lake Dissolved Oxygen and Temperature Data:

NOTE: Physical parameter data within Black Lake will be collected as temperature and depth profiles. Specific conductivity and pH will also be collected automatically while the profile data is being collected. Readings for temperature and dissolved oxygen profiles will be collected every meter starting at 0.5 meters below the lake's surface. Specific conductivity and pH will be collected automatically as the profile data is being collected. However, nutrient samples (nitrates, SRP, TP) will only be collected above and below the thermocline (two depths rather than three). This is due to budgetary constraints for laboratory analysis.

(1) Anchors should be released from the front and back of the boat to remain stationary at exact deepest point coordinates.

(2) Label sample bottles using indelible marker with the following: site name, date, parameter(s), monitoring project (205j).
(3) Ensure cable is connecting the multiparameter probe to the handheld device.
(4) Put sonde over side of boat and leave at 0.5 meters below the water's surface for several minutes to equilibrate to water conditions - while doing so create a folder and lake name.
(5) When readings have stabilized, take the first measurement at 0.5 meters below the lake's surface, then every consecutive meter until the lake's bottom is reached. Do this for both dissolved oxygen and temperature.
(6) Collect pH and specific conductivity data at the lake's deepest point. This data will be automatically collected as the temperature and DO profiles are taken every meter, starting 0.5 meters below the lake's surface.

Collecting Nutrient Samples: In-Lake

(1) Anchors should be released from the front and back of the boat to remain stationary at exact deepest point coordinates.
(2) Label sample bottles using indelible marker with the following: site name, date, parameter(s), monitoring project (205j).
(3) Rinse the Kemmerer sampling device with surface water 3 times - empty water through surgical tube each time. This is only necessary at the surface.
(4) Using the depth finder and knowledge of the location of the thermocline within Black Lake, prepare to take nutrient samples above and below the thermocline. Rinse all sample bottles three times with lake water before collecting the sample and capping it. Do not touch the inside of the cap or the bottle, or it will be considered contaminated. If a bottle has been contaminated, set it aside and use a different bottle. Try to avoid any contamination as number of acid-washed bottles from LSSU are limited.
(5) Lock Kemmerer sampler in open position by pulling on both green ends at the same time (you will hear it click to open position).
    a. When Kemmerer is lowered into the water, drop the weight on the rope to trigger spring mechanism that closes the sampler. Pull out of water, avoiding contact with the boat.
    b. Use finger to push spring at the bottom of the Kemmerer bottle to release flow through the connecting tube and let enough water flow through to rinse any old water out of the tube.

(6) Total Phosphorus Sample Collection:

    a. Fill the 250 mL sample bottle with lake water from above and below the thermocline (250 mL sample bottles for TP). Leave a bit of headspace for the sample to expand when it freezes. Place the sample bottle on ice in a cooler immediately. Place in laboratory freezer when back in the office. Samples will be delivered within 28 days (hold time).

(7) Soluble Reactive Phosphorus and Nitrates Sample Collection:

a. NOTE: the method for collecting SRP and nitrates in a single 125 mL bottle requires filtration. SRP and nitrates are collected in a ~100 mL sample and then filtered on-site and stored in a 125 mL bottle.
b. Rinse the syringe 3X with sample water.
c. Fill the syringe full (50-60 mL) with sample water.
d. Attach a clean syringe filter.
e. Expel 3 - 5 mL through the syringe filter.
f. Press the syringe by hand to filter the water into the 125 mL bottle.
g. Remove the syringe filter.
h. Repeat steps 2,3,5, and 6 until the sample bottles contain 100 mL. One syringe filter can be used repeatedly for the same sample until it breaks or clogs.
i. Leave a bit of headspace for the sample to expand when it freezes. Place the sample bottle on ice in a cooler immediately. Place in laboratory freezer when back in the office. Samples will be delivered within 28 days (hold time).
j. Notes:
    i. Avoid touching the tip of the syringe or filter with your hand.
    ii. Do not pull water into the syringe while the filter is attached.
    iii. Syringe should be rinsed 3X by DI water before reuse.

Collecting Secchi Readings and Chlorophyll-a Samples: In-Lake

Please see Appendix E for full methodology of Secchi data collection and chlorophyll-*a* data collection.

Analytical methods for all in-lake data collection can be found in the Appendices.

Black Lake Tributaries: Monitoring Schedule, Location, Parameters, and Procedures

Monitoring Schedule, Location, Parameters:

5 critical tributaries at a total of 8 sites will be monitored by The Watershed Council eight times during the course of the grant period. These tributaries were deemed 'critical' based on existing water quality and watershed inventory data (sourced from the 2018 Black Lake Tributary study, EGLE data in the Black Lake Watershed, Watershed Council Water Quality Monitoring Programs Data, Site Visitations, University of Michigan SEAS resource inventory data, and more). The tributary sites include two sites on Rainy River, two sites on Stony Creek, two sites on the Upper Black River, and one site each on Stewart Creek and Cold Creek. Water quality and watershed inventory data indicated the following reasons for selecting the 5 critical tributaries mentioned above:

- **Upper Black River (North Black River Road):** This site has had high *E. coli* readings in previous monitoring events (exceeding standards for Total Body Contact in 2022).

- **Upper Black River (Milligan Highway):** This site is adjacent to two high priority agricultural sites and is in proximity to a 'moderate severity' road-stream crossing in terms of degradation. This site is unwadeable, and thus, no discharge data can be collected.
- **Stony Creek (North County Line Road):** This site was selected based on results from the 2018 Black Lake Tributary study. Results indicated low dissolved oxygen, elevated temperatures, and exceedances of TP, TN, and sulfate. Furthermore, this site received a grade of 'C' for the Watershed Council's VSM program in 2023, indicating average macroinvertebrate diversity in response to water quality issues.
- **Stony Creek (M68):** This site demonstrates TN and sulfate exceedances based on the 2018 tributary study.
- **Cold Creek (North Porter Road):** This site is ideal for monitoring in comparison to Cold Creek (Roost Road). The Roost Road site is not accessible for discharge, and the North Porter Road location is closer to a high priority agricultural site, is within a designated critical area for not meeting water quality standards and is near a road-stream crossing labeled 'moderate severity' in terms of degradation (information sourced from the 2024 SEAS resource inventory report).
- Rainy River (North Palmer Road): This site will be used as a point of comparison between the downstream (North Palmer Road) and upstream (North Allis Highway) locations on the Rainy River. Water quality of this critical river will be fully captured with multiple monitoring sites.
- **Rainy River (North Allis Highway):** This site has had high *E. coli* readings in previous monitoring events (exceeding standards for both Partial Body Contact and Total Body Contact in 2022).
- **Stewart Creek (South Black River Road):** This site is within a designated critical area for not meeting water quality standards, a designated critical area for streambank erosion, and a designated critical area for agriculture.

Monitoring events will occur twice in the spring, four times in the summer, and twice in the fall over 2024 and 2025. The grant period ends in March of 2026. Half (four) of the tributary sampling events will be wet-weather events.

Wet-weather sampling will be conducted following large precipitation events (defined as either 0.5" of precipitation over a 24-hour period or 0.25" of precipitation over a 12-hour period). Dry-weather sampling will be conducted following antecedent dry weather of at least three days. Tributary data collection will include temperature, dissolved oxygen, specific conductivity, pH, nitrates, total phosphorus, SRP, TSS, chloride, and discharge. Monitoring locations and methods of collection can be referenced below (Figure 10, Tables 9, 10).

Procedures:

Preparing for Tributary Monitoring:

1) Calibrate the YSI EXO 1s Multiparameter Probe according to the user manual. Watershed Council staff have been trained by a Xylem professional to calibrate the EXO 1s probe for all

relevant parameters (i.e. pH, conductivity, dissolved oxygen) and have ample experience with probe calibration.

2) Charge iPads and ensure that FieldMaps data entry boxes/electronic sheets are prepared in advance.
3) Ensure that the multiparameter probe handheld device has folders created relevant to the monitoring at hand.
4) Ensure that a map with a list of exact coordinates has been made and is accessible to field staff.
5) Collect all equipment related to monitoring and travel. Watershed Council staff have a comprehensive list of materials required for field days.
6) Bring a stream monitoring data sheet.
7) Weather will be monitored in advance by relevant field staff.

Collecting Physical Tributary Data

Physical parameters, including water temperature, dissolved oxygen, pH, and conductivity, will be measured *in-situ* using a YSI EXO 1s multiparameter Sonde (see Appendix A for specifications). Physical measurements with the EXO 1s will be made mid-stream and at mid-depth. For non-wadable sites, the EXO 1s will be lowered (using a probe cable) into the water to receive physical water quality data. The EXO 1s will be calibrated per user manual instructions in the Watershed Council office laboratory prior to each monitoring event. If calibration fails, the unit will be calibrated again and if unsuccessful, YSI technical support will be contacted to resolve the issue. If unable to calibrate with technical support or if there are any other serious issues affecting performance, the EXO 1s will be sent to YSI for repairs and a Hach Hydrolab Minisonde will be used instead. Field data will be stored electronically in the handheld EXO 1s display unit and recorded on iPads as a backup if the handheld is not properly storing data. Field staff will also fill out a stream monitoring data sheet.

Collecting Discharge Data

Discharge will be measured immediately after water sample collection during all monitoring events at six out of eight tributary sites. Discharge will be measured along a cross-sectional profile, recording channel width, water depth, and flow velocity at multiple locations in the cross section to calculate the volume of the water per unit time passing through the site. At relevant sites, cross-sectional profiles will be located as close as possible to the mouth of the stream or point of confluence. Sites are selected to capture river, stream, or creek discharge that is not subject to backflow from Black Lake itself. Tools employed for discharge measurements include tape measure, anchoring pins, wading rod, and the Xylem SonTek FlowTracker2. Cross-sectional profiles will be measured at each site and recorded on the field datasheet (Appendix B) according to the following procedure:

(1) Complete the assembly of the FlowTracker2 prior to beginning any data collection. Details are provided in user manual.

(2) Determine the best place for the cross-sectional profile at the site. To avoid error in flow velocity measurements, the profile will be located in an area of the stream that is a single

channel (i.e., not braided and without islands), relatively free of debris, without undercut stream banks, and of sufficient depth across the majority of the profile such that the sensor on the flow velocity meter is completely submersed (>0.2 feet).

(3) Extend the measuring tape across the stream perpendicular to the stream's flow and affix the tape tightly to unmoving structures (e.g., large trees) on both sides of the stream, or use the anchoring pins if necessary.

(4) Place fully assembled FlowTracker2 device into water, beginning at either the left or right bank. Specify which bank data collection will begin at using the handheld device.

(5) Using the handheld device, follow the prompts on the screen to collect your first, and subsequent 9+, measurements. Be sure to enter site numbers, site name, operator name, and other critical details. Intervals for data collection will be selected based on changes in depth and flow velocity along the profile or at regular intervals for stream channels with relatively uniform depths and flow velocities. A minimum of 10 locations along the cross-section will be measured and recorded for small streams (<20 feet wide) and a minimum of 20 locations for large streams and rivers. Flow at each station will be no greater than 10% of the total discharge.

(6) Follow all handheld prompts to collect discharge data at each selected interval. Again, full details are available in TOMWC's written procedure (draft format) or the FlowTracker2 user manual.

Note: Measurements will be taken at 0.6 of the depth for stations that are 1.5 ft. or less and at both 0.2 and 0.8 for stations that are greater than 1.5 ft.

Collecting Tributary Nutrient Samples

Water samples for chemical analyses will be collected using the grab sample method at wadable sites. At non-wadable sites, a weighted Kemmerer will be lowered down from a bridge into the water (see lake monitoring procedures to understand process of using a Kemmerer). Small plastic bottles (250 mL) washed with 10% hydrochloric acid will be used to collect samples for analyses of total phosphorus and total suspended solids. 125 mL plastic bottles will be used to collect samples for analyses of nitrates, SRP, and chloride. These three parameters can be collected together via a ~100 mL water sample and then filtered into a 125 mL bottle (see SRP, nitrates, chloride instructions below). Indelible marker will be used to write site name, sample site location, and date on sample bottles (along with project – 205j). The bottles will be rinsed three times at the site with water from the stream/Black Lake prior to collecting the sample. Water samples will be collected at mid-stream and mid-depth by uncapping and inverting the bottle, keeping an air pocket in the bottle until halfway between the surface and bottom of site is reached, flipping over to fill, and capping securely. The water samples will be stored in a cooler with ice, with the exception of TSS (refrigerated upon arriving back at office) and transported under chain of custody to LSSU CFRE (Appendix D). If water samples cannot be delivered immediately to the laboratory, then the bottles for chemical analyses will be frozen after being partially emptied to prevent

container damage and consequent contamination. Frozen samples will be delivered to the laboratory and analyzed within 28 days.

Soluble Reactive Phosphorus, Nitrates, and Chloride Sample Collection:

(1) NOTE: the method for collecting SRP, nitrates, and chloride in a single 125 mL bottle requires filtration. SRP and nitrates are collected in a ~100 mL sample and then filtered on-site and stored in a 125 mL bottle. While typically nitrate and chloride parameters do not require filtration, they are optional steps in the methods provided. These optional steps are required by the lab since the Seal Analyzer requires filtration to avoid sedimentation and clogging in the system. Filtering the samples for nitrate and chloride analysis are not expected to affect the results since nitrate and chloride are soluble ions.
(2) Rinse the syringe 3X with sample water.
(3) Fill the syringe full (50-60 mL) with sample water.
(4) Attach a clean syringe filter.
(5) Expel 3 - 5 mL through the syringe filter.
(6) Press the syringe by hand to filter the water into the 125 mL bottle.
(7) Remove the syringe filter.
(8) Repeat steps 2,3,5, and 6 until the sample bottles contain 100 mL. One syringe filter can be used repeatedly for the same sample until it breaks or clogs.
(9) Leave a bit of headspace for the sample to expand when it freezes. Place the sample bottle on ice in a cooler immediately. Place in laboratory freezer when back in the office. Samples will be delivered within 28 days (hold time).
(10) Notes:
    i. Avoid touching the tip of the syringe or filter with your hand.
    ii. Do not pull water into the syringe while the filter is attached.
    iii. Syringe should be rinsed 3X by DI water before reuse.

Table 9. *Monitoring Sites, Frequency, and Parameters for the Black Lake Watershed Water Quality Monitoring.*

Waterbody	Latitude	Longitude	Monitoring Frequency	Temp	DO	Sp. Cond.	pH	NO3-	TP	SRP	TSS	Chloride	Discharge	Chl-*a*	Secchi
Upper Black River: N Black River Rd	45.467987	-84.303405	2x spring, 4x summer, 2x fall - ½ wet weather	X	X	X	X	X	X	X	X	X	Discharge not possible		
Upper Black River: Milligan Hwy	45.277985	-84.243639	2x spring, 4x summer, 2x fall - ½ wet weather	X	X	X	X	X	X	X	X	X	Discharge not possible		
Stony Creek: N County Line Rd	45.4173518	-84.2475017	2x spring, 4x summer, 2x fall - ½ wet weather	X	X	X	X	X	X	X	X	X	X		
Stony Creek: M68	45.357557	-84.196292	2x spring, 4x summer, 2x fall - ½ wet weather	X	X	X	X	X	X	X	X	X	X		
Cold Creek:	45.415657	-84.147692	2x spring, 4x summer,												

N Porter Rd			2x fall - ½ wet weather	X	X	X	X	X	X	X	X	X	X		
Rainy River: N Palmer Rd	45.431071	-84.208168	2x spring, 4x summer, 2x fall - ½ wet weather	X	X	X	X	X	X	X	X	X	X		
Rainy River: N Allis Hwy	45.408693	-84.129225	2x spring, 4x summer, 2x fall - ½ wet weather	X	X	X	X	X	X	X	X	X	X		
Stewart Creek: S Black River Rd	45.4147635	-84.2786968	2x spring, 4x summer, 2x fall - ½ wet weather	X	X	X	X	X	X	X	X	X	X		
Black Lake (Deepest Point, ~50 ft)	45.4506896	-84.2718692	Bi-monthly June – August, Monthly September and October in 2024/2025	X	X	X	X	X	X	X		X		X	X

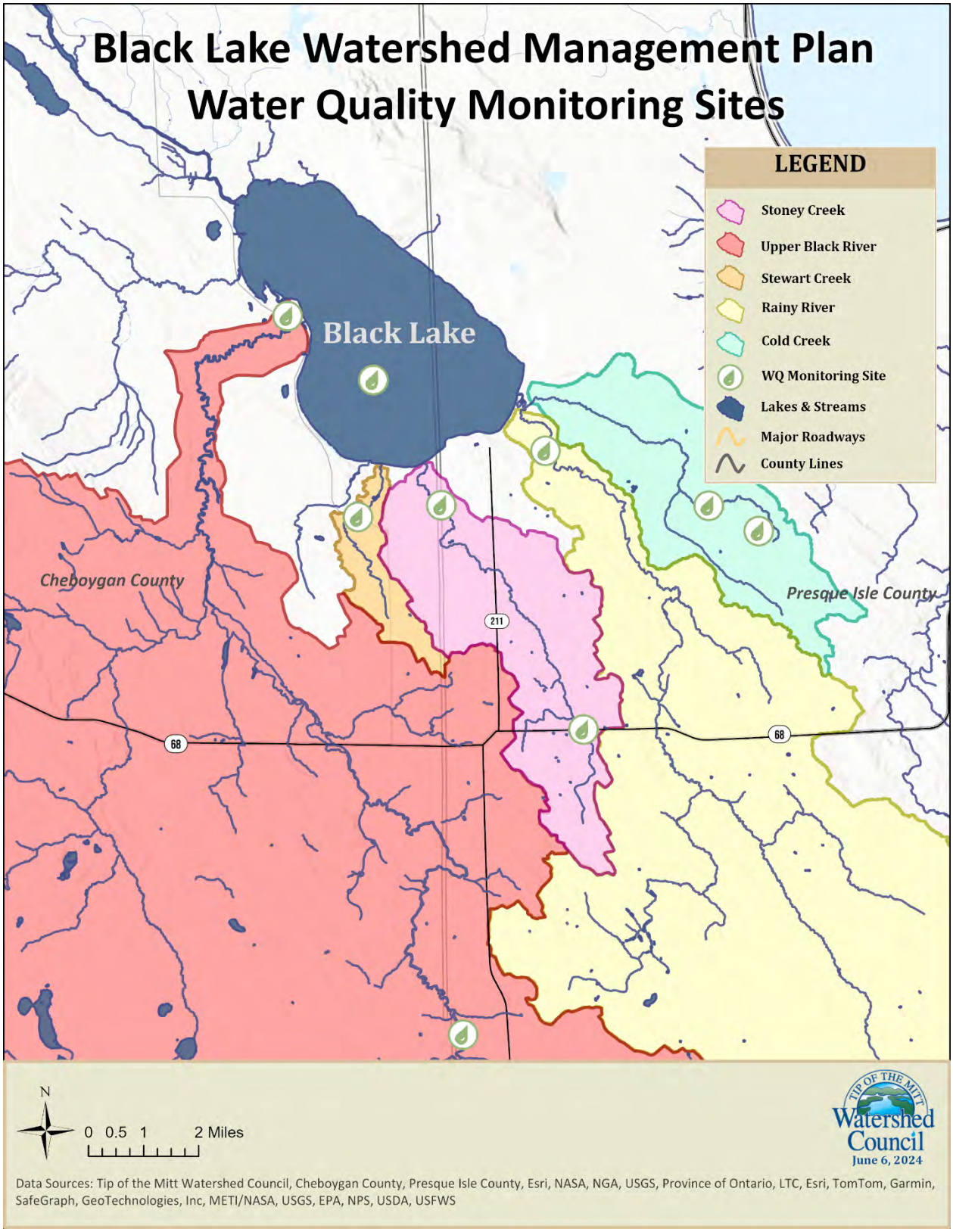


Figure 10. *Black Lake Watershed Tributary Monitoring Sites.*

Table 10. *Methods of Data Collection Used for Water Quality Monitoring Parameters.*

Water Quality Parameter	Method of Collection
Temperature	YSI EXO 1s Multiparameter Sonde
Dissolved Oxygen	YSI EXO 1s Multiparameter Sonde
Specific Conductivity	YSI EXO 1s Multiparameter Sonde
pH	YSI EXO 1s Multiparameter Sonde
Nitrates	Filtered Grab Sample (analyzed via laboratory)
Total Phosphorus	Grab Sample (analyzed via laboratory)
Soluble Reactive Phosphorus	Filtered Grab Sample (analyzed via laboratory)
Total Suspended Solids	Grab Sample (analyzed via laboratory)
Chloride	Filtered Grab Sample (analyzed via laboratory)
Discharge	Xylem SonTek FlowTracker2
Chlorophyll-*a*	Composite Grab Sample (analyzed via laboratory)
Secchi Depth	Secchi Disc Lowered into Black Lake

Analytical Methods

Analytical chemistry for water samples will be performed by LSSU laboratory staff at their facility in Sault Ste. Marie (Center for Freshwater Research and Education). Analytical procedures for the chosen laboratory are provided in a SharePoint folder accessible to relevant staff (205j QAPP SOPs).

Information about the specific data that will be gathered, data sources, methods of collection, and analytical protocols is provided in Table 11. Detection limits and methods for sample analysis can be found in Table 12.

Table 11. *Summary of Sample Collection, Data Sources, and Analyses Across Black Lake and Tributaries.*

Sample Type	Parameters	Data Source	Method of Collection	Analytical Protocols and Methods
Physical Lake Water Quality	• Temperature • Dissolved Oxygen • PH • Specific Conductivity • Secchi Depth	Watershed Council Staff	• YSI EXO 1s Multiparamete r Probe	YSI EXO 1s will be calibrated and maintained per user manual instructions. See appendix.
Chemical Lake Water Quality	• Nitrates • Total Phosphorus • Soluble Reactive Phosphorus • Chlorophyll-*a*	Collection: Watershed Council Staff, and Roger Bergstedt (June –August chl-a and Secchi only) Analysis: Lake Superior State University Center for Freshwater Research and Education	• Composite chlorophyll-a sampler, Secchi discs, Kemmerer water sampler to collect samples in bottles, filters and syringes for filtration of SRP, nitrates	• See SOPs.

Physical Stream Water Quality	• Temperature • Dissolved Oxygen • PH • Conductivity	Watershed Council Staff	Measured in situ with a YSI EXO 1s multiparameter sonde. Field data will be stored electronically in the Surveyor® unit and recorded on iPads.	EXO 1s sonde will be calibrated and maintained per user manual instructions. See Appendix A for probe specifications.
Chemical Stream Water Quality	• Nitrates • Total Phosphorus • SRP • TSS • Chloride	Collection: Tip of the Mitt Watershed Council Analysis: Lake Superior State University Center for Freshwater Research and Education	Grab samples will be collected mid-stream at mid-depth uncapping and inverting the bottle, keeping an air pocket in the bottle until halfway between the surface and bottom of stream, flipping to fill, and capping securely.	See Table 12 and SOPs.
Stream Discharge	For each section of the profile: • Channel width • Average depth • Average velocity	Watershed Council Staff	Profile measurements will be made with a nylon measuring tape, top-setting wading rod, and Xylem Sontek FlowTracker2 flow velocity meter.	FlowTracker2 will be calibrated and maintained in accordance with manual requirements. The FlowTracker2 calculates stream discharge.

Documentation and Records

Data Management and Reporting

Digital water quality data from the EXO handheld unit will be downloaded onto a Watershed Council computer following each monitoring season. Results of chemical analyses of water samples will be delivered electronically to The Watershed Council by the chosen laboratory via email and stored on The Watershed Council server. All water quality data gathered during the project will be compiled in AirTable. Discharge data and field notes will be entered manually into a separate AirTable file. All digital data associated with the project will be stored on The Watershed Council server, which is backed up daily with a back-up copy of all server data stored off-site.

All project data and associated reports will be shared with EGLE, via an upload to SharePoint upon project completion. Water chemistry data from this project will be submitted to EGLE in an EGLE-approved format for inclusion in the National Water Quality Monitoring Council's Water Quality Portal. All project data will be provided to the Watershed Advisory Committee to guide efforts to reduce nonpoint source pollution impacts. In addition, all project data will be made available to the public via The Watershed Council website (www.watershedcouncil.org).

Data specifically from Roger Bergstedt via VLM efforts will be reported to Anna Watson, Monitoring Coordinator. Collected chl-*a* samples will be delivered directly to her and then sent to LSSU for analysis.

Sample Custody Procedures

Chain of custody forms will be maintained to record water sample information and track transfer of samples to the laboratories, as well as delivery of results from the laboratories. Sample information will be recorded on the chain of custody forms with a pen and will include the following information: name of the waterbody, name of the sample site, sample type, date and time of collection, analyses required, name of sampler and organization, and transportation conditions (temperature, protection from sunlight, etc.). Chain of custody forms will be used when samples are transferred between parties. The Chain of Custody Forms can be found in Appendix D.

Instrument Testing, Maintenance, and Calibration; Inspection of Supplies

Water Quality and Discharge Instrument Calibration/Inspection:

(1) The YSI EXO 1s multiprobe sonde and EXO 1s Handheld will be used, inspected and maintained according to manufacturer's specifications. Due to *in-situ* use of this instrument, holding times are not applicable. However, the instruments will be calibrated according to manufacturer's specifications.

(2) A Xylem SonTek FlowTracker2 Handheld will be used, inspected and maintained according to manufacturer's specifications. Due to *in-situ* use of this instrument, holding times are not applicable. However, the instruments will be calibrated according to manufacturer's specifications.

Data Quality Objectives

The objectives for data collection in this project are:

(1) Perform *in-situ* water quality monitoring, accurately measuring and recording data.
(2) Collect water samples, preserve adequately until delivery to laboratory, and analyze samples using accepted standard methods to produce accurate concentration values for chemical constituents.
(3) Measure discharge in streams by collecting accurate channel width, water depth, and flow velocity data at stream cross-sectional profiles.

The data quality objective for this project is to ensure that the characterization data is of known and acceptable quality with the locations of field measurements and sample collection precisely identified. Attainment of data quality objectives is primarily controlled by the propensity for error while collecting field data (i.e., physical parameter measurements, water sample collection, and discharge measurements) and analyzing water samples, though also subject to error that can occur during transfer of custody, data entry, and data calculations. A degree of uncertainty in the accuracy of *in-situ* measurements and laboratory analyses is inherent. However, the degree of uncertainty will be minimized through adherence to this QAPP.

The QAPP for this project is designed to accomplish the following data quality objectives:

(1) Establish Quality Assurance/Quality Control (QA/QC) criteria used to control and assess the data that is collected.
(2) Provide comparable methods for *in-situ* measurements, sample collection, sample preparation, analytical methods, and calculations.
(3) Whenever possible, utilize USEPA, USGS, or EGLE approved methods containing QA/QC protocols that allow for data quality verification.
(4) Utilize written standard operating procedures (SOPs) or published reference methods when USEPA, USGS, or EGLE approved methods are not available.
(5) Ensure that all data collection activities are properly performed and discrepancies resolved by reviewing data delivered from field and laboratory staff.

Measurement Quality Objectives for *in-situ* field measurements, water sample collection, water sample preparation, and water sample analysis phases of data collection are defined by:

(1) Detection limit: the lowest concentration of analyte that the analytical method can reliably detect.

(2) Accuracy**:** how close results are to a true or expected value.
(3) Precision: the level of agreement among multiple measurements of the same parameter being measured.
(4) Representativeness: the degree to which data collected accurately represent the population of interest.
(5) Completeness: the degree to which data collected are sufficient, valid, or usable.
(6) Comparability: the similarity of analytical methods, *in-situ* measurements, and data calculations with other related projects.

Detection limits (Table 12) are determined by the chosen laboratory and based on procedures used to analyze water samples (205j QAPP SOPs). One expression of accuracy is to compare the measured value of a known standard or reference sample to its actual value; the measured value should be within 20 percent of the known value. Another expression of accuracy is derived from field blank samples. One field blank will be collected for each analytical parameter during each event, and the data quality objective will be a measured value below the detection limit. It is expected that 100 percent of the blank values will be equal to or below the detection limit.

Table 12. *Detection Limits and Approved USEPA Methods Used.*

Parameter	Detection Limit	Determinative Methods*	Equivalent Methods**	Holding Times
Total Nitrogen (aqueous)	0.01 mg/L	EPA-127-D Rev. A	EPA 351.2	28 days at -20°C
Total Phosphorus (aqueous)	0.005 mg/L	EPA-155-D Rev. 0	EPA 365.1	28 days at -20°C
Nitrates	0.008 mg/L	EPA-127-D Rev. A	EPA 353.2	28 days at -20°C
Soluble Reactive Phosphorus	0.003 mg/L	EPA-155-D Rev. 0	EPA 365.1	28 days at -20°C

Total Suspended Solids	2.5 mg/L for a 200 mL sample	SM 2540 D	N/A	28 days, refrigerated
Chloride (aqueous)	0.1 mg/L	EPA-105-D Rev. A	SM 4500-CL-E	28 days at -20°C
Chlorophyll-*a*	0.5 ug/L	SM 10200 H	N/A	28 days at -20°C

*SM is Standard Methods for the Examination of Water and Wastewater, 21st edition.

** Provided by Seal Analytical

Duplicate samples will be collected for every parameter being measured to ensure precision throughout the project period. Duplicate water samples will be collected typically every other sampling event. Relative percent difference (RPD) will be used to assess duplicate sample data. RPD is calculated by: 1) calculating the mean of the first sample and the duplicate sample; 2) calculating the difference between the samples; 3) dividing the difference (numerator) by the mean (denominator); and 4) multiplying the quotient by 100. If results from RPD exceed 20%, then data will be assigned a remark code in the database: "D", which indicates duplicate exceeded RPD target. Data flagged with the remark code will be reported to EGLE and EGLE will be consulted regarding actions to address flagged data.

Representativeness is the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Sample sites were chosen as close to the stream mouths as possible to comprehensively assess nonpoint source pollution from each sub-watershed. For sample collection, representativeness will be assured by following work plans and applying proper collection techniques, including correct sample sizes and volumes, sampling times, and sampling locations. Sample volume depends on the analytical methods used by the laboratories and should be sufficient to allow for QA/QC sample analysis and reanalysis, as necessary. In the laboratory, representativeness, precision, and accuracy will be ensured by using the appropriate sample preparation techniques, following appropriate analytical procedures, and by meeting the required sample holding times.

Completeness can be thought of in terms of what data the project originally planned to collect versus how much data was actually collected. The completeness objective is to generate usable data for at least 90 percent of the environmental data collected during the project.

The objective for data comparability is to generate data that are comparable between sampling locations and comparable over time. Data comparability will be promoted by consistently: 1) using standard approved methods, 2) following methods for *in-situ* measurements and sample collection detailed in this QAPP, 3) using the analytical methods included in this QAPP, and 4) achieving the

required detection limits detailed in the QAPP. The methods that will be used to collect data for this project are the same as used in prior monitoring projects for these water bodies, so data will be comparable. Any deviations from *in-situ* measurements, sample collection, and analytical methods will be documented.

The Quality Control Officer will review all project data received by field and laboratory staff. Corrective actions will be instituted as necessary.

Quality Control Requirements for Data Management

(1) All *in-situ* field measurement data will be recorded on the YSI Exo1s handheld or on an iPad. All values will be checked twice by Watershed Council staff. Electronic datasheets will incorporate essential QAPP procedures. Data will be stored on the YSI EXO 1s handheld device.
(2) EXO 1s handheld data will be downloaded onto a computer following each monitoring event and checked for errors by Watershed Council staff.
(3) Results from water sample analyses by the chosen laboratory that are sent electronically will be copied and pasted into the project's AirTable file by Watershed Council staff. If results are sent in hard-copy format, then staff will input the data into the project's AirTable file.
(4) Data will be reviewed in table format and scanned for outliers by the Quality Control Officer.
(5) All data analyses and results will be reviewed by Watershed Council staff periodically to assure accuracy.
(6) Electronic data will be stored on the Watershed Council server, which is backed up daily with a back-up copy of all server data stored off-site.

Use of Existing Environmental Data

Existing environmental data from EPA's How's My Waterway, Tip of the Mitt Watershed Council, Little Traverse Bay Bands of Odawa, and other sources will be compiled for each major water body or sub-watershed in AirTable. These secondary data will be assessed by the Quality Assurance Officer and EGLE staff. The data will only be used if their quality is determined to be sufficient for the purposes of this project. Any secondary water quality and discharge data found to be comparable will be used to assess variability and changes in physical parameter measurements, chemical constituent concentrations, discharge rates, and streambank erosion. Comparable secondary data may be used to describe trends (i.e., changes occurring over time) or the range of conditions for specific parameters at specific sites.

Management Assessment and Oversight

This project is funded through the EGLE Water Resource Division Nonpoint Source Program 205j grants. Per grant agreement, The Watershed Council will provide quarterly reports containing a summary of accomplishments for the quarter and expenditures associated with the EGLE grant. Quarters are as follows: January-March; April-June; July-September; October-December. As part of the quarterly reporting process, The Watershed Council will evaluate project tasks conducted to date and make

modifications to the work plan as necessary. At the project's end, water chemistry data will be submitted to EGLE in a format compatible with the USEPA WQX (STORET) database (template to be provided by EGLE). Reports will be available to the other organizations and agencies as requested. In addition, the progress and final reports will be presented to The Watershed Council program staff during staff meetings.

Data Review, Validation, Verification, and Reconciliation with Data Quality Objectives

Data Review and Validation

The criteria used to accept or reject data based on quality for chemical analyses of water samples will follow the listed SOPs for LSSU. If sample data are determined to be unacceptable, samples will be re-analyzed if possible or new samples collected if feasible and analyzed. The Project Administrator, QA Officer, and laboratory managers will review data to validate it. Sample data will be reviewed to assess completeness (i.e., the same number of results received as samples delivered), to ensure that QA/QC results meet method requirements, and to ensure results were generated using methods outlined in this QAPP.

Data will also be reviewed and validated through the following:

(1) The Project Administrator and QA Officer will monitor that quality assurance protocols are followed and will report any occurrences possibly affecting data quality.
(2) If deviation from the QAPP is noted at any point during sampling or the data management process, the affected samples may be deleted from the dataset. Re-sampling will be conducted by the QA Officer if warranted and feasible. Otherwise, a gap may be left in the monitoring record.
(3) If QA/QC is not met for a particular set of sample parameters, that data will be flagged and reviewed by the Project Administrator, QA Officer, and project partners to determine follow-up corrective actions.
(4) All corrective actions will be documented and communicated to EGLE by the Project Administrator.

Data Verification and Reconciliation with Data Quality Objectives

Data will be verified by:

(1) Obtaining and evaluating the complete raw dataset, including data from routine samples, QA/QC samples, instrument calibration, etc.
(2) Performing QA/QC checks for each dataset to ensure it meets requirements established in the QAPP.
(3) Checking the calculations and the final results.
(4) Checking for transcription errors.

(5) Reviewing logbooks to verify such things as holding time violations, proper sample collection and preservation, consistent use of the same descriptive terms and reporting units, and consistent use of station coordinates (latitude and longitude).

This project essentially has real-time auditing - should any audit reveal a departure from this QAPP, The Watershed Council and/or the water quality laboratory staff conducting the analyses will identify cause and impact, and take necessary actions, such as requesting additional QA/QC validation, reanalyzing samples, or recollecting samples.

In instances where there are recurrent problems with the quality of a particular variable or sample, which might arise from unforeseen matrix effects or interferences, and it is determined by the responsible party that the issue cannot be resolved, that data will be discarded from the dataset with accompanying explanation.

Data Analysis

All results and summary statistics (min, max, mean) will be calculated and displayed for each tributary in a chart.

Tributaries will be prioritized for implementation and marked as Critical Areas (see inventory QAPP) based on the following factors:

(1) highest nutrient concentration (average over eight monitoring events).
(2) Maximum values will be compared to the State of Michigan criteria. Where the State of Michigan lacks numeric criteria, EPA Ecoregion criteria will be used. Tributaries exceeding standards or ecoregion criteria will be prioritized.
(3) Where prior data exists, data trends will be analyzed over time. If a significant increase is present (represented by an R-squared value of 0.70 or more) for nutrients, chloride, temperature, conductivity, or pH, those tributaries will be prioritized. If a significant decrease is present (represented by an R-squared value of 0.70 or more) for dissolved oxygen or pH, those tributaries will be prioritized.

Appendix A. Specifications for YSI EXO 1s Multiparameter Sonde

EXO Sonde Specifications*		EXO1[5] with depth
Memory	>1,000,000 logged readings, 512 MB total memory	
Software	Kor Software for Windows; Kor Mobile for Android	
Communications		
Computer Interface	YSIP via USB Signal Output Adapter (SOA) and Bluetooth	4
Output Options	All: RS-232 & SDI-12 via DCP-SOA Modbus & RS-485 via Modbus-SOA EXO3 & EXO3[5]: SDI-12 Native Output	External power required
Temperature		–
Operating	-5 to 50 °C (23-122 °F)	9 - 16 V
Storage	-20 to 80 °C (-4 to 176 °F)	–
Depth Rating	0 to 250 m (0 to 820 ft)	–
Sampling Rate	Up to 4 Hz (0.25 seconds)	4.75 cm (1.87 in)
Sensor Options	Conductivity/Temperature, Depth, Dissolved Oxygen, fDOM, ISE Ammonium, ISE Chloride, ISE Nitrate, pH, pH/ORP, Rhodamine, Total Algae (PC or PE), Turbidity, UV Nitrate	46.41 cm (18.27 in)
Warranty	3 years	0.56 kg (1.24 lbs)

*Specifications indicate typical performance and are subject to change.

EXO Sensor Specifications

Sensor	Range	Resolution[1]	Accuracy[2]
Conductivity (Non-Wiped)	0 to 200 mS/cm	0.001 to 0.01 mS/cm	±0.5% of reading or 0.001 mS/cm, whichever is greater (0 to 100 mS/cm) ±1.0% of reading (100 to 200 mS/cm)
Temperature	-5 to 50 °C	0.001 °C	-5 to 35 °C: ±0.01 °C (-5 to 35 °C) ±0.05 °C (35 to 50 °C)
Conductivity (Wiped)	0 to 100 mS/cm	0.001 to 0.01 mS/cm	±1.0% of reading or 2 µS/cm, whichever is greater
Temperature	-5 to 50 °C (23 to 158°F)	0.001 °C	±0.2 °C
Depth or Vented Level	0 to 10, 100 or 250 m	0.001 m	±0.04% Full Scale
	0 to 10 m	0.001 m	±0.03% Full Scale
Dissolved Oxygen	0 to 500% air saturation	0.1% air saturation	±1% of reading or 1% saturation, whichever is greater (0 to 200%) ±5% of reading (200 to 500%)
	0 to 50 mg/L	0.01 mg/L	±0.1 mg/L or 1% of reading, whichever is greater (0 to 20 mg/L) ±5% of reading (20 to 50 mg/L)
fDOM	0 to 300 ppb QSU	0.01 ppb QSU	Linearity: $r^2 \geq 0.999$ for 0 to 300 for serial dilution of 300 ppb Quinine Sulfate Solution Minimum Detection Limit of 0.1 ppb Quinine Sulfate Equivalents
ISE Ammonium	0 to 200 mg/L-N (NH_4^+)	0.01 mg/L	±10% of reading or ±2 mg/L-N, whichever is greater
ISE Chloride	0 to 1000 mg/L-Cl (Cl^-)	0.01 mg/L	±15% of reading or ±5 mg/L-Cl, whichever is greater
ISE Nitrate	0 to 200 mg/L-N (NO_3^-)	0.01 mg/L	±10% of reading or ±2 mg/L-N, whichever is greater
pH	0 to 14 pH units	0.01 pH units	±0.1 within ±10 °C of calibration temperature ±0.2 for all other temperatures
ORP	-999 to 999 mV	0.1 mV	±20 mV
Rhodamine	0 to 100 RFU	0.01 RFU	±5% or 0.1 µg/L whichever is greater Linearity: $r^2 > 0.999$
	0 to 1,000 µg/L	0.01 µg/L	
TAL-Chlorophyll	0 to 100 RFU or 0 to 400 µg/L chl	0.01 RFU or 0.01 µg/L of pigment	Linearity: $r^2 \geq 0.999$ for Rhodamine WT across full range
TAL-Phycocyanin	0 to 100 RFU or 0 to 400 µg/L PC		
TAL-Phycoerythrin	0 to 100 RFU or 0 to 400 µg/L PE		
Turbidity	0 to 4000 FNU, NTU	0.1 FNU, NTU	0 to 999 FNU: 0.3 FNU or ±2% of reading, whichever is greater 1000 to 4000 FNU: ±5% of reading
UV Nitrate (NitraLED)	0 to 10 mg/L-N (NO_3^-)	0.01 mg/L-N	± 0.4 mg/L-N or 5% of reading, whichever is greater (full temp range)

Appendix B. Specifications for Xylem SonTek FlowTracker2

Part I: Probe	
Velocity Range	**XZ:** ±0.001 to 4.0 m/s (0.003 to 13 ft/s), **Y:** ±0.001 to 1.0 m/s (0.003 to 3.25 ft/s)
Velocity Resolution	0.0001 m/s (0.0003 ft/s)
X & Y Velocity Accuracy	±1% of measured velocity, ±0.25 cm/s
Z Velocity Accuracy	±3% of measured velocity
Acoustic Frequency	10.0 MHz
Sampling Volume Location	10 cm (3.93 in) from the center transducer
Sampling Volume Size	0.25 cc
Minimum Depth	0.02 m (0.79 in)
Depth Measurement Range	0 to 10 m (0 to 32.81 ft)
Depth Measurement Resolution	0.001 m (0.003 ft)
Temperature Sensor	Resolution: ±0.01° C, Accuracy: ±0.1° C
Tilt Sensor	Resolution: (7) significant digits, Accuracy: ±1.0°
Communication Protocol	RS–232
Operating/Storage Temperature	–20° C to 50° C (–4° F to 122° F)
Optional Extension Cables	1.5, 3.5, or 8.5 m
Sampling Rate	1*, 2, 5*, or 10* Hz
Physical Specifications	
Probe Head Dimensions	**2D:** (L)13.3 cm (5.22 in); (W) 6.1 cm (2.39 in); (H) 2.3 cm (0.90 in), **2D/3D:** (L)13.3 cm (5.22 in); (W) 6.1 cm (2.39 in); (H) 7.5 cm (2.96 in)
Standard Cable Length	1.5 m (4.92 ft)
Weight in Air	**2D:** 0.90 kg (1.98 lbs)
Weight in Water	**2D:** 0.30 kg (0.66 lbs)
Depth Sensor Accuracy	
+/- 0.1% of FS (temperature compensated over full operating range)	
+/- 0.05% Static (steady-state at 25° C)	
Additionally compensated for real-time water velocity, temperature, salinity, and altitude.	

**Lab Probe Only*

Part II: Handheld	
Bluetooth	Class 2, Range = 10 m (33 ft) nominal
USB	Micro USB, IP-67
Storage Temperature	-30° to 70° C (-22° F to 158° F)[3]
Physical Specifications	
Waterproof Rating	Field: IP–67 (1m submersible); Lab: IP–68 (30 m, 42 PSI)
Handheld Dimensions	(L)10.4 cm (4.1 in); (W) 6.4 cm (2.5 in); (H) 23.7cm (9.3 in)
Weight in Air	0.75 kg (1.65 lbs)
Weight in Water	-0.25 kg (-0.55 lbs)
Power	
Input Battery Voltage	8–12 VDC
Battery Life	12 hours continuous use, typical settings[1]
Power Supply	Field: 8x AA Batteries; Lab: 8–12 VDC
Power Consumption	1 W (Average)
Probe Interface	
Battery Power to Probe	8–12 VDC
Data Transfer	RS–232
Data Storage	16 GB. Up to 10k discharge measurements. Up to 10 million velocity samples
GPS	
H. Position Accuracy	Up to 2.5 m (8.2 ft) nominal[2]
Frequency	L1 (1.575 MHz), SBAS compensation (WAAS, EGNOS, MSAS, GAGAN)
LCD	
Resolution	320 x 240 TFT Transmissive
Operating Temperature	
Alkaline Batteries: -20° to 45° C (-4° F to 113° F)	
NiMH: -20° to 50° C (-4° F to 122° F)	

[1] *Defined as power on with screen on at 100% brightness, ADV sensor pinging 50% of the time, GPS off, and no sleep periods. Actual battery life will vary depending on FlowTracker2 settings, manner of use and brand of battery.*

[2] *Ideal conditions and settings. GPS data are intended for approximate georeferencing and site ID.*

[3] *Remove batteries from FlowTracker2 handheld if storage temperatures exceeds operating temperature of Alkaline and NiMH batteries as stipulated above.*

Appendix C. Stream Monitoring Datasheet

Stream Monitoring Survey Form

Stream Name: _____Site Location:_____

Date: _____ Time: _____ Collector Name(s):_____

Weather (today & recent events):_____

_____

FlowTracker2 Discharge Reading: _____

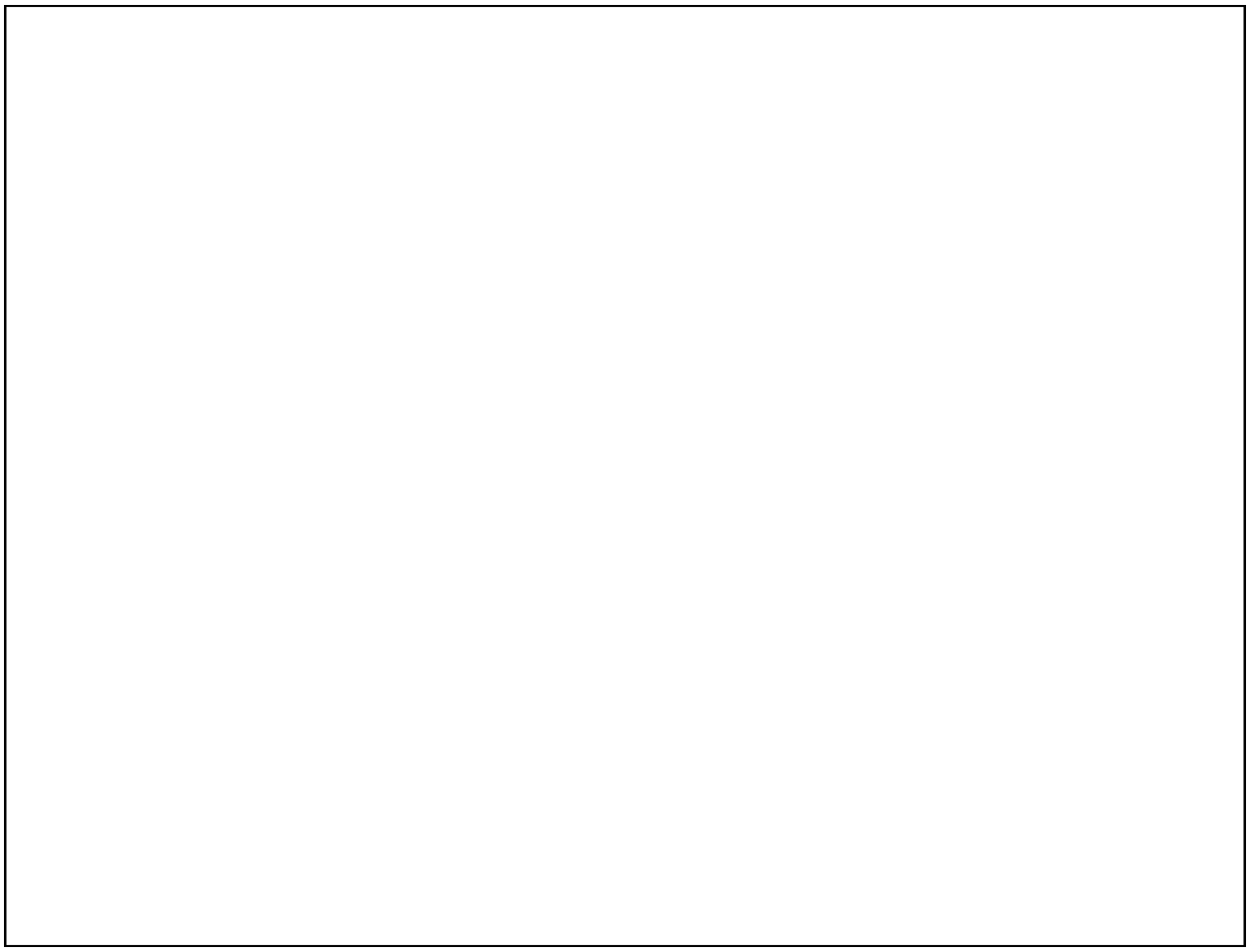
Physical Data: **Water samples collected?** Yes No

Collection Depth (meters)	**Temperature** (° Centigrade)	**Dissolved Oxygen** (mg/l)	**Conductivity** (microSiemens)	**pH**	**Maximum Depth** (meters)

Other comments:

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Site Sketch:



Appendix D. Chain of Custody Form

CHAIN OF CUSTODY

Water Analytical Lab
Center for Freshwater Research and Education
Lake Superior State University
Phone: (906) 635 - 2072
100 Salmon Run Way
Email: cogden@lssu.edu
Sault Ste. Marie, MI 49783

Client Name:	Project:	
Address:	Sampled By:	Phone #:

Sample ID	Date Sampled	Time Sampled	# of Bottles	Size (mL)	**Analysis Requests**	Condition?	Filtered?	Preserved?

Appendix E. Volunteer Lake Monitoring QAPP Instructions: Chlorophyll-*a* and Secchi Depth

Secchi Disc Depth - Water Clarity (Take this measurement weekly)

Equipment needed: Secchi disc, tape measure or rope, datasheet, pencil

Secchi disc measurements should be taken between 10:00 a.m. and 3:00 pm in deepest location of the lake (or deepest point of the basin you are monitoring in the lake).

1. Lower the Secchi disc over the shaded side of the boat, keeping track of the number of feet on the rope or tape. Make sure you are holding the rope straight up and down.

2. When the disc disappears, record its depth to the nearest half foot. Take the depth reading at the surface of the water, not where you are holding it.

3. Next drop the disc a foot or two more and then raise it until you can see the disc again. Note the number of feet on the rope.

4. Add the two measurements together and divide by two. This is the Secchi disc reading. Record this number on the data sheet.

Things to Remember:

5. Secchi disc readings should be taken as close to one week apart as possible. However, avoid bad weather for safety reasons and because readings are strongly affected by waves, rain, and clouds.
6. Secchi disc readings should be taken during the middle of the day when the sun is directly overhead.
7. A minimum of two readings per month during the months of June, July, and August are required for data to be used for trend analyses.
8. Do NOT wear sunglasses when collecting Secchi disc data.
9. Check the Secchi disc to make sure it is securely connected to the measuring tape or rope.
10. The Secchi disc should hang straight down when taking your reading. Record depth to the nearest half-foot.
11. If you go out of town, try to arrange for a substitute monitor (many lakes have alternates, call the Watershed Council for their names).
12. Return datasheets and chlorophyll-a sample tubes in September or October (keep tubes in a cool, dark place during transport, e.g. a cooler).
13. If you see anything unusual, please note it on your datasheet with the date. If a potentially serious water quality problem, please contact the Watershed Council.

For assistance please contact us at (231) 347-1181, info@watershedcouncil.org. Return datasheet and chlorophyll-a sample tubes in fall to the Watershed Council office (426 Bay St., Petoskey).

VOLUNTEER LAKE MONITORING DATA SHEET

Lake Name: Lake Basin:

DATE & TIME	WEATHER CONDITIONS (note sun & clouds, wind direction & speed, waves, and recent rainstorms)	MONITOR NAMES	SECCHI DISC DEPTH (ft)	TEMPERATURE (°C or °F)		CHL-a VOLUME (cc's)	AIS Observed (yes/no)*
				Water	Air		

For assistance call the Watershed Council at (231) 347-1181, ext 1111.

*If Aquatic Invasive Species (AIS) aren't observed, write "no". If AIS are observed, write "yes," fill out an Aquatic Invasive Species Incident Report, and notify the Watershed Council ASAP at the contact above. Consult Identification guide.

Return datasheet and chlorophyll-a test tubes in September to the Watershed Council office (426 Bay St., Petoskey).

Tip of the Mitt Volunteer Lake Monitoring Program

Algae Abundance) Monitoring Instructions

General Instructions

All volunteers are required to attend a training prior to monitoring to ensure that quality data are collected. Before or during your first field day, **please write the lake name** and the basin you are monitoring at the top of the datasheet. During each field day, fill in the date/time, weather conditions, monitor names, temperature and volume columns on the data sheet. Use pencils or waterproof pens to avoid ink running/smearing when it gets wet. Remember: **safety first**! Working on water can be hazardous – please take precautions by obeying boating and water safety laws and do not take risks when it comes to bad weather (we would much rather miss data than miss you!). If have you have any questions, please contact us at (231) 347-1181, info@watershedcouncil.org.

Why monitor chlorophyll-a?

Chlorophyll-*a* is a pigment found in all green plants, including algae. Water samples collected by volunteers are analyzed for chlorophyll-a to estimate the amount of phytoplankton (minute free-floating algae) in the water column. There is a strong relationship between chlorophyll-a concentrations and Secchi disc depth. Greater amounts of chlorophyll-a indicate greater phytoplankton densities, which reduce water clarity and, thus, the Secchi disc depth as well. So why collect chlorophyll-a data? The chlorophyll-a data provides support for Secchi disc depth data used to determine the productivity of the lake, but it can also help differentiate between turbidity caused by algal blooms versus turbidity caused by other factors such as sediments (dirt) or calcite.

The amount of chlorophyll in algal cells varies among species as well as with changing light conditions at different depths in the lake. Changing seasons also create different light conditions that, in turn, affect chlorophyll production. To account for some of this variability, algal chlorophyll is monitored six times over the summer season, every other week from early June to late August.

Collecting a water sample for chlorophyll-a analysis is the most difficult task for volunteers. After checking water clarity, volunteers collect a water sample from the lake's surface to twice the Secchi disc reading. Research has shown that, because of light attenuation, most algal growth occurs in this zone (2 x Secchi disc depth), which is called the photic zone. The challenge for volunteers is to collect a representative water sample from throughout the photic zone. This is accomplished with the "composite sampler", which is simply a plastic bottle inside a weighted can that is attached to a measuring tape or rope and lowered through the water. A hole drilled in the cap controls the rate of flow into the bottle. The trick is to lower and raise the sampler at a steady rate, such that the bottle is roughly ¾ full when it reaches the surface. Although seemingly difficult, the volunteers seem to master this sampling procedure very quickly.

Once the water sample has been successfully collected, the volunteer returns home to filter a specific volume of the water sample. A syringe and filter holder are used to push sample water through the filter. The filter is then carefully transferred into a test tube, which is labeled with lake name and date, covered with aluminum foil to prevent sun exposure, and stored in the freezer. At the end of the sampling season, volunteers deliver all tubes with filters and datasheets to the Watershed Council office, which are then transported to the University of Michigan Biological Station for analysis.

Low chlorophyll-*a* levels indicate relatively small amounts of algae in the lake and generally good water quality. High chlorophyll-a levels indicate heavier algal growth, which could be an indication of water quality impairment. Steady increases or decreases over time in chlorophyll-*a* concentrations or water clarity indicate that fundamental changes are occurring in the lake ecosystem. Similar to Secchi disc transparency readings, chlorophyll-*a* results provide an estimate of the level of biological productivity, or trophic state, of lakes. The median value of the summer chlorophyll monitoring results is used to calculate the Carlson TSI value for the lake, which is compared with the Secchi disc and total phosphorus TSI values for trophic status determination.

Chlorophyll-*a* Water Sample Collection and Filtering Instructions (Perform this test bi-weekly)
Equipment needed: composite sampler, tape measure or rope, clothespin or other marker, syringe, filter holder, filters, tweezers, bowl, tube, cap, label, cooler for sample storage.

Part One--Collecting the Water Sample

14. Measure out twice the Secchi disc depth reading on the measuring tape or rope and mentally note this depth or mark with a clothes-pin or other item.
15. Rinse the composite sampler twice at monitoring site with lake water, filling halfway, capping, shaking vigorously, and emptying into lake.
16. Lower the composite sampler over the boat (on the same side as the Secchi disc reading was collected) at a constant rate until it reaches twice the Secchi disc depth (or when the clothes-pin or other marker reaches the surface of the water).
17. Immediately raise the sampler at the same rate it was lowered. When the sampler reaches the top it should be almost full (at least ½ full, but not completely full). NOTE: If it is filled to the top or less than half full, take another sample. The water sample needs to be representative of the photic zone, which extends from the water surface to the depth where enough sunlight penetrates to allow algae to grow. The photic zone is approximately equal to twice the Secchi disc depth.
18. After collecting the water sample, place in cooler and keep cool/out of direct sunlight until the filtration process can begin.

Part Two--Filtering the Water Sample

19. The filtering of the sample should take place as soon as you return to your home. This part of the test should be conducted away from direct sunlight in a semi-dark room.
20. Set out all materials needed for filtering the water sample. Materials include syringe, filter holder attachment, filters, tweezers, tube, label, and bowls for holding water.
21. Rinse out the bowl that will hold the sample water with a small amount of sample water. Pour a portion of the sample water into the bowl.
22. Withdraw a full 60 cc of water from the bowl with the syringe, place the empty filter holder on the end of the syringe and push water through to rinse these items.
23. Unscrew the filter holder assembly, use tweezers to place one filter on the apparatus, make sure rubber O-ring is in place, and reassemble (screw back together).
24. Fill the syringe with 60cc of sample water, attach the filter holder, and press the water through the filter. Check the printed labels to determine if more than 60 cc are needed for the lake you are monitoring. If

120cc are needed, refill the syringe and press through the same filter. If more than 120cc are required, use a second filter (i.e., the maximum amount of water pressed through 1 filter = 120cc).

25. Next, unscrew the filter holder, carefully remove the filter with tweezers, place the filter into a plastic tube, and cap the plastic tube.
26. Fill in the date on the prepared labels and affix to the tube.
27. Cover the tube with aluminum foil and place in the freezer. Store until the fall.

AQ300 method

EPA-105-D Rev. A

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Chloride in Drinking, Saline and Surface Waters, Domestic and Industrial Waste

1 SCOPE

This method covers the determination of chloride in drinking, surface, and saline waters, and domestic and industrial wastes.

This method is approved for the Clean Water Act for use in wastewater compliance monitoring, under National Pollutant Discharge Elimination System (NPDES).This method is equivalent to USGS Method I-2187-85 and Standard Methods 4500-Cl^- E (1997).

Even though this mercuric thiocyanate method is not listed at 40 CFR part 143.4 for use in drinking water compliance monitoring, under National Secondary Drinking Water Regulations (NSDWR). The NSDWR regulations are not federally enforceable (see 40 CFR part 143.1). Accordingly, the EPA Office of Ground Water and Drinking Water has given SEAL Analytical its opinion that this SEAL Analytical method would be acceptable for measuring chloride in drinking water and that this SEAL method may be used for compliance monitoring under NSDWR.

2 RANGE OF APPLICATION

Range	2.0 – 100 mg Cl/L

3 METHOD DETECTION LIMIT

By EPA Procedure	MDL = 0.3 mg Cl/L

4 METHOD PRINCIPLE

The thiocyanate ion (SCN^-) is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionized mercuric chloride. In the presence of ferric ions, the liberated thiocyanate ions forms a highly-colored ferric thiocyanate. The absorbance of this complex is measured spectrophotometrically at 480nm.

5 REFERENCES

Methods for Chemical Analysis of Waters and Wastes, US EPA 600/4-79-020, 1983: Method 325.2

Standards Methods for the Examination of Water and Wastewater, APHA/AWWA/WEF, method 4500-Cl-E (18th, 19th, 20th Ed.).

6 INTERFERENCES

Fumes from concentrated hydrochloric acid may cause positive bias.

Bias from sample turbidity or color is correctable, using sample blanking feature of AQ software.

7 REAGENTS: CHEMICALS REQUIRED AND SAFETY INFORMATION

Consult the safety data sheets (SDS) for details on safe handling of chemicals.

Chemical	Formula	C.A.S. No.	Safety Classification
Iron (III) nitrate nonahydrate	$Fe(NO_3)_3 \cdot 9H_2O$	7782-61-8	GHS03, GHS07
Mercury (II) thiocyanate	$Hg(SCN)_2$	582-85-8	GHS06, GHS08, GHS09
Methanol	CH_3OH	67-56-1	GHS02, GHS06, GHS08
Nitric acid, concentrated	HNO_3	7697-37-2	GHS03, GHS05
Sodium chloride	NaCl	7647-14-5	--

GHS01: Danger – Explosive	GHS02: Danger – Flammable	GHS03: Danger – Oxidizing
GHS04: Warning – Compressed Gas	GHS05: Warning/Danger – Corrosive	GHS06: Danger – Toxic
GHS07: Warning – Irritant	GHS08: Danger – Health Hazard	GHS09: Warning/Danger – Aquatic Toxicity

Note: Persons using this method should be familiar with normal laboratory practice. This method does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to ensure compliance with local regulatory conditions.

8 REAGENT SOLUTIONS

Use reagent-grade chemicals, certified for analytical or general laboratory use. SEAL recommends using ACS Reagent Grade whenever possible. Reagents of technical or commodity grade must be validated by the user. Use high-purity reagent water, distilled or deionized, and free from organic contamination, therefore Grade 1 (ISO Standard 3696) or better than Type II (ASTM Standard D1193) waters are suitable.

8.1 MERCURIC THIOCYANATE REAGENT

Mercury (II) thiocyanate	4.17 g
Methanol	dilute to 1 L

Dissolve 4.17 g mercury (II) thiocyanate in approximately 500 mL of methanol. Dilute to 1 liter with methanol and mix. Filter this reagent through filter paper.

8.2 FERRIC NITRATE SOLUTION, 20.2%

Iron (III) nitrate nonahydrate	202 g
Nitric acid, concentrated	31.5 mL
DI Water	dilute to 1 L

Dissolve 202 g iron (III) nitrate nonahydrate in approximately 500 mL of deionized water. Add 31.5 mL of nitric acid, conc., and mix. Dilute to 1 liter with deionized water.

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8.3 COMBINED COLOR REAGENT

Mercuric thiocyanate solution (above)	150 mL
Ferric nitrate solution (above)	150 mL
DI Water	dilute to 1 L

Add 150 mL mercuric thiocyanate solution and 150 mL ferric nitrate solution to a 1 liter volumetric flask. Dilute to 1 liter with deionized water and mix. Filter this reagent (using Whatman No. 1 filter paper or equivalent). Precipitation may occur as the combined color reagent stands.

Prepare monthly a fresh portion of filtered reagent for daily use.

9 STANDARD SOLUTIONS

9.1 CHLORIDE STOCK STANDARD SOLUTION (1000 mg Cl/L)

Sodium chloride	1.648 g
DI water	dilute to 1 L

Dissolve 1.648 g pre-dried (140°C) sodium chloride in deionized water. Dilute to 1 liter in a volumetric flask.

Stable for 6 months, in absence of contamination or evaporation.

9.2 AUTO CALIBRATION STANDARD – CHLORIDE – Cl (100 mg Cl/L)

CHLORIDE Stock Standard (1000 mg Cl/L, above)	50 mL
DI Water	dilute to 500 mL

Transfer 50 mL CHLORIDE Stock Standard (1000 mg Cl/L) to a 500 mL volumetric flask. Fill to the mark with deionized water and invert to mix.

Stable for 6 months, in absence of contamination or evaporation.

9.3 MANUAL CALIBRATION

These are suggested concentrations for manual calibration standards.

Concentration, mg Cl/L	0	1.0	2.0	5.0	15	25	50	75	100
Volume (mL) Auto Calibration Standard Solution diluted as indicated with DI Water	--	1.0	2.0	5.0	15	25	50	75	100
Final Volume, mL	100	100	100	100	100	100	100	100	100

Prepare weekly.

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10 SAMPLE PRESERVATION AND STORAGE

Samples may be collected into plastic or glass containers. Samples do not require preservation.

Samples should be analyzed as soon as possible after collection.

If storage is required, samples to be reported for EPA's NSDWR or NPDES compliance monitoring programs must be analyzed within 28 days of collection.

The laboratory should consult the most currently acceptable sample storage and preservation procedures as mandated by the EPA.

11 PROCEDURE

Prepare standards and reagents as described in Sections 8 and 9. The laboratory must determine standard concentrations that are most suitable to their needs for calibration within the range of application for this method. The concentrations listed within this method are only suggestions.

Samples should be filtered through 0.45 µm membrane filter. Any reagents having visible particulates should also be filtered.

Pour calibration standards, quality control solutions and samples into sample cups and reagent wedges, according to the user-defined work list.

Before running the analysis batch, check the analyzer for sufficient reagent water, fresh reaction segments, correct location of reagent wedges and a waste collection bottle in place.

After chloride analyses are finished for the day, clean the cuvette to remove deposits. Fill a reagent wedge with SEAL Cuvette Cleaning Solution (p/n 5676) and place it in Position 1 of the reagent tray. Within SEAL discrete analyzer software, go to Maintenance and Setup → Extra Wash.

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12 TEST PARAMETERS

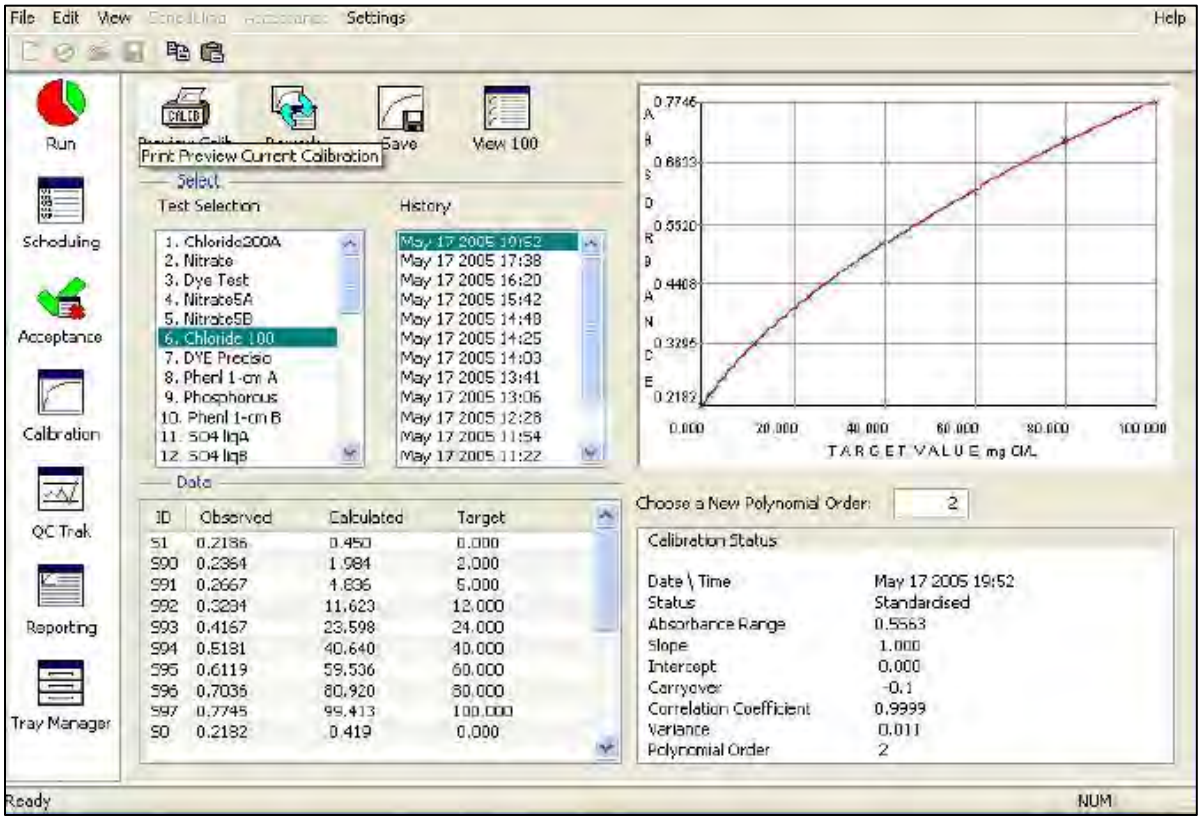
PARAMETER	AQ SETTING
Test name	Chloride 100
Units	mg Cl/L
Decimals	2
Test type	End Point
Sample volume (μL)	100
Water volume (μL)	280
Number of mixes	2
Cuvette primes	1
Cuvette washes	2
Baseline on Wash	Ticked
Reaction time (seconds)	420
Wavelength (nm)	480
Polynomial order	2 (3 if range is extended to 1 mg/L)
Number of reagents	1
1. Cl color reagent (μL)	340

DEFINITIONS:

Test name:	Name which appears on the final report
Units:	Concentration units appearing against the reported result
Decimals:	Number of decimal places in the reported result
Test type:	The type of test the software will perform
Sample volume:	Volume (in microliters) of the sample used in the test
Water volume:	Volume (in microliters) of water from the water reservoir used in the test
Number of mixes:	Number of mixes of the sample + reagent in the reaction well
Cuvette primes:	Number of times the cuvette is flushed with reagent (no sample) prior to sampling
Cuvette washes:	Number of washes of the cuvette between aspirations of finished reaction liquid
Baseline on Wash:	Water baseline measured between aspirations to provide drift correction
Reaction time:	Time (in seconds) between addition of sample + reagent and measurement of the reaction mixture
Wavelength:	Interference filter wavelength to be used in the test
Polynomial order:	Polynomial order to be used when fitting the standard points to the standard graph (1 = linear)
Number of reagents:	Number of reagents defined for the test
Reagent volume:	Volume (in microliters) of the reagent used in the test

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13 STANDARDIZATION



* Curve run on AQ2

DEFINITIONS:

Abs. Range: Difference between the absorbance of the highest standard and the absorbance of the blank

Variance: Calculated as follows:

$$\text{Variance} = \frac{\sum(\text{Deviations, i.e., errors})^2}{\sum(\text{Observed values})^2} \times 100$$

Carryover (%): Calculated as follows:

$$\text{Carryover (\%)} = \frac{(A - B)}{C} \times 100\%$$

Where, A = absorbance of carryover blank (S0)
B = absorbance of blank (S1)
C = calibration absorbance range

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14 PERFORMANCE VALIDATION DATA

14.1 DETECTION LIMIT STUDY

Replicates of 2.0 mg Cl/L chloride standard in reagent water***

	Concentration (mg Cl/L)		
	1.90	2.04	2.32
	1.97	2.14	2.36
	2.04	2.14	2.29
	1.91	2.23	2.35
	2.04	2.16	2.24
	2.02	2.29	2.38
	2.05	2.22	2.28
	2.18	2.22	2.41
	1.97	2.16	2.38
	1.99	2.25	2.42
	2.00	2.06	2.43
	1.97	2.26	2.42
	1.93	2.21	2.44
	2.07	2.29	2.44
	1.92	2.17	2.43
Statistics			
Mean	2.00	2.19	2.37
Std. Deviation	0.07	0.07	0.06
MDL*	0.19	0.19	0.16

14.2 PERFORMANCE STUDY

Replicates of 5.0 mg Cl/L chloride standard in reagent water***

	Concentration (mg Cl/L)		
	4.73	4.74	5.13
	4.64	4.67	5.23
	4.76	4.85	5.20
	4.73	4.90	5.10
	4.72	4.83	5.16
	4.61	5.24	5.05
	4.74	4.74	5.18
	4.65	4.90	5.12
	4.71	4.75	5.24
	4.83	4.94	5.19
Statistics			
Mean	4.71	4.86	5.16
Std. Deviation	0.06	0.16	0.06
% RSD**	1.3	3.2	1.1
% Recovery	94.3	97.1	103.2

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14.1 PRECISION STUDY

Replicates of 20.0 mg Cl/L chloride standard in water***

Concentration (mg Cl/L)

Statistics			
Mean	19.74	19.23	20.6
% Recovery	97.3	96.3	102.7
Std. Deviation	0.16	0.26	0.24
% RSD**	0.8	1.4	1.1
Maximum	19.97	19.82	21.25
Minimum	19.52	18.73	20.44

Replicates of 75.0 mg Cl/L chloride standard in water***

Concentration (mg Cl/L)

Statistics			
Mean	75.52	75.56	77.54
% Recovery	100.4	101.5	103.3
Std. Deviation	0.71	0.78	0.74
% RSD**	0.9	1.0	1.0
Maximum	76.37	76.85	78.77
Minimum	74.67	74.25	76.21

Data was collected on an AQ2 Discrete Analyzer

* MDL is calculated by multiplying the Standard Deviation by the Student-t value for the number of replicates run.

** %RSD is calculated by dividing the Standard Deviation by the mean, then multiplying by 100.

*** To prepare these standards, refer to Section 9.

15 REVISIONS

September 18, 2018 Rev. A AQ300 Method Created

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AQ300 method

EPA-127-D Rev A

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Nitrate-N + Nitrite-N in Drinking and Surface Waters, Domestic and Industrial Wastes

1 SCOPE

This method covers the determination of Nitrate-N + Nitrite-N in sewage and effluents, raw and finished drinking waters and industrial wastes.

This method, equivalent to USEPA Method 353.2 Rev. 2.0 (1993), is approved for the Clean Water Act for use in wastewater compliance monitoring, under National Pollutant Discharge Elimination System (NPDES). This method is also equivalent to Standard Methods 4500-NO_3^- F (2000), ASTM Method D-3867-04A and USGS Method I-2545-90.

This method is also approved for the Safe Drinking Water Act for use in drinking water compliance monitoring, under National Primary Drinking Water Regulations (NPDWR).

2 RANGE OF APPLICATION

Range	0.012 – 2.0 mg N/L

3 METHOD DETECTION LIMIT

By EPA Procedure	MDL = 0.003 mg N/L

4 METHOD PRINCIPLE

The sample is mixed with pH buffer and then transferred to a copperized cadmium coil, where nitrate is chemically reduced to nitrite. The chemically-reduced sample is mixed with color reagent, prepared in dilute phosphoric acid. Original nitrite, plus nitrite from chemical reduction, reacts with sulfanilamide to form a diazonium compound. This species couples with N-(1-naphthyl)-ethylenediamine dihydrochloride to form a reddish-purple azo dye that is measured photometrically at 520nm. Separate results for nitrite are obtained using AQ method EPA-115. The 115 method is similarly equivalent to USEPA method 353.2, except that cadmium reduction is omitted.

5 REFERENCES

Methods for the Determination of Inorganic Substances in Environmental Samples, EPA 600/R 93/100, August 1993: Method 353.2, Revision 2.0.

Standard Methods for the Examination of Water and Wastewater, APHA/AWWA/WEF, method 4500 NO_3^- F (2000)

6 INTERFERENCES

Samples containing strong oxidants or reductants, such as chlorine or sodium thiosulfate, may cause low results by decreasing nitrate reduction efficiency. See Section 11.1 for guidance on sample pre-treatment.

Highly alkaline or overly-acidified samples may give low results due to a shift in pH. Neutralize the pH as needed.

Low results might be obtained for samples that contain high concentrations of iron, copper or other metals, therefore EDTA is included to eliminate this interference.

Samples that contain oil and grease may coat the surface of the cadmium. This interference may be eliminated by sample pretreatment with activated carbon or by extracting the sample with an organic solvent.

Bias from sample turbidity or color is correctable, using sample blanking feature of AQ software.

7 REAGENTS: CHEMICALS REQUIRED AND SAFETY INFORMATION

Consult the safety data sheets (SDS) for details on safe handling of chemicals.

Chemical	Formula	C.A.S. No.	Safety Classification
Ammonium chloride, anhydrous (low in nitrate)	NH_4Cl	12125-02-9	GHS07
Ammonium hydroxide, concentrated	NH_4OH	1336-21-6	GHS05, GHS07, GHS09
Copper (II) sulfate anhydrous or pentahydrate	$CuSO_4$	7758-98-7	GHS07, GHS09
	$CuSO_4 \bullet 5H_2O$	7758-99-8	GHS07, GHS09
EDTA disodium salt dihydrate	$C_{10}H_{14}N_2Na_2O_8 \bullet 2H_2O$	6381-92-6	GHS07, GHS09
N-(1-napthyl)-ethylenediamine dihydrochloride	$C_{12}H_{14}N_2 \bullet 2HCl$	1465-25-4	GHS07
Phosphoric acid, concentrated	H_3PO_4	7664-38-2	GHS05
Sodium hydroxide	NaOH	1310-73-2	GHS05
Sodium nitrate	$NaNO_3$	7631-99-4	GHS03, GHS07
Sodium nitrite	$NaNO_2$	7632-00-0	GHS03, GHS06, GHS09
Sulfanilamide	$C_6H_8N_2O_2S$	63-74-1	--
Sulfuric acid, concentrated	H_2SO_4	7664-93-9	GHS05
Triton® X-100	t-Oct-C_6H_4-$(OCH_2CH_2)_x$-OH x=9-10	9002-93-1	GHS05, GHS07, GHS09

GHS01: Danger – Explosive	GHS02: Danger – Flammable	GHS03: Danger – Oxidizing
GHS04: Warning – Compressed Gas	GHS05: Warning/Danger – Corrosive	GHS06: Danger – Toxic
GHS07: Warning – Irritant	GHS08: Danger – Health Hazard	GHS09: Warning/Danger – Aquatic Toxicity

Note: Persons using this method should be familiar with normal laboratory practice. This method does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to ensure compliance with local regulatory conditions.

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8 REAGENT SOLUTIONS

Use reagent-grade chemicals, certified for analytical or general laboratory use. SEAL recommends using ACS Reagent Grade whenever possible. Reagents of technical or commodity grade must be validated by the user. Use high-purity reagent water, distilled or deionized, and free from organic contamination, therefore Grade 1 (ISO Standard 3696) or better than Type II (ASTM Standard D1193) waters are suitable.

8.1 TRITON® X-100, 7.5% (w/v)

Triton® X-100 (neat liquid)	15 g
DI Water	dilute to 200 mL

Tare a 400 or 600 mL beaker on a scale. Add 15 g of Triton® X-100 neat to the beaker. Add 150 mL of deionized water to the beaker and allow to stir. The Triton® X-100 will thicken initially, but will dissolve with continued stirring. Dilute to 200 mL total volume. If particulates are seen, filter this reagent, e.g., using filter paper.

Store in refrigerator. Discard after six months, or if solids are seen.

8.2 COPPER (II) SULFATE 2% (w/v) (for Cd coil preparation)

Copper (II) sulfate pentahydrate	31.3 g
or	
Copper (II) sulfate anhydrous	20.0 g
DI water	dilute to 1 L

In a 1 L volumetric flask, dissolve 31.3 g copper (II) sulfate pentahydrate or 20.0 g copper (II) sulfate anhydrous in about 800 mL deionized water. Fill to the mark with deionized water and mix well.

8.3 HYDROCHLORIC ACID, 6 normal (for Cd coil preparation)

Hydrochloric acid, concentrated	250 mL
DI Water	dilute to 500 mL

Slowly add 250 mL hydrochloric acid, concentrated, to about 125 mL of deionized water. CAUTION, the container will become very warm. Cool to room temperature and adjust the final volume to 500 mL.

8.4 AMMONIUM CHLORIDE BUFFER STOCK, pH 8.55 ± 0.05

Ammonium chloride, anhydrous, low in nitrate	180 g
EDTA disodium salt dihydrate	2.0 g
Ammonium hydroxide, concentrated, for pH adjustment	pH 8.55
DI Water	dilute to 1 L

Dissolve 180 g ammonium chloride and 2.0 g EDTA disodium salt dihydrate in about 800 mL deionized water. Adjust the pH to 8.55 ± 0.5 using ammonium hydroxide, concentrated and dilute to 1 L.

SEAL recommends low in nitrate ammonium chloride, product number 6451 from GFS Chemicals.

NOTE ACS grade ammonium chloride may contain nitrate contamination. An alternate recipe for the ammonium chloride buffer is:

> **CAUTION—FUMES!** To a 1 liter container add about 400 mL deionized water. Carefully add 280 mL (333 g) hydrochloric acid, concentrated, 227 mL (204 g) ammonium hydroxide, concentrated and 2.0 g EDTA disodium salt dihydrate. Cool to room temperature. Adjust to pH 8.55 ± 0.5 using ammonium hydroxide, concentrated and dilute to 1 L.

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8.5 WORKING BUFFER, 0.0375% surfactant

Ammonium chloride buffer stock (above)	200 mL
7.5% (w/v) Triton® X-100 solution (above)	1.0 mL

To 200 mL of ammonium chloride buffer stock, add 1.0 mL 7.5% (w/v) Triton® X-100. Mix thoroughly.

Prepare fresh every two weeks.

8.6 SULFANILAMIDE-NEDD

Sodium hydroxide	1.0 g
Phosphoric acid, concentrated	20 mL
Sulfanilamide	7.5 g
N-(1-naphthyl)-ethylenediamine dihydrochloride	0.375 g
DI Water	dilute to 500 mL

Dissolve 1.0 g sodium hydroxide pellets in about 250 mL deionized water. Carefully add 20 mL phosphoric acid, concentrated (low in nitrite). Add 7.5 g sulfanilamide and 0.375 g N-(1-naphthyl)-ethylenediamine dihydrochloride and stir to dissolve. Dilute to 500 mL with deionized water. Filter this reagent, e.g., using filter paper. As the reagent slowly turns pink, re-filter as needed.

Solution is stable for 1 month when refrigerated in a dark bottle. Discard when background absorbance of analyzed blanks exceeds 0.04 AU.

8.7 SULFURIC ACID, 5 normal (for preservation of stock)

Sulfuric acid, concentrated	70 mL
DI Water	dilute to 500 mL

Slowly add 70 mL sulfuric acid, concentrated to about 400 mL of deionized water. CAUTION, the container will become very warm. Cool to room temperature and dilute to 500 mL with deionized water. This reagent is available commercially.

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8.8 OPEN TUBULAR CADMIUM REACTOR COIL (OTCR)

The OTCR is a 14" coiled cadmium tube having a purple cladding. Within the OTCR, nitrate is chemically reduced to nitrite. There are different techniques for preparing your OTCR for use, which is dependent upon how often it is used.

NEW COIL

Perform an **Acid Strip** and **Install** the coil. In the MAINTENANCE menu, prime the syringe and **Regenerate** twice with 2% $CuSO_4$.

DAILY START-UP (when the coil is fluidically installed and recently used):

In the MAINTENANCE menu, prime the syringe and **Regenerate** once with water (instead of 2% $CuSO_4$).

IDLE COIL (when the coil has sat idle for 3 to 7 days):

Perform a **Water/Air Cleaning** and install the coil. In the MAINTENANCE menu, prime the syringe and regenerate twice with 2% $CuSO_4$.

LOW REDUCTION EFFICIENCY

Follow NEW COIL instructions.

Installation

- The exposed ends are sleeved with Tygon® tubing, p/n 5719. The tee connector on the rotating sampler arm connects to a 15 cm piece of 1/16" o.d. tubing.
- Moisten the free end of this tube and insert it into the OTCR inlet sleeve, leaving 1 mm gap from the cadmium coil end.
- Locate the 1/16" o.d. dilutor transfer line, which passes beneath the sampler arm cosmetic cover. Insert the end of this tube into the other sleeve at the outlet of the OTCR.
  ****Important**** Avoid making crimps or kinks to these 1/16" o.d. tubes.

Water/Air Cleaning

- Remove the coil by gently sliding the soft sleeve tubes off the cadmium ends.
- Use a 6" piece of Tygon® tubing to connect the male luer of a 50 mL syringe to the coil. SEAL recommends tubing p/n 116-0536-18, having 0.11" i.d.
- Using the syringe, rapidly draw deionized water into the coil, while purposely drawing air in alternation. Done vigorously, this technique expels the previous activated copper coating, seen as fine black flakes.

Acid Strip

- Remove the coil by gently sliding the soft sleeve tubes off the cadmium ends and attach the coil to the syringe as described above (Water/Air cleaning)
- Draw 6 N HCl into the coil and stand for 2–5 minutes.
- Perform **Water/Air Cleaning**

Regenerate using AQ Software

- In MAINTENANCE menu, select the Cadmium coil icon.
- Place copper sulfate (or water) in position 15; 50 or 100 ppm high standard nitrate in position 14; and working buffer in position 13.
- Click "continue" to run regeneration.

Determining Reduction Efficiency

To measure reduction efficiency, run a nitrite–N standard with the same concentration as a nitrate–N standard (normally mid-range). Reduction efficiency is calculated as follows:

$$\%\ \text{Reduction Efficiency} = \frac{\text{N-NO}_3\ \text{Result}}{\text{N-NO}_2\ \text{Result}} \times 100\%$$

The user can judge >85% nitrate reduction efficiency for the cadmium coil, by comparing the nitrate absorbance observed for the current calibrated range to the corresponding absorbance from a previous nitrate calibration.

Refer to SEAL Analytical AQ Technical Tips series, Cd Coil Regeneration, for more information.

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9 STANDARD SOLUTIONS

9.1 NITRATE-N STOCK STANDARD SOLUTION (500 mg N/L)

Sodium nitrate	3.034 g
Sulfuric acid, 5 normal (above)	up to 7 mL
DI water	dilute to 1 L

Dissolve 3.034 g sodium nitrate (dried at 105°C) in deionized water in a 1 liter volumetric flask. Up to 7 mL sulfuric acid, 5 normal, may be added for preservation. Dilute to the mark with deionized water.

9.2 NITRITE-N STOCK STANDARD SOLUTION (250 mg N/L)

Sodium nitrite	1.231 g
DI water	dilute to 1 L

Dissolve 1.231 g sodium nitrite (dried at 105°C) in deionized water in about 800 mL deionized water in a 1 liter volumetric flask. Dilute to the mark with deionized water.

Store up to 1 month in an amber bottle at 4°C.

9.3 AUTO CALIBRATION STANDARD – NITRATE-N (2.0 mg N/L)

NITRATE-N Stock Standard (500 mg N/L, above)	1.0 mL
DI water	dilute to 250 mL

To a 250 mL volumetric flask pipet 1.0 mL NITRATE-N stock standard (500 mg N/L) and dilute to the mark with deionized water.

Prepare every two weeks.

9.4 MANUAL CALIBRATION

These are suggested concentrations for manual calibration standards.

Concentration, mg NO_3-N/L	0	0.01	0.05	0.1	0.4	1.0	1.6	2.0
Volume (mL) Auto Calibration Standard Solution diluted as indicated with Calibration Diluent	--	0.5	2.5	5	20	50	80	100
Final Volume, mL	100	100	100	100	100	100	100	100

Prepare weekly.

9.5 REDUCTION EFFICIENCY CHECK STANDARD – NITRITE-N (1.0 mg N/L)

NITRITE-N Stock Standard (250 mg N/L, above)	2.0 mL
DI water	dilute to 500 mL

To a 500 mL volumetric flask pipet 2.0 mL NITRITE-N stock standard (250 mg N/L) and dilute to the mark with deionized water.

Prepare twice weekly.

** Additional suggestion check standard concentrations

Concentration, mg NO_2 – N/L	0.5	1.5
Volume (mL) NITRITE-N Stock Standard diluted as indicated with deionized water	0.2	0.6
Final Volume	100	100

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10 SAMPLE PRESERVATION AND STORAGE

Samples may be collected into plastic or glass containers.

Sample preservation and holding time requirements are as follows, for samples to be reported for drinking water compliance monitoring under the Safe Drinking Water Act and wastewater compliance monitoring under the Clean Water Act.

	Safe Drinking Water Act	Clean Water Act
For Nitrate	Preserve by cooling to 4°C Analyze within 48 hours If chlorinated, analyze within 14 days	Preserve by cooling to 4°C Analyze within 48 hours
For Nitrite	Preserve by cooling to 4°C Analyze within 48 hours	Preserve by cooling to 4°C Analyze within 48 hours
For Nitrate+Nitrite (combined)	Preserve by cooling to 4°C Acidify to pH < 2 Analyze within 28 days	Preserve by cooling to 4°C Acidify to pH < 2 Analyze within 28 days

For preservation:

To prepare 5 N sulfuric acid, add 70 mL of sulfuric acid, concentrated, to about 400 mL of deionized water. Cool to room temperature and dilute 500 mL. For the preservation acid, transfer the volume of sulfuric acid, 5 normal, shown in the table (± 0.25 mL) to a 2 L bottle. Dilute to volume with deionized water.

Sulfuric acid, preservation level	None	1.0 mL/L	1.4 mL/L	2.0 mL/L
Sulfuric acid, 5 normal, volume added per 2 L	--	14 mL	21 mL	29 mL

11 PROCEDURE

Prepare standards and reagents as described in Sections 8 and 9. The laboratory must determine standard concentrations that are most suitable to their needs for calibration within the range of application for this method. The concentrations listed within this method are only suggestions.

Any reagents having visible particulates should be filtered.

Pour calibration standards, quality control solutions and samples into sample cups and reagent wedges, according to the user-defined work list.

Before running the analysis batch, check the analyzer for sufficient reagent water, fresh reaction segments, correct location of reagent wedges and a waste collection bottle in place.

11.1 CHEMISTRY TROUBLESHOOTING TIPS

Typically, calibration standards do not require matrix matching to account for field sample preservation, up to 2 mL/L of sulfuric acid, concentrated. To verify, add 5 mL typical preserved field sample to an equal volume of working buffer. Similarly, mix equal volumes of a calibrated standard with the working buffer. The measured pH values should agree within 0.25 pH unit, within the pH range of 8.2 to 8.6.

Samples containing more than about 1 ppm residual chlorine require pre-treatment to prevent loss of nitrate reduction efficiency. Studies for nitrate reduction efficiency indicated that two drops of 1% (w/v) sodium sulfite (Na_2SO_3) effectively dechlorinated a 25 mL sample containing 5 ppm residual chlorine. Studies further indicated that adding 1% (w/v) sodium sulfite in excess of full dechlorination, between 1% and 6% volume-basis excess of the aliquot volume, caused a negative bias but did not cause persistent loss of coil reduction efficiency. In contrast, adding excess sodium thiosulfate, as suggested by USEPA Method 353.2, caused persistent loss of coil reduction efficiency.

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12 TEST PARAMETERS

PARAMETER	AQ SETTING
Test name	NO3_NO2 2
Units	mg N/L
Decimals	3
Test type	Cadmium reduction
Sample volume (µL)	500
Water volume (µL)	0
Number of mixes	2
Cuvette primes	1
Cuvette washes	2
Reduction time (seconds)	25
Cadmium flush volume*	430
Reaction time (seconds)	480
Wavelength (nm)	520
Polynomial order	1
Number of reagents	2
1. Working Buffer (µL)	265
2. Sulfanilamide – NEDD (µL)	350
Advanced Test Parameters	☒ Extra Debubbling Action

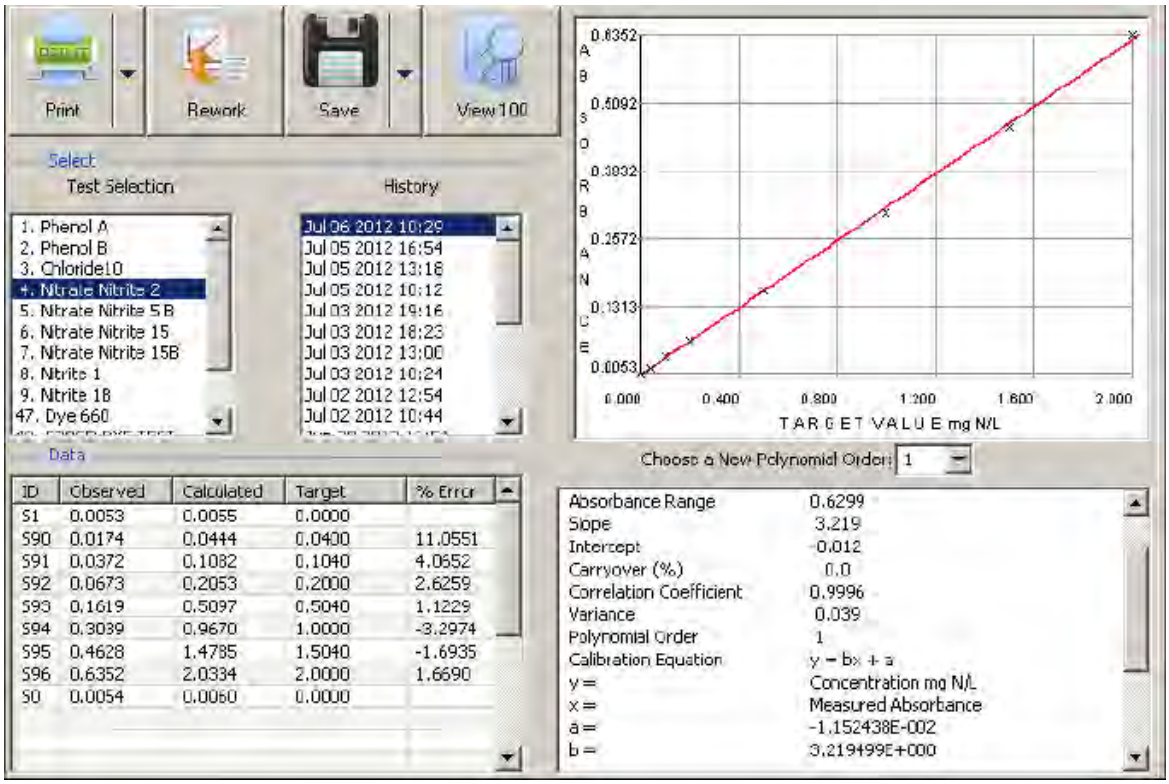
*Cadmium Flush Volume subject to slight changes, contact SEAL Tech Support for more information

DEFINITIONS:

Test name:	Name which appears on the final report
Units:	Concentration units appearing against the reported result
Decimals:	Number of decimal places in the reported result
Test type:	The type of test the software will perform
Sample volume:	Volume (in microliters) of the sample used in the test
Water volume:	Volume (in microliters) of water from the water reservoir used in the test
Number of mixes:	Number of mixes of the sample + reagent in the reaction well
Cuvette primes:	Number of times the cuvette is flushed with reagent (no sample) prior to sampling
Cuvette washes:	Number of washes of the cuvette between aspirations of finished reaction liquid
Baseline on Wash:	Water baseline measured between aspirations to provide drift correction
Reaction time:	Time (in seconds) between addition of sample + reagent and measurement of the reaction mixture
Wavelength:	Interference filter wavelength to be used in the test
Polynomial order:	Polynomial order to be used when fitting the standard points to the standard graph (1 = linear)
Number of reagents:	Number of reagents defined for the test
Reagent volume:	Volume (in microliters) of the reagent used in the test

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13 STANDARDIZATION



*Curve run on AQ2

DEFINITIONS:

Abs. Range: Difference between the absorbance of the highest standard and the absorbance of the blank

Variance: Calculated as follows:

$$\text{Variance} = \frac{\sum(\text{Deviations, i.e., errors})^2}{\sum(\text{Observed values})^2} \times 100$$

Carryover (%): Calculated as follows:

$$\text{Carryover (\%)} = \frac{(A - B)}{C} \times 100\%$$

Where, A = absorbance of carryover blank (S0)
B = absorbance of blank (S1)
C = calibration absorbance range

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14 PERFORMANCE VALIDATION DATA

14.1 DETECTION LIMIT STUDY

Replicates of 0.008 mg N/L nitrate standard in reagent water***

	Concentration (mg N/L)		
	0.002	0.010	0.009
	0.004	0.010	0.009
	0.007	0.011	0.009
	0.003	0.010	0.010
	0.003	0.010	0.009
	0.006	0.009	0.010
	0.004	0.011	0.010
	0.005	0.010	0.010
	0.006	0.011	0.009
	0.004	0.011	0.011
	0.005	0.012	0.010
	0.007	0.012	0.010
	0.003	0.011	0.010
	0.007	0.010	0.009
	0.003	0.010	0.010
Statistics			
Mean	0.004	0.011	0.01
Std. Deviation	0.002	0.001	0.001
MDL*	0.005	0.002	0.002

14.2 PERFORMANCE STUDY

Replicates of 0.02 mg N/L nitrate standard in reagent water***

	Concentration (mg N/L)			
	0.021	0.023	0.021	0.026
	0.018	0.023	0.024	0.025
	0.019	0.023	0.025	0.025
	0.019	0.023	0.021	0.024
	0.019	0.023	0.022	0.024
	0.019	0.024	0.024	0.022
	0.019	0.023	0.023	0.026
	0.019	0.022	0.021	0.021
	0.021	0.023	0.023	0.023
	0.021	0.023	0.022	0.022
Statistics				
Mean	0.020	0.023	0.023	0.024
Std. Deviation	0.001	0.000	0.001	0.002
% RSD**	5.5	2.0	6.3	7.4
% Recovery	97.5	115.0	113.0	119.0

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14.3 PRECISION STUDY

Replicates of 1.0 mg N/L nitrate standard in water***

Concentration (mg N/L)

Statistics				
Mean	1.06	1.05	1.08	1.13
% Recovery	106.2	105.1	107.6	112.6
Std. Deviation	0.024	0.049	0.030	0.036
% RSD**	2.2	4.7	2.8	3.2
Maximum	1.11	1.15	1.12	1.17
Minimum	1.02	0.98	1.03	1.04

Replicates of 2.0 mg N/L nitrate standard in water***

Concentration (mg N/L)

Statistics				
Mean	2.16	2.06	1.99	2.00
% Recovery	108.1	102.8	99.5	100.1
Std. Deviation	0.058	0.047	0.074	0.029
% RSD**	2.7	2.3	3.7	1.5
Maximum	2.31	2.13	2.01	2.02
Minimum	2.11	1.97	1.81	1.94

Data was collected on an AQ2 Discrete Analyzer

* MDL is calculated by multiplying the Standard Deviation by the Student-t value for the number of replicates run.

** %RSD is calculated by dividing the Standard Deviation by the mean, then multiplying by 100.

*** To prepare these standards, refer to Section 9.

15 REVISIONS

September 17, 2018 Rev A AQ300 Method Created

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AQ300 method

EPA-155-D Rev 0

www.seal-analytical.com

o-Phosphate–P in Drinking, Saline and Surface Waters, and Domestic and Industrial Wastes

1 SCOPE

This method covers the determination of o-Phosphate–P in surface and saline waters, drinking waters and domestic and industrial waste waters. Samples which have been digested according to USEPA methods 365.1, 365.2 or 365.3 and have been neutralized for pH may also be analyzed using this method.

This method, equivalent to USEPA Method 365.1, Rev 2.0, is approved for the Clean Water Act for use in wastewater compliance monitoring under National Pollutant Discharge Elimination System (NPDES). For NPDES monitoring, this method is also equivalent to Standard Methods 4500-P-F (1999 forward) and USGS Method I-4601-85.

This method is also approved for the Safe Drinking Water Act for use in drinking water compliance monitoring under National Primary Drinking Water Regulations (NPDWR).

2 RANGE OF APPLICATION

Range	0.003 – 0.3 mg P/L

3 METHOD DETECTION LIMIT

By EPA Procedure	MDL = 0.0007 mg P/L

4 METHOD PRINCIPLE

Reaction with acidic molybdate in the presence of antimony forms an antimony phospho-molybdate complex. This complex is chemically reduced by ascorbic acid to an intensely blue complex: phosphomolybdenum blue. The absorbance of this complex is measured photometrically at 880nm

5 REFERENCES

Methods for the Determination of Inorganic Substances in Environmental Samples, USEPA 600/R 93/100, August 1993: Method 365.1, Rev. 2.0

Standard methods for the Examination of Water and Wastewater, APHA/AWWA/WEF, method 4500-P-F (1999 forward).

6 INTERFERENCES

Interferences can come from a variety of analytes including barium, lead, silver, silica, nitrite, sulfide, arsenate, hexavalent chromium, and arsenic; however the effects of these are usually negligible in natural waters. See Section 11.1, Chemistry Troubleshooting Tips for specifics.

Arsenate is determined similarly to phosphorus and should be considered when present in concentrations higher than phosphorus. However, at concentrations found in seawater, it does not interfere.

Filtration of samples for total or total hydrolysable phosphorus should only occur after digestion.

Bias from sample turbidity or color is correctable, using sample blanking feature of AQ software.

7 REAGENTS: CHEMICALS REQUIRED AND SAFETY INFORMATION

Consult the safety data sheets (SDS) for details on safe handling of chemicals.

Chemical	Formula	C.A.S. No.	Safety Classification
Ammonium molybdate tetrahydrate	$(NH_4)_6Mo_7O_{24} \bullet 4H_2O$	12054-85-2	--
Antimony potassium tartrate trihydrate	$C_8H_4K_2O_{12}Sb_2 \bullet 3\ H_20$	28300-74-5	GHS07, GHS09
Ascorbic acid	$C_6H_8O_6$	50-81-7	--
Potassium phosphate monobasic	KH_2PO_4	7778-77-0	--
Sulfuric acid, concentrated	H_2SO_4	7664-93-9	GHS05

GHS01: Danger – Explosive	GHS02: Danger – Flammable	GHS03: Danger – Oxidizing
GHS04: Warning – Compressed Gas	GHS05: Warning/Danger – Corrosive	GHS06: Danger – Toxic
GHS07: Warning – Irritant	GHS08: Danger – Health Hazard	GHS09: Warning/Danger – Aquatic Toxicity

Note: Persons using this method should be familiar with normal laboratory practice. This method does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to ensure compliance with local regulatory conditions.

8 REAGENT SOLUTIONS

Use reagent-grade chemicals certified for analytical or general laboratory use. SEAL recommends using ACS Reagent Grade whenever possible. Reagents of technical or commodity grade must be validated by the user. Use high-purity reagent water, distilled or deionized, and free from organic contamination, therefore Grade 1 (ISO Standard 3696) or better than Type II (ASTM Standard D1193) waters are suitable.

8.1 AMMONIUM MOLYBDATE, 4% (w/v)

Ammonium molybdate tetrahydrate	4.0 g
DI Water	dilute to 100 mL

Dissolve 4.0 g ammonium molybdate tetrahydrate in approximately 80 mL deionized water. Stir until completely dissolved, may take up to 1 hour. Dilute to 100 mL and store in a plastic bottle.

Store this reagent in a plastic container for up to 3 weeks. Refrigerate.

8.2 SULFURIC ACID, 5 normal

Sulfuric acid, concentrated	70 mL
DI Water	dilute to 500 mL

Slowly add 70 mL sulfuric acid, concentrated to about 400 mL of deionized water. Caution, the container will become very warm. Cool to room temperature and dilute to 500 mL with deionized water.

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8.3 ANTIMONY POTASSIUM TARTRATE, 3g/L

Antimony potassium tartrate trihydrate	1.5 g
DI water	dilute to 500 mL

Dissolve 1.5 g antimony potassium tartrate trihydrate in about 400 mL deionized water. Dilute to 500 mL and mix well. Store at 4°C in a dark bottle.

Refrigerate in a dark bottle. Prepare fresh monthly.

8.4 WORKING PHOSPHATE COLOR REAGENT

Sulfuric acid, 5 normal (above)	see table
Antimony potassium tartrate, 3 g/L (above)	10 mL
Ammonium molybdate, 4% w/v (above)	10 mL
DI water	dilute to 100 mL

To a 100 mL volumetric flask, add the volume of sulfuric acid, 5 normal according to the table:

Calibration diluent (Section 9.2), preservation level	None	0.5mL/L	1.0mL/L	1.5 mL/L	2.0mL/L
Sulfuric acid, 5 normal added to color reagent	30 mL	27 mL	24 mL	21 mL	18 mL

Then add 10 mL antimony potassium tartrate, 3 g/L to the sulfuric acid, 5 normal, and swirl to mix. Add 10 mL ammonium molybdate, 4% w/v. Swirl the contents, fill the flask to the mark with deionized water and mix well.

Store this reagent in a plastic container for up to 3 weeks. Discard if the reagent turns blue or becomes turbid.

8.5 WORKING ASCORBIC ACID, 5.0 g/L

Ascorbic acid, fine granular	0.50 g
DI water	dilute to 100 mL

Dissolve 0.50 g ascorbic acid, fine granular, in about 80 mL deionized water. Dilute to 100 mL and mix well.

Prepare fresh daily.

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9 STANDARD SOLUTIONS

9.1 PHOSPHATE-P STOCK STANDARD SOLUTION (1000 mg X/L)

Potassium dihydrogen orthophosphate, anhydrous	4.394 g
Sulfuric acid, 5 normal (above)	up to 10 mL
DI water	dilute to 1 L

Dissolve 4.394 g potassium dihydrogen orthophosphate, anhydrous (dried at 105°C) in about 800 mL deionized water in a 1 liter volumetric flask. Up to 10 mL sulfuric acid, 5 normal, may be added for preservation. Dilute to the mark with deionized water.

Store at 4°C.

9.2 CALIBRATION DILUENT (for acid-preserved samples)

Sulfuric acid, 5 normal (above)	see table
DI water	dilute to 2 L

Use this solution as the diluent for automated and manual dilutions and also as the blank and diluent for auto-calibrations. **Note**: use of sulfuric acid for preservation of field samples is not allowed for compliance monitoring analysis of o-phosphate in drinking waters. See section 10 for details.

Choose the level of sulfuric acid closest to the level of acid added to field samples for preservation. Transfer the volume of sulfuric acid, 5 normal, shown in the table (± 0.25 mL) to a 2 liter bottle. Dilute to volume with deionized water.

Sulfuric acid, preservation level	None	0.5mL/L	1.0mL/L	1.5 mL/L	2.0mL/L
Sulfuric acid, 5 normal, volume added per 2 L	--	7 mL	14 mL	21 mL	29 mL

9.3 PHOSPHATE INTERMEDIATE STANDARD SOLUTION (10 mg P/L)

Phosphate Stock Standard (1000 mg P/L, above)	2.0 mL
Calibration diluent	dilute to 200 mL

Pipet 2.0 mL PHOSPHATE-P stock standard (1000 mg P/L) to a 200 mL volumetric flask. Fill to the mark with Calibration Diluent and invert to mix.

Store at 4°C

9.4 AUTO CALIBRATION STANDARD – PHOSPHATE-P (0.3 mg P/L)

PHOSPHATE Intermediate Standard (10 mg X/L, above)	15 mL
Calibration diluent	dilute to 500 mL

Transfer 15 mL PHOSPHATE-P intermediate standard (10 mg P/L) to a 500 mL volumetric flask. Fill to the mark with Calibration Diluent and invert to mix.

Prepare fresh weekly. Store at 4°C.

9.5 MANUAL CALIBRATION

These are suggested concentrations for manual calibration standards.

Concentration, mg P/L	0	0.003	0.015	0.03	0.075	0.15	0.225	0.3
Volume (mL) Auto Calibration Standard Solution diluted as indicated with Calibration Diluent	--	1.0	5.0	10	25	50	75	100
Final Volume, mL	100	100	100	100	100	100	100	100

Prepare weekly

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10 SAMPLE PRESERVATION AND STORAGE

Samples may be collected into plastic or glass containers.

Samples to be reported for ortho-phosphate for EPA's drinking water compliance monitoring programs should NOT be filtered, digested, or undergo hydrolysis. The samples should be cooled to ≤ 6°C and must be analyzed within 48 hours of collection. Do not use acid for preservation.

Samples to be reported for dissolved ortho-phosphate for EPA's wastewater compliance monitoring programs must be filtered immediately, then cooled to ≤ 6°C and must be analyzed within 48 hours of collection. Do not use acid for preservation.

Samples to be reported for total-phosphorus for EPA's wastewater compliance monitoring programs must be preserved with sulfuric acid to a pH < 2, cooled to ≤ 6°C and must be analyzed within 28 days. Digestion is required as described in USPEA 365.1, 365.2 or 365.3. Do not filter prior to digestion. After digestion, neutralize with sodium hydroxide as described in USEPA method 365.1 or 365.2. If pH neutralization is not desired, analyze the finished digests using SEAL method EPA-119-D instead. Call SEAL Analytical technical Support for assistance.

11 PROCEDURE

Prepare standards and reagents as described in Sections 8 and 9. The laboratory must determine standard concentrations that are most suitable to their needs for calibration within the range of application for this method. The concentrations listed within this method are only suggestions.

Any reagents having visible particulates should be filtered.

Pour calibration standards, quality control solutions and samples into sample cups and reagent wedges, according to the user-defined work list.

Before running the analysis batch, check the analyzer for sufficient reagent water, fresh reaction segments, correct location of reagent wedges and a waste collection bottle in place.'

After o-phosphate analyses are finished for the day, clean the cuvette to remove deposits. Fill a reagent wedge with SEAL Cuvette Cleaning Solution (p/n 5676) and place it in Position 1 of the reagent tray. Within SEAL discrete analyzer software, go to Maintenance—Cuvette Functions and select Extra Wash.

11.1 CHEMISTRY TROUBLESHOOTING TIPS

Glassware should be washed with 1:1 HCl rinsed with phosphate color reagent, and rinsed thoroughly with deionized water. If glassware is reserved solely for the determination of phosphorus, then treatment with 1:1 HCl and phosphate color reagent is only required occasionally. Commercial detergent should never be used.

As much as 50 mg Fe^{3+}/L, 10 mg Cu^{2+}/L, and 10 mg SiO_2/L can be tolerated. High silica concentrations cause positive interference and high iron concentrations can cause precipitation, which causes a subsequent loss of phosphorus. For silica concentrations of 20, 50, and 100 mg/L, phosphorus results will be elevated by 0.0005, 0.015, and 0.025 mg/L, respectively.

Hexavalent chromium and nitrite interfere to give results about 3% low at concentrations of 1mg/L and 10 to 15% low at 10 mg/L. Sulfide (Na_2S) and silicate do not interfere at concentrations of 1.0 and 10 mg/L, respectively.

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12 TEST PARAMETERS

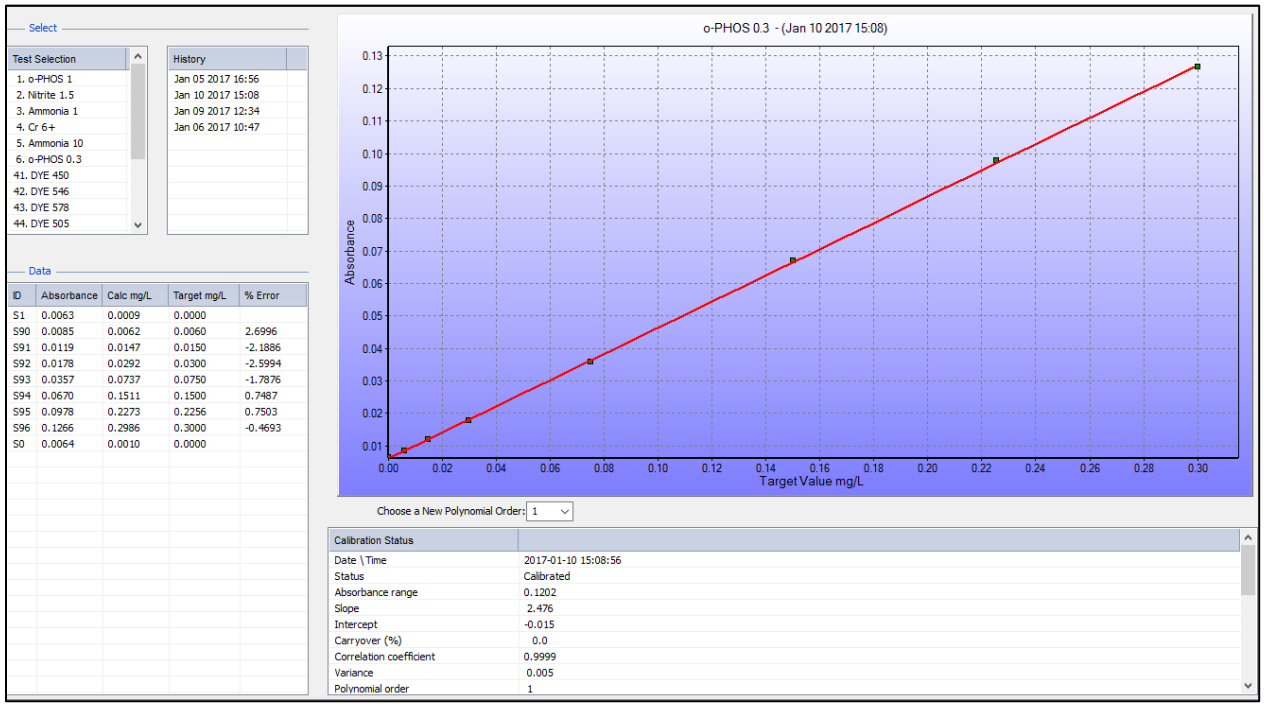
PARAMETER	AQ300 SETTING
Test name	o-PHOS 0.3
Units	mg P/L
Decimals	4
Test type	End Point
Sample volume (µL)	500
Water volume (µL)	0
Number of mixes	2
Cuvette primes	4
Cuvette washes	2
Baseline on Wash	Ticked
Reaction time (seconds)	480
Wavelength (nm)	880
Polynomial order	1
Number of reagents	2
1. PO4 color reagent (µL)	55
2. Ascorbic acid (µL)	60

DEFINITIONS:

Test name:	Name which appears on the final report
Units:	Concentration units appearing against the reported result
Decimals:	Number of decimal places in the reported result
Test type:	The type of test the software will perform
Sample volume:	Volume (in microliters) of the sample used in the test
Water volume:	Volume (in microliters) of water from the water reservoir used in the test
Number of mixes:	Number of mixes of the sample + reagent in the reaction well
Cuvette primes:	Number of times the cuvette is flushed with reagent (no sample) prior to sampling
Cuvette washes:	Number of washes of the cuvette between aspirations of finished reaction liquid
Baseline on Wash:	Water baseline measured between aspirations to provide drift correction
Reaction time:	Time (in seconds) between addition of sample + reagent and measurement of the reaction mixture
Wavelength:	Interference filter wavelength to be used in the test
Polynomial order:	Polynomial order to be used when fitting the standard points to the standard graph (1 = linear)
Number of reagents:	Number of reagents defined for the test
Reagent volume:	Volume (in microliters) of the reagent used in the test

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13 STANDARDIZATION



DEFINITIONS:

Abs. Range: Difference between the absorbance of the highest standard and the absorbance of the blank

Variance: Calculated as follows:

$$\text{Variance} = \frac{\sum(\text{Deviations, i.e., errors})^2}{\sum(\text{Observed values})^2} \times 100$$

Carryover (%): Calculated as follows:

$$\text{Carryover (\%)} = \frac{(A - B)}{C} \times 100\%$$

Where, A = absorbance of carryover blank (S0)
B = absorbance of blank (S1)
C = calibration absorbance range

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14 PERFORMANCE VALIDATION DATA

14.1 DETECTION LIMIT STUDY

Replicates of 0.003 mg P/L nitrate standard in reagent water***

	Concentration (mg P/L)			
	0.0029	0.0023	0.0027	0.0027
	0.0030	0.0023	0.0029	0.0026
	0.0033	0.0022	0.0029	0.0027
	0.0024	0.0018	0.0027	0.0020
	0.0021	0.0022	0.0025	0.0020
	0.0027	0.0021	0.0026	0.0022
	0.0027	0.0016	0.0029	0.0024
	0.0028	0.0018	0.0030	0.0025
	0.0029	0.0022	0.0027	0.0020
	0.0028	0.0021	0.0028	0.0029
	0.0027	0.0019	0.0031	0.0025
	0.0032	0.0023	0.0032	0.0032
	0.0032	0.0022	0.0028	0.0031
	0.0026	0.0022	0.0030	0.0026
	0.0029	0.0019	0.0028	0.0033
Statistics				
Mean	0.0028	0.0021	0.0028	0.0026
Std. Deviation	0.0003	0.0002	0.0002	0.0004
MDL*	0.0008	0.0006	0.0005	0.0011

14.2 PERFORMANCE STUDY

Replicates of 0.015 mg P/L nitrate standard in reagent water***

	Concentration (mg P/L)			
	0.0126	0.0125	0.0132	0.0124
	0.0130	0.0128	0.0128	0.0131
	0.0135	0.0131	0.0131	0.0134
	0.0129	0.0126	0.0130	0.0133
	0.0127	0.0123	0.0130	0.0129
	0.0138	0.0123	0.0133	0.0132
	0.0134	0.0125	0.0129	0.0140
	0.0133	0.0125	0.0132	0.0139
	0.0128	0.0126	0.0129	0.0136
	0.0138	0.0126	0.0137	0.0138
Statistics				
Mean	0.0132	0.0126	0.0131	0.0134
Std. Deviation	0.0004	0.0002	0.0003	0.0005
% RSD**	3.4	1.9	2.0	3.7
% Recovery	87.9	83.9	87.4	89.1

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14.3 PRECISION STUDY

Replicates of 0.15 mg P/L nitrite standard in water***

Concentration (mg P/L)

Statistics				
Mean	0.1471	0.1464	0.1464	0.1477
% Recovery	98.0	97.6	97.6	98.4
Std. Deviation	0.0007	0.0011	0.0009	0.0009
% RSD**	0.5	0.8	0.6	0.6
Maximum	0.1481	0.1488	0.1481	0.1493
Minimum	0.1456	0.1450	0.1454	0.1458

Replicates of 0.3 mg P/L nitrite standard in water***

Concentration (mg P/L)

Statistics				
Mean	0.2974	0.2957	0.2967	0.2998
% Recovery	99.1	98.6	98.9	99.6
Std. Deviation	0.0017	0.0024	0.0016	0.0014
% RSD**	0.6	0.8	0.6	0.5
Maximum	0.3003	0.2993	0.3006	0.3008
Minimum	0.2952	0.2906	0.2945	0.2957

* MDL is calculated by multiplying the Standard Deviation by the Student-t value for the number of replicates run.

** %RSD is calculated by dividing the Standard Deviation by the mean, then multiplying by 100.

*** To prepare these standards, refer to Section 9.

15 REVISIONS

January 31, 2017 Rev 0 Method created and support data acquired

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Standard Operating Procedure for Analysis of Chlorophyll-a in Water

General

This method is used to determine chlorophyll a and pheophytin in natural water bodies using visible wavelength spectrometry.

Phytoplankton containing chlorophyll a in a measured volume of sample is concentrated by filtration through a glass fiber filter. The photo-pigments are extracted from the phytoplankton by grinding the filter with a tissue grinder and steeping the filter slurry in 90% aqueous acetone solution overnight. The filter slurry is then centrifuged to clarify the solution and then the supernatant is transferred to a glass spectrophotometric cell. For the pheophytin corrected chlorophyll a, the sample's absorbance is measured at 750 and 664 nm before acidification and 750 and 665 nm after acidification with 0.1 N HCl. No calibration of the instrument is required. Absorbance values are entered into a set of equations in the computer that utilize the extinction coefficients of the pure pigments in 90% acetone. Concentrations are reported in µg/L.

Equipment and Supplies

Filtration

- Vacuum filtration system
- Whatman GF/C Glass Fiber Filter (e.g., 47 mm)
- Small roll of aluminum foil, cut in 3 inch squares
- 500 mL graduated cylinder
- Extra fine tip black marker
- 2 Rinse bottles (1 small, 1 large)

Extraction

- Film canister
- Buffered acetone
- Fume hood in dark room

Spectrophotometric analysis

- UV/Vis Spectrophotometer
- 1 cm path length UV quartz glass cuvette
- 1-5 mL pipette with tips

- 100 μL pipette with tips
- 0.1 N HCl

Reagents

Saturated Magnesium Carbonate Solution: Add 10 grams magnesium carbonate to 1000 mL of de-ionized water. The solution is allowed to settle for a minimum of 24 hours. Only the clear "powder free" solution is used during subsequent steps.

90 % (v/v) Buffered Acetone: Add 100 mL of the Magnesium Carbonate solution to 900 mL of ACS grade acetone in a 1-L volumetric flask.

0.1 N Hydrochloric Acid: Add 0.85 mL of concentrated HCl (ACS grade) to 100 mL of deionized water.

Chlorophyll-a check standard: To prepare a 0.5 mg/L reporting limit check standard, add 0.5 mL of a certified chlorophyll stock standard (10mg/L ± 1 mg/L, Turner Designs SKU: 10-850) with a 0.5 mL volumetric pipet to a 10 mL volumetric flask that has been rinsed with 90% aqueous acetone solution. Bring to volume with 90 % aqueous acetone solution and cap. Wrap flask in aluminum foil and store in refrigerator before use. Make fresh from stock each time right before samples are analyzed. Store stock solution in the freezer between uses.

Procedure

Filtration

1. Shake sample bottle to ensure sample is thoroughly mixed. Use a graduated cylinder to measure the volume of the sample. Filter as much volume as needed to clog the GF/C glass fiber filter. Record the total volume filtered.
2. Once the sample is completely filtered, rinse the funnel with deionized water (about 10-20 mL). When nearly dry, use filter forceps to remove and fold the filter in half with the algae facing in, using the filtrate edge as a guide (not the filter edge). Then, fold the filter in half again while lining up the filtrate edge. Wrap the folded filter in aluminum foil and place it in a labeled bottle or bag Bottles should be labeled for each sample separately with the date, site, project, sample ID, and sample rep.
3. Store in the lab freezer. At the bottom of the prep worksheet record the time that the samples are placed in the freezer.
4. Compose a Chain of Custody with volume filtered, sample date, filtration date and sample ID (lab number or site name) of the individual samples.

Extraction

1. Retrieve the chlorophyll packet associated with the first available batch in the Chain of Custody from the lab freezer. Record date/time/analyst in the Chlorophyll Run Log.
2. In subdued lighting, unwrap sample filter from foil and make sure sample label information matches the Chlorophyll Run Log. Place folded filter in an opaque film canister.
3. Add 10 ml of buffered acetone to the canister 24 hours prior to analysis to extract chlorophyll pigments.
4. Store samples in freezer (-20 C) for 24 hours.

Chlorophyll-a Analysis

1. After 24 hours, analyze on the spectrophotometer.
2. Turn the spectrophotometer on 30 min before analysis. Make sure to auto zero the instrument at each wavelength before analysis.
3. Room lights should be dimmed during chlorophyll measurements to avoid changes in absorbance values.
4. Zero the spectrophotometer with a buffered acetone blank.
5. Wearing gloves, transfer 3 mL of extract to a 1-cm cuvette and read optical density (OD) at 750 and 664 nm. The absorption at 750 nm is subtracted from the reading at 664 nm to correct for the presence of turbidity and colored materials.
6. Acidify the extract in the cuvette with 0.1 mL of 0.1 N HCl. Gently agitate the acidified extract (lightly “flick” the cuvette with finger), wait for 90 sec, and read OD at 750 and at 665 nm.
7. Rinse the cuvette with 90% acetone and shake dry prior to measurement of the next sample.
8. Under test use the smart test Chl-a and Chl-a acid for before acidification and after acidification. Make sure you have 90% buffered acetone in the B slot when running the test.

Calculations

$$Chlorophyll - a\ (\mu g/L) = \frac{26.7\ (E_{664b} - E_{665a}) \times V_1}{V_2 \times L}$$

$$Pheophytin\ (\mu g/L) = \frac{26.7\ (1.7E_{665a} - E_{664b}) \times V_1}{V_2 \times L}$$

Chlorophyll/Pheophytin Ratio:

$$\text{Absorption peak ratio} = \frac{E_{665a}}{E_{664b}}$$

where:

E_{664b}= Subtract 750 nm value (turbidity correction) from absorbance at 664 nm before acidification

E_{665a} = turbidity-corrected absorbance at 665 nm after acidification

V_1 = volume of 90% Acetone (mL)

V_2 = volume of sample filtered (L)

L = path length (cm)

Quality Control

- If a blank failure occurs at the start of a batch, re-zero the spectrophotometer and reread the blank before continuing. If this does not correct the problem, run a 90% acetone sample to help determine whether the problem is caused by a spectrophotometer malfunction or blank contamination.
- As a laboratory control sample (LCS), analyze the chlorophyll a check standard at the beginning of every batch during spectrophotometric analysis.
- Calculate percent recovery of LCS as follows:

$$\%\ Rec = \frac{26.7\ (E_{664b} - E_{665a})}{4 \times 0.2} \times 100\%$$

  The acceptance limit for recovery is 85-115%.

- As a quick check of the standard during sample analysis, the difference between E_{664b} and E_{665a} should be between 0.025-0.034 AU to pass recovery limits. If the difference exceeds these limits, re-zero the spec and re-run the blank and standard.
- If standard has repeated low failures, it is possible that the standard was exposed to heat or light over time and has degraded. Make a new batch of working standard.
- Analyze a laboratory replicate for 5% of samples. The acceptance limit is ≤25% RPD.
- If absorbencies for sample duplicates do not appear similar, re-run both duplicates at the end of the batch.

Waste Disposal

Do not pour acetone or any reagent/standard containing acetone down the sink. Pour any waste acetone in the waste flask located in the fume hood. When this is full, empty the flask into an unfilled acetone bottle and label it with “Hazardous Waste”, waste content, amount, date generated and initials. Follow the Hazardous Waste Management manual to dispose of full waste acetone bottles.

References

10200 H. Chlorophyll. Standard Methods for the Examination of Water and Wastewater 20th edition.

Standard Operating Procedure for: Spectrophotometric Determination of Corrected and Uncorrected Chlorophyll a and Pheophytin, BB-29-1.2. Biology Section, Department of Environmental Protection Bureau of Laboratories, Tallahassee, Florida.

Standard Operating Procedure for Analysis of Chlorophyll-a in Water

General

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Phytoplankton containing chlorophyll a in a measured volume of sample is concentrated by filtration through a glass fiber filter. The photo-pigments are extracted from the phytoplankton by grinding the filter with a tissue grinder and steeping the filter slurry in 90% aqueous acetone solution overnight. The filter slurry is then centrifuged to clarify the solution and then the supernatant is transferred to a glass spectrophotometric cell. For the pheophytin corrected chlorophyll a, the sample's absorbance is measured at 750 and 664 nm before acidification and 750 and 665 nm after acidification with 0.1 N HCl. No calibration of the instrument is required. Absorbance values are entered into a set of equations in the computer that utilize the extinction coefficients of the pure pigments in 90% acetone. Concentrations are reported in µg/L.

Equipment and Supplies

Filtration

- Vacuum filtration system
- Whatman GF/C Glass Fiber Filter (e.g., 47 mm)
- Small roll of aluminum foil, cut in 3 inch squares
- 500 mL graduated cylinder
- Extra fine tip black marker
- 2 Rinse bottles (1 small, 1 large)

Extraction

- Film canister
- Buffered acetone
- Fume hood in dark room

Spectrophotometric analysis

- UV/Vis Spectrophotometer
- 1 cm path length UV quartz glass cuvette
- 1-5 mL pipette with tips

- 100 μL pipette with tips
- 0.1 N HCl

Reagents

Saturated Magnesium Carbonate Solution: Add 10 grams magnesium carbonate to 1000 mL of de-ionized water. The solution is allowed to settle for a minimum of 24 hours. Only the clear "powder free" solution is used during subsequent steps.

90 % (v/v) Buffered Acetone: Add 100 mL of the Magnesium Carbonate solution to 900 mL of ACS grade acetone in a 1-L volumetric flask.

0.1 N Hydrochloric Acid: Add 0.85 mL of concentrated HCl (ACS grade) to 100 mL of deionized water.

Chlorophyll-a check standard: To prepare a 0.5 mg/L reporting limit check standard, add 0.5 mL of a certified chlorophyll stock standard (10mg/L ± 1 mg/L, Turner Designs SKU: 10-850) with a 0.5 mL volumetric pipet to a 10 mL volumetric flask that has been rinsed with 90% aqueous acetone solution. Bring to volume with 90 % aqueous acetone solution and cap. Wrap flask in aluminum foil and store in refrigerator before use. Make fresh from stock each time right before samples are analyzed. Store stock solution in the freezer between uses.

Procedure

Filtration

1. Shake sample bottle to ensure sample is thoroughly mixed. Use a graduated cylinder to measure the volume of the sample. Filter as much volume as needed to clog the GF/C glass fiber filter. Record the total volume filtered.
2. Once the sample is completely filtered, rinse the funnel with deionized water (about 10-20 mL). When nearly dry, use filter forceps to remove and fold the filter in half with the algae facing in, using the filtrate edge as a guide (not the filter edge). Then, fold the filter in half again while lining up the filtrate edge. Wrap the folded filter in aluminum foil and place it in a labeled bottle or bag Bottles should be labeled for each sample separately with the date, site, project, sample ID, and sample rep.
3. Store in the lab freezer. At the bottom of the prep worksheet record the time that the samples are placed in the freezer.
4. Compose a Chain of Custody with volume filtered, sample date, filtration date and sample ID (lab number or site name) of the individual samples.

Extraction

1. Retrieve the chlorophyll packet associated with the first available batch in the Chain of Custody from the lab freezer. Record date/time/analyst in the Chlorophyll Run Log.
2. In subdued lighting, unwrap sample filter from foil and make sure sample label information matches the Chlorophyll Run Log. Place folded filter in an opaque film canister.
3. Add 10 ml of buffered acetone to the canister 24 hours prior to analysis to extract chlorophyll pigments.
4. Store samples in freezer (-20 C) for 24 hours.

Chlorophyll-a Analysis

1. After 24 hours, analyze on the spectrophotometer.
2. Turn the spectrophotometer on 30 min before analysis. Make sure to auto zero the instrument at each wavelength before analysis.
3. Room lights should be dimmed during chlorophyll measurements to avoid changes in absorbance values.
4. Zero the spectrophotometer with a buffered acetone blank.
5. Wearing gloves, transfer 3 mL of extract to a 1-cm cuvette and read optical density (OD) at 750 and 664 nm. The absorption at 750 nm is subtracted from the reading at 664 nm to correct for the presence of turbidity and colored materials.
6. Acidify the extract in the cuvette with 0.1 mL of 0.1 N HCl. Gently agitate the acidified extract (lightly “flick” the cuvette with finger), wait for 90 sec, and read OD at 750 and at 665 nm.
7. Rinse the cuvette with 90% acetone and shake dry prior to measurement of the next sample.
8. Under test use the smart test Chl-a and Chl-a acid for before acidification and after acidification. Make sure you have 90% buffered acetone in the B slot when running the test.

Calculations

$$Chlorophyll - a\ (\mu g/L) = \frac{26.7\ (E_{664b} - E_{665a}) \times V_1}{V_2 \times L}$$

$$Pheophytin\ (\mu g/L) = \frac{26.7\ (1.7E_{665a} - E_{664b}) \times V_1}{V_2 \times L}$$

Chlorophyll/Pheophytin Ratio:

$$\text{Absorption peak ratio} = \frac{E_{665a}}{E_{664b}}$$

where:

E_{664b}= Subtract 750 nm value (turbidity correction) from absorbance at 664 nm before acidification

E_{665a} = turbidity-corrected absorbance at 665 nm after acidification

V_1 = volume of 90% Acetone (mL)

V_2 = volume of sample filtered (L)

L = path length (cm)

Quality Control

- If a blank failure occurs at the start of a batch, re-zero the spectrophotometer and reread the blank before continuing. If this does not correct the problem, run a 90% acetone sample to help determine whether the problem is caused by a spectrophotometer malfunction or blank contamination.
- As a laboratory control sample (LCS), analyze the chlorophyll a check standard at the beginning of every batch during spectrophotometric analysis.
- Calculate percent recovery of LCS as follows:

$$\%\ Rec = \frac{26.7\ (E_{664b} - E_{665a})}{4 \times 0.2} \times 100\%$$

  The acceptance limit for recovery is 85-115%.

- As a quick check of the standard during sample analysis, the difference between E_{664b} and E_{665a} should be between 0.025-0.034 AU to pass recovery limits. If the difference exceeds these limits, re-zero the spec and re-run the blank and standard.
- If standard has repeated low failures, it is possible that the standard was exposed to heat or light over time and has degraded. Make a new batch of working standard.
- Analyze a laboratory replicate for 5% of samples. The acceptance limit is ≤25% RPD.
- If absorbencies for sample duplicates do not appear similar, re-run both duplicates at the end of the batch.

Waste Disposal

Do not pour acetone or any reagent/standard containing acetone down the sink. Pour any waste acetone in the waste flask located in the fume hood. When this is full, empty the flask into an unfilled acetone bottle and label it with “Hazardous Waste”, waste content, amount, date generated and initials. Follow the Hazardous Waste Management manual to dispose of full waste acetone bottles.

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Standard Operating Procedure for Total Nitrogen/Total Phosphorous

General

This method apply to digestion of natural water samples for analysis of total nitrogen and total phosphorous. Organic nitrogen and ammonium are converted to nitrate and phosphorous compounds are liberated as ortho-Phosphate-P. The TN and TP of the digested samples can be tested by The SEAL Methods for Nitrite/Nitrate (EPA-127-D Rev A) and o-Phosphate-P (EPA-155-D Rev 0), respectively.

Apparatus

Digestion Tubes: 20 mL vials with caps lined with Teflon7 liners. Soak vials and caps in 10% HCl for 24 hours, then rinse 3x with Milli-Q water (MQW). Do not clean with soap.

Autoclave: Capable of achieving a temperature of 120˚C for a minimum of 120 minutes.

Reagents

PPE: safety glasses, gloves, and lab coat.

Digestion Reagent

NaOH Reagent (1.5 M): **60 grams NaOH** in ~800 mL MQW in 1000 mL volumetric flask. Add MQW to the mark. (Note: Analyze any new batch of NaOH for N and P background. Some NaOH labelled Allow nitrogen has an unsuitably high background.)

$K_2S_2O_8$ Digestion Reagent: Dissolve 20 grams **Recrystallized $K_2S_2O_8$** and 50 mL of 1.5 M sodium hydroxide solution to 400 mL MQW in 500 mL volumetric flask. Add MQW to the mark. The persulfate requires washing/recrystallization to remove nitrogen contaminants. Persulfate recrystallization procedure: **Appendix A.**

Standards, Nitrogen Stock

500 ppm nitrate-N stock: Dry reagent grade potassium nitrate (KNO_3) for 2 hours at 105˚C. Dissolve 3.6090g in ~200 mL MQW in a 1000 mL volumetric flask. Dilute to the mark with MWQ.

50 ppm nitrate-N stock: Dry reagent grade potassium nitrate for 2 hours at 105˚C. Dissolve .361 g in ~200 mL MQW in a 1000 mL volumetric flask. Dilute to the mark with MQW. Alternative: Dilute 500 ppm N stock 1+9 with MQW.

500 ppm nitrite-N stock: Dry reagent grade sodium nitrite in a desiccator. Dissolve .616 g in about 50 mL MWQ in a 250 mL volumetric flask. Dilute to the mark with MWQ. Storage time is one month. This stock is diluted and digested for a cadmium column efficiency check.

Standards, Phosphorous stock

1000 ppm phosphate-P stock: Dry primary standard grade KH_2PO_4 for 2 hours at 105˚C. Dissolve .2195 g in ~80 mL MWQ in a 100 mL volumetric flask. Dilute to the mark with MWQ.

25 ppm phosphate-P intermediate standard stock: Add 2.5 mL of 1000 ppm phosphate stock into a 100 mL volumetric flask. Dilute to the mark with MWQ.

Standards, spiking

50 ppm N stock: The 50 ppm N stock prepared above can be used although an independently prepared stock of the same concentration in preferred.

25 ppm N stock: The 25 ppm P stock prepared above can be used although an independently prepared stock of the same concentration in preferred.

Working standards, low level Nitrogen:

Standard Conc. mg N/L	Vol. Of Stock mL	Conc. Of Stock mg/L	Final Volume mL
1.0	4.0	50	200
0.5	1.0	50	100
0.1	0.2	50	100
0.05*	0.1	50	100
0.02	0.04	50	100
0.01	0.02	50	100

*Concentration used for midpoint check standard

1.0 mg/L nitrite-N (column efficiency check standard). Add 0.200 mL of 500 ppm nitrite-N stock to a 100 mL volumetric flask. Add MQW to the mark.

Working standards, low level Phosphorous

Standard Conc. µg P/L	Vol. of Stock mL	Conc. of Stock mg/L	Final Volume mL
500	1.0	50	100
200	0.400	50	100
100	0.200	50	100
50*	0.200	50	200
20	0.200 0.020	5 50	100
10	0.100 0.010	5 50	100

* Concentration used for midpoint check standard

These are the working standards most frequently used for the analysis of TN and TP. Alternate standards for other ranges may be found in the analytical procedure for that range. Standards other than those specified can be calculated as well. Expanded ranges should also be checked

for complete digestion using standards and spikes. TN has routinely been run up to 50 mg/L and TP up to 25 mg/L for some projects (primarily wastewater).

Procedure

1. Pipette 8 mL (using 10 mL pipette) of each standard or sample into digestion tube. Rinse the pipette tip three times with MQW between sets of standards and between standards and samples.
2. Additional samples/standards to be included in any run are:
    a. Method blank (CCB): at least one MQW must be digested per tray of 30 samples.
    b. Check standards (CCV): at least one extra mid-range must be digested per tray of 30 samples.
    c. Column efficiency check: at least one must be digested with each set of samples to determine the efficiency of the cadmium coil for nitrate-N determination. Digesting 2 replicates is preferred.
    d. QC standards: at least one mid-range QC should be digested with the run. Digesting 2 or more replicates is preferred in case digests must be re-run.
    e. Spikes (SPKM): 10% of low level samples should be spiked by adding 16 µL of 25 ppm P stock and 16 µL of N (Urea) stock.
3. Add 4 mL (with a 5 mL pipette) $K_2S_2O_8$ digestion solution to sample and standards.
4. Cover sample with foil and cap with Teflon7 lined cap. Invert rack to mix.
5. Autoclave for 50 minutes at 121˚C (250˚F) @ 17 psi.
6. When digestion cycle is complete and pressure and temperature gages on autoclave indicate 0 psi (0 kPa) and less than 80°C, remove the digests from the autoclave and allow them to cool sufficiently to be handled comfortably. Mix each tube by manual inversion (3 times).
7. If the digests are not going to be processed immediately, cool them to room temperature and then refrigerate (holding time after digestion is 28 days).
8. Analyze for PO_4^{3-} per SEAL o-Phosphate-P (EPA-155-D Rev 0).
9. Analyze for (NO_3^- + NO_2^-) -N as per SEAL Nitrite/Nitrate (EPA-127-D Rev A).

QAQC in general

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action
Minimum Five-point initial Calibration	Initial calibration prior to sample analysis	Correlation coefficient for linear regression > 0.998	Correct problem then repeat initial calibration
Method blank	One per analytical batch of 10 samples or less	No analytes detected	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank
Continuing Calibration verification Standard (CCV)	One per analytical batch of 10 samples or less	±10%	Re-analyze CCV. If same response is obtained, trouble shoot the instrument & re-start analysis. If same response is obtained, prepare new standards & re-start analysis.
Matrix Spikes (SPKM)	One per analytical batch of 10 samples or less	±20%	Re-analyze and re-make if needed. If results are not acceptable, spike a different sample. If second sample is not acceptable, spike all samples in that work order to check for matrix interference. If second spike is acceptable notify your supervisor.
Replicate/Duplicate Sample	One per analytical batch of 10 samples or less	±10%	Re-analyze sample. If same response is obtained, trouble shoot process. Re-analyze affected samples as appropriate.

Waste Disposal

Waste cannot be sewered. All waste is to be poured into labeled hazardous waste. Waste is not to be stored for longer than 90 days.

Appendix A: Potassium persulfate recrystallization

1. Dissolve 100 g of potassium persulfate in approximately 600 ml of MQW previously heated to 60° C. Use a stir bar and a 1000 mL flask.
2. Filter the solution rapidly through a sintered glass funnel.
3. Rinse the 1000 mL flask.
4. Pour filtrate back into the flask used to heat the potassium persulfate solution.
5. Cool solution to about 4° C by placing the flask in ice water. Whirl the flask continuously to prevent the solution from freezing.
6. Filter the 4° C solution and wash with 1 or 2 squeezes of ice cold MQW, save the white solid.
7. Discard the filtrate from the sidearm flask.
8. Rinse the flask used to cool the solution with MQW.
9. Fill the flask with 450ml of MQW and heat to 60° C.
10. Add the crystals from step 5 and mix into solution.
11. Repeat steps 4 and 5. The white granules on top of the filter are crystals.
12. Dry crystals in vacuum over anhydrous calcium chloride. Rapid drying in a good vacuum and thus at a low temperature is essential as this will minimize the sulfuric acid formation on the crystals.

The yield is about 80%. The effect is illustrated by the blank obtained in the standard procedure: 0.178 µmole for the original reagent, 0.020 µmole after one recrystallization and 0.010 µmole of N after two recrystallizations.

Standard Operating Procedure for Total Nitrogen/Total Phosphorous

General

This method apply to digestion of natural water samples for analysis of total nitrogen and total phosphorous. Organic nitrogen and ammonium are converted to nitrate and phosphorous compounds are liberated as ortho-Phosphate-P. The TN and TP of the digested samples can be tested by The SEAL Methods for Nitrite/Nitrate (EPA-127-D Rev A) and o-Phosphate-P (EPA-155-D Rev 0), respectively.

Apparatus

Digestion Tubes: 20 mL vials with caps lined with Teflon7 liners. Soak vials and caps in 10% HCl for 24 hours, then rinse 3x with Milli-Q water (MQW). Do not clean with soap.

Autoclave: Capable of achieving a temperature of 120˚C for a minimum of 120 minutes.

Reagents

PPE: safety glasses, gloves, and lab coat.

Digestion Reagent

NaOH Reagent (1.5 M): **60 grams NaOH** in ~800 mL MQW in 1000 mL volumetric flask. Add MQW to the mark. (Note: Analyze any new batch of NaOH for N and P background. Some NaOH labelled Allow nitrogen has an unsuitably high background.)

$K_2S_2O_8$ Digestion Reagent: Dissolve 20 grams **Recrystallized $K_2S_2O_8$** and 50 mL of 1.5 M sodium hydroxide solution to 400 mL MQW in 500 mL volumetric flask. Add MQW to the mark. The persulfate requires washing/recrystallization to remove nitrogen contaminants. Persulfate recrystallization procedure: **Appendix A.**

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50 ppm nitrate-N stock: Dry reagent grade potassium nitrate for 2 hours at 105˚C. Dissolve .361 g in ~200 mL MQW in a 1000 mL volumetric flask. Dilute to the mark with MQW. Alternative: Dilute 500 ppm N stock 1+9 with MQW.

500 ppm nitrite-N stock: Dry reagent grade sodium nitrite in a desiccator. Dissolve .616 g in about 50 mL MWQ in a 250 mL volumetric flask. Dilute to the mark with MWQ. Storage time is one month. This stock is diluted and digested for a cadmium column efficiency check.

Standards, Phosphorous stock

1000 ppm phosphate-P stock: Dry primary standard grade KH_2PO_4 for 2 hours at 105˚C. Dissolve .2195 g in ~80 mL MWQ in a 100 mL volumetric flask. Dilute to the mark with MWQ.

25 ppm phosphate-P intermediate standard stock: Add 2.5 mL of 1000 ppm phosphate stock into a 100 mL volumetric flask. Dilute to the mark with MWQ.

Standards, spiking

50 ppm N stock: The 50 ppm N stock prepared above can be used although an independently prepared stock of the same concentration in preferred.

25 ppm N stock: The 25 ppm P stock prepared above can be used although an independently prepared stock of the same concentration in preferred.

Working standards, low level Nitrogen:

Standard Conc. mg N/L	Vol. Of Stock mL	Conc. Of Stock mg/L	Final Volume mL
1.0	4.0	50	200
0.5	1.0	50	100
0.1	0.2	50	100
0.05*	0.1	50	100
0.02	0.04	50	100
0.01	0.02	50	100

*Concentration used for midpoint check standard

1.0 mg/L nitrite-N (column efficiency check standard). Add 0.200 mL of 500 ppm nitrite-N stock to a 100 mL volumetric flask. Add MQW to the mark.

Working standards, low level Phosphorous

Standard Conc. µg P/L	Vol. of Stock mL	Conc. of Stock mg/L	Final Volume mL
500	1.0	50	100
200	0.400	50	100
100	0.200	50	100
50*	0.200	50	200
20	0.200 0.020	5 50	100
10	0.100 0.010	5 50	100

* Concentration used for midpoint check standard

These are the working standards most frequently used for the analysis of TN and TP. Alternate standards for other ranges may be found in the analytical procedure for that range. Standards other than those specified can be calculated as well. Expanded ranges should also be checked

for complete digestion using standards and spikes. TN has routinely been run up to 50 mg/L and TP up to 25 mg/L for some projects (primarily wastewater).

Procedure

1. Pipette 8 mL (using 10 mL pipette) of each standard or sample into digestion tube. Rinse the pipette tip three times with MQW between sets of standards and between standards and samples.
2. Additional samples/standards to be included in any run are:
    a. Method blank (CCB): at least one MQW must be digested per tray of 30 samples.
    b. Check standards (CCV): at least one extra mid-range must be digested per tray of 30 samples.
    c. Column efficiency check: at least one must be digested with each set of samples to determine the efficiency of the cadmium coil for nitrate-N determination. Digesting 2 replicates is preferred.
    d. QC standards: at least one mid-range QC should be digested with the run. Digesting 2 or more replicates is preferred in case digests must be re-run.
    e. Spikes (SPKM): 10% of low level samples should be spiked by adding 16 µL of 25 ppm P stock and 16 µL of N (Urea) stock.
3. Add 4 mL (with a 5 mL pipette) $K_2S_2O_8$ digestion solution to sample and standards.
4. Cover sample with foil and cap with Teflon7 lined cap. Invert rack to mix.
5. Autoclave for 50 minutes at 121˚C (250˚F) @ 17 psi.
6. When digestion cycle is complete and pressure and temperature gages on autoclave indicate 0 psi (0 kPa) and less than 80°C, remove the digests from the autoclave and allow them to cool sufficiently to be handled comfortably. Mix each tube by manual inversion (3 times).
7. If the digests are not going to be processed immediately, cool them to room temperature and then refrigerate (holding time after digestion is 28 days).
8. Analyze for PO_4^{3-} per SEAL o-Phosphate-P (EPA-155-D Rev 0).
9. Analyze for (NO_3^- + NO_2^-) -N as per SEAL Nitrite/Nitrate (EPA-127-D Rev A).

QAQC in general

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action
Minimum Five-point initial Calibration	Initial calibration prior to sample analysis	Correlation coefficient for linear regression > 0.998	Correct problem then repeat initial calibration
Method blank	One per analytical batch of 10 samples or less	No analytes detected	Correct problem then re-prep and analyze method blank and all samples processed with the contaminated blank
Continuing Calibration verification Standard (CCV)	One per analytical batch of 10 samples or less	±10%	Re-analyze CCV. If same response is obtained, trouble shoot the instrument & re-start analysis. If same response is obtained, prepare new standards & re-start analysis.
Matrix Spikes (SPKM)	One per analytical batch of 10 samples or less	±20%	Re-analyze and re-make if needed. If results are not acceptable, spike a different sample. If second sample is not acceptable, spike all samples in that work order to check for matrix interference. If second spike is acceptable notify your supervisor.
Replicate/Duplicate Sample	One per analytical batch of 10 samples or less	±10%	Re-analyze sample. If same response is obtained, trouble shoot process. Re-analyze affected samples as appropriate.

Waste Disposal

Waste cannot be sewered. All waste is to be poured into labeled hazardous waste. Waste is not to be stored for longer than 90 days.

Appendix A: Potassium persulfate recrystallization

1. Dissolve 100 g of potassium persulfate in approximately 600 ml of MQW previously heated to 60° C. Use a stir bar and a 1000 mL flask.
2. Filter the solution rapidly through a sintered glass funnel.
3. Rinse the 1000 mL flask.
4. Pour filtrate back into the flask used to heat the potassium persulfate solution.
5. Cool solution to about 4° C by placing the flask in ice water. Whirl the flask continuously to prevent the solution from freezing.
6. Filter the 4° C solution and wash with 1 or 2 squeezes of ice cold MQW, save the white solid.
7. Discard the filtrate from the sidearm flask.
8. Rinse the flask used to cool the solution with MQW.
9. Fill the flask with 450ml of MQW and heat to 60° C.
10. Add the crystals from step 5 and mix into solution.
11. Repeat steps 4 and 5. The white granules on top of the filter are crystals.
12. Dry crystals in vacuum over anhydrous calcium chloride. Rapid drying in a good vacuum and thus at a low temperature is essential as this will minimize the sulfuric acid formation on the crystals.

The yield is about 80%. The effect is illustrated by the blank obtained in the standard procedure: 0.178 µmole for the original reagent, 0.020 µmole after one recrystallization and 0.010 µmole of N after two recrystallizations.

Appendix C

K&A Final Black Lake Interim Report (2025)

KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING

Technical Memorandum

To:	Rusty Gowland, President Bev Haas, Secretary, Steve Speth, Board Member Black Lake Preservation Society	**Date:**	December 16, 2025
From:	Mark Kieser, Senior Scientist Kieser & Associates, LLC	**cc:**	Lauren Day, Associate Director, TOMWC Natalie Crum, Project Manager, K&A
RE:	Interim Phase II & III Water Quality Monitoring Report for Black Lake, Cheboygan and Presque Isle Counties, Michigan		

Overview

The Black Lake Preservation Society (BLPS) retained Kieser & Associates, LLC (K&A) in February of 2023 to support their interest and related concerns for protecting the water quality of Black Lake. Situated in Cheboygan and Presque Isle counties of northern lower Michigan, Black Lake is a 10,000-acre waterbody with a watershed area of approximately 547 square miles. The lake supports a variety of warm and cool water fish species including the presence of lake sturgeon (specifically reared in the lake and Upper Black River). BLPS water quality concerns relate to recent occurrences of Harmful Algal Blooms (HABs) that began appearing in late fall of 2020. With no obvious explanations for these blooms, K&A recommended targeted collection of relevant water quality information to begin to pinpoint possible causes.

Subsequent to 2020 HABs events, additional occurrences were documented in 2021 and 2022, then again in 2024 and 2025. While the watershed of Black Lake is largely undeveloped, and historically collected data otherwise suggest exceptional water quality conditions in tributaries and the lake, the onset of these reported blue-green algal blooms prompted BLPS to seek water resources consulting support. K&A identified a range of information gathering needs in these regards. A series of phased work plans have been authorized by the BLPS since 2023 for the purposes of performing lake, tributary, sediment and groundwater monitoring and analysis of Black Lake conditions. The information presented in this memorandum details the ongoing compilation of these recent studies attempting to define potential causes of HABs events. These efforts will ultimately target management needs to mitigate causal factors. Such efforts are now operating concurrently with the development of a Watershed Management Plan (WMP) being led by the Tip of the Mitt Watershed Council (Council). This memorandum is being submitted on behalf of the BLPS to the Council for inclusion in the WMP to support future water quality protection and restoration needs for Black Lake.

As such, this Technical Memorandum is considered an interim K&A summary of monitoring results describing BLPS and K&A monitoring and assessment activities on Black Lake. It has been prepared for sharing relevant information with the Council and WMP stakeholders as the impetus for developing future planning needs and initiatives for mitigation specific to the lake (and not the contributing watershed). Updates are expected given forthcoming 2026 monitoring efforts by K&A that will build upon findings herein. Outcomes to date have been synthesized as priority actions for inclusion in related sections of the WMP draft submission to the Michigan Department of Environment, Great Lakes, and Energy (EGLE).

Monitoring data collected by the Council are not yet available for integration with interim K&A analyses presented herein. It is expected that data being separately collected under the auspices of the WMP efforts will ultimately be integrated for optimal planning in later updates of this memorandum as appropriate. K&A's assessments described herein principally focus on issues contributing to overall water quality conditions in the lake, particularly related to phosphorus loading as the causal factor for HABs. The assessment does not seek to define broader watershed phosphorus loading management needs as will become evident with K&A findings. The WMP will otherwise address relevant needs in the broader watershed.

Background

K&A received BLPS authorizations to complete a range of phased efforts to build upon historic data reviews and ongoing collection of new data. Phases I and II are largely completed with relevant findings reported in this technical memorandum. Phase III efforts are also nearly complete with the exception of final shallow groundwater monitoring at an established nearshore location scheduled in May, 2026. Otherwise, collected data and analyses to date are reported herein.

Successive phases of K&A work are outlined as follows.

Phase I

- BLPS Board interactions for input and feedback on emerging issues
- Review of HABs conditions to identify potential data gaps and next step considerations
- Completion of a preliminary phosphorus (P) mass balance using readily available information to clarify phosphorus source contributions to Black Lake
- Compilation of Phase I findings

Phase II

- Install real-time automated lake water level/temperature instrumentation in the Upper and Lower Black Rivers in close proximity to the lake
- Conduct water quality sampling of the lake, tributaries and groundwater
- Measure tributary flows during sample collection
- Compute tributary phosphorus loads using flow and concentration data

- Collect and analyze Black Lake sediments for chemical parameters and possible presence of blue-green algal species (i.e., cyanobacteria)
- Compile CLMP data collected by the BLPS as it becomes available
- Conduct shallow groundwater testing at select shoreline locations for phosphorus and bacteria associated with septic system drain field discharges

Phase III

- Develop and deploy a voluntary, online Septic System survey for Black Lake residents
- Expand shoreline groundwater testing with additional volunteer sites
- Support the WMP HABs subcommittee with K&A findings
- Provide information and support for WMP integration of septic system considerations for Black Lake

Information from these efforts is reported in the remainder of this memorandum. For K&A monitoring efforts to date, laboratory reports are provided in Attachment A.

Lake Water Quality Monitoring

Both the BLPS and K&A have been conducting water quality sampling on and around Black Lake since 2023. BLPS participation in the Cooperative Lakes Monitoring Program (CLMP) collects data throughout the summer while K&A monitoring focused on water quality conditions in August of 2023 and May of 2024. CLMP monitors one deep lake station whereas K&A monitored six Black Lake locations in 2023 (Figure 1); three open-lake locations (BLD-1 to BLD-3) (43-45 feet deep) and three nearshore stations (BLS-1 to BLS-3) (3-6 feet deep). A subset of the 2023 stations was monitored by K&A in 2024.

Both data sets are relevant to describing important conditions during the ice-free season when HABs events may occur on Black Lake. CLMP data for dissolved oxygen/temperature profiles illustrate year-to-year variability in how the lake stratifies. This influences important ecological and physico-chemical conditions in the lake. As such, K&A first summarizes 2023 and 2024 DO/temperature profile data from CLMP efforts to enhance characterization of Black Lake water quality conditions in alignment with K&A efforts. (CLMP data from 2025 were not available at the time of this reporting.) Following the presentation of select BLPS data, K&A data are presented throughout the remainder of this document.

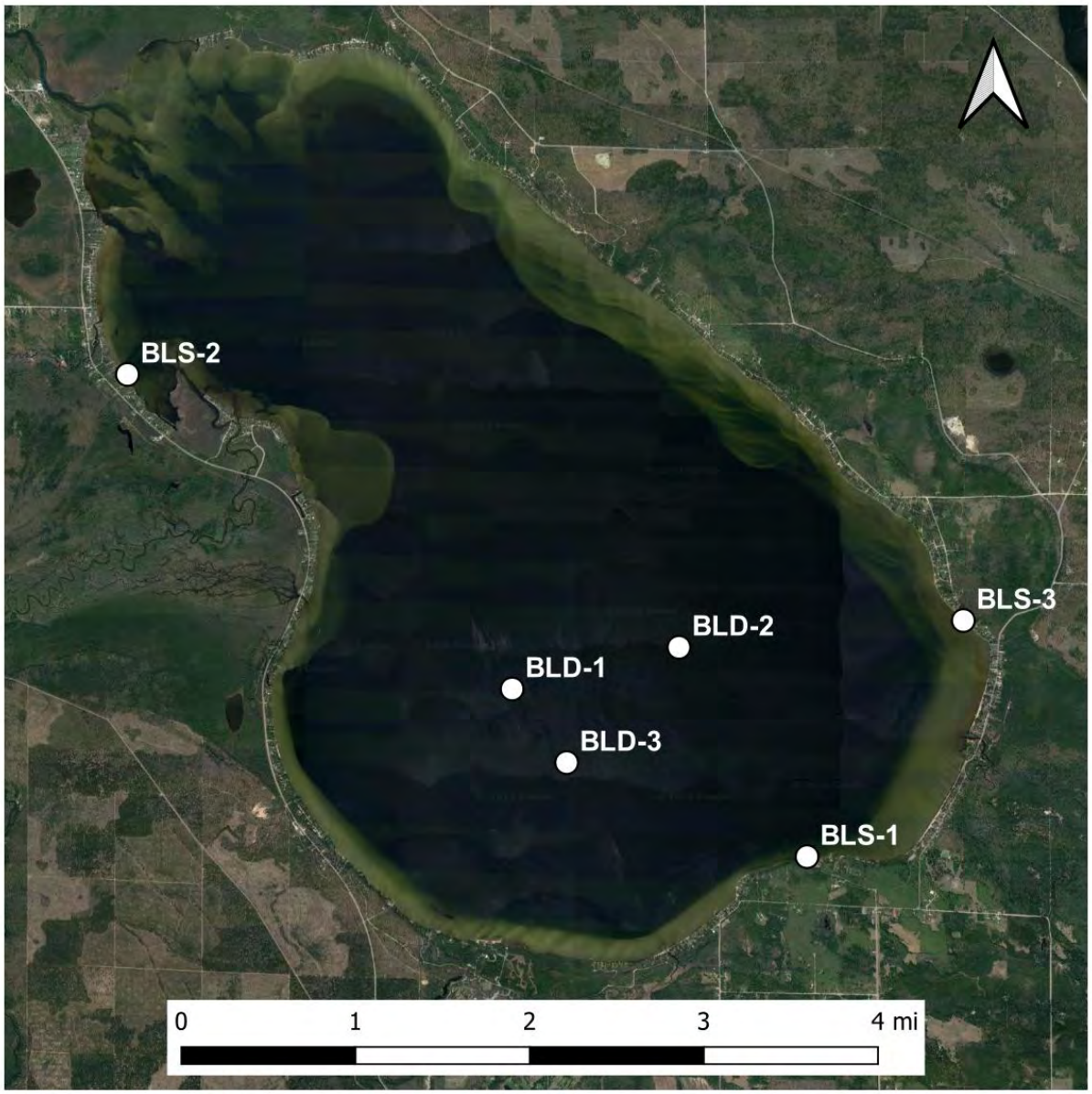


Figure 1 – K&A Black Lake water quality sampling locations.

CLMP Data Collection by BLPS

CLMP is a lake water quality sampling program through which volunteers collect and report water quality parameters for lakes throughout Michigan. Collected data typically include temperature and dissolved oxygen profiles, concentrations of chlorophyll *a* and Total Phosphorus (TP), and Secchi disk readings. The BLPS began participation in this program in 2023. As such, they collected monthly to twice-monthly dissolved oxygen and temperature profiles throughout 2023, 2024, and 2025.

Dissolved oxygen and temperature data that are now uploaded on the CLMP website, are plotted in Figures 2-5 for the CLMP deep-water station just north of BLD-1 in Figure 1.[1] Figure 2 presents the DO depth profiles for 2023; Figure 3 presents corresponding temperature profiles. Corresponding data from 2024 is presented in Figures 4 and 5, respectively. Differing patterns of stratification are discussed following Figure 5.

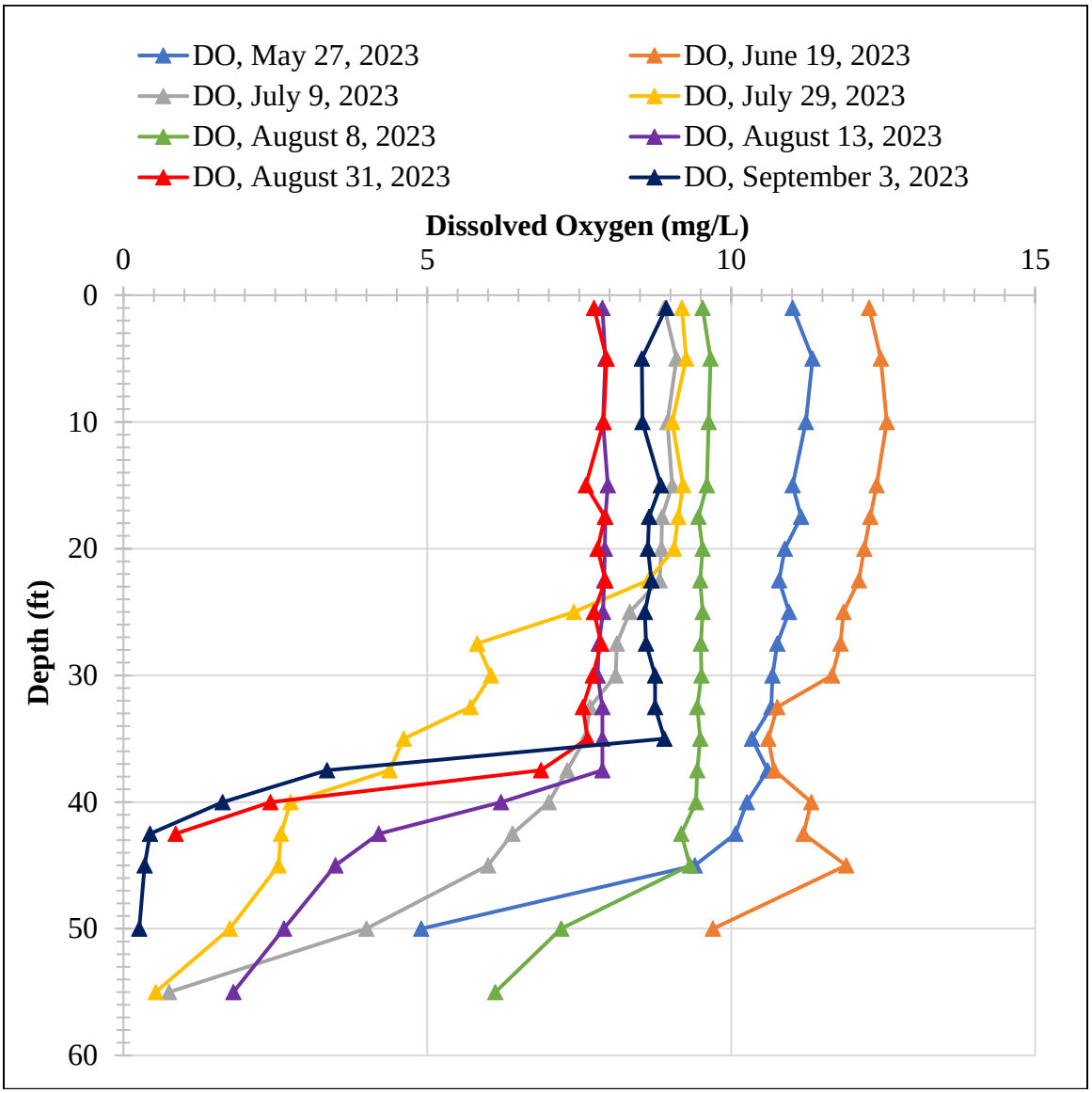


Figure 2 - CLMP Black Lake dissolved oxygen profiles for 2023.

[1] E-mail Communication from Marie Slocum, BLPS CLMP volunteer to the BLPS and K&A on March 19, 2025.

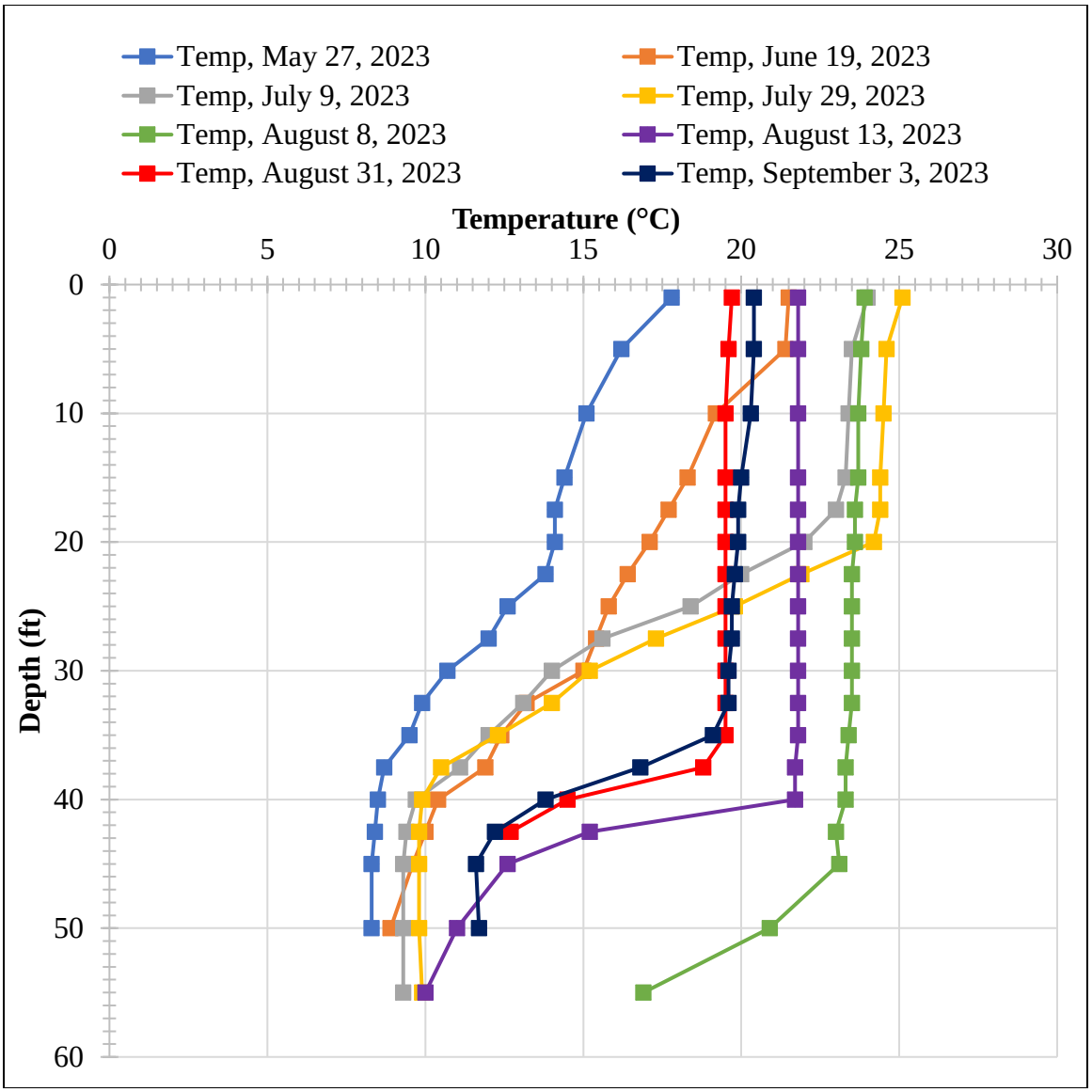


Figure 3 - CLMP Black Lake temperature profiles for 2023.

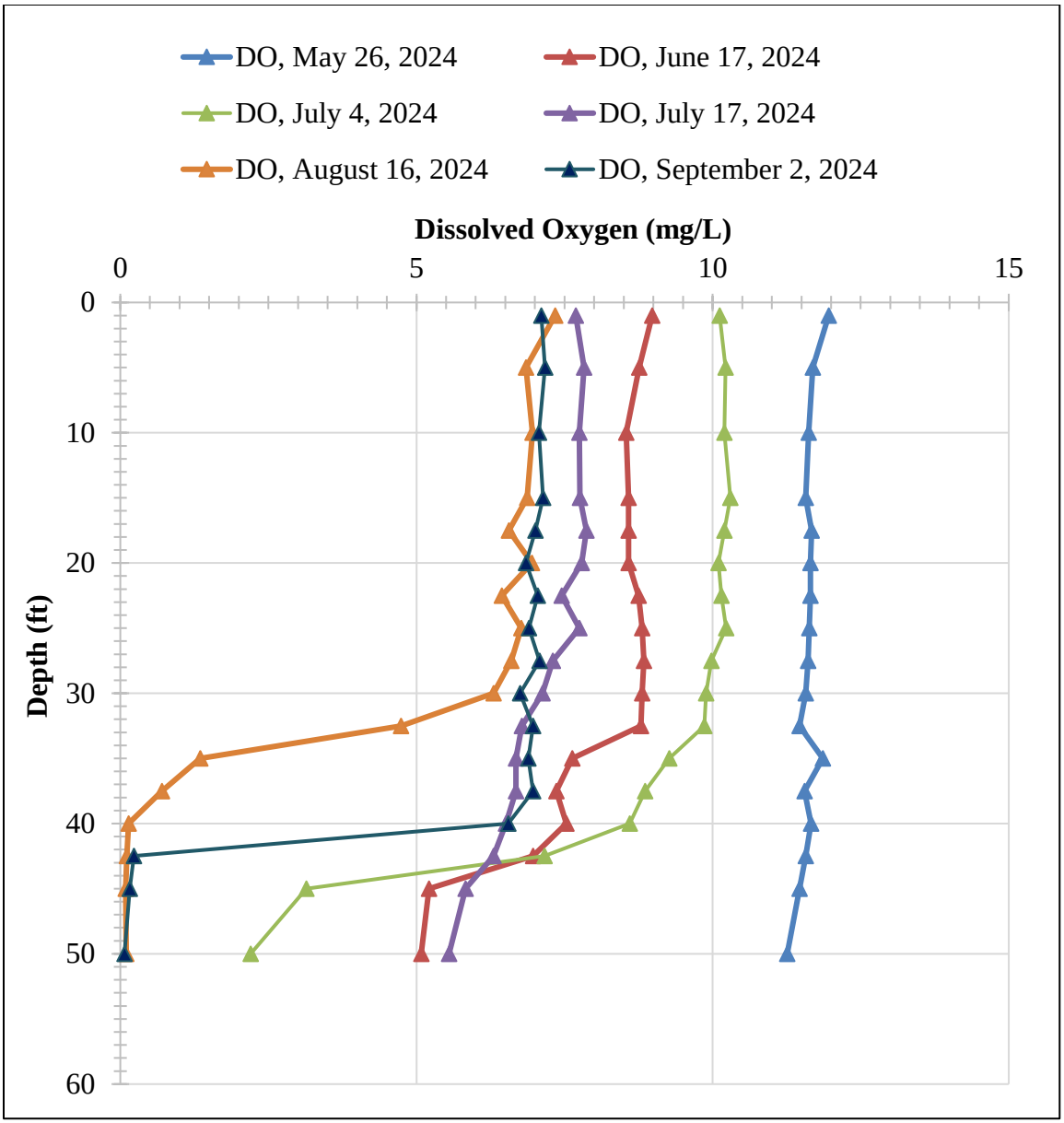


Figure 4 - CLMP Black Lake dissolved oxygen profiles for 2024.

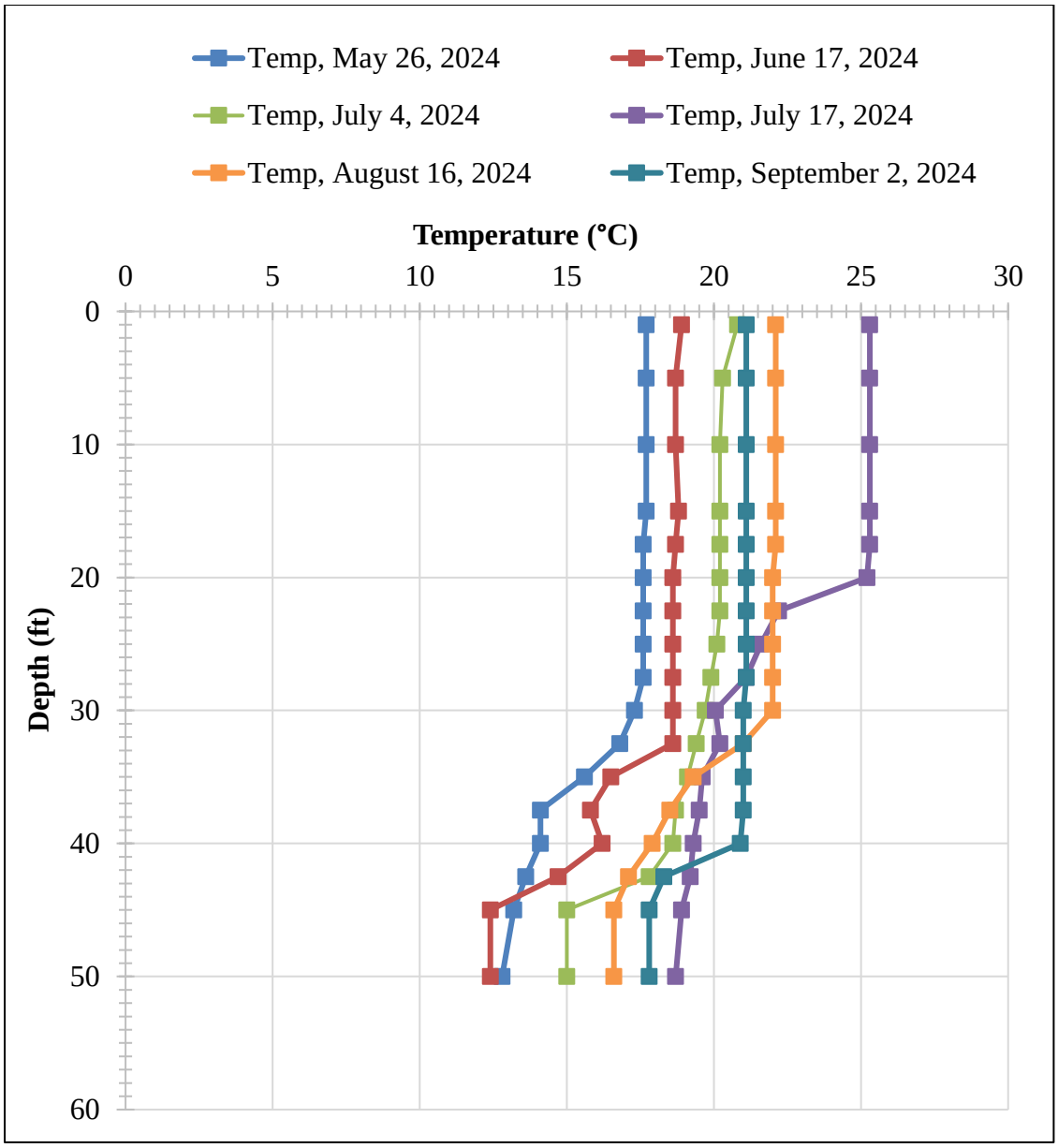


Figure 5 - CLMP Black Lake temperature profiles for 2024.

Relevant information from these profiles is summarized here reflecting substantial variations in year-to-year stratification conditions.

- Bottom water DO levels dropped below the 5 mg/L MI EGLE threshold for extended periods in July through August of 2023
- Bottom water DO in 2024 went below 5 mg/L for only a portion of the summer season
- Generally weak thermal stratification was noted throughout the summer monitoring period in 2024 compared to 2023 suggesting more wind-induced water column mixing in 2024
- Bottom water temperatures were moderate in 2024 and by mid-July, generally remained above 17°F; bottom water temperatures in deeper lakes that do not experience wind-driven circulation below the thermocline are typically <10°F

by late summer (compared to 8-11°F for comparable 2023 Black Lake bottom temperatures)

Year-to-year variations in physical conditions of the lake with respect to dissolved oxygen and temperature are quite evident with two years of comparative data (2023 and 2024). These DO/temperature data provide a valuable reference to conditions that influence critical ecological considerations, particularly the fisheries community of the lake, as well as potential physico-chemical influences exerted by lake sediments in areas of the lake bottom that experience low dissolved oxygen.

2023 Late Summer K&A Sampling

Water quality samples were collected by K&A on August 31, 2023 at all sites.[2] Samples at open-lake stations were collected at the surface, middle, and bottom depths, and at mid-depths for nearshore stations. Samples collected from each open-lake site were analyzed for total phosphorus (TP), soluble reactive phosphorus (SRP), and nitrate-nitrogen (NO_3). In addition, DO, temperature, and conductivity were measured from the surface to bottom at three-foot intervals. Secchi disk depth was measured at each of the open lake stations, and a chlorophyll *a* sample was collected at BLD-1 using a composite sampler lowered to two-times the Secchi depth.

NO_3 and iron analyses were conducted at Merit Laboratories, Inc., of Lansing, Michigan. Chlorophyll *a*, SRP, and TP analyses were conducted by Great Lakes Environmental Center (GLEC) in Traverse City, Michigan.

August 2023 water quality sampling results are summarized in Table 1. Non-detect and/or low nitrate and iron concentrations were found throughout the water column at both open lake and nearshore stations. K&A Secchi disk readings at open lake stations ranged from 11.9 - 16.0 feet, indicative of mesotrophic conditions.[3] SRP levels at all locations and all depths were very low ($\leq$ 2 µg/L) for both open water and nearshore stations. These indicate likely P-limiting algal growth conditions. They may also reflect the higher chlorophyll *a* level measured in open water (i.e., 5 µg/L). Lower SRP levels are typical of oligotrophic and mesotrophic lakes at this time of the season often due to algal uptake.

TP concentrations ranged from 17-33 µg/L at open lake stations across all depths sampled, and from 25-38 µg/L at nearshore stations. TP levels at open lake stations were relatively consistent throughout the water column at each open lake location. While DO/temperature profiles were very consistent across all three of these stations (Figures 6-8), notable TP variations were, however, observed between locations (e.g., 17 µg/L at BLS-2, 23 µg/L at BLS-1, and 33 µg/L at BLS-3). Though sampling conditions on the date of sample collection where calm, TP variability between these locations may

[2] Sampling participants included Mark Kieser and Natalie Crum of K&A, and Marie Slocum of the BLPS.
[3] Carlson, R. E. (1996). A coordinator's guide to volunteer lake monitoring methods. North American Lake Management Society, 96, 305.

preliminarily suggest lake circulation pattern influence. These were 50-300% higher than the level reported for comparable late summer 2023 CLMP sampling.

Table 1 - Black Lake August 31, 2023 in-lake sample results from K&A monitoring.

Site	Nitrate (µg/L)	Iron (mg/L)	SRP (µg/L)	TP (µg/L)	Chlorophyl *a* (µg/L)
BLD-1B	<500	<0.02	2	25	-
BLD-1M	<500	<0.02	2	23	-
BLD-1S	<500	<0.02	2	23	5
BLD-2B	<500	0.02	2	18	-
BLD-2M	<500	<0.02	1	18	-
BLD-2S	<500	<0.02	1	17	-
BLD-3B	<500	0.02	1	32	-
BLD-3M	<500	<0.02	2	33	-
BLD-3S	<500	<0.02	2	33	-
BLS-1M	<500	0.05	3	25	-
BLS-2M	<500	0.04	1	33	-
BLS-3M	<500	<0.02	2	38	-

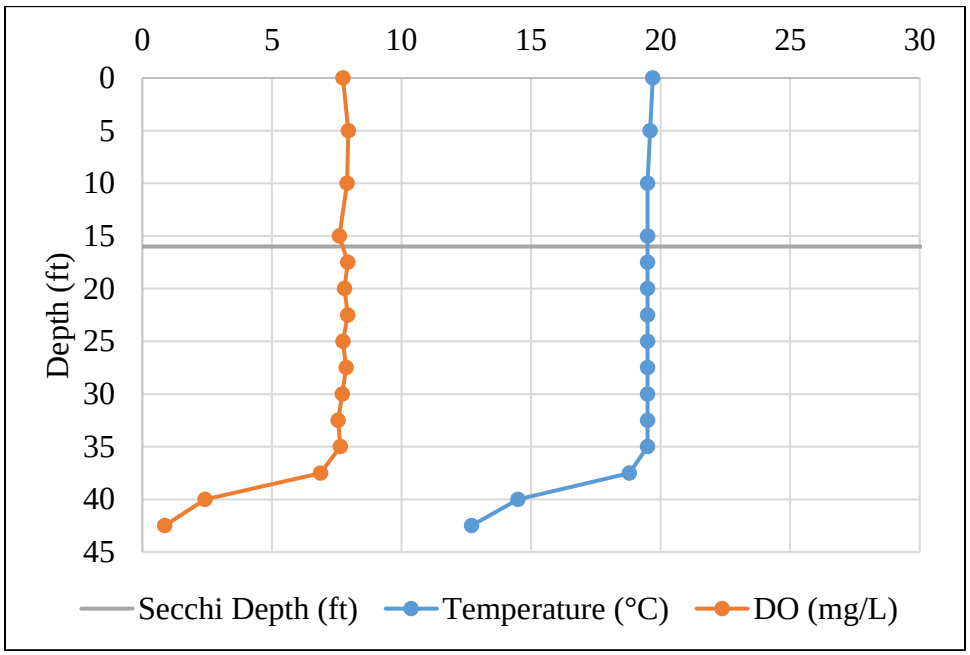


Figure 6 - August 31, 2023 BLD-1 temperature and dissolved oxygen profiles.

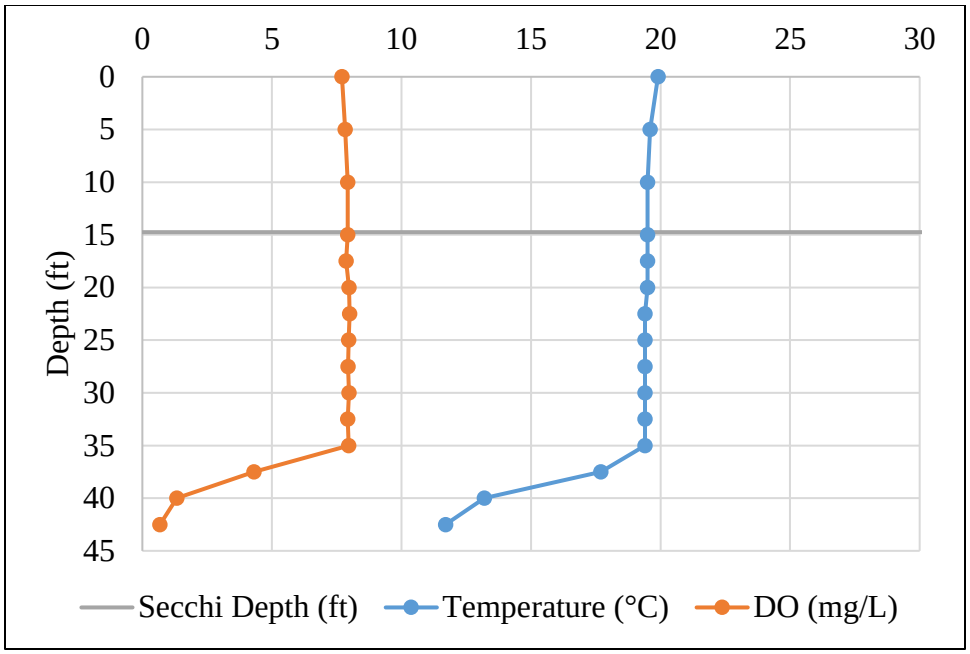


Figure 7 - August 31, 2023 BLD-2 temperature and dissolved oxygen profiles.

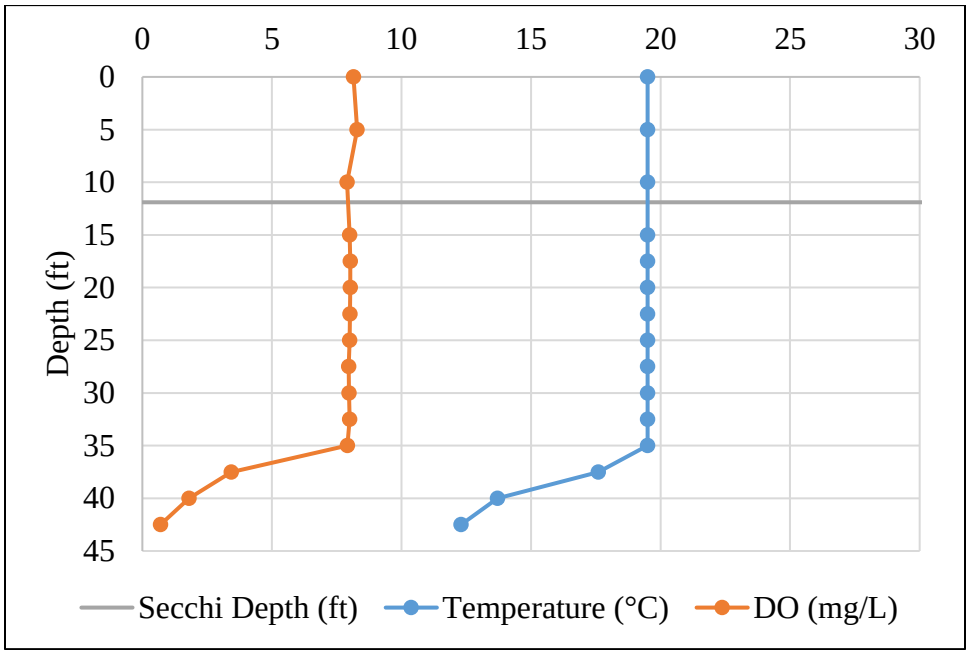


Figure 8 - August 31, 2023 BLD-3 temperature and dissolved oxygen profiles.

Some TP variability was also noted between nearshore sampling locations (25-38 µg/L). Of these, the lowest nearshore concentration was observed off the public boat launch at Onaway State Park where there were no nearby shoreline residences or inflowing tributaries.

In the embayment near the mouth of Mud Creek and the Upper Black River confluence with Black Lake, the nearshore TP concentration was 33 µg/L. As noted later in Table 4

of this document, measured TP concentrations in these two rivers were 30 µg/L and 29 µg/L, respectively. Concurrent flow measurements from the Upper Black and Mud Creek at the time of this sampling suggest that they are quite likely the dominant water quality influencers at this nearshore location. At nearshore station BLS-3, TP was measured at 38 µg/L. This location was in close proximity to an extended area of shoreline residential properties, and quite distant from the nearest tributary to the south (i.e., the Rainy River/Cold Creek confluence).

Sediment Sampling

Sediment samples were taken at all 3 "Deep" stations in order to analyze sediment phosphorus concentrations and iron/phosphorus ratios (Table 2). Phosphorus concentrations were slightly elevated on a mg/kg basis, but not to a point that should cause concern. This is especially true given the high presence of iron and the resulting iron/phosphorus ratios of 30 and higher. This is a strong indicator of sediment phosphorus retention[4] and backs up the mass balance determination that the lake sediment is acting as a sink rather than a source.

Table 2 - Black Lake sediment sampling results.

Station	Iron (mg/kg)	TP (mg/kg)	Ratio (Iron/TP)
BLD-1	44,000	1,280	34.4
BLD-2	52,000	1,490	34.9
BLD-3	44,000	1,470	29.9

Notable with sediments was the identification of the blue-green algal species, *Dolichospermum*. A composite surficial sample from each of the three sediment samples (see inset photo at right of Black Lake sediments) revealed the presence this toxin-producing species that is nitrogen-fixing with gas vesicles that can make it planktonic. Blooms of this blue-green can often form during calm weather. Sampling of such a bloom on Black Lake in November 16, 2024 would go on to show the remarkable, near monolithic composition of *Dolichospermum* in the HABs bloom. (See Attachment A for PhycoTech, Inc. species testing results.)



2024 Spring K&A Sampling

Spring sampling of in-lake water quality was conducted on May 15, 2024 at one deep station, BLD-1. Water quality sampling results are provided in Table 3. Minimal nitrate/nitrite and iron concentrations were found throughout the water column. The Secchi disk reading was 12.5 feet, indicative of mesotrophic conditions. Chlorophyll *a* was sampled at 0.5 µg/L, while TP ranged from 23-33 µg/L. This is a very low

[4] Jensen, H. S., Kristensen, P., Jeppesen, E., & Skytthe, A. (1992). Iron: phosphorus ratio in surface sediment as an indicator of phosphate release from aerobic sediments in shallow lakes. In Sediment/Water Interactions: Proceedings of the Fifth International Symposium (pp. 731-743). Springer Netherlands.

chlorophyll *a* value, albeit it was taken early in the year. As with the late summer sampling, the TP values are somewhat elevated for a mesotrophic lake. Reported TP values from this K&A monitoring event are approximately twice those reported for surface water samples in CLMP data collection for May of 2024.

SRP concentrations were 5 µg/L in all three 2024 profile samples at BLD-1 in contrast with the 2 µg/L found during late summer 2023 sampling. This is notable as SRP made up 3-12% of TP within the late summer samples, and 15-27% within spring samples. Algal growth is limited by bioavailable phosphorus, of which SRP is representative at low concentrations. SRP at 5 µg/L is high enough to exceed phosphorus growth limitations and create the potential for nuisance algal formation.[5] Temperature stratification was not yet established by the May 2024 sampling event, and dissolved oxygen remained high throughout the water column (Figure 9).

Table 3 - Black Lake 5/15/24 in-lake sample results.

Station	NO_3/NO_2 (µg/L)	Iron (mg/L)	SRP (µg/L)	TP (µg/L)	Chlorophyl *a* (µg/L)
BLD-1S	32	<0.02	5	23	0.5
BLD-1M	<3	0.04	5	25	-
BLD-1B	46	<0.02	5	33	-

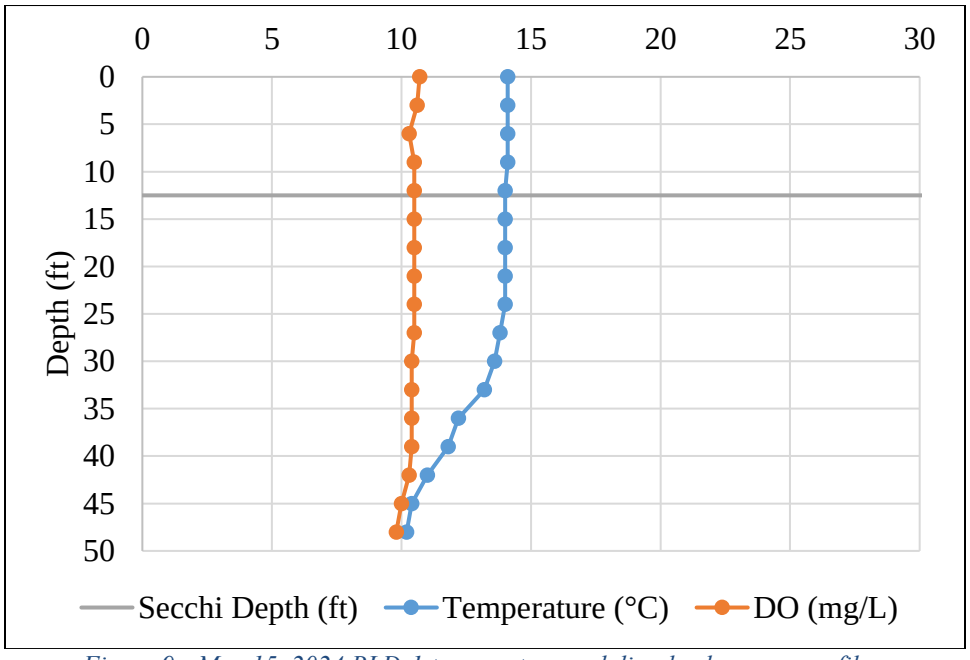


Figure 9 - May 15, 2024 BLD-1 temperature and dissolved oxygen profiles.

[5] Vuorio, K., Järvinen, M., & Kotamäki, N. (2020). Phosphorus thresholds for bloom-forming cyanobacterial taxa in boreal lakes. Hydrobiologia, 847, 4389-4400.

Tributary Water Quality

K&A analyzed water quality from seven inflowing tributaries plus the lake outflow (Figure 10). Contiguous with in-lake sampling, samples were collected on August 31, 2023 and on May 15, 2024 at all eight locations. All collected samples were analyzed for TP and SRP. Late summer samples were additionally analyzed for nitrate (NO_3). Spring samples were additionally analyzed for nitrate/nitrite (NO_3/NO_2), total suspended solids (TSS), and chloride. NO_3, TSS, and chloride analyses were conducted at Merit Laboratories, Inc., of Lansing, Michigan. SRP, TP and NO_3/NO_2 analyses were conducted by Great Lakes Environmental Center (GLEC) in Traverse City, Michigan.

2023 Late Summer Sampling

Water quality sampling results from August 31, 2023 are provided in Table 4. All nitrate samples were below the detection limit. SRP concentrations in inflowing tributaries ranged from 1-8 µg/L, while TP concentrations in these tributaries ranged from 29-63 µg/L. The SRP and TP concentrations at the Lower Black River outflow were <1 and 30 µg/L, respectively. Phosphorus concentrations during this sampling generally decreased going from the influent tributaries to the in-lake water column and finally to the outflow. SRP can decrease from sediment attachment or algal/plant uptake, while TP decreases as particulate phosphorus settles out of the water column of the lake.

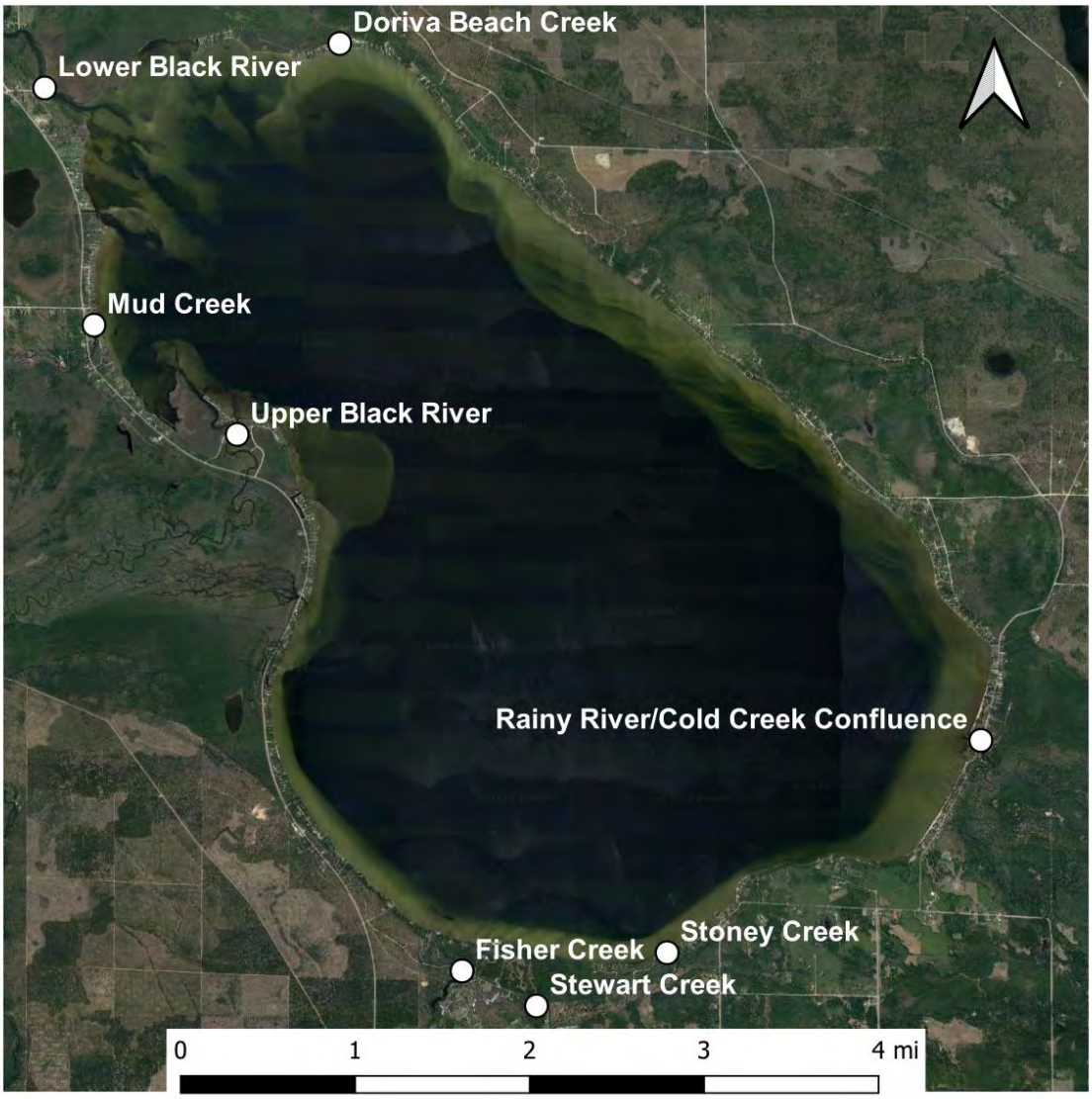


Figure 10 - Map of Black Lake K&A tributary sampling locations.

Table 2 - Black Lake 8/31/23 tributary sampling results.

Site	Nitrate (mg/L)	SRP (µg/L)	TP (µg/L)
Doriva Beach Creek	<0.5	8	63
Fisher Creek	<0.5	1	51
Lower Black River	<0.5	0	44
Mud Creek	<0.5	4	30
Rainy River/Cold Creek Confluence	<0.5	8	59
Stewart Creek	<0.5	1	51
Stoney Creek	<0.5	1	64
Upper Black River	<0.5	6	29

2024 Spring Sampling

Water quality sampling results from the spring tributary sampling on May 15, 2024 are provided in Table 5. SRP and TP concentrations were similar to those found in the late summer, ranging from 1-9 µg/L and 32-64 µg/L, respectively. In watersheds where agriculture is present, phosphorus concentrations are generally higher in spring months following fertilizer applications. These sample results indicate that agriculture may have little to no impact on spring phosphorus loading to Black Lake. Nitrate/nitrite, TSS, and chloride were also found at low levels. Stewart Creek was the exception for chloride.

Table 3 - Black Lake May 15, 2024 tributary sampling results.

Site	NO_3/NO_2 (µg/L)	SRP (µg/L)	TP (µg/L)	TSS (mg/L)	Chloride (mg/L)
Doriva Beach Creek	<3	8	54	3.9	4
Fisher Creek	14	7	60	5.2	16
Lower Black River	12	8	38	4.4	5
Mud Creek	<3	1	36	4.7	<4
Rainy River/Cold Creek Confluence	<3	9	64	2.5	4
Stewart Creek	8	9	51	4.4	28
Stoney Creek	22	8	53	2.3	15
Upper Black River	11	1	32	4.3	5

Flows and Phosphorus Loading

Flows were measured for both tributary sampling events utilizing a Marsh-McBirney 2000 velocity meter with cross-sectional measurements. Flows are crucial to understanding water quality in environmental systems, as water quality issues are often driven by the mass loading of constituents (mass loading being the product of flow and concentration). When flow is taken into account, the importance of the Upper Black River becomes clear (Table 4). The Upper Black River contributed 95% and 91% of the total tributary SRP and TP loads, respectively on August 31, 2023. On May 15, 2024, the Upper Black River contributed 42% and 75% of SRP and TP loads, respectively. The other major contributor on this date was the Rainy River/Cold Creek confluence, which contributed 33% and 13% of the SRP and TP loads, respectively. All other tributaries are relatively insignificant in terms of loading to the lake. The Lower Black River discharges exceeded the combined influent tributary loads for SRP on May 15, 2024, and for TP on both dates.

K&A also installed two remote water level loggers, one on the Upper Black River and one on the Lower Black River, allowing for continuous monitoring of water levels at these locations. Bathymetry and cross-sections were also measured for these locations on select site visits by K&A. The manual flow measurement allow for the estimation of flows as a function of water depth. The Upper Black River on average contributed 54% of the flow of the Lower Black River during the period of September 2023 through April 2025 (Figure 11).

Table 4 - Black Lake calculated tributary flows and phosphorus loads (cfs = cubic feet per second).

Site	8/31/23			5/15/24		
	Flow (cfs)	**SRP (lbs/day)**	**TP (lbs/day)**	**Flow (cfs)**	**SRP (lbs/day)**	**TP (lbs/day)**
Doriva Beach Creek	0.9	0.0	0.3	0.5	0.0	0.1
Fisher Creek	1.1	0.0	0.3	1.0	0.0	0.3
Lower Black River	427.2	0.9	101.3	786.3	33.9	161.0
Mud Creek	5.3	0.1	0.9	13.4	0.1	2.6
Rainy River/Cold Creek Confluence	2.6	0.1	0.8	27.4	1.3	9.5
Stewart Creek	0.7	0.0	0.2	4.4	0.2	1.2
Stoney Creek	0.0	0.0	0.0	15.2	0.7	4.3
Upper Black River	176.7	5.7	27.6	318.2	1.7	54.9

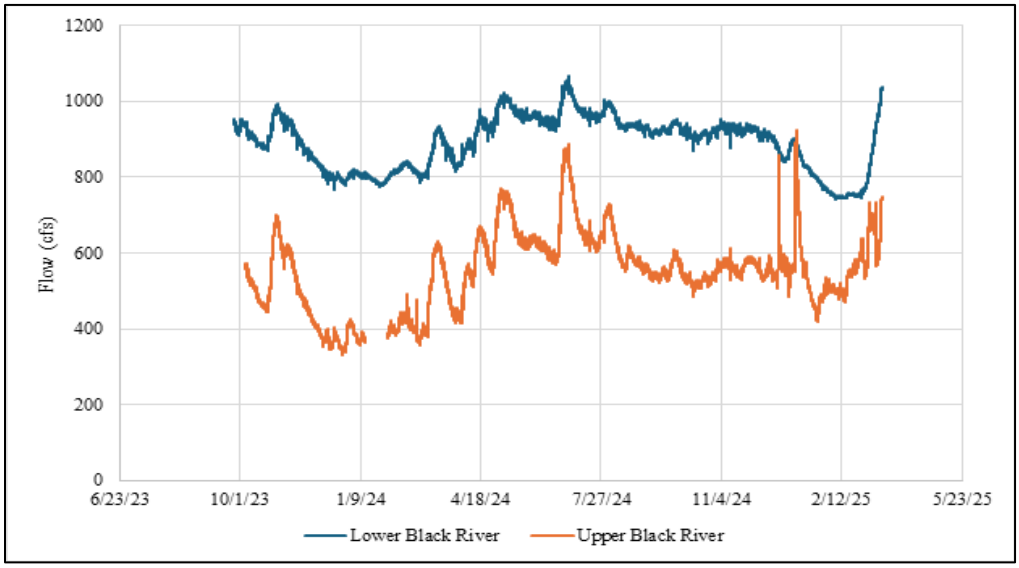


Figure 11 - Calculated flows for the Upper and Lower Black River during the period of September, 2023 through mid-March 2025.

Black Lake Phosphorus Mass Balance

Phosphorus is a critical nutrient in freshwater environments that drives aquatic plant life and algal growth. This "primary productivity" in turn, influences the health of a lake and its recreational and ecological quality. Excessive phosphorus contributions to a water body can result in eutrophication, formation of harmful algal blooms, and other water quality issues. Having an understanding of the phosphorus dynamics of an aquatic system provides lake managers with the information needed to effectively mitigate potential water quality issues by targeting problematic, but manageable sources of this nutrient to their lake. The preliminary Black Lake Phosphorus Mass Balance developed in 2023 was therefore intended to guide next step management considerations to protect water quality and address pressing challenges. (The original technical memorandum for this initial

effort is included in Attachment B. The memorandum also includes a synopsis of HABs conditions reported through 2023.)

All previously collected data for Black Lake and tributaries prior to K&A monitoring were typically reported in summary fashion, with limited supporting details on dates of collection and specific locations, particularly for historic lake water quality monitoring. Available tributary data were not accompanied by flow measurements at the time of their collection, precluding the ability to directly compute pollutant loading necessary to construct a phosphorus mass balance. K&A therefore used a combination of watershed hydrology modeling with available concentration data to produce an initial mass balance for the lake. K&A sampling data from August 2023 and May of 2024 were ultimately used to corroborate and update initial mass balance assumptions.

K&A's updates to the mass balance analysis indicated that septic systems could be a significant contributor of bioavailable phosphorus during the late summer (Figure 12). The distributed nature of septic systems around the shoreline of Black Lake can be compared to individual points of tributary discharges. From Table 6, most tributaries in late summer are inconsequential in terms of their SRP contributions. Septic systems can be loading phosphorus to the lake from all shoreline areas.

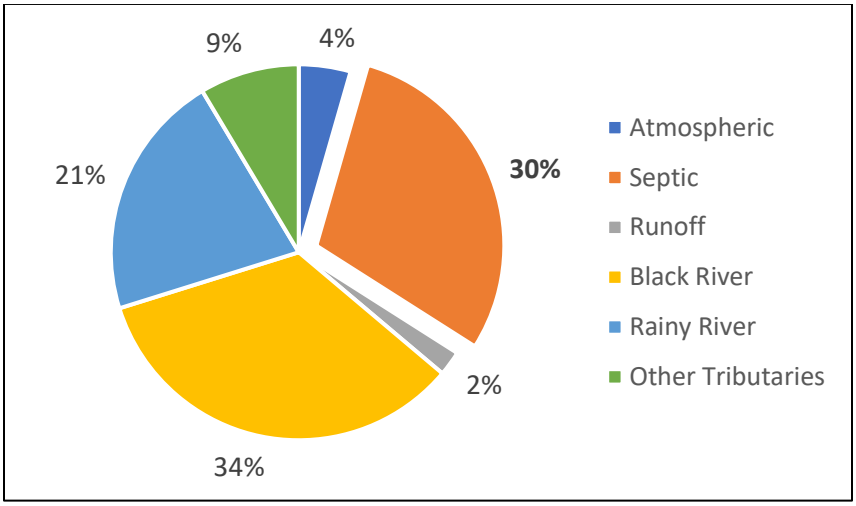


Figure 12 - Modeled bioavailable phosphorus contributions during August 2023.

The largest tributary source of SRP, the Upper Black River, discharges in reasonably close proximity to the lake outlet, the Lower Black River. How much of these Upper Black River discharges circulate throughout the entire lake is unknown, but they are not likely distributed across all shorelines like septic systems. Furthermore, given the long and shallow nature of the nearshore slope to the drop-off in Black Lake, shoreline areas can more easily be influenced by shoreline loading. Notably, blue-green algal blooms are typically spotted along shorelines.

These physical conditions suggest that elevated septic system loading might quickly impact nearshore areas during quiescent periods from limited mixing with the open lake. Mass balance updates estimated that septic loading in areas with contributing septic

systems could increase nearshore SRP concentrations by as much as 1 µg/L/day during these conditions. As HABs can be triggered at concentrations as low as 5 µg/L SRP, septic systems could very likely be a cause of HABs seen on Black Lake based on this preliminary mass balance understanding.

Septic System Voluntary On-line Survey

There are no readily accessible public data on septic system ages, use and maintenance for all residential systems around Black Lake. Absent such information, it was difficult to refine estimates in the mass balance which forced the use broad-based assumptions for these septic system conditions. Just how much impact these systems might actually have on lake water quality could not be refined without additional demographics. K&A therefore prepared an on-line, voluntary septic system survey to obtain additional quantitative and qualitative information on septic conditions to best inform septic system loading contributions to Black Lake.[6] (These characteristics were, for example, used to verify Figure 12 loading assumptions.)

Access to the on-line survey was provided via several outreach efforts by the BLPS using an advertised QR code. As of November 2025, the survey received 125 unique responses (out of an estimated 800 residences on the lake). Of the responses, 81% identified as seasonal residents, while 19% identified as permanent year-round occupants (Figure 13A). For both seasonal and permanent residents, the average number of occupants was 3. The typical average length of stay for seasonal residents was two months. Respondents reported typically having 0-10 guests per year, who usually stayed for an average of 0-7 days.

The most frequently reported home and septic system ages fell within the 25-50 year and 0-25 year age ranges, respectively (Figure 13B and C). Some 52 respondents reported having septic systems over 25 years old, indicating that a significant portion of residences on Black Lake may be approaching the timeframe where performance is likely to diminish absent replacement or upgrades. Older septic systems are also more prone to ponding and backups, increasing the likelihood of septic system drainage leaching into the lake. Over 70 respondents reported their drain field as being within 150 feet of the lake (Figure 13D), which may also increase the risk of septic system discharges reaching the lake.

While some survey metrics could be concerning for optimal septic system function, 82% of respondents (Figure 13E) indicated they routinely pump their septic system, and among those who routinely pump, 87% reported pumping every 5 years or less (Figure 13F). Routine pumping can help prolong the system's life and reduce the likelihood of failures, ponding, backups, and possible discharges of phosphorus-laden leachate to the lake.

[6] Survey can be accessed by going to www.ka-survey.com

After an update to the on-line survey in 2025, select metrics that were determined to be favorable for reducing the risk of septic system loading were scored to inform respondents of their potential septic system conditions in relation to water quality protection of Black Lake. Respondents could receive a maximum of 10 points depending on their system conditions and its maintenance. Such scoring would indicate whether they are adequately practicing safe septic system maintenance, or if there was opportunity for improvement. The average score of those who responded following the survey update was 7, indicating that the majority of respondents had taken above-average measures to ensure safer septic system practices.

Overall, survey findings to date show that while many septic systems are older than ideal and close to the shoreline, numerous residents are taking precautions to protect system performance with routine pumping every 5 years or less, implementing low-flow devices in their home, and limiting the number of people using water features in the home over an extended period of time.

A summary of the survey findings can be found in Table 7. Lake residents are still encouraged to complete the survey, which will be kept anonymous. Data from the survey will continue to inform nutrient load estimation to the lake and will not be used to target specific residences.

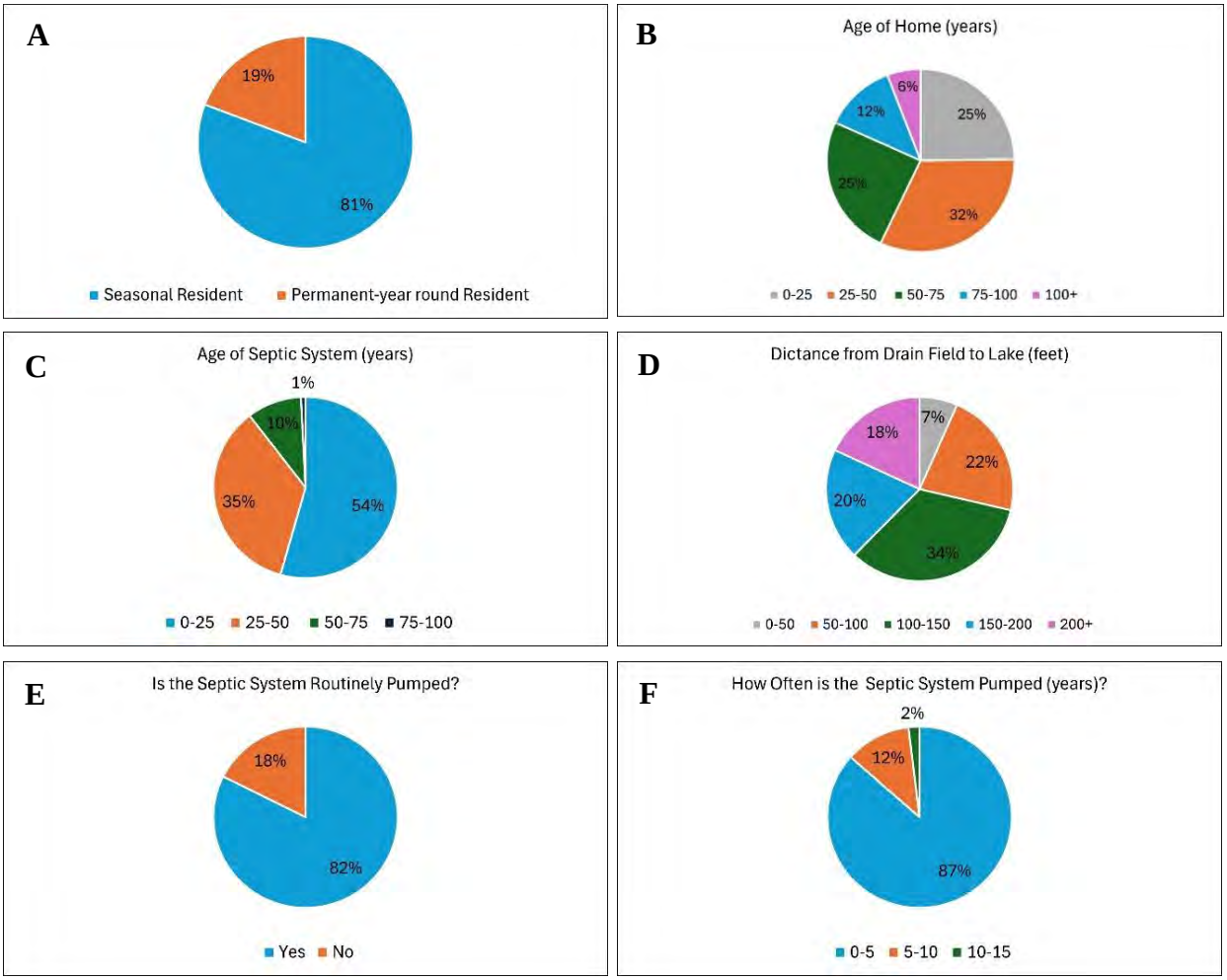


Figure 13A-F. Statistical analysis of online septic System Survey summations through October of 2025 include the following: A) shows the residential status of Black Lake homeowners; B) shows the age of homes around the lake; C) shows the age of septic systems around the lake; D) shows the distance of the drain fields from the lake; E) indicates whether homeowners regularly pump their septic systems; F) shows how frequently septic systems are being pumped.

Table 7 - Summary of select septic survey responses for determining septic characteristics of Black Lake.

	Question	Mode of Responses
Seasonal Resident	Number of Seasonal Residents	2 People
	Average Length of Stay	0-15 Days
Permanent Residents	Number of Permanent Residents	2 People
All Respondents	Average Number of Guests per year	0-5 People
	Average Length of guest stay	0-5 Days
	Home age	25-50 Years
	Septic System age	25-50 Years
	Distance of Drain field to Lake	100-150 Feet
	How often is the Tank Routinely Pumped	3-5 Years

Septic System Drain Field Monitoring & Modeling

Recurrent, summer to late fall blue-green algal blooms have been noted in both nearshore and open waters of Black Lake over the past five years even after most seasonal residency has ended (typically September-November). With BLPS support, K&A has now completed over two years of shallow groundwater monitoring along select areas of Black Lake's shoreline to assess whether septic systems may be directly contributing to these HABs conditions. Thus, the primary purpose of this sampling has been to verify whether septic system drain fields are actually contributing dissolved phosphorus to nearshore waters. Secondarily, inputs of bacteria into the lake are of interest as a health concern for human and pet contact during recreational access in nearshore waters.

Groundwater sampling results now clearly show that for older septic systems with drain fields within 50-100 feet of the lakeshore, high levels of soluble phosphorus and *E. coli* bacteria (reflecting human waste inputs) are reaching the lake. As phosphorus can be the primary stimulant for the harmful blue-green algal blooms, late-season groundwater phosphorus levels near the shoreline can be 200 times higher than those measured in the open lake. The detected presence of *E. coli* in shallow nearshore groundwater (at select locations with levels above state health standards), also suggests bathers may be exposed to harmful viral pathogens associated with human waste from septic system discharges.

Three primary sampling approaches that have been employed on Black Lake to reveal these conditions include:

1) An initial screening of three volunteer residential properties in September of 2023 using temporary groundwater sampling wells (one site had a newer septic system; two others had old systems);
2) The establishment of permanent groundwater monitoring wells at one of the three initial sites with well sampling now conducted in May, September and December of each year. (December 2025 sampling results were not yet available at the time of this writing; May 2026 will be the next monitoring event), and;
3) An additional round of nearshore groundwater sampling at another eleven volunteer locations in October of 2025 (where sampling was completed using temporary wells along shorelines, and 20 feet offshore at select locations).

Details and results from these three efforts are provided as follows. Property addresses and owners have not been disclosed per their agreement to cooperate in these monitoring efforts. Only general location descriptions are provided herein. Generalized sampling descriptors discussed here match those found in lab reports included in Attachment A.

Initial Nearshore Groundwater Screening for Phosphorus and Bacteria (2023)



Three locations across northeast and southern shorelines of Black Lake were examined in the first-round of nearshore shallow groundwater sampling in September of 2023. At each volunteer location, decontaminated PCV, 1-inch diameter well screens were manually advanced into the shallow groundwater table through manually excavated soil pits (in beach sands) and/or through 3.5-inch diameter boreholes pre-drilled to the water table (at elevated shoreline locations). Each temporary well was placed within approximately 12 feet or less of the water's edge. Wells were spaced every 10-15 feet along the shoreline at locations considered downgradient of septic system drain fields as identified by property owners. Well screens were pushed into the shallow groundwater table.

These temporary wells were each purged for approximately ten minutes using a low-flow peristaltic pump with clean, dedicated polyethylene tubing before extracting groundwater samples. Chloride, nitrate, SRP, TP, and *E. coli* were analyzed at select temporary wells. (Chloride and nitrate were analyzed by Merit Laboratories of Lansing, MI; phosphorus analyses were completed by the Great Lakes Environmental Center lab in Traverse City, MI; *E. coli* samples were field-processed and analyzed.) Homeowner's were privately informed of all sampling results from these efforts.

Table 8 presents all analytical data collected for samples from monitored temporary wells in 2023. A single well at the northern shoreline location with the newest system (S1-1) had the lowest level of SRP (3 µg/L) detected during this initial round of monitoring. (Other attempted well placements failed to produce sufficient groundwater volumes for sampling.) The 3 µg/L of SRP is considered herein as representative of an unimpacted groundwater condition, particularly since there was no bacterial detection at this S1 location.

At the two southern shoreline sites with older septic systems (S2 and S3), SRP, TP, and *E. coli* were all detected where sampled (some at elevated levels) (Table 8). There did not appear to be any correlation between chloride, SRP/TP, and *E. coli* in S2 or S3 well samples.

Nearshore shallow groundwater samples at S2 revealed varying levels of *E. coli* across wide swaths of the shoreline. These were accompanied by elevated levels of SRP ranging from 35-117 µg/L. The highest SRP level of 117 µg/L corresponded to the highest level of *E. coli* reported at 547.5 cfu/100mL. This level of bacteria in shallow groundwater exceeds the state of Michigan, full body contact of criterion of 300 cfu/100mL established for surface waters. During the September 2023 monitoring, nitrates were only detected in temporary well S2-3 at 5.6 mg/L, also corresponding to the highest SRP level measured at this southern shoreline site.

Table 8 - Black Lake temporary shallow groundwater sampling results ("-" indicates no sample collected).

Date	Site Code	Chloride (mg/L)	Nitrate (mg/L)	SRP (µg/L)	TP (µg/L)	*E. coli* (cfu/100mL)	Age of System (years)	Drain Field Distance from Lake (ft)
9/27/23	S1-1	11	<0.5	3	-	-	18	50
	S2-1	9	<0.5	35	-	307.6	50	250
	S2-2	8	<0.5	56	-	21.6		
	S2-3	7	5.6	117	-	547.5		
	S2-6	22	<0.5	93	-	4.1		
	S3-1	12	<0.5	-	198	1	42	100
	S3-2	11	<0.5	-	230	3.1		
	S3-3	14	<0.5	398	457	<1		
	S3-4	11	<0.5	132	317	9.7		
	S3-5	11	<0.5	-	305	<1		
	S3-6	5	<0.5	-	313	72.8		

SRP concentrations at the S3 site were as high as 398 µg/L during this September 27, 2023 sampling. At the S3-3 location, this level was of considerable concern for septic system leachate-impacted groundwater discharging to the lake. Notable was the SRP to TP ratio of 87% at this particular temporary well location. This strongly suggests that the phosphorus levels in shallow groundwater at the shoreline are related to drain field discharges, though *E. coli* detected presence was variable across this same shoreline. Elevated TP levels were broadly distributed across a wide area along this shoreline suggesting a wide groundwater plume discharging to the lake. Based on these elevated phosphorus levels in groundwater, permanent shallow groundwater monitoring wells were ultimately placed at this particular shoreline location with the owner's permission.

Establishing a Nearshore Shallow Groundwater Monitoring Station (2023-2026)

Three permanent groundwater wells were set to intercept shallow groundwater at locations immediately downgradient of an older system (Site 3) that revealed some of the highest concentrations noted in Table 8. One "upgradient" well was installed approximately 30 feet from the lakeward side of the drain field, a second at a "mid-gradient" location (serving as a cross-gradient well) with a third well set directly "downgradient" of the drain field within 8 feet of the water's edge (in line with the upgradient well). Stainless steel well screens were manually driven 1-3 feet into the shallow groundwater table. Wells installed on September 27, 2023 were developed with removal of 10 standing well volumes per standard well development procedures, and then allowed to stand undisturbed until the first formal well sampling event in December of 2023.

A well sampling schedule was established for the months of December, May and September to bracket periods of seasonal occupation. Prior to sample collection, static water level measurements are made in each well followed by purging with a low-flow

peristaltic pump and dedicated sample tubing. Purging is continued for 10 minutes and/or until 1.5 gallons are removed. Purging is immediately followed by sample collection for SRP analysis. Beginning in September of 2024, field-screening for bacteria was added to the sampling regimen.[7] Periodically, other analytes have also been collected.

Groundwater sampling results are presented in Table 9. The highest SRP concentration seen during sampling was 634 µg/L on December 2, 2023 with a corresponding TP level of 1,230 µg/L at the upgradient location. These concentrations reflect septic system discharges to groundwater immediately downgradient of the drain field. Near the lakeshore, SRP and TP levels had dropped to 111 µg/L and 248 µg/L, respectively. These levels were generally consistent with some of the higher levels observed along the lakeshore three months earlier during the temporary groundwater well sampling event at this location (Table 8).

By mid-May of 2024, SRP levels in all three wells had essentially dropped to background levels of 2-4 µg/L following seven months of non-occupancy. This strongly suggests that phosphorus plumes are temporal as groundwater appears to effectively flush drain field discharges at some point between December and May. In turn, phosphorus loading to the lake appears to restart sometime between May and September during seasonal occupancy. Such seasonal discharges correspond to HABs blooms now being reported from July through November.

Though low concentrations in September of 2024 did not show a rebound of drain field loading to the shallow groundwater, the presence of *E. coli* and total coliform bacteria suggested there is some residual discharge. By December of 2024, a substantial rebound in drain field loading is evident with SRP and TP concentrations, particularly at the shoreline well (S3-Down). At S3-Down, greater than 99% of phosphorus being measured was in dissolved form, directly indicating soluble phosphorus discharges from the drain field to the shallow groundwater were continuing after seasonal occupancy ended in September.

This pattern of groundwater flushing during non-occupancy conditions followed by a summer rebound of the plume is clearly evident at this site with May and September, 2025 monitoring data. (December GLEC lab data are still pending.) This pattern of seasonal phosphorus discharges to the lake is illustrated in Figure 14 for this nearshore well at S3-Down.

[7] *E. coli* and total coliform samples were analyzed on-site using a field-screening method with the Aquagenx CBT EC+TC Most Probable Number (MPN) Kit to detect the presence or absence of fecal bacteria at each testing site. This is not an EPA-approved method for typical health department analyses (where sample hold times are only 6 hours between collection and lab analysis). It is intended to provide a semi-quantitative indication of the presence of these bacteria.

Table 9 - Black Lake permanent shallow groundwater monitoring well sampling results (indicates data are still under review).*

Date	Site	SRP (µg/L)	TP (µg/L)	*E. coli* (cfu/100mL or MPN/100ml)	Total Coliform (cfu/100mL or MPN/100ml)	NO_3/NO_2 µg/L
12/2/2023	S3-Up	634	1,230	-	-	-
	S3-Mid	2	42	-	-	-
	S3-Down	111	248	-	-	-
5/14/2024	S3-Up	2	-	-	-	<3
	S3-Mid	4	-	-	-	<3
	S3-Down	4	-	-	-	<3
9/28/2024	S3-Up	0.5	-	17	56	<3
	S3-Mid	0.7	-	0	>100	5
	S3-Down	1	-	4.7	23	<3
12/8/2024	S3-Up	245	333	-	-	-
	S3-Mid	13	20	-	-	-
	S3-Down	499	501	-	-	-
5/2/2025	S3-Up	0.8	-	0	0	<2
	S3-Mid	0.9	-	0	>1,000	<2
	S3-Down	1	-	0	>1,000	<2
9/26/2025	S3-Up	383	-	*	*	-
	S3-Mid	27	-	*	*	-
	S3-Down	201	-	*	*	-
	TMW-S3	179	-	*	*	-

The seasonal discharge pattern revealed in Figure 14 tends to correspond to HABs blooms now being reported from July through November. These seasonal levels of high phosphorus in groundwater discharging to the lake also coincide with some of the lowest seasonal tributary flows annually experienced in the fall of each year. These late season tributary flows also have very low phosphorus concentrations (Tables 4 and 6). This affirms that these are exceptionally clean streams with limited watershed pollutant impact. This also suggests that late summer tributary inflows are not necessarily potent sources of phosphorus during summer to fall harmful algal bloom events. These high-quality stream conditions stand in stark contrast to confirmed summer to fall seasonal septic system drain field discharges to the lake.

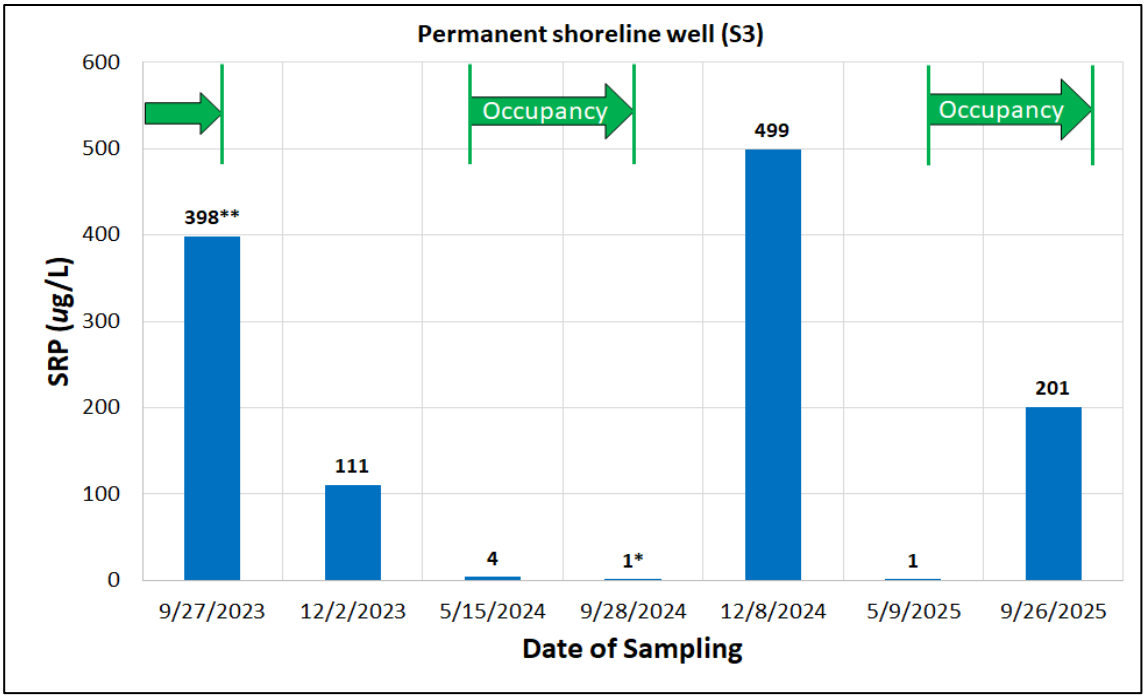


Figure 14 - Seasonal change in SRP concentrations at a permanent shoreline well (S3-Down) at a seasonal residence. Sample from September 28, 2024 with 1 represents an unexpected anomaly to the seasonal pattern. The sample with 398** was collected from a temporary well near S3 because the S3 well was newly installed; well development was insufficient to sample on the date of installation.*

Additional Nearshore Groundwater Monitoring (2025)

Based on findings of elevated SRP and bacterial levels in shallow groundwater from the initial rounds of temporary and permanent shallow groundwater sampling, K&A worked with the BLPS for over a year to identify additional candidate sites for testing. Using available information and BLPS outreach, eleven additional shoreline residences in both Cheboygan and Presque Isle Counties were identified for expanded geographic testing with the temporary monitoring well strategy.

K&A recommended the broader geographic assessment of shoreline areas for new volunteer homeowners interested in assessing conditions on their properties. Parameters for potential volunteer selection included an analysis of historic shoreline *Cladophora* surveys by the Tip of the Mitt Watershed Council in 2005 and 2017, and preliminary feedback from an online K&A septic system survey. K&A presented a list of considerations for preferable sites at the August 17, 2024 BLPS public meeting that included:

- Septic systems substantially greater than 20 years old
- Pump-outs occurring much less frequently than 2-3 years
- Seasonal or year-round use
- Drain fields less than 100 feet from lake shoreline
- Presence of shoreline *Cladophora*
- Targeting of up to six shoreline samples per location

- SRP and *E. coli* sampling
- Results provided confidentially to homeowners

Selected sites would have 3-6 temporary sampling points for groundwater testing along shorelines, with select locations including one in-lake well. With the observed site conditions and presence of *Cladophora*, all temporary groundwater sampling wells were strategically placed along the shoreline to intercept the expected path of a drain field discharge plume. Groundwater samples from each site were collected for SRP analysis and field screening for the potential presence of *E. coli* and/or total coliforms. Bacterial screening was considered a secondary indicator of drain field discharges to groundwater. The presence of these indicator organisms also alerts residents to the potential for associated pathogens where they may recreate along the shoreline.

Following BLPS securing written property access to conduct the voluntary monitoring, the selected volunteer sites were visited over the period of October 14-15, 2025 to perform this sampling. Representative areas of the Black Lake shoreline that were sampled are outlined in Figure 15.

Groundwater Sampling:
At each site, stainless-steel drive-point piezometers (16-inch length, 1-inch diameter, 9-inch screen length) with stainless-steel riser pipe were manually installed using a 20-lb well driver. Each well was placed such that the screened interval extended at least 1 foot below the ground surface so as to be fully within the saturated zone of the water table. Additionally at each site, nearshore wells were installed 10-20 feet apart, with an in-lake well positioned 20 feet from one nearshore well. The purpose of this in-lake sampling was to examine the extent of potential plume upwelling away from the shoreline to better characterize discharge conditions.

To obtain representative samples, all wells were purged for a minimum of 10 minutes prior to sampling to remove stagnant water from the well casing using a low-flow peristaltic pump similar to other K&A groundwater sampling efforts. Following 10 minutes of purging (or >1.5 gallons), *ex situ* parameter collection included dissolved oxygen (DO), temperature, specific conductivity, pH, and oxidation–reduction potential (ORP) measured using a calibrated multi-parameter probe. Groundwater samples were then collected for laboratory analysis of SRP and for field screening of bacteria. (The inset photo at right shows nearshore and in-lake well sampling layout and equipment.)





Figure 15 - Sampling areas for October 2025 nearshore groundwater testing on Black Lake.

Equipment Decontamination:
To prevent cross-contamination between sampling sites, all equipment was thoroughly decontaminated after each use. The decontamination process consisted of the following sequential steps:

- Cleaning: Equipment was washed with a phosphate-free detergent (Liquinox) to remove residual materials and organic matter
- Rinsing: A tap water rinse was used to remove detergent residues
- Sanitization: Equipment was rinsed with a 10% bleach solution to disinfect and eliminate microbial contaminants
- Final Rinse: A final rinse using deionized (DI) water was performed to remove any remaining chlorine or tap water residues (DI water was provided by GLEC)

All decontaminated equipment was stored in clean containers or covered with protective material until reused at subsequent sampling locations.

Sampling Analyses:
Groundwater samples were divided into two analytical groups, SRP and bacteria to ensure representative and accurate measurements. All SRP samples were field-filtered using 0.45 micron syringe filters into 125 ml plastic sample containers (filters and containers were provided by GLEC). Samples were then frozen and transported to GLEC

in Traverse City, MI on October 16th, 24 - 48 hours after sampling. *E. coli* and total coliform samples were analyzed on-site using a field-screening method with the Aquagenx CBT EC+TC Most Probable Number (MPN) Kit to detect the presence or absence of fecal bacteria at each testing site.[8]

Results:
Table 10 presents results from the eleven locations with nearshore groundwater sampling in October 2025. Also included with each location are the number of samples collected, the average SRP concentration of the collected samples, the range in SRP concentrations measured, bacterial field-screening levels, and the estimated age of the on-site septic system per owner feedback. (Attachment A includes lab reports.)

Table 10 - October 2025 groundwater sample results per location sampled at the shoreline.

Volunteer Site (VS)	No. of samples/ site	Ave. SRP (µg/L)	Range of SRP (µg/L)	Range of *E. coli* (MPN/100ml)	Range of Total Coliform (MPN/100ml)	Approx. Age of System (years)
VS- 1	1	30.0	30.0	0.0	>100	30
VS - 2	2	22.2	17.4 - 27.0	0.0 - 2.6	48.4 - >100	30
VS - 3	2	53.1	15.1 - 91.0	1.0 - 1.2	>100	20
VS - 4	3	16.7	7.7 - 30.0	0.0 - 13.6	>100	20
VS - 5	3	58.3	31.0 - 76.0	0.0 - 48.3	>100	25
VS - 6	3	10.0	4.2 - 13.1	>100	>100	20
VS - 7	3	6.6	4.5 - 7.6	0.0 - 4.7	>100	30
VS - 8	3	12.6	8.5 - 20.3	9.6 - >100	48.4 - >100	26
VS - 9	4	10.1	8.6 - 12.5	13.6 - >100	>100	50
VS - 10	6	8.7	5.2 - 12.6	0.0 - 1.0	48.4 - >100	20
VS - 11	4	44.6	13.2 - 81.0	0.0	4.7 - 48.3	25

Average SRP in nearshore shallow groundwater across the eleven sites ranged from 6.6 to 58.3 µg/L. The highest reported levels were 91µg/L. At all sites, at least one groundwater well location indicated septic system drain field impacts by phosphorus. These nearshore groundwater SRP levels can be compared to S1-1 from the 2023 monitoring event at 3 µg/L SRP where no background drain field impacts were evident (Table 8).

Only two of eleven locations were non-detect for *E. coli* while four others of the eleven locations had elevated *E. coli* screening levels. Total coliform bacteria were noted in all groundwater samples. These results suggest that nearshore groundwater is likely receiving drain field discharges at all locations sampled.

[8] Reported field screening numbers are not intended to test for 'regulatory' thresholds that might otherwise be test public beaches by health departments. Additionally, all private property bacterial samples were collected as groundwater, not surface water. County health departments collect surface water samples to test safety of swimming beaches.

Table 11 presents similar October test results for select in-lake samples. *E. coli* was detected at four of the seven in-lake temporary monitoring wells; total coliform was found at every location tested. SRP concentrations ranged from 2.0 to 154 µg/L, with six of the seven samples showing elevated levels indicative of a septic system source. At VS-9, nearshore groundwater concentrations of SRP ranged from 8.6 - 12.5 µg/L (Table 10) while the corresponding in-lake groundwater concentration was the highest recorded during the October 2025 sampling at 154 µg/L (Table 11). Both V-5 and VS-9 had the highest in-lake SRP concentrations with the VS-5 level close to the average SRP reported for corresponding nearshore testing levels. The data confirm what was initially identified in the temporary in-lake monitoring well (TMW-S3) tested at Site S3 in September 2025 (Table 9).

Table 11 - October 2025 groundwater sample results for in-lake temporary groundwater monitoring wells.

Volunteer Site (VS)	SRP (µg/L)	*E. coli* (MPN/100 ml)	Total Coliform (MPN/100 ml)
VS - 1	14.6	1.1	>100
VS - 4	8.0	9.1	>100
VS - 5	51.0	2.6	>100
VS - 6	2.0	0	48.4
VS - 8	13.1	2.6	>100
VS - 9	154.0	0	>100
VS - 11	12.7	0	>100

Although shallow nearshore groundwater sampling to date on Black Lake represents only about 2% of the estimated 800 properties on the shoreline, data provide important insights into potential lake-wide septic system loading conditions. These include:

- Only one of the 14 properties (7%) sampled between 2023 monitoring (Table 8) and the recent October 2025 efforts exhibited shoreline SRP concentrations below 5 µg/L, a threshold that can trigger cyanobacterial growth.[9,10,11] Extrapolated lake-wide, this suggests that approximately 93% of lakeshore properties may discharge groundwater containing SRP above bloom-forming levels.
- Only five of the 13 properties (39%) had *E. coli* levels below 5 MPN/100 mL, suggesting that roughly 61% of shoreline septic systems could be contributing measurable bacterial contamination to the lake.

[9] Vuorio, K., Järvinen, M., & Kotamäki, N. (2020). Phosphorus thresholds for bloom-forming cyanobacterial taxa in boreal lakes. *Hydrobiologia*, *847*, 4389-4400.
[10] Liu, J-H, Lu, Y., DAO, G-H, Wang, S-N, Song, K-Y, and H-Y HU. In Press. Algal Growth Potential Based Nitrogen and Phosphorus Criteria for Bloom Control. Water Cycle. https://doi.org/10.1016/j.watcyc.2025.10.004
[11] Jianga, M., Zhoua, Y., Caoc, X., Jia, X., Zhanga,W., Huangd, W., Zhanga, J., and Z. Zheng. 2019. The concentration thresholds establishment of nitrogen and phosphorus considering the effects of extracellular substrate-to-biomass ratio on cyanobacterial growth kinetics. Science of the Total Environment. Volume 662, 20 April 2019, p 307-312.

- Total coliforms exceeded 100 MPN/100 mL at every tested site, implying that nearly all nearshore properties are likely influenced by subsurface microbial discharges from septic systems.

While these extrapolations are based on a limited dataset, they indicate that septic system drain field discharges to shallow groundwater flowing into Black Lake likely play a significant role in nutrient and bacterial loading to nearshore areas. The consistent presence of total coliforms and periodic peaks in SRP and *E. coli* suggest that especially, older systems are likely key contributors to localized water quality concerns. Data from locations with only 20-year old septic systems suggest these may also be contributing to elevated nearshore phosphorus concentrations.

Nearshore Phosphorus Loading Model

A simplified mechanistic model was advanced by K&A to analyze potential daily changes in soluble phosphorus concentrations (SRP) in nearshore waters of Black Lake given the inflow of groundwater receiving septic system drain field discharges. The model was developed to forecast nearshore phosphorus concentrations (as µg/L) and daily loading (as lbs SRP/day) in the context of blue-green (cyanobacteria) algal bloom formation on Black Lake. The model computations are based on daily timesteps and assume a static volume of water in a nearshore area receiving both groundwater and mixing with open lake water. Attachment C to this memorandum describes the technical basis and application of the model to Black Lake conditions. This section highlights findings and implications for Black Lake.

The tool was developed to preliminarily answer questions on just how much shallow groundwater discharging to the lake is adding to nearshore surface water concentrations sufficient to potentially trigger HABs events. The answer to the question is quite relevant given sufficient evidence now demonstrating drain field discharges are contributing phosphorus in shallow nearshore groundwater, both at the shoreline and in-lake. This is demonstrated with model simulation of Site 2 conditions from the September 2023 groundwater sampling event. Figure 16 provides the conceptual depiction for modeling of this setting.

Figure 17 presents the predicted nearshore concentrations for this entire 100-foot wide section of beachfront representing the range of measured concentrations from 35 to 117 µg/L of soluble phosphorus in shallow groundwater. These predicted concentrations within 100 feet of the shoreline suggest that within 1-3 days there would be ample phosphorus available to stimulate harmful algal blooms when weather (principally low to no winds, high sunlight) provides optimal bloom conditions. These projections are based on conservative groundwater velocity assumptions of 28 feet/day.

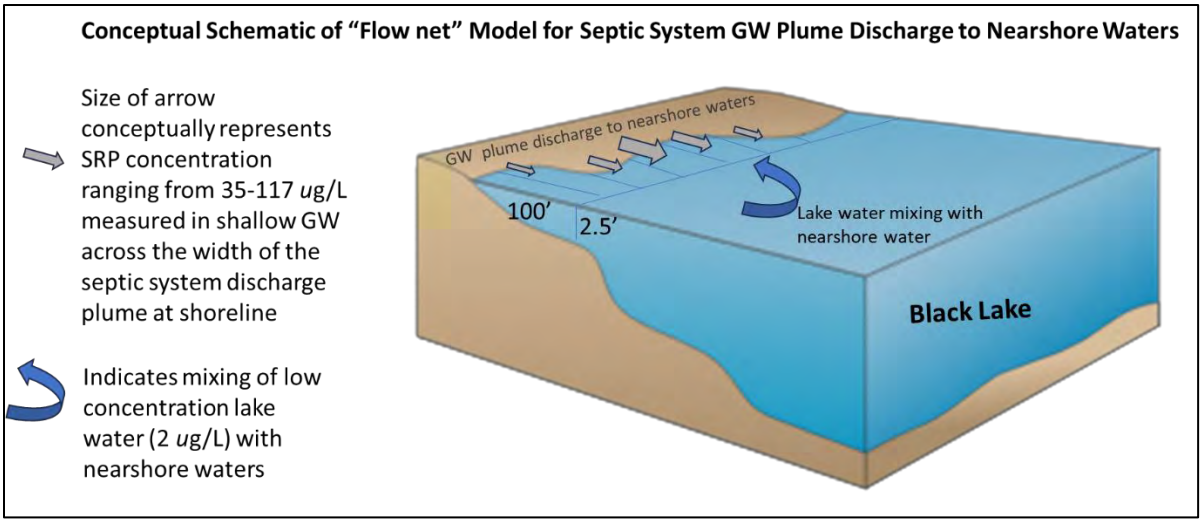


Figure 16 - Conceptual schematic of the nearshore model for September 2023 Site 2.

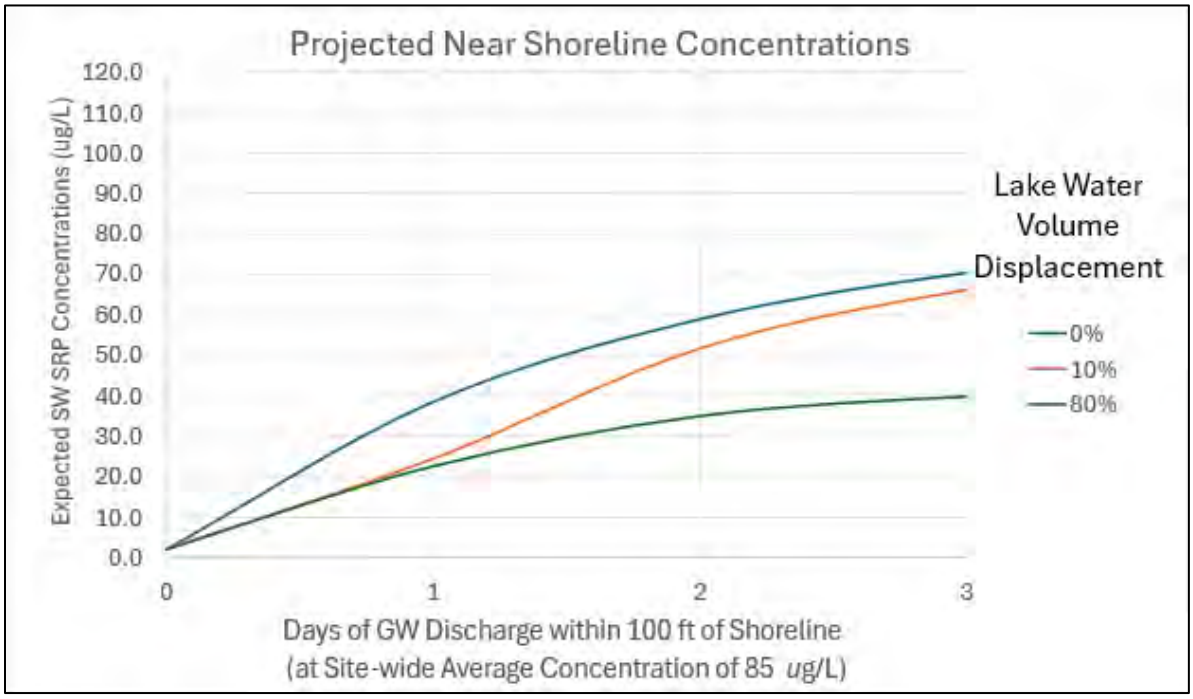


Figure 17 - Projected in-lake SRP concentration increases in nearshore Surface Waters (SW) over three days for the 100-foot wide beachfront (extending out 100 feet from shore) using 2023 shallow groundwater data from September of 2023 for Site S2.

It is likely that there could be periods of 1-3 days with no to low winds reflecting the 10% mixing condition with open lake water (at 2 µg/L). Over longer timeframes, these conditions may be best modelled assuming an 80% mixing condition with open lake water. Thus, on a calm day following any period of high winds (leaving nearshore water concentrations starting at 2 µg/L), model projections from Figure 17 suggest that nearshore SRP concentrations at this location could rise to 25 µg/L within a day under 10% mixing conditions. Whereas the preliminary Black Lake mass balance model theorized a 1 µg/L per day increase in nearshore waters, the model (using actual

monitoring data) suggests nearshore concentrations in areas with substantial drain field contributions could be much higher. This has substantial repercussions for Black Lake water quality management given the frequency of nearshore HABs occurrences now being reported during and after the summer recreational season.

Septic System Management on Black Lake

Future work on mitigating septic system drain field discharges to Black Lake will need to be more than just informational. It must target, test and ultimately implement a range of options to address the immediate and long-term concerns of phosphorus and bacterial contributions to the lake that are now well-documented. More frequent pumping of holding tanks, household water conservation and replacement are the standard fare for addressing these challenges. These will either provide some relief, or represent the most expensive alternative to reducing phosphorus (and bacterial) loads to Black Lake absent other interventions. A range of alternatives are therefore recommended to be pursued for consideration and testing. The scope for these far-reaching efforts is now being discussed by K&A with the BLPS, anticipating that grant support will be pursued.

The BLPS initiated an innovative septic system education effort called the Fresh Start Program in 2021.[12] The program focuses on information to help maintain functional septic systems, recognizing how poorly performing septic systems are suspected to be a key contributor to HABs on Black Lake. The Fresh Start campaign encourages homeowners to inspect their systems and initiate more frequent pump-outs of holding tanks. Figure 18 illustrates the program objectives in the context Black Lake water quality. This volunteer-led effort by the BLPS demonstrated some of the most targeted concerns with Black Lake septic systems contributing to HABs issues.

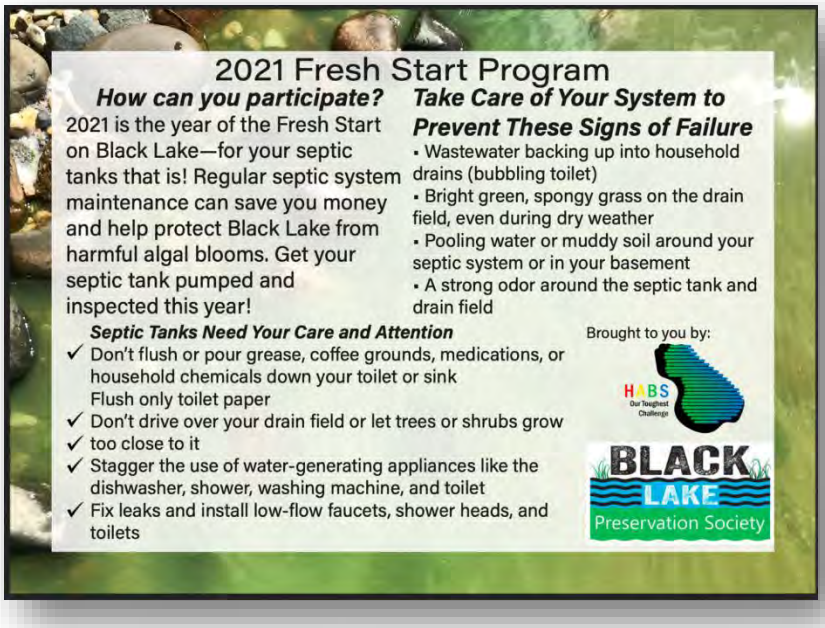


Figure 18 - Illustration of the BLPS Fresh Start Program.

[12] See: https://www.blacklakepreservationsociety.org/healthy-septic-systems.html

Besides wise use of indoor water consumption, pumping out septic systems on a routine basis is the primary recommendation in state and federal educational programs for maintaining septic systems.[13] System replacements are recommended with failures that typically manifest through clogged plumbing or ponding of septage waste above drain fields. Breakthrough of drain field leachate to surface waters, is not, however, considered in the same context of these known infrastructure system failures, nor is it addressed by these state or federal outreach programs. Once soils beneath a drain field become phosphorus-saturated, dissolved phosphorus in leachate makes it way to the shallow groundwater table and eventually into surface waters. While there may be some retention in the shallow aquifer, soluble phosphorus (and bacteria associated with human waste) can travel with groundwater and vent to nearby lakes and streams. This is now documented in Black Lake.

These groundwater conditions have also been well-documented in the scientific literature, but what is not well-established are alternatives to address this breakthrough to surface waters short of septic system replacement. Such replacement would also need to include removal and replacement of P-saturated drain field soils. Absent soil replacement, there remains no capacity to retain soluble phosphorus that will otherwise continue to move towards surface waters. This is critical given the K&A nearshore modeling which indicates shallow groundwater may be moving to the lake at a velocity of 28 feet per day.

There have been some commercially-advertised treatment system enhancements for improved sediment retention in septic tanks but few in terms of reducing drain field discharges of phosphorus. Enhancements are not well-studied in the scientific literature nor are they endorsed by regulatory agencies and health departments. The default response by the agencies is system removal and replacement with expensive, modern technology often requiring more maintenance than traditional systems and often a larger drain field footprint.

The Need for Septic System Enhancements and Alternatives

On many lakes, including Black Lake, replacing septic systems is likely a costly endeavor, and the space available on lake lots can also be quite limiting. For older systems (>25 years old), the useful life of drain field soil phosphorus retention is likely expended. K&A testing on Black Lake confirms this condition. For systems constructed in the last 20 years, homeowner expectations are no doubt that these should have ample lifespan to continue performance with no backups or ponded septage on the property. What is not an expectation or consideration is leachate breakthrough to the lake. This remains a concern for all septic systems on shoreline properties.

Organizations like the Tip of the Mitt Watershed Council have been sounding this alarm for decades and actively support lake communities with septic system maintenance information.[14] Their past studies of the Black Lake shoreline dating back to 2005

[13] See, for example, https://www.epa.gov/septic/septicsmart
[14] See, for example, https://watershedcouncil.org/wp-content/uploads/2023/09/2022-Proper-Septic-Maintenance-For-Homeowners.pdf

highlighted concerns with drain field discharges based on the observed presence of the green filamentous alga, *Cladophora* attached to hard surfaces along the shoreline.[15] Most lake residents have probably heard about and/or seen these growths of *Cladophora* along their shorelines or on their neighbors' lakeshore. (See inset example at right.)



The presence of this alga, particularly when it is observed nearly year-round, is a direct indication of soluble phosphorus in septic system drain field leachate reaching the shoreline via shallow groundwater. The missing link between shoreline studies of *Cladophora* presence and its indication of breakthrough, is actual measurement of phosphorus (and bacteria) in shallow groundwater. Without measurement to quantify the level of phosphorus contributions to surface waters, concern over breakthrough remains hypothetical, and possible water quality and health implications are easily dismissed. Thanks to BLPS efforts and funding, these data now exist to quantify impacts which should drive action.

Importantly, septic systems age from their first day of use. Their ability over time to keep phosphorus and bacteria out of groundwater is always diminishing. Complete replacement of tanks, drain fields and drain field soils (when there is no other space on a lakefront property) are physically and financially limiting. Therefore, other "alternatives" for improving performance and reducing discharges to the lake are needed. Towards this end, K&A has been pursuing a number of potentially cost-effective options that could address needs to protect Black Lake water quality. Some of these alternatives are novel, others proven, yet few have been tested on Black Lake or other northern Michigan lakes suffering water quality impacts from septic system discharge impacts.

The remainder of this section introduces K&A information presented on potential alternatives or enhancements at the August 23, 2025 BLPS Public Meeting at the Onaway State Park Pavilion.[16] These and other alternatives have been proposed to the BLPS for consideration in 2026 to address mid- to long-term needs to mitigate soluble phosphorus discharges to Black Lake. Evaluation of options will come through pilot-testing accompanied by ongoing K&A research through the BLPS and other possible funding sources as outlined in the Black Lake WMP. As these are pursued, so too should other near-term options to more immediately mitigate confirmed phosphorus plumes from shallow groundwater in nearshore areas. These will additionally be considered with mitigation alternatives.

[15] "A Nutrient Pollution Shoreline Survey on Black Lake, 2005." Prepared by the Tip of the Mitt Watershed Council.
[16] See: https://youtu.be/ZCSPNxjVjUs

Mid- to long-term options introduced to the public by K&A in August of 2025 included those noted in the inset at right. Summary details provided in August for each suggested alternative approach are provided as follows.





The use of deep-rooted vegetation between the drain field and shoreline has already been pilot-tested by K&A with reported success.[17]



Where individual system replacement is not possible along stretches of the lake shoreline, an off-lake cluster system can serve multiple homeowners where constructed on backlot properties far distant from the lake.

[17] See: https://midwestglaciallakes.org/2019/04/15/project-spotlight-mitigating-septic-discharge-with-riparian-vegetation/

Alternative: In-tank P Precipitation

- Waterloo EC-P™ suited for use on individual, small flow septic systems
- Process mimics the natural phosphorus removal of iron-rich soils
- Up to 99% of total phosphorus removal claim
- Natural iron electrodes installed in septic with small current applied to electrodes
- Electrochemistry process removes P by precipitation of iron-phosphate minerals





Commercial systems exist that can be retrofitted to new septic tanks that use electrodes to precipitate phosphorus within the septic tank, eliminating its movement to the drain field and ultimately the lake.

Alternative: Add-on Phosphorus Box Treatment

- Add-on or add-in phosphorus capture box to existing system
- Located between septic tank and drain field
- Wastewater filtered through adsorbent media before release to drain field
- Media targets soluble (bioavailable) P
- 50-90% effective at removing phosphorus
- Media change-out required
- Proven effective in Agricultural field discharges



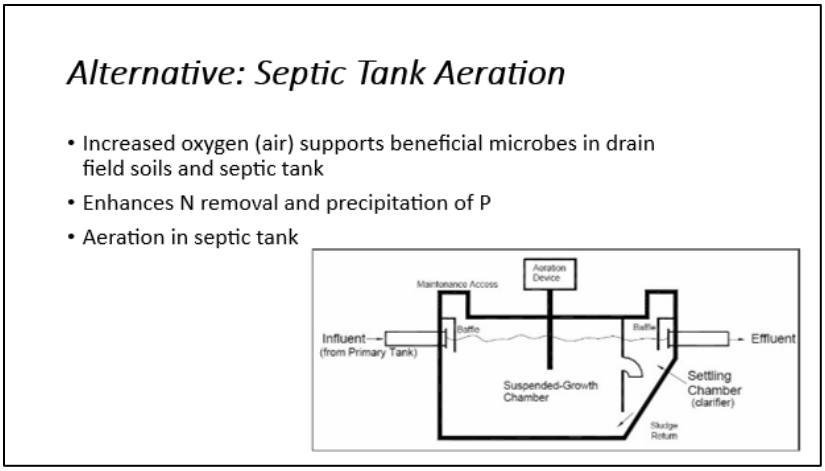
Add-on structures with P adsorptive media have been devised and installed in agricultural settings. Adaptation to septic tank applications is possible.

Alternative: Interception Trench

- Trench system along length of the shoreline on each affected property
- 2-3 foot deep trench, 1-2 feet wide
- Filled with filtration media to remove P and bacteria
- Located between drain field and shoreline
- Trench surface blended into existing landscape
- Commonly used for contaminant plumes
- Eventual replacement necessary



Pollution mitigation technology has long used special media to intercept and remove pollutants from groundwater. Where there are long stretches of beach at the water's edge, trenching with placement of sorbent media presents an option to mitigate ongoing or legacy phosphorus plumes.



Some commercial applications for aeration in the septic tank increases sludge production and may offer solutions to reduce E. coli bacteria levels in water reaching drain fields.[18]

In summary, sufficient data now exist that demonstrate what appears to be widespread impacts by septic systems on Black Lake. Such information should now lead to action; action that is grounded in good science and engineering practice. This should involve pilot testing and continued monitoring. Where pilot tests show demonstrable success, at-scale adoption might be in order. But recognizing the old adage "that one size does not fit all," multiple alternatives will likely need to be pursued. Such a strategy has been separately relayed to the Tip of the Mitt Watershed Council for inclusion in their draft Watershed Management Plan for the Black Lake Watershed. Continued support and diligence will fall on the backs of lake residents. External funding will also be necessary. All of these elements will be a part of the continued focus of K&A on behalf of the BLPS.

[18] See, for example, Aero-Stream | Septic Tank Problems & Solutions | Delivery To U.S. & Canada

ATTACHMENT A

Analytical Lab Reports for the December 16, 2025 Interim Memorandum

ATTACHMENT A

Lake, Tributary and Sediment Laboratory Reports

Analytical Laboratory Report

Report ID: S52901.01(01)
Generated on 09/05/2023

Report to

Attention: John Hart
Kieser & Associates
536 E. Michigan Ave. Ste 300
Kalamazoo, MI 49007

Phone: 269-344-7117 FAX:
Email: jhart@kieser-associates.com

Addtional Contacts: Doug Ervin, John Jacobson

Report produced by

Merit Laboratories, Inc.
2680 East Lansing Drive
East Lansing, MI 48823

Phone: (517) 332-0167 FAX: (517) 332-6333

Contacts for report questions:
John Laverty (johnlaverty@meritlabs.com)
Barbara Ball (bball@meritlabs.com)

Report Summary

Lab Sample ID(s): S52901.01-S52901.20
Project: Black Lake WQ
Collected Date(s): 08/31/2023
Submitted Date/Time: 09/01/2023 08:15
Sampled by: John J Hart
P.O. #:

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Maya Murshak
Technical Director

Analytical Laboratory Report

General Report Notes

Analytical results relate only to the samples tested, in the condition received by the laboratory.
Methods may be modified for improved performance.
Results reported on a dry weight basis where applicable.
'Not detected' indicates that parameter was not found at a level equal to or greater than the reporting limit (RL).
When MDL results are provided, then 'Not detected' indicates that parameter was not found at a level equal to or greater than the MDL.
40 CFR Part 136 Table II Required Containers, Preservation Techniques and Holding Times for the Clean Water Act specify that samples for acrolein and acrylonitrile, and 2-chloroethylvinyl ether need to be preserved at a pH in the range of 4 to 5 or if not preserved, analyzed within 3 days of sampling.
QA/QC corresponding to this analytical report is a separate document with the same Merit ID reference and is available upon request.
Full accreditation certificates are available upon request. Starred (*) analytes are not NELAP accredited.
Samples are held by the lab for 30 days from the final report date unless a written request to hold longer is provided by the client.
Report shall not be reproduced except in full, without the written approval of Merit Laboratories, Inc.
Limits for drinking water samples, are listed as the MCL Limits (Maximum Contaminant Level Concentrations)
PFAS requirement: Section 9.3.8 of U.S. EPA Method 537.1 states "If the method analyte(s) found in the Field Sample is present in the FRB at a concentration greater than 1/3 the MRL, then all samples collected with that FRB are invalid and must be recollected and reanalyzed."
Samples submitted without an accompanying FRB may not be acceptable for compliance purposes.
Wisconsin PFAs analysis: MDL = LOD; RL = LOQ. LOD and LOQ are adjusted for dilution.

Report Narrative

There is no additional narrative for this analytical report

Laboratory Certifications

Authority	Certification ID
Michigan DEQ	#9956
DOD ELAP & ISO/IEC 17025:2017	#69699
WBENC	#2005110032
Ohio VAP	#CL0002
Indiana DOH	#C-MI-07
New York NELAC	#11814
North Carolina DENR	#680
North Carolina DOH	#26702
Pennsylvania DEP	#68-05884
Wisconsin DNR	FID# 399147320

Qualifier Descriptions

Qualifier	Description
!	Result is outside of stated limit criteria
B	Compound also found in associated method blank
E	Concentration exceeds calibration range
F	Analysis run outside of holding time
G	Estimated result due to extraction run outside of holding time
H	Sample submitted and run outside of holding time
I	Matrix interference with internal standard
J	Estimated value less than reporting limit, but greater than MDL
L	Elevated reporting limit due to low sample amount
M	Result reported to MDL not RDL
O	Analysis performed by outside laboratory. See attached report.
R	Preliminary result
S	Surrogate recovery outside of control limits
T	No correction for total solids
X	Elevated reporting limit due to matrix interference
Y	Elevated reporting limit due to high target concentration
b	Value detected less than reporting limit, but greater than MDL
e	Reported value estimated due to interference
j	Analyte also found in associated method blank
p	Benzo(b)Fluoranthene and Benzo(k)Fluoranthene integrated as one peak.
x	Preserved from bulk sample

Glossary of Abbreviations

Abbreviation	Description
RL/RDL	Reporting Limit
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
SW	EPA SW 846 (Soil and Wastewater) Methods
E	EPA Methods
SM	Standard Methods
LN	Linear
BR	Branched

Method Summary

Method	Version
E200.8	EPA Method 200.8 Revision 5.4
E300.0	EPA Method 300.0 Revision 2.1 (1993)
SW3015A	SW 846 Method 3015A Revision 1 February 2007

Sample Summary (20 samples)

Sample ID	Sample Tag	Matrix	Collected Date/Time
S52901.01	BLD-1S	Surface Water	08/31/23 10:20
S52901.02	BLD-1M	Surface Water	08/31/23 10:40
S52901.03	BLD-1B	Surface Water	08/31/23 10:50
S52901.04	BLD-2S	Surface Water	08/31/23 11:25
S52901.05	BLD-2M	Surface Water	08/31/23 11:35
S52901.06	BLD-2B	Surface Water	08/31/23 11:40
S52901.07	BLD-3S	Surface Water	08/31/23 09:20
S52901.08	BLD-3M	Surface Water	08/31/23 09:40
S52901.09	BLD-3B	Surface Water	08/31/23 09:45
S52901.10	BLS-1M	Surface Water	08/31/23 12:10
S52901.11	BLS-2M	Surface Water	08/31/23 17:05
S52901.12	BLS-3M	Surface Water	08/31/23 19:05
S52901.13	Mud Creek	Surface Water	08/31/23 12:00
S52901.14	Lower Black River	Surface Water	08/31/23 14:20
S52901.15	Upper Black River	Surface Water	08/31/23 16:45
S52901.16	Fisher Creek	Surface Water	08/31/23 12:50
S52901.17	Stoney Creek	Surface Water	08/31/23 11:15
S52901.18	Rainy River / Cold Conf	Surface Water	08/31/23 09:10
S52901.19	Doriva Beach Creek	Surface Water	08/31/23 10:10
S52901.20	Stewart Creek	Surface Water	08/31/23 12:41

Analytical Laboratory Report

Lab Sample ID: S52901.01
Sample Tag: BLD-1S
Collected Date/Time: 08/31/2023 10:20
Matrix: Surface Water
COC Reference: 140082

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR
1	125ml Plastic	HNO3	Yes	3.4	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3015A	09/05/23 10:10	CCM	

Inorganics

Method: E300.0, Run Date: 09/01/23 10:45, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	6	5	0.08	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.04	mg/L	5	14797-55-8	

Metals

Method: E200.8, Run Date: 09/05/23 11:27, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Iron	Not detected	0.02		mg/L	5	7439-89-6	

Analytical Laboratory Report

Lab Sample ID: S52901.02
Sample Tag: BLD-1M
Collected Date/Time: 08/31/2023 10:40
Matrix: Surface Water
COC Reference: 140082

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR
1	125ml Plastic	HNO3	Yes	3.4	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3015A	09/05/23 10:10	CCM	

Inorganics

Method: E300.0, Run Date: 09/01/23 10:57, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	6	5	0.08	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.04	mg/L	5	14797-55-8	

Metals

Method: E200.8, Run Date: 09/05/23 11:29, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Iron	Not detected	0.02		mg/L	5	7439-89-6	

Analytical Laboratory Report

Lab Sample ID: S52901.03
Sample Tag: BLD-1B
Collected Date/Time: 08/31/2023 10:50
Matrix: Surface Water
COC Reference: 140082

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR
1	125ml Plastic	HNO3	Yes	3.4	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3015A	09/05/23 10:10	CCM	

Inorganics

Method: E300.0, Run Date: 09/01/23 11:10, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	6	5	0.08	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.04	mg/L	5	14797-55-8	

Metals

Method: E200.8, Run Date: 09/05/23 11:30, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Iron	Not detected	0.02		mg/L	5	7439-89-6	

Analytical Laboratory Report

Lab Sample ID: S52901.04
Sample Tag: BLD-2S
Collected Date/Time: 08/31/2023 11:25
Matrix: Surface Water
COC Reference: 140082

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR
1	125ml Plastic	HNO3	Yes	3.4	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3015A	09/05/23 10:10	CCM	

Inorganics

Method: E300.0, Run Date: 09/01/23 11:23, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	6	5	0.08	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.04	mg/L	5	14797-55-8	

Metals

Method: E200.8, Run Date: 09/05/23 11:32, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Iron	Not detected	0.02		mg/L	5	7439-89-6	

Analytical Laboratory Report

Lab Sample ID: S52901.05
Sample Tag: BLD-2M
Collected Date/Time: 08/31/2023 11:35
Matrix: Surface Water
COC Reference: 140082

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR
1	125ml Plastic	HNO3	Yes	3.4	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3015A	09/05/23 10:10	CCM	

Inorganics

Method: E300.0, Run Date: 09/01/23 11:36, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	6	5	0.08	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.04	mg/L	5	14797-55-8	

Metals

Method: E200.8, Run Date: 09/05/23 11:38, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Iron	Not detected	0.02		mg/L	5	7439-89-6	

Analytical Laboratory Report

Lab Sample ID: S52901.06
Sample Tag: BLD-2B
Collected Date/Time: 08/31/2023 11:40
Matrix: Surface Water
COC Reference: 140082

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR
1	125ml Plastic	HNO3	Yes	3.4	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3015A	09/05/23 10:10	CCM	

Inorganics

Method: E300.0, Run Date: 09/01/23 11:49, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	6	5	0.08	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.04	mg/L	5	14797-55-8	

Metals

Method: E200.8, Run Date: 09/05/23 11:39, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Iron	0.02	0.02		mg/L	5	7439-89-6	

Analytical Laboratory Report

Lab Sample ID: S52901.07
Sample Tag: BLD-3S
Collected Date/Time: 08/31/2023 09:20
Matrix: Surface Water
COC Reference: 140082

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR
1	125ml Plastic	HNO3	Yes	3.4	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3015A	09/05/23 10:10	CCM	

Inorganics

Method: E300.0, Run Date: 09/01/23 12:02, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	6	5	0.08	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.04	mg/L	5	14797-55-8	

Metals

Method: E200.8, Run Date: 09/05/23 11:41, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Iron	Not detected	0.02		mg/L	5	7439-89-6	

Analytical Laboratory Report

Lab Sample ID: S52901.08
Sample Tag: BLD-3M
Collected Date/Time: 08/31/2023 09:40
Matrix: Surface Water
COC Reference: 140082

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR
1	125ml Plastic	HNO3	Yes	3.4	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3015A	09/05/23 10:10	CCM	

Inorganics

Method: E300.0, Run Date: 09/01/23 12:15, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	6	5	0.08	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.04	mg/L	5	14797-55-8	

Metals

Method: E200.8, Run Date: 09/05/23 11:42, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Iron	Not detected	0.02		mg/L	5	7439-89-6	

Analytical Laboratory Report

Lab Sample ID: S52901.09
Sample Tag: BLD-3B
Collected Date/Time: 08/31/2023 09:45
Matrix: Surface Water
COC Reference: 140082

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR
1	125ml Plastic	HNO3	Yes	3.4	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3015A	09/05/23 10:10	CCM	

Inorganics

Method: E300.0, Run Date: 09/01/23 12:27, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	6	5	0.08	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.04	mg/L	5	14797-55-8	

Metals

Method: E200.8, Run Date: 09/05/23 11:44, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Iron	0.02	0.02		mg/L	5	7439-89-6	

Analytical Laboratory Report

Lab Sample ID: S52901.10
Sample Tag: BLS-1M
Collected Date/Time: 08/31/2023 12:10
Matrix: Surface Water
COC Reference: 140082

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR
1	125ml Plastic	HNO3	Yes	3.4	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3015A	09/05/23 10:10	CCM	

Inorganics

Method: E300.0, Run Date: 09/01/23 13:32, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	6	5	0.08	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.04	mg/L	5	14797-55-8	

Metals

Method: E200.8, Run Date: 09/05/23 11:45, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Iron	0.05	0.02		mg/L	5	7439-89-6	

Analytical Laboratory Report

Lab Sample ID: S52901.11
Sample Tag: BLS-2M
Collected Date/Time: 08/31/2023 17:05
Matrix: Surface Water
COC Reference: 140082

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR
1	125ml Plastic	HNO3	Yes	3.4	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3015A	09/05/23 10:10	CCM	

Inorganics

Method: E300.0, Run Date: 09/01/23 13:45, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	6	5	0.08	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.04	mg/L	5	14797-55-8	

Metals

Method: E200.8, Run Date: 09/05/23 11:47, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Iron	0.04	0.02		mg/L	5	7439-89-6	

Analytical Laboratory Report

Lab Sample ID: S52901.12
Sample Tag: BLS-3M
Collected Date/Time: 08/31/2023 19:05
Matrix: Surface Water
COC Reference: 140082

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR
1	125ml Plastic	HNO3	Yes	3.4	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3015A	09/05/23 10:10	CCM	

Inorganics

Method: E300.0, Run Date: 09/01/23 13:57, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	6	5	0.08	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.04	mg/L	5	14797-55-8	

Metals

Method: E200.8, Run Date: 09/05/23 11:48, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Iron	Not detected	0.02		mg/L	5	7439-89-6	

Analytical Laboratory Report

Lab Sample ID: S52901.13
Sample Tag: Mud Creek
Collected Date/Time: 08/31/2023 12:00
Matrix: Surface Water
COC Reference: 140084

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR

Inorganics

Method: E300.0, Run Date: 09/01/23 09:53, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Nitrate-N	Not detected	0.5	0.06	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S52901.14
Sample Tag: Lower Black River
Collected Date/Time: 08/31/2023 14:20
Matrix: Surface Water
COC Reference: 140084

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR

Inorganics

Method: E300.0, Run Date: 09/01/23 10:03, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Nitrate-N	Not detected	0.5	0.06	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S52901.15
Sample Tag: Upper Black River
Collected Date/Time: 08/31/2023 16:45
Matrix: Surface Water
COC Reference: 140084

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR

Inorganics

Method: E300.0, Run Date: 09/01/23 10:13, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Nitrate-N	Not detected	0.5	0.06	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S52901.16
Sample Tag: Fisher Creek
Collected Date/Time: 08/31/2023 12:50
Matrix: Surface Water
COC Reference: 140084

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR

Inorganics

Method: E300.0, Run Date: 09/01/23 10:23, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Nitrate-N	Not detected	0.5	0.06	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S52901.17
Sample Tag: Stoney Creek
Collected Date/Time: 08/31/2023 11:15
Matrix: Surface Water
COC Reference: 140084

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR

Inorganics

Method: E300.0, Run Date: 09/01/23 10:33, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Nitrate-N	Not detected	0.5	0.06	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S52901.18
Sample Tag: Rainy River / Cold Conf
Collected Date/Time: 08/31/2023 09:10
Matrix: Surface Water
COC Reference: 140084

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR

Inorganics

Method: E300.0, Run Date: 09/01/23 10:43, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Nitrate-N	Not detected	0.5	0.06	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S52901.19
Sample Tag: Doriva Beach Creek
Collected Date/Time: 08/31/2023 10:10
Matrix: Surface Water
COC Reference: 140084

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR

Inorganics

Method: E300.0, Run Date: 09/01/23 10:53, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Nitrate-N	Not detected	0.5	0.06	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S52901.20
Sample Tag: Stewart Creek
Collected Date/Time: 08/31/2023 12:41
Matrix: Surface Water
COC Reference: 140084

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	3.4	IR

Inorganics

Method: E300.0, Run Date: 09/01/23 11:03, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Nitrate-N	Not detected	0.5	0.06	mg/L	5	14797-55-8	

Merit Laboratories Login Checklist

Lab Set ID: S52901
Client: KIESER (Kieser & Associates)
Project: Black Lake WQ
Submitted: 09/01/2023 08:15 Login User: PFD

Attention: John Hart
Address: Kieser & Associates
536 E. Michigan Ave. Ste 300
Kalamazoo, MI 49007

Phone: 269-344-7117 FAX:
Email: jhart@kieser-associates.com

Selection				Description	Note
Sample Receiving					
01.	[X] Yes	[ ] No	[ ] N/A	Samples are received at 4C +/- 2C Thermometer #	IR 3.4
02.	[X] Yes	[ ] No	[ ] N/A	Received on ice/ cooling process begun	
03.	[ ] Yes	[X] No	[ ] N/A	Samples shipped	
04.	[X] Yes	[ ] No	[ ] N/A	Samples left in 24 hr. drop box	
05.	[ ] Yes	[X] No	[ ] N/A	Are there custody seals/tape or is the drop box locked	
Chain of Custody					
06.	[X] Yes	[ ] No	[ ] N/A	COC adequately filled out	
07.	[X] Yes	[ ] No	[ ] N/A	COC signed and relinquished to the lab	
08.	[X] Yes	[ ] No	[ ] N/A	Sample tag on bottles match COC	
09.	[ ] Yes	[X] No	[ ] N/A	Subcontracting needed? Subcontacted to:	
Preservation					
10.	[X] Yes	[ ] No	[ ] N/A	Do sample have correct chemical preservation	
11.	[X] Yes	[ ] No	[ ] N/A	Completed pH checks on preserved samples? (no VOAs)	
12.	[ ] Yes	[X] No	[ ] N/A	Did any samples need to be preserved in the lab?	
Bottle Conditions					
13.	[X] Yes	[ ] No	[ ] N/A	All bottles intact	
14.	[X] Yes	[ ] No	[ ] N/A	Appropriate analytical bottles are used	
15.	[X] Yes	[ ] No	[ ] N/A	Merit bottles used	
16.	[X] Yes	[ ] No	[ ] N/A	Sufficient sample volume received	
17.	[ ] Yes	[X] No	[ ] N/A	Samples require laboratory filtration	
18.	[X] Yes	[ ] No	[ ] N/A	Samples submitted within holding time	
19.	[ ] Yes	[ ] No	[X] N/A	Do water VOC or TOX bottles contain headspace	

Corrective action for all exceptions is to call the client and to notify the project manager.

Client Review By: _____ Date: _____

Merit Laboratories Bottle Preservation Check

Lab Set ID: S52901 Submitted: 09/01/2023 08:15

Client: KIESER (Kieser & Associates)

Project: Black Lake WQ

Initial Preservation Check: 09/01/2023 08:42 PFD

Preservation Recheck (E200.8): N/A

Attention: John Hart
Address: Kieser & Associates
536 E. Michigan Ave. Ste 300
Kalamazoo, MI 49007

Phone: 269-344-7117 FAX:
Email: jhart@kieser-associates.com

Sample ID	Bottle / Preservation	pH (Orig)	Add ml	pH (New)	Notes
S52901.01	125ml Plastic HNO3	<2			
S52901.02	125ml Plastic HNO3	<2			
S52901.03	125ml Plastic HNO3	<2			
S52901.04	125ml Plastic HNO3	<2			
S52901.05	125ml Plastic HNO3	<2			
S52901.06	125ml Plastic HNO3	<2			
S52901.07	125ml Plastic HNO3	<2			
S52901.08	125ml Plastic HNO3	<2			
S52901.09	125ml Plastic HNO3	<2			
S52901.10	125ml Plastic HNO3	<2			
S52901.11	125ml Plastic HNO3	<2			
S52901.12	125ml Plastic HNO3	<2			

Merit Laboratories, Inc.
2680 East Lansing Dr., East Lansing, MI 48823
Phone (517) 332-0167 Fax (517) 332-4034
www.meritlabs.com

C.O.C. PAGE # _____ OF _____ 140082

CHAIN OF CUSTODY RECORD

REPORT TO

CONTACT NAME: John Hart
COMPANY: Kieser and Associates
ADDRESS: 536 E. Michigan Ave
CITY: Kalamazoo STATE: MI ZIP CODE: 49007
PHONE NO.: (269)-334-7117 FAX NO.: P.O. NO.:
E-MAIL ADDRESS: jhart@kieser-associates.com QUOTE NO.:

INVOICE TO

CONTACT NAME: Becky Haugh ☐ SAME
COMPANY:
ADDRESS:
CITY: STATE: ZIP CODE:
PHONE NO.: E-MAIL ADDRESS: bhaugh@kieser-associates.com

PROJECT NO./NAME: Black Lake WQ
SAMPLER(S) - PLEASE PRINT/SIGN NAME: John J. Hart John J Hart

TURNAROUND TIME REQUIRED ☐ 1 DAY ☐ 2 DAYS ☐ 3 DAYS ☒ STANDARD ☐ OTHER _____

DELIVERABLES REQUIRED ☒ STD ☐ LEVEL II ☐ LEVEL III ☐ LEVEL IV ☐ EDD ☐ OTHER _____

MATRIX CODE: GW=GROUNDWATER WW=WASTEWATER S=SOIL L=LIQUID SD=SOLID SL=SLUDGE DW=DRINKING WATER O=OIL WP=WIPE A=AIR W=WASTE

ANALYSIS (ATTACH LIST IF MORE SPACE IS REQUIRED)

Certifications: ☐ OHIO VAP ☐ Drinking Water ☐ DoD ☐ NPDES

Project Locations: ☐ Detroit ☐ New York ☐ Other _____

Special Instructions

MERIT LAB NO. (FOR LAB USE ONLY)	YEAR DATE	YEAR TIME	SAMPLE TAG IDENTIFICATION-DESCRIPTION	MATRIX	# OF BOTTLES	# Containers & Preservatives: NONE	HCl	HNO_3	H_2SO_4	NaOH	MeOH	OTHER	Iron	NO_3 CN; trate	chloride
52901.01	8/31/23	10:20	BLD-1S	SW	2	1		1					X	X	X
.02	8/31/23	10:40	BLD-1M										X	X	X
.03	8/31/23	10:50	BLD-1B										X	X	X
.04	8/31/23	11:25	BLD-2S										X	X	X
.05	8/31/23	11:35	BLD-2M										X	X	X
.06	8/31/23	11:40	BLD-2B										X	X	X
.07	8/31/23	9:20	BLD-3 S										X	X	X
.08	8/31/23	9:40	BLD-3 M										X	X	X
.09	8/31/23	9:45	BLD-3 B										X	X	X
.10	8/31/23	12:10	BLS-1 SM										X	X	X
.11	8/31/23	5:05	BLS-2M										X	X	X
.12	8/31/23	7:05	BLS-3M	↓	↓	↓		↓					X	X	X

RELINQUISHED BY: SIGNATURE/ORGANIZATION: John Hart ☒ Sampler	DATE: 9/1/23	TIME: 12:30	
RECEIVED BY: SIGNATURE/ORGANIZATION	DATE	TIME	
RELINQUISHED BY: SIGNATURE/ORGANIZATION	DATE	TIME	
RECEIVED BY: SIGNATURE/ORGANIZATION	DATE	TIME	

RELINQUISHED BY: SIGNATURE/ORGANIZATION: Merit Storage	DATE: 9/1/23	TIME: 0815	
RECEIVED BY: SIGNATURE/ORGANIZATION: Pat	DATE: 9/1/23	TIME: 0815	

SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS

SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS

NOTES: TEMP. ON ARRIVAL 3, 4

PLEASE NOTE: SIGNING ACKNOWLEDGES ADHERENCE TO MERIT'S SAMPLE ACCEPTANCE POLICY ON REVERSE SIDE

Rev. 5.18.12

Merit Laboratories, Inc.
2680 East Lansing Dr., East Lansing, MI 48823
Phone (517) 332-0167 Fax (517) 332-4034
www.meritlabs.com

C.O.C. PAGE # 1 OF 2

140084

CHAIN OF CUSTODY RECORD

REPORT TO

CONTACT NAME: John Hart
COMPANY: Kieser and Associates
ADDRESS: 536 E. Michigan Ave.
CITY: Kalamazoo STATE: MI ZIP CODE: 49007
PHONE NO.: (269)-334-7117 FAX NO.: P.O. NO.:
E-MAIL ADDRESS: jhart@kieser-associates.com QUOTE NO.:

INVOICE TO

CONTACT NAME: Becky Hough ☒SAME
COMPANY:
ADDRESS:
CITY: STATE: ZIP CODE:
PHONE NO.: E-MAIL ADDRESS: bhough@kieser-associates.com

PROJECT NO./NAME: Black Lake WQ
SAMPLER(S) - PLEASE PRINT/SIGN NAME: John J Hart John J Hart

TURNAROUND TIME REQUIRED ☐ 1 DAY ☐ 2 DAYS ☐ 3 DAYS ☒ STANDARD ☐ OTHER

DELIVERABLES REQUIRED ☒ STD ☐ LEVEL II ☐ LEVEL III ☐ LEVEL IV ☐ EDD ☐ OTHER

MATRIX CODE: GW=GROUNDWATER WW=WASTEWATER S=SOIL L=LIQUID SD=SOLID SL=SLUDGE DW=DRINKING WATER O=OIL WP=WIPE A=AIR W=WASTE

ANALYSIS (ATTACH LIST IF MORE SPACE IS REQUIRED)

Certifications
☐ OHIO VAP ☐ Drinking Water
☐ DoD ☐ NPDES

Project Locations
☐ Detroit ☐ New York
☐ Other

Special Instructions

MERIT LAB NO. FOR LAB USE ONLY	YEAR DATE	YEAR TIME	SAMPLE TAG IDENTIFICATION-DESCRIPTION	MATRIX	# OF BOTTLES	# Containers & Preservatives: NONE	HCl	HNO_3	H_2SO_4	NaOH	MeOH	OTHER	Nitrate (NO_3)
52901.13	8/31/23	12:00	Mud Creek	SW	1	1							X
.14	8/31/23	2:20	Lower Black River										X
.15	8/31/23	4:45	Upper Black River										X
.16	8/31/23	12:50	Fisher Creek										X
.17	8/31/23	11:15	Stoney Creek										X
.18	8/31/23	9:10	Rainy River/cold Conf										X
.19	8/31/23	10:10	Doriva Beach Creek										X
			Cains Creek										X
.20	8/31/23	12:41	Stewart Creek										X

RELINQUISHED BY: SIGNATURE/ORGANIZATION		DATE	TIME
John Hart	☒Sampler	9/1/23	12:30
RECEIVED BY: SIGNATURE/ORGANIZATION		DATE	TIME
RELINQUISHED BY: SIGNATURE/ORGANIZATION		DATE	TIME
RECEIVED BY: SIGNATURE/ORGANIZATION		DATE	TIME

RELINQUISHED BY: SIGNATURE/ORGANIZATION	DATE	TIME
Merit Storage	9/1/23	0815
Pete D	9/1/23	0815

SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS
SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS

NOTES: TEMP. ON ARRIVAL 3.4

PLEASE NOTE: SIGNING ACKNOWLEDGES ADHERENCE TO MERIT'S SAMPLE ACCEPTANCE POLICY ON REVERSE SIDE

Rev. 5.18.12

Great Lakes Environmental Center

Project Number: 2592-B15

September 27, 2023

Kieser & Associates-Black Lake WQ
536 E. Michigan Ave., Suite 300
Kalamazoo, MI 49007

Attention: John Hart

Project Description: Water Quality Sampling

Dear Client,

Enclosed is a copy of your laboratory report relating to samples, as they were received. All tests have met or exceeded QC criteria. Test results are in compliance with The NELAC Institute Standards. Sediment Fe was analyzed by ALS laboratories. Visit our web site for a full list of tests for which GLEC (Lab 2059) is accredited through the New Hampshire Environmental Laboratory Accreditation Program (NH ELAP).

Please don't hesitate to call if you have questions or require further information.

Data Qualifiers:

J = Estimated result below the RL but above the MDL

Sincerely,

Michelle A. Moore
Laboratory Coordinator and Research Scientist/Nutrient Chemistry

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Total Phosphorus

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K08310012	BLD-1 Sed	8/31/2023	1280	mg/kg dr	99.132	46.2616		9/26/2023		BSC
9K08310016	BLD-2 Sed	8/31/2023	1490	mg/kg dr	102.171	47.6798		9/26/2023		BSC
9K08310020	BLD-3 Sed	8/31/2023	1470	mg/kg dr	98.319	45.8822		9/26/2023		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Wednesday, September 27, 2023

Method: SM 4500-P F

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Total Phosphorus

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K08310001	Mud Creek	8/31/2023	0.0300	mg/L	0.003	0.0014		9/14/2023		BSC
9K08310002	Lower Black River	8/31/2023	0.0440	mg/L	0.003	0.0014		9/14/2023		BSC
9K08310003	Upper Black River	8/31/2023	0.0285	mg/L	0.003	0.0014		9/14/2023		BSC
9K08310004	Fisher Creek	8/31/2023	0.0508	mg/L	0.003	0.0014		9/14/2023		BSC
9K08310005	Stoney Creek	8/31/2023	0.0642	mg/L	0.003	0.0014		9/14/2023		BSC
9K08310006	Rainy River/Cold Conf	8/31/2023	0.0589	mg/L	0.003	0.0014		9/14/2023		BSC
9K08310007	Doriva Beach Creek	8/31/2023	0.0633	mg/L	0.003	0.0014		9/14/2023		BSC
9K08310008	Stewart Creek	8/31/2023	0.0505	mg/L	0.003	0.0014		9/14/2023		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Monday, October 09, 2023

Method: SM 4500-P F

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K08310009	BLD-1S	8/31/2023	0.0226	mg/L	0.003	0.0014		9/14/2023		BSC
9K08310010	BLD-1M	8/31/2023	0.0234	mg/L	0.003	0.0014		9/14/2023		BSC
9K08310011	BLD-1B	8/31/2023	0.0245	mg/L	0.003	0.0014		9/14/2023		BSC
9K08310013	BLD-2S	8/31/2023	0.0167	mg/L	0.003	0.0014		9/14/2023		BSC
9K08310014	BLD-2M	8/31/2023	0.0178	mg/L	0.003	0.0014		9/14/2023		BSC
9K08310015	BLD-2B	8/31/2023	0.0183	mg/L	0.003	0.0014		9/14/2023		BSC
9K08310017	BLD-3S	8/31/2023	0.0328	mg/L	0.003	0.0014		9/14/2023		BSC
9K08310018	BLD-3M	8/31/2023	0.0329	mg/L	0.003	0.0014		9/14/2023		BSC
9K08310019	BLD-3B	8/31/2023	0.0322	mg/L	0.003	0.0014		9/14/2023		BSC
9K08310021	BLS-1	8/31/2023	0.0250	mg/L	0.003	0.0014		9/14/2023		BSC
9K08310022	BLS-2	8/31/2023	0.0331	mg/L	0.003	0.0014		9/14/2023		BSC
9K08310023	BLS-3	8/31/2023	0.0377	mg/L	0.003	0.0014		9/14/2023		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 4500-P F

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Soluble Reactive Phosphorus

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K08310001	Mud Creek	8/31/2023	0.0038	mg/L	0.001	0.000153		9/14/2023		BSC
9K08310002	Lower Black River	8/31/2023	0.0004	mg/L	0.001	0.000153	J	9/14/2023		BSC
9K08310003	Upper Black River	8/31/2023	0.0056	mg/L	0.001	0.000153		9/14/2023		BSC
9K08310004	Fisher Creek	8/31/2023	0.0006	mg/L	0.001	0.000153	J	9/14/2023		BSC
9K08310005	Stoney Creek	8/31/2023	0.0007	mg/L	0.001	0.000153	J	9/14/2023		BSC
9K08310006	Rainy River/Cold Conf	8/31/2023	0.0075	mg/L	0.001	0.000153		9/14/2023		BSC
9K08310007	Doriva Beach Creek	8/31/2023	0.0084	mg/L	0.001	0.000153		9/14/2023		BSC
9K08310008	Stewart Creek	8/31/2023	0.0008	mg/L	0.001	0.000153	J	9/14/2023		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Monday, October 09, 2023

Method: SM 4500-P F

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K08310009	BLD-1S	8/31/2023	0.0015	mg/L	0.001	0.000153		9/14/2023		BSC
9K08310010	BLD-1M	8/31/2023	0.0016	mg/L	0.001	0.000153		9/14/2023		BSC
9K08310011	BLD-1B	8/31/2023	0.0017	mg/L	0.001	0.000153		9/14/2023		BSC
9K08310013	BLD-2S	8/31/2023	0.0011	mg/L	0.001	0.000153		9/14/2023		BSC
9K08310014	BLD-2M	8/31/2023	0.0012	mg/L	0.001	0.000153		9/14/2023		BSC
9K08310015	BLD-2B	8/31/2023	0.0021	mg/L	0.001	0.000153		9/14/2023		BSC
9K08310017	BLD-3S	8/31/2023	0.0018	mg/L	0.001	0.000153		9/14/2023		BSC
9K08310018	BLD-3M	8/31/2023	0.0015	mg/L	0.001	0.000153		9/14/2023		BSC
9K08310019	BLD-3B	8/31/2023	0.0012	mg/L	0.001	0.000153		9/14/2023		BSC
9K08310022	BLS-2	8/31/2023	0.0006	mg/L	0.001	0.000153	J	9/14/2023		BSC
9K08310023	BLS-3	8/31/2023	0.0023	mg/L	0.001	0.000153		9/14/2023		BSC
9K08310025	BLS-1	8/31/2023	0.0026	mg/L	0.001	0.000153		9/14/2023		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 4500-P F

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

chla

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K08310024	BLD-1	8/31/2023	0.00480	mg/L	2.4733333E-05	0.000000294		9/12/2023		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Wednesday, September 27, 2023

Method: EPA Method 445.0

GREAT LAKES ENVIRONMENTAL CENTER, INC.

CHAIN OF CUSTODY RECORD

Traverse City, MI - Laboratory
739 Hastings Street
Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: Kieser and Associates

Report Results To: John Hart

Address: 536 E. Michigan Ave, Kalamazoo MI 49007

Phone: 269-344-7117 E-mail: jhart@kieser-associates.com

Section II.

Project Name: Black Lake WQ

Project Number:

P.O.#:

Sampled by: (initials) ☐ GLEC _____ ☒ Client JJH

Section III. Sample Information at Collection

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.	Requested Analysis: LP	SRP						pH of Sample Upon Receipt
1		Mud Creek	8/31/23	12:00	SW	Grab	Y (TP)	Y (SRP)	Glass	250	2	X	X						<2
2		Lower Black River	8/31/23	2:20								X	X						<2
3		upper Black River	8/31/23	4:45								X	X						<2
4		Fisher Creek	8/31/23	12:50								X	X						<2
5		Stoney Creek	8/31/23	11:15								X	X						<2
6		Rainy River/Cold Conf	8/31/23	9:10								X	X						<2
7		DeTiva Beach Creek	8/31/23	10:10								X	X						<2
8		[illegible] Creek										X	X						X

CG 9/5/23

Client Notes:

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: KA Mark Kieser	9.1.23	10:47	Print Name & Organization Carrie Gorman	9/1/23	10:50
Signature MK			Signature		
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: 2.6 °C Initials: CG Bottle ID #, if applicable 29312 ☒ Received on Wet Ice

Notes/Anomalies/Discrepancies:

GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; SW = SURFACE WATER; E = EFFLUENT; GW = GROUNDWATER; SL = SLUDGE; AO = AQUATIC ORGANISM

GLEC
Great Lakes Environmental Center

GREAT LAKES ENVIRONMENTAL CENTER, INC.

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Traverse City, MI - Laboratory
739 Hastings Street
Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: Kieser and Associates
Report Results To: John Hart
Address: 536 E. Michigan Ave Kalamazoo MI 49007
Phone: (269)-334-7117 E-mail: jhart@kieser-associates.com

Section II.

Project Name: Black Lake WQ
Project Number:
P.O.#:
Sampled by: (initials) ☐ GLEC _____ ☒ Client JJH

Section III. **Sample Information at Collection**

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.
1		Stewart Creek	8/31/23	12:40	SW	grab	Y (TP)	Y (SRP)	glass	250	2
2	[redacted]										
3											
4											
5											
6											
7											
8											

Section IV. Requested Analysis

#	TP	SRP	Sediment TP	Sediment Iron					pH of Sample Upon Receipt
1	X	X							<2
2	[redacted]								
3									
4									
5									
6									
7									
8									

Client Notes:

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Mark Kieser KA	9/1/23	10:47	Print Name & Organization: Connie Gorman GLEC	9/11/23	10:50
Signature: Mark K			Signature		
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: 2.6 °C Initials: CG Bottle ID #, if applicable 29312 ☒ Received on Wet Ice

Notes/Anomalies/Discrepancies:

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CHAIN OF CUSTODY RECORD

Traverse City, MI - Laboratory
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Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: Kieser & Associates, LLC
Report Results To: John Hart
Address: 536 E. Michigan Ave Kalamazoo MI, 49007
Phone: (269) 334-7117 E-mail: jhart@kieser-associates.com

Section II.

Project Name: Black Lake WQ
Project Number:
P.O.#:
Sampled by: (initials) ☐ GLEC _____ ☒ Client JJH

Section III. Sample Information at Collection

Section IV. Requested Analysis

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.	TP	SRP	Sediment TP	Sediment Iron					pH of Sample Upon Receipt
1		BLD-1S	8/31/23	10:20	SW	Grab	Yes (TP)	Y(SRP)	Glass	250	2	X	X							<2
2		BLD-1M	8/31/23	10:40	SW	↓	↓	↓	↓	250	2	X	X							<2
3		BLD-1B	8/31/23	10:50	SW	↓	↓	↓	↓	250	2	X	X							<2
4		BLD-1 Sed	8/31/23	11:00	S	↓	No	N	↓	500	1			X	X					
5		BLD-2S	8/31/23	11:25	SW	↓	Yes (TP)	Y(SRP)	↓	250	2	X	X							<2
6		BLD-2M	8/31/23	11:35	SW	↓	↓	↓	↓	250	2	X	X							<2
7		BLD-2B	8/31/23	11:40	SW	↓	↓	↓	↓	250	2	X	X							<2
8		BLD-2 Sed	8/31/23	11:50	S	↓	No	N	↓	500	1			X	X					

Client Notes:

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: K&A Mark Kieser	9.1.23	10:47	Print Name & Organization: Carrie Gorman GLEC	9/1/23	10:50
Signature: Mark Kieser			Signature: CG		
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: 2.6 °C Initials: CG Bottle ID #, if applicable 29312 ☒ Received on Wet Ice

Notes/Anomalies/Discrepancies:

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Report Results To: John Hart
Address: 536 E. Michigan Ave Kalamazoo MI, 49007
Phone: (269) 334-7117 E-mail: jhart@kieser-associates.com

Section II.

Project Name: Black Lake WQ
Project Number:
P.O.#:
Sampled by: (initials) ☐ GLEC _____ ✱ Client JJH

Section III. Sample Information at Collection

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.
1		BLD-3S	8/31/23	9:20	SW	Grab	Yes (TP)	Y (SRP)	glass	250	2
2		BLD-3M	8/31/23	9:40	SW	↓	↓	↓	↓	250	2
3		BLD-3B	8/31/23	9:45	SW	↓	↓	↓	↓	250	2
4		BLD-3Sed	8/31/23	10:00	S	↓	No	N	↓	500	1
5		BLS-03	8/31/23	7:05	SW	↓	Yes (TP)	Y (SRP)	↓	250	2
6		BLS-01	8/31/23	12:10	SW	↓	↓	↓	↓	250	2
7		BLS-02	8/31/23	5:05	SW	↓	↓	↓	↓	250	2
8		BLD-1	8/31/23	10:45		Comp	No	Y	filter	NA	NA

Section IV. Requested Analysis

#	TP	SRP	Sediment TP	Sediment Iron	Chl-a				pH of Sample Upon Receipt
1	X	X							<2
2	X	X							<2
3	X	X							<2
4			X	X					
5	X	X							<2
6	X	[redacted]							<2
7	X	X							<2
8					X				

Client Notes:

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Mark Kieser K:A	9/1/23	10:47	Print Name & Organization: Carrie Gorman GLEC	9/1/23	10:50
Signature: MK			Signature: CG		
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: 2.6 °C Initials: CG Bottle ID #, if applicable 29312 ☒ Received on Wet Ice

Notes/Anomalies/Discrepancies:

GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; SW = SURFACE WATER; E = EFFLUENT; GW = GROUNDWATER; SL = SLUDGE; AO = AQUATIC ORGANISM

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Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: Kieser & Associates
Report Results To: ~~[illegible]~~ Mark Kieser
Address: 536 E. Michigan Ave., Kalamazoo, MI 49007
Phone: 269-344-7117 E-mail: MKieser@Kieser-associates.com

Section II.

Project Name:
Project Number:
P.O.#:
Sampled by: (initials)
☐ GLEC _____ ☐ Client _____

Section III. Sample Information at Collection

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.
1		BLS-1	8.31.23	12:10	water	grab	None	Y	Glass	150	1
2											
3											
4											
5											
6											
7											
8											

Section IV. Requested Analysis

BRS									pH of Sample Upon Receipt
X									

Client Notes: Sample frozen after filtering

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Kieser & Associates, Julie Kieser			Print Name & Organization	9-1-23	
Signature			Signature	9-6-23	10:31
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: _____ °C Initials: _____ Bottle ID #, if applicable _____ ☐ Received on Wet Ice

Notes/Anomalies/Discrepancies: _____

GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; SW = SURFACE WATER; E = EFFLUENT; GW = GROUNDWATER; SL = SLUDGE; AO = AQUATIC ORGANISM

IFCB Algal Analysis Report - Full Assemblage

PhycoTech, Inc. | 269.983.3654 | www.phycotech.com

PLEASE READ ALL INFORMATION BEFORE INTERPRETING DATA

IFCB Analysis Overview:

The Imaging FlowCytobot (IFCB, McLane Research Laboratories, Inc.) is an automated submersible imaging flow cytometer that generates high-resolution images of suspended particles in-flow. At PhycoTech, Inc. we use the IFCB as a bench instrument to provide a rapid, high-level picture of algal assemblage. The IFCB can trigger on image particulates between 2-250 µm, however, it most reliably tallies particulates 8-250 µm. The average overall algal GALD across all phytoplankton analyzed at PhycoTech (n>10K) is approximately 50 µm. IFCB captured images are classified using a random forest classifier model that we are constantly building and improving.

Important Analysis Information:

1. Live samples are tallied more accurately than preserved samples.
2. Unpreserved samples received more than 24 hours after sampling will provide unreliable results.
3. 'Unclassified' images (see below) are included in 'Total Algae' counts (1 NU as 1 cell per image).
4. Picoplankton may be entrained in 'Detritus'. These cells are not counted and biovolume is not calculated.
5. Although not included in the Taste and Odor (TO) functional group, some diatoms may cause taste and odor events.
6. Taste and Odor (TO) functional group taxa are not consistent toxin producers and are not included in the Total HAB Concentration.
7. IFCB data is semi-quantitative. Concentration and total biovolume have not yet been fully compared to manual measurements for validation or calibration for all systems and system types. The data produced has the most utility comparing dominant taxa groups, functional class and thresholds of critical water quality indicators.
8. The processing of your sample with the IFCB produces an abundant number of images, more than a manual counter would be able to see. Due to differences in counting methods, the data in this report cannot be directly compared to a manual count.
9. IFCB images for your samples are archived at PhycoTech, Inc., and are available via a 'box' link upon request (please allow 7 business days for delivery).

NOTE - Aphanizomenon taxa abbreviations:

IFCB Taxa ID	Taxa included	Notes
Aph. flos-aquae	Aphanizomenon flos-aquae	May produce saxitoxin.
Aph. gracile-Sphaero.-Chrys.	Aphanizomenon gracile, Sphaerospermopsis, & Chrysosporum	May produce microcystin, anatoxin A, and/or cylindrospermopsin.

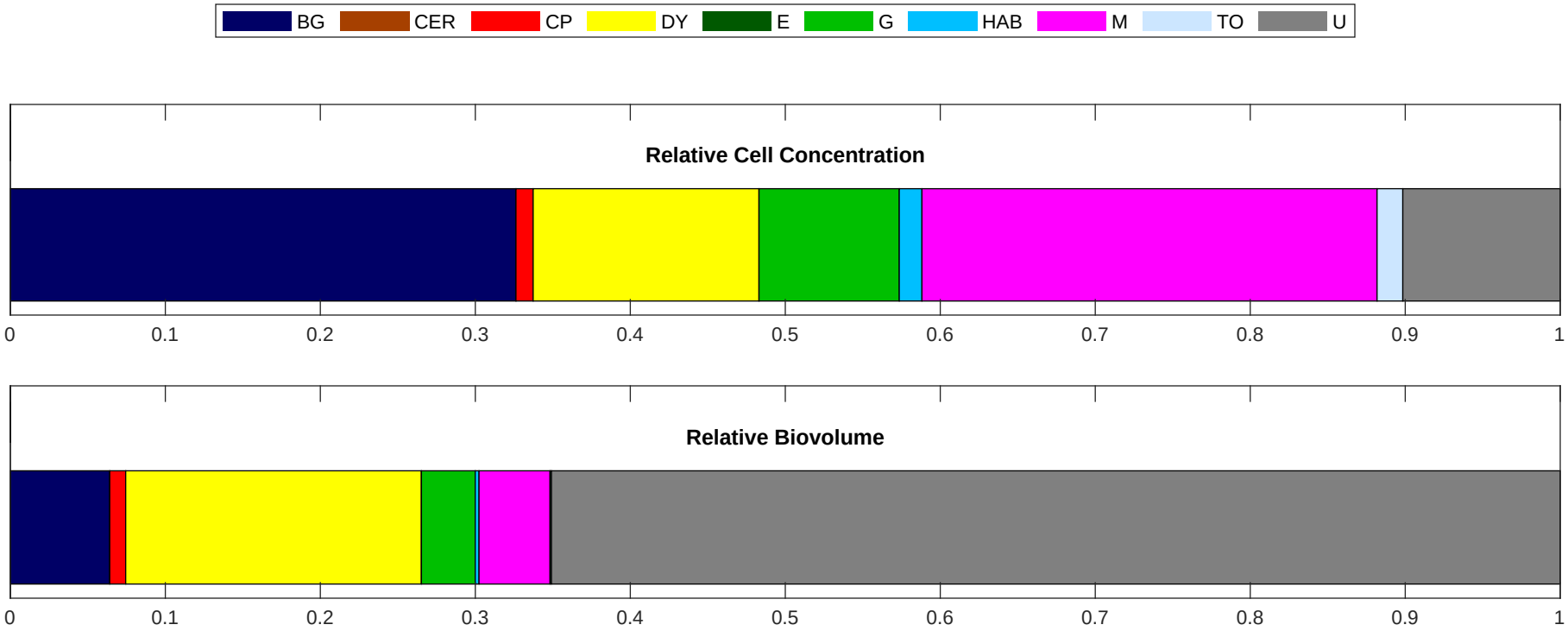
Algal Functional Group Classifications:

	Functional Group	What does it indicate?
BG	Non-harmful Cyanobacteria	Generally benign and indicative of good water quality.
CER	Ceratium	Often present in tannic/high organic content water bodies. Active migrator in the water column. May cause significant taste and odor at high densities.
CP	Cryptophytes & Dinoflagellates	Often dominate in spring, or in tannic/high organic content water bodies. Generally indicate good water quality.
DY	Chrysophytes, Haptophytes & Diatoms	Generally indicate good water quality. If high densities, can cause significant taste and odor.
E	Euglenophytes	Often present in high organic content water bodies. Co-occurs with Cryptophytes and non-coliform bacteria. High densities can be indicative of poor water quality.
G	Chlorophytes	Generally indicate good water quality. If very high densities, indicates high nitrate concentrations.
TO	Taste and Odor Producers	Algae that often produce taste and odor issues. Diatoms that can produce taste and odor problems, but do so less often, are not included in this group.
HAB	Harmful Cyanobacteria	May produce toxins, but not always producing. Toxins are generally detectable above 5000 cells/mL. Indicative of poor water quality often with high phosphate or low TN:TP ratios.
M	Miscellaneous	All other groups, generally neutral. Includes small Chlorophytes or Cyanobacteria less than 9um in diameter.
U	Unclassified	Images that the classifier cannot confidently identify. Includes small flagellates entrained in detritus, taxa not yet included in the classifier, partial images and images with multiple taxa.

Sample ID: D20231031T202123
Customer ID: 418
Tracking Code: 230007-418
Sample Info: BLS 1-3

System: Black Lake
Site: BLS 1-3 Sed
Station: NaN
Level: Benthic

Date Sampled: 8/31/2023
Date Received: 10/13/2023
Date Analyzed: 10/31/2023



Total Algal Concentration: 6922 cells/mL
HAB Concentration: 101 cells/mL
HAB Relative Concentration: 1%

Total Biovolume: 4947364 um^3/mL
HAB Biovolume: 12209 um^3/mL
HAB Relative Biovolume: 0%

Sample ID: D20231031T202123
Customer ID: 418
Tracking Code: 230007-418
Sample Info: BLS 1-3

System: Black Lake
Site: BLS 1-3 Sed
Station: NaN
Level: Benthic

Date Sampled: 8/31/2023
Date Received: 10/13/2023
Date Analyzed: 10/31/2023

Taxa	Group	NU/mL	Cells/mL	Biovolume um^3/mL	Relative Biovolume %
Aphanocapsa-Aphanothece	BG	166	2146	271430	5.49
Cyanophyta	BG	81	198	56258	1.14
Cryptomonas	CP	12	12	14255	0.29
Peridinales	CP	12	12	27890	0.56
Rhodomonas	CP	53	53	8805	0.18
Detritus	DET	117	0	0	0
Aulacoseira	DY	53	618	384696	7.78
Centrics	DY	16	16	6810	0.14
Fragilaria	DY	20	355	477837	9.66
Navicula-Nitzschia	DY	4	4	9895	0.2
Pennate Diatoms	DY	16	16	64792	1.31
Protozoan	EXCLUDE	8	0	0	0
Zooplankton	EXCLUDE	4	0	0	0
Chlorophytes	G	287	372	138804	2.81
Crucigenia-Crucigniella	G	8	24	5151	0.1
Desmodesmus-Scenedesmus	G	16	97	15366	0.31
Pediastrum	G	8	129	6348	0.13
Staurastrum	G	4	4	5955	0.12
Dolichospermum	HAB	4	16	1789	0.04
Taxa below 9um	M	2033	2033	226675	4.58
Pseudanabaena	TO	12	115	4499	0.09
unclassified	U	703	703	3220107	65.09

PhycoTech, Inc.
620 Broad Street - Suite 100 - St. Joseph - MI 49085 - Phone: 269-983-3654 - Fax: 269-983-3653
info@phycotech.com - www.phycotech.com

Algae Analysis

Report and Data Set

Customer ID: 418

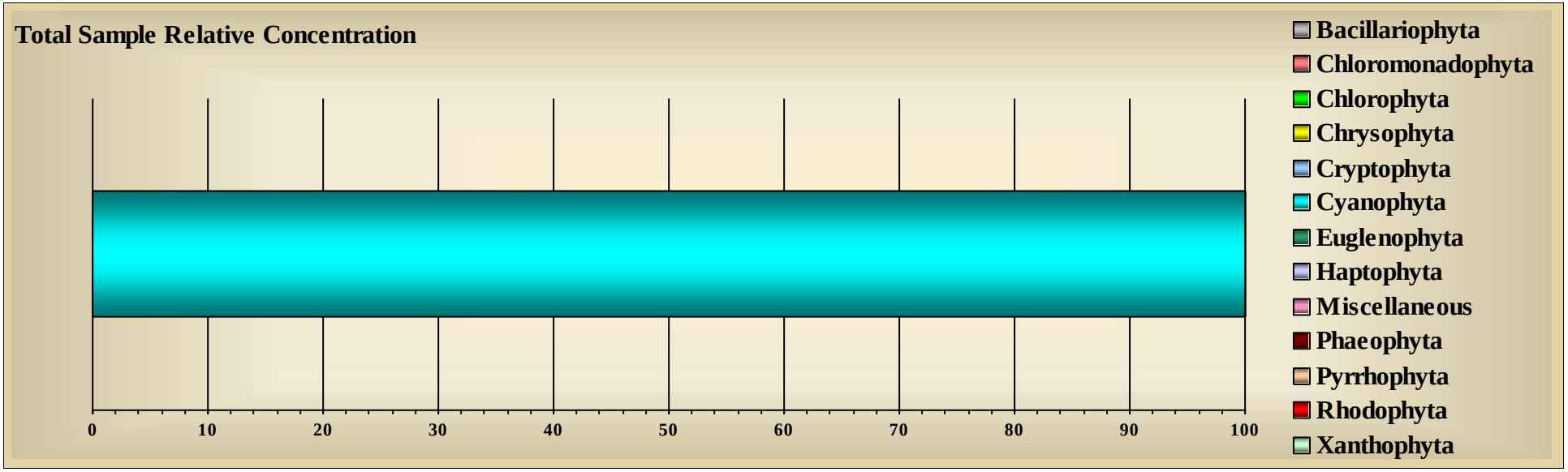
Tracking Code:	250001-418	**Sample ID:**	Black Lake	**Replicate:**	.
Customer ID:	418	**Sample Date:**	11/16/2024	**Sample Level:**	Epi
Job ID:	1	**Station:**	.	**Sample Depth:**	0
System Name:	Black Lake	**Site:**	BLS 1-6 Sed	**Preservative:**	Lugols
Report Notes:	.				

Division: Cyanophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Relative Concentration
4011	*Dolichospermum*	*circinale*	.	.	.	.	Vegetative	70.00
1000468	*Dolichospermum*	*lemmermannii/flos-aquae*	.	.	.	.	Vegetative	27.00
4091	*Woronichinia*	*naegeliana*	.	.	.	.	Vegetative	3.00

Summary for Division ~ Cyanophyta (3 detail records) **Sum Total Cyanophyta** 100.00

SUMMARY GRAPHICS



Species List

Division: Cyanophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	PhysiState	Structure	Authority
4011	Dolichospermum	circinale	.	.	.		Vegetative	Rabenhorst
1000468	Dolichospermum	lemmermannii/flos-aquae	.	.	.		Vegetative	.
4091	Woronichinia	naegeliana	.	.	.		Vegetative	Unger

20-Sep-2023

Ben Cook
Great Lakes Environmental Center
739 Hastings St
Traverse City, MI 49686

Re: **Kieser** Work Order: **23091198**

Dear Ben,

ALS Environmental received 3 samples on 14-Sep-2023 10:00 AM for the analyses presented in the following report.

The analytical data provided relates directly to the samples received by ALS Environmental - Holland and for only the analyses requested.

Sample results are compliant with industry accepted practices and Quality Control results achieved laboratory specifications. Any exceptions are noted in the Case Narrative, or noted with qualifiers in the report or QC batch information. Should this laboratory report need to be reproduced, it should be reproduced in full unless written approval has been obtained from ALS Environmental. Samples will be disposed in 30 days unless storage arrangements are made.

The total number of pages in this report is 12.

If you have any questions regarding this report, please feel free to contact me:

ADDRESS: 3352 128th Avenue, Holland, MI, USA
PHONE: +1 (616) 399-6070 FAX: +1 (616) 399-6185

Sincerely,

Jodi Blouw

Electronically approved by: Jodi Blouw

Jodi Blouw

Report of Laboratory Analysis

Certificate No: FL E871106

ALS Group, USA

Date: 20-Sep-23

Client: Great Lakes Environmental Center
Project: Kieser
Work Order: **23091198**

Work Order Sample Summary

Lab Samp ID	Client Sample ID	Matrix	Tag Number	Collection Date	Date Received	Hold
23091198-01	BLD-1 Sed	Sediment		8/31/2023 11:00	9/14/2023 10:00	☐
23091198-02	BLD-2 Sed	Sediment		8/31/2023 11:50	9/14/2023 10:00	☐
23091198-03	BLD-3 Sed	Sediment		8/31/2023 10:00	9/14/2023 10:00	☐

Client: Great Lakes Environmental Center
Project: Kieser
WorkOrder: **23091198**

QUALIFIERS, ACRONYMS, UNITS

Qualifier	Description
*	Value exceeds Regulatory Limit
**	Estimated Value
a	Analyte is non-accredited
B	Analyte detected in the associated Method Blank above the Reporting Limit
E	Value above quantitation range
H	Analyzed outside of Holding Time
Hr	BOD/CBOD - Sample was reset outside Hold Time, value should be considered estimated.
J	Analyte is present at an estimated concentration between the MDL and Report Limit
n	Analyte accreditation is not offered
ND	Not Detected at the Reporting Limit
O	Sample amount is > 4 times amount spiked
P	Dual Column results percent difference > 40%
R	RPD above laboratory control limit
S	Spike Recovery outside laboratory control limits
U	Analyzed but not detected above the MDL
X	Analyte was detected in the Method Blank between the MDL and Reporting Limit, sample results may exhibit background or reagent contamination at the observed level.

Acronym	Description
DUP	Method Duplicate
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LOD	Limit of Detection (see MDL)
LOQ	Limit of Quantitation (see PQL)
MBLK	Method Blank
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
PQL	Practical Quantitation Limit
RPD	Relative Percent Difference
TDL	Target Detection Limit
TNTC	Too Numerous To Count
A	APHA Standard Methods
D	ASTM
E	EPA
SW	SW-846 Update III

Units Reported	Description
% of sample	Percent of Sample
mg/Kg-dry	Milligrams per Kilogram Dry Weight

Client: Great Lakes Environmental Center
Project: Kieser
Work Order: 23091198

Case Narrative

Samples for the above noted Work Order were received on 9/14/2023. The attached "Sample Receipt Checklist" documents the status of custody seals, container integrity, preservation, and temperature compliance.

Samples were analyzed according to the analytical methodology previously transmitted in the "Work Order Acknowledgement". Methodologies are also documented in the "Analytical Result" section for each sample. Quality control results are listed in the "QC Report" section. Sample association for the reported quality control is located at the end of each batch summary. If applicable, results are appropriately qualified in the Analytical Result and QC Report sections. The "Qualifiers" section documents the various qualifiers, units, and acronyms utilized in reporting. A copy of the laboratory's scope of accreditation is available upon request.

With the following exceptions, all sample analyses achieved analytical criteria.

No deviations or anomalies were noted.

ALS Group, USA

Date: *20-Sep-23*

Client: Great Lakes Environmental Center
Project: Kieser
Sample ID: BLD-1 Sed
Collection Date: 8/31/2023 11:00 AM

Work Order: 23091198
Lab ID: 23091198-01
Matrix: SEDIMENT

Analyses	Result	Qual	MDL	Report Limit	Units	Dilution Factor	Date Analyzed
METALS BY ICP-MS		Method: **SW6020B**			Prep: SW3050B / 9/19/23		Analyst: **STP**
Iron	**22,000**		**35**	**44**	**mg/Kg-dry**	1	9/19/2023 21:26
MOISTURE		Method: **SW3550C**					Analyst: **SGH**
Moisture	**75**		**0.10**	**0.10**	**% of sample**	1	9/14/2023 18:30

Note: See Qualifiers page for a list of qualifiers and their definitions.

ALS Group, USA

Date: *20-Sep-23*

Client: Great Lakes Environmental Center
Project: Kieser
Sample ID: BLD-2 Sed
Collection Date: 8/31/2023 11:50 AM

Work Order: 23091198
Lab ID: 23091198-02
Matrix: SEDIMENT

Analyses	Result	Qual	MDL	Report Limit	Units	Dilution Factor	Date Analyzed
METALS BY ICP-MS		Method: **SW6020B**			Prep: SW3050B / 9/19/23		Analyst: **STP**
Iron	**21,000**		**41**	**52**	**mg/Kg-dry**	1	9/19/2023 21:28
MOISTURE		Method: **SW3550C**					Analyst: **SGH**
Moisture	**80**		**0.10**	**0.10**	**% of sample**	1	9/14/2023 18:30

Note: See Qualifiers page for a list of qualifiers and their definitions.

ALS Group, USA

Date: *20-Sep-23*

Client: Great Lakes Environmental Center
Project: Kieser
Sample ID: BLD-3 Sed
Collection Date: 8/31/2023 10:00 AM

Work Order: 23091198
Lab ID: 23091198-03
Matrix: SEDIMENT

Analyses	Result	Qual	MDL	Report Limit	Units	Dilution Factor	Date Analyzed
METALS BY ICP-MS		Method: **SW6020B**			Prep: SW3050B / 9/19/23		Analyst: **STP**
Iron	**19,000**		**35**	**44**	**mg/Kg-dry**	1	9/19/2023 21:30
MOISTURE		Method: **SW3550C**					Analyst: **SGH**
Moisture	**76**		**0.10**	**0.10**	**% of sample**	1	9/14/2023 18:30

Note: See Qualifiers page for a list of qualifiers and their definitions.

ALS Group, USA

Date: 20-Sep-23

Client: Great Lakes Environmental Center

Work Order: 23091198

Project: Kieser

QC BATCH REPORT

Batch ID: **224721** Instrument ID **ICPMS3** Method: **SW6020B**

MBLK Sample ID: **MBLK-224721-224721** Units: **mg/Kg** Analysis Date: **9/19/2023 09:22 PM**

Client ID: Run ID: **ICPMS3_230919B** SeqNo: **9993902** Prep Date: **9/19/2023** DF: **1**

Analyte	Result	MDL	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Iron	U	8	10								

LCS Sample ID: **LCS-224721-224721** Units: **mg/Kg** Analysis Date: **9/19/2023 09:24 PM**

Client ID: Run ID: **ICPMS3_230919B** SeqNo: **9993903** Prep Date: **9/19/2023** DF: **1**

Analyte	Result	MDL	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Iron	518.3	8	10	500	0	104	80-120	0			

MS Sample ID: **23091492-02AMS** Units: **mg/Kg** Analysis Date: **9/19/2023 09:53 PM**

Client ID: Run ID: **ICPMS3_230919B** SeqNo: **9993926** Prep Date: **9/19/2023** DF: **1**

Analyte	Result	MDL	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Iron	7702	9.1	11	570.8	7747	-7.81	75-125	0			SO

MSD Sample ID: **23091492-02AMSD** Units: **mg/Kg** Analysis Date: **9/19/2023 10:02 PM**

Client ID: Run ID: **ICPMS3_230919B** SeqNo: **9993933** Prep Date: **9/19/2023** DF: **1**

Analyte	Result	MDL	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Iron	9388	8.7	11	542.3	7747	303	75-125	7702	19.7	20	SO

The following samples were analyzed in this batch: 23091198-01A 23091198-02A 23091198-03A

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Client: Great Lakes Environmental Center
Work Order: 23091198
Project: Kieser

QC BATCH REPORT

Batch ID: **R382397** Instrument ID **MOIST** Method: **SW3550C**

MBLK Sample ID: **WBLKS-R382397** Units: **% of sample** Analysis Date: **9/14/2023 06:30 PM**
Client ID: Run ID: **MOIST_230914E** SeqNo: **9980823** Prep Date: DF: **1**

Analyte	Result	MDL	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Moisture	U	0.1	0.10								

LCS Sample ID: **LCS-R382397** Units: **% of sample** Analysis Date: **9/14/2023 06:30 PM**
Client ID: Run ID: **MOIST_230914E** SeqNo: **9980822** Prep Date: DF: **1**

Analyte	Result	MDL	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Moisture	100	0.1	0.10	100	0	100	98-102	0			

DUP Sample ID: **23091198-01A DUP** Units: **% of sample** Analysis Date: **9/14/2023 06:30 PM**
Client ID: **BLD-1 Sed** Run ID: **MOIST_230914E** SeqNo: **9980819** Prep Date: DF: **1**

Analyte	Result	MDL	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Moisture	75.12	0.1	0.10	0	0	0	0-0	75.42	0.399	10	

The following samples were analyzed in this batch: 23091198-01A 23091198-02A 23091198-03A

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

GLEC
Great Lakes Environmental Center

GREAT LAKES ENVIRONMENTAL CENTER, INC.

CHAIN OF CUSTODY RECORD

Traverse City, MI - Laboratory
739 Hastings Street
Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: GLEC
Report Results To: Ben Cook
Address: 739 Hastings St TC, MI 49686
Phone: 231-941-2230 E-mail: bcook@glec.com

Section II.

Project Name: Kieser
Project Number: 2592-00
P.O.#: 19002
Sampled by: (initials) ☐ GLEC _____ ☒ Client Kieser

Section III. Sample Information at Collection

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.
1		BLD-1 Sed	8/31/23	11:00	sediment	G	N/A	N	glass	40mL	1
2		BLD-2 Sed	↓	11:50	↓	↓	↓	↓	↓	↓	↓
3		BLD-3 Sed	↓	10:00	↓	↓	↓	↓	↓	↓	↓
4											
5											
6											
7											
8											

Section IV. Requested Analysis

Fe Sediment	pH of Sample Upon Receipt
X	
↓	
↓	

23091198
GLEC: Great Lakes Environmental Center
Project: Kieser

Client Notes:

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Carrie Gorman GLEC	9/13/23	13:16			
Signature: CG			Signature		
Print Name & Organization: Fedex			Print Name & Organization: Karly Yablonski	9/14/23	1000
Signature			Signature: Karly Yablonski		

FOR LAB USE ONLY
Temperature of Samples: 2.8°C IR3 °C Initials: _____ Bottle ID #, if applicable _____ ☐ Received on Wet Ice
Notes/Anomalies/Discrepancies: _____
GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; E = EFFLUENT; SL = SLUDGE; SW = SURFACE WATER; GW = GROUNDWATER; AO = AQUATIC ORGANISM

ALS Group, USA
Holland, Michigan

Sample Receipt Checklist

Client Name: **GLEC** Date/Time Received: **14-Sep-23 10:00**

Work Order: **23091198** Received by: **KYB**

Checklist completed by Karly Yablonski (eSignature) 14-Sep-23 (Date) Reviewed by: Jodi Blouw (eSignature) 14-Sep-23 (Date)

Matrices: Sediment
Carrier name: FedEx

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on shipping container/cooler?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time?	Yes ☑	No ☐	
Container/Temp Blank temperature in compliance?	Yes ☑	No ☐	
Sample(s) received on ice?	Yes ☑	No ☐	
Temperature(s)/Thermometer(s):	2.8/3.8C	IR3	
Cooler(s)/Kit(s):			
Date/Time sample(s) sent to storage:	9/14/2023 10:51:36 AM		
Water - VOA vials have zero headspace?	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	Yes ☐	No ☐	N/A ☑
pH adjusted?	Yes ☐	No ☐	N/A ☑
pH adjusted by:			

Login Notes:

Client Contacted: Date Contacted: Person Contacted:

Contacted By: Regarding:

Comments:

CorrectiveAction:

Great Lakes Environmental Center

Project Number: 2592-B15

June 12, 2024

Kieser & Associates-Black Lake WQ
536 E. Michigan Ave., Suite 300
Kalamazoo, MI 49007

Attention: Natalie Howard

Project Description: Water Quality Sampling

Dear Client,

Enclosed is a copy of your laboratory report relating to samples, as they were received. All tests have met or exceeded QC criteria. Sediment Fe was analyzed by ALS Labs. Test results are in compliance with The NELAC Institute Standards. Visit our web site for a full list of tests for which GLEC (Lab 2059) is accredited through the New Hampshire Environmental Laboratory Accreditation Program (NH ELAP).

Please don't hesitate to call if you have questions or require further information.

Data Qualifiers:

U = Analyte not detected
J = Estimated result below the RL but above the MDL

Sincerely,

Michelle A. Moore
Laboratory Coordinator and Research Scientist/Nutrient Chemistry

Great Lakes Environmental Center, Inc.
739 Hastings St., Traverse City, MI 49686
Phone: 231-941-2230; Fax: 231-941-2240; www.glec.com

CHAIN OF CUSTODY RECORD

GLEC
Great Lakes Environmental Center, Inc.
739 Hastings Street
Traverse City, Michigan 49686
Phone (231) 941-2230
Fax (231) 941-2240
www.GLEC.com

Section I

Submitting Company: KEA Black Lake -9K
Report Results To: Natalie Howard
Address: nhoward@kieser-associates.com
Phone: 269-344-7117 E-mail

Section II

Project Name:
Project Number:
P.O.#:
Sampled by: (initials) ☐GLEC _____ ☐Client _____

Section III: Sample Information at Collection

#	GLEC No.	Sample Identification	Depth	Date	Time	Grab or Composite	Preservative	Filtered Y or N	Sample Containers Type	Size	No.	SRP	NO2	TSS
1		Lower Black River	SW	5-14-24	4:00	Grab	HNO3/HNO2 H2SO4	Y	Glass Plastic	250 250/125	2 2	X	X	X
2		Stoney Creek	SW	5-14-24	11:15	"	[redacted]	Y	"	"	2 1/1	X	X	X
3		Dorivo Creek	SW	"	9:10	"	"	Y	"	"	2 1/1	X	X	X
4		Fisher Creek	SW	"	10:46	"	"	Y	"	"	2 1/1	X	X	X
5		Stewart Creek	SW	"	10:24	"	"	Y	"	"	2 1/1	X	X	X
6		Rainy/Cold	SW	"	12:41	"	"	Y	"	"	2 1/1	X	X	X
7		Rainy	SW	"	1:00	"	"	Y	"	"	2 1/1	X	X	X
8		Upper Black	SW	"	2:25	"	"	Y	"	"	2 1/1	X	X	X
9		Mud	SW	"	1:30	"	"	Y	"	"	2 1/1	X	X	X
10			SW	"		"	"	Y	"	"	2 1/1	X	X	X

Section IV

Requested Analysis

pH of Sample Upon Receipt

Matrix Codes S = Sediment SW = Surface Water GW = Groundwater E = Effluent AO = Aquatic Organism SL = Sludge

Client Notes

Released By	Date	Time	Received By	Date	Time
Name & Organization (print): Mark Kieser KEA			Name & Organization (print):		
Signature: Mark A. Kieser	5-15-24	10:05	Signature:	5-15-24	10:05
Name & Organization (print):			Name & Organization (print):		
Signature:			Signature:		

FOR LAB USE ONLY

Temperature of Samples: 4.3 °C Initials: CTG Bottle ID #, if applicable: 30724 Black Lake - Stoney TS ☒ Received on Wet Ice

Notes/Anomalies/Discrepancies:

CHAIN OF CUSTODY RECORD

GLEC Great Lakes Environmental Center, Inc.
739 Hastings Street
Traverse City, Michigan 49686
Phone (231) 941-2230
Fax (231) 941-2240
www.GLEC.com

0056

Section I

Submitting Company: KEA - Black Lake -9K
Report Results To: Natalie Howard
Address: nhoward@kieserassociates.com
Phone: 269 - 344-7117 E-mail

Section II

Project Name:
Project Number:
P.O.#:
Sampled by: (initials) ☐GLEC _____ ☐Client _____

Section III: Sample Information at Collection

#	GLEC No.	Sample Identification	Depth	Date	Time	Grab or Composite	Preservative	Filtered Y or N	Sample Containers Type	Size	No.
1		BLD - 1S	3'	5-14-24	10:56	grab	TP & NO3	SRP	Glass	250	3
2		BLD - 1M	25'	"	10:51	grab	H2SO4	Y	"	"	"
3		BLD - 1B	45'	"	10:40	grab	"	"	"	"	"
4		BLD - 1B	50'	"	11:08	Composite	None	NO	Glass	4oz.	1
5		BLD - 1	0-25'	"	9:45	"	None	Y	Filter		
6											
7											
8											
9											
10											

Section IV

Requested Analysis

TP	SRP	NO3/NO2	Sediment TP	Sediment TC	Chl a
X	X	X			
X	X	X			
X	X	X			
			X	X	
					X

pH of Sample Upon Receipt

Matrix Codes S = Sediment SW = Surface Water GW = Groundwater E = Effluent AO = Aquatic Organism SL = Sludge

Client Notes: 3 SW & 1 sediment from Black Lake

Released By	Date	Time
Name & Organization (print): Mark Kieser KEA	5-15-24	10:05
Signature: Mark Kieser		
Name & Organization (print):		
Signature:		

Received By	Date	Time
Name & Organization (print):		
Signature:	5-15-24	10:05
Name & Organization (print):		
Signature:		

FOR LAB USE ONLY

Temperature of Samples: 4.3 °C Initials: CTG Bottle ID #, if applicable: 30724 Black Lake - Stoney ☒ Received on Wet Ice

Notes/Anomalies/Discrepancies:

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Total Suspended Solids

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K05140059A	Lower Black River	5/14/2024	4.3	mg/L	0.5	0.45		5/17/2024		BSC
9K05140059B	Lower Black River	5/14/2024	4.4	mg/L	0.5	0.45		5/17/2024		BSC
9K05140063	Stoney Creek	5/14/2024	2.3	mg/L	0.5	0.45		5/17/2024		BSC
9K05140067	Dorivo Creek	5/14/2024	3.9	mg/L	0.5	0.45		5/17/2024		BSC
9K05140071	Fisher Creek	5/14/2024	5.2	mg/L	0.5	0.45		5/17/2024		BSC
9K05140075	Stewart Creek	5/14/2024	4.4	mg/L	0.5	0.45		5/17/2024		BSC
9K05140079	Rainy/Cold	5/14/2024	2.5	mg/L	0.5	0.45		5/17/2024		BSC
9K05140083	Rainy	5/14/2024	5.2	mg/L	0.5	0.45		5/17/2024		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Wednesday, June 12, 2024

Method: SM 2540 D

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K05140087	Upper Black	5/14/2024	12.0	mg/L	0.5	0.45		5/17/2024		BSC
9K05140091	Mud	5/14/2024	4.7	mg/L	0.5	0.45		5/17/2024		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 2540 D

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Total Phosphorus

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K05140101	BLD-1B	5/14/2024	1380	mg/kg dr	93.897	84.5073		5/30/2024		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Wednesday, June 12, 2024

Method: SM 4500-P F

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Total Phosphorus

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K05140057	Lower Black River	5/14/2024	0.0379	mg/L	0.003	0.0014		5/21/2024		BSC
9K05140061	Stoney Creek	5/14/2024	0.0525	mg/L	0.003	0.0014		5/21/2024		BSC
9K05140065	Dorivo Creek	5/14/2024	0.0537	mg/L	0.003	0.0014		5/21/2024		BSC
9K05140069	Fisher Creek	5/14/2024	0.0598	mg/L	0.003	0.0014		5/21/2024		BSC
9K05140073	Stewart Creek	5/14/2024	0.0505	mg/L	0.003	0.0014		5/21/2024		BSC
9K05140077	Rainy/Cold	5/14/2024	0.0637	mg/L	0.003	0.0014		5/21/2024		BSC
9K05140081	Rainy	5/14/2024	0.0507	mg/L	0.003	0.0014		5/21/2024		BSC
9K05140085	Upper Black	5/14/2024	0.0323	mg/L	0.003	0.0014		5/21/2024		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Wednesday, June 12, 2024

Method: SM 4500-P F

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K05140089	Mud	5/14/2024	0.0362	mg/L	0.003	0.0014		5/21/2024		BSC
9K05140092	BLD-1S	5/14/2024	0.0230	mg/L	0.003	0.0014		5/21/2024		BSC
9K05140095	BLD-1M	5/14/2024	0.0254	mg/L	0.003	0.0014		5/21/2024		BSC
9K05140098	BLD-1B	5/14/2024	0.0333	mg/L	0.003	0.0014		5/21/2024		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 4500-P F

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Soluble Reactive Phosphorus

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K05140056	Lower Black River	5/14/2024	0.0081	mg/L	0.001	0.00015		5/22/2024		BSC
9K05140060	Stoney Creek	5/14/2024	0.0076	mg/L	0.001	0.00015		5/22/2024		BSC
9K05140064	Dorivo Creek	5/14/2024	0.0076	mg/L	0.001	0.00015		5/22/2024		BSC
9K05140068	Fisher Creek	5/14/2024	0.0067	mg/L	0.001	0.00015		5/22/2024		BSC
9K05140072	Stewart Creek	5/14/2024	0.0089	mg/L	0.001	0.00015		5/22/2024		BSC
9K05140076	Rainy/Cold	5/14/2024	0.0085	mg/L	0.001	0.00015		5/22/2024		BSC
9K05140080	Rainy	5/14/2024	0.0086	mg/L	0.001	0.00015		5/22/2024		BSC
9K05140084	Upper Black	5/14/2024	0.0007	mg/L	0.001	0.00015	J	5/22/2024		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Wednesday, June 12, 2024

Method: SM 4500-P F

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K05140088	Mud	5/14/2024	0.0010	mg/L	0.001	0.00015		5/22/2024		BSC
9K05140093	BLD-1S	5/14/2024	0.0054	mg/L	0.001	0.00015		5/22/2024		BSC
9K05140096	BLD-1M	5/14/2024	0.0054	mg/L	0.001	0.00015		5/22/2024		BSC
9K05140099	BLD-1B	5/14/2024	0.0051	mg/L	0.001	0.00015		5/22/2024		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 4500-P F

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Nitrate/Nitrite-Nitrogen

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K05140058	Lower Black River	5/14/2024	0.0116	mg/L	0.005	0.00312		5/24/2024		BSC
9K05140062	Stoney Creek	5/14/2024	0.0216	mg/L	0.005	0.00312		5/24/2024		BSC
9K05140066	Dorivo Creek	5/14/2024	<0.00312	mg/L	0.005	0.00312	U	5/24/2024		BSC
9K05140070	Fisher Creek	5/14/2024	0.0144	mg/L	0.005	0.00312		5/24/2024		BSC
9K05140074	Stewart Creek	5/14/2024	0.0079	mg/L	0.005	0.00312		5/24/2024		BSC
9K05140078	Rainy/Cold	5/14/2024	<0.00312	mg/L	0.005	0.00312	U	5/24/2024		BSC
9K05140082	Rainy	5/14/2024	<0.00312	mg/L	0.005	0.00312	U	5/24/2024		BSC
9K05140086	Upper Black	5/14/2024	0.0114	mg/L	0.005	0.00312		5/24/2024		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Wednesday, June 12, 2024

Method: SM 4500-NO3(F)-N

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K05140090	Mud	5/14/2024	<0.00312	mg/L	0.005	0.00312	U	5/24/2024		BSC
9K05140094	BLD-1S	5/14/2024	0.0322	mg/L	0.005	0.00312		5/24/2024		BSC
9K05140097	BLD-1M	5/14/2024	<0.00312	mg/L	0.005	0.00312	U	5/24/2024		BSC
9K05140100	BLD-1B	5/14/2024	0.0465	mg/L	0.005	0.00312		5/24/2024		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 4500-NO3(F)-N

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

chla

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifier	AnalysisDate	Comments	Initials
9K05140103	BLD-1	5/14/2024	0.00047	mg/L	0.000093	0.00000042		5/21/2024		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Wednesday, June 12, 2024

Method: EPA Method 445.0

10-Jun-2024

Ben Cook
Great Lakes Environmental Center
739 Hastings St
Traverse City, MI 49686

Re: **Kieser - Black Lake** Work Order: **24051775**

Dear Ben,

ALS Environmental received 1 sample on 30-May-2024 10:30 AM for the analyses presented in the following report.

The analytical data provided relates directly to the samples received by ALS Environmental - Holland and for only the analyses requested.

Sample results are compliant with industry accepted practices and Quality Control results achieved laboratory specifications. Any exceptions are noted in the Case Narrative, or noted with qualifiers in the report or QC batch information. Should this laboratory report need to be reproduced, it should be reproduced in full unless written approval has been obtained from ALS Environmental. Samples will be disposed in 30 days unless storage arrangements are made.

The total number of pages in this report is 10.

If you have any questions regarding this report, please feel free to contact me:

ADDRESS: 3352 128th Avenue, Holland, MI, USA
PHONE: +1 (616) 399-6070 FAX: +1 (616) 399-6185

Sincerely,

Jodi Blouw

Electronically approved by: Jodi Blouw

Jodi Blouw

Report of Laboratory Analysis

Certificate No: FL E871106

ALS Group, USA

Date: 10-Jun-24

Client: Great Lakes Environmental Center
Project: Kieser - Black Lake
Work Order: **24051775**

Work Order Sample Summary

Lab Samp ID	Client Sample ID	Matrix	Tag Number	Collection Date	Date Received	Hold
24051775-01	BLD - 1B	Sediment		5/14/2024 11:08	5/30/2024 10:30	☐

Client: Great Lakes Environmental Center
Project: Kieser - Black Lake
WorkOrder: **24051775**

QUALIFIERS, ACRONYMS, UNITS

Qualifier	Description
*	Value exceeds Regulatory Limit
**	Estimated Value
a	Analyte is non-accredited
B	Analyte detected in the associated Method Blank above the Reporting Limit
E	Value above quantitation range
H	Analyzed outside of Holding Time
Hr	BOD/CBOD - Sample was reset outside Hold Time, value should be considered estimated.
J	Analyte is present at an estimated concentration between the MDL and Report Limit
n	Analyte accreditation is not offered
ND	Not Detected at the Reporting Limit
O	Sample amount is > 4 times amount spiked
P	Dual Column results percent difference > 40%
R	RPD above laboratory control limit
S	Spike Recovery outside laboratory control limits
U	Analyzed but not detected above the MDL
X	Analyte was detected in the Method Blank between the MDL and Reporting Limit, sample results may exhibit background or reagent contamination at the observed level.

Acronym	Description
DUP	Method Duplicate
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LOD	Limit of Detection (see MDL)
LOQ	Limit of Quantitation (see PQL)
MBLK	Method Blank
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
PQL	Practical Quantitation Limit
RPD	Relative Percent Difference
TDL	Target Detection Limit
TNTC	Too Numerous To Count
A	APHA Standard Methods
D	ASTM
E	EPA
SW	SW-846 Update III

Units Reported	Description
% of sample	Percent of Sample
mg/Kg-dry	Milligrams per Kilogram Dry Weight

Client: Great Lakes Environmental Center
Project: Kieser - Black Lake
Work Order: 24051775

Case Narrative

Samples for the above noted Work Order were received on 5/30/2024. The attached "Sample Receipt Checklist" documents the status of custody seals, container integrity, preservation, and temperature compliance.

Samples were analyzed according to the analytical methodology previously transmitted in the "Work Order Acknowledgement". Methodologies are also documented in the "Analytical Result" section for each sample. Quality control results are listed in the "QC Report" section. Sample association for the reported quality control is located at the end of each batch summary. If applicable, results are appropriately qualified in the Analytical Result and QC Report sections. The "Qualifiers" section documents the various qualifiers, units, and acronyms utilized in reporting. A copy of the laboratory's scope of accreditation is available upon request.

With the following exceptions, all sample analyses achieved analytical criteria.

Metals:
No deviations or anomalies were noted.

Wet Chemistry:
Batch R404921, Method SW3550C, Sample BLD - 1B (24051775-01A): Sample analyzed after hold time due to being received after expiration date. MOISTURE
No other deviations or anomalies were noted.

ALS Group, USA

Date: *10-Jun-24*

Client: Great Lakes Environmental Center
Project: Kieser - Black Lake
Sample ID: BLD - 1B
Collection Date: 5/14/2024 11:08 AM

Work Order: 24051775
Lab ID: 24051775-01
Matrix: SEDIMENT

Analyses	Result	Qual	MDL	Report Limit	Units	Dilution Factor	Date Analyzed
METALS BY ICP-MS		Method: **SW6020B**			Prep: SW3050B / 6/4/24		Analyst: **STP**
Iron	**21,000**		**460**	**570**	**mg/Kg-dry**	10	6/5/2024 19:19
MOISTURE		Method: **SW3550C**					Analyst: **SML**
Moisture	**79**	H	**0.10**	**0.10**	**% of sample**	1	5/30/2024 15:54

Note: See Qualifiers page for a list of qualifiers and their definitions.

ALS Group, USA

Date: 10-Jun-24

Client: Great Lakes Environmental Center

Work Order: 24051775

Project: Kieser - Black Lake

QC BATCH REPORT

Batch ID: **241334** Instrument ID **ICPMS3** Method: **SW6020B**

MBLK Sample ID: **MBLK-241334-241334** Units: **mg/Kg** Analysis Date: **6/5/2024 07:03 PM**

Client ID: Run ID: **ICPMS3_240605B** SeqNo: **10835453** Prep Date: **6/4/2024** DF: **1**

Analyte	Result	MDL	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Iron	U	8	10								

LCS Sample ID: **LCS-241334-241334** Units: **mg/Kg** Analysis Date: **6/5/2024 07:05 PM**

Client ID: Run ID: **ICPMS3_240605B** SeqNo: **10835454** Prep Date: **6/4/2024** DF: **1**

Analyte	Result	MDL	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Iron	513.1	8	10	500	0	103	80-120	0			

MS Sample ID: **24051784-01BMS** Units: **mg/Kg** Analysis Date: **6/5/2024 07:22 PM**

Client ID: Run ID: **ICPMS3_240605B** SeqNo: **10835465** Prep Date: **6/4/2024** DF: **10**

Analyte	Result	MDL	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Iron	4421	86	110	538.8	3528	166	75-125	0			SO

MSD Sample ID: **24051784-01BMSD** Units: **mg/Kg** Analysis Date: **6/5/2024 07:24 PM**

Client ID: Run ID: **ICPMS3_240605B** SeqNo: **10835466** Prep Date: **6/4/2024** DF: **10**

Analyte	Result	MDL	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Iron	3623	84	110	526.3	3528	17.9	75-125	4421	19.8	20	SO

The following samples were analyzed in this batch: 24051775-01A

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Client: Great Lakes Environmental Center
Work Order: 24051775
Project: Kieser - Black Lake

QC BATCH REPORT

Batch ID: **R404921** Instrument ID **MOIST** Method: **SW3550C**

MBLK Sample ID: **MBLK-R404921** Units: **% of sample** Analysis Date: **5/30/2024 03:54 PM**
Client ID: Run ID: **MOIST_240530E** SeqNo: **10819214** Prep Date: DF: **1**

Analyte	Result	MDL	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Moisture	U	0.1	0.10								

LCS Sample ID: **LCS-R404921** Units: **% of sample** Analysis Date: **5/30/2024 03:54 PM**
Client ID: Run ID: **MOIST_240530E** SeqNo: **10819213** Prep Date: DF: **1**

Analyte	Result	MDL	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Moisture	99.99	0.1	0.10	100	0	100	98-102	0			

DUP Sample ID: **24051586-01A DUP** Units: **% of sample** Analysis Date: **5/30/2024 03:54 PM**
Client ID: Run ID: **MOIST_240530E** SeqNo: **10819193** Prep Date: DF: **1**

Analyte	Result	MDL	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Moisture	10.55	0.1	0.10	0	0	0	0-0	10.2	3.37	10	

DUP Sample ID: **24051648-07B DUP** Units: **% of sample** Analysis Date: **5/30/2024 03:54 PM**
Client ID: Run ID: **MOIST_240530E** SeqNo: **10819200** Prep Date: DF: **1**

Analyte	Result	MDL	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Moisture	26.15	0.1	0.10	0	0	0	0-0	26.64	1.86	10	

The following samples were analyzed in this batch: 24051775-01A

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

24051775

GLEC: Great Lakes Environmental Center
Project: xxx

NVIRONMENTAL CENTER, INC.

OF CUSTODY RECORD

Traverse City, MI - Laboratory
739 Hastings Street
Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: GLEC
Report Results To: Ben Cook
Address: 739 Hastings Street
Phone: 231-941-2230 E-mail: bcook@glec.com

Section II.

Project Name: Kieser - Black Lake
Project Number: 2592-00
P.O.#: 19841
Sampled by: (initials)
☐ GLEC _____ ☒ Client Kieser

Section III. Sample Information at Collection

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.
1		BLD - 1B	5-14-24	11:08	Sed	Comp	4°C	N	Glass	40ml	1
2											
3											
4											
5											
6											
7											
8											

Section IV. Requested Analysis

Sediment									pH of Sample Upon Receipt
X									

Client Notes:

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization:			Print Name & Organization		
Signature			Signature Ben Cook	5-29-24	14:00
Print Name & Organization			Print Name & Organization		
Signature			Signature [signature]	5-30-24	10:30

FOR LAB USE ONLY

Temperature of Samples: _____ °C Initials: _____ Bottle ID #, if applicable _____ ☐ Received on Wet Ice 12.1c DFR

Notes/Anomalies/Discrepancies: _____

GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; E = EFFLUENT; SL = SLUDGE; SW = SURFACE WATER; GW = GROUNDWATER; AO = AQUATIC ORGANISM

ALS Group, USA
Holland, Michigan

Sample Receipt Checklist

Client Name: **GLEC** Date/Time Received: **30-May-24 10:30**

Work Order: **24051775** Received by: **CMK**

Checklist completed by Caleb Koetje (eSignature) 30-May-24 (Date) Reviewed by: Jodi Blouw (eSignature) 30-May-24 (Date)

Matrices: Sediment
Carrier name: Courier

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on shipping container/cooler?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time?	Yes ☑	No ☐	
Container/Temp Blank temperature in compliance?	Yes ☑	No ☐	
Sample(s) received on ice?	Yes ☐	No ☑	
Temperature(s)/Thermometer(s):	12.1c	DF2	
Cooler(s)/Kit(s):			
Date/Time sample(s) sent to storage:	5/30/2024 3:31:45 PM		
Water - VOA vials have zero headspace?	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	Yes ☐	No ☐	N/A ☑
pH adjusted?	Yes ☐	No ☐	N/A ☑
pH adjusted by:			

Login Notes:

Client Contacted: Date Contacted: Person Contacted:

Contacted By: Regarding:

Comments:

CorrectiveAction:

Analytical Laboratory Report

Report ID: S62226.01(01)
Generated on 05/24/2024

Report to

Attention: Natalie Howard
Kieser & Associates
536 E. Michigan Ave. Ste 300
Kalamazoo, MI 49007

Phone: 269-344-7117 FAX:
Email: data@kieser-associates.com

Addtional Contacts: Doug Ervin

Report produced by

Merit Laboratories, Inc.
2680 East Lansing Drive
East Lansing, MI 48823

Phone: (517) 332-0167 FAX: (517) 332-6333

Contacts for report questions:
John Laverty (johnlaverty@meritlabs.com)
Barbara Ball (bball@meritlabs.com)

Report Summary

Lab Sample ID(s): S62226.01-S62226.12
Project: Black Lake
Collected Date(s): 05/14/2024
Submitted Date/Time: 05/17/2024 15:00
Sampled by: Mike Foster / Mark Kieser
P.O. #:

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Maya Murshak
Technical Director

General Report Notes

Analytical results relate only to the samples tested, in the condition received by the laboratory.
Methods may be modified for improved performance.
Results reported on a dry weight basis where applicable.
'Not detected' indicates that parameter was not found at a level equal to or greater than the reporting limit (RL).
When MDL results are provided, then 'Not detected' indicates that parameter was not found at a level equal to or greater than the MDL.
40 CFR Part 136 Table II Required Containers, Preservation Techniques and Holding Times for the Clean Water Act specify that samples for acrolein and acrylonitrile, and 2-chloroethylvinyl ether need to be preserved at a pH in the range of 4 to 5 or if not preserved, analyzed within 3 days of sampling.
QA/QC corresponding to this analytical report is a separate document with the same Merit ID reference and is available upon request.
Starred (*) analytes are not NY NELAP accredited.
Samples are held by the lab for 30 days from the final report date unless a written request to hold longer is provided by the client.
Report shall not be reproduced except in full, without the written approval of Merit Laboratories, Inc.
Limits for drinking water samples, are listed as the MCL Limits (Maximum Contaminant Level Concentrations)
PFAS requirement: Section 9.3.8 of U.S. EPA Method 537.1 states "If the method analyte(s) found in the Field Sample is present in the FRB at a concentration greater than 1/3 the MRL, then all samples collected with that FRB are invalid and must be recollected and reanalyzed."
Samples submitted without an accompanying FRB may not be acceptable for compliance purposes.
Wisconsin PFAs analysis: MDL = LOD; RL = LOQ. LOD and LOQ are adjusted for dilution.
All accreditations/certifications held by this laboratory are listed on page 3. Not all accreditations/certifications are applicable to this report.
For a specific list of accredited analytes, please feel free to contact the laboratory or visit https://www.meritlabs.com/certifications.

Report Narrative

There is no additional narrative for this analytical report

Laboratory Accreditations (For Reference Only)

Authority	Accreditation ID
Michigan DEQ	#9956
DOD ELAP & ISO/IEC 17025:2017	#69699 PJLA Testing
WBENC	#2005110032
Ohio VAP	#CL0002
Indiana DOH	#C-MI-07
New York NELAC	#11814
North Carolina DENR	#680
North Carolina DOH	#26702
Pennsylvania DEP	#68-05884
Wisconsin DNR	FID# 399147320

Qualifier Descriptions

Qualifier	Description
!	Result is outside of stated limit criteria
B	Compound also found in associated method blank
E	Concentration exceeds calibration range
F	Analysis run outside of holding time
G	Estimated result due to extraction run outside of holding time
H	Sample submitted and run outside of holding time
I	Matrix interference with internal standard
J	Estimated value less than reporting limit, but greater than MDL
L	Elevated reporting limit due to low sample amount
M	Result reported to MDL not RDL
O	Analysis performed by outside laboratory. See attached report.
R	Preliminary result
S	Surrogate recovery outside of control limits
T	No correction for total solids
X	Elevated reporting limit due to matrix interference
Y	Elevated reporting limit due to high target concentration
b	Value detected less than reporting limit, but greater than MDL
e	Reported value estimated due to interference
j	Analyte also found in associated method blank
o	Associated EIS outside of control limits
p	Benzo(b)Fluoranthene and Benzo(k)Fluoranthene integrated as one peak.
q	Qualifier ion ratio outside of control limits
x	Preserved from bulk sample

Glossary of Abbreviations

Abbreviation	Description
RL/RDL	Reporting Limit
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
SW	EPA SW 846 (Soil and Wastewater) Methods
E	EPA Methods
SM	Standard Methods
LN	Linear
BR	Branched

Method Summary

Method	Version
E200.8	EPA Method 200.8 Revision 5.4
SM4500-Cl- E	Standard Method 4500-Cl- E 2011
SW3015A	SW 846 Method 3015A Revision 1 February 2007

Analytical Laboratory Report

Sample Summary (12 samples)

Sample ID	Sample Tag	Matrix	Collected Date/Time
S62226.01	Stoney	Water	05/14/24 11:15
S62226.02	Lower Black River	Water	05/14/24 16:00
S62226.03	Rainy/Cold	Water	05/14/24 12:41
S62226.04	Rainy	Water	05/14/24 13:00
S62226.05	Dorivo	Water	05/14/24 09:10
S62226.06	Mud	Water	05/14/24 13:30
S62226.07	Fisher	Water	05/14/24 10:46
S62226.08	Upper Black	Water	05/14/24 14:23
S62226.09	Stewart	Water	05/14/24 10:24
S62226.10	Black Lake BLD-1S	Water	05/14/24 10:56
S62226.11	Black Lake BLD-1M	Water	05/14/24 10:51
S62226.12	Black Lake BLD-1B	Water	05/14/24 10:40

Analytical Laboratory Report

Lab Sample ID: S62226.01
Sample Tag: Stoney
Collected Date/Time: 05/14/2024 11:15
Matrix: Water
COC Reference: 166125

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250mL Plastic	None	Yes	3.3	IR

Inorganics

Method: SM4500-Cl- E, Run Date: 05/23/24 16:34, Analyst: SSM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride*	15	1		mg/L	1	16887-00-6	

Analytical Laboratory Report

Lab Sample ID: S62226.02
Sample Tag: Lower Black River
Collected Date/Time: 05/14/2024 16:00
Matrix: Water
COC Reference: 166125

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250mL Plastic	None	Yes	3.3	IR

Inorganics

Method: SM4500-Cl- E, Run Date: 05/23/24 16:34, Analyst: SSM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride*	5	1		mg/L	1	16887-00-6	

Analytical Laboratory Report

Lab Sample ID: S62226.03
Sample Tag: Rainy/Cold
Collected Date/Time: 05/14/2024 12:41
Matrix: Water
COC Reference: 166125

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250mL Plastic	None	Yes	3.3	IR

Inorganics

Method: SM4500-Cl- E, Run Date: 05/23/24 16:34, Analyst: SSM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride*	4	2		mg/L	2	16887-00-6	

Analytical Laboratory Report

Lab Sample ID: S62226.04
Sample Tag: Rainy
Collected Date/Time: 05/14/2024 13:00
Matrix: Water
COC Reference: 166125

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250mL Plastic	None	Yes	3.3	IR

Inorganics

Method: SM4500-Cl- E, Run Date: 05/23/24 16:34, Analyst: SSM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride*	5	2		mg/L	2	16887-00-6	

Analytical Laboratory Report

Lab Sample ID: S62226.05
Sample Tag: Dorivo
Collected Date/Time: 05/14/2024 09:10
Matrix: Water
COC Reference: 166125

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250mL Plastic	None	Yes	3.3	IR

Inorganics

Method: SM4500-Cl- E, Run Date: 05/23/24 16:34, Analyst: SSM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride*	4	1		mg/L	1	16887-00-6	

Analytical Laboratory Report

Lab Sample ID: S62226.06
Sample Tag: Mud
Collected Date/Time: 05/14/2024 13:30
Matrix: Water
COC Reference: 166125

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250mL Plastic	None	Yes	3.3	IR

Inorganics

Method: SM4500-Cl- E, Run Date: 05/23/24 17:14, Analyst: SSM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride*	Not detected	4		mg/L	4	16887-00-6	

Analytical Laboratory Report

Lab Sample ID: S62226.07
Sample Tag: Fisher
Collected Date/Time: 05/14/2024 10:46
Matrix: Water
COC Reference: 166125

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250mL Plastic	None	Yes	3.3	IR

Inorganics

Method: SM4500-Cl- E, Run Date: 05/23/24 17:15, Analyst: SSM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride*	16	1		mg/L	1	16887-00-6	

Analytical Laboratory Report

Lab Sample ID: S62226.08
Sample Tag: Upper Black
Collected Date/Time: 05/14/2024 14:23
Matrix: Water
COC Reference: 166125

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250mL Plastic	None	Yes	3.3	IR

Inorganics

Method: SM4500-Cl- E, Run Date: 05/23/24 17:15, Analyst: SSM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride*	5	1		mg/L	1	16887-00-6	

Analytical Laboratory Report

Lab Sample ID: S62226.09
Sample Tag: Stewart
Collected Date/Time: 05/14/2024 10:24
Matrix: Water
COC Reference: 166125

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250mL Plastic	None	Yes	3.3	IR

Inorganics

Method: SM4500-Cl- E, Run Date: 05/23/24 16:31, Analyst: SSM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride*	28	20		mg/L	1	16887-00-6	

Analytical Laboratory Report

Lab Sample ID: S62226.10
Sample Tag: Black Lake BLD-1S
Collected Date/Time: 05/14/2024 10:56
Matrix: Water
COC Reference: 166125

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250mL Plastic	None	Yes	3.3	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3015A	05/22/24 14:00	CCM	

Metals

Method: E200.8, Run Date: 05/22/24 15:27, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Iron, Dissolved	Not detected	0.02		mg/L	5	7439-89-6	x

x-Preserved from bulk sample

Analytical Laboratory Report

Lab Sample ID: S62226.11
Sample Tag: Black Lake BLD-1M
Collected Date/Time: 05/14/2024 10:51
Matrix: Water
COC Reference: 166125

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250mL Plastic	None	Yes	3.3	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3015A	05/22/24 14:00	CCM	

Metals

Method: E200.8, Run Date: 05/22/24 15:30, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Iron, Dissolved	0.04	0.02		mg/L	5	7439-89-6	x

x-Preserved from bulk sample

Analytical Laboratory Report

Lab Sample ID: S62226.12
Sample Tag: Black Lake BLD-1B
Collected Date/Time: 05/14/2024 10:40
Matrix: Water
COC Reference: 166125

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250mL Plastic	None	Yes	3.3	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3015A	05/22/24 14:00	CCM	

Metals

Method: E200.8, Run Date: 05/22/24 15:32, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Iron, Dissolved	Not detected	0.02		mg/L	5	7439-89-6	x

x-Preserved from bulk sample

Merit Laboratories Login Checklist

Lab Set ID: S62226
Client: KIESER (Kieser & Associates)
Project: Black Lake
Submitted: 05/17/2024 15:00 Login User: MMC

Attention: Natalie Howard
Address: Kieser & Associates
536 E. Michigan Ave. Ste 300
Kalamazoo, MI 49007

Phone: 269-344-7117 FAX:
Email: data@kieser-associates.com

Selection				Description	Note
Sample Receiving					
01.	[X] Yes	[ ] No	[ ] N/A	Samples are received at 4C +/- 2C Thermometer #	IR 3.3
02.	[X] Yes	[ ] No	[ ] N/A	Received on ice/ cooling process begun	
03.	[ ] Yes	[X] No	[ ] N/A	Samples shipped	
04.	[ ] Yes	[X] No	[ ] N/A	Samples left in 24 hr. drop box	
05.	[ ] Yes	[ ] No	[X] N/A	Are there custody seals/tape or is the drop box locked	
Chain of Custody					
06.	[X] Yes	[ ] No	[ ] N/A	COC adequately filled out	
07.	[X] Yes	[ ] No	[ ] N/A	COC signed and relinquished to the lab	
08.	[X] Yes	[ ] No	[ ] N/A	Sample tag on bottles match COC	
09.	[ ] Yes	[X] No	[ ] N/A	Subcontracting needed? Subcontacted to:	
Preservation					
10.	[X] Yes	[ ] No	[ ] N/A	Do sample have correct chemical preservation	
11.	[ ] Yes	[ ] No	[X] N/A	Completed pH checks on preserved samples? (no VOAs)	
12.	[X] Yes	[ ] No	[ ] N/A	Did any samples need to be preserved in the lab?	Diss Iron
Bottle Conditions					
13.	[X] Yes	[ ] No	[ ] N/A	All bottles intact	
14.	[X] Yes	[ ] No	[ ] N/A	Appropriate analytical bottles are used	
15.	[X] Yes	[ ] No	[ ] N/A	Merit bottles used	
16.	[X] Yes	[ ] No	[ ] N/A	Sufficient sample volume received	
17.	[X] Yes	[ ] No	[ ] N/A	Samples require laboratory filtration	Diss Iron
18.	[X] Yes	[ ] No	[ ] N/A	Samples submitted within holding time	
19.	[ ] Yes	[ ] No	[X] N/A	Do water VOC or TOX bottles contain headspace	

Corrective action for all exceptions is to call the client and to notify the project manager.

Client Review By: _____ Date: _____

Merit Laboratories, Inc.
2680 East Lansing Dr., East Lansing, MI 48823
Phone (517) 332-0167 Fax (517) 332-4034
www.meritlabs.com

C.O.C. PAGE # _____ OF _____ 166125

CHAIN OF CUSTODY RECORD

REPORT TO

CONTACT NAME: Natalie Howard
COMPANY: Kieser & Associates LLC
ADDRESS: 536 E Michigan Ave
CITY: Kalamazoo STATE: MI ZIP CODE: 49007
PHONE NO.: (269) 344-7117 CELL NO.: P.O. NO.:
E-MAIL ADDRESS: data@kieser-associates.com QUOTE NO.:

INVOICE TO

CONTACT NAME: Becky Hough ☑ SAME
COMPANY:
ADDRESS:
CITY: STATE: ZIP CODE:
PHONE NO.: E-MAIL ADDRESS: Bhough@kieser-associates.com

PROJECT NO./NAME: BLack Lake
SAMPLER(S) - PLEASE PRINT/SIGN NAME: Mike Foster + Mark Kieser

TURNAROUND TIME REQUIRED ☐ 1 DAY ☐ 2 DAYS ☐ 3 DAYS ☒ STANDARD ☐ OTHER _____

DELIVERABLES REQUIRED ☒ STD ☐ LEVEL II ☐ LEVEL III ☐ LEVEL IV ☐ EDD ☐ OTHER _____

MATRIX CODE: W=WATER GW=GROUNDWATER WW=WASTEWATER S=SOIL L=LIQUID SD=SOLID SL=SLUDGE DW=DRINKING WATER O=OIL WP=WIPE A=AIR WS=WASTE

ANALYSIS (ATTACH LIST IF MORE SPACE IS REQUIRED)

Certifications
☐ OHIO VAP ☐ Drinking Water
☐ DoD ☐ NPDES

Project Locations
☐ Detroit ☐ New York
☐ Other _____

Special Instructions

MERIT LAB NO. (FOR LAB USE ONLY)	COLLECTION DATE	COLLECTION TIME	SAMPLE TAG IDENTIFICATION-DESCRIPTION	MATRIX	# OF BOTTLES	# Containers & Preservatives: NONE	HCl	HNO_3	H_2SO_4	NaOH	MeOH	OTHER	Chloride	Dissolved Iron
62226.01	5/14/24	11:15	Stoney	W	1	X							X	
.02	5/14/24	4:00	Lower Black River	W	1	X							X	
.03	5/14/24	12:41	Rainy/cold	W	1	X							X	
.04	5/14/24	1:00	Rainy	W	1	X							X	
.05	5/14/24	9:10	Dorivo	W	1	X							X	
.06	5/14/24	1:30	Mud	W	1	X							X	
.07	5/14/24	10:46	Fisher	W	1	X							X	
.08	5/14/24	2:23	Upper black	W	1	X							X	
.09	5/14/24	10:24	Stewart	W	1	X							X	
.10	5/14/24	10:56	Black Lake BLD-1S	W	1	X								X
.11	5/14/24	10:51	Black Lake BLD-1M	W	1	X								X
.12	5/14/24	10:46	Black Lake BLD-1B	W	1	X								X

RELINQUISHED BY: SIGNATURE/ORGANIZATION: Natalie Howard Kieser & Associates ☐ Sampler	DATE: 5/17/24	TIME: 10:30	
RECEIVED BY: SIGNATURE/ORGANIZATION:	DATE: 5/17/24	TIME: 1030	
RELINQUISHED BY: SIGNATURE/ORGANIZATION:	DATE: 5/17/24	TIME: 1500	
RECEIVED BY: SIGNATURE/ORGANIZATION: M Chilcott	DATE: 5/17/24	TIME: 1500	

RELINQUISHED BY: SIGNATURE/ORGANIZATION:	DATE:	TIME:	
RECEIVED BY: SIGNATURE/ORGANIZATION:	DATE:	TIME:	

SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS
SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS

NOTES: TEMP. ON ARRIVAL 3.3

PLEASE NOTE: SIGNING ACKNOWLEDGES ADHERENCE TO MERIT'S SAMPLE ACCEPTANCE POLICY ON REVERSE SIDE

Rev. 1.26.22

PhycoTech, Inc.
620 Broad Street - Suite 100 - St. Joseph - MI 49085 - Phone: 269-983-3654 - Fax: 269-983-3653
info@phycotech.com - www.phycotech.com

Algae Analysis

Report and Data Set

Customer ID: 418

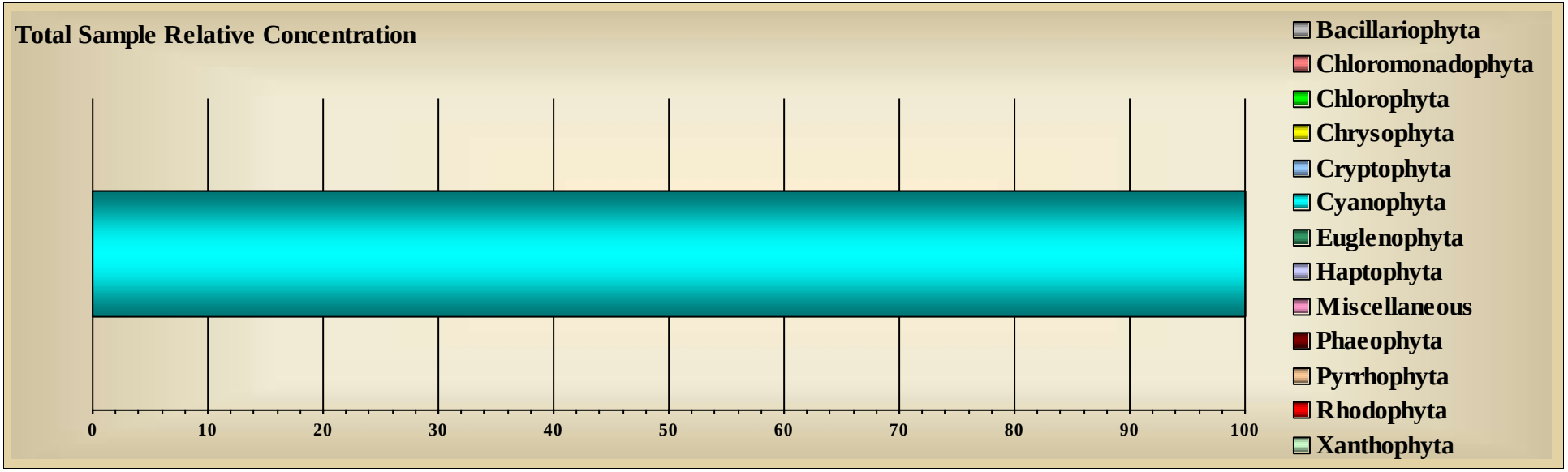
Tracking Code:	250001-418	**Sample ID:**	Black Lake	**Replicate:**	.
Customer ID:	418	**Sample Date:**	11/16/2024	**Sample Level:**	Epi
Job ID:	1	**Station:**	.	**Sample Depth:**	0
System Name:	Black Lake	**Site:**	BLS 1-6 Sed	**Preservative:**	Lugols
Report Notes:	.				

Division: Cyanophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Relative Concentration
4011	*Dolichospermum*	*circinale*	.	.	.	.	Vegetative	70.00
1000468	*Dolichospermum*	*lemmermannii/flos-aquae*	.	.	.	.	Vegetative	27.00
4091	*Woronichinia*	*naegeliana*	.	.	.	.	Vegetative	3.00

Summary for Division ~ Cyanophyta (3 detail records) **Sum Total Cyanophyta** 100.00

SUMMARY GRAPHICS



Species List

Division: Cyanophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	PhysiState	Structure	Authority
4011	Dolichospermum	circinale	.	.	.		Vegetative	Rabenhorst
1000468	Dolichospermum	lemmermannii/flos-aquae	.	.	.		Vegetative	.
4091	Woronichinia	naegeliana	.	.	.		Vegetative	Unger

ATTACHMENT A

September 2023 Shallow Groundwater Monitoring Laboratory Reports

Great Lakes Environmental Center

Project Number: 2592-B15

October 19, 2023

Kieser & Associates-Black Lake WQ
536 E. Michigan Ave., Suite 300
Kalamazoo, MI 49007

Attention: John Hart

Project Description: Water Quality Sampling

Dear Client,

Enclosed is a copy of your laboratory report relating to samples, as they were received. All tests have met or exceeded QC criteria. Test results are in compliance with The NELAC Institute Standards. Visit our web site for a full list of tests for which GLEC (Lab 2059) is accredited through the New Hampshire Environmental Laboratory Accreditation Program (NH ELAP).

Please don't hesitate to call if you have questions or require further information.

Sincerely,

Michelle A. Moore
Laboratory Coordinator and Research Scientist/Nutrient Chemistry

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Total Phosphorus

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K09270036	S3-6	9/27/2023	0.313	mg/L	0.015	0.007		10/17/2023		BSC
9K09270037	S3-Downstream	9/27/2023	0.296	mg/L	0.015	0.007		10/17/2023		BSC
9K09270038	S3-5	9/27/2023	0.305	mg/L	0.015	0.007		10/17/2023		BSC
9K09270039	S3-4	9/27/2023	0.317	mg/L	0.015	0.007		10/17/2023		BSC
9K09270040	S3-3	9/27/2023	0.457	mg/L	0.03	0.014		10/17/2023		BSC
9K09270041	S3-2	9/27/2023	0.230	mg/L	0.015	0.007		10/17/2023		BSC
9K09270042	S3-1	9/27/2023	0.198	mg/L	0.015	0.007		10/17/2023		BSC
9K09270043	S3-Midgrade	9/27/2023	0.102	mg/L	0.012	0.0056		10/17/2023		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 4500-P F

Thursday, October 19, 2023

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K09270044	S3-Upgradient	9/27/2023	0.128	mg/L	0.006	0.0028		10/17/2023		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 4500-P F

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Soluble Reactive Phosphorus

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K09260026	S1A	9/26/2023	0.0033	mg/L	0.001	0.00015		10/4/2023		BSC
9K09270027	S2-1	9/27/2023	0.0352	mg/L	0.005	0.00075		10/4/2023		BSC
9K09270028	S2-2	9/27/2023	0.056	mg/L	0.01	0.0015		10/4/2023		BSC
9K09270029	S2-3	9/27/2023	0.117	mg/L	0.01	0.0015		10/4/2023		BSC
9K09270030	S2-6	9/27/2023	0.093	mg/L	0.01	0.0015		10/4/2023		BSC
9K09270031	S3-Downstream	9/27/2023	0.0030	mg/L	0.001	0.00015		10/4/2023		BSC
9K09270032	S3-4	9/27/2023	0.132	mg/L	0.01	0.0015		10/4/2023		BSC
9K09270033	S3-3	9/27/2023	0.398	mg/L	0.05	0.0075		10/4/2023		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Thursday, October 19, 2023

Method: SM 4500-P F

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K09270034	S3-Upgradient	9/27/2023	0.0039	mg/L	0.001	0.00015		10/4/2023		BSC
9K09270035	S3-Midgradient	9/27/2023	0.0031	mg/L	0.001	0.00015		10/4/2023		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 4500-P F

GLEC
Great Lakes Environmental Center

GREAT LAKES ENVIRONMENTAL CENTER, INC.

CHAIN OF CUSTODY RECORD

Traverse City, MI - Laboratory
739 Hastings Street
Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: Kieser & Associates, LLC
Report Results To: John Hart
Address: 536 E. Michigan Ave, Suite 300
Phone: (269) 344-7117 E-mail: jhart@kieser-associates.com

Section II.

Project Name: Black Lake
Project Number:
P.O.#:
Sampled by: (initials) ☐ GLEC _____ ☒ Client KM KBA

Section III. Sample Information at Collection

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.
1		S1A	9.26.23	5:40	SW	Grab	No	Y	Glass	250	1
2		S2-1	9.27.23	8:49	SW	Grab	No	Y	Glass	250	1
3		S2-2	↓	8:54	↓	↓	↓	↓	↓	↓	1
4		S2-3		9:00							1
5		S2-6		9:06							1
6		S3-Downstream		1:06							1
7		S3-4		1:42							1
8		S3-3	↓	1:55	↓	↓	↓	↓	↓	↓	1

Section IV. Requested Analysis

HP	SRP							pH of Sample Upon Receipt
	X							
	X							
	X							
	X							
	X							
	X							
	X							
	X							

Client Notes:

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Mark Kieser K&A	9.28.23	12:25	Print Name & Organization		
Signature: Mark Kieser			Signature: BeR	9.28.23	12:25
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: 2.1 °C Initials: L Bottle ID #, if applicable S3-1 ☒ Received on Wet Ice

Notes/Anomalies/Discrepancies:

GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; SW = SURFACE WATER; E = EFFLUENT; GW = GROUNDWATER; SL = SLUDGE; AO = AQUATIC ORGANISM

GLEC
Great Lakes Environmental Center

GREAT LAKES ENVIRONMENTAL CENTER, INC.

CHAIN OF CUSTODY RECORD

Traverse City, MI - Laboratory
739 Hastings Street
Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: Kieser & Associates, LLC
Report Results To: John Hart
Address: 536 E. Michigan Ave, Suite 300
Phone: (269) 344 - 7117 E-mail: jhart@kieser-associates.com

Section II.

Project Name: Black Lake
Project Number:
P.O.#:
Sampled by: (initials) KM
☐ GLEC _____ ☒ Client KKA

Section III. Sample Information at Collection

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.
1		S3-Upgradient	9.27.23	3:20	SW	Grab	N	Y	Glass	250	1
2		S3-Midgradient	9.27.23	3:10	SW	Grab	N	Y	Glass	250	1
3		S3-6		12:41	SW	Grab	Y	N	Glass	250	1
4		S3-Downstream		1:09							1
5		S3-5		1:36							1
6		S3-4		1:42							1
7		S3-3		1:55							1
8		S3-2		2:05							1

Section IV. Requested Analysis

#	TP	SRP							pH of Sample Upon Receipt
1		X							
2		X							
3	X								CL
4	X								CL
5	X								CL
6	X								CL
7	X								CL
8	X								CL

Client Notes:

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Mark Kieser K:A	9.28.23	12:25	Print Name & Organization		
Signature: MKieser			Signature: [illegible]	9-28-23	12:25
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: 2.1 °C Initials: L Bottle ID #, if applicable S3-1 ☑ Received on Wet Ice

Notes/Anomalies/Discrepancies:

GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; SW = SURFACE WATER; E = EFFLUENT; GW = GROUNDWATER; SL = SLUDGE; AO = AQUATIC ORGANISM

GLEC
Great Lakes Environmental Center

GREAT LAKES ENVIRONMENTAL CENTER, INC.

CHAIN OF CUSTODY RECORD

Traverse City, MI - Laboratory
739 Hastings Street
Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: Kieser & Associates
Report Results To: John Hart
Address: 536 E. Michigan Ave., Suite 300
Phone: 269-344-7117 E-mail: jhart@kieser-associates.com

Section II.

Project Name: Black Lake
Project Number:
P.O.#:
Sampled by: (initials) KM
☐ GLEC _____ ☑ Client KBA

Section III. Sample Information at Collection

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.
1		S3 - 1	9.27.23	2:45	SW	Grab	Y	N	Glass	250	1
2		S3-Midgrade	↓	3:10	↓	↓	↓	↓	↓	↓	1
3		S3-Upgradient		3:20	↓	↓	↓	↓	↓	↓	1
4											
5											
6											
7											
8											

Section IV. Requested Analysis

#	TP	SRP							pH of Sample Upon Receipt
1	X								cc
2	X								cc
3	X								cc
4									
5									
6									
7									
8									

Client Notes:

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Mark Kieser KBA	9.28.23	12:25	Print Name & Organization		
Signature			Signature	9.28.23	12:25
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: 2.1 °C Initials: _____ Bottle ID #, if applicable S3-1 ☑ Received on Wet Ice

Notes/Anomalies/Discrepancies: _____

GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; SW = SURFACE WATER; E = EFFLUENT; GW = GROUNDWATER; SL = SLUDGE; AO = AQUATIC ORGANISM

ATTACHMENT A

Permanent Groundwater Monitoring Well Laboratory Reports

Analytical Laboratory Report

Report ID: S53856.01(01)
Generated on 09/29/2023

Report to

Attention: John Hart
Kieser & Associates
536 E. Michigan Ave. Ste 300
Kalamazoo, MI 49007

Phone: 269-344-7117 FAX:
Email: jhart@kieser-associates.com

Addtional Contacts: Doug Ervin, John Jacobson

Report produced by

Merit Laboratories, Inc.
2680 East Lansing Drive
East Lansing, MI 48823

Phone: (517) 332-0167 FAX: (517) 332-6333

Contacts for report questions:
John Laverty (johnlaverty@meritlabs.com)
Barbara Ball (bball@meritlabs.com)

Report Summary

Lab Sample ID(s): S53856.01-S53856.15
Project: Black Lake
Collected Date(s): 09/26/2023 - 09/27/2023
Submitted Date/Time: 09/28/2023 08:15
Sampled by: Kaitlyn McGee
P.O. #:

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Maya Murshak
Technical Director

General Report Notes

Analytical results relate only to the samples tested, in the condition received by the laboratory.
Methods may be modified for improved performance.
Results reported on a dry weight basis where applicable.
'Not detected' indicates that parameter was not found at a level equal to or greater than the reporting limit (RL).
When MDL results are provided, then 'Not detected' indicates that parameter was not found at a level equal to or greater than the MDL.
40 CFR Part 136 Table II Required Containers, Preservation Techniques and Holding Times for the Clean Water Act specify that samples for acrolein and acrylonitrile, and 2-chloroethylvinyl ether need to be preserved at a pH in the range of 4 to 5 or if not preserved, analyzed within 3 days of sampling.
QA/QC corresponding to this analytical report is a separate document with the same Merit ID reference and is available upon request.
Full accreditation certificates are available upon request. Starred (*) analytes are not NELAP accredited.
Samples are held by the lab for 30 days from the final report date unless a written request to hold longer is provided by the client.
Report shall not be reproduced except in full, without the written approval of Merit Laboratories, Inc.
Limits for drinking water samples, are listed as the MCL Limits (Maximum Contaminant Level Concentrations)
PFAS requirement: Section 9.3.8 of U.S. EPA Method 537.1 states "If the method analyte(s) found in the Field Sample is present in the FRB at a concentration greater than 1/3 the MRL, then all samples collected with that FRB are invalid and must be recollected and reanalyzed."
Samples submitted without an accompanying FRB may not be acceptable for compliance purposes.
Wisconsin PFAs analysis: MDL = LOD; RL = LOQ. LOD and LOQ are adjusted for dilution.
All accreditations/certifications held by this laboratory are listed on page 3. Not all accreditations/certifications are applicable to this report.

Report Narrative

There is no additional narrative for this analytical report

Laboratory Accreditations

Authority	Accreditation ID
Michigan DEQ	#9956
DOD ELAP & ISO/IEC 17025:2017	#69699
WBENC	#2005110032
Ohio VAP	#CL0002
Indiana DOH	#C-MI-07
New York NELAC	#11814
North Carolina DENR	#680
North Carolina DOH	#26702
Pennsylvania DEP	#68-05884
Wisconsin DNR	FID# 399147320

Qualifier Descriptions

Qualifier	Description
!	Result is outside of stated limit criteria
B	Compound also found in associated method blank
E	Concentration exceeds calibration range
F	Analysis run outside of holding time
G	Estimated result due to extraction run outside of holding time
H	Sample submitted and run outside of holding time
I	Matrix interference with internal standard
J	Estimated value less than reporting limit, but greater than MDL
L	Elevated reporting limit due to low sample amount
M	Result reported to MDL not RDL
O	Analysis performed by outside laboratory. See attached report.
R	Preliminary result
S	Surrogate recovery outside of control limits
T	No correction for total solids
X	Elevated reporting limit due to matrix interference
Y	Elevated reporting limit due to high target concentration
b	Value detected less than reporting limit, but greater than MDL
e	Reported value estimated due to interference
j	Analyte also found in associated method blank
p	Benzo(b)Fluoranthene and Benzo(k)Fluoranthene integrated as one peak.
x	Preserved from bulk sample

Glossary of Abbreviations

Abbreviation	Description
RL/RDL	Reporting Limit
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
SW	EPA SW 846 (Soil and Wastewater) Methods
E	EPA Methods
SM	Standard Methods
LN	Linear
BR	Branched

Method Summary

Method	Version
E300.0	EPA Method 300.0 Revision 2.1 (1993)

Sample Summary (15 samples)

Sample ID	Sample Tag	Matrix	Collected Date/Time
S53856.01	S1N-A	Liquid	09/26/23 17:40
S53856.02	S1C-A	Liquid	09/26/23 17:40
S53856.03	S2-1	Liquid	09/27/23 08:48
S53856.04	S2-2	Liquid	09/27/23 08:54
S53856.05	S2-3	Liquid	09/27/23 09:00
S53856.06	S2-6	Liquid	09/27/23 09:06
S53856.07	S3-6	Liquid	09/27/23 12:41
S53856.08	S3-Downstream	Liquid	09/27/23 13:09
S53856.09	S3-5	Liquid	09/27/23 13:36
S53856.10	S3-4	Liquid	09/27/23 13:42
S53856.11	S3-3	Liquid	09/27/23 13:55
S53856.12	S3-2	Liquid	09/27/23 14:05
S53856.13	S3-1	Liquid	09/27/23 14:45
S53856.14	S3-Midgrade	Liquid	09/27/23 15:10
S53856.15	S3-Upgradient	Liquid	09/27/23 15:20

Analytical Laboratory Report

Lab Sample ID: S53856.01
Sample Tag: S1N-A
Collected Date/Time: 09/26/2023 17:40
Matrix: Liquid
COC Reference: 140093

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	5.1	IR

Inorganics

Method: E300.0, Run Date: 09/28/23 11:05, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Nitrate-N	Not detected	0.5	0.06	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S53856.02
Sample Tag: S1C-A
Collected Date/Time: 09/26/2023 17:40
Matrix: Liquid
COC Reference: 140093

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	5.1	IR

Inorganics

Method: E300.0, Run Date: 09/28/23 11:15, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	11	5	0.06	mg/L	5	16887-00-6	

Analytical Laboratory Report

Lab Sample ID: S53856.03
Sample Tag: S2-1
Collected Date/Time: 09/27/2023 08:48
Matrix: Liquid
COC Reference: 140093

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	5.1	IR

Inorganics

Method: E300.0, Run Date: 09/28/23 11:25, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	9	5	0.06	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.06	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S53856.04
Sample Tag: S2-2
Collected Date/Time: 09/27/2023 08:54
Matrix: Liquid
COC Reference: 140093

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	5.1	IR

Inorganics

Method: E300.0, Run Date: 09/28/23 11:36, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	8	5	0.06	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.06	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S53856.05
Sample Tag: S2-3
Collected Date/Time: 09/27/2023 09:00
Matrix: Liquid
COC Reference: 140093

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	5.1	IR

Inorganics

Method: E300.0, Run Date: 09/28/23 11:46, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	7	5	0.06	mg/L	5	16887-00-6	
Nitrate-N	5.6	0.5	0.06	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S53856.06
Sample Tag: S2-6
Collected Date/Time: 09/27/2023 09:06
Matrix: Liquid
COC Reference: 140093

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	5.1	IR

Inorganics

Method: E300.0, Run Date: 09/28/23 11:56, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	22	5	0.06	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.06	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S53856.07
Sample Tag: S3-6
Collected Date/Time: 09/27/2023 12:41
Matrix: Liquid
COC Reference: 140093

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	5.1	IR

Inorganics

Method: E300.0, Run Date: 09/28/23 12:05, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	5	5	0.08	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.04	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S53856.08
Sample Tag: S3-Downstream
Collected Date/Time: 09/27/2023 13:09
Matrix: Liquid
COC Reference: 140093

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	5.1	IR

Inorganics

Method: E300.0, Run Date: 09/28/23 12:18, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	7	5	0.08	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.04	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S53856.09
Sample Tag: S3-5
Collected Date/Time: 09/27/2023 13:36
Matrix: Liquid
COC Reference: 140093

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	5.1	IR

Inorganics

Method: E300.0, Run Date: 09/28/23 12:31, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	11	5	0.08	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.04	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S53856.10
Sample Tag: S3-4
Collected Date/Time: 09/27/2023 13:42
Matrix: Liquid
COC Reference: 140093

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	5.1	IR

Inorganics

Method: E300.0, Run Date: 09/28/23 12:43, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	11	5	0.08	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.04	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S53856.11
Sample Tag: S3-3
Collected Date/Time: 09/27/2023 13:55
Matrix: Liquid
COC Reference: 140093

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	5.1	IR

Inorganics

Method: E300.0, Run Date: 09/29/23 08:36, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	14	5	0.06	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.06	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S53856.12
Sample Tag: S3-2
Collected Date/Time: 09/27/2023 14:05
Matrix: Liquid
COC Reference: 140093

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	5.1	IR

Inorganics

Method: E300.0, Run Date: 09/29/23 08:46, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	11	5	0.06	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.06	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S53856.13
Sample Tag: S3-1
Collected Date/Time: 09/27/2023 14:45
Matrix: Liquid
COC Reference: 140094

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	5.1	IR

Inorganics

Method: E300.0, Run Date: 09/29/23 08:56, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	12	5	0.06	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.06	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S53856.14
Sample Tag: S3-Midgrade
Collected Date/Time: 09/27/2023 15:10
Matrix: Liquid
COC Reference: 140094

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	5.1	IR

Inorganics

Method: E300.0, Run Date: 09/29/23 09:06, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	9	5	0.06	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.06	mg/L	5	14797-55-8	

Analytical Laboratory Report

Lab Sample ID: S53856.15
Sample Tag: S3-Upgradient
Collected Date/Time: 09/27/2023 15:20
Matrix: Liquid
COC Reference: 140094

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	250ml Plastic	None	Yes	5.1	IR

Inorganics

Method: E300.0, Run Date: 09/29/23 09:16, Analyst: JDP

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Chloride	36	5	0.06	mg/L	5	16887-00-6	
Nitrate-N	Not detected	0.5	0.06	mg/L	5	14797-55-8	

Merit Laboratories Login Checklist

Lab Set ID: S53856
Client: KIESER (Kieser & Associates)
Project: Black Lake
Submitted: 09/28/2023 08:15 Login User: MMC

Attention: John Hart
Address: Kieser & Associates
536 E. Michigan Ave. Ste 300
Kalamazoo, MI 49007

Phone: 269-344-7117 FAX:
Email: jhart@kieser-associates.com

Selection				Description	Note
Sample Receiving					
01.	[X] Yes	[ ] No	[ ] N/A	Samples are received at 4C +/- 2C Thermometer #	IR 5.1
02.	[X] Yes	[ ] No	[ ] N/A	Received on ice/ cooling process begun	
03.	[ ] Yes	[X] No	[ ] N/A	Samples shipped	
04.	[ ] Yes	[X] No	[ ] N/A	Samples left in 24 hr. drop box	
05.	[ ] Yes	[ ] No	[X] N/A	Are there custody seals/tape or is the drop box locked	
Chain of Custody					
06.	[X] Yes	[ ] No	[ ] N/A	COC adequately filled out	
07.	[X] Yes	[ ] No	[ ] N/A	COC signed and relinquished to the lab	
08.	[X] Yes	[ ] No	[ ] N/A	Sample tag on bottles match COC	
09.	[ ] Yes	[X] No	[ ] N/A	Subcontracting needed? Subcontacted to:	
Preservation					
10.	[X] Yes	[ ] No	[ ] N/A	Do sample have correct chemical preservation	
11.	[ ] Yes	[ ] No	[X] N/A	Completed pH checks on preserved samples? (no VOAs)	
12.	[ ] Yes	[X] No	[ ] N/A	Did any samples need to be preserved in the lab?	
Bottle Conditions					
13.	[X] Yes	[ ] No	[ ] N/A	All bottles intact	
14.	[X] Yes	[ ] No	[ ] N/A	Appropriate analytical bottles are used	
15.	[X] Yes	[ ] No	[ ] N/A	Merit bottles used	
16.	[X] Yes	[ ] No	[ ] N/A	Sufficient sample volume received	
17.	[ ] Yes	[X] No	[ ] N/A	Samples require laboratory filtration	
18.	[X] Yes	[ ] No	[ ] N/A	Samples submitted within holding time	
19.	[ ] Yes	[ ] No	[X] N/A	Do water VOC or TOX bottles contain headspace	

Corrective action for all exceptions is to call the client and to notify the project manager.

Client Review By: _____ Date: _____

Merit Laboratories, Inc.

2680 East Lansing Dr., East Lansing, MI 48823
Phone (517) 332-0167 Fax (517) 332-4034
www.meritlabs.com

C.O.C. PAGE # _____ OF _____

140093

CHAIN OF CUSTODY RECORD

REPORT TO

CONTACT NAME: John Hart
COMPANY: Kieser & Associates
ADDRESS: 536 E. Michigan Ave., Suite 300
CITY: Kalamazoo STATE: MI ZIP CODE: 49007
PHONE NO.: (269) 344-7117 FAX NO.: P.O. NO.:
E-MAIL ADDRESS: jhart@kieser-associates.com QUOTE NO.:

INVOICE TO

CONTACT NAME: Becky Hough ☐ SAME
COMPANY:
ADDRESS:
CITY: STATE: ZIP CODE:
PHONE NO.: E-MAIL ADDRESS: bhough@kieser-associates.com

PROJECT NO./NAME: Black Lake
SAMPLER(S) - PLEASE PRINT/SIGN NAME: Kaitlyn McGee

TURNAROUND TIME REQUIRED ☐ 1 DAY ☐ 2 DAYS ☐ 3 DAYS ☒ STANDARD ☐ OTHER _____

DELIVERABLES REQUIRED ☒ STD ☐ LEVEL II ☐ LEVEL III ☐ LEVEL IV ☐ EDD ☐ OTHER _____

MATRIX CODE: GW=GROUNDWATER WW=WASTEWATER S=SOIL L=LIQUID SD=SOLID SL=SLUDGE DW=DRINKING WATER O=OIL WP=WIPE A=AIR W=WASTE

ANALYSIS (ATTACH LIST IF MORE SPACE IS REQUIRED)

Certifications
☐ OHIO VAP ☐ Drinking Water
☐ DoD ☐ NPDES
Project Locations
☐ Detroit ☐ New York
☐ Other _____
Special Instructions

MERIT LAB NO. FOR LAB USE ONLY	YEAR DATE	TIME	SAMPLE TAG IDENTIFICATION-DESCRIPTION	MATRIX	# OF BOTTLES	# Containers & Preservatives: NONE	HCl	HNO_3	H_2SO_4	NaOH	MeOH	OTHER	Chloride	Nitrate
53856.01	9-26-23	5:40	S1N-A	L	1	X								X
.02	9-26-23	5:40	~~S1O-A~~ S1C-A										X	
.03	9-27-23	8:48	S2-1										X	X
.04		8:54	S2-2										X	X
.05		9:00	S2-3										X	X
.06		9:06	S2-6										X	X
.07		12:41	S3-6										X	X
.08		1:09	S3-Downstream										X	X
.09		1:36	S3-5										X	X
.10		1:42	S3-4										X	X
.11		1:55	S3-3										X	X
.12	↓	2:05	S3-2	↓	↓	↓							X	X

RELINQUISHED BY: SIGNATURE/ORGANIZATION: Kaitlyn McGee	☒ Sampler	DATE: 9-27-23	TIME: 8:26
RECEIVED BY: SIGNATURE/ORGANIZATION:		DATE:	TIME:
RELINQUISHED BY: SIGNATURE/ORGANIZATION:		DATE:	TIME:
RECEIVED BY: SIGNATURE/ORGANIZATION:		DATE:	TIME:

RELINQUISHED BY: SIGNATURE/ORGANIZATION: Merit Drop Box		9/28/23	0815
RECEIVED BY: SIGNATURE/ORGANIZATION: M Dulcolo		9/28/23	0815

SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS
SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS

NOTES: TEMP. ON ARRIVAL 5.1

PLEASE NOTE: SIGNING ACKNOWLEDGES ADHERENCE TO MERIT'S SAMPLE ACCEPTANCE POLICY ON REVERSE SIDE

Rev. 5.18.12

Merit Laboratories, Inc.
2680 East Lansing Dr., East Lansing, MI 48823
Phone (517) 332-0167 Fax (517) 332-4034
www.meritlabs.com

C.O.C. PAGE # _____ OF _____ 140094

CHAIN OF CUSTODY RECORD

REPORT TO

CONTACT NAME: John Hart
COMPANY: Kieser & Associates
ADDRESS: 536 E. Michigan Ave., Suite 300
CITY: Kalamazoo STATE: MI ZIP CODE: 49007
PHONE NO.: 269-344-7117 FAX NO.: P.O. NO.:
E-MAIL ADDRESS: jhart@kieser-associates.com QUOTE NO.:

INVOICE TO

CONTACT NAME: Becky Hough ☐ SAME
COMPANY:
ADDRESS:
CITY: STATE: ZIP CODE:
PHONE NO.: E-MAIL ADDRESS: bhough@kieser-associates.com

PROJECT NO./NAME: Black Lake
SAMPLER(S) - PLEASE PRINT/SIGN NAME: Kathryn McGee

TURNAROUND TIME REQUIRED ☐ 1 DAY ☐ 2 DAYS ☐ 3 DAYS ☒ STANDARD ☐ OTHER _____

DELIVERABLES REQUIRED ☒ STD ☐ LEVEL II ☐ LEVEL III ☐ LEVEL IV ☐ EDD ☐ OTHER _____

MATRIX CODE: GW=GROUNDWATER WW=WASTEWATER S=SOIL L=LIQUID SD=SOLID SL=SLUDGE DW=DRINKING WATER O=OIL WP=WIPE A=AIR W=WASTE

MERIT LAB NO. (FOR LAB USE ONLY)	YEAR DATE	YEAR TIME	SAMPLE TAG IDENTIFICATION-DESCRIPTION	MATRIX	# OF BOTTLES	# Containers & Preservatives: NONE	HCl	HNO_3	H_2SO_4	NaOH	MeOH	OTHER	ANALYSIS: Chloride	Nitrate	Special Instructions
53856.13	9.27.23	2:45	S3-1	L	1	X							X	X	
.14	↓	3:10	S3-Midgrade	L	1	X							X	X	
.15	↓	3:20	S3-Upgradient	L	1	X							X	X	

Certifications: ☐ OHIO VAP ☐ Drinking Water ☐ DoD ☐ NPDES
Project Locations: ☐ Detroit ☐ New York ☐ Other _____

RELINQUISHED BY: SIGNATURE/ORGANIZATION		DATE	TIME
Kathryn McGee Kieser & Associates ☐ Sampler		9.27.23	8:26
RECEIVED BY: SIGNATURE/ORGANIZATION		DATE	TIME
RELINQUISHED BY: SIGNATURE/ORGANIZATION		DATE	TIME
RECEIVED BY: SIGNATURE/ORGANIZATION		DATE	TIME

RELINQUISHED BY: SIGNATURE/ORGANIZATION		DATE	TIME
	Merit Drop Box	9/28/23	0815
RECEIVED BY: SIGNATURE/ORGANIZATION		DATE	TIME
	M Chilcote	9/28/23	0815

SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS
SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS

NOTES: TEMP. ON ARRIVAL 5.1

PLEASE NOTE: SIGNING ACKNOWLEDGES ADHERENCE TO MERIT'S SAMPLE ACCEPTANCE POLICY ON REVERSE SIDE

Rev. 5.18.12

Great Lakes Environmental Center

Project Number: 2592-B15

December 18, 2023

Kieser & Associates-Black Lake WQ
536 E. Michigan Ave., Suite 300
Kalamazoo, MI 49007

Attention: John Hart and Kaitlyn McGee

Project Description: Water Quality Sampling

Dear Client,

Enclosed is a copy of your laboratory report relating to samples, as they were received. All tests have met or exceeded QC criteria. Test results are in compliance with The NELAC Institute Standards. Visit our web site for a full list of tests for which GLEC (Lab 2059) is accredited through the New Hampshire Environmental Laboratory Accreditation Program (NH ELAP).

Please don't hesitate to call if you have questions or require further information.

Sincerely,

Michelle A. Moore
Laboratory Coordinator and Research Scientist/Nutrient Chemistry

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Total Phosphorus

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K12020045	Site 3 Up	12/2/2023	1.23	mg/L	0.15	0.07		12/12/2023		BSC
9K12020046	Site 3 Mid	12/2/2023	0.0313	mg/L	0.003	0.0014		12/12/2023		BSC
9K12020047	Site 3 Mid	12/2/2023	0.0416	mg/L	0.003	0.0014		12/12/2023		BSC
9K12020048	Site 3 Down	12/2/2023	0.151	mg/L	0.012	0.0056		12/12/2023		BSC
9K12020049	Site 3 Down	12/2/2023	0.248	mg/L	0.012	0.0056		12/12/2023		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Monday, December 18, 2023

Method: SM 4500-P F

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Soluble Reactive Phosphorus

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K12020050	Site 3 Up	12/2/2023	0.474	mg/L	0.08	0.012		12/12/2023		BSC
9K12020051	Site 3 Up	12/2/2023	0.634	mg/L	0.1	0.015		12/12/2023		BSC
9K12020052	Site 3 Mid	12/2/2023	0.0016	mg/L	0.001	0.00015		12/12/2023		BSC
9K12020053	Site 3 Mid	12/2/2023	0.0062	mg/L	0.001	0.00015		12/12/2023		BSC
9K12020054	Site 3 Down	12/2/2023	0.0347	mg/L	0.004	0.0006		12/12/2023		BSC
9K12020055	Site 3 Down	12/2/2023	0.111	mg/L	0.01	0.0015		12/12/2023		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Monday, December 18, 2023

Method: SM 4500-P F

GLEC
Great Lakes Environmental Center

GREAT LAKES ENVIRONMENTAL CENTER, INC.

CHAIN OF CUSTODY RECORD

Traverse City, MI - Laboratory
739 Hastings Street
Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: Kieser & Associates, LLC
Report Results To: John Hart / Kaitlyn McGee
Address: 536 E. Michigan Ave, Kalamazoo, MI
Phone: 269-344-7117 E-mail: jhart@kieser-associates.com

Section II.

Project Name:
Project Number:
P.O.#:
Sampled by: (initials) ☐ GLEC _____ ☐ Client _____

Section III. All Black Lake Samples — **Sample Information at Collection**

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.	Requested Analysis: PH	pH of Sample Upon Receipt
1		Site 3 UP	12-2-23	9:48	GW	Grab	H_2SO_4	N	Glass	250		X	<2
2		Site 3 Mid		10:20								X	<2
3		Site 3 Mid		10:25								X	<2
4		Site 3 Down		10:07								X	<2
5		Site 3 Down		10:12								X	<2
6													
7													
8													

Client Notes: All groundwater (GW) samples

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Mark Kieser K&A	12.4.23	10:15	Print Name & Organization: Carie Gorman	12/4/23	10:16
Signature: Mark J. Kieser			Signature: CG		
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: 5 °C Initials: CG Bottle ID #, if applicable 29613 ☒ Received on Wet Ice

Notes/Anomalies/Discrepancies:

GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; SW = SURFACE WATER; E = EFFLUENT; GW = GROUNDWATER; SL = SLUDGE; AO = AQUATIC ORGANISM

GLEC
Great Lakes Environmental Center

GREAT LAKES ENVIRONMENTAL CENTER, INC.

CHAIN OF CUSTODY RECORD

Traverse City, MI - Laboratory
739 Hastings Street
Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: Kieser & Associates
Report Results To: John Hart / Kaitlyn McGee
Address: 536 E. Michigan Ave, Kalamazoo, MI
Phone: 269-344-7117 E-mail: jhart@kieserassociates.com

Section II.

Project Name:
Project Number:
P.O.#:
Sampled by: (initials)
☐ GLEC _____ ☐ Client _____

Section III. All samples from Black Lake **Sample Information at Collection**

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered (Y or N)	Sample Containers: Type	Size	No.	Requested Analysis: SRA	pH of Sample Upon Receipt
1		Site 3 UP	12.2.23	9:48	GW	Grab	—	Y	Glass	250		X	
2		Site 3 UP		9:55								X	
3		Site 3 Mid		10:20								X	
4		Site 3 Mid		10:25								X	
5		Site 3 Down		10:07								X	
6		Site 3 Down		10:12								X	
7													
8													

Client Notes: All groundwater (GW) samples

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Mark Kieser K & A	12.4.23	10:15	Print Name & Organization: Carrie Gorman	12/4/23	10:16
Signature: Mark A. Kieser			Signature: CG		
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: .5 °C Initials: CG 29613 CG 12/4/23 Bottle ID #, if applicable 29613 ☑ Received on Wet Ice

Notes/Anomalies/Discrepancies:

GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; SW = SURFACE WATER; E = EFFLUENT; GW = GROUNDWATER; SL = SLUDGE; AO = AQUATIC ORGANISM

Great Lakes Environmental Center

Project Number: 2592-B16

May 29, 2024

Kieser & Associates-Black Lake-Septic
536 E. Michigan Ave., Suite 300
Kalamazoo, MI 49007

Attention: Natalie Howard

Project Description: Water Quality Sampling

Dear Client,

Enclosed is a copy of your laboratory report relating to samples, as they were received. All tests were performed within the maximum holding times and have met or exceeded analytical QC criteria. Visit our web site for a full list of tests for which GLEC (Lab 2059) is accredited by the National Environmental Laboratory Accreditation Conference (NELAC).

Please don't hesitate to call if you have questions or require further information.

Data Qualifiers:

U = Analyte not detected

Sincerely,

Michelle A. Moore
Laboratory Coordinator and Research Scientist/Nutrient Chemistry

Great Lakes Environmental Center, Inc.
739 Hastings St., Traverse City, MI 49686
Phone: 231-941-2230; Fax: 231-941-2240; www.glec.com

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Septic

REPORT OF ANALYSIS

Soluble Reactive Phosphorus

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
K005140001	SS3-upgradient	5/14/2024	0.0023	mg/L	0.001	0.00015		5/22/2024		BSC
K005140003	SS3-midgradient	5/14/2024	0.0035	mg/L	0.001	0.00015		5/22/2024		BSC
K005140005	SS3-downgradient	5/14/2024	0.0035	mg/L	0.001	0.00015		5/22/2024		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 4500-P F

Wednesday, May 29, 2024

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Septic

REPORT OF ANALYSIS

Nitrate/Nitrite-Nitrogen

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
K005140002	SS3-upgradient	5/14/2024	<0.00312	mg/L	0.005	0.00312	U	5/24/2024		BSC
K005140004	SS3-midgradient	5/14/2024	<0.00312	mg/L	0.005	0.00312	U	5/24/2024		BSC
K005140006	SS3-downgradient	5/14/2024	<0.00312	mg/L	0.005	0.00312	U	5/24/2024		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Wednesday, May 29, 2024

Method: SM 4500-NO3(F)-N

CHAIN OF CUSTODY RECORD

GLEC
Great Lakes Environmental Center, Inc.
739 Hastings Street
Traverse City, Michigan 49686

Phone (231) 941-2230
Fax (231) 941-2240
www.GLEC.com

Section I

Submitting Company: K&A
Report Results To: Natalie Howard
Address: Black Lake 10K
Phone: 269-344-7017
E-mail: nhoward@kieser-associates.com

Section II

Project Name:
Project Number:
P.O.#:
Sampled by: (initials) ☐GLEC _____ ☐Client _____

Section III: Sample Information at Collection

#	GLEC No.	Sample Identification	Depth	Date	Time	Grab or Composite	Preservative	Filtered Y or N	Sample Containers Type	Size	No.	Section IV: Requested Analysis SRP	NO_3/NO_2
1		SS3-upgradient	GW	5-14-24	2:04	Composite	NO_3/NO_2 H_2SO_4	SRP Y	Glass	125mL	2	X	X
2		SS3-midgradient	GW	5-14-24	2:18	"	"	Y	"	"	2	X	X
3		SS3-downgradient	GW	5-14-24	2:35	"	"	Y	"	"	2	X	X
4													
5													
6													
7													
8													
9													
10													

pH of Sample Upon Receipt

Matrix Codes: S = Sediment SW = Surface Water GW = Groundwater E = Effluent AO = Aquatic Organism SL = Sludge

Client Notes: Report these septic system samples separate from other results

Released By	Date	Time	Received By	Date	Time
Name & Organization (print): Mark S. Kieser K&A	5-15-24	10:05	Name & Organization (print):		
Signature: Mark S. Kieser			Signature: BL	5-15-24	10:05
Name & Organization (print):			Name & Organization (print):		
Signature:			Signature:		

FOR LAB USE ONLY

Temperature of Samples: 4.3 °C Initials: CTG Bottle ID #, if applicable: 30724 BlackLake-Stacy ☒ Received on Wet Ice

Notes/Anomalies/Discrepancies:

Great Lakes Environmental Center

Project Number: 2592-B15

October 15, 2024

Kieser & Associates-Black Lake WQ
536 E. Michigan Ave., Suite 300
Kalamazoo, MI 49007

Attention: Natalie Howard

Project Description: Water Quality Sampling

Dear Client,

Enclosed is a copy of your laboratory report relating to samples, as they were received. All tests have met or exceeded QC criteria. Sediment Fe was analyzed by ALS Labs. Test results are in compliance with The NELAC Institute Standards. Visit our web site for a full list of tests for which GLEC (Lab 2059) is accredited through the New Hampshire Environmental Laboratory Accreditation Program (NH ELAP).

Please don't hesitate to call if you have questions or require further information.

Data Qualifiers:

U = Analyte not detected
J = Estimated result below the RL but above the MDL

Sincerely,

Michelle A. Moore
Laboratory Coordinator and Research Scientist/Nutrient Chemistry

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Soluble Reactive Phosphorus

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K09280104	S-3 up	9/28/2024	0.0005	mg/L	0.001	0.00015	J	10/3/2024		BSC
9K09280105	S-3 mid	9/28/2024	0.0007	mg/L	0.001	0.00015	J	10/3/2024		BSC
9K09280106	S-3 down	9/28/2024	0.0010	mg/L	0.001	0.00015		10/3/2024		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 4500-P F

Tuesday, October 15, 2024

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Nitrate/Nitrite-Nitrogen

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifie	AnalysisDate	Comments	Initials
9K09280104	S-3 up	9/28/2024	<0.00312	mg/L	0.005	0.00312	U	10/9/2024		BSC
9K09280105	S-3 mid	9/28/2024	0.0052	mg/L	0.005	0.00312		10/9/2024		BSC
9K09280106	S-3 down	9/28/2024	<0.00312	mg/L	0.005	0.00312	U	10/9/2024		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 4500-NO3(F)-N

Tuesday, October 15, 2024

GLEC
Great Lakes Environmental Center

GREAT LAKES ENVIRONMENTAL CENTER, INC.

CHAIN OF CUSTODY RECORD

Traverse City, MI - Laboratory
739 Hastings Street
Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: Kieser & Associates
Report Results To: Natalie Howard
Address: 536 E. Michigan Ave., Ste 300
Phone: 269-344-7117 E-mail: nhoward@kieser-associates.com

Section II.

Project Name: Black Lake
Project Number:
P.O.#:
Sampled by: (initials) ☐ GLEC ____ ☒ Client KA/MK

Section III. Sample Information at Collection

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.
1		S-3 up	9-28-24	10:50	GW	G	H_2SO_4	Y for NO_3+NO_2	Glass	150	1
2		S-3 mid	"	11:10	"	"		Y for RP	"	"	1
3		S-3 down	"	11:20	"	"		No-NO_3	"	"	2
4											2
5											
6											
7											
8											

Section IV. Requested Analysis

NO_3+NO_2	RP								pH of Sample Upon Receipt
✓	✓								22
✓	✓								22
✓	✓								22

Client Notes:

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Mark Kieser KiA	9-30-24		Print Name & Organization		
Signature: MKieser			Signature: [illegible]	9-31-24	10:30
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: 1.2 °C Initials: [illegible] Bottle ID #, if applicable Lake Is-TSJ ☒ Received on Wet Ice
Notes/Anomalies/Discrepancies:
GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; SW = SURFACE WATER; E = EFFLUENT; GW = GROUNDWATER; SL = SLUDGE; AO = AQUATIC ORGANISM

Great Lakes Environmental Center

Project Number: 2592-B15

January 8, 2025

Kieser & Associates-Black Lake WQ
536 E. Michigan Ave., Suite 300
Kalamazoo, MI 49007

Attention: Mark Kieser

Project Description: Water Quality Sampling

Dear Client,

Enclosed is a copy of your laboratory report relating to samples, as they were received. All tests have met or exceeded QC criteria. Test results are in compliance with The NELAC Institute Standards. Visit our web site for a full list of tests for which GLEC (Lab 2059) is accredited through the New Hampshire Environmental Laboratory Accreditation Program (NH ELAP).

Please don't hesitate to call if you have questions or require further information.

Sincerely,

Michelle A. Moore
Laboratory Coordinator and Research Scientist/Nutrient Chemistry

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Total Phosphorus

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifier	AnalysisDate	Comments	Initials
9K12080109	S3-up	12/8/2024	0.333	mg/L	0.03	0.014		12/11/2024		BSC
9K12080110	S3-mid	12/8/2024	0.0199	mg/L	0.003	0.0014		12/11/2024		BSC
9K12080111	S3-down	12/8/2024	0.501	mg/L	0.03	0.014		12/11/2024		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 4500-P F

Wednesday, January 08, 2025

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Soluble Reactive Phosphorus

LabSampleID	SampleDescription	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifier	AnalysisDate	Comments	Initials
9K12080109	S3-up	12/8/2024	0.245	mg/L	0.02	0.003		12/11/2024		BSC
9K12080110	S3-mid	12/8/2024	0.0132	mg/L	0.001	0.00015		12/11/2024		BSC
9K12080111	S3-down	12/8/2024	0.499	mg/L	0.05	0.0075		12/11/2024		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 4500-P F

GLEC
Great Lakes Environmental Center

GREAT LAKES ENVIRONMENTAL CENTER, INC.

CHAIN OF CUSTODY RECORD

Traverse City, MI - Laboratory
739 Hastings Street
Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: Kieser & Associates
Report Results To: M. Kieser
Address: 834 E. Michigan Ave, Kalamazoo
Phone: 269-344-7117 E-mail:

Section II.

Project Name: Black Lake
Project Number:
P.O.#:
Sampled by: (initials)
☐ GLEC _____ ☐ Client _____

Section III. Sample Information at Collection

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.
1		S3 - up	12-8-24	12:42	GW	grab	TP-HCl	SRP	Glass	250	2
2		S3 - mid	"	13:05	"	"	"	"	"	"	1
3		S3 - down	"	13:27	"	"	"	"	"	"	"
4											
5											
6											
7											
8											

Section IV. Requested Analysis

#	Tot P	SRP							pH of Sample Upon Receipt
1	X	X							LL
2	X	X							LL
3	X	X							LL
4									
5									
6									
7									
8									

Client Notes:

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Mark Kieser K&A	12-9-24	9:40	Print Name & Organization		
Signature: Mark K			Signature	12-9-24	9:40
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: 2.1 °C Initials: [illegible] Bottle ID #, if applicable 11989 Waters ☑ Received on Wet Ice
Notes/Anomalies/Discrepancies:
GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; SW = SURFACE WATER; E = EFFLUENT; GW = GROUNDWATER; SL = SLUDGE; AO = AQUATIC ORGANISM

Great Lakes Environmental Center

Project Number: 2592-B15

May 9, 2025

Kieser & Associates-Black Lake WQ
536 E. Michigan Ave., Suite 300
Kalamazoo, MI 49007

Attention: Natalie Crum

Project Description: Water Quality Sampling

Dear Client,

Enclosed is a copy of your laboratory report relating to samples, as they were received. All tests have met or exceeded QC criteria. Test results are in compliance with The NELAC Institute Standards. Visit our web site for a full list of tests for which GLEC (Lab 2059) is accredited through the New Hampshire Environmental Laboratory Accreditation Program (NH ELAP).

Please don't hesitate to call if you have questions or require further information.

Data Qualifiers:

J = Estimated result below the RL but above the MDL
U = Analyte not detected

Sincerely,

Michelle A. Moore
Laboratory Coordinator and Research Scientist/Nutrient Chemistry

NELAP ACCREDITED TNI LABORATORY

Great Lakes Environmental Center, Inc.
739 Hastings St., Traverse City, MI 49686
Phone: 231-941-2230; Fax: 231-941-2240; www.glec.com

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Soluble Reactive Phosphorus

Lab ID	Sample Description	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifier	Analysis Date	Comments	Initials
9K050200014	Black Lake-S3-down	5/2/2025	0.0010	mg/L	0.001	0.00047		5/8/2025		BSC
9K050200013	Black Lake-S3-mid	5/2/2025	0.0009	mg/L	0.001	0.00047	J	5/8/2025		BSC
9K050200012	Black Lake-S3-up	5/2/2025	0.0008	mg/L	0.001	0.00047	J	5/8/2025		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Friday, May 09, 2025

Method: SM 4500-P F

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Nitrate/Nitrite-Nitrogen

Lab ID	Sample Description	Sample Date	Result	Units	Rep Limit	MDL	Lab Qualifier	Analysis Date	Comments	Initials
9K050200017	Black Lake-S3-down	5/2/2025	<0.0022	mg/L	0.005	0.0022	U	5/9/2025		BSC
9K050200016	Black Lake-S3-mid	5/2/2025	<0.0022	mg/L	0.005	0.0022	U	5/9/2025		BSC
9K050200015	Black Lake-S3-up	5/2/2025	<0.0022	mg/L	0.005	0.0022	U	5/9/2025		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Friday, May 09, 2025

Method: SM 4500-NO3(F)-N

CHAIN OF CUSTODY RECORD

GLEC
Great Lakes Environmental Center, Inc.
739 Hastings Street
Traverse City, Michigan 49686

Phone (231) 941-2230
Fax (231) 941-2240
www.GLEC.com

Section I

Submitting Company	Kieser & Associates
Report Results To	data@kieser-associates.com
Address	536 E. Michigan Ave., Kalamazoo, MI
Phone	269-344-7117
E-mail	

Section II

Project Name	Black Lake
Project Number	
P.O.#	
Sampled by: (initials)	☐ GLEC ____ ☒ Client MSK

Section III: Sample Information at Collection

#	GLEC No.	Sample Identification	Date (start-end)	Time (start-end)	Matrix Code	Grab or Composite	Preservative	Filtered (Y or N)	Sample Containers: Type	Size	No.	Section IV: Requested Analysis: FHM Chronic	C. dubia Chronic	FHM 96-hr acute	C. dubia 48-hr acute	D. magna 48-hr acute	SRP	NO_3-NO_2	pH of Sample Upon Receipt
	Example:	**Final Effluent**	**1/30-31/2023**	**0800-0800**	**WW**	**C**	**none**	**N**	**cube**	**4L**	**2**	×	×						
1	34074/32476	Black Lake-S3-up	5-2-25	1:41	SW	G	HNO_3 H_2SO_4	SRP	2 6log	250							4	4	✓
2	34078/32494	" " -S3-mid	"	2:00	SW	G	"	SRP	2 "	250							4	4	✓
3	34162/32477	" " -S3-down	"	2:16	SW	G	"	SRP	2 "	250							4	4	✓
4																			
5																			
6																			
7																			
8																			
9																			
10																			

Matrix Codes S = Sediment SW = Surface Water GW = Groundwater E = Effluent AO = Aquatic Organism SL = Sludge

Client Notes

Released By	Date	Time	Received By	Date	Time
Name & Organization (print) Mark S. Kieser, K&A			Name & Organization (print) Michelle Moore		
Signature Mark S. Kieser	5-2-25	16:30	Signature Michelle Moore	5-2-25	16:30
Name & Organization (print)			Name & Organization (print)		
Signature			Signature		

Temperature of Samples: 8 °C Initials: MM Bottle ID #, if applicable: 34078

☐ Received on Wet Ice

Notes/Anomalies/Discrepancies:

Great Lakes Environmental Center

Project Number: 2592-B15

October 6, 2025

Kieser & Associates-Black Lake WQ
536 E. Michigan Ave., Suite 300
Kalamazoo, MI 49007
Attention: Mark Kieser

Project Description: Water Quality Sampling

Dear Client,

Enclosed is a copy of your laboratory report relating to samples, as they were received. All tests have met or exceeded QC criteria. Test results are in compliance with The NELAC Institute Standards. Visit our web site for a full list of tests for which GLEC (Lab 2059) is accredited through the New Hampshire Environmental Laboratory Accreditation Program (NH ELAP).

Please don't hesitate to call if you have questions or require further information.

Sincerely,

Michelle A. Moore
Laboratory Coordinator and Research Scientist/Nutrient Chemistry

Great Lakes Environmental Center, Inc.
739 Hastings St., Traverse City, MI 49686
Phone: 231-941-2230; Fax: 231-941-2240; www.glec.com

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Soluble Reactive Phosphorus

Lab ID	Sample Description	Sample Date	Result	Units	Rep Limit	MDL	Qualifier	Analysis Date	Comments	Initials
9K092600022	S-1 UP	9/26/2025	0.383	mg/L	0.05	0.0235		10/6/2025		BSC
9K092600023	S-2 MID	9/26/2025	0.027	mg/L	0.008	0.00376		10/6/2025		BSC
9K092600024	S-3 DOWN	9/26/2025	0.201	mg/L	0.02	0.0094		10/6/2025		BSC
9K092600025	TM-S4	9/26/2025	0.170	mg/L	0.02	0.0094		10/6/2025		BSC
9K092600026	TM-S4	9/26/2025	0.179	mg/L	0.02	0.0094		10/6/2025		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 4500-P F

Monday, October 06, 2025

GLEC
Great Lakes Environmental Center

GREAT LAKES ENVIRONMENTAL CENTER, INC.

CHAIN OF CUSTODY RECORD

Traverse City, MI - Laboratory
739 Hastings Street
Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: Kieser & Associates
Report Results To: Mark Kieser
Address: 536 E. Michigan Ave, Ste 300, Kalamazoo
Phone: 269-344-7117 E-mail: mkieser@kieser-associates.com

Section II.

Project Name: Black Lake
Project Number:
P.O.#:
Sampled by: (initials) ☐ GLEC _____ ☑ Client MSK

Section III. **Sample Information at Collection**

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.
1		S-1 up	9-26-25	10:50	water	grab	None	Y	Plastic	125	1
2		S-2 mid	"	11:19	"	"	"	Y	"	"	"
3		S-3 down	"	11:41	"	"	"	Y	"	"	"
4		TM-54	"	11:52	"	"	"	Y	"	"	"
5		TM-54	"	12:01	"	"	"	Y	"	"	"
6											
7											
8											

Section IV. Requested Analysis

4									pH of Sample Upon Receipt
SR									
✓									
✓									
✓									
✓									
✓									

Client Notes: Samples received frozen

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Mark S. Kieser, K&A	5-26-25	15:00	Print Name & Organization		
Signature: Mark Kieser			Signature: Bam	9-26-25	15:00
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: _____ °C Initials: _____ Bottle ID #, if applicable _____ ☐ Received on Wet Ice

Notes/Anomalies/Discrepancies: _____

GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; SW = SURFACE WATER; E = EFFLUENT; GW = GROUNDWATER; SL = SLUDGE; AO = AQUATIC ORGANISM

ATTACHMENT A

October 2025 Temporary Groundwater Monitoring Laboratory Reports

Great Lakes Environmental Center

Project Number: 2592-B15

October 20, 2025

Kieser & Associates-Black Lake WQ
536 E. Michigan Ave., Suite 300
Kalamazoo, MI 49007
Attention: Natalie Crum

Project Description: Water Quality Sampling

Dear Client,

Enclosed is a copy of your laboratory report relating to samples, as they were received. All tests have met or exceeded QC criteria. Test results are in compliance with The NELAC Institute Standards. Visit our web site for a full list of tests for which GLEC (Lab 2059) is accredited through the New Hampshire Environmental Laboratory Accreditation Program (NH ELAP).

Please don't hesitate to call if you have questions or require further information.

Sincerely,

Michelle A. Moore
Laboratory Coordinator and Research Scientist/Nutrient Chemistry

Great Lakes Environmental Center, Inc.
739 Hastings St., Traverse City, MI 49686
Phone: 231-941-2230; Fax: 231-941-2240; www.glec.com

Great Lakes Environmental Center

739 Hastings St., Traverse City MI 49686 - (231) 941-2230 - FAX: (231) 941-2240

Client ID:

Kieser-Black Lake WQ

REPORT OF ANALYSIS

Soluble Reactive Phosphorus

Lab ID	Sample Description	Sample Date	Result	Units	Rep Limit	MDL	Qualifier	Analysis Date	Comments	Initials
9K101400027	VS-1 A	10/14/2025	0.0101	mg/L	0.001	0.00047		10/17/2025		BSC
9K101400028	VS-1 B	10/14/2025	0.030	mg/L	0.004	0.00188		10/17/2025		BSC
9K101400029	VS-1 C	10/14/2025	0.0146	mg/L	0.002	0.00094		10/17/2025		BSC
9K101400030	VS-2 A	10/14/2025	0.025	mg/L	0.004	0.00188		10/17/2025		BSC
9K101400031	VS-2 B	10/14/2025	0.0174	mg/L	0.002	0.00094		10/17/2025		BSC
9K101400032	VS-2 C	10/14/2025	0.027	mg/L	0.004	0.00188		10/17/2025		BSC
9K101400033	VS-3 A	10/14/2025	0.0151	mg/L	0.002	0.00094		10/17/2025		BSC
9K101400034	VS-3 C	10/14/2025	0.091	mg/L	0.01	0.0047		10/17/2025		BSC
9K101400035	VS-4 A	10/14/2025	0.0077	mg/L	0.001	0.00047		10/17/2025		BSC
9K101400036	VS-4 B	10/14/2025	0.030	mg/L	0.004	0.00188		10/17/2025		BSC
9K101400037	VS-4 C	10/14/2025	0.0125	mg/L	0.001	0.00047		10/17/2025		BSC
9K101400038	VS-4 D	10/14/2025	0.0080	mg/L	0.001	0.00047		10/17/2025		BSC
9K101400039	VS-5 A	10/14/2025	0.0082	mg/L	0.001	0.00047		10/17/2025		BSC
9K101400040	VS-5 B	10/14/2025	0.031	mg/L	0.004	0.00188		10/17/2025		BSC
9K101400041	VS-5 C	10/14/2025	0.068	mg/L	0.01	0.0047		10/17/2025		BSC
9K101400042	VS-5 D	10/14/2025	0.076	mg/L	0.01	0.0047		10/17/2025		BSC
9K101400043	VS-5 E	10/14/2025	0.051	mg/L	0.01	0.0047		10/17/2025		BSC
9K101400044	VS-6 A	10/14/2025	0.0042	mg/L	0.001	0.00047		10/17/2025		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Monday, October 20, 2025

Method: SM 4500-P F

Lab ID	Sample Description	Sample Date	Result	Units	Rep Limit	MDL	Qualifier	Analysis Date	Comments	Initials
9K101400045	VS-6 B	10/14/2025	0.0131	mg/L	0.001	0.00047		10/17/2025		BSC
9K101400046	VS-6 C	10/14/2025	0.0127	mg/L	0.001	0.00047		10/17/2025		BSC
9K101400047	VS-6 D	10/14/2025	0.0020	mg/L	0.001	0.00047		10/17/2025		BSC
9K101400048	VS-7 A	10/14/2025	0.0076	mg/L	0.001	0.00047		10/17/2025		BSC
9K101400049	VS-7 B	10/14/2025	0.0045	mg/L	0.001	0.00047		10/17/2025		BSC
9K101400050	VS-7 C	10/14/2025	0.0076	mg/L	0.001	0.00047		10/17/2025		BSC
9K101500051	VS-8 A	10/15/2025	0.0085	mg/L	0.001	0.00047		10/17/2025		BSC
9K101500052	VS-8 B	10/15/2025	0.0091	mg/L	0.001	0.00047		10/17/2025		BSC
9K101500053	VS-8 C	10/15/2025	0.0203	mg/L	0.002	0.00094		10/17/2025		BSC
9K101500054	VS-8 D	10/15/2025	0.0131	mg/L	0.001	0.00047		10/17/2025		BSC
9K101500055	VS-9 A	10/15/2025	0.0125	mg/L	0.001	0.00047		10/17/2025		BSC
9K101500056	VS-9 B	10/15/2025	0.0094	mg/L	0.001	0.00047		10/17/2025		BSC
9K101500057	VS-9 C	10/15/2025	0.0100	mg/L	0.001	0.00047		10/17/2025		BSC
9K101500058	VS-9 D	10/15/2025	0.0086	mg/L	0.001	0.00047		10/17/2025		BSC
9K101500059	VS-9 E	10/15/2025	0.154	mg/L	0.02	0.0094		10/17/2025		BSC
9K101500060	VS-10 A	10/15/2025	0.0097	mg/L	0.001	0.00047		10/17/2025		BSC
9K101500061	VS-10 B	10/15/2025	0.0052	mg/L	0.001	0.00047		10/17/2025		BSC
9K101500062	VS-10 C	10/15/2025	0.0078	mg/L	0.001	0.00047		10/17/2025		BSC
9K101500063	VS-10 D	10/15/2025	0.0126	mg/L	0.001	0.00047		10/17/2025		BSC
9K101500064	VS-10 E	10/15/2025	0.0079	mg/L	0.001	0.00047		10/17/2025		BSC
9K101500065	VS-10 F	10/15/2025	0.0088	mg/L	0.001	0.00047		10/20/2025		BSC
9K101500066	Doriva Creek	10/15/2025	0.0108	mg/L	0.001	0.00047		10/20/2025		BSC
9K101500067	VS-11 A	10/15/2025	0.081	mg/L	0.01	0.0047		10/20/2025		BSC
9K101500068	VS-11 B	10/15/2025	0.041	mg/L	0.004	0.00188		10/20/2025		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 4500-P F

Lab ID	Sample Description	Sample Date	Result	Units	Rep Limit	MDL	Qualifier	Analysis Date	Comments	Initials
9K101500069	VS-11 C	10/15/2025	0.043	mg/L	0.004	0.00188		10/20/2025		BSC
9K101500070	VS-11 D	10/15/2025	0.0132	mg/L	0.001	0.00047		10/20/2025		BSC
9K101500071	VS-11 E	10/15/2025	0.0127	mg/L	0.001	0.00047		10/20/2025		BSC
9K101500072	Stoney Creek	10/15/2025	0.0069	mg/L	0.001	0.00047		10/20/2025		BSC

LabQualifiers:

U - Analyte not detected.

J - Result between MDL and RL should be considered estimated.

Method: SM 4500-P F

GLEC
Great Lakes Environmental Center

GREAT LAKES ENVIRONMENTAL CENTER, INC.

CHAIN OF CUSTODY RECORD

Traverse City, MI - Laboratory
739 Hastings Street
Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: Kieser & Associates, LLC
Report Results To: Natalie Crum
Address: 536 E Michigan Ave, Kalamazoo, MI
Phone: (269) 344-7117 E-mail: data@kieser-associates.com

Section II.

Project Name: Black Lake
Project Number:
P.O.#:
Sampled by: (initials)
☐ GLEC _____ ☒ Client NC + MA + MK

Section III. Sample Information at Collection

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.	Requested Analysis: SRP	pH of Sample Upon Receipt
1		VS-1 A	10/14/25	8:15	GW	Grab	N	Y	Plast.C	125 mL	1	X	
2		VS-1 B		8:40									
3		VS-1 C		8:55									
4		VS-2 A		9:40									
5		VS-2 B		10:20									
6		VS-2 C		10:15									
7		VS-3A		3:00									
8		VS-3C		3:15									

Client Notes:

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Mark S. Kieser K&A	10-16-25	10:50	Print Name & Organization		
Signature: Mark S. Kieser			Signature: Bark	10-16-25	10:50
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: _____ °C Initials: _____ Bottle ID #, if applicable _____ ☒ Received on Wet Ice

Frozen

Notes/Anomalies/Discrepancies: _____

GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; E = EFFLUENT; SL = SLUDGE; SW = SURFACE WATER; GW = GROUNDWATER; AO = AQUATIC ORGANISM

GLEC
Great Lakes Environmental Center

GREAT LAKES ENVIRONMENTAL CENTER, INC.

CHAIN OF CUSTODY RECORD

Traverse City, MI - Laboratory
739 Hastings Street
Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: Kieser & Associates LLC
Report Results To: Natalie Crum
Address: 536 E Michigan Ave Kalamazoo, MI 49007
Phone: (269) 344-7117 E-mail: data@kieser-associates.com

Section II.

Project Name: Black Lake
Project Number:
P.O.#:
Sampled by: (initials) ☐ GLEC _____ ☒ Client NC+MA+MK

Section III. Sample Information at Collection

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.	SRP
1		VS-4 A	10/14/25	11:25	GW	Grab	N	Y	Plastic	125 mL	1	X
2		VS-4 B	↓	11:20	↓	↓	↓	↓	↓	↓	↓	↓
3		VS-4 C		11:39								
4		VS-4 D		11:51								
5		VS-5 A		12:55								
6		VS-5 B		12:50								
7		VS-5 C		12:58								
8		VS-5 D	↓	1:07	↓	↓	↓	↓	↓	↓	↓	↓

Section IV. Requested Analysis

pH of Sample Upon Receipt

Client Notes:

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Mark S. Kieser IS/A	10-16-25	10:50	Print Name & Organization		
Signature: Mark S. K.			Signature	10-16-25	10:54
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: _____ °C Initials: _____ Bottle ID #, if applicable _____ ☒ Received on Wet Ice Frozen

Notes/Anomalies/Discrepancies: _____

GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; SW = SURFACE WATER; E = EFFLUENT; GW = GROUNDWATER; SL = SLUDGE; AO = AQUATIC ORGANISM

GLEC
Great Lakes Environmental Center

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CHAIN OF CUSTODY RECORD

Traverse City, MI - Laboratory
739 Hastings Street
Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: Kieser & Associates LLC
Report Results To: Natalie Crum
Address: 536 E Michigan Ave Kalamazoo MI, 49007
Phone: (269)344-7112 E-mail: datw@kieserassociates.com

Section II.

Project Name: Black Lake
Project Number:
P.O.#:
Sampled by: (initials)
☐ GLEC _____ ☒ Client NK + MA + MK

Section III. Sample Information at Collection

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.
1		VS-5 E	10/14/25	1:15	GW	Grab	N	Y	Plastic	125mL	1
2		VS-6 A		4:55							
3		VS-6 B		4:57							
4		VS-6 C		5:23							
5		VS-6 D		5:20							
6		VS-7 A		6:58							
7		VS-~~B~~ B		6:40							
8		VS-7 C	↓	6:22	↓	↓	↓	↓	↓	↓	↓

Section IV. Requested Analysis

SRP									pH of Sample Upon Receipt
X									
↓									

Client Notes:

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization:			Print Name & Organization		
Signature			Signature [signature]	10/16/25	10:50
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: _____ °C Initials: _____ Bottle ID #, if applicable _____ ☒ Received on Wet Ice

Frozen

Notes/Anomalies/Discrepancies: _____

GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; SW = SURFACE WATER; E = EFFLUENT; GW = GROUNDWATER; SL = SLUDGE; AO = AQUATIC ORGANISM

GLEC
Great Lakes Environmental Center

GREAT LAKES ENVIRONMENTAL CENTER, INC.

CHAIN OF CUSTODY RECORD

Traverse City, MI - Laboratory
739 Hastings Street
Traverse City, MI 49686

www.glec.com
Phone (231)941-2230
Fax (231)941-2240

Section I.

Submitting Company: Kieser & Associates LLC
Report Results To: Natalie Crum
Address: 536 E Michigan Ave Kalamazoo MI, 49007
Phone: (269) 344-7112 E-mail: data@kieser-associates.com

Section II.

Project Name: Black Lake
Project Number:
P.O.#:
Sampled by: (initials) ☐ GLEC _____ ☒ Client NC + MA + MK

Section III. Sample Information at Collection

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.
1		VS-8A	10/15/25	8:50	GW	Grab	N	Y	Plastic	125 mL	1
2		VS-8B		8:25							
3		VS-8C		8:20							
4		VS-8D		8:40							
5		VS-9A		10:37							
6		VS-9B		10:25							
7		VS-9C		10:12							
8		VS-9D		10:15							

Section IV. Requested Analysis

SRP									pH of Sample Upon Receipt
X									

Client Notes:

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Mark S. Kieser K&A	10-16-25	10:50	Print Name & Organization		
Signature: Mark S. Kieser			Signature: Bob	10-16-25	10:50
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: _____ °C Initials: _____ Bottle ID #, if applicable _____ ☒ Received on Wet Ice

Frozen

Notes/Anomalies/Discrepancies: _____

GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; E = EFFLUENT; SL = SLUDGE; SW = SURFACE WATER; GW = GROUNDWATER; AO = AQUATIC ORGANISM

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739 Hastings Street
Traverse City, MI 49686

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Section I.

Submitting Company: Kieser & Associates, LLC
Report Results To: Natalie Crum
Address: 536 E. Michigan Ave. 49007
Phone: 269-344-7117 E-mail:

Section II.

Project Name: Black Lake
Project Number:
P.O.#:
Sampled by: (initials) ☐ GLEC _____ ☒ Client NC | MK | MA

Section III. Sample Information at Collection

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.
1		VS-9 E	10-15-25	8:35	GW	grab	N	Y	Plastic	125	1
2		VS-10 A		10:40							
3		VS-10 B		12:00							
4		VS-10 C		12:20							
5		VS-10 D		12:10							
6		VS-10 E		12:45							
7		VS-10 F		12:50							
8		Doriva Creek		4:30							

Section IV. Requested Analysis

5RP									pH of Sample Upon Receipt
✓									
✓									
✓									
✓									
✓									
✓									
✓									
✓									

Client Notes:

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Mark S. Kieser K&A	10-16-25	10:50	Print Name & Organization		
Signature: Mark D. K			Signature:	10/16/25	10:50
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: _____ °C Initials: _____ Bottle ID #, if applicable _____ ☒ Received on Wet Ice

Frozen

Notes/Anomalies/Discrepancies: _____

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Section I.

Submitting Company: Kieser Associates, LLC
Report Results To: Natalie Crum
Address: 536 E. Michigan Ave, Kalamazoo
Phone: 269-344-7117 E-mail:

Section II.

Project Name:
Project Number:
P.O.#:
Sampled by: (initials)
☐ GLEC _____ ☐ Client _____

Section III. Sample Information at Collection

#	GLEC No.	Sample Identification	Sample Information: Date	Time	Matrix	Grab or Composite	Preservative	Filtered Y or N	Sample Containers: Type	Size	No.
1		VS-11 A	10-15-25	2:25	GW	Grab	N	Y	Plast	125	1
2		VS-11 B	"	2:35	"	"	"	"	"	"	"
3		VS-11 C	"	2:50	"	"	"	"	"	"	"
4		VS-11 D	"	3:17	"	"	"	"	"	"	"
5		VS-11 E	"	2:55	"	"	"	"	"	"	"
6		Stoney Creek	10-15-25	8:35	"	"	"	"	"	"	"
7											
8											

Section IV. Requested Analysis

pH of Sample Upon Receipt									
X									
X									
X									
X									
X									
X									

Client Notes:

RELEASED BY / ORGANIZATION	DATE	TIME	RECEIVED BY / ORGANIZATION	DATE	TIME
Print Name & Organization: Mark S. Kieser KA	10-16-25	10:50	Print Name & Organization		
Signature: Mark S. K			Signature	10-16-25	10:51
Print Name & Organization			Print Name & Organization		
Signature			Signature		

FOR LAB USE ONLY

Temperature of Samples: _____ °C Initials: _____ Bottle ID #, if applicable _____ ☒ Received on Wet Ice

Notes/Anomalies/Discrepancies: Frozen

GLEC may subcontract out analyses that we do not perform.

MATRIX CODES: S = SEDIMENT; SW = SURFACE WATER; E = EFFLUENT; GW = GROUNDWATER; SL = SLUDGE; AO = AQUATIC ORGANISM

ATTACHMENT B

K&A Preliminary Black Lake Mass Balance Memorandum

KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING

Technical Memorandum

To:	Rusty Gowland, President Black Lake Preservation Society	**Date:**	July 7, 2023
From:	Mark Kieser, Senior Scientist Mike Foster, Environmental Engineer John Hart, Watershed Scientist Kieser & Associates, LLC	**cc:**	Beverly Haas, BLPS
RE:	Black Lake (Cheboygan County, MI) Preliminary Phosphorus Mass Balance		

Purpose

This technical memorandum provides an overview of methods, findings, and conclusions regarding a preliminary phosphorus mass balance analysis for Black Lake in Cheboygan County, Michigan. It has been prepared by Kieser & Associates, LLC (K&A) under contract with the Black Lake Preservation Society (BLPS). Phosphorus is a critical nutrient in freshwater environments that drives aquatic plant life and algal growth. This primary productivity, in turn, influences the health of a lake and its recreational and ecological quality. Excessive phosphorus contributions to a water body can result in eutrophication, formation of harmful algal blooms, and other water quality issues. Having an understanding of the phosphorus dynamics of an aquatic system provides management entities with the information they need to effectively mitigate potential water quality issues by targeting problematic, but manageable sources of this nutrient to their lake. This preliminary Black Lake Phosphorus Mass Balance is therefore intended to guide next step management considerations to protect water quality and address pressing challenges. Supporting technical details are provided in appendices to this memorandum.

K&A Approach

A phosphorus mass balance for a lake uses estimates of mass inputs and outputs of phosphorus to the system (see Figure 1). These inputs and outputs are typically estimated using data or modeling, and are typically expressed on an average annual basis as pounds of phosphorus per year (lbs P/yr). Phosphorus reaches the lake from a variety of potential input pathways including:

- Atmospheric deposition
- Direct stormwater runoff from lands adjacent to the lake
- Tributaries which receive: 1) non-point source diffuse (overland) runoff, and; 2) direct inputs from points sources such as wastewater treatment plants and/or urban stormwater outfalls
- Septic systems via shallow groundwater, and
- Lake sediments

Phosphorus can exit the system via the lake outlet or deposition to lake sediments. An explanation of each of these unique pathways is provided as follows. This includes how source loads were computed for the Black Lake phosphorus mass balance.

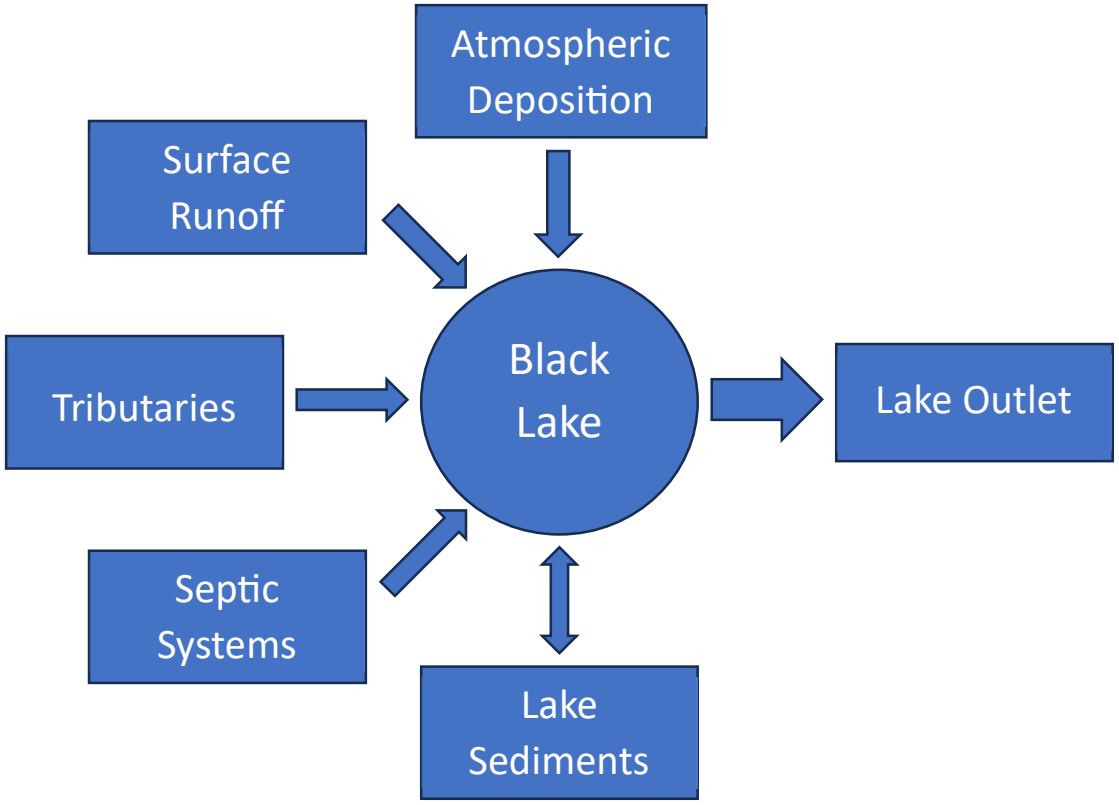


Figure 1 - Diagram of mass balance inputs and outputs.

Atmospheric Deposition: A small percentage of particulate phosphorus from terrestrial sources can become airborne by wind erosion before settling out elsewhere in the landscape. The mass of phosphorus that becomes airborne increases with the presence of industrial and agricultural activities, while in natural areas it can be minimal. Atmospheric deposition is typically given as a mass per area per a unit of time onto the lake surface. While this rate can vary throughout the year, measuring it can be burdensome and it is often modeled as a constant. Atmospheric phosphorus deposition rates for this Black Lake analysis were informed by appropriate scientific literature sources.[1, 2]

Surface Runoff: When precipitation impacts the ground, it can dislodge sediment as well as solubilize and in turn, mobilize compounds upon contact. If precipitation exceeds the ground's capacity to infiltrate water, it will flow overland, carrying dislodged sediment and dissolved compounds. This runoff can then enter Black Lake tributaries, or the lake from directly adjacent lands. For the purpose of this Black Lake mass balance, "surface runoff" includes only water estimated to directly flow to the lake from the surrounding shoreline; tributaries are covered as a separate input. Surface runoff phosphorus mass loading is a function of runoff volume and runoff phosphorus concentrations. For Black Lake, numbers

[1] Dolan, D. M., & S. C. Chapra. (2012). Great Lakes total phosphorus revisited: 1. Loading analysis and update (1994–2008). Journal of Great Lakes Research, 38(4), 730-740.
[2] Han, H., Bosch, N., & J. D. Allan. (2011). Spatial and temporal variation in phosphorus budgets for 24 watersheds in the Lake Erie and Lake Michigan basins. Biogeochemistry, 102, 45-58.

used for the runoff fraction (the fraction of precipitation that becomes runoff) and phosphorus concentration were informed by previous K&A[3] and Michigan regional runoff studies.[4]

Tributaries: Water enters tributaries via surface runoff and groundwater. Contributions can also come from "piped" discharges that may be associated with municipal and industrial discharges, or urban stormwater. Modeling these various inputs discretely for each tributary was not possible for this preliminary evaluation. Thus, total tributary phosphorus mass loading to Black Lake was calculated as a function of: 1) estimated flow volume, and; 2) phosphorus concentrations from previous studies.[5] This approach does not account for any "point source" contributions from piped discharges, which given the nature of the watershed, are likely to be miniscule or non-existent.

None of the Black Lake tributaries have active USGS gaging stations, and no flow measurements appear to have been collected during past tributary sampling events. Therefore, flows had to be extrapolated from data available in adjacent watersheds.[6] This was accomplished by calculating a flow to watershed area ratio and then applying it to Black Lake tributaries after their drainage areas were calculated using GIS software and watershed delineation techniques. These were backchecked with a deterministic watershed model (see Appendix A of this memorandum). A breakdown of watershed drainage areas and extrapolated mean flows for tributaries to Black Lake are shown in Table 1.

Table 1 - Black Lake watershed components with their sizes and calculated flows (where applicable)(cfs = cubic feet/second; n/a = not applicable).

Area	Size (mi^2)	Mean Flow (cfs)
Black Lake Watershed	**558.3**	**n/a**
Black Lake	15.9	n/a
Direct Drainage	27.2	n/a
Mud Creek	26.4	37
Black River	349.8	493
Fisher Creek	3.5	5
Stewart Creek	2.5	4
Stony Creek	9.3	13
Rainy River	109.2	154
Cold Creek	10.2	14
Unnamed East Drainage	1.5	2
Dorivo Beach Creek	1.5	2
Cains Creek	1.5	2

[3] Kieser & Associates. (2014). Arcadia Creek Water Quality Monitoring Project, DEQ #2012-0502. Prepared for Western Michigan University.
[4] Cave, K., Quasebarth, T., & E. Harold. (1994). Selection of Storm Water Pollutant Loading Factors. Rouge River National Wet Weather Demonstration Project Technical Memorandum RPO-MOD-TM34. 00. Detroit, Michigan.
[5] Tip of the Mitt Watershed Council. (2018). Black Lake Tributary Study: An assessment of six rivers and streams that supply Black Lake. Prepared for the Black Lake Preservation Society.
[6] U.S. Geological Survey. (2023). National Water Information System data available on the World Wide Web (USGS Water Data for the Nation), accessed [June 23, 2023], at URL [https://dashboard.waterdata.usgs.gov].

Groundwater and Septic Systems: Groundwater flow rates are typically very low compared to stream or river flows. Such groundwater flows as commonly measured in lateral speeds of feet per year. Since phosphorus concentrations in groundwater are also typically low, groundwater is generally not a large source of phosphorus. However, inland lakes often have shoreline residences that utilize septic systems which, when old or failing, can increase localized background phosphorus concentrations by a factor of 1000.

Septic system phosphorus loads to Black Lake were collectively estimated using an established empirical model[7] successfully applied to lakes in previous K&A septic system phosphorus loading studies.[8] (See Appendix B to this memorandum for a summary of K&A empirical computations for Black Lake septic system loads.)

Lake Sediments: The lake bottom can act as both a source and a sink for phosphorus. Particulate phosphorus can settle out of the water column, which makes lake sediments act as a phosphorus sink. Under anaerobic (low oxygen) or anoxic (no oxygen) conditions, soluble phosphorus in lake sediment can become mobilized and enter the water column making lake sediments act as a phosphorus source. The overall phosphorus contribution to or from the lake bottom is called the sediment phosphorus flux. This flux is difficult to measure directly, but can be estimated using sediment P data, bottom water P concentrations, and dissolved oxygen/temperature profiles throughout the water column. Such data for Black Lake, however, are not readily available, sparse or simply do not exist.

For this application, K&A coarsely estimated sediment phosphorus flux by calculating the difference between the lake outflows and the sum of other inputs.

Outlet: The lake outlet removes phosphorus from the system as water exits the lake. This mass is calculated as a function of outflow volume and lake phosphorus concentrations. For Black Lake, lake phosphorus concentration numbers were informed by available Black Lake water quality data.[9] Outflow volumes used data from past Alverno Dam outflow measurements[10] that were successfully backchecked using the watershed ratios described above for estimating Black Lake tributary inputs.

Findings

Total Phosphorus Inputs: Based on the K&A mass balance approach described above, the annual total phosphorus (TP) load to Black Lake was preliminarily calculated to be 12,891 pounds (i.e., 12,891 lbs TP/yr) (see Figure 2). The majority of this comes from tributaries which provide and estimated 10,913 lbs TP/yr, or 85% of the total load. The majority of the tributary load comes from the Black River (5,816 lbs TP/yr) and the Rainy River (3,630 lbs TP/yr), while all other tributaries provide a combined 1,466 lbs TP/yr. Atmospheric deposition (892 lbs TP/yr), septic systems (800 lbs/yr), and surface runoff from shoreline areas (286 lbs TP/yr) provide the remainder of the estimated annual phosphorus load.

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[7] Reckhow, K. H., Beaulac, M. N., & J. T. Simpson. (1980). Modeling phosphorus loading and lake response under uncertainty: A manual and compilation of export coefficients. USEPA 440/5-80-011. Washington, DC.
[8] See, for example: the 2011 Cedar Lake Watershed Management Plan at: https://cedarlakewmp.net/
[9] Tip of the Mitt Watershed Council. Volunteer Lake Monitoring Program, accessed [June 23, 2023], at URL [https://www.watershedcouncil.org/volunteer-lake-monitoring.html].
[10] Black Lake Association. Water Level and Dam Information, accessed [June 23, 2023], at URL [https://www.blacklakeassociation.com/resources/water-level-and-dam-information].

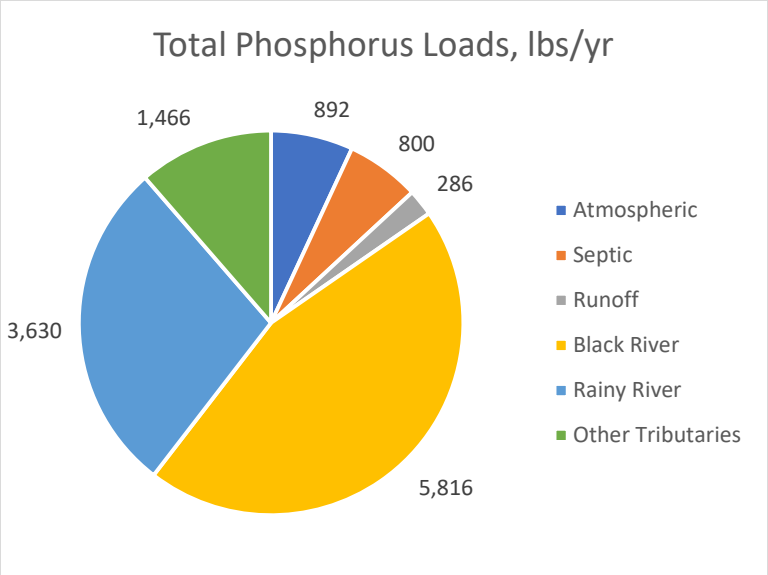


Figure 2 – Preliminary Black Lake annual Total Phosphorus (TP) estimated loads (lbs/yr) by source.

Phosphorus Mass Balance: The outflow load for Black Lake was calculated to be 8,997 lbs TP/yr. The net sediment flux can then be calculated as the difference between the estimated annual incoming load and annual outgoing load, yielding a negative flux of 3,893 pounds per year. This suggests that lake sediments accumulate particulate phosphorus that settles out of the water column. A buildup of phosphorus in the sediments could represent a potential source of soluble P release under low dissolved oxygen levels. This, followed by wind-mixing across the relatively shallow Black Lake, could result in bottom waters mixing with shallow surface waters. However, limited available data showing low concentrations in bottom waters in late summer do not necessarily support sediment P release as a potential source of phosphorus to surface waters.[11] The net phosphorus flux (or overall balance) of the incoming and outgoing loads, suggests lake sediments are likely acting as an annual sink (or repository) for 3,893 pounds of phosphorus. The overall annual mass balance components are illustrated in Figure 3.

[11] Tip of the Mitt Watershed Council, (circa 2020). Summary of Historic Black Lake Water Quality Data provided to K&A by BLPS.

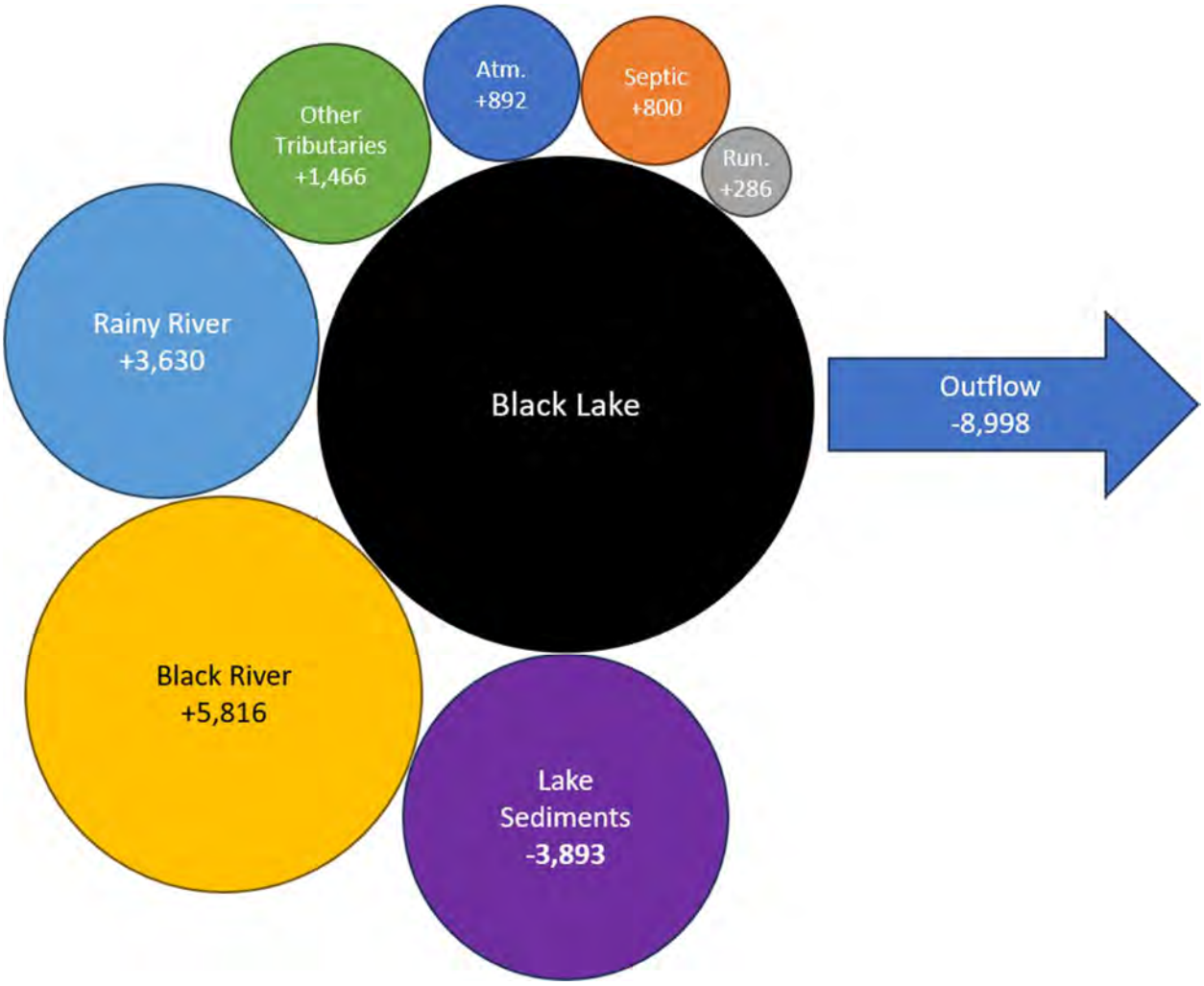


Figure 3 - Black Lake phosphorus mass balance illustration. Numbers given are in pounds per year. ('+' indicates an incoming load; '-' indicates an outgoing load. "Atm." stands for atmospheric deposition, while "Run." stands for runoff from shoreline areas.

Bioavailable Phosphorus: When measuring or discussing phosphorus, "total phosphorus" is often the analyte used as the comparative metric to discuss lake health. TP is relatively easy to measure in a lab, and easy to understand when talking about nutrient loading issues. In terms of actual ecosystem impacts, however, phosphorus loading can be the cause of a range of water quality impacts, and not a symptom. Excess nutrient loading can cause eutrophication, algal blooms, and disrupted ecology.

These issues commonly involve algae or plant growth, so it is crucial to consider that these organisms cannot utilize all the forms of phosphorus that are collectively represented by the "total phosphorus" analysis. Instead, plants and algae can only utilize what is considered "bioavailable phosphorus" (BAP). Aquatic macrophytes (plants) largely depend on BAP in sediments that is captured by root systems. Algae relay on BAP in the water column. Blue-green algae (which are actually primitive cyanophytic bacteria) also rely on BAP to grow. Dissolved phosphorus in septic system discharges, for instance, is nearly 100% bioavailable, while phosphorus attached to sediment in runoff or tributary contributions might only be 30% bioavailable, and then only over a longer timeframe. Analyzing phosphorus sources in terms of BAP

can provide a better picture of sources that may require more management attention to address related water quality issues.

BAP estimates for Black Lake were calculated using reported TP concentrations described previously and conversion factors as informed by scientific literature.[12] The estimated annual BAP load to Black Lake was therefore calculated to be 6,697 pounds (Figure 4). Of this load, most of the sources make up the fraction of the total similar to what they do for the TP load. Septic system loads are the notable exception, contributing 800 pounds per year of BAP. This is 12% of the BAP total, while septic system load only makes up 6% of the TP load.

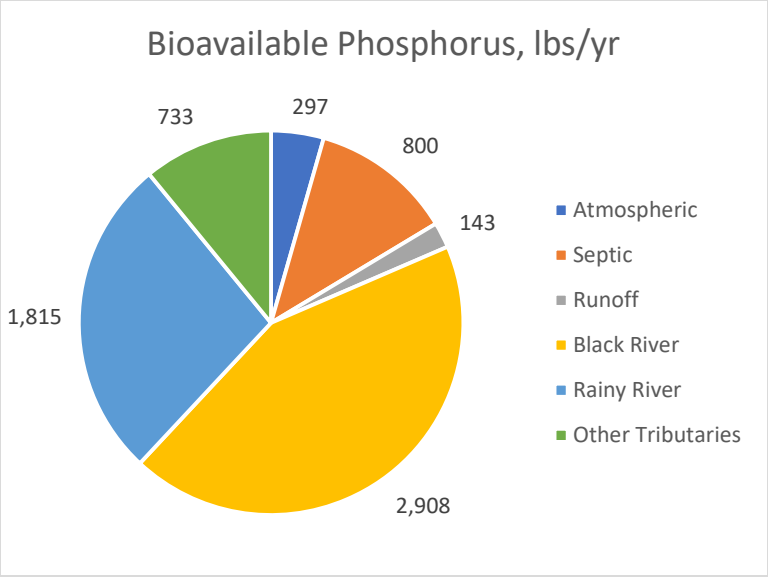


Figure 4 - Black Lake annual Bioavailable Phosphorus (BAP) load (lbs/yr) by source.

Discussion

Reported total phosphorus concentrations in Black Lake and its tributaries are low (5-15 µg/L)[11] considering other inland lakes in Michigan. The trophic state of the lake could be considered oligotrophic to borderline mesotrophic when examining chlorophyll and/or phosphorus concentrations. Conventional wisdom would suggest that harmful algal blooms (HAB) are rare in oligotrophic systems. However, HABs have been recorded on Black Lake in recent years (see Appendix C for a summary discussion), and recent studies[13] have suggested that HAB formation on oligotrophic lakes may be becoming more common.

HABs are comprised of cyanobacteria, which unlike green algae, are capable of producing toxins. While blooms of both green algae and blue-greens can be driven by the presence of excess phosphorus,

[12] Dijkstra, M. L., Auer, M. T., Kuczynski, A., & R. Lambert. (2020). Determination of bioavailable phosphorus in water samples using bioassay methods. MethodsX, 7, 100807.

[13] Reinl, K. L., Brookes, J. D., Carey, C. C., Harris, T. D., Ibelings, B., Morales-Williams, A. M., De Senerpont Domis, L.N., Atkins, K., S., Isles, P. D. F., Mesman, J. P., North, R. ,L., Rudstam, L. G., Stelzer, J. A. A., Venkiteswaran, J. J., Yokota, K. & Q. Zhan. (2021). Cyanobacterial blooms in oligotrophic lakes: Shifting the high-nutrient paradigm. Freshwater Biology, 66(9), 1846-1859.

cyanobacteria can outcompete green algae when iron and phosphorus are limited.[14, 15] Under anaerobic (low oxygen) conditions, cyanobacteria can also utilize ferrous iron released from lake sediments that is unavailable to green algae.

Research suggests that the types of nitrogen (nitrate, nitrite, ammonia, and urea) present and their ratio (nitrate & nitrite: ammonia & ammonium) may impact the type and abundance of cyanobacteria present in a particular lake, especially those that are capable of producing toxins.[16,17] Additionally, measurements of the dissolved portion of phosphorus (as soluble reactive phosphorus--SRP), combined with the soluble portion of nitrogen (primarily nitrate) can be important to determine the nutrient that may be responsible for driving HABs.[18] This information can also inform managers whether blooms are co-nutrient driven (nitrogen and phosphorus inputs combined).[19,20]

Available Black Lake water quality data limited to sampling results from every three years over the period of 1995-2019, reveal Total Nitrogen to Total Phosphorus (TN:TP) ratios of >20 suggesting that blooms may be limited by phosphorus. Research also suggests much higher ratios with abundant TN could potentially stimulate toxin production.[13] The highest reported Total Nitrogen levels in Black Lake were observed in 2019 across this time period with corresponding TN:TP ratios averaging 116. The lack of yearly monitoring data for TP and TN, as well as an entire absence of data for soluble forms of these nutrients, makes it difficult to discern trends in N:P ratios that might otherwise shed light on HABs that have become problematic in recent years.

HAB formation may be driven by pulses bioavailable phosphorus concentrations.[13] For mesotrophic and eutrophic lakes, mitigating HABs often involves limiting watershed phosphorus sources. As the K&A mass balance suggests, low tributary concentrations make phosphorus reductions across the large Black Lake watershed difficult. This relates to the challenge of broadly distributed watershed reduction efforts absent targeting of very discrete P sources. It is also possible that a portion of largest tributary phosphorus loading may be bypassing the lake due to the Black River's proximity to the lake outlet. Collectively, these conditions suggest that wide-scale watershed phosphorus loading reductions may

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[14]Sorichetti, R. J., Creed, I. F., & C. G. Trick. (2014). Evidence for iron-regulated cyanobacterial predominance in oligotrophic lakes. Freshwater biology, 59(4), 679-691.

[15] Molot, L. A., Watson, S. B., Creed, I. F., Trick, C. G., McCabe, S. K., Verschoor, M. J., ... & S. L. Schiff. (2014). A novel model for cyanobacteria bloom formation: the critical role of anoxia and ferrous iron. Freshwater Biology, 59(6), 1323-1340.

[16] Harris, T. D., Smith, V. H., Graham, J. L., Van de Waal, D. B., Tedesco, L. P., & N. Clercin. (2016). Combined effects of nitrogen to phosphorus and nitrate to ammonia ratios on cyanobacterial metabolite concentrations in eutrophic Midwestern USA reservoirs. Inland Waters, 6(2), 199–210. https://doi.org/10.5268/IW-6.2.938

[17] Wagner, N. D., Osburn, F. S., Wang, J., Taylor R. B., Boedecker, A. R., Chambliss, K., Brooks, B. W., & J. T. Scott. (2019). Biological Stoichiometry Regulates Toxin Production in *Microcystis aeruginosa* (UTEX 2385). Toxins 2019, 11, 601; doi:10.3390/toxins11100601.

[18] Guo, T., Johnson, L. T., LaBarge, G. A., Penn, C. J., Stumpf, R. P., Baker, D. B., & G. Shao. (2021). Less Agricultural Phosphorus Applied in 2019 Led to Less Dissolved Phosphorus Transported to Lake Erie. Environmental Science & Technology, 55(1), 283291.

[19] Paerl, H. W., Scott, J. T., McCarthy, M. J., Newell, S. E., Gardner, W. S., Havens, K. E., Hoffman, D. K., Wilhelm, S. W., & W. A. Wurtsbaugh. (2016). It Takes Two to Tango: When and Where Dual Nutrient (N & P) Reductions Are Needed to Protect Lakes and Downstream Ecosystems. Environmental Science & Technology, 50(20), 10805–10813. https://doi.org/10.1021/acs.est.6b02575.

bring limited benefit to the lake, particularly when tributary loads may be at their lowest contributing levels in late summer/low flow timeframe of HABs. (This does not discount any condition where tributary loading of nitrates may be increasing over time and potentially driving water quality changes. Data are simply absent to draw definitive conclusions in these latter regards.)

If late summer HABs are potentially triggered by phosphorus pulses, a likely seasonally-impactful source may be septic systems. Septic system phosphorus loads may be inconsequential with well-managed or newer systems, however, aging systems can potentially be providing a significant BAP source load to the lake. As discussed earlier, septic system loads are estimated to comprise 12% of the annual Black Lake BAP load. These source contributions change throughout the year, however. Tributary flows are highest in the spring and lowest in the late summer. Conversely, septic system loading on Michigan lakes is often highest in the late summer and into the fall due to seasonally-occupied residences and the slow velocity of groundwater flow resulting in peak loads in late summer. This may suggest that for seasonally adjusted loads in August, 19% or more of the monthly BAP load to Black Lake could come from septic systems (Figure 5), even with assuming evenly distributed loads from other sources.

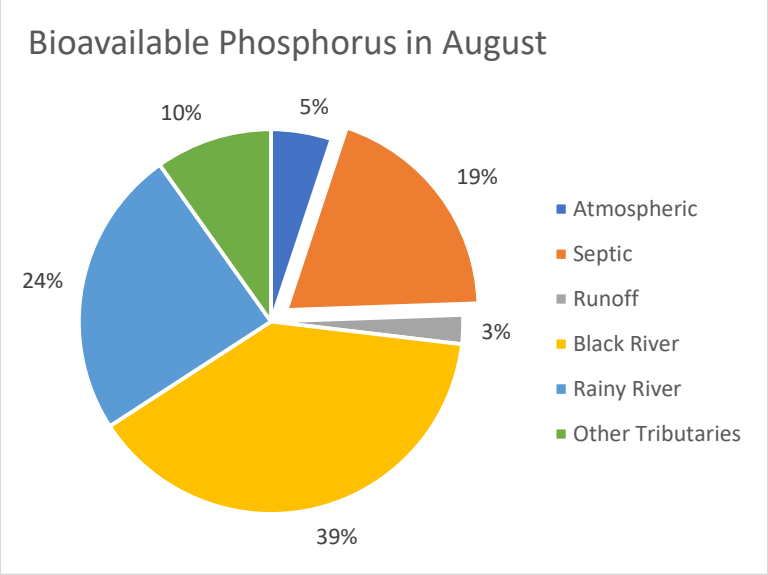


Figure 5 - Black Lake August Bioavailable Phosphorus (BAP) load proportion by source.

This is significant as this is the time of year that HABs have been recorded on Black Lake. Septic system loads can be concentrated in very small areas along the lakeshore, and can feature phosphorus concentrations measured in milligrams rather than micrograms in shallow groundwater discharging to the lake.[21] HABs could feasibly develop in such areas under quiescent/warm water temperature conditions before migrating further out into the lake. Whether potential late summer septic system loading and distribution would be sufficient to stimulate a lake-wide bloom as noted by the BLPS in late 2022, is unknown without additional information.

[21] Oldfield, L., Rakhimbekova, S., Roy, J. W., & C. E. Robinson. (2020). Estimation of phosphorus loads from septic systems to tributaries in the Canadian Lake Erie Basin. Journal of Great Lakes Research, 46(6), 1559-1569.

Conclusions

Something appears to have changed in Black Lake for this system to be producing recurrent late summer blue-green algal blooms since 2020. Intermittent tributary sampling with only concentration data and no flow measurements, along with lake water quality data collected every three years make it difficult to clearly define what has or may be changing. Using limited available data, the preliminary mass balance suggests there are no tributary "smoking guns" that should necessarily be targeted with watershed management strategies that could produce measurable and significant benefits to overall lake water quality related to phosphorus reduction. Limited lake water quality data suggest that lake sediments are not a critical source of phosphorus recirculation in the lake, but rather appear to act as an annual sink for particulate phosphorus.

The mass balance does, however, suggest that there may be relevant seasonal P loading conditions associated with septic systems. If this loading has reached a tipping point, where lack of maintenance and seasonally intensive use is triggering HABs, blue-green algal blooms could remain a seasonal problem on Black Lake. Such septic system loads could also be compounding HAB conditions related to nitrogen inputs. If such loads are a bloom trigger, future management of this source may be closer at hand given that vested stakeholder actions (or inaction) are directly impairing stakeholder uses. This can be contrasted to having to work with potentially hundreds of watershed land owners (having limited to no vested interest in Black Lake), on thousands of distributed parcels where only limited potential benefits to water quality might be achieved.

To more clearly define future management targets and realistic approaches to effect change in these regards, the preliminary Black Lake phosphorus mass balance has importantly, yielded findings on what is missing in terms of critical data needs, and what should be assessed going forward. Importantly, K&A focuses here on the assessment needs.

- K&A would recommend that monthly monitoring of nutrient conditions at the epilimnion, thermocline and hypolimnion be conducted to better characterize nutrient conditions in the lake throughout the growing season. Parameters should include total and soluble reactive phosphorus, total nitrogen and nitrates, chlorophyll *a*, and iron. Sediment phosphorus and sediment iron analyses would also be informative and should be completed in the spring and late fall.
- Any tributary sampling conducted on Black Lake should include soluble phosphorus and nitrates in addition to other parameters. Without question, sampling must include contemporaneous flow measurements.
- A targeted nearshore study of septic system BAP loading conditions at very select locations should be completed. These efforts should be supplemented with an anonymous/confidential lake-wide resident survey of septic system usage, history and maintenance. Collectively, these data would provide valuable information to better define the need for and value of more specific management efforts around septic system loads.
- Specific monitoring of HABs conditions should be conducted during blooms (see Appendix C for additional related recommendations).
- Performing a circulation model analysis of the lake would provide insight into how often and how much of the Black River flow exits the lake before mixing with the eastern portion of lake. If

this were substantial, this could shift future tributary management interests to other drainage areas such as the Rainy River.

Appendix A: HAWQS Watershed Model

To support the phosphorus mass balance analysis, the US EPA's Hydrologic and Water Quality System (HAWQS) tool[22] was also utilized to provide insight into loading for the Black Lake watershed. HAWQS is an internet browser-based tool that acts as an interface for the Soil and Water Assessment Tool (SWAT) model.[23] Running a SWAT model takes a degree of expertise and can be very time-consuming (well beyond the scope of this preliminary K&A phosphorus mass balance). HAWQS serves to provide ready-to-use model defaults for larger pre-delineated watersheds (such as the Black Lake watershed). While HAWQS output is not as accurate as a dedicated SWAT model output, this is somewhat offset by the speed and ease of use.

Flow rates and annual water volumes predicted by the Black Lake HAWQS appear to be reasonable; model-predicted phosphorus loads to the lake, however, resulted in concentrations that were an order of magnitude (i.e., 50+ µg/L) higher than what has historically been observed. As a result, phosphorus loads generated by HAWQS were not utilized for the mass balance analysis. Since water volume predictions were reasonable, these were utilized to backcheck calculations used for the tributary and outflow portions of the mass balance analysis. These HAWQS flow calculations also provided valuable insight suggesting an average Black Lake flushing time (the time it takes for one water volume to be replaced) of 166-222 days under a range of observed conditions. This rate, though dependent on dam outflow conditions, is useful from a management perspective to understand that the flushing rate appears to be less than one year. This suggests that what enters the lake via tributaries may be largely flushed out in the same year, recognizing the back-calculated phosphorus flux.

[22] Yen, H., Daggupati, P., White, M. J., Srinivasan, R., Gossel, A., Wells, D., & J. G. Arnold. (2016). Application of large-scale, multi-resolution watershed modeling framework using the Hydrologic and Water Quality System (HAWQS). Water, 8(4), 164.

[23] Arnold, J. G., Moriasi, D. N., Gassman, P. W., Abbaspour, K. C., White, M. J., Srinivasan, R., ... & M. K. Jha. (2012). SWAT: Model use, calibration, and validation. Transactions of the ASABE, 55(4), 1491-1508.

Appendix B: Empirical Modeling/Assumptions for Preliminary Septic System P Loading for Mass Balance

Septic system loads to Black Lake were preliminarily estimated for the K&A phosphorus mass balance using the empirical equation from Reckhow *et al.* (1980)[7]:

$$W_s = EC_{st} * C_t * (EV + SSV)$$

where:

- W_s = Annual load from septic system (lbs/yr)
- EC_{st} = Export coefficient (lbs/yr)
- C_t = Total number of capita-years/residence
- EV = Environmental Variables: $EV = 0.143 * [(1 - SP) + (1 - PA) + (1 - DR) + (1 - S)]$
  - SP = soil permeability factor (dimensionless)
  - PA = phosphorus adsorption capacity factor (dimensionless)
  - DR = drainage factor (dimensionless)
  - S = slope factor (dimensionless)
- SSV = Septic System Variables: $SSV = 0.143 * [(1 - A) + (1 - M) + (1 - DS)]$
  - A = age factor (dimensionless)
  - M = maintenance factor (dimensionless)
  - DS = distance factor (dimensionless)

Assumptions for the Black Lake septic system load estimation include the following based on 810 homes assuming 80-90% are seasonally-use (Gowland, personal communication, 2023)[24] are provided in Table B1. K&A conservatively assumed three people per household. Table B2 identifies variables considered in calculating septic system assumptions and assigned factors for this preliminary load estimation.

[24] Gowland, R. (2023). Personal Communication regarding number of Black Lake residences and seasonal useage. June 21, 2023 email from Rusty Gowland to Mark Kieser, Kieser & Associates, LLC, Kalamazoo, MI.

Table B1. K&A assigned values and coefficients used for preliminary Blake Lake septic system loading.

Item	Metric	Equation Variable	Metric Value	Metric-related Coefficient**
Soil Permeability	inches/hour	SP	5.8	0.51
Phosphorus Adsorption Capacity	lbs/acre	PA	1,450	0.50
Depth to Water Table	Inches	DR	3.5	0.45
Slope	%	S	3.5	0.95
System Age	Years	A	20	0.05
Maintenance Frequency	Years	M	5	0.64
Distance to Lake	feet	DS	80	0.38
Capita Years	*	C_t	880.9	880.9
Export Coefficient	lbs/year	EC_{st}	1.8	1.8

* Residence years on lake normalized for number of residences, number of occupants per residence, and fraction of year residence is occupied.

** Refer to Table 2 for relationship of coefficient to metric value

Table B2. Variables considered in calculating septic system assumptions and assigned factors. (Source: Limno-Tech, 1989).[25]

Parameter	Range	Assigned Factors
Soil Permeability	>10	0.75
(in/hr)	1-10	0.5
	0-1	0.25
Phosphorus Adsorption Capacity	1600-2000	.75
(lbs/ac/top 3 feet of soil)	1300-1600	.5
	1000-1300	.25
Soil Drainage	6	.75
(depth to water table)	0.5-1.8	.15
	0	.05
Slope	0	1
(%)	>0-6	1
	>6-12	.75
	>12-18	.75
	>18-25	.5
	>25	.25
Age	0-2.5	1
(years)	>2.5-5	.75
	>5-8	.5
	>8-11	.25
	>11	.05
Maintenance Frequency	0-2	1
(years)	>2-5	.75
	>5-8	.5
	>8-11	.25
	>11	.05
Distance to Lake	<50	.05
(ft)	>50-75	.25
	>75-100	.5
	>100-200	.75
	>200	1

[25] Limno-Tech, Inc. (1989). Variables for Modeling Phosphorus Loading from Septic Systems to Lakeshore.

Appendix C: Summary of Recent Black Lake Reported HABs Conditions

Recent reports of blue-green algal blooms, some of these exhibiting algal toxins, are of concern for Black Lake water quality in terms of both recreational and health hazards, but also whether something has changed that is now triggering these conditions. Given these "Harmful Algal Blooms" (HABs) can be driven by nutrients, this appendix has been included with the Phosphorus Mass Balance technical memorandum. Information herein, and relevant BLPS considerations, will be presented separately as part of the K&A scope of work in 2023. The following summary includes relevant details of reported conditions, available data, public reporting gaps, and future considerations for assessing conditions that may be driving these blooms. Historic data are presented first starting with initial HABs reports from 2020.

2020 HABs Reporting

HABs were first identified on Black Lake by a concerned resident and sampled by EGLE on 9/9/20 and 9/11/20 (see Figure C1) off of Silver Beach Road and Waverly Avenue. Aaron Parker of EGLE reached out to BLPS on 9/14/23 and informed everyone that preliminary results using Abraxis test strips[26] revealed microcystin concentrations >10 µg/L at the Silver Beach Road sample site and a non-detection off of Waverly Avenue.



Figure C6. September 11, 2020 HAB off of Silver Beach Road (photo provided to K&A by Beverly Haas).

[26] See, for example, https://us.vwr.com/store/product/26604089/null.

The EPA's recreational guidance for microcystin (MC) is 8 µg/L.[27] EGLE also mentioned that previous testing in other locations on the lake yielded non-detections from the Abraxis test strips. Samples from Waverly and Silver Beach were then sent to Michigan Department of Health & Human Services (MDHHS) laboratory for testing. Subsequently, to be cautious until the testing results became available, the District Health Department No. 4 in Cheboygan County issued a public health awareness bulletin on 9/15/20 warning residents to avoid the bloom. Lab samples were processed and completed on 9/19/20.

On 9/23/20 another cyanobacteria bloom was reported on the lake. Aaron Parker contacted BLPS again on 9/23/20 with MDHHS/ EGLE testing results from the previous samples from 9/9-9/11 samples showing that Silver Beach Road had a high concentration of MC (210 µg/L) while the state park, boat launch, and other locations had no detections. He also commented that EGLE was aware of the algal blooms reported on the lake on the 23rd. Instead of retesting, EGLE relayed that based on the previous testing results from earlier in September, that residents should just assume that the current blooms are toxin-producing and that EGLE would work to arrange follow-up testing. The local health department then issued another public health awareness bulletin on 9/25/23.

EGLE reached back out on 10/6/20 and informed BLPS that samples collected on 9/23/20 were elevated for microcystin based on the strip tests but due to their budget constraints, they would be unable to send any more samples to the lab and that the blooms should just be avoided. They also did not indicate how highly elevated the samples were in this communication based on the strip tests, inferring that re-testing never occurred by EGLE or MDHHS. Results of MC testing a select Black Lake locations in 2020 are summarized in Table C1.

Table C1. Microcystin results from 2020 testing from MDHHS Lansing Lab. (The first two samples were collected off of Waverly Road. The next three samples were collected off of Silver Beach Road.)

Site	Date Sampled	MC Results (µg/L)
State Park Pavilion	9/09/2020	<0.5
DNR Boat Launch	9/09/2020	<0.5
Dock	9/11/2020	210
End of Dock	9/11/2020	<0.5
Shoreline	9/11/2020	<0.5

2021 HABs Reporting

In 2021, residents reported a harmful algal bloom at the end of September. EGLE sent out a representative to collect initial samples from Cedar Beach Lane on 9/30/23. Samples were collected from a dock and the nearby shore. EGLE also sent out a communication to BLPS on 10/5/23 that they received a report of an algal bloom off of Birch Ridge Road and would arrange for sample collection later that week. They also highlighted that based on the testing results from last year, all blooms should be assumed to be producing cyanotoxins and should be avoided.

[27] US Environmental Protection Agency (EPA). (2019). Draft Technical Support Document: Implementing the 2019 Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin. 304(May). https://www.epa.gov/wqc/draft-technical-support-document-implementing-2019-recommended-human-health-recreational-ambient.

Subsequent sampling by EGLE occurred on 10/5/23 by Birch Ridge Road at a nearby dock and shoreline and Waverly Road by the boat launch and seawall. Notably, no Abraxis test strips were used, the Health Department did not issue any bulletin for these blooms, and there were no formal communications to the residents.

Results were reported out by EGLE on 10/20/21 (15-19 days later). All three sample sites had elevated levels of microcystin. EGLE reminded residents to avoid cyanobacteria blooms and to report if they see any others but did not mention any instance of retesting. HABs sampling results from 2022 are summarized in Table C2. Figure C2 identifies locations of sampling stations in 2022.

Table C2. Microcystin (MC) results from 2021 testing from MDHHS Lansing Lab.

Site	Date Sampled	MC Results (µg/L)
Cedar Beach Dock	9/30/2021	<0.5
Cedar Beach Shore	9/30/2021	49.2
Birch Ridge Beach	10/5/2021	2,913.1
Birch Ridge Dock	10/5/2021	117.8
Waverly Boat Ramp	10/5/2021	60.4
Waverly Sea Wall	10/5/2021	10.9



Figure C7. Locations of EGLE testing with results embedded from 2021.

2022 HABs Reporting

There is very limited information on Black Lake HABs in 2022. According to the Michigan Harmful Algal Bloom Reports map, there was one instance of a reported HAB on 9/8/22 that was confirmed to be an algal community capable of producing algal toxins, though cyanotoxins were not sampled.[28] Based on the lack of information provided in the State's Mapping tool, K&A was unable to identify who made this determination, whether the local health department or EGLE. Additionally, to K&A's knowledge, there was no formal communication with EGLE or MDHHS for this event; no bulletin or notice occurred and no testing occurred. It is uncertain whether this somewhat nebulous state website reporting was related to BLPS board members observations of a lake-wide blue-green algal bloom late in the 2022 recreational season.

Black Lake HABs Summary

In summary, HABs appear to be a relatively recent occurrence on Black Lake. Sporadic testing by EGLE and County Health lab analyses confirmed these periodically have exceeded EPA's action level of microcystin at 8 µg/L. Specific and/or generalized avoidance notifications were typically provided by these agencies. Re-testing of microcystin levels does not appear to be a routine part of agency sampling; notably, EGLE indicated they were constrained by state budgets in 2021. Uncorroborated citing of late season, apparent lake-wide bloom appears to have gone untested in 2022.

Conclusions

K&A concludes that agency support to Black Lake residents and the BLPS is limited to testing of observed HABs. This includes only limited/sporadic public notifications related to HABs toxin conditions. There also appears to be no agency impetus or resources to focus on potential causes and solutions of these blooms on Black Lake. These latter items should therefore be addressed in forthcoming watershed management planning efforts, but more specifically with algal-toxin testing of bloom conditions. Moreover, a consistent public notification process of HABs results, testing of algal bloom species when these occur, assessment of potential triggers for the recent blooms, and intentionality on addressing causational factors where possible should be considered. As such, K&A would recommend the following actions:

1. HABs notification protocol or system directed by the BLPS and supported where possible by the county and state
2. Bloom sampling to determine blue-green algal species present which can help discern the nature of the predominant species, their habitat preferences, triggers and eventually, potential mitigation strategies
3. Targeted sediment sampling to assess the presence and nature of resident blue-greens
4. Seasonal water quality sampling of the lake with a more robust suite of parameters targeting especially relevant conditions in late summer that could be triggering blooms

[28] Michigan Harmful Algal Bloom Reports map, Accessed June 9th 2023: https://mdhhs.maps.arcgis.com/apps/webappviewer/index.html?id=b05d6b7498ca4ce29a586f1f2b9cefeb

ATTACHMENT C

K&A Statistical Model for Nearshore Black Lake SRP Concentrations

ATTACHMENT C

Statistical Model for Nearshore Estimates of SRP Concentrations in Black Lake

A simplified mechanistic approach was advanced by K&A to analyze potential daily changes in soluble phosphorus concentrations (SRP) in nearshore waters of Black Lake given the inflow of groundwater (GW) receiving septic system drain field discharges. This 'model' was developed to forecast nearshore phosphorus concentrations (as µg/L) and daily loading (as lbs SRP/day) in the context of blue-green (cyanobacteria) algal bloom formation on Black Lake. The model computations assume a static volume of water in a nearshore area receiving both GW and mixing with open lake water. The timestep of the computations is daily.

"Flow net analysis is a graphical method used in geotechnical engineering to visualize and analyze groundwater flow through porous media like soil. It uses a network of perpendicular flow lines (paths of water) and equipotential lines (lines of equal total head) to calculate seepage rates. The method is based on Darcy's Law and is particularly useful for estimating seepage losses and uplift pressures."

A "flow net" analysis was used to evaluate nearshore area water volumes potentially affected by septic system discharges from shallow groundwater discharging to, and upwelling into the lake. A water balance for a defined nearshore area can be envisioned by the following Figure 1 schematic.

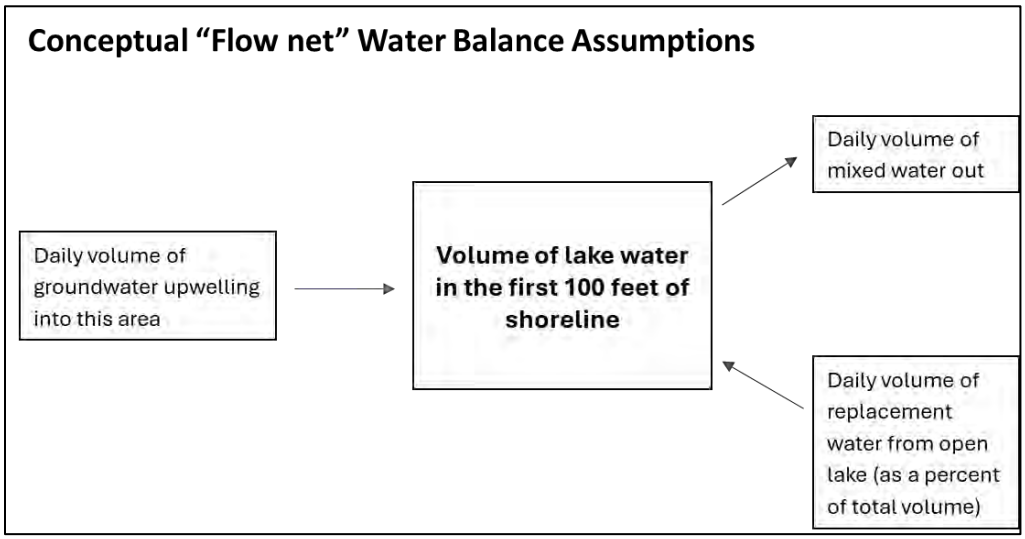


Figure 1 - Conceptual schematic of Flow Net analysis for predicting nearshore phosphorus concentrations from measured shallow groundwater data on Black Lake.

The flow net assumptions for GW discharging to the lake include the following:

- Inflowing GW volume is estimated based on aquifer statistics derived from the State of Michigan Well Logic tool.[1] K&A used location data for a series of temporary, shallow GW wells sampled along the shoreline at Site 2 in September of 2023 to simulate

[1] See: https://www.egle.state.mi.us/wellogic/Login.aspx?ReturnUrl=%2fwellogic

nearshore conditions. The average spacing of the wells was fourteen feet eight inches (14.7 feet). From the Well Logic tool, the average unconfined aquifer along the shoreline is 20 feet deep, consisting of medium grained sand. Medium grained sand has a hydraulic conductivity of between 28 feet/day to 280 feet/day. Using a flow net configuration, the modeled velocity of the GW inflow to the lake was estimated using the conservative (lower hydraulic conductivity/slower velocity) value of 28 feet/day. For the area receiving groundwater flow, a one-foot wide by 3.5-feet deep GW SRP plume was used.[2]

- The volume of lake water was calculated as a triangular one-foot-wide section for a distance of 100 feet from the shoreline. The daily volume of GW was calculated by flow (gallons/day) = velocity (ft/day) x area (square feet).
- The SRP load calculation (lbs P/day) used the one-foot wide segment and SRP concentrations measured in each well with average spacing of 14.7 feet. Therefore, the SRP load for each well's influence was then calculated across this length of shoreline.
- Based on actual shallow groundwater sampling in the nearshore area, Figure 2 depicts the hypothetical modeled shoreline segments with gray arrows conceptually depicting SRP concentrations for each 14.7-foot wide beach section extending out 100 feet from shoreline (with a water depth at the lakeward extent of the mixing zone being 2.5 feet).

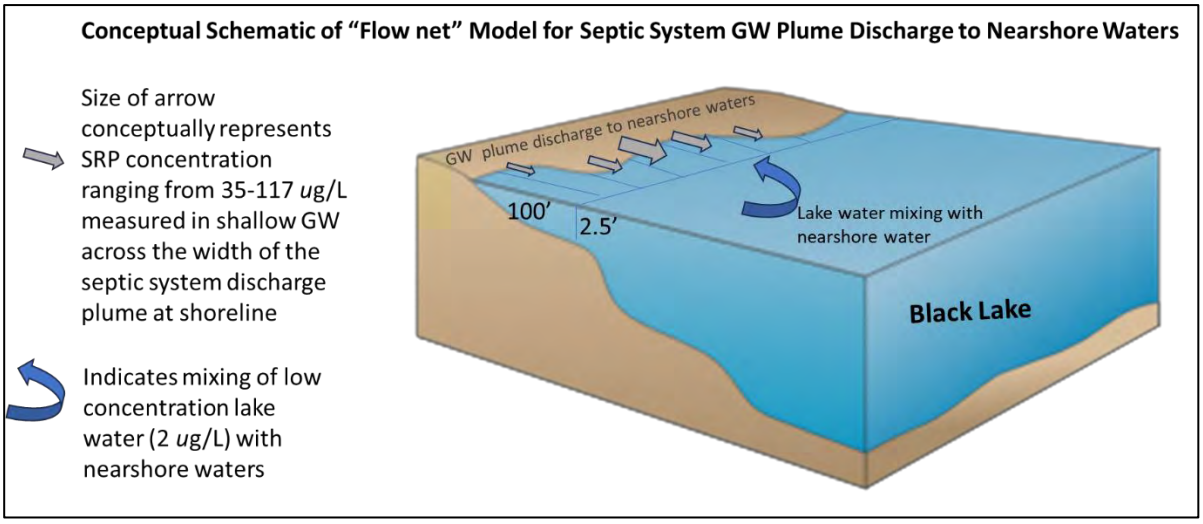


Figure 2 - Conceptual schematic of nearshore model.

- The beginning SRP concentration was modeled at 2 µg/L.

[2] Wang, S., Robinson, C. E., Spoelstra, J., Schneidewind, U. and J.W. Roy. 2024. Phosphorus loading to nearshore waters from legacy septic system groundwater plumes in a Great Lakes coastal community. J. Great Lakes Research, Volume 50, Issue 6, December 2024, 102453. (Available at: https://www.sciencedirect.com/science/article/pii/S0380133024002193)

- The statistical model then used the SRP concentration of each day's lake volume being the previous days calculated SRP concentration. The model was set up to give the expected SRP concentrations of the lake volume for six months.
- The model was run three times for each GW SRP concentration scenario. First with 0% of the nearshore volume of lake water replaced by open lake water, then with 10% replaced (at 2 µg/L SRP in the open lake) and finally, 80% replacement on any given day. The results were then graphed to show both short durations (3 days) and long durations (up to one month) of nearshore SRP concentrations. In each mixing scenario, nearshore SRP concentrations plateaued within ten days of the start of the model runs.

Model Outputs

Using 2023 beach monitoring data for SRP at this location, the following graphics present accumulating nearshore concentrations after 3 days and up to 30-days of what are assumed late summer groundwater discharges along 100 feet of lakefront (Figures 3 and 4, respectively). These figures represent just the one 14.7-foot wide beach segment with the highest measured SRP groundwater concentration of 117 µg/L in July of 2023. Both plots illustrate surface water concentrations assuming no mixing of open lake water (at 2 µg/L), 10% mixing and 80% mixing. Notable is the potential for build-up of over time even with high mixing of 80%.

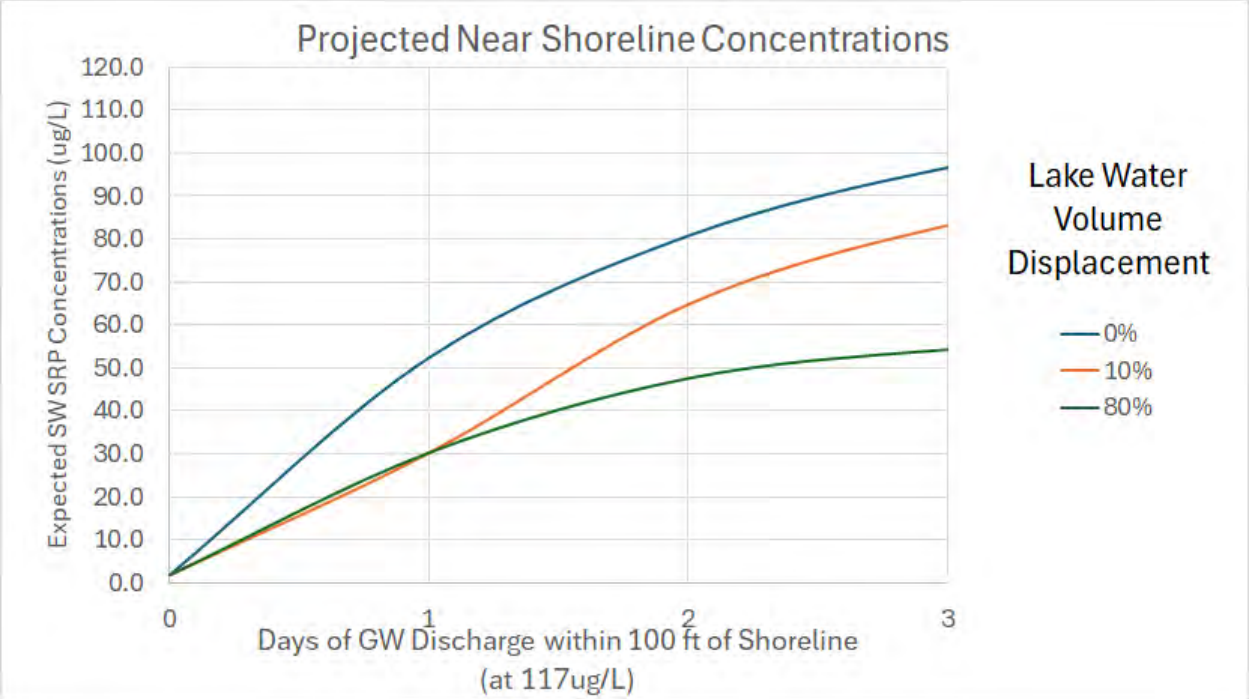


Figure 3 - Predicted nearshore concentrations over three days in the 14.7-foot wide model segment to 100 feet from shoreline with a measured nearshore groundwater concentration of 117 µg/L. Concentrations are predicted for three mixing scenarios of 0%, 10% and 80% with open lake water at 2 µg/L.

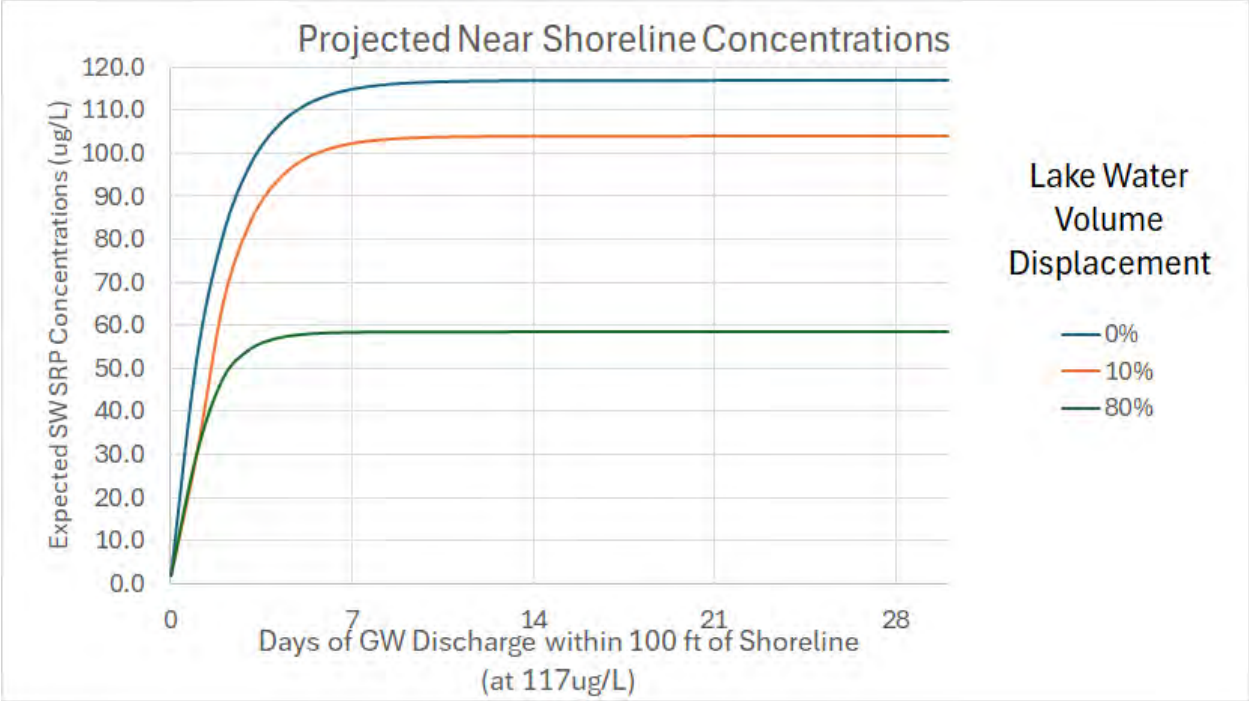


Figure 4 - Predicted nearshore concentrations over one month in the 14.7-foot wide model segment to 100 feet from shoreline with a measured nearshore groundwater concentration of 117 µg/L. Concentrations are predicted for three mixing scenarios of 0%, 10% and 80% with open lake water at 2 µg/L.

Figure 5 presents the predicted nearshore concentrations for this entire 100-foot wide section of beachfront representing the range of measured concentrations from 35 to 117 µg/L of soluble phosphorus in shallow groundwater. These predicted concentrations within 100 feet of the shoreline suggest that there would be ample phosphorus available to stimulate harmful algal blooms when weather (principally low to no winds, high sunlight) provided optimal bloom conditions.

It is likely that there could be periods of 1-3 days with no to low winds reflecting the 10% mixing condition. Over longer timeframes, these conditions may be best modelled assuming 80% mixing condition. Thus, on a calm day following any period of high winds (leaving nearshore water concentrations starting at 2 µg/L), model projections from Figure 5 suggest that nearshore SRP concentrations at this location could rise to 25 µg/L within a day under 10% mixing conditions. These concentrations would be more than sufficient to trigger a bloom assuming 4-6 µg/L are bloom-triggering SRP concentrations.[3,4,5]

[3] Vuorio, K., Järvinen, M., & Kotamäki, N. (2020). Phosphorus thresholds for bloom-forming cyanobacterial taxa in boreal lakes. *Hydrobiologia*, *847*, 4389-4400.
[4] Liu, J-H, Lu, Y., DAO, G-H, Wang, S-N, Song, K-Y, and H-Y HU. In Press. Algal Growth Potential Based Nitrogen and Phosphorus Criteria for Bloom Control. Water Cycle. https://doi.org/10.1016/j.watcyc.2025.10.004
[5] Jianga, M., Zhoua, Y., Caoc, X., Jia, X., Zhanga,W., Huangd, W., Zhanga, J., and Z. Zheng. 2019. The concentration thresholds establishment of nitrogen and phosphorus considering the effects of extracellular substrate-to-biomass ratio on cyanobacterial growth kinetics. Science of the Total Environment. Volume 662, 20 April 2019, p 307-312.

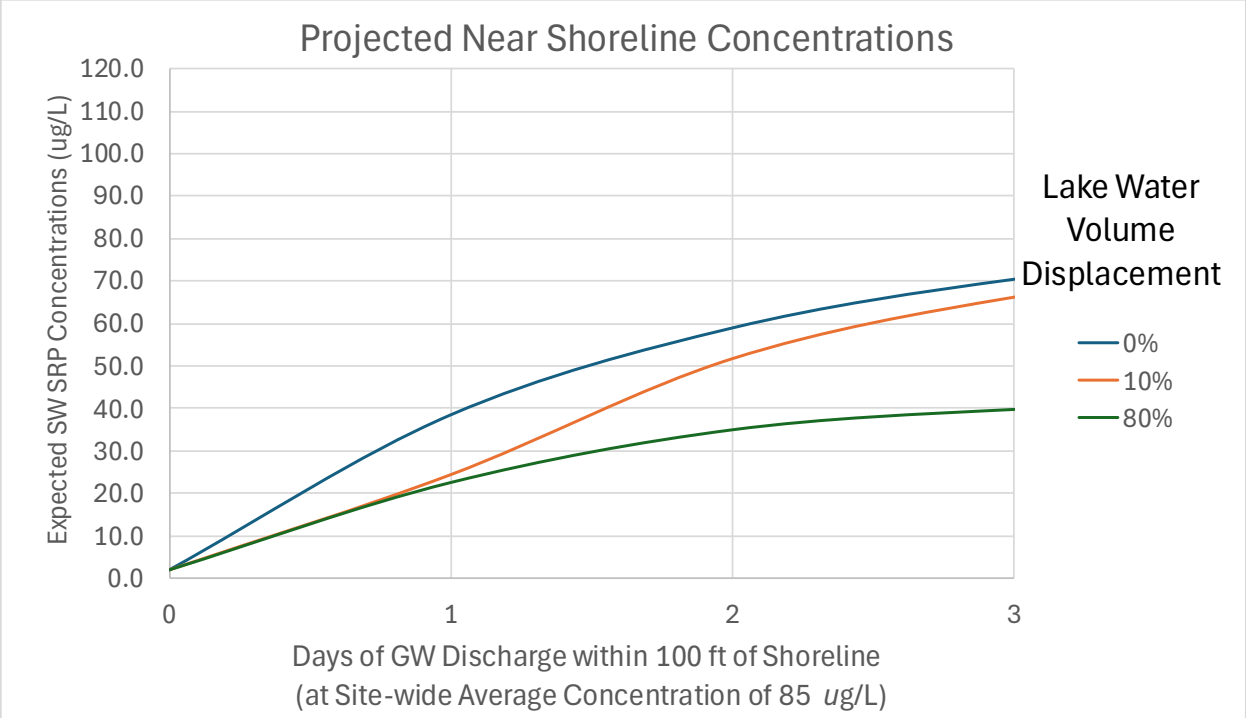


Figure 5 - Projected SRP nearshore concentrations for the 100-foot beachfront using 2023 shallow groundwater data from September of 2023.

Appendix D

Black Lake, Cheboygan County: 2023 Aquatic Macrophyte Report

BLACK LAKE, CHEBOYGAN COUNTY:
2023 AQUATIC MACROPHYTE REPORT



Lake: Black

County: Cheboygan

Lake Surface Area: 10113-acres

Littoral Area: 4796-acres

Shoreline Length: 21.2 mi

Survey Type: Point-intercept

Date of Survey: 9/8/2022-9/9/2022 & 8/4/2023

Observer[s]: Jeremy Hartsock, Lucy Breda, William Herbert, Olivia Coskie, Kelly Baltusis, Jo Latimore

Author[s]: Jeremy Hartsock, Olivia Coskie

Email: hartsoc4@msu.edu

Results Summary:

An aquatic macrophyte survey (aquatic plants and macroalgae) of Black Lake was started on August 8, 2022 (western side) and completed on August 4, 2023 (eastern side). A total of 32 macrophyte species were identified. Aquatic invasive species (AIS) were not detected during the survey.

Lake Description:

Black Lake is a 10,113-acre natural lake in Cheboygan County, located about 5.5 mi north of Onaway, MI [45.452081°, -84.271117°]. It is the tenth largest inland lake in the state of Michigan by surface area. The maximum lake depth is 50 ft and average Secchi depth was 14 ft on August 4, 2023. The water of Blak Lake is typically stained dark. Approximately 29% of Black Lake is less than 10ft deep, nearly 9% is 10-20 ft deep, 17% is 20-30 ft deep, and 45% is water greater than 30 ft deep. There are approximately 500 residences around Black Lake (Cwalinski and Hanchin, 2011). Shoreland disturbance (i.e., the proportion of the shoreland area with urban or agricultural land cover) is rated at 24% (Midwest Glacial Lakes Partnership Conservation Planner - link in reference section) (Figure 1a). The proportion of Lost Lake's watershed disturbed (i.e., all the land surrounding a lake that contributes rainfall and snowmelt to the lake) is 8%. The primary hard-surfaced public access site is located on the south shore of the lake within the Onaway State Park, and other smaller public boat launch sites are found around the lake (Figure 1).

Management History:

To the best of our knowledge, no herbicide treatments to control AIS have been carried out at Black Lake (see https://mienviro.michigan.gov/nsite/map/help).

Survey Objectives:

A point-intercept survey was carried out at Black Lake to 1) obtain baseline data about the aquatic macrophyte community, 2) map the spatial distribution of macrophytes and richness patterns and 3) locate potentially problematic AIS.

Methods:

We conducted a modified point-intercept survey. 244 equidistant sampling points were established in the littoral zone (i.e., 0 – 25 ft) at Black Lake using GIS software (Figure 1). At each sampling point, a double-sided rake was tossed twice, one toss to the starboard and one to the port side of the research vessel to snag aquatic macrophytes. Individual macrophytes were identified to the lowest possible taxonomic unit. Small leaf pondweeds (e.g., *Potamogeton foliosus*, *P. pusillus, P. obtusifolius*), however, were lumped into a single category - "small leaf pondweed sp. ", and macroalgae were grouped into three categories: *Chara sp.*, *Nitella sp.*, and *Nitellopsis obtusa*. Environmental variables measured included water depths and plant abundance (see Hauxwell et al. 2010; Supplementary 1) at each sampling point, and water transparency was sampled using multiple Secchi disk readings from the deepest region of the lake. A lake water sample was collected and analyzed for total bicarbonate, electrical conductivity, and pH levels by the EGLE environmental laboratory.

Survey Observations:

The water at Black Lake has a pH of 8.1, electrical conductivity of 315 umho/cm, and total alkalinity is 170 mg/L. From 244 littoral zone sampling points visited (Figure 1), we encountered macrophytes at 99 sampling points (41% of points) (Figure 2). The majority of macrophyte encounters were in the northern portion of the lake near the Upper/Lower Black River entrances, and along the protected western shoreline. In total, 32 macrophyte species were observed (Table 1), and AIS were not encountered. The highest richness observation at an individual sampling point was 9 species (Figure 2). The most frequently encountered macrophytes were variable-leaf watermilfoil and muskgrass, being present at 22% and 19% of sampling points visited (Table 1). Overall, the plant community at Black Lake is quite even, with several species having frequency of occurrence above 10%.

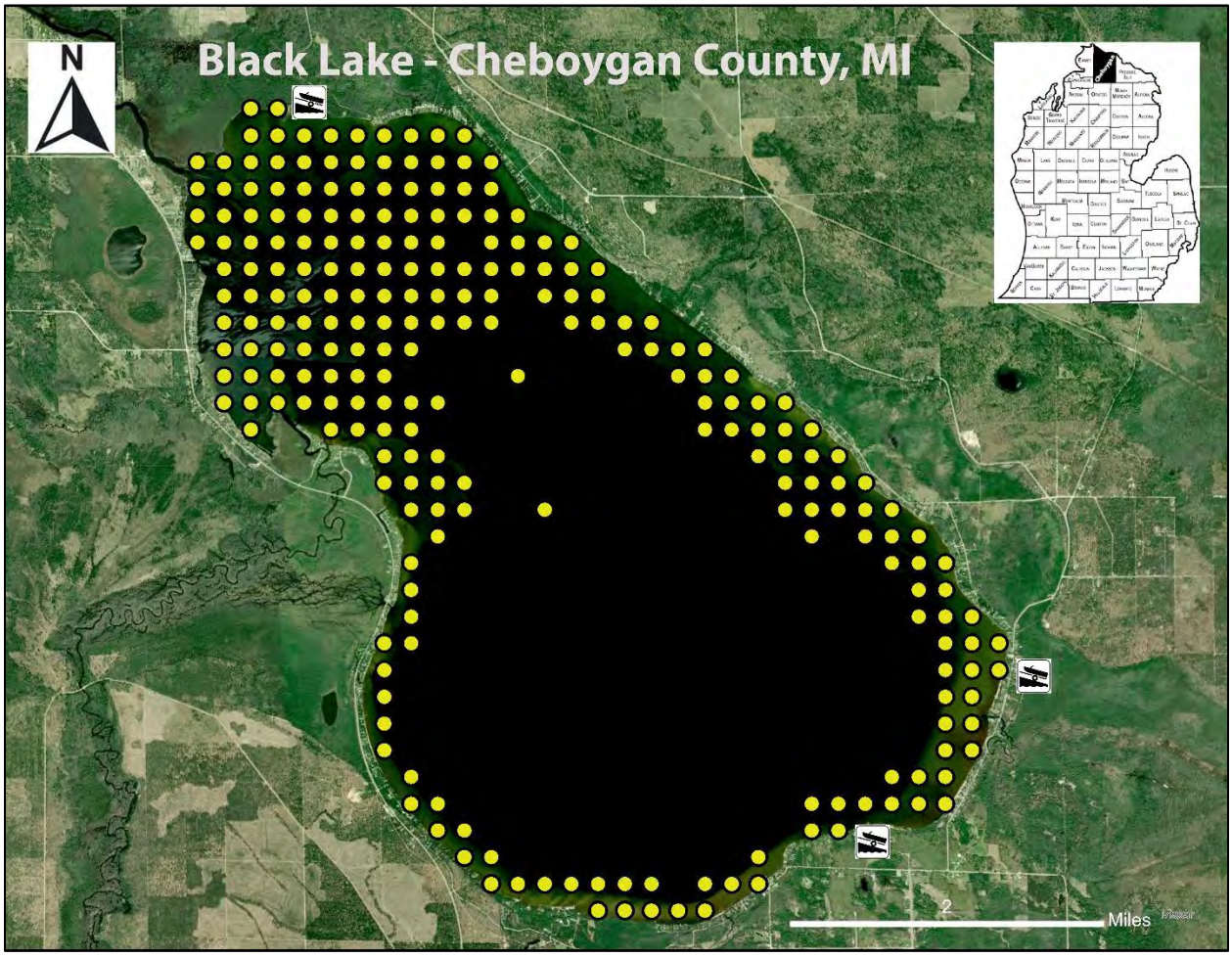


Figure 1. Black Lake (Cheboygan County) littoral zone (0-25 ft) sampling point locations.

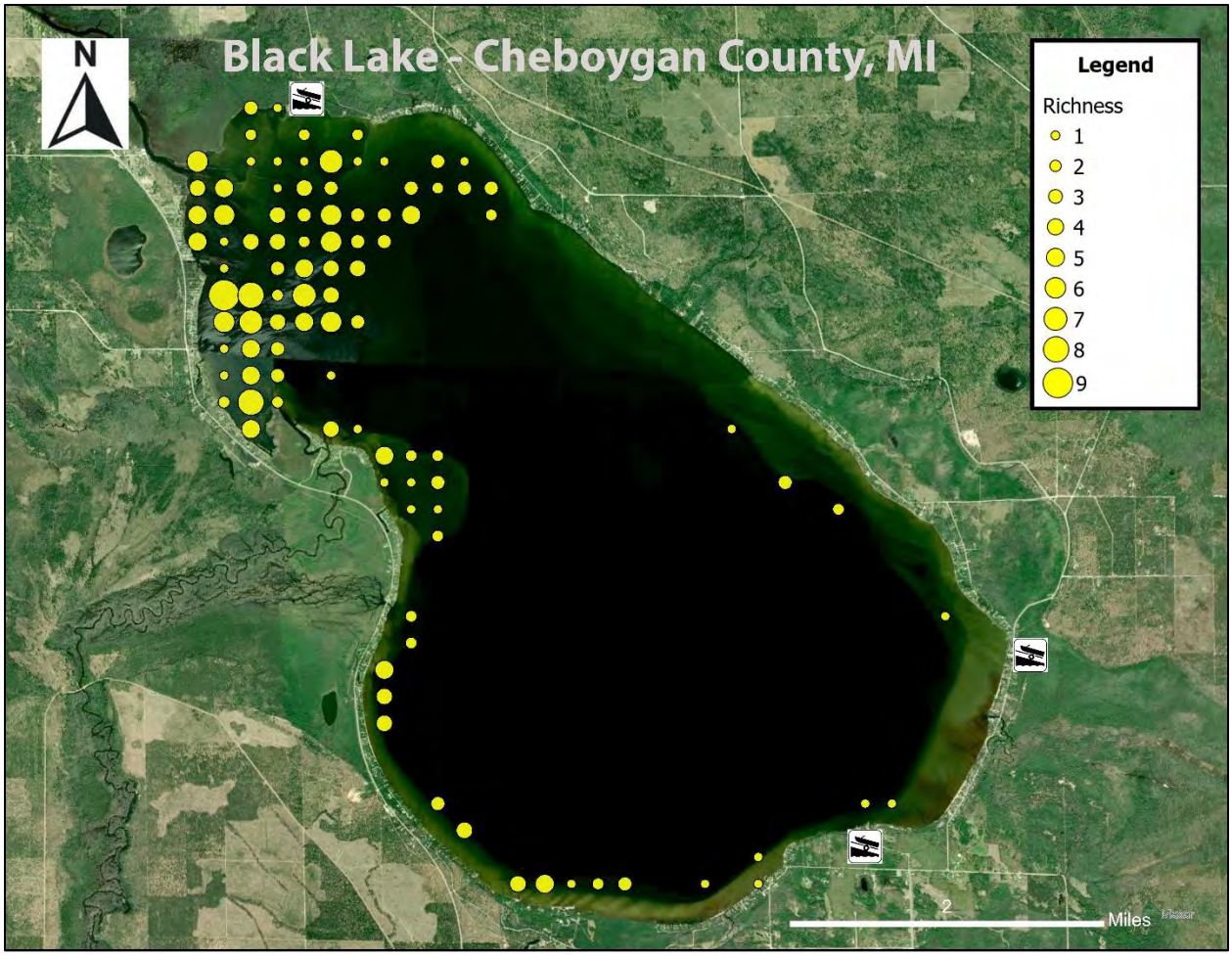


Figure 2. Black Lake species richness distribution map (number of aquatic macrophyte species per point).

Table 1. 2023 Black Lake littoral zone (0-25 ft) aquatic macrophyte species checklist from 244 points surveyed, and taxa occurrence metrics. All aquatic species encountered are native to the state of Michigan. (N) = native species.

Common name		Scientific name	Total sites present	Frequency of occurrence (%)*	Relative proportion (%)[+]
Variable-leaf watermilfoil	(N)	*Myriophyllum heterophyllum*	53	21.7	16.9
Muskgrass	(N)	*Chara sp.*	47	19.3	15.0
Slender naiad	(N)	*Najas flexilis*	29	11.9	9.3
Water celery	(N)	*Vallisneria americana*	27	11.1	8.6
Flat-stem pondweed	(N)	*Potamogeton zosteriformis*	26	10.7	8.3
Variable-leaf pondweed	(N)	*Potamogeton gramineus*	24	9.8	7.7
Greater bladderwort	(N)	*Utricularia macrorhiza*	19	7.8	6.1
Canadian waterweed	(N)	*Elodea canadensis*	13	5.3	4.2
Coontail	(N)	*Ceratophyllum demersum*	11	4.5	3.5
Illinois pondweed	(N)	*Potamogeton illinoensis*	10	4.1	3.2
Northern watermilfoil	(N)	*Myriophyllum sibricum*	7	2.9	2.2
Fries pondweed	(N)	*Potamogeton friesii*	7	2.9	2.2
Water stargrass	(N)	*Heteranthera dubia*	5	2.0	1.6
Sago pondweed	(N)	*Stuckenia pectinata*	5	2.0	1.6
Southern naiad	(N)	*Najas guadalupensis*	4	1.6	1.3
Small nitella	(N)	*Nitella tenuissima*	4	1.6	1.3
Clasping-leaf pondweed	(N)	*Potamogeton richardsonii*	4	1.6	1.3
Bullhead pond lily	(N)	*Nuphar variegata*	3	1.2	1.0
White-stem pondweed	(N)	*Potamogeton praelongus*	2	0.8	0.6
Fern pondweed	(N)	*Potamogeton robbinsii*	2	0.8	0.6
Stiff pondweed	(N)	*Potamogeton strictifolius*	2	0.8	0.6
Arrowhead	(N)	*Sagittaria sp.*	2	0.8	0.6
Water marigold	(N)	*Bidens beckii*	1	0.4	0.3
Aquatic moss	(N)	*Bryophyta sp.*	1	0.4	0.3
Stonewort	(N)	*Nitella sp.*	1	0.4	0.3
Small-leaf pondweed	(N)	*Potamogeton sp.*	1	0.4	0.3
Emergent Bulrush	(N)	*Schoenoplectus sp.*	1	0.4	0.3
Burreed	(N)	*Sparganium sp.*	1	0.4	0.3
Bird's nest stonewort	(N)	*Tolypella intricata*	1	0.4	0.3
Whorled watermilfoil	(N)	*Myriophyllum verticillatum*	V.O.	-	-
White pond lily	(N)	*Nymphaea odorata*	V.O.	-	-
Floating-leaf pondweed	(N)	*Potamogeton natans*	V.O.	-	-

*Frequency of occurrence (%) based on all sampling points (=244) including those lacking vegetation.

[+]Relative proportion of taxa based on summed plant species occurrences (=313).

V.O. = Visual observation

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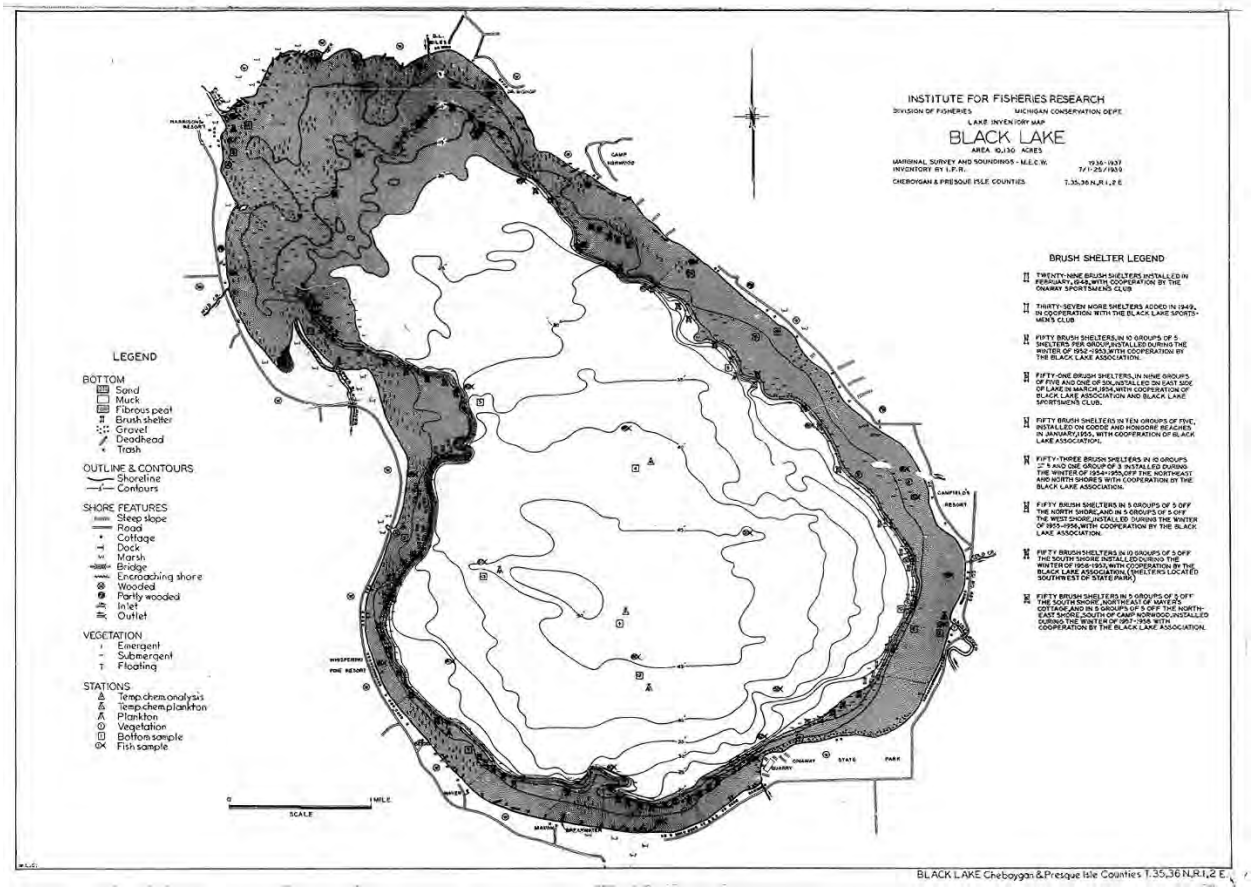
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Acknowledgements: Funding for this project was provided by the Michigan Department of Natural Resources through a research grant awarded to Daniel Hayes, Jo Latimore, and Erick Elgin.

Fullness Rating	Coverage	Description
1		Only few plants. There are not enough plants to entirely cover the length of the rake head in a single layer.
2		There are enough plants to cover the length of the rake head in a single layer, but not enough to fully cover the tines.
3		The rake is completely covered and tines are not visible.

Supplementary 1. Illustration of rake fullness rankings used during the survey (Hauxwell et al. 2010)



Supplementary 2. Black Lake bathymetric map.

Appendix E

Black Lake Shoreline Survey (2017)

Black Lake Shoreline Survey 2017

By Tip of the Mitt Watershed Council

Black Lake ASSOCIATION

Tip of the Mitt Watershed Council

Respected Advocacy.
Innovative Education.
Sound Science.

Report written by:

Dave D. Edwards
Monitoring and Research Director

February 2018
Data collected by Watershed Protection Team 2017

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SUMMARY

During the summer of 2017, the Black Lake Association (BLA) contracted with Tip of the Mitt Watershed Council to conduct a shoreline survey of Black Lake. The survey was designed to replicate and add parameters not reported in a similar 2005 survey. Conditions that can impact water quality were documented in categories representative of the three biggest threats to inland lakes: nutrient pollution, habitat loss, and shoreline erosion. The shoreline assessment was conducted on a parcel by parcel basis around the entirety of Black Lake. Survey results indicate that human activity around Black Lake shoreline is likely impacting the lake ecosystem and water quality to some degree.

Development and Shoreline Vegetation

Of all shoreline parcels (805) surveyed in 2017, 88% (705) were considered developed. Developed was defined as the parcel containing some building structure. This was similar to the 2005 survey when 702 of the 805 parcels (87%) surveyed were developed. At water's edge, 42% (338) of parcels had little to no vegetation (beyond manicured lawn). Lack of vegetation on shoreline property is variable around the lake. However, poor greenbelts were concentrated along the northern and southeastern shoreline. Healthy greenbelts are also variable around the lake, and are partially concentrated along the south – south western shoreline.

Erosion and Shoreline Alterations

Erosion was documented along 45% (361) of properties on the shoreline. A majority of these erosion areas (295 shoreline properties) were identified as "minor" erosion. Meaning, exposed soils were present or contained a gully up to 1" deep. Erosion was not reported in 2005, therefore we are unable to compare 2017 data to previous surveys. Shoreline alterations were similar when compared to a 2005 survey. In 2017, 81% of shoreline properties showed some form of alteration. A majority of this alteration was in the form of cobble and boulder rip-rap at water's edge. In 2005 and 2017, 80% and 81% shoreline properties showed some type of alteration, respectively.

Nutrients and *Cladophora*

The number of shoreline areas with signs of nutrient pollution in 2017 lightly decreased relative to the 2005 survey. *Cladophora*, an algal indicator of nutrient pollution, was documented at 27% of all properties in 2017, down from 33% in 2005. However, areas of concern in 2005 remained in 2018. Interestingly, all surveys (1991, 2001, 2005, and 2017) documented *Cladophora* in similar locations around Black Lake. This could indicate consistent nutrient inputs from year to year via groundwater or tributary input.

In conclusion, data collected during 2017 indicate small shoreline changes from 2005. Areas of concern remain concentrated along the northern and southwestern shoreline. These areas have poor greenbelts and documented *Cladophora* growth. Solutions exist for areas of concern and these are often simple and low cost, such as regular septic system maintenance, proper lawn care practices, and wise land use along the shoreline. Erosion sites can be repaired through greenbelt enhancement by allowing vegetation to regrow on the shoreline, providing improved nutrient filtration and erosion resistance. Periodic repetition of shoreline surveys is important for identifying new and chronic problem sites, determining long-term trends of near-shore nutrient inputs and shoreline alterations associated with land-use changes, and for assessing the success of remedial actions.

INTRODUCTION

Background

During the late spring and early summer of 2017, a shoreline survey was conducted on Black Lake by the Tip of the Mitt Watershed Council to document shoreline conditions that impact water quality. The entire shoreline was surveyed to document the following: algae (*Cladophora*) presence as a nutrient pollution indicator, erosion, shoreline alterations, greenbelts, and tributary inlets and outlets.

According to Watershed Council records, Black Lake has had three shoreline surveys conducted prior to 2017. The first in 1991 and the second in 2001, were limited surveys only covering certain areas of Black Lake shoreline. Additionally, these surveys focused on areas for the presence and relative density of algal (*Cladophora*) growth. The third in 2005 was a bit more comprehensive by noting shoreline alterations, substrate conditions, property developments, and aquatic plants. The 2005 survey also encompassed the entire Black Lake shoreline. The report from 2005, focused on *Cladophora* presence and relative nutrient input. During the summer of 2017, the Black Lake Association contracted with the Tip of the Mitt Watershed Council to conduct the most comprehensive assessment to date of Black Lake shoreline conditions. The following 2017 survey results provide a comprehensive dataset documenting shoreline conditions on Black Lake that can be used as a lake management tool. Where possible, the Watershed Council has compared 2017 survey results with previous survey results.

Shoreline Development Impacts

Lake shorelines are an important interface linking the landscape to water within a watershed. A shoreline is the area in which a transfer of water and nutrients occurs from land to water. This transitional zone does not necessarily have an exact line between the landscape and water. Lake shorelines vary based on shape, size, and vegetation. Accordingly, human activities along shorelines have high potential for degrading water quality of Black Lake. Development of shoreline properties for residential, commercial, or other use have an impact on Black Lake in a

variety of ways and in various degrees. For example, as more shoreline vegetation is removed, the potential for nutrients and pollutants to run off the landscape and enter Black Lake increases. Additionally, as the Black Lake Watershed terrain is altered, nutrients and sediment from soils from eroded areas can often end up in Black Lake.

Nutrient pollution can have adverse impacts on aquatic ecosystems and pose a danger to human health. While nutrients are necessary to sustain a healthy aquatic ecosystem, excess nutrients will stimulate nuisance aquatic plant growth of both macrophytes (aquatic plants that grow in or near water and are either emergent, submergent, or floating) and algae. Additionally, algal blooms pose a public health risk as some species (i.e. blue green algae) produce toxins, including hepatotoxins (toxins that cause liver damage) and neurotoxins (toxins that affect the nervous system). Excess plant and algae growth can degrade water quality by depleting the ecosystem's dissolved oxygen. During nighttime respiration, plants compete with other organisms for a limited oxygen supply. Furthermore, the decomposition of algae and plants has the potential to deplete dissolved oxygen due to the aerobic activity of decomposers, particularly in the deeper waters of stratified lakes.

In general, large lakes such as Black Lake are less sensitive to nutrient pollution. With the increased volume, large lakes tend to have greater dissolved oxygen and increased dilution of nutrients. By contrast, small lakes generally have a lesser ability to dilute nutrients. Nutrient pollution can be more problematic in small lakes due to extensive shallow areas that can support more aquatic plant growth. However, even large lakes can develop problematic nutrient levels and algae issues.

Surface waters receive nutrients through a variety of natural and cultural (human) sources. Natural sources of nutrients include stream inflows, groundwater inputs, surface runoff, organic inputs from riparian (shoreline) areas, and atmospheric deposition. Springs and seeps, streams, and artesian wells are often naturally high in nutrients due to the geologic strata they encounter. Nearby wetland seepages may also discharge nutrients at certain times of the year.

Cultural sources include septic systems, fertilizers, and stormwater runoff from roads, driveways, parking lots, roofs, and other impervious surfaces. Poor agricultural and forestry practices, which oftentimes results in soil erosion, and wetland destruction also contribute to nutrient pollution. Furthermore, some cultural sources (e.g., malfunctioning septic systems) pose a potential health risk due to bacterial and viral contamination.

Severe nutrient pollution is detectable through chemical analyses of water samples, physical water measurements, and the utilization of biological indicators. Although chemical analyses of water samples to check for nutrient pollution can be effective, they are oftentimes more labor intensive and costlier than other methods. Typically, water samples are analyzed to determine nutrient concentrations (usually forms of phosphorus and nitrogen), but other chemical constituents, such as chloride, can be measured. Physical measurements, such as water temperature and conductivity (i.e., the water's ability to conduct an electric current), are primarily used to detect malfunctioning septic systems. Biologically, nutrient pollution can be detected along the lake shore by noting the presence of *Cladophora* algae, a bio-indicator.

Cladophora is a branched, filamentous green algal species that occurs naturally in small amounts in Northern Michigan lakes. *Cladophora* occurrence is governed by specific environmental requirements for temperature, substrate, nutrients, and other factors. This algae bio-indicator is found most commonly in the wave splash zone and shallow shoreline areas of lakes and grows best on stable substrates such as rocks and logs. Artificial substrates such as concrete or wood seawalls are also suitable. *Cladophora* prefers water temperatures in a range of 50 to 70 degrees Fahrenheit, which means that the optimal time for growth and detection in Northern Michigan lakes is from mid-May to early July, and September to October.

The nutrient availability in Northern Michigan lakes is typically less than what is needed for *Cladophora* to achieve large, dense areas/growths. Therefore, shoreline locations where relatively high concentrations of nutrients, particularly phosphorus, are entering a lake can be identified by noting the presence of *Cladophora*. Although the growth of *Cladophora* can be

influenced by factors such as current patterns, shoreline topography, substrate composition, and wave action, the presence or absence of any significant growth is a powerful lake-wide screening tool. The existence of chronic nutrient loading problems can be revealed and *Cladophora* presence can assess the effectiveness of any remedial actions. Comparing the number the total number of algal growths areas along the shoreline can reveal trends in nutrient inputs due to changing land use. One factor contributing to nutrient input is bank erosion.

Erosion along the shoreline can degrade the lake's water quality. Stormwater runoff carries sediments into the lake and impacts the lake ecosystem in a variety of ways. Sediments reduce organism respiration by clogging the gills of fish, insects, and other aquatic organisms. Excessive sediments smother fish spawning beds and fill interstitial spaces that provide habitat for a variety of aquatic organisms. Suspended sediments absorb sunlight energy and increase water temperatures. In addition, nutrients (particularly phosphorus) adhere to sediments that wash in from eroded areas, which can lead to nuisance aquatic plant growth and algal blooms. To help prevent erosion and runoff of nutrients, healthy shoreline greenbelts are essential.

Shoreline greenbelts are essential for maintaining a healthy aquatic ecosystem. A greenbelt consisting of a variety of native woody and herbaceous plant species provides habitat for near-shore aquatic organisms as well as other shoreline-dependent wildlife. They also help stabilize shorelines against wave and ice action with their extensive network of deep, fibrous roots. Greenbelts provide shade to nearshore areas, which is particularly important for lakes with cold water fisheries. Lastly, and perhaps most importantly, greenbelts provide a mechanism to filter pollutants carried by stormwater from rain events and snowmelt. Another pollutant and nutrient delivery mechanism is a tributary.

The primary function of a tributary is to drain the landscape. Therefore, tributaries have a significant potential for influencing a lake's water quality as they are one of the primary conduits through which water is delivered to a lake from its watershed. Inlet streams may

provide exceptionally high-quality waters that benefit the lake ecosystem. Conversely, they have the potential to deliver polluted waters that degrade the lake's water quality. Outlet streams flush water out of the lake, providing the means to remove contaminants that have accumulated in the lake ecosystem. While conducting shore surveys, noting inlet tributary locations is very helpful when evaluating shoreline algae conditions because nutrient concentrations are generally higher in streams than in lakes. The relatively higher nutrient levels delivered from streams often lead to naturally heavier *Cladophora* and other algal growth in nearby shoreline areas.

Study Area

Located in the north eastern tip of the Lower Peninsula, Black Lake resides in Grant, Waverly, North Allis, and Bearinger Townships of Cheboygan and Presque Isle Counties. By surface area, Black Lake is the eighth largest inland Lake in the State of Michigan. While the Lake contains a surface area of 10,143 acres, it has a Watershed surface area of 357,000 acres (547 square miles). A ratio of the watershed size to the lake surface area can provide a descriptive measure of how susceptible a lake and its tributaries are to nutrient enrichment. A high ratio can suggest lakes are more susceptible to nutrient enrichment because of the increased opportunity for precipitation to contact soils and leach mineral before discharging into the lake. Black Lake's Watershed ratio is 35.04 (357,000/10,143 acres). Meaning, Black Lake has 1 acre of Lake surface for every 35.04 acres of its Watershed surface. This measurement does not consider water volume, but a watershed-to-lake-area ratio of 35.04 is relatively high for Northern Michigan Lakes. For comparison, Mullett, Charlevoix, and Burt Lakes contain watershed ratios of 9.74, 12.84, and 12.47, respectively. However, Black Lake is not as deep or large as either Lake. As a drainage lake, Black Lake contains some groundwater input, many important inflows, and one main outflow. The important inflows and outflow provide a mechanism to flush excess nutrients out of the system.

According to digitized bathymetry maps acquired from the Michigan Geographic Data Library, the deepest area of Black Lake is located directly in the southern basin with a maximum depth

of ~50 feet. Relatively shallow areas are found in the northern shore, toward the Lower Black River outflow (Figure 1).

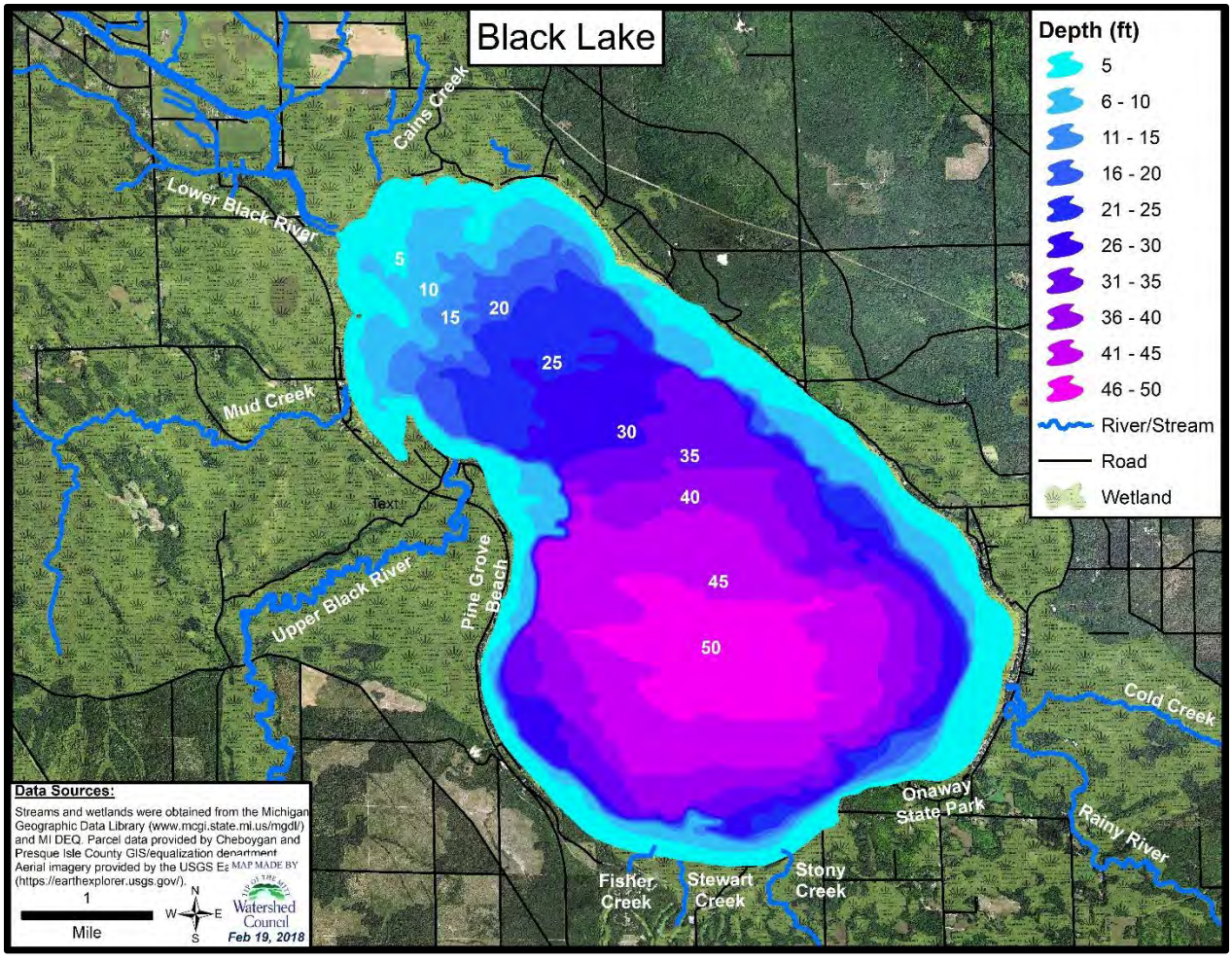


Figure 1 Map of Black Lake Depths (bathymetry) and Features

Black Lake contains eight primary inlets and one primary outlet. The Upper Black River and Mud Creek enter along the western shore. Fisher, Stewart, Stony, and Cold Creeks along with the Rainy River flow into the southern basin. Cains Creek flows in at the northern most basin. The only main outlet from Black Lake is the Lower Black River in the northern shore. The lower Black River then flows into the Cheboygan River and out to Lake Huron.

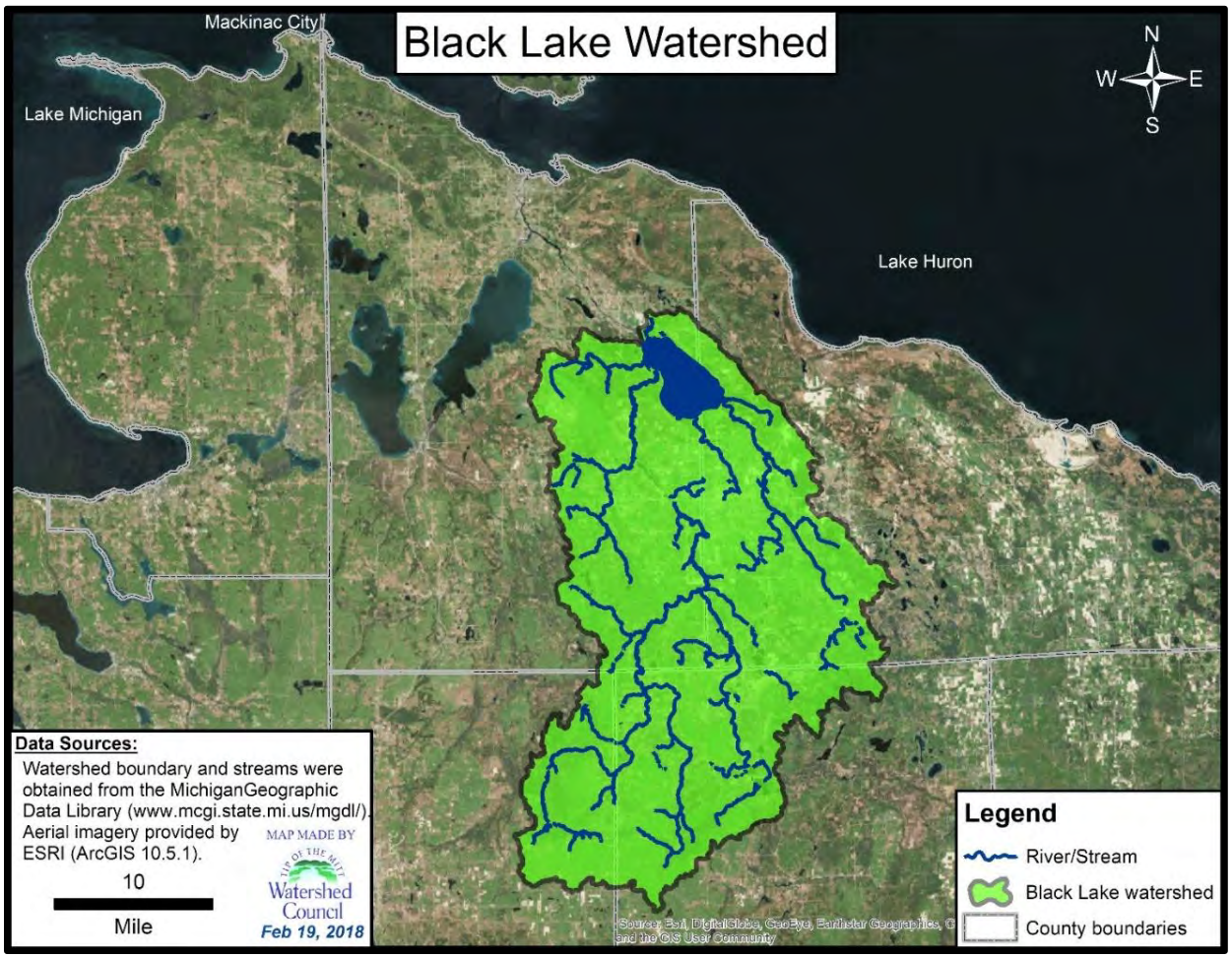


Figure 2 Map of Black Lake Watershed

Land cover statistics were generated for the watershed using data from the NOAA Coastal Great Lakes Land Cover Project (Table 1). Based on 2016 data, much of Black Lake's Watershed land cover is forest and wetlands (combined totaling 71.75%). There is some agricultural land cover (4.2%) and even less urban (1.33%). Since 1975, forested land has decreased about 9.17%, of which 4.13% occurring since the year 2000. Grassland and scrub/shrub land cover collectively have increased around 9.55%, likely as a result of logging. Other land cover categories have remained extremely consistent. Of particular importance is the stability of wetland cover within the Watershed.

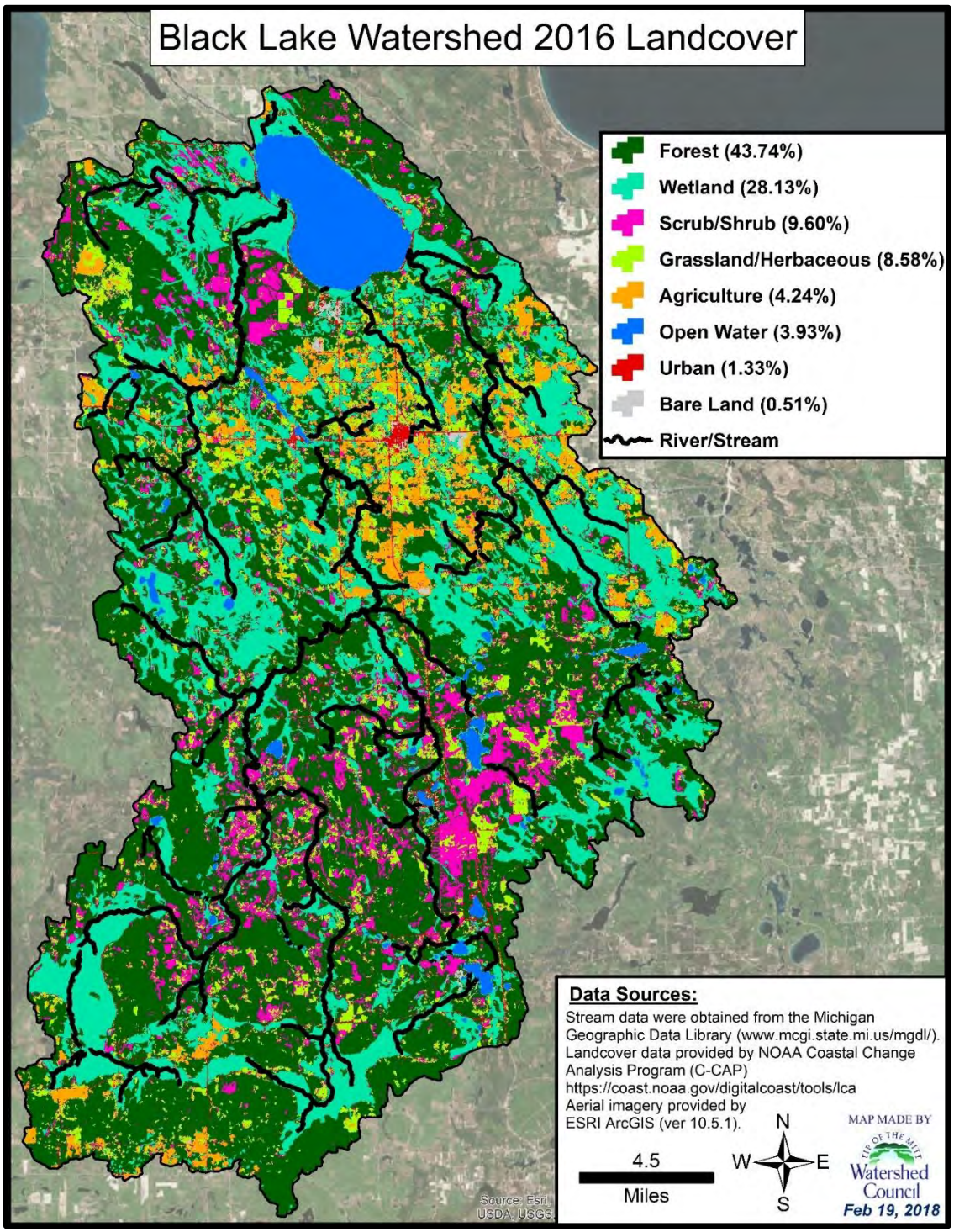


Figure 3 Black Lake Watershed Landcover – 2016

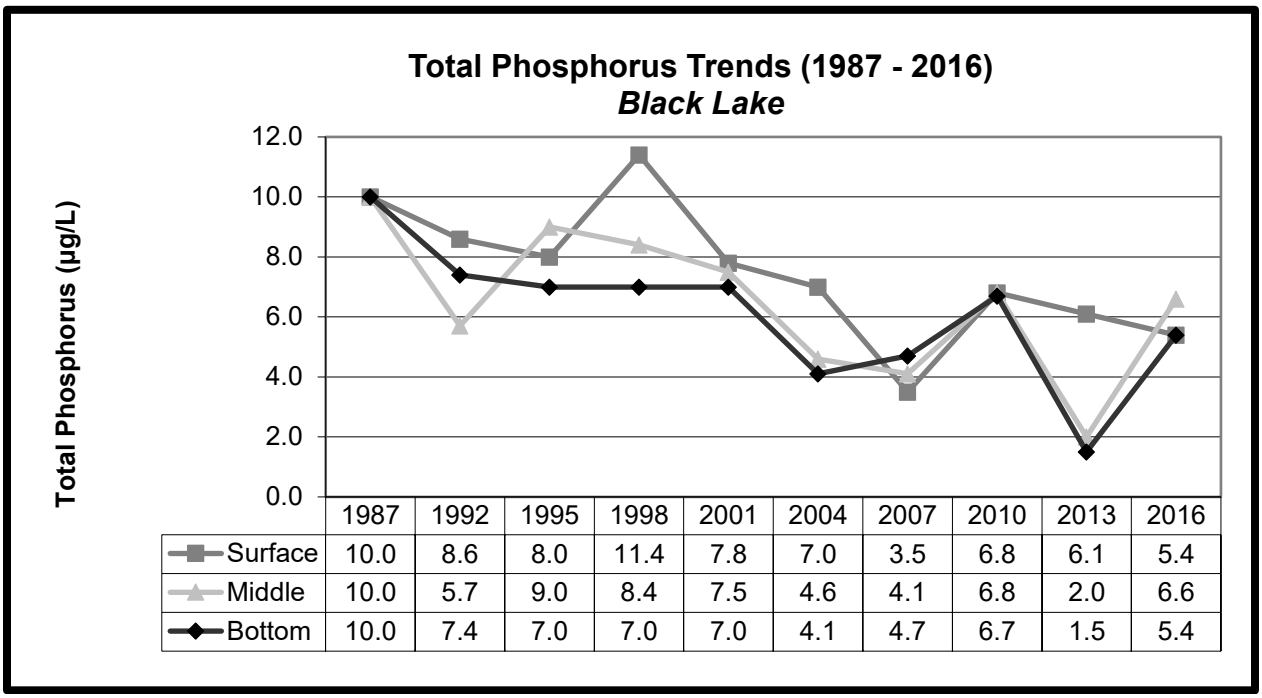
Table 1 Black Lake Watershed landcover change since 1975.

Land Cover Type	1975 (%)	1985 (%)	1996 (%)	2001 (%)	2006 (%)	2010 (%)	2016 (%)	% Change 1975 - 2016	**% Change 2000 – 2016**
Agriculture	4.90	4.93	5.08	4.26	4.25	4.24	4.24	-0.66	**-0.02**
Bare Land	0.39	0.41	0.42	0.49	0.50	0.51	0.51	0.12	**0.03**
Urban	1.18	1.19	1.23	1.33	1.33	1.33	1.33	0.15	**0.00**
Forest	52.91	50.90	48.79	47.87	47.36	45.71	43.74	-9.17	**-4.13**
Grassland	4.91	5.44	7.17	7.89	8.10	7.88	8.58	3.67	**0.69**
Scrub/Shrub	3.72	5.16	5.35	6.17	6.46	8.34	9.60	5.88	**3.44**
Wetland	28.04	28.01	27.99	28.11	28.11	28.12	28.13	0.09	**0.09**

Water Quality Data

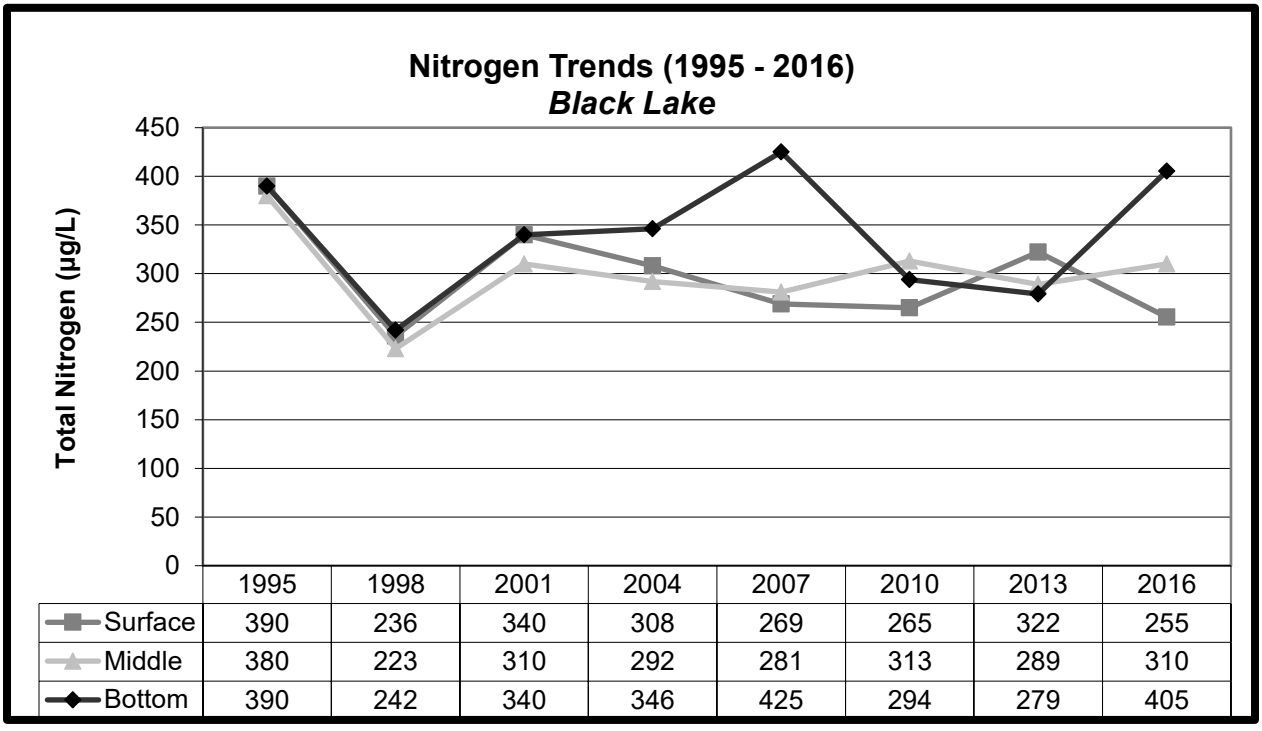
Volunteers have actively engaged with water quality monitoring programs coordinated by Tip of the Mitt Watershed Council. In addition, Watershed Council staff monitor Black Lake water quality as a part of the Comprehensive Water Quality Monitoring Program (CWQM). Volunteer Lake Monitoring and CWQM data began in 1986 and 1987, respectively.

From these programs, data clearly indicate Black Lake water quality remains high. Total phosphorous measurements collected as part of the CWQM program show decreasing concentrations throughout the last 20 years (Figure 4). Nitrogen monitoring began in 1995 and has remained relatively stable, ranging between 250 – 350 µg/L (Figure 5). Chloride measurements have been on the rise in recent years, which could be a result of winter roadside salt application and other nonpoint source pollution within the watershed (Figure 6).



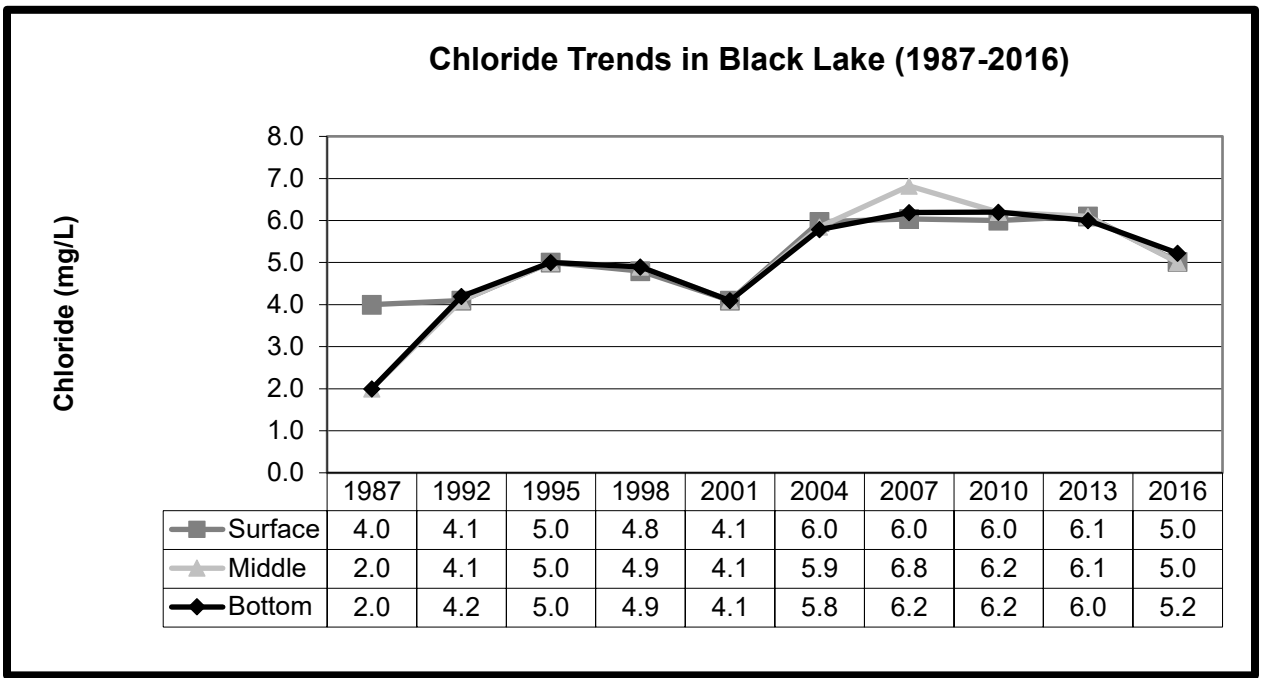
	1987	1992	1995	1998	2001	2004	2007	2010	2013	2016
Surface	10.0	8.6	8.0	11.4	7.8	7.0	3.5	6.8	6.1	5.4
Middle	10.0	5.7	9.0	8.4	7.5	4.6	4.1	6.8	2.0	6.6
Bottom	10.0	7.4	7.0	7.0	7.0	4.1	4.7	6.7	1.5	5.4

Figure 4 Black Lake Phosphorus Trends from 19987 through 2016



	1995	1998	2001	2004	2007	2010	2013	2016
Surface	390	236	340	308	269	265	322	255
Middle	380	223	310	292	281	313	289	310
Bottom	390	242	340	346	425	294	279	405

Figure 5 Black Lake Nitrogen Trends from 1995 through 2016



	1987	1992	1995	1998	2001	2004	2007	2010	2013	2016
Surface	4.0	4.1	5.0	4.8	4.1	6.0	6.0	6.0	6.1	5.0
Middle	2.0	4.1	5.0	4.9	4.1	5.9	6.8	6.2	6.1	5.0
Bottom	2.0	4.2	5.0	4.9	4.1	5.8	6.2	6.2	6.0	5.2

Figure 6 Black Lake Chloride Trends from 1987 through 2016

Since 1987, local volunteers have ventured out to Black Lake to record Secchi disk depth, temperature, and collect a water sample for a *chlorophyll-a* measurement. These data align with above nutrient data, indicating clear and clean water. However, these trends suggest Black Lake has become clearer, with reduced *chlorophyll-a*, and potentially less biological productivity in recent years. Secchi disk records the transparency (turbidity) of Black Lake by measuring the visibility in the water column. As can be seen in Figure 7, Black Lake transparency has slightly increased since volunteers first began recording these data in 1987. This indicates a clearing in the water column. *Chlorophyll-a* provides a measure of available food at the base of the lake ecosystem. Without *chlorophyll-a*, biological life in a lake can be hindered. While variable, *chlorophyll-a* values have decreased but could be rebounding within recent years (Figure 8). At the end of each sampling year, a trophic status index (TSI) is calculated (Figure 9). This value is a measure of biological productivity in a lake at the time of Secchi disk and *chlorophyll-a* sampling. A TSI value ranges from 0 to 100, where a score below 38 describes a lake devoid of nutrients, low biological productivity, and very clear water. A TSI score of 39 – 49 indicates a mesotrophic lake system. Mesotrophic simply means the lake has a moderate amount of nutrients. When nutrients become a problem and productivity becomes too high, a lake is

considered “eutrophic” (TSI value above 50). Black Lake has historically been in the mesotrophic category.

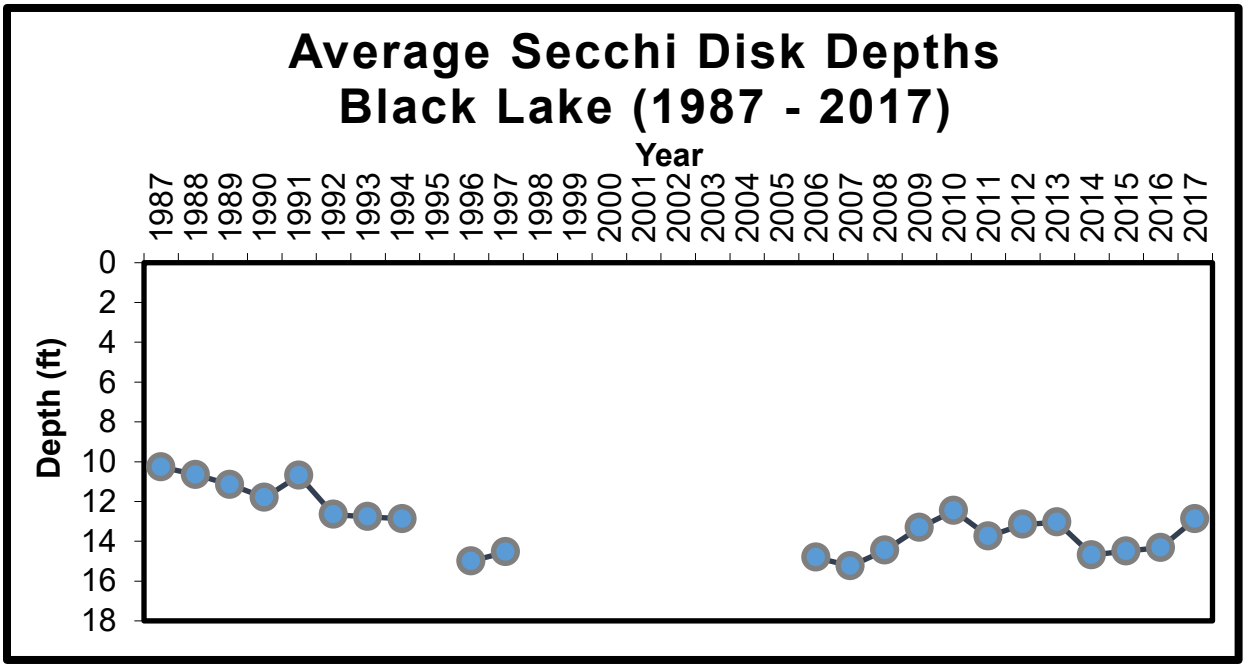


Figure 7 Average Secchi Disk depths collected by Black Lake Volunteers since 1987

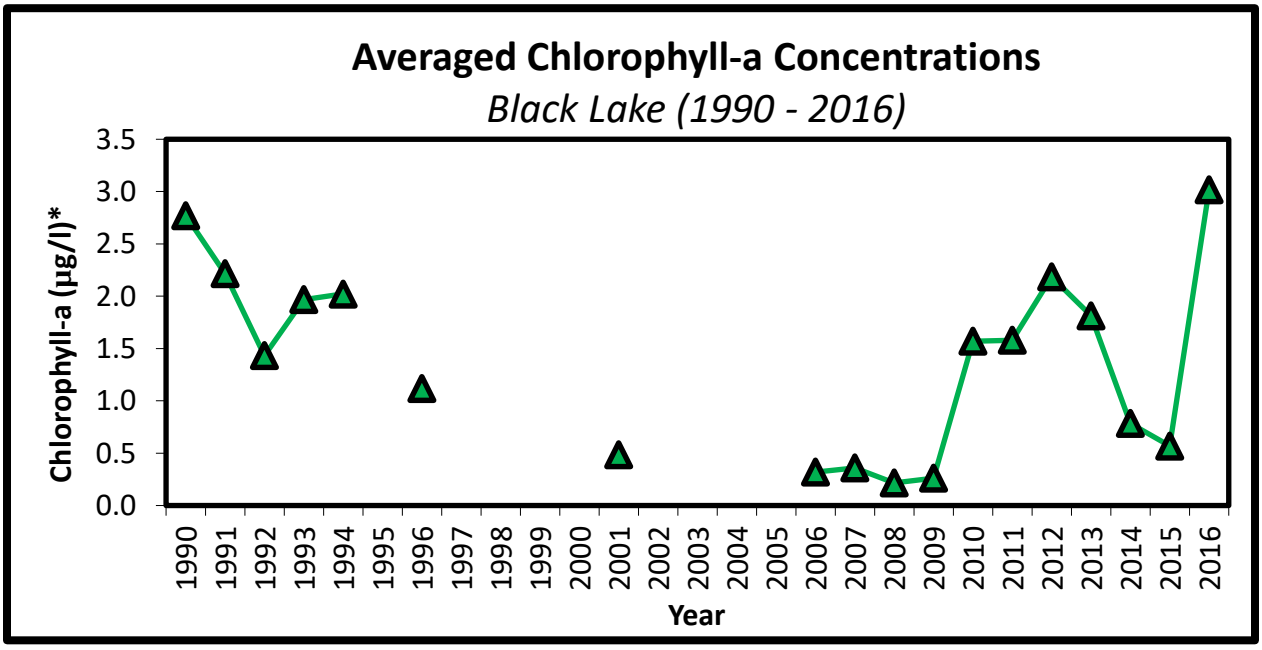


Figure 8 Average Chlorophyll-a concentrations collected by Black Lake Volunteers. Missing values indicate data not available for that particular year

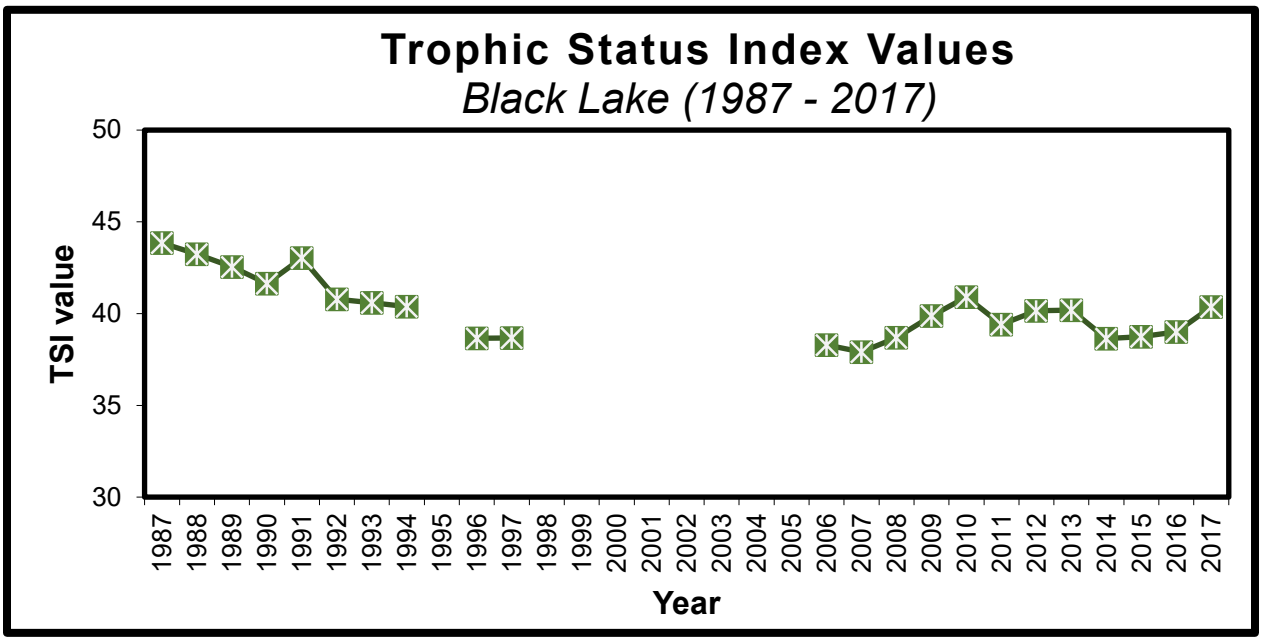


Figure 9 Trophic Status Index (TSI) from data collected by Black Lake Volunteers since 1987

SHORELINE SURVEY METHODS

Black Lake was surveyed by kayak during June and July of 2017 to document shoreline conditions. Shoreline conditions were surveyed by traveling as close to the shoreline as possible (usually within 20 feet) and noting *Cladophora* growth, substrate type, erosion conditions, greenbelt length, greenbelt depth, shoreline alterations, and tributaries. All information was recorded on field data sheets and subsequently compiled into a database. Field photos were geotagged, and recorded field data were linked to spatial data and in ESRI ArcGIS (v10.5.1) for analyses to be conducted to show where good and bad areas exist around Black Lake.

Parameters

Shoreline property features were documented by photographing and noting physical features on a data sheet. Developed parcels were noted on field data sheets and included as a separate column in the database. Properties described as developed indicate the presence of buildings or other permanent structures, including roadways, boat launching sites, and recreational properties (i.e.- parks with pavilions and parking lots). Properties with only mowed or cleared areas, seasonal structures (such as docks or travel trailers), or unpaved pathways were not

considered developed. Additionally, large parcels that had structures in an area far from the water's edge were not considered developed. The length and area of developed versus undeveloped shoreline was not calculated. After noting development status, *Cladophora* was identified in the area.

Many species of filamentous green algae are commonly found growing in the nearshore regions of lakes. Positive identification of the species usually requires the aid of a microscope. However, *Cladophora* usually has a unique appearance and texture that is quite distinct to a trained surveyor. These were the sole criteria upon which identification was based. Other species of filamentous green algae can respond to an external nutrient source in much the same way as *Cladophora*, though their value as an indicator species is not thought to be as reliable. When other species occurred in especially noticeable, large, dense growths, they were recorded on the data sheets and described the same as those of *Cladophora*.

When *Cladophora* was observed, it was described in terms of the length of shoreline with growth, the relative growth density, and any observed shoreline features potentially contributing to the growth. Both shoreline length and growth density are subjective estimates. Growth density is determined by estimating the percentage of substrate covered with *Cladophora* using the following categorization system:

Table 2 Categorization system for Cladophora density

Density Category	Field Notation	Substrate Coverage (%)
Very Light	(VL)	0 *
Light	(L)	1- 20
Light to Moderate	(LM)	21-40
Moderate	(M)	41-60
Moderate to Heavy	(MH)	61-80
Heavy	(H)	81-99
Very Heavy	(VH)	90-100 *

**Very Light is noted when a green shimmer is noticed on hard substrate, but no filamentous growth present. Very Heavy overlaps with heavy and is distinguished by high percentage of substrate coverage and long filamentous growth.*

Among other things, the distribution and size of each *Cladophora* growth is dependent on the amount of suitable substrate present. The extent of suitable substrate should therefore be taken into account when interpreting the occurrence of individual growths, and assessing the overall distribution of *Cladophora* along a particular stretch of shoreline. Substrate types were noted during the survey, using the following abbreviations: m = soft muck or marl, s = sand, g = gravel (0.1" to 2.5" diameter), r = rock (2.5" to 10" diameter), b = boulder (>10" diameter), and w = woody debris. Substrate suitable for *Cladophora* growth include the g, r, b, and w types. However, the extent of suitable substrate along a shoreline parcel in terms of distance was not documented. Erosion conditions were similarly noted along each shoreline.

Erosion was noted based on shoreline areas that exhibited: areas of bare soil, leaning or downed trees, exposed tree roots, undercut banks, slumping hunks of sod, excessive deposits of sediments, or muddy water. Similar to *Cladophora*, shoreline erosion was recorded on field data sheets with extent and relative severity estimates (light, moderate, or heavy/severe). For example "Mx20" indicated 20 feet of shoreline with moderate erosion. Additional information about the nature of the erosion, such as potential causes, were also noted.

Minor: exposed soils, gullies up to 1" deep.
Moderate: exposed soils, gullies > 1" & < 6", banks undercut by <6", minor slumping.
Severe: exposed soils, gullies > 6", banks undercut by > 6", severe slumping, tree fall

Greenbelts were rated based on the length of shoreline with a greenbelt and the average depth of the greenbelt from the shoreline into the property. Ratings ranged from zero to four and were based on the following.

Length	0: None, 1: 1-10%, 2: 10-25%, 3: 25-75%, 4:>75%
Depth	0: None, 1: <10 ft, 2: 10-40 ft, 3: >40 ft

Greenbelt ratings for length and depth were summed to produce an overall greenbelt score.

Tributaries were noted on the field data sheets and included in a separate column in the database. Additional information was included in the database in a "comments" column. The comments column also included notes about shoreline alterations. Shoreline alterations (structures) were noted with the following abbreviated descriptions:

SB = steel bulkhead (i.e., seawall)
CB = concrete bulkhead
WB = wood bulkhead
BB = boulder bulkhead
RR = rock rip-rap
BH = permanent boathouse
DP = discharge pipe

Data Processing

Upon completion of surveying the entire Black Lake shoreline, all field data were transferred to a Microsoft Excel® workbook. Digital photographs and GPS data were uploaded to a computer and processed for use. Linking field and equalization data allows shoreline conditions documented during the survey to be referenced by parcel identification number or parcel owner name. Field data were linked to Cheboygan and Presque Isle Counties parcel data in a Geographic Information System (GIS) with the aid of GPS and photographs.

In order to display survey results without pinpointing specific parcels, a new map layer was developed using the parcel map data layer acquired from the county equalization department and a Black Lake shoreline layer. The new map layer consists of a narrow band following the shoreline, split into polygons that contain field and equalization data. This data layer was overlaid with other GIS data from the State of Michigan to produce the maps contained in this report.

RESULTS

Following are results of the 2017 survey documenting shoreline conditions at 805 parcels on Black Lake. Approximately 88% (705) of shoreline properties on Black Lake were considered developed.

Cladophora

Noticeable growths of *Cladophora* or other filamentous green algae were found along the shoreline at 214 parcels (27% of total parcels surveyed; Table 3). At properties where *Cladophora* growth was observed, 70% (150 parcels) consisted of light or very light growth, whereas only 19% (42 parcels) had moderate to heavy growth.

Table 3 Cladophora density results

***Cladophora* Density**	**Parcels**	**Percent (%)**
Very light	92	43
Light	58	27
Light to Moderate	22	10
Moderate	26	12
Moderate to Heavy	11	5
Heavy	4	2
Very Heavy	1	<1

The few moderate to heavy patches of *Cladophora* growth were located along the western and northern shores of Black Lake (Figure 10). A few parcels along the eastern shoreline contained moderate *Cladophora* growth. Properties with little to no *Cladophora* growth were around the lake with large sections along the southern, western, and northern shorelines.

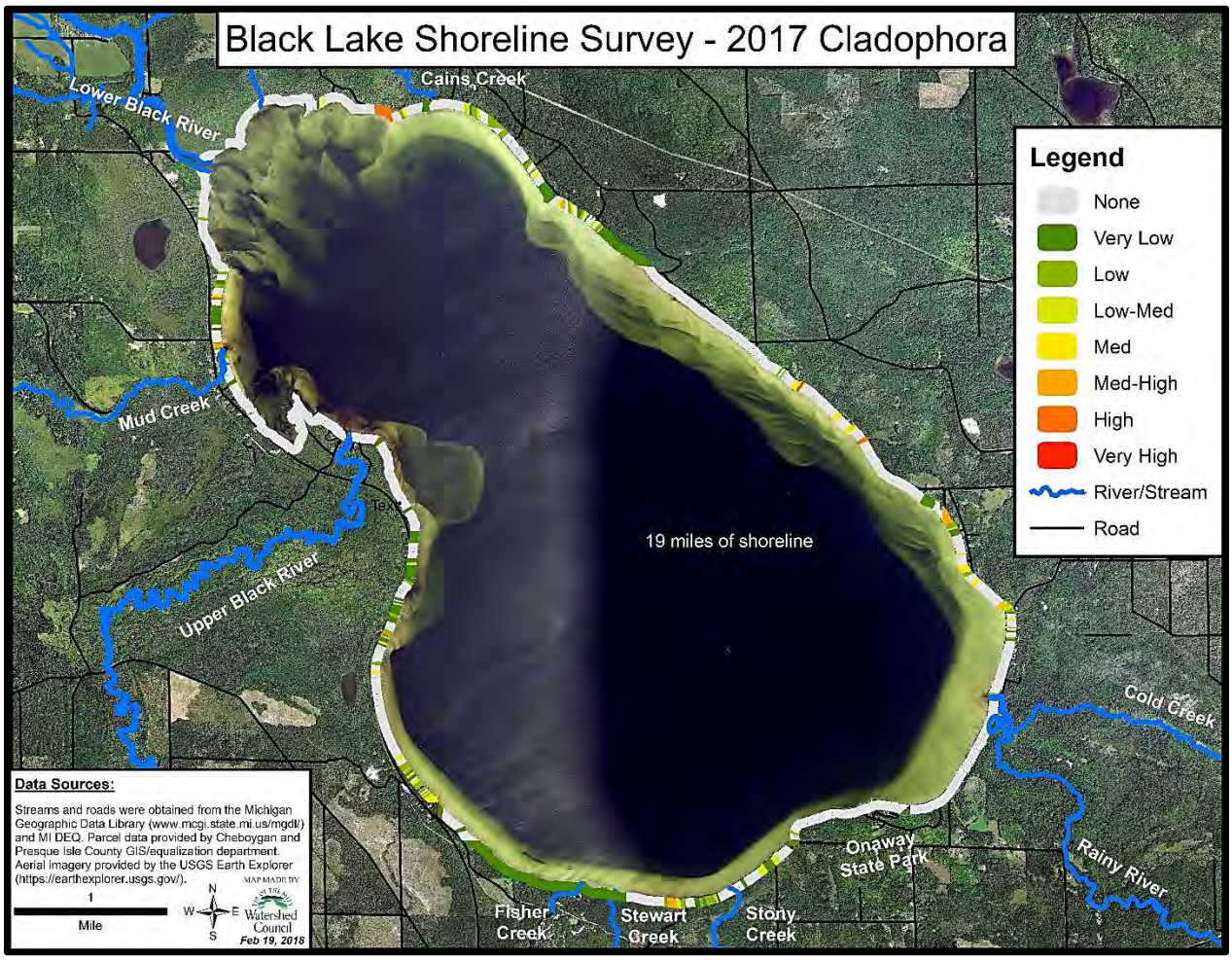


Figure 10 Cladophora density around Black Lake Shoreline

Interestingly, similar areas documenting *Cladophora* in 2018 were identified in the surveys of 1991 and 2001 (Figure 11), as well as 2005. These areas of concern are highlighted along the western shore. However, there appears to be fewer areas towards the south along the western shore.

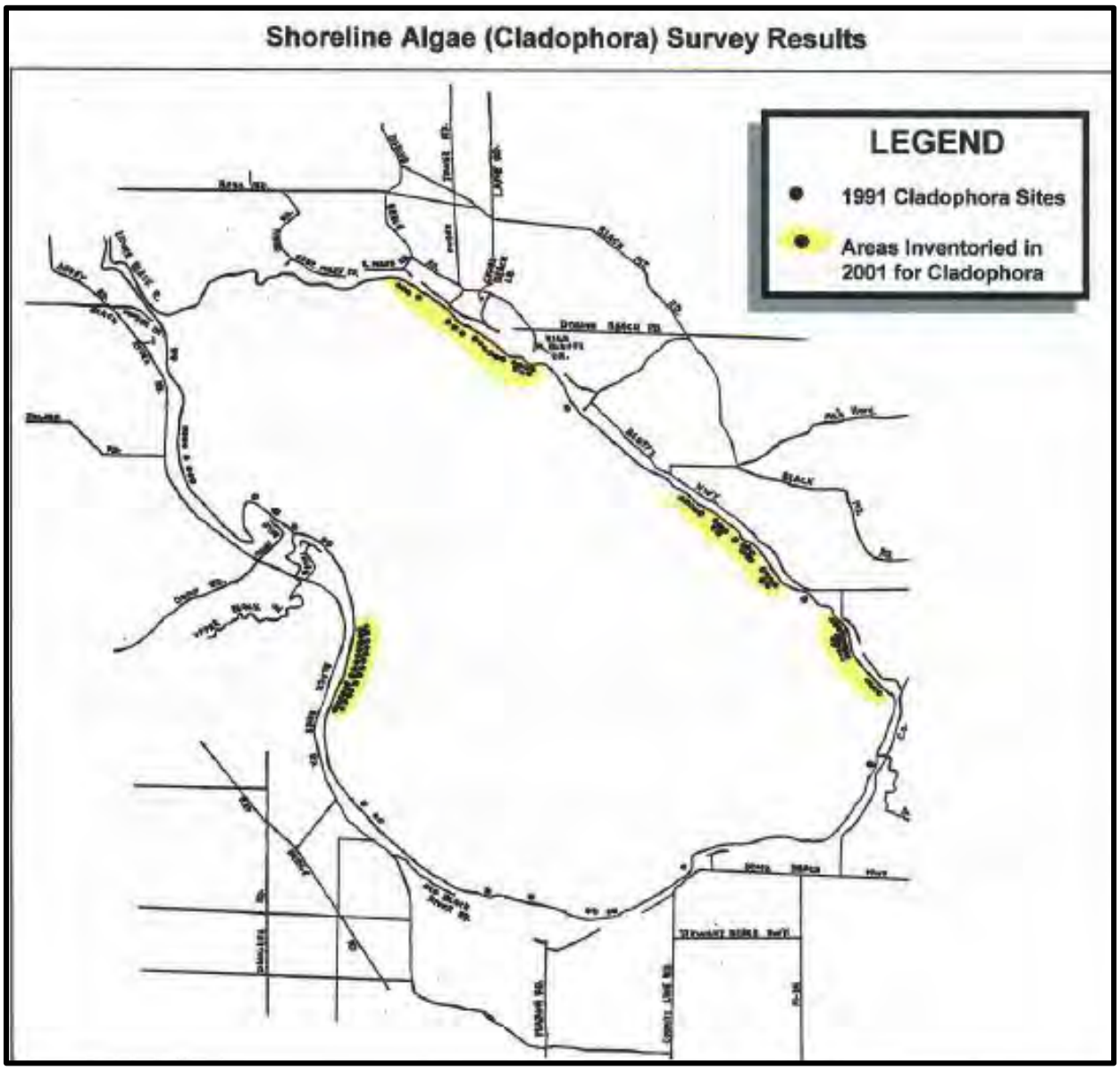


Figure 11 Cladophora from 1991 and 2001 survey

Greenbelt Scores

Greenbelt scores ranged from 0 (little to no greenbelt) to 7 (exemplary greenbelt). Only 30% of shoreline greenbelts along Black Lake were found to be in good or excellent condition (Table 4). Of 805 surveyed, 338 parcels (42%) received a greenbelt rating in the poor or very poor categories.

Table 4 Greenbelt rating results

Greenbelt Rating		Number of Parcels	Percent (%)
0	Very Poor (absent)	139	24
1-2	Poor	145	18
3-4	Moderate	228	28
5-6	Good	153	19
7	Excellent	86	11

Greenbelt status varied around Black Lake. However, many clusters of properties along the northern shoreline were ranked in the very poor (absent) to poor categories (Figure 12). Clusters along the western and southern shoreline were in the moderate to excellent rating.

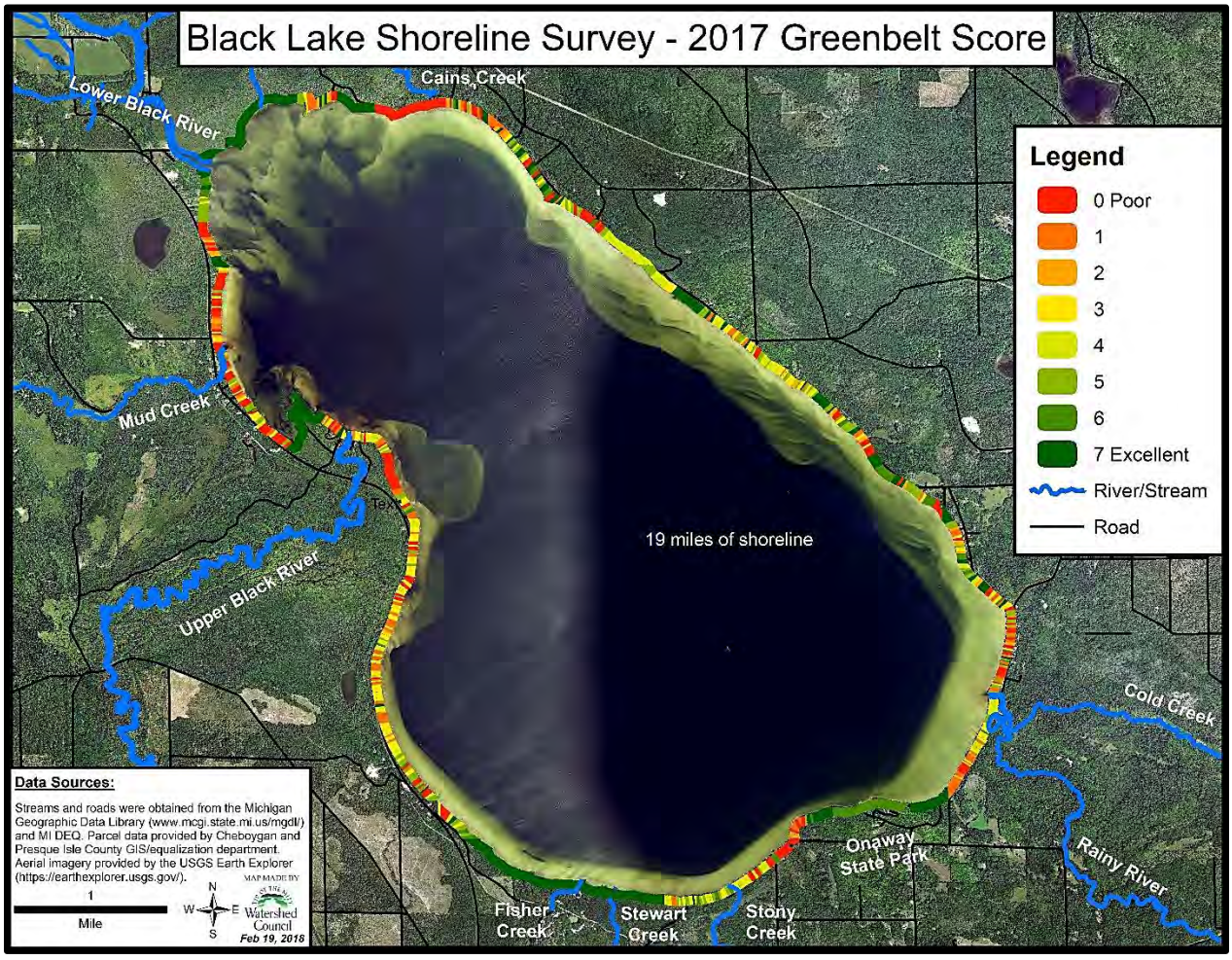


Figure 12 Greenbelt Scores around Black Lake shoreline

Shoreline alterations

Some form of shoreline alteration was noted at 80% of shoreline properties (Table 6). Of the alterations, 30% are rip-rap, while seawalls (wooden, concrete, or metal), account for approximately 28% of all shoreline alterations. Artificial beach sand is also noticeable around the shoreline.

Table 6 Shoreline alteration results

Alteration Type	Number of Parcels*	Percent With Alteration (%)*
Riprap (small)	25	3
Riprap (boulder)	105	13
Mixed riprap	115	14
Seawalls	223	28
'Artificial' Beach Sand	225	28
Discharge Pipes	68	8
Unaltered	164	20

**Numbers and percentages quantify alteration type, many parcels had multiple alterations*

Erosion

Erosion was noted at 361 parcels (45%) on the Black Lake shoreline (Table 6). Most of the erosion (37%) was classified as minor in terms of severity, while less than 1% of properties were considered severe. (Figure 13).

Table 5 Shoreline erosion severity results

Erosion Category	Number of Properties	Percent of Properties (%)
Minor	295	37
Moderate	56	7
Severe	10	<1
TOTAL	361	45

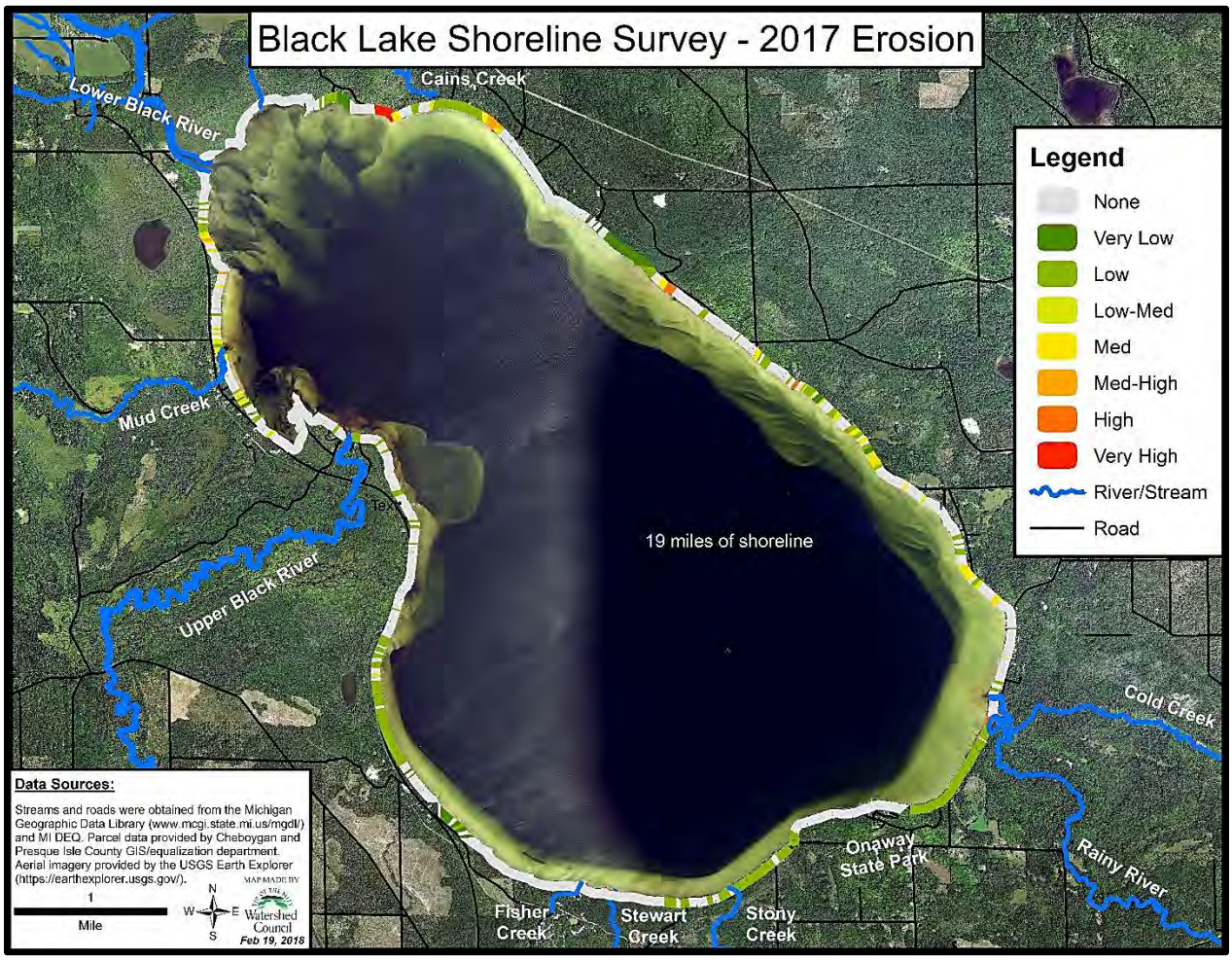


Figure 13 Erosion severity around Black Lake shoreline

DISCUSSION

In general, development of shoreline parcels can negatively impact a lake's water quality due to a multitude of factors. For Black Lake, the lack of native vegetation at water's edge is likely the greatest threat. Among the most serious impacts to water quality include:

1) Loss of vegetation that would otherwise absorb and filter pollutants in stormwater runoff as well as stabilize shoreline areas and prevent erosion.

2) Increased impervious surface area such as roofs, driveways and roads, which leads to greater inputs of stormwater runoff and associated pollutants.

3) Waste and byproducts of human activity such as septic leachate, fertilizers and decomposing yard waste that potentially reach and contaminate the lake water.

Clearly, there are many problems associated with development, but there are also many solutions for reducing or even eliminating impacts. Numerous best management practices have been developed that help minimize negative impacts to water quality and can be utilized during or after the development of shoreline parcels. A buffer of diverse, native plants can be planted/maintained along the shoreline to filter pollutants and reduce erosion. Impacts from stormwater generated from roofs, roads, and driveways can be reduced using rain barrels, rain gardens, grassy swales, and many other techniques. Leachate reaching the lake from septic systems can be minimized by pumping the septic tank regularly, having all components of the septic system inspected regularly and replacing the septic system when necessary. Mulch can be composted far from the shoreline and fertilizers applied sparingly, if at all.

Results from the 2017 shoreline survey indicate that some of the aforementioned issues may pose a threat to the water quality and overall health of Black Lake. Widespread removal of shoreline vegetation is the paramount concern. Over half (70%) of all shorelines exhibited greenbelts that were in poor, very poor, or moderate condition. Erosion is also a concern, with light to moderate erosion commonly occurring throughout the same areas most heavily impacted by vegetation removal. Algal indicators of nutrient pollution are far less extensive than the above issues. Although interestingly, the areas with documented *Cladophora* growth were similar to previous surveys, indicating potential for groundwater input or small changes to nutrient inputs. Future work should document what the nutrient load is to Black Lake as this information is relatively unknown. Fortunately, wetland areas surrounding Black Lake have remained intact.

Wetlands are incredibly important as they provide habitat for insects and other macroinvertebrates, amphibians and reptiles, waterfowl, and fish. Fish use wetlands as sources of food, protection from predators, and as spawning grounds. Waterfowl rely heavily on wetland areas during times of migration, to find food, and as protection. Wetland areas essentially act as a “nutrient sponge” and significantly help filter nutrients such as phosphorus and nitrogen before water enters Black Lake. Resiliency of Black Lake water quality could very

well depend on the wetland areas immediately surrounding the lake. Another issue to consider are septic system maintenance.

Outreach regarding septic system maintenance, phasing out of old systems, and properly siting new systems may be playing a role in reduction in nutrient pollution related to septic systems. Where human-caused nutrient pollution is occurring, the source has to be identified in order to address the problem. Although impeded by factors such as wind, wave action, currents, and groundwater paths, efforts by trained personnel to identify specific nutrient input from septic systems on individual properties are often successful.

Further improvements would benefit the lake's ecosystem and reduce impacts associated with increasing lakeshore development. The easiest, and perhaps most beneficial way would be to have native vegetation at water's edge. A lack of vegetation on the lake's shoreline, which provides habitat and acts as a food source, can impact the abundance and diversity of aquatic organisms, ranging from minute crustaceans to top tier predator fish. Furthermore, the absence of vegetation can lead to increased shoreline erosion and less filtration of pollutants. Although a large number of greenbelts are in poor condition, 11% of properties received a perfect score, indicating exemplary greenbelt health. Properties with healthy, intact greenbelts provide a model for improvement for other shoreline properties. Compared to other lakes in the region, Black Lake has a relatively high number of parcels exhibiting shoreline alterations, poor greenbelts, and a moderate level of *Cladophora* growth (Table 7).

Table 6 Shore survey statistics from Northern Michigan lakes

Lake Name	Survey Date	*Cladophora**	Heavy Algae*	Erosion*	Poor Greenbelts*	Alterations*
Beals Lake	2016	0%	0%	0%	17%	0%
Black Lake	2017	27%	2%	45%	42%	80%
Burt Lake	2009	47%	29%	4%	36%	46%
Charlevoix, Lake	2012	22%	19%	14%	34%	79%
Crooked Lake	2012	29%	26%	14%	51%	65%
Douglas Lake	2015	27%	6%	17%	53%	60%
Huffman Lake	2015	14%	0%	7%	57%	70%
Huron, Duncan Bay	2013	41%	2%	19%	45%	63%
Huron, Grass Bay	2013	0%	0%	4%	0%	8%
Lance Lake	2014	19%	0%	12%	35%	31%
Larks Lake	2006	4%	0%	ND	12%	29%
Mullett Lake	2016	44%	6%	36%	59%	76%
Pickerel Lake	2012	27%	33%	15%	52%	64%
Round Lake	2014	21%	0%	27%	44%	44%
Scotts Lake	2016	0%	0%	2%	18%	7%
Silver Lake	2014	3%	0%	70%	53%	65%
Six Mile Lake	2016	10%	24%	13%	41%	37%
Thumb Lake	2007	4%	0%	ND	ND	39%
Walloon Lake	2016	62%	2%	17%	39%	80%
Wildwood Lake	2014	5%	0%	22%	45%	50%
AVERAGE	NA	23%	11%	18%	41%	52%

**Percentages are in relation to number of parcels on the lake shore, except for "heavy algae", which is the percent of only parcels that had Cladophora growth. Erosion is the percentage of parcels with moderate to severe erosion and poor greenbelts include those in the poor or very poor categories. ND=no data.*

Although many properties on Black Lake are experiencing some form of erosion, the majority (82% of all erosion sites) are considered minor and less than 3% of all erosion is considered to be severe. Many properties with patches of lawn at water's edge experience a minor undercutting caused by waves and ice shove. Properties with artificial beach sand usually experience some loss of sand into the Lake, evidenced by small erosional rills leading into the Lake. Although not catastrophic, these types of minor erosion do have the ability to degrade the water and habitat quality of Black Lake. To prevent changes to the lake ecosystem, changes should be made in shoreline property management. Mismanagement of shoreline properties can degrade the lake's water quality, diminish fisheries, and even create an environment that

poses threats to human health. Therefore, Tip of the Mitt Watershed Council offers a number of recommendations.

RECOMMENDATIONS

The full value of a shoreline survey is only achieved when the information is used to educate riparian property owners about preserving water quality, and to help them rectify any problem situations. The following are recommended follow-up actions:

1. Keep the specific results of the survey confidential (e.g., do not publish a list of sites where *Cladophora* algae were found) as some property owners may be sensitive to publicizing information regarding their property.
2. Send a general summary of the survey results to all shoreline residents.
3. Organize and sponsor an informational session to present findings of the survey to shoreline residents and provide ideas and options for improving shoreline management practices that would help protect and improve the Lake's water quality.
4. Inform owners of properties with heavy *Cladophora* growths of specific results for their property, ask them to fill out a questionnaire in an attempt to interpret causes of the growth, and offer individualized recommendations for water quality protection.
5. Inform owners of properties with poor greenbelt scores and those with severely eroded shorelines of specific results for their property. Supply these property owners with information (e.g., brochures) regarding the benefits of greenbelts and/or the problems associated with erosion. Encourage property owners to improve greenbelts using a mix of native plants and to correct erosion problems. Property owners can contact the Watershed Council for more information on how to improve greenbelts and/or correct erosion problems.
6. Utilize the Internet and other organizations' websites to share survey information. A general summary report and this detailed report can be posted on websites because they do not contain any property-specific information. Property-specific information can be shared by randomizing and encrypting the shoreline survey database and providing

property owners with a code number that refers specifically to survey results from their property. The Watershed Council is available to assist with this approach.

7. Continue to support the Tip of the Mitt Watershed Council Volunteer Lake and Stream Monitoring programs by providing volunteer support. The information collected by volunteers is extremely valuable for evaluating water quality and determining trends. Lake residents are encouraged to continue supplying volunteer help and volunteers should attend training sessions held by the Watershed Council to ensure that a complete set of quality data is being collected each year.
8. Repeat some version of the survey periodically (ideally every 5 - 10 years), coupled with the follow-up activities described previously, in order to promote water quality awareness and good management practices on an ongoing basis. During each subsequent survey, more details about shoreline features are added to the database, which can be utilized for other water resource management applications.
9. The Michigan Natural Shoreline Partnership has developed a new educational tool called the Michigan Shoreland Stewards Program, which is a voluntary web-based survey designed to educate shoreline property owners on the importance of lake-friendly management practices. The survey asks questions related to management practices in each of the four sections of a shoreland property: upland, buffer, shoreline and lake. Responses to the questions are rated to determine the shoreland steward recognition level. A gold, silver, bronze or starter level rating can be achieved. Encourage Black Lake residents to visit www.mishorelandstewards.org to take the survey.

LITERATURE AND DATA REFERENCED

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Tip of the Mitt Watershed Council. 2005 A Nutrient Pollution Shoreline Survey on black Lake. Tip of the Mitt Watershed Council. Petoskey, MI. http://www.watershedcouncil.org/

Appendix A:

Watershed landcover change based on NOAA Coastal Change Analysis Program (C-CAP).

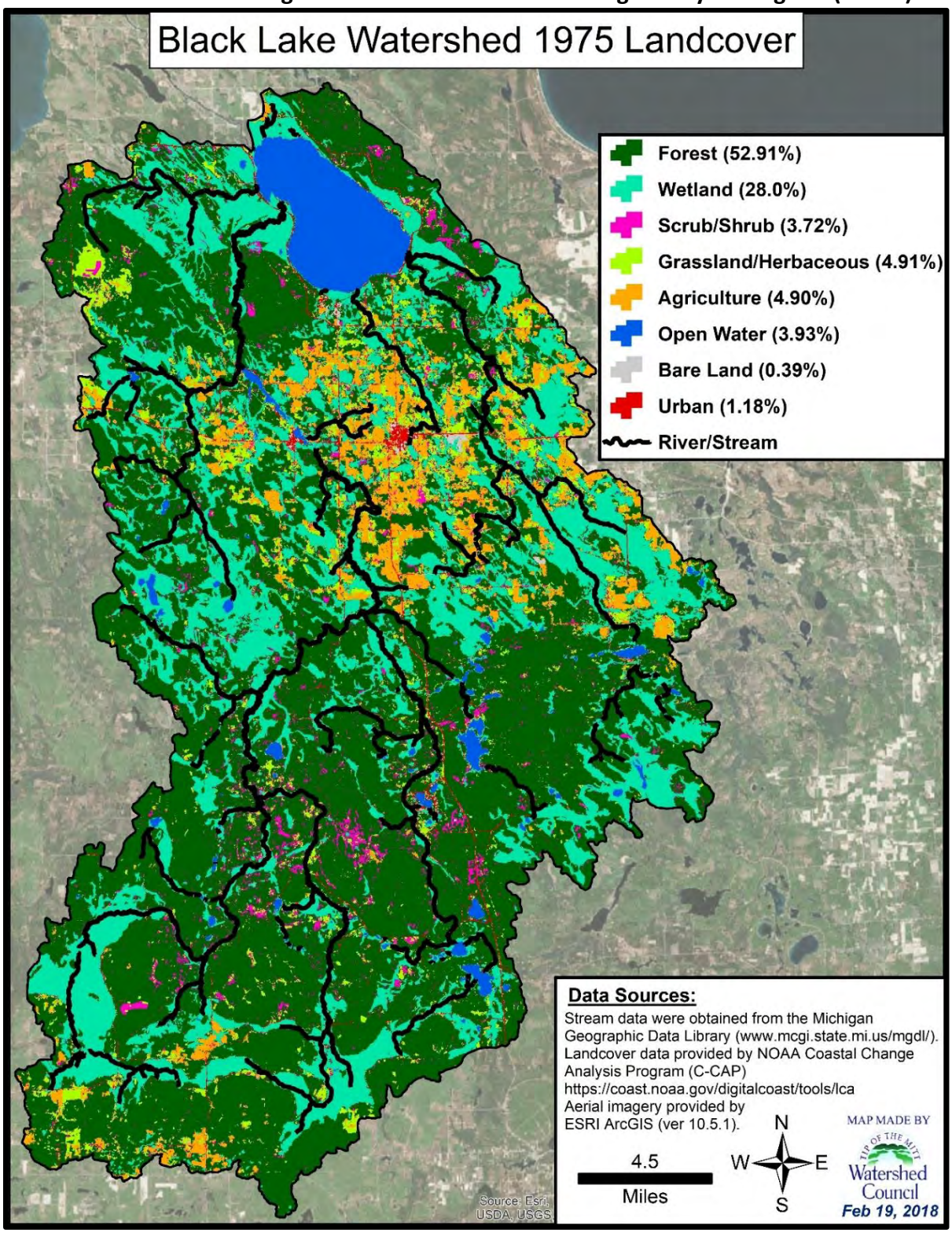


Figure 14 Watershed Land Cover Statistics, 1975

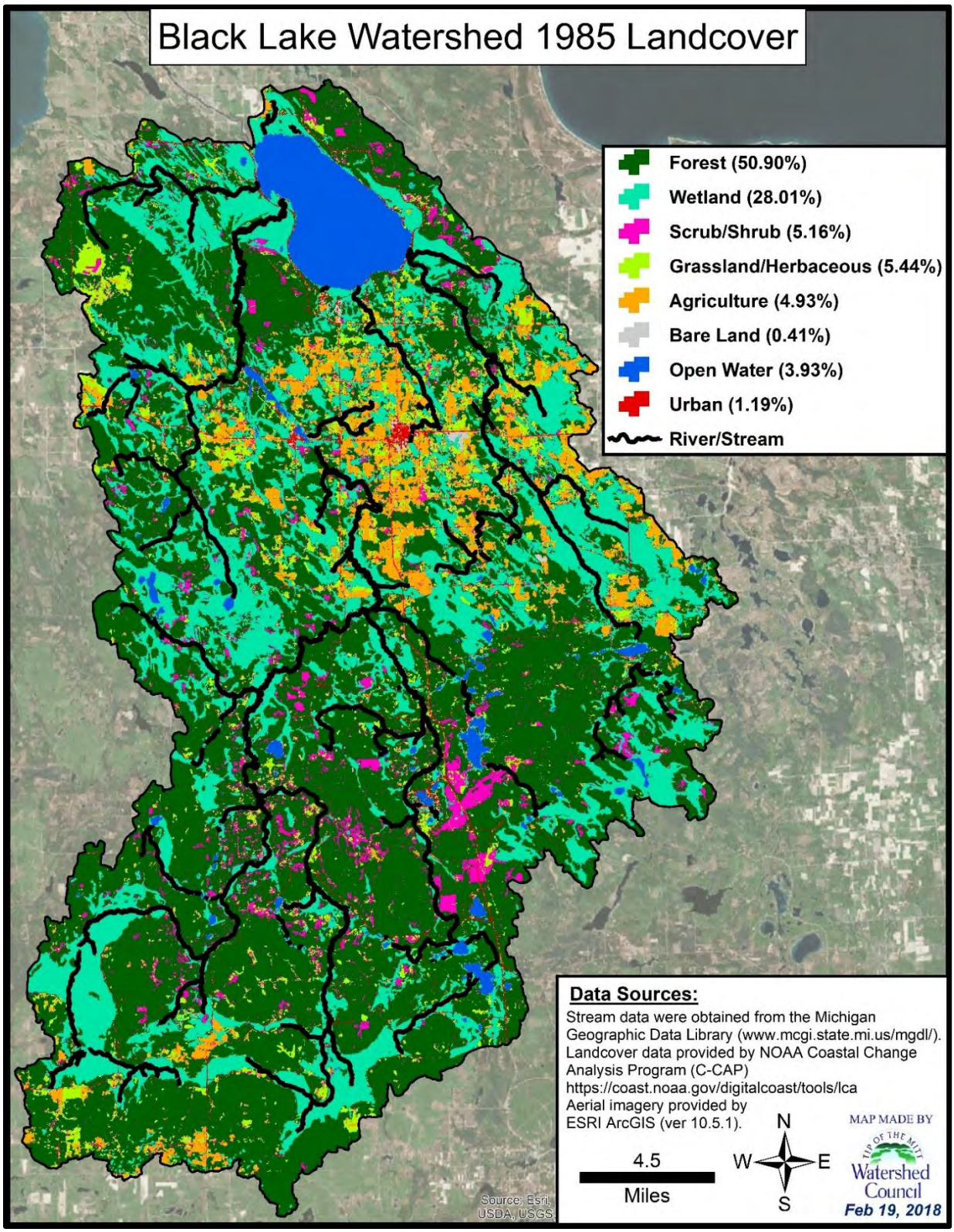


Figure 15 Watershed Land Cover statistics, 1985

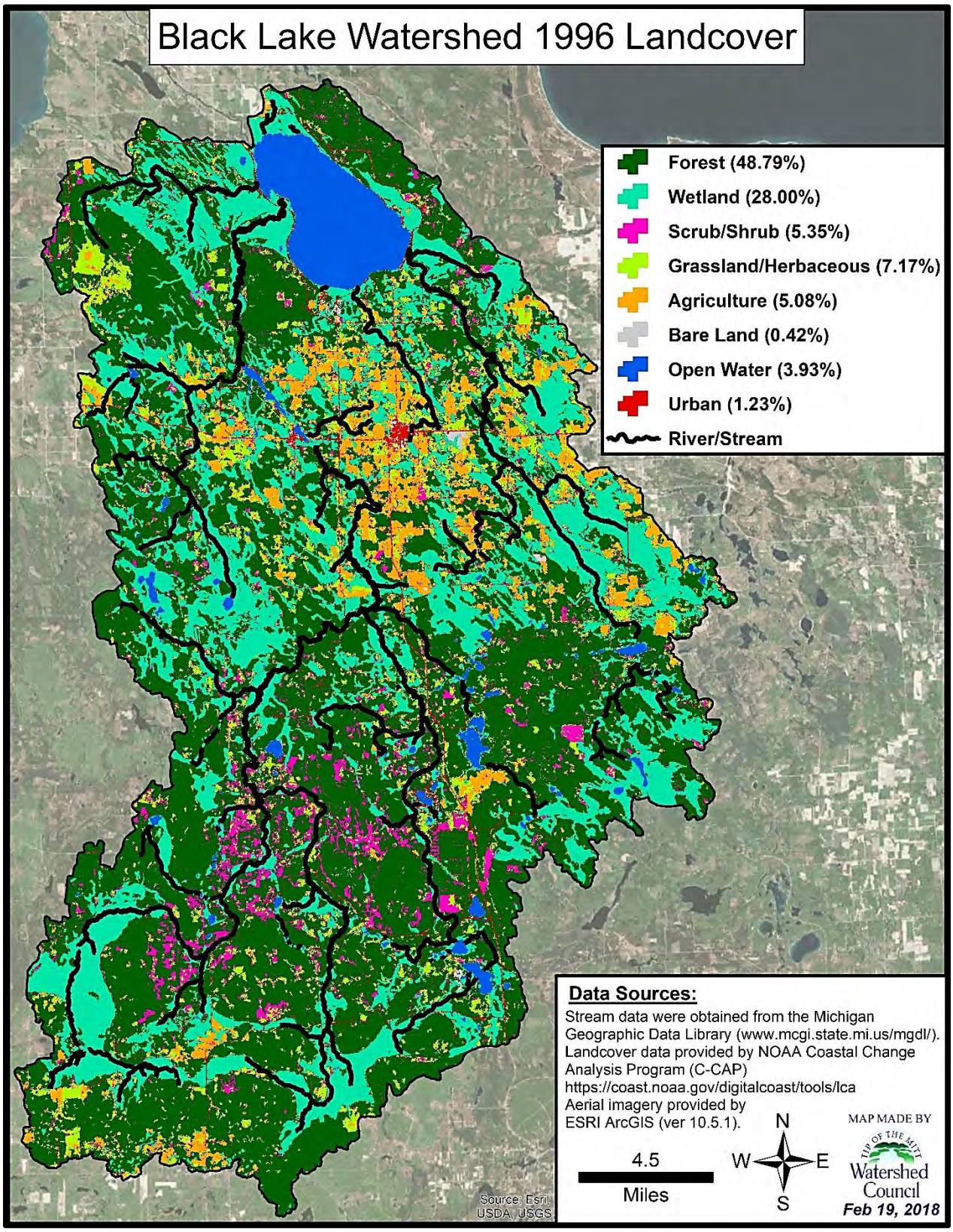


Figure 16 Watershed Land Cover Statistics, 1996

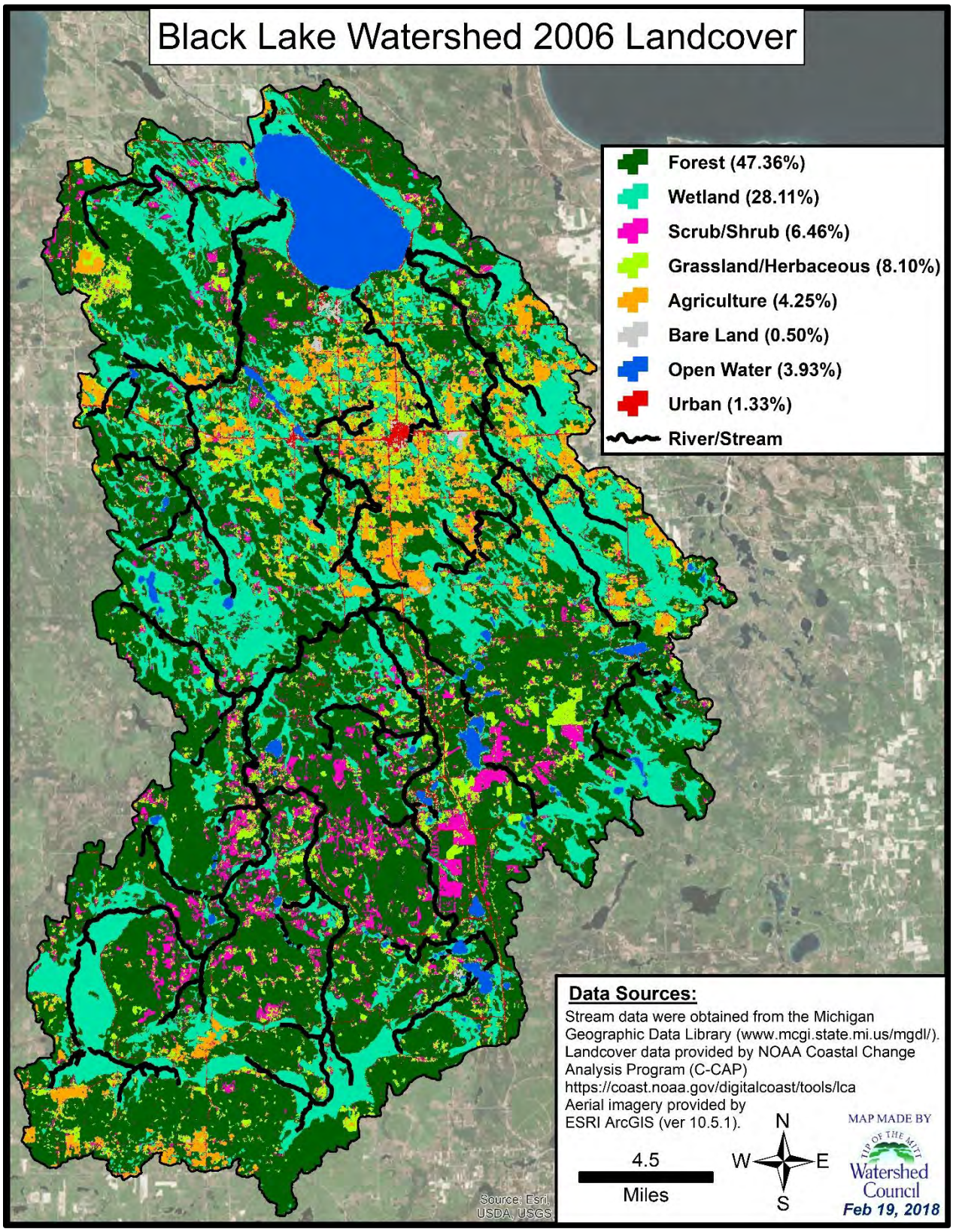


Figure 17 Watershed land cover statistics, 2006

Appendix F

2023 Black Lake Drone Shoreline Survey Analysis Report

freshwater solutions LLC
science • innovation • application

2023 Black Lake
Drone Shoreline Survey Analysis Report

Prepared by Ron Reimink, Freshwater Solutions, LLC

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Drone Survey Analysis

Using archived shoreline video footage collected via drone by Dennis Wiand (ZeroGravity Aerial, LLC) in 2023, comprehensive shoreline analysis was completed in March 2024. The shoreline was examined for the baseline features of: Natural Shoreline (NS), Greenbelt (GB), No Greenbelt (NGB); Sea Wall (SW), Rip Rap (RR), Inlet (IN), Drainpipe (DP), Lake Water Irrigation (LWI), Beach Sanding (BS), Detectable Algal Growth (DAG), Terrestrial Invasives (TI), and Erosion (ER). Each occurrence of these individual features was recorded by creating a color-coded “placemark” in Google Earth Pro. Each colored “placemark” was labeled with the feature name (abbreviated), number, low-altitude video descriptor, and time stamp. Table 1 shows the total number and percentages of properties (parcels) within each category. A brief description of each category follows. Using Google Earth Pro and county records, the number of lakefront properties were identified as 803 (large, publicly-owned parcels were counted as one parcel). The total number of parcels was then used to find the percentage of parcels with baseline features.

Aerial drone surveying of shorelines offers some distinct advantages over conventional methods. Archived footage can be revisited for years to come, providing valuable temporal comparisons. The .kmz files generated on Google Earth Pro provide powerful visual aids for educational purposes. Aerial images capture a more complete picture of the shoreline, giving a useful “birds eye view” of the area. Finally, aerial drone footage, analyzed with a consistent protocol, reduces subjectivity and provides for accurate lake-to-lake comparisons.

This analyzed survey provides invaluable information for lake association boards as they set water quality preservation goals. However, it does have a few limitations. There is some inherent subjectivity in qualifying shoreline types (Greenbelt, No Greenbelt, Natural Shoreline). In general, we gave lake frontage directly lakeward of each residence highest priority when classifying the shoreline (especially for larger parcels)

and generally used ~75% of frontage as necessary for inclusion in specific categories. Additionally, some shoreline features may be missed due to the angle of the camera, the camouflage nature of the feature, shadows, extremely high water levels, or simple human error. Even with those limitations, however, this report will provide the BLA board with a valuable tool for setting goals to help preserve water quality in Black Lake.

We would be happy to assist the BLA board in specific and realistic goal setting. In general, we would encourage an increase in Greenbelts and Lake Water Irrigation Systems while at the same time decreasing Beach Sanding, Sea Walls, Rip Rap and Drain Pipes. Through education over time, we believe it's possible to improve your numbers and make significant advances in water quality preservation on Black Lake.

This analysis might provide a good opportunity for BLA to create a video explaining the harmful practice of beach sanding, for example, and the benefits of greenbelts. The video could be shown at an annual meeting, or even just as an email blast with educational information included. We put together a summary (below) about the benefits of greenbelts if you care to use it. If funds are available, another idea would be to have a matching program, where your association matches up to a certain amount ($250, for example) of costs for any riparian who wishes to convert their frontage to a board-approved greenbelt.

As more lakes utilize this evolving drone-capture and computer analysis technology for shoreline surveys, the power of comparison will become increasingly beneficial. Table 2 below shows comparisons for 11 other regional lakes in NW Michigan. We plan to grow this comparison database in 2024 and beyond, providing even more benefit to BLA and others. We have also developed an algorithm whereby we can provide an actual numerical score for each lake. This will likely evolve as we learn more about how riparian practices impact water quality, but the comparison data found in Table 3 can give some initial insight for those lake associations participating.

Finally, it is important to understand that none of these categories or suggestions are meant to be divisive amongst Black Lake riparians. This survey is not meant to 'point a finger' at those people who have certain negative characteristics in their landscape. The most useful action steps are purely from an education standpoint of letting riparians know what is best for the lake and perhaps providing incentive for making an eco-friendlier landscape. **Our expectation is that just general information (percentages) will be shared with BLA membership and specific property information will only be accessed by a lake biologist or designated board members.**

Categories

Each county parcel (property) is classified as either *Natural Shoreline, Greenbelt, or No Greenbelt*. Beyond that, we documented noticeable *Erosion, Beach Sanding, Detectable Algal Growth, Drain Pipes, Rip Rap, Sea Walls, Inlets, Lake Water Irrigation*

Systems, and Terrestrial Invasive Plants. In all, we documented 1,896 total "placemarks" in Google Earth Pro.

We created a standard color scheme for the "placemarks" to be used on all future shoreline analyses across the state. In general, shades of *green* denote riparian-controlled *positive* attributes for preserving lake water quality, shades of *red* for riparian-controlled *negative* attributes, and shades of yellow for attributes we observed that are not directly controlled by individual riparians. Below are the standardized label colors.







Table 1: Category Site Numbers and Percentages of Parcels

Black Lake 2023		
Category	**Sites**	**Percentage of properties**
Natural Shoreline (NS)	91	11.3%
Greenbelt (GB)	21	2.6%
No Greenbelt (NGB)	691	86.1%
Sea Wall (SW)	172	21.4%
Beach Sanding (BS)	296	36.9%
Rip Rap (RR)	267	33.3%
Drain Pipe (DP)	107	13.3%
Lake Water Irrigation (LWI)	110	13.7%
Detectable Algal Growth (DAG)	51	6.4%
Erosion Evidence (EE)	64	8.0%
Inlet (IN)	17	2.1%
Terrestrial Invasives (TI)	9	1.1%
Total Parcels	803	
Total Placemarks	1896	

Table 2: NW Michigan Lake Comparisons

	L Traver.		Lime		Glen		Fisher		Elk		Skegemog		NLL		SLL		L. Herring		Cyrstal		Portage		Black	
Category	Sites	%	Sites	%	Sites	%	Sites	%	Sites	%	Sites	%	Sites	%	Sites	%	Sites	%	Sites	%	Sites	%	Sites	%
Natural Shoreline (NS)	30	20.6%	7	5.8%	106	14.5%	0	0.0%	199	22.2%	44	23.8%	166	33.9%	180	22.0%	51	44.0%	51	4.7%	43	11.2%	91	11.3%
Greenbelt (GB)	33	22.6%	35	29.2%	428	58.5%	47	80.0%	131	14.6%	12	6.5%	75	15.3%	63	7.7%	4	3.4%	24	2.2%	8	2.1%	21	2.6%
No Greenbelt (NGB)	82	56.2%	73	60.8%	198	27.0%	12	20.0%	565	63.1%	129	69.7%	248	50.7%	575	70.3%	61	52.6%	1015	93.1%	334	86.8%	691	86.1%
Sea Wall (SW)	11	7.5%	7	5.8%	15	2.0%	1	2.0%	54	6.0%	6	3.2%	29	5.9%	88	10.8%	9	7.8%	112	10.3%	169	43.9%	172	21.4%
Beach Sanding (BS)	15	10.3%	15	12.5%	116	15.8%	11	19.0%	147	16.4%	36	19.5%	72	14.7%	97	11.9%	22	19.0%	697	63.9%	50	13.0%	296	36.9%
Rip Rap (RR)	87	59.6%	49	40.8%	95	13.0%	8	14.0%	568	63.5%	132	71.4%	248	50.7%	422	51.6%	15	12.9%	738	67.7%	112	29.1%	267	33.3%
Drain Pipe (DP)	3	2.1%	6	5.0%	34	4.6%	0	0.0%	16	1.8%	3	1.6%	44	9.0%	71	8.7%	0	0.0%	43	3.9%	12	3.1%	107	13.3%
Lake Water Irrigation (LWI)	12	8.2%	2	1.7%	69	9.4%	0	0.0%	259	28.9%	43	23.2%	127	26.0%	158	19.3%	8	6.9%	102	9.4%	45	11.7%	110	13.7%
Detectable Algal Growth (DAG)	14	9.6%	13	10.8%	35	4.8%	0	0.0%	47	5.3%	16	8.6%	54	11.0%	36	4.4%	43	37.1%	102	9.4%	353	91.7%	51	6.4%
Erosion Evidence (EE)	1	0.7%	13	10.8%	95	13.0%	0	0.0%	8	0.9%	1	0.5%	N.A.	N.A.	N.A.	N.A.	6	5.2%	1	0.1%	3	0.8%	64	8.0%
Inlet (IN)	8	N.A.	14	N.A.	13	N.A.	2	N.A.	5	0.6%	0	0.0%	7	1.4%	36	4.4%	2	1.7%	8	0.7%	9	2.3%	17	2.1%
Terrestrial Invasives (TI)	8	N.A.	4	N.A.	0	N.A.	24	N.A.	N.A.	N.A.	N.A.	N.A.	16	3.3%	41	5.0%	0	0.0%	0	0.0%	0	0.0%	9	1.1%
Total Parcels	145		115		732		59		895		185		489		818		116		1090		385		803	
Total Placemarks	304		238		1204		105		1999		422		1086		1767		221		2900		1138		1896	

Table 3: Whole Lake Best Management Practice (BMP) Score Comparisons

	Whole Lake BMP Score								
Lake	NS	GB	LWI	SW	NGB	BS	RR	DP	Score
Glen	0.145	0.585	0.094	0.020	0.270	0.158	0.130	0.046	103.17
Fisher	0.000	0.800	0.000	0.020	0.200	0.190	0.140	0.000	104.00
Lime	0.058	0.292	0.017	0.058	0.608	0.125	0.408	0.050	80.11
Little Traverse	0.206	0.226	0.082	0.075	0.562	0.103	0.596	0.021	83.43
Elk	0.222	0.146	0.289	0.060	0.631	0.164	0.635	0.018	81.33
Skegemog	0.238	0.065	0.232	0.032	0.697	0.195	0.714	0.016	77.37
NL Leelanau	0.339	0.153	0.260	0.059	0.507	0.147	0.507	0.090	89.35
SL Leelanau	0.220	0.077	0.193	0.108	0.703	0.119	0.516	0.087	76.25
Lower Herring	0.440	0.034	0.069	0.078	0.526	0.190	0.129	0.000	90.58
Crystal	0.047	0.022	0.094	0.103	0.931	0.639	0.677	0.039	50.80
Portage	0.112	0.021	0.117	0.439	0.868	0.130	0.291	0.031	55.53
Black	0.113	0.026	0.137	0.214	0.861	0.369	0.333	0.133	58.85

Lake BMP Score Categories	Values
Outstanding	≥110
Working Towards Excellence	100 to 110
Educating for Change	90 to 100
Potential for Great Improvement	<90

*It is important to understand that this Whole Lake BMP Score is a gauge for how well individual riparian properties are being managed on a lake, by a lake biologist or shoreline stewardship committee. Percentages for each category are computed by dividing the total found for each item by the number of parcels identified around the lake. Should you want to compute a "lake health" score, for example, you would need to take into consideration other things such as detectable algal growth, terrestrial invasives, erosion, water chemistry parameters, etc. Again, it is important to understand that this whole lake BMP score is designed to **educate and motivate private riparians** as a "team" (with leadership from their lake association) and to motivate them to improve their own individual shoreline for the good of all. If individuals want to know how well they are doing individually, we suggest they use a tool such as one provided by the Shoreline Stewardship Program, where they can "score the shore" for their own property.

Category Explanations

Natural Shoreline (NS)

This is shoreline left mostly in its natural state and untouched by humans.

Greenbelt (GB)

Please see Appendix 1 for a more detailed description of a greenbelt.

No Greenbelt (NGB)

We recorded the number of properties that did not have a greenbelt or natural shoreline between their lawn and the water. For our standardized analysis, a greenbelt must be at least 10 feet deep and cover at least 75% of the lake frontage. Other groups define a greenbelt using different criteria that are more constraining. See Appendix 1 for more information about greenbelts and why they are important. A major goal to improve and maintain lake health would be to increase the number of properties that have a greenbelt.

Sea Wall (SW)

Sea walls are a barrier at the water's edge, generally consisting of wood, steel or concrete. We included rock seawalls in our analysis if they were of a vertical nature and wouldn't pass the "turtle test" (a barrier with a slope a turtle could climb to reach dry land). Sea walls are not usually necessary and cause excess damage to neighboring lake frontage due to redirection and concentration of wave energy. Most lake biologists agree they are the most damaging action a riparian can take for lake ecosystem health.

Beach Sanding (BS)

These are shorelines where beach sand has been either brought in or sandy soil maintained to create an unnatural sandy beachfront. A permit is necessary for adding sand artificially because of the negative impact it has on the lake ecology. Much of the sand can get washed into the lake and dispersed in the winter or after a heavy rain, causing more sand to be needed each year. Often there is no barrier between runoff waters and the lake, and any chemicals or nutrients in runoff water will immediately drain into the lake.

Rip Rap Barriers (RR)

Rip rap is usually defined as a rock barrier at the water's edge (of any size) that is not natural. This has historically been a popular way to minimize erosion, but more ecofriendly methods have recently been developed. We recommend having a greenbelt, using coir logs, or doing bioengineering that help a greenbelt take hold.

Drain Pipe (DP)

Drain pipes are often used to direct stormwater away from dwellings and into the lake. Tiles are placed underground around a structure to filter water towards the drain. This

can put excess runoff and nutrients into the lake, since the water is not filtered through soil, and plants do not have a chance for nutrient uptake. Drain pipes are sometimes difficult to identify and are often well hidden by rip rap or vegetation.

Lake Water Irrigation (LWI)

If riparians feel the need to have a manicured lawn, a lake water irrigation system is better than well water. This utilizes nutrient-rich water from the lake, eliminating the need for fertilizer application.

Detectable Algal Growth (DAG)

Detectable algal growth may indicate an excess of nutrients (often phosphorus) in the water. It is not always clear where the nutrients are coming from, so riparians or a lake biologist may want to gather more information to help identify the species and source of the algal growth. These areas will be interesting to watch if future drone surveys are completed to see if they are consistently present, growing, or if they were just a short-term occurrence.

Erosion Evidence (EE)

Erosion is natural and not necessarily a bad thing, but it is something that can be monitored and documented for rapid changes due to more regular and severe weather events. Large lakes near the Lake Michigan coast often experience more severe erosion. Riparians often mend minor erosion damage during spring clean-up, so not all erosion damage can be documented unless a drone survey is completed soon after ice out in the spring.

Inlet (IN)

Inlets are natural and positive for the lake, but excess nutrients through an inlet can cause problems. It is sometimes difficult to detect small stream inlets due to camera angle and heavy vegetation.

Terrestrial Invasive (TI)

Timing of the drone survey is critical for identifying terrestrial invasive plants. For example, Yellow Flag Iris usually blooms in late May and Purple Loosestrife later in the summer in our region. This 2023 survey was completed when some terrestrial invasive species were not blooming. Therefore, only 9 colonies were observed.

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Black Lake Analysis Nuances

One thing we have learned from conducting various research projects on several dozen lakes over the last 40 years, is that each lake is unique and "one size fits all" does not apply to most lake problems. We are finding the same thing to be true when analyzing aerial drone footage for shoreline surveys. When analyzing the aerial drone imaging on Black Lake, we documented the following nuances:

Beach Sanding: The soil is naturally very sandy in most places, so we recorded beach sanding as any area near shore that looked like it was maintained as sand (plants discouraged or not allowed to grow), even if sand was not artificially brought in.

Rip Rap: Some shorelines were naturally rockier, so we recorded rip rap as any area with rocks that were intentionally moved into piles (often on property corners), larger in size, or wider in scope.

County Parcels: The parcel data supplied by Cheboygan and Presque Isle Counties were sometimes difficult to understand due to beach access across a road or a narrowing of property at the lake front. We had to make some subjective decisions for a few parcels. The property labeled Union Building Corp. was considered only one property, however we did document multiple placemarks for some categories.

Detectable Algal Growth and Shadows: Some of the shoreline video had strong shadows near shore, making it difficult at times to distinguish between shadows and detectable algal growth. We only recorded detectable algal growth when it was most definitive. It is quite possible some algae were passed over in the shadows.

Miscellaneous Notes: Properties with plants in the water yet mowed up to the water's edge were counted as No Greenbelt. Also, NGB 140 and 140.5 were labeled as such due to an analyzing error. Therefore, NGB total is 691 (not 690 as you will see on the .kmz file). Stones cemented together were labeled as Seawall. Rip Rap was difficult to discern in some cases due to a naturally rocky shore (see note above under Rip Rap). Beach Sanding was also subjective due to very sandy soil in some areas (see note above under Beach Sanding). Erosion was only documented if obvious and extensive. Some Inlets may have been missed as only those obvious on the drone footage were recorded. On drone segments 12 & 13 (around the peninsula by the river), we didn't record any category twice even though some properties have two "waterfronts". Finally, for drone segments 17 & 18 (Union Building Corp.), we did not split the shoreline into separate lakefront types (GB, NGB, NS), but we did document more than one of some other categories.

Appendix 1: What is a Greenbelt?

This brief summary is meant to serve as a template that could be used to send out to lake association members to start educating them on the importance of greenbelts.

What is a greenbelt?

A greenbelt is a strip of land (no smaller than 10 feet deep for our analysis) along the shoreline that is dominated by native vegetation. It acts as a buffer zone between a manicured lawn and the lake. One benefit of a greenbelt is to control shoreline erosion. The roots of plants hold the soil and sand in place. Another benefit is its ability to stop nutrients from leaching into the lake. Having too many nutrients can lead to nutrient loading and possible algal blooms. Other noteworthy benefits include providing a natural habitat for insects and larger animals and for deterring geese from easily accessing the mown lawn. Plus, it reduces cost and time spent manicuring a lawn, leaving more time for recreation!

What plants should be included in a greenbelt?

There are many beautiful perennial plants that can be included in a greenbelt. Plants should only be used if they are native to the area. These do not need to be trees that block your view of the lake, but can be low shrubs or beautiful flowering plants.

Does an entire shoreline need to be a greenbelt?

Of course, there needs to be accessibility to the lake and any amount of greenbelt is better than none! It is suggested that at least 75% of your shoreline is covered with a greenbelt, leaving plenty of space for water accessibility and recreation. The more greenbelt the better!

How can my frontage become a greenbelt?

Contact your lake biologist or designated shoreline steward. They would love to come to your property and discuss ideas to incorporate a greenbelt into your landscape! For more information about greenbelts, check out the Tip of the Mitt's website found at: *https://www.watershedcouncil.org/greenbelts.html* or the Michigan Natural Shoreline Partnership website at: https://www.mishorelinepartnership.org/.

Appendix G

Social Indicator Survey Results

Black Lake Watershed Social Indicator Survey Results 2024

Surveyed Population Information

The Black Lake Watershed Resident Social Indicator Survey was available online from July 19, 2024, though November 11, 2024. Through various outreach efforts, the Watershed Council was able to garner 77 responses. The average age of the surveyed population was 64, and 51.47% of those surveyed had at least a 4 year college degree (Table 1). Of those surveyed, 94% claimed to be the decision maker of the household. The majority (56.72%) responded that they live in an isolated, rural, non-farm residence within the Watershed (Table 2). When the surveyed population was asked where they seek information on water quality, the top two responses were the internet (28.08%), and newsletter/brochure/factsheet (22.60%) (Table 3). In the future, these two sources should continue to be used to distribute information in the Watershed.

Table 1: Demographics of Surveyed Population

Demographics	**Surveyed Population**
Age	Average age 64.18
Education (4 year college degree or higher)	51.47%

Table 2: Location of Residences of the Surveyed Population

Response	**Frequency**	**Percentage**
In a town, village or city	11	16.42%
In an isolated, rural, non-farm residence	38	56.72%
Rural subdivision or development	13	19.40%
On a farm	5	7.46%

Table 3: Sources respondents seek for water quality information

Response	**Frequency**	**Percentage**
Newsletters/brochure/factsheet	33	22.60%
Internet	41	28.08%
Radio	5	3.42%
Workshops/demonstrations/meetings	12	8.22%
Conversations with others	14	9.59%
Trade publications/magazines	31	21.23%
None of the above	10	6.85%

Survey Results

In the survey, respondents were asked about the current health of the Watershed. When asked to rate the current health from “very poor” to “very good,” the majority (58.82%) claimed the Watershed’s health to be “good” (Table 4). The surveyed population was also asked their opinion on the current trend for conditions within the Watershed. Results in Table 5 show the majority (59.15%) of respondents claimed the Watershed conditions are “slowly improving.” This majority opinion is different from results on the same question in the 2023 Social Indicator Survey distributed by students from the University of Michigan School for Environment and Sustainability (SEAS). The 2023 SEAS survey found that 58.5% of respondents had the opinion that Watershed conditions were “Slowly worsening,” indicating that citizens had concerns about the Watershed’s future.

Table 4: Respondents’ Opinion on the Current Health of the Watershed

Current Health of the Watershed	**Frequency**	**Percentage**
Very Poor	0	0.00%
Poor	3	4.41%
Okay	15	22.06%
Good	40	58.82%
Very Good	10	14.71%

Table 5: Respondents’ Opinion on the Trend for Conditions in the Watershed

Trend for Conditions in the Watershed	**Frequency**	**Percentage**
Worsening	0	0.00%
Slowly worsening	3	4.23%
Staying the same	16	22.54%
Slowly improving	42	59.15%
Improving	10	14.08%

Surveyed Population Awareness

Consequences of Poor Water Quality

This section of the survey details how poor water quality can lead to a variety of consequences for the community. Those surveyed were asked to rank a variety of issues from not a problem (1) to severe problem (4). It is important to note that responses marked as “don’t know” were excluded from the results in this section. Based on the results in Table 6, respondents were most concerned about poor water quality leading to excessive aquatic plant or algae growth, and the loss of desirable fish species. The surveyed population was least concerned about contaminated drinking water being a consequence of poor water quality in the Watershed.

Table 6: Consequences of Poor Water Quality

Consequence of Poor Water Quality	**Mean**	**Standard Deviation**
Excessive aquatic plant or algae	2.32	1.08
Loss of desirable fish species	2.18	1.15
Reduced beauty of lakes or streams	1.88	1.08
Polluted swimming areas	1.82	0.94
Contaminated fish	1.79	1.01
Reduced opportunities for water recreation	1.78	0.98
Contaminated drinking water	1.36	0.75

Water Impairments

The water impairment section of the survey lists water pollutants and conditions that are generally present in water bodies. The pollutants and conditions become an issue when present in excessive amounts. Respondents were asked to rate problem severity from not a problem (1) to severe problem (4). It is important to note that responses marked as “don’t know” were excluded from the results in this section. Results in Table 7 show that the surveyed population was most concerned about invasive aquatic plants and animals, as well as habitat alteration. Respondents were least concerned about total dissolved solids (TDS), and chlorides including road salts.

Table 7: Survey Respondents’ Mean Scores for Water Impairments

Water Impairment	**Mean**	**Standard deviation**
Invasive aquatic plants and animals	2.77	1.14
Habitat alteration	2.51	1.05
Algae	2.32	1.04
Phosphorus	2.31	1.02
Bacteria and viruses	2.20	1.00
Nitrogen	2.11	1.01
Sedimentation	2.00	0.89
Trash or debris	2.00	1.00
Toxic materials	1.88	0.99
Salt/TDS/Chlorides	1.83	1.03

Sources of Water Pollution

This survey section discussed the most problematic sources of water pollution, which survey respondents were asked to rate between not a problem (1) and severe problem (4). It is important to note that responses marked as “don’t know” were excluded from the results in this section.Those surveyed were most concerned about the following sources of water pollution: improperly maintained septic systems, droppings from waterfowl, and excessive use of fertilizers and pesticides. Respondents were least concerned about erosion from construction sites, and discharge from sewage treatment plants (Table 8).

Table 8: Survey Respondents’ Mean Scores of the Potential Sources of Water Pollution

Water Pollution Sources	**Mean**	**Standard Deviation**
Improperly maintained septic system	2.76	1.07
Droppings from waterfowl	2.56	1.06
Excessive use of lawn fertilizers/pesticides	2.52	1.01
Erosion from shorelines/streambanks	2.33	0.83
Septic disposal	2.24	1.02
Yard Maintenance	2.15	0.96
Drainage/filling of wetlands	2.11	1.01
Removal of riparian vegetation	2.10	0.92
Land development or redevelopment	2.04	0.97
Stormwater runoff from streets/highways	1.94	0.96
Street salt and sand	1.88	1.05
Littering/illegal dumping	1.87	1.06
Erosion from farm fields	1.76	0.85
Discharge from industry into streams and lakes	1.75	0.94
Stormwater runoff from houses/parking lots	1.74	0.80
Erosion from construction sites	1.57	0.77
Discharge from sewage treatment plants	1.50	0.84

Practices to Improve Water Quality

This section of the survey was used to measure participants' familiarity with certain actions that could improve water quality. The most used practices were using phosphate free fertilizer, following manufacturer's instructions when fertilizing lawns or gardens, and using a rain barrel to conserve water. The surveyed population was most unfamiliar with restoring native plant communities (Table 9). Many respondents claimed to know how to use phosphate free fertilizers, and follow manufacturer recommendations for fertilizers, but are not doing so. It may be important to clarify in the future if they are not using fertilizer on their property, or if they are not following recommendations when fertilizing.

Table 9: Surveyed Population's Familiarity with Practices to Improve Water Quality

Practice to improve water quality	**Not relevant for my property**	**Never heard of it**	**Somewhat familiar with it**	**Know how to use it ; Not using it**	**Currently using it**
Following manufacturer's instructions when fertilizing lawn or garden	1.41%	1.41%	16.90%	33.80%	46.48%
Create a rain garden	24.64%	7.25%	15.94%	8.70%	43.48%
Follow pesticide application instructions	0.00%	1.41%	18.31%	36.62%	43.66%
Use phosphate free fertilizer	5.63%	7.04%	15.49%	23.94%	47.89%
Use rain barrel	4.23%	8.45%	28.17%	14.08%	45.07%
Plant trees/shrubs	2.82%	5.63%	9.86%	59.15%	22.54%
Restore native plant communities	11.94%	16.42%	8.96%	31.34%	31.34%
Plant vegetated riparian buffer	18.84%	13.04%	11.59%	23.19%	33.33%
Use porous pavement	14.29%	5.71%	10.00%	8.57%	61.43%

Attitudes and Willingness to Take Action

Water Quality Related Attitudes

The surveyed population was asked their level of agreement on water quality related statements in order to determine their opinion and attitudes on certain topics. Responses ranged from strongly disagree (1) to strongly agree (5). Respondents most agreed with the statements: “the quality of life in my community depends on good water quality in local streams, rivers, and lakes,” as well as “it is my personal responsibility to help protect water quality.” Respondents most disagreed with the statement “I would be willing to pay more to improve water quality.” According to Table 10, the previous statement had a mean response of 3.19, meaning that the majority felt neutral regarding the statement.

Table 10: Respondents Attitudes Towards Water Quality Related Statements

Statements to Determine Water Quality Related Attitudes	**Mean**	**Standard Deviation**
The quality of life in my community depends on good water quality in local streams, rivers and lakes	4.45	0.73
It is my personal responsibility to help protect water quality	4.42	0.71
Using recommended management practices on farms improves water quality	4.35	0.76
My actions have an impact on water quality	4.25	0.87
It is important to protect water quality even if it slows economic development	4.20	0.89
The way that I care for my lawn and yard can influence water quality in local streams and lakes	4.13	1.02
I would be willing to change the way I care for my lawn and yard to improve water quality	3.79	1.01
I would be willing to change management practices to improve water quality	3.77	0.98
I would be willing to pay more to improve water quality	3.19	1.32

Willingness to Take Action

The surveyed population identified improperly maintained septic systems as the leading concern regarding pollution sources (Table 8). It is recommended by the State of Michigan that septic systems are thoroughly cleaned every 3-5 years to remove all sludge, effluent, and scum from the tank. The surveyed population was asked if they would be willing to try this practice. Results showed that the majority (69.35%) claim they would be willing to try this practice, or they already are using this practice (Table 11). The surveyed population was also asked what factors might limit their ability to implement this practice. Large limiting factors included property features making it difficult, physical and health limitations, and the population not knowing how to do it.

Table 11: Respondents Willingness to Clean Your Septic Tank Every 3-5 Years

Would you be willing to clean your septic tank every 3-5 years?	**Frequency**	**Percentage**
Yes, or already do	43	69.35%
Maybe	13	20.97%
No	6	9.68%

It is important that guidelines are followed to ensure that septic systems are the proper size and type for use. The surveyed population was asked if they would be willing to try this practice. The majority (67.80%) of respondents claimed that they would be willing to try this practice or are already using this practice (Table 12). Those surveyed were also asked what factors might limit their ability to implement this practice. The most limiting factor for this practice was identified as it being difficult to implement with farming systems.

Table 12: Respondents Willingness to Follow Guidelines to Ensure That Septic Systems are the Proper Size and Type

Would you be willing to follow guidelines to ensure that your septic system is the proper size and type for its use?	**Frequency**	**Percentage**
Yes, or already do	40	67.80%
Maybe	10	16.95%
No	9	15.25%

Social Indicator Score Comparison

Table 13: Social Indicator Score Comparison for Black Lake, and Elk River Chain of Lakes Watersheds

Social Indicator Category	Social Indicator Criteria	Black Lake Watershed Residents	ERCOL Watershed Residents
Awareness	Consequences of Poor Water Quality	1.88	1.34
	Water Impairments	2.19	1.53
	Sources of Water Pollution	2.05	1.55
	Practices to Improve Water Quality		1.79
Attitudes and Willingness to Take Action	Water Quality - Related Attitudes	4.06	4.11
	Willingness to Take Action	2.57	1.76
Constraints to Behavior Changes and Adopting Key Practices	Constraints to Behavior Change		3.11
	Constraints to Adopting Key Practices		3.58

Surveyed Population Trusted Sources of Information

The surveyed population was asked to rate how much they trust the following information sources from not at all (1) to am not familiar (4). Those who responded “am not familiar” to this question were excluded from the results below. The most trusted sources were identified as soil and conservation districts, university extensions, and Tip of the Mitt Watershed Council. The least trusted sources of the respondents were local tribes, local garden centers, and lawn care companies (Table 14).

Table 14: Trustworthiness of Information Sources

Information Source	**Mean**	**Standard Deviation**
Soil and Water Conservation District	3.16	1.09
University Extension	3.13	1.02
Tip of the Mitt Watershed Council	2.93	1.15
Local Lake Associations	2.84	1.15
Black Lake Watershed Advisory Committee	2.79	1.13
State agricultural agency	2.69	1.24
State environmental agency	2.65	1.21
U.S. Environmental Protection Agency	2.64	1.22
Local government	2.51	1.07
Environmental groups	2.34	1.08
Local community leader	2.14	1.14
Local tribes	2.08	1.23
Local garden center	2.04	0.97
Lawn care company	1.63	1.00

Appendix G

SEAS Team Final Report (and Appendices)

Understanding Nonpoint Source Pollution and Public Perceptions: A Study of the Black Lake Watershed

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Spring 2024

Land Acknowledgement

Before the arrival of settler Europeans, the northern portion of Michigan's Lower Peninsula was and continues to be the home of the Three Fires Confederacy of Ojibwe, Odawa, and Potawatomi peoples. This community of Indigenous people lived on their ancestral lands for hundreds of years, maintaining villages along the Lake Michigan and Huron shorelines, along the Inland Waterway, and around the Black Lake Watershed. The Anishinaabe people have and continue to protect, restore, and respect the land, water, creatures, and people of this beautiful region.

As students of the University of Michigan School for Environment and Sustainability, we recognize the first and most steadfast stewards of this area. During our time in the Black Lake Watershed, we engaged with community members, some of whom are Indigenous people, in official and unofficial capacities to gather an understanding of the community we are serving. We are honored to contribute to the further protection of the Black Lake Watershed and are committed to engaging in the thoughtful care and consideration of all people, lands, waters, and beings for the next seven generations. We collectively understand that this acknowledgment does not absolve settler-colonial privilege or diminish colonial structures of violence at any level.

Tip of the Mitt Watershed Council Land Acknowledgement:
We would like to recognize that our service area lies within the traditional homelands of the Anishinaabek. We will continue to work alongside them to honor and protect this area for the next seven generations.

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List of Acronyms

BLA - Black Lake Association
BLPS - Black Lake Preservation Society
BMP - Best Management Practices
CFP - Commercial Forest Program
EGLE - Michigan Department of Environment, Great Lakes and Energy
EPA - Environmental Protection Agency
ERCOL - Elk River Chain of Lakes
FAMD - Factor Analysis of Mixed Data
HAB - Harmful Algal Bloom
MDARD - Michigan Department of Agriculture and Rural Development
MDNR - Michigan Department of Natural Resources
QFP - Qualified Forest Program
RSX - Road/Stream Crossing
SEAS - School for Environment and Sustainability
SIDMA - Social Indicator Data Management Analysis
TOMWC - Tip of the Mitt Watershed Council

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Executive Summary

As graduate students at the University of Michigan School for Environment and Sustainability and consultants to the Tip of the Mitt Watershed Council, we studied nonpoint source pollution causing degraded water quality and harmful algal blooms in Northern Michigan's Black Lake Watershed. To determine the location and impact of this nonpoint source pollution, we conducted four geographic inventories: analyzing streambank erosion, road/stream crossings, agricultural activity, and forestry operations, all of which are the most frequent contributors to nonpoint source pollution. A priority parcel analysis and critical areas analysis complemented the four geographic inventories and identified priority areas for conservation within the watershed. In addition, we created and implemented a social indicator survey for Black Lake Watershed residents to understand current practices, behaviors, beliefs, and attitudes toward water protection strategies. The combination of quantitative and qualitative information informed our recommendations for Tip of the Mitt Watershed Council and the Black Lake Watershed community.

Key findings include:

Social Indicator Survey: A gap exists in the watershed resident's awareness of the consequences of poor water quality, the types of pollutants impairing waterways, and the sources of pollutants impairing waterways.

Streambank Erosion: Two sites ranked severe, with many Upper Black River areas having high greenbelt potential.

Road/Stream Crossings: 57.1% of assessed sites ranked as moderate to major severity for crossing condition and pollution potential, aligning closely with the 61.2% across the watershed.

Agriculture Activity: 26% of agriculture sites pose a high priority for nonpoint source pollution, mainly along the Rainy River.

Forestry Operations: 12.76% of all forest land is protected under Qualified Forest Programs, Commercial Forest Programs, and State Parks, while the Watershed itself is composed of 47% forest land.

Priority Parcel Analysis: 66% of the total watershed acreage is protected lands and there are only 8 parcels deemed high priority for protection.

Critical Areas Analysis: Combining results from Road/Stream Crossings, Agriculture, and Streambank inventories identified 11 critical areas, primarily within a 10 km radius southwest of Black Lake.

These findings led to the following key recommendations:

- Launch education campaigns to inform residents about the consequences of poor water quality, the types of pollutants impairing waterways, and the sources of pollutants impairing waterways to ameliorate the current awareness gaps in the Black Lake Watershed.
- Encourage greenbelt development on properties along the Upper Black River between Tower Pond and Kleber Dam to help prevent further streambank erosion and pollutant loading.
- Resurvey road/stream crossings (especially moderate to major sites) to properly allocate resources for reducing runoff potential and removing possible aquatic barriers and invasive species to improve overall ecosystem productivity.
- Perform ground truthing surveys of agricultural activity sites and logging sites to gain a better understanding of the site condition and potential pollutant loading.

The data gathered from the four geographic inventories, priority parcel analysis, critical areas analysis, and the social indicator survey will be incorporated into the Tip of the Mitt Watershed Council's Black Lake Watershed Management Plan. While awaiting the completion of the watershed management plan, the Black Lake Watershed community can utilize these recommendations to guide their community-based and organization-based efforts to improve watershed health. Beyond the Black Lake Watershed, this research and our recommendations are designed for communities facing nonpoint source pollution and degrading water quality, especially for communities without consistent access to researchers or funding.

Chapter 1: Problem Definition and Background

Cultural Background

The Black Lake Watershed holds a deep historical and cultural significance as the ancestral and contemporary homelands of the Three Fires Confederacy of the Ojibwe, Odawa, and Potawatomi peoples. Long before the arrival of European settlers, the Anishinaabe people cared for this land through farming, fishing, and forest management.[1] Beyond subsistence practices, the tribes living in the region practiced rich community gatherings that involved sharing cooking traditions, music, dances, art, and songs that are still practiced today. As settlers took over the lands of these Indigenous communities, the Anishinaabe people, their traditions, and culture were threatened. Their resilience allowed them to adapt and survive amidst countless threats brought on by the colonization of the United States. To reclaim their treaty rights, many tribes sought federal recognition from the federal government. Within the Black Lake Watershed, there are no federally recognized tribes, but the watershed boundaries are directly adjacent to the reservation lands of Little Traverse Bands of Odawa Indians.

Situated in the northern lower peninsula of Michigan, the Black Lake Watershed spans 350,000 acres (547 square miles) in Cheboygan, Montmorency, Otsego, and Presque Isle counties. Renowned for its recreational opportunities including swimming, boating, and fishing, the watershed nurtures a self-sustaining sturgeon population amidst its diverse ecosystems.[2] These qualities attract many tourists, seasonal, and year-long residents who participate in the strong community around Black Lake.[3] While the population of a watershed is difficult to measure, the estimated population is made up of roughly 21,416 people of predominantly White descent (95.2%) with American Indian/Alaskan Native having the second highest representation (1.6%). The median income last recorded in 2021 was $52,226.[4] This income is lower than the state average of $63,202 as well as the country's average of $70,784.[5,6]

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[1] "History - Ocqueoc Township." Ocqueoc Township, 13 Jan. 2023, ocqueoctwpmi.gov/history/. Accessed 2 Apr. 2024.
[2] "Black Lake." *Tip of the Mitt Watershed Council*, www.watershedcouncil.org/black-lake.html. Accessed 16 Mar. 2023.
[3] Huron Pines Resource Conservation and Development Council. *Black Lake Watershed Stewardship Initiative Nonpoint Source Pollution Management Plan*. June 2002.
[4]U.S. Census Bureau Quickfacts: Otsego County, Montmorency County, Presque Isle County, and Cheboygan County, Michigan. (n.d.). https://www.census.gov/quickfacts/fact/table/otsegocountymichigan,montmorencycountymichigan,presqueislecountymichigan,cheboygancountymichigan/PST045222 (Calculated using proportions of county within the Black Lake Watershed)
[5] U.S. Census Bureau Quickfacts: Michigan. (n.d.-a). https://www.census.gov/quickfacts/fact/table/MI/INC110221
[6] Kollar, J. S. and M. (2022, September 13). Income in the United States: 2021. Census.gov. https://www.census.gov/library/publications/2022/demo/p60-276.html

The community surrounding the Black Lake Watershed has made major commitments to safeguarding its waters for recreational enjoyment and ecological preservation. Some residents consider the watershed to be "part of their soul" and prioritize protecting their water and advocate for the significance of this resource to their cultural, ecological, recreational, and economic way of life.[7] Organizations such as the Tip of the Mitt Watershed Council (TOMWC), the Black Lake Association, the Black Lake Preservation Society, Sturgeon for Tomorrow, and Huron Pines work tirelessly to protect this community's watershed.

TOMWC's mission is to advocate for northern Michigan's waters by protecting the lakes, streams, wetlands, and groundwater in their area of service through advocacy, education, water quality monitoring, research, and restoration actions. They do this by working locally, regionally, and throughout the Great Lakes Basin to empower others to make positive changes. They have led multiple watershed advisory committees including the Black Lake Watershed Advisory Committee since 2021.[8,9] Through watershed advisory committees, TOMWC develops cooperative relationships and collaborates with surrounding communities to advance water quality and northern Michigan's local economy.[10]

The Black Lake Association, founded in 1928, and the Black Lake Preservation Society, founded in 2018, work to engage year-round and seasonal residents in community-building and conservation efforts. These two organizations serve as the key communicators amongst lake residents, and help monitor the watershed's quality and health. The Black Lake Association provides basic ground rules for all members and the community at large, which include prohibiting the use of harmful pesticides and herbicides, encouraging routine septic system evaluations, and limiting the amount of lawn grooming along the beachfront. The described actions and mission provided on the website are consistent with the standard functions of lake associations in the state of Michigan. Several Black Lake residents created an additional lake association in 2014, the Black Lake Preservation Society, with the desire to increase environmental advocacy taking place in the watershed. The Preservation Society's "sole mission…is to protect and preserve the ecology of Black Lake, its tributaries and watershed through advocacy and program development; and to operate in a transparent, professional and neighborly manner."[11] Both the Black Lake Association and the Black Lake Preservation Society participate in the Black Lake Watershed Advisory Committee. The Advisory Committee brings interested participants within the watershed together to distribute information and updates about the watershed throughout the year. The committee will also be providing valuable input and feedback throughout the development of the Black Lake Watershed Management Plan and will

[7] Quote shared by an individual at the Black Lake Watershed Advisory Committee Meeting on August 14th, 2023
[8] "Advisory Committees." *Tip of the Mitt Watershed Council*, www.watershedcouncil.org/watershed-advisorycommittees.html. Accessed 16 Mar. 2023.
[9] "Youth Education." *Tip of the Mitt Watershed Council*, www.watershedcouncil.org/youth-education.html. Accessed 16 Mar. 2023.
[10] Tip of the Mitt Watershed Council. *Black Lake Watershed Management Planning.* 2022.
[11] Black Lake Preservation Society. BLACK LAKE PRESERVATION SOCIETY. (n.d.). Retrieved February 1, 2023, from https://www.blacklakepreservationsociety.org/

serve as a vehicle to assist with implementation. Beyond the two operating lake associations and the Advisory Committee in the Black Lake Watershed, this community has benefitted from collaboration with other organizations including Huron Pines and Sturgeon for Tomorrow.[12]

Environmental Background

Michigan has a unique responsibility to address water quality issues because it is surrounded by the Great Lakes, which contain 20% of the world's surface freshwater, and contains 11,000 inland lakes.[13] Michigan's inland lakes not only provide significant economic revenue through recreation and tourism, but they also supply clean drinking water and ecological resources.[14] Understanding how and why water quality issues arise and affect these inland lakes is key to maintaining the many benefits these waters provide.

In Michigan and across the country, water quality issues are becoming more prevalent, including in bodies of water that are not normally susceptible to these issues, such as those with cooler water temperatures and more undisturbed watersheds.[15] In particular, harmful algal blooms (HABs) have been occurring more frequently in areas with a previous history of high water quality. Anthropogenic activities such as urban development and agriculture can lead to an overabundance of nutrients through runoff and erosion that encourage algae growth in lakes and surrounding tributaries. Temperature plays an important role in algal growth as warmer water temperatures encourage bloom formation. Climate change, which has increased global temperatures both on land and water, plays a significant role in the timing and frequency in which HABs form. As the Earth continues to warm due to climate change, seasons will lengthen and the time frame that HABs can form will increase. Beyond temperature, climate change is predicted to increase precipitation as well as facilitate greater run-off and erosion events.[16]

The ninth largest lake in Michigan, Black Lake, has been impacted by anthropogenic activities despite being categorized as a pristine northern lake due to its location and characteristics, including high water quality and healthy ecosystems. Soon after annual HABs emerged in the lake, they tested positive for microcystin, a toxic chemical that is produced by blue-green algae. The lake is oligotrophic, meaning it is relatively low in plant nutrients but contains high amounts of oxygen in the deeper parts of the lake.[17] This lake characteristic makes HABs surprising

[12] "Black Lake Watershed." *Tip of the Mitt Watershed Council*, www.watershedcouncil.org/black-lakewatershed.html. Accessed 16 Mar. 2023.
[13]"Learn about Inland Lakes and Streams." *Www.michigan.gov*, www.michigan.gov/egle/public/learn/inland-lakes-and-streams. Accessed 2 Apr. 2023.
[14]Fuller, Erin, et al. *Protecting Michigan's Inland Lakes: A Guide for Local Governments*.
[15]Brooks, B. W., Lazorchak, J. M., Howard, M. D. A., Johnson, M.-V. V., Morton, S. L., Perkins, D. A. K., Reavie, E. D., Scott, G. I., Smith, S. A., & Steevens, J. A. (2016). Are harmful algal blooms becoming the greatest inland water quality threat to public health and aquatic ecosystems? *Environmental Toxicology and Chemistry*, *35*(1), 6–13. https://doi.org/10.1002/etc.3220
[16] United States Environmental Protection Agency. (2023, July 26). Climate Change Indicators: Weather and Climate | US EPA. US EPA. https://www.epa.gov/climate-indicators/weather-climate
[17]Tip of the Mitt Watershed Council. *Black Lake Watershed Management Planning.* 2022.

because oligotrophic lakes do not foster the typical conditions for HABs to occur. The lake itself measures a maximum depth of 50 feet with an elevation of 610 feet.[18]

Black Lake resides in the Black Lake Watershed which comprises roughly 37.7% of the Cheboygan River Watershed (1,461 square miles).[19] In total, 19 subwatersheds make up the Black Lake Watershed (Figure 1.2).Black Lake's headwaters are in the Upper Black River in Montmorency and Otsego County. Other tributaries include Fisher, Stewart, and Stoney Creek on the south end as well as the Rainy River and Cold Creek, which share a mouth on Black Lake. Cains Creek comes in on the north side of the lake and Mud Creek flows in on the west. The lake's outlet is the Lower Black River, which flows towards the Cheboygan River and then into Lake Huron. The upper reaches of the Upper Black River and its tributaries have excellent brook trout fisheries. Lake sturgeon rearing facilities exist in five counties throughout the state, including the Black River facility, to encourage an increase in sturgeon populations within the area. The Black River Sturgeon facility, in collaboration with Michigan State University and the Michigan Department of Natural Resources, works to understand the preferred ecology and impediments to population growth of lake sturgeon.[20]

[18] U.S. Geological Survey Geographic Names Information System: Black Lake (Michigan). Retrieved April 10, 2023, from https://edits.nationalmap.gov/apps/gaz-domestic/public/summary/621515
[19]Tip of the Mitt Watershed Council. *Black Lake Watershed*. 2022.
[20] "Lake Sturgeon Management," Michigan Department of Natural Resources, 2016, https://www.michigan.gov/dnr/managing-resources/fisheries/sturgeon

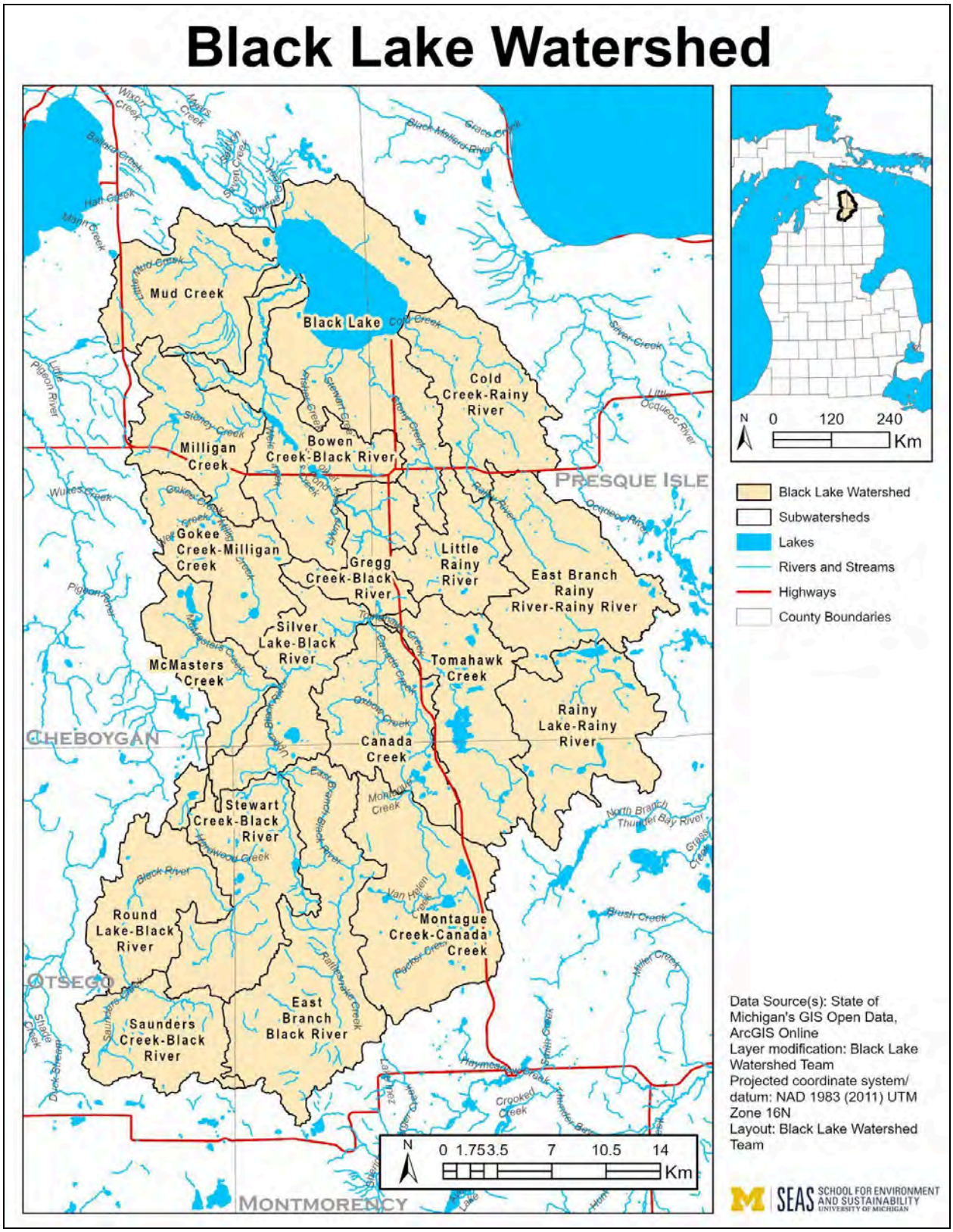


Figure 1.1. Map of Black Lake Watershed

Much of the Black Lake watershed is forested land (47%) and wetlands (31%) (Figure 1.2 and Table 1.1). Despite the significant amount of forestry and wetland land cover in the watershed, approximately 88% of Black Lake's shoreline is developed.

Typical contributors to nonpoint source pollution—agriculture and urban areas—accounted for about 10.05% of the watershed's area in 2021. With very few significant changes in land cover classes from 2001 through 2021 (Table 1.1), the water quality issues in the Black Lake Watershed appeared to occur from other causes. The only notable land cover change occurred within the shrub class, yet there is no reason to believe such a transition would lead to water quality issues. Beyond this limited land cover change, the Black Lake Watershed and this region of northern Michigan remains a relatively pristine ecosystem, including the Pigeon River Country State Forest, which is the largest block of contiguous, undeveloped wildlands in the lower peninsula of Michigan.[21] Due to the natural characteristics of this watershed, the emergence of HABs is alarming and highly motivating for TOMWC and the broader community to address.

[21]"Pigeon River Country State Forest." Michigan.gov, 2024, www.michigan.gov/dnr/places/state-forests/prc. Accessed 2 Apr. 2024.

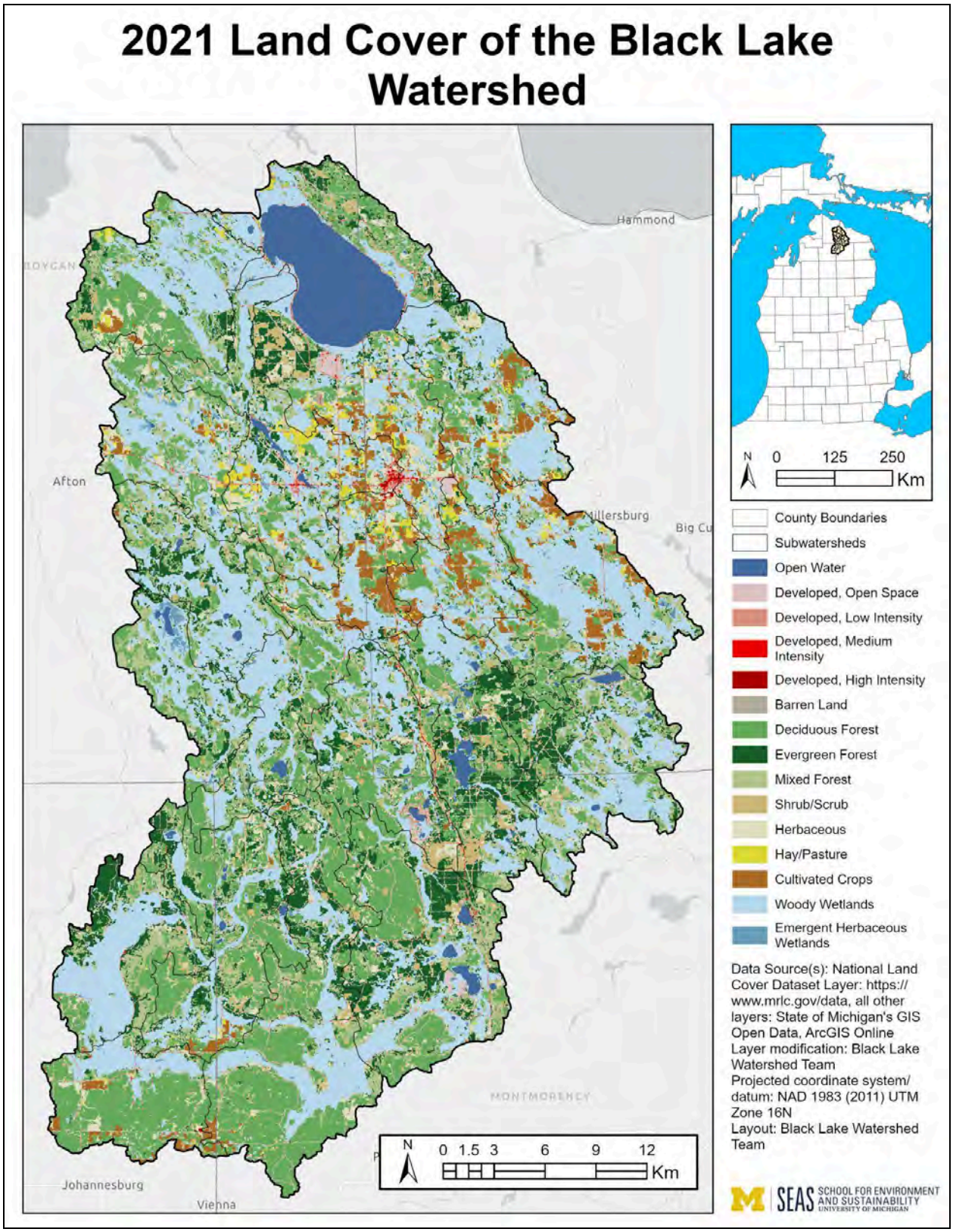


Figure 1.2. Black Lake Watershed Land Cover in 2021

Table 1.1. Percentage of Land Cover Classes in the Black Lake Watershed from 2001-2021

Land Cover Class	2001	2004	2006	2008	2011	2013	2016	2019	2021	Percent Change 2001 - 2021
Open Water	3.88	3.94	3.86	3.87	3.93	3.97	3.87	3.76	3.74	-0.04
Developed, Open Space	3.84	3.84	3.83	3.83	3.83	3.82	3.83	3.80	3.80	-0.01
Developed, Low Intensity	1.22	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	0.01
Developed, Medium Intensity	0.16	0.16	0.16	0.17	0.17	0.18	0.18	0.21	0.21	0.36
Developed, High Intensity	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.57
Barren Land	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.06	0.06	0.13
Deciduous Forest	23.63	23.58	23.25	23.38	23.29	23.35	23.13	23.73	23.77	0.01
Evergreen Forest	11.51	11.46	11.30	10.83	10.36	10.18	10.09	10.37	10.69	-0.07
Mixed Forest	12.65	12.68	12.79	12.84	12.78	12.76	12.82	12.82	12.76	0.01
Shrub/Scrub	2.08	2.37	2.63	2.68	2.39	2.82	3.60	3.01	2.65	0.27
Herbaceous	6.13	5.87	5.76	5.89	6.75	6.39	5.75	5.45	5.53	-0.10
Hay/Pasture	1.44	1.43	1.44	1.49	1.48	1.49	1.43	1.43	1.41	-0.02
Cultivated Crops	2.77	2.81	3.05	3.10	3.15	3.21	3.36	3.36	3.36	0.21
Woody Wetlands	29.68	29.55	29.48	29.74	29.74	29.75	29.84	29.83	29.75	0.00
Emergent Herbaceous Wetlands	0.93	1.00	1.15	0.89	0.82	0.78	0.78	0.90	1.00	0.07

Water Quality Standards

Water quality standards are the foundation of the water quality-based pollution control program mandated by the Clean Water Act.[22] The Environmental Protection Agency's Handbook for Developing Watershed Plans to Restore and Protect Our Waters describes water quality standards as the goals, pollution limits, and protection requirements for each waterbody**.** Meeting these limits helps to ensure that waters will remain useful to humans and aquatic life. Standards also

[22] Goodwin, K. (2024). Michigan Water Quality Standards. Michigan.gov. https://www.michigan.gov/egle/about/organization/water-resources/glwarm/water-quality-standards#:~:text=Designated%20uses%20include%3A%20agriculture%2C%20navigation

drive water quality restoration activities by aiding in determining which waterbodies must be addressed, what level of restoration is required, and which activities need to be modified to ensure that the water body meets its minimum standards.

The TOMWC's Comprehensive Water Quality Monitoring (CWQM) Program measures levels of specific conductivity, pH, dissolved oxygen, nitrate-nitrogen, total nitrogen, total phosphorus, and chloride every three years since 1995 during the springtime in Black Lake and the Upper Black River.[23] The Watershed Council's Volunteer Lake Monitoring (VLM) Program also monitors water transparency, chlorophyll-a, and water temperatures each summer in Black Lake from June through August. Additional water chemistry monitoring was conducted by both TOMWC and the Black Lake Preservation Society in 2018 in six previously unmonitored tributaries. In 2017, TOMWC conducted a Black Lake Shoreline survey to help identify the activities along the lake that could potentially pose a risk to the water quality of the watershed. Through this survey, TOMWC found that the loss of native vegetation, human-made infrastructure, and human-made waste all pose the greatest threats to Black Lake's water quality.

Water Quality Parameter Descriptions [24]

This section contains descriptions of the various water quality parameters that have been collected in the Black Lake Watershed and associated EGLE requirements for each parameter.

Total Dissolved Solids (TDS)

Due to a lack of conductivity standards within the state, measuring total dissolved solids is utilized. EGLE Part 4 Water Quality Standards (WQS) Rule 51 provides a framework for regulating total dissolved solids (TDS) concentrations with a TDS maximum of 750 mg/L.

pH and Dissolved Oxygen

EGLE Part 4 WQS states that pH should be within 6.5 and 9 in all surface waters of Michigan and a minimum of 5 mg/L of dissolved oxygen is needed for warm water lakes while 7 mg/L is needed for cold water lakes.

Temperature

EGLE Part 4 WQS set monthly maximum temperatures for streams supporting cold-water fish at 65° Fahrenheit for May, 68° Fahrenheit for both July and August, and 56° Fahrenheit for October. It also set monthly maximum temperatures for streams supporting warm-water fish at 70° Fahrenheit for May, 83° Fahrenheit for July, 81° Fahrenheit for August, and 64° Fahrenheit for October.

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[23] Tip of the Mitt Watershed Council. "Comprehensive Water Quality Monitoring." Tip of the Mitt Watershed Council, watershedcouncil.org/projects/comprehensive-water-quality-monitoring/. Accessed 19 Apr. 2024.
[24] Tip of the Mitt Watershed Council. Black Lake Tributary Study: An assessment of six rivers and streams that supply Black Lake. 2018.

Phosphorus, Nitrogen, and Chloride Trends

There is no numerical standard for nutrient concentration limits for surface waters in Michigan, and regulation is limited to the following standards from EGLE Part 4 WQS Rule 60. Phosphorus from point source discharges should have a maximum monthly average of 1 milligram per liter of total phosphorus (TP) unless other limits are deemed appropriate by the department. For streams in Northern Michigan, a total phosphorus concentration of 12 micrograms per liter or less is considered ideal to minimally impact conditions, protect designated uses, and provide flexible management.[25] The recommended amount of total nitrogen in Northern Michigan is 440 micrograms per liter and the recommended amount of chloride is 230 micrograms per liter and 860 micrograms per liter for chronic toxicity and acute toxicity respectively.[26,27]

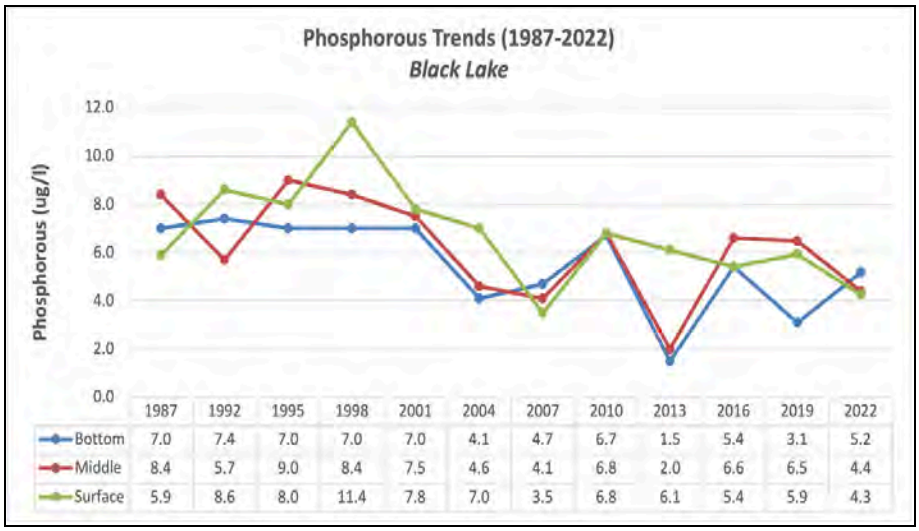
Chlorophyll-a Concentrations

Chlorophyll-a concentrations display the amount of algae that is growing in a waterbody. Higher concentrations indicate that there is an excess amount of algae present, which can be due to runoff, fertilizers, or septic waste as these provide the nutrients needed for excess algal growth. Lower concentrations indicate healthier water quality as algal formation is not as apparent.

Black Lake Nutrient Trends

Black Lake has repeatedly measured below the TP standard of 12 micrograms per liter since 1987.[28] TP trends have fluctuated over the past several decades, reaching a high in 1998 at 11.4ug/L and most recently dropping to a low of 4.3ug/L (Figure 1.4).

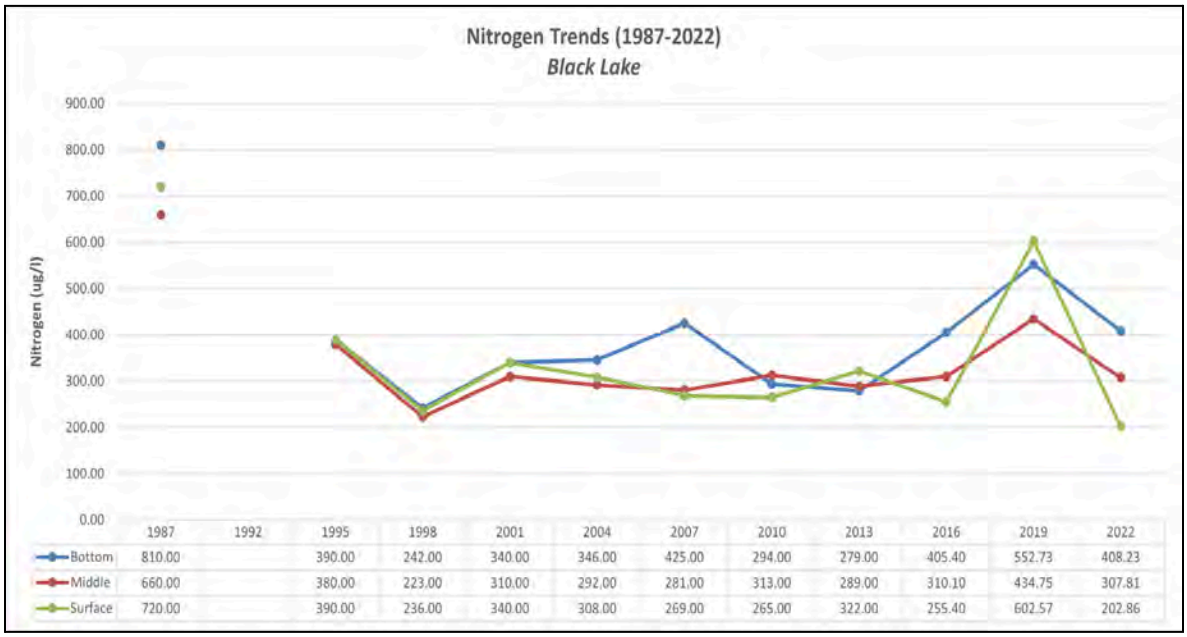
[25] United States Environmental Protection Agency. (2000). *Ecoregion VIII: Nutrient Poor Largely Glaciated Upper Midwest and Northeast*.
[26] Tip of the Mitt Watershed Council. *Black Lake Tributary Study: An assessment of six rivers and streams that supply Black Lake*. 2018.
[27] United States Environmental Protection Agency. (2013). *Road Salt TMDLs and Road Salt Reduction Strategies in New Hampshire.*
[28] CWQM Water Quality Data. 27 May 2022.



	1987	1992	1995	1998	2001	2004	2007	2010	2013	2016	2019	2022
Bottom	7.0	7.4	7.0	7.0	7.0	4.1	4.7	6.7	1.5	5.4	3.1	5.2
Middle	8.4	5.7	9.0	8.4	7.5	4.6	4.1	6.8	2.0	6.6	6.5	4.4
Surface	5.9	8.6	8.0	11.4	7.8	7.0	3.5	6.8	6.1	5.4	5.9	4.3

Figure 1.3. Black Lake Phosphorous Trends from 1987-2022[26]

Total nitrogen remained relatively steady below the recommended amount of nitrogen (440 micrograms per liter) until 2019 when it gradually increased from an average of 297ug/L in 2013 to 602.57ug/L at the surface, which may have signified a weather event (Figure 1.5).



	1987	1992	1995	1998	2001	2004	2007	2010	2013	2016	2019	2022
Bottom	810.00		390.00	242.00	340.00	346.00	425.00	294.00	279.00	405.40	552.73	408.23
Middle	660.00		380.00	223.00	310.00	292.00	281.00	313.00	289.00	310.10	434.75	307.81
Surface	720.00		390.00	236.00	340.00	308.00	269.00	265.00	322.00	255.40	602.57	202.86

Figure 1.4. Black Lake Nitrogen Trends from 1987-2022[26]

Chloride can be seen on a downward trend in 2007 going from a middle reading of 6.82mg/L to 4.02mg/L in 2022 (Figure 1.6).

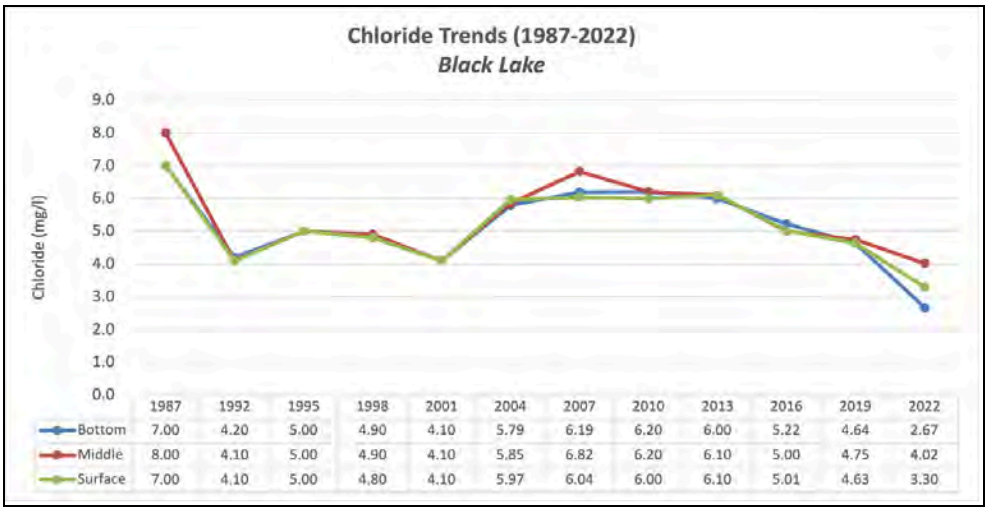


Figure 1.5. Black Lake Chloride Trends from 1987-2022[26]

Black Lake measured the highest Chlorophyll-a concentration in 1990 with an average of 2.77ug/L and again in 2012 with an average of 2.19ug/L. From 2001 to 2009 and 2014 to 2020, concentrations were the lowest with the most recent measurement being 0.37ug/L (Figure 1.7). Overall, the low concentrations are not a cause for concern, however, it raises the question of why these HABs are forming if chlorophyll-a concentrations are not reflecting the outbreaks.

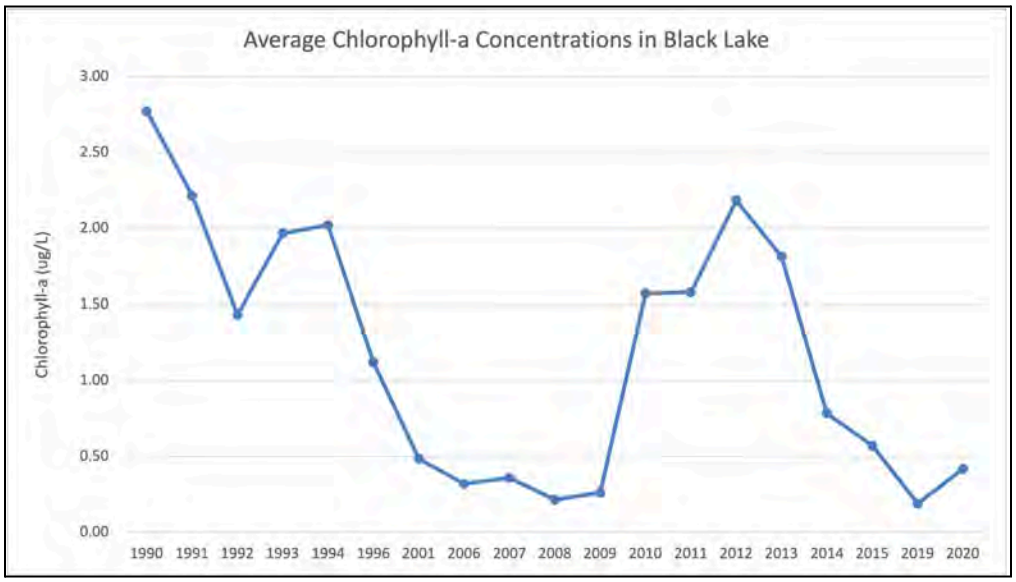


Figure 1.6. Average Chlorophyll-a concentrations in Black Lake 1990-2020 collected by Black Lake volunteers[29]

Overall, the trends observed in Black Lake are not very alarming and most recorded data meet the water quality parameters previously mentioned. However, with relatively normal levels, it

[29] VLM Comprehensive Database with QAPP Quality Controls. 4 May 2021.

raises the question of why the lake has been experiencing HABs over the last several years since the data does not directly point to concerning findings.

Water Quality Parameters of Subwatersheds

The previously explored tributary study by Tip of the Mitt Watershed Council in 2018 covered six subwatersheds: Stony Creek, Cold Creek, Fisher Creek, Rainy River, Stewart Creek, and Cains Creek. Monitoring sites (Figure 1.8) provide baseline data although many sites were dry or did not have information for August (temperature, dissolved oxygen, conductivity, and pH). All of the respective tributary data as well as in-depth summaries of the data can be seen in Appendix 1. Table 1.4 summarizes the study by identifying which streams met the water quality parameters. Sites that had varying data (some meeting standards, some not meeting standards) are represented by a yellow “Varied” box while consistently not met parameters are represented by a red “Not Met” box. Sites that consistently meet the parameters are represented by a green “All Sites” box.

All monitoring sites did not meet the set limits in at least three different parameters throughout the study. Stewart Creek, Rainy River, and Cold Creek all had parameters that were consistently not met in higher amounts than Cain’s Creek, Stony Creek, and Fisher Creek’s monitoring sites. Because all sites had varying levels of recorded data, it is fair to say that the health of the overall water bodies are unknown given that some monitoring sites recorded parameters that were within the limits while others did not.

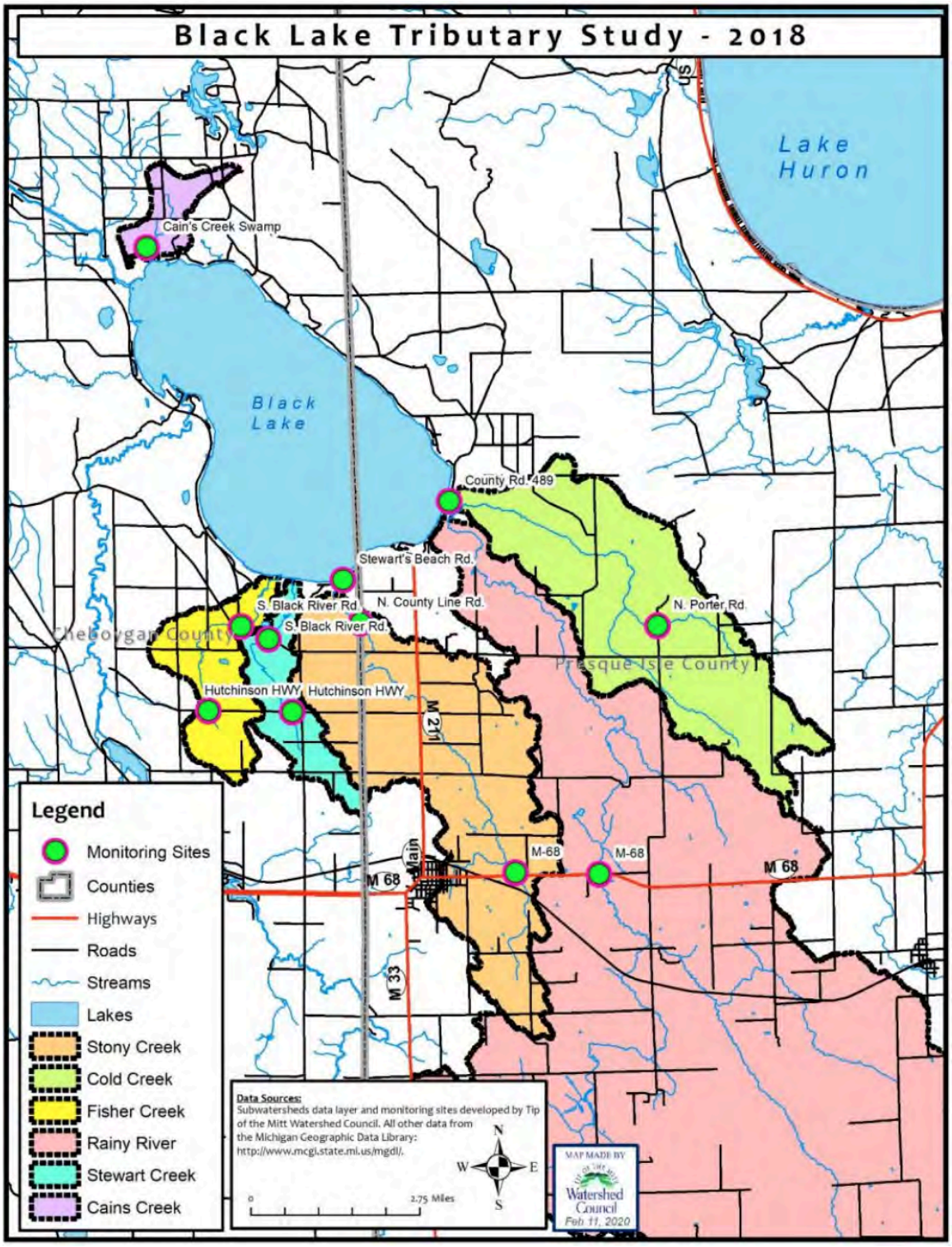


Figure 1.7. Black Lake Tributary Study Monitoring Locations [30]

[30] Tip of the Mitt Watershed Council. *Black Lake Tributary Study: An assessment of six rivers and streams that supply Black Lake*. 2018.

Table 1.2. Water Quality Parameters From Tributary Study

		Monitoring Sites					
Water Quality Parameters	**Limit**	Cain's Creek	Fisher Creek	Stewart Creek	Stony Creek	Rainy River	Cold Creek
TDS	**750 mg/L**	All Sites	All Sites	All Sites	All Sites	All Sites	All Sites
pH	**6.5-9**	All Sites	All Sites	All Sites	All Sites	All Sites	All Sites
Dissolved O_2	**5-7 mg/L****	All Sites	Varied	All Sites	Varied	Not Met	All Sites
Temperature	**Varies****	All Sites	Varied	All Sites	Varied	Varied	All Sites
Phosphorous	**12 µg/L**	Varied	All Sites	Varied	Varied	Varied	Varied
Nitrogen	**440 µg/L**	Varied	Varied	Varied	Varied	Varied	Not Met
Chloride	**5 mg/L**	Varied	Varied	Not Met	Varied	Slightly Elevated	Slightly Elevated

**Note: Dissolved O_2 varies based on cold or warm water fisheries

**Note: Temperature varies based on month

Designated Uses

Water quality standards are developed for designated or beneficial uses to aid in protecting those uses and implementing policies and procedures that keep high-quality waters from degrading.[31] The EPA's handbook describes designated or beneficial uses as descriptions of water quality expectations or water quality goals. A designated use is a legally recognized description of a desired use of the waterbody. State and tribal governments are primarily responsible for designating uses of water bodies within their jurisdictions. Two types of criteria are used to measure whether standards are being met. Numeric criteria set numeric limits for water quality

[31] Tip of the Mitt Watershed Council. (2017). *Burt Lake Watershed Management Plan*.

parameters and narrative criteria are non-numeric descriptions of desirable or undesirable water quality conditions.[31]

The State of Michigan has established a set of designated uses that can be measured for impairment based on the water quality standards described in the previous section. Rule 100 of the water quality standards states that all surface waters of the State are designated for, and shall be protected for, eight particular uses described in Table 1.2.[31]

Table 1.3. Surface Water Designated Uses in the State of Michigan[31]

Designated Use	General Definition
Agriculture	Livestock watering, irrigation, and crop spraying
Navigation	Navigation of inland waters
Warmwater fishery	Supports warmwater species
Coldwater fishery	Support coldwater species
Other Indigenous aquatic life and wildlife	Supports other indigenous animals, plants, and macroinvertebrates
Partial body contact recreation	Supports boating, wading, and fishing activities
Total body contact recreation	Supports swimming activities between May 1 to October 31
Public water supply*	Surface waters meet human cancer and non-cancer values set for drinking water
Industrial water supply	Water utilized in industrial or commercial applications
Fish Consumption	There is a statewide, mercury-based fish consumption advisory that applies to all of Michigan's inland lakes, including those within the Mullett Lake Watershed.

The State of Michigan has also developed water quality standards to help determine if designated uses are impaired (Table 1.3).[31]

Table 1.4. Water Quality Standards in the State of Michigan[31]

Parameter	Water Quality Standards	Designated Uses Affected
Dissolved Solids	Not to exceed 500 mg/L monthly average or 750 mg/L at any time as a result of controllable point sources	All
pH	Between 6.5 to 9.0	All
Taste or odor producing substances	The surface waters of the state shall contain no taste-producing or odor-producing substances in concentrations which impair or many impair their use for a public, industrial, or agricultural water supply source or which impair the palatability of fish as measured by test procedures approved by the department.	Public Water Supply* Industrial Water Supply Agricultural Water Supply Fish Consumption
Toxic substances (selected shown here; see rule for complete listing)	DDT and metabolites: below 0.00011 µg/L	All but navigation
	Mercury, including methylmercury: below 0.0013 µg/L	
	PCBs (class): below 0.00012 µg/L	
	2,3,7,8 - TCDD: below 0.0000000031 µg/L	
Radioactive substances	Pursuant to U.S. nuclear regulatory commission and EPA standards	All but navigation
Plant nutrients	Phosphorus: 1 mg/L maximum monthly average for permitted point source discharges. Regulation for surface waters is limited to the following narrative standard from Rule 60 (323.1060): "nutrients shall be limited to the extent necessary to prevent stimulation of growth of aquatic rooted, attached, suspended, and floating plants, fungi or bacteria which are or may become injurious to the designated uses of the waters of the state."	All
Microorganisms	30-Day Geometric Mean: below 130 *E. coli* per 100 ml	Total body contact
	Daily Maximum Geometric Mean: 300 *E. coli* per 100 ml	Total body contact
	Daily Maximum Geometric Mean: below 1,000 *E. coli* per 100 ml	Partial body contact
	Human sewage discharges (treated or untreated) below 200 fecal coliform per 100 ml 30-day mean or 400 fecal coliform per 100 ml in 7 days or less	Total body contact
Dissolved oxygen	Minimum 7 mg/L for coldwater designated streams, inland lakes, and Great Lakes/connecting waters; minimum 5 mg/L for all other waters	Cold water fishery
	Minimum 5 mg/L daily average	Warm water fishery
Temperature	Natural daily and seasonal temperature fluctuations shall be preserved: Maximum monthly averages for inland lakes (ºF): J F M A M J J A P O N D 45 45 50 60 70 75 80 85 80 70 60 50	Cold water fishery Other indigenous aquatic life and wildlife
	Maximum monthly averages for warm water streams in this watershed (ºF): J F M A M J J A P O N D 38 38 41 56 70 80 83 81 74 64 49 39	Warm water fishery
	Maximum monthly averages for cold water streams in this watershed (ºF): J F M A M J J A P O N D 38 38 43 54 65 68 68 68 63 56 48 40	Cold water fishery

The status of a designated use in a watershed can be met, impaired, threatened, or under review/unknown. The use is unimpaired if the available physical and analytical data indicates that all applicable water quality standards are being consistently met. If the available data indicates that water quality standards are not being consistently met, then the designated use is considered to be impaired. If an assessment unit is expected to not meet a particular designated use within the next two years (Integrated Report listing cycle), it is identified as threatened. A use that is designated as under review or unknown means there is insufficient physical or analytical data available to determine a status for the use and that additional studies are necessary.[31]

The Clean Water Act (CWA) requires Michigan to prepare a biennial report on the quality of its water resources as the principal means of conveying water quality protection/monitoring information to the United States EPA and the United States Congress. The Water Quality and Pollution Control in Michigan, Sections 303(d), 305(b), and 314 Integrated Report satisfies the listing requirements of Section 303(d) and the reporting requirements of Section 305(b) and 314 of the CWA.[32] The Section 303(d) list includes Michigan water bodies that are not attaining one or more designated uses and require the establishment of Total Maximum Daily Loads (TMDLs) to meet and maintain Water Quality Standards.[31]

In 2022, the state enacted a statewide mercury TMDL. Several water bodies are listed as not meeting the fish consumption designated use because of state fish consumption advisories that have been issued. This may be due to elevated fish tissue levels of mercury and PCBs in some species as a result of atmospheric deposition of these pollutants. This issue is being addressed at the state and regional levels and is beyond the scope of the Black Lake Watershed Management Plan.[31]

Designated Uses in the Black Lake Watershed

The Black Lake Watershed includes water bodies designated to be used as cold water and warm water fisheries. The coldwater fishery lakes and streams are considered designated trout streams or designated trout lakes for the State of Michigan and only apply to the Michigan Department of Natural Resources. There are various water bodies in Michigan designated and protected as coldwater fisheries including the following:

1. All inland lakes identified as coldwater fisheries in the Coldwater Lakes of Michigan publication by the Department of Natural Resources.
2. All Great Lakes and their connecting waters, except for the entire Keweenaw waterway, including Portage lake, Houghton county, and Lake St. Clair.

[32] Michigan Department of Environment, Great Lakes, and Energy. (2022). *Water Quality and Pollution Control in Michigan 2022 Sections 303(d), 305(b), and 314 Integrated Report*.

3. All lakes listed in the publication Designated Trout Lakes and Regulations by the director of the Department of Natural Resources.

4. All waters listed in the publication Designated Trout Streams for the State of Michigan by the director of the Department of Natural Resources.[31]

Coldwater streams and lakes within the Black Lake Watershed, such as Rainy River, Stony Creek, and Fisher Creek, are therefore designated and protected for coldwater fisheries. Two sites within the watershed, Kleber and Tower Pond are 303(d) listed, designated as impaired bodies of water due to current mercury levels not safe for consumption.[33]

While the majority of assessed surface waters in the Black Lake Watershed are currently meeting all of the designated uses of the State, the watershed remains vulnerable to nonpoint source pollution and other environmental stressors. Existing and future activities will invariably create a risk of degradation to some or all of the designated uses. Thus, it is critical to enact preventative and restorative actions to ensure future use of watershed resources.

The uncertainty around the source of HABs occurring in Black Lake, other water quality issues, and the lack of an EPA and Michigan Department of Environment, Great Lakes and Energy (EGLE) approved watershed management plan for the Black Lake Watershed has led to increasing public support for an approved management plan, according to TOMWC. Establishing a baseline of public perception and attitudes towards water quality issues, water protection, and water management will allow for organizations to effectively address public concerns. A more informed community and an approved watershed management plan for Black Lake will be key to addressing water quality issues and implementing watershed protection strategies and initiatives.

[33] Michigan Department of Environment, Great Lakes, and Energy. (2022). Statewide Mercury TMDL 2022 Locations. www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Programs/WRD/GLWARM/TMDL-statewide/2022-Statewide-Mercury-TMDL-Locations.pdf?rev=703537f56c634bb585de62d423dbcc45&hash=219BE0B2FA7A42D2E543D5BE91290F1D

Chapter 2: Project Description, Goals, and Objectives

Project Description

As water quality concerns have increased within the Black Lake Watershed over the past several years, TOMWC and members of the two Black Lake associations started to advocate for a watershed management plan. The primary purpose of a watershed management plan is to guide watershed coordinators, resource managers, policy makers, and community organizations to restore and protect the quality of lakes, rivers, streams, and wetlands by providing specific recommendations. A significant component of the watershed management planning process is conducting resource inventories that assess different types of nonpoint source pollution and surveying the watershed residents to understand the perspectives of major stakeholders. Considering this need for insightful data and recommendations for how to manage, mitigate, and effectively adapt to these water quality issues, TOMWC collaborated with the University of Michigan's School for Environment and Sustainability (SEAS). We, as four SEAS graduate students, gathered and analyzed data from watershed inventories and social indicator surveys to provide concrete recommendations for TOMWC. This information will directly inform the content and direction of the Black Lake Watershed management plan and guide actions and protocols of TOMWC.

Project Goals

The overall goal of this project is to contribute positively and effectively to TOMWC and the Black Lake Watershed community by providing quantitative and qualitative data as well as a capacity to understand the current environmental status of the Black Lake Watershed.

This overall goal was accomplished by completing a comprehensive assessment of nonpoint source pollution throughout the watershed. This assessment included performing field surveys and inventories to document and evaluate nonpoint source pollution originating from streambank erosion, road/stream crossings (RSX), agriculture activity and forestry management.

Specifically, the following goals were achieved:

1) Determine relative pollutant contributions from high priority tributaries and their associated watersheds to gain an understanding of high pollutant loading areas throughout the watershed. We did this by completing field surveys to document and evaluate nonpoint source pollution originating from streambank erosion, RSX, agricultural activity, and forestry management.

2) Identify land parcels to be prioritized for protection. To accomplish this goal, we completed a GIS-based priority parcel analysis to rank properties.

3) Determine attitudes, beliefs, and behaviors of watershed residents related to water quality to form a baseline of public perception. We achieved this by surveying residents, visitors, and local officials using the US EPA Social Indicators Data Management and Analysis tool (SIDMA Tool).

Theory of Change

A Theory of Change is a model that depicts a set of expected outcomes following predetermined intervention strategies. The model provides a guide on how to successfully complete each of our project goals and can potentially be a template for other lakes that are experiencing similar socio-ecological effects. Included are the various factors that are linked together to address the individual goals of the project and how it will be accomplished (Figure 2.1).

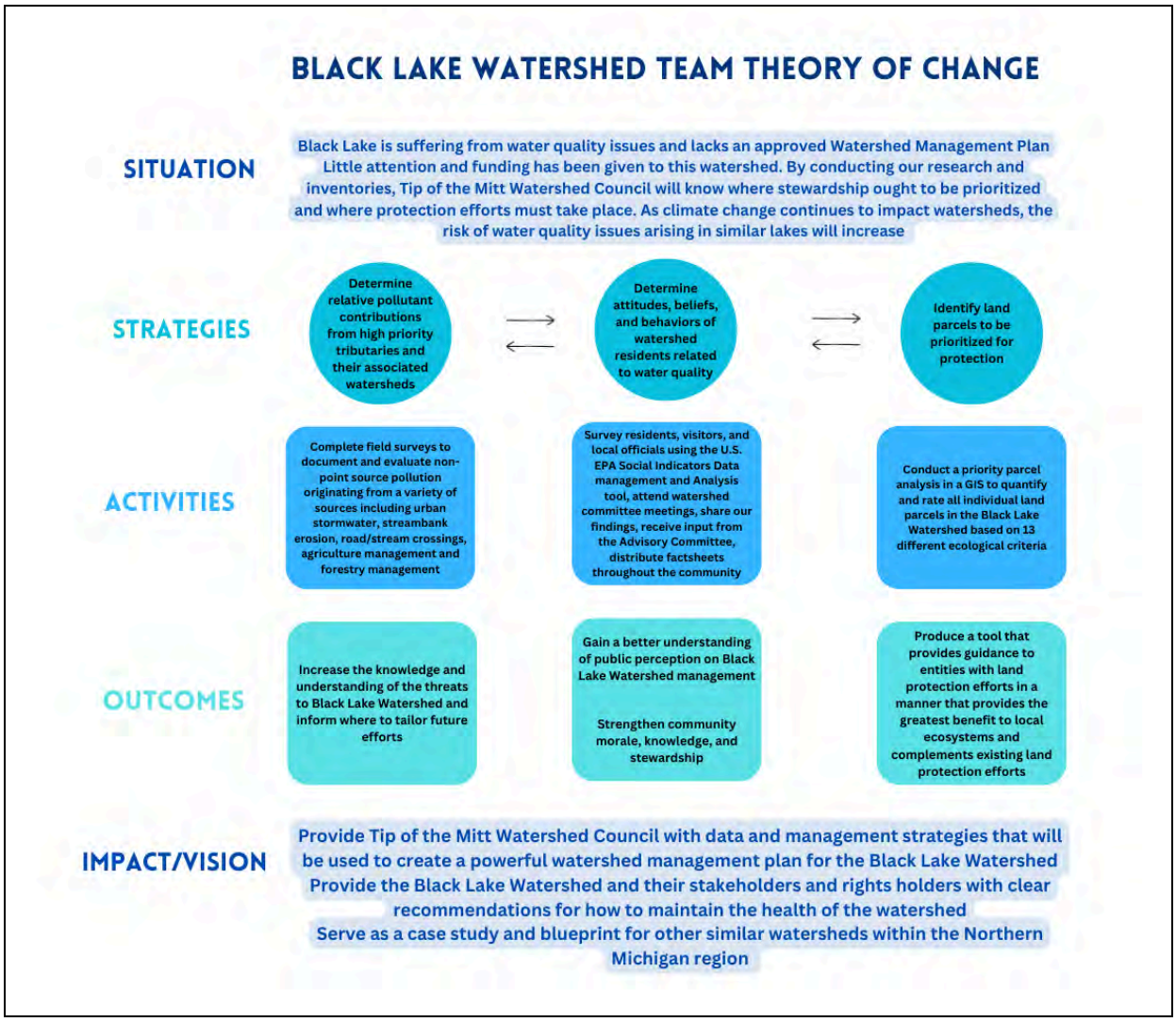


Figure 2.1. Theory of Change Model

Project Significance

A significant aspect of our project was identifying potential nonpoint source pollution that might contribute to the annual harmful algal blooms (HABs) in Black Lake. The exact drivers and mechanisms behind these blooms remain elusive, hindering proactive solutions to the issue. By investigating the role of nonpoint source pollution in HABs, we aimed to develop effective mitigation strategies and propose local ordinances for the residents of Black Lake.

Black Lake holds a unique status as a pristine inland lake, making our findings invaluable not only for addressing its specific challenges, but also as a model for similar northern inland lakes with minimal human disturbances, limited runoff, and no direct connections to major waterways.

Chapter 3: Methods

Methods Overview

This project aligns with our positions as researchers to work as boundary spanners for the Black Lake community. As boundary spanners, we straddle the divide between information users (stakeholders) and information producers (us as researchers).[34] It is important to be able to take our research and properly convey it to the public in a respectful yet informative manner. As we met with local organizations and gave presentations throughout this project, we needed to provide the entities who conduct land protection efforts and water stewardship within the Black Lake Watershed with up-to-date information as we collected it. Keeping the public informed strengthens not only the trust between us and the respective parties but also shows that even outsiders of the Black Lake Watershed want what is best for it.

To accomplish our project goals, two distinct forms of research were conducted for this project. First, extensive watershed inventory surveys were conducted that measured the impact caused by road-stream crossings, stream banks, agricultural lands, and forestry lands to determine their potential relative pollutant contributions. This work was heavily informed by Michigan's Department of the Environment, Great Lakes, and Energy (EGLE) non-point source protocols and experienced specialists from the EGLE office. Along with this, an analysis of priority parcels and critical areas within the watershed was performed to understand where remediation efforts could be targeted.

Second, we conducted a social indicator survey with Black Lake Watershed residents, including those living on Black Lake and those residing throughout the watershed and subwatersheds. Following the format of the EGLE's Social Monitoring Survey format and protocols, residents were surveyed using an online survey format that maintains anonymity and records their responses within the Social Indicators Data Management and Analysis (SIDMA) tool. Once collected, the data was analyzed and shared with TOMWC for continued use and monitoring. These survey results serve as the public perception baseline for TOMWC to continue to track.

Beyond these two project approaches, we conducted direct community engagement through formal and informal meetings. As graduate researchers, we presented our plans, research approaches, and preliminary findings to the Black Lake Watershed Advisory Committee four times throughout 2023 and 2024. In addition to sharing our progress, we facilitated discussions with the members of the committee, where we asked for their input, insights, feedback, and recommendations.

[34] Goodrich, K. A., Sjostrom, K. D., Vaughan, C., Nichols, L., Bednarek, A., & Lemos, M. C. (2020). Who are boundary spanners and how can we support them in making knowledge more actionable in sustainability fields? *Current Opinion in Environmental Sustainability*, *42*, 45–51. https://doi.org/10.1016/j.cosust.2020.01.001

Social Indicator Survey Methods

The Black Lake Watershed Resident Survey was distributed to residents, landowners, renters, stakeholders, and other engaged citizens in the Black Lake Watershed. There were two separate methods for distributing this survey to the largest number of Black Lake Watershed Residents possible. This survey was conducted at a broad scale to gather as many responses and engagements with the survey as possible.

Information Collected in Survey

The information collected in the survey collected the respondents' attitudes, behaviors, knowledge, and beliefs in the following subject areas:
-Rating of water quality
-Water resources
-Water impairments
-Sources of water pollution
-Consequences of poor water quality
-Practices to improve water quality
-Opinions of specific water practices
-Making decisions for the respondent's property
-Demographic data
-Sources of water quality information
-Septic system care

Reaching the Black Lake Watershed Advisory Committee Members

Emails were forwarded from us by TOMWC to all 85 members of the Black Lake Watershed Advisory Committee. To ensure success, we utilized a "four-wave design." In this method, the initial contact email included background information and a link to the Black Lake Watershed Residents Survey (Appendix 2). This initial survey distribution occurred in June 2023. The second, third, and fourth email contacts served as reminders to engage in the Watershed Resident Survey. These subsequent correspondences provided a smaller section on background information and a link to the Black Lake Watershed Residents Survey. Every three weeks, stakeholders with known email addresses received an email, reminding them to complete the survey. This reminder correspondence was sent three times before the survey closed to the public in September 2023.

Reaching other Black Lake Watershed Residents:

Black Lake Association members, Black Lake Preservation Society members, and general Black Lake residents accessed the survey through a website link shared through association or society presidents, social media content on the TOMWC's Facebook and Instagram accounts and website, and in-person meetings and community engagements (Appendix 3). The link to the survey was included in both lake association newsletters and through the lake associations'

Facebook pages. This method of distribution resulted in a broader, more diverse set of survey results.

Selection of Survey Population

The target population for this survey consisted of resident landowners and renters in the Black Lake Watershed area. This survey population had an oversample of individuals from the Black Lake Association membership lists, the Black Lake Preservation Society membership lists, and the Black Lake Watershed Advisory Committee membership, rights holders, and stakeholders lists. We recognize that engaging with this population resulted in a bias for older, wealthier, and/or more educated persons being surveyed, and fewer renters, as compared to the general population. Providing the link through social media and the TOMWC's website was an attempt to mitigate some of this bias. We utilized the summer months of June, July, August, and September of 2023 to capture as many responses from the watershed residents as possible. During this period of the year, watershed residents were more likely to enjoy and engage with the watershed, perhaps making them more likely to participate in this survey.

Survey Questions

This survey was meant to be comparable to prior survey information collected and utilized by TOMWC, such as the Elk River Chain of Lakes Watershed Residents Survey and the Lake Charlevoix Watershed Survey. This comparability allowed us to improve our data collection and ultimately our knowledge of this area of the state. We were able to measure changes in varying watersheds over the years. This will also contribute to the larger known data set collected for the Great Lakes Basin. To guarantee this comparability, we utilized the SIDMA Tool to create the survey, just as TOMWC has done to collect watershed resident data in the past.

The survey contained 11 sections with questions to determine the public's awareness of and attitudes toward water quality. Additionally, these questions collected information on how well citizens in the watershed understand specific Best Management Practices (BMPs) and asked about their constraints for implementing those BMPs in the Black Lake Watershed. Thirteen demographic questions were also included. For a list of the survey questions, please see the survey instrument included in Appendix 2.

Most questions provide respondents with multiple choices of answers from which to choose. There were seven questions with a written option. There was also space available for comments at the end of the survey. All comments were transcribed and reported to the TOMWC.

Quality Control

This survey underwent evaluation by the University of Michigan's Institutional Review Board (IRB) to evaluate the quality and security of the Black Lake Watershed Resident Survey. This survey was submitted for review on April 21, 2023. The survey was promptly approved by the Institutional Review Board with minor revisions necessary.

Given that this survey was distributed through email addresses and the internet, we were watchful of robot responses, AI responses, or responses from those outside of our survey sample. We continually monitored the responses to discard any false survey submissions. We monitored survey responses by coding quality, which was assessed by randomly selecting one of every ten survey submissions. This survey was checked for suspicious responses and if suspicious responses were found, all survey submissions were checked.

Data Management and Analysis

The responses from submitted surveys were automatically recorded and stored in the SIDMA tool. The SIDMA Tool generated indicator scores for four areas: awareness, attitudes, constraints, and behavior. These scores were useful when compared to other audiences and surveys. TOMWC and our team will maintain the SIDMA Tool surveys and data analysis electronically. The data analysis will continue to be securely maintained by TOMWC for five years.

Road/Stream Crossings Inventory Methods

We performed a road/stream crossing inventory in the Black Lake Watershed. Priority was given to conducting inventories at RSX that were deemed a "time-sensitive" matter before navigating any sites. "Time-sensitive" is subjective and may include reasons such as possible obstructions to the structure, dangerous risks including power lines in the stream, or the presence of HABS. It is an umbrella term based on the personal opinion of the surveyor. We visited the 39 sites marked as "time sensitive" and in varying conditions within the watershed.

These inventories followed the Great Lakes Road/Stream Crossing Inventory protocol established (2011) by the U.S. Forest Service, U.S. Fish and Wildlife Service, Michigan Department of Natural Resources, Wisconsin Department of Natural Resources, Huron Pines, Conservation Resource Alliance, Michigan Technological University, and road commissions (Appendix 4).

- Field work was performed from August 7th to August 25th in 2023.
- Equipment used to collect data included a digital GPS camera, Sontek FlowTracker, measuring tape, compass, and other standard field equipment. Data was collected on iPads which were connected to cell phone hotspots when available for better accuracy of GPS points.
- Site sketches were hand-drawn using a paper datasheet. Site sketches were photographed and stored in the Survey123 form. They were also scanned in as high-resolution PDFs and stored on the TOMWC server.
- Photographs were taken at each RSX of the culvert inlet and outlet, upstream and downstream conditions near the culvert, and road approaches on both sides.
- Field data was collected using Survey123 on smartphones and/or tablets to enhance post-processing.

- Pollutant loading estimates for sediment were calculated by applying the formulas that accompany the Great Lakes Road/Stream Crossing Inventory. Pollutant loading estimates for phosphorus and nitrogen were determined by applying an overall phosphorus concentration of 0.0005 lbP/lb of soil and a nitrogen concentration of 0.001 lbN/lb of soil. Soil texture was determined and a correction factor was used to better estimate nutrient nutrient-holding capacity of the soil. Sand is the dominant soil texture for the Black Lake Watershed, thus a correction factor of 0.85 was used. The Survey123 form developed by the Michigan Department of Natural Resources (DNR) was used in the field to record measurements that replicate the Stream Crossing Data Sheet (appendix 4).
- The data was also uploaded to https://great-lakes-stream-crossing-inventory-michigan.hub.arcgis.com/ in collaboration with the Michigan DNR.
- RSX were ranked/prioritized according to their severity (minor, moderate, major) concerning nonpoint source pollution threats and barriers to aquatic species passage. For simplicity, sites that were ranked severe were considered major, and sites with "moderate-to major" were considered "moderate."
- GPS coordinates and the alpha-numeric codes will identify RSX when they are displayed in final reports.
- Sites that did not contain usable data were disregarded from the analysis (usable data meaning measurable as some structures were noted without any collected data from the site).
- Fish passage was only considered at the sites that were updated and if updated sites did not have any fish passage data, their score was subjective based on the surveyor.

Additional Analysis: Multivariate Analysis of Road/Stream Crossing Data

We also utilized FAMD (Factor Analysis of Mixed Data) to analyze the acquired RSX data set that contains both categorical and continuous variables. FAMD is useful when analyzing data sets that contain quantitative and qualitative data which reflects the categories of RSX sites. FAMDs help identify possible relationships between different variables. To conduct this analysis, R packages "FactoMineR" and "factoextra" were installed. Categorical variables were then changed to an ordinal formation. For the variable Invasive.Species, a ranking system was implemented: 1 = "Low", 2 and 3 = "Intermediate", and 4 = "High." For the variable Road.Condition, a ranking system was also implemented: 0 = "Good", 2 = "Fair", and 4 = "Poor." Rows that contained "NA" values were omitted from all analyses. 40 data points were originally collected (4 to include the sites that were not accessible for our project, and 1 site that was mistakenly resurveyed outside of Black Lake's watershed boundary) but do not take away from the results obtained from the analysis.

Forestry Desktop Analysis Methods

We conducted a forestry inventory desktop analysis for the Black Lake Watershed by reviewing recent watershed-wide land-cover datasets, collaborating with the Natural Resources Conservation Service (NRCS), Michigan Agriculture Environmental Assurance Program, American Forest Foundation (American Tree Farm System), Michigan Department of Agriculture & Rural Development (MDARD) and Department of Natural Resources (DNR).

Forest management plans aid in the security of watershed health, economic services, and social benefits. Outside of county, state, and national designation of protected forests, they are promoted towards private property through various incentive programs. These programs seek to have positive impacts on the water, soil, and other natural resources provided by the landowners' forests. The DNR, American Forest Foundation (AFS), Michigan Department of Agriculture and Rural Development (MDARD), and National Resource Conservation Service (NRCS) are responsible for maintaining these programs (Table 3.1).

The inventory desktop analysis used the following steps developed and used previously by TOMWC:

1) Prioritize subwatersheds for inventories:
    - Acquire and compile the most current land cover data available.
    - Identify areas within the watershed with forest land cover using the 2019 National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP).
    - Assess forest land cover change over time within the watersheds.
    - Consult with the State of Michigan Forest Resources Division to understand area forest management goals, standards, and regulations for soil and water quality practices, BMPs, and voluntary and mandatory programs.
    - Acquire spatial data of areas with Forest Stewardship Programs or Forestry Management Plans and create a map of parcels enrolled.

Table 3.1. Private landowners tax incentive programs for forestry management as described by Tip of the Mitt Watershed Council

Program	**Affiliate**	**Description**
Commercial Forest Program (CFP)	DNR	This program reduces property taxes on private lands with at least 40 contiguous acres of forest. A forest management plan (including BMPs) is required to enroll, but compliance with the plan is not enforced. Landowners must allow public access for hunting, fishing, and trapping.
Qualified Forest Program (QFP)	MDARD	This program reduces property taxes on private lands with at least 20 contiguous acres of forest. A forest management plan (including BMPs) is required to enroll. Allowing public access is not a requirement on land enrolled in the QFP.
Forest Stewardship Program	DNR	The program offers cost-share for the development of a forest management plan (including BMPs) with the help of a private consulting forester. The plan can then be used for enrollment in tax- incentive programs like the Commercial Forest Program (CFP) or Qualified Forest Program (QFP). Landowners can also get a sign that gives public recognition of their conservation efforts.
American Tree Farm System	American Forest Foundation (AFS)	The program guides landowners in creating a forest management plan, which can be used for enrollment in tax- incentive programs like the CFP or QFP. It also requires members to follow all state designated BMPs for forest management, and landowners receive a sign that gives public recognition of their conservation efforts. The landowners' forest must be between 10-10,000 acres.
Michigan Agriculture Environmental Assurance Program (MAEAP)	MDARD	Requires landowners to develop a management plan and follow Michigan BMPs. The management plan can be used for enrollment in tax- incentive programs like the CFP or QFP. Landowners also receive a sign that gives public recognition of their conservation efforts.
Environmental Quality Incentives Program (EQIP)	NRCS	Offers cost-share to landowners to help fund conservation-oriented practices, including the development of forest management plans, planting trees and shrubs, creating early successional habitat, marking timber in preparation for sale, and other practices

Stream Bank Erosion Methods

We performed a streambank survey using methodologies developed and used extensively by TOMWC staff for similar surveys.[35] These methodologies were employed to document and assess streambank erosion. These surveys were carried out from August 7th to August 25th in 2023.

Desktop and Field Survey Methods

The streambank surveys document conditions and activities at riverside properties that will potentially impact water quality and the stream ecosystem. Streambank conditions were surveyed in the navigable river sections by traveling in two kayaks on each side of the river. The stream reach that was inventoried was the Black River between Kleber Dam and Tower Plant and Tower Pond. This area was inventoried due to the high concentration of properties along the river banks. To gain a better idea of streambank erosion in areas that are less developed within the watershed, a desktop analysis was also conducted by TOMWC summer interns. The desktop analysis was conducted for the Fisher, Stewart, Stony, Rainy, and Cold tributaries to flag any points of erosion. The sites from this desktop analysis were determined by apparent magnitude and visited from August 7th to August 25th in 2023. Streambank conditions for these sites were surveyed by spot-checking the sites found to have erosion from the desktop analysis.

Streambank conditions 500' upstream and 500' downstream at each crossing were documented. Erosion, streambank alterations, tributary streams, and the presence of invasive species were documented for all streamside properties. All data was documented using Survey123, with data on the form found in Appendix 6. A survey was filled out completely at each location where streambank erosion is found (multiple erosion sites for one property went on the same form). GPS coordinates, greenbelts, streambank alterations, invasive species, and tributary information for each property were recorded in the form. Photographs of each property were stored in the form.

Shoreline alterations were surveyed and noted with the following abbreviated descriptions:

SB = steel bulkhead (i.e., seawall)
BB = boulder bulkhead
CB = concrete bulkhead RR = rock rip-rap
WB = wood bulkhead
BR = Mixed boulder/rock riprap
BH = permanent boathouse
BS = beach sand
G = groin
DP = discharge pipe

[35] Tip of the Mitt Watershed Council. (2017). *Burt Lake Watershed Management Plan*.

The problem trend, which is the trend of the erosion identified, was identified as decreasing, stable, or increasing. Decreasing or stable problem trends were identified by physical indicators including new plant growth in previously eroding areas and other evidence that the streambank slope is not actively eroding but rather has reached a temporary or permanent equilibrium. Increasing problem trends were identified as slopes that are too unstable to support new growth of plants and that have active rivulets and gullies along their face.

Common or emerging invasive species occurring in the riparian area and that are visible from the river channel were noted on field datasheets. Invasive species that were noted, but are not limited to, are purple loosestrife, invasive Phragmites, Japanese knotweed, common and glossy buckthorn, and European frog-bit. Tributary streams were noted on the field datasheets and included in a separate column in the database. Additional information regarding shoreline property features or shoreline conditions recorded on field data sheets was included in the database in a “comments” column. Site sketches were done by hand and photographed to be included in the form.

Data Processing

Upon completing field work, all field data from Survey123 was downloaded and stored on the TOMWC server. Points and information collected using Survey123 were overlaid with county parcel data. The linked field and equalization data allowed streambank conditions documented during the survey to be referenced by property identification number or property owner name. Erosion severity calculations were made using data collected in the field and the scoring system found below.

The final products of the streambank survey include a comprehensive database stored on the TOMWC’s server, a complete set of GPS digital photographs, GIS data layers of streambank parcels including both county equalization and streambank survey data, and a map displaying results. The streambank survey database contains a sequential listing of properties. The database contains all data collected in the field and identification numbers that correspond to those in GIS data layers and on hard-copy maps. Data was presented in the WMP via a map and a table with GPS coordinates.

Table 3.2. Streambank Erosion Scoring System

Condition of bank	**Points**		**Soil type or texture**	**Points**
Toe and upper bank eroding	5		Sand	3
Toe undercutting	3		Gravel	2
Toe stable, upper bank eroding	1		Stratified	2
			Clay, loam	1
Problem trend	**Points**		**Vegetative cover on bank slope**	**Points**
Increasing	5		0-10%	5
Combination	3		10-50%	3
Decreasing or stable	1		50-100%	1
Side-slope of bank	**Points**		**Apparent cause of erosion**	**Points**
1:1 (vertical)	5		Light access traffic	1
1:2 or 1:3	2		Obstruction in river	1
1:4 or flatter	1		Bank seepage	1
			Gullying by side channels	1
			Bend in river	2
			Wave action (impoundments)	2
			Road-stream crossing (runoff)	3
			Moderate access traffic	3
			Heavy access traffic (foot, horse, etc.)	5
Length of eroded bank	**Points**		**Mean height of eroded bank**	**Points**
More than 50 feet	5		More than 20 feet	7

20 to 50 feet	3		10 to 20 feet	5
Less than 20 feet	1		5 to 10 feet	3
			Less than 5 feet	1
Depth of river	**Points**		**Current**	**Points**
3 feet or more	2		Fast	2
Less than 3 feet	1		Slow	1
			Total Points for Site	

Total score indicates the severity of the erosion:

More than 36 = severe
30 to 36 = moderate
Less than 30 = minor

Sediment loads for major streambank erosion were determined by using a Direct Volume Method for each erosion site. Lateral recession rates (LRR) ranged from 0.03 to 0.4, depending on severity, and an average soil weight density for loamy sand/sandy loam of 100.

$$\text{(eroding area)} \times \text{(lateral recession rate)} \times \text{(density)} = \text{erosion in tons/year}$$
$$\text{2000 lbs/ton}$$

The eroding area is in square feet, the lateral recession rate is in feet/year, and density is in pounds/cubic feet (pcf).

To determine the phosphorus loads, the following formula was used:

Sediment (T/year) x .0005 lbP/lb x 2000 lb/T x soil correction factor (.85)

To determine the nitrogen loads, the following formula was used:

Sediment (T/year) x .001 lbN/lb x 2000 lb/T x soil correction factor (.85)

Agriculture Survey Methods

An agriculture survey was completed using the Animal Feeding Operations Inventory developed by EGLE to identify feeding operation activity in the Black Lake Watershed (Appendix 7). TOMWC interns completed the desktop analysis and we completed ground truthing during August 7th to August 25th of 2023. Sub watersheds within the Black Lake Watershed were

chosen based on the percentage of land containing croplands and pastures from common land units provided by EGLE. The subwatersheds containing agricultural land were inventoried.

The desktop analysis consisted of analyzing aerial photographs taken from Google Earth and Michigan Imagery Services to identify the location and characteristics of animal feeding operations (AFOs). ArcGIS Pro was used for the analysis and all data was stored in a geodatabase on the Watershed Council's servers as well as the SharePoint file managed by EGLE. The Fishnet tool was utilized to create a grid of the area of interest for ease of analysis. The AFOs were identified based on the characteristics laid out in the Animal Feeding Operations Inventory (Appendix 7). The AFOs were then prioritized based on the following ranking system:

High Priority

- Any size dairy or beef operations in close proximity to water bodies with:
    - Observable drainage pathways leading to surface waters from identified sources
    - No manure storage found, or,
    - Storage is lacking, or otherwise disorganized
- Operations with potential livestock access issues

Medium Priority

- Hobby farms with:
    - Potential access issues
    - Observable drainage pathways leading to surface waters from identified sources
- Any size or type of AFO with manure storage structures near the water body, but no strong evidence of water quality impacts observable via aerials.

Low Priority

- Any size or type of AFO not near the observable connection to the water body.

After the desktop analysis was completed by TOMWC interns, we encountered issues in accessing the geospatial data gathered. The layers created to identify parcels containing agricultural activity and characteristics of the parcels had broken data sources that we were not able to access. The only data available was the GPS points for 32 sites that were identified as having agricultural land. These 32 sites were ground-truthed by the team from August 7th to 25th of 2023 to determine the status of the area. This followed the Field Check Methodology from the Animal Feeding Operations Inventory (Appendix 7) to confirm the proximity to a water body, type, size, storage, and maintenance of the AFOs identified. During the ground truthing, it was found that many of the sites identified in the desktop analysis did not contain agricultural activity, so we redid the desktop analysis. After the desktop analysis was completed the second time, the data that was gathered from the ground truthing was matched with the desktop analysis through the GPS points of the 32 sites and the GPS points for the common land units used in the desktop analysis.

Priority Parcel Analysis Methods

One of the most effective tools for long-term water quality protection is permanent protection of land, particularly sensitive lands such as those containing wetlands. Although the watershed already contains protected land owned by governments and conservancies, there remain many land parcels in sensitive areas that should be protected to safeguard the watershed's lakes, streams, wetlands, and groundwater. A "Priority Parcel Analysis" was performed in ArcGIS Pro by TOMWC staff to quantify and rate all individual land parcels in the Black Lake watershed based on multiple ecological criteria using methodology developed by TOMWC[36]. The analysis produced a tool that guides land conservancies, governmental entities, and others with permanent land protection efforts in a manner that provides the greatest benefit to local ecosystems, while also complementing existing land protection efforts. Descriptions of selection criteria and the scoring system used to determine priority parcels are described below.

Parcel Size: Larger blocks of contiguous land typically have higher ecological value due to their potential to harbor a greater diversity of habitat types and species. Larger parcels are also more time and cost-effective to protect than smaller parcels. The selection threshold for parcel size criteria during this process was 10 acres. The larger the parcel, the more points it will receive.

Groundwater Recharge Potential: Groundwater discharge is essential for maintaining the healthy cold water fisheries that prevail in Northern Michigan. Land with highly permeable soils allows precipitation to percolate relatively quickly through the soils and recharge groundwater supplies. Predominant soil type and associated permeability was determined for each parcel using the physical properties found in county soil surveys. Parcels were scored based on acreage containing soils with high ground water recharge potential, with the minimum threshold set at one acre.

Presence of Wetlands: Wetlands provide a variety of important functions that contribute to the health of surface waters, including fish and wildlife habitat, water quality protection, flood control, and erosion prevention. Digital GIS data layers containing results of the National Wetlands Inventory (NWI) were used to determine the presence of wetlands on individual parcels. Parcels were scored based on wetland acreage identified in the NWI, with any parcel with wetlands scoring at least one point.

Lake and Stream Riparian Ecosystems: Activities on land immediately adjacent to a waterbody are critically important to maintaining water quality and ecological health. Properties with lake or stream shorelines were given scores based on the total shoreline distance contained within the parcel. Properties with at least 100 feet of shoreline were prioritized for protection.

[36]Tip of the Mitt Watershed Council. (2017). *Burt Lake Watershed Management Plan*.

Steep Slopes: Areas with steep slopes are at greater risk of erosion, particularly when developed. To prevent erosion and reduce sedimentation of surface waters in the watersheds, land parcels with steep slopes should be permanently protected. GIS data from the State of Michigan was used to determine the highest percent slope on a parcel and scored accordingly. Properties with slopes greater than 20% will receive points.

Protected Land Adjacency: Properties adjacent to protected lands such as State Forests or conservancy lands have a high ecological value because they provide a buffer to preexisting protected lands and increase the contiguous protected area, which essentially expands the biological corridor for species migration and interaction. Protected lands include properties owned by the federal government, tribal governments, the State of Michigan, local governments, universities, land conservancies, and private owners (conservation easements). Properties bordering protected lands were scored based on the number of adjacent protected land parcels.

Presence of State or Federally Listed Threatened or Endangered Species: Threatened and endangered species represent an important aspect of biodiversity. The Michigan Natural Features Inventory developed a probability model and rarity index based on existing threatened and endangered species information, called the Biological Rarity (Biorarity) Index. Properties within or touching upon the model's grid cells that have a high probability of threatened and endangered species occurrence scored points; receiving a higher score as the rarity index number increases.

Proximity to Development: Properties near urban areas have a high conservation value due to the imminent threat of development. Because these properties are near population centers, they have the greatest potential for public use and provide the most gain in terms of ecosystem preservation. NOAA CCAP (Coastal Change Analysis Program) land cover data and MGDL municipal boundary data were used to identify urban areas and growth corridors. Parcels were scored based on proximity to these areas.

Natural Land Cover Types: Land in its natural state is more ecologically valuable than altered land because natural land cover tends to contain a greater diversity of habitat and species, and is more resilient to invasion by non-native species. NOAA's CCAP land cover dataset was used to determine a percent coverage of natural land cover types for each parcel. Parcels with greater than 50% natural land cover received points.

Drinking Water Protection Areas: Wellhead protection areas are critical recharge zones that maintain aquifer water supplies and sustain local municipal drinking water systems. Development within these areas can jeopardize water sources by contaminating water supplies or inhibiting the infiltration of rainwater. Points were assigned to parcels that lie within wellhead protection areas and based on the percentage of the parcel within the area.

Exceptional Resources: This criteria provides a fixed, two point score increase to any parcel adjacent to an exceptional resource. Exceptional resources are locally occurring conditions that are rare, vulnerable to degradation, and have high intrinsic value. The following were identified as critical resources for this analysis: critical dunes, blue-ribbon trout streams, forests with an average age of greater than 90 years, and undeveloped lakes.

Criteria for Prioritization and Scoring:

1. Parcel Size (acreage) (GIS Field "acre_scr")
    a. Acres >= 10 AND acres < 20 — 1 pts
    b. Acres >= 20 AND acres < 40 — 2 pts
    c. Acres >= 40 AND acres < 80 — 3 pts
    d. Acres >= 80 — 4 pts
2. Groundwater Recharge Potential (acreage) (GIS Field "gw_rcg_scr")
    a. Groundwater Recharge Acres >= 0 AND < 5 — 1 pts
    b. Groundwater Recharge Acres >= 5 AND < 10 — 2 pts
    c. Groundwater Recharge Acres >= 10 AND < 20 — 3 pts
    d. Groundwater Recharge Acres >= 20+ — 4 pts
3. Wetland Preservation (acreage) (GIS Field "wetld_scr")
    a. Wetland Acres > 0 AND < 2 — 1 pts
    b. Wetland Acres >= 2 AND < 5 — 2 pts
    c. Wetland Acres >= 5 AND < 10 — 3 pts
    d. Wetland Acres >= 10+ — 4 pts
4. Lake Shoreline/Riparian Protection (linear feet) (GIS Field "Lk_Scr")
    a. Lake Shore Distance > 100' AND < 200' — 1 pts
    b. Lake Shore Distance >= 200' AND < 400' — 2 pts
    c. Lake Shore Distance >= 400' AND < 600' — 3 pts
    d. Lake Shore Distance >= 600' — 4 pts
5. River and Stream Shoreline/Riparian Protection (linear feet) (GIS Field "stream_scr")
    a. Stream Distance >= 100' AND < 500' — 1 pts
    b. Stream Distance >= 500' AND < 1000' — 2 pts
    c. Stream Distance >= 1000' AND < 2000' — 3 pts
    d. Stream Distance >= 2000' — 4 pts
6. Steep Slopes for Erosion Prevention (GIS Field "slope_scr")
    a. Slopes >= 20 and < 30% — 1 pts
    b. Slopes >= 30 and < 35% — 2 pts
    c. Slopes >= 35 and < 40% — 3 pts
    d. Slopes > 40% — 4 pts
7. Proximity to Protected Lands (Wildlife Corridors) (GIS Field "protct_scr")
    a. Parcel edge within 250' of conservation lands — 1 pts
    b. Abutting conservation land — 2 pts

    c. Linking conservation land 3 pts
    d. Adjacent to conservancy lands and doubles size 4 pts
8. Threatened/Endangered Species (using MNFI model) (GIS Field “endang_scr”)
    a. Probability = 'Low' AND "RI" >= 3 AND "RI" < 4 1 pts
    b. Probability = 'Low' AND "RI" >=4 2 pts
    c. Probability = 'Moderate' AND "RI" >=0 3 pts
    d. Probability = 'High' AND "RI" >=0 4 pts
9. Proximity to Development (CCAP land cover = “Developed”) (GIS Field “devpres_scr”)
    a. Adjacent to any “developed” land cover 1 pts
    b. Within 2.5 miles of City Development or .75 miles of non-incorporated development 2 pts
    c. Within .75 miles of City Development 3 pts
    d. Within City Development 4 pts
10. Natural Land Cover Types (CCAP = non-agriculture, non-developed) (GIS Field “NatPct_Scr”)
    a. Natural Land Cover >= 50% AND < 70% 1 pts
    b. Natural >= 70% AND < 80% 2 pts
    c. Natural Land Cover >= 80% AND < 90% 3 pts
    d. Natural Land Cover >= 90% 4 pts
11. Drinking Water Protection Areas (GIS Field “wellHD_scr”)
    a. Wellhead Protection Area >= 1% and < 20% 1 pts
    b. Wellhead Protection Area >= 20% and < 35% 2 pts
    c. Wellhead Protection Area >= 35% and < 50% 3 pts
    d. Wellhead Protection Area > 50% 4 pts
12. Exceptional Resources (Multiple GIS Fields)
    a. Lakeshore w/Shoreline <= 25 parcels/mile average 2 pts
    b. Intersects a Blue Ribbon Trout Stream 2 pts
    c. Intersects Critical Dune Habitat 2 pts

All land parcels in the Black Lake watershed were analyzed and scored using the twelve listed criteria for a total of 47 points possible. The scores for each criterion were summed to produce a total “priority” score for each land parcel. Priority rankings of high, medium, and low were assigned to parcels based on priority scores. Rankings vary for each analysis depending on results and natural groupings and breaks in the data. The rankings were split into five equal-interval categories representing priorities for permanent land protection. The categories are in the following table:

Table 3.3. Ranking Categories for Priority Parcel Analysis

Priority for Permanent Land Protection	**Parcel Score Range**
Very Low	0-6
Low	7-11
Moderate	12-22
High	23-29
Very High	30+

GIS data layers developed during the prioritization process contained both county equalization information and priority criteria scores for all parcels in the watershed. The GIS data, associated databases, and maps were made available to local land conservancies, state agencies, and local governments to prioritize land protection activities and guide landscape development planning. Permanent protection or low-impact development in high-priority areas will help maintain the ecological integrity of the most sensitive areas and protect water resources throughout the watershed. Results of the Priority Parcel Analysis also provide valuable assistance in conservation efforts to protect threatened and endangered species, as well as to improve wildlife corridors throughout the watershed.

Determining Critical Areas Methods

Critical areas are the areas within a watershed with the greatest need for restoration. Critical areas were determined after all resource inventories were complete and the results were tabulated. The methodology for determining critical areas is based on a ranking system used previously by TOMWC.[31] The watershed was divided into one-mile square grid cells and each cell was scored based on multiple criteria. For each criterion, the percent coverage within individual grid cells was determined and a score was assigned to the cell. Scores for all criteria were summed to produce a total score. Critical areas were determined based on areas where grid cells scored in the highest tier(s) (tiers created by the scores of each cell; higher scores = higher tier). However, personal knowledge of problematic watershed areas by surveyors, committee members, natural resource professionals, and others were taken into account when developing the final critical areas map (e.g. areas with notable pollution).

1. Developed base GIS data layer for analysis. Utilized the one square mile gridded data layer for groundwater recharge developed in the Groundwater Inventory and Mapping Project (a cooperative effort between the Water Bureau - Michigan Department of Environmental Quality, USGS - Michigan Water Science Center and Michigan State

University Institute of Water Research, RS & GIS and Biosystems and Agricultural Engineering) to perform an assessment of critical areas. Selected all cells that intersect the Black Lake Watershed in a GIS and exported to make a new layer that will be used throughout the assessment.

2. Urban land cover. Determined all areas classified as urban or residential in the most recent land-cover dataset. Used the following system for grid cells:
    a. Urban/residential >= 10% and < 25% SCORE = 1
    b. Urban/residential >= 25% and < 40% SCORE = 2
    c. Urban/residential >= 40% and < 55% SCORE = 3
    d. Urban/residential >= 55% SCORE = 4
3. Agricultural landcover. Determined all areas classified as agriculture in the most recent land-cover dataset. Used the following system for grid cells:
    a. Agriculture >= 10% and < 25% SCORE = 1
    b. Agriculture >= 25% and < 40% SCORE = 2
    c. Agriculture >= 40% and < 55% SCORE = 3
    d. Agriculture >= 55% SCORE = 4
4. Problematic agricultural activity. Used agricultural inventory information from the WMP, used the following system for scoring:
    a. Prob ag sites = 1 and acreage < 20 SCORE = 1
    b. Prob ag sites = 1 and acreage > 20 SCORE = 2
    c. Prob ag sites > 1 and acreage < 20 SCORE = 3
    d. Prob ag sites > 1 and acreage > 20 SCORE = 4
5. Problematic forestry activity. Used forestry inventory information from the WMP, used the following scoring system:
    a. Prob forest sites = 1 and acreage < 10 SCORE = 1
    b. Prob forest sites = 1 and acreage > 10 SCORE = 2
    c. Prob forest sites > 1 and acreage < 10 SCORE = 3
    d. Prob forest sites > 1 and acreage > 10 SCORE = 4
6. Road stream crossings (RSX). Used RSX inventory information from WMP, used the following scoring system:
    a. Severe sites = 1 SCORE = 1
    b. Severe sites = 2 SCORE = 2
    c. Severe sites = 3 SCORE = 3
    d. Severe sites >= 4 SCORE = 4
7. Streambank erosion. Used streambank erosion inventory information from WMP, used the following scoring system:
    a. Severe sites = 1 SCORE = 1
    b. Severe sites = 2 SCORE = 2
    c. Severe sites = 3 SCORE = 3
    d. Severe sites >= 4 SCORE = 4

8. Poor greenbelts (GB). Used shoreline survey information from WMP, used the following scoring system:
    a. Poor GB >= 5 parcels and < 10 SCORE = 1
    b. Poor GB >= 10 parcels and < 20 SCORE = 2
    c. Poor GB >= 20 parcels and < 30 SCORE = 3
    d. Poor GB >= 30 SCORE = 4
9. Shoreline erosion. Used shoreline survey information from WMP, used the following scoring system:
    a. Severe erosion >= 2 parcels and <= 4 SCORE = 1
    b. Severe erosion > 4 parcels and <= 7 SCORE = 2
    c. Severe erosion > 7 parcels and <= 10 SCORE = 3
    d. Severe erosion > 10 SCORE = 4
10. Shoreline nutrient pollution. Used shoreline survey information from WMP (strong indicators = heavy algae growth ratings including MH, H, and VH; as well as septic leachate detector strong signals), used the following scoring system:
    a. Strong indicators >= 5 parcels and < 10 SCORE = 1
    b. Strong indicators >= 10 parcels and < 20 SCORE = 2
    c. Strong indicators >= 20 parcels and < 30 SCORE = 3
    d. Strong indicators >= 30 SCORE = 4
11. Steep slopes. Used slope maps made with digital elevation models, used the following scoring system:
    a. Slopes >= 20 and < 30% SCORE = 1
    b. Slopes >= 30 and < 35% SCORE = 2
    c. Slopes >= 35 and < 40% SCORE = 3
    d. Slopes >= 40 SCORE = 4
12. Water quality impairments. Compiled water quality information from all sources were used to perform this assessment, though only data from 1990 to present was used. Poor water quality indicators used for this assessment include: dissolved oxygen < 7 mg/L; pH < 6.5 and > 9.0; total phosphorus > 30 ug/L; total nitrogen > 500 ug/L; suspended solids > 40 mg/L; chloride > 30 mg/L; E. coli > 300 organisms/100 mL; and macroinvertebrate community rating = poor.
    a. Poor WQ indicators >= 2 parcels and < 5 SCORE = 1
    b. Poor WQ indicators >= 5 parcels and < 10 SCORE = 2
    c. Poor WQ indicators >= 10 parcels and < 15 SCORE = 3
    d. Poor WQ indicators >= 15 SCORE = 4

A final GIS map was created to visualize the different areas deemed critical and in need of restoration. The results will help to prioritize management efforts within the Black Lake Watershed. The criteria that was omitted during the ranking process was forestry activity due to performing only a desktop analysis. Agricultural activities were included even though ground

truthing is needed as high priority sites were identified from the desktop analysis.

Chapter 4: Results

Social Indicator Survey

Surveyed Population Information

The Black Lake Watershed Resident Social Indicator Survey was available online from June 16, 2023 through September 30th, 2023. The survey garnered 42 individual responses.

The surveyed population demographics are compared to the demographics of the Black Lake Watershed counties in Table 4.1, indicating a significantly more educated, older subsection of the watershed resident population, although a similar racial breakdown. When asked if the surveyed individuals made the home and lawn care decisions in their household, 85% responded “yes.” The large majority (72.5%) do not utilize professional lawn care services. The majority (59%) of respondents live in an isolated, rural, non-farm residence (Table 4.2). When asked where they seek information regarding water quality issues, most survey respondents selected internet and newsletters/brochures/factsheets, providing guidance for the best strategies TOMWC can communicate information (Table 4.3).

Table 4.1. Demographic Comparison between Surveyed Populations (highlighted) and Counties in the Black Lake Watershed

Demographics	Surveyed Population	Otsego County	Montmorency County	Presque Isle County	Cheboygan County
Age	63.5	44.8	56	55.7	51.6
Race (Percentage of White People)	94.70%	95.80%	96.20%	96.20%	92.50%
Education (Bachelor's Degree or higher)	87.10%	26.80%	14.30%	19.20%	22.70%

Table 4.2. Location of Residences of the Surveyed Population with Predominant Location Highlighted

Location of Residence	Percentage of Surveyed Population
In an isolated, rural, non-farm residence	59%
Rural subdivision or development	25.6%
In a town, village, or city	15.4%
On a farm	0%

Table 4.3. Sources that Survey Respondents Seek for Water Quality Issue Information with Top Sources Highlighted

Source	Percent of responses
Internet	70%
Newsletters/Brochures/Factsheet	63%
Workshops/demonstrations/meetings	32.5%
Conversations with others	30%
Newspapers/magazines	27.5%
Radio	2.5%
None of the above	2.5%

Survey Results

48.8% of the surveyed population rated the current health of the Black Lake Watershed as "Good" and 24.4% stated "Very good," resulting in the large majority believing the watershed is in good health. Yet when asked what is the trend for conditions in the Black Lake Watershed, 58.5% claimed the watershed was "Slowly worsening," indicating significant concern for the future of the watershed.

Surveyed Population Awareness

Consequences of Poor Water Quality

The "Consequences of Poor Water Quality" section asked participants to rank various consequences on a scale ranging from "Not a Problem" (1) to "Severe Problem" (3). The consequences of poor water quality that were perceived to be the most severe problems in the

Black Lake Watershed were excessive aquatic plants or algae and the loss of desirable fish species (Table 4.4). Polluted swimming areas and contaminated drinking water were ranked as the least problematic consequences of poor water quality.

Table 4.4. Survey Respondents' Mean Scores of the Potential Consequences of Poor Water Quality in the Black Lake Watershed

Potential Consequence of Poor Water Quality	Mean	SD
Excessive aquatic plants or algae	2.66	0.91
Loss of desirable fish species	2.55	1.03
Reduced beauty of lakes or streams	1.86	0.91
Reduced opportunities for water recreation	1.81	0.91
Contaminated fish	1.65	0.94
Polluted swimming areas	1.55	0.79
Contaminated drinking water	1.32	0.75

Water Impairments

The "Water Impairments" perceived to pose the greatest threat to the Black Lake Watershed were phosphorus and invasive aquatic plants while Salt, TDS, Chlorides, and trash or debris were deemed to pose the lowest threat to water quality (Table 4.5).

Table 4.5. Survey Respondents' Mean Scores of the Potential Water Impairments in the Black Lake Watershed

Water Impairments	Mean	SD
Phosphorus	3	0.82
Invasive aquatic plants and animals	2.92	0.84
Algae in the water	2.79	0.77
Habitat alteration harming local fish	2.77	0.99
Nitrogen	2.61	0.78
Sedimentation (dirt and soil) in the water	2.28	0.89
Toxic materials in the water	2.1	1.02
Bacteria and viruses in the water (such as E.coli / coliform)	2.04	0.92
Salt / TDS / Chlorides	1.81	0.98
Trash or debris in the water	1.79	0.81

Sources of Water Pollution

The most problematic sources of water pollution from the surveyed population's perspective were the excessive use of lawn fertilizers and/or pesticides and improperly maintained septic systems while the least problematic sources were discharges from industries into lakes and streams and discharges from sewage treatment plants.

Table 4.6. Survey Respondents' Mean Scores of the Potential Sources of Water Pollution

Potential Sources of Water Pollution	Mean	SD
Excessive use of lawn fertilizers and/or pesticides	2.88	0.93
Improperly maintained septic systems	2.84	0.86
Droppings from geese, ducks and other waterfowl	2.79	0.87
Removal of riparian vegetation	2.66	0.9
Soil erosion from shorelines and/or streambanks	2.61	0.9
Yard maintenance	2.57	1.04
Septic disposal	2.43	1.07
Drainage/filling of wetlands	2.31	1.04
Land development or redevelopment	1.97	0.9
Soil erosion from farm fields	1.94	0.93
Street salt and sand	1.84	0.93
Stormwater runoff from rooftops and/or parking lots	1.84	0.82
Stormwater runoff from streets and/or highways	1.83	0.95
Littering/illegal dumping of trash	1.65	0.88
Soil erosion from construction sites	1.63	0.76
Discharges from industry into streams and lakes	1.6	0.97
Discharges from sewage treatment plants	1.53	0.88

Practices to Improve Water Quality

Measuring awareness through one final focal point, the "Practices to Improve Water Quality" survey section asked participants about their level of experience with various practices that improve water quality. The most used practices were following the manufacturer's instructions when fertilizing a lawn or garden and following pesticide application instructions for a lawn or garden, yet many practices were deemed familiar to the participants, garnering many high mean scores (Table 20). The least used practices were using porous pavement and creating a rain

garden.

Table 4.7. Survey Respondents' Mean Scores of the Practices to Improve Water Quality in the Black Lake Watershed

Practices to Improve Water Quality	Mean	SD
Following the manufacturer's instructions when fertilizing lawn or garden	3.52	0.58
Follow pesticide application instructions for lawn and garden	3.48	0.59
Plant trees/shrubs	3.34	0.79
Use phosphate free fertilizer	3.33	0.66
Restore native plant communities	3.24	0.91
Plant vegetated riparian buffer	3.03	1.05
Use rain barrels	2.81	0.49
Use porous pavement	2.79	1.18
Create a rain garden	2.03	1.03

Surveyed Population Attitudes and Willingness to Take Action

Water Quality Related Attitudes

To determine water quality related attitudes, participants were asked to determine their level of agreement with each water quality related statement (Table 4.8). Notably, participants agreed most with the following statements: "The way that I care for my lawn and yard can influence water quality in local streams and lakes," "The quality of life in my community depends on good water quality in local streams, rivers and lakes," "Using recommended management practices on farms improves water quality," and "It is my personal responsibility to help protect water quality." These statements indicate attitudes and desires to protect the local ecosystem and watershed at large. The statement "I would be willing to pay more to improve water quality (for example: through local taxes or fees)" garnered the lowest mean score, indicating negative attitudes toward monetary investments into improving water quality.

Table 4.8. Water Quality Related Attitudes in the Black Lake Watershed

Statements to Determine Water Quality Related Attitudes	Mean	SD
The way that I care for my lawn and yard can influence water quality in local streams and lakes.	4.75	0.44
The quality of life in my community depends on good water quality in local streams, rivers and lakes.	4.72	0.55
Using recommended management practices on farms improves water quality.	4.7	0.46
It is my personal responsibility to help protect water quality.	4.7	0.46
My actions have an impact on water quality.	4.65	0.48
It is important to protect water quality even if it slows economic development.	4.5	0.64
I would be willing to change the way I care for my lawn and yard to improve water quality.	4.35	0.74
I would be willing to change management practices to improve water quality.	4.23	0.78
I would be willing to pay more to improve water quality (for example: though local taxes or fees)	3.77	1.01

Willingness to Take Action

94.3% of the participants are willing or already practice regular septic system servicing while 97.2% of the participants indicated that they are already or willing to try proper septic sizing (Table 4.9).

Table 4.9. Willingness to Try Regular Septic System Servicing in the Black Lake Watershed

Willingness to Try Regular Septic System Servicing	Percent of Surveyed Participants
Yes or already do	94.30%
Maybe	5.70%
No	0%

Table 4.10. Willingness to Try Proper Septic System Sizing in the Black Lake Watershed

Willingness to Try Proper Septic Sizing	Percent of Surveyed Participants
Yes or already do	97.20%
Maybe	2.80%
No	0%

Surveyed Population Constraints to Behavior Change and Adopting Key Practices

Constraints to Behavior Change

"Concerns about resale value" and "Approval of my neighbors" proved to be the largest constraints to behavior change, while "Personal out-of-pocket expenses" was the lowest, indicating that the financial burden of behavior change is not constraining the respondents' behavior.

Table 4.11. Potential Constraints to Behavior Change in the Black Lake Watershed

Potential Constraint to Behavior Change	Mean	SD
Concerns about resale value	3.76	0.63
Approval of my neighbors	3.69	0.79
The need to learn new skills or techniques	3.53	0.89
Not being able to see a demonstration of the practice before I decide	3.53	0.88
Don't know where to get information and/or assistance about those practices	3.51	0.74
No one else I know is implementing the practice	3.51	0.8
Environmental damage caused by practice	3.42	1.09
Lack of available information about a practice	3.21	0.95
My own physical abilities	3.05	1.11
Not having access to the equipment that I need	3.03	1.08
Personal out-of-pocket expense	2.8	1.14

Specific Constraints to Adopting Key Practices

For both regular septic system servicing and proper septic system sizing, participants were asked if there were any barriers that limited their ability to implement each practice. The largest

constraints to regular septic system servicing were the “Physical or health limitations” and that the practice is “Hard to use with my farming system”, while “Cost” and “Don’t know how to do it” were determined to be the smallest constraints (Table 4.12). The practice of proper septic system sizing shared the same largest constraints (Table 4.13), while “Cost” and “The features of my property make it difficult” were the two smallest constraints.

Table 4.12. Specific Constraints to Regular Septic System Servicing in the Black Lake Watershed

Specific Constraints to Regular Septic System Servicing	Mean	SD
Physical or health limitations	3.97	0.17
Hard to use with my farming system	3.97	0.18
Insufficient proof of water quality benefit	3.86	0.52
Desire to keep things the way they are	3.84	0.52
The features of my property make it difficult	3.81	0.54
Lack of equipment	3.81	0.64
Time required	3.79	0.54
Don't know how to do it	3.78	0.59
Cost	3.45	0.87

Table 4.13. Specific Constraints to Proper Septic System Sizing in the Black Lake Watershed

Specific Constraints to Proper Septic System Sizing	Mean	SD
Hard to use with my farming system	3.97	0.18
Physical or health limitations	3.81	0.64
Insufficient proof of water quality benefit	3.74	0.77
Lack of equipment	3.7	0.75
Desire to keep things the way they are	3.68	0.83
Time required	3.68	0.79
Don't know how to do it	3.68	0.79
The features of my property make it difficult	3.59	0.95
Cost	3.38	1.05

Social Indicator Score Comparison

Following this, we compare the social indicator scores demonstrated by the 2023 Black Lake Watershed Residents with the social indicator scores demonstrated by the 2016 Elk River Chain of Lakes (ERCOL) Watershed Residents. These two watershed communities were surveyed using very similar Social Indicator Surveys with the same Social Indicator Criteria, making this an effective comparison. This comparison creates a scale by which readers can understand the social indicator scores and provides readers with an increased level of context.

Notably, the Black Lake Watershed Residents received lower social indicator scores than the ERCOL Watershed Residents in three of the four awareness criteria, indicating a gap in the Black Lake Watershed Residents' awareness. Aside from awareness, the Black Lake Watershed Residents scored high indicator scores compared to the ERCOL Watershed Residents in attitudes and willingness to take action category and in the constraints to behavior change and adopting key practices category (Table 4.14).

Table 4.14. Social Indicator Score Compared Between Black Lake and ERCOL Watershed Resident Surveys

Social Indicator Category	**Social Indicator Criteria**	**Black Lake Watershed Residents**	**ERCOL Watershed Residents**
Awareness	Consequences of Poor Water Quality	1.26	1.34
	Water Impairments	1.48	1.53
	Sources of Water Pollution	1.54	1.55
	Practices to Improve Water Quality	1.89	1.79
Attitudes and Willingness to Take Action	Water Quality- Related Attitudes	4.49	4.11
	Willingness to Take Action	1.98	1.76
Constraints to Behavior Changes and Adopting Key Practices	Constraints to Behavior Change	3.36	3.11
	Constraints to Adopting Key Practices	3.75	3.58

Surveyed Population Trusted Sources of Information

As a final, closed-ended question, participants were asked to share their level of trust in a variety of information sources, which helps to inform the best information mediums to use throughout the development of the BLWMP. Participants placed significant trust in the TOMWC, Local Lake Associations, Soil and Water Conservation District, the U.S. Environmental Protection Agency, and University Extension and little trust in Lawn Care Companies and Local Community Leaders (Table 4.15). The high level of trust in TOMWC and Local Lake Associations may have been influenced by the methods of survey distribution. The survey was distributed by TOMWC and shared through Local Lake Associations, perhaps creating a more biased sample of survey respondents.

Table 4.15. Respondents' Trust in Information Sources where the mean score indicates trust level in descending order

Information Source	**Mean Score**
Tip of the Mitt Watershed Council	3.27
Local Lake Associations	3.25
Soil and Water Conservation District	3.17
U.S. Environmental Protection Agency	3.12
University Extension	3.11
Black Lake Watershed Advisory Committee	3.06
State agricultural agency	2.81
State environmental agency	2.85
Environmental groups	2.71
Local government	2.5
Local tribes	2.46
Local garden center	2.21
Local community leader	2.1
Lawn care company	1.87

Lastly, survey respondents had the opportunity to share additional thoughts, comments, and concerns at the end of the survey. Individuals mentioned a variety of topics including harmful algal blooms, poor septic maintenance and inability to access septic system information, run-off and application of lawn care chemicals, and the communication disconnect that can occur from a seasonal watershed resident population. To see the Open Comments, please see Appendix 8.

Road/Stream Crossings (RSX)

Pollutant potential is high at RSXs and increases when their condition deteriorates. When structures, such as culverts, bridges, and fords, begin displaying signs of failure, such as structural problems due to improper installation, all aspects of fluvial ecosystems have the potential to be impacted. Pollution that exists as a result of poor RSX conditions pose health effects to aquatic organisms and has the possibility of introducing metals, bacteria, excessive nutrients, and other nonpoint source pollutants into surrounding streams. Increased sedimentation because of crossings poses the greatest threat to fluvial ecosystems as it worsens water quality as well as impacts the overall habitat.[37] Monitoring RSXs and updating inventories are critical to watershed management to further understand the risks that fluvial ecosystems are exposed to. Information retained from these inventories helps identify sediment pollution that may be entering nearby waterways. Consistently updating these inventories allows for officials to document any changes that may have occurred over time.

Over 200 RSX sites have been identified within the Black Lake Watershed using the Great Lakes Stream Crossing Dashboard, however of these there were only 165 total sites that contained usable data (Figure 4.2). Usable data means that the Great Lakes Stream Crossing Inventory Protocol was followed when updating sites. Sites are assigned a severity ranking reflecting erosion, pollution potential, and fish passage, automatically calculated based on built-in formulas within the Survey123 app. Of the 165 sites, 64 (38.8%) were considered “minor” severity, 73 (44.2%) were considered “moderate” severity, and 28 (17%) were considered “major” severity. Out of 165 sites, 25 are considered “time sensitive” and should have immediate attention. “Time sensitive” is subjective and manually input into the Survey123 form. Reasoning may be due to possible obstructions to the structure, failing roadways, dangerous risks such as power lines in the stream, the presence of HABs, low fish passage, etc.



Figure 4.1. Examples of RSXs visited

[37] Road & Stream Crossings. *Tip of the Mitt Watershed Council*. Retrieved November 25, 2023, from https://watershedcouncil.org/our-work/watershed-protection/fish-passage/crossings/

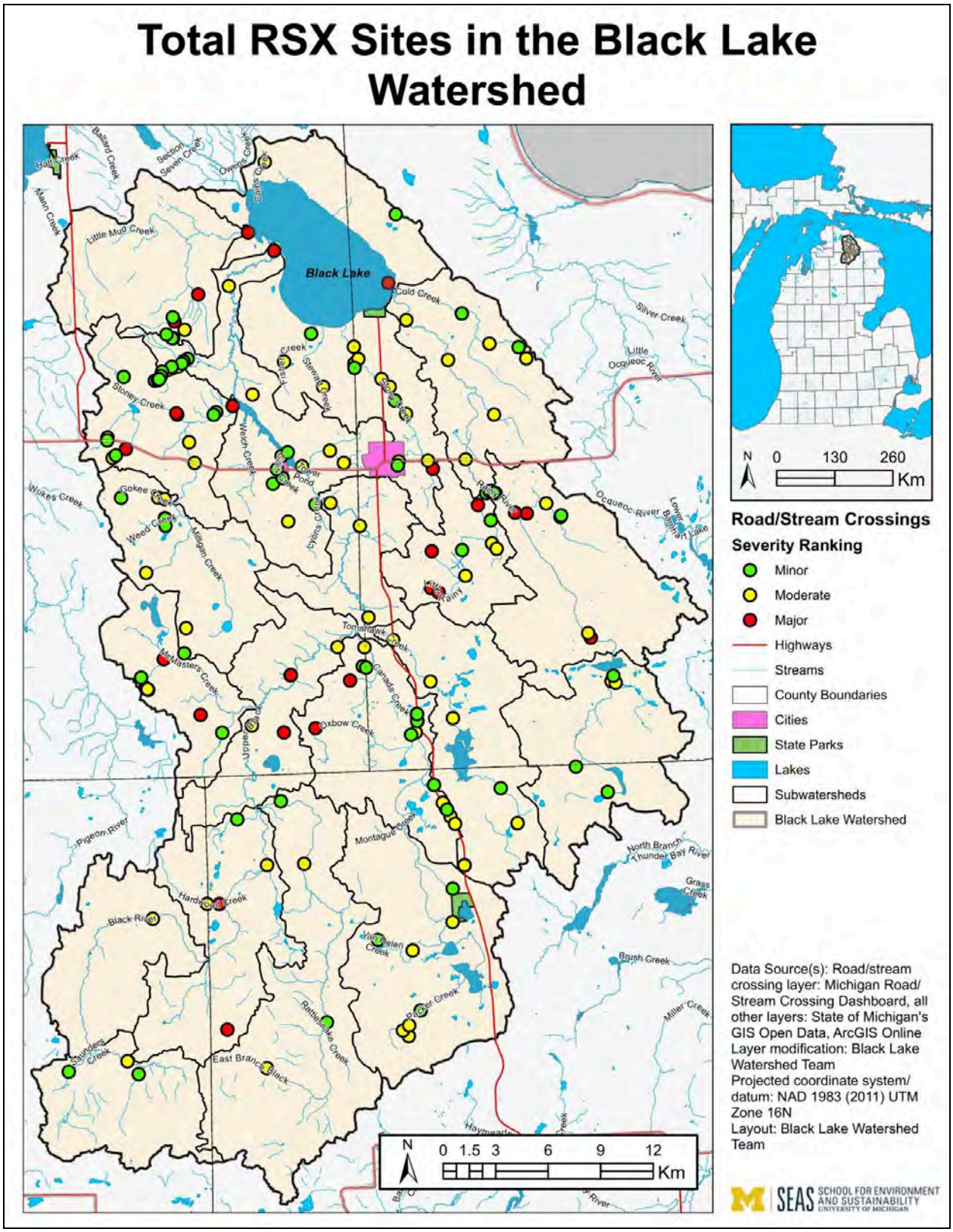


Figure 4.2. All RSX Sites (old and new data) within the Black Lake Watershed

Table 4.16. Number of RSX Sites within the Subwatershed of the Black Lake Watershed for each RSX Severity Ranking (old and new data)

	Road/Stream Crossing Severity Ranking			
Subwatershed	Minor	Moderate	Major	Total
Black Lake**	5	11	3	19
Bowen Creek-Black River**	11	7	1	19
Milligan Creek**	9	4	4	17
Canada Creek**	8	4	2	14
Tomahawk Creek	2	9	0	11
East Brank Rainy River-Rainy River**	4	3	3	10
Little Rainy River**	3	3	4	10
Gokee Creek-Black River	5	4	0	9
Cold Creek-Rainy River**	2	6	0	8
Montague Creek-Canada Creek**	3	5	0	8
McMasters Creek**	2	2	3	7
Mud Creek**	2	2	3	7
Rainy Lake-Rainy River	3	2	0	5
Silver Lake-Black River	0	2	3	5
Stewart Creek-Black River	1	2	2	5
East Branch Black River**	2	2	0	4
Butler Creek-Black River	0	3	0	3
Saunders Creek-Black River**	2	1	0	3
Round Lake-Black River	0	1	0	1
All Subwatersheds	**64**	**73**	**28**	**165**

**Note: two asterisks denote subwatersheds that contain time sensitive sites

***Note: “severe” rankings were an option for severity rankings; for simplicity of this project, “severe” rankings were joined with “major” rankings

RSX Sites Visited

Only 39 of the total 200 RSX sites were visited based on the criteria laid out in the methods section. Of these sites, 35 were able to be successfully updated and were located in 11 of the 19 total subwatersheds. Of the 35 sites, 15 were considered “minor” severity (42.9%), 9 were considered “moderate” severity (25.7%), and 11 were considered “major” severity (31.4%) (Figure 4.3). 25 of the 35 sites visited changed from their previous ranking from the last time they were surveyed (71%). Of the 25, 19 decreased in severity (76%) while 6 increased in severity (24%) (Table 4.17). The change in ranking is reflected by the colors indicated in the table. Grey sites did not change in ranking, green sites decreased in severity ranking, and red sites increased in severity ranking. 18 of the 35 sites were still deemed time sensitive after further analysis of the collected data.

Table 4.17. Comparison of Site Rankings Before and After Revisiting

	Road/Stream Crossing Severity Ranking	
Site ID	**Previous Ranking**	**Current Ranking**
Snake Trail #2**	Major	Major
Logging road south of 68**	Major	Minor
CC04	Major	Moderate
CC06	Moderate	Major
Clark bridge fields access rd	Major	Major
ER01.5	Major	Minor
KC01	Major	Minor
LR00.75	Major	Major
LR01	Moderate	Minor
LR02.7	Moderate	Moderate
LR04	Moderate	Major
LR04.5	Moderate	Major
MB09.5	Major	Major
MB09.7	Major	Minor
MB10.2	Major	Moderate

MB10.3	Major	Moderate
MB10.5	Moderate	Major
MB21	Major	Moderate
MB24	Moderate	Minor
MB26	Moderate	Minor
MB33	Major	Moderate
MC08	Moderate	Minor
MC09	Minor	Minor
RR02	Moderate	Moderate
RR09	Moderate	Major
RR11	Moderate	Minor
SC03	Moderate	Moderate
SC04	Major	Moderate
SC05A	Major	Minor
SC05B	Major	Major
SC08	Moderate	Minor
SC10	Moderate	Major
SC15	Major	Minor
SC16	Moderate	Minor
URB LR03	Minor	Minor

**Note: asterisks denote sites where there was no Site ID and the Crossing Name was used instead

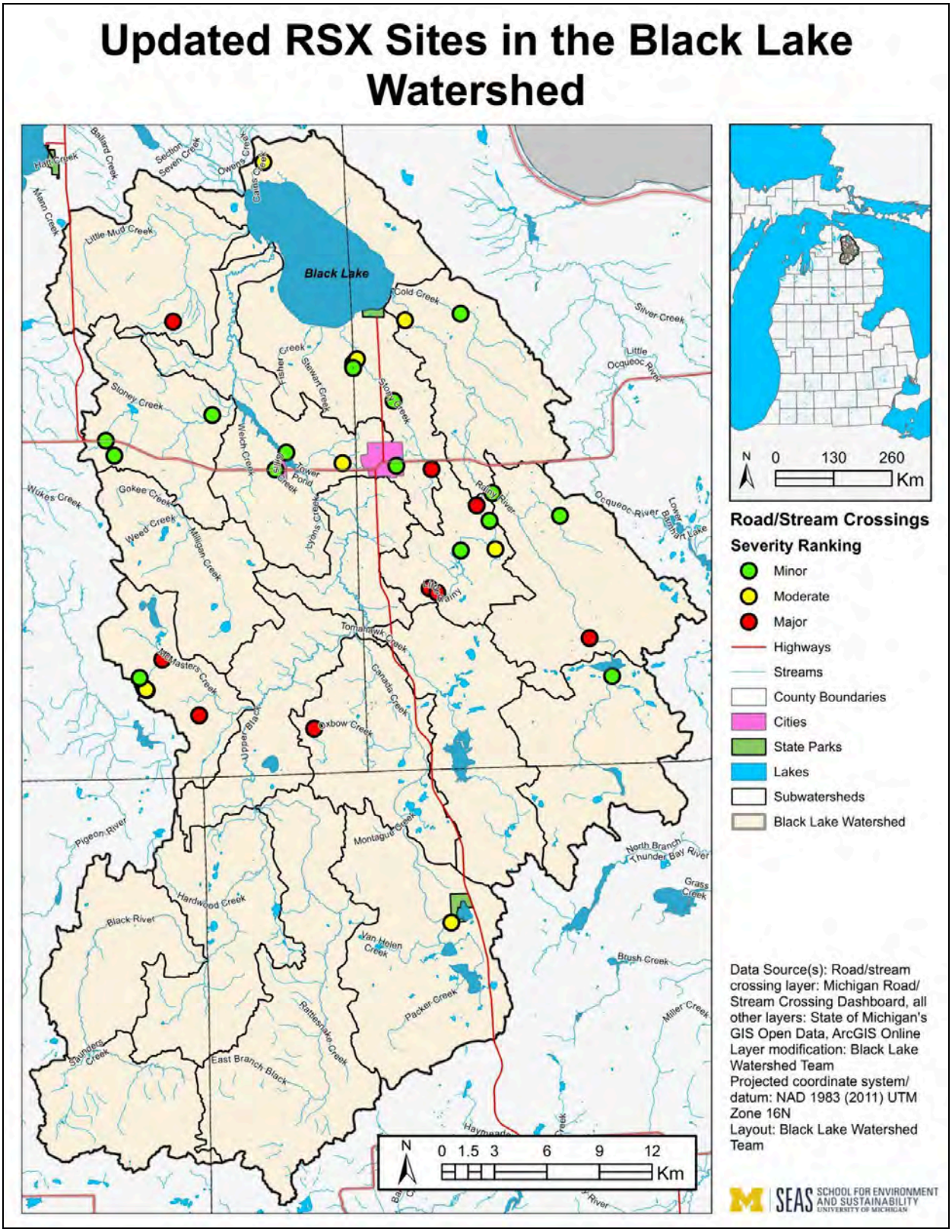


Figure 4.3. RSX Sites within the Black Lake Watershed that were Updated in 2023

Table 4.18. RSX Sites Updated in 2023

	Road/Stream Crossing Severity Ranking			
Subwatersheds	Minor	Moderate	Major	Total
Black Lake**	3	3	2	8
Little Rainy River**	2	1	3	6
McMasters Creek**	1	2	3	6
Bowen Creek-Black River**	2	1	0	3
East Branch Rainy River**	2	0	1	3
Milligan Creek**	3	0	0	3
Cold Creek-Rainy River**	1	1	0	2
Canada Creek**	0	0	1	1
Montague Creek-Canada Creek	0	1	0	1
Mud Creek**	0	0	1	1
Rainy Lake-Rainy River	1	0	0	1
All Subwatersheds	**15**	**9**	**11**	**35**

**Note: asterisks denote subwatersheds that contain time sensitive sites
***Note: “severe” rankings were an option for severity rankings; for simplicity of this project, “severe” rankings were joined with “major” rankings

RSXs are imperative to the survival of aquatic species. Because of the risks that impacted crossings pose towards aquatic life, i.e. interfering with travel, mating, resource availability, and risk to additional dangers, fish passage is recorded to determine aquatic organisms’ ability to freely move amongst the site. These variables at a site are measured and given fish passage scores. Scores can be interpreted as follows: “0” = most species and life stages cannot pass at most flows; “0.5” = some species and life stages cannot pass at most flows; “0.9” = barrier at high flows; “1” = not a barrier. Of the 35 RSX sites visited, only 11.4% of sites posed no barrier at any time. 34.3% of the time there was a barrier at high flows, with over half (54.3%) threatening some or all species from passing regardless of flow (Table 4.18).

Table 4.19. Fish Passage Score Rankin of RSX Sites Updated in 2023

	Fish Passage Scores			
Subwatershed	Score: 0	Score: 0.5	Score: 0.9	Score: 1
Black Lake	2	4	2	0
Little Rainy River	1	0	5	0
McMasters Creek	3	2	1	0
Bowen Creek-Black River	0	0	2	1
East Branch Rainy River	0	1	2	0
Milligan Creek	1	1	0	1
Cold Creek-Rainy River	1	0	0	1
Canada Creek	0	0	0	1
Montague Creek	1	0	0	0
Mud Creek	1	0	0	0
Rainy Lake-Rainy River	1	0	0	0
All Subwatersheds	**11**	**8**	**12**	**4**

Pollutant loading estimates (Sediment Tons/yr) were automatically generated within the Survey123 app for the Great Lakes Road/Stream Crossing Inventory. Pollutant loading estimates for Phosphorus lbs/year were calculated by applying an overall phosphorus concentration of 0.0005 lbP/lb of soil. Pollutant loading estimates for Nitrogen lbs/year were calculated by applying an overall nitrogen concentration of 0.001 lbN/lb of soil. The texture of soil influences the nutrient holding capacity, therefore to better estimate pollutant loadings of phosphorus and nitrogen, a correction factor of 0.85 was used to represent the dominant soil texture (sand/silty loam).[38] Notably, the Little Rainy River subwatershed had the highest pollutant loading and the Gokee Creek-Black River subwatershed had the second highest. The Round Lake-Black River subwatershed reported no pollutant loadings (Table 13).

[38] Streambank Erosion. *NRCS, WI.* Field Office Technical Guide.

Table 4.20. Pollutant Loading for all RSX Sites within Subwatersheds in the Black Lake Watershed

	Pollutant Loading Estimate		
Subwatershed	Sediment tons/yr	Phosphorus lb/yr	Nitrogen lb/yr
Little Rainy River	52	44	88
Gokee Creek-Black River	40	34	67
Black Lake	35	29	59
Stewart Creek-Black River	27	23	46
Silver Lake-Black River	26	22	44
Bowen Creek-Black River	19	17	33
Milligan Creek	16	13	27
East Branch Rainy River-Rainy River	16	13	26
Canada Creek	14	12	24
Tomahawk Creek	14	12	24
Montague Creek-Canada Creek	12	10	21
Cold Creek-Rainy River	11	9	19
East Branch Black River	11	9	18
Mud Creek	6	5	10
McMasters Creek	5	4	8
Saunders Creek-Black River	4	4	7
Butler Creek-Black River	2	2	3
Rainy Lake-Rainy River	2	2	3
Round Lake-Black River	0	0	0
Total	**312**	**264**	**527**

Factor Analysis of Mixed Data (FAMD)

The FAMD helped to visualize and understand the relationship between invasive species abundance and other variables. The most prominent features of an FAMD are its "dimensions." Dimensions are variables that are otherwise not accounted for within the dataset but still contribute to it, such as weather conditions and temperature. The purpose of dimensions is to explain variance in a dataset. FAMD is a multivariate statistical analysis that compares possible associations between quantitative and qualitative variables of a dataset. As mentioned in the methods section, data that we collected at RSX sites were tabulated and specific measured variables were included in the FAMD analysis (such as the invasive species abundance, the water velocity, the size of the structure, etc.). The full study can be accessed in Appendix 10. A scree plot was initially created to identify the dimensions that most explained the variability (Figure 4.4). In simple terms, Dim (dimension) 1 is able to explain 26.55% of the variance within the RSX data and Dim 2 is able to explain roughly 16.04%.

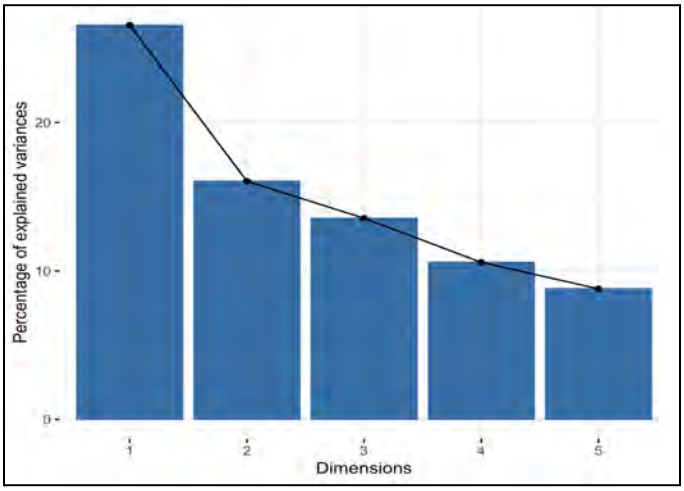


Figure 4.4. Five dimensions and their associated percentage of the variability in they explain in the RSX data

Figure 4.5 displays all of the variables, both categorical and continuous. It can be seen that Structure.Height contributes the most to Dim 1 and Road.Condition contributes the most to Dim 2. When a variable "contributes" to a dimension, it is explaining how much it accounts for the variation within the data. Invasive.Species appears to contribute nearly the same to Dim 1 as it does Dim 2, meaning there are possible relationships between both dimensions.

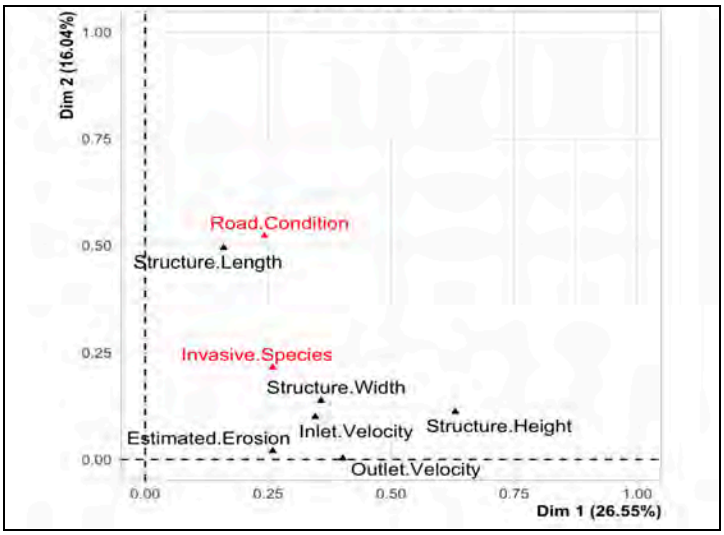


Figure 4.5. Graph of categorical (red: road condition and invasive species abundance) and continuous (black: structure length, width, height, estimated erosion, and inlet/outlet velocity) variables.

Figure 4.6 displays our two categorical variables and their rankings. The dashed lines help to visualize the separation between positive and negative contributions between variables. For example, the horizontal line helps separate what variables contribute positively or negatively to Dim 2, while the vertical line separates the variables that contribute positively or negatively to Dim 1. “Poor” road conditions appear to contribute the most to Dim 1 as well as “Good” road conditions and “Intermediate” and “High” species abundance. “Low” invasive species and “Fair” road conditions contribute negatively to Dim 1. “Low” invasive species abundance negatively contributes the most to Dim 2, however “Intermediate” invasive species also contributes negatively. “Fair” road conditions contribute positively along with “Good” road conditions and “High” invasive species to Dim 2. There is an almost linear relationship seen between the invasive species rankings in this figure in respect to the road conditions (despite the poor road condition) which means that there may be a possible interdependence between the two variables.

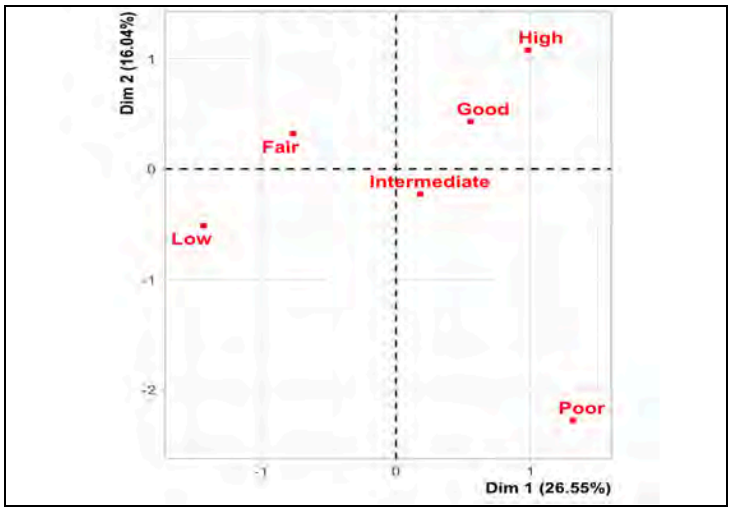


Figure 4.6. Graph of categorical variables (road condition and invasive species abundance)

The final figure (Figure 4.7) depicts the species abundance for each site. Clusters are based on invasive species abundance. Outliers exist for all clusters, but appear to be relatively close to their respective grouping. This graph represents the information depicted in Figure 4.6 but displays how the individual data points are positioned in respect to their invasive species abundance. “High” invasive species clusters contribute positively to Dim 1 as do “Intermediate” invasive species; however, “Low” invasive species contribute the most to Dim 2 (negatively to both Dim 2 and Dim 1). To conclude the analysis, it is apparent that the sites that were revisited have more characteristics in common than what someone would expect from reading the raw data (based on the created clusters), and that there is an obvious trend of similarity regarding invasive species abundance and other variables at RSX sites. This analysis helped determine that there may be an underlying pattern to invasive species abundance given that there are clusters of data formed in relation to the other documented characteristics of RSX sites (road condition, structure height, width, estimated erosion, etc.). The FAMD analysis was not necessary for our project, however it was completed for a previous course.

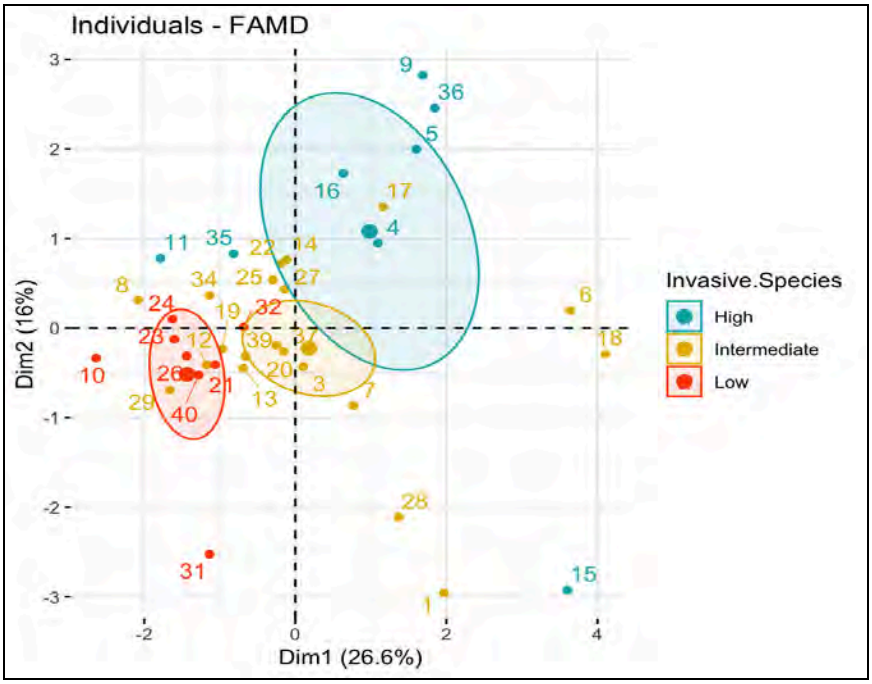


Figure 4.7. Individual data in respect to invasive species abundance

Forestry

As discussed in the methods section under Forestry, a desktop inventory was performed on forested areas within the Black Lake watershed. This inventory aimed to locate forested lands enrolled within management programs. The programs observed were the Qualified Forest Program (QFP) and the Commercial Forest Program (CFP). These are voluntary tax incentive programs for private landowners offered through the Michigan Department of Resources (MDNR). Information was collected from the Michigan Geographic Data Library as well as correspondence with MDARD.

Figure 4.8 presents all forest cover within the Black Lake watershed. The forest types range from deciduous, mixed and evergreen forest, accounting for 47% of the watershed's land cover.

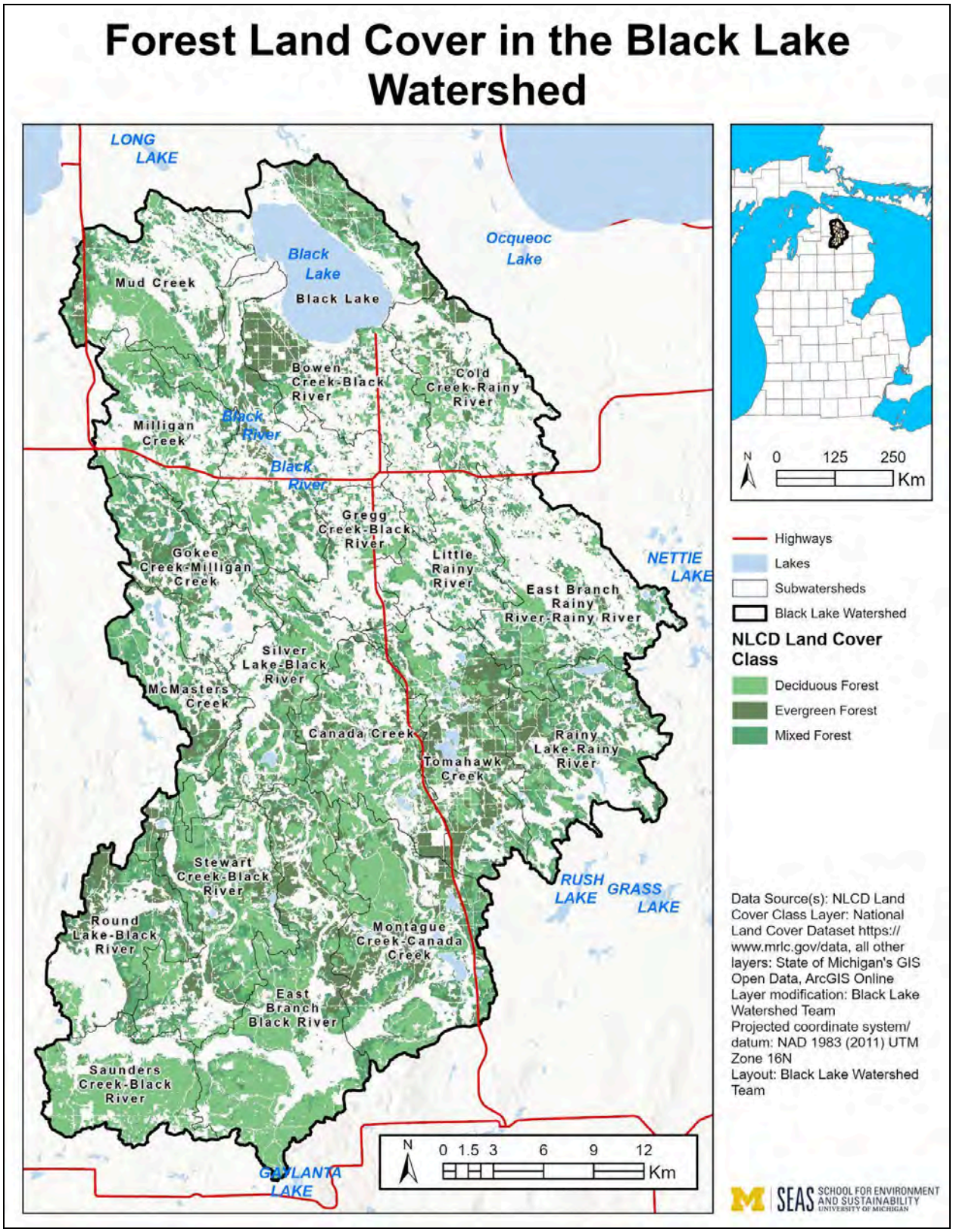


Figure 4.8. Forest Land Cover of the Black Lake Watershed

There are no national forest lands within the watershed, therefore only state parks were included. QFP and CFPs on private land account for 12,463.5 acres of the Black Lake Watershed. In total, CFPs, QFPs and state parks combined account for about 12,887 acres of managed forest land out of 165,000 acres of forest land cover. Therefore, 7.8% of all forested land is managed through those three indicators. The managed forest land can be found below in Table 4.21 and seen in Figure 4.9.

There are two state parks, Onaway State Park and Cheboygan State Park, in the counties of Montmorency (Cheboygan State Park) and Presque Isle (Onaway State Park), accounting for 423.7 acres managed by the DNR. The Commercial Forest Program accounted for 4.9% of the managed forest in Black Lake's watershed, which is 630.54 acres within 12 parcels in the southern end of the watershed. Qualified Forest Program accounted for 91.8% of the acres managed through the three program chosen. This is a sum of 11,832.97 acres of the forested land in the watershed.

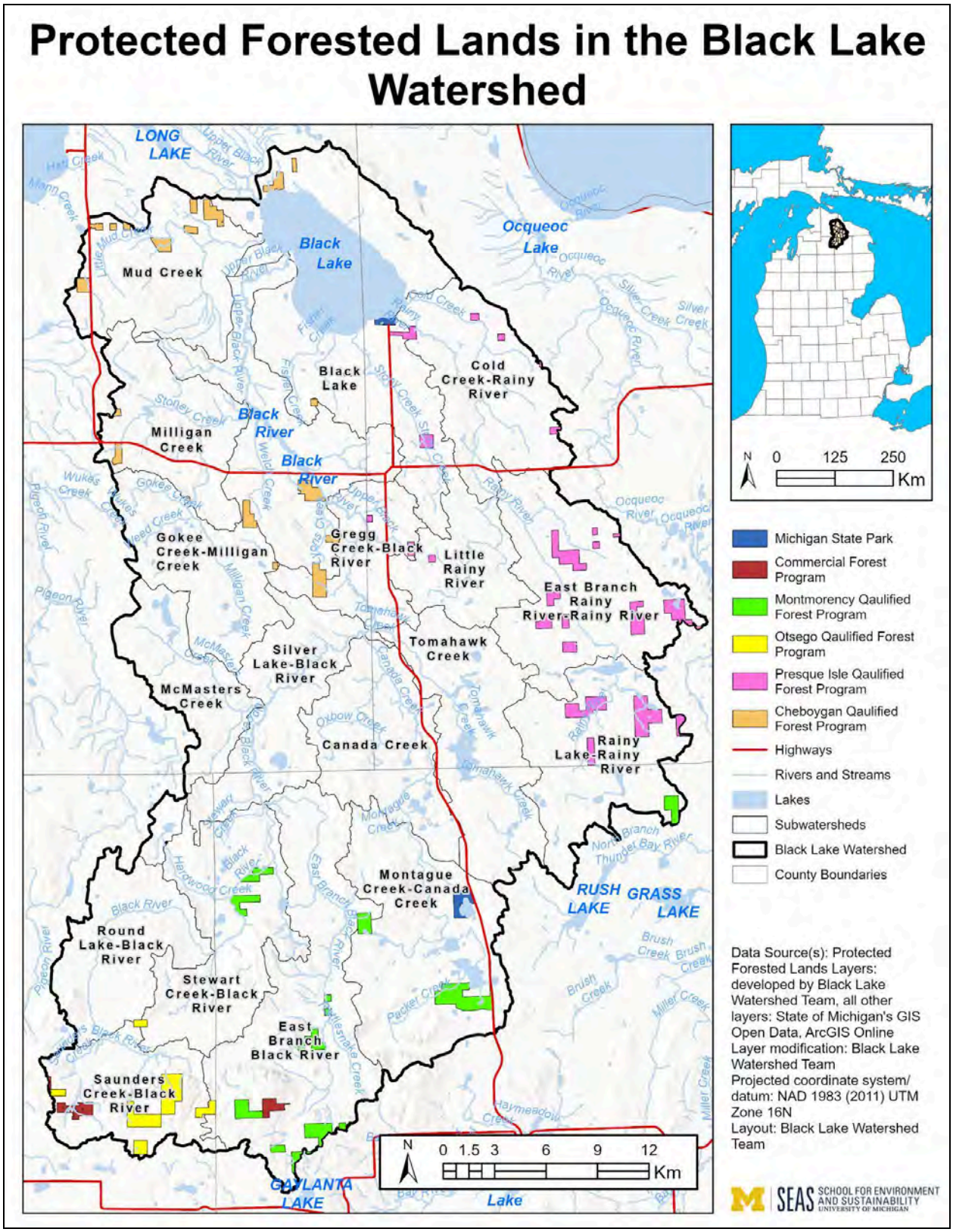


Figure 4.9. QFPs, CFP and state parks protected forest land in the Black Lake Watershed

Table 4.21. Management type, county, acres and parcels enrolled within the watershed

Form of Management	County	Acres	Parcels Enrolled	Total Acres Protected
State Park	Otsego	0	0	423.69
	Cheboygan	0	0	
	Montmorency	290.28	1	
	Presque Isle	133.41	1	
Qualified Forest Program	Presque Isle	4288.45	57	11832.97
	Cheboygan	2485.92	35	
	Otsego	1722.18	10	
	Montmorency	3336.42	49	
Commercial Forest Program	Presque Isle	0	0	630.54
	Cheboygan	0	0	
	Otsego	403.54	6	
	Montmorency	227	6	
Total Acres Protected within the watershed				**12887.2**

Stream Bank Erosion

Streambank erosion is a naturally occurring process that removes sediment and other materials from the bank of a stream. When this process is accelerated, the stream system can be altered and can have detrimental impacts on the health of the stream and the watershed as a whole[39]. The inventory conducted in the Black Lake Watershed provides insight into where streambank erosion is occurring and provides guidance on where targeted action can be taken to address pollutant loading from streambank erosion within the watershed. As stated in our methods, a desktop analysis of Fisher Creek, Stewart Creek and Stony Creek was performed and identified erosion spots along these creeks were visited along with the shoreline of the Upper Black River between Kleber Dam and Tower Pond.

Upper Black River

[39] Stream Bank Erosion and Control. (n.d.). WASHTENAW COUNTY CONSERVATION DISTRICT. Retrieved March 3, 2024, from https://www.washtenawcd.org/stream-bank-erosion-and-control.html

A total of 43 sites were identified to have erosion occuring along the Upper Black River between Tower Pond and Kleber Dam (Figure 4.10). Of these sites, a majority (72%) had 51-100% bank vegetation cover and 81% had an increasing problem trend (Figure 4.11). None of the sites along the Upper Black River had a decreasing problem trend, but eight of them had a stable problem trend. One or more streambank structures were present at 33 sites, with 24 having a dock and 15 having riprap present (Figure 4.12).

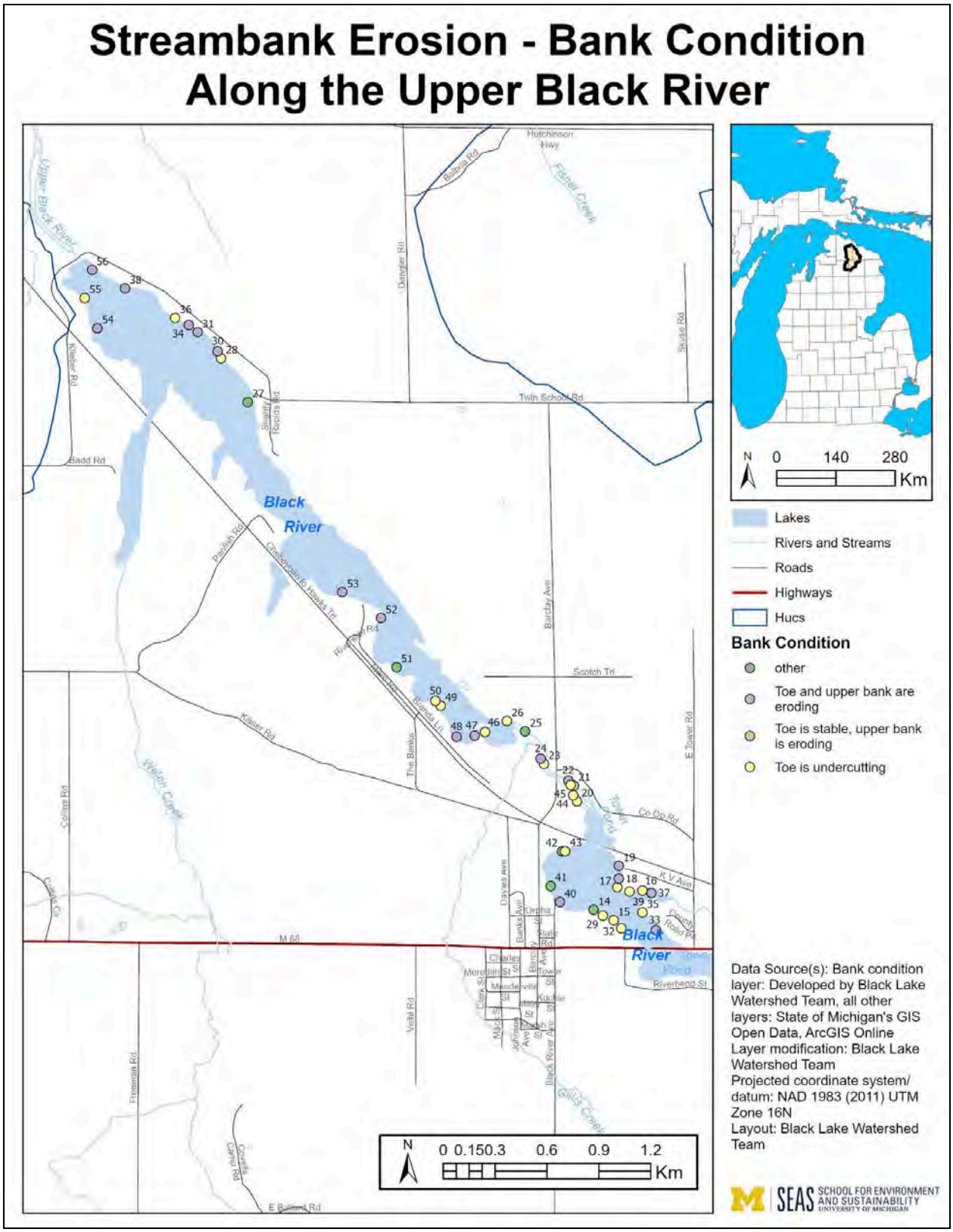


Figure 4.10. Bank condition for streambank erosion sites located along the Black River

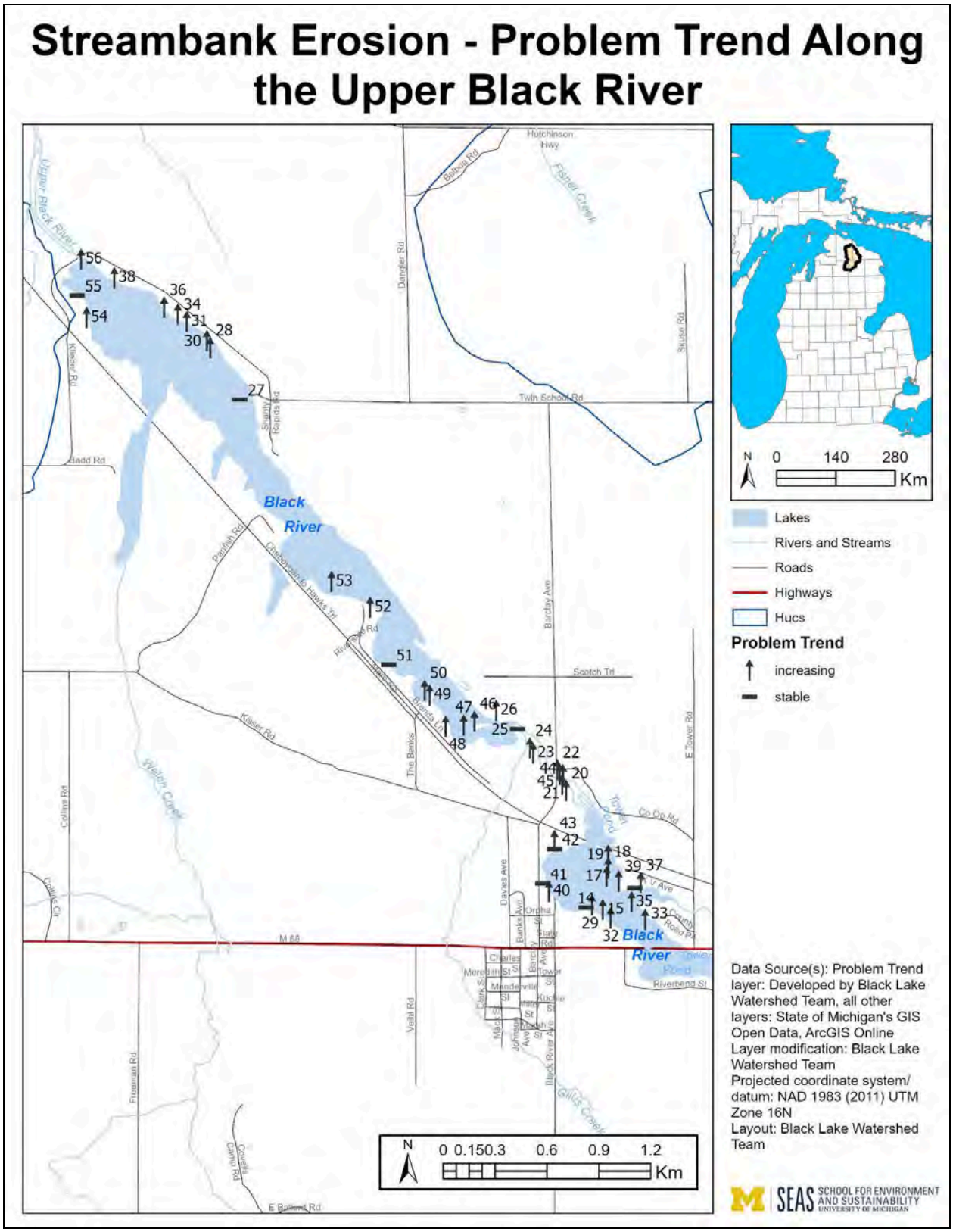


Figure 4.11. Bank condition for streambank erosion sites located along the Black River

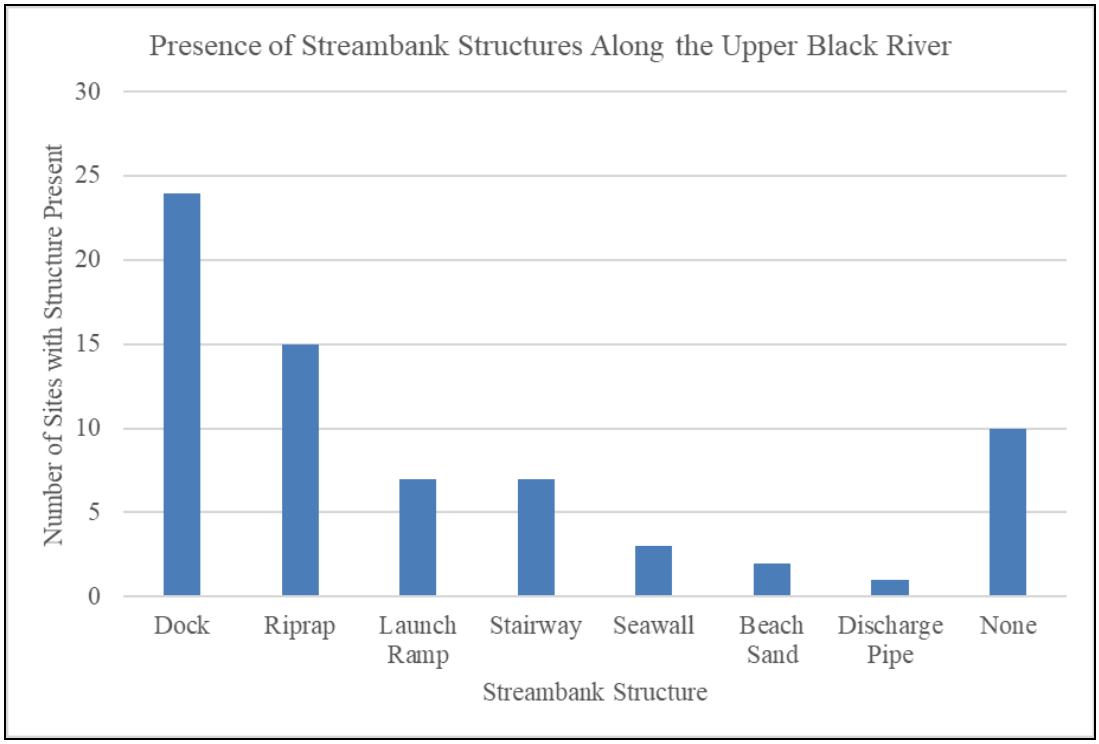


Figure 4.12. Presence of streambank structures at erosion sites along the Upper Black River

Greenbelt scores were given to all sites based on what percentage of the shoreline the greenbelt covered. For the purpose of this inventory, greenbelts were defined as a buffer of vegetation along the streambank between the water and shoreline development. The two most common scores were 0 (no greenbelt present) and 3 (extends 25-75% of shoreline) which 12 sites had (Figure 4.13).

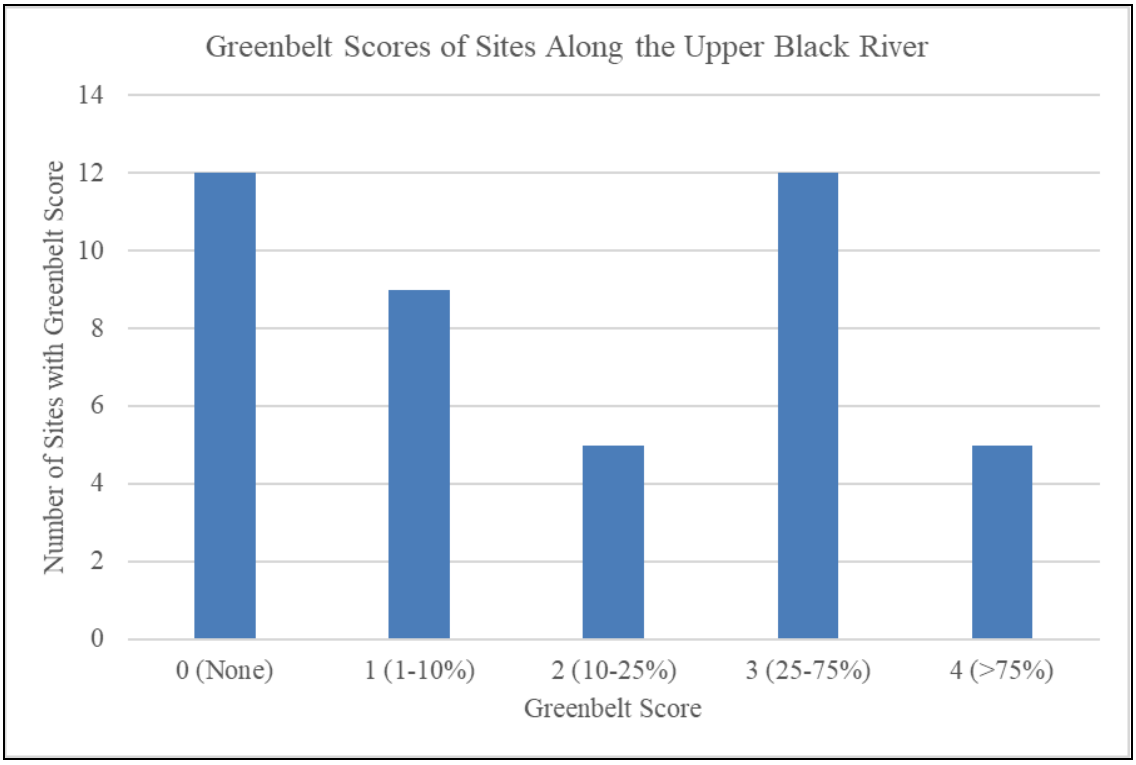


Figure 4.13. Greenbelt scores based upon the percentage of the shoreline the greenbelt extends for sites along the Upper Black River

Rainy River

The desktop analysis that was performed for the tributaries in the Black Lake Watershed found eight sites of erosion along the Rainy River (Figure 4.14). All eight of these sites were visited during August 2023 and any erosion present was documented. Seven of the eight sites had erosion occurring, with five of them having 0-10% of vegetation present on the bank. The problem trend for six out of the eight sites is increasing, with only one site decreasing and another site seeing a combination of increasing and decreasing at the site (Table 4.22).

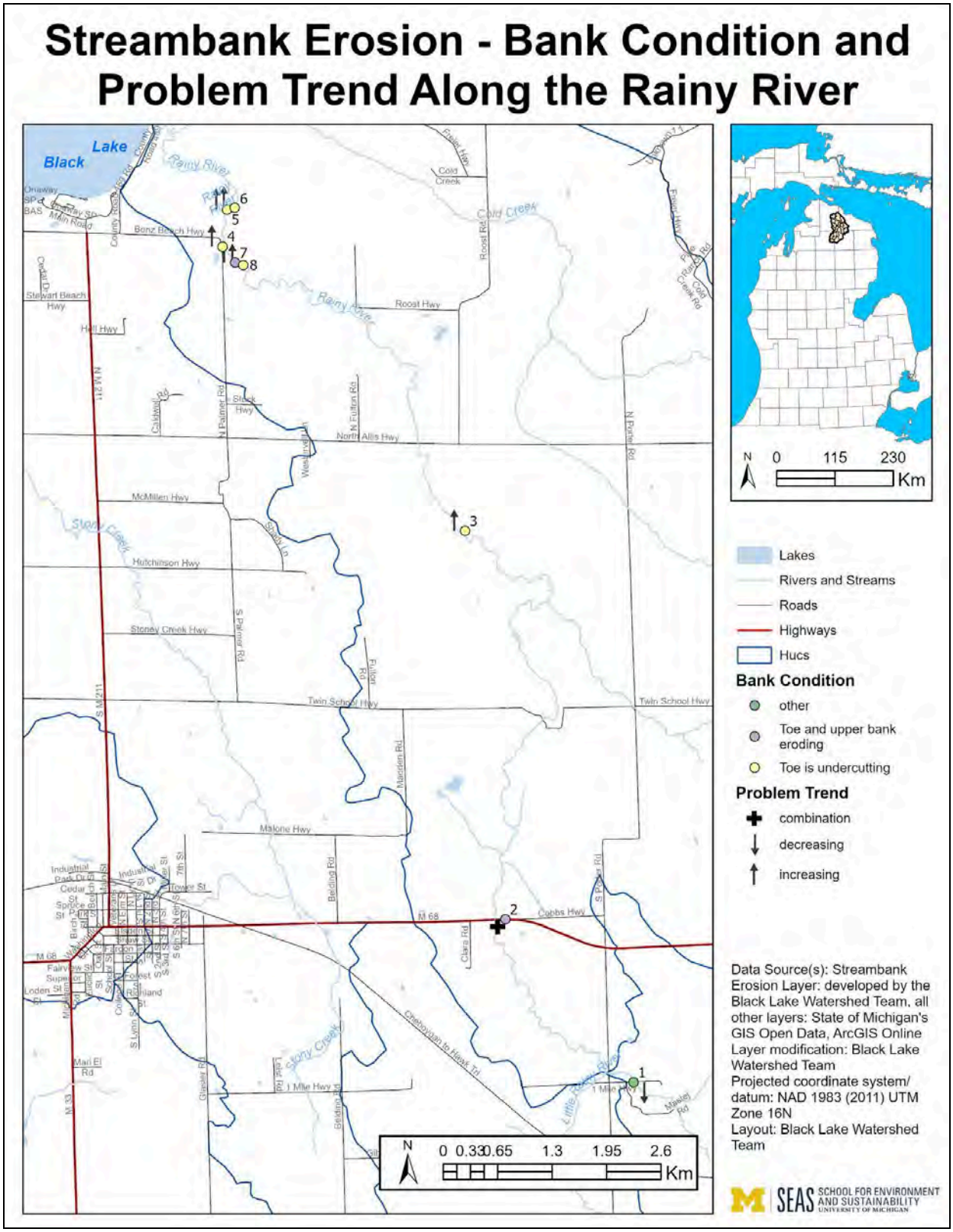


Figure 4.14. Bank condition and problem trend for streambank erosion sites located along the Rainy River

Table 4.22. Percentage of bank with vegetation, bank condition and problem trend of streambank erosion sites along the Rainy River

Site ID	Bank Vegetation Cover	Bank Condition	Problem Trend
1	51-100%	no erosion	decreasing
2	11-50%	toe and upper bank are eroding	combination
3	51-100%	toe is undercutting	increasing
4	0-10%	toe is undercutting	increasing
5	0-10%	toe is undercutting	increasing
6	0-10%	toe is undercutting	increasing
7	0-10%	toe and upper bank are eroding	increasing
8	0-10%	toe is undercutting	increasing

Fisher Creek, Stewart Creek and Stony Creek

The desktop analysis performed for the tributaries in the Black Lake Watershed found two sites of erosion along Fisher Creek, two sites of erosion along Stewart Creek and one site of erosion along Stony Creek (Figure 4.15). All of these sites were visited in August of 2023. All of these sites had 51-100% vegetation bank cover. Only two of the sites saw erosion occurring, one on Fisher Creek and one on Stewart creek, all of the others saw no erosion occurring with a decreasing or stable problem trend. The erosion occurring at the Fisher Creek site has a decreasing problem trend and the erosion occurring at the Stewart Creek site has an increasing problem trend (Table 4.23).

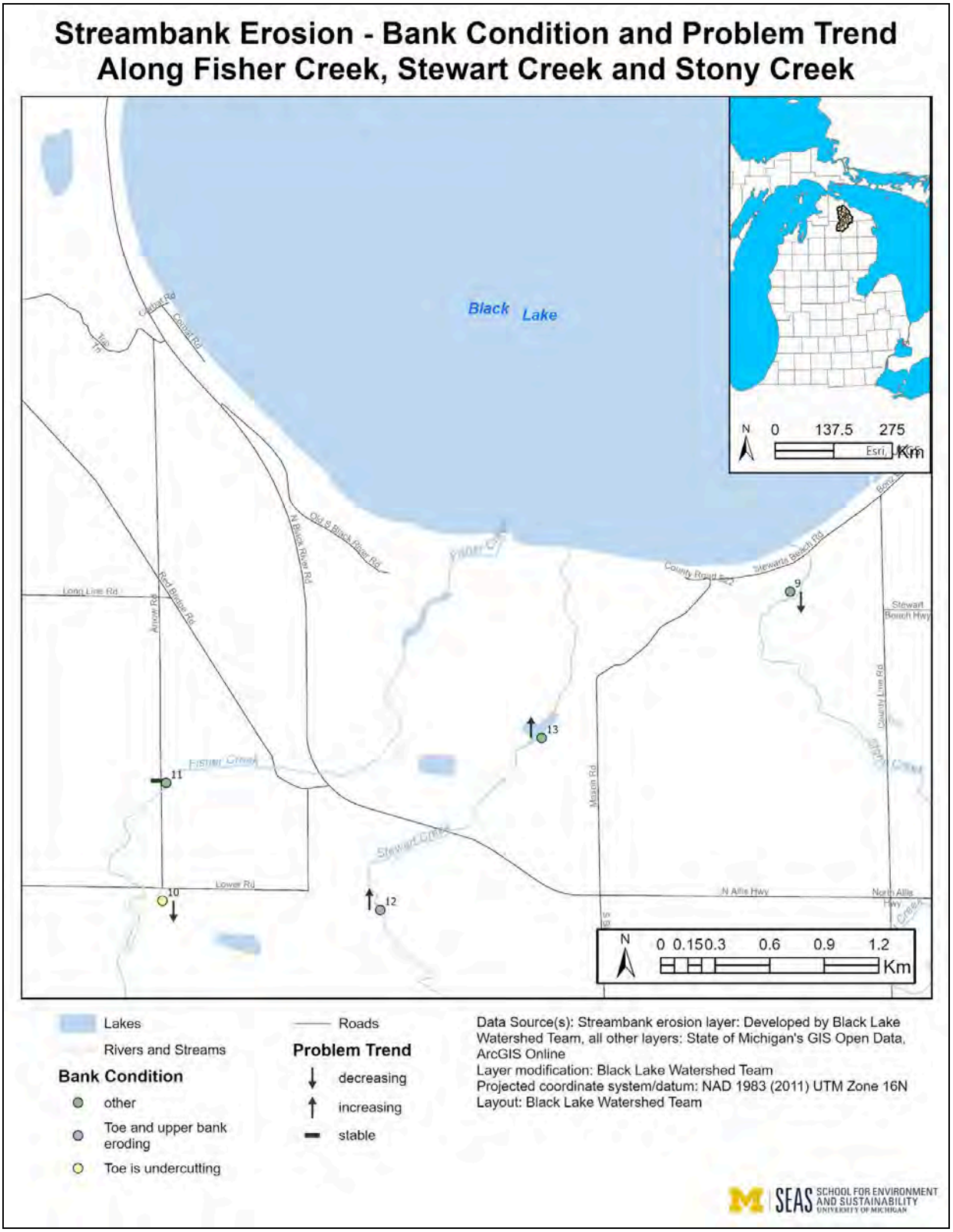


Figure 4.15. Bank condition and problem trend for streambank erosion sites located along Fisher Creek, Stewart Creek, and Stony Creek

Table 4.23. Percentage of bank with vegetation, bank condition and problem trend of streambank erosion sites along Stony Creek, Fisher Creek and Stewart Creek

Site ID	Stream	Bank Vegetation Cover	Bank Condition	Problem Trend
9	Stony Creek	51-100%	no erosion	decreasing
10	Fisher Creek	51-100%	toe is undercutting	decreasing
11	Fisher Creek	51-100%	no erosion	stable
12	Stewart Creek	51-100%	toe and upper bank are eroding	increasing
13	Stewart Creek	51-100%	no erosion	increasing

Severity of erosion was given a ranking of minor, moderate or severe based upon our scoring criteria described in the methods section. This incorporated various aspects of the site to come up with a total score, with total scores below 30 being deemed minor, total scores between 30 and 36 being deemed moderate and total scores above 36 being deemed severe. Of the 56 sites visited within the watershed, only two sites were given a ranking of severe. A majority of the sites, 38, were given a ranking of minor and 16 were given a ranking of moderate (Table 4.24).

Table 4.24. Total number of sites of erosion severity ranking for each tributary surveyed

	Severity of Erosion		
Tributary	Minor	Moderate	Severe
Upper Black River	31	11	1
Rainy River	2	5	1
Fisher Creek	2	0	0
Stewart Creek	2	0	0
Stony Creek	1	0	0
Total Sites	**38**	**16**	**2**

Sediment loadings were calculated for each site using a direct volume method. This was then used to determine estimated pollutant loadings from phosphorus and nitrogen. Upper Black River has the most amount of pollutant loadings, with more nitrogen loadings. The total amount of pollutant loading from streambank erosion in the Black Lake Watershed was 229.76 pounds per year of phosphorus and 459.53 pounds per year of nitrogen.

Table 4.25. Sediment and nutrient loadings for each tributary surveyed

Tributary	**Number of Sites**	**Sediment Loads (tons/year)**	**Phosphorus Loads (lbs/year)**	**Nitrogen Loads (lbs/year)**
Upper Black River	43	257.62875	218.9844375	437.968875
Rainy River	8	12.5	10.625	21.25
Fisher Creek	2	0.03	0.0255	0.051
Stewart Creek	2	0.15	0.1275	0.255
Stony Creek	1	0.00105	0.0008925	0.001785
Total		**270.3098**	**229.76333**	**459.52666**

Agriculture

The agriculture inventory consisted of a desktop analysis of the 2008 common land units showing individual contiguous farming parcels in the Black Lake Watershed, as laid out in our methods section. This inventory aims to identify where agriculture activity is present and determine the associated potential locations of nonpoint source pollution.

150 parcels were found to contain agricultural activity, with the majority of sites concentrated in the northern part of the Black Lake Watershed, just south of Black Lake (Figure 4.16). The Black Lake subwatershed had the most amount of agricultural activity, with 29 sites identified. Gregg-Creek Black River, Little Rainy River, and Bowen Creek-Black River had the next highest number of sites with 22, 20 and 19 sites respectively (Figure 4.17)

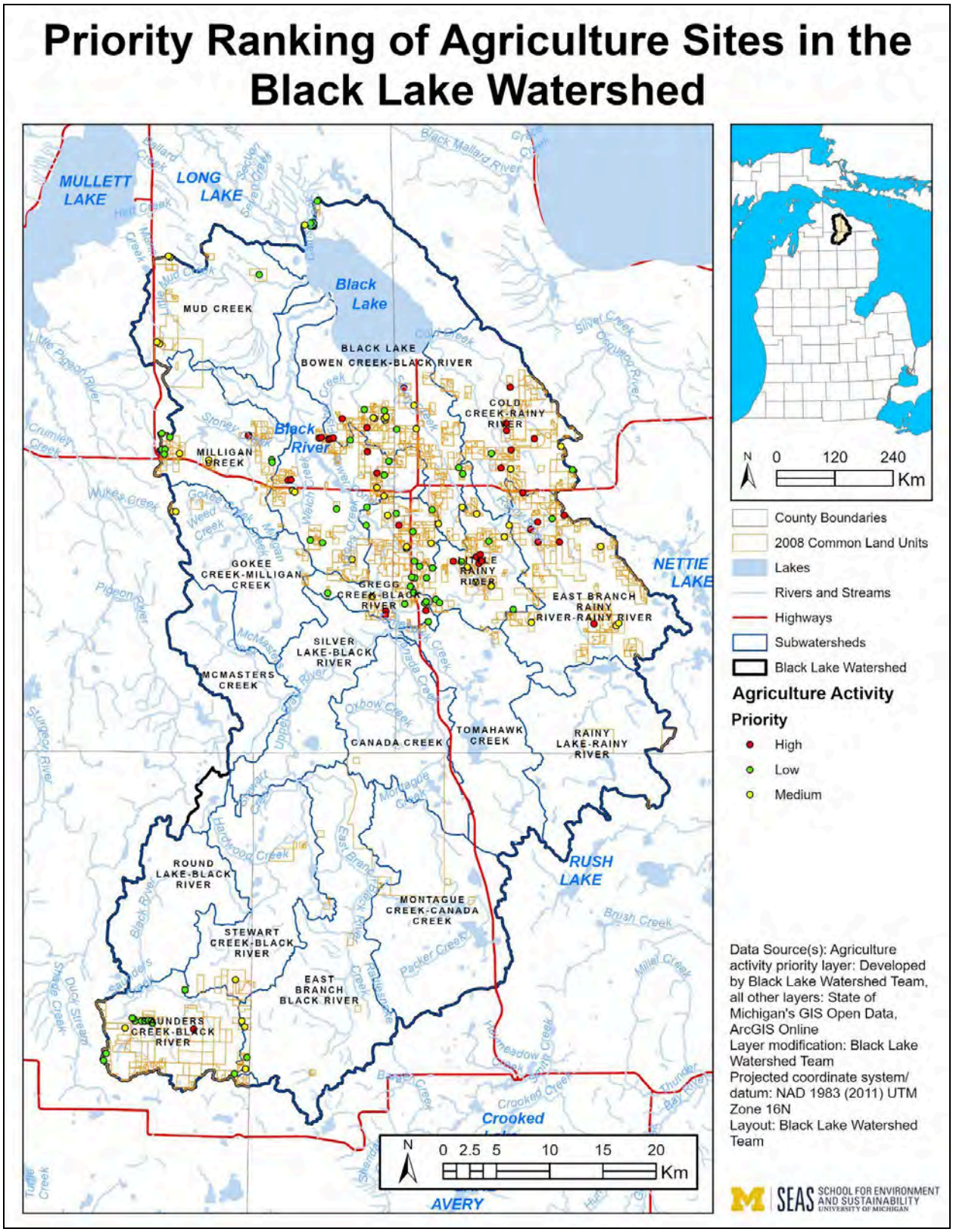


Figure 4.16. Locations and priority ranking of agriculture activity locations within the Black Lake Watershed

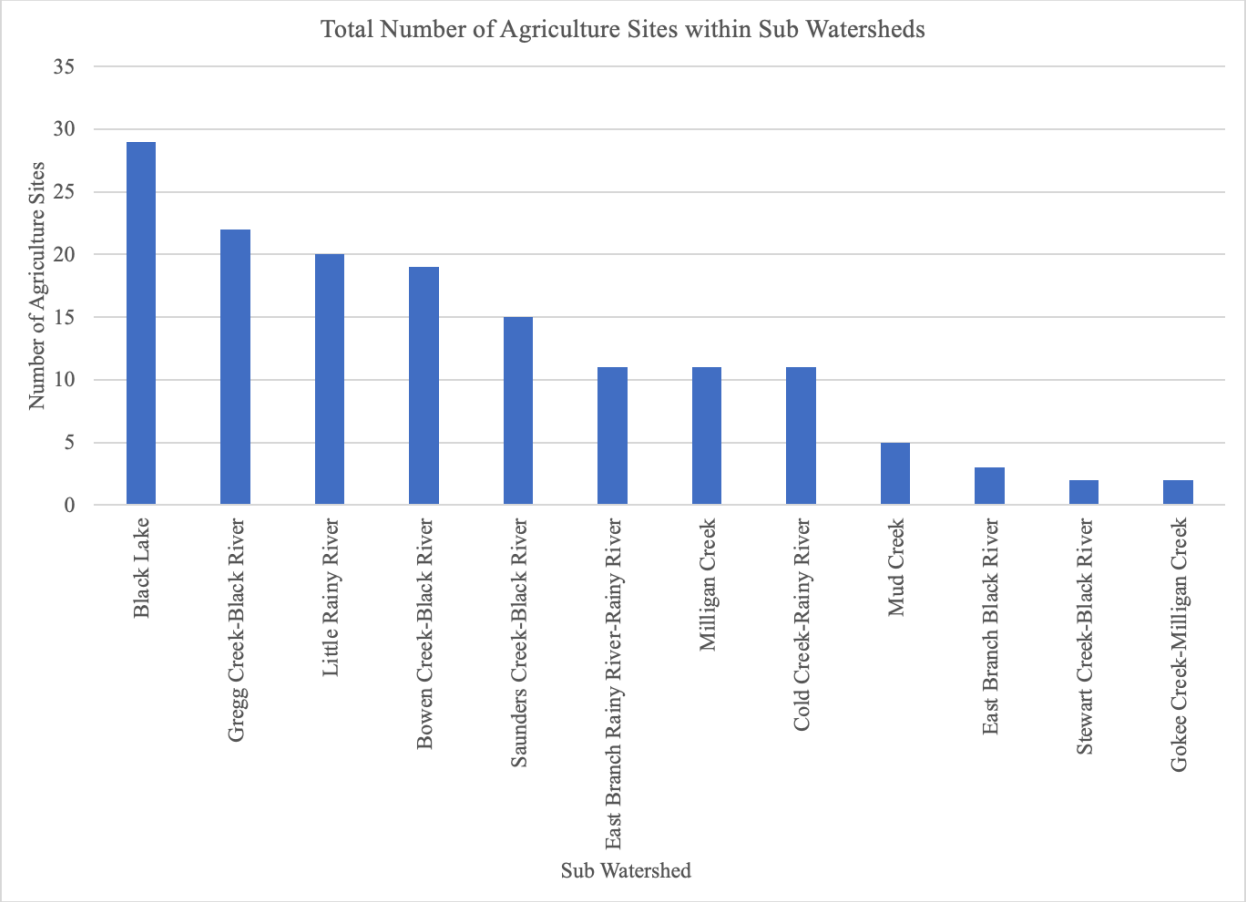


Figure 4.17. Total number of agriculture sites within sub watersheds of the Black Lake Watershed

Of the 150 sites identified, 93 of them were located adjacent to a body of water. 17 of these sites were located adjacent to the Rainy River. The Black River and Little Rainy River each had 12 located adjacent to them. The operation type of the identified site and an associated size of operation was given to all sites. The most common operation was unknown operation, which were parcels that had agricultural activity present in the form of animals and structures, but were unable to identify what kind of operation was being run. There were 34 hobby operations, 5 beef operations and one dairy operation. The size of the operations were determined by the number of animals and buildings seen at the site in the aerial imagery as described in Appendix 7. The most common size was also unknown, which were operations that spanned multiple overlapping parcels or where we were unable to identify the number of buildings located within the parcels. There was one large sized operation, 16 medium sized operations, 49 small sized operations, and 29 hobby operations.

Table 4.26. Number of agricultural sites for each operation type and size

	Size of Operation					
Type of Operation	Hobby	Large	Medium	Small	Unknown	**Grand Total**
Beef			4	1		**5**
Dairy				1		**1**
Hobby	25			5	4	**34**
Unknown	4	1	12	42	51	**110**
Grand Total	**29**	**1**	**16**	**49**	**55**	**150**

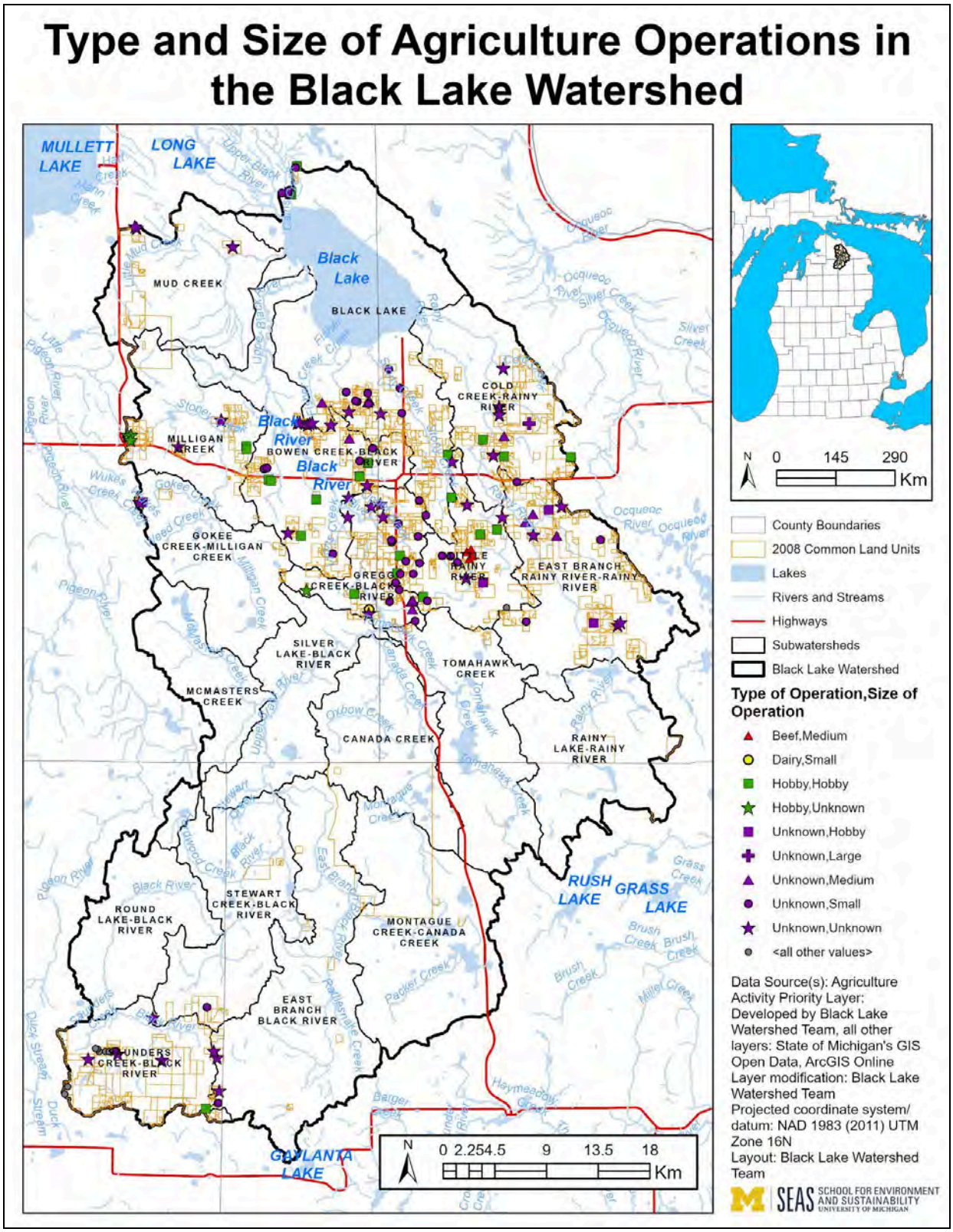


Figure 4.18. Type and size or operations at agriculture sites within the Black Lake Watershed

The quality of manure storage structures present at the site and the maintenance of the site were also evaluated using the methods outlined in Appendix 7. Most of the sites had good or fair storage quality, 51% and 30% of sites respectively. Of the 22 sites with poor storage quality, 19 of them were adjacent to a body of water and 32% of those were located adjacent to the Rainy River. Most of the sites also had good or fair maintenance quality, 37% and 39% of sites respectively. Of the 29 sites with poor maintenance quality, 27 of them were located adjacent to a body of water. Of these sites, 22% of those were located adjacent to the Rainy River and 15% were located adjacent to Tower Pond.

A ranking of priority was given to all agricultural sites identified based upon the type and size of operation at the site, the adjacency to a body of water and the quality of storage and maintenance. Of the 150 sites, 68 were given low priority, 45 were given medium priority and 37 were given high priority. All of those deemed high priority are located adjacent to a body of water and 16% of those also have poor maintenance and storage quality. 30% of the sites ranked high priority are located adjacent to the Rainy River, which are 11 of the total 17 sites located adjacent to the Rainy River.

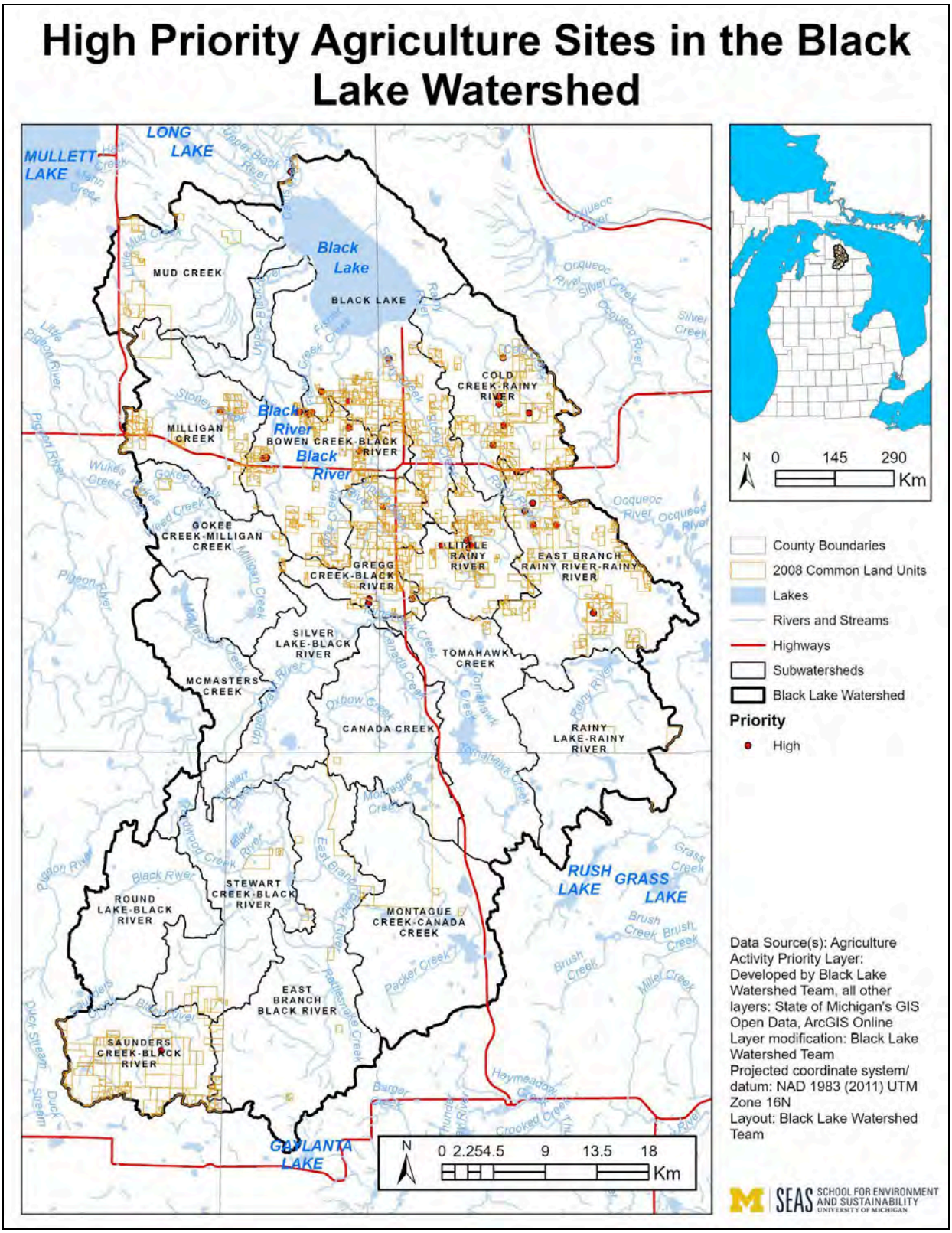


Figure 4.19. All high priority agriculture sites within subwatersheds in the Black Lake Watershed

Priority Parcel Analysis

A parcel analysis identifies parcels in the watershed that are vulnerable to land use changes and would most benefit the water quality of the watershed if permanently protected by land conservancies, governmental entities, or others with permanent land protection efforts. This analysis guides where protection efforts should be prioritized and gives insight into currently protected lands within the watershed. The Black Lake Watershed contains 8,308 parcels with an average of 41.69 acres per parcel. A majority of the watershed (66%) is already protected land controlled by various organizations including the Michigan DNR, the US Fish and Wildlife Service, the Little Traverse Conservancy, and Private Landowners easements with Headwaters Land Conservancy or Little Traverse Conservancy (Table 4.27, Figure 4.20). Conservation easements were assigned low priority in the map shown in Figure 4.20, but were considered protected parcels in the analysis due to land conservancies asking for their easements to be omitted from public maps. Of the 5 priority parcel levels, the largest category is moderate priority which covers 16% of the watershed, followed by low priority with 10% of the watershed. The three least common priority levels are high, very low and very high covering 3%, 2% and 1% of the watershed respectively. The very high parcels have an average parcel size of 467.45 acres, which is 11 times larger than the watershed average (Table 4.27).

Table 4.27. Total number of parcels and acreage of each priority parcel level and corresponding watershed percentage.

Priority Parcel Level	**Number of Parcels**	**Total Acres**	**Average Acres per Parcel**	**Percent of Watershed***
Very Low	899	10,230.44	11.38	2.95
Low	3,288	35,059.1	10.66	10.12
Moderate	2,180	56,124.11	25.75	16.20
High	45	11,857.66	263.50	3.42
Very High	8	3,739.63	467.45	1.08
Protected	1,888	229,365	121.49	66.22
Total	**8,308**	**346,375.9**	**41.69**	**100**

* Percentages based on total acreage

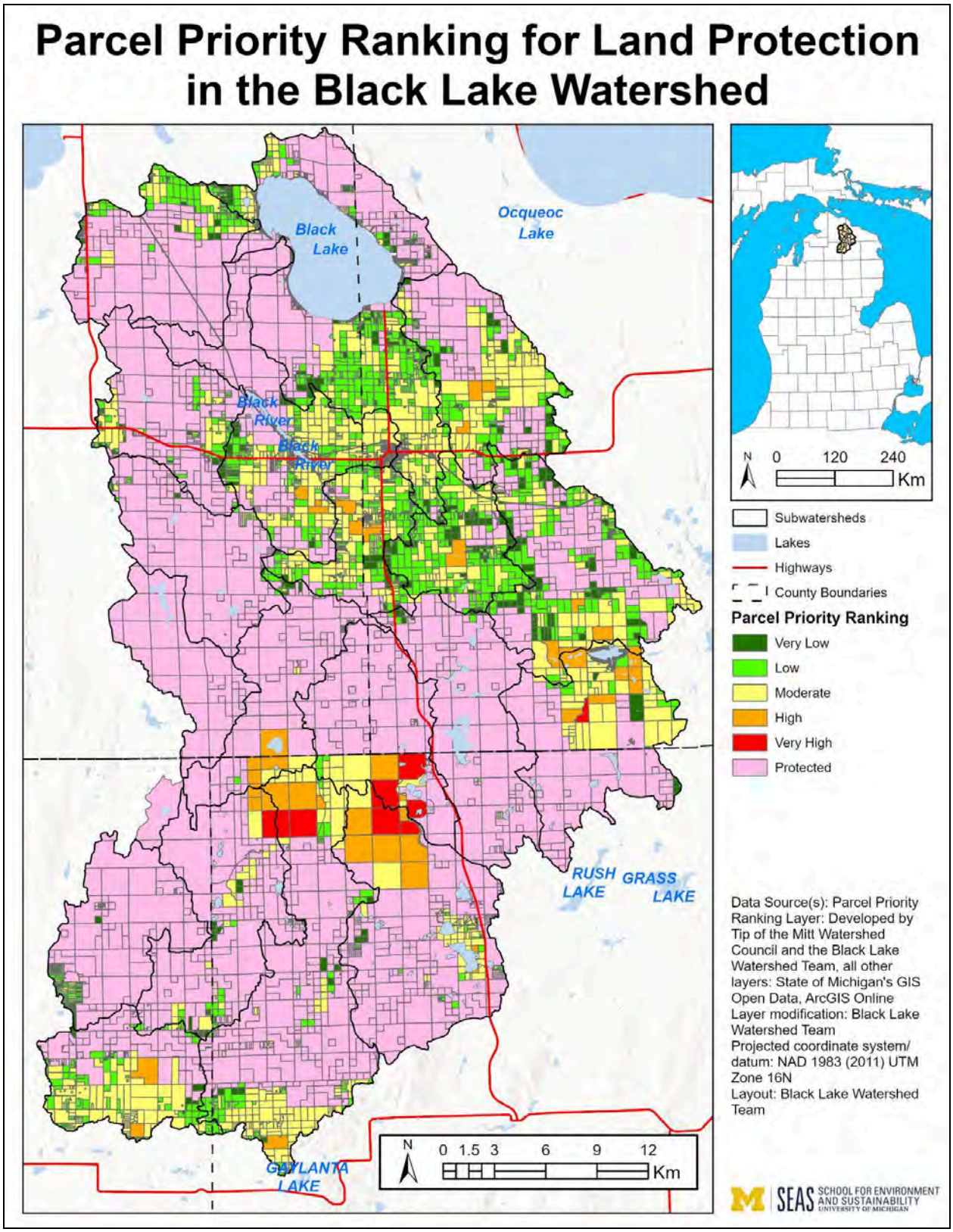


Figure 4.20. Ranking of priority parcels for land protection in the Black Lake Watershed

Much of the unprotected land is concentrated in the area surrounding Onaway below Black Lake and the parcels deemed very high priority are concentrated in the northern part of Montmorency County. All of the subwatersheds contained protected parcels, with Round Lake-Black River and Tomahawk Creek subwatersheds containing the most protected acreage, containing 22,426 and 20,078 acres respectively. These parcels account for 96% of the Round Lake-Black River subwatershed and 95% of the Tomahawk Creek subwatershed. McMasters Creek subwatershed has the highest percentage of protected acres; 100% of all acres in the subwatershed are protected.

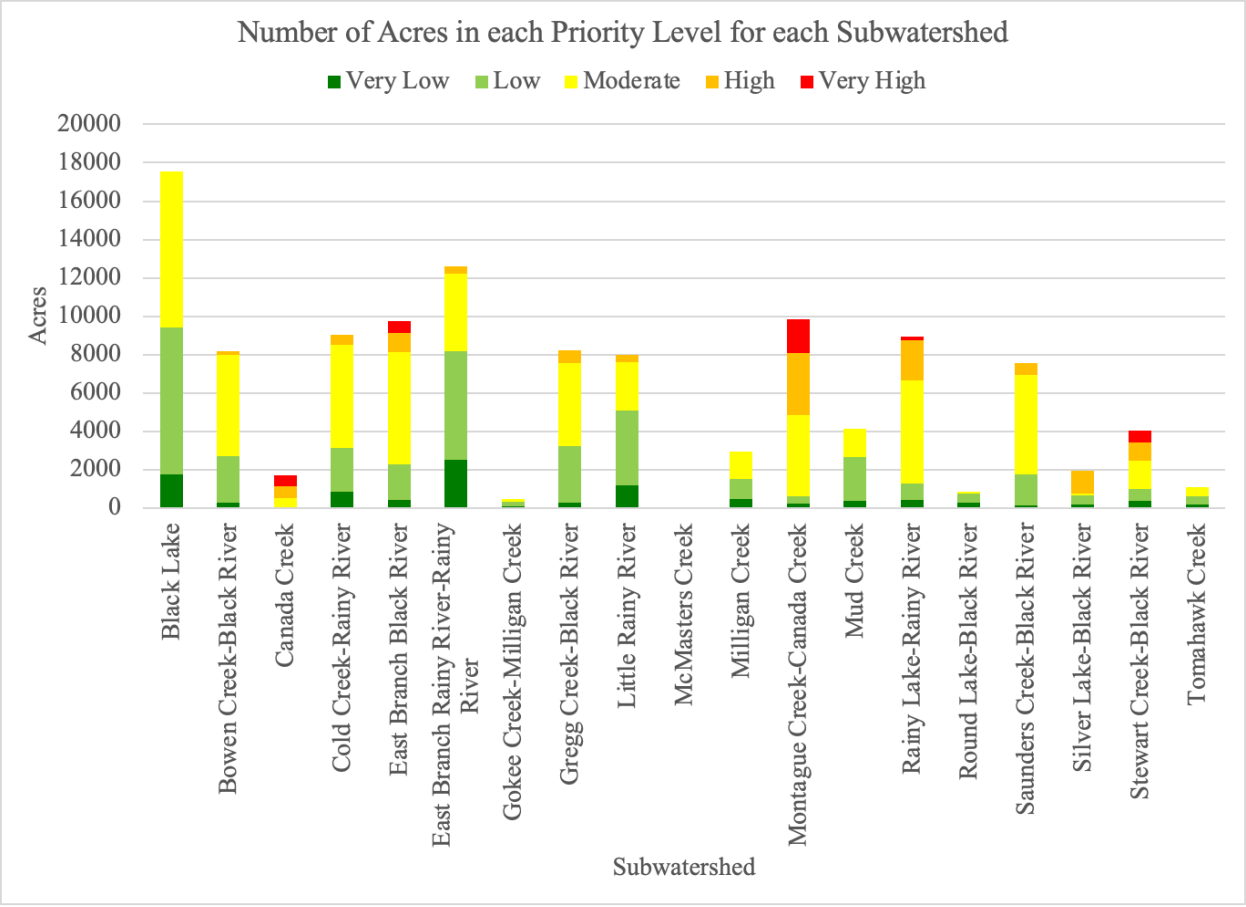


Figure 4.21. Total number of parcels in each priority level for all sub watersheds in the Black Lake Watershed.

Only 5 subwatersheds contained parcels deemed very high priority. Montague Creek-Canada Creek subwatershed had the highest number with four parcels containing 1,753 acres. East Branch Black River, Stewart Creek-Black River, Canada Creek, and Rainy Lake-Rainy River subwatersheds each contained one parcel with a very high priority level containing 637, 635, 560, and 154 acres respectively. This illustrates only a few areas within the watershed are highly vulnerable to land use changes.

Critical Areas Analysis

The critical areas analysis identified areas throughout the watershed with the greatest need for restoration. As stated in the methods section, areas were determined once all resource inventories were completed. There were 16 identified areas that presented a need for the most restoration and/or need for attention. The 16 areas include three regions of RSX, three areas with high priority agriculture sites, three streambank erosion areas with increasing problem trends, two sites that have low greenbelt scores, and five tributary sites that did not meet required water quality standards during the TOMWC tributary study. Areas that were identified were within 12 of the 19 subwatersheds. Critical RSXs spanned across 9 of the 19 subwatersheds and high priority agricultural sites spanned across 5. The forestry inventory was not included in the analysis as ground truthing is needed to identify possible areas of concern.

The subwatersheds and their respective sources can be seen in Table 4.28. The critical areas analysis identified three RSX regions that had a high abundance of sites ranking “Major.” An area of RSX sites is identified about 10 Km south of Tower. Three different areas with high priority agriculture sites were identified, primarily along the Rainy River. On the Rainy River alone, there are 11 agriculture sites deemed high priority as well as increased streambank erosion trends and “Major” RSX sites. A number of high priority agriculture sites and “Major” RSXs are located along the Little Rainy River. Near the Rainy River-Cold Creek confluence there are several streambank erosion sites with increasing problem trends as well. Other concerns are seen surrounding Tower and Kleber Pond and neighboring tributaries. Several high priority agriculture sites in addition to low greenbelt scores and RSXs ranking “Major” make up the area seen between the city of Tower and Black Lake’s shorelines. Looking at all inventories together, the regions surrounding both the Black River and Rainy River are identified as the most critical areas within the watershed.

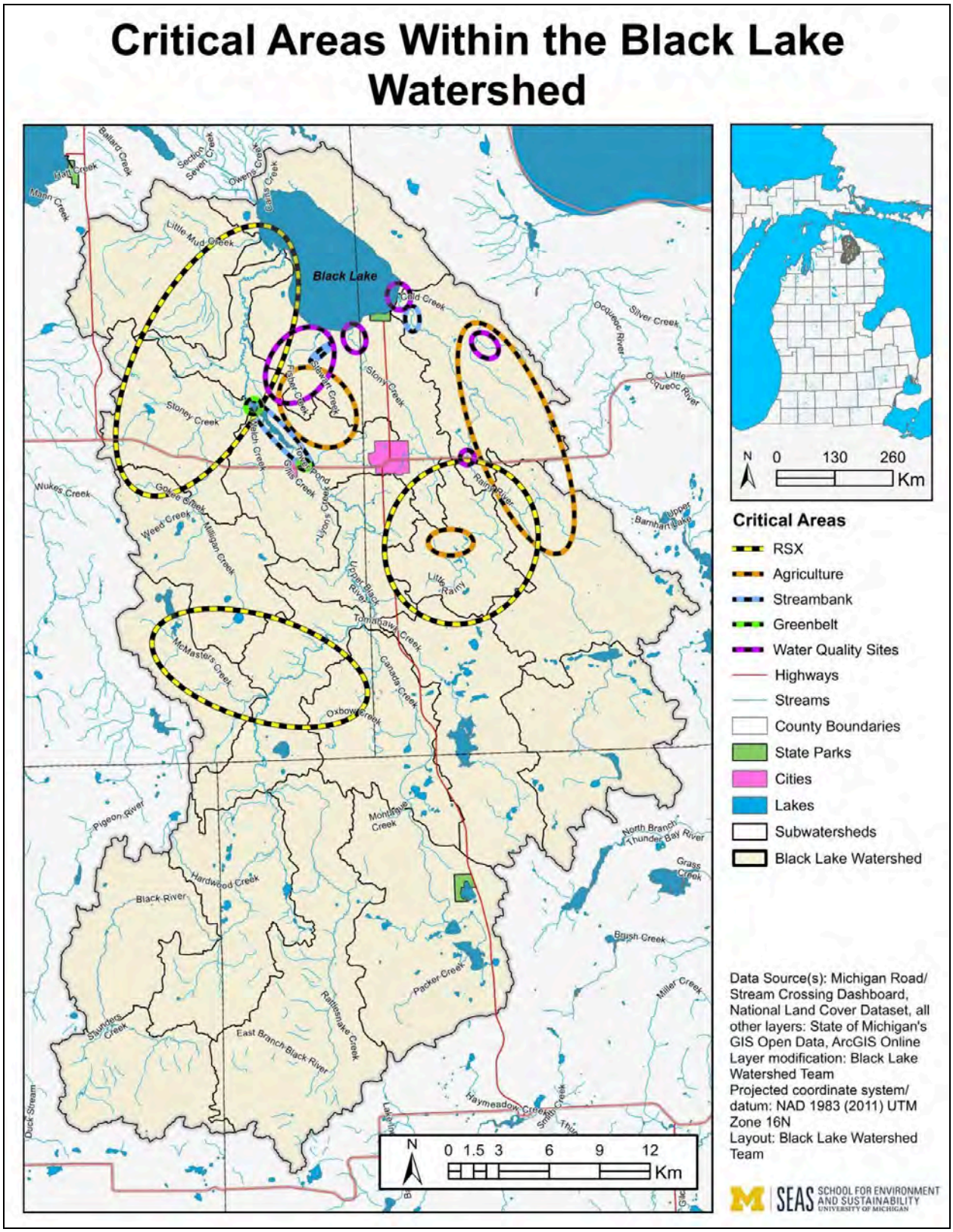


Figure 4.22. Critical Areas identified in the Black Lake Watershed

Table 4.28. Critical Areas Identified in the Black Lake Watershed

Source	Critical Area Subwatershed	Critical Area Location
RSX/Hydrologic Disruption	Black Lake Watershed	Stony Creek
	Bowen Creek-Black River Watershed	Upper Black River
	Canada Creek Watershed	Canada Creek, Oxbow Creek
	East Branch Rainy River-Rainy River Watershed	Rainy River
	Little Rainy River Watershed	Little Rainy River
	McMasters Creek Watershed	McMasters Creek
	Milligan Creek Watershed	Milligan Creek, Stoney Creek
	Mud Creek Watershed	Little Mud Creek
	Silver Lake-Black River Watershed	Upper Black River
Streambank Degradation	Black Lake Watershed	Increasing erosion along Stewart Creek
	Bowen Creek-Black River Watershed	Low greenbelt scores and increasing erosion on Kleber Pond and the Black River between Kleber Dam and M-68
	Cold Creek-Rainy River Watershed	Increasing erosion along Rainy River
Agriculture	Black Lake Watershed	Poor maintenance and storage near Fisher Creek, Stewart Creek
	Bowen Creek-Black River	Poor maintenance and storage near Fisher Creek, Stewart Creek
	Cold Creek-Rainy River Watershed	Cold Creek, Rainy River
	East Branch Rainy River-Rainy River Watershed	Rainy River

	Little Rainy River Watershed	Little Rainy River
[Tributary Sites]	Black Lake Watershed	Fisher Creek, Stewart Creek, Stony Creek,
	Cold Creek-Rainy River	Cold Creek, Rainy River

Chapter 5: Discussion and Recommendations

Social Indicator Survey

The results of the Social Indicator Survey demonstrate a clear concern for the present and future health of the Black Lake Watershed. This demonstrated concern ensures that Tip of the Mitt Watershed Council (TOMWC) can move forward under the assumption there will be substantive community participation and high levels of potential receptiveness. The term "Black Lake Watershed Resident/s" refers to only those represented in the survey responses, not all Black Lake Watershed residents.

Compared to the results of the 2016 Elk River Chain of Lakes (ERCOL) Social Indicator Survey, Black Lake Watershed Residents scored lower in most awareness categories. Black Lake Watershed Residents scored lower than the ERCOL Watershed Residents in the following awareness categories: awareness of the consequences of poor water quality, the types of pollutants impairing waterways, and the sources of pollutants impairing waterways. Black Lake Watershed Residents scored higher in their awareness of the practices needed to improve water quality. Many surveyed Black Lake Watershed Residents actively utilize practices such as planting trees/shrubs and following fertilizer instructions. The trend of Black Lake Watershed Residents achieving lower awareness scores than the ERCOL Residents provides an opportunity for education by TOMWC. To ameliorate the current awareness gaps in the Black Lake Watershed, TOMWC could steer education campaigns to inform residents about the consequences of poor water quality, the types of pollutants impairing waterways, and the sources of pollutants impairing waterways. In order to take advantage of existing programs, TOMWC might host a special water quality information session during a Black Lake Watershed Advisory Committee Meeting or dedicate one of their "Ice Breaker Speaker Series" to water quality issues in pristine, Northern Michigan watersheds. To connect to Black Lake Watershed Residents' greatest areas of concern, TOMWC might discuss and emphasize the risk of excessive aquatic plants and algae, the loss of desirable species, and the reduction in opportunities for water recreation during these education campaign efforts. As shown in the survey results, Black Lake Watershed residents view TOMWC as a trusted source of information, meaning TOMWC can serve as effective messengers to deploy these educational campaigns.

Black Lake Watershed Residents demonstrated positive water quality-related attitudes, such as understanding that the quality of life in a community depends on the health of the watershed and acknowledging that individual actions have impacts on water quality. They also indicated high levels of willingness to take action. Compared to the ERCOL Watershed Residents indicator scores, the Black Lake Watershed Residents scored considerably higher in both attitudes and willingness. To continue and take advantage of these high indicator scores, TOMWC can continue to promote and encourage actions such as regular septic system servicing and proper septic system sizing. One statement, "I would be willing to pay more to improve water quality (for example: through local taxes or fees)" garnered the greatest level of disagreement. To address this concern, TOMWC could increase their messaging around watershed investments, stating that potential local taxes and fees will preserve the beauty and economic value of watershed residents' homes and properties.

Black Lake Watershed Residents indicated limited constraints to behavior changes and limited constraints to adopting new and specific environmental practices with considerably higher indicator scores than the ERCOL Watershed Residents. Notably, Black Lake Watershed Residents shared concerns regarding resale value of homes and approval from their neighbors if they were to change their present behaviors by installing a greenbelt along their lakeshore property instead of a grass lawn, for example. Both of these concerns pertain to public perception. Discussing constraints to certain practices, Black Lake Watershed Residents shared they experienced physical or health limitations and that the practices are hard to use with their farming system. TOMWC might limit the constraints of Black Lake Watershed Residents by hosting a skills sharing workshop to create greater community understanding to combat concerns of public perception, forming a practice implementation team to assist those with physical or health limitations, and partnering with local farmers to navigate the constraints faced by fellow farmers trying to adopt certain practices. In this component of the Social Indicator Survey, the inherent bias of the survey begins to appear. Surprisingly, the personal out-of-pocket expenses of behavior changes garnered the lowest mean score, indicating participation from individuals of a higher socio-economic status. The financial burdens of certain behavior changes, such as replacing faulty septic systems or regular septic system servicing, are well documented.[40] This financial barrier to behavior change must be addressed by TOMWC because it is likely a major concern for those not represented in this survey. The lack of the financial concern demonstrated by the survey participants is due to bias.

Black Lake Watershed Residents indicated different trust levels in different information sources. TOMWC received the highest mean score, displaying the watershed residents' immense trust in the organization. This trust validates and encourages the continued efforts of the Watershed Council throughout the development and completion of the BLWMP. Local community leaders

[40]Natasha Blakely, "Rights vs. Regulations: Property Rights Big Barrier to Septic System Codes," Michigan Public, March 2, 2021, https://www.michiganpublic.org/environment-science/2021-03-02/rights-vs-regulations-property-rights-big-barrier-to-septic-system-codes

and lawn care companies received the lowest trust levels from survey participants. We encourage TOMWC to utilize their own messenger power as the BLWMP is completed and published.

The results of this quantitative survey aligned with our qualitative observations and informal interactions. People in this region are, on average, highly aware and are willing to take action and change behavior. Having an engaged, motivated, and willing community will facilitate more adoption of sustainable actions in the entire watershed. Often, highly engaged community members act as environmental leaders, facilitating important discussions, providing feedback, and distributing recommendations to other residents around the watershed. By tapping into a supportive social network, the Black Lake Watershed Advisory Committee might form environmental teams within the community that hold individuals accountable and provide resources to facilitate the necessary behavior changes. The environmental behavior researcher Henk Staats and their colleagues contributed significantly to this concept through the creation of "Eco-Teams," determining that teams provided multiple forms of motivation for individuals to take on more sustainable behaviors.[41] The prevalence of highly motivated individuals in the Black Lake Watershed may prove to be their largest asset. The establishment of Black Lake Watershed "eco-teams" can lower concerns regarding approval from neighbors or the resale value of their home. As more watershed residents adopt environmental practices such as updated septic systems or the establishment of shoreline green belts, the public perception concerns will decrease. Beyond this, "eco-teams" provide ample opportunities for knowledge sharing and increased cooperative actions, whether in advocating for a BLWMP or increased septic system funding avenues for those in financial need.

We acknowledge the inherent limitations that these results contain due to low response rates and a non-representative sample. When compared to the general populations of the counties within the Black Lake Watershed, the surveyed respondents were older and more highly educated than the average county citizen. We recognize that these results are strongly biased toward waterfront residents due the survey distribution methods and are not indicative of the watershed as a whole. These results can inform Lake Association education campaigns and various policy efforts, but should not be taken to reflect the watershed as a whole. To address this existing bias, TOMWC will be doing an additional mailing survey to supplement these results and garner a greater more representative sample.

Despite the limitations that exist in the survey responses, it remains crucial that we explore the findings of this survey to gather insights into a portion of the Black Lake Watershed Community.

[41]Staats, H., Harland, P., & Wilke H. (2004). Effecting durable change: A team approach to improve environmental behavior in the household. Environment and Behavior, 36: 341-367.

Table 5.1. Social Indicator Survey Recommendations

Social Indicator Survey Topic	**Recommendations for TOMWC**
Awareness	**Direct education campaigns to address resident awareness gaps on water quality consequences, pollutants, and their sources in the Black Lake Watershed** -Provide special water quality information sessions during a Black Lake Watershed Advisory Committee Meeting -Dedicate an "Ice Breaker Speaker Series" on water quality issues in pristine, Northern Michigan watersheds, including harmful algal blooms -Emphasize the risk of excessive aquatic plants and algae, the loss of desirable species, and the reduction in opportunities for water recreation during these education campaigns
Attitudes and Willingness to Take Action	**Facilitate, promote and encourage actions such as regular septic system servicing and proper septic system sizing** -Increase messaging around watershed investments and emphasize that potential local taxes and fees will preserve the beauty and economic value of watershed residents' homes and properties
Constraints to Behavior Change and Adopting Key Practices	**Limit the real and perceived constraints of Black Lake Watershed Residents** -Host a skills sharing workshop to create greater community understanding to combat concerns of public perception -Form a practice implementation team to assist those with physical or health limitations -Provide access to grants and funding to lessen the financial burden of behavior changes -Partner with local farmers to navigate the constraints faced by fellow farmers trying to adopt certain practices

Road/Stream Crossings

RSXs fell into three categories based on their overall condition: “Minor,” “Moderate” and “Major,” and could be considered “time sensitive” based on the severity of the site. As mentioned in the results section, 18 sites were still considered a “time sensitive” matter after we surveyed the area. This means that nearly half of the sites were no longer considered “time sensitive” and could have been addressed prior to us updating the site. Issues that could have been addressed to remove a site’s time sensitivity could include fixing the structure, implementing new infrastructure, removing debris from the stream, etc. For the total watershed, 25 sites were considered “time sensitive,” meaning 72% of the sites that were most recently visited need to have immediate attention. All sites impact the watershed uniquely based on the frequency of usage, the type of crossing that is present, and, most importantly, their overall condition. Addressing sites based on their need of maintenance is an important first step in allocating resources. However, sites that were no longer deemed a time sensitive matter (i.e. repaired, no longer a crossing that exhibits concerning characteristics) are still critical to address and revisit, especially sites that were ranked moderate or major.

Over 40% of all sites in the Black Lake Watershed have not been updated within the Stream Crossing Dashboard since 2015. Of the sites surveyed, 71% of sites changed in severity ranking. This highlights the importance of resurveying sites as many are subject to change. Extrapolating over 100 RSX sites suggests that nearly 30 of them may experience a decline in their ranking if they were visited.

Since some sites haven't been revisited in recent years, only the ones that were resurveyed were included in the fish passability section of the results. Current stream crossing conditions impact 88.6% of aquatic life, emphasizing the need for timely assessment. Fish passage is crucial both at the individual and ecosystem levels. Poor fish passage directly impacts migration, affecting food webs. Habitat fragmentation, degradation, altered hydrology, and poor crossing design can lead to species loss and create issues for other species in the ecosystem. It's crucial to properly assess and address RSXs that impact fish passability to mitigate future passage threats. Mitigation strategies may involve crossing designs that prioritize ecological connectivity. Challenges may arise with such designs due to the effects of climate change and its unpredictability with weather patterns, posing threats to aquatic life's need for thermoregulation.

When discussing the results of the RSX inventories, it's crucial that we address limitations, particularly regarding site accessibility. Among the 39 selected sites for resurvey, we encountered four either on private property or that we simply couldn't locate. We faced accessibility challenges with several sites located off main roads or inaccessible by standard vehicles. Physical barriers and steep inclines prevented us from accessing the sites and using essential tools for survey updates. We encountered obstacles in recording water velocity at many sites, which required us to perform a float test instead of using a Flow Tracker. Consistent

weather conditions during the surveys raise questions about potential variations under different conditions. Many sites lacked measurable flows or were dry, impacting our ability to estimate erosion and pollutant loadings accurately. It was crucial for us to carefully evaluate RSXs in poor condition but with little water present to produce more accurate assessments of erosion potential and pollutant loadings in the watershed.

Technological difficulties interfered with data collection. Some sites were challenging to locate due to a lack of cellular service. Other technological issues included categories that did not automatically calculate values for variables, such as fish passability. During data analysis, we observed that some sites were missing this crucial variable, so we assigned rankings based on collected data and visual observations.

Another significant limitation is our ability to interpret the condition of the crossing. Although we ranked a site as 'major' and a time-sensitive matter, others may not share the same assessment. While proper training was conducted before fieldwork, because no project personnel had prior experience with RSXs and updating inventories, the severity, or lack thereof, of sites was interpreted based on our observations and personal interpretations of the current conditions.

FAMD

Invasive species can dramatically alter ecosystems as they fight for the same resources as native species. It is expected to see an increase of nearly 36% of invasive species between 2005 and 2050.[42] As seen in Figure 4.5, the FAMD suggests that the presence of plant invasive species is determined by many factors within a specific site, especially the condition of the road. Previous studies support this with one explaining that “Evidence suggests that roads can have an important effect on the spread of invasive plant species…[and] show[s] that a small change in conditions of the environment favoring the invasive species can change the case for the road…”.[43] Another study addresses vehicle usage and its role in floral invasive species abundance. Their results reveal how “primary dispersal of [an invasive species] interacts with secondary dispersal by vehicles’ airflow, dependent on traffic volume” which suggests that roads more heavily traveled are at a higher risk of introducing invasive species.[44] This is interesting as roads that are less traveled have less consistent upkeep/maintenance and tend to harbor more invasive species as a result. The study concludes with the importance of general maintenance (i.e. mowing) along high-use roads as well as isolated populations in the area.[40]

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[42] IUCN. (2022). Invasive alien species and climate change. https://www.iucn.org/resources/issues-brief/invasive-alien-species-and-climate-change

[43] Deeley B, Petrovskaya N. Propagation of invasive plant species in the presence of a road. J Theor Biol. (2022). doi: 10.1016/j.jtbi.2022.111196. Epub 2022 Jun 16. PMID: 35716722.

[44] Lemke, A., Kowarik, I., & von der Lippe, M. (2018). How traffic facilitates population expansion of invasive species along roads: The case of common ragweed in Germany. Journal of Applied Ecology, 56(2), 413–422. https://doi.org/10.1111/1365-2664.13287

Together, these studies portray a possible positive feedback loop between road usage and invasive plant species abundance in *both* scenarios; as roads are more heavily traveled, invasive species may become more abundant due to vehicular airflow as well as roads that are less traveled that have less consistent upkeep. Roads that receive more traffic compared to others will inevitably deteriorate and harbor the appropriate conditions needed for invasive species to spread even further. On the contrary, roads that are less traveled and do not receive the same amount of upkeep due to its lack of usage will also harbor more invasives. It is possible that variables such as traffic and/or general maintenance/upkeep may have been the missing linkage in understanding the role between RSXs and invasive species. Overall, further studies are needed to understand the impacts of confounding variables on both RSXs and invasive species abundance.

A major limitation of this analysis is that only data from updated sites was utilized. The insights derived from the analysis are drawn from only a portion of the data that would be available if all RSX sites were considered. It would be valuable to rerun the FAMD once all RSXs in the watershed are updated to compare the findings of the analysis.

Table 5.2. Road/stream Crossing Recommendations

Topic	**Recommendations for TOMWC**
Major and Moderate Ranking Sites	**Identify strategies to mitigate runoff from RSXs** -Resurvey major and moderate RSX sites to understand how many need further assistance -Document failing or inadequate infrastructure and communicate needed repairs to parties with the adequate resources to do so (structural as well as their respective roadways i.e. filling in damaged roads) -Suggesting the implementation of diversions away from nearby streams, such as barriers or native vegetation to reduce runoff potential
Habitat Degradation	**Encourage fish passage and ecosystem productivity** -Address and remove barriers to aquatic organisms as well as clear debris from crossings -Remove invasive species and advocate for stronger invasive species management to prevent further habitat degradation

Forestry

Although CFP and QFP were the programs chosen to represent, there are other existing voluntary management programs for private landowners. These two programs are the best indicators for management because the other programs in Table 3.1 overlap the identified programs. Spatial data can not be released because of privacy rights of the landowners for the other programs. Therefore, the usage of CFP and QFP ensure that the same acres will not be accounted for twice.

The key limitation was accessible data. This is in regards to privacy concerns for private landowners as well as availability to geospatial data layers online. Spatial data for the various programs for landowners (Table 3.1) can not be shared therefore, the maps offered from this inventory can not account for all programs offering protection in some sense. In addition, this inventory only represents protected forest land as parcels located within the CFP, QFP and State Parks. There are State Forests within the watershed and are omitted from this inventory due to inaccessible downloadable and usable geographic information. This gap reinforces the recommendation for windshield surveys to supplement this desktop analysis.

Table 5.3. Forestry Activity Recommendations

Topic	**Recommendations for TOMWC**
Windshield Survey	**Conduct thorough windshield surveys in the watershed** -Confirm the condition of the forest rather than just the location of the protected forest, resulting in specific recommendations curated towards water health on specific properties -Locate logging sites within the watershed and the condition of those locations
Consistent New Enrollment	**Encourage Watershed Residents to enroll in public or private forestry conservation programs** -Emphasize the direct positive impacts of conserved forests on the watershed health, preventing further development, and maintaining the health of the forest ecosystem -Promote the private landowners tax incentive programs

Stream Bank Erosion

Upper Black River

Along the Upper Black River between Tower Pond and Kleber Dam, 43 locations had streambank erosion occurring. Of these 43 locations, none of the sites had a decreasing problem trend illustrating that streambank erosion will likely continue to occur if action is not taken. This section of the Upper Black River contains many shoreline properties which increases the likeliness of a structure being present at a location. 33 of the sites had at least one structure present, with 72% having a dock present and 45% having riprap present. Structures such as riprap can help to minimize streambank erosion by providing armor protection for the bank, but other hard structures can cause streambank erosion to increase by disrupting the natural flow of sediments and water along the bank. The high percentage of docks present leads to concerns that they may be causing increased streambank erosion. Having a greenbelt present along the shoreline can help to prevent erosion by providing the shoreline with a buffer zone of vegetation. 72% of the 43 sites had a greenbelt present which were given a score between 1-4. The most common greenbelt score was a 3, which 12 sites were given, however the next highest score was a 1, which 9 sites were given. This means that properties along the shoreline have the potential to improve their current greenbelts to further prevent streambank erosion. Increasing property owner awareness of how to maintain a healthy streambank along this section of the river can help to address the erosion occurring. This can aid in the development of greenbelts along the shoreline and the removal of hard structures contributing to erosion. Providing property owners with resources on how they can implement various stabilization and protection measures will also help increase the likelihood that action will be taken to address streambank erosion.

Rainy River

Of the 8 sites identified to have erosion occurring, 5 of them had 0-10% vegetation cover and an increasing problem trend. These 5 sites were all located at an outer bend along the stream and the erosion appeared to be from natural causes. This indicates that erosion will continue to occur at these sites and will likely accelerate with the lack of vegetation cover. All 8 of the sites had erosion occurring at the toe, with 5 having undercutting occurring as well. Undercutting causes vegetation roots to be exposed and can eventually cause trees and shrubs to fall into the stream, greatly impacting stream and watershed health. Placing riprap along the bank toe at all of these sites can help to reduce undercutting and provide protection for vegetation along the bank.

Fisher Creek, Stewart Creek and Stony Creek

Of the 5 sites identified along these three creeks, only two of them had erosion occurring, one along Fisher Creek and one along Stewart Creek. All 5 of these sites had 51-100% vegetation cover and only the two sites along Stewart Creek had an increasing problem trend. From this we

can conclude that streambank erosion along these three streams will likely decrease. The two sites along Stewart Creek should be monitored so that action can be taken if erosion begins to increase.

Of the 56 total sites that were surveyed for streambank erosion, only two of them were given a ranking of severe. One of these sites is along the Rainy River and the other is along the Upper Black River. These two sites should be given priority and the appropriate stabilization and protection measures should be implemented to prevent further erosion. Priority should also be given to the moderate sites along the Upper Black River, as many of these sites had an increasing problem trend meaning the situation could become worse.

There were a few inherent limitations of our streambank erosion inventory, including time and site accessibility constraints. We did not have time to survey all tributaries in the Black Lake Watershed for erosion so there may be sections where streambank erosion is occurring and was not documented. Many of the sites that were visited from the desktop portion of our inventory did not have erosion occuring which could mean the aerial imagery used was outdated and did not give a current representation of streambank erosion along those tributaries.

Table 5.4. Streambank Erosion Recommendations

Topic	**Recommendations for TOMWC**
Shoreline Property	**Educate property owners on shoreline management and encourage greenbelt implementation.** -Encourage advisory committee members to educate their friends, colleagues, and other community members with properties along the Upper Black River on greenbelt benefits and implementation strategies -Create factsheets/handouts for property owners on stabilization and protection strategies that can be implemented for streambank erosion and who can help implement said strategies
Severe and Moderate Ranking Sites	**Determine a targeted implementation strategy to mitigate further erosion.** -Visit severe and moderate sites with an increasing problem trend to determine a targeted implementation strategy

Agriculture

In the Black Lake Watershed, 150 parcels were identified to have agricultural activity present. The Black Lake subwatershed had the most amount of agriculture activity with 29 sites located within the subwatershed. The agriculture activity occurring in the watershed is mainly hobby or small sized operations (52%), there was only one large sized operation. Hobby and small sized operations generally have less runoff occurring than larger operations, but they have a higher chance of having poor storage and maintenance qualities. Of the total 150 sites, 62% were located adjacent to a body of water. With half of all agriculture sites in the watershed adjacent to water, there is a higher chance of nonpoint source pollution from agriculture activity entering the waterways. 19 of these sites adjacent to water had poor storage quality, and 27 of these sites have poor maintenance quality. Only 37 of the 150 total sites were given a high priority, all of these sites were located next to a body of water. These 37 sites should be visited to gain a better understanding of the agricultural activity occurring and what can be implemented to reduce the chance of nonpoint source pollution entering the waterways from these sites.

The Rainy River had the most agricultural sites adjacent to it, with 17 sites. 32% of the sites with poor storage quality were located next to the Rainy River and 22% of the sites with poor maintenance quality were located next to the Rainy River. Of the total 17 sites along the Rainy River, 11 of them were given high priority. Due to this, nonpoint source pollution may be entering the Rainy River from agriculture activity in the area and should be prioritized during surveys to gain a better understanding of what is actually happening at these sites.

There were a few inherent limitations of our agriculture inventory, including time and site accessibility constraints. There were issues with accessing data from the agriculture inventory that was completed by the TOMWC interns and many of the sites identified to have agriculture activity that were visited did not have agriculture activity occurring there. This led to the desktop portion of the survey being redone which led us to not have time to survey the sites identified on the ground. The sites identified are private property so sites that were visited were surveyed from public roads adjacent to the land parcel. This could have led to not being able to get a full understanding of the activity occurring and the potential of nonpoint source pollution occurrences. A majority of the site operations were deemed unknown, which were parcels that had agricultural activity present but the kind of operation was unable to be identified. A majority of the site sizes were deemed unknown also, which were operations that spanned multiple overlapping parcels and the number of buildings located in the parcels were unable to be identified. This leads to a majority of the sites having non descriptive data which could lead to inaccurate prioritization for these sites.

Table 5.5. Agriculture Activity Recommendations

Topic	Recommendations for TOMWC
Ground Truthing	**Perform a ground truthing survey to further understand the agriculture activity in the watershed.** -Visit all high priority sites -Give priority to the sites along the Rainy River
Runoff	**Encourage implementation of practices that reduce runoff** -Encourage agriculture land owners to implement practices to reduce runoff including planting native vegetation, reducing livestock access to waterways and improving manure storage -Create factsheets/handouts for property owners on the benefits of reducing runoff and who can help them implement best management practices -Encourage the involvement in various programs that help implement best management practices such as the Great Lake Restoration Initiative[45] and Regional Conservation Partnership Program with NRCS,[46] the Conservation Reserve Program and Conservation Reserve Enhancement Program with United States Department of Agriculture Farm Service Agency,[47] and the Michigan Agriculture Environmental Assurance Program (MAEAP) through MDARD.[48] The Cheboygan, Presque Isle, Montmorency and Otsego conservation districts can also help landowners in their involvement in the previously mentioned programs.

[45] USDA NRCS. "Great Lakes Restoration Initiative | Natural Resources Conservation Service." Www.nrcs.usda.gov, 5 Dec. 2023, www.nrcs.usda.gov/programs-initiatives/great-lakes-restoration-initiative. Accessed 22 Apr. 2024.
[46] USDA NRCS. "Regional Conservation Partnership Program." Natural Resources Conservation Service, www.nrcs.usda.gov/programs-initiatives/rcpp-regional-conservation-partnership-program. Accessed 22 Apr. 2024.
[47] USDA Farm Service Agency. "Conservation Programs." Usda.gov, 2013, www.fsa.usda.gov/programs-and-services/conservation-programs/index. Accessed 22 Apr. 2024.
[48] State of Michigan Department of Agriculture and Rural Development. "Michigan Agriculture Environmental Assurance Program." Michigan.gov, 2023, www.michigan.gov/mdard/environment/maeap. Accessed 22 Apr. 2024.

Priority Parcel Analysis

The analysis conducted for the Black Lake Watershed found that 66% of the total 350,000 acres in the watershed is already protected land controlled by various organizations including the Michigan DNR, the US Fish and Wildlife Service, the Little Traverse Conservancy, and Private Landowners easements with Headwaters Land Conservancy or Little Traverse Conservancy. The rest of the unprotected parcels were given a priority level of very low, low, moderate, high and very high. This designates if the parcel is vulnerable to land use changes, with very low being not vulnerable and very high being very vulnerable. Only 8 parcels were given a level of very high priority, four of which are located in the Montague Creek-Canada Creek subwatershed. These parcels account for a little over 1% of the watershed, but have an average parcel size of 467.45 acres which is 11 times larger than the average parcel size in the watershed of 41.69 acres. This illustrates that protecting these few highly vulnerable parcels can greatly benefit the water quality health of the watershed due to their large average parcel size. Two other categories, protected and high priority level, also contain a higher average parcel acreage than the watershed average. The 1,888 parcels that are protected have an average parcel size of 121.49 acres, causing the majority of the watershed to be protected. The 45 parcels deemed high priority have an average size of 263.50 acres, which also illustrates that protecting these few parcels will have great impact on the watershed health.

There were a few inherent limitations in our priority parcel analysis, including using outdated GIS data and time constraints. The Michigan Natural Features Inventory provided the Biorarity Index Feature layer but they no longer update this data. The most recent update was from 2013 so it may include outdated information.

Table 5.6. Priority Parcel Recommendations

Topic	**Recommendations for TOMWC**
High and Very High Priority Parcels	**Encourage the protection of specific parcels and locations that offer great benefit to watershed health quality.** -Visit high and very high priority parcels to determine feasibility of protection, giving priority to large parcels near Montague Creek, Canada Creek and East Branch Black River -Encourage the protection of parcels, giving priority to parcels that lead to the greatest benefit

Critical Areas Analysis

The critical areas analysis provides a baseline on what areas should be attended to first when addressing the water quality issues being experienced throughout the watershed. Interestingly, many areas identified as critical were within 10km of Black Lake itself. This is important as it is possible that these areas may be a factor in the HABs that have become more prevalent in recent years. Extrapolating from this data, it's conceivable that addressing these critical areas could have a positive impact on mitigating HAB occurrences. The reference sites for the tributary study were marked in Figure 4.24 to visualize their location in respect to the identified critical areas which happened to be located in close proximity to the sites found in the analysis. The high priority agricultural areas, poor RSX conditions and increasing streambank problem trends noted in the analysis may be contributing to the poor water quality measured at the monitoring sites. We recommend monitoring the sites that were utilized in the tributary study to document changes as different strategies are implemented throughout the watershed to address the growing water quality issues.

Critical areas may benefit from certain BMPs depending on the site. Recommendations for the critical areas analysis reflect the recommendations provided by the individual inventories to avoid repetitiveness.

There were significant limitations to this analysis. The current map depicts both recent and outdated information. As previously mentioned, over 40% of the RSX sites have not been updated since 2015. It is difficult to assume what areas truly are in need of the most attention due to the lack of recent available data. This is also relevant in regards to the forestry and agriculture inventories. Ground truthing is needed for both agriculture and forestry inventories to identify what areas are in need of attention. Although high priority agricultural areas were taken into consideration for the critical areas analysis, these sites (once ground truthed) may not be as serious as noted through the desktop analysis. The same applies with the forestry inventory as ground truthing is needed to determine what areas significantly need to be addressed.

Table 5.7. Critical Areas Recommendations

Topic	**Recommendations for TOMWC**
Critical Areas	**Ground truth and determine BMPs for individual inventories based on current conditions.** -See recommendations for RSX, streambank, agriculture, and forestry inventories -Allocate resources to sites deemed critical

Chapter 6: Conclusion

As TOMWC begins constructing the Black Lake Watershed Management Plan, this report will serve as a foundational component, enabling TOMWC to expand upon our efforts and foster deeper engagement with the Black Lake Watershed community. From our resource inventories, we determined water quality issues may be arising from poor road/stream crossing conditions, increasing trends of streambank erosion and the presence of high impact agricultural activity. Our critical areas analysis identified critical areas within 10 kilometers of Black Lake which may be a factor in the HABs as an increasing problem trend. We strongly advocate for TOMWC to conduct visits and monitoring of all high-priority parcels and critical areas outlined in our findings. Moreover, it is imperative for TOMWC to enhance community education in the Black Lake Watershed, ensuring equitable access to information on water quality, HABs, environmental behavior change, and securing funding for septic systems and shoreline property improvements. The upcoming second edition of the Black Lake Watershed Resident Survey will further document any changes over the next year and reach a broader sample of the watershed community. With these recommendations, we envision the development of a robust and practical watershed management plan that will offer essential guidance to watershed coordinators, resource managers, policymakers, and community organizations in their efforts to restore and safeguard the Black Lake Watershed. Additionally, we, as researchers, hope for this document to serve as a model for other communities grappling with poor water quality and harmful algal blooms in similar watersheds, informing their actions.

Appendix

Appendix 1. Black Lake Tributary Study Visuals and Data

Stony Creek

There were three total sites monitored at Stony Creek. Monitoring sites with data measured below the Rule 51 TDS Maximum of 750mg/L with an average of 280mg/L. Recorded pH showed an average of 7 which falls within the Michigan WQS of 6.5-9. Stony Creek at Stewart's Beach Rd. initially met the WQS dissolved oxygen of 7mg/L during May (9mg/L) and didn't meet it again until October (~11mg/L) while at N. County Line Rd. levels were consistently low until October when it then measured at 9mg/L. All sites exceeded July and August temperature standards for a cold-water fishery but were within the standards for May and October. All sites measured far below the EPA's chloride toxicity levels, however an influx is seen during the months of August and October, suggestive of some pollution being introduced or a rain event. Stony Creek at N. County Line Rd. measured the highest at 237.5 µg/L in August which is far above the EPA's suggested TP concentrations of 12µg/L. The site was never below the EPA's suggested TP concentrations, however the other two sites were. Stony Creek at M-68 was consistently below the 12µg/L. Stony Creek at Stewart's Beach Rd. was also below the 12µg/L except for the month of August where it read ~16µg/L. Stony Creek at N. County Line Rd. consistently did not meet the EPA's TN reference condition of 440 µg/L reaching a high of ~1400µg/L. Its levels were lower during the months of May and October, however there is a difference of roughly 1000µg/L between May and July as well as about 700µg/L between August and October.

Cold Creek

Cold Creek was monitored at N. Porter Rd. The site measured below the Rule 51 TDS Maximum of 750mg/L with an average of 270mg/L between May and October. The site's pH was relatively consistent and increased from 7.6 to 7.8 from May to October which is within the Michigan WQS of 6.5-9. Dissolved oxygen remained above the 5mg/L required for warm-water fisheries. Recorded temperatures are consistent with the set standards for a warm-water fishery. Chloride levels were slightly above the EPA's toxicity level of 5mg/L ranging from 6mg/L in May to 11.5 in October. TP concentrations were elevated in May at 17µg/L exceeding the EPA's suggested concentrations of 12µg/L but decreased to 10µg/L in October. TN concentrations exceed the TN reference condition of 440 µg/L for minimally impacted conditions for Northern Michigan in May at 650µg/L and in October at 1650µg/L.

Fisher Creek

There were two sites monitored at Fisher Creek. Fisher Creek at Hutchinson Highway was dry during July and August providing minimal data to compare. Both sites measured below the Rule 51 TDS Maximum of 750mg/L with an average of 250mg/L. Recorded pH at S. Black River Rd. showed an average of 8 which falls within the Michigan WQS of 6.5-9. Fisher Creek at S. Black River Rd. initially met the WQS dissolved oxygen of 7mg/L during May (9mg/L), however dropped below the WQS in July and August, and increased to 11mg/L in October. Fisher Creek at Hutchinson Highway was slightly elevated above the temperature standards for a cold-water fishery in May while at S. Black River Rd. standards were never exceeded. Fisher Creek at Hutchinson Highway measured below the EPA's chloride toxicity levels, however at S. Black River Rd. levels were over tenfold likely due to an impoundment of a golf course. TP concentrations were consistently below the EPA's suggested concentrations of 12µg/L with Hutchinson Highway reading the highest in October at ~8µg/L. TN concentrations were consistently below the EPA's TN reference condition of 440µg/L except for at Hutchinson Highway where it was measured at ~1300µg/L in October.

Rainy River

One site was monitored at Rainy River (another site at the Rainy River/Cold Creek confluence). The site at M-68 was below the Rule 51 TDS Maximum of 750mg/L, however fluctuated from ~150mg/L in May to averaging ~300mg/L July through October. Rainy River's pH measured at about 7.7 in October which falls within the Michigan WQS of 6.5-9. Dissolved oxygen concentrations were too low to meet the WQS dissolved oxygen of 7mg/L for coldwater fisheries at 4.7mg/L. Temperatures were consistent with the temperature standards for a cold-water fishery for the months of May and October but exceeded July and August. Chloride levels measured slightly above the EPA's toxicity level of 5mg/L averaging 7mg/L May through October. TP concentrations exceed the EPA's suggested concentrations of 12µg/L July through October peaking at 24µg/L in August which is likely due to a weather event. TN concentrations consistently exceed the TN reference condition of 440 µg/L for minimally impacted conditions for Northern Michigan and steadily increase from 500 µg/L in May to 1100 µg/L in October.

Stewart Creek

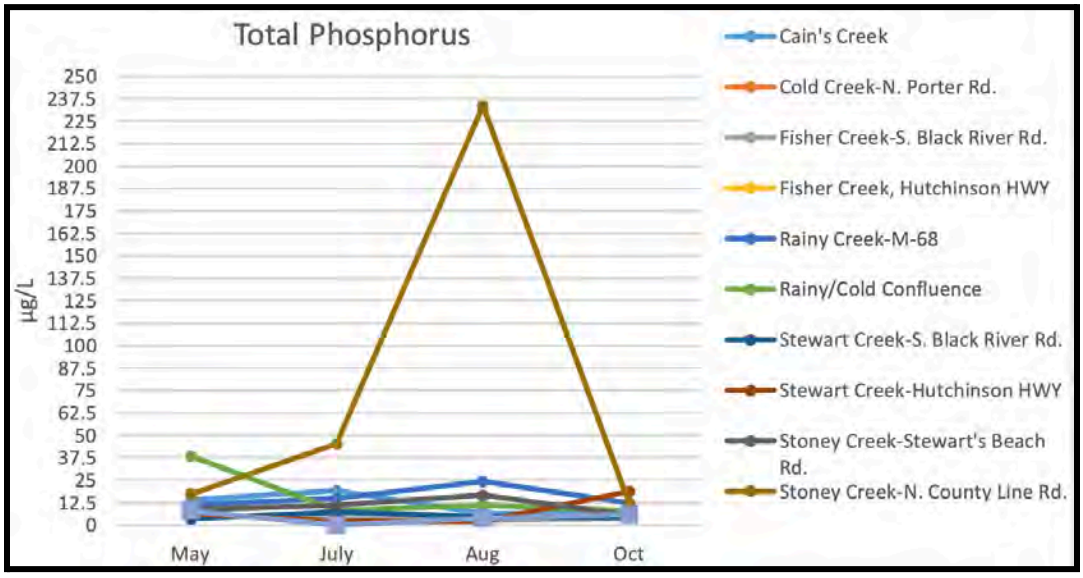
Two sites were measured at Stewart Creek: S. Black River Rd. and Hutchinson Highway. Both sites were below the Rule 51 TDS Maximum of 750mg/L although Stewart Creek at S. Black River Rd. measured the highest in July at ~375mg/L. The sites also fluctuated in pH with S. Black River Rd. measuring the most basic at 8.3 which still falls within the Michigan WQS of 6.5-9. Dissolved oxygen decreased between May and July but still remained above the 5mg/L required for warm water fisheries. Throughout all months of the study, Stewart Creek was below the temperature maximums set for warm water streams, although in July at S. Black River Rd. temperatures almost exceed the limit. Both sites exceed the EPA's chloride toxicity levels especially at S. Black River Rd. where it has the second highest chloride levels maintaining around 25mg/L over the course of the study. Hutchinson Highway decreases from 12.5mg/L in

May to ~5mg/L in July and increases to 23mg/L in October. TP concentrations at each site are well below the EPA's suggested concentrations of 12µg/L until October when there is an increase to 19µg/L seen at Hutchinson Highway. TN concentrations at each site were exceptionally higher than the TN reference condition of 440 µg/L for minimally impacted conditions for Northern Michigan. Stewart Creek at Hutchinson Highway had the highest TN concentrations in July and August measuring at 2411.4 µg/L and 3178.4 µg/L respectively. At S. Black River Rd., TN concentrations were below 440 µg/L for May and August, however exceeded the standards in July and October.

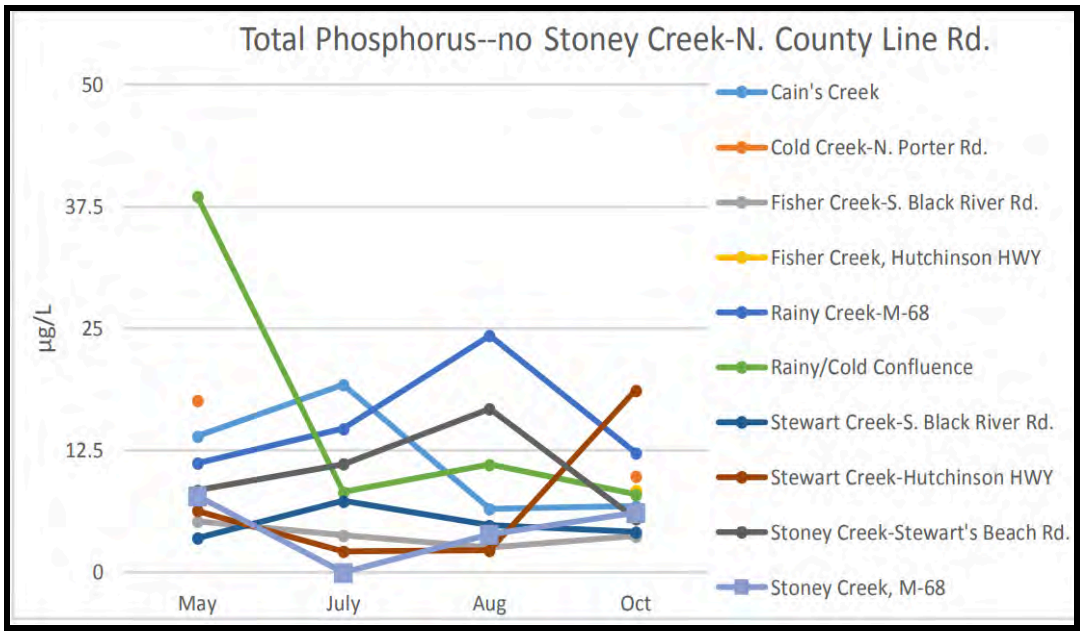
Cain's Creek

Only one site was monitored at Cain's Creek. Data measured below the Rule 51 TDS Maximum of 750mg/L with an average of 230mg/L. Recorded pH showed an average of 7.8 which falls within the Michigan WQS of 6.5-9. Dissolved oxygen averaged 9mg/L which is above the 5mg/L required for waters that are not coldwater designated streams. Throughout all months of the study, Cain's Creek was below the temperature maximums set for warm water streams. Chloride levels are low and below the EPA's toxicity levels but increase between May and June (2mg/L to ~10mg/L). TP levels exceed the EPA's suggested concentrations of 12µg/L during the months of May and June (~15µg/L) but decrease during the months of August and October (6µg/L). The TN level exceeded the USEPA TN reference condition of 440 µg/L for minimally impacted conditions for Northern Michigan streams in May and October.

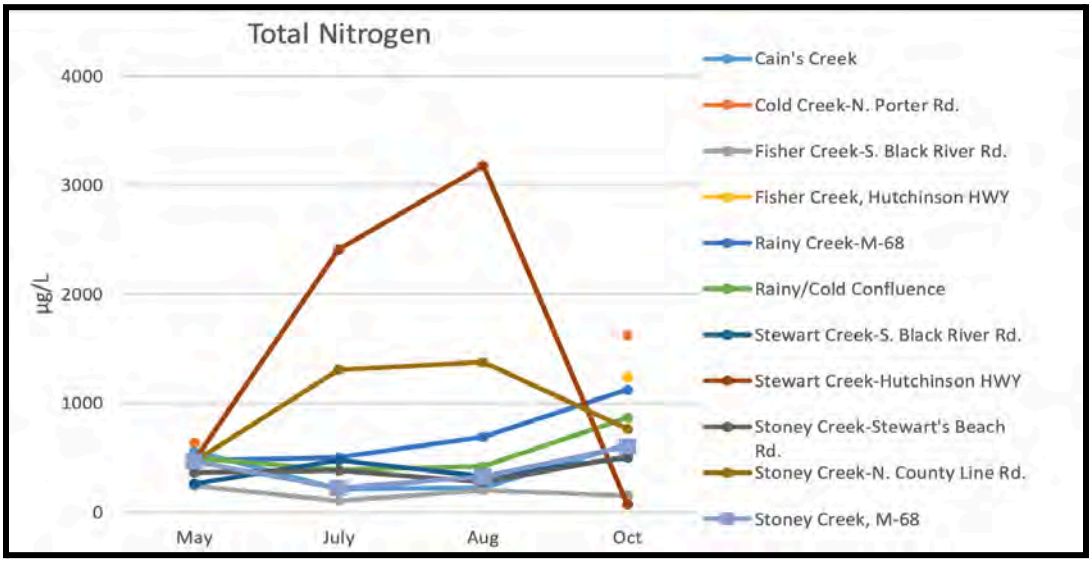
2018 Total Phosphorous Levels in Black Lake Tributaries



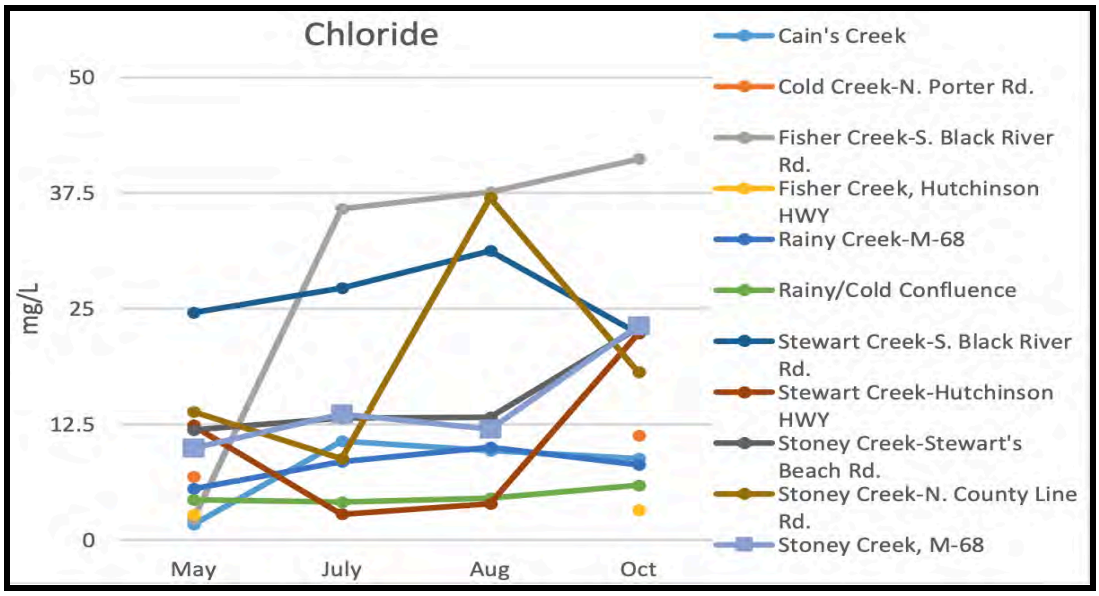
2018 Total Phosphorous Levels in Black Lake Tributaries Without Stoney Creek at N. County Line Rd.



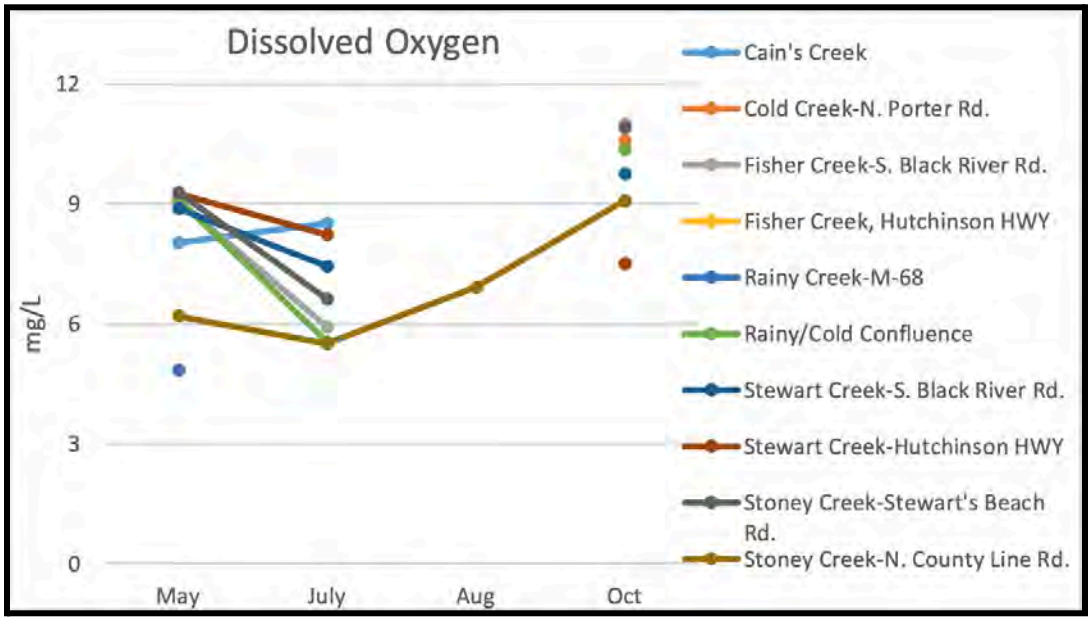
2018 Total Nitrogen Levels in Black Lake Tributaries



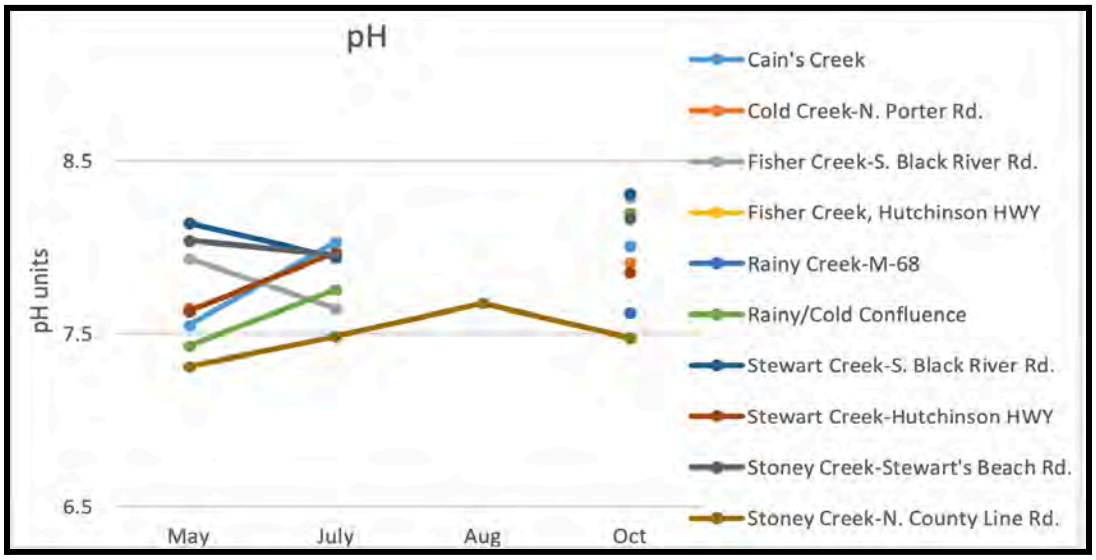
2018 Chloride Levels in Black Lake Tributaries



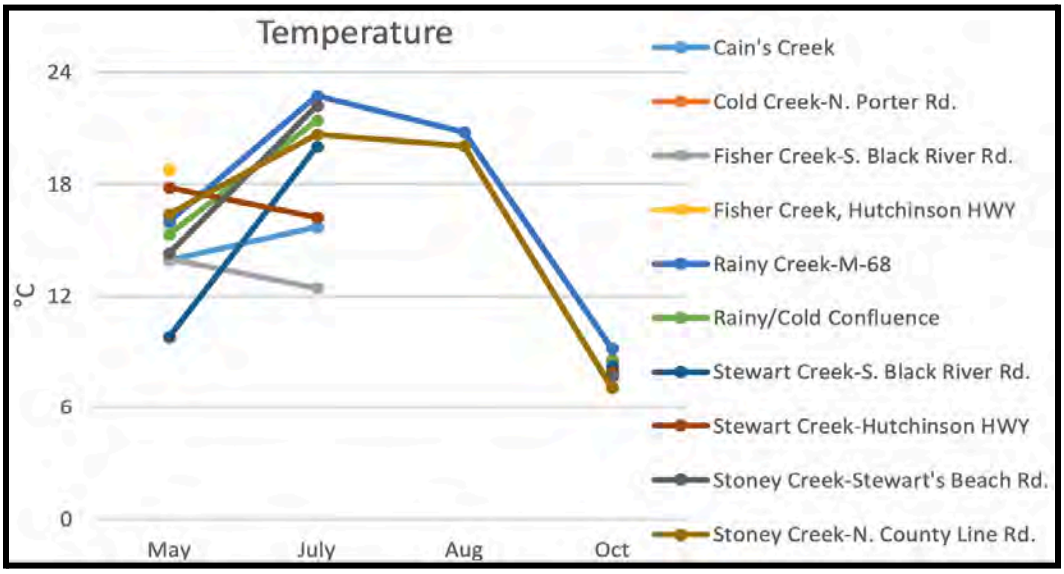
2018 Dissolved Oxygen Levels in Black Lake Tributaries



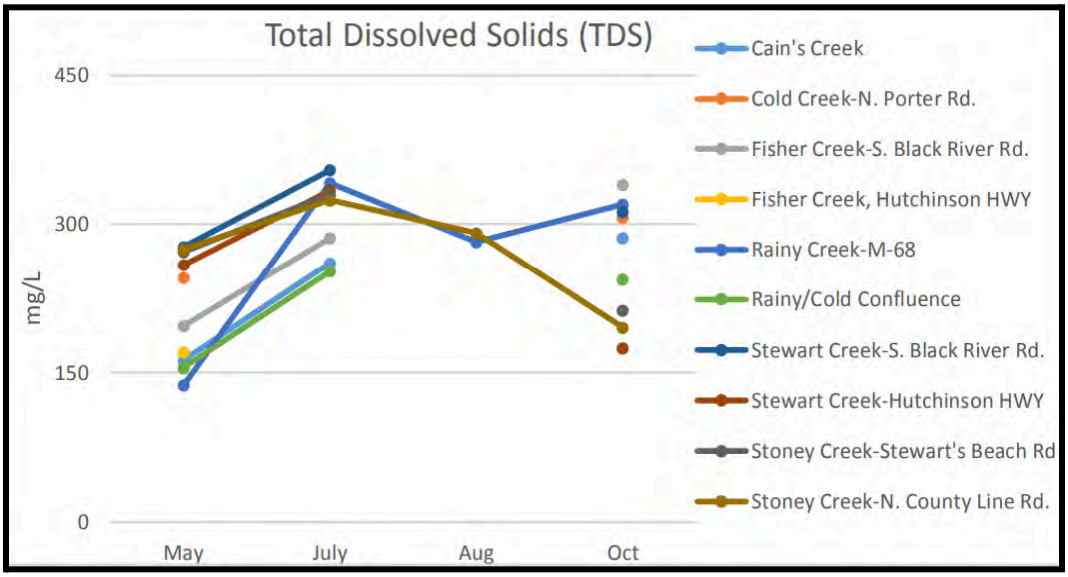
2018 pH Levels in Black Lake Tributaries



2018 Temperature Records of Black Lake Tributaries



2018 Total Dissolved Solids (TDS) Concentrations of Black Lake Tributaries



Appendix 2. Advance and Reminder Emails sent to the Black Lake Watershed Advisory Committee

Advance Email

Dear Black Lake Watershed Resident,

We need your help to better understand the current status of the Black Lake Watershed. Tip of the Mitt Watershed Council and students from the University of Michigan School for Environment and Sustainability are working to protect water quality of the Black Lake Watershed. As someone who makes decisions on the management of your property, your insights are particularly important and valuable, and we would greatly appreciate your participation in a survey. This will help us learn how we might best serve the needs of landowners and homeowners in the watershed.

Please complete this survey if you are a homeowner or renter within the Black Lake Watershed. [Insert Survey Link]

Your participation in the survey is completely voluntary. Let me assure you that your responses will remain confidential. Responses for all watershed residents completing the survey will be analyzed together, and no individual responses will be identified in any way. Your name will not be used in any report although you can request a copy of the final report so that you are able to see the full results.

Your participation in this survey is very important, to ensure we understand the management activities and the needs and interests of the community in the watershed. If you have any questions about the survey please contact me. Please complete one survey per person.
Thank you in advance for your help.

Let's work together to protect the water quality of the Black Lake Watershed.

Sincerely,

Dana Pflughoeft
University of Michigan SEAS Graduate Student Tip
of the Mitt Watershed Council Consultant
blacklakewatershedteam@umich.edu
231-645-4628

First Reminder Email

Dear Black Lake Watershed Resident,

Recently, a link to an online survey asking for your thoughts about watershed and land management issues was sent to you. Your response is important to accurately represent the opinions about these issues in the Black Lake Watershed.

Here is the link to the survey: [insert survey]

Please complete one survey per person. The survey population is limited to homeowners and renters in the Black Lake Watershed.

If you have already completed the survey, please accept my sincere thanks. If not, please take approximately 20 minutes to complete the survey soon. If you have any questions about the survey, please contact me. I am glad to answer your questions.

Let's work together to protect the water quality of the Black Lake Watershed.

Thank you for your help.

Dana Pflughoeft
University of Michigan SEAS Graduate Student Tip
of the Mitt Watershed Council Consultant
blacklakewatershedteam@umich.edu
231-645-4628

Second Reminder Email

Dear Black Lake Watershed Resident,

About three weeks ago, I sent an email including a link to a survey asking for your input on land and water issues in the Black Lake Watershed.

Here is the link again to the Black Lake Watershed Residents survey [insert link to survey].

Please complete one survey per person. The survey population is limited to homeowners and renters in the Black Lake Watershed.

Your response is important to accurately represent the opinions about these issues in the Black Lake Watershed. To be sure that the results are representative of the interests and opinions of the watershed, we need to hear from you. If you have already completed the survey, please accept my sincere thanks. If not, please take approximately 20 minutes to complete the survey soon. If you have any questions about the survey, please contact me. I am glad to answer your questions.

Let's work together to protect the water quality of the Black Lake Watershed.

Thank you for your help.

Dana Pflughoeft
University of Michigan SEAS Graduate Student Tip
of the Mitt Watershed Council Consultant
blacklakewatershedteam@umich.edu
231-645-4628

Final Reminder

Dear Black Lake Watershed Resident,

I am writing one final time to encourage you to complete and submit the Black Lake Watershed Residents Survey. If you have already returned the survey, thank you! If not please take a few moments to complete and submit the survey.

Here is the link to the survey: [link to survey]

I understand this survey may not be a top priority, or that you may be hesitant to share information about your land management practice. This survey is important because information received will be used to serve the needs of landowners in your area. By participating in this survey, you will help shape our outreach programs and technical services. Let's work together to protect the water quality of the Black Lake Watershed.

Please complete one survey per person. The survey population is limited to homeowners and renters in the Black Lake Watershed.

Please be assured that your responses will be confidential. Your name and answers will NOT be used in any reports or correspondence with the public.

Feel free to contact me if you have any questions, concerns, or comments. I would appreciate hearing from you.

Thank you for your help.

Dana Pflughoeft
University of Michigan SEAS Graduate Student Tip
of the Mitt Watershed Council Consultant
blacklakewatershedteam@umich.edu
231-645-4628

Appendix 3. Social Survey Social Media Posts

First, Second, and Third Social Media Post:







[Include QR code to the survey in all forms of public engagement] Text to Accompany Images on Facebook, Instagram, and Newsletters:
We need your help to better understand the current status of the Black Lake Watershed. Tip of the Mitt Watershed Council and students from the University of Michigan School for Environment and Sustainability are working to protect water quality of the Black Lake Watershed. As someone who makes decisions on the management of your property, your insights are particularly important and valuable, and we would greatly appreciate your participation in a survey. This will help us learn how we might best serve the needs of landowners and homeowners in the watershed.

By participating in this survey, you will help shape outreach programs and technical assistance options that may be provided. Your participation in this survey is completely voluntary. You may choose not to answer any question or stop participating in the online survey at any time. By completing and submitting this survey, you are consenting to be part of this research project. Responses will be confidential.

Take the survey with this link: [Insert Link]

Let’s work together to protect the water quality of the Black Lake Watershed.

Appendix 4. Great Lakes Stream Crossing Inventory Instructions

Great Lakes Stream Crossing Inventory Instructions

This protocol was developed, reviewed, and tested by the following organizations: Michigan DNR, U.S. Forest Service, Trout Unlimited, Wisconsin DNR, U.S. Fish & Wildlife Service, Huron Pines, Conservation Resource Alliance, Michigan Technological University, and road commissions. Funding for development and testing was provided by the U.S. Forest Service, U.S. Fish & Wildlife Service, and The Nature Conservancy.

This document is a guide to completing the *Stream Crossing Data Sheet* (new version forthcoming) and the Great Lakes Stream Crossing Inventory Survey, a Survey 123 application. Please use the below link to MI DNR ArcGIS HUB site or contact Mike Rubley (RubleyM1@michigan.gov) for access to the Survey 123 application. Careful attention to this guidance will ensure consistent crossing assessments, which is critical for identifying problems and prioritizing remediation.

The document can be accessed through the link below.

https://www.midnr.com/Publications/pdfs/ArcGISOnline/Guides/Stream_Crossing/Great_Lakes_Stream_Crossing_Inventory_Instructions.pdf

Appendix 5. Stream Crossing Data Sheet for Road Stream Crossing Inventory

Stream Crossing Data Sheet

Site ID:_____

Location Information

Stream Name:_____ Stream Flow Type: Perennial Intermittent Ephemeral Concentrated Wetland Flow
HUC 12 Watershed Code:_____ Reach Code:_____
Crossing Name:_____ Name of Observer(s): _____
Data Source/Affiliation:_____Date:_____
GPS Waypoint:_____ GPS Lat/Long:_____ Bearing:_____
State:_____ County:_____ Township:_____ Range:_____ Sec:_____
Adjacent Landowner Information:_____ Additional Comments:_____
Utilities Present: Buried Gas Lines Gas Fiber Optic Overhead Lines Municipal Lines
Road/Crossing Owner: Federal State County Township City Tribal Private
Other:_____

Crossing Information

Road/Crossing Surface: Paved Gravel Sand Native Surface Grass/Vegetated
Condition: New Pavement or Well Graded Old Pavement or Rutted Broken Pavement or Rilled/Gullied Impassible
Road Core Integrity: Good Fair Poor
Frequent Road Overtopping: Yes No Unknown **Diversion Potential:** Yes No
Structure/Stream Alignment: Good Alignment Fair Alignment Poor Alignment
Structure Skew: No Skew Moderate Skew Major Skew
Road Width at Culvert (ft):_____Structure Length (ft):[1]_____
Location of Low Point: **At Stream Other** **Runoff Path: Roadway Ditch**
Left Approach: Length (ft):_____Slope: <1% 1-5% 6-10% >10% **Ditch Vegetation:** None Partial Heavy
Right Approach: Length (ft):_____Slope: 0% 1-5% 6-10% >10% **Ditch Vegetation:** None Partial Heavy

Upstream Embankment Fill Depth (ft):___Slope: Gentle (3:1, 15^0, 33%) Moderate (2:1, 22.5^0, 41%) Steep (1:1, 45^0, 100%) Gentle (0:1, 90^0)
Inlet Armoring/Rip-rap: None Gravel Rock Concrete Metal Woody Vegetation Other:_____
Is Bank Armoring/Rip-rap Functional at the Inlet or Upstream Side: Good Fair Poor
Downstream Embankment Fill Depth (ft):_____Slope: Gentle (3:1, 15^0, 33%) Moderate (2:1, 22.5^0, 41%) Steep (1:1, 45^0, 100%) Gentle (0:1, 90^0)
Outlet Armoring/Rip-rap: None Gravel Rock Concrete Metal Woody Vegetation Other:_____
Is Bank Armoring/Rip-rap Functional at the Outlet or Downstream Side: Good Fair Poor
Use a new row for each distinct gully/erosion location. Note prominent streambank erosion within 50 feet of crossing.

Location of	Erosion Dimensions (ft)	Eroded Material	Material

Erosion Ditch, approach, or streambank Left or right facing downstream	**Length**	**Width**	**Depth**	**Reaching Stream?**		**Eroded** Sand, Silt, Clay, Gravel, Loam, Sandy Loam or Gravelly Loam.
				Yes	**No**	
				Yes	**No**	
				Yes	**No**	
				Yes	**No**	
				Yes	**No**	

If there is erosion occurring, can corrective actions, such as road drainage measures, be installed to address the problem? **Y** **N**
Extent of Erosion: Minor Moderate Severe Stabilized
Erosion Notes:

[1]- Fill out for primary culvert (culvert #1). If multiple culverts are used, number each and use embedded table. Form Date: May 11, 2021

Structure Information

Crossing Type: Culvert(s) no.:_____ Ford Dam Bridge Other:_____
Crossing Use: Road Railroad Farm Crossing Trail Driveway Decommissioned Road Other:_____
Additional Crossing Use: Not Applicable Wetland Equalization/Cross Drainage High Water Relief Portable Bridge Engineered Structure Other:
_____
Structure Shape: Round Square/Rectangle Open Bottom Square/Rectangle Pipe Arch Native Bottom Arch Ellipse
Other:_____
Structure Material: **Metal** **Concrete** **Plastic** **Wood** **Rock** **Clay** **Other:**_____

Structure Interior: Smooth Corrugated

Structure Width (ft):[1]_____

Bridge Wetted Width (ft): _____

Structure Height (ft): [1]_____

Substrate in Structure: None Sand Gravel Rock Mixture

Stream Flow: None < ½ Bankfull < Bankfull = Bankfull > Bankfull

Crossing Affected by Impoundment No Upstream Downstream

Multiple Culverts/Spans				
Number the culverts/spans left to right, facing downstream. Include #s in site sketch on back page				
Culvert/ Span #	**Width (ft) Length (ft) Height (ft)**			**Material**

Inlet Type: Projecting Mitered Headwall Apron Wingwall 10-30° Wingwall 30-70° Wingwall >70° Trash Rack Headwall and Wingwall Other _____

Wingwall Material: Not Applicable Wood Logs Concrete Steel Other_____

Structure Inlet Water Depth (ft): [1]_____ **Embedded Depth (ft):**[1]_____

Water Velocity (ft/sec): [1]_____ **Upstream Pond (if present) Length:**_____

Width:_____ **Sediment Wedge Present:** Yes No

Outlet Type: At Stream Grade Cascade over Riprap Freefall into Pool Freefall onto Riprap Outlet Apron Other_____

Structure Outlet Water Depth (ft): [1]_____**Embedded Depth (ft):**[1]_____

Water Velocity (ft/sec): [1]_____ **Velocity Measured With:** Meter or Float Test **Velocity Measured at** Surface or_____ ft Below Surface **Perch Height (ft):** [1] _____ or NA **Scour Pool (if present) Length:** _____ **Width:** _____ **Depth:**_____ **Sediment Deposit:** Yes No

Plugged:_____**%** Inlet In Structure Outlet **Crushed:**_____**%** Inlet In Structure Outlet

Rusted Through? Yes No

General Condition:

❑ No deficiencies. New structure or nearly new condition.

❑ Not new, but no noticeable corrosion, abrasion, chipping, spalling, or cracking. No shape changes

such as barrel distortion (bowing, bending, warping), bulging, inlet or outlet damaged.

❑ Light superficial corrosion or abrasion or chipping or spalling or cracking. No shape changes (described above).

- ❑ Moderate deterioration from corrosion or abrasion (small rust flakes or indication that rust is slightly deeper than the surface level) or cracking or spalling or chipping (few minor cracks or localized chipping in the concrete). OR minor shape changes (described above).
- ❑ Moderate to major deterioration from corrosion or abrasion (less than 5% of the structure has small holes or is nearly rusted through) or cracking or spalling or chipping (several small cracks or moderate chipping in the concrete). OR Moderate shape changes (described above).
- ❑ Major deterioration from corrosion or abrasion (5-10% of the structure is rusted through) or cracking or spalling or chipping (medium sized cracks, widespread chipping, exposed metal reinforcement). OR Major shape changes (described above) reducing the capacity of the structure by less than 30%. OR segment disconnection (segments of concrete or metal culvert disconnecting internally) but no evidence of water piping.
- ❑ Major deterioration from corrosion or abrasion (10-50% of the length of structure is rusted through) or cracking or spalling or chipping (large chunks sloughing off, large cracks, exposed metal reinforcement). OR Major shape changes (described above) reducing the capacity of the structure by up to 50%. OR segment disconnection with evidence of water piping under or around the culvert.
- ❑ Severe deterioration from corrosion or abrasion (more than 50% of the structure is rusted through) or cracking or spalling or chipping (more than 50% of the structure is compromised). Or Major shape changes (described above) reducing the capacity of the structure by greater than 50%. OR Segment disconnect causing major subsurface erosion/piping and/or partial fill failure and/or sink holes in the fill.
- ❑ Deterioration, shape changes, or segment disconnection more severe than the previous category to the extent that the road manager should be contacted to determine if the road should be closed.

❑ Road closed. Impassible. Partial or full crossing failure.

Representative Reach (measured in a riffle outside of zone of influence of crossing)

Reach Location: Upstream Downstream **Distance From Crossing (ft):**_____

Bankfull Width (ft):_____ **Wetted Width (ft):** _____**Water Depth (ft):** _____

Water Velocity (ft/sec): _____

Velocity Measured With: Meter or Float Test

Velocity Measured at Surface or _____ft Below Surface

Dominant Substrate: Clay Organics Silt Sand Gravel Cobble Boulder Bedrock

Channel Stability Assessment

Indicators of Channel Equilibrium

- ❑ The channel has a well-defined bankfull contour that clearly demarcates an obvious, well connected floodplain near the bankfull elevation throughout most of the reach. In sand bed systems, there is often fresh sand deposition on or forming this bank.

❑ Perennial riparian vegetation is abundant and well established along the bankfull contour, but not below it.
❑ There is leaf litter, thatch, or wrack in most pools (if pools are present)
❑ The channel contains embedded woody debris of the size and amount consistent with what is naturally available in the riparian area.
❑ There is little or no active undercutting or burial of riparian vegetation.
❑ If mid-channel bars and/or point bars are present, they are not densely vegetated with perennial vegetation.
❑ There are channel pools, the spacing between pools tends to be regular and the bed is not planar (flat or uniform gradient) through the reach.
❑ The larger bed material supports abundant mosses or periphyton.

Indicators of Active Degradation

❑ The channel is characterized by deeply undercut banks with exposed living roots of trees or shrubs.
❑ There are abundant bank slides or slumps.
❑ The lower banks are uniformly scoured and not vegetated.
- ❑ The channel elevation below the road is much lower in elevation than above the road. The road has stopped a headcut from progressing up stream <u>(all other factors should be assessed away from the road).</u>
- ❑ Riparian vegetation is declining in stature or vigor, or many riparian trees and shrubs along the banks are leaning or falling into the channel <u>(do not consider trees from outside of the bank that have fallen into the channel or an occasional wind-tripped bank tree).</u>

❑ An obvious historic floodplain has recently been abandoned, as indicated by the age structure of its riparian vegetation.
❑ The channel bed appears scoured to bedrock or dense clay.
❑ Head cuts, “nick points” are present.
❑ In-stream infrastructure such as bank stabilization structures or fish habitat structures are exposed or being undercut by the stream.

Indicators of Active Aggradation

❑ There is an active floodplain with fresh splays of coarse sediment (sand and larger that is not vegetated) deposited in the current or previous year.
❑ There are partially buried living tree trunks or shrubs along the banks.
❑ Perennial terrestrial or riparian vegetation is encroaching into the channel or onto channel bars below the bankfull contour.
❑ There are avulsion channels on the floodplain or adjacent valley floor.

Overall Channel Stability

❑ Equilibrium
❑ Degradation
❑ Aggradation

Entrenchment

❑ Entrenched
❑ Moderately Entrenched
❑ Slightly Entrenched

Photos – enter photo number in blank corresponding to location

❑ Inlet_____ ❑Upstream Conditions_____ ❑ Downstream Conditions_____
❑ Outlet _____❑Road Approach – Left _____ ❑ Road Approach – Right_____
❑Representative Reach_____

Channel Stability Assessment

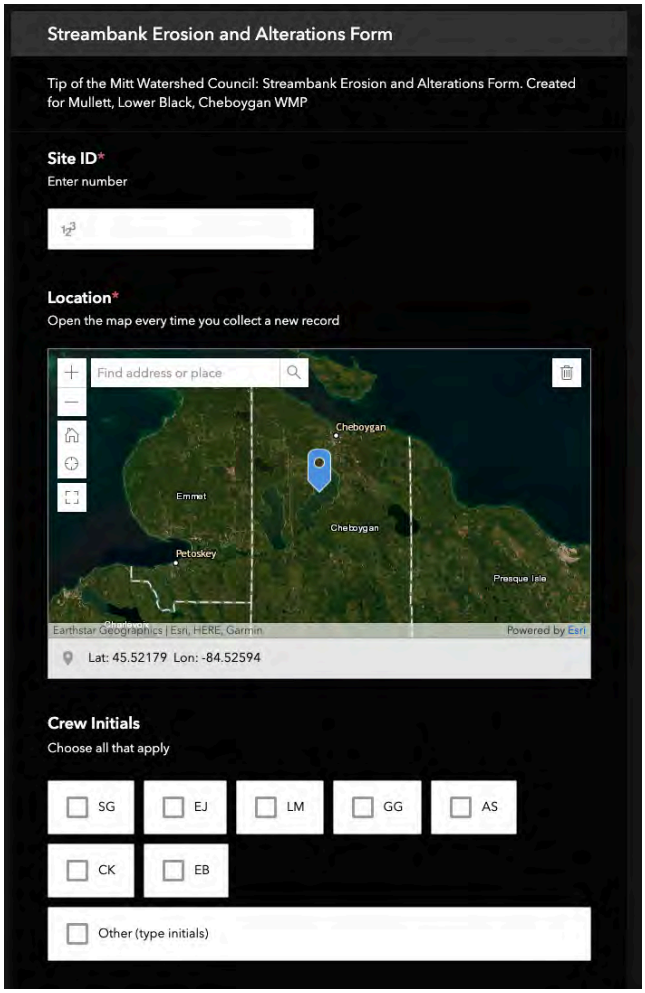
Do you believe there is a time-sensitive maintenance need at the site? Yes No **Why?_____**
Were any non-native invasive species observed at the site? Yes No **If yes, what species were observed?_____**

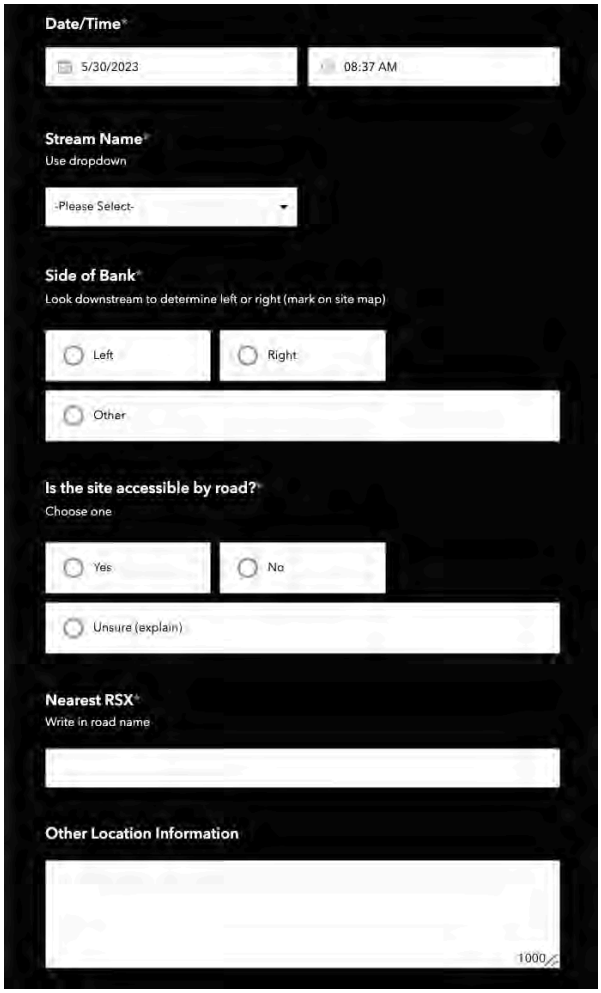
Site Comments: *(Describe any site factors or context unique to the site not captured in the above protocol. Record the cause of any of the issues noted above (plugging, ponding, sediment deposition, etc…). If upstream sediment deposition is observed, please indicate here. Factors unique to fords should be recorded here: wetted width across the ford, approach armoring, streambed armoring.)*

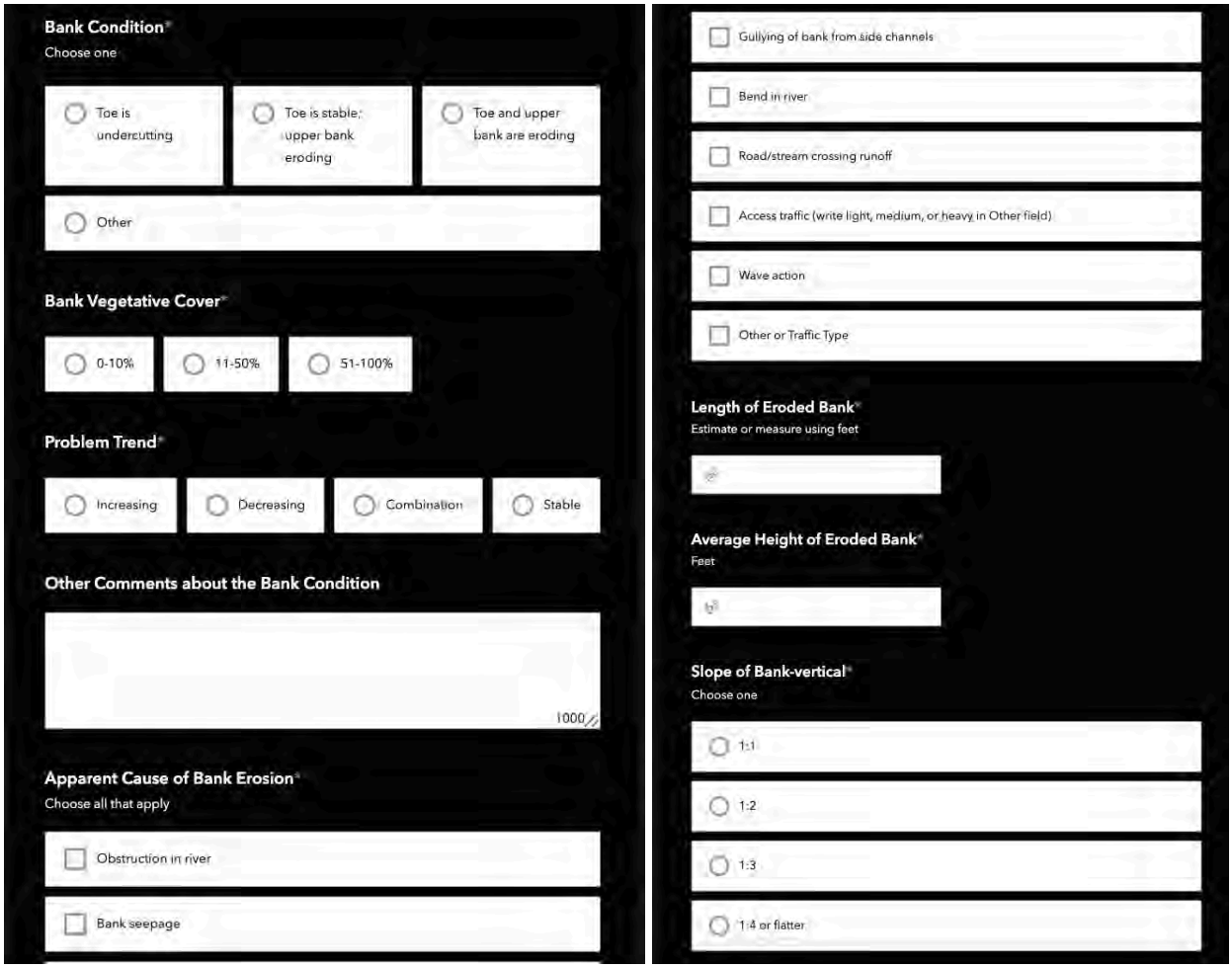
Site Sketch

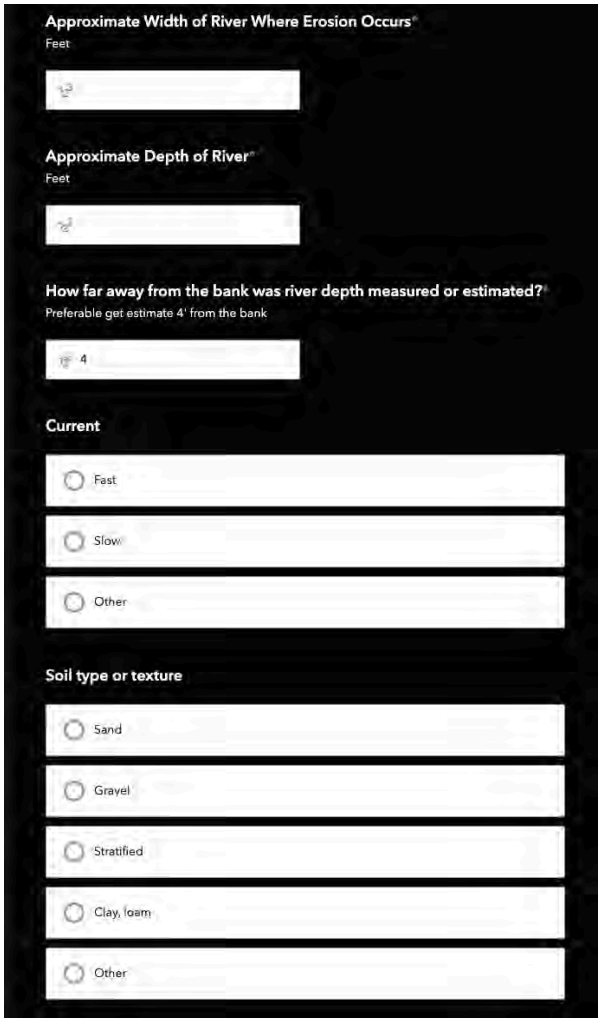
Draw an overhead sketch of crossing. Be sure to mark North on the map and to indicate the direction of flow. Include major features documented on form, such as erosion sites, multiple culverts, scour pool, impounded water, etc.

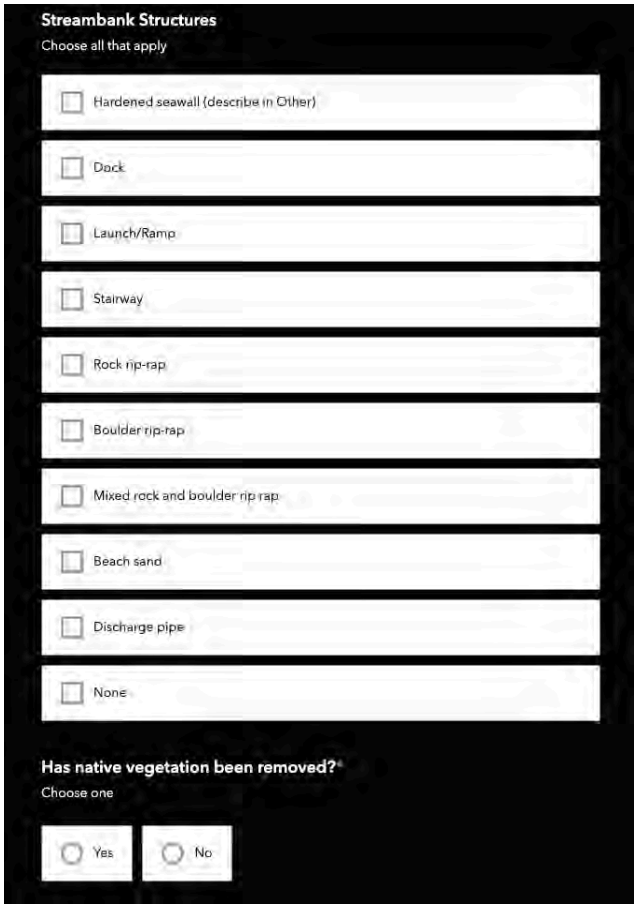
Appendix 6. Survey123 Form for Streambank Erosion Inventory

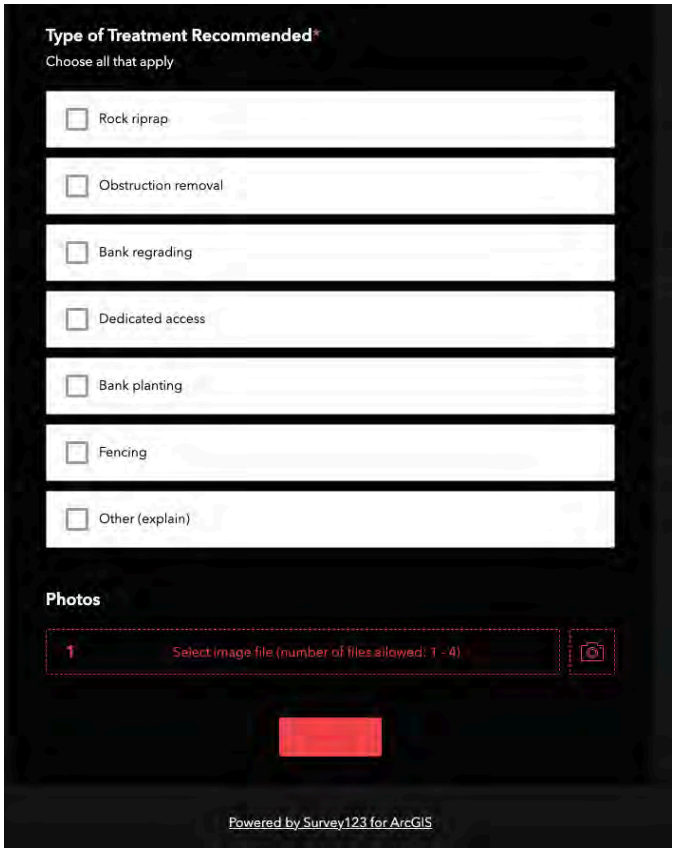





Bank Condition*
Choose one
Toe is undercutting
Toe is stable; upper bank eroding
Toe and upper bank are eroding
Other
Bank Vegetative Cover*
0-10%
11-50%
51-100%
Problem Trend*
Increasing
Decreasing
Combination
Stable
Other Comments about the Bank Condition
1000
Apparent Cause of Bank Erosion*
Choose all that apply
Obstruction in river
Bank seepage
Gullying of bank from side channels
Bend in river
Road/stream crossing runoff
Access traffic (write light, medium, or heavy in Other field)
Wave action
Other or Traffic Type
Length of Eroded Bank*
Estimate or measure using feet
Average Height of Eroded Bank*
Feet
Slope of Bank-vertical*
Choose one
1:1
1:2
1:3
1:4 or flatter


Approximate Width of River Where Erosion Occurs*
Feet
Approximate Depth of River*
Feet
How far away from the bank was river depth measured or estimated?*
Preferable get estimate 4' from the bank
4
Current
Fast
Slow
Other
Soil type or texture
Sand
Gravel
Stratified
Clay, loam
Other


Streambank Structures
Choose all that apply
Hardened seawall (describe in Other)
Dock
Launch/Ramp
Stairway
Rock rip-rap
Boulder rip-rap
Mixed rock and boulder rip rap
Beach sand
Discharge pipe
None
Has native vegetation been removed?*
Choose one
Yes
No


Type of Treatment Recommended*
Choose all that apply
Rock riprap
Obstruction removal
Bank regrading
Dedicated access
Bank planting
Fencing
Other (explain)
Photos
1
Select image file (number of files allowed: 1 - 4)
Powered by Survey123 for ArcGIS

Appendix 7. Animal Feeding Operations Inventory

Animal Feeding Operations Inventory

Purpose

Animal feeding operations (AFOs) are potentially significant contributors of nonpoint source (NPS) pollutants. This paper outlines an approach for cataloging, evaluating, and prioritizing AFOs within a Geographic Information System (GIS), for inclusion in a nine-element watershed management plan. This paper only looks at the AFO itself and not at the land application of manure.

The primary objective of an AFO inventory is to establish a prioritized list of locations, which stakeholders can use to systematically contact landowners about the incorporation of best management practices (BMPs) within their operation. The incorporation and systematic response to specific information within a watershed management plan allows stakeholders to develop implementation proposals that are more competitive.

Recommended Data Layers

The evaluation of AFOs within a watershed should always begin with a desktop analysis. The compilation of the following data layers is recommended when identifying AFOs within the planning area:

- Subwatershed Boundaries - the United State Geologic Survey (USGS) has created a nested set of watersheds for the entire country known as the hydrologic unit codes (HUCs). The twelve digits HUCs are the smallest unit in this cataloging system and are referred to as a subwatershed. Subwatersheds typically range in size from 10,000 to 40,000 acres. The location of AFOs should be compiled at the subwatershed level.
- Aerial Photographs - High resolution imagery (<1 ft. resolution) is critical in identifying and preliminarily evaluating the condition of an AFO. ArcMap provides good medium and high resolution aerial photographs. Aerial photographs are accessed within ArcMap in the following location: file>add data> add base maps. Medium resolution aerial photographs are activated at scales from 1:54,000 to 1:3,001 and are good for initial identification of AFOs. High resolution aerial images are activated at a 1:3,000 scale or less, and provide for a detailed evaluation of the site.

High resolution photographs can also be obtained using the SIGGIS street view and birds eye add in tool bar. This tool provides high resolution aerial and bird's eye view photographs by simply clicking on the desired location in the ArcMap environment. A pop-up box with the image will appear. This tool should be used in tandem with the previously mentioned images, because point locations cannot be added onto the images derived from the SIGGIS tool. The tool provides the same images, with the advantage of a faster loading rate than ArcMap. The SIGGIS add in tool can be downloaded from the following location: http://www.arcgis.com/home/item.html?id=cb1bd2804d0f42d2b903952c2d781170

- Confined Animal Feed Operations (CAFOs) – Facilities that house a large number of animals or are found to be a significant contributor of pollutants are required to obtain a National Pollution Discharge Elimination System (NPDES) permit from Michigan's Department of

Environmental Quality (MDEQ). The number of animals needed to qualify as a large operation depends on the type of animal housed at the facility, see appendix B. Locational information is required as part of the permit, therefore all CAFOs within the subwatershed can and should be mapped. CAFOs locations can be obtained using MDEQ's MiWaters Site Map Explorer at: https://miwaters.deq.state.mi.us/nsite/. Click on the filter tab and select "Concentrated Animal Feeding Operation" under "Site Type". Then zoom in to the area of interest. Pink dots indicate CAFO locations. If there is a number in the pink dot this indicates more than one CAFO is located in this area. Zoom in further to get the exact location of the CAFOs.

- Waterbodies - An important step in this process is to identify what sites are in proximity to waterbodies. It is important to consider the potential impacts these facilities have on the different type of aquatic systems within a watershed. Shapefiles identifying the rivers, wetlands and lakes within the planning area should be incorporated into this process. Proximity to waterbodies should be included as part of the AFOs spatial datasets attribute table.
- Road Network - The road network within the planning area is needed. Maps with the location of the AFOs are printed and used to navigate the subwatershed during the windshield survey.
- Public Land Survey (Sections) - Using a grid overlay is optional, but recommended as it provides a way of systematically moving through a subwatershed. This is particularly important if the identification of AFOs can't be completed in one session. Sections are approximately 640 acres and are recommended as the grid overlay but, other grids systems can certainly be used.
- Topographic Data- elevation data of all AFOs should be evaluated, with particular attention paid to facilities in proximity to waterbodies. Contours or digital elevation models (DEMs) can be used. It is important to understand the direction water is likely flowing when runoff occurs on the site and how that runoff maybe impacting water quality.

Indicators of Animal Operations

AFOs can be easily identified using aerial photographs. The following section discusses some of the distinguishing characteristics that help to identify an AFO. These characteristics are interrelated and should be used as in conjunction with each other when evaluating if an operation is an AFO.

Manure Storage Structures

Animals produce waste and larger AFOs collect animal waste in manure storage structures. Manure storage structures are typically square or rectangular in shape (Figure 1), although older structures can be circular and elevated (Figure 2).

Manure storage structures typically appear to be holding a dark or turbid fluid but sometime may appear empty. Although manure storage structures are a very distinct feature, some AFOs have manure storage beneath the structures that house the animals. Similarly, smaller AFOs will not have manure storage structures, but will have areas where the manure is piled. Therefore, this feature may not be present on all AFOs.



Figure 1. A typical small manure storage structure



Figure 2. An older empty circular manure storage structure

Building Types

AFOs are typically long linear white buildings of varying sizes, depending on the number of animals they are housing. Figure 3 shows a larger AFO. It is also important to consider the kind of animal that may be present. The presence of the ring in Figure 4 indicates that horses are likely kept at this facility.



Figure 3. Larger operation with typical white structures of an AFO.



Figure 4. A small horse facility with a discernable exercise ring.

Feedlots/Bare Earth Areas

The presence of animals can result in the loss of ground vegetation. Patches of bare earth are a characteristic of AFOs (Figures 5 and 6).



Figure 5. Patches of bare earth.



Figure 6. Patches of bare earth area associated with AFO.

Feed Storage

There are three characteristic feed storage structures found on AFOs: bagged silage, silos, and silage bunkers. Bagged silage are typically long white tube like structures but can also be rectangular in shape (Figure 7). Silos are the classic tall cylindrical structures associated with agricultural operations (Figure 7).

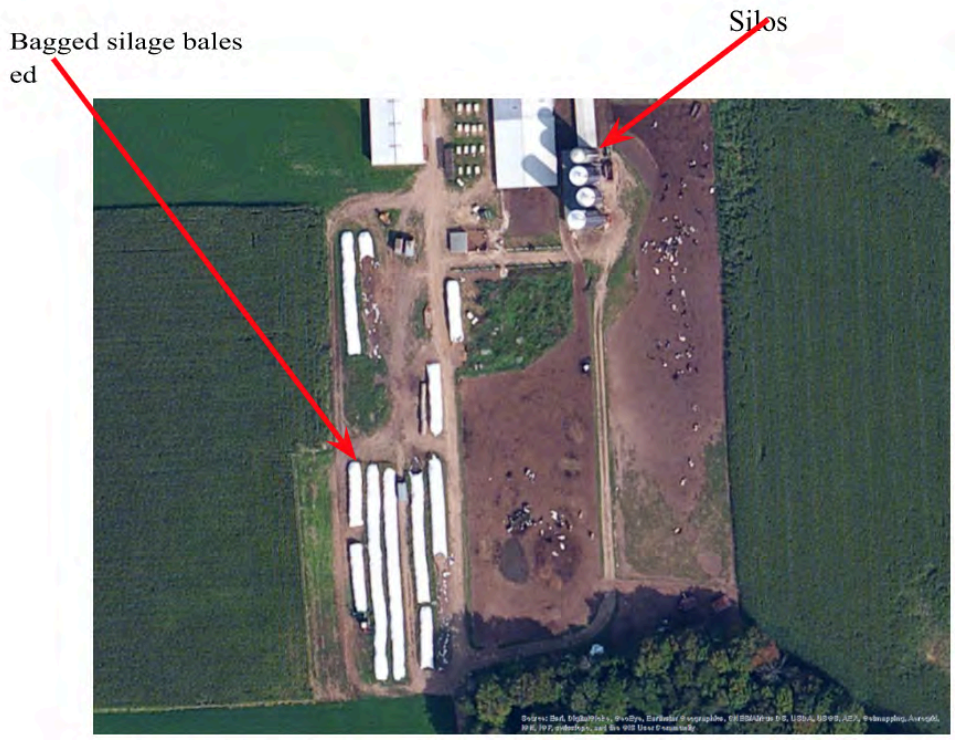


Figure 7. Typical form of bagged silage bales and silos on an AFO.



Figure 8. Example of the foil like appearance of a silage bunker.

Depending on the angle of the sun, the surface of a silage bunker can take on a tin foil like appearance (Figure 8). Another way of distinguishing silage bunkers are a series of circles, which are car tires piled on top to help keep the material covering the feed in place (Figure 17).

Feeder Stations

Feed for animals are often placed in feeder stations. Figure 9 shows several feeder stations out in a feedlot. An indicator typically associated with feeder stations is patches of bare earth. In a pasture setting, feeder stations are often moved around, and the bare earth areas have a distinct circular and/or rectangular pattern (Figure 10).



Figure 9. Feeder stations in feedlot



Figure 10. Feeder station outlines in pasture

Identification of Potential Sources of NPS Pollutants within AFOs

While reviewing aerial photographs for evidence of potential animal feeding operations you can also begin to identify sources of nonpoint source pollutants that have the potential to impact water quality. The items listed below should be considered when attempting to locate sources of nonpoint source pollutants at animal feeding operations:

- Proximity to water body
    - The closer a potential source is to a water body, the likelihood of it impacting water quality usually increases. The areas adjacent to water bodies and the connected upland area should be reviewed with an especially close eye.
    - Are there areas of bare, disturbed soil along surface waters? Does the stream channel become overly wide relative to other areas upstream and downstream at these sites? These could be areas where animals have direct access to surface water (It's possible

some aerials might even show animals accessing the stream at the time the picture was taken).

- Look for signs of fencing or other barriers that would indicate animals are not allowed direct access to streams.



Figure 11: Arrows indicate areas of bare soil where animals may have access to the stream. Banks appear disturbed.

- Review the features that indicate the site is an animal feeding operation. Look for any obvious drainage pathways near feed lots, pasture areas, silos, bunkers, or other impervious surfaces to surface water.



Figure 12: Arrows indicate natural drainage path from a feedlot area through a field to surface water.



Figure 13: Disturbed areas show temporary locations for animal feeding. Arrow indicates drainage flow path from feeding area, potentially transporting nutrients and pathogens to surface water.

- Manure Storage
    - Search the site for potential manure storage infrastructure, including above ground storage structures and earthen manure storage structures.
        - Above ground storage structures are often tall, circular structures (Depending on the lighting in the aerial photograph, you may be able to judge how full the structure is, which could give insight on the number of animals present). Are there any drainage pathways nearby leading to surface waters?



Figure 14: Arrow indicates above ground manure storage structure.

- Earthen manure storage structure are lined, pond-like structures. Are they located close to surface water bodies?



Figure 15: Arrow indicates earthen manure storage structure.

- If there are no signs of storage structures, look for areas where equipment have frequented (bare soil) or other sectioned-off areas where manure piles could be kept. Piles might be visible from aerials.

- Silage Storage
  - Search the site for bunkers or silos. If these are in close proximity to water bodies or there are obvious drainage pathways leading to surface waters these could be sources.



Figure 16: Arrow indicates silos, potential sources of nutrients



Figure 17: Orange arrows indicate silage storage bunkers. Blue arrows show cows in close proximity to stream.

- Look at the site as a whole. Do buildings and equipment appear to be in good condition? Are things neat and orderly? Review the general management practices in place. If things overall look disorganized, there could be problems.

Prioritization

Using evidence collected during review of aerial photographs, sites can be prioritized based on the likelihood that water quality is being negatively impacted. The type of animal operation, the size of the operation, and the management practices being utilized at AFOs can be used to determine how severe that impact may be and what sites should be referred for further follow-up (site visit, drive by during windshield survey).

Type

Below are examples of different types of animal feeding operations including dairy, beef, poultry, swine, and hobby farms. Characteristics of each are noted, as well as the size.

- Dairy



Figure 18: Dairy operation

Characteristics that indicate this is a potential dairy operation include:

- Presence of a circular storage structure for liquid manure
- Silos for storing feed
- Red arrow indicates milking parlor structure with direct road access for trucks
- Top of the image shows hutches for calves
- Limited pasture area
- *Based on the size and number of structures, this operation is categorized as “Medium”

- Beef



Figure 19: Potential beef operation

Characteristics that indicate this is a potential beef operation include:

- No obvious milking parlor building
- No obvious liquid manure storage structures
- Larger areas for pasture
- *Based on the size of structures, this is categorized as a “Small” beef operation

- Poultry:



Figure 20: Poultry operation

Characteristics that indicate this is a potential poultry operation include:

- Fans lining the outside of long building with nearby dust/feather piles (see red arrow)
- Long buildings are connected to a more central building for processing. Easy road access as well (see blue arrow)
- *Based on the size and number of structures present this operation would be categorized as "Large"

- Swine



Figure 21: Swine operation (with visible manure storage structure)

Characteristics that indicate this is a potential swine operation include:

- Presence of circular manure storage structure (for slurry manure)
- Red arrow indicates feeders positioned at end of buildings
- Blue arrow indicates fans (without dust piles nearby)
- No on-site processing building
- Easy truck access.
- Based on the size and number of structures present this operation would be categorized as "Medium"

Example 2 below has no additional manure storage, but still has all other above characteristics.



Figure 22: Potential swine operation (without visible manure storage structure).

- Hobby (horse, miscellaneous)



Figure 23: Potential hobby farm (sheep)

Characteristics that indicate this is a potential hobby farm operation include:

- Pasture area
- No sizable structures for storing manure
- No sizable structures to house animals

Size

Large, medium, and small classifications are based on the numbers provided in Appendix B, which are the regulatory definitions of large, medium, and small CAFOs.

- Large
- Medium
- Small
- Hobby

Storage

- How is manure and silage being stored? Is it sufficient?

Maintenance

Orderly vs disorganized

High Priority

- Any size dairy or beef operations in close proximity to water bodies with:
    - Observable drainage pathways leading to surface waters from identified sources
    - No manure storage found, or,
    - Storage is lacking, or otherwise disorganized
- Operations with potential livestock access issues

Medium Priority

- Hobby farms with:
    - Potential access issues
    - Observable drainage pathways leading to surface waters from identified sources
- Any size or type AFO with manure storage structures near the water body, but no strong evidence of water quality impacts observable via aerials.

Low Priority

- Any size or type of AFO not near observable connection to the water body.

AFO Field Check Methodology

Once aerial photograph identification and prioritization of animal feeding operations has been completed a field check should be performed to determine if the information gathered and conclusions made are accurate. The intent of the field check is not to do an on the ground inspection of every site but to drive by the identified sites and check the potential sources that can be observed either from the road or from within an adjacent stream. Reprioritization might be necessary based on the information gathered while performing the field check. Appendix C is an example of a field data sheet that could be used to collect the necessary data. At least two people should perform the field check. This allows one person to drive and another to make observations. However, it might be beneficial to have a third person to navigate. Prior to performing the field check the most efficient route to the sites should be identified.

Confirming Potential Sources

Proximity to water body

- Confirm the presence or absence of nearby water bodies identified on aerial photographs. If a water body has been identified adjacent to the site, walk the water body to identify potential sources of pollutants and complete the appropriate sections of the Pollutant Source Identification Data Sheet (Appendix D). This includes identifying if there is a vegetated buffer between the operation and the surface water which could help reduce pollutant impacts in a run off event. If the water has an odor, sheen, or distinct color change it is probable that there is a pollutant source nearby. Potential sources of pollutants that can be observed from the surface water include:

        - Evidence of livestock access such as disturbed soil along the banks and widening of the stream. Also look for fences or other barriers that would restrict cattle access.
        - Pipes directly discharging to the surface water or run off paths from the operation into the surface water.
    - If there are road side ditches adjacent to the site follow them and determine if they have a surface water connection and if they do complete the appropriate sections of the Pollutant Source Identification Data Sheet (Appendix D).

Type

- Determine or confirm if the operation is dairy, beef, swine, poultry, or hobby/horse.

Size

- Confirm the size of the operation. Are there new buildings that are not on the aerials?

Storage

- How are manure, and silage being stored? Is silage covered?

Maintenance and storage

- To the best of your ability from what you can see from the road document the overall cleanliness and organization of the site.
    - Note if buildings and equipment appear to be maintained.

Reprioritization

Once the field check has been completed use this additional information and determine if the sites have been prioritized correctly or if they need to be reprioritized based on the prioritization methodology.

Appendix B

Regulatory Definitions of Large CAFOs, Medium CAFO, and Small CAFOs

A **Large CAFO** confines at least the number of animals described in the table below.

A **Medium CAFO** falls within the size range in the table below and either:

- has a manmade ditch or pipe that carries manure or wastewater to surface water; **or**
- the animals come into contact with surface water that passes through the area where they're confined.

If an operation is found to be a significant contributor of pollutants, the permitting authority may designate a medium-sized facility as a CAFO.

A **Small CAFO** confines fewer than the number of animals listed in the table **and** has been designated as a CAFO by the permitting authority as a significant contributor of pollutants.

Animal Sector	Size Thresholds (number of animals)		
	Large CAFOs	Medium CAFOs[1]	Small CAFOs[2]
cattle or cow/calf pairs	1,000 or more	300 - 999	less than 300
mature dairy cattle	700 or more	200 - 699	less than 200
veal calves	1,000 or more	300 - 999	less than 300
swine (weighing over 55 pounds)	2,500 or more	750 - 2,499	less than 750
swine (weighing less than 55 pounds)	10,000 or more	3,000 - 9,999	less than 3,000
horses	500 or more	150 - 499	less than 150
sheep or lambs	10,000 or more	3,000 - 9,999	less than 3,000
turkeys	55,000 or more	16,500 - 54,999	less than 16,500
laying hens or broilers (liquid manure handling systems)	30,000 or more	9,000 - 29,999	less than 9,000
chickens other than laying hens (other than a liquid manure handling systems)	125,000 or more	37,500 - 124,999	less than 37,500
laying hens (other than a liquid manure handling systems)	82,000 or more	25,000 - 81,999	less than 25,000
ducks (other than a liquid manure handling systems)	30,000 or more	10,000 - 29,999	less than 10,000
ducks (liquid manure handling systems)	5,000 or more	1,500 - 4,999	less than 1,500

[1] Must also meet one of two "method of discharge" criteria to be defined as a CAFO or may be designated.
[2] Never a CAFO by regulatory definition, but may be designated as a CAFO on a case-by-case basis.

Appendix C

Animal Feeding Operation Survey Data Sheet					Site ID #:			
NOTES: Use one data sheet per GPS location.					Date:			
					Photo numbers:			
Watershed:					Investigator(s):			
GPS	Lat:		Long:		Site Address:			
Proximity to Water Body								
Adjacent to a water body?								
Road side ditch that connects to a water body?								
*If answered yes to the either question above complete the appropriate sections of the Pollutant Source Identification Data Sheet								
Notes:								
Type of Operation								
Aerial Information	Dairy	Beef	Swine	Poultry	Hobby	Unknown		
Field Check Information	Dairy	Beef	Swine	Poultry	Hobby	Unknown		
Notes:								
Size of Operation								
Aerial Information	Large	Medium	Small	Hobby	Unknown			
Field Check Information	Large	Medium	Small	Hobby	Unknown			
Notes:								
Storage								
Aerial Information	Good	Fair	Poor					
Field Check Information	Good	Fair	Poor					
Notes:								
Maintenance								
Aerial Information	Good	Fair	Poor					
Field Check Information	Good	Fair	Poor					
Notes:								
Priority								
Aerial Information	High	Medium	Low					
Field Check Information	High	Medium	Low					
Notes:								

Appendix D

Pollutant Source Identification Data Sheet Instructions

NOTE: This data sheet is set up to collect all necessary parameters to use the Spreadsheet Tool for Estimating Pollutant Loads (STEPL) program to calculate pollutant load estimates. Section 319 and 205(j) grantees should submit this form as part of a Quality Assurance Project Plan (QAPP) document to the Department of Environmental Quality (DEQ) Nonpoint Source (NPS) Program for approval. NPS Program staff is available to help select the appropriate pollutant source sections to include on the field data sheet.

<u>Suggested Equipment checklist</u>

Maps with waterways and roads labeled
Field data sheets (many copies or electronic data recorder)

Clipboard
Pens/pencils
GPS unit
Tape measure (100 ft)
Folding ruler (6 ft)
Camera with extra batteries
Compass
Waders, hip boots, or wading shoes
Traffic cones
Brush clearing tools
First aid kit
Insect repellant/sunscreen
Lunch/snacks/water for long field day

General tips

Follow these guidelines to gather information for documenting nonpoint sources for inclusion in a watershed management plan. This form should be used to document pollutant sources and should not be used as a general watershed characterization form. For example, if you come across a road stream crossing and do not see any pollutant sources to document (e.g. no noticeable erosion), then you do not need to fill out this form for that site. While there is no section for documenting high quality areas for protection it would be beneficial to note those areas in the comment box at the end of the field form.

This form should be used as a walking inventory is conducted but could be used in conjunction with a driving or kayak inventory. It is unrealistic and unnecessary to try to walk an entire watershed to document all potential pollutant sources. Therefore, to be the most efficient with this form, it should be used in areas that have already been prioritized based on other methods (i.e., Total Maximum Daily Load areas and waters on the state's nonattainment list should be a priority as well as other known sources that have already been documented).

In general, face downstream when determining "left bank" or "right bank." The only exception is when you are documenting erosion locations at a road stream crossing, in which case always face the crossing to determine left/right bank.

Photographic documentation

Taking pictures and documenting where the pictures are taken is a highly useful tool and strongly recommended. Make an effort to get a representative set of photos for each site and take detailed notes.

Site specific information

As field inventories are conducted, site specific Global Positioning System (GPS) information should be recorded in the decimal degrees format using the World Geodetic System (WGS) 1984 geographic coordinate system.

Determining the number of "years present"
The number of years a problem has been present is needed to get an estimate of annual pollutant loads. Use your best professional judgment to estimate the number of years. It may be helpful to speak with nearby landowners or to look at aerial photos.

Determining erosion severity
Erosion severity has been divided into four categories: slight, moderate, severe, or very severe. Technically, the categories are based on the following rates:

Category	Erosion rate (feet/year)
Slight	0.01-0.05
Moderate	0.06-0.2
Severe	0.3-0.5
Very severe	> 0.5

Determining the severity of erosion is somewhat subjective. Use other observations throughout the watershed to determine if the erosion is slight, moderate, severe, or very severe compared to other locations. Gathering information from sites where Best Management Practices (BMP) can be implemented should be a priority activity. Funding BMPs at severe/very severe erosion sites will generally be favored over funding BMPs at slight/moderate erosion sites. Slight/moderate erosion sites should not be the main focus of inventory work.

Determining the "soil texture" type
Determining soil texture can be a difficult task and is a required parameter for calculating pollutant loads for potential nonpoint pollution sources. Therefore, soil texture has been divided into four categories. Choose between the following four general categories:

1. Clay – feels sticky, malleable material
2. Silt – feels smooth, very fine particles
3. Sand – feels gritty
4. Organic – muck, mixture of coarse leaf and wood material

Use the table to match the general soil texture category with the STEPL category.

General soil texture identified in field	**STEPL Category to use for calculations**
Clay	Clay
Silt	Silt loam
Sand	Fine sandy loam
Organic (mixture of detritus, sand, silt, and clay)	Organic

To fill out the data sheet and obtain the most accurate information in an organized manner, it is important to COMPLETELY fill out the data sheet. After field work is complete it may be difficult

to determine if a blank field means that the item was not assessed or whether it was not applicable. Instead of leaving a field blank, write NA for items that were not applicable.

All length measurements should be made in feet and recorded to the nearest 0.1 foot. Do not record inches, even for measurements that are less than one foot. For example, record 0.5 feet instead of 6 inches. Measurements longer than 20 feet should be rounded to the nearest foot if you are not confident in the precision of the measurement.

The following instructions for each section are organized in the same order as the field data sheet.

Be sure to fill in the general information at the top of each field sheet including watershed, tributary name, GPS coordinates, site identification, date, photo numbers (so later you can keep track of what photos went with each site), and the names/initials of the people in the field crew. Next, since this field form will only be used to DOCUMENT POTENTIAL POULLUTANT SOURCES, you will circle all of the appropriate source categories that apply to your location.

SECTION 1. ROAD RUNOFF



http://ridgetoriver.com/land_use.html

Figure 3. Road runoff has the potential to increase the amount of nonpoint source pollution that enters water bodies.

A road running parallel to (or close to) a water body would be the first indication that road runoff may be a potential pollutant source. A visual cue that it is a source would be rills (see definition page 8) running from the road surface (Figure 3 and Figure 4a).

Road surface: Circle the type of road surface. Unimproved refers to any two-track or dirt road.

Length contributing to runoff: Estimate the length of road contributing to runoff.

Distance of road from water: Estimate the distance of the road from the water body.

Years erosion present: Use your best professional judgment to determine the number of years the observed erosion has been present (see page 2).

Soil texture: Determine if the soil is mostly clay, sand, silt, or organic material. See the bottom of page 2 for more guidance.

SECTION 2. GULLY EROSION

Location: Face downstream and determine if the observed erosion is on the left bank or right bank.

Apparent cause: There are several possible causes of gully erosion. Some common examples include overland runoff due to poor vegetation cover, overgrazing, human activities, improper land use, or improper irrigation design.

Soil texture: Determine if the soil is mostly clay, sand, silt, or organic material. See the bottom of page 2 for more guidance.

Erosion top/bottom width/depth/length: Measure the top and bottom width of the erosion area along with the depth and length. Measurements should be rounded to the nearest 0.1 foot.

Years erosion present: Use your best professional judgment to determine the number of years

the observed erosion has been present (see page 2).

SECTION 3. INADEQUATE RIPARIAN BUFFER

Only fill out this section if there is an inadequate buffer and there is opportunity to restore the riparian area. For example, if the lack of buffer is due to a roadway and runoff is observed, then SECTION 2. ROAD RUNOFF should be filled out, not this section. The adequacy of a buffer will depend on soil type, slope, and upland land use so an adequate buffer width at one site may not be the appropriate width at a different site. For example, the Natural Resources Conservation Service filter strip standard requires a minimum of 20 feet between water bodies and cropland. However, if the riparian area is steeply sloped, the filter strip may need to be wider than 20 feet.

Existing buffer/filter strip dimensions: Facing downstream, estimate the current width and length of the buffer area on the left bank and the right bank. If there are miles of inadequate buffer than estimate current conditions as best as you can. Aerial photos may help get a more accurate estimate.

Length of buffer needed: Estimate the length of buffer needed on the left bank and right bank. If miles of buffer are needed it is suggested to take a GPS reading at the upstream point and at the downstream point and use aerial photos in conjunction with walking the site to get an accurate estimate.

Estimated contributing acreage: Use aerial photos to estimate the amount of acreage contributing nonpoint source pollution for the left and/or right bank.

Riparian habitat: Circle the description of habitat for each bank.

Upland land use: Determine the current upland land use on the left and right bank. This refers to the area beyond the riparian zone.

SECTION 4. LIVESTOCK ACCESS

Location: Face downstream and determine if the observed livestock access is on the left bank or right bank.

Aquatic vegetation/algal blooms: Determine if there is: no increased plant/algal growth, slight, moderate, or extensive growth downstream of the livestock access to the water.

Soil texture: Determine if the soil is mostly clay, sand, silt, or organic material. See the description at the bottom of page 2 for more guidance.

Number/type of animal: Determine the approximate number of animals that have access to the watercourse and write down what animals are present. It is important to estimate the number of animals to get an idea of how significantly the livestock access could impact water quality.

Erosion type (select all that apply): If you observe livestock access, but no erosion, then circle "none" for the erosion type. If you observe erosion, determine if the type of erosion is a rill, streambank, or gully (can circle more than one category if applicable). A rill is the initial sign of erosion and is most common on slopes. Rills are much smaller than a gully (Figure 4a). Determine if the rill exhibits minor, moderate, or severe erosion. For streambank erosion that is a direct result of livestock access, measure the height and length of the eroding bank and determine the erosion severity (Remember, if the streambank erosion is not associated with livestock access, then if would fall under SECTION 4. STREAMBANK EROSION, not SECTION 5. LIVESTOCK ACCESS). A gully erodes sharply into the soil and it is often difficult to step across (Figure 4b). Measure the top/bottom erosion width, depth, and length.



http://en.wikipedia.org/wiki/Rill http://www.fs.fed.us/GRAIP/gallery/Gully1.jpg

Figure 4. An example of a rill (a) compared to the size of a gully (b).

Years erosion present: Use your best professional judgment to determine the number of years the observed erosion has been present (see page 2).

Length of access: Estimate the total length of streambank where the livestock have access and round to the nearest 0.1 foot.

SECTION 5. AGRICULTURAL RUNOFF

Location: Face downstream and determine if the observed agricultural runoff is on the left bank or right bank.

Potential pollutant source (circle all that apply): If you observe a potential nonpoint agricultural source of pollution, determine if it is from cropland/pasture manure runoff, cropland erosion/runoff, or feedlot erosion/runoff (circle more than one category if applicable). For cropland/pasture manure runoff, determine if the erosion/runoff severity is slight, moderate, severe, or very severe. For cropland erosion/runoff, the type of tillage needs to be identified. The field form separates tillage practice into three general categories: no-tillage, reduced tillage, and conventional tillage. Descriptive text and pictures for tillage examples that fall into these categories are provided (Figure 5). Also, determine the type of crop, estimate acreage of the source (again, may be more accurate to utilize aerial photos), and erosion/runoff severity (slight, moderate, severe, or very severe). For feedlot erosion/runoff, estimate the number of animals and note the type of animal. Estimate the distance of the source from the water (round to the nearest 0.1 foot). Determine if the severity of the erosion/runoff is slight, moderate, severe, or very severe. Estimate the area of the source in acres. To estimate acreage it may be easier to use aerial photos to obtain accurate size estimates for lots. Estimate the percent of the feedlot that is paved and select the appropriate range.



http://www.ars.usda.gov/images/docs/9372_9566/image003.gif

No-till fields: crops are planted without disturbing the soil through tillage



http://www.extension.iastate.edu/CropNews/2009/0302alkahsi.htm

No-till soybeans planted in corn residue.

Strip tillage (falls into no-till category): a form of tillage where only narrow strips are tilled



http://www.extension.org/pages/28317/reducing-tillage-to-save-fuel

Strip tillage was used to prepare this field for corn planting.

General photo depicting a side-by-side comparison of a no-till field versus conventional tillage practices.



http://www.ok.gov/conservation/Conservation_Districts/Garfield_County_No-Till_Conference_2011.html
No-till soybeans growing in wheat residue.



http://extension.oregonstate.edu/malheur/agriculture/watershed-management
Strip tilled corn planted in wheat residue.

Reduced tillage: method of soil tillage which leaves at least 30% crop residue on the soil surface



http://farmconnection.wordpress.com/
After planting – corn (circled in red) growing after being planted into 30% soybean residue.

Conventional tillage: the traditional method of farming in which the soil is prepared for planting by tillage practices that result in less than 30% residue cover



http://www.tifton.uga.edu/sewrl/radio/gibbover.htm



http://oregonprogress.oregonstate.edu/spr99/images/snapbeans.jpg

Figure 5. Tillage practices vary in the amount of crop residue left on the field.



http://www.extension.umn.edu/cropenews/2008/08MNCN28.html

Before planting – surface residue coverage after stalk chopping and chisel plowing in a field of corn

residue.



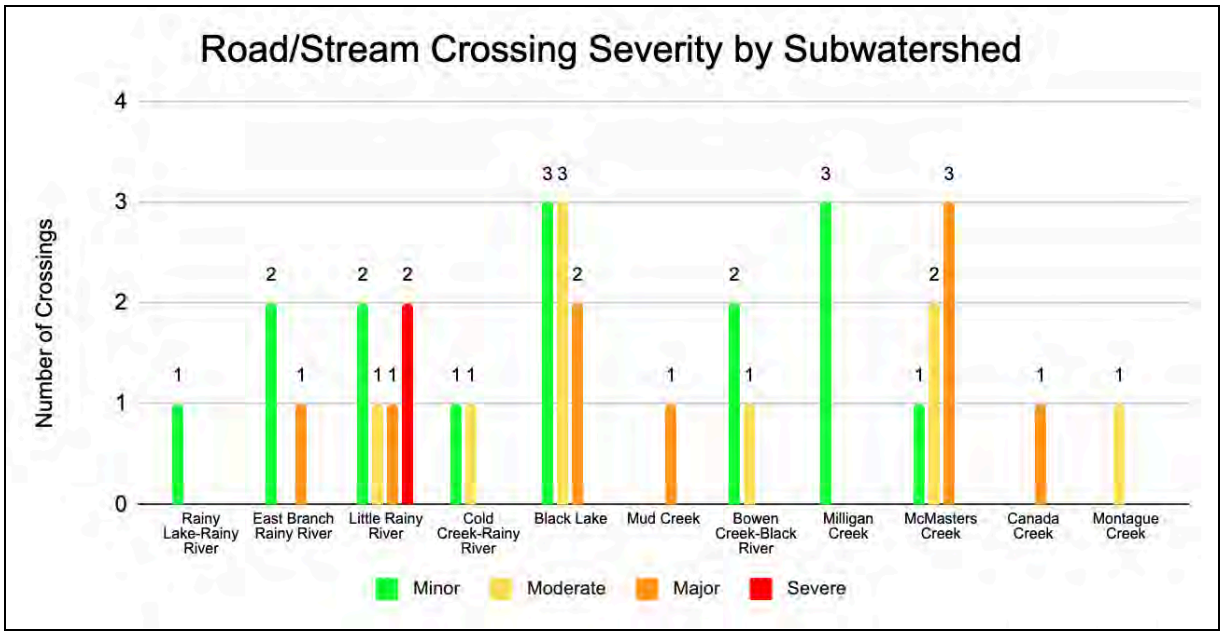
http://www.avanzi.unipi.it/ricerca/quadro_gen_ric/solil_tillage/image_soli_tillage/Image15.jpg

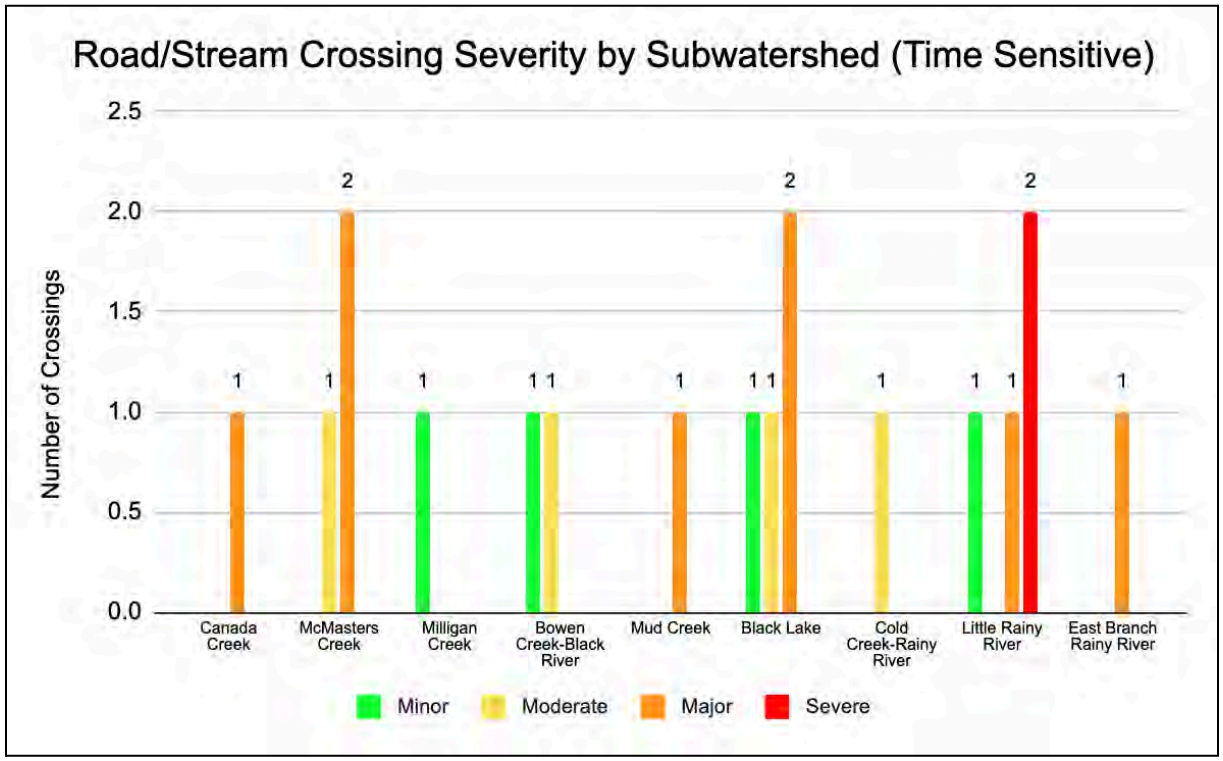
Appendix 8. Social Indicator Survey Open Comment Section

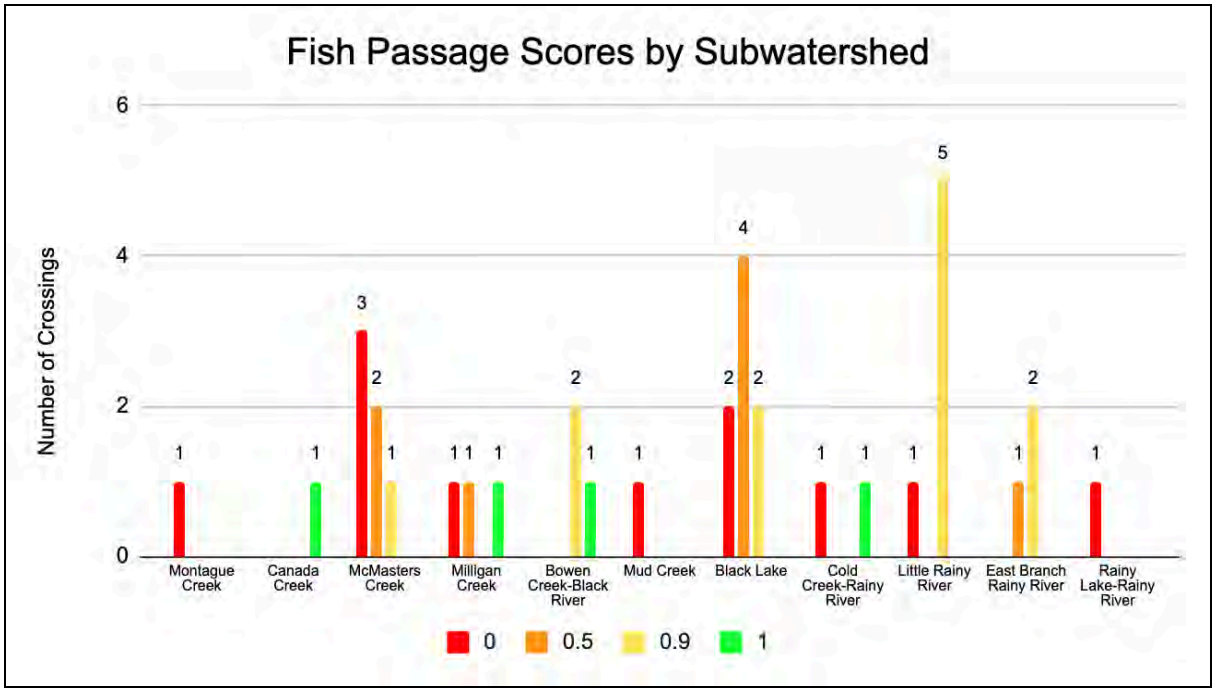
Survey Participant	Open Comment
1	"You didn't mention **HABS** which is our biggest threat"
2	"Some of the questions were worded in such a way to be confusing. I am a member of all the organizations listed but could only choose one. I think the government should handle inspections but not maintenance. I work for a Michigan science-related research agency and **septics** are likely to be regulated soon in the future. I do not know when my septic tanks were installed. I have 2 and that information was not available when we bought the property and is not listed in Cheboygan County records."
3	"Farm and agricultural practices should be regulated to enforce poor water quality from **runoff and application**"
4	"Surveys should be distributed through more than one outlet on Facebook. Currently, I've only seen it on Black Lake Preservation Society, which is a private,

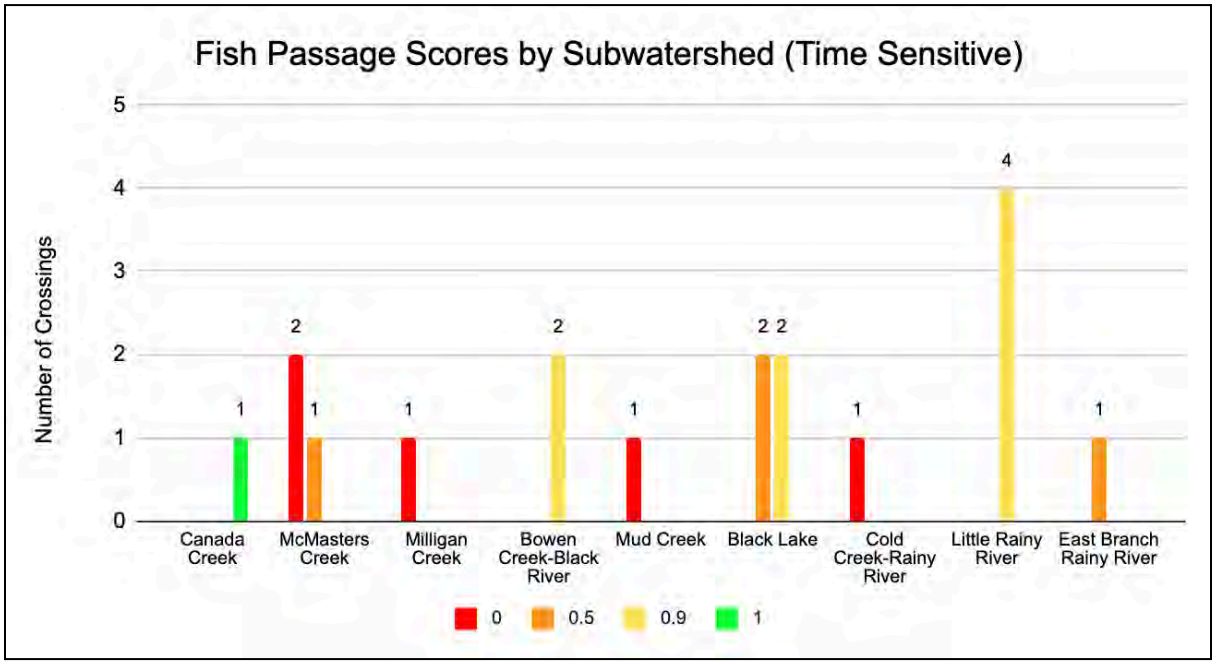
	restricted page. Also, membership in organizations listed is not limited to a single organization. I'm a member of both the Black Lake Association and Tip of the Mitt. Comment re last question - I think that local authorized agency inspection is a good idea, but maintenance of a septic system is the homeowners responsibility."
5	"You seem convinced that septic systems are THE issue in the watershed. There are other problems. We get significant lakefront erosion because the Alverno dam is not lowered in the winter. There is nothing I can do to prevent erosion of my lakefront until that issue is addressed."
6	"Great survey"
7	"**A significant number of residents are seasonal, so problems, options and local opinions are frequently not communicated effectively.** This makes even discussing local issues difficult, not to mention any consideration of possible solution alternatives. This appears to me to be a governmental choice. One example is the utility billing regulations that require seasonal residents to pay a significant premium for services. This discourages any ownership in local problem definition and solution suggestions. Additionally, lack of local utility service {water and sewer} means these are individually addressed, or perhaps ignored until a crisis occurs."
8	"I'd like to learn more about protecting water quality of Black Lake and local watersheds"
9	"Native wildlife will continue to use the lake and have some impact on swimmers;_ however, the eradication of filtering plants, **poorly maintained or inadequate septic systems and the overuse of pesticides and fertilizers continue unabated.** It is a shame that so many lake residents are advocates of restoring the lake quality and yet continue to blacktop their driveways and ignore their gardening and septic practices. I do believe that mandated inspections at the sale of a home and perhaps at intervals with penalties for failure will be helpful to investigate if homeowners cannot be compelled through education to curb these practices."
10	"Thank you for the opportunity to have input"
11	"UAW for 50 years and look at all the **beautiful lawns** from our lake. Two biggest problems"
12	"**Chemicals used for home maintenance** need to be addressed also"
13	"We need to manage clean water but not at the expense of wasted land. I see too much amazing property in the area wasted with drainage mounds."
14	"Black Lake has severe swimmers itch problems that need to be addressed ASAP."

Appendix 9. RSX Graphs


Road/Stream Crossing Severity by Subwatershed
Number of Crossings
4
3
2
1
0
Rainy Lake-Rainy River
East Branch Rainy River
Little Rainy River
Cold Creek-Rainy River
Black Lake
Mud Creek
Bowen Creek-Black River
Milligan Creek
McMasters Creek
Canada Creek
Montague Creek
Minor
Moderate
Major
Severe


Road/Stream Crossing Severity by Subwatershed (Time Sensitive)
Number of Crossings
2.5
2.0
1.5
1.0
0.5
0.0
Canada Creek
McMasters Creek
Milligan Creek
Bowen Creek-Black River
Mud Creek
Black Lake
Cold Creek-Rainy River
Little Rainy River
East Branch Rainy River
Minor
Moderate
Major
Severe


Fish Passage Scores by Subwatershed
Number of Crossings
6
4
2
0
Montague Creek
Canada Creek
McMasters Creek
Milligan Creek
Bowen Creek-Black River
Mud Creek
Black Lake
Cold Creek-Rainy River
Little Rainy River
East Branch Rainy River
Rainy Lake-Rainy River
0
0.5
0.9
1


Fish Passage Scores by Subwatershed (Time Sensitive)
Number of Crossings
5
4
3
2
1
0
Canada Creek
McMasters Creek
Milligan Creek
Bowen Creek-Black River
Mud Creek
Black Lake
Cold Creek-Rainy River
Little Rainy River
East Branch Rainy River
0
0.5
0.9
1

Appendix 10. Multivariate FAMD Analysis Report

Multivariate Analysis of Invasive Species and Road/Stream Crossings in the Black Lake Watershed

Analysis and writing produced by Andrea Behrmann

12 December, 2023

This report and its findings will be briefly mentioned in the final deliverable of my current masters project, but not as in depth as this paper. Its purpose is to provide a baseline understanding of possible interactions between RSXs and invasive species.

Abstract: To aid Tip of the Mitt Watershed Council in creating a Watershed Management Plan (WMP) for the Black Lake Watershed in Northern Michigan, road/stream crossing (RSX) inventories were updated by the Black Lake Watershed Master's Project Team. Multiple variables were measured and updated to represent the current state of RSX sites that were previously identified as "time-sensitive" and/or in need of maintenance. An FAMD and Cluster Analysis were conducted to further explore the relationship between most measurable variables to determine interconnectedness with a focus specifically on invasive species abundance. Invasive species are detrimental to ecosystems, especially in delicate ecosystems like Black Lake, and it's important to understand the consequences that follow their overall existence.

Introduction

Black Lake is located in the northern, lower peninsula of Michigan in the Black Lake Watershed. The watershed covers 350,000 acres (547 square miles) in Cheboygan, Montmorency, Otsego, and Presque Isle counties. This area is well-known for the recreational opportunities, including swimming, boating and fishing. The watershed also provides the necessary conditions, ecosystems, and climate for the Black Lake self-sustaining sturgeon population.

Black Lake is currently suffering from water quality issues that have only surfaced in recent years. Since 2018, annual harmful algal blooms have been observed and tested positive for microcystin, a toxic chemical that is produced by blue-green algae. Despite the blooms that typically occur around late summer/early fall, water quality remains high. The uncertainty around the source of these HABs and the lack of an Environmental Protection Agency (EPA) and Michigan Department of Environment, Great Lakes and Energy (EGLE) approved watershed management plan for the Black Lake Watershed has led to increasing public support for an approved management plan.

Alongside Tip of the Mitt Watershed Council, EGLE, the DNR (Department of Natural Resources), and other Black Lake organizations, collaboration with University of Michigan master's students has been progressive in addressing the water quality issues that Black Lake has been experiencing. Extensive watershed inventory surveys were conducted that measured the impact caused by

road stream crossings (RSX), stream banks, stormwater infrastructure, agricultural, and forestry lands to determine their potential relative pollutant contributions. This analysis will focus on RSXs in particular and their individual roles in pollutant loading with regard to specifically the presence of invasive species, as well as water flow, structure size, and road conditions. The RSX inventory (Fig. 1) was the most widespread given the number of tributaries to Black Lake and took the longest to update because of this. The symbology of the points represent the overall condition of the crossing and possible deterioration. Sites were predetermined and chosen based on if the site was a time sensitive matter/needed maintenance. The Michigan Stream Crossing Dashboard as well as their ArcGIS shapefile were used to identify these. The overarching goal of this research paper is to understand the possible relationships present between all previously mentioned variables, but most importantly the role of invasive species and its impact on other variables.

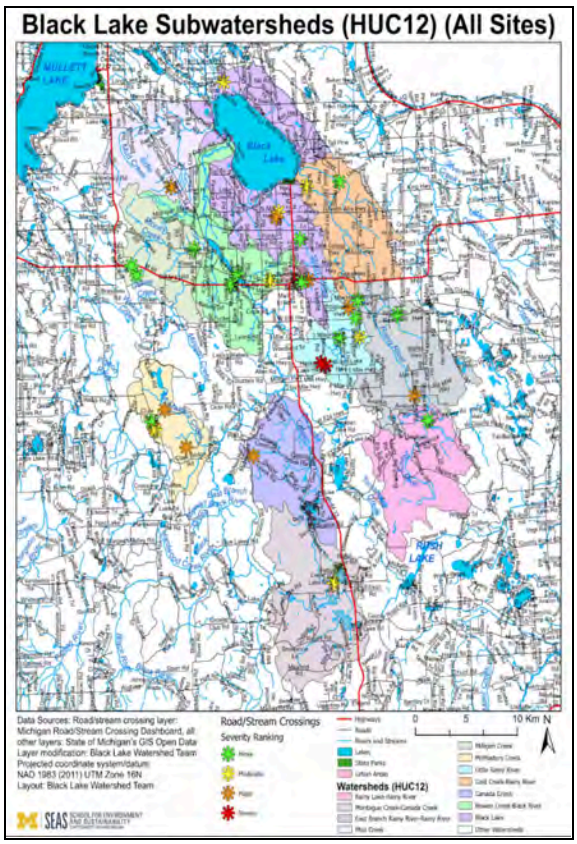


Figure 1. RSX sites

Dataset and Collection

Data was collected from 36 sites in total (40 originally, however 4 were either private property or could not be located due to being physically inaccessible). Each site was evaluated using the methods outlined in the DNR's RSX Inventory instructions and can be accessed online due to its lengthy stature: Great Lakes Road Stream Crossing Inventory Instructions (hyperlinked) (DNR, 2020). All information/data can be found on the Great Lakes Stream Crossing Dashboard (hyperlinked). Upon visiting the sites, information regarding the crossing, stream, road, embankments, approaches, erosion, and representative reach/riffle were recorded along with the total summary (if applicable). Needed equipment included waders, a Flow Tracker, yard stick, transect, cleaning supplies, a notebook to recreate the site, and iPads to record the information in Survey123. The estimated erosion (tons/year) is automatically calculated by the Survey123 form and takes into account the approaches (left and right) of the crossing as well as any present erosion at the site both on the structure itself or within the surrounding stream. The approaches were

identified by facing downstream and identifying left and right this way. Road Condition was measured based on the interpretation of all team members. Road Condition ranged from good (0), fair (2), or poor (4). Waterflow was measured on both the inlet and outlet side of structures using a Flow Tracker (ft/sec) (0.2 feet above sea floor), however if no flow was present or if a site were inaccessible to measure with the Flow Tracker a float test was performed (ft/sec) and was observed at the surface. The total number of invasive species was recorded at all sites (if any were present). The structural length, width, and height were all recorded if feasible (feet). Their measurements included total size, i.e. above and below water. If accessibility was an issue, specific measurements were estimated.

Analysis

An FAMD (Factor Analysis of Mixed Data) was initially utilized to analyze the data set that contains both categorical and continuous variables. To conduct this analysis, R packages "FactoMineR" and "factoextra" needed to be installed. Categorical variables were then changed to an ordinal formation. For the variable Invasive.Species, a ranking system was implemented: 1 = "Low", 2 and 3 = "Intermediate", and 4 = "High." For the variable Road.Condition, a ranking system was also implemented: 0 = "Good", 2 = "Fair", and 4 = "Poor." Rows that contained "NA" values were omitted from all analyses.

A cluster analysis was also performed on the data set, however categorical variables were removed to identify any formed groupings. To perform the cluster analysis, the Canberra distance was first calculated. The Canberra distance "calculates the sum of the absolute differences between the components of the two points, divided by the sum of their absolute values" (Eskandar, 2023). This method was chosen over the Euclidean method as it is more robust to outliers (which was seen when utilizing the Euclidean method). To account for different units, the data was scaled. Scaling removes any dominating values and allows for an equal contribution from all variables.

Results

FAMD

A screeplot was initially created to identify the dimensions that most explained the variability within the data set (Figure 2). This was to assure myself that the correct number of dimensions were included in the graphs produced by running an FAMD. Most notably, Dimension 1 (Dim 1) explains the most variability at 26.55%, however the following dimensions explain less than 20%. Dimension 2 (Dim 2) follows with the second highest explanation of variability at 16.04.

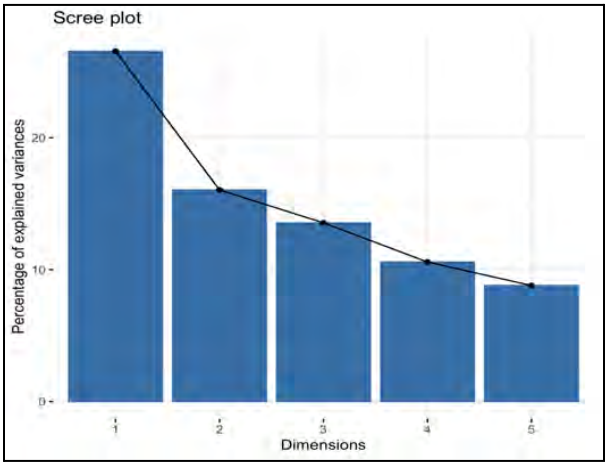


Figure 2. Scree plot

When performing an FAMD, several plots are generated to account for the information utilized. Essentially a PCA for the

quantitative variables and an MCA for the qualitative, all of the respective graphs are automatically created. Figure 3 displays all of the variables, both categorical and continuous. It can be seen that Structure.Height contributes the most to Dim 1. Road.Condition contributes the most to Dim 2, however Structure.Length closely follows. It is interesting to see that Invasive.Species contributes nearly the same to Dim 1 as it does Dim 2.

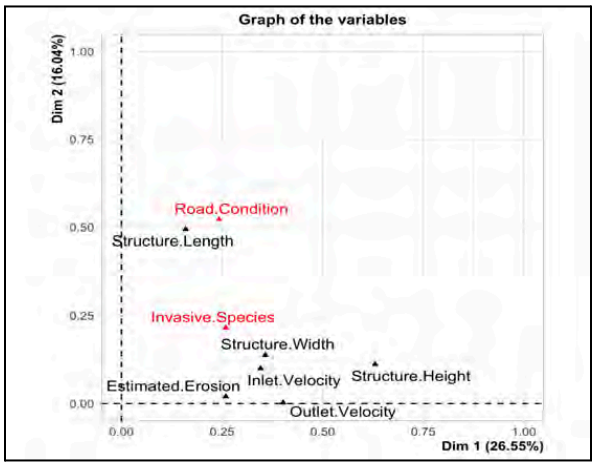


Figure 3. Graph of categorical and continuous variables

A graph of the categories (Figure 4) displays our two categorical variables and their rankings. “Poor” road conditions appears to contribute the most to Dim 1 although “Good” road conditions along with “Intermediate” and “High” species abundance contribute positively to Dim 1 as well. “Low” invasive species and “Fair” road conditions contribute negatively to Dim 1. “Low” invasive species abundance negatively contributes the most to Dim 2, however “Intermediate” invasive species also contributes negatively. “Fair” road conditions contributes positively along with “Good” road conditions and “High” invasive species to Dim 2. What is interesting to see is the almost linear relationship seen between the invasive species rankings in this figure in respect to the road conditions.

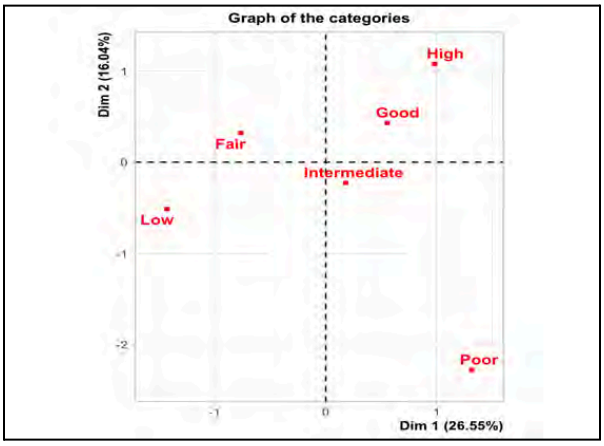


Figure 4. Graph of categorical variables

A graph solely made up of the quantitative variables (Figure 5) shows how each variable contributes to Dim 1 and Dim 2. This information repeats what is seen in Figure 2, but removes the categorical variables. It is still true that Structure.Height contributes the most to Dim 1, yet many other variables contribute to it as well. All variables contribute positively to Dim 1 except Estimated.Erosion. Structure.Length still contributes the most to Dim 2, however Structure.Height and Estimated.Erosion contribute as well. Outlet.Velocity, Inlet.Velocity, and Structure.Width contribute negatively to Dim 2.

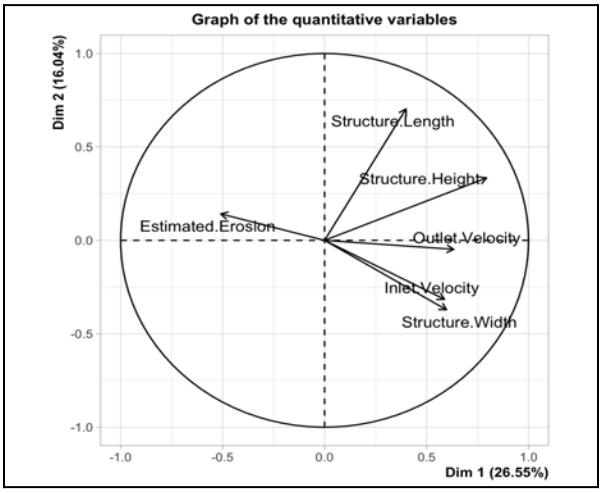


Figure 5. Graph of quantitative variables

The final figure (Figure 6) depicts each row of data (site). Clusters are based on invasive species abundance. Outliers exist for all clusters, but appear to be relatively close to their respective grouping. This graph represents the information depicted in Figure 3 but displays how the individual data points position themselves in respect to their invasive species abundance. "High" invasive species clusters contribute positively to Dim 1 as do "Intermediate" invasive species, however; "Low" invasive species contributes the most to Dim 2 (negatively to both Dim 2 and Dim 1).

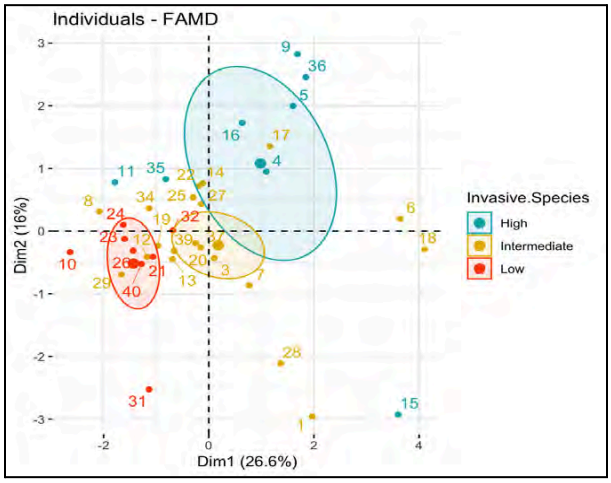


Figure 6. Individual data in respect to invasive species abundance

Cluster Analysis

A cluster analysis was also performed on the data set, however categorical variables were removed to identify any formed groupings. To perform the cluster analysis, the Canberra distance was first calculated. The Canberra distance "calculates the sum of the absolute differences between the components of the two points, divided by the sum of their absolute values" (Eskandar, 2023). This method was chosen over the Euclidean method as it is more robust to outliers (which was initially seen when utilizing the Euclidean method). To account for different units, the data was scaled. Scaling removes any dominating values and allows for an equal contribution from all variables.

Overall, two large clusters are apparent, however four smaller clusters can be seen as well (Figure 7). It appears that the two main clusters represent the sites that contribute the most to Dim 1 or Dim 2. It is possible that the amount of invasive species and road conditions of each site play a part in determining the formation of the smaller clusters. Overall, the distances between each site are not drastically different. It is noted that there are more sites in the first cluster than the second cluster.

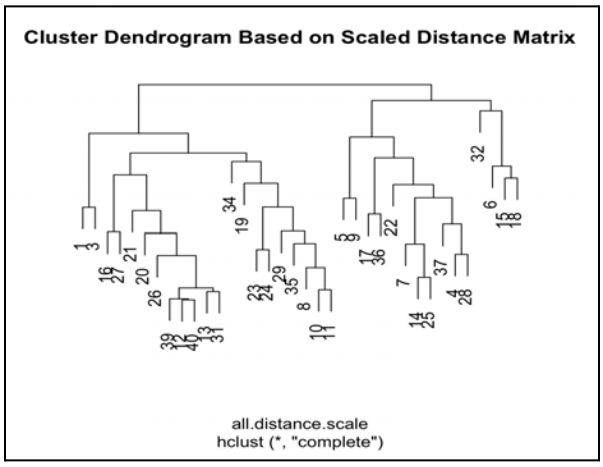


Figure 7. Cluster dendrogram based on Canberra distance

Discussion

The implications of these findings suggest that invasive species may be dependent on factors within a specific site, especially that of the road condition. Previous studies support this with one explaining that "Evidence suggests that roads can have an important effect on the spread of invasive plant species…[and] show[s] that a small change in conditions of the environment favouring the invasive species can change the

case for the road…" (Deeley, 2022). Another study addresses vehicle usage and its role in invasive species abundance. Their results reveal how "primary dispersal of [an invasive species] interacts with secondary dispersal by vehicles' airflow, dependent on traffic volume" which suggests that roads more heavily traveled are at a higher risk of introducing invasive species (Lemke, 2019). This also supports the notion that roads that are less traveled consequently have less consistent upkeep/maintenance and will harbor more invasive species. The study concludes with the importance of general maintenance (i.e. mowing) along high-use roads as well as isolated populations in the area (Lemke, 2019).

Together, these studies portray a possible positive feedback loop between road usage and invasive species abundance; as roads are more heavily traveled, invasive species may become more abundant due to vehicular airflow. Roads that receive more traffic compared to others will inevitably deteriorate and harbor the appropriate conditions needed for invasive species to spread even further. It can be seen that some variables (dimensions) that were not measured during data collection explain the contribution of the variables that were accounted for. It is possible that variables such as traffic and/or general maintenance/upkeep may have been the missing linkage in understanding the role between RSXs and invasive species. Overall, further studies are needed to understand the impacts of confounding variables on both RSXs and invasive species abundance

Closing Statement

Because I am not an invasive species specialist (nor are any of my project mates), it is very possible that there may have been more invasive species at sites that were not accounted for and for that, we do recommend revisiting all sites. Given the nature of our overall project, we recommend that all sites be visited regardless, making time-sensitive ones the initial priority.

References

Deeley, B., Petrovskaya, N. (2022). Propagation of invasive plant species in the presence of a road, *Journal of Theoretical Biology, Volume 548,*111196,ISSN 0022-5193. https://doi.org/10.1016/j.jtbi.2022.111196.

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Eskandar, S. (2023, March 26). *Exploring common distance measures for machine learning and Data Science: A Comparative Analysis*. Medium. https://medium.com/@eskandar.sahel/exploring-common-distance-measures-for-machine-learning-and-data-science-a-comparative-analysis-ea0216c93ba3#:~:text=Canberra%20distance%20calculates%20the%20sum,outliers%20than%20other%20distance%20measures.

Kassambara, Galpaccru, Riad, & Visitor. (2017, September 24). *FAMD - factor analysis of mixed data in R: Essentials*. STHDA. http://www.sthda.com/english/articles/31-principal-component-methods-in-r-practical-guide/115-famd-factor-analysis-of-mixed-data-in-r-essentials/

Lemke, A, Kowarik, I, von der Lippe, M. How traffic facilitates population expansion of invasive species along roads: The case of common ragweed in Germany. *J Appl Ecol*. 2019; 56: 413–422. https://doi.org/10.1111/1365-2664.13287

R Code

```
> rsx <- read.csv("rsx.mva.csv")
> rsx <- na.omit(rsx)

>install.packages("FactoMineR")
>install.packages("factoextra")

>library(FactoMineR)
>library(factoextra)

>rsx_famd <- FAMD(rsx)
>fviz_screeplot(rsx_famd)
>fviz_mfa_ind(rsx.famd,
          habillage = "Invasive.Species",
          palette = c("#00AFBB", "#E7B800",
         "#FC4E07"),
          addEllipses = TRUE, ellipse.type =
         "confidence",
          repel = TRUE)

>rsx.fix <- rsx[,-4: -5]

>all.distance.scale = dist(scale(rsx.fix),
method = "canberra")

>plot(hclust(all.distance.scale, main =
"Cluster Dendogram based on scaled distance
matrix", sub = NULL, xlab = NULL, ylab =
NULL, yaxt = "n")
```