2024 SUMMARY OF WATER QUALITY RESULTS

EAST AND WEST TWIN LAKES

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Twin Lakes Property Owners Association

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SUMMARY:
This document is intended to summarize recent East and West Twin Lakes water quality monitoring efforts.

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EXECUTIVE SUMMARY

This report provides a comprehensive evaluation of the water quality and ecological status of East and West Twin Lakes, located adjacent to Lewiston, Michigan. This report will review results from the 2024 sampling events and, in comparison with historical data and statewide inland lake studies, examine key water quality parameters to assess the health of the lakes and guide future management decisions.

BACKGROUND AND OBJECTIVES

The Twin Lakes Property Owners Association initiated a water quality monitoring program in 2024 to track changes in lake conditions, evaluate the effectiveness of improvement measures, and understand the impact of environmental factors on water quality. East Twin Lake (approximately 830 acres) and West Twin Lake (about 1,300 acres) have long served as recreational and ecological assets for the community, and ongoing monitoring is critical to maintaining their health.

METHODOLOGY

Water samples were collected during multiple seasonal events in 2024 and compared with historical datasets from the Cooperative Lakes Monitoring Program (CLMP) and studies by the USGS and EGLE. Parameters analyzed include Secchi depth (water clarity), total phosphorus (TP), soluble reactive phosphorus (SRP), nitrate, ammonia, dissolved oxygen, pH, temperature, specific conductivity, chlorophyll-a, and trophic state indices. Algal composition and microcystin levels were also examined to assess potential harmful algal bloom (HAB) risks.

KEY FINDINGS

Water Clarity

West Twin Lake consistently exhibited approximately 2 feet greater Secchi depth than East Twin Lake. Although 2024 measurements were lower than historical values, likely influenced by overcast skies and heavy rainfall, historical data indicate both lakes generally surpass the statewide medians for clarity.

Nutrient Concentrations

Total phosphorus levels have shown a gradual increase in East Twin Lake and a decrease in West Twin Lake over the past decades, with seasonal peaks in summer exceeding spring values. SRP and nitrate concentrations remain very low, reducing the risk of algal overgrowth from these nutrients. Ammonia levels were somewhat variable but remained below EPA thresholds.

Dissolved Oxygen

Dissolved oxygen declined notably over the sampling period, with fall levels dropping below expected values, signaling a need for continued monitoring to determine if this represents an anomaly or a developing trend.

Other Parameters

pH values were consistently basic (ranging from 8.0 to 8.7) and within acceptable state standards. Temperature trends reflected typical seasonal variation, and specific conductivity readings were below median values observed in other Michigan lakes.

Chlorophyll-a and Trophic State

West Twin Lake's chlorophyll-a concentrations aligned with historical data, whereas East Twin Lake exhibited lower than median values. Composite trophic state calculations indicate that West Twin Lake falls within the oligotrophic category (low productivity) while East Twin Lake is mesotrophic, suggesting moderate productivity with potential for seasonal variations.

Algal Composition

Although total cyanobacterial concentrations in East Twin Lake fall into a moderate-risk category based on WHO guidelines, 95–98% of these are non-toxin-producing strains. Microcystin tests returned non-detectable levels, indicating a low immediate risk of harmful algal blooms.

Conclusions and Recommendations

Both lakes generally exhibit water quality characteristics that exceed those of many inland Michigan lakes. However, the observed seasonal fluctuations in nutrient levels, dissolved oxygen, and algal communities highlight the importance of continued monitoring. It is recommended that future sampling events target optimal weather conditions to reduce data variability and that management efforts focus on mitigating nutrient inputs, particularly phosphorus, from residential and other non-point sources.

This ongoing monitoring and analysis will ensure that the lakes continue to provide ecological and recreational benefits to the community, while also supporting informed decisions regarding lake management and conservation.

INTRODUCTION

East and West Twin lakes lie adjacent to the community of Lewiston in Montmorency County, Michigan. East Twin Lake is a small to medium sized inland lake with a surface area of about 830 acres and is relatively shallow with an average depth of around 6 feet and a max depth of about 26 feet. East Twin Lake's water level is largely maintained by precipitation throughout the year but does likely have some groundwater contribution to its waters. East Twin Lake outlets to West Twin Lake via a culvert at the west end of the lake. Although there is usually flow through this culvert, extended spells of dry weather can cause East Twin Lake's level to fall enough that no flow occurs from East Twin to West Twin. West Twin Lake, the larger of the two lakes, is a medium-sized inland lake with a surface area of about 1,300 acres and an average depth of about 8 feet, with a maximum depth of about 35 feet. West Twin Lake's water level is partially maintained via the outfall from East Twin Lake, but also likely has some spring fed sources. West Twin Lake outlets through a culvert to the Middle Branch Big Creek which is part of the Au Sable River watershed. Both East and West Twin Lake are multisport lakes, drawing large amounts of people for swimming, fishing, and boating in the summer, and a dedicated contingent of ice fishermen in the winter.

Lewiston is a town of about 980 permanent residents that lies in the extreme southwest corner of Montmorency County. Established as a lumber town in the late 1800s, a large mill was run on the east end of East Twin Lake for several decades until area resources were depleted and the lumber companies moved on. After a brief resurgence as a farming community in the early 1900s, Lewiston became a premier vacation destination after World War II due largely to the amenities offered by East and West Twin Lakes. To this day, Lewiston and the Twin Lakes remain an "up north" refuge for Michigan residents and out of state visitors.

The Twin Lakes Property Owners Association has a mission to protect the East and West Twin Lakes, and as part of that mission, elected to begin a lake monitoring program in 2024. Monitoring the characteristics and quality of East and West Twin Lakes provides insights into how the lakes change over time, the impact that improvement activities have on the lakes, and how environmental factors or invasive species affect the lakes. Additionally, with historical water quality data, trends can be identified and analyzed so more educated decisions can be made on which improvement activities to pursue or avoid. The following report outlines the most recent water quality data collected in 2024 and includes references to State of Michigan water quality regulatory criteria and Michigan inland lakes data collected on 729 inland lakes by the United States Geological Survey (USGS) and the Michigan Department of Environment, Great Lakes & Energy (EGLE, formerly DEQ).

SAMPLE SITE LOCATIONS

All samples were collected withing 2 feet of the water surface. Samples were collected at the sites shown below.

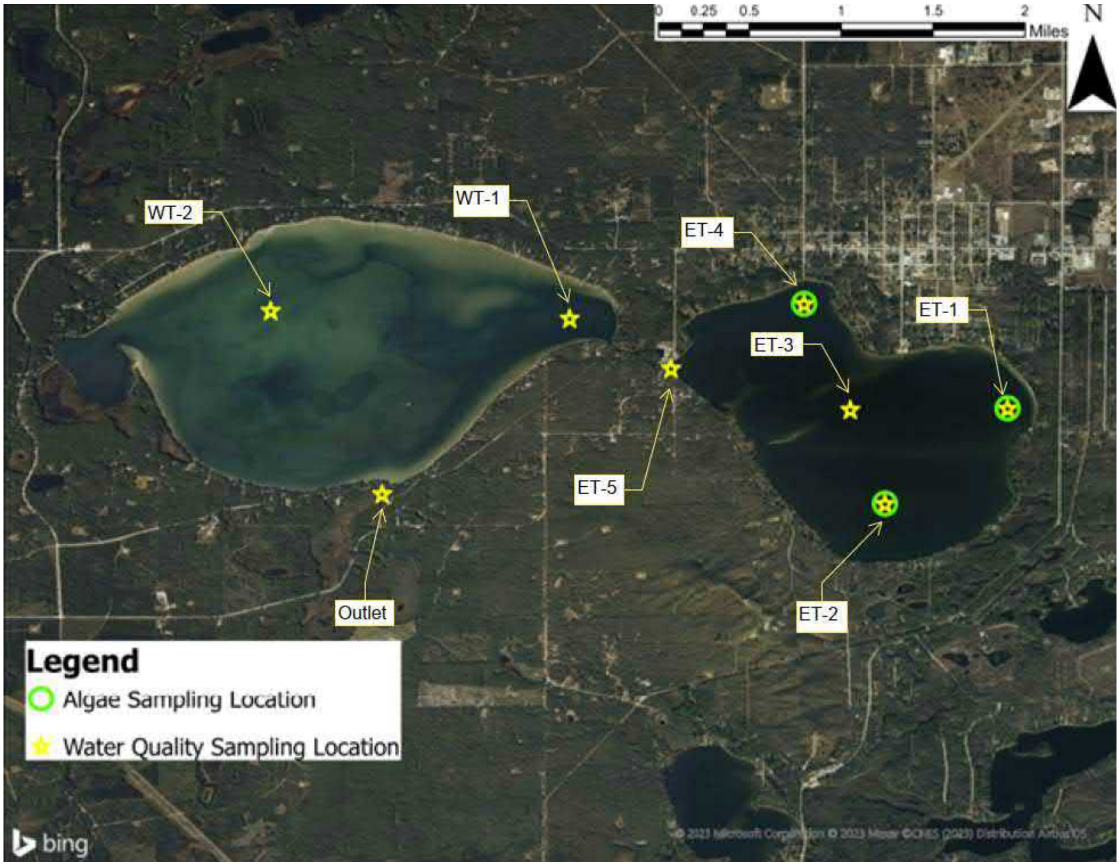

Figure 1 Sampling locations on East and West Twin Lakes in 2024.

PARAMETERS MONITORED

Parameters monitored on East and West Twin Lakes during 2024 include:

- Total phosphorus (TP)
- Orthophosphate, also referred to as soluble reactive phosphorus (SRP)
- Total Nitrate
- Total Nitrite
- Total Nitrogen
- Total Kjeldahl Nitrogen (TKN)
- Ammonia
- Chloride
- Dissolved Oxygen (DO)
- Temperature (Temp)
- Specific Conductivity (SpC)
- PH
- Total Suspended Solids (TSS)
- Secchi Depth, also referred to as water clarity
- Chlorophyll-a
- Pheophytin-a

Phosphorus, orthophosphate, nitrate, ammonia, chlorophyll-a, algal identification and enumeration, and microcystins were analyzed by a NELAP certified laboratory. Dissolved oxygen, temperature, specific conductivity, pH and Secchi depth (i.e., water column visibility) were measured in the field using a calibrated Hydrolab Quanta Multi-Probe Meter.

Standard methods utilized to analyze and measure the concentration of each parameter are listed in the table below.

Parameter	***Standard Method***
Total Phosphorus	EPA 0365.3
Orthophosphate	EPA 0300.0
Total Nitrate	EPA 0300.0
Total Nitrite	EPA 0300.0
Total Nitrogen	CALCULATION
Total Kjeldahl Nitrogen	CALCULATION
Ammonia	SM 4500-NH3 G
Chloride	EPA 0300.0
Chlorophyll-a	SM 10200 H
Pheophytin-a	SM 10200 H
Total Suspended Solids	SM2540D
Dissolved Oxygen	Quanta – Table 4500-O found in the 19th Edition of Standard Methods for the Examination of Water and Wastewater.
Temperature	Quanta
Specific Conductivity	Quanta – Table 3 in ISO 7888-1985 Water Quality – Determination of Electrical Conductivity.
pH	Quanta
Secchi Depth	Quanta

Table 1 - Standard methods utilized by the laboratories to measure the concentration of each parameter. Some parameters were measured in the field using a Hydrolab Quanta multi-parameter probe

RESULTS

SECCHI DEPTH (WATER CLARITY)

Secchi depth is a measurement of water clarity. The higher the Secchi depth, the higher the water clarity is. Water clarity is often associated with "good" water quality. However, invasive species such as Dreissenid mussels (i.e., zebra and quagga mussels) can increase water clarity through filtering of particulate matter in the water and allow for more light to hit the bottom of the lake, thus increasing the growth of algae and aquatic plants and causing a lower Secchi depth.

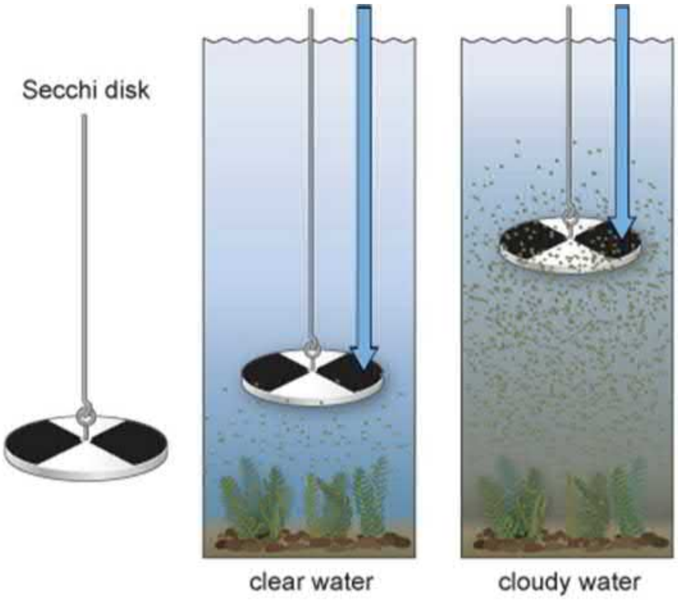

Figure 2 - Secchi disk. Secchi depth is measured using the Secchi disk. The disk is dropped into the water out of the sunlight. The depth at which the disk is no longer visible is the Secchi depth. Sunglasses cannot be worn while taking the Secchi Depth.

Water clarity can also influence the fish community and angler success through direct and indirect mechanisms including, but not limited to fish feeding success (visual predatory fish can "see" more fish to pursue as prey when water clarity increases), changes in ultraviolet light (which can be harmful to fish), changes in the abundance and density of aquatic plants, and alterations to fish reproductive behavior and success (Source: Bunnell et al, 2021). Therefore, the optimum balance for lakes such as East and West Twin Lakes is not too clear to limit the excess growth of algae and aquatic plants and not too cloudy so that the water appears dirty and does not allow for a productive, healthy lake.

The water clarity varies between East and West Twin Lake, with West Twin Lake historically measuring a Secchi depth about 2 feet deeper than East Twin Lake, a trend which continued through the 2024 sampling events. The 2024 sampling events recorded much shallower Secchi depths than measured in previous years, however this is likely due to weather during each event. All three sampling events occurred on days with heavy cloud cover and substantial rain events. Between the low light conditions and agitation of the water from heavy rains, it is likely that these readings were an anomaly when compared with historic results. However, Secchi measurements during optimal weather over the coming years will help to solidify that assumption. Despite this likely weather effect on data collection, West Twin Lake still measured an average Secchi depth about 2.0 feet deeper than East Twin Lake.

Michigan does not have a set water quality standard for Secchi Depth. However, Minnesota has a variety of water quality standards for Secchi Depths on different water bodies. The most applicable criteria are:

- Lakes and Reservoirs in North Central Hardwood Forest Ecoregion - Not to be below 4.6 ft.
- Lakes and Reservoirs in Western Corn Belt Plains and Northern Glaciated Plains Ecoregion - Not to be below 3.0 ft.

Secchi depth data collected from 729 inland lakes in Michigan by the United States Geological Survey (USGS) and Michigan Department of Environment, Great Lakes, & Energy (EGLE) has provided "median" values that have been used to compare with the results from East and West Twin Lake. As discussed above, the results from the 2024 events come in much lower than the medians found in the USGS study, but when comparing the Secchi depth results from the historical CLMP collections between 1993 and 2022, we see that West Twin Lake has always shown water clarity depths exceeding the USGS medians. East Twin Lake has shown some more varied results in the CLMP studies but still averages a water clarity that exceeds the USGS median values. This means that both East and West Twin Lake have historically had water clarity that exceeds most other inland lakes in Michigan. The Secchi results for East and West Twin Lakes are shown in the figures below.

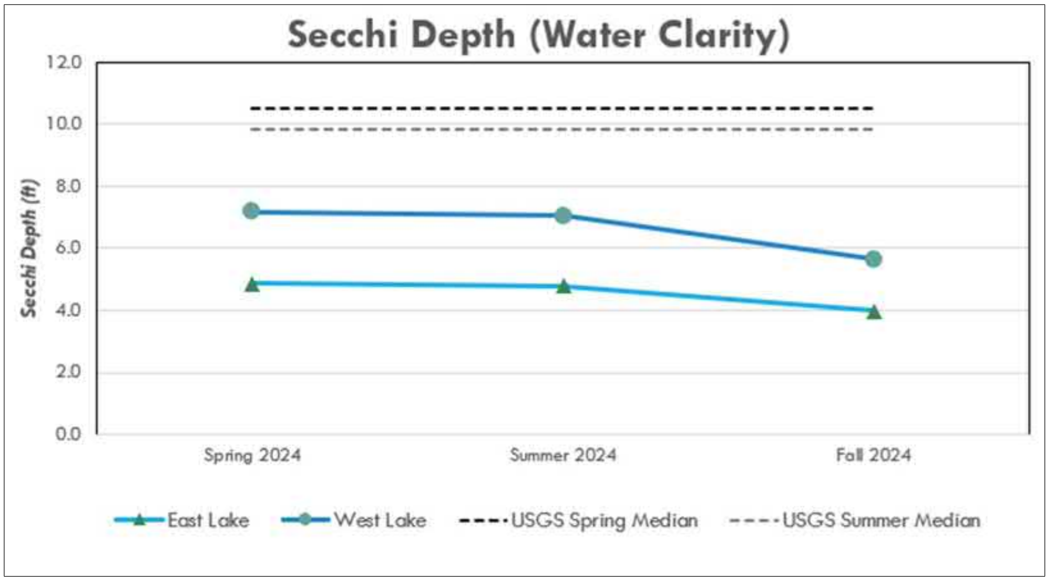

Figure 3 - Secchi depths measured in East and West Twin Lakes in 2024.

An increase in Secchi depth is caused by the reduction of particulate matter suspended in the water column and reduction of algae blooms, phytoplankton, and zooplankton. Conversely, a decrease in Secchi depth is due to an increase in particulate matter suspended in water, algae, phytoplankton, and zooplankton. An increase in particulate matter can be caused by more runoff and boat traffic, and an increase in algae blooms, phytoplankton, and zooplankton can be due to excess nutrients in the water.

PHOSPHORUS

Phosphorus is an element that is a major component in all lifeforms regardless of species or size. In fact, after calcium, phosphorus is the second most abundant mineral in the human body. Phosphorus can also be found in inorganic forms like in rocks. Total phosphorus is the measurement of all types of phosphorus (both organic and inorganic) within the water.

The main concern with phosphorus regarding inland lakes is that too much phosphorus can lead to excess algal and aquatic plant growth. Excess algal growth can lead to reduced dissolved oxygen, reduced water clarity, unpleasant odors/discolored water, and many more undesirable water quality issues. Excess aquatic plant growth can be an issue for motorboats, as it can become tangled in propellers.

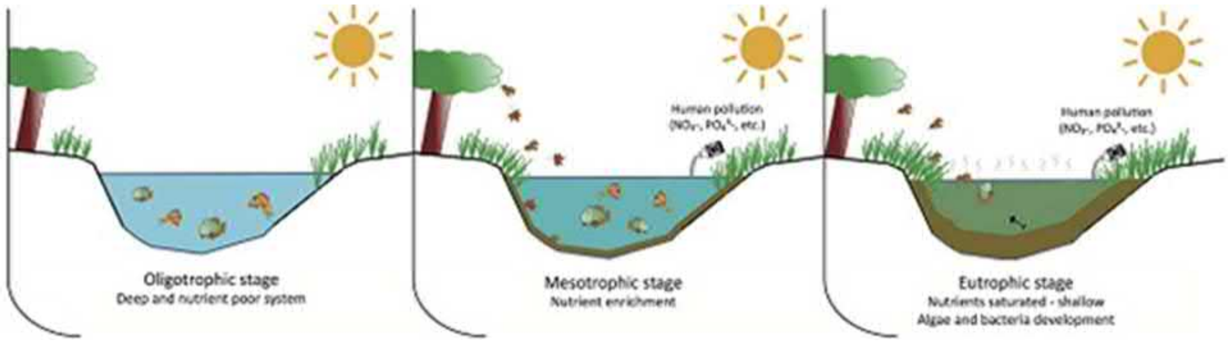

Figure 4 - Eutrophication of a water body over time.

Phosphorus is a key factor for plant and algal growth because it is the limiting nutrient for their growth. A limiting nutrient is defined as a component that limits the amount of the product that can be formed or its rate of formation, because it is present in small quantities. Too much phosphorus in a lake year after year can lead to hastened aging of a lake, or "eutrophication".

Monitoring and managing total phosphorus in the water column is a staple component of many lake management plans around the state. In Michigan, it is common to associate elevated phosphorus levels in lakes with agricultural areas within a lake's watershed. High phosphorus-load sediment can commonly be found in precipitation runoff from crop fields and many of these fertilizers are still extremely high in phosphorus and other nutrients. However, as the lakes around Michigan have seen continued residential development over the last 100 years, there are two sources of phosphorus that can be attributed to the residents on the lakes themselves. First, common lawn fertilizers used by homeowners and lawn maintenance companies frequently included phosphorus as a key ingredient. Sprinkler and stormwater runoff leeches the excess phosphorus and due to proximity to the lake, deposits it in the water column. Many lake management plans now include informational campaigns that encourage homeowners to use a "Zero Phosphorus" fertilizer to try to minimize the amount of excess phosphorus entering the lake through this avenue.

Second, due to the location and time period that many lakes in Michigan experienced their residential buildup, many homes were built utilizing a private septic system since no public sanitary sewer was available. Human waste can be extremely high in phosphorus and therefore septic systems adjacent to lakes can be a problematic source for unwanted nutrient loads in inland lakes. New or fully functioning septic systems will minimize the amount of nutrient loaded wastewater that is outlet through the leach field, but an even more potent source of contamination is aging septic systems that have cracked or overflowing main tanks. These types of malfunctioning systems can allow for concentrated sources of waste to seep into groundwater and eventually deposit nutrient loads into adjacent water bodies.

East and West Twin Lakes total phosphorus data is shown below and the graphs also compare this data to median concentrations of TP measured in 729 inland lakes around the state of Michigan. The data was collected by the United States Geological Survey (USGS) and EGLE. Currently in the state of Michigan, there is not a surface water quality standard for total phosphorus that applies to inland lakes and streams.

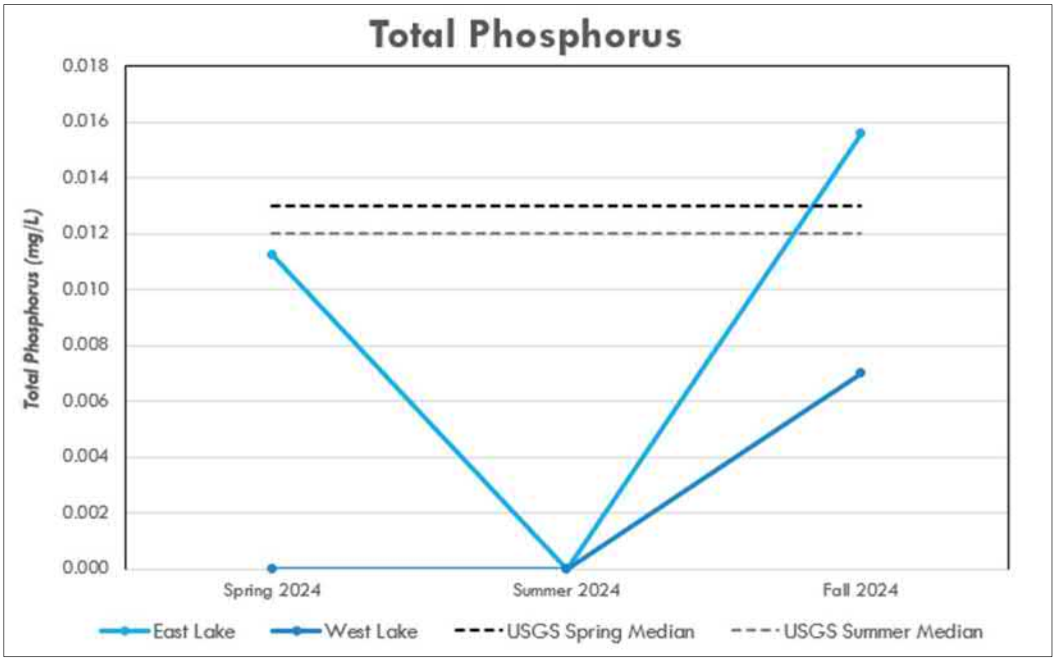

Figure 5 - Total phosphorus measurements in East and West Twin Lakes in 2024.

Both East and West Twin Lake have been enrolled in the Cooperative Lakes Monitoring Program (CLMP) since the 1990s and therefore we have a relatively reliable source of information on total phosphorus concentrations over the past 30 years. This data shows that in East Twin Lake, the total phosphorus concentrations have been slowly climbing, while the total phosphorus concentrations in West Twin Lake have been slowly decreasing. We also see a trend where the concentrations of total phosphorus in the summer of each year typically measure about 30-70% higher than measured in the spring. The USGS inland lake study sees about a 10% elevation in these concentrations between spring and summer, so both East and West Twin Lake are experiencing a larger than average increase in seasonal change of phosphorus concentrations. Results from 2024 show unexpectedly low concentrations of total phosphorus in West Twin Lake, as results from both the spring and summer samplings were below analytical detection limits, but East Twin Lake also had an unexpectedly low concentration of total phosphorus in the summer sampling event, which also was below detection limits. Results between spring and fall in East Twin Lake follow the historical pattern of a seasonal increase in total phosphorus concentration, with an increase of about 45% in total concentration.

Total phosphorus may increase due to an increase of external inputs of phosphorus into the lake from lawns, soil erosion, or runoff from tributary drains. Additionally, phosphorus can be released from bottom sediments if dissolved oxygen is very low near the surface of the sediment and when temperature is elevated. Phosphorus may decrease due to the reduction in runoff and can also be reduced when dissolved oxygen levels are higher, and temperatures are lower near the surface of bottom sediment. While there are some deeper basins in East and West Twin Lake, the relative shallow depths of the lake do not indicate that the lake experiences a full stratification every year which can lead to the type of phosphorus internal loading problems that fully stratified lakes experience. However, the summer dissolved oxygen readings were below USGS medians for inland lakes and fall measurements came in even below State of Michigan standards for both warm-water and cold-water fisheries. This type of oxygen depletion could be a source of phosphorus internal loading in the lake if the water is becoming anoxic near the sediments at the bottom of the lake.

SOLUBLE REACTIVE PHOSPHORUS

Orthophosphate, also known as soluble reactive phosphorus (SRP), is a main constituent in fertilizers used for agriculture and residential purposes. SRP is a form of phosphorus that is readily available for plant, algae, and other biota use. SRP can be introduced into a lake or stream via runoff, animal waste, and plant and animal decomposition. SRP is included in the measurement of total phosphorus since it is a form of phosphorus.

Phosphorus Cycle

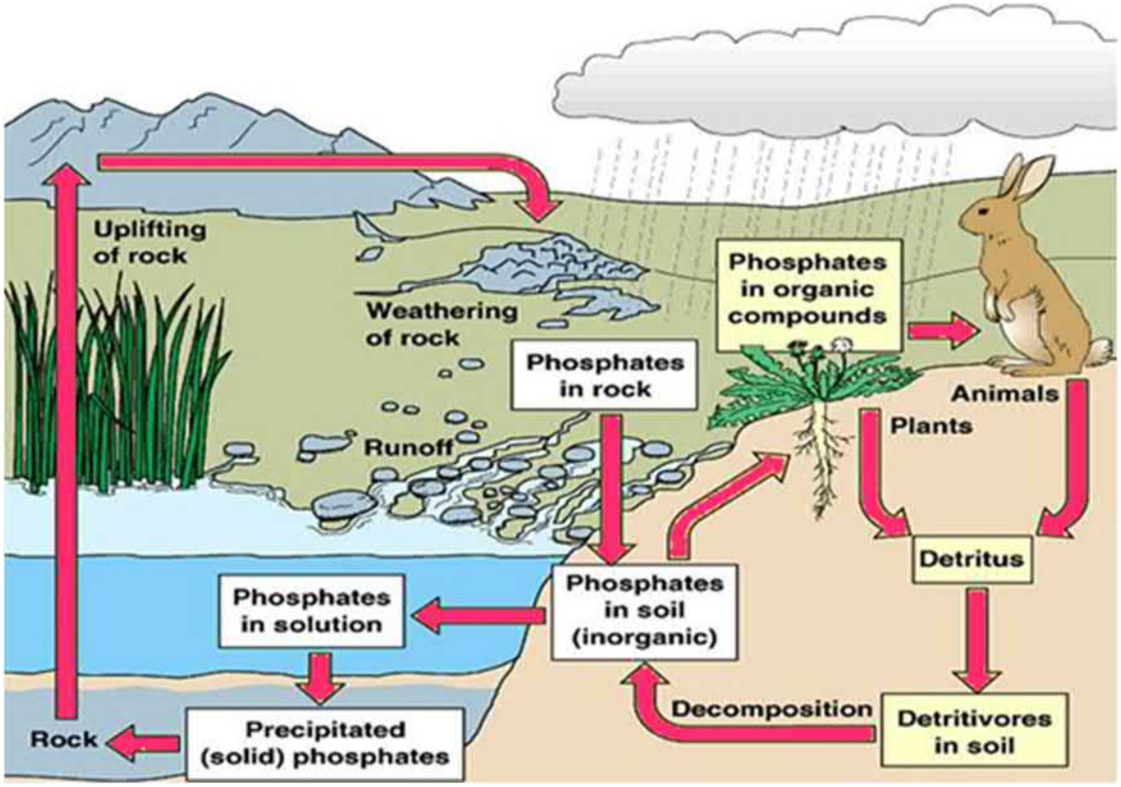

Figure 6 - The figure depicts inputs of phosphorus from both organic and inorganic, soluble and insoluble phosphorus into a water system. The figure also shows the cycle of phosphorus out of a water system and back into inorganic and organic forms.

Concentrations of SRP in both East and West Twin Lake were below the analytical detection limits, meaning the concentrations are extremely low. Having low concentrations of SRP in the surface water of the lake is conducive to minimizing algae blooms, as the algae have little to no phosphorus available for immediate uptake and growth. Continuing to encourage landowners surrounding both East and West Twin Lake to use fertilizers with zero percent phosphorus, if used at all, and reducing or eliminating yard waste entering the lake will help in the continued minimization of SRP available for nuisance plant and algae growth within the lake.

NITRATE

Nitrate is a form of nitrogen that is naturally found in aquatic and terrestrial ecosystems. However, nitrate may be introduced into the environment at unnatural levels by sewage, fertilizers, and manure used as fertilizer. Nitrate may also become incorporated into an aquatic ecosystem by atmospheric deposition. According to USGS, “more than 3 million tons of nitrogen are deposited in the United States each year from the atmosphere, derived either naturally from chemical reactions or from the combustion of fossil fuels, such as coal and gasoline.” (Source: USGS Water Science School, Nitrogen and Water).

When at excessive levels, nitrate leads to eutrophication of a water body, much like phosphorus. The presence of nutrients like nitrogen and phosphorus can lead to excessive algae growth, which can deplete dissolved oxygen in the water and severely harm water quality. At its most severe, this process can even lead to anoxic “dead zones,” such as those found in the Gulf of Mexico and Lake Erie. Dead zones refer to areas that are completely depleted of oxygen that cannot support the majority of aquatic life.

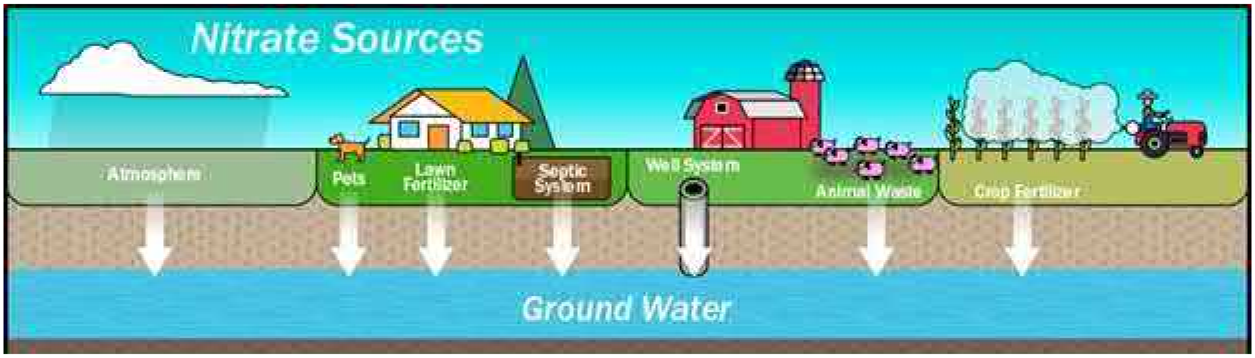

Figure 7 - Nitrate sources to groundwater and surface water. Source: Aquasana, Nitrates in Drinking Water – Reasons to Avoid Nitrates.

Both East and West Twin Lake’s nitrate levels are well below USGS Michigan inland lake median levels during spring collection. Summer and fall sampling events also yielded concentrations below analytical detection limits, which puts results well below the USGS summer level medians.

AMMONIA

Ammonia is another form of nitrogen that exists naturally in an aquatic environment. Natural sources include the decomposition of organic material and vegetation, gas exchange with the atmosphere, forest fires, animal and human waste, and the nitrogen fixation process. Just like nitrate, SRP, and TP, ammonia levels can become too high in the environment due to human influence. Unnatural sources of ammonia include commercial fertilizer, yard waste disposal, industrial applications, and wastewater treatment plant effluent.

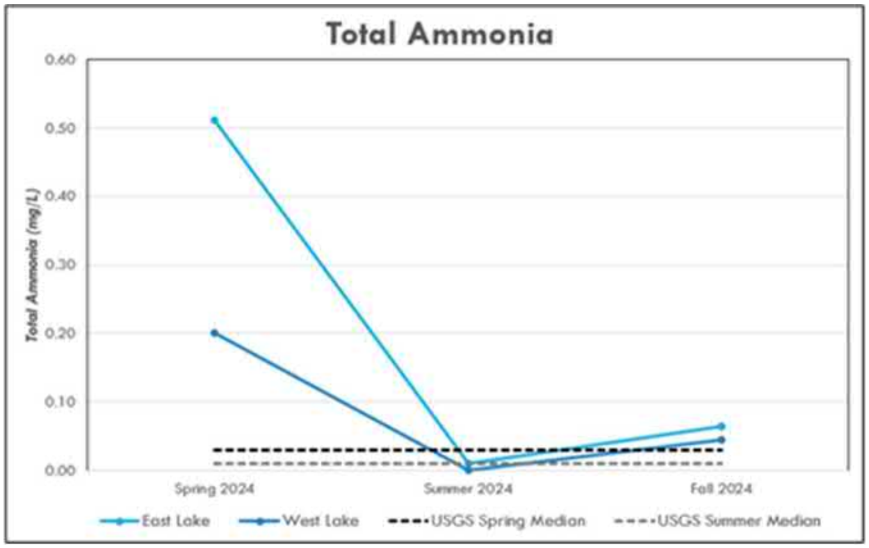

Figure 8 - Ammonia concentrations in East and West Twin Lakes in 2024.

Unlike other forms of nitrogen which have indirect effects on aquatic life due to the over enrichment of water, ammonia causes direct toxic effects on aquatic life. When ammonia is present in water at high enough levels, it is difficult for aquatic organisms to sufficiently excrete the toxicant, leading to toxic buildup in internal tissues and blood, and potentially death. Environmental factors, such as pH and temperature, can affect ammonia toxicity to aquatic animals. (Source: United States Environmental Protection Agency, Aquatic Life Criteria – Ammonia).

Ammonia levels in the Twin Lakes showed concentrations well above USGS Michigan inland lake median levels during spring and fall sampling, and concentrations below the USGS median levels during the summer sampling. These concentrations are still well below the recommended EPA water quality criteria which recommends an acute criterion magnitude of 17 mg Total Ammonia Nitrogen (TAN) per liter at pH 7 and 20°C for a one-hour average duration, not to be exceeded more than once every three years on average and a chronic criterion magnitude of 1.9 mg TAN/L at pH 7 and 20°C for a 30-day average duration, not to be exceeded more than once every three years on average.

With only one year of data to compare against, these results cannot be taken as a flag for a larger problem on the lake, especially when considering all concentrations still come in well below EPA water quality standards. However, the results should be monitored year over year to consider whether higher than average concentrations of ammonia may be linked with the historic milling of pine on the lake and whether these concentrations could be a contributing factor towards some of the problems experienced on East and West Twin Lakes.

TOTAL KJELDAHL NITROGEN

Total Kjeldahl Nitrogen (TKN) is a measure of the total concentration of organic nitrogen and ammonia present in water. It can be an important indicator of nitrogen pollution, as it combines both the ammonia component and organic nitrogen compounds that can be converted into ammonia through microbial processes. TKN results can aid in understanding what types of nitrogen may be entering the lake from organic sources such as manure or sanitary contamination. Elevated levels of TKN in water often result from sources like agricultural runoff, wastewater discharges, or industrial effluents, which contribute excess nitrogen to aquatic ecosystems. When too much excess nitrogen is present in these ecosystems, it can promote excessive growth of photosynthetic organism which can lead to poor water quality characteristics and algae blooms. Excessive biological growth of photosynthetic organisms, known as eutrophication, can lead to reduced oxygen levels in the water, harming fish and other aquatic organisms. Furthermore, the decomposition of organic nitrogen compounds can contribute to the development of hypoxic or anoxic conditions, where oxygen can become too low to support local biodiversity.

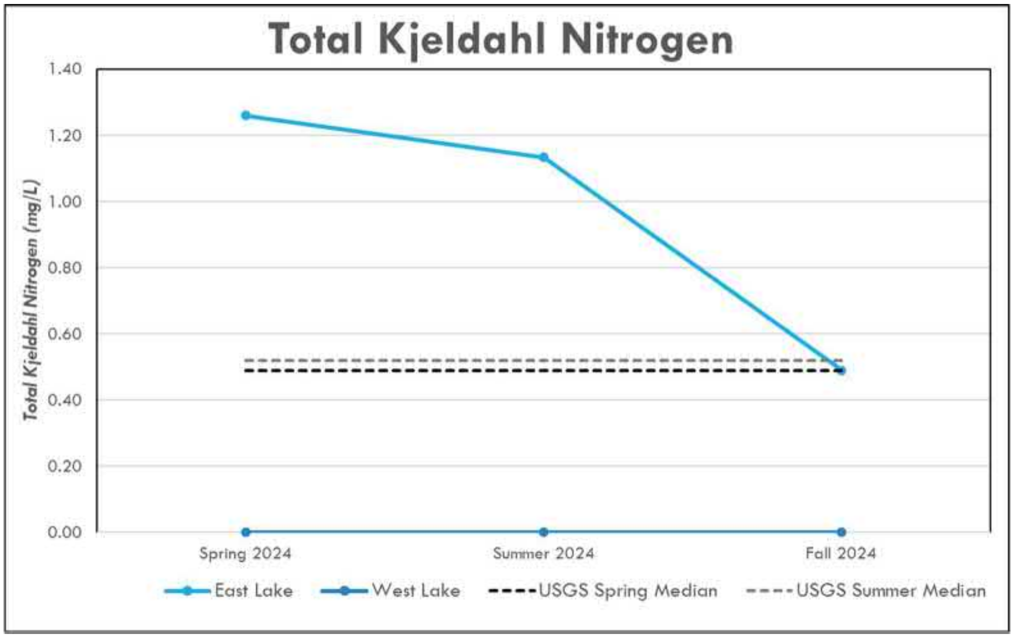

Figure 9 - TKN measurements in East and West Twin Lakes in 2024.

The State of Michigan does not have surface water concentration action levels set for TKN, but the USGS Inland Lake Study does have spring and summer median levels. West Twin Lake had results below method detection limits for all sampling events in 2024, meaning very low levels of organically linked nitrogen. East Twin Lake had average results from the spring and summer events that were above the USGS medians in spring and summer, with the fall event results coming in below the USGS medians. When compared with the ammonia concentrations, the summer results from East Twin Lake are of the most interest. With negligible amounts of ammonia found in the lake, it means that the vast majority of the TKN concentration is from organically linked nitrogen, which could indicate that the lake is experiencing an unwanted deposit of organically linked nitrogen between the spring and summer seasons from something like agricultural runoff, native animal waste, and/or septic leach into the lake. Future monitoring of the lakes should continue to include monitoring for both nitrogen and phosphorus as these are important indicators for the health of the aquatic ecosystem of the Twin Lakes but should also consider TKN as a compound of interest to help understand if septic leach may be causing unwanted nutrient leach into East Twin Lake.

TOTAL NITROGEN

Total Nitrogen (TN) is a calculation of all organic and inorganic nitrogen in a sample, giving an indication of the total available nitrogen in an ecosystem. Total nitrogen concentration is obtained by calculating total nitrate/nitrite and TKN, then adding all concentrations together. As discussed in other parts of this report, nitrogen is a critical nutrient required for the biological processes of organisms in a lake's ecosystem. A healthy, self-regulating ecosystem will typically have a nutrient available in limited quantities which can prevent unchecked, unwanted growth by aquatic plants or algae which can cause lake eutrophication, which is frequently either nitrogen or phosphorus. Human activities have been shown to allow excess and unwanted nutrients to enter lakes through runoff, groundwater leach, or direct outfall. These excess nutrients can throw an ecosystem out of balance and lead to poor water quality characteristics, including algae blooms.

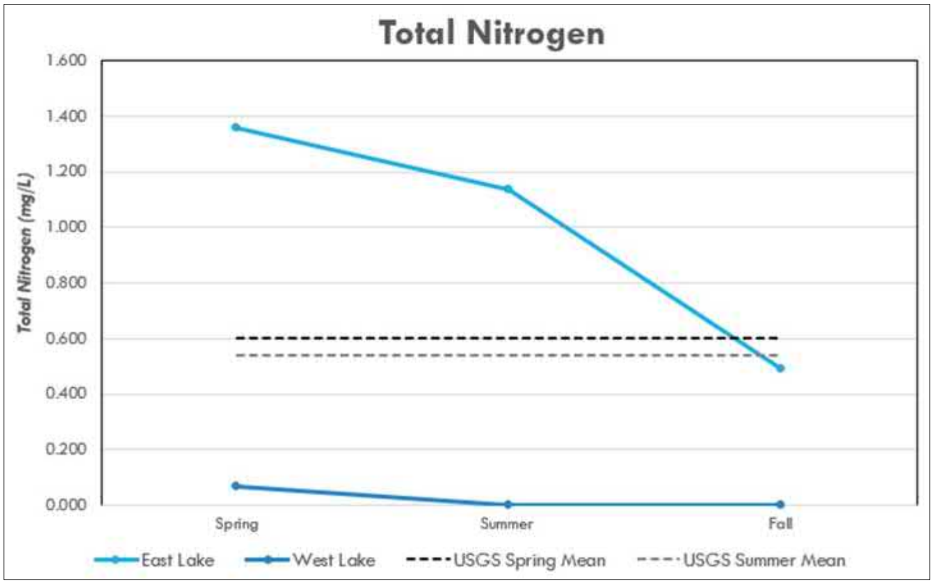

Figure 10 - Total Nitrogen concentration in East and West Twin Lakes in 2024.

The State of Michigan does not have a surface water standard set for total nitrogen, but the USGS inland lake study does have median levels found from their data. Similar to the TKN results, we see that West Twin Lake has extremely low levels of TN during all sampling events in 2024. East Twin Lake follows the same pattern seen in the TKN sampling of having TN results in spring and summer that are about twice the USGS median concentrations for that season, with a fall result that comes in below both media concentrations. Similar patterns lead to the same conclusions outlined in the TKN section of this report. TN should continue to be monitored in any long-term lake monitoring plan to aid in the understanding of limiting nutrients in this system, especially if algal and/or plant growth are excessive or deficient.

CHLORIDE

Chloride is a chemical compound composed of chlorine bonded with another element such as sodium, potassium, or calcium. It commonly occurs as sodium chloride which is the main component of table salt and road salt. Chloride is naturally found in seawater and mineral deposits and can also be found in small concentrations of freshwater ecosystems. Human activities, primarily the use of road salts for de-icing, water softener treatments, wastewater discharge, and industrial runoff, have contributed to a steady increase of chloride concentrations in freshwater ecosystems in the Great Lakes regions since the turn of the 20th century.

Excessive chloride levels in freshwater ecosystems can be harmful to aquatic life, disrupting the balance of these environments. High concentrations of chloride can lead to changes in water salinity, which affects the osmoregulation of freshwater species, making it difficult for fish and invertebrates to survive. For example, elevated chloride levels can cause fish to lose their ability to regulate fluid balance, leading to dehydration and death. Furthermore, chloride can harm sensitive plant species and disrupt the food chain, impacting biodiversity and the overall health of freshwater ecosystems. The increasing presence of chloride in freshwater environments is a growing concern as urbanization and road salt usage continue to rise.

As part of the Natural Resources and Environmental Protection Act, the state of Michigan has set maximum allowable concentrations of chloride in surface waters of the state. These concentrations are either 50 milligrams per liter or 125 milligrams per liter on a monthly average and vary between the two concentrations based on whether the surface water is a Great Lake or connecting water body (50 mg/L), or a public water supply (125 mg/L). The USGS lake study only sets an average spring concentration for chloride, which is 9.0 mg/L.

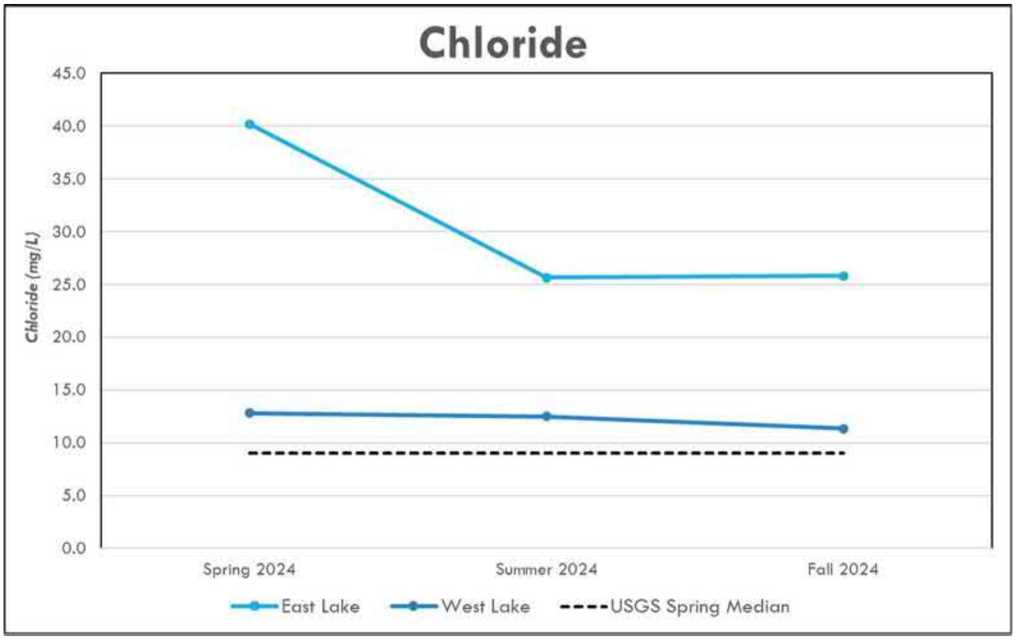

Figure 11 - Chloride concentrations in East and West Twin Lakes in 2024.

For West Twin Lake, the chloride concentration was relatively steady between all seasonal sampling events occurring between 11.0 and 13.0 mg/L for all locations and all events. While this concentration is slightly higher than the USGS average, the consistent results that trend down over the course of the year are an encouraging sign. East Twin Lake consistently returned concentrations of chloride that were more than double the concentrations seen in West Twin Lake. Summer and Fall results remained consistent with results occurring between 25.0 and 26.1 mg/L, but the Spring event had noticeably higher chloride results with a low result of 26.5 mg/L, but a high result 56.7 mg/L. Although the monthly average for the Spring sampling would still have fallen below EGLE's surface water action level, the high concentration in East Twin Lake, especially when compared with West Twin Lake, raises a slight concern without knowledge of what chloride levels have been for the past several decades in the lake. The chloride concentrations of both lakes should continue to be monitored to ensure levels do not become high enough to severely disrupt biological activity in the lake.

DISSOLVED OXYGEN

Dissolved oxygen is a measurement of how much oxygen gas is dissolved in the water and is typically measured in milligrams per liter (mg/L). It is important to have high enough dissolved oxygen concentrations within the water to support fish, macroinvertebrates, and other aquatic life. Dissolved oxygen can be reduced by excess algal growth and subsequent decay, water that's too warm, an increase in oxygen demand from aerobic bacteria, and insufficient wave action. Dissolved oxygen may be increased by increased wave action, cooler temperatures, and more photosynthetic activity from aquatic plants and macrophytes. East and West Twin Lakes show characteristics of both warm-water and cold-water fisheries, with East Twin Lake leaning towards warm water fishery characteristics and West Twin Lake leaning towards cold water fishery characteristics. The state of Michigan requires warm-water fisheries to keep a dissolved oxygen level of 5.0 mg/L in surface waters, while designated cold-water fisheries must maintain a surface water dissolved oxygen level of 7.0 mg/L.

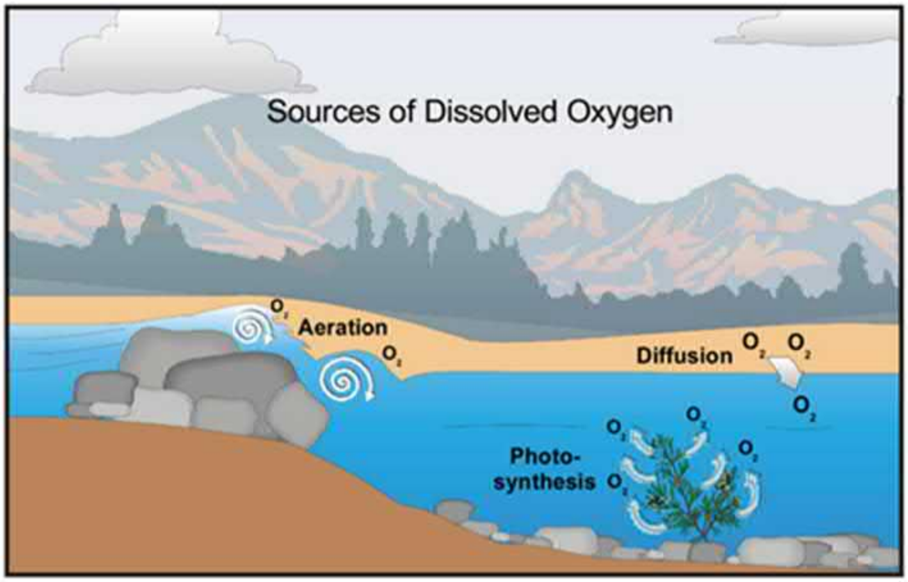

Figure 12 - Sources of dissolved oxygen in surface water. Source: Vernier Experiments, Biochemical Oxygen Demand

Although this study has only one year of data, both East and West Twin Lake showed a steady decline in dissolved oxygen over the course of the sampling year. The spring event showed DO concentrations well above both USGS inland lake median concentrations and SOM fishery standards. The summer event showed concentrations in both lakes that are below the USGS medians, but still above both warm-water and cold-water fishery standards. The fall event showed a sharp decline in dissolved oxygen levels that fell to below 4.0 mg/L in both lakes. Typically, dissolved oxygen measured in fall events is about equal to or higher than summer concentrations due to the cooling of water, which can then hold a larger amount of DO. While the results from a single sampling event should not be used as evidence for a large systemic problem in the lake, DO should continue to be monitored on both lakes to determine whether this collection was an anomaly or whether the lakes are exhibiting an unexplained consumption of dissolved oxygen. These dissolved oxygen trends should be compared against continued chlorophyll-a concentrations, phosphorus concentrations, and algal identification and enumeration analysis to determine if algal blooms could be the cause of an unwanted drop in DO across East and West Twin Lakes.

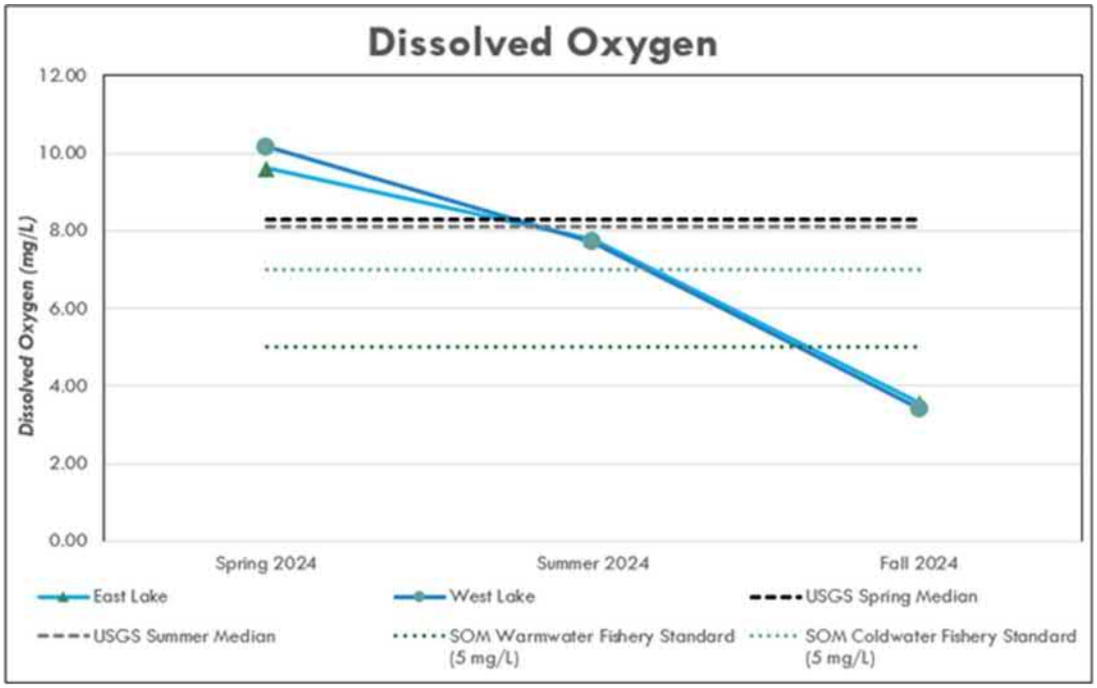

Figure 13 - Dissolved Oxygen concentrations in East and West Twin Lakes in 2024.

pH

pH is a measurement of how many hydrogen ions are in the water and thus, is a measurement of how acidic (pH ranging from 0 – 7) or basic (pH ranging from 7 – 14) the water is. Michigan lakes and streams tend to have more basic water due to the large amount of limestone present in the bedrock.

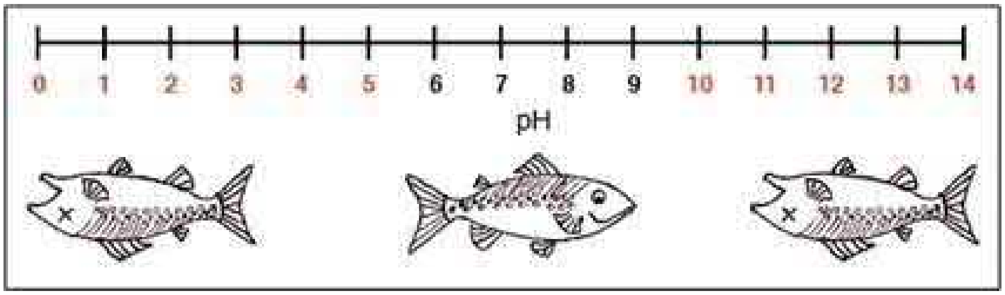

Figure 14 - Range of pH where fish are happy.

In inland lakes, pH may also be indicative of how productive a lake is and how much photosynthesis is occurring within a body of water. The pH will be higher if the lake is very productive and there is a lot of plant growth. Ideally, the pH of Michigan water bodies should be within a range of 6.5 – 9.0. (MDEQ Rule 53 of Michigan Water Quality Standards (Part 4 of Act 451)).

pH can increase due to an increase in dissolved oxygen concentration, an increase in photosynthetic activity of aquatic plants and algae in the water, and an increase in the hardness of the water (i.e. higher calcium and magnesium concentrations in the water). pH can decrease due to a reduction in dissolved oxygen concentration, and an increase in carbon dioxide concentration in the water. Results from the 2024 monitoring event show that the pH ranges in both East and West Twin Lake are on the basic side, with a range between 8.0 and 8.7, but are still within State of Michigan water quality standards.

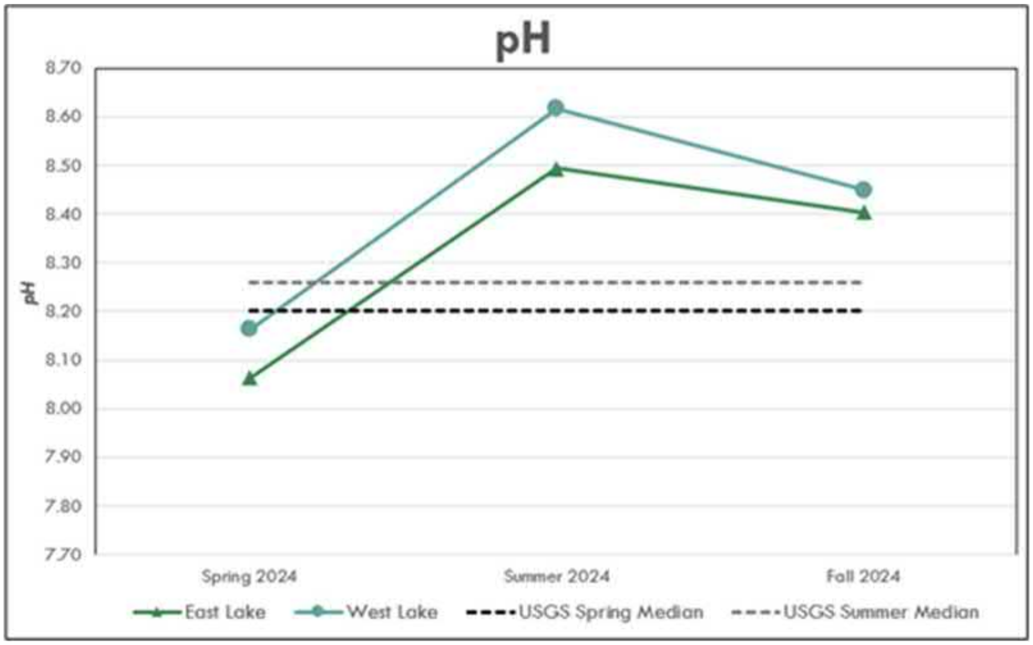

Figure 15 - pH in East and West Twin Lakes in 2024.

TEMPERATURE

Water temperature in a lake can greatly impact its water quality, biological activity, and growth. Warmer water holds less dissolved oxygen, a component which is critical to the survival of aquatic species, and cooler water holds more dissolved oxygen.

The State of Michigan has the following water quality standards for temperature in inland lakes, according to MDEQ Part 4 Water Quality Standards (R 323.1072, Rule 72): Inland lakes shall not receive a heat load which would:

- Increase the temperature of the thermocline or hypolimnion or decrease the volume thereof.
- Increase the temperature of the receiving waters at the edge of the mixing zone more than 3 degrees Fahrenheit above the existing natural water temperature.
- Increase the temperature of the receiving waters at the edge of the mixing zone to temperatures greater than the following monthly maximum temperatures:

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
45	45	50	60	70	75	80	85	80	70	60	50

Temperature will increase if there is an increase in impervious surfaces (pavement, roadways, roofs) in the watershed. These surfaces increase in temperature when the sun warms them, and when it rains, the stormwater absorbs the heat from these surfaces, and flows into a lake, river, or stream, thus elevating the temperature. Temperature will also increase if there is a higher concentration of suspended solids. These solids absorb energy from sunlight, thus increasing the temperature of the waterbody that they are suspended in.

Temperature in waterbodies naturally increase and decrease seasonally as atmospheric temperatures increase and decrease. East and West Twin Lakes show a typical change in temperature from spring through fall, with summer temperatures reading slightly above USGS inland lake medians, which can be expected from generally shallow lakes. Water temperatures should continue to be collected during lake sampling events to compare against results for other analyses which may lead to correlation trends with nutrient concentrations, dissolved oxygen, or algal identification and enumeration.

Figure 16 - Favored temperature range for freshwater fish. Source: Bass Pro Shops.

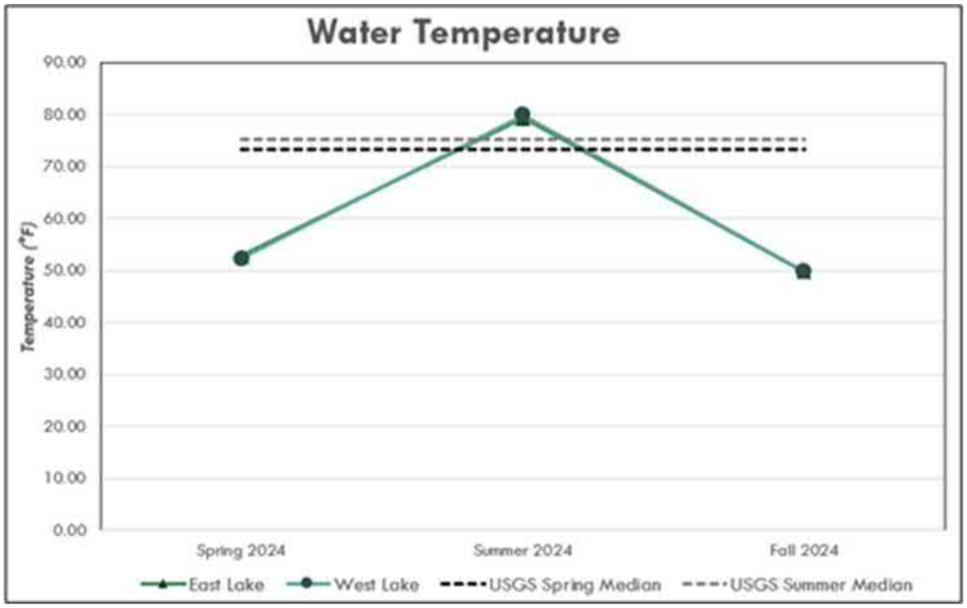

Figure 17 - Temperatures in East and West Twin Lakes in 2024.

SPECIFIC CONDUCTIVITY

Conductivity is a measure of the ability of water to pass an electrical current. Conductivity will increase or decrease depending on the quantity of positively or negatively charged ions (chloride, nitrate, sulfate, phosphate, sodium, magnesium calcium, iron, aluminum, etc.) dissolved in the water. Conductivity is also temperature-dependent, so specific conductivity corrects the conductivity measurement to 25°C. Specific conductivity is impacted by the geology of the area. For example, lakes with a large amount of limestone in the surrounding area will have higher specific conductivity due to dissolved carbonate ions. Specific conductivity will also increase if the watershed is larger, as there is more land surface area that is being drained and contributing ions to the runoff water that feeds the lake. Pollutants such as fertilizers, pesticides, road salts, and wastewater from septic fields will increase specific conductivity. Specific conductivity will be reduced if pollutant inputs to the lake are reduced and evaporation is minimized, among other pathways.

Type of Water	***Specific Conductivity (mS/cm)***
Distilled Water	0.0005 - 0.003
Melted Snow	0.002 - 0.042
Tap Water	0.05 - 0.8
Potable Water in the US	0.03 - 1.5
Freshwater Streams	0.1 - 2.0
Industrial Wastewater	10
Seawater	55

Table 2 - Specific conductivity measured in various types of water. Source: Fondriest Environmental

For inland lakes in the State of Michigan, there is not a set water quality standard for specific conductivity. However, there are comparison criteria derived from the USGS and EGLE study of Michigan inland lakes. A good rule of thumb is that the higher the concentration specific conductivity is, the more dissolved ions there are, which can colloquially be said to be “saltier.” A higher concentration doesn’t necessarily mean that the water quality is poor, and a low concentration doesn’t mean that the lake is healthy. Just like temperature, the lake needs the right balance of ion concentrations to maintain its health. Results for the 2024 sampling event for East and West Twin Lakes show a conductivity range below the USGS inland lake median concentration, but still well within an expected range of concentration.

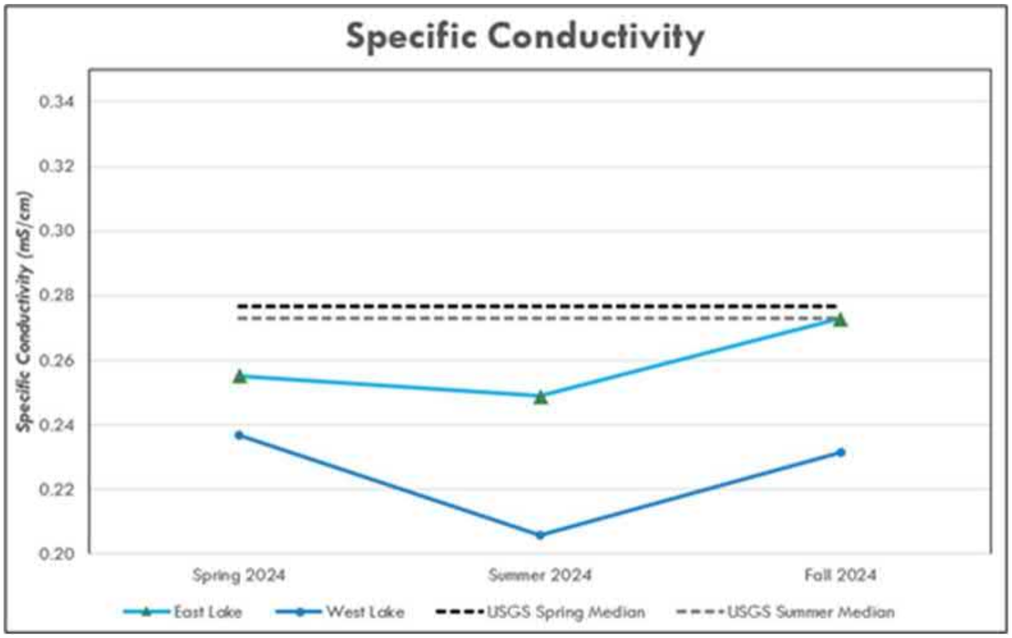

Figure 18 -Specific conductivity measured in East and West Twin Lakes in 2024.

TOTAL SUSPENDED SOLIDS

Total Suspended Solids (TSS) refer to particles, such as sediment, organic matter, and pollutants, that are suspended in water and can be filtered out by a fine mesh. These particles are small enough to remain dispersed in the water column but large enough to be captured through filtration processes. TSS is commonly measured in milligrams per liter (mg/L) and is a critical parameter for evaluating water quality. Some suspended particles can come from natural sources such as erosion, algae, or agitated waters, but there can also be TSS contributions from humans from activities such as water recreation, construction, agriculture, or wastewater discharge. When suspended solids accumulate in the water, they can obstruct light penetration which can directly affect water clarity and can lead to adverse ecological effects. While some suspended solids are to be expected in most freshwater bodies, the presence of high TSS levels can severely degrade the water quality of freshwater systems. Suspended solids can smother aquatic plants and animals, disrupt habitats, and lower oxygen levels as organic matter decomposes. Additionally, they may carry harmful chemicals, such as heavy metals, pesticides, or nutrients like nitrogen and phosphorus, which can lead to eutrophication, algae blooms, and the depletion of dissolved oxygen. These effects can lead to a decline in biodiversity, the health of aquatic ecosystems, and the quality of water for human use, impacting everything from recreational activities to drinking water supplies.

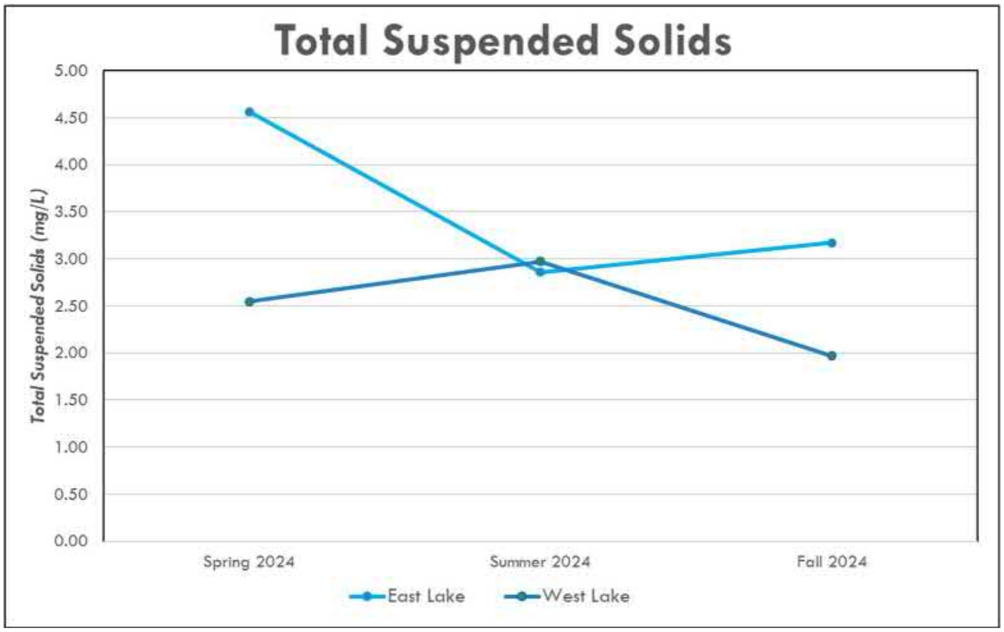

Figure 19 - Total Suspended Solids concentrations in East and West Twin Lakes in 2024.

The State of Michigan does not have concentrations requirements for TSS in surface waters of the state but typically assumes that any water body with a TSS under 20 mg/L can be considered clear water. Both East and West Twin Lake showed relatively low levels of TSS during the 2024 sampling period, with averages for both lakes coming in under 3.8 mg/L. This parameter can continue to be monitored during yearly sampling events, but as it is typically associated with water clarity measured with Secchi depths, it may be considered a redundant parameter. Should water clarity continue to be an issue on one or both lakes, TSS should monitored to ensure an understanding of the amount of suspended material that may be refracting light and lowering Secchi depth measurements.

CHLOROPHYLL-A

Chlorophyll-a is used as a measurement to determine the relative amount of algal presence within the water and is measured in milligrams per liter (mg/L). While this measurement does not give an exact concentration of how many algal cells are present within the water, it does serve as an indication of how much algae is present in the water. Ideally, chlorophyll-a concentration should be low enough to provide balance in the aquatic ecosystem. A chlorophyll-a sample is collected only in the surface water of the lake, as chlorophyll is a green pigment found in plants, algae, and phytoplankton used to absorb sunlight to provide energy for photosynthesis. Chlorophyll-a is not measured at the bottom of the lake, as sunlight does not penetrate down that far. Therefore, organisms with chlorophyll in their tissues do not live at the bottom of the lake, as they would not survive without the sunlight necessary to produce energy to live.

Chlorophyll-a concentrations increase due to an increase in phytoplankton and algae in the water column. If phytoplankton and algae populations decrease, so will Chlorophyll-a concentrations. In Michigan, chlorophyll-a concentrations have been decreasing in some lakes due to the presence of zebra mussels. Zebra mussels significantly increase water clarity and reduce chlorophyll-a since their diet is primarily composed of phytoplankton. Zebra mussels are capable of filtering about one liter of water per day while feeding primarily on algae. (Source: USGS Nonindigenous Aquatic Species, Dreissena polymorpha). The figure below represents a basic food web in a lake that has zebra mussels. Note that zebra mussels can disrupt the lower levels of the food web by eating algae and plankton, which would otherwise be eaten by fish and other native mussels.

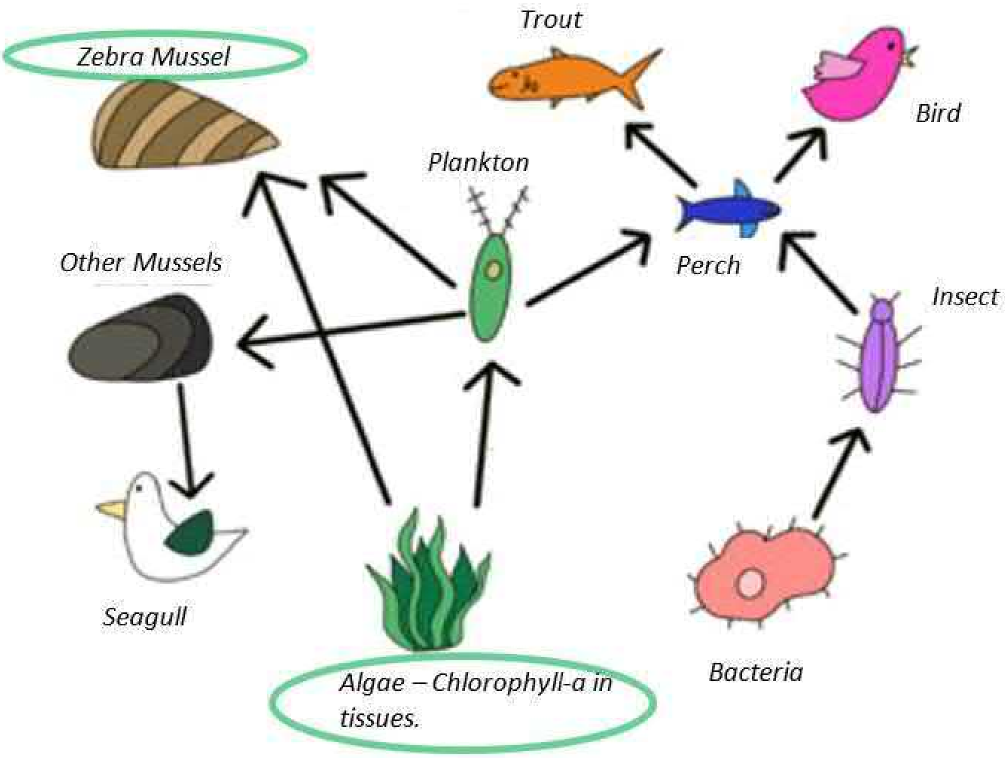

Figure 20 - Zebra mussel in the food web within the Great Lakes region (simplified). Zebra mussels eat algae, which contain chlorophyll-a. Source: Teacher Pay Teacher.

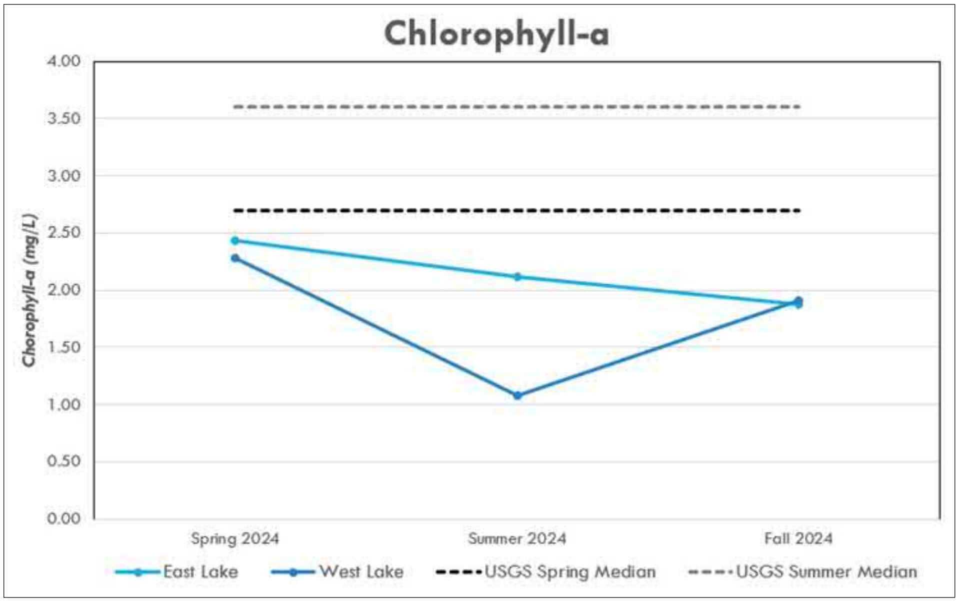

Figure 21 - Chlorophyll-a concentrations in East and West Twin Lakes in 2024.

The State of Michigan does not have a water quality standard for Chlorophyll-a, however, the USGS Michigan inland lakes study and report did quantify median concentrations of chlorophyll-a in the spring and summer within Michigan inland lakes. Since 1999, East and West Twin Lake have had chlorophyll-a sampling performed as part of the CLMP program. This study has shown a steady decrease in the average chlorophyll-a concentrations in West Twin Lake and a steady increase in the chlorophyll-a concentration in East Twin Lake. Results from the 2024 sampling show that chlorophyll-a concentrations in West Twin Lake fall within the expected range based on CLMP historical data. Concentrations within East Twin Lake were below median concentrations from the last 25 years of CLMP data. Both lakes also had results below the spring and summer medians from the USGS inland lake study. While lower chlorophyll-a concentrations generally mean higher water clarity which is often associated with "better" water quality, algae play an important role in a lake's ecosystem. Chlorophyll-a and algal identification and enumeration should remain part of the yearly water quality monitoring on East and West Twin Lake to ensure proper biodiversity and concentrations of algae remain in the lakes to support the lake's ecology.

TROPHIC STATE INDEX

The Trophic State Index is a classification system designed to rate a body of water based on the amount of biological productivity taking place in the water. Productivity within a lake is defined as a lake's ability to support plant and animal life. The rating scale is from 1 – 100, with the least productive body of water being a "1" and the most productive body of water being a "100." Specific ratings are correlated to classes of lakes, for example:

- *<u><30: Oligotrophic Lake</u>* – Clear water, oxygen throughout the year in bottom of lake.
- *<u>40 – 50: Mesotrophic Lake</u>* – Water moderately clear; increasing chance of reduced dissolved oxygen in bottom of lake.
- *<u>50 – 60: Eutrophic Lake</u>* – Anoxic hypolimnia, excess plant and algal growth possible.
- *<u>70 – 80: Hypereutrophic Lake</u>* – Light limited productivity. Dense algae and aquatic plants.

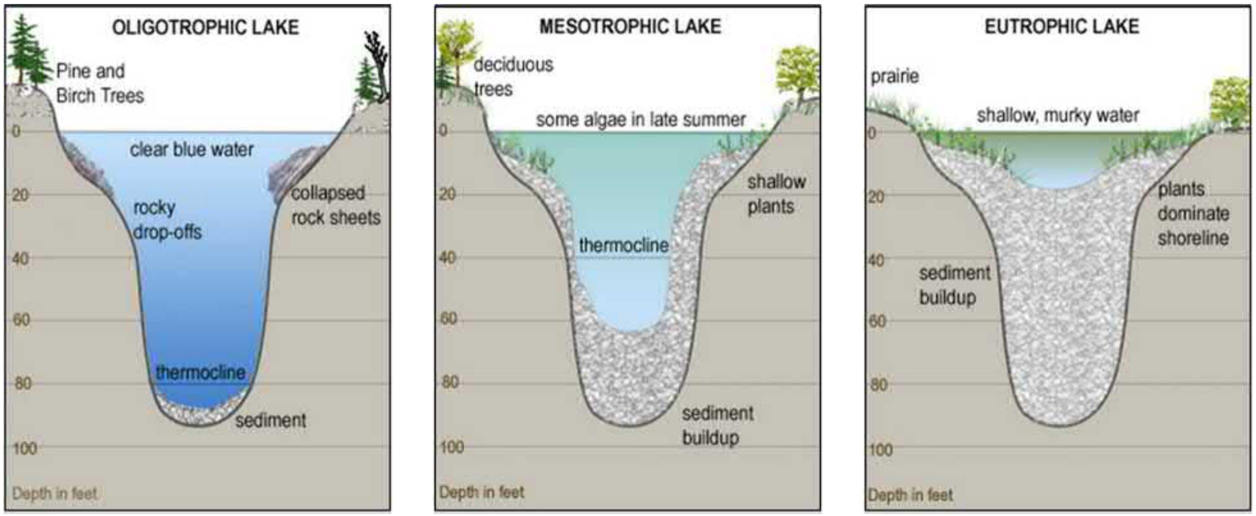

Figure 22 - Trophic states of lakes and associated characteristics. Source: RMB Environmental Laboratories, Inc.

Trophic State ratings are calculated by using three different variables using three different calculations. The variables are Secchi Depth, chlorophyll-a, and total phosphorus.

Trophic State Index Calculations (Source: Carlson 1977):

<u>Secchi Depth</u>

$$TSI(SD) = 10\left[6 - \frac{\ln SD}{\ln 2}\right]$$

<u>Chlorophyll-a</u>

$$TSI(CHL) = 9.81\ln(CHL) + 30.6$$

<u>Total Phosphorus</u>

$$TSI(TP) = 14.42\ln(TP) + 4.15$$

The table below outlines each Trophic State, general conditions of a lake with that trophic status, and a range of Secchi depth, chlorophyll-a, and total phosphorus concentrations within each state.

TROPHIC STATUS	TSI	CHLOR-A (MG/L)	SECCHI (FT)	TP (MG/L)	FISHERIES AND RECREATION
Algal scums, few aquatic plants.	>80	>0.1550	<0.8	0.192 – 0.384	Rough fish dominate; summer fish kills possible.
Hypereutrophic – Light limited productivity. Dense algae and aquatic plants.	**70 – 80**	0.0560 – 0.1550	0.8 – 1.6	0.096 – 0.192	
Blue-green algae dominate, algal scums and aquatic plant problems.	60 – 70	0.0200 – 0.0560	1.6 – 3	0.048 – 0.096	Nuisance plants, algae, and low transparency may discourage recreation.
Eutrophic – Anoxic hypolimnia, excess plant and algal growth possible.	**50 – 60**	0.0073 – 0.0200	3 – 7	0.024 – 0.048	Warm-water fisheries only. Bass may dominate.
Mesotrophic – Water moderately clear; increasing chance of reduced dissolved oxygen in bottom of lake.	**40 – 50**	0.0026 – 0.0073	7 – 13	0.012 – 0.024	Hypolimnetic anoxia results in loss of salmonids. Walleye may predominate.
Bottom of shallower lakes may become oxygen depleted.	30 – 40	0.00095 – 0.0026	13 – 26	0.006 – 0.012	Salmonid fisheries in deep lakes only.
Oligotrophic– Clear water, oxygen throughout the year in bottom of lake.	**<30**	<0.00095	>26	<0.006	Salmonid fisheries dominate.

Table 3 -Trophic status and associated parameter concentrations, associated environmental characteristics.

Using data from the CLMP studies performed on East and West Twin Lakes since the 1990s, we can calculate the trophic status for both lakes through the 2024 sampling event. Results from the individual calculations of Secchi depth, chlorophyll-a, and total phosphorus give a trophic status that varies between oligotrophic and mesotrophic status. When using a composite calculation to average these levels between all three metrics, we find that West Twin Lake would fall under the oligotrophic status, with composite TSI calculations between 34 and 38 since the 1990s. East Twin Lake comes in slightly higher with average TSI levels between 42 and 44, which places it into the mesotrophic status. These results show that TSI levels in both lakes is holding relatively steady over the last 25+ years of data collection for the TSI metrics.

Trophic status calculations for both lakes based on chlorophyll-a, total phosphorus, and Secchi depth are shown in the figures below. The composite TSI score is the average of the three trophic statuses calculated from chlorophyll-a, total phosphorus, and Secchi depth.

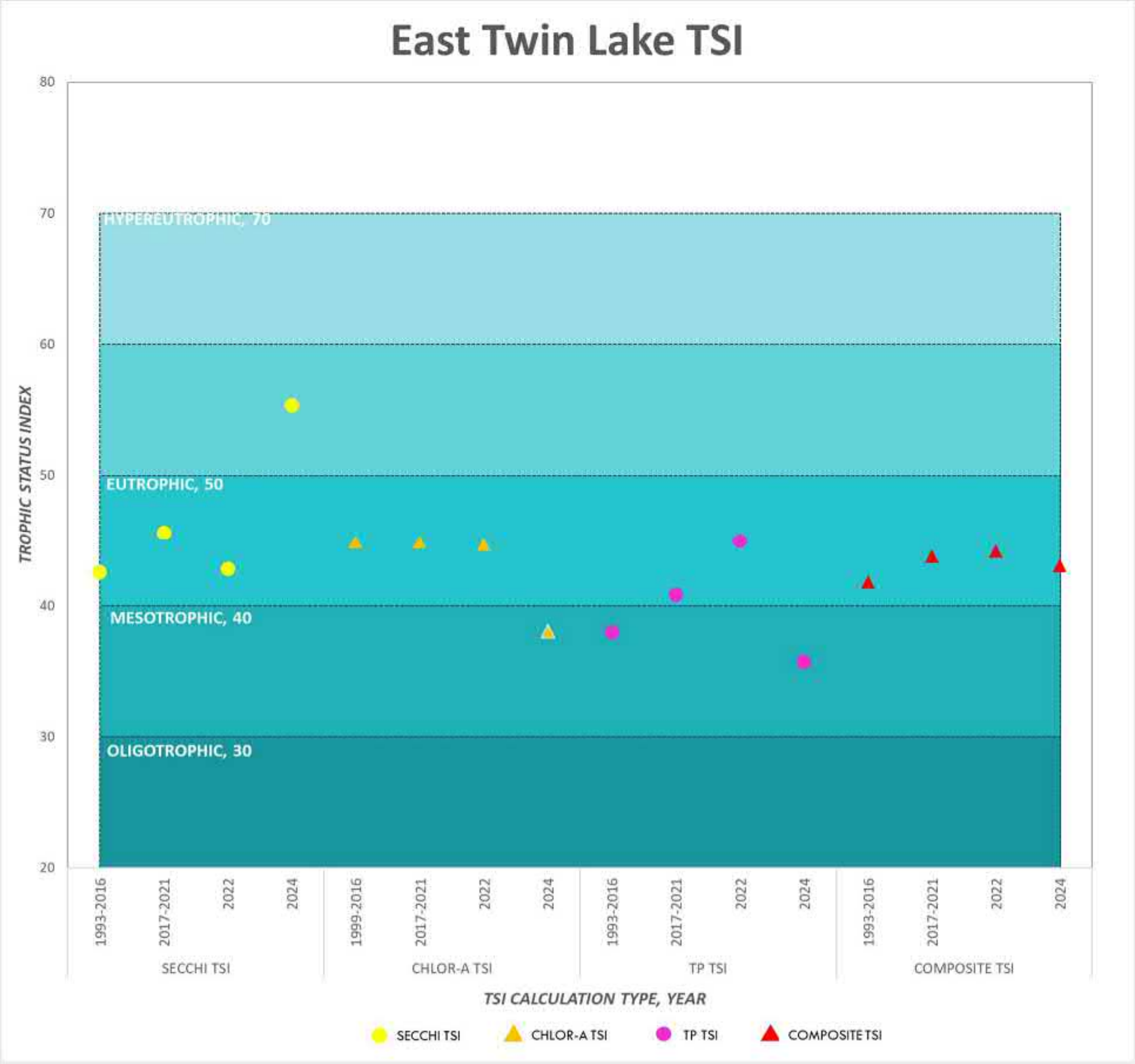

Figure 23 - Trophic status of East Twin Lake over time.

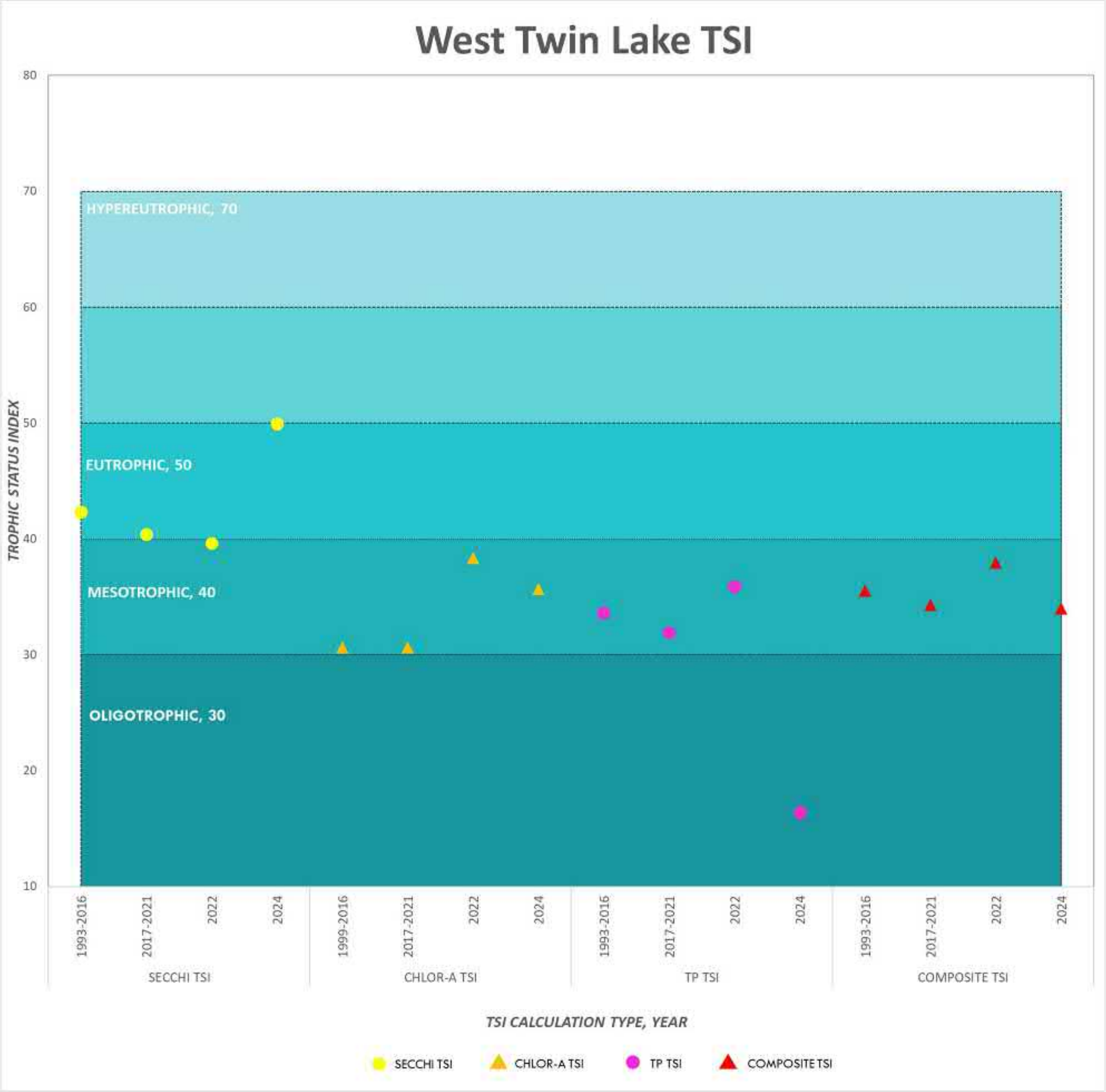

Figure 24 - Trophic status of West Twin Lake over time.

ALGAE ANALYSIS

Algae are a vital component of inland lake ecosystems, playing a critical role in the food web by producing oxygen and serving as the base for many aquatic organisms. Through photosynthesis, algae convert sunlight, carbon dioxide, and water into organic compounds that support a wide range of organisms, including fish and other aquatic species. However, when algae grow excessively, they can create environmental problems, such as unwanted algal blooms.

Harmful algal blooms (HABs) occur when the algae population increases rapidly and becomes concentrated in a particular area. These blooms are typically caused by an overabundance of nutrients, such as nitrogen and phosphorus, often from human activities like agricultural runoff or wastewater discharge. Warm temperatures, calm water conditions, and high nutrient levels all contribute to the formation and growth of HABs in inland lakes. Some species of algae, particularly blue-green algae (cyanobacteria), can produce toxins like microcystins, which pose significant health risks to humans and animals. Microcystins are potent liver toxins that can contaminate water sources, making them unsafe for drinking, recreational activities, and even fishing. Exposure to these toxins can lead to serious health problems, including liver damage or respiratory issues. Therefore, monitoring and controlling algae growth is essential to protect water quality and ensure public safety in inland lakes.

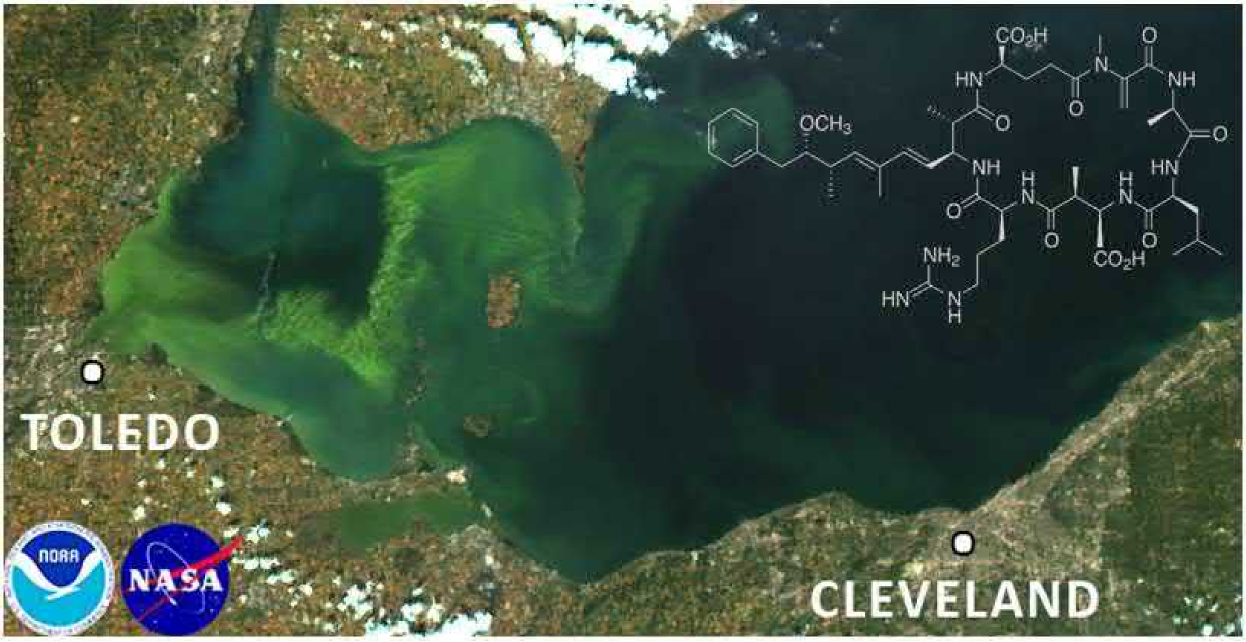

Figure 25 - Algae bloom in western Lake Erie and microcystin variant LR chemical structure. Source: Great Lakes Today

To understand the existing algal community in East Twin Lake, algal identification and enumeration analyses, as well as microcystin testing were performed on 3 samples pulled from ET-1, ET-2, and ET-4. These tests help determine which species of algae are present in the lake at the time of sample collection, and the relative abundance of different types of algae. Microcystin testing is particularly important as it reveals whether toxin-producing algae are present and if the microcystin levels are high enough to pose a risk to human health. By regularly monitoring these factors, lake managers can better understand the algae community and mitigate potential risks associated with harmful algal blooms.

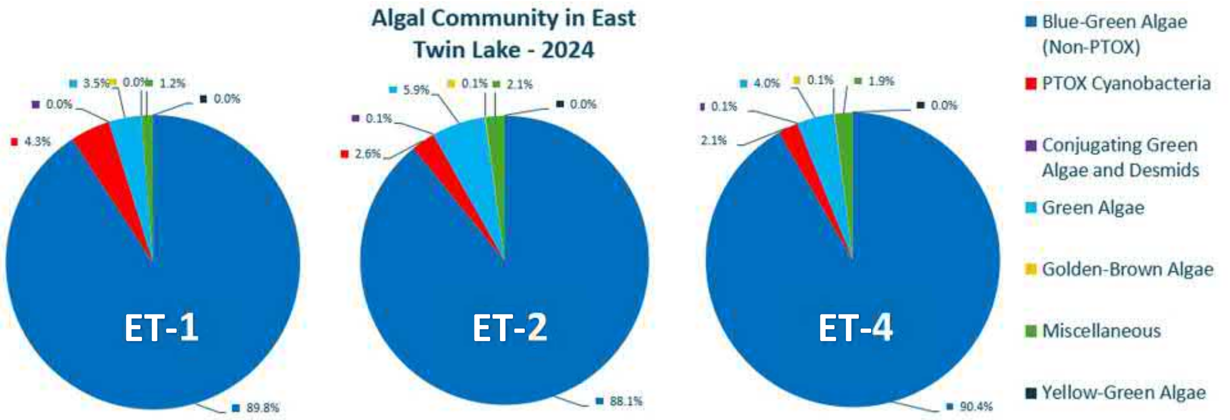

Figure 26 - Algal community in East Twin Lake in 2024 sample event. Samples collected on 10/15/24. Non-PTOX Blue-Green Algae dominate the ecosystem.

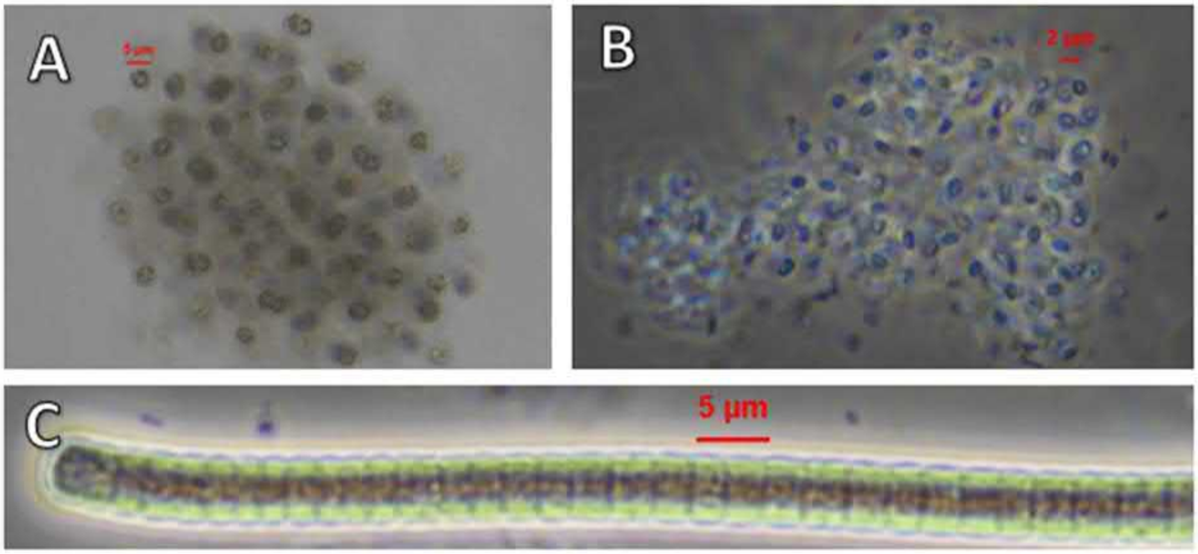

Figure 27 – Examples of algae found in East Twin Lake. (A – Microcystis sp.; B – Anathece sp.; C – Phormidium sp.)

There is a lack of uniformity across state, federal, and international organizations when it comes to determining the "correct" action levels for potentially harmful algae, which may lead to harmful algal blooms (HABs). Different organizations have varying criteria for assessing risks associated with algae, making it challenging to establish consistent guidelines for public safety. In Michigan, the focus is on microcystin concentrations, a toxin produced by certain species of cyanobacteria, rather than on the total concentration of algae. Michigan follows the World Health Organization (WHO) guidelines, which set action levels of 1 µg/L for microcystin in drinking water and 20 µg/L in recreational water. In the case of East Twin Lake, microcystin testing yielded results of "nondetect," meaning that any microcystin concentration in the samples was at or below 0.05 µg/L, indicating no immediate threat to public health based on microcystin levels.

Date	Sample Site Location	Total Microcystins/Nodularins (ng/mL)
WHO Recreational Waters Exposure Value		*20*
10/15/2024	ET-1	ND
	ET-2	ND
	ET-4	ND

Table 5 - Total Microcystin and Nodularin toxin concentrations in East Twin Lake in 2024.

The WHO provides brackets to estimate the probability of acute health problems based on the concentration of cyanobacteria. These brackets classify the risk as low, moderate, or high, with low probability occurring when the cyanobacterial concentration is less than 20,000 cells/mL, moderate risk between 20,000 and 100,000 cells/mL, and high risk above 100,000 cells/mL. At East Twin Lake, the concentration of potentially toxic (PTOX) cyanobacteria ranged from 1,100 to 2,200 cells/mL, which falls within the low-risk category according to WHO guidelines. However, the total concentration of cyanobacteria at the lake ranged from 39,000 to 57,000 cells/mL, which falls into the moderate-risk category. It is important to note that the WHO guidelines do not differentiate between toxin-producing (PTOX) and non-toxin-producing (non-PTOX) cyanobacteria in their risk assessments, potentially overestimating the risk based on total cell concentration.

Although East Twin Lake's total cyanobacterial concentration falls within the moderate-risk category, 95% to 98% of the cyanobacterial community is composed of non-toxin-producing strains. This suggests that the actual risk of harmful algal blooms causing health issues is relatively low. While the presence of blue-green algae indicates that the lake could experience HABs under ideal conditions, the dominance of non-PTOX cyanobacteria significantly reduces the likelihood of a toxic event. We would still recommend that any visible algal blooms in the lake be reported to the Michigan Department of Environment, Great Lakes, and Energy (EGLE) for immediate testing of microcystin concentrations. This will help ensure public safety by providing accurate information about the potential health risks associated with the algae in the water.

SUMMARY AND DISCUSSION

In 2023, the Twin Lakes Property Owners Association initiated an investigation into monitoring options for East and West Twin Lakes after members collecting data for the Cooperative Lakes Monitoring Program observed a downward trend in lake clarity, particularly in East Twin Lake. In response, a targeted sampling program was launched in 2024 to evaluate a range of water quality parameters, including nutrient concentrations, Secchi depth, chloride, total Kjeldahl nitrogen, and dissolved oxygen, with the intention of helping aid in future monitoring and management decisions. Historically, both lakes have exhibited mesotrophic characteristics. The 2024 results show that while East Twin Lake continues to reflect a mesotrophic status, West Twin Lake is trending toward an oligotrophic state. Although an encouraging sign to see the lakes staying on the border between oligotrophic and mesotrophic status, some anomalous readings in key parameters underscore the need for continued monitoring of lake characteristics.

The 2024 sampling campaign provides valuable insights into the current condition and trends of both Twin Lakes. The persistent mesotrophic status of East Twin Lake, indicated by stable nutrient levels and moderate biological productivity, suggests that its ecological character remains relatively unchanged. West Twin Lake's shift toward an oligotrophic state, as evidenced by increased water clarity and lower nutrient indicators, points to a potentially positive development in its water quality. However, the results from some parameters warrant caution. Variations in Secchi depth, chloride, TKN, and especially dissolved oxygen levels suggest that the 2024 data could be either a temporary anomaly or a potential signal of emerging issues. For instance, the notable decline in dissolved oxygen during the fall raises concerns about possible shifts in the lake's biogeochemical cycles that may affect aquatic life. These mixed signals emphasize the importance of continued long-term monitoring to distinguish between short-term variability and systemic change.

Based on the current findings, the following objectives are recommended to ensure sustainable management of East and West Twin Lakes:

ONGOING MONITORING

- Implement a yearly water quality monitoring program that routinely measures nutrient concentrations, water clarity (Secchi depth), chlorophyll-a, and dissolved oxygen.
- Include periodic assessments of the lake's algal biodiversity to better understand ecological dynamics and potential shifts in trophic status.

PHOSPHORUS MANAGEMENT

- Continue exploring methods to minimize phosphorus deposition into the lakes.
- Strategies may include expanding outreach and education programs for homeowners, testing and reducing point source pollution (such as stormwater outfalls), and investigating non-point sources such as degrading or leaking septic systems.

INVESTIGATIVE STUDIES

- If a continued downward trend in water clarity is observed without corresponding increases in algal biomass, additional studies should be conducted.
- Future investigations could focus on the vegetative cover of the lake, sedimentation patterns from erosion, and lake bottom composition to determine if historical activities (such as sawmill operations) are impacting vegetative ecology.
- Assessing the impact of wake and sport boat activity may also be warranted to determine if these factors are adversely affecting lake health.

Overall, the 2024 results provide a cautiously optimistic outlook for both lakes. The variability in certain water quality parameters underscores the necessity for a sustained, adaptive monitoring approach. This will allow for timely identification of emerging issues and the implementation of targeted lake management programs to protect the ecological integrity and recreational value of East and West Twin Lakes.

APPENDIX A

Laboratory Reports

Prein&Newhof
Engineers ▪ Surveyors ▪ Environmental ▪ Laboratory

May 02, 2024

Spicer Group
2464 Byron Station Dr. SW
Suite C
Byron Center, MI 49315

RE: Twin Lakes- Spring 2024

Order No.: 2404J57

Guide to Reading Lab Result

Dear Ehrland Bosworth:

Prein&Newhof Laboratory received 8 sample(s) on 4/30/2024 on your behalf. Your test results are provided in your Prein&Newhof Laboratory analytical report. Please carefully review your analytical report, noting the following.

There were no problems with the analytical events associated with this report unless noted in the Case Narrative.

Any analyte that exceeds the client provided permit level are noted on the report with an "*" in the Qual field. Quality control data is within laboratory defined or method specified acceptance limits except if noted.

When testing for PFHxS, PFOA, PFOS, MeFOSAA, and EtFOSAA results include both branched and linear isotopes. We extract a Method Blank and analyze it with the preparation batch. Method Blank analytes are within the Reporting Limit (RL).

To learn more about interpreting your Lab Report, follow the link above to view our "Guide to Reading Lab Results". If you have any concerns about your test results or need additional help, please call: 616-364-7600 or email me: sbylsma@preinnewhof.com.

We use EPA Approved Methods for all regulated parameters. EPA Lab #: MI000014

Thank you for trusting Prein&Newhof with your testing needs.

Sincerely,

Steve Bylsma
Laboratory Manager

CLIENT:	Spicer Group	**Lab Order:**	2404J57
Project:	Twin Lakes- Spring 2024		

Lab ID:	2404J57-01	**Matrix:**	AQUEOUS	**Collection Date:**	4/29/2024 11:15:00 AM
Client ID:	ET-1	**Sampler:**	E. Bosworth	**Received Date:**	4/30/2024 9:32:00 AM

Analyses	**Result**	**RL**	**Qual**	**Units**	**DF**	**Date Analyzed**
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	2.31	0.800		mg/m³	1	4/30/2024 2:00:12 PM
Pheophytin A	ND	0.800		mg/m³	1	4/30/2024 2:00:12 PM

Lab ID:	2404J57-02	**Matrix:**	AQUEOUS	**Collection Date:**	4/29/2024 11:27:00 AM
Client ID:	ET-2	**Sampler:**	E. Bosworth	**Received Date:**	4/30/2024 9:32:00 AM

Analyses	**Result**	**RL**	**Qual**	**Units**	**DF**	**Date Analyzed**
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	1.84	0.800		mg/m³	1	4/30/2024 2:00:12 PM
Pheophytin A	ND	0.800		mg/m³	1	4/30/2024 2:00:12 PM

Lab ID:	2404J57-03	**Matrix:**	AQUEOUS	**Collection Date:**	4/29/2024 11:03:00 AM
Client ID:	ET-3	**Sampler:**	E. Bosworth	**Received Date:**	4/30/2024 9:32:00 AM

Analyses	**Result**	**RL**	**Qual**	**Units**	**DF**	**Date Analyzed**
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	2.99	0.800		mg/m³	1	4/30/2024 2:00:12 PM
Pheophytin A	ND	0.800		mg/m³	1	4/30/2024 2:00:12 PM

Lab ID:	2404J57-04	**Matrix:**	AQUEOUS	**Collection Date:**	4/29/2024 10:50:00 AM
Client ID:	ET-4	**Sampler:**	E. Bosworth	**Received Date:**	4/30/2024 9:32:00 AM

Analyses	**Result**	**RL**	**Qual**	**Units**	**DF**	**Date Analyzed**
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	2.54	0.800		mg/m³	1	4/30/2024 2:00:12 PM
Pheophytin A	ND	0.800		mg/m³	1	4/30/2024 2:00:12 PM

Qualifiers:

<	Not Detected at the Reporting Limit	H	Holding times for preparation or analysis exceeded
MCL	Maximum Contaminant Level	PL	Permit Limit
RL	Reporting Limit		

Original

CLIENT: Spicer Group **Lab Order:** 2404J57
Project: Twin Lakes- Spring 2024

Lab ID: 2404J57-05 **Matrix:** AQUEOUS **Collection Date:** 4/29/2024 11:36:00 AM
Client ID: ET-5 **Sampler:** E. Bosworth **Received Date:** 4/30/2024 9:32:00 AM

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	2.65	0.800		mg/m³	1	4/30/2024 2:00:12 PM
Pheophytin A	ND	0.800		mg/m³	1	4/30/2024 2:00:12 PM

Lab ID: 2404J57-06 **Matrix:** AQUEOUS **Collection Date:** 4/29/2024 12:43:00 PM
Client ID: WT-1 **Sampler:** E. Bosworth **Received Date:** 4/30/2024 9:32:00 AM

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	1.82	0.800		mg/m³	1	4/30/2024 2:00:12 PM
Pheophytin A	1.23	0.800		mg/m³	1	4/30/2024 2:00:12 PM

Lab ID: 2404J57-07 **Matrix:** AQUEOUS **Collection Date:** 4/29/2024 12:08:00 PM
Client ID: WT-2 **Sampler:** E. Bosworth **Received Date:** 4/30/2024 9:32:00 AM

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	2.73	0.800		mg/m³	1	4/30/2024 2:00:12 PM
Pheophytin A	ND	0.800		mg/m³	1	4/30/2024 2:00:12 PM

Lab ID: 2404J57-08 **Matrix:** AQUEOUS **Collection Date:** 4/29/2024 12:25:00 PM
Client ID: Outlet **Sampler:** E. Bosworth **Received Date:** 4/30/2024 9:32:00 AM

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	2.37	0.800		mg/m³	1	4/30/2024 2:00:12 PM
Pheophytin A	0.948	0.800		mg/m³	1	4/30/2024 2:00:12 PM

Qualifiers:

<	Not Detected at the Reporting Limit	H	Holding times for preparation or analysis exceeded
MCL	Maximum Contaminant Level	PL	Permit Limit
RL	Reporting Limit		

Prein&Newhof
Engineers ▪ Surveyors ▪ Environmental ▪ Laboratory

3260 Evergreen Drive, NE
Grand Rapids, MI 49525
t. 616-364-7600
f. 616-364-6955

CHAIN OF CUSTODY

Client Name: SPICER GROUP
Billing Address: 2464 BYRON STATION DR SW
BYRON CENTER, MI 49315
Phone Number: (269) 744-1364
Email Report to: EHELAND.BOSWORTH@SPICERGROUP.COM
Email Invoice to: C5GIBBINGS@GMAIL.com (additional)
Project Name: TWIN LAKES- SPRING 2024
Project Number:
Sampling Personnel: EHELAND BOSWORTH

Wastewater	W
Drinking Water	D
Groundwater	G
Soil	S
Sludge	L
Other	X

No. 53727

LAB USE	Sample Information				Preservative						Analysis Requested												
Lab Sample ID #	Date Collected	Time Collected	Sample Description and Location (e.g. MW-1)	MATRIX	None	H2SO4	HNO3	HCL	NaOH	Other	CHLOR-A												
4j571	4/29/24	11^{15}	ET-1	SW	X																		
2	↓	11^{27}	ET-2	↓	↓						↓												
3	↓	11^{03}	ET-3	↓	↓						↓												
4	↓	10^{50}	ET-4	↓	↓						↓												
5	↓	11^{36}	ET-5	↓	↓						↓												
6	↓	12^{43}	WT-1	↓	↓						↓												
7	↓	12^{08}	WT-2	↓	↓						↓												
8	↓	12^{25}	OUTLET	↓	↓						↓												

Comments: bottles received are clear, plastic bottles AEB 4/30/24 2°C

Relinquished By: (Signature)	Date	Time	Received By: (Signature)	Date	Time
	4/30/24	932			

Relinquished By: (Signature)	Date	Time	Received for Laboratory By: (Signature)	Date	Time
				4/30/24	9:32 AM

08-May-2024

Ehrland Bosworth
Spicer Group
2464 Byron Station Dr SW
Suite C
Byron Center, MI 49315

Re: **Twin Lakes - Spring 2024** Work Order: **24042031**

Dear Ehrland,

ALS Environmental received 8 samples on 30-Apr-2024 08:35 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 25.

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,

Electronically approved by: Chad Whelton

Chad Whelton
Project Manager

Report of Laboratory Analysis

Certificate No: FL E871106

ALS Group, USA

Date: 08-May-24

Client: Spicer Group
Project: Twin Lakes - Spring 2024
Work Order: **24042031**

Work Order Sample Summary

Lab Samp ID	Client Sample ID	Matrix	Tag Number	Collection Date	Date Received	Hold
24042031-01	ET-1	Surface Water		4/29/2024 11:15	4/30/2024 08:35	☐
24042031-02	ET-2	Surface Water		4/29/2024 11:27	4/30/2024 08:35	☐
24042031-03	ET-3	Surface Water		4/29/2024 11:03	4/30/2024 08:35	☐
24042031-04	ET-4	Surface Water		4/29/2024 10:50	4/30/2024 08:35	☐
24042031-05	ET-5	Surface Water		4/29/2024 11:36	4/30/2024 08:35	☐
24042031-06	WT-1	Surface Water		4/29/2024 12:43	4/30/2024 08:35	☐
24042031-07	WT-2	Surface Water		4/29/2024 12:08	4/30/2024 08:35	☐
24042031-08	Outlet	Surface Water		4/29/2024 12:25	4/30/2024 08:35	☐

Client: Spicer Group
Project: Twin Lakes - Spring 2024
Work Order: 24042031

Case Narrative

Samples for the above noted Work Order were received on 04/30/2024. 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.

Wet Chemistry:

Batch R402970b, Method E365.1 R2.0, Sample 24042031-01D MSD: The MSD recovery was outside of the control limit. However, the MS recovery and the RPD between the MS and MSD was in control. No qualification is required for this analyte: Phosphorus, Total.

ALS Group, USA

Date: 08-May-24

Client: Spicer Group
Project: Twin Lakes - Spring 2024
WorkOrder: **24042031**

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
mg NH3-N/L	Milligrams Ammonia-Nitrogen per Liter
mg/L	Milligrams per Liter

Client: Spicer Group
Project: Twin Lakes - Spring 2024 **Work Order:** 24042031
Sample ID: ET-1 **Lab ID:** 24042031-01
Collection Date: 4/29/2024 11:15 AM **Matrix:** SURFACE WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**SW9056A**			Analyst: **CLJ**
Chloride	**48.2**		**4.0**	**mg/L**	4	5/1/2024 01:30 PM
Nitrogen, Nitrate	**0.0899**	J	**0.10**	**mg/L**	1	4/30/2024 06:50 PM
Nitrogen, Nitrite	U		0.10	mg/L	1	4/30/2024 06:50 PM
NITROGEN, TOTAL			**CALCULATION**			Analyst: **RZM**
Nitrogen, Total	**1.3**		**1.0**	**mg/L**	1	5/3/2024 09:12 AM
AMMONIA AS NITROGEN			**E350.1 R2.0**			Analyst: **JMT**
Ammonia as Nitrogen	**0.51**		**0.020**	**mg NH3-N/L**	1	5/3/2024 11:27 AM
PHOSPHORUS, TOTAL			**E365.1 R2.0**			Analyst: **EE**
Phosphorus, Total	U		0.050	mg/L	1	5/2/2024 10:14 PM
PHOSPHORUS, ORTHO-P (AS P)			**E365.1**			Analyst: **JMT**
Phosphorus, Ortho-P (As P)	U		0.050	mg/L	1	5/1/2024 08:49 AM
NITROGEN, TOTAL KJELDAHL			**A4500-NH3 G-11**		Prep: A4500-N B 5/1/24 12:53	Analyst: **JMT**
Nitrogen, Total Kjeldahl	**1.2**		**1.0**	**mg/L**	1	5/2/2024 12:59 PM
TOTAL SUSPENDED SOLIDS			**A2540 D-15**		Prep: FILTER 5/2/24 14:20	Analyst: **SRN**
Total Suspended Solids	**2.40**		**1.2**	**mg/L**	1	5/3/2024 02:31 PM

Note: See Qualifiers page for a list of qualifiers and their definitions.

Client: Spicer Group
Project: Twin Lakes - Spring 2024 **Work Order:** 24042031
Sample ID: ET-2 **Lab ID:** 24042031-02
Collection Date: 4/29/2024 11:27 AM **Matrix:** SURFACE WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**SW9056A**			Analyst: **CLJ**
Chloride	**47.0**		**4.0**	**mg/L**	4	5/1/2024 01:40 PM
Nitrogen, Nitrate	**0.0935**	J	**0.10**	**mg/L**	1	4/30/2024 07:19 PM
Nitrogen, Nitrite	U		0.10	mg/L	1	4/30/2024 07:19 PM
NITROGEN, TOTAL			**CALCULATION**			Analyst: **RZM**
Nitrogen, Total	**1.4**		**1.0**	**mg/L**	1	5/3/2024 09:12 AM
AMMONIA AS NITROGEN			**E350.1 R2.0**			Analyst: **JMT**
Ammonia as Nitrogen	**0.51**		**0.020**	**mg NH3-N/L**	1	5/3/2024 11:31 AM
PHOSPHORUS, TOTAL			**E365.1 R2.0**			Analyst: **EE**
Phosphorus, Total	**0.056**		**0.050**	**mg/L**	1	5/2/2024 10:26 PM
PHOSPHORUS, ORTHO-P (AS P)			**E365.1**			Analyst: **JMT**
Phosphorus, Ortho-P (As P)	U		0.050	mg/L	1	5/1/2024 08:52 AM
NITROGEN, TOTAL KJELDAHL			**A4500-NH3 G-11**		Prep: A4500-N B 5/1/24 12:53	Analyst: **JMT**
Nitrogen, Total Kjeldahl	**1.3**		**1.0**	**mg/L**	1	5/2/2024 01:00 PM
TOTAL SUSPENDED SOLIDS			**A2540 D-15**		Prep: FILTER 5/2/24 14:20	Analyst: **SRN**
Total Suspended Solids	**4.20**		**1.2**	**mg/L**	1	5/3/2024 02:31 PM

Note: See Qualifiers page for a list of qualifiers and their definitions.

Client: Spicer Group

Project: Twin Lakes - Spring 2024 **Work Order:** 24042031

Sample ID: ET-3 **Lab ID:** 24042031-03

Collection Date: 4/29/2024 11:03 AM **Matrix:** SURFACE WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**SW9056A**			Analyst: **CLJ**
Chloride	**56.7**		**4.0**	**mg/L**	4	5/1/2024 01:50 PM
Nitrogen, Nitrate	**0.123**		**0.10**	**mg/L**	1	4/30/2024 07:29 PM
Nitrogen, Nitrite	U		0.10	mg/L	1	4/30/2024 07:29 PM
NITROGEN, TOTAL			**CALCULATION**			Analyst: **RZM**
Nitrogen, Total	**1.3**		**1.0**	**mg/L**	1	5/3/2024 09:12 AM
AMMONIA AS NITROGEN			**E350.1 R2.0**			Analyst: **JMT**
Ammonia as Nitrogen	**0.52**		**0.020**	**mg NH3-N/L**	1	5/3/2024 11:32 AM
PHOSPHORUS, TOTAL			**E365.1 R2.0**			Analyst: **EE**
Phosphorus, Total	U		0.050	mg/L	1	5/2/2024 10:31 PM
PHOSPHORUS, ORTHO-P (AS P)			**E365.1**			Analyst: **JMT**
Phosphorus, Ortho-P (As P)	U		0.050	mg/L	1	5/1/2024 08:53 AM
NITROGEN, TOTAL KJELDAHL			**A4500-NH3 G-11**	Prep: A4500-N B 5/1/24 12:53		Analyst: **JMT**
Nitrogen, Total Kjeldahl	**1.2**		**1.0**	**mg/L**	1	5/2/2024 01:01 PM
TOTAL SUSPENDED SOLIDS			**A2540 D-15**	Prep: FILTER 5/2/24 14:20		Analyst: **SRN**
Total Suspended Solids	**3.60**		**1.2**	**mg/L**	1	5/3/2024 02:31 PM

Note: See Qualifiers page for a list of qualifiers and their definitions.

Client: Spicer Group
Project: Twin Lakes - Spring 2024 **Work Order:** 24042031
Sample ID: ET-4 **Lab ID:** 24042031-04
Collection Date: 4/29/2024 10:50 AM **Matrix:** SURFACE WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**SW9056A**			Analyst: **CLJ**
Chloride	**30.9**		**4.0**	**mg/L**	4	5/1/2024 01:59 PM
Nitrogen, Nitrate	**0.0739**	J	**0.10**	**mg/L**	1	4/30/2024 07:39 PM
Nitrogen, Nitrite	U		0.10	mg/L	1	4/30/2024 07:39 PM
NITROGEN, TOTAL			**CALCULATION**			Analyst: **RZM**
Nitrogen, Total	**1.4**		**1.0**	**mg/L**	1	5/3/2024 09:12 AM
AMMONIA AS NITROGEN			**E350.1 R2.0**			Analyst: **JMT**
Ammonia as Nitrogen	**0.51**		**0.020**	**mg NH3-N/L**	1	5/3/2024 11:33 AM
PHOSPHORUS, TOTAL			**E365.1 R2.0**			Analyst: **EE**
Phosphorus, Total	U		0.050	mg/L	1	5/2/2024 10:35 PM
PHOSPHORUS, ORTHO-P (AS P)			**E365.1**			Analyst: **JMT**
Phosphorus, Ortho-P (As P)	U		0.050	mg/L	1	5/1/2024 08:55 AM
NITROGEN, TOTAL KJELDAHL			**A4500-NH3 G-11**		Prep: A4500-N B 5/1/24 12:56	Analyst: **JMT**
Nitrogen, Total Kjeldahl	**1.3**		**1.0**	**mg/L**	1	5/2/2024 01:06 PM
TOTAL SUSPENDED SOLIDS			**A2540 D-15**		Prep: FILTER 5/2/24 14:20	Analyst: **SRN**
Total Suspended Solids	**6.80**		**1.2**	**mg/L**	1	5/3/2024 02:31 PM

Note: See Qualifiers page for a list of qualifiers and their definitions.

Client: Spicer Group
Project: Twin Lakes - Spring 2024 **Work Order:** 24042031
Sample ID: ET-5 **Lab ID:** 24042031-05
Collection Date: 4/29/2024 11:36 AM **Matrix:** SURFACE WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**SW9056A**			Analyst: **CLJ**
Chloride	**26.5**		**4.0**	**mg/L**	4	5/1/2024 02:09 PM
Nitrogen, Nitrate	**0.0910**	J	**0.10**	**mg/L**	1	4/30/2024 07:49 PM
Nitrogen, Nitrite	U		0.10	mg/L	1	4/30/2024 07:49 PM
NITROGEN, TOTAL			**CALCULATION**			Analyst: **RZM**
Nitrogen, Total	**1.4**		**1.0**	**mg/L**	1	5/3/2024 09:12 AM
AMMONIA AS NITROGEN			**E350.1 R2.0**			Analyst: **JMT**
Ammonia as Nitrogen	**0.51**		**0.020**	**mg NH3-N/L**	1	5/3/2024 11:34 AM
PHOSPHORUS, TOTAL			**E365.1 R2.0**			Analyst: **EE**
Phosphorus, Total	U		0.050	mg/L	1	5/2/2024 10:57 PM
PHOSPHORUS, ORTHO-P (AS P)			**E365.1**			Analyst: **JMT**
Phosphorus, Ortho-P (As P)	U		0.050	mg/L	1	5/1/2024 08:56 AM
NITROGEN, TOTAL KJELDAHL			**A4500-NH3 G-11**		Prep: A4500-N B 5/1/24 12:56	Analyst: **JMT**
Nitrogen, Total Kjeldahl	**1.3**		**1.0**	**mg/L**	1	5/2/2024 01:12 PM
TOTAL SUSPENDED SOLIDS			**A2540 D-15**		Prep: FILTER 5/2/24 14:20	Analyst: **SRN**
Total Suspended Solids	**8.00**		**1.2**	**mg/L**	1	5/3/2024 02:31 PM

Note: See Qualifiers page for a list of qualifiers and their definitions.

Client: Spicer Group
Project: Twin Lakes - Spring 2024 **Work Order:** 24042031
Sample ID: WT-1 **Lab ID:** 24042031-06
Collection Date: 4/29/2024 12:43 PM **Matrix:** SURFACE WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**SW9056A**			Analyst: **CLJ**
Chloride	**12.9**		**1.0**	**mg/L**	1	4/30/2024 07:58 PM
Nitrogen, Nitrate	**0.0627**	J	**0.10**	**mg/L**	1	4/30/2024 07:58 PM
Nitrogen, Nitrite	U		0.10	mg/L	1	4/30/2024 07:58 PM
NITROGEN, TOTAL			**CALCULATION**			Analyst: **RZM**
Nitrogen, Total	**0.063**	J	**1.0**	**mg/L**	1	5/3/2024 09:12 AM
AMMONIA AS NITROGEN			**E350.1 R2.0**			Analyst: **JMT**
Ammonia as Nitrogen	**0.20**		**0.020**	**mg NH3-N/L**	1	5/3/2024 11:35 AM
PHOSPHORUS, TOTAL			**E365.1 R2.0**			Analyst: **EE**
Phosphorus, Total	U		0.050	mg/L	1	5/2/2024 11:00 PM
PHOSPHORUS, ORTHO-P (AS P)			**E365.1**			Analyst: **JMT**
Phosphorus, Ortho-P (As P)	U		0.050	mg/L	1	5/1/2024 08:57 AM
NITROGEN, TOTAL KJELDAHL			**A4500-NH3 G-11**		Prep: A4500-N B 5/1/24 12:56	Analyst: **JMT**
Nitrogen, Total Kjeldahl	U		1.0	mg/L	1	5/2/2024 01:13 PM
TOTAL SUSPENDED SOLIDS			**A2540 D-15**		Prep: FILTER 5/2/24 14:20	Analyst: **SRN**
Total Suspended Solids	**1.80**		**1.2**	**mg/L**	1	5/3/2024 02:31 PM

Note: See Qualifiers page for a list of qualifiers and their definitions.

Client: Spicer Group
Project: Twin Lakes - Spring 2024 **Work Order:** 24042031
Sample ID: WT-2 **Lab ID:** 24042031-07
Collection Date: 4/29/2024 12:08 PM **Matrix:** SURFACE WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**SW9056A**			Analyst: **CLJ**
Chloride	**12.9**		**1.0**	**mg/L**	1	4/30/2024 08:08 PM
Nitrogen, Nitrate	**0.0691**	J	**0.10**	**mg/L**	1	4/30/2024 08:08 PM
Nitrogen, Nitrite	U		0.10	mg/L	1	4/30/2024 08:08 PM
NITROGEN, TOTAL			**CALCULATION**			Analyst: **RZM**
Nitrogen, Total	**0.069**	J	**1.0**	**mg/L**	1	5/3/2024 09:12 AM
AMMONIA AS NITROGEN			**E350.1 R2.0**			Analyst: **JMT**
Ammonia as Nitrogen	**0.20**		**0.020**	**mg NH3-N/L**	1	5/3/2024 11:37 AM
PHOSPHORUS, TOTAL			**E365.1 R2.0**			Analyst: **EE**
Phosphorus, Total	U		0.050	mg/L	1	5/2/2024 11:04 PM
PHOSPHORUS, ORTHO-P (AS P)			**E365.1**			Analyst: **JMT**
Phosphorus, Ortho-P (As P)	U		0.050	mg/L	1	5/1/2024 09:00 AM
NITROGEN, TOTAL KJELDAHL			**A4500-NH3 G-11**		Prep: A4500-N B 5/1/24 12:56	Analyst: **JMT**
Nitrogen, Total Kjeldahl	U		1.0	mg/L	1	5/2/2024 01:14 PM
TOTAL SUSPENDED SOLIDS			**A2540 D-15**		Prep: FILTER 5/2/24 14:20	Analyst: **SRN**
Total Suspended Solids	**3.60**		**1.2**	**mg/L**	1	5/3/2024 02:31 PM

Note: See Qualifiers page for a list of qualifiers and their definitions.

Client: Spicer Group
Project: Twin Lakes - Spring 2024 **Work Order:** 24042031
Sample ID: Outlet **Lab ID:** 24042031-08
Collection Date: 4/29/2024 12:25 PM **Matrix:** SURFACE WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**SW9056A**			Analyst: **CLJ**
Chloride	**12.7**		**1.0**	**mg/L**	1	4/30/2024 08:18 PM
Nitrogen, Nitrate	**0.0655**	J	**0.10**	**mg/L**	1	4/30/2024 08:18 PM
Nitrogen, Nitrite	U		0.10	mg/L	1	4/30/2024 08:18 PM
NITROGEN, TOTAL			**CALCULATION**			Analyst: **RZM**
Nitrogen, Total	**0.066**	J	**1.0**	**mg/L**	1	5/3/2024 09:12 AM
AMMONIA AS NITROGEN			**E350.1 R2.0**			Analyst: **JMT**
Ammonia as Nitrogen	**0.18**		**0.020**	**mg NH3-N/L**	1	5/3/2024 11:38 AM
PHOSPHORUS, TOTAL			**E365.1 R2.0**			Analyst: **EE**
Phosphorus, Total	U		0.050	mg/L	1	5/2/2024 11:08 PM
PHOSPHORUS, ORTHO-P (AS P)			**E365.1**			Analyst: **JMT**
Phosphorus, Ortho-P (As P)	U		0.050	mg/L	1	5/1/2024 09:01 AM
NITROGEN, TOTAL KJELDAHL			**A4500-NH3 G-11**		Prep: A4500-N B 5/1/24 12:56	Analyst: **JMT**
Nitrogen, Total Kjeldahl	U		1.0	mg/L	1	5/2/2024 01:16 PM
TOTAL SUSPENDED SOLIDS			**A2540 D-15**		Prep: FILTER 5/2/24 14:20	Analyst: **SRN**
Total Suspended Solids	**4.40**		**1.2**	**mg/L**	1	5/3/2024 02:31 PM

Note: See Qualifiers page for a list of qualifiers and their definitions.

QC BATCH REPORT

Client: Spicer Group
Work Order: 24042031
Project: Twin Lakes - Spring 2024

Batch ID: **239395** Instrument ID **LACHAT2** Method: **A4500-NH3 G-11**

MBLK Sample ID: **MBLK-239395-239395** Units: **mg/L** Analysis Date: **5/2/2024 12:23 PM**
Client ID: Run ID: **LACHAT2_240502A** SeqNo: **10720445** Prep Date: **5/1/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	U	1.0								

LCS Sample ID: **LCS-239395-239395** Units: **mg/L** Analysis Date: **5/2/2024 12:24 PM**
Client ID: Run ID: **LACHAT2_240502A** SeqNo: **10720446** Prep Date: **5/1/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	9.202	1.0	10	0	92	76-132	0			

LCS Sample ID: **LCS2-239395-239395** Units: **mg/L** Analysis Date: **5/2/2024 12:27 PM**
Client ID: Run ID: **LACHAT2_240502A** SeqNo: **10720449** Prep Date: **5/1/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	9.443	1.0	10	0	94.4	76-132	0			

MS Sample ID: **24041717-01C MS** Units: **mg/L** Analysis Date: **5/2/2024 12:30 PM**
Client ID: Run ID: **LACHAT2_240502A** SeqNo: **10720451** Prep Date: **5/1/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	14.16	1.0	10	3.794	104	68-130	0			

MS Sample ID: **24041970-01B MS** Units: **mg/L** Analysis Date: **5/2/2024 12:47 PM**
Client ID: Run ID: **LACHAT2_240502A** SeqNo: **10720465** Prep Date: **5/1/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	11.7	1.0	10	1.107	106	68-130	0			

MSD Sample ID: **24041717-01C MSD** Units: **mg/L** Analysis Date: **5/2/2024 12:31 PM**
Client ID: Run ID: **LACHAT2_240502A** SeqNo: **10720452** Prep Date: **5/1/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	14.38	1.0	10	3.794	106	68-130	14.16	1.54	15	

MSD Sample ID: **24041970-01B MSD** Units: **mg/L** Analysis Date: **5/2/2024 12:48 PM**
Client ID: Run ID: **LACHAT2_240502A** SeqNo: **10720466** Prep Date: **5/1/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	11.22	1.0	10	1.107	101	68-130	11.7	4.19	15	

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Batch ID: **239395** Instrument ID **LACHAT2** Method: **A4500-NH3 G-11**

The following samples were analyzed in this batch:			
	24042031-01D	24042031-02D	24042031-03D

Batch ID: **239396** Instrument ID **LACHAT2** Method: **A4500-NH3 G-11**

MBLK Sample ID: **MBLK-239396-239396** Units: **mg/L** Analysis Date: **5/2/2024 01:02 PM**
Client ID: Run ID: **LACHAT2_240502A** SeqNo: **10720478** Prep Date: **5/1/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	U	1.0								

LCS Sample ID: **LCS-239396-239396** Units: **mg/L** Analysis Date: **5/2/2024 01:04 PM**
Client ID: Run ID: **LACHAT2_240502A** SeqNo: **10720479** Prep Date: **5/1/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	9.431	1.0	10	0	94.3	76-132	0			

LCS Sample ID: **LCS2-239396-239396** Units: **mg/L** Analysis Date: **5/2/2024 01:05 PM**
Client ID: Run ID: **LACHAT2_240502A** SeqNo: **10720480** Prep Date: **5/1/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	9.022	1.0	10	0	90.2	76-132	0			

MS Sample ID: **24042031-04D MS** Units: **mg/L** Analysis Date: **5/2/2024 01:07 PM**
Client ID: **ET-4** Run ID: **LACHAT2_240502A** SeqNo: **10720482** Prep Date: **5/1/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	11.93	1.0	10	1.312	106	68-130	0			

MS Sample ID: **24041900-01C MS** Units: **mg/L** Analysis Date: **5/2/2024 01:51 PM**
Client ID: Run ID: **LACHAT2_240502A** SeqNo: **10720518** Prep Date: **5/1/2024** DF: **5**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	49.8	5.0	10	48.46	13.4	68-130	0			SO

MSD Sample ID: **24042031-04D MSD** Units: **mg/L** Analysis Date: **5/2/2024 01:11 PM**
Client ID: **ET-4** Run ID: **LACHAT2_240502A** SeqNo: **10720485** Prep Date: **5/1/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	11.86	1.0	10	1.312	105	68-130	11.93	0.588	15	

MSD Sample ID: **24041900-01C MSD** Units: **mg/L** Analysis Date: **5/2/2024 01:54 PM**
Client ID: Run ID: **LACHAT2_240502A** SeqNo: **10720521** Prep Date: **5/1/2024** DF: **5**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	49.66	5.0	10	48.46	12	68-130	49.8	0.271	15	SO

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Client: Spicer Group
Work Order: 24042031
Project: Twin Lakes - Spring 2024

QC BATCH REPORT

Batch ID: **239396** Instrument ID **LACHAT2** Method: **A4500-NH3 G-11**

The following samples were analyzed in this batch:

24042031-04D	24042031-05D	24042031-06D
24042031-07D	24042031-08D	

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Client: Spicer Group
Work Order: 24042031
Project: Twin Lakes - Spring 2024

QC BATCH REPORT

Batch ID: **239481** Instrument ID **TSS** Method: **A2540 D-15**

MBLK Sample ID: **MBLK-239481-239481** Units: **mg/L** Analysis Date: **5/3/2024 02:31 PM**
Client ID: Run ID: **TSS_240503A** SeqNo: **10726264** Prep Date: **5/2/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Total Suspended Solids	U	0.60								

LCS Sample ID: **LCS-239481-239481** Units: **mg/L** Analysis Date: **5/3/2024 02:31 PM**
Client ID: Run ID: **TSS_240503A** SeqNo: **10726263** Prep Date: **5/2/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Total Suspended Solids	107	6.0	100	0	107	75-111	0			

DUP Sample ID: **24042064-01E DUP** Units: **mg/L** Analysis Date: **5/3/2024 02:31 PM**
Client ID: Run ID: **TSS_240503A** SeqNo: **10726256** Prep Date: **5/2/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Total Suspended Solids	35.5	3.0	0	0	0	0-0	34.5	2.86	10	

DUP Sample ID: **24042090-02A DUP** Units: **mg/L** Analysis Date: **5/3/2024 02:31 PM**
Client ID: Run ID: **TSS_240503A** SeqNo: **10726262** Prep Date: **5/2/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Total Suspended Solids	9.5	3.0	0	0	0	0-0	10	5.13	10	

The following samples were analyzed in this batch:

24042031-01A 24042031-02A 24042031-03A
24042031-04A 24042031-05A 24042031-06A
24042031-07A 24042031-08A

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

QC BATCH REPORT

Batch ID: **R402781C** Instrument ID **IC4** Method: **SW9056A**

MBLK Sample ID: **MBLK-R402781C** Units: **mg/L** Analysis Date: **4/30/2024 05:13 PM**

Client ID: Run ID: **IC4_240430A** SeqNo: **10712713** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Chloride	U	1.0								
Nitrogen, Nitrate	U	0.10								
Nitrogen, Nitrite	U	0.10								

LCS Sample ID: **LCS-R402781C** Units: **mg/L** Analysis Date: **4/30/2024 05:03 PM**

Client ID: Run ID: **IC4_240430A** SeqNo: **10712712** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Chloride	9.508	1.0	10	0	95.1	88-110	0			
Nitrogen, Nitrate	1.963	0.10	2	0	98.1	90-110	0			
Nitrogen, Nitrite	1.916	0.10	2	0	95.8	89-113	0			

MS Sample ID: **24041999-01F MS** Units: **mg/L** Analysis Date: **4/30/2024 05:52 PM**

Client ID: Run ID: **IC4_240430A** SeqNo: **10712718** Prep Date: DF: **160**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Chloride	1791	160	1600	404.8	86.6	88-110	0			S
Nitrogen, Nitrate	312.3	16	320	0	97.6	90-110	0			H
Nitrogen, Nitrite	307.3	16	320	0	96	89-113	0			H

MSD Sample ID: **24041999-01F MSD** Units: **mg/L** Analysis Date: **4/30/2024 06:02 PM**

Client ID: Run ID: **IC4_240430A** SeqNo: **10712719** Prep Date: DF: **160**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Chloride	1821	160	1600	404.8	88.5	88-110	1791	1.66	15	
Nitrogen, Nitrate	316.6	16	320	0	99	90-110	312.3	1.38	15	H
Nitrogen, Nitrite	312	16	320	0	97.5	89-113	307.3	1.51	15	H

The following samples were analyzed in this batch:

24042031-01B	24042031-02B	24042031-03B
24042031-04B	24042031-05B	24042031-06B
24042031-07B	24042031-08B	

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Client: Spicer Group
Work Order: 24042031
Project: Twin Lakes - Spring 2024

QC BATCH REPORT

Batch ID: **R402784** Instrument ID **LACHAT2** Method: **E365.1**

MBLK Sample ID: **MBLK-R402784** Units: **mg/L** Analysis Date: **5/1/2024 08:47 AM**
Client ID: Run ID: **LACHAT2_240501A** SeqNo: **10713149** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Ortho-P (As P)	U	0.050								

LCS Sample ID: **LCS-R402784** Units: **mg/L** Analysis Date: **5/1/2024 08:48 AM**
Client ID: Run ID: **LACHAT2_240501A** SeqNo: **10713150** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Ortho-P (As P)	1.032	0.050	1	0	103	90-110	0			

MS Sample ID: **24042031-01C MS** Units: **mg/L** Analysis Date: **5/1/2024 08:50 AM**
Client ID: **ET-1** Run ID: **LACHAT2_240501A** SeqNo: **10713152** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Ortho-P (As P)	0.9841	0.050	1	0.01452	97	90-110	0			

MSD Sample ID: **24042031-01C MSD** Units: **mg/L** Analysis Date: **5/1/2024 08:51 AM**
Client ID: **ET-1** Run ID: **LACHAT2_240501A** SeqNo: **10713153** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Ortho-P (As P)	0.992	0.050	1	0.01452	97.7	90-110	0.9841	0.8	20	

The following samples were analyzed in this batch:

24042031-01C	24042031-02C	24042031-03C
24042031-04C	24042031-05C	24042031-06C
24042031-07C	24042031-08C	

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Client: Spicer Group
Work Order: 24042031
Project: Twin Lakes - Spring 2024

QC BATCH REPORT

Batch ID: **R402866B** Instrument ID **IC4** Method: **SW9056A**

MBLK	Sample ID: **MBLK-R402866B**				Units: **mg/L**		Analysis Date: **5/1/2024 01:11 PM**			
Client ID:	Run ID: **IC4_240501A**				SeqNo: **10717150**		Prep Date:		DF: **1**	
Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Chloride	U	1.0								

LCS	Sample ID: **LCS-R402866B**				Units: **mg/L**		Analysis Date: **5/1/2024 01:00 PM**			
Client ID:	Run ID: **IC4_240501A**				SeqNo: **10717149**		Prep Date:		DF: **1**	
Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Chloride	9.447	1.0	10	0	94.5	88-110	0			

MS	Sample ID: **24050002-01A MS**				Units: **mg/L**		Analysis Date: **5/1/2024 02:29 PM**			
Client ID:	Run ID: **IC4_240501A**				SeqNo: **10717158**		Prep Date:		DF: **10**	
Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Chloride	130	10	100	37.02	93	88-110	0			

MSD	Sample ID: **24050002-01A MSD**				Units: **mg/L**		Analysis Date: **5/1/2024 02:39 PM**			
Client ID:	Run ID: **IC4_240501A**				SeqNo: **10717159**		Prep Date:		DF: **10**	
Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Chloride	130.2	10	100	37.02	93.2	88-110	130	0.148	15	

The following samples were analyzed in this batch:

24042031-01B	24042031-02B	24042031-03B
24042031-04B	24042031-05B	

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Client: Spicer Group
Work Order: 24042031
Project: Twin Lakes - Spring 2024

QC BATCH REPORT

Batch ID: **R402970b** Instrument ID **SKALAR2** Method: **E365.1 R2.0**

MBLK Sample ID: **MBLK3-R402970b** Units: **mg/L** Analysis Date: **5/2/2024 09:07 PM**
Client ID: Run ID: **SKALAR2_240502A** SeqNo: **10723005** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Total	U	0.050								

LCS Sample ID: **LCS3-R402970b** Units: **mg/L** Analysis Date: **5/2/2024 09:12 PM**
Client ID: Run ID: **SKALAR2_240502A** SeqNo: **10723006** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Total	2.597	0.050	2.5	0	104	90-110	0			

MS Sample ID: **24041874-01F MS** Units: **mg/L** Analysis Date: **5/2/2024 09:20 PM**
Client ID: Run ID: **SKALAR2_240502A** SeqNo: **10723008** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Total	2.609	0.050	2.5	0.03888	103	90-110	0			

MS Sample ID: **24042031-01D MS** Units: **mg/L** Analysis Date: **5/2/2024 10:18 PM**
Client ID: **ET-1** Run ID: **SKALAR2_240502A** SeqNo: **10723022** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Total	2.693	0.050	2.5	-0.0241	109	90-110	0			

MSD Sample ID: **24041874-01F MSD** Units: **mg/L** Analysis Date: **5/2/2024 09:24 PM**
Client ID: Run ID: **SKALAR2_240502A** SeqNo: **10723009** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Total	2.684	0.050	2.5	0.03888	106	90-110	2.609	2.86	20	

MSD Sample ID: **24042031-01D MSD** Units: **mg/L** Analysis Date: **5/2/2024 10:22 PM**
Client ID: **ET-1** Run ID: **SKALAR2_240502A** SeqNo: **10723023** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Total	2.795	0.050	2.5	-0.0241	113	90-110	2.693	3.72	20	S

The following samples were analyzed in this batch:

24042031-01D	24042031-02D	24042031-03D
24042031-04D	24042031-05D	24042031-06D
24042031-07D	24042031-08D	

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Batch ID: **R403012B** Instrument ID **LACHAT2** Method: **E350.1 R2.0**

MBLK Sample ID: **MBLK-R403012B** Units: **mg NH3-N/L** Analysis Date: **5/3/2024 11:21 AM**
Client ID: Run ID: **LACHAT2_240503A** SeqNo: **10725650** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Ammonia as Nitrogen	U	0.020								

LCS Sample ID: **LCS-R403012B** Units: **mg NH3-N/L** Analysis Date: **5/3/2024 11:22 AM**
Client ID: Run ID: **LACHAT2_240503A** SeqNo: **10725651** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Ammonia as Nitrogen	1.06	0.020	1	0	106	90-110	0			

MS Sample ID: **24042031-01D MS** Units: **mg NH3-N/L** Analysis Date: **5/3/2024 11:28 AM**
Client ID: **ET-1** Run ID: **LACHAT2_240503A** SeqNo: **10725656** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Ammonia as Nitrogen	1.538	0.020	1	0.5074	103	90-110	0			

MS Sample ID: **24042102-01B MS** Units: **mg NH3-N/L** Analysis Date: **5/3/2024 01:14 PM**
Client ID: Run ID: **LACHAT2_240503A** SeqNo: **10725744** Prep Date: DF: **1000**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Ammonia as Nitrogen	1156	20	1	1147	900	90-110	0			SO

MSD Sample ID: **24042031-01D MSD** Units: **mg NH3-N/L** Analysis Date: **5/3/2024 11:29 AM**
Client ID: **ET-1** Run ID: **LACHAT2_240503A** SeqNo: **10725657** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Ammonia as Nitrogen	1.547	0.020	1	0.5074	104	90-110	1.538	0.583	20	

MSD Sample ID: **24042102-01B MSD** Units: **mg NH3-N/L** Analysis Date: **5/3/2024 01:16 PM**
Client ID: Run ID: **LACHAT2_240503A** SeqNo: **10725745** Prep Date: DF: **1000**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Ammonia as Nitrogen	1130	20	1	1147	-1700	90-110	1156	2.27	20	SO

The following samples were analyzed in this batch:

24042031-01D	24042031-02D	24042031-03D
24042031-04D	24042031-05D	24042031-06D
24042031-07D	24042031-08D	

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

24042031

SPICER GROUP - BYRON CENTER: Spicer Group

Project: Twin Lakes - Spring 2024

Simi Valley, CA	**Cincinnati, OH**	**Fort Collins, CO** **0 490 1511**		**Houston, TX** **+1 281 530 5656**	**Valparaiso, IN** **+1 219 299 8127**	**South Charleston, WV** **+1 304 356 3168**
		d, MI **399 6070**		**Middletown, PA** **+1 717 944 5541**	**Salt Lake City, UT** **+1 801 266 7700**	**Rochester, NY** **+1 585 288 5380**

Chain of Custody Form

Page 1 of 1

COC ID: 063509

ALS Project Manager:

ALS Work Order #:

	Project Information				**Parameter/Method Request for Analysis**
Pur		**Name**	TWIN LAKES-SPRING 2024	A	NO₂, NO₃, TKN, NH₃, TOTAL N
Quote #		**Project Number**		B	ORTHO-PHOS
Company Name	SPICER GROUP	**Bill To Company**	TWIN LAKES PROPERTY OWNERS ASSOC	C	TOTAL PHOSPHORUS
Send Report To	EHRLAND BOSWORTH	**Invoice Attn**	COLIN GIBBINGS	D	TSS
Address	2464 BYRON STATION DR SW SUITE C	**Address**	P.O. BOX 807	E	CHLORIDE
				F	
City/State/Zip	BYRON CENTER MI 49315	**City/State/Zip**	LEWISTON, MI 49756	G	
Phone	(269) 744-1364	**Phone**		H	
Fax		**Fax**		I	
e-Mail Address	EHRLAND.BOSWORTH@SPICERGROUP.COM	**e-Mail Address**	C5GIBBINGS@GMAIL.com	J	

No.	Sample Description	Date	Time	Matrix	Pres.	# Bottles	A	B	C	D	E	F	G	H	I	J	Hold
1	ET-1	4/29/24	11:15	SW		4	X	X	X	X	X						
2	ET-2		11:27														
3	ET-3		11:03														
4	ET-4		10:50														
5	ET-5		11:36														
6	WT-1		12:43														
7	WT-2		12:08														
8	OUTLET		12:25														
9																	
10																	

Sampler(s) Please Print & Sign EHRLAND BOSWORTH

Shipment Method

Turnaround Time in Business Days (BD) Other:

☐ 10 BD ☐ 5 BD ☐ 3 BD ☐ 2 BD ☐ 1 BD

Results Due Date:

Relinquished by:	**Date:** 4/30/24	**Time:** 835	**Received by:**
Relinquished by:	**Date:** 4/30/24	**Time:** 0835	**Received by (Laboratory):**
Logged by (Laboratory): DFS	**Date:** 4/30/24	**Time:** 0900	**Checked by (Laboratory):**

Preservative Key: 1-HCl 2-HNO_3 3-H_2SO_4 4-NaOH 5-$Na_2S_2O_3$ 6-$NaHSO_4$ 7-Other 8-4°C 9-5035

Notes:

Cooler ID	**Cooler Temp.**
IR3	4.3°C pH37

QC Package: (Check One Box Below)

☐ Level II Std QC
☐ Level III Std QC/Raw Date
☐ Level IV SW846/CLP
☐ Other

☐ TRRP Checklist
☐ TRRP Level IV

Note:
1. Any changes must be made in writing once samples and COC Form have been submitted to ALS Environmental.
2. Unless otherwise agreed in a formal contract, services provided by ALS Environmental are expressly limited to the terms and conditions stated on the reverse.
3. The Chain of Custody is a legal document. All information must be completed accurately.

ALS-COC-2022-R00

ALS Group, USA
Holland, Michigan

Sample Receipt Checklist

Client Name: **SPICER GROUP - BYRON CENTE**

Date/Time Received: **30-Apr-24 08:35**

Work Order: **24042031**

Received by: **DS**

Checklist completed by Diane Shaw eSignature 30-Apr-24 Date

Reviewed by: Chad Whelton eSignature 02-May-24 Date

Matrices: Surface Water
Carrier name: Client

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): 4.3/5.3 c IR3
Cooler(s)/Kit(s):
Date/Time sample(s) sent to storage: 4/30/2024 9:49:09 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: pH check <2.

Client Contacted:
Date Contacted:
Person Contacted:
Contacted By:
Regarding:

Comments:

CorrectiveAction:

Prein&Newhof
Engineers ▪ Surveyors ▪ Environmental ▪ Laboratory

August 07, 2024

Spicer Group
2464 Byron Station Dr. SW
Suite C
Byron Center, MI 49315

RE: Twin Lakes- Summer 2024

Order No.: 2408012

Guide to Reading Lab Result

Dear Ehrland Bosworth:

Prein&Newhof Laboratory received 8 sample(s) on 8/1/2024 on your behalf. Your test results are provided in your Prein&Newhof Laboratory analytical report. Please carefully review your analytical report, noting the following.

There were no problems with the analytical events associated with this report unless noted in the Case Narrative.

Any analyte that exceeds the client provided permit level are noted on the report with an "*" in the Qual field. Quality control data is within laboratory defined or method specified acceptance limits except if noted.

When testing for PFHxS, PFOA, PFOS, MeFOSAA, and EtFOSAA results include both branched and linear isotopes. We extract a Method Blank and analyze it with the preparation batch. Method Blank analytes are within the Reporting Limit (RL).

To learn more about interpreting your Lab Report, follow the link above to view our "Guide to Reading Lab Results". If you have any concerns about your test results or need additional help, please call: 616-364-7600 or email me: sbylsma@preinnewhof.com.

We use EPA Approved Methods for all regulated parameters. EPA Lab #: MI000014

Thank you for trusting Prein&Newhof with your testing needs.

Sincerely,

Steve Bylsma
Laboratory Manager

CLIENT: Spicer Group **Lab Order:** 2408012
Project: Twin Lakes- Summer 2024

Lab ID: 2408012-01 **Matrix:** AQUEOUS **Collection Date:** 7/31/2024 12:00:00 PM
Client ID: ET-1 **Sampler:** E. Bosworth **Received Date:** 8/1/2024 9:57:00 AM

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	2.24	0.800		mg/m³	1	8/1/2024 2:00:00 PM
Pheophytin A	1.94	0.800		mg/m³	1	8/1/2024 2:00:00 PM

Lab ID: 2408012-02 **Matrix:** AQUEOUS **Collection Date:** 7/31/2024 12:10:00 PM
Client ID: ET-2 **Sampler:** E. Bosworth **Received Date:** 8/1/2024 9:57:00 AM

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	1.50	0.800		mg/m³	1	8/1/2024 2:00:00 PM
Pheophytin A	1.38	0.800		mg/m³	1	8/1/2024 2:00:00 PM

Lab ID: 2408012-03 **Matrix:** AQUEOUS **Collection Date:** 7/31/2024 12:20:00 PM
Client ID: ET-3 **Sampler:** E. Bosworth **Received Date:** 8/1/2024 9:57:00 AM

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	2.24	0.800		mg/m³	1	8/1/2024 2:00:00 PM
Pheophytin A	1.16	0.800		mg/m³	1	8/1/2024 2:00:00 PM

Lab ID: 2408012-04 **Matrix:** AQUEOUS **Collection Date:** 7/31/2024 11:30:00 AM
Client ID: ET-4 **Sampler:** E. Bosworth **Received Date:** 8/1/2024 9:57:00 AM

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	2.03	0.800		mg/m³	1	8/1/2024 2:00:00 PM
Pheophytin A	1.10	0.800		mg/m³	1	8/1/2024 2:00:00 PM

Qualifiers:

<	Not Detected at the Reporting Limit	H	Holding times for preparation or analysis exceeded
MCL	Maximum Contaminant Level	PL	Permit Limit
RL	Reporting Limit		

Original

CLIENT: Spicer Group **Lab Order:** 2408012
Project: Twin Lakes- Summer 2024

Lab ID: 2408012-05 **Matrix:** AQUEOUS **Collection Date:** 7/31/2024 12:30:00 PM
Client ID: ET-5 **Sampler:** E. Bosworth **Received Date:** 8/1/2024 9:57:00 AM

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	2.80	0.800		mg/m³	1	8/1/2024 2:00:00 PM
Pheophytin A	ND	0.800		mg/m³	1	8/1/2024 2:00:00 PM

Lab ID: 2408012-06 **Matrix:** AQUEOUS **Collection Date:** 7/31/2024 2:00:00 PM
Client ID: WT-1 **Sampler:** E. Bosworth **Received Date:** 8/1/2024 9:57:00 AM

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	1.98	0.800		mg/m³	1	8/1/2024 2:00:00 PM
Pheophytin A	ND	0.800		mg/m³	1	8/1/2024 2:00:00 PM

Lab ID: 2408012-07 **Matrix:** AQUEOUS **Collection Date:** 7/31/2024 1:30:00 PM
Client ID: WT-2 **Sampler:** E. Bosworth **Received Date:** 8/1/2024 9:57:00 AM

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	ND	0.800		mg/m³	1	8/1/2024 2:00:00 PM
Pheophytin A	2.27	0.800		mg/m³	1	8/1/2024 2:00:00 PM

Lab ID: 2408012-08 **Matrix:** AQUEOUS **Collection Date:** 7/31/2024 1:45:00 PM
Client ID: Outlet **Sampler:** E. Bosworth **Received Date:** 8/1/2024 9:57:00 AM

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	ND	0.800		mg/m³	1	8/1/2024 2:00:00 PM
Pheophytin A	1.26	0.800		mg/m³	1	8/1/2024 2:00:00 PM

Qualifiers:

<	Not Detected at the Reporting Limit	H	Holding times for preparation or analysis exceeded
MCL	Maximum Contaminant Level	PL	Permit Limit
RL	Reporting Limit		

Original

Prein&Newhof
Engineers ▪ Surveyors ▪ Environmental ▪ Laboratory

3260 Evergreen Drive, NE
Grand Rapids, MI 49525
t. 616-364-7600
f. 616-364-6955

SAME AS 2404557

Client Name: SPICER GROUP
Billing Address:
Phone Number: (269) 744-1364
Email Report to: EHELAND.BOSWORTH@SPICERGROUP.COM
Email Invoice to: CSGIBBINGS@GMAIL.COM
Project Name: TWIN LAKES SUMMER SAMPLING
Project Number:
Sampling Personnel: EBB

CHAIN OF CUSTODY

Wastewater	W
Drinking Water	D
Groundwater	G
Soil	S
Sludge	L
Other	X

No. 54572

LAB USE	Sample Information				Preservative						Analysis Requested												
Lab Sample ID #	Date Collected	Time Collected	Sample Description and Location (e.g. MW-1)	MATRIX	None	H2SO4	HNO3	HCL	NaOH	Other	CHLOR-A												
80121	7/31/24	1200	ET-1	W	X						X												
2	↓	1210	ET-2	↓	↓						↓												
3		1220	ET-3																				
4		1130	ET-4																				
5		1230	ET-5																				
6		1400	WT-1																				
7		1330	WT-2																				
8		1345	OUTLET																				

Comments: Samples received in translucent bottles.

Relinquished By: (Signature)	Date	Time	Received By: (Signature)	Date	Time
	8/1/24	0957			
Relinquished By: (Signature)	**Date**	**Time**	**Received for Laboratory By: (Signature)**	**Date**	**Time**
			S. Dieum	8/1/24	09:57

5°C

08-Aug-2024

Ehrland Bosworth
Spicer Group
2464 Byron Station Dr SW
Suite C
Byron Center, MI 49315

Re: **Twin Lakes - Summer Sampling** Work Order: **24080045**

Dear Ehrland,

ALS Environmental received 8 samples on 01-Aug-2024 09:00 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 22.

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,

Electronically approved by: Chad Whelton

Chad Whelton
Project Manager

Client: Spicer Group
Project: Twin Lakes - Summer Sampling
Work Order: **24080045**

Work Order Sample Summary

Lab Samp ID	Client Sample ID	Matrix	Tag Number	Collection Date	Date Received	Hold
24080045-01	ET-4	Surface Water		7/31/2024 11:30	8/1/2024 09:00	☐
24080045-02	ET-1	Surface Water		7/31/2024 12:00	8/1/2024 09:00	☐
24080045-03	ET-2	Surface Water		7/31/2024 12:10	8/1/2024 09:00	☐
24080045-04	ET-3	Surface Water		7/31/2024 12:20	8/1/2024 09:00	☐
24080045-05	ET-5	Surface Water		7/31/2024 12:30	8/1/2024 09:00	☐
24080045-06	WT-2	Surface Water		7/31/2024 13:30	8/1/2024 09:00	☐
24080045-07	Outlet	Surface Water		7/31/2024 13:45	8/1/2024 09:00	☐
24080045-08	WT-1	Surface Water		7/31/2024 14:00	8/1/2024 09:00	☐

Client: Spicer Group
Project: Twin Lakes - Summer Sampling
Work Order: 24080045

Case Narrative

Samples for the above noted Work Order were received on 08/01/2024. 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.

Wet Chemistry:

Batch R409031E, Method SW9056A, Sample 24080045-01B MS/MSD: The MS/MSD recovery was above the upper control limit. The corresponding result in the parent sample may be biased high for this analyte: Chloride.

Client: Spicer Group
Project: Twin Lakes - Summer Sampling
WorkOrder: **24080045**

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
mg NH3-N/L	Milligrams Ammonia-Nitrogen per Liter
mg/L	Milligrams per Liter

Client: Spicer Group
Project: Twin Lakes - Summer Sampling **Work Order:** 24080045
Sample ID: ET-4 **Lab ID:** 24080045-01
Collection Date: 7/31/2024 11:30 AM **Matrix:** SURFACE WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**SW9056A**			Analyst: **QTN**
Chloride	**26.1**		**4.0**	**mg/L**	4	8/5/2024 07:13 PM
Nitrogen, Nitrate	U		0.10	mg/L	1	8/1/2024 09:47 PM
Nitrogen, Nitrite	U		0.10	mg/L	1	8/1/2024 09:47 PM
NITROGEN, TOTAL			**CALCULATION**			Analyst: **JB**
Nitrogen, Total	**0.94**	J	**1.0**	**mg/L**	1	8/5/2024 03:30 PM
AMMONIA AS NITROGEN			**E350.1 R2.0**			Analyst: **EE**
Ammonia as Nitrogen	U		0.020	mg NH3-N/L	1	8/6/2024 01:29 PM
PHOSPHORUS, TOTAL			**E365.1 R2.0**			Analyst: **EE**
Phosphorus, Total	U		0.050	mg/L	1	8/5/2024 09:57 PM
PHOSPHORUS, ORTHO-P (AS P)			**E365.1**			Analyst: **MGS**
Phosphorus, Ortho-P (As P)	U		0.050	mg/L	1	8/1/2024 03:07 PM
NITROGEN, TOTAL KJELDAHL			**A4500-NH3 G-11**	Prep: A4500-N B 8/2/24 08:55		Analyst: **MGS**
Nitrogen, Total Kjeldahl	**0.94**	J	**1.0**	**mg/L**	1	8/5/2024 12:05 PM
TOTAL SUSPENDED SOLIDS			**A2540 D-15**	Prep: FILTER 8/5/24 15:20		Analyst: **SRN**
Total Suspended Solids	**2.80**		**1.2**	**mg/L**	1	8/6/2024 02:19 PM

Note: See Qualifiers page for a list of qualifiers and their definitions.

Client: Spicer Group
Project: Twin Lakes - Summer Sampling **Work Order:** 24080045
Sample ID: ET-1 **Lab ID:** 24080045-02
Collection Date: 7/31/2024 12:00 PM **Matrix:** SURFACE WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**SW9056A**			Analyst: **QTN**
Chloride	**25.3**		**4.0**	**mg/L**	4	8/5/2024 08:01 PM
Nitrogen, Nitrate	U		0.10	mg/L	1	8/1/2024 10:17 PM
Nitrogen, Nitrite	U		0.10	mg/L	1	8/1/2024 10:17 PM
NITROGEN, TOTAL			**CALCULATION**			Analyst: **JB**
Nitrogen, Total	**1.2**		**1.0**	**mg/L**	1	8/5/2024 03:30 PM
AMMONIA AS NITROGEN			**E350.1 R2.0**			Analyst: **EE**
Ammonia as Nitrogen	**0.016**	J	**0.020**	**mg NH3-N/L**	1	8/6/2024 01:42 PM
PHOSPHORUS, TOTAL			**E365.1 R2.0**			Analyst: **EE**
Phosphorus, Total	U		0.050	mg/L	1	8/5/2024 10:01 PM
PHOSPHORUS, ORTHO-P (AS P)			**E365.1**			Analyst: **MGS**
Phosphorus, Ortho-P (As P)	U		0.050	mg/L	1	8/1/2024 03:11 PM
NITROGEN, TOTAL KJELDAHL			**A4500-NH3 G-11**		Prep: A4500-N B 8/2/24 08:55	Analyst: **MGS**
Nitrogen, Total Kjeldahl	**1.2**		**1.0**	**mg/L**	1	8/5/2024 12:08 PM
TOTAL SUSPENDED SOLIDS			**A2540 D-15**		Prep: FILTER 8/5/24 15:20	Analyst: **SRN**
Total Suspended Solids	**2.20**		**1.2**	**mg/L**	1	8/6/2024 02:19 PM

Note: See Qualifiers page for a list of qualifiers and their definitions.

Client: Spicer Group
Project: Twin Lakes - Summer Sampling **Work Order:** 24080045
Sample ID: ET-2 **Lab ID:** 24080045-03
Collection Date: 7/31/2024 12:10 PM **Matrix:** SURFACE WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**SW9056A**			Analyst: **QTN**
Chloride	**25.7**		**4.0**	**mg/L**	4	8/5/2024 08:11 PM
Nitrogen, Nitrate	U		0.10	mg/L	1	8/1/2024 10:26 PM
Nitrogen, Nitrite	U		0.10	mg/L	1	8/1/2024 10:26 PM
NITROGEN, TOTAL			**CALCULATION**			Analyst: **JB**
Nitrogen, Total	**0.93**	J	**1.0**	**mg/L**	1	8/5/2024 03:30 PM
AMMONIA AS NITROGEN			**E350.1 R2.0**			Analyst: **EE**
Ammonia as Nitrogen	**0.033**		**0.020**	**mg NH3-N/L**	1	8/6/2024 01:46 PM
PHOSPHORUS, TOTAL			**E365.1 R2.0**			Analyst: **EE**
Phosphorus, Total	U		0.050	mg/L	1	8/5/2024 10:05 PM
PHOSPHORUS, ORTHO-P (AS P)			**E365.1**			Analyst: **MGS**
Phosphorus, Ortho-P (As P)	U		0.050	mg/L	1	8/1/2024 03:12 PM
NITROGEN, TOTAL KJELDAHL			**A4500-NH3 G-11**		Prep: A4500-N B 8/2/24 08:55	Analyst: **MGS**
Nitrogen, Total Kjeldahl	**0.93**	J	**1.0**	**mg/L**	1	8/5/2024 12:10 PM
TOTAL SUSPENDED SOLIDS			**A2540 D-15**		Prep: FILTER 8/5/24 15:20	Analyst: **SRN**
Total Suspended Solids	**3.80**		**1.2**	**mg/L**	1	8/6/2024 02:19 PM

Note: See Qualifiers page for a list of qualifiers and their definitions.

Client: Spicer Group
Project: Twin Lakes - Summer Sampling **Work Order:** 24080045
Sample ID: ET-3 **Lab ID:** 24080045-04
Collection Date: 7/31/2024 12:20 PM **Matrix:** SURFACE WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**SW9056A**			Analyst: **QTN**
Chloride	**25.5**		**4.0**	**mg/L**	4	8/5/2024 08:21 PM
Nitrogen, Nitrate	U		0.10	mg/L	1	8/1/2024 10:36 PM
Nitrogen, Nitrite	U		0.10	mg/L	1	8/1/2024 10:36 PM
NITROGEN, TOTAL			**CALCULATION**			Analyst: **JB**
Nitrogen, Total	**1.2**		**1.0**	**mg/L**	1	8/5/2024 03:30 PM
AMMONIA AS NITROGEN			**E350.1 R2.0**			Analyst: **EE**
Ammonia as Nitrogen	U		0.020	mg NH3-N/L	1	8/6/2024 01:50 PM
PHOSPHORUS, TOTAL			**E365.1 R2.0**			Analyst: **EE**
Phosphorus, Total	U		0.050	mg/L	1	8/5/2024 10:09 PM
PHOSPHORUS, ORTHO-P (AS P)			**E365.1**			Analyst: **MGS**
Phosphorus, Ortho-P (As P)	U		0.050	mg/L	1	8/1/2024 03:13 PM
NITROGEN, TOTAL KJELDAHL			**A4500-NH3 G-11**	Prep: A4500-N B 8/2/24 08:55		Analyst: **MGS**
Nitrogen, Total Kjeldahl	**1.2**		**1.0**	**mg/L**	1	8/5/2024 12:11 PM
TOTAL SUSPENDED SOLIDS			**A2540 D-15**	Prep: FILTER 8/5/24 15:20		Analyst: **SRN**
Total Suspended Solids	**2.40**		**1.2**	**mg/L**	1	8/6/2024 02:19 PM

Note: See Qualifiers page for a list of qualifiers and their definitions.

Client: Spicer Group

Project: Twin Lakes - Summer Sampling

Work Order: 24080045

Sample ID: ET-5

Lab ID: 24080045-05

Collection Date: 7/31/2024 12:30 PM

Matrix: SURFACE WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**SW9056A**			Analyst: **QTN**
Chloride	**25.6**		**4.0**	**mg/L**	4	8/5/2024 08:31 PM
Nitrogen, Nitrate	U		0.10	mg/L	1	8/1/2024 10:46 PM
Nitrogen, Nitrite	U		0.10	mg/L	1	8/1/2024 10:46 PM
NITROGEN, TOTAL			**CALCULATION**			Analyst: **JB**
Nitrogen, Total	**1.4**		**1.0**	**mg/L**	1	8/5/2024 03:30 PM
AMMONIA AS NITROGEN			**E350.1 R2.0**			Analyst: **EE**
Ammonia as Nitrogen	U		0.020	mg NH3-N/L	1	8/6/2024 01:54 PM
PHOSPHORUS, TOTAL			**E365.1 R2.0**			Analyst: **EE**
Phosphorus, Total	U		0.050	mg/L	1	8/5/2024 10:13 PM
PHOSPHORUS, ORTHO-P (AS P)			**E365.1**			Analyst: **MGS**
Phosphorus, Ortho-P (As P)	U		0.050	mg/L	1	8/1/2024 03:14 PM
NITROGEN, TOTAL KJELDAHL			**A4500-NH3 G-11**		Prep: A4500-N B 8/2/24 08:55	Analyst: **MGS**
Nitrogen, Total Kjeldahl	**1.4**		**1.0**	**mg/L**	1	8/5/2024 12:12 PM
TOTAL SUSPENDED SOLIDS			**A2540 D-15**		Prep: FILTER 8/5/24 15:20	Analyst: **SRN**
Total Suspended Solids	**3.40**		**1.2**	**mg/L**	1	8/6/2024 02:19 PM

Note: See Qualifiers page for a list of qualifiers and their definitions.

Client: Spicer Group
Project: Twin Lakes - Summer Sampling **Work Order:** 24080045
Sample ID: WT-2 **Lab ID:** 24080045-06
Collection Date: 7/31/2024 01:30 PM **Matrix:** SURFACE WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**SW9056A**			Analyst: **QTN**
Chloride	**12.6**		**1.0**	**mg/L**	1	8/1/2024 10:55 PM
Nitrogen, Nitrate	U		0.10	mg/L	1	8/1/2024 10:55 PM
Nitrogen, Nitrite	U		0.10	mg/L	1	8/1/2024 10:55 PM
NITROGEN, TOTAL			**CALCULATION**			Analyst: **JB**
Nitrogen, Total	U		1.0	mg/L	1	8/5/2024 03:30 PM
AMMONIA AS NITROGEN			**E350.1 R2.0**			Analyst: **EE**
Ammonia as Nitrogen	U		0.020	mg NH3-N/L	1	8/6/2024 01:59 PM
PHOSPHORUS, TOTAL			**E365.1 R2.0**			Analyst: **EE**
Phosphorus, Total	U		0.050	mg/L	1	8/5/2024 10:17 PM
PHOSPHORUS, ORTHO-P (AS P)			**E365.1**			Analyst: **MGS**
Phosphorus, Ortho-P (As P)	U		0.050	mg/L	1	8/1/2024 03:15 PM
NITROGEN, TOTAL KJELDAHL			**A4500-NH3 G-11**	Prep: A4500-N B 8/2/24 08:55		Analyst: **MGS**
Nitrogen, Total Kjeldahl	U		1.0	mg/L	1	8/5/2024 12:13 PM
TOTAL SUSPENDED SOLIDS			**A2540 D-15**	Prep: FILTER 8/5/24 15:20		Analyst: **SRN**
Total Suspended Solids	**2.60**		**1.2**	**mg/L**	1	8/6/2024 02:19 PM

Note: See Qualifiers page for a list of qualifiers and their definitions.

Client: Spicer Group
Project: Twin Lakes - Summer Sampling **Work Order:** 24080045
Sample ID: Outlet **Lab ID:** 24080045-07
Collection Date: 7/31/2024 01:45 PM **Matrix:** SURFACE WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor		Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**SW9056A**				Analyst: **QTN**
Chloride	**12.6**		**1.0**	**mg/L**	1		8/1/2024 11:05 PM
Nitrogen, Nitrate	U		0.10	mg/L	1		8/1/2024 11:05 PM
Nitrogen, Nitrite	U		0.10	mg/L	1		8/1/2024 11:05 PM
NITROGEN, TOTAL			**CALCULATION**				Analyst: **JB**
Nitrogen, Total	U		1.0	mg/L	1		8/5/2024 03:30 PM
AMMONIA AS NITROGEN			**E350.1 R2.0**				Analyst: **EE**
Ammonia as Nitrogen	**0.040**		**0.020**	**mg NH3-N/L**	1		8/6/2024 02:21 PM
PHOSPHORUS, TOTAL			**E365.1 R2.0**				Analyst: **EE**
Phosphorus, Total	U		0.050	mg/L	1		8/5/2024 10:22 PM
PHOSPHORUS, ORTHO-P (AS P)			**E365.1**				Analyst: **MGS**
Phosphorus, Ortho-P (As P)	U		0.050	mg/L	1		8/1/2024 03:19 PM
NITROGEN, TOTAL KJELDAHL			**A4500-NH3 G-11**			Prep: A4500-N B 8/2/24 08:55	Analyst: **MGS**
Nitrogen, Total Kjeldahl	U		1.0	mg/L	1		8/5/2024 12:14 PM
TOTAL SUSPENDED SOLIDS			**A2540 D-15**			Prep: FILTER 8/5/24 15:20	Analyst: **SRN**
Total Suspended Solids	**3.80**		**1.2**	**mg/L**	1		8/6/2024 02:19 PM

Note: See Qualifiers page for a list of qualifiers and their definitions.

Client: Spicer Group
Project: Twin Lakes - Summer Sampling **Work Order:** 24080045
Sample ID: WT-1 **Lab ID:** 24080045-08
Collection Date: 7/31/2024 02:00 PM **Matrix:** SURFACE WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
ANIONS BY ION CHROMATOGRAPHY			**SW9056A**			Analyst: **QTN**
Chloride	**12.6**		**1.0**	**mg/L**	1	8/1/2024 11:15 PM
Nitrogen, Nitrate	U		0.10	mg/L	1	8/1/2024 11:15 PM
Nitrogen, Nitrite	U		0.10	mg/L	1	8/1/2024 11:15 PM
NITROGEN, TOTAL			**CALCULATION**			Analyst: **JB**
Nitrogen, Total	U		1.0	mg/L	1	8/5/2024 03:30 PM
AMMONIA AS NITROGEN			**E350.1 R2.0**			Analyst: **EE**
Ammonia as Nitrogen	U		0.020	mg NH3-N/L	1	8/6/2024 02:23 PM
PHOSPHORUS, TOTAL			**E365.1 R2.0**			Analyst: **EE**
Phosphorus, Total	U		0.050	mg/L	1	8/5/2024 10:44 PM
PHOSPHORUS, ORTHO-P (AS P)			**E365.1**			Analyst: **MGS**
Phosphorus, Ortho-P (As P)	U		0.050	mg/L	1	8/1/2024 03:20 PM
NITROGEN, TOTAL KJELDAHL			**A4500-NH3 G-11**	Prep: A4500-N B 8/2/24 08:55		Analyst: **MGS**
Nitrogen, Total Kjeldahl	U		1.0	mg/L	1	8/5/2024 12:18 PM
TOTAL SUSPENDED SOLIDS			**A2540 D-15**	Prep: FILTER 8/5/24 15:20		Analyst: **SRN**
Total Suspended Solids	**3.40**		**1.2**	**mg/L**	1	8/6/2024 02:19 PM

Note: See Qualifiers page for a list of qualifiers and their definitions.

QC BATCH REPORT

Batch ID: **244560** Instrument ID **LACHAT2** Method: **A4500-NH3 G-11**

MBLK Sample ID: **MBLK-244560-244560** Units: **mg/L** Analysis Date: **8/5/2024 11:57 AM**

Client ID: Run ID: **LACHAT2_240805A** SeqNo: **11009818** Prep Date: **8/2/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	U	1.0								

LCS Sample ID: **LCS-244560-244560** Units: **mg/L** Analysis Date: **8/5/2024 11:59 AM**

Client ID: Run ID: **LACHAT2_240805A** SeqNo: **11009819** Prep Date: **8/2/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	10.09	1.0	10	0	101	76-132	0			

LCS Sample ID: **LCS2-244560-244560** Units: **mg/L** Analysis Date: **8/5/2024 12:00 PM**

Client ID: Run ID: **LACHAT2_240805A** SeqNo: **11009820** Prep Date: **8/2/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	10.64	1.0	10	0	106	76-132	0			

MS Sample ID: **24080045-01D MS** Units: **mg/L** Analysis Date: **8/5/2024 12:06 PM**

Client ID: **ET-4** Run ID: **LACHAT2_240805A** SeqNo: **11009825** Prep Date: **8/2/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	11.21	1.0	10	0.9411	103	68-130	0			

MSD Sample ID: **24080045-01D MSD** Units: **mg/L** Analysis Date: **8/5/2024 12:07 PM**

Client ID: **ET-4** Run ID: **LACHAT2_240805A** SeqNo: **11009826** Prep Date: **8/2/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen, Total Kjeldahl	12.27	1.0	10	0.9411	113	68-130	11.21	9.03	15	

The following samples were analyzed in this batch:

24080045-01D
24080045-02D
24080045-03D
24080045-04D
24080045-05D
24080045-06D
24080045-07D
24080045-08D

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Client: Spicer Group
Work Order: 24080045
Project: Twin Lakes - Summer Sampling

QC BATCH REPORT

Batch ID: **244670** Instrument ID **TSS** Method: **A2540 D-15**

MBLK Sample ID: **MBLK-244670-244670** Units: **mg/L** Analysis Date: **8/6/2024 02:19 PM**
Client ID: Run ID: **TSS_240806A** SeqNo: **11013320** Prep Date: **8/5/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Total Suspended Solids	U	0.60								

LCS Sample ID: **LCS-244670-244670** Units: **mg/L** Analysis Date: **8/6/2024 02:19 PM**
Client ID: Run ID: **TSS_240806A** SeqNo: **11013318** Prep Date: **8/5/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Total Suspended Solids	101	6.0	100	0	101	75-111	0			

DUP Sample ID: **24080026-01A DUP** Units: **mg/L** Analysis Date: **8/6/2024 02:19 PM**
Client ID: Run ID: **TSS_240806A** SeqNo: **11013299** Prep Date: **8/5/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Total Suspended Solids	67.33	4.0	0	0	0	0-0	66	2	10	

DUP Sample ID: **24080081-01A DUP** Units: **mg/L** Analysis Date: **8/6/2024 02:19 PM**
Client ID: Run ID: **TSS_240806A** SeqNo: **11013316** Prep Date: **8/5/2024** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Total Suspended Solids	10.29	1.7	0	0	0	0-0	10.86	5.41	10	

The following samples were analyzed in this batch:

24080045-01A	24080045-02A	24080045-03A
24080045-04A	24080045-05A	24080045-06A
24080045-07A	24080045-08A	

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

QC BATCH REPORT

Batch ID: **R409003** Instrument ID **LACHAT2** Method: **E365.1**

MBLK Sample ID: **MBLK-R409003** Units: **mg/L** Analysis Date: **8/1/2024 03:05 PM**
Client ID: Run ID: **LACHAT2_240801B** SeqNo: **11003621** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Ortho-P (As P)	U	0.050								

LCS Sample ID: **LCS-R409003** Units: **mg/L** Analysis Date: **8/1/2024 03:06 PM**
Client ID: Run ID: **LACHAT2_240801B** SeqNo: **11003622** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Ortho-P (As P)	0.9222	0.050	1	0	92.2	90-110	0			

MS Sample ID: **24080045-01C MS** Units: **mg/L** Analysis Date: **8/1/2024 03:09 PM**
Client ID: **ET-4** Run ID: **LACHAT2_240801B** SeqNo: **11003624** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Ortho-P (As P)	0.9875	0.050	1	-0.003874	99.1	90-110	0			

MSD Sample ID: **24080045-01C MSD** Units: **mg/L** Analysis Date: **8/1/2024 03:10 PM**
Client ID: **ET-4** Run ID: **LACHAT2_240801B** SeqNo: **11003625** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Ortho-P (As P)	0.9191	0.050	1	-0.003874	92.3	90-110	0.9875	7.18	20	

The following samples were analyzed in this batch:

24080045-01C	24080045-02C	24080045-03C
24080045-04C	24080045-05C	24080045-06C
24080045-07C	24080045-08C	

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Client: Spicer Group
Work Order: 24080045
Project: Twin Lakes - Summer Sampling

QC BATCH REPORT

Batch ID: **R409031E** Instrument ID **IC4** Method: **E300.0**

MBLK Sample ID: **MBLK-E-R409031E** Units: **mg/L** Analysis Date: **8/1/2024 09:38 PM**
Client ID: Run ID: **IC4_240801A** SeqNo: **11006012** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Chloride	U	1.0								
Nitrogen, Nitrate	U	0.10								
Nitrogen, Nitrite	U	0.10								

LCS Sample ID: **LCS-E-R409031E** Units: **mg/L** Analysis Date: **8/1/2024 09:28 PM**
Client ID: Run ID: **IC4_240801A** SeqNo: **11006011** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Chloride	9.523	1.0	10	0	95.2	90-110	0			
Nitrogen, Nitrate	1.932	0.10	2	0	96.6	90-110	0			
Nitrogen, Nitrite	2.092	0.10	2	0	105	90-110	0			

MS Sample ID: **24080045-01B MS** Units: **mg/L** Analysis Date: **8/1/2024 09:57 PM**
Client ID: **ET-4** Run ID: **IC4_240801A** SeqNo: **11006018** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Chloride	40.25	1.0	10	28.81	114	88-110	0			SE
Nitrogen, Nitrate	1.943	0.10	2	0	97.2	90-110	0			
Nitrogen, Nitrite	1.893	0.10	2	0	94.7	89-113	0			

MSD Sample ID: **24080045-01B MSD** Units: **mg/L** Analysis Date: **8/1/2024 10:07 PM**
Client ID: **ET-4** Run ID: **IC4_240801A** SeqNo: **11006019** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Chloride	40.44	1.0	10	28.81	116	88-110	40.25	0.47	15	SE
Nitrogen, Nitrate	1.953	0.10	2	0	97.7	90-110	1.943	0.498	15	
Nitrogen, Nitrite	1.904	0.10	2	0	95.2	89-113	1.893	0.574	15	

The following samples were analyzed in this batch:

24080045-01B	24080045-02B	24080045-03B
24080045-04B	24080045-05B	24080045-06B
24080045-07B	24080045-08B	

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Client: Spicer Group
Work Order: 24080045
Project: Twin Lakes - Summer Sampling

QC BATCH REPORT

Batch ID: **R409178a** Instrument ID **SKALAR2** Method: **E365.1 R2.0**

MBLK Sample ID: **MBLK4-R409178a** Units: **mg/L** Analysis Date: **8/5/2024 09:07 PM**
Client ID: Run ID: **SKALAR2_240805A** SeqNo: **11011185** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Total	U	0.050								

LCS Sample ID: **LCS4-R409178a** Units: **mg/L** Analysis Date: **8/5/2024 09:11 PM**
Client ID: Run ID: **SKALAR2_240805A** SeqNo: **11011186** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Total	2.491	0.050	2.5	0	99.6	90-110	0			

MS Sample ID: **24080041-02A MS** Units: **mg/L** Analysis Date: **8/5/2024 09:48 PM**
Client ID: Run ID: **SKALAR2_240805A** SeqNo: **11011195** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Total	2.591	0.050	2.5	0.1103	99.2	90-110	0			

MS Sample ID: **24080045-08D MS** Units: **mg/L** Analysis Date: **8/5/2024 10:47 PM**
Client ID: **WT-1** Run ID: **SKALAR2_240805A** SeqNo: **11011209** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Total	2.57	0.050	2.5	0.003548	103	90-110	0			

MSD Sample ID: **24080041-02A MSD** Units: **mg/L** Analysis Date: **8/5/2024 09:52 PM**
Client ID: Run ID: **SKALAR2_240805A** SeqNo: **11011196** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Total	2.69	0.050	2.5	0.1103	103	90-110	2.591	3.75	20	

MSD Sample ID: **24080045-08D MSD** Units: **mg/L** Analysis Date: **8/5/2024 10:51 PM**
Client ID: **WT-1** Run ID: **SKALAR2_240805A** SeqNo: **11011210** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Phosphorus, Total	2.57	0.050	2.5	0.003548	103	90-110	2.57	0.0121	20	

The following samples were analyzed in this batch:

24080045-01D	24080045-02D	24080045-03D
24080045-04D	24080045-05D	24080045-06D
24080045-07D	24080045-08D	

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Client: Spicer Group
Work Order: 24080045
Project: Twin Lakes - Summer Sampling

QC BATCH REPORT

Batch ID: **R409186B** Instrument ID **IC4** Method: **SW9056A**

MBLK Sample ID: **MBLK-B-R409186B** Units: **mg/L** Analysis Date: **8/5/2024 04:29 PM**
Client ID: Run ID: **IC4_240805A** SeqNo: **11011771** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Chloride	U	1.0								

LCS Sample ID: **LCS-B-R409186B** Units: **mg/L** Analysis Date: **8/5/2024 04:20 PM**
Client ID: Run ID: **IC4_240805A** SeqNo: **11011770** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Chloride	9.515	1.0	10	0	95.2	88-110	0			

MS Sample ID: **24080045-01B MS** Units: **mg/L** Analysis Date: **8/5/2024 07:23 PM**
Client ID: **ET-4** Run ID: **IC4_240805A** SeqNo: **11011780** Prep Date: DF: **4**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Chloride	65.59	4.0	40	26.09	98.8	88-110	0			

MSD Sample ID: **24080045-01B MSD** Units: **mg/L** Analysis Date: **8/5/2024 07:32 PM**
Client ID: **ET-4** Run ID: **IC4_240805A** SeqNo: **11011781** Prep Date: DF: **4**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Chloride	65.38	4.0	40	26.09	98.2	88-110	65.59	0.33	15	

The following samples were analyzed in this batch:

24080045-01B 24080045-02B 24080045-03B
24080045-04B 24080045-05B

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Client: Spicer Group
Work Order: 24080045
Project: Twin Lakes - Summer Sampling

QC BATCH REPORT

Batch ID: **R409258a** Instrument ID **SKALAR2** Method: **E350.1 R2.0**

MBLK Sample ID: **MBLK1-R409258a** Units: **mg NH3-N/L** Analysis Date: **8/6/2024 01:22 PM**
Client ID: Run ID: **SKALAR2_240806A** SeqNo: **11014418** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Ammonia as Nitrogen	U	0.020								

LCS Sample ID: **LCS1-R409258a** Units: **mg NH3-N/L** Analysis Date: **8/6/2024 01:25 PM**
Client ID: Run ID: **SKALAR2_240806A** SeqNo: **11014419** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Ammonia as Nitrogen	1.086	0.020	1	0	109	90-110	0			

MS Sample ID: **24080045-01D MS** Units: **mg NH3-N/L** Analysis Date: **8/6/2024 01:33 PM**
Client ID: **ET-4** Run ID: **SKALAR2_240806A** SeqNo: **11014421** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Ammonia as Nitrogen	1.052	0.020	1	0.008921	104	90-110	0			

MSD Sample ID: **24080045-01D MSD** Units: **mg NH3-N/L** Analysis Date: **8/6/2024 01:37 PM**
Client ID: **ET-4** Run ID: **SKALAR2_240806A** SeqNo: **11014422** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Ammonia as Nitrogen	1.021	0.020	1	0.008921	101	90-110	1.052	3.01	20	

The following samples were analyzed in this batch:

24080045-01D	24080045-02D	24080045-03D
24080045-04D	24080045-05D	24080045-06D
24080045-07D	24080045-08D	

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Simi Valley, CA
+1 805 526 7161

Kelso, WA
+1 360 577 7222

Cincinnati, OH
+1 513 733 5336

Everett, WA
+1 425 356 2600

Fort Collins, CO
+1 970 490 1511

Holland, MI
+1 616 399 6070

Chain of Custody Form

Page 1 of 1

COC ID: 065672

24080045

SPICER GROUP - BYRON CENTER: Spicer Group
Project: Twin Lakes - Summer 2024

ALS Project Manager:

Customer Information		**Project Information**			
Purchase Order		Project Name	Twin Lakes Summer Sampling	A	Nitrate, Nitrite, TKN, Ammonia
Quote #		Project Number		B	PO4
Company Name	Spicer Group	Bill To Company	Twin Lakes Homeowners Assn	C	Total Phos.
Send Report To	Ehland Bosworth	Invoice Attn	Colin Gibbings	D	TSS
Address	2464 Byron Station Dr SW Suite C	Address		E	Chloride
				F	
City/State/Zip	Byron Center, MI 49315	City/State/Zip		G	
Phone	(269) 744-1364	Phone		H	
Fax		Fax		I	(Same as 24042031)
e-Mail Address	Ehland.Bosworth@SpicerGroup.com	e-Mail Address	C5Gibbings@Gmail.com	J	

No.	Sample Description	Date	Time	Matrix	Pres.	# Bottles	A	B	C	D	E	F	G	H	I	J	Hold
1	ET-4	7/31/24	1130	W	3,7,8	4	X	X	X	X	X						
2	ET-1		1200														
3	ET-2		1210														
4	ET-3		1220														
5	ET-5		1230														
6	WT-2		1330														
7	Outlet		1345														
8	WT-1		1400														
9																	
10																	

Sampler(s) Please Print & Sign: E. Bosworth

Shipment Method:

Turnaround Time in Business Days (BD): ☐ 10 BD ☒ 5 BD ☐ 3 BD ☐ 2 BD ☐ 1 BD Other ______

Results Due Date:

Relinquished by:	Date: 8/1/24	Time: 900	Received by:
Relinquished by:	Date: 8/1/24	Time: 0900	Received by (Laboratory):
Logged by (Laboratory): Ke	Date: 8/1/24	Time: 1405	Checked by (Laboratory):

Preservative Key: 1-HCl 2-HNO_3 3-H_2SO_4 4-NaOH 5-$Na_2S_2O_3$ 6-$NaHSO_4$ 7-Other 8-4°C 9-5035

Notes:

Cooler ID	Cooler Temp.
123 PU38	3.6°C

QC Package: (Check One Box Below)
☐ Level II Std QC
☐ Level III Std QC/Raw Date
☐ Level IV SW846/CLP
☐ Other ______
☐ TRRP Checklist
☐ TRRP Level IV

Note: 1. Any changes must be made in writing once samples and COC Form have been submitted to ALS Environmental.
2. Unless otherwise agreed in a formal contract, services provided by ALS Environmental are expressly limited to the terms and conditions stated on the reverse.
3. The Chain of Custody is a legal document. All information must be completed accurately.

ALS-COC-2022-R00

ALS Group, USA
Holland, Michigan

Sample Receipt Checklist

Client Name: **SPICER GROUP - BYRON CENTE**
Date/Time Received: **01-Aug-24 09:00**
Work Order: **24080045**
Received by: **KRW**

Checklist completed by Keith Wierenga (eSignature) 01-Aug-24 (Date)
Reviewed by: Alex J. Csaszar (eSignature) 01-Aug-24 (Date)

Matrices: Water
Carrier name: ALS - Holland

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): 3.6/4.6 C IR3
Cooler(s)/Kit(s):
Date/Time sample(s) sent to storage: 8/1/2024 2:07:00 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: pH Check <2

Client Contacted:
Date Contacted:
Person Contacted:
Contacted By:
Regarding:

Comments:

CorrectiveAction:

Prein&Newhof
Engineers ▪ Surveyors ▪ Environmental ▪ Laboratory

October 23, 2024

Spicer Group
2464 Byron Station Dr. SW
Suite C
Byron Center, MI 49315

RE: Twin Lakes Fall Sampling

Order No.: 2410D13

Guide to Reading Lab Result

Dear Ehrland Bosworth:

Prein&Newhof Laboratory received 8 sample(s) on 10/17/2024 on your behalf. Your test results are provided in your Prein&Newhof Laboratory analytical report. Please carefully review your analytical report, noting the following.

There were no problems with the analytical events associated with this report unless noted in the Case Narrative.

Any analyte that exceeds the client provided permit level are noted on the report with an "*" in the Qual field. Quality control data is within laboratory defined or method specified acceptance limits except if noted.

When testing for PFHxS, PFOA, PFOS, MeFOSAA, and EtFOSAA results include both branched and linear isotopes. We extract a Method Blank and analyze it with the preparation batch. Method Blank analytes are within the Reporting Limit (RL).

To learn more about interpreting your Lab Report, follow the link above to view our "Guide to Reading Lab Results". If you have any concerns about your test results or need additional help, please call: 616-364-7600 or email me: sbylsma@preinnewhof.com.

We use EPA Approved Methods for all regulated parameters. EPA Lab #: MI000014

Thank you for trusting Prein&Newhof with your testing needs.

Sincerely,

Steve Bylsma
Laboratory Manager

Original

CLIENT:	Spicer Group	**Lab Order:**	2410D13
Project:	Twin Lakes Fall Sampling		

Lab ID:	2410D13-01	**Matrix:**	AQUEOUS	**Collection Date:**	10/15/2024 12:02:00 PM
Client ID:	ET-1	**Sampler:**	BPP	**Received Date:**	10/17/2024 11:10:00 A

Analyses	**Result**	**RL**	**Qual**	**Units**	**DF**	**Date Analyzed**
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	2.40	0.800	H	mg/m^3	1	10/17/2024 2:00:42 PM
Pheophytin A	ND	0.800	H	mg/m^3	1	10/17/2024 2:00:42 PM

Lab ID:	2410D13-02	**Matrix:**	AQUEOUS	**Collection Date:**	10/15/2024 12:09:00 PM
Client ID:	ET-2	**Sampler:**	BPP	**Received Date:**	10/17/2024 11:10:00 A

Analyses	**Result**	**RL**	**Qual**	**Units**	**DF**	**Date Analyzed**
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	1.52	0.800	H	mg/m^3	1	10/17/2024 2:00:42 PM
Pheophytin A	ND	0.800	H	mg/m^3	1	10/17/2024 2:00:42 PM

Lab ID:	2410D13-03	**Matrix:**	AQUEOUS	**Collection Date:**	10/15/2024 11:53:00 AM
Client ID:	ET-3	**Sampler:**	BPP	**Received Date:**	10/17/2024 11:10:00 A

Analyses	**Result**	**RL**	**Qual**	**Units**	**DF**	**Date Analyzed**
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	2.27	0.800	H	mg/m^3	1	10/17/2024 2:00:42 PM
Pheophytin A	ND	0.800	H	mg/m^3	1	10/17/2024 2:00:42 PM

Lab ID:	2410D13-04	**Matrix:**	AQUEOUS	**Collection Date:**	10/15/2024 11:45:00 AM
Client ID:	ET-4	**Sampler:**	BPP	**Received Date:**	10/17/2024 11:10:00 A

Analyses	**Result**	**RL**	**Qual**	**Units**	**DF**	**Date Analyzed**
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	1.87	0.800	H	mg/m^3	1	10/17/2024 2:00:42 PM
Pheophytin A	ND	0.800	H	mg/m^3	1	10/17/2024 2:00:42 PM

Qualifiers:	<	Not Detected at the Reporting Limit	H	Holding times for preparation or analysis exceeded
	MCL	Maximum Contaminant Level	PL	Permit Limit
	RL	Reporting Limit		

Analytical Report

(continuous)

WO#: **2410D13**

Date Reported: **10/23/2024**

CLIENT: Spicer Group **Lab Order:** 2410D13
Project: Twin Lakes Fall Sampling

Lab ID: 2410D13-05 **Matrix:** AQUEOUS **Collection Date:** 10/15/2024 12:22:00 PM
Client ID: ET-5 **Sampler:** BPP **Received Date:** 10/17/2024 11:10:00 A

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	1.50	0.800	H	mg/m³	1	10/17/2024 2:00:42 PM
Pheophytin A	ND	0.800	H	mg/m³	1	10/17/2024 2:00:42 PM

Lab ID: 2410D13-06 **Matrix:** AQUEOUS **Collection Date:** 10/15/2024 12:54:00 PM
Client ID: WT-1 **Sampler:** BPP **Received Date:** 10/17/2024 11:10:00 A

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	1.12	0.800	H	mg/m³	1	10/17/2024 2:00:42 PM
Pheophytin A	ND	0.800	H	mg/m³	1	10/17/2024 2:00:42 PM

Lab ID: 2410D13-07 **Matrix:** AQUEOUS **Collection Date:** 10/15/2024 1:30:00 PM
Client ID: WT-2 **Sampler:** BPP **Received Date:** 10/17/2024 11:10:00 A

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	ND	0.800	H	mg/m³	1	10/17/2024 2:00:42 PM
Pheophytin A	ND	0.800	H	mg/m³	1	10/17/2024 2:00:42 PM

Lab ID: 2410D13-08 **Matrix:** AQUEOUS **Collection Date:** 10/15/2024 1:10:00 PM
Client ID: Outlet **Sampler:** BPP **Received Date:** 10/17/2024 11:10:00 A

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CHLOROPHYLL				**SM 10200H**		Analyst: **TE**
Chlorophyll a	7.80	0.800	H	mg/m³	1	10/17/2024 2:00:42 PM
Pheophytin A	3.12	0.800	H	mg/m³	1	10/17/2024 2:00:42 PM

Qualifiers:

<	Not Detected at the Reporting Limit	H	Holding times for preparation or analysis exceeded
MCL	Maximum Contaminant Level	PL	Permit Limit
RL	Reporting Limit		

Original

Prein&Newhof
Engineers▪Surveyors▪Environmental▪Laboratory

3260 Evergreen Drive, NE
Grand Rapids, MI 49525
t. 616-364-7600
f. 616-364-6955

Client Name: Spicer Group
Billing Address:

Phone Number: 269-744-1364
Email Report to: Ehrland.Bosworth@spicergroup.com
Email Invoice to: C5GIBBINGS@gmail.com
Project Name: Twin Lakes Fall Sampling
Project Number:
Sampling Personnel: BPP

CHAIN OF CUSTODY

Wastewater	W
Drinking Water	D
Groundwater	G
Soil	S
Sludge	L
Other	X

LAB USE	Sample Information				Preservative						Analysis Requested												
Lab Sample ID #	Date Collected	Time Collected	Sample Description and Location (e.g. MW-1)	MATRIX	None	H2SO4	HNO3	HCL	NaOH	Other	Chlorophyll a												
10D13-1	10/15/24	1202	ET-1	W	✓						✓												
2	10/15/24	1209	ET-2	W	✓						✓												
3	10/15/24	1153	ET-3	W	✓						✓												
4	10/15/24	1145	ET-4	W	✓						✓												
5	10/15/24	1222	ET-5	W	✓						✓												
6	10/15/24	1254	WT-1	W	✓						✓												
7	10/15/24	1330	WT-2	W	✓						✓												
8	10/15/24	1310	OUTLET	W	✓						✓												

Comments: "Report To" & "Invoice To" same as project 2404J57

4°c

Relinquished By: (Signature)	Date	Time	Received By: (Signature)	Date	Time
	10/17/24	950		10/17/24	
Relinquished By: (Signature)	**Date**	**Time**	**Received for Laboratory By: (Signature)**	**Date**	**Time**
	10/17/24			10/17/24	11:10

METIRI

Metiri Group - Holt
1914 Holloway Dr, Holt, MI 48842 - Phone (517) 699-0345 - www.metirigroup.com

November 05, 2024

Ehrland Bosworth
Spicer Group, Inc.
416 N. Homer St. #109
Lansing, MI 48912

RE: East + West Twin Lakes- Fall Event
24J0243

Thank you for selecting Metiri Group - Holt as your analytical laboratory. The samples submitted have been analyzed in accordance with all method and NELAC standards, as applicable. Any exceptions to compliance are noted in the report.

Please note that TO-15 samples will be disposed of 7 calendar days after the reporting date. All other samples will be disposed of 30 days after the reporting date.

If you have any questions regarding these results, or if we may be of further assistance to you, please contact us at (517) 699-0345.

Sincerely,

Sophie Snow For Jacob Sutherlund
Project Manager
jacob.sutherlund@metirigroup.com
517-273-4922

Table of Contents

Spicer Group, Inc.	Project: East + West Twin Lakes- Fall Event	
416 N. Homer St. #109	Project Number:	
Lansing, MI 48912	Project Manager: Ehrland Bosworth	Reported: 11/05/2024 16:49

Work Order Case Narrative

Please note the TKN analysis was performed by Metiri Group Geneva, IL. Their report AAJ0611 is attached.

Samples in this Report

Lab ID	Sample	Matrix	Date Sampled	Date Received
24J0243-01	WT01	Water	10/15/2024 11:00	10/16/2024
24J0243-02	WT02	Water	10/15/2024 11:10	10/16/2024
24J0243-03	Outlet	Water	10/15/2024 11:20	10/16/2024
24J0243-04	ET01	Water	10/15/2024 11:40	10/16/2024
24J0243-05	ET02	Water	10/15/2024 11:50	10/16/2024
24J0243-06	ET03	Water	10/15/2024 12:00	10/16/2024
24J0243-07	ET04	Water	10/15/2024 12:10	10/16/2024
24J0243-08	ET05	Water	10/15/2024 12:20	10/16/2024

Spicer Group, Inc.	Project: East + West Twin Lakes- Fall Event	
416 N. Homer St. #109	Project Number:	
Lansing, MI 48912	Project Manager: Ehrland Bosworth	Reported: 11/05/2024 16:49

Sample Results

Sample: WT01

24J0243-01 (Surface Water)

Field Analysis

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
‡	1	Total Inorganic Nitrogen	0.00		mg/L	10/15/24	1	CALC	BDK0088

Anions by Ion Chromatography

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
	1	Chloride	11	1.0	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Nitrate-N	ND	0.01	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Nitrite-N	ND	0.01	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Orthophosphate	ND	0.05	mg/L	10/16/24	1	EPA 300.0	BDJ0251

WetLab

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
	1	AMMONIA AS N	0.0479	0.0100	mg/L	10/22/24	1	SM 4500 NH3 G	BDJ0367
	1	Nitrate+Nitrite	ND	0.0200	mg/L	10/16/24	1	[CALC]	[CALC]
‡	1	Nitrate-N + Nitrite-N	0.00		mg/L	10/16/24	1	CALC	BDJ0251
	1	Phosphorus	ND	0.010	mg/L	10/21/24	1	EPA 365.3	BDJ0342
	1	Total Inorganic Nitrogen	0.0479	0.0300	mg/L	10/22/24	1	[CALC]	[CALC]
	1	TOTAL SUSPENDED SOLIDS	ND	2.5	mg/L	10/16/24	1	SM2540D	BDJ0253

Spicer Group, Inc.
416 N. Homer St. #109
Lansing, MI 48912

Project: East + West Twin Lakes- Fall Event
Project Number:
Project Manager: Ehrland Bosworth

Reported: 11/05/2024 16:49

Sample Results

(Continued)

Sample: WT02

24J0243-02 (Surface Water)

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
Field Analysis									
‡	1	Total Inorganic Nitrogen	0.00		mg/L	10/15/24	1	CALC	BDK0088

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
Anions by Ion Chromatography									
	1	Chloride	11	1.0	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Nitrate-N	ND	0.01	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Nitrite-N	ND	0.01	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Orthophosphate	ND	0.05	mg/L	10/16/24	1	EPA 300.0	BDJ0251

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
WetLab									
	1	AMMONIA AS N	0.0405	0.0100	mg/L	10/22/24	1	SM 4500 NH3 G	BDJ0367
	1	Nitrate+Nitrite	ND	0.0200	mg/L	10/16/24	1	[CALC]	[CALC]
‡	1	Nitrate-N + Nitrite-N	0.00		mg/L	10/16/24	1	CALC	BDJ0251
	1	Phosphorus	ND	0.010	mg/L	10/21/24	1	EPA 365.3	BDJ0342
	1	Total Inorganic Nitrogen	0.0405	0.0300	mg/L	10/22/24	1	[CALC]	[CALC]
	1	TOTAL SUSPENDED SOLIDS	ND	2.5	mg/L	10/16/24	1	SM2540D	BDJ0253

Sample Results

(Continued)

Sample: Outlet

24J0243-03 (Surface Water)

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
Field Analysis									
‡	1	Total Inorganic Nitrogen	0.00		mg/L	10/15/24	1	CALC	BDK0088

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
Anions by Ion Chromatography									
	1	Chloride	12	1.0	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Nitrate-N	ND	0.01	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Nitrite-N	ND	0.01	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Orthophosphate	ND	0.05	mg/L	10/16/24	1	EPA 300.0	BDJ0251

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
WetLab									
	1	AMMONIA AS N	0.0381	0.0100	mg/L	10/22/24	1	SM 4500 NH3 G	BDJ0367
	1	Nitrate+Nitrite	ND	0.0200	mg/L	10/16/24	1	[CALC]	[CALC]
‡	1	Nitrate-N + Nitrite-N	0.00		mg/L	10/16/24	1	CALC	BDJ0251
	1	Phosphorus	0.021	0.010	mg/L	10/21/24	1	EPA 365.3	BDJ0342
	1	Total Inorganic Nitrogen	0.0381	0.0300	mg/L	10/22/24	1	[CALC]	[CALC]
	1	TOTAL SUSPENDED SOLIDS	59	2.5	mg/L	10/16/24	1	SM2540D	BDJ0253

Spicer Group, Inc.	Project: East + West Twin Lakes- Fall Event	
416 N. Homer St. #109	Project Number:	
Lansing, MI 48912	Project Manager: Ehrland Bosworth	Reported: 11/05/2024 16:49

Sample Results

(Continued)

Sample: ET01

24J0243-04 (Surface Water)

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
Field Analysis									
‡	1	Total Inorganic Nitrogen	0.00		mg/L	10/15/24	1	CALC	BDK0088

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
Anions by Ion Chromatography									
	1	Chloride	26	1.0	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Nitrate-N	ND	0.01	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Nitrite-N	ND	0.01	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Orthophosphate	ND	0.05	mg/L	10/16/24	1	EPA 300.0	BDJ0251

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
WetLab									
	1	AMMONIA AS N	0.0389	0.0100	mg/L	10/22/24	1	SM 4500 NH3 G	BDJ0367
	1	Nitrate+Nitrite	ND	0.0200	mg/L	10/16/24	1	[CALC]	[CALC]
‡	1	Nitrate-N + Nitrite-N	0.00		mg/L	10/16/24	1	CALC	BDJ0251
	1	Phosphorus	0.018	0.010	mg/L	10/21/24	1	EPA 365.3	BDJ0342
	1	Total Inorganic Nitrogen	0.0389	0.0300	mg/L	10/22/24	1	[CALC]	[CALC]
	1	TOTAL SUSPENDED SOLIDS	3.0	2.5	mg/L	10/16/24	1	SM2540D	BDJ0253

Sample Results

(Continued)

Sample: ET02

24J0243-05 (Surface Water)

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
Field Analysis									
‡	1	Total Inorganic Nitrogen	0.00		mg/L	10/15/24	1	CALC	BDK0088

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
Anions by Ion Chromatography									
	1	Chloride	25	1.0	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Nitrate-N	ND	0.01	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Nitrite-N	ND	0.01	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Orthophosphate	ND	0.05	mg/L	10/16/24	1	EPA 300.0	BDJ0251

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
WetLab									
	1	AMMONIA AS N	0.0323	0.0100	mg/L	10/22/24	1	SM 4500 NH3 G	BDJ0367
	1	Nitrate+Nitrite	ND	0.0200	mg/L	10/16/24	1	[CALC]	[CALC]
‡	1	Nitrate-N + Nitrite-N	0.00		mg/L	10/16/24	1	CALC	BDJ0251
	1	Phosphorus	0.017	0.010	mg/L	10/21/24	1	EPA 365.3	BDJ0342
	1	Total Inorganic Nitrogen	0.0323	0.0300	mg/L	10/22/24	1	[CALC]	[CALC]
	1	TOTAL SUSPENDED SOLIDS	3.8	2.5	mg/L	10/16/24	1	SM2540D	BDJ0253

Sample Results
(Continued)

Sample: ET03

24J0243-06 (Surface Water)

Field Analysis

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
‡	1	Total Inorganic Nitrogen	0.00		mg/L	10/15/24	1	CALC	BDK0088

Anions by Ion Chromatography

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
	1	Chloride	26	1.0	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Nitrate-N	ND	0.01	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Nitrite-N	ND	0.01	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Orthophosphate	ND	0.05	mg/L	10/16/24	1	EPA 300.0	BDJ0251

WetLab

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
	1	AMMONIA AS N	0.0677	0.0100	mg/L	10/22/24	1	SM 4500 NH3 G	BDJ0367
	1	Nitrate+Nitrite	ND	0.0200	mg/L	10/16/24	1	[CALC]	[CALC]
‡	1	Nitrate-N + Nitrite-N	0.00		mg/L	10/16/24	1	CALC	BDJ0251
	1	Phosphorus	0.010	0.010	mg/L	10/21/24	1	EPA 365.3	BDJ0342
	1	Total Inorganic Nitrogen	0.0677	0.0300	mg/L	10/22/24	1	[CALC]	[CALC]
	1	TOTAL SUSPENDED SOLIDS	3.4	2.5	mg/L	10/16/24	1	SM2540D	BDJ0253

Spicer Group, Inc.
416 N. Homer St. #109
Lansing, MI 48912

Project: East + West Twin Lakes- Fall Event
Project Number:
Project Manager: Ehrland Bosworth
Reported: 11/05/2024 16:49

Sample Results
(Continued)

Sample: ET04
24J0243-07 (Surface Water)

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
Field Analysis									
‡	1	Total Inorganic Nitrogen	0.00		mg/L	10/15/24	1	CALC	BDK0088
Anions by Ion Chromatography									
	1	Chloride	26	1.0	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Nitrate-N	ND	0.01	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Nitrite-N	ND	0.01	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Orthophosphate	ND	0.05	mg/L	10/16/24	1	EPA 300.0	BDJ0251
WetLab									
	1	AMMONIA AS N	0.0450	0.0100	mg/L	10/22/24	1	SM 4500 NH3 G	BDJ0367
	1	Nitrate+Nitrite	ND	0.0200	mg/L	10/16/24	1	[CALC]	[CALC]
‡	1	Nitrate-N + Nitrite-N	0.00		mg/L	10/16/24	1	CALC	BDJ0251
	1	Phosphorus	0.018	0.010	mg/L	10/21/24	1	EPA 365.3	BDJ0342
	1	Total Inorganic Nitrogen	0.0450	0.0300	mg/L	10/22/24	1	[CALC]	[CALC]
	1	TOTAL SUSPENDED SOLIDS	3.3	2.5	mg/L	10/16/24	1	SM2540D	BDJ0253

Sample Results
(Continued)

Sample: ET05

24J0243-08 (Surface Water)

Field Analysis

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
‡	1	Total Inorganic Nitrogen	0.00		mg/L	10/15/24	1	CALC	BDK0088

Anions by Ion Chromatography

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
	1	Chloride	26	1.0	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Nitrate-N	ND	0.01	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Nitrite-N	ND	0.01	mg/L	10/16/24	1	EPA 300.0	BDJ0251
	1	Orthophosphate	ND	0.05	mg/L	10/16/24	1	EPA 300.0	BDJ0251

WetLab

		Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
	1	AMMONIA AS N	0.0288	0.0100	mg/L	10/22/24	1	SM 4500 NH3 G	BDJ0367
	1	Nitrate+Nitrite	ND	0.0200	mg/L	10/16/24	1	[CALC]	[CALC]
‡	1	Nitrate-N + Nitrite-N	0.00		mg/L	10/16/24	1	CALC	BDJ0251
	1	Phosphorus	0.015	0.010	mg/L	10/21/24	1	EPA 365.3	BDJ0342
	1	Total Inorganic Nitrogen	ND	0.0300	mg/L	10/22/24	1	[CALC]	[CALC]
	1	TOTAL SUSPENDED SOLIDS	2.5	2.5	mg/L	10/16/24	1	SM2540D	BDJ0253

Notes and Definitions

Item	Definition
Dry	Sample results reported on a dry weight basis.
MDL	Method Detection Limit (only displays if reported to the MDL)
ND	Analyte NOT DETECTED at or above the reporting limit.
DF	Dilution Factor
DL	Detection Limit
‡	Parameter not included in NELAC Scope of Analysis.
Soil pH measured in water at degree C	
RPD	Relative Percent Difference
%REC	Percent Recovery
Source	Sample that was matrix spiked or duplicated.
PQL, Practical Quantitation Limit = Method Reporting Limit (MRL).	

Accreditation Number(s):

MI001292024-1

WORK ORDER

24J0243

Printed: 11/05/2024 4:49 pm

Project: **East + West Twin Lakes- Fall Event**
Project Number:
Project Manager: **Jacob Sutherlund**
PO Number:

Report To:
Spicer Group, Inc.
Ehrland Bosworth
416 N. Homer St. #109
Lansing, MI 48912
Phone: (989) 224-2355
Fax: (989) 224-2357

Invoice To:
Spicer Group, Inc.
Ehrland Bosworth
416 N. Homer St. #109
Lansing, MI 48912
Phone: (989) 224-2355
Fax: (989) 224-2357

Date Received: 10/16/2024 08:05 AM
Date Due: 10/23/2024 (5.00 day TAT)

Logged In By: Kelly Williams
Received By: Kelly Williams

Analysis		Comments
24J0243-01 WT01 [Water] Sampled 10/15/2024 11:00:00AM		
Ammonia-MI	NONE	
Chloride-MI	NONE	
Nitrate+Nitrite Calc-MI	NONE	Short hold
Nitrate+Nitrite-MI	NONE	
Nitrate-MI	NONE	Short hold
Nitrite-MI	NONE	Short hold
Orthophosphate-MI	NONE	Short hold
Phosphorus-MI	NONE	
TIN-MI (Calc)	NONE	
Total Inorganic Nitrogen-MI	NONE	
Total Suspended Solids-MI	NONE	
24J0243-02 WT02 [Water] Sampled 10/15/2024 11:10:00AM		
Ammonia-MI	NONE	
Chloride-MI	NONE	
Nitrate+Nitrite Calc-MI	NONE	Short hold
Nitrate+Nitrite-MI	NONE	
Nitrate-MI	NONE	Short hold
Nitrite-MI	NONE	Short hold
Orthophosphate-MI	NONE	Short hold
Phosphorus-MI	NONE	
TIN-MI (Calc)	NONE	
Total Inorganic Nitrogen-MI	NONE	
Total Suspended Solids-MI	NONE	

Analysis		**Comments**
24J0243-03 Outlet [Water] Sampled 10/15/2024 11:20:00AM		
Ammonia-MI	NONE	
Chloride-MI	NONE	
Nitrate+Nitrite Calc-MI	NONE	Short hold
Nitrate+Nitrite-MI	NONE	
Nitrate-MI	NONE	Short hold
Nitrite-MI	NONE	Short hold
Orthophosphate-MI	NONE	Short hold
Phosphorus-MI	NONE	
TIN-MI (Calc)	NONE	
Total Inorganic Nitrogen-MI	NONE	
Total Suspended Solids-MI	NONE	
24J0243-04 ET01 [Water] Sampled 10/15/2024 11:40:00AM		
Ammonia-MI	NONE	
Chloride-MI	NONE	
Nitrate+Nitrite Calc-MI	NONE	Short hold
Nitrate+Nitrite-MI	NONE	
Nitrate-MI	NONE	Short hold
Nitrite-MI	NONE	Short hold
Orthophosphate-MI	NONE	Short hold
Phosphorus-MI	NONE	
TIN-MI (Calc)	NONE	
Total Inorganic Nitrogen-MI	NONE	
Total Suspended Solids-MI	NONE	
24J0243-05 ET02 [Water] Sampled 10/15/2024 11:50:00AM		
Ammonia-MI	NONE	
Chloride-MI	NONE	
Nitrate+Nitrite Calc-MI	NONE	Short hold
Nitrate+Nitrite-MI	NONE	
Nitrate-MI	NONE	Short hold
Nitrite-MI	NONE	Short hold
Orthophosphate-MI	NONE	Short hold
Phosphorus-MI	NONE	
TIN-MI (Calc)	NONE	
Total Inorganic Nitrogen-MI	NONE	
Total Suspended Solids-MI	NONE	
24J0243-06 ET03 [Water] Sampled 10/15/2024 12:00:00PM		
Ammonia-MI	NONE	
Chloride-MI	NONE	
Nitrate+Nitrite Calc-MI	NONE	Short hold
Nitrate+Nitrite-MI	NONE	
Nitrate-MI	NONE	Short hold
Nitrite-MI	NONE	Short hold
Orthophosphate-MI	NONE	Short hold
Phosphorus-MI	NONE	
TIN-MI (Calc)	NONE	
Total Inorganic Nitrogen-MI	NONE	
Total Suspended Solids-MI	NONE	

Analysis		**Comments**
24J0243-07 ET04 [Water] Sampled 10/15/2024 12:10:00PM		
Ammonia-MI	NONE	
Chloride-MI	NONE	
Nitrate+Nitrite Calc-MI	NONE	Short hold
Nitrate+Nitrite-MI	NONE	
Nitrate-MI	NONE	Short hold
Nitrite-MI	NONE	Short hold
Orthophosphate-MI	NONE	Short hold
Phosphorus-MI	NONE	
TIN-MI (Calc)	NONE	
Total Inorganic Nitrogen-MI	NONE	
Total Suspended Solids-MI	NONE	
24J0243-08 ET05 [Water] Sampled 10/15/2024 12:20:00PM		
Ammonia-MI	NONE	
Chloride-MI	NONE	
Nitrate+Nitrite Calc-MI	NONE	Short hold
Nitrate+Nitrite-MI	NONE	
Nitrate-MI	NONE	Short hold
Nitrite-MI	NONE	Short hold
Orthophosphate-MI	NONE	Short hold
Phosphorus-MI	NONE	
TIN-MI (Calc)	NONE	
Total Inorganic Nitrogen-MI	NONE	
Total Suspended Solids-MI	NONE	

Samples subcontracted to: Metiri Group - Geneva

24J0243-01 WT01 [Water] Sampled 10/15/2024 11:00:00AM		
SUB-TKN-Geneva	NONE	Need to sub
24J0243-02 WT02 [Water] Sampled 10/15/2024 11:10:00AM		
SUB-TKN-Geneva	NONE	Need to sub
24J0243-03 Outlet [Water] Sampled 10/15/2024 11:20:00AM		
SUB-TKN-Geneva	NONE	Need to sub
24J0243-04 ET01 [Water] Sampled 10/15/2024 11:40:00AM		
SUB-TKN-Geneva	NONE	Need to sub
24J0243-05 ET02 [Water] Sampled 10/15/2024 11:50:00AM		
SUB-TKN-Geneva	NONE	Need to sub
24J0243-06 ET03 [Water] Sampled 10/15/2024 12:00:00PM		
SUB-TKN-Geneva	NONE	Need to sub
24J0243-07 ET04 [Water] Sampled 10/15/2024 12:10:00PM		
SUB-TKN-Geneva	NONE	Need to sub
24J0243-08 ET05 [Water] Sampled 10/15/2024 12:20:00PM		
SUB-TKN-Geneva	NONE	Need to sub

24J0243 **Sample Receipt Log**

Default Cooler

Samples Received at: **4.0°C**

Were Custody Seals present and signed?	No	Container/preservative correct for test requested?	Yes
Received on Ice	Yes	Sufficient amount sent for tests requested?	Yes
Within proper temp	Yes	Required containers sealed in separate bags?	No
Were all TO-15 samples received at ambient?	No	Were all samples inspected and sampled correctly?	Yes
Was a chain of custody received?	Yes	Were bubbles absent in volatile samples?	No
COCs complete/signed in the appropriate places?	Yes	Sufficient remaining holding time for analyses?	Yes
Were all samples listed on COC received?	Yes	If Applicable pH documented for necessary samples?	Yes
Did all samples/container labels agree with COCs?	Yes	If applicable, was the chlorine test negative?	No
Did all containers arrive in good condition?	Yes	If applicable, samples free of oxidizers?	No
Containers Intact	Yes	Thermometer # : 10003954 used?	Yes

Nitrate+Nitrite Calc-MI

Nitrite-MI   Nitrate-MI

Total Inorganic Nitrogen-MI

Nitrate+Nitrite-MI   Ammonia-MI

METIRI

Analytical Laboratory

1914 Holloway Drive
Holt, MI 48842
Phone: 517 699 0345
Fax: 517 699 0388
email: lab@fibertec.us

8660 S. Mackinaw Trail
Cadillac, MI 49601
Phone: 231 775 8368
Fax: 231 775 8584

Geoprobe
11766 E. Grand River Rd.
Brighton, MI 48116
Phone: 810 220 3300
Fax: 810 220 3311

Chain of Custody #

PAGE ____ of ____

Client Name: SPICER GROUP

Contact Person: EHRLAND BOSWORTH

Project Name/ Number: EAST + WEST TWIN LAKES - FALL EVENT

Email distribution list: EHRLAND.BOSWORTH@SPICERGROUP.COM

Quote#

Purchase Order#

S	Soil	GW	Ground Water
A	Air	SW	Surface Water
O	Oil	WW	Waste Water
P	Wipe	X	Other: Specify

Deliverables

- ☐ Level 2
- ☐ Level 3
- ☐ Level 4
- ☐ EDD

Date	Time	Sample #	Client Sample Descriptor	MATRIX (SEE RIGHT CORNER FOR CODE)	# OF CONTAINERS	PARAMETERS TSS	Nitrate, Nitrite, NH3	Total N, Chloride,	TKN	Total Phos, Ortho-Phos						HOLD SAMPLE	Remarks:
10/15	11:00		WT01	SW	4												
10/15	11:10		WT02														
10/15	11:20		Outlet														
10/15	11:40		ET01														Received By Lab
10/15	11:50		ET02														OCT 16
10/15	12:00		ET03														Initials. VW
10/15	12:10		ET04														
10/15	12:20		ET05														

Comments:

Sampled/Relinquished By:	Date/ Time 10/16 9:05	Received By:
Relinquished By:	Date/ Time	Received By:
Relinquished By:	Date/ Time	Received By Laboratory:

Turnaround Time ALL RESULTS WILL BE SENT BY THE END OF THE BUSINESS DAY

______1 bus. day ______2 bus. days ______3 bus. days ______4 bus. days

✓ 5-7 bus. days (standard) Other (specify time/date requirement): ____________________

LAB USE ONLY

Metiri project number: 24J0243

Temperature upon receipt at Lab: 4.0°C

Received On Ice

Please see back for terms and conditions

November 05, 2024

Fibertec Environmental Services
Fibertec Environmental Services
1914 Holloway Dr.
Holt, MI 48842

RE: Special SVOA Reporting Limits
AAJ0611

Metiri Analytical Group Inc, - Geneva received sample(s) on 10/17/2024 for the analyses presented in the following report.

All data for the associated quality control (QC) met EPA, method, or internal laboratory specifications except where noted in the case narrative. If you are comparing these results to external QC specifications or compliance limits and have any questions, please contact us.

This final report of laboratory analysis consists of this cover letter, case narrative, analytical report, dates report, and any accompanying documentation including, but not limited to, chain of custody records, raw data, and letters of explanation or reliance. This report may not be reproduced, except in full, without the prior written approval of Suburban Laboratories, Inc.

If you have any questions regarding these test results, please call me at (708) 544-3260.

Sincerely,

Emily Ducote

Emily Ducote
Project Manager

Notes and Definitions

Item	Definition
J	Analyte detected below quantitation limit (QL)
U	Analyte included in the analysis, but not detected

General Comments:
- All results reported in wet weight unless otherwise indicated. (dry = Dry Weight)
- Sample results relate only to the analytes of interest tested and to sample as received by the laboratory.
- Environmental compliance sample results meet the requirements of 35 IAC Part 186 unless otherwise indicated.
- Waste water analysis follows the rules set forth in 40 CFR part 136 except where otherwise noted.
- Accreditation by the State of Illinois is not an endorsement or a guarantee of the validity of data generated.
- For more information about the laboratories' scope of accreditation, please contact us at (708) 544-3260 or the Agency at (217) 782-6455.
- All radiological results are reported to the 95% confidence level.

Abbreviations:
- Reporting Limit: The concentration at which an analyte can be routinely detected on a day to day basis, and which also meets regulatory and client needs.
- Quantitation Limit: The lowest concentration at which results can be accurately quantitated.
- J: The analyte was positively identified above our Method Detection Limit and is considered detectable and usable; however, the associated numerical value is the approximate concentration of the analyte in the sample.
- ATC: Automatic Temperature Correction. - TNTC: Too Numerous To Count
- TIC: Tentatively Identified Compound (GCMS library search identification, concentration estimated to nearest internal standard).
- SS: (Surrogate Standard): Quality control compound added to the sample by the lab.
-LA: Lab Accident - No valid data to report.
-VO: Insufficient Volume provided
-BR: Received broken
-IP: Invalid Sampling

Method References:
For a complete list of method references please contact us.
- E: USEPA Reference methods
- SW: USEPA, Test Methods for Evaluating Solid Waste (SW-846)
- M: Standard Methods for the Examination of Water and Wastewater

Illinois Department of Public Health Accredited #17585

Illinois Environmental Protection Agency Accredited #100225

Table of Contents

Fibertec Environmental Services	Project: Special SVOA Reporting Limits	
1914 Holloway Dr.	Project Number:	
Holt, MI 48842	Project Manager: Fibertec Environmental Services	Reported: 11/05/2024 14:21

Samples in this Report

Lab ID	Sample	Matrix	Date Sampled	Date Received
AAJ0611-01	WT01	Water	10/15/2024 11:00	10/17/2024
AAJ0611-02	WT02	Water	10/15/2024 11:10	10/17/2024
AAJ0611-03	Outlet	Water	10/15/2024 11:20	10/17/2024
AAJ0611-04	ET01	Water	10/15/2024 11:40	10/17/2024
AAJ0611-05	ET02	Water	10/15/2024 11:50	10/17/2024
AAJ0611-06	ET03	Water	10/15/2024 12:00	10/17/2024
AAJ0611-07	ET04	Water	10/15/2024 12:10	10/17/2024
AAJ0611-08	ET05	Water	10/15/2024 12:20	10/17/2024

Fibertec Environmental Services	Project: Special SVOA Reporting Limits	
1914 Holloway Dr.	Project Number:	
Holt, MI 48842	Project Manager: Fibertec Environmental Services	Reported: 11/05/2024 14:21

Sample Results

Sample: WT01

AAJ0611-01 (Water)

Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
Wetchem							
Nitrogen, Kjeldahl, Total	ND	3.78	mg/L	10/31/24	1	SM 4500-Norg D	BAJ0849

Sample Results

(Continued)

Sample: WT02

AAJ0611-02 (Water)

Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
Wetchem							
Nitrogen, Kjeldahl, Total	ND	3.78	mg/L	10/31/24	1	SM 4500-Norg D	BAJ0849

Sample Results

(Continued)

Sample: Outlet

AAJ0611-03 (Water)

Analyte	Result	Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
Wetchem								
Nitrogen, Kjeldahl, Total	2.66	J	3.78	mg/L	10/31/24	1	SM 4500-Norg D	BAJ0849

Sample Results

(Continued)

Sample: ET01

AAJ0611-04 (Water)

Wetchem

Analyte	Result	Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
Nitrogen, Kjeldahl, Total	1.25	J	3.78	mg/L	10/31/24	1	SM 4500-Norg D	BAJ0849

Sample Results

(Continued)

Sample: ET02

AAJ0611-05 (Water)

Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
Wetchem							
Nitrogen, Kjeldahl, Total	ND	3.78	mg/L	10/31/24	1	SM 4500-Norg D	BAJ0849

Sample Results

(Continued)

Sample: ET03

AAJ0611-06 (Water)

Wetchem

Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
Nitrogen, Kjeldahl, Total	ND	3.78	mg/L	10/31/24	1	SM 4500-Norg D	BAJ0849

Sample Results

(Continued)

Sample: ET04

AAJ0611-07 (Water)

Analyte	Result	Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
Wetchem								
Nitrogen, Kjeldahl, Total	1.20	J	3.78	mg/L	10/31/24	1	SM 4500-Norg D	BAJ0849

Fibertec Environmental Services	Project: Special SVOA Reporting Limits	
1914 Holloway Dr.	Project Number:	
Holt, MI 48842	Project Manager: Fibertec Environmental Services	Reported: 11/05/2024 14:21

Sample Results

(Continued)

Sample: ET05

AAJ0611-08 (Water)

Analyte	Result /Qual	PQL	Units	Date Analyzed	DF	Method	Prep Batch
Wetchem							
Nitrogen, Kjeldahl, Total	ND	3.78	mg/L	10/31/24	1	SM 4500-Norg D	BAJ0849

Quality Control

Wetchem

Analyte	Result/ Qual	PQL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
Method: SM 4500-Norg D										
Batch: BAJ0849 - TKN Prep										
Blank (BAJ0849-BLK1)					Prepared: 10/30/24 14:08 Analyzed: 10/31/24 11:34					
Nitrogen, Kjeldahl, Total	ND	3.78	1.19	mg/L						

Fibertec Environmental Services	Project: Special SVOA Reporting Limits	
1914 Holloway Dr.	Project Number:	
Holt, MI 48842	Project Manager: Fibertec Environmental Services	Reported: 11/05/2024 14:21

Quality Control

(Continued)

Wetchem (Continued)

Analyte	Result/ Qual	PQL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
LCS (BAJ0849-BS1)					Prepared: 10/30/24 14:08	Analyzed: 10/31/24 11:36				
Nitrogen, Kjeldahl, Total	14.2			mg/L	15.0		94	80-120		

Quality Control

(Continued)

Wetchem (Continued)

Analyte	Result/ Qual	PQL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
LCS Dup (BAJ0849-BSD1)					Prepared: 10/30/24 14:08	Analyzed: 10/31/24 11:40				
Nitrogen, Kjeldahl, Total	15.2			mg/L	15.0		101	80-120	7	200

Quality Control
(Continued)

Wetchem (Continued)

Analyte	Result/ Qual	PQL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
Matrix Spike (BAJ0849-MS1)	**Source: AAJ0611-08**				Prepared: 10/30/24 14:08	Analyzed: 10/31/24 11:52				
Nitrogen, Kjeldahl, Total	15.1			mg/L	15.0	ND	101	80-120		

Quality Control
(Continued)

Wetchem (Continued)

Analyte	Result/ Qual	PQL	MDL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
Matrix Spike Dup (BAJ0849-MSD1)	**Source: AAJ0611-08**				Prepared: 10/30/24 14:08	Analyzed: 10/31/24 11:56				
Nitrogen, Kjeldahl, Total	15.7			mg/L	15.0	ND	105	80-120	4	20

Fibertec environmental services

Analytical Laboratory
1914 Holloway Drive
Holt, MI 48842
Phone: 517 699 0345
Fax: 517 699 0388
email: lab@fibertec.us

8660 S. Mackinaw Trail
Cadillac, MI 49601
Phone: 231 775 8368
Fax: 231 775 8584

Geoprobe
11766 E. Grand River Rd.
Brighton, MI 48116
Phone: 810 220 3300
Fax: 810 220 3311

Chain of Custody #
24J0243-S
PAGE 1 of 1

Client Name: Metiri Group - Holt
Contact Person: Jacob Sutherlund
Project Name/ Number: 24J0243
Email distribution list: lab.holt@metirigroup.com
Quote#
Purchase Order#

Date	Time	Sample #	Client Sample Descriptor	MATRIX (SEE RIGHT CORNER FOR CODE)	# OF CONTAINERS	TKN	HOLD SAMPLE	Remarks:
10/15/24	11:00		WT1	SW	1	✓		
10/15/24	11:10		WT2	SW	1	✓		
10/15/24	11:20		Outlet	SW	1	✓		
10/15/24	11:40		ET1	SW	1	✓		
10/15/24	11:50		ET2	SW	1	✓		
10/15/24	12:00		ET3	SW	1	✓		
10/15/24	12:10		ET4	SW	1	✓		
10/15/24	12:20		ET5	SW	1	✓		

PARAMETERS

Matrix Code

S	Soil	GW	Ground Water
A	Air	SW	Surface Water
O	Oil	WW	Waste Water
P	Wipe	X	Other: Specify

Deliverables
☐ Level 2
☐ Level 3
☐ Level 4
☒ EDD

AAJ0611
Fibertec Environmental Services

Comments:

Sampled/Relinquished By:	Date/ Time 10/16/24 15:00	Received By: Fed ex
Relinquished By:	Date/ Time	Received By:
Relinquished By:	Date/Time OCT 17 2024 9am	Received By Laboratory:

Turnaround Time ALL RESULTS WILL BE SENT BY THE END OF THE BUSINESS DAY

______1 bus. day ______2 bus. days ______3 bus. days ______4 bus. days

X 5-7 bus. days (standard) Other (specify time/date requirement): ______

LAB USE ONLY

Fibertec project number:

Temperature upon receipt at Lab: 2.0° T107

Please see back for terms and conditions

√ JSutherland

Fibertec
environmental
services

Analytical Laboratory

1914 Holloway Drive
Holt, MI 48842
Phone: 517 699 0345
Fax: 517 699 0388
email: lab@fibertec.us

8660 S. Mackinaw Trail
Cadillac, MI 49601
Phone: 231 775 8368
Fax: 231 775 8584

Geoprobe
11766 E. Grand River Rd.
Brighton, MI 48116
Phone: 810 220 3300
Fax: 810 220 3311

Chain of Custody #
24J0243-S

PAGE 1 of 1

Client Name: Metiri Group - Holt

Contact Person: Jacob Sutherlund

Project Name/ Number: 24J0243

Email distribution list: lab.holt@metirigroup.com

Quote#

Purchase Order#

PARAMETERS

Date	Time	Sample #	Client Sample Descriptor	MATRIX (SEE RIGHT CORNER FOR CODE)	# OF CONTAINERS	TKN	HOLD SAMPLE
10/15/24	11:00		~~WT1~~ ① WT01	SW	1	✓	
10/15/24	11:10		~~WT2~~ WT02	SW	1	✓	
10/15/24	11:20		Outlet	SW	1	✓	
10/15/24	11:40		~~ET1~~ ET01	SW	1	✓	
10/15/24	11:50		~~ET2~~ ET02	SW	1	✓	
10/15/24	12:00		~~ET3~~ ET03	SW	1	✓	
10/15/24	12:10		~~ET4~~ ET04	SW	1	✓	
10/15/24	12:20		~~ET5~~ ET05	SW	1	✓	

Matrix Code

S	Soil	GW	Ground Water
A	Air	SW	Surface Water
O	Oil	WW	Waste Water
P	Wipe	X	Other: Specify

Deliverables

☐ Level 2
☐ Level 3
☐ Level 4
☐ EDD

Remarks:

Comments:
① Kz 10/21/24

Sampled/Relinquished By:

Relinquished By:	Date/ Time	Received By:
Relinquished By:	Date/ Time	Received By:
	Date/ Time	Received By Laboratory:

Turnaround Time ALL RESULTS WILL BE SENT BY THE END OF THE BUSINESS DAY

____1 bus. day
____2 bus. days
____3 bus. days
____4 bus. days
X 5-7 bus. days (standard)
Other (specify time/date requirement): ________

LAB USE ONLY

Fibertec project number:

Temperature upon receipt at Lab:

Please see back for terms and conditions

APPENDIX B

Algal Analysis Laboratory Reports

GreenWater laboratories

205 Zeagler Drive, Suite 302
Palatka FL 32177

www.greenwaterlab.com
Ph: +1 386-328-0882

Spicer Group Algal ID and Enumeration Report

Prepared: March 10, 2025
Prepared By: GreenWater Laboratories

Samples: 3 (Collected on 10/15/24)

1. ET-1
2. ET-2
3. ET-4

Sample 1: ET-1

Total cell numbers in the ET-1 sample collected on 10/15/24 were 51,396 cells/mL. Blue-green algae (Cyanobacteria; 48,367 cells/mL) was the most abundant algal group in the sample accounting for 94.1% of total cell numbers. Other algal groups in the sample were diatoms (Bacillariophyceae; 527 cells/mL), desmids (Charophyta; 14 cells/mL), green algae (Chlorophyta; 1,796 cells/mL), golden-brown algae (Chrysophyceae; 6 cells/mL), cryptophytes (Cryptista; 5 cells/mL), dinoflagellates (Dinoflagellata; 25 cells/mL), euglenoids (Euglenophyta; 0.1 cells/mL), unknown algae (Unknown; 630 cells/mL) and yellow-green algae (Xanthophyceae; 24 cells/mL). The most abundant alga in the sample was the colonial cyanophyte *Anathece* sp. (36,652 cells/mL; Fig. 1). A total of 68 species were observed in the sample with green algae the most diverse group with 32 taxa observed.

Total cell numbers of potentially toxigenic cyanobacteria (PTOX Cyano) were 2,218 cells/mL (4.3% of total cell numbers). PTOX Cyano species observed in the sample included *Radiocystis geminata* (2,182 cells/mL; Fig. 2), *Microcystis botrys* (27 cells/mL; Fig. 3) and *Dolichospermum fuscum* (9 cells/mL; Fig. 4).

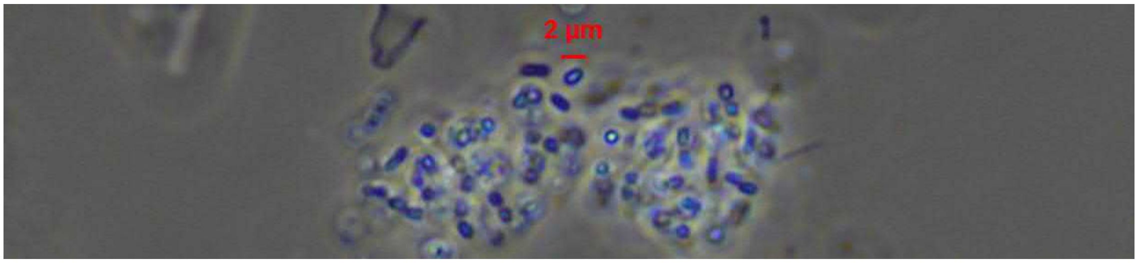

Fig. 1 *Anathece* sp. 600X (scale bar = 2µm)

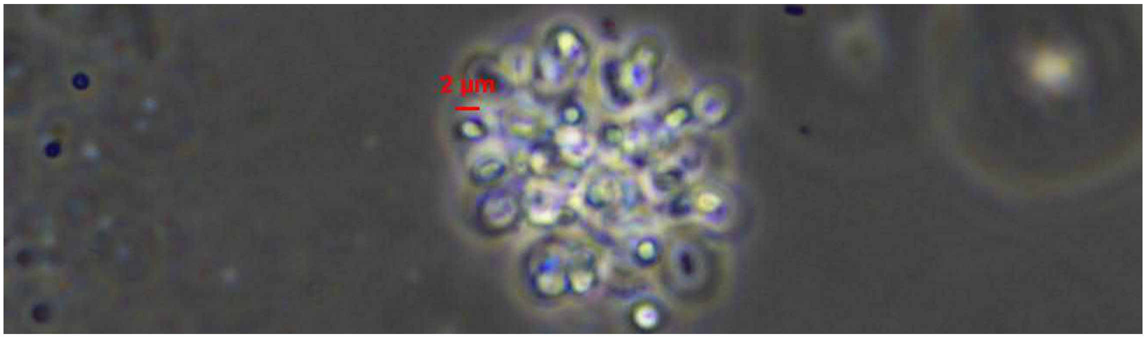

Fig. 2 *Radiocystis geminata* 600X (scale bar = 2µm)

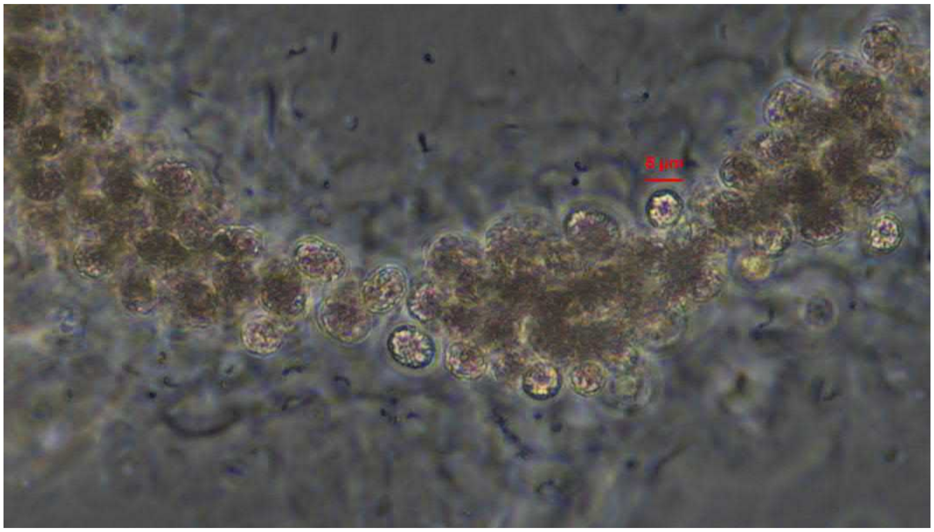

Fig. 3 *Microcystis botrys* 600X (scale bar = 5µm)

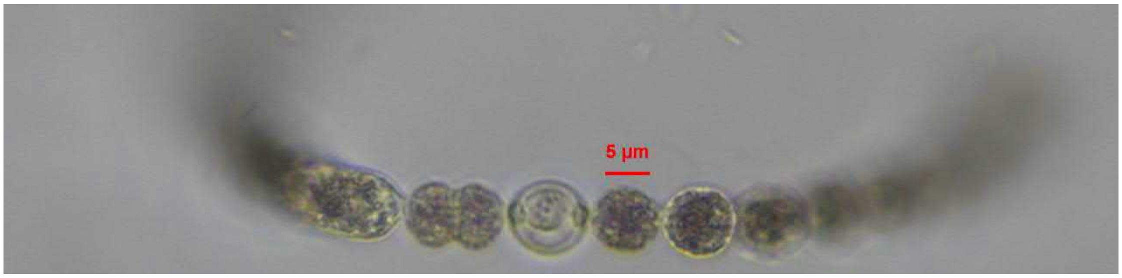

Fig. 4 *Dolichospermum fuscum* 600X (scale bar = 5µm)

Sample 2: ET-2

Total cell numbers in the ET-2 sample collected on 10/15/24 were 45,307 cells/mL. Blue-green algae (Cyanobacteria; 41,079 cells/mL) was the most abundant algal group in the sample accounting for 90.7% of total cell numbers. Other algal groups in the sample were diatoms (Bacillariophyceae; 490 cells/mL), desmids (Charophyta; 36 cells/mL), green algae (Chlorophyta; 2,672 cells/mL), golden-brown algae (Chrysophyceae; 35 cells/mL), cryptophytes (Cryptista; 8 cells/mL), dinoflagellates (Dinoflagellata; 38 cells/mL), euglenoids (Euglenophyta; 0.1 cells/mL), haptophytes (Haptophyta; 24 cells/mL), unknown algae (Unknown; 921 cells/mL) and yellow-green algae (Xanthophyceae; 3 cells/mL). The most abundant alga in the sample was the colonial cyanophyte *Anathece* sp. (37,524 cells/mL; Fig. 5). A total of 86 species were observed in the sample with green algae the most diverse group with 38 taxa observed.

Total cell numbers of potentially toxigenic cyanobacteria (PTOX Cyano) were 1,180 cells/mL (2.6% of total cell numbers). PTOX Cyano species observed in the sample included *Radiocystis geminata* (1,091 cells/mL), *Microcystis botrys* (67 cells/mL), *Dolichospermum fuscum* (17 cells/mL), cf. *Phormidium* sp. (3 cells/mL; Fig. 6) and *Anagnostidinema/Geitlerinema* sp. (2 cells/mL; Fig. 7).

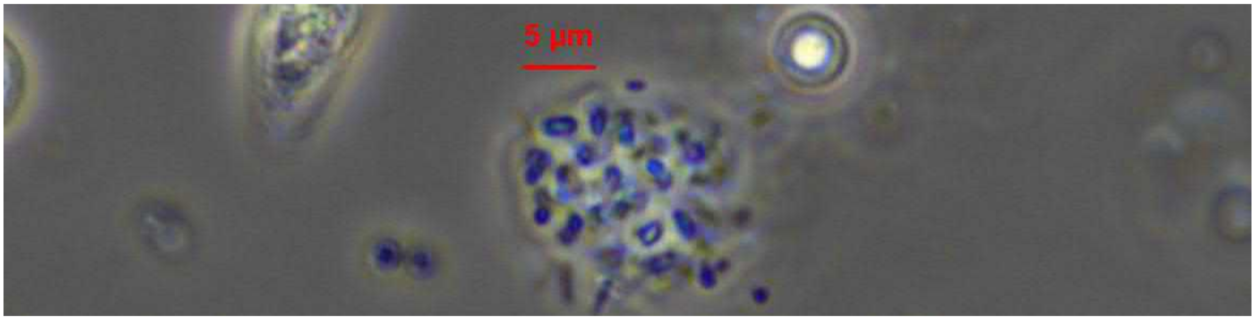

Fig. 5 *Anathece* sp. 600X (scale bar = 5µm)

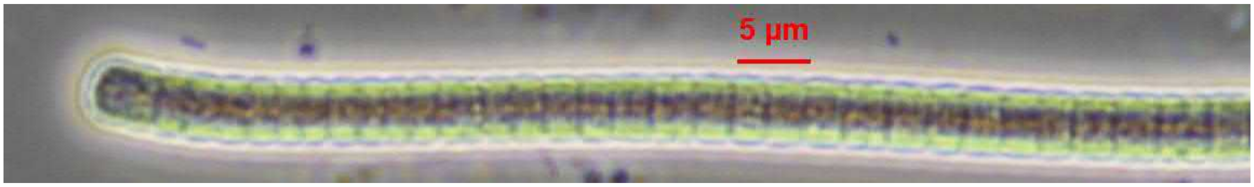

Fig. 6 cf. *Phormidium* sp. 600X (scale bar = 5µm)

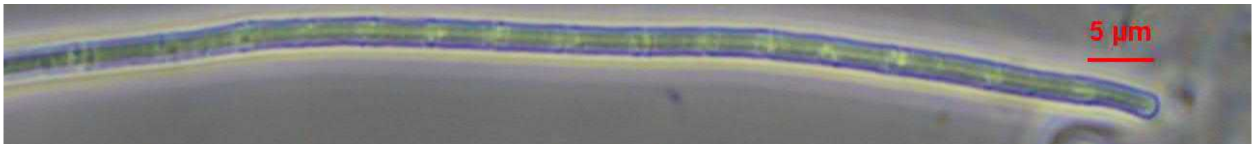

Fig. 7 *Anagnostidinema/Geitlerinema* sp. 600X (scale bar = 5µm)

Sample 3: ET-4

Total cell numbers in the ET-4 sample collected on 10/15/24 were 63,037 cells/mL. Blue-green algae (Cyanobacteria; 58,334 cells/mL) was the most abundant algal group in the sample accounting for 92.5% of total cell numbers. Other algal groups in the sample were diatoms (Bacillariophyceae; 459 cells/mL), desmids (Charophyta; 51 cells/mL), green algae (Chlorophyta; 2,535 cells/mL), golden-brown algae (Chrysophyceae; 38 cells/mL), cryptophytes (Cryptista; 14 cells/mL), dinoflagellates (Dinoflagellata; 31 cells/mL), euglenoids (Euglenophyta; 0.1 cells/mL), unknown algae (Unknown; 1,212 cells/mL) and yellow-green algae (Xanthophyceae; 24 cells/mL). The most abundant alga in the sample was the colonial cyanophyte *Anathece* sp. (53,232 cells/mL; Fig. 8). A total of 99 species were observed in the sample with green algae the most diverse group with 46 taxa observed.

Total cell numbers of potentially toxigenic cyanobacteria (PTOX Cyano) were 1,352 cells/mL (2.1% of total cell numbers). PTOX Cyano species observed in the sample included *Radiocystis geminata* (1,091 cells/mL), cf. *Leptolyngbya* sp. (153 cells/mL; Fig. 9) *Microcystis botrys* (73 cells/mL), *Dolichospermum fuscum* (13 cells/mL), *Microcystis* sp. (9 cells/mL; Fig. 10), *Oscillatoria/Tenebriella* sp. (8 cells/mL; Fig. 11), cf. *Phormidium* sp. (3 cells/mL) and *Microcystis wesenbergii* (2 cells/mL; Fig. 12).

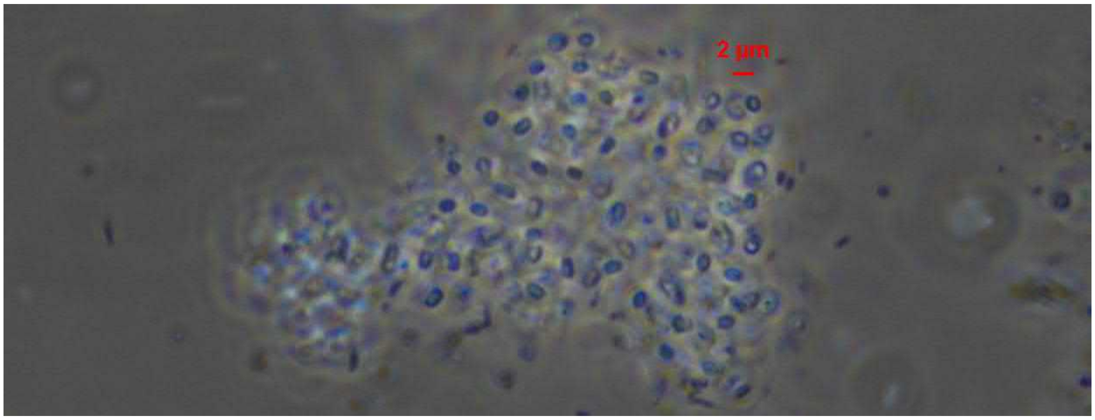

Fig. 8 *Anathece* sp. 600X (scale bar = 2µm)

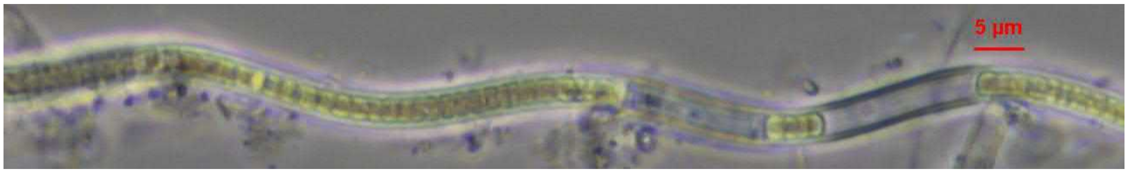

Fig. 9 cf. *Leptolyngbya* sp. 600X (scale bar = 5µm)

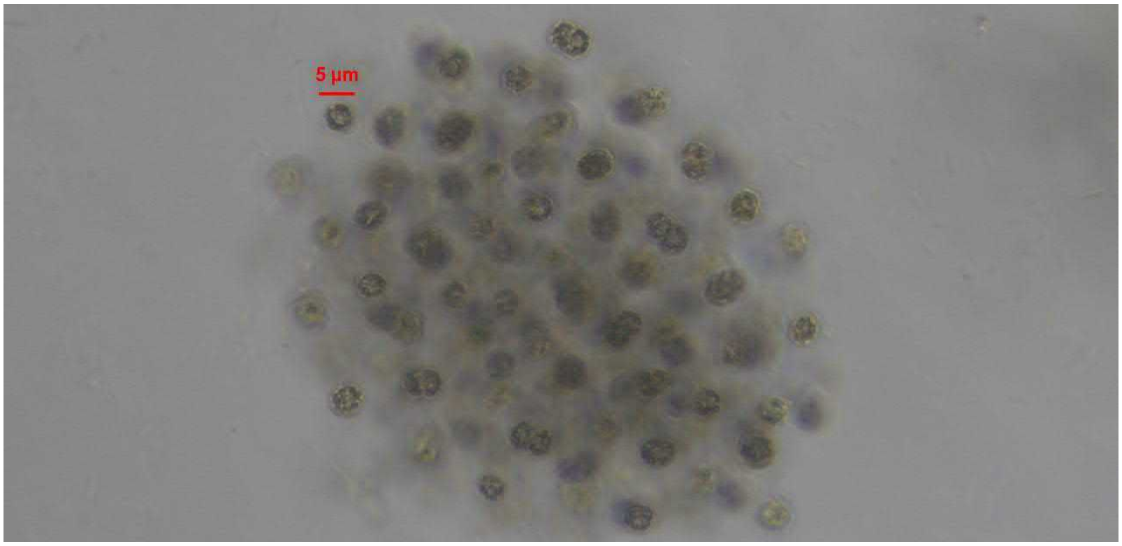

Fig. 10 *Microcystis* sp. 600X (scale bar = 5µm)

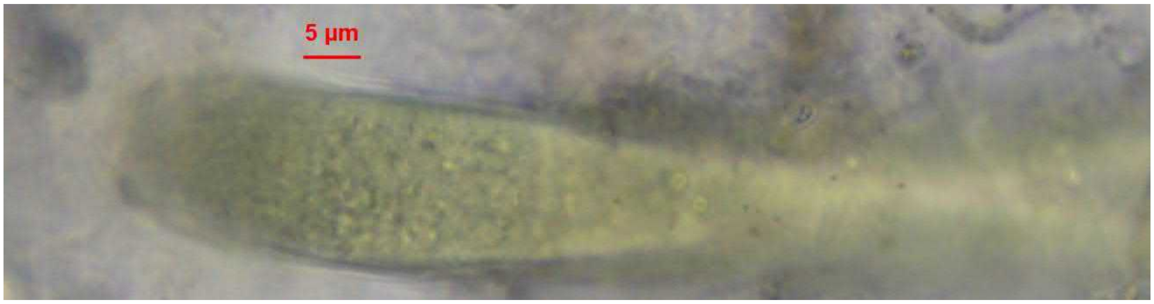

Fig. 11 *Oscillatoria/Tenebriella* sp. 600X (scale bar = 5µm)

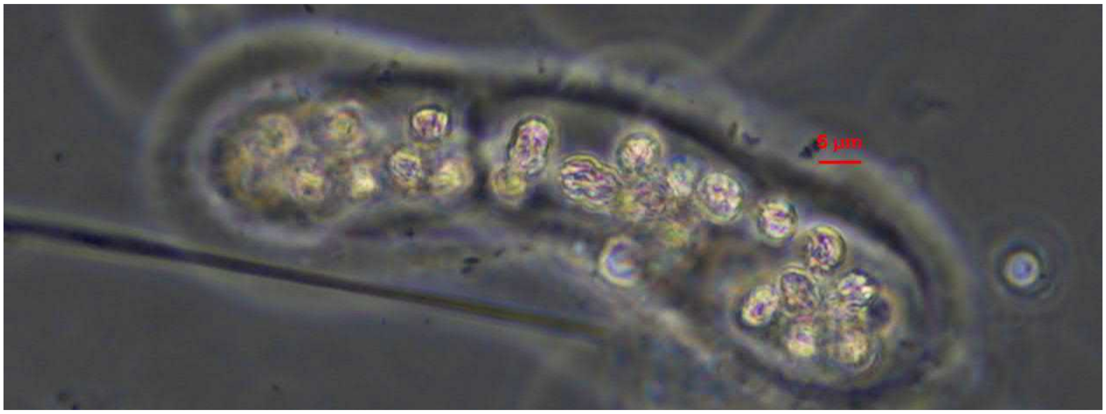

Fig. 12 *Microcystis wesenbergii* 600X (scale bar = 5µm)

Submitted by: Andrew D. Chapman

Andrew D. Chapman, M.S.

Date: 3/10/2025

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GreenWater laboratories

205 Zeagler Drive, Suite 302
Palatka FL 32177

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Analysis Report

Report #241015_Spicer_Group

Table 1: Client and sample receipt information

Submitted to: Ehrland Bosworth
Project: NA
PO/Contract#: NA
Organization: Spicer Group
Address: 2464 Byron Station Dr SW, Suite C, Byron Center, MI 49315
Email: ehrland.bosworth@spicergroup.com
Sample Receipt Date: 21 October 2024
Temp Upon Receipt: 20.2 ºC upon arrival
Date Report Prepared: 23 October 2024
Prepared by: Laura Kostrzewski

Table 2: Laboratory identification (Lab ID), sample identification, description/site, collection date, and matrix

Lab ID	Sample ID	Site	Date	Matrix/Notes
GWL24-1323	NA	ET-1	15 October 2024	Surface Water
GWL24-1324	NA	ET-2	15 October 2024	Surface Water
GWL24-1325	NA	ET-4	15 October 2024	Surface Water

Table 3: Test, method, standard operating procedure (SOP), analyte and acronym

Test	**Method**	**SOP#**	**Analyte**	**Acronym**
MC Suite	LC-MS/MS	62	*D*-Asp^{3}-microcystin-RR	[Asp^{3}]MC-RR
		62	microcystin-RR	MC-RR
		62	nodularin	NOD-R
		62	microcystin-YR	MC-YR
		62	microcystin-HtyR	MC-HtyR
		62	microcystin-LR	MC-LR
		62	*D*-Asp^{3}-microcystin-LR	[Asp^{3}]MC-LR
		62	Dha^{7}-microcystin-RR	[Dha^{7}]MC-LR
		62	microcystin-HilR	MC-HilR
		62	microcystin-WR	MC-WR
		62	*D*-leucine^{1}-microcystin-LR	[Leu^{1}]MC-LR
		62	microcystin-LA	MC-LA
		62	microcystin-LY	MC-LY
		62	microcystin-LW	MC-LW
		62	microcystin-LF	MC-LF

Sample Preparation/Extraction

Table 4: Sample preparation SOP#, name and description

SOP#	NAME	Description
30	Cellular Lysis and Preparation of Water Samples	Three freeze/thaw cycles are used for raw water (and all Method 546) samples. A bead ruptor or tissue grinder are used for benthic algae.

Method Modifications

None.

Abbreviations and Qualifier Flags (QF)

Abbreviations

MRL	Method Reporting Limit	FS	Field Sample
MDL	Method Detection Limit	LFSM	Lab Fortified Sample Matrix
Blank	Water/buffer free from interferences	LFSMD	Lab Fortified Sample Matrix Duplicate
LFB	Lab Fortified Blank	LD	Lab Duplicate
MB	Method Blank	IS	Internal Standard
CCC	Continued Calibration Check	—	Not Analyzed
ND	Not Detected above the MDL/MRL	NA	Not Applicable

Qualifier	Flag
CL	Analytical result is estimated due to ineffective quenching.
J	Analyte was positively identified; the associated numerical value is estimated.
PT	The reported result is estimated because the sample was not analyzed within required holding time.
B	Analytical result is estimated. Analyte was detected in associated reagent blank as well as the samples.
E	Analytical result is estimated. Values achieved were outside calibration range.
N	Spiked sample (LFSM) control was outside limits (water ± 30%; complicated matrix and within 2x MDL ±50%)
T	The reported result is estimated because the sample exceeded temperature threshold when received

LC-MS/MS Results

Table 5: LC-MS/MS results reported in µg/L = ng/mL = ppb

Lab ID	Analyte	Result Value	units	LFSM Level	Avg. %Rec	QF	Analyst	Analysis date
GWL24-1323	[Asp^3]MC-RR	<0.05	µg/L	0.1	68%	N	LK	10/23/2024
GWL24-1323	MC-RR	<0.05	µg/L	0.1	100%	N	LK	10/23/2024
GWL24-1323	NOD-R	<0.05	µg/L	0.1	109%	N	LK	10/23/2024
GWL24-1323	MC-YR	<0.05	µg/L	0.1	61%	N	LK	10/23/2024
GWL24-1323	MC-HtyR	<0.05	µg/L	0.1	68%	N	LK	10/23/2024
GWL24-1323	MC-LR	<0.05	µg/L	0.1	80%	N	LK	10/23/2024
GWL24-1323	[Asp^3]MC-LR	<0.05	µg/L	0.1	80%	N	LK	10/23/2024
GWL24-1323	[Dha^7]MC-LR	<0.05	µg/L	0.1	87%	N	LK	10/23/2024
GWL24-1323	MC-HilR	<0.05	µg/L	0.1	68%	N	LK	10/23/2024
GWL24-1323	MC-WR	<0.05	µg/L	0.1	50%	N	LK	10/23/2024
GWL24-1323	[Leu^1]MC-LR	<0.05	µg/L	0.1	99%	N	LK	10/23/2024
GWL24-1323	MC-LA	<0.05	µg/L	0.1	75%	N	LK	10/23/2024
GWL24-1323	MC-LY	<0.05	µg/L	0.1	76%	N	LK	10/23/2024
GWL24-1323	MC-LW	<0.05	µg/L	0.1	78%	N	LK	10/23/2024
GWL24-1323	MC-LF	<0.05	µg/L	0.1	67%	N	LK	10/23/2024
GWL24-1324	[Asp^3]MC-RR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1324	MC-RR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1324	NOD-R	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1324	MC-YR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1324	MC-HtyR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1324	MC-LR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1324	[Asp^3]MC-LR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1324	[Dha^7]MC-LR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1324	MC-HilR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1324	MC-WR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1324	[Leu^1]MC-LR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1324	MC-LA	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1324	MC-LY	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1324	MC-LW	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1324	MC-LF	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1325	[Asp^3]MC-RR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1325	MC-RR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1325	NOD-R	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1325	MC-YR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1325	MC-HtyR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1325	MC-LR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1325	[Asp^3]MC-LR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1325	[Dha^7]MC-LR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1325	MC-HilR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1325	MC-WR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1325	[Leu^1]MC-LR	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1325	MC-LA	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1325	MC-LY	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1325	MC-LW	<0.05	µg/L	0.1		N	LK	10/23/2024
GWL24-1325	MC-LF	<0.05	µg/L	0.1		N	LK	10/23/2024

Summary of Results

Table 6: Summary of test results reported in µg/L = ng/mL = ppb

Site	Sum **MC Suite**
ET-1	ND
ET-2	ND
ET-4	ND
MDL (ng/mL):	*0.05*

Submitted by: Amanda Foss

Amanda Foss
Lab Director

Date: October 25, 2024

This results in this report relate only to the samples listed above.
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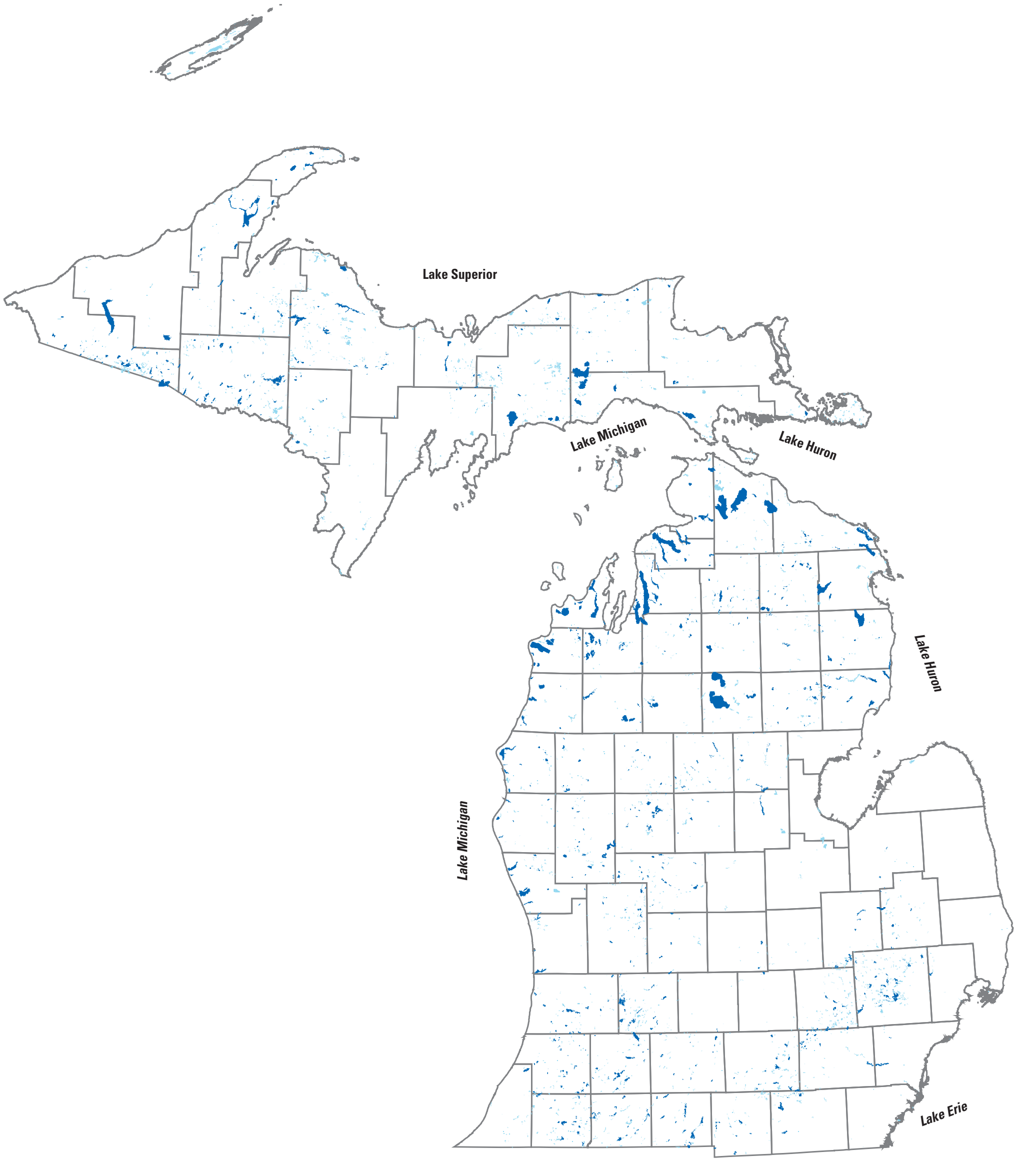
APPENDIX C

USGS Water-Quality Characteristics of Michigan's Inland Lakes 2001 – 10

Prepared in cooperation with the Michigan Department of Natural Resources and Environment

Water-Quality Characteristics of Michigan's Inland Lakes, 2001–10



Scientific Investigations Report 2011–5233

U.S. Department of the Interior
U.S. Geological Survey

Cover: Map showing inland lakes greater than 25 acres in Michigan.

Water-Quality Characteristics of Michigan's Inland Lakes, 2001–10

By L.M. Fuller and C.K. Taricska

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KEN SALAZAR, Secretary

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Conversion Factors and Abbreviations

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
meter (m)	3.281	foot (ft)
	Area	
acre	4,047	square meter (m^2)
acre	0.004047	square kilometer (km^2)
	Volume	
milliliter (mL)	0.0338140227	ounce (oz)
	Concentration	
microgram per liter (µg/L)	0.001	milligram per liter (mg/L)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
°F=(1.8×°C)+32

Vertical coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L). The pore sizes of filters used in processing water samples for chemical analysis are given in micrometers (µm); a micrometer is one-thousandth of a millimeter (mm).

Specific conductance is given in microsiemens per centimeter (µS/cm).

Abbreviations used in this report

AU/cm – Absorbance Units per centimeter
$CaCO_3$ – calcium carbonate
CLMP – Cooperative Lakes Monitoring Program
CMI – Clean Michigan Initiative
DO – dissolved oxygen
GPS – Global Positioning System
Lat-Long – latitude-longitude
LWQA – Lake Water Quality Assessment
MDEQ – Michigan Department of Environmental Quality
MDNRE – Michigan Department of Natural Resources and Environment
MRL – minimum reporting level
NLA – National Lakes Assessment
NPDES – National Pollutant Discharge Elimination System
NWIS – National Water Information System
R^2 –coefficient of determination
SDT – Secchi-disk transparency
SRS – Standard Reference Samples
STORET – Storage and Retrieval
TP – total phosphorus
TSI – Trophic State Index
USEPA – U.S. Environmental Protection Agency
USGS – U.S. Geological Survey

Water-Quality Characteristics of Michigan's Inland Lakes, 2001–10

By L.M. Fuller and C.K. Taricska

Abstract

The U.S. Geological Survey and the Michigan Department of Environmental Quality (MDEQ) jointly monitored for selected water-quality constituents and properties of inland lakes during 2001–10 as part of Michigan's Lake Water-Quality Assessment program. During 2001–10, 866 lake basins from 729 inland lakes greater than 25 acres were monitored for baseline water-quality conditions and trophic status. This report summarizes the water-quality characteristics and trophic conditions of the monitored lakes throughout the State; the data include vertical-profile measurements, nutrient measurements at three discrete depths, Secchi-disk transparency (SDT) measurements, and chlorophyll *a* measurements for the spring and summer, with major ions and other chemical indicators measured during the spring at mid-depth and color during the summer from near-surface samples.

In about 75 percent of inland lake deep basins (index stations), trophic characteristics were associated with oligotrophic or mesotrophic conditions; 5 percent or less were categorized as hypereutrophic, and 80 percent of hypereutrophic lakes had a maximum depth of 30 feet or less. Comparison of spring and summer measurements shows that water clarity based on SDT measurements were clearer in the spring than in the summer for 63 percent of lakes. For near-surface measurements made in spring, 97 percent of lakes can be considered phosphorus limited and less than half a percent nitrogen limited; for summer measurements, 96 percent of lakes can be considered phosphorus limited and less than half a percent nitrogen limited. Spatial patterns of major ions, alkalinity, and hardness measured in the spring at mid-depth all showed lower values in the Upper Peninsula of Michigan and a southward increase toward the southern areas of the Lower Peninsula, though the location of increase varied by constituent. A spatial analysis of the data based on U.S. Environmental Protection Agency Level III Ecoregions separated potassium, sulfate, and chloride concentrations fairly well, with a pattern of lower values in northern ecoregions trending toward higher values in southern ecoregions; lower and higher concentrations of magnesium, hardness, calcium, and alkalinity were well separated, but middle-range concentrations in central Michigan ecoregions were mixed. The highest concentrations of chloride and sodium were in the southeastern area of the Lower Peninsula.

Lakes with multiple basins showed few statistically significant differences in constituent concentrations at the 95-percent confidence level among combinations of depths between basins. The most statistically significant differences were found for water temperature, with significant differences in somewhat less than half the combinations in the spring and just a few combinations in the summer. The lack of significant differences between major basins of multibasin lakes indicates that monitoring of trophic characteristics in all major basins might not be necessary for the majority of constituents in future sampling programs.

Trophic characteristics based on the 2001–10 dataset were compared to trophic characteristics resulting from other Michigan sampling programs, including the volunteer Cooperative Lakes Monitoring Program coordinated by the MDEQ (measurements on 250 lakes in 2011), trophic-state predictions produced by relating existing measurements to remotely sensed data (measurements for about 3,000 lakes), and the National Lakes Assessment (NLA) statistically valid, probability-designed lakes program (measurements for 50 lakes in Michigan and about 1,100 lakes nationally). A higher percentage of oligotrophic lakes resulted when using SDT from the volunteer data and the 2001–10 dataset than when using the predicted measurements from remotely sensed data or the NLA. Comparing trophic characteristics from differently designed programs provides multiple interpretations of lake water-quality status in Michigan lakes.

No directional statistically significant difference was found at the 95-percent confidence level among historical nutrients and trophic characteristics when comparing 445 lakes with historical data for 1974–84 with the 2001–10 dataset, though SDT did show statistically significant differences at the 95-percent confidence level. Depending on the primary indicator, 50–66 percent of lakes did not change trophic-status class, 13–23 percent moved towards the oligotrophic end of the TSI scale, and 20–25 percent moved a class towards the eutrophic end of the TSI scale.

Increasing percentages of urban-dominant land cover in the drainage areas of lakes had a more positive correlation with chloride concentration than did increased percentages of other land-cover classes; there was also a slight correlation of urban-dominant land cover and calcium concentration. Removing data for lakes in southeastern Lower Michigan, known from previous reports to be higher in chloride, still resulted in a positive relation even though the coefficient of determination (R^2 value) decreased from 0.55 to 0.39. Dominant land-cover drainage areas were not strongly related to nutrients with respect to a linear relation, nor were lake drainage-area sizes.

Introduction

Michigan has more than 11,000 inland lakes. These resources provide numerous recreational opportunities for tourists and local residents, and they support a recreational industry in Michigan valued at $15 billion per year (Stynes, 2002). Knowledge of water-quality characteristics in these lakes is essential for the effective management of these resources.

Historically, the U.S. Geological Survey (USGS) and the Michigan Department of Environmental Quality (MDEQ) have jointly monitored water quality in Michigan's lakes and rivers. During the 1990s, however, funding for surface-water-quality monitoring was greatly reduced, and funds devoted to monitoring inland lakes through the Federal Clean Water Act Clean Lakes Program (Section 314) were eliminated. In 1998, citizens of Michigan passed the Clean Michigan Initiative (CMI) to clean up, protect, and enhance Michigan's environmental infrastructure. MDEQ and USGS jointly redesigned and implemented the Lake Water-Quality Assessment (LWQA) monitoring program because of expanding water-quality data needs, resulting in part from the new CMI program (Michigan Department of Environmental Quality, 2001).

Through the LWQA monitoring program, all Michigan lakes larger than 25 acres (with developed public boat-launch access) were monitored during 2001–10 (figs. 1*A* and 1*B*). The LWQA monitoring-program design incorporates the watershed-management units and 5-year rotational cycle currently being used by the MDEQ Ambient Surface Water Chemistry Monitoring Program (Michigan Department of Environmental Quality, 2000) to assess Michigan's rivers, Great Lakes connecting channels, and bays (fig. 2).

The 5-year basin-monitoring cycle identifies 45 watershed-management units on the basis of statewide drainage to the Great Lakes. Each year, 7 to 10 of the major watersheds in Michigan are monitored and assessed. This is done to ensure that specific watersheds are monitored in the 5-year cycle to assist in (1) statewide water-quality assessments, (2) the National Pollutant Discharge Elimination System (NPDES) permitting process, and (3) resource-management decisions. The monitoring emphasizes data collection to classify each lake by its primary biological productivity (trophic status) and document its general chemical characteristics.

History of Monitoring on Michigan's Inland Lakes

In 1973, the Michigan Department of Natural Resources (currently separate agencies: MDEQ and MDNR) began systematically monitoring the quality of Michigan inland lakes under Section 314 of the Clean Water Act. In previous years, few water-chemistry data had been collected on Michigan lakes, which hampered documentation of changes in lake water quality. Initially, it was expected that the "significant" lakes, defined as public lakes greater than or equal to 50 acres, could be sampled every 5 years. By 1979, however, more than half of the significant lakes had not been sampled. The U.S. Environmental Protection Agency (USEPA) increased funding under the Clean Water Act to assist states in assessing the quality of lakes. Also, a one-time grant from USEPA was awarded to the State of Michigan in June 1980 for the purpose of inventorying and classifying unsampled lakes.

Carlson's Trophic State Index (TSI) was chosen to classify lakes for five reasons: (1) the index works well over a broad range of trophic conditions; (2) lakes can be classified by total phosphorus (TP), transparency, and chlorophyll *a*; (3) the index is well suited for Michigan because it was developed by use of data from Michigan and Minnesota lakes; (4) the index is a continuum with divisions to distinguish general categories; and (5) TP, transparency, or chlorophyll *a* data previously collected could be evaluated. Because TSI may underestimate the trophic condition in lakes dominated by macrophytes, the relative abundance of submergent macrophytes was observed and noted in the lakes to assist with the TSI classification.

Purpose and Scope

This report summarizes the results of the 10-year data-collection project (2001–10) for the Michigan LWQA program. An explanation of sampled constituents is provided, and sample-collection methods used for the analysis are described. These constituents are summarized as a statewide deep-basin (index station) dataset and also as a comparison of multiple-basin lakes by season and sampling depth. Other Michigan sampling programs are compared with these data to determine whether all sampling programs provide the same results for Michigan inland lakes. Historical data are compared to current lake data to determine whether temporal changes have occurred, and the relation of land cover to lake water quality is discussed.

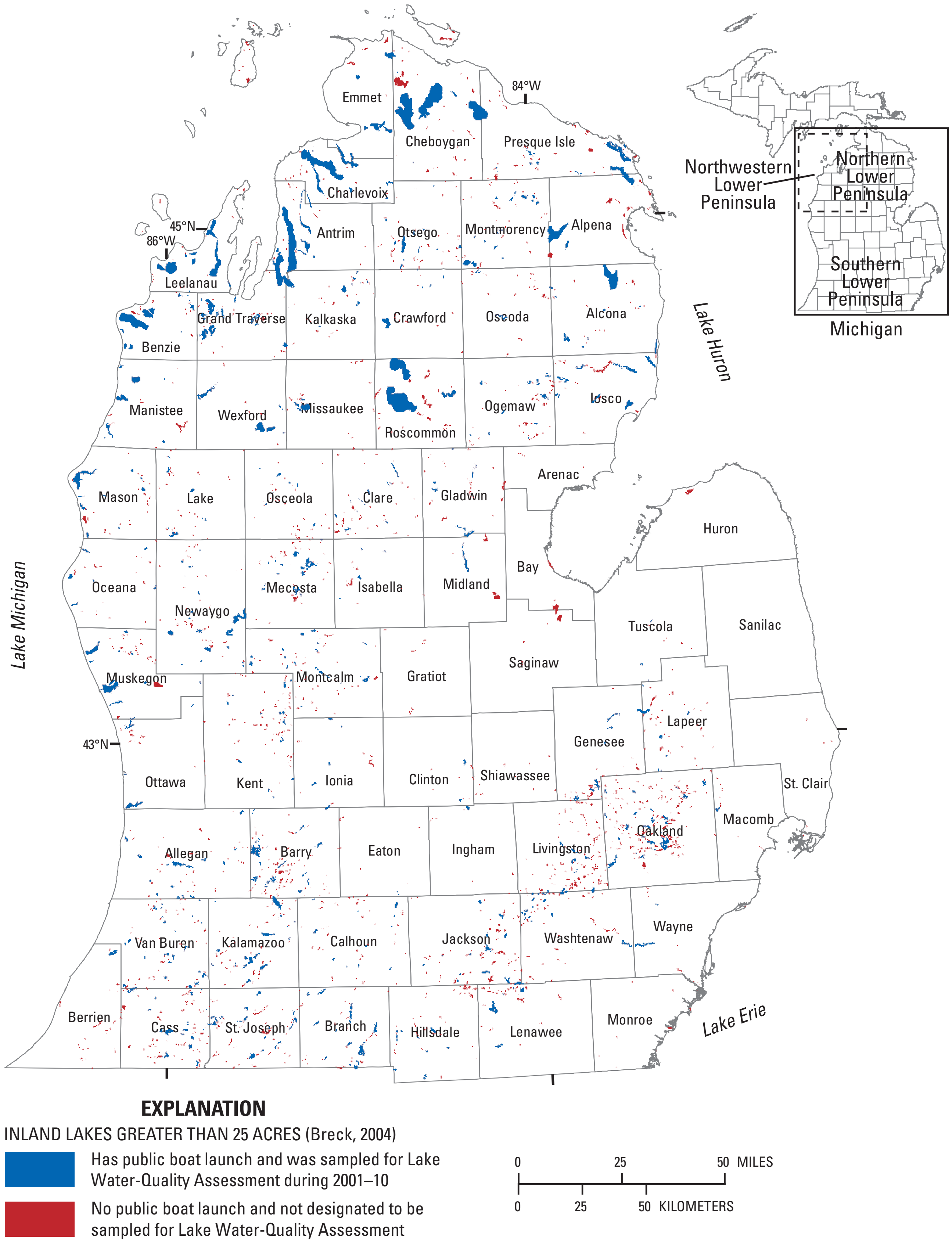

Figure 1*A*. Inland lakes greater than 25 acres in the Lower Peninsula of Michigan.

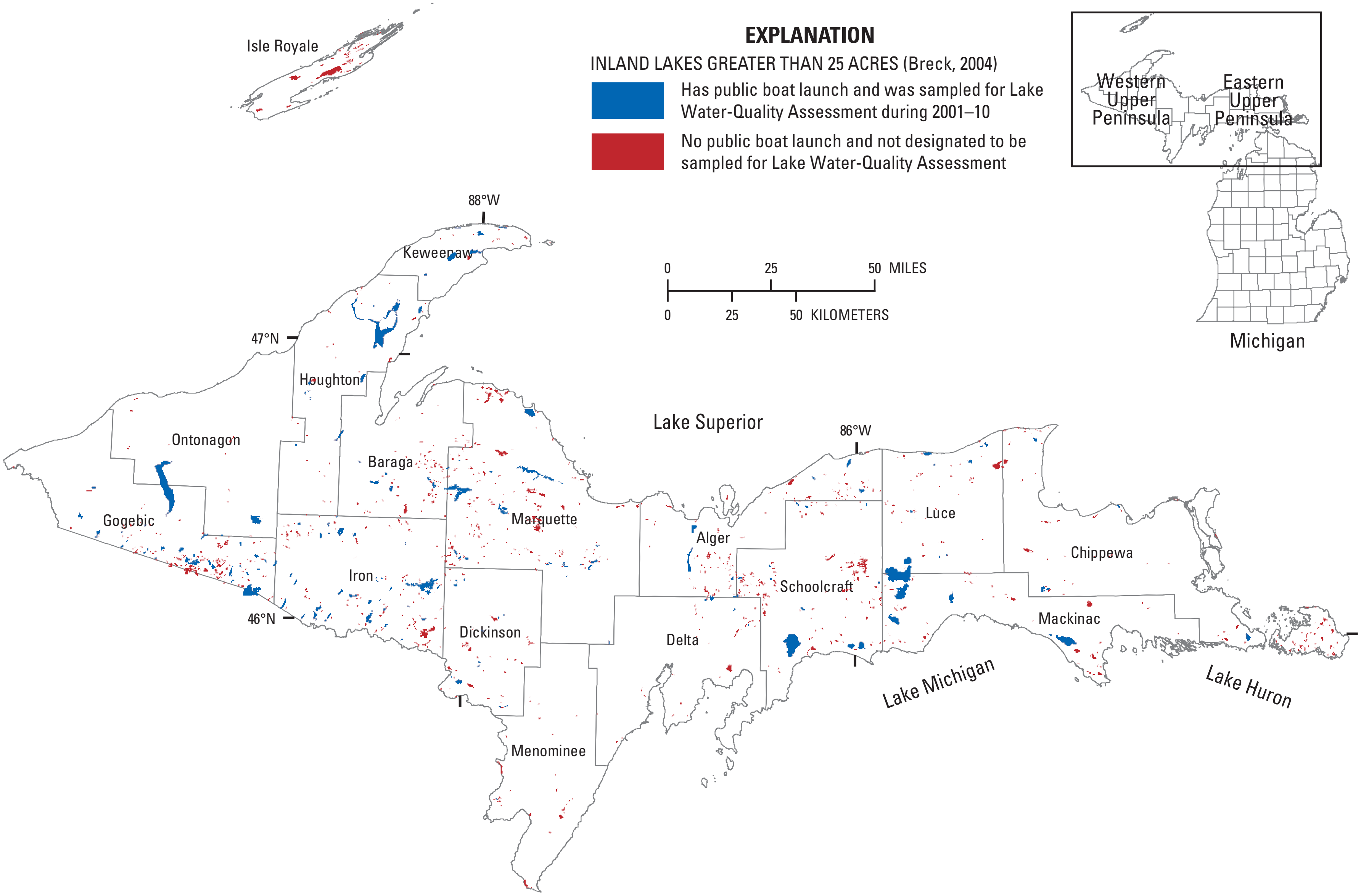

Figure 1*B*. Inland lakes greater than 25 acres in the Upper Peninsula of Michigan.

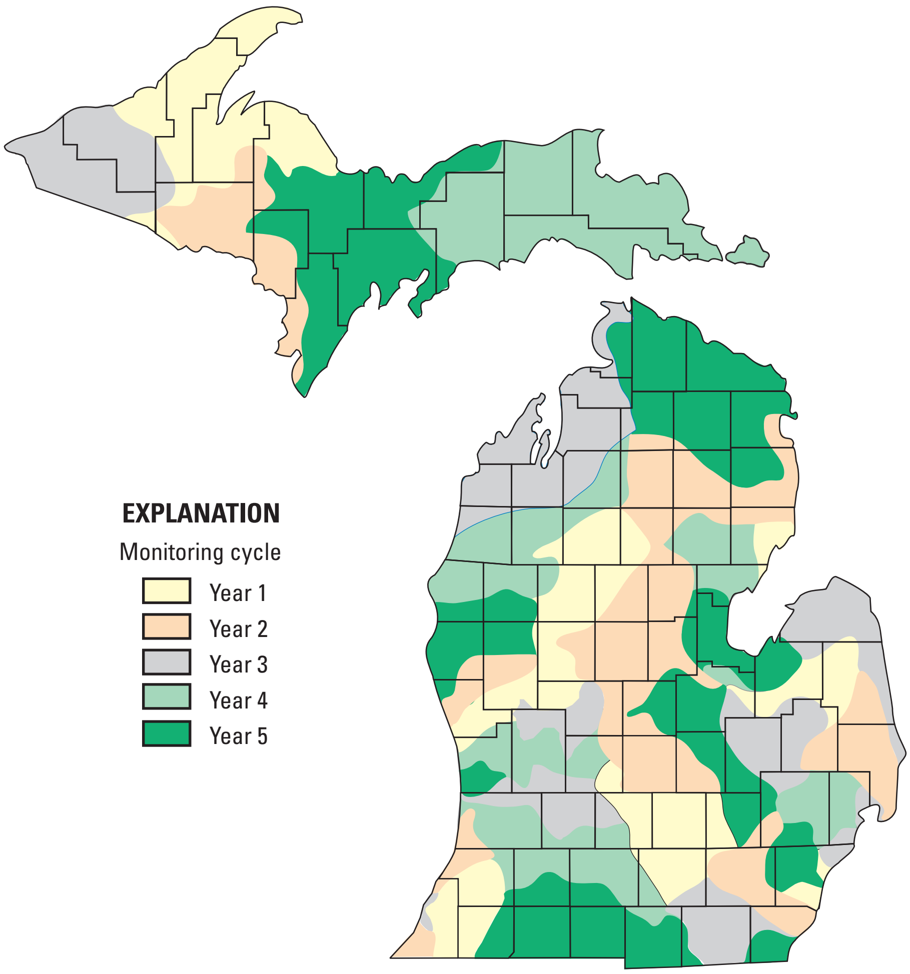

Figure 2. Watershed-management units and 5-year rotational cycle for Lake Water-Quality Assessment in Michigan.

Water-Quality Data-Collection Methods

The sampling methodology was designed to replicate the methods and techniques historically used by MDEQ to sample inland lakes. Care was taken to minimize deviation from past sampling methods, locations, or laboratory-analysis methods that could create variability in the data owing to changes in techniques or methods rather than actual changes in lake water quality.

Lake and Site Selection

Lakes sampled in a given year were selected randomly from 7 to 10 major watersheds throughout Michigan on the basis of watershed-management units and 5-year rotational cycle currently being used by MDEQ Ambient Surface Water Chemistry Monitoring Program (Michigan Department of Environmental Quality, 2000) to assess Michigan's rivers, Great Lakes connecting channels, and bays. Lakes targeted for monitoring under the LWQA monitoring program were 25 acres or larger with public boat-launch access. Each watershed is to be sampled on a 5-year rotation until all lakes meeting these criteria are sampled. After the first 5-year rotation (2001–05), a selection of lakes had been sampled in all 45 major watersheds in Michigan.

The sampling site in each major lake basin was as close as possible to the known historical sampling location (index station) in the deepest basin of each lake. Geographic coordinates for each sampling site were established with a handheld Global Positioning System (GPS) unit. Once the sample site was located with a GPS unit, the site was verified by comparing the depth measured with an electronic depth finder to measured depths from previous visits.

Site Identification

All previously sampled lake basins were identified with a USEPA Storage and Retrieval (STORET) number. Data stored in the USGS National Water Information System (NWIS) are referenced with a USGS station number, which is the latitude-longitude (Lat-Long) of the location where the sample was collected. A sequence number indicating the depth at which a sample was collected was then incorporated into the station number as the last two digits. The lake-station numbering system is summarized below:

Lat-Long-01	Vertical profile data
Lat-Long-02	Sample collected 3 ft above lake bottom
Lat-Long-03	Depth-integrated sample through the photic zone
Lat-Long-05	Sample collected 3 ft below lake surface
Lat-Long-06	Sample collected at mid-depth or metalimnion

Sampling Strategy

All lakes selected for monitoring within a given year were sampled once during spring turnover (usually April) and again in late summer (August or September), when they are typically thermally stratified. Samples collected during spring turnover, when water is well mixed, represent average water quality in the lake as a whole. Samples collected in late summer, when water is warmest and algae and aquatic macrophyte growth is at its peak, represent water-quality characteristics when biological productivity is the greatest specific to each zone of the lake.

Discrete lake-water samples were collected at several depths representing each zone of the lake water column (epilimnion, metalimnion, hypolimnion) at the index station (deepest basin) of each lake. Additional sample locations were used for those lakes that had multiple deep basins where complete interbasin mixing was unlikely.

Before sample collection, vertical profiles of dissolved oxygen (DO) concentration, water temperature, specific conductance, and pH were measured to determine thermal stratification. Water clarity was measured with a Secchi disk, and the photic zone was determined as twice the Secchi disk depth. During late-summer sampling, a qualitative macrophyte evaluation was made in the littoral zone of each lake to refine the trophic-state evaluation, and a measure of color was added during 2007–10.

Field and Laboratory Methods

Water Sampling

Standard MDEQ and USGS field methods were used to collect and preserve samples. During spring sampling, three discrete samples were collected. One sample was collected 3 ft below the surface, another 3 ft above the bottom, and the third at mid-depth. Summer sampling used the same sample depths except in stratified lakes, where the mid-depth sample was collected from the center of the metalimnion (thermocline). During spring sampling, only mid-depth samples were collected on shallow lakes when depth prohibited collection of three discrete samples. Samples were recorded in the database as the "3 ft below lake surface" samples when depth prohibited collection of three discrete samples during the summer. The depths at which the samples were recorded for these shallow lakes were noted for both spring and summer.

Water samples collected near bottom, near surface, and at mid-depth were analyzed for nutrients; samples for analyses of all other water-quality characteristics were collected only in the spring from mid-depth. All water samples except for chlorophyll *a* samples were collected as discrete samples with a Van Dorn-style sampler. Water samples for chlorophyll *a* analysis were depth-integrated composite samples collected by lowering a bottle sampler through the photic zone. On those lakes where the photic zone extended to the lake bottom, the bottle sampler was lowered to within 1 ft of the lake bottom with care taken not to disturb bottom sediments.

Water samples for nutrients were preserved with sulfuric acid (H_2SO_4) to a pH of less than 2, and water samples for selected ions (calcium, magnesium, sodium, and potassium) were preserved with nitric acid (HNO_3) to a pH of less than 2. Chlorophyll *a* samples were filtered onsite through a 0.45 µm combination acetate, nitrate cellulose filter (filter type HAWP 047 00). The filter then was placed in a vial containing 10 milliliters (mL) of 90 percent acetone. All samples then were overnight shipped in coolers with ice to the MDEQ laboratory for analysis of chlorophyll *a* and ions. Nutrient analyses were completed either by the MDEQ or its contract laboratory. Standard analytical methods approved by the USEPA were used for sample analyses (table 1).

Table 1. Properties and constituents, laboratory analytical methods, and reporting levels of water-quality data samples collected from Michigan lakes during 2001–10.

[MRL, minimum reporting level; mg/L, milligrams per liter; $CaCO_3$, calcium carbonate; µg/L, microgams per liter; AU/cm, Absorbance Units per centimeter; USEPA, U.S. Environmental Protection Agency]

Property or constituent	Units	MRL[1]	Method	Reference
Alkalinity, water unfiltered (acid neutralizing capacity)	mg/L as $CaCO_3$	20	310.1	USEPA, 1983
Calcium, total recoverable	mg/L	1	7140/215.1	USEPA, 1983
Chloride, dissolved	mg/L	1	325	USEPA, 1983
Hardness, total	mg/L as $CaCO_3$	5	Calculated SM 2340 B	Clesceri and others, 1998
Magnesium, total recoverable	mg/L	1	7450/242.1	USEPA, 1983
Sodium, total recoverable	mg/L	1	7770/273.1	USEPA, 1983
Sulfate	mg/L	2	375.1	USEPA, 1983
Potassium, total recoverable	mg/L	.1	7610/258.1	USEPA, 1983
Nitrogen, ammonia plus organic, total	mg/L	.1	351.2	USEPA, 1983
Nitrogen, ammonia, total	mg/L	.01	350.1	USEPA, 1983
Nitrogen, nitrate plus nitrite, total	mg/L	.01	353.2	USEPA, 1983
Phosphorus, total	mg/L	.005	365.4	USEPA, 1983
Chlorophyll *a*	µg/L	1	SM 10200 H	Clesceri and others, 1998
Absorbance at 400 nanometers (color)	AU/cm	.007	SM 2004B	Clesceri and others, 1998

[1] Established reporting levels for various analytical procedures (Oblinger-Childress and others, 1999).

Trophic-Status Evaluation

A biologically productive lake is desirable for many activities such as fishing and maintaining a healthy wildlife population; however, a lake can be overly productive. Eventually, if excessive plant and algal growth goes unchecked, the lake may become impaired. The MDEQ classifies lakes on their level of primary biological productivity or trophic status. A lake with low productivity is classified as oligotrophic, and a lake with moderate productivity is classified as mesotrophic. A biologically productive lake is classified as eutrophic, and an excessively biologically productive lake is classified as hypereutrophic. The trophic status of lakes can be compared and tracked over time to help evaluate eutrophication resulting from nutrient enrichment, which may reflect changes in land-use practices.

The primary biological productivity in each lake basin was evaluated by MDEQ with Carlson's TSI (Carlson, 1977). Carlson's TSI was developed for use with lakes that have few rooted aquatic plants and little non-algal turbidity (U.S. Environmental Protection Agency, 2007). Late-summer sample data are used in this evaluation because primary biological productivity is at its peak and lakes are typically at maximum thermal stratification. Carlson's TSI was computed from TP concentrations (collected near the surface), chlorophyll *a* concentrations (collected in the photic zone; fig. 3), and Secchi-disk measurements (fig. 4).

Carlson's TSI is a numerical scale ranging from 0 to 100. The low end of the scale represents low primary biological productivity (oligotrophy), the middle of the scale represents moderate biological productivity (mesotrophy), the high end of the scale represents a very biologically active lake (eutrophy), and the highest end of the scale represents excessive biological productivity (hypereutrophy). Carlson and Simpson (1996) suggest TSI ranges for northern temperate lakes whereby a TSI value less than 40 represents oligotrophic conditions; 40–50, mesotrophic; 50–70, eutrophic; and greater than 70, hypereutrophic.

Although the concept of TSI ranges is simple, the interpretation can be complex because of their interdependency. The TSI values computed from any of the three indicators (chlorophyll *a*, TP, and Secchi-disk transparency (SDT)) will not necessarily be the same. There is a chemical and physical environment that can influence particular indicators and the interrelation with one another (Wetzel, 2001).

The MDEQ has adopted a modified scale and interpretation of the three indicators to account for regional characteristics (Michigan Department of Natural Resources, 1982). TSI values less than 38 represent oligotrophic conditions; 38–48, mesotrophic; 49–61, eutrophic; and greater than 61, hypereutrophic.

Figure 3. U.S. Geological Survey technician preparing to collect a chlorophyll *a* measurement.

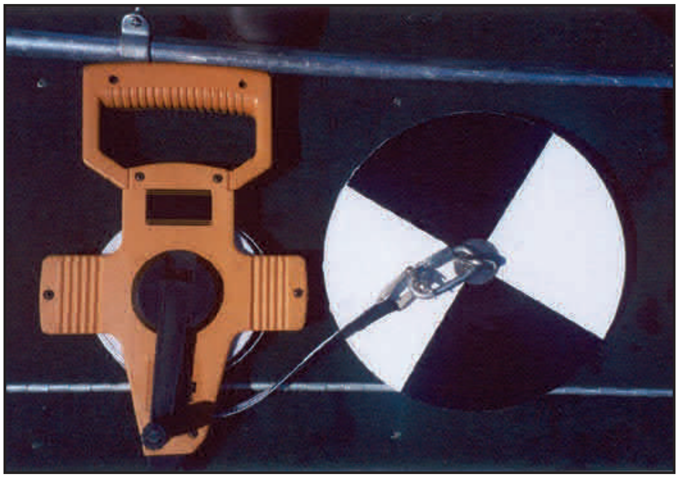

Figure 4. Secchi disk, which is lowered into the water attached to a measuring tape to determine the Secchi-disk transparency (depth at which the Secchi disk disappears).

Walker (1979) proposed that averaging the TSI values from all three indicators would provide a means of reducing the effects of individual sampling and measurement errors, thus developing a robust estimate of the index. Carlson's TSI may underestimate the trophic state of lakes dominated by macrophytes. The relative abundance of submergent macrophytes was used to indicate more productive conditions than indicated by TSI values. Walker assumed that "moderate" and "dense" growths of macrophytes were indicative of mesotrophic and eutrophic conditions, respectively. Therefore, if the TSI indicated mesotrophic conditions but "dense" growths of aquatic macrophytes were present, the lake would then be classified as eutrophic. For lakes with multiple basins, the TSI values from the index station (deepest basin) were used to determine the trophic state of these lakes.

The following equations were used to calculate the TSI values for each indicator, and were then averaged for lakes presented in appendix 1 and are summarized in table 2 for determining the trophic-status classification:

$$\text{TSI Secchi disk} = 60 - 14.41 * \ln\,(\text{Secchi-disk transparency, in meters}) \qquad (1)$$

$$\text{TSI chlorophyll } a = 9.81 * \ln\,(\text{chlorophyll } a\text{, in micrograms per liter}) + 30.6 \qquad (2)$$

$$\text{TSI total phosphorus} = 14.42 * \ln\,(\text{total phosphorus, in micrograms per liter}) + 4.15 \qquad (3)$$

Table 2. Lake trophic state and classification ranges of Trophic State Index for total phosphorus, Secchi-disk transparency, and chlorophyll *a*.

[Based on Michigan Department of Natural Resources (1982) and modified by the State of Michigan to account for regional characteristics; TSI, Trophic State Index; SDT, Secchi-disk transparency; Chl-*a*, chlorophyll *a*; TP, total phosphorus; m, meter; µg/L, micrograms per liter; mg/L, milligrams per liter; <, less than; >, greater than]

Lake trophic state	Carlson's TSI	SDT (m)	Chl-*a* (µg/L)	TP (mg/L)
Oligotrophic	< 38	> 4.6	< 2.2	< 0.010
Mesotrophic	38–48	2.3–4.6	2.2–6	.010–.020
Eutrophic	49–61	.9–2.2	6.1–22	.021–.050
Hypereutrophic	> 61	< .9	> 22	> .050

Quality Assurance of Data, Treatment of Censored Data, and Access to Data

In accordance with USGS policy, analytical laboratories that provide chemical, radiochemical, and biological analyses are regularly reviewed and evaluated to ensure that data quality is appropriately maintained (U.S. Geological Survey, 1998). During the review process for the Michigan lake-sample analyses, any samples that did not follow prescribed processing protocol were excluded from the database. In a few instances, sample bottles leaked and were not processed. For these reasons, some samples of various constituents were removed. The tables in this report note the number of samples analyzed for the respective constituents.

The MDEQ laboratory and their private contract laboratory provided analytical results with associated data-qualifier descriptions. All analytical methods used were matched with the appropriate USGS constituent codes and methods, in addition to the remarks codes for less-than and estimated data, before the data were stored in the USGS National Water Information System (NWIS) database. Both laboratories participated in the USGS Standard Reference Sample (SRS) program, and the laboratories were evaluated by using performance evaluation samples called SRS. The SRS were submitted to the laboratories semiannually for performance-comparison purposes. Statistical evaluation of the results provided information to compare the analytical performance between laboratories and to determine possible analytical deficiencies and problems. Although the SRS project is not a certification program, participation is required for all laboratories that provide water-quality data for the USGS. Any analyte measured by an individual laboratory that did not receive marginal or higher ratings during the evaluation period was not used in the data analysis for this report. Laboratory-evaluation results for the Michigan Department of Environmental Quality lab number 341 can be found under the results tab at *http://bqs.usgs.gov/srs/*.

In addition to the actual measurement done by the laboratories for each constituent, some data also were censored—that is, reported as “nondetect” or “less than (<)”—or estimated (E). Nondetects result when analysis for a specific constituent yields no evidence of the constituent being present in the sample. Less-than data result when a constituent is detected but the concentration is less than the minimum reporting level (MRL) for that constituent; for example, < 0.01 mg/L. This occurs when an exact value cannot be assigned to a constituent but can be assigned various ranges less than applicable reporting limits. Estimated values are assigned for a variety of reasons where the analysis deviates from strict protocol or ideal analytical conditions, such as extrapolation or minor loss of sample during preparation.

A conservative approach to the treatment of censored data was used from Data Interpretation Example number 1 from Bonn (2008). Half the reporting limit was used for all nondetect and less-than data values, except when more than 5 percent of the data values were nondetect and less-than values, in which case the Helsel and Cohn (1988) adjusted maximum likelihood method was used to assist in the creation of summary statistics. All LWQA monitoring data were archived in the USEPA data-management system (STORET), as well as in the USGS NWIS database. These data are available to the public on the Internet at *http://mi.waterdata.usgs.gov/nwis/qw*, *http://www.epa.gov/storet*, and *http://www.michigan.gov/miswims*.

Statewide Water Quality of Inland Lakes

During 2001–10, lakes greater than 25 acres (with developed public boat-launch access) were sampled in all 45 of Michigan’s watershed-management units. Of the 729 lakes sampled, 109 were lakes with more than 1 major basin. In all, 866 lake basins were assessed and used in the analysis for this report. All lake basins included vertical-profile measurements, nutrient measurements at three discrete depths, SDT measurements (unless the Secchi disk hit the bottom of the lake, in which case no SDT depth was recorded), and depth-integrated chlorophyll *a* measurements all for spring and summer, with major ions and physical properties measured only for spring mid-depth and color only for summer during 2007–10.

In the spring, 52 lakes were deemed too shallow for the collection of near-lake-surface and near-lake-bottom measurements, thus only mid-depth samples were collected for all lake basins in the spring. In the summer, 58 lakes were deemed too shallow; thus, measurements were recorded in the near lake surface and not for mid-depth or lake bottom. Measurements for shallow lakes were made in the spring from 1 to 6 ft and in the summer from 1 to 5 ft. These measurements could be reflective of the near surface or mid-depth or metalimnion measurement depths.

For summary statistics, the spring measurements deemed too shallow for three discrete measurements were moved from near surface to mid-depth to allow comparison between the two seasons. For other analyses where a near-surface sample was required (such as phosphorus for TSI calculation), the single measurement noted in the mid-depth or metalimnionin the spring, or near surface for the summer was used. Of the shallow lakes, 48 were determined to be too shallow in the spring and summer, 4 lakes were determined to be too shallow only in the spring, and 10 lakes were determined to be too shallow only in the summer.

A few properties and constituents measured are reported as missing data values owing to leaking, improperly preserved samples, field meters not functioning correctly or losing battery power, and other similar circumstances. Four lakes, one with multiple basins, were resampled and are noted in appendix 1. The resampled data were used in this analysis, though available measurements for the original sample date are stored in NWIS.

Index Station (Deepest-Basin) Data Comparison

During 2001–10, the 729 lakes sampled had measurements from the index station (deepest basin). A statistical summary of the index station (deepest-basin) water-quality data collected at various depths are listed in table 3. The data are summarized below by physical and chemical category.

Table 3. Statistical summary, by physical property or consitutent, of Michigan lakes sampled in the index station (deepest basin) during 2001–10. (The Helsel and Cohn (1988) adjusted maximum liklihood method was used to create summary statistics for constituents with greater than 5 percent of the data as nondetects or less-than values; otherwise, half the reporting limit was used for all nondetect and less-than data values.

[Min, minimum; 25 Per, 25 Percentile; Med, median; 75 Per, 75 Percentile; Max, Maximum; St. Dev, standard deviation; µg/L, micrograms per liter; mg/L, milligrams per liter; deg C, degrees Celsius; µS/cm, microsiemens per centimeter; std units, standard units; AU/cm, absorbance units per centimeter; $CaCO_3$, calcium carbonate; <, less-than sign noting greater than 5 percent of data were nondetects or less-than values and adjusted maximum liklihood method was used]

				Spring					
Constituent	**Units**	**Count**	**Min**	**25 Per**	**Med**	**Mean**	**75 Per**	**Max**	**St. Dev**
Secchi-disk transparency	meters	697	0.30	2.10	3.20	3.64	4.70	14.80	2.01
Chlorophyll *a*	µg/L	724	<1.0	1.10	2.70	4.42	5.63	52.00	5.68
Dissolved oxygen	**Units**	**Count**	**Min**	**25 Per**	**Med**	**Mean**	**75 Per**	**Max**	**St. Dev**
Near surface	mg/L	729	5.3	7.8	8.30	8.76	9.50	14.20	1.53
Mid-depth or metalimnion	mg/L	728	0	2.2	6.75	5.88	8.50	15.60	3.71
Near bottom	mg/L	727	0	1	7.70	6.36	10.40	14.10	4.44
Water temperature	**Units**	**Count**	**Min**	**25 Per**	**Med**	**Mean**	**75 Per**	**Max**	**St. Dev**
Near surface	deg C	729	1.5	20	23.00	20.72	25.00	29.00	6.58
Mid-depth or metalimnion	deg C	728	2.5	9.5	16.75	15.84	22.00	28.50	6.98
Near bottom	deg C	728	2.5	5	6.50	8.31	10.00	27.00	4.82
Specific conductance	**Units**	**Count**	**Min**	**25 Per**	**Med**	**Mean**	**75 Per**	**Max**	**St. Dev**
Near surface	µS/cm	728	12	164	276.50	274.01	359.00	1,230.00	158.20
Mid-depth or metalimnion	µS/cm	729	12	161	285.00	290.58	388.00	1,380.00	175.04
Near bottom	µS/cm	729	13	172	312.00	309.74	419.00	1,390.00	182.72
pH	**Units**	**Count**	**Min**	**25 Per**	**Med**	**Mean**	**75 Per**	**Max**	**St. Dev**
Near surface	std units	727	5.1	7.9	8.20	8.12	8.40	9.60	0.55
Mid-depth or metalimnion	std units	724	4.8	7.3	7.70	7.65	8.10	9.50	0.66
Near bottom	std units	723	4.5	7.1	7.50	7.49	8.00	9.90	0.66
Ammonia plus organic nitrogen	**Units**	**Count**	**Min**	**25 Per**	**Med**	**Mean**	**75 Per**	**Max**	**St. Dev**
Near surface	mg/L	683	0.050	0.35	0.49	0.53	0.64	2.19	0.26
Mid-depth or metalimnion	mg/L	729	0.050	0.35	0.49	0.52	0.65	2.89	0.26
Near bottom	mg/L	682	0.050	0.38	0.52	0.58	0.71	4.70	0.35
Ammonia	**Units**	**Count**	**Min**	**25 Per**	**Med**	**Mean**	**75 Per**	**Max**	**St. Dev**
Near surface	mg/L	682	0.001	0.01	0.03	0.06	0.07	0.68	0.10
Mid-depth or metalimnion	mg/L	728	0.001	0.01	0.03	0.07	0.08	0.67	0.10
Near bottom	mg/L	682	0.001	0.02	0.05	0.12	0.15	4.00	0.23

Table 3. Statistical summary, by physical property or consitutent, of Michigan lakes sampled in the index station (deepest basin) during 2001–10. (The Helsel and Cohn (1988) adjusted maximum liklihood method was used to create summary statistics for constituents with greater than 5 percent of the data as nondetects or less-than values; otherwise, half the reporting limit was used for all nondetect and less-than data values.)—Continued

[Min, minimum; 25 Per, 25 Percentile; Med, median; 75 Per, 75 Percentile; Max, Maximum; St. Dev, standard deviation; µg/L, micrograms per liter; mg/L, milligrams per liter; deg C, degrees Celsius; µS/cm, microsiemens per centimeter; std units, standard units; AU/cm, absorbance units per centimeter; $CaCO_3$, calcium carbonate; <, less-than sign noting greater than 5 percent of data were nondetects or less-than values and adjusted maximum liklihood method was used]

Summer									
Constituent	**Units**	**Count**	**Min**	**25 Per**	**Med**	**Mean**	**75 Per**	**Max**	**St. Dev**
Secchi-disk transparency	meters	693	0.3	2.1000	3.00	3.14	4.00	11.30	1.48
Chlorophyll *a*	µg/L	727	0.5	2.0000	3.60	6.10	6.00	120.00	9.98
**Color	AU/cm	285	<0.007	<0.007	0.01	0.01	0.01	0.15	0.01
Dissolved oxygen	**Units**	**Count**	**Min**	**25 Per**	**Med**	**Mean**	**75 Per**	**Max**	**St. Dev**
Near surface	mg/L	729	5.3	7.6	8.10	8.12	8.50	15.80	1.01
Mid-depth or metalimnion	mg/L	729	0.1	2.2	6.20	5.49	7.90	15.50	3.44
Near bottom	mg/L	728	0	0.3	0.50	2.22	3.40	13.10	2.96
Water temperature	**Units**	**Count**	**Min**	**25 Per**	**Med**	**Mean**	**75 Per**	**Max**	**St. Dev**
Near surface	deg C	729	16.5	22.5	24.00	23.91	25.50	29.00	2.21
Mid-depth or metalimnion	deg C	729	6.5	15	20.00	18.74	22.50	28.00	4.99
Near bottom	deg C	727	3.5	7	11.00	13.05	19.50	28.00	6.62
Specific conductance	**Units**	**Count**	**Min**	**25 Per**	**Med**	**Mean**	**75 Per**	**Max**	**St. Dev**
Near surface	µS/cm	728	12	162.75	273.00	271.13	358.00	1,310.00	157.79
Mid-depth or metalimnion	µS/cm	729	12	167	288.00	288.59	382.00	1,380.00	171.93
Near bottom	µS/cm	729	12	187	320.00	323.65	438.00	1,390.00	186.13
pH	**Units**	**Count**	**Min**	**25 Per**	**Med**	**Mean**	**75 Per**	**Max**	**St. Dev**
Near surface	std units	728	5.1	8	8.26	8.19	8.50	9.60	0.54
Mid-depth or metalimnion	std units	729	4.8	7.3	7.70	7.66	8.10	9.50	0.67
Near bottom	std units	728	5.2	6.9	7.30	7.29	7.60	9.50	0.65
Ammonia plus organic nitrogen	**Units**	**Count**	**Min**	**25 Per**	**Med**	**Mean**	**75 Per**	**Max**	**St. Dev**
Near surface	mg/L	678	0.05	0.38	0.52	0.58	0.69	2.64	0.32
Mid-depth or metalimnion	mg/L	729	0.05	0.39	0.54	0.61	0.73	3.10	0.34
Near bottom	mg/L	678	0.05	0.53	0.86	1.07	1.36	7.58	0.82
Ammonia	**Units**	**Count**	**Min**	**25 Per**	**Med**	**Mean**	**75 Per**	**Max**	**St. Dev**
Near surface	mg/L	678	0.0010	0.0050	0.01	0.02	0.03	0.82	0.05
Mid-depth or metalimnion	mg/L	729	0.0010	0.0060	0.02	0.05	0.04	4.00	0.18
Near bottom	mg/L	678	0.0010	0.0343	0.22	0.48	0.68	6.79	0.68

Table 3. Statistical summary, by physical property or consitutent, of Michigan lakes sampled in the index station (deepest basin) during 2001–10. (The Helsel and Cohn (1988) adjusted maximum liklihood method was used to create summary statistics for constituents with greater than 5 percent of the data as nondetects or less-than values; otherwise, half the reporting limit was used for all nondetect and less-than data values.)—Continued

[Min, minimum; 25 Per, 25 Percentile; Med, median; 75 Per, 75 Percentile; Max, Maximum; St. Dev, standard deviation; µg/L, micrograms per liter; mg/L, milligrams per liter; deg C, degrees Celsius; µS/cm, microsiemens per centimeter; std units, standard units; AU/cm, absorbance units per centimeter; $CaCO_3$, calcium carbonate; <, less-than sign noting greater than 5 percent of data were nondetects or less-than values and adjusted maximum liklihood method was used]

Spring—continued

Total phosphorus	Units	Count	Min	25 Per	Med	Mean	75 Per	Max	St. Dev
Near surface	mg/L	683	0.003	0.009	0.013	0.018	0.021	0.234	0.018
Mid-depth or metalimnion	mg/L	729	0.003	0.009	0.014	0.018	0.020	0.203	0.017
Near bottom	mg/L	683	0.003	0.010	0.014	0.024	0.022	1.880	0.081

Nitrate plus nitrite	Units	Count	Min	25 Per	Med	Mean	75 Per	Max	St. Dev
Near surface	mg/L	683	0.001	0.05	0.09	0.26	0.21	6.70	0.56
Mid-depth or metalimnion	mg/L	728	0.001	0.05	0.10	0.26	0.21	6.70	0.55
Near bottom	mg/L	683	0.001	0.05	0.10	0.27	0.21	5.90	0.55

Total nitrogen (sum of ammonia + organic nitrogen and nitrate + nitrite)	Units	Count	Min	25 Per	Med	Mean	75 Per	Max	St. Dev
Near surface	mg/L	683	0.116	0.46	0.60	0.79	0.86	7.72	0.66
Mid-depth or metalimnion	mg/L	729	0.107	0.46	0.62	0.78	0.86	7.75	0.65
Near bottom	mg/L	683	0.059	0.47	0.66	0.85	0.95	6.85	0.69

Mid-depth or metalimnion	Units	Count	Min	25 Per	Med	Mean	75 Per	Max	St. Dev
*Alkalinity (as $CaCO_3$)	mg/L	729	<20	64.00	116.00	109.53	150.00	323.00	58.20
*Calcium - total	mg/L	729	1.100	20.50	35.00	34.17	45.50	98.60	19.03
*Chloride	mg/L	726	0.500	4.00	9.00	16.72	19.00	278.00	25.14
*Hardness - calculated	mg/L	729	2.500	76.00	136.00	130.70	178.00	337.00	72.62
*Potassium - total	mg/L	729	0.050	0.60	1.00	1.20	1.60	5.40	0.82
*Magnesium - total	mg/L	729	0.500	5.40	11.30	11.08	16.00	28.20	6.57
*Sodium - total	mg/L	728	<1.0	2.20	4.95	8.28	8.60	154.00	13.00
*Sulfate	mg/L	727	1.000	3.00	6.00	10.50	14.00	142.00	12.58

Table 3. Statistical summary, by physical property or consitutent, of Michigan lakes sampled in the index station (deepest basin) during 2001–10. (The Helsel and Cohn (1988) adjusted maximum liklihood method was used to create summary statistics for constituents with greater than 5 percent of the data as nondetects or less-than values; otherwise, half the reporting limit was used for all nondetect and less-than data values.)—Continued

[Min, minimum; 25 Per, 25 Percentile; Med, median; 75 Per, 75 Percentile; Max, Maximum; St. Dev, standard deviation; µg/L, micrograms per liter; mg/L, milligrams per liter; deg C, degrees Celsius; µS/cm, microsiemens per centimeter; std units, standard units; AU/cm, absorbance units per centimeter; $CaCO_3$, calcium carbonate; <, less-than sign noting greater than 5 percent of data were nondetects or less-than values and adjusted maximum liklihood method was used]

Summer—continued									
Total phosphorus	**Units**	**Count**	**Min**	**25 Per**	**Med**	**Mean**	**75 Per**	**Max**	**St. Dev**
Near surface	mg/L	678	0.00250	0.008	0.012	0.016	0.017	0.172	0.016
Mid-depth or metalimnion	mg/L	729	0.00250	0.011	0.015	0.021	0.022	0.420	0.024
Near bottom	mg/L	678	0.00250	0.015	0.029	0.075	0.066	2.160	0.152
Nitrate plus nitrite	**Units**	**Count**	**Min**	**25 Per**	**Med**	**Mean**	**75 Per**	**Max**	**St. Dev**
Near surface	mg/L	678	<0.01	0.0020	0.00	0.05	0.01	3.10	0.22
Mid-depth or metalimnion	mg/L	728	<0.01	0.0020	0.00	0.07	0.01	3.60	0.26
Near bottom	mg/L	678	<0.01	0.0020	0.00	0.06	0.02	3.60	0.20
Total nitrogen (sum of ammonia + organic nitrogen and nitrate + nitrite)	**Units**	**Count**	**Min**	**25 Per**	**Med**	**Mean**	**75 Per**	**Max**	**St. Dev**
Near surface	mg/L	678	<0.01	0.396	0.54	0.63	0.73	4.11	0.40
Mid-depth or metalimnion	mg/L	728	<0.01	0.425	0.59	0.68	0.79	4.44	0.44
Near bottom	mg/L	678	<0.01	0.56	0.89	1.13	1.42	7.59	0.83

*Spring only.

**Summer only 2007–10.

Vertical Profile

Dissolved oxygen, water temperature, specific conductance, and pH were measured throughout the water column. Boxplots for comparison of individual constituents measured in the spring and summer at specific depths are shown in figures 5–8. (In these figures and similar figures later in the report, “adjacent” values represent up to one step above the 75th percentile for upper adjacent, or one step below the 25th percentile for lower adjacent, “outside” values if present represent values between 1 and 2 steps above the 75th and below the 25th, and “detached” values if present represent values more than 2 steps above the 75th or below the 25th. One step is equal to 1.5 times the height of the box, or interquartile range. (Helsel and Hirsch, 2002); the other statistics should be self-explanatory.)

Dissolved oxygen concentration is a critical factor in lake ecosystems; DO is a component of many chemical and biological processes and is important in determining the productivity of a lake. It is critical to many organisms for respiration and is an important controlling factor regarding the diversity of fish and other living organisms that lakes support. Dissolved oxygen is fairly consistent between spring and summer for the near surface and mid-depth or metalimnion but is lower in the summer than in the spring for the majority of measurements (fig. 5). This could be the result of incomplete lake turnover in the spring. If a lake does not mix completely, anoxic conditions develop in the hypolimnion during the summer months (Denys, 2009).

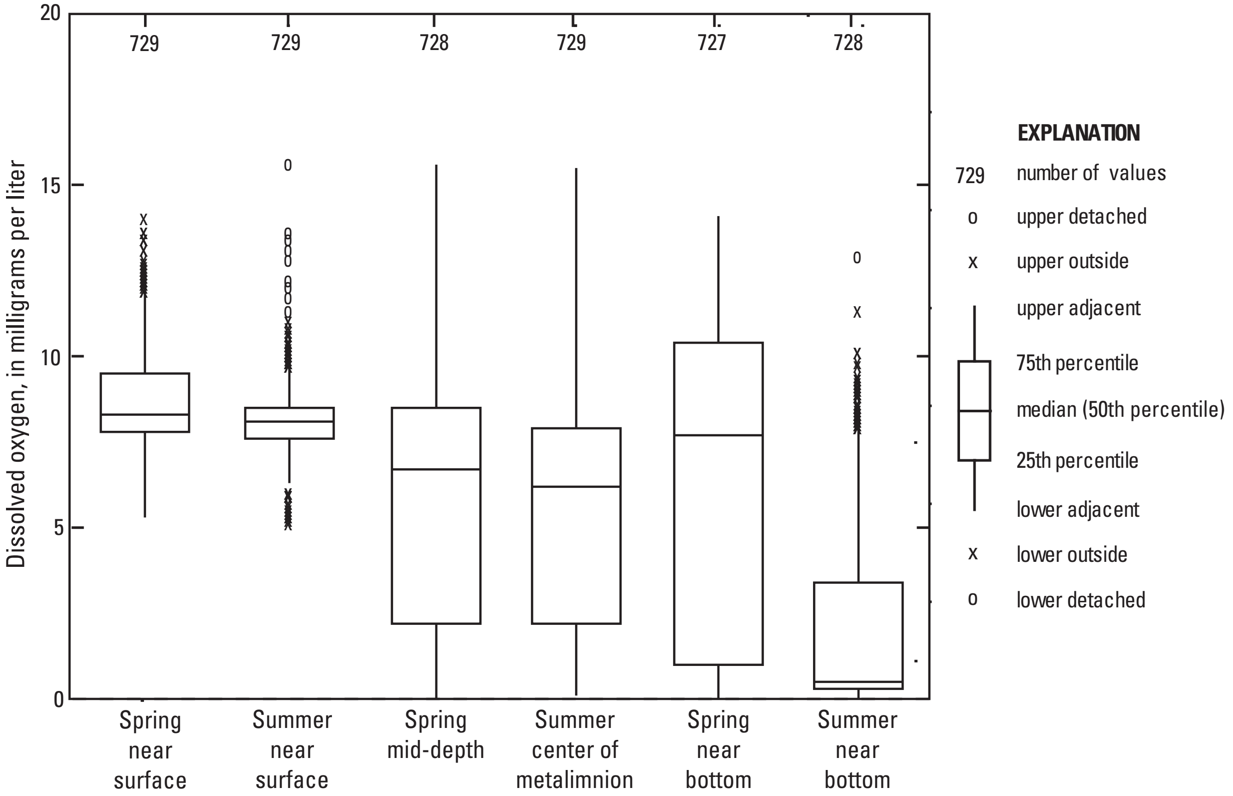

Figure 5. Statistical distribution of dissolved oxygen for spring and summer for near surface, mid-depth or metalimnion, and near bottom for the index stations (deepest basins) in Michigan lakes measured during 2001–10.

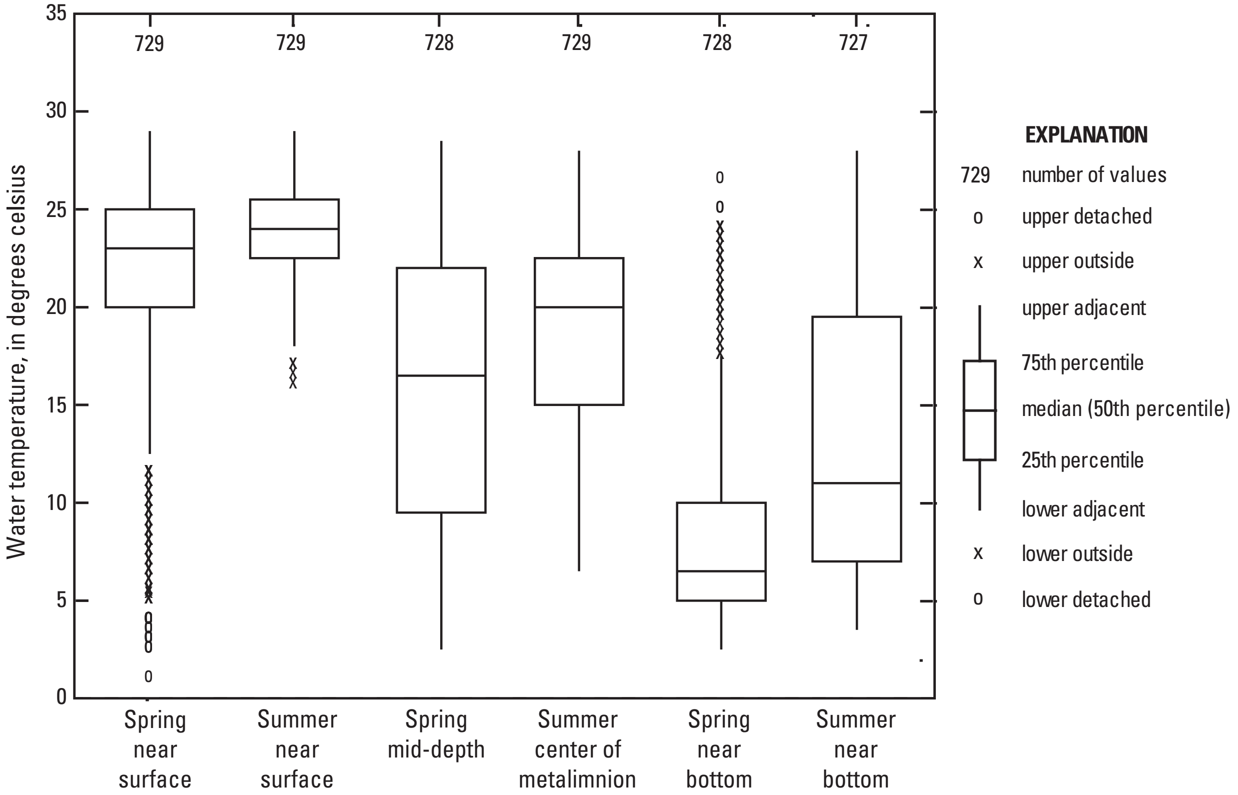

Figure 6. Statistical distribution of water temperature for spring and summer for near surface, mid-depth or metalimnion, and near bottom for the index stations (deepest basins) in Michigan lakes measured during 2001–10.

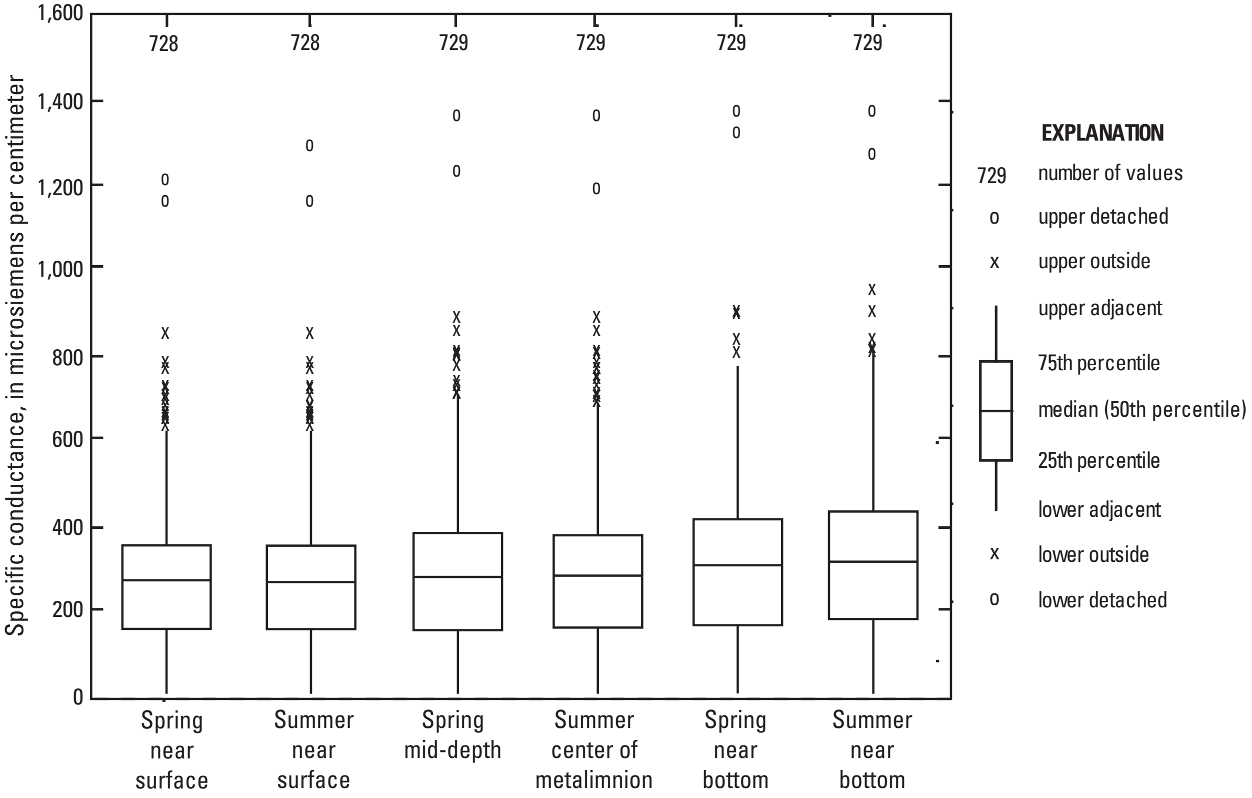

Figure 7. Statistical distribution of specific conductance for spring and summer for near surface, mid-depth or metalimnion, and near bottom for the index stations (deepest basins) in Michigan lakes measured during 2001–10.

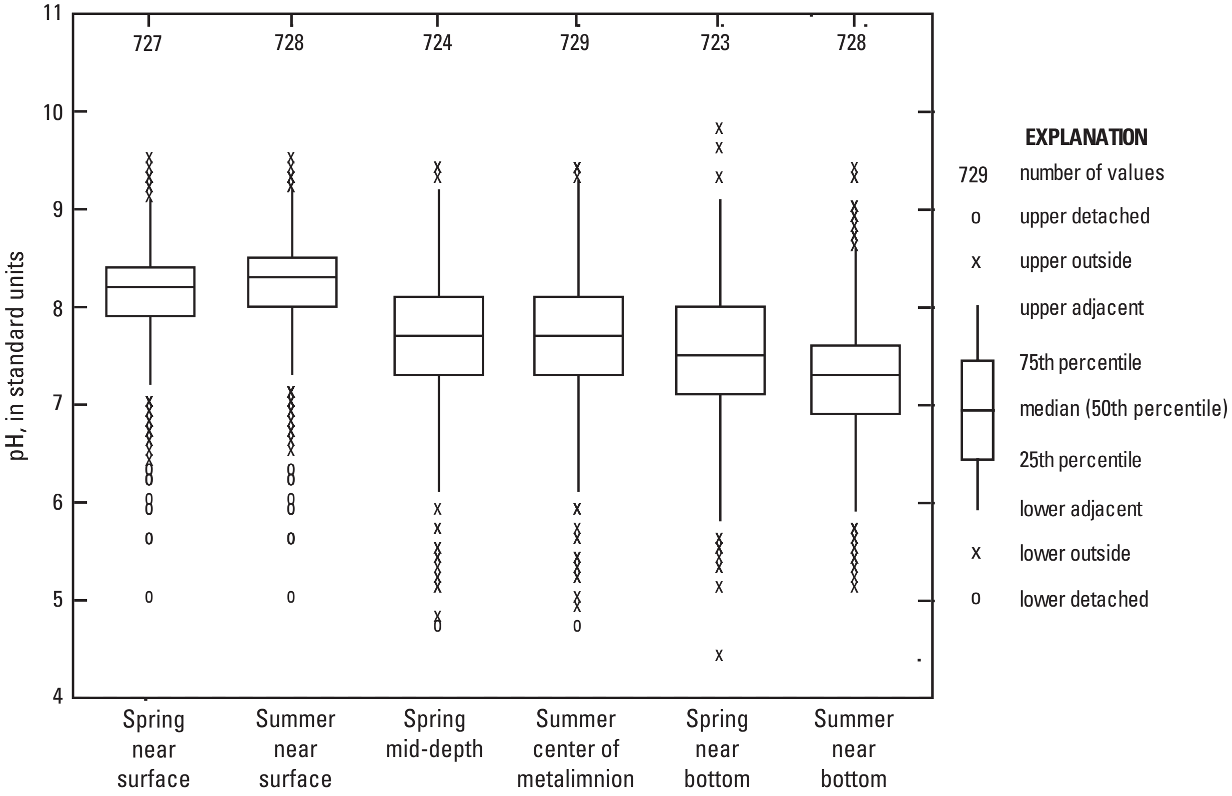

Figure 8. Statistical distribution of pH for spring and summer for near surface, mid-depth or metalimnion, and near bottom for the index stations (deepest basins) in Michigan lakes measured during 2001–10.

Water temperature in lakes is important because of the role it plays in lake stratification and its relation to chemical and biological processes. Thermal stratification is a phenomenon found in most Michigan lakes, whereby a layer of less dense, warm water is isolated from mixing with a denser, colder layer as the thermocline is established in the summer. The extent of thermal stratification in lakes depends on the interaction between the size and depth of the lake basin, solar heating, and local wind characteristics. Water temperature for the majority of lakes undergoes the greatest change between seasons for near-bottom measurements, where temperature is greater in the summer than in the spring (fig. 6). Water temperature was the most different for the majority of lake's near bottom measurements, where the temperature difference is greatest between the top and bottom measurements in the summer than in the spring. The smaller difference between top and bottom measurements in the spring is most likely because the lakes were close to complete turnover, and the greater difference in the summer was most likely owing to surface warming, which can result in lake stratification (though not all lakes stratified).

Specific conductance is a measure of the ability of water to conduct an electrical current and is an indicator of the concentration of dissolved solids in water. As the concentration of dissolved minerals increases, specific conductance also increases. While a lake is stratified, specific conductance generally is higher near the bottom because of the release of dissolved materials (such as iron, manganese, and phosphorus) from the bottom sediments under anoxic conditions. Specific conductance is fairly similar between the spring and summer depth comparisons, though the mean does show a slight overall increase with depth (fig. 7).

The pH of a lake is a measure of the hydrogen ion activity in the lake water; it is defined as the negative logarithm of the hydrogen ion concentration and varies over a 14-unit log scale. A pH of 7.0 is neutral, values less than 7.0 indicate acidic conditions, and values greater than 7.0 indicate alkaline conditions. The pH in most natural surface water ranges from 6.5 to 8.5, but pH values outside this range do occur. Overall, the pH in measured lakes is slightly lower as the measurement depth increases (fig. 8). Many chemical and biological processes, including photosynthesis, nitrification, and calcium-carbonate dissolution, control pH in lake water. Algae and aquatic plants produce oxygen and consume carbon dioxide by the photosynthesis process during the day and produce carbon dioxide when they respire at night. Carbon dioxide then combines with water to form carbonic acid, thereby creating a diurnal fluctuation of pH. This fluctuation is important because it affects the solubility of many chemical constituents and because aquatic organisms have limited pH tolerances. It has been shown that pH values greater than 8.5 will accelerate the release of phosphorus from lake-bottom sediment (James and Barko, 1991). At 6 to 7 percent of lakes (the majority less than 30 ft deep), measured pH was greater than 8.5 at mid-depth or metalimnion for spring or summer. Less than 2 percent of lakes had a pH greater than 8.5 for all three discrete sampling depths. Four percent of lakes had a pH value less than 6.5, with less than 2 percent of lakes with a pH less than 6.5 for all three discrete sampling depths; these latter lakes are solely in the Upper Peninsula.

The spatial distribution of the percentage of DO in the water column below two critical levels is shown in figure 9. Available data indicate that a healthy warmwater fish population requires DO concentrations of at least 2–5 mg/L (Kalff, 2002). Dissolved oxygen concentrations below 0.5 mg/L were categorized as anoxic for Michigan lakes according to Wehrly and others (2011). While some species have evolved to survive weeks to months with low DO, there can still be negative effects with longer periods of low DO such as inefficient food conversion for fish species. The portion of the water column with low DO can become unavailable to species, such as those requiring refuge during the day in deeper water from predators. Effects and stressors from low DO are dependent on the length of time of the low DO period and the lake system (Kalff, 2002).

Although there were a greater percentage of lakes in the summer than in the spring with DO below 2 and 0.5 mg/L, the lakes seem to be somewhat evenly distributed spatially among the Michigan lakes measured. In the spring, 34 percent of lakes had 25–69 percent of the water column (25–69 percent of the total lake depth) below 2.0 mg/L and 12 percent had 25–50 percent of the water column below 0.5 mg/L. In the summer, 58 percent of lakes had 25–86 percent of the water column below 2.0 mg/L and 30 percent had 25–83 percent of the water column below 0.5 mg/L.

The spatial distribution of mid-depth or metalimnion specific conductance and pH measurements is shown in figure 10. While specific conductance is similar among the spring and summer measurements, it varies noticeably by lower values in the Upper Peninsula of Michigan (hereinafter, "Upper Peninsula") compared to increasingly higher from the north to south of the Lower Peninsula of Michigan (hereinafter, "Lower Peninsula"). The highest values have been noted in the southeastern part of the Lower Peninsula. Lake-water pH does not vary noticeably among the spring and summer measurements, or spatially throughout Michigan, though most of the measurements below 6.5 seem to be solely in the Upper Peninsula. Lillie and Mason (1983) also found for Wisconsin that the majority of lakes with lower pH values were located in the northeast region of Wisconsin, and was "probably indicative of the large number of brown-stained lakes" in that region.

To determine whether differences among the vertical-profile measurements at different depth measurements in the deepest basin were statistically significant, and also whether differences between same depth measurements in the deepest basin between spring and summer were statistically significant, the Wilcoxon signed-rank test (Helsel and Hirsch, 2002) was used; results are listed in tables 4 and 5, respectively. The Wilcoxon signed-rank test is used for paired data to determine whether the median difference equals zero. There was a statistically significant difference at the 95-percent confidence level between spring and summer for all measurements except DO at mid-depth or metalimnion. There was also a statistically significant difference at the 95-percent confidence level among DO, water temperature, specific conductance, and pH between all measurement depths.

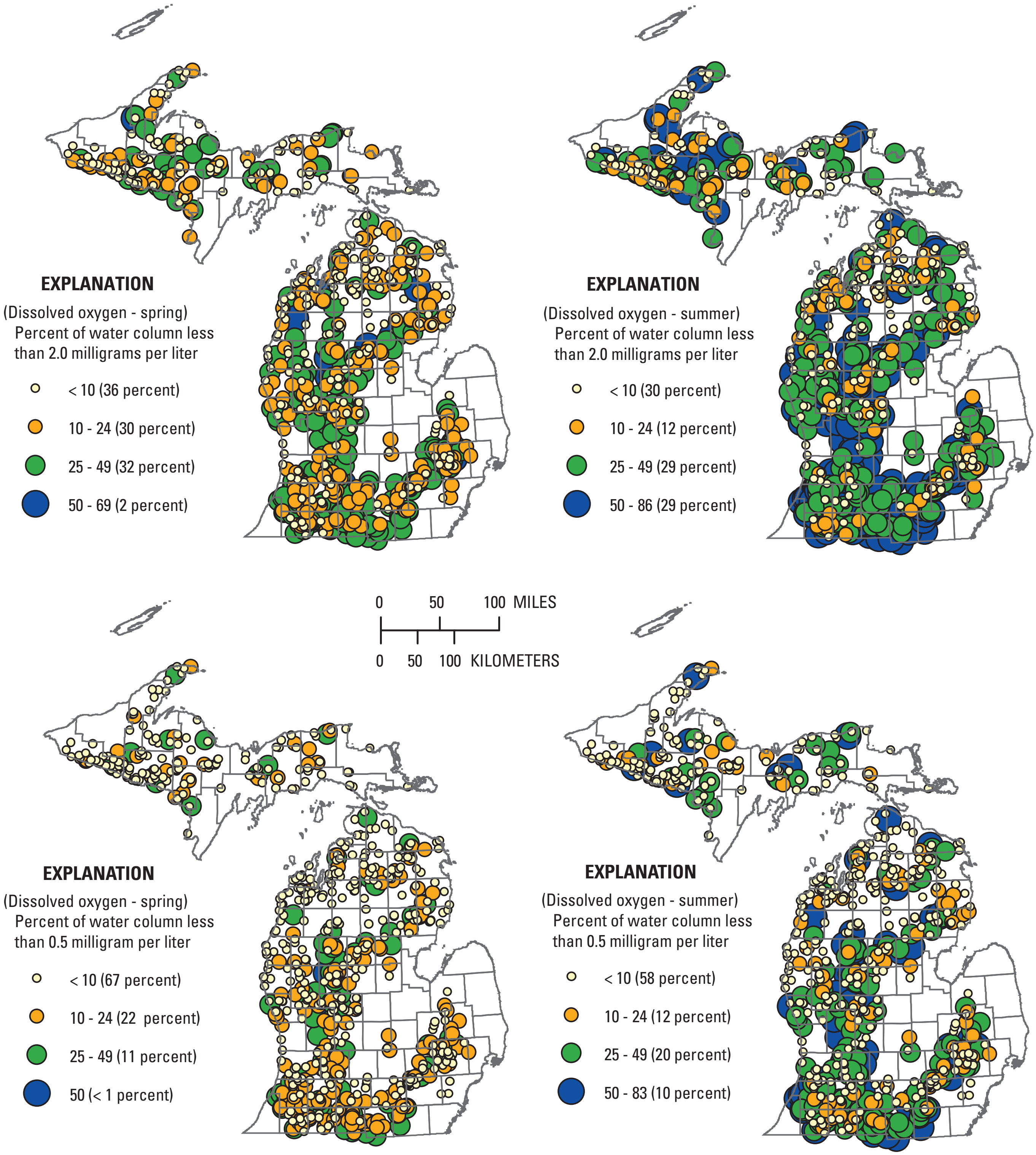

Figure 9. Spatial distribution of dissolved oxygen and the percentage of the water column below 0.5 and 2.0 milligrams per liter in spring and summer measurements for Michigan inland lakes during 2001–10.

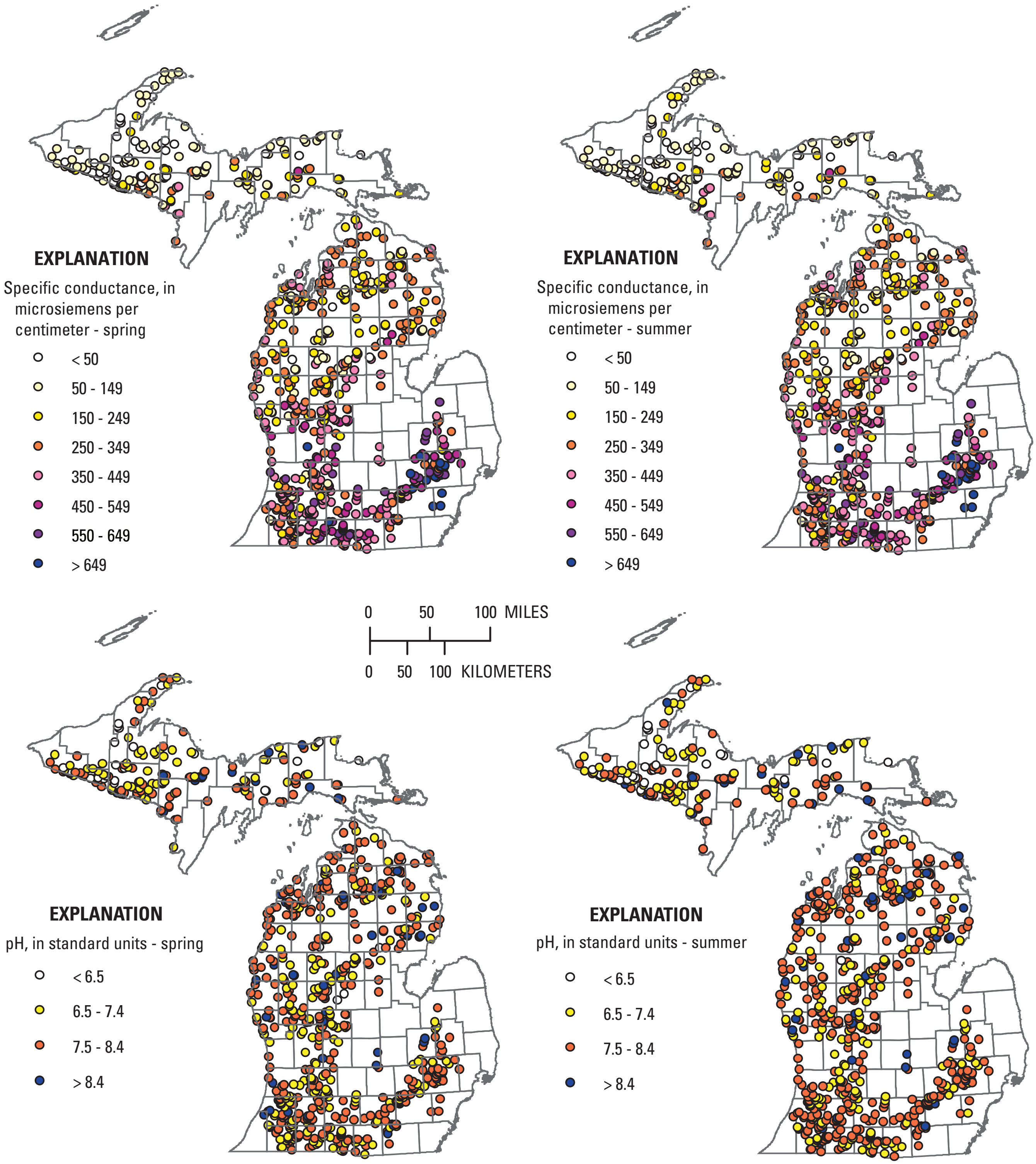

Figure 10. Spatial distribution of specific conductance and pH in spring and summer mid-depth or metalimnion measurements for Michigan inland lakes during 2001–10.

Table 4. Results of Wilcoxon signed-rank test to determine statistical significance among Michigan lakes spring and summer measurements throughout the vertical profile at measured depths for 2001–10.

[Significant at 95-percent confidence level if p-value result is less than 0.05]

Constituent	Sample size	Spring and summer
Dissolved oxygen		p-value
Near surface	729	0.00
Mid-depth or metalimnion	728	.49
Near bottom	727	.00
Water temperature		p-value
Near surface	729	0.00
Mid-depth or metalimnion	728	.00
Near bottom	727	.00
Specific conductance		p-value
Near surface	728	0.00
Mid-depth or metalimnion	729	.00
Near bottom	729	.00
pH		p-value
Near surface	727	0.00
Mid-depth or metalimnion	724	.01
Near bottom	723	.00

Table 5. Results of Wilcoxon signed-rank test to determine statistical significance among Michigan lakes in the vertical profile between measured depths for 2001–10.

[Significant at 95-percent confidence level if p-value result is less than 0.05]

	Sample size	Near surface and mid-depth	Sample size	Near surface and near bottom	Sample size	Mid-depth and near bottom
Spring		p-value		p-value		p-value
Dissolved oxygen	728	0.00	727	0.00	727	0.02
Water temperature	728	.00	728	.00	728	.00
Specific conductance	728	.00	728	.00	729	.00
pH	724	.00	723	.00	723	.00
Summer		p-value		p-value		p-value
Dissolved oxygen	729	0.00	729	0.00	729	0.00
Water temperature	729	.00	727	.00	727	.00
Specific conductance	728	.00	728	.00	729	.00
pH	728	.00	728	.00	728	.00

Trophic Status: Secchi-Disk Transparency, Chlorophyll *a*, and Total Phosphorus

At about 75 percent of inland lake index stations (deep basins) measured, trophic characteristics were associated with oligotrophic or mesotrophic conditions—74 percent if SDT was used as the sole indicator, 78 percent if chlorophyll *a* was used, and 84 percent if TP was used to determine the TSI values and trophic classifications. Differences in the percentages separating the oligotrophic and mesotrophic classes were greater when the three indicators were compared (fig. 11). Five percent of the lakes or fewer were categorized as hypereutrophic when using any of the three indicators. Land-cover data (Homer, 2004) show that the dominant land-cover type for lakes in northern Lower Michigan is mostly forested, with urban and agriculture as the dominant land cover for southern Lower Michigan; these land-cover differences could play a role in the trophic-classification spatial difference in Lower Michigan.

Fewer lakes were available for using SDT as the sole indicator because the Secchi disk hit the bottom of some lakes. In these instances, recording the depth of the lake would give a false sense of the TSI class. For example, if a lake has a maximum depth of about 6 to 9 ft (2 to 3 m) and the Secchi disk hit bottom, recording the lake depth for the SDT would be misleading because it would be associated with a mesotrophic to eutrophic TSI category. If a Secchi disk hit bottom, it might be indicative of a clear oligotrophic lake. Of the 36 lakes where the Secchi disk hit bottom, all but one lake might be considered shallow: 28 of the lakes were considered too shallow to allow for three discrete-depth measurements; in 7 lakes, maximum depth ranged from 7.5 to 20 ft; the last lake had a depth of 48 ft. For the lakes too shallow for three discrete-depth measurements, the single TP measurement from summer was used to compute the TSI and trophic status. Statistical distributions of individual measurements made in the spring and summer for SDT and chlorophyll *a* in the summer total for phosphorus used to compute TSI are shown in figure 12.

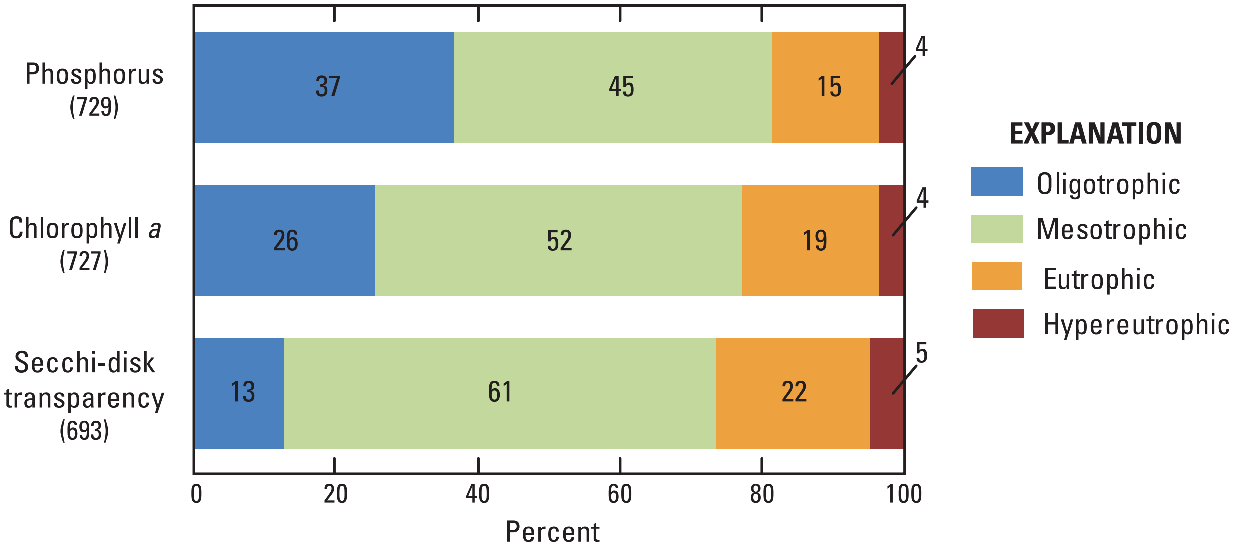

Figure 11. Trophic-status distribution using Secchi-disk transparency, chlorophyll *a*, or total phosphorus as the indicator.

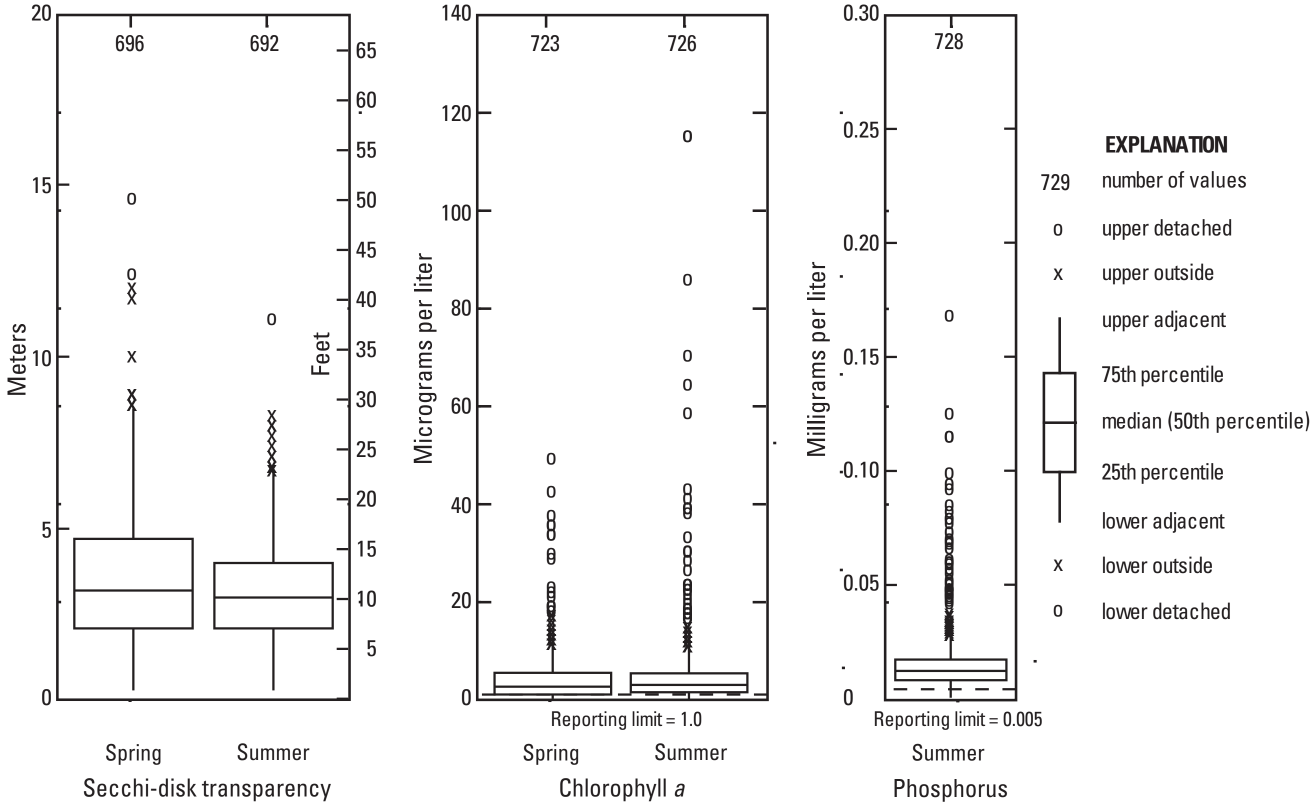

Figure 12. Statistical distribution of Secchi-disk transparency and chlorophyll *a* in spring and summer measurements and near-surface phosphorus in summer measurements at the index stations (deepest basins) in Michigan lakes during 2001–10.

The spatial distribution of mesotrophic and eutrophic lakes in Michigan is fairly even around the State. Oligotrophic lakes are more numerous and dense in the northern part of the Lower Peninsula, and hypereutrophic lakes are more numerous in the southern part of the Lower Peninsula, as is evident in figure 13. As lake depth decreases, the TSI values increase, as can be seen in figure 14. More than 80 percent of hypereutrophic lakes, regardless of the sole indicator used to compute the TSI, were 30 ft deep or less, with the deepest hypereutrophic lake measured at 52 ft. Bottom sediments in shallow lakes can play a major role in nutrient releases throughout the water column during wind-induced sediment resuspension and/or biological processes. The resuspension of sediment results in high levels of turbidity and nutrients in the lake. These conditions affect light penetration and influence algal productivity (Søndergaard and others, 2003).

There was a statistically significant difference at the 95-percent confidence level among spring and summer SDT and chlorophyll *a* measurements for individual lakes (table 6). However, there were fairly even counts of lakes with increases and decreases in the SDT and Chlorophyll *a* measurements among spring and summer in comparing all lakes; thus, an overall positive or negative relation between seasons was not found. For SDT measurements, there were slightly more clearer lakes in the spring than summer for 63 percent of lakes measured. Water clarity can be reduced by the presence of suspended sediment, dissolved organic substances, free-floating algae, and zooplankton, but algae commonly are the dominant affect on the clarity of lake water. Therefore, as a lake becomes more productive during summer months, it generally is expected that water clarity would decrease.

Color

True color, as by the spectrophotometric method, was added to the LWQA monitoring program during summer 2007–10 (fig. 15), and it provides a standardized means to assess lake-water color. Although color is a measure of the appearance of water, true color measures of water result when dissolved substances have been removed. Suspended matter, which includes algae and non-algal matter, can affect water color, as can climatic events such as increased rainfall (and thus runoff) and drought conditions. High levels of color in water can have a negative effect on lake biota if they prevent light from reaching necessary depths (Florida LAKEWATCH, 2004). A study by Webster and others (2008) showed both color and TP had a strong positive effect on chlorophyll *a* and a negative effect on Secchi transparency. Webster and others (2008) suggest misinterpretation of these widely used trophic-status indicators could occur without corresponding color measurements.

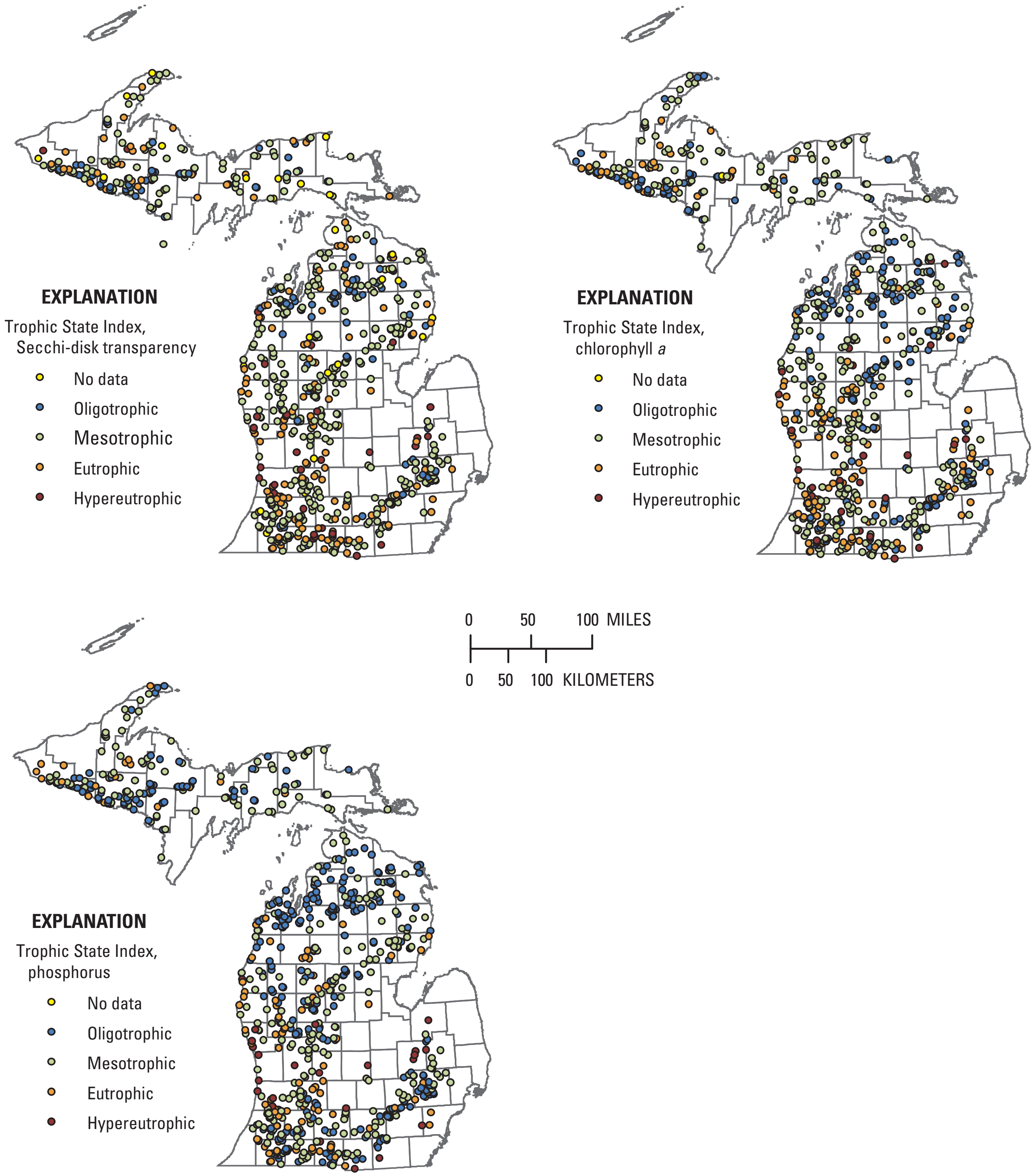

Figure 13. Spatial distribution of trophic status for Michigan inland lakes during 2001–10.

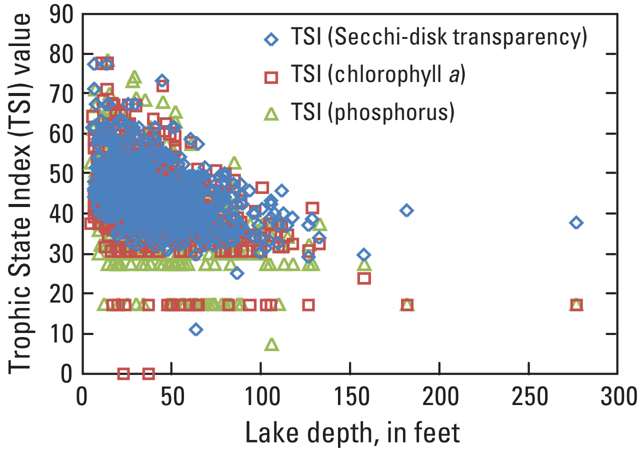

Figure 14. Trophic State Index (TSI) values compared to lake depth for Michigan inland lakes during 2001–10.

Table 6. Results of Wilcoxon signed-rank test to determine statistical significance between Michigan lakes spring and summer measurements of Secchi-disk transparency and chlorophyll *a* for 2001–10.

[Significant at 95-percent confidence level if p-value result is less than 0.05]

Measurement	Sample size	p-value
Secchi-disk transparency	693	0.00
Chlorophyll *a*	724	.00

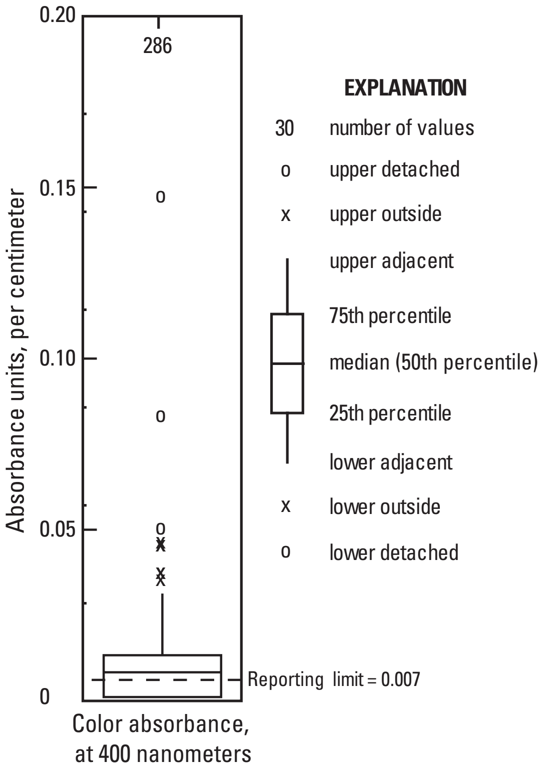

Figure 15. Statistical distribution of true color in the summer near-surface measurements at the index stations (deepest basins) in Michigan lakes during 2007–10.

Nutrients

Total phosphorus, Kjeldahl nitrogen (ammonia plus organic nitrogen), ammonia, and nitrate plus nitrite all were sampled near surface, at mid-depth or metalimnion, and near bottom during spring and summer. Total nitrogen was calculated by summing Kjeldahl nitrogen and nitrate plus nitrite. For those lakes considered too shallow to allow for three discrete-depth measurements, the available measurements were used in this analysis. Individual lake measurements for spring and summer at the three discrete depths are shown in figures 16–19. Nitrate plus nitrite values were higher in the spring than summer for the majority of lakes, whereas ammonia and ammonia plus organic nitrogen were higher in the summer near-bottom measurements. This pattern, along with the DO being lower in the summer near bottom (fig. 5), suggests that nutrient cycling and conversion was occurring in the summer at near-bottom depths.

Phosphorus and nitrogen are required for algae and aquatic macrophyte growth. The concentration of these nutrients will determine the quantity of plants that a lake can support. The quantity and diversity of the algae and aquatic macrophyte communities in turn plays an important role in the quantity and diversity of fish and other living organisms in the environment. However, if excessive amounts of nutrients are present, algal blooms and excessive growth of aquatic macrophytes can occur. Commonly, it requires only small additional quantities of nutrients above those that are naturally present to increase the primary productivity of a lake to the point where eutrophication becomes a concern. The nutrient in shortest supply tends to be the limiting control on production (Kalff, 2002). The spatial distribution of total nitrogen and TP for near-surface measurements in the spring and summer are shown in figure 20.

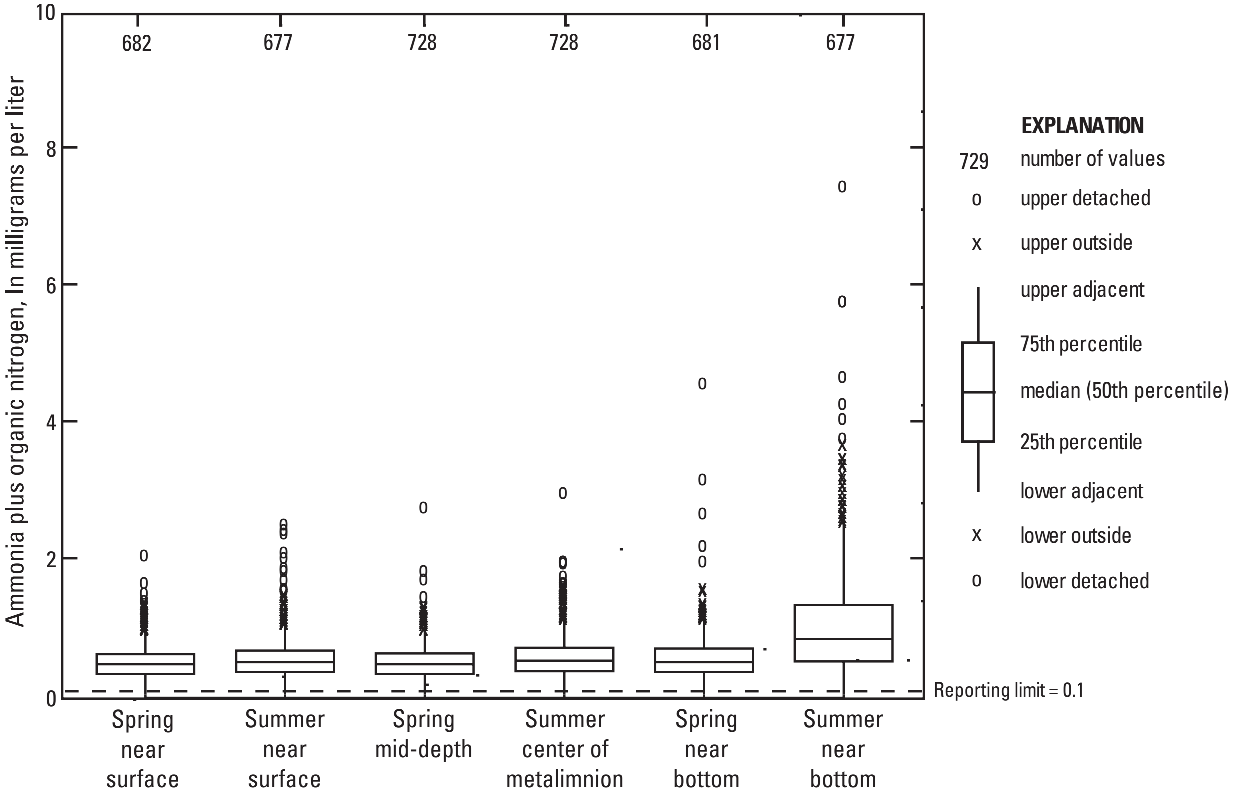

Figure 16. Statistical distribution of Kjeldahl nitrogen (ammonia plus organic nitrogen) in spring and summer near-surface, mid-depth or metalimnion, and near-bottom measurements at the index stations (deepest basins) in Michigan lakes during 2001–10.

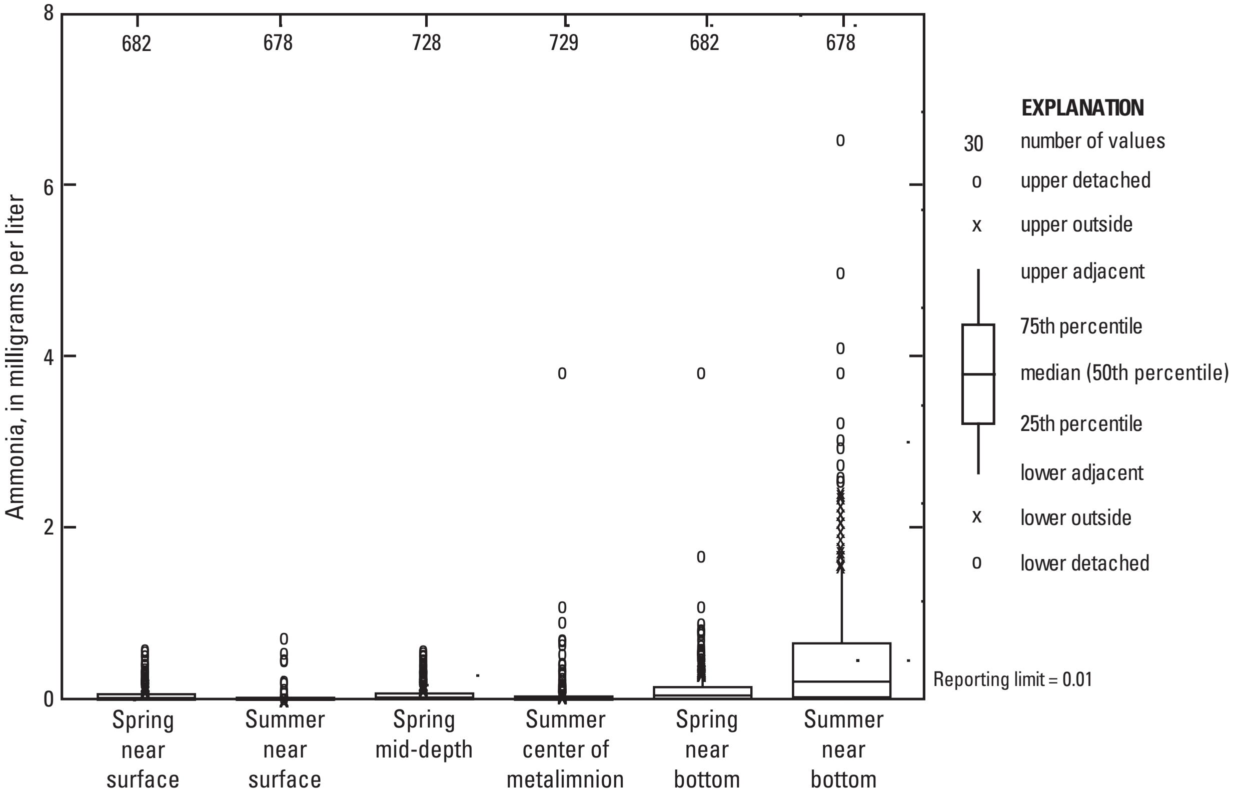

Figure 17. Statistical distribution of ammonia in spring and summer near-surface, mid-depth or metalimnion, and near-bottom measurements at the index stations (deepest basins) in Michigan lakes during 2001–10.

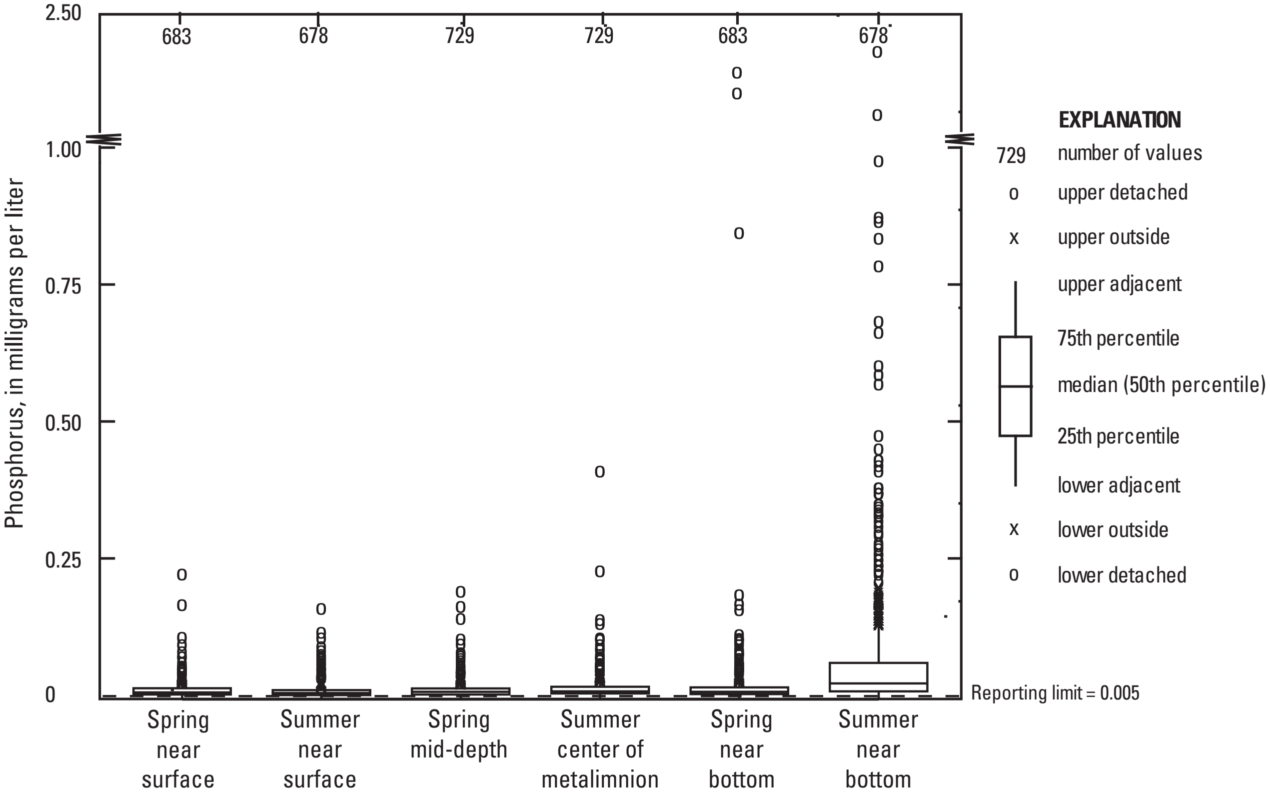

Figure 18. Statistical distribution of total phosphorus in spring and summer for near-surface, mid-depth or metalimnion, and near-bottom measurements at the index stations (deepest basins) in Michigan lakes during 2001–10.

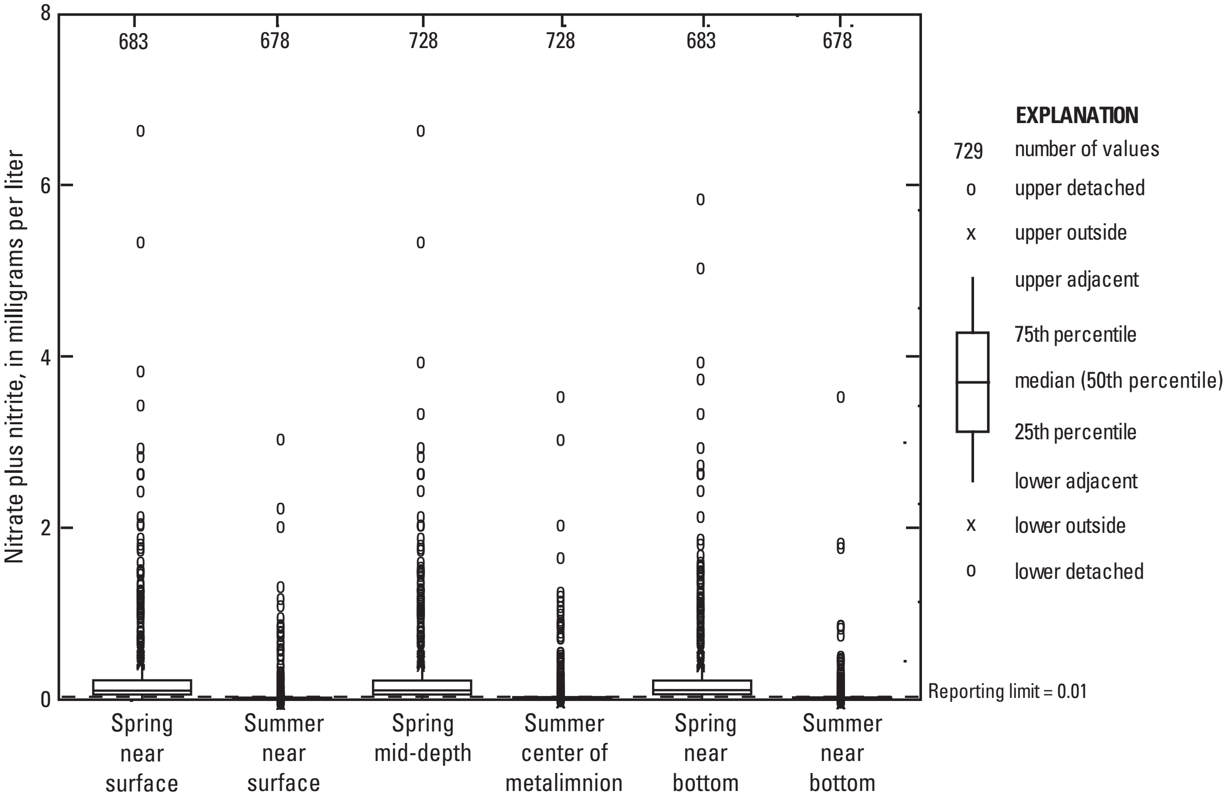

Figure 19. Statistical distribution of nitrate plus nitrite in spring and summer for near-surface, mid-depth or metalimnion, and near-bottom measurements at the index stations (deepest basins) in Michigan lakes during 2001–10.

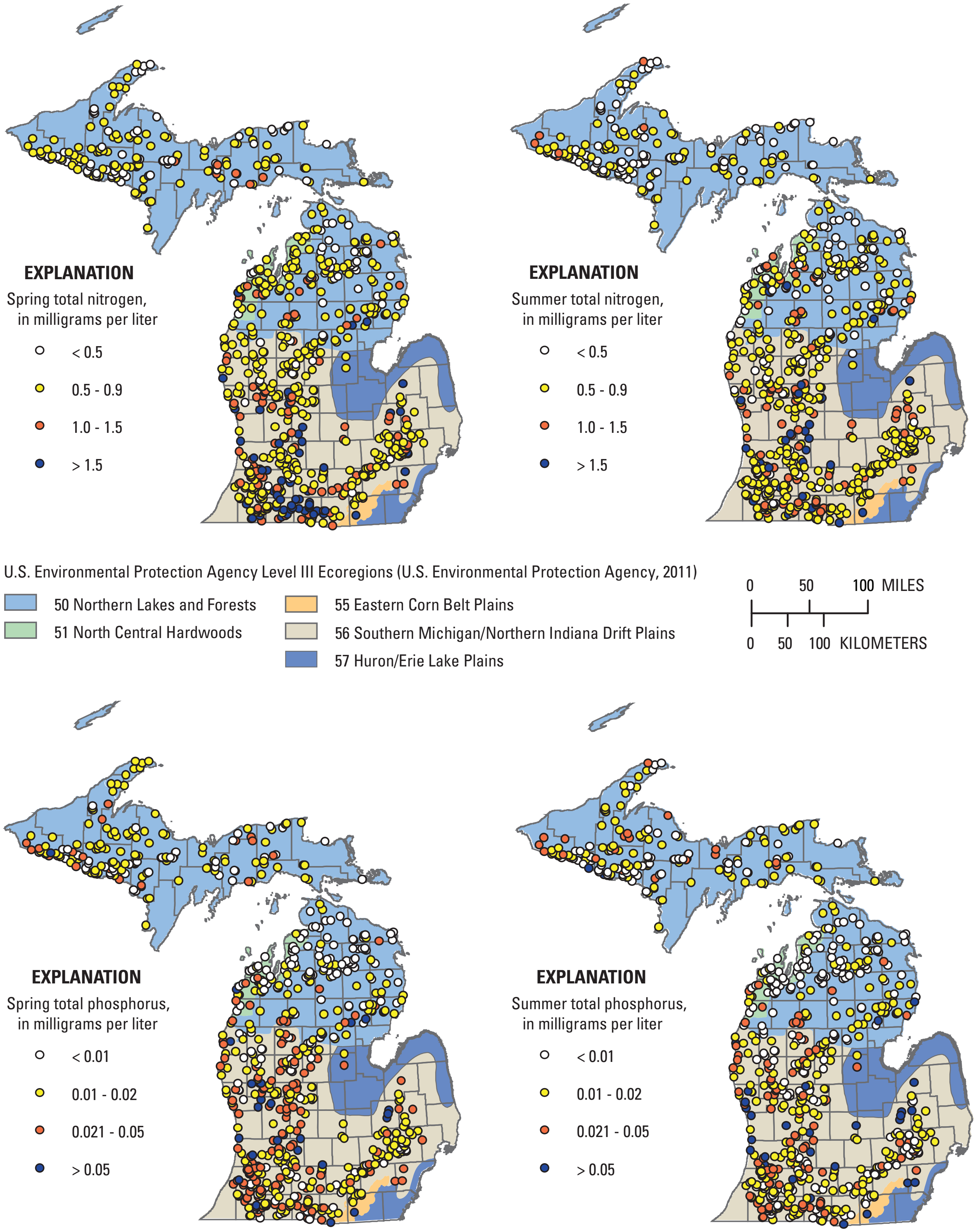

Figure 20. Spatial distribution of total nitrogen and total phosphorus for both spring and summer near surface measurements for Michigan inland lakes during 2001–10.

Lakes with total nitrogen to TP ratios greater than 15:1 near surface generally are considered phosphorus limited; ratios ranging from 10:1 to 15:1 indicate a transition situation; and a ratio less than 10 to 1 indicates nitrogen limitation (Vollenweider, 1968, 1969, 1976). On the basis of near-surface measurements from Michigan lakes during 2001–10 in the spring, 97 percent of the lakes can be considered phosphorus limited and less than a half percent nitrogen limited; for summer measurements, 96 percent would be phosphorus limited, and less than a half percent nitrogen limited. Following these same guidelines for the mid-depth or metalimnion measurements, similar percentages of phosphorus-limited lakes (around mid-90 percents) and nitrogen-limited lakes (less than 1 percent) occurred during both seasons, as well as for the spring near bottom; on the basis of summer near-bottom measurements, 75 percent of the lakes were phosphorus limited and 14 percent nitrogen limited.

To determine whether differences among the nutrient measurements at different depths and also between spring and summer were statistically significant, the Wilcoxon signed-rank test was used. Results are listed in tables 7 and 8, respectively. For the spring, all nutrients measured were statistically significant at the 95-percent confidence level among all depths except for ammonia plus organic nitrogen and TP between the near surface and mid-depth measurements. For summer, differences among all nutrients measured were statistically significant at the 95-percent confidence level among all depths except for nitrate plus nitrite between mid-depth or metalimnion and near bottom. On a lake-by-lake basis, there were more differences in nutrients among depths in the spring than in the summer between the near surface and mid-depth. All differences in nutrient concentrations were determined to be statistically significant at the 95-percent confidence level among spring and summer measurements at the discrete depths.

Table 8. Results of Wilcoxon signed-rank test to determine statistical significance among Michigan lakes spring and summer nutrients at measured depths for 2001–10.

[Significant at 95-percent confidence level if p-value result is less than 0.05]

Constituent	Sample size	Spring and summer
Ammonia plus organic nitrogen		p-value
Near surface	678	0.00
Mid-depth or metalimnion	729	.00
Near bottom	678	.00
Ammonia		p-value
Near surface	678	0.00
Mid-depth or metalimnion	728	.00
Near bottom	678	.00
Total phosphorus		p-value
Near surface	678	0.01
Mid-depth or metalimnion	729	.00
Near bottom	678	.00
Nitrate plus nitrite		p-value
Near surface	678	0.00
Mid-depth or metalimnion	728	.00
Near bottom	678	.00

Table 7. Results of Wilcoxon signed-rank test to determine statistical significance among Michigan lakes nutrients at measured depths for 2001–10.

[Significant at 95-percent confidence level if p-value result is less than 0.05]

	Sample size	Near surface and mid-depth	Sample size	Near surface and near bottom	Sample size	Mid-depth and near bottom
Spring		p-value		p-value		p-value
Ammonia plus organic nitrogen	683	0.96	682	0.00	682	0.00
Ammonia	682	.00	682	.00	682	.00
Total phosphorus	683	.95	683	.00	683	.00
Nitrate plus nitrite	683	.00	683	.00	683	.03
Summer		p-value		p-value		p-value
Ammonia plus organic nitrogen	678	0.00	678	0.00	678	0.00
Ammonia	678	.00	678	.00	678	.00
Total phosphorus	678	.01	678	.00	678	.00
Nitrate plus nitrite	678	.00	678	.00	678	.47

Major Ions and Physical Properties

In the spring, major ions and various physical properties of water were measured at mid-depth to establish "whole lake" baseline water-quality conditions after mixing and before potential summer stratification. Catchment runoff contributes to the concentration of major ions, along with those naturally present that together yield the salinity in inland lakes. Sources of major ions can include local geology, human activities, and climatic variation, and the concentration and mix of major ions influence lake biota (Kalff, 2002); statistical distributions of measurements of major ions and associated properties are shown in figures 21 and 22. There were spatial patterns of lower values in the Upper Peninsula, with increasing values towards the southern part of Michigan, for all major ions and physical properties, although the location of increase and intensity varied by constituent and property.

U.S. Environmental Protection Agency level III ecoregions (U.S. Environmental Protection Agency, 2011), which were created on the basis of land cover, geology, physiography, vegetation, climate, soils, wildlife, and hydrology, are shown in figures 23*A* and 23*B* along with constituent values. Potassium, sulfate, and chloride concentrations fairly closely followed the level III ecoregion boundaries. Magnesium, hardness, calcium, and alkalinity middle-range values were spatially diverse, though low to middle values were found in the Northern Lakes and Forest ecoregion covering the Upper Peninsula and the northern Lower Peninsula, and middle to higher values were found in the southern Michigan/Northern Indiana Drift Plains ecoregion. Alkalinity and magnesium concentrations were the lowest in the Upper Peninsula, but the higher concentrations started in the eastern end of the Upper Peninsula and continued to increase southward, with the highest measurements in the southern Lower Peninsula. Sodium and chloride concentrations were lower in the Upper Peninsula and in most of the Lower Peninsula, but higher concentrations were clustered in the southeastern Lower Peninsula, especially for lakes in Genesee, Livingston, and Oakland Counties. Higher concentrations of sodium and chloride observed in the southeastern Lower Peninsula are most likely a result from the use of road salt for deicing roads, parking lots, and other impervious surfaces during the winter months. Elevated concentrations of chlorides can inhibit plant growth, impair reproduction, and reduce the diversity of organisms in streams (Mullaney and others, 2009).

Examination of Multibasin Lakes

Of the 729 Michigan lakes measured, 109 have at least two deep basins, 26 have three deep basins, and 2 have four deep basins where thermal stratification is likely to occur during the summer. All these secondary basins were measured, replicating the same water-quality parameters measured at the index stations (deepest basins). The basins were ranked 1 through 4 by their maximum depth; examples of multiple-basin lakes are shown in figure 24.

The Wilcoxon signed-rank test was used to determine statistical significance of differences in measurements among multiple basins. When basins 1 and 2 were compared for the spring, differences in SDT, water temperature for mid-depth and near bottom, pH for near surface, and nitrate plus nitrite for near surface and mid-depth were determined to be statistically significant at the 95-percent confidence level. Differences in chlorophyll *a*, water temperature, potassium, and magnesium were also statistically significant at the 95-percent confidence level between other basin combinations. In the summer, differences in water temperature near-bottom measurements, pH for near-surface measurements, and nitrate plus nitrite for near-bottom measurements were statistically significant at the 95-percent confidence level between basins 1 and 2. Differences in DO and water temperature were statistically significant at the 95-percent confidence level between other basin combinations. There were not enough lakes with four basins to test for significant difference between the fourth basins. The resulting p-values are listed in table 9. Owing to the lack of statistical significance overall for differences between constituents in lakes with multiple basins, one basin measurement per lake would be sufficient, perhaps with some exceptions depending on desired constituents.

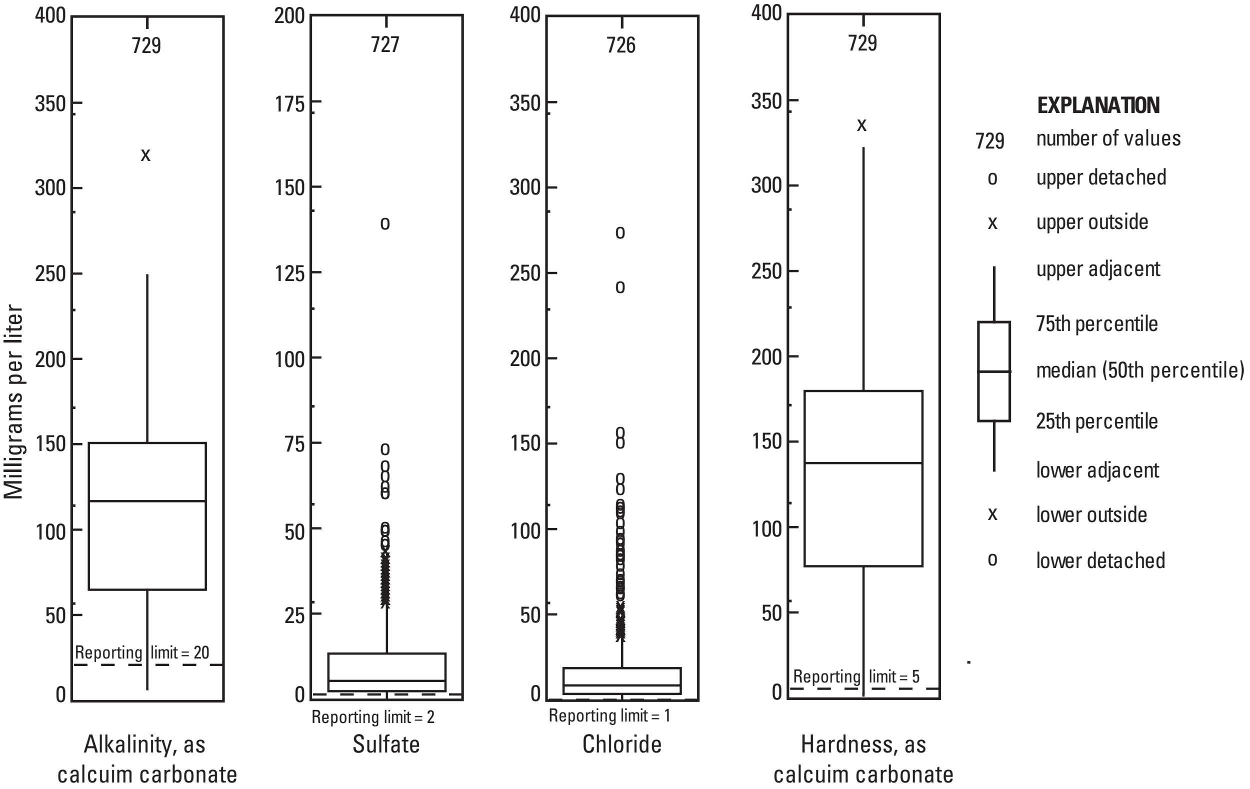

Figure 21. Statistical distribution of alkalinity, sulfate, chloride, and hardness in spring measurements at the index stations (deepest basins) in Michigan lakes during 2001–10.

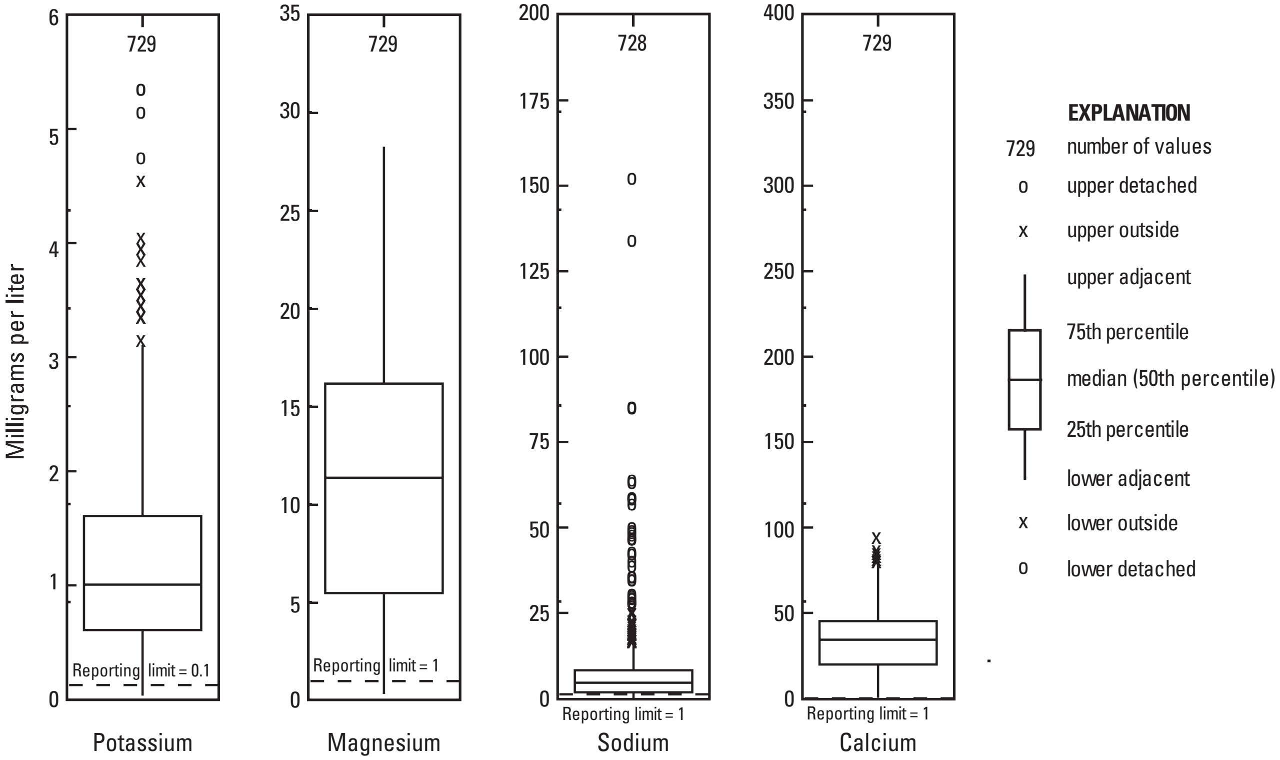

Figure 22. Statistical distribution of potassium, magnesium, sodium, and calcium in spring measurements at the index stations (deepest basins) in Michigan lakes during 2001–10.

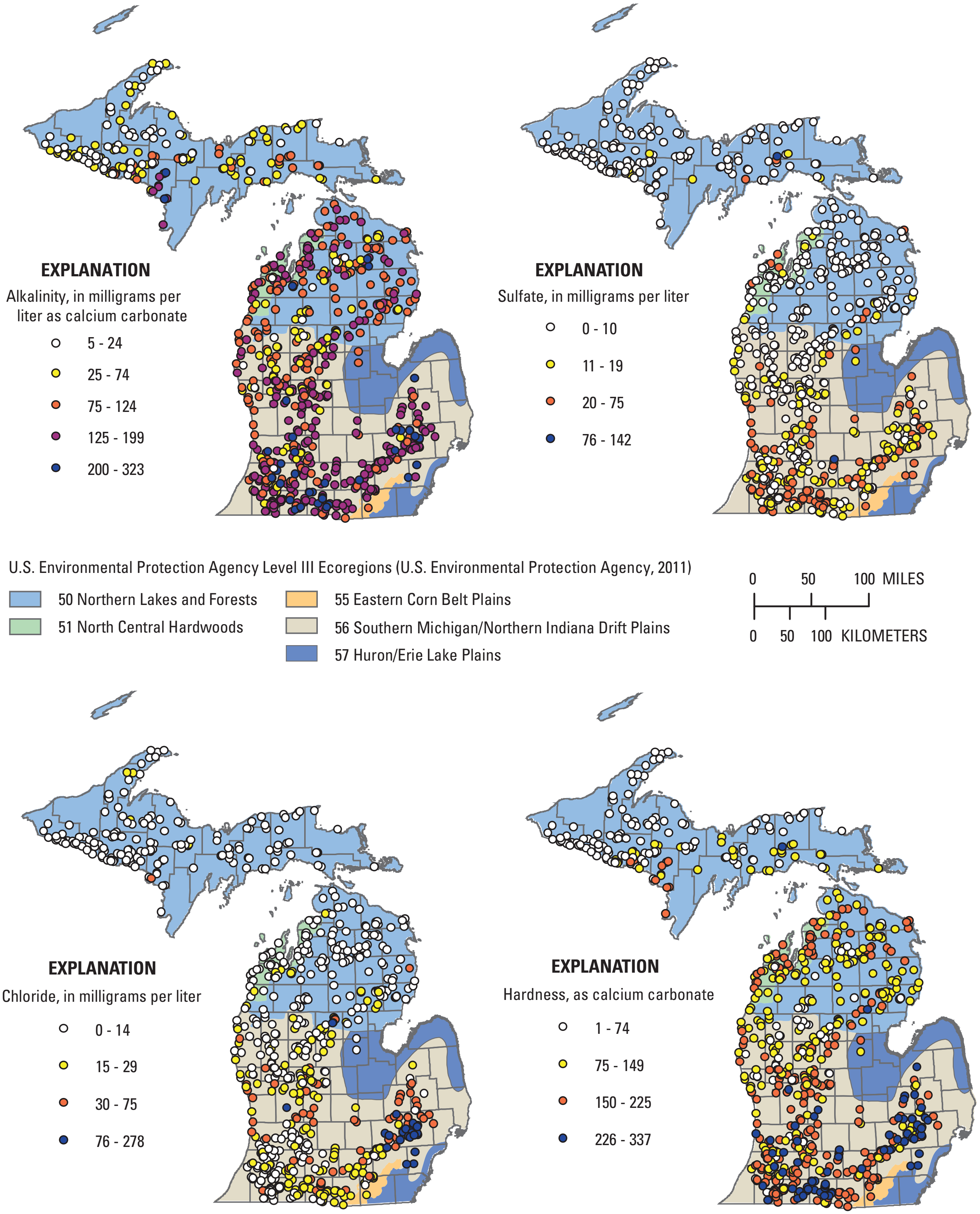

Figure 23*A*. Spatial distribution of alkalinity, sulfate, chloride, and hardness measured at Michigan inland lakes during 2001–10 in relation to U.S. Environmental Protection Agency Level III ecoregions.

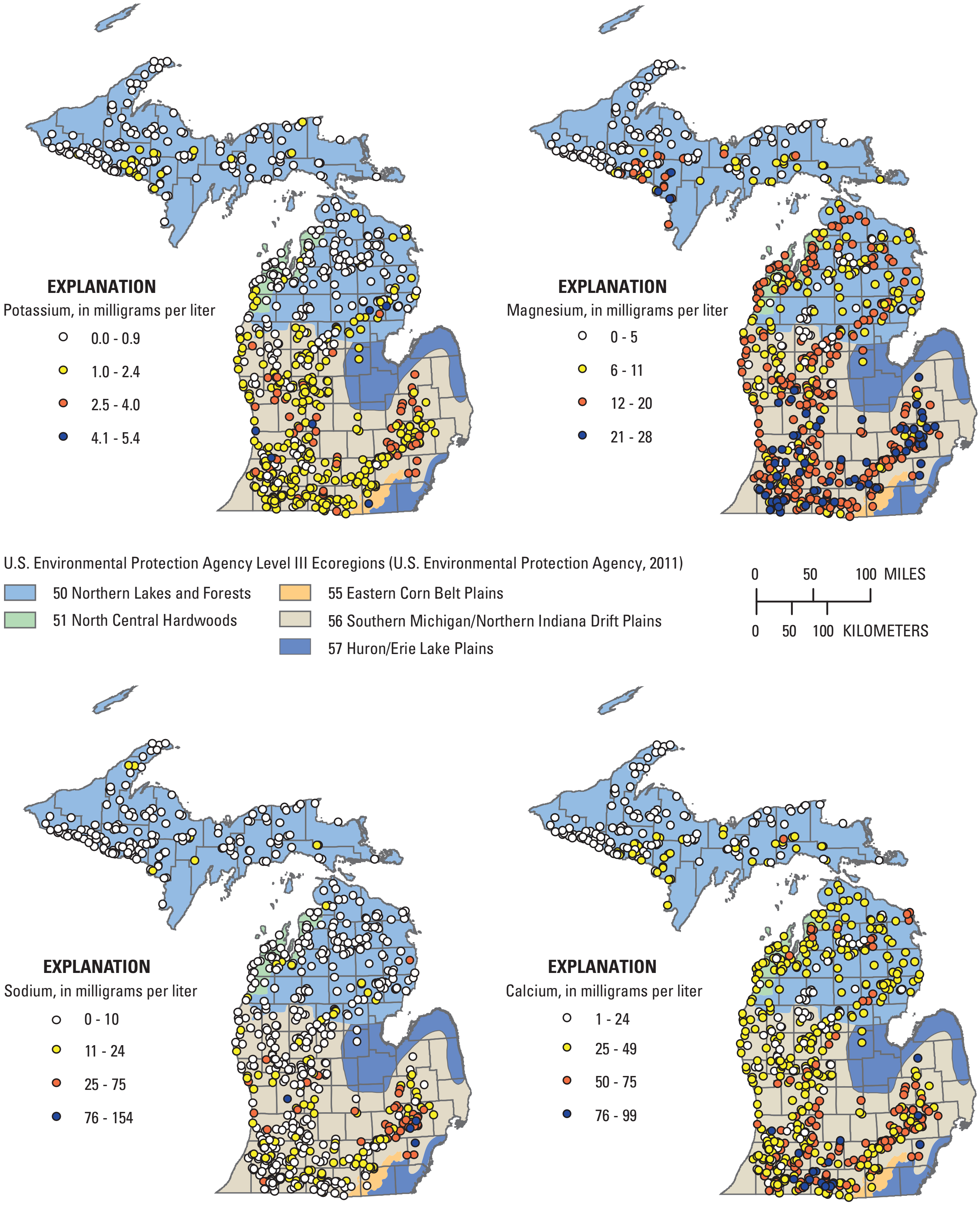

Figure 23*B*. Spatial distribution of potassium, magnesium, sodium, and calcium measured at Michigan inland lakes during 2001–10 in relation to U.S. Environmental Protection Agency Level III ecoregions.

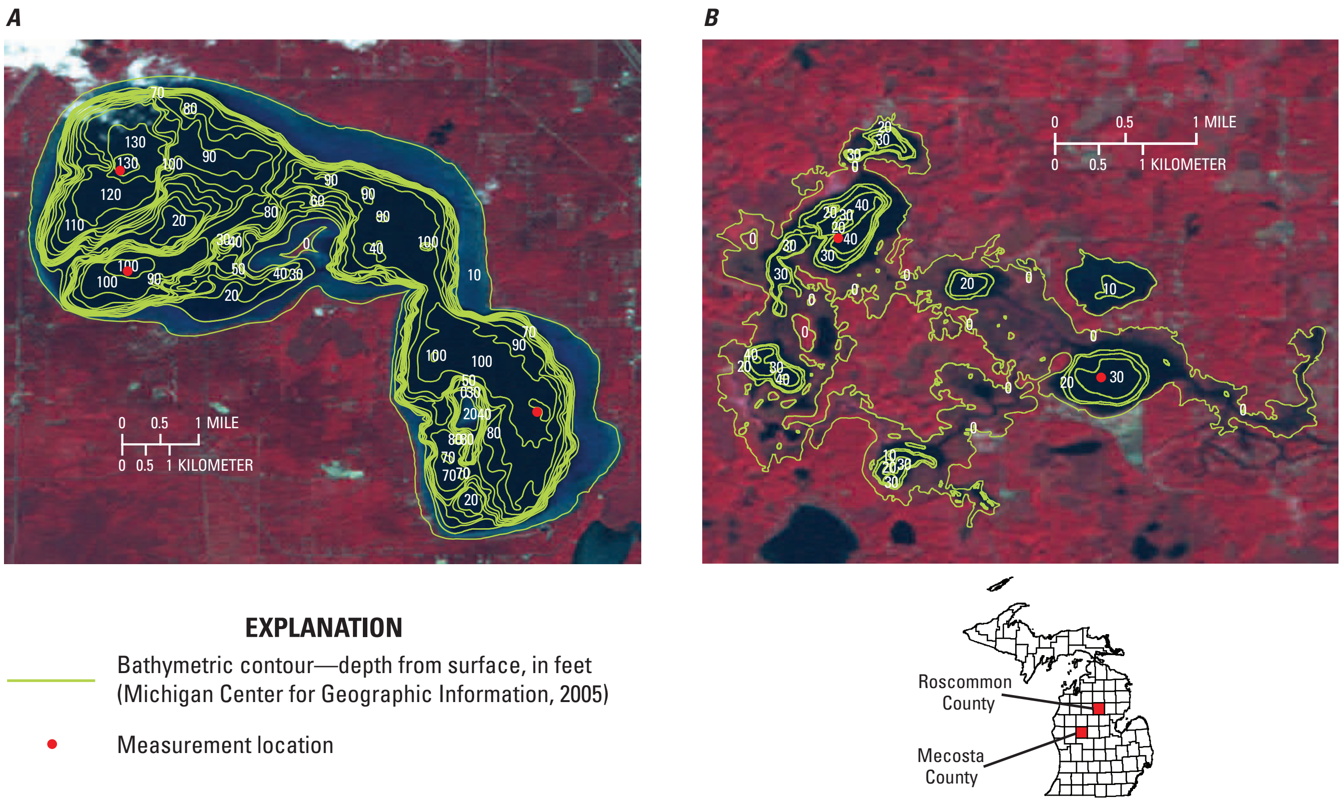

Figure 24. Multiple-basin lake examples in Michigan shown over Landsat satellite imagery for September 11, 2009. *A*, Higgins Lake in Roscommon County. *B*, Martiny Lake in Mecosta County.

Table 9. Results of Wilcoxon signed-rank test to determine statistical significance among Michigan lakes with multiple basins, by constituent, for 2001–10.

[$CaCO_3$, calcium carbonate; ~, not enough measurements to produce p-value; significant at 95-percent confidence level if p-value result is less than 0.05]

	Basin					
Spring	**1 and 2**		**1 and 3**		**2 and 3**	
Constituent	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
Secchi-disk transparency	109	0.70	26	0.20	26	0.71
Chlorophyll *a*	108	0.88	26	0.03	26	0.07
Dissolved oxygen	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
Near surface	109	0.25	26	0.78	26	0.51
Mid-depth or metalimnion	109	0.70	26	0.48	26	0.98
Near bottom	108	0.88	26	0.65	26	0.56
Water temperature	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
Near surface	109	0.68	26	0.22	26	0.57
Mid-depth or metalimnion	109	0.00	26	0.03	26	0.05
Near bottom	108	0.00	26	0.07	26	0.38
Specific conductance	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
Near surface	109	0.51	26	0.88	26	0.32
Mid-depth or metalimnion	109	0.67	26	0.95	26	0.47
Near bottom	109	0.53	26	0.57	26	0.57
pH	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
Near surface	109	0.04	26	0.17	26	0.95
Mid-depth or metalimnion	108	0.26	26	0.19	26	0.17
Near bottom	108	0.79	26	0.72	26	0.81
Ammonia plus organic nitrogen	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
Near surface	106	0.79	23	0.81	23	0.88
Mid-depth or metalimnion	109	0.13	26	0.66	26	0.06
Near bottom	106	0.81	23	0.48	23	0.84
Ammonia	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
Near surface	105	0.98	23	0.66	23	0.65
Mid-depth or metalimnion	108	0.10	26	0.90	26	0.50
Near bottom	105	0.06	23	0.47	23	0.64
Total phosphorus	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
Near surface	104	0.27	23	0.74	23	0.34
Mid-depth or metalimnion	109	0.79	26	0.64	26	0.29
Near bottom	106	0.32	23	0.93	23	0.84
Nitrate plus nitrite	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
Near surface	106	0.03	23	0.58	23	0.60
Mid-depth or metalimnion	109	0.04	26	0.74	26	0.39
Near bottom	106	0.25	23	0.70	23	0.41

Table 9. Results of Wilcoxon signed-rank test to determine statistical significance among Michigan lakes with multiple basins, by constituent, for 2001–10.—Continued

[$CaCO_3$, calcium carbonate; ~, not enough measurements to produce p-value; significant at 95-percent confidence level if p-value result is less than 0.05]

	Basin					
Summer	**1 and 2**		**1 and 3**		**2 and 3**	
Constituent	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
Secchi-disk transparency	107	0.58	25	0.17	25	0.29
Chlorophyll *a*	109	0.18	26	0.37	26	0.84
**Color	45	0.13	8	~	8	~
Dissolved oxygen	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
Near surface	109	0.70	26	0.28	26	0.16
Mid-depth or metalimnion	109	0.41	26	0.28	26	0.03
Near bottom	108	0.81	26	0.67	26	0.57
Water temperature	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
Near surface	109	0.41	26	0.30	26	0.79
Mid-depth or metalimnion	109	0.19	26	0.13	26	0.14
Near bottom	107	0.00	26	0.03	26	0.24
Specific conductance	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
Near surface	109	0.30	26	0.40	26	0.77
Mid-depth or metalimnion	109	0.10	26	0.43	26	0.94
Near bottom	109	0.42	26	0.12	26	0.29
pH	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
Near surface	109	0.01	26	0.24	26	0.63
Mid-depth or metalimnion	109	0.25	26	0.42	26	0.95
Near bottom	109	0.63	26	0.25	26	0.51
Ammonia plus organic nitrogen	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
Near surface	105	0.54	23	0.56	23	0.92
Mid-depth or metalimnion	109	0.45	26	0.40	26	0.37
Near bottom	105	0.45	23	0.47	23	0.41
Ammonia	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
Near surface	105	0.60	23	0.14	23	0.96
Mid-depth or metalimnion	109	0.54	26	0.22	26	0.84
Near bottom	105	0.17	23	0.76	23	0.85
Total phosphorus	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
Near surface	105	0.76	23	0.33	23	0.15
Mid-depth or metalimnion	109	0.33	26	0.40	26	0.77
Near bottom	105	0.08	23	0.55	23	0.27
Nitrate plus nitrite	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
Near surface	105	0.28	23	0.49	23	0.66
Mid-depth or metalimnion	109	0.47	26	0.40	26	0.55
Near bottom	105	0.03	23	0.36	23	0.31

Table 9. Results of Wilcoxon signed-rank test to determine statistical significance among Michigan lakes with multiple basins, by constituent, for 2001–10.—Continued

[CaCO$_3$, calcium carbonate; ~, not enough measurements to produce p-value; significant at 95-percent confidence level if p-value result is less than 0.05]

	Basin					
Spring—continued	**1 and 2**		**1 and 3**		**2 and 3**	
Mid-depth or metalimnion	**Sample size**	**p-value**	**Sample size**	**p-value**	**Sample size**	**p-value**
*Alkalinity (as CaCO3)	109	0.59	26	0.26	26	0.33
*Calcium - total	109	0.95	26	0.10	26	0.30
*Chloride	108	0.82	25	0.35	25	0.86
*Hardness - calculated	109	0.98	26	0.24	26	0.16
*Potassium - total	109	0.97	26	0.05	26	0.30
*Magnesium - total	109	0.63	26	0.69	26	0.01
*Sodium - total	109	0.58	26	0.85	26	0.29
*Sulfate	108	0.07	25	1.00	26	0.11

*Spring only.

**Summer only 2007–10.

Comparisons With Other Lake-Monitoring Data for Michigan

Volunteers coordinated by the original MDNR (now the MDEQ) began sampling lakes in 1974 and continue to sample (in 2010) approximately 250 inland lakes each year through the Michigan Cooperative Lakes Monitoring Program (CLMP). The objectives of the CLMP are to help citizen volunteers monitor indicators of water quality in their lakes such as SDT, chlorophyll *a*, phosphorus, DO, and temperature; to perform aquatic-plant surveys along with identifying whether exotic species are present; and to document changes in lake quality over time (*http://www.micorps.net/lakeoverview.html*).

Chlorophyll *a* and SDT data were used from the CLMP to determine trophic-status conditions from those lakes monitored for 2001–10. Lake data were chosen for the month of August of each year, and only one measurement for that month in the primary sampling station (deepest basin) was used to determine trophic-status conditions. The month of August corresponded to when measurements were made for the summer sampling season, which allowed a comparable time period between the two datasets. The majority of lakes have been sampled for multiple years, but some lakes are or are not measured each year for various reasons, which is why the number of measurements per year has varied. The resulting trophic-status conditions by percent for each year are shown in figure 25.

Data from the CLMP in addition to supplemental data specific to the Upper Peninsula, which was jointly measured by USGS and MDEQ, were used to extend the existing SDT measurements to produce TSI predictions for Michigan lakes greater than 20 acres based on satellite imagery. The remote sensing processes to produce the predicted TSI values are summarized in Fuller and others (2011). The statewide predictions for Michigan inland lakes greater than 20 acres without interference from clouds, cloud shadows, haze, dense vegetation, or shoreline for the periods 2003–05, 2007–08, and 2009–10 are shown in figure 26.

The National Lakes Assessment (NLA)—based on chemical, physical, and biological data—measured lakes nationwide during 2007 to provide a statistically valid, probability-designed estimate of the condition of lakes on a national and regional scale (U.S. Environmental Protection Agency, 2009). Michigan was one of the States that opted to increase the number of measurements collected to provide State-specific estimates. The calculated TSI values were weighted on the basis of lake size and ecological region by use of a mapping and analysis tool (NLA Data Viewer) developed by USEPA (Kiddon, 2009). The tool was used to obtain the data and produce the percentages of trophic-status categories for Michigan data and also for the Nation for comparison to those produced using trophic-status criteria specific to Michigan (from table 2) using SDT, chlorophyll *a*, and phosphorus; results are shown in figure 27.

When SDT was compared for the current (2001–10) 729 deepest basin in lakes greater than 25 acres with public boat launch (fig. 11) to the CLMP from Michigan's volunteer monitoring network for years 2001 through 2010 (fig. 25), similar percentages for trophic-status categories emerged; on average, however, the CLMP percentage for the oligotrophic class was slightly higher and for the hypereutrophic class was slightly lower. It makes sense that more volunteers might be living on or having access to clearer lakes than impaired lakes. When the SDT data for 2001–10 were compared to the remote sensing statewide predicted layer with predictions for all lakes greater than 20 acres (fig. 26) regardless of public or volunteer access, the percentage for the oligotrophic class was lower.

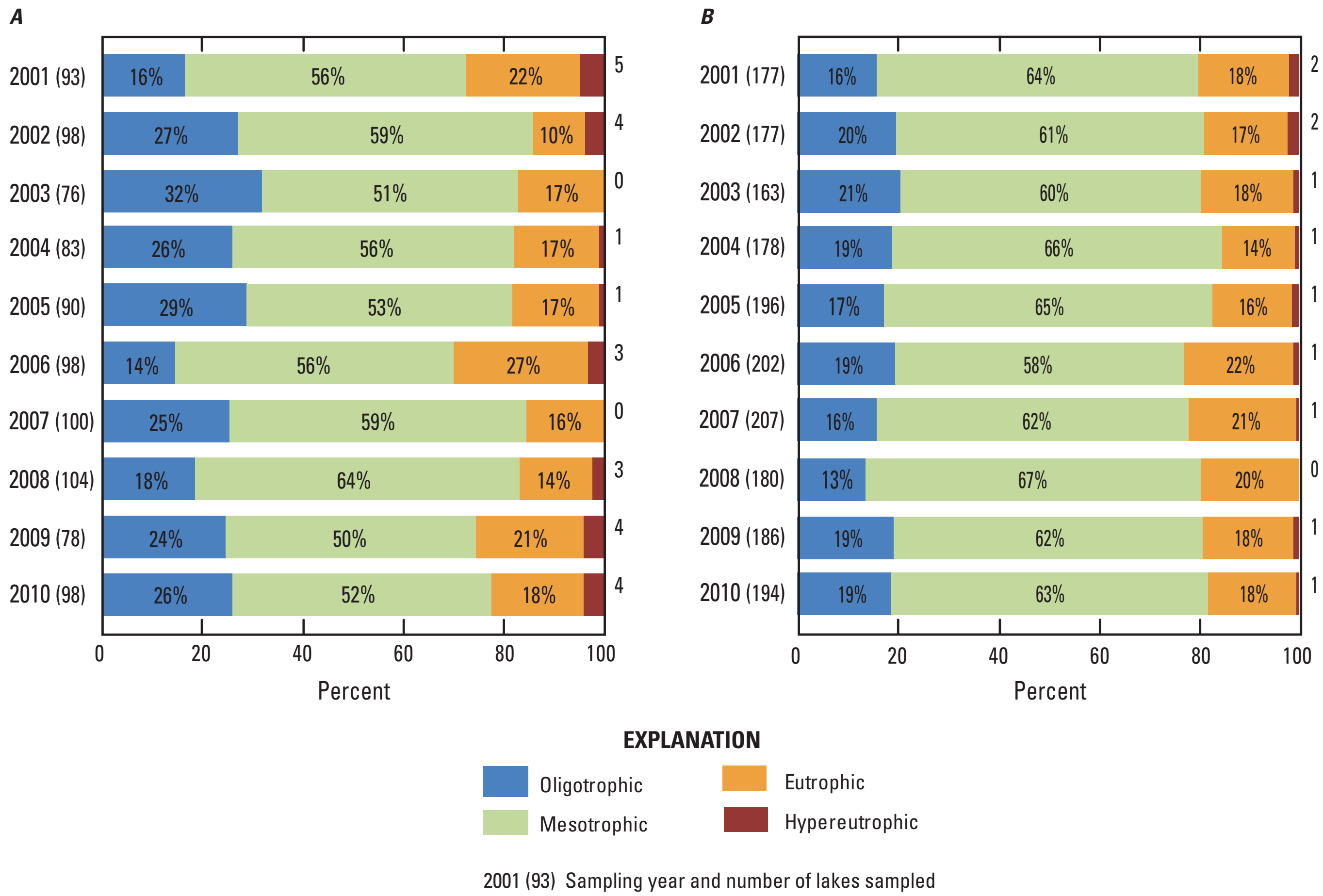

Figure 25. Trophic status based on data from the Cooperative Lakes Monitoring Program for one date per lake during the month of August for 2001–10 calculated from *A,* chlorophyll *a* and *B*, Secchi-disk transparency.

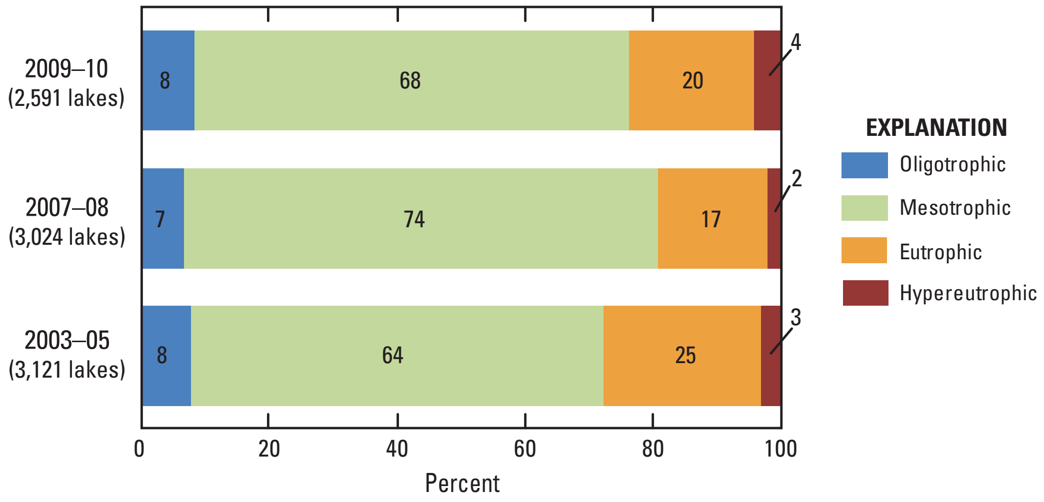

Figure 26. Statewide predictions of trophic status, by time period, produced by relating existing Secchi-disk transparency measurements to satellite imagery to produce predictions for all Michigan lakes greater than 20 acres.

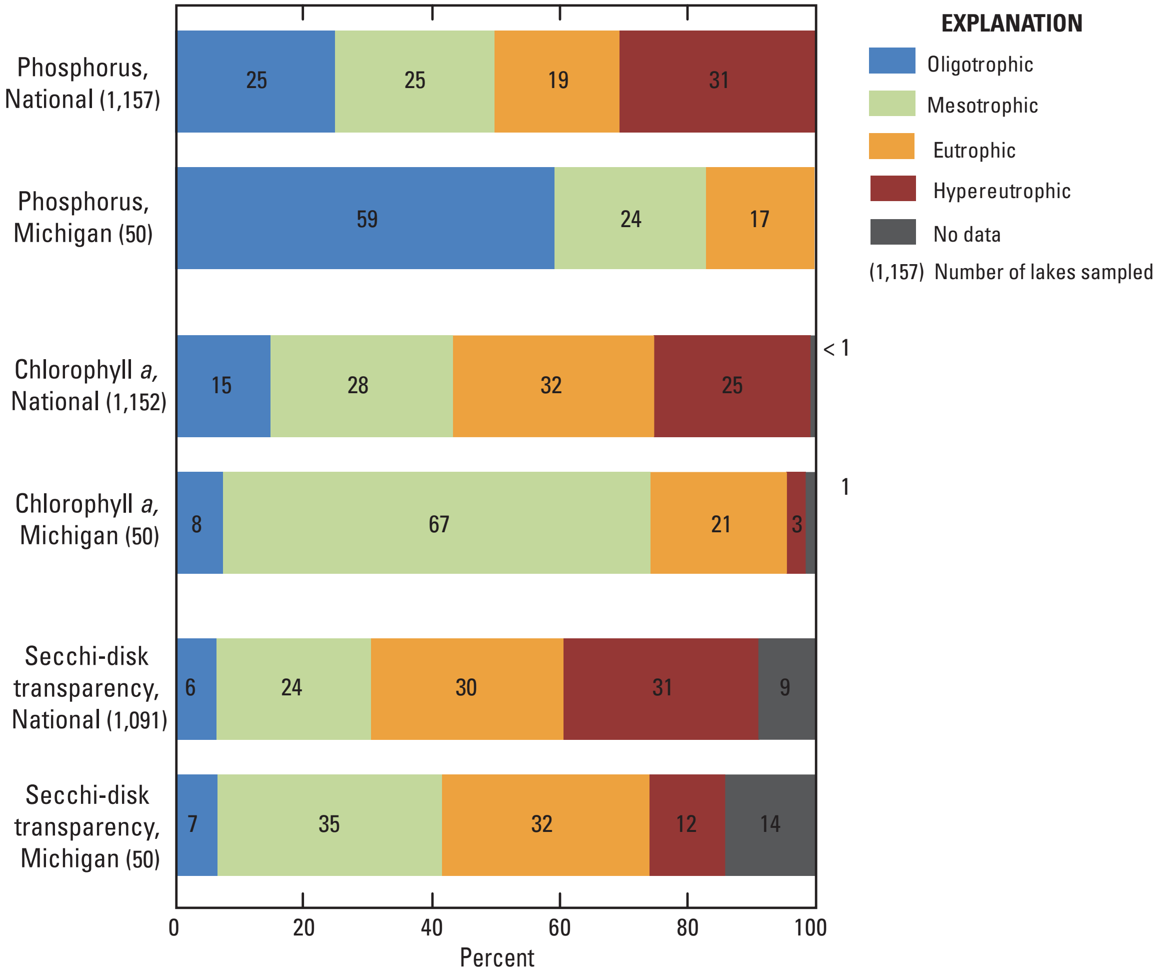

Figure 27. National Lakes Assessment trophic status (statistically valid, probability-weighted design) comparing Michigan and National data using total phosphorus, chlorophyll *a*, and Secchi-disk transparency.

This finding might suggest that Michigan lakes with public boat launch access and volunteer access might be clearer than Michigan lakes overall, regardless of public or volunteer access. The percentages for NLA (fig. 27) SDT Michigan-specific trophic classes and National classes are lower than those for the current 2001–10 dataset but more consistent with the remote sensing statewide predicted layer. The percentage for the mesotrophic class is much lower than for any of the other three datasets and higher for the eutrophic and hypereutrophic classes than for any of the other three datasets. Also, there was a substantial amount of unavailable data in the NLA set, which might be the cause of the difference between classes.

When chlorophyll *a* was compared for the current (2001–10) 729 deepest basin in lakes greater than 25 acres with public boat launch (fig. 11) to the CLMP from Michigan's volunteer monitoring network for years 2001 through 2010 (fig. 25) similar percentages for trophic-status categories emerged. Chlorophyll *a* data were not available from remote sensing statewide predicted layer. The NLA (fig. 27) chlorophyll *a* data resulted in a lower percentage of oligotrophic lakes and a slightly higher percentage for mesotrophic lakes, but results were more comparable for the eutrophic and hypereutrophic classes. The trophic category percentages for the National lakes are not as comparable for any of the trophic classes, which could suggest lake differences nationally are not as comparable for chlorophyll *a*.

Comparison with Historical Measurements

Historical near-surface summer measurements made during 1974–84 for 445 lakes using standard protocols of the MDRNE were compared to their current (2001–10) lake measurements. Selection of the subset of 445 historical lake measurements was based on comparable sampling methods. The constituents compared were total nitrogen, TP, chlorophyll *a*, and SDT; increases and decreases for each constituent are shown in figure 28.

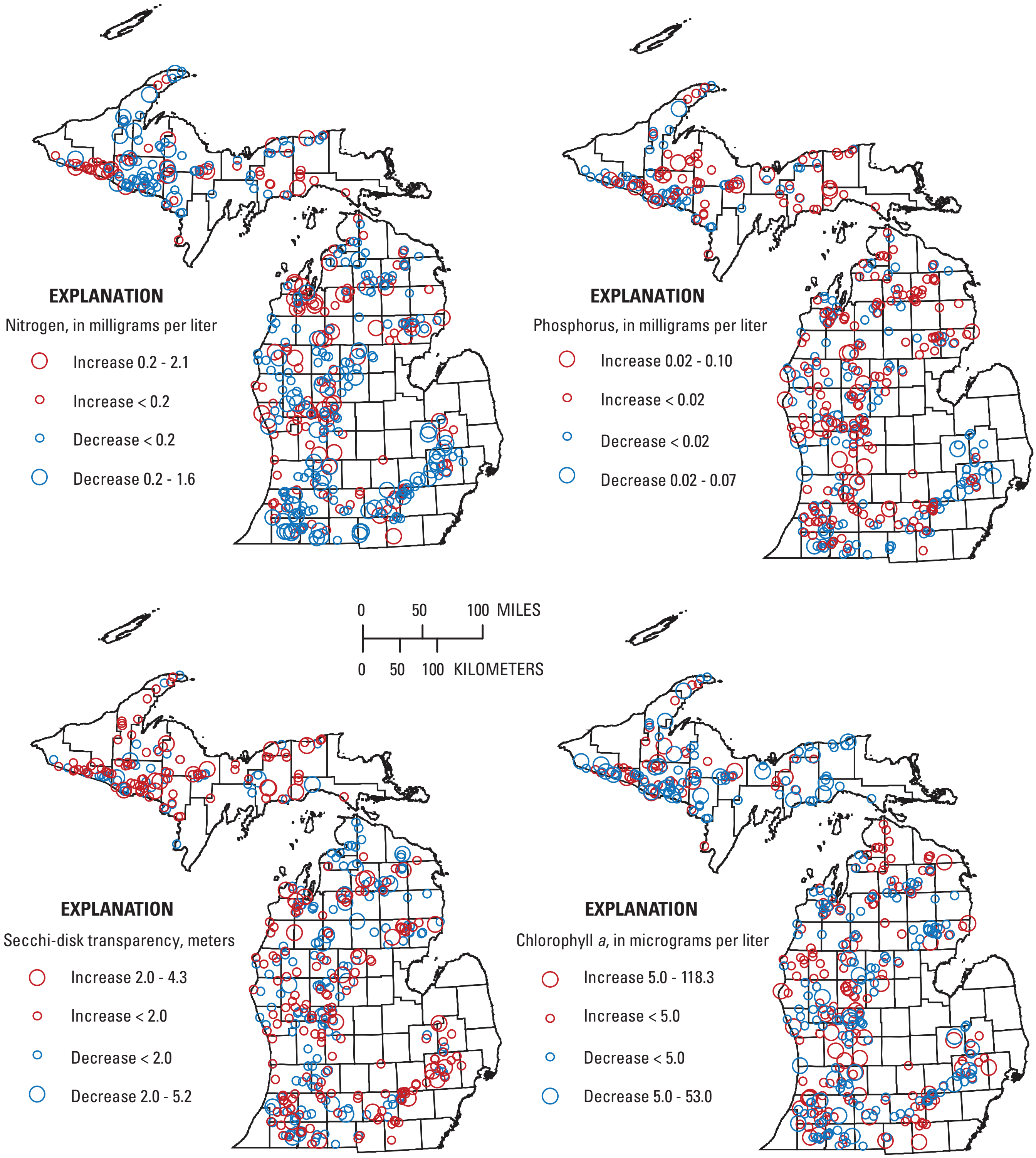

Figure 28. Increase (higher values) or decrease (smaller values) in property and constituent values from historical to current measurements for Michigan inland lakes.

The Wilcoxon signed-rank test was used to determine statistical significance of differences among the historical and current measurements, as listed in table 10. SDT showed statistically significant differences among historical and current measurements at the 95-percent confidence level; however, as is evident in figure 28, the number and distribution around the State is fairly even between the increasing and decreasing values. Even though comparison of historical to current values showed statistically significant differences at the 95-percent confidence level, these difference did not indicate an overall trend towards clearer lakes or impaired lakes.

Table 10. Results of Wilcoxon signed-rank test to determine statistical significance of differences among historical and current Michigan lakes property and constituent values for 2001–10.

[Significant at 95-percent confidence level if p-value result is less than 0.05]

Property or constituent	Sample size	p-value
Secchi-disk transparency	434	0.02
Chlorophyll *a*	444	.60
Total nitrogen	445	.55
Total phosphorus	445	.30

The trophic-status conditions are fairly comparable among current and historical measured lakes, with 87 percent of current lakes and 84 percent of historical lakes classified as oligotrophic or mesotrophic, using TP as the primary indicator; 80 percent of current lakes and 76 percent of historical lakes classified as oligotrophic or mesotrophic, using chlorophyll *a* as the primary indicator; and 78 percent of both current and historical lakes classified as oligotrophic or mesotrophic using SDT as the primary indicator (fig. 29). Although the percentage of lakes classified as oligotrophic and mesotrophic are comparable between historical and current measurements using any of the three primary indicators, this result does not necessarily mean that the same lakes were in these categories between historical and current measurements. Depending on the primary indicator, 50–66 percent of lakes did not change trophic-status conditions between the historical and current measurements, 13–23 percent moved towards the oligotrophic end of the TSI scale, and 20–25 percent moved towards the eutrophic end of the TSI scale (table 11). Further spatial analysis might help to identify patterns, hotspots, or certain lake characteristics (such as lake depth or land cover) where potential positive or negative trends for nutrients or trophic classes could be identified, but the current analysis comparing the 445 lakes did not seem to show patterns spatially, nor does it indicate overall increases or decreases.

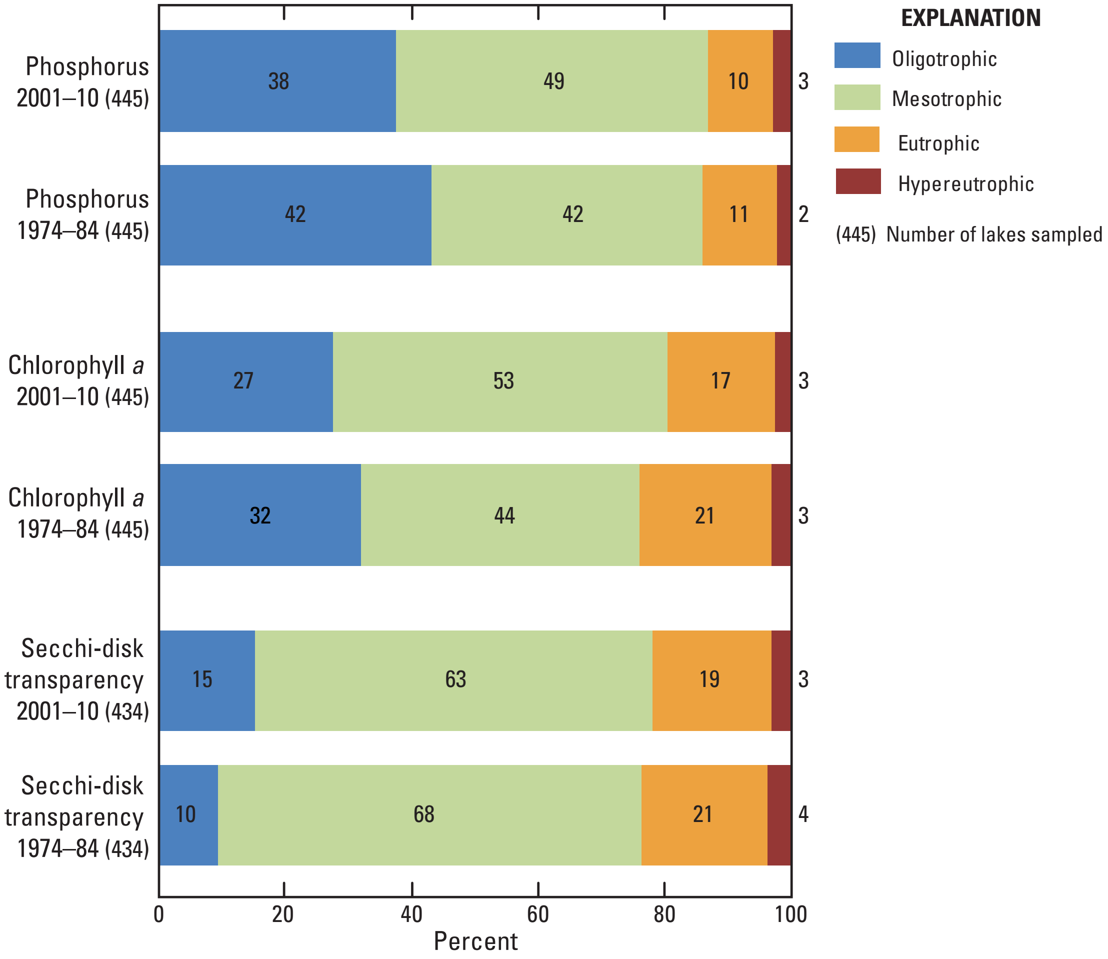

Figure 29. Historical and current trophic status for comparable lakes based on total phosphorus, chlorophyll *a*, and Secchi-disk transparency.

Table 11. Comparison of historical and current trophic status and percentage of lakes decreasing, not changing, or increasing classes for 2001–10.

[TSI, trophic state index]

	Towards oligotrophic	Same	Towards eutrophic
	←		→
	Percent		
	Down class	Same class	Up class
TSI (Secchi-disk transparency)	13	66	20
TSI (Chlorophyll *a*)	24	50	25
TSI (Phosphorus)	23	57	20

Relation of Lake Water Quality to Land Cover

The dominant land cover for each lake was found by first selecting catchments from the National Hydrography Dataset Plus, using version 1 for lakes in hydrologic region 7 and version 2 for lakes in hydrologic region 4 (Horizon Systems Corporation, 2011). Catchments that touched or intersected each lake were selected as the lake drainage basin, and the dominant National Land Cover Database 2001 class was chosen for each lake drainage basin (Homer and others, 2004). The five dominant land-cover classes that resulted for the 729 lakes were agriculture (185 lakes), forest (433 lakes), urban (59 lakes), wetlands (51 lakes), and barren (1 lake).

The forest- and wetland-dominant land-cover drainage areas are the only two in the Upper Peninsula. The majority of agriculture-dominated drainage areas are in the southwest area of the Lower Peninsula. Although most of the urban-dominated drainage areas are in the southeast area of the Lower Peninsula, some are in larger city areas on the west side of the Lower Peninsula, especially along Lake Michigan. The spatial distribution of dominant land-cover drainage areas is shown in figure 30.

Water type for the 729 measured lakes was color coded by dominant land cover on a trilinear (Piper) diagram analysis (fig. 31). For lake-drainage areas where the dominant land-cover class was less than 40 percent, the next dominant land-cover class was added to the figure. Although the patterns for agriculture- and forest-dominated lake-drainage areas are somewhat similar, patterns for urban- and potentially wetland-dominated lake-drainage areas had some differences. Urban lakes differ with respect to chloride and nitrate plus nitrite, which are higher than for the other dominant land-cover classes. Calcium also is somewhat lower than for the other classes. If wetland-dominated classes are representative of more natural waters, then lakes in urban-dominated land-cover classes could have lower calcium and higher chloride and nitrate plus nitrite than lakes with more natural water and wetland drainage areas.

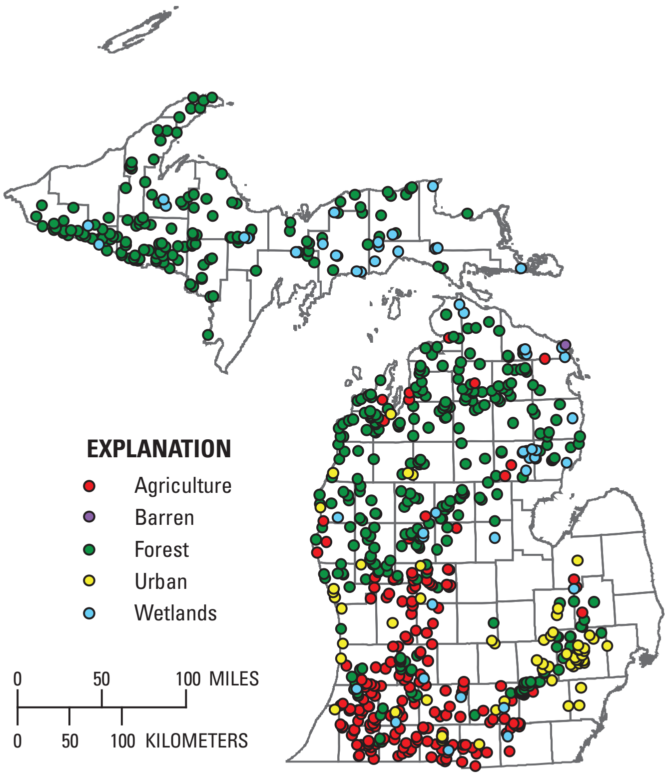

Figure 30. Spatial distribution of dominant National Land Cover Data 2001 class for Michigan inland lakes drainage areas for 2001–10.

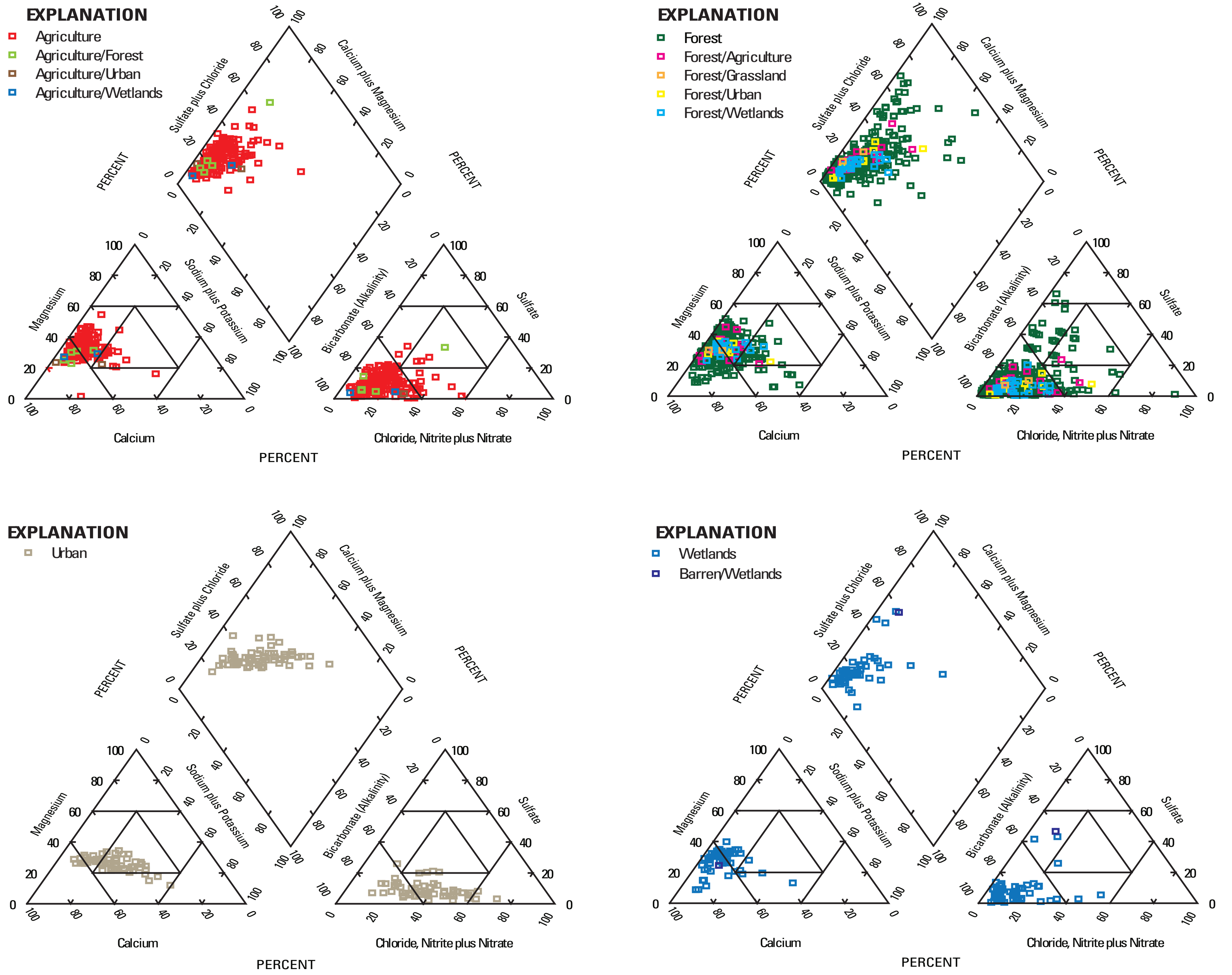

Figure 31. Trilinear (Piper) diagram analysis, color coded by National Land Cover Data 2001 majority class for lake-drainage areas.

Water type also was color coded by USEPA level III ecoregions (U.S. Environmental Protection Agency, 2011); Michigan glacial landsystems (Michigan Department of Environmental Quality and others, 2005); 6-digit hydrologic unit code boundaries (Steeves and Nebert, 1994); ecological drainage units (Higgins and others, 2005); and trophic status calculated from lake measurements using SDT, chlorophyll *a*, and TP as the primary indicators. These classification systems were used to test whether any noticeable driving factors were separating lake-water type. Although some properties and constituents individually showed separation between groups, these classification systems did not result in the degree of separation that is seen in the land-cover data between all constituents used to determine water type. These additional trilinear (Piper) diagram analyses are presented in appendix 2.

Linear regression graphs for chloride and calcium for spring mid-depth measurements (fig. 32) show a positive relation with lakes that have urban land cover as the dominant class, though the relation is stronger for chloride than calcium. Positive chloride trends were found by Syed and Fogarty (2005) for the Clinton River at Mount Clemens, which drains four southeastern Michigan counties, with the southern part of the watershed being composed of more than 50 percent urban land cover in 2001. Chloride has been found in elevated levels in groundwater in southeastern Michigan, including Oakland County (Aichele, 2004; Myers and others, 2000). Also in Oakland County, a strong positive relation was found between chloride in stream water and degree of urban development in the watershed (Aichele, 2005). By removing chloride measurements for Oakland, Livingston, and Genesee Counties in southeastern Michigan, there still was a positive relation between chloride and percent land cover (fig. 33), though the coefficient of determination (R^2) value decreased from 0.55 to 0.39. The relations are weak between lake-drainage area size and nutrients when using linear relations. These results can be viewed in appendix 3. Further spatial analysis might help to identify patterns, hotspots, or certain lake characteristics (such as lake depth or landcover) where overall potential positive or negative relations could be identified.

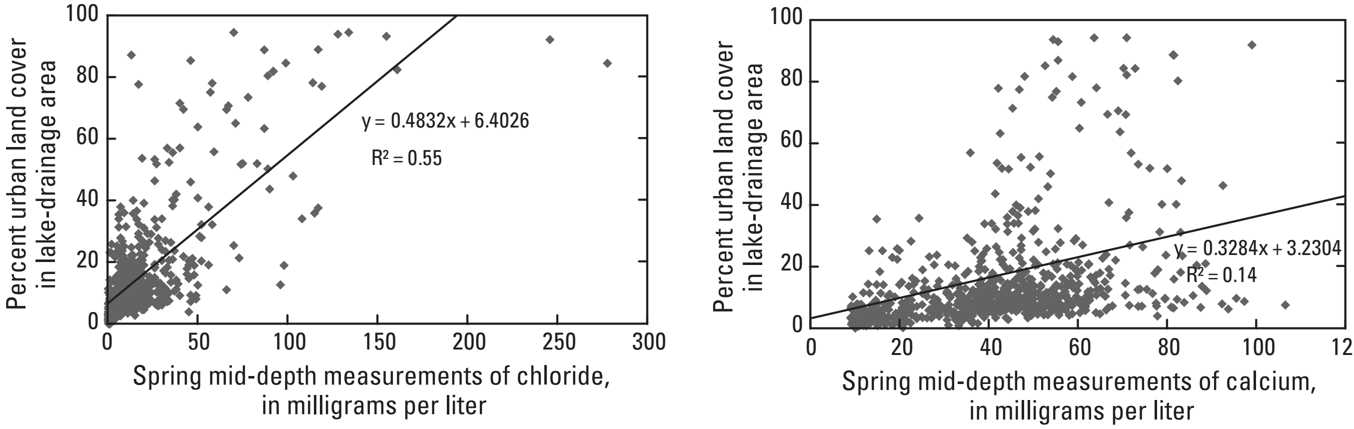

Figure 32. Chloride and calcium mid-depth measurements made in spring compared to percent urban National Land Cover Data 2001 for lake-drainage areas.

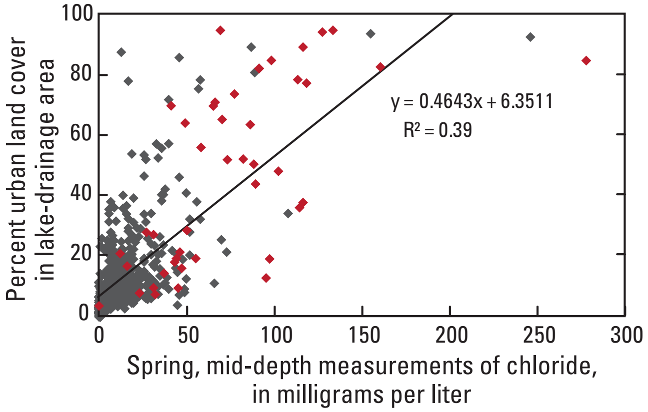

Figure 33. Chloride mid-depth measurements made in spring compared to percent urban National Land Cover Data 2001 for lake-drainage areas, excluding Oakland, Livingston, or Genesee County data (shown in red) from the regression analysis.

Summary and Conclusions

During 2001–10, 729 lakes greater than 25 acres (with public boat-launch access) were jointly monitored by the U.S. Geological Survey (USGS) and the Michigan Department of Environmental Quality (MDEQ) as part of Michigan's Lake Water-Quality Assessment program. Of the 729 lakes sampled, 109 have more than one major basin, 26 had three, and 2 have four major basins, for a total of 866 basins that were assessed and used in the analyses for this report. All lake basins included vertical-profile measurements; nutrient measurements at three discrete depths; Secchi-disk transparency (SDT) measurements (unless the Secchi disk hit the bottom of the lake in which case no SDT depth was recorded); and depth-integrated chlorophyll *a* measurements for the spring and summer, with major ions and physical properties measured for spring mid-depth and true color for summer for 2007–10. In the spring, 52 lakes were deemed too shallow for the collection of 3 discrete-depth measurements, with 58 lakes being too shallow in the summer.

Deep-basin measurements in the vertical profile for dissolved oxygen (DO) showed that in the spring, 12 percent of lakes had 25-50 percent of the water column (25–50 percent of the total lake depth) below below 0.5 mg/L. In the summer, 30 percent of lakes had 25–83 percent of the water column below 0.5 mg/L Specific conductance showed a spatial pattern of lower values in the Upper Peninsula and increasingly higher values from the north to south in the Lower Peninsula. Lake-water pH did not vary as noticeably throughout the State, but measurements below 6.5 were mostly in the Upper Peninsula. Comparisons of the vertical profile at discrete depths corresponding to near surface, mid-depth or metalimnion, and near bottom show statistically significant differences at the 95-percent level among all depths and constituents except DO for mid-depth between spring and summer.

In about 75 percent of inland lake deep basins measured, depending whether SDT, chlorophyll *a*, or TP was used as the primary indicator, trophic characteristics were associated with oligotrophic or mesotrophic conditions. Five percent or fewer were categorized as hypereutrophic when using any of the three indicators, with more than 80 percent of hypereutrophic lakes having a maximum depth of 30 ft or less. Deeper lakes were correlated with lower Trophic State Index (TSI) values reflecting towards the oligotrophic end of the scale. There was a statistically significant difference at the 95percent confidence level between spring and summer SDT and chlorophyll *a* measurements. There were somewhat even increases and decreases in the SDT measurements among spring and summer when comparing all lakes; an overall statistical increase or decrease was not found. SDT measurements were clearer in the spring than in the summer in 63 percent of lakes.

During 2001–10, on the basis of near-surface measurements made in the spring, 97 percent can be considered phosphorus limited and less than half a percent nitrogen limited; for the summer measurements, 96 percent can be considered phosphorus limited and less than half a percent nitrogen limited. Differences in concentrations of the majority of nutrients were statistically significant at the 95-percent confidence level between discrete sampling depths, and differences in concentrations of all nutrients were statistically significant at the 95-percent confidence level between spring and summer measurements.

All major ions and physical properties measured in the spring at mid-depth showed spatial patterns of lower values in the Upper Peninsula that increased southward to the southern areas in the Lower Peninsula, though the location of increase varied by constituent. U.S. Environmental Protection Agency Level III Ecoregions separated potassium, sulfate, and chloride values fairly well; separated lower and higher values for magnesium, hardness, calcium, and alkalinity; and were mixed spatially for middle-range values. The highest concentrations of chloride and sodium were in the southeastern part of the Lower Peninsula.

For the majority of constituents measured, differences in concentrations for lakes with more than one major basin did not prove to be overall statistically significant at the 95-percent confidence level between basins. There were more statistically significant differences in the spring than in the summer. However, it is notable that the most statistically significant differences at the 95-percent confidence level were found for water temperature at various depth and basin combinations; this finding indicates that water temperature could be a useful single measure of a multiple-basin lake for gaining an understanding of the lake as a whole.

Comparison of other Michigan lake-sampling programs producing trophic-status determinations for Michigan inland lakes revealed a few interesting relations to the current (20001–10) dataset. For example, volunteers coordinated by the MDEQ (former MDNR) started sampling in 1974 and continue to sample to date (2010) approximately 250 inland lakes each year through the Cooperative Lakes Monitoring Program (CLMP). When the primary sampling station (deepest-basin) measurement per lake for TSI from SDT in the month of August during 2001–10 is compared, the percentage of lakes in the oligotrophic class is higher than in the 2001–10 dataset. The hypereutrophic class has a lower percentage of lakes than the 2001–10dataset, whereas the mesotrophic and eutrophic classes are fairly comparable. This difference might result from more CLMP volunteers living near or otherwise having access to clearer lakes. Results from comparing TSI from chlorophyll *a*, the are more varied by year for the CLMP data.

Data from the CLMP, in addition to supplemental data specific to the Upper Peninsula (jointly collected by USGS and MDEQ), were used to extend the existing SDT measurements to produce TSI predictions using remotely sensed data for Michigan lakes greater than 20 acres. The three time periods of available TSI predictions from SDT include 3,121 lakes for 2003–05; 3,024 lakes for 2007–08; and 2,591 lakes for 2009–10. The predictions on average for the three periods result in a lower percentage of lakes in the oligotrophic category, a higher percentage in the mesotrophic category, about the same percentage in the eutrophic category, and a slightly lower percentage in the hypereutrophic category compared to the 2001–10 dataset. The predictions are an interesting comparison and extension to program monitoring based on public boat-launch access or volunteer residence or access, with some noticeable differences in percentages for trophic classes.

The National Lakes Assessment (NLA) is a statistically valid, probability-designed estimate of the condition of lakes on a national and regional scale, and it includes 50 lakes measured in Michigan during 2007. Percentages Michigan NLA lakes in the oligotrophic and mesotrophic trophic classes were larger than those in the 2001–10 lake data, though combining the two classes produced similar results. Of the Michigan lakes from the 2001–10 data that were greater than 25 acres (with public boat-launch access), a higher percentage of lakes were in the oligotrophic class (except when using phosphorus as the sole indicator) than the Michigan NLA lakes. When trophic status was determined by using SDT was the sole indicator for lakes for 2001–10, 74 percent of lakes were classified as oligotrophic or mesotrophic, compared to only 42 percent from the NLA Michigan lakes (though SDT depth was not recorded for 14 percent of the NLA Michigan lakes); 5 percent were classified as hypereutrophic, compared to 12 percent of the NLA Michigan lakes.

Data for 445 lakes measured historically by the MDNRE during 1974–84 were compared to 2001–10 lake measurements. Four constituents were comparable between the two time periods: total nitrogen, TP, chlorophyll *a*, and SDT. Of the four, only SDT was found to have statistically significant differences between datasets at the 95-percent confidence level, though no overall historical increasing or decreasing trend in SDT is evident. Depending on the primary indicator, 50–66 percent of lakes did not change trophic-status class, 13–23 percent moved down a class towards the oligotrophic end of the TSI scale, and 20–25 percent moved up a class towards the eutrophic end of the TSI scale.

Dominant land cover was calculated for each lake drainage area, resulting in five dominant land-cover classes of agriculture, forest, urban, wetlands, and barren. Lake water types were shown on a tri-linear (Piper) diagram analysis that assisted in the identification of higher chloride concentrations in urban-dominant drainage areas and somewhat lower calcium than in other land-cover classes. Although previous reports document high chloride concentrations in southeastern Lower Michigan, removing data from lakes in this area still resulted in a positive relation between percent urban land cover and chloride, though the coefficient of determination (R^2) value decreased from 0.55 to 0.39.

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Appendix 2

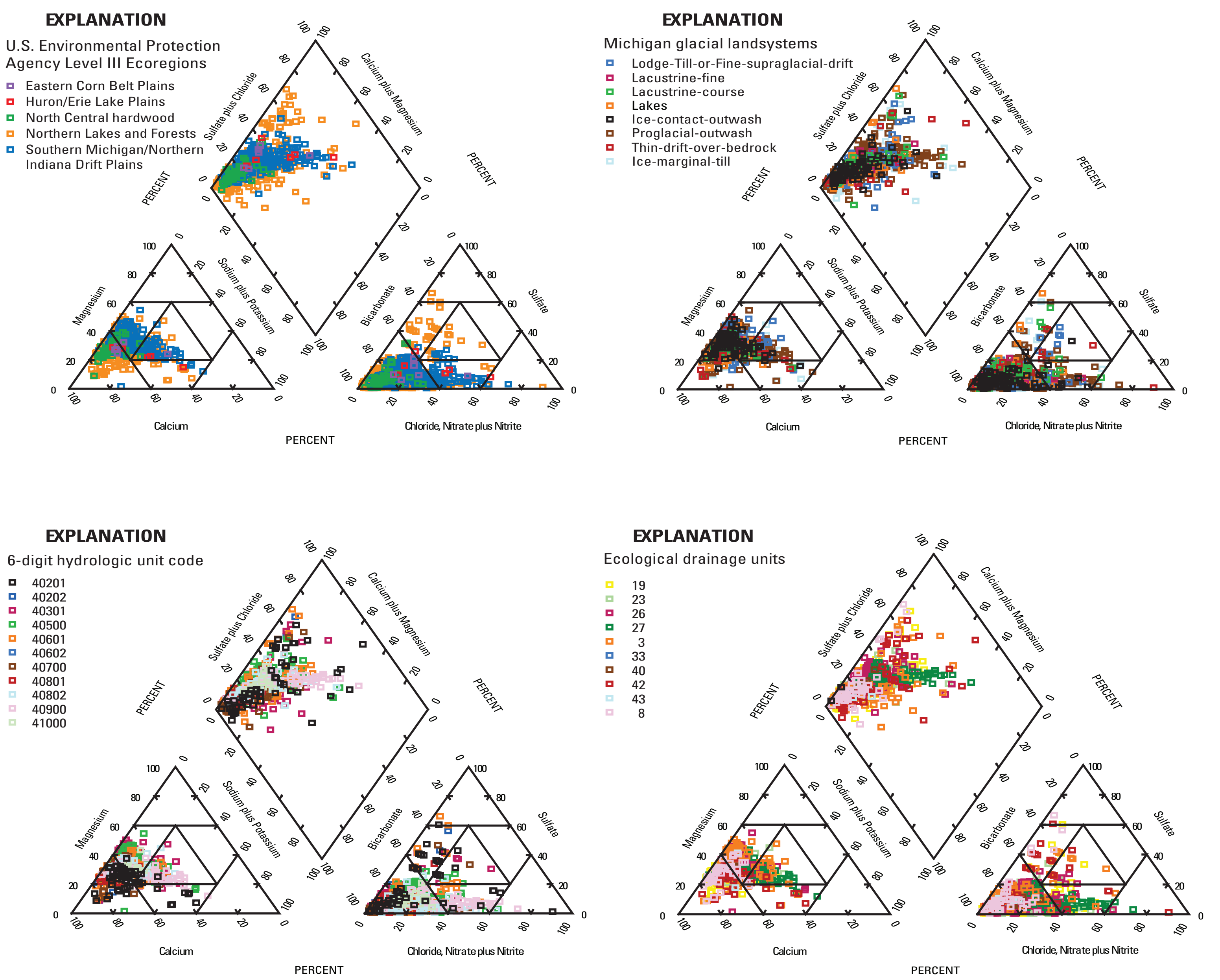

Figure 2–1. Trilinear (Piper) diagram analysis, color coded by U.S. Environmental Protection Agency Level III Ecoregions, Michigan glacial landsystems, 6-digit hydrologic unit codes, and ecological drainage units.

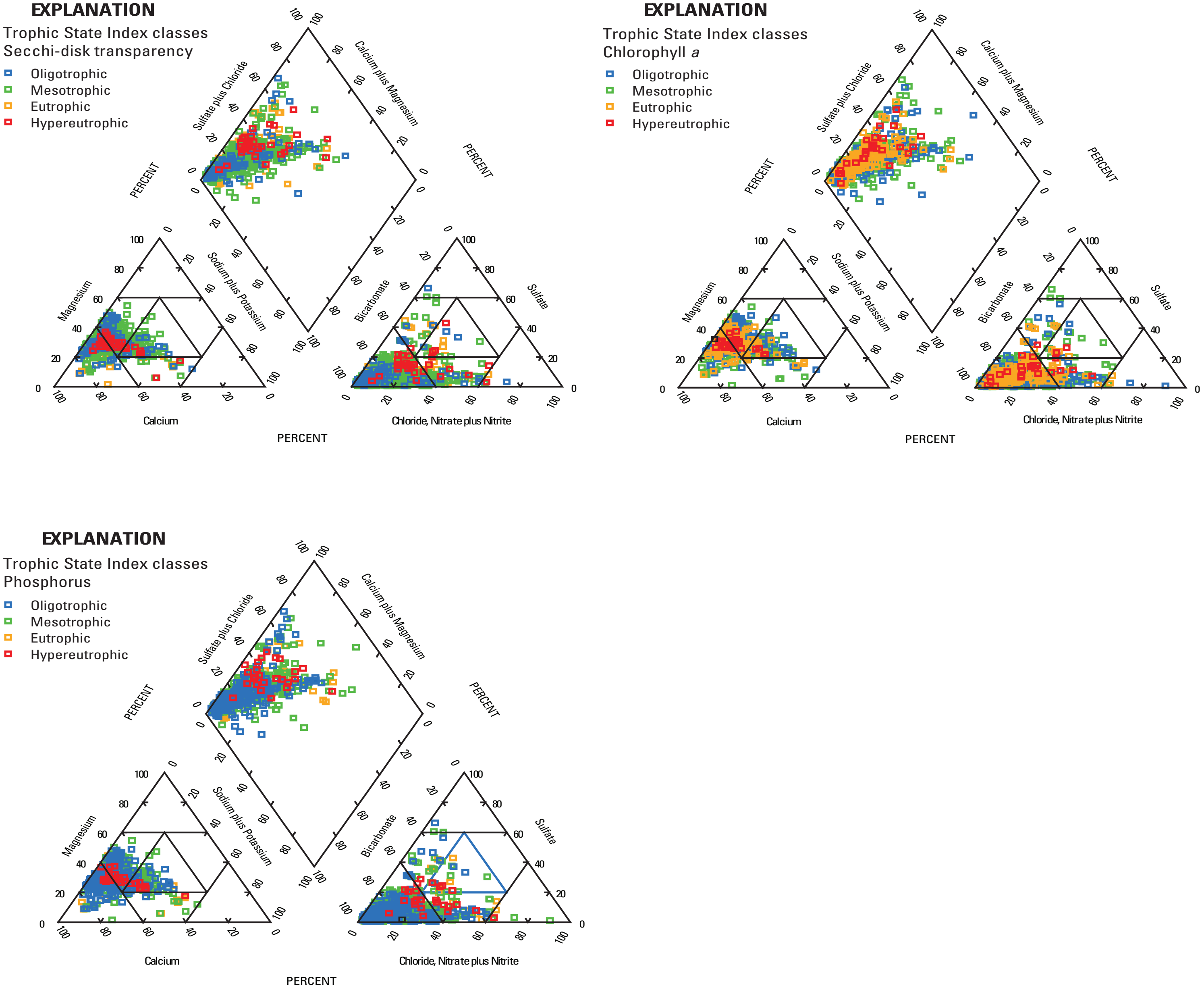

Figure 2–2. Trilinear (Piper)diagram analysis, color coded by Trophic State Index classes using Secchi-disk transparency, chlorophyll *a*, or total phosphorus as the primary indicator.

Appendix 3

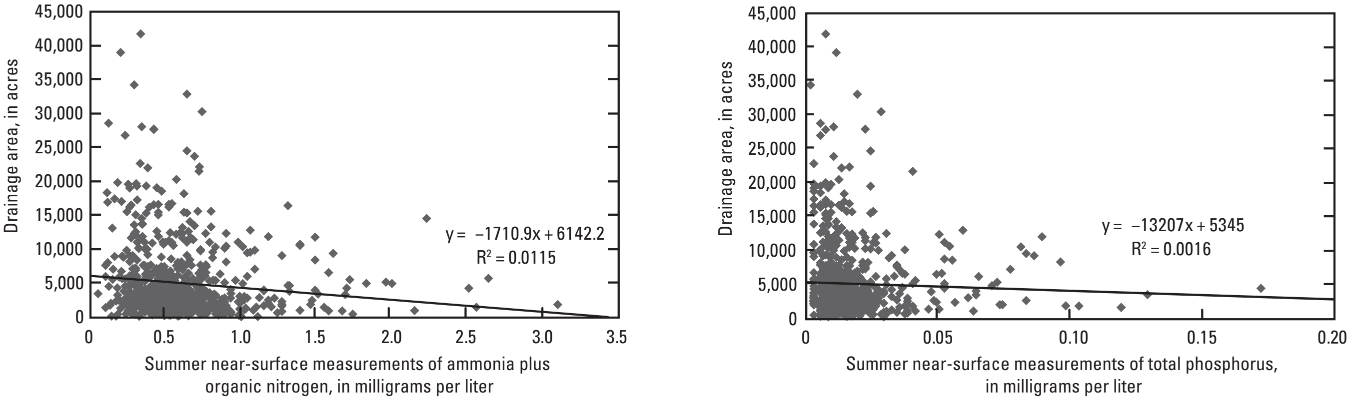

Figure 3–1. Ammonia plus organic nitrogen and total phosphorus near-surface measurements made in summer compared to lake drainage-area size.

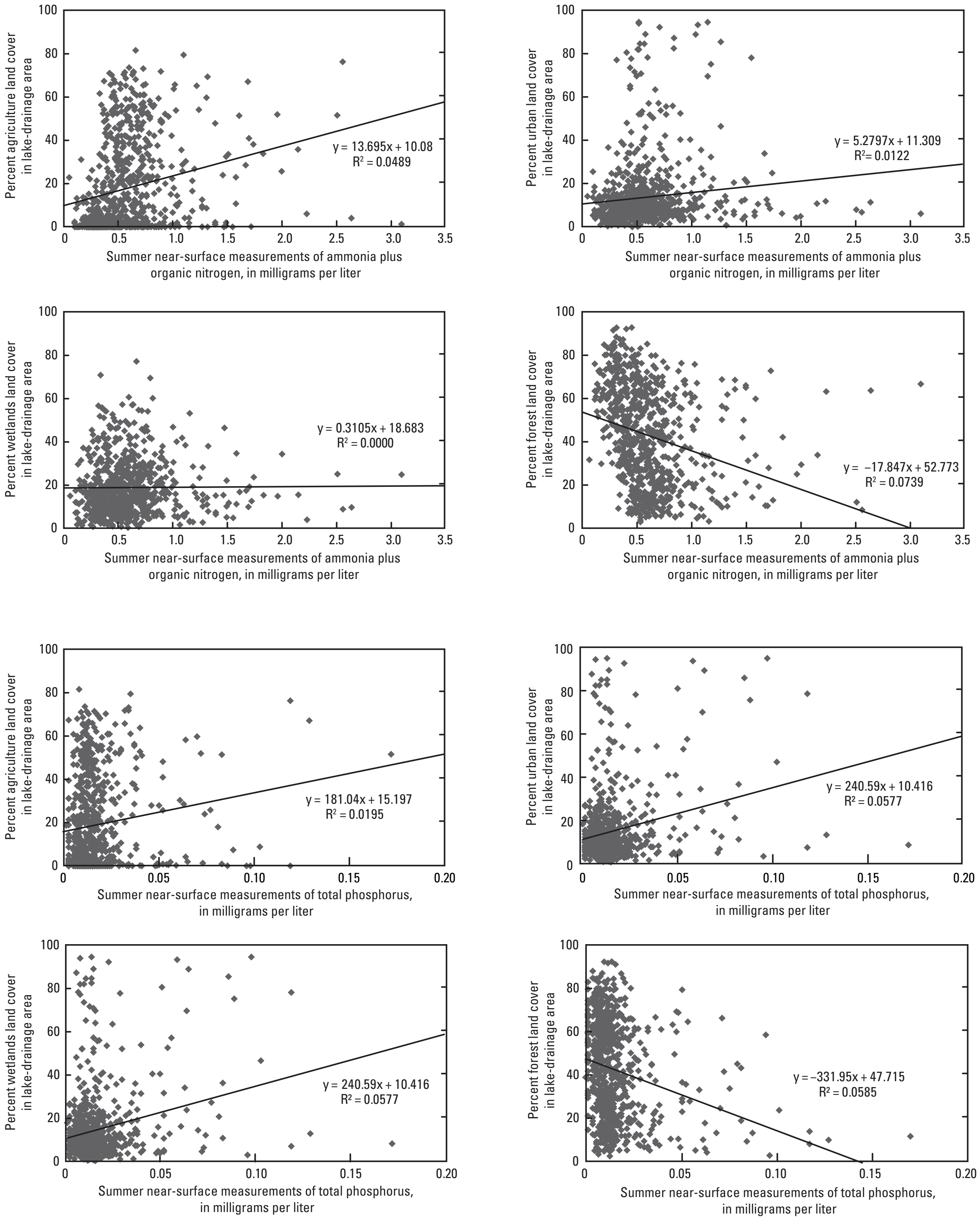

Figure 3–2. Ammonia plus organic nitrogen and total phosphorus near-surface measurements made in summer compared to dominant percent National Land Cover Data 2001 (Homer, 2004) for lake drainage areas.

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