2024 Lake Windermere Water Quality Report

lake windermere ambassadors

healthy water for healthy communities

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EXECUTIVE SUMMARY

The Lake Windermere Ambassadors Society (LWA) direct a Community-Based Water Monitoring and Citizen-Science Education program within the Lake Windermere Watershed. 2024 marked the eighteenth year of lake monitoring since the Lake Windermere Project began collecting water quality data in 2006.

In 2024, the Lake Windermere Ambassadors water quality monitoring program collected physical and chemical water quality parameters at three sample sites on Lake Windermere weekly during the summer, from late May to mid-September. The lake sampling regime included water temperature, turbidity/clarity, pH, conductivity, depth, dissolved oxygen, total dissolved phosphorus and total phosphorus. Tributary flows and water quality were monitored at Windermere Creek outlets. In partnership with the Interior Health Authority, *E. coli* data was collected at public swim beaches weekly, through July and August, excluding weeks with a statutory holiday Monday.

Findings from 2024 show Lake Windermere's water quality supports aquatic life and recreation. However, Lake Windermere reached its highest temperature recorded by the Ambassadors since 2011 of 24.9°C, continuing a long-term warming trend. Despite this, overall water quality remained stable, with dissolved oxygen, turbidity, pH, and conductivity levels generally within acceptable limits. Phosphorus levels exceeded guidelines in mid-summer, especially at the South site, indicating possible nutrient inputs from runoff or sediment release. Average Phosphorus levels exceeded Ministry of Environment threshold values significantly in June and July at the South and Middle sites. Water clarity was high, and beach water quality at Kinsmen, Windermere, and James Chabot remained excellent all season, with no *E. coli* exceedances or beach closures. Lake levels showed a typical seasonal rise and fall, but 2023 and 2024 had the lowest summer depth averages on record, pointing to potential climate-driven changes in inflow and evaporation.

The annual fall waterbird survey recorded only 700 birds—the lowest count since 2019—with key species like American Coots absent and few grebes or gulls observed, likely due to delayed migration from unusually warm fall weather. While no invasive aquatic plants were detected, stress on native vegetation was noted in high-use areas, likely from sediment stirred up by boating. The report recommends protecting sensitive zones through no-motorized areas, continued monitoring, and public education to safeguard water quality, habitat health, and biodiversity.

Collectively, the 2024 monitoring data highlights generally good water quality conditions in Lake Windermere, despite emerging signs of environmental stress from climate change, nutrient loading, and recreation impacts. Continued long-term monitoring, adaptive management, and proactive stewardship are essential to safeguard the lake's ecological integrity into the future.

Our major funders for this project and its final report include the Columbia Valley Local Conservation Fund, the District of Invermere, the Regional District of East Kootenay, Columbia Basin Trust, BC Community Gaming Grants, BC Hydro, the Columbia Valley Community Foundation, TDFEF, Redi Grant, and Canada Summer Jobs.

1. INTRODUCTION

Lake Windermere is one of two headwater lakes of the Columbia River in Southeast British Columbia, Canada. The lake is a long widening of the Columbia River, with an average depth of ~3-4 m (10-13 ft). Birds, fish, and wildlife depend on the lake and its outflows into the Columbia Wetlands. Historically, Lake Windermere has supported several fish species and is used by hundreds of species of resident and migratory birds (McPherson & Hlushak, 2008). The Columbia Wetlands are of international importance because they are one of the vastest intact wetlands in North America (Ramsar, 2004). Humans depend on Lake Windermere for social, cultural, environmental, and economic values. Not only is it a drinking water source, but the lake is heavily used for recreation, motorized and non-motorized, business opportunities, and for traditional values.

1.1 Climate

Lake Windermere sits within the Southern Rocky Mountain Trench in the Interior Douglas Fir (IDF) biogeoclimatic zone (Braumandl & Curran, 2002). The region is temperate and experiences all four seasons, characterized by relatively mild, cool winters and dry, hot summers. Average annual precipitation is 300-400 mm (Urban Systems, 2012; District of Invermere, 2017), and most rainfall historically occurs in May and June. Spring freshet usually occurs between late May and early July. The year's warmest days have historically been recorded in July and August. Invermere, BC, saw a hot, dry summer in 2024, with multiple July heat waves pushing temperatures into the high 30s and low 40s. Snowpack levels were well below normal—averaging just 57% across the province—and began melting early in April, with over half gone by early June. This gradual but early melt reduced streamflow and increased drought and wildfire risk, making for a season of extreme heat and environmental strain.

1.2 Watershed Characteristics

Lake Windermere sits at approximately 800 masl and is bordered east and west by two distinct mountain ranges, the Rocky Mountain Range and the Purcell Mountain Range respectively. The lake flows from south to north as it is part of the main channel of the Columbia River which begins at the north shore of Columbia Lake which is approximately 20 km upstream. Lake Windermere flushes on average every 47 days, contributing to its relatively good water quality (McKean & Nordin, 1985).
The main tributary entering Lake Windermere is Windermere Creek, a fourth-order mountain stream with a watershed that drains an area of approximately 90 km² (NHC, 2013). Some significant developments within the Lake Windermere watershed include an active gypsum mine, active and historical forest harvesting activities, forest service roads, highways, agricultural and grazing activities, golf courses, as well as urban and residential development (McPherson et al., 2014).

1.3 Community-Based Water Monitoring

Concerns about increased development and changes to Lake Windermere in the early 2000s prompted the creation of a community-based water quality-monitoring program and watershed stewardship education initiative in the form of the Lake Windermere Ambassadors Society.

The Lake Windermere Ambassadors (LWA) are a community-led, charitable non-profit society formed in 2010 to protect Lake Windermere in perpetuity. The LWA has overseen a

Community-Based Water Monitoring program on Lake Windermere since their inception, using the assistance of volunteers and essential baseline data collected by Wildsight's Lake Windermere Project. Since 2010, the LWA has added to the monitoring program based on needs and available resources, including tributary monitoring, invasive species monitoring, and wildlife surveys.

From 2006 to 2009, the Lake Windermere Project worked to assess the quality of Lake Windermere's waters for wildlife and human recreational uses. In 2010, the BC Ministry of Environment took those four years of data and determined an updated list of Water Quality Objectives for Lake Windermere. These objectives are a benchmark against which the LWA compares present conditions to evaluate whether the lake water quality suits recreational and ecological needs. By testing lake water quality weekly in the summer, the LWA has fourteen years of water quality data for Lake Windermere. This data allows the LWA to detect seasonal and annual changes in water quality and to communicate information about Lake Windermere to inform and advise on sustainable watershed planning and restoration initiatives in the Upper Columbia watershed.

1.4 Sample Sites

Water quality is sampled at three locations on Lake Windermere, historically monitored by the BC Ministry of Environment and the Lake Windermere Project. These locations include North (Timber Ridge/Fort Point), Middle (Windermere) and South (Rushmere) sample sites (Figure 1).

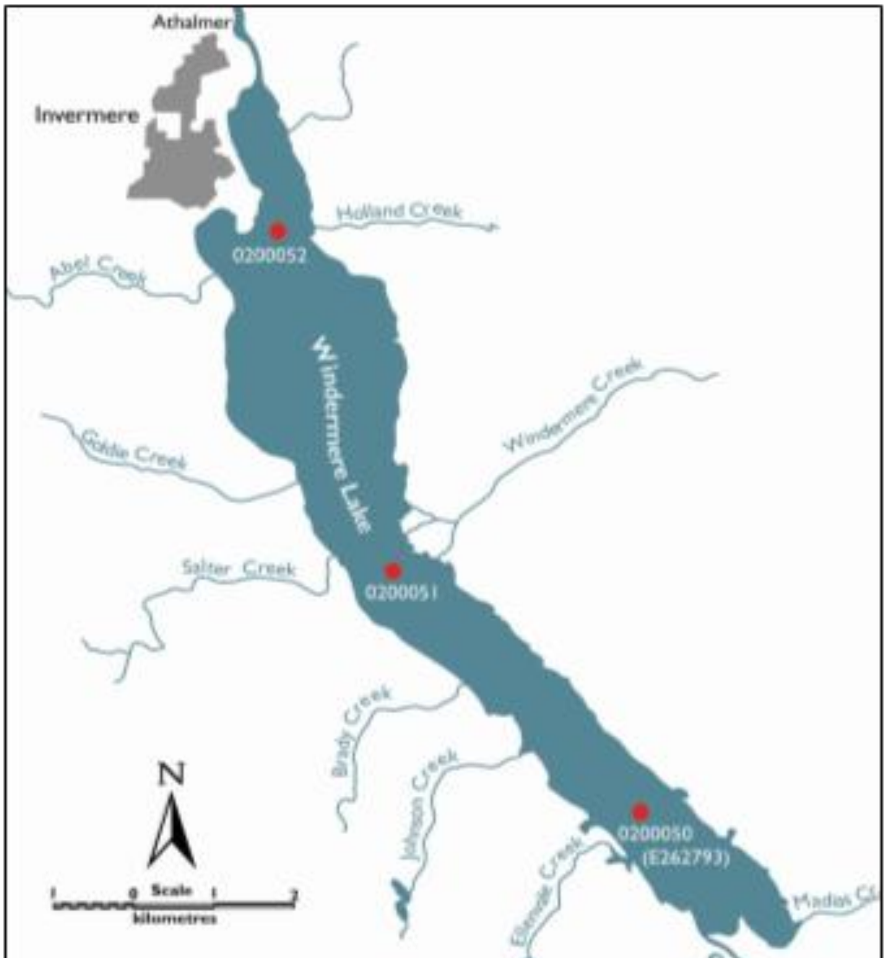


Figure 1: Lake Windermere Sampling Sites: North (0200052), Middle (0200051), and South (0200050).

2. LAKE WINDERMERE WATER QUALITY

2.1 Temperature

Overview

Water temperature is critically essential to lake health as it directly impacts water chemistry (ex., dissolved oxygen, specific conductivity, water density) and influences the rate of chemical and biological reactions. Which, in turn, impacts the ability of aquatic life to grow, survive, and reproduce in each environment (Alberta Regional Aquatics Monitoring Program, 2008). Due to the Lake's shallow depth, Windermere has a naturally elevated temperature relative to other freshwater lakes (Neufeld et al., 2010). Unlike deep lakes, Lake Windermere does not stratify into different layers of temperature and density within the water column (McKean & Nordin, 1985).

Warm and clear water makes Lake Windermere a desirable lake for human recreation. However, average summer water temperatures have historically exceeded the BC Ministry of Environment's (MOE) Temperature Guidelines for protecting freshwater aquatic life (Neufeld et al., 2010). For example, many freshwater fish species observed in this lake have optimum temperatures below 18 °C for rearing, spawning, and incubation (Ministry of Environment, 2017a). In contrast, historical monthly water temperatures in Lake Windermere have been recorded up to 25 °C (Neufeld et al., 2010).

To adjust for the natural warmer temperatures in Lake Windermere, the MOE (Ministry of Environment) has set the maximum allowable average monthly water temperatures at 20 °C, 25 °C, and 23 °C in June, July, and August, respectively (Neufeld et al., 2010). These guidelines are based on the MOE recommendation that lake water temperatures should remain within ± 1 °C of natural conditions.

Results

The highest temperature in 2024 was 24.9 °C, recorded on July 17th at the Middle sample site (Figure 2a). This value is very close to meeting the MOE objective of 25 °C for July, however, there were no instances when the average monthly water temperatures exceeded the MOE maximums during the year. This is the highest recorded temperature by the Ambassadors to date. On the same day, the North Upper site was recorded at 24.4 °C, the North Lower site was 24.1 °C and the South site was 22.9 °C (Figure 2a). This highest day was 1.5 degrees higher than in 2023, where the highest temperature recorded was 23.4 °C, on August 1st at the North Upper sample station.

Figure 2b shows the seasonal water temperature averages from 2011-2024. The data for the season’s sampling duration varied over the 13 years, so to make a more accurate comparison between seasonal water temperatures, the averages were taken between June-August sampling dates. Even with these adjustments, 2023 had the highest average of 21.0 °C, and 2015 and 2021 had the second and third- highest average of 20.5 °C and 20.4 °C respectively (Figure 2b). In 2023, of the days sampled, the average temperature was higher in June, July and August by 0.8 °C than in the same time period in 2024. The general trend in average seasonal water temperatures over the last 13 years shows an increase in temperature of 2.5 °C. A linear regression analysis and trendline was conducted using Microsoft Excel. Refer to section 10.0 for full explanation (Figure 2b).

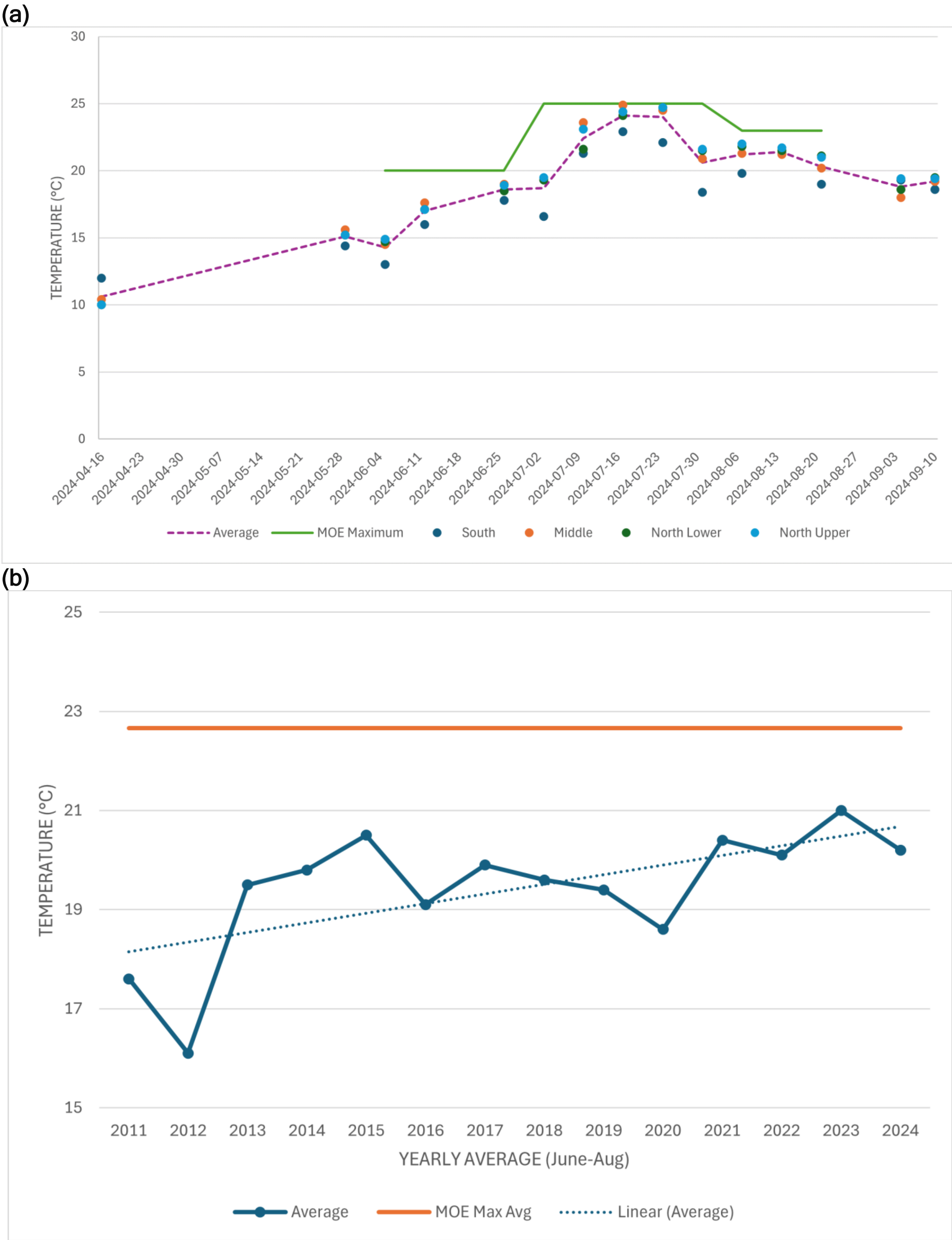


Figure 2: (a) Average Lake Windermere water temperatures are recorded weekly at the three sample sites from April 16th to September 10th, 2024. (b) Average Annual Water Temperature (June-August) From 2011-2024. *Note: Lines are for interpretation only, and do not represent continuous measurements.*

2.2 Dissolved Oxygen

Overview

Dissolved Oxygen (DO) is another name for the free oxygen gas dissolved in water. Some amount of DO is required for almost all species of aquatic life to survive. However, too much or too little oxygen can harm aquatic life and negatively affect water quality (Ministry of Environment, 2017a). Oxygen can be transferred to water from the atmosphere or produced by submerged aquatic plants and phytoplankton during photosynthesis. It is then removed from the water by respiration, chemical reactions, and organic decomposition in aquatic plants and animals. For example, a large amount of decomposing plant material within a lake can decrease DO concentrations in the water because oxygen is consumed during the decomposition process (Neufeld et al., 2010).

The capacity for water to hold dissolved oxygen is inversely related to water temperature. The inverse relationship between water temperature and dissolved oxygen means warmer water holds less oxygen than cooler water which holds more oxygen (Ministry of Environment, 2017a). Warmer waters also directly influence the rates of biogeochemical reactions and transformation processes within the water column and sediment bed. Temperatures increase metabolic rates, which affect Biochemical Oxygen Demand decay, sediment oxygen demand, nitrification, photosynthesis, respiration, and decreased dissolved oxygen levels (Harvey et al., 2011).

The MOE recommends that DO never drop below an instantaneous minimum of 5 mg/L. The guideline for an average of five samples taken over 30 days is 8 mg/L (Neufeld et al., 2010; Truelson, 1997). It is also recommended that DO not exceed a maximum of 15 mg/L to prevent adverse effects of toxicity (Neufeld et al., 2010).

Results

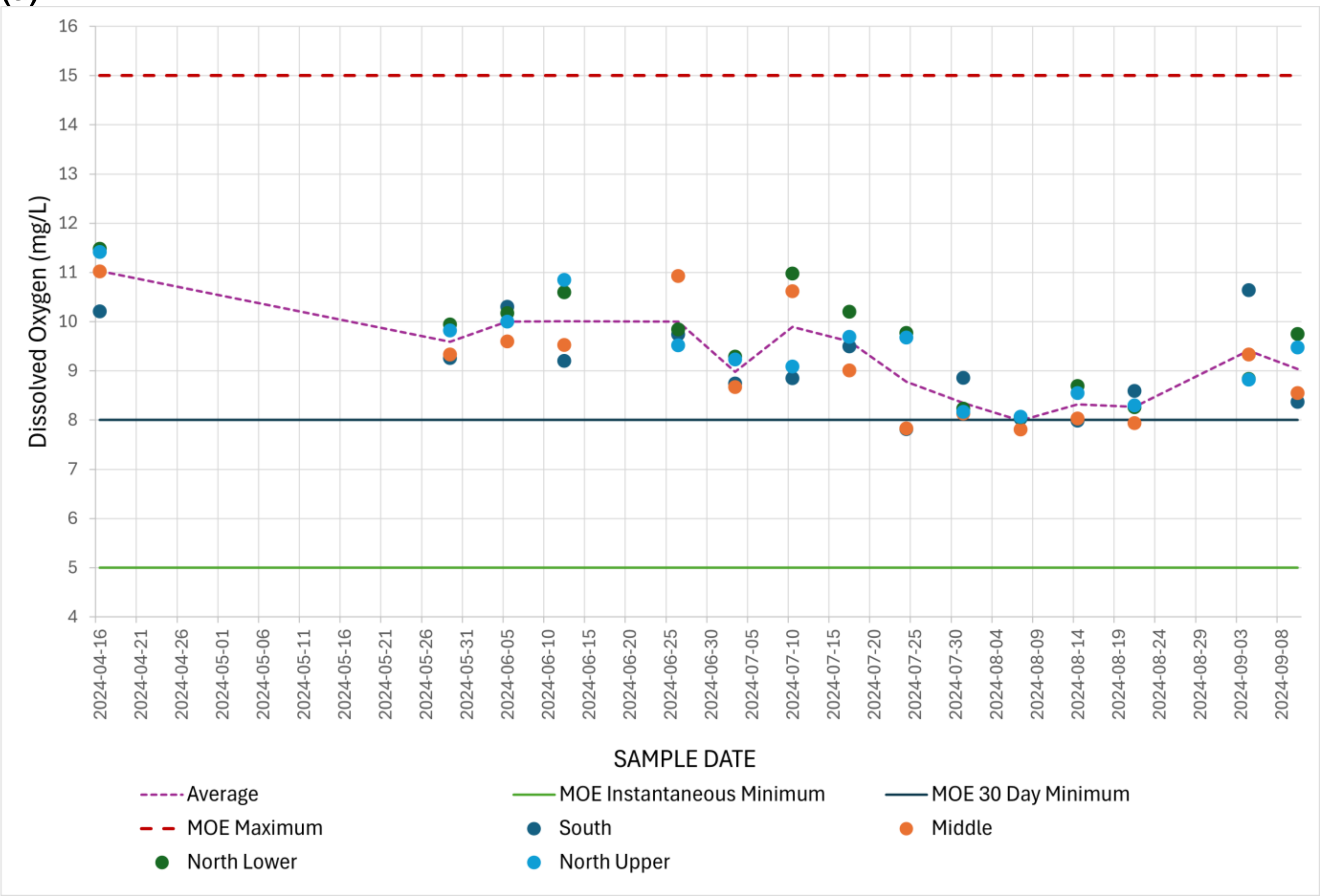
During the 2024 monitoring season, the average DO values of five sites over 30 days did not fall below the MOE 8 mg/L minimum threshold for an extended period, and they did not drop below the instantaneous minimum of 5mg/L, nor did they exceed the 15mg/L maximum recommended by MOE (Figure 3a).

The Instantaneous values ranged between a low of 7.8 mg/L recorded on August 7th at the Middle sample site and a high of 11.48 mg/L recorded on April 16th at the North Lower sample site. Higher temperatures in July and August correspond to slightly lower DO, which is expected due to reduced oxygen solubility in warm water (Figure 3a).

An analysis was conducted on the correlation between water temperatures and DO, resulting in a negative (inverse) correlation of -0.64. (Figure 3b). A linear regression analysis and trendline was conducted using Microsoft Excel. Refer to section 10.0 for full explanation. This correlation between the increase in water temperatures and the decrease in DO coincides with Figure 3c. This correlation could indicate that the initial decrease in DO is related to the initial increase in temperature (Figure 3c).

Interestingly, in 2024, the highest average DO values are seen at the North sample sites, more specifically the North Lower site, calculated across the 2024 sampling season from April 16-September 10 (Figure 3d). This contrasts with previous years where higher DO values were recorded at the South sample site, thought to be due to the proximity to the Columbia wetlands, which have abundant aquatic plant life that photosynthesizes and contribute oxygen to the water and/or due to the slightly cooler temperatures of water flowing out of the wetlands, which holds more oxygen.

(a)



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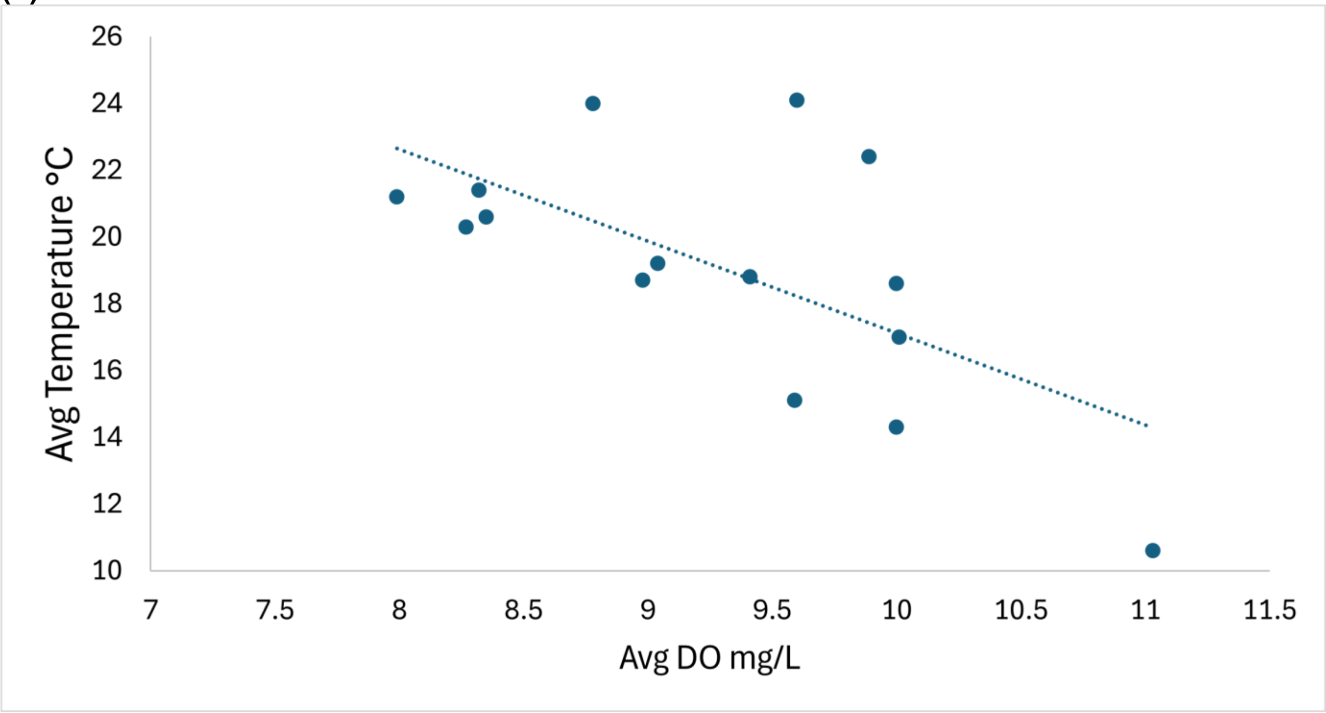

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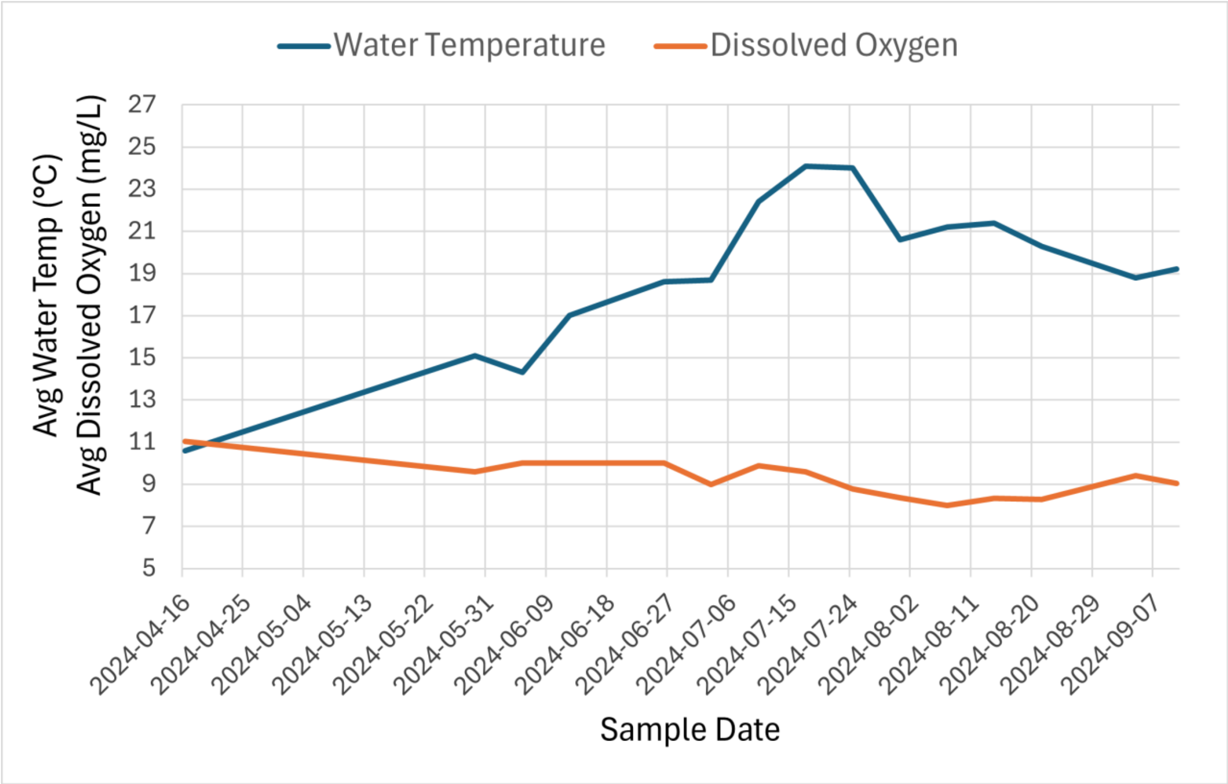

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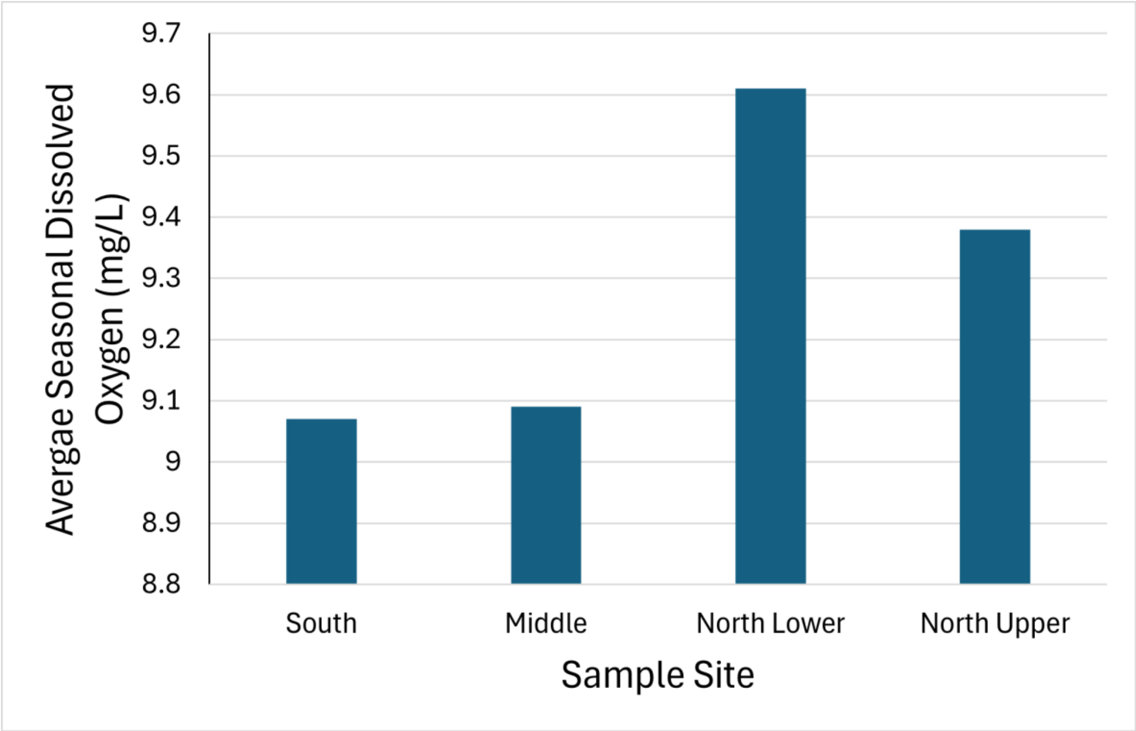


Figure 3: (a) Lake Windermere Dissolved Oxygen levels; instantaneous DO values, average DO over 30-days and all five sites, and MOE minimum allowable DO instantaneous and average values. Calculated over 14 weeks, between April 16 and September 10, 2024. (b) Lake Windermere 2024 Inverse Correlation between Dissolved Oxygen and Water Temperature Averages. (c) Lake Windermere 2024 Water Temperature Average and Average Dissolved Oxygen. (d) Average DO level over the sample season 2024 calculated from April 16-September 10. *Note: Lines are for interpretation only, and do not represent continuous measurements.*

2.3 Turbidity

Overview

Turbidity is a measure of the light scattered by particles suspended in water and indicates the clarity of the water. Suspended particles in the water consist of silt, clay, organics, algae, and other microorganisms. These particles may carry pathogens and chemicals harmful to human health and reduce light penetration, thus affecting primary and secondary productivity. When waters are highly turbid, such as when they are filled with lots of suspended sediment, light does not penetrate as easily to reach aquatic plants, which reduces photosynthesis, reducing the amount of oxygen in the water. Fish can become stressed due to reduced ability to navigate, clogging of gills, and other physiological stressors (Ministry of Environment, 2017a).

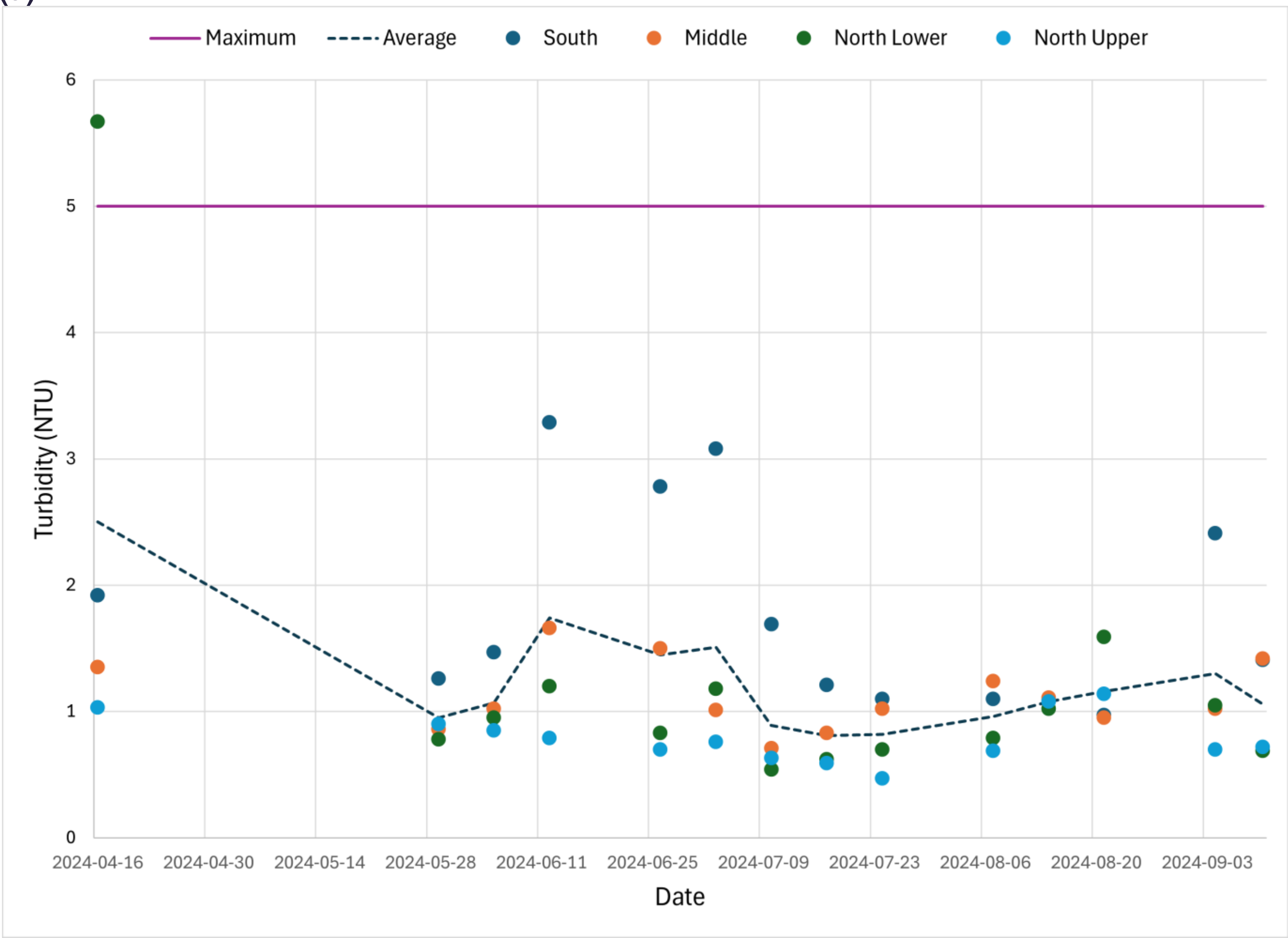
Since aquatic life in Lake Windermere has adapted to seasonal flushes of sediment into the lake, the acceptable amount of turbidity depends on the time of year. The most turbid waters typically occur during “freshet” (the spring runoff period), or after heavy rainfalls. The turbidity objectives for Lake Windermere are set to protect recreational water quality and aquatic life (Neufeld et al, 2010). The turbid-flow period coincides with freshet and commences when the accumulated snowpack melts in the spring, increasing streamflow. It ends in the summer when the snow in the watershed has melted, flows return to normal and water levels are more stable. The turbid flow period occurs between May 1st to August 15th. The MOE turbid-flow maximum indicates that the 95th percentile of turbidity measurements taken in 5 days over 30 days should not exceed 5 NTU (turbidity units). The clear-flow period is set between August 16th through April 30th. During this time, turbidity values tend to be very low, with any elevated values resulting from rain events and physical disturbances of stream banks. The MOE maximum turbidity during the clear flow period should be <5 NTU. The mean turbidity (based on a minimum of five weekly samples collected within 30 days) during the clear-flow (non-freshet) period should be <1 NTU. (Neufeld et al, 2010).

Results

Turbidity in 2024 did remain within the acceptable ranges for recreational water quality and aquatic life except for one peak exceedance of 5.67 NTU recorded at the North Lower site on April 16, also our Ice Off sampling day. The mean 30-day turbidity values for 2024 did not exceed MOE recommendations, however, many of the clear-flow period values exceeded 1 NTU, which is the MOE target for turbidity from August 16 through April 30. (Figure 4a).
The 2024 turbidity peak at the North Lower site was significantly lower than the peak turbidity of 2020 (middle) 2021(south), and 2022 (south). Perhaps the combination of reduced snowpack and early melt resulted in lower peak flows and a shortened freshet period in the East Kootenay region. This could have diminished streambank erosion and reduced sediment transport, contributing to lower turbidity levels during the freshet season. Overall, turbidity was well within acceptable limits. Freshet started in early June, peaking slightly in mid-June to early July.The South sample site generally had the highest turbidity values, consistent with previous years data, likely due to sediment entering the Columbia River through Dutch Creek and settling out in Lake Windermere (Figure 4a).

Figure 4b compares the 2024 seasonal averages for water temperature, dissolved oxygen and turbidity: From April to September 2024, average turbidity levels remained well below the Ministry of Environment’s maximum threshold of 5 NTU throughout both the turbid-flow (May 1-Aug 15) and clear-flow (Aug 16-Apr 30) periods. However, during the clear-flow period, average turbidity values slightly, but consistently, exceeded the target mean of 1 NTU, ranging from 1.06 to 1.3 NTU. The highest average turbidity occurred on April 16 (2.5 NTU) and June 12 (1.74 NTU), likely due to runoff. Average water temperature followed a seasonal trend, peaking in mid-July at 24.9°C, which corresponded with slightly lower average dissolved oxygen (DO) levels; however, all average DOs remained within acceptable ranges. (Figure 4b).

(a)



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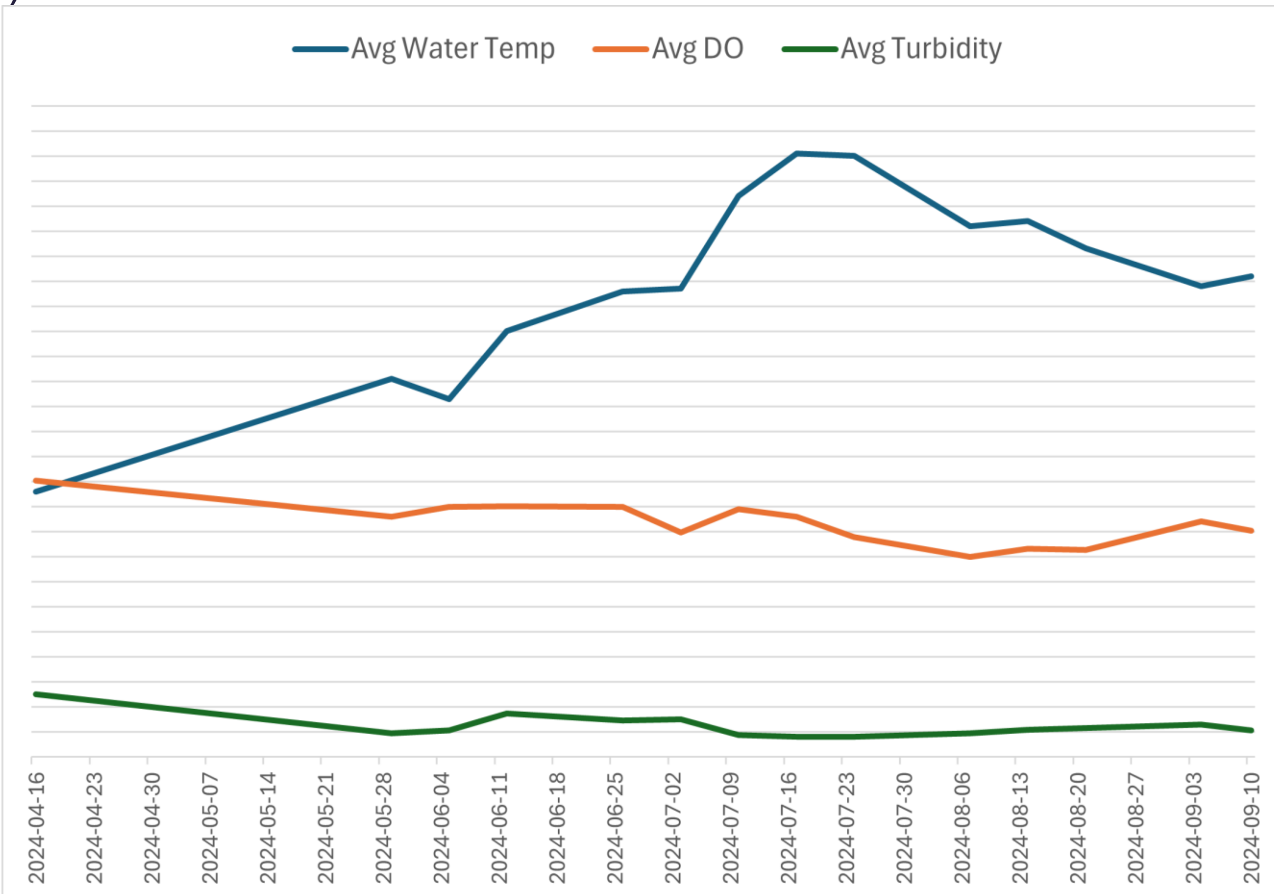


Figure 4: (a) Lake Windermere 2024 Turbidity (NTU) Levels; mean 30-day Turbidity, recommended maximums, and site-specific measurements. (b) Comparing 2024 seasonal averages for water temperature, dissolved oxygen and turbidity. *Note: Lines are for interpretation only, and do not represent continuous measurements.*

2.4 pH

Overview

pH measures the free hydrogen ion concentration (H+). pH is reported on a scale from 0 to 14. Solutions with a pH between 0 and 7 represent an acidic environment, and solutions between 7 and 14 represent a basic or alkaline environment. pH is reported in logarithmic units, meaning a change in one unit of pH represents a ten-fold change in the actual pH of the solution. For instance, water with a pH of 4.5 is ten times more acidic than water with a pH of 5.5, while water with a pH of 3.5 is one hundred times more acidic than water with a pH of 5.5.

The pH of natural lakes is rarely neutral because of dissolved salts and carbonates, aquatic plants, and the mineral composition of the surrounding soils. pH can fluctuate daily as well as seasonally. Many aquatic species are sensitive to sudden changes in pH. However, most species have adapted to the natural pH fluctuations spread over time. If the pH of a lake changes dramatically within a short time frame, it could indicate a pollution event or some other form of disturbance. The water in Lake Windermere consistently trends towards slightly alkaline (pH values around 8.5), characteristic of lakes fed by water flowing over limestone bedrock materials in the Canadian Rockies (BC Ministry of Health, 2007; Rollins, 2004). No

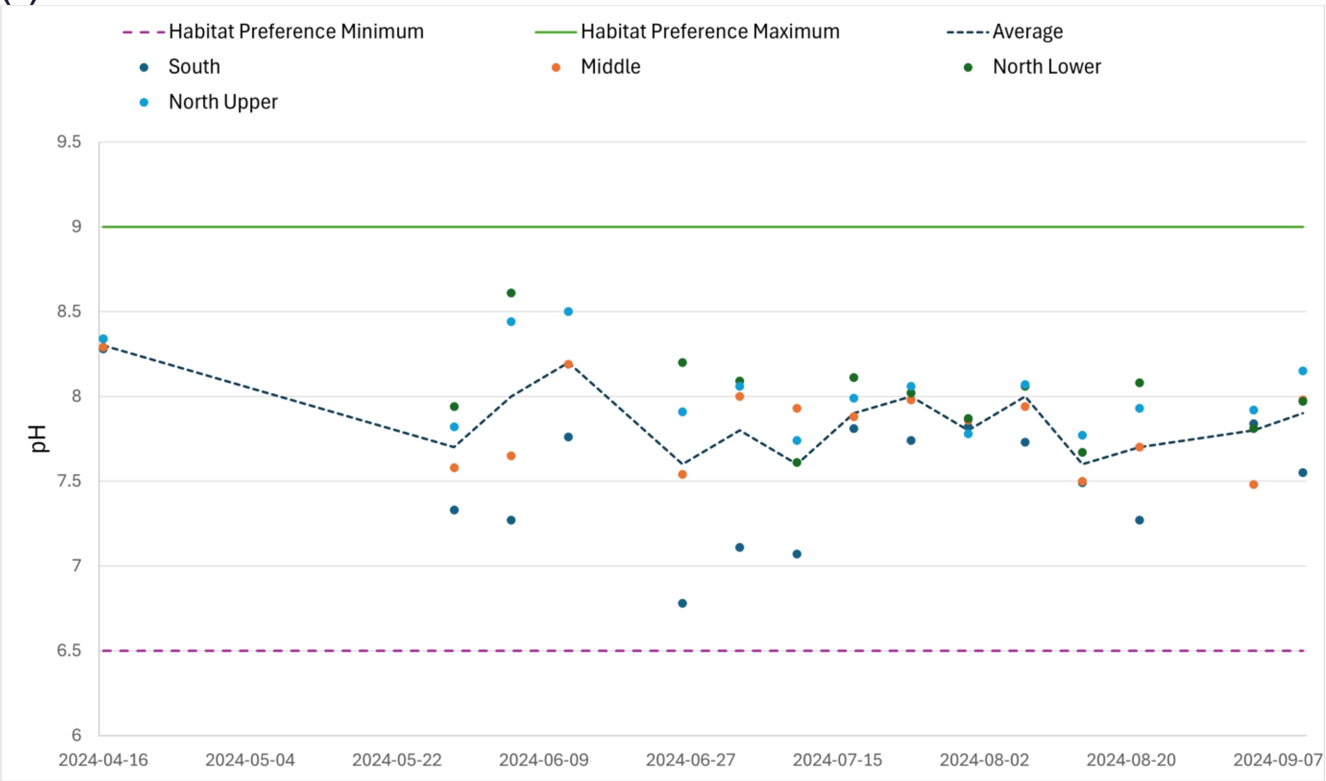
MOE objective is set for pH in Lake Windermere; however, most aquatic organisms prefer a habitat where pH stays within 6.5-9.0 (Neufeld et al., 2010).

Results

All four monitoring locations–South, Middle, North Lower, and North Upper–exhibited consistent pH patterns, with minor variation between sites. The North Lower site recorded a season-high pH of 8.61 on June 5th (Figure 5a). Throughout the sampling season, average pH values across all sites remained within the optimal habitat preference range, indicating stable and healthy conditions for aquatic life. The average pH ranged from 7.6 to 8.3, with the highest average reading on April 16 and the lowest average on June 26 and August 14. (Figure 5a).

Using the daily average pH and turbidity numbers, there is a correlation of r=0.53 which suggests a moderate positive relationship – when turbidity increases, pH tends to increase as well. The p-value (~0.050) is right on the threshold of statistical significance, meaning the relationship is potentially meaningful, but not strongly conclusive yet given the small dataset for 2024 (Figure 5b). For more explanation of the correlation analysis, see section 10.0.

(a)



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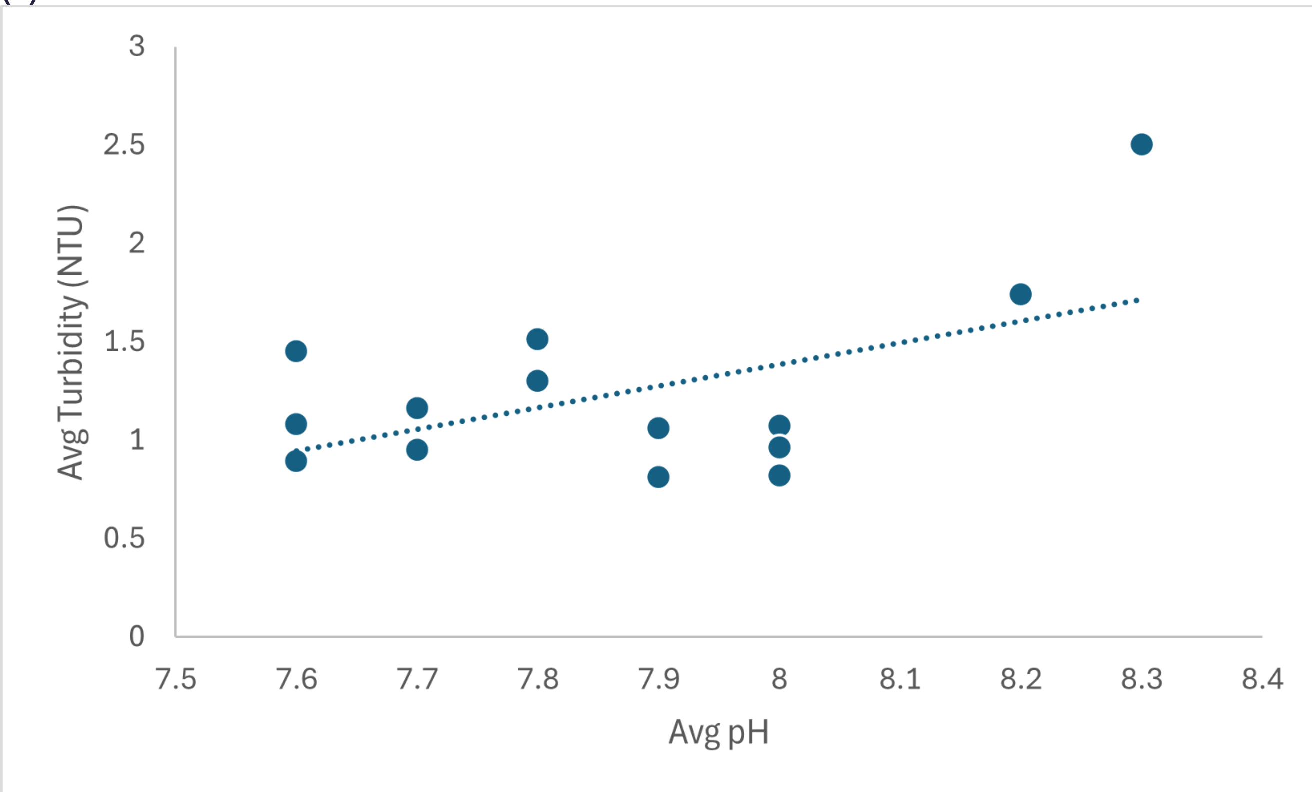


Figure 5: (a) Lake Windermere pH recordings from 2024. Maximum and minimum requirements. (b) Lake Windermere 2024, correlation between average daily pH values and average daily turbidity values. *Note: Lines are for interpretation only, and do not represent continuous measurements.*

2.5 Specific Conductivity

Overview

Specific conductivity measures the ability of water to conduct an electrical current. It is affected by the presence and mobility of ions in the water. Conductive ions include dissolved salts and inorganic compounds like chlorides, sulfides, and carbonates. For this reason, a measure of conductivity in water may be used as an indicator of water pollution. For instance, specific conductivity readings can provide insights about pollutants such as sewage, road salts, or an oil spill.

Water conductivity is directly related to water temperature. As temperature increases, so does the mobility of the ions, and in turn, a higher conductivity reading is produced (Behar, 1997). Readings are reported at a standard temperature of 20°C, which is corrected when needed by the measuring device. Water's specific conductivity can be affected by the bedrock of the surrounding area. Lake Windermere's watershed is surrounded by weathering-prone bedrock including limestone and clay, giving higher conductivity values compared to more stable bedrock materials such as granite.

Interior systems in BC can range in specific conductivity up to 500 µS/cm, depending on the geology of the drainage basin (British Columbia Ministry of Environment, 2010). Since values have remained consistent over time in Lake Windermere (on average between 200-300 µS/cm), there are no MOE objectives set. It is, however, still important to monitor and observe if changes in conductivity are occurring which might negatively affect aquatic health. Freshwater streams generally support diverse aquatic life within a specific conductivity range of 150-300 µS/cm (Behar, 1997; Weaver & Northrup, 2016). Readings that fall outside this range should be interpreted with caution and may warrant further investigation. However, it's important to consider local context—historical Specific Conductivity values for this region may commonly exceed this range, especially during freshet. Given the geology of the watershed, naturally elevated Specific Conductivity levels are to be expected and may differ from those observed in more typical freshwater streams or lakes.

Results

The results of Specific Conductivity in Lake Windermere in 2024 ranged between 186.0 µS/cm (South site) to 411.3 µS/cm (North Lower site) in 2024 (Figure 6). They showed elevated levels in the early spring, with average values exceeding the recommended maximum of 300 µS/cm on April 16 (390.2 µS/cm), May 29 (337.9 µS/cm), and June 5 (313.8 µS/cm). All four sites exceeded 300 µS/cm on April 16, and three sites exceeded 300 µS/cm on May 29. On June 5 two sites exceeded the ideal conductivity range, and on June 12, one site was recorded to exceed the ideal conductivity range as well. Conductivity values were generally the highest at the North Upper and North Lower sites, particularly in the spring, suggesting possible localized sources of dissolved solids entering the area. Such sources may include road salts, storm water runoff, and spring runoff. After June 12, all measured values across the four monitoring sites remained below the 300 µS/cm threshold. Therefore, the data illustrates a clear seasonal trend, with a peak in conductivity during the springtime which coincides, followed by decreasing values throughout late spring to mid-summer, with the lowest average being recorded in July (233.7 µS/cm), followed by a gradual rise toward September. These patterns likely reflect natural hydrological processes such as snowmelt dilution and seasonal variations in water input and human activity (Figure 6).

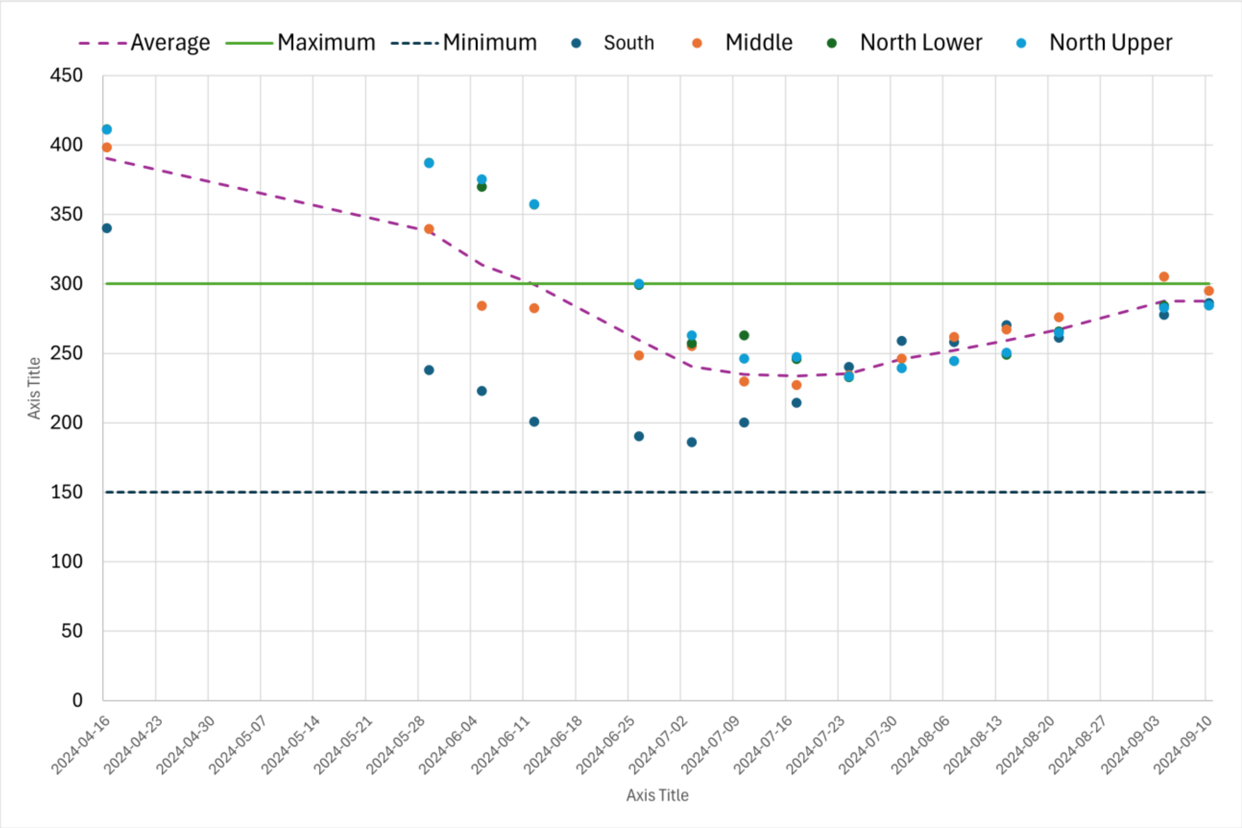


Figure 6: Lake Windermere Specific conductivity (µS/cm) measurements 2024. Recommended maximum and minimum values and average conductivity across all sample sites. *Note: Lines are for interpretation only, and do not represent continuous measurements.*

2.6 Phosphorus

Overview

Phosphorus (P) is a nutrient essential for life. Phosphorus is used by plants and aquatic animals for processes involved in photosynthesis and metabolism. When present in low quantities, this nutrient can limit the growth of aquatic life. When present in high quantities, it can lead to excessive algal and aquatic plant growth and overproduction of bacteria, affecting other aquatic life and human health through toxic algal blooms.

Phosphorus exists in two primary forms in water: dissolved and particulate. Dissolved Phosphorus is more readily available to algae and aquatic plants for growth and photosynthesis (US EPA, 2012). Particulate Phosphorus is attached to particles in the water and is not always available to aquatic plants or animals. "Total P" is a combined measurement of the dissolved and particulate forms. Total P is often the parameter monitored during water quality objective studies.

Phosphorus is naturally derived from soil erosion and biological recycling within the lake. Natural sources of Phosphorus include nutrient cycling and soil mineral transport while the two primary human-caused inputs of phosphorus into waterways in North America are agricultural runoff and wastewater. Within the Lake Windermere watershed, possible anthropogenic sources of phosphorus in the tributaries and the lake include agricultural runoff, golf course and resort fertilizer runoff, waterfront lawn & garden fertilizer runoff, municipal stormwater runoff containing detergents and other phosphate-bearing chemicals, leaky shoreline septic systems, and internal loading caused by the disturbance to lake bottom sediments.

Historic sampling results indicate that Lake Windermere is oligotrophic exhibiting low nutrient levels, clear waters, and the Total Phosphorus is within limits of growth of aquatic life. However, more recent data leans towards a possible shift to mesotrophic. The Ministry of Environment (MOE) recommends that the Total Phosphorus in Lake Windermere does not exceed a concentration of 10 µg/L (0.01 mg/L) to protect drinking water sources and aquatic life. As recently as 2015, however, the LWA found that water samples after ice-off significantly exceeded the MOE recommendations for Total Phosphorous concentrations in Lake Windermere.

Results

For this report, it's important to note that phosphorus results include data from sampling that occurred at the South and Middle sites monthly, with North Lower and North Upper sites only shown here in April due to their inclusion in the BC MOE Level 3 Lake Monitoring Stewardship Program for the remainder of the season. These samples were processed in a different lab and for that reason, were not included in this analysis. Results for these have been displayed below, separately for now, until more research into the labs methodology is done. They can be included in the analysis only if the methods used at both labs are comparable and statistical analysis is implemented to ensure reliable interpretation.

Figure 7a presents 2024 monthly Total Phosphorus concentrations and average Phosphorus levels collected from Lake Windermere between April 16 and September 4, 2024. In April, average Phosphorus levels were below both the Ministry of Environment (MOE) maximum guideline for drinking water sources (10 µg/L) and the aquatic life protection range (5-15 µg/L), with an average of 4.7 µg/L. However, average values exceeded the 10 µg/L MOE threshold in June (8.8 µg/L), July (8.1 µg/L), and peaked significantly on July 31st at 13.3 µg/L—well above the MOE drinking water maximum. The South site in particular reached 17.6 µg/L on July 31st, surpassing the upper guideline for aquatic life. By early September, Phosphorus levels declined to an average of 6.85 µg/L, returning to within acceptable limits. These seasonal fluctuations highlight a midsummer phosphorus peak that may reflect watershed nutrient inputs or internal loading, emphasizing the importance of continued monitoring and source identification. Internal loading is caused by the release of phosphorus from lake sediment into the water column. This process can contribute to harmful algal blooms and water clarity issues in lakes. (Figure 7a).

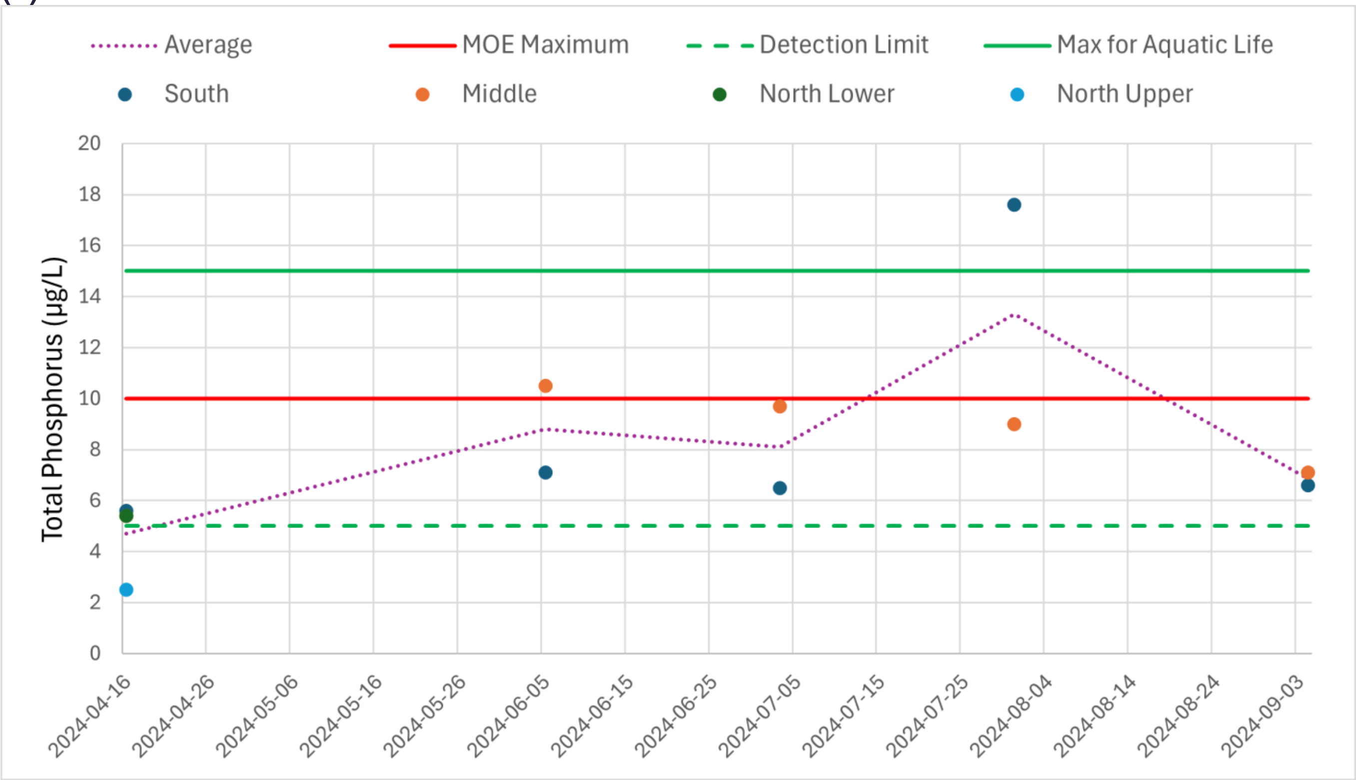
Our data suggests that when total phosphorus levels are high, turbidity is also elevated — meaning there are more suspended sediments in the water. This indicates that much of the total phosphorus may be attached to particles, rather than dissolved in the water. Because algae can only use dissolved phosphorus, the potential for algal blooms may not be as high as total phosphorus levels alone would suggest. (Figure 7b). Dissolved phosphorus levels may be a better indicator of algal growth risk in Lake Windermere.

Figures 7c indicates Dissolved Phosphorus levels were stable and low (2.5 µg/L) through April to early July but increased markedly in late July (6.2 µg/L average) and again in early September (4.3 µg/L average), with the South site reaching 6.1 µg/L. While Dissolved Phosphorus never exceeded the MOE maximum of 10 µg/L, values in late summer surpassed the 5 µg/L detection threshold, indicating a potential increase in bioavailable phosphorus.

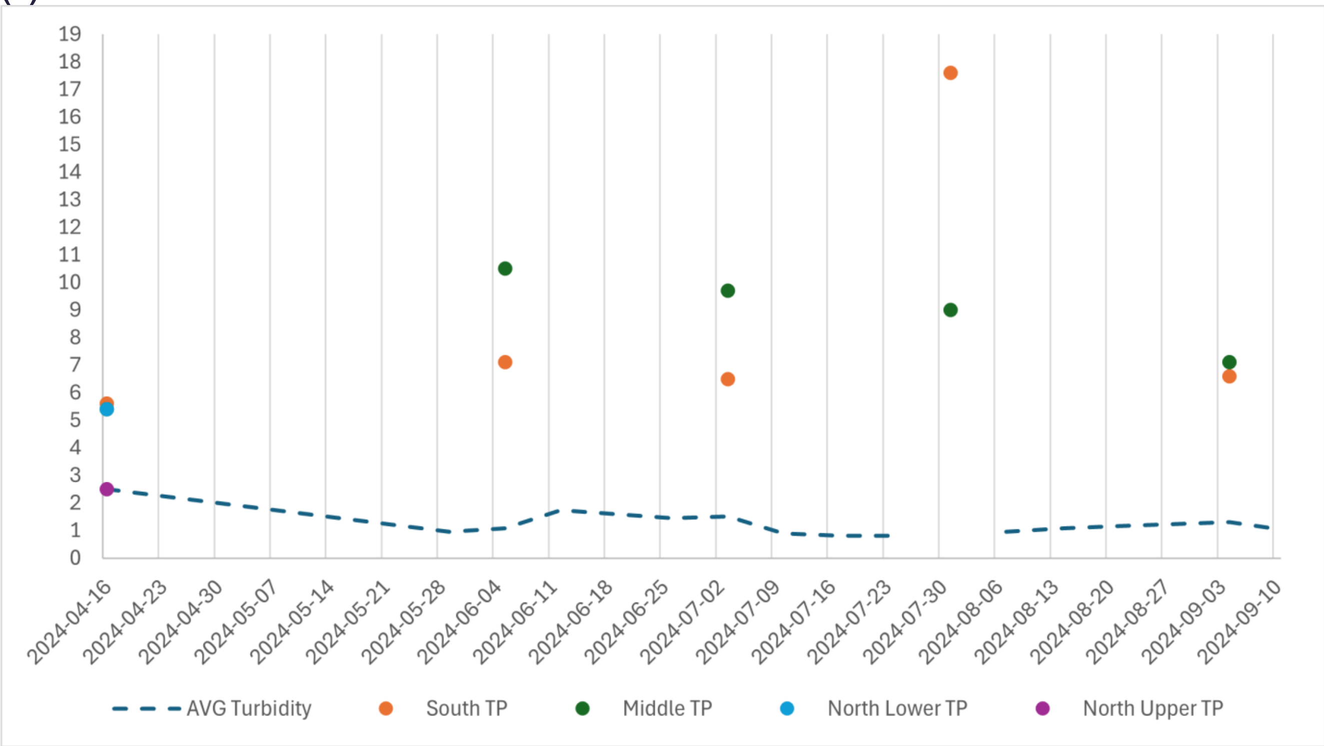
These seasonal trends highlight a midsummer nutrient pulse in both Total and Dissolved Phosphorus, likely driven by factors such as runoff, sediment release, or internal loading. Continued monitoring is recommended to assess sources and manage potential impacts on aquatic health (Figure 7c).

Figure 7d displays average Total Phosphorus concentrations measured during the summer months (June through August) in Lake Windermere from 2011 to 2024, compared against the maximum guideline of 10 µg/L. It's important to point out that in 2023 there was only one day of Phosphorus data included here, and that the 2024 data does not include the North Upper and North Lower sites as these were done through the BC MOE Lake Monitoring Program so the results and year over year trend could significantly change if the missing data is accounted for. There is notable variability over the 14-year period. The highest concentrations occurred in 2011 (27.3 µg/L) and 2013 (25.4 µg/L), significantly exceeding the MOE threshold and indicating major Phosphorus loading events in those years. However, from 2014 to 2020, Phosphorus levels generally declined and remained below or near the 10 µg/L limit, reaching a low of 2.8 µg/L in 2017. A slight upward trend is observed after 2020, with levels exceeding the MOE guideline in 2021 and again in 2024, the latter being the highest recorded in the last three years. While the overall trend since 2011 suggests improvement in phosphorus concentrations, the recent uptick in 2021 and 2024 warrants attention. These elevated values may reflect increased runoff, land-use impacts, increased recreation impacts or changing climatic conditions influencing nutrient cycling. Ongoing monitoring is essential to track these shifts and ensure protection of aquatic ecosystem health and water quality objectives.

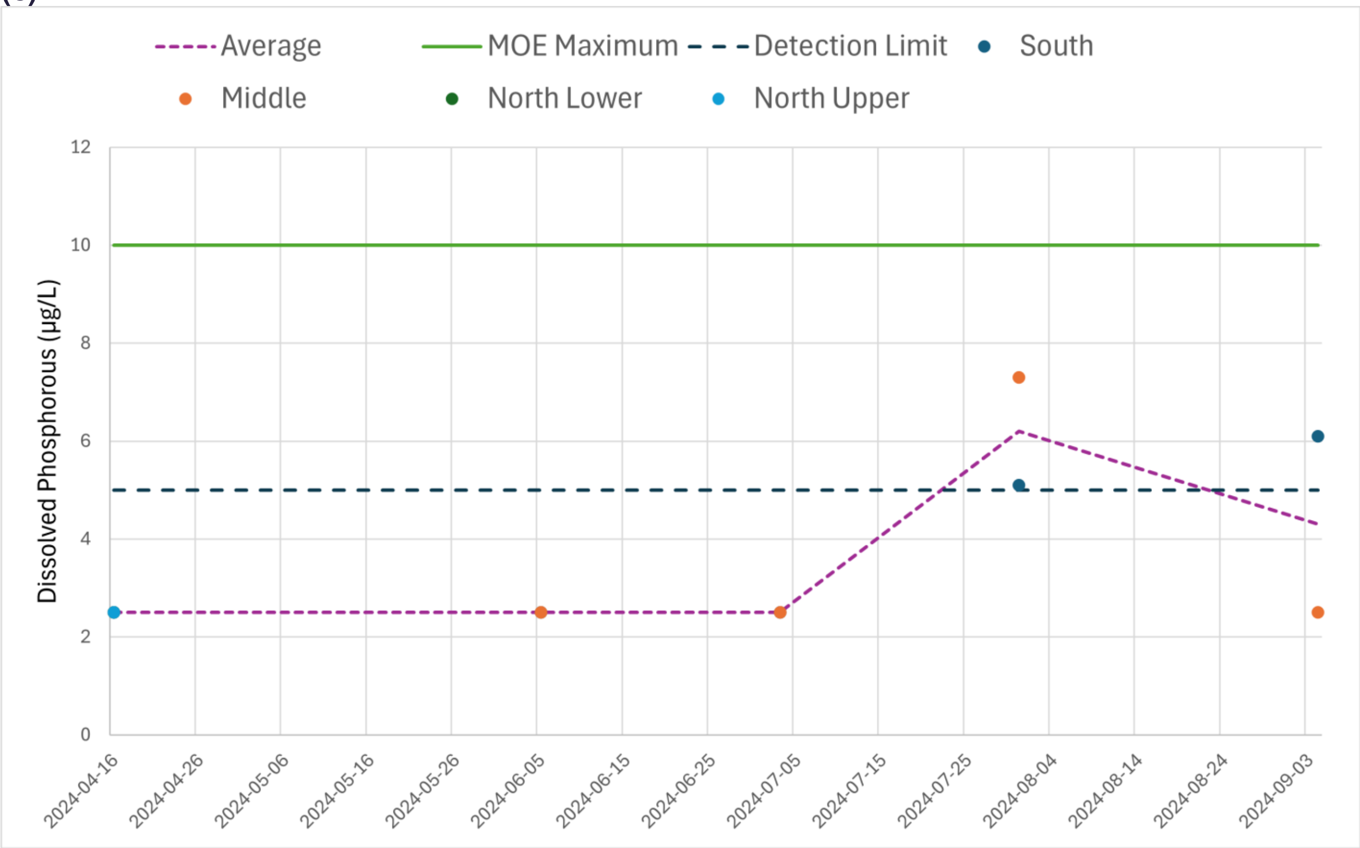
(a)



(b)


19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
2024-04-16
2024-04-23
2024-04-30
2024-05-07
2024-05-14
2024-05-21
2024-05-28
2024-06-04
2024-06-11
2024-06-18
2024-06-25
2024-07-02
2024-07-09
2024-07-16
2024-07-23
2024-07-30
2024-08-06
2024-08-13
2024-08-20
2024-08-27
2024-09-03
2024-09-10
AVG Turbidity
South TP
Middle TP
North Lower TP
North Upper TP

(c)


Average
MOE Maximum
Detection Limit
South
Middle
North Lower
North Upper
Dissolved Phosphorous (µg/L)
12
10
8
6
4
2
0
2024-04-16
2024-04-26
2024-05-06
2024-05-16
2024-05-26
2024-06-05
2024-06-15
2024-06-25
2024-07-05
2024-07-15
2024-07-25
2024-08-04
2024-08-14
2024-08-24
2024-09-03

(d)

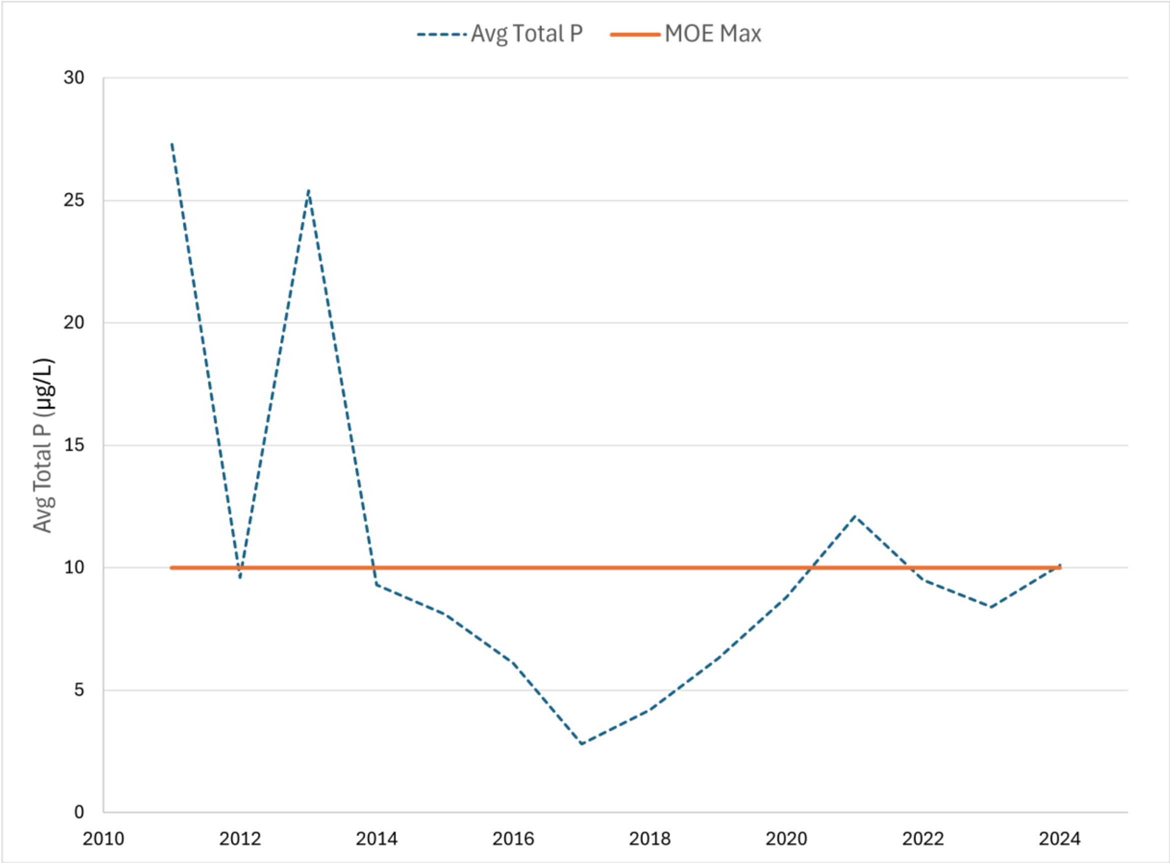


Figure 7: (a) Monthly Total Phosphorus, collected from Lake Windermere between April 16 and September 10, 2024. (b) Average Total Phosphorus, collected from Lake Windermere compared to Average Turbidity, between April 16 th and September 9th, 2024 (c) Monthly Dissolved Phosphorus, collected from Lake Windermere between April 16 and September 10, 2024. (d) Average Total Phosphorus data, 2011-2024. *Note: Lines are for interpretation only, and do not represent continuous measurements. The "Detection limit" is the limit at which the extraction procedure can detect* Phosphorus *in water; values below this line were considered "undetectable".*

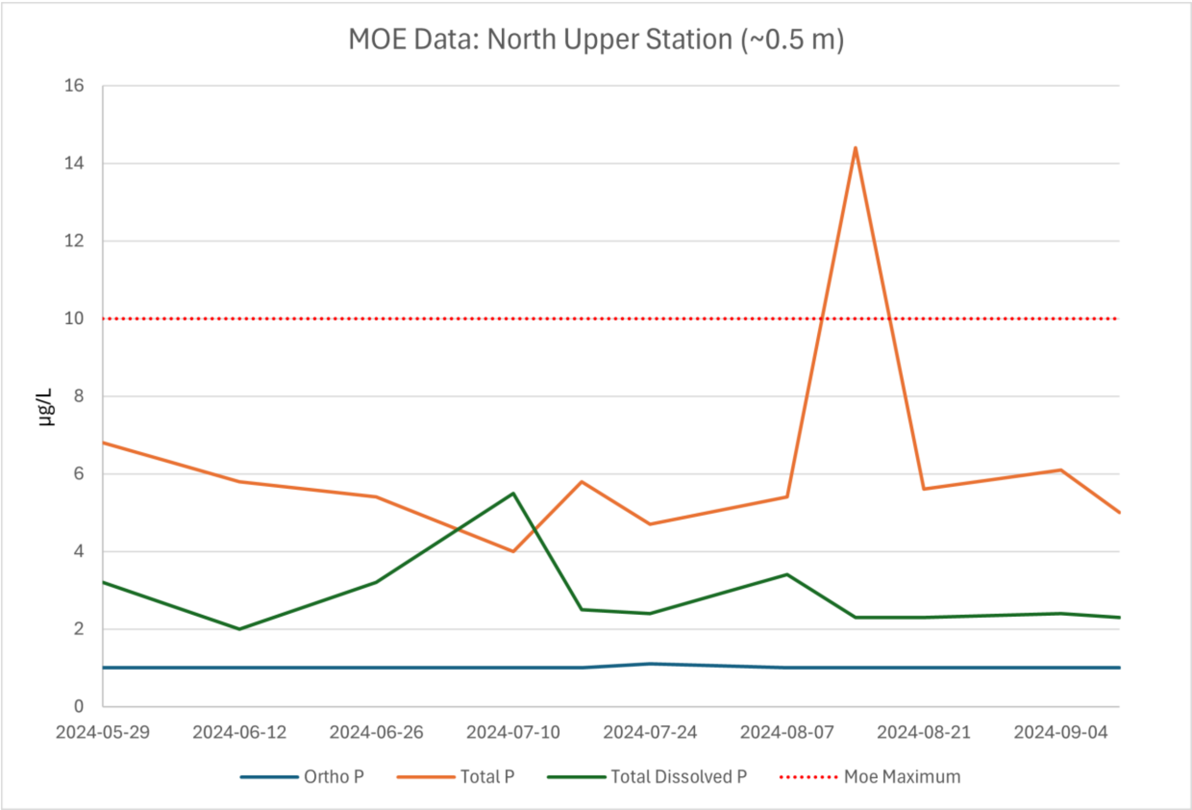
Results for the 2024 BC Lake Stewardship and Monitoring Program Level 3 Phosphorus Data

Between May 29 and September 10, 2024, Phosphorus levels at the North Upper site in Lake Windermere were generally stable and within acceptable limits. Total Phosphorus (TP) ranged from 4.0 to 14.4 µg/L, with most values below the provincial maximum of 10 µg/L. A single exceedance occurred on August 14 (14.4 µg/L), most likely an anomaly, or contamination from a sediment particle or zooplankter in the sample collected. Ortho-Phosphorus remained low (1.0-1.1 µg/L), indicating limited immediately bioavailable phosphorus. Total Dissolved Phosphorus varied from 2.0 to 5.5 µg/L, with the highest reading on July 10, suggesting shifts in Phosphorus forms rather than increased loading. Overall, Phosphorus concentrations suggest low risk of eutrophication during this period, with the one notable exception (Figure 7e).

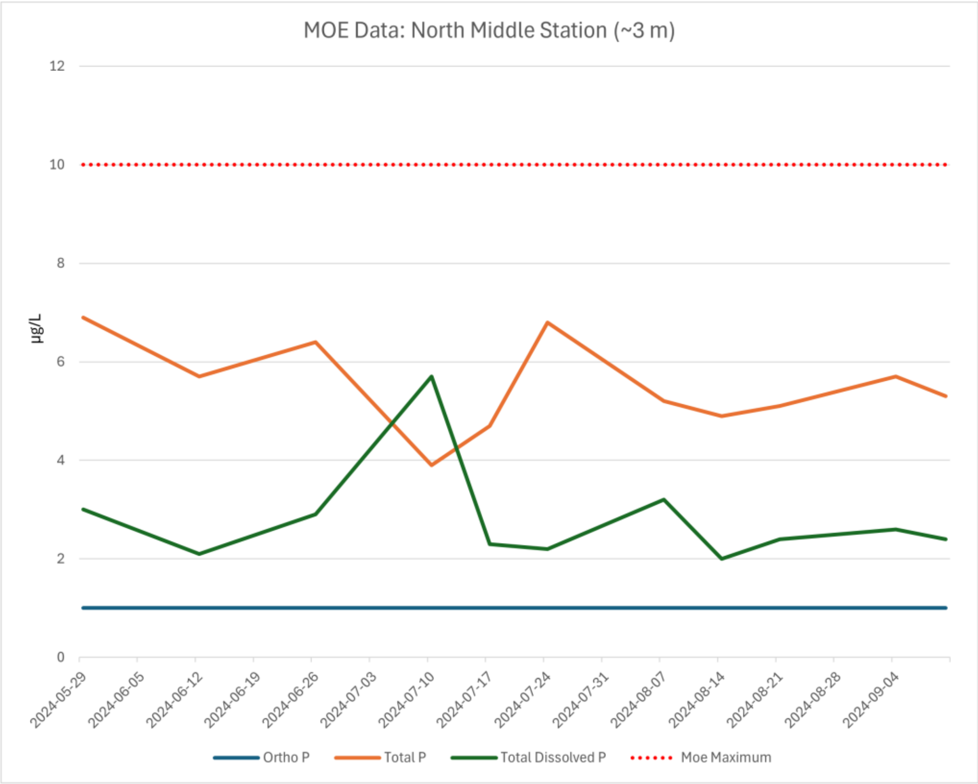
From May 29 to September 10, 2024, Phosphorus levels at the North site at mid depth (approx. 3 m depth) in Lake Windermere remained stable and below the provincial guidelines of 10 µg/L. Total Phosphorus (TP) values ranged from 3.9 to 6.9 µg/L, with no exceedances. Ortho-Phosphorus consistently measured 1.0 µg/L, suggesting minimal immediately bioavailable Phosphorus. Total Dissolved Phosphorus fluctuated between 2.0 and 5.7 µg/L, peaking on July 10. These results indicate low phosphorus enrichment and a low risk of eutrophication throughout the monitoring period at this level (Figure 7f).

Between May 29 and September 10, 2024, Phosphorus levels at the North Lower site (approx. 5 m depth) in Lake Windermere remained below the provincial maximum of 10 µg/L. Total Phosphorus (TP) ranged from 4.7 to 8.1 µg/L, peaking on June 26 but still within acceptable limits. Ortho-Phosphorus was consistently low (1.0 µg/L) except on May 29 (3.0 µg/L), indicating limited immediately available phosphorus. Total Dissolved Phosphorus fluctuated between 2.0 and 5.4 µg/L, with the highest concentrations observed in mid-summer. Overall, Phosphorus levels suggest moderate nutrient presence without significant eutrophication risk at for the North Site (Figure 7g).

(e)



(f)



(g)

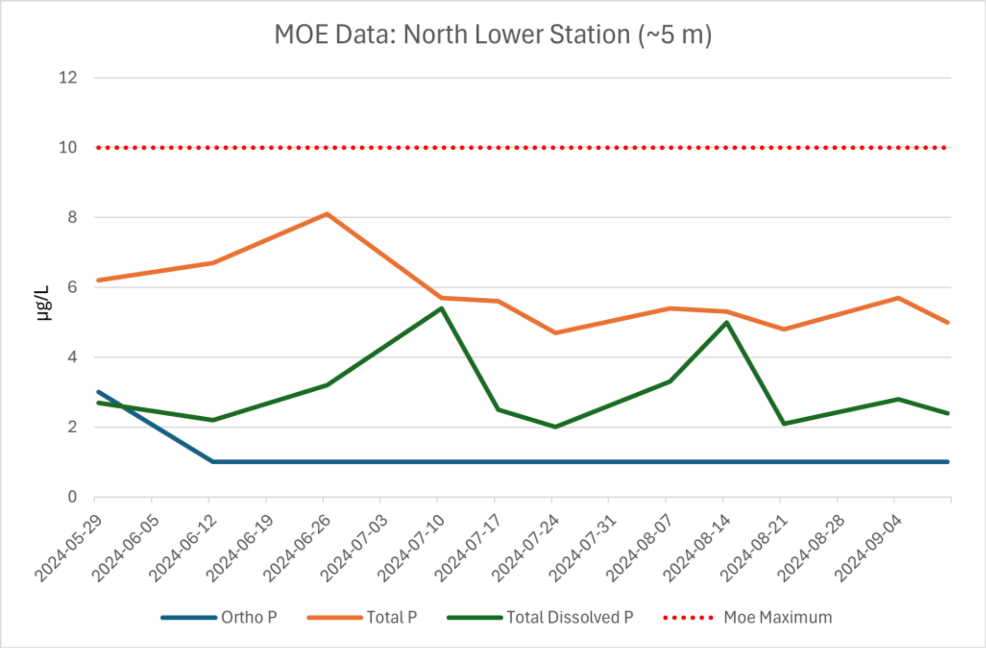


Figure 7: (e) 2024 BC Lake Stewardship and Monitoring Program Level 3 Data: Ortho P, Total P and Total Dissolved P for the Lake Windermere Ambassadors North Upper (~0.5 m depth) monitoring Site. May 29-Sept 10, 2024 (f) 2024 BC Lake Stewardship and Monitoring Program Level 3 Data: Ortho P, Total P and Total Dissolved P for the Lake Windermere Ambassadors North Middle (~3 m depth) monitoring Site. May 29-Sept 10, 2024. (g) 2024 BC Lake Stewardship and Monitoring Program Level 3 Data: Ortho P, Total P and Total Dissolved P for the Lake Windermere Ambassadors North Lower (~5 m depth) monitoring Site. May 29-Sept 10, 2024, *note: Lines are for interpretation only, and do not represent continuous measurements.*

2.7 Secchi Depth

Overview

Secchi depth is related to water clarity and measures how deep light can penetrate the water column. Changes in water clarity, like turbidity, can result from the suspended particles in the water. These suspended particles can consist of zooplankton, phytoplankton, bacteria, pollutants, or sediment (clay and silt). Clear water lets a beam of light penetrate more deeply into the lake than murky water. Sunlight is needed for aquatic plants to photosynthesize and for phytoplankton to grow and reproduce (Ministry of Environment, 2017a). Therefore, Secchi measures how deep the photosynthetic zone goes into the water column.

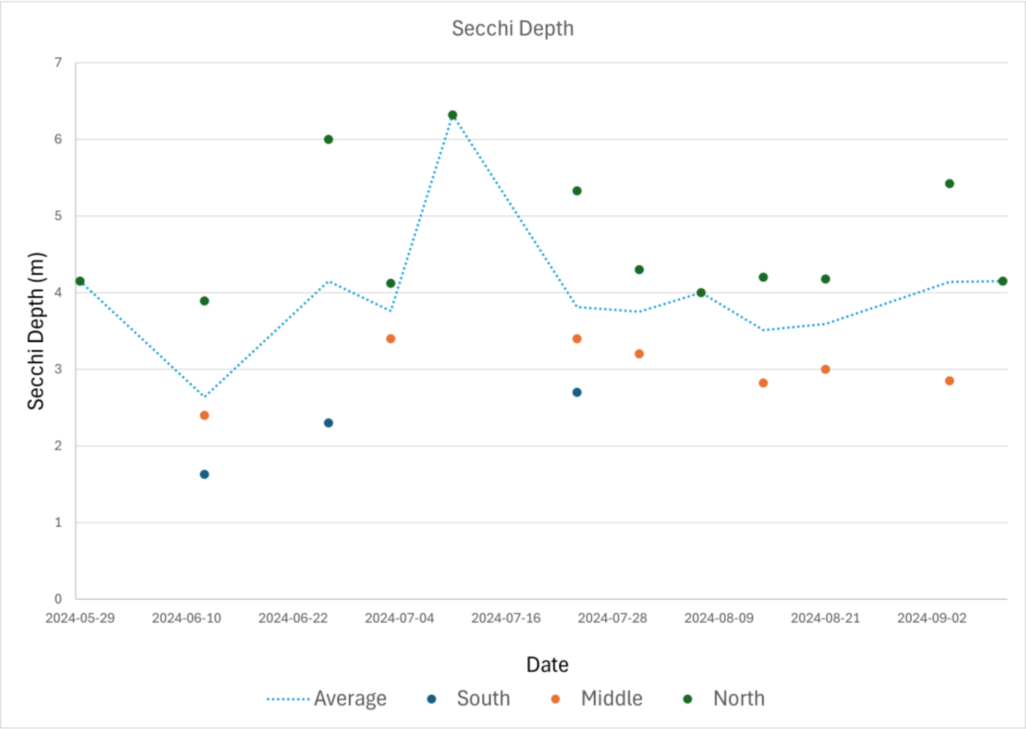
Secchi data collected year after year can provide information about trends in water clarity. Secchi depth generally follows the inverse pattern of turbidity. When turbidity is high, the Secchi depth is low because it is difficult to see deep into the water. There are no objectives for Secchi depth in Lake Windermere (Neufeld et al., 2010). Following the objectives set for turbidity, we should expect the Secchi depth to be lower in the spring during freshet and higher in the summer as the lake flushes out over time.

Results

Between May 29 and September 10, 2024, weekly Secchi depth measurements were taken in Lake Windermere to monitor water clarity. Overall, water clarity showed a general seasonal pattern, with lower transparency in the early summer months and improved clarity by mid-July. The lowest recorded average Secchi depth occurred on June 12, with an average of 2.64 metres. This drop in clarity is likely due to spring runoff that increased turbidity. In contrast, the highest clarity was observed on July 10, with a Secchi depth of 6.32 metres at the North site. This peak likely reflects more stable weather conditions with reduced sediment input. (Figure 8a)

Between May and September 2024, total lake depths and Secchi depths were recorded at the South, Middle, and North sites of Lake Windermere to assess both maximum water depth and clarity over the summer season. It is important to note that Secchi depths were not recorded at the South and Middle sites on several dates because the Secchi disk remained visible all the way to the bottom, meaning the water column was shallower than the Secchi depth. As a result, these measurements could not be included in the dataset to maintain consistency. Secchi depth tends to appear lower in the South sample site, because this site is much shallower than the North site. Despite these gaps, the data show that the North site consistently recorded the greatest water clarity, while the South site tended to have lower transparency when measurable. Overall, the mid-summer period showed the clearest water conditions (Figure 8b)

(a)



(b)

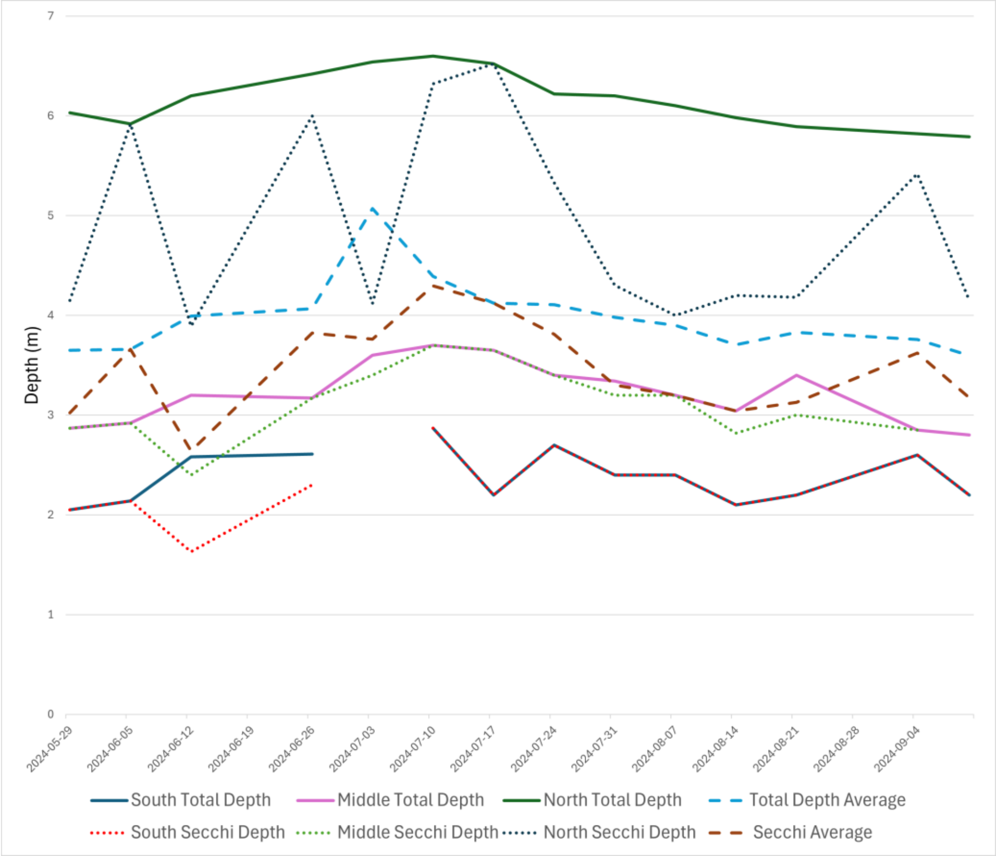


Figure 8: (a) Lake Windermere Secchi depth (meters) measured weekly for the sampling period May 29th to September 10th, 2024. Secchi depths the same depth as the water column were not included. (b) Lake Windermere Maximum Secchi Depth and Maximum Total Lake Depth in 2024. *Note: Lines are for interpretation only, and do not represent continuous measurements.*

2.8 Total Depth

Overview

Lake Windermere is a widening of the central Columbia River channel, which makes it different from typical lakes around Southern BC. The main difference is that it is very shallow, on average, 3.4 m depth in mid-summer. It also has a high-water exchange rate (flushing) which allows water to flow through more quickly than an average lake, giving it a better capacity to carry sediments and nutrients downstream because of this faster flow. The average water depth is recorded for all three sample sites throughout the lake, but this is not representative of Lake Windermere. This lack of representation is because the South end, where water flows in from the Columbia Wetlands, tends to be much shallower than the other two sites. The North sample site is the deepest point in the lake, measuring on average between 6-7m in depth. Depth can be essential for aquatic life, recreational boaters, and drinking water users. Shallow water poses more risks to boaters because they can more easily be caught on sediment bars or clog their motors with aquatic vegetation growing from the bottom of the lake. From an ecological point of view, boating activities in shallow lakes are associated with increased turbidity and nutrient release as boat motors stir up the benthic layers of lakes, resulting in both recreational and ecological issues regarding recreational activities in shallow lakes. Furthermore, lakes lacking water depth also warm up more quickly, posing issues for drinking water quality and aquatic life's survival. Currently, there is no objective set for lake depth in Lake Windermere, but levels below 2m generally cause concern.

Thermal stratification occurs when water separates into layers in deeper lakes, with cooler, denser water falling to the bottom. Due to Lake Windermere's shallow depths, the lake does not stratify, creating little difference between the North Upper and North Lower water quality samples.

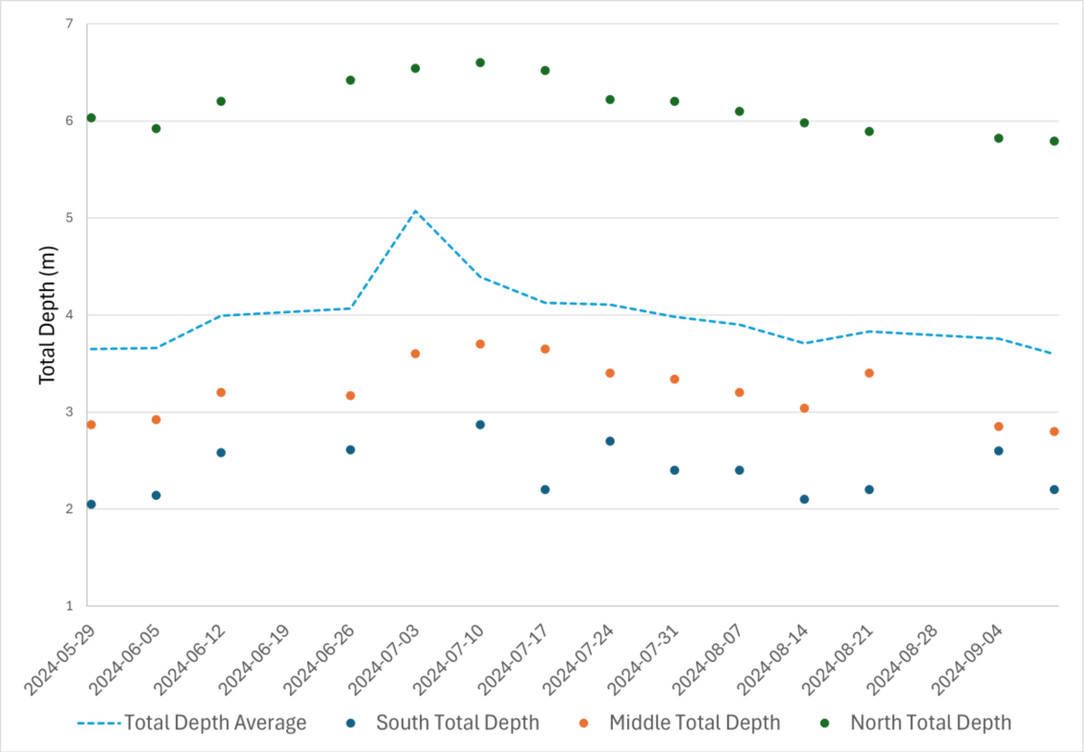
Results

From late May to early September 2024, total water depth was measured weekly at three primary monitoring sites on Lake Windermere: South, Middle, and North. The North site consistently recorded the greatest depths, ranging from 5.79 to 6.6 metres, reflecting its deeper bathymetry compared to the other locations. In contrast, the South site remained the shallowest, typically ranging from 2.05 to 2.87 metres, while the Middle site ranged from 2.8 to 3.7 metres. The average total depth across all three sites gradually increased from 3.65 m on May 29 to a seasonal peak of 5.07 m on July 3, likely corresponding with maximum water levels following spring runoff. After this peak, a progressive decline in average depth was observed through late summer, falling to 3.60 m by September 10, likely due to evaporation and reduced inflow later in the season. The data demonstrate the consistent depth gradient across the lake, with the northern basin being significantly deeper than the southern and central portions. This depth variation is important context for interpreting other parameters, such as Secchi depth, as deeper sites allow for greater vertical clarity measurement and reduced bottom interference. Additionally, the mid-season peak in water depth aligns with other seasonal hydrological patterns observed in the lake, including high runoff and inflows from tributaries during early summer. (Figure 9a)

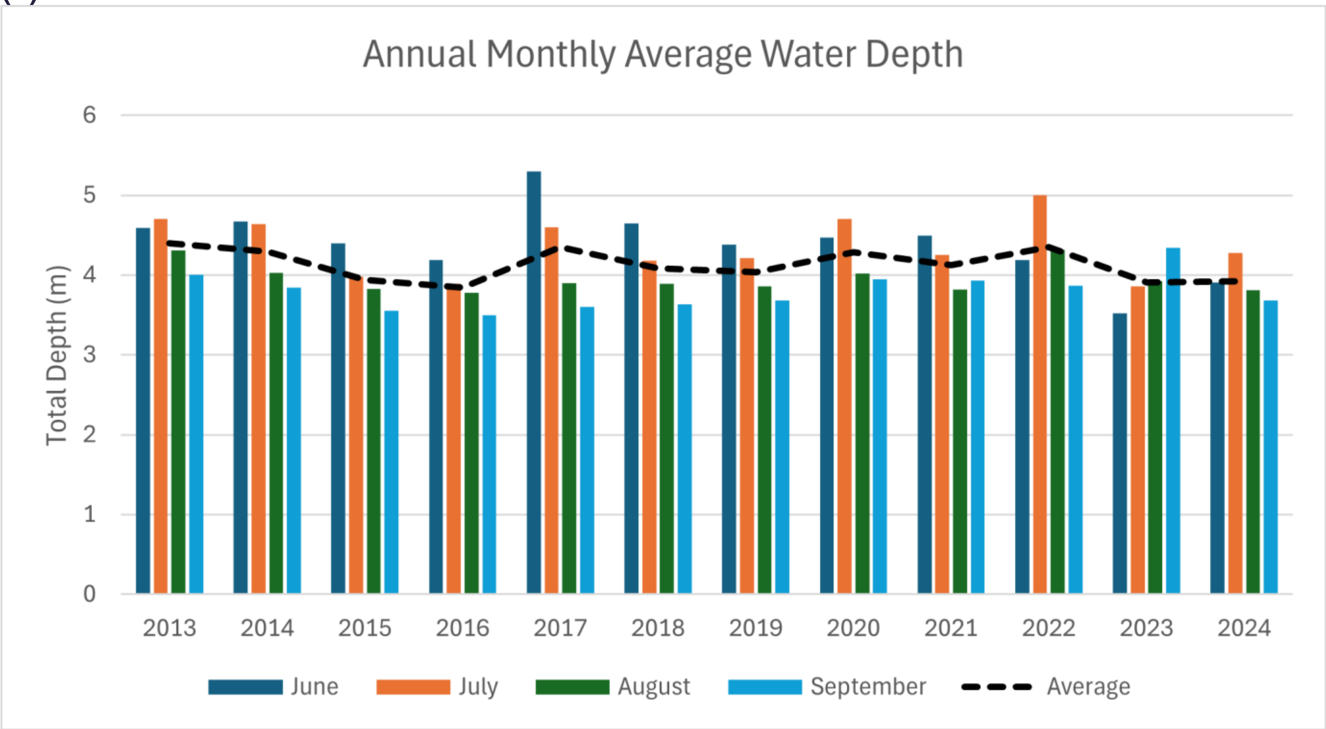
The data from 2013 to 2024 illustrate that typically, water levels are highest in June, following spring snowmelt and freshet, and gradually decline through the summer, reaching the lowest levels by September. This seasonal pattern is consistent throughout the dataset, although the magnitude of monthly averages varies between years. The year 2017 stands out with the highest June water level (5.3 m) and one of the highest summer averages (4.35 m), indicative of an especially high freshet or above-average precipitation. Conversely, 2023 and 2024 represent two of the lowest water years in the record, with average summer depths of 3.91 m and 3.92 m, respectively. In 2023, September levels (4.34 m) appear higher than those in June and July, which is atypical for the season. However, this apparent reversal is likely due to very limited data collected in June and July of 2023, rather than an actual shift in flow patterns. On average, water depths have slightly declined in recent years, with values after 2020 tending to cluster below the long-term average of approximately 4.1 m. These shifts may reflect broader climatic or watershed changes, including drier summers, reduced snowpack, or altered inflow timing. Overall, the data emphasize the importance of continued monitoring to assess changes in seasonal hydrology and support water resource management in the Lake Windermere watershed. (Figure 9b)

Figure 9c shows the trend in average annual water depths in Lake Windermere, calculated from measurements collected between June and September from 2013 to 2024. While year-to-year variability is apparent, a slight declining trend is observed over the long term, especially in more recent years. Notably, 2023 and 2024 recorded the lowest average annual depths of the past decade, at 3.91 m and 3.92 m, respectively. These low values align with the monthly averages shown in Figure 9b and may indicate a shift toward drier summer conditions, lower snowmelt volumes, or earlier runoff timing.
It is also important to consider that limited sampling in early summer months in 2023 may have contributed to lower reported annual averages, potentially underrepresenting peak freshet depths. Continued and consistent data collection will be essential to accurately detect long-term hydrological trends and assess potential climate-driven changes in the watershed. (Figure 9c)

(a)



(b)



(c)

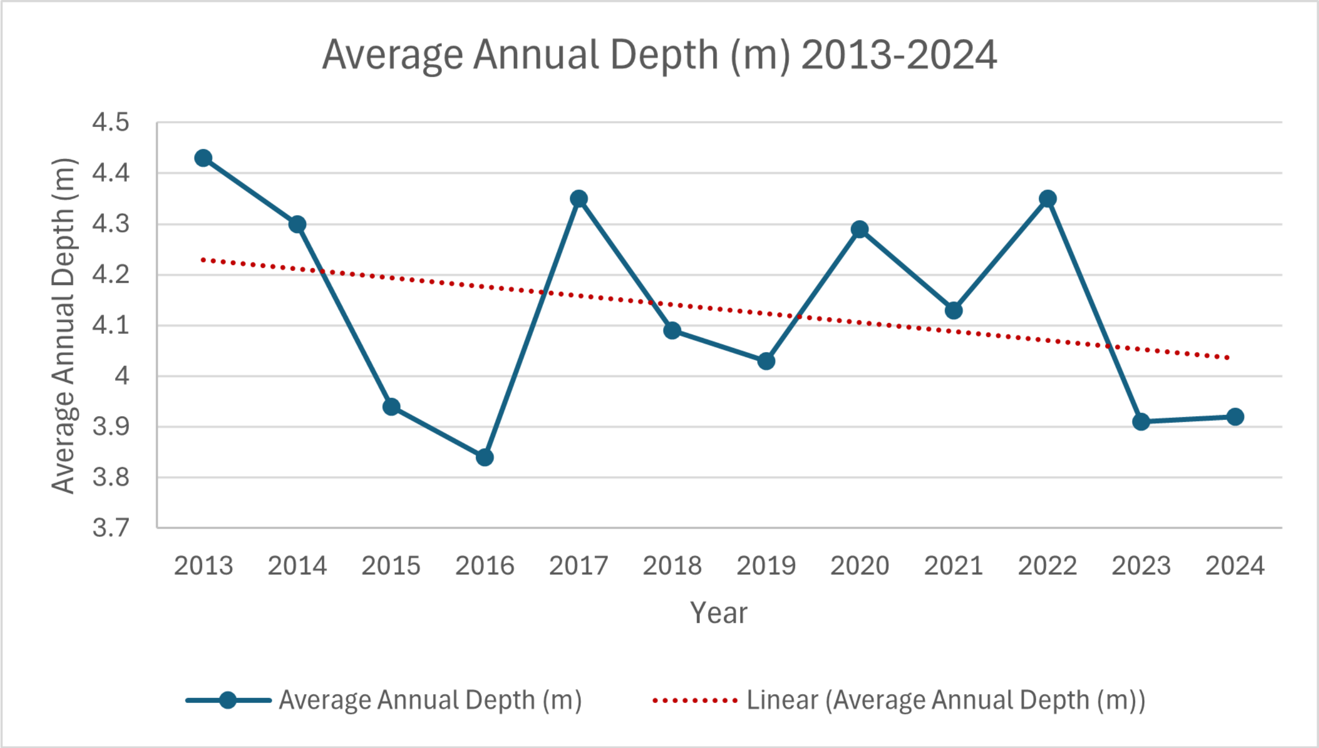


Figure 9: (a) Lake Windermere Total Depth (m) of different survey sites and depth-averaged across all sites, measured between May 29 and September 10, 2024. (b) Average Monthly Water Depths from 2013-2024. (c) Trendline of Changes in Average Annual Water Depths from 2013-2024. Using measurements taken June through September. *Note: Lines are for interpretation only, and do not represent continuous measurements.*

3.0 Waterbirds

Overview

LWA retained the services of Goldeneye Ecological Services to conduct Waterbird Surveys annually from 2019-2024 (except for 2023) to learn more about the bird populations using Lake Windermere. It has been found that Lake Windermere provides significant bird habitat for large migrant flocks and breeding birds (Darvill, 2018). The lake is important for large flocks of migratory birds, such as American coots (Fulica americana) and four grebe species- three considered at-risk species (Darvill, 2018).

Results

The 2024 fall waterbird survey on Lake Windermere was conducted on October 10 under calm and mostly overcast conditions with mild temperatures around 9°C. A total of 700 individual birds was recorded across the lake during the 2.5-hour survey—the lowest count since the survey began in 2019, and significantly lower than peak years such as 2021 (2,673 birds) and in 2020 (1,668 birds). Notably, American Coots were absent from the count for the first time since 2019, despite being one of the most abundant species in previous years (e.g., 1,850 in 2021). Similarly, numbers of grebes and gulls were much lower, with only 9 Red-necked Grebes and 18 unidentified gulls recorded, compared to dozens or even hundreds in earlier years.

A total of 248 Green-winged Teal and 132 Mallards were observed, both representing relatively high counts for their species and contributing significantly to the overall tally. However, species-at-risk such as Horned Grebe, Western Grebe, and Surf Scoter were present in very low numbers or not at all; no Surf Scoters were recorded this year, and only 9 Western Grebes were seen, compared to 17 in 2022 and 50 in 2021. Environmental conditions may have contributed to the low numbers observed. The long stretch of unseasonably warm and sunny weather leading up to the 2024 survey could have delayed migration, resulting in fewer birds staging on the lake at the time of the count. Additionally, fewer birds were noted around key habitat areas such as James Chabot Provincial Park, where gulls and coots are often concentrated.

In summary, the 2024 survey reflects a marked decrease in overall waterbird abundance, particularly among historically dominant species like American Coot and various grebes. While this could be a temporary fluctuation driven by weather or migratory timing, it underscores the importance of continued long-term monitoring to track trends in bird use and species composition on Lake Windermere.


Goldeneye Ecological Service Principal Biologist, Rachel Darvill, Conducting Aquatic Bird Inventory on Lake Windermere in fall 2024.

4.0 Swim Beach Water Quality

Overview

Escherichia coli (*E. coli)* is a type of fecal coliform bacteria found in the intestines of most healthy warm-blooded animals. Most *E. coli* is harmless, though some can produce toxins that cause illness. *E. coil* in water can indicate sewage or animal waste contamination. Other coliform bacteria are commonly found in soil or vegetation and are part of the natural microbial flora. The count of *E. coli* colonies per 100mL of water is a common way to measure how many of these species of bacteria are present in the water. However, it is essential to know that this value represents a total count of all *E. coli* colonies, which means it does not necessarily contain the strains which produce toxins harmful to humans. A higher *E. coli* count increases the probability that the water could contain a toxin producing strain.

An *E. coli* assessment determines whether beach water quality meets recognized health standards for recreation such as swimming. The LWA has an ongoing agreement with the Interior Health Authority (IHA) to collect public beach water samples; the IHA laboratory analyzes samples for *E. coli* bacteria in compliance with Health Canada Guidelines. Samples are collected at three public beaches around the lake: James Chabot Provincial Park (Athalmer), Kinsmen Beach (Invermere), and Windermere Beach (Windermere).

The Health Canada Guidelines for recreational water used for “primary contact” activities (e.g., swimming):

- Geometric Mean Concentration (minimum of five samples taken over 30 days): ≤200 *E. coli*/100mL
- Single Sample Maximum Concentration: ≤400 *E. coli*/100mL

Results

E. coli monitoring at Kinsmen Beach, Windermere Beach, and James Chabot Beach during July and August 2024 showed consistently excellent water quality across all three locations, with all recorded values remaining well within Health Canada’s acceptable limits for recreational use. Most results were extremely low, with many readings below the detection limit (<2 CFU/100 mL), particularly at Windermere Beach, which showed the most stable and consistently low bacterial levels across its three sampling sites. Kinsmen Beach also maintained low *E. coli* concentrations throughout the season, with slightly more variability at the Central site but no exceedances or elevated health risk. James Chabot Beach displayed similarly low levels, aside from a brief spike on July 29, when the Central and West sides reached 120 and 60 CFU/100 mL respectively. These readings were still within acceptable limits but significantly higher than baseline values. Overall, the monitoring results indicate excellent water quality for swimming and recreational activities at all three beaches, with no advisories or closures required during the 2024 summer season.

5.0 Aquatic Invasive Species Inventory

Overview

As part of our commitment to protecting the ecological health of Lake Windermere, the Ambassadors continued annual monitoring for aquatic invasive plants in 2024 with the professionals from Goldeneye Ecological Services. This proactive initiative focuses on early detection of invasive species that could threaten native plant communities, water quality, and overall lake health. The program also provides valuable insight into the condition and diversity of native aquatic vegetation, helping inform conservation efforts and lake management strategies. Surveys were conducted at five high-risk shoreline sites and 11 offshore locations on Lake Windermere.

Results

No invasive aquatic plant species were detected during either the shoreline or boat-based surveys, consistent with past years’ findings. While invasive species were absent, the surveys recorded a diverse range of native aquatic plants, which are vital to the lake’s ecosystem. However, several sites—including Pete’s Marina and Tretheway Docks—showed signs of stress on native plant communities. At some locations, plants were found coated in thick sediment, likely caused by motorized boating activity. A noticeable decline in plant abundance and diversity was also observed at some sites compared to previous years (Darvill, 2025).

The report emphasizes the importance of maintaining native aquatic vegetation, which supports biodiversity, stabilizes sediments, improves water quality, and contributes to climate resilience. It recommends the creation of "no-motorized boating" zones in sensitive areas, ongoing monitoring, habitat restoration, and increased public education on the ecological value of submerged aquatic plants to ensure the long-term health of Lake Windermere's ecosystem (Darvill, 2025).

6.0 Tributary Monitoring

Overview

Besides the Central Columbia River Channel, Windermere Creek is the primary source of inflow into Lake Windermere. This tributary stream drains an area of approximately 90 km and provides essential fish spawning habitat (NHC, 2013). At the same time, Abel Creek is a much smaller tributary than Windermere Creek. Monitoring efforts are made as Abel Creek runs into Lake Windermere from the Paddy Ryan Lakes Reservoir used by the District of Invermere.

From 2007 to 2018, the Columbia Basin Water Quality Monitoring Program (CBWQM) ran on Windermere Creek. This project oversaw scientific data collection in East and West Kootenay streams through the fieldwork undertaken by local volunteers and non-profit organizations. LWA has continued monitoring Windermere Creek and now monitors Abel Creek as a continuation of this project.
Water chemistry follows similar protocols and uses the same equipment as lake water quality monitoring, with data collected for dissolved oxygen, specific conductivity, pH, Turbidity, and temperature.

Flow/velocity measurements are taken using a meter stick to obtain surface velocity based on the principle of conversion of kinetic to potential energy. This measurement method overestimates average channel flow but underestimates actual surface flow due to friction. While not exact, if measured carefully and repeated the same way each time, this measurement can provide a general idea of how flow volumes change seasonally within a given stream area.

Results

The sampling results from the 2024 Creek Surveys will be provided in a supplementary report.

7.0 Acknowledgements

The 2024 Lake Windermere community-based water quality-monitoring project was made possible thanks to generous funding support from:

- District of Invermere
- Regional District of East Kootenay
- Resident Direct Grant (RDEK)
- Columbia Basin Trust
- Columbia Valley Community Foundation
- Columbia Valley Local Conservation Fund
- TD Friends of the Environment Foundation
- BC Community Gaming Grants
- Canada Summer Jobs
- Living Lakes Canada
- Eco Canada
- BC Hydro
- Community Donors and Supporters

In-kind support provided by the District of Invermere through use and delivery of the tin boat and fuel. Additional in-kind support provided by community volunteer, Gavin Jacobs for the use of his personal boat, and by the Interior Health Authority for swim beach samples.

A big thanks goes out to all our citizen scientists!

A final thank you goes out to the following people for their assistance with our community-based water quality-monitoring program for 2024:

- MJ Reid, Water Stewardship Assistant
- Emma Bowins, Living Lakes Canada
- Caily Craig, Columbia Lake Stewardship Society
- Rachel Darvill, Goldeneye Ecological Services
- Rachel Milner, Columbia Lake Stewardship Society
- Gavin Jacobs, Volunteer Boat Captain
- Amy Baxter, BC Lake Stewardship Society

8.0 References

Alberta Regional Aquatics Monitoring Program. (n.d.). Retrieved Jan 12, 2022, from: http://www.rampalberta.org/river/water+sediment+quality/chemical/temperature+and+dissolved+oxygen.aspx

BC Ministry of Health. (2007). *Hardness in Groundwater.* Water Stewardship Information Series. Retrieved Jan 23, 2022, from: http://www.rdn.bc.ca/cms/wpattachments/wpID2284atID3802.pdf

Behar, S. (1997). *Testing the Waters: Chemical and Physical Vital Signs of a River.* Montpelier, VT: River Watch Network.

Braumandl, T. F., & Curran, M. P. (2002). *A Field Guide for Site Identification and Interpretation for the Nelson Forest Region.* Victoria: BC Ministry of Forests, Forest Science Program.

Darvill, R. (2018). *Insight into the Waterbirds of Lake Windermere.* Prepared for the Lake Windermere Ambassadors. Published January 2019.

Darvill, R. (2025). *Lake Windermere Aquatic Invasive Plant Inventory – 2024.* Prepared for the Lake Windermere Ambassadors. Goldeneye Ecological Services. 24 pp.

Harvey, R., Lee, L., Khan, A., & Paterson, R. (2011). The influence of air temperature on water temperature and the concentration of dissolved oxygen in Newfoundland rivers. *Canadian Water Resources Journal*, 36(2), 171-192. https://doi.org/10.4296/cwrj3602849

McKean, C. J. P., & Nordin, R. N. (1985). *Upper Columbia River, Columbia and Windermere lakes sub-basin, water quality assessment and objectives.* BC Ministry of Environment. February 1985.

McPherson, S., & Hlushak, D. (2008). *Windermere Lake Foreshore Fish and Wildlife Habitat Assessment.* Consultant report prepared for the East Kootenay Integrated Lake Management Partnership. Interior Reforestation Co. Ltd., Cranbrook, BC.

McPherson, S., Kuchapski, K., & MacDonald, R. (2014). *Windermere Creek 2009-2012 Water Quality Monitoring Report.* A Columbia Basin Water Quality Monitoring Project. Prepared by Lotic Environmental Ltd.

Ministry of Environment. (2017a). *British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture.* Water Protection & Sustainability Branch. Retrieved from: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/wqgs-wqos/approved-wqgs/wqg_summary_aquaticlife_wildlife_agri.pdf

Ministry of Environment. (2017b). *FACTSHEET: Invasive quagga mussels and zebra mussels.* Retrieved from: https://news.gov.bc.ca/factsheets/invasive-quagga-mussels-and-zebra-mussels

Neufeld, A., Swain, L., & Reiberger, K. (2010). *Water quality assessment and objectives for Windermere Lake.* Technical Report. First Update. November 2010. Ministry of Environment.

NHC. (2013). *Windermere Creek Hydrotechnical Assessment.* Report prepared for the Regional District of East Kootenay by Northwest Hydraulic Consultants Ltd. and Dr. Richard McCleary. Dated January 18, 2013.

Ramsar Convention on Wetlands. (2004). *EKES and Festivals Celebrate World Wetlands Day with Ramsar Announcement.* Retrieved Jan 31, 2018, from: http://archive.ramsar.org/cda/en/ramsar-activities-wwds-world-wetlandsday-2004-18480/main/ramsar/1-63-78%5E18480_4000_0__

Rollins, J. (2004). *Caves of the Canadian Rockies and the Columbia Mountains.* Rocky Mountain Books Ltd.

Truelson, R. L. (1997). *Ambient water quality criteria for dissolved oxygen.* Water Management Branch, Ministry of Environment, Lands and Parks.

Urban Systems. (2012). *District of Invermere Source Protection Plan for Paddy Ryan Reservoirs – Draft Report.* Prepared for the District of Invermere. Retrieved Dec 10, 2018, from: http://www.invermerewater.ca/wpcontent/uploads/2016/04/2012-0306_PaddyRyanReservoirsDraftSourceProtectionPlan.pdf

US EPA. (2012). *Water Monitoring and Assessment: 5.6 Phosphorous.* US EPA's Web Archive. Retrieved Jan 31, 2018, from: https://archive.epa.gov/water/archive/web/html/vms56.html

Weaver, J., & Nortrup, M. (2016). *National Capital Regional Network (NCRN) Resource Brief: Specific Conductance in Streams.* U.S. National Park Service

Appendix A
Sampling methodology

Water Quality
Lake Windermere is sampled following the BC Ministry of Environment Water Quality Assessment and Objectives for Lake Windermere (Neufeld et al. 2010). Water quality laboratory analysis was completed by CARO Analytical (Kelowna, BC). The following water quality data were collected at all three sample sites:

a) Weekly (May -September) -in situ (field measured) data including depth, Secchi depth, water temperature, specific conductivity, pH, dissolved oxygen (DO), and turbidity

b) Monthly (April -September) -Total Phosphorous and Total Dissolved Phosphorous

Water sampling took place within a four-hour timeframe on Tuesday or Wednesday mornings, from May to September 2024. Volunteer citizen scientists were joined by at least one trained LWA staff member for all lake excursions and assisted with field data collection.

Lake Sample sites were first located by boat using a hand-held Garmin eTrex20 GPS with the preprogrammed coordinates that align with the sample sites in *Figure 1*. Once at a sample site, depth and Secchi depth measurements were taken using a weighted Secchi disk and meter line. Water temperature, Dissolved oxygen and conductivity were read using a YSI ProDSS meter. pH is read using a Hannah Waterproof pH Tester. Turbidity was read using a Hach 2100QPortable Turbidimeter calibrated to 10 NTU.

The North site was sampled at two depths (Upper and Lower) since this is the deepest part of the lake. The Upper water sample was collected at approximately 1m below the surface. The Lower water sample depth depended on the total depth of the water column: If the total depth was less than 5m then the Lower water sample was collected 1m above the lake bottom, but if the total depth was greater than 5m then the water sample was collected at 4m (due to the maximum length of the YSI. The Middle and South sites were sampled at 1m below the surface only. All water samples were collected using a horizontal VanDorn sampler.

When monthly phosphorous samples were collected, a cooler containing sample bottles was brought on board the boat. Water samples were collected into bottles, which were then kept on ice while being shipped via ACE Courier to CARO laboratories in Kelowna for analysis.

Aquatic Invasive Plants Survey
Please see Darvill (2025)

Water Birds
Please see Darvill (2022), the same procedure was used in 2024

Swim Beaches
Bacteriology samples were collected on Mondays July through September (excluding long weekend holidays) before 1:00pm from three public beaches, Windermere Beach, James Chabot Beach, and Kinsmen Beach. Each beach had three sample sites spread along the designated swimming areas. Sample bottles were filled using a triple-rinsed beaker dipped inverted below the water’s surface then turned upright within the middle of the water column.

Filled bottles were immediately kept on ice until delivery to the Invermere Health Unit located at 110 10 St, Invermere, BC with a copy of each associated requisition form. From there, custody of samples was transferred to the IHA, and samples were sent to their labs for analysis.

9.0 Data Analysis and QA/QC

Raw data were first subjected to a quality control evaluation, to assess the accuracy and validity of the laboratory and field methods. Field sampling protocols followed those outlined above. For water quality with in-situ data collection, instruments were calibrated once monthly as per manufacturer's specifications and expired, or outdated solutions were discarded and replaced. All data was reviewed by the LWA for consistency and anomalies before being analyzed. Data was analyzed by plotting parameters over time in Excel, for the current sampling year and past sampling years whenever possible. Geometric means of samples were taken where indicated, and included all samples taken within a 30-day period between start and end of sampling. CARO laboratory's analysis for Total and Total Dissolved Phosphorous was completed using Persulfate Digestion / Automated Colorimetry (Ascorbic Acid) referencing the Guidelines for Canadian Drinking Water Quality (Health Canada Feb 2017). CARO assessed accuracy using laboratory control samples, trip blanks, and duplicate samples. Aquatic Invasive Plant Survey: Please see Darvill (2025) Waterbirds: Please see Darvill (2022) Swim Beaches: Sample results were obtained from the Interior Health Authority (IHA) and analyzed for geometric mean as well as individual sample result over time. Please contact the IHA if you have specific questions about their QA/QC protocol for lab samples. https://www.interiorhealth.ca/FindUs/_layouts/FindUs/info.aspx?type=Location&loc=Invermere%20He alth%20Centre&svc=&ploc=
Public Beaches | Environmental & Seasonal Health | IH

10.0 Regression Analysis and Trendlines

How the Trend Line and Regression Analysis Were Done

To understand how our data has changed over time, we applied a linear trend line to each dataset using the statistical method of linear regression. This helps us see if there is a consistent trend—such as an increase or decrease—over a period of years.
We used Microsoft Excel to generate the trend lines and calculate statistical values. Excel's built-in tools allowed us to plot the data and add a linear trend line. We also confirmed the results using Python, a widely used scientific computing program, to ensure accuracy.

What is a Linear Trend Line and Regression?

A linear trend line is a straight line drawn through a set of data points to show the general direction or pattern in the data over time. This is done using linear regression, which is a mathematical method for estimating the relationship between a dependent variable (our measurement) and an independent variable (time, in this case).
The regression analysis produces several key values:

- **Trend line equation**: Shows the estimated rate of change over time.
- **R (correlation coefficient)**: A number between -1 and 1 that shows the strength and direction of the trend. A positive number means the data is generally increasing over time; a negative number means it is decreasing.
- **R^2 (coefficient of determination)**: A value between 0 and 1 that shows how much of the variation in the data can be explained by time. For example, an R^2 of 0.40 means 40% of the variation is related to time.

- **P-value**: Indicates whether the trend is statistically significant. A p-value below 0.05 suggests that the trend is likely real and not due to random chance.

Why It Matters

This approach helps us identify long-term trends in our data and assess whether observed changes are meaningful. Whether we're looking at environmental conditions, biological measurements, or human activity patterns, regression analysis provides a reliable way to track how things are changing and support informed decision-making.