Lake Windermere
2016 Water Quality Monitoring Results

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Final Report

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Acknowledgements

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This project would not have been a success without the dedication and support of community volunteers and partners. Acknowledgement is also due to Lake Windermere Ambassadors' Watershed Stewardship Assistant, Katie Watt, who rose to the occasion to model stewardship and offer her unique talents to this project.

Thank you to the following for providing assistance, expertise and insights into this monitoring report: Rachel Darvill (Goldeneye Ecological Services), Pat Wray (East Kootenay Invasive Species Council), Suzanne Bayley (Columbia Wetlands Stewardship Partners), and Rick Nordin (BC Lakes Stewardship Society).

Executive Summary

2016 marked the eleventh year of lake monitoring since the Lake Windermere Project started data collection in 2006. The spring and summer of 2014-2016 brought mild climatic conditions without the major flooding events which characterized 2012-2013. Measured lake depths in 2016 were comparable to those in 2006-2008, and shallower than average levels in more recent years (2012, 2014). Lake Windermere met Objectives for temperature, dissolved oxygen, and turbidity throughout the summer. This means the water was clear, cool, and well oxygenated: all in line with historic levels. Beach monitoring results showed that shoreline bacteria levels did not exceed the recommended Guidelines for safe swimming on any of Lake Windermere's public beaches over the summer.

Last year, our monitoring project detected high values for phosphorus at ice-off, exceeding Water Quality Objectives for the lake. In 2016, however, phosphorus values were below or at the Objective throughout the sampling season. It is not yet clear or conclusive whether there is an overall increasing trend in phosphorus levels and productivity in Lake Windermere. In order to recognize changes in phosphorus from year to year, the report recommends this parameter continue to be monitored closely in 2017.

The Ambassadors' annual aquatic plant survey found no invasive species in Lake Windermere for the seventh year of sampling, and presence of the unknown algae found in 2015 could not be detected again this year. No invasive mussels were detected through veliger sampling in 2016.

Questions about this report?

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Introduction

People living around and visiting Lake Windermere depend on having water that is clean enough for recreation whether swimming, fishing or waterskiing, as well as to draw from as a drinking water source. Lake Windermere is also home to sixteen species of fish and is used by several hundred species of resident and migratory birds, all of which depend on the water being in a good condition. The main factors affecting water quality in the lake are human uses and development in the watershed; from road building and housing development, to stream modifications and shoreline erosion. From 2006 to 2009, the Lake Windermere Project worked to assess the quality of the lake's waters for wildlife and human recreational uses. In 2010, the Ministry of Environment took those four years of data, as well as historic data, and determined Water Quality Objectives for Lake Windermere. These Objectives serve as a benchmark against which we can compare present conditons. They are used to evaluate if the lake is in good condition for recreation as well as for fish and wildlife. By continuing to test lake water quality on a weekly basis every summer, the Lake Windermere Ambassadors now have a baseline of eleven years of water quality data. Their continued efforts will allow for detection of changes in water quality over time, as well as helping to inform sustainable watershed planning and restoration initiatives in the Upper Columbia Basin.

In 2016, Lake Windermere Ambassadors' volunteers and staff sampled lake water at three locations monitored historically by the Ministry of Environment, and then by the Lake Windermere Project. The sites include a North (Timber Ridge), Middle (Windermere) and South (Rushmere) section of the lake (See Figure 1).

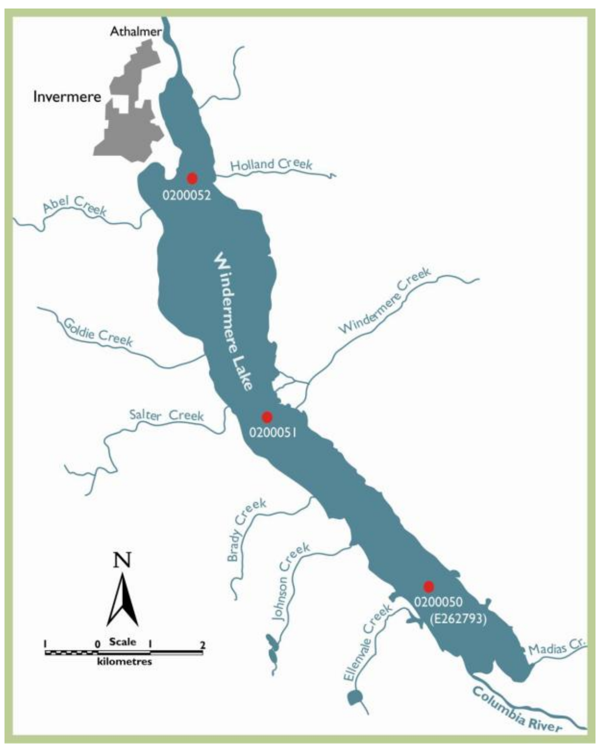
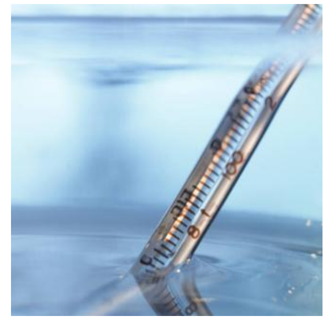


Figure 1: Lake Windermere Sampling Sites: North Station (0200052), Middle Station (0200051), and South Station (0200050)

The rest of this report documents highlights of 2016 sampling results for Temperature, Dissolved Oxygen, Turbidity, Secchi Depth, Phosphorus, pH (acidity), Conductivity, Depth, Aquatic Plants, and Beaches.

Temperature



Overview

Water temperature is of critical importance to aquatic life. Lower temperatures are generally more desirable for fish as they offer higher levels of oxygen. The Ministry of Environment determined how warm Lake Windermere can get during the summer before stresses start to occur and have set Water Quality Objectives for temperature at an average of 20°C, 23°C and 25°C in June, July and August respectively.

Results

Desite being known as a warm lake perfect for swimming, all three water monitoring stations on Lake Windermere had temperature readings consistently below the maximum °C recommended for aquatic life throughout the summer season (see Figure 2). The highest temperature measured in the lake was 21.8°C, on August 16th at Windermere Creek, which was below the objective for this month (23°C).

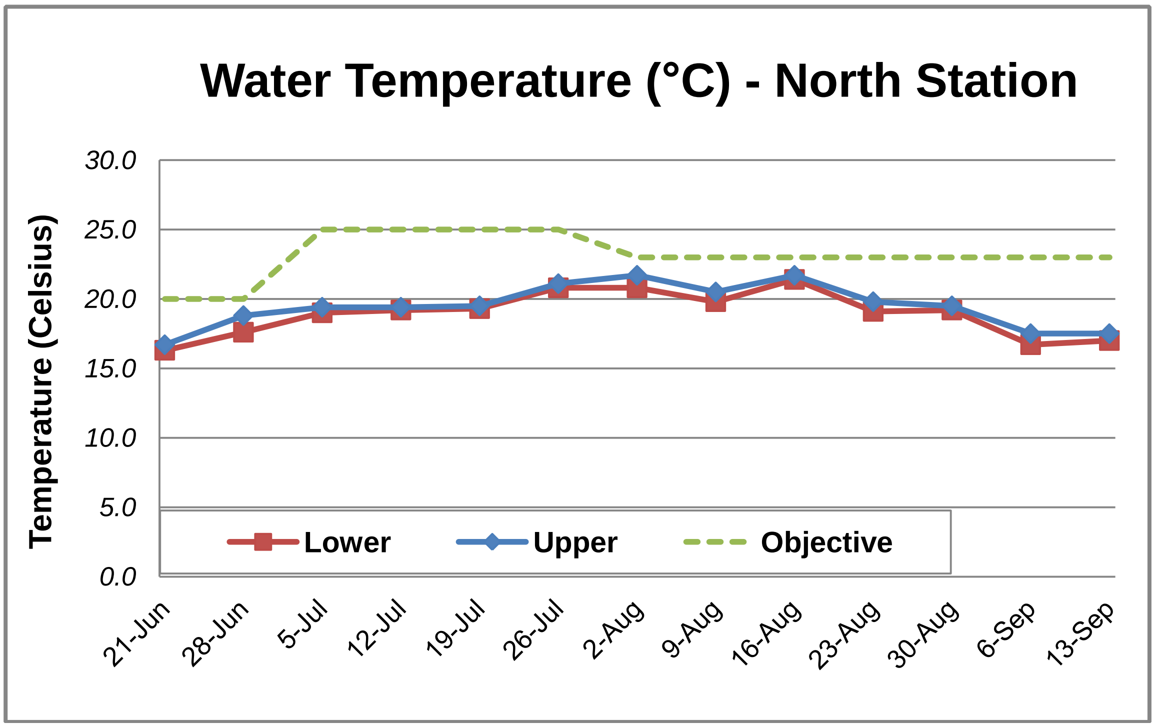


Figure 2: Example of water temperature data: North (Timber Ridge) Station, 2016. Timber Ridge is the deepest section of the lake, therefore upper and lower samples are taken for comparison. Blue diamonds represent weekly samples at the Upper (surface) layer; red squares represent weekly samples at the Lower (1 metre from bottom) layer. Water temperature objectives vary by month, as is shown by the green dotted line.

Note: Lines are for interpretation and do not represent continuous measurements.

Dissolved Oxygen

Overview

Dissolved oxygen (DO) is a measure of the amount of oxygen dissolved in water. Oxygen enters the lake through wind action and plant photosynthesis. Fish and other aquatic life need oxygen to survive.
How much oxygen is enough? The Ministry of Environment determined that oxygen should never drop to or below 5 milligrams per litre (instantaneous minimum), and the average of five samples taken over 30 days should be at or above 8 milligrams per litre (mg/L) to support aquatic life.

Results

Average oxygen levels were always sufficient for aquatic life during the 2016 sampling season. Similar to 2014-15, this year's results presented a few occasions of supersaturated levels of dissolved oxygen. Note that South and Mid Stations are surface samples only, as the lower average depth means stratification is unlikely to occur. The consistently higher DO results at the South end of the lake may be attributable to its proximity to abundant aquatic plant life (Columbia Wetlands) and lower water temperatures (cooler water holds more oxygen).

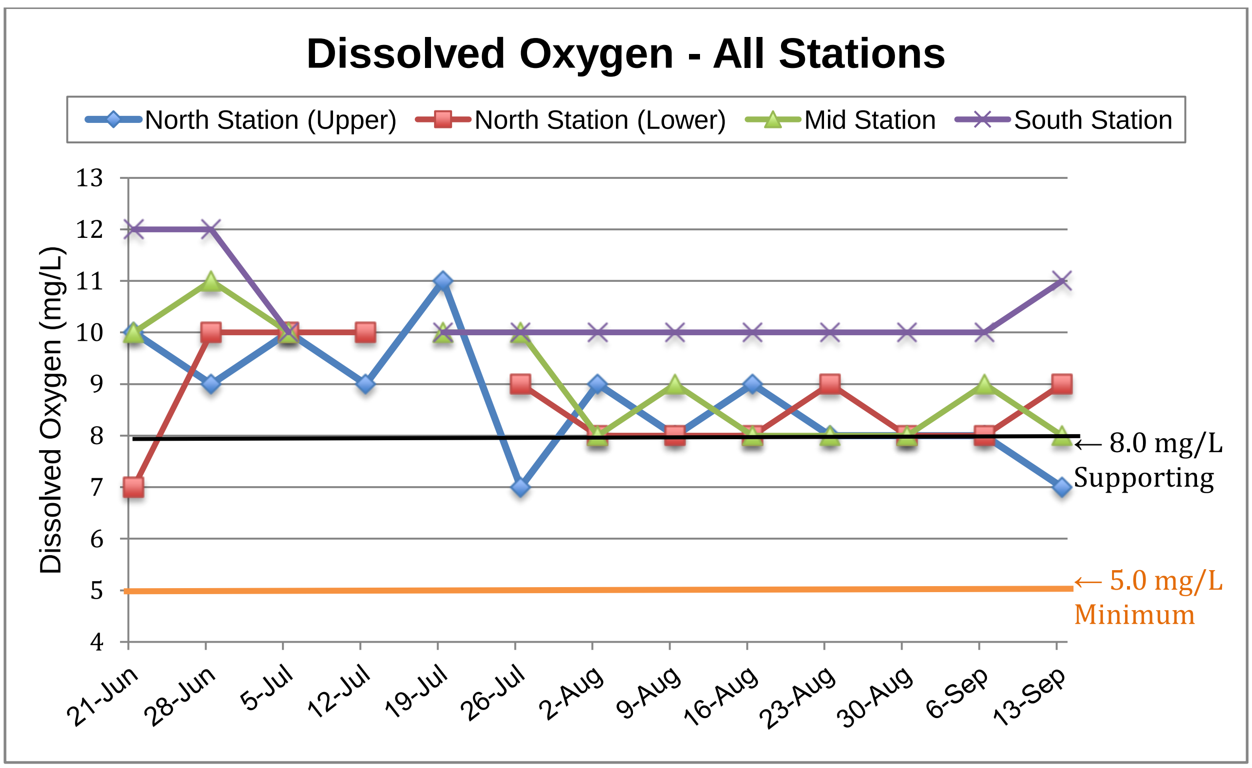


Figure 3: 2016 Dissolved Oxygen levels: All Stations. Green, Blue, Purple and Red Lines = Measured Oxygen levels; Orange line = Minimum for instantaneous readings (5.0); Black line = Objective for average oxygen measured over a 30-day period (8.0) to support aquatic life.

Turbidity

Overview

Turbidity is a measure of the light scattered by particles suspended in water, and indicates the cloudiness or clarity of the water. When waters are highly turbid, light cannot penetrate to reach aquatic plants, which reduces photosynthesis. Fish become stressed due to reduced ability to navigate, clogging of gills, and other factors. Since aquatic life in Lake Windermere has adapted to seasonal flushes of sediment into the lake, how much turbidity should be in the water (Water Quality Objective) depends on the time of year.

The turbidity Objectives for Lake Windermere are set to protect recreational water quality and aquatic life. During spring runoff (May 1 – August 15), in what is known as "turbid flow", the 95th percentile of turbidity measurements taken in 5 days over a 30-day period should not exceed 5 NTU (turbidity units). During "clear flow" (August 16 – April 30), the maximum turbidity at any time should be less than or equal to 5 NTU. Additionally, the objectives for "clear flow" is that the average of 5 samples over 30 days should not exceed 1 NTU.

Results

In 2016, turbidity levels in the lake remained safely below Objectives throughout the summer. This is in contrast to the 2012 and 2013 seasons, which saw some of the highest turbidity levels on record. The Objectives for turbidity during the turbid flow period (95th percentile below 5 NTU) were not exceeded at any of the stations. During "clear flow" after August 15th, the maximum turbidity Objective value was never exceeded at any station.

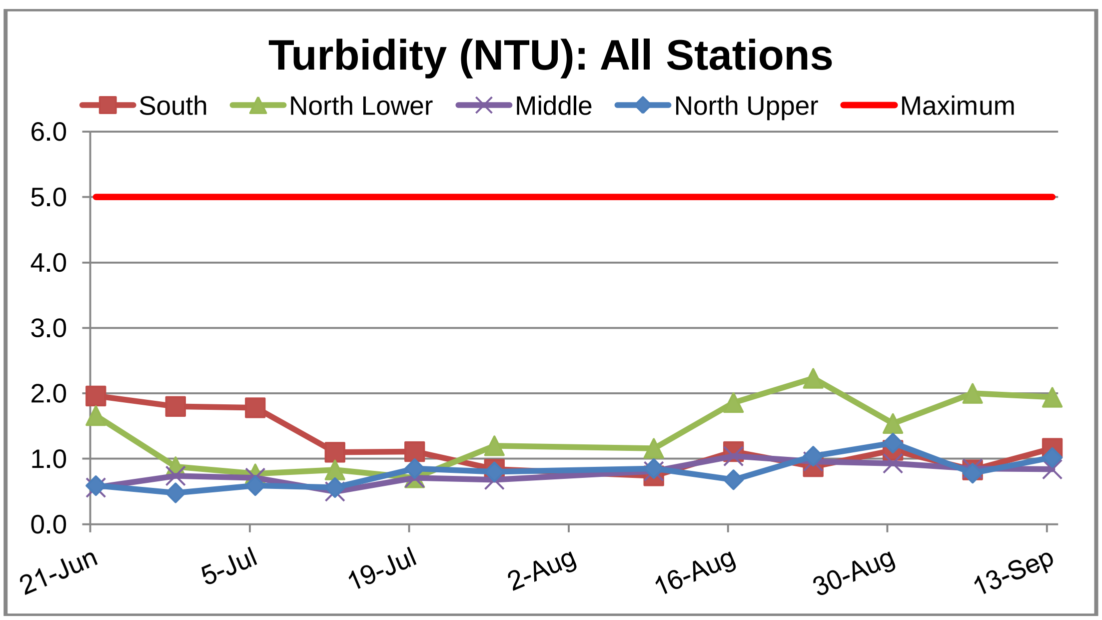


Figure 4: Turbidity measured in 2016, all stations. Coloured points are turbidity values. Solid red line is the Maximum Objective for a 30-day period during the Turbid Flow period (5.0 NTU), and for any one point during the Clear Flow period. **Note:** Lines are for interpretation and do not represent continuous measurements.

Secchi Depth

Overview

A Secchi disc gives us a reading of water transparency according to the depth of the measurement. Secchi depth, like turbidity, is a measure of the suspended particles in the water. These suspended particles can be a combination of zooplankton, algae, pollutants, and silt. Secchi data collected year after year can provide valuable information on trends in transparency in monitored lakes.

Results

The average Secchi depth for Lake Windermere in 2016 was 3.75 m +/- 0.55 m. The average from 2006, 2007, 2008 and 2011 was 4.51 m +/- 0.84 m. In 2012, average Secchi depth was much lower, at 2.92 m. The graph below shows that Secchi depths were relatively consistent throughout the whole summer, indicating clear water even during the usually turbid spring runoff period.

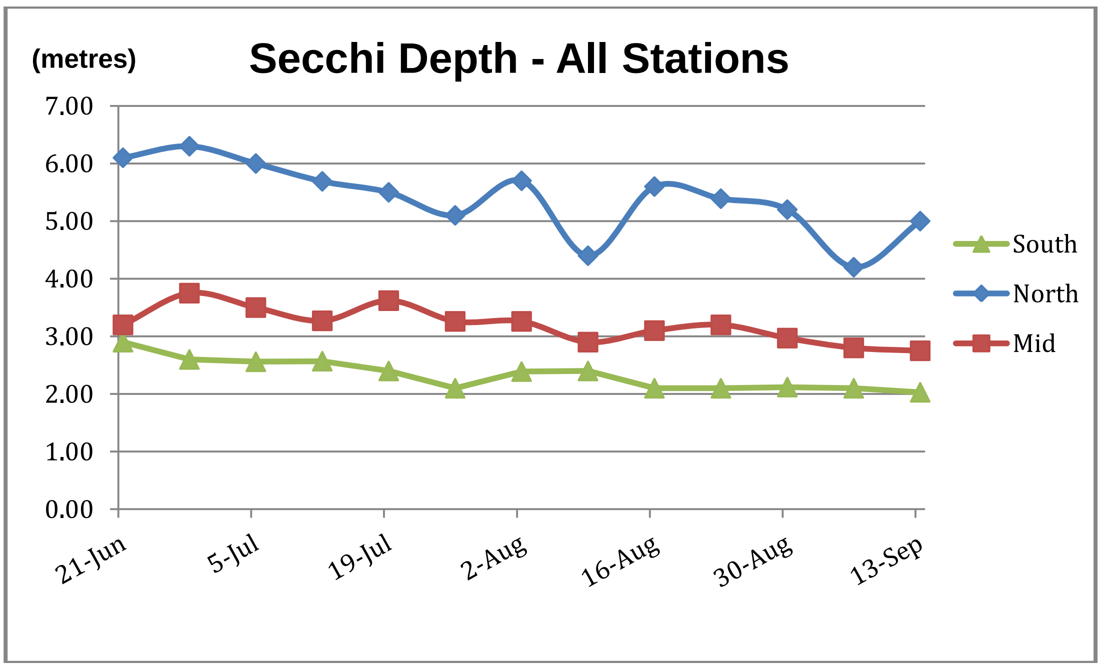


Figure 5: Secchi Depth – All Stations 2016. Compared to other lakes throughout BC measured during the BC Lake Stewardship Society's annual "Secchi Dip-in" in July 2016, Lake Windermere's clarity was close to the median. The clearest lake in BC was Gun Lake (Thompson-Nicola Region) with a Secchi depth of 21.4 m. The majority of BC lakes had clarity between 4 and 8 meters (BCLSS newsletter, October 2016).

Phosphorus

Overview

Phosphorus is a nutrient that is usually found in limited quantities in natural lakes. In excess, phosphorus can lead to algal blooms. Anthropogenic inputs (ie. from human activities) of phosphorus into lakes are one of the main contributors to excessive phosphorus and algal blooms. Historic results from sampling for phosphorus indicate that Lake Windermere is “oligotrophic.” This means that low nutrient levels and clear waters have been the norm in this lake. A report by Neufeld et al. (2010) notes that “phosphorus concentrations have remained quite similar, if not declined, since the 1970s”.

The Ministry of Environment (MOE) determined that the most Total Phosphorus (TP) that should be present in Lake Windermere is a concentration of 0.01 milligrams per liter (mg/L), collected at spring ice-off, to protect drinking water sources and aquatic life. Although phosphorus objectives were not set for summer in Lake Windermere, these levels have been monitored annually to increase understanding of nutrient dynamics in the lake.

Results

Sampling results in 2016 indicated phosphorus levels to be at or below the Objective above. This is in contrast to 2014 and 2015, where phosphorus was found to exceed the Objective for Lake Windermere after ice-off, leading the Lake Windermere Ambassadors to recommend increased vigilence in land-use management practices and more robust monitoring for this limiting nutrient.

As suggested by this year’s results, an increasing trend in phosphorus levels in Lake Windermere remains inconclusive, however contined monitoring is warranted. Taken into consideration with other critical variables, phosphorus results can indicate changes to trophic status and overall trends in lake productivity.

For example, measurements for lake clarity and oxygen levels can provide further information regarding productivity in the lake. Dissolved Oxygen rates for this year were measured at normal levels, suggesting a balance in photosynthetic activity of plants. Water clarity (turbidity and Secchi depth) results indicated a clear lake in 2016, suggesting that inputs from silt and other on-land activities were likely assimilated or flushed over time. As a widening of Columbia River, Lake Windermere is well-mixed and has a relatively rapid flushing rate of every 47 days, meaning nutrients are typically incorporated fairly well. Chlorophyll a can be measured to determine the amount of algae living in a lake. In 2014, chlorophyll a results were within the “oligotrophic” range. Rick Nordin of BC Lake Stewardship Society has recommended the Ambassadors reintroduce this parameter to sampling protocol on Lake Windermere in 2017, to help determine changes over time.

Human activities that can contribute to increasing phosphorus levels in the lake include (and are not limited to) the following: tree harvesting, agriculture, septic leaching, and stormwater run-off. Taking steps to ensure that sediment, fertilizers, septic and other phosphate-based chemicals do not enter the water body will help to prevent future changes in the productivity of Lake Windermere.

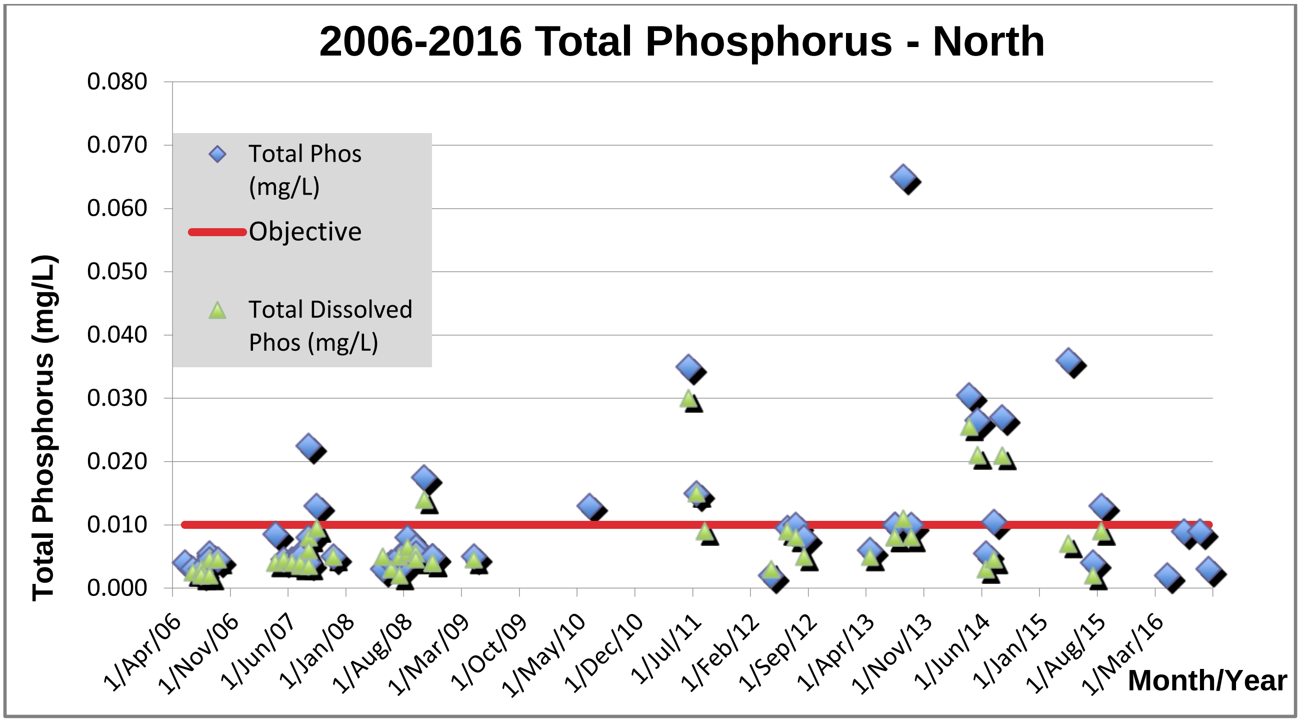


Figure 6: Total and Dissolved Phosphorus readings from May 2006 through September 2016 (Note: only Total Phosphorus was sampled in 2016). In past reports, figures have included a trendline to surmise any possible indication of an increasing overall trend in phosphorus in the lake over time. However, varied sampling technique and analytical measurement over time make trend data suspect, and as such these have been removed.

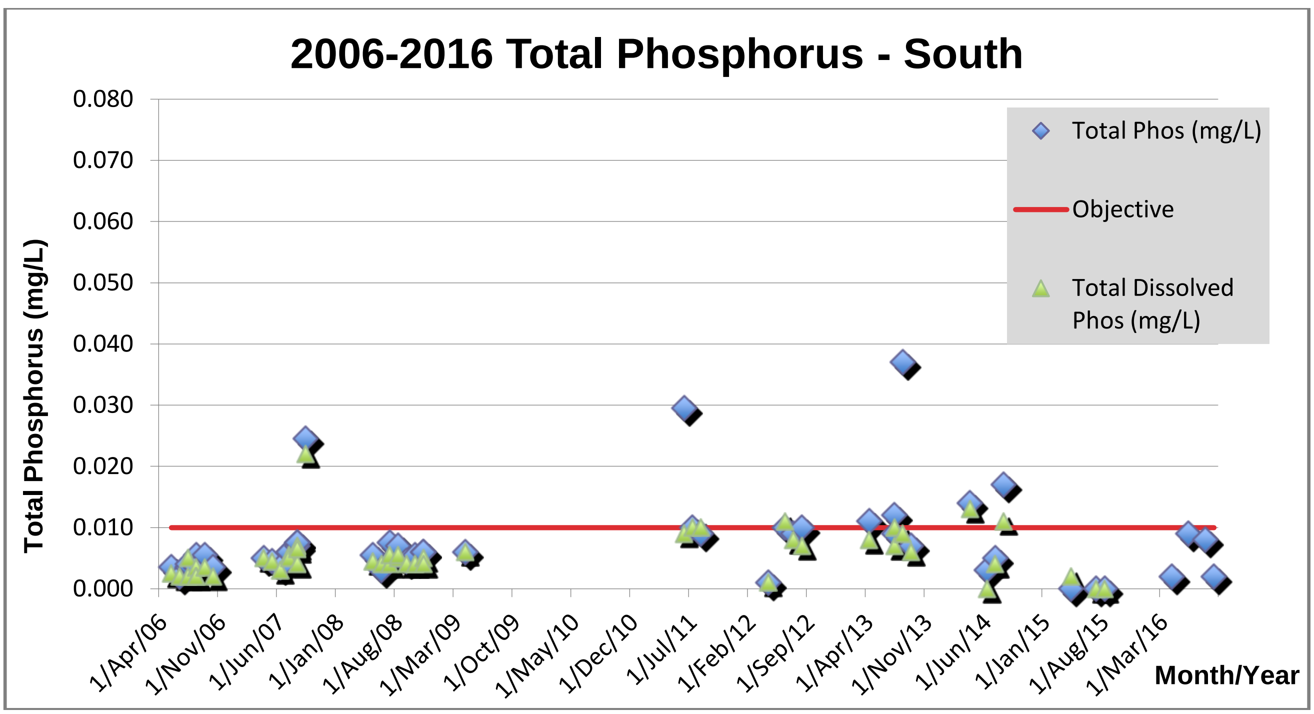


Figure 7: South Station Total and Dissolved Phosphorus readings from May 2006 through September 2016 (Note: only Total Phosphorus was sampled in 2016).

pH

<u>Overview</u>

Water is neutral at a pH level of 7, growing more acidic at lower values and alkaline (basic) at higher values. The water in Lake Windermere has historically been basic. This is characteristic of lakes fed by water flowing over limestone materials such as those present in the Canadian Rockies.

There is no Objective set for pH in Lake Windermere, however the majority of aquatic organisms prefer a habitat wherein pH ranges from 6.5-9.0.

<u>Results</u>

As per historic conditions, the pH in the lake tended towards basic in 2016. The South end of the lake was closer to neutral than the downstream sections of the lake during the spring snowmelt season, while in later summer months the Middle section of the lake tended towards neutral.

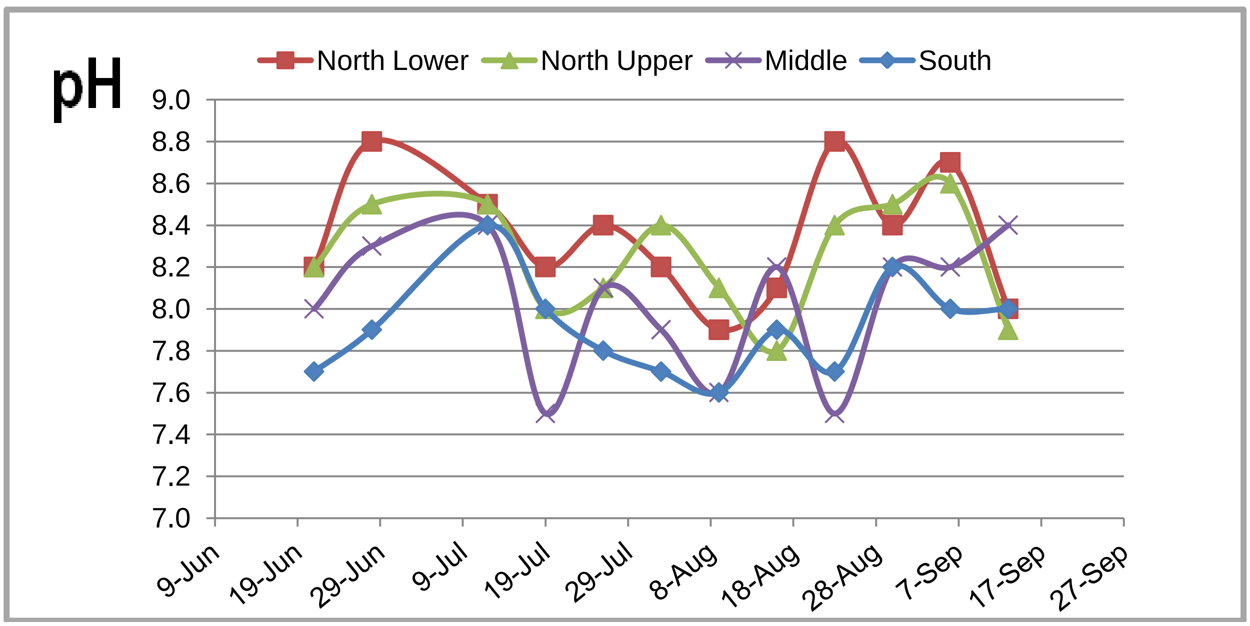


Figure 8: pH of Lake Windermere, all stations measured in 2016.
Note: Lines are for interpretation and do not represent continuous measurements.

Conductivity

<u>Overview</u>

Conductivity is a measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, sodium, magnesium, calcium, iron, and aluminum cations. Conductivity is affected by temperature: the warmer the water, the higher the conductivity.

Conductivity levels offer a clue to the nature of the kind of water flowing into the lake. A failing sewage system on the lakeshore raises the lake's conductivity because of the addition of chloride, phosphate, and nitrate; conversely, an oil spill lowers the conductivity.

The Ministry of Environment has not set Objectives for conductivity in Lake Windermere. Nonetheless, these values should be monitored regularly to detect any sudden changes that might be due to an unwanted discharge of pollution into the lake.

<u>Results</u>

Conductivity at all three stations remained relatively consistent over the summer. As depicted in Figure 10, the South end of the lake appears to be less conductive; temperature influence is likely a factor as water at the South end is cooler on average. In contrast, highly mineralized run-off or nutrient-rich soils, entering the water body through rain events, contribute to higher conductivity levels. Historically, water quality sampling at Windermere Creek has shown higher levels of conductivity than Lake Windermere, ranging from 700 to 1,000 uS/cm. As the lake's second largest tributary, this creek may have an influence on lake conductivity, though this influence appears to be minimal.

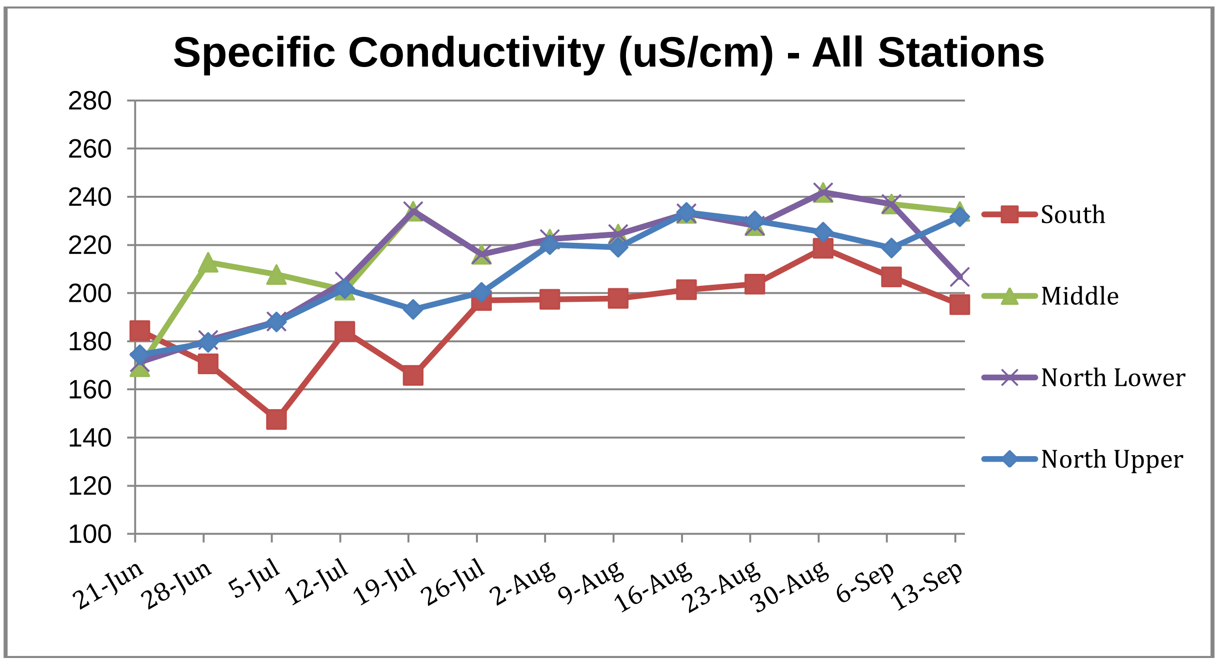


Figure 10: Conductivity results for Lake Windermere, all stations measured in 2016.
Note: Lines are for interpretation and do not represent continuous measurements.

Depth

This year's lake depth measured shallower than 2011-2013, however it closely resembled depths recorded on average between 2006 and 2008. Lake depth was highest during the June and July freshet, and slowly decreased over the summer, as can be expected due to warmer temperatures and evaporation. Figure 11 shows that site depth was fairly stable at all sampling stations throughout the summer, and consistent with historic water level differences from South to North. Figure 12 shows lake depth in 2016 compared to 2015, 2014, 2012, and 2011, and the 2006-2008 average.

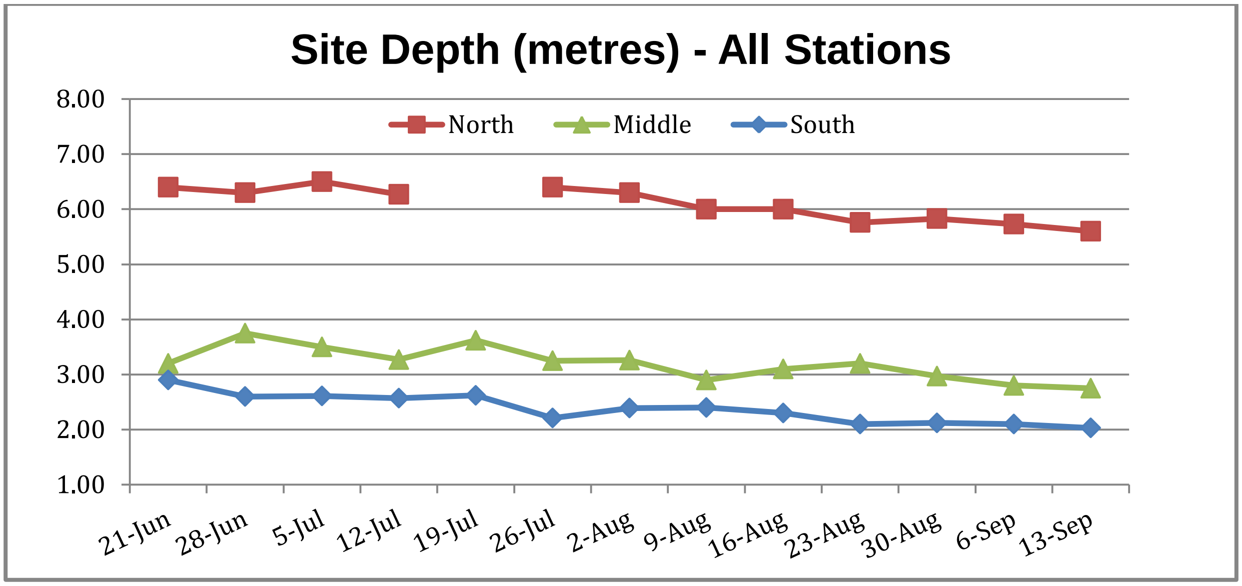


Figure 11: Water depth in Lake Windermere 2016, recorded throughout the summer at all stations. Due to strong wind conditions, the sampling crew was unable to obtain an accurate Site Depth reading on July 19th.

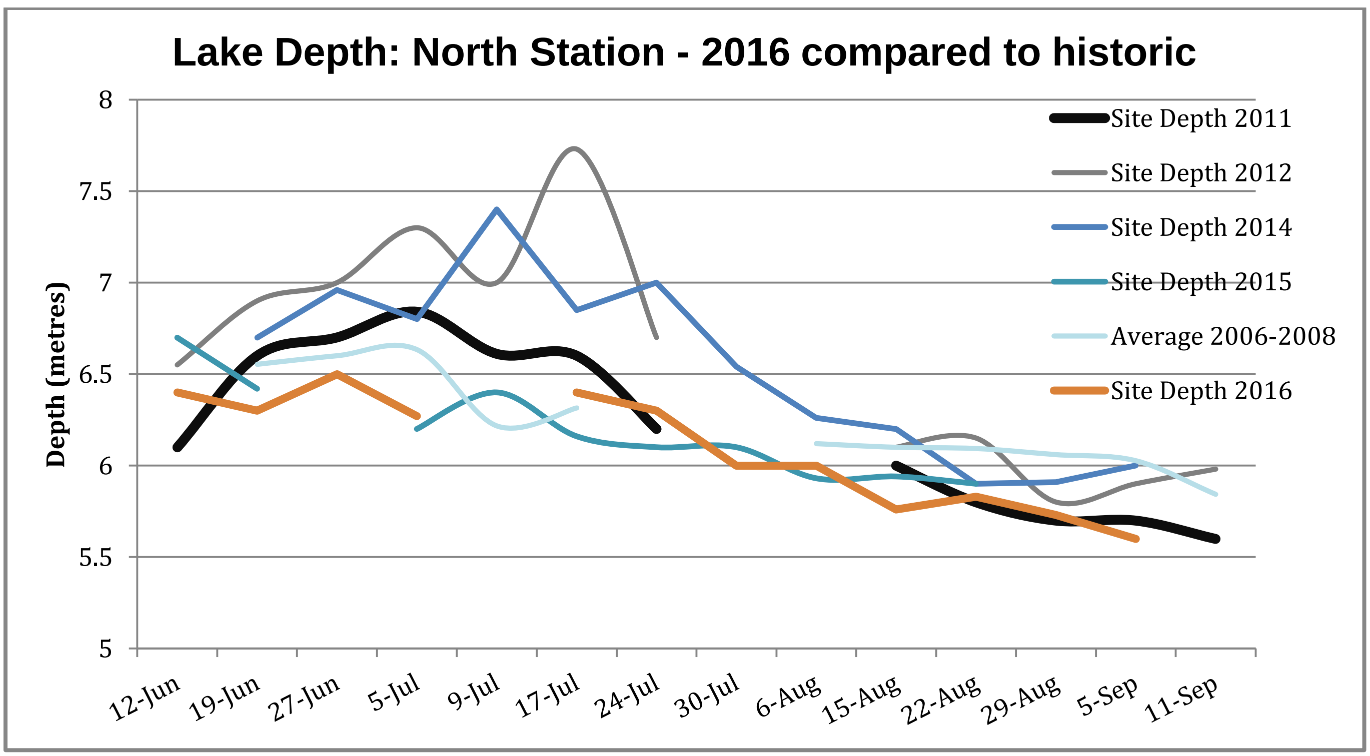
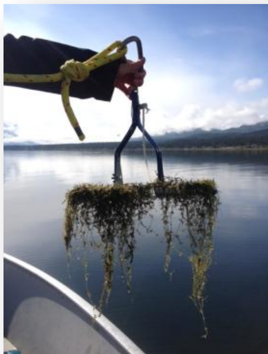


Figure 12: Water depth at the North Station, 2016 compared to historic.
Note: Data were not collected on all sampling days – some data points interpolated to smooth the line

Aquatic Plant Survey and Veliger Sampling



Following British Columbia Aquatic Invasive Species Survey Methods, both offshore and shoreline sampling were conducted by Rachel Darvill (Golden Eye Ecological Services) with assistance from Megan Peloso (Program Coordinator, Lake Windermere Ambassadors) at 11 sites on Lake Windermere over a 2-day period in September. Underwater visual observations were conducted along 100m transects at high risk locations (near boat docks and marinas) to detect small infestations. Twelve native species were identified and no aquatic invasive species were detected either offshore or from shoreline surveys.

Pat Wray (East Kootenay Invasive Plant Council) attended the second day of monitoring, and conducted veliger sampling to detect zebra or quagga mussel larvae in the lake. Using a plankton tow net, 9 samples were taken across 3 sites. A vertical tow was used in deeper sections, and a horizontal tow was used in shallower parts. Lab results indicated that no veligers were detected in these samples.

2016 marked the seventh year of aquatic plant monitoring on Lake Windermere for the purpose of detecting aquatic invasive plant species. Find the full report depicting 2016 results for the Aquatic Plant Survey, written and compiled by Rachel Darvill, on our website: www.lakeambassadors.ca.

Swim Beach Water Quality

In 2016, Interior Health analyzed public beach water samples collected by Lake Windermere Ambassadors for *E-coli* bacteria, in compliance with Health Canada Guidelines. This method allows the program to assess whether swim beach water quality meets recognized health standards.

Health Canada – Guidelines for Canadian Recreational Quality

For fresh recreational waters used for primary contact activities, the guideline values are as follows:

- Geometric mean concentration (minimum of five samples taken over 30 days): ≤ 200 *E. coli*/100 mL
- Single-sample maximum concentration: ≤ 400 *E. coli*/100 mL

The 2016 beach monitoring program assessed two sample locations on James Chabot Beach, two on Kinsmen Beach, and one on Windermere Beach.

The geometric mean did not exceed the 200 colonies/ 100 mL recommended for contact recreation on any of the public beaches on Lake Windermere, nor did any single sample exceed 400 colonies/ 100 mL. The highest single sample was 86 colonies, on August 8, 2016 at James Chabot.

The highest geomean values over a 30-day period were as follows:

James Chabot = 6.3 *E. coli*/100 mL
Kinsmen Beach = 9.9 *E. coli*/100 mL
Windermere = 6.1 *E. coli*/100 mL

Results of swim beach sampling are updated throughout the summer season and can be found by searching for Kinsmen, James Chabot or Windermere beaches at theswimguide.org.

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