



Lake Windermere 2015 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 possible without the dedication and support of community volunteers and partners. Acknowledgement is also due to Lake Windermere Ambassadors' Watershed Stewardship Assistant, Ella Swan, who contributed enthusiastic leadership to the community-based water quality monitoring project for the second consecutive year.

Executive Summary

2015 marked the tenth year of lake monitoring since the Lake Windermere Project started data collection in 2006. The spring and summer of 2014 and 2015 brought mild climatic conditions without the major flooding events which characterized 2012 and 2013. Measured lake depths in 2015 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 show that shoreline bacteria levels did not exceed the recommended Guidelines for safe swimming on any of Lake Windermere's public beaches over the summer.

Total phosphorus levels at ice-off exceeded the Objective for the Lake at two sampling stations in 2015. A slight increasing trend in this nutrient has been observed in the lake in recent years, warranting continued monitoring in conjunction with efforts on land to keep excess nutrients out of the lake.

The Ambassadors' annual aquatic plant survey found no invasive species in Lake Windermere this year, though an unknown algae was found and has not yet been identified by experts. No invasive mussels were detected through veliger sampling this year.

Questions about this report?

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Introduction

People living around and recreating on Lake Windermere depend on having water that is clean enough to swim in, fish in and recreate on, as well as to draw from as a drinking water source. Lake Windermere is 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. 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 five 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 conditions. 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 ten years of water quality data. Their continued efforts will allow for detection of changes in water quality over time.

In 2015, 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).

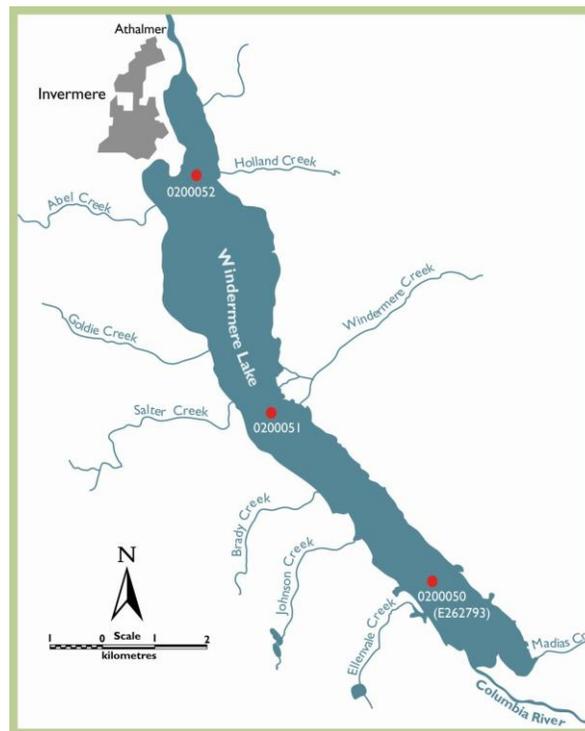


Figure 1: Lake Windermere Sampling Sites: North Station (0200052), Middle Station (0200051), and South Station (0200050)

The rest of this report documents highlights of 2015 sampling results for Temperature, Dissolved Oxygen, Turbidity, Secchi Depth, Phosphorus, pH (acidity), Conductivity, Depth, Aquatic Plants, Beaches, as well as trend analyses of composite data where possible.

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

Overall, Lake Windermere's water temperature was within the limits to protect aquatic life in 2015. With the exception of temperature readings at the North Station on June 30th, temperatures at all three water monitoring stations remained consistently below the maximum recommended temperatures throughout the summer (see Figure 2). The highest temperature reading in the lake was 22.8°C, measured July 7th and 14th on the upper strata of the North Station, which was below the objective for this month.

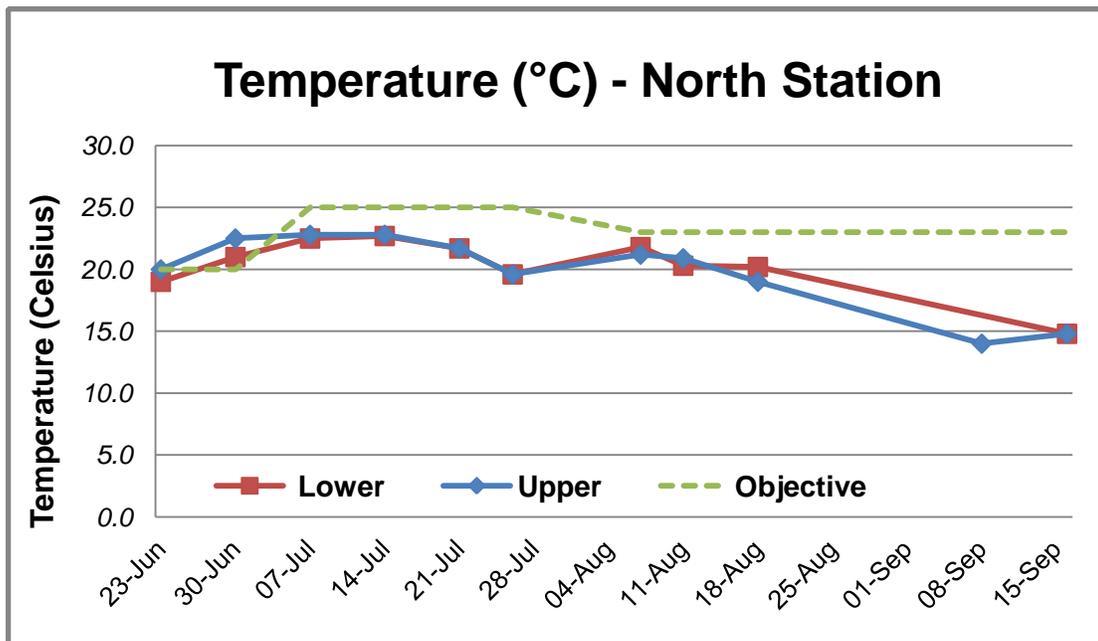


Figure 2: Example of water temperature data: North (Timber Ridge) Station, 2015. Timber Ridge is the deepest section of the lake, therefore upper and lower samples are taken for comparison. Blue diamonds represent weekly samples at the Upper (surface) layer; red squares represent weekly samples at the Lower (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 is a measure of the amount of oxygen dissolved in water. Fish and other aquatic life need oxygen to survive. The Ministry of Environment determined levels of oxygen necessary to protect aquatic life in Lake Windermere (Water Quality Objectives).

How much oxygen is enough? The Ministry of Environment determined that oxygen should never drop to or below 5 milligrams per liter (instantaneous minimum), and the average of five samples taken over 30 days should be at or above 8 milligrams per liter (mg/L) to support aquatic life.

Results

Average oxygen levels were always sufficient for aquatic life during the 2015 sampling season. This year's results did not present the supersaturated levels of dissolved oxygen noted in 2014, rather they resembled the average value recorded from 2006-2013 (9 mg/L).

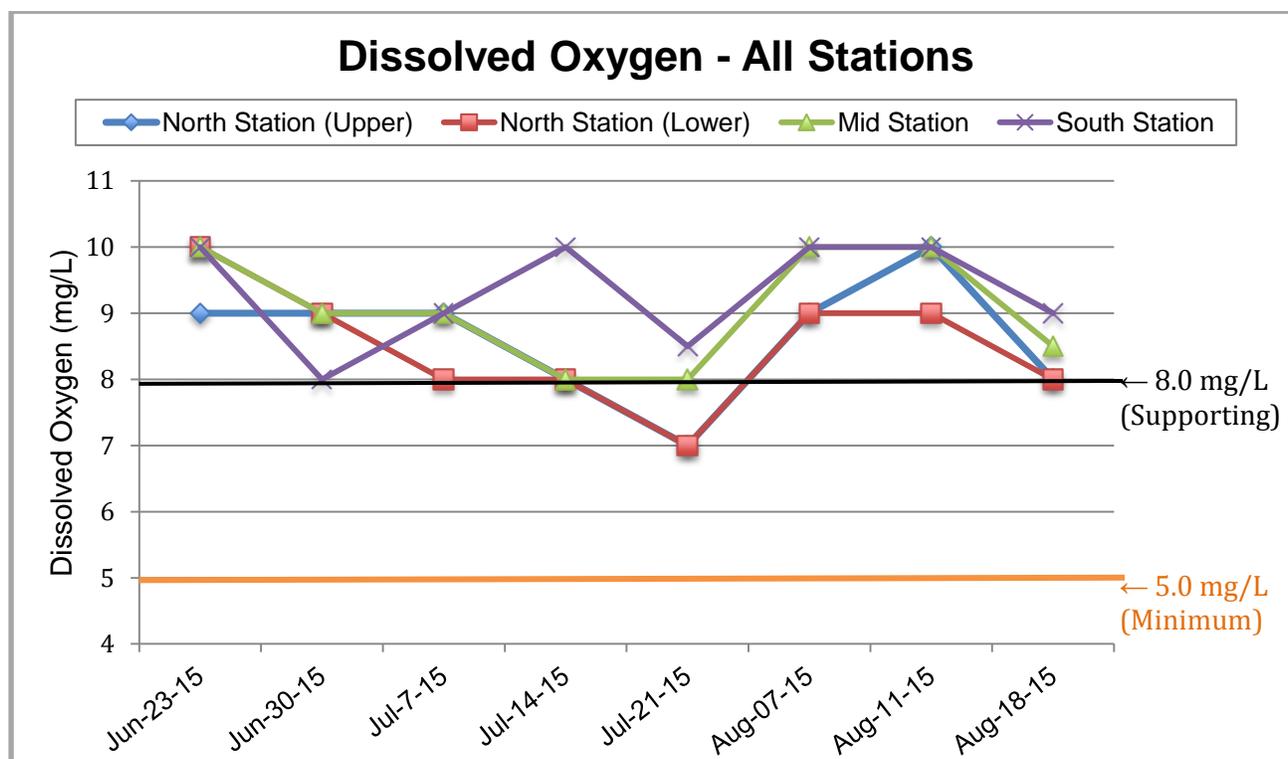


Figure 3: 2015 Dissolved Oxygen levels: All Stations. Green, Blue, Purple and Red Lines = Measured Oxygen levels; Orange line = Minimum for instantaneous readings (5.0); Black line = Objective for average oxygen measured over a 30-day period (8.0) to support aquatic life.

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 then 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 time of year.



The Objectives for Lake Windermere for turbidity 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

Turbidity levels in the lake in 2015 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.

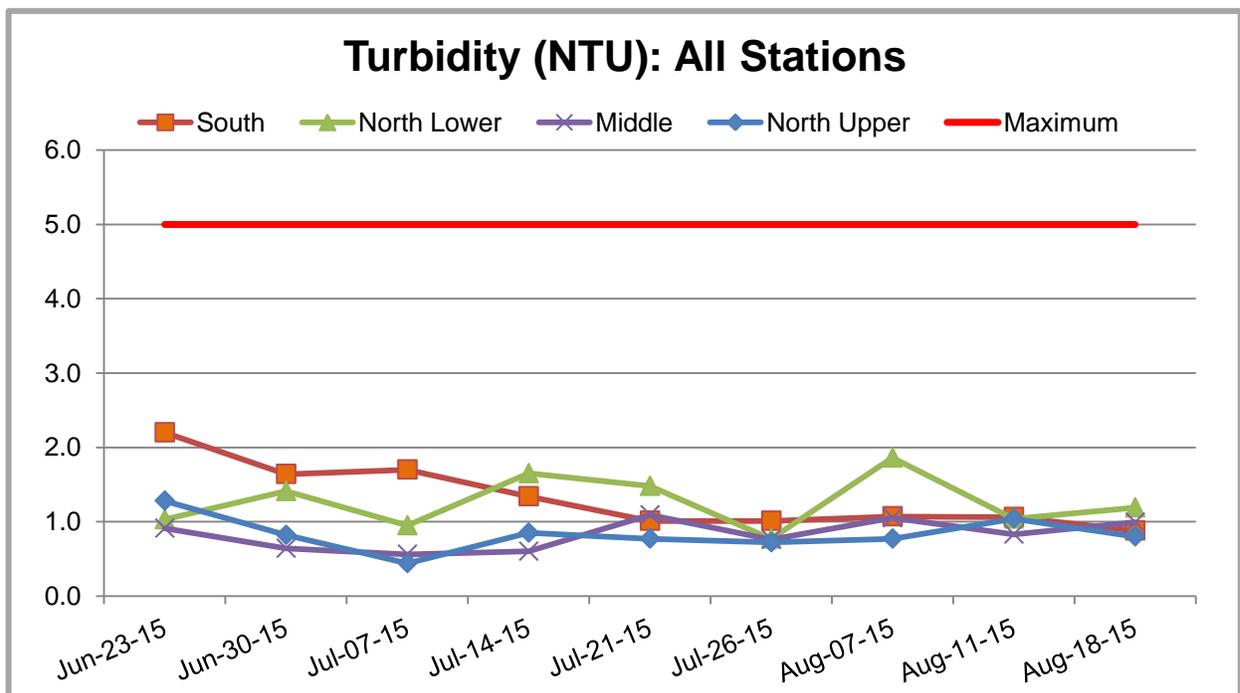


Figure 4: Turbidity measured in 2015, all stations. Coloured points are turbidity values. Solid red line is the Maximum Objective for a 30-day period during the Turbid Flow period (5.0 NTU), and for any one point during the Clear Flow period.

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

Secchi Depth

Overview

A Secchi disk 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 things such as 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 2015 was 3.76 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.

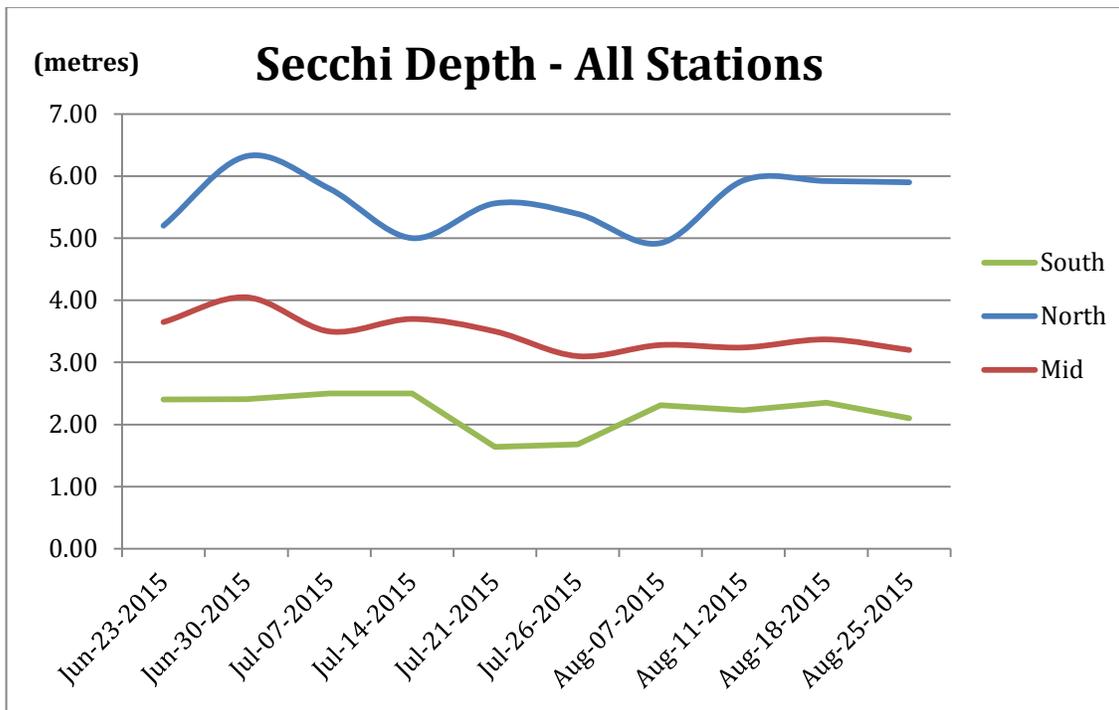


Figure 5: Secchi Depth – All Stations 2015

Compared to other lakes throughout BC measured during the BC Lake Stewardship Society’s annual “Secchi Dip-in” in July 2014 (2015 measurements were not yet available), Lake Windermere’s clarity was close to the median. The clearest lake in BC had a Secchi depth of 22 m. The majority of BC lakes had clarity between 4 and 8 meters (BCLSS newsletter, October 2014).

Phosphorus

Overview

Phosphorus is a nutrient that is usually found in limited quantities in natural lakes. In high quantities it leads to algae blooms. Unnatural inputs of phosphorus into lakes are one of the main contributors to algae 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.



The Ministry of Environment (MOE) determined that the most total phosphorus that should be present in Lake Windermere (Objective) 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 summer phosphorous levels were not set by the MOE for Lake Windermere, these levels have been monitored annually to increase understanding of nutrient dynamics in the lake.

Results

After ice-off, North and South stations exceeded Objectives for Total Phosphorus (0.01 mg/L). At the North station, samples were taken one metre from the bottom and one metre from the top, both measured values were 0.036 mg/L. At the South Station, one sample was taken with total phosphorus measured at 0.025 mg/L.

Total Dissolved phosphorus was also analyzed with these samples. At the North Station, the upper sample measured 0.007 mg/L in Total Dissolved phosphorus, and the lower sample measured 0.002 mg/L.

According to Rick Nordin, PhD Aquatic Ecologist and advisor at the BC Lake Stewardship Society, different results for Total phosphorus and Total Dissolved phosphorus can indicate higher contributions of inorganic or non bio-available phosphorus which typically comes in the form of particulates or silt. Since higher levels of Total phosphorus were recorded in Lake Windermere at springtime after ice-off, while Total Dissolved phosphorus levels remained below the objective, it is plausible that episodic in-flows of water characteristic of spring freshets contributed inorganic silt to the lake through its tributaries.

Figure 7 and 8 below show an increasing trend in Total phosphorus at the North and South ends of the lake over time. The “Water Quality Objectives for Lake Windermere” (Neufeld, 2010) report notes, “*phosphorus concentrations have remained quite similar, if not declined, since the 1970s.*” Given the fact that this important nutrient was found to exceed the Objective for Lake Windermere for the second year after ice-off, increased vigilance in watching nutrient levels in the lake is warranted.

While this trend should continue to be monitored closely in years to come, it would be inaccurate to conclude from these measurements alone that Lake Windermere is undergoing early eutrophication. Although phosphorus is one indicator of trophic status, there are other critical variables to take into consideration to understand overall productivity and level of nutrients. For example, 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, suggesting increases in the nutrient phosphorus had not led to an increase in algal productivity in the lake.

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 2015, suggesting that inputs from silt and other on-land activities are 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 assimilated fairly well.

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.

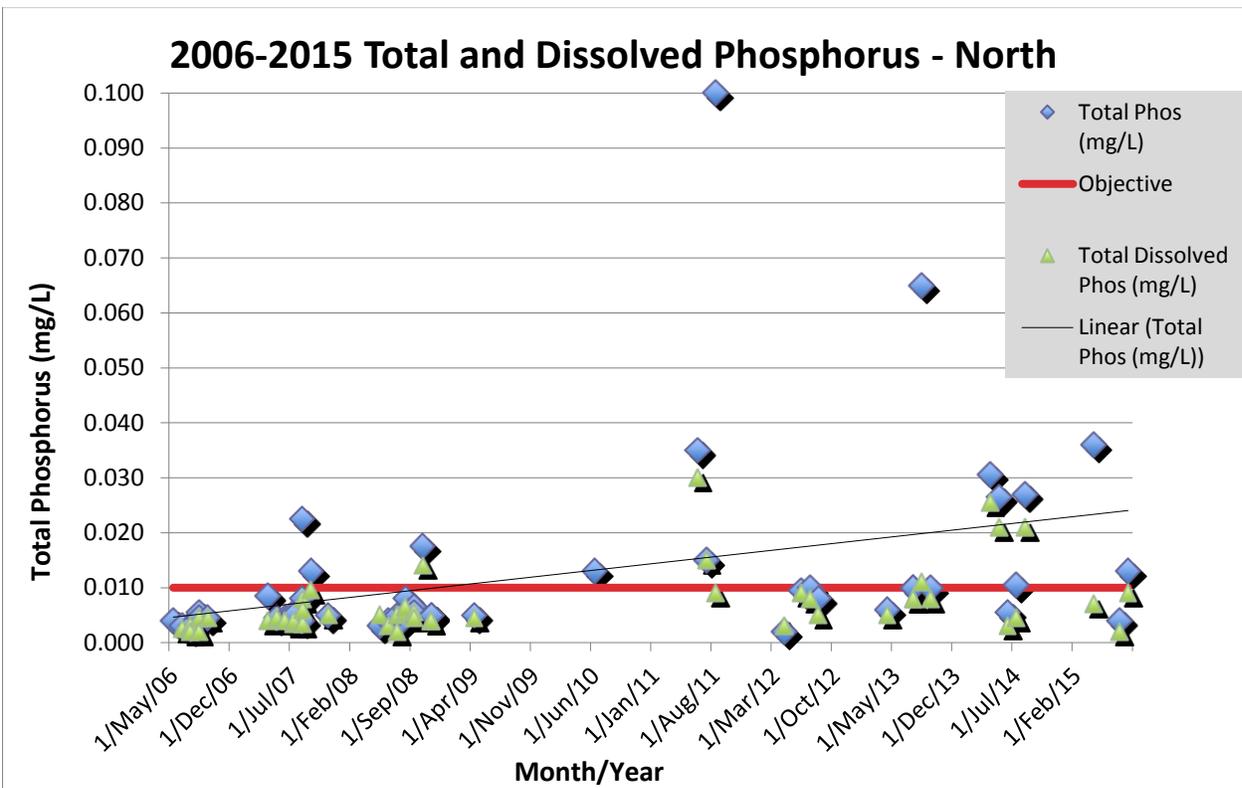


Figure 6: Total and Dissolved Phosphorus readings from May 2006 through August 2015. The black linear trend line illustrates an increase in Total Phosphorus in the lake over time.

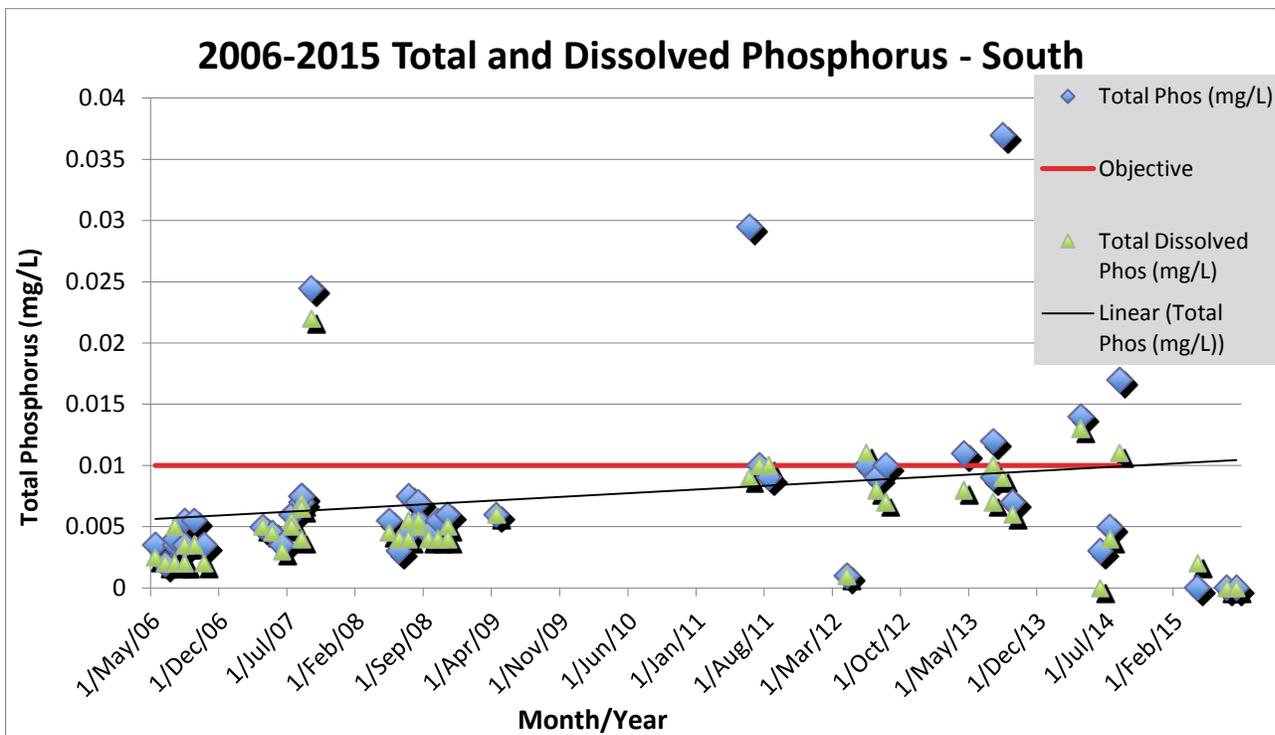


Figure 7: South Station Total and Dissolved Phosphorus readings from May 2006 through August 2015. The black linear trend line illustrates an increase in Total Phosphorus in the lake over time.

pH

Overview

Water is neutral at a 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, however the majority of aquatic organisms prefer a habitat wherein pH ranges from 6.5-9.0.

Results

As per historic conditions, the pH in the lake tended towards basic in 2015. 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.

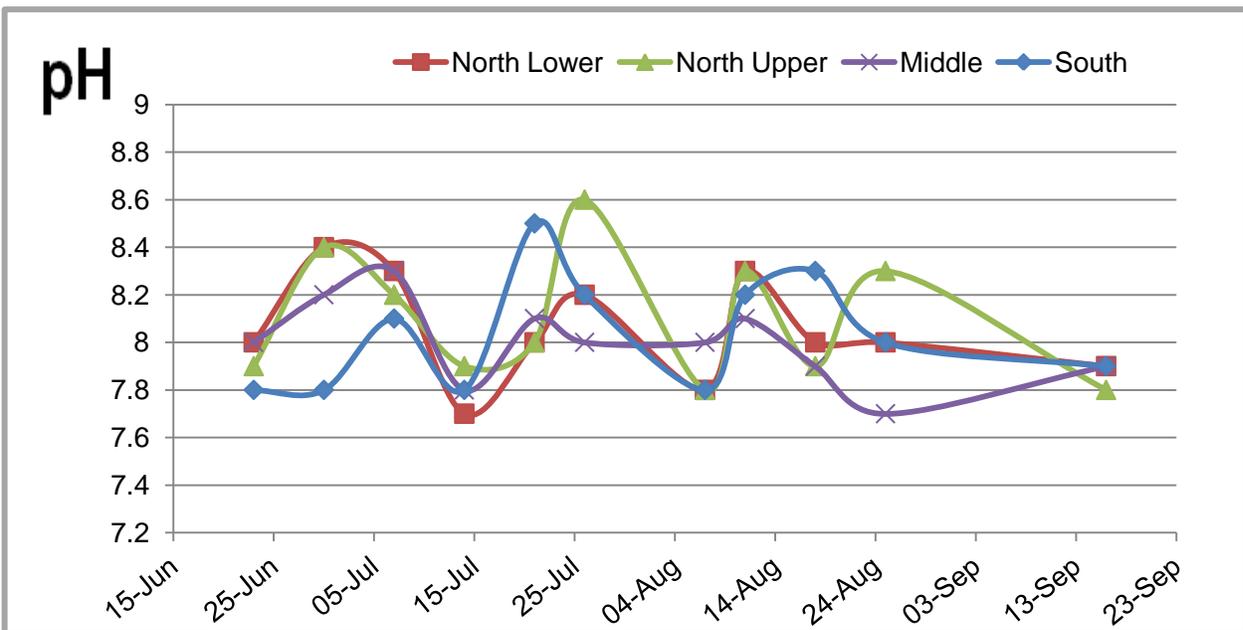


Figure 8: pH of Lake Windermere, all stations measured in 2015.

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

Conductivity

Overview

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; an oil spill lowers the conductivity.

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

Results

Conductivity at all three stations remained relatively consistent over the summer, with a notable spike in July at the Middle Station. The influence of temperature on conductivity may be a factor, since water temperature peaked in July and then decreased. In addition, highly mineralized run-off or nutrient-rich soils can enter the water body through rain events, contributing 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.

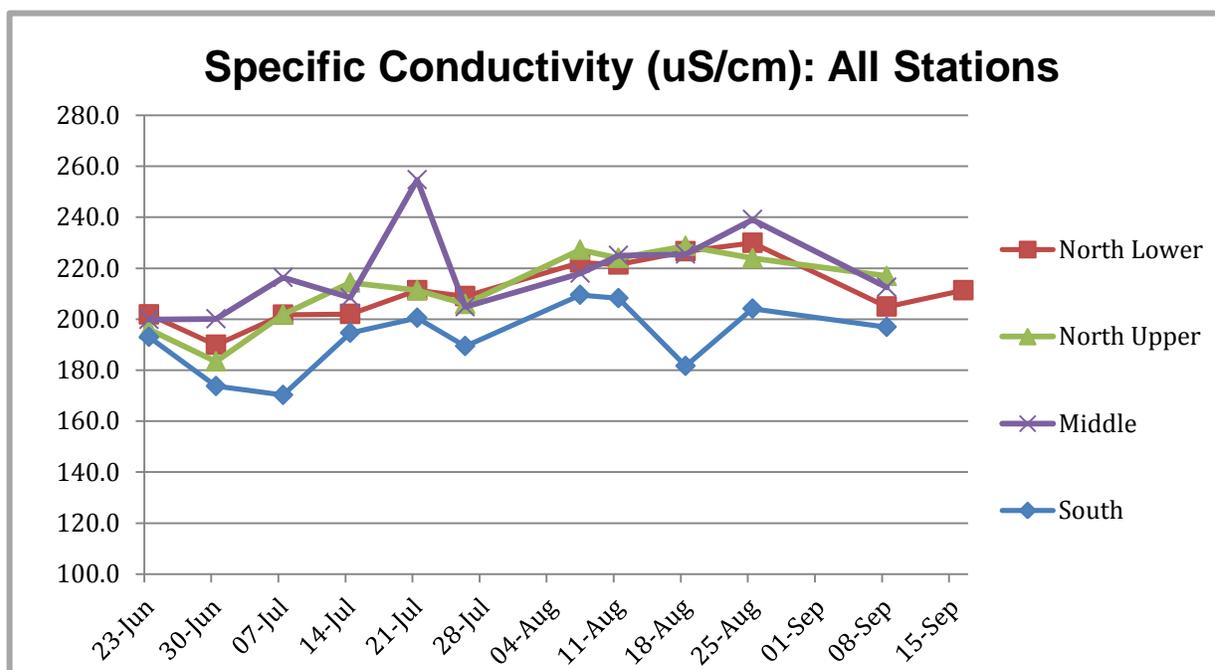


Figure 10: Conductivity results for Lake Windermere, all stations measured in 2015.

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

Depth

This year's lake depth measured shallower than more recent years, 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. Below are two graphs illustrating depth. Figure 10 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 11 shows lake depth in 2015 compared to 2014, 2012, and 2011, and the average between 2006 and 2008.

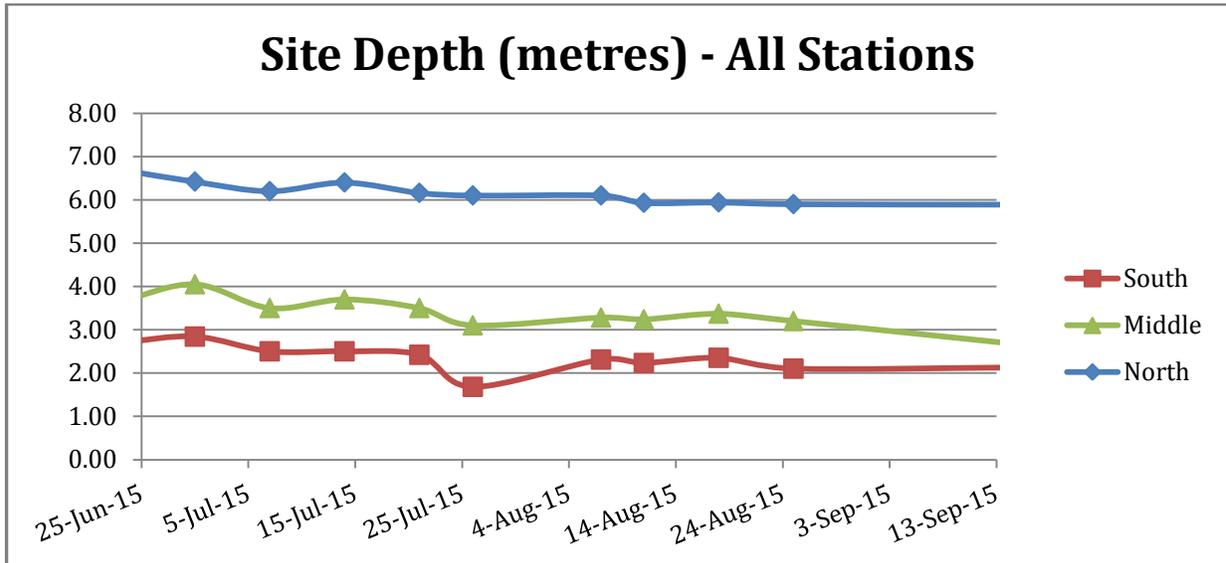


Figure 11: Water depth in Lake Windermere 2015, recorded throughout the summer at all stations.

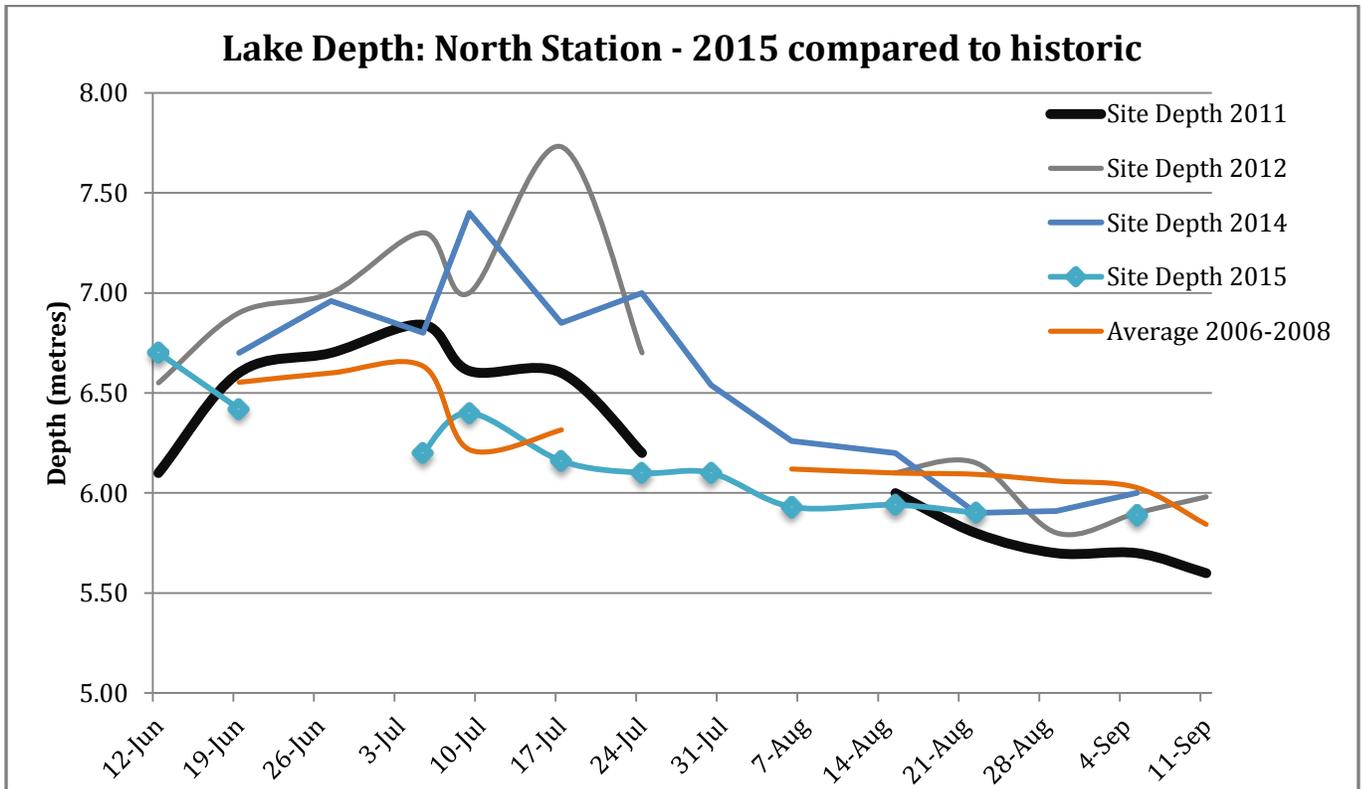
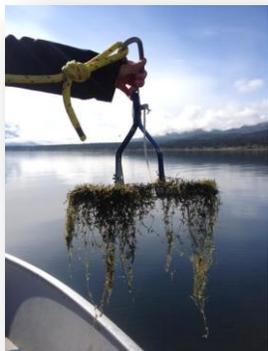


Figure 12: Water depth at the North Station, 2015 compared to historic.

*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 also conducted along 100m transects at high risk locations (near boat docks and marinas) to detect small infestations. Twelve native species were identified during sampling and no aquatic invasive species were detected. One unknown microfilamentous algae species was found at two locations near Athalmer. Samples were collected with a thatch rake and sent to the the University of British Columbia for identification. Results were inconclusive with no positive ID made by experts.

Linda McVetty (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 indicate that no veligers were collected in these samples.



A full report depicting 2015 results for the Aquatic Plant Survey, written and compiled by Rachel Darvill, can be found on our website: www.lakeambassadors.ca.

Swim Beach Water Quality

In 2015, Interior Health updated its protocols to analyze beach water samples for the *E-coli* bacteria, in compliance with Health Canada Guidelines. This new analysis method allowed the program to gain a better assessment of whether swim beach water quality met recognized standards than in previous years, when the water was tested for fecal coliform bacteria.

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 2015 beach monitoring program assessed two sample locations on James Chabot Beach, two on Kinsmen Beach, and one on Windermere Beach. Note that water samples collected between August 10th and September 14th were not viable due to shipping delays (too long in transit). Therefore, this data could not be included in the annual report.

The geometric mean did not exceed the 200 colonies/ 100 mL recommended for contact recreation on any of the public beaches, nor did any single sample exceed 400 colonies/ 100 mL. The highest single sample was 35 colonies, on July 27, 2015 at Kinsmen Beach.

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

James Chabot = 8.0 *E. coli*/100 mL
Kinsmen Beach = 11.0 *E. coli*/100 mL
Windermere = 1.0 *E. coli*/100 mL



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References

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