ENVIRONMENTAL QUALITY SERIES

# Shawnigan Lake: Water Quality Objectives Attainment (2015-2019)

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**Cover Photograph:**
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# EXECUTIVE SUMMARY

Water quality objectives (WQO) were developed for Shawnigan Lake in 2007 and were designed to protect existing and future water uses (Rieberger, 2007). Ambient WQO were set for dissolved oxygen, water clarity (Secchi depth), total phosphorus, total nitrogen, N:P ratio, turbidity, total organic carbon, chlorophyll *a, E. coli*, enterococci and fecal coliforms. WQO attainment monitoring was conducted in 2018 and 2019 to determine if these objectives were being met and to understand the overall state of water quality in Shawnigan Lake.

Non-point sources of waste are the only major input of pollutants to Shawnigan Lake. These are potentially derived from urban runoff, land development, on-site septic systems, agriculture, marinas and boating, industrial and forestry activities. Despite the increase in development and land-use changes in the watershed, the WQO attainment data presented in this report indicate that the overall state of lake water quality continues to be good. While some of the WQOs were exceeded, the data show that the lake remains oligotrophic (low nutrients and low biological productivity), and there is no indication of overall deterioration in water quality.

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## 1. INTRODUCTION

As part of the Province of British Columbia Ministry of Environment and Climate Change Strategy's (ENV) mandate to manage and protect water bodies, water quality assessments and Water Quality Objective (WQO) reports have been created for numerous lakes, rivers and marine surface waters. These reports provide a list of objectives to protect water quality that are tailored to the specific water body for which they have been created, considering natural local water quality, water uses, water movement, and waste discharges. While the WQOs currently have no legal standing, they can direct resource managers aiming to protect the water body in question and are used as a standard against which to measure any changes in the water quality of that water body. The science-based information and trends identified help inform local government on drinking water, liquid waste and land use planning, water quality targets and effective monitoring of those plans. Once objectives have been developed, periodic monitoring (approximately every three to five years) is undertaken to determine whether they are being met.

Shawnigan Lake is located within the Shawnigan Lake watershed as part of the Nanaimo Lowland (NAL) ecoregion (Figure 1). WQOs for the lake were developed by Rieberger (2007) to protect drinking water, primary contact recreation, and aquatic life (Table 1). Objectives were based on data collected between 2003 and 2005, as well as historical data. Water quality monitoring to determine objectives attainment occurred between 2007 and 2014 (see published attainment report by Kopat *et al.*, 2019a) and again in 2018 and 2019; this report presents any changes in the watershed since 2015 and summarizes 2018-2019 sampling results.

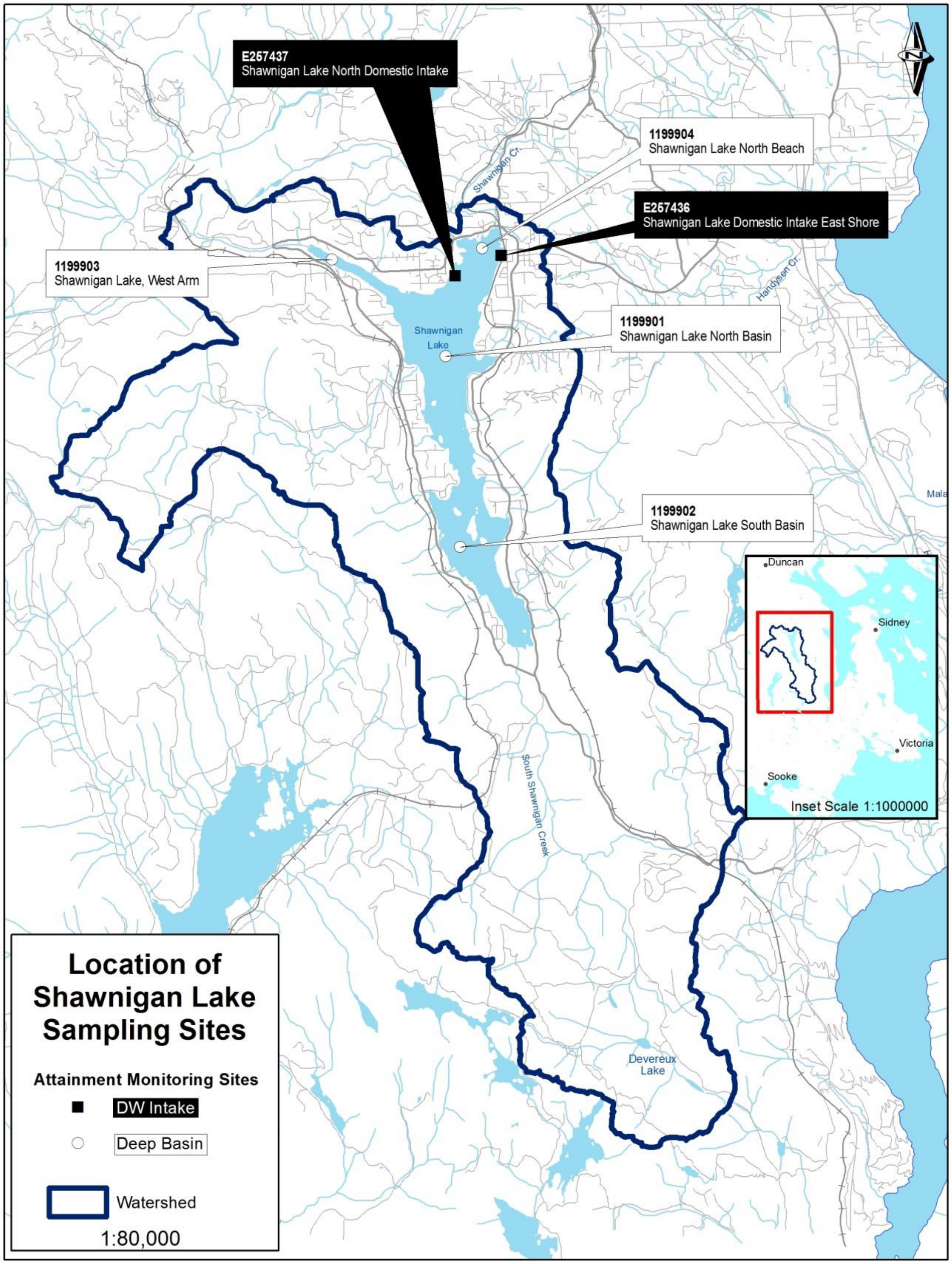



*Figure 1. Water quality attainment sampling sites within the Shawnigan Lake watershed (2018-2019).*

*Table 1. Water Quality Objectives for Shawnigan Lake.*

<table>
<tr><th>Site (see Figure 1)</th><th>1199901</th><th>1199902</th><th>1199903</th><th>1199904</th><th>E257436</th><th>E257437</th></tr>
<tr><td>Designated Water Uses</td><td colspan="6">Drinking water, recreation (primary contact), aquatic life</td></tr>
<tr><td colspan="7">Characteristics</td></tr>
<tr><td>Dissolved Oxygen[1]</td><td colspan="4">≥ 5 mg/L</td><td></td><td></td></tr>
<tr><td>Secchi Depth[2]</td><td colspan="4">≥ 5 m</td><td></td><td></td></tr>
<tr><td>Total Phosphorus[3]</td><td colspan="4">≤ 8 µg/L at spring overturn</td><td></td><td></td></tr>
<tr><td>Total Nitrogen[4]</td><td colspan="4">≤ 250 µg/L</td><td></td><td></td></tr>
<tr><td>N:P Ratio[5]</td><td colspan="4">≥ 30:1</td><td></td><td></td></tr>
<tr><td>Turbidity[6]</td><td></td><td></td><td colspan="2">≤ 1 NTU</td><td></td><td></td></tr>
<tr><td>Total Organic Carbon</td><td colspan="4">≤ 4 mg/L</td><td></td><td></td></tr>
<tr><td>Chlorophyll-a [7]</td><td colspan="2">≤ 2 µg/L</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Escherichia coli [8]</td><td></td><td></td><td colspan="4">≤ 10 CFU/100 mL (90th percentile)</td></tr>
<tr><td>Enterococci[8]</td><td></td><td></td><td colspan="4">≤ 3 CFU/100 mL (90th percentile)</td></tr>
<tr><td>Fecal Coliforms[8]</td><td></td><td></td><td colspan="4">≤ 10 CFU/100 mL (90th percentile)</td></tr>
</table>

*1 This objective applies to any depth of the water column throughout the year.*

*2 Annual mean.*

*3 This objective applies to the average of at least three samples taken throughout the water column (surface, mid depth, one metre above bottom) for sites 1199901 and 1199902 and to the average of at least two samples (surface and one metre above bottom) for sites 1199903 and 1199904.*

*4 This objective applies to the average of at least three samples taken throughout the water column (surface, mid depth, one metre above bottom) for sites 1199901 and 1199902 and to the average of at least two samples (surface and one metre above bottom) for sites 1199903 and 1199904, at spring overturn.*

*5 The N:P ratio is calculated using average total nitrogen and total phosphorus concentrations.*

*6 This objective applies to any grab sample taken within 10 m of a domestic water intake (E257436 and E257437). It also applies to sites 1199903 and 1199904 which likely reflect conditions near domestic intakes on the lake.*

*7 Values are to be growing season averages for epilimnetic water in the main basin of the lake.*

*8 The 90th percentiles are calculated from at least five weekly samples collected in a period of 30 days. For values recorded as <1, a value of 0 should be used to calculate the statistic. If any of the objectives are exceeded, further sampling should be conducted during the summer low flow and fall freshet periods, consisting of at least 5 weekly samples in a 30-day period.*

## 2. CHANGES IN THE WATERSHED SINCE LAST ATTAINMENT MONITORING REPORT:

- The 2016 census showed the watershed supports a population of 8558 people (2016 Census; CVRD, 2016), which represents a 5% increase relative to the 2011 population, and a 129% increase relative to the 1986 population. The population has likely continued to increase since the 2016 census.
- The watershed area is characterized by incremental changes, with ongoing redevelopment of existing properties, in some cases converting former seasonal residences to year-round occupancy (Moore, *pers. comm.* 2019).
- The unique characteristic of the population growth in Electoral Area B is that the majority of the growth is outside of the Urban Containment Boundaries. Rather than concentrating population growth in the village area where there is potentially enough density to support a sewer system, the continuing growth around the lake requires continuing and increasing reliance on individual septic systems (Moore, *pers. comm*. 2019).

- The CVRD is working on an update to the South Sector Liquid Waste Management Plan, which will include recommendations for future options for dealing with liquid waste in the Shawnigan watershed (Moore, *pers. comm.* 2019).
- Invasive Eurasian watermilfoil (*Myriophyllum spicatum L.*) has been confirmed in Shawnigan Lake. The perennial aquatic plant established in the late 1970's and continues to be an increasing problem (Moore, *pers. comm.* 2019; Williams *et al.*, 2018).

## 3. SAMPLING AND ANALYTICAL METHODS

As part of the WQO attainment monitoring recommended in Table 2, six water quality sites within Shawnigan Lake were sampled between March 2018 and March 2019: two deep basin sites (south and north basins), two shallow sites (West Arm and near the lake outlet) and two water intake sites (Figure 1). Sampling occurred on March 1, 2018 and March 19, 2019 to asses the spring overturn conditions (; Rieberger, 2007) and on May 8, 2018 and August 30, 2018 to assess summer conditions. All sampling was conducted as per standard ENV sampling protocols (BC ENV, 2013).

*Table 2. Recommended water quality sampling program (Rieberger, 2007) including EMS IDs, timing of sampling events and characteristics to be measured. Note that parameters in addition to those with objectives (Table 1) are included.*

<table>
<tr><th>Site</th><th>Depth</th><th>Parameters</th><th>Timing</th></tr>
<tr><td>1199901<br>1199902</td><td>●Surface<br>●mid-depth<br>●bottom (1m above surface)</td><td rowspan="4">●Anions: dissolved chloride<br>●Field Measurements: DO profile, temperature profile, Secchi depth<br>●Nutrients: total P, dissolved P, total N, total organic N, $NO_3$-N+$NO_2$-N, $NO_2$-N, ammonia, total organic C, total inorganic C<br>●Physical Properties: conductivity, pH, total solids, total dissolved solids, turbidity<br>●Total Metals<br>●Biological: phytotoplankton(1), zooplankton(2), chlorophyll a</td><td rowspan="5">Spring overturn (preferably before February 28)</td></tr>
<tr><td></td><td></td></tr>
<tr><td>1199903<br>1199904</td><td>●Surface<br>●bottom (1m above surface)</td></tr>
<tr><td></td><td></td></tr>
<tr><td>E257436<br>E257437</td><td>●Surface<br>●bottom (1m above surface)</td><td>E. coli, enterococci, fecal coliforms(3)</td></tr>
</table>

*1. Surface (0.5 m) unconcentrated 1 L sample preserved with Lugol's solution.*

*2. Vertical haul from 10 m to surface. Preserved in 5% formalin. Mouth size of net must be recorded.*

*3. If any of these results exceed objective levels, further sampling should be conducted during the summer low flow period and the fall freshet, consisting of at least 5 weekly samples in a 30-day period.*

Note standardized provincial sampling methodology for grab samples at depth has changed since the 2006-2014 WQO attainment report (Kopat *et al.*, 2019). Two different sampling protocols were used in the 2018 and 2019 sampling. The first in August 2018 was according to previous procedures (i.e. those used in Rieberger, 2007 and Kopat *et al.*, 2019) with samples collected from the surface, mid-depth and 1 m from the bottom. The second procedure, used at sites 1199901 and 1199902 on all four 2018 and 2019 sample dates (March 1, 2018, May 8, 2018, August 30, 2018 and March 19, 2019) employed composite sampling. In this methodology, the position of the thermocline (steep temperature change with depth, also called the metalimnion) was first determined. Next, composite samples from both the epilimnion (above the thermocline) and hypolimnion (below the thermocline) were collected using a Van Dorn sampler. Each composite sample consisted of three grab samples: one from 1 m from the top, one from 1 m from the bottom and one from the middles of each of the layers. The composite sample from the epilimnion is considered a representative surface or shallow water sample and the one from the hypolimnion is a representative deeper water sample.

Microbiological monitoring follows a different protocol than water chemistry samples. A minimum of five weekly samples (*E.coli*) are obtained over a 30-day period (Rieberger (2007). Samples were not collected at 11999013 and 1199904 to enable comparison to the WQO. In the 2018 and 2019 sampling at each intake site (E257436 and E257437) only four instead of five samples were collected in 30 days for one of the sample periods. The Aug 16, 2019 sample date was missing for E257436 and the Nov 8, 2019 sample date was missing from E257437, both due to inability to collect a sample.

In 2018 additional water samples were collected at perimeter sites around the lake and in the upper Shawnigan Creek watershed by the Shawnigan Research Group; these data will be summarized in a separate report. One set of depth profiles (January 16, 2018) presented in this report was also collected by the Shawnigan Research Group. The instrument cable limited the depth of the profile to only 10m.

## 4. RESULTS AND OBJECTIVES ATTAINMENT

A summary of attainment of the WQOs are presented in Table 3 and Table 4. Several additional water quality parameters were recommended for monitoring by Rieberger (2007) to provide important information regarding the overall water quality of Shawnigan Lake (Table 2). Some of these data (e.g. temperature, pH, true colour, phytoplankton, and zooplankton) are discussed below with the attainment parameters, while the remaining data are summarized in Appendix I. Site-specific raw data can be obtained at our Environmental Monitoring System website: https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/environmental-monitoring-system.

*Table 3. Attainment results for North Basin Site (1199901), South Basin site (1199902), West Arm site (1199903), and North Beach site (1199904) for spring overturn sampling.*

| **PARAMETER** | **OBJECTIVE** | **1199901** | | **1199902** | | **1199903** | | **1199904** | |
|---|---|---|---|---|---|---|---|---|---|
| | | **2018** | **2019** | **2018** | **2019** | **2018** | **2019** | **2018** | **2019** |
| Dissolved Oxygen | ≥ 5 mg/L (Any depth throughout year) | Y | Y | **N** (2018-08-30) | Y | **N** (2018-08-30) | Y | Y | Y |
| N : P Ratio | > 30:1 (calculated using average TN and TP) | Y | Y | Y | Y | Y | Y | Y | Y |
| Total Organic Carbon | ≤ 4 mg/L | Y | Y | Y | Y | **N** (Avg=4.06) (2018-03-01) | Y | Y | Y |
| Total Nitrogen | ≤ 250 µg/L (Average at spring overturn) | Y | **N** (Avg=256) | Y | Y | **N** (Avg=274) | **N** (Avg=255) | Y | Y |
| Total Phosphorus | ≤ 8 µg/L (Average at spring overturn) | Y | Y | Y | Y | Y | Y | Y | Y |
| Secchi Depth | **Annual** Mean ≥ 5 m | Y | INSD (n=1) | **N** (Avg=4.5) | INSD (n=1) | **N** (Avg=4.6) | INSD (n=1) | Y | INSD (n=1) |
| Chlorophyll *a* | ≤ 2 µg/L (**Annual growing** season average, May - August samples) | Y | ND | Y | ND | | | | |
| Turbidity | **Monthly** Mean ≤ 1 NTU | | | | | Y | Y | Y | Y |
| | Instantaneous ≤ 5 NTU | | | | | Y | Y | Y | Y |
| *E. coli* | ≤ 10 CFU/100 mL (90th percentile) | | | | | ND | ND | ND | ND |
| Enterococci | ≤ 3 CFU/100 mL (90th percentile) | | | | | ND | ND | ND | ND |
| Fecal Coliform | ≤ 10 CFU/100 mL (90th percentile) | | | | | ND | ND | ND | ND |

*Y = Objective Met, N = Objective Not Met, ND = No Data Collected, INSD = Insufficient Data*

*Table 4. Attainment results for intake sites East Shore E257436 and North E257437*

| Site | PARAMETER | OBJECTIVE | Summer Sampling (CFU/100 mL) | Fall Sampling (CFU/100 mL) |
|---|---|---|---|---|
| | | | Aug & Sept 2018 | Nov 2018 |
| **East Shore E257436** | *E. coli* | ≤ 10 CFU/100 mL (90th percentile) | INSD (n=4) | Y |
| | Enterococci | ≤ 3 CFU/100 mL (90th percentile) | ND | ND |
| | Fecal Coliform | ≤ 10 CFU/100 mL (90th percentile) | ND | ND |
| **North E257437** | *E. coli* | ≤ 10 CFU/100 mL (90th percentile) | **N** | INSD (n=4) |
| | Enterococci | ≤ 3 CFU/100 mL (90th percentile) | ND | ND |
| | Fecal Coliform | ≤ 10 CFU/100 mL (90th percentile) | ND | ND |

*Y = Objective Met, N = Objective Not Met, ND = No Data Collected, INSD = Insufficient Data*

## 4.1 Temperature

While there are no WQOs for temperature in Shawnigan Lake, temperature is a key parameter for water quality in lakes. Water quality guidelines for temperature have been developed in BC for several water uses (Oliver and Fidler, 2001). For drinking water supplies, it is recommended that water temperature be less than 15 °C to protect the aesthetic quality of the water. For the protection of aquatic life in streams, the optimum temperature ranges for salmonids are based on specific life history stages such as incubation, rearing, migration and spawning. However, in lakes, the allowable change in temperature is ±1 °C from naturally occurring levels (Oliver and Fidler, 2001).

Water temperature was measured at each lake site, and vertical profiles of temperature in the water column at the deep stations are illustrated in Figure 2. Generally, the water column in Shawnigan Lake is well mixed during the winter/early-spring months, and then becomes thermally stratified during the summer months, with a thermocline occurring between 3 m and 10 m in depth (depending on the site). This stratifies the water column into two primary zones, the epilimnion (warmer surface waters) and the hypolimnion (cooler bottom waters). The water temperature ranged from a minimum of 4°C to 7°C in the winter months to a maximum surface water temperature of 17°C to 21°C in May and August for all sites.

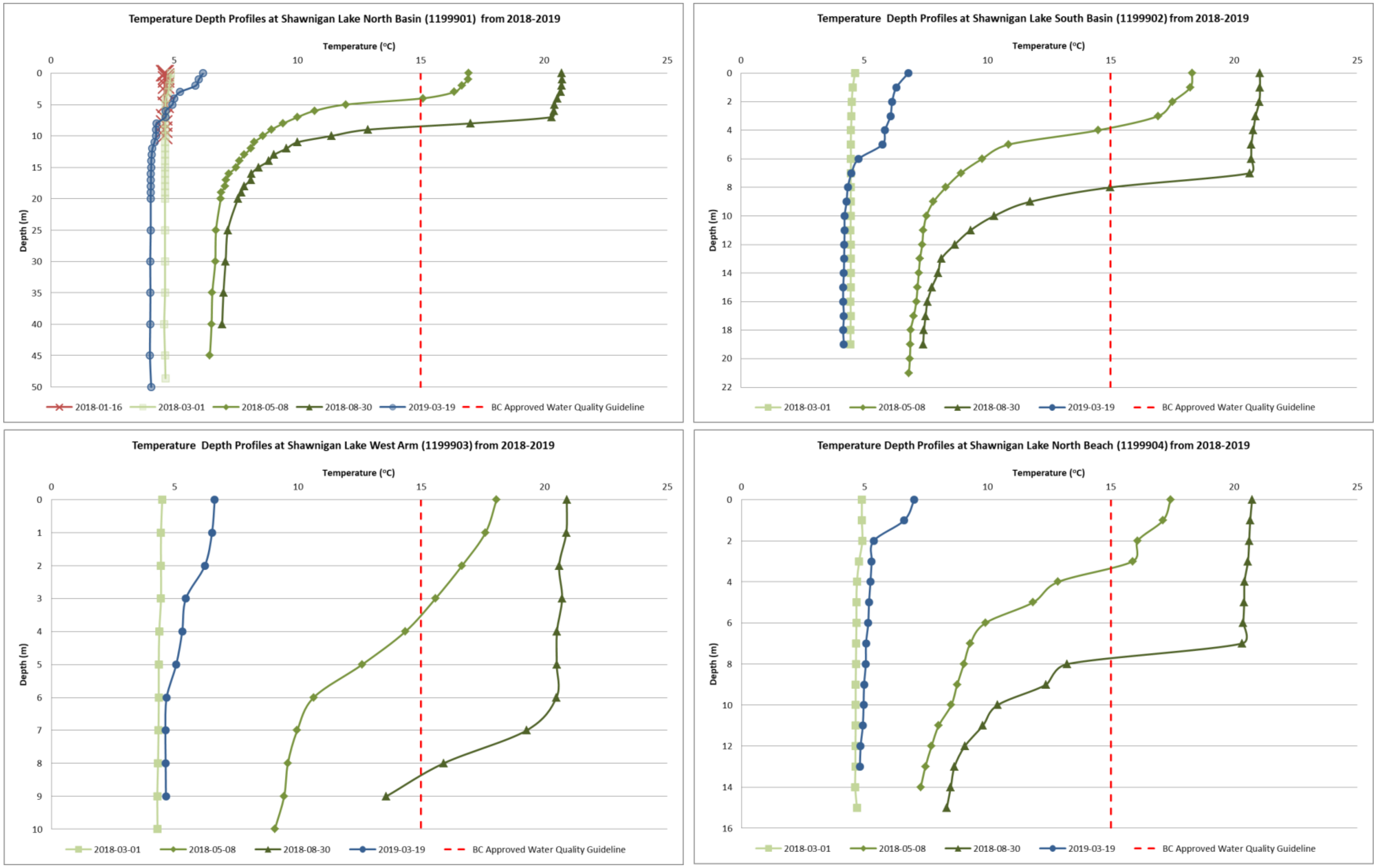



*Figure 2. Temperature profiles for Shawnigan Lake deep and shallow basin sites (2018-2019).*

Although surface water temperatures in the summer months exceed the BC WQO Water Quality Guidelines (WQGs) for aquatic life, there is sufficient cooler, oxygenated water available for fish at lower depths in the lake, especially at the North Basin site. Cooler water holds more oxygen due to increasing solubility of oxygen with decreasing water temperature.

Water temperature profiles at the intake depths were not collected, and it is unknown if the intake temperatures at these sites are a concern. Based on the temperature profiles for the other sites on the lake (Figure 2), the intakes are near the thermocline, and therefore temperatures would be cooler than in the surface waters. It is recommended that future monitoring include vertical temperature profiles at the intake sites to determine the actual temperatures of intake water.

## 4.2 Dissolved Oxygen

Dissolved oxygen (DO) concentrations are critical for the survival of aquatic organisms, especially species sensitive to low oxygen levels, such as salmonids (BC Environment and Lands, 1997). When deeper waters no longer mix with surface waters due to thermal stratification (see temperature profiles, Figure 2), concentrations of DO can decrease. This often occurs because of decomposition of organic material (e.g. phytoplankton algae) which requires oxygen from the water column, especially in eutrophic (high levels of nutrients and high biological productivity) lakes.

The DO objective for Shawnigan Lake (≥ 5 mg/L at any depth) was met during every spring overturn sampling date in 2018 and 2019. However, during other times of the year (primarily in the late-summer) the DO objective was not met at the South Basin (1199902) and West Arm (1199903) sites. The South Basin had DO concentrations below 5 mg/L on August 30, 2018 in the bottom 7 m (Figure 3). The West Arm exhibited low summer DO (< 5 mg/L) in the bottom 1 meter on August 30, 2018 (Appendix I, Figure 7).

While there was limited DO in the bottom waters of the South Basin and West Arm of Shawnigan Lake, there was still sufficient oxygenated water throughout the remainder of the water column. It is likely that fish will have avoided the deep de-oxygenated waters, in addition to the warm surface waters, and resided in mid-depths where there would have been suitable temperature and oxygen conditions.

In addition to the need for DO by aquatic organisms, low DO concentrations at the lake bottom can increase the potential for internal nutrient loading. This happens under anoxic reducing conditions, when nutrients (e.g. phosphorus) and some metals can be released from lake-bottom sediments and re-suspended back into the water column (Wetzel, 2001). Increases in nutrients can lead to algal blooms and subsequently further deplete DO levels when these algae die.

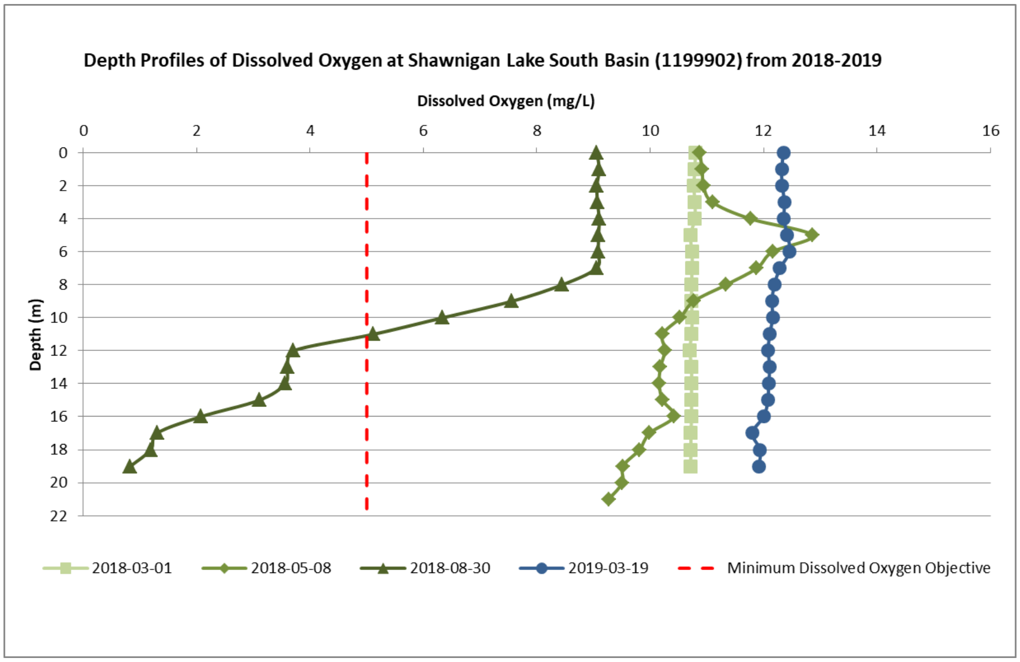



*Figure 3. Shawnigan Lake South Basin dissolved oxygen profiles (2018-2019).*

## 4.3 pH

Surface water pH in BC is governed primarily by the amount of precipitation and the rate of weathering of the surrounding soils and bedrock (McKean and Nagpal, 1991). Low pH levels (acidic conditions) can have a variety of lethal and sub-lethal effects on fish, including physical damage to the gills and numerous physiological impacts (McKean and Nagpal, 1991). While there is no WQO for pH, the provincial water quality guideline for the protection of aquatic life is a pH range between 6.5 and 9.0 pH units. There is also an aesthetic guideline of pH 6.5 to 8.5 for drinking water (McKean and Nagpal, 1991). Corrosion of metal plumbing may occur outside the low and high ends of this range, while scaling or encrustation of metal pipes may occur at high pH (McKean and Nagpal, 1991). The effectiveness of chlorine as a disinfectant is also reduced outside of this range.

At the deep and shallow basin sites in Shawnigan Lake, field measurements of pH taken in 2018 and 2019 ranged from 5.91 to 7.55 (Appendix I, Figure 9), while laboratory measurements of pH in samples collected from these locations ranged from 7.08 to 7.89. There are often differences between lab and field pH values, due to holding times of the samples. It is best to record pH in the field, and on occasion use two different probes, comparing results from each to conduct QA/QC.

The general pattern for all the deep basin sites in the summer months was decreasing pH with increasing depth (Appendix I, Figure 9). There were several instances where pH was below the minimum objective of 6.5 in each of the deep basin sites. However, a decrease in pH with increasing depth is quite common and likely due to an increase in $CO_2$ concentrations from myriad of decomposition processes in the hypolimnion (Wetzel, 2001).

## 4.4 Water Clarity - Turbidity

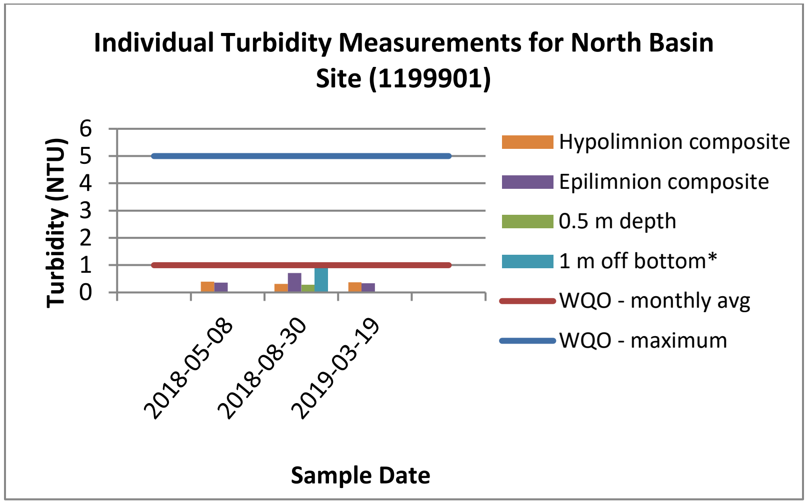
Turbidity is a measurement of suspended particulate matter in water (e.g. silt, clay, organic material, micro-organisms), and high levels of turbidity increases the risk of bacterial growth on the suspended particulates, along with interfering with the disinfection of drinking water (Rieberger, 2007). The turbidity objective for Shawnigan Lake is a mean monthly value that does not exceed 1 NTU, with no individual sample to exceed 5 NTU. This applies only to the West Arm (1199903) and North Beach (1199904) sites, as it was established to protect the quality of the drinking water near domestic intakes.

The sampling frequency was insufficient to determine monthly means, and therefore individual measurements were compared to both the mean value as well as the maximum objective. In addition, the data from the two deep basin sites were compared to the objective to help understand overall lake conditions.

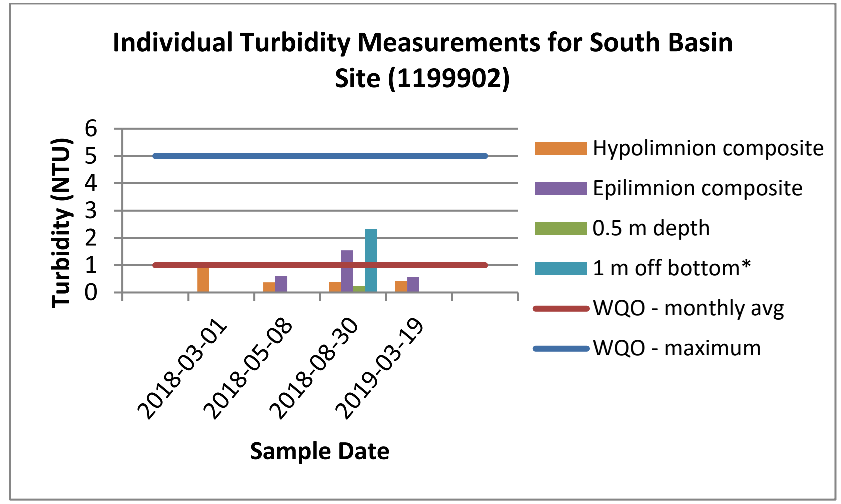
In general, individual turbidity values at all sites remained below the mean objective of 1 NTU (

Figure 4). Turbidity exceeded the objective at the bottom depth of the South Basin sampling station during the summer (maximum 2.3 NTU), which is likely due to the internal nutrient loading processes, and increased decomposition of material near the sediment surface (supported by true colour results in Section 4.6). Shawnigan Creek drains into the south basin of Shawnigan Lake and carries particulates from the watershed into to the lake during rainy periods; creek sampling coordinated with lake sampling would help determine if specific turbidity events in the lake are directly linked to the creek or to internal nutrient processes. There were no exceedances of the maximum WQO of 5 NTU.

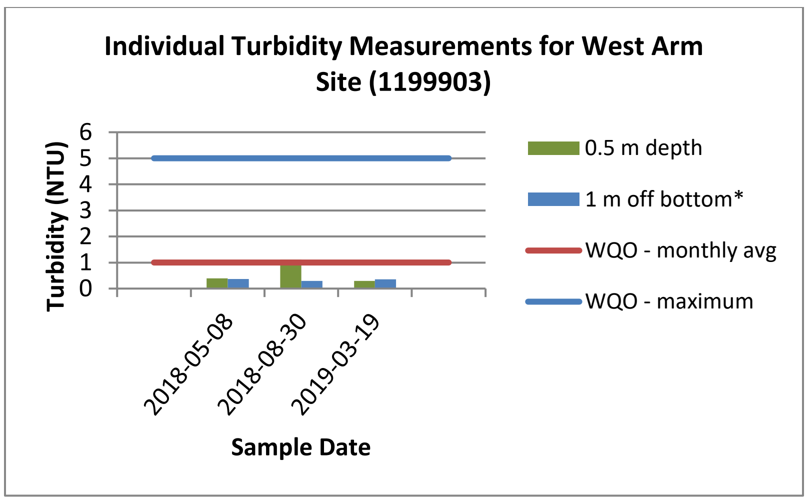
Vancouver Island Health Authority's (VIHA) goal for sources of drinking water where the systems do not receive filtration (which includes Shawnigan Lake) is turbidity levels of 1 NTU or less (95% of days) and not above 5 NTU on more than 2 days in a 12-month period, when sampled at the intake (Charmaine Enns, VIHA, *pers. comm.,* 2009). It should be noted that turbidity values above 2 NTU are considered likely to affect disinfection in a chlorine-only system. An alternative to this would be to treat the raw water prior to chlorination (e.g. filtration) to remove some of the turbidity and increase chlorine efficiency.



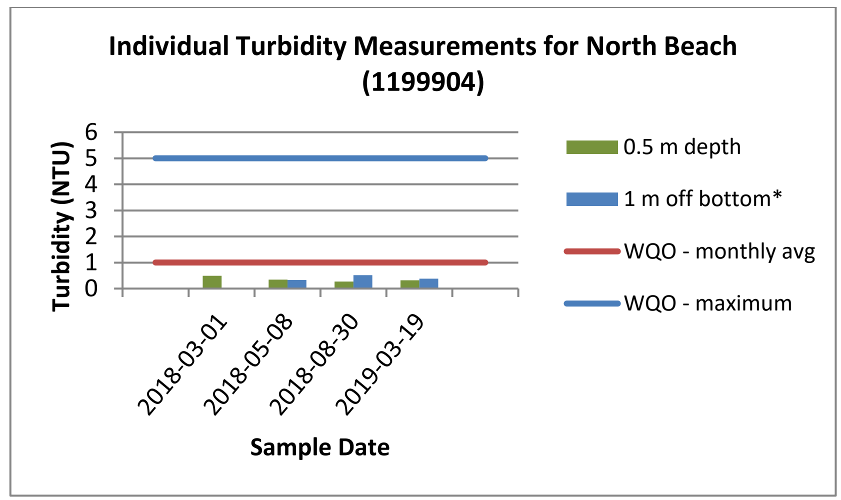

*Note that sampling depth was at 40 m.*




*Note that sampling depth was at 19 m.*




*Note that sampling depth was at 9 m.*




*Note that sampling depth was at 13 m.*

*Figure 4. Turbidity field monitoring results for Shawnigan Lake deep basin sites (2018-2019).*

## 4.5 Water Clarity – Secchi Depth

Another common measure of water clarity in lakes is Secchi depth, which is assessed by lowering a standard 20 cm black and white Secchi disc into the water column until it is no longer visible. As water clarity is primarily affected by colour, suspended solids, and algal growth, Secchi disc readings provide a simple, inexpensive means of indicating changes in water quality (Rieberger, 2007). Furthermore, it can be compared to historical data which has been collected for decades. Mean annual Secchi depth readings taken by BC ENV (North Basin site only) (Figure 5) generally met the objective of ≥5 meters (Appendix I Figure 10). However, in most years, only one measurement was collected (at spring overturn), which makes it difficult to compare against an annual average. Secchi depth values (n=3) failed to meet the objective at the West Arm and South Basin sites in 2018 (Table 5). This is likely due to the shallow, constricted nature of the West Arm and wind effects, in addition to increased recreational boating activity (which creates turbulence in the surface waters). The sampling frequency was insufficient to determine means in 2019.

## 4.6 True Colour

Colour in water is attributed to the presence of organic and inorganic matter absorbing different light frequencies. True colour is a measure of the dissolved colour in water after the particulate matter has been removed. An increase in true colour can affect the aesthetic acceptability of water, and if a drinking water source with high organic matter content and true colour is chlorinated, disinfection by-products may be produced, posing a risk to human health (Health Canada, 2006). Rieberger (2007) did not propose a true colour WQO for Shawnigan Lake, however, the provincial recreational Water Quality Guideline is that the 30-day average (based on a minimum of five samples) should not exceed 15 True Colour Units (TCU) (Moore and Caux, 1997).

Two composite samples (hypolimnion and epilimnion) were taken throughout the water column for the North and South basin lake sites. Samples were collected at two depths for the West Arm and North Beach sites. Both composite and standard sampling was conducted on August 30, 2018 for the North and South basin lake sites. True colour ranged from 6.4 TCU to a maximum of 23.7 TCU (

Table 6). The requisite sampling frequency to compare to the recreational water quality guideline for true colour was not met, but high colour observed at the South Basin and West Arm sites in August 2018 suggests there is potential for exceedance of WQG for colour for recreational use. High colour values are likely linked to a summer algal bloom occurring at the time of sampling, where algal concentrations were high and dominant species comprised mostly of cyanobacteria (blue-green algae) (Tables 13 and 14).

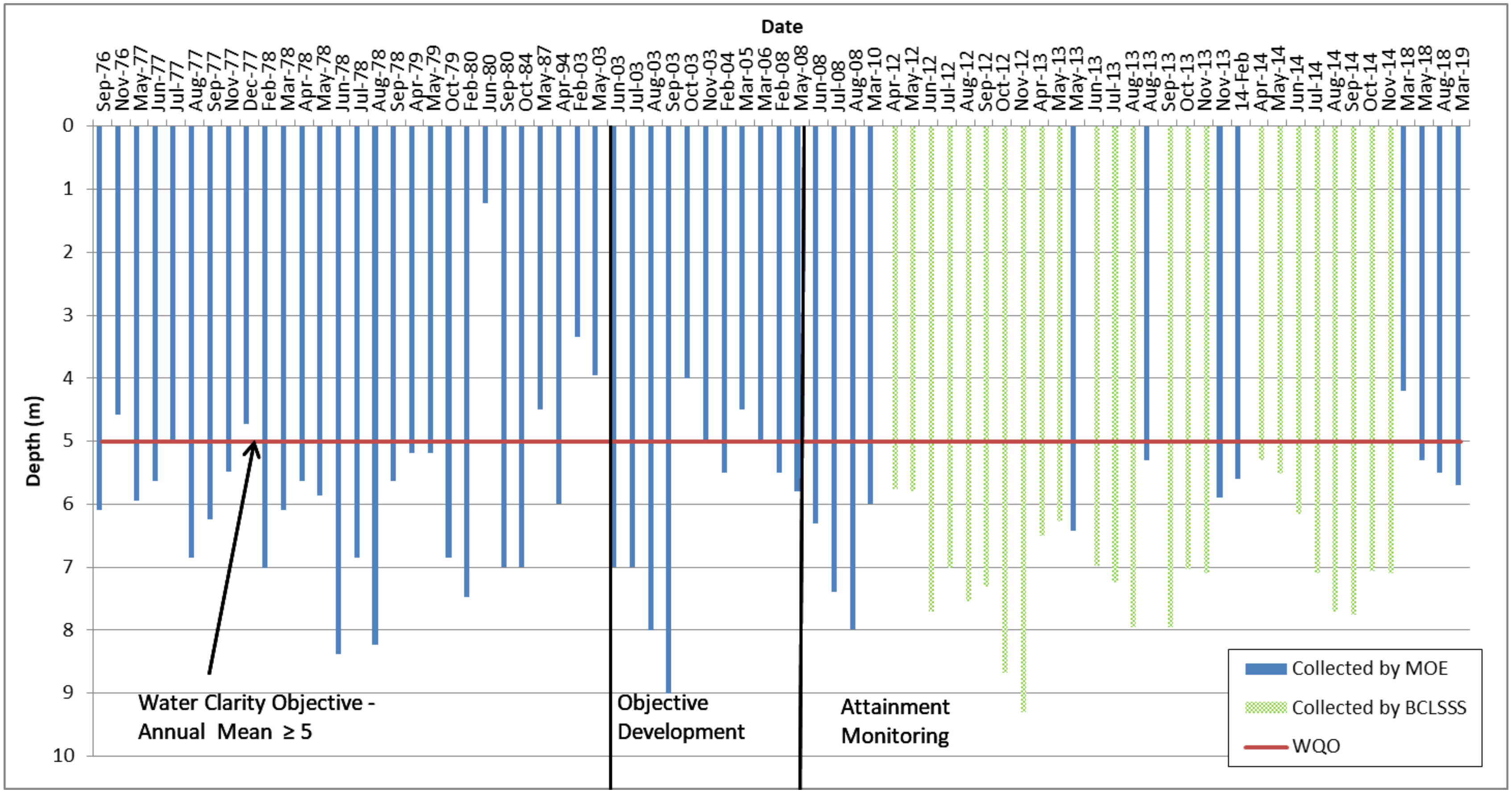



*Figure 5. Individual Secchi disk readings for Shawnigan Lake North Basin site (1199901) (1976-2019) including data provided from BCLSSS program.*

*Table 5. Annual mean Secchi depths (m) for the Shawnigan Lake Basin Sites*. **Highlighted** values do not meet the WQO.*

| Year | North Basin 1199901 | | South Basin 1199902 | | West Arm 1199903 | | North Beach - 1199904 | |
|---|---|---|---|---|---|---|---|---|
| | Mean | n | Mean | n | Mean | n | Mean | n |
| 1976-1979 | 6.1 | 26 | 5.8 | 23 | | | | |
| 1980-1987 | 5.4 | 5 | 7.0 | 1 | | | | |
| 1994 | 6.0 | 1 | | | | | | |
| 2003-2005 | 5.6 | 9 | 5.9 | 8 | 5.9 | 9 | 6.3 | 7 |
| 2006 | 5.0 | 1 | 5.5 | 1 | 5.0 | 1 | 4.5** | 1 |
| 2007 | | | 4.0** | 1 | | | | |
| 2008 | 6.6 | 5 | 6.1 | 5 | **4.5** | 5 | 6.7 | 5 |
| 2010 | 6.0 | 1 | 5.3 | 1 | 5.8 | 1 | 5.2 | 1 |
| 2012 | 7.1 | 10 | | | | | | |
| 2013 | 6.8 | 11 | 5.6 | 3 | **4.6** | 3 | 6.6 | 3 |
| 2014 | 6.6 | 9 | 4.5** | 1 | 4.1** | 1 | 5.0 | 1 |
| 2018 | 5.0 | 4 | **4.5** | 3 | **4.6** | 3 | 5.0 | 3 |
| 2019 | 5.7** | 1 | 18.3** | 1 | 6.5** | 1 | 6.9** | 1 |

*Note that historical data (1977-2005) was included in this table, but the WQO applies only to data collected between 2006-2019.

**In some instances, Secchi depths were only measured on one day for the year, and therefore no average Secchi depth could be calculated. In those instances, guideline attainment could not be assessed.

*Table 6. True colour (TCU) results for the Shawnigan Lake basin sites during attainment monitoring (2018-2019). Elevated (>15 TCU) true colour results are highlighted.*

| Date | North Basin (1199901) | | South Basin (1199902) | | West Arm (1199903) | | North Beach (1199904) | |
|---|---|---|---|---|---|---|---|---|
| | Hypolimnion Composite | Epilimnion Composite | Hypolimnion Composite | Epilimnion Composite | Surface | Bottom | Surface | Bottom |
| 5-May-2018 | 12.8 | 13.1 | 11.4 | 14.3 | 12.2 | 12.2 | 11.7 | 12.9 |
| 30-Aug-2018 | 6.4 | 10.9 | 7.6 | 17.1 | 15.7 | 6.8 | 7.2 | 12.5 |
| | Surface 6.7 | Bottom 12.8 | Surface 6.8 | Bottom 23.7 | | | | |
| 19-Mar-2019 | 13.7 | 14 | 13.9 | 14.1 | 12.7 | 13.4 | 12.9 | 13.0 |

## 4.7 Nutrients - Nitrogen

Nitrogen is an important nutrient for lakes and can influence the biological productivity and ecology of waters. The balance between phosphorus and nitrogen also plays an important role. Nitrogen sources include: atmospheric deposition, nitrogen fixation in the water and sediments, and watershed inputs from surface and subsurface sources (e.g. sewage and agriculture) (Wetzel, 2001). In watersheds where drinking water is a priority, it is desirable that nutrient levels remain low to avoid algal blooms and foul-tasting water.

The objective for total nitrogen (≤ 250 µg/L at spring overturn, when the lake is well mixed) was exceeded at the North basin site in 2019 with an exceedance of 256 µg/L, and at the West Arm site in 2018 and 2019 with exceedances of 274 µg/L and 255 µg/L, respectively (Table 7). The results indicate that total nitrogen concentrations have been more variable in recent years, and the difference between years appears to be larger. Total nitrogen measurements can vary depending on processes occurring during the time of sampling (e.g. temperature, light, algal biomass at the sampling location), and are therefore difficult to interpret. Water quality trends in Shawnigan Lake from 2001-2007 (Mazumder, 2015) and 2008-2014 (Kopat *et al.*, 2019) indicated a gradual increasing trend of nitrogen and phosphorus concentrations in the lake. Spring overturn total nitrogen concentrations have decreased since 2014 at the North and South basin sites but increased at the West Arm site in 2018. Although the concentration decreased slightly at the West Arm site in 2019, it remained above the WQO. However, if future attainment monitoring shows an increasing trend in total nitrogen, further investigation should be made into causal factors and implications of nitrogen increases in the lake.

*Table 7. Mean spring overturn total nitrogen concentrations (µg/L) for Shawnigan Lake basin sites (1977-2019)**

| Date | North Basin 1199901 | South Basin 1199902 | West Arm 1199903 | North Beach 1199904 |
|---|---|---|---|---|
| 11-May-77 | 230 | **257** | 200 | |
| 17-Apr-78 | 245 | **275** | **300** | 230 |
| 08-Mar-79 | **257** | 235 | -- | -- |
| 21-Feb-80 | **253** | -- | -- | -- |
| 10-Mar-83 | 227 | -- | -- | -- |
| 04-Mar-84 | 223 | -- | -- | -- |
| 26-Mar-97 | 225 | -- | -- | -- |
| 08-Apr-99 | 235 | -- | -- | -- |
| 22-Mar-00 | **260** | -- | -- | -- |
| 07-Feb-01 | **263** | **283** | -- | -- |
| 21-Mar-01 | 195 | 247 | -- | -- |
| 11-Feb-03 | **250** | -- | **290** | **265** |
| 12-Feb-04 | **270** | 313 | 460 | 340 |
| 10-Mar-05 | 234 | 226 | **307** | **290** |
| 28-Mar-06 | **277** | 240 | **255** | **255** |
| 01-Mar-07 | 220 | 200 | 235 | 220 |
| 25-Feb-08 | **313** | **250** | **250** | 245 |
| 25-Feb-10 | 153 | 167 | 215 | 205 |
| 12-Feb-14 | **302** | **329** | **261** | **287** |
| 1-Mar-18 | **250** | 217 | **274** | 242 |
| 19-Mar-19 | **256** | 217 | **255** | 240 |

*Mean of at least three samples taken throughout the water column (surface, mid-depth, one metre above bottom) for sites 1199901 and 1199902 (two composite samples were taken throughout the water column in 2018 and 2019) and at least two samples (surface and one metre above bottom) for sites 1199903 and 1199904, at spring overturn.

**Note that 1977-2014 results are shown only for the purpose of demonstrating trends for this parameter.

***For 2006-2019 sample results, grey highlighted values exceed proposed WQO for total nitrogen of ≤ 250 µg/L.

## 4.8 Nutrients - Phosphorus

Phosphorus is a limiting nutrient that is used by phytoplankton (floating algae) and is the biological limiting nutrient in most freshwater systems. Increased phosphorus leads to increased algal production, reduced water clarity, increased taste and odour concerns for drinking water purveyors, and undesirable conditions (e.g. reduced oxygen) for some fish species. Phosphorus levels in lakes increase due to inputs of sewage, sediments eroded from soils in the watershed, seepage from septic tanks, fertilizers from agricultural activities and internal loading (Wetzel, 2001).

The phosphorus objective (≤ 8 µg/L) was met during every spring overturn (mixed lake conditions) sampling date from 2018 to 2019 (Table 8).

*Table 8. Spring overturn (January – March) mean* total phosphorus concentrations (µg/L) for the Shawnigan Lake basin sites.*

| Year | North Basin (1199901) | South Basin (1199902) | West Arm (1199903) | North Beach (1199904) |
|---|---|---|---|---|
| 1979 | 8.3 | 7.0 | -- | -- |
| 1980 | 8.7 | -- | -- | -- |
| 1984 | 8.0 | -- | -- | -- |
| 1992 | 4.0 | -- | -- | -- |
| 1993 | 3.0 | -- | -- | -- |
| 1995 | 3.0 | -- | -- | -- |
| 1997 | 6.0 | -- | -- | -- |
| 2000 | 7.0 | -- | -- | -- |
| 2001 | 7.5 | -- | -- | -- |
| 2003 | 4.3 | 4.0 | 4.5 | 4.0 |
| 2004 | 2.3 | 3.7 | 3.5 | 3.5 |
| 2005 | 2.3 | 3.0 | 3.5 | 3.5 |
| 2006 | 3.3 | 3.3 | 3.0 | 2.5 |
| 2007 | 6 | 4.3 | 6 | 5 |
| 2008 | 6 | 5.7 | 5.5 | 6.5 |
| 2010 | 3.7 | 3.7 | 3.5 | 3.5 |
| 2014 | 5.0 | 7.3 | 7.5 | 5.1 |
| 2018 | 6.7 | 5.7 | 6.6 | 5.7 |
| 2019 | 6.0 | 6.4 | 4.8 | 4.5 |

* *Mean of at least three samples taken throughout the water column (surface, mid-depth, one metre above bottom) for sites 1199901 and 1199902 (two composite samples were collected throughout the water column for 2018 and 2019) and the average of at least two samples (surface and one metre above bottom) for sites 1199903 and 1199904, at spring overturn.*

Lake sediments can be a major source of phosphorus when hypolimnetic oxygen becomes depleted, producing anoxic reducing conditions. Phosphorus is usually bound with bottom sediments, but in anoxic conditions phosphorus can be released into the water column from the sediments. This release of phosphorus from lake sediments is known as internal loading (see section on dissolved oxygen), and can lead to algal blooms, along with a further depletion of dissolved oxygen when these algae die. This process of internal phosphorus loading can be a natural occurrence in many lakes but is often the result of excessive external nutrient loading to the lake (Wetzel, 2001). In Shawnigan Lake, phosphorus values during the late-spring to summer (May – September) were reviewed as concentrations can be elevated at this time of year, especially at depth. The total phosphorus values in the hypolimnion ranged from 3.9 µg/L to 11.2 µg/L, with the West Arm having the highest value. The elevated hypolimnetic phosphorus concentrations observed here are likely the result of internal loading and reduced mixing of the water during the summer stratification period.

## 4.9 Nutrients – Nitrogen to Phosphorus Ratio

Nitrogen to Phosphorus (N:P) ratios are useful indicators in lakes to determine whether primary production is limited by phosphorus or nitrogen concentrations (Rieberger, 2007). In general, if N:P is <20, lakes are N limited and if N:P is >20, lakes are P limited (Rieberger, 2007). Different algae utilize nitrogen and phosphorus in different ratios and comparing these values to what is available in the water can be a valuable diagnostic tool (Nordin, 1985). Most lakes, including Shawnigan Lake, are phosphorus limited, and N:P ratios tend to decrease with increasing eutrophication, thus, decreasing N:P ratios would indicate deteriorating water quality. The proposed water quality objective for N:P ratios in Shawnigan Lake is 30:1. All sites met the objective in 2018 and 2019, and values ranged from 30:1 to 53:1 (Appendix I; Table 10).

## 4.10 Nutrients – Total Organic Carbon

Organic carbon is another important nutrient in lakes, but it is also an important water quality parameter to consider with respect to drinking water sources. The B.C. provincial water quality guideline for total organic carbon (TOC) in source water with chlorination is 4 mg/L to prevent the production of disinfection by-products during treatment with chlorine (Moore, 1998). Rieberger (2007) followed this guideline (Max TOC of 4 mg/L at any time) to minimize the formation of hazardous by-products from chlorination of any domestic water sources in Shawnigan Lake. One relatively minor exceedance of 4.34 mg/L occurred in 2018 at the West Arm site (Appendix I; Table 11).

## 4.11 Biological Analyses

### *4.11.1 Chlorophyll a*

Chlorophyll *a* is the primary photosynthetic pigment of algae, cyanobacteria, and other photosynthetic organisms (Wetzel, 2001). Measuring chlorophyll *a* is a standard approach used to quantify phytoplankton in lakes and is used as a surrogate of phytoplankton biomass. There is generally a strong positive relationship between phosphorus and chlorophyll *a*, and often an inverse relationship with water clarity (Nordin, 1985).

The objective for chlorophyll *a* (≤2 µg/L based on growing season average for the main basin) was not exceeded in 2018 (Table 9). Growing season data were not collected in 2019 for this report. The chlorophyll *a* objective does not apply to the West Arm and North Beach sites and it was previously acknowledged that these two areas of the lake generally show higher chlorophyll-*a* concentrations (Rieberger, 2007).

Table 9 gives the mean chlorophyll *a* concentrations at the four lake sites during the growing season for five time periods between 1977 and 2019. The 2018 highest concentration (3.17 µg/L) and highest average summer concentration (2.00 µg/L) was measured at the North Basin site. The 2018 growing season averages in the main basin of the lake met the chlorophyll-*a* objective of ≤2 µg/L.

*Table 9. Annual growing season averages (April-Oct.) for chlorophyll-a concentrations (μg/L) for Shawnigan Lake basin sites. Shaded values represent objective exceedances (means calculated for data collected prior to 2008 not compared to guideline). Note the objective does not apply to West Arm and North Beach sites.*

| Year | Measure | North Basin (1199901) | South Basin (1199902) | West Arm (1199903) | North Beach (1199904) |
|---|---|---|---|---|---|
| 1977-79 | Mean (μg/L) | 3.04 | 2.95 | 2.24 | 0.30 |
| | N | 12 | 10 | 8 | 3 |
| 2003-2004 | Mean (μg/L) | 0.78 | 0.94 | 1.24 | 0.78 |
| | N | 8 | 8 | 7 | 8 |
| 2008 | Mean (μg/L) | 1.77 | **2.75** | 6.38 | 1.17 |
| | N | 8 | 4 | 4 | 3 |
| 2013 | Mean (μg/L) | **2.94** | **3.10** | 6.40 | 2.32 |
| | N | 2 | 2 | 2 | 2 |
| 2018 | Mean (μg/L) | 2.00 | 1.38 | 1.45 | 0.89 |
| | N | 2 | 2 | 2 | 2 |

#### *4.11.2 Phytoplankton*

Phytoplankton communities in lakes are typically comprised of a diverse assemblage of taxonomic algal groups (Wetzel, 2001). These communities are constantly changing in response to changes in nutrients, available light, mixing conditions and other growing conditions. While there are no WQO for phytoplankton in Shawnigan Lake, these key primary producers are important to monitor in aquatic ecosystems, because changes in community composition may indicate changes in lake water chemistry (Rieberger, 2007). Excessive nutrients can lead to algal blooms and surfacing scums which can impact taste and odours to drinking water, requiring more expensive treatment to remove algal particles. Furthermore, these blooms can reduce water clarity, decrease hypolimnetic oxygen levels, and increase the risk of toxins produced by cyanobacteria (Rieberger, 2007).

Overall, the number of phytoplankton species observed and the total phytoplankton concentrations were similar between all four sites in Shawnigan Lake. During 2018 and 2019, there was a broad range of diversity with a total of 144 species identified, and 11 dominant species (species richness >10%). Although most species or genera that were reported in previous studies (Nordin and McKean, 1984; Rieberger, 2007) were present, the dominant species differed. It is important to note that there is likely considerable interannual variability in phytoplankton community composition, as demonstrated in comparisons between sampling periods.

The phytoplankton data collected at the four deep basin sites were summarized, and the dominant species are listed for the North and South Basins in Appendix I; Table 12, and for the West Arm and

North Beach sites in Appendix I; Table 13. All sampling sites in Shawnigan Lake had relatively high numbers of species present and greater overall abundance during the summer growing season (May - August), as compared to the spring overturn (March).

General phytoplankton dynamics for oligotrophic lakes as outlined by Rieberger (2007) are consistent with taxonomic results for this report. Diatoms and cryptophytes were dominant in March and the cyanobacteria populations peaked in August. Similarities of the dominant species and the months in which they occurred were the diatom *Asterionella formosa* in March, the golden-brown algae *Dinobryon divergens* in May, and the blue-green algae *Lyngbya cf limnetica* in August.

The North Basin and West Arm sites had higher total species richness with 91 and 105 species found, compared to 90 species at the South Basin site and 86 species at the North Beach site (Appendix I; Table 14).

#### *4.11.3 Zooplankton*

Zooplankton are important to the aquatic food web and are largely influenced by the number and types of phytoplankton they feed upon, along with predation pressure from planktivorous fish like kokanee (land locked sockeye salmon, *Oncorhynchus nerka)*, juvenile rainbow trout (*O. mykiss*), and introduced species such as smallmouth bass (*Micropteus dolomieu*) and yellow perch (*Perca flavascens*) (Rieberger, 2007; Gregory, 2014). As with phytoplankton, there are no zooplankton WQO in Shawnigan Lake. However, sampling was conducted from 2018-2019 since zooplankton are sensitive to changes in water quality and are useful indicators of change. Specifically, zooplankton responds to dissolved oxygen concentrations, various contaminants, and changes in food quality/abundance (Nordin and McKean, 1984).

As with most lakes, Shawnigan Lake zooplankton communities vary seasonally. Data from attainment sampling is consistent with Rieberger (2007), indicating a dominance of rotifers, specifically *Keratella cochlearis*, which were found at all sites on all sampling dates. Copepods of the order Calanoida / Cyclopoida were also dominant and found across all sampling sites.  These zooplankton are likely feeding on an abundance of phytoplankton during the late-winter/early-spring blooms. The attainment data are somewhat limited, but the zooplankton communities are consistent with oligotrophic conditions (Wetzel, 2001). A summary of the dominant species from 2018-2019 are found in (Appendix I; Table 15).

#### *4.11.4 Microbiological Indicators*

Bacteria often enter surface waters via non-point sources, including wild and domestic animal feces, as well as seepage from leaking or failing septic systems. Microbiological indicators are monitored to evaluate of the risk of disease from these various pathogens (Warrington, 2001). Studies have shown that *Escherichia coli* is the main thermo-tolerant coliform species present in fecal samples (94%) of humans and other endotherms such as birds and mammals, (Tallon *et al.*, 2005), and at contaminated bathing beaches (80%) (Davis *et al.*, 2005). Where total coliform concentrations are higher than those of

*E. coli*, one can assume a high likelihood of contributions from non-fecal sources. Thus, there is limited benefit in measuring both groups.

*E. coli* was the only bacteriological indicator sampled in Shawnigan Lake at the intake sites (E257436 and E257437) in 2018 and 2019 (Appendix 1; Table 16). Enterococci and fecal coliforms were not analyzed due to changes in ENV's monitoring recommendations that identified *E. coli* as the most appropriate microbial indicator to use for the assessment of risks to human health in fresh water (Rieberger, 2010).

The *E. coli* objective for Shawnigan Lake is a 90$^{th}$ percentile of ≤10 CFU/100mL (based on at least five weekly samples in 30 days) and applies to areas of the lake where drinking water is withdrawn (Rieberger, 2007). *E. coli* was measured 9 times in 2018 at the East Shore intake site (E257436), with concentrations ranging from below detection limits (< 1 CFU/100 mL) to a maximum of 20 CFU/100 mL. The requisite sampling frequency (a minimum of five samples in a 30-day period) was met in the fall, with a 90$^{th}$ percentile of 3.6 CFU/100 mL, but not in the summer of 2018. Fall samples all had concentrations below 5 CFU/100 mL. The 90$^{th}$ percentile of the four samples collected in the summer was 17.9 CFU/100 mL. Though requisite sampling frequency was not met in the summer, the value suggests there is good likelihood that the WQO would have been exceeded.

At the North intake (E257437), *E. coli* was measured 9 times in 2018, with concentrations ranging from below detection limits (<1 CFU/100 mL) to a maximum of 15 CFU/100 mL. *E. coli* concentrations were much higher at the North intake site in 2018 than from 2008-2013 where they ranged from below detection limits (<1 CFU/100 mL) to a maximum of 2 CFU/100 mL. The requisite sampling frequency was met in the summer of 2018, and the 90$^{th}$ percentile was 15 CFU/100 mL. The 90$^{th}$ percentile of the four samples collected in the fall was 3.4 CFU/100 mL. Though requisite sampling frequency was not met in the fall, the value suggests there is good likelihood that the WQO would have been met.

The highest levels of *E. coli* were observed at the intake sites during the summer low-flow period, corresponding to the peak population and recreation season, warmest temperatures, and maximum retention times. Of the two times when the requisite sampling frequency was met at the two intake sites, the objective was exceeded on one occasion (90$^{th}$ percentile of 15 CFU/100 mL) during the summer of 2018 at the North intake site. There were no exceedances of the BC WQGs for primary recreation for *E. coli* (200 CFU/100mL, based on geometric mean) at either site.

## 5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overall, the state of Shawnigan Lake water quality continues to be good. While some of the water quality objectives were exceeded, the data presented in this report indicate that the lake remains oligotrophic, and there is no indication of overall lake deterioration. There was local concern that an increase in development and land-use changes in the watershed, (e.g. urban runoff, land development, on-site septic systems, agriculture, marinas and boating, industrial and logging activities) were impacting water quality, but the 2018-2019 data indicate few WQO exceedances in Shawnigan Lake. For analysis of data from tributary creeks, see Kopat *et al.* (2019b).

Attainment results for the main basins (north basin site 1199901 and south basin site 1199902) of Shawnigan Lake are representative of overall lake conditions. Several key water quality parameters (dissolved oxygen, N:P ratio, total organic carbon, total phosphorus and chlorophyll-*a*) in these two basins consistently met WQO in both years of sampling. On the other hand, results for*,* total nitrogen and Secchi depth were met intermittently. Total nitrogen data were considered with historical data to confirm that an apparent increasing trend is not fully supported by the recent data. A nutrient budget study should be conducted to help understand nutrient status and cycling.

Similar to the main basins, the west arm site (1199903) and north beach site (1199904), also consistently met WQO for total phosphorus, dissolved oxygen, and N:P ratio. Results for total organic carbon and Secchi depth were met intermittently. These shallower basins have additional WQO for turbidity and bacteria, which were met in all cases (turbidity), or there was no data collected to compare to WQO (bacteria). However, the few bacteriological samples that were collected at the drinking water intake sites (E257436 and E257437) indicate relatively low concentrations of bacteria, with some exceedances during the summer. Any exceedance highlights the need for water purveyors to appropriately treat water for domestic use.

To enable comparison to all WQOs in place for Shawnigan Lake, it is recommended that effort be made to obtain the appropriate data (sampling frequency and locations) for parameters for which insufficient or no data were collected.

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## APPENDIX I - OBJECTIVES ATTAINMENT WATER QUALITY RESULTS

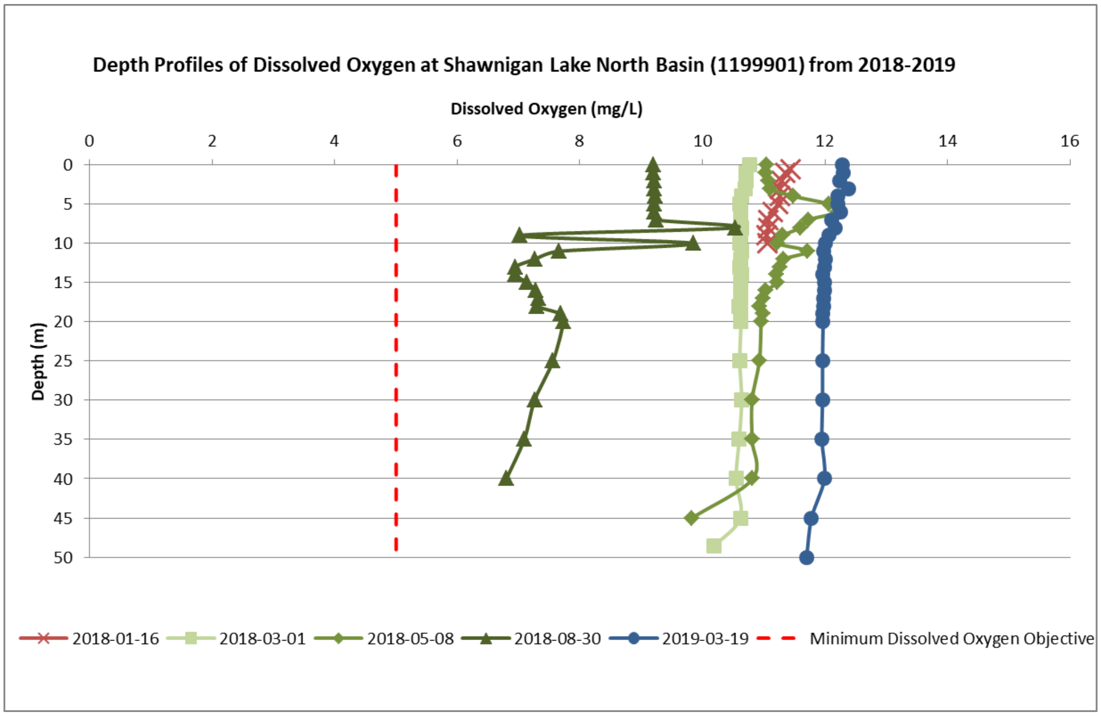



*Figure 6. Shawnigan Lake North Basin dissolved oxygen profiles (2018-2019).*

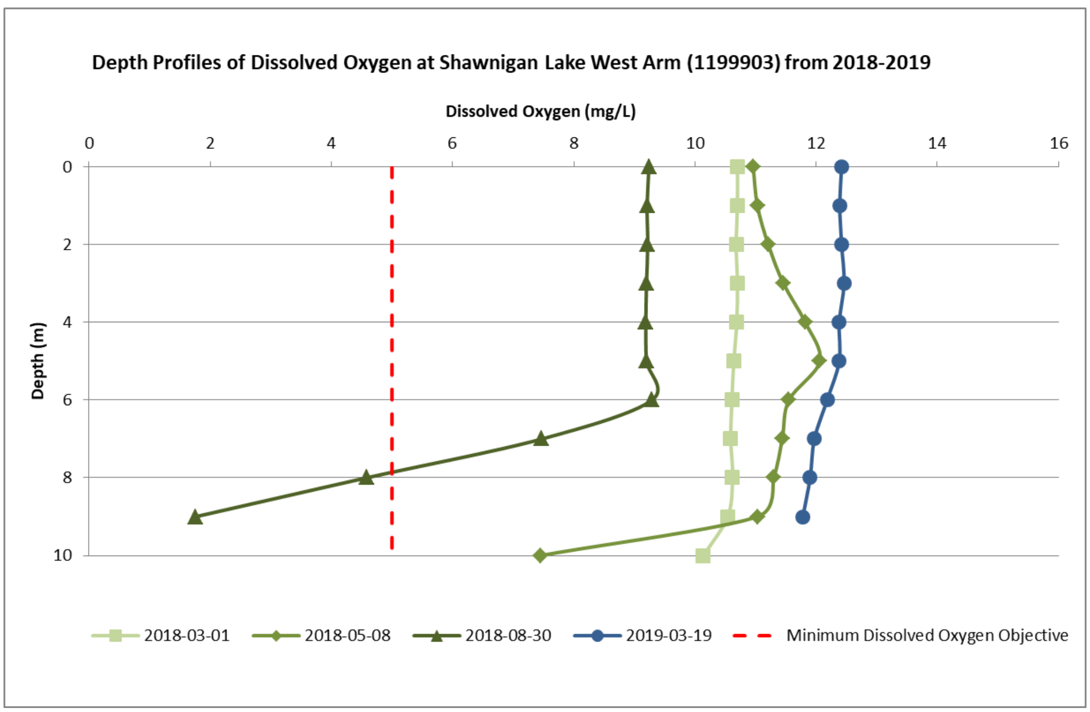



*Figure 7. Shawnigan Lake West Arm dissolved oxygen profiles (2018-2019).*

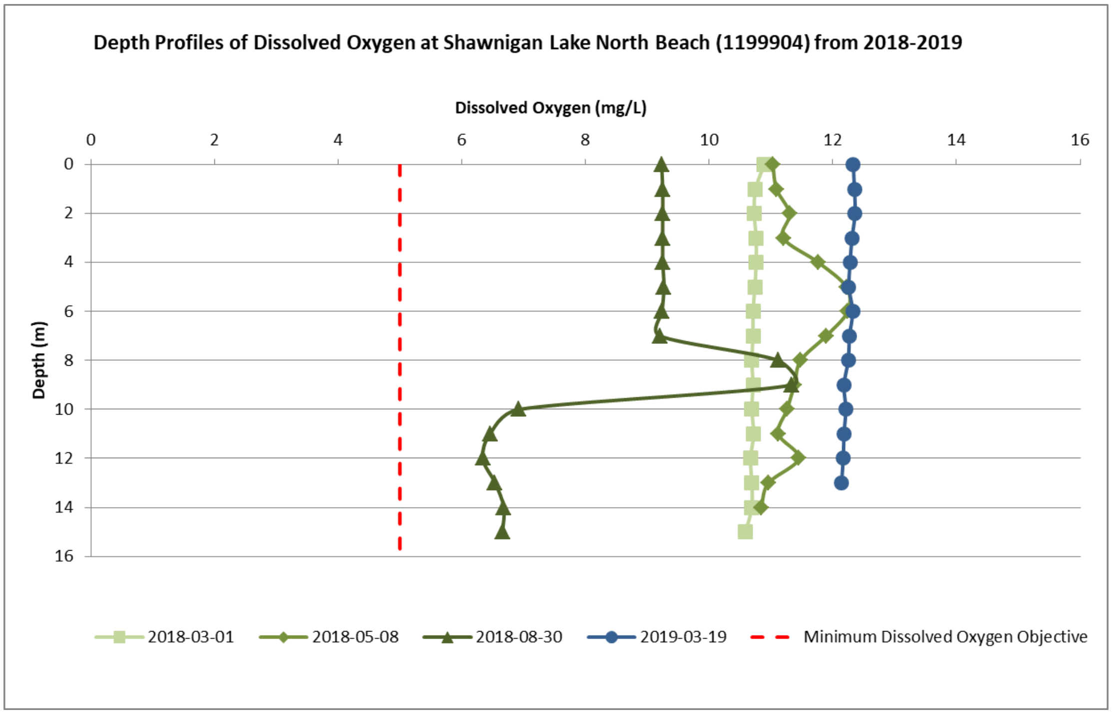



*Figure 8. Shawnigan Lake North Beach dissolved oxygen profiles (2018-2019).*

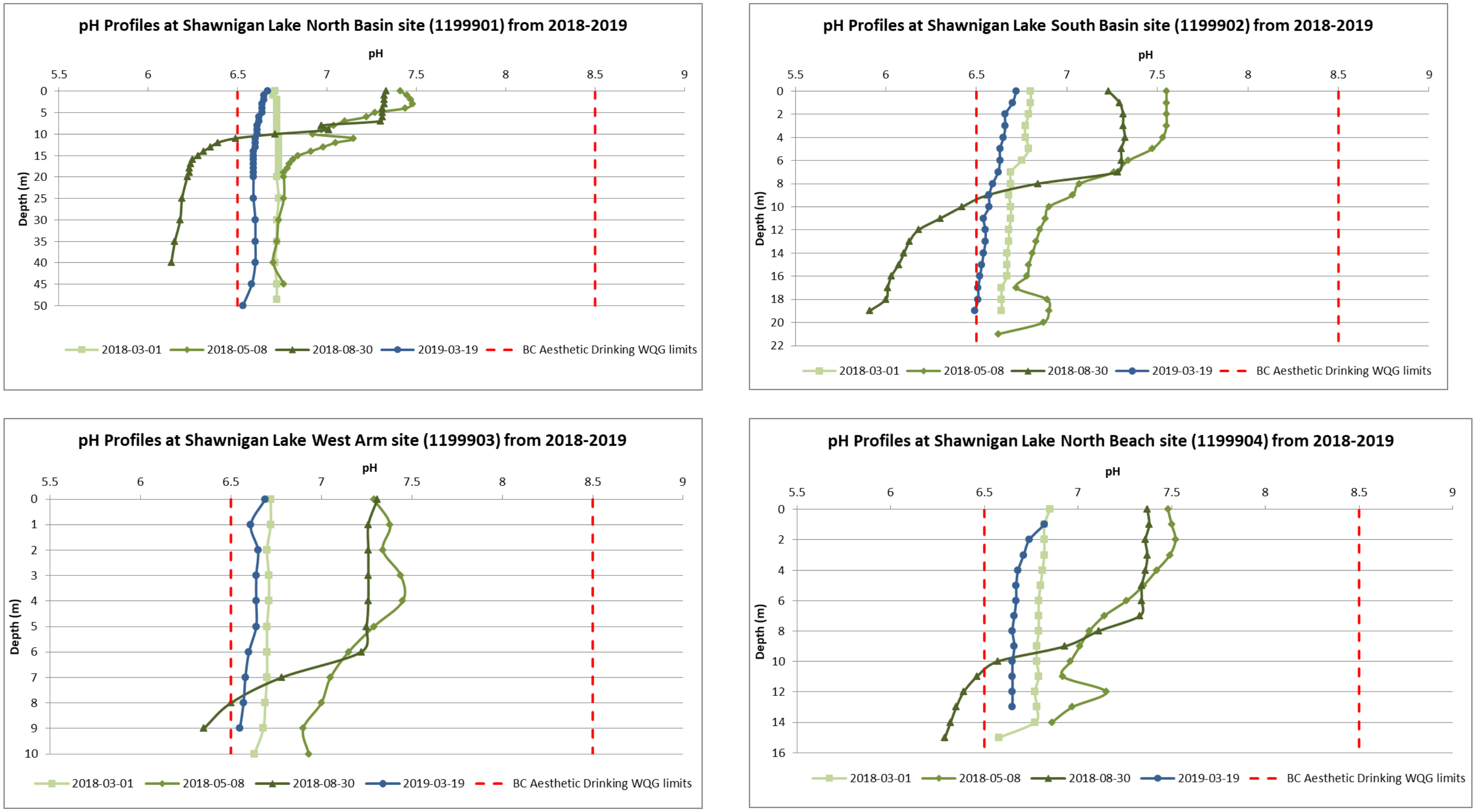



*Figure 9. pH profiles for Shawnigan Lake Deep Basin sites (2018-2019).*

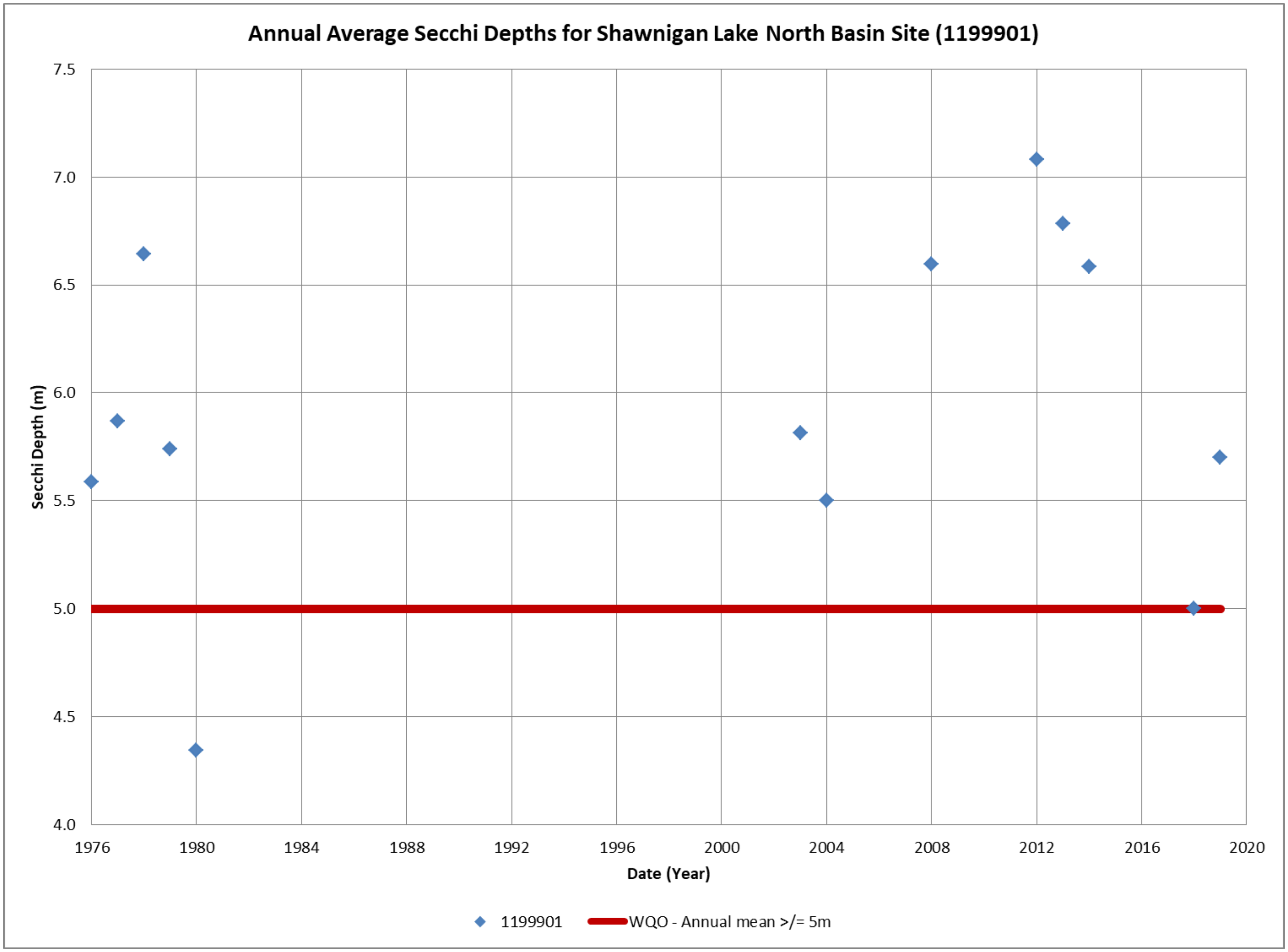
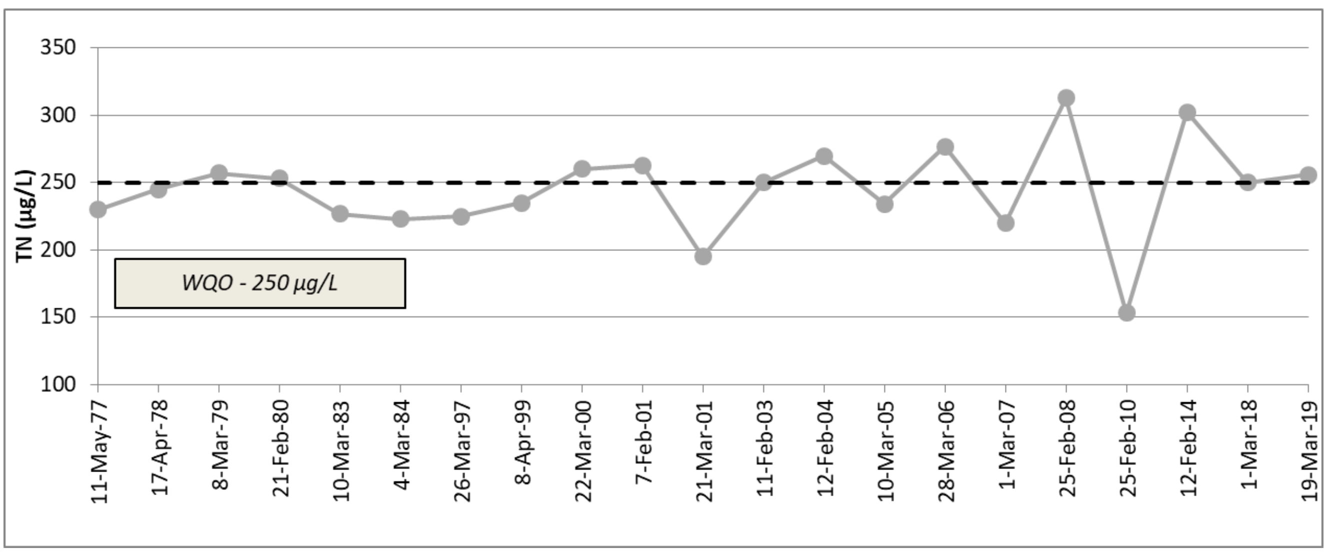



*Figure 10. Annual average Secchi depths for Shawnigan Lake North Basin site (1199901) (1976-2019).*

*Table 10. N:P ratios (mean* total N µg/L:mean* total P µg/L) for the Shawnigan Lake basin sites, 1976-2019. 1976-2014 results are shown only for the purpose of demonstrating trends for this parameter.*

| Year | North Basin (1199901) | South Basin (1199902) | West Arm (1199903) | North Beach (1199904) |
|---|---|---|---|---|
| | N:P ratios (mean total N (µg/L) : mean total P (µg/L)) | | | |
| 1976-1979 | 30:1 | 34:1 | 36:1 | 33:1 |
| 1980-1989 | 34:1 | 26:1 | -- | -- |
| 1990-1999 | 58:1 | -- | -- | -- |
| 2000-2005 | 36:1 | 32:1 | 54:1 | 58:1 |
| 2006 | 83:1 | 72:1 | 85:1 | 102:1 |
| 2007 | 37:1 | 46:1 | 39:1 | 44:1 |
| 2008 | 52:1 | 44:1 | 45:1 | 38:1 |
| 2010 | 42:1 | 45:1 | 61:1 | 59:1 |
| 2014 | 61:1 | 45:1 | 35:1 | 56:1 |
| 2018 | 40:1 | 35:1 | 30:1 | 45:1 |
| 2019 | 43:1 | 34:1 | 53:1 | 53:1 |

** Mean of at least three samples taken throughout the water column (surface, mid-depth, one meter above bottom). Two composite samples were taken throughout the water column in 2018 and 2019.*




** Mean of at least three samples taken throughout the water column (surface, mid-depth, one meter above bottom), at spring overturn. Two composite samples were taken throughout the water column in 2018 and 2019.*

*Figure 11. Total nitrogen annual averages for Shawnigan Lake North Basin site (1199901) (1977-2019).*

*Table 11. Total organic carbon for the Shawnigan Lake basin sites (2018-2019). Exceedances are highlighted.*

| Date | North Basin (1199901) | | | South Basin (1199902) | | | West Arm (1199903) | | North Beach (1199904) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Surface** (mg/L) | **10 m** (mg/L) | **Bottom** (mg/L) | **Surface** (mg/L) | **10 m** (mg/L) | **Bottom** (mg/L) | **Surface** (mg/L) | **Bottom** (mg/L) | **Surface** (mg/L) | **Bottom** (mg/L) |
| 01-Mar-2018 | 3.49 | — | 3.72 | 3.54 | — | 3.46 | 3.77 | 4.34 | 3.76 | 3.60 |
| 08-May-2018 | 3.56 | — | 3.06 | 3.57 | — | 3.34 | 3.53 | 3.48 | 3.50 | 3.23 |
| 30-Aug-2018 | 3.09 | 2.95 | 2.91 | 3.06 | 3.05 | 3.40 | 3.45 | 3.08 | 3.15 | 3.16 |
| 19-Mar-2019 | 3.59 | — | 3.78 | 3.54 | — | 3.53 | 3.35 | 3.20 | 3.31 | 3.33 |

*Table 12. Summary of dominant (i.e. >10% of sample) Phytoplankton species for the North Basin and South Basin sites (2018-2019).*

| Group | Species | Date | | | |
|---|---|---|---|---|---|
| | | **March 1, 2018** | **May 8, 2018** | **August 30, 2018** | **March 19, 2019** |
| **North Basin Site (EMS 1199901)** | | **Number of cells/mL (% of total sample)** | | | |
| **Diatoms** | **Order: Centrales** | | | | |
| | *Melosira italica* | — | 145.6 (38.66%) | — | 18.2 (10.66%) |
| | **Order: Pennales** | | | | |
| | *Asterionella formosa* | 302.4 (38.57%) | — | — | 32.2 (18.85%) |
| | *Fragilaria crotonensis* | 316.4 (40.36%) | — | — | — |
| **Cyanophyta (Blue-green)** | **Order: Oscillatoriales** | | | | |
| | *Lyngbya cf limnetica* | — | — | 28.0 (19.42%) | — |
| **Chlorophyta (Green)** | **Order: Chlorococcales** | | | | |
| | *Botryococcus braunii* | — | — | 22.4 (15.53%) | — |
| **Cryptophyte** | **Order: Cryptomonadales** | | | | |
| | *Chroomonas acuta* | 109.2 (13.93%) | — | 15.4 (10.68%) | 77.0 (45.08%) |
| **Chrysophyta (Golden Brown)** | **Order: Ochromonadales** | | | | |
| | *Dinobryon divergens*[1] | — | 130.2 (34.57%) | — | — |
| | **Total Number of Cells per Sample** | **784** | **377** | **144** | **171** |
| **South Basin Site (EMS 1199902)** | | | | | |
| **Diatoms** | **Order: Centrales** | | | | |
| | *Melosira italica* | — | 89.3 (17.03%) | — | 28.0 (13.16%) |
| | **Order: Pennales** | | | | |
| | *Asterionella formosa* | 338.8 (57.08%) | — | — | 64.4 (30.26%) |
| | *Fragilaria crotonensis* | 84.0 (14.15%) | 197.6 (37.68%) | — | — |
| **Cyanophyta (Blue-green)** | **Order: Chroococcales** | | | | |
| | *Gloeocapsa sp.* | — | — | 33.6 (13.56%) | — |
| | **Order: Oscillatoriales** | | | | |
| | *Lyngbya cf limnetica* | — | — | 28.0 (11.30%) | — |
| **Chlorophyta (Green)** | **Order: Tetrasporales** | | | | |
| | *Gloeocystis cf ampla* | — | — | 28.0 (11.30%) | — |
| **Cryptophyte** | **Order: Cryptomonadales** | | | | |
| | *Chroomonas acuta* | 81.2 (13.68%) | — | — | 77.0 (36.18%) |
| **Chrysophyta (Golden Brown)** | **Order: Ochromonadales** | | | | |
| | *Dinobryon divergens*[1] | — | 58.9 (11.23%) | — | — |
| | **Total Number of Cells per Sample** | **594** | **524** | **248** | **213** |

*[1]Note: Some of the Dinobryon divergens and Dinobryon sertularia are similar and difficult to distinguish.*
*UID = unidentified due to lack of size and/or missing morphological characters.*

*Table 13. Summary of dominant (i.e. >10% of sample) Phytoplankton species for the West Arm and North Beach sites (2018-2019).*

| Group | Species | Date | | | |
|---|---|---|---|---|---|
| | | **March 1, 2018** | **May 8, 2018** | **August 30, 2018** | **March 19, 2019** |
| **West Arm Site (EMS 1199903)** | | Number of cells/mL (% of total sample) | | | |
| **Diatoms** | **Order: Centrales** | | | | |
| | *Melosira italica* | — | 110.6 (17.59%) | — | — |
| | **Order: Pennales** | | | | |
| | *Asterionella formosa* | 211.4 (51.01%) | — | — | 105.0 (39.68%) |
| | *Fragilaria crotonensis* | 119.0 (28.72%) | 67.2 (10.69%) | — | — |
| **Chlorophyta (Green)** | **Order: Chlorococcales** | | | | |
| | *Sphaerocystis schroeteri* | — | — | 39.2 (21.71%) | — |
| **Cryptophyte** | **Order: Cryptomonadales** | | | | |
| | *Chroomonas acuta* | — | 89.6 (14.25%) | 35.0 (19.38%) | 89.6 (33.86%) |
| | *Cryptomonas ovata / erosa* | — | 91.0 (14.48%) | 21.0 (11.63%) | — |
| **Chrysophyta (Golden Brown)** | **Order: Ochromonadales** | | | | |
| | *Dinobryon cf sertularia* [1] | — | 92.4 (14.70%) | — | — |
| **Total Number of Cells per Sample** | | **414** | **629** | **181** | **265** |
| **North Beach Site (EMS 1199904)** | | | | | |
| **Diatoms** | **Order: Centrales** | | | | |
| | *Melosira italica* | — | 106.4 (36.19%) | — | — |
| | **Order: Pennales** | | | | |
| | *Asterionella formosa* | 285.6 (69.39%) | — | — | 71.4 (31.29%) |
| | *Tabellaria fenestrata* | — | — | — | 37.8 (16.56%) |
| **Cyanophyta (Blue-green)** | **Order: Oscillatoriales** | | | | |
| | *Lyngbya cf limnetica* | — | — | 84.0 (37.50%) | — |
| **Chlorophyta (Green)** | **Order: Chlorococcales** | | | | |
| | *Botryococcus braunii* | — | — | 33.6 (15.00%) | — |
| | *Sphaerocystis schroeteri* | — | — | 22.4 (10.00%) | — |
| **Cryptophyte** | **Order: Cryptomonadales** | | | | |
| | *Chroomonas acuta* | 89.6 (21.77%) | 36.4 (12.38%) | — | 67.2 (29.45%) |
| | *Cryptomonas ovata / erosa* | — | 37.8 (12.86%) | — | — |
| **Total Number of Cells per Sample** | | **412** | **294** | **224** | **228** |

*[1]Note: Some of the Dinobryon divergens and Dinobryon sertularia are similar and difficult to distinguish.*
*UID = unidentified due to lack of size and/or missing morphological characters.*

*Table 14. Seasonal averages of total number of species and cell count for all phytoplankton data for Shawnigan Lake (2018-2019).*

| Sample Year | Sample Month | Total Number of Species | | | | | Total number of cells/mL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | North Basin (1199901) | South Basin (1199902) | West Arm (1199903) | North Beach (1199904) | Average | North Basin (1199901) | South Basin (1199902) | West Arm (1199903) | North Beach (1199904) | Average |
| 2018 | March | 23 | 35 | 30 | 28 | **29** | 784 | 594 | 414 | 412 | **551** |
| 2018 | May | 58 | 54 | 68 | 44 | **56** | 377 | 524 | 629 | 294 | **456** |
| 2018 | August | 61 | 61 | 77 | 67 | **67** | 144 | 248 | 181 | 224 | **199** |
| 2019 | March | 36 | 37 | 49 | 35 | **39** | 171 | 213 | 265 | 228 | **219** |
| **Total Species Richness for Site** | | **91** | **90** | **105** | **86** | | | | | | |

*Table 15. Summary of dominant (>10% of sample) Zooplankton species for Shawnigan Lake (2018 – 2019).*

| Group | | | Species | Stage | Date | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | March 1, 2018 | May 8, 2018 | August 30, 2018 | March 19, 2019 |
| **North Basin Site (1199901)** | | | | | Number of cells/mL (% of total sample) | | | |
| Phylum Arthropoda | Class Maxillopoda | Subclass Copepoda | **Order : Calanoida** | | | | | |
| | | | UID Calanoida / Cyclopoida | nauplii | 518 (17.26%) | 2294 (18.20%) | 1296 (18.60%) | 2625 (14.23%) |
| Phylum Rotifera | | | Kellicottia longispina | | — | 1363 (10.82%) | 1102 (15.82%) | — |
| | | | Keratella cochlearis | | 335 (11.16%) | 6118 (48.55%) | 1814 (26.03%) | 10150 (55.03%) |
| | | | Polyarthra spp. | | 749 (24.95%) | — | — | — |
| | | | **Total Number of Cells per Sample** | | **3,002** | **12,601** | **6,968** | **18,443** |
| **South Basin Site (1199902)** | | | | | | | | |
| Phylum Arthropoda | Class Maxillopoda | Subclass Copepoda | **Order : Cyclopoida** | | | | | |
| | | | UID | copepodid | 71 (16.03%) | — | — | — |
| | | | **Order : Calanoida** | | | | | |
| | | | UID Calanoida / Cyclopoida | nauplii | 115 (25.96%) | 6176 (21.96%) | 1401 (21.85%) | 2638 (17.30%) |
| Phylum Rotifera | | | Keratella cochlearis | | 61 (13.77%) | 10076 (35.69%) | 2102 (32.79%) | 6329 (41.52%) |
| | | | **Total Number of Cells per Sample** | | **443** | **28,122** | **6,411** | **15,245** |
| **West Arm Site (1199903)** | | | | | | | | |
| Phylum Arthropoda | Class Maxillopoda | Subclass Copepoda | **Order : Calanoida** | | | | | |
| | | | UID Calanoida / Cyclopoida | nauplii | 544 (18.08%) | — | 4250 (43.67%) | — |
| Phylum Rotifera | | | Keratella cochlearis | | 540 (17.95%) | 10966 (69.62%) | 1546 (15.88%) | 16821 (63.46%) |
| | | | Polyarthra spp. | | 1162 (38.62%) | — | — | — |
| | | | **Total Number of Cells per Sample** | | **3,009** | **15,751** | **9,733** | **26,508** |
| **North Beach Site (1199904)** | | | | | | | | |
| Phylum Arthropoda | Class Maxillopoda | Subclass Copepoda | **Order : Cyclopoida** | | | | | |
| | | | UID | copepodid | 674 (10.93%) | — | — | — |
| | | | **Order : Calanoida** | | | | | |
| | | | UID Calanoida / Cyclopoida | nauplii | 836 (13.56%) | 1769 (23.06%) | 2732 (32.55%) | 2630 (11.72%) |
| | | | **Order: Cladocera** | | | | | |
| | | | Daphnia longiremis | adult | — | 991 (12.92%) | — | — |
| Phylum Rotifera | | | Kellicottia longispina | | — | 907 (11.82%) | 1066 (12.70%) | |
| | | | Keratella cochlearis | | 1316 (21.35%) | 2603 (33.93%) | 1391 (16.97%) | 13512 (60.20%) |
| | | | Polyarthra spp. | | 1287 (20.88%) | — | — | |
| | | | **Total Number of Cells per Sample** | | **6,164** | **7,672** | **8,393** | **22,444** |
| | | | **Average Total per Sample** | | **3,155** | **16,037** | **7,876** | **20,660** |

*UID = unidentified due to lack of size and/or missing morphological characters.*

*Table 16. Summary of 2018 E.coli (CFU/100mL) samples collected at the East Shore (E257436) and North (E257437) domestic water intake sites.*

| Site | Sample Year | Count | Min | Max | Avg | SD | Geomean | 90th percentile |
|---|---|---|---|---|---|---|---|---|
| East Shore E257436 | summer | 4 | 2 | 20 | 9.5 | 8.6 | 5.28 | 17.9* |
| | fall | 5 | <1 | 4 | 2 | 1.4 | 0.64 | 3.6 |
| North E257437 | summer | 5 | 2 | 15 | 7.6 | 6.8 | 4.27 | 15 |
| | fall | 4 | <1 | 4 | 2 | 1.4 | 0.68 | 3.4 |

*Statistics are calculated based on five samples collected in a 30 day period, unless the sample count indicates otherwise. Grey highlighted 90th percentile values exceed the applicable WQO. *Value based on only 4 samples cannot be directly compared to WQO.*

*Table 17. Summary of 2018-2019 general chemistry water grab samples taken at Shawnigan Lake North Basin site (1199901).*

| Parameter | Units | Minimum | Maximum | Average | Std Dev | Count |
|---|---|---|---|---|---|---|
| **GENERAL** | | | | | | |
| Ammonia (N) - Total | mg/L | <0.005 | 0.013 | 0.007 | 0.003 | 9 |
| Ammonia - Dissolved | mg/L | <0.005 | <0.005 | N/A | N/A | 2 |
| Carbon, Organic - Total | mg/L | 2.9 | 3.78 | 3.29 | 0.34 | 11 |
| Chlorophyll *a* | mg/L | 0.0008 | 0.0032 | 0.0017 | 0.0010 | 4 |
| Hardness - Total | mg/L | 19.53 | 22.46 | 20.64 | 1.16 | 5 |
| Hardness - Dissolved | mg/L | 19.5 | 22.5 | 20.5 | 1.2 | 6 |
| Kjeldahl Nitrogen - Total | mg/L | 0.11 | 0.13 | 0.12 | 0.01 | 4 |
| Nitrate (NO3) - Dissolved | mg/L | <0.003 | 0.166 | 0.100 | 0.058 | 10 |
| Nitrate + Nitrite | mg/L | 0.129 | 0.143 | 0.134 | 0.006 | 4 |
| Nitrate + Nitrite, Dissolved | mg/L | <0.0032 | 0.166 | 0.100 | 0.058 | 10 |
| Nitrogen - Nitrite, Dissolved | mg/L | <0.001 | 0.001 | 0.001 | 0.00003 | 10 |
| Nitrogen (N) - Total | mg/L | 0.149 | 0.261 | 0.221 | 0.044 | 11 |
| Nitrogen, Organic - Total | mg/L | 0.115 | 0.116 | 0.116 | 0.001 | 2 |
| Ortho-Phosphate - Dissolved | mg/L | <0.001 | <0.001 | N/A | N/A | 4 |
| pH | pH units | 6.13 | 7.71 | 6.80 | 0.36 | 113 |
| Phosphorus (P) - Total | mg/L | 0.0039 | 0.0079 | 0.0053 | 0.0012 | 11 |
| Phosphorus - Dissolved | mg/L | 0.003 | 0.003 | 0.003 | 0.0002 | 2 |
| Specific Conductivity | µS/cm | 52.0 | 86.0 | 56.3 | 3.6 | 116 |
| Sulphate (SO4) - Dissolved | mg/L | 2.76 | 2.78 | 2.77 | 0.01 | 2 |
| Sulfur - Total | mg/L | 0.82 | 0.83 | 0.83 | 0.01 | 2 |
| True Colour | Col. Unit | 6.4 | 14.0 | 11.3 | 3.1 | 8 |
| Turbidity | NTU | 0.28 | 0.97 | 0.47 | 0.24 | 8 |
| **METALS/SEMI-METALS** | | | | | | |
| Ag - T (Silver) | mg/L | <0.000005 | <0.00001 | N/A | N/A | 5 |
| Ag - D | mg/L | <0.000005 | <0.000005 | N/A | N/A | 3 |
| Al - T (Aluminum) | mg/L | 0.0072 | 0.0396 | 0.0278 | 0.0128 | 5 |
| Al - D | mg/L | 0.0247 | 0.0253 | 0.0251 | 0.0003 | 3 |
| As - T (Arsenic) | mg/L | 0.000107 | 0.00021 | 0.000142 | 0.000041 | 5 |
| As - D | mg/L | 0.000106 | 0.000124 | 0.000116 | 0.000009 | 3 |
| B - T (Boron) | mg/L | 0.007 | 0.01 | 0.009 | 0.001 | 5 |
| B - D | mg/L | 0.008 | 0.009 | 0.008 | 0.0002 | 3 |
| Ba - T (Barium) | mg/L | 0.00493 | 0.00610 | 0.00529 | 0.00046 | 5 |
| Ba - D | mg/L | 0.005 | 0.00538 | 0.00513 | 0.00021 | 3 |
| Be - T (Beryllium) | mg/L | <0.00001 | <0.0001 | N/A | N/A | 5 |
| Be - D | mg/L | <0.00001 | <0.00001 | N/A | N/A | 3 |

| Parameter | Units | Minimum | Maximum | Average | Std Dev | Count |
|---|---|---|---|---|---|---|
| Bi - T (Bismuth) | mg/L | <0.000005 | <0.00005 | N/A | N/A | 5 |
| Bi - D | mg/L | <0.000005 | <0.000005 | N/A | N/A | 3 |
| Ca - T (Calcium) | mg/L | 5.76 | 6.72 | 6.18 | 0.37 | 5 |
| Ca- D | mg/L | 5.80 | 6.28 | 5.98 | 0.21 | 4 |
| Cd - T (Cadmium) | mg/L | <0.000005 | <0.000005 | N/A | N/A | 5 |
| Cd - D | mg/L | <0.000005 | <0.000005 | N/A | N/A | 3 |
| Cl - D (Chloride) | mg/L | 4.23 | 4.71 | 4.46 | 0.20 | 10 |
| Co - T (Cobalt) | mg/L | 0.000023 | 0.0001 | 0.000059 | 0.000039 | 5 |
| Co - D | mg/L | 0.000016 | 0.000018 | 0.000017 | 0.000001 | 3 |
| Cr - T (Chromium) | mg/L | <0.0001 | 0.0040 | 0.0009 | 0.0017 | 5 |
| Cr - D | mg/L | <0.0001 | 0.0002 | 0.0001 | 0.00004 | 3 |
| Cu T (Copper) | mg/L | 0.00056 | 0.00159 | 0.00091 | 0.00041 | 5 |
| Cu - D | mg/L | 0.0005 | 0.00095 | 0.00071 | 0.00022 | 3 |
| Fe - T (Iron) | mg/L | 0.0119 | 0.312 | 0.0948 | 0.1231 | 5 |
| Fe - D | mg/L | 0.0218 | 0.0263 | 0.0247 | 0.0025 | 3 |
| K - T (Potassium) | mg/L | 0.253 | 0.299 | 0.281 | 0.018 | 5 |
| K - D | mg/L | 0.244 | 0.298 | 0.277 | 0.029 | 3 |
| Li - T (Lithium) | mg/L | <0.0005 | <0.0005 | N/A | N/A | 3 |
| Li - D | mg/L | <0.0005 | <0.0005 | N/A | N/A | 3 |
| Mg - T (Magnesium) | mg/L | 1.18 | 1.38 | 1.26 | 0.07 | 5 |
| Mg - D | mg/L | 1.14 | 1.22 | 1.19 | 0.03 | 4 |
| Mn - T (Manganese) | mg/L | 0.0027 | 0.103 | 0.0236 | 0.0444 | 5 |
| Mn - D | mg/L | 0.00091 | 0.00175 | 0.00144 | 0.00046 | 3 |
| Mo - T (Molybdenum) | mg/L | 0.000055 | 0.000143 | 0.000092 | 0.000038 | 5 |
| Mo - D | mg/L | 0.000058 | 0.000061 | 0.000060 | 0.000002 | 3 |
| Na - T (Sodium) | mg/L | 2.69 | 3.63 | 3.03 | 0.40 | 5 |
| Na - D | mg/L | 2.66 | 2.84 | 2.77 | 0.09 | 3 |
| Ni - T (Nickel) | mg/L | 0.000135 | 0.00112 | 0.000481 | 0.000400 | 5 |
| Ni - D | mg/L | 0.000108 | 0.000146 | 0.000128 | 0.000019 | 3 |
| Pb - T (Lead) | mg/L | 0.0000193 | 0.00005 | 0.0000409 | 0.0000136 | 5 |
| Pb - D | mg/L | 0.0000116 | 0.0000221 | 0.0000176 | 0.0000054 | 3 |
| Sb - T (Antimony) | mg/L | 0.000024 | 0.0001 | 0.000056 | 0.000040 | 5 |
| Sb - D | mg/L | 0.000027 | 0.00003 | 0.000028 | 0.000002 | 3 |
| Se - T (Selenium) | mg/L | <0.00004 | <0.00005 | N/A | N/A | 5 |
| Se - D | mg/L | <0.00004 | <0.00004 | N/A | N/A | 3 |
| Si - T (Silica) | mg/L | 1.59 | 2.95 | 2.54 | 0.55 | 5 |
| Si - D | mg/L | 2.56 | 2.73 | 2.66 | 0.09 | 3 |
| Silica: D | mg/L | 5.62 | 5.89 | 5.76 | 0.19 | 2 |
| Sn - T (Tin) | mg/L | <0.00001 | <0.0001 | N/A | N/A | 5 |

| Parameter | Units | Minimum | Maximum | Average | Std Dev | Count |
|---|---|---|---|---|---|---|
| Sn - D | mg/L | <0.00001 | <0.00001 | N/A | N/A | 3 |
| Sr - T (Strontium) | mg/L | 0.0237 | 0.0266 | 0.0248 | 0.0011 | 5 |
| Sr - D | mg/L | 0.0239 | 0.0247 | 0.0242 | 0.0004 | 3 |
| Ti - T (Titanium) | mg/L | <0.0003 | <0.0003 | N/A | N/A | 2 |
| Tl - T (Thallium) | mg/L | <0.000002 | <0.00001 | N/A | N/A | 5 |
| Tl - D | mg/L | <0.000002 | <0.000002 | N/A | N/A | 3 |
| U - T (Uranium) | mg/L | 0.0000054 | 0.00001 | 0.0000073 | 0.0000024 | 5 |
| U - D | mg/L | 0.0000049 | 0.0000058 | 0.0000054 | 0.0000005 | 3 |
| V - T (Vanadium) | mg/L | 0.00021 | 0.0005 | 0.00033 | 0.00016 | 5 |
| V - D | mg/L | <0.0002 | <0.0002 | N/A | N/A | 3 |
| Zn - T (Zinc) | mg/L | 0.00114 | 0.003 | 0.00210 | 0.00091 | 5 |
| Zn - D | mg/L | 0.00095 | 0.00184 | 0.00135 | 0.00045 | 3 |

*Table 18. Summary of 2018-2019 general chemistry water grab sample statistics taken at Shawnigan Lake South Basin site (1199902).*

| Parameter | Units | Minimum | Maximum | Average | Std Dev | Count |
|---|---|---|---|---|---|---|
| **GENERAL** | | | | | | |
| Ammonia (N) - Total | mg/L | <0.005 | 0.0132 | 0.0064 | 0.0029 | 8 |
| Ammonia - Dissolved | mg/L | <0.005 | <0.005 | N/A | N/A | 2 |
| Carbon, Organic - Total | mg/L | 3.02 | 3.57 | 3.35 | 0.22 | 10 |
| Chlorophyll *a* | mg/L | 0.00125 | 0.00151 | 0.001365 | 0.00010755 | 4 |
| Hardness - Total | mg/L | 17.15 | 22.58 | 19.51 | 2.55 | 5 |
| Hardness - Dissolved | mg/L | 15.7 | 22.6 | 18.6 | 2.9 | 6 |
| Kjeldahl Nitrogen - Total | mg/L | <0.105 | 0.11 | 0.11 | 0.002 | 4 |
| Nitrate (NO3) - Dissolved | mg/L | <0.003 | 0.146 | 0.083 | 0.046 | 11 |
| Nitrate + Nitrite | mg/L | 0.108 | 0.111 | 0.109 | 0.001 | 4 |
| Nitrate + Nitrite, Dissolved | mg/L | <0.0032 | 0.146 | 0.083 | 0.046 | 11 |
| Nitrogen - Nitrite, Dissolved | mg/L | <0.001 | <0.001 | N/A | N/A | 11 |
| Nitrogen (N) - Total | mg/L | 0.142 | 0.276 | 0.204 | 0.038 | 10 |
| Nitrogen, Organic - Total | mg/L | 0.1 | 0.103 | 0.102 | 0.002 | 2 |
| Ortho-Phosphate - Dissolved | mg/L | <0.001 | 0.0012 | 0.0011 | 0.0001 | 4 |
| pH | pH units | 5.91 | 7.68 | 6.84 | 0.44 | 91 |
| Phosphorus (P) - Total | mg/L | 0.036 | 0.0083 | 0.0059 | 0.0015 | 10 |
| Phosphorus - Dissolved | mg/L | 0.002 | 0.003 | 0.002 | 0.0004 | 2 |
| Specific Conductivity | µS/cm | 48.0 | 65.0 | 53.0 | 4.5 | 82 |
| Sulphate (SO4) - Dissolved | mg/L | 2.77 | 2.78 | 2.78 | 0.01 | 2 |
| Sulfur - Total | mg/L | 0.72 | 0.79 | 0.76 | 0.05 | 2 |
| True Colour | Col. Unit | 6.8 | 23.7 | 14.0 | 5.2 | 9 |
| Turbidity | NTU | 0.26 | 2.33 | 0.89 | 0.70 | 10 |
| **METALS/SEMI-METALS** | | | | | | |
| Ag - T (Silver) | mg/L | <0.000005 | <0.00001 | N/A | N/A | 5 |
| Ag - D | mg/L | <0.000005 | <0.000005 | N/A | N/A | 3 |
| Al - T (Aluminum) | mg/L | 0.0094 | 0.0633 | 0.0436 | 0.0228 | 5 |
| Al - D | mg/L | 0.0385 | 0.0409 | 0.0398 | 0.0012 | 3 |
| As - T (Arsenic) | mg/L | 0.000098 | 0.000230 | 0.000140 | 0.000055 | 5 |
| As - D | mg/L | 0.000093 | 0.000114 | 0.000106 | 0.000011 | 3 |
| B - T (Boron) | mg/L | 0.008 | 0.01 | 0.009 | 0.001 | 5 |
| B - D | mg/L | 0.008 | 0.009 | 0.008 | 0.001 | 3 |
| Ba - T (Barium) | mg/L | 0.00407 | 0.00696 | 0.00492 | 0.00123 | 5 |
| Ba - D | mg/L | 0.00383 | 0.004 | 0.00391 | 0.00009 | 3 |
| Be - T (Beryllium) | mg/L | <0.00001 | <0.0001 | N/A | N/A | 5 |
| Be - D | mg/L | <0.00001 | <0.00001 | N/A | N/A | 3 |

| Parameter | Units | Minimum | Maximum | Average | Std Dev | Count |
|---|---|---|---|---|---|---|
| Bi - T (Bismuth) | mg/L | <0.000005 | <0.00005 | N/A | N/A | 5 |
| Bi - D | mg/L | <0.000005 | <0.000005 | N/A | N/A | 3 |
| Ca - T (Calcium) | mg/L | 5.02 | 6.75 | 5.84 | 0.84 | 5 |
| Ca- D | mg/L | 4.43 | 5.29 | 4.91 | 0.38 | 4 |
| Cd - T (Cadmium) | mg/L | <0.000005 | <0.000005 | N/A | N/A | 5 |
| Cd - D | mg/L | <0.000005 | <0.000005 | N/A | N/A | 3 |
| Cl - D (Chloride) | mg/L | 3.92 | 5.61 | 4.63 | 0.49 | 11 |
| Co - T (Cobalt) | mg/L | 0.000032 | 0.000130 | 0.000065 | 0.000047 | 5 |
| Co - D | mg/L | 0.000022 | 0.000027 | 0.000024 | 0.000003 | 3 |
| Cr - T (Chromium) | mg/L | <0.0001 | 0.0002 | 0.0001 | 0.00002 | 5 |
| Cr - D | mg/L | <0.0001 | 0.0001 | 0.0001 | 0.00002 | 3 |
| Cu T (Copper) | mg/L | 0.00068 | 0.00166 | 0.00093 | 0.00041 | 5 |
| Cu - D | mg/L | 0.00063 | 0.00137 | 0.00094 | 0.00038 | 3 |
| Fe - T (Iron) | mg/L | 0.0175 | 0.535 | 0.1436 | 0.2194 | 5 |
| Fe - D | mg/L | 0.0305 | 0.0384 | 0.0338 | 0.0041 | 3 |
| K - T (Potassium) | mg/L | 0.233 | 0.3 | 0.274 | 0.025 | 5 |
| K - D | mg/L | 0.225 | 0.272 | 0.254 | 0.025 | 3 |
| Li - T (Lithium) | mg/L | <0.0005 | <0.0005 | N/A | N/A | 3 |
| Li - D | mg/L | <0.0005 | <0.0005 | N/A | N/A | 3 |
| Mg - T (Magnesium) | mg/L | 1.07 | 1.39 | 1.20 | 0.13 | 5 |
| Mg - D | mg/L | 1.07 | 1.13 | 1.09 | 0.03 | 4 |
| Mn - T (Manganese) | mg/L | 0.0029 | 0.134 | 0.0296 | 0.0584 | 5 |
| Mn - D | mg/L | 0.00161 | 0.00257 | 0.00193 | 0.00055 | 3 |
| Mo - T (Molybdenum) | mg/L | 0.000053 | 0.000085 | 0.000064 | 0.000013 | 5 |
| Mo - D | mg/L | 0.000051 | 0.000062 | 0.000057 | 0.000006 | 3 |
| Na - T (Sodium) | mg/L | 2.55 | 3.69 | 3.07 | 0.55 | 5 |
| Na - D | mg/L | 2.51 | 2.74 | 2.65 | 0.12 | 3 |
| Ni - T (Nickel) | mg/L | 0.000135 | 0.0005 | 0.000297 | 0.000187 | 5 |
| Ni - D | mg/L | 0.00011 | 0.000225 | 0.000154 | 0.000062 | 3 |
| Pb - T (Lead) | mg/L | 0.0000301 | 0.000139 | 0.0000703 | 0.0000425 | 5 |
| Pb - D | mg/L | 0.0000157 | 0.0000185 | 0.0000172 | 0.0000014 | 3 |
| Sb - T (Antimony) | mg/L | 0.000025 | 0.0001 | 0.000055 | 0.000041 | 5 |
| Sb - D | mg/L | 0.000022 | 0.000026 | 0.000025 | 0.000002 | 3 |
| Se - T (Selenium) | mg/L | <0.00004 | <0.00005 | N/A | N/A | 5 |
| Se - D | mg/L | <0.00004 | <0.00004 | N/A | N/A | 3 |
| Si - T (Silica) | mg/L | 1.55 | 3.21 | 2.70 | 0.67 | 5 |
| Si - D | mg/L | 2.72 | 3.02 | 2.90 | 0.16 | 3 |
| Silica: D | mg/L | 5.96 | 6.24 | 6.10 | 0.20 | 2 |
| Sn - T (Tin) | mg/L | <0.00001 | <0.0001 | N/A | N/A | 5 |

| Parameter | Units | Minimum | Maximum | Average | Std Dev | Count |
|---|---|---|---|---|---|---|
| Sn - D | mg/L | <0.00001 | <0.00001 | N/A | N/A | 3 |
| Sr - T (Strontium) | mg/L | 0.0220 | 0.0404 | 0.0272 | 0.0077 | 5 |
| Sr - D | mg/L | 0.0212 | 0.0226 | 0.0220 | 0.0007 | 3 |
| Ti - T (Titanium) | mg/L | <0.0003 | 0.00043 | 0.000365 | 0.000092 | 2 |
| Tl - T (Thallium) | mg/L | <0.000002 | <0.00001 | N/A | N/A | 5 |
| Tl - D | mg/L | <0.000002 | <0.000002 | N/A | N/A | 3 |
| U - T (Uranium) | mg/L | 0.0000051 | 0.00001 | 0.0000072 | 0.0000026 | 5 |
| U - D | mg/L | 0.000005 | 0.0000054 | 0.0000052 | 0.0000002 | 3 |
| V - T (Vanadium) | mg/L | 0.00028 | 0.0005 | 0.00037 | 0.00012 | 5 |
| V - D | mg/L | <0.0002 | 0.00024 | 0.00022 | 0.00002 | 3 |
| Zn - T (Zinc) | mg/L | 0.00104 | 0.003 | 0.00196 | 0.00097 | 5 |
| Zn - D | mg/L | 0.00084 | 0.00111 | 0.00101 | 0.00015 | 3 |

*Table 19. Summary of 2018-2019 general chemistry water grab sample statistics taken at Shawnigan Lake West Arm site (1199903).*

| Parameter | Units | Minimum | Maximum | Average | Std Dev | Count |
|---|---|---|---|---|---|---|
| **GENERAL** | | | | | | |
| Ammonia (N) - Total | mg/L | <0.005 | 0.0203 | 0.0080 | 0.0052 | 8 |
| Ammonia - Dissolved | mg/L | <0.005 | <0.005 | N/A | N/A | 2 |
| Carbon, Organic - Total | mg/L | 3.08 | 4.34 | 3.51 | 0.35 | 10 |
| Chlorophyll *a* | mg/L | 0.00106 | 0.00184 | 0.00145 | 0.00041 | 4 |
| Hardness - Total | mg/L | 22.70 | 29.60 | 25.02 | 2.46 | 7 |
| Hardness - Dissolved | mg/L | 22.7 | 28.6 | 24.7 | 2.0 | 8 |
| Kjeldahl Nitrogen - Total | mg/L | 0.10 | 0.15 | 0.12 | 0.02 | 5 |
| Nitrate (NO3) - Dissolved | mg/L | <0.003 | 0.155 | 0.095 | 0.058 | 10 |
| Nitrate + Nitrite | mg/L | 0.137 | 0.156 | 0.143 | 0.008 | 5 |
| Nitrate + Nitrite, Dissolved | mg/L | <0.0032 | 0.155 | 0.095 | 0.058 | 10 |
| Nitrogen - Nitrite, Dissolved | mg/L | <0.001 | 0.001 | 0.001 | 0.0001 | 10 |
| Nitrogen (N) - Total | mg/L | 0.169 | 0.287 | 0.237 | 0.040 | 10 |
| Nitrogen, Organic - Total | mg/L | 0.093 | 0.113 | 0.104 | 0.010 | 3 |
| Ortho-Phosphate - Dissolved | mg/L | <0.001 | <0.001 | N/A | N/A | 5 |
| pH | pH units | 6.35 | 7.89 | 7.01 | 0.40 | 50 |
| Phosphorus (P) - Total | mg/L | 0.0038 | 0.0112 | 0.0066 | 0.0022 | 10 |
| Phosphorus - Dissolved | mg/L | 0.003 | 0.003 | 0.003 | 0 | 2 |
| Specific Conductivity | µS/cm | 55.0 | 81.0 | 63.8 | 5.8 | 42 |
| Sulphate (SO4) - Dissolved | mg/L | 2.77 | 2.78 | 2.78 | 0.01 | 2 |
| Sulfur - Total | mg/L | 0.66 | 0.85 | 0.76 | 0.10 | 3 |
| True Colour | Col. Unit | 6.8 | 15.7 | 12.3 | 2.5 | 8 |
| Turbidity | NTU | 0.29 | 1.12 | 0.43 | 0.28 | 8 |
| **METALS/SEMI-METALS** | | | | | | |
| Ag - T (Silver) | mg/L | <0.000005 | <0.00001 | N/A | N/A | 7 |
| Ag - D | mg/L | <0.000005 | <0.000005 | N/A | N/A | 4 |
| Al - T (Aluminum) | mg/L | 0.0085 | 0.0349 | 0.0217 | 0.0091 | 7 |
| Al - D | mg/L | 0.0202 | 0.0266 | 0.0223 | 0.0029 | 4 |
| As - T (Arsenic) | mg/L | 0.000118 | 0.00018 | 0.000145 | 0.000024 | 7 |
| As - D | mg/L | 0.000114 | 0.000135 | 0.000128 | 0.000010 | 4 |
| B - T (Boron) | mg/L | 0.007 | 0.01 | 0.009 | 0.001 | 7 |
| B - D | mg/L | 0.007 | 0.010 | 0.008 | 0.001 | 4 |
| Ba - T (Barium) | mg/L | 0.00528 | 0.00672 | 0.00596 | 0.00053 | 7 |
| Ba - D | mg/L | 0.00534 | 0.00628 | 0.00561 | 0.00045 | 4 |
| Be - T (Beryllium) | mg/L | <0.00001 | <0.0001 | N/A | N/A | 7 |
| Be - D | mg/L | <0.00001 | <0.00001 | N/A | N/A | 4 |

| Parameter | Units | Minimum | Maximum | Average | Std Dev | Count |
|---|---|---|---|---|---|---|
| Bi - T (Bismuth) | mg/L | <0.000005 | <0.00005 | N/A | N/A | 7 |
| Bi - D | mg/L | <0.000005 | <0.000005 | N/A | N/A | 4 |
| Ca - T (Calcium) | mg/L | 6.83 | 9.56 | 7.84 | 0.95 | 7 |
| Ca- D | mg/L | 7.63 | 9.03 | 8.14 | 0.56 | 5 |
| Cd - T (Cadmium) | mg/L | <0.000005 | <0.000005 | N/A | N/A | 7 |
| Cd - D | mg/L | <0.000005 | <0.000005 | N/A | N/A | 4 |
| Cl - D (Chloride) | mg/L | 4.27 | 5.40 | 4.65 | 0.37 | 10 |
| Co - T (Cobalt) | mg/L | 0.000022 | 0.0001 | 0.000056 | 0.000041 | 7 |
| Co - D | mg/L | 0.000017 | 0.000022 | 0.000019 | 0.000002 | 4 |
| Cr - T (Chromium) | mg/L | <0.0001 | 0.0004 | 0.0002 | 0.0001 | 7 |
| Cr - D | mg/L | <0.0001 | 0.0002 | 0.0001 | 0.00002 | 4 |
| Cu T (Copper) | mg/L | 0.00058 | 0.00076 | 0.00067 | 0.00006 | 7 |
| Cu - D | mg/L | 0.0006 | 0.00070 | 0.00066 | 0.00005 | 4 |
| Fe - T (Iron) | mg/L | 0.019 | 0.153 | 0.0683 | 0.0567 | 7 |
| Fe - D | mg/L | 0.0246 | 0.039 | 0.0304 | 0.0062 | 4 |
| K - T (Potassium) | mg/L | 0.273 | 0.319 | 0.300 | 0.020 | 7 |
| K - D | mg/L | 0.274 | 0.304 | 0.293 | 0.014 | 4 |
| Li - T (Lithium) | mg/L | <0.0005 | <0.0005 | N/A | N/A | 4 |
| Li - D | mg/L | <0.0005 | <0.0005 | N/A | N/A | 4 |
| Mg - T (Magnesium) | mg/L | 1.27 | 1.39 | 1.32 | 0.05 | 7 |
| Mg - D | mg/L | 1.24 | 1.48 | 1.32 | 0.09 | 5 |
| Mn - T (Manganese) | mg/L | 0.0030 | 0.082 | 0.0257 | 0.0374 | 7 |
| Mn - D | mg/L | 0.00167 | 0.00253 | 0.00200 | 0.00041 | 4 |
| Mo - T (Molybdenum) | mg/L | 0.000051 | 0.000079 | 0.000060 | 0.000009 | 7 |
| Mo - D | mg/L | 0.000054 | 0.000058 | 0.000056 | 0.000002 | 4 |
| Na - T (Sodium) | mg/L | 2.92 | 3.60 | 3.26 | 0.20 | 7 |
| Na - D | mg/L | 3.09 | 3.30 | 3.20 | 0.09 | 4 |
| Ni - T (Nickel) | mg/L | 0.000087 | 0.0005 | 0.000280 | 0.000206 | 7 |
| Ni - D | mg/L | 0.000104 | 0.000225 | 0.000138 | 0.000058 | 4 |
| Pb - T (Lead) | mg/L | 0.0000183 | 0.0000870 | 0.0000449 | 0.0000301 | 7 |
| Pb - D | mg/L | 0.0000114 | 0.0000175 | 0.0000143 | 0.0000026 | 4 |
| Sb - T (Antimony) | mg/L | 0.000025 | 0.000100 | 0.000058 | 0.000040 | 7 |
| Sb - D | mg/L | 0.000024 | 0.000028 | 0.000026 | 0.000002 | 4 |
| Se - T (Selenium) | mg/L | <0.00004 | <0.00005 | N/A | N/A | 7 |
| Se - D | mg/L | <0.00004 | 0.000042 | 0.000041 | 0.000001 | 4 |
| Si - T (Silica) | mg/L | 1.65 | 3.21 | 2.53 | 0.62 | 7 |
| Si - D | mg/L | 2.86 | 3.37 | 3.01 | 0.24 | 4 |
| Silica: D | mg/L | 6.65 | 6.71 | 6.68 | 0.04 | 2 |
| Sn - T (Tin) | mg/L | <0.00001 | <0.0001 | N/A | N/A | 7 |

| Parameter | Units | Minimum | Maximum | Average | Std Dev | Count |
|---|---|---|---|---|---|---|
| Sn - D | mg/L | <0.00001 | <0.00001 | N/A | N/A | 4 |
| Sr - T (Strontium) | mg/L | 0.0262 | 0.0297 | 0.0276 | 0.0012 | 7 |
| Sr - D | mg/L | 0.0264 | 0.0283 | 0.0270 | 0.0009 | 4 |
| Ti - T (Titanium) | mg/L | <0.0003 | <0.00035 | N/A | N/A | 3 |
| Tl - T (Thallium) | mg/L | <0.000002 | <0.00001 | N/A | N/A | 7 |
| Tl - D | mg/L | <0.000002 | <0.000002 | N/A | N/A | 4 |
| U - T (Uranium) | mg/L | 0.0000045 | 0.00001 | 0.0000071 | 0.0000027 | 7 |
| U - D | mg/L | 0.0000048 | 0.0000051 | 0.0000050 | 0.0000001 | 4 |
| V - T (Vanadium) | mg/L | 0.00022 | 0.00050 | 0.00035 | 0.00014 | 7 |
| V - D | mg/L | <0.0002 | 0.00023 | 0.00021 | 0.00002 | 4 |
| Zn - T (Zinc) | mg/L | 0.00141 | 0.003 | 0.00220 | 0.00077 | 7 |
| Zn - D | mg/L | 0.00133 | 0.00177 | 0.00163 | 0.00020 | 4 |

*Table 20. Summary of 2018-2019 general chemistry water grab sample statistics taken at Shawnigan Lake North Beach site (1199904).*

| Parameter | Units | Minimum | Maximum | Average | Std Dev | Count |
|---|---|---|---|---|---|---|
| **GENERAL** | | | | | | |
| Ammonia (N) - Total | mg/L | <0.005 | 0.0102 | 0.0063 | 0.0021 | 6 |
| Ammonia - Dissolved | mg/L | <0.005 | <0.005 | N/A | N/A | 2 |
| Carbon, Organic - Total | mg/L | 3.15 | 3.76 | 3.38 | 0.22 | 8 |
| Chlorophyll *a* | mg/L | 0.000802 | 0.00144 | 0.00103 | 0.00028 | 4 |
| Hardness - Total | mg/L | 19.75 | 21.81 | 21.16 | 0.74 | 6 |
| Hardness - Dissolved | mg/L | 19.4 | 21.8 | 20.8 | 0.97 | 7 |
| Kjeldahl Nitrogen - Total | mg/L | 0.10 | 0.12 | 0.11 | 0.01 | 4 |
| Nitrate (NO3) - Dissolved | mg/L | <0.003 | 0.14 | 0.098 | 0.048 | 8 |
| Nitrate + Nitrite | mg/L | 0.13 | 0.14 | 0.13 | 0.006 | 4 |
| Nitrate + Nitrite, Dissolved | mg/L | <0.0032 | 0.14 | 0.098 | 0.048 | 8 |
| Nitrogen - Nitrite, Dissolved | mg/L | <0.001 | <0.001 | N/A | N/A | 8 |
| Nitrogen (N) - Total | mg/L | 0.165 | 0.249 | 0.222 | 0.028 | 8 |
| Nitrogen, Organic - Total | mg/L | 0.094 | 0.103 | 0.0985 | 0.006 | 2 |
| Ortho-Phosphate - Dissolved | mg/L | 0.001 | 0.0013 | 0.0011 | 0.0001 | 4 |
| pH | pH units | 6.29 | 7.75 | 6.97 | 0.37 | 67 |
| Phosphorus (P) - Total | mg/L | 0.0029 | 0.0059 | 0.0047 | 0.0009 | 8 |
| Phosphorus - Dissolved | mg/L | 0.003 | 0.003 | 0.003 | 0.0003 | 2 |
| Specific Conductivity | µS/cm | 52.0 | 63.0 | 56.7 | 2.6 | 63 |
| Sulphate (SO4) - Dissolved | mg/L | 2.75 | 2.76 | 2.76 | 0.007 | 2 |
| Sulfur - Total | mg/L | 1.09 | 1.15 | 1.11 | 0.03 | 3 |
| True Colour | Col. Unit | 7.2 | 13.0 | 11.7 | 2.3 | 6 |
| Turbidity | NTU | 0.27 | 0.52 | 0.38 | 0.09 | 7 |
| **METALS/SEMI-METALS** | | | | | | |
| Ag - T (Silver) | mg/L | <0.000005 | <0.00001 | N/A | N/A | 6 |
| Ag - D | mg/L | <0.000005 | <0.000005 | N/A | N/A | 3 |
| Al - T (Aluminum) | mg/L | 0.0079 | 0.0372 | 0.0234 | 0.0134 | 6 |
| Al - D | mg/L | 0.0257 | 0.0311 | 0.0277 | 0.0030 | 3 |
| As - T (Arsenic) | mg/L | 0.000107 | 0.000180 | 0.000140 | 0.000027 | 6 |
| As - D | mg/L | 0.000107 | 0.000122 | 0.000114 | 0.000008 | 3 |
| B - T (Boron) | mg/L | 0.0078 | 0.01 | 0.009 | 0.0009 | 6 |
| B - D | mg/L | 0.0082 | 0.0096 | 0.009 | 0.0007 | 3 |
| Ba - T (Barium) | mg/L | 0.00472 | 0.00519 | 0.00504 | 0.00018 | 6 |
| Ba - D | mg/L | 0.00484 | 0.0052 | 0.0051 | 0.00019 | 3 |
| Be - T (Beryllium) | mg/L | <0.00001 | <0.0001 | N/A | N/A | 6 |
| Be - D | mg/L | <0.00001 | <0.00001 | N/A | N/A | 3 |

| Parameter | Units | Minimum | Maximum | Average | Std Dev | Count |
|---|---|---|---|---|---|---|
| Bi - T (Bismuth) | mg/L | <0.000005 | <0.00005 | N/A | N/A | 6 |
| Bi - D | mg/L | <0.000005 | <0.000005 | N/A | N/A | 3 |
| Ca - T (Calcium) | mg/L | 5.98 | 6.59 | 6.39 | 0.23 | 6 |
| Ca- D | mg/L | 5.78 | 6.50 | 6.21 | 0.33 | 4 |
| Cd - T (Cadmium) | mg/L | <0.000005 | <0.000005 | N/A | N/A | 6 |
| Cd - D | mg/L | <0.000005 | <0.000005 | N/A | N/A | 3 |
| Cl - D (Chloride) | mg/L | 4.13 | 4.76 | 4.40 | 0.26 | 8 |
| Co - T (Cobalt) | mg/L | 0.00002 | 0.00010 | 0.00006 | 0.00004 | 6 |
| Co - D | mg/L | 0.00002 | 0.00002 | 0.00002 | 0.00000 | 3 |
| Cr - T (Chromium) | mg/L | 0.0001 | 0.0002 | 0.0001 | 0.0001 | 6 |
| Cr - D | mg/L | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 3 |
| Cu T (Copper) | mg/L | 0.00058 | 0.00072 | 0.00064 | 0.00005 | 6 |
| Cu - D | mg/L | 0.00060 | 0.00063 | 0.00062 | 0.00002 | 3 |
| Fe - T (Iron) | mg/L | 0.0150 | 0.0443 | 0.0303 | 0.0127 | 6 |
| Fe - D | mg/L | 0.0247 | 0.0664 | 0.0391 | 0.0236 | 3 |
| K - T (Potassium) | mg/L | 0.249 | 0.319 | 0.274 | 0.029 | 6 |
| K - D | mg/L | 0.258 | 0.304 | 0.286 | 0.024 | 3 |
| Li - T (Lithium) | mg/L | <0.0005 | <0.0005 | N/A | N/A | 3 |
| Li - D | mg/L | <0.0005 | <0.0005 | N/A | N/A | 3 |
| Mg - T (Magnesium) | mg/L | 1.17 | 1.31 | 1.27 | 0.05 | 6 |
| Mg - D | mg/L | 1.19 | 1.30 | 1.24 | 0.05 | 4 |
| Mn - T (Manganese) | mg/L | 0.0030 | 0.0082 | 0.0043 | 0.0020 | 6 |
| Mn - D | mg/L | 0.00096 | 0.00229 | 0.00143 | 0.00074 | 3 |
| Mo - T (Molybdenum) | mg/L | 0.000052 | 0.000091 | 0.000069 | 0.000016 | 6 |
| Mo - D | mg/L | 0.000058 | 0.000067 | 0.000061 | 0.000005 | 3 |
| Na - T (Sodium) | mg/L | 2.72 | 3.47 | 3.09 | 0.29 | 6 |
| Na - D | mg/L | 2.75 | 2.92 | 2.84 | 0.09 | 3 |
| Ni - T (Nickel) | mg/L | 0.00011 | 0.00050 | 0.00032 | 0.00020 | 6 |
| Ni - D | mg/L | 0.00012 | 0.00020 | 0.0001 | 0.00004 | 3 |
| Pb - T (Lead) | mg/L | 0.00002 | 0.00005 | 0.00004 | 0.00001 | 6 |
| Pb - D | mg/L | 0.000010 | 0.000018 | 0.000014 | 0.000004 | 3 |
| Sb - T (Antimony) | mg/L | 0.000026 | 0.0001 | 0.000064 | 0.000040 | 6 |
| Sb - D | mg/L | 0.000024 | 0.000030 | 0.000027 | 0.000003 | 3 |
| Se - T (Selenium) | mg/L | <0.00004 | <0.00005 | N/A | N/A | 6 |
| Se - D | mg/L | <0.00004 | <0.00004 | N/A | N/A | 3 |
| Si - T (Silica) | mg/L | 1.57 | 2.99 | 2.38 | 0.65 | 6 |
| Si - D | mg/L | 2.62 | 3.00 | 2.83 | 0.19 | 3 |
| Silica: D | mg/L | 5.68 | 5.70 | 5.69 | 0.01 | 2 |
| Sn - T (Tin) | mg/L | <0.00001 | <0.0001 | N/A | N/A | 6 |

| Parameter | Units | Minimum | Maximum | Average | Std Dev | Count |
|---|---|---|---|---|---|---|
| Sn - D | mg/L | <0.00001 | <0.00001 | N/A | N/A | 3 |
| Sr - T (Strontium) | mg/L | 0.0237 | 0.0280 | 0.0258 | 0.0019 | 6 |
| Sr - D | mg/L | 0.0235 | 0.0240 | 0.024 | 0.0003 | 3 |
| Ti - T (Titanium) | mg/L | <0.0003 | <0.0003 | N/A | N/A | 3 |
| Tl - T (Thallium) | mg/L | <0.000002 | <0.00001 | N/A | N/A | 6 |
| Tl - D | mg/L | <0.000002 | <0.000002 | N/A | N/A | 3 |
| U - T (Uranium) | mg/L | 0.000005 | 0.00001 | 0.000008 | 0.000002 | 6 |
| U - D | mg/L | 0.000006 | 0.000006 | 0.000006 | 0.0000002 | 3 |
| V - T (Vanadium) | mg/L | 0.00022 | 0.00050 | 0.00036 | 0.00015 | 6 |
| V - D | mg/L | <0.0002 | <0.0002 | N/A | N/A | 3 |
| Zn - T (Zinc) | mg/L | 0.00105 | 0.00300 | 0.00226 | 0.00093 | 6 |
| Zn - D | mg/L | 0.00101 | 0.00112 | 0.00108 | 0.00006 | 3 |