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# Water Quality Assessment of the Ephemeral Streams and Overland Runoff into Tyhee Lake

## Spring 2018 Data Summary

June 2021

BRITISH COLUMBIA

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**Cover Photographs:**
Lisa Torunski, East Creek looking south to Tyhee Lake.

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The final report was prepared by co-op student, Natalie Fuller and edited by Lisa Torunski Environmental Impact Assessment Biologist and Greg Tamblyn, Water Quality Section Head, with contributions from co-op student, Dylan Harvey.

## EXECUTIVE SUMMARY

Overland runoff from roads, rural subdivisions, and agricultural operations, collects into ephemeral streams at the north end and east side of Tyhee Lake, British Columbia during the spring and presumably during high precipitation events. This document presents a summary of the ambient water quality for select ephemeral streams and overland runoff flowing into Tyhee Lake, during the spring snowmelt in 2018.

The Tyhee Lake catchment basin, of approximately 35 $km^2$, is located two kilometres off Highway 16 at Telkwa and twelve kilometres east of Smithers, in north-central B.C., within Wet'suwet'en territory. The lake is 318 hectares and has a maximum depth of 22.2 metres (Boyd et al., 1985). The water uses to be protected in Tyhee Lake include private domestic use, recreation, aquatic life, and wildlife.

The objective of the spring sampling project was to evaluate the potential risks to the aquatic environment of Tyhee Lake from agricultural inputs, entering the lake through ephemeral streams and overland runoff occurring during spring snowmelt.

The report describes the sampling program design in which five water samples were collected from nine sites from April 15 to May 13, 2018. The sample results are summarized and compared to the British Columbia (B.C.) Water Quality Guidelines (WQG) for physical, chemical, and microbial indicators.

Of the nine streams sampled, seven were downgradient of agricultural activities of various intensities (e.g., hayfields, dairy pastures, hobby horse farm); there were no agricultural activities upstream of the other two streams, one of which was used as a reference site owing to minimal upstream anthropogenic activity.

The data was collected with the help of the Tyhee Lake Protection Society.

The following conclusions were drawn from the water quality data collected.

The B.C. WQG for temperature, pH, chloride, nitrogen species (nitrate, nitrite, and ammonia) and *Escherichia coli* (*E. coli)* were met at all sites. Turbidity, total suspended sediments, total organic carbon, and total phosphorus concentrations were higher among those sites with upstream agricultural land use than those sites without. The results suggest that spring snowmelt ephemeral stream water quality is influenced by upstream agricultural land use, however, the sampling results indicate a low potential for impacts to aquatic life or recreational uses in Tyhee Lake based on measured concentrations and duration of inputs. Cumulative nutrient loading from all anthropogenetic sources including agriculture and residences may have the potential to affect the lake's future trophic status and water uses.

This report is intended to inform local land users, residents, and local governments about water quality in areas within the Tyhee Lake watershed and concludes with monitoring and management recommendations for the protection of existing water users.

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## ACRONYMS

| Abbreviation | Definition |
|---|---|
| B.C. | British Columbia |
| DOC | Dissolved Organic Carbon |
| *E. coli* | *Escherichia coli* |
| ENV | The Ministry of Environment and Climate Change Strategy |
| NTU | Nephelometric turbidity units |
| TOC | Total Organic Carbon |
| TSS | Total Suspended Solids |
| WQG | Water Quality Guidelines |
| WQO | Water Quality Objective |

# 1. INTRODUCTION

Tyhee Lake is located near Telkwa in north-west British Columbia, within Wet'suwet'en territory. The lake is 318 hectares and has a maximum depth of 22.2 metres (Boyd et al., 1985). The lake is fed primarily by overland runoff from perennial and ephemeral streams and drains into the Bulkley River via Tyhee Creek. The lake is highly productive and contains a variety of aquatic life, including a range of plant and fish species. Abundant non-rooted plant species that absorb nutrients from the water column include, northern water-milfoil (Myriophyllum sibiricum), Potamogeton spp., and duckweed spp. (Lemna minor and Spirodela polyhiza), Columbian watermeal (Wolffia coumbiana), and Ceratophyllum demersumm (Rysavy and Sharpe, 1995). Fish species in the lake include pygmy whitefish (Prosopium coulterii), burbot (Lota lota), rainbow (Oncorhynchus mykiss) and cutthroat trout (Oncorhynchus clarkii) and northern pikeminnow (Ptychocheilus oregonensis). The lake has been intermittently stocked with fish since 1955 (Boyd et al., 1985).

Land use around the lake is varied. Residential lakefront properties are distributed around most of the lake, including some rural housing on the eastern hillside. Tyhee Lake Provincial Park is located on the west side of the lake and covers approximately 1.5 kilometres of shoreline. A public beach and boat launch, accessed from within the Provincial Park, are used for recreational activities such as swimming, boating, and fishing. On the north end of the lake, there is a bible camp and a hobby horse farm. There is a small floatplane base at the northwest end of the lake. Agricultural land use, which consists of several hay fields and a dairy farm, is concentrated on the northeast and southeast upland areas around the lake.

Members of the Tyhee Lake Protection Society approached the B.C. Ministry of Environment and Climate Change Strategy (ENV) for information regarding the water quality of some perennial and ephemeral streams entering the lake from the north end and east side of the lake during spring melt. Overland runoff during spring snow melt is of particular concern. Spring melts can cause overland runoff to pick-up contaminants from upslope anthropogenic land activities and carry them into a watershed. Runoff from agricultural land has been shown to carry excessive nutrients originating from land applications of manures and fertilizers (Nordin, 1985). The runoff is a potential source of fecal pathogens from livestock and animal manures (Bicudo and Goyal, 2003). The potential effects of agricultural land use practises on lake water quality have been a source of concern in the past (Rysavy and Sharpe, 1995).

To address these concerns, physical, chemical, and microbial indicators were used to evaluate the water quality of the select streams entering Tyhee Lake.

## 1.1 Project Objectives

The study was a collaborative project between ENV and the Tyhee Lake Protection Society to support stewardship and water protection in the Tyhee Lake watershed. The water quality of ephemeral streams and overland runoff entering the lake during spring melt were assessed. The objectives of the project were to evaluate the potential risks agricultural land use may pose to the aquatic environment of Tyhee Lake and to make monitoring and management recommendations for the protection of existing water uses. Additionally, by reviewing the existing lake water quality data the study aimed to estimate the trophic status of the lake over time.

## 2. METHODOLOGY

### 2.1 Study Design

ENV staff trained volunteers to collect water samples based on approved methods (ENV, 2013). Nine sites representing ephemeral streams and an overland runoff that flow into Tyhee Lake in the spring along its north end and east side were selected for water quality sampling (Figure 1). One was a reference site and eight had upstream agricultural land uses, hobby farm activity or minimal domestic influences. Members of the Tyhee Lake Protection Society collected weekly surface water grab samples for five consecutive weeks from April 15 to May 13, 2018 (Table 1), during spring melt. The flows are ephemeral (only existing for a short period following precipitation or snowmelt) and it was noted that by the beginning of July, surface water flows had ceased at all sample sites. Table 2 is a list of the sampling sites including the Environmental Monitoring System (EMS) reference numbers, latitude and longitude and site descriptions and Appendix B contains photos of each sampling location.

Field parameters including temperature, conductivity and pH were measured using a YSI63 handheld meter and recorded on field sheets. Other observations including water clarity, odour and weather conditions were also noted. Copies of the field sheets can be found in Appendix A. Each week a site was randomly selected from which to collect a replicate sample for quality control purposes. All water samples were shipped to ALS Environmental in Burnaby for lab analysis. The parameters selected for analyses were pH, total organic carbon, turbidity, conductivity, total suspended solids, nitrogen and phosphorus species, chloride, and *Escherichia coli (E. coli*.).

Summary statistics were calculated from the water chemistry data. Replicate data used for quality assurance and control purposes was not included in these calculations. For results below the detection limit, a value of half the detection limit was substituted. Where available, historic stream and lake data were also used in the assessment. The results of the analysis were compared to current B.C. WQGs for recreational use and the protection of aquatic life[1]. Site conditions and water quality were compared between sites. This was done to provide a water quality assessment at the site level and identify any sites of potential concern.

*Table 1. Tyhee Lake 2018 spring melt ephemeral stream sample collection dates.*

| **Week** | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|
| Date | April 15 | April 22 | April 29 | May 06 | May 13 |

## 3. RESULTS

Table 3 shows summary statistics for the parameters of interest for each sample site. The B.C. WQGs are provided for comparison. Appendix C contains the raw data.

[1] The streams were not considered domestic water sources due to their ephemeral nature and upstream land uses, therefore comparison of the water quality results to drinking water quality guidelines was not the focus of the assessment but is mentioned where appropriate.

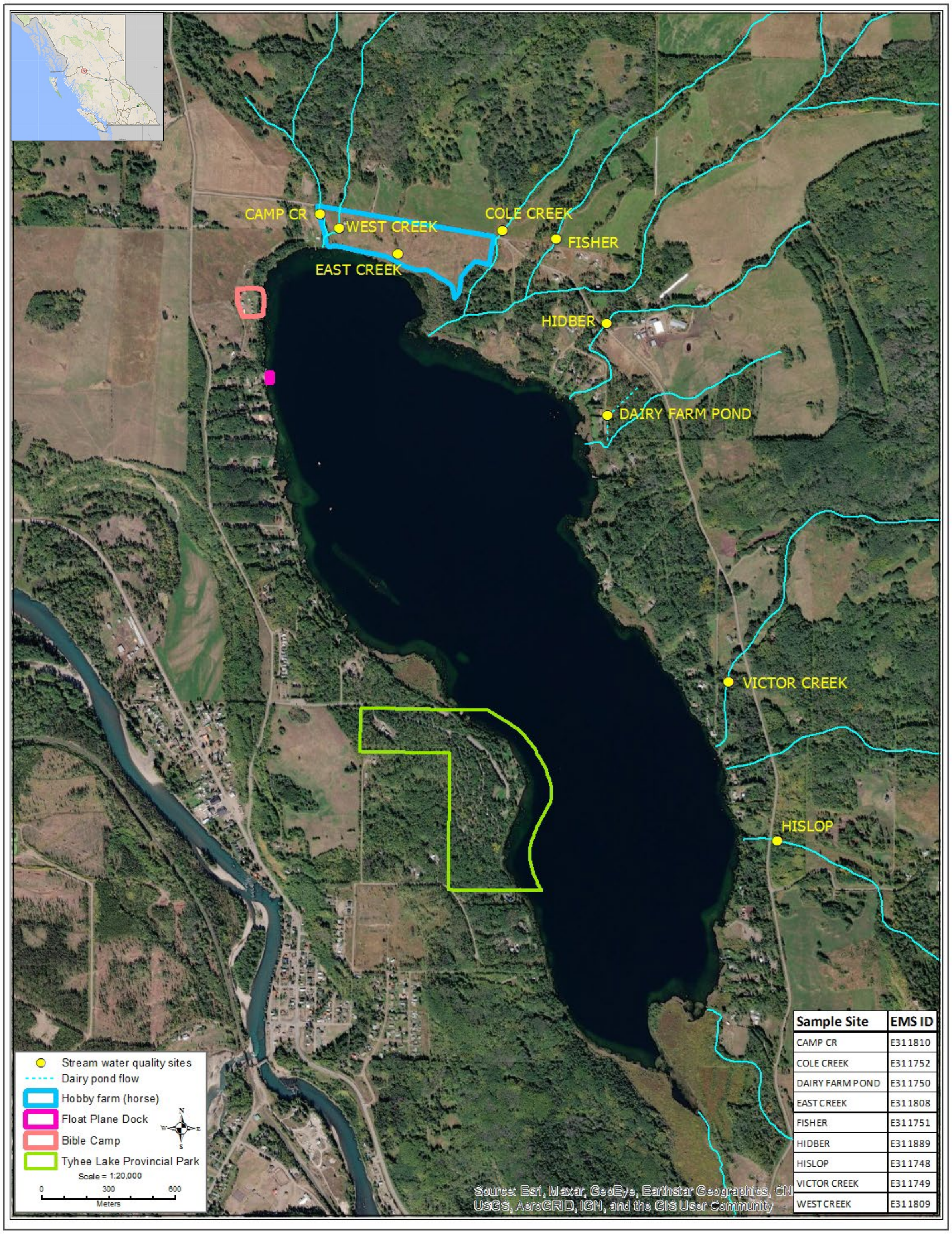


*Figure 1. Project location near Telkwa, B.C. and individual sampling sites on the east side of Tyhee Lake.*

*Table 2. Description and site locations.*

| Site Name[1] | EMS ID | Lat. Long. | Description |
|---|---|---|---|
| **<u>CAMP CR</u>** DOWNSTREAM OF TYHEE LK RD | E311810 | 54.72988 N<br>127.05076 W | The flow is through the Tyhee David property between a private residence and the horse hobby farmland. The sample site is downstream of the Tyhee Lake road culvert and upstream of the confluence with West Creek through Tyhee David Property (E311809) to the east. |
| **<u>WEST CREEK</u>** THROUGH TYHEE DAVID PROPERTY | E311809 | 54.72873 N<br>127.04935 W | The drainage crosses Tyhee Lake Road through a culvert west of Fisher Road and flows past the horse barn on the Tyhee David property. The sample site is downstream of the culvert, and upstream of the confluence with Camp Creek (E311810). |
| **<u>EAST CREEK</u>** THROUGH TYHEE DAVID PROPERTY | E311808 | 54.72759 N<br>127.04311 W | The drainage crosses Tyhee Lake Road through a culvert west of Fisher Rd, through the Tyhee David property. The sample site is downstream of the culvert. The upstream land use is hay and horse fields. |
| **<u>COLE CR</u>** AT TYHEE LK RD | E311752 | 54.72873 N<br>127.03741 W | The drainage crosses Tyhee Lake Road through a culvert west of Fisher Rd. The sample site is upstream of the culvert crossing. The upstream land use is hay fields. |
| CREEK CROSSING **<u>FISHER RD</u>** NEAR OCTAGON HOUSE | E311751 | 54.72847 N<br>127.03347 W | The drainage crosses Fisher Road through a culvert 200m east of the Tyhee Lake Road and Fisher Road junction. The upstream land use is hay fields. |
| CREEK EAST OF **<u>HIDBER RD</u>** | E311889 | 54.72570 N<br>127.03052 W | The drainage crosses Tyhee Lake Road through a culvert east of Hidber Road. The upstream land use is a dairy farm and hay fields. |
| **<u>DAIRY FARM SETTLING POND</u>** OUTFLOW NEAR LAKE RD | E311750 | 54.72223 N<br>127.02962 W | The drainage is on the east side of Lake Road. The upstream land use is a dairy farm and an associated settling pond. |
| **<u>VICTOR CR</u>** NEAR PENNER RD | E311749 | 54.71085 N<br>127.02158 W | The drainage of Victor Cr is east of Penner Road and downstream of Tyhee Lake Road. The upstream land use is hay fields. |
| CREEK NEAR **<u>HISLOP RD</u>** | E311748 | 54.70292 N<br>127.01767 W | The ephemeral creek is to the north of Hislop Road at Tyhee Lake Road. The sample location is on the upstream end of a culvert crossing Tyhee Lake Road. The upstream land use is rural residential land[2] with but no agriculture. |

[1] The **bolded**, <u>underlined</u> portion of the site name indicates the short names the sites are referred to throughout the report.

[2] The residential land use presents the potential for domestic septic systems or drainage pipes discharge that if exist would be confounding factors at the Hislop Road site reference.

*Table 3. Mean values ± standard deviations from five weekly samples(n=5) collected at each site.*

| Variable | Site | | | | | | | | | B.C. WQG | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Camp Cr | West Cr | East Cr | Cole Cr | Fisher Rd | Hidber Rd | Dairy Farm Settling Pond Outflow | Victor Cr | Hislop Rd (Ref) | Recreation | Freshwater Aquatic Life |
| Temp. – field (*°C*) | 6.0 ± 4.6 | 7.2 ± 4.7 | 7.6 ± 5.2 | 8.8 ± 3.8 | 4.8 ± 2.9 | 5.4 ± 4.2 | 11.2 ± 5.7 | 4.1 ± 3.8 | 7.4 ± 5.1 | No appreciable change to swimmers | 19 (max daily temp.) |
| Conductivity (*uS/cm*) | 190 ± 34 | 210 ± 15 | 164 ± 84 | 169 ± 108 | 232 ± 20 | 186 ± 47 | 385 ± 74 | 161 ± 25 | 294 ± 112 | - | - |
| pH (*pH*) | 8.06 ± 0.21 | 8.13 ± 0.13 | 7.78 ± 0.23 | 7.83 ± 0.30 | 8.03 ± 0.22 | 7.98 ±0.15 | 8.45 ± 0.14 | 7.99 ± 0.17 | 8.22 ± 0.27 | 5 - 9 | 6.5 - 9 |
| Total Organic Carbon (mg/L) | 18.4 ± 1.5 | 14.2 ± 0.79 | 23.9 ± 6.0 | 23.0 ± 5.3 | 17.0 ± 0.4 | 20.7 ± 2.5 | 13.1 ± 1.3 | 18.6 ± 2.3 | 16.4 ± 4.9 | - | Within 20% of background median |
| TOC (median – mg/L)) | **18.5** | 14.1 | **25.5** | **24.9** | 16.8 | **22.0** | 12.7 | **17.7** | 14.5 | | |
| *Total Suspended Solids (*mg/L*) | 2.5 ± 1.4 | **11.72 ± 14.92** | 3.9 ± 4.1 | 4.0 ± 4.4 | 2.5 ± 1.5 | **30.9 ± 33.3** | **26.0 ± 48.2** | **22.8 ± 13.6** | 3.7 ± 3.0 | - | Change from background of 10 mg/L at any time during high flows |
| **Turbidity (*NTU*) | 4.67 ± 4.08 | **11.58 ± 12.55** | **9.58 ± 9.72** | **29.5 ± 13.7** | 2.48 ± 0.85 | **18.34 ± 16.92** | **12.34 ± 20.92** | **19.64 ± 12.46** | **11.66 ± 10.59** | | Change from background of 5 NTU at any time during high flows |
| Phosphorous, Total (*mg/L*) | 0.0211 ± 0.0141 | 0.0351 ± 0.0335 | 0.0429 ± 0.0174 | 0.0566 ± 0.0086 | 0.0219 ± 0.0132 | 0.0657 ± 0.0580 | 0.1995 ± 0.1528 | 0.0407 ± 0.0229 | 0.0303 ± 0.0325 | 0.01 (for lakes) | 0.005-0.015 (for lakes) |
| Orthophosphate (*mg/L*) | 0.0068 ± 0.0069 | 0.0065 ± 0.0050 | 0.0061 ± 0.0013 | 0.0120 ± 0.0035 | 0.0062 ± 0.0047 | 0.0139 ± 0.0151 | 0.1498 ± 0.0975 | 0.0021 ± 0.0008 | 0.0081 ± 0.0113 | - | - |

| Variable | Site | | | | | | | | | B.C. WQG | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Camp Cr | West Cr | East Cr | Cole Cr | Fisher Rd | Hidber Rd | Dairy Farm Settling Pond Outflow | Victor Cr | Hislop Rd (Ref) | Recreation | Freshwater Aquatic Life |
| ***Ammonia, Total (*mg/L*) | 0.0106 ± 0.0019 | 0.0188 ± 0.0144 | 0.0131 ± 0.0035 | 0.0154 ± 0.0037 | 0.0128 ± 0.0040 | 0.0117 ± 0.0062 | 0.0233 ± 0.0249 | 0.0096 ± 0.0021 | 0.0114 ± 0.0051 | - | Table 26C & 26D in Appendix D |
| Nitrate (*mg/L*) | 0.0264 ± 0.0358 | 0.0772 ± 0.1390 | 0.0041 ± 0.0057 | 0.0442 ± 0.0955 | 0.0056 ± 0.0050 | 0.2726 ± 0.1862 | 0.2602 ± 0.5483 | 0.2579 ± 0.2257 | 0.0680 ± 0.1084 | 10 | Max: 32.8<br>Average: 3 |
| ****Nitrite (*mg/L*) | 0.0009 ± 0.0009 | 0.0011 ± 0.0013 | 0.0007 ± 0.0005 | 0.0007 ± 0.0004 | 0.0006 ± 0.0003 | 0.0008 ± 0.0005 | 0.0019 ± 0.0028 | 0.0008 ± 0.0006 | 0.0005 ± 0 | 1 | Table 26B in Appendix D |
| Chloride (*mg/L*) | 5.44 ± 2.24 | 9.69 ± 4.18 | 11.23 ± 9.29 | 5.3 ± 8.0 | 13.3 ± 4.4 | 7.11 ± 3.98 | 5.43 ± 4.81 | 2.55 ± 1.80 | 10.53 ± 5.33 | Max:600 | 30-d average: 150 |
| E.Coli (*CFU/100ml*)[1] | 66 ± 116 | 55 ± 74 | 16 ± 15 | 2 ± 3 | 9 ± 14 | 80 ± 75 | 4 ± 3 | 57 ± 103 | 7 ± 9 | 200 | - |

**Bolded values indicate results outside of their respective B.C. WQG thresholds.**

* Bolded values where sample variability is greater than 10mg/L; ** Bolded values where sample variability is greater than 5 NTU; *** and **** B.C. WQG for ammonia is pH and temperature dependent and for nitrite is chloride dependent

[1] Maximum drinking water quality guideline for *E. coli* is 10 CFU/100mL

## 3.1 Tyhee Lake Water Quality 1950s to 2015– Phosphorus, Turbidity and Bacteriology

Lake sediments reveal that Tyhee Lake is naturally eutrophic based on diatom assemblages and diatom- inferred spring total phosphorus ranging from 0.035mg/L to 0.043 mg/L[2] prior to European settlement (Reavie, and Smol, 1997). These sediments also reveal that significant eutrophication has occurred post 1950s due to anthropogenic influences. Since the mid 1980s, Tyhee Lake has been considered phosphorous limited, with a nitrogen to phosphorous ratio greater than 15:1 (Boyd, 1985). Average total phosphorous concentrations measured at spring overturn from 1986 to 1999 ranged from 0.005 mg/L to 0.040 mg/L. More recent spring phosphorous concentrations measured at the lake's deep station, from 2016 to 2018 (B.C. Lake Monitoring Network[3], 2018) show an average of 0.022 mg/L, which remains within the historic ranges observed, and supports a proposed summer average phosphorus water quality objective (WQO) of 0.04mg/L for Tyhee Lake (Zirnhelt, 2015).

The average turbidity WQO set for the lake is 1 NTU from five samples collected weekly in 30 days (Boyd *et al.*, 1985). Between 2002 and 2003 this objective was surpassed in three of seven sample sets. The maximum WQO of 5 NTU was never exceeded (Downie and Kokelj, 2004). The historic data shows both objectives were attained from 2004 to 2011 (Zirnhelt, 2015) but the parameter has not been measured again in the lake since 2011.

The most recent microbial sampling for Tyhee Lake was conducted in 2013 at four sample locations: near the public beach on the west side, near Lock Road at the south end, between Hidber and Penner Roads on the east side and near the bible camp at the north end. The beach site had a geometric mean of 4.8 CFU/100mL which was below the water quality objective of 77 CFU/100mL. The results (90$^{th}$ percentile) from each of the other three sites were below the drinking water quality objective of 10 CFU/100mL at lake intakes (Zirnhelt, 2015).

Table 4 is a list of the water quality objectives for Tyhee Lake. However, the stream data was not directly compared to these objectives as they pertain to the lake.

*Table 4. Water Quality Objectives for Tyhee Lake (established and proposed between 1996 and 2015).*

| Parameter | Water Quality Objective |
|---|---|
| Colour (near water intakes) [1, *] | Long-term objective: 15 TCU (maximum) |
| *Escherichia coli* bacteria[2] | Drinking water intakes: <10 CFU/100 mL (90th percentile) with a minimum of 5 weekly samples collected over a 30-day period<br>Recreational beaches: geometric mean ≤ 77 CFU/100mL |
| Turbidity[1] | < 1 NTU (average); < 5 NTU (maximum) |
| Total Phosphorus[3] | Summer average of 40 μg/L (0.04 mg/L). |

[1] Formally established in 1996
[2] Interim WQO as proposed by Downie and Kokelj in the 2004 objectives attainment report for the Smithers lakes, but not formally established.
[3] Interim WQO as proposed by Zirnhelt in 2015 draft attainment report for the Smithers lakes, but not formally established.
[*] Not assessed in this study

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[2] These concentrations result from modeling that takes into consideration the relationships between water chemistry variables and diatom distributions in the surface sediments of B.C. lakes.
[3] B.C. Lake Monitoring Network internet link: https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/lake-monitoring/bc-lake-monitoring-network

## 3.2 Spring 2018 Water Quality

### 3.2.1 pH

pH is a measure of the concentration of hydrogen ions (H+) in water measured on a logarithmic scale between zero and fourteen. A pH between zero and seven is acidic (the lower the number, the more acidic the water) and a pH greater than seven is alkaline (the higher the number, the more basic the water). A pH of seven is neutral. The B.C. WQG for the protection of aquatic life is between 6.5 to 9.0 pH units (McKean and Nagpal, 1991).

The two largest factors that determine pH in freshwater in B.C. are precipitation and weathering of sediments (McKean and Nagpal, 1991). Increases or decreases of pH can affect aquatic communities in terms of both composition and abundance for all taxonomic levels.

The average pH values across the study area ranged from 7.78 at East Creek to 8.45 at the Dairy Farm settling pond outflow, with average pH of 8.22 at the Hislop road reference site. pH at all sample sites were within the WQG range of 6.5 to 9 pH.

### 3.2.2 Temperature

Temperature has a substantial influence on how species respond to physical or chemical stressors. Many anthropogenic activities can affect surface water temperature. This includes the use of settling ponds upstream of receiving water bodies. For example, during certain seasons, and related to depth of flow and capacity, the water in the settling pond may be warmer than the receiving water (Oliver and Fidler, 2001). The WQG is set to protect aquatic life at every life stage from adverse effects caused by extreme temperatures (Oliver and Fidler, 2001). As optimal temperatures are species specific the temperature guidelines are set for specific fish species and life stages when the community composition is known. Volunteers noted fish in the outflow from the Dairy Farm settling pond on May 13, 2018; however, the species and life stage were not noted. Therefore, the general guideline of 19°C for the protection of all aquatic life was used for comparison with the water quality results from all sample sites. Over the five-week sampling period, the average temperatures across the study area ranged from between 4.1°C and 4.8°C at Victor and Fisher creeks to 11.2°C at the Dairy Farm settling pond outflow, with average temperatures of 7.4°C at the Hislop Road reference site. The spring temperature readings at all sites were below the general WQG of 19°C for the protection of aquatic life.

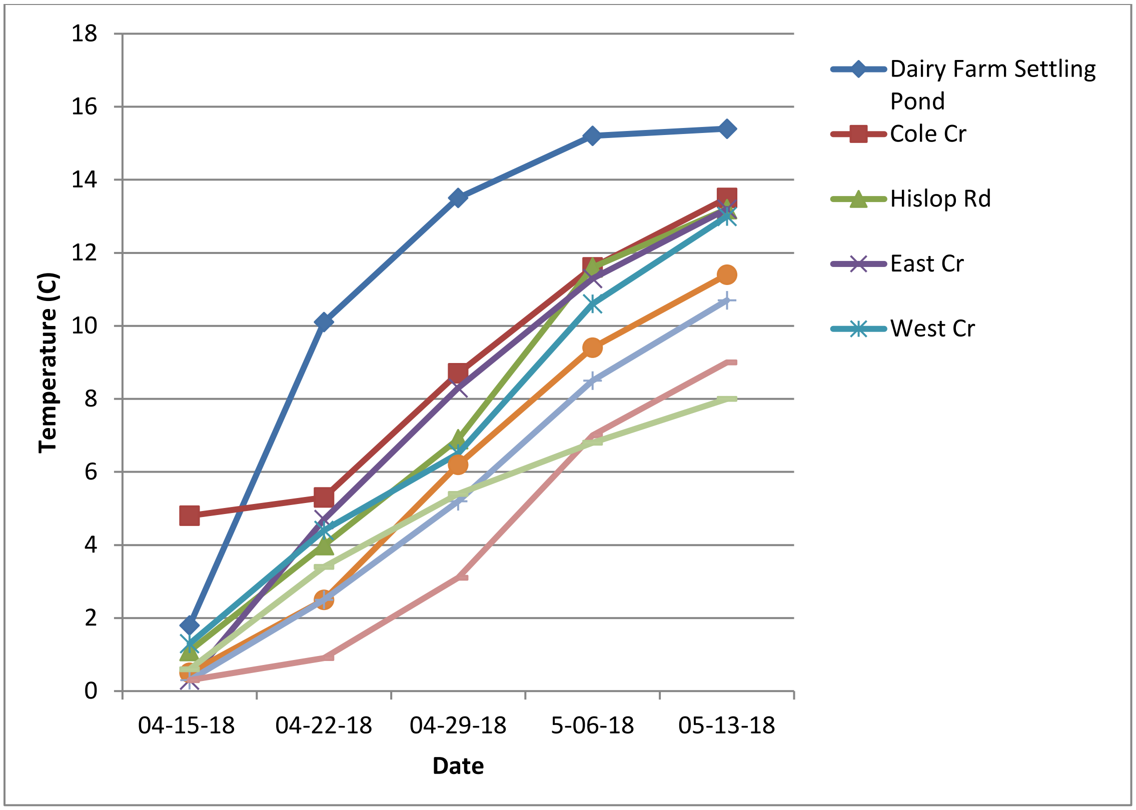


*Figure 2. Water temperature at each site over five weeks as measured in the field with a YSI63 handheld meter showing the temperature trajectory over the sampling period.*

### 3.2.3 Total Organic Carbon

Total organic carbon (TOC) is comprised of dissolved (DOC) and particulate organic carbon in water. Humic substances found in partially degraded terrestrial and aquatic plant materials, make up much of the organic carbon in water (Moore, 1998). Knowing the amount of carbon in a freshwater stream is an indicator of the organic character of the stream.

Organic contaminants (natural organic substances, insecticides, herbicides, and other agricultural chemicals and waste products) enter waterways in rainfall runoff and influence TOC concentrations in the receiving waters. TOC as an indicator of environmental effects arising from anthropogenic activities, provides a speedy and convenient way of determining the degree of organic contamination. The larger the carbon or organic content, the more oxygen is consumed in the water as the organics decompose. A high organic content means an increase in the growth of microorganisms which contribute to the depletion of oxygen and can create unfavorable conditions for aquatic life (Moore, 1998).

The TOC WQG concentration for the protection of aquatic life is based on background levels or an appropriate reference site. The WQG suggests that a 30-day median of TOC should be within ± 20% of a seasonally adjusted median background level.

The study design did not include sample sites upstream of potential "contaminant" sources and therefore the sample location on the creek near Hislop Road was used as a reference site[4] since the upstream land use was rural domestic with no notable agricultural influence. The 30-day median from the Hislop Road site was 14.5 mg/L (Table 3); this would provide a threshold range of 11.6 mg/L to 17.4.mg/L. Five sites exceeded the upper threshold. Listed in order of highest exceedance (25.5 mg/L) to lowest exceedance (17.7 mg/L), the sites were East Creek through the Tyhee David Property, Cole Creek, Hidber Road, Camp Creek and Victor Creek.

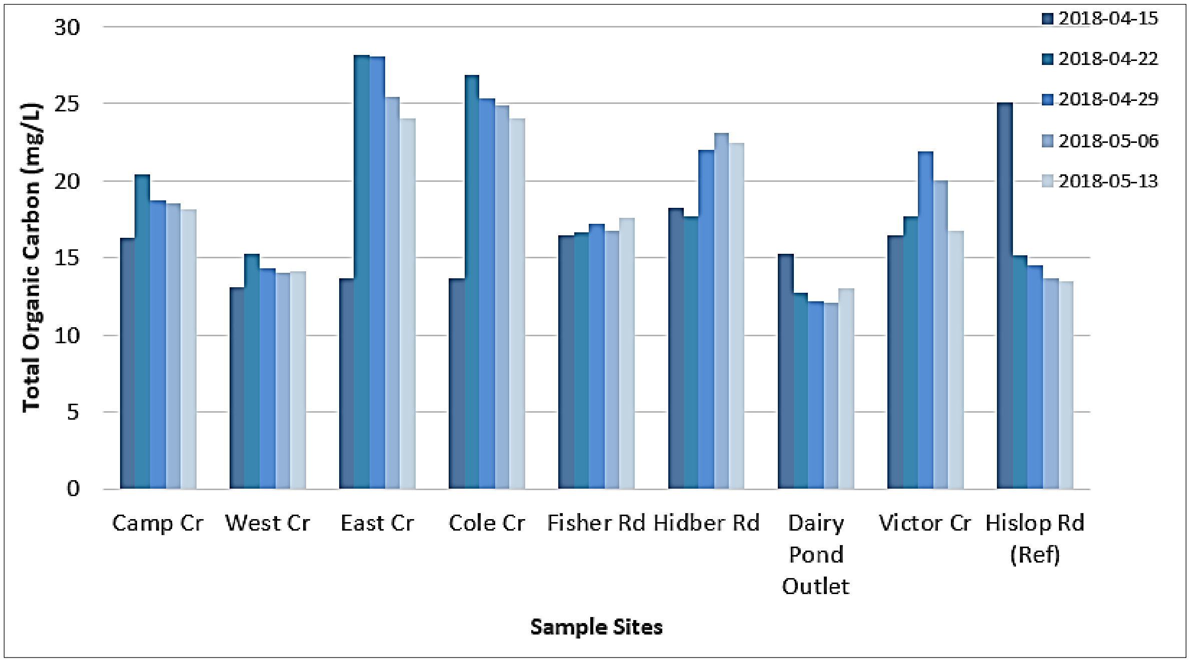


*Figure 3. Total organic carbon concentrations in water samples collected at each site over five consecutive weeks between April and May 2018.*

### 3.2.4 Turbidity and Total Suspended Solids

Turbidity is a measurement of the amount of light scattering caused by suspended particles in the water and is highly correlated to TOC and total suspended solids (TSS) concentrations. TSS include all the undissolved particulate matter in a sample. High quantities of suspended sediments may inhibit primary production and smother benthic invertebrate communities (Singleton, 1985; as cited Caux *et al.*, 1997). For the protection of aquatic life, the water quality guidelines for turbidity and suspended sediment are based on changes from background levels. The guidelines suggest that during high flows or turbid water events, such as spring runoff, when background is between 8 and 50 NTU, the turbidity guideline is a change of no more than 5 NTU. The change from background for TSS should be no more than 10 mg/L at any time when background is 25 to 100 mg/L during high flows or in turbid waters.

The guidelines are site-specific to assess the influence of anthropogenic causes on the water quality. Factors, including sediment compositions, are site-specific and because of site differences it is not appropriate to use Hislop Creek as a reference when reviewing and interpreting the turbidity data.

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[4] Potential confounding factors at the Hislop road site related to its use as a reference site is the possibility of leaking septic systems or drainage pipes from rural domestic discharge

In the absence of a suitable reference site or upstream background data for each site, the water quality guidelines for these parameters could not be precisely determined or assessed against the water quality sampling results. Instead, the variability in the concentrations within a site and between sites was described and assessed. Figure 4 shows the turbidity results for all sites for each date sampled.

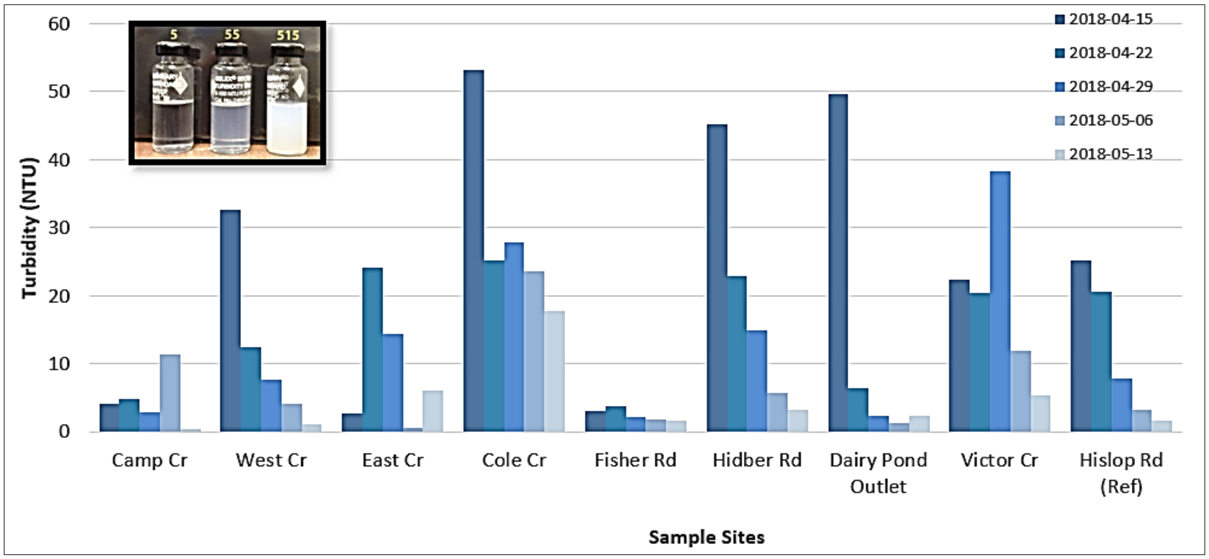


*Figure 4. Turbidity measures from water samples collected at each site over five consecutive weeks between April and May 2018. The inset in the top left demonstrates turbidity of 5 NTU, 55 NTU and 515 NTU.*

Turbidity values at the Fisher Rd creek showed the least variability over the five-week sampling period with values ranging from 1.63 to 3.67 NTU. All other sites show a much larger range of turbidity values over the sampling period, especially Hidber Road (3.2 to 45.2 NTU) and the outflow from the Dairy Farm settling pond (1.2 to 49.6 NTU). The highest turbidity values for West, Cole, and Hislop Creeks, the Dairy Farm settling pond outflow and Hidber Road occurred on the first week of sampling, at the start of the spring melt. The highest values observed at Camp, East and Victor Creeks occurred somewhere within the second to fourth week of sampling. Turbidity values at all sites except Cole Creek were less than 7 NTU in the last week of sampling. At Cole Creek, turbidity values started higher in the first week of sampling relative to the other sites at 53.2 NTU and remained higher than all the other sites in the final week of sampling at 17.8 NTU. Similar patterns of declining concentrations over the sampling period were observed for TSS (Figure 5). Over the five-week period average turbidity and TSS were highest at Cole Creek and Hidber Road respectively compared to all other sites, but the results show the highest initial concentrations of both were from the Dairy Pond outlet.

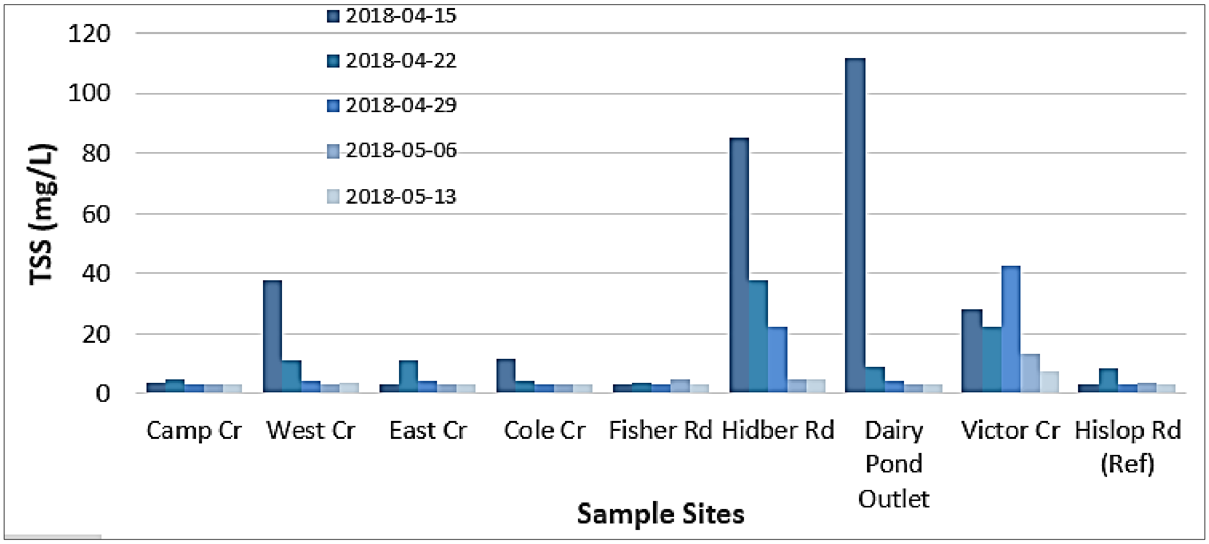


*Figure 5. Total suspended solids (TSS) concentrations in water samples collected at each sample site over five consecutive weeks between April and May 2018.*

### 3.2.5 Total Phosphorous and Ortho-phosphorous

Total phosphorous is a combination of both organic (found in plant or animal tissues and other organic materials) and inorganic compounds. Phosphorous is an important nutrient in lakes for primary productivity and is shown to be the major limiting nutrient in Tyhee Lake (Boyd *et al.*, 1985). Currently there are no drinking water, recreation, or aquatic life protection guidelines for total phosphorous in streams. This is due to other conditions that limit algal growth before nutrients do, such as water velocity, substrate, light, temperature, and grazing pressure (Nordin, 1985). However, nutrient concentrations can indicate effects of agricultural land use on the water quality. Fertilizers and manures used in agricultural practices often contain high concentrations of phosphorous.

Prior to the 2018 sampling program, ephemeral streams surrounding Tyhee Lake were sampled in the spring of 1995 and 2001 by ENV (Table C1). The data is publicly available and stored in the EMS database. This data suggests these streams experienced a short flush of total phosphorus at the onset of spring melt followed by a quick decline in total phosphorus concentrations. Concentrations were higher in March than April in both years. Of the sites sampled historically, five are included in the current study (Fisher, Hislop, West Creek (aka Horse Farm historically), Victor and Yakisda Bik'a Camp creek. Among these sites, the highest total phosphorous concentration was 1.28 mg/L found at Yakisda Bik'a Camp creek in 1995, which was a site located further downstream from the 2018 Camp Creek sample site. Total phosphorus concentrations in 2001 were lower than those measured in 1995.

In 2018, total phosphorous concentrations were below 0.1 mg/L in most samples (Figure 6). The exceptions were at Hidber Road where total phosphorus on the first week of sampling (April 15) was 0.162 mg/L; West Creek where the concentration on the last week of sampling was 0.140 mg/L; and all samples collected at the settling pond outflow. Over the entire sampling period, the settling pond outflow concentrations were consistently above 0.1 mg/L with the five samples in 30-day average of 0.199 ± 0.153mg/L (SD). Table 3 shows that the average total phosphorus concentrations at East, Cole and Victor Creeks, Hidber Road and the Dairy Farm settling pond outflow in the spring were above the recommended summer average total phosphorus concentration of 0.04mg/L for Tyhee Lake (Zirnhelt, 2015).

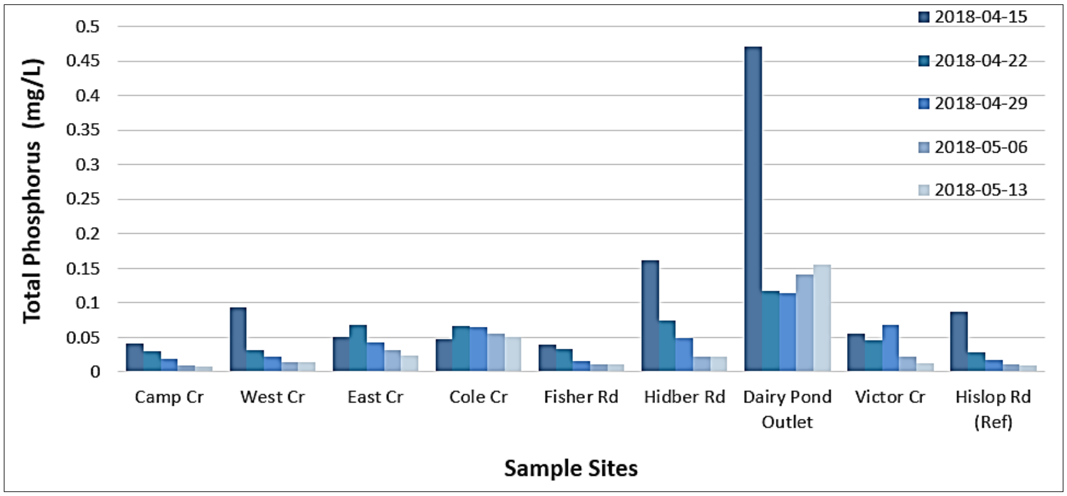


*Figure 6. Total phosphorous concentrations from five water samples collected at each site over five consecutive weeks between April and May 2018.*

Orthophosphate is an inorganic and readily available form of phosphorous and is naturally produced through the phosphorous cycle. It is found in low concentrations in waters not contaminated by anthropogenic activities (Oram, 2009). Manures and fertilizers used on agricultural lands often contain high concentrations of orthophosphates, which can then make their way into a waterbody through overland runoff. Because the compounds are readily available for uptake they are more directly related to algal concentration in streams. There are no guidelines for orthophosphate.

Orthophosphate levels followed a similar pattern to total phosphate. However, the difference between the outflow from the Dairy Farm settling pond and the other sample sites was even more noticeable. The outflow from the Dairy Farm settling pond had an average orthophosphate concentration of 0.15 ± 0.097mg/L, which was over tenfold greater than the next highest site. Average orthophosphate concentrations at the remaining sites were all between 0.002 mg/L to 0.0139 mg/L, with Victor Creek and Hidber Road being the lowest and highest respectively.

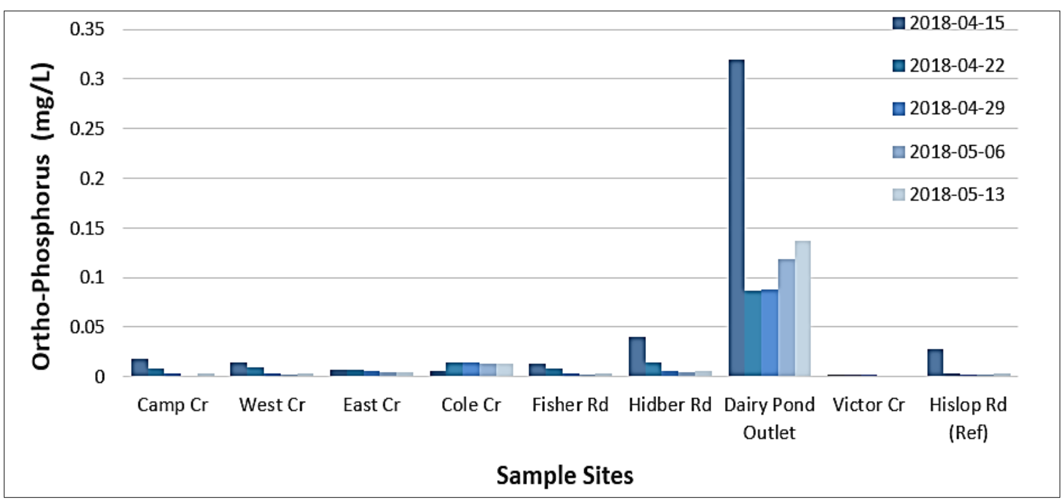


*Figure 7. Orthophosphate concentrations from five water samples collected at each site over five consecutive weeks between April and May 2018.*

### 3.2.6 Nitrogen – Nitrate, Nitrite and Ammonia

Nitrogen compounds are essential nutrients for life and move through the nitrogen cycle in numerous forms. The most common forms of nitrogen in aquatic environments are nitrate, nitrite, and ammonia. If concentrations of nitrogen are too high, they can be harmful to aquatic ecosystems by allowing excessive algal growth, direct toxicity to aquatic organisms and decreasing dissolved oxygen through nitrification (Nordin and Pommen, 1986). Although nitrogen compounds can be naturally sourced, industrial activities including agricultural practices can elevate concentrations. To protect the most sensitive freshwater species and life stages, ENV has water quality guidelines for three forms of inorganic nitrogen (nitrate, nitrite, and ammonia). The nitrate guideline consists of a short-term limit of 32.8 mg/L and a long-term average (calculated using five samples collected over 30 days) of 3.0 mg/L for the protection of aquatic life. The aquatic life guidelines for nitrite and ammonia are site-specific. The nitrite guideline is based on chloride concentration. As chloride concentrations increase the maximum allowable nitrite concentration increases. The ammonia guideline is based on site pH and temperature. As pH and temperature increase ammonia becomes more toxic and therefore the ammonia guideline value decreases. Recreational guidelines have been set for nitrate and nitrite as thresholds of less than 10.0 mg/L and 3.0 mg/L respectively, to account for the potential of accidental ingestion of water during recreational activities (Nordin and Pommen, 1986). The WQG tables for ammonia and nitrite are in Appendix D.

Hidber Road had the highest average nitrate concentration (0.2726 ± 0.1862 mg/L). The outflow from the Dairy Farm settling pond and Victor Creek had concentrations that were very close to Hidber Road, with averages of 0.2602 ± 0.5483 mg/L and 0.2579 ± 0.2257 mg/L respectively. The remaining sites had substantially lower nitrate concentrations with averages between 0.004 mg/L and 0.068 mg/L. Most nitrite concentrations were below the laboratory's detection limit of ≤ 0.0001 mg/L, which is two to three orders of magnitude lower than the guideline limits, based on chloride concentrations between two and 10 mg/L. A one-time maximum nitrite concentration of 0.007 mg/L was reported at the outflow of the Dairy Farm settling pond. This value is an order of magnitude below guideline limits. The site with the highest average ammonia concentrations (0.0233 ± 0.0249 mg/L) was the Dairy Farm settling pond outflow. This site also had the lowest guideline limit of 3.64 mg/L (May 13, 2108) due to the higher pH and temperature recorded here, compared to the other sites. The lowest average ammonia concentration (0.0096 ± 0.0021 mg/L) was reported in Victor Creek. Concentrations at all sites were below the short-term and long-term aquatic life WQG set for each of the three forms of nitrogen (*i.e*. nitrate, nitrite, and ammonia) and the recreational WQG for nitrate and nitrite.

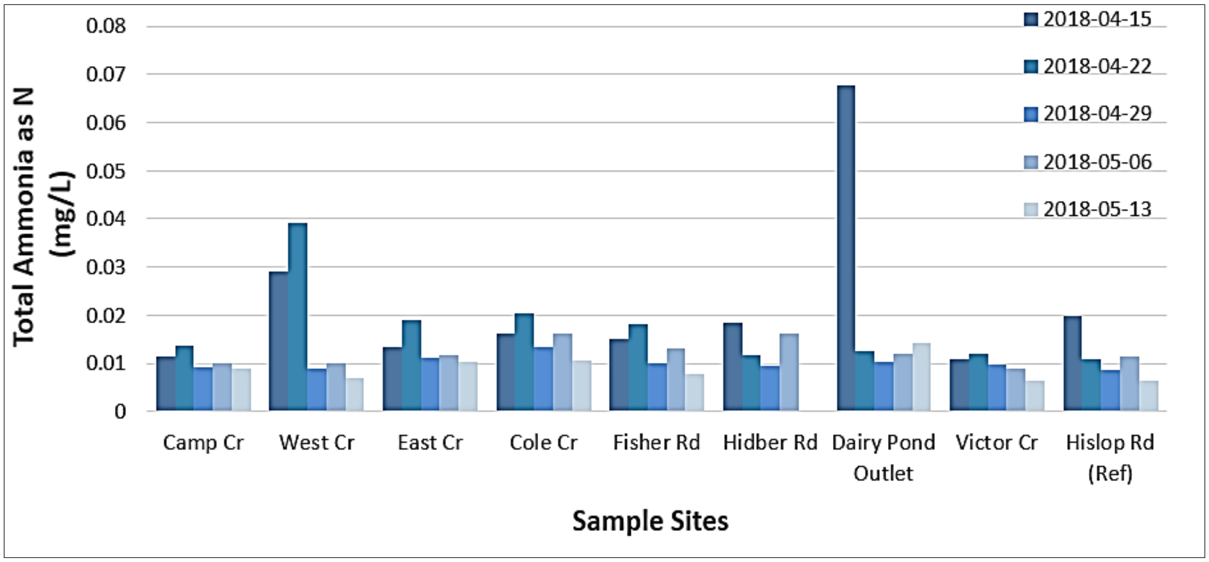


*Figure 8. Ammonia concentrations in water samples collected at each site over five consecutive weeks between April and May 2018. WQGs are temperature and pH dependent and are not shown on the figure.*

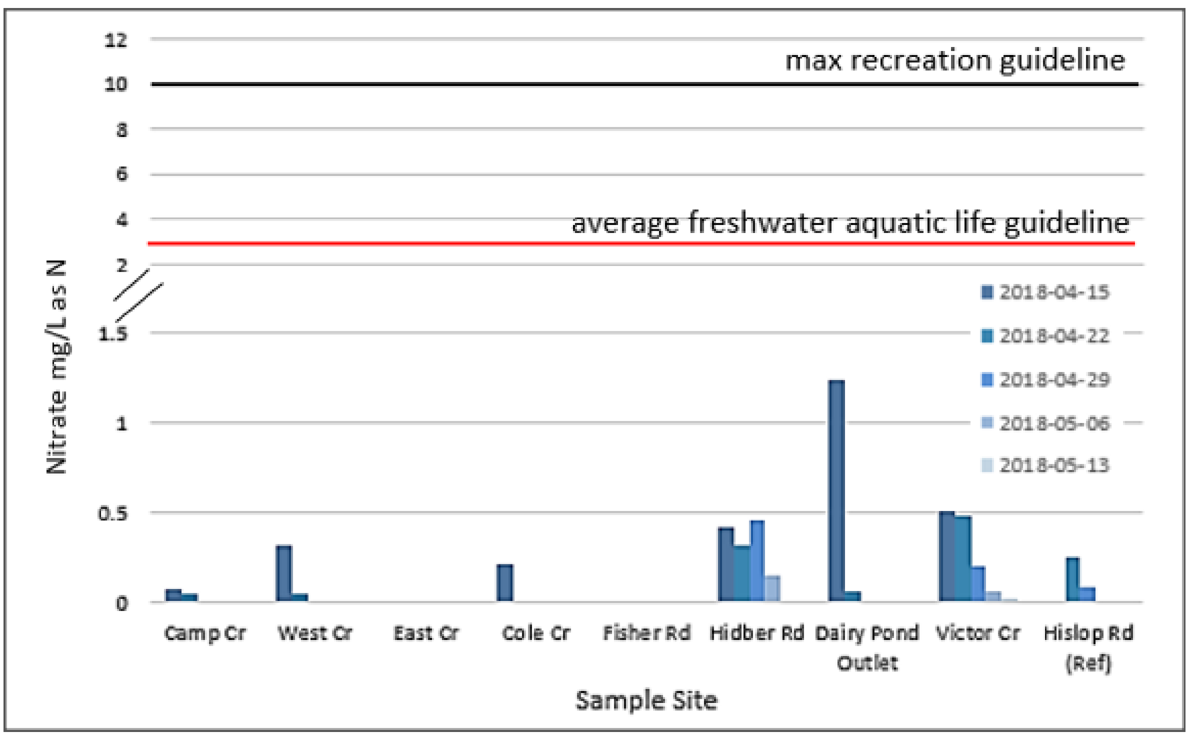


*Figure 9. Nitrate concentrations in water samples collected at each site over five consecutive weeks between April and May 2018. Note the y-axis discontinuity after 1.5 mg/L. The chronic and acute recreational WQG are indicated as solid lines.*

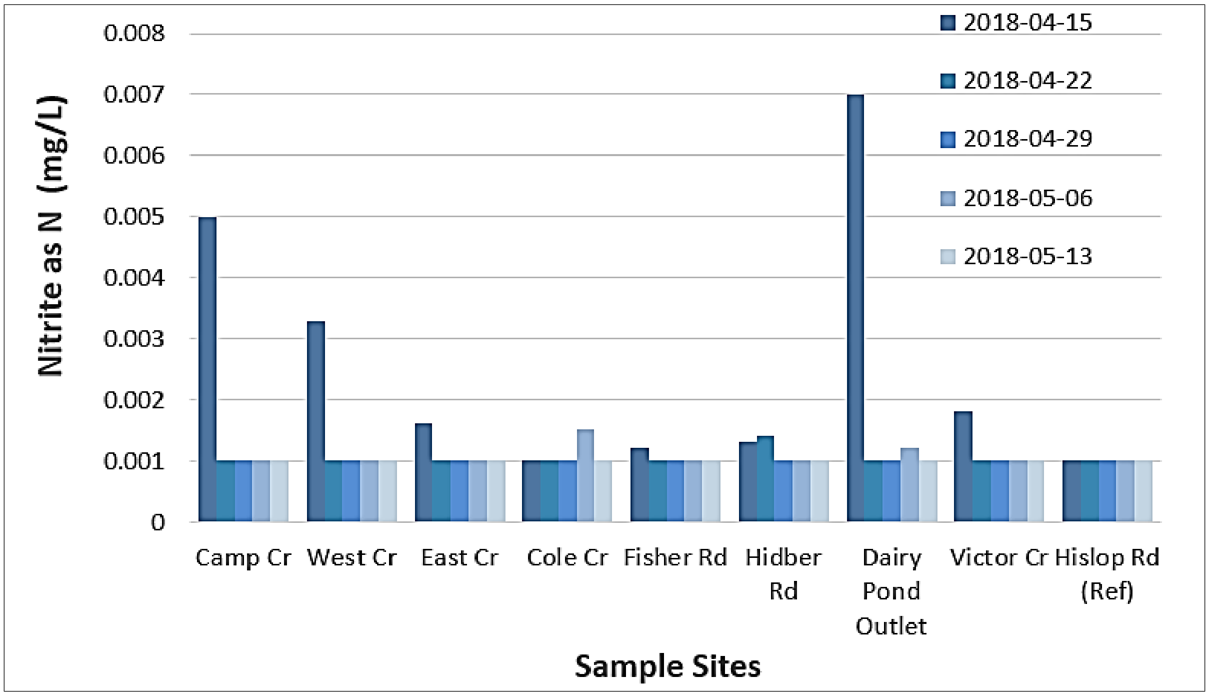


*Figure 10. Nitrite concentrations in water samples collected at each site over five consecutive weeks between April and May 2018. WQGs are chloride dependent and not shown on the figure.*

### 3.2.7 Chloride

Low concentrations of sodium chloride are found naturally in freshwater sources. Elevated chloride concentrations can lead to impaired growth and reproduction of freshwater organisms or can be lethal due to the disruption of their osmoregulation processes (Nagpal, 2003). The main anthropogenic source of chloride to the environment in B.C. is the application of road salts, which leach into the surrounding environment (Nagpal, 2003). Streams and rivers are highly affected by this practice because of their proximity to roads. Chloride may also be sourced in some fertilizers, which contain potassium chloride, and from other anthropogenic influences such as sewage, irrigation drainage, and refuse leachates (Nagpal, 2003). For the protection of freshwater aquatic life, short-term chloride concentrations should not exceed a maximum of 600 mg/L at any time. To protect against long-term effects, the average concentration should not exceed 150 mg/L (minimum of five samples in 30 days).

Chloride concentrations did not exceed either the short-term or long-term thresholds at any site. The chloride data did not follow the same pattern as the other measured nutrients, probably due to differences in their primary anthropogenic sources. The site with the highest average chloride concentration was the creek crossing at Fisher Road (13.3 ± 4.41 mg/L) and the site with the lowest average concentration was Victor Creek (2.55 ±1.80 mg/L). The highest one-time maximum was 27.6mg/L at East Creek on April 15, week one of five.

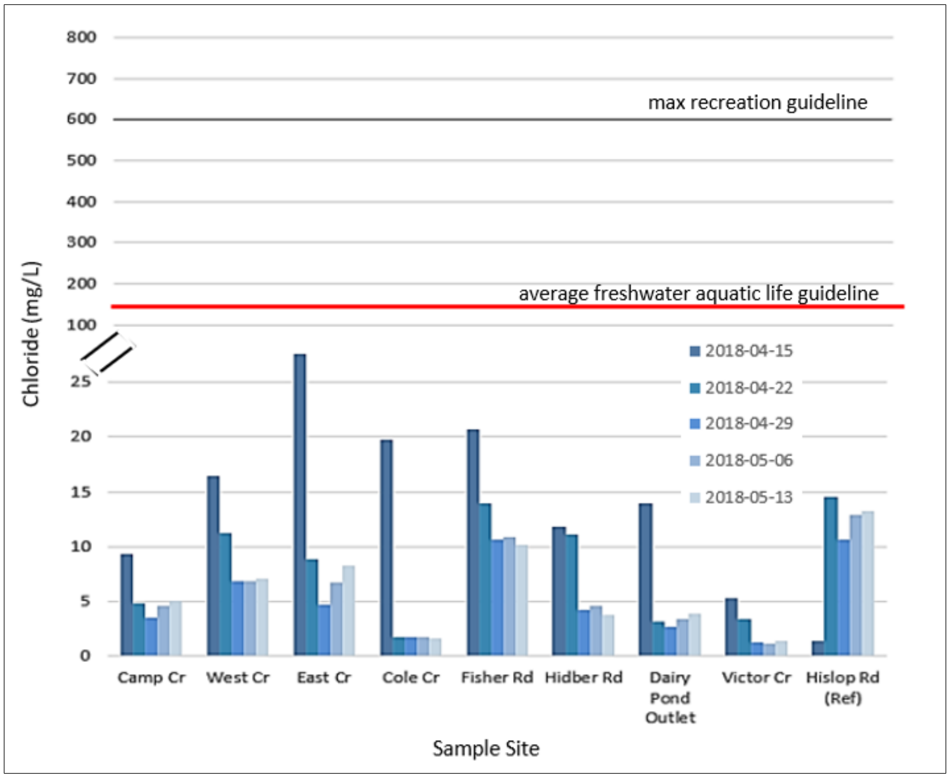


*Figure 11. Chloride concentrations from five water samples collected at each site over five consecutive weeks between April and May 2018. Note the y-axis discontinuity at 30 mg/L.*

### 3.2.8 Microbiology

Microbial indicators are used to assess the potential of fecal contamination. Bacterial indicators are not typically disease-causing, but are used to indicate the potential of water-borne pathogens that may cause diseases (Meays, 2005). Many different microbes can be used to assess fecal contamination. *E. coli* is considered the better indicator of fecal contamination compared to either total coliforms or fecal coliforms (Health Canada, 2012). The 2018 spring sampling program focused on *E. coli*, an organism that inhabits a mammal's intestinal tract. Many factors, such as rainfall, wildlife use, temperature and light exposure can all affect the amount of *E. coli* in a water body, causing concentrations to be sporadic (Meays, 2005). The microbial water quality guideline recommended for both general livestock use (ENV, 2001) and primary contact recreation (e.g. swimming, wading, and diving) (ENV, 2017), is a geometric mean of less than or equal to 200 *E. coli*/100 ml. The geometric mean is calculated for a minimum of five samples within a 30-day period to accurately assess the quantity of *E. coli* present because of their irregular and uneven distribution. This guideline has been set to minimize the risk of potential gastrointestinal diseases to water users.

All sites had geometric means below the WQG of 200 *E. coli*/100 ml (Table C-1). Hidber Road had the highest geometric mean of 54.19 CFU/100 ml. Cole Creek had the lowest with 1.32 CFU/100 ml. The highest one time maximum (270 CFU/100 ml) was from Camp Creek (Figure 12). This however does not indicate a long-term trend, as the rest of the samples from the site were much lower. The highest *E. coli* concentrations were on April 15 (the first sample week) at all sites. The exception was East Creek, where the highest concentration was on April 22 (the second sample week).

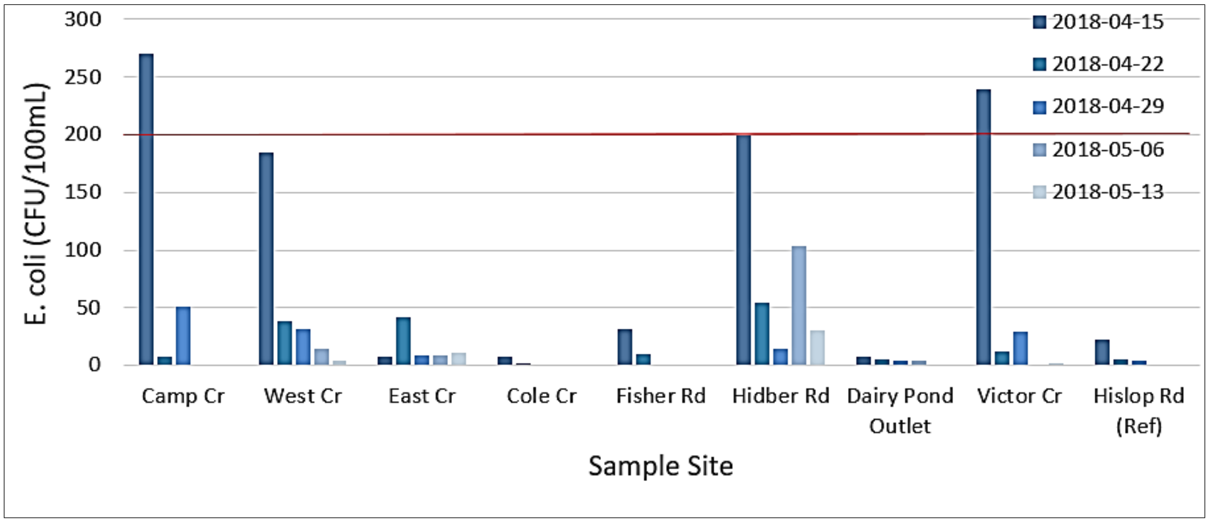


*Figure 12. Escherichia coli concentrations in water samples collected at each site over five consecutive weeks between April and May 2018. The red line represents the BC livestock and recreational WQG.*

## 3.3 Discussion

### 3.3.1 Total Organic Carbon

Most types of organic carbon found in surface waters are naturally occurring, and non-toxic to aquatic life and to humans. TOC in natural surface waters can range from 1 mg/L to over 30 mg/L, with the highest values typically emanating from sphagnum bogs or other types of wetlands. In high concentrations (>15 mg/L), organic carbon can impart a brownish or tea-colour to water, but these levels are still not toxic to aquatic life.

Spring runoff TOC concentrations in the ephemeral streams entering Tyhee Lake were within the range of the natural surface waters but five sites exceeded the derived upper water quality guideline for the protection of aquatic life. The three highest concentrations measured were from sites with upstream hobby farm and agricultural activity suggesting these activities may be influencing TOC concentrations. For example, Schepers and Francis (1982) found that grazing livestock increased total organic carbon by 11% in runoff waters on account of increased soil erosion and production of animal wastes.

### 3.3.2 Nutrients

Nitrogen has not historically been a limiting nutrient in Tyhee Lake. Concentrations of nitrogen species in the streams did not exceed water quality guidelines designed to protect the environment from negative impacts; however, concentrations during spring melt were higher at sites located downstream of the dairy farm, suggesting nutrients could be entering the lake from the dairy farm.

Phosphorous is the limiting nutrient for primary productivity in Tyhee Lake (Boyd et al., 1985). Reavie and Smol (1997) found that Tyhee Lake was most likely naturally mesotrophic before anthropogenic influences, based on the diatom community composition in a sediment core from the lake. Increased human activity since the 1950s has increased primary productivity in the lake resulting in algae blooms and increase plant growth (Reavie and Smol, 1997). Table 5 is an estimation of the trophic status of the lake between 2015 and 2018 based on deep station (EMS

E216924) chlorophyll *a* and total phosphorus concentrations. The data shows that with annual average chlorophyll *a* concentrations ranging from 6.82 ug/L to 10.80 ug/L and average total phosphorous concentrations ranging from 23 ug/L to 31 ug/L the lake is mostly in a eutrophic state (B.C. Lake Monitoring Network, 2018).

*Table 5. Tyhee Lake trophic status estimations based on deep station average chlorophyll a and average total phosphorus concentration, 2015 – 2018.*

| **Trophic state** | Chl a uglL | TP ug/L | **Year** | **Chlorophyll a ug/L** | **Total Phosphorus ug/L** | **Trophic Status** |
|---|---|---|---|---|---|---|
| | | | 2015 | 8.18 | 22.76 | low-eutrophic |
| Oligotrophic | 0-2 | 1-10 | 2016 | 10.80 | 30.43 | eutrophic |
| Mesotrophic | 2-7 | 10-30 | 2017 | 7.47 | 30.83 | eutrophic |
| Eutrophic | >7 | >30 | 2018 | 6.82 | 25.00 | mesotrophic |

Increases in nitrogen and phosphorous from anthropogenic sources can lead to eutrophication. Eutrophication can have negative impacts on aquatic life and reactional activities because the process can result in harmful algal blooms, decreased oxygen levels, fish kills and poor water quality.

The highest total phosphorus concentrations are in the bottom waters of the lake in late summer. These observations suggest that phosphorus is likely being lost from the water column to the sediments. Problems often arise when phosphorus is released from the sediments of eutrophic lakes as it is regularly associated with the proliferation of nuisance algal blooms, and excess aquatic plant growth. Anecdotally, there have been reports of large increases in algae growth in areas around the lake over the past thirty years. So much so that some areas are no longer accessible for fishing and recreation due to extreme algae and macrophyte growth.

The stream results showed that concentrations of orthophosphate, a readily available form of phosphorous, were considerably higher in the outflow from the Dairy Farm settling pond compared to the other sites (Figure 7) and may indicate elevated nutrients coming from a higher intensity anthropogenic activity source. To a lesser extent, this may also be the case related to land use above Cole Creek and Hidber Road.

### 3.3.3 Microbial Indicators of Water-Borne Pathogens

Diseases caused by water-borne pathogens have become an increasing health concern around the world. While this concern is mostly related to drinking water contamination, some pathogens can cause diseases or infections in people involved in aquatic recreational activities (Warrington, 1988). Microbial indicators, such as *E. coli,* signal when fecal contamination is entering a waterbody, and are an indirect measurement for pathogen abundance, as the pathogens themselves are often found in lower numbers with uneven distribution (Meays, 2005). However, indicator organisms do not specify the source of contamination because the same organisms can be found in the feces of all warm-blooded mammals.

*E. coli* results showed that all sampled tributaries are a source of microbial inputs to the lake. At the onset of the spring melt, concentrations of E. coli were considerably higher in Camp, West and

Victor Creeks as well Hidber Road, although there was no discernable pattern between *E. coil* concentrations and upstream land uses. All results were below the livestock and recreational use guidelines. However, the water in these streams are unsuitable as raw drinking water sources, partly due to *E. coli* concentrations that exceeded the drinking water guideline.

Differences in environmental conditions, such as light exposure, temperature and nutrients are important in determining *E. coli* survival (Meays, 2005). Temperatures across the sites were similar but nutrient concentrations were not and light exposure was not accounted for. Light exposure may have varied between samples sites as some were located on fields and some were in more forested areas.

In the past, research concerning the influence of livestock farms on fecal contamination in runoff has been inconclusive because the sources of microbes cannot be definitively discerned between livestock, wildlife, and humans (Bicudo and Goyal, 2003). However, bacteria source tracking is a growing field where the sample microorganisms are compared with those found in a known fecal source (Health Canada, 2012). This type of analysis would be needed to scientifically confirm the sources of *E. coli*.

## 4. CONCLUSION AND RECOMMENDATIONS

For two or three months each year, the ephemeral streams around Tyhee Lake flow from the onset of spring melt in April until they dry up, usually by the month of July. Overland runoff from roads, rural subdivisions, and agricultural operations collects into these streams during the spring and presumably during high precipitation events. This report looked at the water quality of these streams during spring melt in 2018.

The water quality results were compared to the B.C. Ministry of Environment and Climate Change Strategy water quality guidelines (WQG). The parameters of interest were assessed for the protection of aquatic life and recreational use where appropriate. The assessment considered the potential for agricultural land use impacts on the streams and the lake.

The study demonstrates that ephemeral stream water quality during spring melt is influenced by the intensity and concentration of upstream agricultural land use.

The main findings of this study were:

- B.C. WQGs were met for temperature, pH, chloride, nitrogen compounds and *E. coli* at all sites.
- Over the five weeks, similar patterns were observed for nutrient concentrations and water clarity; sample weeks with higher nutrient concentrations also had higher turbidity and total suspended solids.
- In general, higher turbidity, TSS, TOC and phosphorous concentrations, were measured coming from the Dairy Farm settling pond outflow, Hidber Road and Cole Creek. Lower concentrations were measured from East Creek and Victor Creek and were lower still from the remaining four sites. The main differences between the sites were the extent or intensity of upstream land use. The former sites generally have more agricultural (livestock and hayfields) and animal husbandry (horse hobby farm) use and disturbance relative to the latter sites.
- Concentrations of orthophosphate were indicative of elevated nutrients levels from anthropogenic sources rather than the conversion of natural organic phosphate compounds.

- Recent deep station lake monitoring for chlorophyll a and total phosphorus concentrations estimate the lake's overall trophic status to be eutrophic.

Historic data and the results of the spring melt sampling program indicate a low potential for short-term impacts to aquatic life or other uses in the downstream receiving environment, based on the concentration levels measured and the duration of input. However, cumulative nutrient (primarily phosphorus) loading from all anthropogenetic sources including agriculture, may have the potential to shift the lake's trophic status and acceptable water uses into the future.

To preserve lake water quality and protect the aquatic resources and lake water uses, the following are recommended:

## 4.1 Recommendations for Future Monitoring and Assessment

Water quality:

- Tyhee Lake water quality monitoring programs should include turbidity. Special attention should be given to any changes in chlorophyll *a* and phosphorous concentrations.
- Future monitoring of the streams should include sites upstream and downstream of land use on each stream for comparison purposes.

Lake Productivity

- To assess temporal changes in lake productivity, a time series of air photos or satellite images of Tyhee Lake could be used to determine if vegetation levels in the lake have changed over time.
- To identify point and non-point sources of phosphorus and their relative contributions to lake phosphorous levels, an update of the watershed phosphorous budget could be undertaken.

## 4.2 Best Management Practices

- A review and assessment of the Code of Practice for Agricultural Environmental Management (https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/8_2019 ) under the *Environmental Management Act* by landowners or a qualified professional retained by them, is recommended to minimize the potential for aquatic effects from agricultural land use activities.
- It is recommended that agricultural landowners identify and implement strategies to reduce known nutrient (primarily phosphorous) inputs and agricultural waste runoff to the lake from upstream agricultural lands. For example, phosphorus loss and TOC loading via surface runoff and erosion may be reduced by conservation tillage and crop residue management, buffer strips, riparian zones, terracing, contour tillage, cover crops, and impoundments (e.g., settling basins).

## REFERENCES


Caux, P., D. Moore and D. MacDonald. 1997. Ambient water quality guidelines (criteria) for turbidity, suspended and benthic sediments. Cadmus Group Inc. and MacDonald Environmental Science Ltd. Prepared for the B.C. Ministry of Environment, Lands and Parks.

Bicudo, J. and S. Goyal. 2003. Pathogens and manure management systems: A review. Environmental Technology 24(1): 115-130.

Boyd, I., C. McKean, R. Nordin and B. Wilkes. 1985. Kathlyn, Seymour, Round, and Tyhee Lakes water quality assessment and objectives: Technical appendix. Water Management Branch, Ministry of Environment, Victoria, B.C.

British Columbia Ministry of Environment and Climate Change Strategy. 2013. The British Columbia Field Sampling Manual Part E Water and Wastewater Sampling. Ministry of Environment. Victoria, B.C.

British Columbia Ministry of Environment and Climate Change Strategy. 2017. B.C. recreation water quality guidelines: Guideline summary. Water Quality Guideline series, WQG-02. Province of British Columbia, Victoria, B.C.

British Columbia Ministry of Environment and Climate Change Strategy. 2021. British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture - Guideline Summary. Water Quality Guideline Series, WQG-20. Prov. B.C., Victoria B.C.

Downie, A. and J. Kokelj. 2004. Attainment of Water Quality Objectives for the Smithers Lakes (Kathlyn, Seymour, Tyhee and Round Lakes), Second Update (2002/03). Environmental Protection Division, Ministry of Environment, Land and Air Protection, Skeena Region.

Environmental Monitoring System. 2018. British Columbia Ministry of Environment.

Health Canada. 2012. Guidelines for Canadian Recreational Water Quality, Third Edition. Water, Air and Climate Change Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario. Available online from https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidelines-canadian-recreational-water-quality-third-edition.html [consulted on 2019-06-30]

McKean C. and N. Nagpal. 1991. Ambient water quality criteria for pH: Technical appendix. Water Quality Branch, Water Management Division, Victoria, B.C.

Meays, C. 2005. Bacterial source tracking and survival of *Escherichia coli*. University of Victoria, Victoria, B.C.

British Columbia Ministry of Environment and Climate Change Strategy. 2018. B.C. Lake Monitoring Network data. Regional Operations Branch, Environmental Protection Division, Victoria, B.C. https://governmentofbc.maps.arcgis.com/apps/MapSeries/index.html?appid=a5ffb1bcffad4407b387292f2e55899f

Moore, D. 1998. Ambient water quality criteria for organic carbon in British Columbia: Technical appendix. Cadmus Group. Prepared for the Ministry of Environment, Lands and Parks, Victoria, B.C.

Nagpal, N. 2003. Ambient water quality guidelines for chloride: Overview. Water, Air and Climate Change Branch, Ministry of Water, Land and Air Protection.

Nordin, R. 1985. Water quality criteria for nutrients and algae: Technical appendix. Water Management Branch, Ministry of Environment, Victoria, B.C.

Nordin, R. and L. Pommen. 1986. Water quality criteria for nitrogen (nitrate, nitrite, and ammonia): Technical appendix. Water Management Branch, Ministry of Environment and Parks, Victoria, B.C.

Oliver, G. and L. Fidler. 2001. Towards a water quality guideline for temperature in the Province of British Columbia. Aspen Applied Science Ltd, Cranbrook B.C. Prepared for the Ministry of Environment, Lands and Parks, Victoria, B.C.

Oram, B. 2009. Total phosphorous and phosphate impact on surface waters. Water Research Center. Available Online from https://www.water-research.net/index.php/phosphate-in-water [consulted on 2019-06-30]

Reavie, E. and J. Smol. 1997. Paleolimnological assessment of the eutrophication history of Tyhee Lake, British Columbia. Department of Biology, Queens' University, Kingston, Ont. Prepared for the Ministry of Environment.

Rysavy, S. and I. Sharpe. 1995.Tyhee Lake management plan, draft. Ministry of Environment, Smithers, B.C.

Schepers and Francis. 1982. Chemical water quality of runoff from grazing land in Nebraska: I. Influence of grazing livestock. Journal of Environmental Quality 11(3):351-354.

Verhille, S. 2013. Understanding microbial indicators for drinking water assessment: Interpretation of test results and public health significance. National Collaborating Centre for Environmental Health.

Warrington, P. 1988. Water quality criteria for microbiological indicators: Technical appendix. Water Management Branch, Ministry of Environment and Parks, Victoria, B.C.

Zirnhelt, N. 2015. Draft Smithers Lakes (Seymour, Tyhee and Round) water quality objectives attainment report: Third Update - 2015, Draft. Environmental Protection Division, Ministry of Environment.

## APPENDIX A: FIELD SHEETS

Keep this record until end

Trevor Sandberg

Tyhee Lake Stream Sampling Program Spring 2018

| Week | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Sample day** | **Sun** | **Mon** | **Tues** | **Wed** | **Thurs** |
| To Lab | Mon | Tues | Wed | Thurs | Fri |

| | | | |
|---|---|---|---|
| EMS Site #: E311810 | | Site Name: Camp Creek | |
| DO NOT RINSE BOTTLES | | | |
| Label Bottles with permanent marker, include the following | | | |
| • Client: Ministry of Environment;<br>• Project: Tyhee Streams;<br>• Sample Id: Is the Site EMS #;<br>• Date/Time: yyyy/mm/dd, 24hh/mm | | | |
| Collect Water Samples | | | |
| DO NOT…<br>Touch the inside of the bottle or the cap with your fingers or with any other equipment<br>Collect your sample from stagnant water<br>Disturb bottom sediment (as much as feasible)<br>Hold the sample for more than the recommended holding time | | | |
| DO…<br>• Sample in the main current of streams<br>• To minimize potential for cross-contamination, stand facing upstream and reach as far upstream as possible to collect the sample | | | |
| | | | |
| A visual assessment of the monitoring site can provide invaluable information and make interpretation of other data easier and more meaningful | | | |
| **WEEK 1** | | **Requisition #** 50235865 | |
| DATE: yyyy/mm/dd 2018/04/15 | | Time:24 hh/mm 17:12 | |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | | | |
| Current weather conditions – rainy, clear, cloudy | | | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C): .5 | pH: 7.67 | Sp Conductivity (uS/cm): 116.9 | |
| Site photos | View upstream | View Downstream ✓ | |
| Comments:<br>Turbidity present. | | | |

Tyhee Lake Stream Sampling Program Spring 2018

| WEEK 2 | | | Requisition # 5023586 | | |
|---|---|---|---|---|---|
| DATE: yyyy/mm/dd 2018/04/22 | | | Time:24 hh/mm 14:08 | | |
| Samples collected | | | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | | ☑ Bacteria 200mL | | ☐ QA/QC sample |
| **Field data:** | | | | | |
| Stream level (normal, high, low) | | | | | |
| Current weather conditions – rainy, clear, cloudy | | | | | |
| Has it rained in the past 24 hours? | | | Yes | | No |
| Water Temperature (°C): 2.5 | | pH: 8.08 | Sp Conductivity (uS/cm): 83.2 | | |
| Site photos | | View upstream | View Downstream | | |
| Comments: | | | | | |

| WEEK 3 | | | Requisition # 5023586 | | |
|---|---|---|---|---|---|
| DATE: yyyy/mm/dd 2018 04 29 | | | Time:24 hh/mm | | |
| Samples collected | | | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | | ☑ Bacteria 200mL | | ☐ QA/QC sample |
| **Field data:** | | | | | |
| Stream level (normal, high, low) | | | high | | |
| Current weather conditions – rainy, clear, cloudy | | | Clear | | |
| Has it rained in the past 24 hours? | | | Yes | | No ✓ |
| Water Temperature (°C): 6.2 | | pH: 7.63 | Sp Conductivity (uS/cm): 146.5 | | |
| Site photos | | View upstream | View Downstream | | |
| Comments: Clear. | | | | | |

Tyhee Lake Stream Sampling Program Spring 2018

| **WEEK 2** | | | **Requisition #** 5023586 | |
|---|---|---|---|---|
| DATE: yyyy/mm/dd 2018/04/22 | | | Time:24 hh/mm 14:08 | |
| Samples collected | | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | | |
| Stream level (normal, high, low) | | | | |
| Current weather conditions – rainy, clear, cloudy | | | | |
| Has it rained in the past 24 hours? | | | Yes | No |
| Water Temperature (°C): 2.5 | | pH: 8.08 | Sp Conductivity (uS/cm): 43.2 | |
| Site photos | | View upstream | View Downstream | |
| Comments: | | | | |

| **WEEK 3** | | | **Requisition #** 5023586 | |
|---|---|---|---|---|
| DATE: yyyy/mm/dd 2018 04 29 | | | Time:24 hh/mm | |
| Samples collected | | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | | |
| Stream level (normal, high, low) | | | high | |
| Current weather conditions – rainy, clear, cloudy | | | Clear | |
| Has it rained in the past 24 hours? | | | Yes | No ✓ |
| Water Temperature (°C): 6.2 | | pH: 7.63 | Sp Conductivity (uS/cm): 146.5 | |
| Site photos | | View upstream | View Downstream | |
| Comments: Clear. | | | | |

Gene Cole

Tyhee Lake Stream Sampling Program Spring 2018

| Week | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Sample day** | **Sun** | **Mon** | **Tues** | **Wed** | **Thurs** |
| To Lab | Mon | Tues | Wed | Thurs | Fri |

| | | | |
|---|---|---|---|
| EMS Site #: | | Site Name: Horse Barn Creek (David's West Creek) | |
| DO NOT RINSE BOTTLES | | | |
| Label Bottles with permanent marker, include the following | | | |
| • Client: Ministry of Environment;<br>• Project: Tyhee Streams;<br>• Sample Id: Is the Site EMS #;<br>• Date/Time: yyyy/mm/dd, 24hh/mm | | | |
| Collect Water Samples | | | |
| DO NOT…<br>Touch the inside of the bottle or the cap with your fingers or with any other equipment<br>Collect your sample from stagnant water<br>Disturb bottom sediment (as much as feasible)<br>Hold the sample for more than the recommended holding time | | | |
| DO…<br>• Sample in the main current of streams<br>• To minimize potential for cross-contamination, stand facing upstream and reach as far upstream as possible to collect the sample | | | |
| | | | |
| A visual assessment of the monitoring site can provide invaluable information and make interpretation of other data easier and more meaningful | | | |
| **WEEK 1** | | **Requisition #** 505235860 | |
| DATE: yyyy/mm/dd 2018/04/15 | | Time:24 hh/mm 18:02 | |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | | High | |
| Current weather conditions – rainy, clear, cloudy | | Clear | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C): 1.3 | pH: 7.71 | Sp Conductivity (uS/cm): | |
| Site photos | View upstream | View Downstream | |
| Comments:<br>Some turbidity | | | |

Gene Cole

Horse Barn Creek

Tyhee Lake Stream Sampling Program Spring 2018

| | | | |
|---|---|---|---|
| **WEEK 2** | | **Requisition #** 505235860 | |
| DATE: yyyy/mm/dd 2018/04/22 | | Time:24 hh/mm 13:45 | |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | | High | |
| Current weather conditions – rainy, clear, cloudy | | Clear | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C): 4.4 | pH: 8.12 | Sp Conductivity (uS/cm): 118.7 | |
| Site photos | View upstream | View Downstream | |
| Comments: Water clear but green tinge. | | | |

| | | | |
|---|---|---|---|
| **WEEK 3** | | **Requisition #** 505235862 | |
| DATE: yyyy/mm/dd 2018/04/29 | | Time:24 hh/mm 16:00 | |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | | High | |
| Current weather conditions – rainy, clear, cloudy | | Clear | |
| Has it rained in the past 24 hours? | | Yes | No ✓ |
| Water Temperature (°C): 6.5 | pH: 7.72 | Sp Conductivity (uS/cm): 148.5 | |
| Site photos | View upstream | View Downstream | |
| Comments: Clear water<br>3 horses on site | | | |

Horse barn cr.

Tyhee Lake Stream Sampling Program Spring 2018

| WEEK 4 | | |
|---|---|---|
| DATE: yyyy/mm/dd 2018/05/06 | Time:24 hh/mm 17:32 | |
| ☑ General 500mL | ☑ Amber glass120mL & preserve with H2SO4 | ☑ Bacteria 200mL |
| Field data: | | |
| Stream level (normal, high, low) | Normal - mid level | |
| Current weather conditions – rainy, clear, cloudy | Clear | |
| Has it rained in the past 24 hours? | Yes | No |
| Water Temperature (°C) 10.6 | pH: 7.84 | Sp Conductivity (uS/cm): 119.4 |
| Site photos | View upstream | View Downstream |
| Comments: Clear weather. Water Clear. 2 horses in pasture affecting creek. 1 horse in adjacent pasture (E of barn) Duplicates done | | |

| WEEK 5 | | |
|---|---|---|
| DATE: yyyy/mm/dd | Time:24 hh/mm 16:38 | |
| ☑ General 500mL | ☑ Amber glass120mL & preserve with H2SO4 | ☑ Bacteria 200mL |
| Field data: | | |
| Stream level (normal, high, low) | Low | |
| Current weather conditions – rainy, clear, cloudy | Clear | |
| Has it rained in the past 24 hours? | Yes | No |
| Water Temperature (°C) 13.0C | pH: 7.53 | Sp Conductivity (uS/cm): 129.0 |
| Site photos | View upstream | View Downstream |
| Comments: Two horses in pasture affecting stream. | | |

Gene Cole

Tyhee Lake Stream Sampling Program Spring 2018

| Week | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Sample day** | **Sun** | **Mon** | **Tues** | **Wed** | **Thurs** |
| To Lab | Mon | Tues | Wed | Thurs | Fri |

| | |
|---|---|
| EMS Site #: | Site Name: Howard Creek |
| DO NOT RINSE BOTTLES | |
| Label Bottles with permanent marker, include the following | |
| • Client: Ministry of Environment;<br>• Project: Tyhee Streams;<br>• Sample Id: Is the Site EMS #:<br>• Date/Time: yyyy/mm/dd, 24hh/mm | |
| Collect Water Samples | |
| DO NOT…<br>Touch the inside of the bottle or the cap with your fingers or with any other equipment<br>Collect your sample from stagnant water<br>Disturb bottom sediment (as much as feasible)<br>Hold the sample for more than the recommended holding time | |
| DO…<br>• Sample in the main current of streams<br>• To minimize potential for cross-contamination, stand facing upstream and reach as far upstream as possible to collect the sample | |
| A visual assessment of the monitoring site can provide invaluable information and make interpretation of other data easier and more meaningful | |

| | | | |
|---|---|---|---|
| **WEEK 1** | | **Requisition #** 50R35 855 | |
| DATE: yyyy/mm/dd 2018/04/15 | | Time:24 hh/mm 18:32 | |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | | High | |
| Current weather conditions – rainy, clear, cloudy | | Clear | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C): .5 | pH: 7.41 | Sp Conductivity (uS/cm): 155.3 | |
| Site photos | View upstream | View Downstream | |

Comments:

Clear. Very shallow.

Error Sampled adjacent ravine, not Howard Creek (Heavy snow melt appeared to be creek - was open field)

Gene Cole
Howard Creek

Tyhee Lake Stream Sampling Program Spring 2018

| WEEK 2 | | Requisition # 50235855 | |
|---|---|---|---|
| DATE: yyyy/mm/dd 2018/04/22 | | Time:24 hh/mm 14:38 | |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | | High | |
| Current weather conditions – rainy, clear, cloudy | | Clear | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C): 4.7 | pH: 7.87 | Sp Conductivity (uS/cm): 69.2 | |
| Site photos | View upstream | View Downstream | |
| Comments: Brownish water | | | |

*

| WEEK 3 | | Requisition # 50235857 | |
|---|---|---|---|
| DATE: yyyy/mm/dd 2018/04/29 | | Time:24 hh/mm 16:15 | |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | | high. | |
| Current weather conditions – rainy, clear, cloudy | | Clear. | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C): 8.3 | pH: 7.47 | Sp Conductivity (uS/cm): 102.2 | |
| Site photos | View upstream | View Downstream | |
| Comments: Murky water. ~3 horse's on site | | | |

Gene Cole
Howard Creek

Tyhee Lake Stream Sampling Program Spring 2018

| WEEK 4 | | | |
|---|---|---|---|
| DATE: yyyy/mm/dd 2018/05/06 | | Time:24 hh/mm 18:40 | |
| ☑ General 500mL | ☑ Amber glass120mL & preserve with H2SO4 | | ☑ Bacteria 200mL |
| Field data: | | | |
| Stream level (normal, high, low) | | Normal | |
| Current weather conditions – rainy, clear, cloudy | | Clear | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C) 11.3 | pH: 7.56 | | Sp Conductivity (uS/cm): 81.1 |
| Site photos | | View upstream | View Downstream |
| Comments: Clear water<br>3 Horses in field | | | |

| WEEK 5 | | | |
|---|---|---|---|
| DATE: yyyy/mm/dd 2018-05-13 | | Time:24 hh/mm 17:25 | |
| ☑ General 500mL | ☑ Amber glass120mL & preserve with H2SO4 | | ☑ Bacteria 200mL |
| Field data: | | | |
| Stream level (normal, high, low) | | | |
| Current weather conditions – rainy, clear, cloudy | | | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C) 13.2 | pH: 7.44 | | Sp Conductivity (uS/cm): 96.0 |
| Site photos | | View upstream | View Downstream |
| Comments: Water clear<br>0 horses in field | | | |

COLE CK 15th

Potsepp Tyhee Lake Stream Sampling Program Spring 2018

| Week | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Sample day** | **Sun** | **Mon** | **Tues** | **Wed** | **Thurs** |
| To Lab | Mon | Tues | Wed | Thurs | Fri |

| | |
|---|---|
| EMS Site #: 7 | Site Name: COLE CK |
| DO NOT RINSE BOTTLES | |
| Label Bottles with permanent marker, include the following | |
| • Client: Ministry of Environment;<br>• Project: Tyhee Streams;<br>• Sample Id: Is the Site EMS #;<br>• Date/Time: yyyy/mm/dd, 24hh/mm 2018/04/15 | |
| Collect Water Samples | |
| DO NOT…<br>Touch the inside of the bottle or the cap with your fingers or with any other equipment<br>Collect your sample from stagnant water<br>Disturb bottom sediment (as much as feasible)<br>Hold the sample for more than the recommended holding time | |
| DO…<br>• Sample in the main current of streams<br>• To minimize potential for cross-contamination, stand facing upstream and reach as far upstream as possible to collect the sample | |

| | | | |
|---|---|---|---|
| A visual assessment of the monitoring site can provide invaluable information and make interpretation of other data easier and more meaningful | | | |
| **WEEK 1** | | **Requisition #** 50235850 | |
| DATE: yyyy/mm/dd 2018/04/15 | | Time:24 hh/mm 17:14 | |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) N | | Normal | |
| Current weather conditions – rainy, clear, cloudy | | Sunny | |
| Has it rained in the past 24 hours? | | Yes | No ✓ |
| Water Temperature (°C): 4.8 | pH: 6.6 | Sp Conductivity (uS/cm): 96.5 | |
| Site photos | View upstream | View Downstream | |
| Comments: tea colour, ~~odour~~ | | | |

odour
colour
clarity

* only 1 bottle has preservative

* REP on replicate bottle

Tyhee Lake Stream Sampling Program Spring 2018

| | | | | |
|---|---|---|---|---|
| **WEEK 2** | | | **Requisition #** 50235851 | |
| DATE: yyyy/mm/dd 2018/04/22 | | | Time:24 hh/mm 16:15 | |
| Samples collected | | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | | |
| Stream level (normal, high, low) | | | low | |
| Current weather conditions – rainy, clear, cloudy | | | clear | |
| Has it rained in the past 24 hours? | | | Yes | No ✓ |
| Water Temperature (ºC): 5.3 | | pH: 7.62 | Sp Conductivity (uS/cm): 54.7 ? | |
| Site photos | | View upstream | View Downstream | |
| Comments: clearing | | | | |

| | | | | |
|---|---|---|---|---|
| **WEEK 3** | | | **Requisition #** 50235852 | |
| DATE: yyyy/mm/dd 2018/04/29 | | | Time:24 hh/mm 14:50 | |
| Samples collected | | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | | |
| Stream level (normal, high, low) | | | | |
| Current weather conditions – rainy, clear, cloudy | | | 10°C air | |
| Has it rained in the past 24 hours? | | | Yes | No |
| Water Temperature (ºC): 8.7°C | | pH: 7.74 | Sp Conductivity (uS/cm): 113.9 | |
| Site photos | | View upstream | View Downstream | |
| Comments: Shallow over long dead grass. -not much flow | | | | |

COLE CREEK. CULVERT (TOP)

COLE CR.

Tyhee Lake Stream Sampling Program Spring 2018

| **WEEK 4** | | | **Requisition #** | | |
|---|---|---|---|---|---|
| DATE: yyyy/mm/dd 2018 | | | Time:24 hh/mm 15:30 | | |
| Samples collected | | | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | | ☑ Bacteria 200mL | | ☐ QA/QC sample |
| **Field data:** | | | | | |
| Stream level (normal, high, low) | | | low | | |
| Current weather conditions – rainy, clear, cloudy | | | clear | | |
| Has it rained in the past 24 hours? | | | Yes | No ✓ | |
| Water Temperature (°C): 11.6 | | pH: 6.9 | | Sp Conductivity (uS/cm): 77.9 | |
| Site photos | | View upstream | | View Downstream | |
| Comments: very small flow | | | | | |

| **WEEK 5** | | | **Requisition #** | | |
|---|---|---|---|---|---|
| DATE: yyyy/mm/dd | | | Time:24 hh/mm 15:33 | | |
| Samples collected | | | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | | ☑ Bacteria 200mL | | ☐ QA/QC sample |
| **Field data:** | | | | | |
| Stream level (normal, high, low) | | | low | | |
| Current weather conditions – rainy, clear, cloudy | | | clear, sunny | | |
| Has it rained in the past 24 hours? | | | Yes | No ✓ | |
| Water Temperature (°C): 13.5 | | pH: 7.00 | | Sp Conductivity (uS/cm): 86.7 | |
| Site photos | | View upstream | | View Downstream | |
| Comments: (almost) very small flow down hill, no water in ditches | | | | | |

Field form

Tyhee Lake Stream Sampling Program Spring 2018

Dunbars

| Week | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Sample day** | **Sun** | **Mon** | **Tues** | **Wed** | **Thurs** |
| To Lab | Mon | Tues | Wed | Thurs | Fri |

EMS Site #: E311951 Site Name: ~~OCTAGON~~ EAST OF OCTAGON ON FISHER RD

DO NOT RINSE BOTTLES

Label Bottles with permanent marker, include the following

- Client: Ministry of Environment;
- Project: Tyhee Streams;
- Sample Id: Is the Site EMS #;
- Date/Time: yyyy/mm/dd, 24hh/mm

GPS N 54.72841 W 127.03345

Collect Water Samples

DO NOT...

Touch the inside of the bottle or the cap with your fingers or with any other equipment
Collect your sample from stagnant water
Disturb bottom sediment (as much as feasible)
Hold the sample for more than the recommended holding time

DO...

- Sample in the main current of streams
- To minimize potential for cross-contamination, stand facing upstream and reach as far upstream as possible to collect the sample

A visual assessment of the monitoring site can provide invaluable information and make interpretation of other data easier and more meaningful

| **WEEK 1** | | **Requisition #** | |
|---|---|---|---|
| DATE: yyyy/mm/dd 2018/04/15 | | Time:24 hh/mm ~~18:13~~ 16:13 | |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |

| **Field data:** | | | |
|---|---|---|---|
| Stream level (normal, high, low) | | | |
| Current weather conditions – rainy, clear, cloudy | | | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C): 0.6 | pH: 7.58 | Sp Conductivity (uS/cm): 127.0 | |
| Site photos | View upstream | View Downstream | |

Comments:
(Odour, colour, clarity)

Tyhee Lake Stream Sampling Program Spring 2018

| WEEK 2 | | Requisition # | |
|---|---|---|---|
| DATE: yyyy/mm/dd 2018/04/22 | | Time:24 hh/mm 18:00 | |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | | | |
| Current weather conditions – rainy, clear, cloudy | | | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C): 3.4 | pH: 7.8 | Sp Conductivity (uS/cm): 109 | |
| Site photos | View upstream | View Downstream | |
| Comments: (Odour, colour, clarity) | | | |

| WEEK 3 | | Requisition # | |
|---|---|---|---|
| DATE: yyyy/mm/dd 2018 04 29 | | Time:24 hh/mm 16:25 | |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** normal to low | | | |
| Stream level (normal, high, low) | | | |
| Current weather conditions – rainy, clear, cloudy | | | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C): 5.4 | pH: 7.3 | Sp Conductivity (uS/cm): 122.3 | |
| Site photos | View upstream | View Downstream | |
| Comments: (Odour, colour, clarity) clear sunny + warm. | | | |

East of Octogon on Tcha

Tyhee Lake Stream Sampling Program Spring 2018

| WEEK 4 | | Requisition # | |
|---|---|---|---|
| DATE: yyyy/mm/dd 2018/05/06 | | Time:24 hh/mm 14:20 | |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | | | |
| Current weather conditions – rainy, clear, cloudy | | Clear Sunny Day 15° C | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C): 6.8 | pH: 7.9 | Sp Conductivity (uS/cm): 137.5 | |
| Site photos | View upstream | View Downstream | |
| Comments: (Odour, colour, clarity) Bluebird Day Sunny 15° C | | | |

| WEEK 5 | | Requisition # | |
|---|---|---|---|
| DATE: yyyy/mm/dd 2018/05/13 | | Time:24 hh/mm 18:00 | |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | | normal ~ low | |
| Current weather conditions – rainy, clear, cloudy | | high overcast 23°C | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C): 8° | pH: 7.41 | Sp Conductivity (uS/cm): 151.4 | |
| Site photos | View upstream | View Downstream | |
| Comments: (Odour, colour, clarity) Clearing up in colour & clarity | | | |

Field form

Dunbars

Tyhee Lake Stream Sampling Program Spring 2018

| Week | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Sample day** | **Sun** | **Mon** | **Tues** | **Wed** | **Thurs** |
| To Lab | Mon | Tues | Wed | Thurs | Fri |

CREEK OF HIDBER RD

| | |
|---|---|
| EMS Site #: E311881 | Site Name: FISHER CR |

DO NOT RINSE BOTTLES

Label Bottles with permanent marker, include the following

- Client: Ministry of Environment;
- Project: Tyhee Streams;
- Sample Id: Is the Site EMS #;
- Date/Time: yyyy/mm/dd, 24hh/mm

Collect Water Samples

DO NOT…

Touch the inside of the bottle or the cap with your fingers or with any other equipment
Collect your sample from stagnant water
Disturb bottom sediment (as much as feasible)
Hold the sample for more than the recommended holding time

DO…

- Sample in the main current of streams
- To minimize potential for cross-contamination, stand facing upstream and reach as far upstream as possible to collect the sample

A visual assessment of the monitoring site can provide invaluable information and make interpretation of other data easier and more meaningful

| | |
|---|---|
| **WEEK 1** | **Requisition #** |
| DATE: yyyy/mm/dd 2018/04/15 | Time:24 hh/mm 16:35 |

Samples collected

| | | | |
|---|---|---|---|
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |

**Field data:**

| | | | |
|---|---|---|---|
| Stream level (normal, high, low) | | | |
| Current weather conditions – rainy, clear, cloudy | | | |
| Has it rained in the past 24 hours? | Yes | No | |
| Water Temperature (°C): 0.3°C | pH: 7.28 | Sp Conductivity (uS/cm): 137.1 | |
| Site photos | View upstream | View Downstream | |

Comments:

ODOUR

COLOUR

CLARITY

Tyhee Lake Stream Sampling Program Spring 2018

| **WEEK 2** | | | **Requisition #** |
|---|---|---|---|
| DATE: yyyy/mm/dd 2018/04/22 | | | Time:24 hh/mm 18:12 |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | | | |
| Current weather conditions – rainy, clear, cloudy | | | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C): 2.5 | pH: 7.8 | Sp Conductivity (uS/cm): 104 | |
| Site photos | View upstream | View Downstream | |
| Comments: Sunny day. Air temp 10°C Lots of run-off. Water colour a bit brown. | | | |

| **WEEK 3** | | | **Requisition #** |
|---|---|---|---|
| DATE: yyyy/mm/dd 2018 04 29. | | | Time:24 hh/mm 16:15 |
| Samples collected 3 | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | | | |
| Current weather conditions – rainy, clear, cloudy | | | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C): 5.2 | pH: 7.4 | Sp Conductivity (uS/cm): 77.6 | |
| Site photos | View upstream | View Downstream | |
| Comments: Sunny + warm colour a bit yellow | | | |

Tyhee Lake Stream Sampling Program Spring 2018

(Creek E of Hidber Rd)

| **WEEK 4** | | | | |
|---|---|---|---|---|
| DATE: yyyy/mm/dd 2018/05/06 | | Time:24 hh/mm 14:40 | | |
| ☑ General 500mL | ☑ Amber glass120mL & preserve with H2SO4 | | ☑ Bacteria 200mL | |
| Field data: | | | | |
| Stream level (normal, high, low) | | High | | |
| Current weather conditions – rainy, clear, cloudy | | Clear Sunny +15°C | | |
| Has it rained in the past 24 hours? | | Yes | No ✓ | |
| Water Temperature (°C) 8.5 | pH: 7.55 | | Sp Conductivity (uS/cm): 88.4 | |
| Site photos | View upstream | | View Downstream | |
| Comments: | | | | |

| **WEEK 5** | | | | |
|---|---|---|---|---|
| DATE: yyyy/mm/dd 2018/05/13 | | Time:24 hh/mm 18:33 | | |
| ☑ General 500mL | ☑ Amber glass120mL & preserve with H2SO4 | | ☑ Bacteria 200mL | |
| Field data: | | | | |
| Stream level (normal, high, low) | | | | |
| Current weather conditions – rainy, clear, cloudy | | high overcast 23°C | | |
| Has it rained in the past 24 hours? | | Yes | No | |
| Water Temperature (°C) 10.7°C | pH: 7.64 | | Sp Conductivity (uS/cm): 107 | |
| Site photos | View upstream | | View Downstream | |
| Comments: | | | | |

Tyhee Lake Stream Sampling Program Spring 2018

Field form Dunbars

| Week | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Sample day** | **Sun** | **Mon** | **Tues** | **Wed** | **Thurs** |
| To Lab | Mon | Tues | Wed | Thurs | Fri |

| | |
|---|---|
| EMS Site #: E311750 | Site Name: DAIRY FARM SETTLING POND CR ON LAKE ROAD |
| DO NOT RINSE BOTTLES | |
| Label Bottles with permanent marker, include the following | |

- Client: Ministry of Environment;
- Project: Tyhee Streams;
- Sample Id: Is the Site EMS #;
- Date/Time: yyyy/mm/dd, 24hh/mm

GPS N54.72220 W127.02962

Collect Water Samples

DO NOT…

Touch the inside of the bottle or the cap with your fingers or with any other equipment
Collect your sample from stagnant water
Disturb bottom sediment (as much as feasible)
Hold the sample for more than the recommended holding time

DO…

- Sample in the main current of streams
- To minimize potential for cross-contamination, stand facing upstream and reach as far upstream as possible to collect the sample

A visual assessment of the monitoring site can provide invaluable information and make interpretation of other data easier and more meaningful

| **WEEK 1** | **Requisition #** |
|---|---|
| DATE: yyyy/mm/dd 2018/04/15 | Time:24 hh/mm 15:21 |

Samples collected

| | | | |
|---|---|---|---|
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |

**Field data:**

| | | |
|---|---|---|
| Stream level (normal, high, low) | | |
| Current weather conditions – rainy, clear, cloudy | BROKEN CLOUD | |
| Has it rained in the past 24 hours? | Yes | No |

| | | |
|---|---|---|
| Water Temperature (°C): 1.8 C | pH: 7.54 | Sp Conductivity (uS/cm): 199.0 |
| Site photos | View upstream | View Downstream |

Comments:
(Odour, colour, clarity) SOME SEDIMENT BEING SUSPENDED

REPLICATE TAKEN THIS SITE

Tyhee Lake Stream Sampling Program Spring 2018

| **WEEK 2** | | | **Requisition #** | | |
|---|---|---|---|---|---|
| DATE: yyyy/mm/dd 2018/04/22 | | | Time:24 hh/mm 18:33 | | |
| Samples collected | | | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | | ☑ Bacteria 200mL | | ☐ QA/QC sample |
| **Field data:** | | | | | |
| Stream level (normal, high, low) | | | | | |
| Current weather conditions – rainy, clear, cloudy | | | | | |
| Has it rained in the past 24 hours? | | | Yes | | No |
| Water Temperature (°C): 10.1 | | pH: 8.3 | | Sp Conductivity (uS/cm): 172 | |
| Site photos | | View upstream | | View Downstream | |
| Comments: (Odour, colour, clarity) creek lower than 1 week ago<br>mainly sunny<br>air temp 10°C<br>creek water warmer than others - warmed up in settling pond. | | | | | |

| **WEEK 3** | | | **Requisition #** | | |
|---|---|---|---|---|---|
| DATE: yyyy/mm/dd 2018/04/29 | | | Time:24 hh/mm 11:00 | | |
| Samples collected | | | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | | ☑ Bacteria 200mL | | ☐ QA/QC sample |
| **Field data:** | | | | | |
| Stream level (normal, high, low) | | | | | |
| Current weather conditions – rainy, clear, cloudy | | | Sunny Clear | | |
| Has it rained in the past 24 hours? | | | Yes | | No |
| Water Temperature (°C): 13.5 | | pH: 8.15 | | Sp Conductivity (uS/cm): 210 | |
| Site photos | | View upstream | | View Downstream | |
| Comments: (Odour, colour, clarity)<br>Sunny & warm. | | | | | |

Dairy farm settling pond

Tyhee Lake Stream Sampling Program Spring 2018

| WEEK 4 | | | Requisition # | |
|---|---|---|---|---|
| DATE: yyyy/mm/dd 2018/05/06 | | | Time:24 hh/mm 15:00 | |
| Samples collected | | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | | |
| Stream level (normal, high, low) | | | low - normal | |
| Current weather conditions – rainy, clear, cloudy | | | clear Sunny +15°C | |
| Has it rained in the past 24 hours? | | | Yes | No |
| Water Temperature (°C): 15.2 | pH: 8.35 | | Sp Conductivity (uS/cm): 315.5 | |
| Site photos | View upstream | | View Downstream | |
| Comments: (Odour, colour, clarity) | | | | |

| WEEK 5 | | | Requisition # | |
|---|---|---|---|---|
| DATE: yyyy/mm/dd 2018/05/13 | | | Time:24 hh/mm 18'46 | |
| Samples collected | | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | | |
| Stream level (normal, high, low) medium to low | | | | |
| Current weather conditions – rainy, clear, cloudy | | | high overcast 23°C | |
| Has it rained in the past 24 hours? | | | Yes | No |
| Water Temperature (°C): 15.4 °C | pH: 8.22 | | Sp Conductivity (uS/cm): 307.0 | |
| Site photos | View upstream | | View Downstream | |
| Comments: (Odour, colour, clarity) Fish in creek! | | | | |

Lisa, see note - on back of the last page re probes.

Tyhee Lake Stream Sampling Program Spring 2018 G. Currie

| Week | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Sample day** | **Sun** | **Mon** Sun | **Tues** Sun | **Wed** Sun | **Thurs** Sun |
| To Lab | Mon | Tues | Wed | Thurs | Fri |

| EMS Site #: E311749 | Site Name: Victor Cr |
|---|---|
| DO NOT RINSE BOTTLES | |
| Label Bottles with permanent marker, include the following | |
| • Client: Ministry of Environment;<br>• Project: Tyhee Streams;<br>• Sample Id: Is the Site EMS #;<br>• Date/Time: yyyy/mm/dd, 24hh/mm | |
| Collect Water Samples | |
| DO NOT…<br>Touch the inside of the bottle or the cap with your fingers or with any other equipment<br>Collect your sample from stagnant water<br>Disturb bottom sediment (as much as feasible)<br>Hold the sample for more than the recommended holding time | |
| DO…<br>• Sample in the main current of streams<br>• To minimize potential for cross-contamination, stand facing upstream and reach as far upstream as possible to collect the sample | |
| A visual assessment of the monitoring site can provide invaluable information and make interpretation of other data easier and more meaningful | |
| **WEEK 1** | **Requisition #** 5023583/ |
| DATE: yyyy/mm/dd 2018/04/15 | Time:24 hh/mm 18:35 |

Samples collected

| | | | |
|---|---|---|---|
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |

**Field data:**

| | | |
|---|---|---|
| Stream level (normal, high, low) | still has ice in it | |
| Current weather conditions – (rainy, clear, cloudy | very light | |
| Has it rained in the past 24 hours? | Yes sprinkle | No |
| Water Temperature (°C): 0.3°C | pH: 7.88 | Sp Conductivity (uS/cm): * 105.5 |
| Site photos | View upstream | View Downstream |

Comments: Cond 106.7
* L Err for Spec Cond. ← used other machine to get

Tyhee Lake Stream Sampling Program Spring 2018
Victor Creek New Location for sampling

| WEEK 2 | | | Requisition #35832 |
|---|---|---|---|
| DATE: yyyy/mm/dd 2018/04/22 | | | Time:24 hh/mm 10:15 am |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | | | |
| Current weather conditions – rainy, clear, cloudy | | sunny, some clouds 1°C | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C): 0.9°C | pH: 7.94 | Sp Conductivity (uS/cm): 86.4 | |
| Site photos | View upstream | View Downstream | |
| Comments: - a bit of white foam on the side of the creek - probably 2' deep * still getting LErr message for sp. cond so I used other machine to get reading | | | |

| WEEK 3 | | | Requisition # 50235833 |
|---|---|---|---|
| DATE: yyyy/mm/dd 2018-04/29 | | | Time:24 hh/mm 14:20 |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☑ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | | | |
| Current weather conditions – rainy, clear, cloudy | | 10° air | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C): 3.1° | pH: 7.58 | Sp Conductivity (uS/cm): 123.7 | |
| Site photos | View upstream | View Downstream | |
| Comments: very muddy REP done as well @22°C 2 days ago, stream was over top of the bridge | | | |

Tyhee Lake Stream Sampling Program Spring 2018

| WEEK 4 | | Requisition # 50235834 | |
|---|---|---|---|
| DATE: yyyy/mm/dd 2018/05/06 | | Time:24 hh/mm 18:40 | |
| Samples collected | | | |
| ☐ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | | | |
| Current weather conditions – rainy, clear, cloudy | | outside temp 23° | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C): 7.0°C | pH: 7.59 | Sp Conductivity (uS/cm): 142.7 | done with probe w/o pink tape |
| Site photos | View upstream | View Downstream | |
| Comments: Tues May 6 19.43 7.9°C 6.88 84.9 w/ pink tape | | | |

| WEEK 5 | | Requisition # | |
|---|---|---|---|
| DATE: yyyy/mm/dd 2018/05/13 | | Time:24 hh/mm 14:48 | |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | | | |
| Current weather conditions – rainy, clear, cloudy | | | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C): 9.0°C | pH: 7.38 | Sp Conductivity (uS/cm): 101.7 | |
| Site photos | View upstream | View Downstream | |
| Comments: | | | |

HISLOP HILL CK

Potseppl Tyhee Lake Stream Sampling Program Spring 2018

| Week | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Sample day** | **Sun** | **Mon** | **Tues** | **Wed** | **Thurs** |
| To Lab | Mon | Tues | Wed | Thurs | Fri |

| | |
|---|---|
| EMS Site #: | Site Name: |
| DO NOT RINSE BOTTLES | |
| Label Bottles with permanent marker, include the following | |
| • Client: Ministry of Environment;<br>• Project: Tyhee Streams;<br>• Sample Id: Is the Site EMS #;<br>• Date/Time: yyyy/mm/dd, 24hh/mm | |
| Collect Water Samples | |
| DO NOT…<br>Touch the inside of the bottle or the cap with your fingers or with any other equipment<br>Collect your sample from stagnant water<br>Disturb bottom sediment (as much as feasible)<br>Hold the sample for more than the recommended holding time | |
| DO…<br>• Sample in the main current of streams<br>• To minimize potential for cross-contamination, stand facing upstream and reach as far upstream as possible to collect the sample | |
| | |
| A visual assessment of the monitoring site can provide invaluable information and make interpretation of other data easier and more meaningful | |
| **WEEK 1** | **Requisition #** 50235826 |
| DATE: yyyy/mm/dd 2018/04/15 | Time:24 hh/mm 17:40 |

| | | | |
|---|---|---|---|
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | normal | | |
| Current weather conditions – rainy, clear, cloudy | clear | | |
| Has it rained in the past 24 hours? | Yes | No | |
| Water Temperature (°C): 11 | pH: 7.90 | Sp Conductivity (uS/cm): | 192.8 ① uS<br>LERR ② |
| Site photos | View upstream | View Downstream | |
| Comments: clear, no odour, ligth brown | | | |

ODOUR
COLOUR
CLARITY

Tyhee Lake Stream Sampling Program Spring 2018

| | | | |
|---|---|---|---|
| **WEEK 2** | | **Requisition #** 50235827 | |
| DATE: yyyy/mm/dd 2018/04/22 | | Time:24 hh/mm 16:25 | |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | | high | |
| Current weather conditions – rainy, clear, cloudy | | clear | |
| Has it rained in the past 24 hours? | | Yes | No ✓ |
| Water Temperature (°C): 4.0 | pH: 8.37 | Sp Conductivity (uS/cm): 171.2 | |
| Site photos | View upstream | View Downstream | |
| Comments: | | | |

| | | | |
|---|---|---|---|
| **WEEK 3** 2018/04/29 | | **Requisition #** 50235828 | |
| DATE: yyyy/mm/dd 2018/04/29 | | Time:24 hh/mm 14:35 | |
| Samples collected | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | ☑ Bacteria 200mL | ☐ QA/QC sample |
| **Field data:** | | | |
| Stream level (normal, high, low) | | | |
| Current weather conditions – rainy, clear, cloudy | | 10°C air | |
| Has it rained in the past 24 hours? | | Yes | No |
| Water Temperature (°C): 6.9°C | pH: 7.93 | Sp Conductivity (uS/cm): 282.3 | |
| Site photos | View upstream | View Downstream | |
| Comments: | | | |

HISLOP HILL RD CULVERT (BOT.)

HISLOP CK

Tyhee Lake Stream Sampling Program Spring 2018

| WEEK 4 | | | | Requisition # | | |
|---|---|---|---|---|---|---|
| DATE: yyyy/mm/dd | | | | Time:24 hh/mm ~~15:30~~ 15:45 | | |
| Samples collected | | | | | | |
| ☐ General 500mL | ☐ Amber glass120mL (preserve with H2SO4) | | ☐ Bacteria 200mL | | ☐ QA/QC sample | |
| Field data: | | | | | | |
| Stream level (normal, high, low) | | | | | | |
| Current weather conditions – rainy, clear, cloudy | | | | | | |
| Has it rained in the past 24 hours? | | | Yes | | No | |
| Water Temperature (ºC): ~~12.6~~ 11.6 | pH: ~~8.9~~ 7.76 | | Sp Conductivity (uS/cm): ~~[illegible]~~ 214.5 | | | |
| Site photos | View upstream | | View Downstream | | | |
| Comments: water clear, med. flow | | | | | | |

| WEEK 5 | | | | Requisition # | | |
|---|---|---|---|---|---|---|
| DATE: yyyy/mm/dd | | | | Time:24 hh/mm 15:45 | | |
| Samples collected | | | | | | |
| ☑ General 500mL | ☑ Amber glass120mL (preserve with H2SO4) | | ☑ Bacteria 200mL | | ☑ QA/QC 3 samples | |
| Field data: | | | | | | |
| Stream level (normal, high, low) | | | med. | | | |
| Current weather conditions – rainy, clear, cloudy | | | clear | | | |
| Has it rained in the past 24 hours? | | | Yes | | No ✓ | |
| Water Temperature (ºC): 13.2 | pH: 7.66 | | Sp Conductivity (uS/cm): ~~[illegible]~~ 246.7 | | | |
| Site photos | View upstream | | View Downstream | | | |
| Comments: moderate flow, decreasing. clear | | | | | | |

## APPENDIX B: STREAM PHOTOS

Pictures were taken and supplied by local volunteer and Tyhee Lake residents, Gene Cole and Mike Dunbar.

*Figure B-1. Camp Creek looking south and downstream (above) and looking north and upstream (below).*

*Figure B-2. West Creek through Tyhee David Property looking south (above) and looking north (below).*

*Figure B-3. East Creek through Tyhee David Property looking south (above) and looking north (below).*

*Figure B-4. Cole Creek looking southwest (above) and looking north (below).*

*Figure B-5. Creek crossing Fisher Road near the octagon house looking southwest (above) and looking northeast (below).*

*Figure B-6.The creek east of Hidber Road (aka Hidbert Road) and looking upstream east of the creek. Taken by Jim Dunbar*

*Figure B-7. Outflow from the Dairy Farm settling pond, looking northeast (above) and the Dairy Farm settling pond looking west (below).*

*Figure B-8. Victor Creek near Penner Road.*

*Figure B-9. Creek near Hislop Road looking southwest (above) and the ditch that feeds the creek, looking north (below)*

## APPENDIX C: WATER QUALITY DATA

*Table C-1. List of Tyhee lake stream sites in historic data assessment, 1995 and 2001. The site data can be found in EMS.*

| Site Name | EMS ID |
|---|---|
| FISHER RD JUNCTION CREEK - NE SIDE TYHEE LAKE[1] | E219765 |
| FOX RD CREEK - TYHEE LAKE, NW | E219761 |
| HISLOP RD CREEK - TYHEE LAKE, SE[1] | E219771 |
| HOEK`S CREEK - TYHEE LAKE, N | E219766 |
| HORSE FARM CREEK - N TYHEE LAKE[1, 2] | E219763 |
| HOWARD`S CREEK - TYHEE LAKE, N | E219764 |
| KOOPMAN`S NORTH CREEK - TYHEE LAKE, N | E219768 |
| KOOPMAN`S SOUTH CREEK - TYHEE LAKE, N | E219769 |
| TYHEE CREEK - OUTLET TO TYHEE LAKE | E243521 |
| VICTOR CREEK - TYHEE LAKE, E[1] | E219770 |
| YAKISDA BIK`A CAMP CREEK - TYHEE LAKE, N[1] | E219762 |

[1] Creeks sampled in 2018

[2] Horse Farm Creek (1995-2001) and West Creek (2018) are the same creek.

*Table C-2. Raw data of results from water samples collected from nine ephemeral streams and overland runoff locations surrounding Tyhee Lake, B.C., for the 2018 Spring Melt Bacteriological Sampling Program. Where two results for a site on a single date the data represents regular/replicate samples.*

| Parameter | Date | Camp Cr | West Cr | East Cr | Cole Cr | Fisher Rd | Hidber Rd | Dairy Farm Settling Pond | Victor Cr | Hislop Rd |
|---|---|---|---|---|---|---|---|---|---|---|
| Conductivity – Field (*uS/cm*) | 04-15-18 | 226.9 | 130 | 155.3 | 96.5 | 127 | 137.1 | 199 | 106.7 | 192.2 |
| | 04-22-18 | 83.2 | 118.7 | 63.2 | 54.7 | 109 | 104 | 172 | 86.4 | 171.2 |
| | 04-29-18 | 146.5 | 188.5 | 102.2 | 113.9 | 122.3 | 77.6 | 210 | 123.7 | 282.3 |
| | 05-06-18 | 113.8 | 119.4 | 81.1 | 77.9 | 137.5 | 88.4 | 275.5 | 142.7 | 214.5 |
| | 05-13-18 | 134.9 | 129 | 96 | 86.7 | 151.4 | 107 | 307 | 101.7 | 246.7 |
| pH – Field (*pH* | 04-15-18 | 7.67 | 7.71 | 7.41 | 6.6 | 7.56 | 7.28 | 7.54 | 7.88 | 7.9 |
| | 04-22-18 | 8.08 | 8.12 | 7.87 | 7.62 | 7.8 | 7.8 | 8.3 | 7.94 | 8.37 |
| | 04-29-18 | 7.63 | 7.72 | 7.47 | 7.04 | 7.3 | 7.4 | 8.15 | 7.58 | 7.93 |
| | 05-06-18 | 7.41 | 7.84 | 7.56 | 6.9 | 7.9 | 7.55 | 8.15 | 7.59 | 7.76 |
| | 05-13-18 | 7.22 | 7.53 | 7.44 | 7 | 7.47 | 7.64 | 8.22 | 7.38 | 7.66 |
| Temperature – Field (*°C*) | 04-15-18 | 0.5 | 1.3 | 0.3 | 4.8 | 0.6 | 0.3 | 1.8 | 0.3 | 1.1 |
| | 04-22-18 | 2.5 | 4.4 | 4.7 | 5.3 | 3.4 | 2.5 | 10.1 | 0.9 | 4 |
| | 04-29-18 | 6.2 | 6.5 | 8.3 | 8.7 | 5.4 | 5.2 | 13.5 | 3.1 | 6.9 |
| | 05-06-18 | 9.4 | 10.6 | 11.3 | 11.6 | 6.8 | 8.5 | 15.2 | 7 | 11.6 |
| | 05-13-18 | 11.4 | 13 | 13.2 | 13.5 | 8 | 10.7 | 15.4 | 9 | 13.2 |
| Conductivity (*uS/cm*) | 04-15-18 | 222 | 232 | 311 | 360 | 234 | 262 | 365/353 | 196 | 111 |
| | 04-22-18 | 157 | 216 | 115 | 97.7 | 201 | 195 | 288 | 163 | 308 |
| | 04-29-18 | 152 | 193 | 102 | 119 | 228 | 144 | 361 | 129/129 | 290 |
| | 05-06-18 | 196 | 201/214 | 140 | 129 | 243 | 152 | 432 | 146 | 349 |
| | 05-13-18 | 221 | 207 | 154 | 138 | 255 | 176 | 481 | 172 | 410/407 |

| Parameter | Date | Camp Cr | West Cr | East Cr | Cole Cr | Fisher Rd | Hidber Rd | Dairy Farm Settling Pond | Victor Cr | Hislop Rd |
|---|---|---|---|---|---|---|---|---|---|---|
| pH (*pH*) | 04-15-18 | 8.14 | 8.16 | 7.88 | 8.13 | 8.00 | 7.94 | 8.40/8.41 | 8.20 | 7.80 |
| | 04-22-18 | 7.79 | 8.03 | 7.47 | 7.44 | 7.75 | 7.76 | 8.31 | 7.79 | 8.26 |
| | 04-29-18 | 7.88 | 7.96 | 7.61 | 7.57 | 7.90 | 7.93 | 8.36 | 7.85/7.86 | 8.14 |
| | 05-06-18 | 8.27 | 8.27/8.18 | 8.03 | 8.03 | 8.25 | 8.10 | 8.64 | 8.12 | 8.50 |
| | 05-13-18 | 8.23 | 8.23 | 7.90 | 7.96 | 8.24 | 8.15 | 8.56 | 8.01 | |
| Total Suspended Solids (*mg/L*) | 04-15-18 | 3.4 | 37.6 | <3.0 | 11.6 | <3.0 | 85.0 | 112/118 | 28,4 | <3.0 |
| | 04-22-18 | 4.5 | 11.3 | 10.9 | 4.1 | 3.67 | 37.9 | 9.1 | 22.5 | 8.7 |
| | 04-29-18 | <3.0 | 4.3 | 4.1 | <3.0 | 2.20 | 22.5 | 4.1 | 42.4/52.2 | 3.3 |
| | 05-06-18 | <3.0 | <3.0/<3.0 | <3.0 | <3.0 | 1.87 | 4.7 | 3.3 | 13.4 | 3.7 |
| | 05-13-18 | <3.0 | 3.9 | <3.0 | <3.0 | 1.63 | 4.5 | <3.0 | 7.3 | <3.0/6.5 |
| Turbidity (NTU) | 04-15-18 | 4.05 | 32.70 | 2.59 | 53.20 | 3.01 | 45.20 | 49.60/50.80 | 22.30 | 25.20 |
| | 04-22-18 | 4.88 | 12.50 | 24.20 | 25.20 | 3.67 | 22.80 | 6.38 | 20.40 | 20.50 |
| | 04-29-18 | 2.77 | 7.60 | 14.40 | 27.90 | 2.20 | 14.90 | 2.25 | 38.30/38.30 | 7.78 |
| | 05-06-18 | 11.30 | 4.02/3.67 | 0.63 | 23.60 | 1.87 | 5.60 | 1.21 | 11.90 | 3.18 |
| | 05-13-18 | 0.37 | 1.08 | 6.07 | 17.80 | 1.63 | 3.20 | 2.26 | 5.30 | 1.66/1.73 |
| Ammonia, Total (*mg/L*) | 04-15-18 | 0.0114 | 0.0290 | 0.0134 | 0.0163 | 0.0150 | 0.0184 | 0.0678/0.0644 | 0.0109 | 0.0199 |
| | 04-22-18 | 0.0136 | 0.0392 | 0.0190 | 0.0204 | 0.0181 | 0.0116 | 0.0124 | 0.0120 | 0.0108 |
| | 04-29-18 | 0.0093 | 0.0088 | 0.0112 | 0.0135 | 0.0099 | 0.0095 | 0.0102 | 0.0097/0.0103 | 0.0086 |
| | 05-06-18 | 0.0099 | 0.0101/0.0088 | 0.0116 | 0.0163 | 0.0130 | 0.0163 | 0.0119 | 0.0090 | 0.0115 |
| | 05-13-18 | 0.0089 | 0.0070 | 0.103 | 0.0105 | 0.0079 | <0.0050 | 0.0142 | 0.0065 | 0.0064/0.0054 |

| Parameter | Date | Camp Cr | West Cr | East Cr | Cole Cr | Fisher Rd | Hidber Rd | Dairy Farm Settling Pond | Victor Cr | Hislop Rd |
|---|---|---|---|---|---|---|---|---|---|---|
| Chloride (*mg/L*) | 04-15-18 | 9.30 | 16.40 | 27.60 | 19.70 | 20.70 | 11.80 | 14.00/12.80 | 5.33 | 1.35 |
| | 04-22-18 | 4.78 | 11.20 | 8.87 | 1.81 | 13.90 | 11.10 | 3.13 | 3.43 | 14.60 |
| | 04-29-18 | 3.50 | 6.89 | 4.68 | 1.76 | 10.60 | 4.29 | 2.67 | 1.33/1.33 | 10.6 |
| | 05-06-18 | 4.59 | 6.82/6.74 | 6.71 | 1.72 | 10.90 | 4.61 | 3.42 | 1.21 | 12.90 |
| | 05-13-18 | 5.02 | 7.14 | 8.28 | 1.59 | 10.20 | 3.75 | 3.92 | 1.45 | 13.20/13.20 |
| Nitrate and Nitrite (mg/L) | 04-15-18 | 0.079 | 0.326 | 0.0159 | 0.215 | 0.0132 | 0.424 | 1.24/1.14 | 0.511 | <0.0032 |
| | 04-22-18 | 0.0456 | 0.0518 | <0.0032 | <0.0032 | 0.01 | 0.323 | 0.0564 | 0.479 | 0.251 |
| | 04-29-18 | 0.0045 | 0.0084 | <0.0032 | <0.0032 | <0.0032 | 0.454 | <0.0032 | 0.207/0.208 | 0.0846 |
| | 05-06-18 | <0.0032 | <0.0032/<0.0032 | <0.0032 | <0.0032 | 0.0032 | 0.155 | <0.0032 | 0.065 | <0.0032 |
| | 05-13-18 | <0.0032 | <0.003 | <0.0032 | <0.0032 | <0.0032 | 0.0141 | <0.0032 | 0.0297 | <0.0032/<0.0032 |
| Nitrate (mg/L) | 04-15-18 | 0.79 | 0.323 | 0.0143 | 0.215 | 0.012 | 0.423 | 1.24/1.13 | 0.509 | <0.0030 |
| | 04-22-18 | 0.0456 | 0.0518 | <0.0030 | <0.0030 | 0.0100 | 0.322 | 0.0564 | 0.479 | 0.251 |
| | 04-29-18 | 0.0045 | 0.0084 | <0.0030 | <0.0030 | <0.0030 | 0.454 | <0.0030 | 0.207/0.208 | 0.0846 |
| | 05-06-18 | <0.0030 | <0.0030/<0.0030 | <0.0030 | <0.0030 | 0.0032 | 0.155 | <0.0030 | 0.065 | <0.0030 |
| | 05-13-18 | <0.0030 | <0.0030 | <0.0030 | <0.0030 | <0.0030 | 0.0141 | <0.0030 | 0.0297 | <0.0030/<0.0030 |
| Nitrite (mg/L) | 04-15-18 | <0.0050 | 0.0033 | 0.0016 | <0.0010 | 0.0012 | 0.0013 | 0.0070/0.0060 | 0.0018 | <0.0010 |
| | 04-22-18 | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 | 0.0014 | <0.0010 | <0.0010 | <0.0010 |
| | 04-29-18 | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010/<0.0010 | <0.0010 |
| | 05-06-18 | <0.0010 | <0.0010/<00010 | <0.0010 | 0.0015 | <0.0010 | <0.0010 | 0.0012 | <0.0010 | <0.0010 |
| | 05-13-18 | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010 | <0.0010/<0.0010 |
| Total Nitrogen (mg/L) | 04-15-18 | 0.771 | 1.07 | 1.10 | 0.740 | 0.926 | 1.67 | 2.44/2.72 | 1.28 | 1.23 |
| | 04-22-18 | 0.808 | 0.693 | 2,22 | 2.40 | 0.892 | 2.33 | 0.682 | 1.18 | 0.819 |
| | 04-29-18 | 0.735 | 0.611 | 1.08 | 1.20 | 0.801 | 1.09 | 0.595 | 0.882/0.870 | 0.676 |
| | 05-06-18 | 0.686 | 0.598/0.575 | 1.01 | 1.480 | 0.765 | 1.02 | 0.651 | 0.766 | 0.565 |
| | 05-13-18 | 0.657 | 0.562 | 0.96 | 0.720 | 0.792 | 1.05 | 0.734 | 0.634 | 0.495/0.518 |

| Parameter | Date | Camp Cr | West Cr | East Cr | Cole Cr | Fisher Rd | Hidber Rd | Dairy Farm Settling Pond | Victor Cr | Hislop Rd |
|---|---|---|---|---|---|---|---|---|---|---|
| Total Organic Nitrogen (mg/L) | 04-15-18 | 0.68 | 0.718 | 1.07 | 0.509 | 0.888 | 1.23 | 1.13/1.51 | 0.76 | 1.21 |
| | 04-22-18 | 0.748 | 0.602 | 2.2 | 2.38 | 0.864 | 1.99 | 0.613 | 0.69 | 0.558 |
| | 04-29-18 | 0.721 | 0.593 | 1.06 | 1.19 | 0.791 | 0.63 | 0.585 | 0.666/0.652 | 0.583 |
| | 05-06-18 | 0.676 | 0.588/0.567 | 1.00 | 1.47 | 0.749 | 0.85 | 0.638 | 0.691 | 0.553 |
| | 05-13-18 | 0.648 | 0.555 | 0.95 | 0.71 | 0.784 | 1.03 | 0.719 | 0.598 | 0.488/0.512 |
| Orthophosphate –Dissolved (mg/L) | 04-15-18 | 0.0184 | 0.0138 | 0.0072 | 0.058 | 0.0137 | 0.04000 | 0.320/0.303 | 0.0027 | 0.0283 |
| | 04-22-18 | 0.0078 | 0.0097 | 0.0075 | 0.0138 | 0.0079 | 0.0141 | 0.0868 | 0.0025 | 0.0039 |
| | 04-29-18 | 0.0033 | 0.0030 | 0.0061 | 0.0145 | 0.0033 | 0.0059 | 0.0874 | 0.0027/0.0025 | 0.0023 |
| | 05-06-18 | 0.0015 | 0.0024/0.0023 | 0.0046 | 0.0131 | 0.0026 | 0.0044 | 0.1180 | 0.0014 | 0.0025 |
| | 05-13-18 | 0.0028 | 0.0036 | 0.0049 | 0.0130 | 0.0033 | 0.0052 | 0.1370 | 0.0011 | 0.0034/0.0034 |
| Phosphorous – Total (mg/L) | 04-15-18 | 0.0406 | 0.0936 | 0.0500 | 0.0467 | 0.0394 | 0.162 | 0.471/0.609 | 0.0555 | 0.0869 |
| | 04-22-18 | 0.0298 | 0.0320 | 0.0676 | 0.0667 | 0.0327 | 0.0736 | 0.117 | 0.0456 | 0.0282 |
| | 04-29-18 | 0.0184 | 0.0217 | 0.0432 | 0.0639 | 0.0155 | 0.0488 | 0.113 | 0.0675/0.0667 | 0.0172 |
| | 05-06-18 | 0.0087 | 0.0141/0.0151 | 0.0312 | 0.0558 | 0.0110 | 0.022 | 0.141 | 0.0224 | 0.0105 |
| | 05-13-18 | 0.0079 | 0.140 | 0.0226 | 0.0501 | 0.0110 | 0.022 | 0.1550 | 0.0124 | 0.0087/0.0095 |
| Total Organic Carbon (mg/L) | 04-15-18 | 16.3 | 13.1 | 13.7 | 13.7 | 16.5 | 18.3 | 15.3/20.5 | 16.5 | 25.1 |
| | 04-22-18 | 20.4 | 15.3 | 28.2 | 26.9 | 16.7 | 17.7 | 12.7 | 17.7 | 15.2 |
| | 04-29-18 | 18.7 | 14.3 | 28.1 | 25.4 | 17.2 | 22.0 | 12.2 | 21.9/21.9 | 14.5 |
| | 05-06-18 | 18.5 | 14.0/14.2 | 25.5 | 24.9 | 16.8 | 23.1 | 12.1 | 20.0 | 13.7 |
| | 05-13-18 | 18.2 | 14.1 | 24.1 | 24.1 | 17.6 | 22.5 | 13 | 16.8 | 13.5/13.3 |
| E. coli (CFU/100mL) | 04-15-18 | 270 | 185 | 8 | 8 | 32 | 200 | 8/8 | 240 | 23 |
| | 04-22-18 | 8 | 39 | 42 | 2 | 10 | 54 | 5 | 12 | 5 |
| | 04-29-18 | 51 | 32 | 9 | <1 | <1 | 14 | 4 | 29/40 | 4 |
| | 05-06-18 | 1 | 14/7 | 9 | 1 | 1 | 103 | 4 | 1 | <1 |
| | 05-13-18 | 1 | 4 | 11 | <1 | <1 | 30 | 1 | 2 | <1/<1 |

*Table C-3. Escherichia coli 90th percentile and geometric concentration (CFU/mL) from five consecutive samples between April and May 2018.*

| Site | 90th percentile | Geometric Mean |
|---|---|---|
| East Creek | 29.6 | 12.45 |
| West Creek | 126.6 | 26.44 |
| Camp Creek | 182.4 | 10.20 |
| Victor Creek | 155.6 | 11.08 |
| Hislop Road | 15.8 | 2.58 |
| Cole Creek | 5.6 | 1.32 |
| Hidber Road | 161.2 | 54.19 |
| Fishers Road | 23.2 | 2.40 |
| Dairy Farm Settling Pond | 6.8 | 3.64 |

## APPENDIX D WATER QUALITY GUIDELINES

**Table 26A.** Water quality guidelines for nitrogen (N).

| Water Use | Nitrate WQG (mg/L N) | Nitrite WQG (mg/L N) | Total Ammonia WQG (mg/L N) |
|---|---|---|---|
| Freshwater Aquatic Life - Long-term Average | 3.0 | 0.02 when $Cl^- \leq 2$ - also see Table 26B | See Table 26C |
| Freshwater Aquatic Life - Short-term Maximum | 32.8 | 0.06 when $Cl^- \leq 2$ - also see Table 26B | See Table 26D |
| Marine Aquatic Life - Long-term Average | 3.7 | None proposed | See Table 26E |
| Marine Aquatic Life - Short-term Maximum | | | See Table 26F |
| Wildlife – Short-term Maximum | 100 * | 10 | |
| Livestock – Short-term Maximum | 100 * | 10 | |

- ** When nitrate and nitrite are present, total nitrate- plus nitrite-nitrogen should not exceed the nitrate WQG.*
- *Source: Water Quality Guidelines for Nitrogen (Nitrate, Nitrite, and Ammonia): Overview Report Update (2009).*

**Table 26B.** Water quality guidelines for nitrite ($NO^{2-}$).

| Chloride (mg/L $Cl^-$) | Freshwater Long-term Average $NO^{2-}$ WQG (mg/L as N) | Freshwater Short-term Maximum $NO^{2-}$ WQG (mg/L as N) |
|---|---|---|
| < 2 | 0.02 | 0.06 |
| 2 to 4 | 0.04 | 0.12 |
| 4 to 6 | 0.06 | 0.18 |
| 6 to 8 | 0.08 | 0.24 |
| 8 to 10 | 0.10 | 0.30 |
| > 10 | 0.20 | 0.60 |

- *The long-term average $Cl^-$ concentration should be used to find the appropriate long-term average $NO^{2-}$ WQG.*
- *Source: Water Quality Guidelines for Nitrogen (Nitrate, Nitrite, and Ammonia): Overview Report Update (2009).*

**Table 26C.** Long-term average water quality guidelines for ammonia nitrogen ($NH_3$ as mg/L N) to protect freshwater aquatic life.

| | Temperature (°C) | | | | | | |
|---|---|---|---|---|---|---|---|
| **pH** | **0.0** | **1.0** | **2.0** | **3.0** | **4.0** | **5.0** | **6.0** |
| 6.5 | 2.08 | 2.05 | 2.02 | 1.99 | 1.97 | 1.94 | 1.92 |
| 6.6 | 2.08 | 2.05 | 2.02 | 1.99 | 1.97 | 1.94 | 1.92 |
| 6.7 | 2.08 | 2.05 | 2.02 | 1.99 | 1.97 | 1.94 | 1.92 |
| 6.8 | 2.08 | 2.05 | 2.02 | 1.99 | 1.97 | 1.94 | 1.92 |
| 6.9 | 2.08 | 2.05 | 2.02 | 1.99 | 1.97 | 1.94 | 1.92 |
| 7.0 | 2.08 | 2.05 | 2.02 | 1.99 | 1.97 | 1.94 | 1.92 |
| 7.1 | 2.08 | 2.05 | 2.02 | 1.99 | 1.97 | 1.94 | 1.92 |
| 7.2 | 2.08 | 2.05 | 2.02 | 1.99 | 1.97 | 1.94 | 1.92 |
| 7.3 | 2.08 | 2.05 | 2.02 | 1.99 | 1.97 | 1.94 | 1.92 |
| 7.4 | 2.08 | 2.05 | 2.02 | 2.00 | 1.97 | 1.95 | 1.92 |
| 7.5 | 2.08 | 2.05 | 2.02 | 2.00 | 1.97 | 1.95 | 1.92 |
| 7.6 | 2.09 | 2.05 | 2.03 | 2.00 | 1.97 | 1.95 | 1.93 |
| 7.7 | 2.09 | 2.05 | 2.03 | 2.00 | 1.98 | 1.95 | 1.93 |
| 7.8 | 1.78 | 1.75 | 1.73 | 1.71 | 1.69 | 1.67 | 1.65 |
| 7.9 | 1.50 | 1.48 | 1.46 | 1.44 | 1.43 | 1.41 | 1.39 |
| 8.0 | 1.26 | 1.24 | 1.23 | 1.21 | 1.20 | 1.18 | 1.17 |
| 8.1 | 1.00 | 0.989 | 0.976 | 0.963 | 0.952 | 0.942 | 0.932 |
| 8.2 | 0.799 | 0.788 | 0.777 | 0.768 | 0.759 | 0.751 | 0.743 |
| 8.3 | 0.636 | 0.628 | 0.620 | 0.613 | 0.606 | 0.599 | 0.594 |
| 8.4 | 0.508 | 0.501 | 0.495 | 0.489 | 0.484 | 0.479 | 0.475 |
| 8.5 | 0.405 | 0.400 | 0.396 | 0.381 | 0.387 | 0.384 | 0.380 |
| 8.6 | 0.324 | 0.320 | 0.317 | 0.313 | 0.310 | 0.308 | 0.305 |
| 8.7 | 0.260 | 0.257 | 0.254 | 0.251 | 0.249 | 0.247 | 0.246 |
| 8.8 | 0.208 | 0.206 | 0.204 | 0.202 | 0.201 | 0.200 | 0.198 |
| 8.9 | 0.168 | 0.166 | 0.165 | 0.163 | 0.162 | 0.161 | 0.161 |
| 9.0 | 0.135 | 0.134 | 0.133 | 0.132 | 0.132 | 0.131 | 0.131 |

***Table 26C continued***

| | Temperature (°C) | | | | | | |
|---|---|---|---|---|---|---|---|
| **pH** | **7.0** | **8.0** | **9.0** | **10.0** | **11.0** | **12.0** | **13.0** |
| 6.5 | 1.90 | 1.88 | 1.86 | 1.84 | 1.82 | 1.81 | 1.80 |
| 6.6 | 1.90 | 1.88 | 1.86 | 1.84 | 1.82 | 1.81 | 1.80 |
| 6.7 | 1.90 | 1.88 | 1.86 | 1.84 | 1.83 | 1.81 | 1.80 |
| 6.8 | 1.90 | 1.88 | 1.86 | 1.84 | 1.83 | 1.81 | 1.80 |
| 6.9 | 1.90 | 1.88 | 1.86 | 1.84 | 1.83 | 1.81 | 1.80 |
| 7.0 | 1.90 | 1.88 | 1.86 | 1.84 | 1.83 | 1.81 | 1.80 |
| 7.1 | 1.90 | 1.88 | 1.86 | 1.84 | 1.83 | 1.81 | 1.80 |
| 7.2 | 1.90 | 1.88 | 1.86 | 1.85 | 1.83 | 1.81 | 1.80 |
| 7.3 | 1.90 | 1.88 | 1.86 | 1.85 | 1.83 | 1.82 | 1.80 |
| 7.4 | 1.90 | 1.88 | 1.87 | 1.85 | 1.83 | 1.82 | 1.80 |
| 7.5 | 1.91 | 1.88 | 1.87 | 1.85 | 1.83 | 1.82 | 1.81 |
| 7.6 | 1.91 | 1.89 | 1.87 | 1.85 | 1.84 | 1.82 | 1.81 |
| 7.7 | 1.91 | 1.89 | 1.87 | 1.86 | 1.84 | 1.83 | 1.81 |
| 7.8 | 1.63 | 1.62 | 1.60 | 1.59 | 1.57 | 1.56 | 1.55 |
| 7.9 | 1.38 | 1.36 | 1.35 | 1.34 | 1.33 | 1.32 | 1.31 |
| 8.0 | 1.16 | 1.15 | 1.14 | 1.13 | 1.12 | 1.11 | 1.10 |
| 8.1 | 0.922 | 0.914 | 0.906 | 0.899 | 0.893 | 0.887 | 0.882 |
| 8.2 | 0.736 | 0.730 | 0.724 | 0.718 | 0.714 | 0.709 | 0.706 |
| 8.3 | 0.588 | 0.583 | 0.579 | 0.575 | 0.571 | 0.568 | 0.566 |
| 8.4 | 0.471 | 0.467 | 0.464 | 0.461 | 0.458 | 0.456 | 0.455 |
| 8.5 | 0.377 | 0.375 | 0.372 | 0.370 | 0.369 | 0.367 | 0.366 |
| 8.6 | 0.303 | 0.301 | 0.300 | 0.298 | 0.297 | 0.297 | 0.296 |
| 8.7 | 0.244 | 0.243 | 0.242 | 0.241 | 0.241 | 0.240 | 0.240 |
| 8.8 | 0.197 | 0.197 | 0.196 | 0.196 | 0.196 | 0.196 | 0.196 |
| 8.9 | 0.160 | 0.160 | 0.160 | 0.160 | 0.160 | 0.161 | 0.161 |
| 9.0 | 0.131 | 0.131 | 0.131 | 0.131 | 0.132 | 0.132 | 0.133 |

- *The average of the 5 measured $NH_3$ values must be less than the average of the 5 corresponding tabled $NH_3$ values (WQGs) obtained by finding the measured pH and temperature values in the table.*
- *No more than 1 of 5 of the measured values can exceed 1.5 times the corresponding WQG.*
- *Source: Water Quality Guidelines for Nitrogen (Nitrate, Nitrite, and Ammonia): Overview Report Update (2009).*

**Table 26D.** Short-term maximum water quality guidelines for ammonia nitrogen ($NH_3$ as mg/L N) to protect freshwater aquatic life.

| | Temperature (°C) | | | | | | |
|---|---|---|---|---|---|---|---|
| **pH** | **0.0** | **1.0** | **2.0** | **3.0** | **4.0** | **5.0** | **6.0** |
| 6.5 | 28.7 | 28.3 | 27.9 | 27.5 | 27.2 | 26.8 | 26.5 |
| 6.6 | 27.9 | 27.5 | 27.2 | 26.8 | 26.4 | 26.1 | 25.8 |
| 6.7 | 26.9 | 26.5 | 26.2 | 25.9 | 25.5 | 25.2 | 24.9 |
| 6.8 | 25.8 | 25.5 | 25.1 | 24.8 | 24.5 | 24.2 | 23.9 |
| 6.9 | 24.6 | 24.2 | 23.9 | 23.6 | 23.3 | 23.0 | 22.7 |
| 7.0 | 23.2 | 22.8 | 22.5 | 22.2 | 21.9 | 21.6 | 21.4 |
| 7.1 | 21.6 | 21.3 | 20.9 | 20.7 | 20.4 | 20.2 | 19.9 |
| 7.2 | 19.9 | 19.6 | 19.3 | 19.0 | 18.8 | 18.6 | 18.3 |
| 7.3 | 18.1 | 17.8 | 17.5 | 17.3 | 17.1 | 16.9 | 16.7 |
| 7.4 | 16.2 | 16.0 | 15.7 | 15.5 | 15.3 | 15.2 | 15.0 |
| 7.5 | 14.4 | 14.1 | 14.0 | 13.8 | 13.6 | 13.4 | 13.3 |
| 7.6 | 12.6 | 12.4 | 12.0 | 11.9 | 11.9 | 11.7 | 11.6 |
| 7.7 | 10.8 | 10.7 | 10.5 | 10.4 | 10.3 | 10.1 | 10.0 |
| 7.8 | 9.26 | 9.12 | 8.98 | 8.88 | 8.77 | 8.67 | 8.57 |
| 7.9 | 7.82 | 7.71 | 7.60 | 7.51 | 7.42 | 7.33 | 7.25 |
| 8.0 | 6.55 | 6.46 | 6.37 | 6.29 | 6.22 | 6.14 | 6.08 |
| 8.1 | 5.21 | 5.14 | 5.07 | 5.01 | 4.95 | 4.90 | 4.84 |
| 8.2 | 4.15 | 4.09 | 4.04 | 3.99 | 3.95 | 3.90 | 3.86 |
| 8.3 | 3.31 | 3.27 | 3.22 | 3.19 | 3.15 | 3.12 | 3.09 |
| 8.4 | 2.64 | 2.61 | 2.57 | 2.54 | 2.52 | 2.49 | 2.47 |
| 8.5 | 2.11 | 2.08 | 2.06 | 2.03 | 2.01 | 1.99 | 1.98 |
| 8.6 | 1.69 | 1.67 | 1.65 | 1.63 | 1.61 | 1.60 | 1.59 |
| 8.7 | 1.35 | 1.33 | 1.32 | 1.31 | 1.30 | 1.29 | 1.28 |
| 8.8 | 1.08 | 1.07 | 1.06 | 1.05 | 1.04 | 1.04 | 1.03 |
| 8.9 | 0.871 | 0.863 | 0.856 | 0.849 | 0.844 | 0.839 | 0.836 |
| 9.0 | 0.703 | 0.697 | 0.692 | 0.688 | 0.685 | 0.682 | 0.681 |

***Table 26D continued***

| | Temperature (°C) | | | | | | |
|---|---|---|---|---|---|---|---|
| **pH** | **7.0** | **8.0** | **9.0** | **10.0** | **11.0** | **12.0** | **13.0** |
| 6.5 | 26.2 | 26.0 | 25.7 | 25.5 | 25.2 | 25.0 | 24.8 |
| 6.6 | 25.5 | 25.2 | 25.0 | 24.7 | 24.5 | 24.3 | 24.1 |
| 6.7 | 24.6 | 24.4 | 24.1 | 23.9 | 23.7 | 23.5 | 23.3 |
| 6.8 | 23.6 | 23.4 | 23.1 | 22.9 | 22.7 | 22.5 | 22.3 |
| 6.9 | 22.5 | 22.2 | 22.0 | 21.8 | 21.6 | 21.4 | 21.3 |
| 7.0 | 21.1 | 20.9 | 20.7 | 20.5 | 20.3 | 20.2 | 20.0 |
| 7.1 | 19.7 | 19.5 | 19.3 | 19.1 | 18.9 | 18.8 | 18.7 |
| 7.2 | 18.1 | 17.9 | 17.8 | 17.6 | 17.4 | 17.3 | 17.2 |
| 7.3 | 16.5 | 16.3 | 16.2 | 16.0 | 15.9 | 15.7 | 15.6 |
| 7.4 | 14.8 | 14.7 | 14.5 | 14.4 | 14.2 | 14.1 | 14.0 |
| 7.5 | 13.1 | 13.0 | 12.9 | 12.7 | 12.6 | 12.5 | 12.4 |
| 7.6 | 11.5 | 11.4 | 11.3 | 11.2 | 11.1 | 11.0 | 10.9 |
| 7.7 | 9.92 | 9.83 | 9.73 | 9.65 | 9.57 | 9.50 | 9.43 |
| 7.8 | 8.48 | 8.40 | 8.32 | 8.25 | 8.18 | 8.12 | 8.07 |
| 7.9 | 7.17 | 7.10 | 7.04 | 6.98 | 6.92 | 6.88 | 6.83 |
| 8.0 | 6.02 | 5.96 | 5.91 | 5.86 | 5.81 | 5.78 | 5.74 |
| 8.1 | 4.80 | 4.75 | 4.71 | 4.67 | 4.64 | 4.61 | 4.59 |
| 8.2 | 3.83 | 3.80 | 3.76 | 3.74 | 3.71 | 3.69 | 3.67 |
| 8.3 | 3.06 | 3.03 | 3.01 | 2.99 | 2.97 | 2.96 | 2.94 |
| 8.4 | 2.45 | 2.43 | 2.41 | 2.40 | 2.38 | 2.37 | 2.36 |
| 8.5 | 1.96 | 1.95 | 1.94 | 1.93 | 1.92 | 1.91 | 1.91 |
| 8.6 | 1.58 | 1.57 | 1.56 | 1.55 | 1.55 | 1.54 | 1.54 |
| 8.7 | 1.27 | 1.26 | 1.26 | 1.25 | 1.25 | 1.25 | 1.25 |
| 8.8 | 1.03 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 |
| 8.9 | 0.833 | 0.832 | 0.831 | 0.831 | 0.832 | 0.834 | 0.838 |
| 9.0 | 0.681 | 0.681 | 0.681 | 0.682 | 0.684 | 0.688 | 0.692 |

***Table 26D continued***

| | Temperature (°C) | | | | | | |
|---|---|---|---|---|---|---|---|
| **pH** | **14.0** | **15.0** | **16.0** | **17.0** | **18.0** | **19.0** | **20.0** |
| 6.5 | 24.6 | 24.5 | 24.3 | 24.2 | 24.0 | 23.9 | 23.8 |
| 6.6 | 23.9 | 23.8 | 23.6 | 23.5 | 23.3 | 23.3 | 23.2 |
| 6.7 | 23.1 | 23.0 | 22.8 | 22.7 | 22.6 | 22.5 | 22.4 |
| 6.8 | 22.2 | 22.0 | 21.9 | 21.8 | 21.7 | 21.6 | 21.5 |
| 6.9 | 21.1 | 21.0 | 20.8 | 20.7 | 20.6 | 20.5 | 20.4 |
| 7.0 | 19.9 | 19.7 | 19.6 | 19.5 | 19.4 | 19.3 | 19.2 |
| 7.1 | 18.5 | 18.4 | 18.3 | 18.2 | 18.1 | 18.0 | 17.9 |
| 7.2 | 17.1 | 16.9 | 16.8 | 16.8 | 16.7 | 16.6 | 16.5 |
| 7.3 | 15.5 | 15.4 | 15.3 | 15.2 | 15.2 | 15.1 | 15.1 |
| 7.4 | 13.9 | 13.9 | 13.8 | 13.7 | 13.6 | 13.6 | 13.5 |
| 7.5 | 12.4 | 12.3 | 12.2 | 12.2 | 12.1 | 12.1 | 12.0 |
| 7.6 | 10.8 | 10.8 | 10.7 | 10.7 | 10.6 | 10.6 | 10.5 |
| 7.7 | 9.37 | 9.31 | 9.26 | 9.22 | 9.18 | 9.15 | 9.12 |
| 7.8 | 8.02 | 7.97 | 7.93 | 7.90 | 7.87 | 7.84 | 7.82 |
| 7.9 | 6.79 | 6.75 | 6.72 | 6.69 | 6.67 | 6.65 | 6.64 |
| 8.0 | 5.71 | 5.68 | 5.66 | 5.62 | 5.61 | 5.60 | 5.74 |
| 8.1 | 4.56 | 4.54 | 4.53 | 4.51 | 4.50 | 4.49 | 4.49 |
| 8.2 | 3.65 | 3.64 | 3.63 | 3.62 | 3.61 | 3.61 | 3.61 |
| 8.3 | 2.93 | 2.92 | 2.92 | 2.91 | 2.91 | 2.91 | 2.91 |
| 8.4 | 2.36 | 2.35 | 2.35 | 2.35 | 2.35 | 2.35 | 2.36 |
| 8.5 | 1.90 | 1.90 | 1.90 | 1.90 | 1.90 | 1.91 | 1.92 |
| 8.6 | 1.54 | 1.54 | 1.54 | 1.55 | 1.56 | 1.56 | 1.57 |
| 8.7 | 1.25 | 1.25 | 1.26 | 1.26 | 1.27 | 1.28 | 1.29 |
| 8.8 | 1.02 | 1.03 | 1.03 | 1.04 | 1.05 | 1.06 | 1.07 |
| 8.9 | 0.842 | 0.847 | 0.853 | 0.861 | 0.870 | 0.880 | 0.891 |
| 9.0 | 0.698 | 0.704 | 0.711 | 0.720 | 0.729 | 0.740 | 0.752 |

- *Source: Water Quality Guidelines for Nitrogen (Nitrate, Nitrite, and Ammonia): Overview Report Update (2009).*