Windermere Creek
Water Quality Monitoring Report
2015 – 2017

Prepared by:
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Prepared for:
The Columbia Basin Water Quality Monitoring Project

July 2018

Suggested Citation

McPherson, S.[1,], K. Baranowska[1], T. Rodgers[2], and L. Duncan[3]. 2018. Windermere Creek water quality monitoring report 2015 to 2017. A Columbia Basin Water Quality Monitoring Project. Prepared by Lotic Environmental Ltd[1], the Lake Windermere Ambassadors[2], and Mainstreams Environmental Society[3]. Prepared for the Columbia Basin Water Quality Monitoring Project.

Acknowledgements

We are very thankful to the following individuals and organizations for their specific support to the Windermere Creek monitoring project, conducted under the Columbia Basin Water Quality Monitoring Project (CBWQ):

- Thea Rodgers, Megan Peloso, Katie Watt, Ella Swan, and Raegan Mallinson for assisting with the field collection;
- CBWQ coordinators Jim and Laura Duncan for their valuable support;
- The Nature Trust of British Columbia for providing access to the monitoring site; and,
- Danielle Marcotte of MacDonald Hydrology Consultants Ltd. for mapping services.

We also acknowledge the following for their support to the CBWQ as a whole:

- Columbia Basin Trust (CBT) for funding the project;
- Kindy Gosal, Heather Mitchell, and Tim Hicks from CBT;
- Karen Nickurak from Columbia Basin Watershed Network;
- Stephanie Strachan, Gail Moyle, and Tim Pascoe from Environment and Climate Change Canada;
- Hans Schreier and Ken Hall, Professors Emeriti, University of British Columbia; and
- Jody Fisher and Jolene Raggett from the BC Ministry of Environment and Climate Change Strategy.

Lastly, we wish to recognize Sherri McPherson, Kathryn Kuchapski, Ryan MacDonald, and Guy Duke for preparing the initial CBWQ report template in 2013.

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Cover photo

Upstream view of Windermere Creek Site NAWIN03, September 26, 2017

Project Highlights

The Columbia Basin Water Quality Monitoring Project (CBWQ) is an environmental stewardship project funded by Columbia Basin Trust. Under the CBWQ, Wildsight Regional and the Lake Windermere Ambassadors conducted baseline water quality monitoring in Windermere Creek from 2009 to 2017. Windermere Creek was identified to be a priority for monitoring because of its fish and wildlife habitat values, its significant influence on Lake Windermere, and because of concerns with anthropogenic influences (gypsum mine, agriculture, residential development). This report summarizes monitoring conducted from 2015 to 2017 at NAWIN03. The monitoring site is located at the downstream end of Windermere Creek, near its confluence with Lake Windermere. Four components were monitored: benthic macro-invertebrate community using Canadian Aquatic Biomonitoring Network (CABIN), water quality, water temperature, and hydrologic characteristics (i.e., velocity and flow).

CABIN modelling determined NAWIN03 to be potentially stressed in 2015 and severely stressed in 2016 and 2017. Total abundance was the metric that reflected these community health condition ratings. Total abundance values was highest in 2015, but then dropped in subsequent years. The 2015 results indicated that the benthic macro-invertebrate community initially recovered from the 2011 flood event documented in McPherson et al. (2014), but then was negatively influenced again in 2016 and 2017. It was uncertain what caused the change in abundance. There were no notable changes evident through the physical habitat, water chemistry, stream temperature, or streamflow results.

The water quality was good at NAWIN03, with most guidelines for the protection of aquatic life met. Aquatic life guideline exceedances occurred for pH, total phosphorus, and dissolved oxygen. These were not likely to impact aquatic life, as they only occurred incidentally. Two drinking water guidelines were also not met, total iron *and E. coli*. The total iron drinking water guideline was set for aesthetic objectives, with no concerns for human health. *E. coli* could be influenced by domestic livestock, wildlife, or potentially septic systems. Since the *E. coli* guideline was exceeded in all samples, it is recommended that water be disinfected prior to consumption.

Continuous water temperature data collected in 2015 and 2017 were reviewed against guidelines for the protection of Bull Trout. In July 2015, the guideline for protection of rearing Bull Trout was exceeded periodically. Summer stream temperatures were cooler in 2017, with no guideline exceedances. In both 2015 and 2017, maximum daily stream temperatures in Windermere Creek during the spawning season periodically exceeded the optimal spawning temperature guideline (i.e., a maximum daily temperature of 10 ºC). Based on the limited 2015 winter stream temperature data, the guideline for minimum temperature during incubation of 2 ºC was also generally not met in late November. This study did not review whether the monitoring site was actually used by Bull Trout for spawning. Based on the temperature data, Bull Trout likely seek out more favourable habitat than what was available at NAWIN03.

Streamflow data, although limited, appeared to follow a typical nival pattern, with higher flows in the spring during freshet, and decreasing flows throughout the summer and fall to a baseflow into the winter months.

The NAWIN03 results augmented the historical dataset, which included monitoring at three other sites in the Windermere Creek watershed: NAWIN01 (2009-2014), NAWIN02 (2009-2010), NAWIN03 (2009-2017), and NAWIN04 (2011-2014) (McPherson et al. 2014). Overall, the nine-year baseline monitoring program provides an understanding of stream conditions given the land-uses at the time. This information will be valuable to help assess changes over time.

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1 Introduction

Community-based water quality monitoring in the Columbia River Basin plays an important role in gathering baseline information to understand watershed function and potential influences of concern. This information can help inform management decisions, to ensure that aquatic ecosystems are preserved, which in turn will contribute to maintaining sustainable communities. It is imperative that current and future water quality and quantity concerns be assessed in the Columbia River Basin as environmental change poses substantial risk to ecosystem and societal health. Changes in land use and climate change have the potential to substantially alter water quality and quantity in the Columbia River Basin (Carver 2017). Current and future reductions in snow accumulation (Barnett et al. 2008) and glacial ice (Jost et al. 2012) have been shown to result in reduced water supply in the Columbia Basin, particularly for the low flow summer periods (Burger et al. 2011). Lower streamflow leads to a reduced ability for streams to dilute pollution, potentially resulting in substantial water quality issues. In addition to climate change, the diverse land uses of the Columbia River Basin, including: recreational and industrial development, stream flow regulation, municipal and industrial waste water, and non-point source pollution present a challenge for community-based water quality management.

A first step in addressing present and future water quality and quantity issues is developing community awareness and involvement. The Columbia Basin Water Quality Monitoring Project (CBWQ) had its beginnings at a 2005 Watershed Stewardship Symposium sponsored by the Columbia Basin Trust (CBT), where the Columbia Basin Watershed Network was born. A key resolution from that meeting was for CBT to build capacity for watershed groups to monitor water quality in their watersheds. Consequently, on a sunny weekend in June 2006 reps from watershed groups from across the Columbia Basin met in Kimberley to attend a monitoring workshop with Dr. Hans Schreier and Dr. Ken Hall from UBC. At the end of the workshop Mainstreams agreed to coordinate the Columbia Basin Water Quality Monitoring Project and four groups began water quality monitoring in September 2007 with the following goals:

1. Develop a science-based model for community-based water quality monitoring;
2. Establish online accessibility to water quality data; and,
3. Link the monitoring project with community awareness activities.

All told, twelve watershed stewardship groups have participated in the project. Data collected by these groups can be found at the CBWQ website www.cbwq.ca.

In order to meet these goals, monitoring has been conducted in Windermere Creek from 2009 to 2017. Monitoring was conducted by two groups during this period. Initially, Wildsight Regional was the lead organization responsible for data collection on Windermere Creek (the Lake Windermere Ambassadors assisted with field data collection). In early 2017, the Lake Windermere Ambassadors took over the monitoring of Windermere Creek for the remainder of the CBWQ project. Four components were monitored: benthic macro-invertebrate community using Canadian Aquatic Biomonitoring Network (CABIN) methods, water quality, water temperature, and hydrologic characteristics (i.e., velocity and flow). This report presents data from 2015-2017, analyses the results, relates biological results to physical monitoring findings, and provides recommendations for future stream health monitoring.

Ongoing funding from the CBT has been and continues to be key to keeping this unique project, guided and administered by community watershed groups, operating until June 2018.

1.1 Windermere Creek background

Windermere Creek originates in the Rocky Mountains, and flows into Lake Windermere, east of the town of Windermere (Figure 1). Windermere Creek is a fourth-order tributary that drains an area of approximately 90 km^2 (Northwest Hydraulic Consultants [NHC] 2013). The headwaters are located near Pedley Pass at approximately 2260 meters above sea level (masl); from there, the system flows west to its confluence with Lake Windermere at approximately 800 masl (Phillips, 2002).

Windermere Creek is the largest tributary flowing into Lake Windermere (besides the Columbia River itself), and as such it has the potential to influence the water quality of the lake. Lake Windermere is used for drinking water, recreation, and provides valuable fish & wildlife habitat. Developments in the Windermere Creek watershed include a gypsum mine, agricultural activities, a golf course, residential development, and historical forest harvesting. Monitoring in 2005 to 2017 was completed at Site NAWIN03, which is located near the outlet of Windermere Creek (Figure 2). Monitoring was completed to help identify if upstream developments may be influencing water quality in the creek.

In addition to monitoring at NAWIN03 in 2015-2017, monitoring was also historically conducted at three other sites higher in the Windermere Creek watershed. The results of monitoring at NAWIN01 (2009-2014), NAWIN02 (2009-2010), NAWIN03 (2009-2017), and NAWIN04 (2011-2014) are provided in McPherson et al. (2014). Past monitoring documented that a significant flooding and erosion event occurred in 2011 just upstream of site NAWIN03, which caused high sediment loading and severely impacted the benthic invertebrate community (McPherson et al. 2014). The intent of this study was thus also to identify if the benthic invertebrate community has recovered since the 2011 event.

Potential future impacts to this creek include any future forest fires, logging or other developments that may occur in the watershed. The gypsum mine closure is also planned, as it will be moving from the Windermere Creek drainage to a new location in Canal Flats in the next few years. Other potential future impacts relate to climate change, which may result in altered hydrologic regimes for the region (Carver 2017)

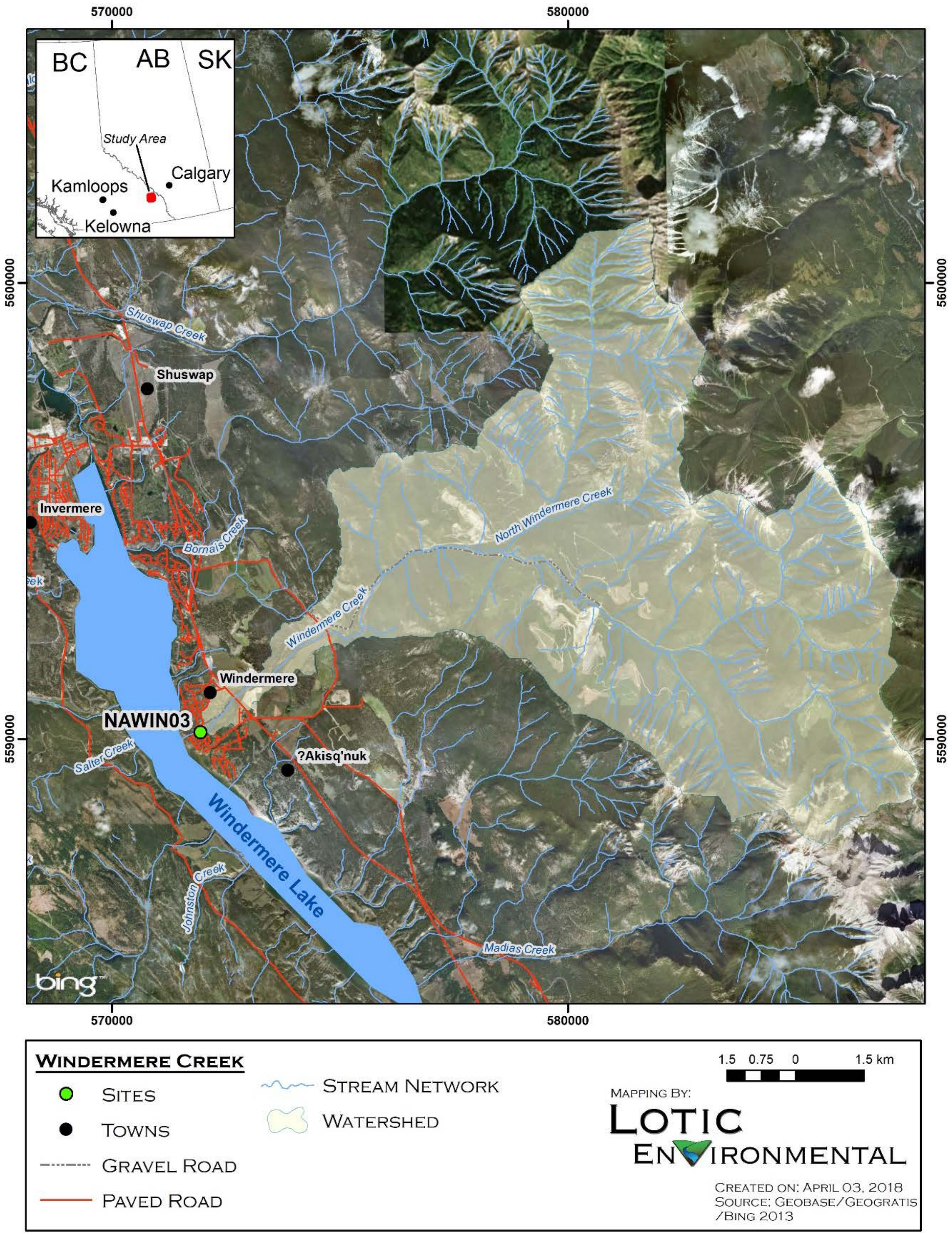

Figure 1. Windermere Creek watershed and monitoring location.

Figure 2. Upstream and downstream views from NAWIN03, respectively, Sept. 26, 2017.

1.2 Fish community

The fish community in Windermere Creek is comprised of six native and four non-native species (Table 1; BC Ministry of Environment [BC MoE] 2018a and BC Resource Inventory Committee [BC RIC] 1994). Three of these fish species are of conservation concern. Bull Trout (interior lineage*)* and Westslope Cutthroat Trout are recognized as a species of Special Concern in BC and by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC; BC Conservation Data Center [BC CDC] 2018). Westslope Cutthroat Trout are listed as a species of Special Concern throughout their range in British Columbia under the federal Species at Risk Act (BC CDC 2018). Burbot is a species of regional concern, and was last observed in July 1998, at the mouth of Windermere Creek (BC MoE 2018a). In Lake Windermere Burbot are historically known to spawn in creek mouth weed beds, other areas with macrophytes, and at the outlet (Westslope Fisheries 2001).

Table 1. Fish species in Windermere Creek. Source: *BC MoE 2018a,* and BC RIC 1994.

Species - common name	scientific name
Native species	
Bull Trout	*Salvelinus confluentus*
Burbot	*Lota lota*
Westslope Cutthroat Trout	*Oncorhynchus clarkii lewisi*
Rainbow Trout	*O. mykiss*
Mountain Whitefish	*Prosopium williamsoni*
Slimy Sculpin	*Cottus cognatus*
Non – native (introduced) species	
Kokanee	O. *nerka*
Eastern brook trout	*Salvelinus. fontinalis*
*Mottled Sculpin	*C. bairdii*
*Spoonhead Sculpin	*C. ricei*

*The Mottled and Spoonhead sculpins were observed in 1997 and may have been misidentified.

While the mainstem stream length is approximately 21 km (BC MoE 2018a), most species are found in the downstream most 2.5 km. This is presumed to be caused by barriers inhibiting upstream migration, including a culvert beneath Windermere Loop Road and a large concrete dam situated on a natural rock falls which poses a permanent barrier to fish migration (BC MoE 2018a; Phillips 2002). Downstream of the barriers, Windermere Creek provides important spawning habitat (NHC 2013). Only Westslope Cutthroat Trout, are found in the upper parts of the watercourse (BC MoE 2018a).

Fishing is a major tourist draw to the area, thus ensuring the water conditions are suitable for the high-value sport fish species is of interest to the stewardship group.

2 Methods

2.1 Data collection, data entry, and initial data presentation, completed by the CBWQ stewardship group

Overall, data were collected following the CBWQ Operating Procedures (CBWQ 2012) and the CABIN Field Procedures for Wadeable Streams (Environment Canada 2012a). Wildsight and the Lake Windermere Ambassadors completed all the field work, downloaded data into standard spreadsheets, and as applicable, conducted initial analyses (i.e., summary graphs, CABIN site reports).

Benthic macro-invertebrates

CABIN sampling was conducted once a year in the fall. Benthic macro-invertebrate samples were analysed by Pina Viola Taxonomy following CABIN laboratory methods (Environment Canada 2012b). The data were entered into the online CABIN database, and site reports were prepared using the CABIN analysis tools.

Water quality

Water quality laboratory analysis was completed by Maxxam (Burnaby, BC). The following water quality data were collected at NAWIN03:

a. Monthly (spring through fall) - total suspended solids (TSS), nutrients, *Escherichia coli* (*E. coli*), and in situ (field measured) data. In situ data were dissolved oxygen (DO), water temperature, specific conductivity, pH, turbidity, and air temperature.
b. Annually (in summer and fall) - in addition to data above, inorganics and metals.
c. Once in 2016 - a duplicate and a blank sample.

The transpose add-in tool created by Devin Cairns (Blue Geosimulation) was used to automate the addition of new water quality data from Maxxam into the existing CBWQ datasets. The tool allowed users to open MS Excel files from Maxxam and chose which MS Excel file to append the new data into. The add-in matched parameter names between files and converted units (e.g., between µm and mg), flagging the data cells that were successfully transferred.

Stream temperature

Hourly average stream temperature (°C) was measured using a HOBO Pro V2 temperature logger. Data were downloaded, summarized in a spreadsheet, with descriptive statistics (daily maximum, minimum, and average) calculated and graphed.

Hydrometric data

Streamflow and velocity data were collected monthly from April to October, with the spring high flow period excluded, due to safety concerns. Velocity is the speed of water and is measured as a unit of distance per time (m/s). Streamflow, also known as discharge, is a measure of the volume of water moving through a stream channel in a given amount of time (m^3/s). Streamflow and velocity were measured using the Head Rod method. Measurements were collected at regular length intervals across the stream using a meter stick. At each interval, the Flowing Water Depth (cm) was measured on the thinner, upstream edge of the meter stick. The meter stick was turned 180 degrees and the 'head' built up on the broader, upstream side of the meter stick was also measured (Depth of Stagnation [cm]). The difference between the Flowing Water Depth and the Depth of Stagnation was inserted into Equation 1, to calculate Velocity

Equation 1. Water Velocity (V)

$$V = \sqrt{[2(\Delta D/100)*9.81]}$$

where ΔD was the average difference between the flowing water depth and the depth of stagnation

Flow was calculated using Equation 2, where the Average Stream Width and Average Depth was determined in the Stream Profile, and the Average Velocity was calculated above.

Equation 2: Stream flow (Q)

Q = Wetted Stream Width (m) x Average Depth (m) x Average Velocity (m/s).

2.2 Analysis overview

Following the data collection and preparation described above completed by the CBWQ, Lotic Environmental Ltd. completed analyses and reporting. This included completing a quality assurance/quality control review (QA/QC) of data, comparing results to applicable guidelines, interpreting results, and providing recommendations.

The Reference Condition Approach (RCA) in CABIN was used to determine the condition of the benthic macro-invertebrate community at the test site (as sampled by the CBWQ group), by comparing the test site results to a group of reference sites with similar environmental characteristics. The Analytical Tools function in the CABIN database was used to run four analyses to review invertebrate test site data (Steps 1a – 1d in Figure 3): BEnthic Assessment of SedimenT (BEAST), River Invertebrate Prediction and Classification System (RIVPACS), community composition metrics, and habitat metrics. Water quality (Step 2), stream temperature (Step 3) and hydrometric (Step 4) analyses followed to provide an overall understanding of stream condition.

The reference model used in the RCA analysis was the Preliminary Okanagan-Columbia Reference Model (2010) provided in the online CABIN database. Because the model was still considered preliminary, with some potential data gaps, caution was exercised when interpreting RCA results (obtained from Steps 1a to 1d). Furthermore, it was important that all subsequent analyses (Steps 2 – 4) were conducted.

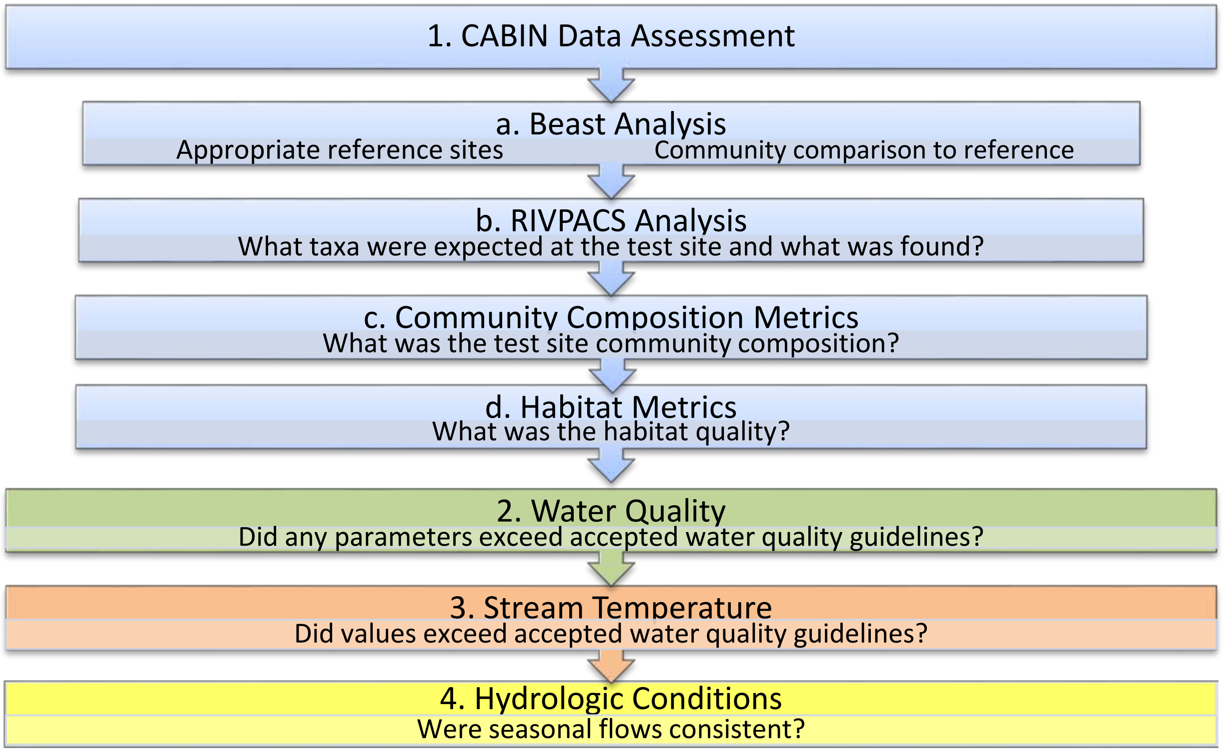

Figure 3. Stream condition analysis steps.

2.3 CABIN data analysis

2.3.1 Reference Condition Approach: BEAST analysis and site assessment

BEAST analysis was used to predict test sites to a reference group from the preliminary Okanagan-Columbia reference model provided by Environment Canada through the CABIN database. BEAST used a classification analysis that determined the probability of test site membership to a reference group based on habitat variables (Rosenberg *et al.* 1999). Habitat variables used to predict group membership in the Okanagan-Columbia reference model were latitude, longitude, percent area of watershed with a gradient <30%, percent area of watershed with permanent ice cover and average channel depth.

CABIN model hybrid multi-dimensional scaling ordination assessment was then used to evaluate benthic community stress based on divergence from reference condition. This analysis placed test sites into assessment bands corresponding to a stress level ranging from unstressed to severely stressed. In the ordination assessment, sites that were unstressed fell within the 90% confidence ellipse around the cloud of reference sites, which means that their communities were similar or equivalent to reference (Rosenberg *et al.* 1999). Potentially stressed, stressed and severely stressed sites indicate mild divergence, divergence, or high divergence of the benthic community from reference condition (Rosenberg *et al.* 1999).

2.3.2 RIVPACS analysis

RIVPACS ratios were calculated in the Analytical tools section of the CABIN database. RIVPACS analysis relied on presence/absence data for individual taxa. The RIVPACS ratio determined the ratio of observed taxa at test sites to taxa expected to be present at the test site based on their presence at reference sites. A RIVPACS ratio close to 1.00 indicated that a site was in good condition, as all taxa expected to be present were found at the test site. A RIVPACS ratio >1.00 could indicate community enrichment, while a ratio <1.00 could indicate that the benthic community was in poor condition.

2.3.3 Community composition metrics

Benthic community composition metrics were calculated in the CABIN database using the Metrics section of the Analytical Tools menu. A collection of relevant measures of community richness, abundance, diversity and composition were selected to describe the test site communities. Using metrics, indicator attributes were used to interpret the response to environmental disturbances. Metrics are complimentary to an RCA analysis.

2.4 Water quality data analysis

2.4.1 Water quality QA/QC

Raw data were first subjected to a quality control evaluation to assess the accuracy and precision of the laboratory and field methods. For all water samples analysed, the laboratory assessed accuracy through the use of matrix spike, spiked blank, and method blank samples. As well, the laboratory measured precision through duplicate sample analysis. As per standard practice, all laboratory quality control results were reviewed and confirmed to meet standard criteria prior to proceeding with processing of field samples (Maxxam 2012).

Field duplicates were submitted to the laboratory to measure both field sampling error plus local environmental variance. Duplicate review was based on relative percent difference (RPD) as determined by Equation 3. For duplicate values at or greater than five times the Reportable Detection Limit (RDL), RPD values >50% indicated a problem, most likely either contamination or lack of sample representativeness (BC MoE 2003). Where RPD values were greater than 50%, the source of the problem was determined, and the impact upon the sample data ascertained (BC MoE 2003). If data were found to be within acceptable ranges, subsequent analyses included only the first of the duplicate samples.

Equation 3: Duplicate sample quality control

Relative Percent Difference = (Absolute difference of duplicate 1 and 2/average of duplicate 1 and 2)*100

$$\text{RPD}= \left(\frac{\text{Duplicate 1} - \text{Duplicate 2}}{(\text{Duplicate 1}+\text{Duplicate 2})/2} \right) \text{X } 100$$

Field blank data were collected to monitor possible contamination prior to receipt at the laboratory. Field blanks were collected using laboratory issued de-ionized water. Field blank results were analysed using Equation 4. Field blank values that were 2 times greater than the reportable detection limit were considered levels of alert (Maxxam 2012, Horvath pers. comm.). Field blank values that exceeded the alert level were reviewed in more detail to identify the potential source(s) for contamination; additionally, other data collected on that day were compared to historical data to identify if there were anomalies possibly related to contamination.

Equation 4: Field Blank sample quality control

$$\text{Blank x difference} = \frac{\text{Field Blank Value}}{\text{Reportable Detection Limit (RDL)}}$$

2.4.2 Guideline review

A guideline is a maximum and/or a minimum value for a characteristic of water, which in order to prevent specified detrimental effects from occurring, should not be exceeded (BC MoE 2018). Water quality results were compared to the applicable provincial and federal guidelines for the protection of aquatic life and drinking water. Exceedances of guidelines were flagged to provide an understanding of the potential impacts to aquatic life or drinking water.

When there was more than one guideline for a parameter, the following hierarchy was applied to determine the guideline that would apply (BC MoE 2016):

a. BC Approved Water Quality Guidelines (BC MoE 2018b)
b. BC Working Water Quality Guidelines (BC MoE 2017)
c. The Canadian Environmental Quality Guidelines (Canadian Council of Ministers of the Environment [CCME] 2017), or Health Canada (2017).

When both long-term and short-term exposure guidelines were available, the long-term guideline was reviewed, since sampling was assumed to have occurred under ‘normal’ conditions.

2.5 Stream temperature analysis

The stream temperature data were reviewed against the BC stream temperature guidelines for the protection of aquatic life and drinking water that were most applicable to the monitored site. The aquatic life guidelines are dependent on the fish species (mostly salmonids) found in the stream for different life stages (rearing, spawning, and incubation) (BC MoE 2018b). Monthly stream temperature averages were also calculated and compared qualitatively among the years.

2.6 Hydrometric data analysis

Hydrometric data were reviewed for consistency and anomalies. Streamflow results were graphed, with seasonal patterns compared qualitatively amongst the years.

3 Results

3.1 CABIN results

3.1.1 Reference Condition Approach: BEAST analysis and site assessment

At NAWIN03 in all years, CABIN BEAST analysis determined the highest probability of reference group membership was to Group 3 (probabilities found in Table 2). The site was thus compared with Reference Group 3, which includes 17 streams, mostly from the Northern Continental Divide Ecoregion. The average channel depth of Reference Group 3 is 22.5 ± 10 cm, which is near the test site’s average depth, which ranged from 21.1 - 26.7 cm amongst the 3 years sampled. A comparison of other individual test site habitat attributes with those of the reference model, and the ordination plots are included in the Site Assessment Reports (Appendix A). The CABIN model assessed NAWIN03 as potentially stressed in 2015 and severely stressed in 2016 and 2017. Below, we explored the CABIN outputs more, to try gain a better understanding of why the site was given this assessment.

Although Reference Group 3 had the highest probabilities of being the best match for NAWIN03 (probability of group membership ranged from 35.3 – 35.6% amongst the three years sampled), the site was also nearly equally matched with Reference Groups 4 and 5 (ranged from 31 – 33% amongst the three years sampled). Ideally, the probability would be higher, indicating a distinctive match to one group. This ‘soft’ match may limit the ability to rely on the CABIN model outputs, thus an emphasis was put on comparing the metrics between this and the previous study (see Section 2.3.3).

Table 2. CABIN model assessment of the test site against reference condition as defined by the preliminary Okanagan-Columbia reference model; assessment, prediction of reference group and probability of group membership.

Site	2015	2016	2017
NAWIN03	🟩 **Potentially Stressed** Group 3; 35.5%	🟥 **Severely stressed** Group 3; 35.6%	🟥 **Severely stressed** Group 3; 35.3%

3.1.2 RIVPACS analysis

The RIVPACS ratio at NAWIN03 was 0.83 in 2015, and 0.94 in both 2016 and 2017 (Table 3). This indicates that most families of taxa were present that were expected based on the reference group in both years. In 2015, there were two families not present at the test site, while in 2016 and 2017, there was only one absent.

Table 3. RIVPACS Observed:Expected Ratios of taxa at test sites. Taxa listed had a probability of occurrence >0.70 at reference sites and were not observed at the test site. Condition indicated as shaded background*.

Site	2015	2016	2017
NAWIN03	🟩 0.83 Hydropsychidae, Taeniopterygidae	🟥 0.94 Taeniopterygidae	🟥 0.94 Taeniopterygidae

***CABIN model condition:** unstressed, potentially stressed, stressed, severely stressed.

3.1.3 Community composition metrics

Key benthic macro-invertebrate metrics that were reviewed in detail include (Table 4): total abundance; percent composition of Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) orders (EPT); percent composition of Chironomidae (non-biting midges) taxa; percent composition of the two dominant taxa; and total number of taxa. In addition to results from this study (2015 to 2017), results from monitoring previously conducted at NAWIN03 in 2010 to 2012 (McPherson et al 2014), are also provided to allow for a greater comparison over time.

Note, that in 2011, there were no benthic macro-invertebrates present (McPherson et al 2011). This was due to a flooding and erosion event that occurred just upstream of site NAWIN03.

Table 4. Benthic macro-invertebrate community composition metrics measured in 3 min kicknet samples at NAWIN03, and the reference group (mean ± standard deviation [SD]). Condition indicated as shaded background*

Metric	**Reference Group 3 (Mean ± SD)**	**Past study****			**This study**		
		🟩 **2010**	🟥 **2011**	🟥 **2012**	🟩 **2015**	🟥 **2016**	🟥 **2017**
Total abundance	5780 ± 4895	5733	0	48	1171	202	143
% EPT taxa	84.9 ± 14.3	67	0	67	68	71	84
% Chironomidae	8.2 ± 13.6	7	0	19	24	6	11
% of 2 dominant taxa	58.9 ± 10.0	63	0	52	53	46	45
Total number of taxa	17.7 ± 2.6	16	0	11	17	18	19

*CABIN model condition: 🟦 unstressed, 🟩 potentially stressed, 🟨 stressed, 🟥 severely stressed.
**McPherson et al. 2014.

Total abundance

Total abundance appeared to be the key benthic macro-invertebrate metric guiding the condition rating at NAWIN03. When abundance was high, as it was in 2010 and 2015 (5733 and 1171 organisms, respectively) the conditions were good (potentially stressed). In all other years, abundance was substantially less (0 to 202 organisms), and this was reflected with a severely stressed condition rating.

The total abundance of organisms can be influenced by many factors including type of stress and the organisms involved (Rosenberg and Resh 1984). Abundance may increase due to nutrient enrichment but decrease in response to toxic effects such as metals contamination or changes in pH, conductivity or dissolved oxygen. At NAWIN03 it did not appear that sediment or water quality influenced abundance. In 2011 and 2012, arsenic in the sediment was high relative to the CCME Interim Sediment Quality Guideline (ISQG). However, the ISQG is the concentration below which adverse biological effects are expected to rarely occur (i.e., fewer than 25% adverse effects occur below this level) (CCME 2018). Arsenic met the sediment quality guidelines in 2013, with sediment quality not measured since. In recent years, all metal water quality parameters assessed met the respective guidelines for the protection of aquatic life.

Proportions of EPT and Chironomidae

The percent of the community made up by individuals of any taxon, either at the family or order level, will vary depending on the taxon's tolerance to pollution, feeding strategy and habitat requirements (Rosenberg and Resh 1984). EPT orders of insects are typically indicators of good water quality. At NAWIN03, excluding 2011, the proportions of EPT were equal or higher during the severely stressed years compared to the potentially stressed years. Percent EPT ranged from 67-84% amongst all years, and thus was also similar to the reference group mean (84.9± 14.3%). Conversely, the Chironomidae family of insects (non-biting midges) are generally tolerant of pollution. Similarly to EPT, Chironomidae proportions did not appear to influence the stressed ratings at NAWIN03. The proportion of Chironomidae in 2015 a potentially stressed year was the highest (24 %); while 2016, which was severely stressed had the lowest proportion (6%). All years had percent Chironomidae within the reference group mean (8.2 ± 13.6 %). The higher percent EPT and lower percent Chironomidae in 2016, indicates an improvement.

Two most abundant taxa

The relative occurrence of the two most abundant taxa is a metric that can relate to impacted streams since only a few taxa end up dominating the community as diversity decreases (Environment Canada 2012c). Opportunistic taxa that are less particular about where they live replace taxa that require special foods or particular types of physical habitat (Environment Canada 2012c). At NAWIN03, the percent of two dominant taxa have been improving, with 2016 and 2017 values being the lowest at 46 and 45 %, respectively. In all years, values were within or close to the reference group mean (58.9 ± 10 %). These results do not corroborate with the CABIN model conditions.

Taxa richness

Taxa richness is the total number of taxa present for a given taxonomic level. There is usually a decrease of intolerant taxa and an increase of tolerant taxa with instream disturbance. However, overall biodiversity of a stream typically declines with disturbance (Environment Canada 2012c). Taxa richness at NAWIN03 has also been improving with time, with the most number of taxa present in 2016 and 2017 (18 and 19 taxa respectively). All values were within the reference group mean (17.7 ± 2.6 taxa).

3.1.4 Habitat conditions

Key physical habitat conditions that could influence benthic macro-invertebrate community health were reviewed amongst the sampling years (Table 5). There were no obvious changes between the 2015 and 2016/17 that would reduce abundance. For example, the depths and velocities, and the percent of fine substrates (sand, and silt and clay), were similar at the test site and/or were within the reference group mean. Embeddedness even showed an improvement, going from a score of 3 (1/2 embedded) to a score of 4 (1/4 embedded).

As reported by McPherson et al. (2014) the 2010 to 2012 habitat data also did not help identify the cause of the severely stressed conditions at NAWIN03 in 2011 and 2012. Similarly to the 2015 to 2016 study period, improvements were evident (e.g., in 2010 embeddedness was 75% and in 2011 and 2012 it was 0% [McPherson et al. 2014]). However, the 2011 CABIN report comments described that a major landslide occurred upstream of NAWIN03 in August 2011, with a tremendous amount of sediment contributed to the creek. The crew were unable to kick for 3 minutes because the net filled with sand. In 2017, evidence of bank erosion and fine sediment deposition remains evident (Figure 4).

Table 5. Select physical habitat characteristics for the predicted reference group, and NAWIN03. Condition indicated as shaded background*

Parameter	Reference group mean ± std dev	2015	2016	2017
Average depth (cm)	22.50 ± 10.5	22.8	21.1	26.7
Average velocity (m/s)	0.50 ± 0.25	0.87	1.1	0.8
% Cobble (6.4 - 25.6 cm)	61 ± 27	7	25	39
% Pebble (1.6 – 6.4 cm)	31 ± 28	48	61	56
% Gravel (0.2 – 1.6 cm)	1 ± 2	40	11	5
% Sand (0.1 – 0.2 cm)	0 ± 0	0	2	0
% silt and clay (<0.1 cm)	0 ± 1	5	3.5	0
Embeddedness (categories: 1 = 100%, 2 = 74%, 3 = 50%, 4 = 25%, 5 = 0%)	4 ± 1	3	4	4

***CABIN model condition:** unstressed, potentially stressed, stressed, severely stressed

Figure 4. September 2017, cross channel view.

3.2 Water quality results

3.2.1 Water quality QA/QC

The relative percent difference calculated for the 2016 parameters sampled in duplicate were calculated (Appendix B1). All but two parameters (86%) were below the alert level of 50%, indicating a high degree of precision in data collection and lab procedures. Turbidity was one of these parameters; however, a field measured and lab analysed sample were compared. Greater than normal variability would be expected when comparing these two different techniques; particularly for turbidity which can be influenced by agitation/settling. Natural variability in turbidity in the water column is also likely.

All but one field blank (94%) were within the acceptable range of 2 times the method detection limits below the alert level, indicating that samples were contaminant free and analysed with precision.

3.2.2 Guideline review

Water quality results were generally good at NAWIN03. All but four non-metal parameters (Appendix B2), and one metal parameter (Appendix B3) met the aquatic life and/or drinking water guidelines. Overall, none of these parameters were likely to negatively impact the aquatic life leading to the low benthic macro-invertebrate abundances. An explanation of this conclusion and details of the exceedances are as follows:

pH: The BC approved water quality guideline for the protection of aquatic life for pH allows for an unrestricted change within the range of 6.5-9.0 (BC MoE 2018b). pH at NAWIN03 ranged from 8.1 to 9.1 pH units, and thus exceeded the upper guideline in one sample. This value was not concerning as it was an isolated reading. Additionally, the geology of the watershed lends itself to having an elevated pH. There is a gypsum mine in the watershed, and the rock has a lot of limestone in it, which has a basic pH.

Dissolved oxygen (DO): DO ranged from 5.5 – 13 mg/L. The BC Approved water quality guideline for aquatic life to protect all fish life stages other than buried embryo /alevin, is a minimum of 8 mg/L, as a long-term average (BC MoE 2018b). This guideline was not met in one sample, collected on November 2, 2015. However, this value was not concerning as it was an isolated reading, and the instantaneous minimum of 5 mg/L was met. As well, the average pH over the study period was 8.44 mg/L.

Total Phosphorus: The total phosphorus guideline for the protection of aquatic life was not met in 2 of the 14 samples (14%). Total phosphorus follows a framework-based approach where concentrations should not (i) exceed predefined ‘trigger ranges’; and (ii) increase more than 50% over the baseline (reference) levels (CCME 2004). The trigger ranges are based on the range of phosphorus concentrations in water that define the reference productivity or trophic status[1] for the site (CCME 2004). Total phosphorus ranged from <0.005 - 0.0307 mg/L at NAWIN03. Based on this data, the baseline range for total phosphorus was determined to be 0.004 - 0.010 mg/L, representing oligotrophic conditions. This is typical of unimpacted areas and generally supports diverse and abundant aquatic life and is self-sustaining (CCME 2004). Data were evaluated against the site specific guideline, calculated as 1.5 x the upper end of the baseline range, which is equivalent to 0.015 mg/L. The exceedance values were 0.0187 mg/L (June 8, 2015) and 0.0307 mg/L (June 13, 2017). The elevated values occurred during the spring freshet period when nutrient loading into a watercourse is anticipated as a result of overland runoff. Since the elevated values were not prolonged, aquatic life impacts were not expected.

E coli*:* The *E. coli* drinking water guideline for raw untreated drinking water is 0 CFU/100 mL (BC MoE 2018b). *E. coli* ranged from 1 - 39 CFU/100 mL, with the guideline exceeded in all samples. The criteria are based on bacteria present in human and animal feces (BC MoE 2018b). Drinking water derived from surface water and shallow ground water sources should receive disinfection as a minimum treatment before human consumption (BC MoE 2018b).

Total Iron: The total iron guideline for drinking water is 300 µg/L (Health Canada 2017). Total iron exceedances of the guideline occurred on July 21, 2015 and June 15, 2017, with values of 385 and 335 µg/L, respectively. The average total iron was 143 µg/L, meeting the guideline. The drinking water guideline was established for aesthetic purposes, based on taste and staining of laundry and plumbing fixtures. Thus there were no health concerns. The aquatic life guideline of 1000 µg/L (BC MoE 2018b) was met in all samples.

3.3 Stream temperature results

Temperature plays an important role in many biological, chemical, and physical processes. The effects of temperature on aquatic organisms are listed in the technical appendix for the BC MoE approved water quality guideline (Oliver & Fidler 2001), with the following generally occurring in aquatic organisms as water temperatures increase:

- Increased cardiovascular and respiratory functions, which in turn may increase the uptake of chemical toxins.
- Increased oxygen demand, while the dissolved oxygen content of water decreases.
- Reduced ability to cope with swimming demands, which is compounded by biological stresses such as predation and disease.
- In waters where dissolved gases are supersaturated, elevated water temperatures may worsen the effects of gas bubble trauma in fish.

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[1] Trophic status refers to the productivity of a waterbody, with eutrophic systems having high productivity and oligotrophic having low. Nutrient addition, primarily phosphorus, contributes to eutrophication, which is when the waterbody’s productivity is accelerated from natural (Wetzel 2001).

At NAWIN03 monthly average water temperature measurements were collected in 2015 from April to November, and in 2017 from July to October (Table 6). Continuous monitoring over a longer time period would be required to determine trends.

Table 6. Monthly average (Avg) and standard deviation (Std Dev) in daily average stream temperature (°C) at NAWIN03.

Month	2015		2017	
	Avg	Std Dev	Avg	Std Dev
January	-	-	-	-
February	-	-	-	-
March	-	-	-	-
April	6.73	0.96	-	-
May	9.13	1.17	-	-
June	10.65	0.94	-	-
July	11.50	0.86	8.85	0.43
August	10.80	0.79	9.05	0.66
September	8.52	0.93	8.05	0.79
October	6.78	1.39	5.99	0.64
November	3.83	1.60	-	-
December	-	-	-	-

*Data were collected for only part of the month

Because of Bull Trout's presence in Windermere Creek, the temperature data were compared to the guidelines for streams with Bull Trout. In general, summer stream temperatures in 2015 were higher than those measured in 2017, with 2015 temperatures nearing and sometimes exceeding the maximum daily Bull Trout rearing temperature of 15 ^{o}C (Figure 5). However, the exceedances were minimal, with temperatures always below 16 ^{o}C. During the warm summer months, fish likely seek out cooler waters (e.g., in deep pools or habitats in Columbia River).

Bull Trout spawning generally occurs from mid-September to late October and often is initiated when water temperatures drop below 9 ^{o}C (McPhail 2007). The maximum daily stream temperatures in Windermere Creek during spawning season did periodically exceed optimal spawning temperature guidelines (i.e. a max daily temperature of 10 ^{o}C). However, it is unknown if fish spawn in the area of the temperature logger, as monitoring of spawning or potential for spawning (based on habitat including gravel size, flows, and water depths) was not part of this study. If Bull Trout spawning occurred, the eggs would incubate overwinter. The Bull Trout egg incubation period is temperature dependant, taking 119-126 days at 2 ^{o}C, 92-95 days at 6 ^{o}C, 74-76 days at 6 ^{o}C, 74-78 days at 8 ^{o}C, and 70 days at 10 ^{o}C (McPhail 2007). After hatching, fry remain in the gravel and generally emerge in June. Based on the limited 2015 winter stream temperature data collected, the guideline for minimum temperature during incubation of 2 ^{o}C was generally not met in late November. These results suggest Bull Trout spawning likely occurs in other locations where groundwater-surface water interactions are high (Baxter and Hauer 2000), as these areas provide consistent year-round water temperatures (i.e., approximately 5^{o}C) (Meisner et al. 1988).

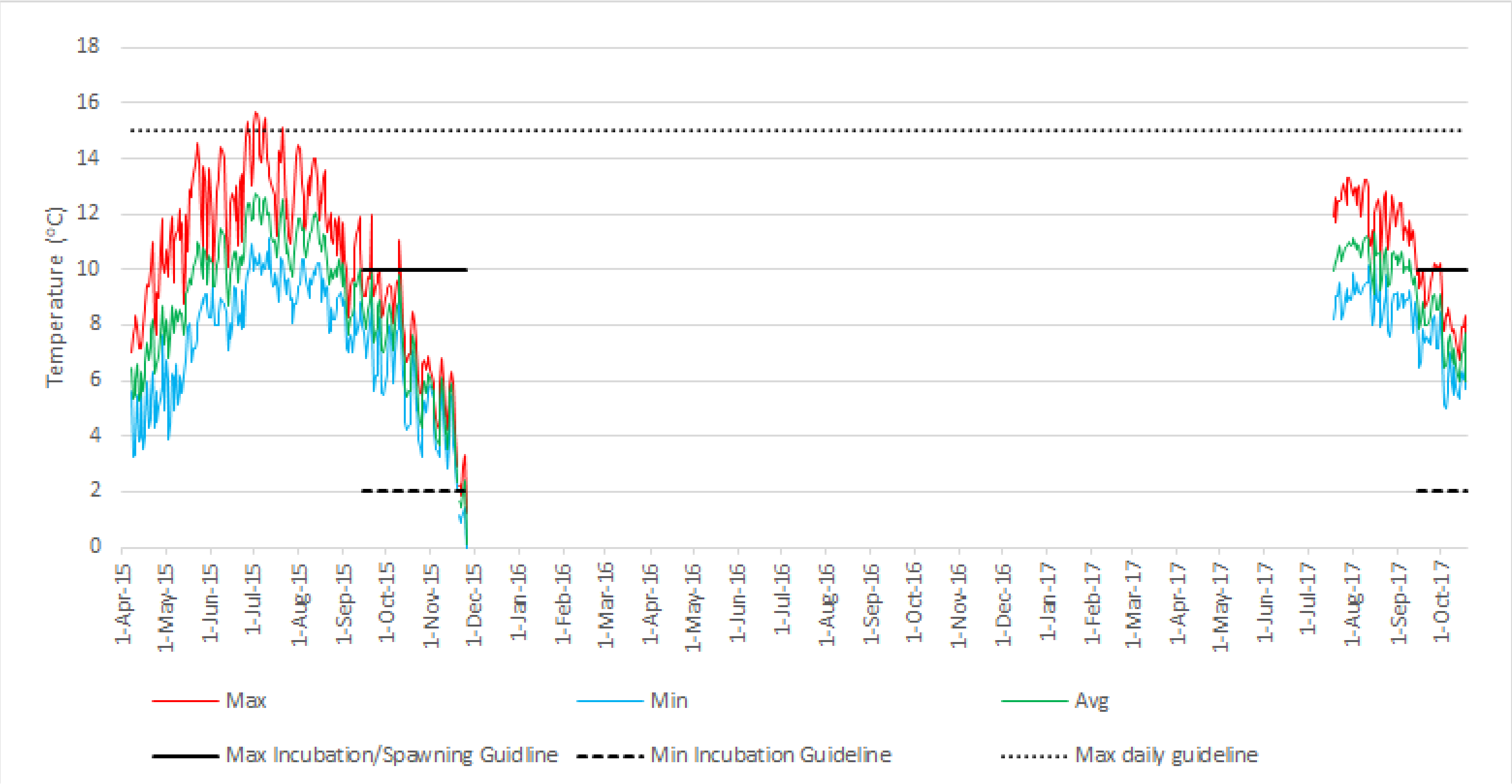

Figure 5. Average daily water temperatures in Windermere Creek (NAWIN03) in 2015 and 2017. The guidelines presented are for the protection of aquatic life for streams with Bull Trout present (BC MoE 2018b).

3.4 Hydrometric results

Streamflow plays an important role in stream ecosystems, influencing aquatic species distributions, water quality (especially turbidity, dissolved oxygen content, and stream temperature), physical habitat (especially substrate characteristics), and fish life history traits (e.g. spawning time).

At NAWIN03, instantaneous streamflow data were collected monthly from spring through fall 2015 to 2017 (Figure 6). The 2016 streamflow results only show a slight freshet period (i.e. high flows due to snowmelt and/or heavy rain). Windermere Creek at NAWIN03 tends to be wadeable at all times. The lack of a more pronounced freshet may have been due to the contribution of groundwater inflows in the creek (MacDonald and Berzins 2009), and/or the construction of an inlet catch basin/drain system as part of restoration on the creek (Crowley 1998). NAWIN03 experienced a more pronounced spring peak in June 2017. In general, flow then decreased through the summer, reaching base-flow levels by the fall.

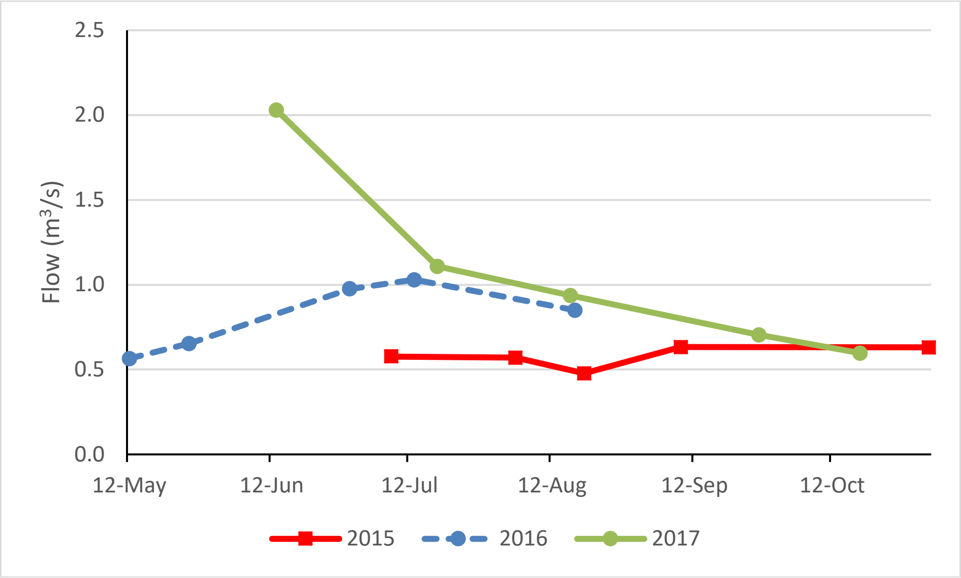

Figure 6. Streamflow at NAWIN03, 2015-2017.

Provincial instream flow guidelines to protect aquatic ecosystems are usually set relative to natural historic flows of each stream. In order to develop these criteria, the annual hydrologic regime of the stream would need to be thoroughly described using a long-term dataset. This would be best achieved using continuous water level loggers and developing level-streamflow relationships. Instantaneous flow measurements at one site cannot be directly related to fish habitat requirements, as flow will vary with channel morphology, and fish can swim to more suitable habitats within the stream. Nevertheless, the hydrometric data collected as part of this project are still important as they can be used to measure changes in streamflow over time. This information can also be used to help explain changes in water quality (e.g., turbidity can increase during high flows) and biological changes such as fish/invertebrate/periphyton species population distributions.

4 Conclusions

The CABIN analysis of the benthic macro-invertebrate data identified NAWIN03 as being potentially stressed in 2015 and severely stressed in 2016 and 2017. Total abundance was the metric that best reflected these community health condition ratings. Total abundance values was highest in 2015, and then dropped in 2016 and 2017. The 2015 results indicated that the benthic macro-invertebrate community initially recovered from the 2011 flood event, but then was negatively influenced again in 2016 and 2017. It was uncertain what caused the conditions to deteriorate. There were no notable changes evident through the physical habitat, water chemistry, stream temperature, or streamflow results. The poor 2016 and 2017 macro benthic-invertebrate results may have been caused by human error during data collection, as there was changeover in staff conducting sampling, and the new staff were learning the techniques. Maintaining consistency in sampling effort and knowledge transfer, especially when organizations change leadership or staff members, is a very large challenge associated with Community-Based Monitoring.

Overall, the water quality was good at NAWIN03, with most guidelines for the protection of aquatic life met. Aquatic life guideline exceedances occurred for pH, total phosphorus, and dissolved oxygen. These were not likely to impact aquatic life because they only occurred incidentally, and mean values over the study period were good. Two drinking water guidelines were also not met, total iron *and E. coli*. The total iron drinking water guideline was set for aesthetic objectives, not human health. The source of *E. coli* was unknown; however, it could have been influenced by domestic livestock, wildlife, or potentially septic systems. Since this guideline was exceeded in all samples, it is recommended that water be disinfected prior to consumption.

Continuous water temperature data were reviewed against guidelines for the protection of Bull Trout. In 2015, there were seven days in July when temperatures exceeded the guideline for protection of Bull Trout rearing. Summer temperatures were cooler in 2017, with no guideline exceedances. The maximum daily stream temperatures in Windermere Creek during the spawning season periodically exceeded the optimal spawning temperature guidelines (i.e., a maximum daily temperature of 10 ºC). However, this study did not review whether the monitoring site was actually used by this species for spawning. Based on the limited 2015 winter stream temperature data, the guideline for minimum temperature during incubation of 2 ºC was generally not met in late November. The Lake Windermere Ambassadors (T. Rodgers pers. comm.), noted that 2017 was a very hot summer, and were thus curious as to why the stream stayed so cool even in late summer. The logger was situated in a shaded area in 2017, but with the staff changeover, it was uncertain where it was relative to 2015. Determining the hydrologic regime of the stream using continuous level loggers is planned for 2018.

Streamflow data, although limited, appeared to follow a typical nival pattern, with higher flows in the spring during freshet, and decreasing flows throughout the summer and fall to a baseflow into the winter months.

5 Recommendations

This study combined with the results of the 2009 to 2012 monitoring, was useful for developing a current understanding of conditions at NAWIN03. The program provided a picture of aquatic invertebrate health and water quality, considering the land-uses at the time. This information can be used in the future to help identify if there are any water quality or benthic macro-invertebrate changes (including improvements) caused by changes in land-use.

There is a variety of other information that was outside of the scope of this monitoring project that could be potentially collected to support a baseline understanding of a watershed. This may include, but not be limited to: 1) conducting fish habitat assessments; 2) confirming the presence of barriers, and the possibility for providing upstream access, if required); and, 3) conducting fish assessments (e.g., composition, abundance and life-history use). The Lake Windermere Ambassadors would need to look at existing data available, to determine where there were information gaps needing to be filled.

6 References

Baxter, C.V., and F.R. Hauer. 2000. Geomorphology, hyporheic exchange, and selection of spawning habitat by bull trout (Salvelinus confluentus). Canadian Journal of Fisheries and Aquatic Sciences. 57(7): 1470-1481.

BC CDC (BC Conservation Data Centre). 2018. BC Species and Ecosystems Explorer. B.C. Ministry of Environment. Accessed at: http://a100.gov.bc.ca/pub/eswp/.

BC Ministry of Environment (BC MoE). 2018a. Fish Information Summary System. Website: http://a100.gov.bc.ca/pub/fidq/main.do;jsessionid=31f493fcb8d91d759539bbbaf51d5deeb30bb2a7b641610f3d1f4a0e1ab70fcc.e3uMah8KbhmLe3iLbNaObxmSay1ynknvrkLOlQzNp65In0

BC Ministry of Environment. 2018b. British Columbia Approved Water Quality Guidelines. Environmental Protection and Sustainability Branch. Accessed at: https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/water-quality-guidelines/approved-water-quality-guidelines.

BC Ministry of Environment. 2017. British Columbia Working Water Quality Guidelines: Aquatic Life, Wildlife, and Agriculture. Water Protection and Sustainability Branch. Accessed at: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/wqgs-wqos/bc_env_working_water_quality_guidelines.pdf.

BC Ministry of Environment. 2016. Environmental Management Act Authorizations, Technical Guidance 4: Annual Reporting Under the Environmental Management Act. Version 1.3. Accessed at: http://www2.gov.bc.ca/assets/gov/environment/waste-management/industrial-waste/industrial-waste/mining-smelt-energy/annual_reporting_guidance_for_mines.pdf

BC Ministry of Environment. 2003. Water quality field sampling manual. Government of British Columbia.

BC Resource Inventory Committee. 1994. Field key to the Freshwater Fishes of British Columbia. Publication #045. Burger, G., J. Schulla, and T. Werner. 2011. Estimates of future flow, including extremes, of the Columbia River headwaters. Water Resources Research, 47: W10520, doi:10.1029/2010WR009716.

Carver, M. 2017. Water Monitoring and Climate Change in the Upper Columbia Basin Summary of Current Status and Opportunities. Report prepared for the Columbia Basin Trust.

CCME. 2018. Canadian Water Quality Guidelines for the Protection of Aquatic Life: Introduction. Updated 2001. Cited in Canadian Environmental Quality Guidelines,1999 (plus updates), Canadian Council of Ministers of the Environment, Winnipeg. Accessed at: http://ceqg-rcqe.ccme.ca/

CCME. 2004. Canadian water quality guidelines for the protection of aquatic life: Phosphorus: Canadian Guidance Framework for the Management of Freshwater Systems. In: Canadian environmental quality guidelines, 2004, Canadian Council of Ministers of the Environment, Winnipeg.

Columbia Basin Water Quality Monitoring Program (CBWQ). 2012. Operating Procedures.

Crowley, S. (1998). Windermere Creek: Restoration Success Through Partnerships in Stewardship. Streamline B.C.'s watershed Restoration Technical Bulletin 3(4), 1-5

Environment Canada. 2012a. Canadian Aquatic Biomonitoring Network: Wadeable Streams Field Manual. Accessed at: http://ec.gc.ca/Publications/default.asp?lang=En&xml=C183563B-CF3E-42E3-9A9E-F7CC856219E1.

Environment Canada. 2012b. Canadian Aquatic Biomonitoring Network Laboratory Methods: Processing, Taxonomy and Quality Control of benthic Macro-invertebrate Samples. Accessed at: http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=CDC2A655-A527-41F0-9E61-824BD4288B98

Environment Canada 2012c. CABIN Module 3 – sample processing and introduction to taxonomy and benthic macro-invertebrates.

Health Canada. 2017. Guidelines for Canadian Drinking Water Quality. Accessed at: https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/water-quality/guidelines-canadian-drinking-water-quality-summary-table.html.

Jost, G., R.D. Moore, D. Gluns, and R.S. Smith. 2012. Quantifying the contribution of glacier runoff to streamflow in the upper Columbia River basin, Canada. Hydrology and Earth Systems Science 16: 849-860, doi:10.5194/hess-16-1-2012.

MacDonald, R. and N. Berzins. 2009. Upper Columbia River Watershed Hydrometric Analysis – Phase 1. Report prepared for The Columbia Basin Trust. 64 pp.

Maxxam Analytics. 2012. Environmental QA/QC Interpretation Guide (COR FCD-00097/5).

McPhail, J.D. 2007. The freshwater fishes of British Columbia. The University of Alberta Press. Edmonton, Alberta. 620 p.

McPherson, S., K. Kuchapski, and R. MacDonald. 2014. Windermere Creek 2009-2012, water quality monitoring report. A Columbia Basin Water Quality Monitoring Project. Prepared by Lotic Environmental Ltd. for Wildsight.

Meisner, J.D., Rosenfeld, J.S., Regier, H.A., 1988. The role of groundwater in the impact of climate warming on stream salmonines. Fisheries 13, 2–8. Cited in MacDonald, R.J., S Boon, J.M. Byrne. 2014. A process-based stream temperature modelling approach for mountain regions. Journal of Hydrology 511:920-931.

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

Oliver G.G., and L.E. Fidler. 2001. Towards a Water Quality Guideline for Temperature in the Province of British Columbia. Prepared by Aspen Applied Sciences Ltd. for the B.C. Ministry of Environment, Lands, and Parks. 54 pp + appendices.

Phillips, B. 2002. Reconnaissance (1:20,000) Fish and Fish Habitat Inventory of the Stoddart Creek, Shuswap Creek, Bornais Creek and Windermere Creek Watersheds. Report prepared for Slocan Forest Products, Radium Division by Artech Consulting, Ltd.

Rosenberg, D.M., T.B. Reynoldson and V.H. Resh. 1999. Establishing reference conditions for benthic invertebrate monitoring in the Fraser River Catchment British Columbia, Canada. Fraser River Action Plan, Environment Canada, Vancouver BC Accessed at: http://www.rem. sfu.ca/FRAP/9832.pdf

Westslope Fisheries. 2001. Local knowledge of Columbia River fisheries in British Columbia, Canada. Consultant report prepared for the Columbia-Kootenay Fisheries Renewal Partnership.

Wetzel, R.G. 2001. Limnology – Lake and River Ecosystems (third edition). Academic Press, San Diego, USA. 1006 pp.

Personal Communications

Horvath, Steve. Senior lab officer. Water and air monitoring & reporting section, BC Ministry of Environment, Surrey.

Appendix A. CABIN data

Site Description

Study Name	CBWQ-Windermere
Site	NAWIN03
Sampling Date	Sep 12 2015
Know Your Watershed Basin	Upper Columbia
Province / Territory	British Columbia
Terrestrial Ecological Classification	Montane Cordillera EcoZone Southern Rocky Mountain Trench EcoRegion
Coordinates (decimal degrees)	50.45889 N, 115.98642 W
Altitude	2664
Local Basin Name	Windermere Creek
	Windermere Creek
Stream Order	4

Figure 1. Location Map

Across Reach

Aerial (No image found)

Up Stream

Cabin Assessment Results

Reference Model Summary	
Model	Columbia-Okanagan Preliminary March 2010
Analysis Date	May 02, 2011
Taxonomic Level	Family
Predictive Model Variables	Depth-Avg Latitude Longitude Reg-Ice Reg-SlopeLT30%

Reference Groups	**1**	**2**	**3**	**4**	**5**
Number of Reference Sites	9	43	17	12	33
Group Error Rate	22.2%	24.5%	22.2%	25.0%	32.4%
Overall Model Error Rate	26.4%				
Probability of Group Membership	0.2%	0.1%	35.5%	31.2%	32.9%
CABIN Assessment of NAWIN03 on Sep 12, 2015	Mildly Divergent				

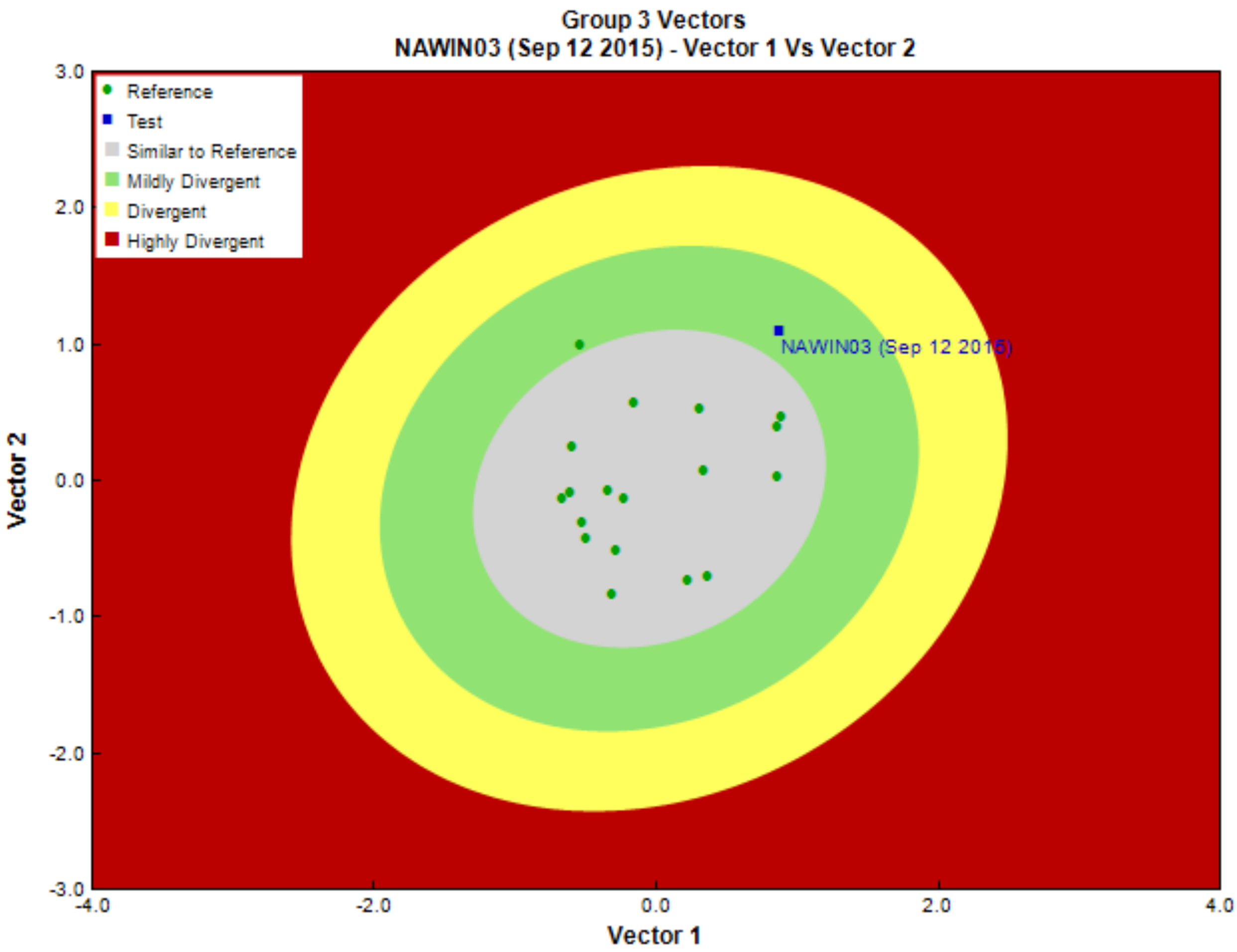

Figure 3. CABIN ordination assessment of the test site with the predicted group of reference sites. Each axis represents the relative abundance of the entire benthic invertebrate community with different organisms weighted differently on each axis.

Sample Information

Sampling Device	Kick Net
Mesh Size	400
Sampling Time	3
Taxonomist	Pina Viola, Consultant
Date Taxonomy Completed	January 08, 2016
	Marchant Box
Sub-Sample Proportion	28/100

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
Annelida	Oligochaeta	Enchytraeida	Enchytraeidae	1	3.6
		Lumbriculida	Lumbriculidae	6	21.4
Arthropoda	Insecta	Coleoptera	Curculionidae	4	14.3
		Diptera	Chironomidae	79	282.1
			Empididae	4	14.3
			Simuliidae	9	32.1
			Stratiomyidae	1	3.6
		Ephemeroptera	Baetidae	65	232.1
			Ephemerellidae	1	3.6
			Heptageniidae	32	114.2
		Plecoptera	Capniidae	15	53.6
			Chloroperlidae	3	10.7
			Nemouridae	96	342.9
			Perlidae	3	10.7
			Perlodidae	4	14.3

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
		Trichoptera	Glossosomatidae	2	7.1
			Rhyacophilidae	3	10.7
			Total	328	1,171.3

Metrics

Name	NAWIN03	Predicted Group Reference Mean ±SD
Bray-Curtis Distance	0.68	0.4 ± 0.2
Biotic Indices		
Hilsenhoff Family index (North-West)	3.8	3.2 ± 0.7
Intolerant taxa	--	
Long-lived taxa	2.0	1.9 ± 1.3
Tolerant individuals (%)	--	0.3
Functional Measures		
% Filterers	2.7	1.8 ± 1.6
% Gatherers	57.0	52.4 ± 14.6
% Predatores	32.0	18.3 ± 13.3
% Scrapers	33.8	61.8 ± 17.2
% Shredder	35.1	30.3 ± 18.6
No. Clinger Taxa	19.0	19.8 ± 3.9
Number Of Individuals		
% Chironomidae	24.1	8.2 ± 13.6
% Coleoptera	1.2	0.8 ± 1.9
% Diptera + Non-insects	30.5	14.3 ± 14.2
% Ephemeroptera	29.9	43.3 ± 15.7
% Ephemeroptera that are Baetidae	66.3	33.9 ± 27.7
% EPT Individuals	68.3	84.9 ± 14.3
% Odonata	--	0.0 ± 0.0
% of 2 dominant taxa	53.4	58.9 ± 10.0
% of 5 dominant taxa	87.5	83.8 ± 7.3
% of dominant taxa	29.3	39.5 ± 10.9
% Plecoptera	36.9	34.7 ± 17.8
% Tribe Tanyatarisini	--	
% Trichoptera that are Hydropsychida	0.0	27.8 ± 25.2
% Tricoptera	1.5	6.9 ± 8.6
No. EPT individuals/Chironomids+EPT Individuals	0.7	0.9 ± 0.1
Total Abundance	1171.4	5780.5 ± 4895.3
Richness		
Chironomidae taxa (genus level only)	1.0	1.0 ± 0.0
Coleoptera taxa	1.0	0.4 ± 0.6
Diptera taxa	4.0	3.4 ± 1.0
Ephemeroptera taxa	3.0	3.4 ± 0.5
EPT Individuals (Sum)	800.0	4527.1 ± 3161.8
EPT taxa (no)	10.0	11.5 ± 1.2
Odonata taxa	--	0.0 ± 0.0
Pielou's Evenness	0.7	0.7 ± 0.1
Plecoptera taxa	5.0	5.3 ± 0.9
Shannon-Wiener Diversity	1.9	1.9 ± 0.3
Simpson's Diversity	0.8	0.8 ± 0.1
Simpson's Evenness	0.3	0.3 ± 0.1
Total No. of Taxa	17.0	17.7 ± 2.6
Trichoptera taxa	2.0	2.8 ± 1.0

Frequency and Probability of Taxa Occurrence

Reference Model Taxa	Frequency of Occurrence in Reference Sites					Probability Of Occurrence at NAWIN03
	Group 1	Group 2	Group 3	Group 4	Group 5	
Baetidae	100%	100%	100%	100%	97%	0.99
Chironomidae	100%	100%	100%	100%	95%	0.98
Chloroperlidae	78%	88%	94%	100%	100%	0.98
Ephemerellidae	78%	100%	100%	100%	100%	1.00
Heptageniidae	100%	100%	100%	100%	100%	1.00

Frequency and Probability of Taxa Occurrence

Reference Model Taxa	Frequency of Occurrence in Reference Sites					Probability Of Occurrence at NAWIN03
	Group 1	Group 2	Group 3	Group 4	Group 5	
Hydropsychidae	11%	92%	78%	92%	86%	0.85
Nemouridae	100%	100%	100%	100%	100%	1.00
Perlodidae	78%	78%	89%	92%	81%	0.87
Rhyacophilidae	100%	92%	100%	100%	95%	0.98
Taeniopterygidae	89%	49%	100%	92%	97%	0.96

RIVPACS Ratios

RIVPACS : Expected taxa P>0.50	11.99
RIVPACS : Observed taxa P>0.50	10.00
RIVPACS : O:E (p > 0.5)	0.83
RIVPACS : Expected taxa P>0.70	9.62
RIVPACS : Observed taxa P>0.70	8.00
RIVPACS : O:E (p > 0.7)	0.83

Habitat Description

Variable	NAWIN03	Predicted Group Reference Mean ±SD
Channel		
Depth-Avg (cm)	22.8	22.5 ± 10.5
Depth-BankfullMinusWetted (cm)	18.00	67.33 ± 71.65
Depth-Max (cm)	26.0	32.9 ± 17.9
Macrophyte (PercentRange)	0	0 ± 0
Reach-%CanopyCoverage (PercentRange)	1.00	0.94 ± 0.80
Reach-DomStreamsideVeg (Category (1-4))	2	3 ± 1
Reach-Pools (Binary)	0	0 ± 1
Reach-Rapids (Binary)	0	0 ± 1
Reach-Riffles (Binary)	1	1 ± 0
Reach-StraightRun (Binary)	1	1 ± 0
Veg-Coniferous (Binary)	1	1 ± 0
Veg-Deciduous (Binary)	1	1 ± 0
Veg-GrassesFerns (Binary)	0	1 ± 0
Veg-Shrubs (Binary)	1	1 ± 0
Velocity-Avg (m/s)	0.87	0.50 ± 0.25
Velocity-Max (m/s)	1.08	0.75 ± 0.28
Width-Bankfull (m)	3.7	15.6 ± 12.8
Width-Wetted (m)	3.2	10.2 ± 7.0
XSEC-VelMethod (Category (1-3))	1	2 ± 1
Landcover		
Reg-Ice (%)	0.00000	0.46949 ± 1.15785
Substrate Data		
%Bedrock (%)	0	0 ± 0
%Boulder (%)	0	6 ± 7
%Cobble (%)	7	61 ± 27
%Gravel (%)	40	1 ± 2
%Pebble (%)	48	31 ± 28
%Sand (%)	0	0 ± 0
%Silt+Clay (%)	5	0 ± 1
D50 (cm)	1.80	79.45 ± 47.98
Dg (cm)	1.7	73.9 ± 48.0
Dominant-1st (Category(0-9))	3	6 ± 1
Dominant-2nd (Category(0-9))	4	6 ± 2
Embeddedness (Category(1-5))	3	4 ± 1
PeriphytonCoverage (Category(1-5))	2	2 ± 1
SurroundingMaterial (Category(0-9))	3	3 ± 1
Topography		
Reg-SlopeLT30% (%)	15.41000	27.92073 ± 14.83033
Water Chemistry		
Ag (mg/L)	0.0000100	0.0000004 ± 0.0000014
Al (mg/L)	0.0091000	0.0059500 ± 0.0039700
Ba (mg/L)	0.0293000	0.0639025 ± 0.0450861

Habitat Description

Variable	NAWIN03	Predicted Group Reference Mean ±SD
Be (mg/L)	0.0002500	0.0000025 ± 0.0000062
Bi (mg/L)	0.0005000	0.0000004 ± 0.0000014
Ca (mg/L)	0.1520000	38.6142857 ± 14.8464843
Cd (mg/L)	0.0000050	0.0000059 ± 0.0000067
Chloride-Dissolved (mg/L)	3.8000000	3.5428571 ± 8.1653449
Co (mg/L)	0.0002500	0.0000043 ± 0.0000057
CO3 (mg/L)	0.2500000	0.0000000 ± 0.0000000
Cr (mg/L)	0.0005000	0.0000833 ± 0.0001403
Cu (mg/L)	0.0007400	0.0001875 ± 0.0001434
Fe (mg/L)	0.0260000	0.0090000
General-Alkalinity (mg/L)	168.0000000	121.5944444 ± 36.7225924
General-DO (mg/L)	9.5000000	10.4922222 ± 0.8833463
General-Hardness (mg/L)	534.0000000	146.8222222 ± 41.6699011
General-pH (pH)	8.6	8.0 ± 0.6
General-SolidsTSS (mg/L)	2.0000000	0.5604289 ± 1.4627232
General-SpCond (µS/cm)	977.0000000	214.2437500 ± 77.1891440
General-TempAir (Degrees Celsius)	11.5	10.5 ± 4.2
General-TempWater (Degrees Celsius)	7.5000000	6.6716667 ± 2.0277755
General-Turbidity (NTU)	6.3200000	0.0000000 ± 0.0000000
HCO3 (mg/L)	205.0000000	0.0000000 ± 0.0000000
Hg (ng/L)	0.0000050	0.0000000 ± 0.0000000
K (mg/L)	0.0009000	0.6471429 ± 0.7154652
Li (mg/L)	0.0061000	0.0011817 ± 0.0004768
Mg (mg/L)	0.0377000	9.8814286 ± 6.1601202
Mn (mg/L)	0.0034000	0.0011426 ± 0.0016097
Mo (mg/L)	0.0013000	0.0024883 ± 0.0065339
Na (mg/L)	0.0033800	2.6357143 ± 3.7712414
Ni (mg/L)	0.0005000	0.0000808 ± 0.0000811
Nitrogen-NH3 (mg/L)	0.0025000	0.0019286 ± 0.0059286
Nitrogen-NO2 (mg/L)	0.0025000	0.0023889 ± 0.0063351
Nitrogen-NO2+NO3 (mg/L)	75.5000000	0.0130000 ± 0.0088111
Nitrogen-NO3 (mg/L)	0.1510000	0.0245003 ± 0.0229452
Nitrogen-TN (mg/L)	0.2030000	0.0688889 ± 0.0759171
Pb (mg/L)	0.0002800	0.0000224 ± 0.0000176
Phosphorus-TP (mg/L)	0.0025000	0.0032778 ± 0.0061816
S (mg/L)	0.1210000	5.0000000
Sb (mg/L)	0.0002500	0.0000361 ± 0.0000135
Se (mg/L)	0.0001600	0.0004382 ± 0.0004486
Si (mg/L)	3.4000000	3.0657143 ± 1.4070046
Sn (mg/L)	0.0025000	0.0000167 ± 0.0000078
Sr (mg/L)	1.7770000	0.1159167 ± 0.0982749
Ti (mg/L)	0.0025000	0.0009000
Tl (mg/L)	0.0000250	0.0000038 ± 0.0000064
U (mg/L)	0.0011800	0.0005298 ± 0.0003220
V (mg/L)	0.0025000	0.0001642 ± 0.0001203
Zn (mg/L)	0.0025000	0.0004083 ± 0.0008361
Zr (mg/L)	0.0002500	0.0000000 ± 0.0000000

Site Description

Study Name	CBWQ-Windermere
Site	NAWIN03
Sampling Date	Oct 23 2016
Know Your Watershed Basin	Upper Columbia
Province / Territory	British Columbia
Terrestrial Ecological Classification	Montane Cordillera EcoZone Southern Rocky Mountain Trench EcoRegion
Coordinates (decimal degrees)	50.45889 N, 115.98642 W
Altitude	2664
Local Basin Name	Windermere Creek
	Windermere Creek
Stream Order	4

Figure 1. Location Map

Across Reach (No image found)
Down Stream (No image found)
Field Sheet (No image found)
Miscellaneous (No image found)
Substrate (No image found)
Up Stream (No image found)

Cabin Assessment Results

Reference Model Summary	
Model	Columbia-Okanagan Preliminary March 2010
Analysis Date	February 27, 2017
Taxonomic Level	Family
Predictive Model Variables	Depth-Avg Latitude Longitude Reg-Ice Reg-SlopeLT30%

Reference Groups	**1**	**2**	**3**	**4**	**5**
Number of Reference Sites	9	43	17	12	33
Group Error Rate	22.2%	24.5%	22.2%	25.0%	32.4%
Overall Model Error Rate			26.4%		
Probability of Group Membership	0.2%	0.1%	35.6%	30.9%	33.2%
CABIN Assessment of NAWIN03 on Oct 23, 2016			Highly Divergent		

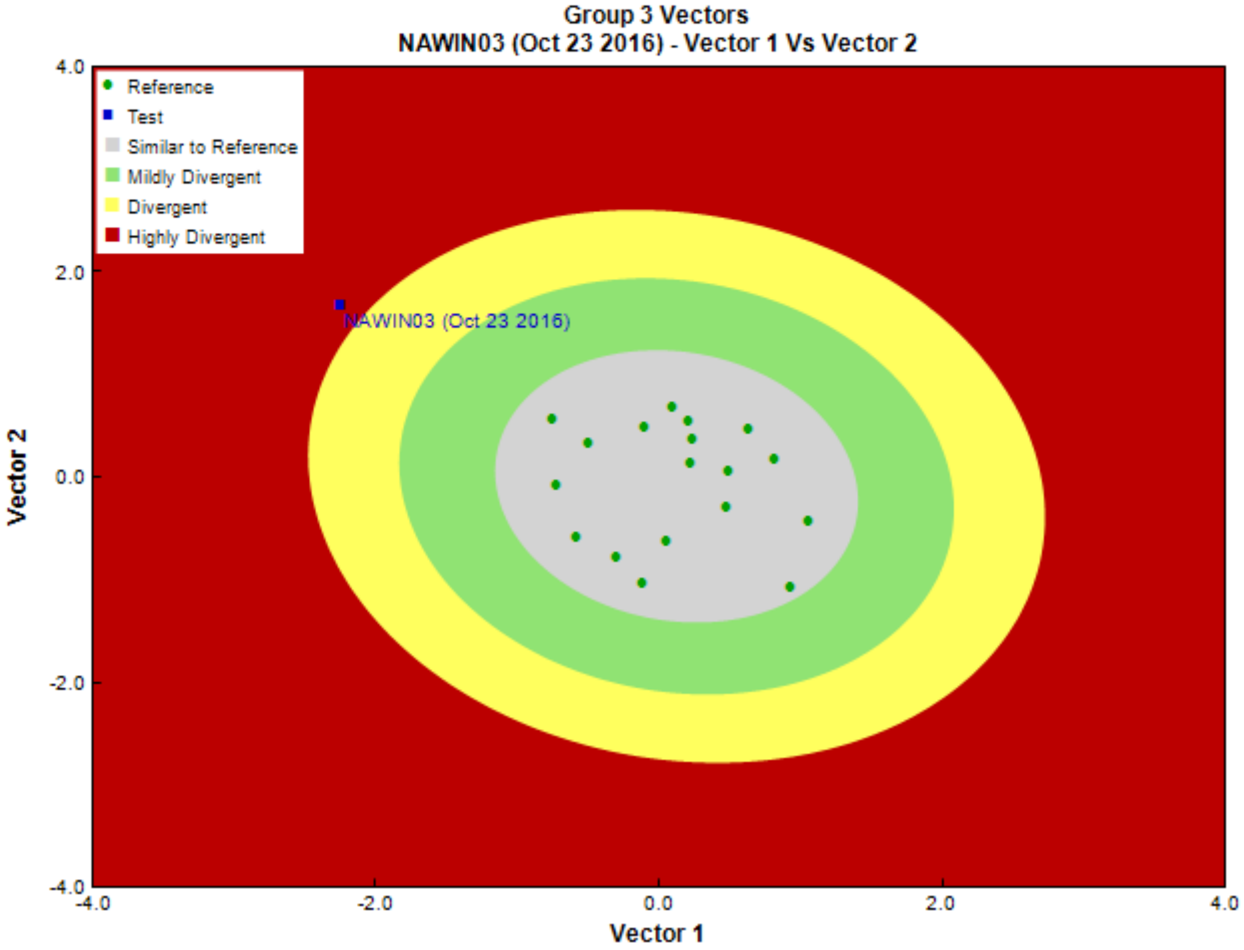

Figure 3. CABIN ordination assessment of the test site with the predicted group of reference sites. Each axis represents the relative abundance of the entire benthic invertebrate community with different organisms weighted differently on each axis.

Sample Information

Sampling Device	Kick Net
Mesh Size	400
Sampling Time	1
Taxonomist	Pina Viola, Consultant
Date Taxonomy Completed	November 05, 2016
	Marchant Box
Sub-Sample Proportion	100/100

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
Annelida	Oligochaeta	Enchytraeida	Enchytraeidae	1	1.0
		Tubificida	Lumbricidae	1	1.0
Arthropoda	Insecta	Coleoptera	Curculionidae	1	1.0
		Diptera	Chironomidae	12	12.0
			Empididae	1	1.0
			Sciomyzidae	1	1.0
			Simuliidae	42	42.0
		Ephemeroptera	Baetidae	50	50.0
			Ephemerellidae	3	3.0
			Heptageniidae	14	14.0
		Plecoptera	Capniidae	28	28.0
			Chloroperlidae	7	7.0
			Nemouridae	26	26.0
			Perlidae	4	4.0
			Perlodidae	1	1.0

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
		Trichoptera	Glossosomatidae	2	2.0
			Hydropsychidae	2	2.0
			Rhyacophilidae	6	6.0
			Total	202	202.0

Metrics

Name	NAWIN03	Predicted Group Reference Mean ±SD
Bray-Curtis Distance	0.92	0.4 ± 0.2
Biotic Indices		
Hilsenhoff Family index (North-West)	3.5	3.2 ± 0.7
Intolerant taxa	--	
Long-lived taxa	1.0	1.9 ± 1.3
Tolerant individuals (%)	--	0.3
Functional Measures		
% Filterers	21.8	1.8 ± 1.6
% Gatherers	24.8	52.4 ± 14.6
% Predatores	37.6	18.3 ± 13.3
% Scrapers	56.9	61.8 ± 17.2
% Shredder	27.2	30.3 ± 18.6
No. Clinger Taxa	18.0	19.8 ± 3.9
Number Of Individuals		
% Chironomidae	5.9	8.2 ± 13.6
% Coleoptera	0.5	0.8 ± 1.9
% Diptera + Non-insects	28.7	14.3 ± 14.2
% Ephemeroptera	33.2	43.3 ± 15.7
% Ephemeroptera that are Baetidae	74.6	33.9 ± 27.7
% EPT Individuals	70.8	84.9 ± 14.3
% Odonata	0.0	0.0 ± 0.0
% of 2 dominant taxa	45.5	58.9 ± 10.0
% of 5 dominant taxa	79.2	83.8 ± 7.3
% of dominant taxa	24.8	39.5 ± 10.9
% Plecoptera	32.7	34.7 ± 17.8
% Tribe Tanyatarisini	--	
% Trichoptera that are Hydropsychida	20.0	27.8 ± 25.2
% Tricoptera	5.0	6.9 ± 8.6
No. EPT individuals/Chironomids+EPT Individuals	0.9	0.9 ± 0.1
Total Abundance	202.0	5780.5 ± 4895.3
Richness		
Chironomidae taxa (genus level only)	1.0	1.0 ± 0.0
Coleoptera taxa	1.0	0.4 ± 0.6
Diptera taxa	4.0	3.4 ± 1.0
Ephemeroptera taxa	3.0	3.4 ± 0.5
EPT Individuals (Sum)	143.0	4527.1 ± 3161.8
EPT taxa (no)	11.0	11.5 ± 1.2
Odonata taxa	0.0	0.0 ± 0.0
Pielou's Evenness	0.8	0.7 ± 0.1
Plecoptera taxa	5.0	5.3 ± 0.9
Shannon-Wiener Diversity	2.2	1.9 ± 0.3
Simpson's Diversity	0.8	0.8 ± 0.1
Simpson's Evenness	0.4	0.3 ± 0.1
Total No. of Taxa	18.0	17.7 ± 2.6
Trichoptera taxa	3.0	2.8 ± 1.0

Frequency and Probability of Taxa Occurrence

Reference Model Taxa	Frequency of Occurrence in Reference Sites					Probability Of Occurrence at NAWIN03
	Group 1	Group 2	Group 3	Group 4	Group 5	
Baetidae	100%	100%	100%	100%	97%	0.99
Chironomidae	100%	100%	100%	100%	95%	0.98
Chloroperlidae	78%	88%	94%	100%	100%	0.98
Ephemerellidae	78%	100%	100%	100%	100%	1.00

Frequency and Probability of Taxa Occurrence

Reference Model Taxa	Frequency of Occurrence in Reference Sites					Probability Of Occurrence at NAWIN03
	Group 1	Group 2	Group 3	Group 4	Group 5	
Heptageniidae	100%	100%	100%	100%	100%	1.00
Hydropsychidae	11%	92%	78%	92%	86%	0.85
Nemouridae	100%	100%	100%	100%	100%	1.00
Perlodidae	78%	78%	89%	92%	81%	0.87
Rhyacophilidae	100%	92%	100%	100%	95%	0.98
Taeniopterygidae	89%	49%	100%	92%	97%	0.96

RIVPACS Ratios

RIVPACS : Expected taxa P>0.50	11.99
RIVPACS : Observed taxa P>0.50	11.00
RIVPACS : O:E (p > 0.5)	0.92
RIVPACS : Expected taxa P>0.70	9.62
RIVPACS : Observed taxa P>0.70	9.00
RIVPACS : O:E (p > 0.7)	0.94

Habitat Description

Variable	NAWIN03	Predicted Group Reference Mean ±SD
Channel		
Depth-Avg (cm)	21.1	22.5 ± 10.5
Depth-BankfullMinusWetted (cm)	31.00	67.33 ± 71.65
Depth-Max (cm)	26.0	32.9 ± 17.9
Macrophyte (PercentRange)	1	0 ± 0
Reach-%CanopyCoverage (PercentRange)	1.00	0.94 ± 0.80
Reach-DomStreamsideVeg (Category (1-4))	4	3 ± 1
Reach-Riffles (Binary)	1	1 ± 0
Slope (m/m)	0.0050000	0.0235102 ± 0.0284557
Veg-Deciduous (Binary)	1	1 ± 0
Veg-Shrubs (Binary)	1	1 ± 0
Velocity-Avg (m/s)	1.10	0.50 ± 0.25
Velocity-Max (m/s)	1.33	0.75 ± 0.28
Width-Bankfull (m)	3.5	15.6 ± 12.8
Width-Wetted (m)	3.4	10.2 ± 7.0
XSEC-VelMethod (Category (1-3))	1	2 ± 1
Landcover		
Reg-Ice (%)	0.00000	0.46949 ± 1.15785
Substrate Data		
%Bedrock (%)	0	0 ± 0
%Boulder (%)	0	6 ± 7
%Cobble (%)	25	61 ± 27
%Gravel (%)	11	1 ± 2
%Pebble (%)	61	31 ± 28
%Sand (%)	0	0 ± 0
%Silt+Clay (%)	2	0 ± 1
D50 (cm)	3.50	79.45 ± 47.98
Dg (cm)	3.4	73.9 ± 48.0
Dominant-1st (Category(0-9))	4	6 ± 1
Dominant-2nd (Category(0-9))	5	6 ± 2
Embeddedness (Category(1-5))	4	4 ± 1
PeriphytonCoverage (Category(1-5))	3	2 ± 1
SurroundingMaterial (Category(0-9))	2	3 ± 1
Topography		
Reg-SlopeLT30% (%)	15.41076	27.92073 ± 14.83033
Water Chemistry		
Ag (mg/L)	0.0000200	0.0000004 ± 0.0000014
Al (mg/L)	0.0110000	0.0059500 ± 0.0039700
As (mg/L)	0.0027100	0.0002175 ± 0.0001795
B (mg/L)	0.0610000	0.0500000
Ba (mg/L)	0.0305000	0.0639025 ± 0.0450861
Be (mg/L)	0.0000500	0.0000025 ± 0.0000062

Habitat Description

Variable	NAWIN03	Predicted Group Reference Mean ±SD
Bi (mg/L)	0.0000500	0.0000004 ± 0.0000014
Ca (mg/L)	0.1590000	38.6142857 ± 14.8464843
Cd (mg/L)	0.0000050	0.0000059 ± 0.0000067
Co (mg/L)	0.0002500	0.0000043 ± 0.0000057
CO3 (mg/L)	0.2500000	0.0000000 ± 0.0000000
Cr (mg/L)	0.0005000	0.0000833 ± 0.0001403
Cu (mg/L)	0.0002500	0.0001875 ± 0.0001434
Fe (mg/L)	0.0240000	0.0090000
General-Alkalinity (mg/L)	170.0000000	121.5944444 ± 36.7225924
General-DO (mg/L)	10.0000000	10.4922222 ± 0.8833463
General-Hardness (mg/L)	549.0000000	146.8222222 ± 41.6699011
General-pH (pH)	8.5	8.0 ± 0.6
General-SolidsTSS (mg/L)	2.0000000	0.5604289 ± 1.4627232
General-SpCond (µS/cm)	964.0000000	214.2437500 ± 77.1891440
General-TempAir (Degrees Celsius)	1.0	10.5 ± 4.2
General-TempWater (Degrees Celsius)	4.7000000	6.6716667 ± 2.0277755
HCO3 (mg/L)	207.0000000	0.0000000 ± 0.0000000
Hg (ng/L)	10.0000000	0.0000000 ± 0.0000000
K (mg/L)	0.0009150	0.6471429 ± 0.7154652
Li (mg/L)	0.0062000	0.0011817 ± 0.0004768
Mg (mg/L)	0.0365000	9.8814286 ± 6.1601202
Mn (mg/L)	0.0023000	0.0011426 ± 0.0016097
Mo (mg/L)	0.0014000	0.0024883 ± 0.0065339
Na (mg/L)	0.0030200	2.6357143 ± 3.7712414
Ni (mg/L)	0.0005000	0.0000808 ± 0.0000811
Nitrogen-NH3 (mg/L)	0.0590000	0.0019286 ± 0.0059286
Nitrogen-NO2 (mg/L)	0.0025000	0.0023889 ± 0.0063351
Nitrogen-NO2+NO3 (mg/L)	0.1550000	0.0130000 ± 0.0088111
Nitrogen-NO3 (mg/L)	0.1550000	0.0245003 ± 0.0229452
Nitrogen-TN (mg/L)	0.2610000	0.0688889 ± 0.0759171
Pb (mg/L)	0.0001000	0.0000224 ± 0.0000176
Phosphorus-OrthoP (mg/L)	0.0025000	0.0035000 ± 0.0018292
Phosphorus-TDP (mg/L)	0.0025000	0.0016667 ± 0.0020151
S (mg/L)	0.1320000	5.0000000
Sb (mg/L)	0.0002500	0.0000361 ± 0.0000135
Se (mg/L)	0.0001400	0.0004382 ± 0.0004486
Si (mg/L)	3.3500000	3.0657143 ± 1.4070046
Sn (mg/L)	0.0025000	0.0000167 ± 0.0000078
SO4 (mg/L)	336.0000000	14.9647059 ± 10.8432549
Sr (mg/L)	2.0700000	0.1159167 ± 0.0982749
Ti (mg/L)	0.0025000	0.0009000
Tl (mg/L)	0.0000250	0.0000038 ± 0.0000064
U (mg/L)	0.0012800	0.0005298 ± 0.0003220
V (mg/L)	0.0025000	0.0001642 ± 0.0001203
Zn (mg/L)	0.0025000	0.0004083 ± 0.0008361
Zr (mg/L)	0.0002500	0.0000000 ± 0.0000000

Site Description

Study Name	CBWQ-Windermere
Site	NAWIN03
Sampling Date	Sep 26 2017
Know Your Watershed Basin	Upper Columbia
Province / Territory	British Columbia
Terrestrial Ecological Classification	Montane Cordillera EcoZone Southern Rocky Mountain Trench EcoRegion
Coordinates (decimal degrees)	50.45889 N, 115.98650 W
Altitude	2634
Local Basin Name	Windermere Creek
	Windermere Creek
Stream Order	4

Figure 1. Location Map

Across Reach
Aerial (No image found)

Up Stream

Cabin Assessment Results

Reference Model Summary	
Model	Columbia-Okanagan Preliminary March 2010
Analysis Date	January 30, 2018
Taxonomic Level	Family
Predictive Model Variables	Depth-Avg Latitude Longitude Reg-Ice Reg-SlopeLT30%

Reference Groups	**1**	**2**	**3**	**4**	**5**
Number of Reference Sites	9	43	17	12	33
Group Error Rate	22.2%	24.5%	22.2%	25.0%	32.4%
Overall Model Error Rate	26.4%				
Probability of Group Membership	0.5%	0.1%	35.3%	31.9%	32.2%
CABIN Assessment of NAWIN03 on Sep 26, 2017	Highly Divergent				

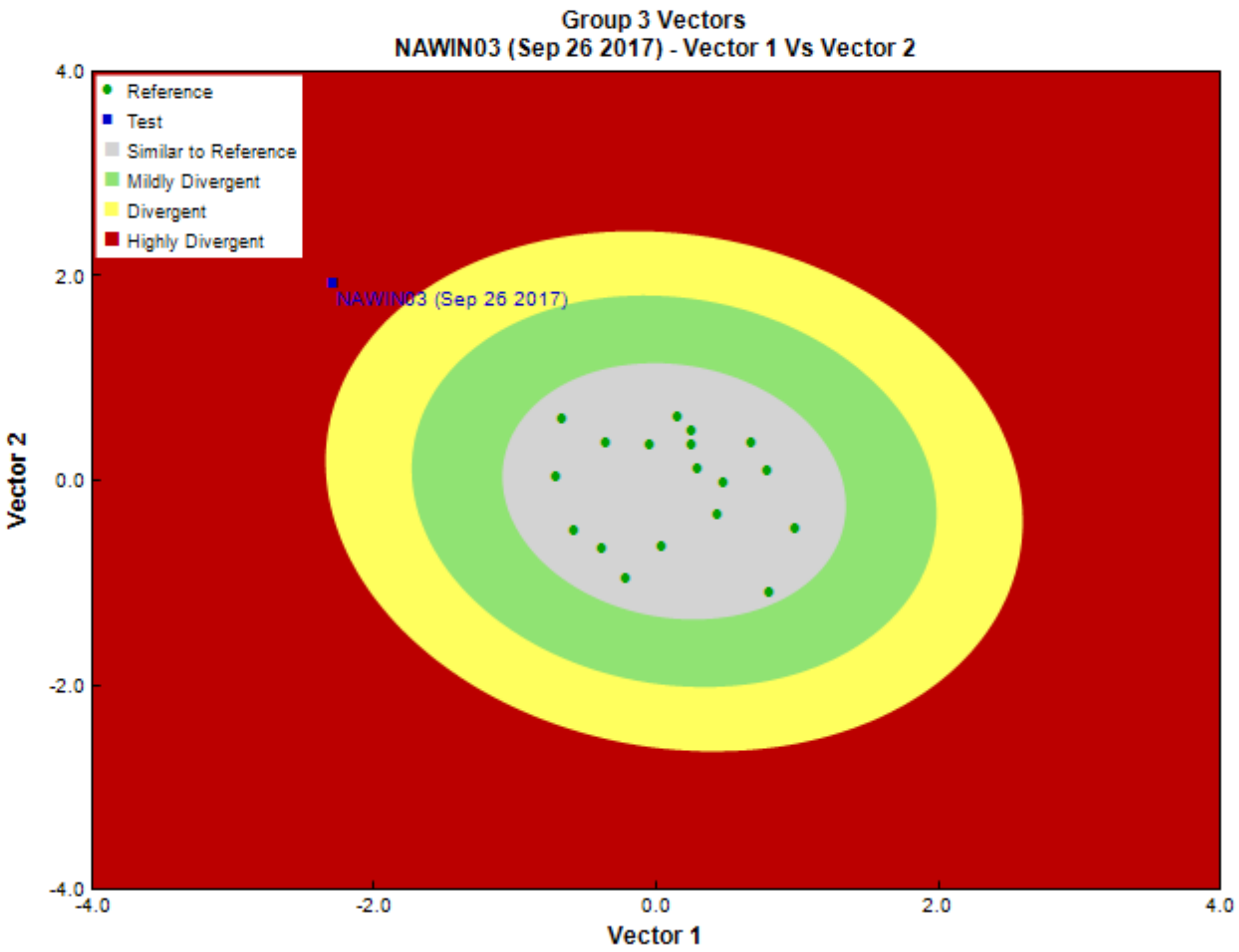

Figure 3. CABIN ordination assessment of the test site with the predicted group of reference sites. Each axis represents the relative abundance of the entire benthic invertebrate community with different organisms weighted differently on each axis.

Sample Information

Sampling Device	Kick Net
Mesh Size	400
Sampling Time	3
Taxonomist	Pina Viola, Consultant
Date Taxonomy Completed	December 02, 2017
	Marchant Box
Sub-Sample Proportion	100/100

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
Annelida	Oligochaeta	Enchytraeida	Enchytraeidae	2	2.0
		Tubificida	Lumbricidae	1	1.0
Arthropoda	Insecta	Coleoptera	Curculionidae	1	1.0
		Diptera	Chironomidae	15	15.0
			Empididae	1	1.0
			Simuliidae	2	2.0
		Ephemeroptera	Baetidae	40	40.0
			Ephemerellidae	1	1.0
			Heptageniidae	12	12.0
		Plecoptera		1	1.0
			Capniidae	6	6.0
			Chloroperlidae	6	6.0
			Nemouridae	24	24.0
			Perlidae	16	16.0
			Perlodidae	4	4.0

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
		Trichoptera	Brachycentridae	1	1.0
			Glossosomatidae	3	3.0
			Hydropsychidae	1	1.0
			Limnephilidae	1	1.0
			Rhyacophilidae	5	5.0
			Total	143	143.0

Metrics

Name	NAWIN03	Predicted Group Reference Mean ±SD
Bray-Curtis Distance	0.93	0.4 ± 0.2
Biotic Indices		
Hilsenhoff Family index (North-West)	3.1	3.2 ± 0.7
Intolerant taxa	--	
Long-lived taxa	2.0	1.9 ± 1.3
Tolerant individuals (%)	--	0.3
Functional Measures		
% Filterers	2.8	1.8 ± 1.6
% Gatherers	35.0	52.4 ± 14.6
% Predatores	35.0	18.3 ± 13.3
% Scrapers	44.8	61.8 ± 17.2
% Shredder	23.1	30.3 ± 18.6
No. Clinger Taxa	20.0	19.8 ± 3.9
Number Of Individuals		
% Chironomidae	10.6	8.2 ± 13.6
% Coleoptera	0.7	0.8 ± 1.9
% Diptera + Non-insects	14.8	14.3 ± 14.2
% Ephemeroptera	37.3	43.3 ± 15.7
% Ephemeroptera that are Baetidae	75.5	33.9 ± 27.7
% EPT Individuals	84.5	84.9 ± 14.3
% Odonata	0.0	0.0 ± 0.0
% of 2 dominant taxa	45.1	58.9 ± 10.0
% of 5 dominant taxa	75.4	83.8 ± 7.3
% of dominant taxa	28.2	39.5 ± 10.9
% Plecoptera	39.4	34.7 ± 17.8
% Tribe Tanyatarisini	--	
% Trichoptera that are Hydropsychida	9.1	27.8 ± 25.2
% Tricoptera	7.7	6.9 ± 8.6
No. EPT individuals/Chironomids+EPT Individuals	0.9	0.9 ± 0.1
Total Abundance	143.0	5780.5 ± 4895.3
Richness		
Chironomidae taxa (genus level only)	1.0	1.0 ± 0.0
Coleoptera taxa	1.0	0.4 ± 0.6
Diptera taxa	3.0	3.4 ± 1.0
Ephemeroptera taxa	3.0	3.4 ± 0.5
EPT Individuals (Sum)	120.0	4527.1 ± 3161.8
EPT taxa (no)	13.0	11.5 ± 1.2
Odonata taxa	0.0	0.0 ± 0.0
Pielou's Evenness	0.8	0.7 ± 0.1
Plecoptera taxa	5.0	5.3 ± 0.9
Shannon-Wiener Diversity	2.3	1.9 ± 0.3
Simpson's Diversity	0.9	0.8 ± 0.1
Simpson's Evenness	0.4	0.3 ± 0.1
Total No. of Taxa	19.0	17.7 ± 2.6
Trichoptera taxa	5.0	2.8 ± 1.0

Frequency and Probability of Taxa Occurrence

Reference Model Taxa	Frequency of Occurrence in Reference Sites					Probability Of Occurrence at NAWIN03
	Group 1	Group 2	Group 3	Group 4	Group 5	
Baetidae	100%	100%	100%	100%	97%	0.99
Chironomidae	100%	100%	100%	100%	95%	0.98

Frequency and Probability of Taxa Occurrence

Reference Model Taxa	Frequency of Occurrence in Reference Sites					Probability Of Occurrence at NAWIN03
	Group 1	Group 2	Group 3	Group 4	Group 5	
Chloroperlidae	78%	88%	94%	100%	100%	0.98
Ephemerellidae	78%	100%	100%	100%	100%	1.00
Heptageniidae	100%	100%	100%	100%	100%	1.00
Hydropsychidae	11%	92%	78%	92%	86%	0.85
Nemouridae	100%	100%	100%	100%	100%	1.00
Perlodidae	78%	78%	89%	92%	81%	0.87
Rhyacophilidae	100%	92%	100%	100%	95%	0.98
Taeniopterygidae	89%	49%	100%	92%	97%	0.96

RIVPACS Ratios

RIVPACS : Expected taxa P>0.50	11.99
RIVPACS : Observed taxa P>0.50	11.00
RIVPACS : O:E (p > 0.5)	0.92
RIVPACS : Expected taxa P>0.70	9.62
RIVPACS : Observed taxa P>0.70	9.00
RIVPACS : O:E (p > 0.7)	0.94

Habitat Description

Variable	NAWIN03	Predicted Group Reference Mean ±SD
Channel		
Depth-Avg (cm)	26.7	22.5 ± 10.5
Depth-BankfullMinusWetted (cm)	40.00	67.33 ± 71.65
Depth-Max (cm)	30.0	32.9 ± 17.9
Macrophyte (PercentRange)	0	0 ± 0
Reach-%CanopyCoverage (PercentRange)	3.00	0.94 ± 0.80
Reach-DomStreamsideVeg (Category(1-4))	2	3 ± 1
Reach-Pools (Binary)	1	0 ± 1
Reach-Riffles (Binary)	1	1 ± 0
Reach-StraightRun (Binary)	1	1 ± 0
Slope (m/m)	15.4483000	0.0235102 ± 0.0284557
Veg-Coniferous (Binary)	1	1 ± 0
Veg-Deciduous (Binary)	1	1 ± 0
Veg-GrassesFerns (Binary)	1	1 ± 0
Veg-Shrubs (Binary)	1	1 ± 0
Velocity-Avg (m/s)	0.80	0.50 ± 0.25
Velocity-Max (m/s)	1.08	0.75 ± 0.28
Width-Bankfull (m)	3.5	15.6 ± 12.8
Width-Wetted (m)	3.3	10.2 ± 7.0
XSEC-VelMethod (Category(1-3))	1	2 ± 1
Landcover		
Reg-Ice (%)	0.00000	0.46949 ± 1.15785
Substrate Data		
%Bedrock (%)	0	0 ± 0
%Boulder (%)	0	6 ± 7
%Cobble (%)	39	61 ± 27
%Gravel (%)	5	1 ± 2
%Pebble (%)	56	31 ± 28
%Sand (%)	0	0 ± 0
%Silt+Clay (%)	0	0 ± 1
D50 (cm)	5.50	79.45 ± 47.98
Dg (cm)	5.2	73.9 ± 48.0
Dominant-1st (Category(0-9))	5	6 ± 1
Dominant-2nd (Category(0-9))	6	6 ± 2
Embeddedness (Category(1-5))	4	4 ± 1
PeriphytonCoverage (Category(1-5))	2	2 ± 1
SurroundingMaterial (Category(0-9))	3	3 ± 1
Topography		
Reg-SlopeLT30% (%)	15.41076	27.92073 ± 14.83033
Water Chemistry		

Habitat Description

Variable	NAWIN03	Predicted Group Reference Mean ±SD
Ag (mg/L)	0.0000100	0.0000004 ± 0.0000014
Al (mg/L)	0.0080000	0.0059500 ± 0.0039700
As (mg/L)	0.0019900	0.0002175 ± 0.0001795
B (mg/L)	0.0250000	0.0500000
Ba (mg/L)	0.0322000	0.0639025 ± 0.0450861
Be (mg/L)	0.0000500	0.0000025 ± 0.0000062
Bi (mg/L)	0.0005000	0.0000004 ± 0.0000014
Ca (mg/L)	0.1410000	38.6142857 ± 14.8464843
Cd (mg/L)	0.0000050	0.0000059 ± 0.0000067
Co (mg/L)	0.0001000	0.0000043 ± 0.0000057
CO3 (mg/L)	0.5000000	0.0000000 ± 0.0000000
Cr (mg/L)	0.0005000	0.0000833 ± 0.0001403
Cu (mg/L)	0.0002500	0.0001875 ± 0.0001434
Fe (mg/L)	0.0250000	0.0090000
General-Alkalinity (mg/L)	170.0000000	121.5944444 ± 36.7225924
General-DO (mg/L)	11.0000000	10.4922222 ± 0.8833463
General-Hardness (mg/L)	496.0000000	146.8222222 ± 41.6699011
General-pH (pH)	8.7	8.0 ± 0.6
General-SolidsTSS (mg/L)	2.0000000	0.5604289 ± 1.4627232
General-SpCond (µS/cm)	877.0000000	214.2437500 ± 77.1891440
General-TempAir (Degrees Celsius)	18.0	10.5 ± 4.2
General-TempWater (Degrees Celsius)	9.6000000	6.6716667 ± 2.0277755
General-Turbidity (NTU)	1.2800000	0.0000000 ± 0.0000000
HCO3 (mg/L)	207.0000000	0.0000000 ± 0.0000000
Hg (ng/L)	5.0000000	0.0000000 ± 0.0000000
K (mg/L)	0.0009190	0.6471429 ± 0.7154652
Li (mg/L)	0.0062000	0.0011817 ± 0.0004768
Mg (mg/L)	0.0350000	9.8814286 ± 6.1601202
Mn (mg/L)	0.0028000	0.0011426 ± 0.0016097
Mo (mg/L)	0.0014000	0.0024883 ± 0.0065339
Na (mg/L)	0.0028100	2.6357143 ± 3.7712414
Ni (mg/L)	0.0005000	0.0000808 ± 0.0000811
Nitrogen-NH3 (mg/L)	0.0100000	0.0019286 ± 0.0059286
Nitrogen-NO2 (mg/L)	0.0025000	0.0023889 ± 0.0063351
Nitrogen-NO2+NO3 (mg/L)	0.1150000	0.0130000 ± 0.0088111
Nitrogen-NO3 (mg/L)	0.1150000	0.0245003 ± 0.0229452
Nitrogen-TN (mg/L)	0.2140000	0.0688889 ± 0.0759171
Pb (mg/L)	0.0001000	0.0000224 ± 0.0000176
Phosphorus-OrthoP (mg/L)	0.0025000	0.0035000 ± 0.0018292
Phosphorus-TP (mg/L)	0.0025000	0.0032778 ± 0.0061816
S (mg/L)	0.1160000	5.0000000
Sb (mg/L)	0.0002500	0.0000361 ± 0.0000135
Se (mg/L)	0.0001300	0.0004382 ± 0.0004486
Si (mg/L)	3.3200000	3.0657143 ± 1.4070046
Sn (mg/L)	0.0025000	0.0000167 ± 0.0000078
SO4 (mg/L)	297.0000000	14.9647059 ± 10.8432549
Sr (mg/L)	1.6600000	0.1159167 ± 0.0982749
Ti (mg/L)	0.0025000	0.0009000
Tl (mg/L)	0.0000050	0.0000038 ± 0.0000064
U (mg/L)	0.0011700	0.0005298 ± 0.0003220
V (mg/L)	0.0025000	0.0001642 ± 0.0001203
Zn (mg/L)	0.0025000	0.0004083 ± 0.0008361
Zr (mg/L)	0.0000500	0.0000000 ± 0.0000000

Appendix B. Water quality data

B1 – Water quality QA/QC

B2 – Water quality, non-metals

B3 – Water quality, metals

Water quality legend

Abbreviation/ symbol	**Description**
QA/QC table/criteria	Duplicate (or REP for replicate): review based on relative percent difference (RPD). Concern level if RPD >50% for general chemistry, if one of a set of duplicate values ≥ 5 times the RDL. Relative percent difference limit (RPD) = [(Result 2 - Result 1) / mean] x 100.
	Field Blank (BLK): recommended alert = 2X reporting limit (RDL)
	Grey highlight: exceedance of QA/QC criteria
^{1}(superscript to guidelines)	Guidelines relevant to background not assessed, as they are intended to be monitored during construction/discharge activity.
(1)	Detection limits raised due to dilution to bring analyte within the calibrated range.
(2)	Sample analyzed past method specific hold time.
AO	Aesthetic objective.
BC App	BC approved water quality guidelines (BC MoE 2018b).
BC Work	BC working water quality guidelines (BC MoE 2017).
CCME	Canadian environmental quality guidelines (CCME 2018).
HC	Health Canada drinking water guidelines (Health Canada 2017).
Red font	Field collected data.
Green highlight	Exceedance of guideline for the protection of aquatic life.
Blue highlight	Exceedance of drinking water guideline.

Appendix B1 - Water quality data, QA/QC

Stewardship Group	Sample Date (dd/mm/yy)	Site Code	Site Name	Nitrite (N)	Nitrate (N)	Alkalinity (Total as CaCO3)	Alkalinity (PP as CaCO3)	Bicarbonate (HCO3)	Carbonate (CO3)	Hydroxide (OH)	Orthophosphate (P)	Nitrate plus Nitrite (N)	Turbidity	Total Phosphorus (P)	Total Nitrogen (N)	Conductivity	Total Suspended Solids
			Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**µg/L**	**mg/L**	**NTU**	**mg/L**	**mg/L**	**uS/cm**	**mg/L**
			RDL	**0.005**	**0.02**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**5**	**0.02**	**0.1**	**0.005**	**0.02**	**1**	**4**
Wildsight Regional	16-11-02	NAWIN03 DUP	WINDERMERE CR	<0.0050	0.152	169	<0.50	206	<0.50	<0.50	<0.0050	0.152	0.92	<0.0050	0.288	957	<4.0
Wildsight Regional	16-11-02	NAWIN03	WINDERMERE CR	<0.0050	0.155	170	<0.50	207	<0.50	<0.50	<0.0050	0.155	3.02	<0.0050	0.261		<4.0
		Duplicate QC	**Calculated RPD (%)**	**0.0**	**-2.0**	**-0.6**	**0.0**	**-0.5**	**0.0**	**0.0**	**0.0**	**-2.0**	**-106.6**	**0.0**	**9.8**	**-**	**0**
Wildsight Regional	16-11-02	NAWIN03FLDBLK	WINDERMERE CR	<0.0050	<0.020	<0.50	<0.50	<0.50	<0.50	<0.50	<0.0050	<0.020	<0.10	<0.0050	0.12	1.5	<4.0
		Blank QC	**X times > than RDL**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**6.0**	**1.5**	**1.0**

Appendix B1 - Water quality data, QA/QC

Sample Date (dd/mm/yy)	Site Code	Site Name	Sulphate (SO4)	Dissolved Chloride (Cl)	Total Ammonia (NH3)	E. Coli
		Units	**mg/L**	**mg/L**	**mg/L**	**CFU**
		RDL	**1**	**0.5**	**0.005**	**1**
16-11-02	NAWIN03 DUP	WINDERMERE CR	341	3.2	0.042	10
16-11-02	NAWIN03	WINDERMERE CR	336		0.059	2
	Duplicate QC	**Calculated RPD (%)**	**1.5**	-	**-33.7**	**133.3**
16-11-02	NAWIN03FLDBLK	WINDERMERE CR	<0.50	<0.50	<0.0050	<1
	Blank QC	**X times > than RDL**	**1.0**	**1.0**	**1.0**	**1**

Appendix B2. Water quality data, non-metals

Stewardship Group	Sample Date (yy/mm/dd)	Site Code	Site Name	Nitrite (N)	Nitrate (N)	Alkalinity (Total as CaCO3)	Alkalinity (PP as CaCO3)	Bicarbonate (HCO3)	Carbonate (CO3)	Hydroxide (OH)	Orthophosphate (P)	Nitrate plus Nitrite (N)
			Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
			Guideline for protection of aquatic life^{avg}	BC App: 0.02 when chloride <2 mg/L (or see Guideline Table)	BC App: 3	-	-	-	-	-	-	BC App: 3
			Guideline for drinking water^{max}	HC: 1	HC: 10	-	-	-	-	-	-	BC App: 10
Wildsight Regional	2015-05-20	NAWIN03	WINDERMERE CR	<0.0050	0.169	-	-	-	-	-	-	0.169
Wildsight Regional	2015-06-08	NAWIN03	WINDERMERE CR	<0.0050	0.106	-	-	-	-	-	<0.0050	0.106
Wildsight Regional	2015-07-21	NAWINO3	WINDERMERE CR	<0.0050	0.118	-	-	-	-	-	<0.0050	0.118
Wildsight Regional	2015-08-04	NAWIN03	WINDERMERE CR	0.0149	0.121	-	-	-	-	-	<0.0050	0.136
Wildsight Regional	2015-08-19	NAWINO3	WINDERMERE CR	<0.0050	0.148	-	-	-	-	-	-	0.148
Wildsight Regional	2015-09-09	NAWIN03	WINDERMERE CR	<0.0050	0.151	168	<0.50	205	<0.50	<0.50	-	0.151
Wildsight Regional	2015-11-02	NAWINO3	WINDERMERE CR	<0.0050	0.17	-	-	-	-	-	-	0.170
Wildsight Regional	2016-05-25	NAWIN03	WINDERMERE CR	<0.0050	0.125	-	-	-	-	-	<0.0050	0.125
Wildsight Regional	2016-06-29	NAWIN03	WINDERMERE CR	<0.0050	0.116	-	-	-	-	-	<0.0050	0.116
Wildsight Regional	2016-07-13	NAWIN03	WINDERMERE CR	<0.0050	0.114	-	-	-	-	-	<0.0050	0.114
Wildsight Regional	2016-08-17	NAWIN03	WINDERMERE CR	<0.0050	0.126	-	-	-	-	-	<0.0050	0.126
Wildsight Regional	2016-11-02	NAWIN03	WINDERMERE CR	<0.0050	0.155	170	<0.50	207	<0.50	<0.50	<0.0050	0.155
Lk Ambassadors	2017-06-13	NAWIN03	WINDERMERE CR	<0.0050	0.113	-	-	-	-	-	<0.0050	0.113
Lk Ambassadors	2017-07-18	NAWIN03	WINDERMERE CR	<0.0050	0.109	-	-	-	-	-	<0.0050	0.109
Lk Ambassadors	2017-08-16	NAWINO3	WINDERMERE CR	<0.0050	0.104	-	-	-	-	-	<0.0050	0.104
Lk Ambassadors	2017-09-26	NAWIN03	WINDERMERE CR	<0.0050	0.115	170	<1.0	207	<1.0	<1.0	<0.0050	0.115
Lk Ambassadors	2017-10-18	NAWIN03	WINDERMERE CR	<0.0050	0.133	-	-	-	-	-	-	0.133

Appendix B2. Water quality data, non-metals

Sample Date (yy/mm/dd)	Dissolved Oxygen	Specific Conductivity	pH	Turbidity	Water Temperature	Air Temperature	Total Hardness (CaCO3)
	mg/L	uS/cm		NTU	C	C	mg/L
	BC App (**minimum**): 8 all stages other than buried embryo. 11 buried embryo not assessed, as spawning confirmation required.	-	BC App: 6.5-9.0.	BC App[1]: Change from background of 8 during clear flow period, and change of 5 during turbid flows	BC App: 19 max. See continuous temperature results for site specific fish species and lifestage guidelines.	-	-
	-	-	HC: 7-10.5	BC App[1]: Change of 1 when background is <5 NTU; change of 5 when background is >5 and <50; change of 10% when background is >50.	BC App^{AO}: 15	-	-
2015-05-20	10	934	9.1	1.4	12.5	23	-
2015-06-08	10	680	8.2	9.2	9.0	16	-
2015-07-21	8	590	8.2	2.0	10.0	15.5	539
2015-08-04	10	631	8.2	1.7	11.2	21	-
2015-08-19	11	623	8.2	1.4	9.9	18	-
2015-09-09	10	618	8.1	1.5	8.9	12	534
2015-11-02	5.5	5.85	8.7	5.6	5.7	3	-
2016-05-25	11	803	8.8	5.3	12.3	22	-
2016-06-29	9	774	8.3	3.5	13.4	28	473
2016-07-13	13	789	8.3	7.5	10.6	17	-
2016-08-17	9	590	8.2	10.4	10.8	21	-
2016-11-02	12	574	8.9	3.0	6.6	9	549
2017-06-13	10	897	8.2	33.0	10.5	20	389
2017-07-18	11	785	8.2	4.8	11.3	21	-
2017-08-16	8	835	8.5	2.3	10.0	16	-
2017-09-26	11	877	8.7	1.3	9.6	16	496
2017-10-18	9	908	8.7	2.3	6.3	8	-

Appendix B2. Water quality data, non-metals

Sample Date (yy/mm/dd)	Total Phosphorus (P)	Total Nitrogen (N)	Total Suspended Solids	Dissolved Sulphate (SO4)	Dissolved Chloride (Cl)	Total Ammonia (N)	E. coli
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	CFU
	CCME: Based on this data, the site is oligotrophic (0.004-0.01); exceedances of 1.5 times the upper value (or 0.015) indicates a potential problem.	-	BC App[1]: Change from background of: ≤ 25 for 24 hr during clear flow, or 10 for 24 hr during turbid period (when natural water is 25-100)	BC App (total sulphate): hardness 0-3 = 128, hardness 31-75 = 218, hardness 76-180 = 309, hardness 181-250 = 429	BC App: 150	BC App: 0.132 - 0.906 based on daily pH and temp, using guideline table.	-
	-	-	-	HC^{AO}: 500	BC App^{AO}: 250	-	BC App: 0
2015-05-20	-	0.283	<4.0	-	-	0.043	1
2015-06-08	0.0187	0.174	12.8	-	-	0.007	15
2015-07-21	<0.0050	0.136	<4.0	313	-	0.008	23
2015-08-04	<0.0050	0.164	<4.0	-	-	0.027	18
2015-08-19	<0.0050	0.166	<4.0	-	-	0.009	12
2015-09-09	<0.0050	0.203	<4.0	-	3.8	<0.0050	5
2015-11-02	-	0.191	4.3	-	-	0.010	2
2016-05-25	0.0055	0.239	5.3	-	-	0.007	1
2016-06-29	<0.0050	0.174	5.3	258	-	0.013	5
2016-07-13	<0.0050	0.15	5.3	-	-	0.023	12
2016-08-17	0.0065	0.151	14.8	-	-	0.120	39
2016-11-02	<0.0050	0.261	<4.0	336	-	0.059	2
2017-06-13	0.0307	0.237	42.0	187	-	0.021	2
2017-07-18	<0.0050	0.110	6.8	-	-	0.008	3
2017-08-16	<0.0050	0.166	<4.0	-	-	0.046	15
2017-09-26	<0.0050	0.214	<4.0	297 (1)	-	<0.020	3 (2)
2017-10-18	-	0.186	<4.0	-	-	<0.020	1

Appendix B3 - Water quality data, metals

Stewardship Group	Sample Date (yy/mm/dd)	Site Code	Site Name	Total Hardness (CaCO3)	Total Aluminum (Al)	Total Antimony (Sb)	Total Arsenic (As)	Total Barium (Ba)	Total Beryllium (Be)	Total Bismuth (Bi)	Total Boron (B)
			Units	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
			Guideline for protection of aquatic life^{avg}	-	BC App (**dissolved Al**): when pH is <6.5 = e[1.6-3.327 (median pH) + 0.402 (median pH)^2]. When pH ≥ 6.5 = 50.	BC Work: 9 (**antimony III**).	BC App: 5 (max)	BC Work: 1000	BC Work: 0.13	-	BC App: 1200
			Calculated aquatic life guideline (where required)	-	50	-	-	-	-	-	-
			Guideline for drinking water^{max}	-	BC App^{AO}: 9500	HC: 6	BC App: 10	HC: 1000	-	BC App: 5000	
Wildsight Regional	2015-07-21	NAWINO3	WINDERMERE CR	539	31.4	<0.50	2.50	30.5	<0.10	<1.0	<50
Wildsight Regional	2015-09-09	NAWIN03	WINDERMERE CR	534	9.1	<0.50	2.53	29.3	<0.10	<1.0	53
Wildsight Regional	2016-06-29	NAWIN03	WINDERMERE CR	473	42.6	<0.50	2.54	34.8	<0.10	<1.0	<50
Wildsight Regional	2016-11-02	NAWIN03	WINDERMERE CR	549	11.0	<0.50	2.71	30.5	<0.10	<1.0	61
Wildsight Regional	2017-06-13	NAWINO3	WINDERMERE CR	389	161.0	<0.50	2.47	87.2	<0.10	<1.0	<50
Wildsight Regional	2017-09-26	NAWIN03	WINDERMERE CR	496	8.0	<0.50	1.99	32.2	<0.10	<1.0	<50

Appendix B3 - Water quality data, metals

Sample Date (yy/mm/dd)	Total Cadmium (Cd)	Total Calcium (Ca)	Total Chromium (Cr)	Total Cobalt (Co)	Total Copper (Cu)	Total Iron (Fe)	Total Lead (Pb)	Total Lithium (Li)	Total Magnesium (Mg)	Total Manganese (Mn)	Total Mercury (Hg)
	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L
	CCME: 10{0.83(log[hardness]) – 2.46}	-	BC Work: 8.9 (**chromium III**)	BC App: 4.0	BC App: when hardness <50 = 2. Hardness >50 = (0.04 x hardness)	BC App^{max}: 1000	BC App: when hardness >8 = (3.31 + e(1.273 In [hardness] - 4.704).	-	-	BC App: (0.0044 x hardness + 0.605)x1000	CCME 0.026
	0.60	-	-	-	19.9	-	27.8	-	-	607.2	-
	HC: 5	-	HC: 50	-	BC App^{AO}: 1000	HC^{AO}: 300	BC App: 10	-	-	HC^{AO}: 50	BC App: 1
2015-07-21	<0.010	156	<1.0	<0.50	<0.50	383	<0.20	5.5	36.6	5.8	<0.010
2015-09-09	<0.010	152	<1.0	<0.50	0.74	26	0.28	6.1	37.7	3.4	<0.010
2016-06-29	<0.010	135	<1.0	<0.50	1.09	66	0.22	5.1	33.1	3.2	<0.010
2016-11-02	<0.010	159	<1.0	<0.50	<0.50	24	<0.20	6.2	36.5	2.3	<0.010
2017-06-13	<0.010	112	<1.0	<0.20	<0.50	335	2.37	3.7	26.7	14.4	<0.010
2017-09-26	<0.010	141	<1.0	<0.20	<0.50	25	<0.20	6.2	35.0	2.8	<0.010

Appendix B3 - Water quality data, metals

Sample Date (yy/mm/dd)	Total Molybdenum (Mo)	Total Nickel (Ni)	Total Potassium (K)	Total Selenium (Se)	Total Silicon (Si)	Total Silver (Ag)	Total Sodium (Na)	Total Strontium (Sr)	Total Sulphur (S)	Total Thallium (Tl)	Total Tin (Sn)	Total Titanium (Ti)	Total Uranium (U)	Total Vanadium (V)
	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L
	BC App: 1000	CCME: when hardness 0 to ≤ 60 = 25. Hardness > 60 to ≤ 180 = e{0.76[ln(hardness)]+1.06}. Hardness >180 = 150.	-	BC App. 2.0	-	BC App: when hardness <100 = 0.05. Hardness >100 = 1.5.	-	-	-	BC Work: 0.8	-	-	BC Work: 8.5	-
	-	150.0	-	-	-	1.5	-	-	-	-	-	-	-	-
	BC App: 250	-	-	BC App: 10	-	-	HC^{AO}: 200	-	-	-	-	-	HC: 20	-
2015-07-21	1.4	<1.0	0.979	0.13	3700	<0.020	3.37	1710	124	<0.050	<5.0	<5.0	1.12	<5.0
2015-09-09	1.3	<1.0	0.9	0.16	3470	<0.020	3.38	1770	121	<0.050	<5.0	<5.0	1.18	<5.0
2016-06-29	1.3	<1.0	0.81	0.21	3400	<0.020	2.69	1570	100	<0.050	<5.0	<5.0	1.06	<5.0
2016-11-02	1.4	<1.0	0.915	0.14	3350	<0.020	3.02	2070	132	<0.050	<5.0	<5.0	1.28	<5.0
2017-06-13	1.1	<1.0	0.761	0.23	3010	<0.020	1.64	1040	69.8	0.018	<5.0	<5.0	0.92	<5.0
2017-09-26	1.4	<1.0	0.919	0.13	3320	<0.020	2.81	1660	116	<0.010	<5.0	<5.0	1.17	<5.0

Appendix B3 - Water quality data, metals

Sample Date (yy/mm/dd)	Total Zinc (Zn)	Total Zirconium (Zr)
	µg/L	µg/L
	BC App: hardness <90 = 7.5. Hardness >90 = 7.5+0.75x(hardness - 90)	-
	312.5	-
	BC App^{AO}: 5000	-
2015-07-21	<5.0	<0.50
2015-09-09	<5.0	<0.50
2016-06-29	<5.0	<5.0
2016-11-02	<5.0	<5.0
2017-06-13	10.2	<0.10
2017-09-26	<5.0	<0.10