Silverton Creek
Water Quality Monitoring Report
2015 – 2017

Prepared by:

Lotic Environmental Ltd, Mainstreams Environmental Society, and Slocan Lake Stewardship Society

Prepared for:

The Columbia Basin Water Quality Monitoring Project

July 2018

Suggested Citation

McPherson, S.[1,], K. Baranowska[1], L. Duncan[2], and A. Meidinger[3]. 2018. Alexander Creek, water quality monitoring report 2015 to 2017. A Columbia Basin Water Quality Monitoring Project. Prepared by Lotic Environmental Ltd[1], Mainstreams Environmental Society[2], and the Slocan Lake Stewardship Society[3], 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 Silverton Creek monitoring project, conducted under the Columbia Basin Water Quality Monitoring Project (CBWQ):

- Ann Meidinger and Margaret Hartley of Slocan Lake Stewardship Society for organizing.
- CBWQ coordinators Jim and Laura Duncan for their valuable support;
- Volunteers Jody Cliff, Leah Main, Claire Peyton, Decker Butzner, Roy Meidinger, John Fyke and Greg Conroy for assistance in the monitoring.
- 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.

Contact Information

Slocan Lake Stewardship Society (slocanlss@gmail.com)
Ann Meidinger (meidingerann@gmail.com)
Website: www.slocanlakess.com

Columbia Basin Water Quality Monitoring Project
Laura Duncan (kootenaylaura@gmail.com)
Jim Duncan (jim.duncan9@me.com)
Website: www.cbwq.ca

Lotic Environmental Ltd.
Sherri McPherson, Senior Aquatic Biologist (sherri.mcpherson@lotic.co)

Columbia Basin Trust
Wendy Horan, Manager, Environment (whoran@cbt.org)

Columbia Basin Watershed Network
Website: www.cbwn.ca

Cover photo: Silverton Creek site NJSLV01, September, 2017

Project Highlights

The Columbia Basin Water Quality Monitoring Project (CBWQ) is an environmental stewardship project funded by the Columbia Basin Trust. Under the CBWQ, Mainstreams Environmental Society partnered with the Slocan lake Stewardship Society to conduct baseline water quality monitoring in Silverton Creek from 2015 to 2017. Silverton Creek was identified as a priority for monitoring since it is connected to the aquifer supplying the community water supply, is an important Bull Trout stream, has had historic mining, and is experiencing increasing development pressures (i.e., logging and recreational activity). Monitoring was conducted at NJSLV01, located at the downstream end of the creek, near the confluence with Slocan Lake. 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 streamflow).

The benthic macro-invertebrate monitoring results identified NJSLV01 as being potentially stressed in all three years sampled. This was evident with some differences from reference group conditions. Specifically, one to two taxa were absent that were expected, total abundance and the proportions of chironomidae taxa were higher than the reference group means, and the proportions of EPT taxa were lower than the reference groups mean.

Water quality showed some signs of potential concern at this site, particularly with the exceedances of the aquatic life guidelines for total cadmium and total zinc in all samples. However, to better determine if there is a potential concern for aquatic life, the dissolved fractions of these metals should be analyzed. Total phosphorus also exceeded the aquatic life guideline, but only in one sample. As well, *Escherichia coli* (*E. coli*) exceeded the drinking water guideline regularly. It was uncertain if the guideline exceedances were the result of anthropogenic influences, or represented normal background conditions. Because of the *E. coli* exceedances, it is recommended that water be disinfected prior to consumption.

Stream temperatures periodically exceeded the maximum guidelines for the protection of Bull Trout rearing and incubation, in August and September, respectively. Stream temperatures were also regularly lower than the Bull Trout minimum guideline for egg incubation during the winter months. However, this study did not review whether the monitoring site was actually used by this species for spawning. Fish would be expected to seek out suitable habitat elsewhere in the watershed. Not enough data were collected to identify a clear pattern in streamflow. The streamflow at NJSLV01 appeared to be highly influenced by precipitation events.

The three-year baseline monitoring program aids in providing an understanding of natural conditions and variation. This baseline will be valuable to help assess changes over time.

Contents

Table of Tables

Table of Figures

Table of Appendices

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 stream flow 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, the Slocan Lake Stewardship Society (or the stewardship group) conducted water quality monitoring in Silverton Creek from 2015 to 2017. 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 the data, 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 Silverton Creek background

Silverton Creek is located in the West Kootenay area of B.C, approximately 85 km north of Nelson. It is situated in the Selkirk Mountains and flows northwest into Slocan Lake (Figure 1). Silverton Creek exits the valley through a 'notch' in the bedrock east of the Village of Silverton, and then flows a short distance through its outwash delta of coarse sediments before entering Slocan Lake.

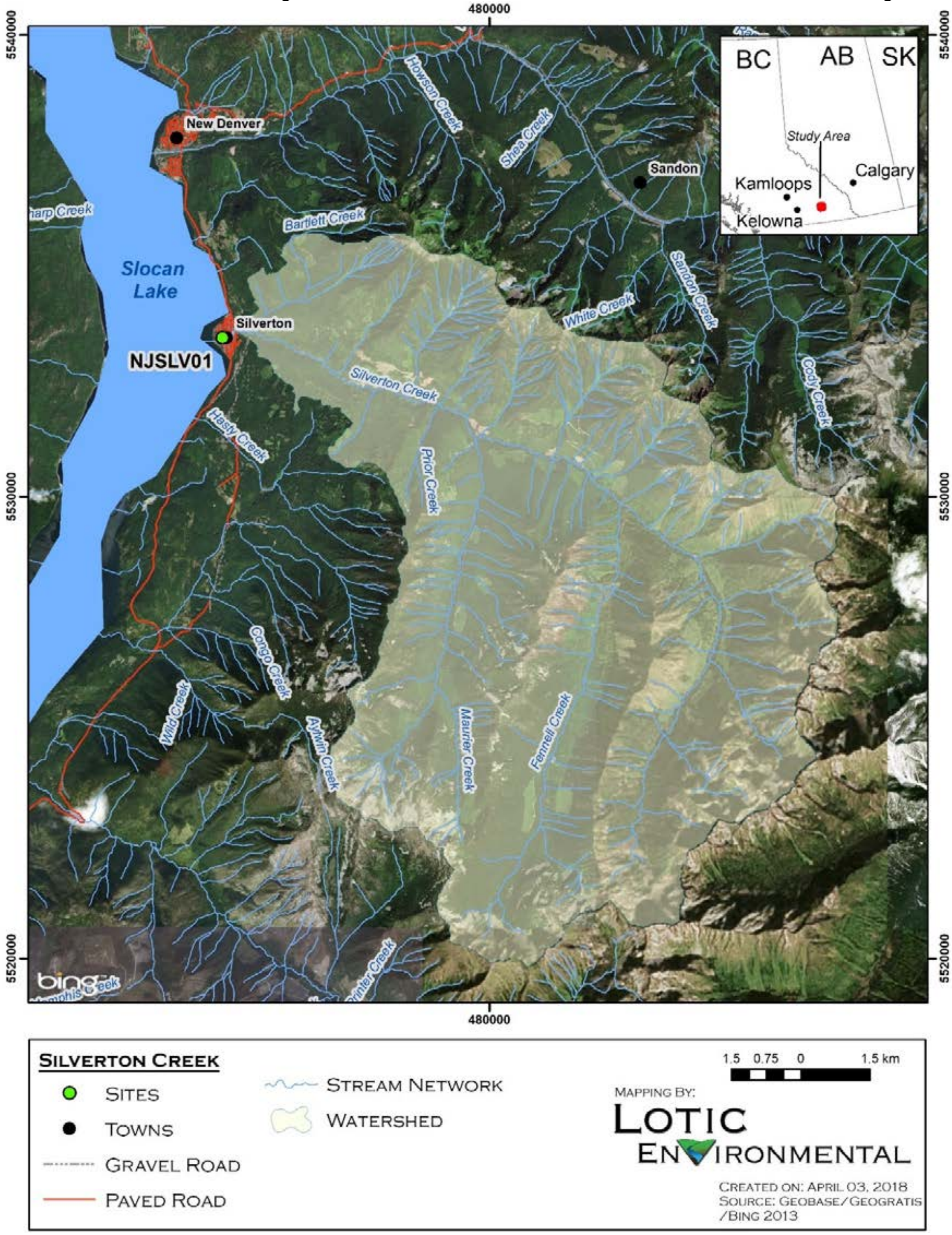

Figure 1. Silverton Creek monitoring location.

Silverton Creek feeds the groundwater aquifer, which is the water supply for the Village of Silverton (two wells are located near the creek outlet, through the bedrock notch). Silverton Creek is also important because it is a major spawning creek for an adfluvial population of blue-listed Bull Trout. The valley system is home to a variety of mountain species including Grizzly Bear, goats, elk, and cougar. Of note, in the winter of 2018, there was a sighting of Mountain Caribou.

Outside of the village of Silverton, the land in the watershed is mostly Provincial Crown Land. However, there are numerous old mine sites on the north side of the creek that are privately owned. A few of these sites are being maintained, but no ore has been extracted in the last three years. Other pressures in the watershed include logging and recreational use. Recreational activities use the extensive logging roads for access and include: hiking, skiing, snowmobiling, all-terrain vehicle (ATV) use, and mountain biking.

Monitoring was conducted at NJSLV01. This site was located near the confluence with Slocan Lake in the Village of Silverton (Figure 2). The site was selected because it was near the mouth of the creek and thus downstream of most uses that could influence creek health.

Figure 2. Downstream and across stream views, respectively, of NJSLV01 monitoring site, September 28, 2017. Sampling by Jody Cliff, Claire Peyton and John Fyke.

1.2 Fish community

Silverton Creek is a fourth order stream. The mainstem stream length is approximately 19 km, with no barriers to upstream fish migration through to its headwaters (BC Ministry of Environment [BC MoE] 2018). The fish community in Silverton Creek is comprised of six native species (Table 1).

Table 1. Fish species historically documented in Silverton Creek (Source: BC MoE 2018a)

Species - common name	Scientific name
Native species	
Bull Trout	*Salvelinus confluentus*
Westslope Cutthroat Trout	*Oncorhynchus clarkii lewisi*
Rainbow Trout	*O. mykiss*
Kokanee	*O. nerka*
Mountain Whitefish	*Prosopium williamsoni*
Sucker species	*Catostomus spp.*

Two 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). Additionally, 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).

2 Methods

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


Figure 3. Upstream view of NJSLV01 with Ann Meidinger, September 2016.

Overall, field data were collected following the CBWQ Operating Procedures (CBWQ 2012) and the CABIN Field Procedures for Wadeable Streams (Environment Canada 2012a). The Slocan lake Stewardship Society completed all the field work (Figure 3), 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 NJSLV01:

a. Monthly (spring through fall 2015 - 2016) – total suspended solids (TSS), nutrients, *Escherichia coli* (E. coli), dissolved chloride, and *in situ* (field measured) data. *In situ data* were dissolved oxygen (DO), water temperature, specific conductivity, pH, turbidity, and air temperature.
b. Monthly (spring through fall 2017) – *In situ*, nutrients, conductivity, dissolved calcium.
c. In June 2015, and again once per year in the fall (coinciding with CABIN monitoring) - in addition to data above, inorganics (alkalinity, bicarbonate, carbonate, and hydroxide) and total metals.
d. 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 Meter Stick 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, from the downstream side of the meter stick, as this area acts as a stilling well. The 'head' built up on the 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 4): 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.

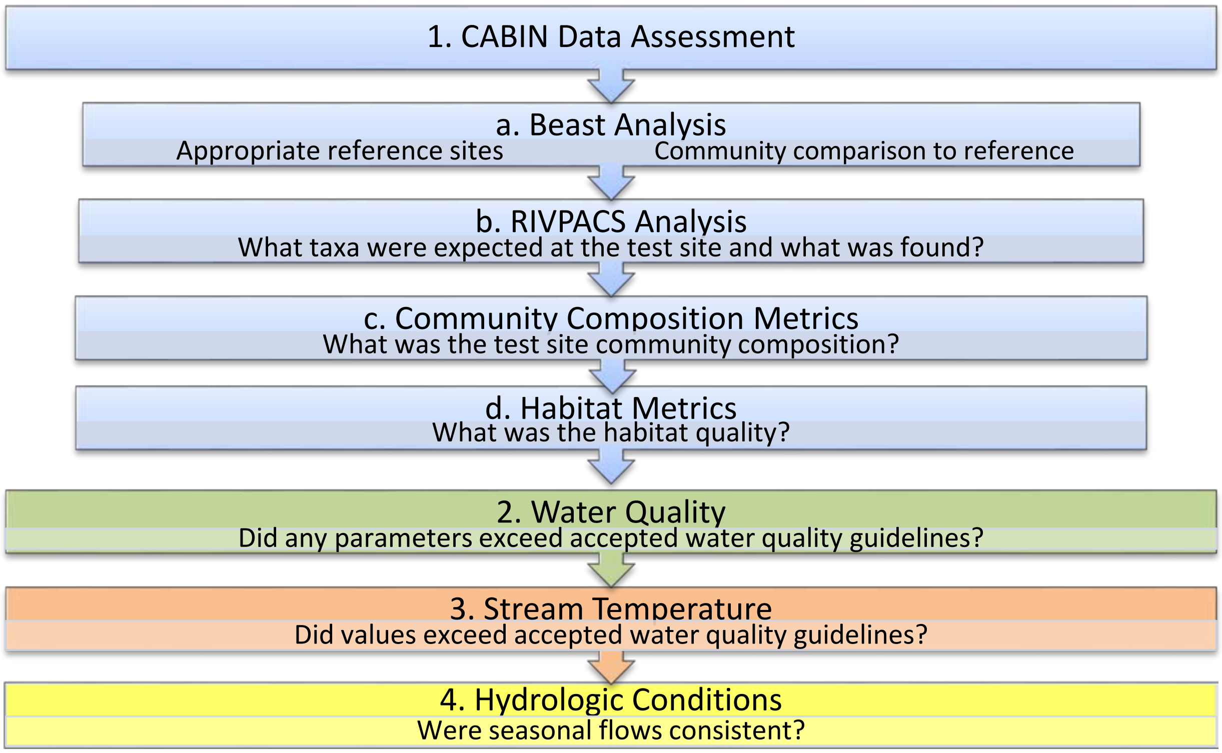

Figure 4. Stream condition analysis steps.

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 NJSLV01, CABIN BEAST analysis determined the highest probability of reference group membership was to Group 4 in all years (probabilities found in Table 2). The site was thus compared with Reference Group 4, which includes 12 streams, mostly from the Columbia Mountain and Highlands Ecoregion. The average channel depth of Reference Group 4 is 23.6 ± 11.1 cm (SD - standard deviation), which is similar to the test sites' average depths of 30.0 - 33.4 cm measured during the three years of monitoring. A comparison of other individual test site habitat attributes against those of the reference model, and the ordination plots are included in the Site Assessment Reports (Appendix A). The CABIN model assessed NJSLV01 as potentially stressed in 2015 and 2016, and unstressed in 2017. Based on the ordination plots, the results are very minimally outside of the reference group; with some years appearing to be right on the dividing line with being the same as the reference group or unstressed.

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
NJSLV01	**Potentially stressed** Group 4; 72.0%	**Potentially stressed** Group 4; 72.3%	**Unstressed** Group 4; 72.0%

3.1.2 RIVPACS analysis

The RIVPACS ratio at NJSLV01 was 0.89 in 2015, and 0.98 in 2016 and 2017 (Table 3). This indicates that most families of taxa expected to be present, based on the reference group, were found at the test site. In 2015 there were two families not present at the test site that were expected, and in 2016 and 2017 there was one family not represented. These results indicate good conditions.

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
NJSLV01	0.89 Capniidae, Rhyacophillidae	0.98 Chloroperlidae	0.98 Capniidae

***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.

Table 4. Benthic macro-invertebrate community composition metrics measured in 3 min kicknet samples, 2015 to 2017 at NJSLV01. Condition indicated as shaded background*

Metric	Reference Group 4 (Mean +/- SD)	NJSLV01		
		2015	2016	2017
Total abundance	587.4 ± 299.1	1185.7	950.0	1745.0
% EPT taxa	87.7 ± 7.4	72.6	75.0	71.0
% Chironomidae	7.4 ± 6.4	22.9	20.9	26.7
% of 2 dominant taxa	57.9 ± 14.2	42.8	48.2	62.9
Total number of taxa	19.3 ± 3.7	21.0	23.0	21.0

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

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. Total abundance at NJSLV01 ranged from 950 - 1186 organisms), and in all years was higher than the reference group mean (587.4 ± 299.1 organisms). There was no evidence of water quality nutrient enrichment to cause the high values. As well, the high zinc and cadmium concentrations did not appear to decrease abundance (see Section 3.2).

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. The percent EPT at NJSLV01 ranged from 71 - 75%, and was slightly lower than the reference group (87.7 ± 7.4 %). Conversely, Chironomidae (non-biting midges), are generally tolerant of pollution. At the test site, the proportion of Chironomidae ranged from 20.9 - 26.7 %; thus, in all years was higher than the reference group mean (7.4 ± 6.4 %). These differences support the model output of potentially stressed.

The relative occurrence of the two most abundant taxon 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 NJSLV01, the proportion of the two dominant taxa ranged from 42.2 - 62.9 %; these values were within the reference group mean (57.9 % ± 14.2 %), indicating a healthy community.

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 the test site amongst the years ranged from 21 - 23 taxa. These values were within the reference group mean (19.3 ±13.7 taxa), indicating healthy conditions.

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). Habitat conditions at the Silverton Creek monitoring site were similar amongst all years monitored and were comparable to the reference group mean. Percent silt and clay was only negligibly higher in 2016 and 2017 (3 %) than the reference group mean (0 ± 0 %). Overall, these habitat characteristics indicated good conditions for the invertebrate community.

Table 5. Select physical habitat characteristics for the predicted reference group, and NJSLV01.

Parameter	Reference group mean ± std dev	2015	2016	2017
Average depth (cm)	23.6 ± 11.1	30.0	33.4	30.0
Average velocity (m/s)	0.48 ± 0.22	0.64	0.65	0.60
% Cobble (6.4 - 25.6 cm)	51 ± 15	62	55	51
% Pebble (1.6 – 6.4 cm)	37 ± 20	33	19	27
% Gravel (0.2 – 1.6 cm)	3 ± 3	0	4	2
% Sand (0.1 – 0.2 cm)	0 ± 0	0	0	0
% silt and clay (<0.1 cm)	0 ± 0	0	3	3

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 2016 field blank parameters analyzed were all within the acceptable range of 2 times the method detection limits. These results indicated that the samples were contaminant free and analysed with precision.

3.2.2 Guideline review

Water quality results met all but two aquatic life and/or drinking water guidelines for the non-metal parameters (Appendix B2), and all but two guidelines for metal parameters (Appendix B3). Exceedance details are provided below. It was noted that turbidity stood out as indicating a stable environment, since values remained low (<6 NTU) even during the spring freshet period. Details on the exceedances are as follows:

Total Phosphorus: The total phosphorus guideline for the protection of aquatic life was not met in one out of the ten samples collected. 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 for the site (CCME 2004). Total phosphorus ranged from <0.005 - 0.0191 mg/L at NJSLV01. 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 occurred in September 2016, with a value of 0.0191 mg/L. The cause of the increased value is unknown, as it did not occur during the normal spring freshet period when nutrient loading into a watercourse is anticipated as a result of overland runoff. Since the exceedance was not prolonged and was only marginally higher than the guideline, aquatic life impacts are not expected. This data provides a valuable baseline for assessing long-term changes resulting from anthropogenic influences.

E coli: *The E. coli* drinking water guideline for raw untreated drinking water is 0 CFU/100 mL (BC MoE 2017). *E. coli* ranged from <1 - 15 CFU/100 mL at NJSLV01, with the guideline exceeded in 35% of 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 cadmium: In aquatic ecosystems, excess cadmium interferes with the uptake of calcium by organisms. In fish and aquatic invertebrates this results in cellular damage, decreases in metabolic activity, increased mortality, decreased growth, and decreased reproductive capacity and success (BC MoE 2018b). In aquatic plants and algae, cadmium uptake causes adverse effects by inhibiting photosynthesis, growth, and chlorophyll synthesis (BC MoE 2018b). Cadmium ranged from 0.091 - 0.215 µg/L at NJSLV01, exceeding the CCME calculated guideline for the protection of aquatic life of 0.09 µg/L. The values were considerably lower than the CCME short term (maximum) guideline of 0.93 µg/L. In BC, the approved water quality guideline relates to the dissolved form of this metal, as this is bioavailable. Future sampling should thus include dissolved metals to confirm if there is a potential concern to aquatic life.

Total zinc: Zinc ranks fourth among metals of the world in annual consumption, and is found in a wide array of products (BC MoE 2018b). Zinc is an essential element in trace amounts for plants and animals, but can be toxic in high concentrations (BC MoE 2018b). Zinc ranged from 9.6 – 15.0 µg/L at NJSLV01, exceeding the calculated BC approved guideline for the protection of aquatic life of 7.5 µg/L. Zinc concentrations were considerably lower than the short term (maximum) guideline of 33 µg/L. Soluble or dissolved zinc is readily available for biological reactions and therefore considered most toxic (BC MoE 2018b). The zinc guideline may also be interpreted in terms of the dissolved metal fraction when the total zinc concentration in the environment exceeds the guideline (BC MoE 2018b). For these reasons, future sampling could include dissolved metal analysis to confirm if there is a potential concern to aquatic life.

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.

Water temperature was monitored intermittently in 2015, and then more consistently in 2016 to 2017 at NJSLV01 (Table 6). 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) from 2015 – 2017 at NJSLV01.

Month	2015		2016		2017	
	Avg	Std Dev	Avg	Std Dev	Avg	Std Dev
January	-	-	-	-	1.01	0.85
February	-	-	-	-	1.14	0.82
March	-	-	-	-	2.39	14978.39
April	5.47	0.40	-	-	4.39	0.61
May	-	-	-	-	5.33	0.58
June	-	-	8.32	1.15	7.30	1.11
July	12.35	0.93	10.70	0.92	11.37	0.80
August	12.66	1.17	11.70	0.61	12.28	0.90
September	8.74	1.14	11.70	0.93	11.24	2.46
October	8.32	0.76	9.08	1.14	6.24	1.22
November	-	-	9.34	1.05	-	-
December	-	-	4.42	0.91	-	

*Data were collected for only part of the month

Because of Bull Trout's presence in Silverton Creek, the temperature data were compared to the guidelines for streams with Bull Trout. In general, the maximum daily Bull Trout rearing temperature of 15 ºC was exceeded during the height of the summer in August (Figure 5). These fish likely seek out cooler waters (e.g., in deep pools), during the warm summer months.

Bull Trout spawning generally occurs from mid-September to late October and often is initiated when water temperatures drop below 9 ºC (McPhail 2007). The maximum daily stream temperatures at NJSLV01 typically did exceed optimal spawning temperature guidelines (i.e. a max daily temperature of 10 ºC) at the start of the spawning season. 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. Bull Trout egg incubation period is temperature dependant, taking 119-126 days at 2 ºC, 92-95 days at 6 ºC, 74-76 days at 6 ºC, 74-78 days at 8 ºC, and 70 days at 10 ºC (McPhail 2007). After hatching, fry remain in the gravel and generally emerge in June. Based on the available winter stream temperature data collected (2016 only), the guideline for minimum temperature during incubation of 2 ºC was generally not met from December through February at the monitoring site. 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 5ºC) (Meisner et al. 1988).

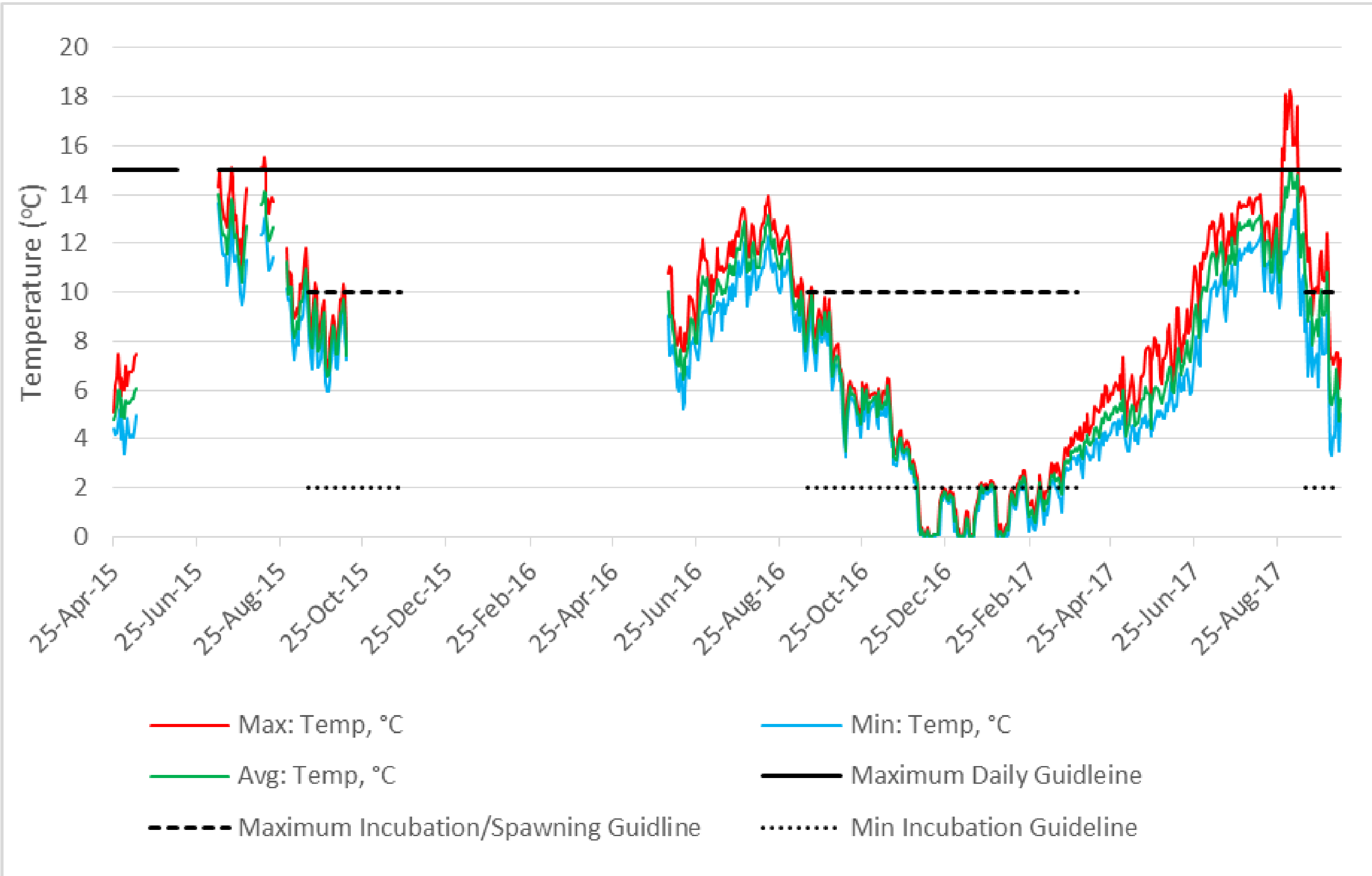

Figure 5. Daily average stream temperatures in Silverton Creek (NJSLV01) from April 25, 2015 to October 10, 2017. The guidelines presented are for the protection of aquatic life for streams with Bull Trout present (BC MoE 2018b).

3.4 Hydrometric results

Figure 6. Sampling stream flow mid-summer at NJSLV01.

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).

The CBWQ generally aimed to collect instantaneous streamflow data monthly from spring through fall. The results showed variability in streamflow patterns amongst the three years sampled at NJSLV01 (Figure 7). Freshet (i.e. high flows due to snowmelt and/or heavy rain) could not be collected for safety reasons, but occurred April – June. Following this, flows decreased, but had intermittent increases, which were likely influenced by precipitation events.

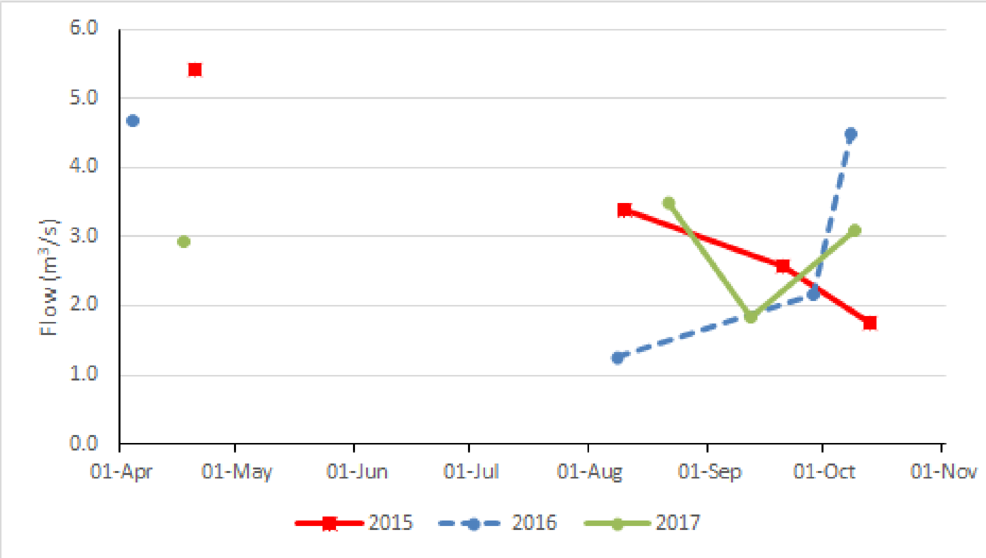

Figure 7. Streamflow at NJSLV01, 2015-2017. No measurements were collected during the spring high flow period, due to safety concerns.

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 monitoring results identified NJSLV01 as being potentially stressed in all three years sampled (2015 to 2017). This was evident with some deviations from reference group conditions. Specifically, one to two taxa were absent that were expected, total abundance and the proportions of chironomidae taxa were higher than the reference group means, and the proportions of EPT taxa were lower than the reference groups mean. Physical habitat conditions were similar to the reference group mean, and did not seem to influence the potentially stressed conditions.

Overall, the water quality showed some signs of potential concern at this site. Three aquatic life guidelines were exceeded. These were total cadmium and total zinc in all samples, and total phosphorus in one sample. Total abundance of benthic macro-invertebrates did not appear to be negatively influenced/reduced by the elevated metal values. One drinking water guideline was regularly exceeded (*E. coli*). The guideline exceedances should be reviewed further if there is concern of anthropogenic activities causing elevated values in the watershed. Otherwise they may simply represent normal background conditions.

Stream temperatures periodically exceeded the maximum guidelines for the protection of Bull Trout rearing and incubation, in August, and September, respectively. The Bull Trout minimum stream temperature guideline for egg incubation was also regularly not met during the winter months. However, this study did not review whether the monitoring site was actually used by this species for spawning. Fish would be expected to seek out suitable habitat elsewhere in the watershed. Not enough data were collected to identify a clear pattern in streamflow. The streamflow at NJSLV01 appeared to be highly influenced by precipitation events.

5 Recommendations

The existing monitoring program was very useful for developing a baseline. Three years of monitoring provides a good picture of aquatic invertebrate health and water quality, assuming that the years captured were relatively representative of general conditions in the watershed and there were no changes in land-use during the years monitored. This information can be used in the future to identify if there are any water quality or benthic macro-invertebrate changes caused by increased disturbance. Obtaining data over a longer period, would help provide a greater understanding of natural variability in the system over time, but we recognize that resources are limited and a three-year period is realistic and achievable. Once baseline data have been attained, sampling should be focussed on other locations experiencing ongoing development pressures.

There is a variety of other information that could potentially be collected to support a baseline understanding of a watershed. This may include, but not be limited to:

1) Collecting dissolved metal water quality data, to confirm if there is a potential concern to aquatic life associated with cadmium and zinc. It is likely that dissolved metal values will be lower, and will meet the guidelines.
2) Determining the hydrologic regime of the stream using continuous level loggers.
3) Conducting fish habitat assessments.
4) Conducting fish assessments (e.g., composition, abundance and life-history use).

The Slocan lake Stewardship Society 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 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 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/.

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.

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.

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.

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.

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.

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

Swain, L. G. 2007. Water Quality Assessment of Elk River at Highway 93 near Elko (1968-2005). BC Ministry of Environment and Environment Canada.

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-Upper Slocan
Site	NJSLV01
Sampling Date	Sep 20 2015
Know Your Watershed Basin	Slocan
Province / Territory	British Columbia
Terrestrial Ecological Classification	Montane Cordillera EcoZone Columbia Mountains and Highlands EcoRegion
Coordinates (decimal degrees)	49.95278 N, 117.35950 W
Altitude	1788
Local Basin Name	Silverton Cr
	Slocan
Stream Order	4

Figure 1. Location Map

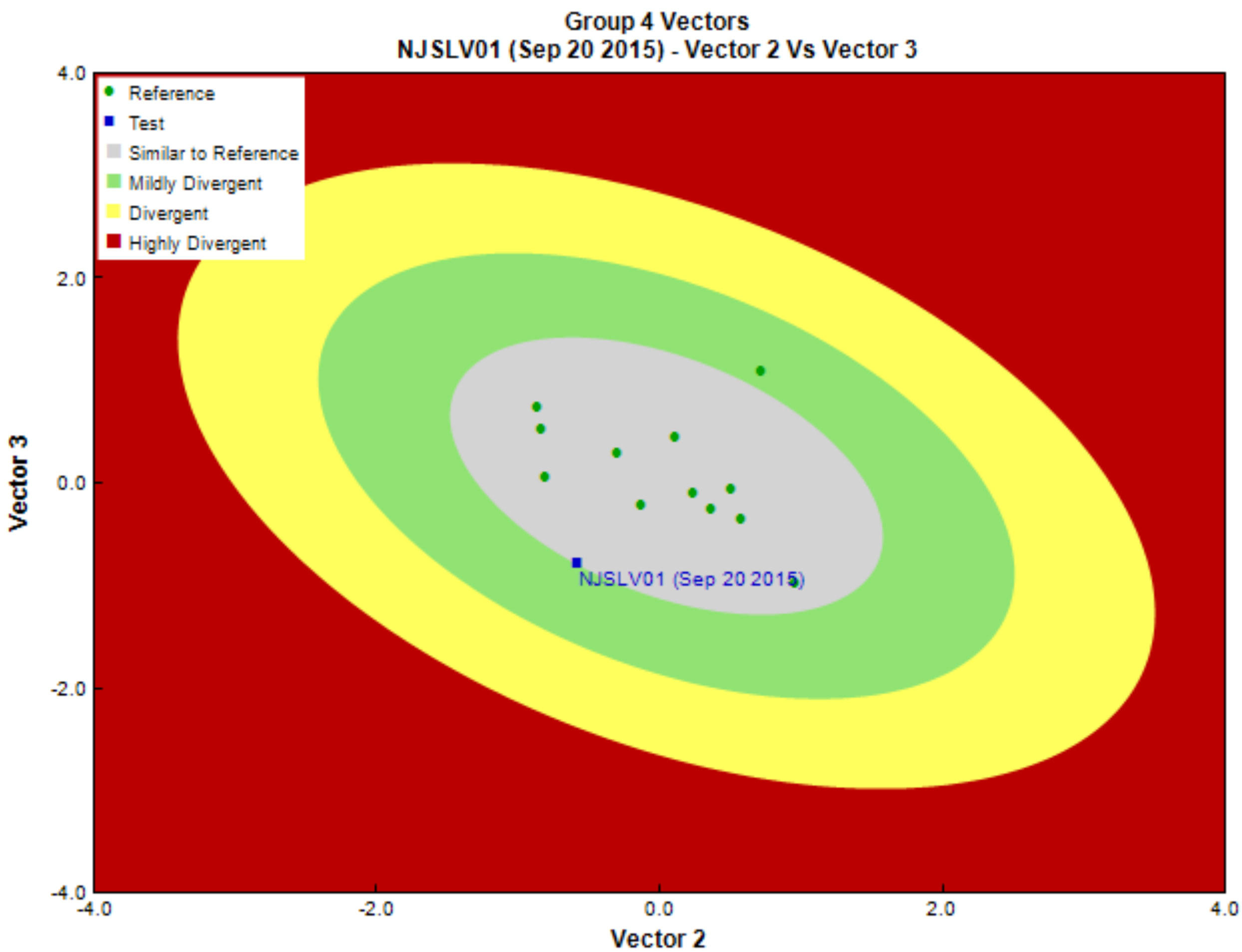

Figure 3. CABIN ordination assessment of the test site with the predicted group of reference sites. Each axis represents the relative abundance of the entire benthic invertebrate community with different organisms weighted differently on each axis.

Sample Information

Sampling Device	Kick Net
Mesh Size	400
Sampling Time	3
Taxonomist	-
Date Taxonomy Completed	-
	-
Sub-Sample Proportion	28/100

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
Annelida	Oligochaeta	Lumbriculida	Lumbriculidae	1	3.6
Arthropoda	Insecta	Coleoptera	Elmidae	1	3.6
		Diptera	Ceratopogonidae	1	3.6
			Chironomidae	76	271.4
			Empididae	2	7.2
			Psychodidae	1	3.6
			Tipulidae	9	32.1
		Ephemeroptera	Baetidae	62	221.5
			Ephemerellidae	11	39.3
			Heptageniidae	66	235.8
		Plecoptera	Chloroperlidae	5	17.8
			Leuctridae	4	14.3
			Nemouridae	7	24.9
			Perlidae	2	7.2
			Perlodidae	1	3.6

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
			Taeniopterygidae	25	89.3
		Trichoptera	Apataniidae	1	3.6
			Glossosomatidae	2	7.1
			Hydropsychidae	2	7.1
			Lepidostomatidae	13	46.4
			Uenoidae	40	142.9
			Total	332	1,185.9

Metrics

Name	NJSLV01	Predicted Group Reference Mean ±SD
Bray-Curtis Distance	0.48	0.4 ± 0.1
Biotic Indices		
Hilsenhoff Family index (North-West)	3.5	3.2 ± 0.3
Intolerant taxa	--	
Long-lived taxa	3.0	2.1 ± 1.0
Tolerant individuals (%)	--	
Functional Measures		
% Filterers	0.6	
% Gatherers	53.3	
% Predatores	26.8	
% Scrapers	61.1	
% Shredder	18.1	
No. Clinger Taxa	27.0	23.2 ± 6.3
Number Of Individuals		
% Chironomidae	22.9	7.4 ± 6.4
% Coleoptera	0.3	1.5 ± 3.9
% Diptera + Non-insects	27.1	10.8 ± 7.6
% Ephemeroptera	41.9	51.7 ± 18.8
% Ephemeroptera that are Baetidae	44.6	40.6 ± 30.0
% EPT Individuals	72.6	87.7 ± 7.4
% Odonata	--	0.0 ± 0.0
% of 2 dominant taxa	42.8	57.9 ± 14.2
% of 5 dominant taxa	81.0	81.6 ± 7.9
% of dominant taxa	22.9	39.8 ± 14.9
% Plecoptera	13.3	31.4 ± 15.4
% Tribe Tanyatarisini	--	
% Trichoptera that are Hydropsychida	3.4	27.0 ± 26.2
% Tricoptera	17.5	4.5 ± 2.8
No. EPT individuals/Chironomids+EPT Individuals	0.8	0.9 ± 0.1
Total Abundance	1185.7	587.4 ± 299.1
Richness		
Chironomidae taxa (genus level only)	1.0	1.0 ± 0.0
Coleoptera taxa	1.0	0.4 ± 0.5
Diptera taxa	5.0	3.3 ± 1.0
Ephemeroptera taxa	3.0	3.8 ± 0.8
EPT Individuals (Sum)	860.7	526.0 ± 285.8
EPT taxa (no)	14.0	13.3 ± 2.7
Odonata taxa	--	0.0 ± 0.0
Pielou's Evenness	0.7	0.7 ± 0.1
Plecoptera taxa	6.0	6.3 ± 1.1
Shannon-Wiener Diversity	2.2	1.9 ± 0.4
Simpson's Diversity	0.8	0.8 ± 0.1
Simpson's Evenness	0.3	0.3 ± 0.1
Total No. of Taxa	21.0	19.3 ± 3.7
Trichoptera taxa	5.0	3.2 ± 1.4

Frequency and Probability of Taxa Occurrence

Reference Model Taxa	Frequency of Occurrence in Reference Sites					Probability Of Occurrence at NJSLV01
	Group 1	Group 2	Group 3	Group 4	Group 5	
Baetidae	100%	100%	100%	100%	97%	1.00

Frequency and Probability of Taxa Occurrence

Reference Model Taxa	Frequency of Occurrence in Reference Sites					Probability Of Occurrence at NJSLV01
	Group 1	Group 2	Group 3	Group 4	Group 5	
Capniidae	78%	55%	50%	92%	68%	0.83
Chironomidae	100%	100%	100%	100%	95%	0.99
Chloroperlidae	78%	88%	94%	100%	100%	0.99
Ephemerellidae	78%	100%	100%	100%	100%	1.00
Heptageniidae	100%	100%	100%	100%	100%	1.00
Hydropsychidae	11%	92%	78%	92%	86%	0.89
Nemouridae	100%	100%	100%	100%	100%	1.00
Perlidae	11%	84%	33%	100%	3%	0.77
Perlodidae	78%	78%	89%	92%	81%	0.89
Rhyacophilidae	100%	92%	100%	100%	95%	0.99
Taeniopterygidae	89%	49%	100%	92%	97%	0.93

RIVPACS Ratios

RIVPACS : Expected taxa P>0.50	13.63
RIVPACS : Observed taxa P>0.50	13.00
RIVPACS : O:E (p > 0.5)	0.95
RIVPACS : Expected taxa P>0.70	11.28
RIVPACS : Observed taxa P>0.70	10.00
RIVPACS : O:E (p > 0.7)	0.89

Habitat Description

Variable	NJSLV01	Predicted Group Reference Mean ±SD
Channel		
Depth-Avg (cm)	30.0	23.6 ± 11.1
Depth-BankfullMinusWetted (cm)	52.00	51.38 ± 29.42
Depth-Max (cm)	58.0	34.6 ± 12.3
Macrophyte (PercentRange)	0	0 ± 0
Reach-%CanopyCoverage (PercentRange)	1.00	1.33 ± 0.78
Reach-DomStreamsideVeg (Category (1-4))	1	4 ± 1
Reach-Pools (Binary)	1	1 ± 0
Reach-Rapids (Binary)	1	0 ± 0
Reach-Riffles (Binary)	1	1 ± 0
Reach-StraightRun (Binary)	1	1 ± 1
Slope (m/m)	0.0160000	0.0988017 ± 0.1465915
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)	0.64	0.48 ± 0.22
Velocity-Max (m/s)	0.99	0.76 ± 0.36
Width-Bankfull (m)	15.2	13.4 ± 9.9
Width-Wetted (m)	13.5	8.5 ± 5.8
XSEC-VelMethod (Category (1-3))	1	1 ± 0
Landcover		
Reg-Ice (%)	0.00000	0.02487 ± 0.06034
Substrate Data		
%Bedrock (%)	0	0 ± 0
%Boulder (%)	5	9 ± 9
%Cobble (%)	62	51 ± 15
%Gravel (%)	0	3 ± 3
%Pebble (%)	33	37 ± 20
%Sand (%)	0	0 ± 0
%Silt+Clay (%)	0	0 ± 0
D50 (cm)	8.25	14.58 ± 14.69
Dg (cm)	8.4	8.2 ± 2.8
Dominant-1st (Category(0-9))	6	7 ± 1
Dominant-2nd (Category(0-9))	7	7 ± 1
Embeddedness (Category(1-5))	3	5 ± 1
PeriphytonCoverage (Category(1-5))	2	1 ± 0

Habitat Description

Variable	NJSLV01	Predicted Group Reference Mean ±SD
SurroundingMaterial (Category(0-9))	3	4 ± 1
Topography		
Reg-SlopeLT30% (%)	12.49000	18.88386 ± 9.29866
Water Chemistry		
Ag (mg/L)	0.0100000	0.0000000 ± 0.0000000
Al (mg/L)	8.2000000	0.0000000 ± 0.0000000
As (mg/L)	0.3800000	0.0000000 ± 0.0000000
B (mg/L)	25.0000000	0.0000000 ± 0.0000000
Ba (mg/L)	11.2000000	0.0000000 ± 0.0000000
Be (mg/L)	0.0500000	0.0000000 ± 0.0000000
Bi (mg/L)	0.5000000	0.0000000 ± 0.0000000
Ca (mg/L)	16.3000000	0.0000000 ± 0.0000000
Cd (mg/L)	0.1630000	0.0000000 ± 0.0000000
Chloride-Dissolved (mg/L)	1.6000000	0.9750000 ± 2.6309780
Co (mg/L)	0.2500000	0.0000000 ± 0.0000000
CO3 (mg/L)	0.2500000	0.0000000 ± 0.0000000
Cr (mg/L)	0.5000000	0.0000000 ± 0.0000000
Cu (mg/L)	0.2500000	0.0000000 ± 0.0000000
Fe (mg/L)	14.0000000	0.0000000 ± 0.0000000
General-Alkalinity (mg/L)	41.0000000	71.7000000 ± 53.9231440
General-DO (mg/L)	10.0000000	11.4175000 ± 0.7986708
General-Hardness (mg/L)	49.1000000	84.2750000 ± 70.6251066
General-pH (pH)	8.3	7.9 ± 0.4
General-SolidsTSS (mg/L)	2.0000000	0.8849836 ± 1.2378575
General-SpCond (µS/cm)	88.6000000	168.9833333 ± 123.7858182
General-TempAir (Degrees Celsius)	15.8	26.0
General-TempWater (Degrees Celsius)	9.4000000	7.3183333 ± 2.7240839
General-Turbidity (NTU)	0.4100000	0.2020000
HCO3 (mg/L)	50.0000000	0.0000000 ± 0.0000000
Hg (ng/L)	0.0050000	0.0000000 ± 0.0000000
K (mg/L)	1.1700000	0.0000000 ± 0.0000000
Li (mg/L)	2.5000000	0.0000000 ± 0.0000000
Mg (mg/L)	2.0500000	0.0000000 ± 0.0000000
Mn (mg/L)	0.5000000	0.0000000 ± 0.0000000
Mo (mg/L)	1.1000000	0.0000000 ± 0.0000000
Na (mg/L)	1.3400000	0.0000000 ± 0.0000000
Ni (mg/L)	0.5000000	0.0000000 ± 0.0000000
Nitrogen-NO2 (mg/L)	0.0025000	0.0027500 ± 0.0062831
Nitrogen-NO2+NO3 (mg/L)	0.0100000	0.0690000
Nitrogen-NO3 (mg/L)	0.0100000	0.0546667 ± 0.0498148
Nitrogen-TN (mg/L)	0.0950000	0.0000000 ± 0.0000000
Pb (mg/L)	0.3300000	0.0000000 ± 0.0000000
Phosphorus-OrthoP (mg/L)	2.5050000	0.0002727 ± 0.0004671
Phosphorus-TP (mg/L)	0.0025000	0.0045833 ± 0.0049992
S (mg/L)	1.5000000	0.0000000 ± 0.0000000
Sb (mg/L)	0.2500000	0.0000000 ± 0.0000000
Se (mg/L)	0.5200000	0.0000000 ± 0.0000000
Si (mg/L)	3540.0000000	0.0000000 ± 0.0000000
Sn (mg/L)	2.5000000	0.0000000 ± 0.0000000
Sr (mg/L)	122.0000000	0.0000000 ± 0.0000000
Ti (mg/L)	2.5000000	0.0000000 ± 0.0000000
Tl (mg/L)	0.0250000	0.0000000 ± 0.0000000
U (mg/L)	0.5900000	0.0000000 ± 0.0000000
V (mg/L)	2.5000000	0.0000000 ± 0.0000000
Zn (mg/L)	12.1000000	0.0000000 ± 0.0000000
Zr (mg/L)	0.2500000	0.0000000 ± 0.0000000

Site Description

Study Name	CBWQ-Upper Slocan
Site	NJSLV01
Sampling Date	Sep 28 2016
Know Your Watershed Basin	Slocan
Province / Territory	British Columbia
Terrestrial Ecological Classification	Montane Cordillera EcoZone Columbia Mountains and Highlands EcoRegion
Coordinates (decimal degrees)	49.95278 N, 117.35944 W
Altitude	1788
Local Basin Name	Silverton Cr
	Slocan
Stream Order	4

Figure 1. Location Map

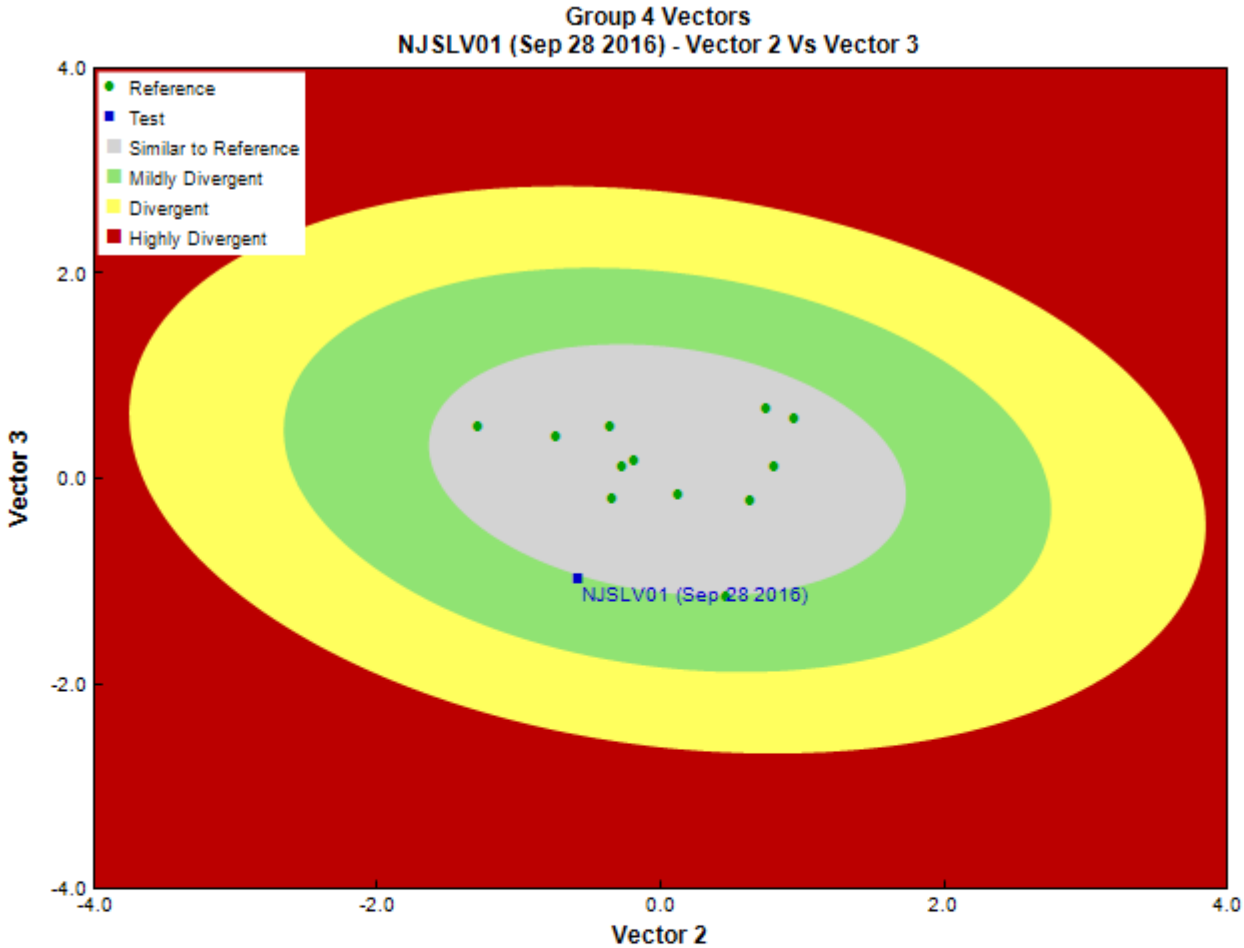

Figure 3. CABIN ordination assessment of the test site with the predicted group of reference sites. Each axis represents the relative abundance of the entire benthic invertebrate community with different organisms weighted differently on each axis.

Sample Information

Sampling Device	Kick Net
Mesh Size	400
Sampling Time	3
Taxonomist	Pina Viola, Consultant
Date Taxonomy Completed	October 09, 2016
	Marchant Box
Sub-Sample Proportion	36/100

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
Annelida	Oligochaeta	Enchytraeida	Enchytraeidae	1	2.8
Arthropoda	Arachnida	Trombidiformes	Sperchontidae	1	2.8
	Insecta	Diptera	Chironomidae	71	197.2
			Empididae	1	2.8
			Psychodidae	3	8.3
			Simuliidae	1	2.8
			Tipulidae	7	19.4
		Ephemeroptera	Baetidae	56	155.6
			Ephemerellidae	18	50.0
			Heptageniidae	23	63.9
		Plecoptera		2	5.6
			Capniidae	2	5.6
			Leuctridae	2	5.6
			Nemouridae	15	41.6
			Perlidae	7	19.4

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
			Perlodidae	5	13.9
			Taeniopterygidae	13	36.1
		Trichoptera	Apataniidae	3	8.3
			Glossosomatidae	1	2.8
			Hydropsychidae	2	5.6
			Lepidostomatidae	9	25.0
			Philopotamidae	1	2.8
			Rhyacophilidae	5	13.9
			Uenoidae	93	258.3
			Total	342	950.1

Metrics

Name	NJSLV01	Predicted Group Reference Mean ±SD
Bray-Curtis Distance	0.51	0.4 ± 0.1
Biotic Indices		
Hilsenhoff Family index (North-West)	2.8	3.2 ± 0.3
Intolerant taxa	--	
Long-lived taxa	2.0	2.1 ± 1.0
Tolerant individuals (%)	--	0.8 ± 0.3
Functional Measures		
% Filterers	1.2	2.2 ± 1.8
% Gatherers	64.6	38.4 ± 12.4
% Predatores	27.2	19.0 ± 8.5
% Scrapers	55.6	63.2 ± 19.7
% Shredder	14.9	27.6 ± 15.2
No. Clinger Taxa	29.0	23.2 ± 6.3
Number Of Individuals		
% Chironomidae	20.9	7.4 ± 6.4
% Coleoptera	0.0	1.5 ± 3.9
% Diptera + Non-insects	25.0	10.8 ± 7.6
% Ephemeroptera	28.5	51.7 ± 18.8
% Ephemeroptera that are Baetidae	57.7	40.6 ± 30.0
% EPT Individuals	75.0	87.7 ± 7.4
% Odonata	0.0	0.0 ± 0.0
% of 2 dominant taxa	48.2	57.9 ± 14.2
% of 5 dominant taxa	76.8	81.6 ± 7.9
% of dominant taxa	27.4	39.8 ± 14.9
% Plecoptera	12.9	31.4 ± 15.4
% Tribe Tanyatarisini	--	
% Trichoptera that are Hydropsychida	1.8	27.0 ± 26.2
% Tricoptera	33.5	4.5 ± 2.8
No. EPT individuals/Chironomids+EPT Individuals	0.8	0.9 ± 0.1
Total Abundance	950.0	587.4 ± 299.1
Richness		
Chironomidae taxa (genus level only)	1.0	1.0 ± 0.0
Coleoptera taxa	0.0	0.4 ± 0.5
Diptera taxa	5.0	3.3 ± 1.0
Ephemeroptera taxa	3.0	3.8 ± 0.8
EPT Individuals (Sum)	708.3	526.0 ± 285.8
EPT taxa (no)	16.0	13.3 ± 2.7
Odonata taxa	0.0	0.0 ± 0.0
Pielou's Evenness	0.7	0.7 ± 0.1
Plecoptera taxa	6.0	6.3 ± 1.1
Shannon-Wiener Diversity	2.2	1.9 ± 0.4
Simpson's Diversity	0.8	0.8 ± 0.1
Simpson's Evenness	0.3	0.3 ± 0.1
Total No. of Taxa	23.0	19.3 ± 3.7
Trichoptera taxa	7.0	3.2 ± 1.4

Frequency and Probability of Taxa Occurrence

Reference Model Taxa	Frequency of Occurrence in Reference Sites					Probability Of Occurrence at NJSLV01
	Group 1	Group 2	Group 3	Group 4	Group 5	
Baetidae	100%	100%	100%	100%	97%	1.00
Capniidae	78%	55%	50%	92%	68%	0.83
Chironomidae	100%	100%	100%	100%	95%	0.99
Chloroperlidae	78%	88%	94%	100%	100%	0.99
Ephemerellidae	78%	100%	100%	100%	100%	1.00
Heptageniidae	100%	100%	100%	100%	100%	1.00
Hydropsychidae	11%	92%	78%	92%	86%	0.89
Nemouridae	100%	100%	100%	100%	100%	1.00
Perlidae	11%	84%	33%	100%	3%	0.77
Perlodidae	78%	78%	89%	92%	81%	0.89
Rhyacophilidae	100%	92%	100%	100%	95%	0.99
Taeniopterygidae	89%	49%	100%	92%	97%	0.93

RIVPACS Ratios

RIVPACS : Expected taxa P>0.50	13.63
RIVPACS : Observed taxa P>0.50	14.00
RIVPACS : O:E (p > 0.5)	1.03
RIVPACS : Expected taxa P>0.70	11.28
RIVPACS : Observed taxa P>0.70	11.00
RIVPACS : O:E (p > 0.7)	0.98

Habitat Description

Variable	NJSLV01	Predicted Group Reference Mean ±SD
Channel		
Depth-Avg (cm)	33.4	23.6 ± 11.1
Depth-BankfullMinusWetted (cm)	50.00	51.38 ± 29.42
Depth-Max (cm)	41.0	34.6 ± 12.3
Macrophyte (PercentRange)	0	0 ± 0
Reach-%CanopyCoverage (PercentRange)	1.00	1.33 ± 0.78
Reach-DomStreamsideVeg (Category (1-4))	1	4 ± 1
Reach-Pools (Binary)	1	1 ± 0
Reach-Rapids (Binary)	1	0 ± 0
Reach-Riffles (Binary)	1	1 ± 0
Reach-StraightRun (Binary)	1	1 ± 1
Slope (m/m)	0.0160000	0.0546683 ± 0.0376269
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)	0.65	0.48 ± 0.22
Velocity-Max (m/s)	0.77	0.76 ± 0.36
Width-Bankfull (m)	13.5	13.4 ± 9.9
Width-Wetted (m)	9.9	8.5 ± 5.8
XSEC-VelMethod (Category (1-3))	1	1 ± 0
Landcover		
Reg-Ice (%)	0.00000	0.02487 ± 0.06034
Substrate Data		
%Bedrock (%)	0	0 ± 0
%Boulder (%)	19	9 ± 9
%Cobble (%)	55	51 ± 15
%Gravel (%)	4	3 ± 3
%Pebble (%)	19	37 ± 20
%Sand (%)	0	0 ± 0
%Silt+Clay (%)	3	0 ± 0
D50 (cm)	11.00	15.12 ± 14.26
Dg (cm)	9.3	8.2 ± 2.8
Dominant-1st (Category(0-9))	6	7 ± 1
Dominant-2nd (Category(0-9))	7	7 ± 1
Embeddedness (Category(1-5))	4	5 ± 1

Habitat Description

Variable	NJSLV01	Predicted Group Reference Mean ±SD
PeriphytonCoverage (Category(1-5))	3	1 ± 0
SurroundingMaterial (Category(0-9))	3	4 ± 1
Topography		
Reg-SlopeLT30% (%)	12.49000	18.88386 ± 9.29866
Water Chemistry		
Ag (mg/L)	0.0000100	0.0000050
Al (mg/L)	0.0104000	0.0049000
As (mg/L)	0.0004000	0.0002700
B (mg/L)	0.0250000	0.0500000
Ba (mg/L)	0.0129000	0.0682000
Be (mg/L)	0.0000500	0.0000100
Bi (mg/L)	0.0005000	0.0000050
Ca (mg/L)	19.8000000	21.1083333 ± 16.8005659
Cd (mg/L)	0.0002050	0.0000050
Chloride-Dissolved (mg/L)	1.6000000	0.9750000 ± 2.6309780
Co (mg/L)	0.0002500	0.0000100
CO3 (mg/L)	0.2500000	0.0000000 ± 0.0000000
Cr (mg/L)	0.0005000	0.0001000
Cu (mg/L)	0.0002500	0.0001000
Fe (mg/L)	0.0050000	0.0080000
General-Alkalinity (mg/L)	46.1000000	71.7000000 ± 53.9231440
General-DO (mg/L)	12.0000000	11.4175000 ± 0.7986708
General-Hardness (mg/L)	59.3000000	84.2750000 ± 70.6251066
General-pH (pH)	7.0	7.9 ± 0.4
General-SolidsTSS (mg/L)	2.0000000	0.8849836 ± 1.2378575
General-SpCond (µS/cm)	126.9000000	168.9833333 ± 123.7858182
General-TempAir (Degrees Celsius)	14.0	26.0
General-TempWater (Degrees Celsius)	8.0000000	7.3183333 ± 2.7240839
General-Turbidity (NTU)	0.8600000	0.2020000
HCO3 (mg/L)	56.2000000	0.0000000 ± 0.0000000
Hg (ng/L)	5.0000000	0.0000000 ± 0.0000000
K (mg/L)	1.3100000	0.6141667 ± 0.4056971
Li (mg/L)	0.0025000	0.0011000
Mg (mg/L)	2.3900000	7.6666667 ± 7.9748848
Mn (mg/L)	0.0005000	0.0006100
Mo (mg/L)	0.0012000	0.0006900
Na (mg/L)	1.7400000	1.5383333 ± 1.2751459
Ni (mg/L)	0.0005000	0.0003000
Nitrogen-NH3 (mg/L)	0.0370000	0.0024545 ± 0.0025045
Nitrogen-NO2 (mg/L)	0.0025000	0.0027500 ± 0.0062831
Nitrogen-NO2+NO3 (mg/L)	0.0480000	0.0690000
Nitrogen-NO3 (mg/L)	0.0480000	0.0546667 ± 0.0498148
Nitrogen-TN (mg/L)	0.1640000	0.0883333 ± 0.0521943
Pb (mg/L)	0.0002500	0.0000520
Phosphorus-OrthoP (mg/L)	0.0025000	0.0002727 ± 0.0004671
Phosphorus-TP (mg/L)	0.0191000	0.0045833 ± 0.0049992
S (mg/L)	4.8000000	5.0000000
Sb (mg/L)	0.0002500	0.0000700
Se (mg/L)	0.0006600	0.0001200
Si (mg/L)	4.0700000	3.1516667 ± 1.2277017
Sn (mg/L)	0.0025000	0.0000100
SO4 (mg/L)	13.0000000	17.2250000 ± 25.9966125
Sr (mg/L)	0.1360000	0.0443000
Ti (mg/L)	0.0025000	0.0005000
Tl (mg/L)	0.0000250	0.0000020
U (mg/L)	0.0006700	0.0011700
V (mg/L)	0.0025000	0.0002000
Zn (mg/L)	0.0150000	0.0010000
Zr (mg/L)	0.0002500	0.0000000 ± 0.0000000

Site Description

Study Name	CBWQ-Upper Slocan
Site	NJSLV01
Sampling Date	Sep 12 2017
Know Your Watershed Basin	Slocan
Province / Territory	British Columbia
Terrestrial Ecological Classification	Montane Cordillera EcoZone Columbia Mountains and Highlands EcoRegion
Coordinates (decimal degrees)	49.95278 N, 117.35944 W
Altitude	1788
Local Basin Name	Silverton Cr
	Slocan
Stream Order	4

Figure 1. Location Map

Across Reach
Aerial (No image found)

Down Stream
Field Sheet (No image found)
Miscellaneous (No image found)
Substrate (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	0.7%	1.6%	8.9%	72.0%	16.8%
CABIN Assessment of NJSLV01 on Sep 12, 2017	Mildly Divergent				

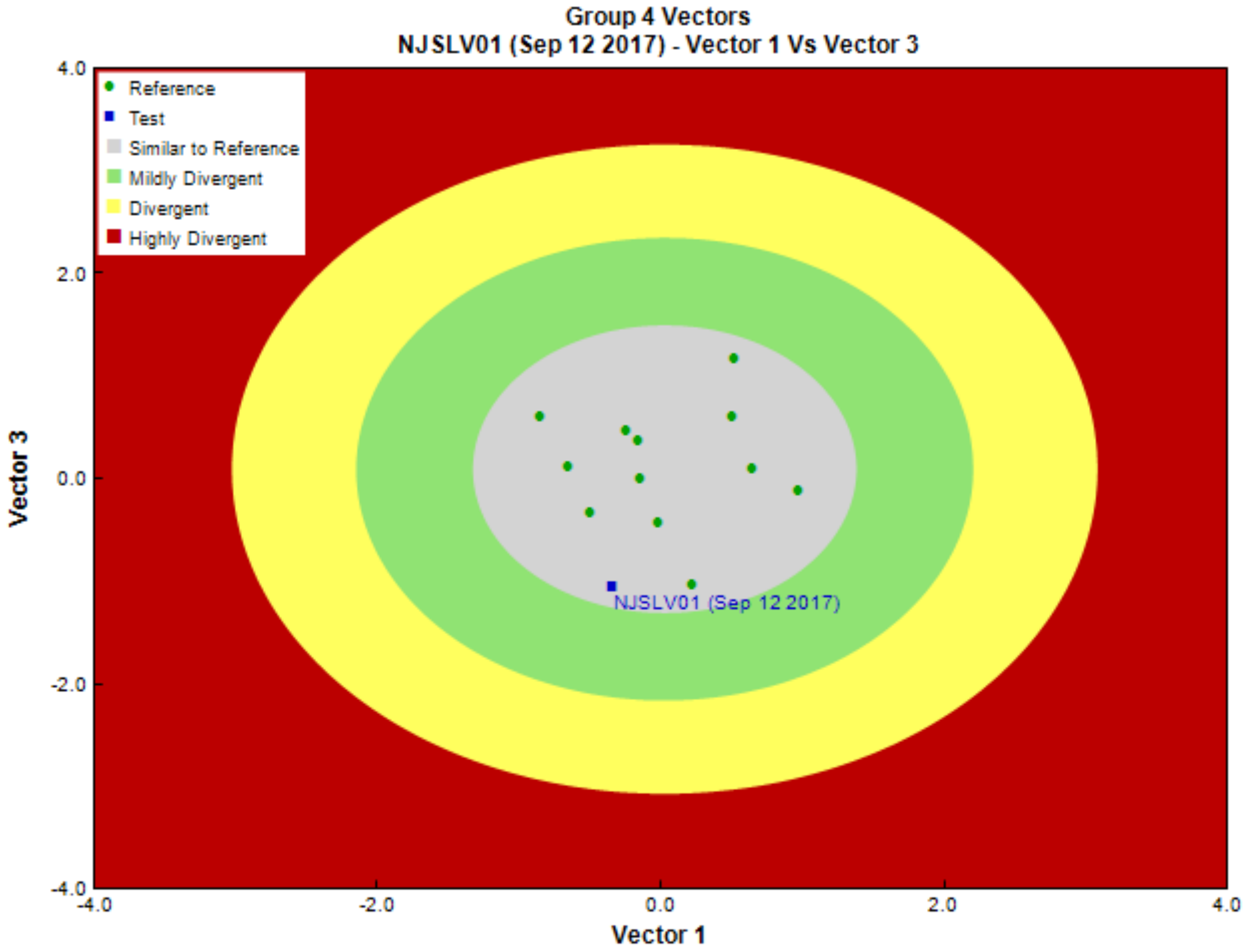

Figure 3. CABIN ordination assessment of the test site with the predicted group of reference sites. Each axis represents the relative abundance of the entire benthic invertebrate community with different organisms weighted differently on each axis.

Sample Information

Sampling Device	Kick Net
Mesh Size	400
Sampling Time	3
Taxonomist	Pina Viola, Consultant
Date Taxonomy Completed	December 10, 2017
	Marchant Box
Sub-Sample Proportion	20/100

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
Arthropoda	Arachnida	Sarcoptiformes		1	5.0
		Trombidiformes	Hydryphantidae	1	5.0
			Lebertiidae	1	5.0
			Sperchontidae	2	10.0
	Insecta	Coleoptera	Elmidae	1	5.0
		Diptera	Chironomidae	93	465.0
			Simuliidae	1	5.0
			Tipulidae	2	10.0
		Ephemeroptera	Ameletidae	2	10.0
			Baetidae	126	630.0
			Ephemerellidae	10	50.0
			Heptageniidae	38	190.0
		Plecoptera	Chloroperlidae	1	5.0
			Nemouridae	10	50.0
			Perlidae	6	30.0

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
			Perlodidae	3	15.0
			Taeniopterygidae	18	90.0
		Trichoptera	Glossosomatidae	3	15.0
			Hydropsychidae	2	10.0
			Lepidostomatidae	1	5.0
			Rhyacophilidae	7	35.0
			Uenoidae	20	100.0
			Total	349	1,745.0

Metrics

Name	NJSLV01	Predicted Group Reference Mean ±SD
Bray-Curtis Distance	0.59	0.4 ± 0.1
Biotic Indices		
Hilsenhoff Family index (North-West)	3.9	3.2 ± 0.3
Intolerant taxa	--	
Long-lived taxa	2.0	2.1 ± 1.0
Tolerant individuals (%)	--	0.8 ± 0.3
Functional Measures		
% Filterers	0.9	2.2 ± 1.8
% Gatherers	45.0	38.4 ± 12.4
% Predatores	33.5	19.0 ± 8.5
% Scrapers	59.6	63.2 ± 19.7
% Shredder	9.2	27.6 ± 15.2
No. Clinger Taxa	27.0	23.2 ± 6.3
Number Of Individuals		
% Chironomidae	26.7	7.4 ± 6.4
% Coleoptera	0.3	1.5 ± 3.9
% Diptera + Non-insects	28.7	10.8 ± 7.6
% Ephemeroptera	50.6	51.7 ± 18.8
% Ephemeroptera that are Baetidae	71.6	40.6 ± 30.0
% EPT Individuals	71.0	87.7 ± 7.4
% Odonata	0.0	0.0 ± 0.0
% of 2 dominant taxa	62.9	57.9 ± 14.2
% of 5 dominant taxa	84.8	81.6 ± 7.9
% of dominant taxa	36.2	39.8 ± 14.9
% Plecoptera	10.9	31.4 ± 15.4
% Tribe Tanyatarisini	--	
% Trichoptera that are Hydropsychida	6.1	27.0 ± 26.2
% Tricoptera	9.5	4.5 ± 2.8
No. EPT individuals/Chironomids+EPT Individuals	0.7	0.9 ± 0.1
Total Abundance	1745.0	587.4 ± 299.1
Richness		
Chironomidae taxa (genus level only)	1.0	1.0 ± 0.0
Coleoptera taxa	1.0	0.4 ± 0.5
Diptera taxa	3.0	3.3 ± 1.0
Ephemeroptera taxa	4.0	3.8 ± 0.8
EPT Individuals (Sum)	1235.0	526.0 ± 285.8
EPT taxa (no)	14.0	13.3 ± 2.7
Odonata taxa	0.0	0.0 ± 0.0
Pielou's Evenness	0.6	0.7 ± 0.1
Plecoptera taxa	5.0	6.3 ± 1.1
Shannon-Wiener Diversity	1.9	1.9 ± 0.4
Simpson's Diversity	0.8	0.8 ± 0.1
Simpson's Evenness	0.2	0.3 ± 0.1
Total No. of Taxa	21.0	19.3 ± 3.7
Trichoptera taxa	5.0	3.2 ± 1.4

Frequency and Probability of Taxa Occurrence

Reference Model Taxa	Frequency of Occurrence in Reference Sites					Probability Of Occurrence at NJSLV01
	Group 1	Group 2	Group 3	Group 4	Group 5	
Baetidae	100%	100%	100%	100%	97%	1.00
Capniidae	78%	55%	50%	92%	68%	0.83
Chironomidae	100%	100%	100%	100%	95%	0.99
Chloroperlidae	78%	88%	94%	100%	100%	0.99
Ephemerellidae	78%	100%	100%	100%	100%	1.00
Heptageniidae	100%	100%	100%	100%	100%	1.00
Hydropsychidae	11%	92%	78%	92%	86%	0.89
Nemouridae	100%	100%	100%	100%	100%	1.00
Perlidae	11%	84%	33%	100%	3%	0.77
Perlodidae	78%	78%	89%	92%	81%	0.89
Rhyacophilidae	100%	92%	100%	100%	95%	0.99
Taeniopterygidae	89%	49%	100%	92%	97%	0.93

RIVPACS Ratios

RIVPACS : Expected taxa P>0.50	13.63
RIVPACS : Observed taxa P>0.50	13.00
RIVPACS : O:E (p > 0.5)	0.95
RIVPACS : Expected taxa P>0.70	11.28
RIVPACS : Observed taxa P>0.70	11.00
RIVPACS : O:E (p > 0.7)	0.98

Habitat Description

Variable	NJSLV01	Predicted Group Reference Mean ±SD
Channel		
Depth-Avg (cm)	30.0	23.6 ± 11.1
Depth-BankfullMinusWetted (cm)	60.00	51.38 ± 29.42
Depth-Max (cm)	44.0	34.6 ± 12.3
Macrophyte (PercentRange)	0	0 ± 0
Reach-%CanopyCoverage (PercentRange)	1.00	1.33 ± 0.78
Reach-DomStreamsideVeg (Category(1-4))	1	4 ± 1
Reach-Pools (Binary)	1	1 ± 0
Reach-Rapids (Binary)	1	0 ± 0
Reach-Riffles (Binary)	1	1 ± 0
Reach-StraightRun (Binary)	1	1 ± 1
Slope (m/m)	0.0160000	0.0546683 ± 0.0376269
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)	0.63	0.48 ± 0.22
Velocity-Max (m/s)	0.89	0.76 ± 0.36
Width-Bankfull (m)	11.9	13.4 ± 9.9
Width-Wetted (m)	9.7	8.5 ± 5.8
XSEC-VelMethod (Category(1-3))	1	1 ± 0
Landcover		
Reg-Ice (%)	0.00000	0.02487 ± 0.06034
Substrate Data		
%Bedrock (%)	0	0 ± 0
%Boulder (%)	17	9 ± 9
%Cobble (%)	51	51 ± 15
%Gravel (%)	2	3 ± 3
%Pebble (%)	27	37 ± 20
%Sand (%)	0	0 ± 0
%Silt+Clay (%)	3	0 ± 0
D50 (cm)	9.00	15.12 ± 14.26
Dg (cm)	8.3	8.2 ± 2.8
Dominant-1st (Category(0-9))	6	7 ± 1
Dominant-2nd (Category(0-9))	7	7 ± 1
Embeddedness (Category(1-5))	4	5 ± 1

Habitat Description

Variable	NJSLV01	Predicted Group Reference Mean ±SD
PeriphytonCoverage (Category(1-5))	2	1 ± 0
SurroundingMaterial (Category(0-9))	3	4 ± 1
Topography		
Reg-SlopeLT30% (%)	12.49000	18.88386 ± 9.29866
Water Chemistry		
Ag (mg/L)	0.0000100	0.0000050
Al (mg/L)	0.0079000	0.0049000
As (mg/L)	0.0004500	0.0002700
B (mg/L)	0.0250000	0.0500000
Ba (mg/L)	0.0124000	0.0682000
Be (mg/L)	0.0000500	0.0000100
Bi (mg/L)	0.0005000	0.0000050
Ca (mg/L)	20.2000000	21.1083333 ± 16.8005659
Cd (mg/L)	0.0002200	0.0000050
Chloride-Dissolved (mg/L)	0.5000000	0.9750000 ± 2.6309780
Co (mg/L)	0.0001000	0.0000100
CO3 (mg/L)	0.5000000	0.0000000 ± 0.0000000
Cr (mg/L)	0.0005000	0.0001000
Cu (mg/L)	0.0002500	0.0001000
Fe (mg/L)	0.0050000	0.0080000
General-Alkalinity (mg/L)	91.0000000	71.7000000 ± 53.9231440
General-DO (mg/L)	9.0000000	11.4175000 ± 0.7986708
General-pH (pH)	8.5	7.9 ± 0.4
General-SolidsTSS (mg/L)	2.0000000	0.8849836 ± 1.2378575
General-SpCond (µS/cm)	141.5000000	168.9833333 ± 123.7858182
General-TempAir (Degrees Celsius)	15.5	26.0
General-TempWater (Degrees Celsius)	9.9000000	7.3183333 ± 2.7240839
General-Turbidity (NTU)	0.8300000	0.2020000
HCO3 (mg/L)	111.0000000	0.0000000 ± 0.0000000
K (mg/L)	1.3900000	0.6141667 ± 0.4056971
Li (mg/L)	0.0010000	0.0011000
Mg (mg/L)	2.4600000	7.6666667 ± 7.9748848
Mn (mg/L)	0.0005000	0.0006100
Mo (mg/L)	0.0014000	0.0006900
Na (mg/L)	1.4900000	1.5383333 ± 1.2751459
Ni (mg/L)	0.0005000	0.0003000
Nitrogen-NH3 (mg/L)	0.0100000	0.0024545 ± 0.0025045
Nitrogen-NO2 (mg/L)	0.0025000	0.0027500 ± 0.0062831
Nitrogen-NO2+NO3 (mg/L)	0.0420000	0.0690000
Nitrogen-NO3 (mg/L)	0.0420000	0.0546667 ± 0.0498148
Nitrogen-TN (mg/L)	0.0910000	0.0883333 ± 0.0521943
Pb (mg/L)	0.0002400	0.0000520
Phosphorus-OrthoP (mg/L)	0.0025000	0.0002727 ± 0.0004671
Phosphorus-TP (mg/L)	0.0025000	0.0045833 ± 0.0049992
S (mg/L)	4.9000000	5.0000000
Se (mg/L)	0.0007800	0.0001200
Si (mg/L)	4.1200000	3.1516667 ± 1.2277017
Sn (mg/L)	0.0025000	0.0000100
SO4 (mg/L)	13.0000000	17.2250000 ± 25.9966125
Sr (mg/L)	0.1420000	0.0443000
Ti (mg/L)	0.0025000	0.0005000
Tl (mg/L)	0.0000050	0.0000020
U (mg/L)	0.0007500	0.0011700
V (mg/L)	0.0025000	0.0002000
Zn (mg/L)	0.0141000	0.0010000
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	Guidelines relevant to background not assessed, as they are intended to be monitored during construction/discharge activity.
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 QA/QC

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)	Turbidity	Total Hardness (CaCO3)
			Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**µg/L**	**mg/L**	**NTU**	**mg/L**
			RDL	**0.005**	**0.02**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**5**	**0.02**	**0.1**	**5**
Slocan Lk Stewardship Society	2016-09-28	NJSLV01 DUP	Silverton Cr	<0.0050	0.047	45.4	<0.50	55.3	<0.50	<0.50	<5	0.047	0.19	-
Slocan Lk Stewardship Society	2016-09-28	NJSLV01	Silverton Cr	<0.0050	0.048	46.1	<0.50	56.2	<0.50	<0.50	<5	0.048	0.86	59.3
		Duplicate QC	**Calculated RPD (%)**	**0.0**	**-2.1**	**-1.5**	**0.0**	**-1.6**	**0.0**	**0.0**	**0.0**	**-2.1**	**-127.6**	**-**

Slocan Lk Stewardship Society	2016-09-28	NJSLV01 BLK	Silverton Cr	<0.0050	<0.020	<0.50	<0.50	<0.50	<0.50	<0.50	<5	<0.020	<0.10	-
		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**	**-**

Appendix B1 - Water quality QA/QC

Sample Date (yy/mm/dd)	Total Phosphorus (P)	Total Nitrogen (N)	Conductivity	Total Suspended Solids	Dissolved Chloride (Cl)	E. Coli
	mg/L	**mg/L**	**uS/cm**	**mg/L**	**mg/L**	**CFU**
	0.005	**0.02**	**1**	**4**	**0.5**	**1**
2016-09-28	<0.0050	0.093	118	<4.0	<1.0	-
2016-09-28	0.0191	0.164	-	<4.0	1.6	<1
	-117.0	**-55.3**	-	**0.0**	**-46.2**	-

2016-09-28	<0.0050	0.021	<1.0	<4.0	<1.0	-
	1.0	**1.1**	**1.0**	**1.0**	**1.0**	**-**

Appendix B2- Water quality, 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)
			Guideline for protection of aquatic life[avg]	BC App: 0.02 when chloride <2 mg/L (or see Guideline Table)	BC App: 3	-	-
			Guideline for drinking water[max]	HC: 1	HC: 10	-	-
			Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Slocan Lk Stewardship Society	2015-04-20	NJSLV01	Silverton Cr	<0.0050	0.114	-	-
Slocan Lk Stewardship Society	2015-05-11	NJSL V01	Silverton Cr	<0.0050	0.129	-	-
Slocan Lk Stewardship Society	2015-06-15	NJSLV01	Silverton Cr	<0.0050	0.034	-	-
Slocan Lk Stewardship Society	2015-07-13	NJSLVO1	Silverton Cr	<0.0050	<0.020	-	-
Slocan Lk Stewardship Society	2015-08-10	NJSLV01	Silverton Cr	<0.0050	0.024	-	-
Slocan Lk Stewardship Society	2015-09-20	NJSLV01	Silverton Cr	<0.0050	<0.020	41	<0.50
Slocan Lk Stewardship Society	2015-10-13	NJSLV01	Silverton Cr	<0.0050	0.042	-	-
Slocan Lk Stewardship Society	2016-04-05	NJSLV01	Silverton Cr	<0.0050	0.175	-	-
Slocan Lk Stewardship Society	2016-05-09	NJSLV01	Silverton Cr	<0.0050	0.117	-	-
Slocan Lk Stewardship Society	2016-06-14	NJSLV01	Silverton Cr	<0.0050	0.043	-	-
Slocan Lk Stewardship Society	2016-07-11	NJSLV01	Silverton Cr	<0.0050	0.025	-	-
Slocan Lk Stewardship Society	2016-08-08	NJSLV01	Silverton Cr	<0.0050	0.024	-	-
Slocan Lk Stewardship Society	2016-09-28	NJSLV01	Silverton Cr	<0.0050	0.048	46.1	<0.50
Slocan Lk Stewardship Society	2016-10-11	NJSLV01	Silverton Cr	<0.0050	0.057	-	-
Slocan Lk Stewardship Society	2017-04-17	NJSLV01	Silverton Cr	<0.0050	0.05	-	-
Slocan Lk Stewardship Society	2017-05-15	NJSLV01	Silverton Cr	<0.0050	0.154	-	-
Slocan Lk Stewardship Society	2017-06-19	NJSLV01	Silverton Cr	<0.0050	0.03	-	-
Slocan Lk Stewardship Society	2017-07-17	NJSLV01	Silverton Cr	<0.0050	<0.020	-	-
Slocan Lk Stewardship Society	2017-08-21	NJSLV01	Silverton Cr	<0.0050	0.023	-	-
Slocan Lk Stewardship Society	2017-09-12	NJSLV01	Silverton Cr	<0.0050	0.042	91	<1.0
Slocan Lk Stewardship Society	2017-10-30	NJSLV01	Silverton Cr	<0.0050	0.035	-	-

Appendix B2- Water quality, non-metals.

Sample Date (yy/mm/dd)	Bicarbonate (HCO3)	Carbonate (CO3)	Hydroxide (OH)	Orthophosphate (P)	Nitrate plus Nitrite (N)	Dissolved Oxygen	Specific Conductivity	pH
	-	-	-	-	BC App: 3	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: 10	-	-	HC: 7-10.5
	mg/L	**mg/L**	**mg/L**	**µg/L**	**mg/L**	**mg/L**	**uS/cm**	**pH units**
2015-04-20	-	-	-	-	0.114	*12*	*95.8*	*7.65*
2015-05-11	-	-	-	<5	0.129	*12*	*94.8*	*7.94*
2015-06-15	-	-	-	<5	0.034	*12*	*77.1*	*7.84*
2015-07-13	-	-	-	<5	<0.020	*9*	*82.2*	*7.73*
2015-08-10	-	-	-	<5	0.024	*11*	*91.7*	*-*
2015-09-20	50	<0.50	<0.50	<5.01	<0.020	*10*	*88.6*	*8.25*
2015-10-13	-	-	-	-	0.042	*13*	*82.5*	*8.40*
2016-04-05	-	-	-	-	0.175	*8*	*162.3*	*8.02*
2016-05-09	-	-	-	<5	0.117	*12*	*68.5*	*-*
2016-06-14	-	-	-	<5	0.043	*13*	*72.0*	*7.74*
2016-07-11	-	-	-	<5	0.025	*9*	*86.2*	*-*
2016-08-08	-	-	-	<5	0.024	*10*	*97.8*	*7.24*
2016-09-28	56.2	<0.50	<0.50	<5	0.048	*12*	*126.9*	*7.02*
2016-10-11	-	-	-	-	0.057	*17*	*89.3*	*6.89*
2017-04-17	-	-	-	-	0.050	*18*	*198.8*	*8.12*
2017-05-15	-	-	-	<5	0.154	*14*	*123.3*	*8.45*
2017-06-19	-	-	-	<5	0.030	*14*	*80.9*	*8.40*
2017-07-17	-	-	-	<5	<0.020	*11*	*89.7*	*8.34*
2017-08-21	-	-	-	<5	0.023	*8*	*125.3*	*8.55*
2017-09-12	111	<1.0	<1.0	<5	0.042	*9*	*141.5*	*8.50*
2017-10-30	-	-	-	-	0.035	*14*	*173.2*	*8.37*

Appendix B2- Water quality, non-metals.

Sample Date (yy/mm/dd)	Turbidity	Water Temperature	Air Temperature	Total Hardness (CaCO3)
	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.	-	-
	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	-	-
	NTU	**°C**	**°C**	**mg/L**
2015-04-20	*0.26*	*5.5*	*15.0*	-
2015-05-11	*1.24*	*7.4*	*20.0*	-
2015-06-15	*0.92*	*10.0*	*22.0*	35.0
2015-07-13	*0.32*	*11.0*	*19.5*	-
2015-08-10	*0.52*	*13.7*	*22.5*	-
2015-09-20	*0.41*	*9.4*	*15.8*	49.1
2015-10-13	*1.60*	*6.5*	*10.0*	-
2016-04-05	*1.65*	*4.0*	*7.0*	-
2016-05-09	*5.87*	*5.5*	*15.0*	-
2016-06-14	*1.09*	*5.0*	*12.0*	-
2016-07-11	*0.91*	*10.5*	*18.5*	-
2016-08-08	*0.52*	*11.4*	*19.2*	-
2016-09-28	*0.86*	*8.0*	*14.0*	59.3
2016-10-11	*1.17*	*5.0*	*6.0*	-
2017-04-17	*0.89*	*5.0*	*12.0*	-
2017-05-15	*1.96*	*5.0*	*14.0*	-
2017-06-19	*3.21*	*8.0*	*16.8*	33.0
2017-07-17	*0.76*	*11.0*	*23.4*	-
2017-08-21	*0.42*	*11.4*	*21.0*	-
2017-09-12	*0.83*	*9.9*	*15.5*	60.5
2017-10-30	*0.52*	*4.8*	*9.7*	-

Appendix B2- Water quality, non-metals.

Sample Date (yy/mm/dd)	Total Phosphorus (P)	Total Nitrogen (N)	Conductivity	Total Suspended Solids	Dissolved Calcium (Ca)
	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).	-
	-	-	-	-	-
	mg/L	mg/L	uS/cm	mg/L	mg/L
2015-04-20	-	0.151	-	<4.0	-
2015-05-11	0.0069	0.183	-	<4.0	-
2015-06-15	<0.0050	0.059	-	<4.0	-
2015-07-13	<0.0050	0.027	-	<4.0	-
2015-08-10	<0.0050	0.074	-	<4.0	-
2015-09-20	<0.0050	0.095	-	<4.0	-
2015-10-13	-	0.099	-	<4.0	-
2016-04-05	-	0.315	-	5.5	-
2016-05-09	0.0068	0.163	-	<4.0	-
2016-06-14	<0.0050	0.066	-	<4.0	-
2016-07-11	<0.0050	0.059	-	<4.0	-
2016-08-08	<0.0050	0.088	-	<4.0	-
2016-09-28	0.0191	0.164	-	<4.0	-
2016-10-11	-	0.185	-	<4.0	-
2017-04-17	-	-	0.128	-	<4.0
2017-05-15	-	0.0054	0.258	-	<4.0
2017-06-19	-	<0.0050	0.084	-	<4.0
2017-07-17	-	<0.0050	0.088	-	<4.0
2017-08-21	-	<0.0050	0.201	-	<4.0
2017-09-12	-	<0.0050	0.091	-	<4.0
2017-10-30	-	-	0.14	-	<4.0

Appendix B2- Water quality, non-metals.

Sample Date (yy/mm/dd)	Dissolved Chloride (Cl)	Total Ammonia (NH3)	E. Coli
	BC App (total chloride): 150	BC App: [Insert range] based on daily pH and temp, using guideline table.	-
	BC App[AO]: 250	-	BC App: 0
	mg/L	mg/L	CFU/100 mL
2015-04-20	<0.50	-	<1
2015-05-11	<0.50	-	<1
2015-06-15	<0.50	-	<1
2015-07-13	<0.50	-	15
2015-08-10	<0.50	-	4
2015-09-20	1.60	-	<1
2015-10-13	0.62	-	2
2016-04-05	0.54	-	<1
2016-05-09	<0.50	-	<1
2016-06-14	<0.50	-	2
2016-07-11	<0.50	-	<1
2016-08-08	0.61	-	5
2016-09-28	1.60	-	<1
2016-10-11	<1.0	-	<1
2017-04-17	-	<0.50	-
2017-05-15	-	<0.50	-
2017-06-19	-	<0.50	-
2017-07-17	-	<0.50	-
2017-08-21	-	<1.0	-
2017-09-12	-	<1.0	-
2017-10-30	-	<1.0	-

Appendix B3 - Water quality, 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)
			Units	mg/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
			Calculated aquatic life guideline (where required)	-	50	-	-	-	-
			Guideline for drinking water[max]	-	BC App[AO]: 9500	HC: 6	BC App: 10	HC: 1000	-
Slocan Lk Stewardship Society	2015-06-15	NJSLV01	Silverton Cr	35	36.1	<0.50	0.36	8.3	<0.10
Slocan Lk Stewardship Society	2015-09-20	NJSLV01	Silverton Cr	49.1	8.2	<0.50	0.38	11.2	<0.10
Slocan Lk Stewardship Society	2016-09-28	NJSLV01	Silverton Cr	59.3	10.4	<0.50	0.4	12.9	<0.10
Slocan Lk Stewardship Society	2017-06-19	NJSLV01	Silverton Cr	33	41.2	<0.50	0.29	6.8	<0.10
Slocan Lk Stewardship Society	2017-09-12	NJSLV01	Silverton Cr	60.5	7.9	<0.50	0.45	12.4	<0.10

Appendix B3 - Water quality, metals.

Sample Date (yy/mm/dd)	Total Bismuth (Bi)	Total Boron (B)	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)
	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L
	-	BC App: 1200	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).	-	-
	-	-	0.09	-	-	-	1.9	-	4.5	-	-
	-	BC App: 5000	HC: 5	-	HC: 50	-	BC App^{AO}: 1000	HC^{AO}: 300	BC App: 10	-	-
2015-06-15	<1.0	<50	0.096	11.7	<1.0	<0.50	1.22	38	0.35	<5.0	1.4
2015-09-20	<1.0	<50	0.163	16.3	<1.0	<0.50	<0.50	14	0.33	<5.0	2.05
2016-09-28	<1.0	<50	0.205	19.8	<1.0	<0.50	<0.50	<10	0.25	<5.0	2.39
2017-06-19	<1.0	<50	0.091	11.1	<1.0	<0.20	1.07	38	0.40	<2.0	1.28
2017-09-12	<1.0	<50	0.215	20.2	<1.0	<0.20	<0.50	<10	0.24	<2.0	2.46

Appendix B3 - Water quality, metals.

Sample Date (yy/mm/dd)	Total Manganese (Mn)	Total Mercury (Hg)	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)
	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	mg/L	µg/L	mg/L
	BC App: (0.0044 x hardness + 0.605)x1000	CCME 0.026	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.	-	-	-
	605.2	-	-	25.0	-	-	-	0.05	-	-	-
	HC^{AO}: 50	BC App: 1	BC App: 250	-	-	BC App: 10	-	-	HC^{AO}: 200	-	-
2015-06-15	1.6	<0.010	<1.0	<1.0	0.861	0.31	3180	<0.020	0.96	87.5	<3.0
2015-09-20	<1.0	<0.010	1.1	<1.0	1.17	0.52	3540	<0.020	1.34	122	<3.0
2016-09-28	<1.0	<0.010	1.2	<1.0	1.31	0.66	4070	<0.020	1.74	136	4.8
2017-06-19	1.8	<0.010	<1.0	<1.0	0.848	0.32	3620	<0.020	0.90	69.5	<3.0
2017-09-12	<1.0	<0.010	1.4	<1.0	1.39	0.78	4120	<0.020	1.49	142	4.9

Appendix B3 - Water quality, metals.

Sample Date (yy/mm/dd)	Total Thallium (Tl)	Total Tin (Sn)	Total Titanium (Ti)	Total Uranium (U)	Total Vanadium (V)	Total Zinc (Zn)	Total Zirconium (Zr)
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
	BC Work: 0.8	-	-	BC Work: 8.5	-	BC App: hardness <90 = 7.5. Hardness >90 = 7.5+0.75x(hardness - 90)	-
	-	-	-	-	-	7.5	-
	-	-	-	HC: 20	-	BC App[AO]: 5000	-
2015-06-15	<0.050	<5.0	<5.0	0.48	<5.0	9.8	<0.50
2015-09-20	<0.050	<5.0	<5.0	0.59	<5.0	12.1	<0.50
2016-09-28	<0.050	<5.0	<5.0	0.67	<5.0	15	<0.50
2017-06-19	<0.010	<5.0	<5.0	0.39	<5.0	9.6	<0.10
2017-09-12	<0.010	<5.0	<5.0	0.75	<5.0	14.1	<0.10