Alexander Creek
Water Quality Monitoring Report
2015 – 2017

Prepared by:
Lotic Environmental Ltd, Mainstreams Environmental Society, and
Elk River Alliance

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Contact Information

Elk River Alliance
  Alya Bennett ayla@elkriveralliance.ca

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

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

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

Columbia Basin Watershed Network website www.cbwn.ca

Cover photo

Upstream view of Alexander Creek site NGALX03, September 12, 2016

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 Elk River Alliance to conduct baseline water quality monitoring in Alexander Creek from 2015 to 2017. Alexander Creek was identified as a priority for monitoring since it is in an area experiencing increasing development pressures (i.e., highway influences, logging activity, road-building, cattle grazing, and proposed coal mining in adjacent valleys). Monitoring was conducted at NGALX03, located at the downstream end of the creek, near the confluence with Michel Creek. 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 results identified NGALX03 as being unstressed in all years sampled. This was evident through all expected taxa were present based on reference group conditions, as well as key metrics being similar or better than the reference group values (i.e., total abundance, % EPT taxa, %chironomidae, %two most dominant taxa, and taxa richness). The benthic macro-invertebrate results were supported by the water quality and hydrometric results.

Water quality was good at NGALX03, with total phosphorous being the only parameter to exceed the aquatic life guidelines. The exceedances occurred once in the spring of 2015 and once in the spring of 2017. All drinking water guidelines were met.

Water temperatures in spring through fall did not exceed the guidelines for rearing Bull Trout. The Bull Trout minimum temperature guideline for egg incubation was 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. Streamflow followed a typical nival pattern of being high in the spring during freshet and decreasing throughout the summer to baseflow in the winter months.

The three-year baseline monitoring program provides an understanding of natural conditions and variation. This baseline will be valuable to 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, the Elk River Alliance (or the stewardship group) conducted water quality monitoring in Alexander 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 Alexander Creek background

Alexander Creek is located approximately 15 km east of Sparwood, B.C. It is a tributary of Michel Creek, which flows into the Elk River near Sparwood. Alexander Creek is a fourth order stream, which flows west from the Continental Divide of the Rocky Mountains. The total length of Alexander Creek from the source to the mouth is over 30 km.

Other general information about Alexander Creek is as follows:

- The majority of Alexander Creek's annual flow is from snow melt. Flows are highest in May and June, and lowest from August to March (generally decreasing over winter). This is consistent with other interior rivers in the area (Swain 2007).
- The geology of the Alexander Creek area is sedimentary with expressions of coal-bearing rock from the Lewis thrust sheet (Grieve & Price, 1987).
- Sensitive Habitat Inventory Mapping (SHIM) was completed on Alexander Creek in 2012 (Figure 1) that identified important habitat characteristics along the watercourse.
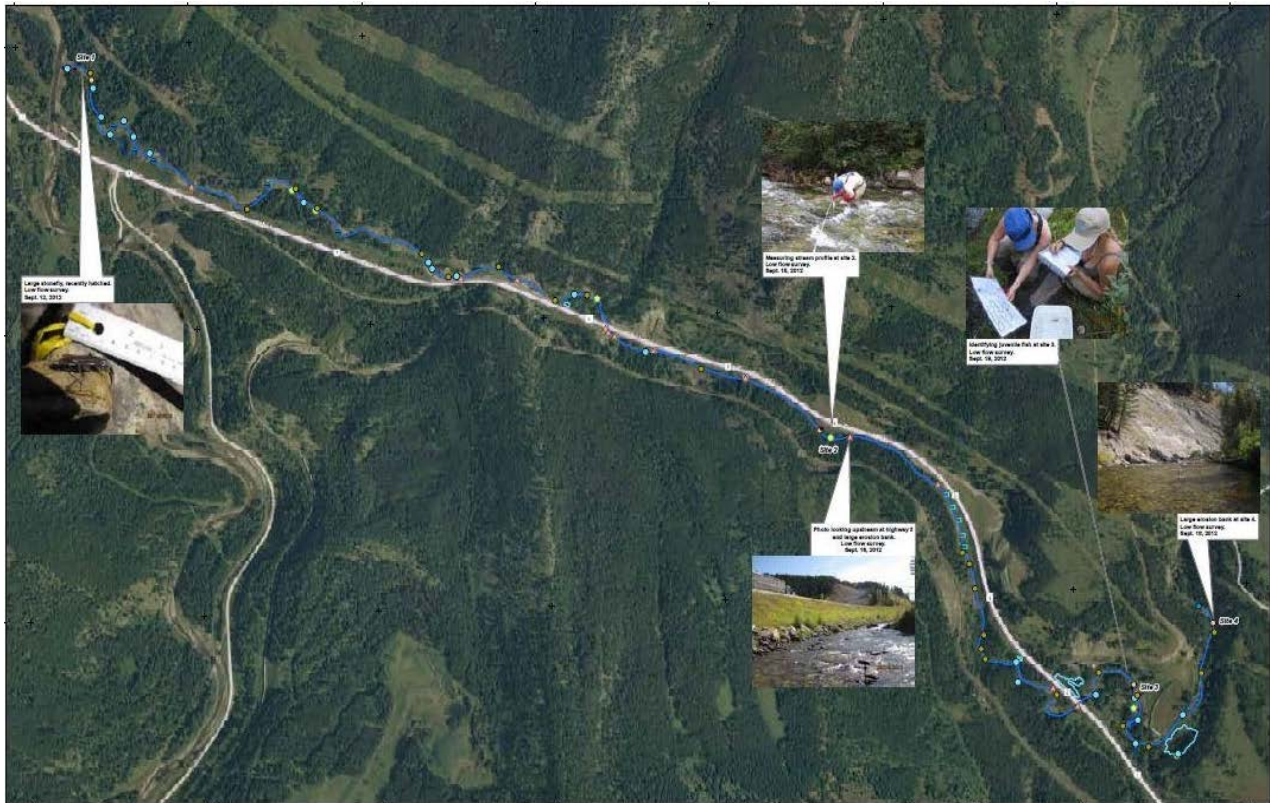
Figure 1. Sensitive Habitat Inventory and Mapping of Alexander Creek, 2012.[1]

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[1] Accessed at:
https://d3n8a8pro7vhmx.cloudfront.net/elkriveralliance/pages/35/attachments/original/1525382836/ERA-Report-FINAL.compressed.pdf?1525382836

Alexander Creek was selected as a priority for CBWQ monitoring, since it was a significant tributary to Michel Creek. It also was in an area with several human (anthropogenic) pressures including: Highway 3 influences, recent logging activities, road-building, grazing lease for cattle, and proposed coal mining in adjacent valleys. Monitoring was conducted at NGALX03. This site was located near the confluence with Michel Creek (Figure 2 and Figure 3). The site was also located immediately downstream of streamside restoration project implemented by the Elk River Alliance from 2016 to 2017. Because of the mounting anthropogenic activities, obtaining a water quality and quantity baseline for Alexander Creek was important. The vision is for the site to be monitored long-term, so trends in stream health can be detected, and options to address potential issues identified.

The riparian zone at the monitoring location is generally dominated by coniferous trees, including Engelmann Spruce, Douglas Fir and Subalpine Fir. Major deciduous trees and shrubs include red osier dogwood, trembling aspen and black cottonwood. The Sparwood Rod and Gun Club rifle range is located immediately upstream of the monitoring location.
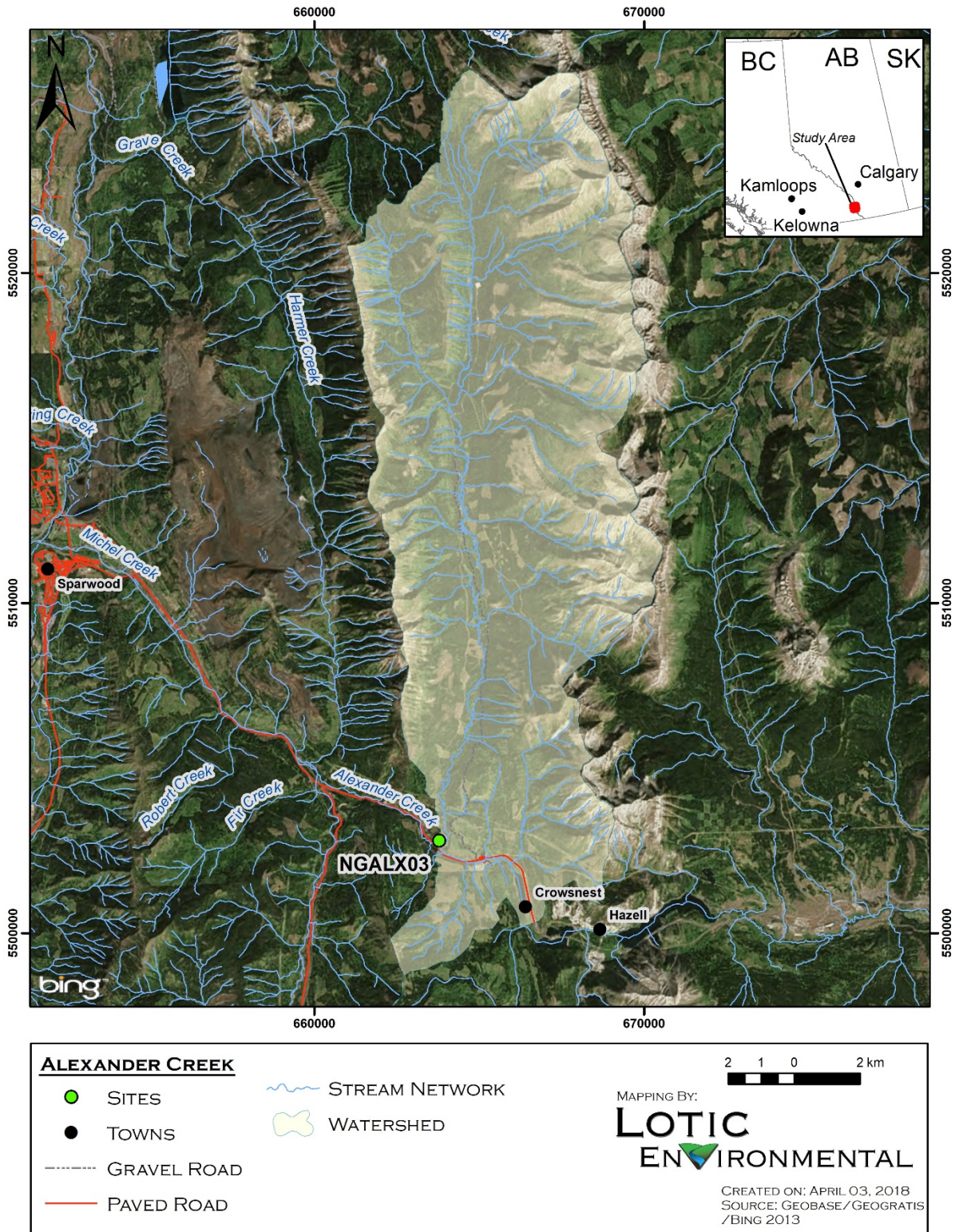
Figure 2. Alexander Creek monitoring location.

Figure 3. Downstream and across stream view of NGALX03 monitoring site, September 2016 and 2017, respectively. Photos by Ayla Bennett and Allie Ferguson.

1.2 Fish community

The fish community in Alexander Creek and the neighbouring Michel Creek is comprised of six native and two non-native species (Table 1). 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).

Table 1. Fish species historically documented in Alexander Creek, and neighbouring Michel Creek* (Source: BC MoE 2018a)

Species - common name	Scientific name
Native species	
Bull Trout	*Salvelinus confluentus*
Westslope Cutthroat Trout	*Oncorhynchus clarkii lewisi*
*Mountain Whitefish	*Prosopium williamsoni*
*Longnose Sucker	*Catostomus catostomus*
*Longnose Dace	*Rhinichthys cataractae*
*Redside shiner	*Richardsonius balteatus*
Non – native (naturalized)	
Rainbow Trout	*O. mykiss*
Eastern Brook Trout	*S. fontinalis*

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). The Elk River Alliance 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 NGALX03:

a. Monthly (spring through fall) - total suspended solids (TSS), orthophosphate, total phosphorus, and *in situ* (field measured) data. *In situ* data were dissolved oxygen (DO), temperature, specific conductivity, pH, turbidity, and air temperature.

b. Once per year (coinciding with CABIN monitoring) - in addition to data above, inorganics (alkalinity, bicarbonate, carbonate, and hydroxide), full suite of nutrients, and metals.

c. One additional time annually (in June or July) – all parameters listed above under a), as well as dissolved sulphate and 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. Measurements were collected for the period from March 28, 2015 – October 10, 2017. 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 Velocity Tube method. Measurements were collected at regular length intervals across the stream using a Velocity Tube. At each interval, the Flowing Water

Depth (cm) was measured, from within the interior of the tube, as this area acts as a stilling well. The 'head' built up on the upstream side of the tube 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.

1. CABIN Data Assessment

a. Beast Analysis
Appropriate reference sites   Community comparison to reference

b. RIVPACS Analysis
What taxa were expected at the test site and what was found?

c. Community Composition Metrics
What was the test site community composition?

d. Habitat Metrics
What was the habitat quality?

2. Water Quality
Did any parameters exceed accepted water quality guidelines?

3. Stream Temperature
Did values exceed accepted water quality guidelines?

4. Hydrologic Conditions
Were seasonal flows consistent?

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

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

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 NGALX03, CABIN BEAST analysis determined the highest probability of reference group membership in all years 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 the test site was 32.3 cm, which was within the range of the Reference Group 3 average depth of 22.5 ± 10 cm. 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 NGALX03 as being Unstressed in all three years reviewed.

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
NGALX03	**Unstressed** Group 3; 85.5%	**Unstressed** Group 3; 85.9%	Unstressed Group 3; 85.6%

3.1.2 RIVPACS analysis

The RIVPACS ratio at NGALX03 was 1.05 in all years monitored (Table 3). All taxa were present that were expected based on reference conditions, indicating good conditions.

Table 3. RIVPACS Observed:Expected Ratios of taxa at test sites.

Site	2015	2016	2017
NGALX03	1.05	1.05	1.05

*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 - 2017 at NGALX03. Condition indicated as shaded background*

Metric	Reference Group 3 (Mean ± standard deviation)	NGALX03		
		2015	2016	2017
Total abundance	5780 ± 4895	5212	7100	9520
% EPT taxa	84.9 ± 14.3	81.7	82.9	83.9
% Chironomidae	8.2 ± 13.6	6.0	9.2	10.8
% of 2 dominant taxa	58.9 ± 10.0	37	45.4	40.8
Total number of taxa	17.7 ± 2.6	20	25	23

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

The total abundance of organisms found at the test site 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. Although the total abundance at NGALX03 increased from 5212 organisms in 2015 to 9520 organisms in 2017, values were within the reference condition mean of 5780 ± 4895 organisms.

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. Percent EPT at the test site slightly increased/improved from 2015 to 2017 (81.7 to 83.9 %), with all values similar to the reference group mean (84.9 ±14.3 %). Conversely, the Chironomidae family of insect (non-biting midges), are generally tolerant of pollution. Their percentages gradually increased from 2015 - 2017 (6.0 to 10.8 %). However, test site values were low overall, and were similar to the reference mean (8.2 ± 13.6 %), further supporting the unstressed determination for the site.

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 this test site, the percentage of the community represented by the two dominant taxa ranged from 37 - 45.4 %. These values were actually lower than the reference group (58.5 ±10 %), further 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 ranged from 20 to 25 taxa over the study period. These values were slightly higher than the reference mean (17.7 ± 2.6 taxa), further supporting the unstressed condition of NGALX03.

3.1.4 Habitat conditions

Key physical habitat conditions that could influence benthic marco-invertebrate community health were reviewed amongst the sampling years (Table 5). Conditions were similar amongst all years monitored and were comparable to the reference group mean. The exception was that percent gravel was higher than the reference group mean in 2015 and 2016. However, gravel typically supports a healthy benthic macro-invertebrate community. These characteristics supported the invertebrate community being characterised as unstressed all years.

Table 5. Select physical habitat characteristics for the predicted reference group, and NGALX03.

Parameter	Reference group mean ± std dev	2015	2016	2017
Average depth (cm)	22.5 ± 10.5	34.4	29.7	32.8
Average velocity (m/s)	0.50 ± 0.25	0.59	0.62	0.67
% Cobble (6.4 - 25.6 cm)	61 ± 27	68	59	66
% Pebble (1.6 – 6.4 cm)	31 ± 28	16	19	23
% Gravel (0.2 – 1.6 cm)	1 ± 2	8	13	1
% Sand (0.1 – 0.2 cm)	0 ± 0	0	3	0
% silt and clay (<0.1 cm)	1 ± 1	5	1	0

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 one sample was below the alert level of 50%, indicating a high degree of precision in data collection and lab procedures. Although the RPD for turbidity was 127%, the comparison was of a field measured and lab analysed sample. Greater than normal variability would be expected when comparing these different techniques; particularly for turbidity which can be influenced by agitation/settling. Natural variability in turbidity in the water column is also possible.

All 2016 field blank parameters analyzed were 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 three aquatic life and/or drinking water guidelines for the non-metal parameters (Appendix B2). All guidelines for metal parameters were met (Appendix B3). Exceedance details are as follows:

Total phosphorus: The total phosphorus guideline for the protection of aquatic life was not met in two out of the fifteen 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[2] for the site (CCME 2004). Excluding the two highest values, total phosphorus ranged from <0.005 - 0.010 mg/L at NGALX03. 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 was evaluated against the site-specific guideline, calculated as 1.5 x the upper end of the baseline range, which is equivalent to 0.015 µg/L. The exceedances occurred in April 2015 and May 2017, with values of 0.018 and 0.024 mg/l, respectively. Nutrient loading into a watercourse is anticipated during the spring, as a result of melting snow and rain events causing overland runoff. Since the exceedances were not prolonged, aquatic life impacts were not expected.

Turbidity and Total Suspended Solids (TSS): The guidelines for turbidity and TSS refer to changes from background, resulting from a direct/known anthropogenic activity (e.g., construction). Because there was no such specific activity, a comparison to the guidelines was not applicable. However, it was noted that turbidity and TSS increased during the spring high flow period (freshet), from April - June. On May 26, 2015, values were highest with turbidity at 39.2 NTU, and TSS at 51.8 mg/l. Conversely, during the clear flow period, turbidity was below 2 NTU and TSS was less than the detectable limit of 4 mg/l. It is normal for these increases to occur during the spring freshet, but they can be exacerbated by loss of vegetative cover in the watershed. These baseline data will be valuable for monitoring changes that may occur with increased development.

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:

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

Overall, monthly average water temperatures were fairly consistent among the three years sampled at NGALX03 (Table 6). Monitoring over a longer time period would be required to determine trends.

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[2] 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).

Table 6. Monthly average (Avg) and standard deviation (Std Dev) in daily average stream temperature (°C) from 2015 – 2017 at NGALX03.

Month	2015		2016		2017	
	Avg	Std Dev	Avg	Std Dev	Avg	Std Dev
January	-	-	-	-	0.11	0.07
February	-	-	-	-	0.33	0.37
March	-	-	-	-	1.25	0.93
April	3.70	0.89	4.49	0.84	2.54	0.41
May	4.85	0.60	5.26	0.63	-	-
June	9.22	0.07	7.32	1.15	8.08	0.94
July	9.36	0.63	9.29	0.70	9.39	0.60
August	9.38	0.97	9.45	0.70	9.54	0.61
September	6.72	1.00	7.14	0.76	7.40	1.71
October	5.84	1.09	4.35	0.95	4.15	0.78
November	-	0.00	2.97	1.03	-	-
December	-	0.00	0.46	0.57	-	-

*Data were collected for only part of the month

Because of Bull Trout's presence in Alexander Creek, the temperature data were compared to the guidelines for streams with Bull Trout. In general, summer stream temperatures in all years were below the maximum daily Bull Trout rearing temperature of 15 ºC (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 in Alexander Creek during spawning season did not exceed optimal spawning temperature guidelines (i.e. a max daily temperature of 10 ºC). 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, the guideline for minimum temperature during incubation of 2 ºC was generally not met from mid-November 2016 through early April 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).
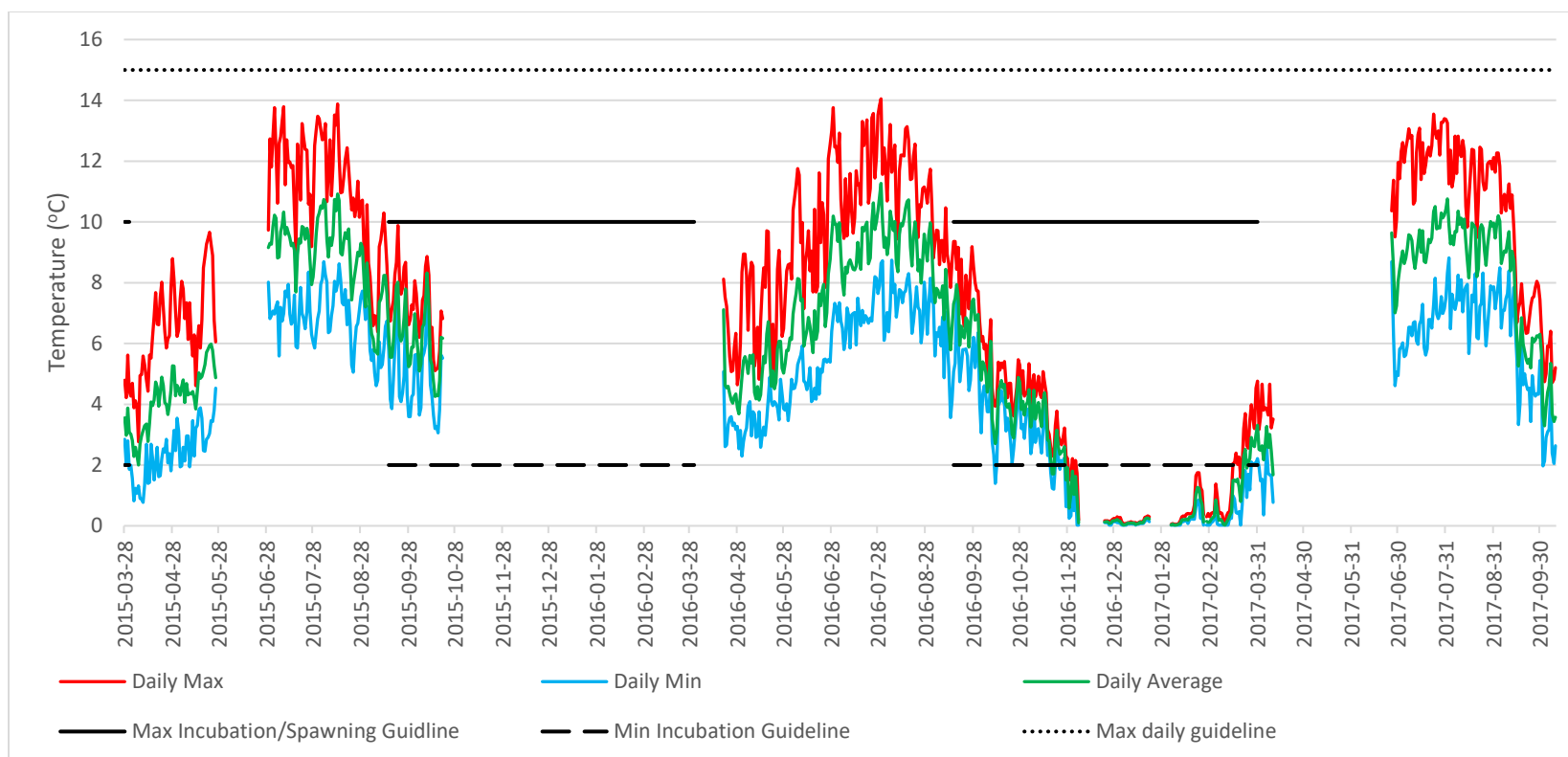
Figure 5. Stream average daily temperatures in Alexander Creek (NGALX01) from March 28, 2015 to October 10, 2017. The guidelines presented are for the protection of aquatic life for streams with Bull Trout present (BC MoE 2018b).

3.4 Hydrometric results

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 show consistencies in streamflow patterns amongst the three years sampled at Alexander Creek. Freshet (i.e. high flows due to snowmelt and/or heavy rain) occurred April – June, followed by decreasing flows (Figure 6). In 2016, there was a slight increase in streamflow in October, which was caused by heavy precipitation.
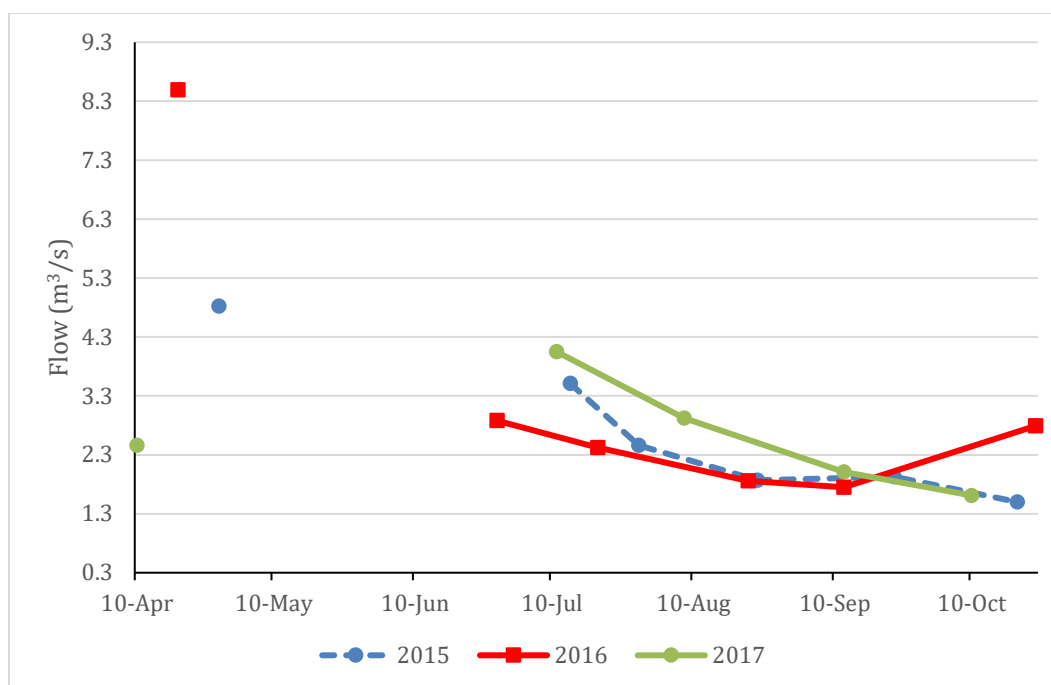
Figure 6. Streamflow at NGALX03, 2015-2017. No measurements were collected during the spring high flow period, due to safety concerns.

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 NGALX03 as being unstressed in all three years sampled (2015-2017). This was evident through all taxa being present that were expected based on reference group conditions, as well as key metrics (i.e., total abundance, % EPT taxa, % chironomidae, % two most dominant taxa, and taxa richness), being similar or better than the reference group values. The benthic macro-invertebrate results were supported by the water quality and hydrometric results.

Water quality was good at NGALX03, with total phosphorous being the only parameter to exceed the aquatic life guidelines. The exceedances occurred once in the spring of 2015 and once in the spring of 2017. All drinking water guidelines were met.

Stream temperatures in spring through fall did not exceed the guidelines for the protection of Bull Trout rearing. The Bull Trout minimum stream temperature guideline for egg incubation was 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. Flows followed a typical nival pattern, with higher flows in the spring during freshet and decreasing throughout the summer and fall towards baseflow in the winter months.

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, of course, 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 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) determining the hydrologic regime of the stream using continuous level loggers, 2) conducting fish habitat assessments, 3) conducting fish assessments (e.g., composition, abundance and life-history use). The Elk River Alliance would need to look at existing data available, to determine where there were information gaps needing to be filled.

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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-Elk
Site	NGALX-03
Sampling Date	Sep 23 2015
Know Your Watershed Basin	Central Kootenay
Province / Territory	British Columbia
Terrestrial Ecological Classification	Montane Cordillera EcoZone Northern Continental Divide EcoRegion
Coordinates (decimal degrees)	49.65523 N, 114.73069 W
Altitude	4291
Local Basin Name	Alexander Creek
	Elk River Watershed
Stream Order	4
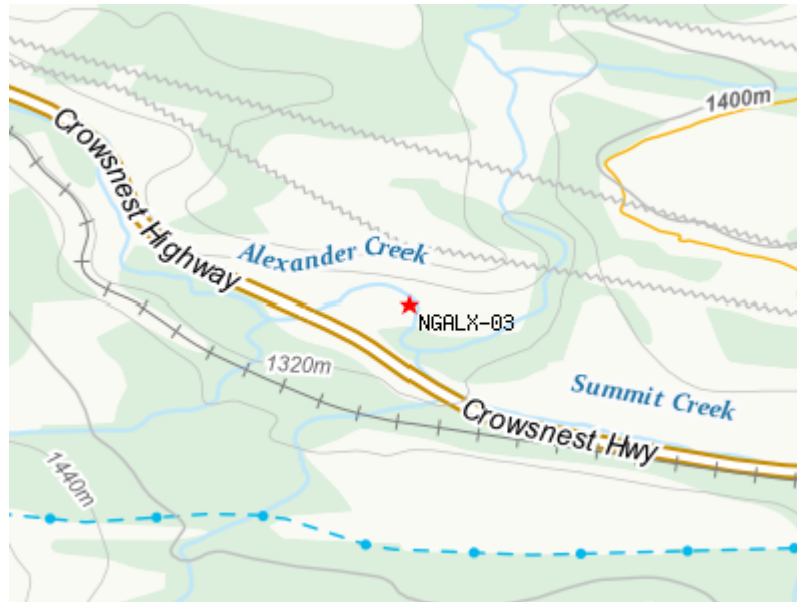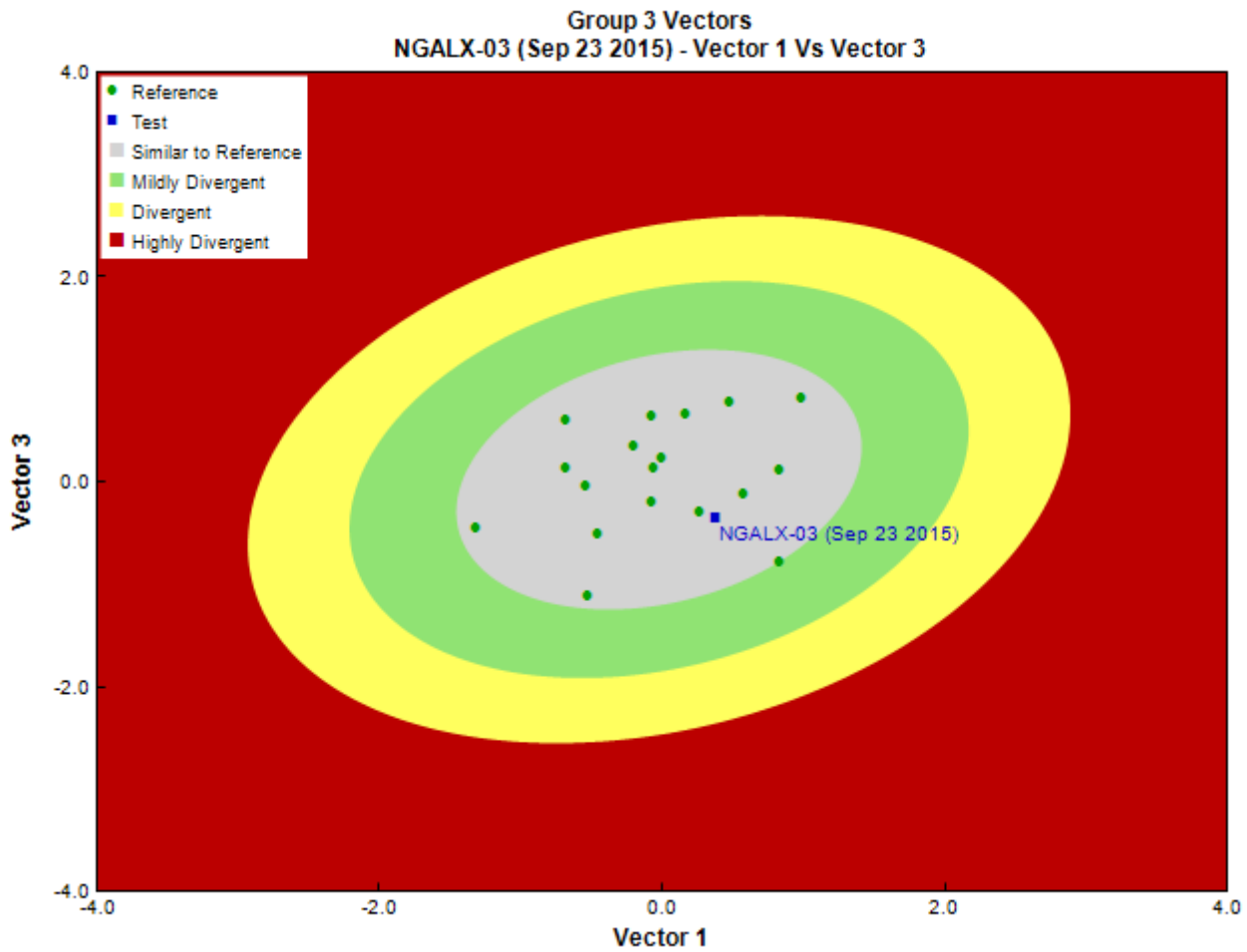
Figure 1. Location Map

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	January 17, 2016
	Marchant Box
Sub-Sample Proportion	8/100

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
Arthropoda	Arachnida	Trombidiformes		1	12.5
			Lebertiidae	3	37.5
	Insecta	Coleoptera	Elmidae	4	50.0
		Diptera	Ceratopogonidae	1	12.5
			Chironomidae	25	312.5
			Psychodidae	37	462.5
			Simuliidae	6	75.0
		Ephemeroptera	Ameletidae	5	62.5
			Baetidae	37	462.5
			Ephemerellidae	95	1,187.5
			Heptageniidae	59	737.5
		Plecoptera	Chloroperlidae	7	87.5
			Leuctridae	3	37.5
			Nemouridae	41	512.5
			Perlodidae	5	62.5

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
			Taeniopterygidae	55	687.5
		Trichoptera	Apataniidae	4	50.0
			Glossosomatidae	10	125.0
			Hydropsychidae	6	75.0
			Rhyacophilidae	7	87.5
			Uenoidae	6	75.0
			Total	417	5,212.5

Metrics

Name	NGALX-03	Predicted Group Reference Mean ±SD
Bray-Curtis Distance	0.4	0.4 ± 0.2
Biotic Indices		
Hilsenhoff Family index (North-West)	3.2	3.2 ± 0.7
Intolerant taxa	--	
Long-lived taxa	1.0	1.9 ± 1.3
Tolerant individuals (%)	--	
Functional Measures		
% Filterers	2.9	
% Gatherers	66.2	
% Predatores	14.4	
% Scrapers	45.3	
% Shredder	25.7	
No. Clinger Taxa	26.0	19.8 ± 3.9
Number Of Individuals		
% Chironomidae	6.0	8.2 ± 13.6
% Coleoptera	1.0	0.8 ± 1.9
% Diptera + Non-insects	17.3	14.3 ± 14.2
% Ephemeroptera	47.1	43.3 ± 15.7
% Ephemeroptera that are Baetidae	18.9	33.9 ± 27.7
% EPT Individuals	81.7	84.9 ± 14.3
% Odonata	--	0.0 ± 0.0
% of 2 dominant taxa	37.0	58.9 ± 10.0
% of 5 dominant taxa	69.0	83.8 ± 7.3
% of dominant taxa	22.8	39.5 ± 10.9
% Plecoptera	26.7	34.7 ± 17.8
% Tribe Tanyatarisini	--	
% Trichoptera that are Hydropsychida	18.2	27.8 ± 25.2
% Tricoptera	7.9	6.9 ± 8.6
No. EPT individuals/Chironomids+EPT Individuals	0.9	0.9 ± 0.1
Total Abundance	5212.5	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	4.0	3.4 ± 0.5
EPT Individuals (Sum)	4250.0	4527.1 ± 3161.8
EPT taxa (no)	14.0	11.5 ± 1.2
Odonata taxa	--	0.0 ± 0.0
Pielou's Evenness	0.8	0.7 ± 0.1
Plecoptera taxa	5.0	5.3 ± 0.9
Shannon-Wiener Diversity	2.4	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	20.0	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 NGALX-03
	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 NGALX-03
	Group 1	Group 2	Group 3	Group 4	Group 5	
Chironomidae	100%	100%	100%	100%	95%	1.00
Chloroperlidae	78%	88%	94%	100%	100%	0.95
Ephemerellidae	78%	100%	100%	100%	100%	1.00
Heptageniidae	100%	100%	100%	100%	100%	1.00
Hydropsychidae	11%	92%	78%	92%	86%	0.80
Nemouridae	100%	100%	100%	100%	100%	1.00
Perlodidae	78%	78%	89%	92%	81%	0.89
Psychodidae	22%	65%	94%	8%	11%	0.82
Rhyacophilidae	100%	92%	100%	100%	95%	1.00
Taeniopterygidae	89%	49%	100%	92%	97%	0.99

RIVPACS Ratios

RIVPACS : Expected taxa P>0.50	12.68
RIVPACS : Observed taxa P>0.50	12.00
RIVPACS : O:E (p > 0.5)	0.95
RIVPACS : Expected taxa P>0.70	10.45
RIVPACS : Observed taxa P>0.70	11.00
RIVPACS : O:E (p > 0.7)	1.05

Habitat Description

Variable	NGALX-03	Predicted Group Reference Mean ±SD
Channel		
Depth-Avg (cm)	34.4	22.5 ± 10.5
Depth-BankfullMinusWetted (cm)	24.00	67.33 ± 71.65
Depth-Max (cm)	44.0	32.9 ± 17.9
Macrophyte (PercentRange)	0	0 ± 0
Reach-%CanopyCoverage (PercentRange)	2.00	0.94 ± 0.80
Reach-DomStreamsideVeg (Category (1-4))	4	3 ± 1
Reach-Pools (Binary)	0	0 ± 1
Reach-Rapids (Binary)	0	0 ± 1
Reach-Riffles (Binary)	1	1 ± 0
Reach-StraightRun (Binary)	0	1 ± 0
Slope (m/m)	0.0100000	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)	0.59	0.51 ± 0.25
Velocity-Max (m/s)	0.70	0.75 ± 0.28
Width-Bankfull (m)	12.0	15.6 ± 12.8
Width-Wetted (m)	9.4	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 (%)	3	6 ± 7
%Cobble (%)	68	61 ± 27
%Gravel (%)	8	1 ± 2
%Pebble (%)	16	31 ± 28
%Sand (%)	0	0 ± 0
%Silt+Clay (%)	5	1 ± 3
D50 (cm)	9.55	79.45 ± 47.98
Dg (cm)	6.1	73.9 ± 48.0
Dominant-1st (Category(0-9))	6	6 ± 2
Dominant-2nd (Category(0-9))	7	6 ± 2
Embeddedness (Category(1-5))	3	4 ± 1
PeriphytonCoverage (Category(1-5))	2	2 ± 1
SurroundingMaterial (Category(0-9))	1	4 ± 2

Habitat Description

Variable	NGALX-03	Predicted Group Reference Mean ±SD
Topography		
Reg-SlopeLT30% (%)	37.34105	27.92073 ± 14.83033
Water Chemistry		
Ag (mg/L)	0.0000000	0.0000000 ± 0.0000000
Al (mg/L)	0.0149000	0.0000000 ± 0.0000000
As (mg/L)	0.0001900	0.0000000 ± 0.0000000
B (mg/L)	0.0000000	0.0000000 ± 0.0000000
Ba (mg/L)	0.0659000	0.0000000 ± 0.0000000
Be (mg/L)	0.0000000	0.0000000 ± 0.0000000
Bi (mg/L)	0.0000000	0.0000000 ± 0.0000000
Ca (mg/L)	46.5000000	0.0000000 ± 0.0000000
Cd (mg/L)	0.0000000	0.0000000 ± 0.0000000
Chloride-Dissolved (mg/L)	1.6000000	3.5428571 ± 8.1653449
Co (mg/L)	0.0000000	0.0000000 ± 0.0000000
Cr (mg/L)	0.0000000	0.0000000 ± 0.0000000
Cu (mg/L)	0.0005100	0.0000000 ± 0.0000000
Fe (mg/L)	0.0240000	0.0000000 ± 0.0000000
General-Alkalinity (mg/L)	1.0700000	121.5944444 ± 36.7225924
General-DO (mg/L)	12.0000000	10.4922222 ± 0.8833463
General-Hardness (mg/L)	166.0000000	146.8222222 ± 41.6699011
General-pH (pH)	8.5	8.0 ± 0.6
General-SolidsTSS (mg/L)	0.0000000	0.5604289 ± 1.4627232
General-SpCond (µS/cm)	321.4000000	214.2437500 ± 77.1891440
General-TempAir (Degrees Celsius)	13.5	10.5 ± 4.2
General-TempWater (Degrees Celsius)	4.0000000	6.6716667 ± 2.0277755
General-Turbidity (NTU)	0.9700000	0.0000000 ± 0.0000000
Hg (ng/L)	0.0000000	0.0000000 ± 0.0000000
K (mg/L)	0.3610000	0.0000000 ± 0.0000000
Mg (mg/L)	12.2000000	0.0000000 ± 0.0000000
Mn (mg/L)	0.0020000	0.0000000 ± 0.0000000
Mo (mg/L)	0.0000000	0.0000000 ± 0.0000000
Na (mg/L)	1.4500000	0.0000000 ± 0.0000000
Ni (mg/L)	0.0000000	0.0000000 ± 0.0000000
Nitrogen-NO2 (mg/L)	0.0025000	0.0023889 ± 0.0063351
Nitrogen-NO2+NO3 (mg/L)	0.0240000	0.0130000 ± 0.0088111
Nitrogen-NO3 (mg/L)	0.0240000	0.0245003 ± 0.0229452
Nitrogen-TN (mg/L)	0.0830000	0.0000000 ± 0.0000000
Phosphorus-OrthoP (mg/L)	0.0000000	0.0035000 ± 0.0018292
Phosphorus-TP (mg/L)	0.0084000	0.0032778 ± 0.0061816
S (mg/L)	7.5000000	0.0000000 ± 0.0000000
Se (mg/L)	0.5000000	0.0000000 ± 0.0000000
Si (mg/L)	2.1900000	0.0000000 ± 0.0000000
Sn (mg/L)	0.0000000	0.0000000 ± 0.0000000
Sr (mg/L)	0.1110000	0.0000000 ± 0.0000000
Ti (mg/L)	0.0000000	0.0000000 ± 0.0000000
Tl (mg/L)	0.0000000	0.0000000 ± 0.0000000
U (mg/L)	0.0006000	0.0000000 ± 0.0000000
V (mg/L)	0.0000000	0.0000000 ± 0.0000000
Zn (mg/L)	0.0000000	0.0000000 ± 0.0000000
Zr (mg/L)	0.0000000	0.0000000 ± 0.0000000

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	0.1%	0.2%	85.9%	12.3%	1.5%
CABIN Assessment of NGALX-03 on Sep 12, 2016	Similar to Reference				
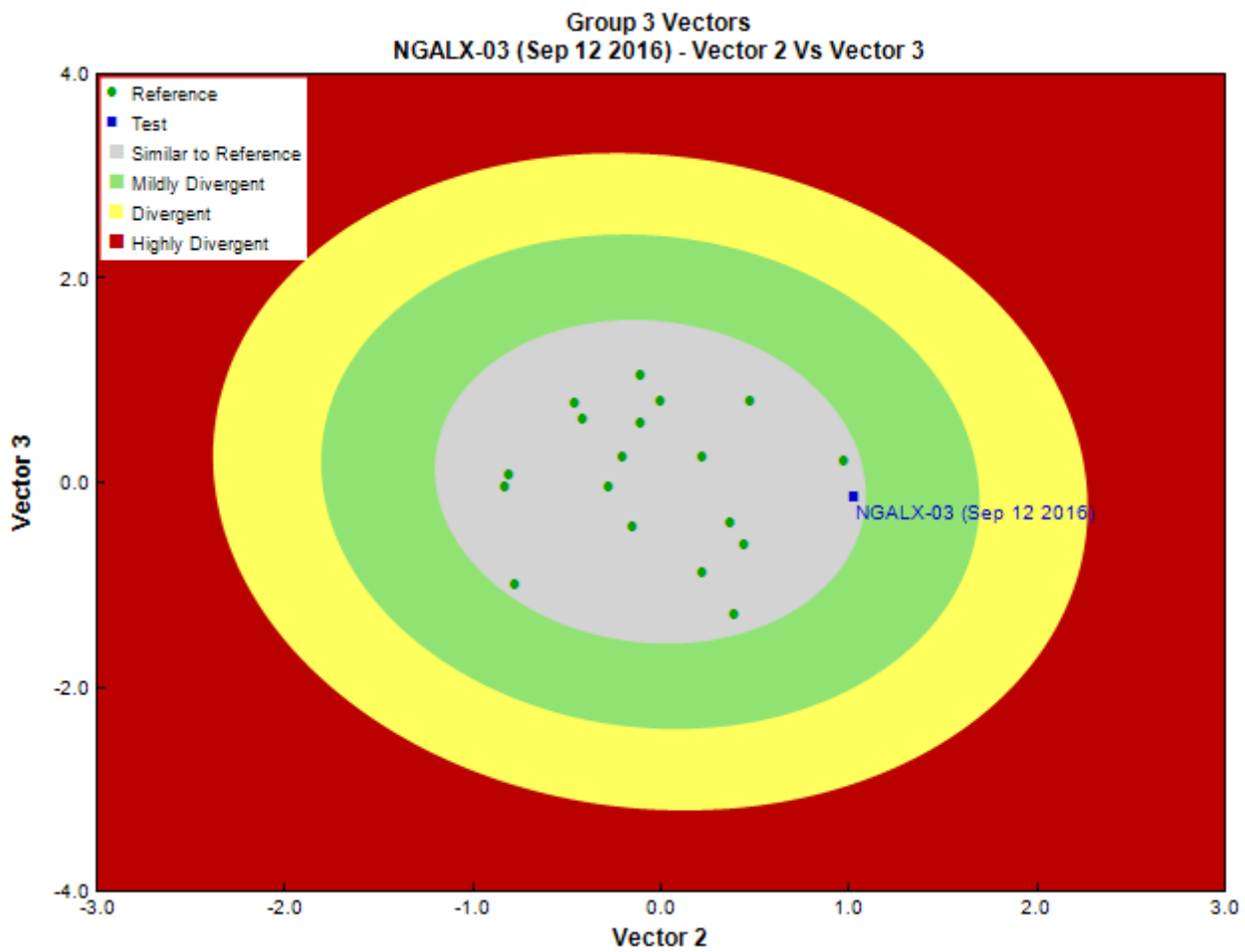
Figure 3. CABIN ordination assessment of the test site with the predicted group of reference sites. Each axis represents the relative abundance of the entire benthic invertebrate community with different organisms weighted differently on each axis.

Sample Information

Sampling Device	Kick Net
Mesh Size	400
Sampling Time	3
Taxonomist	Pina Viola, Consultant
Date Taxonomy Completed	October 24, 2016
	Marchant Box
Sub-Sample Proportion	6/100

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
Arthropoda	Arachnida	Trombidiformes		1	16.7
			Hygrobatidae	1	16.7
			Lebertiidae	2	33.3
			Sperchontidae	1	16.7
	Insecta	Coleoptera	Elmidae	7	116.7
		Diptera	Ceratopogonidae	3	50.0
			Chironomidae	39	650.0
			Empididae	1	16.7
			Psychodidae	17	283.3
			Simuliidae	1	16.7
			Tipulidae	1	16.7
		Ephemeroptera	Ameletidae	2	33.3
			Baetidae	50	833.3
			Ephemerellidae	112	1,866.7
			Heptageniidae	44	733.3

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
		Plecoptera	Chloroperlidae	11	183.3
			Leuctridae	5	83.3
			Nemouridae	17	283.3
			Perlodidae	5	83.4
			Taeniopterygidae	4	66.7
		Trichoptera	Apataniidae	4	66.7
			Brachycentridae	1	16.7
			Glossosomatidae	81	1,350.0
			Hydropsychidae	2	33.4
			Rhyacophilidae	10	166.7
			Uenoidae	4	66.7
			Total	426	7,100.3

Metrics

Name	NGALX-03	Predicted Group Reference Mean ±SD
Bray-Curtis Distance	0.58	0.4 ± 0.2
Biotic Indices		
Hilsenhoff Family index (North-West)	2.5	3.2 ± 0.7
Intolerant taxa	--	
Long-lived taxa	2.0	1.9 ± 1.3
Tolerant individuals (%)	--	0.3
Functional Measures		
% Filterers	0.9	1.8 ± 1.6
% Gatherers	51.2	52.4 ± 14.6
% Predatores	17.8	18.3 ± 13.3
% Scrapers	49.1	61.8 ± 17.2
% Shredder	9.2	30.3 ± 18.6
No. Clinger Taxa	28.0	19.8 ± 3.9
Number Of Individuals		
% Chironomidae	9.2	8.2 ± 13.6
% Coleoptera	1.6	0.8 ± 1.9
% Diptera + Non-insects	15.5	14.3 ± 14.2
% Ephemeroptera	48.9	43.3 ± 15.7
% Ephemeroptera that are Baetidae	24.0	33.9 ± 27.7
% EPT Individuals	82.8	84.9 ± 14.3
% Odonata	0.0	0.0 ± 0.0
% of 2 dominant taxa	45.4	58.9 ± 10.0
% of 5 dominant taxa	76.7	83.8 ± 7.3
% of dominant taxa	26.4	39.5 ± 10.9
% Plecoptera	9.9	34.7 ± 17.8
% Tribe Tanyatarisini	--	
% Trichoptera that are Hydropsychida	2.0	27.8 ± 25.2
% Tricoptera	24.0	6.9 ± 8.6
No. EPT individuals/Chironomids+EPT Individuals	0.9	0.9 ± 0.1
Total Abundance	7100.0	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	6.0	3.4 ± 1.0
Ephemeroptera taxa	4.0	3.4 ± 0.5
EPT Individuals (Sum)	5866.7	4527.1 ± 3161.8
EPT taxa (no)	15.0	11.5 ± 1.2
Odonata taxa	0.0	0.0 ± 0.0
Pielou's Evenness	0.7	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	0.3	0.3 ± 0.1
Total No. of Taxa	25.0	17.7 ± 2.6
Trichoptera taxa	6.0	2.8 ± 1.0

Frequency and Probability of Taxa Occurrence

Reference Model Taxa	Frequency of Occurrence in Reference Sites					Probability Of Occurrence at NGALX-03
	Group 1	Group 2	Group 3	Group 4	Group 5	
Baetidae	100%	100%	100%	100%	97%	1.00
Chironomidae	100%	100%	100%	100%	95%	1.00
Chloroperlidae	78%	88%	94%	100%	100%	0.95
Ephemerellidae	78%	100%	100%	100%	100%	1.00
Heptageniidae	100%	100%	100%	100%	100%	1.00
Hydropsychidae	11%	92%	78%	92%	86%	0.80
Nemouridae	100%	100%	100%	100%	100%	1.00
Perlodidae	78%	78%	89%	92%	81%	0.89
Psychodidae	22%	65%	94%	8%	11%	0.82
Rhyacophilidae	100%	92%	100%	100%	95%	1.00
Taeniopterygidae	89%	49%	100%	92%	97%	0.99

RIVPACS Ratios

RIVPACS : Expected taxa P>0.50	12.69
RIVPACS : Observed taxa P>0.50	13.00
RIVPACS : O:E (p > 0.5)	1.02
RIVPACS : Expected taxa P>0.70	10.45
RIVPACS : Observed taxa P>0.70	11.00
RIVPACS : O:E (p > 0.7)	1.05

Habitat Description

Variable	NGALX-03	Predicted Group Reference Mean ±SD
Channel		
Depth-Avg (cm)	29.7	22.5 ± 10.5
Depth-BankfullMinusWetted (cm)	12.00	67.33 ± 71.65
Depth-Max (cm)	35.6	32.9 ± 17.9
Macrophyte (PercentRange)	0	0 ± 0
Reach-%CanopyCoverage (PercentRange)	1.00	0.94 ± 0.80
Reach-DomStreamsideVeg (Category (1-4))	1	3 ± 1
Reach-Riffles (Binary)	1	1 ± 0
Slope (m/m)	0.0096600	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)	0.62	0.50 ± 0.25
Velocity-Max (m/s)	0.83	0.75 ± 0.28
Width-Bankfull (m)	11.5	15.6 ± 12.8
Width-Wetted (m)	9.5	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 (%)	5	6 ± 7
%Cobble (%)	59	61 ± 27
%Gravel (%)	13	1 ± 2
%Pebble (%)	19	31 ± 28
%Sand (%)	3	0 ± 0
%Silt+Clay (%)	1	0 ± 1
D50 (cm)	8.75	79.45 ± 47.98
Dg (cm)	4.8	73.9 ± 48.0
Dominant-1st (Category(0-9))	6	6 ± 1
Dominant-2nd (Category(0-9))	7	6 ± 2
Embeddedness (Category(1-5))	5	4 ± 1
PeriphytonCoverage (Category(1-5))	3	2 ± 1
SurroundingMaterial (Category(0-9))	2	3 ± 1
Topography		
Reg-SlopeLT30% (%)	37.34105	27.92073 ± 14.83033

Habitat Description

Variable	NGALX-03	Predicted Group Reference Mean ±SD
Water Chemistry		
Ag (mg/L)	0.0000100	0.0000004 ± 0.0000014
Al (mg/L)	0.0032000	0.0059500 ± 0.0039700
As (mg/L)	0.0001100	0.0002175 ± 0.0001795
B (mg/L)	0.0250000	0.0500000
Ba (mg/L)	0.0661000	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)	47.6000000	38.6142857 ± 14.8464843
Cd (mg/L)	0.0000050	0.0000059 ± 0.0000067
Chloride-Dissolved (mg/L)	1.1000000	3.5428571 ± 8.1653449
Co (mg/L)	0.0002500	0.0000043 ± 0.0000057
CO3 (mg/L)	2.4700000	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)	0.0150000	0.0090000
General-Alkalinity (mg/L)	150.0000000	121.5944444 ± 36.7225924
General-DO (mg/L)	11.0000000	10.4922222 ± 0.8833463
General-Hardness (mg/L)	169.0000000	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)	312.6000000	214.2437500 ± 77.1891440
General-TempAir (Degrees Celsius)	7.0	10.5 ± 4.2
General-TempWater (Degrees Celsius)	6.0000000	6.6716667 ± 2.0277755
General-Turbidity (NTU)	1.3000000	0.0000000 ± 0.0000000
HCO3 (mg/L)	178.0000000	0.0000000 ± 0.0000000
Hg (ng/L)	5.0000000	0.0000000 ± 0.0000000
K (mg/L)	0.3760000	0.6471429 ± 0.7154652
Li (mg/L)	0.0025000	0.0011817 ± 0.0004768
Mg (mg/L)	12.3000000	9.8814286 ± 6.1601202
Mn (mg/L)	0.0015000	0.0011426 ± 0.0016097
Mo (mg/L)	0.0005000	0.0024883 ± 0.0065339
Na (mg/L)	1.3400000	2.6357143 ± 3.7712414
Ni (mg/L)	0.0005000	0.0000808 ± 0.0000811
Nitrogen-NO2 (mg/L)	0.0025000	0.0023889 ± 0.0063351
Nitrogen-NO2+NO3 (mg/L)	0.0380000	0.0130000 ± 0.0088111
Nitrogen-NO3 (mg/L)	0.0380000	0.0245003 ± 0.0229452
Nitrogen-TN (mg/L)	0.1920000	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)	6.1000000	5.0000000
Sb (mg/L)	0.2500000	0.0000361 ± 0.0000135
Se (mg/L)	0.0006000	0.0004382 ± 0.0004486
Si (mg/L)	2.3100000	3.0657143 ± 1.4070046
Sn (mg/L)	0.0025000	0.0000167 ± 0.0000078
SO4 (mg/L)	17.3000000	14.9647059 ± 10.8432549
Sr (mg/L)	0.1100000	0.1159167 ± 0.0982749
Ti (mg/L)	0.0025000	0.0009000
Tl (mg/L)	0.0000250	0.0000038 ± 0.0000064
U (mg/L)	0.0005800	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-Elk
Site	NGALX-03
Sampling Date	Sep 12 2017
Know Your Watershed Basin	Central Kootenay
Province / Territory	British Columbia
Terrestrial Ecological Classification	Montane Cordillera EcoZone Northern Continental Divide EcoRegion
Coordinates (decimal degrees)	49.65544 N, 114.73064 W
Altitude	4317
Local Basin Name	Alexander Creek
	Elk River Watershed
Stream Order	4
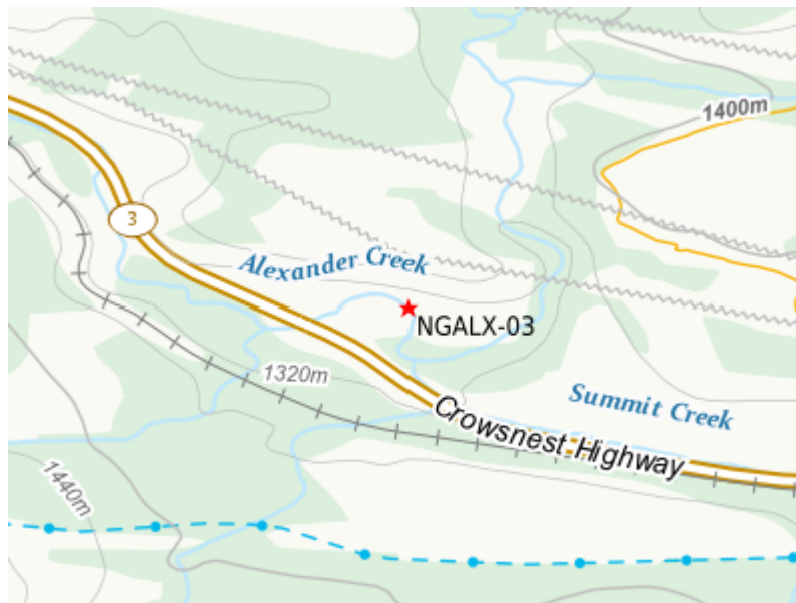
Figure 1. Location Map

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	0.1%	0.2%	85.6%	12.6%	1.5%
CABIN Assessment of NGALX-03 on Sep 12, 2017	Similar to Reference				
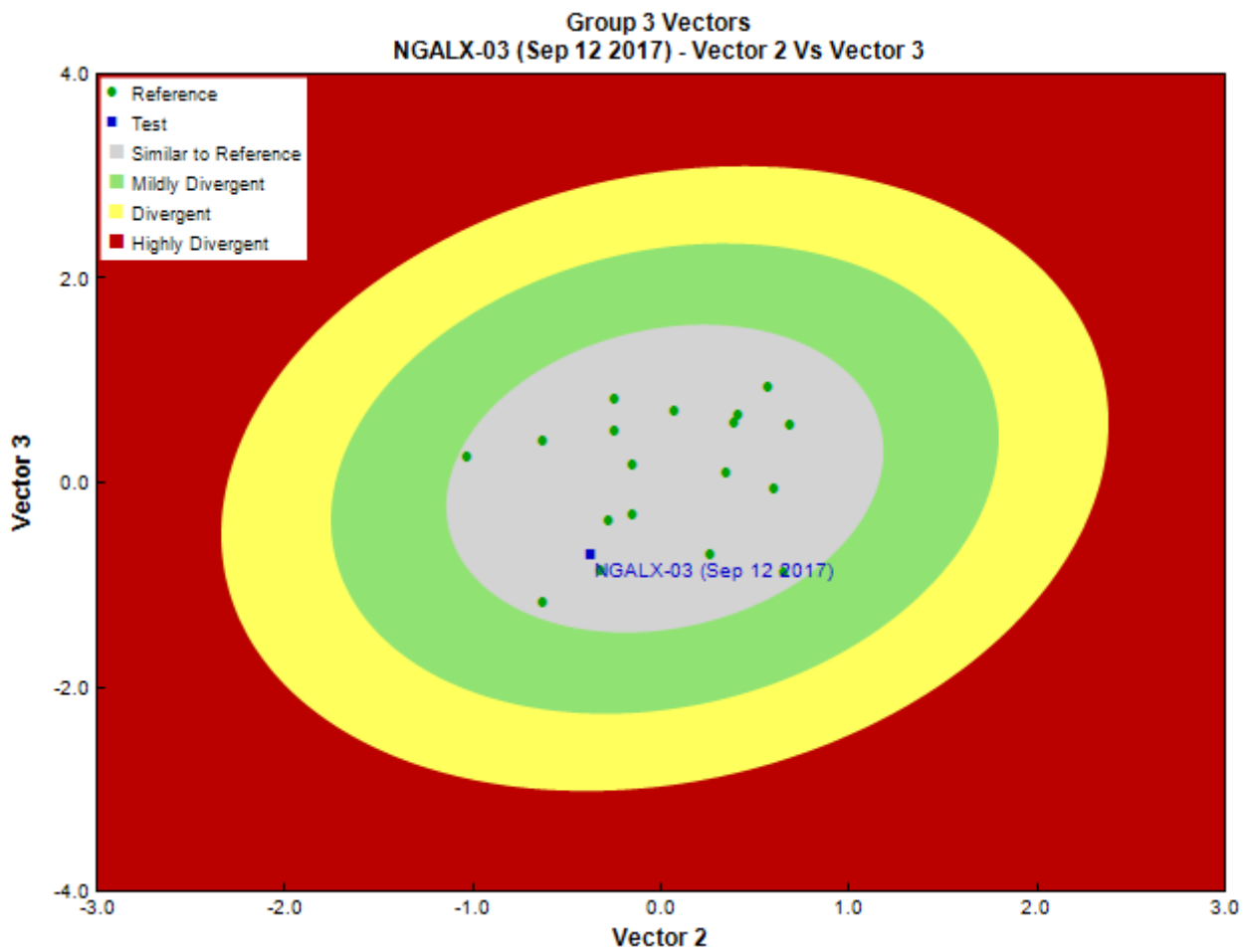
Figure 3. CABIN ordination assessment of the test site with the predicted group of reference sites. Each axis represents the relative abundance of the entire benthic invertebrate community with different organisms weighted differently on each axis.

Sample Information

Sampling Device	Kick Net
Mesh Size	400
Sampling Time	3
Taxonomist	Pina Viola, Consultant
Date Taxonomy Completed	December 16, 2017
	Marchant Box
Sub-Sample Proportion	5/100

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
Arthropoda	Insecta	Coleoptera	Elmidae	6	120.0
		Diptera	Ceratopogonidae	3	60.0
			Chironomidae	51	1,020.0
			Empididae	1	20.0
			Pelecorhynchidae	1	20.0
			Psychodidae	11	220.0
			Simuliidae	2	40.0
			Tipulidae	1	20.0
		Ephemeroptera	Ameletidae	2	40.0
			Baetidae	97	1,940.0
			Ephemerellidae	96	1,920.0
			Heptageniidae	54	1,080.0
		Plecoptera	Capniidae	3	60.0
			Chloroperlidae	2	40.0
			Leuctridae	1	20.0

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
			Nemouridae	63	1,260.0
			Perlodidae	3	60.0
			Taeniopterygidae	34	680.0
		Trichoptera		3	60.0
			Apataniidae	2	40.0
			Glossosomatidae	16	320.0
			Hydropsychidae	9	180.0
			Rhyacophilidae	13	260.0
			Uenoidae	2	40.0
			Total	476	9,520.0

Metrics

Name	NGALX-03	Predicted Group Reference Mean ±SD
Bray-Curtis Distance	0.55	0.4 ± 0.2
Biotic Indices		
Hilsenhoff Family index (North-West)	3.0	3.2 ± 0.7
Intolerant taxa	--	
Long-lived taxa	2.0	1.9 ± 1.3
Tolerant individuals (%)	--	0.3
Functional Measures		
% Filterers	2.3	1.8 ± 1.6
% Gatherers	56.9	52.4 ± 14.6
% Predatores	17.9	18.3 ± 13.3
% Scrapers	45.8	61.8 ± 17.2
% Shredder	23.1	30.3 ± 18.6
No. Clinger Taxa	29.0	19.8 ± 3.9
Number Of Individuals		
% Chironomidae	10.8	8.2 ± 13.6
% Coleoptera	1.3	0.8 ± 1.9
% Diptera + Non-insects	14.8	14.3 ± 14.2
% Ephemeroptera	52.6	43.3 ± 15.7
% Ephemeroptera that are Baetidae	39.0	33.9 ± 27.7
% EPT Individuals	83.9	84.9 ± 14.3
% Odonata	0.0	0.0 ± 0.0
% of 2 dominant taxa	40.8	58.9 ± 10.0
% of 5 dominant taxa	76.3	83.8 ± 7.3
% of dominant taxa	20.5	39.5 ± 10.9
% Plecoptera	22.4	34.7 ± 17.8
% Tribe Tanyatarisini	--	
% Trichoptera that are Hydropsychida	21.4	27.8 ± 25.2
% Tricoptera	8.9	6.9 ± 8.6
No. EPT individuals/Chironomids+EPT Individuals	0.9	0.9 ± 0.1
Total Abundance	9520.0	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	7.0	3.4 ± 1.0
Ephemeroptera taxa	4.0	3.4 ± 0.5
EPT Individuals (Sum)	7940.0	4527.1 ± 3161.8
EPT taxa (no)	15.0	11.5 ± 1.2
Odonata taxa	0.0	0.0 ± 0.0
Pielou's Evenness	0.7	0.7 ± 0.1
Plecoptera taxa	6.0	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	0.3	0.3 ± 0.1
Total No. of Taxa	23.0	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 NGALX-03
	Group 1	Group 2	Group 3	Group 4	Group 5	
Baetidae	100%	100%	100%	100%	97%	1.00
Chironomidae	100%	100%	100%	100%	95%	1.00
Chloroperlidae	78%	88%	94%	100%	100%	0.95
Ephemerellidae	78%	100%	100%	100%	100%	1.00
Heptageniidae	100%	100%	100%	100%	100%	1.00
Hydropsychidae	11%	92%	78%	92%	86%	0.80
Nemouridae	100%	100%	100%	100%	100%	1.00
Perlodidae	78%	78%	89%	92%	81%	0.89
Psychodidae	22%	65%	94%	8%	11%	0.82
Rhyacophilidae	100%	92%	100%	100%	95%	1.00
Taeniopterygidae	89%	49%	100%	92%	97%	0.99

RIVPACS Ratios

RIVPACS : Expected taxa P>0.50	12.69
RIVPACS : Observed taxa P>0.50	14.00
RIVPACS : O:E (p > 0.5)	1.10
RIVPACS : Expected taxa P>0.70	10.45
RIVPACS : Observed taxa P>0.70	11.00
RIVPACS : O:E (p > 0.7)	1.05

Habitat Description

Variable	NGALX-03	Predicted Group Reference Mean ±SD
Channel		
Depth-Avg (cm)	32.8	22.5 ± 10.5
Depth-BankfullMinusWetted (cm)	25.00	67.33 ± 71.65
Depth-Max (cm)	40.0	32.9 ± 17.9
Macrophyte (PercentRange)	0	0 ± 0
Reach-%CanopyCoverage (PercentRange)	2.00	0.94 ± 0.80
Reach-DomStreamsideVeg (Category(1-4))	2	3 ± 1
Reach-Riffles (Binary)	1	1 ± 0
Reach-StraightRun (Binary)	1	1 ± 0
Slope (m/m)	0.0080000	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)	0.67	0.50 ± 0.25
Velocity-Max (m/s)	0.89	0.75 ± 0.28
Width-Bankfull (m)	11.6	15.6 ± 12.8
Width-Wetted (m)	9.1	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 (%)	10	6 ± 7
%Cobble (%)	66	61 ± 27
%Gravel (%)	1	1 ± 2
%Pebble (%)	23	31 ± 28
%Sand (%)	0	0 ± 0
%Silt+Clay (%)	0	0 ± 1
D50 (cm)	10.00	79.45 ± 47.98
Dg (cm)	10.0	73.9 ± 48.0
Dominant-1st (Category(0-9))	6	6 ± 1
Dominant-2nd (Category(0-9))	7	6 ± 2
Embeddedness (Category(1-5))	5	4 ± 1
PeriphytonCoverage (Category(1-5))	2	2 ± 1
SurroundingMaterial (Category(0-9))	3	3 ± 1
Topography		

Habitat Description

Variable	NGALX-03	Predicted Group Reference Mean ±SD
Reg-SlopeLT30% (%)	37.34106	27.92073 ± 14.83033
Water Chemistry		
Ag (mg/L)	0.0000100	0.0000004 ± 0.0000014
Al (mg/L)	0.0015000	0.0059500 ± 0.0039700
As (mg/L)	0.0000500	0.0002175 ± 0.0001795
B (mg/L)	0.0250000	0.0500000
Ba (mg/L)	0.0434000	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)	47.8000000	38.6142857 ± 14.8464843
Cd (mg/L)	0.0000050	0.0000059 ± 0.0000067
Chloride-Dissolved (mg/L)	1.4000000	3.5428571 ± 8.1653449
Co (mg/L)	0.0001000	0.0000043 ± 0.0000057
CO3 (mg/L)	3.9000000	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)	0.0130000	0.0090000
General-Alkalinity (mg/L)	163.0000000	121.5944444 ± 36.7225924
General-DO (mg/L)	11.0000000	10.4922222 ± 0.8833463
General-Hardness (mg/L)	174.0000000	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)	322.0000000	214.2437500 ± 77.1891440
General-TempAir (Degrees Celsius)	16.0	10.5 ± 4.2
General-TempWater (Degrees Celsius)	7.3000000	6.6716667 ± 2.0277755
General-Turbidity (NTU)	0.6000000	0.0000000 ± 0.0000000
HCO3 (mg/L)	191.0000000	0.0000000 ± 0.0000000
Hg (ng/L)	5.0000000	0.0000000 ± 0.0000000
K (mg/L)	0.4580000	0.6471429 ± 0.7154652
Li (mg/L)	0.0027000	0.0011817 ± 0.0004768
Mg (mg/L)	13.3000000	9.8814286 ± 6.1601202
Mo (mg/L)	0.0005000	0.0024883 ± 0.0065339
Na (mg/L)	1.8600000	2.6357143 ± 3.7712414
Ni (mg/L)	0.0005000	0.0000808 ± 0.0000811
Nitrogen-NO2 (mg/L)	0.0025000	0.0023889 ± 0.0063351
Nitrogen-NO2+NO3 (mg/L)	0.0100000	0.0130000 ± 0.0088111
Nitrogen-NO3 (mg/L)	0.0100000	0.0245003 ± 0.0229452
Nitrogen-TN (mg/L)	0.0920000	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)	6.4000000	5.0000000
Sb (mg/L)	0.0002500	0.0000361 ± 0.0000135
Se (mg/L)	0.0006400	0.0004382 ± 0.0004486
Si (mg/L)	2.5000000	3.0657143 ± 1.4070046
Sn (mg/L)	0.0025000	0.0000167 ± 0.0000078
SO4 (mg/L)	15.8000000	14.9647059 ± 10.8432549
Sr (mg/L)	0.0760000	0.1159167 ± 0.0982749
Ti (mg/L)	0.0025000	0.0009000
Tl (mg/L)	0.0000050	0.0000038 ± 0.0000064
U (mg/L)	0.0003700	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	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 Phosphorus (P)
			Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L
			Detection Limit (RDL)	0.005	0.02	0.5	0.5	0.5	0.5	0.5	0.005	0.02	0.1	0.005
Elk River Alliance	2016-09-12	NGALX03	Alexander Creek- site 3	<0.0050	0.038	150	2.06	178	2.47	<0.50	<5	0.038	1.3	<0.0050
Elk River Alliance	2016-09-12	NGALX03 DUP	Alexander Creek- site 3	<0.0050	0.035	158	2.27	187	2.72	<0.50	<5	0.035	0.29	<0.0050
		Duplicate QC	Calculated RPD (%)	0.0	8.2	-5.2	-9.7	-4.9	-9.6	0.0	0.0	8.2	127.0	0.0
Elk River Alliance	2016-09-12	NGALX03 BLK	Alexander Creek- site 3	<0.0050	<0.020	0.66	<0.50	0.81	<0.50	<0.50	<5	<0.020	<0.10	<0.0050
		Blank QC	X times > than RDL	1.0	1.0	1.3	1.0	1.6	1.0	1.0	1.0	1.0	1.0	1.0

Appendix B1 - Water Quality, QA/QC

Sample Date (yy/mm/dd)	Total Nitrogen (N)	Conductivity	Total Suspended Solids	Dissolved Sulphate (SO4)	Dissolved Chloride (Cl)
	mg/L	uS/cm	mg/L	mg/L	mg/L
	0.02	**1**	**4**	**0.5**	**0.5**
2016-09-12	0.192		<4.0	17.3	1.1
2016-09-12	0.151	307	<4.0	17.5	1.1
	23.9	**-**	**0.0**	**-1.1**	**0.0**
2016-09-12	0.104	1	<4.0	<0.50	<0.50
	5.2	**1.0**	**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)
			Units	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	-	-
			Guideline for drinking water[max]	BC App: 1	BC App: 10	-	-
Elk River Alliance	2015-04-28	NGALX03	Alexander Creek- site 3	-	-	-	-
Elk River Alliance	2015-05-26	NGALX03	Alexander Creek- site 3	-	-	-	-
Elk River Alliance	2015-07-14	NGALX03	Alexander Creek- site 3	-	-	-	-
Elk River Alliance	2015-07-29	NGALX03	Alexander Creek- site 3	-	-	-	-
Elk River Alliance	2015-08-24	NGALX03	Alexander Creek- site 3	-	-	-	-
Elk River Alliance	2015-09-23	NGALX03	Alexander Creek- site 3	<0.0050	0.024	138	1.07
Elk River Alliance	2015-10-20	NGALX03	Alexander Creek- site 3	-	-	-	-
Elk River Alliance	2016-04-19	NGALX03	Alexander Creek- site 3	-	-	-	-
Elk River Alliance	2016-05-25	NGALX03	Alexander Creek- site 3	-	-	-	-
Elk River Alliance	2016-06-28	NGALX03	Alexander Creek- site 3	-	-	-	-
Elk River Alliance	2016-07-20	NGALX03	Alexander Creek- site 3	-	-	-	-
Elk River Alliance	2016-08-23	NGALX03	Alexander Creek- site 3	-	-	-	-
Elk River Alliance	2016-09-12	NGALX03	Alexander Creek- site 3	<0.0050	0.038	150	2.06
Elk River Alliance	2016-10-24	NGALX03	Alexander Creek- site 3	-	-	-	-
Elk River Alliance	2017-04-10	NGALX03	Alexander Creek- site 3	-	-	-	-
Elk River Alliance	2017-05-09	NGALX03	Alexander Creek- site 3	-	-	-	-
Elk River Alliance	2017-06-26	NGALX03	Alexander Creek- site 3	-	-	-	-
Elk River Alliance	2017-07-11	NGALX03	Alexander Creek- site 3	-	-	-	-
Elk River Alliance	2017-08-08	NGALX03	Alexander Creek- site 3	-	-	-	-
Elk River Alliance	2017-09-12	NGALX03	Alexander Creek- site 3	<0.0050	<0.020	163	3.2
Elk River Alliance	2017-10-10	NGALX03	Alexander Creek- site 3	-	-	-	-

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
	mg/L	mg/L	mg/L	µg/L	mg/L	mg/L	uS/cm	
	-	-	-	-	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
2015-04-28	-	-	-	<5	-	*13*	*294.5*	*8.53*
2015-05-26	-	-	-	-	-	*12*	*240.8*	*8.46*
2015-07-14	-	-	-	<5.01	-	*11*	*294.8*	*8.51*
2015-07-29	-	-	-	<5	-	*9*	*305.6*	*8.56*
2015-08-24	-	-	-	<5.01	-	*11*	*310.4*	*8.42*
2015-09-23	166	1.28	<0.50	<5	0.024	*12*	*321.4*	*8.46*
2015-10-20	-	-	-	-	-	*10*	*314.5*	*8.5*
2016-04-19	-	-	-	-	-	*12*	*274.6*	*8.17*
2016-05-25	-	-	-	<5	-	*14*	*258.9*	*8.76*
2016-06-28	-	-	-	<5.01	-	*11*	*283.7*	*8.61*
2016-07-20	-	-	-	<5	-	*10*	*293.7*	*8.59*
2016-08-23	-	-	-	<5	-	*11*	*304.9*	*8.77*
2016-09-12	178	2.47	<0.50	<5	0.038	*11*	*312.6*	*8.58*
2016-10-24	-	-	-	-	-	*12*	*281.3*	*8.67*
2017-04-10	-	-	-	-	-	*12*	*341.3*	*8.37*
2017-05-09	-	-	-	<5.01	-	*12*	*297*	*8.44*
2017-06-26	-	-	-	<5	-	*11*	*268.5*	*8.46*
2017-07-11	-	-	-	<5	-	*-*	*286*	*8.36*
2017-08-08	-	-	-	<3	-	*10*	*303.2*	*8.64*
2017-09-12	191	3.9	<1.0	<5	<0.020	*11*	*322*	*8.5*
2017-10-10	-	-	-	-	-	*12*	*323.9*	*8.52*

Appendix B2 - Water quality, non-metals

Sample Date (yy/mm/dd)	Turbidity	Water Temperature	Air Temperature	Total Hardness (CaCO3)	Total Phosphorus (P)	Total Nitrogen (N)
	NTU	C	C	mg/L	mg/L	mg/L
	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.	-	-	CCME: Based on this data, this 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 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	-	-	-	-
2015-04-28	4.17	5.5	16.5	-	0.0176	-
2015-05-26	39.2	6.5	12	-	-	-
2015-07-14	1.95	7.5	18.5	145	<0.0050	-
2015-07-29	1.58	12.1	21	-	<0.0050	-
2015-08-24	0.94	9	20	-	<0.0050	-
2015-09-23	0.97	4	13.5	166	0.0084	0.083
2015-10-20	0.65	7.1	8.7	-	-	-
2016-04-19	18.4	7.3	21	-	-	-
2016-05-25	3.96	8	18	-	0.0107	-
2016-06-28	1.41	12	26	156	0.01	-
2016-07-20	1.39	12.2	21	-	<0.0050	-
2016-08-23	1.11	10.6	18	-	<0.0050	-
2016-09-12	1.3	6	7	169	<0.0050	0.192
2016-10-24	0.93	4	6	-	-	-
2017-04-10	1.58	3.4	4	-	-	-
2017-05-09	10.2	5.6	14	-	0.0242	-
2017-06-26	3.63	10.2	25	141	0.0092	-
2017-07-11	2.05	10.5	15	-	0.007	-
2017-08-08	0.91	12.6	20	-	<0.0050	-
2017-09-12	0.06	7.3	16	174	<0.0050	0.092
2017-10-10	0.53	5.1	10	-	-	-

Appendix B2 - Water quality, non-metals

Sample Date (yy/mm/dd)	Total Suspended Solids	Dissolved Sulphate (SO4)	Dissolved Chloride (Cl)
	mg/L	mg/L	mg/L
	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 suphate): hardness 0-3 = 128, hardness 31-75 = 218, hardness 76-180 = 309, hardness 181-250 = 429	BC App (total chloride): 150
	-	HC[AO]: 500	BC App[AO]: 250
2015-04-28	5.3	-	-
2015-05-26	51.8	-	-
2015-07-14	<4.0	12.5	-
2015-07-29	<4.0	-	-
2015-08-24	<4.0 (2)	-	-
2015-09-23	<4.0	15.3	1.6
2015-10-20	<4.0	-	-
2016-04-19	33.3	-	-
2016-05-25	<4.0	-	-
2016-06-28	<4.0	13.6	-
2016-07-20	<4.0	-	-
2016-08-23	<4.0	-	-
2016-09-12	<4.0	17.3	1.1
2016-10-24	<4.0	-	-
2017-04-10	<4.0	-	-
2017-05-09	13.8	-	-
2017-06-26	<4.0	12.1	
2017-07-11	<4.0	-	-
2017-08-08	<4.0	-	-
2017-09-12	<4.0	15.8	1.4
2017-10-10	<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)
			Units	mg/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
			Calculated aquatic life guideline (where required)	-	50	-	-	-
			Guideline for drinking water[max]	-	BC App[AO]: 9500	HC: 6	BC App: 10	HC: 1000
Elk River Alliance	2015-07-14	NGALX03	Alexander Creek- site 3	145	18.3	<0.50	0.13	57.7
Elk River Alliance	2015-09-23	NGALX03	Alexander Creek- site 3	166	14.9	<0.50	0.19	65.9
Elk River Alliance	2016-06-28	NGALX03	Alexander Creek- site 3	156	10.4	<0.50	0.11	62.2
Elk River Alliance	2016-09-12	NGALX03	Alexander Creek- site 3	169	3.2	<0.50	0.11	66.1
Elk River Alliance	2017-06-26	NGALX03	Alexander Creek- site 3	141	31.6	<0.50	0.12	54.5
Elk River Alliance	2017-09-12	NGALX03	Alexander Creek- site 3	174	<3.0	<0.50	0.12	43.4

Appendix B3 - Water quality, metals

Sample Date (yy/mm/dd)	Total Beryllium (Be)	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)
	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
	BC Work: 0.13	-	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).	-
	-	-	-	0.23	-	-	-	6.36	-	9.06	-
	-	-	BC App: 5000	HC: 5	-	HC: 50	-	BC App^{AO}: 1000	BC App^{AO}: 300	BC App: 10	-
2015-07-14	<0.10	<1.0	<50	<0.010	40.6	<1.0	<0.50	<0.50	35	<0.20	<5.0
2015-09-23	<0.10	<1.0	<50	<0.010	46.5	<1.0	<0.50	0.51	24	<0.20	<5.0
2016-06-28	<0.10	<1.0	<50	0.01	43	<1.0	<0.50	<0.50	18	<0.20	<5.0
2016-09-12	<0.10	<1.0	<50	<0.010	47.6	<1.0	<0.50	<0.50	15	<0.20	<5.0
2017-06-26	<0.10	<1.0	<50	<0.010	39.2	<1.0	<0.20	<0.50	24	<0.20	3
2017-09-12	<0.10	<1.0	<50	<0.010	47.8	<1.0	<0.20	<0.50	13	<0.20	2.7

Appendix B3 - Water quality, metals

Sample Date (yy/mm/dd)	Total Magnesium (Mg)	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)
	mg/L	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.	-	-	-
	-	605.70	-	-	135.64	-	-	-	1.5	-	-	-
	-	BCApp[AO]: 50	BC App: 1	BC App: 250	-	-	BC App: 10	-	-	HC[AO]: 200	-	-
2015-07-14	10.7	2	<0.010	<1.0	<1.0	0.378	0.46	1970	<0.020	1.31	94.9	4.4
2015-09-23	12.2	2	<0.010	<1.0	<1.0	0.361	0.5	2190	<0.020	1.45	111	7.5
2016-06-28	11.8	1.6	<0.010	<1.0	<1.0	0.324	0.52	2100	<0.020	1.26	105	5.5
2016-09-12	12.3	1.5	<0.010	<1.0	<1.0	0.376	0.6	2310	<0.020	1.34	110	6.1
2017-06-26	10.6	2.3	<0.010	<1.0	<1.0	0.348	0.47	2000	<0.020	1.25	94.2	3.8
2017-09-12	13.3	1.2	<0.010	<1.0	<1.0	0.458	0.64	2500	<0.020	1.86	76	6.4

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 - 330 = 7.5 + 0.75 x (hardness - 90)	-
	-	-	-	-	-	58.875	-
	-	-	-	HC: 20	-	BC App[AO]: 5000	-
2015-07-14	<0.050	<5.0	<5.0	0.5	<5.0	<5.0	<0.50
2015-09-23	<0.050	<5.0	<5.0	0.6	<5.0	<5.0	<0.50
2016-06-28	<0.050	<5.0	<5.0	0.51	<5.0	<5.0	<0.50
2016-09-12	<0.050	<5.0	<5.0	0.58	<5.0	<5.0	<0.50
2017-06-26	<0.010	<5.0	<5.0	0.49	<5.0	<5.0	<0.10
2017-09-12	<0.010	<5.0	<5.0	0.37	<5.0	<5.0	<0.10