Birchlands Creek Water Quality Monitoring Report 2015 – 2017

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Cover photo

Upstream view from Birchlands Creek monitoring site, NABIR02, September 30. 2015.

Project Highlights

The Columbia Basin Water Quality Monitoring Project (CBWQ) is an environmental stewardship project funded by the Columbia Basin Trust. Under the CBWQ, Wildsight Golden conducted baseline water quality monitoring in Birchlands Creek from 2015 - 2017. Four components were monitored: benthic macro-invertebrate community using Canadian Aquatic Biomonitoring Network (CABIN), water quality, water temperature, and hydrologic characteristics (i.e., velocity and flow).

Monitoring was conducted at two sites, NABIR01 and NABIR02, located at the downstream end of the creek, near the confluence with the Columbia River. The watershed has forestry and rural residential development pressures. NABIR01 was originally monitored in 2015, as it was downstream of an area that was periodically dredged, a timber framing company, and rural activity. However, the site was in a depositional area with sandy substrate, and was not suitable for a CABIN comparison to reference streams. Thus, monitoring was moved upstream approximately 0.8 km to NABIRO2 in 2016-2017.

The CABIN analysis of the benthic macro-invertebrate results identified NABIR02 as stressed in 2015 and unstressed in 2016 and 2017. Improvements in the invertebrate community that supported the analysis were: more expected taxa present based on reference group conditions, decreased percent of the two most dominant taxa, and increased taxa richness. The reason for these improvements was not apparent in the general water quality results, but may have related to sediment, temperature and/or hydrologic conditions.

Water quality was monitored at NABIR01 in 2015, and NABIR02 in 2016 and 2017. Overall, the water quality was good. Although three drinking water guidelines were exceeded (pH, E. coli, and total iron) and aquatic life guidelines (pH, total phosphorus), the guideline exceedances likely only had negligible drinking water and aquatic life impacts.

Water temperature monitoring was discontinuous in 2015 when collected at NABIR01, but was more constant in 2016 and 2017 when water temperature monitoring moved to NABIR02. Summer temperatures in 2015 were high and regularly exceeded guidelines for drinking water and the protection of aquatic life. This was likely influenced by the low flow conditions and the lack of riparian vegetation present at NABIR01. In 2016 and 2017, summer temperatures were lower, and the maximum daily aquatic life temperature guideline was not exceeded; however, the spawning and incubation maximum and the drinking water guidelines were still often exceeded in the summer.

Hydrologic data were collected at NABIR01 in 2015, and at NABIR02 in 2016 and 2017. Overall, flows followed a typical pattern of being high in the spring during freshet, decreasing throughout the summer, to a base level in the winter months. There were slight shifts in the intensity and timing of spring freshet annually. In the summer of 2015, the low flow period started earlier, and flows were the lowest. These early low flows likely negatively influenced the benthic macro-invertebrate community.

The three-year baseline monitoring program provides some 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 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, representatives 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.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, Wildsight Golden (or the stewardship group) conducted water quality monitoring in Birchlands Creek from 2015 - 2017. Four components were monitored: benthic macro-invertebrate community using Canadian Aquatic Biomonitoring Network (CABIN) methods, water quality, 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 operating until June 2018. CBWQ is unique because it is a grass-roots project guided and administered by community watershed groups.

1.1 Birchlands Creek background

Birchlands Creek was selected as a priority for CBWQ monitoring, since the watershed has many land use pressures with the potential to impact the aquatic environment. These include agriculture, forestry, rural land development (e.g., water withdrawals, and septic systems), CP rail activities (dredging, railway crossing with coal particulates), and Canadian Timberframers (and mill). Birchlands Creek is an important domestic source of water for local residents and is also a tributary to the Columbia Headwaters. Obtaining baseline data is important to understanding changes that may occur over time. Monitoring data will also contribute to advancing the understanding of this broader system, since the Columbia Headwaters, which include the Columbia River mainstem and its tributaries, have only limited water quality / quantity data available (Carver 2017).

Other general information about Birchlands Creek is that is approximately 10.5 km long, and is fed by several additional tributaries. The topography of the upper watershed is mountainous, while the lower region flattens out abruptly. In the valley bottom, near the highway bridge and railway, the river takes a 90 degree turn. Here, debris accumulates and is dredged periodically. Birchlands Creek is a dynamic system that typically experiences flooding during the spring freshet period (thus it is also known as Washout Creek). The climate for the area exhibits cold winters with moderate snowfall, and moderately dry summers. Wildlife known in the area include, but are not limited to, large carnivores (wolf, grizzly, black bear, cougar, coyote), ungulates (white tailed, mule deer, elk), and numerous bird species.

Monitoring was conducted at NABIR01 and NABIR02 (Figure 1, Figure 2), located at the downstream end of the creek, near the confluence with the Columbia River. NABIR01 was the original location for monitoring (in 2015), as it was downstream of the CP Rail dredging activities, and also downstream of Canadian Timberframers, forestry and rural impacts. However, the site was in a depositional area, with sandy substrate, and thus was not applicable to a CABIN comparison with reference sites. Thus monitoring was moved upstream 0.8 km to NABIRO2 in 2016-2017.


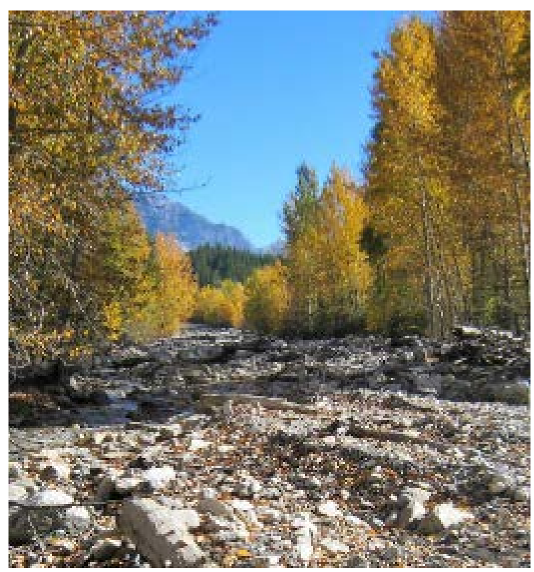

Figure 1. Upstream views of NABIR01, Apr 20, 2015 (left); and NABIR02, Sept 30, 2015 (right). Photos by Rachel Darvill.

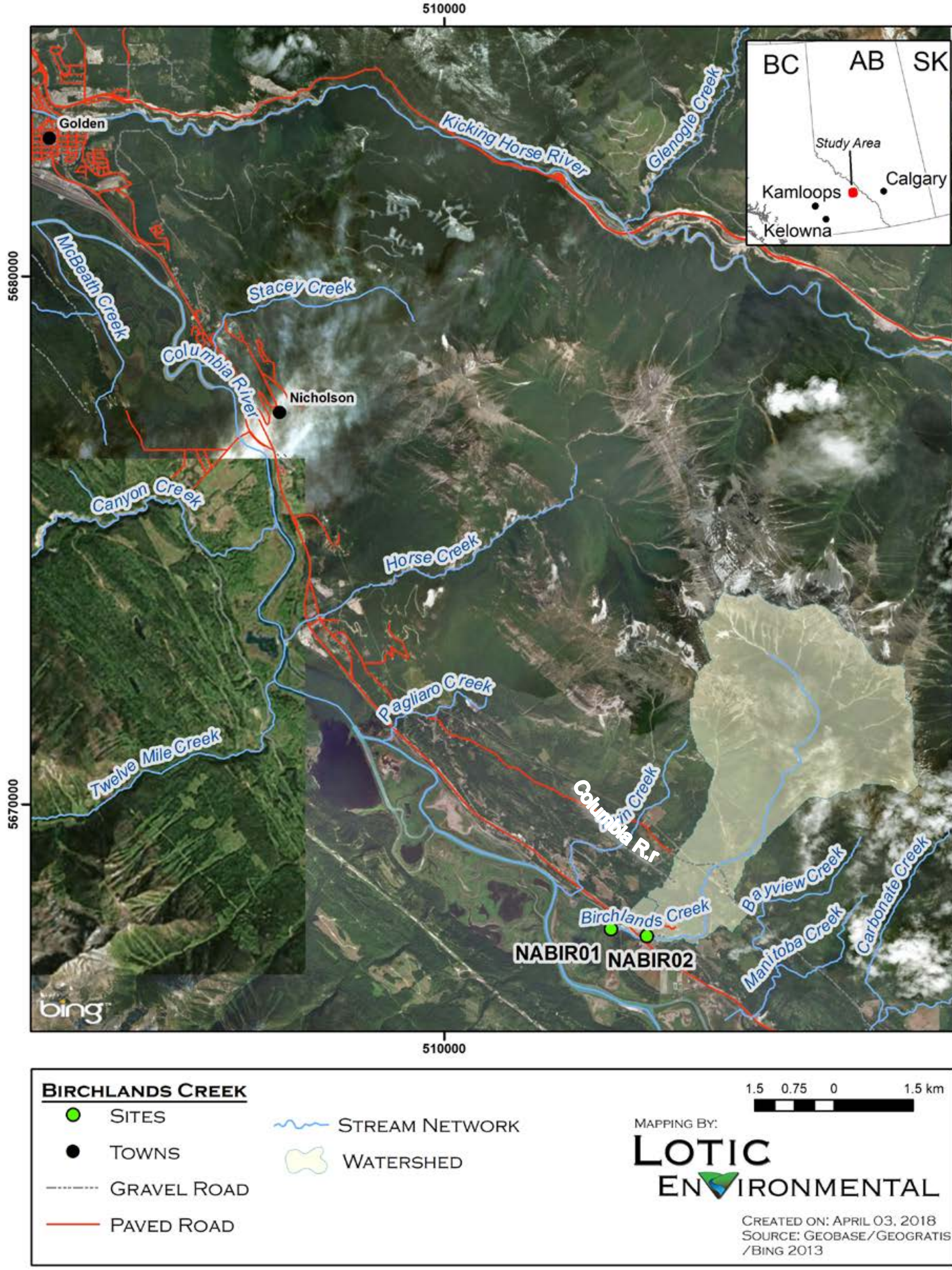

Figure 2. Birchlands Creek monitoring locations.

1.2 Fish community

There were no data on fish presence available for Birchlands Creek on Habitat Wizard (BC MoE 2018a). However, the following fish species have been sampled downstream in the Columbia River near (i.e., within 4 km) Birchland Creek with no known obstacles to fish migration evident between the site and the Columbia River:

- Bull Trout (*Salvelinus confluentus*)
- Rainbow Trout (*Oncorhynchus mykiss*)
- Brook Trout (*Salvelinus fontinalis*)

Additionally, local knowledge suggests that kokanee (*O. nerka*) spawn at the mouth of Birchlands Creek.

Bull trout are a fish species of conservation concern. Bull Trout (interior lineage) 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).

2 Methods

2.1 Data collection, data entry, and initial data presentation, completed by 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 CBWQ stewardship group 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, at NABIR02. CABIN was not completed at NABIR01, as the sandy substrate would not allow for comparison with the Columbia CABIN model (S. Strachan pers. comm.). 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 monitoring was conducted at NABIR01 in 2015, and at NABIR02 in 2016 and 2017. Table 1 provides a general summary of the parameters collected each year. Maxxam Analytics (Burnaby, BC) completed the water quality laboratory analysis.

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. With the add-in tool, users opened 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.

Table 1. Water quality parameters monitored at NABIR01 and NABIR02, 2015-2017

Frequency and parameters	2015		2016		2017	
	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
Monthly (spring - fall): nutrients, total suspended solids, dissolved chloride, and *in situ* data	Yes	-	-	Yes	-	Yes
Once annually: inorganics**, metals	Yes	-	-	Yes	-	Yes
Monthly(spring - fall) - *Escherichia coli*	Yes	-	-	-	-	Yes
Once annually - duplicate and blank	-	-	-	Yes	-	-

* *In situ* (field measured) parameters were: dissolved oxygen (DO), temperature, specific conductivity, pH, turbidity, and air temperature.
** Inorganics – alkalinity, bicarbonate, carbonate, hydroxide,

Stream temperature

Hourly stream temperature (°C) was measured using a HOBO Pro V2 temperature logger. Measurements were taken from May 21, 2015 to October 29, 2017 (measured at NABIR01 in 2015, and NABIR02 in 2016-2017). The data were downloaded into a spreadsheet, and stream temperature statistics (daily maximum, minimum, and average) were calculated and graphed.

Hydrometric data

Hydrometric data were collected monthly as both a flow and a velocity. Velocity is the speed of water and is measured as a unit of distance per time (m/s). Flow, also known as discharge, measures the volume of water moving through a point in a given amount of time (m^3/s). Flow 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 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). 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 data preparation described above completed by the CBWQ, Lotic Environmental Ltd. completed analyses and reporting. This included completing a quality assurance/quality control review (QA/QC) of data, comparing results to applicable guidelines, interpreting results, and providing recommendations.

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

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

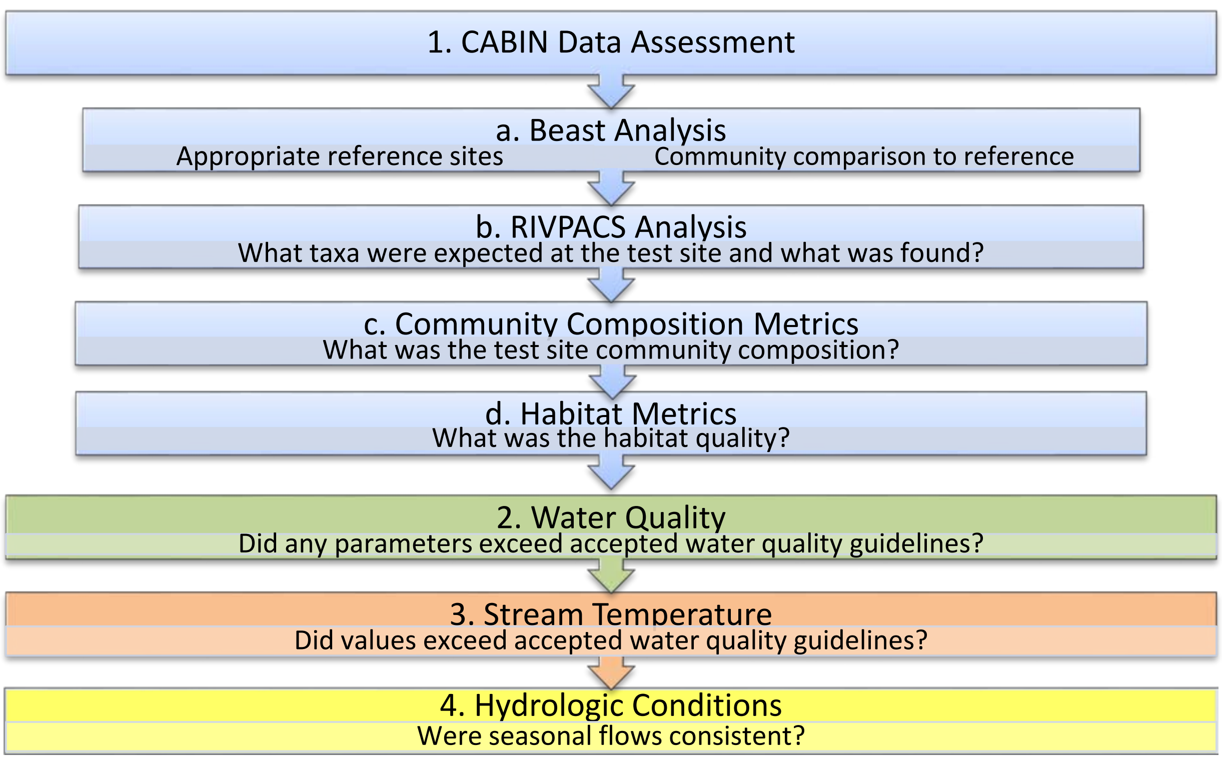

Figure 3. Stream condition analysis steps.

2.3 CABIN data analysis

2.3.1 Reference Condition Approach: BEAST analysis and site assessment

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

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

2.3.2 RIVPACS analysis

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

2.3.3 Community composition metrics

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

2.4 Water quality data analysis

2.4.1 Water quality QA/QC

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

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

Equation 3: Duplicate sample quality control

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

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

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 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 risks.

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 used in the review, 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 averages were also calculated and compared among the years.

2.6 Hydrometric data analysis

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

3 Results

3.1 CABIN results

3.1.1 Reference Condition Approach: BEAST analysis and site assessment

For NABIR02, CABIN BEAST analysis determined the highest probability of reference group membership was to Group 5 in 2015 - 2017 (probabilities found in Table 2). The site was thus compared with Reference Group 5, which includes 33 streams, mostly from the Columbia Mountain and Highlands and Western Continental Ranges ecoregions. The average channel depth of Reference Group 5 is 21.5 ± 9.7 cm (SD - standard deviation), which is higher than the test site's average depth of 9.7 cm. A comparison of other individual test site habitat attributes with the reference model means, and the ordination plots are included in the Site Assessment Reports (Appendix A). The CABIN model assessed NABIR02, as potentially stressed in 2015 and unstressed in 2016 and 2017.

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
NABIR02	**Potentially stressed** Group 5; 72.5%	**Unstressed** Group 5; 72.5%	**Unstressed** Group 5; 71.3%

3.1.2 RIVPACS analysis

The RIVPACS ratio at NABIR02 increased from 0.63 in 2015, to 0.94 in 2016-17, supporting the CABIN model assessment above (Table 3). In 2015, four families of taxa were not present at the test site that were expected based on the reference group; while in 2016 and 2017, only one family was not present that was expected.

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
NABIR02	0.63 Chironomidae, Chloroperlidae, Ephemerelidae, Rhyacophilidae	0.94 Ephemerelidae	0.94 Rhyacophilidae

*__CABIN model condition:__ unstressed, potentially stressed, stressed, severely stressed.

3.1.3 Community composition metrics

Key metrics that were reviewed in detail to better understand the possible rationale for the health ratings (Table 4). Metrics reviewed were: 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 NABIR02. Condition indicated as shaded background*

Metric	Reference Group 5 (Mean ± SD)	NABIR02 2015	NABIR02 2016	NABIR02 2017
Total abundance	2163.6 ± 1274.4	1631.8	2285.7	2975.0
% EPT taxa	93.7 ± 5.3	99.4	95.0	90.7
% Chironomidae	4.6 ± 5.0	0.0	3.4	5.6
% of 2 dominant taxa	60.2 ± 11.4	89.7	62.4	77.2
Total number of taxa	16.0 ± 3.0	10	16	14

*__CABIN model condition:__ unstressed, potentially stressed, stressed, severely stressed.

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 and dissolved oxygen. Although total abundance at NABIR02 was lowest in 2015 (1631.8 organisms), it was within the reference group mean (2163.6 ± 1274.4 organisms), meaning that it did not influence the condition assessment.

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 % EPT was high in all years at the test site, with values similar to that of the reference site. Chironomidae (non-biting midges), are generally tolerant of pollution. There were no Chironomidae at the test site in 2015, and only a small percentage in subsequent years (<6%) Values for these two community metrics were within the reference group means, indicating healthy conditions.

Relative occurrence of the two most abundant taxon is a metric that can relate to impacted streams, since as diversity declines, a few taxa end up dominating the community. 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 percent of the two dominant taxa was highest in 2015 (89.7%), and greater than the reference group mean. Values decreased in subsequent years, with a low of 62.4% in 2016, indicating an improvement.

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 (Environment Canada 2012c). However, overall biodiversity of a stream typically declines with disturbance (Environment Canada 2012c). Taxa richness at the test site was also lowest in 2015 (10 taxa), and lower than the reference group mean (16 ± 3 taxa). Values increased in 2016 - 2017 to be within the reference group mean, with the highest being 16 taxa in 2016. These results further support the model outputs of potentially stressed in 2015 and unstressed in 2016 and 2017.

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). It stood out that % gravel was high and % cobble was low in 2015, relative to the reference group mean, and the other years sampled. This transition from finer substrate to courser substrate may contribute to why NABIR02 had a lower quality benthic macro-invertebrate community in 2015 relative to the subsequent two years sampled.

Table 5. Select physical habitat characteristics for the predicted reference group, and NABIR02.

Parameter	Reference group mean	2015	2016	2017
Average depth (cm)	21.5 ± 9.7	7.0	7.0	15.0
Average velocity (m/s)	0.51 ± 0.27	0.44	0.71	0.38
% Cobble (6.4 - 25.6 cm)	64 ± 17	18	62	58
% Pebble (1.6 – 6.4 cm)	31 ± 16	50	30	40
% Gravel (0.2 – 1.6 cm)	2 ± 2	32	6	2
% Sand (0.1 – 0.2 cm)	0 ± 0	0	0	0
% silt and clay (<0.1 cm)	0 ± 0	0	0	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. All but one parameter was below the concern level of 50%, indicating a high degree of precision in data collection and lab procedures. Although the RPD for turbidity was 109%, 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 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 five aquatic life and/or drinking water guidelines at NABIR01, and all but one guideline at NABIR02 (Appendix B2 – non-metal data, and Appendix B3 – metal data). Details on the exceedances are as follows:

pH: The BC approved water quality guideline for the protection of aquatic life for pH allows for an unrestricted change within the range of 6.5-9.0 (BC Ministry of Environment [BC MoE] 2017). pH at NABIR01 ranged from 8.13 to 9.45 pH units, and exceeded the upper guideline in 38% of samples. The pH at NABIR02 ranged from 6.97 to 9.4 pH units, and exceeded the upper guideline in 29% of samples. The mean at both NABIR01 and NABIR02 met the guidelines (8.58 and 8.65 pH units, respectively).

These elevated pH values are not concerning if they reflect natural background conditions and are not elevated as a result of a particular anthropogenic influence/discharge to the watercourse. However, if there is a discharge into the system, then pH and carbon dioxide should be monitored more thoroughly in accordance with the BC guidelines to ensure guidelines are met and there are no impacts on the aquatic environment.

The drinking water guideline for pH is 7 - 10.5 (Health Canada 2017). On April 19, 2016, the field measured pH was 6.97, which was below this guideline. No health risks likely resulted, since the guideline is established to maximize treatment effectiveness, control corrosion, and reduce leaching from distribution system and plumbing components (Health Canada 2017).

Total Phosphorus: The total phosphorus guideline for the protection of aquatic life was not met in one out of the three samples collected at NABIR01, and one of ten samples collected at NABIR02. Total phosphorus follows a framework-based approach where concentrations should not (i) exceed predefined 'trigger ranges'; and (ii) increase more than 50% over the baseline (reference) levels (CCME 2004). The trigger ranges are based on the range of phosphorus concentrations in water that define the reference productivity or trophic status[1] for the site (CCME 2004). Total phosphorus ranged from <0.005 - 0.0192 mg/L at NABIR01, and <0.005 - 0.0243 mg/L at NABIR02. 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 exceedances occurred in June 2015 at NABIR01, and May 2016 at NABIR02. 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 are not expected. This data provides a valuable baseline for assessing long-term changes resulting from anthropogenic influences.

Escherichia coli (**E. coli)**: The E. coli drinking water guideline for raw untreated drinking water is 0 CFU/100 mL (BC MoE 2001). At NABIR01, the guideline was exceeded in one of four samples. At NABIR02, the guideline was exceeded in 4 of the 8 samples. Overall, values were relatively low, with the highest being 8 CFU/100 mL.

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

E. coli is a bacteria found in human and animal feces, which can cause intestinal infection if present in untreated drinking water (BC MoE 2001). The source of E. coli could be livestock or wildlife that graze along the creek upstream of the sites. Drinking water derived from surface water and shallow ground water sources should receive disinfection as a minimum treatment before human consumption (BC MoE 2001). Boiling for at least one minute would be recommended as an effective treatment (HealthLink BC 2018).

Aluminum: Total aluminum at NABIR01 in June 2015 was 69.9 µg/L. This value was higher than the BC Approved aquatic life guideline of 50 µg/L. However, this guideline was for the dissolved fraction, which is the bio-available form of this metal. Since only the total fraction was analysed, it is unknown if there was an exceedance. The short term/maximum aquatic life guideline for dissolved aluminum (100 µg/L) was met.

During annual sampling at NABIR02 in the fall of 2016 and 2017, values were substantially lower (maximum of 13.2 µg/L). It is likely that higher NABIR01 value was due to sampling during the high flow period, where overland runoff influenced water quality. The higher values could also be related to the monitoring site's downstream location, or another influence from upstream in the watershed. However, we did note that other metals were notably higher at NABIR01 in 2015, than at NABIR02 in 2016-17 (e.g., total iron, total manganese).

Total Iron: Total iron at NABIR01 in 2015 was 374 µg/L, exceeding the drinking water guideline of 300 µg/L. The guideline is in place for aesthetic reasons, as it is based on taste and staining of laundry and plumbing fixtures; with no evidence of dietary iron toxicity in the general population (Health Canada 2017). The guideline was met in 2016-17 at NABIR02, with the highest value being 24 µg/L.

Turbidity and Total Suspended Solids (TSS): The guidelines for turbidity and TSS relate to changes from background, resulting from a direct/known anthropogenic activity (e.g., construction). Because there was no known specific activity like this, 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. Highest values were on May 20, 2015 (NABIR01), where turbidity was 47.2 NTU, and TSS was 65 mg/L. Subsequent years also had high values in the spring. Although it is normal for increases to occur during the freshet, values do appear to be particularly high at times in Birchlands Creek (Figure 4).

Figure 4. Very turbid water observed when not conducting formal monitoring at Birchlands Creek. May 23, 2017 (Photo by R. Darvill).

During the clear flow period (July to October) values were lower. Amongst all years turbidity during this time ranged from 0.8 - 6.68 NTU, while TSS ranged from <4 – 6.5 mg/L. Some of these values too, appear to be high; as typically streams in the region are clear through the summer and fall low flow period (i.e., turbidity at <3 NTU). Although the cause(s) is unknown, turbidity can result from: loss of vegetative cover in the watershed, forestry road maintenance. Also, the upper part of the watershed is very steep, and may be prone to mass wasting. A study of upslope influences on turbidity and suspended solids may help pinpoint areas or activities of concern that could be improved. This baseline data will be valuable for monitoring changes that may occur over time, particularly if the level of development increases.

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.

In 2015, water temperature was only monitored for the full month in October (Table 6). Given the incomplete dataset in 2015, average daily temperatures were not compared with other years sampled. In 2016-17, temperature was monitored in full from June through September. During this period monthly average water temperatures were fairly consistent at NABIR02. 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 NABIR01 (2015) and NABIR02 (2016-17).

Month	2015		2016		2017	
	Avg	Std Dev	Avg	Std Dev	Avg	Std Dev
January	-	-	-	-	0.93	0.49
February	-	-	-	-	0.89	0.63
March	-	-	-	-	1.72	0.70
April	-	-	--		4.05	0.98
May	8.75	0.43	7.21	0.82	5.73	0.79
June	10.30	1.20	9.71	1.79	8.58	1.50
July	-	-	12.43	1.08	11.89	0.96
August	16.75	2.16	12.85	0.95	12.26	1.09
September	9.28	0.00	9.05	0.97	9.35	2.11
October	6.28	2.21	5.03	1.49	4.34	1.18
November	3.62	0.61	-	-	-	-
December	-	-	0.70	0.50	-	-

*Data were collected for only part of the month

Since the fish species distribution is not known for Birchland Creek, results were compared to the temperature guideline for streams with unknown fish distributions. This guideline states that the maximum daily temperature cannot exceed 19ºC. Additionally, maximum daily temperature during times that fish eggs are incubating (i.e. the spring and fall) cannot exceed 12ºC. Given the site's elevation (816 m), spring spawning (i.e., by Rainbow Trout) would be expected following freshet, with incubation occurring through to mid-July. Fall-spawning (i.e., by Bull Trout, Mountain Whitefish, and Brook Trout) starts as early as mid-September, with incubation occurring through to the spring.

The 2015 data, collected from NABIR01, showed very high temperatures in the summer (Figure 4). This may be due to low flows which occurred in 2015 (see next section), and/or to the lack of riparian vegetation at this site. Also in 2015, sand often filled the tube the Hobo devise sat in. These factors likely increased temperatures. If the logger was actually reflecting stream temperatures, then all temperature guidelines were exceeded in the summer months of 2015. The Creek also experienced high temperatures in October of 2015, which exceeded daily maximum and spawning temperature guidelines. Additionally, the large differences between the minimum and maximum daily temperatures in October suggest high temperature fluctuations.

In 2016 and 2017, the temperature logger location was moved slightly upstream to NABIR02. During this period, stream temperatures were noticeably lower than in 2015. The maximum daily temperature guideline was met. The spawning and incubation maximum temperatures were still often exceeded from May through August.

The stream temperatures exceeded the drinking water temperature guideline of 15 ºC multiple times throughout the summer in all years sampled, as well as in the fall of 2015. The drinking water guideline is an aesthetic objective. Temperature indirectly affects health and aesthetics through impacts on disinfection, corrosion control and formation of biofilms in the distribution system (Health Canada 2017).

Since it was unverified whether Bull Trout inhabit Birchlands Creek, a detailed review of temperature guidelines pertaining to the species was not done. For general information purposes, the maximum daily temperature guideline for Bull Trout rearing is 15ºC, the maximum spawning and incubation temperature is 10ºC, and the minimum incubation is 2ºC. Based on the Birchlands temperature data, these guidelines would often not be met. Bull trout would thus be expected to seek out habitats elsewhere, where temperatures are suitable. For example, Bull Trout typically spawn where there is groundwater upwelling (McPhail 2007), as these areas provide consistent water temperatures (i.e., 5ºC) supporting incubation requirements (Meisner et al. 1988).

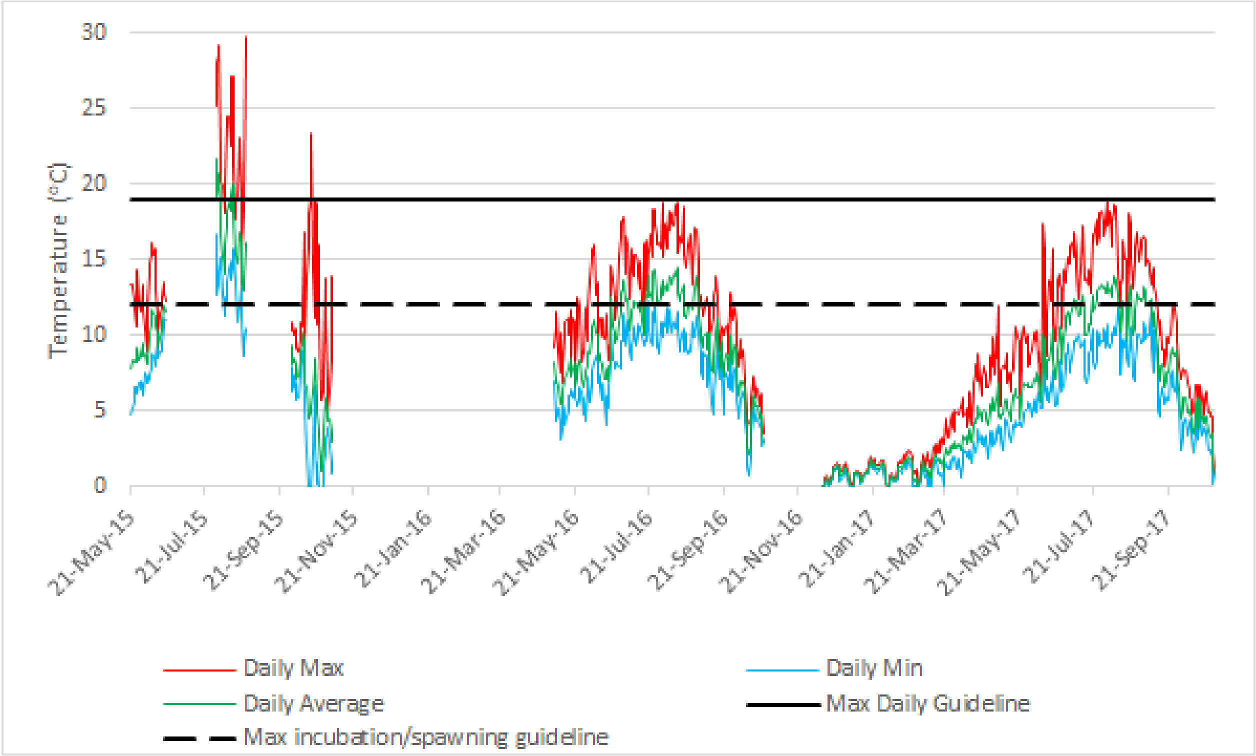

Figure 5. Stream water temperatures in Birchlands Creek from May 21, 2015 to October 29, 2017 (measured at NABIR01 in 2015, and NABIR02 in 2016-2017). The guidelines presented are for streams with unknown fish species present (BC MoE 2018b).

3.4 Hydrometric results

Stream flow 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). Flow data for Birchlands Creek were collected monthly at NABIRO1 in April - August 2015. Monitoring was then moved to NABIRO2, with date collected in October 2015, May - October 2016, and April – October 2016/17. A comparison of findings between the two sites was limited, since the changed location may have influenced results. For example, since NABIR01 was a depositional area with sandy sediment it may have exhibited lower flows, if flow ran subsurface.

Flow at NABIR01 in 2015 saw a spring freshet that was intermediate relative to the two years at NABIR02, but the summer low flow period started earlier (June 20) and was lowest of all years (ranged from 0.15 - 0.02 m^3/s) (Figure 7). In 2016, the spring peak flow was the highest and occurred earliest of all years (1.62 m^3/s on May 4). This was followed by a steady drop to moderate level of 0.44 m^3/s by May 16. The 2017 peak occurred later and was lower (0.948 m^3/s on June 21). In both 2016 and 2017, flows were lowest in August, and rose slightly through the fall.

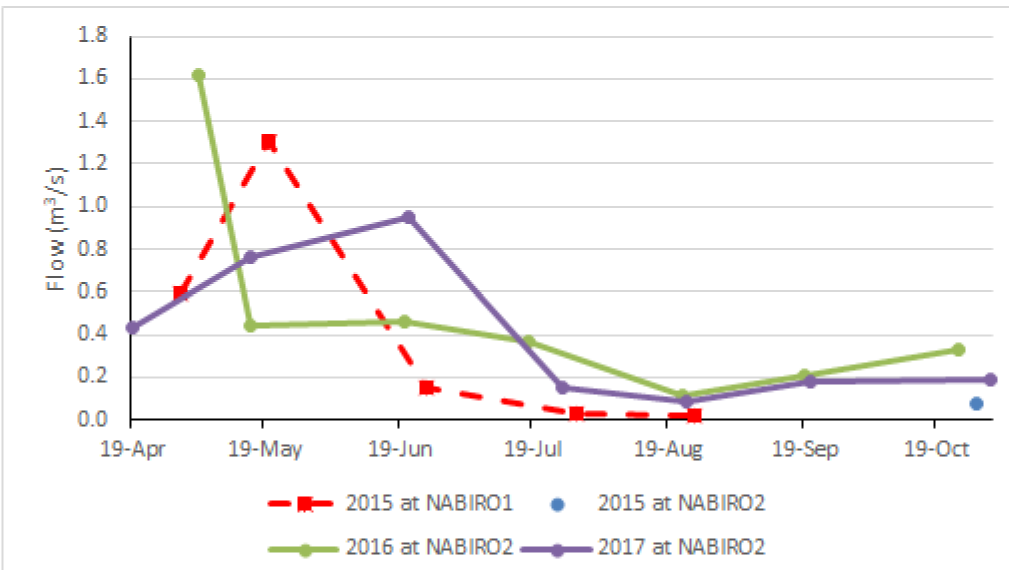

Figure 6. Water flow (discharge) at NABIRO1 and NABIRO2, 2015 - 2017.

Provincial instream flow guidelines to protect aquatic ecosystems are usually set relative to natural historic flows of each stream. In order to develop these criteria, the annual hydrologic regime of the stream would need to be thoroughly described in a long-term dataset. This would be best achieved using continuous level loggers and developing level-discharge (flow) 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 show changes in flow patterns with time.

4 Conclusions

Overall, the benthic macro-invertebrate results identified NABIR02 as being stressed in 2015 and unstressed in 2016 and 2017. Improvements in the invertebrate community were evident to support the analysis. Specifically in 2016 - 2017, more taxa were present that were expected based on reference group conditions, percent of the two most dominant taxa decreased, and taxa richness increased. Possible reasons for these improvements were evident in the abiotic results. The substrate was comprised of a higher proportion of finer substrate (gravel 0.2 – 1.6 cm). As well, water temperatures, and flows were indicative of lower quality conditions. The other chemical water quality results did not indicate a change amongst the years that would influence the benthic invertebrate community.

Water quality was monitored at NABIR01 in 2015, and NABIR02 in 2016 and 2017. Overall, three drinking water quality guidelines (pH, E. coli, and total iron) and two aquatic life guidelines (pH, total phosphorus) were exceeded. Further analysis revealed that the guideline exceedances were likely to only have negligible impacts on aquatic life and drinking water. They should be reviewed further if there is concern of anthropogenic influences relating to them in the watershed; otherwise, they may simply represent normal background conditions. Additionally, non-metal parameters reviewed in detail (pH, total phosphorus, turbidity/TSS, and E. coli) revealed that water quality was similar amongst all years/sites sampled. Lastly, even though 2015 metal concentrations were higher than those of 2016 and 2017, there were no guideline exceedances that would negatively impact aquatic life.

Water temperature monitoring was discontinuous in 2015 when collected at NABIR01, but was more constant in 2016 and 2017 at NABIR02. Summer temperatures in 2015 were high and regularly exceeded guidelines for drinking water and the protection of aquatic life (maximum daily for streams with unknown fish distributions, and maximum incubation and spawning). This was likely influenced by the low flow conditions (with the logger out of the water) and/or the site not being suitable for monitoring. In 2016 and 2017, summer temperatures were lower, and the maximum daily aquatic life temperature guideline was met. However, the spawning and incubation maximum was still often exceeded in the summer, as was the drinking water guideline.

Hydrometric data were collected at NABIR01 in 2015, and at NABIR02 in 2016 – 2017. Flow followed a typical pattern of being high in the spring during freshet and decreasing throughout the summer to a base level in the winter months. However, there were slight shifts in magnitude and timing of the spring freshet annually. In 2015, flows were the lowest in the summer, starting earlier. The low flows would likely negatively influence the benthic macro-invertebrate community, corroborating the CABIN analysis of the community being stressed. However, this could not be verified due to the confounding factor of the monitoring location changing between the years.

5 Recommendations

The existing monitoring program was very good 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 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.

Two recommendations for additional study stemmed from the findings of this baseline assessment. First, a study of upslope influences on turbidity and suspended solids may pinpoint areas or activities of concern that could be improved. This could also involve correlating higher TSS and turbidity values with precipitation events. Second, Wildsight Golden is also hoping to learn more about the fisheries values of the creek, as fish use and distribution is currently unknown. A fish and fish habitat assessment would achieve this.

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Strachan, Stephanie. Environmental Monitoring Scientist, Environment & Climate Change Canada

Appendix A. CABIN data

Site Description

Study Name	CBWQ-Upper Columbia
Site	NABIR02
Sampling Date	Sep 30 2015
Know Your Watershed Basin	
Province / Territory	British Columbia
Terrestrial Ecological Classification	Montane Cordillera EcoZone Southern Rocky Mountain Trench EcoRegion
Coordinates (decimal degrees)	51.15875 N, 116.80208 W
Altitude	2847
Local Basin Name	Birchlands Creek
	Upper Columbia
Stream Order	3

Figure 1. Location Map

Cabin Assessment Results

Reference Model Summary	
Model	Columbia-Okanagan Preliminary March 2010
Analysis Date	October 17, 2016
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%	0.3%	16.0%	11.2%	72.5%
CABIN Assessment of NABIR02 on Sep 30, 2015	Mildly Divergent				

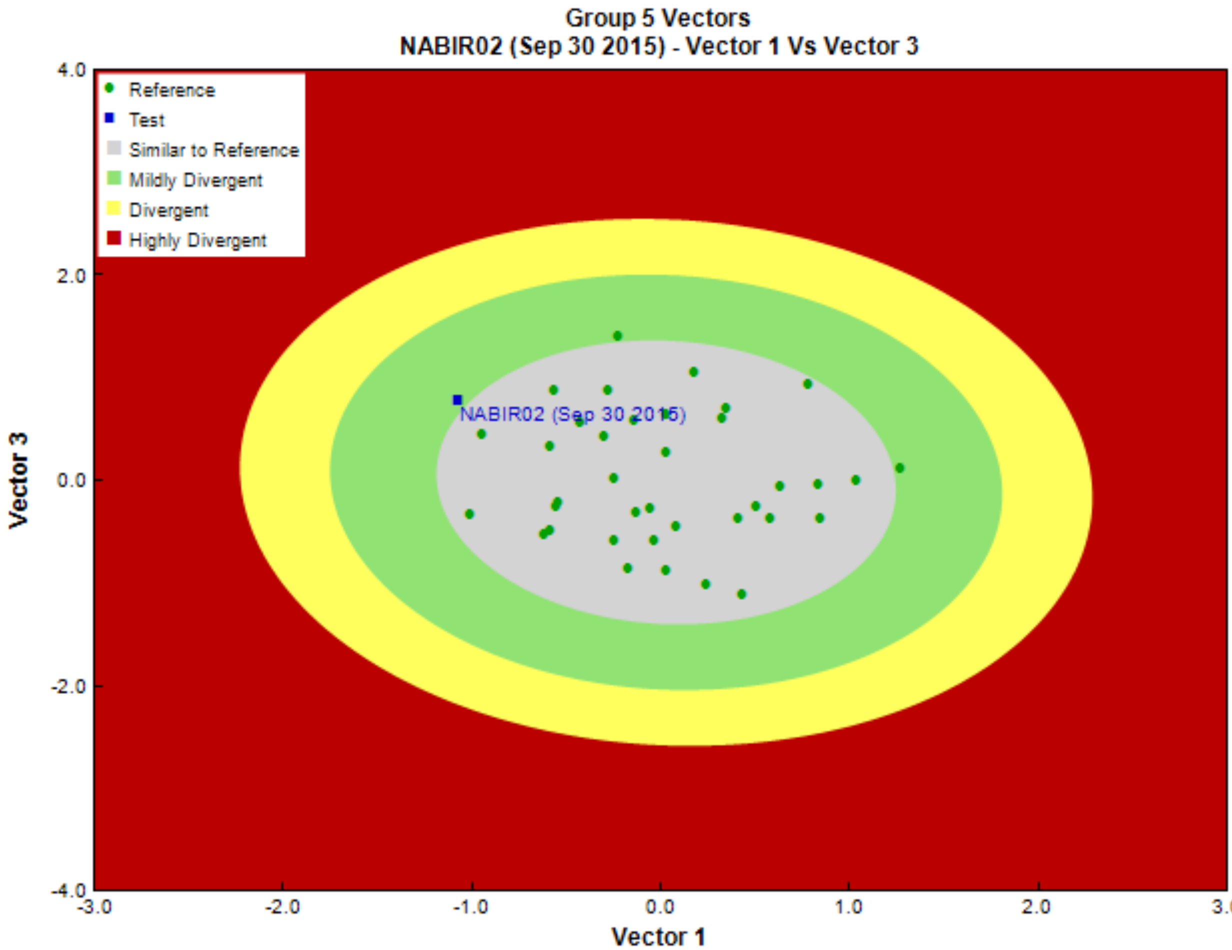

Figure 3. CABIN ordination assessment of the test site with the predicted group of reference sites. Each axis represents the relative abundance of the entire benthic invertebrate community with different organisms weighted differently on each axis.

Sample Information

Sampling Device	Kick Net
Mesh Size	400
Sampling Time	3
Taxonomist	Pina Viola, Consultant
Date Taxonomy Completed	December 10, 2015

Sample Information

	Marchant Box
Sub-Sample Proportion	22/100

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
Arthropoda	Insecta	Diptera	Empididae	1	4.5
			Tipulidae	1	4.5
		Ephemeroptera	Ameletidae	3	13.6
			Baetidae	1	4.5
			Heptageniidae	17	77.3
		Plecoptera	Capniidae	8	36.4
			Nemouridae	28	127.2
			Taeniopterygidae	294	1,336.4
		Trichoptera	Hydropsychidae	3	13.6
			Rhyacophilidae	3	13.6
			Total	359	1,631.6

Metrics

Name	NABIR02	Predicted Group Reference Mean ±SD
Bray-Curtis Distance	0.56	0.4 ± 0.1
Biotic Indices		
Hilsenhoff Family index (North-West)	2.1	2.8 ± 0.3
Intolerant taxa	--	1.0 ± 0.0
Long-lived taxa	--	1.0 ± 0.0
Functional Measures		
% Filterers	0.8	
% Gatherers	90.8	
% Predatores	1.9	
% Scrapers	86.9	
% Shredder	92.2	
No. Clinger Taxa	13.0	19.8 ± 3.4
Number Of Individuals		
% Chironomidae	0.0	4.6 ± 5.0
% Coleoptera	0.0	0.0 ± 0.0
% Diptera + Non-insects	0.6	6.3 ± 5.3
% Ephemeroptera	5.8	44.9 ± 17.3
% Ephemeroptera that are Baetidae	4.8	26.1 ± 20.5
% EPT Individuals	99.4	93.7 ± 5.3
% Odonata	--	0.0 ± 0.0
% of 2 dominant taxa	89.7	60.2 ± 11.4
% of 5 dominant taxa	97.5	84.5 ± 5.9
% of dominant taxa	81.9	39.3 ± 12.3
% Plecoptera	91.9	42.9 ± 17.2
% Tribe Tanyatarisini	--	
% Trichoptera that are Hydropsychida	50.0	27.4 ± 27.1
% Tricoptera	1.7	5.8 ± 5.7
No. EPT individuals/Chironomids+EPT Individuals	1.0	1.0 ± 0.1
Total Abundance	1631.8	2163.6 ± 1274.4
Richness		
Chironomidae taxa (genus level only)	0.0	0.9 ± 0.2
Coleoptera taxa	0.0	0.1 ± 0.2
Diptera taxa	2.0	2.4 ± 1.0
Ephemeroptera taxa	3.0	3.7 ± 0.5
EPT Individuals (Sum)	1622.7	2023.9 ± 1195.7
EPT taxa (no)	8.0	12.3 ± 1.9
Odonata taxa	--	0.0 ± 0.0
Pielou's Evenness	0.3	0.7 ± 0.1
Plecoptera taxa	3.0	5.5 ± 1.1
Shannon-Wiener Diversity	0.8	1.9 ± 0.3
Simpson's Diversity	0.3	0.8 ± 0.1
Simpson's Evenness	0.1	0.3 ± 0.1

Metrics

Name	NABIR02	Predicted Group Reference Mean ±SD
Total No. of Taxa	10.0	16.0 ± 3.0
Trichoptera taxa	2.0	3.2 ± 1.0

Frequency and Probability of Taxa Occurrence

Reference Model Taxa	Frequency of Occurrence in Reference Sites					Probability Of Occurrence at NABIR02
	Group 1	Group 2	Group 3	Group 4	Group 5	
Baetidae	100%	100%	100%	100%	97%	0.98
Chironomidae	100%	100%	100%	100%	95%	0.96
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%	0.86
Nemouridae	100%	100%	100%	100%	100%	1.00
Perlodidae	78%	78%	89%	92%	81%	0.84
Rhyacophilidae	100%	92%	100%	100%	95%	0.96
Taeniopterygidae	89%	49%	100%	92%	97%	0.97

RIVPACS Ratios

RIVPACS : Expected taxa P>0.50	12.53
RIVPACS : Observed taxa P>0.50	9.00
RIVPACS : O:E (p > 0.5)	0.72
RIVPACS : Expected taxa P>0.70	9.55
RIVPACS : Observed taxa P>0.70	6.00
RIVPACS : O:E (p > 0.7)	0.63

Habitat Description

Variable	NABIR02	Predicted Group Reference Mean ±SD
Channel		
Depth-Avg (cm)	7.0	21.5 ± 9.7
Depth-BankfullMinusWetted (cm)	22.00	38.14 ± 36.11
Depth-Max (cm)	8.6	31.0 ± 16.5
Discharge (m^3/s)	0.025	0.000 ± 0.000
Macrophyte (PercentRange)	0	0 ± 0
Reach-%CanopyCoverage (PercentRange)	2.00	1.54 ± 1.28
Reach-%Logging (PercentRange)	0	0 ± 0
Reach-DomStreamsideVeg (Category (1-4))	3	2 ± 1
Reach-Pools (Binary)	1	1 ± 0
Reach-Rapids (Binary)	0	0 ± 0
Reach-Riffles (Binary)	1	1 ± 0
Reach-StraightRun (Binary)	1	0 ± 1
Slope (m/m)	0.0470000	0.0873274 ± 0.1782569
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)	0.44	0.51 ± 0.27
Velocity-Max (m/s)	0.59	0.78 ± 0.40
Width-Bankfull (m)	13.2	13.7 ± 16.4
Width-Wetted (m)	2.9	9.0 ± 13.1
XSEC-VelMethod (Category (1-3))	1	2 ± 1
Landcover		
Reg-Ice (%)	0.00000	3.06094 ± 5.65390
Substrate Data		
%Bedrock (%)	0	1 ± 1
%Boulder (%)	0	3 ± 3
%Cobble (%)	18	64 ± 17
%Gravel (%)	32	2 ± 2
%Pebble (%)	50	31 ± 16

Habitat Description

Variable	NABIR02	Predicted Group Reference Mean ±SD
%Sand (%)	0	0 ± 0
%Silt+Clay (%)	0	0 ± 0
D50 (cm)	2.70	19.61 ± 30.65
Dg (cm)	2.5	20.3 ± 30.8
Dominant-1st (Category(0-9))	3	7 ± 1
Dominant-2nd (Category(0-9))	5	6 ± 1
Embeddedness (Category(1-5))	4	4 ± 1
PeriphytonCoverage (Category(1-5))	1	2 ± 1
SurroundingMaterial (Category(0-9))	3	4 ± 2
Topography		
Reg-SlopeLT30% (%)	21.53400	16.26604 ± 8.50298
Water Chemistry		
Chloride-Dissolved (mg/L)	0.8300000	0.4147059 ± 0.6325189
General-DO (mg/L)	9.0000000	11.0635135 ± 0.9899052
General-pH (pH)	8.9	7.7 ± 0.7
General-SolidsTSS (mg/L)	4.0000000	2.8140173 ± 7.8143482
General-SpCond (µS/cm)	248.4000000	160.3567568 ± 118.4083015
General-TempAir (Degrees Celsius)	16.0	10.5 ± 0.7
General-TempWater (Degrees Celsius)	8.3000000	5.5262162 ± 1.8860693
General-Turbidity (NTU)	0.9400000	0.1015000 ± 0.0459619
Nitrogen-NH3 (mg/L)	0.0130000	0.0119375 ± 0.0293336
Nitrogen-NO2 (mg/L)	0.0050000	0.0074306 ± 0.0217095
Nitrogen-NO2+NO3 (mg/L)	0.1040000	0.0315000 ± 0.0316491
Nitrogen-NO3 (mg/L)	0.1040000	0.0699722 ± 0.0547511

Site Description

Study Name	CBWQ-Upper Columbia
Site	NABIR02
Sampling Date	Sep 19 2016
Know Your Watershed Basin	Upper Columbia
Province / Territory	British Columbia
Terrestrial Ecological Classification	Montane Cordillera EcoZone Southern Rocky Mountain Trench EcoRegion
Coordinates (decimal degrees)	51.15869 N, 116.80200 W
Altitude	2660
Local Basin Name	Birchlands Creek
	Upper Columbia
Stream Order	3

Figure 1. Location Map

Across Reach

Site Description

Study Name	CBWQ-Upper Columbia
Site	NABIR02
Sampling Date	Sep 20 2017
Know Your Watershed Basin	Upper Columbia
Province / Territory	British Columbia
Terrestrial Ecological Classification	Montane Cordillera EcoZone Southern Rocky Mountain Trench EcoRegion
Coordinates (decimal degrees)	51.15875 N, 116.80204 W
Altitude	2683
Local Basin Name	Birchlands Creek
	Upper Columbia
Stream Order	3

Figure 1. Location Map

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

Cabin Assessment Results

Reference Model Summary	
Model	Columbia-Okanagan Preliminary March 2010
Analysis Date	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	0.2%	0.2%	16.2%	12.0%	71.3%
CABIN Assessment of NABIR02 on Sep 20, 2017			Similar to Reference		

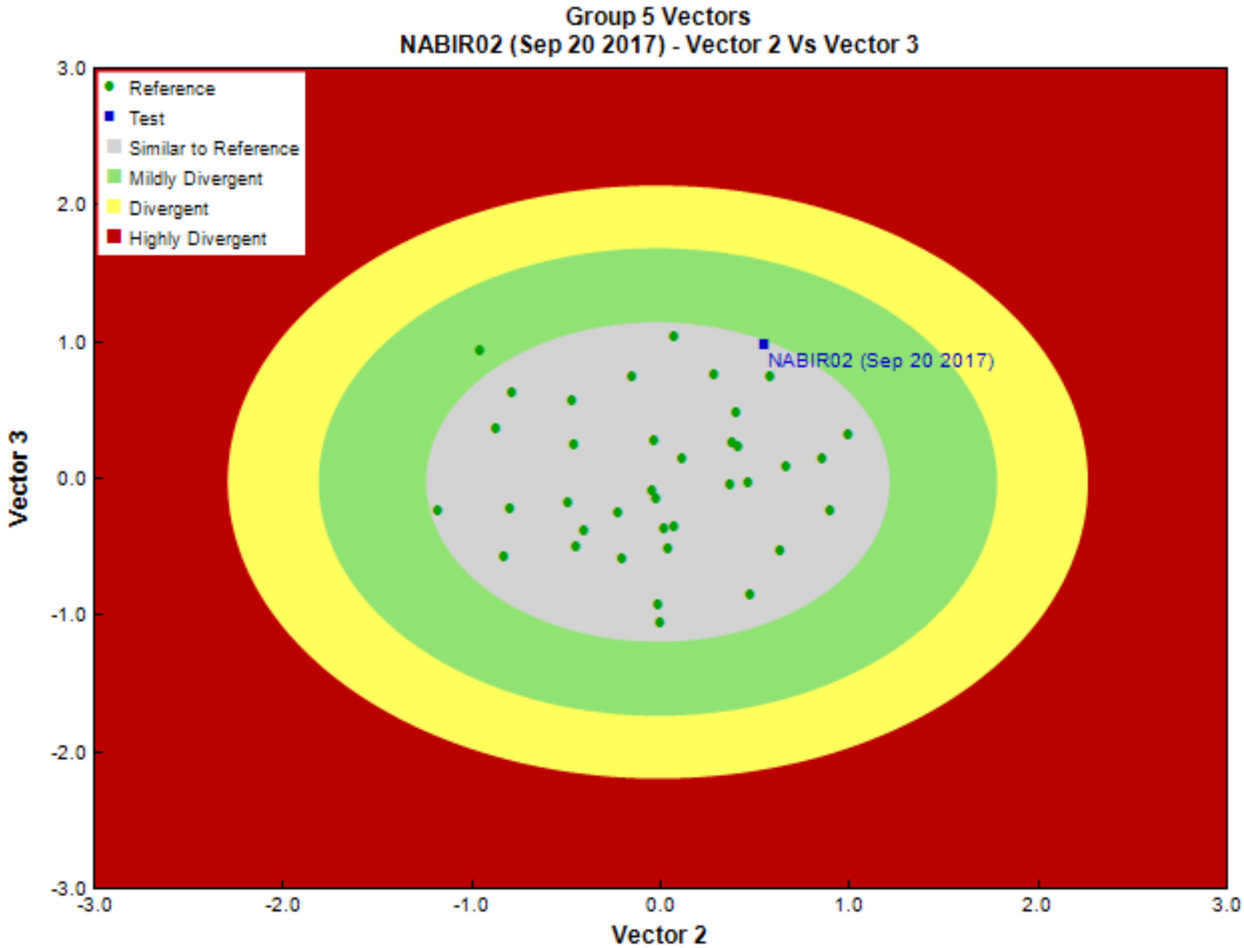

Figure 3. CABIN ordination assessment of the test site with the predicted group of reference sites. Each axis represents the relative abundance of the entire benthic invertebrate community with different organisms weighted differently on each axis.

Sample Information

Sampling Device	Kick Net
Mesh Size	400
Sampling Time	3
Taxonomist	Pina Viola, Consultant
Date Taxonomy Completed	December 17, 2017
	Marchant Box
Sub-Sample Proportion	12/100

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
Arthropoda	Insecta	Diptera	Chironomidae	20	166.7
			Empididae	11	91.7
			Psychodidae	1	8.3
			Tipulidae	1	8.3
		Ephemeroptera	Ameletidae	2	16.7
			Baetidae	8	66.6
			Ephemerellidae	1	8.3
			Heptageniidae	21	175.0
		Plecoptera		2	16.7
			Capniidae	7	58.3
			Chloroperlidae	6	50.0
			Nemouridae	52	433.3
			Perlodidae	2	16.7
			Taeniopterygidae	222	1,850.0
		Trichoptera	Hydropsychidae	1	8.3

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
			Total	357	2,974.9

Metrics

Name	NABIR02	Predicted Group Reference Mean ±SD
Bray-Curtis Distance	0.57	0.4 ± 0.1
Biotic Indices		
Hilsenhoff Family index (North-West)	2.5	2.8 ± 0.3
Intolerant taxa	--	1.0 ± 0.0
Long-lived taxa	--	1.0 ± 0.0
Tolerant individuals (%)	--	0.3
Functional Measures		
% Filterers	0.3	1.7 ± 1.7
% Gatherers	85.4	50.6 ± 14.6
% Predatores	11.2	15.3 ± 9.0
% Scrapers	72.0	67.2 ± 16.8
% Shredder	79.0	38.1 ± 18.2
No. Clinger Taxa	14.0	19.8 ± 3.4
Number Of Individuals		
% Chironomidae	5.6	4.6 ± 5.0
% Coleoptera	0.0	0.0 ± 0.0
% Diptera + Non-insects	9.3	6.3 ± 5.3
% Ephemeroptera	9.0	44.9 ± 17.3
% Ephemeroptera that are Baetidae	25.0	26.1 ± 20.5
% EPT Individuals	90.7	93.7 ± 5.3
% Odonata	0.0	0.0 ± 0.0
% of 2 dominant taxa	77.2	60.2 ± 11.4
% of 5 dominant taxa	91.8	84.5 ± 5.9
% of dominant taxa	62.5	39.3 ± 12.3
% Plecoptera	81.4	42.9 ± 17.2
% Tribe Tanyatarisini	--	
% Trichoptera that are Hydropsychida	100.0	27.4 ± 27.1
% Tricoptera	0.3	5.8 ± 5.7
No. EPT individuals/Chironomids+EPT Individuals	0.9	1.0 ± 0.1
Total Abundance	2975.0	2163.6 ± 1274.4
Richness		
Chironomidae taxa (genus level only)	1.0	0.9 ± 0.2
Coleoptera taxa	0.0	0.1 ± 0.2
Diptera taxa	4.0	2.4 ± 1.0
Ephemeroptera taxa	4.0	3.7 ± 0.5
EPT Individuals (Sum)	2683.3	2023.9 ± 1195.7
EPT taxa (no)	10.0	12.3 ± 1.9
Odonata taxa	0.0	0.0 ± 0.0
Pielou's Evenness	0.5	0.7 ± 0.1
Plecoptera taxa	5.0	5.5 ± 1.1
Shannon-Wiener Diversity	1.4	1.9 ± 0.3
Simpson's Diversity	0.6	0.8 ± 0.1
Simpson's Evenness	0.2	0.3 ± 0.1
Total No. of Taxa	14.0	16.0 ± 3.0
Trichoptera taxa	1.0	3.2 ± 1.0

Frequency and Probability of Taxa Occurrence

Reference Model Taxa	Frequency of Occurrence in Reference Sites					Probability Of Occurrence at NABIR02
	Group 1	Group 2	Group 3	Group 4	Group 5	
Baetidae	100%	100%	100%	100%	97%	0.98
Chironomidae	100%	100%	100%	100%	95%	0.96
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%	0.86
Nemouridae	100%	100%	100%	100%	100%	1.00

Frequency and Probability of Taxa Occurrence

Reference Model Taxa	Frequency of Occurrence in Reference Sites					Probability Of Occurrence at NABIR02
	Group 1	Group 2	Group 3	Group 4	Group 5	
Perlodidae	78%	78%	89%	92%	81%	0.84
Rhyacophilidae	100%	92%	100%	100%	95%	0.96
Taeniopterygidae	89%	49%	100%	92%	97%	0.97

RIVPACS Ratios

RIVPACS : Expected taxa P>0.50	12.53
RIVPACS : Observed taxa P>0.50	12.00
RIVPACS : O:E (p > 0.5)	0.96
RIVPACS : Expected taxa P>0.70	9.55
RIVPACS : Observed taxa P>0.70	9.00
RIVPACS : O:E (p > 0.7)	0.94

Habitat Description

Variable	NABIR02	Predicted Group Reference Mean ±SD
Channel		
Depth-Avg (cm)	15.0	21.5 ± 9.7
Depth-BankfullMinusWetted (cm)	37.00	38.14 ± 36.11
Depth-Max (cm)	18.5	31.0 ± 16.5
Macrophyte (PercentRange)	0	0 ± 0
Reach-%CanopyCoverage (PercentRange)	2.00	1.54 ± 1.28
Reach-DomStreamsideVeg (Category(1-4))	3	3 ± 1
Reach-Pools (Binary)	1	1 ± 0
Reach-Riffles (Binary)	1	1 ± 0
Reach-StraightRun (Binary)	1	0 ± 1
Slope (m/m)	0.0380000	0.0581357 ± 0.0554952
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)	0.38	0.51 ± 0.27
Velocity-Max (m/s)	0.54	0.78 ± 0.40
Width-Bankfull (m)	14.3	13.7 ± 16.4
Width-Wetted (m)	2.9	9.0 ± 13.1
XSEC-VelMethod (Category(1-3))	1	2 ± 1
Landcover		
Reg-Ice (%)	0.00000	3.06094 ± 5.65390
Substrate Data		
%Bedrock (%)	0	1 ± 1
%Boulder (%)	0	3 ± 3
%Cobble (%)	58	64 ± 17
%Gravel (%)	2	2 ± 2
%Pebble (%)	40	31 ± 16
%Sand (%)	0	0 ± 0
%Silt+Clay (%)	0	0 ± 0
D50 (cm)	7.00	19.61 ± 30.65
Dg (cm)	6.7	20.3 ± 30.8
Dominant-1st (Category(0-9))	6	7 ± 1
Dominant-2nd (Category(0-9))	5	6 ± 1
Embeddedness (Category(1-5))	4	4 ± 1
PeriphytonCoverage (Category(1-5))	1	2 ± 1
SurroundingMaterial (Category(0-9))	3	3 ± 1
Topography		
Reg-SlopeLT30% (%)	21.53000	16.26604 ± 8.50298
Water Chemistry		
Ag (mg/L)	0.0100000	0.0000025 ± 0.0000029
Al (mg/L)	13.2000000	0.0068250 ± 0.0065408
As (mg/L)	0.0500000	0.0007150 ± 0.0011508
B (mg/L)	25.0000000	0.0333333 ± 0.0288675
Ba (mg/L)	155.0000000	0.1105900 ± 0.0816788

Habitat Description

Variable	NABIR02	Predicted Group Reference Mean ±SD
Be (mg/L)	0.0500000	0.0000050 ± 0.0000058
Bi (mg/L)	0.5000000	0.0000025 ± 0.0000029
Ca (mg/L)	46.0000000	23.0705882 ± 17.1292507
Cd (mg/L)	0.0050000	0.0000025 ± 0.0000029
Chloride-Dissolved (mg/L)	1.3000000	0.4147059 ± 0.6325189
Co (mg/L)	0.1000000	0.0000108 ± 0.0000045
CO3 (mg/L)	4.5000000	0.0000000 ± 0.0000000
Cr (mg/L)	0.5000000	0.0000500 ± 0.0000577
Cu (mg/L)	0.2500000	0.0003225 ± 0.0003721
Fe (mg/L)	24.0000000	0.0050000 ± 0.0028284
General-Alkalinity (mg/L)	176.0000000	68.5944444 ± 52.1098452
General-Conductivity (µS/cm)	241.1000000	110.5428571 ± 89.3409737
General-DO (mg/L)	8.0000000	11.0635135 ± 0.9899052
General-Hardness (mg/L)	202.0000000	88.7500000 ± 65.9614844
General-pH (pH)	9.0	7.7 ± 0.7
General-TempAir (Degrees Celsius)	7.0	10.5 ± 0.7
General-TempWater (Degrees Celsius)	6.9000000	5.5262162 ± 1.8860693
General-Turbidity (NTU)	4.1400000	0.1015000 ± 0.0459619
HCO3 (mg/L)	206.0000000	0.0000000 ± 0.0000000
Hg (ng/L)	5.0000000	0.0000000 ± 0.0000000
K (mg/L)	0.5660000	0.3252941 ± 0.2988993
Li (mg/L)	1.0000000	0.0009650 ± 0.0007595
Mg (mg/L)	21.2000000	7.6670588 ± 6.3323257
Mn (mg/L)	1.5000000	0.0003198 ± 0.0001463
Mo (mg/L)	2.3000000	0.0006200 ± 0.0004410
Na (mg/L)	0.7910000	0.8885294 ± 0.7285025
Ni (mg/L)	0.5000000	0.0001300 ± 0.0001937
Nitrogen-NH3 (mg/L)	0.0100000	0.0119375 ± 0.0293336
Nitrogen-NO2 (mg/L)	0.0025000	0.0074306 ± 0.0217095
Nitrogen-NO2+NO3 (mg/L)	0.0880000	0.0315000 ± 0.0316491
Nitrogen-NO3 (mg/L)	0.0880000	0.0699722 ± 0.0547511
Pb (mg/L)	0.1000000	0.0000215 ± 0.0000198
Phosphorus-OrthoP (mg/L)	0.0025000	0.0008750 ± 0.0012583
Phosphorus-TP (mg/L)	2.0000000	0.0025000 ± 0.0041986
S (mg/L)	8.7000000	11.5000000 ± 12.0208153
Sb (mg/L)	0.2500000	0.0000270 ± 0.0000061
Se (mg/L)	0.0500000	0.0000450 ± 0.0000614
Si (mg/L)	2580.0000000	1.8247059 ± 0.6920511
Sn (mg/L)	2.5000000	0.0000050 ± 0.0000058
Sr (mg/L)	71.7000000	0.0823000 ± 0.1023104
Ti (mg/L)	2.5000000	0.0005000 ± 0.0000000
Tl (mg/L)	0.0050000	0.0000020 ± 0.0000028
U (mg/L)	1.1700000	0.0004868 ± 0.0003873
V (mg/L)	2.5000000	0.0002425 ± 0.0003161
Zn (mg/L)	2.5000000	0.0005500 ± 0.0006403
Zr (mg/L)	0.0500000	0.0000000 ± 0.0000000

Up Stream

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%	0.3%	16.0%	11.2%	72.5%
CABIN Assessment of NABIR02 on Sep 19, 2016	Similar to Reference				

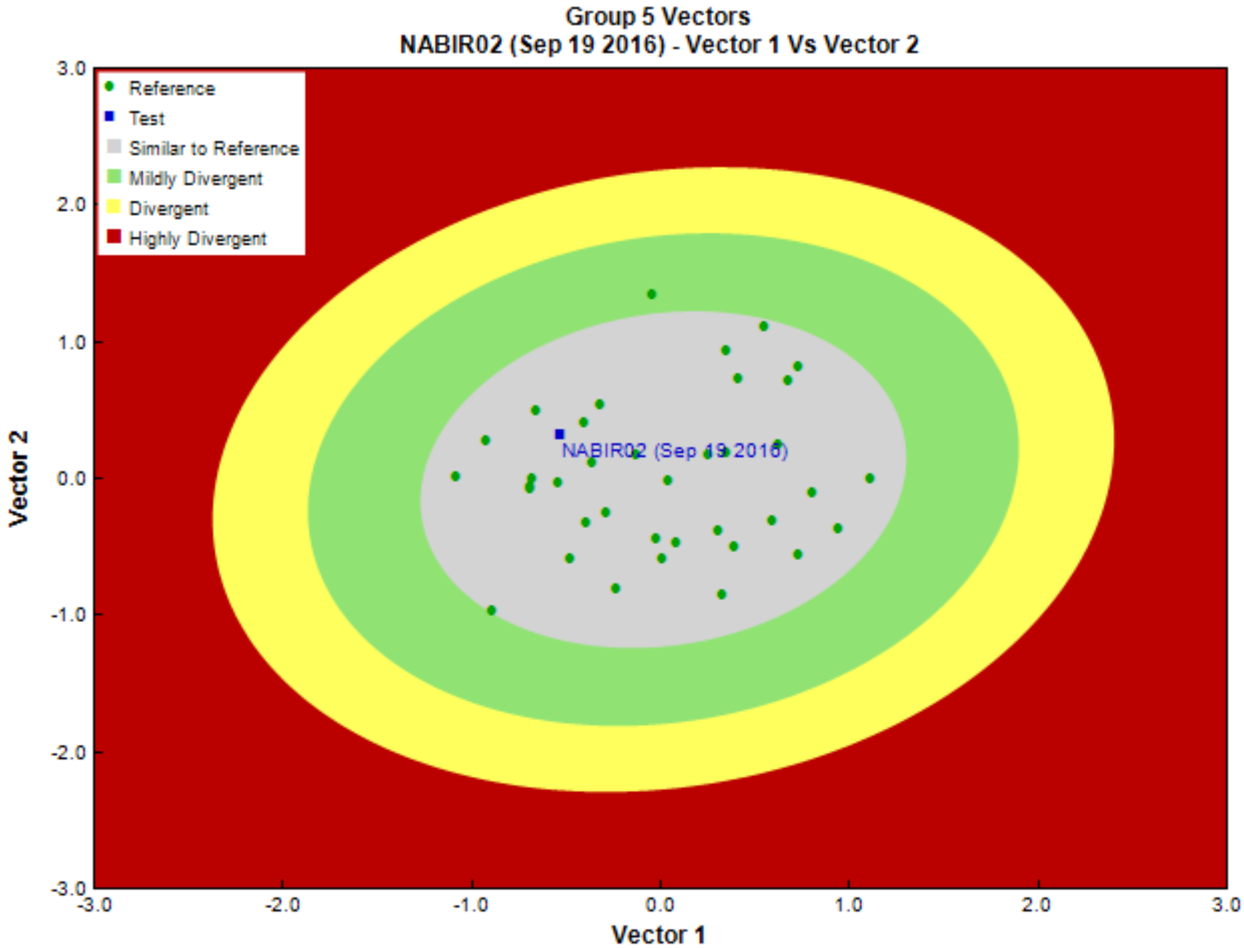

Figure 3. CABIN ordination assessment of the test site with the predicted group of reference sites. Each axis represents the relative abundance of the entire benthic invertebrate community with different organisms weighted differently on each axis.

Sample Information

Sampling Device	Kick Net
Mesh Size	400
Sampling Time	3
Taxonomist	Pina Viola, Consultant
Date Taxonomy Completed	October 13, 2016
	Marchant Box
Sub-Sample Proportion	14/100

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
Arthropoda	Arachnida	Sarcoptiformes		1	7.1
	Insecta	Coleoptera	Curculionidae	1	7.1
		Diptera	Chironomidae	11	78.6
			Empididae	1	7.1
			Simuliidae	3	21.4
		Ephemeroptera	Ameletidae	1	7.1
			Baetidae	13	92.9
			Heptageniidae	56	400.0
		Plecoptera	Capniidae	5	35.7
			Chloroperlidae	24	171.4
			Leuctridae	2	14.3
			Nemouridae	47	335.7
			Perlodidae	6	42.9
			Taeniopterygidae	143	1,021.4
		Trichoptera	Hydropsychidae	4	28.6

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
			Lepidostomatidae	1	7.1
			Rhyacophilidae	1	7.1
			Total	320	2,285.5

Metrics

Name	NABIR02	Predicted Group Reference Mean ±SD
Bray-Curtis Distance	0.36	0.4 ± 0.1
Biotic Indices		
Hilsenhoff Family index (North-West)	2.5	2.8 ± 0.3
Intolerant taxa	--	1.0 ± 0.0
Long-lived taxa	--	1.0 ± 0.0
Tolerant individuals (%)	--	0.3
Functional Measures		
% Filterers	2.2	1.7 ± 1.7
% Gatherers	70.6	50.6 ± 14.6
% Predatores	15.6	15.3 ± 9.0
% Scrapers	74.7	67.2 ± 16.8
% Shredder	62.2	38.1 ± 18.2
No. Clinger Taxa	18.0	19.8 ± 3.4
Number Of Individuals		
% Chironomidae	3.4	4.6 ± 5.0
% Coleoptera	0.3	0.0 ± 0.0
% Diptera + Non-insects	4.7	6.3 ± 5.3
% Ephemeroptera	21.9	44.9 ± 17.3
% Ephemeroptera that are Baetidae	18.6	26.1 ± 20.5
% EPT Individuals	95.0	93.7 ± 5.3
% Odonata	0.0	0.0 ± 0.0
% of 2 dominant taxa	62.4	60.2 ± 11.4
% of 5 dominant taxa	88.7	84.5 ± 5.9
% of dominant taxa	44.8	39.3 ± 12.3
% Plecoptera	71.2	42.9 ± 17.2
% Tribe Tanyatarisini	--	
% Trichoptera that are Hydropsychida	66.7	27.4 ± 27.1
% Tricoptera	1.9	5.8 ± 5.7
No. EPT individuals/Chironomids+EPT Individuals	1.0	1.0 ± 0.1
Total Abundance	2285.7	2163.6 ± 1274.4
Richness		
Chironomidae taxa (genus level only)	1.0	0.9 ± 0.2
Coleoptera taxa	1.0	0.1 ± 0.2
Diptera taxa	3.0	2.4 ± 1.0
Ephemeroptera taxa	3.0	3.7 ± 0.5
EPT Individuals (Sum)	2164.3	2023.9 ± 1195.7
EPT taxa (no)	12.0	12.3 ± 1.9
Odonata taxa	0.0	0.0 ± 0.0
Pielou's Evenness	0.6	0.7 ± 0.1
Plecoptera taxa	6.0	5.5 ± 1.1
Shannon-Wiener Diversity	1.7	1.9 ± 0.3
Simpson's Diversity	0.7	0.8 ± 0.1
Simpson's Evenness	0.2	0.3 ± 0.1
Total No. of Taxa	16.0	16.0 ± 3.0
Trichoptera taxa	3.0	3.2 ± 1.0

Frequency and Probability of Taxa Occurrence

Reference Model Taxa	Frequency of Occurrence in Reference Sites					Probability Of Occurrence at NABIR02
	Group 1	Group 2	Group 3	Group 4	Group 5	
Baetidae	100%	100%	100%	100%	97%	0.98
Chironomidae	100%	100%	100%	100%	95%	0.96
Chloroperlidae	78%	88%	94%	100%	100%	0.99
Ephemerellidae	78%	100%	100%	100%	100%	1.00
Heptageniidae	100%	100%	100%	100%	100%	1.00

Frequency and Probability of Taxa Occurrence

Reference Model Taxa	Frequency of Occurrence in Reference Sites					Probability Of Occurrence at NABIR02
	Group 1	Group 2	Group 3	Group 4	Group 5	
Hydropsychidae	11%	92%	78%	92%	86%	0.86
Nemouridae	100%	100%	100%	100%	100%	1.00
Perlodidae	78%	78%	89%	92%	81%	0.84
Rhyacophilidae	100%	92%	100%	100%	95%	0.96
Taeniopterygidae	89%	49%	100%	92%	97%	0.97

RIVPACS Ratios

RIVPACS : Expected taxa P>0.50	12.53
RIVPACS : Observed taxa P>0.50	13.00
RIVPACS : O:E (p > 0.5)	1.04
RIVPACS : Expected taxa P>0.70	9.55
RIVPACS : Observed taxa P>0.70	9.00
RIVPACS : O:E (p > 0.7)	0.94

Habitat Description

Variable	NABIR02	Predicted Group Reference Mean ±SD
Channel		
Depth-Avg (cm)	7.0	21.5 ± 9.7
Depth-BankfullMinusWetted (cm)	39.50	38.14 ± 36.11
Depth-Max (cm)	8.0	31.0 ± 16.5
Macrophyte (PercentRange)	0	0 ± 0
Reach-%CanopyCoverage (PercentRange)	1.00	1.54 ± 1.28
Reach-%Logging (PercentRange)	0	0 ± 0
Reach-DomStreamsideVeg (Category (1-4))	3	3 ± 1
Reach-Pools (Binary)	1	1 ± 0
Reach-Riffles (Binary)	1	1 ± 0
Reach-StraightRun (Binary)	1	0 ± 1
Slope (m/m)	0.0260000	0.0581357 ± 0.0554952
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)	0.71	0.51 ± 0.27
Velocity-Max (m/s)	0.89	0.78 ± 0.40
Width-Bankfull (m)	15.4	13.7 ± 16.4
Width-Wetted (m)	4.2	9.0 ± 13.1
XSEC-VelMethod (Category (1-3))	1	2 ± 1
Landcover		
Reg-Ice (%)	0.00000	3.06094 ± 5.65390
Substrate Data		
%Bedrock (%)	0	1 ± 1
%Boulder (%)	2	3 ± 3
%Cobble (%)	62	64 ± 17
%Gravel (%)	6	2 ± 2
%Pebble (%)	30	31 ± 16
%Sand (%)	0	0 ± 0
%Silt+Clay (%)	0	0 ± 0
D50 (cm)	8.20	19.61 ± 30.65
Dg (cm)	7.0	20.3 ± 30.8
Dominant-1st (Category(0-9))	6	7 ± 1
Dominant-2nd (Category(0-9))	5	6 ± 1
Embeddedness (Category(1-5))	3	4 ± 1
PeriphytonCoverage (Category(1-5))	1	2 ± 1
SurroundingMaterial (Category(0-9))	3	3 ± 1
Topography		
Reg-SlopeLT30% (%)	21.53373	16.26604 ± 8.50298
Water Chemistry		
Ag (mg/L)	0.0100000	0.0000025 ± 0.0000029
Al (mg/L)	5.6000000	0.0068250 ± 0.0065408

Habitat Description

Variable	NABIR02	Predicted Group Reference Mean ±SD
As (mg/L)	0.0500000	0.0007150 ± 0.0011508
B (mg/L)	25.0000000	0.0333333 ± 0.0288675
Ba (mg/L)	145.0000000	0.1105900 ± 0.0816788
Be (mg/L)	0.0500000	0.0000050 ± 0.0000058
Bi (mg/L)	0.5000000	0.0000025 ± 0.0000029
Ca (mg/L)	46.9000000	23.0705882 ± 17.1292507
Cd (mg/L)	0.0050000	0.0000025 ± 0.0000029
Chloride-Dissolved (mg/L)	1.4000000	0.4147059 ± 0.6325189
Co (mg/L)	0.2500000	0.0000108 ± 0.0000045
CO3 (mg/L)	4.7300000	0.0000000 ± 0.0000000
Cr (mg/L)	0.5000000	0.0000500 ± 0.0000577
Cu (mg/L)	0.2500000	0.0003225 ± 0.0003721
Fe (mg/L)	5.0000000	0.0050000 ± 0.0028284
General-Alkalinity (mg/L)	167.0000000	68.5944444 ± 52.1098452
General-DO (mg/L)	10.0000000	11.0635135 ± 0.9899052
General-Hardness (mg/L)	200.0000000	88.7500000 ± 65.9614844
General-pH (pH)	8.7	7.7 ± 0.7
General-SolidsTSS (mg/L)	2.0000000	2.8140173 ± 7.8143482
General-SpCond (µS/cm)	249.1000000	160.3567568 ± 118.4083015
General-TempAir (Degrees Celsius)	9.5	10.5 ± 0.7
General-TempWater (Degrees Celsius)	8.5000000	5.5262162 ± 1.8860693
General-Turbidity (NTU)	2.1600000	0.1015000 ± 0.0459619
HCO3 (mg/L)	194.0000000	0.0000000 ± 0.0000000
Hg (ng/L)	0.0050000	0.0000000 ± 0.0000000
K (mg/L)	0.5430000	0.3252941 ± 0.2988993
Li (mg/L)	2.5000000	0.0009650 ± 0.0007595
Mg (mg/L)	20.2000000	7.6670588 ± 6.3323257
Mn (mg/L)	0.5000000	0.0003198 ± 0.0001463
Mo (mg/L)	2.6000000	0.0006200 ± 0.0004410
Na (mg/L)	0.7630000	0.8885294 ± 0.7285025
Ni (mg/L)	0.5000000	0.0001300 ± 0.0001937
Nitrogen-NH3 (mg/L)	0.0590000	0.0119375 ± 0.0293336
Nitrogen-NO2 (mg/L)	0.0025000	0.0074306 ± 0.0217095
Nitrogen-NO2+NO3 (mg/L)	0.0910000	0.0315000 ± 0.0316491
Nitrogen-NO3 (mg/L)	0.0910000	0.0699722 ± 0.0547511
Nitrogen-TDN (mg/L)	0.18	0.00 ± 0.00
Pb (mg/L)	0.1000000	0.0000215 ± 0.0000198
Phosphorus-OrthoP (mg/L)	0.0025000	0.0008750 ± 0.0012583
Phosphorus-TDP (mg/L)	0.0025000	0.0012500 ± 0.0015000
S (mg/L)	10.2000000	11.5000000 ± 12.0208153
Sb (mg/L)	0.2500000	0.0000270 ± 0.0000061
Se (mg/L)	0.0500000	0.0000450 ± 0.0000614
Si (mg/L)	2550.0000000	1.8247059 ± 0.6920511
Sn (mg/L)	2.5000000	0.0000050 ± 0.0000058
Sr (mg/L)	78.6000000	0.0823000 ± 0.1023104
Ti (mg/L)	2.5000000	0.0005000 ± 0.0000000
Tl (mg/L)	0.0250000	0.0000020 ± 0.0000028
U (mg/L)	1.2600000	0.0004868 ± 0.0003873
V (mg/L)	2.5000000	0.0002425 ± 0.0003161
Zn (mg/L)	2.5000000	0.0005500 ± 0.0006403
Zr (mg/L)	0.2500000	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)	Total Nitrogen (N)
			Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	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**	**0.02**
Wildsight Golden	2016-09-19	NABIR02	Birchland 2	<0.0050	0.091	167	3.94	194	4.73	<0.50	<0.0050	0.091	2.16	<0.0050	0.176
Wildsight Golden	2016-09-19	NABIR02 DUP	Birchland 2	<0.0050	0.096	164	3.22	192	3.86	<0.50	<0.0050	0.096	0.64	<0.0050	0.168
		Duplicate QC	**Calculated RPD (%)**	**1.0**	**-5.3**	**1.8**	**20.1**	**1.0**	**20.3**	**1.0**	**1.0**	**-5.3**	**108.6**	**1.0**	**4.7**
Wildsight Golden	2016-09-19	NABIR02 FLD BLNK	Birchland 2	<0.0050	<0.020	<0.50	<0.50	<0.50	<0.50	<0.50	<0.0050	<0.020	<0.10	<0.0050	0.089
		Blank QC	**X times > than RDL**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0**	**4.45**

Appendix B1 - Water Quality QA/QC

Sample Date yy/mm/dd)	Conductivity	Total Suspended Solids	Dissolved Chloride (Cl)	Total Ammonia (N)
	uS/cm	**mg/L**	**mg/L**	**mg/L**
	1	**4**	**0.5**	**0.005**
2016-09-19	-	<4.0	1.4	0.059
2016-09-19	361	5.3	1	0.043
	-	**-28.0**	**33.3**	**31.4**
2016-09-19	1.4	<4.0	<0.50	<0.0050
	1.4	**0**	**0**	**0**

Appendix B2 - Water quality, non-metal

Stewardship Group	Sample Date yy/mm/dd)	Site Code	Site Name	Nitrite (N)	Nitrate (N)	Alkalinity (Total as CaCO3)	Alkalinity (PP as CaCO3)	Bicarbonate (HCO3)	Carbonate (CO3)	Hydroxide (OH)	Orthophosphate (P)	Nitrate plus Nitrite (N)
			Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	mg/L
			Guideline for protection of aquatic life[avg]	BC App: 0.02 when chloride <2 mg/L (or see Guideline Table)	BC App: 3	-	-	-	-	-	-	BC App: 3
			Guideline for drinking water[max]	HC: 1	HC: 10	-	-	-	-	-	-	BC App: 10
Wildsight Golden	2015-04-30	NABIR01	Birchland 1	<0.0050	0.383	-	-	-	-	-	-	0.383
Wildsight Golden	2015-05-20	NABIR01	Birchland 1	<0.0050	0.198	-	-	-	-	-	<5	0.198
Wildsight Golden	2015-06-25	NABIR01	Birchland 1	<0.0050	0.059	127	<0.50	155	<0.50	<0.50	<5	0.059
Wildsight Golden	2015-07-29	NAB1R01	Birchland 1	<0.0050	0.088	-	-	-	-	-	<5	0.088
Wildsight Golden	2015-08-25	NAB1R01	Birchland 1	-	0.1	-	-	-	-	-	0.005	0.1
Wildsight Golden	2015-09-30	NABIR01	Birchland 1	<0.0050	0.104	-	-	-	-	-	-	0.104
Wildsight Golden	2015-10-28	NABIR01	Birchland 1	-	-	-	-	-	-	-	-	-
Wildsight Golden	2015-10-28	NABIR02	Birchland 2	<0.0050	0.121	-	-	-	-	-	-	0.121
Wildsight Golden	2016-05-04	NABIR02	Birchland 2	<0.0050	0.236	-	-	-	-	-	<0.0050	0.236
Wildsight Golden	2016-05-16	NABIR02	Birchland 2	<0.0050	0.163	-	-	-	-	-	<0.0050	0.163
Wildsight Golden	2016-06-20	NABIR02	Birchland 2	<0.0050	0.076	-	-	-	-	-	<0.0050	0.076
Wildsight Golden	2016-07-18	NABIR02	Birchland 2	<0.0050	0.083	-	-	-	-	-	<0.0050	0.083
Wildsight Golden	2016-08-22	NABIR02	Birchland 2	<0.0050	0.101	-	-	-	-	-	<0.0050	0.101
Wildsight Golden	2016-09-19	NABIR02	Birchland 2	<0.0050	0.091	167	3.94	194	4.73	<0.50	<0.0050	0.091
Wildsight Golden	2016-10-24	NABIR02	Birchland 2	<0.0050	0.183	-	-	-	-	-	-	0.183
Wildsight Golden	2017-04-19	NABIR02	Birchland 2	<0.0050	0.1	-	-	-	-	-	-	0.1
Wildsight Golden	2017-05-16	NABIR02	Birchland 2	0.0054	0.290	-	-	-	-	-	<0.0050	0.295
Wildsight Golden	2017-06-21	NABIR02	Birchland 2	<0.0050	0.054	-	-	-	-	-	<0.0050	0.054

Appendix B2 - Water quality, non-metal

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)
Wildsight Golden	2017-07-26	NABIR02	Birchland 2	<0.0050	0.089	-	-	-	-	-	<0.0050	0.089
Wildsight Golden	2017-08-23	NABIR02	Birchland 2	<0.0050	0.122	-	-	-	-	-	<0.0050	0.122
Wildsight Golden	2017-09-20	NABIR02	Birchland 2	<0.0050	0.088	176	3.8	206	4.5	<1.0	<0.0050	0.088
Wildsight Golden	2017-10-31	NABIR02	Birchland 2	<0.0050	0.113	-	-	-	-	-	-	0.113

Appendix B2 - Water quality, non-metal

Sample Date yy/mm/dd)	Site Code	Dissolved Oxygen	Specific Conductivity	pH	Turbidity	Water Temperature	Air Temperature	Total Hardness (CaCO3)
		mg/L	uS/cm		NTU	C	C	mg/L
		BC App (**minimum**): 8 all stages other than burried embryo. 11 buried embryo not assessed, as spawning confirmation required.	-	BC App: 6.5-9.0.	BC App[1]: Change from background of 8 during clear flow period, and change of 5 during turbid flows	BC App: 19 max. See continuous temperature results for site specific fish species and lifestage guidelines.	-	-
		-	-	HC: 7-10.5	BC App[1]: Change of 1 when background is <5 NTU; change of 5 when background is >5 and <50; change of 10% when background is >50.	BC App[AO]: 15	-	-
2015-04-30	NABIR01	11	303.5	8.36	29.5	5.5	14	-
2015-05-20	NABIR01	11	267.2	8.48	47.2	11.6	27	-
2015-06-25	NABIR01	10	247.4	8.13	4.59	17.3	28.5	199
2015-07-29	NAB1R01	8	137.1	8.73	4.83	15.6	22	-
2015-08-25	NAB1R01	9	295.6	9.05	1.04	18.4	20	-
2015-09-30	NABIR01	8	254.5	8.5	0.8	9.9	12	-
2015-10-28	NABIR01	10	252.8	9.33	1.41	6.5	8	-
2015-10-28	NABIR02	9	235.2	9.45	1.15	6.2	9	-
2016-05-04	NABIR02	10	181.6	8.18	24.9	7	18	-
2016-05-16	NABIR02	12	207	8.88	2.91	8	19	-
2016-06-20	NABIR02	11	237.9	8.63	6.24	12	26	-
2016-07-18	NABIR02	10	256.8	9.4	6.68	13.9	21.5	-
2016-08-22	NABIR02	11	264.2	8.3	3.53	11.1	13	-
2016-09-19	NABIR02	10	249.1	8.74	2.16	8.5	9.5	-
2016-10-24	NABIR02	10	205.7	9.18	2.52	3.4	2	-
2017-04-19	NABIR02	12	253.7	6.97	7.32	6.4	12	-
2017-05-16	NABIR02	11	218.3	7.43	45.3	6.5	12.5	-
2017-06-21	NABIR02	9	195.8	7.73	5.56	7.8	12	-

Appendix B2 - Water quality, non-metal

Sample Date yy/mm/dd)	Site Code	Dissolved Oxygen	Specific Conductivity	pH	Turbidity	Water Temperature	Air Temperature	Total Hardness (CaCO3)
2017-07-26	NABIR02	*9*	*291.5*	*8.8*	*1.72*	*14.5*	*28.5*	-
2017-08-23	NABIR02	*9*	*313.2*	*8.9*	*1.84*	*14.7*	*27.5*	-
2017-09-20	NABIR02	*8*	*241.1*	*9.01*	*4.14*	*6.9*	*7*	-
2017-10-31	NABIR02	*10*	*210.3*	*9.08*	*2.43*	*1.6*	*(-1)*	-

Appendix B2 - Water quality, non-metal

Sample Date yy/mm/dd)	Site Code	Total Phosphorus (P)	Total Nitrogen (N)	Total Suspended Solids	Dissolved Chloride (Cl)	Total Ammonia (N)	E. coli
		mg/L	mg/L	mg/L	mg/L	mg/L	CFU
		CCME: Based on this data, this site was oligotrophic (0.004-0.01); exceedances of 1.5 times the upper value (or 0.015) indicates a potential problem.	-	BC App[1]: Change from background of: ≤ 25 for 24 hr during clear flow, or 10 for 24 hr during turbid period (when natural water is 25-100)	BC App (total chloride): 150	BC App: 0.114 to 1.92 based on daily pH and temp, using guideline table.	-
		-	-	-	BC App[AO]: 250	-	HC: 0
2015-04-30	NABIR01	-	-	48	0.54	0.0065	<1
2015-05-20	NABIR01	-	-	65	-	0.018	<1
2015-06-25	NABIR01	0.0192	<0.50	7.8	0.84	0.086	<1
2015-07-29	NAB1R01	<0.0050	-	<4.0	1.1	0.016	8
2015-08-25	NAB1R01	0.0084	-	4.3	<0.5	0.005	-
2015-09-30	NABIR01	-	-	<4.0	0.83	0.013	-
2015-10-28	NABIR01	-	-	-	-	-	-
2015-10-28	NABIR02	-	-	<4.0	0.95	0.017	<1
2016-05-04	NABIR02	-	-	30	0.87	0.011	-
2016-05-16	NABIR02	<0.0050	-	<4.0	0.7	0.0063	-
2016-06-20	NABIR02	0.0068	-	6.3	0.83	0.012	-
2016-07-18	NABIR02	0.0103	-	6.5	0.89	0.014	-
2016-08-22	NABIR02	0.005	-	<4.0	<1.0	0.023	-
2016-09-19	NABIR02	<0.0050	0.176	<4.0	1.4	0.059	-
2016-10-24	NABIR02	-	-	<4.0	1.1	0.036	-
2017-04-19	NABIR02	-	-	9.5	2.1	0.019	<1
2017-05-16	NABIR02	0.0243	-	43.5	1.0	0.15	<1
2017-06-21	NABIR02	0.0067	-	7.5	<0.50	0.018	1

Appendix B2 - Water quality, non-metal

Sample Date yy/mm/dd)	Site Code	Total Phosphorus (P)	Total Nitrogen (N)	Total Suspended Solids	Dissolved Chloride (Cl)	Total Ammonia (N)	E. coli
2017-07-26	NABIR02	<0.0050	-	<4.0	0.63	0.017	1
2017-08-23	NABIR02	<0.0050	-	<4.0	1.4	<0.020	2
2017-09-20	NABIR02	0.0055	-	<4.0	1.3	<0.020	6
2017-10-31	NABIR02	-	-	<4.0	1.3	<0.020	<1

Appendix B3 - Water quality, metals.

Stewardship Group	Sample Date (yy/mm/dd)	Site Code	Site Name	pH	Total Hardness (CaCO3)	Total Aluminum (Al)	Total Antimony (Sb)	Total Arsenic (As)	Total Barium (Ba)
			Units	ph units	mg/L	µg/L	µg/L	µg/L	µg/L
			Guideline for protection of aquatic life[avg]	BC App:6.5-9.0	-	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]	HC: 7-10.5	-	BC App[AO]: 9500	HC: 6	BC App: 10	HC: 1000
Wildsight Golden	2015-06-25	NABIR01	Birchland Cr 1		199	69.8	<0.50	0.2	170
Wildsight Golden	2016-09-19	NABIR02	Birchland Cr 2		200	5.6	<0.50	<0.10	145
Wildsight Golden	2017-09-20	NABIR02	Birchland Cr 2		202	13.2	<0.50	<0.10	155

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)	Total Magnesium (Mg)
	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L
	BC Work: 0.13	-	BC App: 1200	CCME: $10^{\{0.83(\log[\text{hardness}]) - 2.46\}}$	-	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).	-	-
	-	-	-	0.28	-	-	-	8.01	-	11.02	-	-
	-		BC App: 5000	HC: 5	-	HC: 50	-	BC App^{AO}: 1000	BC App^{AO}: 300	BC App: 10	-	-
2015-06-25	<0.10	<1.0	<50	<0.010	47.8	<1.0	<0.50	0.96	374	0.49	<5.0	19.2
2016-09-19	<0.10	<1.0	<50	<0.010	46.9	<1.0	<0.50	<0.50	<10	<0.20	<5.0	20.2
2017-09-20	<0.10	<1.0	<50	<0.010	46	<1.0	<0.20	<0.50	24	<0.20	<2.0	21.2

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)	Total Thallium (Tl)	Total Tin (Sn)
	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/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.	-	-	-	BC Work: 0.8	-
	605.88	-	-	162.06	-	-	-	1.5	-	-	-	-	-
	BC App^{AO}: 50	BC App: 1	BC App: 250	-	-	BC App: 10	-	-	HC^{AO}: 200	-	-	-	-
2015-06-25	14.2	<0.010	3.3	1.5	0.62	0.14	2620	<0.020	0.662	78.2	8	<0.050	<5.0
2016-09-19	<1.0	<0.010	2.6	<1.0	0.543	<0.10	2550	<0.020	0.763	78.6	10.2	<0.050	<5.0
2017-09-20	1.5	<0.010	2.3	<1.0	0.566	<0.10	2580	<0.020	0.791	71.7	8.7	<0.010	<5.0

Appendix B3 - Water quality, metals.

Sample Date (yy/mm/dd)	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
	-	BC Work: 8.5	-	BC App: hardness <90 = 7.5. Hardness 90 - 330 = 7.5 + 0.75 x (hardness - 90)	-
	-	-	-	90.25	-
	-	HC: 20	-	BC App[AO]: 5000	-
2015-06-25	<5.0	1.17	<5.0	<5.0	<0.50
2016-09-19	<5.0	1.26	<5.0	<5.0	<0.50
2017-09-20	<5.0	1.17	<5.0	<5.0	<0.10