Mather Creek
Water Quality Monitoring Report
2015 – 2017

Prepared by:
Lotic Environmental Ltd, and Mainstreams Environmental Society

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Contact Information

Mainstreams Environmental Society
Laura Duncan (kootenaylaura@gmail.com)
Jim Duncan (jim.duncan9@me.com)
Website: www.mainstreams.ca

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

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

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

Columbia Basin Watershed Network
Website: www.cbwn.ca

Cover photo: Mather Creek site NGMAT01, April 20, 2015

Project Highlights

The Columbia Basin Water Quality Monitoring Project (CBWQ) is an environmental stewardship project funded by Columbia Basin Trust. Under the CBWQ, Mainstreams Environmental Society conducted baseline water quality monitoring in Mather Creek from 2015 to 2017. Mather Creek watershed was identified to be a priority for monitoring because of its high value to humans and exceptional diversity of wildlife. 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 focussed at NGMAT01, located at the downstream end of Mather Creek, near the confluence with the Kootenay River. Sites NGMAT02 and NGMAT03 were added in 2017, to monitor *Escherichia coli (*E. coli) only, which was shown to be a water quality parameter of concern.

The CABIN analysis of benthic macro-invertebrate monitoring results identified that NGMAT01 improved from being stressed in 2015 to being potentially stressed in 2016 and 2017. The improvement was evident through higher percent EPT taxa, lower percent chironomidae, and lower percent of two most dominant taxa. It is unknown what lead to the improvement since physical conditions (i.e., substrate, general water chemistry, water temperature, and streamflow) were similar amongst the years.

Overall, the water quality was good. Two guidelines for the protection of aquatic life not met were total phosphorus and pH. However, negative impacts were not expected since, on average, values were within the respective guidelines. The *E. coli* guideline protecting drinking water from direct adverse health effects was exceeded. Since this guideline was exceeded in all samples, it is recommended that water be disinfected prior to consumption.

Continuous water temperature monitoring results identified that the guidelines for the protection of aquatic life and drinking water (aesthetic objective) were regularly exceeded in the summer months. The summer high temperatures were above optimal for Bull Trout and Westslope Cutthroat Trout rearing. The Bull Trout minimum temperature guideline for egg incubation was also regularly not met during the winter. However, it is unknown whether the monitoring site is used by these species for spawning and rearing, and if required, fish would be expected to seek out suitable habitats elsewhere in the watershed. Overall, monthly average temperatures were consistent among the years. Flow patterns in the creek were also generally consistent among years, peaking in the spring during freshet, and declining throughout the summer and early fall.

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 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.

As a part of the CBWQ, Mainstreams Environmental Society (Mainstreams, or the stewardship group) conducted water quality monitoring in Mather Creek from 2015 to 2017. The following 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 streamflow). 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 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 Monitoring sites

The Mather Creek watershed was identified as a priority for monitoring because of its considerable use as a water source, primarily for domestic and irrigation purposes, and for its broad range of ecosystems which provide habitat to support an exceptional diversity of wildlife and supply favorable conditions for forestry, agriculture, and recreation. For a detailed description of the watershed, see *The Mather Watershed Story* on the CBWQ website (www.cbwq.ca).

NGMAT01 was the main site where monitoring was conducted along Mather Creek (Figure 1, Figure 2). Sites NGMAT02 and NGMAT03 were added in 2017, in order to monitor *Escherichia coli (*E. coli) only, which was shown to be a water quality parameter of concern.

NGMAT01 was located near the confluence with the Kootenay River, on The Nature Trust of British Columbia's Cherry Creek Wildlife Property. The site was selected because it was near the mouth of the creek and thus downstream of most uses that could affect water quality.

NGMAT02 and NGMAT03 were located upstream from NGMAT01 (Figure 3). At NGMAT02, the creek flowed under Highway 95A via two large culverts. The area was a popular informal summer recreation spot, with domestic cattle occasionally present. NGMAT03 was located in the upper watershed at the Lost Dog Main Forest Service Road Bridge, near Mather Creek's confluence with Cherry Creek. Logging was the only industrial activity in the vicinity of NGMAT03, although the upper watershed was popular with hunters and berry-pickers.

Figure 1. Downstream view of site NGMAT01, Sept 26, 2017. Photo: Susan Bond.

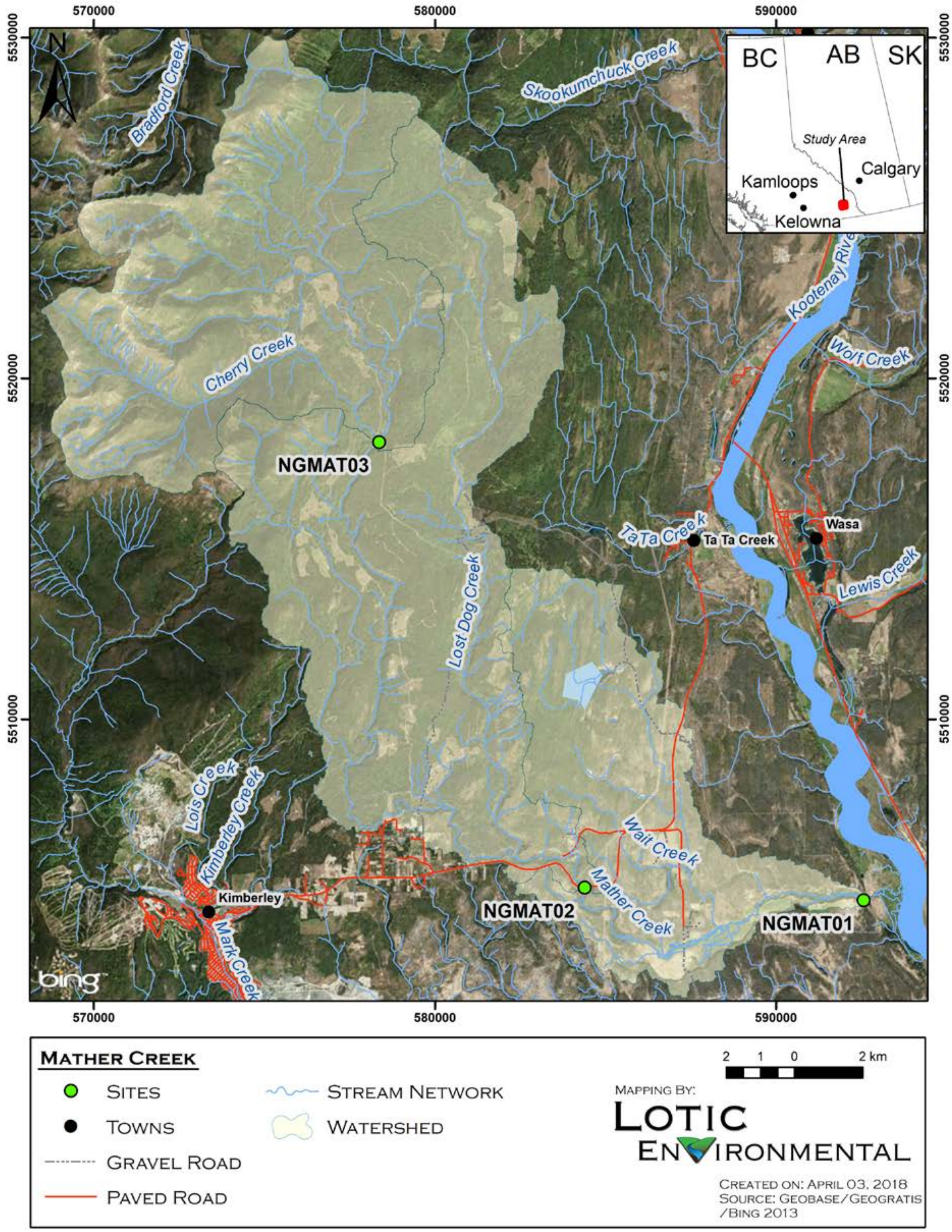

Figure 2. Mather Creek monitoring locations

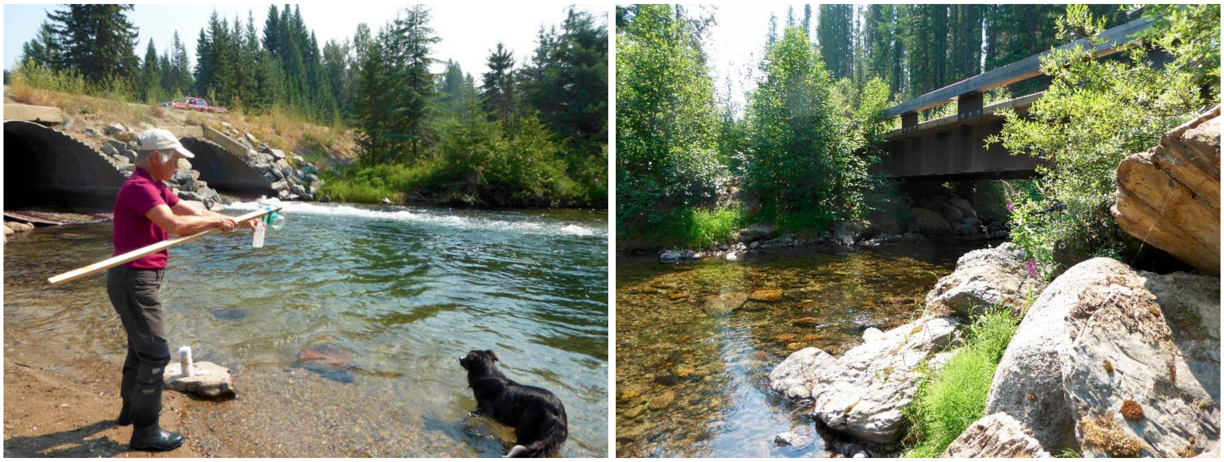

Figure 3. Cross channel views of site NGMAT02 (left), and NGMAT03 (right), July 19, 2017. Photos: Susan Bond.

1.2 Fish community

The fish community in Mather Creek is comprised of seven native and three 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 Mather Creek (Source: BC MoE 2018a).

Species - common name	Scientific name
Native species	
Mountain Whitefish	*Prosopium williamsoni*
Bull Trout	*Salvelinus confluentus*
Westslope Cutthroat Trout	*Oncorhynchus clarkii lewisi*
Northern Pikeminnow	*Ptychocheilus oregonensis*
Redside Shiner	*Richardsonius balteatus*
Sucker spp	*Catostomus spp.*
Sculpin spp.	*Cottus spp.*
Non – native (naturalized)	
Kokanee*	O. *nerka*
Rainbow Trout	*O. mykiss*
Eastern Brook Trout	*S. fontinalis*

* Not listed in BC MoE 2018a, but observed by Mainstreams.

Kokanee were observed at NGMAT01 during the monitoring period. This was of interest since the species was not listed in the provincial fisheries database as being historically sampled in Mather Creek. (Figure 4). These fish were observed in the fall and were potentially spawning.

Figure 4. Kokanee at NGMAT01, Sept 21, 2015.

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. 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 NGMAT01:

a. Monthly (spring through fall) - nutrients, total suspended solids (TSS), dissolved chloride, E. coli, and *in situ* (field measured) data. *In situ* data were dissolved oxygen (DO), temperature, specific conductivity, pH, turbidity, and air temperature.
b. Annually, in the fall (coinciding with CABIN monitoring) - in addition to data above, inorganics, and metals.
c. Once in 2016 - a duplicate and blank sample of non-metal parameters.

Additionally, at sites NGMAT02 and NGMAT03, *E. coli* was sampled once in July and in August, 2017. A duplicate was collected in August at all three sites, with the duplicate samples sent to a separate laboratory for analysis (Passmore Laboratory Ltd).

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. Using 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 in the 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 taken for the period from April 20, 2015 – October 13, 2017. The data were downloaded into a spreadsheet, and descriptive statistics (daily maximum, minimum, and average) were calculated and graphed.

Hydrometric data

Hydrometric data were collected monthly. 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 5): BEnthic Assessment of SedimenT (BEAST), River Invertebrate Prediction and Classification System (RIVPACS), community composition metrics, and habitat metrics. Water quality (Step 2), stream temperature (Step 3) and hydrometric (Step 4) analyses followed to provide an overall understanding of stream condition.

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

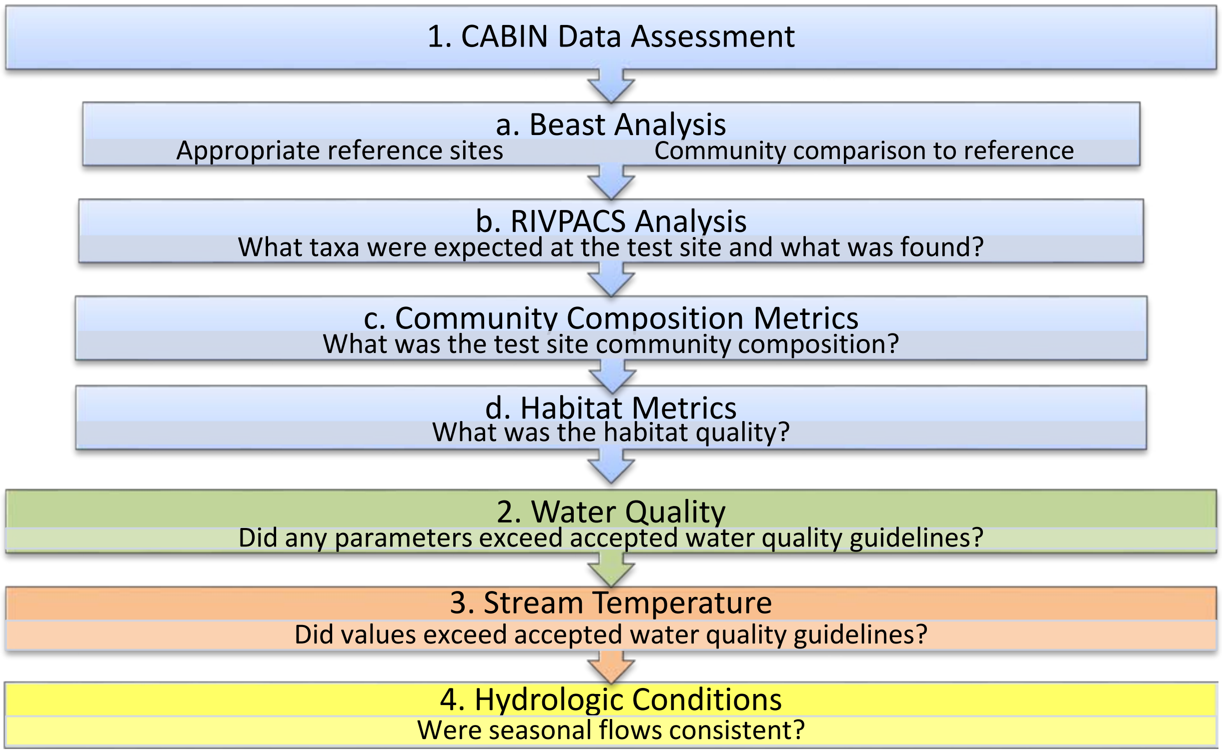

Figure 5. Stream condition analysis steps.

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 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 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. Streamflow results were graphed, with seasonal patterns compared qualitatively among the years.

3 Results

3.1 CABIN results

3.1.1 Reference Condition Approach: BEAST analysis and site assessment

At NGMAT01, CABIN BEAST analysis determined the highest probability of reference group membership was to Group 3 (Table 2). The site was thus compared with Reference Group 3, which includes 17 streams, mostly from the Northern Continental Divide Ecoregion. The average channel depth of Reference Group 3 was 22.5 ± 10 cm, which is near the test site's average depths of 18.2 - 22.1 cm measured over the three years monitored. 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 NGMAT01 as stressed in 2015, which improved in 2016 and 2017 to potentially stressed.

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
NGMAT01	**Stressed** Group 3; 74.4%	**Potentially stressed** Group 3; 75.3%	**Potentially stressed** Group 3; 74.5%

3.1.2 RIVPACS analysis

The RIVPACS ratio at NGMAT01 was 0.87 in both 2015 and 2016, and 0.97 in 2017 (Table 3). The lower ratio in 2015 and 2016 was attributed to two families not present that were expected based on the taxa found in the reference sites. In 2017, only one family was not present. Overall, most expected taxa were present at the site in all years monitored, indicating a healthy community.

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
NGMAT01	0.87 Chloroperlida, Taeniopterygidae	0.87 Perlodidae, Taeniopterygidae	0.97 Taeniopterygidae

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

3.1.3 Community composition metrics

Key benthic macro-invertebrate metrics that were reviewed in detail (Table 4) include: 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 at NGMAT01, 2015-2017. Condition indicated as shaded background*

Metric	Reference Group 3 (Mean ± std dev)	NGMAT01		
		2015	2016	2017
Total abundance	5780 ± 4895	10,000	5,287	2,393
% EPT taxa	84.9 ± 14.3	26.8	48.1	64.2
% Chironomidae	8.2 ± 13.6	17.0	6.9	4.8
% of 2 dominant taxa	58.9 ± 10.0	50.6	49.3	39.5
Total number of taxa	17.7 ± 2.6	25	24	27

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

Total abundance at NGMAT01 decreased considerably throughout the study period, from 10,000 organisms in 2015 to 2,393 organisms in 2017. However, all values were within the broad reference group mean of 5,780 ± 4895 organisms, indicating that abundance levels did not likely influence the condition rating throughout the study period. 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 (Environment Canada 2012c). Water quality at NGMAT01 did not show a change over time that would influence invertebrate abundance (Section 2.4).

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). The percent composition of EPT orders of insects are typically indicators of good water quality. While percent EPT at this site was low in 2015 (26.8%), values increased in the subsequent monitoring years (up to 64.2% in 2017), indicating an improvement in community health. Meanwhile, Chironomidae family of insects are generally tolerant of pollution. Decreases in the proportion of Chironomidae was also indicative of improving stream health over the study period, with values decreasing from 17% to 4.8%. These results support the CABIN analysis of the site improving from stressed in 2015 to potentially stressed in 2016 and 2017.

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 the test site, the percent of two dominant taxa decreased with time (from 50.6% in 2015 to 39.5% in 2017), also indicating good conditions.

Taxa richness is the total number of taxa present for a given taxonomic level. Although there is usually a decrease of intolerant taxa and an increase of tolerant taxa with instream disturbance, the overall biodiversity of a stream typically declines with disturbance (Environment Canada 2012c). Taxa richness at the test site was similar throughout the monitoring period (25-27 taxa), and was slightly higher than the reference mean (17.7 ± 2.6 taxa).

3.1.4 Habitat Conditions

Key physical habitat conditions that could influence benthic macro-invertebrate community health were compared amongst the sampling years (Table 5). Conditions were largely unchanged, and similar to the reference group mean. The characteristics reviewed did not explain the changes seen in the invertebrate community.

Table 5. Select physical habitat characteristics for the predicted reference group, and NGMAT01 during CABIN sampling.

Parameter	Reference group mean ± std dev	2015	2016	2017
Average Depth (cm)	22.5 ± 10.5	18.2	22.1	18.5
Average Velocity (m/s)	0.75 ± 0.28	0.54	0.47	0.66
% Cobble (6.4 - 25.6 cm)	61 ± 27	57	59	65
% Pebble (1.6 – 6.4 cm)	31 ± 28	41	40	35
% Gravel (0.2 – 1.6 cm)	1 ± 2	2	1	0
% Sand (0.1 – 0.2 cm)	0 ± 0	0	0	0
% silt and clay (<0.1 cm)	1 ± 3	0	0	0

3.2 Water quality results

3.2.1 Water quality QA/QC

The relative percent difference for the 2016 parameters sampled in duplicate were all below the concern level of 50% (Appendix B1). Also, all 2016 field blank parameters analysed 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.

August 2017 *E. coli* samples that were tested by two labs showed that the relative percent difference was >50% for two of the three sites. This may be related to variability in the water column, or possibly to sampling error or laboratory procedures. Nonetheless, the outcome confirmed that *E.coli* was a parameter of potential concern.

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:

pH: The drinking water guideline for pH is 7 - 10.5 (Health Canada 2017). On May 20, 2016, the field measured pH was 6.47, 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). A pH of 6.47 is also slightly below the BC guideline pH range of 6.5 - 9.0 for the protection of aquatic life. The mean pH throughout the monitoring period was 8.01, meeting both guidelines.

Total phosphorus: The total phosphorus guideline for the protection of aquatic life was not met in 2 out of the 15 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[1] for the site (CCME 2004). Total phosphorus ranged from <0.005 - 0.0255 mg/L at NGMAT01. Based on these data, the baseline range for total phosphorus was determined to be 0.004 - 0.010 mg/L, representing oligotrophic conditions (CCME 2004). 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. Exceedances occurred on May 25, 2015 and June 14, 2017. 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. These data provide 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 colony forming units (CFU)/100 ml (BC MoE 2001, Health Canada 2017). E. coli values ranged from 1 to 46 CFU/100 ml, with the guideline exceeded in all 27 samples. 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 at NGMAT01 could be domestic livestock that graze along the creek upstream of the site.

Because of its potential to harm human health, E. coli monitoring was expanded in 2017 to other parts of Mather Creek. Samples were collected at NGMAT02 and NGMAT03, located upstream from NGMAT01 (Figure 2, Figure 3), on one occasion in both July and August 2017. E. coli was present in all samples collected from all three sites.

Amongst all monitoring results from 2015-17, 20 of the 27 samples had E. coli values between 1 and 10 CFU/100 ml, with values below 10 indicating a low level for concern (Yeow pers. comm.). However, 6 samples were greater than 20 CFU/100 ml, which is considered serious fecal contamination (Yeow pers. comm.). E. coli could be present along most, if not all, of Mather Creek. The number of households that draw drinking water from Mather Creek or its tributaries is unknown; however, 34 domestic use water licences have been issued in the watershed (BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development 2018). Drinking water derived from surface water and shallow groundwater 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).

[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).

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.

Overall, monthly average water temperatures were fairly consistent among the three years sampled at NGMAT01 (Table 6). One notable difference was that the spring temperatures (March and April) were higher in 2016 compared to 2017. 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 NGMAT01.

Month	2015		2016		2017	
	Avg	Std Dev	Avg	Std Dev	Avg	Std Dev
January	-	-	0.13	0.15	0.05	0.01
February	-	-	0.41	0.36	0.04	0.02
March	-	-	2.42	1.04	0.69	0.63
April	7.70	1.09	6.69	1.60	3.97	1.31
May	9.54	1.24	9.23	0.96	8.18	1.26
June	16.09	1.62	12.01	1.81	10.40	1.66
July	16.78	1.36	15.39	1.15	15.46	0.63
August	15.25	1.53	15.09	0.89	15.09	1.01
September	10.63	1.52	11.14	1.49	11.00	2.47
October	6.87	2.31	6.16	1.71	5.24	0.90
November	1.73	1.63	2.86	1.44	-	-
December	0.08	0.08	0.06	0.08	-	-

*Data were collected for only part of the month

Because of Bull Trout's presence in Mather Creek, stream temperature data were compared to the special guidelines for Bull Trout. In general, summer stream temperatures in all years regularly exceeded the maximum daily Bull Trout rearing temperature of 15ºC (Figure 6). Water temperatures also exceeded maximum Westslope Cutthroat Trout rearing temperatures in the summer (16ºC – not shown on figure). These fish likely seek out deeper, cooler waters (e.g., in the Kootenay River), 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 9ºC (McPhail 2007). The maximum daily water temperatures at the monitoring location in Mather Creek exceeded optimal spawning temperature guidelines (i.e., a max daily temperature of 10ºC) early in the fall of all years sampled. However, it is unknown if fish spawn in the location of the temperature logger, as monitoring of spawning or potential for spawning (based on habitat characteristics such as gravel size, flows, and depths) were not part of this study. If spawning occurs in Mather Creek, it may occur in other locations, particularly areas where groundwater – surface water interactions are high (Baxter and Hauer 2000), as these areas provide relatively consistent year-round water temperatures (i.e., approximately 5ºC) (Meisner *et al.* 1988). The guideline for minimum water temperature during egg incubation is 2ºC. Temperatures at the Mather Creek monitoring location were regularly below the minimum threshold during the winter. Anchor ice may have formed in the area of the temperature logger as temperatures dropped to 0ºC in the winter months. Again, this may be a site-specific condition related to the temperature logger location, and does not preclude the potential for successful Bull Trout incubation elsewhere in the creek, particularly areas with groundwater upwelling.

Stream temperatures also regularly exceeded the drinking water temperature guideline of 15ºC in the summer months. 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).

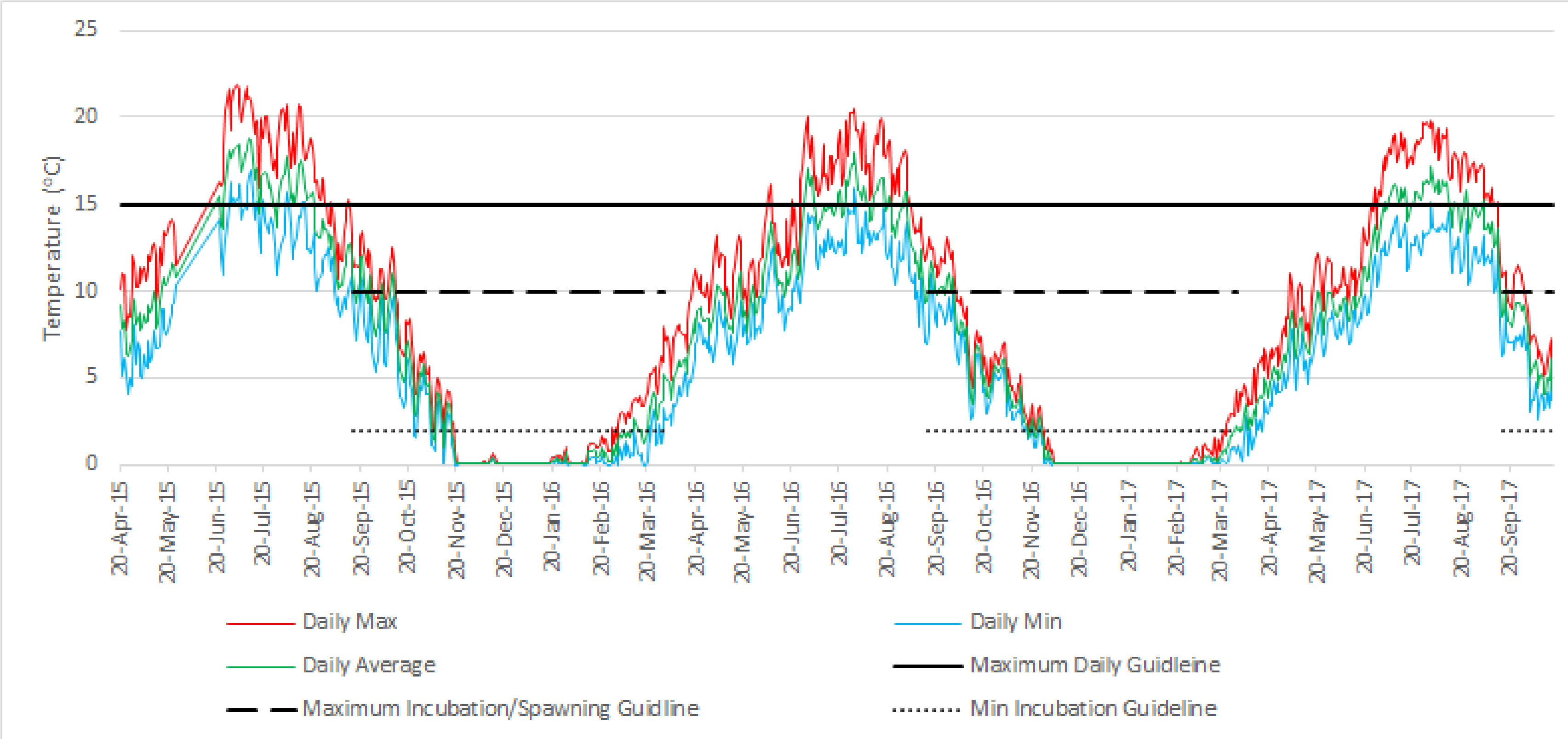

Figure 6. Average daily stream water temperatures in Mather Creek (NGMAT01) from April 20, 2015 to October 17, 2017. The guidelines presented are for the protection of aquatic life for streams with Bull Trout present (BC MoE 2018b).

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 streamflow results show consistencies among the three years sampled at NGMAT01. Freshet (i.e., high streamflow due to snowmelt and/or heavy rain) occurred April – June, followed by decreasing streamflow (Figure 7). October 2016 had a slight increase in streamflow, likely due to fall precipitation. Streamflow in 2015 was slightly lower than in the two years that followed.

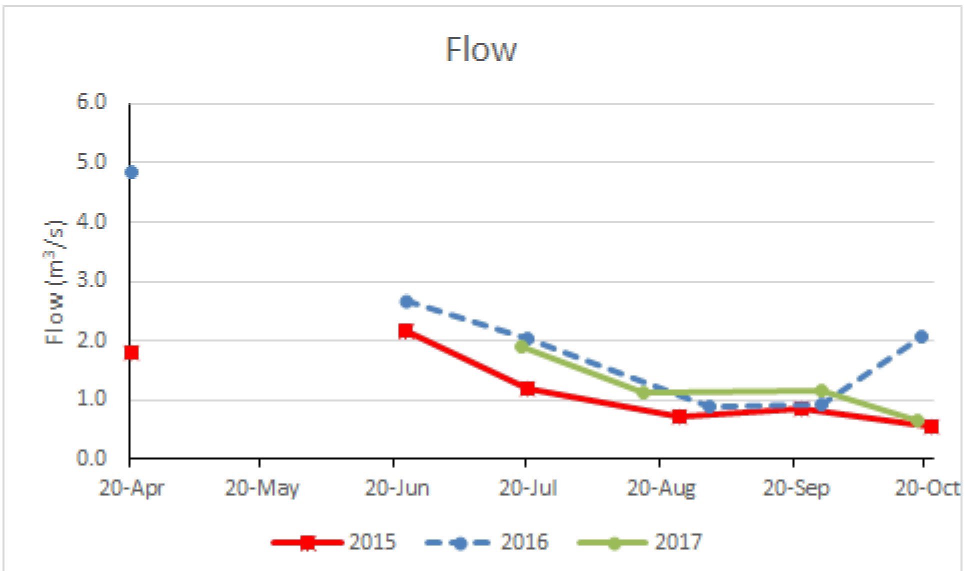

Figure 7. Streamflow in Mather Creek (site NGMAT01), 2015-2017. No measurements were taken during the spring high flow period due to safety concerns.

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 in a long-term dataset. This would be best achieved using continuous level loggers and developing water level-streamflow relationships. Instantaneous streamflow 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 evaluate changes in streamflow patterns with time.

4 Conclusions

The CABIN analysis of the benthic macro-invertebrate monitoring results identified that NGMAT01 improved from being stressed in 2015 to being potentially stressed in 2016/17. The invertebrate metrics showed improvements in community characteristics, supporting the evaluation. This was evident through higher percent EPT taxa, lower percent chironomidae, as well as lower percent of 2 most dominant taxa. It is unknown what lead to the improvement since physical conditions (i.e., substrate, general water chemistry, water temperature, flow and velocity) were similar among the years. It is possible that the improvement was the result of natural variation. The reasons that NGMAT01 was identified as being ‘potentially stressed’ rather than ‘unstressed’ by the CABIN model in 2016 and 2017 appeared to be due to the absence of 1-2 taxa, and a lower %EPT compared to the reference group. However, we noted that some community metrics at NGMAT01 were even better than the reference group’s (i.e., % of 2 dominant taxa and total number of taxa), which may be an indication of the Preliminary Okanagan-Columbia Reference Model’s limitations.

Overall, the water quality was good at this site, with two guidelines for the protection of aquatic life not met. Specifically, total phosphorus was high in 2 of the 10 samples, and pH was lower than the guideline in 1 of 21 samples. One guideline protecting drinking water from direct adverse health effects was exceeded, E. coli. Since this guideline was exceeded in all samples, it is recommended that water be disinfected prior to consumption. The guideline exceedances should be reviewed further if there is concern of anthropogenic influences in the watershed. Otherwise they may simply represent normal background conditions.

A review of daily water temperatures collected over the three-year period identified that the guidelines for the protection of aquatic life and drinking water were regularly exceeded in the summer months. The high temperatures are above optimal rearing temperatures for temperature sensitive fish species known to be in Mather Creek, namely Bull Trout and Westslope Cutthroat Trout. The Bull Trout minimum temperature guideline for egg incubation was also regularly not met during the winter. However, this study did not review whether the monitoring site was actually used by these species for rearing and spawning, and fish are expected to seek out suitable habitat elsewhere in the watershed. Overall, monthly average temperatures were consistent among the years. Flow patterns in the creek were also generally consistent among years, peaking in the spring during freshet and declining throughout the summer and early fall. These flow and temperature consistencies suggest Mather Creek has a relatively stable source of year-round water.

5 Recommendations

The existing monitoring program was very good for developing a baseline. Three years of monitoring provide a good picture of benthic macro-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 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.

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Appendix A. CABIN data

Site Description

Study Name	CBWQ-Central Kootenay
Site	NGMAT01
Sampling Date	Sep 21 2015
Know Your Watershed Basin	Central Kootenay
Province / Territory	British Columbia
Terrestrial Ecological Classification	Montane Cordillera EcoZone Southern Rocky Mountain Trench EcoRegion
Coordinates (decimal degrees)	49.68753 N, 115.71656 W
Altitude	2595
Local Basin Name	Mather Cr
	Mather Cr
Stream Order	4

Figure 1. Location Map

Up Stream

Cabin Assessment Results

Reference Model Summary	
Model	Columbia-Okanagan Preliminary March 2010
Analysis Date	September 06, 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	0.0%	21.2%	74.4%	4.0%	0.4%
CABIN Assessment of NGMAT01 on Sep 21, 2015	Divergent				

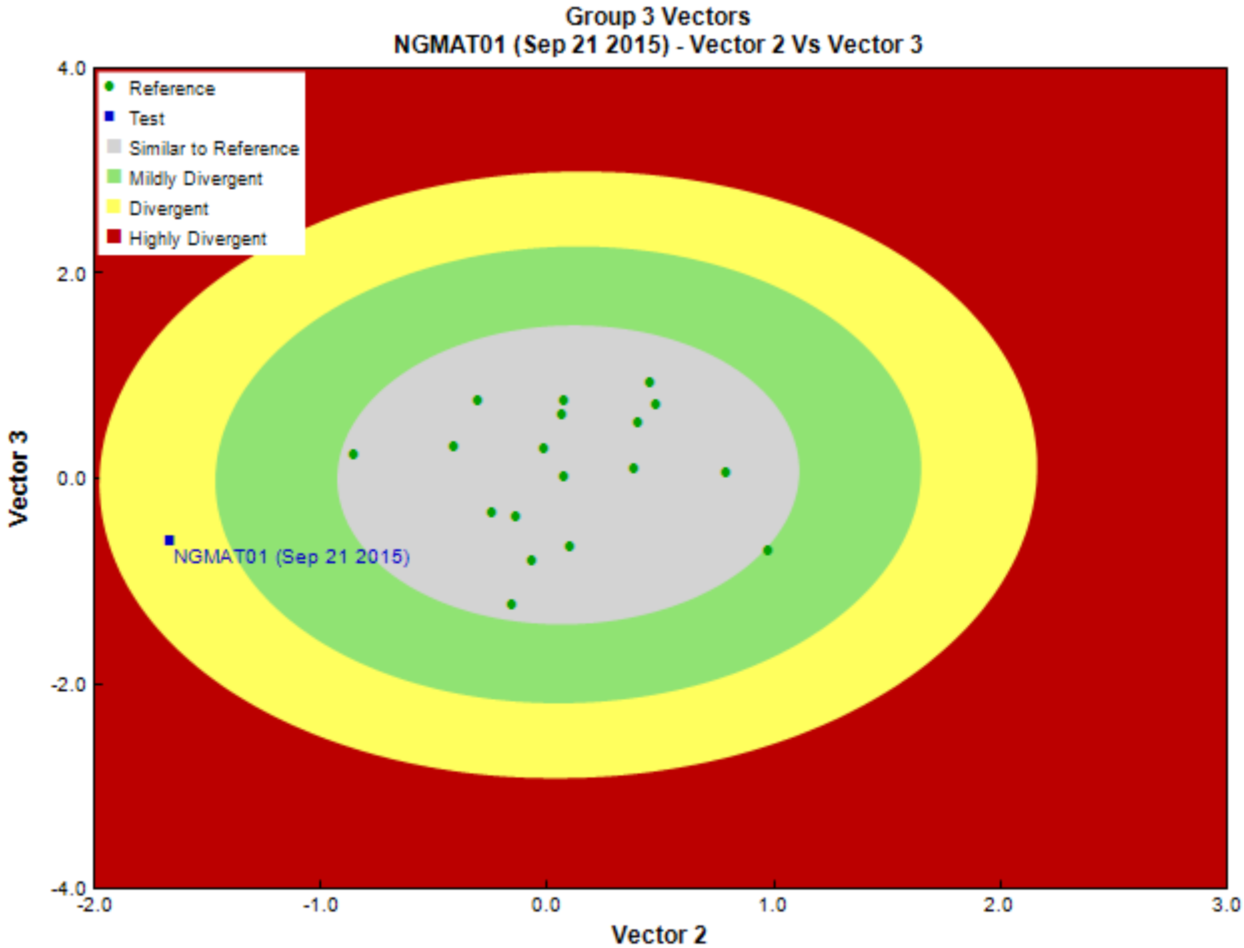


Figure 3. CABIN ordination assessment of the test site with the predicted group of reference sites. Each axis represents the relative abundance of the entire benthic invertebrate community with different organisms weighted differently on each axis.

Sample Information

Sampling Device	Kick Net
Mesh Size	400
Sampling Time	3
Taxonomist	Pina Viola, Consultant
Date Taxonomy Completed	January 01, 2016
	Marchant Box
Sub-Sample Proportion	5/100

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
Annelida	Oligochaeta	Tubificida	Naididae	168	3,360.0
Arthropoda	Arachnida	Trombidiformes	Aturidae	1	20.0
			Lebertiidae	1	20.0
			Sperchontidae	4	80.0
			Torrenticolidae	5	100.0
	Insecta	Coleoptera	Dytiscidae	1	20.0
			Elmidae	77	1,540.0
		Diptera	Chironomidae	85	1,700.0
			Empididae	6	120.0
			Psychodidae	13	260.0
			Simuliidae	1	20.0
			Tipulidae	4	80.0
		Ephemeroptera	Ameletidae	1	20.0
			Baetidae	11	220.0
			Ephemerellidae	24	480.0

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
			Heptageniidae	1	20.0
			Leptophlebiidae	15	300.0
		Plecoptera	Nemouridae	1	20.0
			Perlidae	4	80.0
			Perlodidae	1	20.0
		Trichoptera	Brachycentridae	3	60.0
			Hydropsychidae	10	200.0
			Hydroptilidae	57	1,140.0
			Lepidostomatidae	5	100.0
			Rhyacophilidae	1	20.0
			Total	500	10,000.0

Metrics

Name	NGMAT01	Predicted Group Reference Mean ±SD
Bray-Curtis Distance	0.87	0.4 ± 0.2
Biotic Indices		
Hilsenhoff Family index (North-West)	4.4	3.2 ± 0.7
Intolerant taxa	--	
Long-lived taxa	7.0	1.9 ± 1.3
Tolerant individuals (%)	0.2	
Functional Measures		
% Filterers	2.8	
% Gatherers	89.6	
% Predatores	24.0	
% Scrapers	29.4	
% Shredder	18.0	
No. Clinger Taxa	25.0	19.8 ± 3.9
Number Of Individuals		
% Chironomidae	17.0	8.2 ± 13.6
% Coleoptera	15.6	0.8 ± 1.9
% Diptera + Non-insects	57.6	14.3 ± 14.2
% Ephemeroptera	10.4	43.3 ± 15.7
% Ephemeroptera that are Baetidae	21.2	33.9 ± 27.7
% EPT Individuals	26.8	84.9 ± 14.3
% Odonata	0.0	0.0 ± 0.0
% of 2 dominant taxa	50.6	58.9 ± 10.0
% of 5 dominant taxa	82.2	83.8 ± 7.3
% of dominant taxa	33.6	39.5 ± 10.9
% Plecoptera	1.2	34.7 ± 17.8
% Tribe Tanyatarisini	--	
% Trichoptera that are Hydropsychida	13.2	27.8 ± 25.2
% Tricoptera	15.2	6.9 ± 8.6
No. EPT individuals/Chironomids+EPT Individuals	0.6	0.9 ± 0.1
Total Abundance	10000.0	5780.5 ± 4895.3
Richness		
Chironomidae taxa (genus level only)	1.0	1.0 ± 0.0
Coleoptera taxa	2.0	0.4 ± 0.6
Diptera taxa	5.0	3.4 ± 1.0
Ephemeroptera taxa	5.0	3.4 ± 0.5
EPT Individuals (Sum)	2680.0	4527.1 ± 3161.8
EPT taxa (no)	13.0	11.5 ± 1.2
Odonata taxa	0.0	0.0 ± 0.0
Pielou's Evenness	0.7	0.7 ± 0.1
Plecoptera taxa	3.0	5.3 ± 0.9
Shannon-Wiener Diversity	2.1	1.9 ± 0.3
Simpson's Diversity	0.8	0.8 ± 0.1
Simpson's Evenness	0.2	0.3 ± 0.1
Total No. of Taxa	25.0	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 NGMAT01
	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%	0.93
Ephemerellidae	78%	100%	100%	100%	100%	1.00
Heptageniidae	100%	100%	100%	100%	100%	1.00
Hydropsychidae	11%	92%	78%	92%	86%	0.81
Nemouridae	100%	100%	100%	100%	100%	1.00
Perlodidae	78%	78%	89%	92%	81%	0.87
Psychodidae	22%	65%	94%	8%	11%	0.85
Rhyacophilidae	100%	92%	100%	100%	95%	0.98
Taeniopterygidae	89%	49%	100%	92%	97%	0.89

RIVPACS Ratios

RIVPACS : Expected taxa P>0.50	13.53
RIVPACS : Observed taxa P>0.50	12.00
RIVPACS : O:E (p > 0.5)	0.89
RIVPACS : Expected taxa P>0.70	10.33
RIVPACS : Observed taxa P>0.70	9.00
RIVPACS : O:E (p > 0.7)	0.87

Habitat Description

Variable	NGMAT01	Predicted Group Reference Mean ±SD
Channel		
Depth-Avg (cm)	18.2	22.5 ± 10.5
Depth-BankfullMinusWetted (cm)	38.00	67.33 ± 71.65
Depth-Max (cm)	30.0	32.9 ± 17.9
Macrophyte (PercentRange)	0	0 ± 0
Reach-%CanopyCoverage (PercentRange)	1.00	0.94 ± 0.80
Reach-DomStreamsideVeg (Category (1-4))	3	3 ± 1
Reach-Pools (Binary)	1	0 ± 1
Reach-Rapids (Binary)	0	0 ± 1
Reach-Riffles (Binary)	1	1 ± 0
Reach-StraightRun (Binary)	1	1 ± 0
Slope (m/m)	0.0291000	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)	0.54	0.51 ± 0.25
Velocity-Max (m/s)	0.74	0.75 ± 0.28
Width-Bankfull (m)	12.1	15.6 ± 12.8
Width-Wetted (m)	8.1	10.2 ± 7.0
XSEC-VelMethod (Category (1-3))	1	2 ± 1
Landcover		
Reg-Agriculture (%)	2.94400	0.00000 ± 0.00000
Reg-Alpine (%)	3.10900	0.00000 ± 0.00000
Reg-Avalanche (%)	2.75700	0.00000 ± 0.00000
Reg-Forest (%)	73.51400	0.00000 ± 0.00000
Reg-Ice (%)	0.00000	0.46949 ± 1.15785
Reg-Lake (%)	0.56040	0.00000 ± 0.00000
Reg-Rangeland (%)	1.89500	0.00000 ± 0.00000
Reg-River (%)	0.00000	0.00000 ± 0.00000
Reg-Wetland (%)	1.24000	0.00000 ± 0.00000
Substrate Data		
%Bedrock (%)	0	0 ± 0
%Boulder (%)	0	6 ± 7
%Cobble (%)	57	61 ± 27
%Gravel (%)	2	1 ± 2
%Pebble (%)	41	31 ± 28

Habitat Description

Variable	NGMAT01	Predicted Group Reference Mean ±SD
%Sand (%)	0	0 ± 0
%Silt+Clay (%)	0	1 ± 3
D50 (cm)	7.00	79.45 ± 47.98
Dg (cm)	6.4	73.9 ± 48.0
Dominant-1st (Category(0-9))	6	6 ± 2
Dominant-2nd (Category(0-9))	5	6 ± 2
Embeddedness (Category(1-5))	4	4 ± 1
PeriphytonCoverage (Category(1-5))	4	2 ± 1
SurroundingMaterial (Category(0-9))	4	4 ± 2
Topography		
Reg-SlopeLT30% (%)	72.16410	27.92073 ± 14.83033
Water Chemistry		
Ag (mg/L)	0.0000100	0.0000000 ± 0.0000000
Al (mg/L)	0.0155000	0.0000000 ± 0.0000000
As (mg/L)	0.0003600	0.0000000 ± 0.0000000
B (mg/L)	0.0500000	0.0000000 ± 0.0000000
Ba (mg/L)	0.0775000	0.0000000 ± 0.0000000
Be (mg/L)	0.0000500	0.0000000 ± 0.0000000
Bi (mg/L)	0.0005000	0.0000000 ± 0.0000000
Ca (mg/L)	31.4000000	0.0000000 ± 0.0000000
Cd (mg/L)	0.0000050	0.0000000 ± 0.0000000
Chloride-Dissolved (mg/L)	2.0000000	3.5428571 ± 8.1653449
Co (mg/L)	0.0002500	0.0000000 ± 0.0000000
CO3 (mg/L)	0.2500000	0.0000000 ± 0.0000000
Cr (mg/L)	0.0050000	0.0000000 ± 0.0000000
Cu (mg/L)	0.0012300	0.0000000 ± 0.0000000
Fe (mg/L)	0.0870000	0.0000000 ± 0.0000000
General-Alkalinity (mg/L)	108.0000000	121.5944444 ± 36.7225924
General-DO (mg/L)	12.0000000	10.4922222 ± 0.8833463
General-Hardness (mg/L)	131.0000000	146.8222222 ± 41.6699011
General-pH (pH)	8.0	8.0 ± 0.6
General-SolidsTSS (mg/L)	2.0000000	0.5604289 ± 1.4627232
General-SpCond (µS/cm)	219.4000000	214.2437500 ± 77.1891440
General-TempAir (Degrees Celsius)	15.0	10.5 ± 4.2
General-TempWater (Degrees Celsius)	11.0000000	6.6716667 ± 2.0277755
General-Turbidity (NTU)	1.5500000	0.0000000 ± 0.0000000
HCO3 (mg/L)	132.0000000	0.0000000 ± 0.0000000
Hg (ng/L)	0.0050000	0.0000000 ± 0.0000000
K (mg/L)	0.6910000	0.0000000 ± 0.0000000
Li (mg/L)	0.0025000	0.0000000 ± 0.0000000
Mg (mg/L)	12.9000000	0.0000000 ± 0.0000000
Mn (mg/L)	0.0050000	0.0000000 ± 0.0000000
Mo (mg/L)	0.0005000	0.0000000 ± 0.0000000
Na (mg/L)	2.7400000	0.0000000 ± 0.0000000
Ni (mg/L)	0.0005000	0.0000000 ± 0.0000000
Nitrogen-NH3 (mg/L)	0.0098000	0.0019286 ± 0.0059286
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)	0.0930000	0.0000000 ± 0.0000000
Pb (mg/L)	0.0001000	0.0000000 ± 0.0000000
Phosphorus-OrthoP (mg/L)	0.0025000	0.0035000 ± 0.0018292
Phosphorus-TP (mg/L)	0.0025000	0.0032778 ± 0.0061816
S (mg/L)	1.5000000	0.0000000 ± 0.0000000
Sb (mg/L)	0.0002500	0.0000000 ± 0.0000000
Se (mg/L)	0.0000500	0.0000000 ± 0.0000000
Si (mg/L)	4.0700000	0.0000000 ± 0.0000000
Sn (mg/L)	0.0025000	0.0000000 ± 0.0000000
Sr (mg/L)	0.0619000	0.0000000 ± 0.0000000
Ti (mg/L)	0.0025000	0.0000000 ± 0.0000000
Tl (mg/L)	0.0000250	0.0000000 ± 0.0000000
U (mg/L)	0.0009400	0.0000000 ± 0.0000000

Habitat Description

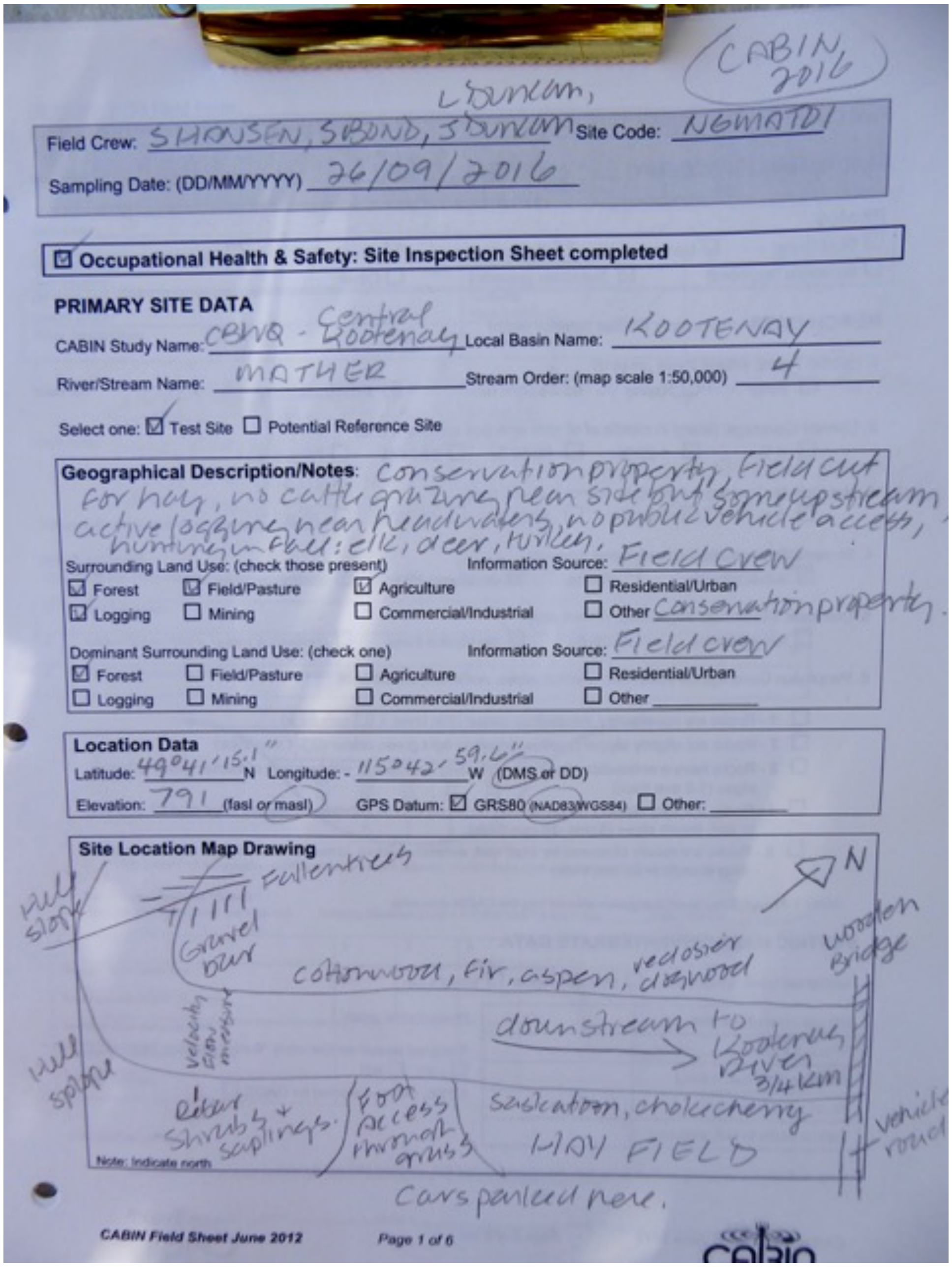
Variable	NGMAT01	Predicted Group Reference Mean ±SD
V (mg/L)	0.0025000	0.0000000 ± 0.0000000
Zn (mg/L)	0.0025000	0.0000000 ± 0.0000000
Zr (mg/L)	0.0002500	0.0000000 ± 0.0000000

Site Description

Study Name	CBWQ-Central Kootenay
Site	NGMAT01
Sampling Date	Sep 26 2016
Know Your Watershed Basin	Central Kootenay
Province / Territory	British Columbia
Terrestrial Ecological Classification	Montane Cordillera EcoZone Southern Rocky Mountain Trench EcoRegion
Coordinates (decimal degrees)	49.68753 N, 115.71656 W
Altitude	2595
Local Basin Name	Mather Cr
	Mather Cr
Stream Order	4

Figure 1. Location Map

Down Stream



CABIN, 2016

Field Crew: SHONSEN, SBOND, S DUNCAN, L DUNCAN, Site Code: NGMAT01

Sampling Date: (DD/MM/YYYY) 26/09/2016

☑ Occupational Health & Safety: Site Inspection Sheet completed

PRIMARY SITE DATA

CABIN Study Name: CBWQ - Central Kootenay Local Basin Name: KOOTENAY

River/Stream Name: MATHER Stream Order: (map scale 1:50,000) 4

Select one: ☑ Test Site ☐ Potential Reference Site

Geographical Description/Notes: Conservation property, Field cut for hay, no cattle grazing near site but some upstream active logging near headwaters, no public vehicle access, hunting in Fall: elk, deer, turkey.

Surrounding Land Use: (check those present) Information Source: Field Crew

☑ Forest ☑ Field/Pasture ☑ Agriculture ☐ Residential/Urban

☑ Logging ☐ Mining ☐ Commercial/Industrial ☐ Other Conservation property.

Dominant Surrounding Land Use: (check one) Information Source: Field crew

☑ Forest ☐ Field/Pasture ☐ Agriculture ☐ Residential/Urban

☐ Logging ☐ Mining ☐ Commercial/Industrial ☐ Other

Location Data

Latitude: 49°41'15.1" N Longitude: - 115°42' 59.6" W (DMS or DD)

Elevation: 791 (fasl or masl) GPS Datum: ☑ GRS80 (NAD83/WGS84) ☐ Other:

Site Location Map Drawing

Note: Indicate north

CABIN Field Sheet June 2012 Page 1 of 6

Field Sheet

Substrate

Up Stream

Cabin Assessment Results

Reference Model Summary	
Model	Columbia-Okanagan Preliminary March 2010
Analysis Date	March 14, 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	0.0%	20.1%	75.3%	4.1%	0.4%

CABIN Assessment of NGMAT01 on Sep 26, 2016	Mildly Divergent

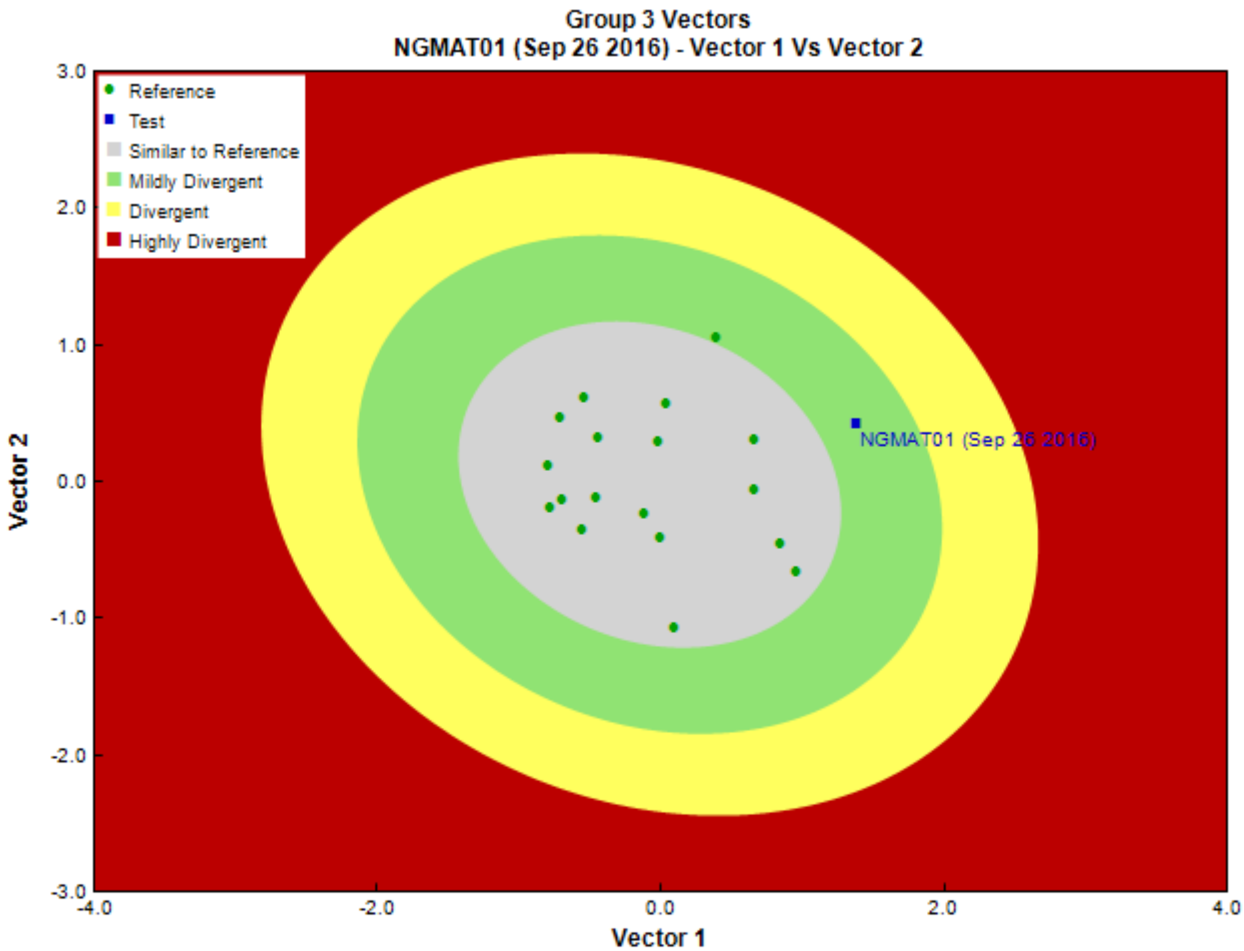


Figure 3. CABIN ordination assessment of the test site with the predicted group of reference sites. Each axis represents the relative abundance of the entire benthic invertebrate community with different organisms weighted differently on each axis.

Sample Information

Sampling Device	Kick Net
Mesh Size	400
Sampling Time	3
Taxonomist	Pina Viola, Consultant
Date Taxonomy Completed	October 19, 2016
	Marchant Box
Sub-Sample Proportion	8/100

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
Annelida	Oligochaeta			3	37.5
		Tubificida	Naididae	121	1,512.5
Arthropoda	Arachnida	Trombidiformes	Aturidae	2	25.0
			Lebertiidae	3	37.5
			Sperchontidae	1	12.5
			Torrenticolidae	4	50.0
	Insecta	Coleoptera	Elmidae	46	575.0
		Diptera	Chironomidae	29	362.5
			Empididae	5	62.5
			Psychodidae	5	62.5
			Simuliidae	1	12.5
			Tipulidae	1	12.5

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
		Ephemeroptera	Baetidae	86	1,075.0
			Ephemerellidae	13	162.5
			Heptageniidae	9	112.5
			Leptophlebiidae	13	162.5
		Plecoptera	Chloroperlidae	1	12.5
			Nemouridae	5	62.5
			Perlidae	4	50.0
			Pteronarcyidae	1	12.5
		Trichoptera	Brachycentridae	7	87.5
			Hydropsychidae	20	250.0
			Hydroptilidae	26	325.0
			Lepidostomatidae	12	150.0
			Rhyacophilidae	5	62.5
			Total	423	5,287.5

Metrics

Name	NGMAT01	Predicted Group Reference Mean ±SD
Bray-Curtis Distance	0.76	0.4 ± 0.2
Biotic Indices		
Hilsenhoff Family index (North-West)	3.9	3.2 ± 0.7
Intolerant taxa	--	
Long-lived taxa	4.0	1.9 ± 1.3
Tolerant individuals (%)	--	0.3
Functional Measures		
% Filterers	6.6	1.8 ± 1.6
% Gatherers	63.1	52.4 ± 14.6
% Predatores	17.7	18.3 ± 13.3
% Scrapers	40.2	61.8 ± 17.2
% Shredder	17.0	30.3 ± 18.6
No. Clinger Taxa	26.0	19.8 ± 3.9
Number Of Individuals		
% Chironomidae	6.9	8.2 ± 13.6
% Coleoptera	11.0	0.8 ± 1.9
% Diptera + Non-insects	41.0	14.3 ± 14.2
% Ephemeroptera	28.8	43.3 ± 15.7
% Ephemeroptera that are Baetidae	71.1	33.9 ± 27.7
% EPT Individuals	48.1	84.9 ± 14.3
% Odonata	0.0	0.0 ± 0.0
% of 2 dominant taxa	49.3	58.9 ± 10.0
% of 5 dominant taxa	73.3	83.8 ± 7.3
% of dominant taxa	28.8	39.5 ± 10.9
% Plecoptera	2.6	34.7 ± 17.8
% Tribe Tanyatarisini	--	
% Trichoptera that are Hydropsychida	28.6	27.8 ± 25.2
% Tricoptera	16.7	6.9 ± 8.6
No. EPT individuals/Chironomids+EPT Individuals	0.9	0.9 ± 0.1
Total Abundance	5287.5	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	5.0	3.4 ± 1.0
Ephemeroptera taxa	4.0	3.4 ± 0.5
EPT Individuals (Sum)	2525.0	4527.1 ± 3161.8
EPT taxa (no)	13.0	11.5 ± 1.2
Odonata taxa	0.0	0.0 ± 0.0
Pielou's Evenness	0.7	0.7 ± 0.1
Plecoptera taxa	4.0	5.3 ± 0.9
Shannon-Wiener Diversity	2.3	1.9 ± 0.3
Simpson's Diversity	0.8	0.8 ± 0.1
Simpson's Evenness	0.3	0.3 ± 0.1
Total No. of Taxa	24.0	17.7 ± 2.6

Metrics

Name	NGMAT01	Predicted Group Reference Mean ±SD
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 NGMAT01
	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%	0.93
Ephemerellidae	78%	100%	100%	100%	100%	1.00
Heptageniidae	100%	100%	100%	100%	100%	1.00
Hydropsychidae	11%	92%	78%	92%	86%	0.81
Nemouridae	100%	100%	100%	100%	100%	1.00
Perlodidae	78%	78%	89%	92%	81%	0.87
Psychodidae	22%	65%	94%	8%	11%	0.85
Rhyacophilidae	100%	92%	100%	100%	95%	0.98
Taeniopterygidae	89%	49%	100%	92%	97%	0.89

RIVPACS Ratios

RIVPACS : Expected taxa P>0.50	13.54
RIVPACS : Observed taxa P>0.50	12.00
RIVPACS : O:E (p > 0.5)	0.89
RIVPACS : Expected taxa P>0.70	10.34
RIVPACS : Observed taxa P>0.70	9.00
RIVPACS : O:E (p > 0.7)	0.87

Habitat Description

Variable	NGMAT01	Predicted Group Reference Mean ±SD
Channel		
Depth-Avg (cm)	22.1	22.5 ± 10.5
Depth-BankfullMinusWetted (cm)	44.00	67.33 ± 71.65
Depth-Max (cm)	34.0	32.9 ± 17.9
Macrophyte (PercentRange)	0	0 ± 0
Reach-%CanopyCoverage (PercentRange)	1.00	0.94 ± 0.80
Reach-DomStreamsideVeg (Category (1-4))	3	3 ± 1
Reach-Pools (Binary)	1	0 ± 1
Reach-Riffles (Binary)	1	1 ± 0
Reach-StraightRun (Binary)	1	1 ± 0
Slope (m/m)	0.0291000	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)	0.47	0.50 ± 0.25
Velocity-Max (m/s)	0.63	0.75 ± 0.28
Width-Bankfull (m)	12.4	15.6 ± 12.8
Width-Wetted (m)	8.1	10.2 ± 7.0
XSEC-VelMethod (Category (1-3))	1	2 ± 1
Landcover		
Reg-Agriculture (%)	2.94000	0.00000 ± 0.00000
Reg-Alpine (%)	3.10900	0.00000 ± 0.00000
Reg-Avalanche (%)	2.75700	0.00000 ± 0.00000
Reg-Forest (%)	73.51400	0.00000 ± 0.00000
Reg-Ice (%)	0.00000	0.46949 ± 1.15785
Reg-Lake (%)	0.56040	0.00000 ± 0.00000
Reg-Rangeland (%)	1.89500	0.00000 ± 0.00000
Reg-River (%)	0.00000	0.00000 ± 0.00000
Reg-Wetland (%)	1.24000	0.00000 ± 0.00000
Substrate Data		

Habitat Description

Variable	NGMAT01	Predicted Group Reference Mean ±SD
%Bedrock (%)	0	0 ± 0
%Boulder (%)	0	6 ± 7
%Cobble (%)	59	61 ± 27
%Gravel (%)	1	1 ± 2
%Pebble (%)	40	31 ± 28
%Sand (%)	0	0 ± 0
%Silt+Clay (%)	0	0 ± 1
D50 (cm)	7.00	79.45 ± 47.98
Dg (cm)	6.6	73.9 ± 48.0
Dominant-1st (Category(0-9))	6	6 ± 1
Dominant-2nd (Category(0-9))	5	6 ± 2
Embeddedness (Category(1-5))	3	4 ± 1
PeriphytonCoverage (Category(1-5))	4	2 ± 1
SurroundingMaterial (Category(0-9))	6	3 ± 1
Topography		
Reg-SlopeLT30% (%)	72.16410	27.92073 ± 14.83033
SlopeLT30% (%)	72.16410	29.33739 ± 12.62448
Water Chemistry		
Ag (mg/L)	0.0010000	0.0000004 ± 0.0000014
Al (mg/L)	0.0103000	0.0059500 ± 0.0039700
As (mg/L)	0.0003600	0.0002175 ± 0.0001795
B (mg/L)	0.0250000	0.0500000
Ba (mg/L)	0.0647000	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)	25.9000000	38.6142857 ± 14.8464843
Cd (mg/L)	0.0000500	0.0000059 ± 0.0000067
Chloride-Dissolved (mg/L)	1.8000000	3.5428571 ± 8.1653449
Co (mg/L)	0.0002500	0.0000043 ± 0.0000057
CO3 (mg/L)	0.2500000	0.0000000 ± 0.0000000
Cr (6) (µg/L)	0.0005000	0.0000000 ± 0.0000000
Cu (mg/L)	0.0002500	0.0001875 ± 0.0001434
Fe (mg/L)	0.0880000	0.0090000
General-Alkalinity (mg/L)	110.0000000	121.5944444 ± 36.7225924
General-Conductivity (µS/cm)	220.0000000	186.8500000 ± 84.0864011
General-DO (mg/L)	12.0000000	10.4922222 ± 0.8833463
General-Hardness (mg/L)	111.0000000	146.8222222 ± 41.6699011
General-pH (pH)	8.3	8.0 ± 0.6
General-SolidsTSS (mg/L)	2.0000000	0.5604289 ± 1.4627232
General-SpCond (µS/cm)	200.7000000	214.2437500 ± 77.1891440
General-TempAir (Degrees Celsius)	10.0	10.5 ± 4.2
General-TempWater (Degrees Celsius)	8.0000000	6.6716667 ± 2.0277755
General-Turbidity (NTU)	1.0700000	0.0000000 ± 0.0000000
HCO3 (mg/L)	134.0000000	0.0000000 ± 0.0000000
Hg (ng/L)	5.0000000	0.0000000 ± 0.0000000
K (mg/L)	0.5040000	0.6471429 ± 0.7154652
Li (mg/L)	0.0025000	0.0011817 ± 0.0004768
Mg (mg/L)	11.1000000	9.8814286 ± 6.1601202
Mn (mg/L)	0.0052000	0.0011426 ± 0.0016097
Mo (mg/L)	0.0005000	0.0024883 ± 0.0065339
Na (mg/L)	2.2200000	2.6357143 ± 3.7712414
Ni (mg/L)	0.0005000	0.0000808 ± 0.0000811
Nitrogen-NH3 (mg/L)	0.0580000	0.0019286 ± 0.0059286
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)	0.1270000	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)	1.5000000	5.0000000
Sb (mg/L)	0.0002500	0.0000361 ± 0.0000135

Habitat Description

Variable	NGMAT01	Predicted Group Reference Mean ±SD
Se (mg/L)	0.0000500	0.0004382 ± 0.0004486
Si (mg/L)	3.7900000	3.0657143 ± 1.4070046
Sn (mg/L)	0.0025000	0.0000167 ± 0.0000078
Sr (mg/L)	0.0535000	0.1159167 ± 0.0982749
Ti (mg/L)	0.0025000	0.0009000
Tl (mg/L)	0.0000250	0.0000038 ± 0.0000064
U (mg/L)	0.0007100	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-Central Kootenay
Site	NGMAT01
Sampling Date	Sep 26 2017
Know Your Watershed Basin	Central Kootenay
Province / Territory	British Columbia
Terrestrial Ecological Classification	Montane Cordillera EcoZone Southern Rocky Mountain Trench EcoRegion
Coordinates (decimal degrees)	49.68753 N, 115.71656 W
Altitude	2595
Local Basin Name	Mather Cr
	Mather Cr
Stream Order	4

Figure 1. Location Map

Across Reach
Aerial (No image found)

Up Stream

Cabin Assessment Results

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

Reference Groups	**1**	**2**	**3**	**4**	**5**
Number of Reference Sites	9	43	17	12	33
Group Error Rate	22.2%	24.5%	22.2%	25.0%	32.4%
Overall Model Error Rate	26.4%				
Probability of Group Membership	0.0%	21.1%	74.5%	4.0%	0.4%
CABIN Assessment of NGMAT01 on Sep 26, 2017	Mildly Divergent				

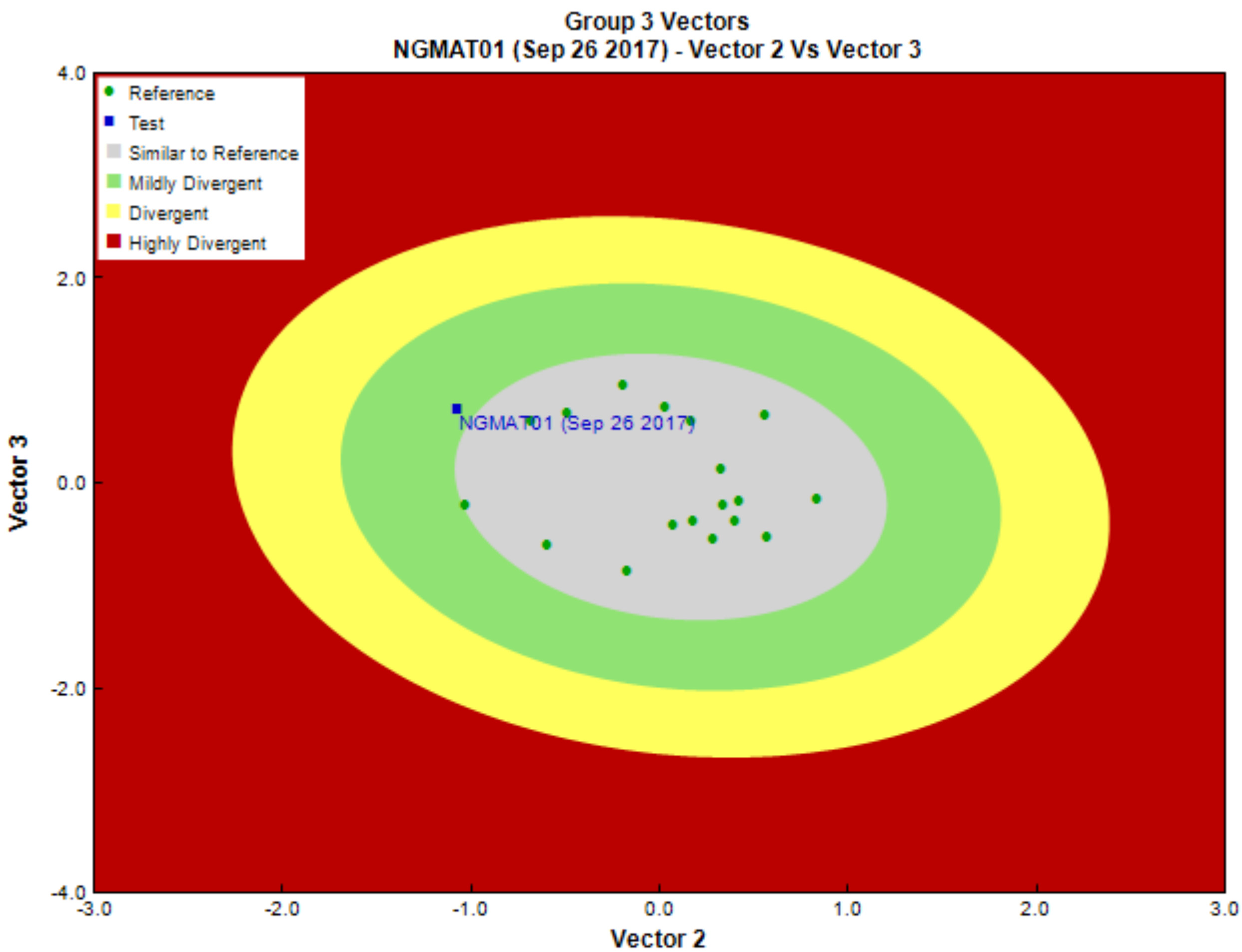


Figure 3. CABIN ordination assessment of the test site with the predicted group of reference sites. Each axis represents the relative abundance of the entire benthic invertebrate community with different organisms weighted differently on each axis.

Sample Information

Sampling Device	Kick Net
Mesh Size	400
Sampling Time	3
Taxonomist	Pina Viola, Consultant
Date Taxonomy Completed	December 17, 2017
	Marchant Box
Sub-Sample Proportion	14/100

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
Annelida	Oligochaeta	Tubificida	Naididae	6	42.9
Arthropoda	Arachnida	Trombidiformes		1	7.1
			Aturidae	1	7.1
			Hydryphantidae	1	7.1
			Lebertiidae	1	7.1
			Sperchontidae	2	14.3
			Torrenticolidae	7	50.0
	Insecta	Coleoptera	Elmidae	79	564.3
		Diptera	Chironomidae	16	114.3
			Empididae	2	14.2
			Psychodidae	2	14.3
			Simuliidae	1	7.1
			Tipulidae	1	7.1
		Ephemeroptera	Baetidae	52	371.4
			Ephemerellidae	24	171.4

Community Structure

Phylum	Class	Order	Family	Raw Count	Total Count
			Heptageniidae	18	128.6
			Leptophlebiidae	16	114.3
		Plecoptera	Chloroperlidae	1	7.1
			Nemouridae	15	107.1
			Perlidae	15	107.2
			Perlodidae	2	14.3
		Trichoptera		2	14.3
			Brachycentridae	4	28.6
			Glossosomatidae	3	21.4
			Hydropsychidae	44	314.3
			Hydroptilidae	2	14.3
			Lepidostomatidae	13	92.9
			Philopotamidae	1	7.1
			Rhyacophilidae	3	21.4
			Total	335	2,392.6

Metrics

Name	NGMAT01	Predicted Group Reference Mean ±SD
Bray-Curtis Distance	0.64	0.4 ± 0.2
Biotic Indices		
Hilsenhoff Family index (North-West)	3.4	3.2 ± 0.7
Intolerant taxa	--	
Long-lived taxa	5.0	1.9 ± 1.3
Tolerant individuals (%)	--	0.3
Functional Measures		
% Filterers	14.9	1.8 ± 1.6
% Gatherers	49.6	52.4 ± 14.6
% Predatores	28.7	18.3 ± 13.3
% Scrapers	46.6	61.8 ± 17.2
% Shredder	33.4	30.3 ± 18.6
No. Clinger Taxa	30.0	19.8 ± 3.9
Number Of Individuals		
% Chironomidae	4.8	8.2 ± 13.6
% Coleoptera	23.8	0.8 ± 1.9
% Diptera + Non-insects	12.0	14.3 ± 14.2
% Ephemeroptera	33.1	43.3 ± 15.7
% Ephemeroptera that are Baetidae	47.3	33.9 ± 27.7
% EPT Individuals	64.2	84.9 ± 14.3
% Odonata	0.0	0.0 ± 0.0
% of 2 dominant taxa	39.5	58.9 ± 10.0
% of 5 dominant taxa	65.4	83.8 ± 7.3
% of dominant taxa	23.8	39.5 ± 10.9
% Plecoptera	9.9	34.7 ± 17.8
% Tribe Tanyatarisini	--	
% Trichoptera that are Hydropsychida	62.9	27.8 ± 25.2
% Tricoptera	21.1	6.9 ± 8.6
No. EPT individuals/Chironomids+EPT Individuals	0.9	0.9 ± 0.1
Total Abundance	2392.9	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	5.0	3.4 ± 1.0
Ephemeroptera taxa	4.0	3.4 ± 0.5
EPT Individuals (Sum)	1521.4	4527.1 ± 3161.8
EPT taxa (no)	15.0	11.5 ± 1.2
Odonata taxa	0.0	0.0 ± 0.0
Pielou's Evenness	0.8	0.7 ± 0.1
Plecoptera taxa	4.0	5.3 ± 0.9
Shannon-Wiener Diversity	2.5	1.9 ± 0.3
Simpson's Diversity	0.9	0.8 ± 0.1
Simpson's Evenness	0.3	0.3 ± 0.1

Metrics

Name	NGMAT01	Predicted Group Reference Mean ±SD
Total No. of Taxa	27.0	17.7 ± 2.6
Trichoptera taxa	7.0	2.8 ± 1.0

Frequency and Probability of Taxa Occurrence

Reference Model Taxa	Frequency of Occurrence in Reference Sites					Probability Of Occurrence at NGMAT01
	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%	0.93
Ephemerellidae	78%	100%	100%	100%	100%	1.00
Heptageniidae	100%	100%	100%	100%	100%	1.00
Hydropsychidae	11%	92%	78%	92%	86%	0.81
Nemouridae	100%	100%	100%	100%	100%	1.00
Perlodidae	78%	78%	89%	92%	81%	0.87
Psychodidae	22%	65%	94%	8%	11%	0.85
Rhyacophilidae	100%	92%	100%	100%	95%	0.98
Taeniopterygidae	89%	49%	100%	92%	97%	0.89

RIVPACS Ratios

RIVPACS : Expected taxa P>0.50	13.53
RIVPACS : Observed taxa P>0.50	13.00
RIVPACS : O:E (p > 0.5)	0.96
RIVPACS : Expected taxa P>0.70	10.33
RIVPACS : Observed taxa P>0.70	10.00
RIVPACS : O:E (p > 0.7)	0.97

Habitat Description

Variable	NGMAT01	Predicted Group Reference Mean ±SD
Channel		
Depth-Avg (cm)	18.5	22.5 ± 10.5
Depth-Max (cm)	30.5	32.9 ± 17.9
Macrophyte (PercentRange)	0	0 ± 0
Reach-%CanopyCoverage (PercentRange)	2.00	0.94 ± 0.80
Reach-DomStreamsideVeg (Category(1-4))	3	3 ± 1
Reach-Pools (Binary)	1	0 ± 1
Reach-Riffles (Binary)	1	1 ± 0
Reach-StraightRun (Binary)	1	1 ± 0
Slope (m/m)	0.0291000	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)	0.66	0.50 ± 0.25
Velocity-Max (m/s)	1.16	0.75 ± 0.28
Width-Bankfull (m)	12.4	15.6 ± 12.8
Width-Wetted (m)	7.0	10.2 ± 7.0
XSEC-VelMethod (Category(1-3))	1	2 ± 1
Landcover		
Reg-Agriculture (%)	2.94400	0.00000 ± 0.00000
Reg-Alpine (%)	3.10900	0.00000 ± 0.00000
Reg-Avalanche (%)	2.75700	0.00000 ± 0.00000
Reg-Forest (%)	73.51400	0.00000 ± 0.00000
Reg-Ice (%)	0.00000	0.46949 ± 1.15785
Reg-Lake (%)	0.56040	0.00000 ± 0.00000
Reg-Rangeland (%)	1.89500	0.00000 ± 0.00000
Reg-River (%)	0.00000	0.00000 ± 0.00000
Reg-Wetland (%)	1.24000	0.00000 ± 0.00000
Substrate Data		

Habitat Description

Variable	NGMAT01	Predicted Group Reference Mean ±SD
%Bedrock (%)	0	0 ± 0
%Boulder (%)	0	6 ± 7
%Cobble (%)	65	61 ± 27
%Gravel (%)	0	1 ± 2
%Pebble (%)	35	31 ± 28
%Sand (%)	0	0 ± 0
%Silt+Clay (%)	0	0 ± 1
D50 (cm)	7.35	79.45 ± 47.98
Dg (cm)	7.2	73.9 ± 48.0
Dominant-1st (Category(0-9))	6	6 ± 1
Dominant-2nd (Category(0-9))	5	6 ± 2
Embeddedness (Category(1-5))	4	4 ± 1
PeriphytonCoverage (Category(1-5))	2	2 ± 1
SurroundingMaterial (Category(0-9))	6	3 ± 1
Topography		
Reg-SlopeLT30% (%)	72.16400	27.92073 ± 14.83033
Water Chemistry		
Ag (mg/L)	0.0000100	0.0000004 ± 0.0000014
Al (mg/L)	0.0093000	0.0059500 ± 0.0039700
As (mg/L)	0.0002500	0.0002175 ± 0.0001795
B (mg/L)	0.0250000	0.0500000
Ba (mg/L)	0.0790000	0.0639025 ± 0.0450861
Be (mg/L)	0.0000500	0.0000025 ± 0.0000062
Bi (mg/L)	0.0000500	0.0000004 ± 0.0000014
Ca (mg/L)	27.6000000	38.6142857 ± 14.8464843
Cd (mg/L)	0.0000050	0.0000059 ± 0.0000067
Chloride-Dissolved (mg/L)	2.1000000	3.5428571 ± 8.1653449
Co (mg/L)	0.0001000	0.0000043 ± 0.0000057
CO3 (mg/L)	2.9000000	0.0000000 ± 0.0000000
Cr (mg/L)	0.0005000	0.0000833 ± 0.0001403
Cu (mg/L)	0.0025000	0.0001875 ± 0.0001434
Fe (mg/L)	0.0590000	0.0090000
General-Alkalinity (mg/L)	133.0000000	121.5944444 ± 36.7225924
General-DO (mg/L)	13.0000000	10.4922222 ± 0.8833463
General-Hardness (mg/L)	119.0000000	146.8222222 ± 41.6699011
General-pH (pH)	8.3	8.0 ± 0.6
General-SolidsTSS (mg/L)	2.0000000	0.5604289 ± 1.4627232
General-SpCond (µS/cm)	226.1000000	214.2437500 ± 77.1891440
General-TempAir (Degrees Celsius)	17.0	10.5 ± 4.2
General-TempWater (Degrees Celsius)	9.0000000	6.6716667 ± 2.0277755
General-Turbidity (NTU)	0.6900000	0.0000000 ± 0.0000000
HCO3 (mg/L)	157.0000000	0.0000000 ± 0.0000000
Hg (ng/L)	5.0000000	0.0000000 ± 0.0000000
K (mg/L)	0.5510000	0.6471429 ± 0.7154652
Li (mg/L)	0.0010000	0.0011817 ± 0.0004768
Mg (mg/L)	12.2000000	9.8814286 ± 6.1601202
Mn (mg/L)	0.0027000	0.0011426 ± 0.0016097
Mo (mg/L)	0.0005000	0.0024883 ± 0.0065339
Na (mg/L)	2.4500000	2.6357143 ± 3.7712414
Ni (mg/L)	0.0005000	0.0000808 ± 0.0000811
Nitrogen-NH4+ (mg/L)	0.0100000	0.0000000 ± 0.0000000
Nitrogen-NO2 (mg/L)	0.0025000	0.0023889 ± 0.0063351
Nitrogen-NO2+NO3 (mg/L)	0.0330000	0.0130000 ± 0.0088111
Nitrogen-NO3 (mg/L)	0.0330000	0.0245003 ± 0.0229452
Nitrogen-TN (mg/L)	0.1820000	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)	0.0059000	0.0032778 ± 0.0061816
S (mg/L)	1.5000000	5.0000000
Sb (mg/L)	0.0002500	0.0000361 ± 0.0000135
Se (mg/L)	0.0000500	0.0004382 ± 0.0004486
Si (mg/L)	3.8200000	3.0657143 ± 1.4070046

Habitat Description

Variable	NGMAT01	Predicted Group Reference Mean ±SD
Sn (mg/L)	0.0025000	0.0000167 ± 0.0000078
SO4 (mg/L)	9.4000000	14.9647059 ± 10.8432549
Sr (mg/L)	0.0583000	0.1159167 ± 0.0982749
Ti (mg/L)	0.0025000	0.0009000
Tl (mg/L)	0.0000050	0.0000038 ± 0.0000064
U (mg/L)	0.0010500	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)
	*Duplicate samples for E. coli in August 2016, were sent to two separate laboratories for analysis, and QA/QC comparison.
	Grey highlight: exceeded QA/QC criteria
1	Guidelines relevant to background not assessed, as they are intended to be monitored during construction/discharge activity.
(1)	RDL raised due to matrix effects
(2)	Sample analyzed past method specific hold time
AO	Aesthetic objective
BC App	BC approved water quality guidelines (BC MoE 2018b).
BC Work	BC working water quality guidelines (BC MoE 2017)
CCME	Canadian environmental quality guidelines (CCME 2018)
HC	Health Canada drinking water guidelines (Health Canada 2017)
Red font	Field collected data
*	Sample arrived at lab too late for testing
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)	Conductivity	Total Suspended Solids
			Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**µg/L**	**mg/L**	**NTU**	**mg/L**	**mg/L**	**uS/cm**	**mg/L**
			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**	**1**	**4**
MAINSTREAMS	2016-09-26	NGMAT01 BLK	Mather Cr	<0.0050	<0.020	<0.50	<0.50	<0.50	<0.50	<0.50	<5	<0.020	0.12	<0.0050	<0.020	1.1	<4.0
		Blank QC	**X times > than RDL**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.2**	**1.0**	**1.0**	**1.1**	**1.0**
MAINSTREAMS	2016-09-26	NGMAT01 DUP	Mather Cr	<0.0050	<0.020	110	<0.50	134	<0.50	<0.50	<5	<0.020	0.79	<0.0050	0.131	220	<4.0
MAINSTREAMS	2016-09-26	NGMAT01	Mather Cr	<0.0050	<0.020	110	<0.50	134	<0.50	<0.50	<5	<0.020	1.21	<0.0050	0.127	-	<4.0
		Duplicate QC	**Calculated RPD (%)**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**-42.0**	**0.0**	**3.1**	**-**	**0.0**
MAINSTREAMS	2017-08-16	NGMAT01	Mather Cr	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAINSTREAMS	2017-08-16	NGMAT01 DUP*	Mather Cr	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Duplicate QC	**Calculated RPD (%)**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
MAINSTREAMS	2017-08-16	NGMAT02	Mather Cr, Site 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAINSTREAMS	2017-08-16	NGMAT02 DUP*	Mather Cr, Site 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Duplicate QC	**Calculated RPD (%)**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
MAINSTREAMS	2017-08-16	NGMAT02	Mather Cr, Site 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAINSTREAMS	2017-08-16	NGMAT02 DUP*	Mather Cr, Site 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Duplicate QC	**Calculated RPD (%)**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Appendix B1 - Water Quality QA/QC

Sample Date (yy/mm/dd)	Site Code	Dissolved Chloride (Cl)	Total Ammonia (N)	E. coli
		mg/L	**mg/L**	**CFU/100mL**
		1	**0.0005**	**1**
2016-09-26	NGMAT01 BLK	<1.0	<0.0050	<1
	Blank QC	**1.0**	**1.0**	**1.0**
2016-09-26	NGMAT01 DUP	1.8	0.07	4
2016-09-26	NGMAT01	1.8	0.058	5
	Duplicate QC	**0.0**	**18.8**	**-22.2**
2017-08-16	NGMAT01	-	-	10
2017-08-16	NGMAT01 DUP*	-	-	5
	Duplicate QC	**-**	**-**	**66.7**
2017-08-16	NGMAT02	-	-	5
2017-08-16	NGMAT02 DUP*	-	-	9
	Duplicate QC	**-**	**-**	**-57.1**
2017-08-16	NGMAT02	-	-	9
2017-08-16	NGMAT02 DUP*	-	-	7
	Duplicate QC	**-**	**-**	**25.0**

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)
			Units	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	-
MAINSTREAMS	2015-04-20	NGMAT01	Mather Cr, site 1	<0.0050	0.038	-
MAINSTREAMS	2015-05-25	NGMAT01	Mather Cr, site 1	<0.0050	<0.020	-
MAINSTREAMS	2015-06-22	NGMAT01	Mather Cr, site 1	<0.0050	<0.020	-
MAINSTREAMS	2015-07-20	NGMAT01	Mather Cr, site 1	<0.0050	<0.020	-
MAINSTREAMS	2015-08-24	NGMAT01	Mather Cr, site 1	<0.0050	<0.020	-
MAINSTREAMS	2015-09-21	NGMAT01	Mather Cr, site 1	<0.0050	<0.020	108
MAINSTREAMS	2015-10-21	NGMAT01	Mather Cr, site 1	<0.0050	<0.020	-
MAINSTREAMS	2016-04-20	NGMAT01	Mather Cr, site 1	<0.0050	0.029	-
MAINSTREAMS	2016-05-25	NGMAT01	Mather Cr, site 1	<0.0050	<0.020	-
MAINSTREAMS	2016-06-22	NGMAT01	Mather Cr, site 1	<0.0050	<0.020	-
MAINSTREAMS	2016-07-20	NGMAT01	Mather Cr, site 1	<0.0050	-	-
MAINSTREAMS	2016-08-31	NGMAT01	Mather Cr, site 1	<0.0050	<2.0	-
MAINSTREAMS	2016-09-26	NGMAT01	Mather Cr, site 1	<0.0050	<0.020	110
MAINSTREAMS	2016-10-19	NGMAT01	Mather Cr, site 1	<0.0050	<0.020	-
MAINSTREAMS	2017-04-24	NGMAT01	Mather Cr, site 1	<0.0050	0.039	-
MAINSTREAMS	2017-05-18	NGMAT01	Mather Cr, site 1	<0.0050	0.021	-
MAINSTREAMS	2017-06-14	NGMAT01	Mather Cr, site 1	<0.0050	<0.020	-
MAINSTREAMS	2017-07-19	NGMAT01	Mather Cr, site 1	<0.0050	<0.020	-
MAINSTREAMS	2017-08-16	NGMAT01	Mather Cr, site 1	<0.0050	0.023	-
MAINSTREAMS	2017-09-26	NGMAT01	Mather Cr, site 1	<0.0050	0.033	133
MAINSTREAMS	2017-10-18	NGMAT01	Mather Cr, site 1	<0.0050	<0.020	-
MAINSTREAMS	2017-07-19	NGMAT02	Mather Cr, site 2	-	-	-
MAINSTREAMS	2017-08-16	NGMAT02	Mather Cr, site 2	-	-	-
MAINSTREAMS	2017-07-19	NGMAT03	Mather Cr, site 3	-	-	-
MAINSTREAMS	2017-08-16	NGMAT03	Mather Cr, site 3	-	-	-

Appendix B2 - Water quality, non metals

Sample Date (yy/mm/dd)	Site Code	Alkalinity (PP as CaCO3)	Bicarbonate (HCO3)	Carbonate (CO3)	Hydroxide (OH)	Orthophosphate (P)	Nitrate plus Nitrite (N)
		mg/L	mg/L	mg/L	mg/L	µg/L	mg/L
		-	-	-	-	-	BC App: 3
		-	-	-	-	-	-
2015-04-20	NGMAT01	-	-	-	-	-	0.038
2015-05-25	NGMAT01	-	-	-	-	9.1	<0.020
2015-06-22	NGMAT01	-	-	-	-	<5	<0.020
2015-07-20	NGMAT01	-	-	-	-	<5	<0.020
2015-08-24	NGMAT01	-	-	-	-	<5	<0.020
2015-09-21	NGMAT01	<0.50	132	<0.50	<0.50	<5	<0.020
2015-10-21	NGMAT01	-	-	-	-	-	<0.020
2016-04-20	NGMAT01	-	-	-	-	-	0.029
2016-05-25	NGMAT01	-	-	-	-	12.2	<0.020
2016-06-22	NGMAT01	-	-	-	-	<5	<0.020
2016-07-20	NGMAT01	-	-	-	-	5.7	<0.020
2016-08-31	NGMAT01	-	-	-	-	<5	<2.0 (1)
2016-09-26	NGMAT01	<0.50	134	<0.50	<0.50	<5	<0.020
2016-10-19	NGMAT01	-	-	-	-	-	<0.020
2017-04-24	NGMAT01	-	-	-	-	-	0.039
2017-05-18	NGMAT01	-	-	-	-	<5	0.021
2017-06-14	NGMAT01	-	-	-	-	5.4	<0.020
2017-07-19	NGMAT01	-	-	-	-	<5	<0.020
2017-08-16	NGMAT01	-	-	-	-	<5	0.023
2017-09-26	NGMAT01	2.4	157	2.9	<1.0	<5	0.033
2017-10-18	NGMAT01	-	-	-	-	-	<0.020
2017-07-19	NGMAT02	-	-	-	-	-	-
2017-08-16	NGMAT02	-	-	-	-	-	-
2017-07-19	NGMAT03	-	-	-	-	-	-
2017-08-16	NGMAT03	-	-	-	-	-	-

Appendix B2 - Water quality, non metals

Sample Date (yy/mm/dd)	Site Code	Dissolved Oxygen	Specific Conductivity	pH
		mg/L	uS/cm	pH units
		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.
		-	-	HC: 7-10.5
2015-04-20	NGMAT01	12	173.5	8.16
2015-05-25	NGMAT01	12	110	7.6
2015-06-22	NGMAT01	10	159.6	7.85
2015-07-20	NGMAT01	10	201.9	7.83
2015-08-24	NGMAT01	11	101.7	8.2
2015-09-21	NGMAT01	12	219.4	8.02
2015-10-21	NGMAT01	12	216.4	7.82
2016-04-20	NGMAT01	11	138.5	6.47
2016-05-25	NGMAT01	13	85.4	8.14
2016-06-22	NGMAT01	11	151.9	8.2
2016-07-20	NGMAT01	12	169.2	8.04
2016-08-31	NGMAT01	11	212.9	8.24
2016-09-26	NGMAT01	12	200.7	8.33
2016-10-19	NGMAT01	14	158.9	8.18
2017-04-24	NGMAT01	14	142.3	7.9
2017-05-18	NGMAT01	14	148.7	8.13
2017-06-14	NGMAT01	13	111.1	7.93
2017-07-19	NGMAT01	12	203.4	8.27
2017-08-16	NGMAT01	12	228.5	8.31
2017-09-26	NGMAT01	13	226.1	8.25
2017-10-18	NGMAT01	14	220.4	8.36
2017-07-19	NGMAT02	-	-	-
2017-08-16	NGMAT02	-	-	-
2017-07-19	NGMAT03	-	-	-
2017-08-16	NGMAT03	-	-	-

Appendix B2 - Water quality, non metals

Sample Date (yy/mm/dd)	Site Code	Turbidity	Water Temperature	Air Temperature
		NTU	C	C
		BC App[1]: Change from background of 8 during clear flow period, and change of 5 during turbid flows	BC App: 19 max. See continuous temperature results for site specific fish species and lifestage guidelines.	-
		BC App[1]: Change of 1 when background is <5 NTU; change of 5 when background is >5 and <50; change of 10% when background is >50.	BC App[AO]: 15	-
2015-04-20	NGMAT01	2.58	5	11
2015-05-25	NGMAT01	21.65	11	16
2015-06-22	NGMAT01	4.66	15	26
2015-07-20	NGMAT01	1.4	15.5	19
2015-08-24	NGMAT01	0.88	12	18
2015-09-21	NGMAT01	1.55	11	15
2015-10-21	NGMAT01	1.26	4	1
2016-04-20	NGMAT01	7.57	8	14.5
2016-05-25	NGMAT01	12.1	8	15
2016-06-22	NGMAT01	2.13	10	13.5
2016-07-20	NGMAT01	1.45	14	21
2016-08-31	NGMAT01	1.03	14	20.5
2016-09-26	NGMAT01	1.21	8	10
2016-10-19	NGMAT01	2.08	5	8
2017-04-24	NGMAT01	22.2	5	11
2017-05-18	NGMAT01	13.6	8.5	16
2017-06-14	NGMAT01	14.6	10	17
2017-07-19	NGMAT01	1.26	16	31.5
2017-08-16	NGMAT01	0.85	15	27
2017-09-26	NGMAT01	0.69	9	17
2017-10-18	NGMAT01	0.68	5	11
2017-07-19	NGMAT02	-	-	-
2017-08-16	NGMAT02	-	-	-
2017-07-19	NGMAT03	-	-	-
2017-08-16	NGMAT03	-	-	-

Appendix B2 - Water quality, non metals

Sample Date (yy/mm/dd)	Site Code	Total Phosphorus (P)	Total Nitrogen (N)	Total Suspended Solids
		mg/L	mg/L	mg/L
		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)
		-	-	-
2015-04-20	NGMAT01	-	0.127	<4.0
2015-05-25	NGMAT01	0.0226	0.219	33.3
2015-06-22	NGMAT01	0.0064	0.088	6.8
2015-07-20	NGMAT01	<0.0050	0.082	<4.0
2015-08-24	NGMAT01	<0.0050	0.111	<4.0
2015-09-21	NGMAT01	<0.0050	0.093	<4.0
2015-10-21	NGMAT01	-	0.073	<4.0
2016-04-20	NGMAT01	-	0.186	11.8
2016-05-25	NGMAT01	0.0136	0.247	15.3
2016-06-22	NGMAT01	0.0055	0.066	<4.0
2016-07-20	NGMAT01	0.0059	0.08	<4.0
2016-08-31	NGMAT01	<0.0050	0.096	<4.0
2016-09-26	NGMAT01	<0.0050	0.127	<4.0
2016-10-19	NGMAT01	-	0.147	<4.0
2017-04-24	NGMAT01	-	0.318	40
2017-05-18	NGMAT01	0.0149	0.173	18.8
2017-06-14	NGMAT01	0.0255	0.106	22
2017-07-19	NGMAT01	<0.0050	0.129	<4.0
2017-08-16	NGMAT01	<0.0050	0.116	<4.0
2017-09-26	NGMAT01	0.0059	0.182	<4.0
2017-10-18	NGMAT01	-	0.098	<4.0
2017-07-19	NGMAT02	-	-	-
2017-08-16	NGMAT02	-	-	-
2017-07-19	NGMAT03	-	-	-
2017-08-16	NGMAT03	-	-	-

Appendix B2 - Water quality, non metals

Sample Date (yy/mm/dd)	Site Code	Dissolved Sulphate (SO4)	Dissolved Chloride (Cl)	Total Ammonia (N)	E. coli
		mg/L	mg/L	mg/L	CFU
		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	BC App: 0.58 to 1.88 based on daily pH and temp, using guideline table.	-
		BC App[AO]: 500	BC App[AO]: 250	-	HC: 0
2015-04-20	NGMAT01	-	2.2	<0.0050	1
2015-05-25	NGMAT01	-	<0.50	0.014	42
2015-06-22	NGMAT01	-	1.1	0.0077	46
2015-07-20	NGMAT01	-	1.5	0.0057	30
2015-08-24	NGMAT01	-	1.6	0.014	14
2015-09-21	NGMAT01	-	2	0.0098	7
2015-10-21	NGMAT01	-	2.2	0.012	3
2016-04-20	NGMAT01	-	0.92	0.032	6
2016-05-25	NGMAT01	-	0.92	0.0081	10
2016-06-22	NGMAT01	-	1.3	0.015	43
2016-07-20	NGMAT01	-	0.96	0.041	*
2016-08-31	NGMAT01	-	<1.0	0.014	19
2016-09-26	NGMAT01	-	1.8	0.058	5
2016-10-19	NGMAT01	-	1.2	0.019	8
2017-04-24	NGMAT01	-	1.6	0.029	22
2017-05-18	NGMAT01	-	1.2	0.05	1
2017-06-14	NGMAT01	-	0.98	0.029	9
2017-07-19	NGMAT01	-	1.2	0.011	4
2017-08-16	NGMAT01	-	1.5	0.042	10
2017-09-26	NGMAT01	9.4	2.1	<0.020	3 (2)
2017-10-18	NGMAT01	-	2.3	0.026	6
2017-07-19	NGMAT02	-	-	-	1
2017-08-16	NGMAT02	-	-	-	5
2017-07-19	NGMAT03	-	-	-	6
2017-08-16	NGMAT03	-	-	-	9

Appendix B3 - Water quality, metals

Stewardship Group	Sample Date (yy/mm/dd)	Site Code	Site Name	Total Hardness (CaCO3)	Total Aluminum (Al)	Total Antimony (Sb)	Total Arsenic (As)	Total Barium (Ba)	Total Beryllium (Be)
			Units	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L
			Guideline for protection of aquatic life[avg]	-	BC App (**dissolved Al**): when pH is <6.5 = e[1.6-3.327 (median pH) + 0.402 (median pH)^2]. When pH ≥ 6.5 = 50.	BC Work: 9 (**antimony III**).	BC App: 5 (max)	BC Work: 1000	BC Work: 0.13
			Calculated aquatic life guideline (where required)	-	50	-	-	-	-
			Guideline for drinking water[max]	-	BC App[AO]: 9500	HC: 6	BC App: 10	HC: 1000	-
MAINSTREAMS	15-09-21	NGMAT01	Mather Cr	131	15.5	<0.50	0.36	77.5	<0.10
MAINSTREAMS	16-09-26	NGMAT01	Mather Cr	111	10.3	<0.50	0.36	64.7	<0.10
MAINSTREAMS	17-09-26	NGMAT01	Mather Cr	119	9.3	<0.50	0.25	70.9	<0.10

Appendix B3 - Water quality, metals

Sample Date (yy/mm/dd)	Total Bismuth (Bi)	Total Boron (B)	Total Cadmium (Cd)	Total Calcium (Ca)	Total Chromium (Cr)	Total Cobalt (Co)	Total Copper (Cu)	Total Iron (Fe)
	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
	-	BC App: 1200	CCME: $10^{\{0.83(\log[\text{hardness}]) - 2.46\}}$	-	BC Work: 8.9 (**chromium III**)	BC App: 4.0	BC App: Hardness <50 = 2. Hardness >50 = 0.04 x hardness	BC App^{max}: 1000
	-	-	0.2	-	-	-	4.8	-
		BC App: 5000	HC: 5	-	HC: 50	-	BC App^{AO}: 1000	BC App^{AO}: 300
15-09-21	<1.0	<50	<0.010	31.4	<1.0	<0.50	1.23	87
16-09-26	<1.0	<50	<0.010	25.9	<1.0	<0.50	<0.50	88
17-09-26	<1.0	<50	<0.010	27.6	<1.0	<0.20	<0.50	59

Appendix B3 - Water quality, metals

Sample Date (yy/mm/dd)	Total Lead (Pb)	Total Lithium (Li)	Total Magnesium (Mg)	Total Manganese (Mn)	Total Mercury (Hg)	Total Molybdenum (Mo)	Total Nickel (Ni)	Total Potassium (K)
	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	mg/L
	BC App: Hardness >8 = (3.31 + e(1.273 ln [hardness] - 4.704).	-	-	BC App: (0.0044 x hardness + 0.605)x1000	CCME 0.026	BC App: 1000	CCME: Hardness 0 to ≤ 60 = 25. Hardness > 60 to ≤ 180 = e{0.76[ln(hardness)]+1.06}. Hardness >180 = 150.	-
	7.3	-	-	605.5	-	-	110.0	-
	BC App: 10	-	-	BC App[AO]: 50	BC App: 1	BC App: 250	-	-
15-09-21	<0.20	<5.0	12.9	5.0	<0.010	<1.0	<1.0	0.691
16-09-26	<0.20	<5.0	11.1	5.2	<0.010	<1.0	<1.0	0.504
17-09-26	<0.20	<2.0	12.2	2.7	<0.010	<1.0	<1.0	0.551

Appendix B3 - Water quality, metals

Sample Date (yy/mm/dd)	Total Selenium (Se)	Total Silicon (Si)	Total Silver (Ag)	Total Sodium (Na)	Total Strontium (Sr)	Total Sulphur (S)	Total Thallium (Tl)	Total Tin (Sn)	Total Titanium (Ti)
	µg/L	µg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L
	BC App. 2.0	-	BC App: Hardness <100 = 0.05. Hardness >100 = 1.5.	-	-	-	BC Work: 0.8	-	-
	-	-	1.5	-	-	-	-	-	-
	BC App: 10	-	-	HC^{AO}: 200	-	-	-	-	-
15-09-21	<0.10	4070	<0.020	2.74	61.9	<3.0	<0.050	<5.0	<5.0
16-09-26	<0.10	3790	<0.020	2.22	53.5	<3.0	<0.050	<5.0	<5.0
17-09-26	<0.10	3820	<0.020	2.45	58.3	<3.0	<0.010	<5.0	<5.0

Appendix B3 - Water quality, metals

Sample Date (yy/mm/dd)	Total Uranium (U)	Total Vanadium (V)	Total Zinc (Zn)	Total Zirconium (Zr)
	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)	-
	-	-	30.3	-
	HC: 20	-	BC App[AO]: 5000	-
15-09-21	0.94	<5.0	<5.0	<0.50
16-09-26	0.71	<5.0	<5.0	<0.50
17-09-26	1.05	<5.0	<5.0	<0.10