Submitted to: Prof. Dr. Eric Demers

FALL 2016 DATA REPORT: WATER QUALITY AND STREAM INVERTEBRATES ASSESSMENT FOR THE MILLSTONE RIVER, NANAIMO, BC.

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Fall 2016

EXECUTIVE SUMMARY

As part of a long term monitoring project, water quality and stream invertebrate assessment were performed on 5 sampling stations distributed along the Millstone River, Nanaimo, British Columbia. Two sampling events occurred at each station on October 30 and Nov 23, 2016, both during high flow periods given the abnormal precipitation that took place. The parameters analyzed at each site were: pH, hardness (mg/L as CaCO3), phosphate (mg/L PO_4^{3-}), nitrate (mg/L NO^{3-}), temperature (°C), conductivity (µS/cm), dissolved oxygen (% and mg/L), turbidity (NTU), alkalinity (mg/L as CaCO3), and total metals. The river was also assessed for stream invertebrates, microbiology, and basic hydrology. Results were compiled and compared to previous years reports. Water quality analyses (with the exception of total metals) were carried out in two laboratories, VIU and ALS, and presented similar trends in their results, despite the different methods employed. ALS results revealed that all stations met water quality guidelines for metals except for aluminum at Station 4 in Bowen Park, during the second sampling event. All other parameters analysed were concentrated either within the applicable guidelines or below the method detection limit. Microbiology tests exposed the presence of fecal coliform in all stations. The stream invertebrates sampling denoted a low taxon richness yet high numbers for the predominant taxon (amphipods), indicating an organic enrichment or pollution for that particular site (Station 4). In general, the Millstone River presents acceptable "health" for supporting aquatic life, which leaves room for improvement in years to come.

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INTRODUCTION & BACKGROUND

Since 1971, the Millstone River has been under the scrutiny of community partnerships and governmental entities alike due to its potential to become a self-sustaining salmon run. The river runs through rural lands, urban settings, and city parks, conferring it significant value for ecological, recreational, and educational purposes (City of Nanaimo, 2008; Harbour City River Stewards, 2016). Given its aforementioned significance, the Millstone River requires unceasing vigilance to guarantee its optimal use as a resource by stewardship groups. To aid this endeavour, Vancouver Island University (VIU), through the Natural Resources Management and Protection Program, has provided a series of environmental monitoring reports over the years, enabling the identification of natural or anthropogenic impacts along the river. The continuity and consistency of these reports are of paramount importance to the decision-making process of this long-term monitoring program.

The waters that constitute the Millstone River originate around Lucid Lake, west of Mount Benson at 619 metre elevation, at this point denominated as Benson Creek (Demers, 2016). This creek flows northerly from Lucid Lake into Brannen Lake, along with several other creeks. The Millstone River drains Brannen Lake meandering for 14 km towards the Southeast, into the Strait of Georgia at the City of Nanaimo's Inner Harbour. Downstream of Brannen Lake, Divers, Cathers, Long and Westwood Lakes drain into the Millstone River, totalling the 26 streams, 16 tributaries and 8 lakes that compose the Millstone watershed (City of Nanaimo, 2008). According to Cook & Baldwin (1994), the total area of the Millstone watershed drainage basin is 93 km^2, of which 46 km^2 is above Brannen Lake.

Historically, Rainbow and Cutthroat trout (*Onchorhyncus mykiss* and *O. Clarkii*), Stickleback (*Gasterosteus aculeatus*), Pumpkinseed (*Lepomis gibbosus*), sculpins (*Cottus sp.*) and crayfish (*Pacifastacus leniusculus*) are some of the residents that have been observed in the reaches of the Millstone. Coho smolts have been stocked in the lower reaches of the Millstone on a number of instances and (Cook & Baldwin, 1994). According to Cook and Baldwin (1994), a fish ladder has been placed in the Millstone River at the Deadman Falls site at Bowen Park (no mention of date of construction found), in order to mitigate the turbulent cascading characteristics that the river assumes at that point. Fish habitat was further enhanced in the Millstone River in the summer of 2007; when Fisheries and Oceans Canada built a side channel circumventing the fish ladder, thus granting anadromous salmonids access to the watershed above the falls and providing new spawning grounds and rearing habitat (Demers, 2016; Harbour City River Stewards, 2016).

The Millstone River courses through rural farmland for the first 12 km, then changes abruptly in Bowen Park, where it becomes turbulent, racing through cascades (Harbour City River Stewards, 2016). Prior to reaching Bowen Park, the land use on the margins of the Millstone changes to urban developments, with mixed residential and commercial use. The adjacent agricultural lands could be promoting unintentional eutrophication of the river through fertilizer runoffs, while the urban settings could be bringing contaminants to the river via stormwater outfalls and/or groundwater. This project encompassed the environmental monitoring campaign for 2016, on the stations along the Millstone River as depicted on figure 1, continuing the provision of data regarding water quality and macroinvertebrate biomonitoring.

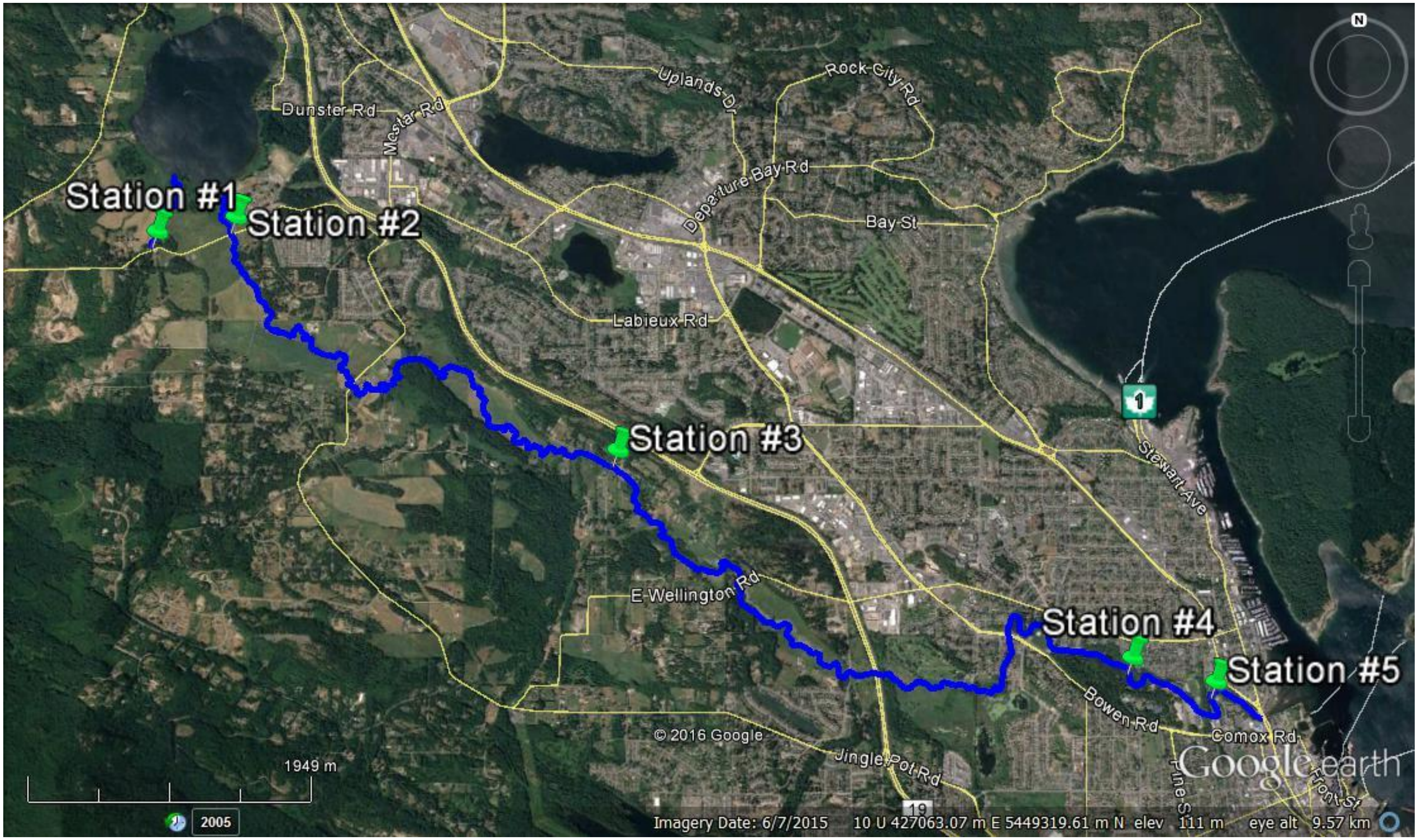


Figure 1: Environmental Monitoring Stations in the Millstone River. Source: Google Earth (accessed on 20/10/2016).

Project Objectives

The objectives of this project were to assess and analyze current general environmental conditions of the Millstone River. All results were compared to past surveys in order to identify or corroborate trends and identify potential contaminants. Monitoring and sampling were performed at five sites along the water course. Water samples were taken from the stream in order to assess water quality. The team conducted basic hydrology tests to determine flow and discharge. Invertebrate collection samples were taken to calculate the predominant taxon and biodiversity and Microbiology testing were performed to indicate coliform presence. The results of this project are of interest for the Department of Fisheries and Oceans Canada as well as the Regional District of Nanaimo and City of Nanaimo.

Methods

Sampling Stations

Five sites were tested (Figure 1); one on Benson Creek and the other four on the Millstone River in Nanaimo, British Columbia. The testing sites are the ones that have been used by the RMOT 306 class in previous years – with adjustments on locations from year to year. All sites are accessible by foot, are relatively safe and can be directly compared to previous results. The sampling sites were entitled "Stations" and coded from 1 (upstream) to 5 (downstream). This study was designed so there would be two sampling times for water quality, during low and high water levels at each site. The sampling events consisted of biological diversity (stream invertebrates) and microbiology samples – which were exclusive to the first campaign – in addition to basic hydrology and water quality.

Station 1 is Benson Creek located on Bigg Road (UTM 10 U 422738 mE, 5450707 mN), on a bridge crossing across the road from Camp Caillet. Access to the site is on the north side of the bridge by foot trail (see figure 2). The system flows north towards Brannen Lake. The canopy cover consists of mostly alder (*Alnus sp.*) and small shrubs. Farmlands and residences are the predominant land use at this point.

Figure 2: Benson Creek flowing north-easterly towards Brannen Lake.

Station 2 is also on Biggs Road on the Millstone River crossing (UTM 10 U 423341 mE, 5450828 mN). Access is on the northwest side of the bridge (the river flows southwest, see figure 3). This location is open to pastures nearby, and close to Brannen Lake penitentiary. When there is a high water level it might not be safe to conduct sampling at this site due to channel depth and discharge. To the north of the bridge canopy consists of alder (*Alnus sp.*), with the opposite side consisting of pastures.

Figure 3: Station 2 at Biggs Road, facing dowstream.

Station 3 is located at the Maxey Road crossing on Durnin Road by a bridge (UTM 10U 426304 mE, 5448953 mN). Access to this site is on the west side of the bridge by an easy foot path, as indicated on figure 4. There are few alder trees (*Alnus sp.*) and pastures that cover this area of the Millstone. Rural properties still characterize the land use of the area, with an accentuation of residences.

Figure 4: Access to Station 3 beside Durnin Road Bridge (downstream side of bridge).

Station 4 is located in Bowen Park in the man-made side channel near the falls (UTM 10U 430233 mE, 5447304 mN). Access is easy through the pathways of Bowen Park. The system flows north, and access to the site is off the main trail along the river about 15 metres (according to the coordinates taken from previous studies). The canopy is diverse with red cedar (*Thuja plicata*), big leaf maple (*Acer macrophyllum*), Douglas Fir (*Pseudotsuga menziesii*) and shrubs of trailing blackberries (*Rubus ursinus*), as observed in figure 5.

Figure 5: Bypass channel on Station 4, Bowen Park, looking upstream.

Station 5 is located under the bridge close to Barsby Park at the end of Prideaux Avenue (UTM 10U 430941 mE, 5447091 mN). The Millstone flows into the Georgia Strait north-easterly of this sampling site. With high water levels, this would be the channel with the greatest depth in comparison to the other stations (see figure 6). A trail that is gradually steep goes down from the bridge to the river. Canopy in the area is diverse and greater than any other station.

Figure 6: Millstone River at Barsby Park bridge, facing downstream, near access to Station 5.

BASIC HYDROLOGY

Basic Hydrological measurements were taken at Stations 2 and 4 on Oct 30, 2016 and Nov 23, 2016. Water velocity (in m^3/s) was measured using a 1 meter ruler and a neutral buoyant ping-pong ball. The time elapsed between releasing the ball as it drifted downstream and when the ball reached exactly 1m was measured and then repeated five times. All five times were then averaged to represent the mean velocity. To measure the cross-sectional area, our team used a tape measure and selected the most representative width of the stream at both stations and measured its wetted width, not including the stream banks, then measured the water depths along this transect. These data were then calculated using the equation Q= A*V where Q represents discharge as (m^3/s), A is the cross-sectional width of the wetted stream and V is the mean water velocity, calculate using the aforementioned method (Demers, 2016).

WATER QUALITY

Field Measurements

Water quality sampling events took place on October 30, 2016 on all five stations. Conditions were abnormal as both a storm and severe rain had recently taken place over all of Nanaimo. Proper midstream samples could not be taken from Station 2 as a result of the heavy rain leading to high water levels and high flow. In lieu of midstream samples, samples were taken from the deepest and fastest flowing section that could be safely reached. At each station, field measurements of water temperature (to the nearest 0.1^{o}C) and dissolved oxygen (to the nearest 0.1 mg/L) were taken. The electronic probe was placed directly in the channel water and held in place until readings stabilized.

Water Sampling

Two sets of water quality samples were taken during each of the two sampling events. Water was sampled in sterile plastic and glass containers for analysis by ALS Environmental laboratory (which also provided such containers) and sampled in reusable unsterilized plastic containers for analysis by students at VIU.

Samples for ALS laboratory were taken from stations 1, 2 and 4 on both events. For each station, samples were collected in three pre-labelled laboratory-supplied containers. All samples were taken by standing on the stream bank or wading into the stream channel, walking upstream. The containers were submerged directly below the water surface facing upstream. Care was taken not to disturb the sediments on the stream bottom and always to procure the nest sample upstream of the previous. All samples for nutrients and total metals were preserved with laboratory-supplied sulphuric acid and nitric acid, respectively. Bottles containing preservatives were inversed five times to ensure adequate mixing of preservative and sample. All samples were stored on ice in a cooler both on site and off site until transportation to the ALS laboratory for analysis within 96 hours.

Samples to be analyzed at VIU were taken in plastic containers and rinsed three times prior to taking a final sample. All vials contained a maximum volume of 500ml and were pre-labelled. A duplicate sample was taken at station 2 during the first sampling campaign and station 3 during the second campaign. The same cares as to not disturb bottom sediments and proceeding upstream after each sample were observed. All samples were stored in a cooler at approximately 4^{o}C and all laboratory analyses were conducted within 96 hours.

VIU Laboratory Analyses

All water quality samples were tested by the authors of this report at VIU facilities for conductivity (as µS/cm), pH, alkalinity (as $CaCO_3$), turbidity (as Nephelometric Turbidity Units), Phosphorus (as PO_4^{3-}) and Nitrogen (as NO_3^-) levels in mg/L, and Hardness in mg/L (as $CaCO_3$).

ALS Laboratory Analyses

Water samples submitted for external analyses were processed as per ALS Laboratory standard analytical procedures. All samples were processed for 'General Parameters', including conductivity, alkalinity, total hardness, and pH, nutrients (ammonia, nitrate, nitrite, orthophosphate and total phosphorus), and total metals (appendix C).

Quality Assurance / Quality Control

Throughout this study, many measures were taken to ensure consistency and minimize potential errors from cross-contamination. All ALS containers were sterilized and VIU containers were rinsed a minimum of three times in sample water before taking the final sample. All samples were preserved and stored as prescribed by the analytical laboratory. All samples were labelled prior to any field activity and the field gear was inspected and organized beforehand to promote best field practices. Replicate samples from Station 2 and Station 3 were taken on the first and second sampling event, respectively, to ensure consistency. A field blank of distilled water was also transported into the field, stored with the rest of the samples and returned to the laboratory for analysis to ensure best practices were followed and no sample contamination occurred.

Data Analyses – Comparison with Applicable Guidelines

All water quality results were compared with the applicable provincial and federal water quality guidelines for the protection of freshwater life. The BC Water Quality Guidelines denotes the maximum allowable concentration and 30-day average concentration for potential acute and chronic toxicity effects, respectively. It is noteworthy that some trace metal parameters such as aluminum were below the analytical detection limits (*e.g.* <0.2 mg/L for aluminum) in one or both sampling events; however, it does not implicate that concentration levels measured below detection limits are also below quality guidelines, *e.g.* water quality of aluminum for aquatic life is 0.10 mg/L (Demers, 2016).

MICROBIOLOGY

Field Sampling

Water samples for total and fecal coliform calculations were collected from each sampling station on Oct 30, 2016. A sterile pre-labelled 120ml Whirl-Pak© bag was used to collect a 100ml sample by directly immersing the bag by hand below the water's surface while facing upstream, then removing the excess of air and tightly winding the bag's seal system. All samples were stored in a cooler with an ice pack and transported to VIU laboratory for analysis within 96hrs.

Laboratory Analyses

In the VIU laboratory, our team tested all samples collected from the Millstone for both total and fecal coliform (*Escherichia coli*) using the m-coliBlue24 membrane filtration method. A 25ml volume of sample water was filtered through a 47μm membrane filter (each marked with 3mm gridlines) using a vacuum pump. Between each sample tested the equipment was rinsed with approximately 5ml of sterile water. Each membrane filter was then transferred to a Petri plate containing an absorbent pad saturated with m-coliBlue24 broth for nutrient. All five membrane filters were incubated at 37˚C for 24hrs and then counted (Demers, 2016).

Bacterial plates were examined after the incubation period of 24 hours (appendix D). A red or blue colony represents a total coliform positive result. A red colony exhibiting three-dimensional shape is counted as 1 Non-Fecal Colony Forming Unit (CFU), similarly, one blue colony exhibiting three-dimensional shape is counted as 1 Fecal CFU. White or Clear colonies are not counted and represent a total coliform negative result. Total counts of each CFU (Fecal and Non-Fecal) were then multiplied by 4 to represent a sample of 100ml, then the Percentage of Fecal Coliform is calculated.

Quality Assurance / Quality Control

To assure quality, the team members that handled the microbiology samples in the laboratory wore sterile latex gloves, rinsed the filter flask thoroughly with sterile water before each sample was processed through the filter, and sterilized the tweezers (by flaming) used to transfer the filter paper before each use. The m-ColiBlue24 Broth used was purchased through the university and in order to be certified for its intended use, the product manufacturer must be subjected to strict quality control standards.

Data Analyses – Comparison with Applicable Guidelines

The microbiology results were compared to the guidelines prescribed by the Ministry of Environment’s Water Quality Criteria for Microbiological Indicators (1981). The guidelines are expressed in CFU/100mL and vary according to the intended use of water (consumption, irrigation, shellfish harvesting, *etc.*), providing a threshold that indicates the risk of disease from pathogenic bacteria.

STREAM INVERTEBRATES

Field Sampling

For the collection of stream invertebrates in the field a variety of tools were needed to successfully sample the organisms from the stream for analysis. A Hess sampler was issued as well as a set of plastic vials with corresponding lids. Before collecting the samples in the field the lids of each of the 8 containers used for sampling were labeled using tape and a marker. The lids were labeled with the current time, date, area sampled and the initials of the person who sampled them. Only 2 subareas of station 4 were able to be sampled due to a large amount of rainfall that rendered it unsafe and impractical to retrieve invertebrates from other stations. The two places chosen for invertebrates sampling were the channel downstream of the “duck pond” in Bowen Park and the channel downstream from an arched foot bridge, also in the Park. The areas sampled had substrate suitable for stream invertebrates habitat and water levels no higher than knee deep, for an effective use of the Hess sampler. The sampler was grounded firmly to the streambed at each area and the sediment encircled by the sampler was then disturbed and manually stirred to dislodge invertebrates, which were funneled by the sampler’s mesh towards a sample container, that is later transferred to a 125 ml plastic sample jar. Water was added to the sample bottle to keep the organisms alive before closing the lid and securing with tape. Any Crayfish caught were added to the total count but then returned to the stream and not taken back to the lab for analysis as their taxonomy is already known. The net was inspected after each sample and water was used to push any remaining contents through before using the sampler again. This process was repeated a total of 8 times for both areas. The samples were then packaged and stored in a refrigerator before analysis took place in the laboratory.

VIU Laboratory Analyses

Once the 8 invertebrate samples were collected on October 29 2016 we then were able to analyze the samples in the lab on November 2, 2016. To analyze the samples we employed two dissection microscopes, two trays, two petri dishes, two tweezers, two water droppers and distilled water. The triplicate samples from each subarea were combined into a single composite sample per subarea. For each sample, the contents were emptied onto the trays and invertebrates were then transferred to the petri dishes for counting and identification, leaving the excess sediments in the trays for later scrutiny. The invertebrates were first identified to order and family levels. To narrow the specimens' taxonomy further, the dissection microscope was used. The number of each taxonomic group identified was counted and noted. Using the Shannon-Weiner diversity index, the abundance of each family and order and the overall diversity of the stream was calculated.

Quality Assurance/Quality Control

For quality assurance methods, the Hess sampler was rinsed thoroughly after each sample, as to not to contaminate the next sample that would be retrieved from a different portion of the channel. The sample containers were inspected for integrity (free of holes and leaks), and the lids were tried on beforehand, and then labelled. In laboratory, each composite sample was processed by different group member. Each group member used different microscopes, trays and especially tools to avoid any unintentional transfer of specimens between the two subareas. A dissection microscope was used to aid in the visualization of features for accurate taxonomic identification.

For quality control, triplicate samples of invertebrates were taken on each site, and the same person collected all samples from each site to guarantee reproducibility of sampling techniques. All calculations were repeated at least twice and inspected by all group members.

Data Analyses

The analysis of the stream invertebrates samples provided valuable data regarding the density, total number of taxa, predominant taxon, and several indexes that serve as an interpretation of the stream suitability for aquatic life, namely: Pollution Tolerance Index, EPT (Ephemeroptera-Plecoptera-Trichoptera) Index, EPT to Total Ratio Index, Predominant Taxon Ratio Index, and an overall Site Assessment Rating

RESULTS AND DISCUSSION

GENERAL FIELD CONDITIONS

Using the equation mentioned in the Hydrology section of Methods, our team was able to calculate the discharge for each station within the stream course, the results from the first event are shown in table 1.

Table 1. Calculated Discharge at Stations 1 and 2 during both sampling events.

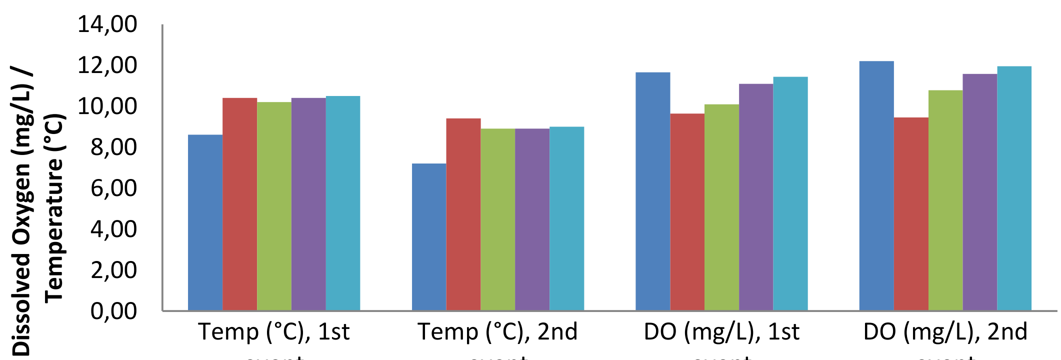
Station	Mean Velocity (m/s)	Wetted Width (m)	Total Discharge (m^3/s)
Station 2, 1st Event	0.24	9.6	2.3
Station 2, 2nd Event	0.38	9.6	3.6
Station 4, 1st Event	0.37	2.15	0.8
Station 4, 2nd Event	0.47	2.15	1.0

As observed in table 1, the discharge measured in both stations increased between sampling events. According to the trends presented by Demers (2016) in his eight years summary report for the Millstone River, this years' discharge surpasses the 36-year median discharge (1979-2015), with the exception of station 4, during the second event in mid-November. It is worth mentioning that station 4 represents the bypass channel in Bowen Park, which is controlled by an intake weir, curbing discharge rate fluctuations at that site. It is our conjecture that this outstanding discharge might be a reflex of the cumulative effects of rainy periods on top of the storms that hit Nanaimo prior to the first sampling event.

WATER QUALITY

Field Measurements

Measurements of dissolved oxygen and temperature were taken in the field during both sampling events. During each event, it is noted that the temperature increased drastically downstream during both events between Stations 1 and 2, where Benson creek (Station 1) receives higher elevation, thus colder, waters from Lucid Lake. Station 2, in turn, is an effluent of Brannen Lake, therefore presenting warmer water from the lake's surface. From Station 2 onwards the temperature drops by the time the river reaches Station 3, followed by a minute gradual increase until reaching Station 5. It is also noted that due to general weather conditions, water temperatures during the second event was lower, as seen in figure 7.



	Temp (°C), 1st event	Temp (°C), 2nd event	DO (mg/L), 1st event	DO (mg/L), 2nd event
Station 1	8,60	7,20	11,65	12,19
Station 2	10,40	9,40	9,63	9,45
Station 3	10,20	8,90	10,09	10,77
Station 4	10,40	8,90	11,09	11,57
Station 5	10,50	9,00	11,43	11,95

Parameters measured in the field per sampling event

Figure 7. Temperature (°C) and dissolved oxygen concentrations (mg/L) measured on both sampling events (October 30 and November 23, 2016).

In an opposite fashion, dissolved oxygen is at its highest levels in Station 1, as a consequence of the lower water temperature, then plummets to its lowest level in Station 2 (also inversely proportional to the temperature), before gradually increasing towards the last station. Associated with the general decrease of temperature between the two events, an increase of dissolved oxygen is noted. This shows a negative correlation between water temperature and dissolved oxygen levels. The dissolved oxygen levels here presented are above the minimum guideline of 9.0 mg/L for early fish life stages, according to the Ministry of Environment, Land and Parks – MELP – (1998).

VIU Laboratory Analyses

MICROBIOLOGY

All samples collected from the Millstone River contained coliform bacteria, including *E. coli* (see table 2). There was no evident pattern to the abundance of coliform, with the highest abundance being at station 4, within Bowen Park (116 CFU/100ml; 8 *E. coli*/100ml), and Station 3 having a significantly lower number of total coliforms, but retaining a high percentage of fecal coliforms. Station 1, the only station before Brannen Lake, had the lowest concentrations of both fecal and non-fecal coliforms (only 4 fecal CFUs and 0 non-fecal CFUs). Due station 1 having zero non-fecal CFUs, station 1 then has the highest concentration of fecal coliform at 100%.

Table 2. Millstone River microbiology results based on samples collected on October 30, 2016.

Station	Fecal (CFU/100ml)	Non-Fecal (CFU/100ml)	Total Coliform (CFU/100ml)	Percent Fecal (%)
Station 1	4	0	4	100
Station 2	8	92	100	8
Station 3	28	8	36	78
Station 4	8	108	116	6.9
Station 5	32	80	112	28

Although station 4 has the highest concentration of total coliforms, station 3 has the highest concentration of fecal coliforms (ignoring the results from station 1). Station 3 has a concentration of fecal coliforms at 78% (see figures 8 and 9). Not surprisingly, the highest percentage of fecal coliforms appeared in the lowest total concentrations of coliforms. Because of this, it is unlikely that these results can be used to represent each station and assume that Stations 1 and 3 are of lower water quality. According to the guidelines could be used for general livestock use, irrigation, and recreation (MELP, 1998).

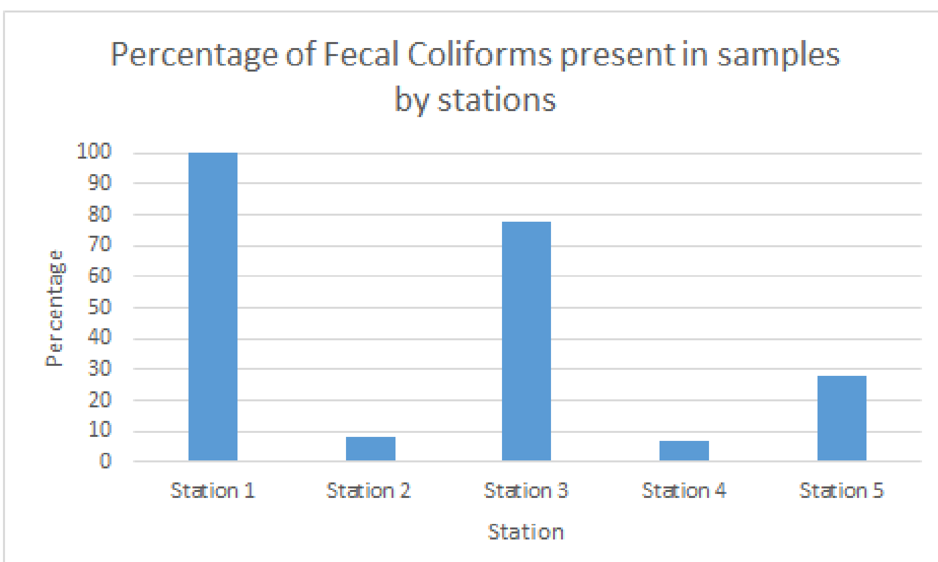


Figure 8. Fecal coliform percentage per sampling station in the Millstone River (2016).

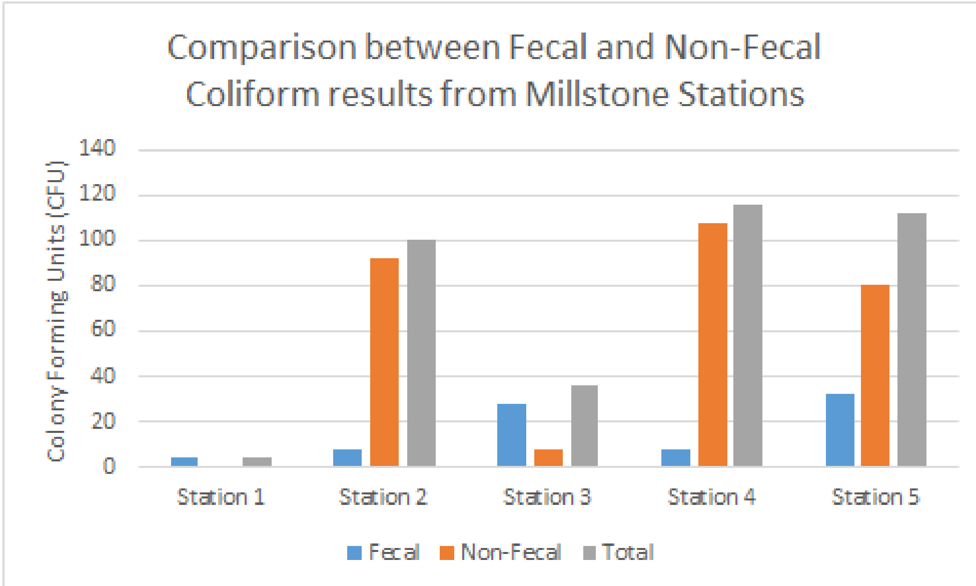


Figure 8. Fecal and non-fecal coliforms (colony forming unit; CFU / 100 ml) measured at five stations during 2016's first sampling event in the Millstone River.

PHYSICOCHEMICAL PARAMETERS

Generally, there were minor fluctuations in all measured parameters, punctuated by a few spikes and drops in concentrations levels, usually followed by stabilization. Stations 3, 4, and 5 presented the most repetition in results or fluctuations in small increments for most parameters, while stations 1 and 2 showed the least congruence (see tables 3 and 4).

Table 3. Millstone River October 30, 2016 Sampling Event Results (replicate taken from Station 2).

Station	Temp. (°C)	DO (mg/L)	pH	Conductivity (μS/cm)	Alkalinity (mg/L as $CaCO_3$)	Hardness (mg/L as $CaCO_3$)	Nitrate (mg/L as NO_3^-)	Phosphate (mg/L as PO_4^{3-})	Turbidity (NTU)
1	8.6	11.65	7.1	26	8.4	18	0.08	0.07	1.47
2	10.4	9.63	6.8	50	15	28	0.46	0.08	2.2
3	10.2	10.09	6.7	55	18	32	0.69	0.08	2.67
4	10.4	11.09	6.9	69	17.8	39	0.17	0.08	5.25
5	10.5	11.43	7	68	18.5	42	0.65	0.44	6.31
Replicate	10.4	9.63	7	51	16.5	32	0.27	0.07	2.52
Trip Blank							0.04	0.04	

Table 4. Millstone River November 23, 2016 Sampling Event Results (replicate taken from Station 3).

Station	Temp. (°C)	DO (mg/L)	pH	Conductivity (µS/cm)	Alkalinity (mg/L as $CaCO_3$)	Hardness (mg/L as $CaCO_3$)	Nitrate (mg/L as NO_3^-)	Phosphate (mg/L as PO_4^{3-})	Turbidity (NTU)
1	7.2	12.19	7.1	19	9.2	21	0.01	0.13	0.93
2	9.4	9.45	6.6	41	15.5	23	0.13	0.03	1.48
3	8.9	10.77	6.8	49	20.8	30	0.07	0.03	2.58
4	8.9	11.57	6.9	63	25.8	35	0.08	0.03	2.47
5	9	11.95	6.9	64	22.3	36	0.07	0.03	5.37
Replicate	8.9	10.77	6.9	53	20	37	0.08	0.04	1.72
Trip Blank							0.01	0.01	

Potential Hydrogen (pH) was measured and ranged between 7.1 and 6.7 during the first sampling event and 7.1 and 6.6 during the second sampling event. pH showed a similar trend to DO in both sampling events, reaching the highest measurement in Station 1, its lowest in Station 2, then stabilizing in the last stations. The average pH during the first sampling event was 6.9 and 6.8 during the second event. Therefore, pH levels were within the aquatic life criteria of 6.5-9.0 (MELP, 1998).

Conductivity measured between 26 and 69 µS/cm during the first event and between 19 and 64 µS/cm during the second event. There was a gradual increase in conductivity downstream from Station 2 during both events. However, in both events, conductivity approximately doubled from Station 1 to Station 2, denoting an increase in dissolved ions coming from Brannen Lake.

Alkalinity measured between 8.4 and 18.5 mg/L during the first event and between 9.2 and 25.8 mg/L during the second event. Following the conductivity pattern, there was a gradual increase in these measurements, accruing downstream, but with a more pronounced increment from Station 1 to Station 2. The average alkalinity for the first sampling event was 15.5 and 18.7 for the second event. These averages indicate moderate acidification sensitivity, according to the guidelines (MELP, 1998). Looking at each station individually, Station 1 consistently presented a high sensitivity to acidification (0-10 mg/L as $CaCO_3$), as Station 2 presented a consistent moderate sensitivity to acidic inputs (10-20 mg/L as $CaCO_3$). Stations 3 to 5 shifted from moderate rating during the first event to low acidification sensitivity during the second event (>20 mg/L as $CaCO_3$).

Hardness was measured between 18 and 42 mg/L during the first event and between 21 and 36 mg/L during the second event. These concentrations were observed to have increased gradually downstream. All hardness levels were below 60 mg/L as $CaCO_3$, indicative of "soft water" (MELP, 1998).

Nitrate was measured between 0.08 and 0.69 mg/L as NO_3^- during the first event. Nitrate concentrations showed the widest fluctuation between stations during this event, with no identifiable trend. During the second sampling event, nitrate measured between 0.01 and 0.13 mg/L. There was no distinguishable pattern during this event as it increased between Stations 1 and 2 and then decreased and levelled out progressively downstream (somewhat similar to what was observed with temperature). All nitrate results were well under the aquatic life criteria that stablishes a maximum concentration of 200mg/L and average of 40 mg/L (MELP, 1998). It is noteworthy, though, that these same guidelines state that most surface waters have less than 0.3 mg/L of nitrate, when there is no anthropogenic input; however, Stations 2, 3, and 5 were above that level during the first sampling event in late October.

Phosphate was measured between 0.07 and 0.44 mg/L (as PO_4^{3-}) during the first event. The levels remained near identical throughout stations 1-4 and then spiked to 0.44mg/L at station 5. During the second event, the phosphate levels ranged between 0.13 and 0.03 mg/L. This event had a near opposite pattern to the first event. Station 1 had the highest concentration of phosphate at 0.13 mg/L and then levels decreased to 0.03mg/L at station 2 and remained at the same levels for all stations downstream.

Turbidity ranged between 1.47 and 6.31 NTUs during the first event and between 0.93 and 5.37 NTUs during the second event. Both events exhibited a similar pattern of increasing progressively downstream (see Tables 3 and 4). In both sampling events, turbidity was greater at Station 5; notwithstanding, there was no increase higher than 5 NTU during any of the sampling events, as stipulated by the guidelines for aquatic life, when the background is equal or lesser than 50 NTU (MELP, 1998).

ALS Laboratory Analyses

The analytical results from ALS Environmental, from Stations 1, 2, and 4 (as per project design) from both sampling events, were compiled and compared to the applicable provincial guidelines for the protection of aquatic life. They are summarized in tables 5 and 6 and only present the concentrations expressed above the method detection limit. Results above the guidelines are stressed in red. ALS analyses are subdivided into: physical tests, anions and nutrients, and total metals, therefore each of these sections is discussed in the same order. After ALS physical tests are discussed, a comparison between their results and the ones obtained at VIU facilities is presented for each sampling event in figures 10 and 11.

Table 5. ALS water quality results for the first sampling event on the Millstone River (October 30, 2016). Results were compared to the BC Water Quality Guidelines. Only parameters expressed above the method detection limit at any station are shown.

Physical Tests (Water)	Unit	Station			Guidelines	Observation
		1	2	4		
Conductivity	µS/cm	32.1	58.6	79.5	-	
Hardness (as $CaCO_3$)	mg/L	13.2	24.5	29.4	<60	Softwater
pH	pH	7.43	7.39	7.55	6.5 - 9.0	
Anions and Nutrients (Water)						
Ammonia, Total (as N)	mg/L	<0.005	0.0106	0.0087	19.7 - 23.2	Temperature/pH dependant
Nitrate (as N)	mg/L	0.0749	0.165	0.222	200	
Nitrite (as N)	mg/L	0.0011	0.0023	0.0018	0.06	
Total Nitrogen	mg/L	0.189	0.383	0.451	-	
Orthophosphate-Dissolved (as P)	mg/L	<0.001	<0.001	0.0023	-	
Phosphorus (P)-Total	mg/L	0.0024	0.0073	0.0092	<0.10	Oligotrophic
N:P	N/A	78.8	52.5	49	16	
Total Metals (Water)						
Calcium (Ca)-Total	mg/L	3.72	6.74	8.37	4 – 8	Moderate
Iron (Fe)-Total	mg/L	0.055	0.185	0.329	1	
Magnesium (Mg)-Total	mg/L	0.96	1.87	2.08	-	
Manganese (Mn)-Total	mg/L	<0.005	0.0133	0.0244	0.69 / 0.81 / 0.86	Hardness dependant
Silicon (Si)-Total	mg/L	3.83	3.48	3.85	-	
Sodium (Na)-Total	mg/L	<2.0	3.1	5.2	-	
Strontium (Sr)-Total	mg/L	0.0151	0.0277	0.0542	-	

Table 6. ALS water quality results for the second sampling event on the Millstone River (November 23, 2016). Results were compared to the BC Water Quality Guidelines. Only parameters expressed above the method detection limit at any station are shown.

Physical Tests (Water)	Unit	Station 1	Station 2	Station 4	Guidelines	Observation
Conductivity	µS/cm	28.4	56	83.6	-	
Hardness (as $CaCO_3$)	mg/L	11.9	22.5	31.1	<60	Softwater
pH	pH	7.38	7.31	7.61	6.5 - 9.0	
Anions and Nutrients (Water)						
Ammonia, Total (as N)	mg/L	<0.005	0.0105	0.0174	19.7 - 23.2	Temperature/pH dependan
Nitrate (as N)	mg/L	0.0683	0.195	0.248	200	
Nitrite (as N)	mg/L	<0.001	<0.001	0.0019	0.06	
Total Nitrogen	mg/L	0.153	0.389	0.498	-	
Orthophosphate-Dissolved (as P)	mg/L	<0.001	0.0011	0.0052	-	
Phosphorus (P)-Total	mg/L	0.0032	0.0069	0.0137	<0.10	Oligotrophic
N:P	N/A	47.8	56.4	36.4	16	
Total Metals (Water)						
Aluminum (Al)-Total	mg/L	<0.20	<0.20	**0.51**	0.1	
Calcium (Ca)-Total	mg/L	3.3	6.22	8.8	4 - 8	
Iron (Fe)-Total	mg/L	0.077	0.286	0.792	1	
Magnesium (Mg)-Total	mg/L	0.9	1.69	2.21	-	
Manganese (Mn)-Total	mg/L	<0.005	0.0319	0.0463	0.67 / 0.79 / 0.88	Hardness dependant
Silicon (Si)-Total	mg/L	3.71	4.09	4.94	-	
Sodium (Na)-Total	mg/L	<2.0	2,9	5.8	-	
Strontium (Sr)-Total	mg/L	0.0144	0.028	0.0595	-	

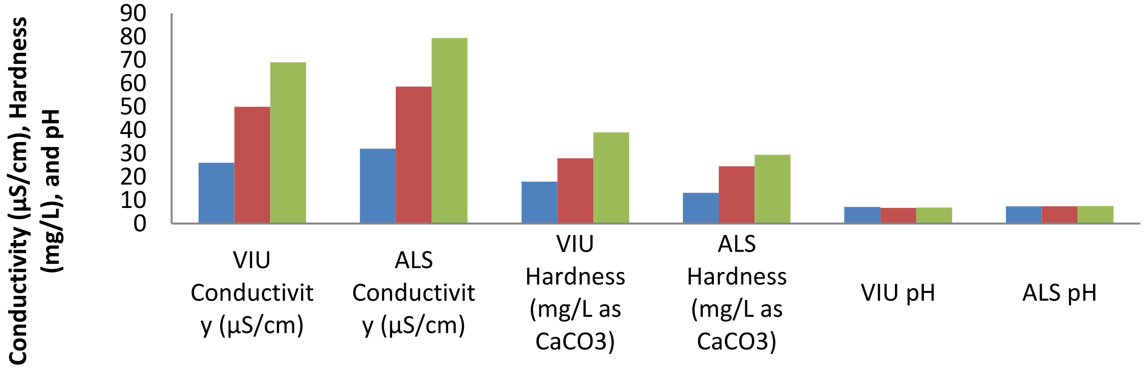
PHYSICAL TESTS

Conductivity increased significantly per station on both sampling events, ranging from 28.4 (Station 1) to 83.6 µS/cm (Station 4). During the first sampling event it increased in increments of roughly two tens. During the second sampling event, conductivity ranged from 28.4 to 83.6 in increments of roughly three tens. The first sampling event presented slightly higher conductivity than the second event – which might be explained by the increase in discharge between events, heightening the dilution factor – except for Station 4.

Hardness also increased downstream on both sampling events. It ranged from 13.2 to 29.4 mg/L (as $CaCO_3$), during the first sampling event and 11.9 to 31.1 for the second event. As noted for conductivity, the first sampling event presented slightly higher hardness than the second event, except for Station 4. During both sampling events, hardness remained below 60 mg/L, thus it is considered "soft water" (MELP, 1998).

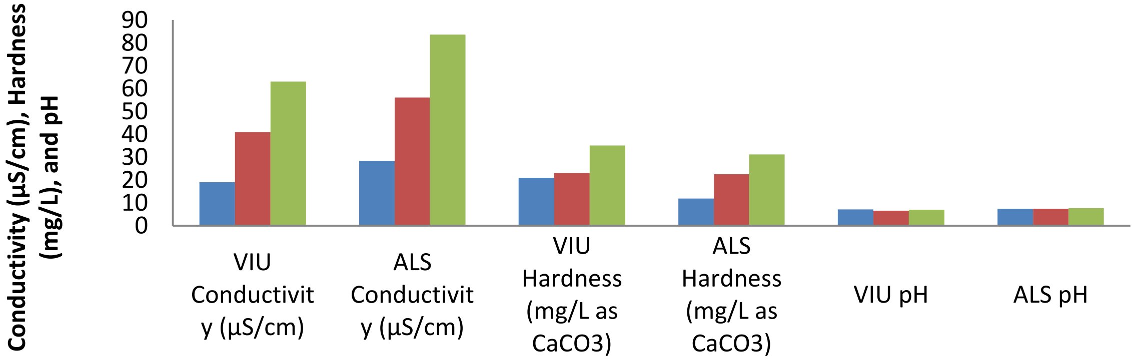
pH levels lowered slightly (becoming more acidic) from Station 1 to Station 2, but then reached its highest level (and more alkaline) on Station 4. This pattern was repeated on both sampling events and the maximum variation in the pH levels was of 0.3 during the second event. pH varied from 7.39 (Station 2) to 7.55 (Station 4) during the first sampling event and 7.31 to 7.61 (also from Stations 2 to 4, respectively). All pH levels were well within the aquatic life criteria of 6.5-9.0 (MELP, 1998).

Figures 10 and 11 isolates ALS physical parameters results and presents them alongside VIU results for the same parameters.



	VIU Conductivity (µS/cm)	ALS Conductivity (µS/cm)	VIU Hardness (mg/L as CaCO3)	ALS Hardness (mg/L as CaCO3)	VIU pH	ALS pH
Station 1	26	32,1	18	13,2	7,1	7,43
Station 2	50	58,6	28	24,5	6,8	7,39
Station 4	69	79,5	39	29,4	6,9	7,55

Figure 9. Graph and table showing the physical parameters results from ALS and VIU for the first sampling event of the Millstone River.



	VIU Conductivity (µS/cm)	ALS Conductivity (µS/cm)	VIU Hardness (mg/L as CaCO3)	ALS Hardness (mg/L as CaCO3)	VIU pH	ALS pH
Station 1	19	28,4	21	11,9	7,1	7,38
Station 2	41	56	23	22,5	6,6	7,31
Station 4	63	83,6	35	31,1	6,9	7,61

Figure 10. Graph and table showing the physical parameters results from ALS and VIU for the second sampling event of the Millstone River.

As illustrated in figures 10 and 11, the trends presented for each physical analysis are the same for ALS and VIU methods. ALS analyses yielded higher results for conductivity, lower results for hardness, and higher results for pH. Such pattern is consistent on both sampling events, which can be viewed as evidence of the quality assurance and control methods taken in place during sampling.

ANIONS AND NUTRIENTS

Ammonia results were below detection limits in Station 1 on both sampling events and had its highest level of 0.0174 at Station 4 on the second event. All results were well under the guidelines, which postulate that the maximum concentration of ammonia should not exceed 19.7 mg/L, and the average over 30-days should not exceed 1.77 mg/L at pH 7 and water temperature of 15°C. At 0°C, these values would be 23.2 mg/L and 2.08 mg/l, respectively. Therefore, the obtained results for ammonia are below the (temperature and pH dependant) maximum range of 19.7 to 23.2 mg/L.

Nitrate increased as the Millstone River flows downstream in both sampling events. The second sampling event had higher concentrations of Nitrate in comparison to the first event, with the exception of Station 1. The first sampling event results ranged from 0.0749 to 0.222 while the results for the second sampling event went from 0.0683 to 0.248 mg/L (as N). The Nitrate criteria stablished by guidelines for aquatic life is a maximum of 200 mg/L and average of 40 mg/L, which are significantly above the results observed in the Millstone River.

Nitrite is represented in its highest concentration at Station 2, during the first sampling event at 0.0023 mg/L, below the guideline maximum of 0.06 mg/L (as N, at a chloride concentration lesser than 2 mg/L). During the second sampling event, Nitrite is only present above the detection limit levels at Station 4 at 0.0019 mg/L.

Total nitrogen does not have applicable guidelines to quantify harmful concentrations. This parameter increased in similar increments from Stations 1 to 4 during both sampling events, since the attained results are alike, although there is a slightly higher concentration in Station 1 during the late-October sampling event. Results ranged from 0.153 (Station 1, first sampling event) to 0.498 (Station 4, second sampling event).

High concentrations of orthophosphate generally occur in conjunction with algal blooms, since this form of phosphorus is the most readily available for uptake during photosynthesis. Orthophosphate was only identified above detection limits at Station 4, during the first sampling event and Stations 2 and 4, during the second sampling event. No trend could be identified based on these results, except that concentrations increased at Station 4, from 0.0023 to 0.0052 mg/L (as P), from the first to the second sampling event.

Total phosphorous can be viewed as the limiting factor that halts extreme proliferation of algal growth. Therefore, its concentration can indicate eutrophication of a water body. During both sampling events, total phosphorous increased in concentration downstream and presented higher concentrations during the second sampling event (except at Station 2). Concentrations ranged from 0.0024 to 0.0092 mg/L during the first sampling event and 0.0032 to 0.00137 mg/L. The Millstone River can be categorized as oligotrophic, provided that none of the results were equal or greater than 0.10 mg/L (as P).

TOTAL METALS

With the exception of aluminum and calcium, all other metals tested were either bellow detection limits or below the maximum allowable guideline values, when applicable. Aluminum was only present above the detection limit, thus also above the guideline maximum (since its detection limit is already above the guidelines, as discussed previously), at Station 4, during the second sampling event. This aluminum contamination does not come as a surprise as it has been recorded during seven out of the eight years of this monitoring project, and the highest concentrations are usually found at the side channel as well. However, the observed concentrations of aluminum were only slightly above the water quality guideline, and aluminum is not considered a serious threat to aquatic life, except in areas of acidic inputs, which is not the case, given that Station 4 presented moderate to low sensitivity to acidification (Demers, 2016). This low acidification sensitivity around Station 4 is further corroborated by the detected levels of calcium. In both sampling events, calcium was found to increase gradually downstream. According to the guidelines, Station 1 would be highly sensitive to acidification, as its calcium concentrations were below 4 mg/L (as Ca), Station 2 has moderate acidification sensitivity, and Station 4 shows low sensitivity to acidic inputs, traits reiterated during both sampling events. This trend matches our alkalinity findings for the Millstone River.

Quality Assurance/Quality Control

In order to guarantee the "continuity of evidence" and tracking of the samples, a Chain of Custody (Appendix B) was filled out for all samples sent to the ALS laboratory. These forms have been signed by the recipient, indicating that the date and time the samples were received, documenting that the samples were within the recommended hold time and preservatives expiration.

For the analyses that were made in the VIU laboratory, replicates taken from Station 2, during the first sampling event, and Station 3, during the second sampling event, were submitted to the same procedures as the other samples. No abnormalities were observed for the replicates results, which displayed minimal fluctuations compared to their analogue samples. A trip blank for each sampling event was also analysed for Nitrate and Phosphate. As expected, they presented very low concentrations for both substances, proving cross-contamination of samples did not occur.

Stream Invertebrates Communities

Total Density

Results of the invertebrate diversity were acceptable but not optimal. After counting the invertebrates for the duck pond outlet, 20 pollution intolerant organisms were found, 117 somewhat tolerant organisms, and 13 pollution tolerant specimens. After using the invertebrate survey interpretation sheet (appendix A), it was shown that the duck pond composite sample have an overall site assessment rating of 2 (actually, 1.75 average rating) out of 4 which indicates marginal conditions. Nonetheless, this area contained higher diversity than the other area sampled. For the area downstream to the foot bridge, 132 somewhat pollution tolerant organisms were found, no pollution intolerant nor pollution tolerant organisms were found. After using the calculations on the same interpretation sheet, this site was determined to be a 1 out of 4 on the overall assessment scale, indicating poor health (Tacogna & Munro, 1995).

Taxon Richness

Tables 7 and 8 list the results discussed in the previous section, which are further illustrated by figures 11 and 12, showing the proportion of stream invertebrates found at each subarea. According to the Streamkeepers Handbook (1995), a low diversity of stream invertebrates with high numbers correlates to organic enrichment/pollution or eutrophication, which makes sense when considering these samples were taken from a urban park and in proximity to a duck pond.

Table 7. Taxon richness from "Foot bridge" subarea at Station 4, sampled on October 30, 2016.

Common name	Pollution tolerance	Number counted	Number of Taxa
Aquatic Beetle	Somewhat tolerant	1	1
Amphipod	Somewhat tolerant	131	1
Total		132	2

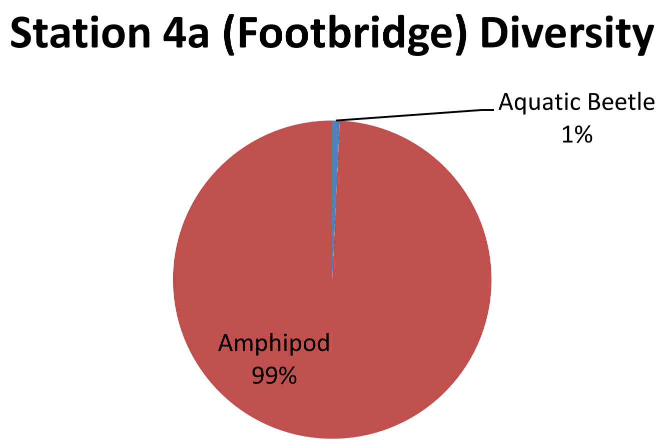


Figure 11. Taxon richness from "Foot bridge" subarea at Station 4, sampled on October 30, 2016.

Table 8. Taxon richness from "duck pond outlet" subarea at Station 4, sampled on October 30, 2016.

Common name	Pollution tolerance	Number counted	Number of taxa
Mayfly Nymph	Intolerant	20	2
Crayfish	Somewhat tolerant	1	1
Amphipod	Somewhat tolerant	116	3
Aquatic Worm	Tolerant	10	2
Water Mite	Tolerant	3	1
Total		150	9

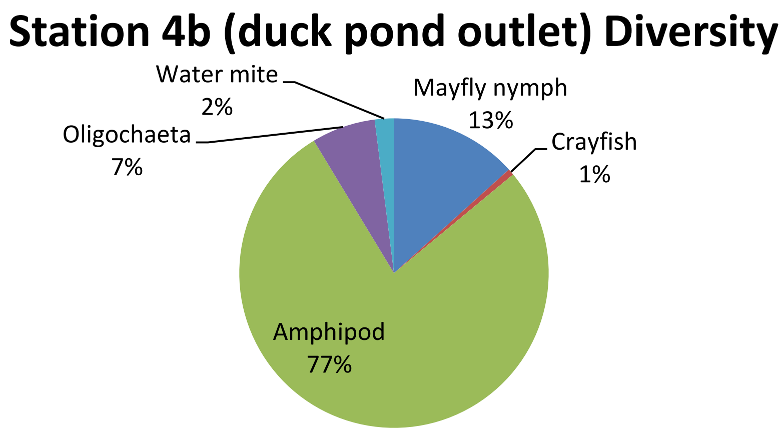


Figure 12. Taxon richness from "duck pond outlet" subarea at Station 4, sampled on October 30, 2016.

The Shannon-Weiner Diversity Index was calculated for each composite sample in order to demonstrate the species diversity for each sub location of Station 4 ("foot bridge" and "duck pond outlet"). The diversity index for the "foot bridge" sampling site was 0.064 versus 0.472 for the "duck pond outlet" site. The index takes into account the proportions of each taxon in the sample, thus the higher the value achieved, the higher the diversity of taxa. Therefore, the "duck pond outlet" sampling site presents the higher stream invertebrates diversity.

Quality Assurance/Quality Control

Calculations for the Shannon-Weiner diversity index and for the overall site assessments were peer-reviewed by the authors. Four replicates were taken from each subarea around Station 4 to form two composite samples, ensuring a better representation of river conditions, given the habitat specificity and high sampling variability of stream invertebrates.

CONCLUSION AND RECOMMENDATIONS

The overall environmental water quality for the Millstone River was proven to be "acceptable", as already identified in the previous eight years of ongoing monitoring (Demers, 2016). The results of the invertebrate collection determined that even organisms in the most sensitive orders and families were able to survive in the Millstone. Spawning Chum (*Oncorhynchus keta*) were present in the channel downstream from the duck pond. The water quality results indicated that the water certainly is not potable, although it is suitable to aquatic life, since no serious deficiency in water quality parameters were observed. A slight aluminum contamination has been detected at Station 4, consistent to the results from previous studies; however, the contamination levels and the nature of the substance do not request for immediate action.

There are a few recommendations to this project that could be implemented in upcoming years, if possible. Although this October had an unprecedented amount of rain, if invertebrate sampling was done earlier in the fall perhaps more sites would be able to be safely sampled. It would also be interesting to examine how the penitentiary close to Brannen Lake (and Station 2) treat their wastewater, to determine if the sudden increase in fecal coliform presence at that point is solely a consequence of the lake's effluent. A side project could be developed inside Bowen Park in order to pinpoint the source of the alumin contamination identified in the side channel. We hope to see this project continue with similar sampling methods in the future as it is a valuable project for both the students to learn and practice environmental monitoring techniques as well as for the organizations that might rely on these results.

ACKNOWLEDGEMENTS

The authors of this report would like to thank professor Dr. Eric Demers for providing the materials and instructions for completing the required activities, Vancouver Island University for the use of its facilities to complete the laboratory analysis of this project. We would also like to thank the Department of Fisheries and Oceans Canada for the funding that made professional water quality analysis possible by the ALS laboratory, which generously offered discounted analytical procedures. Lastly, we would like to acknowledge the Snuneymuxw first nation for allowing us to use their land for educational purposes.

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Appendix

APPENDIX A. INVERTEBRATE SURVEY FIELD DATA SHEETS

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Millstone		Date: Oct 29
Station Name: 4a - downstream fr. curved foot bridge		Flow status:
Sampler Used: Hess	Number of replicates 4	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.09 x 4 = 0.36 m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	EPT1	EPT4
	Mayfly Nymph (EPT)	EPT2	EPT5
	Stonefly Nymph (EPT)	EPT3	EPT6
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 0	D1 0
Category 2	Alderfly Larva		
	Aquatic Beetle	1	1
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
	Crayfish		
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	131	1
	Watersnipe Larva		
Sub-Total		C2 132	D2 2
Category 3	Aquatic Worm (oligochaete)		
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
Pollution Tolerant	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite		
Sub-Total		C3 0	D3 0
TOTAL		CT 132	DT 2

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell CT:

S1: 132

DENSITY: Invertebrate density per total area sampled:

S1: 132 ÷ 0.36 m^2 = S2: 366.666 /m^2

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (Col. C)

S3: 1 31

SECTION 2 - WATER QUALITY ASSESSMENTS

POLLUTION TOLERANCE INDEX: Sub-total number of taxa found in each tolerance category.

Good	Acceptable	Marginal	Poor
>22	17-22	11-16	[illegible]

3 x D1 + 2 x D2 + D3

3 x 0 + 2 x 1 + 0 = S4: 2

EPT INDEX: Total number of EPT taxa.

Good	Acceptable	Marginal	Poor
>8	5-8	2-4	0-1

EPT4 + EPT5 + EPT6

0 + 0 + 0 = S5: Ø

EPT TO TOTAL RATIO INDEX: Total number of EPT organisms divided by the total number of organisms.

Good	Acceptable	Marginal	Poor
0.75-1.0	0.50-0.74	0.25-0.49	<0.25

(EPT1 + EPT2 + EPT3) / CT

(0 + 0 + Ø) / 132 = S6: Ø

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell DT:

S7: 2

PREDOMINANT TAXON RATIO INDEX: Number of invertebrate in the predominant taxon (S3) divided by CT.

Good	Acceptable	Marginal	Poor
<0.40	0.40-0.59	0.60-0.79	0.80-1.0

Col. C for S3 / CT

131 / 132 = S8: 0.9924

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S4, S5, S6, S8), then calculate the average.

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

Assessment	Rating
Pollution Tolerance Index	R1 1
EPT Index	R2 1
EPT To Total Ratio	R3 1
Predominant Taxon Ratio	R4 1

Average Rating
Average of R4, R5, R6, R8
1

INVERTEBRATE SURVEY FIELD DATA SHEET (Page 1 of 2)

Stream Name: Millstone		Date: 2016/10/29
Station Name: 4b - Duck Pond outlet		Flow status: High Flow
Sampler Used: Hess	Number of replicates 4	Total area sampled (Hess, Surber = 0.09 m^2) x no. replicates 0.36 m^2

Column A Pollution Tolerance	Column B Common Name	Column C Number Counted	Column D Number of Taxa
Category 1	Caddisfly Larva (EPT)	EPT1	EPT4
	Mayfly Nymph (EPT)	EPT2 20	EPT5 2
	Stonefly Nymph (EPT)	EPT3	EPT6
	Dobsonfly (hellgrammite)		
Pollution Intolerant	Gilled Snail		
	Riffle Beetle		
	Water Penny		
Sub-Total		C1 20	D1 2
Category 2	Alderfly Larva		
	Aquatic Beetle		
	Aquatic Sowbug		
	Clam, Mussel		
	Cranefly Larva		
	Crayfish	1	1
Somewhat Pollution Tolerant	Damselfly Larva		
	Dragonfly Larva		
	Fishfly Larva		
	Amphipod (freshwater shrimp)	116	3
	Watersnipe Larva		
Sub-Total		C2 117	D2 4
Category 3	Aquatic Worm (oligochaete)	10	2
	Blackfly Larva		
	Leech		
	Midge Larva (chironomid)		
Pollution Tolerant	Planarian (flatworm)		
	Pouch and Pond Snails		
	True Bug Adult		
	Water Mite	3	1
Sub-Total		C3 13	D3 3
TOTAL		CT 150	DT 9

INVERTEBRATE SURVEY INTERPRETATION SHEET (Page 2 of 2)

SECTION 1 - ABUNDANCE AND DENSITY

ABUNDANCE: Total number of organisms from cell CT: **S1** 150

DENSITY: Invertebrate density per total area sampled:

S1 150 ÷ 0.36 m^2 = **S2** 416.66 $/m^2$

PREDOMINANT TAXON:

Invertebrate group with the highest number counted (Col. C) **S3** 116

SECTION 2 - WATER QUALITY ASSESSMENTS

POLLUTION TOLERANCE INDEX: Sub-total number of taxa found in each tolerance category.

Good	Acceptable	Marginal	Poor
>22	17-22	(11-16)	[illegible]

3 x D1 + 2 x D2 + D3

3 x 2 + 2 x 4 + 3 = **S4** 11

EPT INDEX: Total number of EPT taxa.

Good	Acceptable	Marginal	Poor
>8	5-8	(2-4)	0-1

EPT4 + EPT5 + EPT6

0 + 2 + 0 = **S5** 2

EPT TO TOTAL RATIO INDEX: Total number of EPT organisms divided by the total number of organisms.

Good	Acceptable	Marginal	Poor
0.75-1.0	0.50-0.74	0.25-0.49	(<0.25)

(EPT1 + EPT2 + EPT3) / CT

(0 + 20 + 0) / 150 = **S6** .13

SECTION 3 - DIVERSITY

TOTAL NUMBER OF TAXA: Total number of taxa from cell DT: **S7** 9

PREDOMINANT TAXON RATIO INDEX: Number of invertebrate in the **predominant taxon** (S3) divided by CT.

Good	Acceptable	Marginal	Poor
<0.40	0.40-0.59	(0.60-0.79)	0.80-1.0

Col. C for S3 / CT

116 / 150 = **S8** .77

SECTION 4 - OVERALL SITE ASSESSMENT RATING

SITE ASSESSMENT RATING: Assign a rating of 1-4 to each index (S4, S5, S6, S8), then calculate the average.

Assessment Rating	
Good	4
Acceptable	3
Marginal	2
Poor	1

Assessment	Rating
Pollution Tolerance Index	R1 2
EPT Index	R2 2
EPT To Total Ratio	R3 1
Predominant Taxon Ratio	R4 2

Average Rating
Average of R4, R5, R6, R8
7/4 = 1.75

APPENDIX B. ALS LABORATORY CHAINS OF CUSTODY

Sample Receipt Confirmation

Report Distribution:

Company Name: Vancouver Island University
Contact: Eric Demers
Address: Nanaimo Campus, 900 Fifth Street
Nanaimo, BC, V9R 5S5
Phone: 250-753-3245
Fax: 250-740-6482
Email: eric.demers@viu.ca
EDD Email: --
Distribution: Hard Copy: Y Email: Y Fax: N EDD: N

Invoice Distribution:

Acct Name: Vancouver Island University
Contact: Accounts Payable
Address: Nanaimo Campus, 900 Fifth Street
Nanaimo, BC, V9R 5S5
Phone: --
Fax: --
Invoice Email: --
Project #: N/A
Account #: MAL100

Client Information:

Job Reference #: ENVIRONMENTAL MONITORING COURSE
Project PO #:
Legal Site Description: N/A
Quote #: N/A
Date Sampled: 29-OCT-16
Date Received: 04-NOV-16
Sampled By: Students
Chain Of Custody: --

Workorder Summary:

Lab Work Order #: L1853599
Estimated completion date: 14-NOV-16
15 Samples received at ALS in VANCOUVER
Client Job #: ENVIRONMENTAL MONITORING COUF
Account Manager: Amber Springer, B.Sc
Estimated sample disposal date: See Sample Disposal Information section below.

Lab Sample ID	Client Sample ID	Date Sampled	Date Received	Sample Due Date	Priority Flag	Sample Type
L1853599-1	RICHARDS CREEK- STATION 2	29-OCT-16 12:13	04-NOV-16 08:20	14-NOV-16		Surface Water
L1853599-2	RICHARDS CREEK- STATION 3	29-OCT-16 11:20	04-NOV-16 08:20	14-NOV-16		Surface Water
L1853599-3	RICHARDS CREEK- STATION 4	29-OCT-16 10:35	04-NOV-16 08:20	14-NOV-16		Surface Water
L1853599-4	COTTLE CREEK- STATION 1	02-NOV-16 15:00	04-NOV-16 08:20	14-NOV-16		Surface Water
L1853599-5	COTTLE CREEK- STATION 2	02-NOV-16 15:00	04-NOV-16 08:20	14-NOV-16		Surface Water
L1853599-6	COTTLE CREEK- STATION 4	02-NOV-16 15:00	04-NOV-16 08:20	14-NOV-16		Surface Water
L1853599-7	MILLSTONE RIVER - STATION 1	30-OCT-16 09:00	04-NOV-16 08:20	14-NOV-16		Surface Water
L1853599-8	MILLSTONE RIVER - STATION 2	30-OCT-16 09:00	04-NOV-16 08:20	14-NOV-16		Surface Water
L1853599-9	MILLSTONE RIVER - STATION 4	30-OCT-16 09:00	04-NOV-16 08:20	14-NOV-16		Surface Water
L1853599-10	ENGLISHMAN RIVER - STATION 1	31-OCT-16 14:00	04-NOV-16 08:20	14-NOV-16		Surface Water
L1853599-11	ENGLISHMAN RIVER - STATION 2	31-OCT-16 14:00	04-NOV-16 08:20	14-NOV-16		Surface Water
L1853599-12	ENGLISHMAN RIVER - STATION 4	31-OCT-16 14:00	04-NOV-16 08:20	14-NOV-16		Surface Water
L1853599-13	DEPARTURE CREEK- STATION 1	02-NOV-16 09:00	04-NOV-16 08:20	14-NOV-16		Surface Water
L1853599-14	DEPARTURE CREEK- STATION 3	02-NOV-16 09:00	04-NOV-16 08:20	14-NOV-16		Surface Water
L1853599-15	DEPARTURE CREEK- STATION 4	02-NOV-16 09:00	04-NOV-16 08:20	14-NOV-16		Surface Water

Analysis Requested :

	Hardness	Total Metals in Water by ICPOES	Total Nitrogen in water by Colour	Ammonia in Water by Fluorescence	Nitrite in Water by IC [Low Level]	Nitrate in Water by IC [Low Level]	Total P in Water by Colour	Conductivity [Automated]	pH by Meter [Automated]	Diss. Orthophosphate in Water by Colour	Sample Handling and Disposal Fee
RICHARDS CREEK-STATION 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
RICHARDS CREEK-STATION 3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
RICHARDS CREEK-STATION 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
COTTLE CREEK-STATION 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
COTTLE CREEK-STATION 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
COTTLE CREEK-STATION 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MILLSTONE RIVER - STATION 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MILLSTONE RIVER - STATION 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MILLSTONE RIVER - STATION 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ENGLISHMAN RIVER - STATION 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ENGLISHMAN RIVER - STATION 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ENGLISHMAN RIVER - STATION 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DEPARTURE CREEK-STATION 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DEPARTURE CREEK-STATION 3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DEPARTURE CREEK-STATION 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Hold Time Exceedences:

The following samples have exceeded recommended holding times prior to sample receipt.

Analysis Requested	Lab Sample ID	Recommended Hold Time	Date Sampled	Date Received
Diss. Orthophosphate in Water by C	L1853599-1, 2, 3	3 days	29-OCT-16	04-NOV-16
Diss. Orthophosphate in Water by C	L1853599-7, 8, 9	3 days	30-OCT-16	04-NOV-16
Diss. Orthophosphate in Water by C	L1853599-10, 11, 12	3 days	31-OCT-16	04-NOV-16
Nitrate in Water by IC (Low Level)	L1853599-1, 2, 3	3 days	29-OCT-16	04-NOV-16
Nitrate in Water by IC (Low Level)	L1853599-7, 8, 9	3 days	30-OCT-16	04-NOV-16
Nitrate in Water by IC (Low Level)	L1853599-10, 11, 12	3 days	31-OCT-16	04-NOV-16

Hold Time Exceedences:

Analysis Requested	Lab Sample ID	Recommended Hold Time	Date Sampled	Date Received
Nitrite in Water by IC (Low Level)	L1853599-1, 2, 3	3 days	29-OCT-16	04-NOV-16
Nitrite in Water by IC (Low Level)	L1853599-7, 8, 9	3 days	30-OCT-16	04-NOV-16
Nitrite in Water by IC (Low Level)	L1853599-10, 11, 12	3 days	31-OCT-16	04-NOV-16
pH by Meter (Automated)	L1853599-1, 2, 3	0.25 hours	29-OCT-16	04-NOV-16
pH by Meter (Automated)	L1853599-7, 8, 9	0.25 hours	30-OCT-16	04-NOV-16
pH by Meter (Automated)	L1853599-10, 11, 12	0.25 hours	31-OCT-16	04-NOV-16
pH by Meter (Automated)	L1853599-4, 5, 6, 13, 14, 15	0.25 hours	02-NOV-16	04-NOV-16

Sample Integrity Observations:
No observations were identified for this work order submission.

Sample Disposal Information:

Where possible, ALS will store samples for 30 days from the date a final report is issued, or 30 days from the date samples are placed on hold without analytical requests, after which samples may be discarded. Air samples collected on re-usable media are an exception, and are stored for 7 days from the date a final report is issued. Longer storage times are available upon request.

For information about ALS accreditations and certifications please contact your Account Manager or visit our webpage at www.alsglobal.com (see Canada downloads).

ALS Group strives to deliver on-time results to our clients at all times. However, there are times when due to capacity issues or other unforeseen circumstances we are unable to meet our expected turnaround times. The information above is related to a recent workorder you have submitted to our laboratory. In the event that you have an inquiry, please refer to the Lab Work Order # when calling your Account Manager.

ALS Group appreciates your business. Thank you for the opportunity to work with you.

ALS En

Short Holding Time

0 *Rush Processing*

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC # ____________

Report To	
Company:	Vancouver Island University
Contact:	Eric Demers
Address:	900 Fifth Street
	Nanaimo
Phone:	250-753-3245 Fax: 250-740-6482
Invoice To	Same as Report ? ☑ Yes ☐ No
Hardcopy of Invoice with Report?	☐ Yes ☑ No
Company:	
Contact:	
Address:	
Phone:	
Lab Work Order # (lab use only)	L1853599-COFC

Report Format / Distribution	
☐ Standard ☐ Other	
☑ PDF ☑ Excel ☐ Digital ☐ Fax	
Email 1:	eric.demers@viu.ca
Email 2:	
Email 3:	
Client / Project Information	
Job #:	Environmental Monitoring Course
PO / AFE:	
LSD:	
Quote #:	
ALS Contact:	Amber Springer
Sampler:	Students

Service Requested (Rush for routine analysis subject to availability)

- ● Regular (Standard Turnaround Times - Business Days)
- ○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
- ○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
- ○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	GENERAL PARAMETERS	NUTRIENTS (P)	TOTAL METALS (P)										Number of Containers
	Richards Creek - Station 2	29-Oct-16	12:13	Surface Water	X	X	X										3
	Richards Creek - Station 3	29-Oct-16	11:20	Surface Water	X	X	X										3
	Richards Creek - Station 4	29-Oct-16	10:35	Surface Water	X	X	X										3
	Cottle Creek - Station 1	02-Nov-15	15:00	Surface Water	X	X	X										3
	Cottle Creek - Station 2	02-Nov-15	15:00	Surface Water	X	X	X										3
	Cottle Creek - Station 4	02-Nov-15	15:00	Surface Water	X	X	X										3
	Millstone River - Station 1	30-Oct-16	9:00	Surface Water	X	X	X										3
	Millstone River - Station 2	30-Oct-16	9:00	Surface Water	X	X	X										3
	Millstone River - Station 4	30-Oct-16	9:00	Surface Water	X	X	X										3
	Englishman River - Station 1	31-Oct-16	14:00	Surface Water	X	X	X										3
	Englishman River - Station 2	31-Oct-16	14:00	Surface Water	X	X	X										3
	Englishman River - Station 4	31-Oct-16	14:00	Surface Water	X	X	X										3

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Detection limits: ammonia [MDL = 0.005 mg/L], nitrite [MDL = 0.001 mg/L], orthophosphate [MDL = 0.001 mg/L], total phosphorus [MDL = 0.002 mg/L], total nitrogen.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Eric Demers	2-Nov-15	19:00	JC	NOV - 4 2016	8:20 am	10 °C				

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC #

Report To
Company: Vancouver Island University
Contact: Eric Demers
Address: 900 Fifth Street
Nanaimo
Phone: 250-753-3245 Fax: 250-740-6482

Invoice To Same as Report ? ☑ Yes ☐ No
Hardcopy of Invoice with Report? ☐ Yes ☑ No
Company:
Contact:
Address:
Phone:

L1853599-COFC

Report Format / Distribution
☐ Standard ☐ Other
☑ PDF ☑ Excel ☐ Digital ☐ Fax
Email 1: eric.demers@viu.ca
Email 2:
Email 3:

Client / Project Information
Job #: Environmental Monitoring Course
PO / AFE:
LSD:
Quote #:
ALS Contact: Amber Springer
Sampler: Students

Service Requested (Rush for routine analysis subject to availability)
● Regular (Standard Turnaround Times - Business Days)
○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT

Analysis Request
Please indicate below Filtered, Preserved or both (F, P, F/P)

Lab Work Order # (lab use only) / Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	GENERAL PARAMETERS	NUTRIENTS (P)	TOTAL METALS (P)	Number of Containers
	Departure Creek - Station 1	02-Nov-16	9:00	Surface Water	X	X	X	3
	Departure Creek - Station 3	02-Nov-16	9:00	Surface Water	X	X	X	3
	Departure Creek - Station 4	02-Nov-16	9:00	Surface Water	X	X	X	3

Short Holding Time
Rush Processing

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Detection limits: ammonia [MDL = 0.005 mg/L], nitrite [MDL = 0.001 mg/L], orthophosphate [MDL = 0.001 mg/L], total phosphorus [MDL = 0.002 mg/L], total nitrogen.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.
By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.
Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Eric Demers	Date (dd-mmm-yy): 2-Nov-15	Time (hh-mm): 19:00	Received by: JC	Date: NOV - 4 2016	Time: 8:20am	Temperature: 10 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

Sample Receipt Confirmation

Report Distribution:

Company Name: Vancouver Island University
Contact: Eric Demers
Address: Nanaimo Campus, 900 Fifth Street
Nanaimo, BC, V9R 5S5
Phone: 250-753-3245
Fax: 250-740-6482
Email: eric.demers@viu.ca
EDD Email: --
Distribution: Hard Copy: Y Email: Y Fax: N EDD: N

Invoice Distribution:

Acct Name: Vancouver Island University
Contact: Accounts Payable
Address: Nanaimo Campus, 900 Fifth Street
Nanaimo, BC, V9R 5S5
Phone: --
Fax: --
Invoice Email: --
Project #: N/A
Account #: MAL100

Client Information:

Job Reference #: ENVIRONMENTAL MONITORING COURSE
Project PO #:
Legal Site Description: N/A
Quote #: N/A
Date Sampled: 21-NOV-16
Date Received: 25-NOV-16
Sampled By: STUDENTS
Chain Of Custody: --

Workorder Summary:

Lab Work Order #: **L1862835**
Estimated completion date: 02-DEC-16
15 Samples received at ALS in **VANCOUVER**
Client Job #: ENVIRONMENTAL MONITORING COUF
Account Manager: Amber Springer, B.Sc
Estimated sample disposal date: See Sample Disposal Information section below.

Lab Sample ID	Client Sample ID	Date Sampled	Date Received	Sample Due Date	Priority Flag	Sample Type
L1862835-1	RICHARDS CREEK - STATION 2	21-NOV-16 14:30	25-NOV-16 14:50	02-DEC-16		SURFACE WATER
L1862835-2	RICHARDS CREEK - STATION 3	21-NOV-16 14:30	25-NOV-16 14:50	02-DEC-16		SURFACE WATER
L1862835-3	RICHARDS CREEK - STATION 4	21-NOV-16 14:30	25-NOV-16 14:50	02-DEC-16		SURFACE WATER
L1862835-4	COTTLE CREEK - STATION 1	23-NOV-16 13:00	25-NOV-16 14:50	02-DEC-16		SURFACE WATER
L1862835-5	COTTLE CREEK - STATION 2	23-NOV-16 13:00	25-NOV-16 14:50	02-DEC-16		SURFACE WATER
L1862835-6	COTTLE CREEK - STATION 4	23-NOV-16 13:00	25-NOV-16 14:50	02-DEC-16		SURFACE WATER
L1862835-7	MILLSTONE RIVER - STATION 1	21-NOV-16 12:20	25-NOV-16 14:50	02-DEC-16		SURFACE WATER
L1862835-8	MILLSTONE RIVER - STATION 2	21-NOV-16 12:35	25-NOV-16 14:50	02-DEC-16		SURFACE WATER
L1862835-9	MILLSTONE RIVER - STATION 4	21-NOV-16 13:20	25-NOV-16 14:50	02-DEC-16		SURFACE WATER
L1862835-10	ENGLISHMAN RIVER - STATION 1	21-NOV-16 14:00	25-NOV-16 14:50	02-DEC-16		SURFACE WATER
L1862835-11	ENGLISHMAN RIVER - STATION 2	21-NOV-16 14:00	25-NOV-16 14:50	02-DEC-16		SURFACE WATER
L1862835-12	ENGLISHMAN RIVER - STATION 4	21-NOV-16 14:00	25-NOV-16 14:50	02-DEC-16		SURFACE WATER
L1862835-13	DEPARTURE CREEK - STATION 1	23-NOV-16 09:00	25-NOV-16 14:50	02-DEC-16		SURFACE WATER
L1862835-14	DEPARTURE CREEK - STATION 3	23-NOV-16 09:00	25-NOV-16 14:50	02-DEC-16		SURFACE WATER
L1862835-15	DEPARTURE CREEK - STATION 4	23-NOV-16 09:00	25-NOV-16 14:50	02-DEC-16		SURFACE WATER

Analysis Requested :	Hardness	Total Metals in Water by ICPOES	Total Nitrogen in water by Colour	Ammonia in Water by Fluorescence	Nitrite in Water by IC [Low Level]	Nitrate in Water by IC [Low Level]	Total P in Water by Colour	Conductivity [Automated]	pH by Meter [Automated]	Diss. Orthophosphate in Water by Colour	Sample Handling and Disposal Fee
RICHARDS CREEK - STATION 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
RICHARDS CREEK - STATION 3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
RICHARDS CREEK - STATION 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
COTTLE CREEK - STATION 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
COTTLE CREEK - STATION 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
COTTLE CREEK - STATION 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MILLSTONE RIVER - STATION 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MILLSTONE RIVER - STATION 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MILLSTONE RIVER - STATION 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ENGLISHMAN RIVER - STATION 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ENGLISHMAN RIVER - STATION 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ENGLISHMAN RIVER - STATION 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DEPARTURE CREEK - STATION 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DEPARTURE CREEK - STATION 3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DEPARTURE CREEK - STATION 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Hold Time Exceedences:

The following samples have exceeded recommended holding times prior to sample receipt.

Analysis Requested	Lab Sample ID	Recommended Hold Time	Date Sampled	Date Received
Diss. Orthophosphate in Water by C	L1862835-1, 2, 3, 7, 8, 9, 10, 11, 12	3 days	21-NOV-16	25-NOV-16
Nitrate in Water by IC (Low Level)	L1862835-1, 2, 3, 7, 8, 9, 10, 11, 12	3 days	21-NOV-16	25-NOV-16
Nitrite in Water by IC (Low Level)	L1862835-1, 2, 3, 7, 8, 9, 10, 11, 12	3 days	21-NOV-16	25-NOV-16
pH by Meter (Automated)	L1862835-1, 2, 3, 7, 8, 9, 10, 11, 12	0.25 hours	21-NOV-16	25-NOV-16

Hold Time Exceedences:

Analysis Requested	Lab Sample ID	Recommended Hold Time	Date Sampled	Date Received
pH by Meter (Automated)	L1862835-4, 5, 6, 13, 14, 15	0.25 hours	23-NOV-16	25-NOV-16

Sample Integrity Observations:

No observations were identified for this work order submission.

Sample Disposal Information:

Where possible, ALS will store samples for 30 days from the date a final report is issued, or 30 days from the date samples are placed on hold without analytical requests, after which samples may be discarded. Air samples collected on re-usable media are an exception, and are stored for 7 days from the date a final report is issued. Longer storage times are available upon request.

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ALS Group strives to deliver on-time results to our clients at all times. However, there are times when due to capacity issues or other unforeseen circumstances we are unable to meet our expected turnaround times. The information above is related to a recent workorder you have submitted to our laboratory. In the event that you have an inquiry, please refer to the Lab Work Order # when calling your Account Manager.

ALS Group appreciates your business. Thank you for the opportunity to work with you.

ALS

Short Holding Time

Rush Processing

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC #

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Vancouver Island University	☐ Standard ☐ Other	● Regular (Standard Turnaround Times - Business Days)
Contact:	Eric Demers	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	900 Fifth Street	Email 1: eric.demers@viu.ca	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Nanaimo	Email 2:	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	250-753-3245 Fax: 250-740-6482	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☐ Yes ☑ No	Job #: Environmental Monitoring Course	
Company:		PO / AFE:	
Contact:		LSD:	
Address:			
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		ALS Contact: Amber Springer / Sampler: Students	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	GENERAL PARAMETERS	NUTRIENTS (P)	TOTAL METALS (P)									Number of Containers
	Richards Creek - Station 2	21-Nov-16	14:30	Surface Water	X	X	X									3
	Richards Creek - Station 3	21-Nov-16	14:30	Surface Water	X	X	X									3
	Richards Creek - Station 4	21-Nov-16	14:30	Surface Water	X	X	X									3
	Cottle Creek - Station 1	23-Nov-16	13:00	Surface Water	X	X	X									3
	Cottle Creek - Station 2	23-Nov-16	13:00	Surface Water	X	X	X									3
	Cottle Creek - Station 4	23-Nov-16	13:00	Surface Water	X	X	X									3
	Millstone River - Station 1	21-Nov-16	12:20	Surface Water	X	X	X									3
	Millstone River - Station 2	21-Nov-16	12:35	Surface Water	X	X	X									3
	Millstone River - Station 4	21-Nov-16	13:20	Surface Water	X	X	X									3
	Englishman River - Station 1	21-Nov-16	14:00	Surface Water	X	X	X									3
	Englishman River - Station 2	21-Nov-16	14:00	Surface Water	X	X	X									3
	Englishman River - Station 4	21-Nov-16	14:00	Surface Water	X	X	X									3

L1862835-COFC

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Detection limits: ammonia [MDL = 0.005 mg/L], nitrite [MDL = 0.001 mg/L], orthophosphate [MDL = 0.001 mg/L], total phosphorus [MDL = 0.002 mg/L], total nitrogen.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.
By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.
Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Eric Demers	Date (dd-mmm-yy) 23-Nov-16	Time (hh-mm) 17:30	Received by: JC	Date: NOV 25 2016	Time: 14:50	Temperature: 9 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

GENF 18.01 Front

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # ____________

Report To	
Company:	Vancouver Island University
Contact:	Eric Demers
Address:	900 Fifth Street
	Nanaimo
Phone:	250-753-3245 Fax: 250-740-6482
Invoice To	Same as Report ? ☑ Yes ☐ No
Hardcopy of Invoice with Report?	☐ Yes ☑ No
Company:	
Contact:	
Address:	
Phone:	Fax:
Lab Work Order # (lab use only)	

Report Format / Distribution	
☐ Standard ☐ Other	
☑ PDF ☑ Excel ☐ Digital ☐ Fax	
Email 1:	eric.demers@viu.ca
Email 2:	
Email 3:	
Client / Project Information	
Job #:	Environmental Monitoring Course
PO / AFE:	
LSD:	
Quote #:	
ALS Contact:	Amber Springer
Sampler:	Students

Service Requested (Rush for routine analysis subject to availability)

- ● Regular (Standard Turnaround Times - Business Days)
- ○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
- ○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
- ○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	GENERAL PARAMETERS	NUTRIENTS (P)	TOTAL METALS (P)	Number of Containers
	Departure Creek - Station 1	23-Nov-16	9:00	Surface Water	X	X	X	3
	Departure Creek - Station 3	23-Nov-16	9:00	Surface Water	X	X	X	3
	Departure Creek - Station 4	23-Nov-16	9:00	Surface Water	X	X	X	3

Short Holding Time

Rush Processing

L1862835-COFC

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Detection limits: ammonia [MDL = 0.005 mg/L], nitrite [MDL = 0.001 mg/L], orthophosphate [MDL = 0.001 mg/L], total phosphorus [MDL = 0.002 mg/L], total nitrogen.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
...ased by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
	23-Nov-16	17:30	JC	NOV 2 5 2016	14:50	9 °C				

APPENDIX C. ALS LABORATORY ANALYTICAL RESULTS

Results Summary L1853599

Job Reference ENVIRONMENTAL MONITORING COURSE
Report To Eric Demers, Vancouver Island University
Date Received 4-nov-2016 8:20
Report Date 14-nov-2016 18:07
Report Version 1

Client Sample ID			MILLSTONE RIVER - STATION 1	MILLSTONE RIVER - STATION 2	MILLSTONE RIVER - STATION 4
Date Sampled			30-out-2016	30-out-2016	30-out-2016
Time Sampled			09:00	09:00	09:00
ALS Sample ID			L1853599-7	L1853599-8	L1853599-9
Parameter	Lowest Detection Limit	Units	Water	Water	Water
Physical Tests (Water)					
Conductivity	2,0	uS/cm	32,1	58,6	79,5
Hardness (as CaCO3)	0,50	mg/L	13,2	24,5	29,4
pH	0,10	pH	7,43	7,39	7,55
Anions and Nutrients (Water)					
Ammonia, Total (as N)	0,0050	mg/L	<0.0050	0,0106	0,0087
Nitrate (as N)	0,0050	mg/L	0,0749	0,165	0,222
Nitrite (as N)	0,0010	mg/L	0,0011	0,0023	0,0018
Total Nitrogen	0,030	mg/L	0,189	0,383	0,451
Orthophosphate-Dissolved (as P)	0,0010	mg/L	<0.0010	<0.0010	0,0023
Phosphorus (P)-Total	0,0020	mg/L	0,0024	0,0073	0,0092
N:P	N/A	N/A	78,8	52,5	49,0
Total Metals (Water)					
Aluminum (Al)-Total	0,20	mg/L	<0.20	<0.20	<0.20
Antimony (Sb)-Total	0,20	mg/L	<0.20	<0.20	<0.20
Arsenic (As)-Total	0,20	mg/L	<0.20	<0.20	<0.20
Barium (Ba)-Total	0,010	mg/L	<0.010	<0.010	<0.010
Beryllium (Be)-Total	0,0050	mg/L	<0.0050	<0.0050	<0.0050
Bismuth (Bi)-Total	0,20	mg/L	<0.20	<0.20	<0.20
Boron (B)-Total	0,10	mg/L	<0.10	<0.10	<0.10
Cadmium (Cd)-Total	0,010	mg/L	<0.010	<0.010	<0.010
Calcium (Ca)-Total	0,050	mg/L	3,72	6,74	8,37
Chromium (Cr)-Total	0,010	mg/L	<0.010	<0.010	<0.010
Cobalt (Co)-Total	0,010	mg/L	<0.010	<0.010	<0.010
Copper (Cu)-Total	0,010	mg/L	<0.010	<0.010	<0.010
Iron (Fe)-Total	0,030	mg/L	0,055	0,185	0,329
Lead (Pb)-Total	0,050	mg/L	<0.050	<0.050	<0.050
Lithium (Li)-Total	0,010	mg/L	<0.010	<0.010	<0.010
Magnesium (Mg)-Total	0,10	mg/L	0,96	1,87	2,08
Manganese (Mn)-Total	0,0050	mg/L	<0.0050	0,0133	0,0244
Molybdenum (Mo)-Total	0,030	mg/L	<0.030	<0.030	<0.030
Nickel (Ni)-Total	0,050	mg/L	<0.050	<0.050	<0.050
Phosphorus (P)-Total	0,30	mg/L	<0.30	<0.30	<0.30
Potassium (K)-Total	2,0	mg/L	<2.0	<2.0	<2.0
Selenium (Se)-Total	0,20	mg/L	<0.20	<0.20	<0.20
Silicon (Si)-Total	0,050	mg/L	3,83	3,48	3,85
Silver (Ag)-Total	0,010	mg/L	<0.010	<0.010	<0.010
Sodium (Na)-Total	2,0	mg/L	<2.0	3,1	5,2
Strontium (Sr)-Total	0,0050	mg/L	0,0151	0,0277	0,0542
Thallium (Tl)-Total	0,20	mg/L	<0.20	<0.20	<0.20
Tin (Sn)-Total	0,030	mg/L	<0.030	<0.030	<0.030
Titanium (Ti)-Total	0,010	mg/L	<0.010	<0.010	<0.010
Vanadium (V)-Total	0,030	mg/L	<0.030	<0.030	<0.030
Zinc (Zn)-Total	0,0050	mg/L	<0.0050	<0.0050	<0.0050

Qualifier Legend
HTC Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable).

Results Summary L1862835

Job Reference ENVIRONMENTAL MONITORING COURSE
Report To Eric Demers, Vancouver Island University
Date Received 25-nov-2016 14:50
Report Date 1-dez-2016 12:19
Report Version 1

Client Sample ID			MILLSTONE RIVER - STATION 1	MILLSTONE RIVER - STATION 2	MILLSTONE RIVER - STATION 4
Date Sampled			21-nov-2016	21-nov-2016	21-nov-2016
Time Sampled			12:20	12:35	13:20
ALS Sample ID			L1862835-7	L1862835-8	L1862835-9
Parameter	Lowest Detection Limit	Units	Water	Water	Water
Physical Tests (Water)					
Conductivity	2,0	uS/cm	28,4	56,0	83,6
Hardness (as CaCO3)	0,50	mg/L	11,9	22,5	31,1
pH	0,10	pH	7,38	7,31	7,61
Anions and Nutrients (Water)					
Ammonia, Total (as N)	0,0050	mg/L	<0.0050	0,0105	0,0174
Nitrate (as N)	0,0050	mg/L	0,0683	0,195	0,248
Nitrite (as N)	0,0010	mg/L	<0.0010	<0.0010	0,0019
Total Nitrogen	0,030	mg/L	0,153	0,389	0,498
Orthophosphate-Dissolved (as P)	0,0010	mg/L	<0.0010	0,0011	0,0052
Phosphorus (P)-Total	0,0020	mg/L	0,0032	0,0069	0,0137
N:P	N/A	N/A	47,8	56,4	36,4
Total Metals (Water)					
Aluminum (Al)-Total	0,20	mg/L	<0.20	<0.20	0,51
Antimony (Sb)-Total	0,20	mg/L	<0.20	<0.20	<0.20
Arsenic (As)-Total	0,20	mg/L	<0.20	<0.20	<0.20
Barium (Ba)-Total	0,010	mg/L	<0.010	<0.010	0,013
Beryllium (Be)-Total	0,0050	mg/L	<0.0050	<0.0050	<0.0050
Bismuth (Bi)-Total	0,20	mg/L	<0.20	<0.20	<0.20
Boron (B)-Total	0,10	mg/L	<0.10	<0.10	<0.10
Cadmium (Cd)-Total	0,010	mg/L	<0.010	<0.010	<0.010
Calcium (Ca)-Total	0,050	mg/L	3,30	6,22	8,80
Chromium (Cr)-Total	0,010	mg/L	<0.010	<0.010	<0.010
Cobalt (Co)-Total	0,010	mg/L	<0.010	<0.010	<0.010
Copper (Cu)-Total	0,010	mg/L	<0.010	<0.010	<0.010
Iron (Fe)-Total	0,030	mg/L	0,077	0,286	0,792
Lead (Pb)-Total	0,050	mg/L	<0.050	<0.050	<0.050
Lithium (Li)-Total	0,010	mg/L	<0.010	<0.010	<0.010
Magnesium (Mg)-Total	0,10	mg/L	0,90	1,69	2,21
Manganese (Mn)-Total	0,0050	mg/L	<0.0050	0,0319	0,0463
Molybdenum (Mo)-Total	0,030	mg/L	<0.030	<0.030	<0.030
Nickel (Ni)-Total	0,050	mg/L	<0.050	<0.050	<0.050
Phosphorus (P)-Total	0,30	mg/L	<0.30	<0.30	<0.30
Potassium (K)-Total	2,0	mg/L	<2.0	<2.0	<2.0
Selenium (Se)-Total	0,20	mg/L	<0.20	<0.20	<0.20
Silicon (Si)-Total	0,050	mg/L	3,71	4,09	4,94
Silver (Ag)-Total	0,010	mg/L	<0.010	<0.010	<0.010
Sodium (Na)-Total	2,0	mg/L	<2.0	2,9	5,8
Strontium (Sr)-Total	0,0050	mg/L	0,0144	0,0280	0,0595
Thallium (Tl)-Total	0,20	mg/L	<0.20	<0.20	<0.20
Tin (Sn)-Total	0,030	mg/L	<0.030	<0.030	<0.030
Titanium (Ti)-Total	0,010	mg/L	<0.010	<0.010	0,028
Vanadium (V)-Total	0,030	mg/L	<0.030	<0.030	<0.030
Zinc (Zn)-Total	0,0050	mg/L	<0.0050	<0.0050	<0.0050

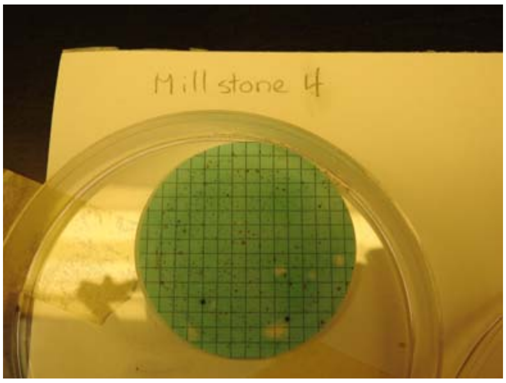
Qualifier Legend

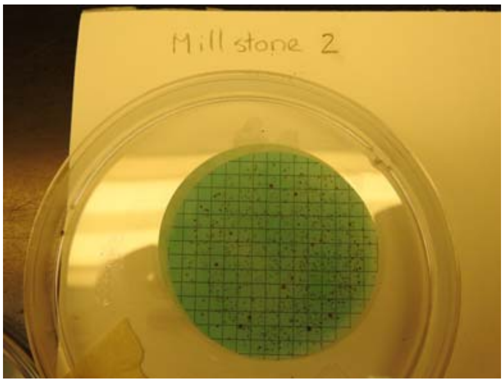
HTC Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable).

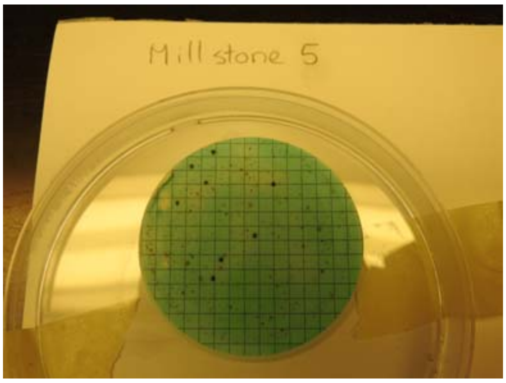
HTD Hold time exceeded for re-analysis or dilution, but initial testing was conducted within hold time.

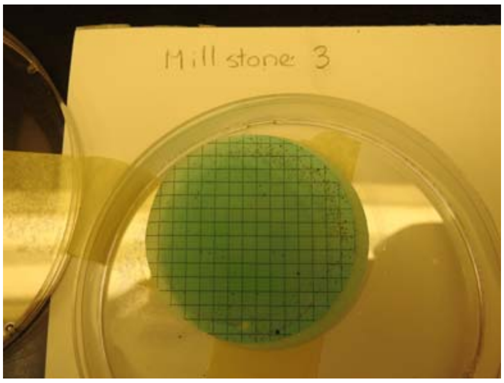
Appendix D. Bacterial Growth Plates


Mill stone 1


Mill stone 4


Mill stone 2


Mill stone 5


Mill stone 3